An Inter-Regional Grid Enabled Center for High Energy Physics Research and Educational Outreach (CHEPREO) at Florida International University

in collaboration with California Institute of Technology, Florida State University and the University of Florida

Year 3 Progress Report

July 31, 2006

U.S National Science Foundation

Table of Contents

Table of Tables

Table of Figures

1. Introduction

Florida International University (FIU), together with the California Institute of Technology, Florida State University, and the University of Florida have created an Inter-Regional Grid Enabled Center for High Energy Physics Research and Educational Outreach (CHEPREO). This report describes the progress achieved in the third year of funding.

Progress was made in all areas, and of special note was the hiring of a PER faculty (Dr. Jeff Saul) by FIU and the increased international work with physicists in Brazil thanks to the improved networking bandwidth.

CHEPREO also benefited from reviews by peers (the CHEPREO External Advisory Committee), students (CHEPREO fellows as well as modeling students), teachers (summer workshop and QuarkNet participants), as well as the funding agencies.

2. Progress at Florida International University

2.1. Physics Research

The primary effort of Florida International University's (FIU's) participation within the CMS collaboration has been to support the United States CMS efforts on the Hadron Calorimeter (HCAL). Specifically, we have been involved with the installation, testing, and commissioning of HCAL at the experimental site (SX5) in the French countryside. FIU's principal institutional responsibility is within the Detector Control Systems (DCS).

The HCAL DCS is comprised of six subsystems which are outside the realm of fast data acquisition. DCS is responsible for high and low voltage systems, laser and radioactive source calibration systems, the forward radiation monitoring system, and finally the downloading and monitoring of the front-end electronics.

Besides the hardware components, there is a large amount of hardware control software, which we refer to as servers in the sense that they act on control commands and 'publish' data describing their state (i.e., temperatures, voltages, currents, positions, etc.). On top of the hardware servers is a sophisticated software layer, which allows for logical segmentation of the detector and can be connected to the overall framework of the full CMS detector. This software is a commercial product called PVSS, and it has found industrial applications in process control. Stephan Linn is the HCAL DCS coordinator.

2.1.1 Progress to Date and Milestones

For the period under discussion we have accomplished the following milestones:

Prepare HCAL for testing: Our primary milestone for this past year was to ready the HCAL system for the Magnet Test and Cosmic Challenge (MTCC). While using a mature DCS system, twelve HCAL wedges were used to accumulate the self-triggered cosmic ray data. In addition, all four barrel and end modules have been tested with the laser and calibrated with a radioactive source system. At this time, the hadronic barrel (HB) calorimeter has been inserted into the solenoid and waits testing in the 4 Tesla magnetic field.

On-time delivery of the HCAL laser system: Designed and built by FIU and Florida State University (FSU), the HCAL laser system was delivered to CERN last summer. The installation, calibration, and commissioning was done by FIU students, Vanessa Gaultney and Luis Lebolo, during an extended stay at the CERN laboratory. At the end of the summer, the laser system was moved to SX5 for use in commissioning of HCAL. The system will be used during the MTCC and then moved to its final location underground.

Hiring of an on-site research scientist: In February 2005, we hired Dr. German Martinez who resides at CERN. Dr. Martinez's responsibilities include laser maintenance and operation, installation and programming of the CAEN Easy low voltage system. He is also part of the group installing the calorimeter at SX5, which involves many miscellaneous activities and project coordination efforts.

Addition of a graduate student to the project: In May 2005, Mr. Luis Lebolo became a graduate student and immediately asked to work on the CHEPREO project. Mr. Lebolo spent 6 weeks in summer 2005, working on the laser calibration system in Bat. 186 at the CERN laboratory. Most of his academic school year since has been spent on classes, however, he continues to assist with the analysis of the laser calibration data. These efforts were presented in talks at the Southeastern Section of the American Physical Society 2005 (SESAPS 05) and the Particles and Nuclei International Conference 2005 (PANIC 05) meetings. Mr. Lebolo will take a masters degree in Physics, and would like to pursue his Ph.D. at another institution within the CMS collaboration. We will be sorry to see him leave, but agree this move is in his best interest, since he was also an undergraduate at FIU.

2.1.2 Plans for the next reporting period

The MTCC will continue to have highest priority until its completion late in the Summer of 2006. We are sending three students to CERN to help with software tasks that can be maintained and upgraded upon return to FIU.

The HCAL group will undertake another series of beam tests in the CERN H2 beam line. This is scheduled to begin in mid-July. We will be spending considerable time at CERN during the summer to help set-up and run the testing operations.

We will also participate in the analysis of test beam data.

We will become involved in the off-line analysis – most probably taking responsibility for an HCAL related project such as jet energy scale or missing energy.

2.1.3 Personnel

Currently, we are hiring a second Research Scientist. This position, funded by FIU, will become a tenure-track line after three years, similarly to the position held by Dr. Linn.

2.2. Education and Outreach Efforts

2.2.1 Overview

Significant progress has also been made in CHEPREO's education and outreach efforts. Highlights of these efforts include:

- Hiring of a Physics Education Research (PER) faculty position in a tenure-earning line.
- Full Operation of Physics Learning Center (Phase I).
- Completion of our 3rd Annual Summer 3-week modeling workshops with plans underway for fourth annual summer workshops.
- Expansion of introductory modeling-based physics classes at FIU.
- Year 3 QuarkNet activities, highlighted by work with high school teachers.
- Matriculation of the first physics PER graduate student.
- A total of 10 funded CHEPREO Undergraduate Fellows with expansion in Fall 2006.
- Expansion of evaluation and assessment of undergraduate and high school programs.
- Establishment of a long-term physics education program.

The CHEPREO E/O effort is a coordinated, multifaceted effort having many components that synergistically support each other. For the purpose of this report, we break the efforts into several major areas, providing links to other relevant components. We begin with personnel changes, followed by a review of the goals of the education and outreach goals, then focus on the two major components of the community: the undergraduate and high school experiences. Current status of assessment and evaluation follows these descriptions. We conclude with discussion of future personnel and space requirements.

2.2.2 Personnel

In Fall 2005, our Physics Education Researcher position was filled by Dr. Jeff Saul. Dr. Saul completed his PER degree under Edward F. Redish at the University of Maryland and completed a postdoctoral position at North Carolina State University (NCSU) before going to the University of Central Florida (UCF) as an Assistant Professor. We hired him from a tenure-track line to come to FIU and work with CHEPREO due to his extensive experience with assessment, activity-based instruction, and the SCALE-UP project. His position is supported by CHEPREO for the first three years after which the university will provide his support. The position is a regular, tenure-earning position. His time towards tenure started immediately.

Dr. Saul is one of only a handful of PER people with extensive experience with workshop/studio style instruction like Modeling and SCALE-UP in calculus-based introductory physics classes. His work on SCALE-UP at NCSU and UCF was on developing effective studio courses for classes of up to 100 students. This will be critical to later stages in the project as we try to mainstream modeling classes to impact more introductory physics students at FIU by implementing large studio classes of 50-80 students. We expect to develop a course that combines elements of Modeling and SCALE-UP for these courses. His current contributions to the project are continuing to adapt the Modeling Curriculum for calculus-based introductory physics courses, working with George O'Brien to implement our assessment and evaluation plan, and running a PER program at FIU. He will also help us develop new modeling classes for the CHEPREO project.

Other changes in personnel included the addition of Priscilla Pamela, a Hispanic woman working with CHEPREO to get a Ph.D. in PER. FIU's College of Education also had personnel changes: Dr. Jiang left the university for a position elsewhere. Dr. O'Brien still leads the group from the College of Education who are working on CHEPREO.

2.2.3 Education and Outreach Milestones and Goals

The year one to three E/O milestones are summarized in **Error! Reference source not found.**. The Y1-3 E/O Milestones have essentially all been completed and we are scheduled to successfully complete years 4 and 5 milestones. The exceptions include the external evaluator reports, space expansion, test-bed schools, and delay in the implementation of the physics education MA. We also recognize the importance of fostering more international exchange between US and Brazilian students and faculty and will work to demonstrate a richer program during year 4 of the project. Along with the exceptions, we have also achieved some unexpected successes.

Hiring of the external evaluator was delayed as the initial external evaluator was hired as the physics education researcher (Saul). The external evaluator selection process is almost complete with the assessment to begin during the summer modeling workshops (see separate section). Expansion of the physical space continues at a somewhat slower pace then expected due to delays in relocation of current tenants. We expect the space to be complete by the end of year 4. The test-bed school concept has been modified and has evolved into a Partner School Model. We found that changing school administrations and changing teachers led us to reevaluate the test-bed school concept.

The Partner school model promotes deeper modeling-based reform demonstrated by multiple modeling-trained teachers and the *teachers'* desire to work together to build modeling expertise. The partner schools have generally been working with both the Physics Department and College of Education faculty in physics and mathematical modeling. Teachers from partner schools have participated in each year of modeling workshops and are sending more students to the physics and education programs at FIU. The focal point of the partnership has been the teachers' participation in different components of the CHEPREO E/O and COE activities. We have continued to encourage administrative support both in the schools and at the district level. We have found very strong support particularly at the district level. Support for the local teaching community extends beyond summer workshops and includes new / modified degree programs.

Creating a physics education MA program was included as a year 3 milestone to capture part of the teacher support umbrella. Changes in the administration and personnel in the College of Education have partly delayed this milestone. A new interim dean has recently been appointed to head the College of Education and we have re-launched our efforts to pursue solutions to meeting the needs of teachers.

Among our unexpected successes we consider the opening of the PLC to all physics education and physics majors a crucial step in the development of our learning community with great potential of increasing the number of applicants to the physics and physics education programs.

Education & Outreach	Status
Y1.1 - Organize PLC Board of Directors, Task Force Focus Groups; Faculty summer salary and release time	Complete
Y1.2 - PLC Inauguration; Establishment Facilities, Purchase Materials, Establish Peer Tutoring, Pilot Modeling Workshop	Complete
Y1.3 - Recruit One Graduate Student / Recruit First Group of Fellows	Complete
Y1.4 - Pre-assessment Activities Completed	Complete
Y1.5 - Test-Bed School Negotiation / Selection	Superseded
Y1.6 - Recruit 2-3 Lead Teachers for QuarkNet	Complete
Y1.7 - Hire PLC Coordinator / Science Educator	Complete
Y1.8 - Year 1 PLC E & O Activity Assessment	Complete
Y2.1 - Faculty summer salary and release time	Complete
Y2.2 - PLC Operational	Complete
Y2.3 - First Fellows Matriculate / Recruit Add'l Fellows, 1 Grad Student	Complete
Y2.4 - Pilot Introductory Modeling University Class at FIU in PLC	Complete
Y2.5 - One Test-Bed High School Operational	Superseded
Y2.6 - Increase Participants in QuarkNet (2nd Year)	Complete
Y2.7 - Standard Modeling Workshops Begin	Complete
Y2.8 - Introduce Participants from Brazil to QuarkNet and Modeling Workshops	Complete
Y2.9 - Year 2 Assessment and Reporting, Outside Evaluator Report	Mostly Complete
Y2.10 Develop Grid Computing Curriculum for mainstreaming in CS Courses	Complete
Y3.1 - Revise PLC Board, Re-Organize Task Force Focus Group; Faculty summer salary and release time	Complete
Y3.2 - PLC Continuation and Scale-up in New Facility – Higher Occupancy, Additional Courses	Mostly Complete
Y3.3 - Second Fellows Matriculate / Grads Students Continue / Recruit Additional Fellows	Complete
Y3.4 - Introductory Modeling Classes Continue / Expand	Complete

Y3.5 - Continue Test-Bed School Development & Expansion of Feeder Pattern School Network (Add development of 4th Test-bed site)	Superseded
Y3.6 - Continue Development of Year 3 QuarkNet Program	Complete
Y3.7 - Standard Modeling Workshops Continue	Complete
Y3.8 - *Expand MA Degree course opportunities in Physics and Mathematics for Teachers*	Delayed
Y3.9 - Year 3 Assessment and Reporting, Outside Evaluator Report	Mostly Complete
Y3.10 Mainstream grid computing in course 1. Invite selected FIU students for conducting summer research at UF.	Complete

Table 1: Original Year 1-3 E/O Milestones

We include a new set of E/O milestones for years 4 and 5 in **Error! Reference source not found.** (the original milestones are included in **Error! Reference source not found.**.)These milestones generally map directly onto the previous milestones, but have been updated and expanded to coincide with our current status. Significant changes include adding the E/O Coordinator, adjusting the schedule of the remainder of the space renovations, updating the role of teachers in the community and partner school activities, updating the schedule for the development of a masters degree component for teachers and adding introductory modeling curricular development. The E/O coordinator will take major responsibilities as described above in this report. The role of high school teachers has evolved to more leadership and voice in the development process. We remain strongly committed to supporting the teachers' needs, and we have found that successful teacher communities are most often led by teachers. We have updated the milestones accordingly. We have also realized that as we teach our introductory modeling classes we are creating significant curricular materials that could be used internationally. We have begun documenting our modifications and are working in collaboration with other college-level modeling instructors to build an exhaustive collection of modeling curricular materials for dissemination. This may lead to workshops directed at college and university faculty, supported through separate funding.

Education & Outreach
Y4.1 - Faculty summer salary and release time
Y4.2 - PLC Operations Continue / Expand
Y4.3 - 3rd Class of Fellows Matriculate (others advance), Grad Students
Y4.4 - Introductory Modeling Classes Continue, Add'l Sections, Equip 2nd Classroom
Y4.5 - Continue Test-Bed School Development & Expansion of Feeder Pattern School Network (including recruitment of more HS graduates to FIU Physics program)
Y4.6 - Continue Development of Year 4 QuarkNet Program
Y4.7 - Standard Modeling Workshops Continue
Y4.8 - Increased PLC Use By Teachers & Pre-Collegiate Students along with Undergraduates
Y4.9 - Year 4 Assessment and Reporting, Outside Evaluator Report

Y4.10 Mainstream grid computing in course 2. Refine material for transfer to FIU. Invite selected FIU students for conducting summer research at UF.
Y5.1 - Faculty summer salary and release time
Y5.2 - PLC Operations Continue / Expand
Y5.3 - 4th Class of Fellows Matriculates (others advance)
Y5.4 - Introductory Modeling Classes Continue, Add'l Sections & Courses
Y5.5 - Continue Test-Bed School Development & Expansion of Feeder Pattern School Network (including recruitment of more HS graduates to FIU Physics program)
Y5.6 - Continue Development of Year 5 QuarkNet Program
Y5.7 - Standard Modeling Workshops Continue
Y5.8 - Increased PLC Use By Teachers & Pre-Collegiate Students along with Undergraduates
Y5.9 - Exchange of Students, Teachers, & faculty USA & Brazil
Y5.10 - Begin expansion of Test-bed (feeder pattern) model to other regional schools
Y5.11 - Develop next 5 year plan for PLC & E & O Activities
Y5.12 - Year 5 Assessment and Reporting, Outside Evaluator Report, 5-Year Summary Report
Y5.13 Publish grid computing material for wider dissemination including demo applications.

Table 2: Original Year 4-5 E/O Milestones

Education & Outreach Updated Y4/5 Milestones
Y4.1 - Hire E/O Coordinator, Coordinator Assumes Responsibilities
Y4.2 - PLC Operations Continue (Open Labs Expand, Student Study Use Expands) / Phase 2 (VH166-170) Renovation Complete / Second Classroom Renovation Complete
Y4.3 - 3rd Class of Fellows Matriculate (others advance), Recruit Graduate Students
Y4.4 - Introductory Modeling Classes Expand, Modeling Expands Vertically into Physics Curriculum
Y4.5 - High School Community Evolves, South Florida Modeling Teachers Lead Reform, High School Students Offered Year Round Program
Y4.6 - QuarkNet Continues in Year 4; Cosmic Ray Detectors Delivered, Installed, and Operational; EPP Outreach Activities Implemented
Y4.7 - Summer Modeling Workshops Continue, Local Leader Development Component
Y4.8 - Increased Integration with Physics Department Reform Efforts; Develop BA & MA Teaching Degree Programs Coordinated Between College of Education and Physics Department
Y4.9 - Year 4 High School, Undergraduate, and Faculty Assessment and Reporting, Outside Evaluator Report
Y4.10 - Dissemination Through Conference Talks, and Publications. Introductory Modeling Curriculum Materials Documented for Dissemination
Y4.11 - Mainstream grid computing in course 2. Refine material for transfer to FIU. Invite selected FIU students for conducting summer research at UF
Y5.1 - E/O Coordinator Expands Role
Y5.2 - PLC Operations Continue (Open Labs Expand, Student Study Use Expands) / Phase 2 (VH166-170) Operational / Second Classroom Equipped and Operational
Y5.3 – 4th Class of Fellows Matriculate (others advance), Recruit Graduate Students
Y5.4 - Introductory Modeling Classes Expand, Modeling Established Throughout Physics Curriculum
Y5.5 - High School Community Established and Expands, Year Round High School Student Program Updated and Operational

Y5.6 - QuarkNet Continues in Year 4; Cosmic Ray Detectors Routine Operation and Analysis; EPP Outreach Activities Expand
Y5.7 - Summer Modeling Workshops Continue, Local Leader Develop
Y5.8 - Increased Integration with Physics Department Reform Efforts
Y5.9 - Year 5 High School, Undergraduate, and Faculty Assessment and Reporting, Outside Evaluator Report
Y5.10 - Dissemination Through Conference Talks, and Publications. Introductory Modeling Curriculum Materials Available for Dissemination
Y5.11 - Develop next 5 year plan for PLC & E & O Activities
Y5.12 Publish grid computing material for wider dissemination including demo applications.

Table 3: Updated Y4/5 E/O Milestones

As we updated the milestones, we also reviewed and revised the education and outreach goals, outcomes, and measures used to evaluate our progress in order to better develop our assessment and evaluation plan for years four and five.

The main objective of the educational outreach component of CHEPREO is to stimulate student interest in science and careers in physics and other STEM fields, to increase the number of physics degrees granted, and to increase public knowledge of physics, particularly elementary particle physics. This has been further divided into 6 sub-objectives:

1. Building a community of scholars including high school and university students, high school teachers, university faculty from Physics and Education, and research scientists.

2. To create physics education leaders within the community of scholars.

3. Using Physics Modeling, outreach, and improved support to create positive learning experiences for HS and undergraduate students.

4. Developing and disseminating a model for increasing minority/Hispanic representation in STEM degree programs.

5. Create and implement an Elementary Particle Physics outreach program to stimulate interest in science and recruit more STEM majors

6. Create, adapt, and implement Elementary Particle Physics activities for high school and undergraduate physics classes

A detailed breakdown of objectives, outcomes and measures can be found in **Error! Reference source not found.**.

2.2.4 Assessment and Evaluation Plan for Years 4 and 5

We are still in the process of developing our assessment and evaluation plan for years four and five of the project. A draft of the plan is outlined in Appendix D. It is organized around our outcomes and measures listed in **Error! Reference source not found.**. The plan has five components:

1. Evaluating implementations of modeling and modeling-type activities in FIU physics classes.
2. Evaluating implementations of modeling and modeling-type activities in HS science classes.
3. Evaluating the strength of the high school community and its connections to the rest of the community of scholars.
4. Evaluating the strength of the university community and its connections to the rest of the community of scholars.
5. Evaluating quality and quantity of the partnerships and linkages in the CHEPREO community overall

The key measures of our evaluation plan include learning assessments, observations, surveys and interviews, analysis of student records, and an external evaluator. The current draft contains a superset of possible measurements. The draft will be culled down to appropriate measures of quality and effectiveness during summer 2006 with the assistance of our external evaluator.

Learning Assessments: A variety of learning assessments are being used to determine learning gains in modeling classes and modeling workshops. These include using a variety of nationally-normed diagnostic tests and analysis of student work in class and on exams to compare modeling student performance with that of students in regular lecture/laboratory classes. We use several types of diagnostic tests to learn about our student population and assess their progress. Some are given as pre-tests, some are given as posts, and some are done both pre and post. Diagnostics given at the beginning of the course help us learn about what students know, how they think, and what skills they have coming into the class. This is particularly important for seeing how the student population understudy compares to that at possible dissemination sites, which in turn will help determine the robustness of our model for increasing representation of minority students in physics and other STEM fields. Examples of pretests include concept inventories such as the Force Concept Inventory (FCI), which measure basic student understanding of key concepts, knowledge and reasoning diagnostics such as the Epstein Basic Skill Diagnostic Test (BSDT) and the Lawson Test of Scientific Reasoning (TSR), and tests of epistemology and cognitive expectations such as the Maryland Physics Expectation Survey (MPEX). In addition, we are also using conceptual quizzes with open-ended questions throughout the term to develop a better understanding of South Florida physics students' preconceptions and establish a baseline to compare with exam results.

Objectives	Outcomes	Direct and Indirect Measures
1. Build a community of scholars • Creating an active and supportive community for undergraduate and graduate physics majors at FIU	• Improved socialization, less isolation • More positive attitude on studying physics • More spontaneous studying in groups • Increased participation in SPS and an	• Examine diversity of interactions, observe community activities, and use small focus group interviews to learn about participants' perceptions • Examine student participation in SPS activities, peer tutoring, and study groups

	increase in SPS activities • Increased participation in peer tutoring • Improved retention in degree program	• Examine student degree progress annually and compare with past trends
• Creating an active and supportive community of HS physics teachers in South Florida (South Florida Physics Modelers - FizMo)	• Create a supportive, interactive environment for South Florida HS Physics teachers • Teachers assisting other teachers with instructional difficulties	• Examine diversity of interactions, observations and evaluation surveys of community activities, and use small focus group interviews to learn about HS teachers' perceptions • Teacher surveys and/or interviews
	• Improvement of HS physics teachers' physics and physics pedagogy knowledge	• Evaluation of concept and problem solving diagnostics as well as expectation/epistemology surveys taken by teachers.
	• Increased in number of HS teachers implementing modeling activities in their physics classes	• Classroom observations, faculty surveys, and/or faculty interviews
	• Improved retention of physics teachers	• Comparison of teachers in community with control peer group
	• Increased number of students entering FIU and other schools as intended physics majors	• Look at number of students listed as intending to major in physics and how many do declare physics as a major annually and compare with trends over the past 10 years.
• bridging high school and university student and faculty communities	• Opportunities for South Florida HS science students to interact with FIU physics students • Opportunities for South Florida HS physics teachers to interact with FIU Physics faculty • Create linkages and partners with universities, school districts, and educational resource institutions to improve the quality of community resources and EO activities • Increase numbers of linkages and partnerships	• Examine number and quality of interactions with partners • Examine number, quality, and progress of linkages
• bridging physics, grid computing, and science & math education communities	• Create & build linkages among opportunities including modeling, QuarkNet, international exchange, and mainstream grid computing for individuals in the community	• Examine number, quality, and progress of linkages
	• build positive relations and mutual support linkages among AS & COE programs and faculty (e.g., Hestenes Modeling and COMAP)	• Examine diversity, quality, and progress of interactions
2. To create physics education leaders within the community of scholars	• Recruit and develop local leaders of teacher development workshops, leaders of South Florida Modelers, and PER projects	• Observations of leadership development • Monitor number and quality of leader activities with leader evaluations • Small focus group interviews and surveys to learn about Leader and participant perceptions

Table 4: CHEPREO Education and Outreach Objectives, Outcomes, and Evaluation Measures

Sub-Objectives	Outcomes	Direct and Indirect Measures
3. Using Physics Modeling, outreach, and improved support to create positive learning experiences for HS and	• Increased use of activity-based learning and modeling-learning cycle in undergraduate and HS physics	• Classroom observations, faculty surveys, or faculty interviews

undergraduate students	classes • Improved learning gains in modeling physics' classes compared to traditional instruction • Increased attendance in modeling physics classes compared to traditional instruction • Increased student interest in science and mathematics • Increased number of students majoring in physics and other STEM fields • Improved retention of physics majors and other STEM majors through BS degree	• Evaluation of concept and problem solving diagnostics as well as student assignments including exam problems • Compare attendance in modeling classes and regular lecture/lab classes • Small focus group interviews and surveys to learn about students' perceptions • Track number of HS students who apply to colleges and Universities to become physics majors or major in other STEM fields • Determine number of applicants, majors, and degrees granted in physics and other STEM fields at FIU
4. Develop and disseminate model for increasing minority/Hispanic representation in STEM degree programs	• Increased number of physics majors applying to FIU • Curriculum and student support changes increase number and retention of successful minority physics majors • Comparable improvements in recruitment and retention at dissemination sites	• Review, evaluate, and test model at FIU • Track number of applicants listing intension to major in physics • Track retention and graduation rates for physics majors and compare with past trends • Use small focus group interviews and surveys to learn about faculty and student perceptions and identify factors key to model success • Evaluate model at dissemination site(s) by tracking physics majors and interviews with faculty and students
5. Create and implement an Elementary Particle Physics (EPP) outreach program to stimulate interest in science and recruit more STEM majors, including but not limited to:	• Increase quantity and quality of physics and EPP outreach activities.	• Examine number and quality of outreach events • Determine number of people impacted by these activities
• On-site or video conference talks on EPP at FIU and participating high schools • Physics Open Houses and physics competitions at FIU for HS students and their parents • Physics programs for HS students including Modern Physics and EPP labs • EPP demonstrations and activities in high school physics classes using Quarknet materials	• Increased numbers of physics and other STEM majors at FIU • Increased undergraduate student interest in of EPP	• Annually monitor number of students majoring in physics and other STEM fields • Annually monitor number of students inquiring about or expressing desire to work in EPP • Evaluate quality and quantity of EPP questions from HS and undergraduate students
• EPP and other physics public lectures and/or demonstration shows	• Increased public interest in EPP	• Evaluate quality and quantity of EPP questions general public
6. Create, adapt, and implement Elementary Particle Physics (EPP) activities for High School and Undergraduate physics classes	• More EPP activities (with student and instructor materials) implemented in high school and undergraduate introductory physics • Improved student understanding of EPP concepts	• Examine number and quality of curricular activities and materials • Evaluate implementation of curricular activities • Determine number of people impacted by these activities • Evaluate with comparisons with control group of student responses on Pretest and exam questions

Table 4: (cont.) CHEPREO Education and Outreach Objectives, Outcomes, and Evaluation Measures

Pre/post and post-only test are given at the end of the course to help us determine students' level of mastery of the course material and cognitive reasoning ability at the end of the course. For example, the FCI given at the beginning of course can tell us students' basic understanding of Newtonian force and motion coming into the course, when give again at the end of the course and compared with the pretest results, we can determine how well students' basic understanding have improved. However, diagnostics to measure more complex student understanding cannot be given at the beginning of the term before students have learned the vocabulary of the course material, let alone developed a good understanding and the ability to apply it. An example of a good post-only diagnostic is the Mechanics Baseline Test (MBT), which looks at students' ability to apply concepts to problem solving. A limited number of interviews will be conducted to ensure the reliability and validity of the diagnostic test results. One issue of particular concern in South Florida with a large Hispanic community where many there are many ESL students is whether a poor score is due to difficulties with language or with the physics. Note that not all types of diagnostics are used for all classes both to avoid skewing results through over testing and to respect the time teachers feel to use as much instructional time as possible to cover content. In addition, careful analysis and comparison of exam results from modeling and regular classes are used as measures of student problem solving ability.

Staff and External Reviewer Observations: EO team members and our external evaluator will conduct two types of observations, classroom observations and event observations. Classroom observations look at how modeling and other PER-based activities are implemented in the classroom and how students respond to them. A protocol like the Reform Teaching Observation Protocol will be used to see to what degree and how well modeling is being implemented in CHEPREO-reformed high school and undergraduate classes. Event observations by CHEPREO senior staff will be used both to evaluate event leadership and how well the event went.

Surveys and Interviews: In addition to documenting the EO evaluation team's perceptions of project leaders, classes and events, it is also important to document the perceptions of the teachers and students participating in the program through surveys (including evaluation forms), and interviews. Both surveys and interviews surveys are useful for gathering participating teacher and student perceptions of what is going well, what factors contributed to success, and where improvements are needed. These factors are important for determining if the workshops and classes are providing a positive learning experience and the nature of that experience. Both surveys and interview will be conducted to gather both good quality quantitative and qualitative data. Surveys provide broad coverage of perceptions from a large number of participants, but with little opportunity to go in-depth or do follow-ups. Interviews provide opportunities to go more in-depth in learning about participant perceptions and pursuing follow-up questions but are limited to a small fraction of the participants. Both are needed to put together a complete picture of how participants see the program.

Analysis of Student Records: Records of attendance, grades, and demographics will be analyzed to look for evidence of students' positive learning experiences, success rates, retention, and the effect of CHEPREO and other department efforts on the number of physics majors entering and graduating from the program. We will be looking for effects on underrepresented minorities in particular.

External Evaluator: When our previous external evaluator (Saul) became our PER specialist, we began a new search for an external evaluator. The evaluator we desire is one who can make 2-3 site visits per year to observe our summer workshops as well as modeling classes taught at FIU and local high schools. The evaluator must have extensive experience in PER, Physics Modeling, reform teaching at the high school and undergraduate level, and educational assessment so that they can provide us with substantial, detailed feedback in their formative assessments to improve our education and outreach efforts. This criteria led us to two people in the first round who met these criteria and were interested in working with us, but were overly committed to their current projects to accept our external evaluator position.

Our second round has led to candidates with experience in implementing and evaluating PER-based curriculum and assessment. In addition these candidates have a research background in either Physics Modeling or institutional change in physics departments. We are currently discussing the requirements of the position with the following three candidates, each who have expressed interest in the position:

Dr. Charles Henderson, Assistant Professor of Physics, Western Michigan University

Dr. Kathleen Harper, Director of Undergraduate Course Development and Physics Modeling Workshop Leader, Ohio State University

Dr. Melissa Dancy, Assistant Professor of Physics, University of North Carolina at Charlotte

We expect to conclude the search and hire an external evaluator in time for them to make their first site visit during the Summer 2006 Modeling Workshops.

2.2.5 Undergraduate Community:

Undergraduates at FIU are supported through introductory modeling classes, CHEPREO Fellowships, and the Physics Learning Center (PLC) space. We have made significant progress in all three areas; modeling classes are filled to capacity with many students wait-listed, Open Labs have been instituted for students in the introductory courses, and the PLC usage has transformed the undergraduate experience for physics majors and students in the introductory courses.

Modeling-based Introductory Physics Courses at FIU: Implementation of modeling-based introductory physics expanded in the past year. Two sections of Physics were offered both in the Fall and Spring terms covering both Physics I and II. Dr. Kramer led a Physics I class in the Fall semester followed by Physics II in the Spring. Dr. Markowitz led a Physics II class in the Fall term and Dr. Saul led a Physics I class in the Spring term. The courses are proving quite popular; previous students actively recruit their friends into the program, student evaluations and preliminary focus group interviews are very positive, and student performance is excellent. To keep up with the demand, enrollment has expanded to 30 students per section, the limit of the room. Further expansion will occur in Fall 2006, when we will operate three simultaneous sections.

We have added open labs to support the modeling students. Open labs are scheduled times when students may visit the PLC, access the lab materials and computers, and learn physics. They may expand upon their in-class labs, work through concepts and problems, and make up missed labs. CHEPREO undergraduate fellows staff the labs for roughly 20 hours-per-week. Their interactions with the students continue under the modeling mode and Socratic dialogue. The open labs have been very well received by the students; many have commented positively in evaluations, as well as in student interviews. The operating hours of the open labs will expand as we train additional fellows.

The modeling-based reform is sparking reform throughout the department. Faculty members are incorporating modeling components in their classes. Modern physics, modern physics laboratory, and intermediate mechanics all have components of modeling such as whiteboarding and group problem solving. Students from the modeling classes continue to work as they did in their modeling classes and encourage classmates to participate as well. In 2004/5, the first group of introductory modeling students entered modern physics (four students). In 2005/6, the second group of introductory modeling students entered modern physics (eight students). Modern physics has also grown from roughly 8-12 students per year to 16-20 per year. We expect this trend to continue and expand as we offer additional modeling classes.

At this stage, we are focusing on revising and documenting our modeling-based curriculum so that additional faculty members can more easily adapt to the modeling classroom. These revisions include updating the well-developed high school mechanics materials to reflect the university curriculum and significantly updating the electricity and magnetism materials that are not completely developed. We are working with several other physics faculty from across the country that have implemented modeling in their introductory classes, adapting their materials in our classroom. All materials will be shared with the larger modeling community through mini-workshops and the web.

Fellow	Class	Years in pgm	MW	HS teach in pgm	Gender	Assist in Class	Open lab	Treisman	PER Research	EPP Research
Vanessa Gaultney	Sr	2	Y	Y	F	Y	Y	Leader		Y
Diane Alvarez	Jr	2	Y	Y	F	Y				Y
Jonathan Diaz	So	1	Y	Y	M			Participant	Y	Y
Francisco Reynoso	So	1	Y	Y	M	Y	Y	Participant		Y
Ida Rodriguez	So	1	Y	Y	F	Y	Y	Leader / Participant		
Ramona Valenzuala	So	1	Y	N	F	Y	Y	Participant		
Guillermo Matranca	Jr	1	Y	N	M					
Greg Azarnia*	Jr	0.5	N	N	M		Y			
Chris Ceron*	Sr	0.5	N	Y	M		Y			
Dalgis Mesa*	Jr	0.5	N	N	F		Y			

Table 5: Demographics and Participation of CHEPREO Fellows

Research and efforts thus far were presented by Drs. Saul and Kramer, graduate student Priscilla Pamela and undergraduate student Vanessa Gaultney at the Summer Salt Lake City American Association of Physics Teachers meeting (AAPT 05), the Southeast Section of the American Physical Society 2005 meeting (SESAPS 05) and the Winter 2005 American Association of Physics Teachers 2006 (AAPT 06) meeting. In addition, Drs. O'Brien and Jiang presented papers at the Annual School Science and Mathematics Association (SSMA) Conference in Fort Worth, Texas in November 2005. Dr. O'Brien presented again at the Annual Meeting of the Association for Science Teacher Education (ASTE) in Portland, Oregon in January 2006. We also hosted the April 2005 Florida AAPT meeting in the Physics Learning Center.

CHEPREO Fellows: Our undergraduate fellows have established themselves as one of the most exciting components of the project. In Spring 2006, 10 fellows worked with CHEPREO. Seven continued from Fall 2005 and were trained through the summer modeling workshops. The three new fellows were added to increase the open lab availability. These students will participate in the summer modeling workshops and continue next year. Recruiting for additional fellows continues both on campus and through the high school teacher network. We expect to competitively fill 6 positions by Fall 2006.

The strategy behind the fellowship program is to train and expose fellows to a variety of experiences that will motivate the students to learn, provide them with skills to do well in their coursework, and launch them into the next phase of their scientific career. The typical structure for the first two years involved educational support of their undergraduate career. As a student this includes taking the introductory modeling courses, participating in Treisman study groups, and taking the summer modeling workshop. As a student *leader*, they assist in the modeling classroom and open labs, lead a Treisman group, and/or work with high school teachers. In the leadership role, they gain experience as educator, influencing their decision for academic or educational careers, as well as building confidence in their understanding of the fundamentals. In the second part of their undergraduate career, fellows are encouraged to participate in elementary particle physics or physics education research, thus producing a very well rounded student. Fellows often pick a mix of activities for any one semester, limited to roughly 15 hours of work-per- week.

The experiences of our current group of fellows are summarized in Table 5. The table shows each fellow's class, number of years in the program, whether they attended a summer modeling workshop, if their high school physics teacher is part of the CHEPREO community, gender, and which activities they participated in during their fellowship. An asterisk indicates the student was added late to cover an immediate need such as an open lab staffing.

Physics Learning Center: Since its opening in March 2005, the PLC has become the center of our undergraduate community, transforming how both physics majors and introductory modeling students learn and interact. Phase I includes the first modeling classroom (capacity 30), the student lounge, and the conference room. The PLC is occupied an average of 16 hours a day, seven days a week as indicated by the sign-in log. The CHEPREO fellows have been granted 24-hour access and use it as their on-campus home. They have almost continual access to the conference room and lounge and access to the classroom when it is not in use. The fellows have taken ownership of the space, regulating its use, designating a quiet study room, keeping the kitchen clean, and even organizing major clean up days several times a semester. All physics majors benefit from the space, with access through the fellows. Introductory modeling students also utilize the space, both through the open labs and through using it as a study center on a limited basis. Access to the PLC has built a very good community as physics majors of various levels interact with each other and with the introductory modeling course students. Faculty and high school physics teachers also interact with these groups in the PLC on a regular basis as they attend meetings or stop by.

Future plans for the PLC include installation of the video conferencing / electronic classroom equipment (installation began on May 30, 2006). Phase II of the PLC has been designed and is awaiting renovation. The space is located adjacent to the existing rooms and will include expanded study group space (allowing uninterrupted access, a PER curriculum library, equipment storage and a formal entrance). No date has been set for these renovations, although their impact is expected to be similar to what we have seen in Phase 1. The final phase includes a second, larger modeling classroom.

2.2.6 High School Community:

The high school community continues to evolve with the third year of summer modeling workshops in 2005, establishment of "FizMo" (the South Florida modeling group that meets regularly), QuarkNet, and high school student focus-based activities. The goal remains to develop leadership in the region that will drive the transformation of the community. As leadership is building, we are experiencing many benefits of having worked with teachers over the past three years including stronger ties with high school and increased enrollment of physics majors.

High school summer physics modeling workshops continued in Year 3, operating our third year of workshops. Two mechanics workshops were held in 2003, supported by our College of Education collaborators to jumpstart the community. In 2004 and 2005, one mechanics and one advanced (models of light / electricity and magnetism) workshop were run each year under CHEPREO support. Workshop leaders have remained consistent throughout, two mechanics leaders (Jeff Steinert and Stan Hutto) from 2003 continue to run the mechanics workshops and the advanced workshop has been run by Mark Schober and Matt Watson. The same leaders will return for the 2006 workshops, assisted by a Florida teacher (Lela Van Loon) for one week.

One of the goals of the high school community has been to establish a vibrant, year-round community. FizMo meets every three weeks in the PLC and is additionally supported by an email listserve. Meetings are organized around teacher needs – discussions of modeling activities, lab equipment demos, FIU open house planning, etc.

The first several meetings were well attended (including one participant driving from the Fort Myers region and another from Tampa participating by phone). However, attendance has dropped. We attribute this drop to several factors including Hurricanes Katrina and Wilma which impacted the region. Several meetings were cancelled, disrupting the initial continuity. A second challenge is to find an ideal meeting time. We are considering organizing a second meeting time with two separate subgroups focusing on different activities with larger meetings on an infrequent basis.

Despite the challenges, a core group of FizMo teachers have been meeting throughout the Spring semester and organized an open house on May 13, 2006, based on the QuarkNet open house of 2005. Students and their parents were invited to FIU for a demo show, lab tour, lunch and build competition. A Trebuchet building competition was held where student teams built their own trebuchets on site and competed for several prizes in several categories. Teachers, undergraduates and faculty all participated in the open house, with plenty of social interactions during the tours, Trebuchet contest, and lunch.

Figure 1: CHEPREO / FIU Physics Open House, May 13, 2006

Our QuarkNet center entered its third year in 2005/06, having 12 active members (down by one from 2004/05). Our goal for 2005/06 was to keep the center active and plan for more extensive activities for 2006/07. As FIU joined CMS and QuarkNet after all major hardware components were built, we have been challenged by defining the central theme of our QuarkNet center. We have found that the most successful centers share several important components including a major hardware project, dedicated space for projects and meetings, and acquisition of cosmic ray detector systems. We and the QuarkNet teachers are investigating several larger projects that could be supported by the center to enhance our QuarkNet Center. The general theme is to generate demonstration / exhibit materials based on EPP that could be either located at the local science museums or travel to schools. The center has also considered offering science museums assistance by volunteering student, teacher, and faculty time at the exhibit for a more meaningful interaction. We all feel that this could be a very stimulating experience for the teachers and their students, as they would gain great pride in display of their materials for many to enjoy. It also has the potential to stimulate science enrollment at both high schools and universities.

2.2.7 FIU's Physics Education Research Group (PERG)

With the hiring of Dr. Saul as our resident PER specialist, we have started a physics education research group (PERG) at FIU consisting of Dr. Saul (Physics), Dr. Kramer (Physics), and Dr. O'Brien (Science Education), one physics graduate student (Pamela), and assistance from the CHEPREO undergraduate fellows. We are hoping to add up to two Science Education graduate students to the group by fall 2006.

In our first year, the PERG has collected and analyzed the data collected from the modeling workshops and modeling classes. We have completed the preliminary analysis that follows. The group is preparing to expand our efforts at FIU to include more focus group and interview studies with FIU physics students and extend these efforts to participating high school modeling classes. In addition, the FIU PERG is currently working on a joint project with Colletta and Philips to analyze the extensive data base Saul has collected to verify and expand on the implications of their study how Pre diagnostic measures correlate with normalized gain published in the December 2006 issue of the American Journal of Physics. This work has interesting implications for helping PER-based reforms reach and surpass 70% normalized FCI gains. We have also started collaboration discussions with current and former Arizona State University Physics Modelers such as Halloun, Desbien, and Brewe to work on joint projects of research and curriculum development.

While the FIU PERG students have workspace with the EPP students as part of the Physics Learning Center, the group also has been allocated space for 3 dedicated rooms for a dedicated curriculum laboratory and interview room, a data analysis room, and a Physics Education Research and Curriculum Development Library. The latter two rooms are in the PLC and are on loan to CHEPREO from the College of Education. The data analysis room is already in use while the other two rooms are still being outfitted with furniture and equipment.

The curriculum laboratory and interview room is for conducting interviews with students and faculty in private for focus groups, interview students of student understanding, and validation interviews for assessment instruments. In addition, it will allow us to field test new activities under development before they are implemented in the classroom. We have procured two hard drive cameras for classroom observations and interviews. We have also procured one professional video camera for experimenting with different microphone set-ups to record and study students working on group activities in class. The data analysis room is for the processing, analysis, and storage of data collected by the PERG. The room has been outfitted with two high-speed duel-core computers for video processing and analysis. Last but not least is the Physics Education Research and Curriculum Development Library for CHEPREO faculty, teachers, and students. The library will be on a key lock both to provide easy 24-hour access and a record of who is using it. The library contains a large collection of curriculum materials, Science/Math Ed and PER books and articles, and a computer station with online access. We have already obtained donations of PER based textbooks from Wiley, Addison-Wesley, and Prentice Hall. There is also a table for teachers to work with the materials and each other. We expect the library and interview rooms to online this summer.

This summer we will begin working with some high school teachers on physics education and physics education research projects. This will form the basis for a PER-based research experiences for teachers proposal next year. In our second year the PERG group expects to complete several short projects and submit our first CHEPREO EO papers for publication.

2.2.8 Assessment and Evaluation

Although a more aggressive program of assessment and evaluation of CHEPREO education and outreach programs is planned for years 4 and 5 (as described above), our program has been limited to pre and post testing, analysis of exam problems, written participant evaluations, a preliminary analysis of student and room use records, and a small number of focus group interviews. We are still analyzing data from this past year but the preliminary results are presented below.

University Community: The Modeling-based Introductory Physics Courses are generating positive results and a buzz on campus. Evaluations are higher than traditional lecture courses (interesting since evaluations for studio courses at other universities are often lower than for traditional courses) and there is a wait list for sections (roughly 50 requests for 30 seats in some cases). We have gathered pre/post diagnostic test data, conceptual quizzes (Regular Lecture/Lab classes only), and student exams in selected classes. We have completed our analysis of the pre/post diagnostic concept test data for year 3 and are continuing with the remainder of the data analysis. The concept tests we applied are described briefly in Table 6. The results are shown in Table 7**Error! Reference source not found.** and Table 8 below. Results from regular lecture sections and SCALE-UP studio classes (similar to modeling classes) from a majority Florida university are included for comparison.

Physics 1 Concept Test	**What it measures**	**# of questions**
Force Concept Inventory version 2 (FCI)	Students' basic understanding of key concepts in Newtonian force and motion	30
Thorton-Sokoloff Energy Questions (NRG)	Students basic understanding of conservation of mechanical energy	4

Physics 2 Concept Test	**What it measures**	**# of questions**
Conceptual Survey of Electricity and Magnetism (CSEM)	Qualitative final exam in electricity and magnetism but with no calculus and no coverage of circuits.	32
Electric Circuit Conceptual Evaluation (Abridged ECCE)	Students' basic understanding of circuits (from a battery and bulb approach – includes RC circuits)	16

Table 6: Multiple Concept tests used as pretests and posttests in calculus-based introductory physics classes in first semester mechanics courses (above) and second semester electricity and magnetism courses (below).

Class	Pretest	Posttest	Normalized gain
Majority Florida University (FCI) 13 Lecture Classes	42.6% ± 3.3%	54.3% ± 4.1%	20.5% ± 5.6%
Majority Florida University (FCI) 6 SCALE-UP Classes	40.5% ± 3.5%	69.2% ± 6.0%	48.3% ± 7.9%
5 FIU Lecture Classes (FCI)	34.4% ± 2.9%	47.9% ± 3.4%	20.5% ± 5.7%
2 FIU Modeling Classes (FCI)	30.2% ± 3.0%	64.9% ± 1.6%	48.2% ± 4.4%
Majority Florida University (NRG)	29.0% ± 6.3%	46.4% ± 7.4%	24.6% ± 10.8%

13 Lecture Classes			
Majority Florida University (NRG) 6 SCALE-UP Classes	23.6% ± 6.4%	60.0% ± 9.0%	47.6% ± 15.0%
5 FIU Lecture Classes (NRG)	22.0% ± 3.1%	35.4% ± 6.4%	17.1% ± 8.9%
2 FIU Modeling Classes (NRG)	23.8% ± 1.7%	57.7% ± 11.0%	59.9% ± 11.0%

Table 7: Pretest and post-test results for both modeling and regular lecture sections of the first semester calculus-based introductory physics course (Physics 1 mechanics). The data from the lecture sections is only from those sections where faculty volunteered their classes for this project. Data is the mean value averaged over classes ± standard deviation.

The pre results for physics 1 show that FIU students come into calculus-based physics classes with a weaker background in Newtonian force and motion than students is the same class at a comparable Florida university with a majority student population. This is not surprising since a significantly larger fraction of the students at FIU have not had any prior physics classes. The pre/post FCI results for physics 1 show the modeling students with an average normalized gain more than twice that of the students in regular sections. A similar result is seen in 4 multiple choice questions on conservation of energy. It is interesting to note that students in the lecture class with the best normalized gains and in the two-year 3 modeling physics 1 classes (the three classes that saw the best improvement in pre/post concept test scores) also saw their confidence in their responses from pre to post improve by 2.1-2.5 standard errors.

Class	Pretest	Posttest	Normalized gain
Majority Florida University (CSEM) 2 Lecture Classes	24.7% ± 0.8%	39.4% ± 3.8%	19.5% ± 5.6%
Majority Florida University (CSEM) 5 SCALE-UP classes	25.8% ± 0.9%	52.6% ± 2.7%	36.5% ± 3.3%
3 FIU Lecture Classes (CSEM)	24.5% ± 2.5%	45.9% ± 4.1%	28.7% ± 2.9%
4 FIU Modeling Classes (CSEM)	24.4% ± 6.2%	44.5% ± 6.3%	26.7% ± 4.4%
Majority Florida University (ECCE)	29.0% ± 0.9%	33.1% ± 0.1%	5.8% ± 1.1%

2 Lecture Classes			
Majority Florida University (ECCE) 5 SCALE-UP classes	28.4% ± 0.6%	54.5% ± 3.9%	36.4% ± 1.7%
3 FIU Lecture Classes (ECCE)	16.1% ± 0.3%	13.0% ± 6.7%	3.2% ± 3.5%
2 FIU Modeling Classes (ECCE)	17.3% ± 0.9%	21.1% ± 11.0%	4.6% ± 3.0%

Table 8: Pretest and post-test results for both modeling and regular lecture sections of the second semester calculus-based introductory physics course (Physics 2 electricity and magnetism). The date from the lecture sections is only from those sections where faculty volunteered to let us use their classes for this project. Data is the mean value averaged over classes ± standard deviation.

The pre date for the physics 2 data for general E&M concepts diagnostic (CSEM) are similar for students at FIU and the majority Florida university while the majority students scored significantly better on the pretest DC circuit concepts diagnostic (ECCE) did significantly. This suggests that the students in both schools have little exposure to electricity and magnetism in general, although the majority students seem to have done some DC circuit work before.

While the Physics 2 modeling classes were very positive experiences for the students in those classes (see below), the pre/post data shows the learning gains by students in the modeling sections were comparable to those in the selected lecture sessions. This result, compared with the majority Florida university results and similar studies with studio physics classes elsewhere, suggests to us that there is either an implementation issue or a curriculum issue that needs to be resolved. Since this issue does not appear in the Physics 1 results, we believe the current electricity and magnetism modeling curriculum (based on HS modeling materials) needs more work to adapt it to a University Physics course. Anecdotal comments from both instructors who have taught the modeling curriculum suggest that the activities may need to be modified to make them work together better to reinforce key concepts and make them a better fit for a calculus-based introductory physics class. In year 4, we will be looking at adapting activities from other PER-based undergraduate curricular materials for E & M and blending them in a spiral approach to better reinforce student understanding of key concepts. On a different note we were surprised that even the lecture classes performed better the comparable classes at the majority Florida University. This is something we would like to study further.

A preliminary study of small focus groups of students in a modeling physics 2 class was conducted in January 2006. The seven students participated in groups of 1-3 students. They were asked questions about their perceptions of the class, how they study and seek help, and what parts of the class were most or least helpful. The seven students had all taken the modeling physics 1 class and chosen to continue with modeling in physics 2. The results were very positive compared with similar interviews conducted with SCALE-UP students at NCSU, UCF, RIT, and MIT. The results can be summarized as follows:

- All 7 students would take a modeling version of physics 1 if they had to take it again. They would recommend it to their friends and they emphasized this was the best way to "really learn physics."

- In studying, they all found the textbook (Young and Freeman) useful but most homework help from open labs or doing homework in groups. They typically spent 5-12 hours per week studying for this class.

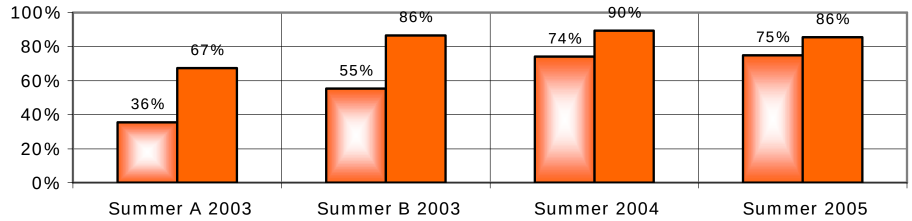
- They found laboratory activities and the worksheets (90% of in-class activities) to be the most helpful for learning and five of the seven were stumped when asked to describe what was the least useful activity in or out of class for helping them learn physics. The other two named the reading quizzes as least helpful since they would have done the reading assignments even without them.

- When asked to make at least one suggestion to improve the course, none could think of anything they would change.

In general, the students particularly liked how the class helped them learn physics and how they appreciated the social aspects of working in groups in and out of class. We plan to do further studies of this kind with both modeling and regular lecture classes.

High School Community: Other than looking at participation records of the events described in the high school community section discussed above, the assessment of the high school community so far is limited to pretest and posttest results from the Summer Workshop participants on concept tests and the collection of some pre and post test results from high school classes. In year four we plan a more aggressive program for assessing the learning gains of high school modeling classes and evaluating how well modeling instruction is being integrated into the high school physics courses. We also plan to use surveys and interviews to learn more about high school teachers and students' perceptions of the program and the how modeling activities are implemented in high school classes.

The concept test results from the Mechanics Modeling summer workshop is given in the graph below. The first two graphs on the left from Summer 2003 start lower than the summer workshops in 2004 and 2005 because of the large number of high school mathematics teachers who participated that first year. In the following years, almost all the teachers participating in the summer workshops were physics teachers. The average FCI normalized gain for the Mechanics workshops is 57% with average post scores above the master level of 85%. This past year, only two of the fifteen high school physics teachers failed to leave the 2005 mechanics modeling workshop with a mastery-level post score.



The CSEM results of teachers in the physics 2 electricity and magnetism workshop were also impressive. The results are show below in Table 9 with the results from FIU lecture sections included for comparison.

Group	CSEM PRE	CSEM Post	Normalized Gain
FIU Lecture Classes	24.5% ± 2.5%	45.9% ± 4.1%	28.7% ± 2.9%
Teacher in Physics 2 Summer Workshop	65.1% ± 20.5%	77.6% ± 9.4%	35.8%

Table 9: Pretest and post-test results for CSEM for teachers in the advanced (E&M) summer modeling workshop and FIU lecture classes.

While we have gathered pretest and posttest FCI results in previous year and are in the process of gather post data as this report is being compiled, we do not have much to day at this time. All we can say at this time from our preliminary analysis is that pre scores average 18-22% correct and that the year one and year two results for teachers in the modeling workshop are only slightly improved than the results from teachers before they have the workshop. This is one of the reason we want to look more carefully at what is being implemented in high school classes n future years.

2.2.9 Future Personnel and Space Requirements:

Two of the biggest challenges for the E/O efforts are personnel and space. Two faculty members from the College of Education have either retired or relocated to another university, leaving us below the planned staffing level. In this year's budget, we are requesting a full-time coordinator to cover the gap left by this staffing shortfall. Most of the cost comes from the salary savings of the two faculty members who have left and it therefore only represents a small increase in budget. The impact of the dedicated CHEPREO E/O coordinator is expected to be significant. The responsibilities will include:

- Liaison for high school teachers, both to contact them concerning upcoming events and to gather information on their needs and requests.
- Organization of introductory physics modeling curricular materials (including web-based dissemination).

- Distribution, collection, checking, and collation of PER assessments for high school and university classes.

- Organization and creation of promotional materials for the E/O program.

These activities are currently handled by a combination of faculty, graduate students, and undergraduates. Placing all of these activities under a single person's care will greatly enhance the effectiveness of the whole project.

A second challenge for the project is acquiring adequate renovated space. The PLC has dramatically improved the experiences of the undergraduates, faculty, and high school teachers. It has already become overcrowded and scheduling sometimes leaves important groups without access and ability to do their work. The FIU administration should be strongly encouraged to complete their commitments. These commitments include phase 2 of the PLC (designed and described above) as well as the second larger classroom for modeling instruction.

2.3. Cyberinfrastructure Update

2.3.1 Overview

Significant progress was made in Year 3. Significant milestones to report are:

- The deployment of Cisco ONS 15454 optical muxes in Miami and Sao Paulo (see Section 2.3.5)

- The integration of the High-Energy Physics groups at FIU in Miami, Sao Paulo, Rio de Janeiro and other locations in Brazil to utilize CHEPREO and WHREN-LILA network resources to improve access to networks and projects in the U.S. (see Section 2.3.6)

- Facilitated FIU's and Brazil's participation in Open Science Grid (see Section 2.3.6)

- Established connectivity to UltraLight to support CHEPREO's research and experimental networking component (see Section 2.3.7)

The foremost goal for Year 4 is to ready the Cyberinfrastructure for CMS experiment data taking that starts in 2007. In 2006, a series of challenges are being staged for communications among Tier1's, Tier2's and Tier3's to ready the network infrastructure. Brazil has established a distributed Tier2 facility involving institutions in Rio de Janeiro and Sao Paulo, supporting Brazil and the region of Latin America assisted by the FIU and Caltech network and grid computing engineering team. FIU, with mentoring by Dr. Jorge Rodriguez of the University of Florida (UF), has administered the Tier3 in the NAP of the Americas, which is collocated with the AMPATH International Exchange Point (IXP) and the Florida LambdaRail (FLR).

The role of CHEPREO Cyberinfrastructure in this goal is to enable Brazil and the region of Latin America to participate as a partner in the CMS experiment with the U.S. and CERN. CMS Tier2's specifications call for good 2.5 – 10G connections to Tier1 facilities. CHEPREO Cyberinfrastructure is aiming to improve the infrastructure to enable the U.S. and Brazilian collaboration to fully participate in the CMS and LHC experiments. In careful discussions with the NSF CHEPREO program officers it was concluded that increasing the bandwidth capacity to 2.5G by the beginning of 2007 is the right thing to do, but to achieve this goal there were budget impacts taken in all areas of the project.

At FIU staff, student support, travel, and other direct costs were impacted in all areas between 12% and 30%. Graduate student support was cut from 3 students to 2 in physics. FIU undergraduate student support was cut by $3,600 in direct support along with the fringe and indirect costs. Within the subcontracts, Caltech reduced the budget in year 4 by 21% impacting the support for CMS students and restricting the scope of what we can do in Brazil to provide support for the distributed Tier-2 computational grid, networking, and HEP collaborative support. FSU reduced their subcontract by 12%, impacting staff and student support for CMS. UF took a 15% cut in their subcontract which will impact grid computing support for universities in Florida to some extent. We have provided a prototype budget for year 5 of CHEPREO which restores the activity support detailed herein and also maintains the increase in the bandwidth at 2.5G. The cost is approximately $426,000 in addition to the PEP 2003 estimates.

We realize that a mid-year review in about January or February, 2007 will be critical in positioning CHEPREO for its year 5 project goals. At that review we propose working closely with the NSF project officers to revisit the CHEPREO milestones and align them to shared objectives and funding.

The following sections provide the rational within CHEPREO's project scope to ready its cyberinfrastructure to facilitate Brazil and Latin America's participation in CMS experiments and data taking in 2007.

2.3.2 Year 4 and 5 CHEPREO Cyberinfrastructure Milestones

The overall IT infrastructure project execution plan closely resembles the 2003 proposal. The following Cyberinfrastructure Milestones table is adapted from the 2003 PEP to reflect current conditions. The milestone tasks fall into the same overall categories whereas the descriptions have been updated to indicate where items have already been phased in over the first three years and are now transitioned to maintain stability and plan for sustainability over the life of the project.

- Y4.1-5.1: Upgrade nodes and add storage for the Tier3 Data Center, as well as keep up with collocation needs at the NAP of the Americas. The Y4.1 upgrade has been placed on hold. Please see Section 2.3.3 for a detailed explanation.
- Y4.2-5.2: Y4.2 reduced cyberinfrastructure staff support by 12% to 50%. These critical staff support funds will have to be supplemented by other projects in the

pipeline, or reductions will be necessary. Y5.2 restores staff support to previous levels.

- Y4.3-5.3: In Y4.3 Active Equipment Maintenance on Existing Equipment was reduced by 12% which has to be made up on other leveraged projects. Y5.3 restores this 12% reduction.
- Y4.4-5.4: Reprogram funds from active equipment and OA&M towards increasing the bandwidth between Miami and Sao Paulo to 2.5 Gbps by the first quarter of 2007 to support CMS data analysis needs for a distributed Tier-2 facility in Brazil.

Please see Appendix A for complete details of the budget request which as also been submitted to the MPS-EPP program officer via a revised budget and budget impact statement.

The FIU Center for Internet Augmented Research and Assessment (CIARA), led by Executive Director Julio Ibarra, Research Director Heidi Alvarez and Chief Operations Officer Chip Cox, is providing network engineering and network resources for international networks, grids and collaborative systems. In particular, with Caltech, UF and FSU, CIARA continues to extend grid-based computing to the FIU Physics Department's expansion into CMS physics. The AMPATH international exchange point, a project of CIARA located in the NAP of the Americas, continues to provide the OSG and UltraLight connectivity extension to South American countries but through the CHEPREO-WHREN-LILA link, rather than the AMPATH research network as reported in Year 1. We continue to develop plans to support Latin America's GRID (LAGRID) as a multi-disciplinary international resource in support of US science in Latin America, interconnecting with North America's and Europe's Grids.

The CHEPREO project objective of serving under-represented communities through research, science, education outreach, Grid-based computing and international networking continued as a major focus of our Year 3 activities.

2.3.3 Tier3 Data Center in the NAP

Plans are in place to expand and upgrade the facility in the next funding cycle. The upgrade would replace aging hardware and include a dedicated storage element that will provide local storage to enhance the facility at FIU.

The cluster hardware will be coming out of warranty at the end of 2006. The first purchase of nodes and the switches were made in late 2003. The second purchase will come off warranty about 6-9 months later. That amounts to 22 nodes that should be targeted for phased replacement starting by the Fall of 2007. The warranty issue is not the only thing driving the need to replace the hardware. There are also considerations with the hardware becoming obsolete as new services and applications take advantage and come to rely more on new high-performance components. There is also greater difficulty in actual administration of computer equipment that is potentially more prone to failure as time ages the components.

We also need to add a dedicated shared storage resource site to the FIU Tier3. Currently the FIU-PG site only provides computational resources and as the OSG matures there will be a greater need to have locally available storage to go with the computing at sites across the Grid. Thus we will definitely need to augment the FIU Tier3 with dedicated storage in Year 4 of the project. The type of storage we are considering would provide about 10TB of disks to OSG and local users, and will be deployed with the evolving OSG/CMS storage middleware.

2.3.4 IT Support Personnel

During Year 3, CIARA hired Mr. Bin Liu, a recent graduate of the FIU Computer Science Master's program and former student of Assistant Professor, Dr. Chi Zhang, who works with Dr. Sanjay Ranka at UF to instantiate grid computing education into the computer science curriculum. Mr. Liu worked with CIARA's Network Engineer, Mr. Ernesto Rubi, to provide network engineering and grid computing support to CHEPREO under the direction of the CIARA Director and Executive Director. Mr. Liu was recruited by Microsoft and accepted a position with the software company in January. Effective April 3, 2006, Mr. Michael Smith joined the team in the same capacity as Mr. Liu. Mr. Smith is a senior in the undergraduate computer science program. He has skills in networking and cluster computing that have been immediately applied towards support of CHEPREO.

Meanwhile, Mr. Ernesto Rubi, who has been with CHEPREO since it began in 2003, is graduating with a Bachelors degree in Computer Engineering this Spring. To recognize Ernesto's professional and academic accomplishments we recommend a 15% increase. This action is also critical to retain his professional expertise for CHEPREO, as well as, other related projects such as WHREN-LILA, AMPATH and CyberBridges. Both positions are now funded 50% from CHEPREO and 50% from AMPATH to insure backup coverage for both projects. This milestone also contains part of the funding for the Caltech Network Engineering support discussed in full in Section 5, as well as part of the funding for Alvarez and Ibarra.

2.3.5 Active Equipment

In Year 3, the link capacity between the U.S. and Brazil was increased from 622Mbps to 1.2Gbps. The increase in capacity was funded from the Western-Hemisphere Research and Education Networks – Links Interconnecting Latin America (WHREN-LILA) project, funded from the NSF International Research Network Connections (IRNC) program, award #0441095, and the FAPESP/ANSP Award #2003/13708-0.

Two Cisco ONS 15454 optical muxes, purchased with Year 2 CHEPREO funds, are in full operation and are being used to terminate the WHREN-LILA international circuit between Miami and Sao Paulo. The WHREN-LILA international circuit was configured on these optical muxes to provide an SDH transport service between the Miami and Sao Paulo end points. Layer 2 and Layer 3 equipment have been connected to the optical muxes to enable mapping of multiple Ethernet VLANs and Layer 3 services.

The exchange points in Miami and Sao Paulo have established a distributed exchange point service that enables networks that are connected at either location to effectively and efficiently exchange traffic in an open exchange environment.

The network diagram of Figure 1 shows the two Cisco ONS with the LILA circuit as a 1.2Gbps service terminated on STM-16 ports, providing the flexibility to upgrade to the port capacity of 2.5Gbps. At the AMPATH international exchange point, the LILA circuit extends to an Ethernet switch from where connections are made to Internet2's Abilene network, to the UltraLight network over NLR, and to the CHEPREO Tier3 cluster, that is now participating in OSG. At the Sao Paulo exchange point, ANSP, RedCLARA (within 60 days) and RNP connect to the Cisco ONS through an Ethernet switch.

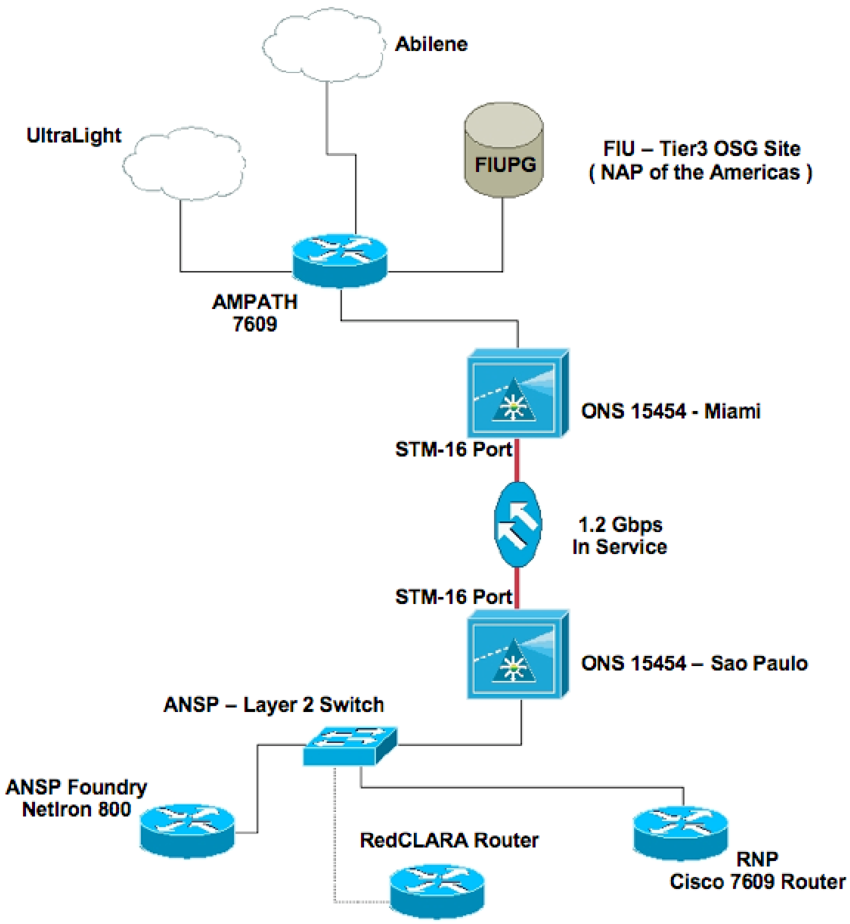


Figure 1: As-Is Network Diagram Showing Cisco ONS And LILA Circuit

In Miami, CHEPREO Year 3 funds were used to purchase Layer 2 and Layer 3 equipment for a Cisco 7609 switch that interconnects with the Cisco ONS 15454 optical mux. This equipment provides CHEPREO with 1 and 10 Gig Ethernet ports to satisfy project requirements.

In Sao Paulo, the CHEPREO-funded Cisco ONS 15454 is being used to create a distributed exchange point architecture that will integrate Layer 1 and Layer 2 services from three collocation sites: Cotia, Barueri and the University of Sao Paulo (USP). The lambda cloud, shown in Figure 2, creating a WDM infrastructure, permits the open interconnection of pairs of Layer 1 or 2 devices in the different POPs connected to the cloud. The Cisco ONS 15454, provided by the NSF-funded CHEPREO project, is being used to facilitate the interconnection of these Layer 1 and 2 devices.

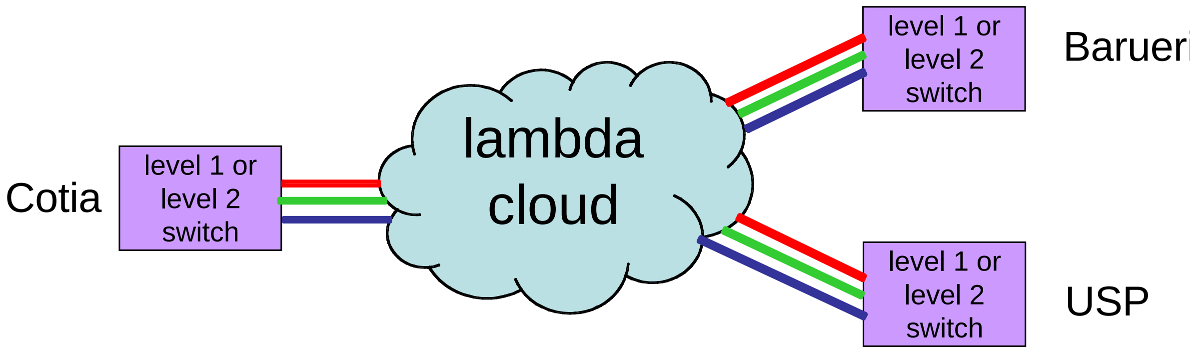


Figure 2: Distributed Exchange Point logical diagram

While discussions occurred to program Year 4 funds to upgrade the ports on the Cisco ONS 15454 to STM-64 capacity to enable incremental bandwidth increases up to 10Gbps on the SDH transport service between Miami and Sao Paulo, the consensus was that the priority should be increasing the bandwidth to 2.5G by the 4th quarter of 2006. Therefore no active equipment is requested in Year 4 or 5 of CHEPREO. This milestone is to maintain the existing active equipment with maintenance contracts, personnel and other direct costs as needed.

The figure on the following page shows the network design with the STM-64 ports for the international link. It is a design that allows a flexible process of increasing the bandwidth on the international link when it is needed. This capacity complements the existing network capacity in Miami that connects to UltraLight, National Lambda Rail and Abilene. In Year 4 the CHEPREO, WHREN-LILA and UltraLight teams will work on a cogent plan to describe the needs and strategies to increase the bandwidth to 10G.

CMS Tier2 specifications call for good 2.5 – 10G connections between Tier1 and Tier2 facilities. Brazil's distributed Tier2 facility will be using FermiLab as its Tier1 facility, to transfer, validate and publish data, and run remote applications. The benefit of upgrading to these ports is that it positions Brazil and Latin America to participate in the LHC-CMS experiments at CERN, in collaboration with partners at FermiLab and other sites in the U.S, as well as, to participate in the CMS Tier2 Milestones plan to prepare for 2007 when data taking starts.

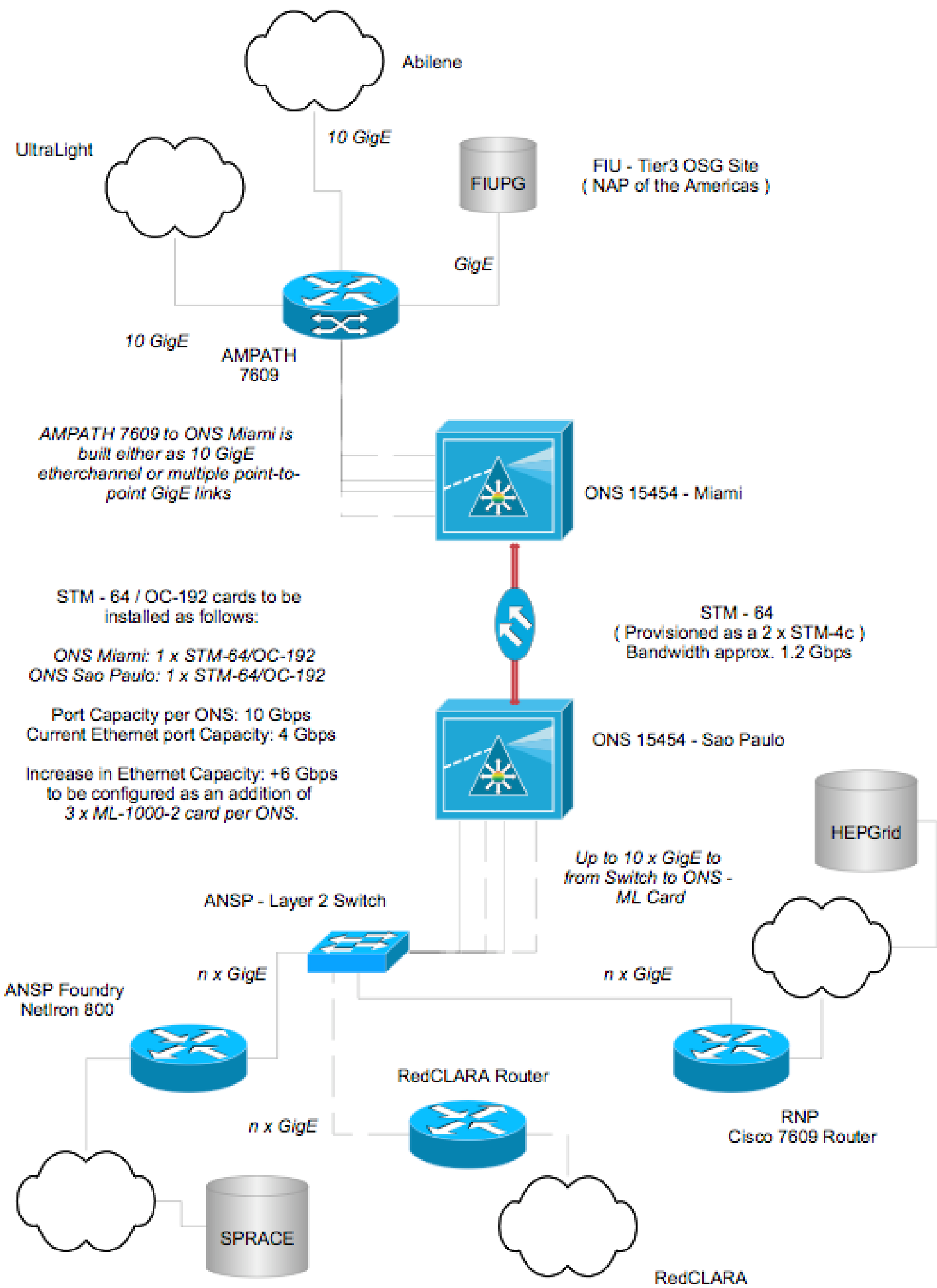


Figure 3: Physical Network Diagram; STM64, 1 and 10 GE ports on both ONS' & LILA Circuit

While we currently have all of the active equipment necessary to increase the bandwidth between Miami and Sao Paulo to 2.5G by the end of this calendar year, Figure 3 provides a future design for the hardware to support requirements of bandwidth increases for the CERN LHC experiments from the U.S., Brazil and Latin America as well as production application requirements supported by the WHREN-LILA project.

2.3.6 International Circuit to Sao Paulo

Prior to CHEPREO, the R&E networks of Brazil were connected to the U.S. through the AMPATH project over 45Mbps DS3 circuits. CHEPREO provided the means to increase the network connection between the U.S. and Brazil to an STM-4 (622Mbps) circuit. Funds provided by CHEPREO were enough to establish the circuit and use it for less than 12 months, but not enough to sustain it for the remaining 3 years of the CHEPREO project. The NSF International Research Network Connections (IRNC) program, Award #0441095, to the Western-Hemisphere Research and Education – Links Interconnecting Latin America (WHREN-LILA) proposal from FIU, coupled with the financial support from Brazil, through the State of Sao Paulo's FAPESP award to the Academic Network of Sao Paulo, Award #2003/13708-0, provided just-in-time funding to sustain the STM-4 circuit and to define a roadmap to increase the bandwidth capacity for CHEPREO.

Today, what was a 45 Mbps DS3 link is now a 1.2Gbps network connection between connecting Miami and Sao Paulo, the U.S. and South America. As 2007, approaches, when data taking will start for the LHC experiments at CERN, the production and research infrastructure provided by CHEPREO and WHREN-LILA, provide significant resources to enable CMS, ATLAS, LHCb and ALICE partners in Brazil to fully participate in the experiments at CERN, which is a benefit to the US CMS research collaboration.

Brazil is moving towards a distributed CMS Tier-2 facility between HEPGrid/UERJ in Rio de Janeiro, under the leadership of Prof. Alberto Santoro, and SPRACE/USP/UNESP in Sao Paulo, under the leadership of Prof. Sergio Novaes. Facilities, UFRGS, CBPF, UFRJ, UFBA, plus other Brazilian institutions are interconnected over the Giga[1] project optical platform. Grid resources in São Paulo and Rio are growing and steps are underway to connect all the sites to create a distributed Tier2 facility for the region that should be useful for all groups participating in the LHC experiments. In Year 3 of CHEPREO, HEPGrid and SPRACE both joined the U.S. Open Science Grid community, and the UltraLight collaboration. HEPGrid has been receiving a large number of submissions from several disciplines, including Biology, many HEP experiments, specifically, programs for calculations on Lattice Gauge Theory from the U.S. OSG community. The availability of the WHREN-LILA link and the additional bandwidth capacity and reliability, DZero job submissions are being received and executed. Lessons learned from this usage are readying the distributed Tier2 to receive a much large load of remote job submissions from the U.S. CMS community. HEPGrid and SPRACE are making more effective use of tools for sustaining multiple data flows, monitoring remote-job execution and conducting analysis, as a result of the improved quality from WHREN-LILA link provides.

[1] Brazil's Giga Project, http://www.rnp.br/en/news/2004/not-040730.html

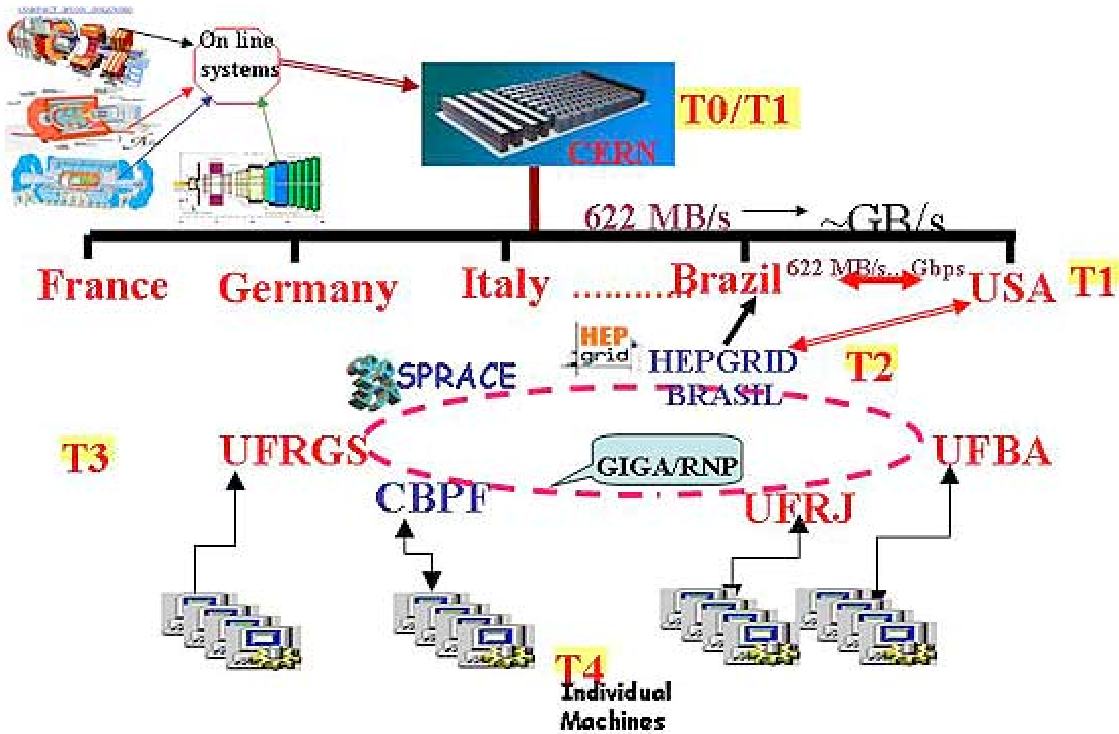


Figure 4: Brazil's Distributed Tier2 facility

CMS Tier2 specifications call for good 2.5 – 10G connections between Tier1 and Tier2 facilities. Brazil's distributed Tier2 facility will be using FermiLab as its Tier1 facility, to transfer, validate and publish data, and run remote applications. Brazil's current connection has a bandwidth capacity of 1.2Gbps, using the WHREN-LILA link between Sao Paulo and Miami. The WHREN-LILA link is configured as a shared production link, supporting the HEP community of Brazil and Latin America, as well as the science and engineering research and education communities of Latin America that collaborate with the U.S.

In preparation for 2007, the CMS Tier2 Milestones Plan[2] calls for Tier2's to demonstrate data transfers to Tier1's, utilizing 50% of their network connection. Current bandwidth capacity of the WHREN-LILA link fails to meet the low-end bandwidth capacity specifications for Tier2 facilities. The PI's of Brazil's distributed Tier2 facility have notified the CHEPREO and WHREN-LILA leadership of their readiness to participate in the CMS Tier2 Milestones Plan, and have also expressed concern of the capacity of the connection to FermiLab to support their participation (please see attached letters from Alberto Santoro and Sergio Novaes). For Brazil to participate at the low end of the scale for Tier2's, the capacity on the WHREN-LILA link must be increased to at least 2.5Gbps.

[2] CMS Tier2 Milestones Plan, http://www.uscms.org/SoftwareComputing/ProjectManagement/DOE_NSFReviews/2006-02/talks/LHCSC_Bloom.pdf

The connection for RedCLARA (the regional network of Latin America) and RNP (the national research and education network of Brazil) to the exchange point in Sao Paulo will be increasing the load on the inter-regional (WHREN-LILA) circuit for connectivity to the U.S. The following table shows current and projected usage[3] of the inter-regional circuit in 2006.

	Current (Mbps)	**2006 Q3 (Mbps)**	**2006 Q4 (Mbps)**
Academic Network of Sao Paulo (ANSP)	120	160	160
RedCLARA		100	100
RNP		100	100
Distributed Tier2 facility	200	200	1244
Total	300	560	1604

Table 10: Current and project international bandwidth utilization for 2006

The table shows that by Q4 of this year, the WHREN-LILA link will be oversubscribed by approximately 30%, as a result of the load from the CMS Tier2 Milestones Plan.

With the CHEPREO Year 4 funding, the schedule to increase capacity to 2.5Gbps on the WHREN-LILA link will be changed to occur in the fourth quarter of 2006, instead of December 2008. .

2.3.7 CHEPREO Cyberinfrastructure Collaborative Learning Communities

Collaborative learning communities help to establish new relationships between students and faculties in different countries and they are an important pathway to achieve a synergy between graduate students, experienced engineers, and research scientists.

Two important examples are the Pan American Advanced Studies Institute (PASI), and the UltraLight Summer Workshop tutorial. The PASI initiative, held at Mendoza, Argentina from May 15 through May 21, 2005, brought together approximately 40 students from the Americas. During this five day event, our students had the opportunity to learn about new ideas and developments in advanced networking technologies. The lectures, seminars, and discussions promoted by leading scientists from North and South America were mainly built on the strengths of the Physics and Astronomy communities already doing research in the Americas. It is important to note that one of our students established his doctorate main line of research during those days.

The UltraLight summer Workshop tutorial, held at CHEPREO's Physics Learning Center from June 8th to June 10th 2005 also helped train one of our students in state-of-the-art network and distributed-system science and technologies. He had the opportunity to have face-to-face contact with some of the managers of the UltraLight project and also had

[3] Usage is calculated from average and maximum utilization

valuable discussions with the other participants, which help to intensify collaboration of our research group and the UltraLight research community.

These efforts are enabling our students to better prepare for their careers and vocations. CHEPREO support for international exchanges are helping them to develop important interdisciplinary skills that give strong support to research activities, by providing them access to appropriate conferences, workshops and summer schools.

In summary, CHEPREO's efforts are an important contribution that is building new relationships between the US and South American researchers.

2.3.8 Network Connections for research and production

Another milestone accomplished in Year 3 was CHEPREO connecting to the UltraLight network. Through the help of a donation of optical equipment from Cisco Systems to the Florida LambdaRail (FLR), FIU-CHEPREO and the University of Florida (UFL) are fully participating in the UltraLight project. The following figure shows the network topology.

Participation in UltraLight is satisfying the requirements of access to an experimental research and education network for the CHEPREO community, as specified in the CHEPREO Project Execution Plan. The diagram shows two distinct connections out of Miami; one terminates in Atlanta, the other in Jacksonville. The connection to Atlanta is to Internet2's Abilene network that provides a production network service for CHEPREO. The connection to Jacksonville connects to the NLR node, where it meets the UltraLight network. FIU and UFL share the connection from Jacksonville to Chicago on the UltraLight network.

Experimental network services (UltraLight/NLR) and Production network services (Abilene) are extended to CHEPREO partners in Brazil over the WHREN-LILA link.

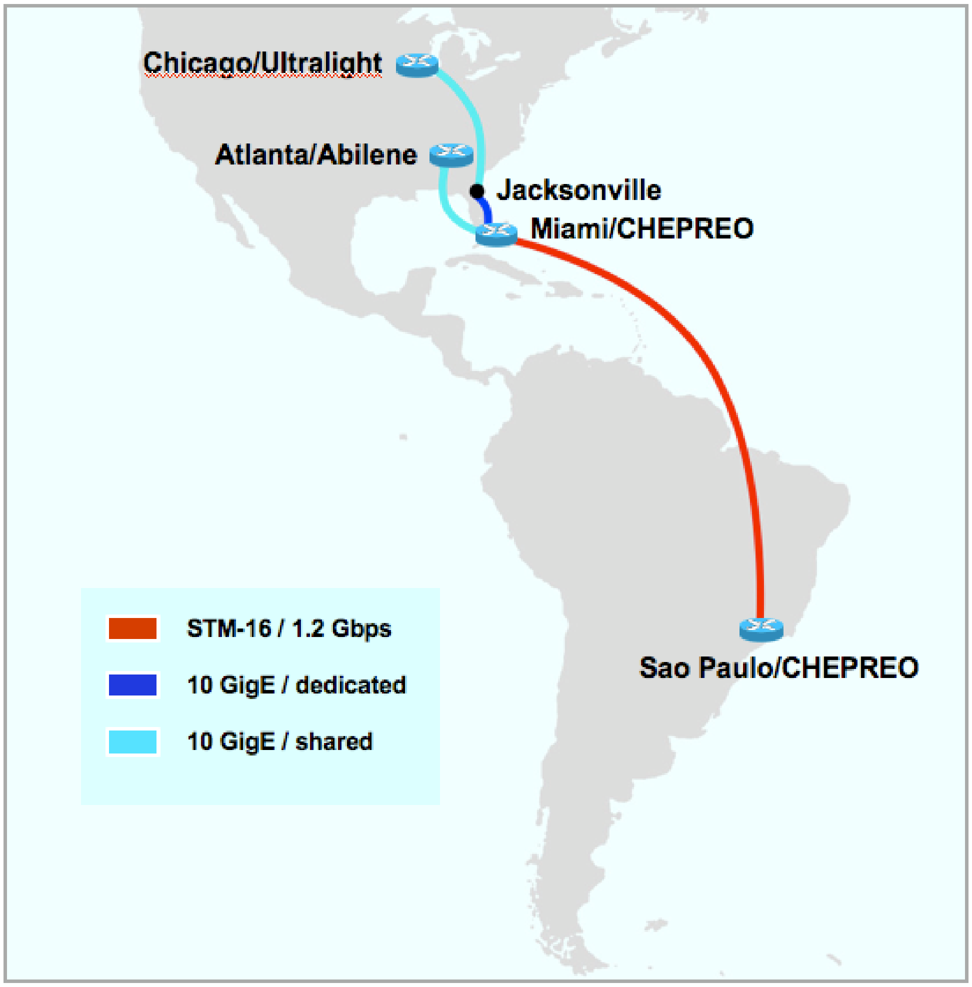


Figure 5: North and South America Inter-Regional Connectivity to Production and Experimental R&E Networks

2.3.9 CIARA Internships in Network Engineering and Grid Computing

CIARA has supported five student interns during Year 3 of CHEPREO. Three of these interns were women and two men with 80% Hispanic. Internships offered through CIARA provide FIU students with an opportunity to be involved in the daily processes of the center and learn about network engineering, grid computing, research applications in science and engineering as well as business practices necessary to support CHEPREO. For example, student interns helped Physics and Education faculty that run the CHEPREO summer workshops to coordinate the logistics for workshop participants. Furthermore, student interns accompany network engineers to the NAP of the Americas where the CHEPREO Tier3 and the AMPATH active equipment reside. They participate in installation and maintenance activities as appropriate to their educational experience.

3. Florida State University-related CHEPREO activities

3.1. Personnel

FSU personnel working with CHEPREO include the following:

Vasken Hagopian	Faculty
Harrison Prosper	Faculty
Yuri Gershtein	Faculty
W. G. D. Dharmaranta	Visiting Faculty (on sabbatical at FSU until 8/05) from Sri Lanka, continuing collaborative work
Jeffrey McDonald	Assistant Scholar/Scientist (until 3/06, takes new position with School of Computational Science of Florida State University)
Kurtis Johnson	Scientist
Andrew Askew	Post Doctoral Fellow
Sharon Hagopian	Scientist
Edgar Carrera	Graduate Student
Sergei Gleyzer	Graduate Student

3.2. Introduction

Florida State University personnel have increased their participation both in CMS and CHEPREO during the past year and plan to further increase the effort during the next few years. Our major contributions during the past year were as follows:

1. Continue to work with FIU Physicists on CMS. Specifically work with the Hadron Calorimeter and, more recently, the integrated Hadron Calorimeter (HCAL) with Electromagnetic Calorimeter (ECAL).

2. Expand the CMS Software environment and create the Open Science Grid. We now have 10 Gbps connectivity.

3. CMS Simulations. Continuing SUSY Simulation effort using the FIU, FSU, FNAL and CERN computers. SUSY Background to signal reduced from a factor of 10,000 to 1 after basic cuts to about 1 to 1 using neural networks.

4. Electron and photon reconstruction and calibration: expanded effort.

5. Test beam and Cosmic challenge effort for 2006 at CERN, including the integrated HCAL and ECAL sub-sections.

6. Teaching and outreach.

3.3. CMS construction, assembly and calibration effort

This task is now completely integrated with FIU Physicists Drs. Steve Linn and Post Doctoral Fellow German Martinez who is permanently at CERN. To reach our goal of 5% accuracy of energy measurement of the HCAL on day one, we have expanded our effort in Integration and Calibration. We continue to built hardware as new problems show up (such as eliminating ground loops by building quartz fiber isolators). We expect to continue this close collaboration during the 2006 Cosmic Challenge and CERN Test Beam effort.

3.4. CMS Software environment and CMS GRID

We are now on the OPEN SCIENCE GRID with five PC computers. Our local cluster has about 70 CPU's and we plan to increase the number of CPU's on the OPEN SCIENCE GRID. The system is functioning well. Please see the next Section which contains further information concerning FSU's computing infrastructure.

3.5. CMS Simulations: Initial emphasis is on SUSY at CMS

Since our very successful collaboration with FIU, in which we combined our resources to simulate more than 450,000 minimal supergravity (mSUGRA) events as they might appear in the CMS detector, we have been studying whether such events could be identified using Bayesian neural networks. The latter differs from the more commonly used neural networks in that one averages over an ensemble of networks, rather than make do with one. In principle, these methods, by construction, are optimal. Professor Baer of FSU and co-workers have shown that, with anticipated integrated luminosities at the LHC, such events could be identified in the di- or tri-lepton final states, at the cost of a greatly reduced signal. Our goal is to ascertain whether, by the use of these optimal methods, supersymmetric events could be identified using purely hadronic observables (jets and missing transverse energy), or, failing this, in states in which at least a single isolated lepton has been identified. The search using purely hadronic observables must contend with a multi-jet background that is 25,000 times greater than the signal after initial cuts! Nevertheless, our tentative conclusion is that it may be feasible to reduce the background to a signal to background ratio of close to 1 to 1. However, this conclusion must be checked, and re-checked, because if it holds it should be of great interest. This effort uses computers at FIU, FSU, FNAL and CERN.

3.6. Electron and Photon Reconstruction and Calibration

The spectacular performance of the CMS lead tungstate calorimeter is degraded by the large amount of material in front of it, looking from the interaction point (up to 1.6 radiation lengths!). This presents a set of unique challenges in calibration (electron and photon energy scales are different), energy reconstruction (one needs to find ways to recover the energy lost in the tracker material) and particle identification.

Prof. Yuri Gershtein, who is a co-head of the LHC Physics Center (LPC) at FNAL, and Dr. Andrew Askew are actively developing algorithms that address the problems above.

In addition to the new algorithms for ECAL calibration and tracker material measurement *in situ*, they are very active in development of the new reconstruction program, CMSSW.

The 2006 CERN CMS Cosmic Challenge and Test Beam effort

We continue to build parts for these efforts and plan to be at CERN as much as possible starting May 2006. We are now building the mounting brackets for the ECAL to be placed on the HCAL Test Beam Motion Table. We expect to take part in the CERN Test Beam effort and two of our CMS students will be at CERN for one month each.

3.7. Teaching

Prof. Harrison Prosper has been leading the Physics Department's science class for elementary school teachers and has made some observations, and gained valuable experience, that we hope will improve the education component of CHEPREO. Chief amongst these observations is that for a newcomer to science “less is definitely more”. The class is almost entirely “hands-on”; however, this is not the most important aspect. What seems to be most important is to keep the experiments and tools as simple as is practically possible so that the science being explored is not obscured. Another observation is that students seem to feel truly empowered once they realize that in science it is perfectly fine to guess, so long as one has a way to check that the guess is right and that one understands, ultimately, why it is right. That is, we should encourage students “to try things out”. What works for elementary school teachers may well work also for students without formal knowledge of particle physics, and CMS in particular. We are currently engaged in discussion about how best to institute workshops intended to provide selected students at FIU (and elsewhere) with formal as well as “hands-on” introductions to CMS physics. The short-term goal of these workshops would be to bring students to the point where they could engage, in a meaningful way, in exploratory CMS analyses, based on simulated events.

4. University of Florida-related CHEPREO activities

The University of Florida (UF) team has led a number of CHEPREO activities with a focus on cyberinfrastructure development, CMS physics activities and grid education. This work leverages our leadership roles in NSF supported GriPhyN, iVDGL, DISUN and UltraLight projects, as well as our foundational role in the Open Science Grid (www.opensciencegrid.org) national cyberinfrastructure, officially inaugurated in July 2005. Teaming with FIU, we have been very effective in utilizing our expertise and knowledge in these areas to deliver these best practices in infrastructure development and pedagogical activities at FIU and Latin America. These activities are described below.

4.1. Personnel

UF personnel working with CHEPREO include the following

Paul Avery	Physics Faculty (local PI) Responsible for overall integration of UF participation in CHEPREO
Sanjay Ranka	Computer Science Faculty. Responsible for Grid education
Rick Cavanaugh	Physics Scientist. Organizes physics analysis activities among CHEPREO universities as well as networking tutorials.
Jorge Rodriguez	Physics Scientist. Responsible for non-networking aspects of CHEPREO cyber infrastructure
Dimitri Bourilkov	Physics Scientist. Supports physics analysis activities within CHEPREO
Bockjoo Kim	Physics Scientist. Supports CMS software installations at CHEPREO sites.
Laukik Chitnis	Computer Science Graduate Student. Works with Prof. Ranka on Grid education
Dave Pokorney	Director of Network Services. Coordinates networking connections with FIU and other CHEPREO Florida universities
Chris Griffin	Network Engineer. Provides engineering support for optical networks at CHEPREO Florida universities.

4.2. Cyberinfrastructure

4.2.1 Networking

In Summer and Fall 2005 Florida Lambda Rail (FLR) was deployed to several universities, in particular the three Florida participants (FIU, UF and FSU) and Florida Institute of Technology (FIT), with whom we began collaborating in 2005 as part of our joint CMS physics activities. UF also began to deploy network and storage hardware exploiting the improvements in connectivity. All of the UF Tier2 equipment is now linked at 10Gbps to the National Lambda Rail (NLR) networking infrastructure through FLR and it is connected at 2 × 10Gbps to the campus research network,. This ultra-fast connectivity is making possible for the first time effective sharing of computing and storage resources within the UF campus and from the other Florida universities.

4.2.2 Computing fabric

Here are the activities for the different participants

New hardware resources at UF: UF made two large-scale computing acquisitions in December 2005. The Tier2 center upgraded its PIII/XEON 100 Mbps-based cluster by adding dual-core dual AMD machines (344 processors) with GigE based networking and 43TB of internal disk. Another acquisition of 172 AMD processors with 43TB of internal disk and was deployed in May 2006. Another 70 TB in high performance RAID storage will be acquired by the end of July. Together these purchases represent approximately an order of magnitude increase in computing and storage capability for the Tier2 center. The UF HPC (High Performance Computing) Center made another acquisition of 800 CPUs that are partially shared with the Tier2 center. None of this equipment is purchased with CHEPREO funds but a fraction of the manpower used to operate and maintain the Tier2 is funded by CHEPREO (Jorge Rodriguez).

FIU Tier3 and Open Science Grid: In 2005, the FIU Tier3 moved from Grid3 to the OSG production grid. It was also upgraded to a RHEL3-based operating system in order to keep pace with CMS applications which require this version to run effectively. No new hardware purchases were made in 2005 due primarily to delays in acquiring appropriate manpower. The FIU Tier3 lost two cluster administrators in 2005. This high turnover rate has affected operations and is principally responsible for the delays in acquiring and installing the additional infrastructure. A new sysadmin was recently hired and is now coming up to speed (he spent several days at UF being trained by Rodriguez to use the ROCKS cluster management software). New storage hardware will be acquired by June 2006 and it is expected that the Tier3 will need a refreshment of hardware in Year 4 and 5 (the currently installed components are coming out of warranty in 2006).

FIT computing infrastructure: FIT is preparing to install a small cluster based on spare equipment using the ROCKS cluster management suite. They also intend to install a Grid User Interface to give their local users access to the OSG grid.

FSU Computing Infrastructure: FSU has submitted an NSF MRI proposal to fund GRID computing that includes 850 Opteron 275 CPU's and over 1 Petabyte of disk. If the MRI is successful, it will be part of the Open Science Grid. Otherwise, FSU will build a more modest Opteron 275 based cluster; the first quad CPU unit has been ordered and will be delivered soon.

Although the FSU system manager Dr. Jeff McDonald has moved 100 ft to join the School of Computational Studies (formerly SCRI) he is still part of CMS. He was replaced by Blake Sharin who is learning the local computer infrastructure operations (70 CPUs). FSU plans to upgrade (actually replace) the Open Science Grid computational infrastructure with the 64 bit Opteron CPU's.

Florida Grid Operations Center: In 2005 UF set up the Florida Grid Operations Center (fGOC) as a first step in creating a Florida Regional Grid linking UF, FIU, FIT and FSU. The fGOC is a recognized entity within Open Science Grid and participates in OSG Operations meetings. The fGOC handles OSG tickets issued from the iGOC (International Grid Operations Center) assigned to sites on the Florida Regional Grid which currently includes Comput Elements (CEs) at Florida (UFlorida-IHEPA) and FIU (FIUPG). It also follows through with problem resolution and insure patches are applied to site infrastructure. The other two Florida sites are either already in OSG's Integration Testbed (ITB), a precursor to joining the OSG production grid, or will join by June 2006 (the FSU CE, which was participating in the OSG ITB, had planned to move a 74 node CE into the OSG production grid but was delayed by the loss of the main sysadmin). At UF the 900 CPU HPC cluster will join the OSG production grid by the end of April. Regular fGOC meetings are held once a month. Jorge Rodriguez coordinates this activity, with Bockjoo Kim providing monitoring support as well as support for the CMS software installations at the Florida physics institutions.

4.3. CMS Physics

Preparations for the CMS Physics Technical Design Report (PTDR): Organizing the Florida work on high-mass di-muon pairs for tests of the Standard Model at highest momentum transfers and for searches for manifestations of new physics like extra dimensions or compositeness. Work on simulation and reconstruction of TeV muons with the fast CMS code FAMOS and with the full analysis chain OSCAR/ORCA/ROOT. These studies are officially recognized in CMS in the Standard Model and SUSY/Beyond Standard Model groups as a major Florida contribution to the PTDR, and first versions of the write-ups included in the official CMS draft of PTDR volume II.

LPC Muon Collaboration: Started a very fruitful collaboration with the newly founded LPC muon group at FNAL on the simulation and reconstruction of muons in general and high energy muons in particular, including for the first time not only information from the central tracker and the muon chambers, but the energy deposits in the electromagnetic and hadron calorimeters on an event-by-event basis as well. A month-long summer visit to the LPC was used to generate and process through the full analysis chain different single and di-muon and pion samples used by several members of the group and to develop and refine the reconstruction algorithms. The plan is to extend this collaboration to analyze real data taken during tests with cosmic muons. Dimitri Bourilkov is coordinating this activity.

CMS Physics Analysis Workshops: UF organized the first U.S. CMS regional physics workshop in Gainesville May 30 – 31 (CMS Southeast Physics Analysis Workshop). The format was a two-day workshop, with approximately 60% of the time devoted to presentations on ongoing physics analysis work at UF, FSU, FIU and FIT, 20% on how to use CMS analysis tools including the grid, and the remainder on organizing and coordinating joint analysis ventures. Faculty, students and postdocs from the CHEPREO institutions constituted the majority of attendees, while physicists from other institutions (Vanderbilt, Texas A&M, Texas Tech) made up the remainder, for a total of approximately 30 people.

It was decided that the data handling and physics requirements of the upcoming Computing, Software, and Analysis challenge (CSA06) provide sufficient motivation and opportunities for physicists at the seven institutions to coordinate with one another. A particularly striking consideration is the fact that the institutions have 10 Gbps connections to the WAN. This capability is important for sharing of the large datasets that will be the basis of CSA06. The next workshop will take place at FIU in early August. Details of the workshop, including all presentations and a workshop summary, may be found at http://www.ivdgl.org/events/index.php#124.

Figure 6: Some of the attendees of the May 30-31 CMS Southeast Physics Analysis Workshop at UF

4.4. Grid Education and Outreach

The grid education effort at UF was focused on developing education material for grid computing and its use for large scale application development. We developed a 150 slide PowerPoint tutorial that covers evolution from Web Services to Grid Services, practical demos of grid applications using extant infrastructure for Web and Grid services and ongoing standards. The target audience is an individual with little or no knowledge of grid computing and having basic programming skills. A high level description of the contents is as follows:

1. *Introduction and Motivation*: We discuss the needs of large scale distributed applications like CMS, OSG and SDSS and talk about the important issues faced by an application developer. This section basically points out the need for grid computing.

2. *Web services*: We describe the importance of web services in the development of large scale applications. We introduce xml and discuss the Web Services architecture. We also discuss various Web Services tools and technologies like SOAP, WSDL and UDDI. We present the relationship of web services to grid services and grid standards.

3. *Grid Services*: We define the key grid concepts such as data management, information services and security. We investigate the various building blocks such as compute nodes, storage, n/w, etc.

4. Grid *Security*: Here we introduce GSI and discuss grid certificates and proxies at length. To be precise, we discuss how gridmap files are used today for authentication and the way to set up authentication and how to get your grid certificate and initiate proxy.

5. *Grid Information services*: We present existing monitoring systems with examples. Then we focus in on monitoring systems used at large in grids today, for e.g. in OSG -- Gridcat, Monalisa, and the globus mds + bdii, glue schema.

6. *Data Management*: We try to answer the following basic questions which encompasses a large spectrum of data management activities on the grid today:
   - How to move data? GridFTP, globus-url-copy
   - Where are the files? RLS
   - What is the data? Metadata catalogue

7. *Job Management*: We introduce GRAM and look at different commands to submit and track jobs. We discuss local schedulers like condor and pbs.

8. *Virtual Data Management*: We describe the need for virtual data systems and the use of VDL to represent an abstract workflow and converting to a concrete workflow.

9. *Grid Scheduling*: We try to understand the general issues in grid-wide scheduling – decentralized ownership and policies, QoS etc. Then we look at some grid schedulers such as SPHINX and Pegasus.

10. *Hands-on exercises*: We provide an example that is easy to understand for a naïve user and then proceed to gridifying the simple application (parallelize and run it on Open Science Grid). We also describe how to use Pacman (used for packaging the components of the Virtual Data Toolkit) for packaging and deployment.

The tutorial is accessible at http://www.cise.ufl.edu/~lchitnis/TutorialGrid.html. Currently, the users can access the material by requesting a login and password from the authors.

Laukik Chitnis from Florida presented portions of this tutorial with emphasis on grid scheduling as part of a Pan-American Advanced Study Institute in May 2005. It was held at Mendoza, Argentina and 40 scientists from the Americas, at the advanced graduate and postgraduate level attended the institute.

In Spring 2005 and Fall 2005, Dr. Chi Zhang integrated the UF tutorial as part of a graduate course at FIU. The course "COP 6611 Advanced Operating System" focuses on distributed computing. The integration includes 8 hours of lectures on Grid, and a course project developed based on the UF example. The course project requires students to "gridify" an application, which finds all the prime factors of a large integer. Students conducted experiments on the Grid3 cluster of AMPATH, and compared the performance with different numbers of nodes.

Beginning in Spring 2006, Dr. Zhang extended the Grid lectures into a mini-course on Grid Computing, as part of the effort in the NSF CyberBridges project (NSF 0537464). Four science students (with backgrounds in Physics, Chemistry, Bioinformatics, and Biomedical Engineering, respectively) are currently taking this course. Under the supervision of Mr. Eric Johnson, a Systems/Networking Manager at FIU, the students have already built a CyberBridges cluster, based on which they will practice Grid Computing. The UF tutorial is the major material used by this course.

In 2005, UF participated and helped organize the Grid Summer School at UTB. Dr. Jorge Rodriguez and Laukik Chitnis presented the section on Building, Maintaining and Operating a Grid . The associated exercises gave students real time experience in using a functional grid. The OSG. This year we intend to create an E&O outreach grid site specifically for E&O activities such the Grid Summer School through OSG E&O Technical Group.

Dr. Sanjay Ranka will teach a course at UF on High Performance Computing during Fall 2006. A major portion of the course will be dedicated to teaching grid computing using the material described above.

5. Caltech-related CHEPREO activities

5.1. Syslog Server

As part of the Ultralight project [NEWM05] CHEPREO works closely with Ultralight collaborators on both advanced network developments and educational outreach programs. Dr. Xun Su has set up a syslog server at FIU to manage Ultralight network equipment. This server is used to collect information about the operational status of Ultralight routers and switches, such as link up/down information and alarm logs, providing a central repository and facilitating anomaly diagnostics, error event analysis, and debugging router mis-configuration. In addition to a daemon running in the background on this server collecting syslog information, a web front-end (http://ultralog.ampath.net/phpsyslogng) has been commissioned enabling user-friendly queries of the syslog event logs.

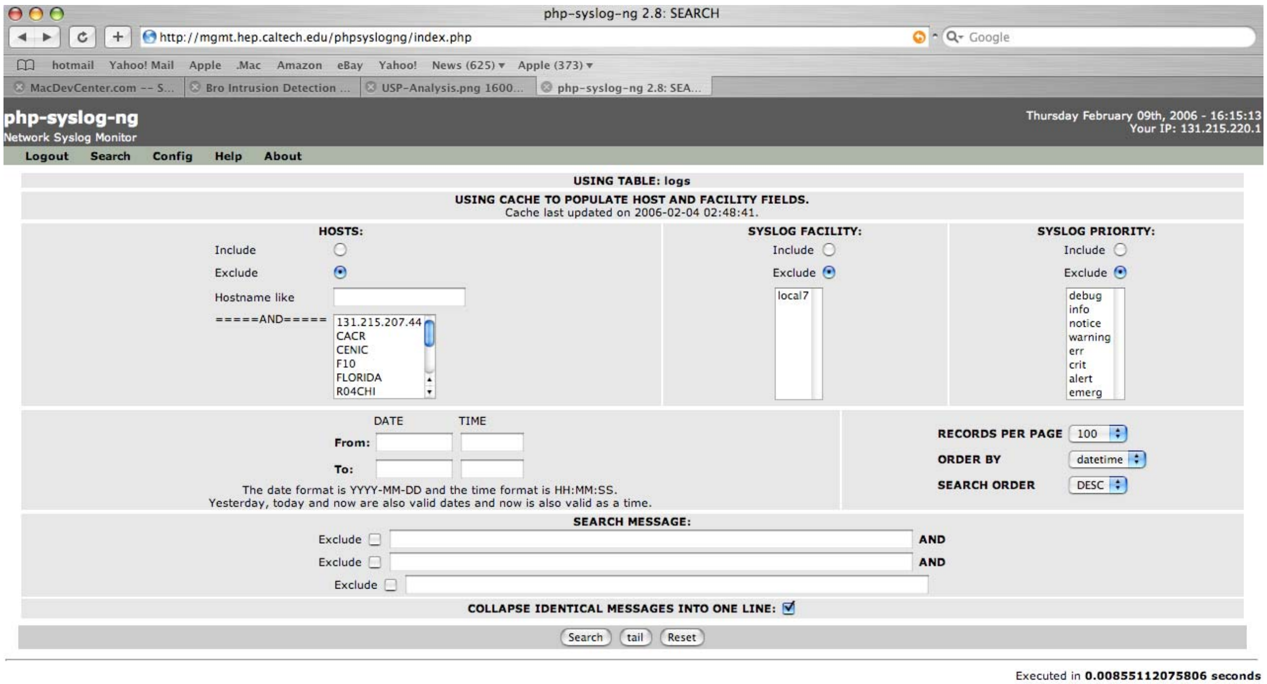


Figure 7: A web interface for Ultralight network syslog information

5.2. *Cisco University Research Program Monitoring Project*

Caltech and FIU have finished the proposed work for the Cisco funded University Research Program (URP). Dr. Su has been working with Dr. Zhang at FIU and his student Bin Liu, on integrating a flow-based traffic monitoring scheme (NetFlow) and a packet-based scheme (NLANR PMA). It helps us to answer questions such as:

- Can sampled flow-level data represent network traffic?
- Can we estimate the accuracy of this representation?
- Can packet-level traces and flow-level records complement each other?

Comparison and integration of flow-based and packet based schemes is non-trivial, as it is a challenge to find the correspondence between the two types of network monitoring data. In particular:

- PMA box and GSR routers synchronize with different time sources and different precisions: the GSR router synchronizes with a NTP server while the PMA box synchronizes with cellular networks using a CDMA signal. [See the figure below for the current setup of the data collection system.]

- PMA provides packet-level traces while Netflow provides flow-level records. More importantly, Netflow samples the incoming packets.

- To protect privacy, IP addresses embedded in monitoring data from different sources may be masked or anonymized using different algorithms. For example, a real IP address embedded in monitoring data could be mapped to an internal IP address in the range of 10.*.*.*. The same original IP address however will always be mapped to the same 10.*.*.* address. The IP address mapping depends not only on the algorithm, but also the runtime status.

- The processing algorithm must be (time and resource) efficient, since the size of monitoring data is large. It is impossible to exhaustively search the entire data set to find the correspondence between the flows.

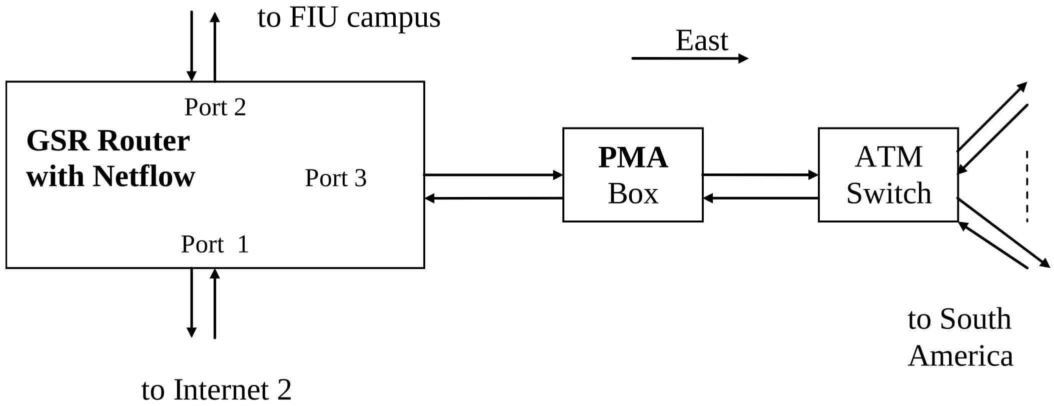


Figure 8: PMA/NetFlow setup at NAP of America, Miami

Our key observation is that although IP addresses are masked, some fields are still available to assist in the matching of different types monitoring data. The TCP/UDP port numbers are not masked, although different flows with different IP addresses may have the same source/destination port number. Also, the TCP SYN flag can be used to uniquely identify a packet in a flow, when the monitoring data to be matched samples the original packet stream.

To reduce the algorithm processing overhead, we have adopted a top-down approach in reducing errors from matching monitoring data. First a coarse-grained but light-weight approach narrows down accuracy of the timestamp difference to 1 minute. Then a fine-grained approach is used to accurately estimate the timestamp difference (with an error margin of less than 10ms) in a reduced search space.

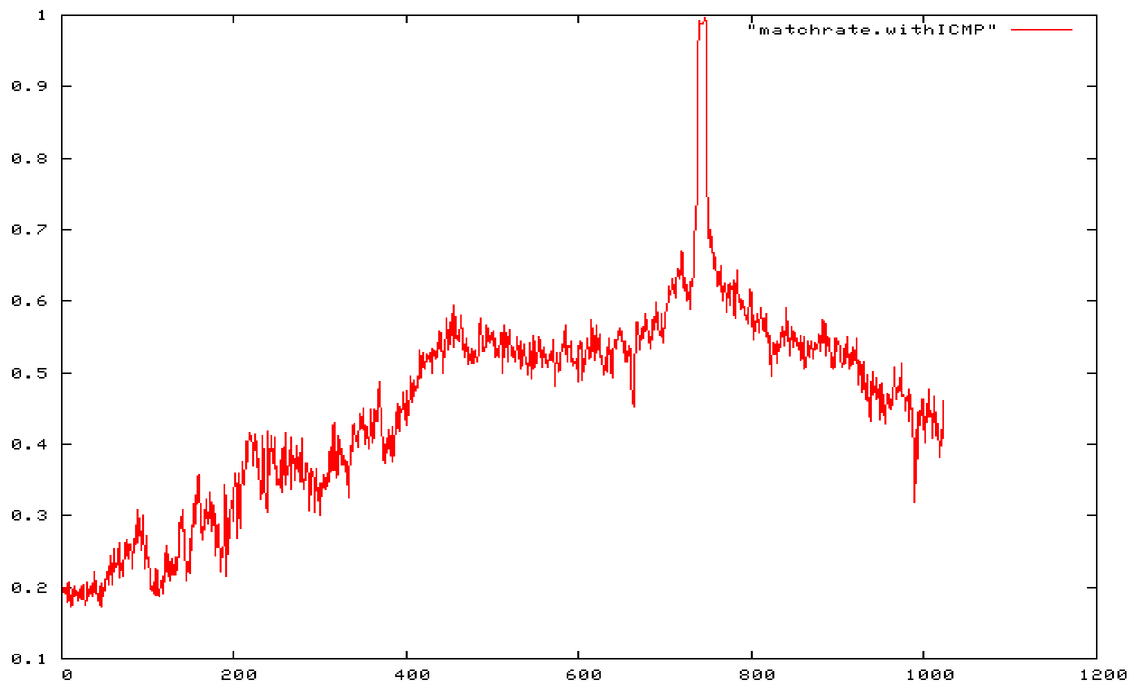


Figure 9: Matching of PMA and NetFlow data

The figure above shows the match rate for a PMA trace and corresponding NetFlow data record. The x-axis is the time of the Netflow timestamp, while the y-axis gives the corresponding match rate. It is clear that for a certain time period (10 segments), the match rate is much higher then other time periods. We can roughly identify the corresponding capturing period of PMA.

5.3. Ultralight Monitoring System

CHEPREO has deployed MonALISA [LEGR04], a global scalable networking and computing resource monitoring system developed by Caltech, at the NAP of the Americas PoP. MonALISA is providing detailed network usage and anomaly monitoring capability, in addition to the SNMP-based MRTG monitors already in place. The MonALISA monitoring application provides us with a more comprehensive view of networking activities related to CHEPREO, and has proven to be an extremely useful tool in collaborative demonstrations such as iGrid 2005 (http://www.igrid2005.org/) and Supercomputing 2005 (http://sc05.supercomputing.org/) , showing network and computing resource usage during distributed physics analysis and large scale wide area data transfers.

5.4. iGrid 2005 - Grid Enabled Analysis Demonstration

Mr. Michael Thomas led the effort in coordinating the Brazilian participation of the Caltech-led Grid Analysis Environment (GAE) [LING04] demonstration at iGrid 2005. This demonstration used national and international networks to demonstrate the next generation of globally distributed physics analysis tools for Particle Physics and eScience research. Technologies and applications being developed in projects such as UltraLight [NEWM05], FAST [WEI07], PPDG (http://www.ppdg.net/), GriphyN (http://www.griphyn.org/), iVDGL (http://www.ivdgl.org/) and ESLEA were used to show components of the so-called "Grid Analysis Environment", a grid infrastructure for physics analysis.

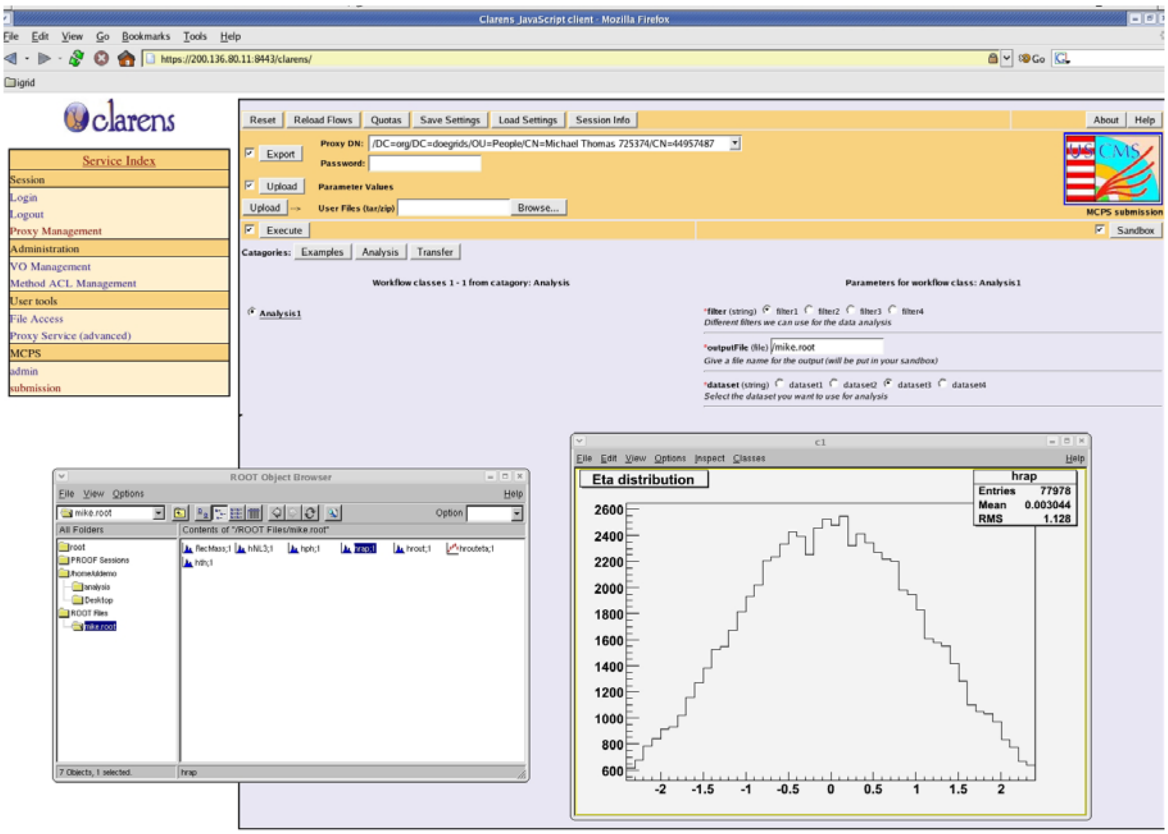


Figure 10: GAE browser client, supporting Grid based analysis and remote access to ROOT files

The figure above shows a web interface of the GAE used during the iGrid Demo that authorized users can utilize for Grid based job submission and large scale file transfer. Results from the analysis are stored in ROOT files [BRUN96].

GAE components are part of the toolbox a physicist, working on the next generation of experiments, will have to manage, control and utilize worldwide Grid resources available for analyzing data produced by high-energy physics experiments such as CMS and ATLAS. During IGRID 2005 we demonstrated on-demand network and resource provisioning in response to event analysis requests issued from several desktop computers. The complex workflows implied by the requests were translated using provisioning algorithms into network flow allocations and scheduled resource booking on remote computers/clusters. Throughout the demonstration we used MonALISA to illustrate the progress of the analysis tasks, data flows in the network, and the effects of the analysis activities on the global system.

To support the IGRID demo which involved Brazil, the CHEPREO team supplied network services to facilitate the movement of analysis data. During the demo several high-energy physics analysis jobs were (remotely) submitted and run at UNESP in Sao Paulo. The analysis was performed using the Monte Carlo Production Service (MCPS) [LING06] deployed in a Clarens server [LING05] running at several sites including USP. From the show floor, a web browser was used to securely access the MCPS interface at USP. A remote dataset was selected by an authorized user and transferred to UNESP as the first stage of the job. The second stage involved running multiple analysis filters on the transferred dataset. Once the analysis was complete we used the Clarens ROOT data visualization tool to view a histogram using the results of the data analysis. Simulated background data transfer jobs were run on the USP network link using iperf and bbcp [HANU01]. This background traffic was injected to show how the data analysis can be performed on shared high speed network links.

5.5. Super Computing 2005 Bandwidth Challenge

The CHEPREO team participated in the Caltech-led Bandwidth Challenge exercise at Super Computing 2006. The Bandwidth Challenge is an important benchmark of what is possible with high performance networking. It is especially important for the LHC experiments, which will generate between petabytes and exabytes of data per year which will be analyzed by physicists around the world. In the near future most of the ATLAS and CMS Tier2 sites, and even some Tier3 sites, will have 10 Gigabit connections and will need to utilize them effectively.

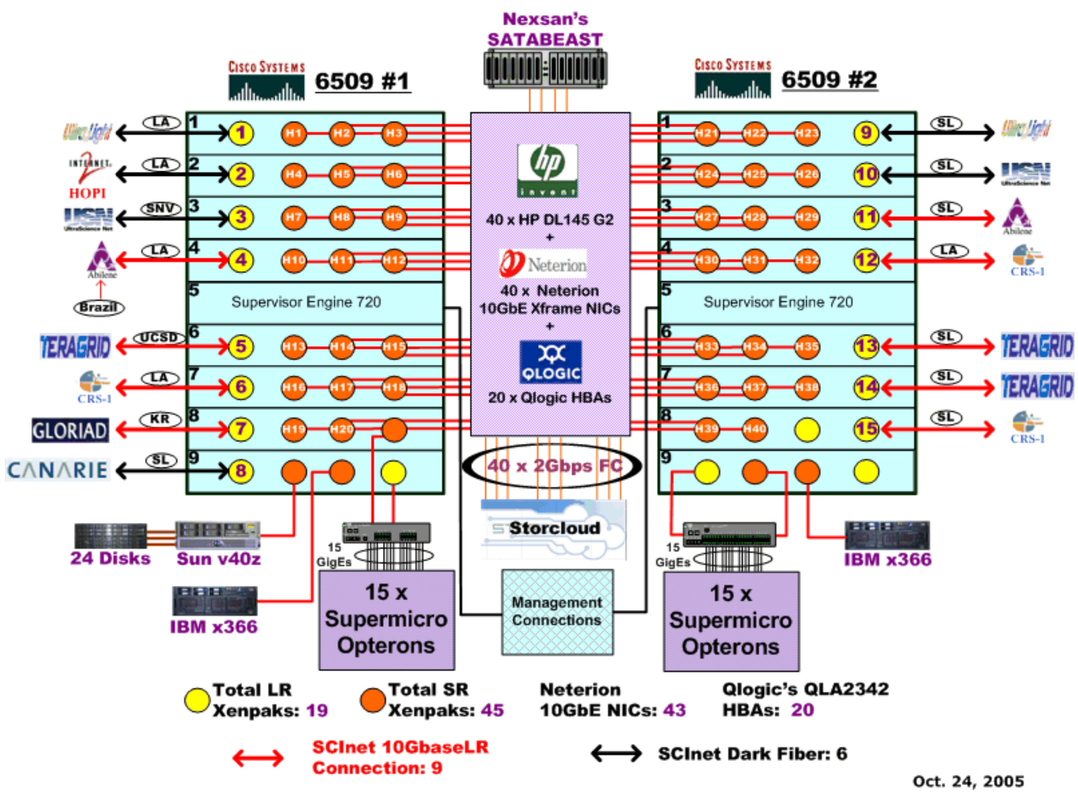


Figure 11: SC05 Caltech show floor setup

Activities like calibration and alignment of detectors for these experiments will rely upon being able to quickly move large amounts of data from the Tier0 detector site at CERN to the Tier-n sites responsible for the data reduction. Part of how these huge data transfers take place is described by the LHC *data hierarchy scheme* [BUNN03], which will be augmented with many transfers between Tier2's. The Bandwidth Challenge demonstrates what is possible with current networks when a focused effort is undertaken and will prepare us for the enormous amounts of data that will generate increasingly more network traffic[4]. The result of this challenge is part of the larger picture for LHC physics, and a step on the way to providing a robust high performance infrastructure for LHC science and other global data intensive science collaborations.

The figure below is a screenshot of MonALISA showing the Brazilian sites involved in the exercise (UNESP and UERJ), which have been participants of the BWC since SC|04 when they set a Brazilian research network speed record of 2Gbps from Brazil to US (and 1Gbps from US to Brazil) over the WHREN-LILA link connecting AMPATH at Miami and ANSP at Sao Paulo.

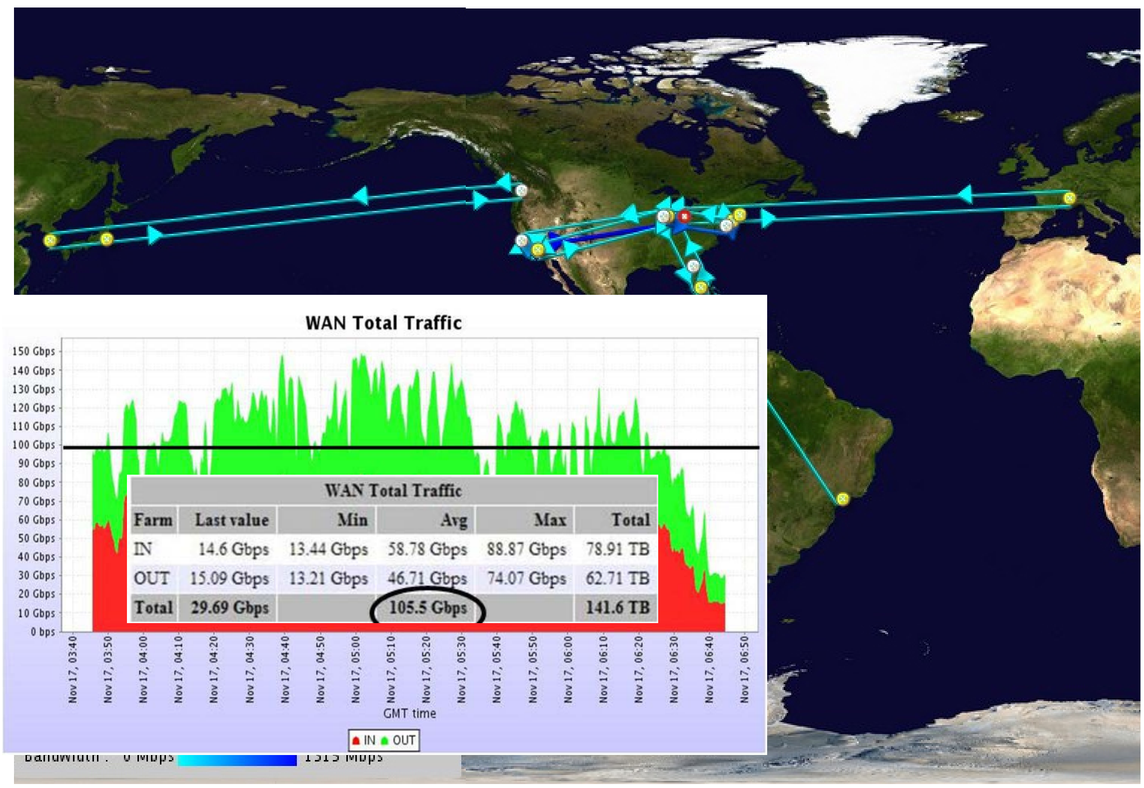


Figure 12: Brazilian participation of the SC05 via CHEPREO-funded WHREN-LILA link and overall WAN traffic during the bandwidth challenge reaching more than 100 Gbps

[4] http://supercomputing.caltech.edu/pictures/misc/traffic_trends.jpg

5.6. Networking Support of the WHREN-LILA Link: Routing Issues

The high-energy physics group at University of Rio de Janiero, a CHEPREO partner, was experiencing routing issues to their HEPGrid cluster. To reach Fermi Lab and CERN, the traffic flow to/from HEPGrid was routed by RNP (The Brazilian National R&E network) via a RED CLARA link between Sao Paulo and Madrid. From Madrid it could reach CERN by going over the GEANT backbone. In order to reach US sites such as Fermi lab, the HEPGrid traffic had to cross the Atlantic Ocean (twice!). There are two issues associated with this routing arrangement: (1) the 622 Mbps RED CLARA link from Sao Paulo to Madrid is shared by many research institutes in South America; (2) the route to US R&E sites is too circuitous (long). As an example the (problematic) route from Fermi Lab (FNAL) to HEPGrid was as follows, indicating a "broken" route from FNAL that went out via ES net towards CENIC (California state R&E network) and then was stuck and unable to reach HEPGrid.

```
[lafex-clued0:~>traceroute prod-frontend.hepgrid.uerj.br
traceroute to prod-frontend.hepgrid.uerj.br (200.143.197.197), 30 hops max,
38byte packets
 1  vlan227.r-d0-fcc1w-cas.fnal.gov (131.225.227.200)  0.518 ms  0.481 ms
0.344ms
 2  vlan303.r-s-hub-fcc.fnal.gov (131.225.15.14)  0.565 ms  0.397 ms  0.367
ms
 3  vlan360.r-s-bdr.fnal.gov (131.225.15.77)  0.468 ms  0.438 ms  0.417 ms
 4  r-x-esnet-starlight (198.49.208.17)  1.567 ms  1.647 ms  1.608 ms
 5  chicr1-chislsdn1.es.net (134.55.207.33)  1.677 ms  1.611 ms  1.621 ms
 6  snvcr1-oc192-chicr1.es.net (134.55.209.53)  49.758 ms  49.725 ms  49.687
ms
 7  cenichpr-1-lo-jmb-704.snvaca.pacificwave.net (207.231.244.1)  50.017 ms
56.567 ms  50.652 ms
 8  lax-hpr--svl-hpr-10ge.cenic.net (137.164.25.12)  60.285 ms  57.751 ms
57.490 ms
 9  * * *
10  * * *
```

A more suitable route is via the newly provisioned WHREN-LILA link between Sao Paulo and Miami. This link has more bandwidth, and is a more direct (shorter) link to the US R&E network. The link has 2xOC-12 (1.2Gbps) circuits funded partly by the CHEPREO project whose mission statement includes improving the networking infrastructure for Brazilian high energy physics community.

To enable the use of the WHREN-LILA link, we are working on making necessary routing changes at the concerned networks. For traffic flowing towards HEPGrid, we have successfully achieved a desired route by having RNP announce the HEPGrid's IP blocks to AMPATH in Miami. AMPATH in turn announces the route information to Abilene and CERN. With help from ESNet we have also ensured that the HEPGrid prefix is accepted by their BGP routing process, and the traffic from Fermi Lab is now routed correctly via WHREN-LILA link. The correct route follows:

```
lafex-clued0:~> traceroute prod-frontend.hepgrid.uerj.br

traceroute to prod-frontend.hepgrid.uerj.br (200.143.197.197), 30 hops max, 38 byte
packets

 1  vlan227.r-d0-fcc1w-cas.fnal.gov (131.225.227.200)  0.450 ms  0.389 ms  0.351 ms
 2  vlan303.r-s-hub-fcc.fnal.gov (131.225.15.14)  0.426 ms  0.415 ms  0.455 ms
 3  vlan360.r-s-bdr.fnal.gov (131.225.15.77)  0.500 ms  0.475 ms  0.420 ms
 4  r-x-esnet-starlight (198.49.208.17)  1.639 ms  1.622 ms  1.624 ms
 5  chicr1-chislsdn1.es.net (134.55.207.33)  1.610 ms  1.678 ms  1.750 ms
 6  aoacr1-oc192-chicr1.es.net (134.55.209.58)  21.925 ms  21.719 ms  21.652 ms
 7  dccr1-oc48-aoacr1.es.net (134.55.209.62)  25.957 ms  25.938 ms  25.909 ms
 8  atlcr1-oc48-dccr1.es.net (134.55.209.66)  54.527 ms  53.021 ms  41.495 ms
 9  abilene-atlcr1.es.net (198.124.216.142)  41.579 ms  41.495 ms  41.432 ms
10  abilene-i2-flr-10g.ampath.net (198.32.252.237)  56.331 ms  54.836 ms  54.763  ms
11  * * *
12  * * *
13  ge-1-0-0-r1-rj.bkb.rnp.br (200.143.252.182)  246.977 ms  247.193 ms  246.806  ms
14  200.143.197.130 (200.143.197.130)  251.856 ms  248.031 ms  248.433 ms
15  prod-frontend.hepgrid.uerj.br (200.143.197.197)  246.738 ms  246.716 ms  246.668
ms
```

Having addressed the routing issues for traffic flowing towards HEPGrid, we then worked on adjusting the route for traffic emanating from HEPGrid. The issue here lies in how RNP would address the policy issue of routing the international traffic from HEPGrid via the WHREN-LILA link, but not other traffic from other network sources and traffic flowing towards other Brazilian sites. We are in discussion with RNP as to how to differentiate the traffic from HEPGrid, and then treat it differently in terms of route choices. The current solution is to use a source-based static routing policy coupled with an access list of sites (IP address blocks) that need to be excluded. Particularly, we have asked our partners at HEPGrid for a list of sites they need to access in Brazil. Based on this list RNP configured their Juniper router to “deny” the access to WHREN-LILA link of the traffic to/from these sites within Brazil (which will be handled by RNP locally), and consequently only let through the flow of international traffic destined to US, Europe and other regions. We made the engineering choice of excluding specific IP addresses instead of registering permitted ones, since the number of local sites that need to be excluded is fewer and more deterministic than the international sites that need to be permitted. As of the writing of this report, the route configuration is in place to properly handle the outbound international (non-Brazilian) traffic for HEPGrid via WHREN-LILA link, and we have the confirmation from the HEPGrid users that we have met their needs in terms of routing.

The next steps in our continuing network engineering support for CHEPREO includes the following: (1) In preparation for the ramp-up of the LHC in 2007 we will start conducting long-running data-transfer performance tests to/from Brazil HEPGrid and SPRACE clusters, using Ultralight testbed; (2) we will work on enabling direct peering between AMPATH and ESNet so that the traffic between Brazilian HEP community and the US DoE Labs can be handled with more efficiency; (3) we will refine our bandwidth provisioning capabilities with regards to the shared WHREN-LILA link so that traffic for

HEP community can be provided with certain level of QoS and/or separation from the traffic from other research communities.

The high energy physics group at University of Rio de Janiero, a CHEPREO partner, was experiencing routing issues to their HEPGrid cluster. To reach Fermi Lab and CERN, the traffic flow to/from HEPGrid was routed by RNP (The Brazilian National R&E network) via a RED CLARA link between Sao Paulo and Madrid. From Madrid it could reach CERN by going over the GEANT backbone. In order to reach US sites such as Fermi lab, the HEPGrid traffic had to cross the Atlantic Ocean (twice!). There are two issues associated with this routing arrangement: (1) the 622 Mbps RED CLARA link from Sao Paulo to Madrid is shared by many research institutes in South America; (2) the route to US R&E sites is too circuitous (long). As an example the (problematic) route from Fermi Lab (FNAL) to HEPGrid was as follows, indicating a “broken” route from FNAL that went out via ES net towards CENIC (California state R&E network) and then was stuck and unable to reach HEPGrid.

```
[lafex-clued0:~>traceroute prod-frontend.hepgrid.uerj.br

traceroute to prod-frontend.hepgrid.uerj.br (200.143.197.197), 30 hops max,
38byte packets

1  vlan227.r-d0-fcc1w-cas.fnal.gov (131.225.227.200)  0.518 ms  0.481 ms
0.344ms
 2  vlan303.r-s-hub-fcc.fnal.gov (131.225.15.14)  0.565 ms  0.397 ms  0.367
ms
 3  vlan360.r-s-bdr.fnal.gov (131.225.15.77)  0.468 ms  0.438 ms  0.417 ms
 4  r-x-esnet-starlight (198.49.208.17)  1.567 ms  1.647 ms  1.608 ms
 5  chicr1-chislsdn1.es.net (134.55.207.33)  1.677 ms  1.611 ms  1.621 ms
 6  snvcr1-oc192-chicr1.es.net (134.55.209.53)  49.758 ms  49.725 ms  49.687
ms
 7  cenichpr-1-lo-jmb-704.snvaca.pacificwave.net (207.231.244.1)  50.017 ms
56.567 ms  50.652 ms
 8  lax-hpr--svl-hpr-10ge.cenic.net (137.164.25.12)  60.285 ms  57.751 ms
57.490 ms
 9  * * *
10  * * *
```

A more suitable route is via the newly provisioned WHREN-LILA link between Sao Paulo and Miami. This link has more bandwidth, and is a more direct (shorter) link to the US R&E network. The link has 2xOC-12 (1.2Gbps) circuits funded partly by the CHEPREO project whose mission statement includes improving the networking infrastructure for Brazilian high energy physics community.

To enable the use of the WHREN-LILA link, we are working on making necessary routing changes at the concerned networks. For traffic flowing towards HEPGrid, we have successfully achieved a desired route by having RNP announce the HEPGrid’s IP blocks to AMPATH in Miami. AMPATH in turn announces the route information to Abilene and CERN. With help from ESNet we have also ensured that the HEPGrid prefix is accepted by their BGP routing process, and the traffic from Fermi Lab is now routed correctly via WHREN-LILA link. The correct route follows:

```
lafex-clued0:~> traceroute prod-frontend.hepgrid.uerj.br
traceroute to prod-frontend.hepgrid.uerj.br (200.143.197.197), 30 hops max, 38 b
yte packets
 1  vlan227.r-d0-fcc1w-cas.fnal.gov (131.225.227.200)  0.450 ms  0.389 ms  0.351
 ms
 2  vlan303.r-s-hub-fcc.fnal.gov (131.225.15.14)  0.426 ms  0.415 ms  0.455 ms
 3  vlan360.r-s-bdr.fnal.gov (131.225.15.77)  0.500 ms  0.475 ms  0.420 ms
 4  r-x-esnet-starlight (198.49.208.17)  1.639 ms  1.622 ms  1.624 ms
 5  chicr1-chislsdn1.es.net (134.55.207.33)  1.610 ms  1.678 ms  1.750 ms
 6  aoacr1-oc192-chicr1.es.net (134.55.209.58)  21.925 ms  21.719 ms  21.652 ms
 7  dccr1-oc48-aoacr1.es.net (134.55.209.62)  25.957 ms  25.938 ms  25.909 ms
 8  atlcr1-oc48-dccr1.es.net (134.55.209.66)  54.527 ms  53.021 ms  41.495 ms
 9  abilene-atlcr1.es.net (198.124.216.142)  41.579 ms  41.495 ms  41.432 ms
10  abilene-i2-flr-10g.ampath.net (198.32.252.237)  56.331 ms  54.836 ms  54.763
 ms
11  * * *
12  * * *
13  ge-1-0-0-r1-rj.bkb.rnp.br (200.143.252.182)  246.977 ms  247.193 ms  246.806
 ms
14  200.143.197.130 (200.143.197.130)  251.856 ms  248.031 ms  248.433 ms
15  prod-frontend.hepgrid.uerj.br (200.143.197.197)  246.738 ms  246.716 ms  246
.668 ms
```

Having addressed the routing issues for traffic flowing towards HEPGrid, we then worked on adjusting the route for traffic emanating from HEPGrid. The issue here lies in how RNP would address the policy issue of routing the international traffic from HEPGrid via the WHREN-LILA link, but not other traffic from other network sources and traffic flowing towards other Brazilian sites. We are in discussion with RNP as to how to differentiate the traffic from HEPGrid, and then treat it differently in terms of route choices. The current solution is to use a source-based static routing policy coupled with an access list of sites (IP address blocks) that need to be excluded. As of the writing of this report, the route configuration is in place to properly handle the outbound international (non-Brazilian) traffic for HEPGrid via WHREN-LILA link, and we have the confirmation from the HEPGrid users that we have met their needs in terms of routing.

The next steps in our continuing network engineering support for CHEPREO includes the following: (1) In preparation for the ramp-up of the LHC in 2007 we will start conducting long-running data-transfer performance tests to/from Brazil HEPGrid and SPRACE clusters, using Ultralight testbed; (2) we will work on enabling direct peering between AMPATH and ESNet so that the traffic between Brazilian HEP community and the US DoE Labs can be handled with more efficiency; (3) we will refine our bandwidth provisioning capabilities with regards to the shared WHREN-LILA link so that traffic for HEP community can be provided with certain level of QoS and/or separation from the traffic from other research communities.

5.7. HEPGRID-UERJ and the Open Science Grid

In May of 2005 Mr. Michael Thomas and Mr. Yang Xia visited the HEPGRID group at UERJ in Rio de Janeiro to assist them with the provisioning of their cluster on the Open Science Grid (OSG). Earlier attempts to install the OSG middleware on the cluster had failed due to incompatibilities between the cluster management software Rocks and the OSG middleware and a corrupted x509 host certificate. This was resolved by using an older version of Rocks that was supported by the OSG middleware and by coordinating with the appropriate certificate authority to reissue the host certificate on short order. A Tier2 workshop was held at UERJ at the end of the week at which time Michael demonstrated the visibility of the UERJ cluster on the OSG monitoring pages as well as the successful running of CMS production jobs on the cluster that were submitted by the CMS production manager at UFL. Michael continued to work with the UERJ team in the following months to help them provision a small 3-node test cluster on the OSG Integration Testbed, allowing UERJ to evaluate any new versions of the OSG middleware before deploying onto their main cluster.

During the same visit Yang and Michael helped UERJ to address some performance issues related to their RAID storage system. The storage system was composed of 2 RAID5 arrays of 8 disks, each attached to a different host system. Initially each RAID5 array was only able to handle app. 5 MB/s of data transfer, far less than the SCSI bus speed of 160MB/s. See Figure 8 for the performance test with the single SCSI RAID5 configuration. Yang reconfigured and rebuilt the RAID arrays with different configuration settings and was able to achieve 80MB/s of disk throughput, an order of magnitude larger than before. Moreover Yang suggested the alternative architecture of using SATA disk versus the SCSI RAID array, as shown in Figure 9.

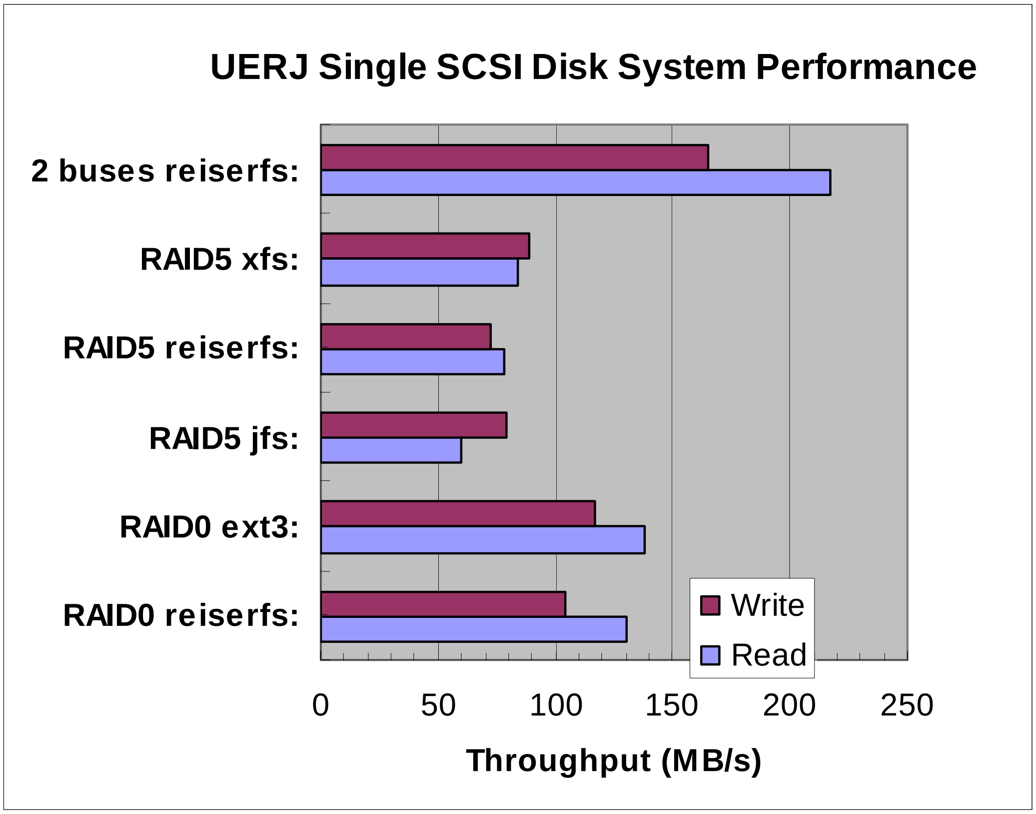


Figure 13: Performance test results with the single SCSI controller at UERJ HEPGrid cluster

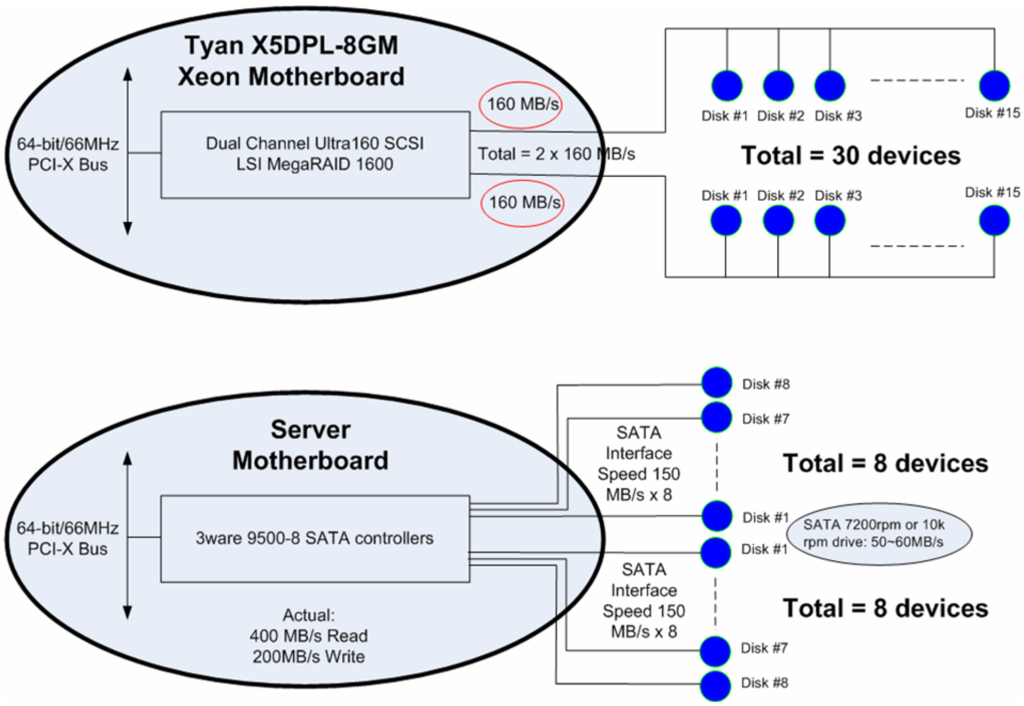


Figure 14: SCSI versus SATA disk array configurations

5.8. Caltech References

[BRUN96] R. Brun, F. Rademakers,"ROOT - An Object Oriented Data Analysis Framework", Proceedings AIHENP'96 Workshop, Lausanne, Sep. 1996, Nucl. Inst. & Meth. in Phys. Res. A 389 (1997) 81-86. (see also http://root.cern.ch/)

[BUNN03] J. Bunn, H. Newman, "Data Intensive Grids for High Energy Physics", in Grid Computing: Making the Global Infrastructure a Reality, edited by Fran Berman, Geoffrey Fox and Tony Hey, March 2003 by Wiley

[HANU01] A. Hanushevsky, A. Trunov, Les Cottrell, "Peer-to-Peer Computing for Secure High Performance Data Copying", in proceedings of Computing for High Energy Physics (CHEP), Beijing, China, September 2001

[LEGR04] I. Legrand, H. Newman, C. Cirstoiu, C. Grigoras, M. Toarta, C. Dobre, "MonALISA: an Agent Based, Dynamic Service System to Monitor, Control and Optimize Grid Based Applications", in Proceedings of Computing for High Energy Physics, Interlaken, Switzerland, 2004 (see also: http://monalisa.caltech.edu)

[LING04] F. van Lingen, J. Bunn, I. Legrand, H. Newman, C. Steenberg, M. Thomas, P. Avery, D. Bourilkov, R. Cavanaugh, L. Chitnis, M. Kulkarni, J. Uk In, A. Anjum, T. Azim, "Grid Enabled Analysis: Architecture, Prototype and Status", in Proceedings of Computing for High Energy Physics, Interlaken, Switzerland, September 2004 (see also: http://gae.caltech.edu)

[LING05] F. van Lingen, J. Bunn, I. Legrand, H. Newman, C. Steenberg, M. Thomas, A. Anjum, T. Azim, "The Clarens Web Service Framework for Distributed Scientific Analysis in Grid Projects", In Proceedings of the International Conference on Parallel Processing Workshops, Oslo, Norway, June 2005, IEEE Computer Society Order Number P2381, ISBN 0-7695-2381-1, pp45-52

[LING06] F. van Lingen, J. Bunn, I. Legrand, H. Newman, C. Steenberg, M. Thomas, Y. Xia, D. Bourilkov, R. Cavanaugh, D. Evans, E. Lipeless, S. Hsu, T. Martin. A. Rana. F. Wuerthwein, "Suporting on Demand, Policy based Monte Carlo Production, Leveraging Clarens, and RunJob", In proceedings of Computing for High Energy Physics, Mumbai India, February 13-17, 2006

[NEWM05] H. Newman, J. Bunn, I. Legrand, S. Low, D. Nae, S. Ravot, C. Steenberg, X. Su, M. Thomas, F. van Lingen, Y. Xia, R. Cavanaugh, S. McKee, "The Ultralight project: The Network as an Integrated and Managed Resource for Data Intensive Science", in Computing In Science and Engineering, Issue on grid computing, 2005 (see also: http://ultralight.org)

[WEI07] David X. Wei, Cheng Jin, Steven H. Low and Sanjay Hegde, "FAST TCP: motivation, architecture, algorithms, performance", IEEE/ACM Transactions on Networking, to appear in 2007 (see also: http://netlab.caltech.edu/FAST/index.html)

APPENDIX A - CHEPREO CYBERINFRASTRUCTURE

CHEPREO CIARA PERSONNEL DISSEMINATION & TRAINING ACTIVITIES			
Account	Destination	Travel Dates	Purpose
HEIDI ALVAREZ:			
CHEPREO:	Tucson, AZ	6/28/05 - 6/30/05	Meetings with NOAO Astronomy working group for LSST to present CHEPREO Outreach model
	Hong Kong	10/23/05 - 11/3/05	Chinese American Networking Symposium 2005 (CANS) Conference
	Arlington, VA	11/06/05 - 11/09/05	NSF CHEPREO Review Meeting
	Gainesville, FL	1/23/06 - 1/25/06	Open Science Grid (OSG) Meeting at the University of Florida
AMPATH:	Philadelphia, PA	9/17/05 - 9/20/05	Internet2 Member Meeting
	San Diego CA	9/26/05 - 9/10/105	iGrid 2005 Meeting
	San Diego CA	3/21/06 - 3/22/06	FirstMile US Spring 2006 Conference
	Townsville, Australia	3/23/06 - 3/4/1/06	PRAGMA 10 Conference
CISCO URP:	Boston, MA	8/3/05 - 8/6/05	Meetings for collaborative advance networking and computing development and outreach wit MIT
JULIO IBARRA:			
AMPATH:	Sao Paolo, Brazil	7/27/05 - 7/31/05	Meetings with Luis Lopez of FAPESP, AMPATH IXP & WHREN
	San Francisco, CA	9/11/05 - 9/12/05	Federal large networking coordination group meeting
	Philadelphia, PA	9/17/05 - 9/20/05	Internet2 Member Meeting
	San Diego, CA	9/26/05 - 9/10/105	iGrid 2005 Meeting
	Chicago, IL	10/11/05 - 10/13/05	LHC Tier2 Meeting
	Hong Kong	10/23/05 - 10/11/3/05	Chinese American Networking Symposium 2005 (CANS) Conference
	Sao Paolo, Brazil	11/7/05 - 11/10/05	TIDIA workshop
	Washington, DC	2/27/06 - 2/28/06	Meeting at the NSF
	San Diego, CA	3/21/06 - 3/24/06	FirstMile US Spring 2006 Conference
	Sao Paulo, Brazil	4/5/06 - 4/8/06	Meetings with Luis Lopez of FAPESP, AMPATH IXP & WHREN
	Arlington, VA	4/23/06 - 4/28/06	Internet2 Member Meeting
	Tampa, Fl	5/1/2006	Florida Lambda Rail (FLR) Board Meeting
CISCO URP:	Vienna, VA	12/11/05 - 12/13/05	Cybersecurity Summit
WHREN:	Milwaukee, WI	7/20/05 - 7/22/05	Open Science Grid Consortium Meeting
	Tampa, Fl	8/4/2005	FLR Board Meeting
	Tampa, Fl	11/7/2005	FLR Board Meeting
	Tampa, Fl	2/13/2006	FLR Board Meeting
	Jacksonville, FL	3/28/06 - 3/29/06	FLR Strategic Planning Meeting

ERNESTO RUBI:			
CHEPREO:	Las Vegas, NV	6/18/05 - 6/23/05	Cisco Networkers 2005
	Brownsville, TX	7/10/05 - 7/15/05	Open Science Grid (OSG) Workshop at the University of Texas
	Vancouver, Brit.Col.	7/17/05 - 7/20/05	Internet2 Joint Techs Workshop
	Orlando, FL	10/19/2005	Florida Lambda Rail (FLR) Meeting
	Albuquerque, NM	2/4/06 - 2/8/06	ESCC/Internet2 Joint Techs Workshop
AMPATH:	Sao Paolo, Brazil	8/27/05 - 8/30/05	Peering Meetings with IRNC/CHEPREO

Table 11: CHEPREO/CIARA Personnel Dissemination & Training Activies

CHEPREO Leveraged Projects Timeline

NSF Award #	YEARS	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0312038	CHEPREO Cyberinfrastructure				Sep-03					Sep-08		
	AMPATH International Exchange Point (IXP)		Jun-01								Dec-09	
0427110	ULTRALIGHT					Sep-04				Aug-08		
0441095	WHREN						Jan-05					Dec-10
0537464	CyberBridges						Oct-05	Dec-06				
	CMS (Actually runs from 1994 – at least 2024)											
0533280	Data Intensive Science University Network (DISUN)						Jun-05					May-10
0086044	GriPhyN	Sep-00					Sep-05					
0122557	IVDGL		Sep-01					Sep-06				
0427110	UltraLight					Sep-04				Sep-08		
0421200	CASTOR MRI						Feb-05	Aug-06				

Table 11: CHEPREO Leveraged Projects Timeline

CHEPREO Leveraged Projects Personnel Support

CIARA Personnel	CHEPREO	IRNC	AMPATH-STI	OTHER
Year 2				
Heidi Alvarez	25%	0%	25%	50% FIU
Julio Ibarra	0%	0%	0%	100% FIU
Ernesto Rubi	50%	0%	0%	50% AMPATH IXP
Fabian Alcantara	50%	0%	0%	50% AMPATH IXP
Bin Lu	Tuition	0%	0%	50% CISCO URP
Xun Su	100%	0%	0%	0%
Ikam Acosta	0%	0%	50%	50% UltraLight
Year 3	CHEPREO	IRNC	AMPATH IXP	OTHER
Heidi Alvarez	25%	25%	10%	40% FIU
Julio Ibarra	8%	8%	44%	40% FIU
Ernesto Rubi	50%	0%	50%	0%
Michael Smith	50%	0%	50%	0%
Xun Su	100%	0%	0%	0%
Year 4	CHEPREO	IRNC	AMPATH IXP	OTHER
Heidi Alvarez	25%	25%	10%	40% FIU
Julio Ibarra	8%	8%	44%	40% FIU
Ernesto Rubi	50%	0%	50%	0%
Michael Smith	50%	0%	50%	0%
Xun Su	100%	0%	0%	0%
Caltech Pro Bono engineering support year 2 – 4				Note: Not funded by CHEPREO.
Harvey Newman				Ultralight/LHCNet
Sylvain Ravot				Ultralight/LHCNet
Yang Xia				Ultralight/LHCNet
Dan Nae				Ultralight/LHCNet
Iosif Legrand				Ultralight/LHCNet
Gregory Denis				VRVS (DOE funded)
Dave Adamczyk				VRVS (DOE funded)
Philippe Galvez				VRVS (DOE funded)
Joao Fernandes				VRVS (DOE funded)

Table 12: Leveraged Projects Personnel Support

Elements of the OISE Contribution			
CHEPREO collaboration	San Diego	09/26/05-09/30/05	iGrid 2005 & GLIF Meeting demonstrations by Rio and Sao Paulo with support from the
CHEPREO collaboration	Seattle, WA	11/12/05 – 11/18/05	SC 2005 demonstrations by Rio and Sao Paulo
Alvarez	Hong Kong	10/23/05 - 11/3/05	Chinese American Networking Symposium 2005 (CANS) Conference
	Townsville, Australia	3/23/06 - 3/4/1/06	PRAGMA 10 Conference
Ibarra	Sao Paolo, Brazil	7/27/05 - 7/31/05	Meetings with Luis Lopez of FAPESP, AMPATH IXP & WHREN
	Hong Kong	10/23/05 - 10/11/3/05	Chinese American Networking Symposium 2005 (CANS) Conference
	Sao Paolo, Brazil	11/7/05 - 11/10/05	TIDIA workshop
	Sao Paulo, Brazil	4/5/06 - 4/8/06	Meetings with Luis Lopez of FAPESP, AMPATH IXP & WHREN
Newman	CERN	Oct. 2005	Led the US CMS delegation, which along with FermiLab provide support for the Tier2 in Rio and its upgrade, as well as CMS physics on CMS
Newman, Xia, Thomas	Rio de Janeiro, Brazil	May 2005	worked during HEPGrid workshop to make HEPGrid a functional OSG Node in
Newman	Rio de Janeiro, Brazil	Feb. 2004 & Dec. 2004	Keynoted the ICFA Digital Divide Workshop and at HEPGrid inauguration
Rubi	Sao Paolo, Brazil	8/27/05 - 8/30/05	Peering Meetings with IRNC/CHEPREO

Table 13: Elements of OISE

Appendix B – Draft E&O Evaluation Plan

Our draft evaluation plan outline for years 4 and 5 follows. The draft represents a superset of possible measurements that will be reduced to focus on assessing the quality and effectiveness of the program. The plan will be refined during summer 2006 in concert with our external evaluator.

1. **Evaluating classes and activities**
   a. ***Understanding the student population***
      i. Pretests of knowledge and skills
         - Concept tests such as FCI, FMCE, IBC, CSEM, and ECCE
         - Lawson Test of Scientific Reasoning (TSR) => looks at whether students are concrete operational or formal operational in scientific thinking
         - Epstein Basic Skills Diagnostic Test (BSDT) => looks at Pre-calc Mathematical thinking
      ii. Effort Quizzes (Effort quizzes are quizzes where students get credit by writing out their answers and their reasoning even if they are not correct).
         - McDermott Pretests/Effort Quizzes
         - Predictions from activities/demos
   b. ***Evaluating implementation of modeling classes and activities***
      i. Classroom observations – RTOP or modified RTOP Protocol
      ii. Small and large focus groups to look at what's working, factors contributing to success, and what needs to be improved.
      iii. Look at learning gains-see next section
   c. **Evaluating Learning gains**
      i. Pre/post diagnostics
         - Concept tests (Note that any one class will use one or two of these)
           <u>FCI,</u>
           <u>FMCE,</u>
           <u>IBC,</u>
           <u>CSEM,</u>
           <u>ECCE,</u>
         - Expectation/Epistemology (Note that any one class will use only one of these)
           <u>MPEX,</u>
           <u>EBAPS</u>
           <u>VASS</u>
           <u>CLASS</u>
         - Knowledge/Skills Diagnostics
           <u>Lawson test of scientific reasoning</u>
           <u>Epstein Mathematical Thinking Diagnostic</u>
      ii. Evaluating Problem Solving
         - Comparing conceptual quizzes (pre) and matched exam problems (post)
         - Detailed analysis of exam problems to identify student difficulties, misconceptions, and matching correct answers with correct reasoning
   d. ***Positive Learning Experience***
      i. Attendance

ii. Course evaluations
iii. Small focus group interviews (see extended description for focus groups listed above)
iv. Increased number of students in Modern Physics sequence

2. **Evaluating Communities**
   a. ***How well is the community functioning and how well is it supporting students and/or teachers***
      i. Observations – monitoring quality and quantity of observations
      ii. Participant and Leader Surveys
      iii. Small Focus Group Interviews
      iv. Large Focus Group Interviews
3. **Evaluating Leadership Development**
   a. ***Observations of leadership development***
   b. ***Monitor number and quality of leader activities with leader evaluations***
   c. ***Small focus group interviews and surveys to learn about Leader and participant perceptions***
4. **Evaluating Development and Dissemination of a model for increasing minority/Hispanic representation in undergraduate physics**
   a. ***Formulate and test hypotheses***
   b. ***Determine which components are most crucial***
      i. ***Small and large focus group interviews***
      ii. ***Surveys***
   c. ***Determine which components are consistent with the literature***
5. **Evaluating EPP outreach and curriculum development**
   a. ***Test activities with teacher and student trials***
   b. ***Evaluate with learning gain assessments (see above)***
   c. ***Surveys and interview to gauge student and instructor perception of impact and effectiveness***

Appendix C – Letters of Support

UNIVERSIDADE DO ESTADO DO RIO DE JANEIRO
Departamento de Física Nuclear e Altas Energias – Instituto de Física
Rua São Francisco Xavier, 524 Rio de Janeiro 20559-900 – RJ – Brasil

Tel. 55-21-2.587.7454 – Fax. 55-21- 2.587.7551

Rio de Janeiro, April 12, 2006

Prof. Harvey Newman
California Institute of Technology
Pasadena, CA

Re: Requirements for network services to the United States

Dear Harvey,

I am pleased to provide you with this letter of support for the NSF funded programs that provide network as well as grid infrastructure to Brazil's CMS program: CHEPREO and WHREN-LILA.

Brazil is developing a Tier2 facility to support Brazil and Latin America's participation in the CMS experiments. It is critical that sufficient network resources be in position from Brazil to U.S. Tier2s, FermiLab and CERN. Presently, I understand that there is a 1.2 Gbps connection between Miami and Sao Paulo. The requirement for a Tier2, set at the US CMS Tier2 workshop last year, is in the range of 2.5 – 10 Gbps. Most US CMS Tier2s now have 10Gbps connections to the Starlight facility and from there to the Fermilab Tier1 facility, for example.

I am particularly concerned about Brazil's ability to participate in the CMS Tier-2 milestones plan. The plan has milestones to demonstrate approximately 5 TB/day and 50% bandwidth capacity to do organized data transfers. The goal is to run Monte Carlo jobs at Tier2 sites, then get the output shipped back to the Tier1. This will require significant network capacity on the WHREN-LILA circuit.

It is with these goals in mind that I completely endorse the efforts of the CHEPREO team to improve the network capacity from the U.S. to Brazil. We also depend on strong support from your Caltech team, both remotely and onsite, and in our discussions with RNP in Brazil and ANSP in Sao Paolo for the local and regional connections. It is critical that Brazil and the region of Latin America be fully able to participate as a partner in the CMS experiment with the U.S. and CERN. The CHEPREO project and increased bandwidth on the WHREN/LILA link are essential to make this possible.

Finally I would like to say that without the help we have had from your group it would very difficult to install all that we have in the present. This is an exemplary action from a collaboration that I hope will be for long duration. Many groups in Latin America now know your action and I am sure will use our facilities.

With best regards,

Alberto Santoro
Professor of Physics
Director, HEPGrid Tier2 Facility
UERJ

Cc: Pete Markowitz
Harvey Newman
Luis Lopez
Heidi Alvarez

SPRACE

São Paulo, 13 April 2006.

Julio Ibarra
Executive Director
Center for Internet Augmented Research and Assessment
Florida International University
Miami, FL 33199

Re: Requirements for network services to the United States

Dear Julio,

As the Principal Investigator of CHEPREO for Brazil, and as a principal user of the WHREN-LILA international link, I bring to your attention the urgency for these projects to be in position to provide greater network capacity for experiments to the U.S. and CERN.

Foremost is Brazil's participation in the experiments of the CERN's Large Hadron Collider. Nowadays we have groups engaged in all four experiments of LHC: CMS, ATLAS, LHCb and ALICE. As these experiments approach readiness in 2007, our bandwidth requirements to the U.S. and to CERN will increase. I urge you to prepare for these events, so that we are not faced with bandwidth bottlenecks that severely impact our experiments and the Brazilian participation in several High Energy Physics collaborations.

The São Paulo Regional Analysis Center (SPRACE, http://hep.ift.unesp.br/SPRACE/) has been processing data produced by the DØ Collaboration since March 2004 together with the Distributed Organization for Scientific and Academic Research (DOSAR). We are also part of the Open Science Grid (OSG). São Paulo's computational capacity is growing. SPRACE just got its second upgrade approved by FAPESP and its cluster will start soon to operate with 240 processors, providing a computational capacity of 1.5 TeraFlops and 15 TeraBytes of RAID disk. Grid resources in São Paulo and Rio are growing and steps are underway to connect all the sites to create a distributed Tier2 facility for the region that should be useful for all groups participating in the LHC experiments. We are also partners of the UltraLight project. We are implementing the concept of manageable optical network, controlled by Grid schedulers, in the KyaTera network, an optical testbed network that interconnects several laboratories, universities and private companies actively involved in the research of information technology. This research will require network services that can support real-time control flows between São Paulo and the U.S. As a result, it is critical that for our plans to succeed that network resources be in position to support these activities in 2007.

I hope that you will be able to take proactive steps to ensure the readiness of the WHREN-LILA link to support our projects and collaborations with the U.S.

Best wishes,

Sérgio F. Novaes
Professor of High Energy Physics
State University of São Paulo
SPRACE Principal Investigator

Cc: Pete Markowitz
Harvey Newman
Luis Lopez
Heidi Alvarez

Rua Pamplona, 145
01405-900 São Paulo, Brazil
+55 (11) 8115-2100
novaes@fnal.gov