



The LHC Physics Center (LPC)

Sarah Eno

U Maryland

(for more information, see <http://www.uscms.org/LPC/LPC.htm>)

LPC



What is the LHC Physics Center?

Located on the 11th floor of the FNAL high rise, the purpose of the LPC is to ensure the US gives the strongest possible assistance to international CMS in software preparations for Day 1 and to enable physics analysis from within the U.S.

- a **critical mass** (clustering) of young people who are actively working on software (reconstruction, particle identification, physics analysis) in a **single** location (11th floor of the high rise),
- a **resource** for University-based US CMS collaborators; a place to find expertise in their time zone, a place to visit with their software and analysis questions,
- a **brick-and-mortar** location for US-based physics analysis, with such physical infrastructure as large meeting rooms, video conferencing, large scale computing, and a “water cooler” for informal discussions of physics.

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Past Year Highlights

Created Feb. 2004

Seven strong working groups!

- 11th floor layout planned and constructed, Web presence, Remote Operations Center work started
- weekly All USCMS meeting Fridays
- 4 well-attended sessions of CMS 101, 4 successful Tevatron/LHC workshops, 4 well-attended sessions of “software tutorials”, tutorials on software tools
- a mini-workshop on LHC turn-on physics, a workshop to initiate LPC cosmic slice effort, hosted for international CMS “physics” week, a US CMS Meeting, a 2-week mini summer school
- French lessons
- Well-liked by funding agencies

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Physical Resources



Web Information

<http://www.uscms.org/LPC/LPC.htm>

The LHC Physics Center at FNAL

The LHC Physics Center (LPC) at FNAL is:

- a "brick and mortar" location for CMS physicists to find experts on all aspects of data analysis, particle ID, software, and event processing within the US, working during hours convenient for U.S.-based physicists
- a center of physics excellence within the US for LHC physics
- a place for workshops/conferences/gatherings on LHC physics
- a place for the training of graduate and postgraduate scientists.
- a center for the development of software and physics analysis in the US
- a "remote operations center" that CMS physicists can use to participate in data taking and quality control for the CMS experiment in the U.S.
- a tool to help provide a graceful transition between the Tevatron and LHC experiments for those physicists participating in both, maximizing the manpower available to each during the transition time.

The center is run by [Avi Yagil](#) (FNAL) and [Sarah Eno](#) (UMD) and is located on the 11th floor of the FNAL hi-rise. **For more information, choose one of the links on the side.**

Time left until July 1, 2007:

696 days 13h 39m 20s

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Remote Operations Center: LHC@FNAL



11th Floor WH



Virtually there,
24/7

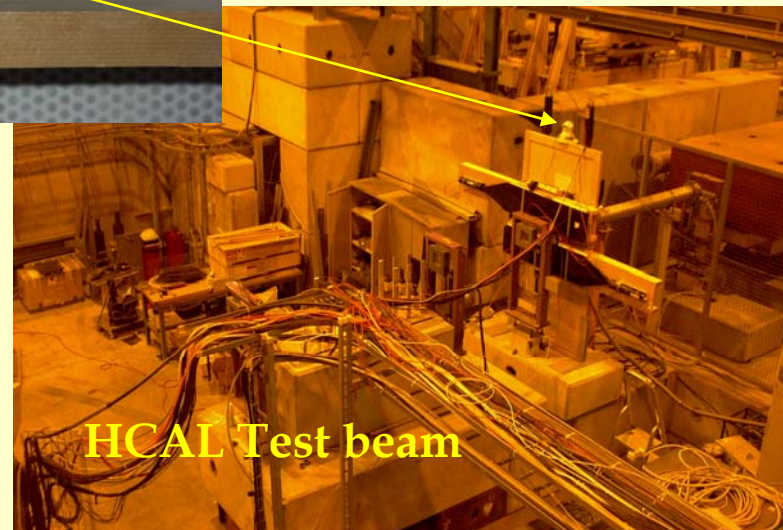


**Erik Gottschalk
(FNAL):**
international
coordinator, long
term planning

**Kaori Maeshima
(FNAL):** WH11 for
test beam and
cosmic ray test,
next-few-year
planning, work



CERN HCAL
Control Room



HCAL Test beam

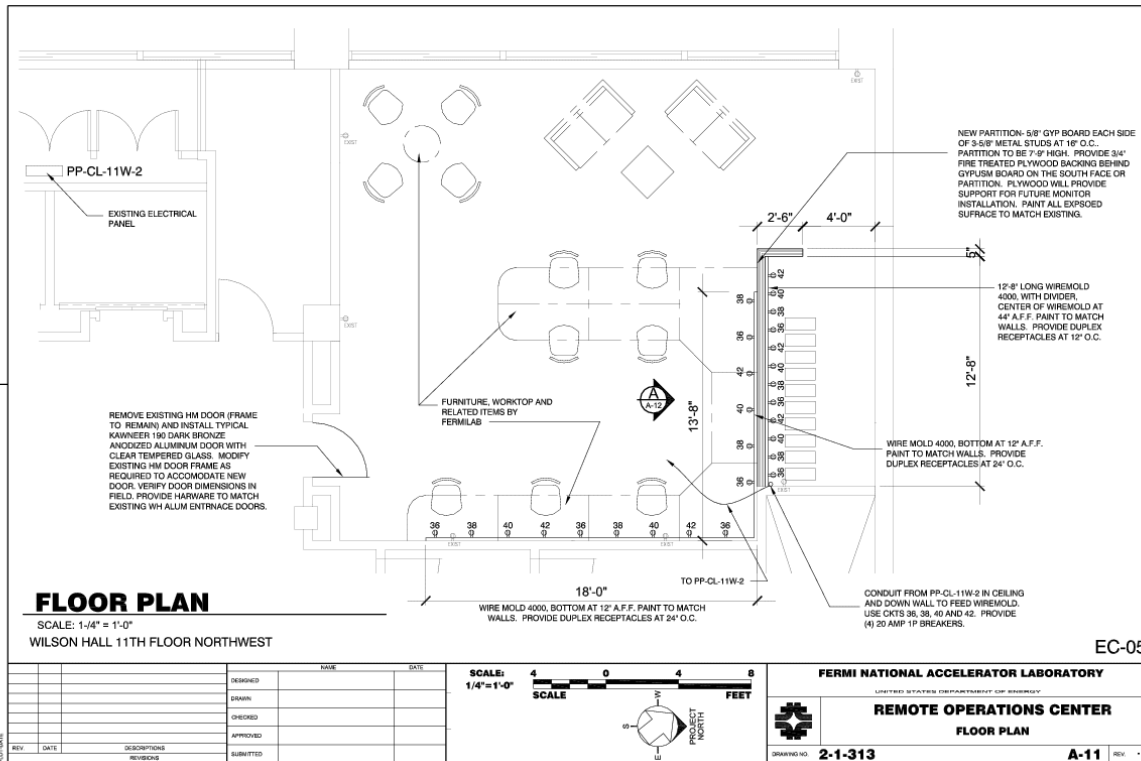
<http://home.fnal.gov/~eeg/remop.html>



ROC

15th Sept. '05.

Contributors: FNAL, MD, Kansas State



- Will be used for cosmic slice test and 2006 test beams
- discussed in trigger working group

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Computer Help



Patrick Gartung

system administration of the Linux PC's at the LPC and the ROC

- all common login PC's and some university PC's

user support for

- Windows and Linux laptops at the LPC
- accessing the UAF resources from the LPC and universities
- the video conference rooms at the LPC
- running CMS software
- setting up the PC's and video conference equipment in the ROC
- developing software configurations for new Linux desktop installations



Workshops

Many workshop: go to LPC web page and choose the “workshops” bullet



All US CMS Meeting

- (almost) every Friday 2:30 PM FNAL time
- well-attended both in person and via vrvs

Typical Agenda

- News from Dan
- News from Ian/Jon
- one topical talk

May 13 EDM report – Liz Sexton-Kennedy
May 20 sLHC – Wesley Smith
May 27 e/gamma – Yuri Gerstein
Jun 3 trigger – Sridhara
Jun 10 jet/met – Rob Harris
Jun 17 (cancel due to cms week?)
Jun 24 (cancel due to cms annual review?)
Jul 1 The CMS Forward Pixel Project – John Conway
Jul 8 Making contact with theorist – Steve Mrenna
Jul 15 muon alignment – Marcus Hohlmann
Jul 22 LPC muon group – Eric James
Jul 27 due to Dan's lecture series
Aug 5 Authorship list requirements – Dan Green
Aug 12 Magnet studies – Rich Smith
Aug 19 Data bases for Cosmic Ray test – Lee Lueking
Aug 26 luminosity preparation – Dan Marlow
Sep 2 cosmic analysis in the U.S. – Yurii Maravin
Sep 9 cosmic workshop
Sep 16 ROC – Kaori
Sep 23 CMS week
Sep 30 Simulation Certification Project – Daniel Elvira
Oct 7 physics workshop
Oct 14 (HCAL meeting at FNAL) MET – Richard Cavanaugh
Oct 21 Calorimetry Task Force – Jeremy Mans
Oct 28 HCAL calibration – Shuichi Kunori
Nov 4 P420 Proposal – Mike Albrow
Nov 11
Nov 18 Tier 2's for me and you – Ken Bloom

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Summer School

Jeff Appel: chair

Tentative dates for the first school (2006):

August 9 (Wednesday) through August 18 (Friday) – with the Sunday off

Format:

10 days, including a 1-day break in the middle (Sunday)

Typical day:

Morning: 3 lectures (8:30–12:30)

Lunch break, including 1.5hrs free time for study, relax (12:30–3pm)

Afternoon:

1 1/4 hr discussion, led by discussion leaders (3–4:15)

2 lectures (4:30–7)



Summer '05

Over 50 University-based physicists visited the LPC for at least 2 weeks this summer.



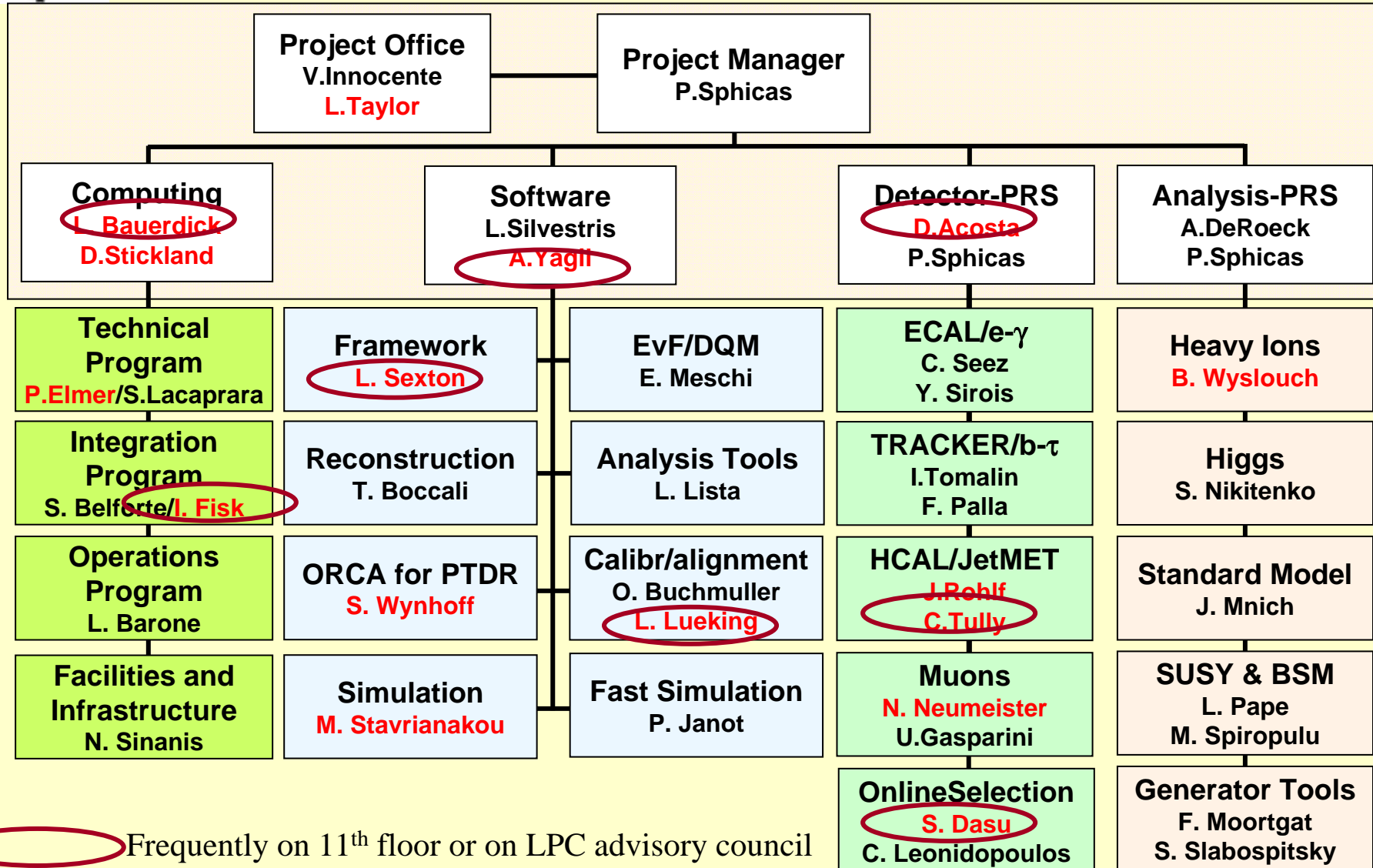
- Summer school
- CMS 101
- tutorials




Interactions with International CMS



Integration with International CMS



 Frequently on 11th floor or on LPC advisory council





Working Groups



Critical Mass: Working Groups

The Working Groups are the heart of the LPC.

- provide an **informal** yet intense platform for work on the fundamental foundations of future LHC physics analysis
- ensure that expertise in all areas necessary for a complete analysis can be found at the LPC
- have been greeted with enthusiasm by international CMS and, by concentrating our efforts this way, have already been able to make substantial contributions to international CMS

Not coordinators of US effort! A concentration of effort at a physical location to be of service to the US

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Work

Concentrate on the fundamentals CMS will need to be ready with physics on day 1:

- calibrations and alignments
- particle identification algorithms
- code certification/ data quality control
- physics preparations

Will bring our experience from currently running experiments to these tasks. Can test ideas using running experiment data.

Bring our knowledge of these topics to start working on prototype physics analyses and prepare for T=0

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Working Groups & US Universities

- a postdoc who is stationed at FNAL working on both CMS and a Tevatron experiment can have a desk on the 11th floor and be near people from both experiments.
- a CMS postdoc can be stationed at FNAL and benefit from having many people close by to interact with
- a postdoc stationed at your university can come for a month, to get up to speed on analysis basics and to form personal connections that will help his/her later work
- students can come for the summer to interact with a wide variety of experts and learn the basics on the CMS environment
- Faculty can come every other week to keep their connections with the experimental community .
- Faculty can come for a day for help with a particularly knotty software or analysis problem

Participation in the groups will both help you do physics and allow you to serve the US and International CMS communities



US University Involvement

Simulation: FNAL, FSU, Kansas State, Kansas, Louisiana Tech/Calumet, Maryland, Northwestern, Notre Dame, Rutgers, UIC, SUNY, Ciemat, Tata

Jet/Met: FNAL, Rochester, MD, Rutgers, Boston, Cal Tech, Princeton, Texas Tech, Iowa, Mississippi, Minnesota, Santa

Muon: FNAL, Carnegie Mellon, Florida, Florida Tech, Pu, Northwestern

e/gamma: FNAL, Northwestern, FSU, Minnesota, MD, B, Diego, Cal Tech

Tracking: FNAL, Colorado, Cornell, Nebraska, UC Riverside, Wisconsin, Kansas State, Calumet

Trigger: Wisconsin, Florida, Northwestern, FNAL, Vanderbilt, Texas A&M, Brown, Maryland

Offline/edm: FNAL, Cornell

Physics: all

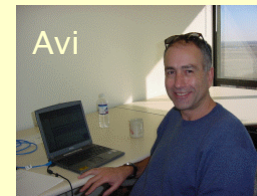
About 1/4 of the non-transient physicists on the 11th floor are University employees. All the (many) transients from Universities.

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Leaders

- **offline/edm:** Liz Sexton-Kennedy (FNAL), Hans Wenzel (FNAL)
- **tracking:** Kevin Burkett (FNAL), Steve Wagner (CO)
- **e/gamma:** Yuri Gershtein (FSU), Heidi Schellman (NW)
- **muon:** Eric James (FNAL) , Michael Schmitt (Northwestern)
- **jet/met:** Rob Harris (FNAL), Marek Zielinski (Roch)
- **simulation:** Daniel Elvira (FNAL), Harry Cheung (FNAL)
- **trigger:** Greg Landsberg (Brown) , Kaori Maeshima (FNAL)
- **Physics:** Boaz Klima (FNAL)



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Theme

Choose projects that benefit most by having people working on different particles at same location (e.g. tracking contributions to electrons, muons, jets, etc)

Simulations \rightarrow particle ID \rightarrow trigger, physics



LPC-Simulations Group

Group Leaders: D. Elvira
H. W. K. Cheung

We have meet bi-weekly every other Monday since October 2004.
Jointly with CMS Simulation Validation during the first 1-1.5 hours.

Helped USCMS institutions to carry out their
own simulation projects

Participating Institutions:

FNAL, FSU, KSU, KU, LTU/Calumet, Maryland, Northwestern, Notre
Dame, Rutgers, UIC (USA), SUNY Buffalo, Puerto Rico

Tata (India)

Ciemat (Spain)

Nanjin (China)

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Main Activities

- Simulation Validation Suite
- Forward Pixels Geometry and Simulation Implementation in CMSSW
- Implementation of the Luminosity Monitoring System in OSCAR
- Implementation of the Zero Degree Calorimeter (ZDC) in OSCAR
- ECAL Crystal Response Studies
- Detailed Instructions for the Generation and Analysis of MC data: MC truth, SimHits, Digis



The Simulation Validation Group

The CMS SVG traces its origins to the LPC-Simulations group back in December 2004.....

Charge from CMS Software Leaders: Develop simulation validation code for basic hit and digi information, as well as physics quantities. This includes comparison of new software releases with "current" code, as well as absolute validation of the physics of the G4 shower, and signal modeling using available data.

Current Activities: We are at stage one, developing code to validate hit derived quantities in new releases against current code.

Institutions and People Involved:

S. Abdullin, H. Cheung, D. Elvira, J. Yarba - FNAL (USA)

P. Arce ciemat - (Spain)

S. Banerjee - Tata (India)

X. Ding - Nanjing/fnal (China)

X. Huang - Mayaguez (Puerto Rico),

A. Kharchilava, M. Strang -SUNY Buffalo (USA),

L. Shabalina - UIC (USA)

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Forward Pixels Geometry Implementation

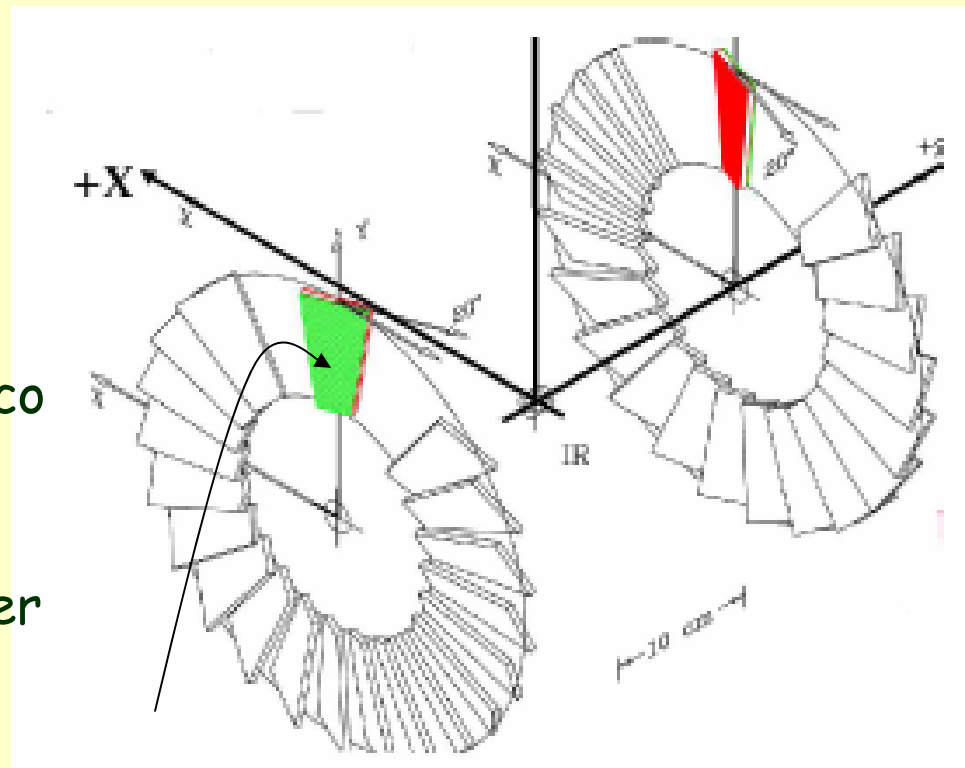
Purpose:

Incorporate details of the updated FP geometry design, using the DDD algorithm capability to write the xml files in a modular way. These will replace the current files which are a translation of the G3 geometry. Implement this geometry into the new CMSSW framework.

People Involved:

Victoria Martin (NW) - left,
Dmitri Onoprienko (KS),
Sunanda Banerjee (Tata/FNAL),
Xingtao Huang (Mayaguez/Pto.Rico)
Neeti Parashar (LT-Calumet)

(close communication with Tracker
and FPix leaders)



Two disks containing 24 blades



Luminosity Monitoring Simulation

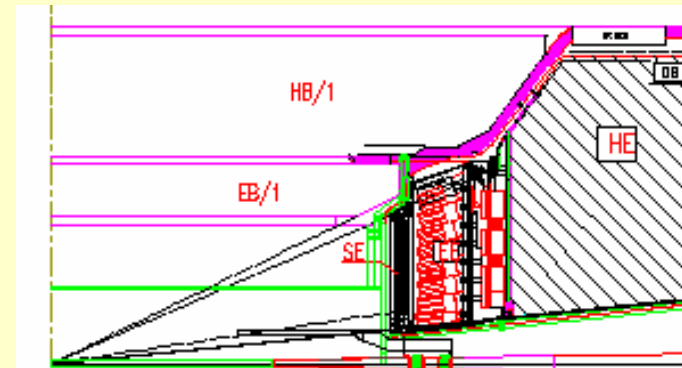
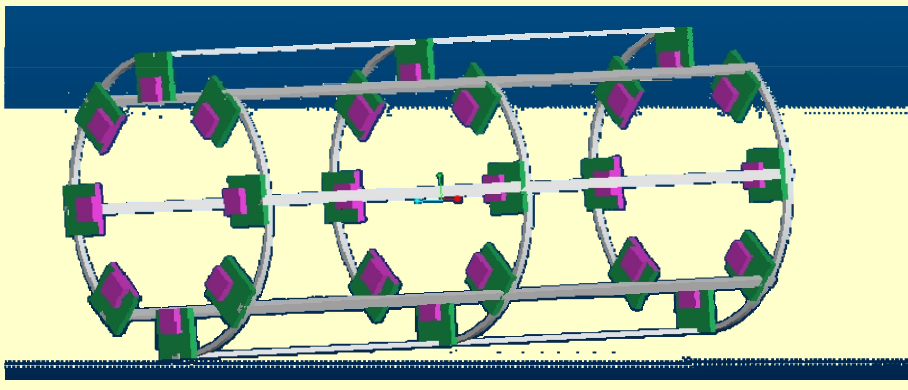
Purpose: Incorporate the Luminosity Monitoring system in OSCAR

People Involved: Lalith Perera (Rutgers)

Status: The LumMonTest package is being tested - close to be released

- Eight telescope arrays per side ($3 \times 8 \times 2 = 48$ sensors)
- Numbering Scheme: each sensor is given a number (1-64)
- Sensors are defined as sensitive volumes, no pixel segmentation yet.
- Hits are defined as a *CaloG4HitCollection*
- Hits (EEM, EHAD >0) and coincidences are counted

LumMonTest has also been integrated to the Full CMS



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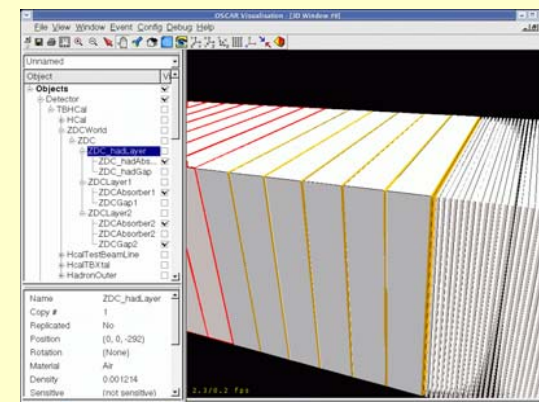
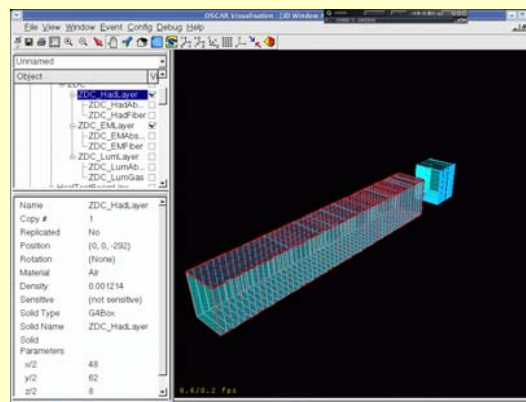
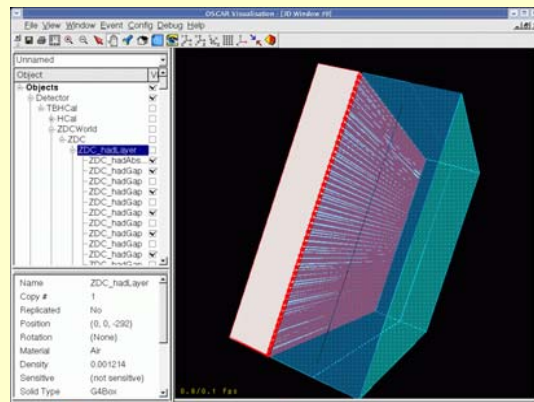
ZDC Simulation

Purpose: Incorporate the ZDC detector in OSCAR

People Involved: Michael Murray-Project Manager (KU)
Megan Lehnherr (KU),
Chadd Smith-main developer (UIC)

Status: ZDCTest was released in OSCAR_3_9_1

Geant4 standalone geometry by Megan translated to xml using toasci package. Then updated by hand using DDD tools (for clarity)



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LPC Tracking Group

- **University Involvement:**
 - FNAL, Colorado, Cornell, Nebraska, UC Davis, UCSB, UC Riverside, Wisconsin, Kansas State, Calumet



LPC Tracking Group

During the past year, we have focused our efforts on two main projects

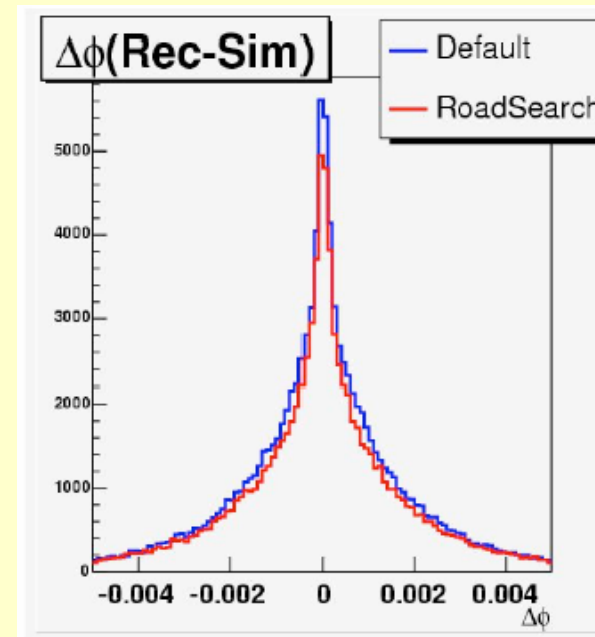
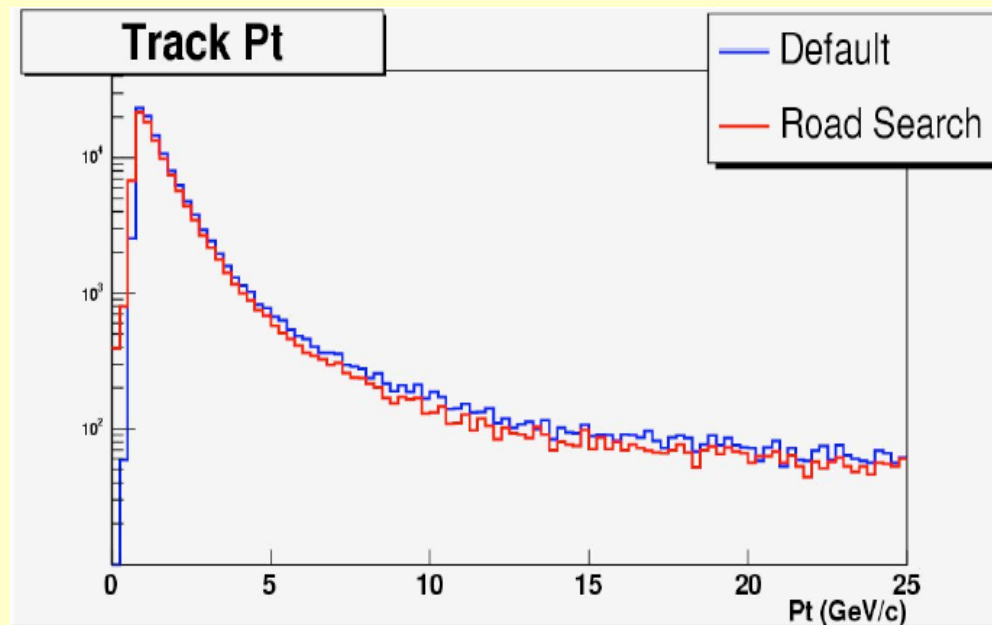
- **Implementation of a Road Search tracking algorithm**
 - Fundamentally different from the default tracking
 - No pixel requirements for seeding so good for startup or cosmic challenge
- **Implementation of Tracking Software in CMSSW**
 - Definition of low-level data structures
 - Porting of reconstruction code



LPC Tracking Group

Development of Road Search Tracking

- First version implemented in ORCA Framework
- Used by others in CMS in alignment studies
- Performance comparable to Combinatorial Track Finder



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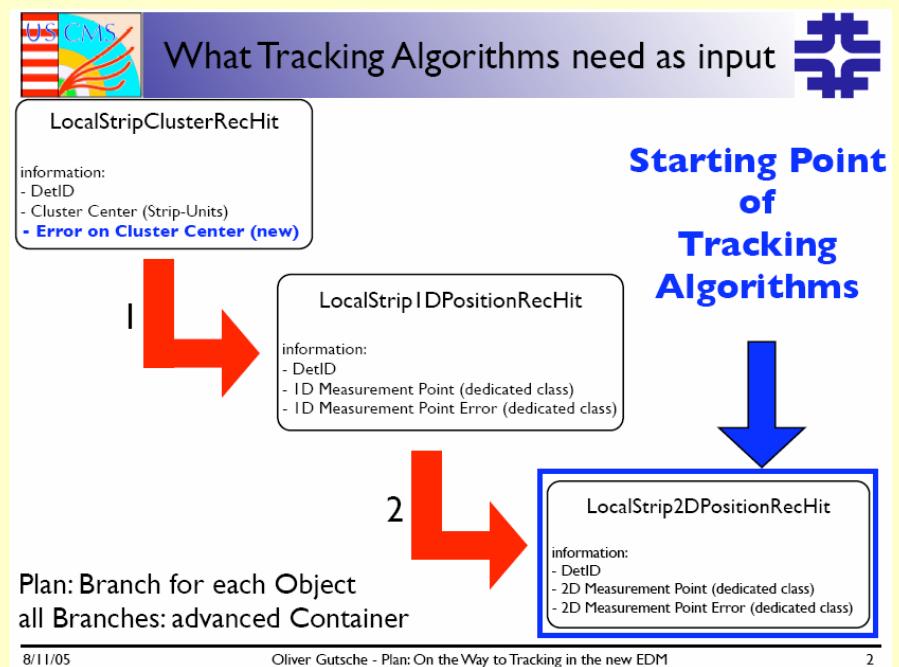
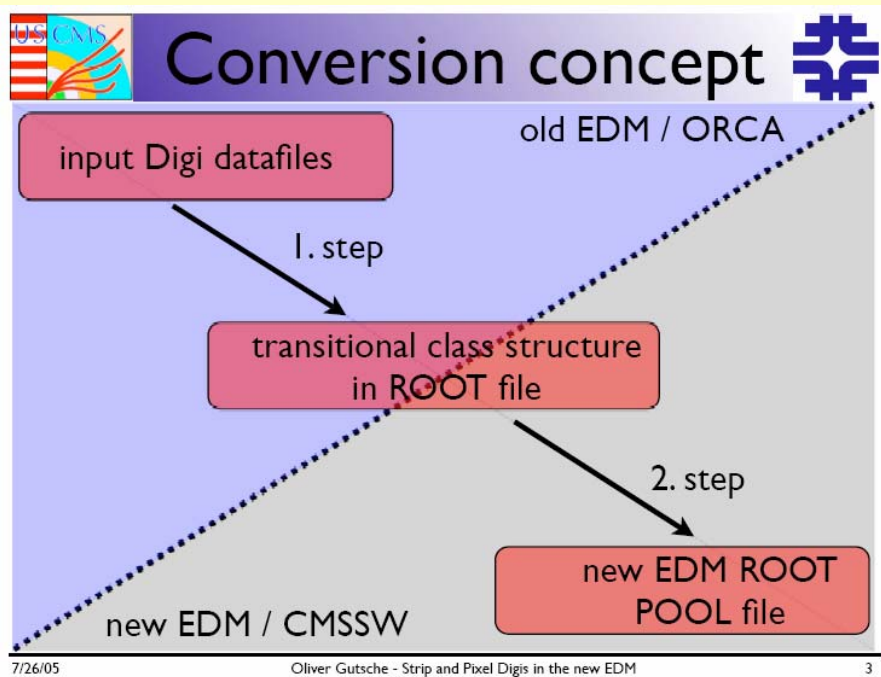


LPC Tracking Group

Implementing Tracking Software in CMSSW

Conversion to New Format

Porting of Reconstruction





LPC EGamma: Universities

Conveners: Yuri Gerstein and Heidi Schellman

- **Minnesota**
 - Rusak, Kubota, 2 post-docs (one at LPC), student: cosmic test, π^0 calibration
- **Florida State**
 - Gershtein, post-doc (at LPC), research scientist, 2 students (1 at LPC next year): tracker material effects/determination, cosmic test, analysis tools
- **Notre Dame**
 - Jessup: cosmic test
- **UC San Diego**
 - Branson+post-doc: π^0 calibration
- **Northwestern**
 - Schellman: monitoring tools
- **Maryland**
 - Hadley + student: monitoring tools
- **Brown**
 - Landsberg + student: analysis tools
- **Caltech**
 - Very useful contacts, especially on software / cosmic test

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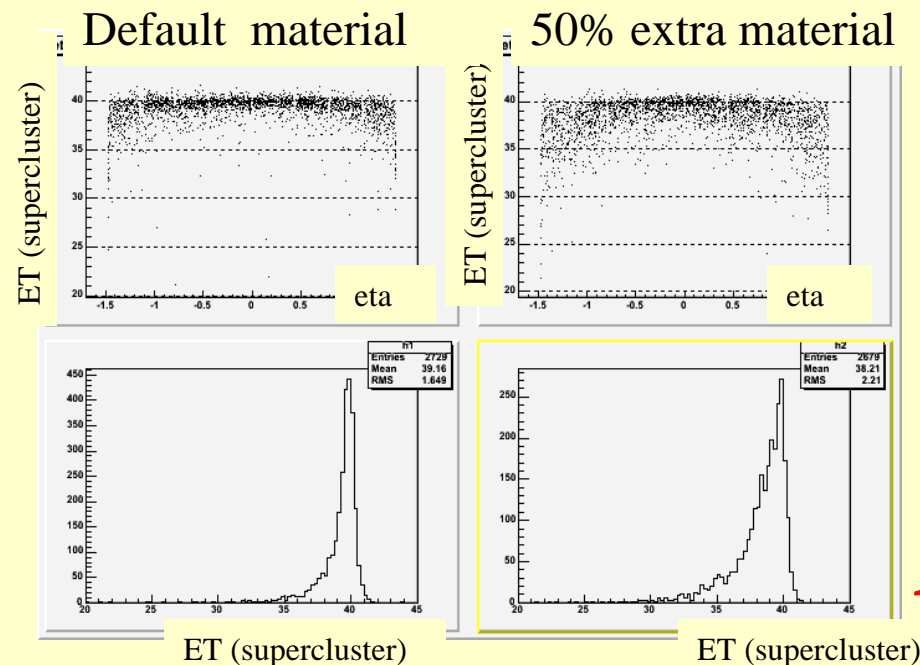


Tracker Material

- All previous experiments tried hard to implement correct material in MC and all miss by a factor of 1.5 to 2
- Huge amount of material before ECAL $0.4\text{-}1.4 X_0$ in 4 T magnetic field
 - Not all the energy makes it to ECAL
 - Electron and photon scales are non-linear and different
 - Most recent examples - Run2 of Tevatron: $D\bar{O}$ missed factor of 2, CDF (their third silicon!) missed 50%
- Doing systematic studies of how extra material affects electron and photon reconstruction, how to measure it in situ, and how to compensate for it.

Effect of 50% more material for 40 GeV electrons:

- energy scale changes
- resolution worsens



Y. Gershtein, A. Askew (FSU)

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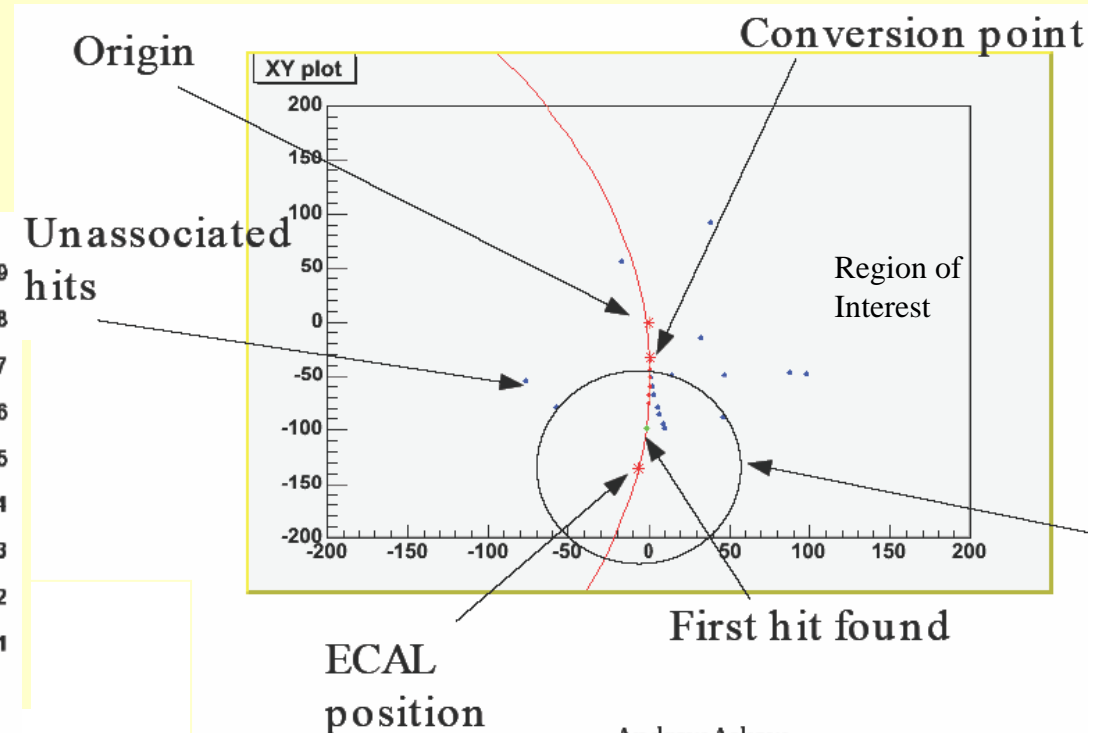
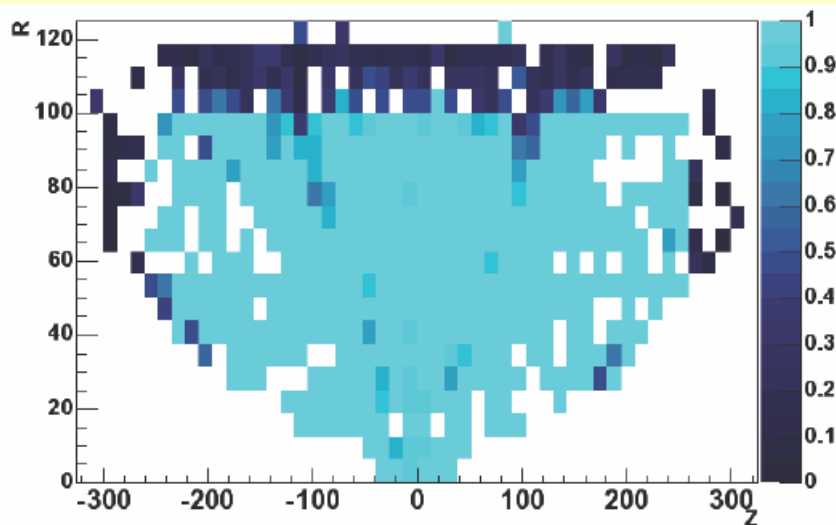


Converted Photons Reconstruction

A. Askew, FSU

- Need robust reconstruction up to the highest possible R
- Work together with LPC tracking group and CERN
- Start from calorimeter clusters
- Energy and position of the cluster + 2 points in the tracker give a road
- Main challenge is to understand the efficiency

Efficiency v.s. R and Z



Andrew Askew



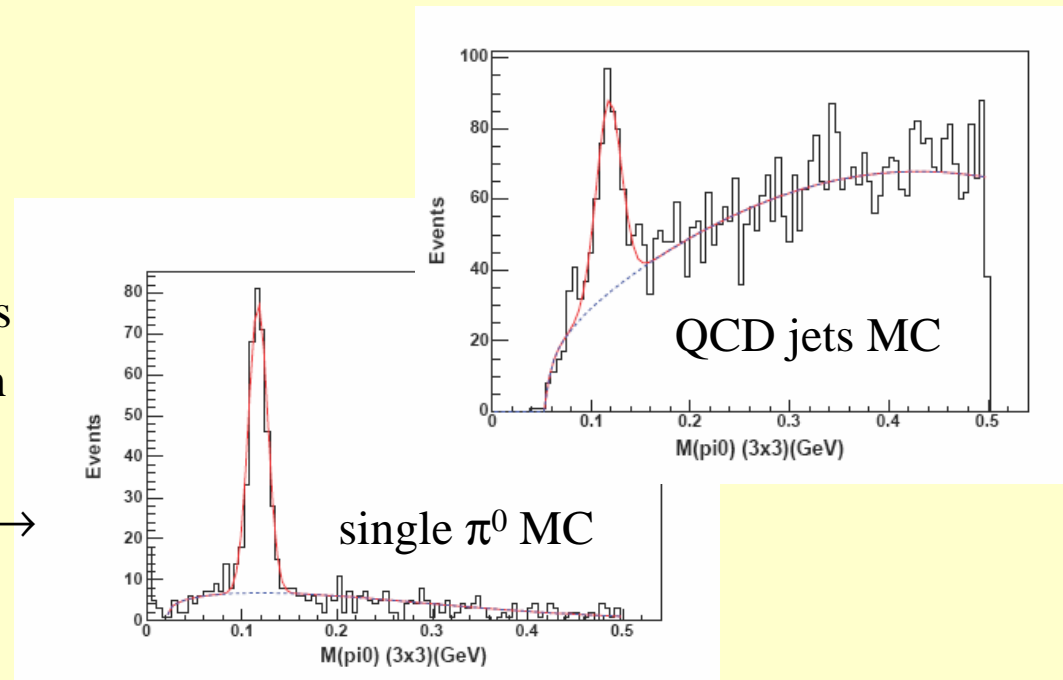
Calibration with π^0

J. Branson (UCSD)

J. Zhang, Rusack (Minnesota)

A. Poblaguev (Yale)

- How to calibrate $7.6E+4$ crystals?
- $W \rightarrow e\nu$: need a lot of data, aligned tracker, excellent understanding of tracker material to tie electron and photon energy scales
- azimuthal inter-calibration is only good to 2-3% (tracker material)
- **Use low energy π^0**
- Developing machinery
- Open for optimization:
 - Clustering algorithms / shape cuts
 - Estimate realistic rates / precision
 - Special runs v.s. global running
 - Improved analysis techniques ($f_2 \rightarrow \pi^0 \pi^0$, etc...)



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Muon Group Status

Active Participants during Past Year :

- Carnegie Mellon
- Florida Tech
- U. of Florida
- Fermilab
- Rice
- Northwestern



LPC Muon Group Activities

- Working on two specific commitments for contributions to Volume I of Physics TDR.
 - Muon Identification algorithm.
 - Comparison of testbeam data with simulation.
- Concurrently, attempting to serve as resource for other ongoing software efforts.
 - Muon Alignment (Florida Tech)
 - TeV Muon Reconstruction (Florida)
- Has the responsibility to produce the low-level code for the CSC's in time for the cosmic challenge



Muon Identification Algorithm

- Muon Reconstruction (Outside-In) : Start by reconstructing a stand-alone track in muon detectors and attempt to match with a reconstructed silicon track.
- Muon Identification (Inside-Out) : Attempt to quantify the “muon compatibility” of any reconstructed silicon track using tracker, calorimeter, and muon system information



JetMET: Institutions and People

Conveners: R. Harris (Fermilab) and M. Zielinski (Rochester)

- Boston: *PRS coordination, jet software in CMSSW*
 - A. Heister, J. Rohlf, F. Varela-Rodriguez
- CalTech: *calorimetry software in ORCA*
 - R. Wilkinson
- Fermilab: *HCAL test beam, calibration and simulation, jet corrections and triggers, jet physics*
 - S. Abdullin, D. Elvira, D. Green, R. Harris,
 - Visiting Physicists/Students: S. Bannerjee, J. Damgov, S. Esen, S. Piperov, E. Yazgan, T. Yetkin
- Florida: *MET software & corrections in CMSSW*
 - R. Cavanaugh
 - Graduate Students: M. Schmitt
- Maryland: *calorimetry issues & software, jet physics*
 - S. Kunori, F. Ratnikov
- Minnesota: *calorimetry software*
 - J. Mans
- Mississippi: *calorimeter and jet calibrations*
 - L. Cremaldi, R. Kroeger, D. Sanders
- Princeton: *PRS coordination*
 - C. Tully
- Rochester: *calorimeter noise suppression, jet efficiency & fake rates, jet & MET resolutions*
 - R. Demina, P. Tipton, M. Zielinski
 - Graduate Students: E. Groves, S. Lockwitz
 - Undergraduate Students: J. Dolen, A. Gennis, C. Justus, D. Prendergast
- Rutgers: *jet corrections based on subclusters*
 - L. Perera
- Rockefeller: *jet energy corrections, impact of noise suppression*
 - A. Bhatti
- Santa Barbara: *jet analysis with CMSSW*
 - C. Campagnari
- Texas Tech: *jet triggers, dijet physics*
 - N. Akchurin
 - Graduate students: K. Gumus

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Improvements for Jets and MET

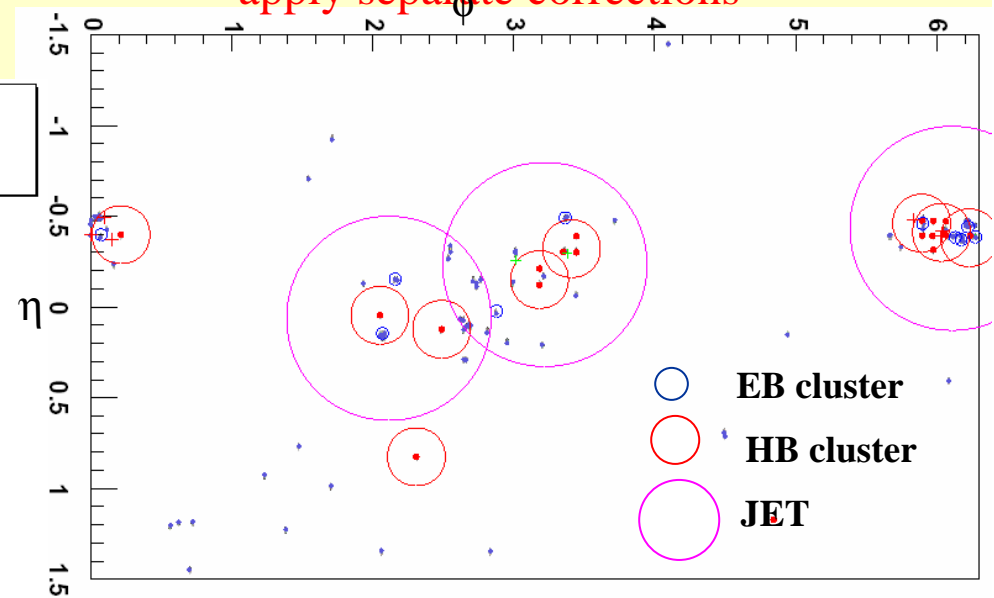
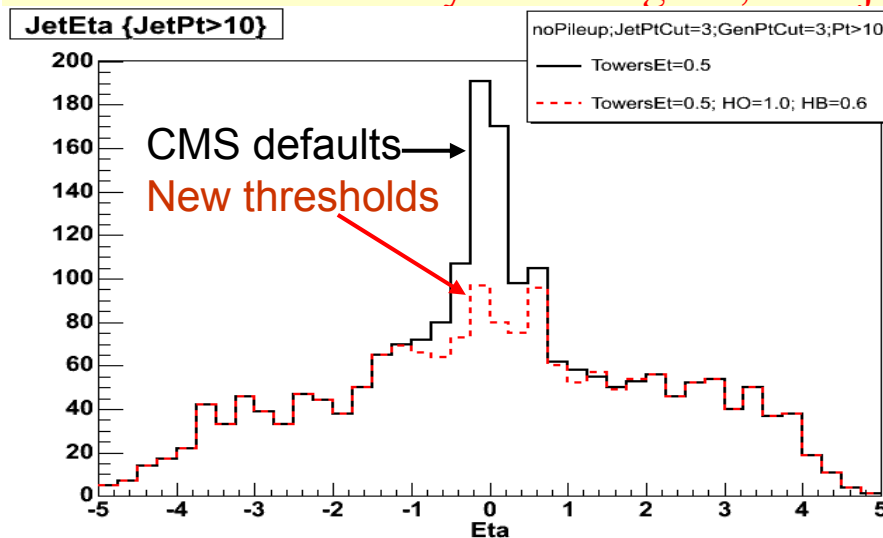
Rochester, Rockefeller, Rutgers, FNAL

- New settings of calorimeter energy thresholds per subdetector for efficient noise suppression

Noise in $R=0.5$ cone reduced from 9 to <1.5 GeV
Loss of real jet energy much smaller (~ 1 GeV)
Sum ET per event reduced by ~ 150 GeV

- Improved reconstruction of low p_T jets (important eg. for $t\bar{t}H$, qqH)
- Jet efficiency remains good, fake-jet

- Related jet/MET studies:
 - Impact on jet response and resolution
 - MET resolution and significance in $Z \rightarrow$ dileptons and QCD dijets
- EFLOW: Jet energy determination based on measured clusters within jet
 - Identify EM and HAD particles and apply separate corrections





Triggers and Physics

Fermilab and Texas Tech

Triggers for PTDR Vol.1

- Reasonable single jet trigger tables.
 - The E_T thresholds, prescales, and rate estimates at L1 and HLT.
 - Four running periods: Lum. = 10^{32} , 10^{33} , 2×10^{33} and $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$.

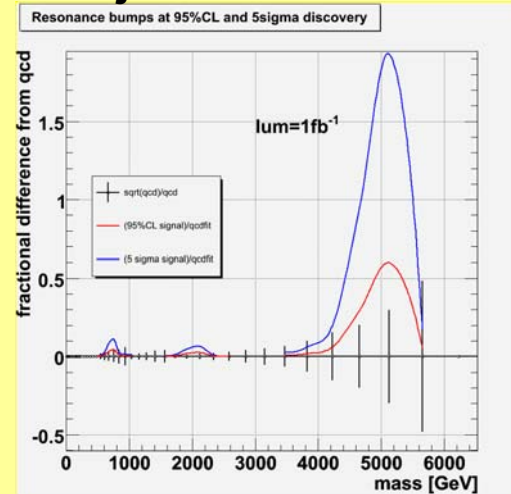
Single Jet Trigger Table for $L = 10^{32}$

Path	L1			HLT	
	E_T (GeV)	Pre-scale	Rate (KHz)	E_T (GeV)	Rate (Hz)
Low	25	2000	0.020	60	2.8
Med	60	40	0.023	120	2.4
High	140	1	0.034	250	2.8

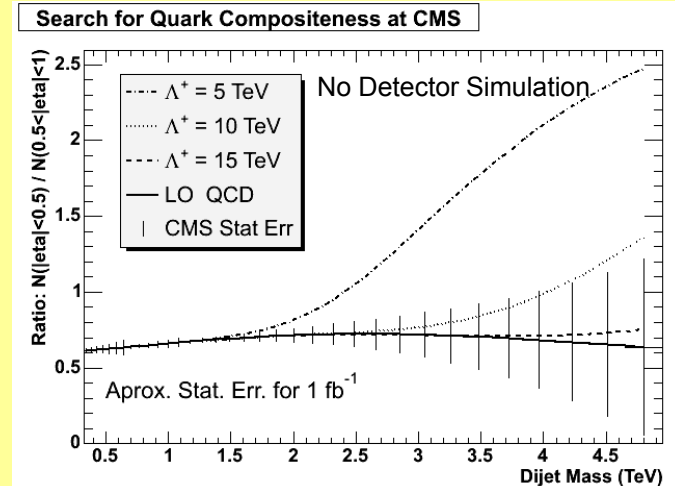
Physics for PTDR Vol. 2

- Dijet Resonances
 - Z' , q^* , ρ_{T8} , etc.
 - K. Gumus Thesis
- Contact Interactions
 - Compositeness, etc.
 - S. Esen Thesis

Dijet Resonances



Contact Interactions





Offline/EDM

The LPC (FNAL/Cornell collaboration) has made a major impact in the area of EDM.

They collaborate closely with approximately 4 European collaborators.



Lots Done

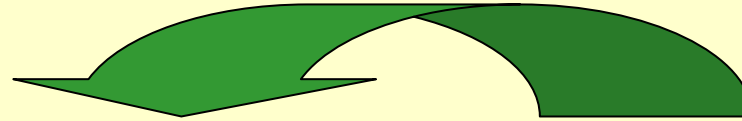
Project Plan

- Phase 0 – Bare Bones (complete by 1 Jun *toward* CPT–DS–201, DONE tagged as the pre3 release of CMSSW)
- Phase 1 – First Implementation complete by 1 Aug *toward* CPT–DS–203
- Phase 2 – All requirements for magnet test complete by 1 Oct *toward* CPT–DS–208
- Phase 3 – Adjustments based on user feedback complete by or before CSA–2006



Cosmic Slice Test at LPC

March 2006



The screenshot shows a web browser window with the address bar containing http://www.phys.ksu.edu/~7Emaravin/cosmic_muon_test.htm. The page title is "US CMS Cosmic Test Webpage" and it is "Scheduled for February-March 2006". The page features the LPC logo and several news items:

- [NEWS: First ECAL cosmic data from SMS in H4! \(08th of August, 2005\)](#)
- [NEWS: Shuichi Kumori's KBOOK tutorial on the 9th of August, 2005 \(Sunrise 3 PM CST\)](#)
- [NEWS: LPC cosmic muon test workshop: the 9th of September, 2005](#)

Contact coordinators: [Nick Hadley and Yurii Maravin](#)
[Send a message to the LPC cosmic mailing list](#)

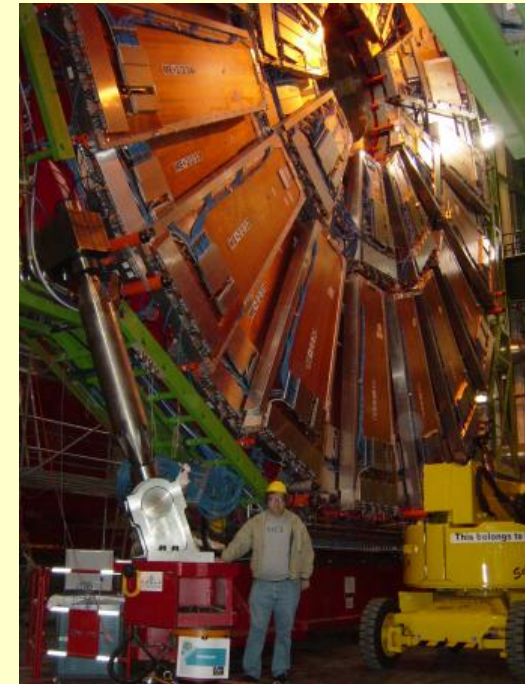
Web pages:
[CMS EMU slice test](#)
[CERN EVF/DQM](#)
[Trigger DAQ \(TrnDAS\)](#)

Mailing list archives:
[LPC cosmic archive](#)

Mailing lists (CERN):
[ECAL cosmic](#)
[Tracker magnet test](#)
[CMS EMU slice test](#)

INTRODUCTION

The main goal of the LPC is to ensure that physicists located in the US have the ability to do competitive physics analysis without leaving the country. The upcoming cosmic slice test and next summer's test beam runs give us an ideal opportunity to prepare the tools we will need to accomplish this goal. We need to be sure we can receive the data, analyze it, and give feedback to the experiment, in real time. We also need to be able to use the data to improve detector performance, particle identification algorithms, and software infrastructure. To achieve that, we set up a set of tasks, sorted by the group below. Most of these tasks do not have names associated with them, so please contact us and the LPC group heads if you want to join the cosmic muon effort and make an impact!



Yurii Maravin, Nick Hadley



LPC



Goals

- Participate in the commissioning of the ROC
- get all cosmic slice/ test beam data to FNAL
- make sure the data is well-documented, easily accessible, and uncorrupted



“Physics” Group

International CMS meetings have very crowded agendas, very large audience. More like a conference than a working group.

Main goal: to provide to US people doing “physics analysis” an informal atmosphere conducive to mentoring.



- First workshop happened Oct 7, 2005
- First bi-weekly meeting happened Nov 3, 2005
- will split if starts to become too large to be real working groups.



“Physics”

Address <http://www.uscms.org/LPC/physics/physics.html> Go Links

Google Search 158 blocked Check AutoLink AutoFill Options

 **Physics Group** 

Admin

Mailing List


lpc-physics@fnal.gov: Ours; currently 134 members ([to subscribe or obtain list](#)).

Meetings

The agendas for the LPC Physics Meetings and the talks are available from the [LPC Physics Agenda Server](#)

Next bi-weekly meeting on [Nov. 17, 2005](#)

Current Activities





Plans for Coming Year

Commissioning of ROC

Physics group

Cosmic slice test

Full summer school

Increased interaction with FNAL theory division



Conclusions

- The LPC is an essential part of US CMS' strategy for doing physics analysis
- The LPC has been embraced by the US CMS physics community
- The LPC has had a substantial impact on both US and international CMS
- The LPC provides a mechanism for contact to the theory community