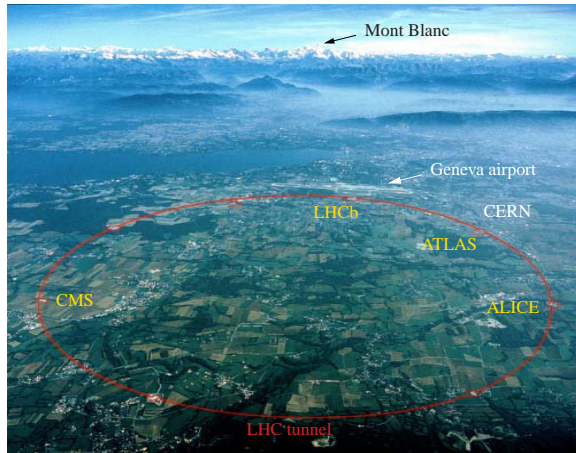
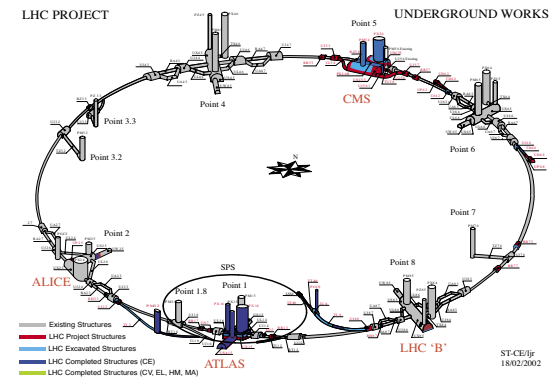




# Physics at the LPC



Boaz Klima  
Fermilab



TeV4LHC Workshop  
October 20, 2005

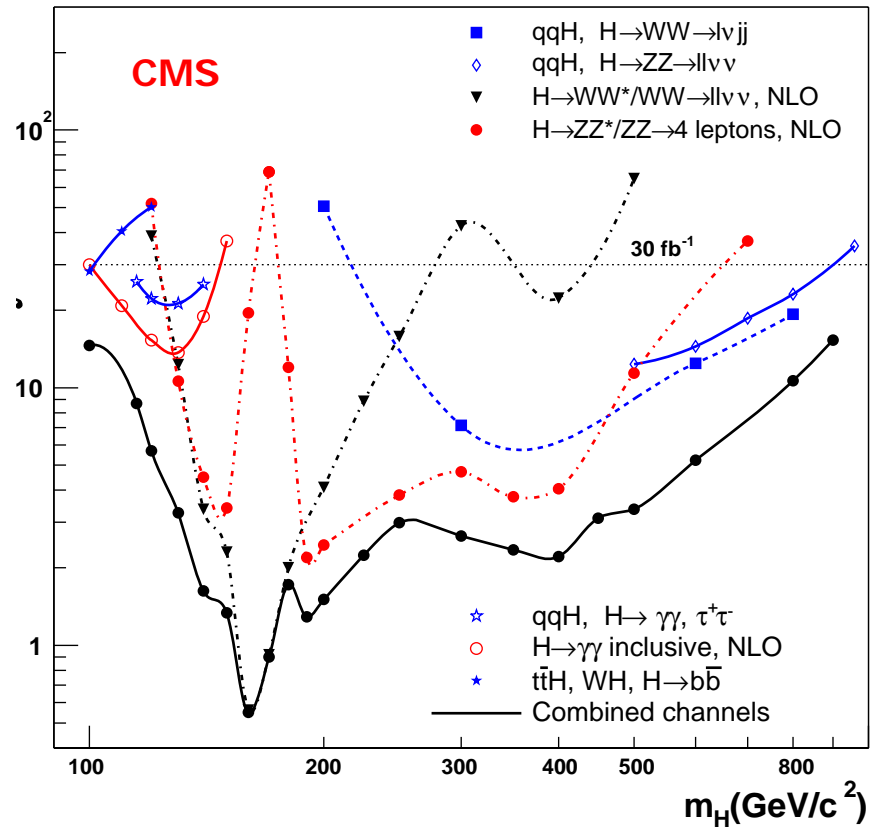
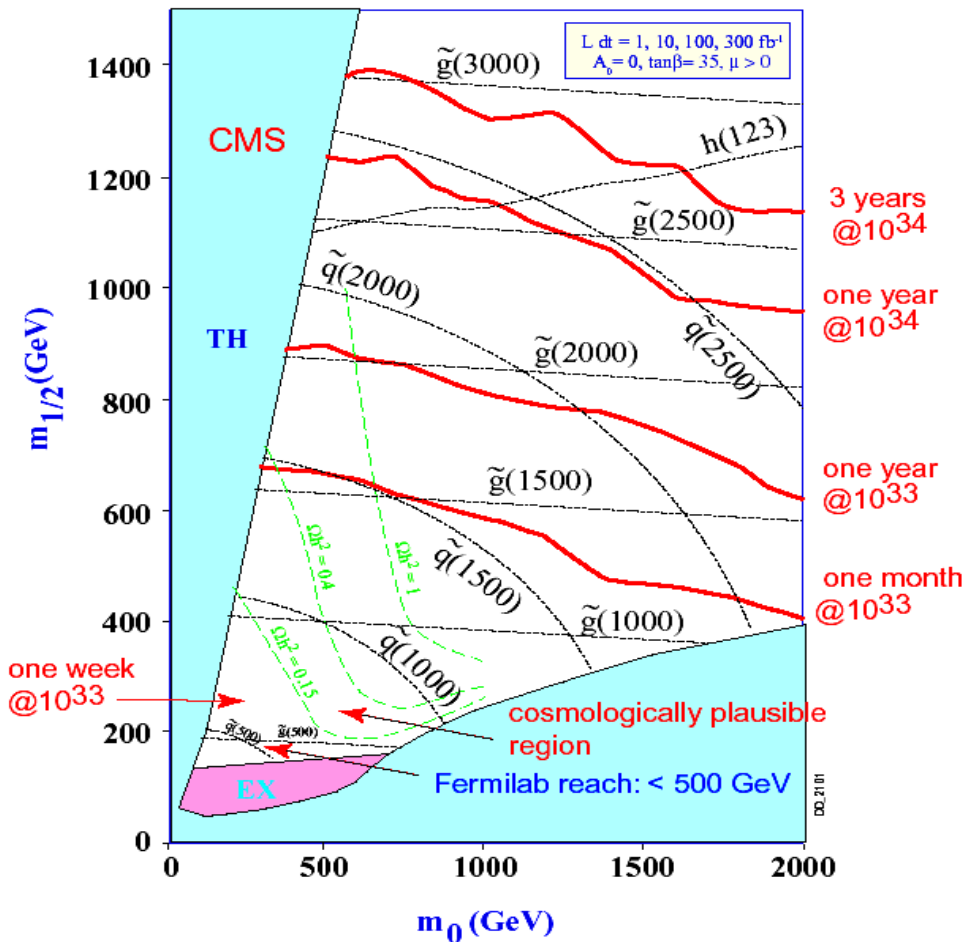


# Tremendous Physics Potential for example...



SUSY

Higgs





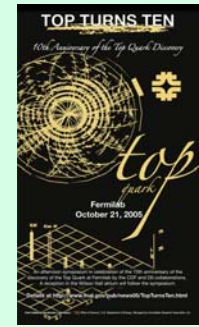
# May Result (Early On) In...



Well, replace 'Top Quark' with 'Higgs Boson' or 'Z' Boson' or 'SUSY' or "Extra Dimensions" or...

if we get our act together

PS: come celebrate with us tomorrow the 10<sup>th</sup> anniversary for the discovery of the Top quark at Fermilab





# ...but There is Competition...



According to Michelangelo Mangano and Fabiola Gianotti's "The First 1-2 years..." (hep-ph/0504221)

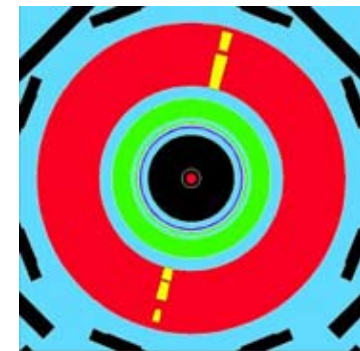
## Conclusions

- LHC has potential for major discoveries already in the first year (months ?) of operation  
Event statistics : 1 day at LHC at  $10^{33}$   $\equiv$  1 year at previous machines for SM processes  
SUSY may be discovered "quickly", light Higgs more difficult ... and what about surprises ?
- Experiments: lot of emphasis on test beams and on construction quality checks  
→ results indicate that detectors "as built" should give good starting-point performance.
- Efficient/robust commissioning with physics data in the various phases (cosmics, one-beam period, first collisions, ...), as well as solid preparation of MC tools, are our next challenges.  
Both are crucial to reach quickly the "discovery-mode" and extract a convincing "early" signal
- The definition of priorities for the physics commissioning and early analyses should match the LHC commissioning plans. There is an immense potential for exciting and rewarding physics, as well as for crucial calibrations/MCtuning/bg-studies/etc, to be done even with lower luminosity. The proper planning of operations for the first 1-2 yrs may have an important impact on the timeliness of major discoveries!

<http://agenda.cern.ch/fullAgenda.php?id=a054821>



Michelangelo at the LHC Physics mini-workshop on Aug. 11, 2005 (@LPC)



Nature: First 'Data' from LHC (=ATLAS)



# So, where are we in general?



- LHC Machine
  - Material from Roger Bailey's report during CMS week (Sept. '05)
- CMS Detector
  - Excerpts from Michel Della Negra's report during CMS week (Sept. '05)

Things look good!



# LHC Installation schedule



R. Bailey  
AB LHC Operations

Cabling

ORL installation

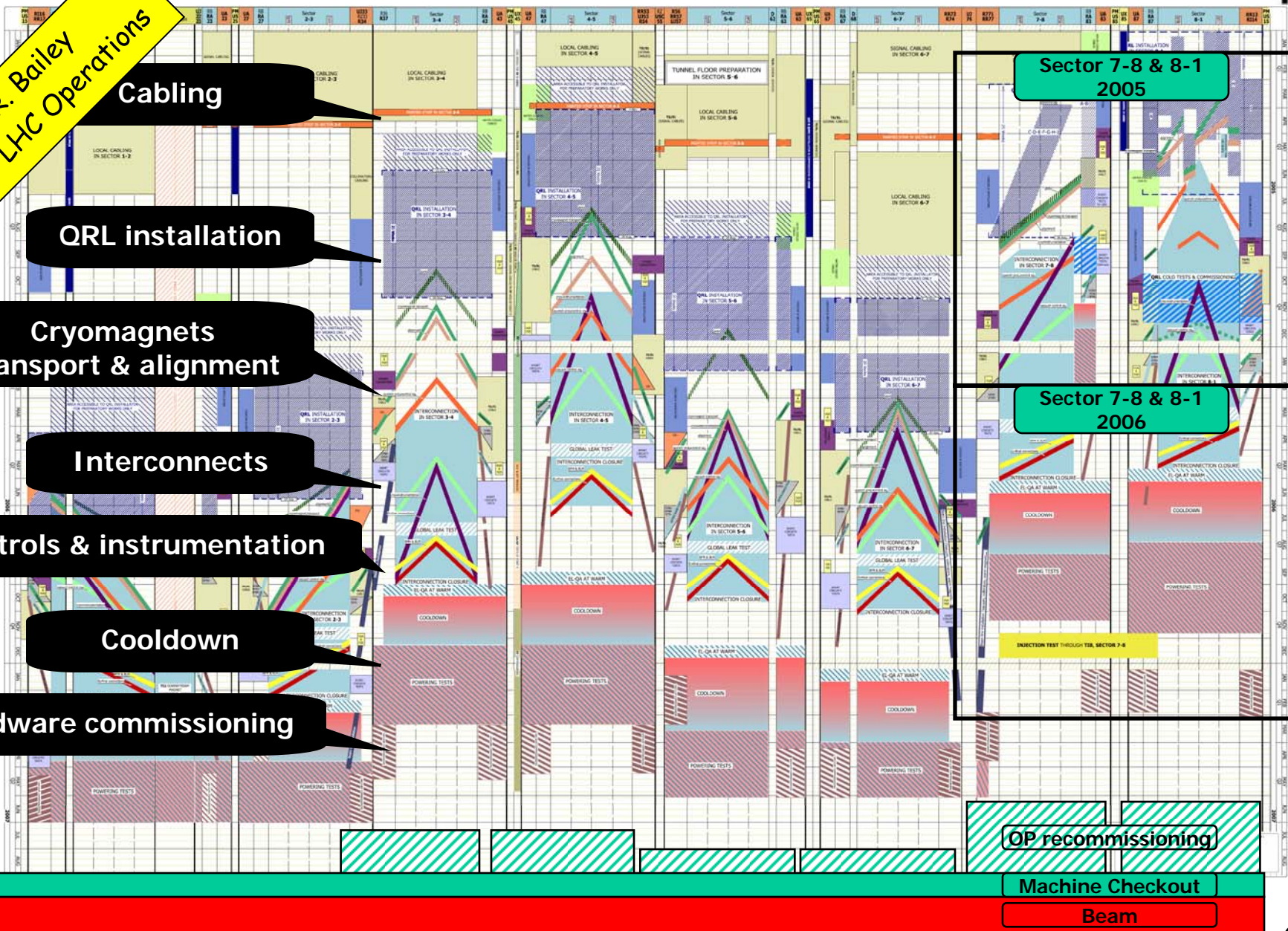
Cryomagnets  
Transport & alignment

Interconnects

Controls & instrumentation

Cooldown

Hardware commissioning



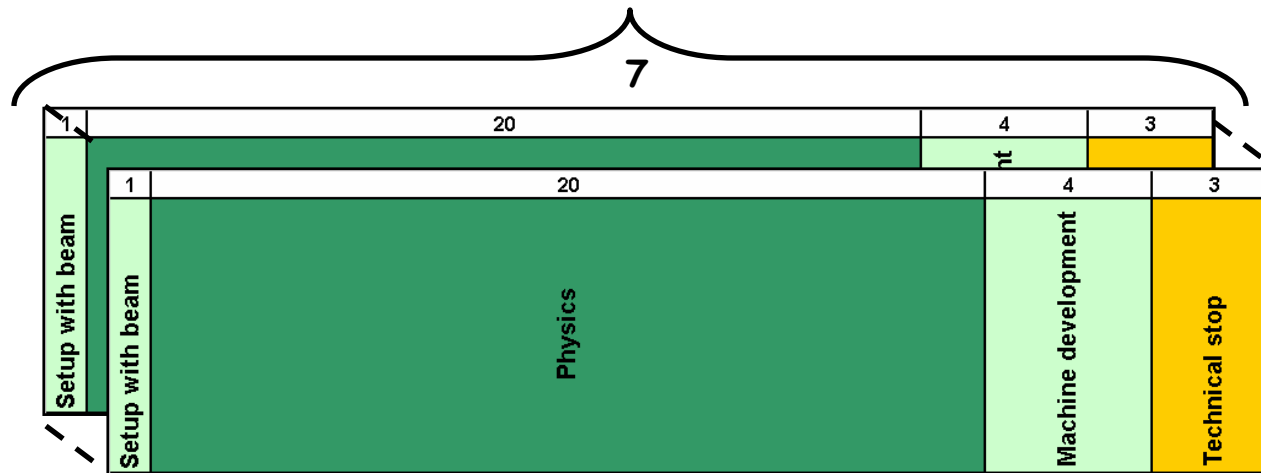


# Breakdown of a normal year



R. Bailey  
AB LHC Operations

January	February	March	April	May	June	July	August	September	October	November	December	
Shutdown		Machine checkout	Setup with beam	Operation						Scrubbing	Shutdown	



~ 140 days for physics per year  
 Not forgetting Heavy Ion and TOTEM operation  
 Leaves ~ 100 days for proton luminosity running  
 ? Efficiency for physics 40% ?  
 ~ 40 days ~ 1000 h ~  $4 \cdot 10^6$  s of colliding beams / year



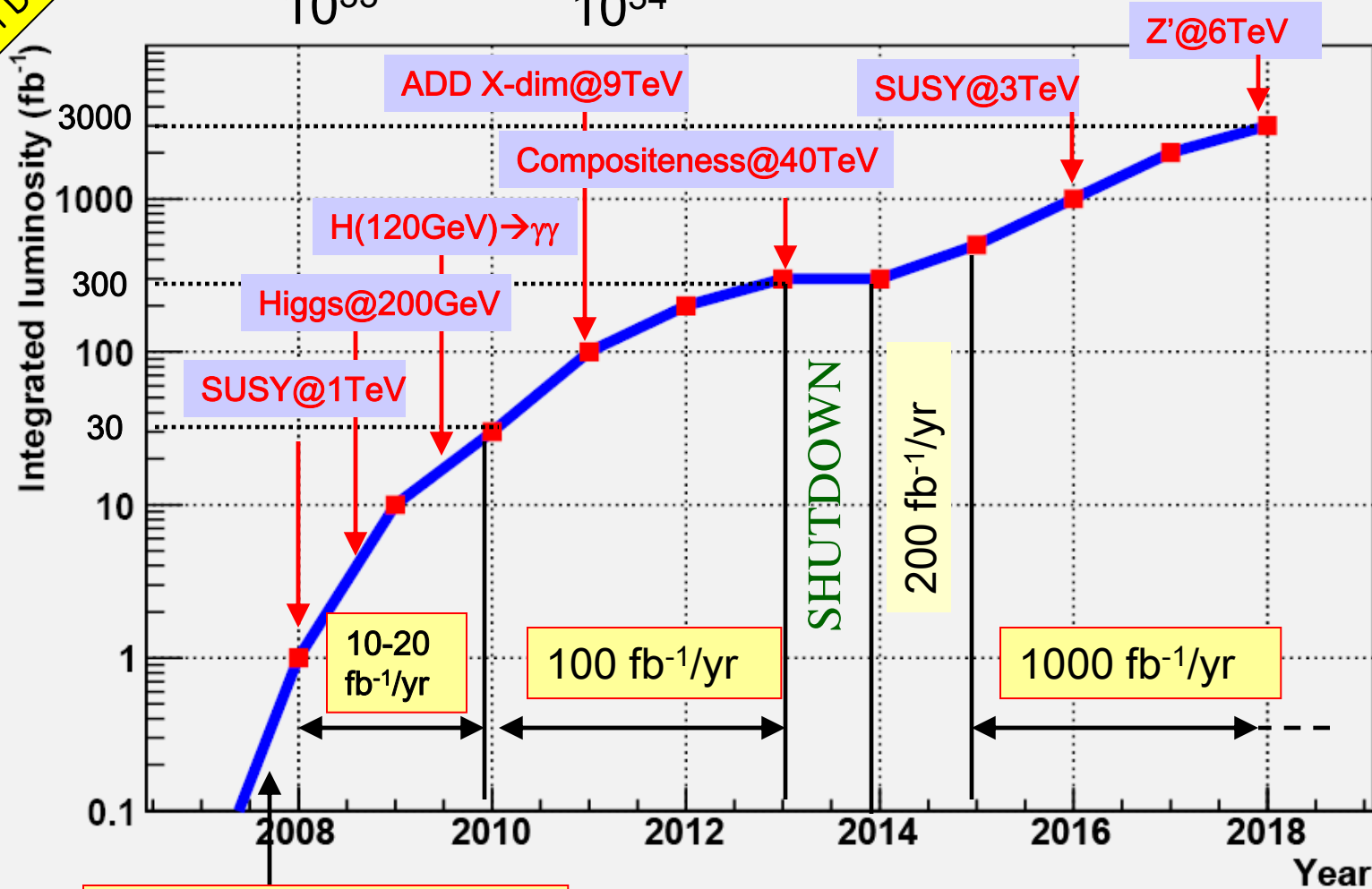
# LHC Luminosity Profile

Michel Della Negra

$L = 10^{33}$

$L = 10^{34}$

SLHC:  $L = 10^{35}$



First physics run:  $O(1\text{fb}^{-1})$





# Running Periods and Samples

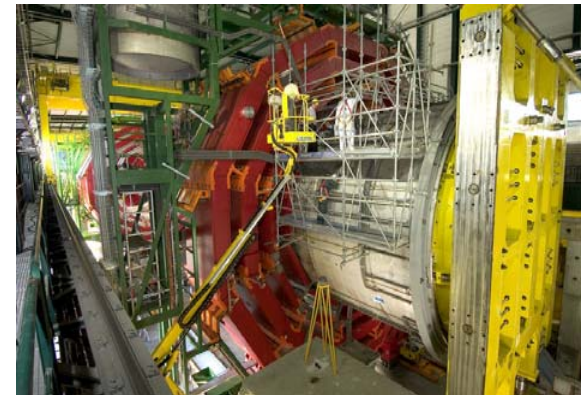


(My biased interpretation...most likely wrong!)

- Pilot Run (late 2007)
  - Luminosity  $\sim 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$
  - Integrated luminosity  $\sim 400 \text{ pb}^{-1}$
- 1<sup>st</sup> Physics Run (2008 )
  - Luminosity  $\sim 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$
  - Integrated luminosity  $\sim 2 \text{ fb}^{-1}$
- "Low Luminosity" running (2008-2009 )
  - Luminosity  $\sim 2 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$
  - Integrated luminosity  $\sim 10 \text{ fb}^{-1}$
- "High Luminosity" running (2010 )
  - Luminosity  $\sim 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$
  - Integrated luminosity  $\sim 50 \text{ fb}^{-1}$



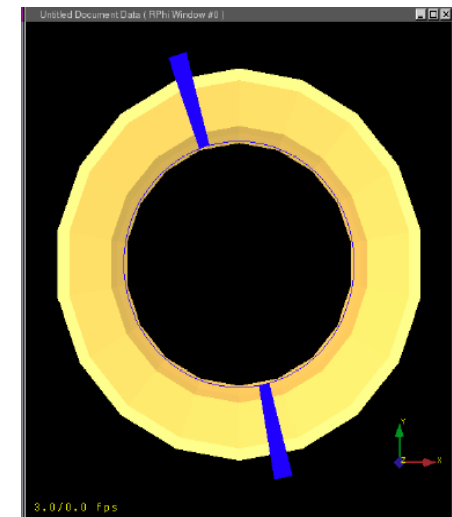
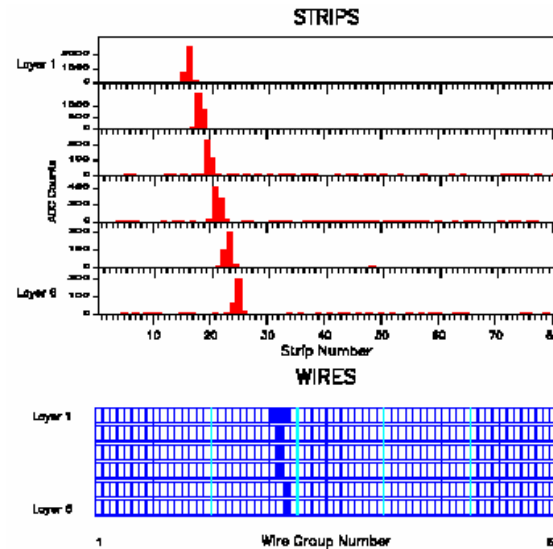
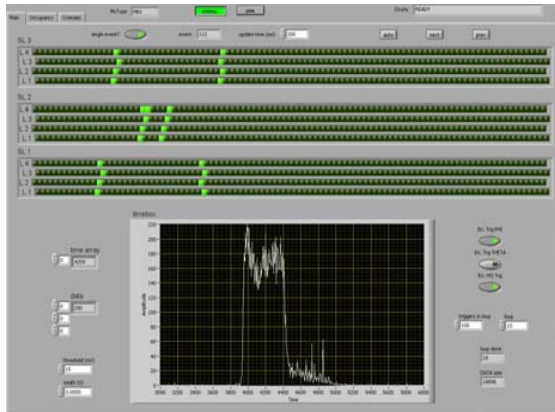
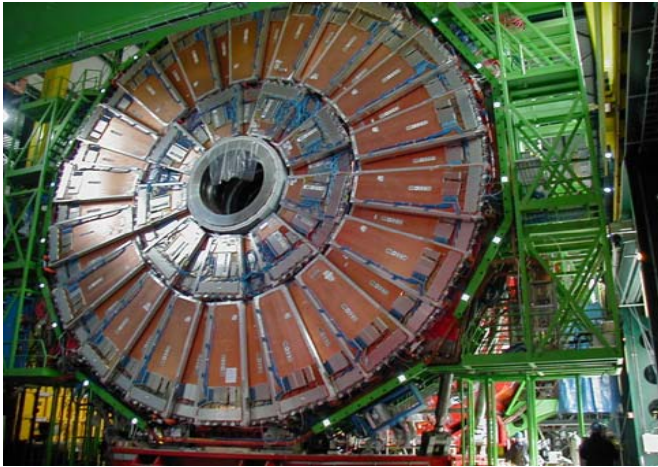
# Coil Swiveling and Insertion



<http://photo.cern.ch/testusers/index.php?dir=Bobine%20CMS>

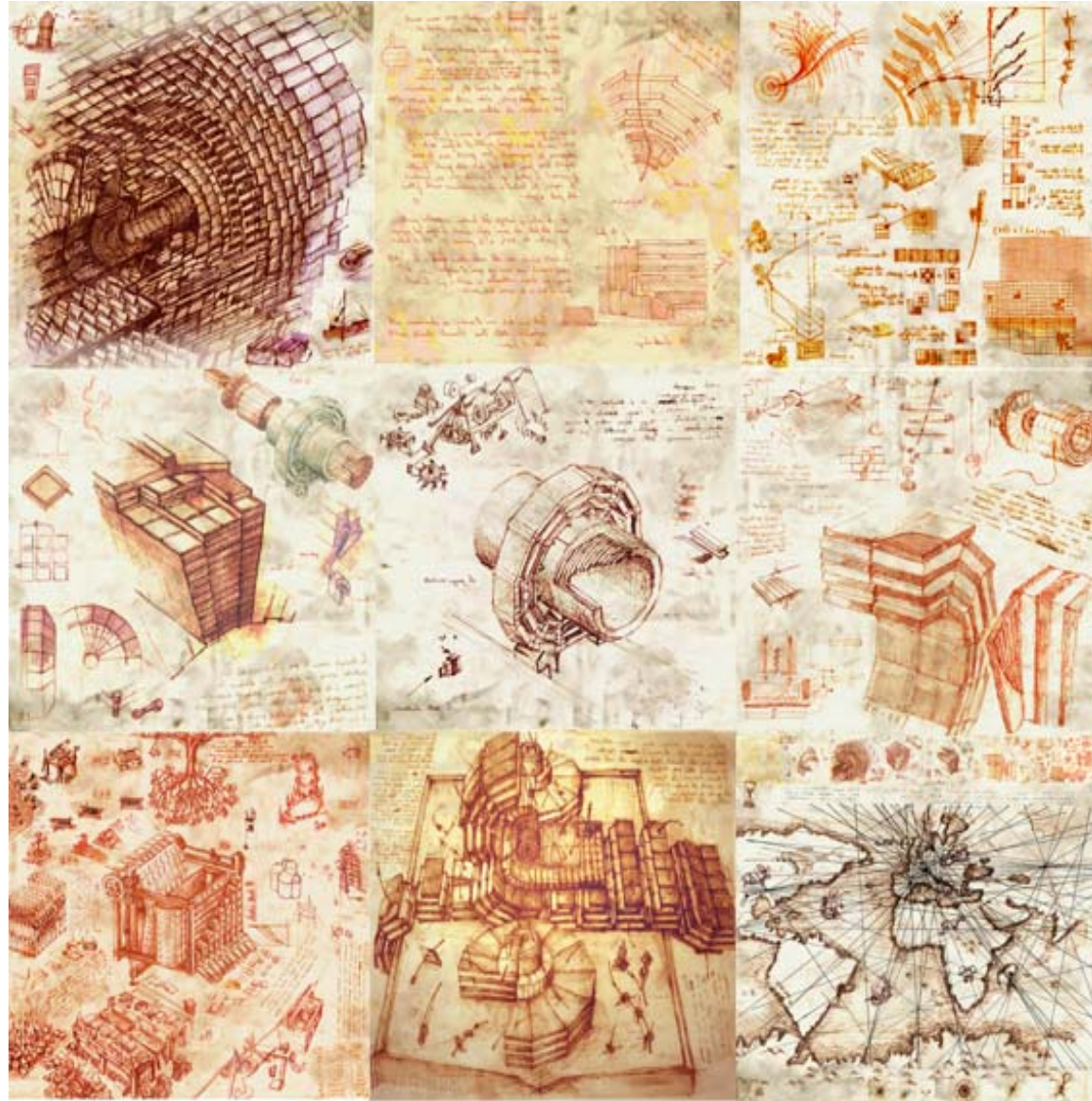


# Commissioning with Cosmics





# Cavern Murals: TDR front pages?

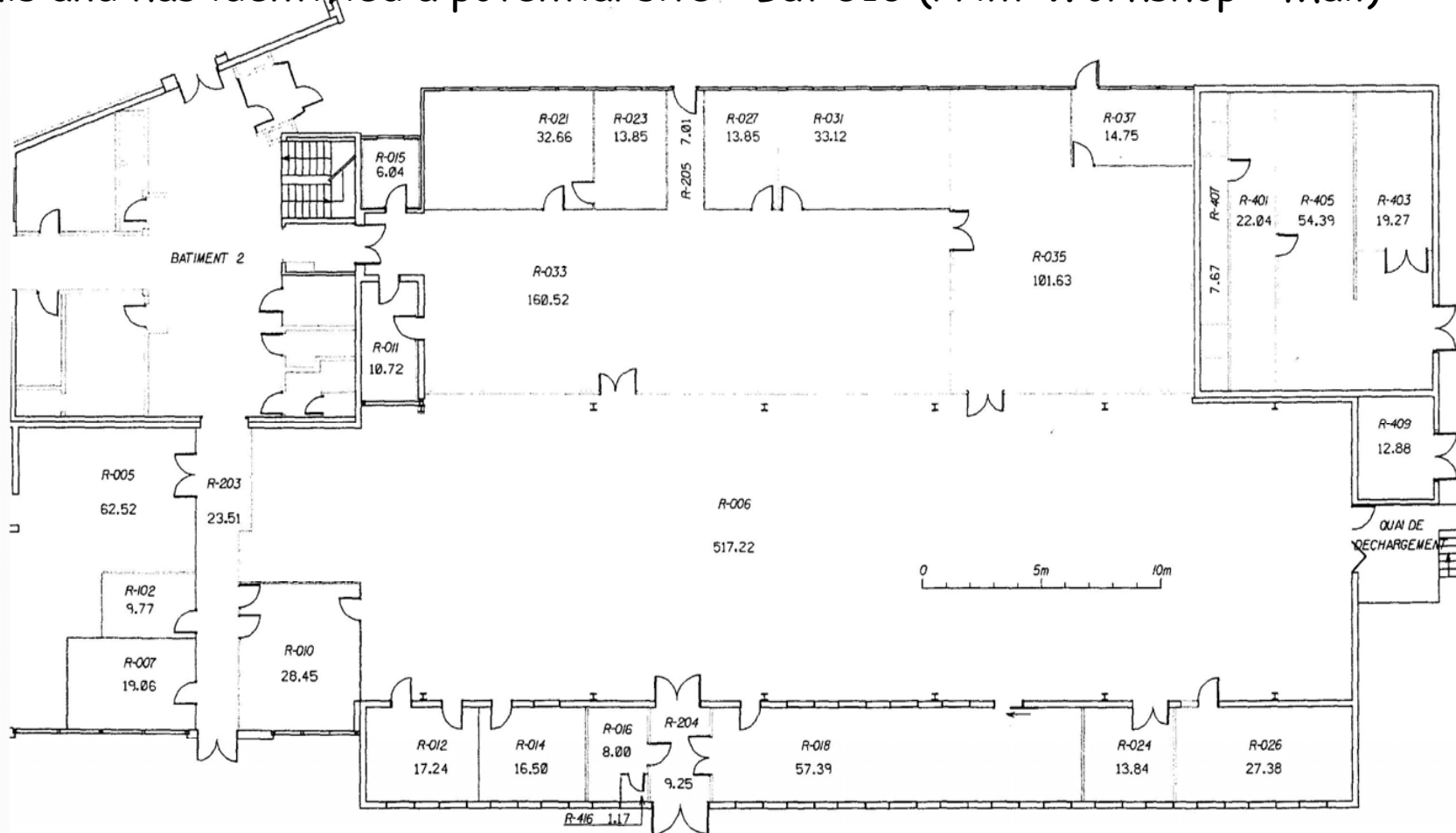




# CMS Control and Analysis Room (CCAR)



Discussions have taken place with CERN Management to create a CMS Control and Analysis Room (CCAR) on the CERN Meyrin site. H. Hoffman is following this and has identified a potential site - Bat 510 (Print Workshop + Mail)





# CMS is Already Doing a Lot



- On Hardware, Software, Triggers, ...
- Tremendous progress & accomplishments, some difficulties and/or delays - **IP5 looks impressive !!**
- Many of our USCMS colleagues are extremely busy these days with hardware, triggers and software and have little (or no) time to think about Physics analysis
- It's our job at the LPC to:
  - help CMS. The LPC is already playing a key role in a few areas; will do even more in the future
  - create an environment in which everyone can get help and support whenever (s)he is ready for Physics
- Well, what is the LHC Physics Center (LPC)?





# What is the LHC Physics Center?



Located on the 11<sup>th</sup> 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

- A **critical mass** (clustering) of young people who are actively working on software (reconstruction, particle identification, physics analysis) in a **single** location (11<sup>th</sup> 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
- ...and basically **TEV4LHC** (Tevatron experience/presence → LHC success)



# LPC's Past Year Highlights



## Seven strong working groups!

- 11th floor layout planned and constructed, Web presence, Remote Operations Center work started
- Weekly All USCMS meeting on Fridays
- 4 well-attended sessions of CMS 101, 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, and a 2-week mini summer school
- Theory/experiment brown bag lunch series, French lessons
- Rumors: we are well-liked by funding agencies





# Resources: 11<sup>th</sup> Floor (WH11)



- Meeting Rooms/Video Conferencing/Internet
- Terminals/printers/office supplies
- Secretarial and computer support
- Coffee machines/Water cooler



○ Meeting rooms



Remote operations center

Room for 60 transients from Universities plus 60 permanent residents

Transient space



Of the 60 permanent slots, 25% are University physicists

Expecting ~20 University-employed postdocs on the 11<sup>th</sup> floor full time by S06



# Web Information



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

Navigation menu items:

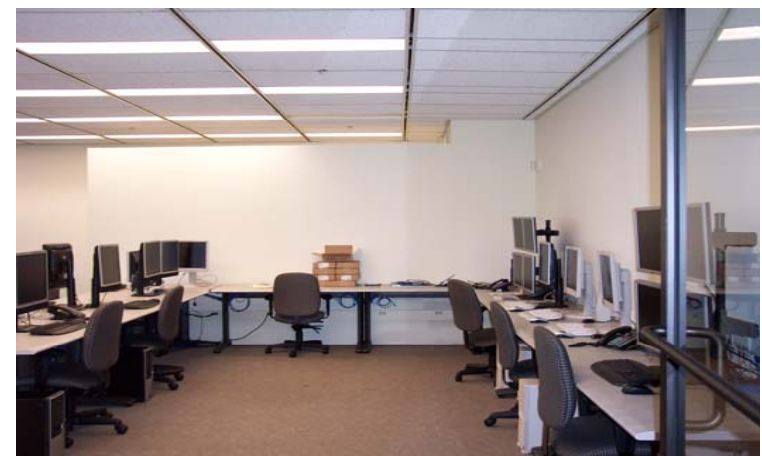
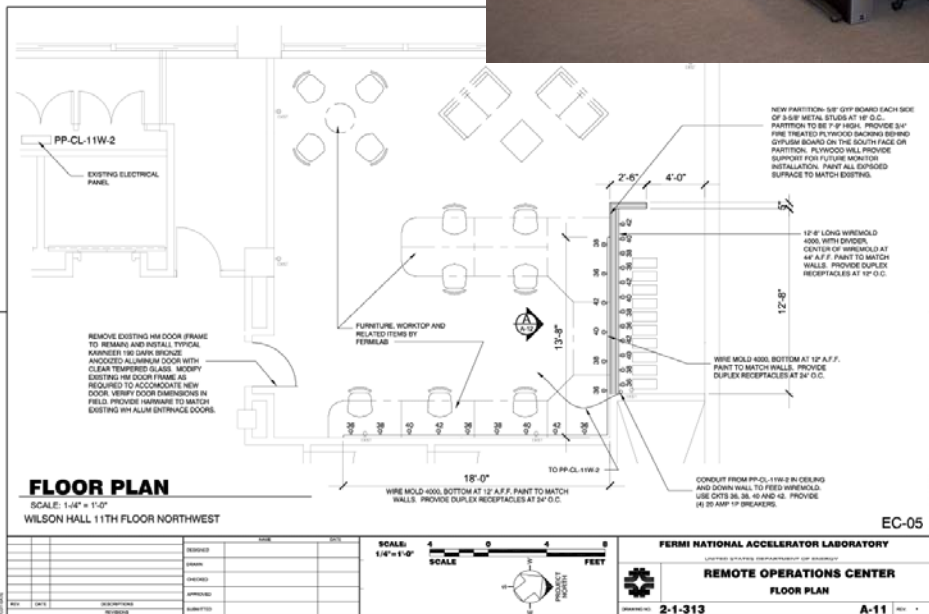
- [Working Groups](#) (and project suggestions)
- [mailing list](#)
- [Agenda Server](#)
- [meeting room information and schedules](#)
- [All US CMS Meetings \(Friday Meeting\)](#)
- [Computing at the LPC](#)
- [LPC Document Database](#)
- [Remote Control Room](#)
- [Workshops](#)
- [new to the LPC?](#)
- [Theory Connection](#)
- [various logos for your talks](#)
- [LPC History & Documents](#)
- [Advisory council](#)
- [Roommate Connection](#)
- [US CMS Jobs](#)
- [Other Useful Links](#)



# Remote Operations Center ROC - LHC@FNAL



Will be used for cosmic slice test and 2006 test beams





# Slice Test - LPC Goals

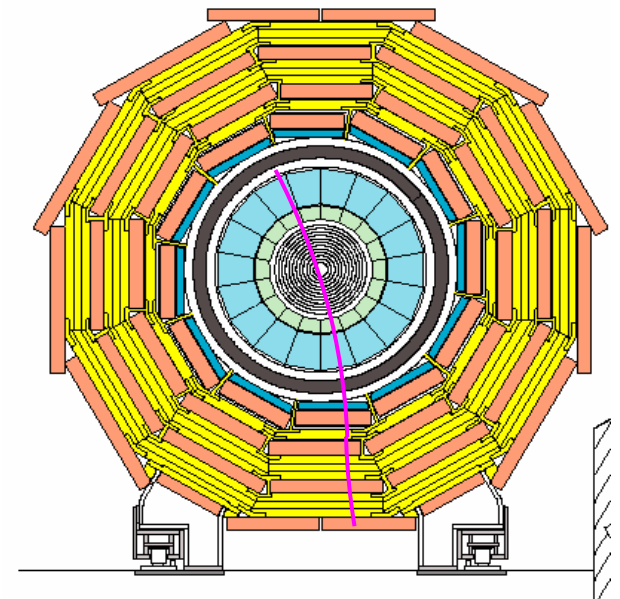


(slide taken from the workshop on 9/9/05)

- Data access
  - Being able to analyze the data efficiently is of a paramount importance: bring the data to LPC!
- Remote Operation Center: infrastructure for
  - Data taking monitoring (feedback to CERN)
  - Data transfer monitoring
- Data analysis
  - Setup the infrastructure for the data analysis at LPC
  - Reconstruction software, development and optimization of algorithms, calibration etc

Extremely Important  
for CMS and LPC

Cosmic Muon Challenge





# Foundation: 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
- Working closely with international CMS groups
- Have been greeted with enthusiasm by international CMS and, by concentrating our efforts this way, have already been able to make substantial contributions to the CMS Collaboration



# LPC Working Groups



There are 7 Working Groups at the LPC

- Simulation
- Trigger
- $e$ - $\gamma$  ID
- $\mu$  ID
- Jet/MET ID
- Tracking
- Offline/EDM

Due to time constraints, in the next several transparencies  
I'll mention briefly activities in just a few of them

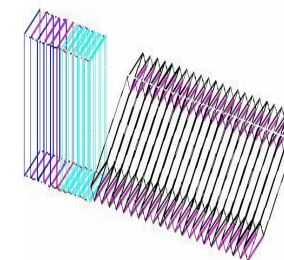
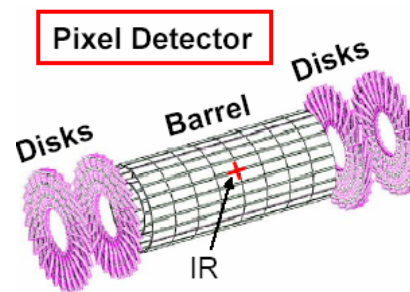
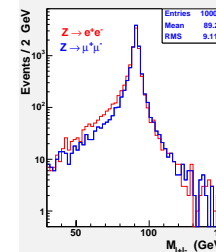
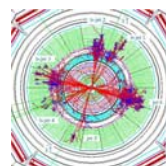


# LPC Simulation Group



## Current Main Activities:

- Simulation Validation Suite
- Forward Pixels Geometry Implementation in CMS' detector simulation program (OSCAR)
- Implementation of the Luminosity Monitoring System in OSCAR
- Implementation of the Zero Degree Calorimeter (ZDC) in OSCAR
- EM Calorimeter (ECAL) Crystal Response Studies
- Detailed Instructions for the Generation and Analysis of Monte Carlo data at all levels: MC truth, SimHits, Digis



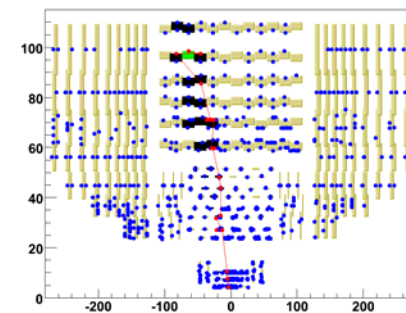
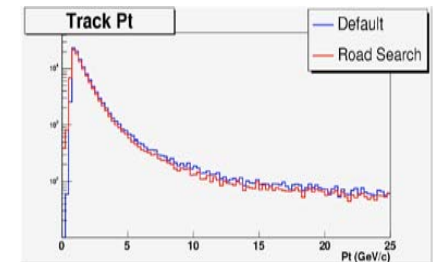
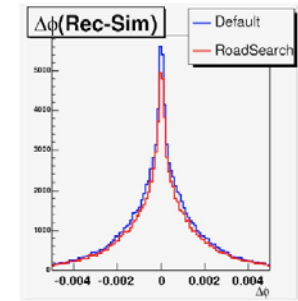


# LPC Tracking Group



## Current Main Activities:

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





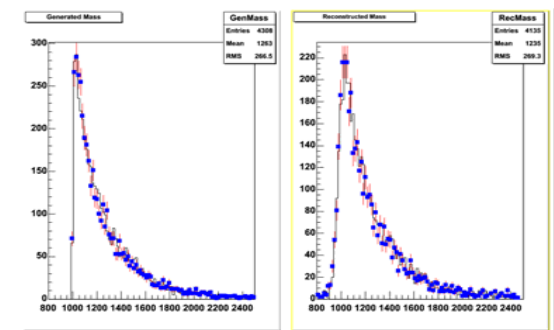
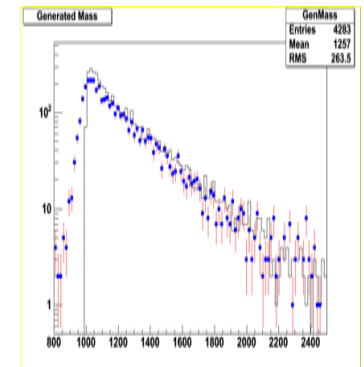


# LPC Muon Group



## Main 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, e.g.
  - Muon Alignment
  - Reconstruction of TeV  $\mu$ 's





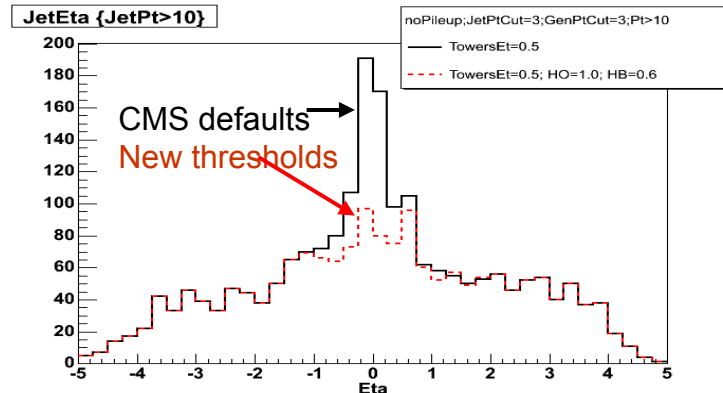
# LPC Jet/MET Group



JET

MET

- LPC JetMET provided the pioneer example of reconstruction in CMSSW framework
- LPC JetMET supports and develops the Jets package
- Implemented algorithms: IterativeCone, MidPoint, KT
- Results consistent with ORCA



- MET package design and implementation
  - Principle: Keep as simple & efficient as possible
  - Coherent design with Jet package in CMSSW
  - Provides detailed record of any applied corrections to MET
  - Early results from converted ORCA data → consistent with ORCA
- Common JetMET Correction Package design
  - Separates out high-level (jets) versus low-level (towers) corrections
  - Enables "light" (reco) as well as "heavy" (analysis) JetMET Data Products
  - Allows for consistent corrections to Jets & MET
- Beam-halo background studies in MET
  - Timing, energy pattern recognition
  - Working to simulate Beam Halo + low-lumi PU
  - Study effect on trigger rates & physics dists



# Motherhood

We (CMS, LPC) have to be ready for physics analysis when first data is collected

- What's data? First collisions? Calibration? Alignment?
- What's physics analysis? At what level?
- Do we care about details, e.g. JES at the beginning?
- Which analyses should definitely be ready on day 1?
- ...and some organizational/scheduling questions
  - admin - how do we (=USCMS) organize ourselves? Who's doing what? When? How?
  - technical - old vs new EDM/FW? MC data availability?

We should not sacrifice the long-term health of the program!



# Path @LPC

Move forward in small steps and re-evaluate where we are on a regular basis

- Everything we do will be transparent to International CMS
- Since it has never been done before (LPC, not physics!) we are stepping onto uncharted territory
- We have some ideas, but they are based on experiences in different environments
- We will all have to work closely together
- Many things have to work well for us to succeed
- ...





# Goals of Physics Workshop



Feedback is not only welcome - it is essential

- Get to know (**communication is the name of the game!**)
  - each other
  - who is doing what wrt Physics analysis
  - what level of support already exists at the LPC (computing, software, algorithms, environment,...)
- Find out where one can fit in
- Join one (or more) of the working groups
- Allow newcomers to learn from the experience of those already active in *CMS* analysis
- Help in shaping up our future - feedback, input
- Begin to enjoy the road to the "promised land"...





# Agenda



Keep it light - enough time for discussion and for (one-on-one) communication

Current Physics Analyses (mainly for TDR)

LPC Activities (past, present, and future)

The future/Our future

Physics Workshop		Last update: Wednesday 05 October 2005
Friday 07 October 2005 09:00-09:30	Introduction	
Friday 07 October 2005 09:30-10:30	Current USCMS Analyses	Roger Rusack (Minnesota)
Friday 07 October 2005 11:00-12:00	Current USCMS Analyses	Joe Incandela (UCSB)
Friday 07 October 2005 13:00-14:30	LPC Activities	Avi Yagil (FNAL)
Friday 07 October 2005 14:30-15:30	What's Next	

Friday 07 October 2005

Introduction (2005-10-07 09:00-09:30)	
09:00	Welcome (20') <span style="float: right;">Boaz Klima</span>
Current USCMS Analyses (2005-10-07 09:30-10:30) <span style="float: right;">Chairperson: Roger Rusack (Minnesota)</span>	
09:30	Analyses by UC Davis and Rochester (20') <span style="float: right;">Maxwell Chertok (UC Davis)</span>
10:00	Analyses by Caltech and UCSD (20') <span style="float: right;">Vladimir Litvin (Caltech)</span>
10:40	Coffee Break (10:40 - 11:00)
Current USCMS Analyses (2005-10-07 11:00-12:00) <span style="float: right;">Chairperson: Joe Incandela (UCSB)</span>	
11:00	Analyses by Texas Tech, Iowa, and FNAL (20') <span style="float: right;">Shuichi Kunori (Maryland)</span>
11:30	Analyses by Florida, FSU and UCLA (20') <span style="float: right;">Darin Acosta (Florida)</span>
12:00	Lunch Break (12:00 - 1:00)
LPC Activities (2005-10-07 13:00-14:30) <span style="float: right;">Chairperson: Avi Yagil (FNAL)</span>	
13:00	Simulations (10') <span style="float: right;">Daniel Elvira (Fermilab)</span>
13:15	Triggers (10') <span style="float: right;">Greg Landsberg (Brown)</span>
13:30	Particle ID (20') <span style="float: right;">Kevin Burkett (Fermilab)</span>
14:00	Computing at the LPC (10') <span style="float: right;">Ian Fisk (Fermilab)</span>
14:15	Newcomer's Experience (10') <span style="float: right;">Cecilia Gerber (UIC)</span>
What's Next (2005-10-07 14:30-15:30)	
14:30	Where do we go from here (15') <span style="float: right;">Boaz Klima</span>
14:45	Discussion (45') <span style="float: right;">All</span>



# My Observations

See presentations at <http://agenda.cern.ch/fullAgenda.php?ida=a055599>

- We have a professionally diverse group of people, wide spectrum of interests and knowledge of CMS
- In fact, we have two (well-separated?) communities
  - Those already doing physics analysis (with whatever is currently available), mainly for the TDR
  - Those yet to start doing any kind of physics analysis on CMS (currently in hardware or software, or newcomers)
- Everybody needs a forum to discuss their efforts: progress, results, problems, dilemmas, feedback etc
  - A place for detailed, informal conversations on physics**
- There is already a level of expertise & experience at the LPC capable of beginning to support these efforts (needs strengthening!)



# Initial Ideas

Feedback is not only welcome - it is essential

- We have to be inclusive



- Provide forum for discussion to ongoing analyses

*Senior/experienced people should help here*



- Create a new analysis effort to do a full blown (generic) analysis (with whatever exists) - started looking at events with complex signature (a few physics objects), namely at  $t\bar{t} \rightarrow e+m+E_T+jets$  (case study, not for TDR!)

*We'll learn together about holes, problems, difficulties*

*And we'll help in solving them for CMS*



- We all have to help in strengthening the foundation of our analysis effort - the LPC working groups

- The ID groups will take care of all object-related studies, e.g. efficiency, fake rate, resolution, trigger eff etc





# Conclusions

- The LHC machine as well as the CMS experiment are on schedule for first collisions in 2007
- The LPC has been embraced by the US CMS physics community
- The LPC has already had substantial impact on both US and international CMS
- The LPC is an essential part of US CMS' strategy for doing physics analysis