CMS Efforts at Fermilab

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Meeting with DOE Program Managers,
DOE Fermilab Site Visit August 23, 2010

Fermilab CERN U.S. DEPARTMENT OF ENERGY National Science Foundation

Instead of an Outline:
Overview of Talking Points

- CMS Performance at 7 TeV
  - highlighting some of the contributions from Fermilab scientists
- Physics Efforts of Fermilab Staff
  - discussion of how Fermilab CMS group is involved in physics
  - involvement in the LHC Physics Center
  - highlights of Fermilab contributions throughout presentation
- Support of U.S. Community
  - Computing Facilities
  - Remote Operations Center
  - LHC Physics Center
- LHC Plan for Running and Upgrades
  - CMS upgrade plans and schedules, Fermilab contributions

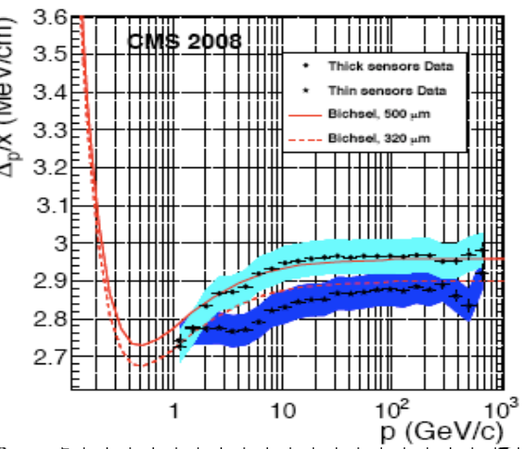
CMS, U.S. CMS, and Fermilab

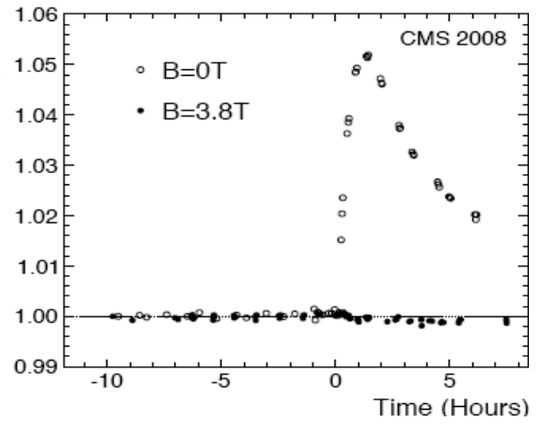
- ★ CMS Collaboration
  - ★ 38 Countries
  - ★ 183 Institutions
  - ★ 1940 Scientific Authors total
  - ★ 1283 paying M&O share (2009)

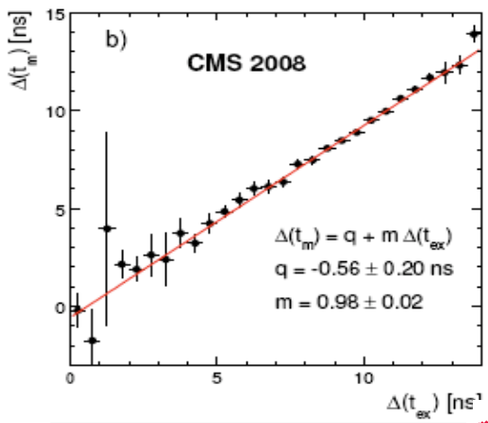
US is by far the largest national group
Fermilab is 2nd largest institutional group – second only to CERN

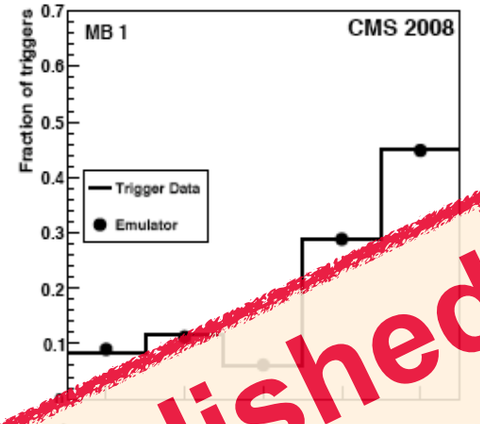
- ★ U.S. CMS (2009 numbers)
  - ★ 48 Institutions (now 49)
  - ★ 648 Scientific Authors
  - ★ 451 with Ph.D 34.5%
  - ★ 197 Graduate Students
- ★ **Fermilab CMS**
  - ★ FTE count Proton Program: 44.1 FTE in FY10, 43.0 in FY11
  - ★ ~41 Senior Scientists
  - ★ 15 Research Associates
  - ★ Fermilab staff on CMS is ~120, > 50% working full time
- ★ Host Institution for U.S. CMS
  - ★ 48 CMS FTE's supported by U.S. CMS Operations Program

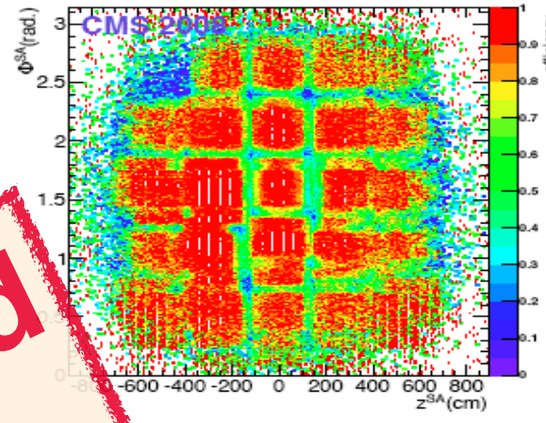
Before Collisions: Detailed Studies with >10^9 Cosmic Muons Recorded by CMS.

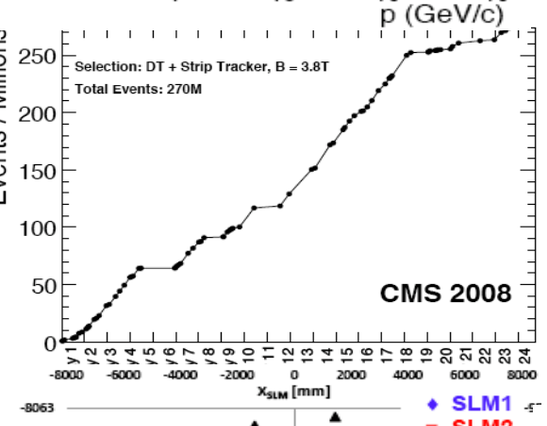


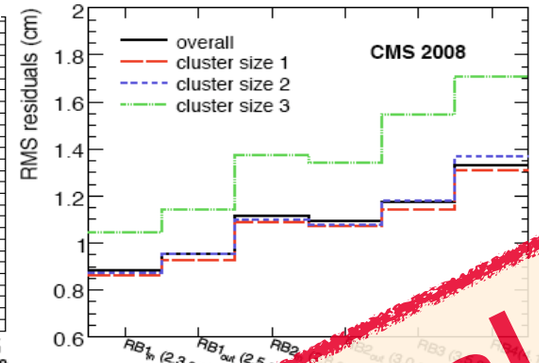


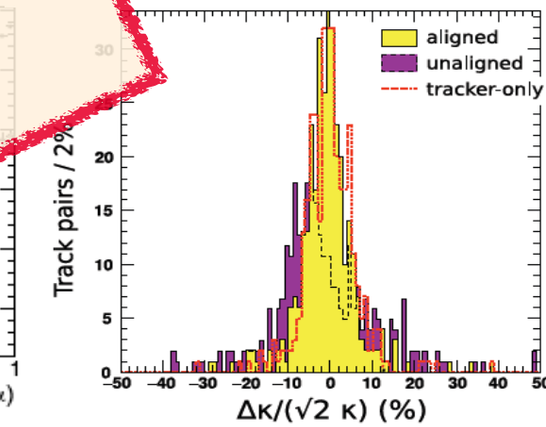


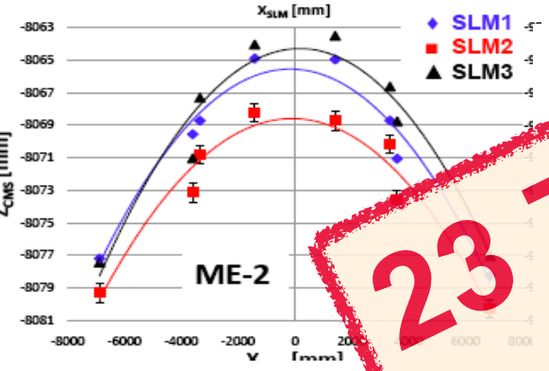


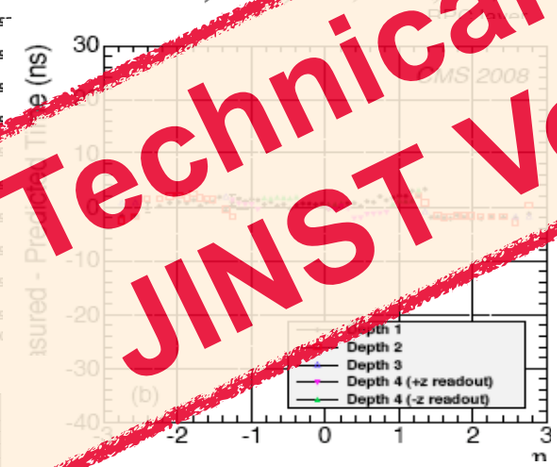


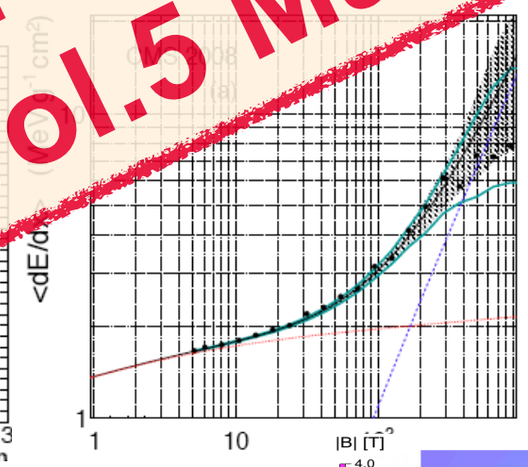


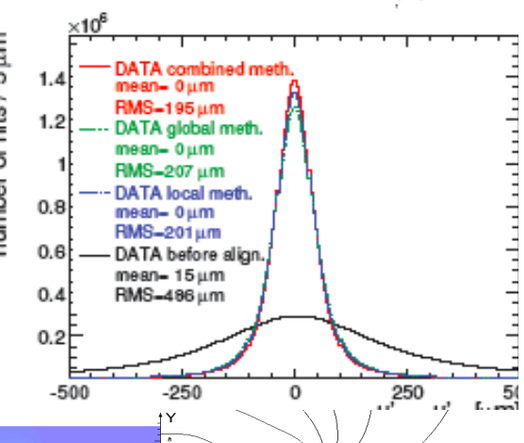


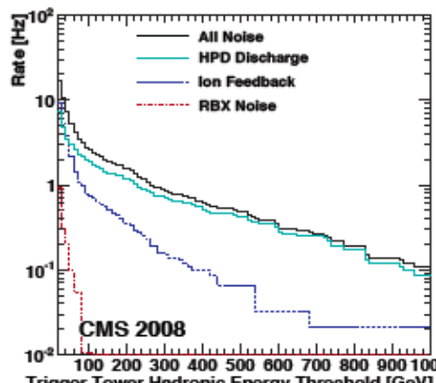


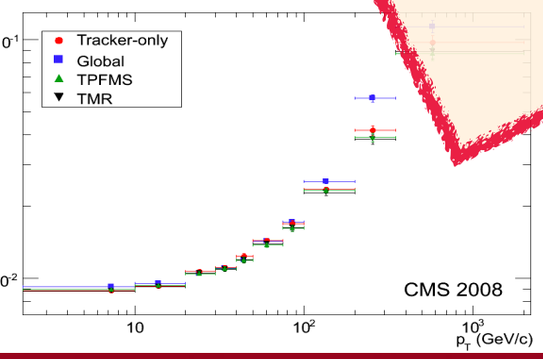


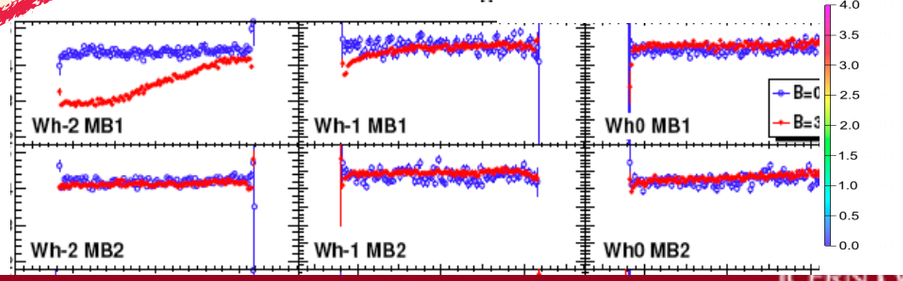


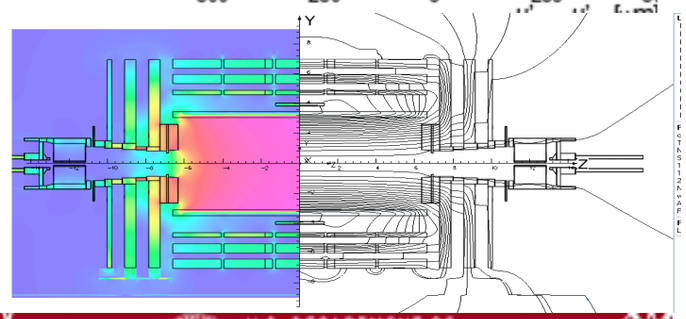


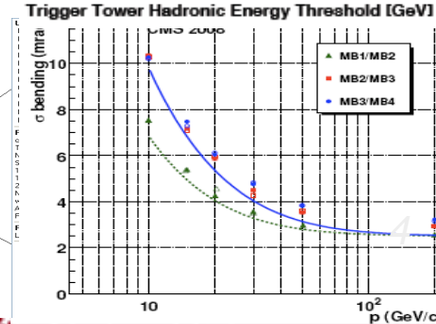










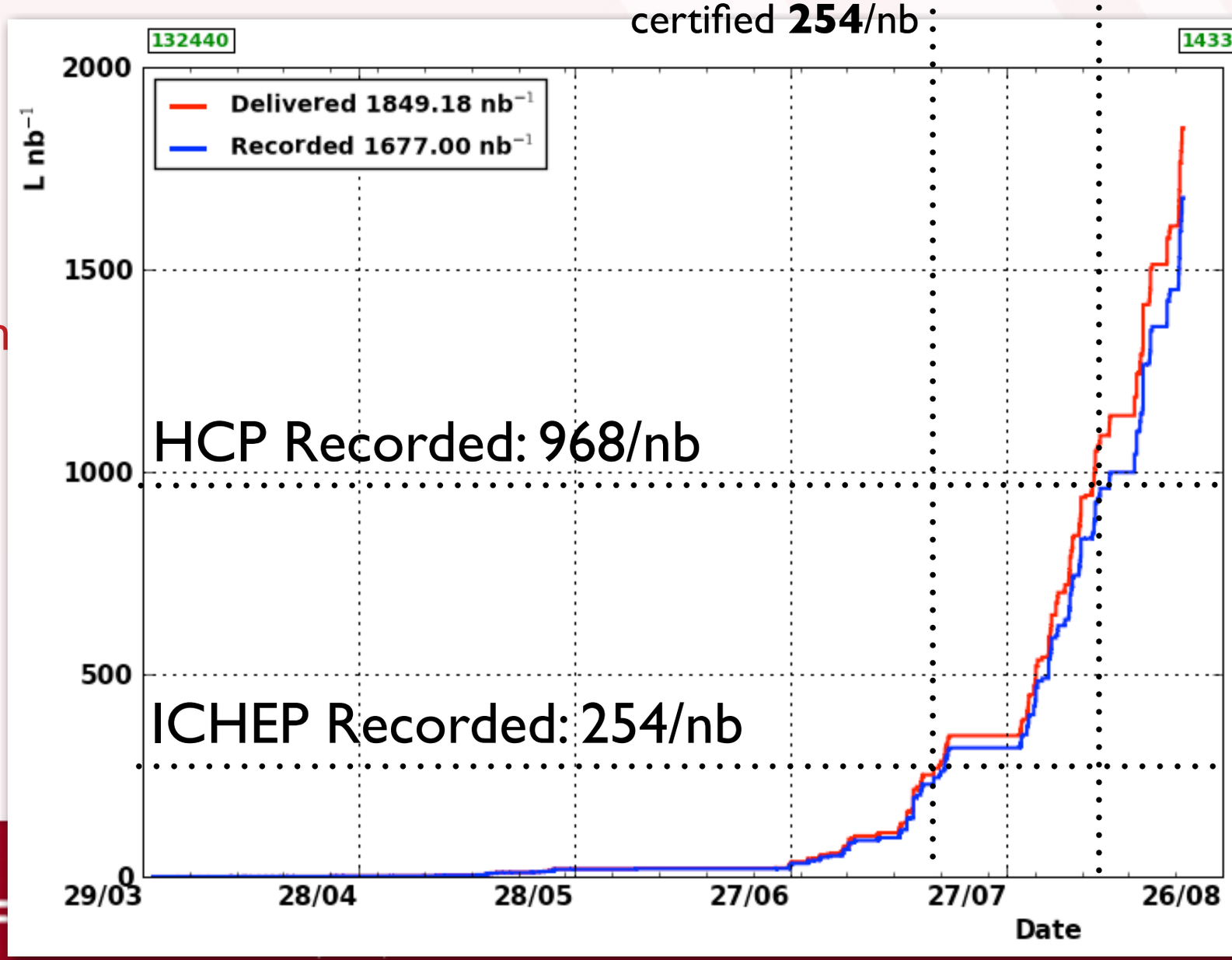


First 4.5 Months of 7 TeV Operations

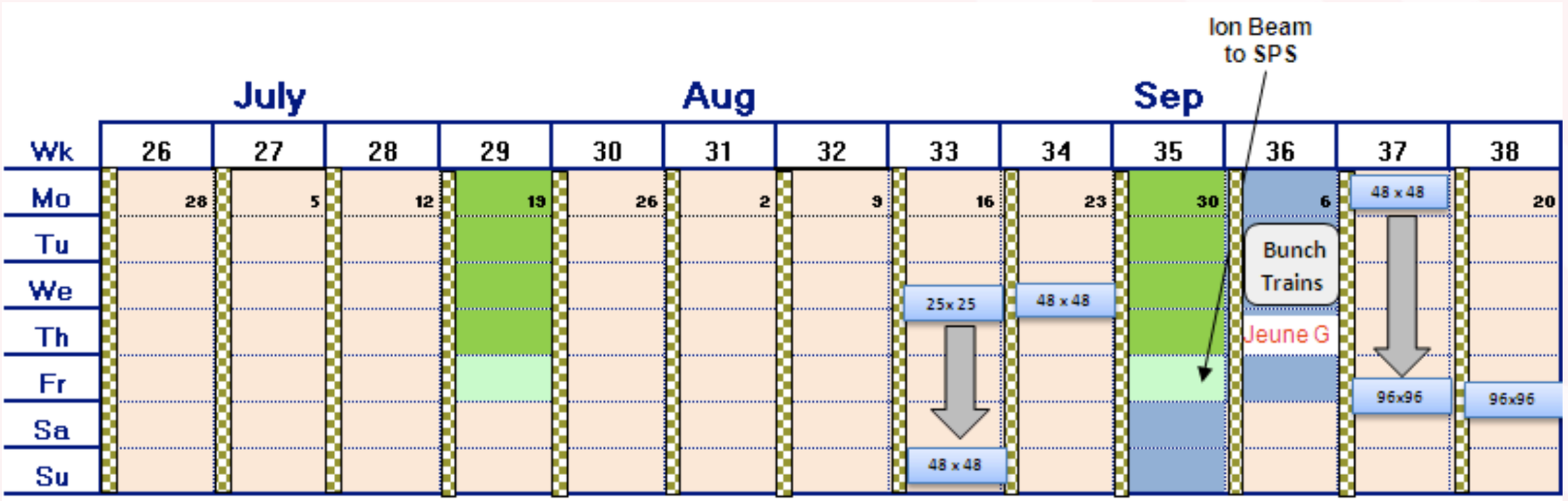
- **~1.85/pb** delivered by LHC
- **~1.68/pb** recorded by CMS
  - Overall CMS data taking efficiency **~90%**
  - Average luminosity per fill ~2E30 cm^{-2} sec^{-1}, peak 6.7E30 cm^{-2} sec^{-1}
    - 250/nb last 24h!
    - 3 ord. of mag. up from March
  - bunch configuration 48x48 (36 colliding IP1/5)
- goal: 1/fb until the end of 2011

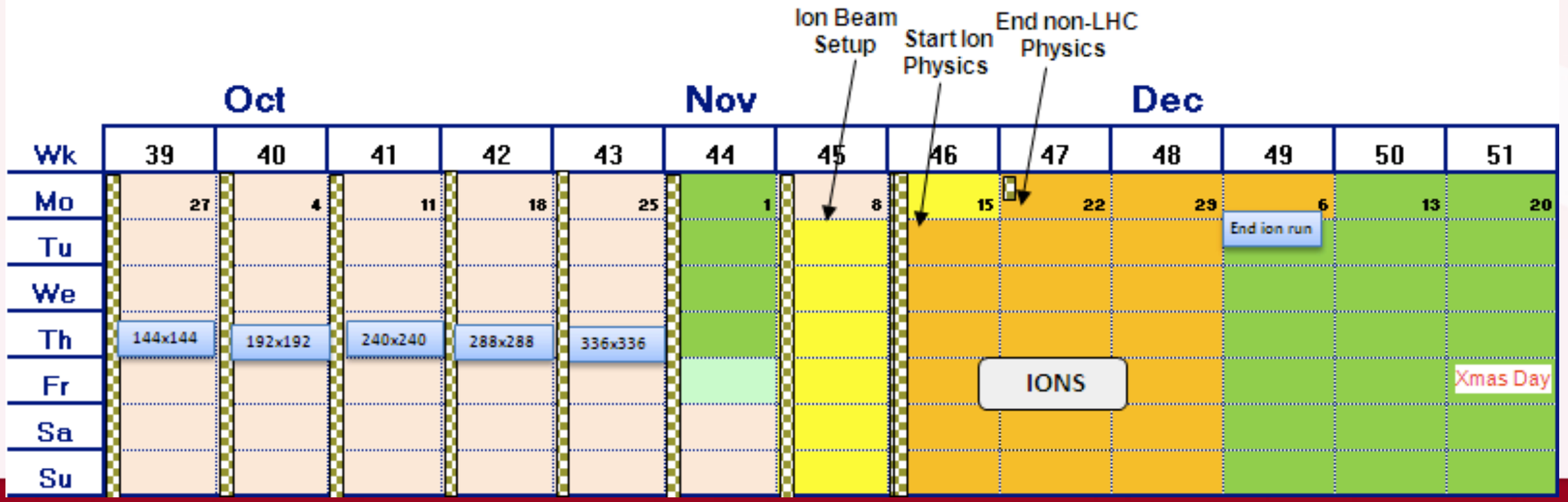
HCP: delivered 1009/nb
recorded 970/nb
certified **840**/nb

ICHEP: delivered 323/nb
recorded 305/nb
certified **254**/nb



LHC Schedule





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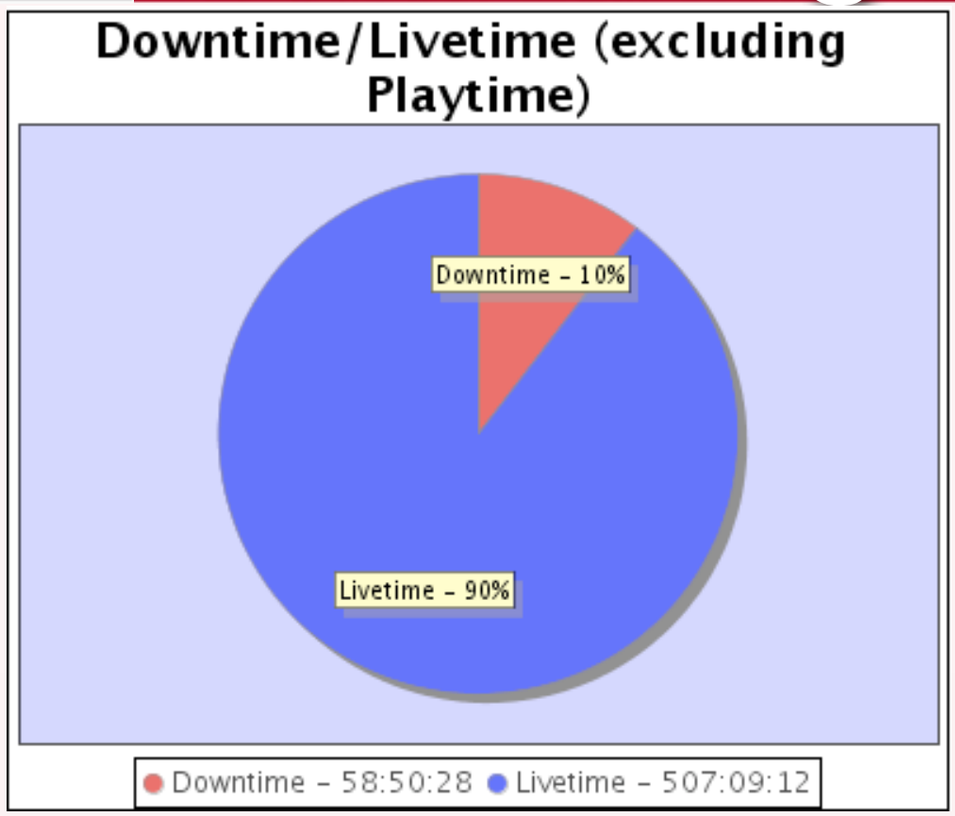
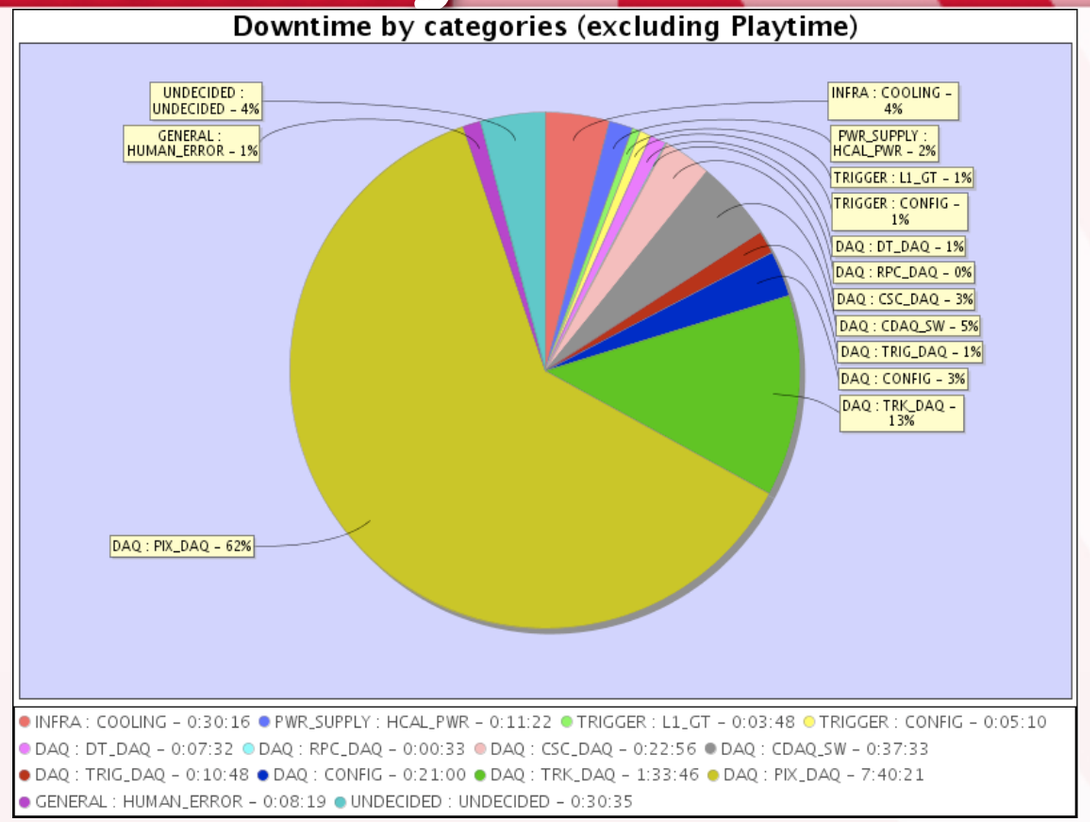
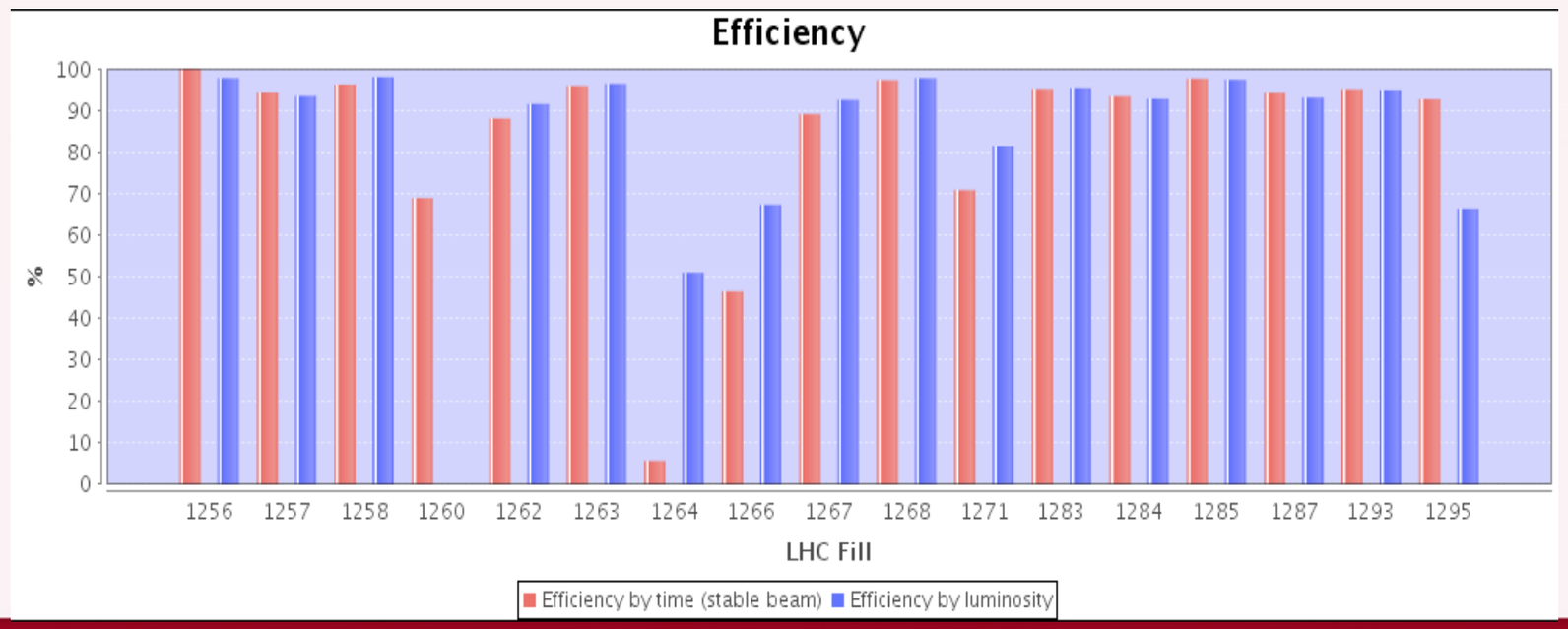
Detector Operations: Data Taking Efficiency







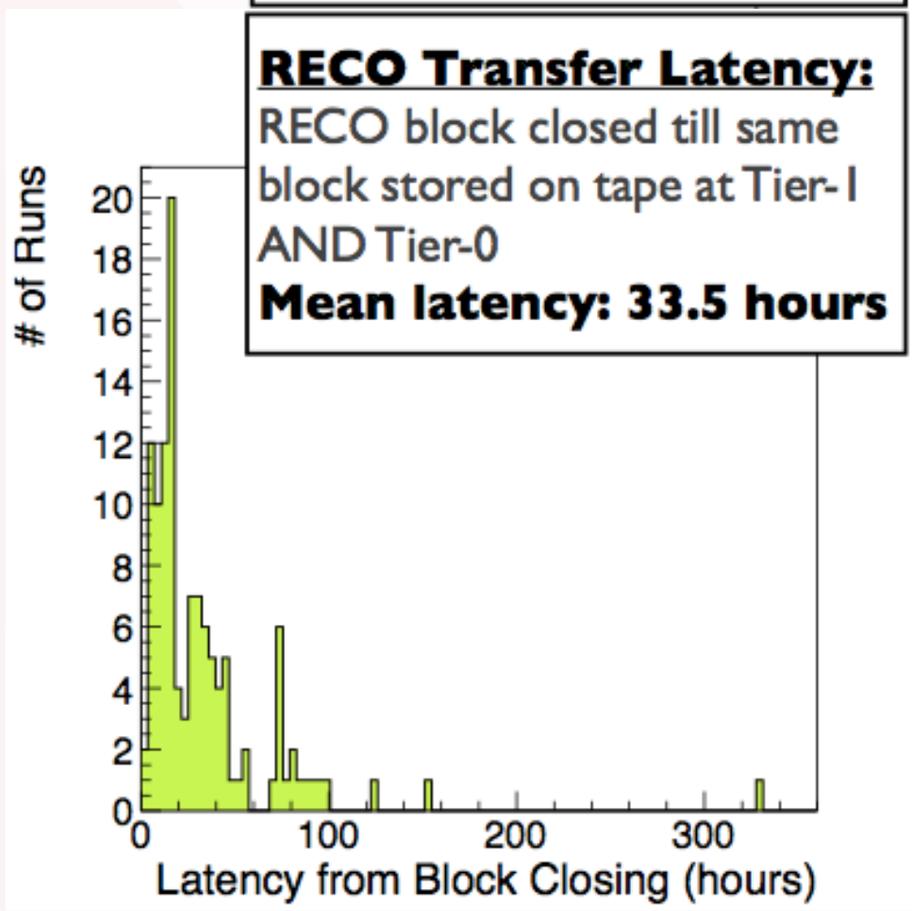
- ★ Inefficiencies include
  - Pixel sync-lost&busy
  - Trk FED OOSync
  - DT re-sync
  - Human error

Data Operations: Data Processing in Distributed System

- Data processing proceeds very smoothly
  - T0, T1 Software and Infrastructure are stable
    - improvement work still ongoing, though
- Tier-1s and Tier-2s work reliably
  - All 7 Tier-1 fully participating, Fermilab top site
  - Many re-processing cycles handled very well
- 49 Tier-2s received collision data
  - U.S. Tier-2s top sites
- Data quickly available for physics analysis at Fermilab and Tier-2s
  - statistics: after run stopped
    RECO: 38.5 hours, Skims: 40.5 hours
- Fermilab: major contributor
  - in T0, T1, Grid, Data Operations, Core Software

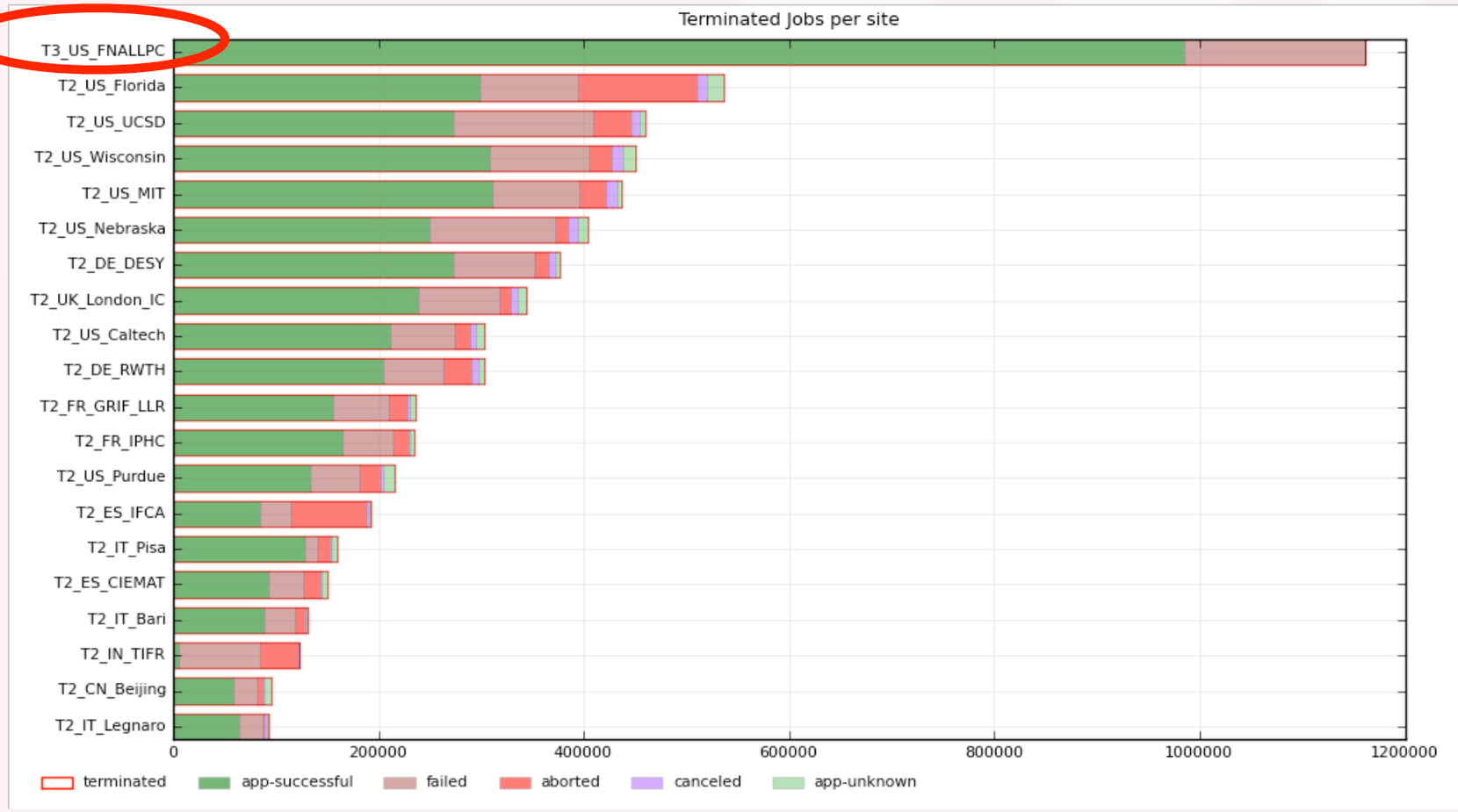
RECO Latency:
Last data of run arrives at T0 till last RECO block closed
Mean latency: 4.9 hours

RECO Transfer Latency:
RECO block closed till same block stored on tape at Tier-1 AND Tier-0
Mean latency: 33.5 hours

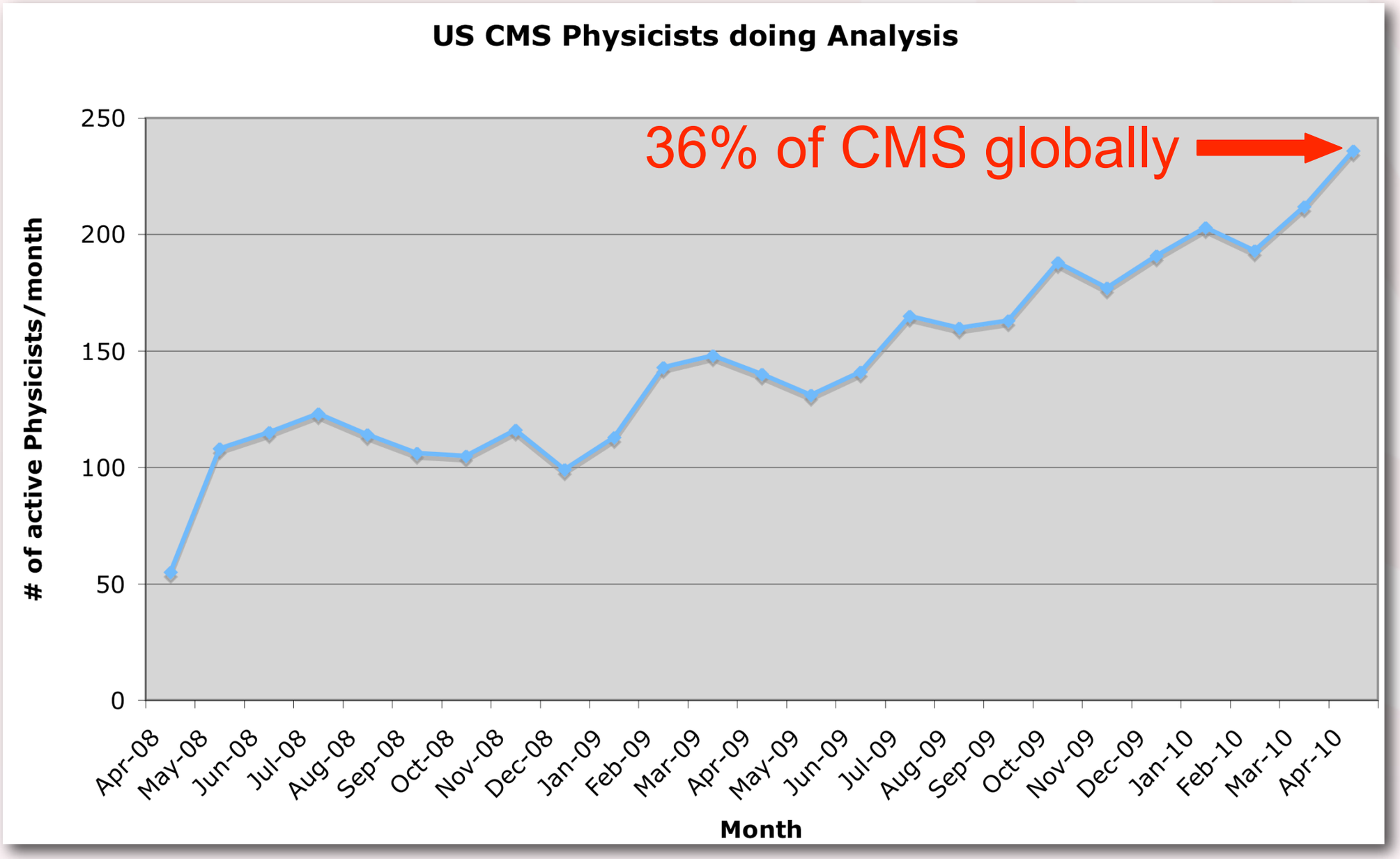


Status of CMS Analysis on the Grid

- Striking rise in the physics anal. “user base”
  - 800 individuals submitted analysis jobs in each of the last months
  - good acceptance of running analysis the “Grid way”
  - large load taken by Fermilab analysis facility and U.S. T2s
  - major Fermilab contributions to make this work, through U.S. CMS and working with U.S. Universities

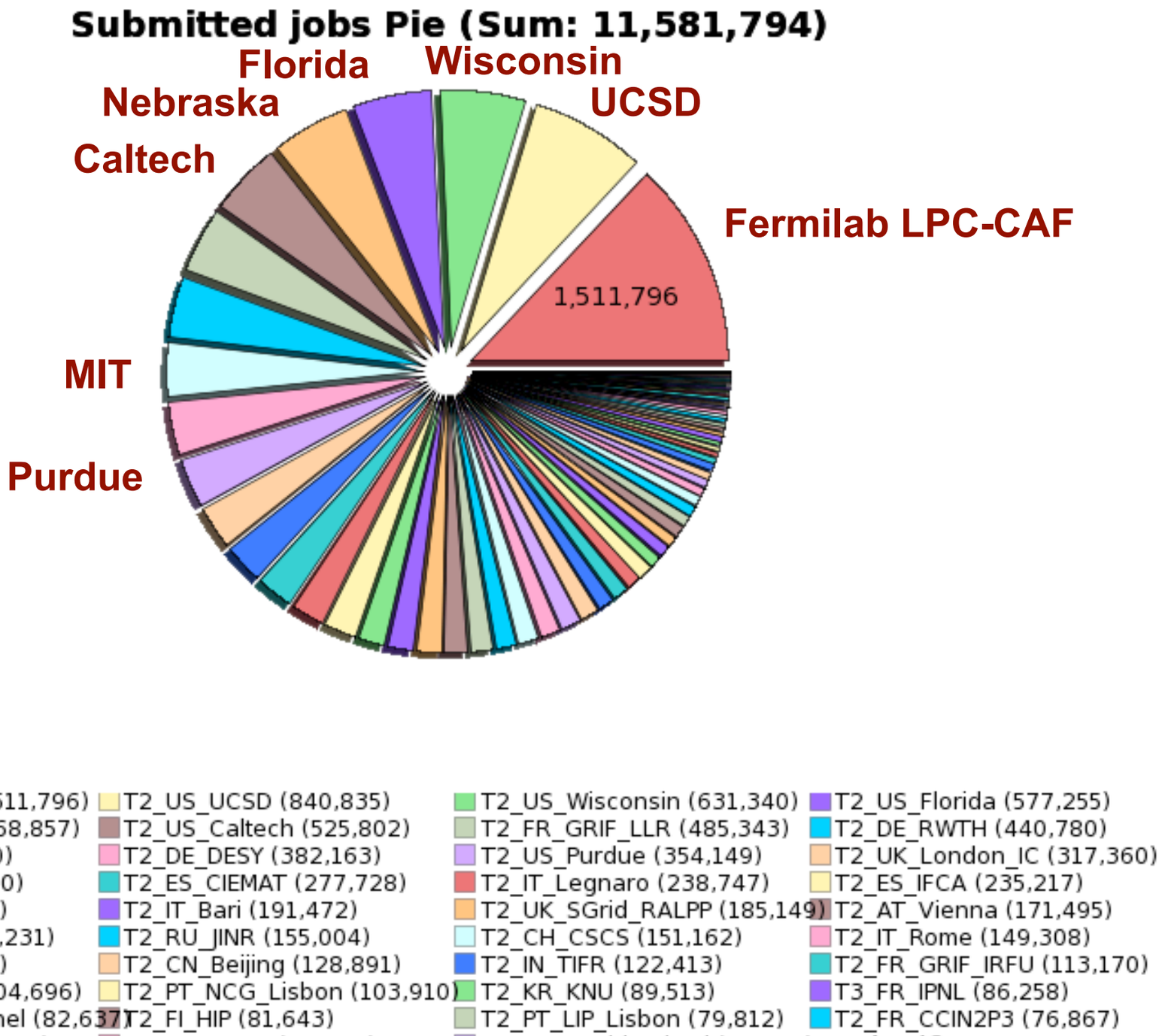


U.S. Physicists Doing Analysis

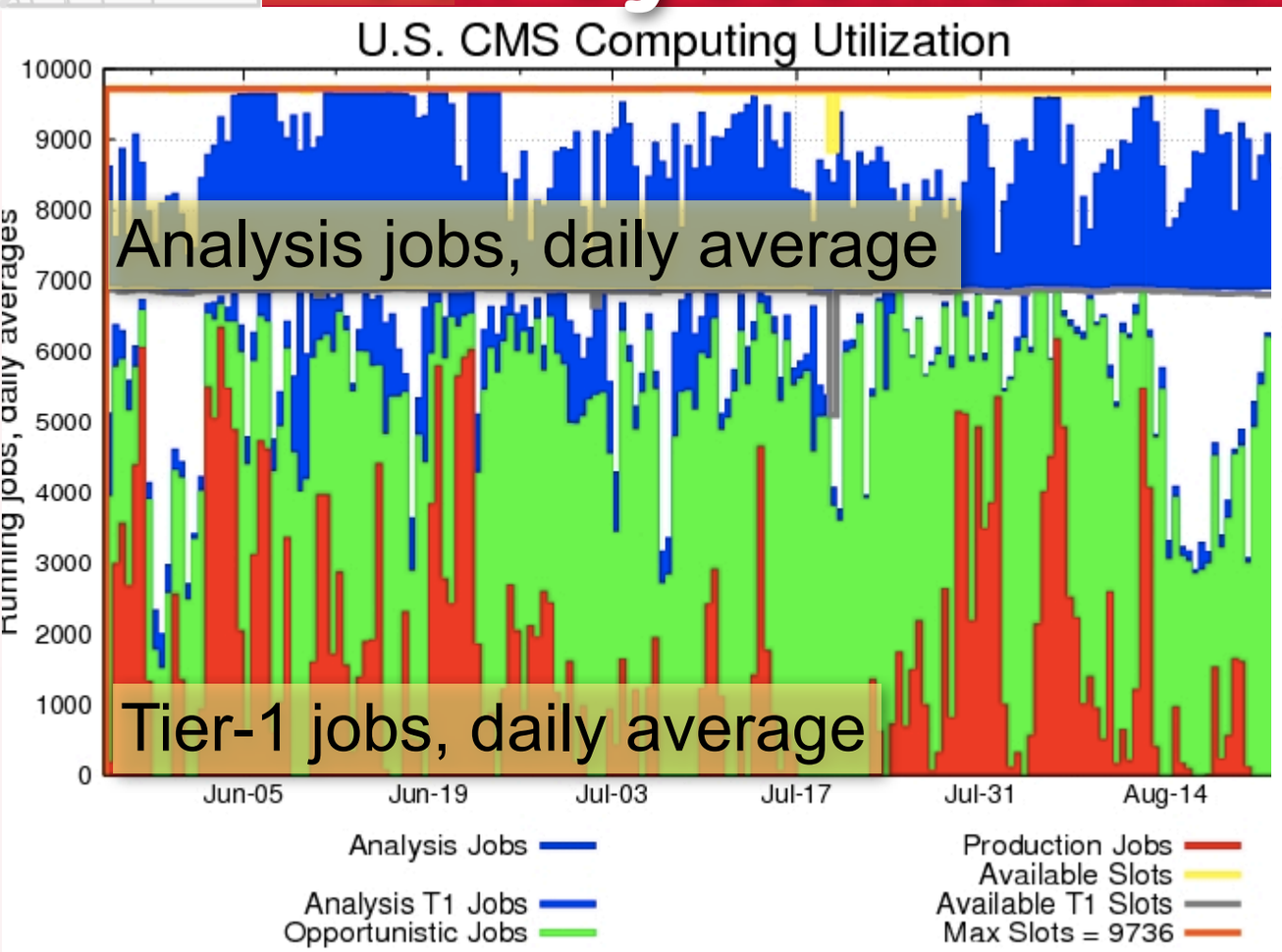


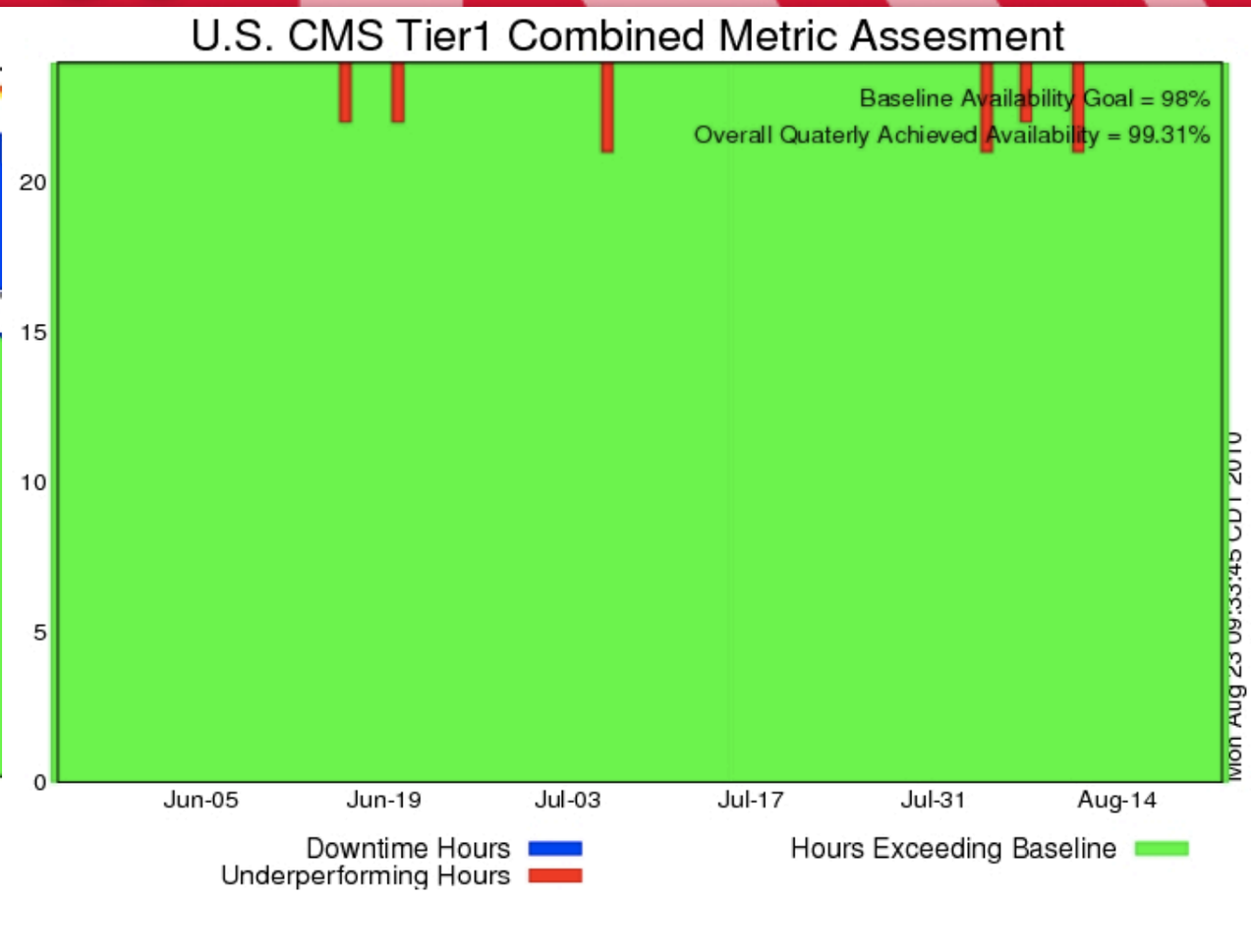
- In April 46/48 US Institutions had submitted Grid analysis jobs
  - tools developed by Fermilab and U.S. participants working w/ Italy

Almost 50% of all CMS Analysis Jobs are running in the U.S.



Fermilab Facilities: "All Systems Are Go"





- Fermilab Facilities running reliably
  - large Tier-1 and Analysis Facilities at Fermilab
  - Fully functional and world-wide performance leaders
  - there are the occasional issues, like e.g. tape library repairs, not impacting operations at this point, but which are being addressed

Organization of CMS Effort at Fermilab

- The U.S. CMS Operations Program draws on resources from all organizations at the lab, in particular:
  - **CMS Center:** overall coordination of Fermilab's contributions to CMS
    - post-docs, Wilson fellows
  - **Computing Division:** CPU & Storage facilities, data access, software development and support, data operations support.
    - scientists, computer professionals, programmers, engineers, technicians, managers
  - **Particle Physics Division:** detector R&D, design, construction, operations
    - scientists mechanical and electronics engineering, technicians, managers
  - Successful coordination of all these resources requires continuous direct interaction of the physicists with the technical staff
- Facilities provided to CMS and U.S. CMS community
  - Tier-1 and analysis computing facilities
  - Remote Operations Center ROC
  - LHC Physics Center LPC at Fermilab

Detector, Computing & Offline Operations Efforts

- Large Fermilab commitments to Operations
  - HCAL, Tracking, Endcap Muons, Data Acquisition, Trigger, Run/ Technical Coordination, Computing Facilities, Data Operations, etc
- Large role for Fermilab staff in CMS leadership:
  - Fermilab has **6 Members in the CMS Management Board**
    - Level-1 positions within CMS organization:
      - Chair CMS Collaboration Board: Dan Green
      - Deputy Upgrade Coordinator: J. Butler
      - Computing Coordinator: I.Fisk, Deputy P.McBride
      - Offline Coordinator Deputy: E.Sexton-Kennedy
      - HCAL Project Leader: J. Spalding
  - Plus **9 Level-2 "Convener"** positions in Computing, Offline, Physics
  - And a large number of Physics leadership positions, shown later

Fermilab provides "convener-level" coordination to ~20% of all CMS Physics, Offline, Computing groups

U.S. CMS Operations Program

Fermilab people in Red ★

Fermilab provides ~50% of management and leadership to U.S. CMS Operations Program

- **DOE/NSF Joint Oversight Group U.S. LHC Research Program Office**
  - **Fermilab Directorate** — G. Bock ★
    - **Program Management Group**
    - **Technical Advisory Board**
    - **Heavy Ion Liaison** — Wyslouch
    - US CMS Operations Program Office — J. Butler /D. Marlow ★
      - **U.S. CMS Collaboration Board** — Nick Hadlley
      - **Outreach**
      - **Maintenance & Operations** — C. Newman-Holmes ★, Upgrade:D. Bortoletto
        - **Muon End cap** — P. Padley
        - **Trigger** — W. Smith
        - **ECAL** — B. Cox
        - **SITRK** — J. Incadela, R. Demina
        - **HCAL** — J. Whitmore ★
        - **DAQ** — V. O'Dell ★
        - **FPIX** — S. Kwan ★
      - **Software& Computing** — L. Bauerdick ★
        - **Tier 1 Facility** — J. Bakken ★
        - **Grid Services and OSG Interfaces** — R. Pordes ★
        - **Distributed Computing Tools** — F. Wuerthwein
        - **Tier 2 Facility** — K. Bloom
        - **Application Services** — P. Elmer
        - **Core Software and Support** — L. Sexton-Kennedy ★

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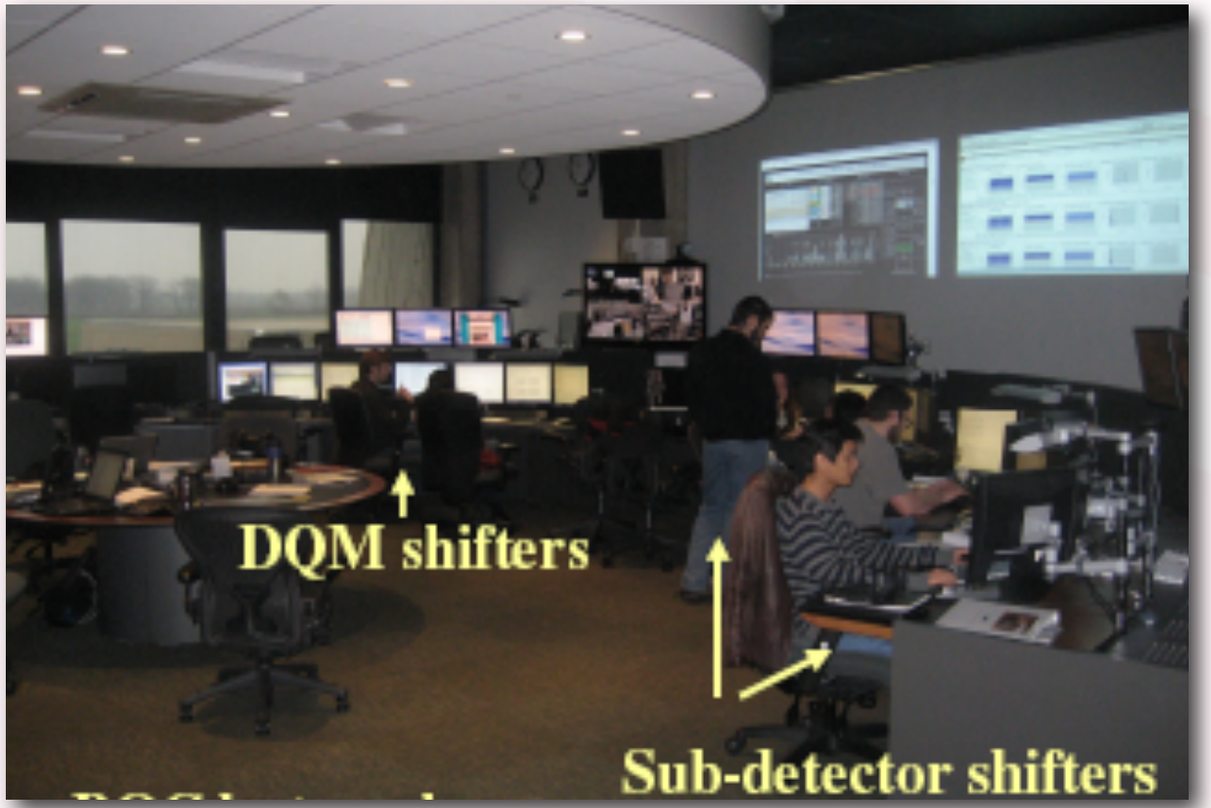
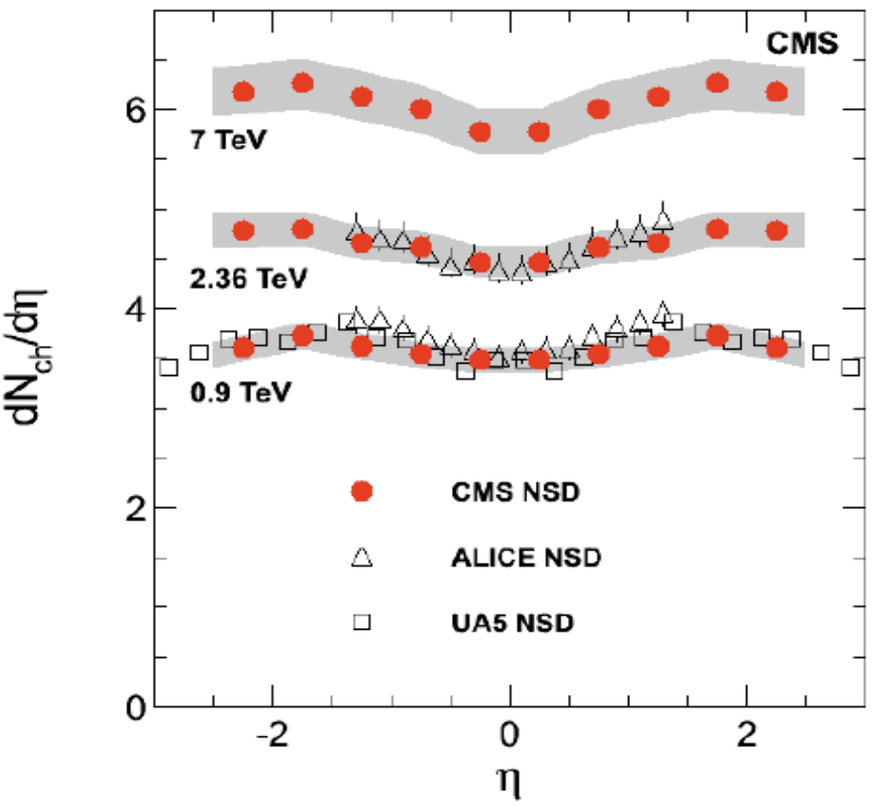
Fermilab Role in Remote Operations

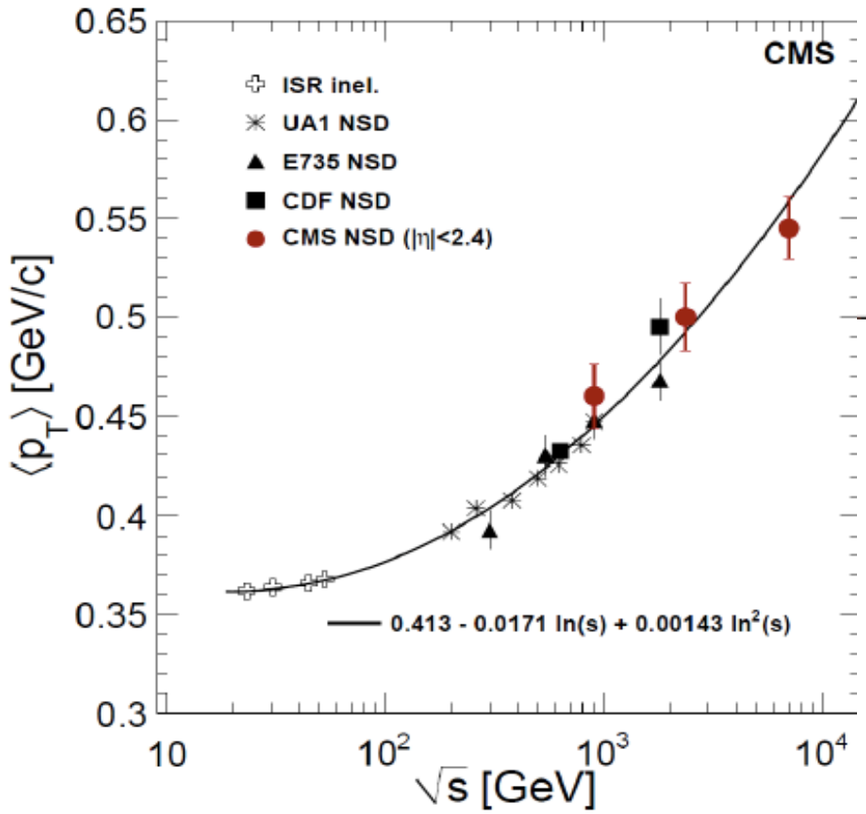
- With the ROC Fermilab pioneered CMS remote Operations
  - There are now several remote Centers in CMS
  - Fermilab physicists have had a major impact on the way operations are staffed and shifts are allocated and accounted
- Remote Shifts get full service credit with CMS
  - Offline DQM, Computing, Data Ops, SubDet shifts (HCAL, Tracker), etc.
- Opportunity taken by many U.S. collaborators:
  - Statistics show that a large number of US universities participate:
  - ~210 shifts, of which only 7 were for Fermilab people
- ROC is a great service to U.S. Community

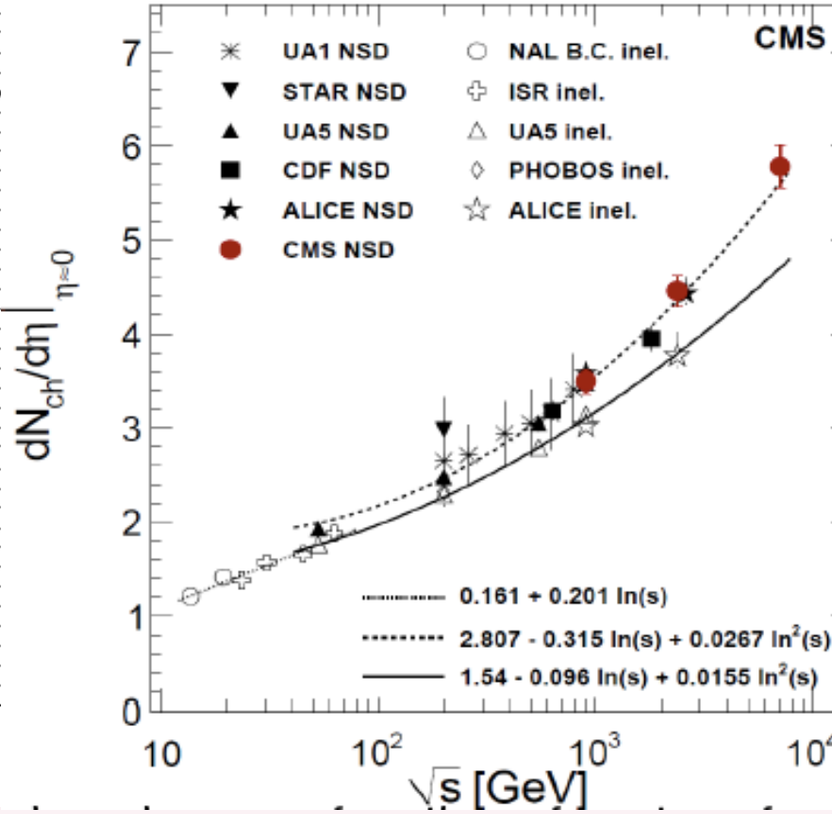


First 7 TeV paper accepted on June 4
Published in PRL

- This shows CMS can turn-around publications quickly
  - "Transverse Momentum and Pseudorapidity Distributions of Charged Hadrons in pp Collisions at √s=7TeV"

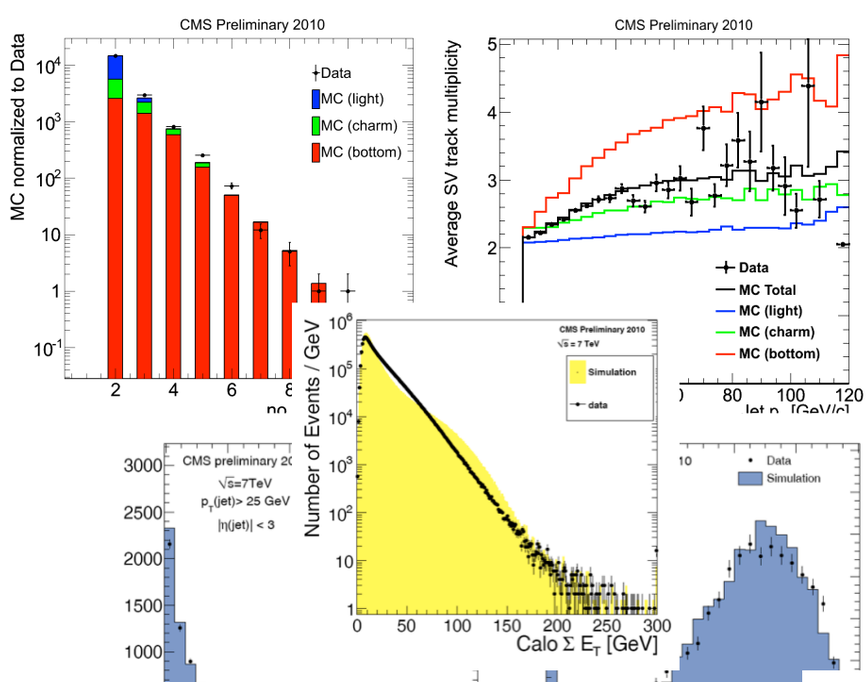


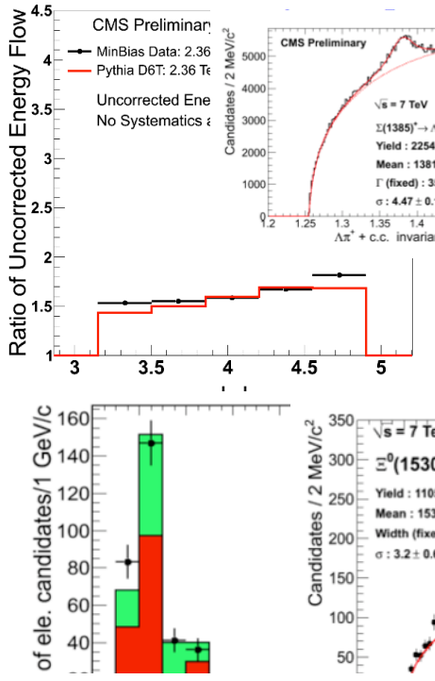


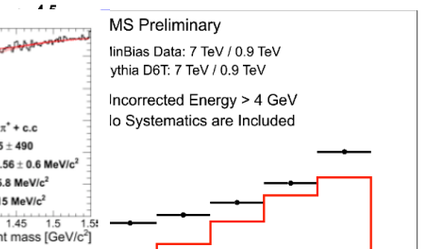


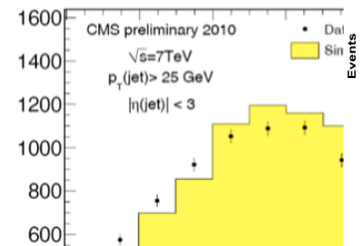
- Fermilab scientists contribute to the publication process as editors, reviewers, etc, and in the publication committee

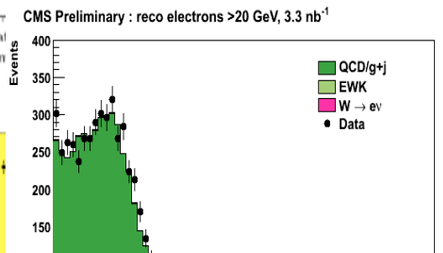
...and plenty of new results coming daily

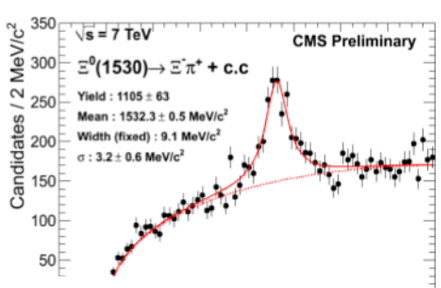


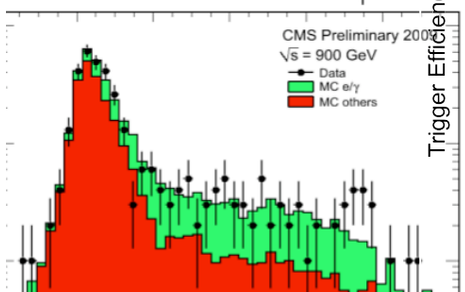


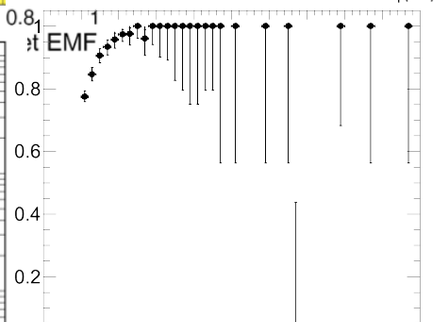


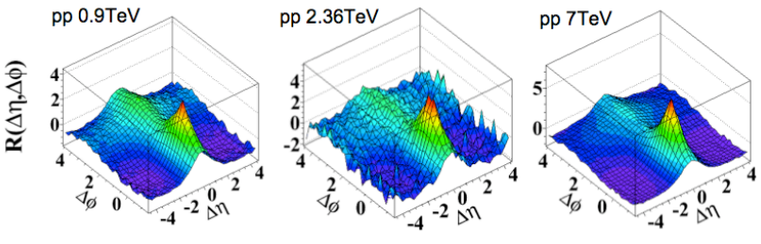


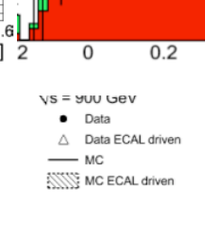


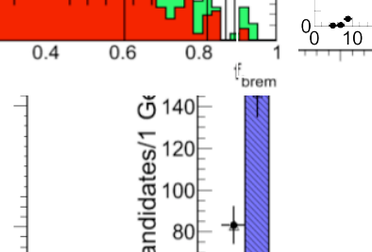


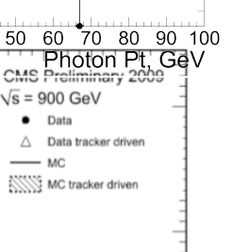


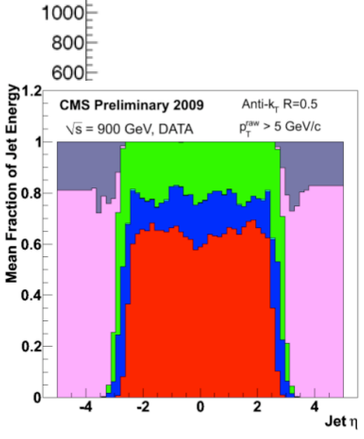


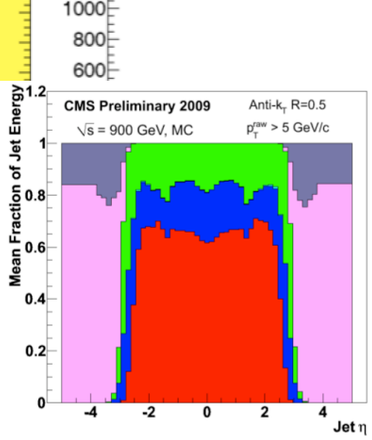


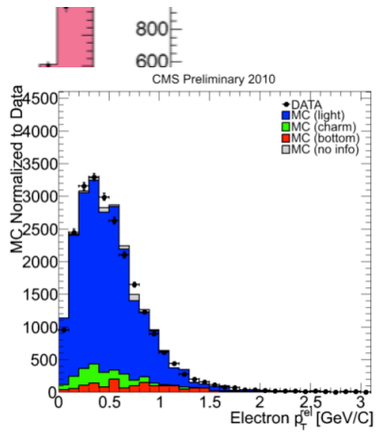


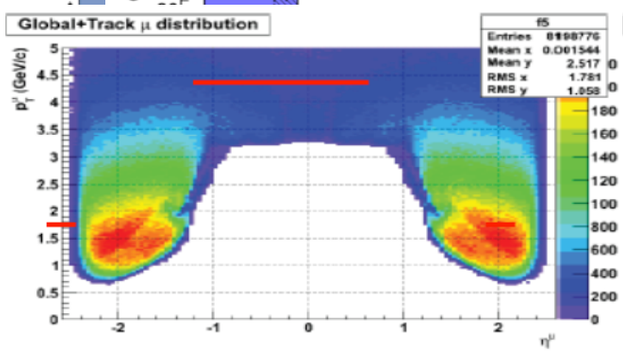


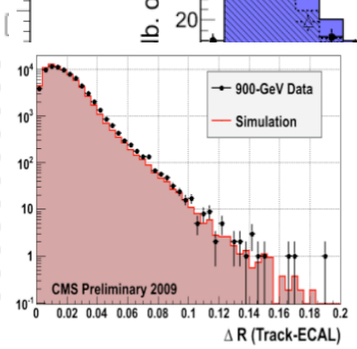


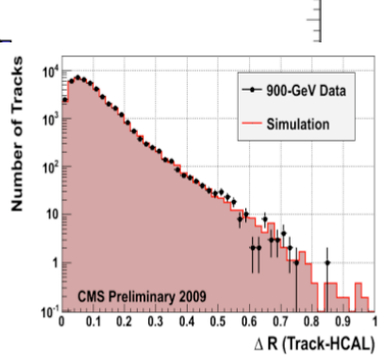












Physics Activities and Plan of Fermilab CMS Group

- Strong participation and leadership in in analysis activities,
  - starting with detector commissioning, alignment and calibration, and extending to a broad program of discovery physics based on an assessment of what can be achieved at each integrated luminosity
    - Commissioning → Detector Performance → Physics Objects → Signatures → Physics Measurements and Discoveries!

	Luminosity	Analysis Activity
→ summer 2010	1 pb^{-1}	Calibration, alignment, measurements of minimum bias *pp* and low P_T leptons and jets.
summer 2010	10 pb^{-1}	First cross section measurements: *W*, *Z*, high P_T jets, top, calibration of high P_T physics objects.
until Nov 2010	100 pb^{-1}	Precision *W*/*Z*/top cross sections, di-boson production, discovery potential in some channels (jets, CMSSM SUSY, TeV *Z*').
2010/2011 physics run	1 fb^{-1}	Discovery phase begins: discovery potential over large range of channels and masses, SM Higgs evidence at M_H > 200 GeV.
starting in 2013	10 fb^{-1}	Possible SM Higgs discovery, high-mass BSM discovery.

Involvement in Physics: Leadership

- Fermilab has the single largest institutional group of senior and junior scientists outside of CERN
- Strongly involved in CMS physics, both broad and focused
  - ⋆ senior scientist working with RA(s)
- Large role in Physics Leadership
  - ⋆ Physics Group Conveners
    - QCD Physics Analysis Group: V.O'Dell (RAs Chetluru, Koussouris, Mason)
    - Jets/Missing Et Physics Object Group: R.Harris (RAs Koussouris, Mason)
    - Tracking Physics Object Group: K.Burkett (RAs Gao, Uplegger, Yumiceva)
    - HCAL Detector Performance Group: F.Chlebana (RAs Sharma, Hirschauer)
  - ⋆ Physics Sub-group conveners:
    - Electro-Weak Vector-Boson Task Force: J.Berryhill (RAs Mishra, Tan)
    - SUSY All-Hadronic: D.Elvira
    - QCD High PT Jets: K.Kousouris
    - Generator Integration and Validation: S.Mrenna

Overview of Fermilab Physics Topics

Group	Activity	Participants
Detector Performance Groups	HCAL	***Chlebana***, Chetluru, Anderson, Vidal, Bhat
	Tracking	***Burkett***, Gao, ***Tkaczyk***
	Pixels	***Kwan***, Joshi, Tan, Yun, Uplegger, Bhat, Yang
	Beam Spot	Burkett, Miao, Spiegel, Tkaczyk, Uplegger, ***Yumiceva***
	Muon Reco	Bloch, (James)
	Trigger Performance	***Berryhill***, Mishra
Physics Objects Groups	Jets/Missing ET	***Harris***, Chlebana, Sharma
	Jet Energy Corr.	Mishra, Chetluru, Kousouris, Klima
	Particle ID	Berryhill, Mishra (Electron ID), Yumiceva (B-Tagging), and others
Physics Analysis Groups	QCD	***O'Dell***, Chetluru, Kousouris, Mason, Harris
	B Physics	Spiegel
	Electroweak Physics	Tan, Green, Miao, Spiegel, Rodrigues, Mishra, *Berryhill*, Cavanaugh, Yang
	Top Physics	Yumiceva, Green, Bauerdick, Bloch, Burkett, Fisk, Gutsche, Hooberman, Sexton-Kennedy, Malik, Plager
	Searches	Bhat, Vidal, Tan, Green, Miao, Rodrigues, Spiegel, Tkaczyk, Bauerdick, Bloch, Burkett, Fisk, Gutsche, Hooberman, Wu, Saoulidou, Elvira

almost all these activities are done collaborating with University colleagues!

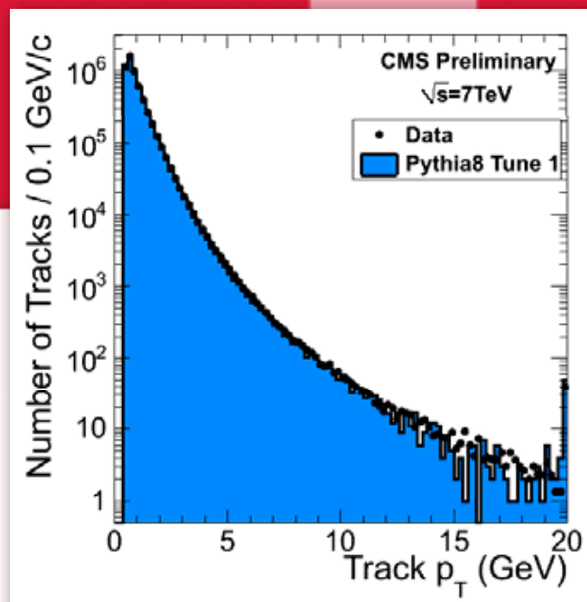
A Selection of CMS Detector Performance and Physics Results (“cartoons”) with emphasis on where Fermilab scientists contributed

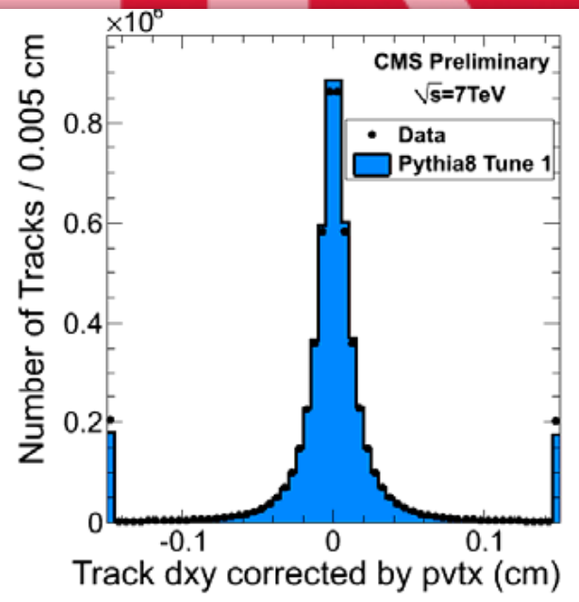
example: ICHEP’10: 11/22 CMS talks given by U.S. people, one of which is a Fermilab RA

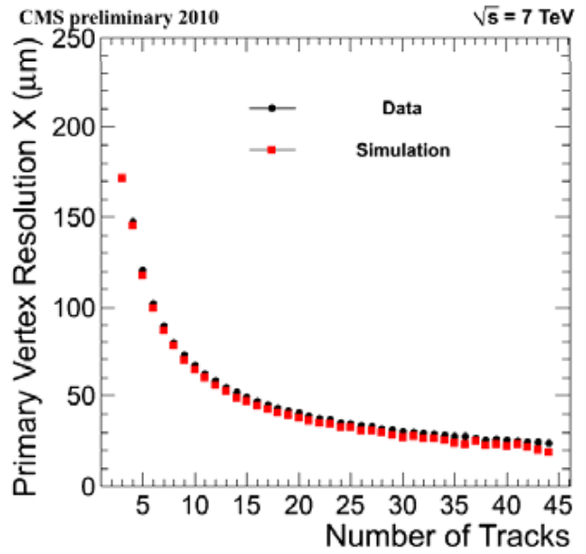
- Fermilab scientists and RAs major contributor to those results!
- About one third of the CMS ICHEP results were associated with LPC work

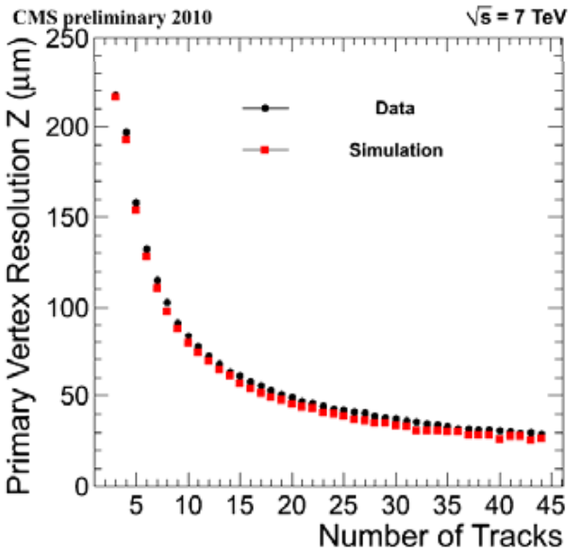
Tracking

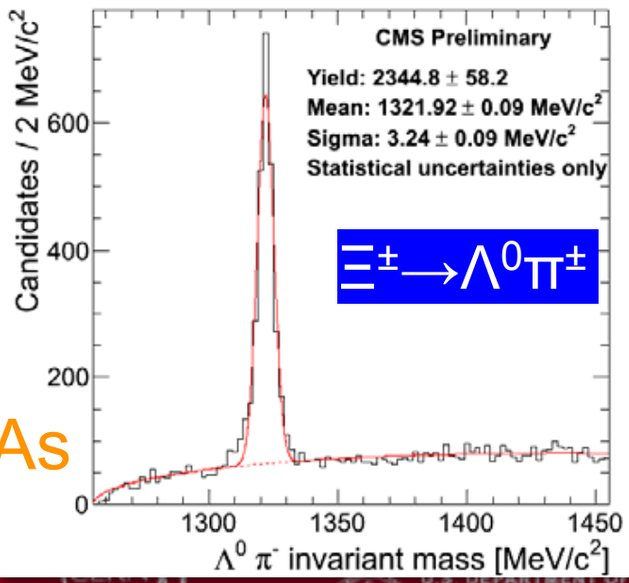
- Commissioning/validation of tracking reconstruction
- Measurement of primary vertex resolution and feedback to LHC
- Measurement of luminous region profile
- Support/training for university contributions:
  - Reconstruction of first resonances
  - Reconstruction of photon conversions

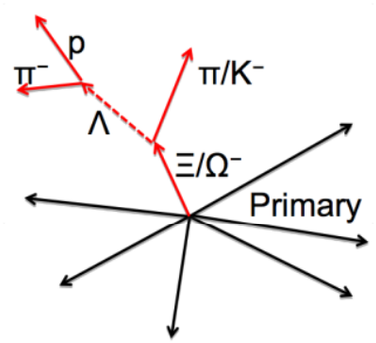










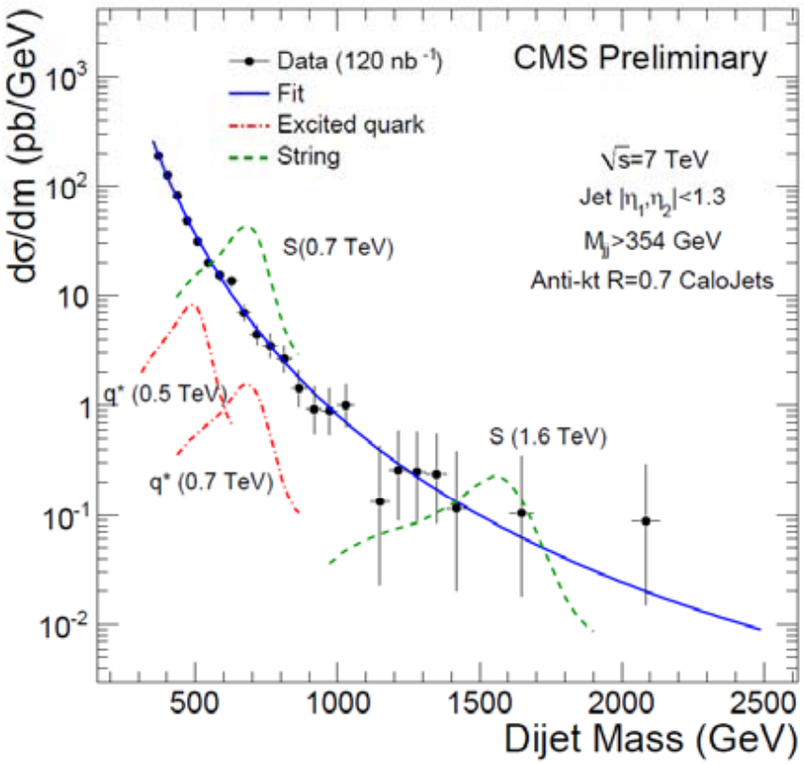


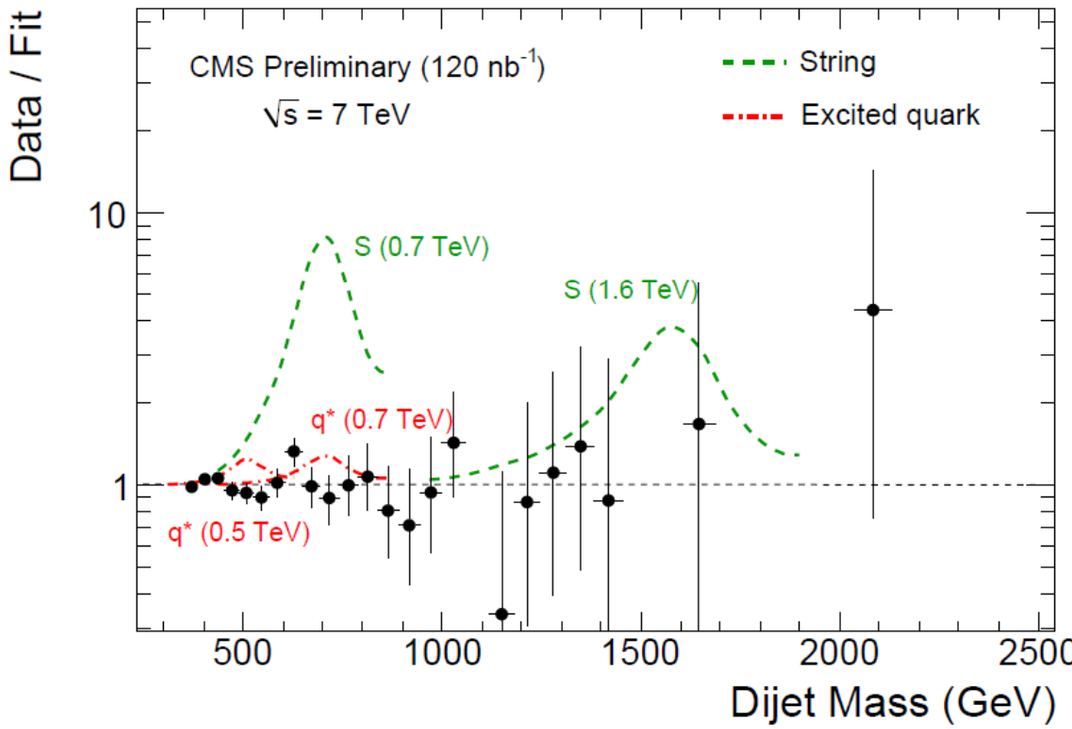
Fermilab: large group of scientists and RAs

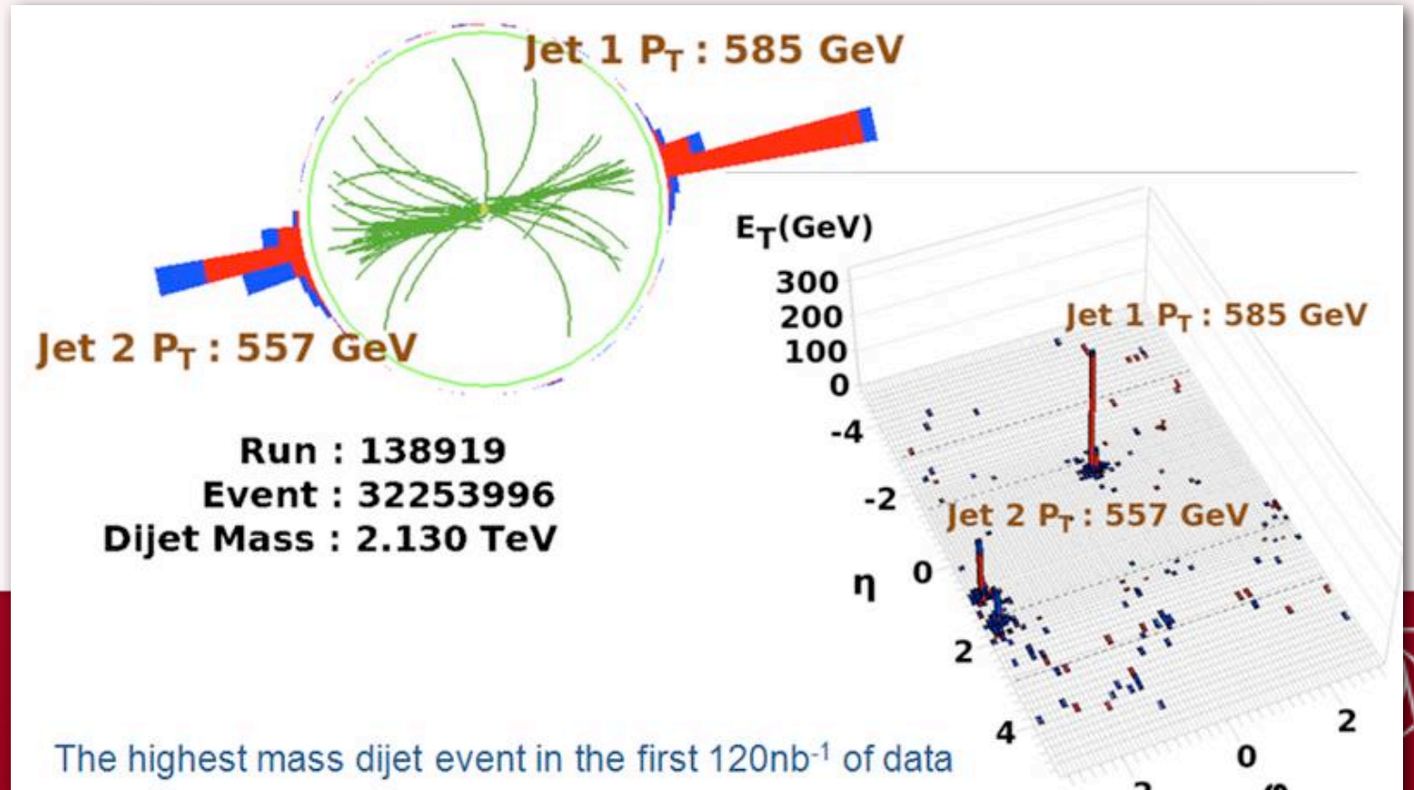
K.Burkett, CMS Tracking Physics Object Group Convener

Jet Physics

- Searches for Dijet Resonances
  - Result approved for ICHEP
  - Analysis lead by Fermilab/LPC (R. Harris as JetMET convener) with many USCMS institutions
    - Brown, Fermilab, Iowa, Rochester, Rutgers, Texas Tech
  - Sets best limit on dijet resonances from string theory: M > 1.67 TeV



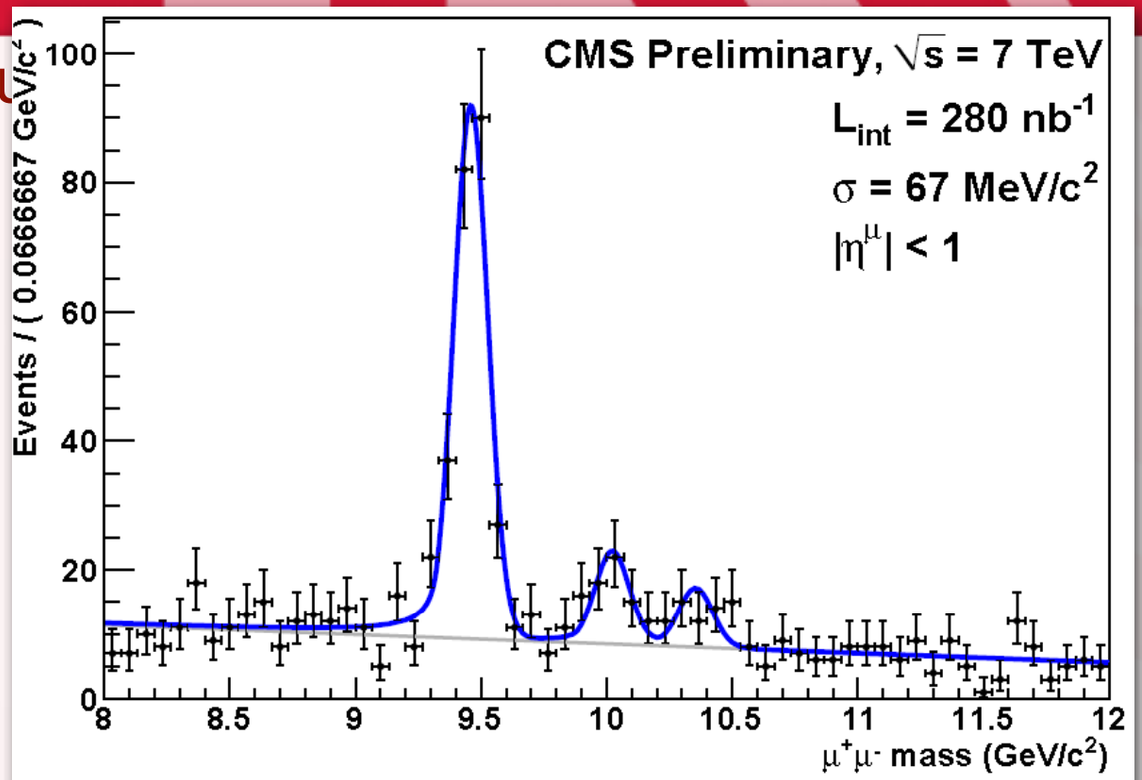


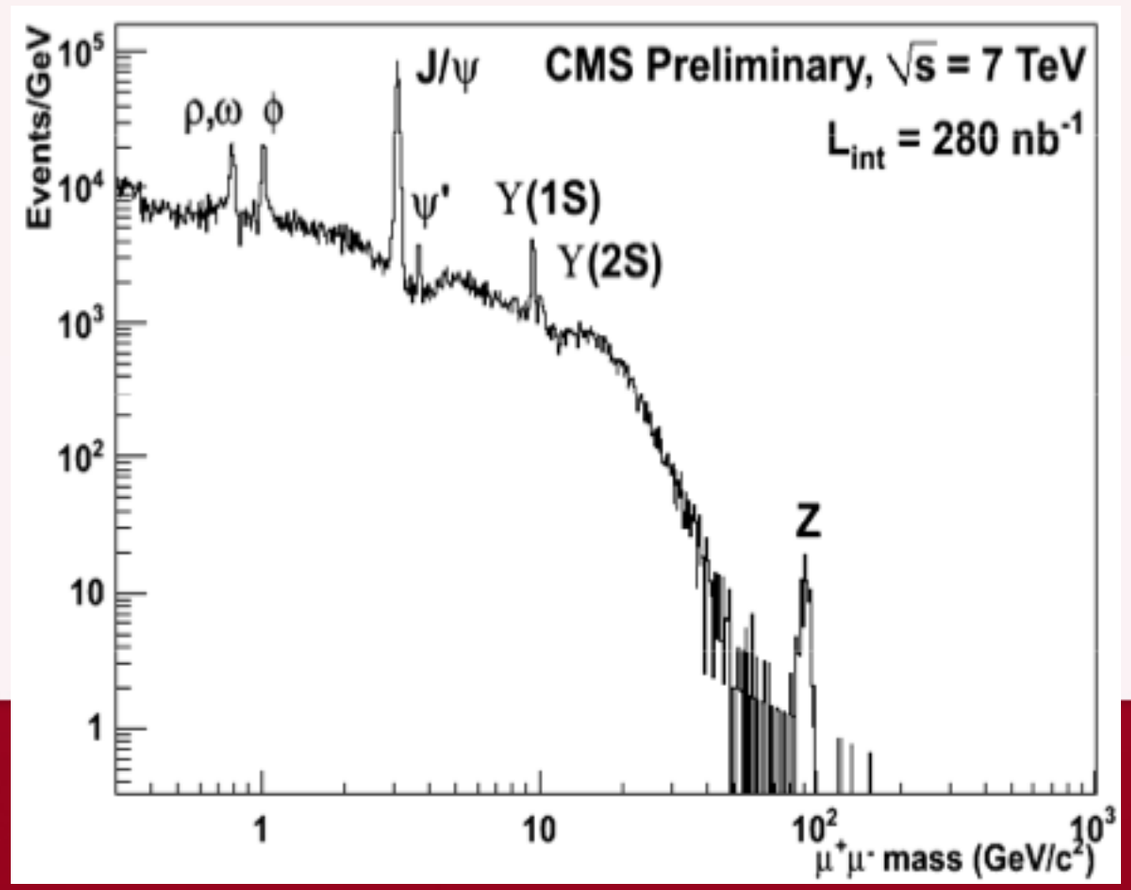


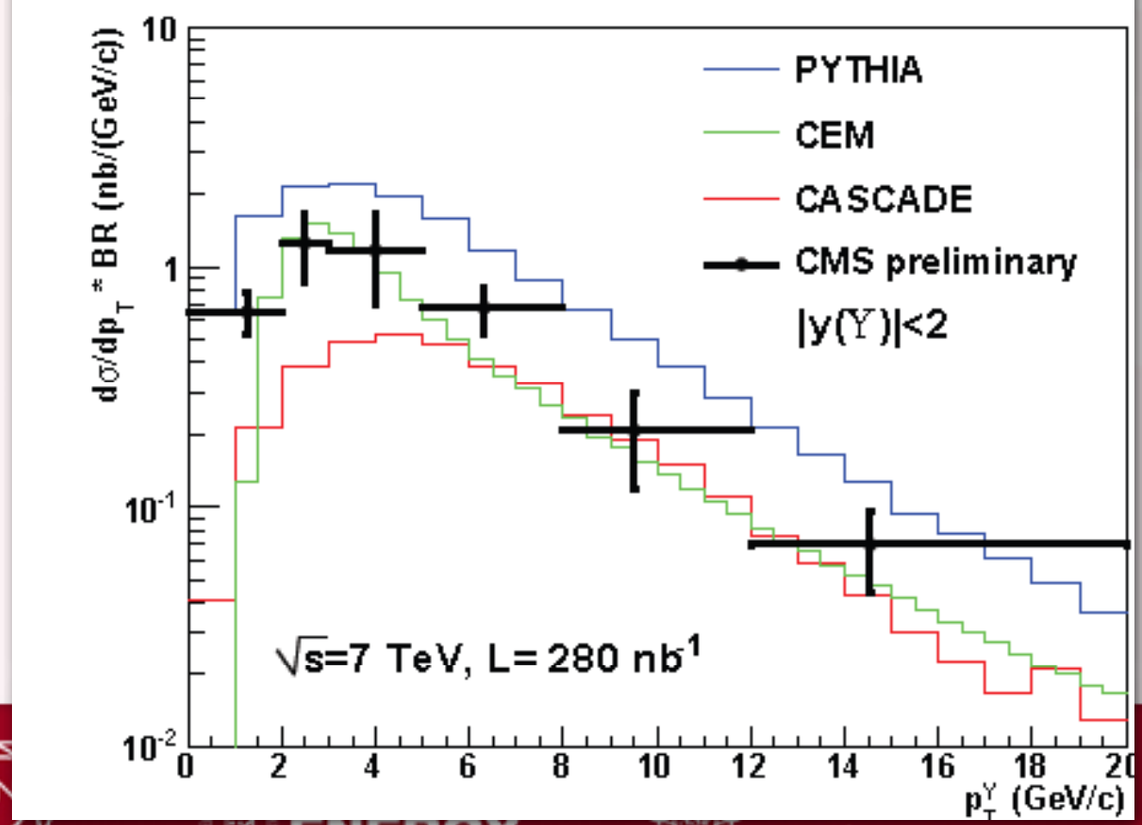
The highest mass dijet event in the first 120nb^{-1} of data

First Quarkonia Studies

- CMS Quarkonia Task Force assembled to condu
- International team of ~60 physicists,
- Fermilab/LPC participation included:
  - leadership of the task force (I.Shipsey)
  - leaders & core team for Y cross section team (Shipsey/Gecse/Leonardo/Anderson/Zheng)
  - Participants in J/psi cross section team
- produced all dimuon mass study
- Spectacular showing at ICHEP: measurements with 280 nb-1 (data less than 3 days old!),
- CMS performing close to design



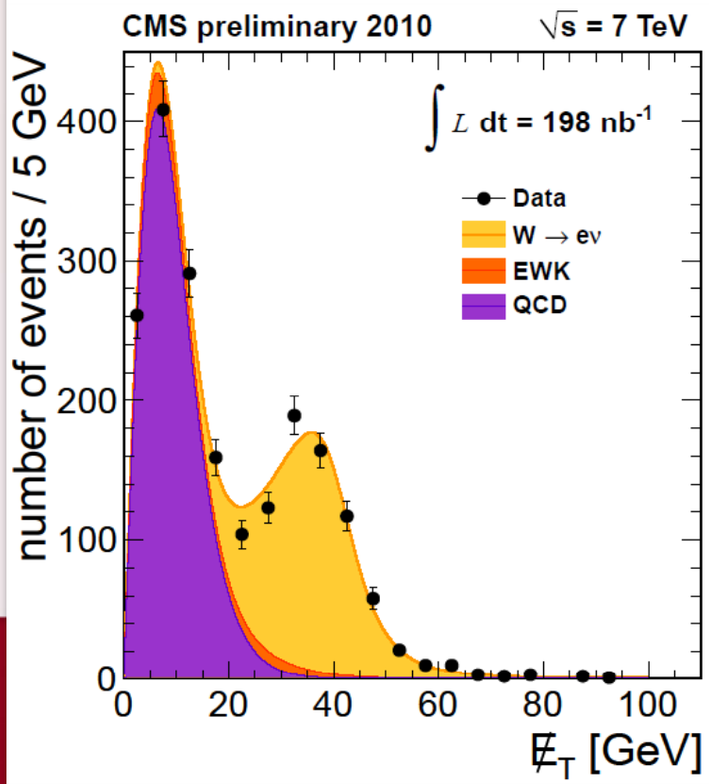




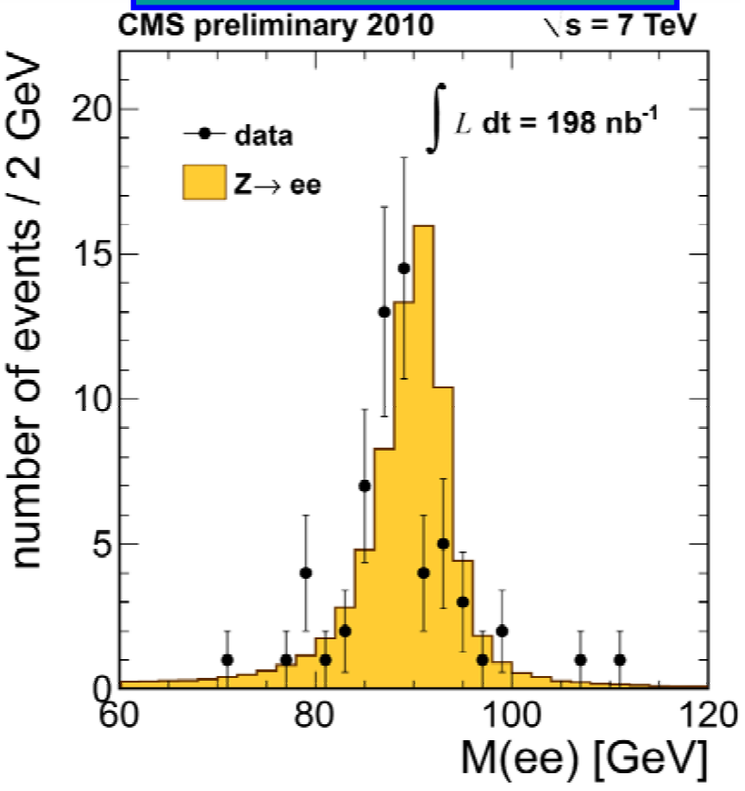
First Vector Boson Studies at CMS

- CMS Vector Boson Task Force assembled to conduct first W/Z measurements
- International team of ~150 physicists, ~20 LPC based
- LPC participation included:
  - leadership of the task force (J. Berryhill)
  - leaders of W →ev and Z→ ee observation teams (K. Mishra, K. Hahn)
  - produced first W→μv and Z→μμ asymmetry measurements (P. Tan, R. Rodrigues)
- Spectacular showing at ICHEP with a full collection of measurements with 200 /nb (data less than 5 days old!),
  performing close to design expectations < 4 months in!

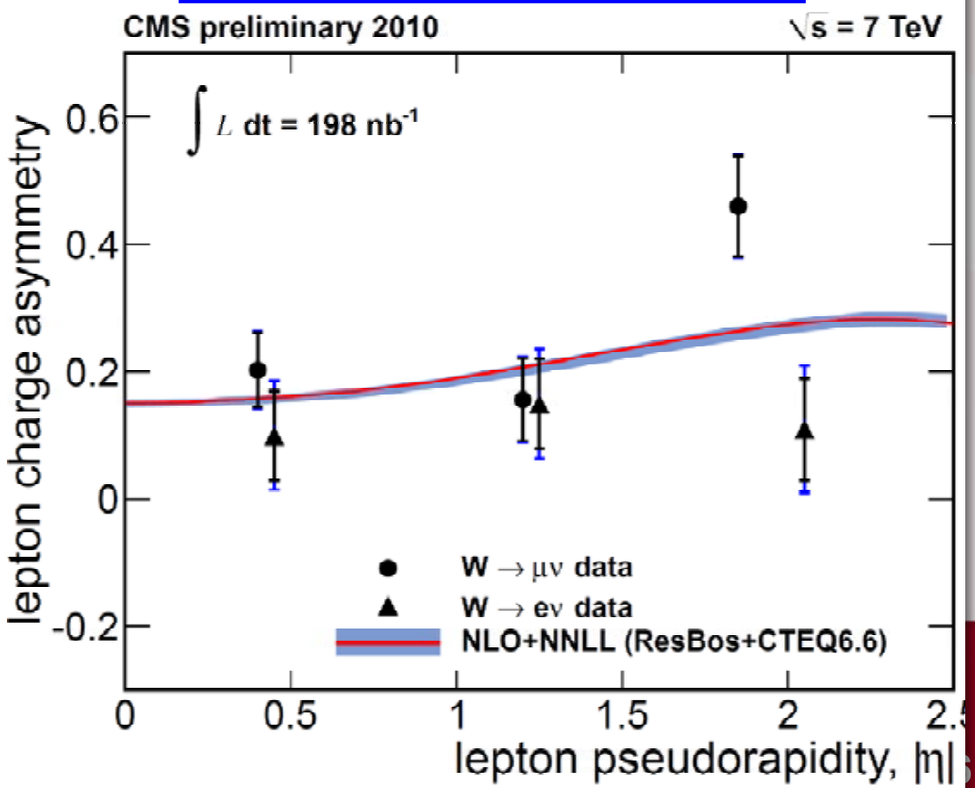
W→ eν Observation



Z→ ee Observation

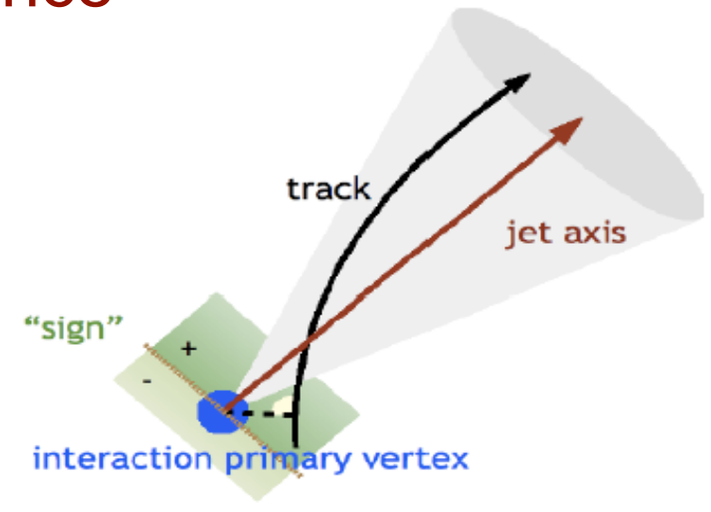


W+/W- Asymmetry

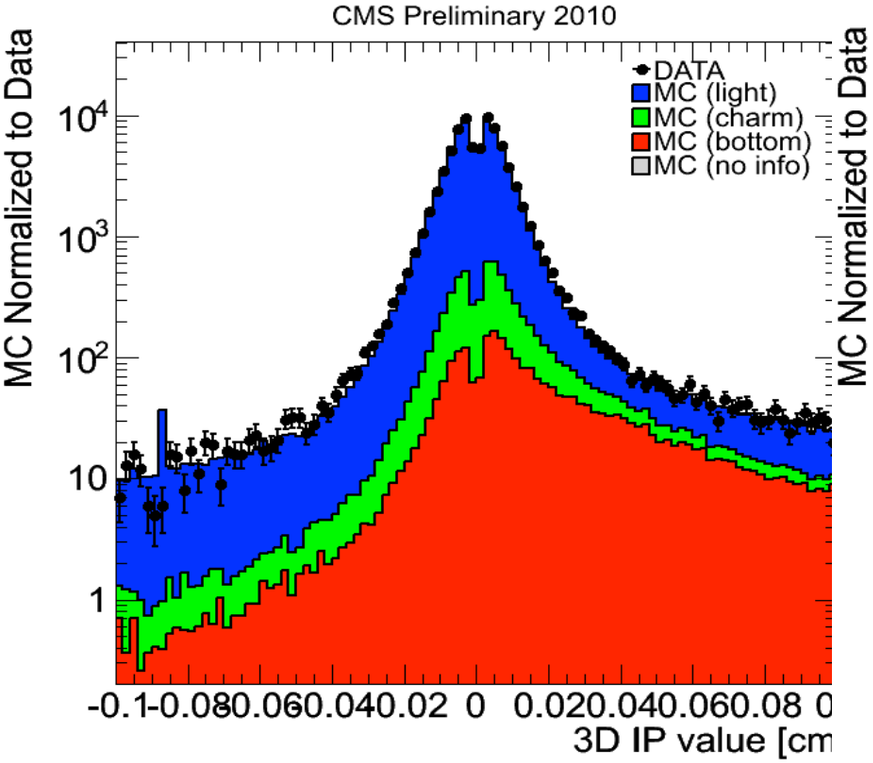


b-tagging : 3D IP Significance

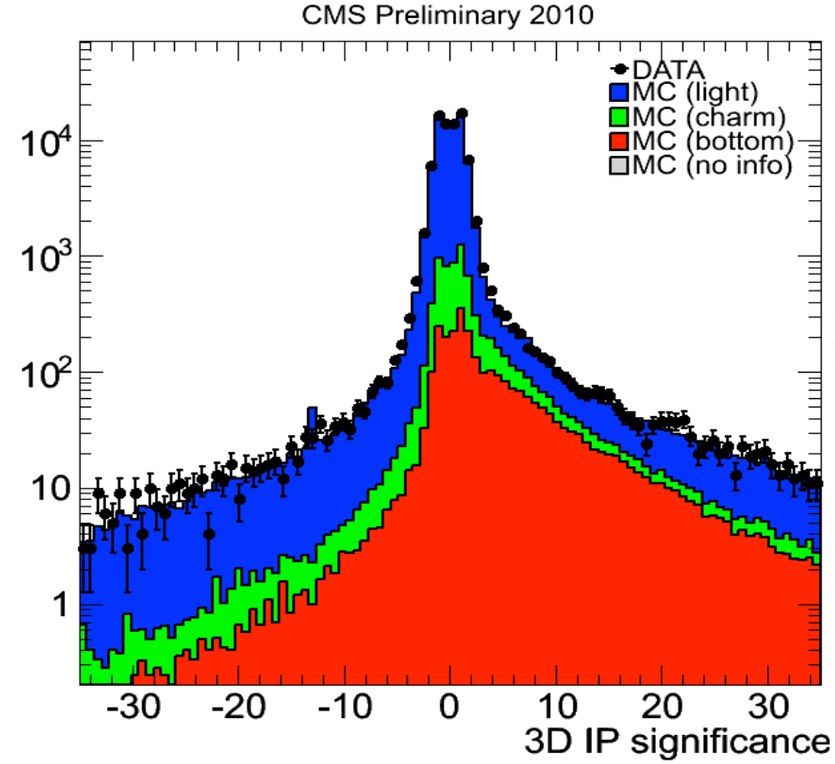
- Excellent alignment and general tracking performance allows for b-tagging based on 3D IP significance:
  - 3D impact parameter value and significance (+zoom into ±2 region) for all tracks with PT>1GeV belonging to jets with pT > 40 GeV and |η| < 1.5 (PFlow Jets anti-kT R=0.5).



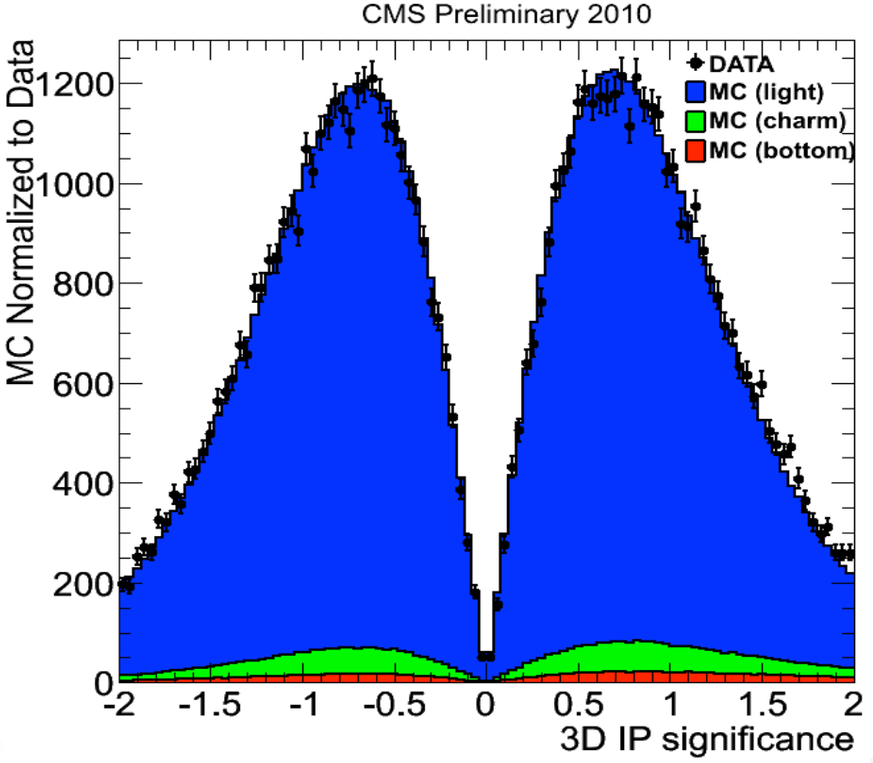
3D IP Value



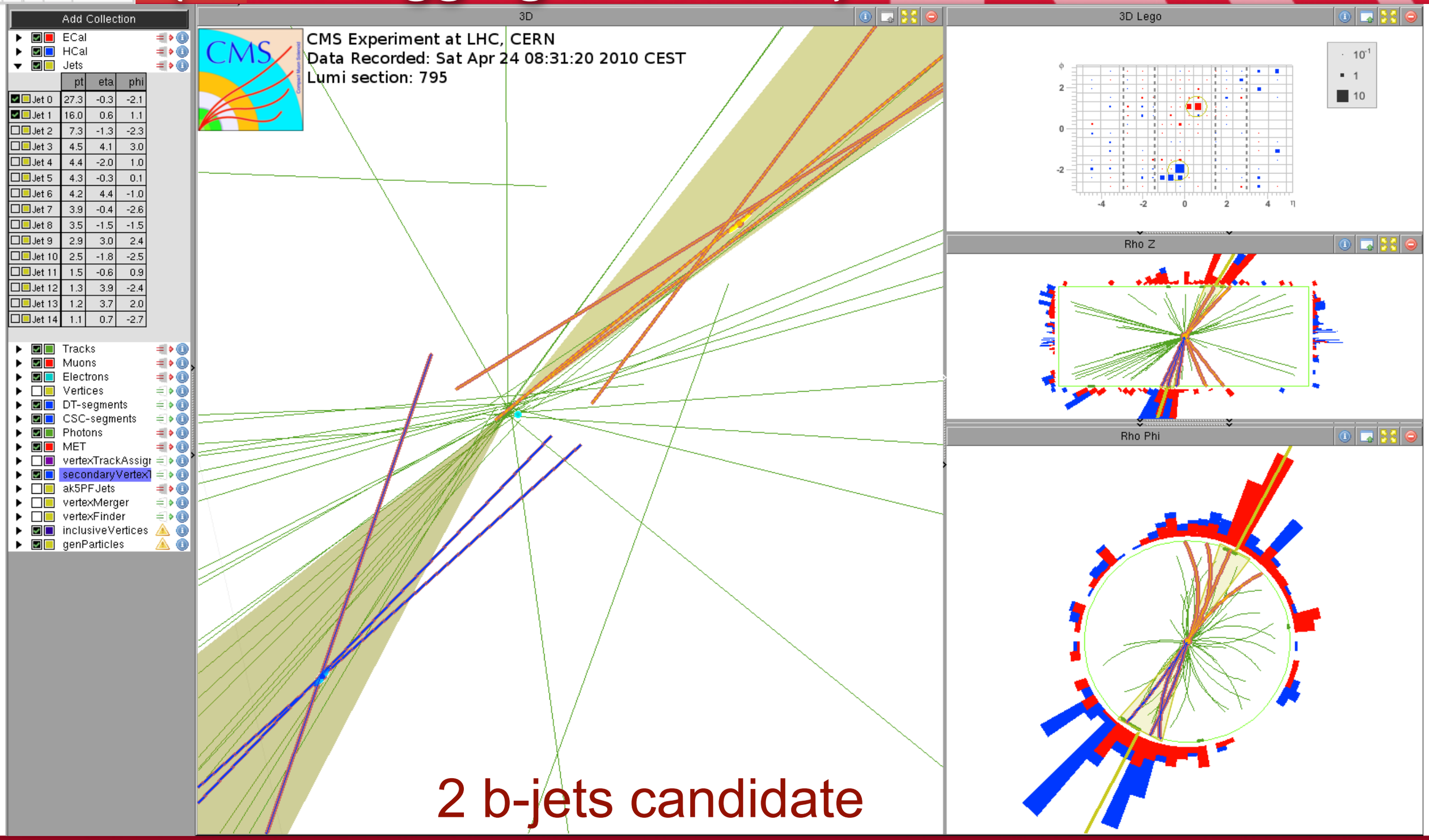
3D IP Significance



3D IP Significance Zoom



CMS Getting Ready for b Physics
(and b-tagging in General)

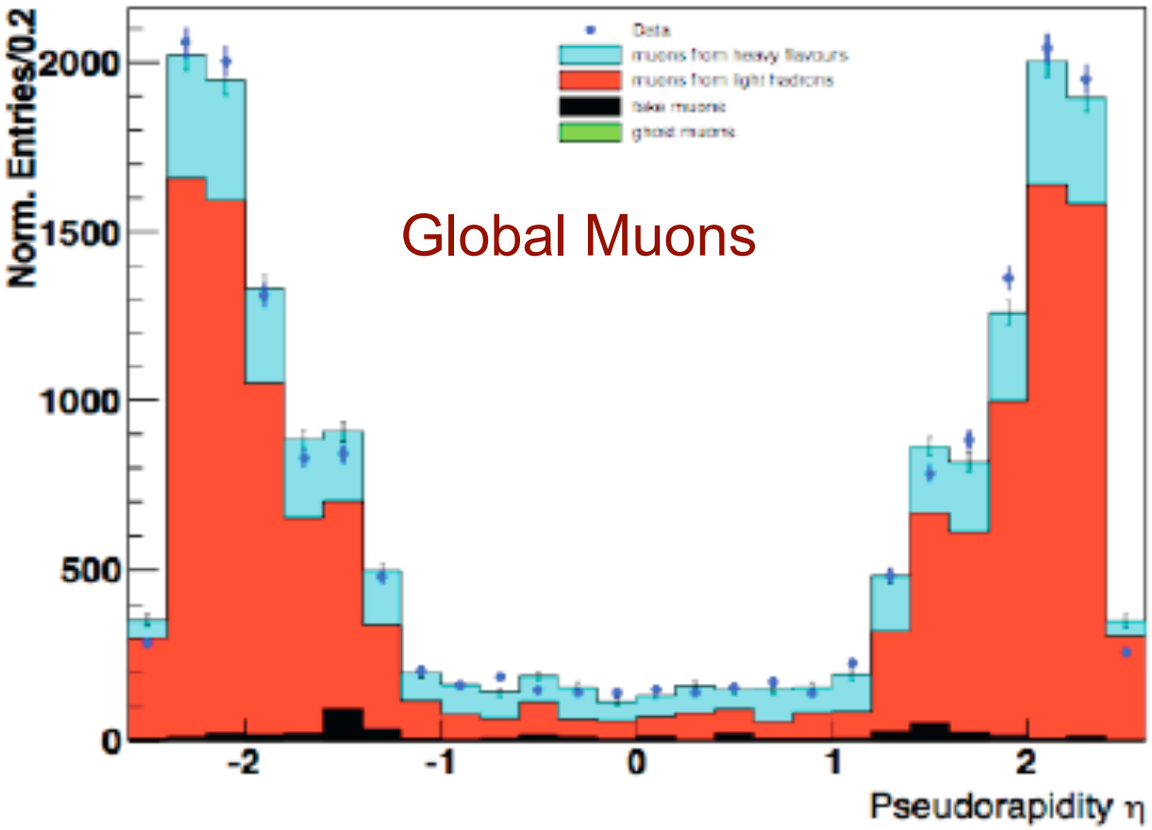


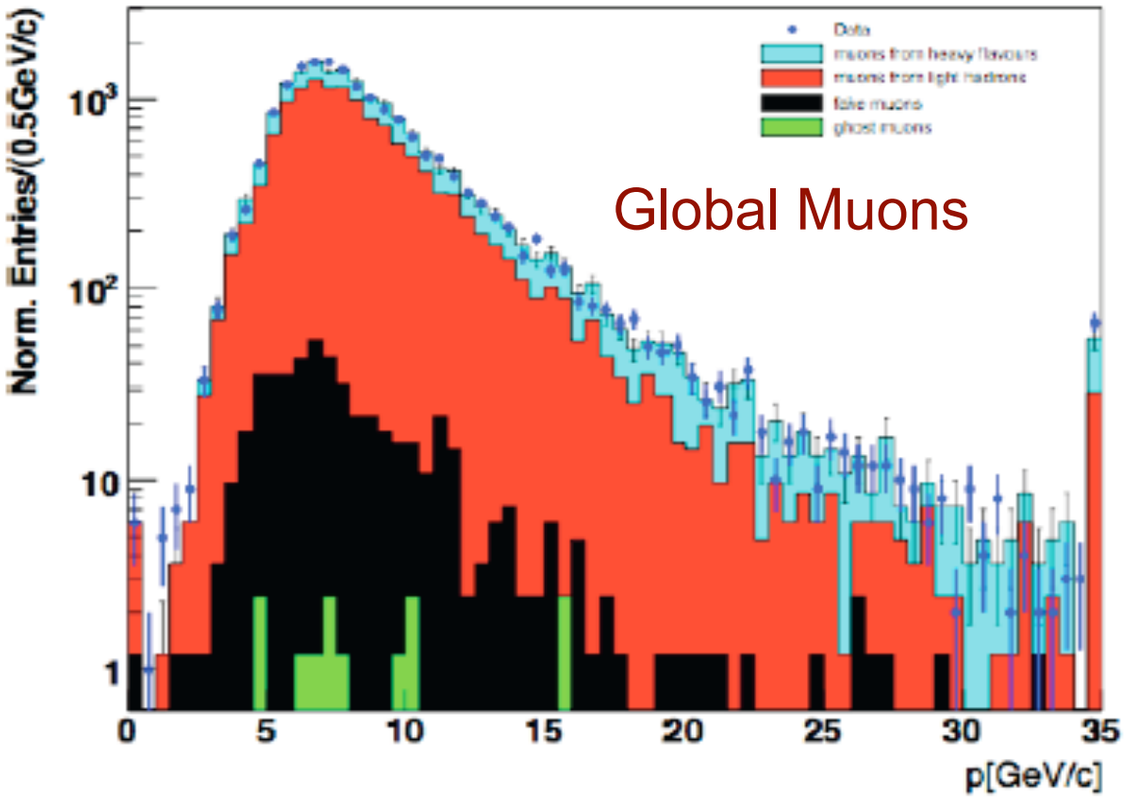
2 b-jets candidate

Fermilab: contributions to visualization

Muon Performance

- ★ “Global Muons” matched tracks from Muon system and Tracker
- ★ “Tracker Muons” tracker tracks matched to one Muon station segment



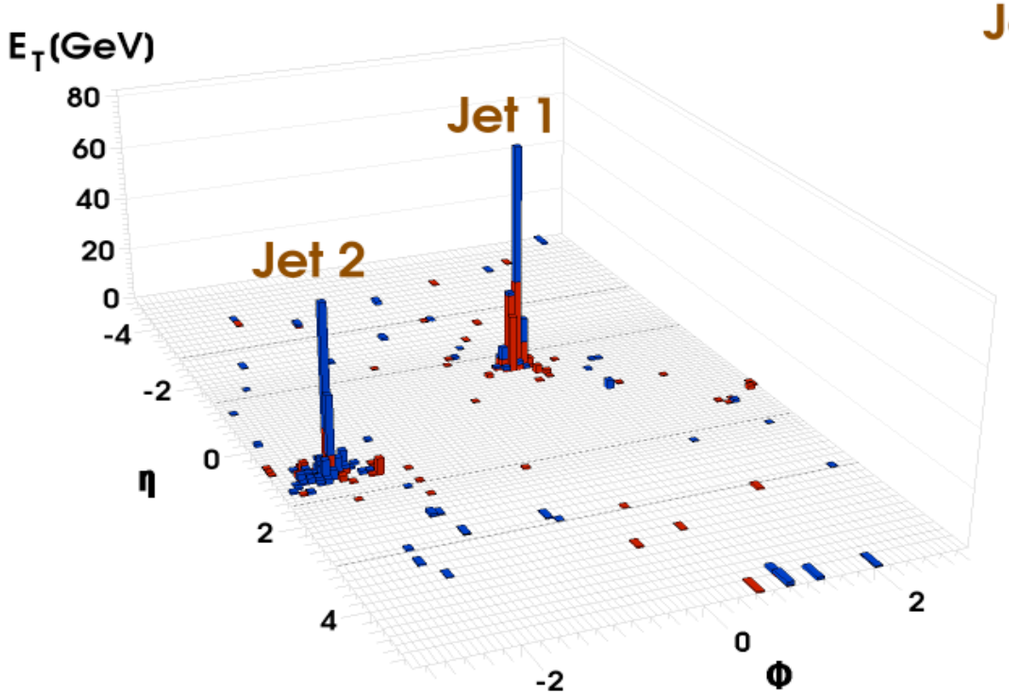


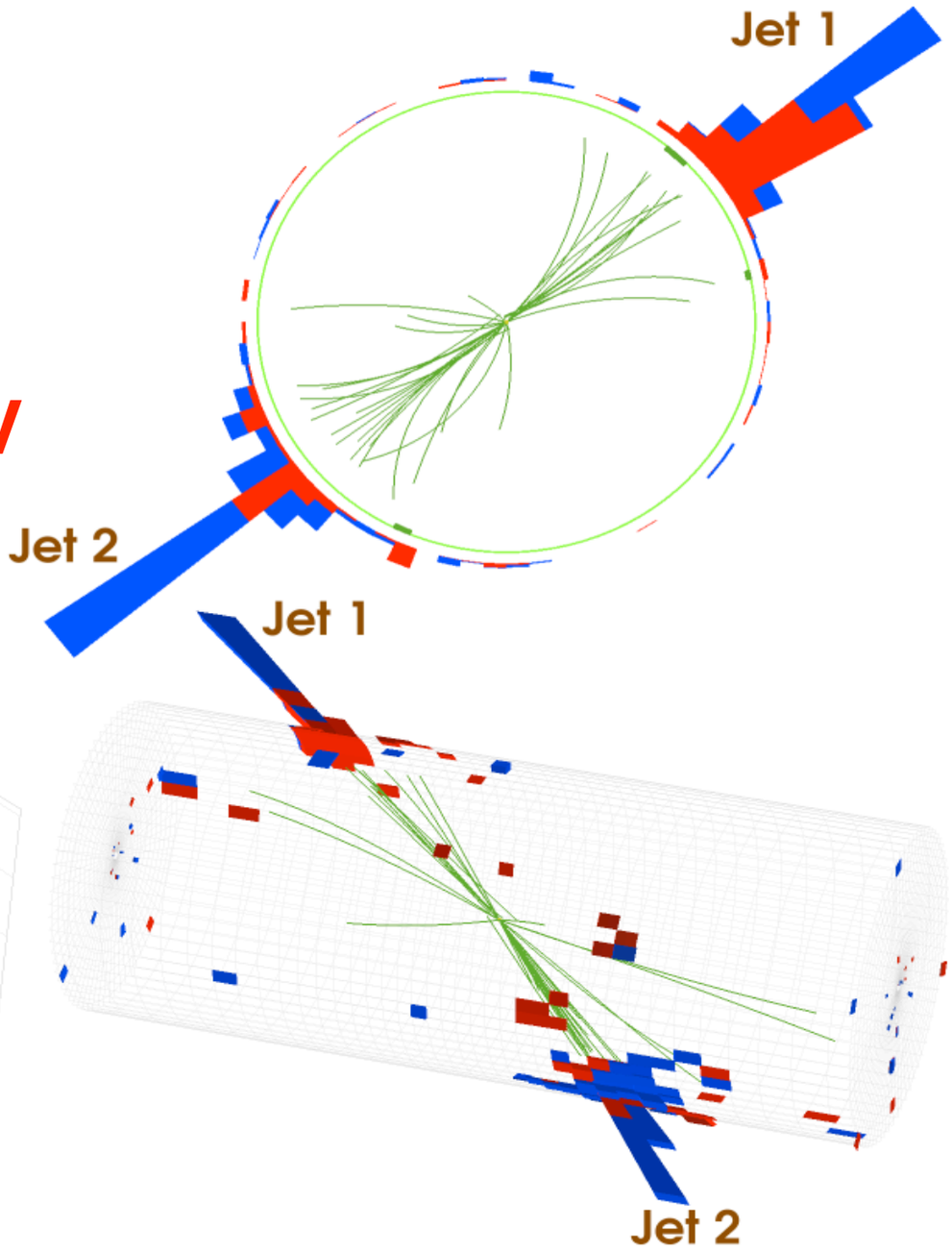
- ★ η and p_T distributions dominated by light hadron decay muons (**red**)
- ★ good agreement with MC prediction including heavy flavor decays (**blue**), punch-through (**black**) and fakes (**green**).

Jets and Missing ET

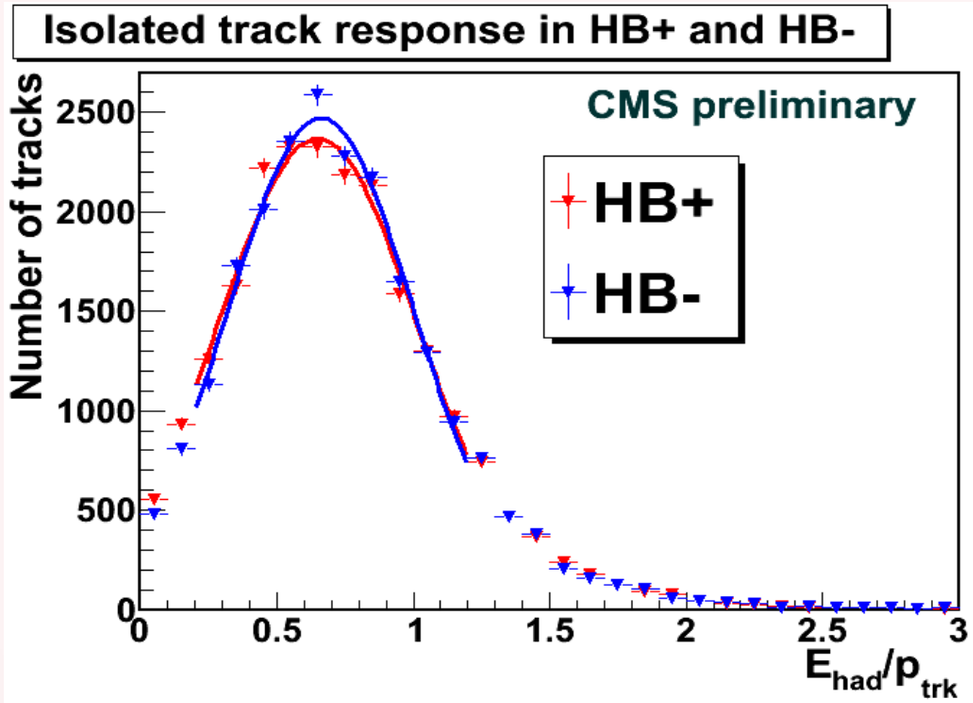
CMS Experiment at LHC, CERN
Run 133450 Event 16358963
Lumi section: 285
Sat Apr 17 2010, 12:25:05 CEST

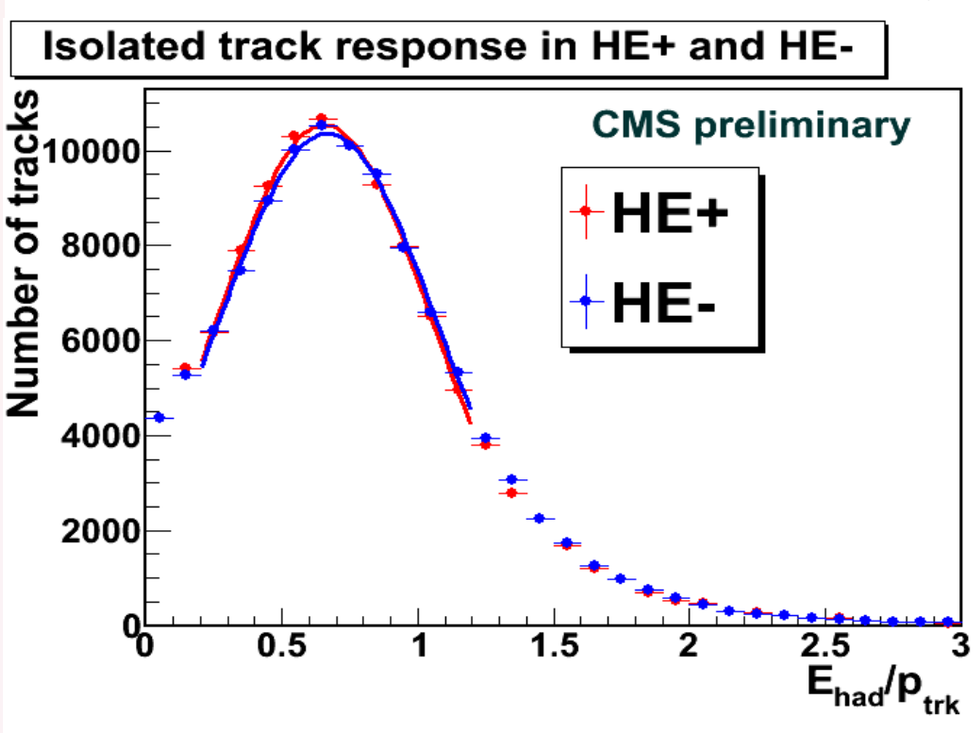
Jet1 p_T : 253 GeV
Jet2 p_T : 244 GeV
Dijet Mass : 764 GeV





HCAL Calibration
Response to Isolated Tracks in HB± and HE±





	mean	RMS	peak
HB+	0.728±0.003	0.393±0.003	0.650±0.004
HB-	0.737±0.003	0.388±0.003	0.661±0.004

Symmetric response ± z

	mean	RMS	peak
HE+	0.757±0.001	0.453±0.001	0.656±0.002
HE-	0.766±0.001	0.454±0.001	0.669±0.002

Uncertainties are statistical. Systematics (under study) will dominate

Fermilab: large group of scientists and RAs

Dijet Physics: Jet Commissioning

- Jet observables are getting ready for physics analysis
  - Three different approaches:
    pure calorimetric, track corrected calorimeter and particle flow.
    - anti-kT R=0.5 algorithm, Dijet selection: Jet Pt > 25 GeV, $\Delta\Phi > 2.1$, $|\eta| < 3$
  - At 7 TeV / 10 pb^{-1}: expect sensitivity M(q*) ~ 1.2 TeV, Λ ~ 3 TeV.

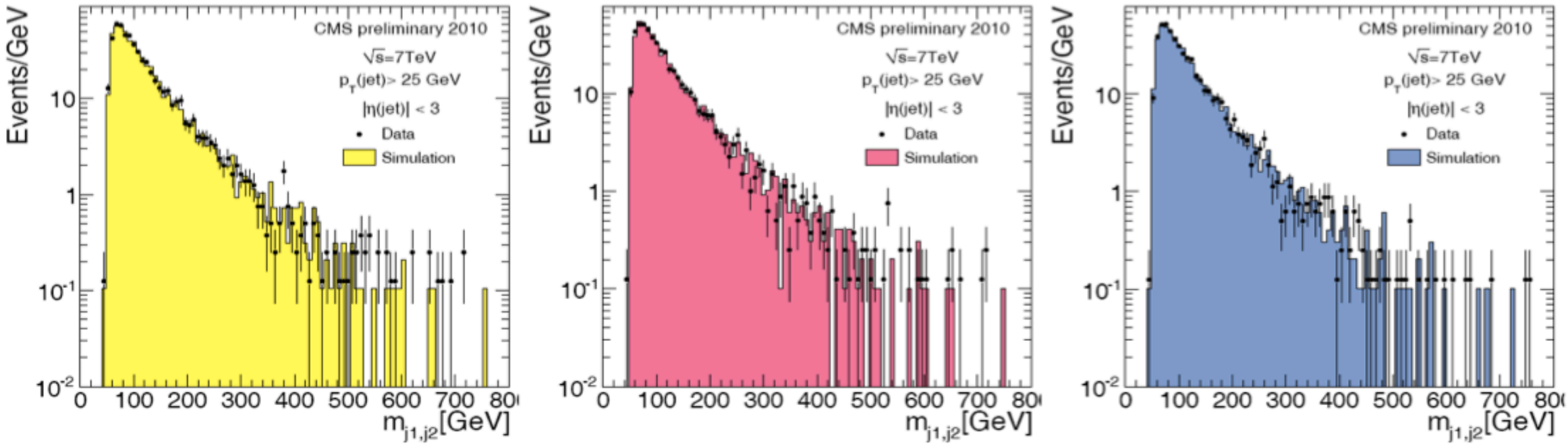
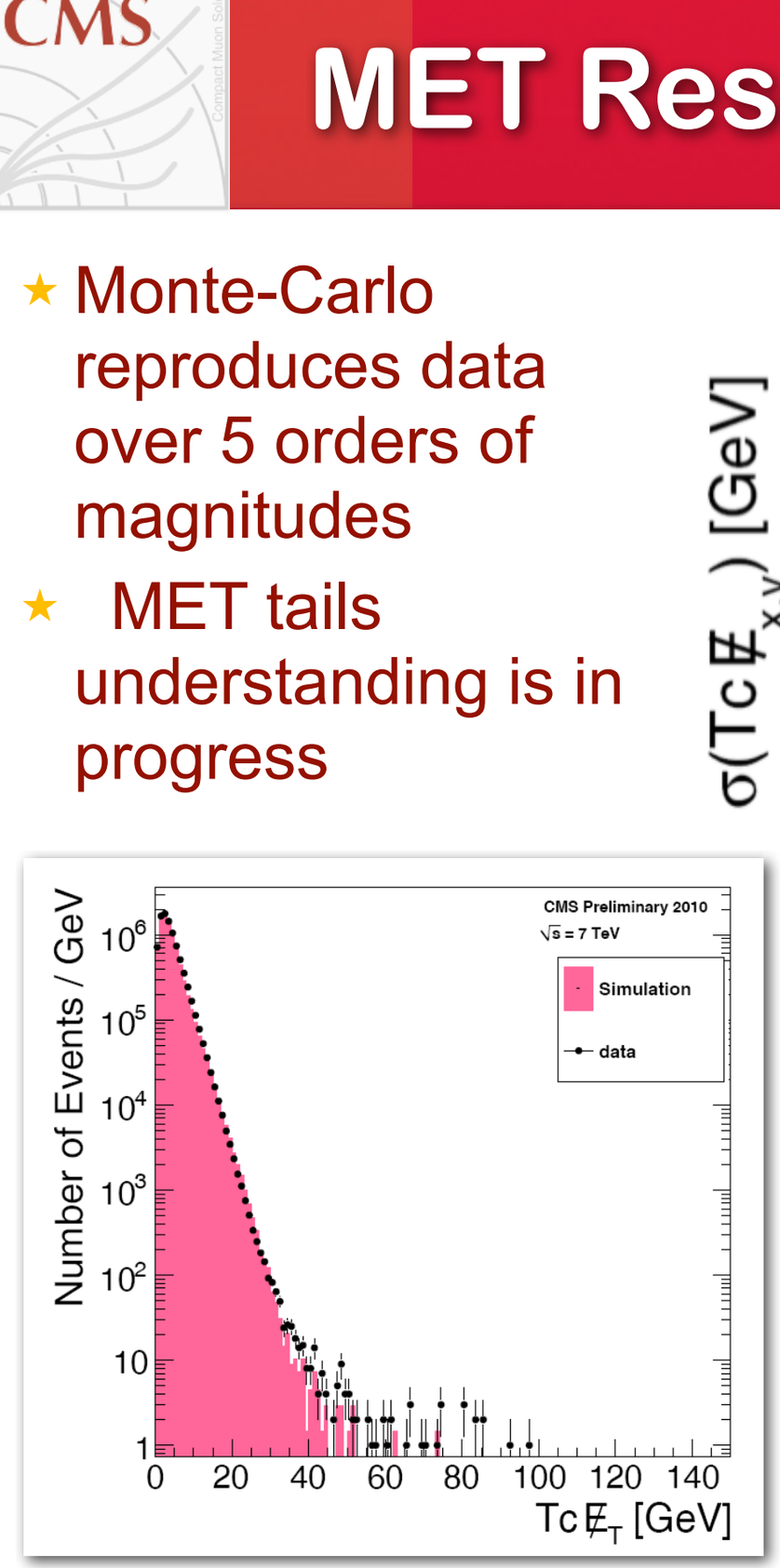
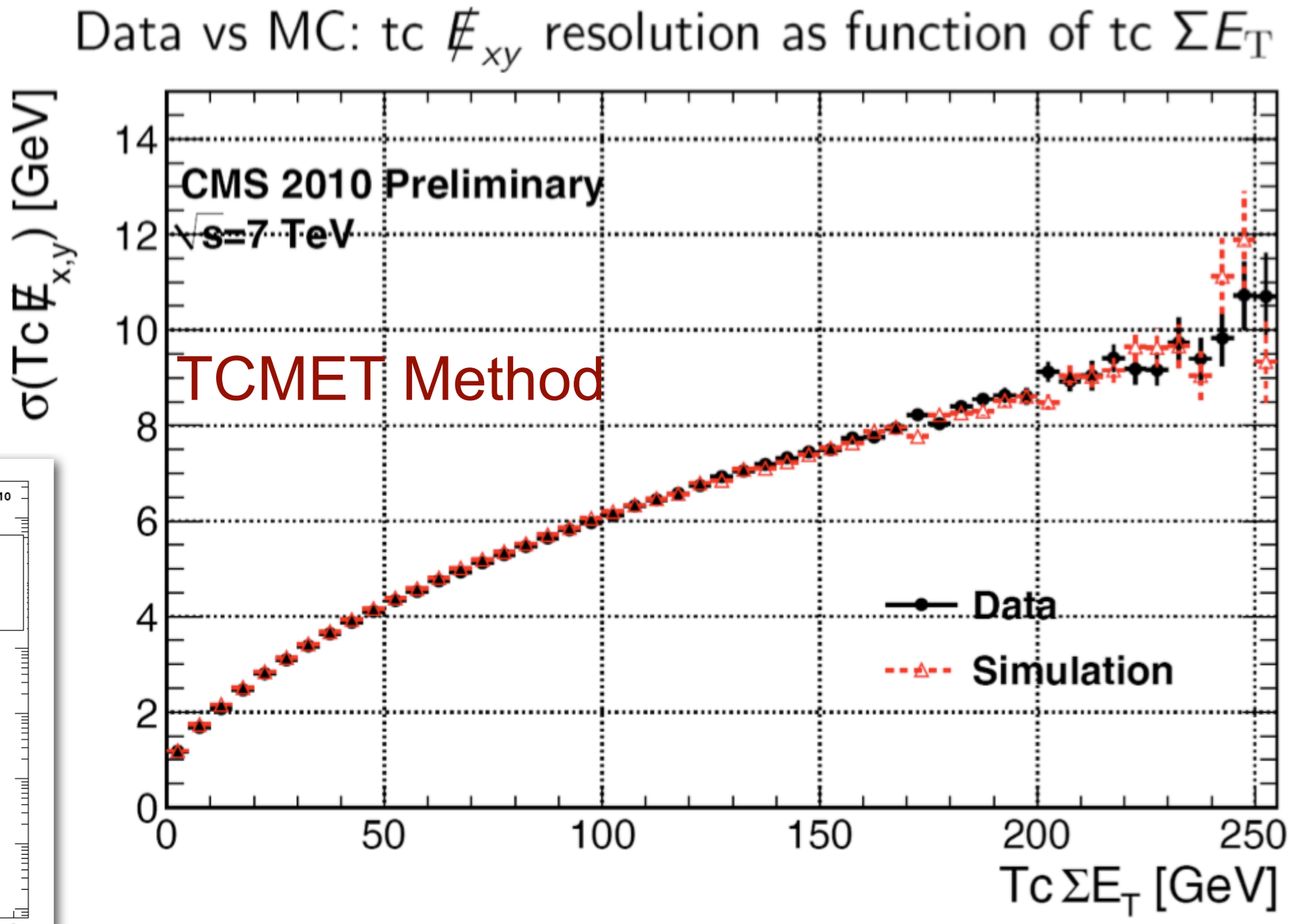


Figure: Data vs MC: Di jet mass $m_{j1,j2}$ for Calorimeter Jets, JPT jets, PFjets.

MET Resolution and Cleanup

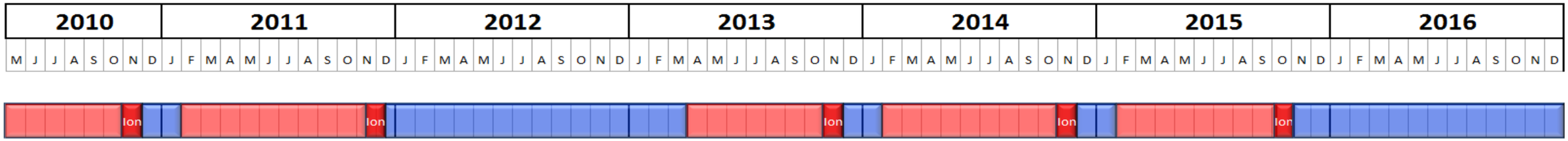
- Monte-Carlo reproduces data over 5 orders of magnitudes
- MET tails understanding is in progress





Fermilab: TCmet: B.Hooberman
MET: R.Harris et al

LHC 10-year Technical Plan For Running and Upgrades



X-Mas maintenance

Machine: Splice Consolidation & Collimation in IR3

ALICE - detector completion

ATLAS - Consolidation and new forward beam pipes

CMS - FWD muons upgrade + Consolidation

LHCb - consolidations

X-Mas maintenance

X-Mas maintenance

Machine: Collimation & prepare for crab cavities & RF cryo system

ATLAS: nw pixel detect. - detect. for ultimate luminosity.

ALICE - Inner vertex system upgrade

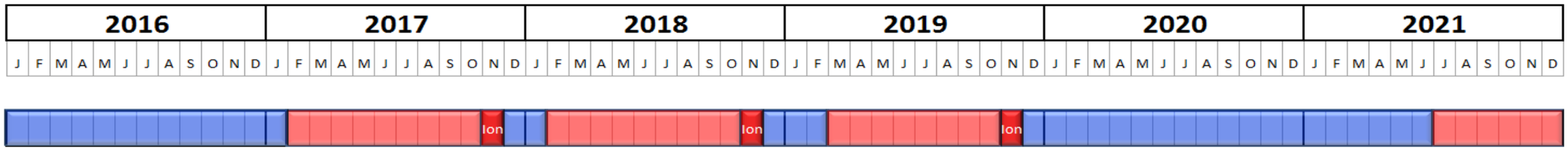
CMS - New Pixel. New HCAL Photodetectors. Completion of FWD muons upgrade

LHCb - full trigger upgrade, new vertex detector etc.

SPS upgrade

SPS upgrade

SPS - LINAC4 connection & **PSB** energy upgrade



Machine: Collimation and prepare for crab cavities & RF cryo system

ATLAS: new pixel detect. - detect. for ultimate luminosity.

ALICE - Inner vertex system

CMS - New Pixel. New HCAL Photodetectors. Completion of FWD muons upgrade

LHCb - full trigger upgrade, new vertex detector etc.

X-Mas maintenance

X-Mas maintenance

Machine - maintenance & Triplet upgrade

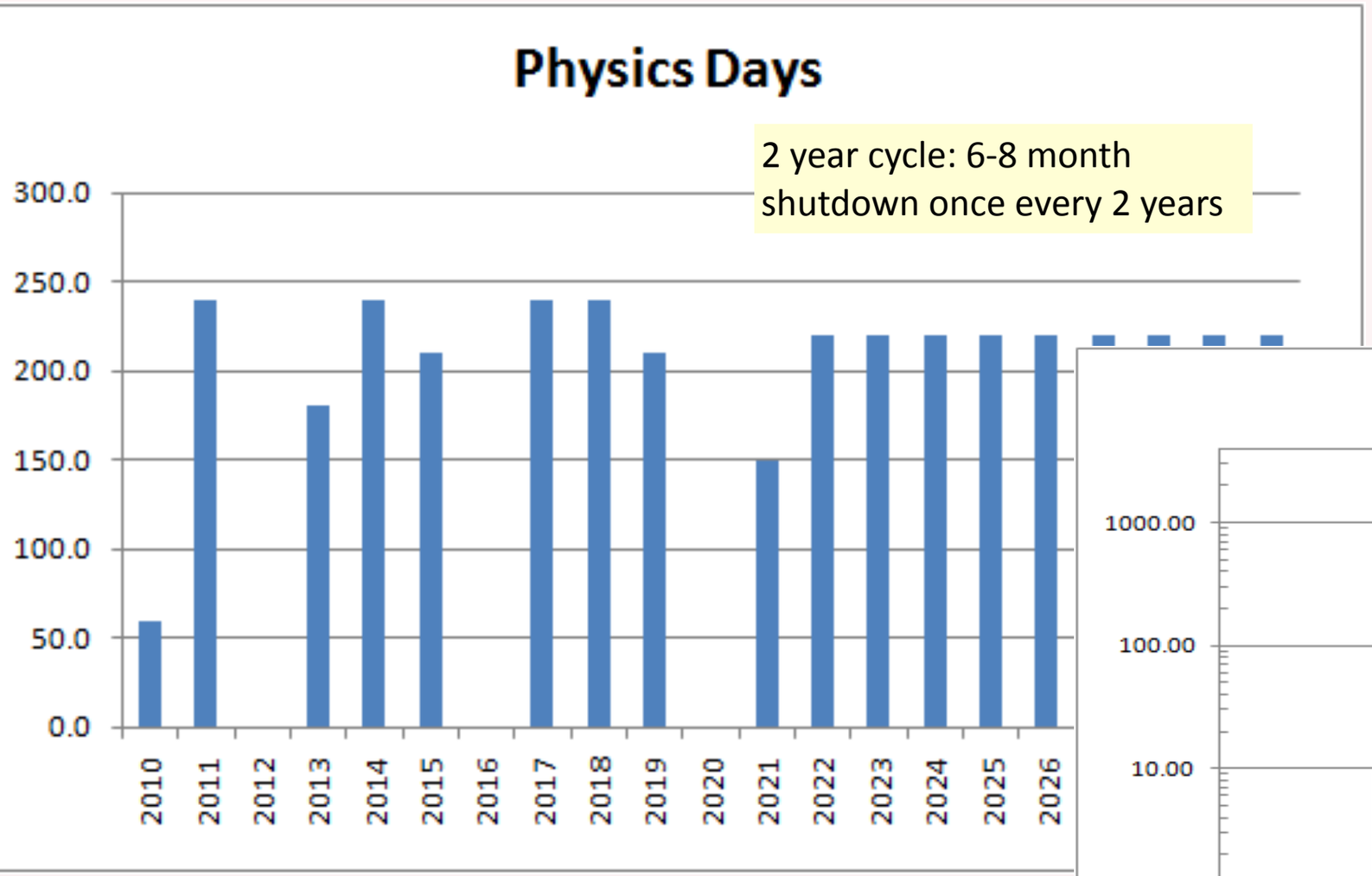
ATLAS - New inner detector

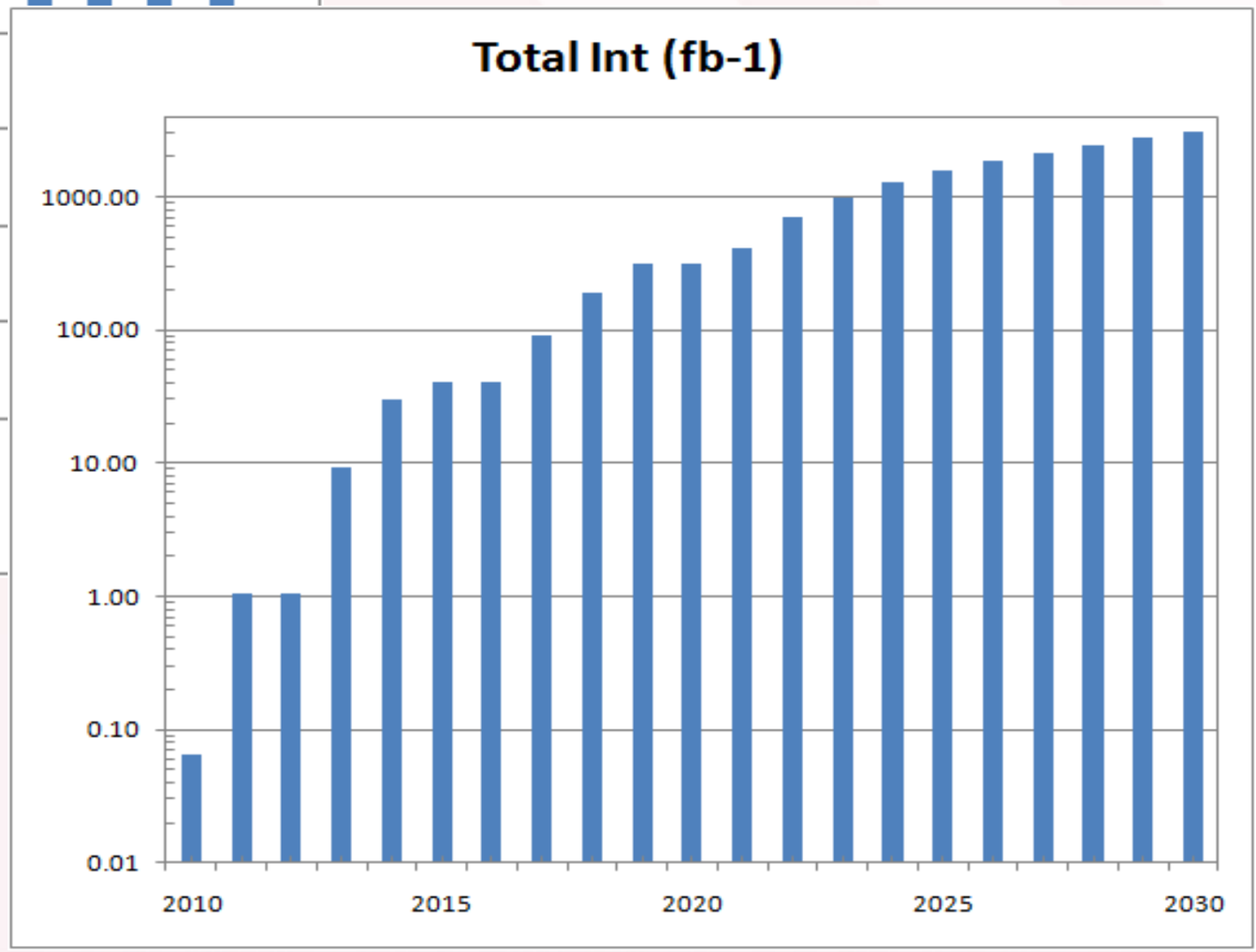
ALICE - Second vertex detector upgrade

CMS - New Tracker

SPS - LINAC4 connection & **PSB** energy upgrade

LHC Preliminary Estimated Integrated Luminosity Expected





Fermilab and 2012 Shutdown

- Fermilab has two major projects to help deliver
  - Hadron Outer Calorimeter: replace HPDs (don't work well in the magnet 0.2T fringe field although they work fine in full 3.8T field) with a commercial Silicon Photomultiplier from Hamamatsu
    - These are avalanche photodiodes operating in Geiger mode
    - sold under the name MPPC (MultiPixel Photon Detector –used in photon counting applications such as PET scanners)
    - Fermilab and India doing this project, will likely be joined by several German institutions
    - Fermilab is leading this project
  - Hadron Forward Calorimeter: replace PMTs with newer PMTs from Hamamatsu
    - Fermilab will do electronics

Fermilab Upgrade R&D for 2016

- Forward Pixel Detector
  - Cooling
  - Mechanics
  - Electronics
  - Assembly and integration
- HCAL
  - Leading R&D on next generation of SiPM
    - More radiation hard
    - More pixels
    - Faster reset time
  - Fermilab will do the front end electronics for the upgrade of the barrel and endcap hadron calorimeter
  - Fermilab will probably lead this project

LHC Physics Center at Fermilab: Overview of the LPC

- Effective remote collaboration is an LHC Challenge
  - Particularly difficult for university groups to be plugged in to day-to-day LHC activities
- Several paths available:
  - Place folks @ CERN
  - Base @ Home Institute
  - Place @ a Regional Center
  - All three options can work!
- The LPC provides the Regional Center in the U.S.
  - by providing a physical space, access to experts, critical mass, an intellectual community, access to computing, etc
- The LPC is all about Engagement

LPC Mission

- The LPC serves CMS
  - Is the Local (FNAL) Center of Excellence for CMS Physics
- The LPC lowers the barrier for directly contributing to CMS -- Economically and transparently
  - Provides direct connections to CMS Physics Organization
  - Provides proximity to outstanding resources
    - computing, software, expertise, intellectual
  - Enables smaller groups to attain critical mass
- The LPC has no real precedent
  - Scale and complexity of CMS unprecedented
  - Collaboration has been essential to get this far
  - By engaging more of the collaboration, more is achieved
  - New forms of engagement needed to enable discoveries
- The LPC will evolve along with CMS
  - transition from detector construction to data analysis

"A shared vision and tight coupling between CMS, the LPC, and the University Community ensures the added-value of the LPC and its status as a cherished CMS resource"

LPC Organization

- New LPC Leadership:
  - I.Shipsey/Purdue and R.Cavenaugh/Fermilab and UIC replacing D.Green
  - significant adjustments in LPC approach
- Shared Governance:
  - Broadened management team through creation of the LPC Management Board to incorporate all stakeholders CMS, USCMS, FNAL.
  - Example: Gigi Rolandi Physics Coordinator is an active member.
- Created LPC Guest Program Committee
  - involving all stakeholders in selection of guests and visitors
- Re-organization of physics groups @ LPC following these guiding principles:
  - a) each group is an **integral part of the corresponding CMS physics organization group**
  - b) self-organized **locally at LPC**: format is **“for the physicists by the physicists”**

LPC Leadership and Participation

- **FNAL Scientists leading groups at the LPC**

Liz Sexton-Kennedy: CMS Deputy Offline Coordinator
Rob Harris: CMS Jet+MET Physics Object Convener
Kevin Burkett: CMS Tracking Physics Object Convener
Frank Chlebana: CMS HCAL Detector Performance Convener
Jeff Berryhill: CMS Vector Boson Task Force Coordinator
Daniel Elvira: CMS All-Hadronic SUSY Coordinator

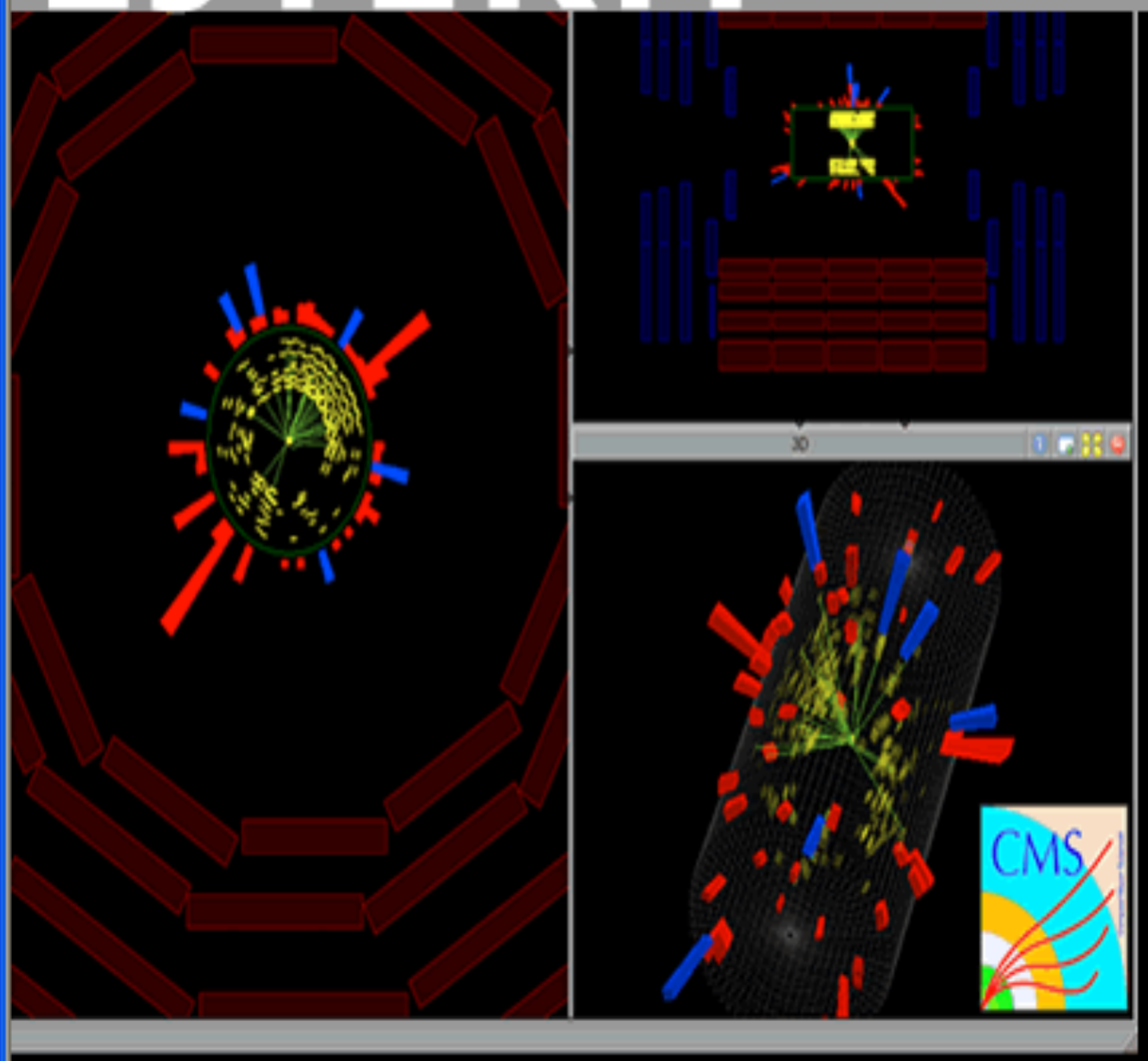
University Scientists at LPC

Ian Shipsey: CMS Quarkonia Task Force Coordinator
Yurii Maravin: CMS W/Z + Gamma Coordinator
Marat Gagaullin: CMS Higgs to gamma-gamma Coordinator
Yuri Gerstein: CMS High-pT Photons Coordinator
Sudhir Malik: CMS Documentation Convener

Universities Actively Participating at the LPC

Brown, Texas Tech, Texas A&M, Purdue, Purdue-Calumet, Johns Hopkins, Nebraska, Kansas, Kansas State, Mississippi, Vanderbilt, Caltech, UC-Davis, Rutgers, Florida State, Florida International, Univ. Ill. Chicago, Rockefeller, Wayne State, Baylor, Boston, UCLA, Iowa, MIT, Buffalo, Puerto Rico, Rochester, ...

EJTERM https://www.physics.purdue.edu/particle/ejterm/



EJTERM Jan 5-9 2010 at LPC, FNAL

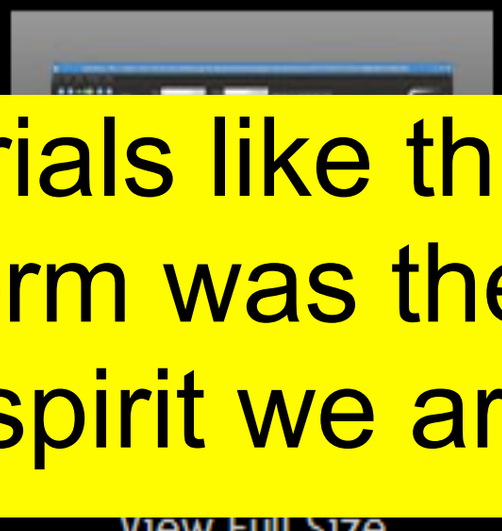
COMMISSIONING AND ANALYSIS OF EARLY DATA WITH CMS

(Due to the LHC turn on this webpage is still under construction)

Registration for EJTERM and the agenda are at:
http://indico.cern.ch/conferenceDisplay.py?confId=69600
(Please note: to register a CERN e-mail (NICE) account is required.)

Speakers for opening session

- Joe Lykken FNAL "The Really Big Picture"
- Eric Prebys FNAL "LHC in Context and Current Status"



View Full Size

Tutorials like this are very successful!
EJTerm was the embodiment of the atmosphere and spirit we are establishing at the LPC.

LPC Fellows Program

- CMS needs to engage more of the collaboration
- Identify and bring, jointly with University community, several leading young CMS scientists to the LPC community ➔ **LPC Fellows**

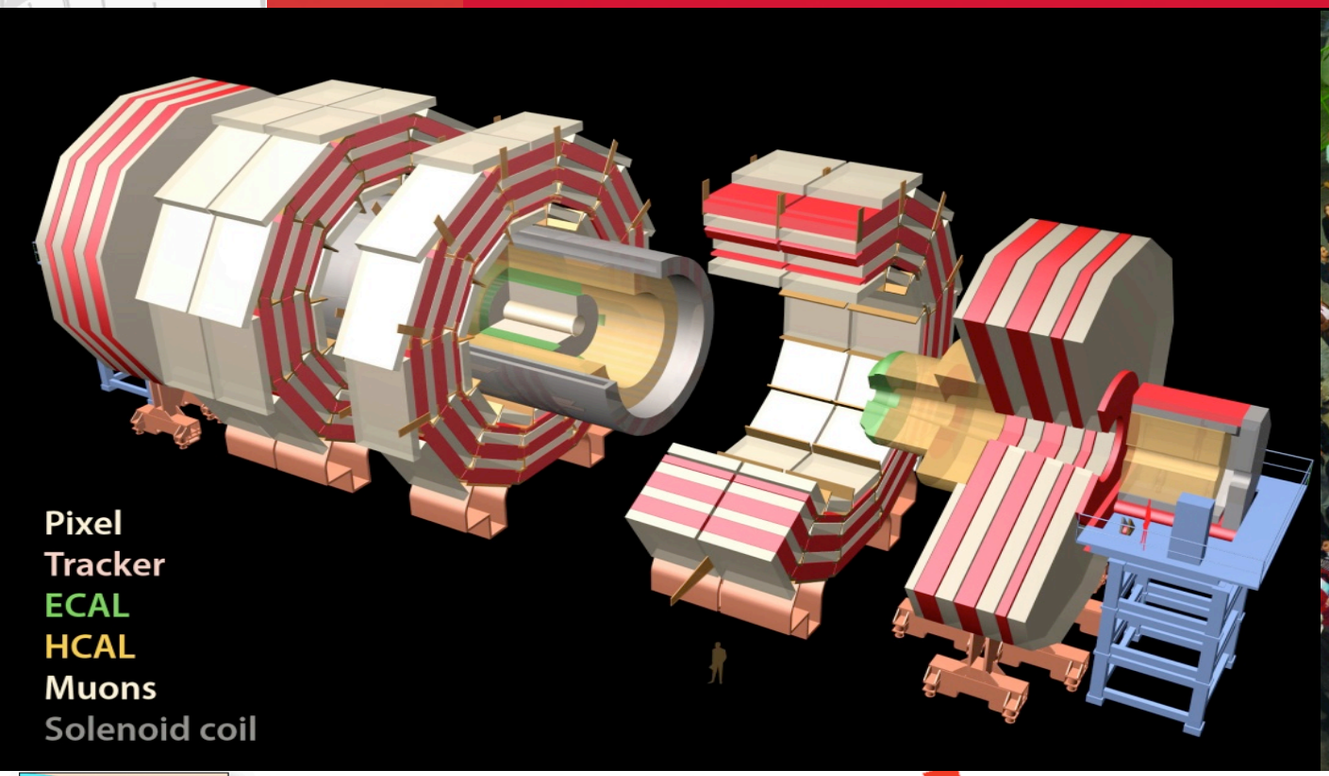
- International competition; Prestigious recognized award
  - build resources in objects and detectors
  - establish and/or lead specific physics analyses
  - help build critical mass & sustain ; help train next generation
- Fellows help ensure that answers to questions are just down the hall
  - Residency requirement 50% at LPC during Fellowship (6 months - 1 year)
  - Open to Faculty, Post-docs, Students (advanced), Lab Scientists
  - First fellows (“guinea pigs”) being identified
  - Program announcement: aim to start the program in the fall
- **EJTerm:** builds human resource capital & helps educate students
- **LPC Fellows:** build object & physics expertise capital utilizing EJTerm student capital

Summary

- Fermilab has crucial and leading roles in CMS, participating in almost all aspects of the experiment
  - Operate and upgrade detectors, software and computing systems
  - Provide first-class facilities for U.S. physicists to participate in CMS
    - Computing Facilities, Remote Operations Center, LHC Physics Center LPC
- Fermilab CMS group has a broad research program
  - Starting from detector commissioning and calibration,
  - Establishing the physics objects and signatures,
  - Re-measuring the standard model, with first discovery potential in the first 2-year run,
  - Toward the exiting discoveries expected beyond the standard model.
- The CMS program will produce exciting science over the coming 15 years, and Fermilab will play a huge part in it

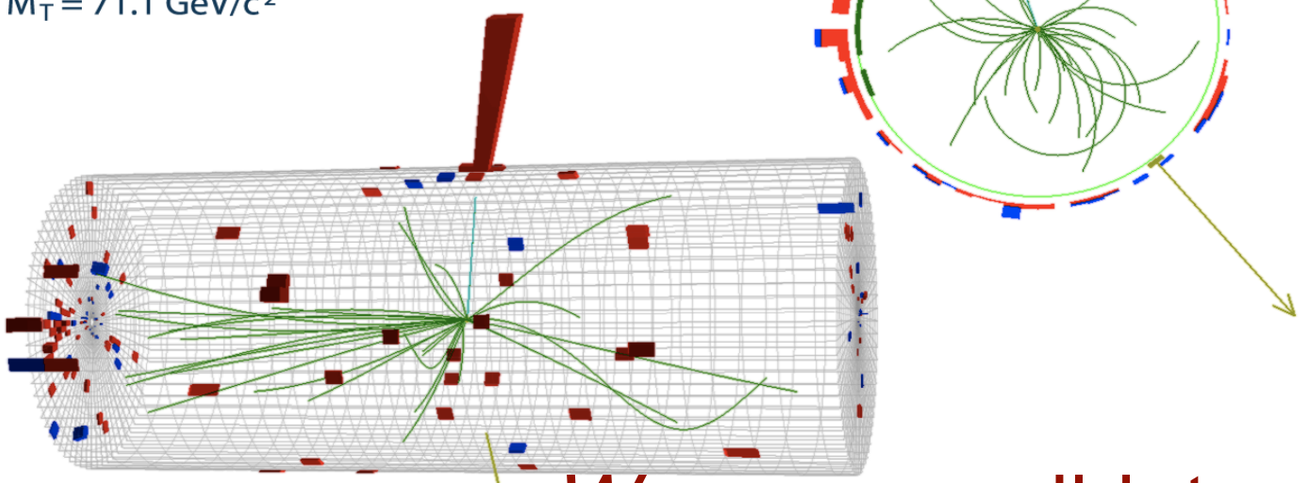
Backup Slides

CMS Experiment



CMS Experiment at LHC, CERN
Run 133874, Event 21466935
Lumi section: 301
Sat Apr 24 2010, 05:19:21 CEST

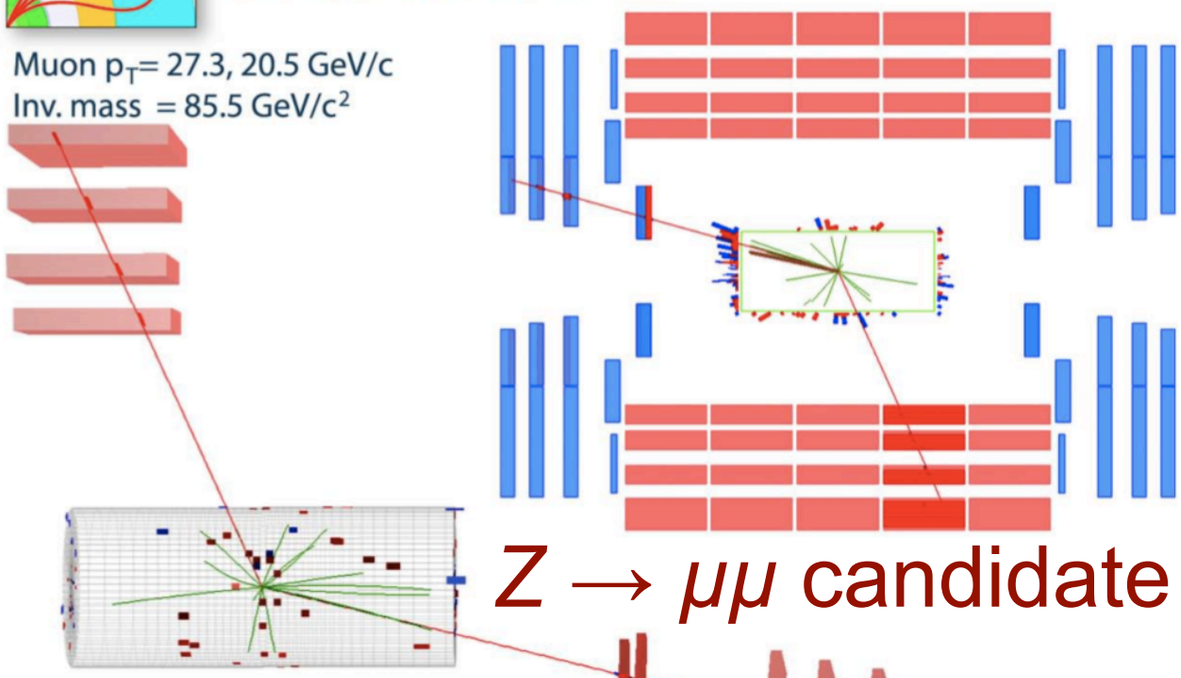
Electron $p_T = 35.6$ GeV/c
$ME_T = 36.9$ GeV
$M_T = 71.1$ GeV/c^2



$W \rightarrow e\nu$ candidate

CMS Experiment at LHC, CERN
Run 136087 Event 39967482
Lumi section: 314
Mon May 24 2010, 15:31:58 CEST

Muon $p_T = 27.3, 20.5$ GeV/c
Inv. mass $= 85.5$ GeV/c^2



$Z \rightarrow \mu\mu$ candidate

CMS Initial Data Taking Successful

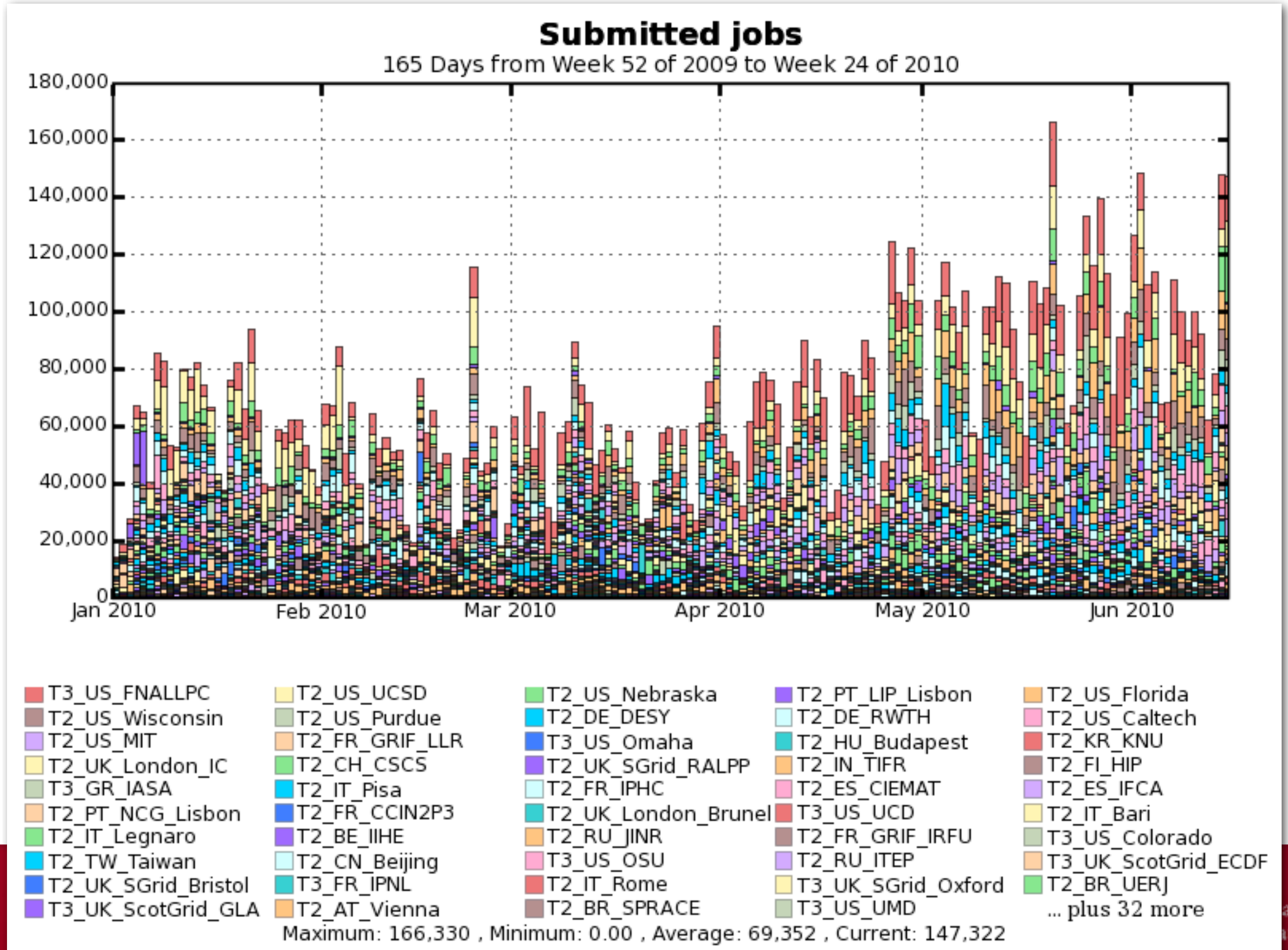
- LHC pilot run (11/23-12/16/2009) at 0.9 and 2.36 TeV
  - Already achieved detailed understanding of detector performance
  - Production of scientific results started within weeks
  - First papers published, more in the pipeline
- Physics run at 7 TeV started 3/30/2010
  - During first 2.5 months CMS operated reliably with ~91% data taking efficiency and collected ~17nb^{-1} of good physics data
- Detector performance results, observation of SM signals
  - shown at conferences, e.g. P-LHC Hamburg this month:
  - Using 16nb^{-1} showed low-mass dimuon resonances, Z and W± observation in muon and electron channel, etc.
  - first 7 TeV paper already published

Expected Development of LHC Program

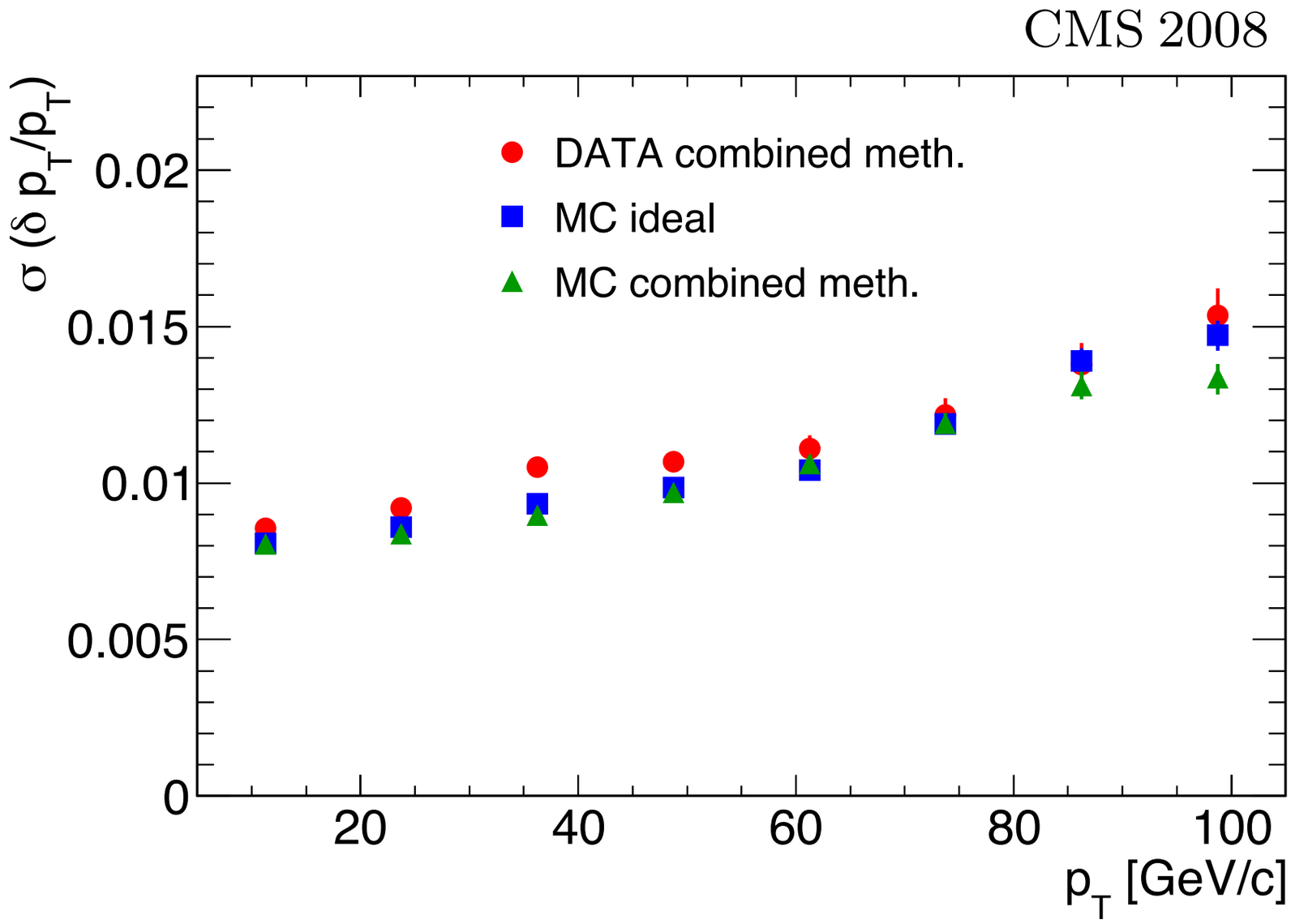
- 2010/11 Physics Run
  - Luminosity goal of 100pb-1 for 2010, and to collect 1fb-1 until end of 2011
- LHC plan being discussed in CERN Council last week
  - Likely to include three shutdowns in the coming decade
- 2012 full-year shutdown
  - To finish repairs to allow the machine to reach full energy
- 2015 full-year shutdown, could be a year later
  - To install components needed to reach design luminosity and beyond
    - Connection of Linac 4, installation of additional collimators
- ~2020 shutdown
  - Major changes to the machine to reach highest possible LHC luminosity
  - Probably a two year shutdown
- CMS upgrade plans aligned with these plans
  - R&D well underway, technical proposal being prepared now

Large Load on Analysis Job Submission

- jobs being submitted from some 49 T2s + 32 T3s; ~> 100,000 jobs/day!



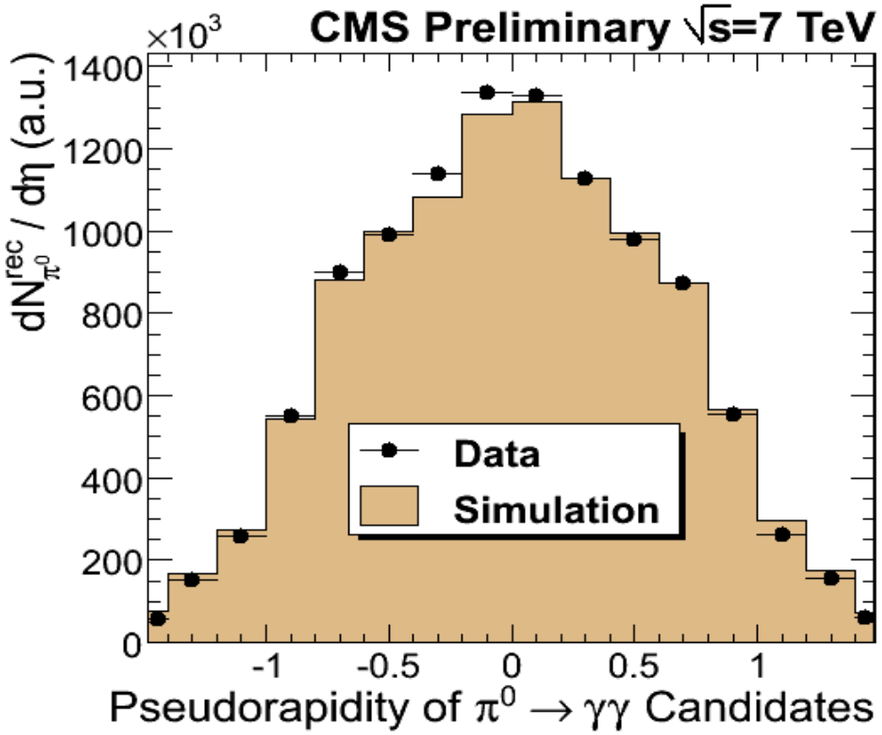
Momentum Resolution (from cosmic μs)

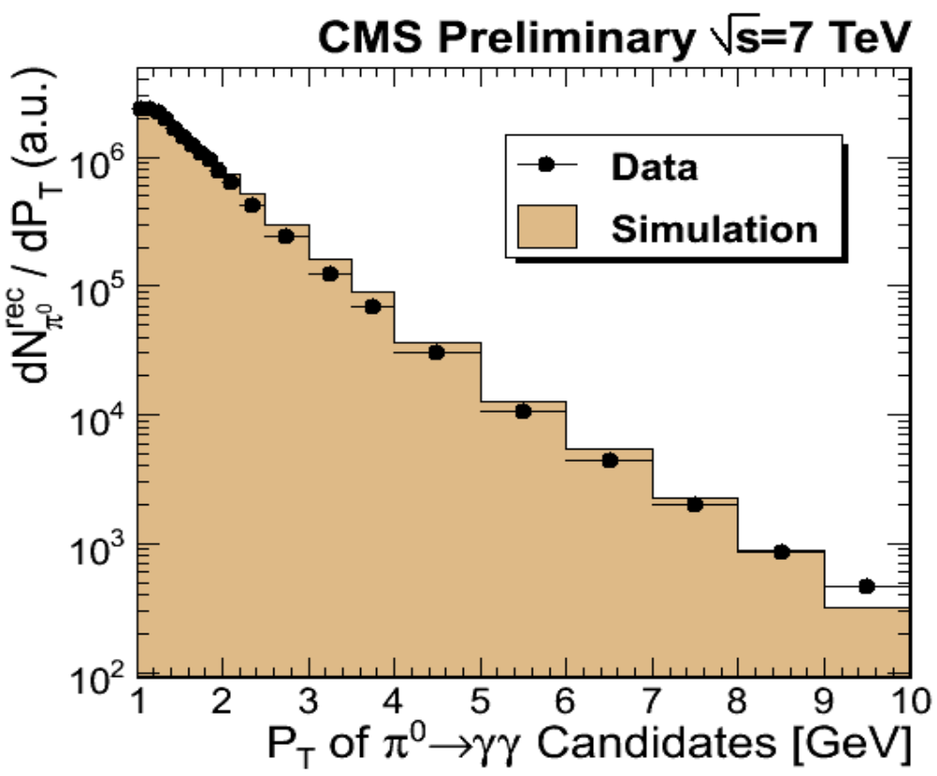


- this is from cosmic μs in the barrel. Believing the MC agreement and extrapolating over all eta, the momentum resolution is in the range of ~ 1-3%/GeV

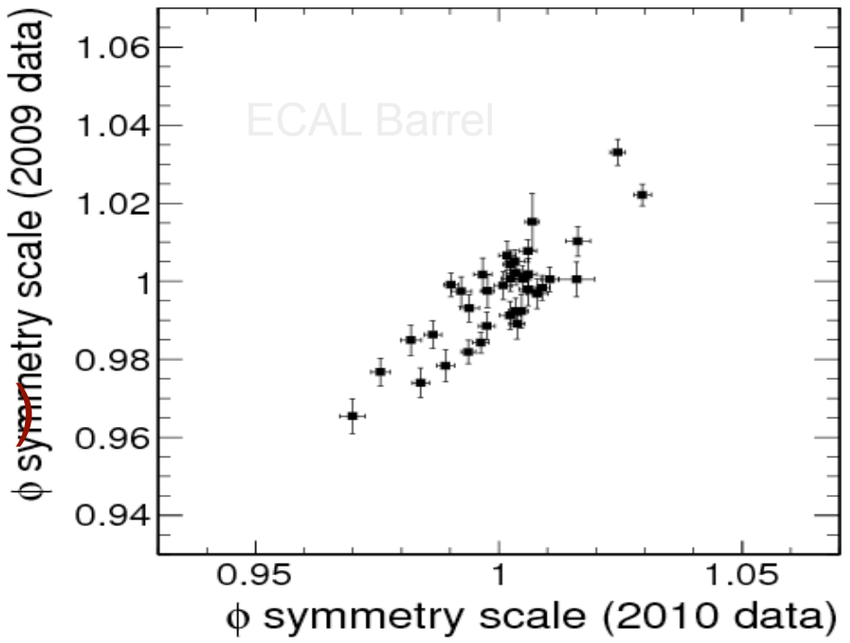
π^0s and ECAL calibration

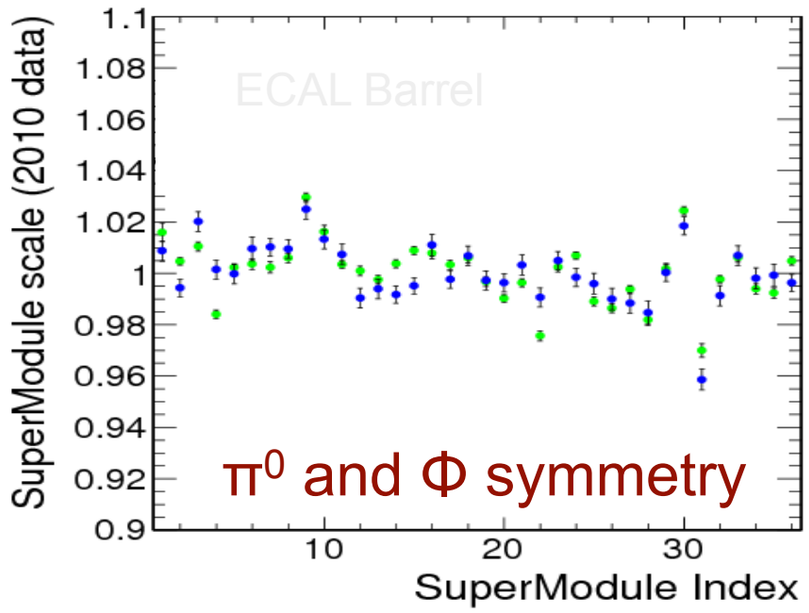
$\pi^0 \rightarrow \gamma\gamma$
η, Φ
distributions



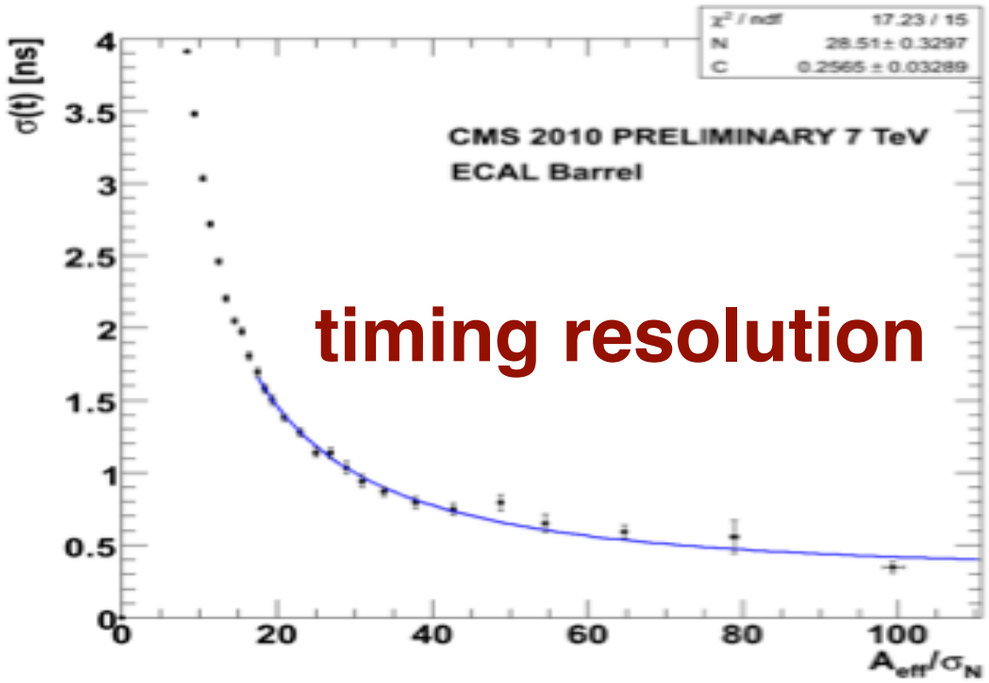


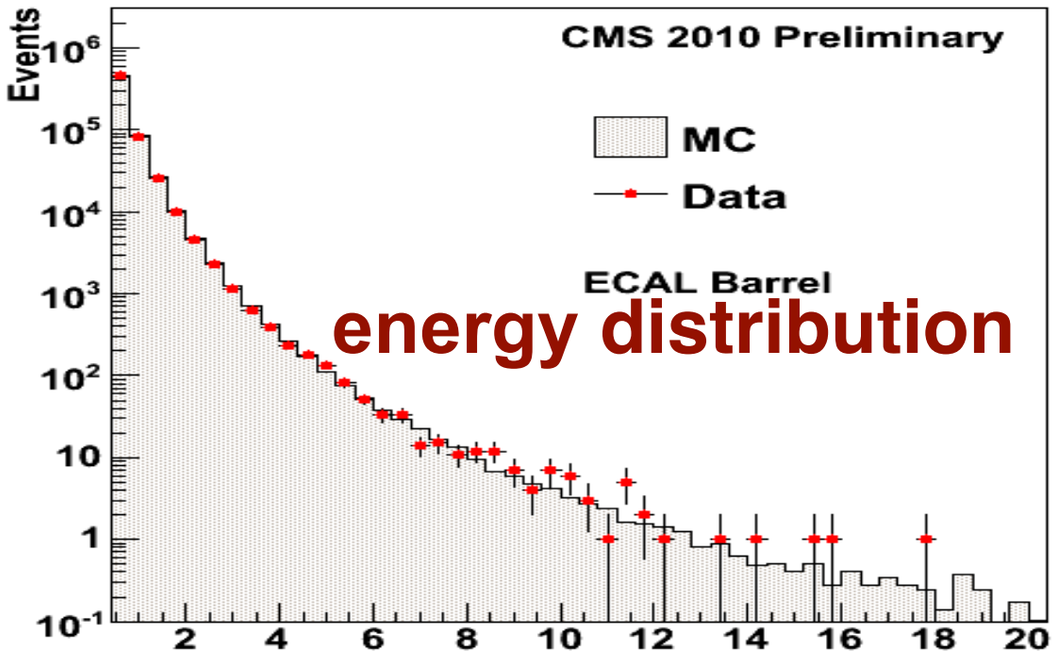
Relative calibration precision ~ 2%
(target ~ 0.5% at 10pb^{-1})

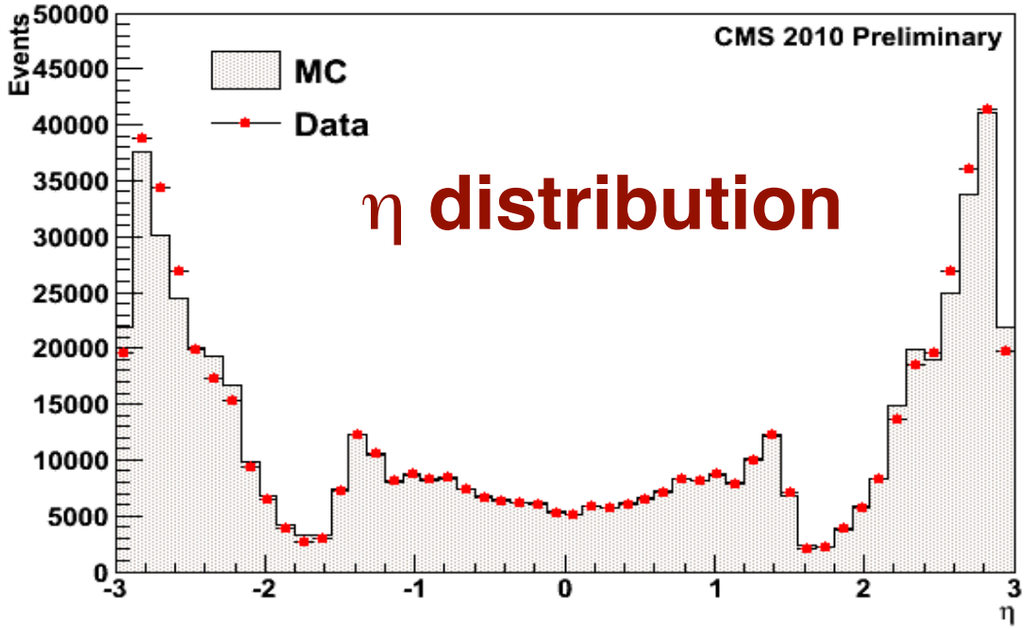


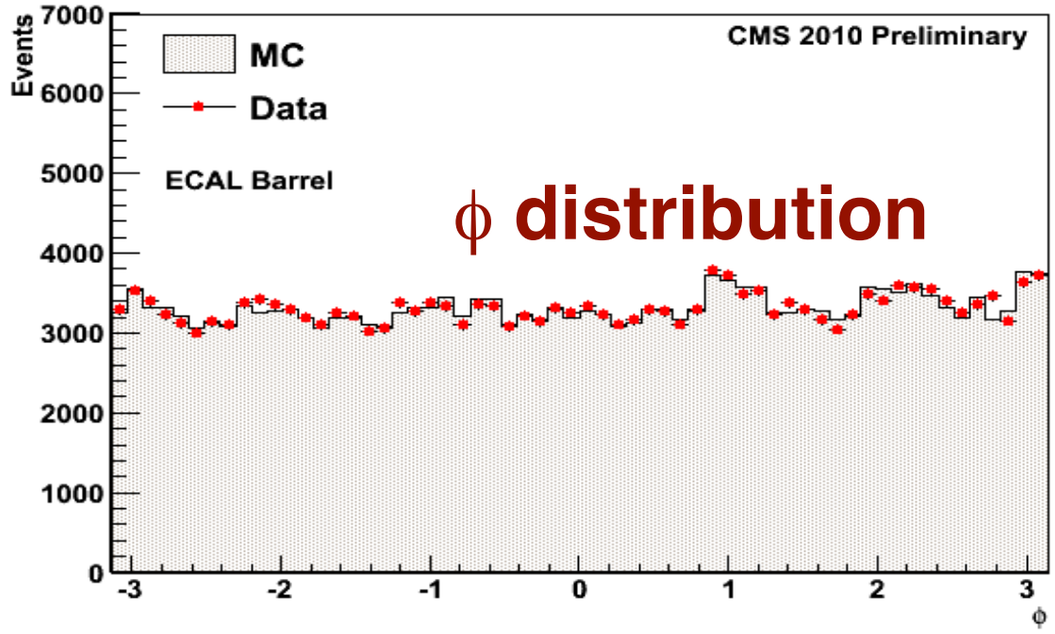


ECAL clusters (electrons and photons)







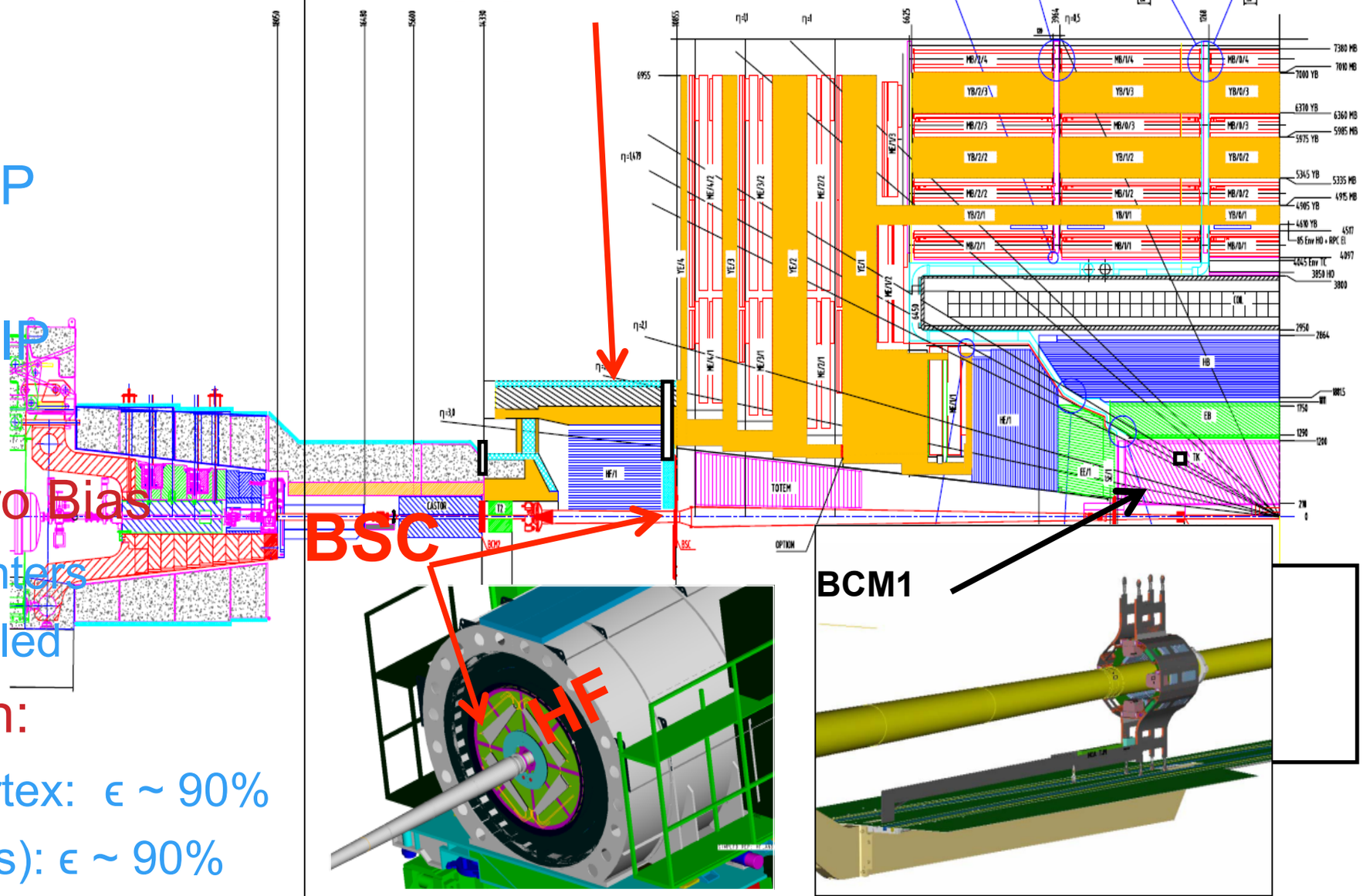


Minimum Bias Triggers

–HF: 2.5 ≤ |η|≤ 5.

–BSC: ± 10.5 m from IP

–BPTX: ± 175 m from IP



Trigger: Min Bias & Zero Bias

–L1 Beam Scintillator Counters

–L1 Trigger “BPTX” prescaled

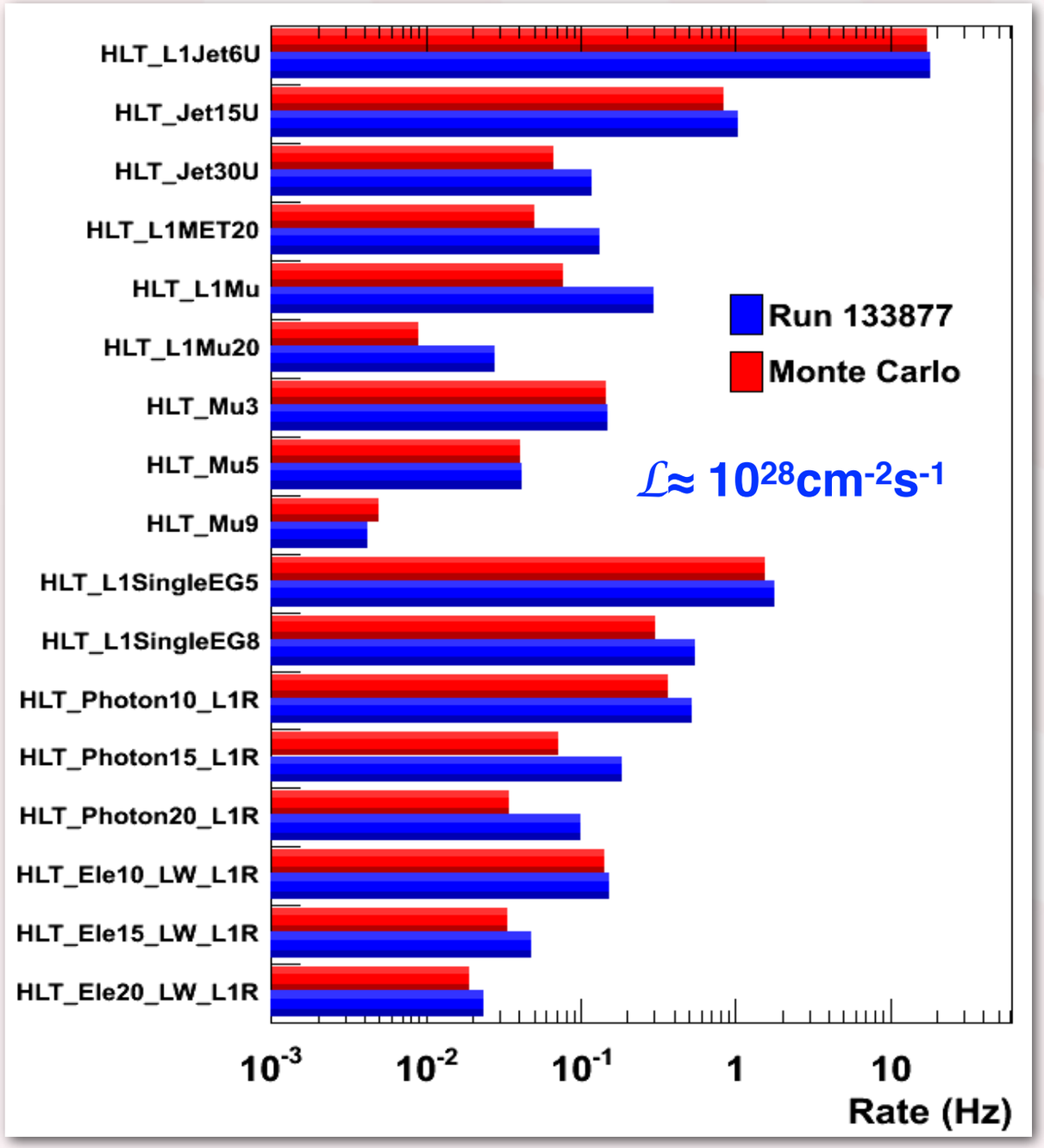
Minimum Bias selection:

–BSC (OR 2 planes) + vertex: ϵ ~ 90%

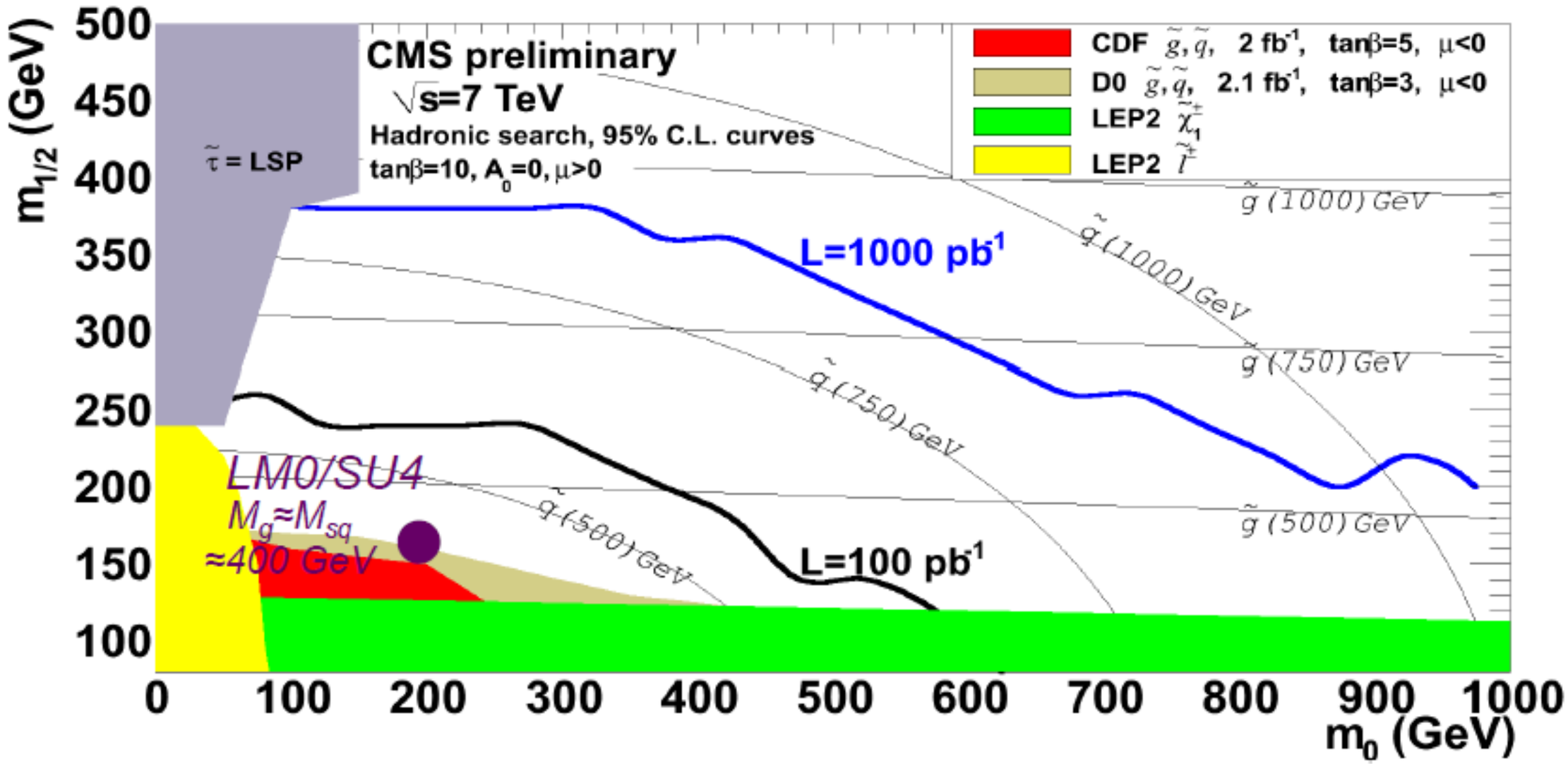
–HF (E > 3 GeV both sides): ϵ ~ 90%

DAQ , L1 and HLT Triggers

- L1/DAQ RUN FLAWLESSY
  - L1 ~ 1KHz, <500 kB/evt,
    HLT ~ 2% CPU loaded
- HLT
  - Farm Capacity ~100 msec/evt
    - Average CPU processing time
      at L1 rate of 50 kHz
  - Up to now we have spent
    ~15 ms/event (min bias dominated)
  - Expect ~ 40 ms/event for a lumi
    of 10^{30} $cm^{-2}s^{-1}$ on average
- Deployed trigger menus for
  10^{27}, 10^{28}, $10^{29}cm^{-2}/s$, $4x10^{29}cm^{-2}/s$
  (developing 10^{30}–$10^{31}cm^{-2}/s$)
  - Rate predictions based on MC & data
  - Primary datasets for $10^{29}cm^{-2}/s$



SUSY sensitivity: inclusive jets + MET



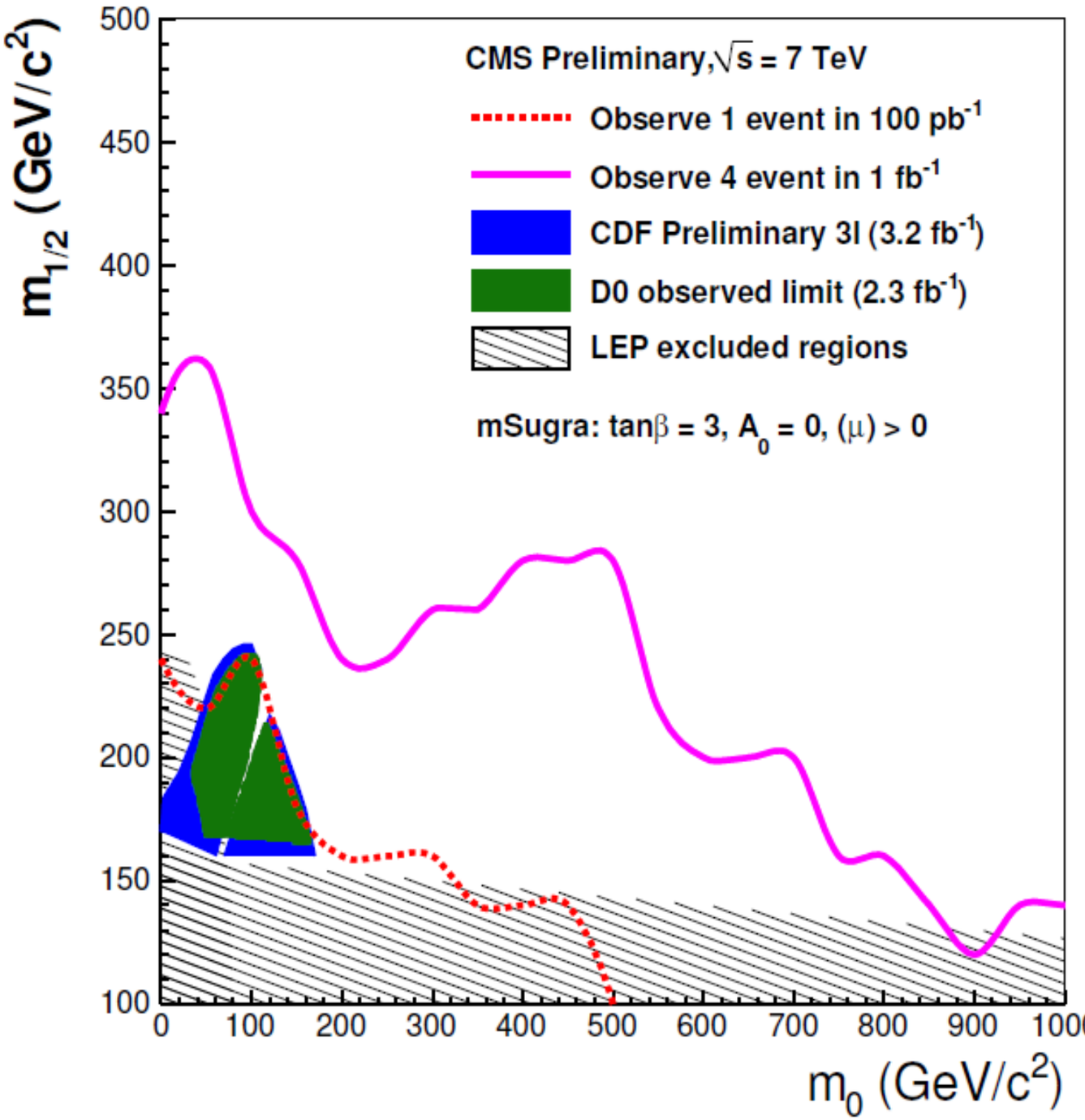
95% CL exclusion-contours of the all-hadronic search (≥3j + MET + lep-veto)

50% uncertainty assumed on SM-Bkg. Surpass Tevatron at ~ 50pb^{-1}

no optimization of selection cuts towards LM0 was performed

(Tevatron data obtained with different tanβ, more data, LEP: direct s-lepton and chargino searches)

Like-Sign Dilepton Search



- 95% CL exclusion-contours of the like-sign di-lepton search

$\mu^{\pm}\mu^{\pm}, e^{\pm}e^{\pm}, e^{\pm}\mu^{\pm}$

Extremely low SM-Bkg.

SM-Bkg ~ 0.4 (4) Events for 100pb^{-1} (1fb^{-1})

Contours:

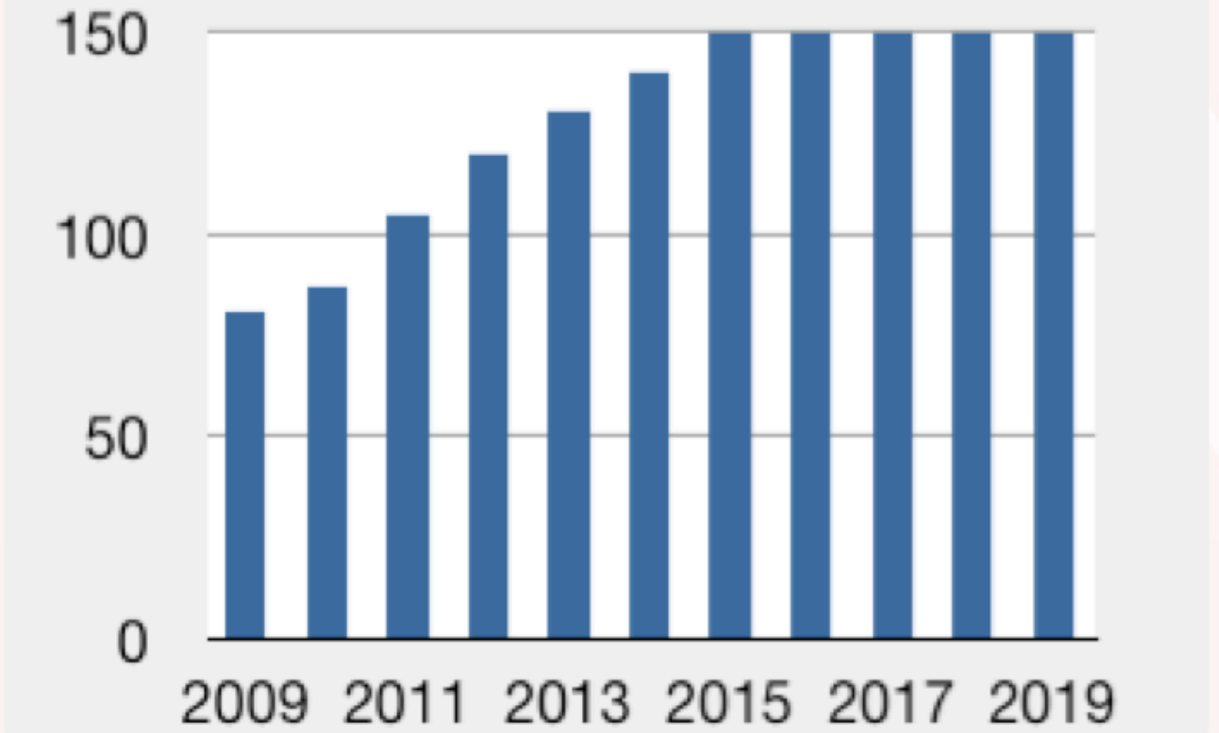
Assuming observation of

- 1 event at 100pb^{-1}
- or 4 Events at 1fb^{-1}

CDF/D0 tri-lepton exclusions

Enter new territory with 100pb^{-1}!

Projected Development of LPC Users at Fermilab



- Estimated that number of resident LPC users from US universities (currently about 75-80) will increase by a factor 2 until the year 2014, with a large uncertainty on this prediction.
- LPC should pick-up expected gradual decrease of UW CERN residents (which is now ~2/3 of US university physicist)
- If we do things right at the LPC, folks will gravitate to it

CMS Physics Organization

Red = US CMS

= FNAL

Physics Coordinator
G. Rolandi
Deputies:
D. Acosta, G. Dissertori

e/γ
P. Meridiani
M. Pieri

Muons
R. Bellan
S. Valuev

Forward Physics
K. Piotrzkowski
H. Jung

QCD
V. O'Dell
F.Sikler

Higgs
A. Korytov
V. Sharma

Jets/MissET
P. Schleper
R. Harris

b-tagging
W. Adam
T.Boccali

Heavy Ions
G. Roland
De Cassagnac

EWK
Monchenault
M.H. Schmitt

SUSY
J. Richman
A. Tapper

ParticleFlow/τ
C. Bernet
S. Gennai

Tracking
K. Burkett
A,. Venturi

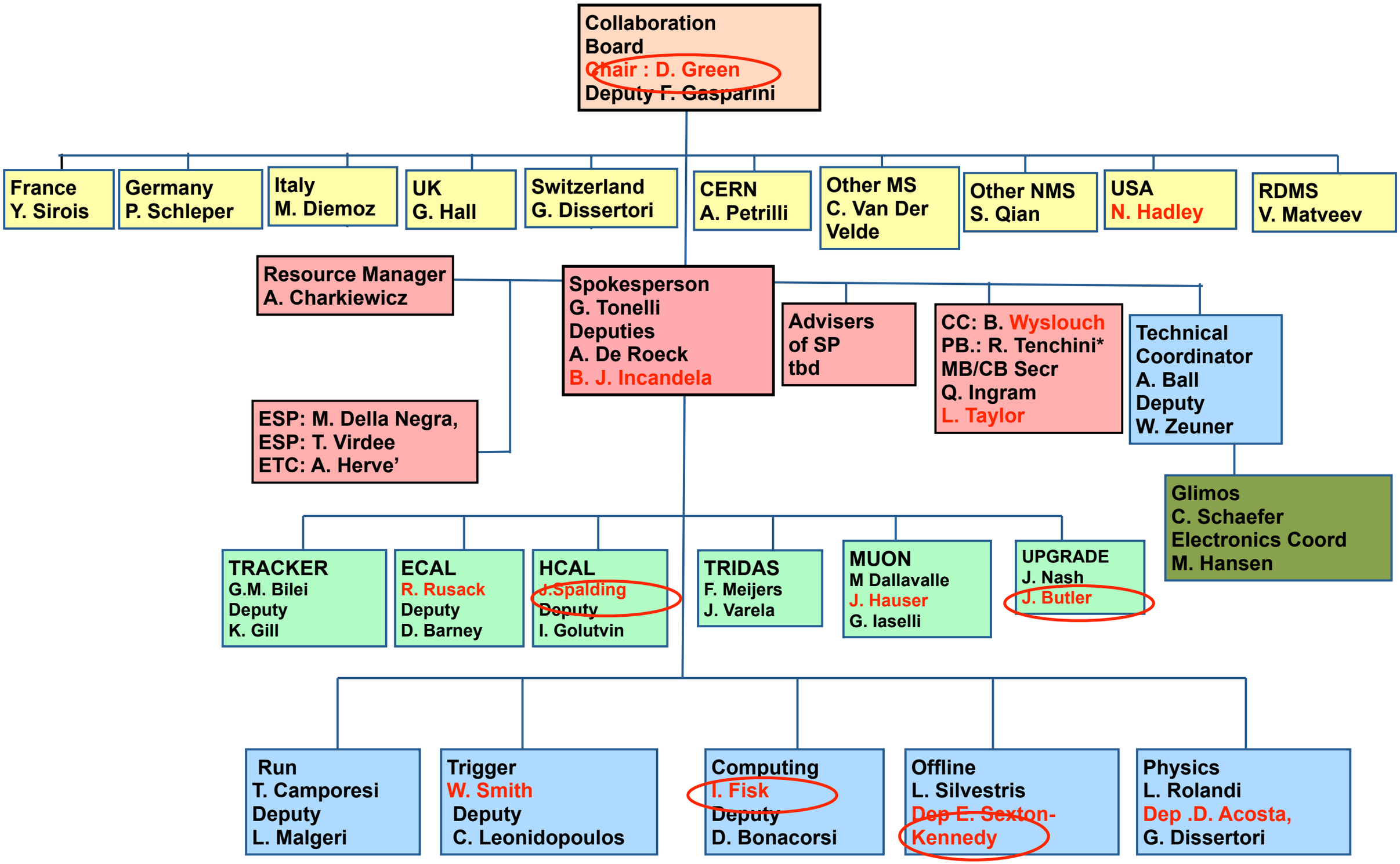
Top
T. Christiansen
F.P.Schlilling

Exotica
G. Landsberg
C. Hill

MC generators
F. Stoeckli
F. Cossutti

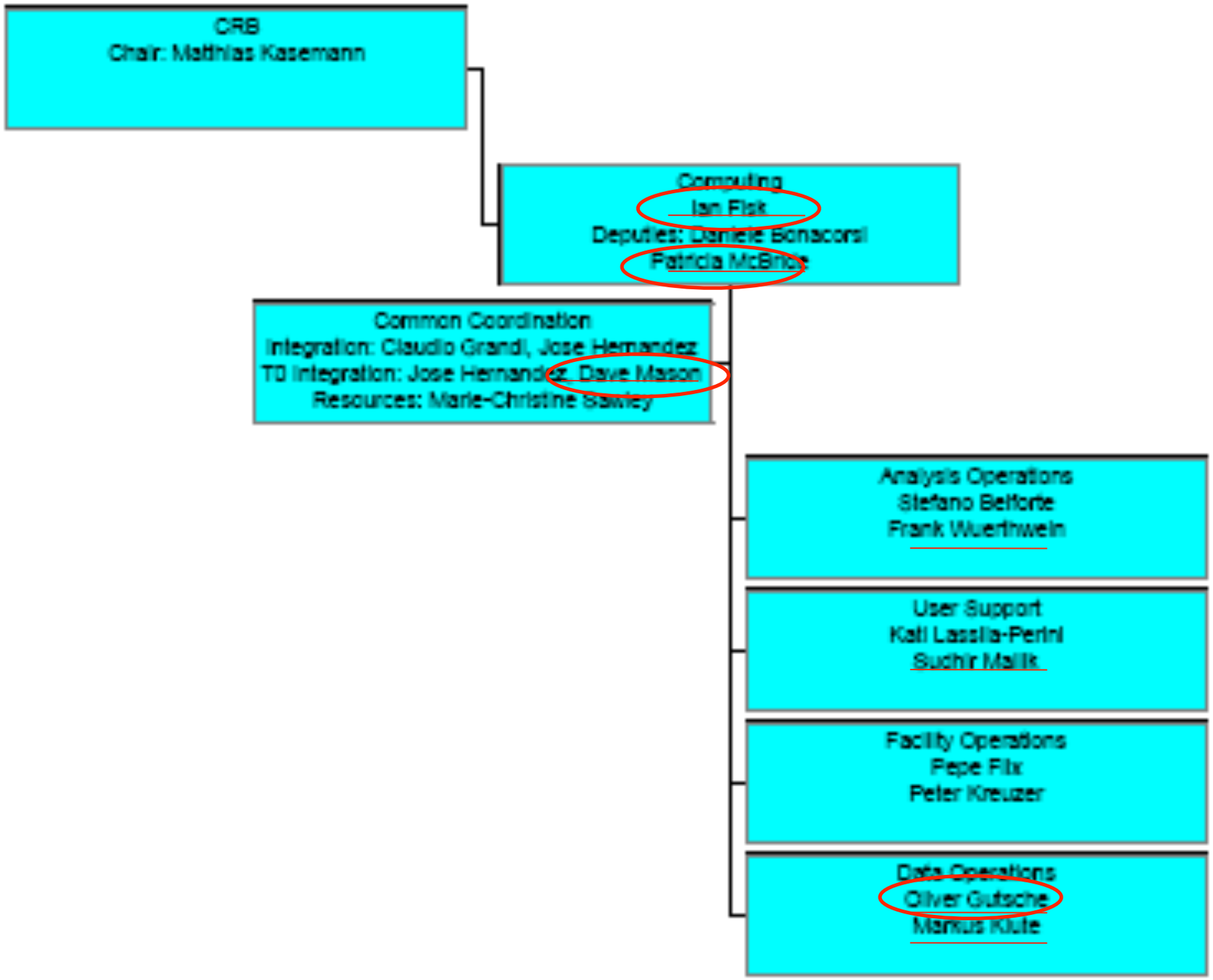
B physics
P. Eerola
C. Lourenco

Management Board 2010

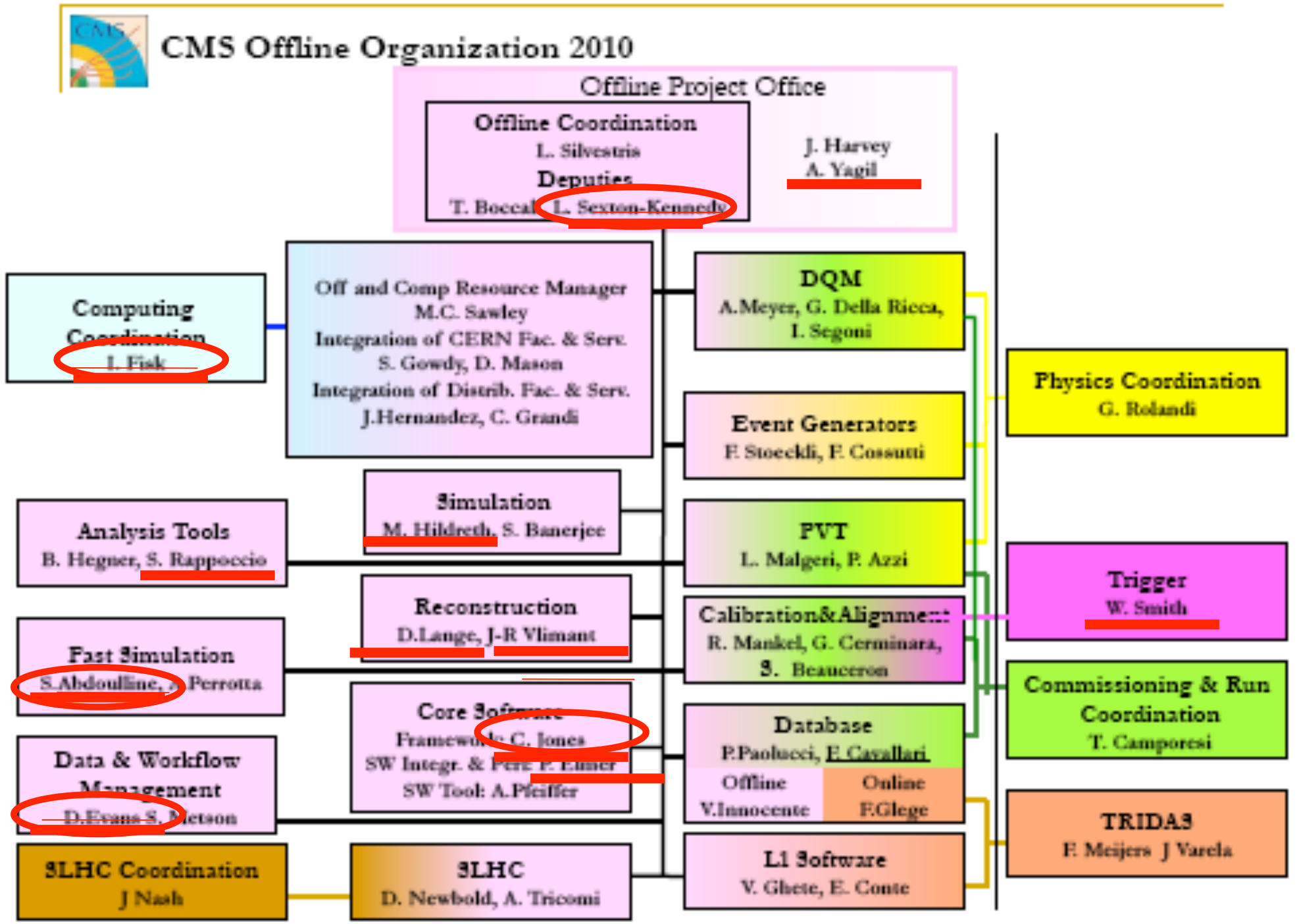


- Still to be endorsed by CB

CMS Computing Organization Chart



CMS Offline Organization Chart



Run coordination 2010