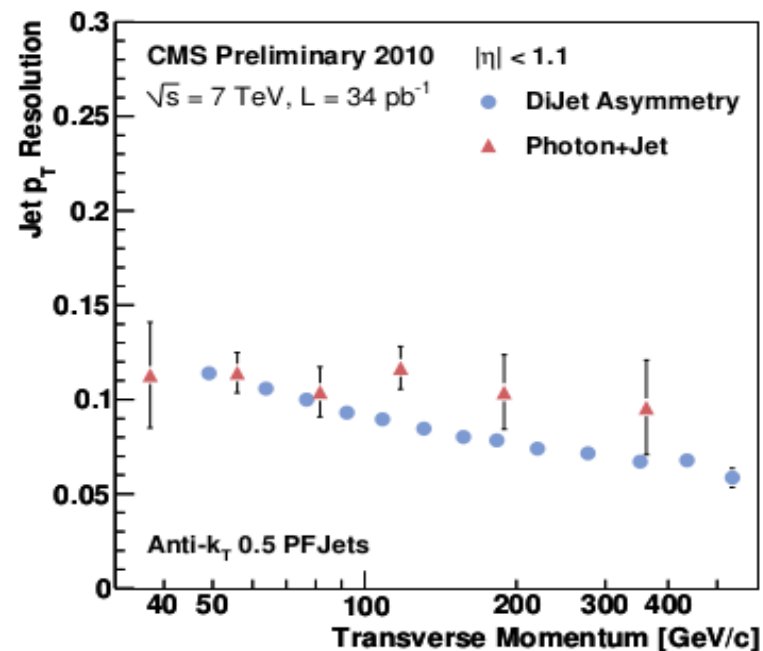
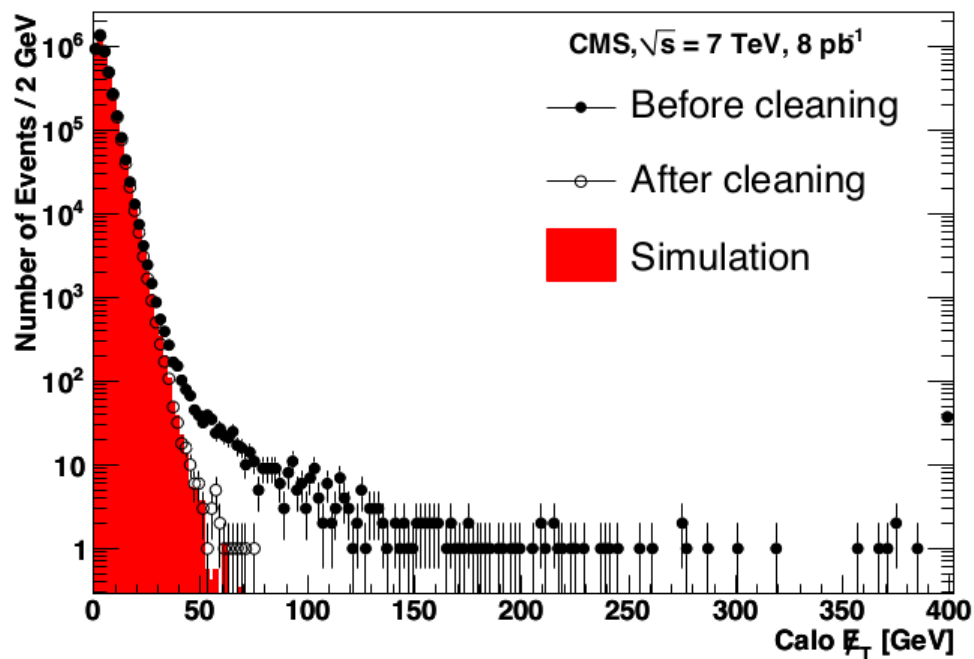
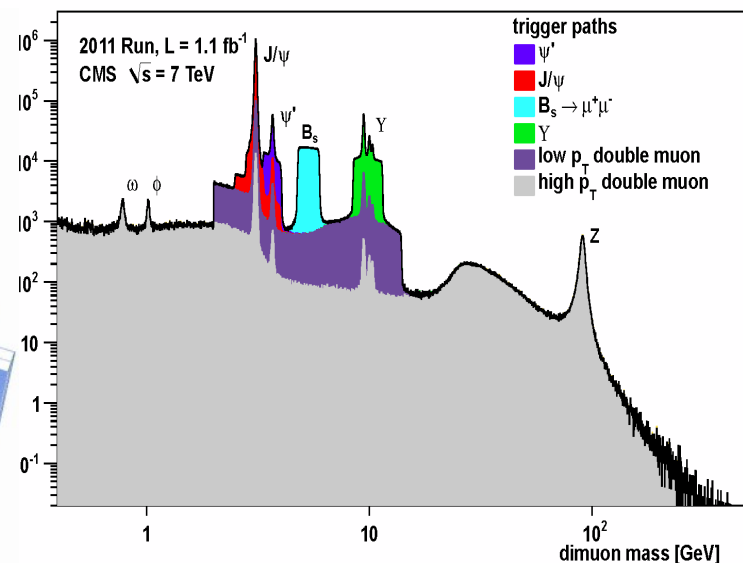
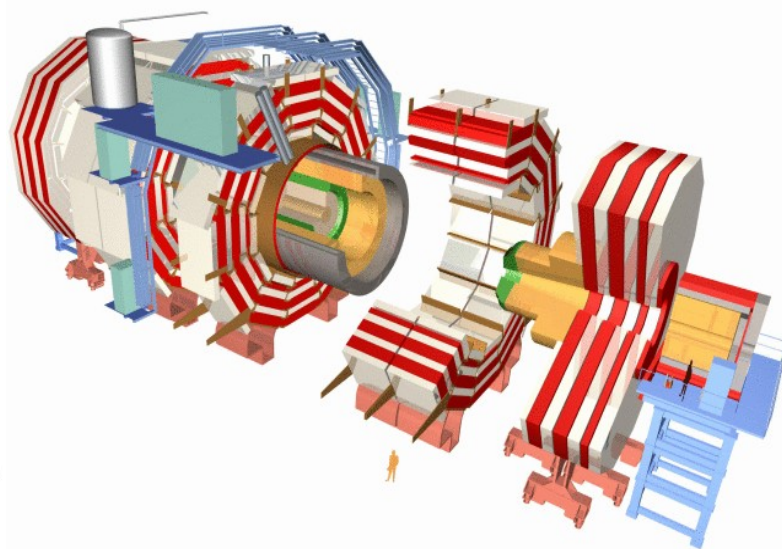
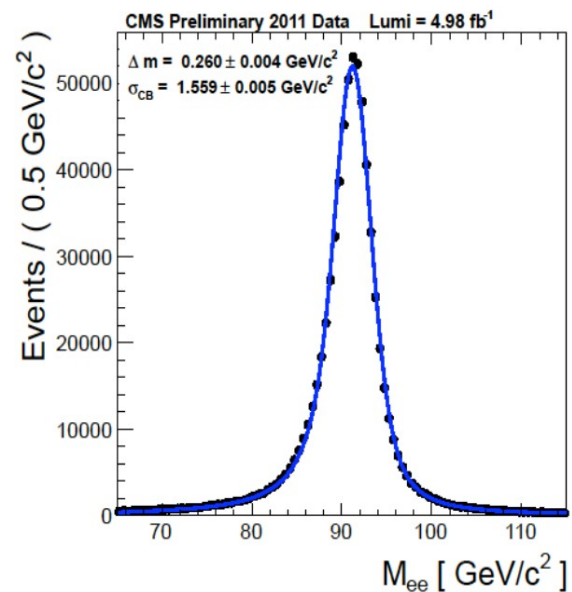


Status and Plans for the Upgrades of the CMS Detector

ICHEP 2012

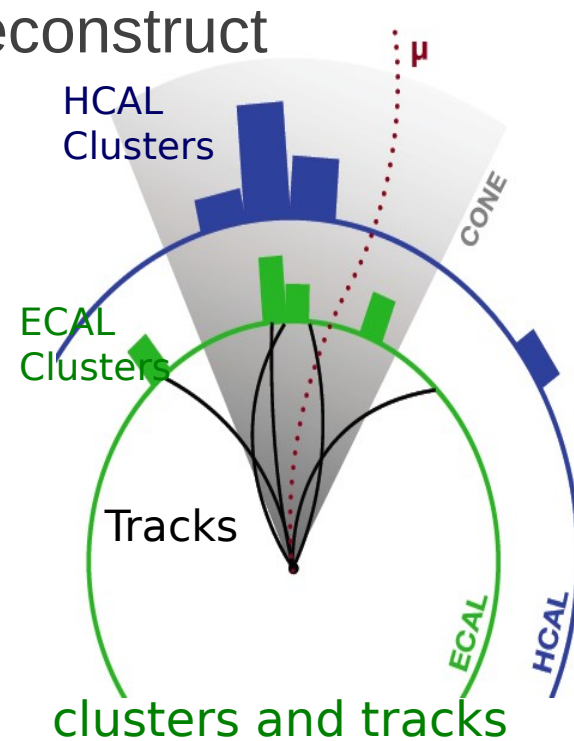
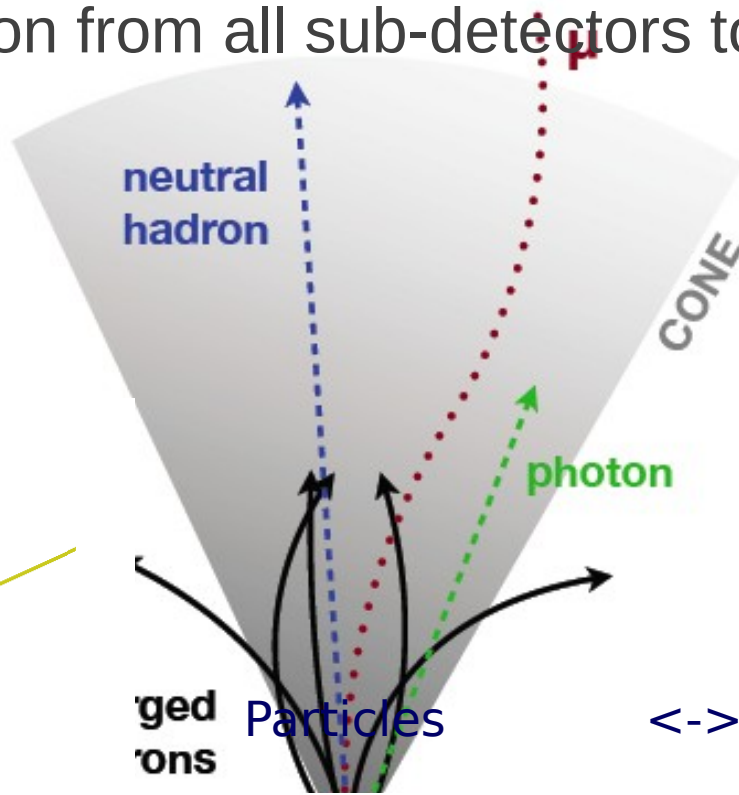
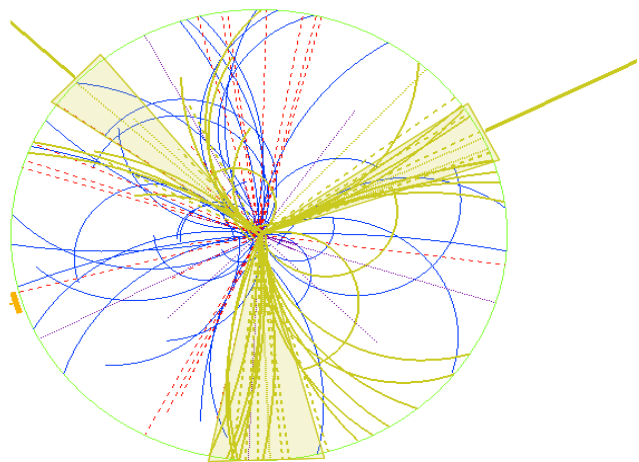
Jeremiah Mans
University of Minnesota



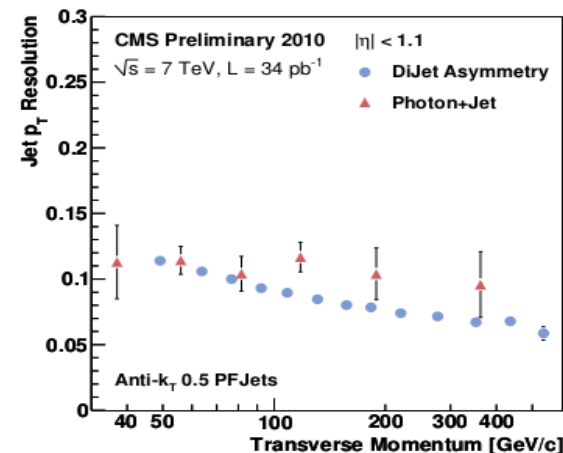
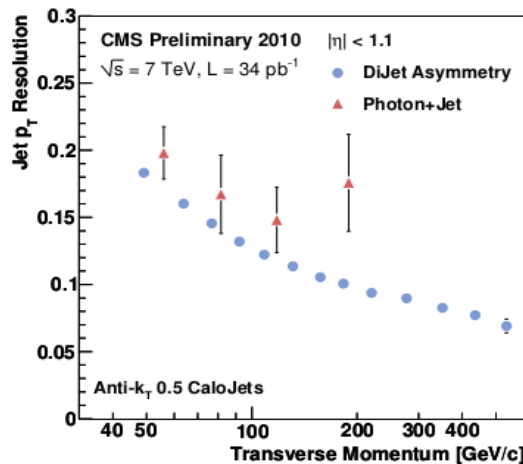
Particle Flow

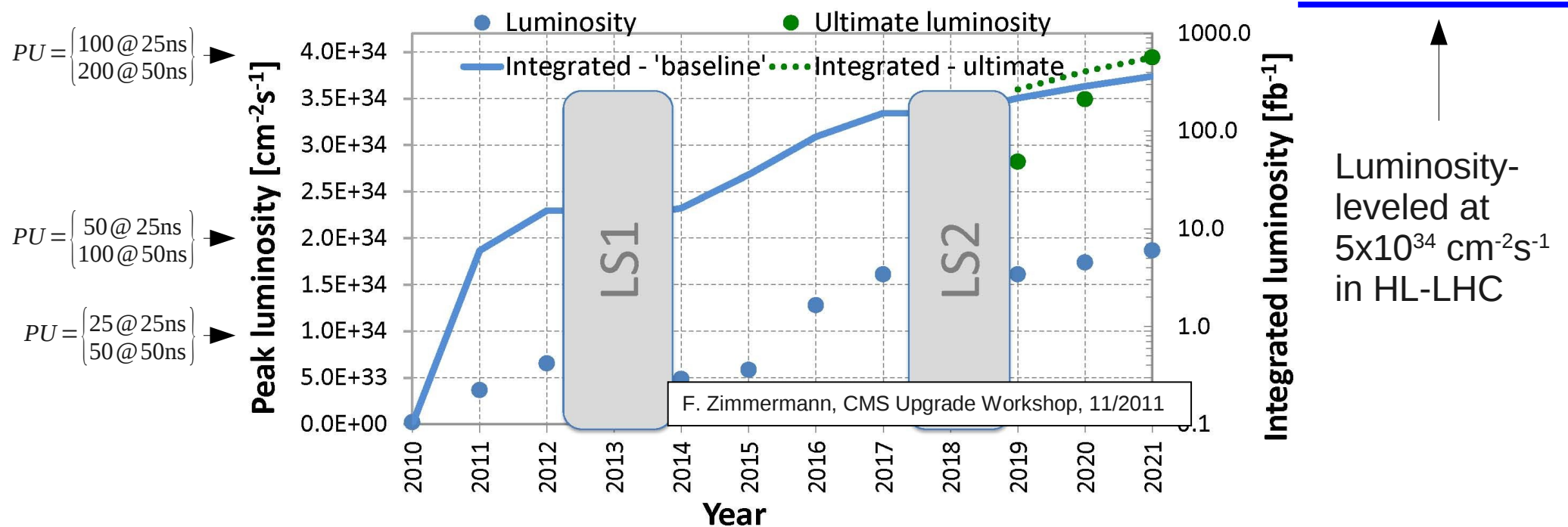
- Combine information from all sub-detectors to reconstruct sea of particles

- Hadrons
- Photons
- Muons/electrons



- Create composite objects
 - Jets, taus, missing ET
- Powerful for lepton isolation at high pile-up





Physics Priorities

Higgs Studies

Branching Fractions (2014-2021)

W-W Scattering (2019-2029)

New Physics Searches

Multilepton signatures

Low-MET SUSY

Long-lived particles

Design Guidance for Upgrades

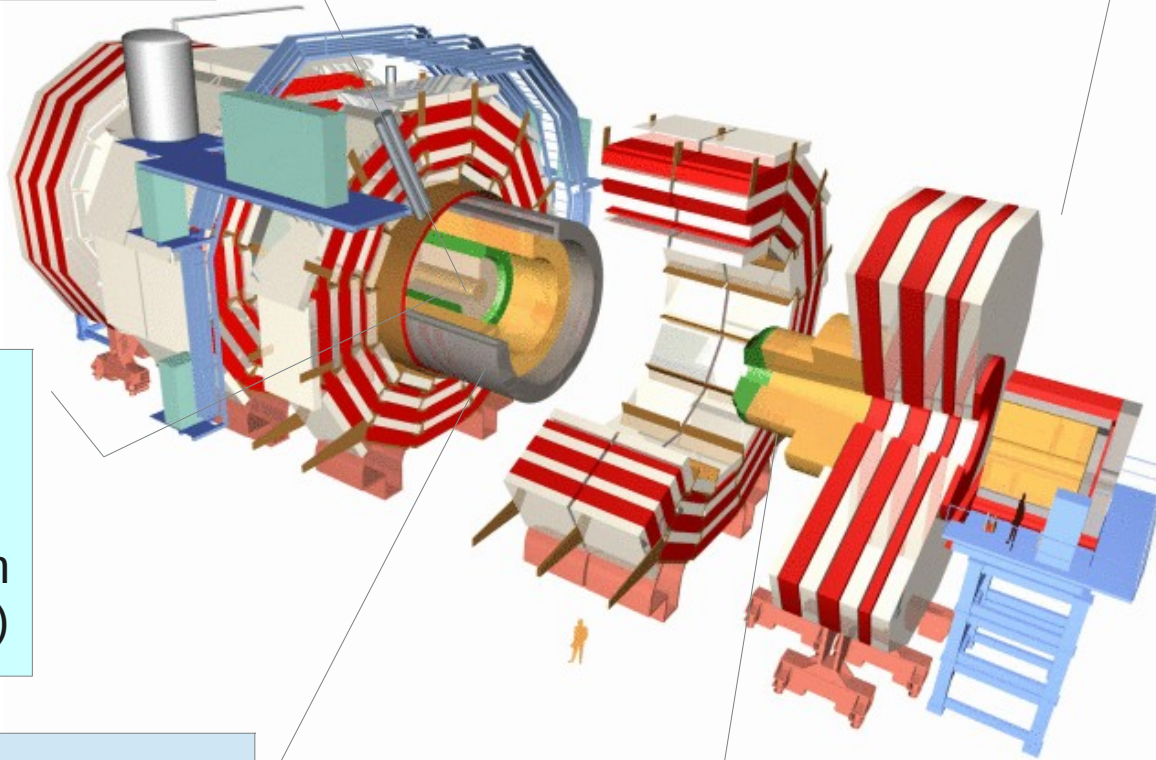
- Particle-flow techniques are valuable, detector updates should be synergistic
- Forward detectors are important
- Hermeticity is important to keep low MET significant
- Detector must be very robust to handle long periods with no access

CMS Upgrades



Install Upgraded Pixel Detector with additional layers and less material

Maintain Muon Performance at High Pileup by Full Installation of 4th Station



Upgraded trigger-capable silicon tracker with better radiation hardness (HL-LHC)

Calorimeter and muon trigger upgrades

Replace HCAL Photodetectors and add depth segmentation for better performance

Radiation-hard forward calorimetry with precision timing (HL-LHC)

Data-acquisition system upgrades

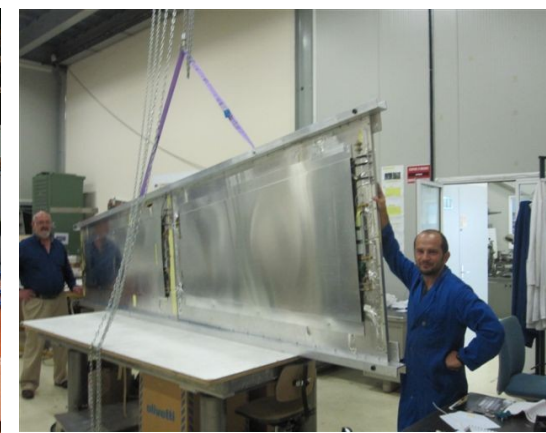
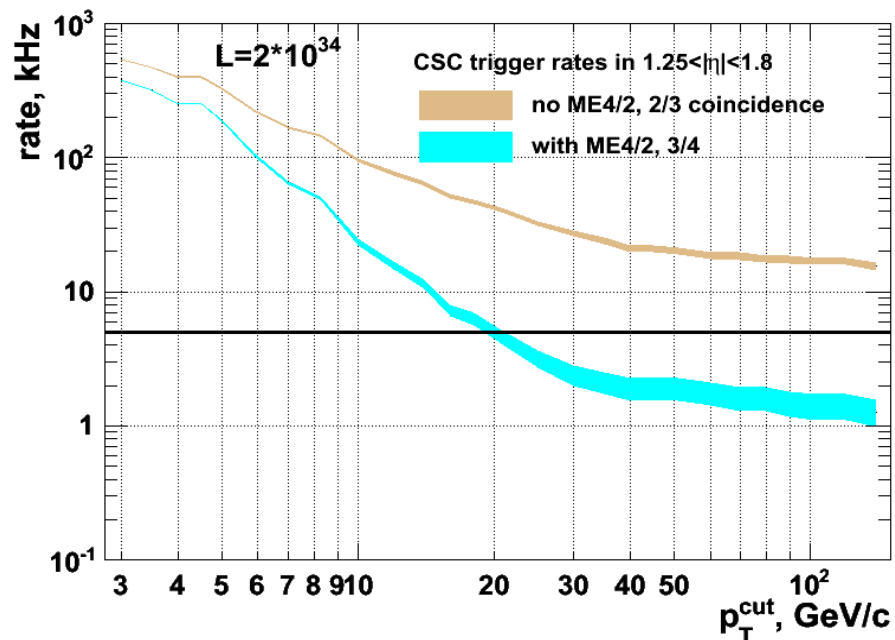
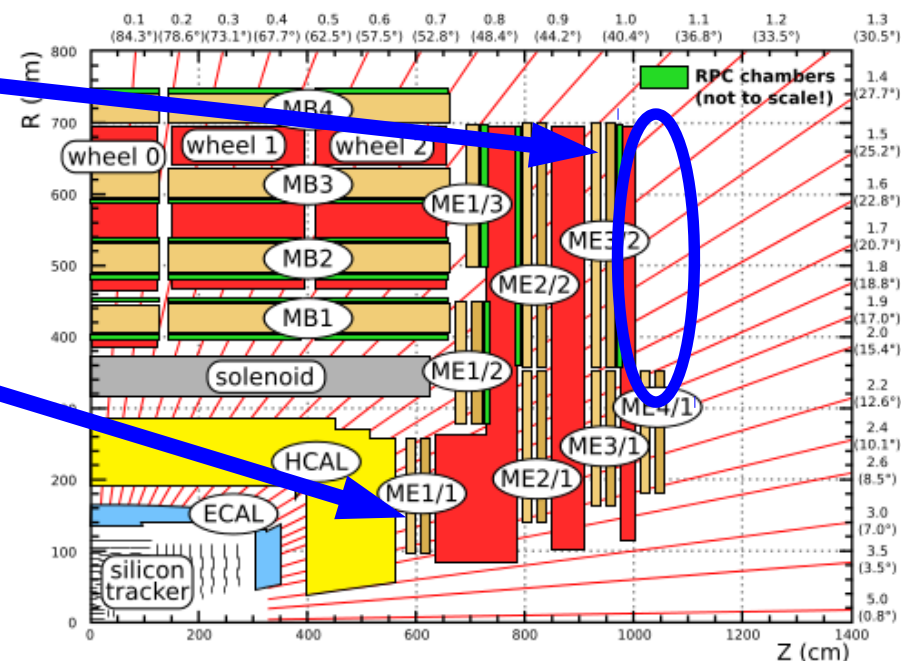
Muon System Upgrades

Install new chambers ($1.25 < |\eta| < 1.8$)

- better P_t resolution,
- better efficiency
- lower rates

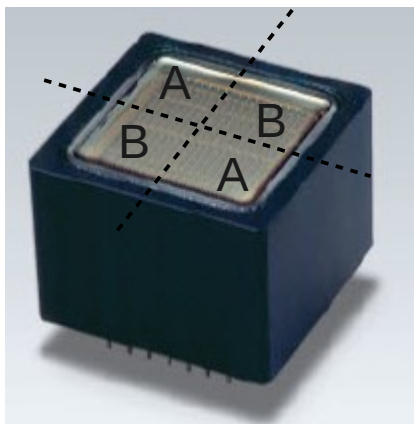
New electronics for ME1/1 ($2.1 < |\eta| < 2.4$)

- higher strip granularity
- more track segments
- improved p_T assignment, fewer fakes

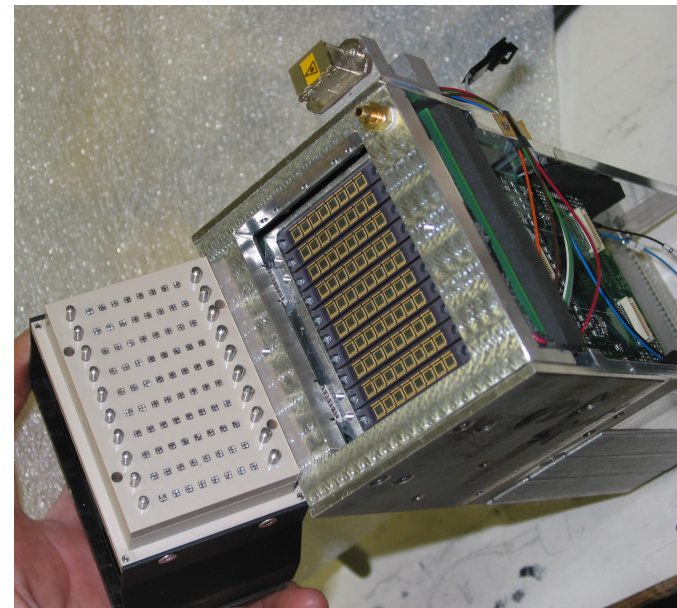


Chamber Construction Underway
Installation in 2013-2014 LHC Stop

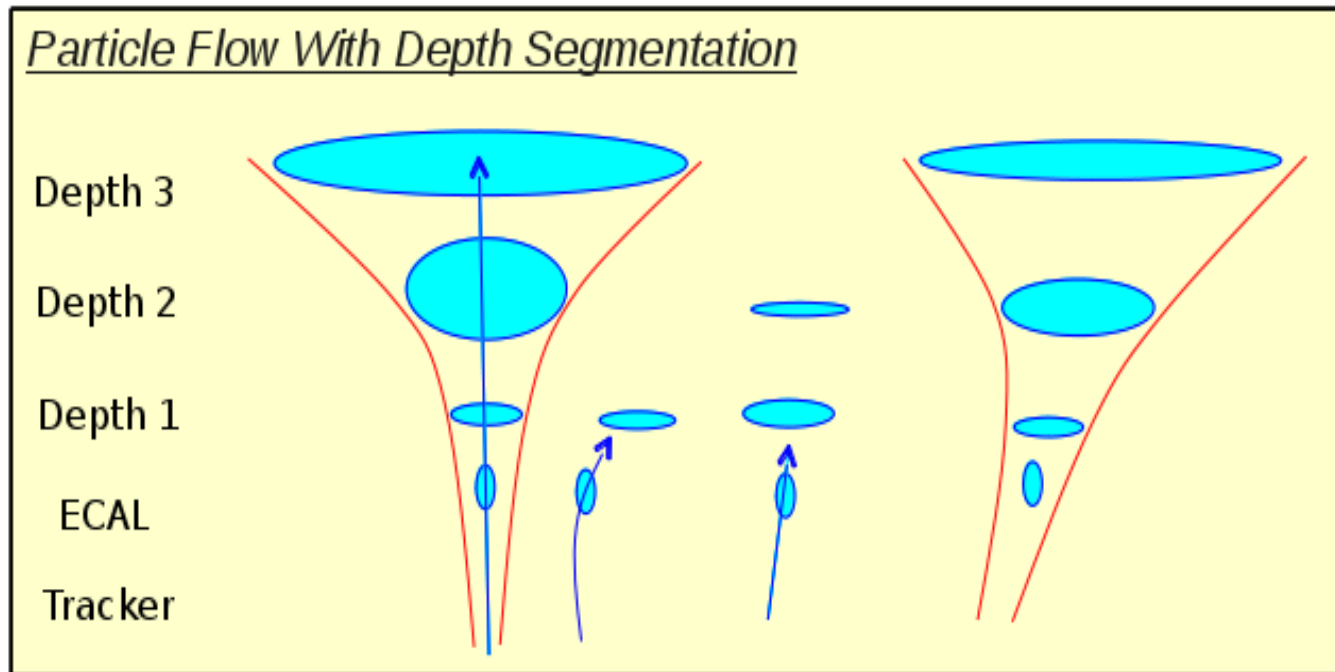
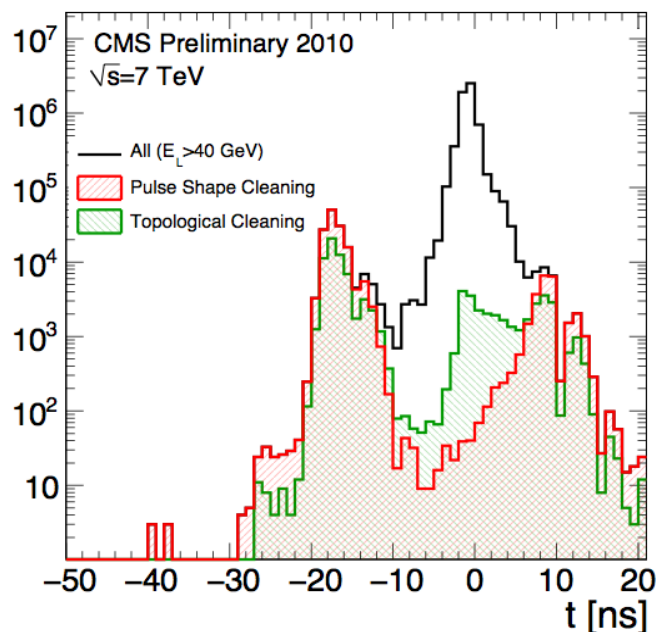
HCAL Upgrades



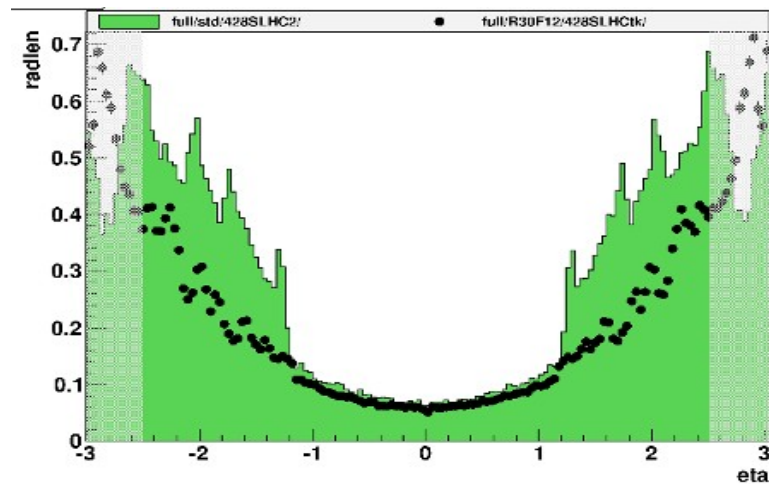
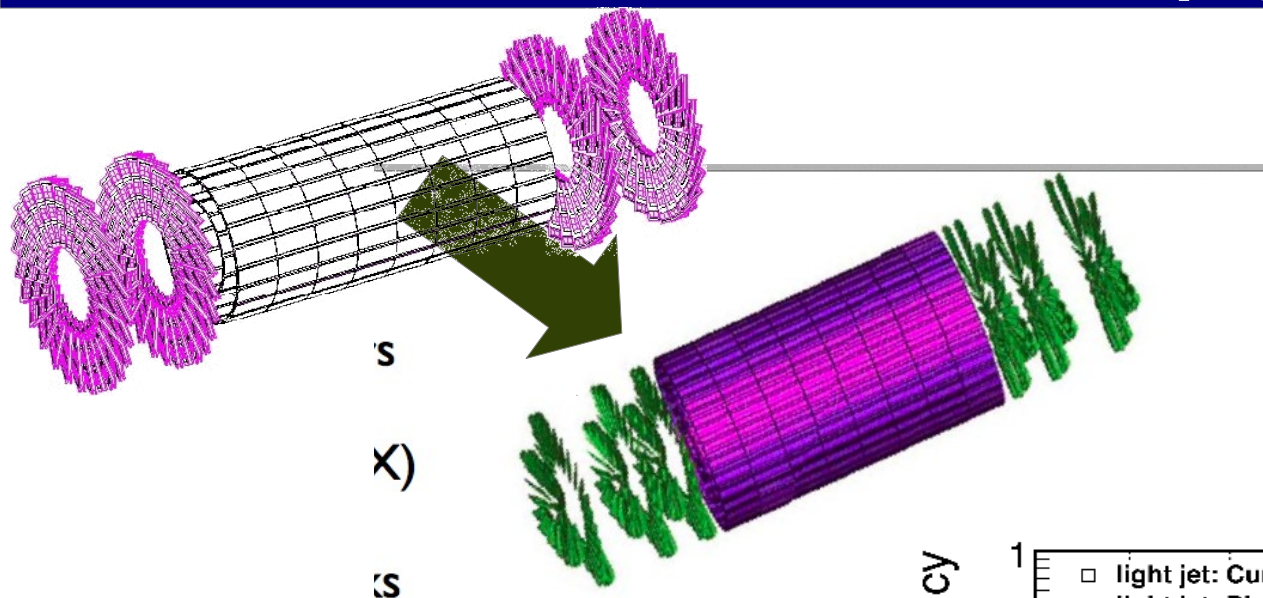
- Replacement of phototransducers in barrel/endcap (HPD \rightarrow SiPM) and forward (multi-anode PMT)
- New electronics with broader dynamic range, TDC capability
- Depth-segmentation added for full barrel/endcap



Details in Paramesvaran's Talk (this session)

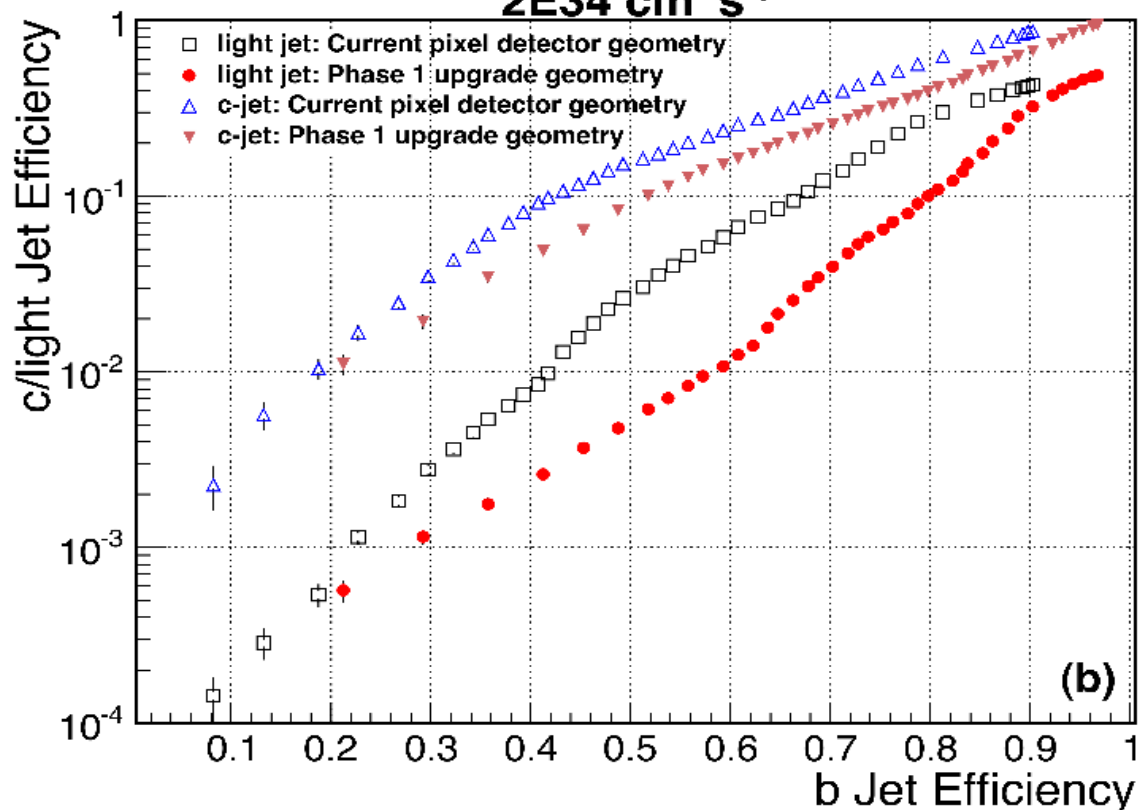
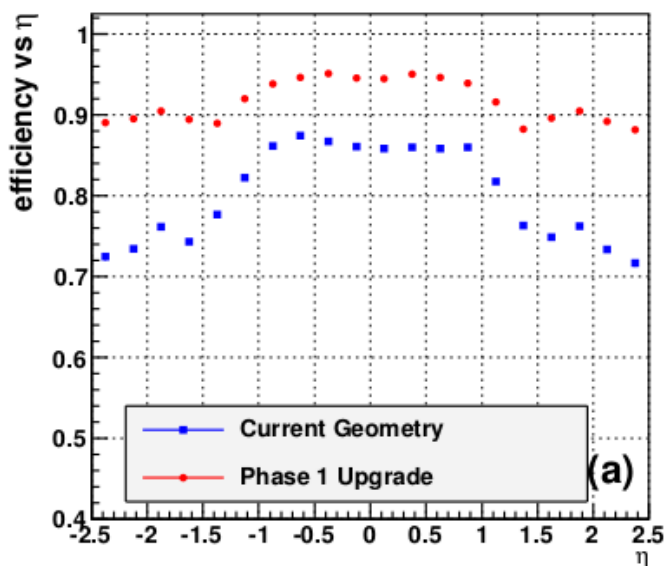


Pixel Tracker Upgrade

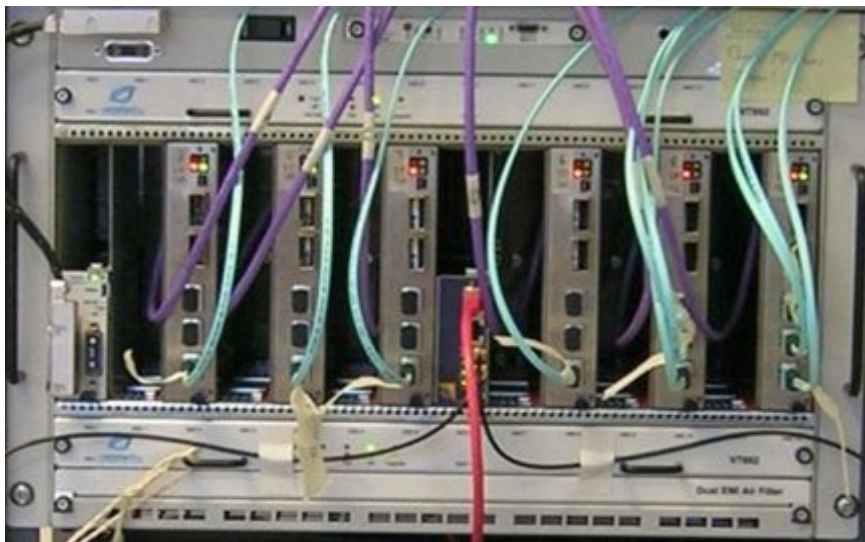
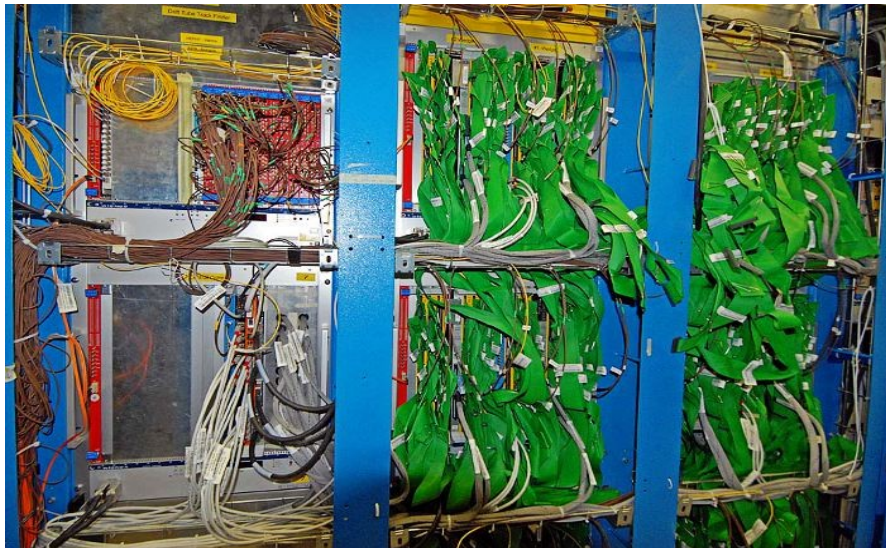


$2E34 \text{ cm}^{-2}\text{s}^{-1}$

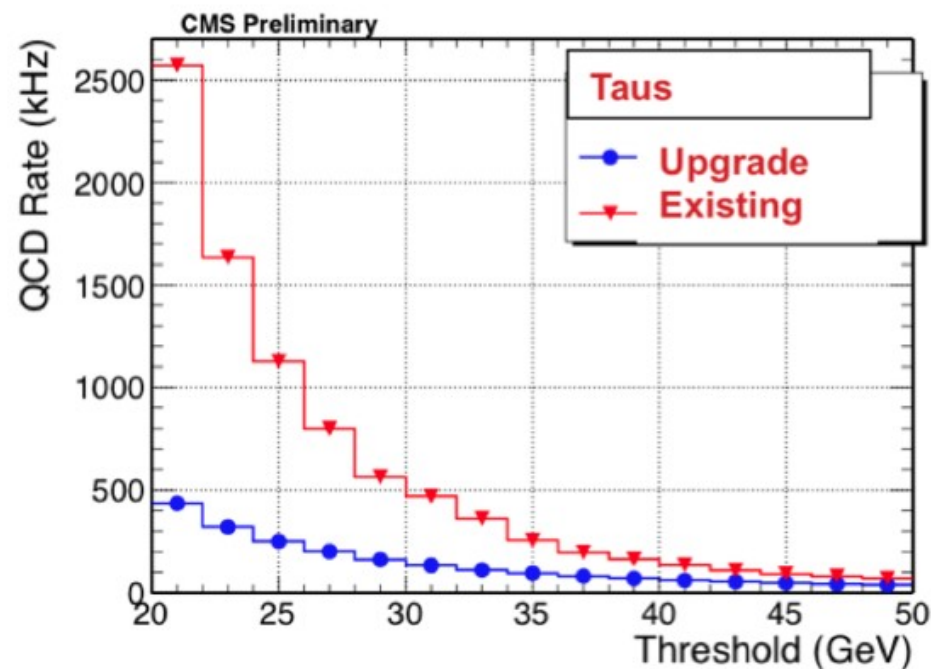
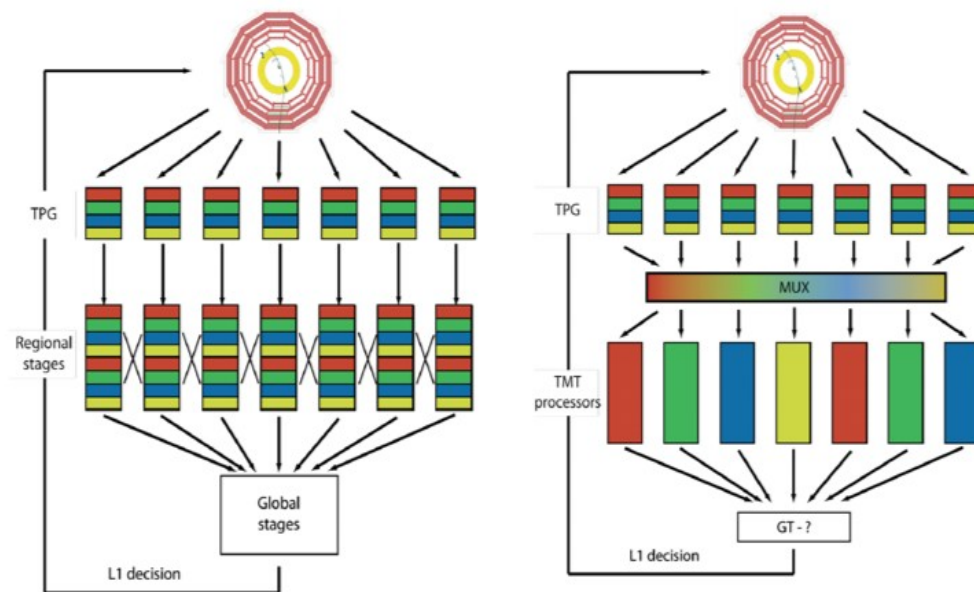
Details in Giordano's Talk (this session)



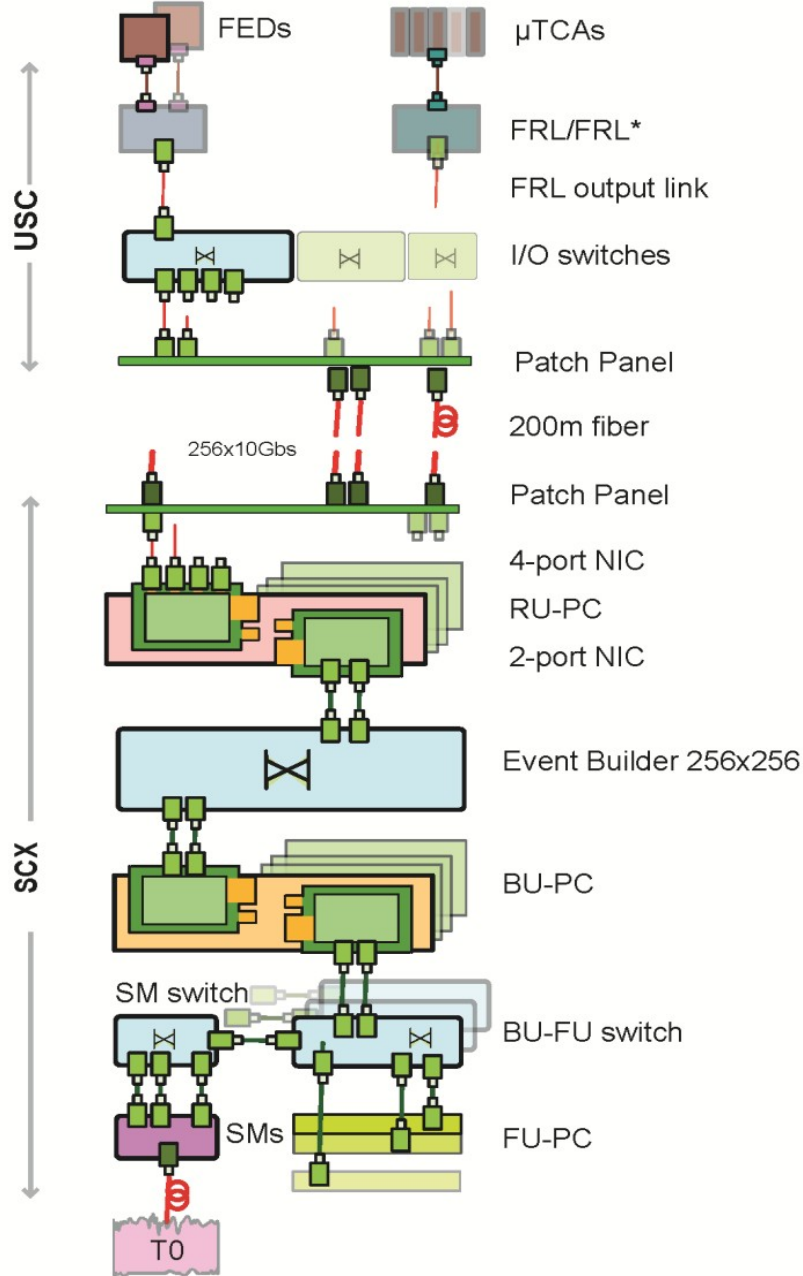
Trigger Upgrades



Details in Furic's Talk (earlier this session)



DAQ Upgrades



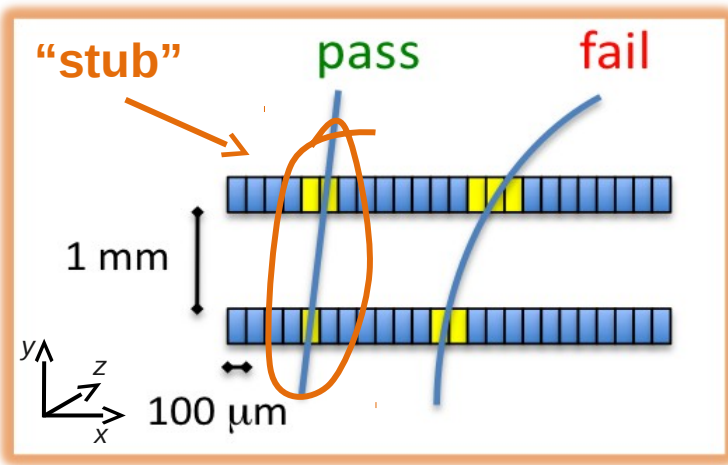
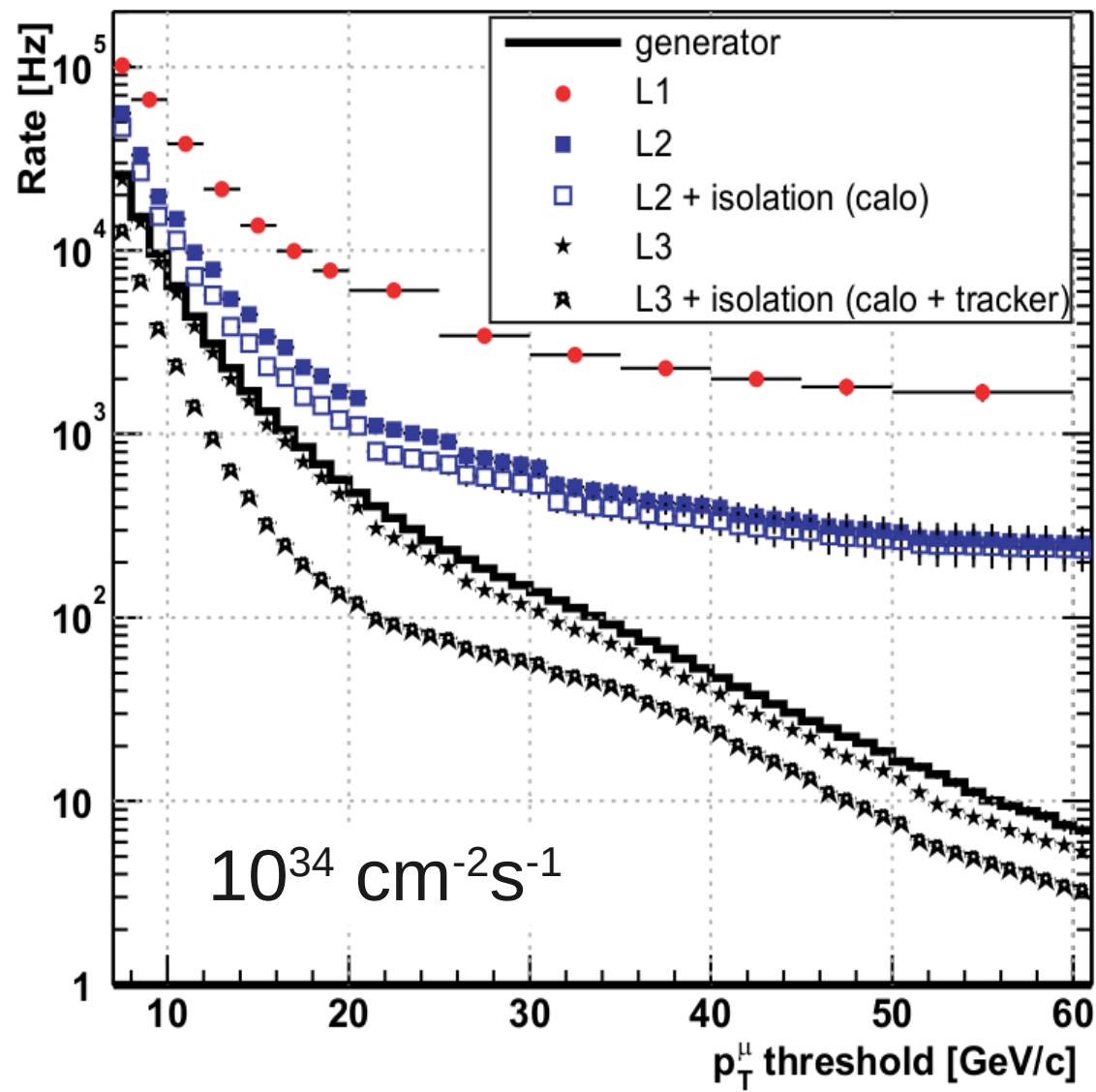
- CMS uses a L1+HLT readout scheme (no L2) which requires a > 1 Tbps DAQ (100 kHz)
- Upgrade allows larger bandwidth for higher luminosity/higher L1 rates, uses commodity 10 GbE/IB hardware
 - DAQ Gen2 will be installed in 2013/2014

HL-LHC Upgrades

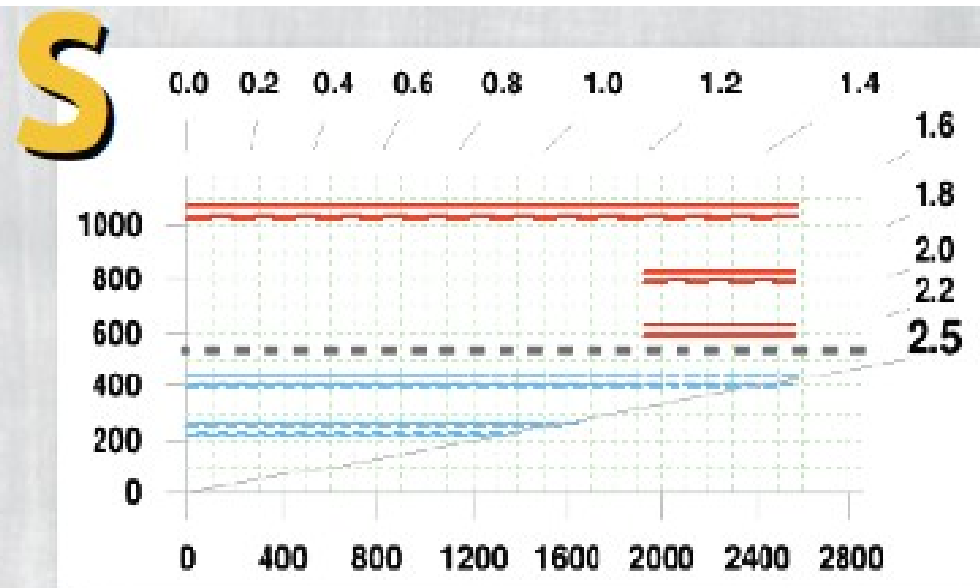
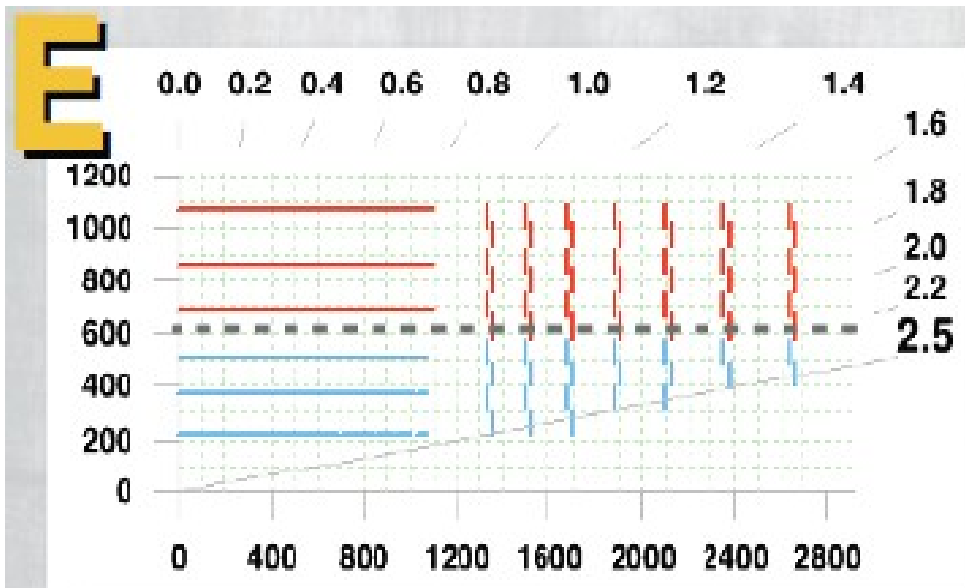
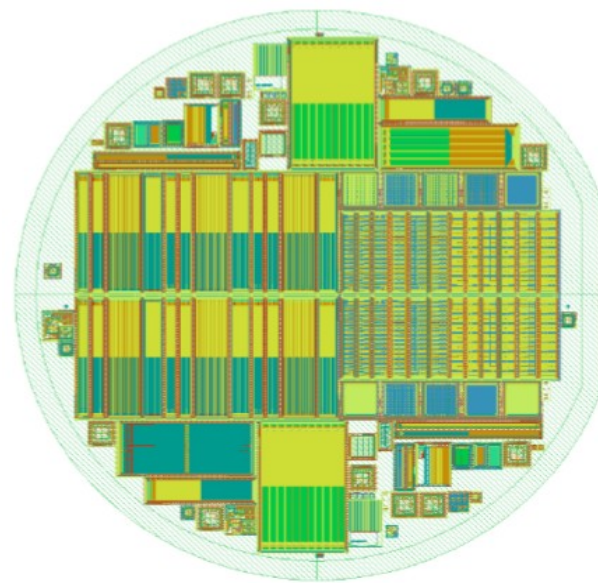
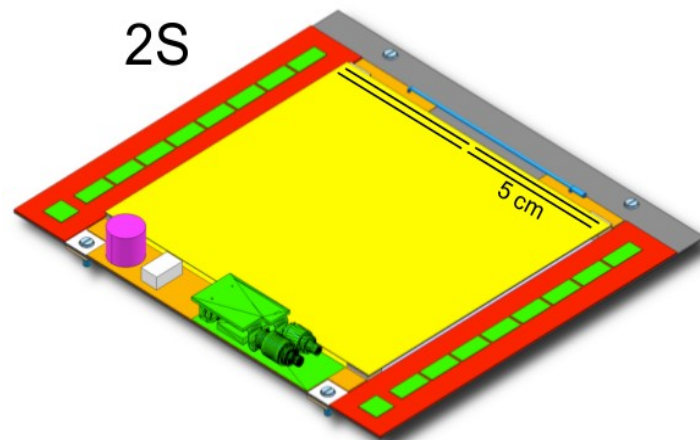
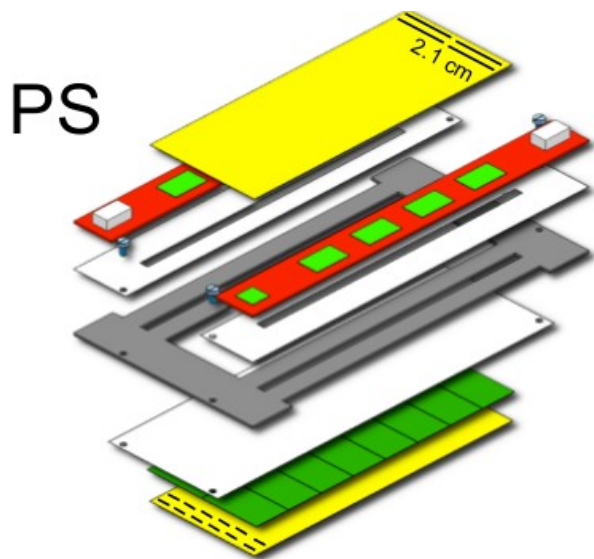
Tracker in Level-1 Trigger



- Without tracker input muon triggering becomes saturated at high luminosity
- A trigger-capable tracker could take advantage of strong CMS magnetic field



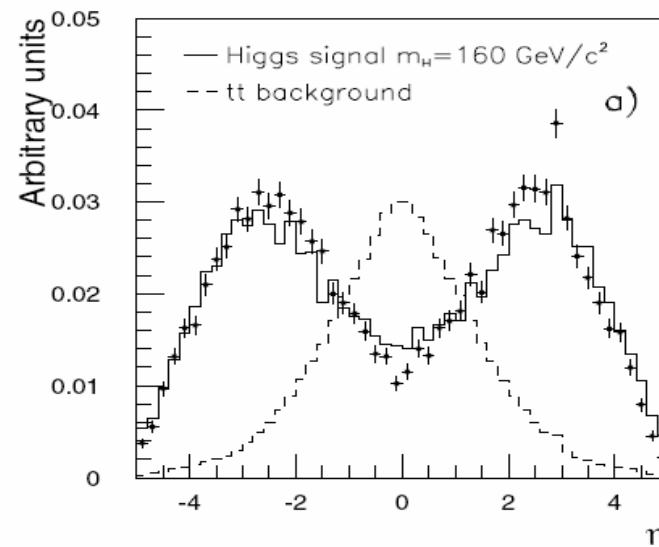
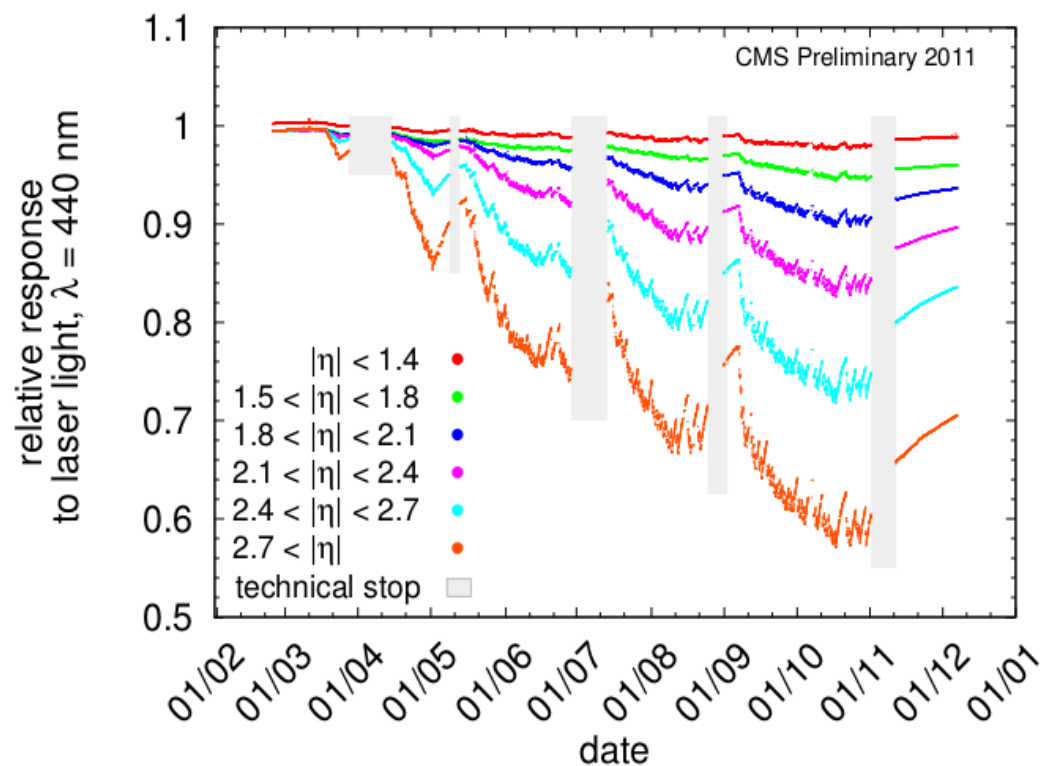
Trigger-Capable Tracker Parts



Forward Calorimetry

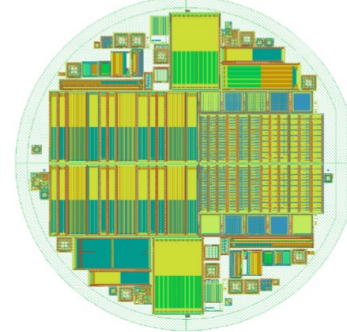
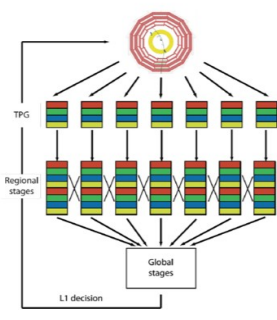
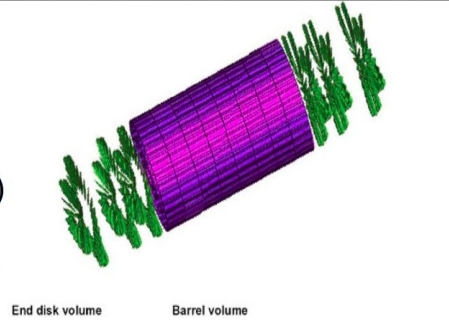
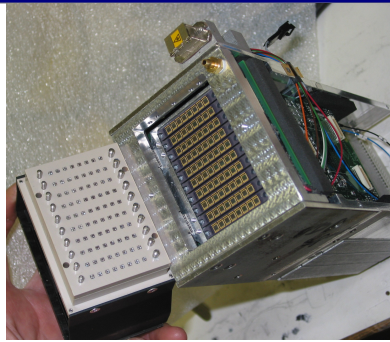


- Endcap ECAL designed for 100-300 fb⁻¹ luminosity
- Very high radiation levels affect crystals and photodetectors
- Modifications at higher $|\eta|$ likely to be necessary for HL-LHC era



- Identification of tag jets for W-W scattering and Higgs physics is challenging
 - Low p_T
 - Forward direction (tracking ineffective)
- Studying the potential of forward detectors with precision timing (20 ps) to allow vertex association between forward jets and central decay products

Conclusions



- CMS has a multi-phase planned upgrade which builds and maintains the core strengths of the CMS design
 - Particle flow techniques: pixel, muon, HCAL
 - Hermeticity: muon, HCAL
 - High rate DAQ, effective L1 trigger
- For the HL-LHC era, CMS is developing new ideas to extract physics from the very busy SL-LHC environment
 - Trigger-capable tracker
 - Forward calorimetry with precision timing