Status and Plans for the Upgrades of the CMS Detector

ICHEP 2012

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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

![Diagram showing Particle Flow process]

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LHC and HL-LHC

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

PU = \[
\begin{array}{c}
100 \text{ @ 25ns} \\
200 \text{ @ 50ns}
\end{array}
\]

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\begin{array}{c}
50 \text{ @ 25ns} \\
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\]

Luminosity-leveled at \(5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}\) in HL-LHC

F. Zimmermann, CMS Upgrade Workshop, 11/2011
- Install Upgraded Pixel Detector with additional layers and less material
- Maintain Muon Performance at High Pileup by Full Installation of 4th Station
- Replace HCAL Photodetectors and add depth segmentation for better performance
- Upgraded trigger-capable silicon tracker with better radiation hardness (HL-LHC)
- Radiation-hard forward calorimetry with precision timing (HL-LHC)
- Calorimeter and muon trigger upgrades
- Data-acquisition system upgrades
**Muon System Upgrades**

**Install new chambers (1.25 < |\eta| < 1.8)**
- better Pt 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 → 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

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
• 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

PS

2S

Trigger plots for E and S channels.
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