Operation and Performance of the CMS Silicon Tracker

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The CMS Silicon Trackers

**Double Sided**

- Strip tracker
- 300 µm (inner) and 500 µm (outer) silicon sensors
- 85 µm to 205 µm pitch
- p-in-n silicon
- No data sparsification in the detector

**Single Sided**

- Pixel tracker
- 285 µm silicon
- 100 × 150 µm pixels
- n-in-n silicon
- Data sparsification on readout chip

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**Pixels**
- 1.1 m² silicon
- 1,440 modules
- 3 layers
- 2 disks
- 66 M channels
- ~97% working fraction

**Strip Tracker**
- 198 m² silicon
- 15,148 modules
- 10 layers/12 disks
- ~4 stereo hits
- 9.6 M channels
- 97.5% working fraction

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**CMS Tracker**
- Together with 3.8 T magnetic field
- \( \sigma(\text{pt})/\text{pt} \sim 1-2\% \) (pt ~ 100 GeV)
- IP resolution: ~10-20 µm

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16,588 Modules

→ R. Castello: Alignment methods

11:15 this track
**Detector status in 2012**

- 92.5 % overall data-taking efficiency
- higher than in 2011 despite higher luminosity

- tracker share of lost lumi 29 %
- 16 % strips, 12 % pixels, 1 % power supplies

Cooling running stable at 4°C (strips) and -10°C (pixels), respectively

Power supplies, detector control system and other services running very stable

→ both detectors running well in 2012 with increased energy and pile-up

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Radiation monitoring

- Acquired radiation dose close to $13 \text{ fb}^{-1}$
- Regular measurements of radiation related quantities performed both with $pp$ collisions and without
- Leakage current ($I_{\text{leak}}$) measured using power supply current and detector control units (DCUs)
- Depletion voltage ($V_{\text{dep}}$)
  - noise scans using random triggers with no beam
  - signal scans using particles from $pp$ collisions
    - full scans (typically after technical stops)
    - small scans on representative power groups 1/month
Comparing Fluka simulation to leakage current measurements (strip tracker only, corrected for sensor temperature)
Radiation monitoring

Simulated vs. observed leakage current
- Includes module type, radius, temperature

CMS Preliminary 2011, 5.0 fb$^{-1}$
Single Hits

- example for S/N ratio high and according to specifications (strips)
- efficiencies in all layers well above 99% (strips and pixel)
Tracking

- CMS uses multi-stage iterative tracking
- subsequent steps with typically relaxed seeding
  → recovering inefficiencies from earlier iterations
  → removing hits on tracks earlier iterations reduces combinatorics at each step
- later iterations are looking for more complicated tracks (lower $p_T$, displaced tracks, etc.)
- seeds are constructed from
  1. pixel triplets
  2. mixed pairs (pixel || strips) + vertex
  3. mixed triplets
  4. strip pairs
- The main tracking algorithm is based on pixel seeds and uses a Kalman filter.
- efficiency for isolated muons very close to 100% for $|\eta| < 2.4$
- single pions with efficiencies above 90 (80)% in the barrel (endcap) region for $p_T > 500$ MeV
Vertexing

Event with 40 reconstructed vertices
Vertexing

- using data-driven split method
- vertex efficiency close to 100% if more than two tracks with $p_T > 0.5$ GeV are attached to it
- good agreement between data and simulation

CMS preliminary 2010

- same data-driven ‘split’ method
- vertex resolution depends on number of tracks and their $p_T$
- approaches 20(30) $\mu$m in $x$ and $y$ ($z$) for high number of tracks
- good data/MC agreement
Summary and Outlook

- CMS silicon tracking detectors with high uptime and data quality during 2010/11/12 data taking
- tracking and vertexing with high efficiency and very good resolution
- regular measurements of radiation related quantities to follow evolution of detector parameters over the lifetime of the experiment
Summary and Outlook

... and all of that to get things like this:

... and many other exciting physics results
Backup
Timing

- scanning ± 10 ns around current setting
- centered around zero within ±1 ns
- well timed in

- scanning delay setting to maximize cluster size (black dots)
- chose working point away from edges of efficiency plateau (red)

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Tracking efficiency

Pions (vs. $\eta$)  

Muons (vs. $p_T$)

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