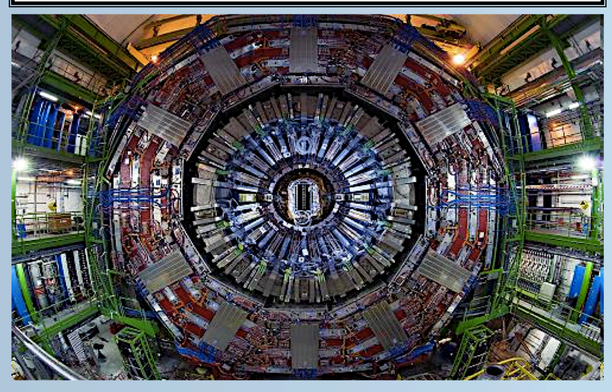
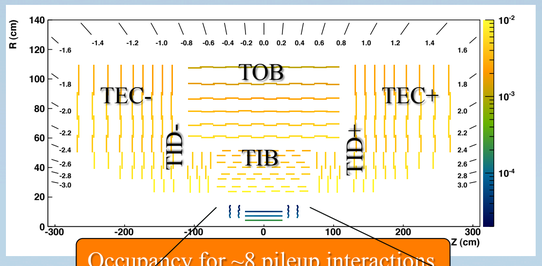
CMS Silicon Pixel & Strip Tracker Performance

Petra Merkel* for the CMS collaboration
*Purdue University, West Lafayette IN USA

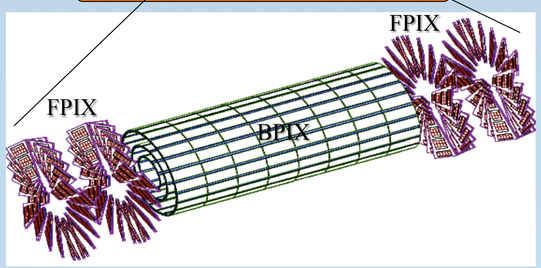
The CMS Tracker (200m² of silicon!)

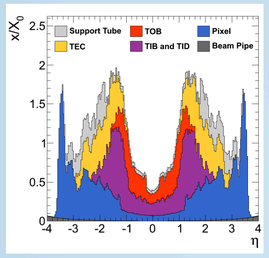
- The CMS silicon tracker measures 5.8m x 2.5m and is immersed in a magnetic field of 3.8T.
- **Pixels:** 1440 modules, 66M pixels
- **Strips:** 15k modules, 9.3M strips
- Barrel:
  - 3 pixel layers (4.4cm < r < 10.2cm)
  - 10 strip layers (r < 1.1m)
- Endcaps (on either side of the barrel):
  - 2 pixel disks
  - 3 small strip disks
  - 9 large strip disks
- Pseudo-rapidity coverage: |η| < 2.5
- ~97% of all pixels and strips are currently active

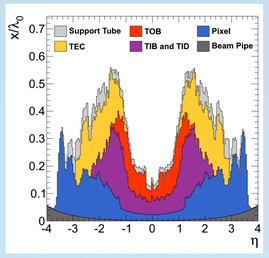




Occupancy for ~8 pileup interactions

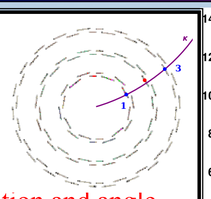


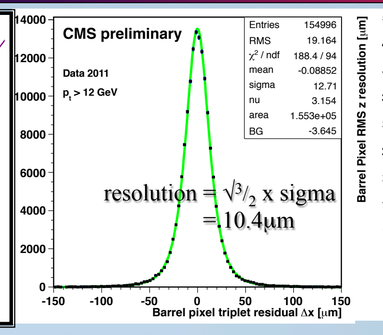


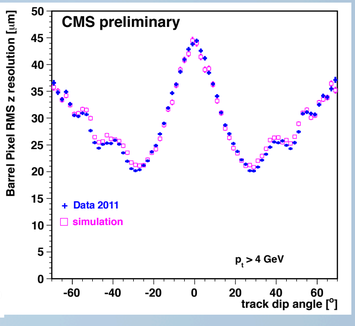


Pixel Hit Resolution

We select tracks with hits in 3 pixel layers, then redefine the track by using the curvature measurement from the full tracker and the position and angle from pixel hits 1 and 3. The residual of the 2. pixel hit to the track is a measure of the pixel hit resolution.



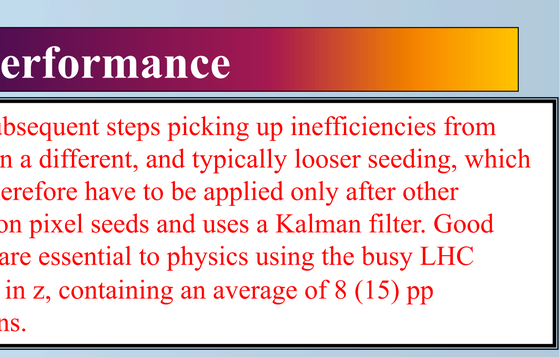




Strip Hit Resolution

We measure the strip detector resolution by using hits on tracks passing overlapping modules. We compare the difference in the hit position to the expected hit position (from the track) between the two hits. The width of this difference is a measure of the hit resolution.

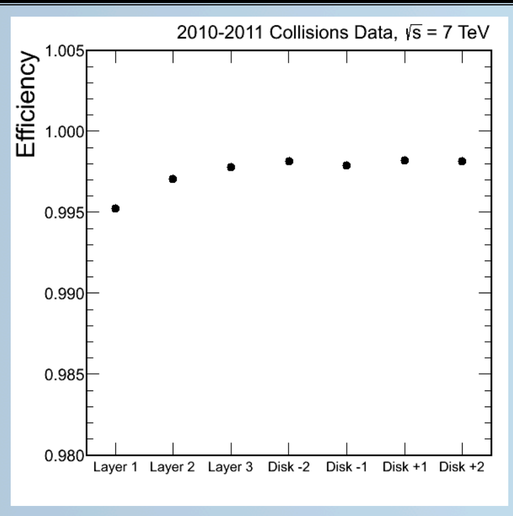
Sensor Layer	Pitch [μm]	Resolution [μm] vs. cluster size 1	2	3	4
TIB 1-2	80	15.0±4.6	14.0±3.6	13.7±4.2	
TIB 3-4	120	24.1±5.2	24.7±4.1	22.1±7.0	
TOB 1-4	183		29.2±9.2	36.1±5.1	24.5±10.3
TOB 5-6	122		12.6±8.3	22.0±4.6	16.3±4.6

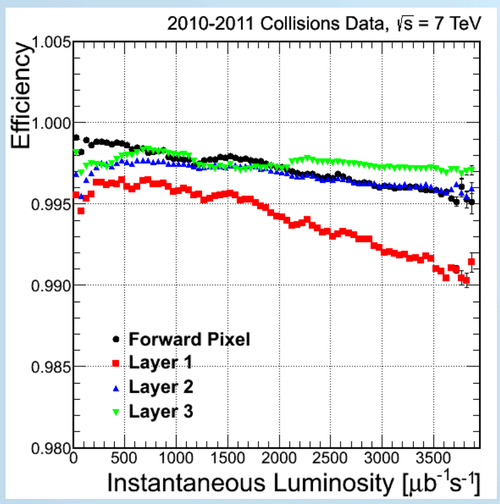


Pixel Hit Finding Efficiency

We use well reconstructed, isolated tracks with a pt>1GeV, which originate from the primary vertex. Trajectories passing near the edges of sensors are excluded. Known bad modules are excluded as well. The hit efficiency is calculated from the present and the missing hits on and near the track (within 0.5mm of the predicted position).

- **The average hit efficiency is measured to be 99%**
- It depends on the instantaneous luminosity, the trigger rate and the presence of beam background
- Sources of inefficiency are readout errors in the frontend electronics and a limited internal buffer size of the readout chips

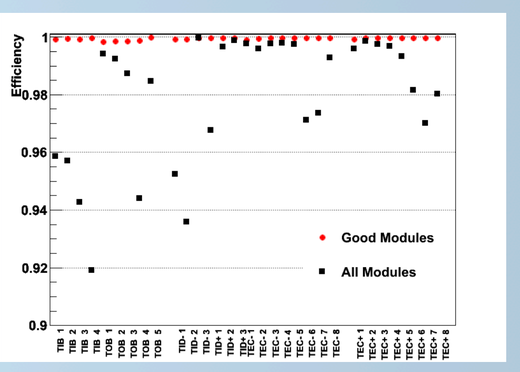




Strip Hit Finding Efficiency

We measure the hit efficiency with tracks with at least 8 hits and not passing near the edges of sensors. The efficiency is calculated from the present and missing hits in the traversed modules. In order to avoid multiple scattering a hit in the subsequent layer is required. Known bad modules are excluded.

- **The average hit efficiency is measured to be 99.8%**

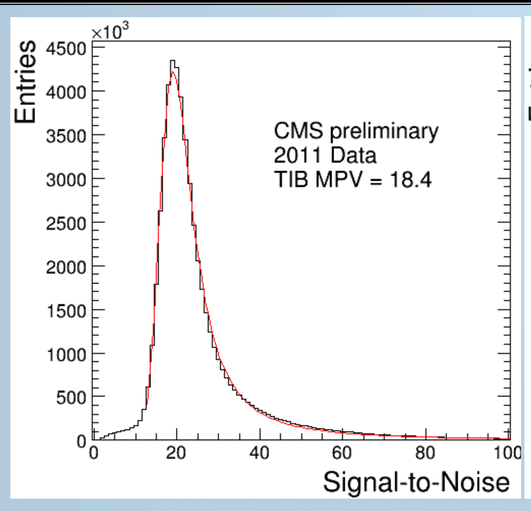


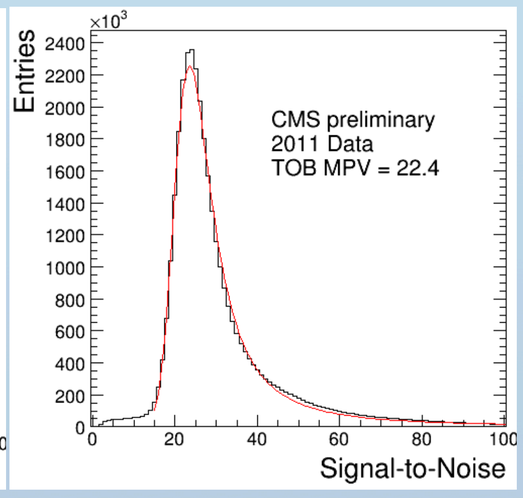
Tracking and Vertexing Performance

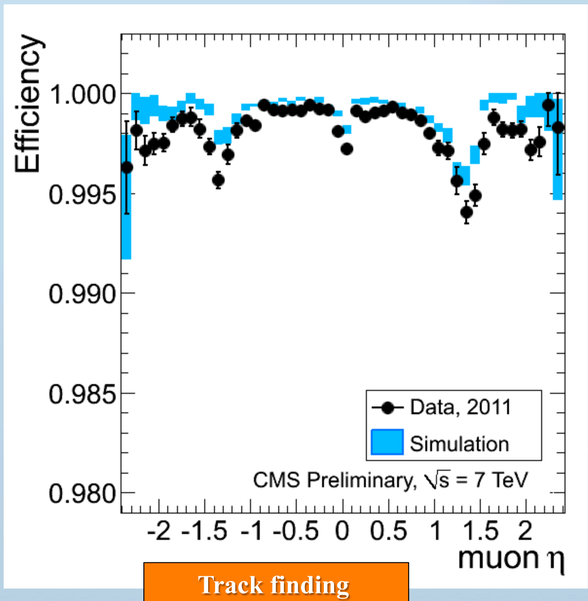
CMS uses an iterative tracking algorithm with subsequent steps picking up inefficiencies from previous steps. Subsequent iterations are based on a different, and typically looser seeding, which could be affected by larger combinatorics, and therefore have to be applied only after other iterations. The main tracking algorithm is based on pixel seeds and uses a Kalman filter. Good primary vertex finding efficiency and resolution are essential to physics using the busy LHC collisions. The luminous region in CMS is ~5cm in z, containing an average of 8 (15) pp interactions for 2011 (2012) data taking conditions.

S/N in the Strip Detector

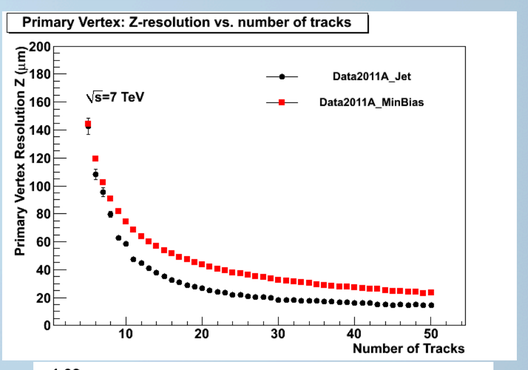
The Signal-to-Noise in the barrel part of the strips is measured using clusters on tracks.

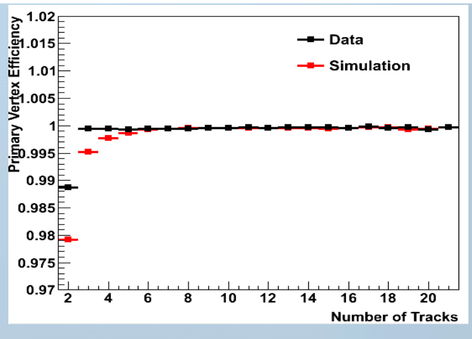






Track finding efficiency using muons from Z decays





Concluding Remarks

The CMS Silicon Tracker is performing according to design specifications

Its excellent performance is key to the successful physics programme of CMS