Operation and Performance of the CMS Silicon Tracker

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on behalf of the CMS collaboration

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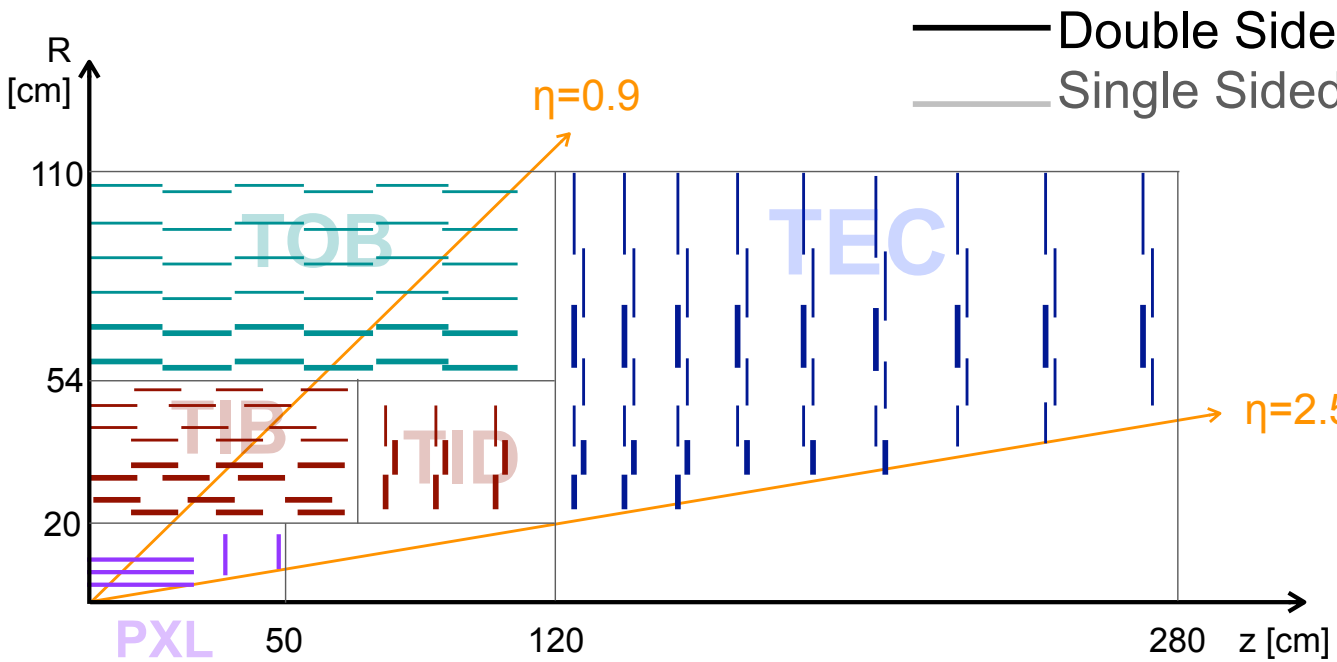
The CMS Silicon Trackers



strip tracker

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

pixel tracker

285μm silicon
100$\times$150 μm pixels
n-in-n silicon
data sparsification on readout chip

Pixels

1.1 m^2 silicon
1440 modules
3 layers
2 disks
66 M channels
$\sim$97% working fraction

+ Strips

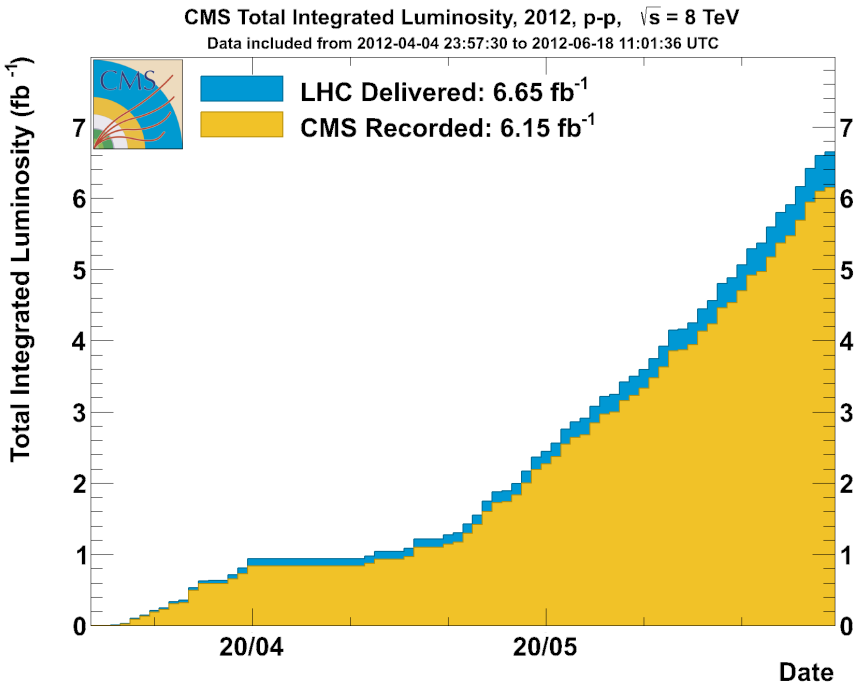
198 m^2 silicon
15148 modules
10 layers/12 disks
$\sim$ 4 stereo hits
9.6 M channels
97.5% working fraction

= CMS Tracker

together with 3.8 T magnetic field
σ(pt)/pt $\sim$ 1-2% (pt$\sim$100 GeV)
IP resolution: $\sim$10-20μm

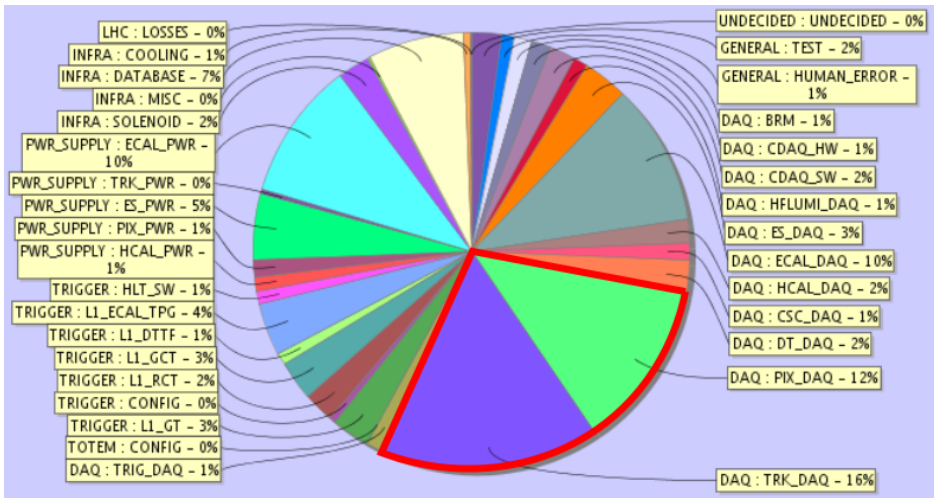
16588 Modules
$\rightarrow$ R.Castello: Alignment methods 11:15 this track

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



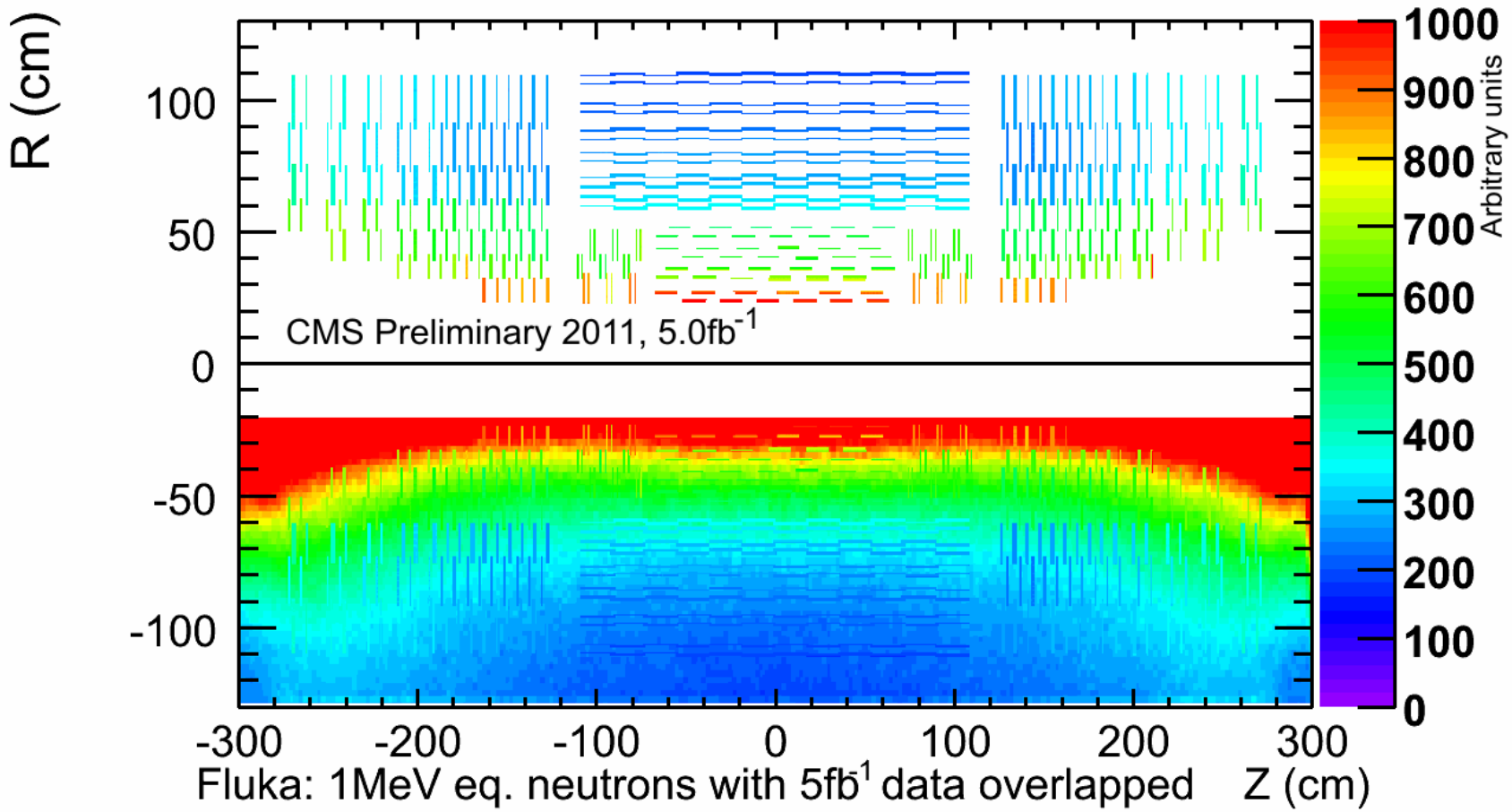
- cooling running stable at 4°C (strips) and -10°C (pixels), respectively
- power supplies, detector control system and other services running very stable

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

Radiation monitoring

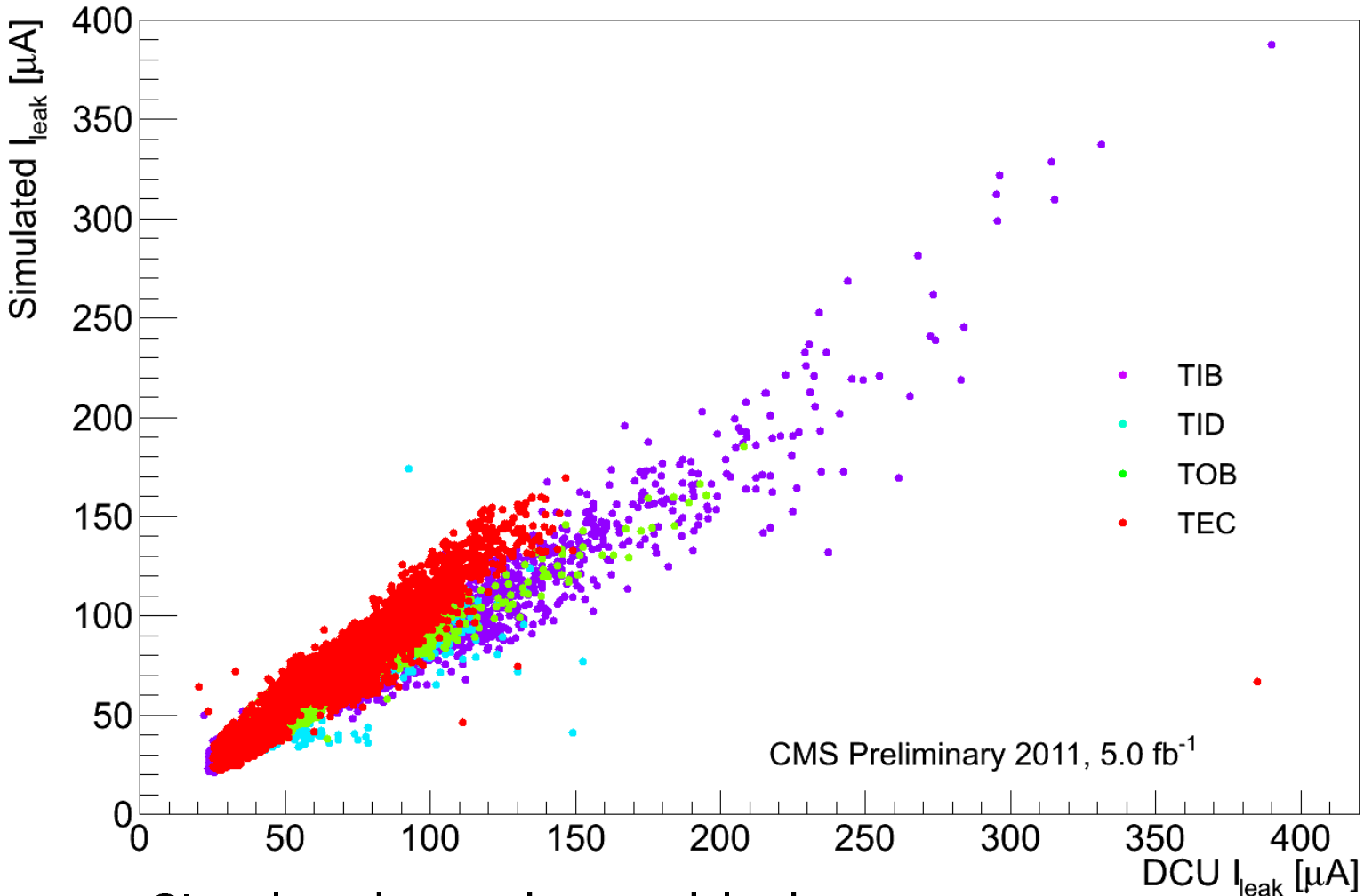
- Acquired radiation dose close to 13 fb^{-1}
- Regular measurements of radiation related quantities performed both with *pp* collisions and without
- Leakage current (I_{leak}) measured using power supply current and detector control units (DCUs)
- Depletion voltage (V_{depl})
  - noise scans using 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

Radiation monitoring



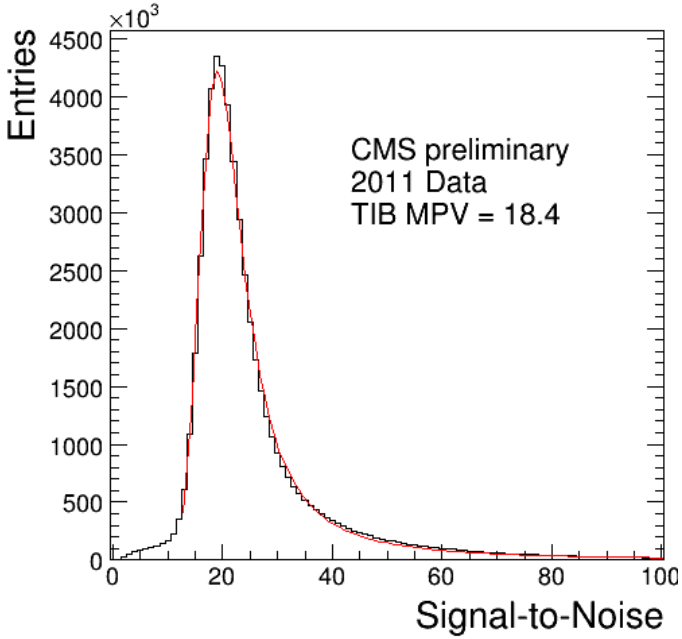
- Comparing Fluka simulation to leakage current measurements (strip tracker only, corrected for sensor temperature)

Radiation monitoring



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

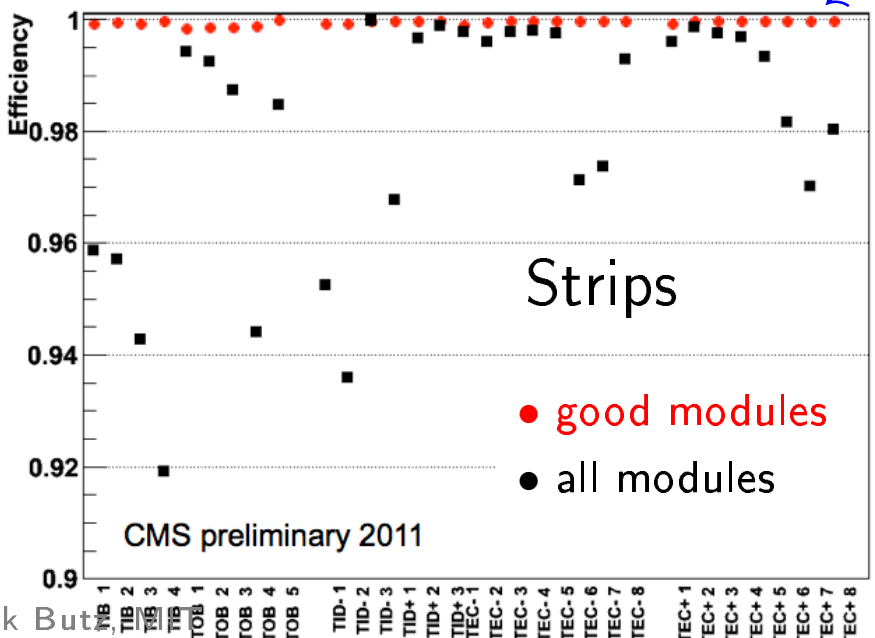
Single Hits

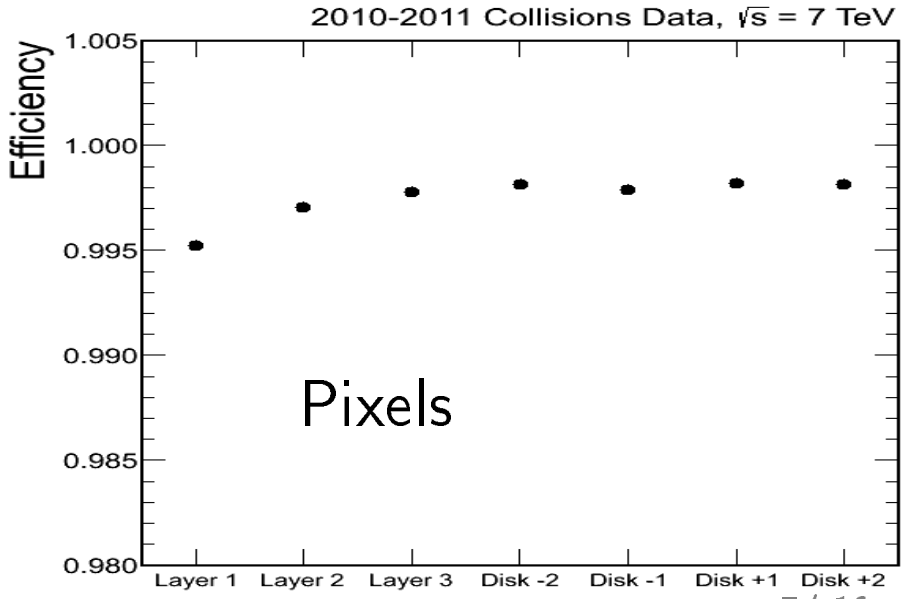


← example for S/N ratio

→ high and according to specifications (strips)

- efficiencies in all layers well above 99% (strips and pixel)





Tracking

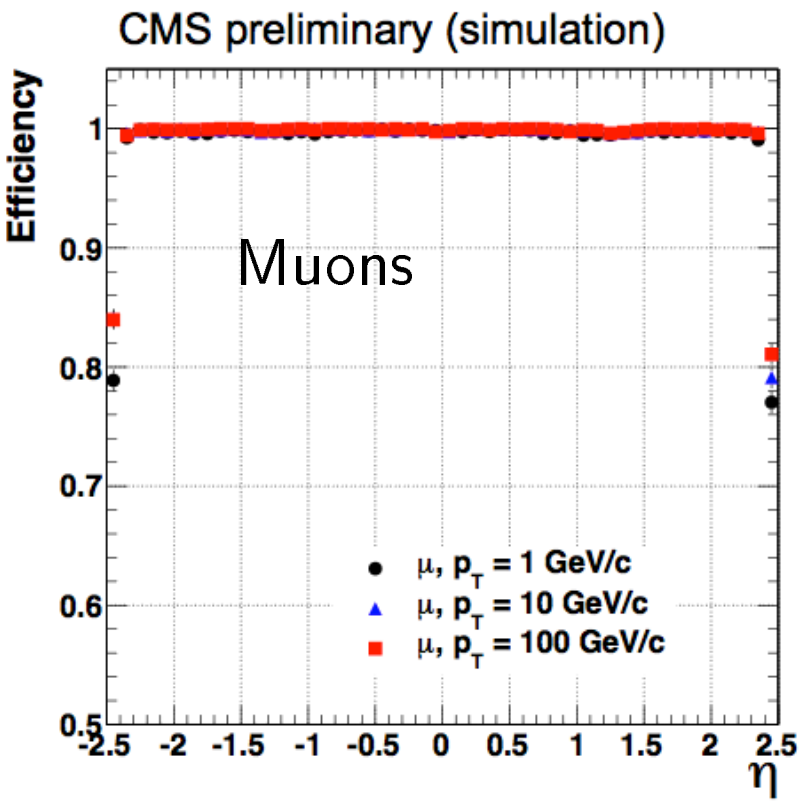
- CMS uses multi-stage iterative tracking
- subsequent steps with typically relaxed seeding

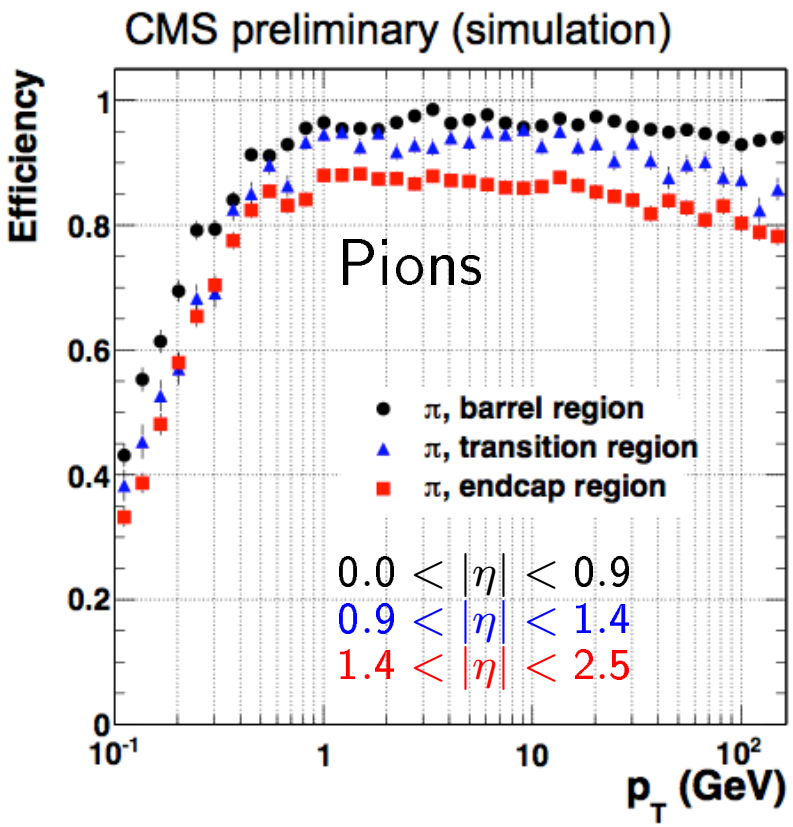
→ recovering inefficiencies from earlier iterations

→ 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.

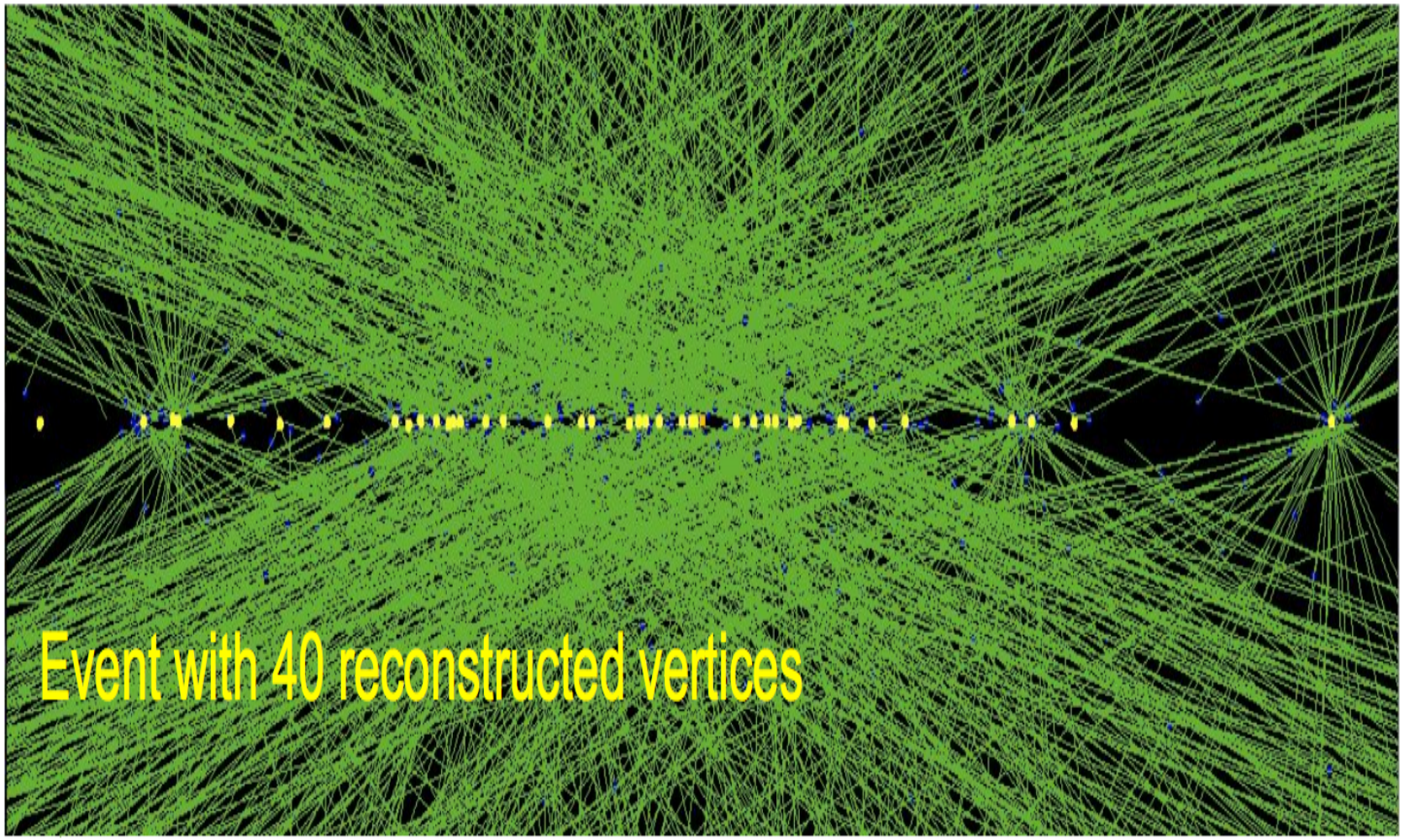
Tracking efficiency





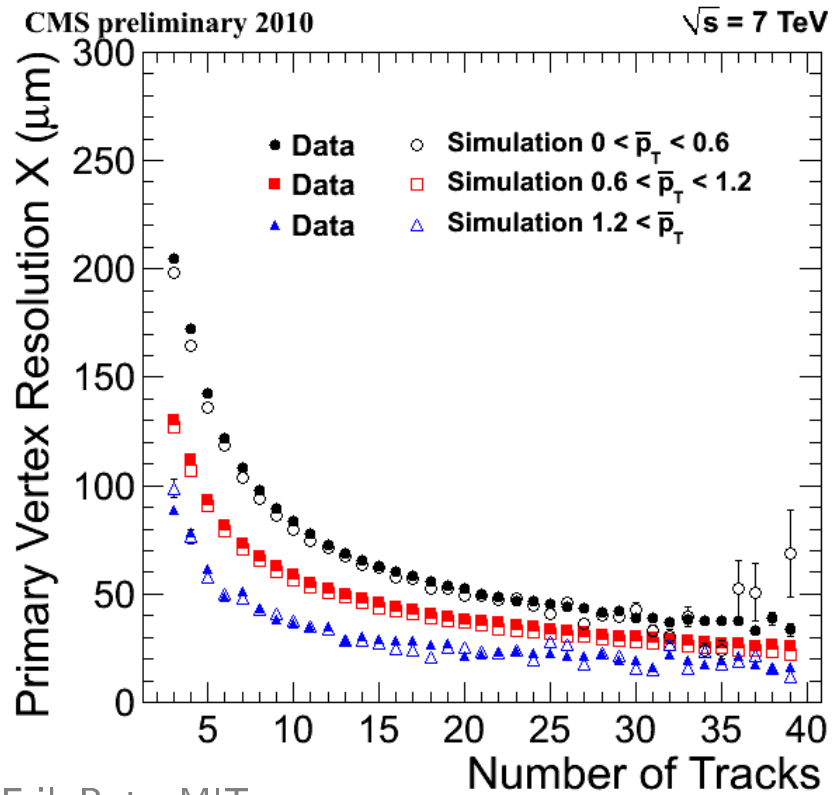
- efficiency for isolated muons very close to 100% for $|\eta| < 2.4$
- single pions with efficiencies above 90 (80)% in the barrel (endcap) region for $p_T > 500$ MeV

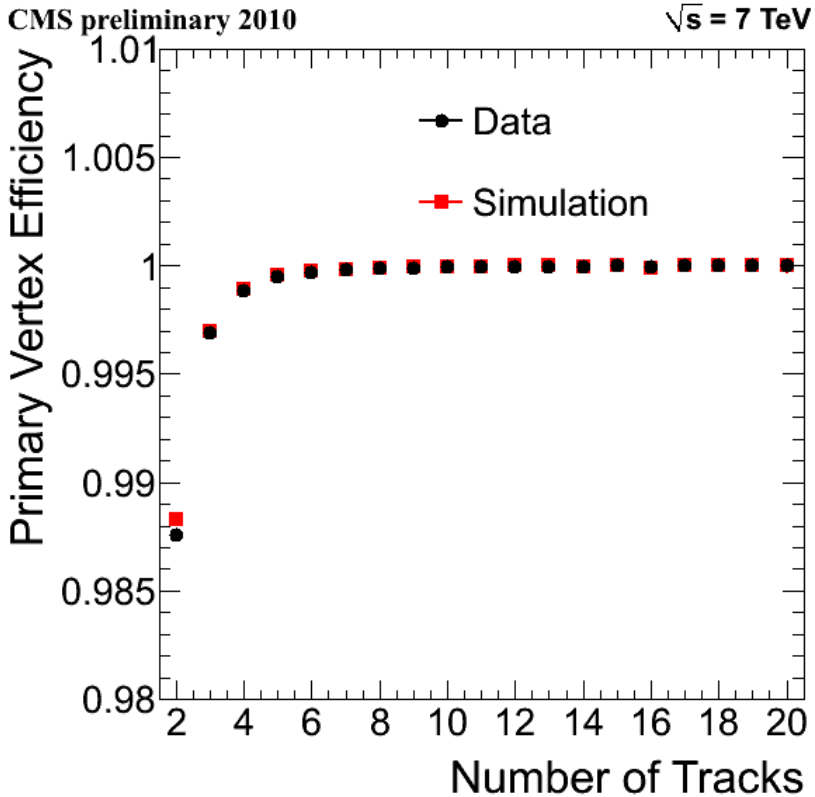
Vertexing



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





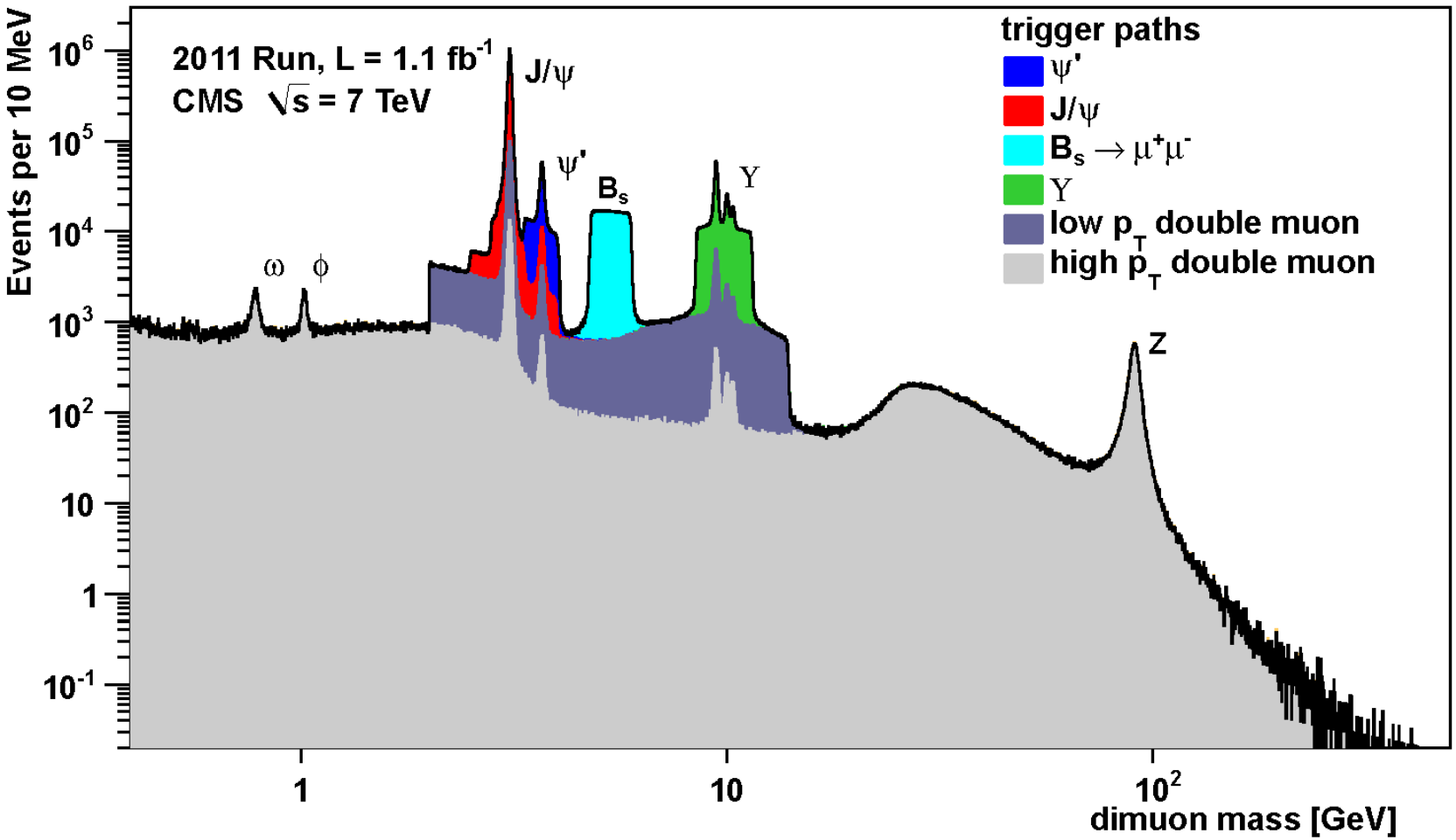
- same data-driven 'split' method
- vertex resolution depends on number of tracks and their p_T
- approaches 20(30) μm in x and y (z) for high number of tracks
- good data/MC agreement

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

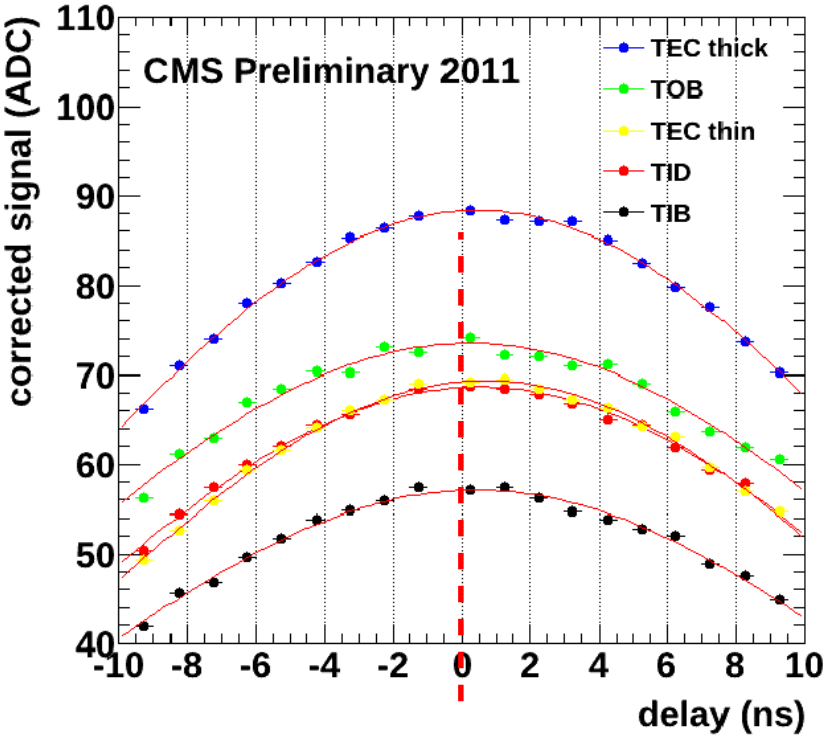
. . . and all of that to get things like this:



. . . and many other exciting physics results

Backup

Timing



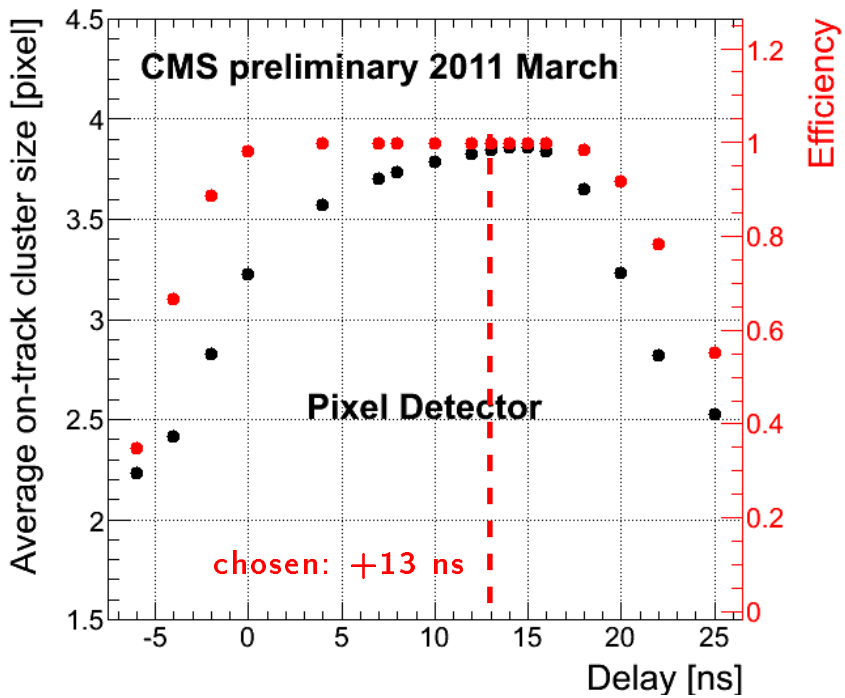
←

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

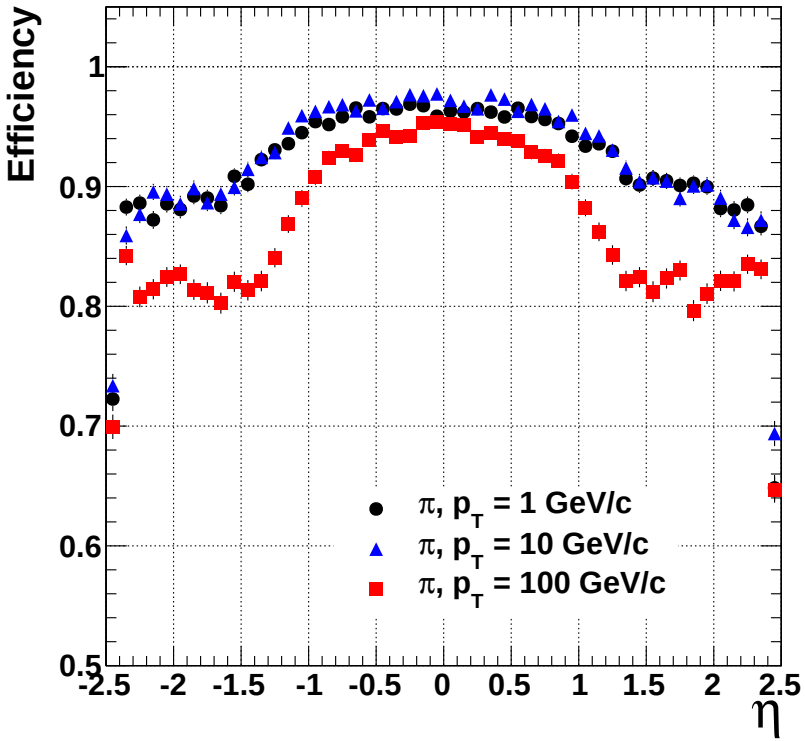
→ well timed in

→

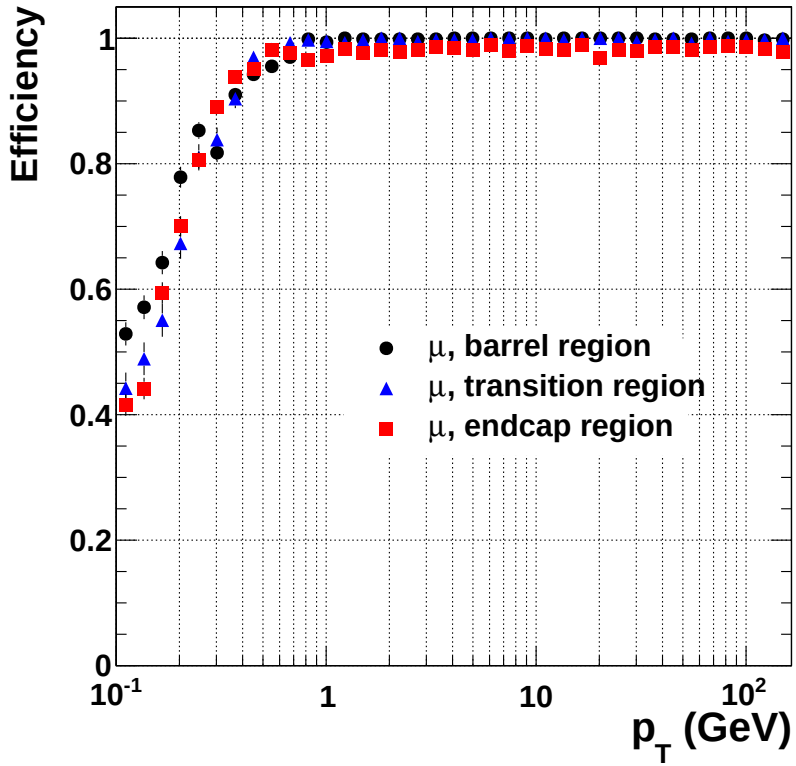
- scanning delay setting to maximize cluster size (black dots)
- chose working point away from edges of efficiency plateau (red)



Tracking efficiency



Pions(vs. η)



Muons(vs. p_T)