Low-mass di-muons at CMS

T. Nicholas Kypreos
University of Florida
for the CMS Collaboration

outline

muon reconstruction

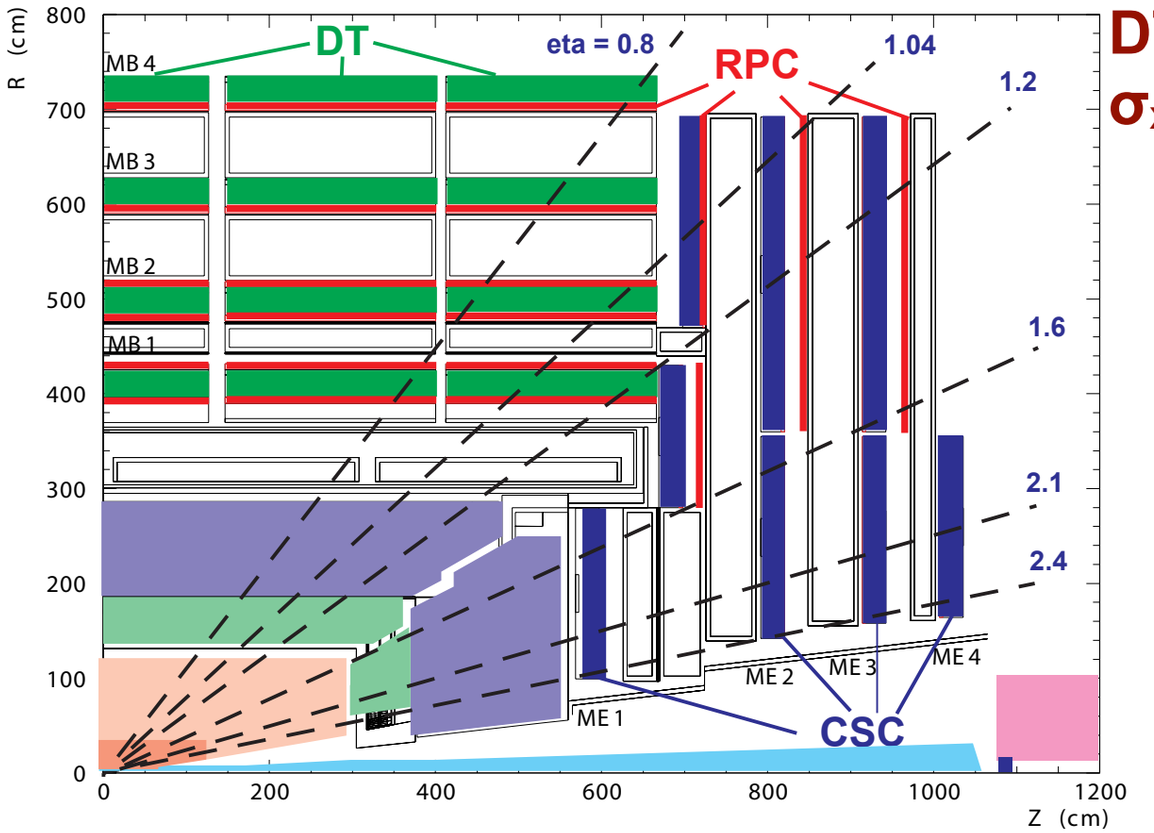
lessons learned from cosmics with fake di-muons

run selection in CMS

event selection

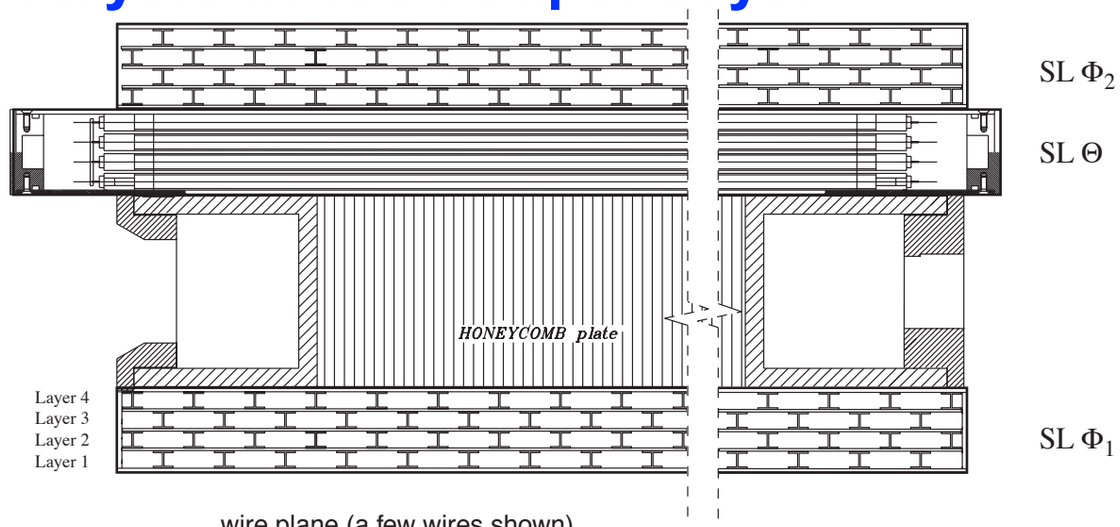
di-muons

CMS muon system



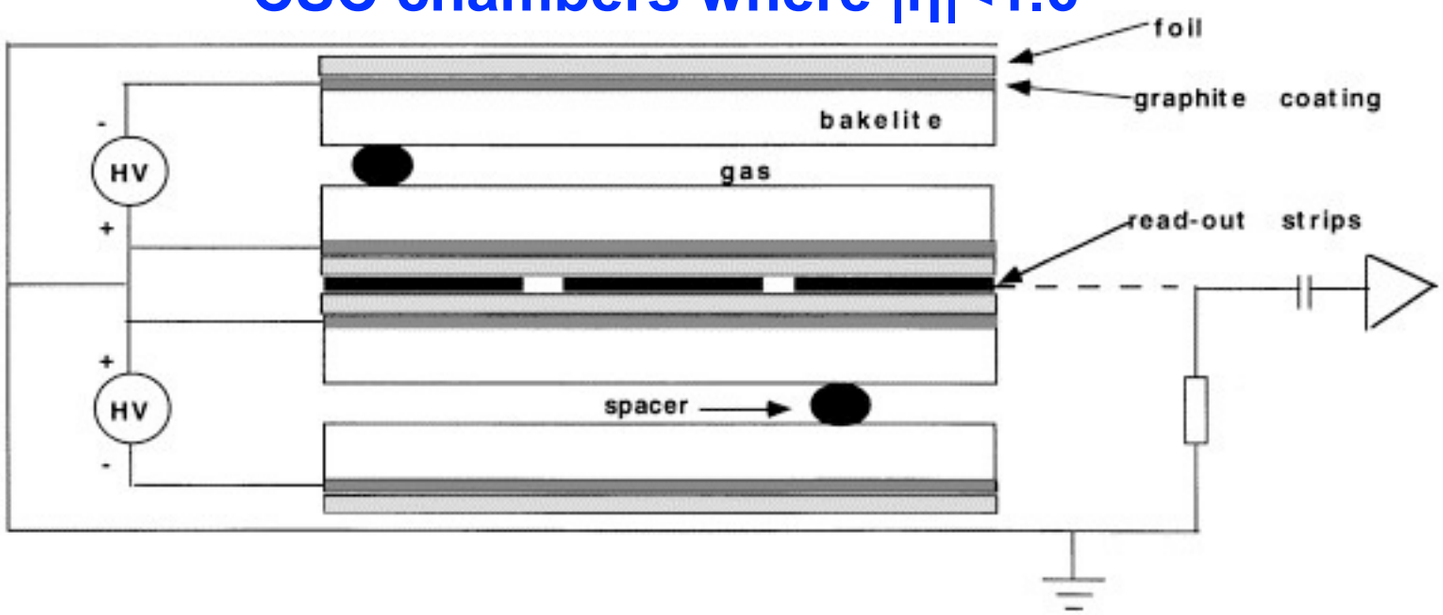
DT
σ_x~200 μm

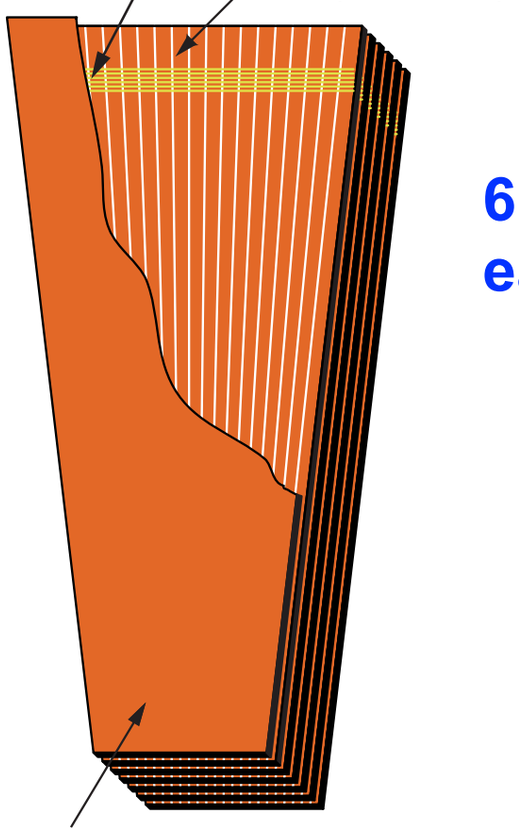
2 Super Layers (φθφ) for first 3 stations
2 φ Super Layers in last station
4 layers in each Super Layer



RPC
σ_t~2 ns

2 RPC chambers for first 2 DT stations
1 RPC chamber for last 2 DT stations and
CSC chambers where |η|<1.6





CSC
σ_x~100-240 μm
6 gaps (layers) for each chamber

muon reconstruction

tracker track

pixel+strip hits

tracker muon

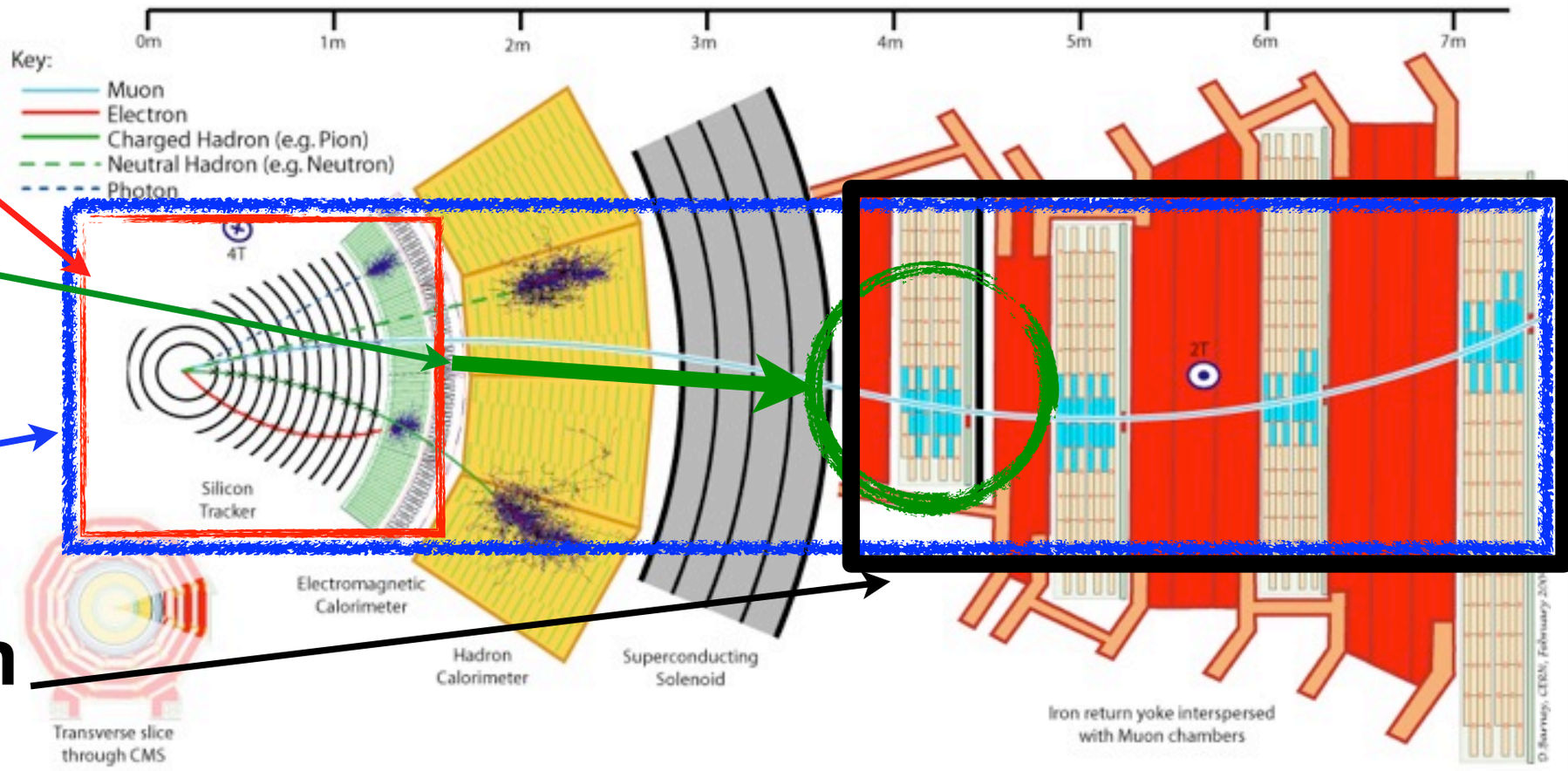
tracker track matched to muon segment

global muon

pixel + strip + muon hits

stand alone muon

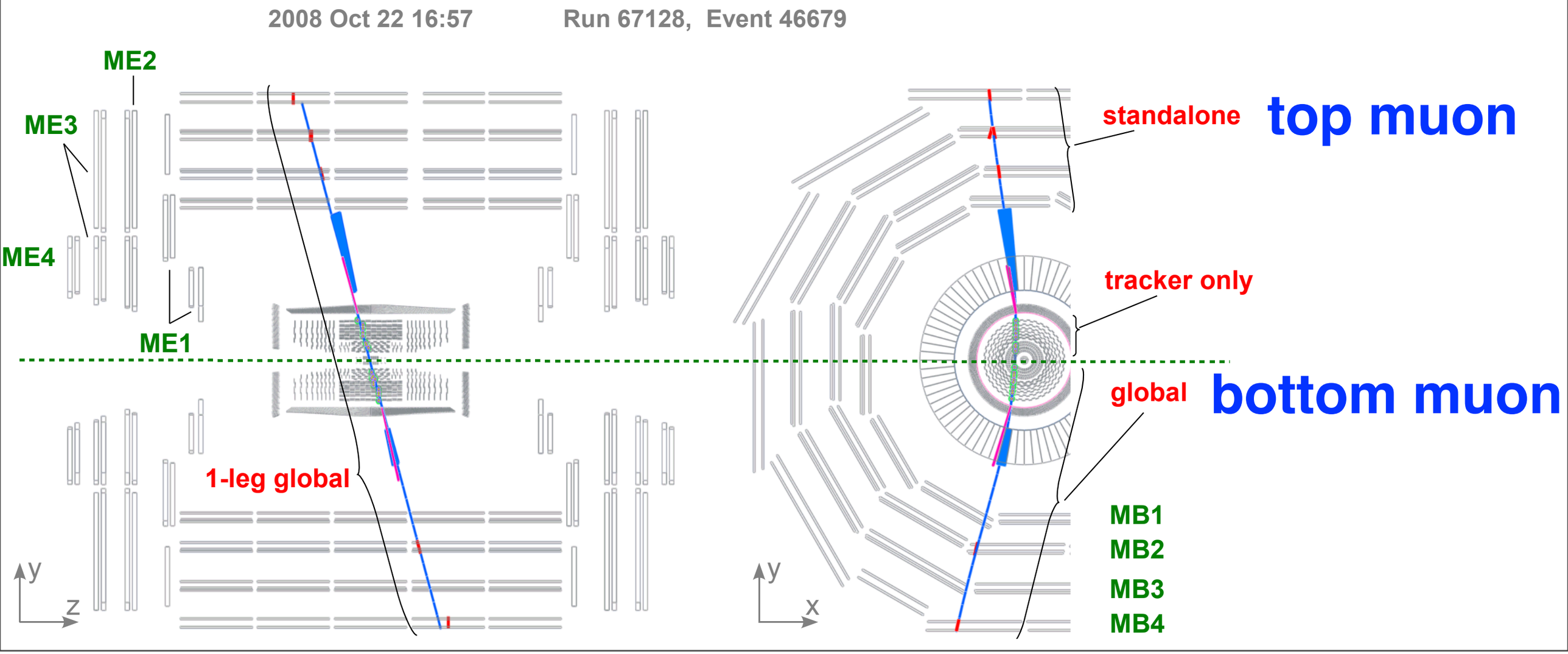
muon hits



- **general complimentary techniques used for muon identification:**
  - **start with tracker and match to segments in the muon system**
  - **start with stand-alone muon and fit all hits with to search for a compatible tracker track**

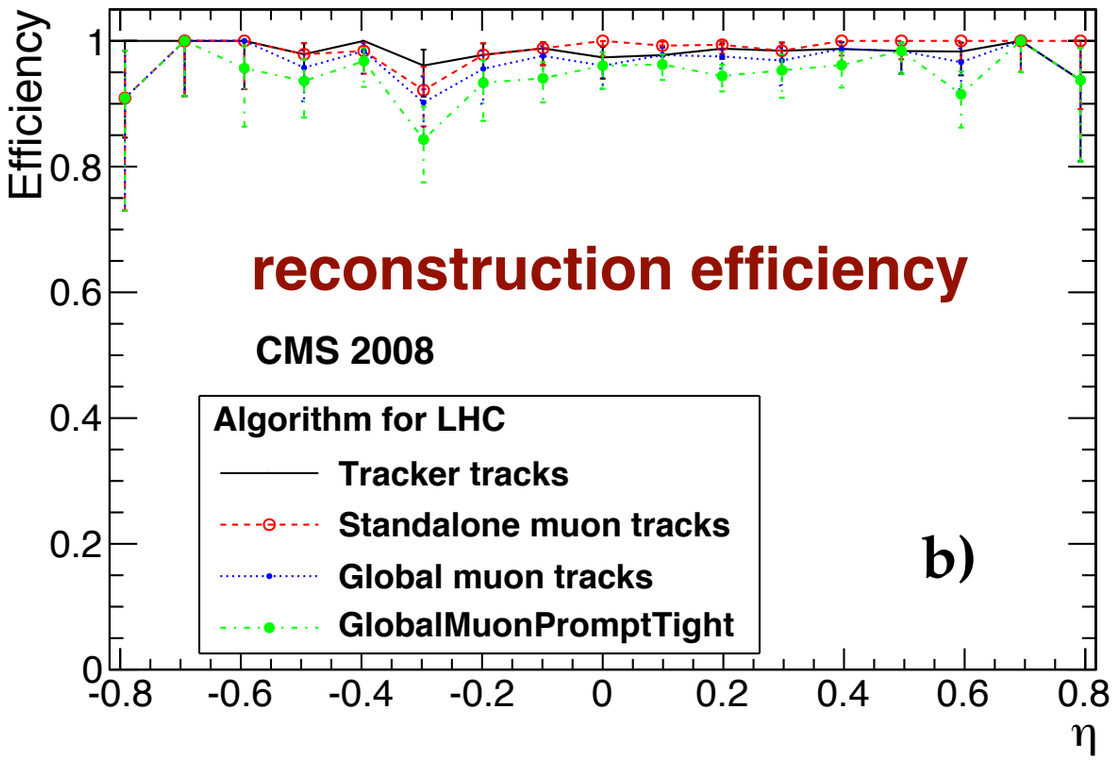
lessons from cosmics

- use cosmic-ray muons to mimic di-muon event properties
- treat muons in the top and bottom half of the detector as a di-muon
  - extract resolution estimates, efficiencies, even a full physics measurement

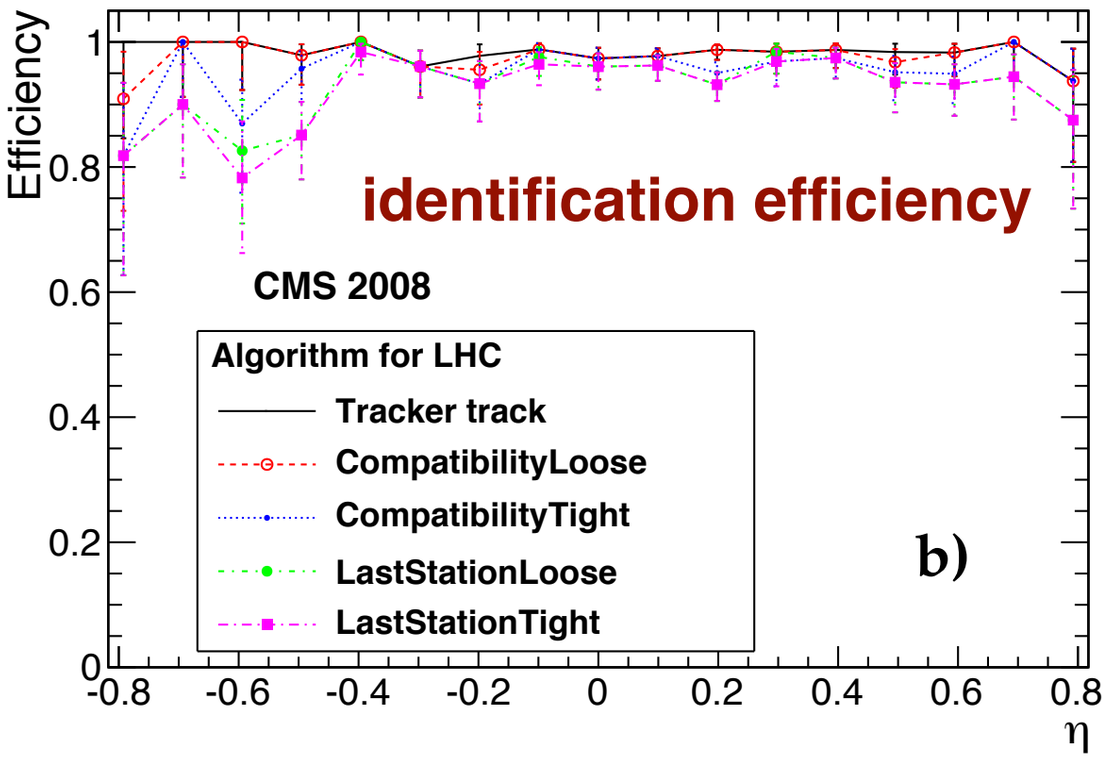


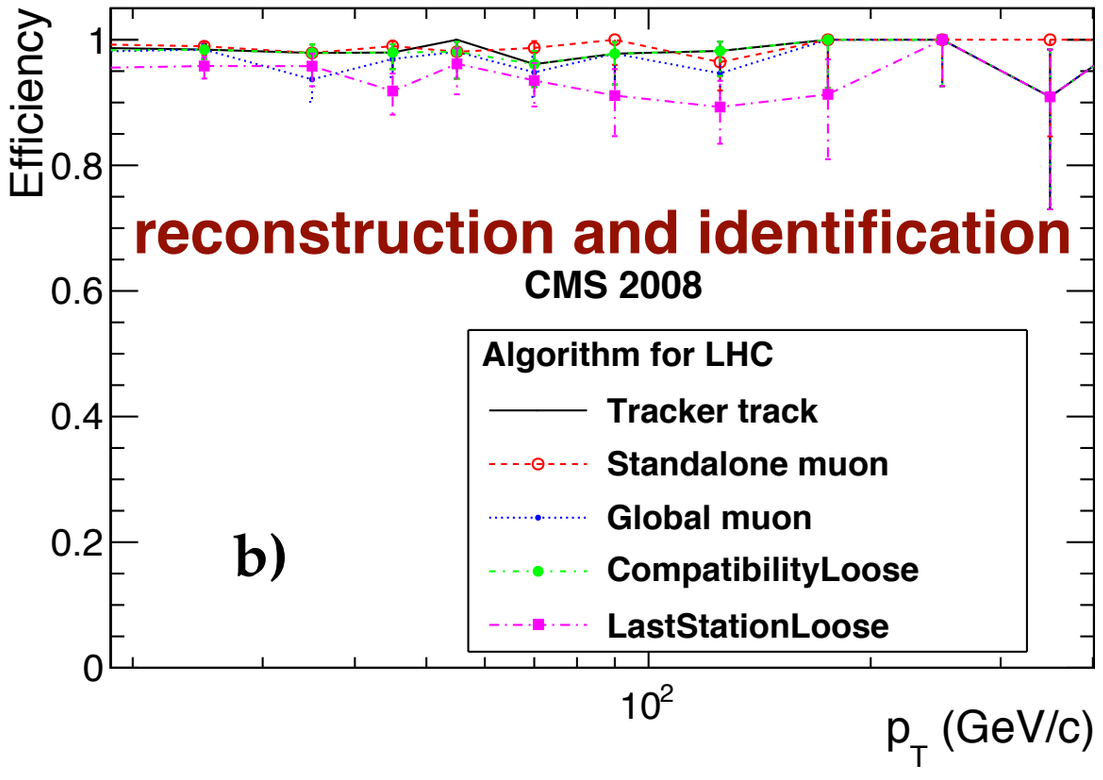
reconstruction and identification

2008 cosmic ray data



muon reconstruction and identification in the barrel





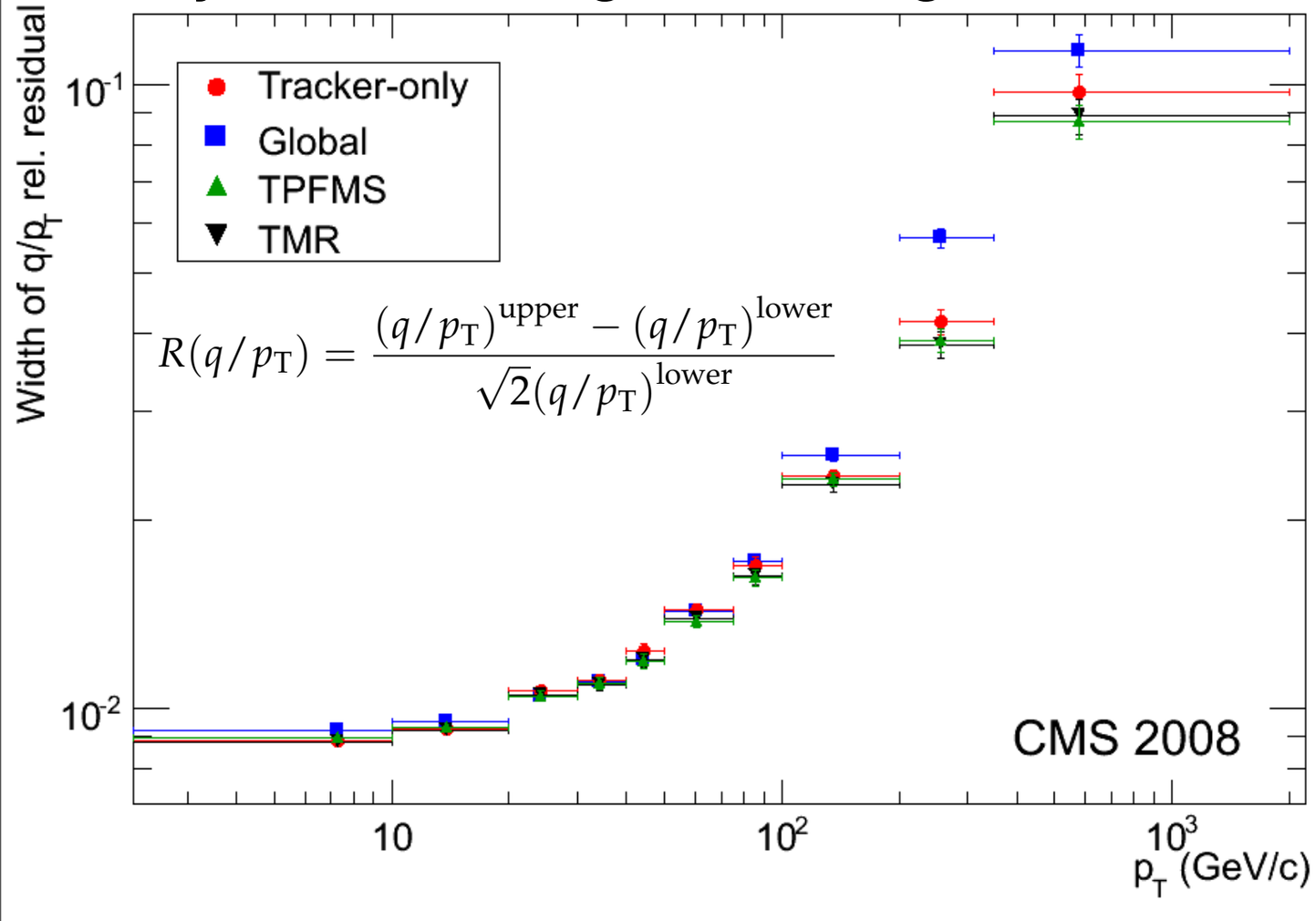
resolutions and physics

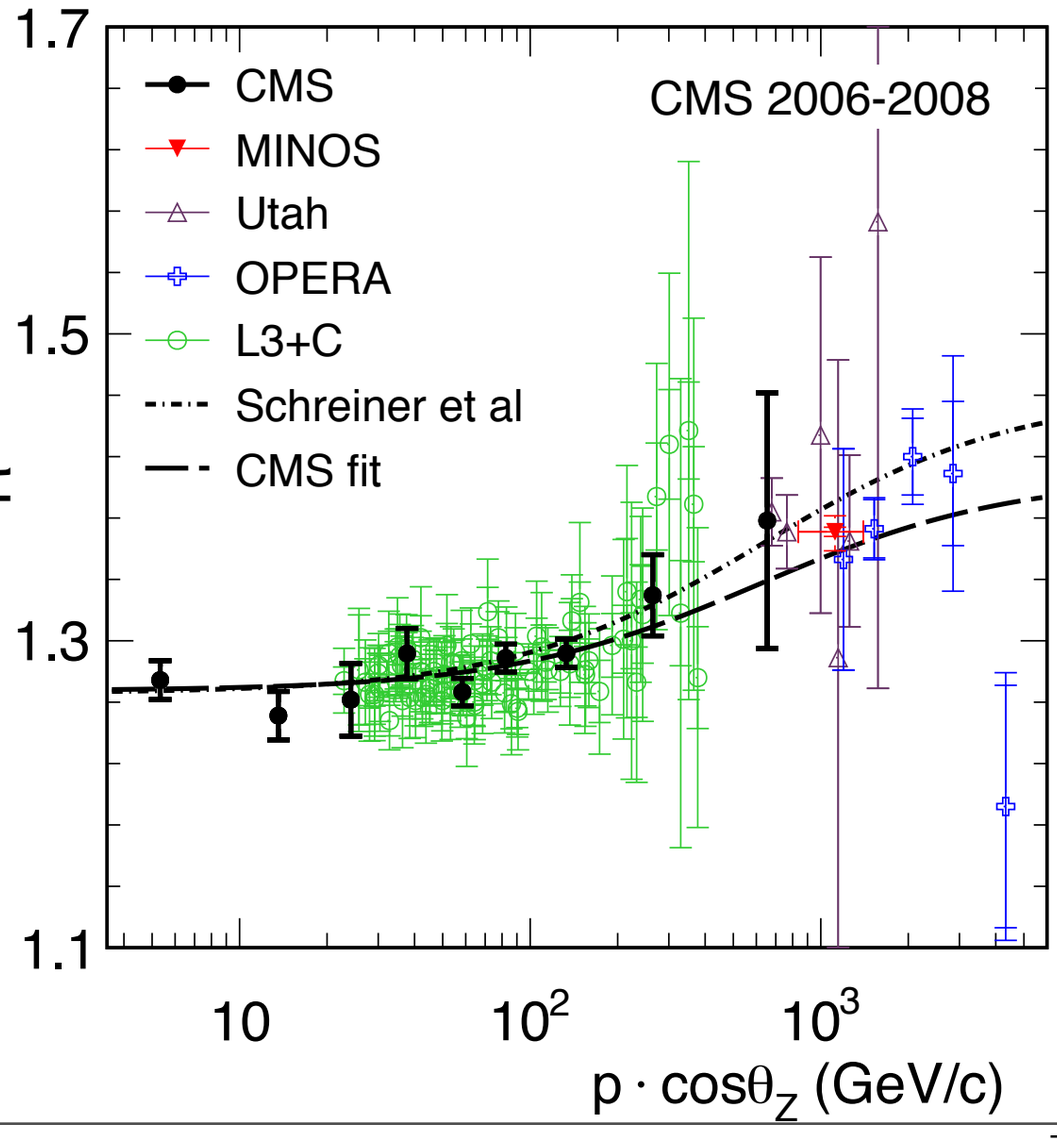
- **measure the transverse momentum resolution using residuals between the top and bottom halves of the detector**
  - **low-pt regime is dominated by multiple scattering**

$$C_T \equiv \frac{1}{2}\left[\left(\frac{q}{p_{\mathrm{T}}}\right)_{\mathrm{top}} + \left(\frac{q}{p_{\mathrm{T}}}\right)_{\mathrm{bottom}}\right]$$

- **measure the ratio of positive to negative muon fluxes using cosmics**
  - **done by averaging the top and bottom legs and fully reconstructing as one long muon**

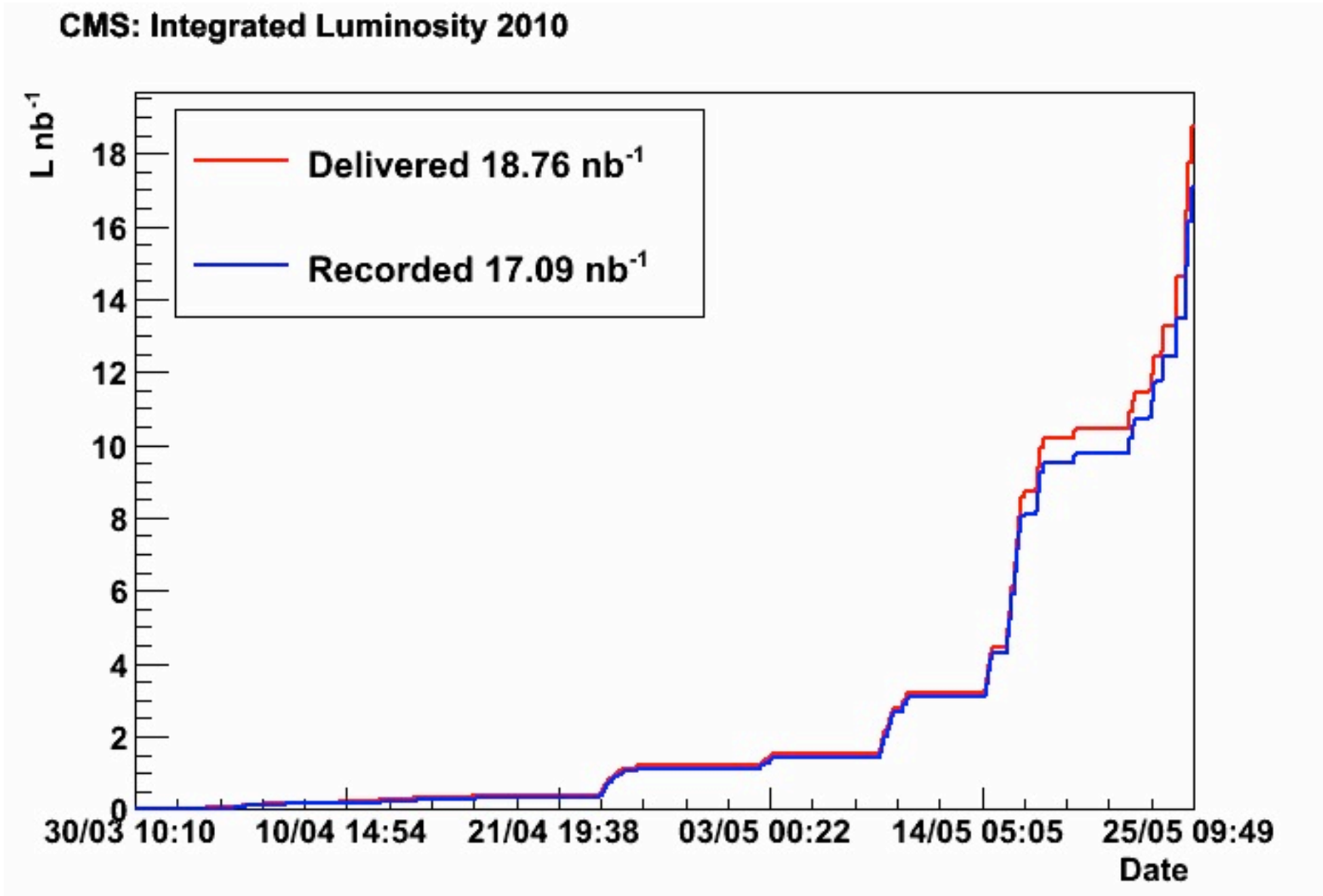
$$R\left(\frac{\mu^+}{\mu^-}\right) = 1.2766 \pm 0.0032\,(stat.) \pm 0.0032\,(syst.)$$





luminosity and run selection

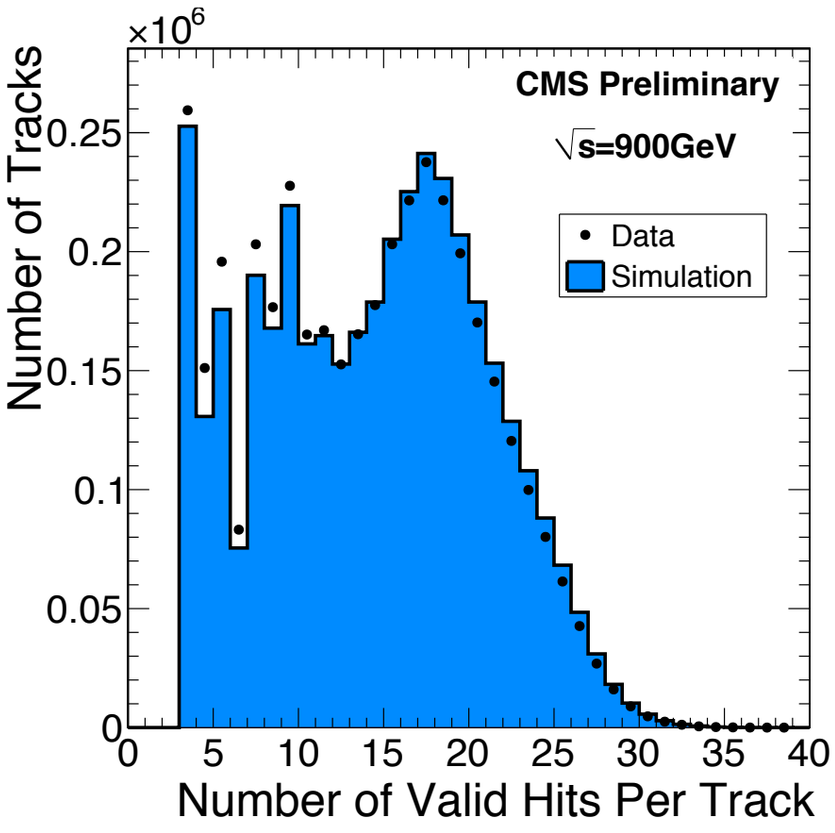
- perform quality checks on all sub-detectors
- data are certified at the level of run and luminosity section
- require good data quality from muon and tracker sub-detectors
  - stable beam, no major problems in drift tubes, cathode strip chambers, or tracker

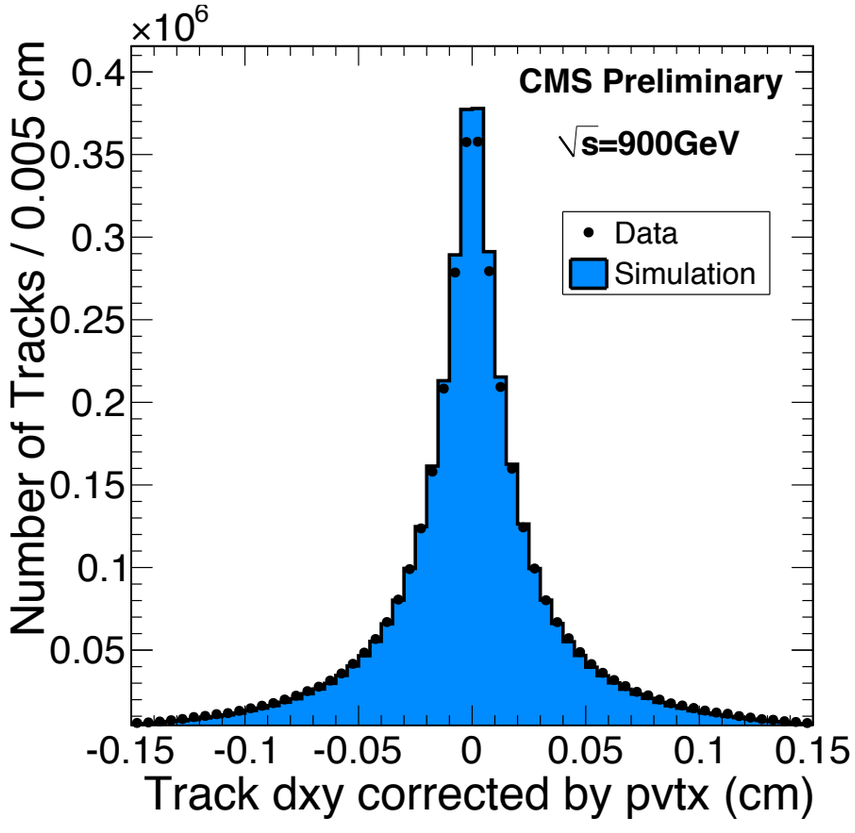


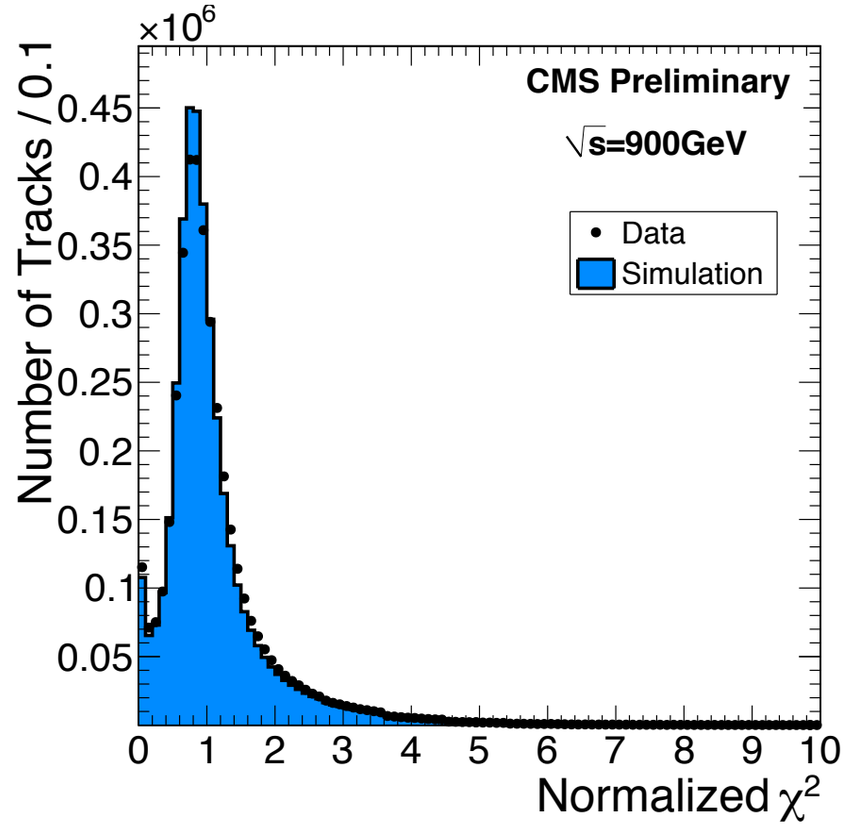
selection criteria

2009 √s = 900 GeV collision data

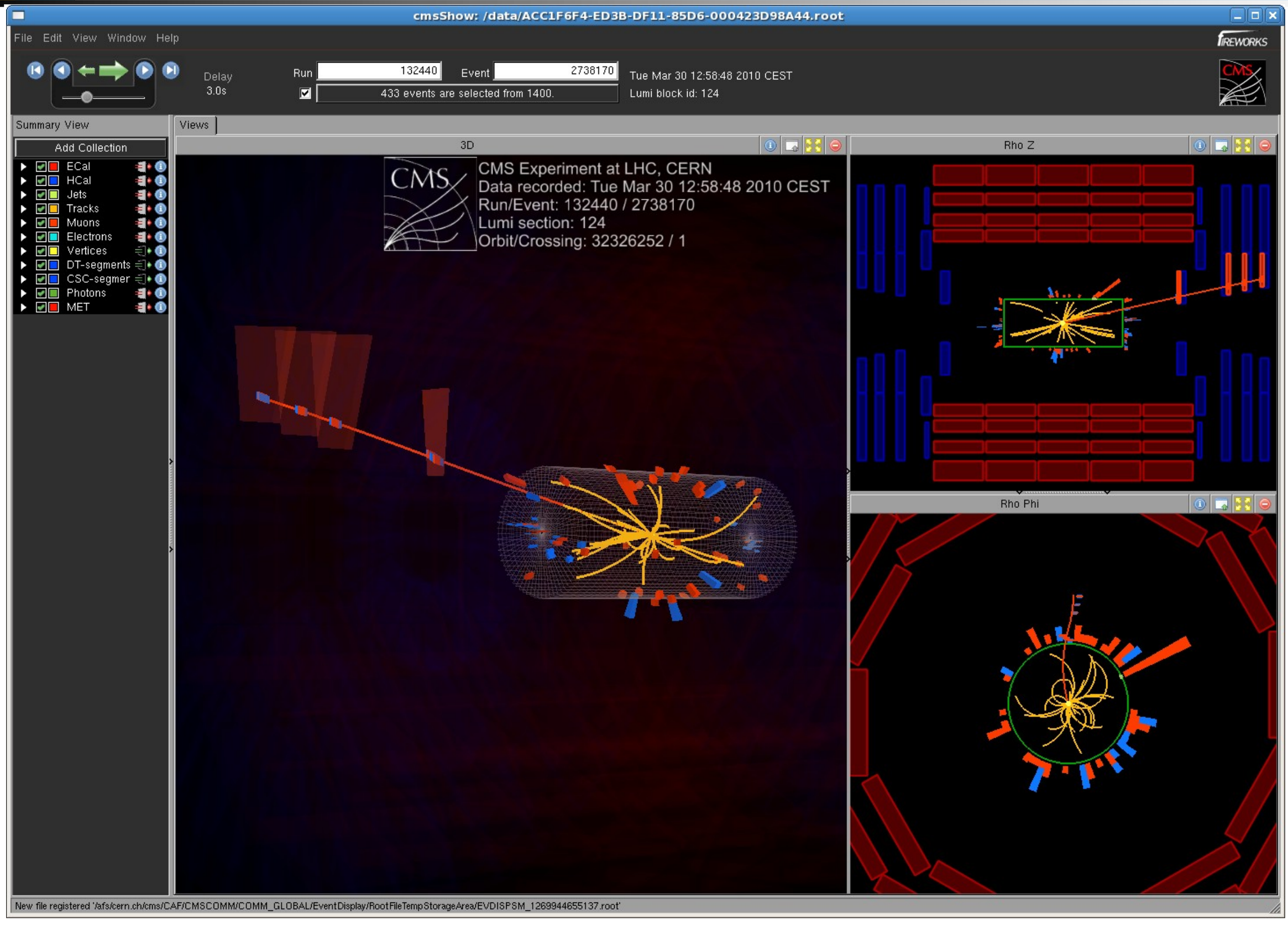
- apply low-level selection criteria on tracker tracks
- some typical track selection criteria
  - number of tracker hits
  - impact parameter,
  - common vertex
  - χ^2





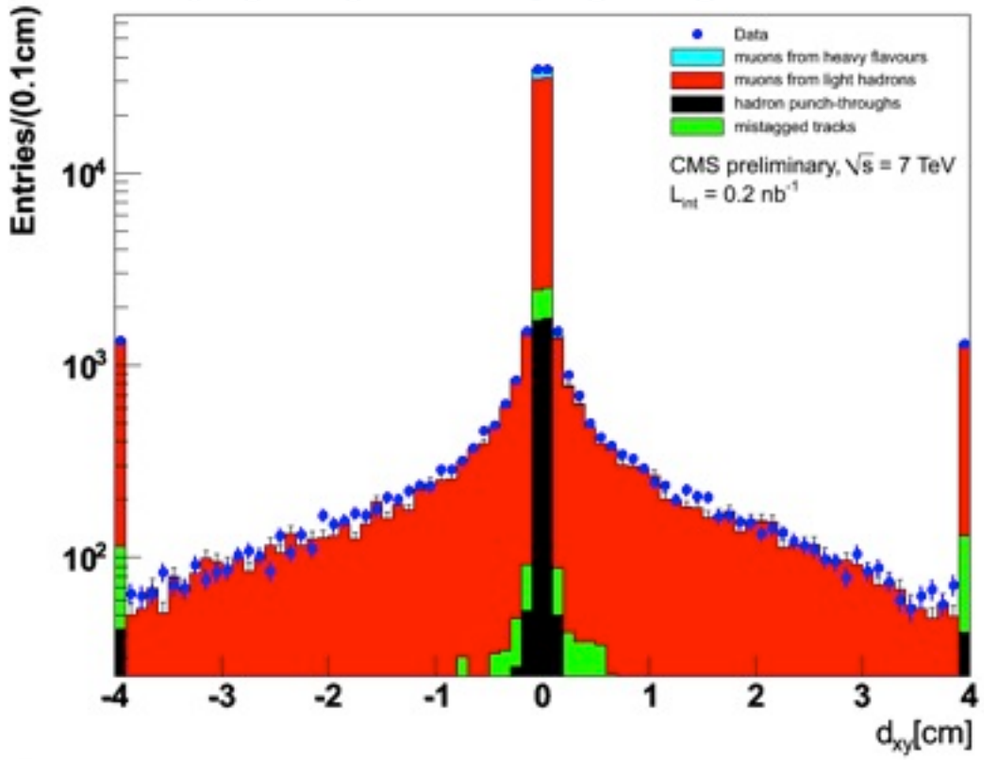


single-muon event display

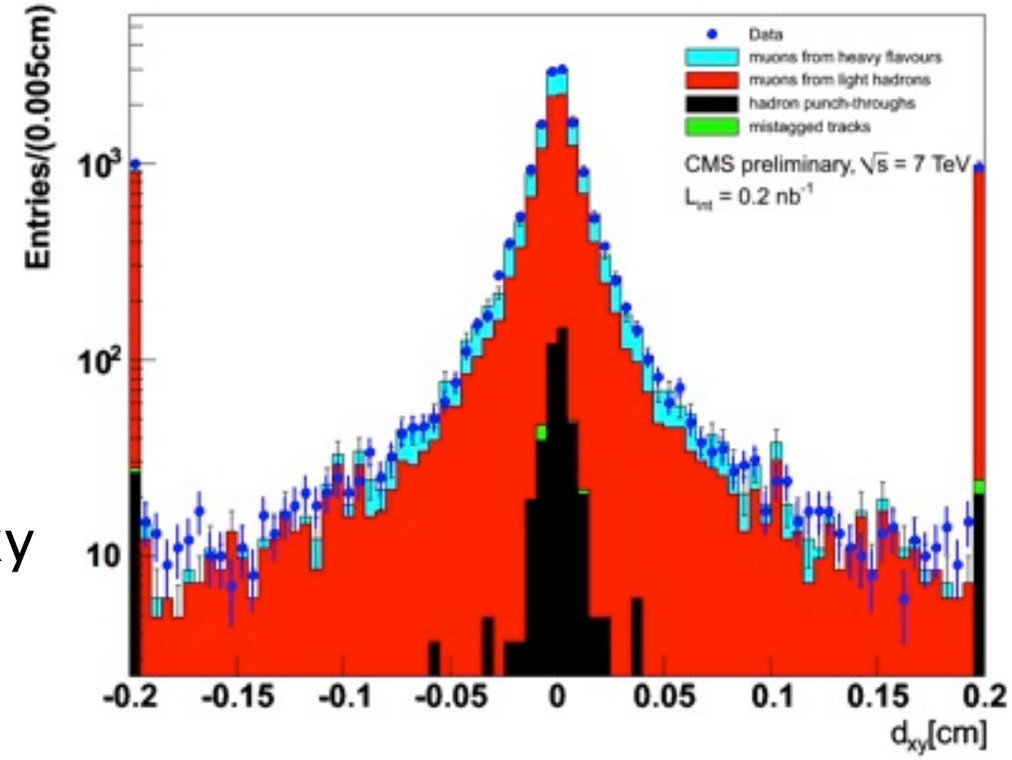


impact parameter distributions

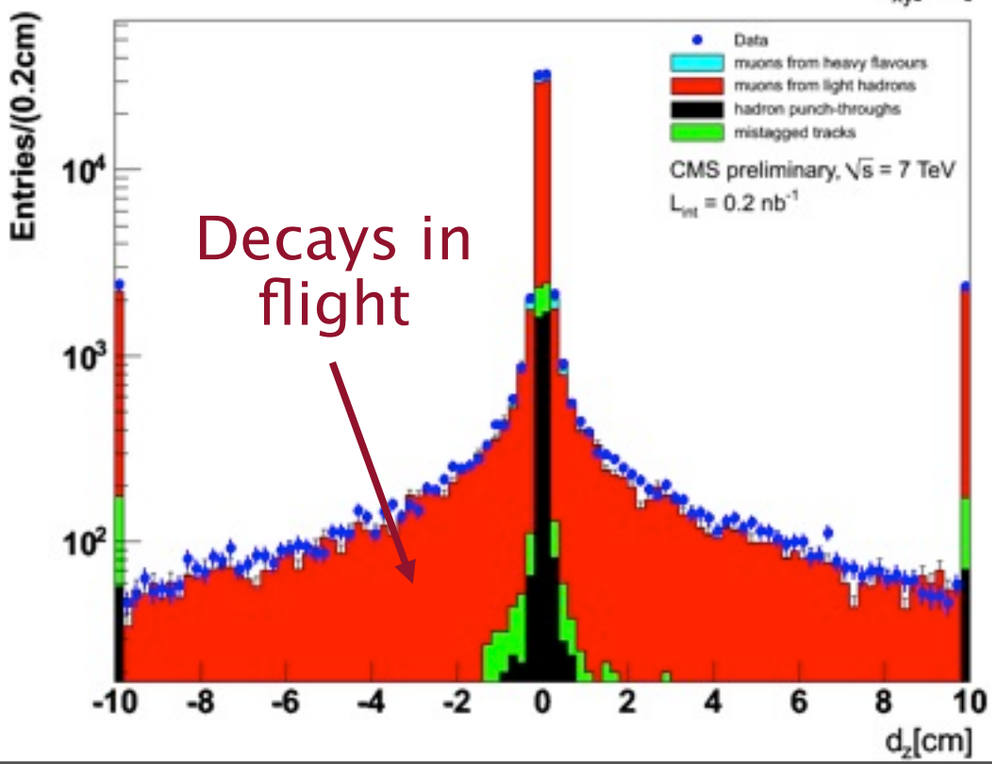
Tracker Muons

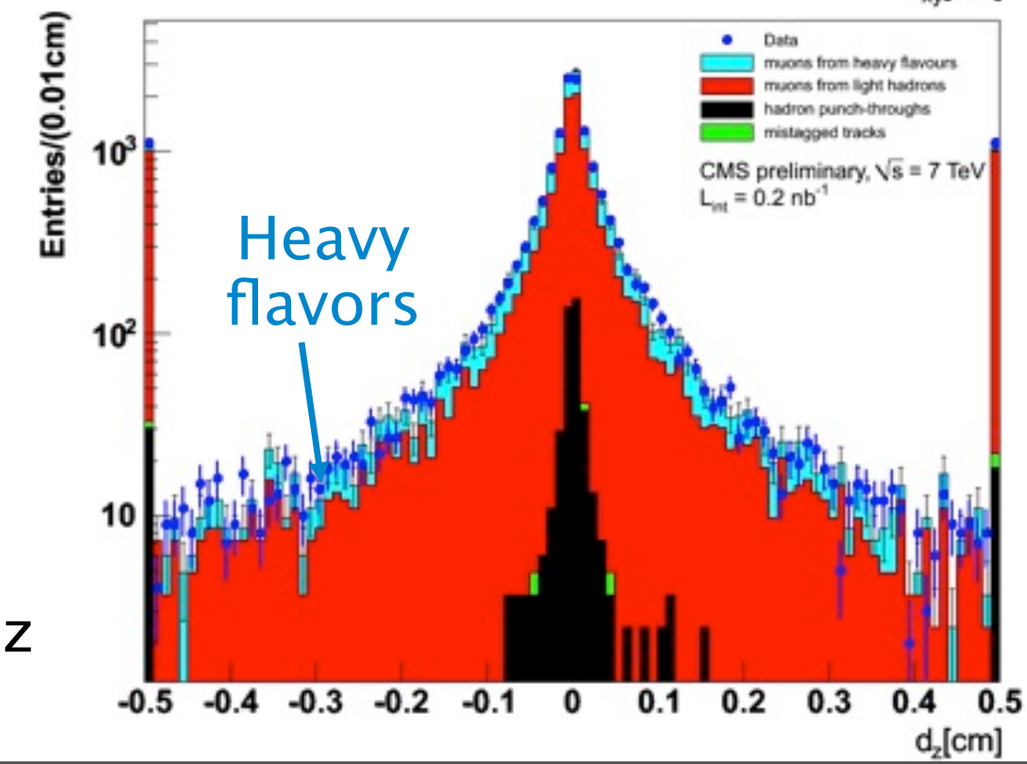


Global Muons



d_{xy}





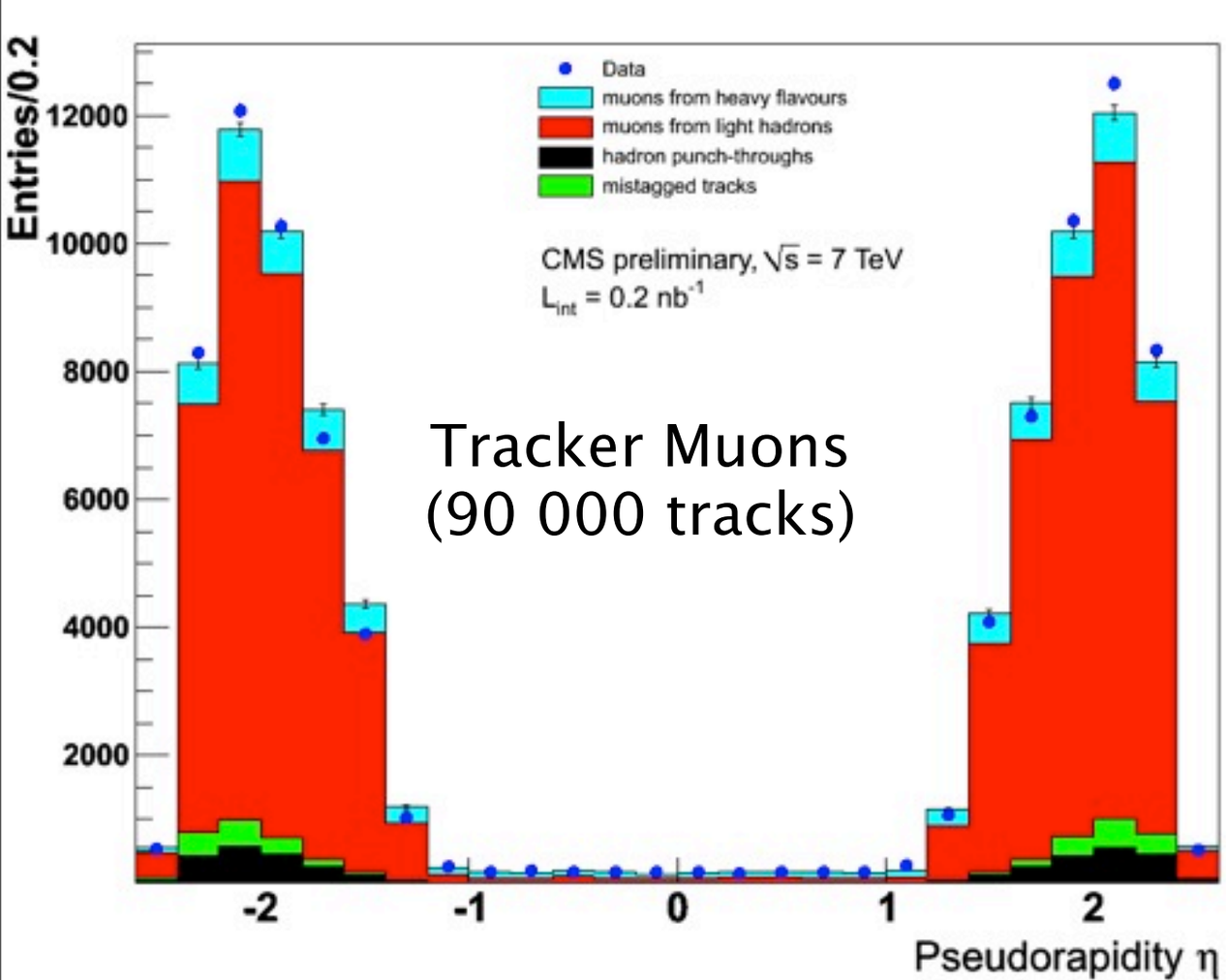
d_z

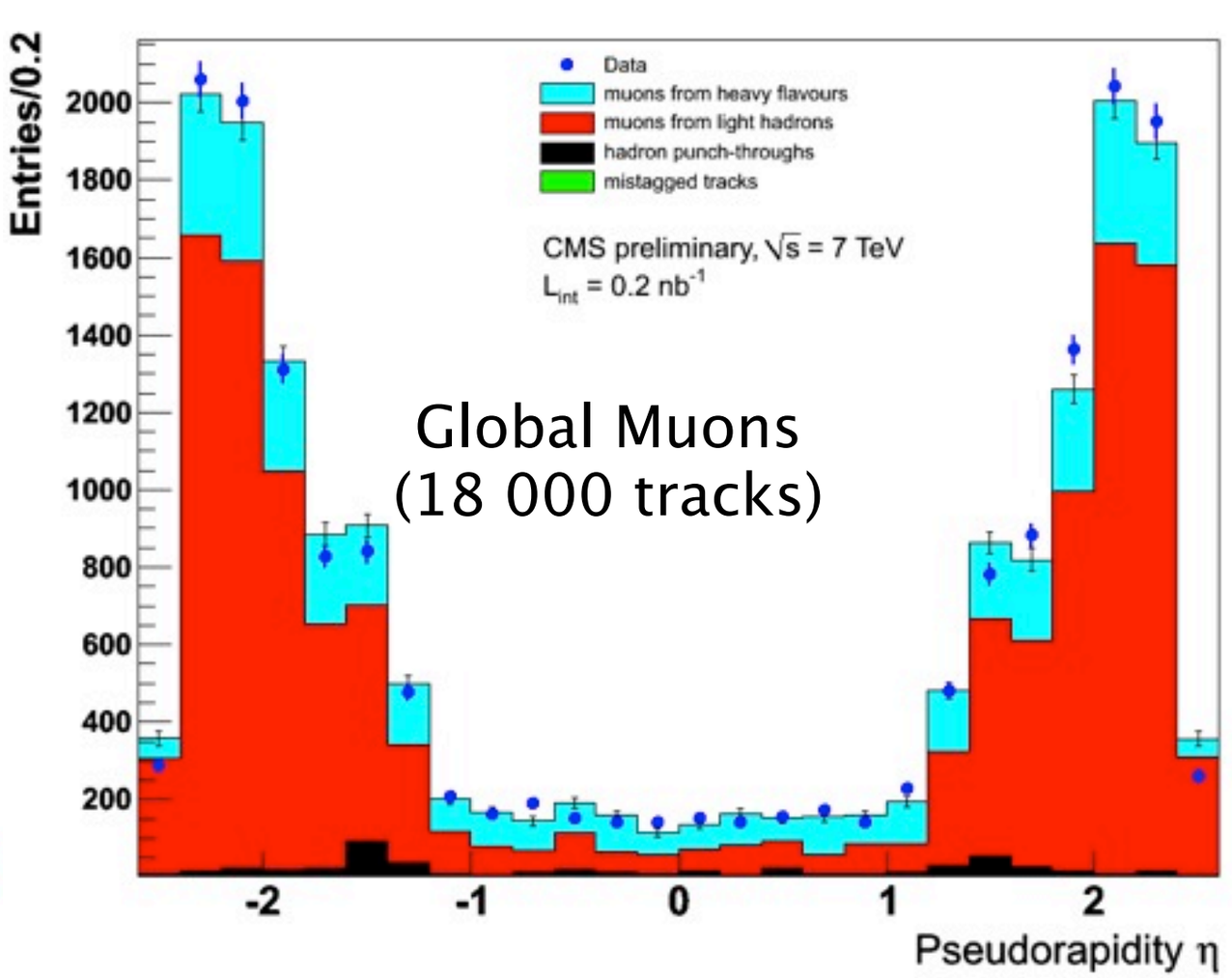
muon pseudo-rapidity

mostly low-pT muons from light hadron decays

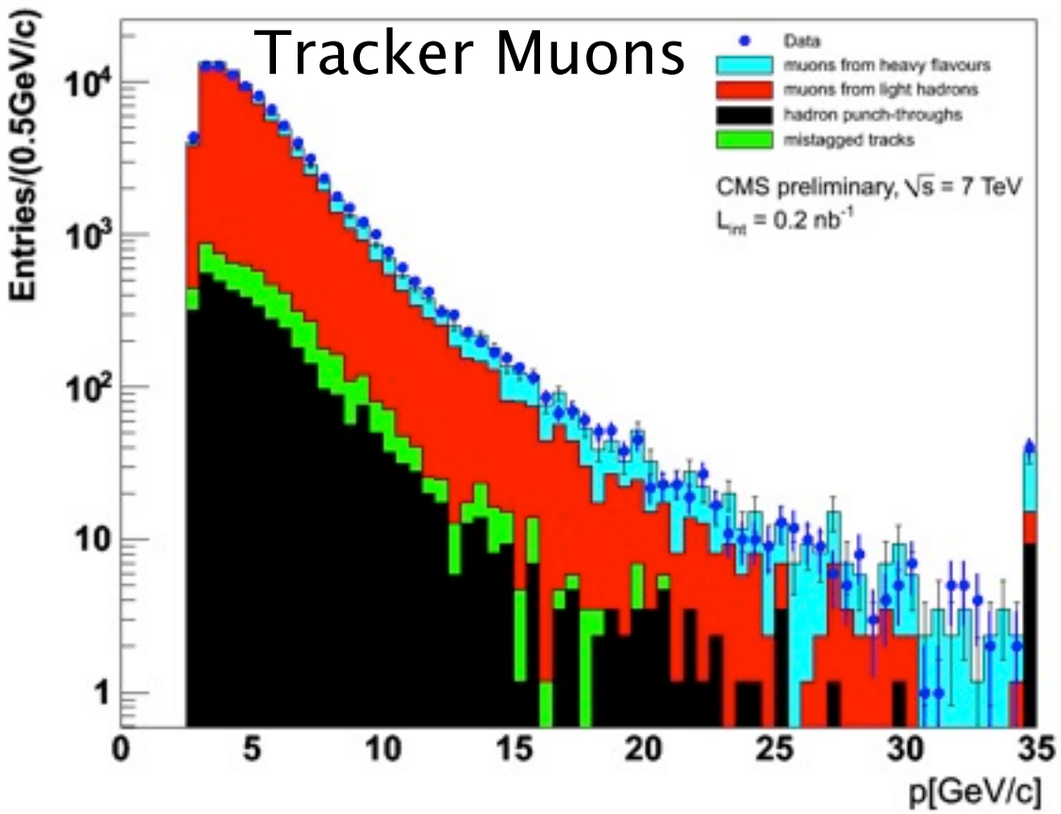
η distribution peaks in forward region because of lower pT thresholds

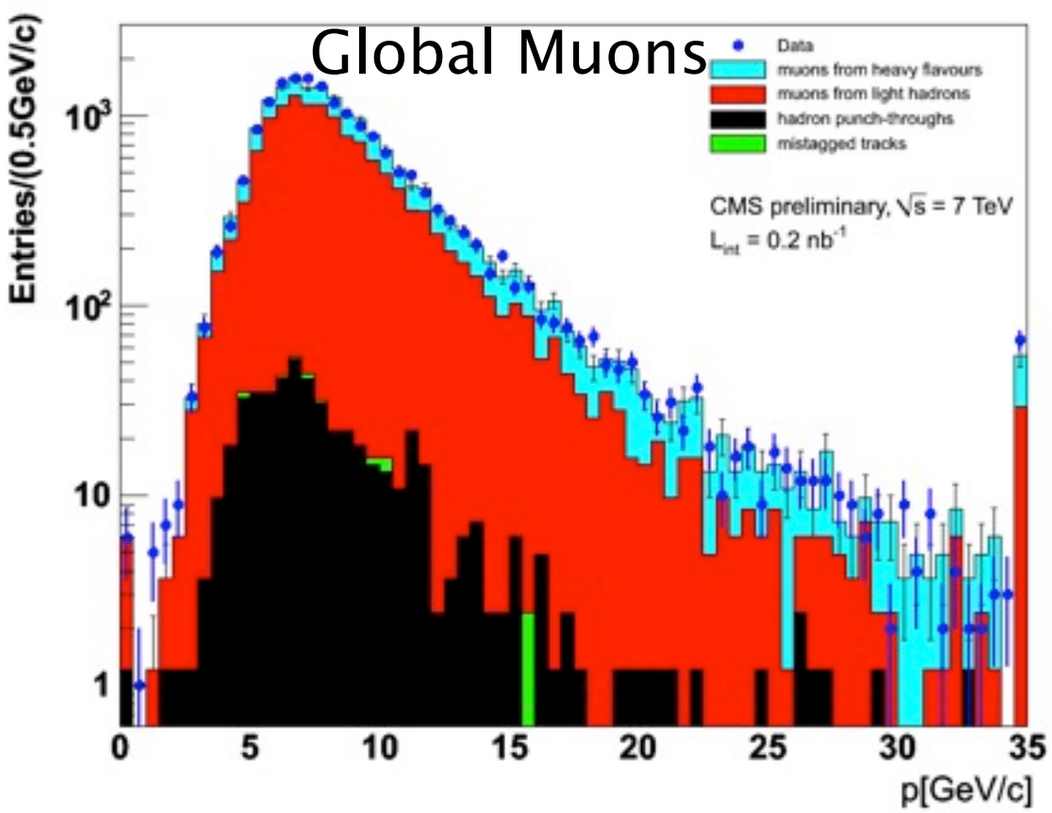
good data-MC agreement including heavy-flavor decays, hadronic punch-throughs, and mistags

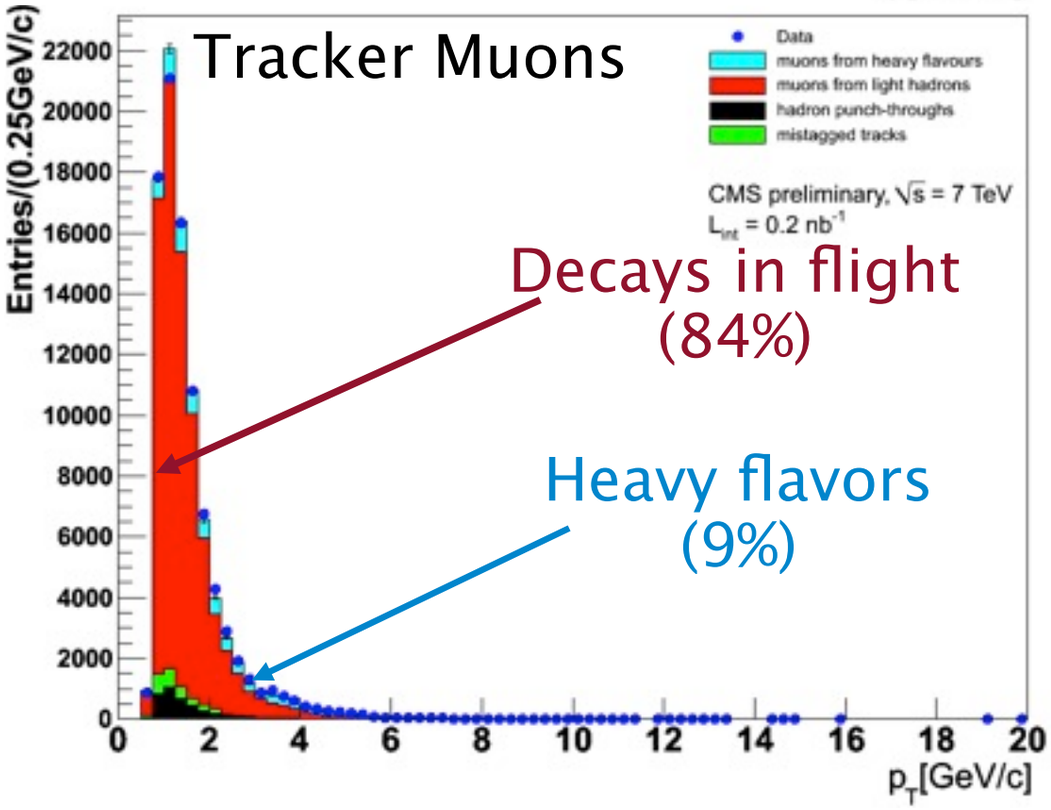


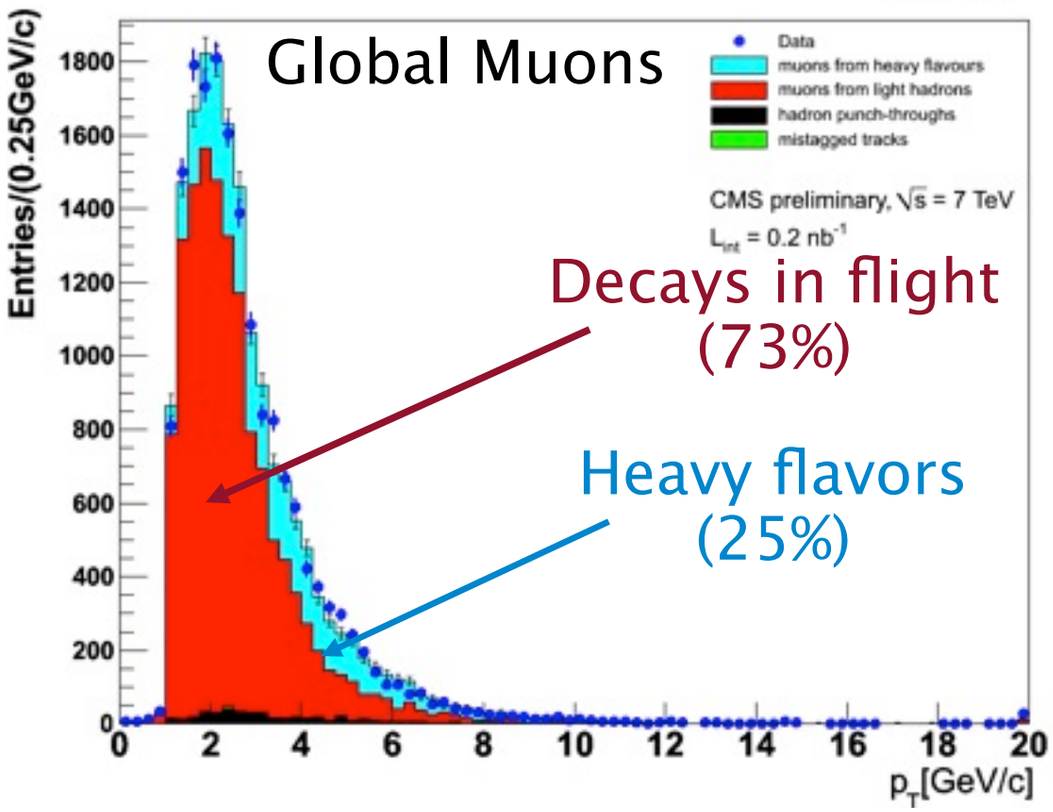


p and p_T spectra

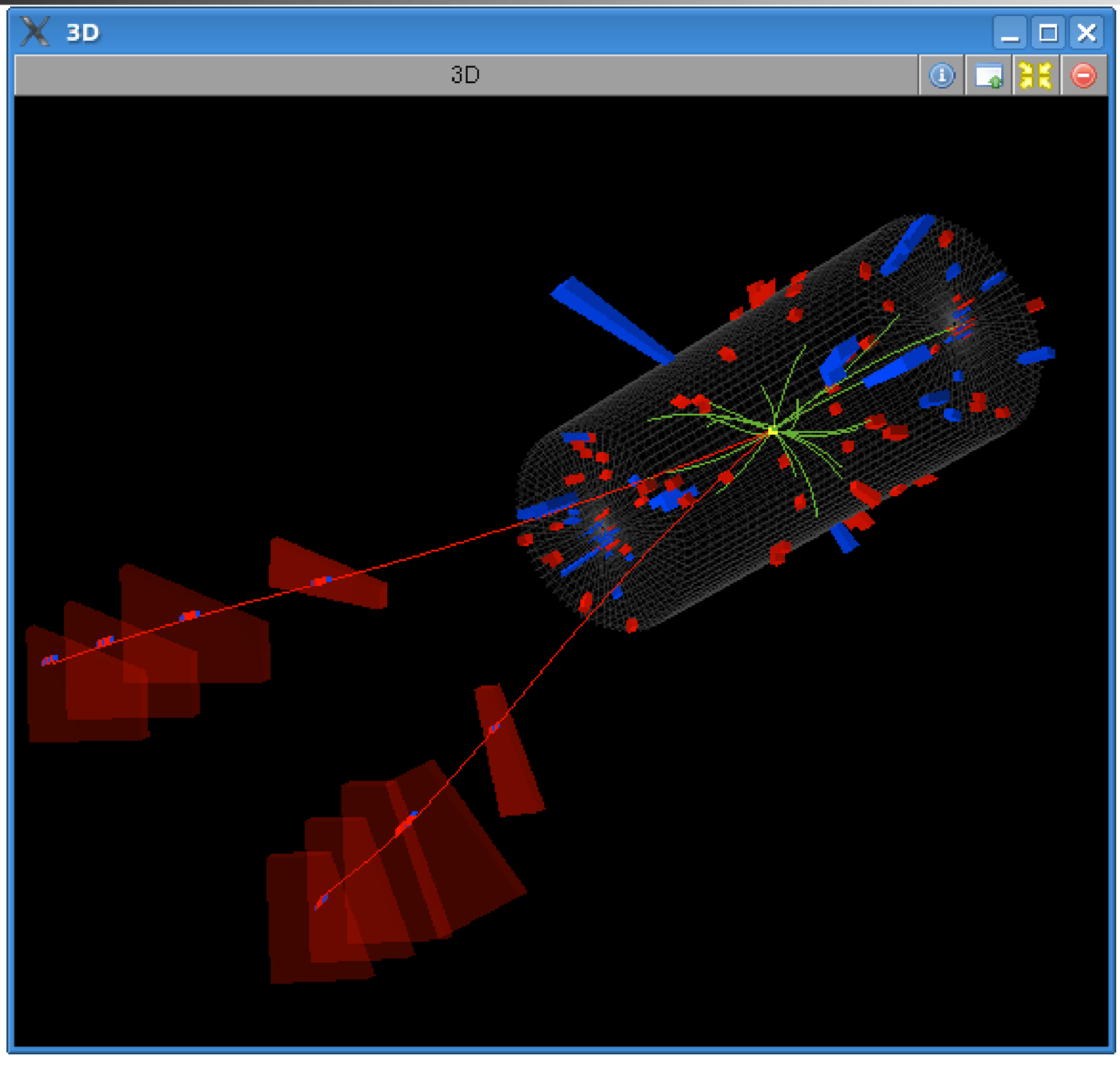






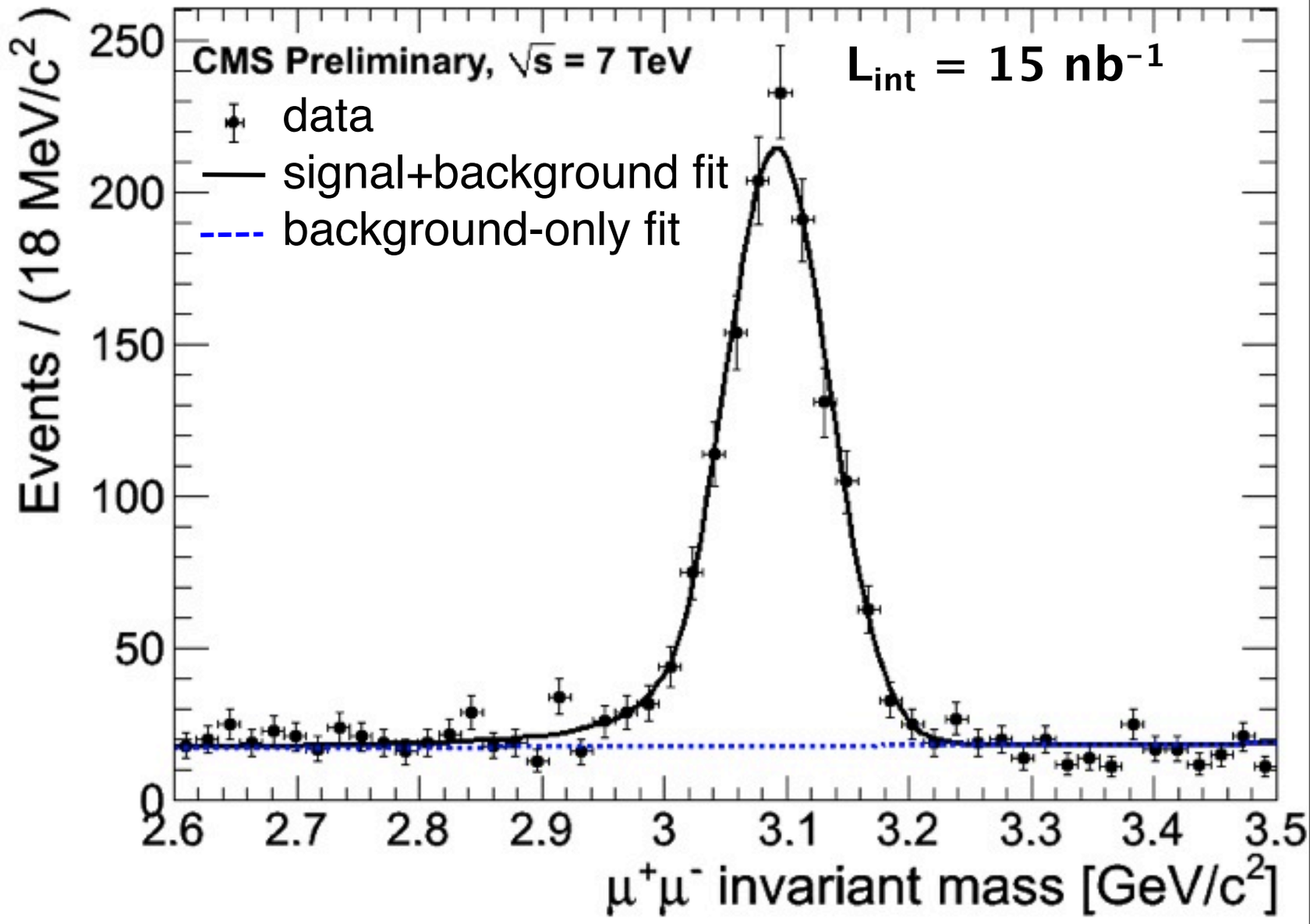


di-muon event display



di-muon invariant mass distribution (J/Ψ)

- **track selection based on:**
  - **impact parameter,**
  - **number of tracker hits**
  - **common vertex**
  - χ^2
- **no trigger requirement**
- **extended ML fit**
  - **signal: crystal ball**
  - **background: exponential**



Signal events: 1230 ± 47
Sigma: 42.7 ± 1.5 (stat.) MeV
M_0: 3.092 ± 0.001 (stat.) GeV
S/B = 5.4 (M_0 ± 2.5σ)
χ^2/ndof = 1.1

summary

acceptance, efficiency, and luminosity measurements are all key to developing physics analyses

handles on muons in CMS coming developing in 7 TeV running but go back as far as cosmic ray analyses low-mass di-muon resonances and distributions are blooming at the LHC