Strangeness results + First look at Pb-Pb collisions at CMS

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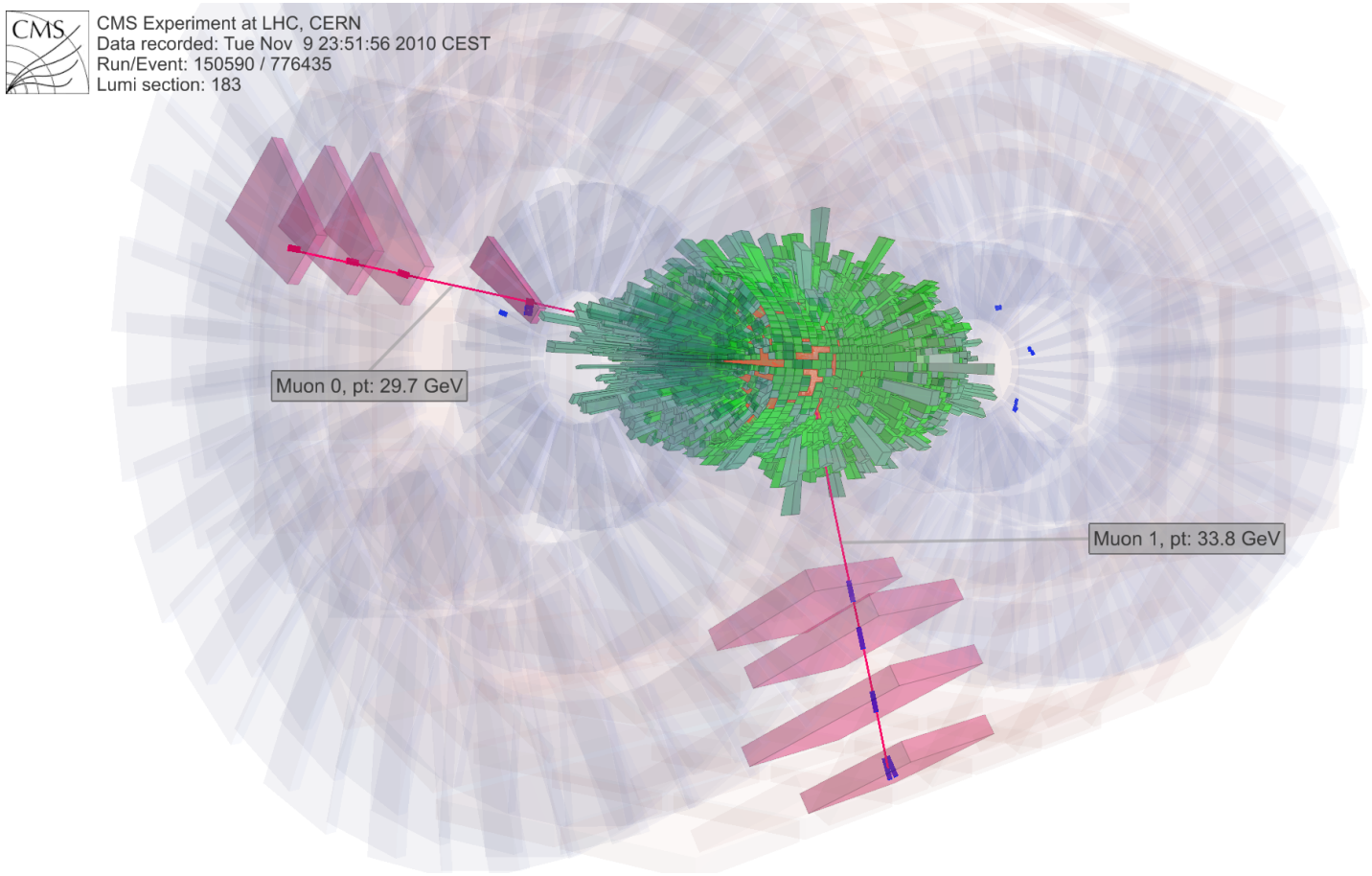


02.12.10, Zimányi School 2010, Budapest, Hungary

Content

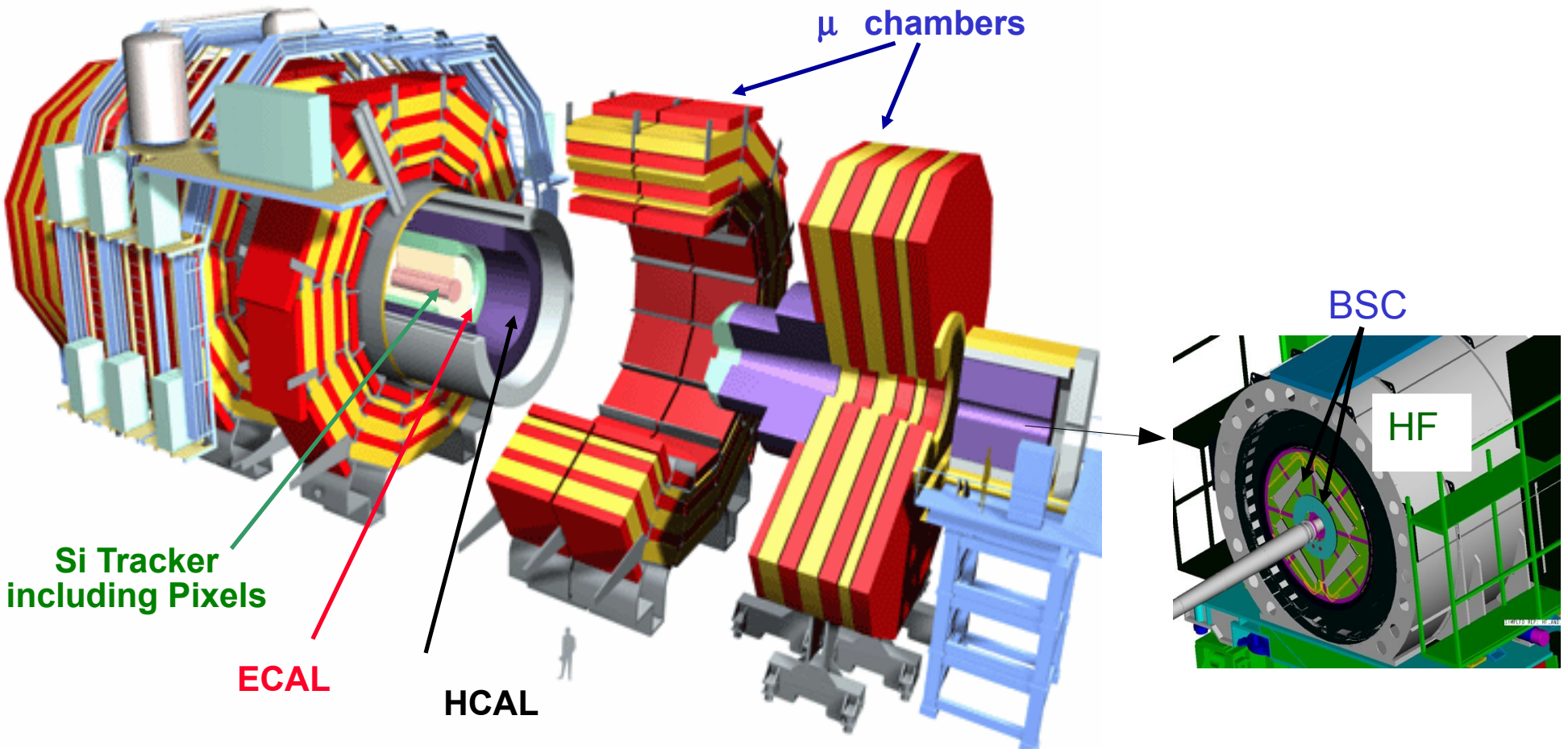
- The CMS detector

- Results on strangeness
  - Weakly decaying neutral hadrons: K^0_s and Λ
  - Multistrange barion: Ξ^- at 0.9 and 7 TeV

- Pb-Pb collisions
  - Performance plots
  - Dijet imbalance

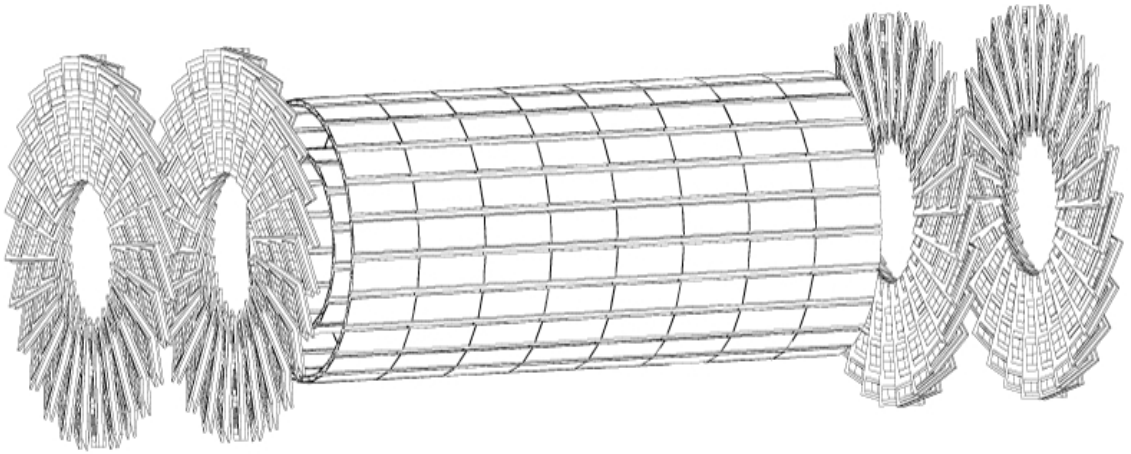
The CMS detector

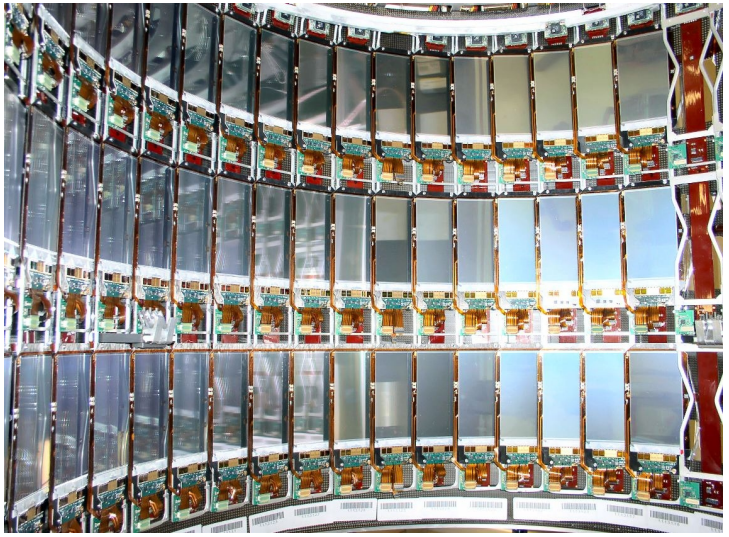
The CMS detector



- Large acceptance tracker
- Hermetic calorimetry
- Excellent muon spectrometer

Tracking system



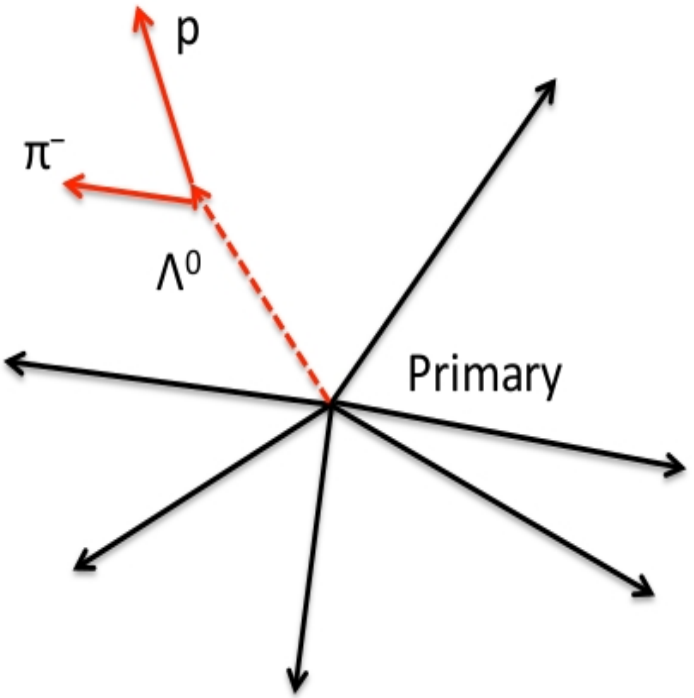


- Silicon tracker including pixels and strips ($|\eta|<2.4$)
- Pixels:
  - 150x100 μm^2, closest to the interaction point
  - 3 barrel layers (4, 7 and 10 cm radii) and 2 endcaps on each side
- Strips:
  - Larger silicon modules, refine momentum resolution

Strangeness

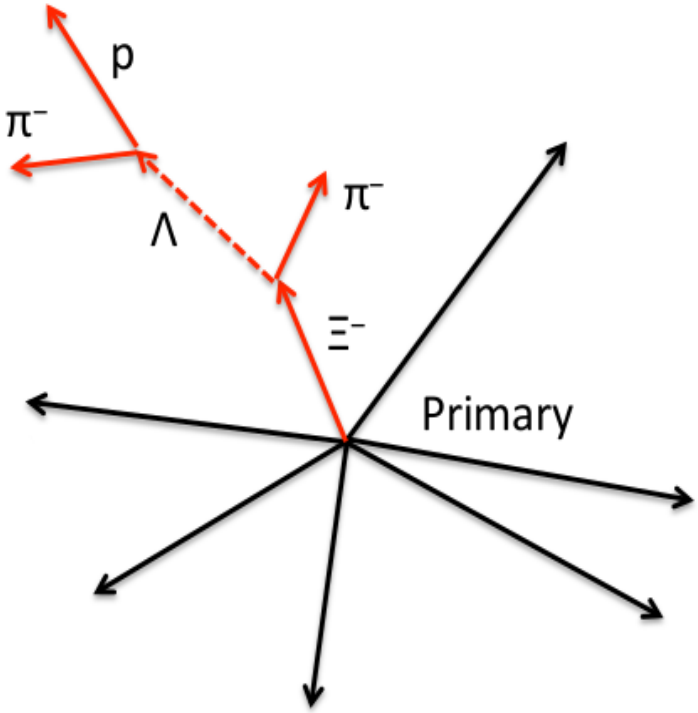
V0

- Fit pair of oppositely charged tracks to common vertex
- Daughter tracks:
  - Of good quality
  - Not from primary vertex
- Secondary vertex
  - Far “enough” from the primary vertex
- Require V0 point back to primary vertex



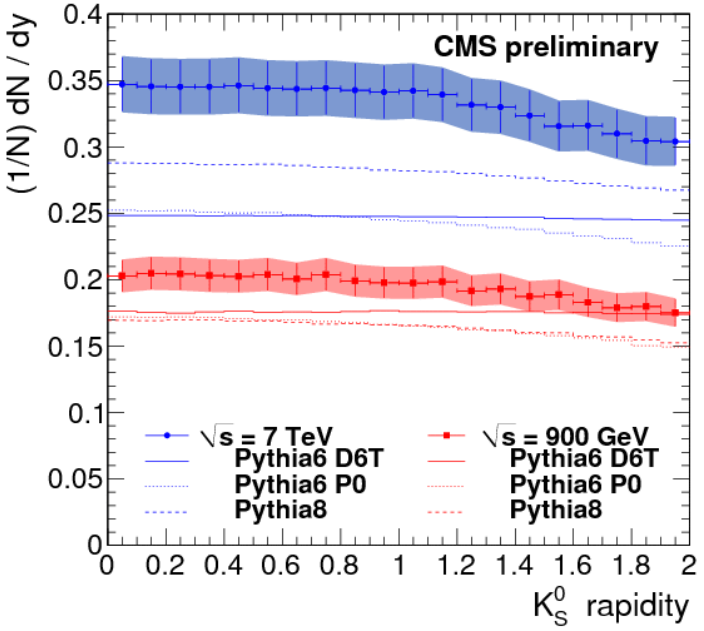
Cascade

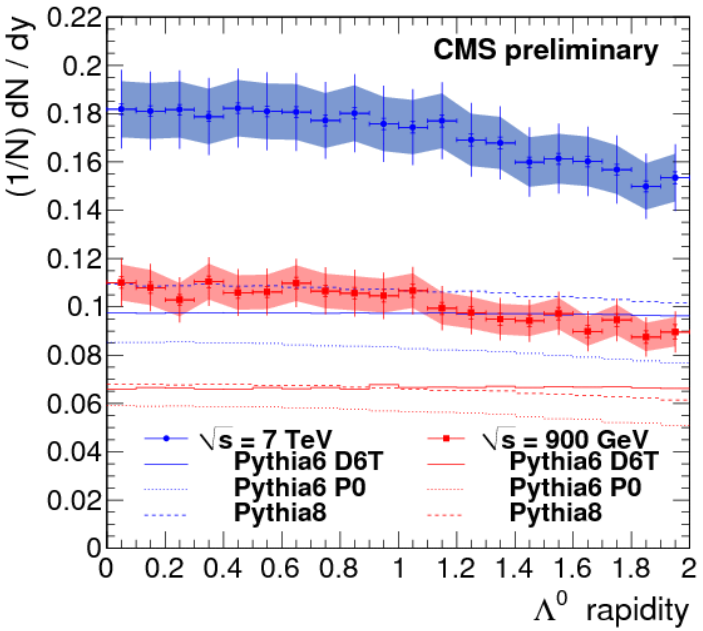
- Fit Λ and correctly signed track to common vertex
- All tracks miss primary
- Secondary vertex within 5σ from primary
- Require Ξ^- point to primary
- Ξ^- vertex well separated from primary

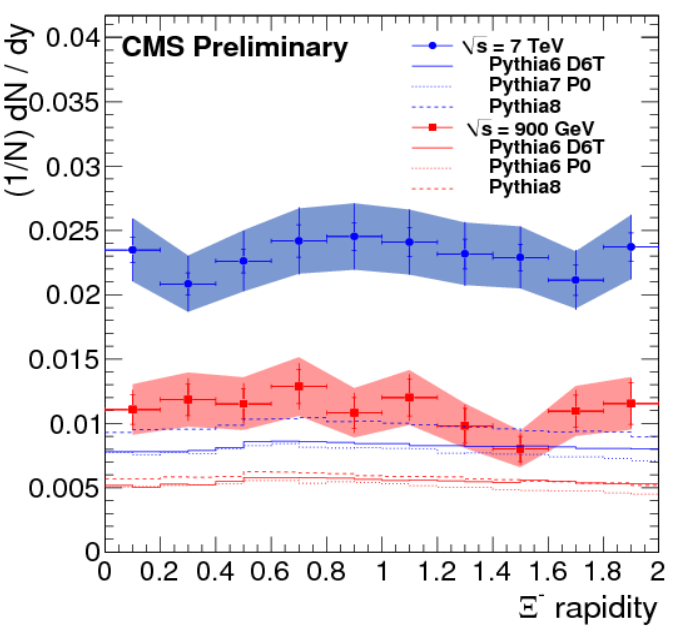


Rapidity density

- The yield is much larger yield than the predictions of MCs
- Deviation increases as the collision energy and mass increases
- Yield starts to decrease at ~1.2

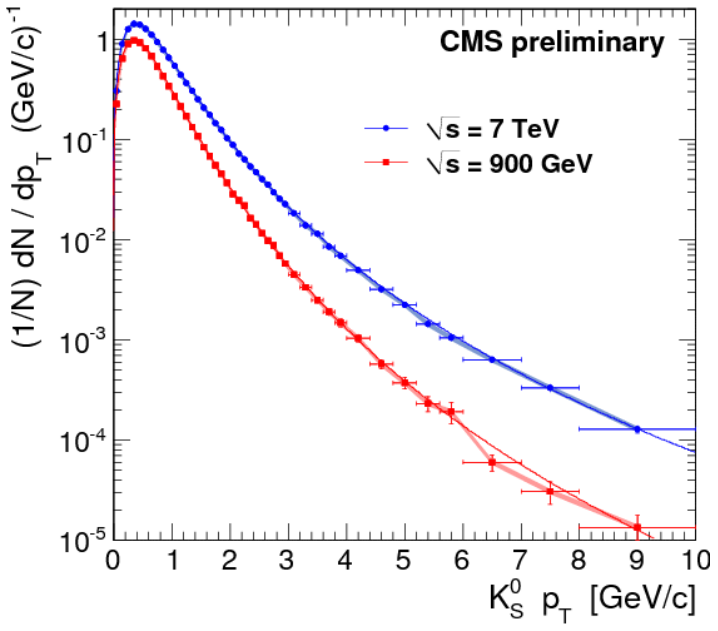


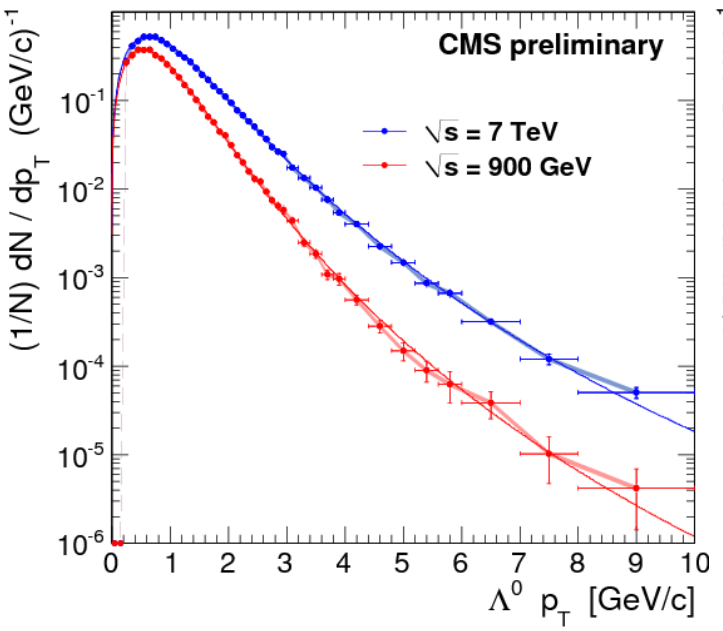


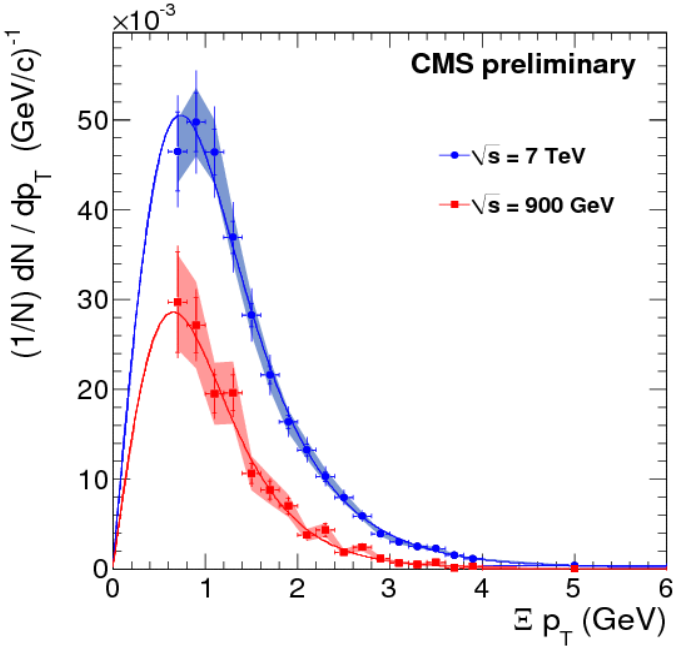


Momentum spectra

- The yield is much larger yield than the predictions of MCs
- Deviation increases as the collision energy and mass increases
- Fitted with the Tsallis function







Excellent fit with the Tsallis distribution

Summary: strangeness

- Larger overall yield of strange particles than MC predictions
- Larger increase from 0.9 to 7 TeV than MC predictions

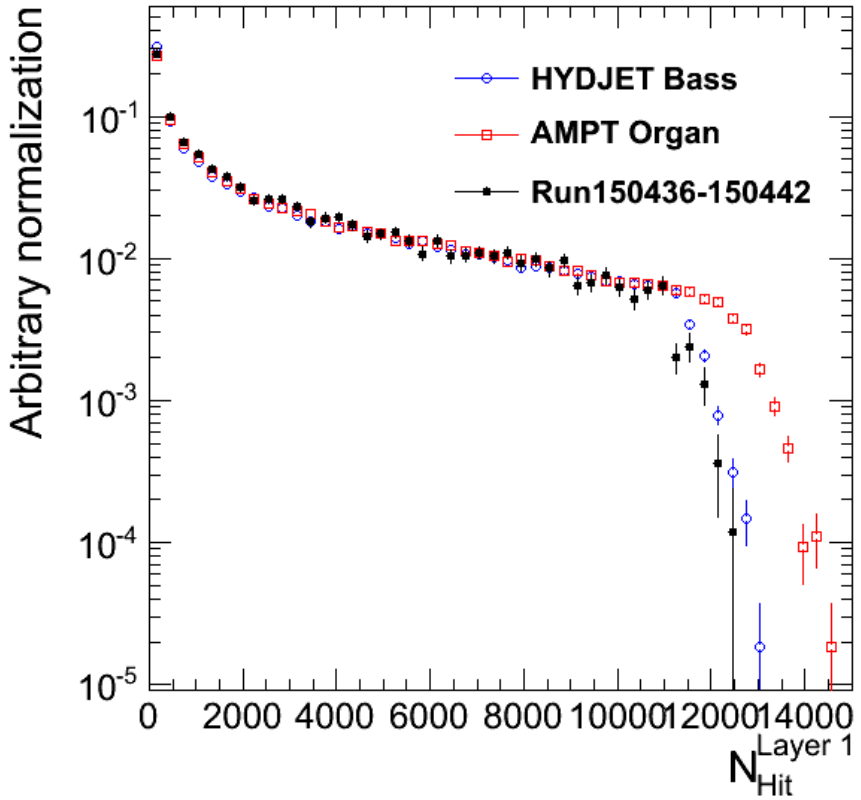
- Rapidity distribution: decrease starts at ~1.2
- Momentum spectra: well fitted with Tsallis distribution

Particle	$\frac{dN}{dy}\|_{y=0}(7\,\text{TeV})$ / $\frac{dN}{dy}\|_{y=0}(0.9\,\text{TeV})$		$\frac{dN}{dy}\|_{y=0}(\text{PYTHIA D6T})$ / $\frac{dN}{dy}\|_{y=0}(\text{Data})$	
	Data	PYTHIA D6T	0.9 TeV	7 TeV
K^0_S	$1.71 \pm 0.02 \pm 0.20$	1.41	$0.87 \pm 0.01 \pm 0.07$	$0.72 \pm 0.01 \pm 0.06$
Λ^0	$1.65 \pm 0.04 \pm 0.26$	1.48	$0.60 \pm 0.01 \pm 0.07$	$0.54 \pm 0.01 \pm 0.06$
Ξ^-	$2.09 \pm 0.09 \pm 0.27$	1.47	$0.48 \pm 0.05 \pm 0.09$	$0.33 \pm 0.02 \pm 0.05$

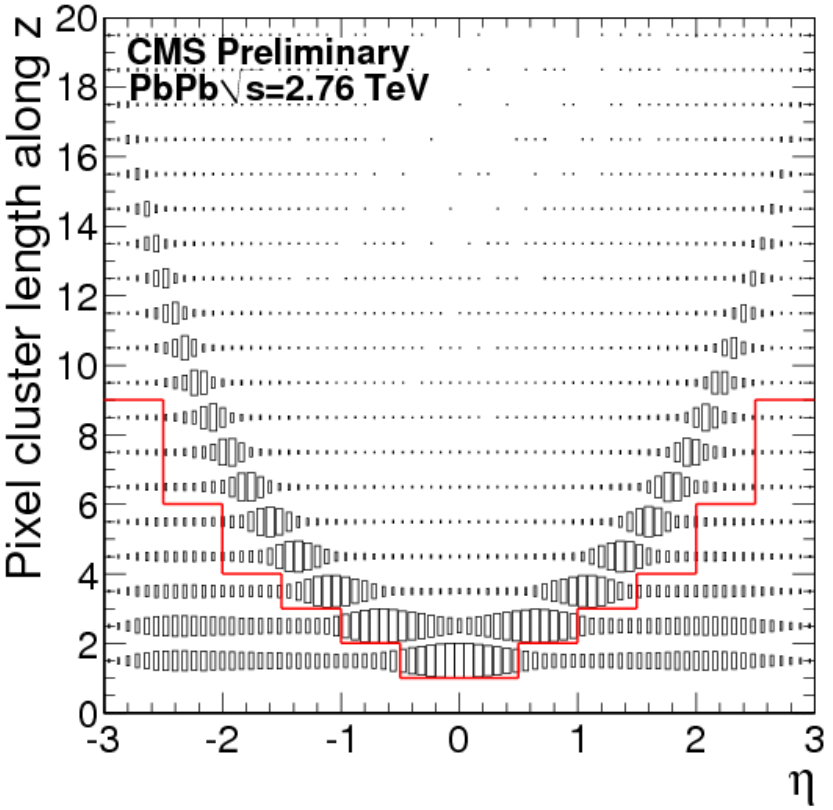
Pb-Pb collisions

Pixel detector

- Pixel clusters



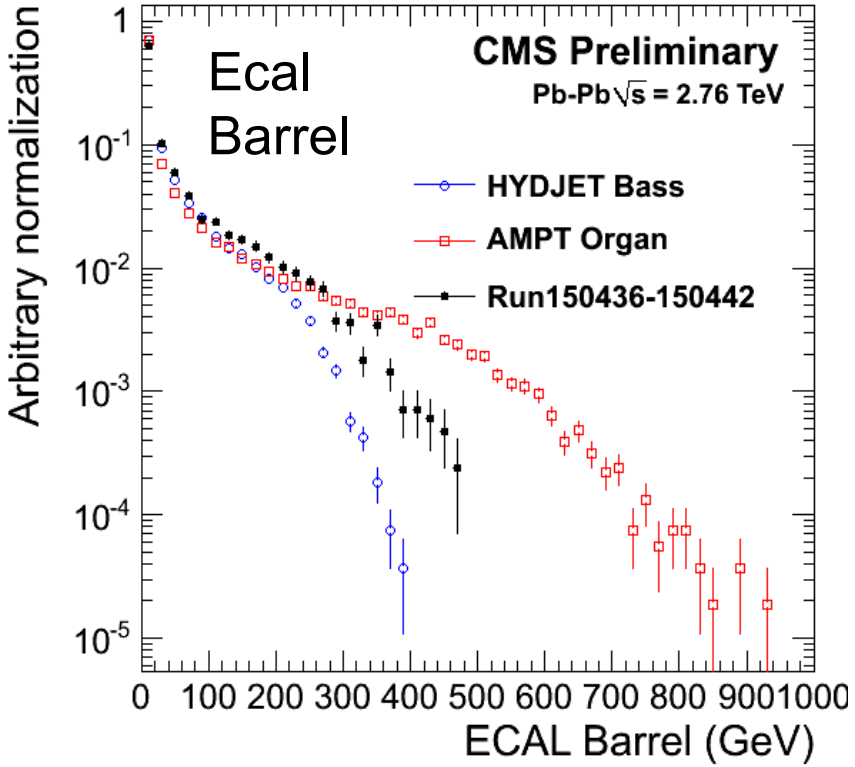
Pixel hit multiplicity agrees well with MC tuned with RHIC Au-Au and LHC p-p collisions

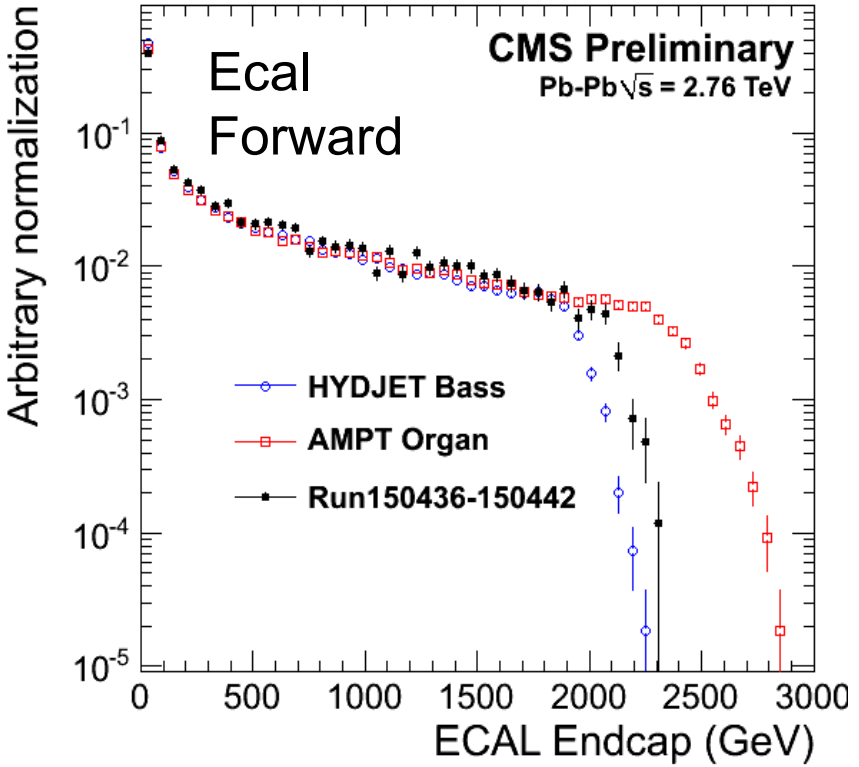


Pixel cluster size along the beam axis vs η. The red curve rejects large part of the background.

ECAL

- Energy in ECAL

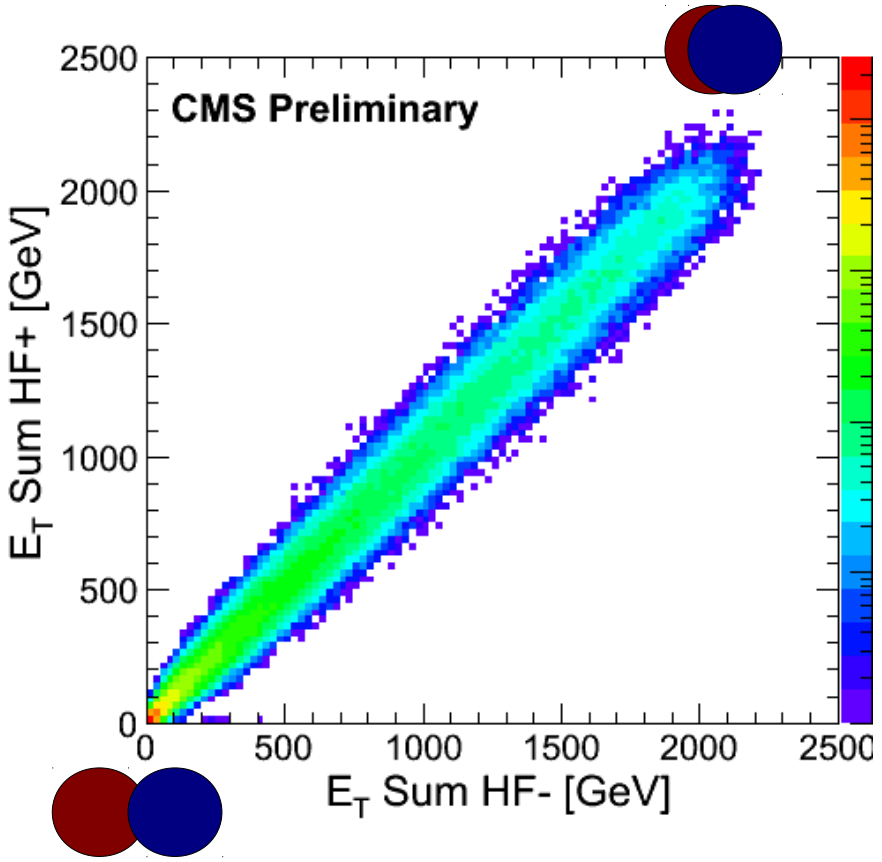




Energy distribution in ECAL Barrel and Endcap well reproduced by tuned MC

HCAL

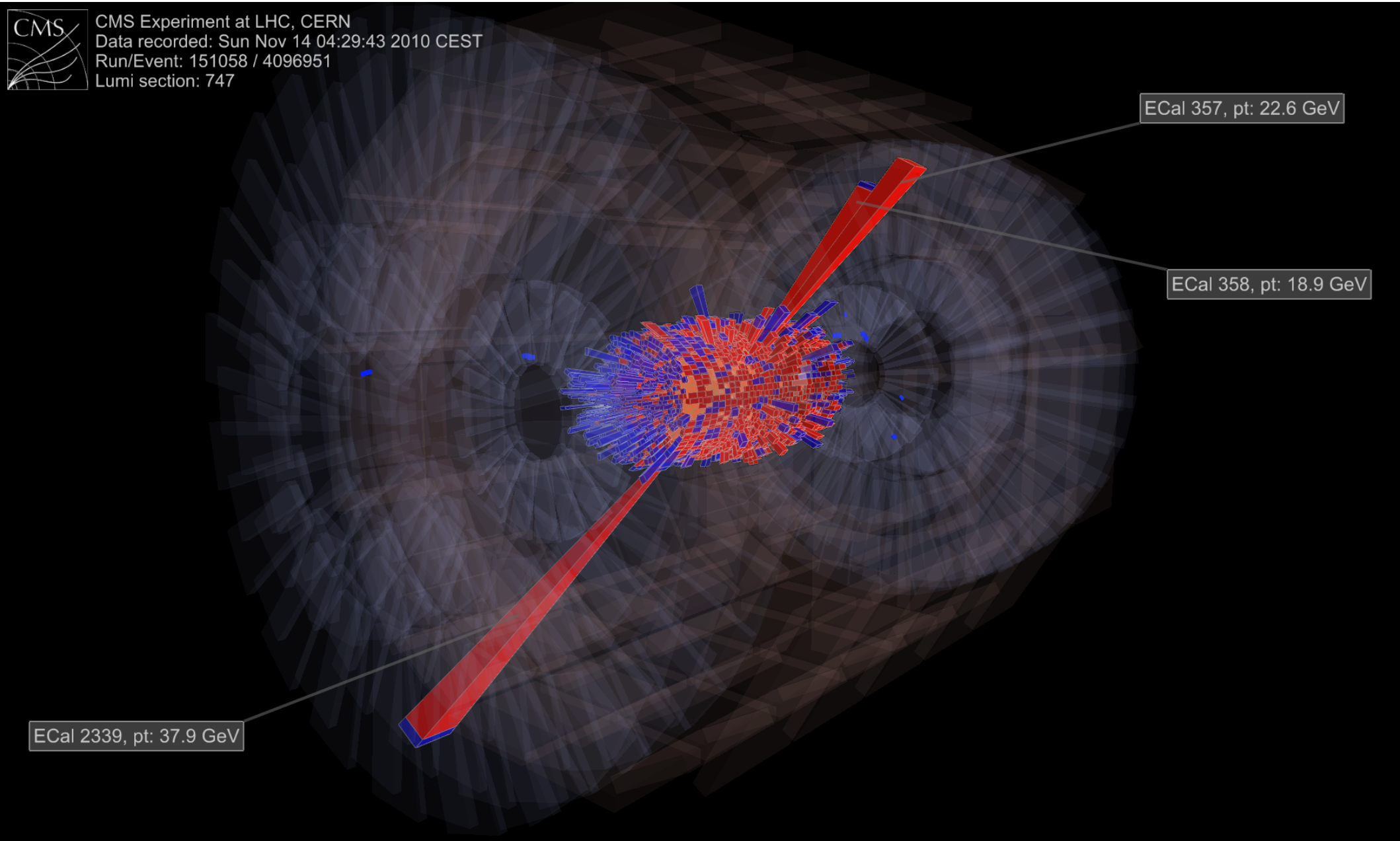
- Energy in HCAL



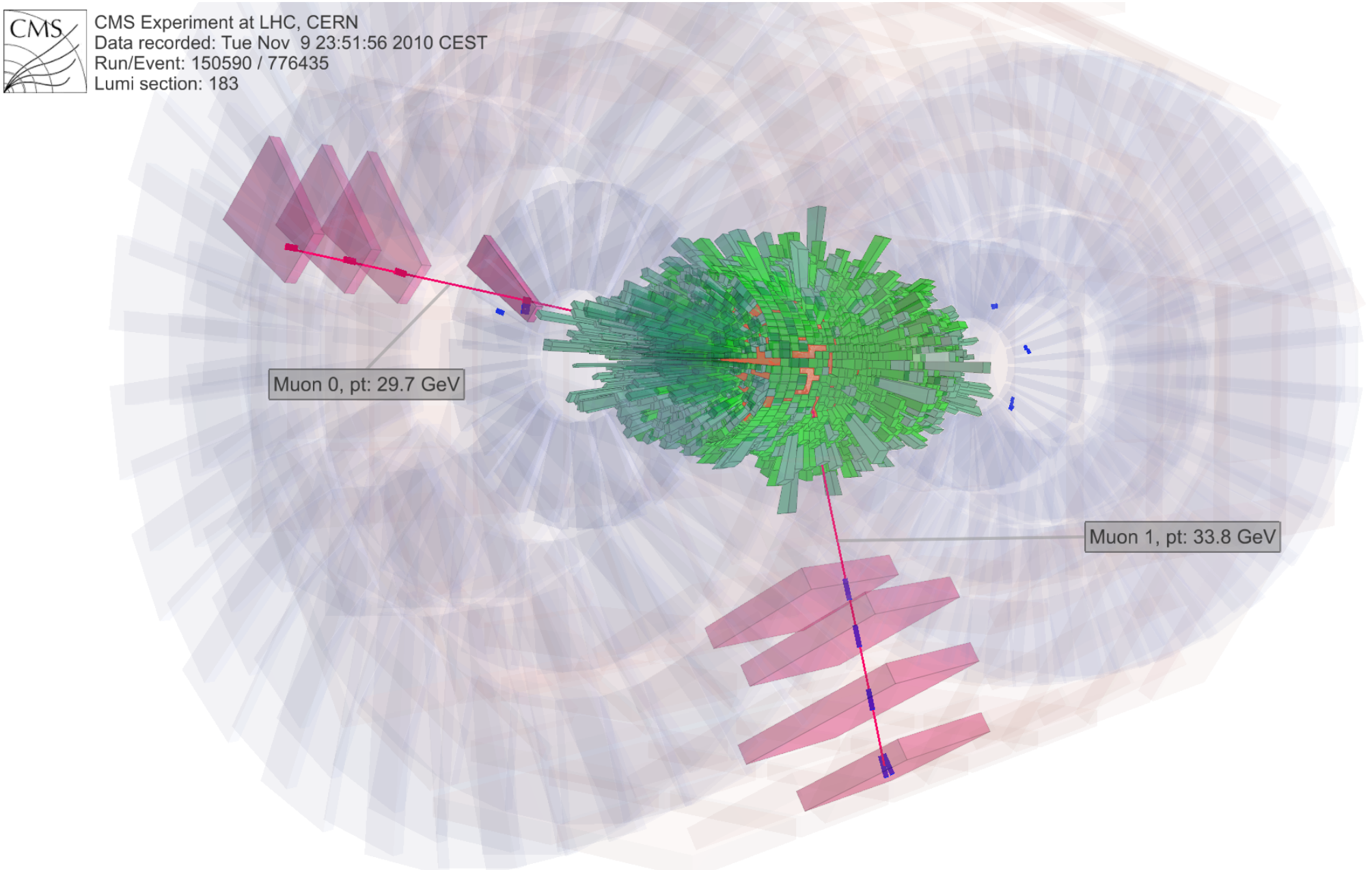
Centrality is determined using HF and/or pixel clusters

Nice correlation between the energy deposits

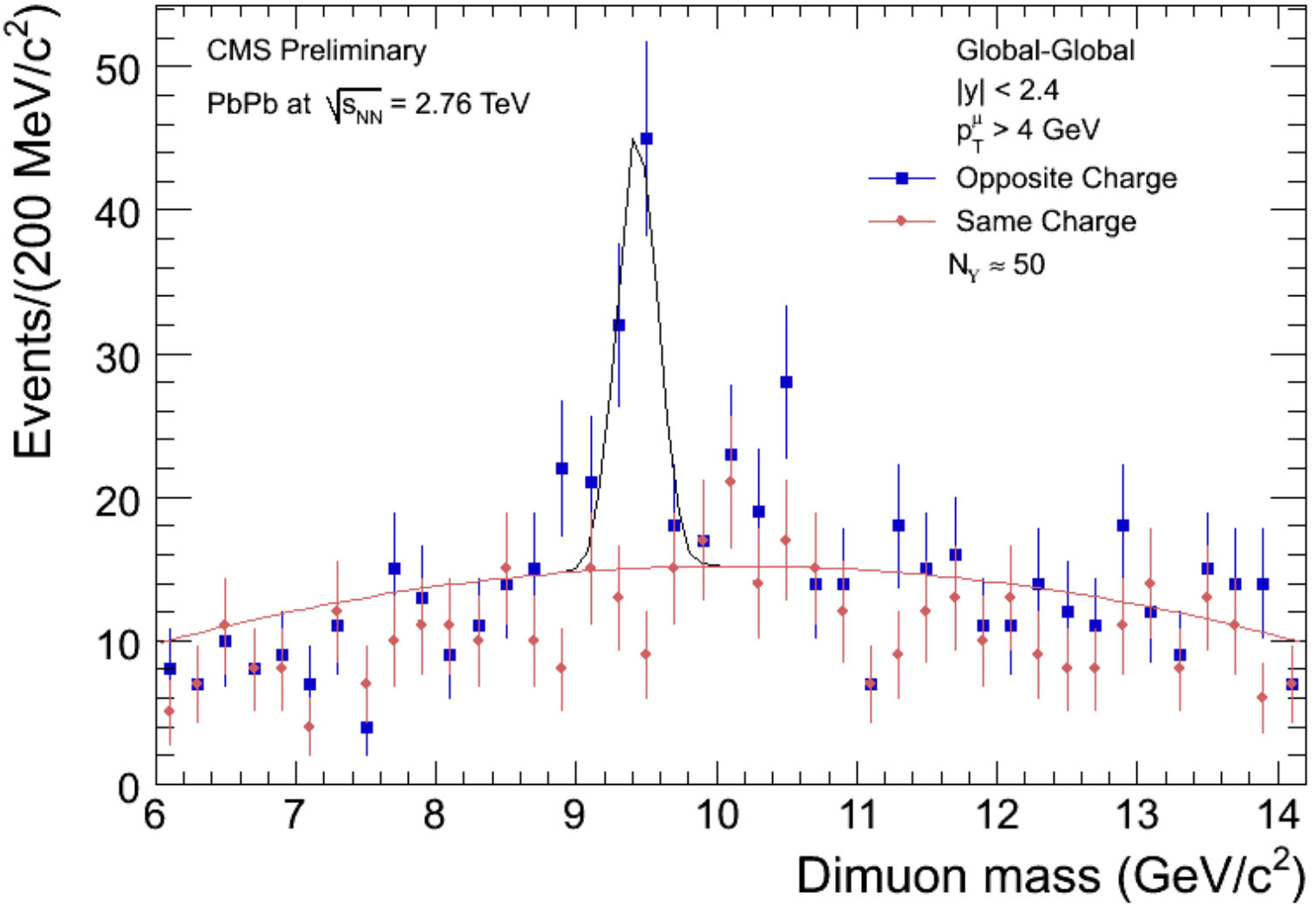
$Z \rightarrow e^+e^-$



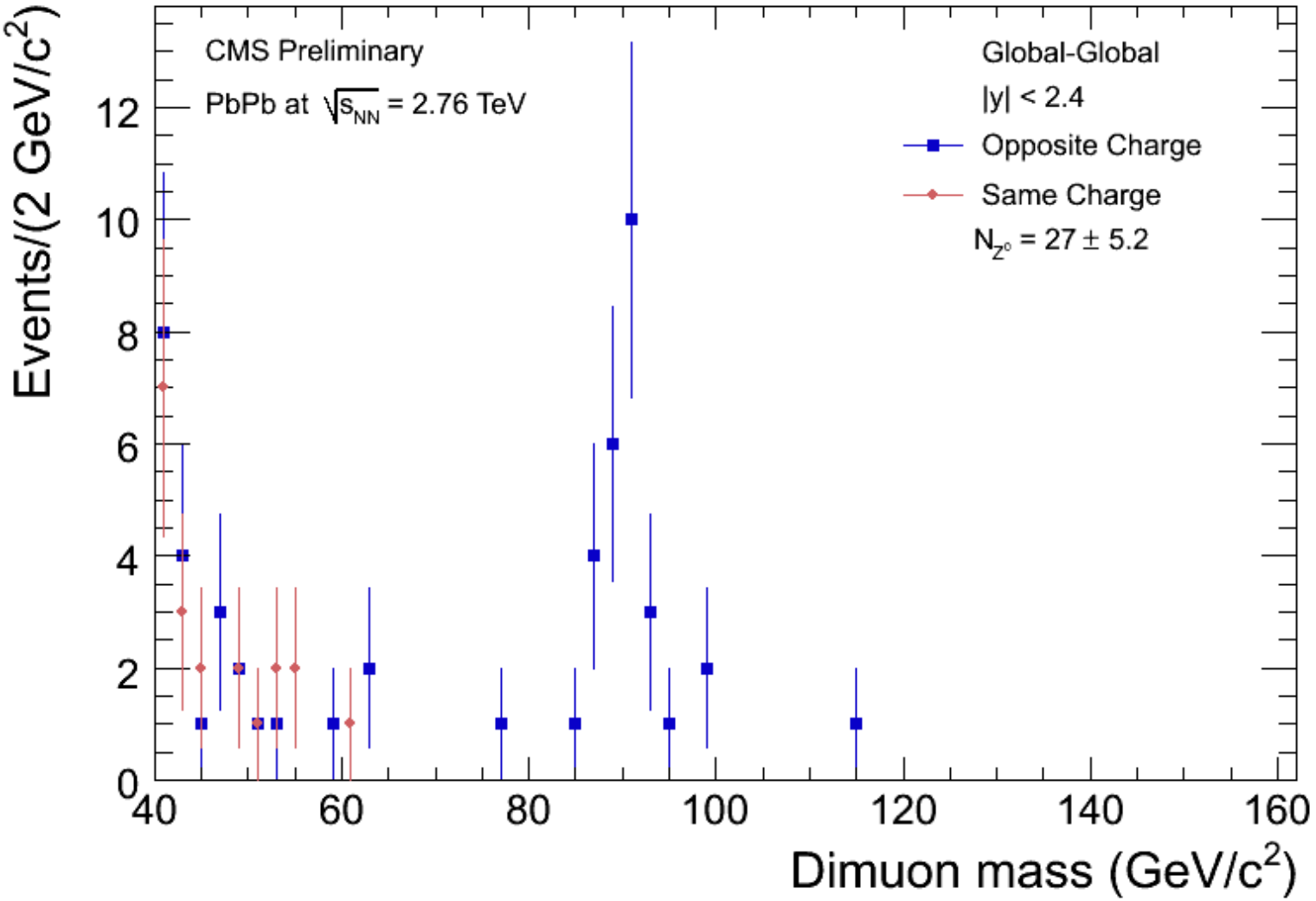
Z→μμ


CMS Experiment at LHC, CERN
Data recorded: Tue Nov 9 23:51:56 2010 CEST
Run/Event: 150590 / 776435
Lumi section: 183
Muon 0, pt: 29.7 GeV
Muon 1, pt: 33.8 GeV

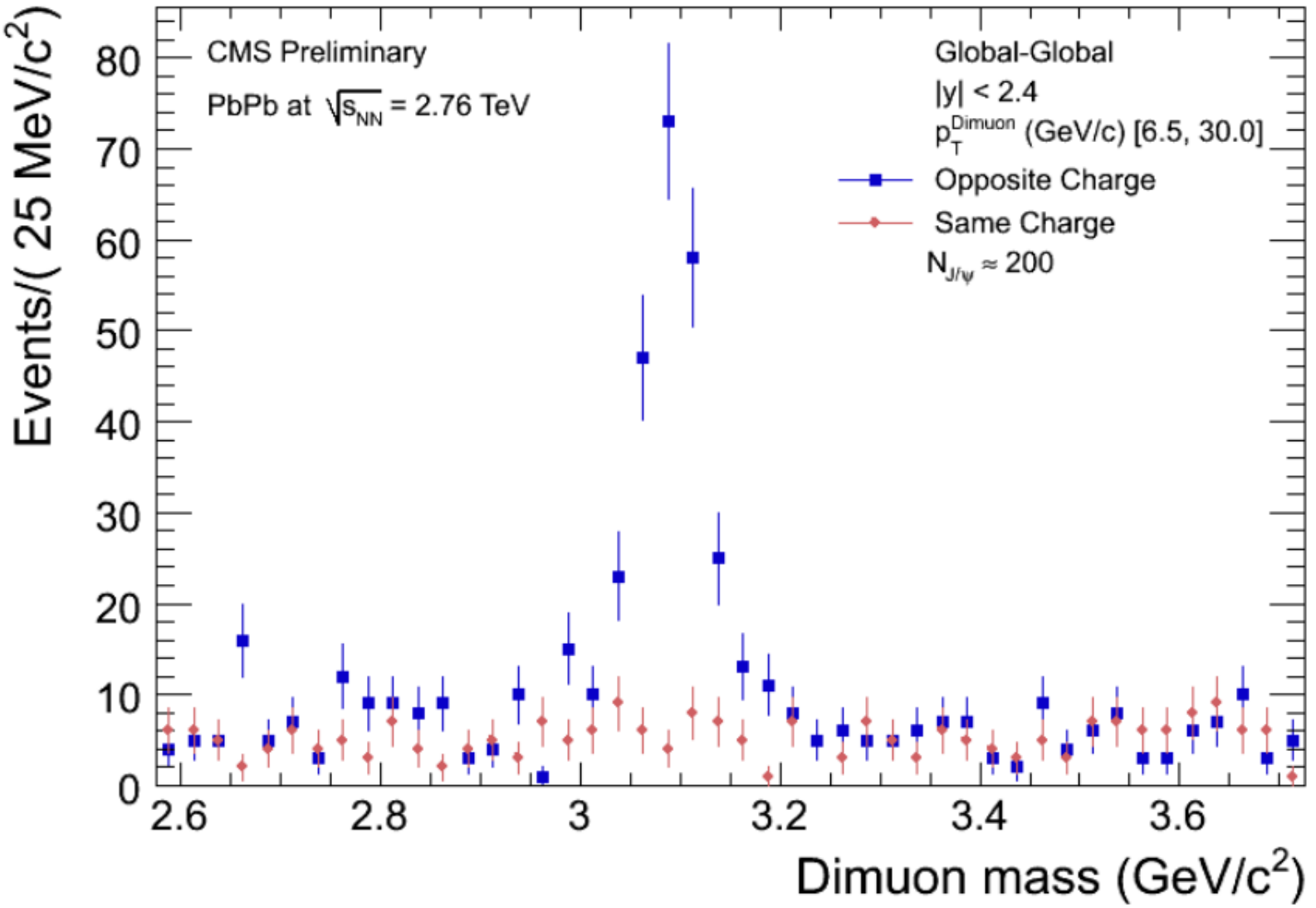
Di-muon: Upsilon



Di-muon: Z^0

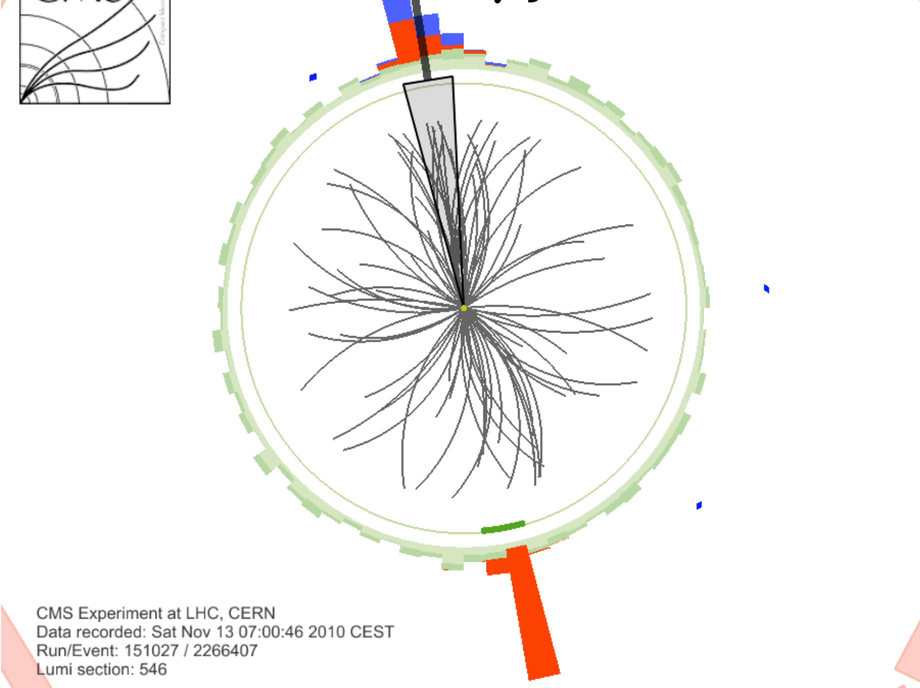

CMS Preliminary
PbPb at $\sqrt{s_{NN}}$ = 2.76 TeV
Global-Global
|y| < 2.4
Opposite Charge
Same Charge
N_{Z^0} = 27 ± 5.2
Events/(2 GeV/c^2)
Dimuon mass (GeV/c^2)
0
2
4
6
8
10
12
40
60
80
100
120
140
160

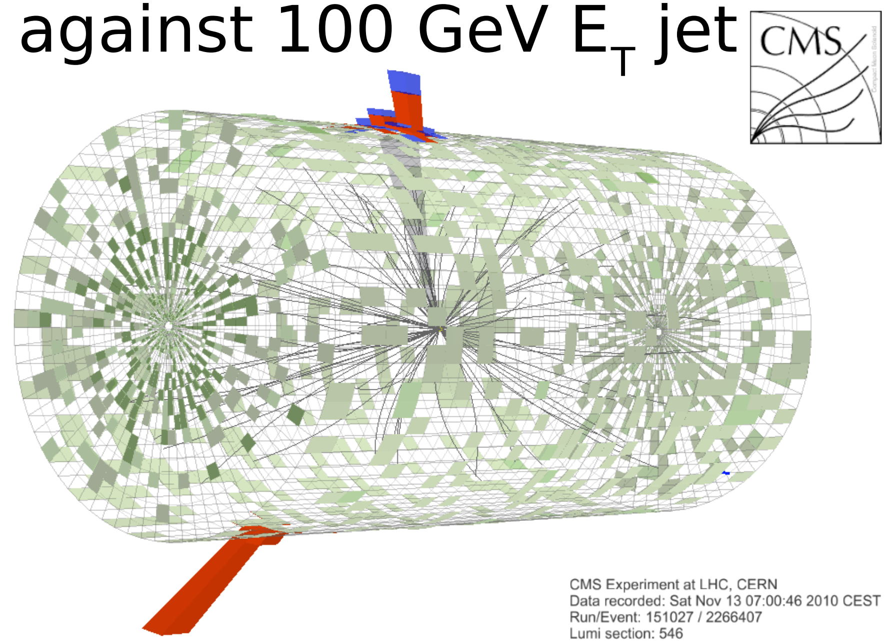
Di-muon: J/ψ

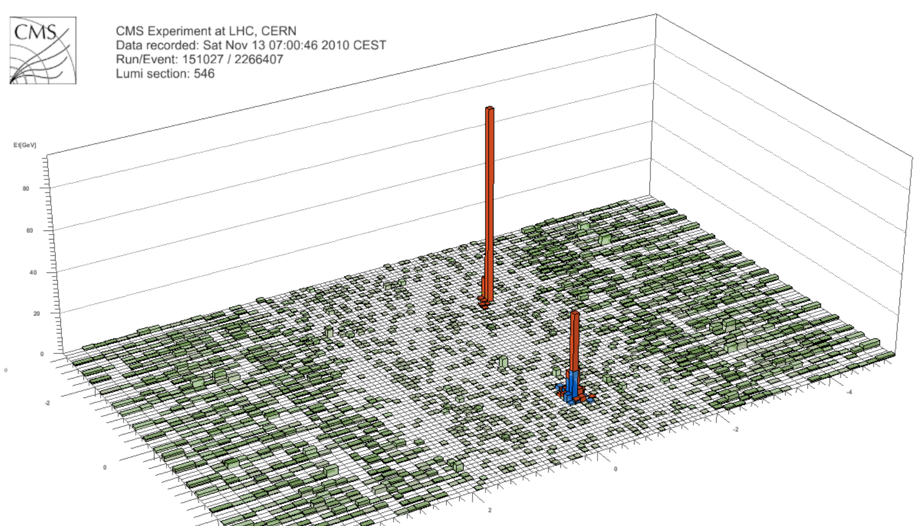

CMS Preliminary
PbPb at $\sqrt{s_{NN}}$ = 2.76 TeV
Global-Global
|y| < 2.4
p_T^{Dimuon} (GeV/c) [6.5, 30.0]
Opposite Charge
Same Charge
$N_{J/\psi} \approx 200$
Events/(25 MeV/c^2)
Dimuon mass (GeV/c^2)
0
10
20
30
40
50
60
70
80
2.6
2.8
3
3.2
3.4
3.6

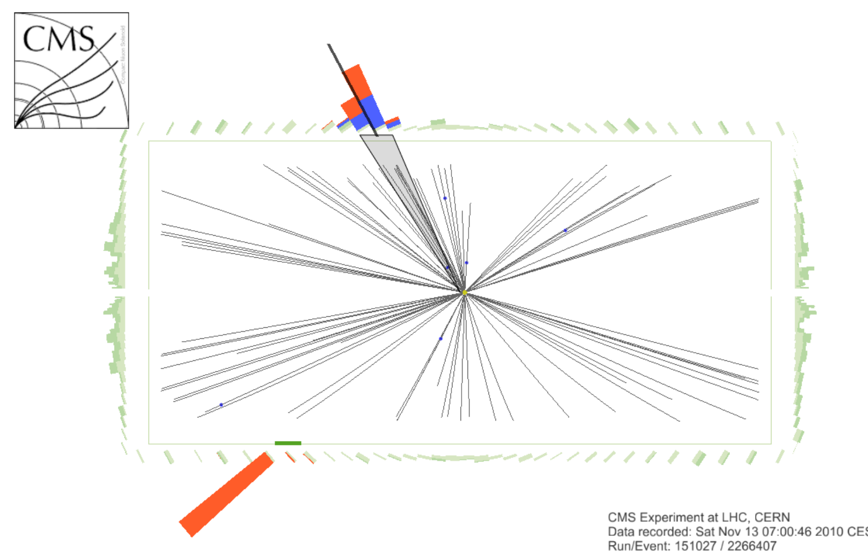
γ-jet

γ jet: 100 GeV photon against 100 GeV E_T jet

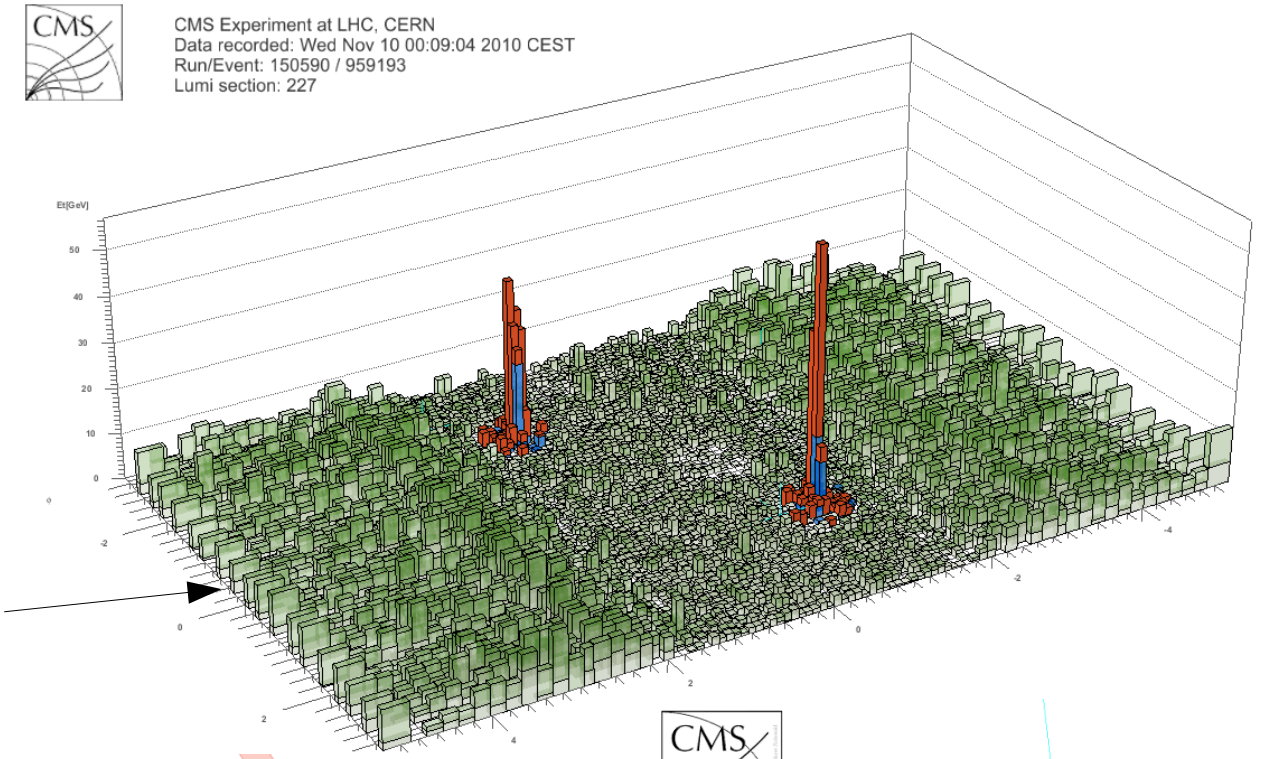




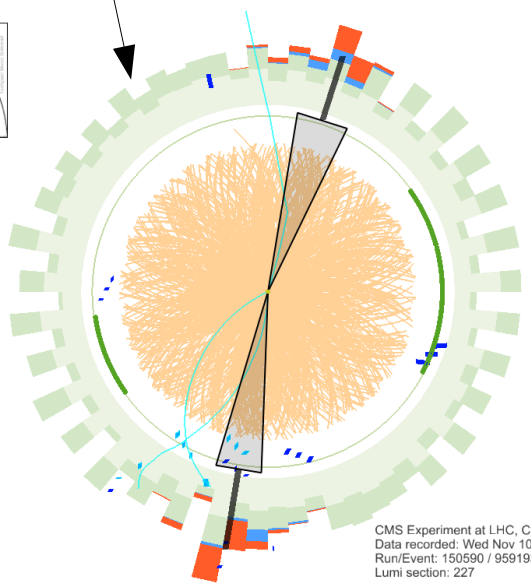


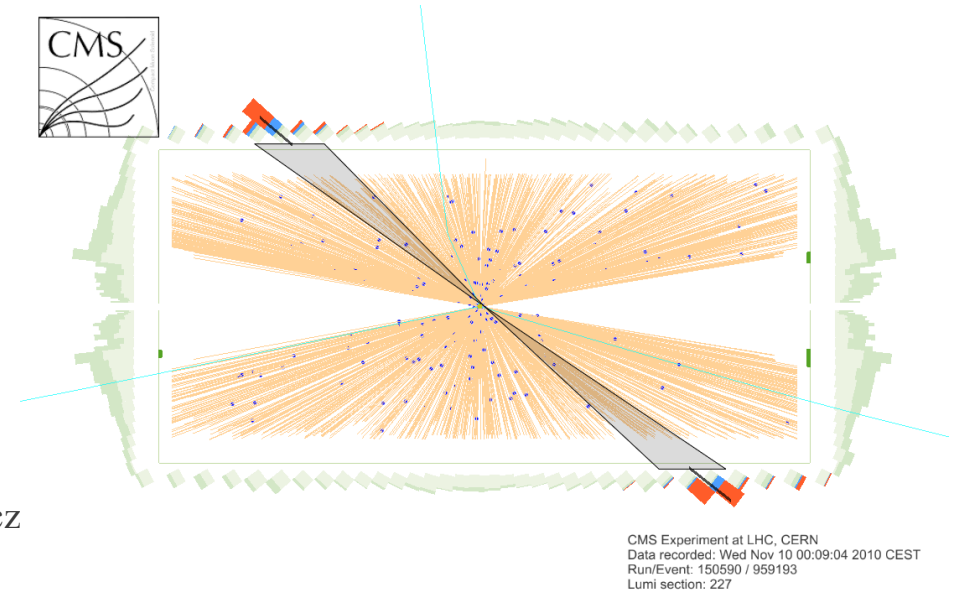


Di-jets

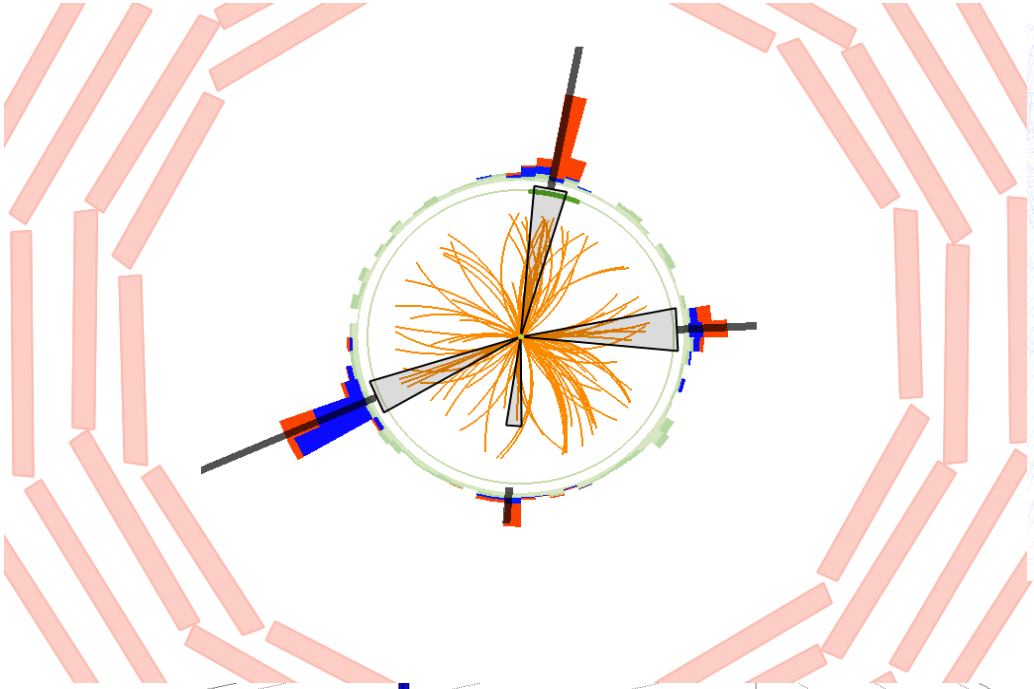


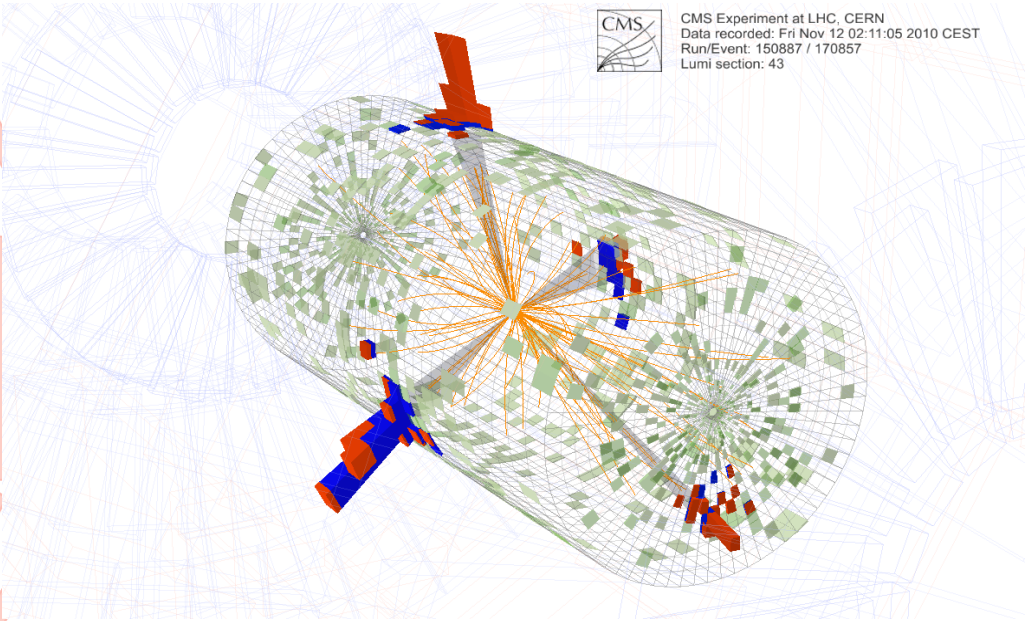
Cog-wheel effect due to projection of ϕ structure of forward calorimeter

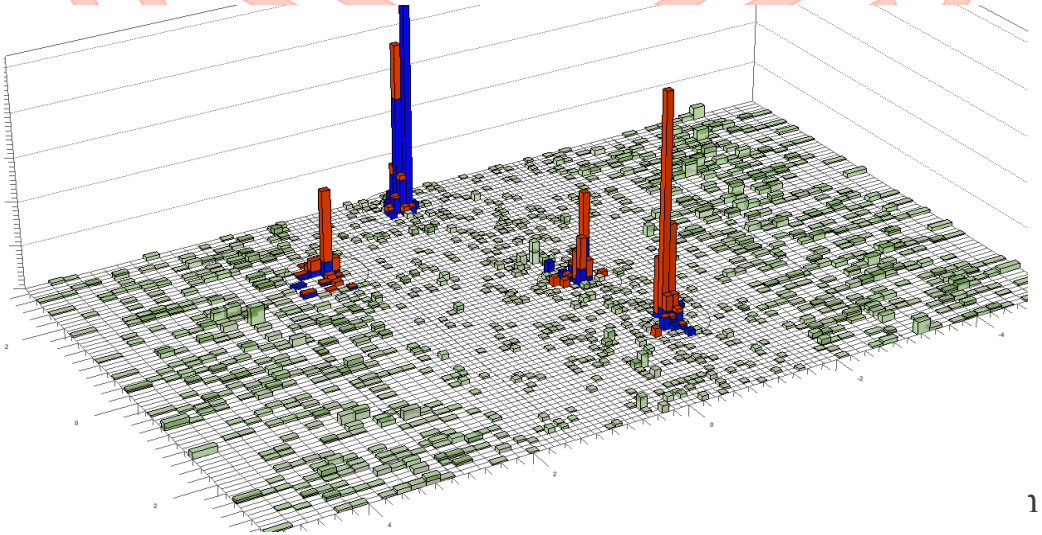


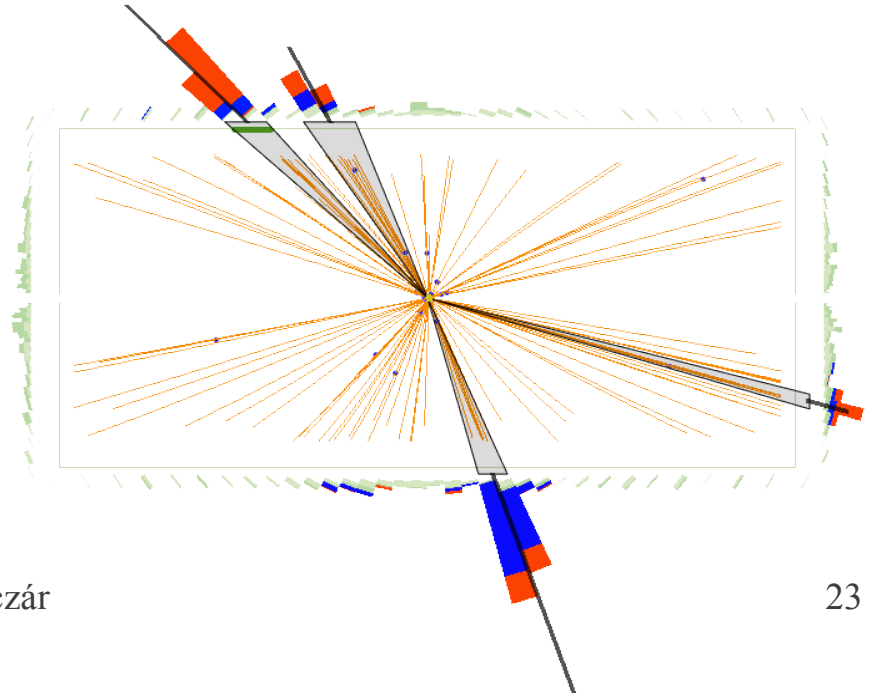


4-jet



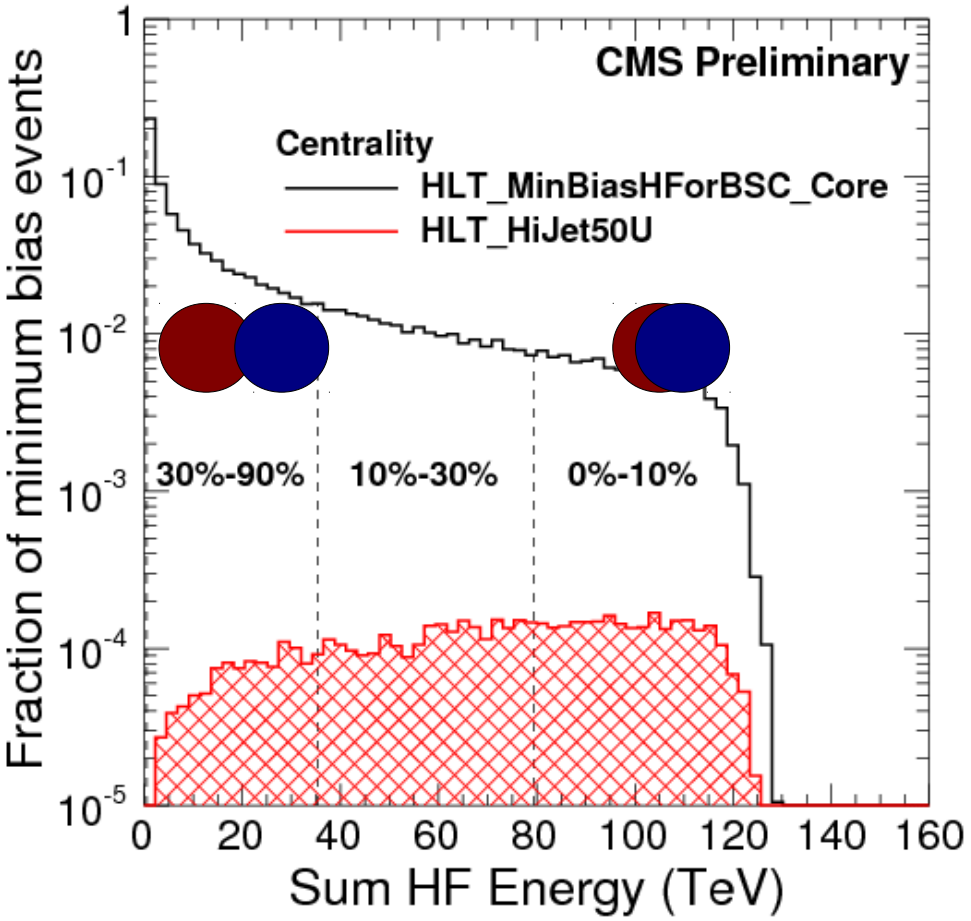

CMS
CMS Experiment at LHC, CERN
Data recorded: Fri Nov 12 02:11:05 2010 CEST
Run/Event: 150887 / 170857
Lumi section: 43





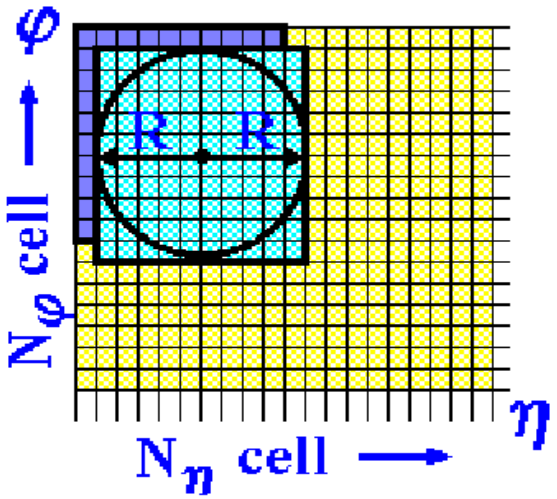
Centrality

- Three centrality bins constructed based on HF (2.9<|η|<5.2)
- Bins correspond to the total nucleus-nucleus interaction cross section
- Number of high E_T jets:
  ~number of binary collisions
- Production of high E_T jets:
  ~number of binary collisions weighted with the frequency distribution of the impact parameter

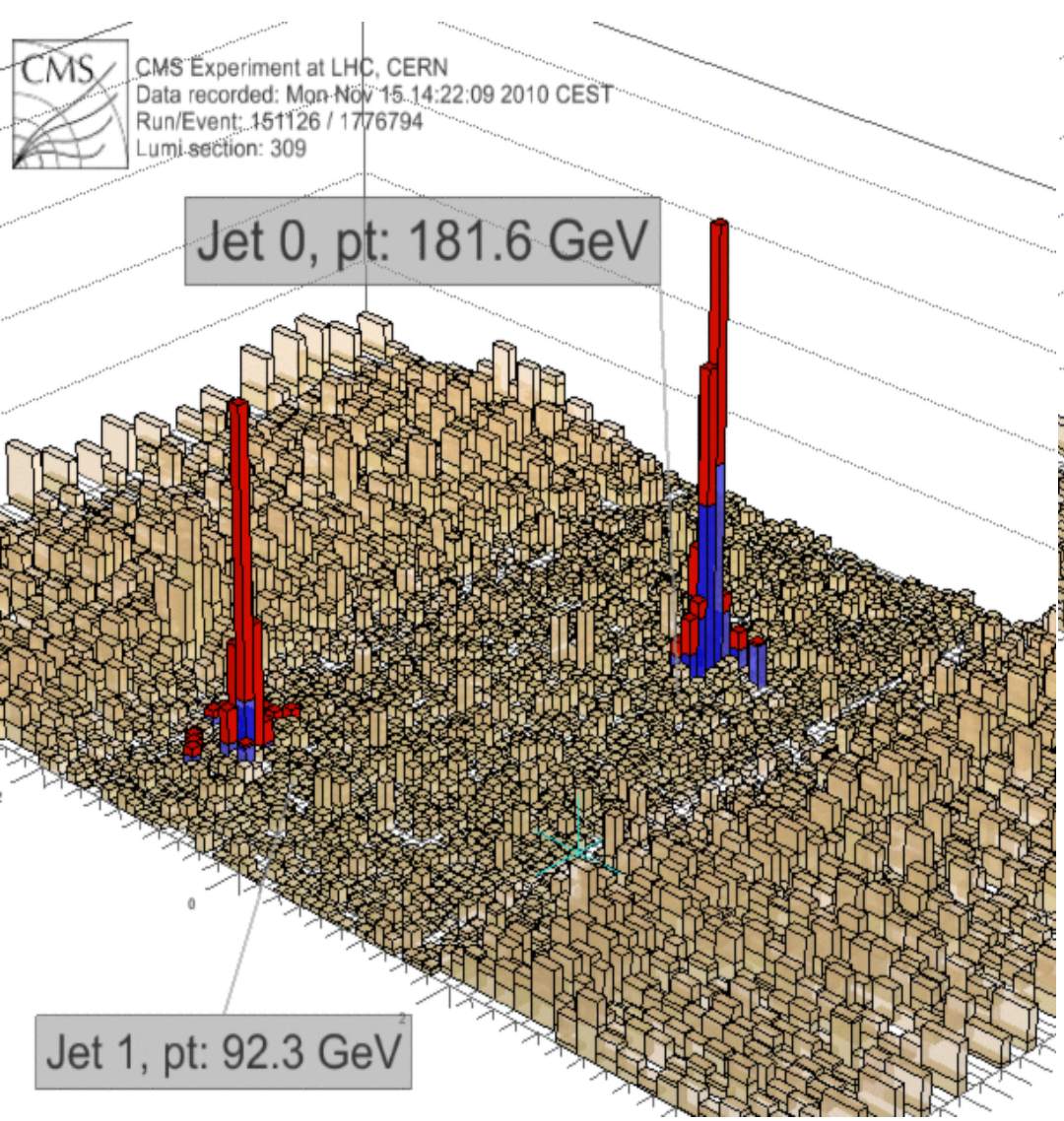


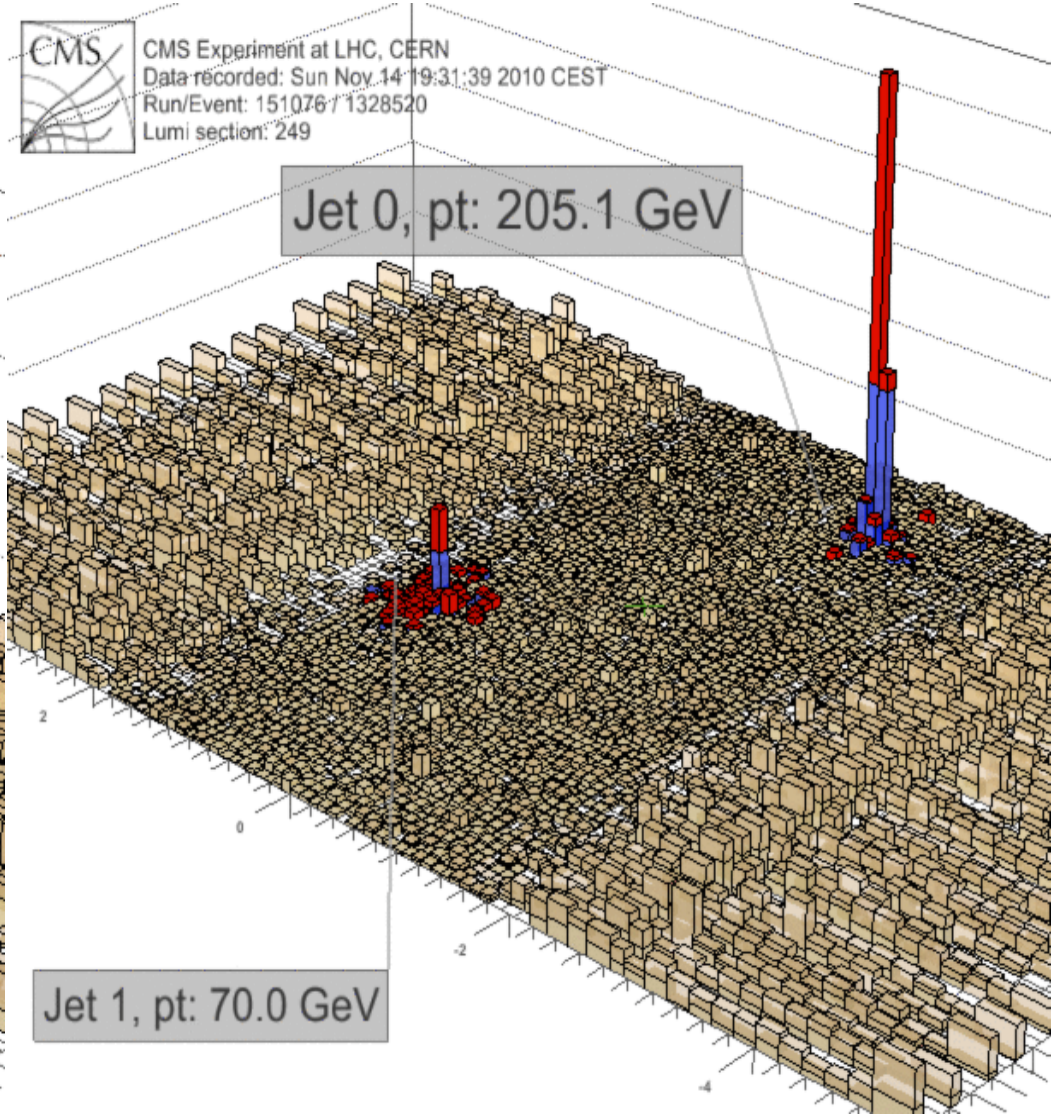
Jet finding

- Large background of soft production: $dN_{ch}/d\eta \approx 1600$ for 5% most central
- Fluctuations give rise to fake jets at small E_T
- Iterative, event-by-event subtraction:
  - The mean tower $\langle E_T(\eta)\rangle$ and dispersion $\sigma(\eta)$ over all towers (n)
  - Recalculate energies: $E_T(n)' = E_T(n) - \langle E_T(\eta)\rangle - \sigma(\eta)$, if $E_T' < 0 \rightarrow E_T' = 0$
  - Using E_T' jets are found
  - $\langle E_T(\eta)\rangle$ and $\sigma(\eta)$ are recalculated using only towers outside of jets
  - Another iteration: $E_T'' = E_T(n) - \langle E_T(\eta)\rangle - \sigma(\eta)$
  - Reconstruct final jets from E_T''



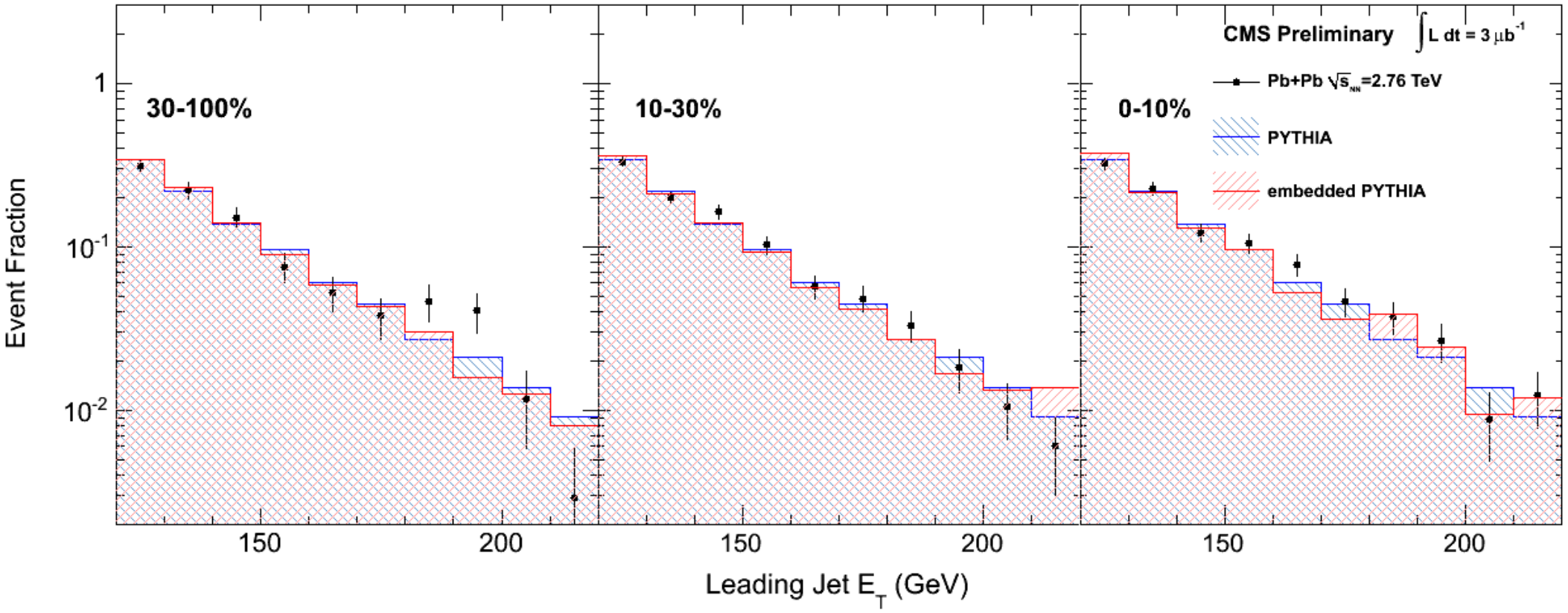
Unbalanced jets





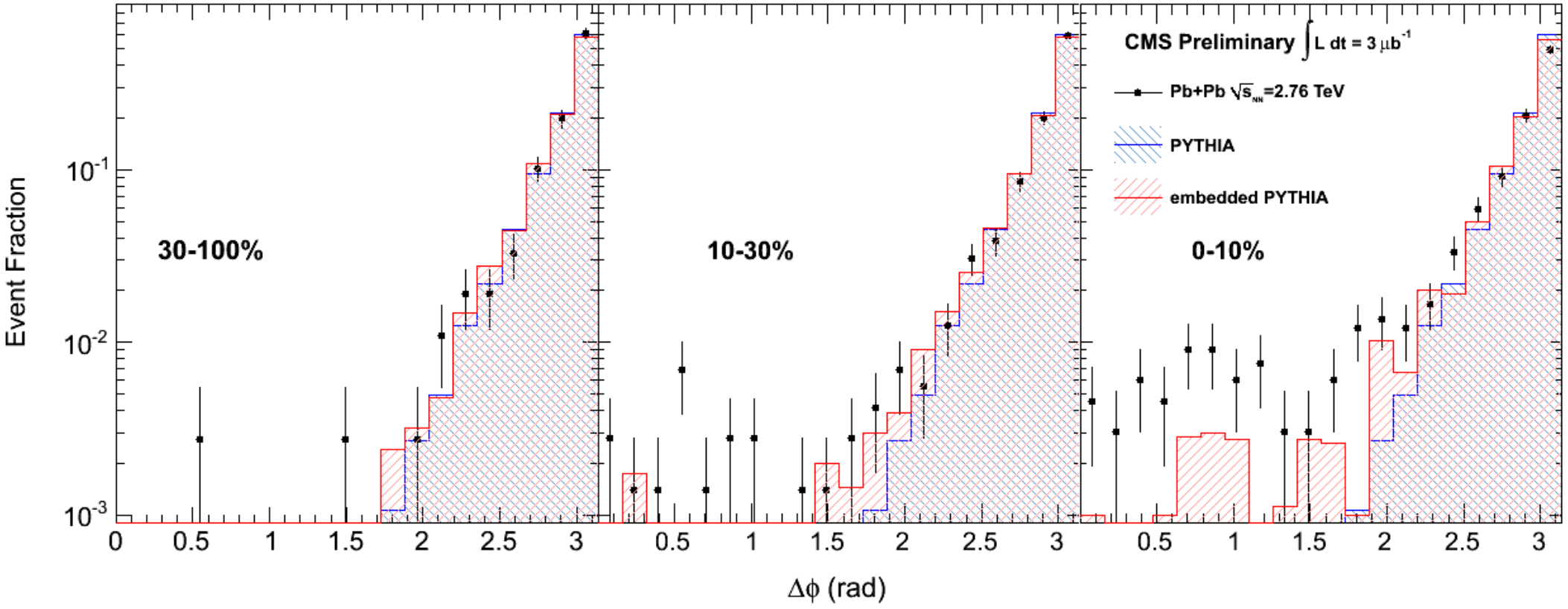
Leading jet E_T

- Leading jet E_T distributions in data, Pythia, embedded Pythia
- Not corrected for smearing due to detector resolution, in/out cone and underlying fluctuations



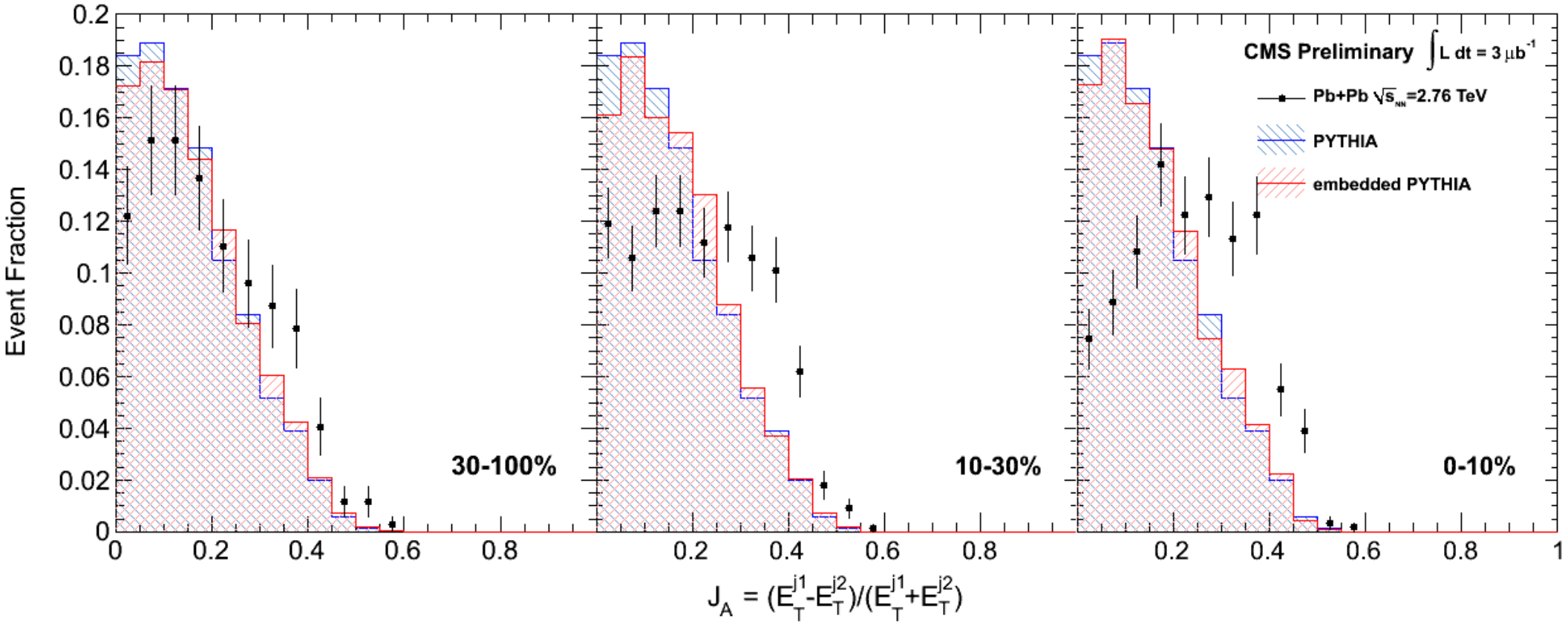
ΔΦ of dijets

- ΔΦ between leading and sub-leading jet
- Pythia, Pythia embedded in minimum bias data and data



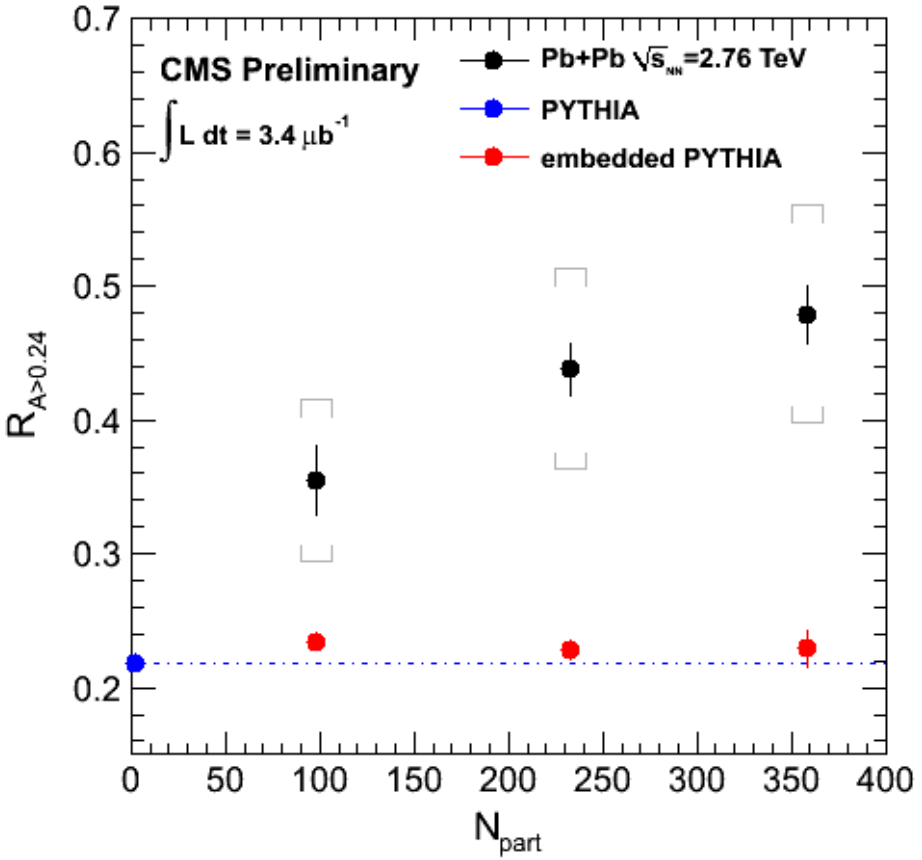
Asymmetry of dijet events

- Imbalance: difference normalized by the sum of dijet E_T
- Large imbalance in central collisions



Asymmetry of dijet events

- Fraction of events A_J>0.24
- Increase for central collisions



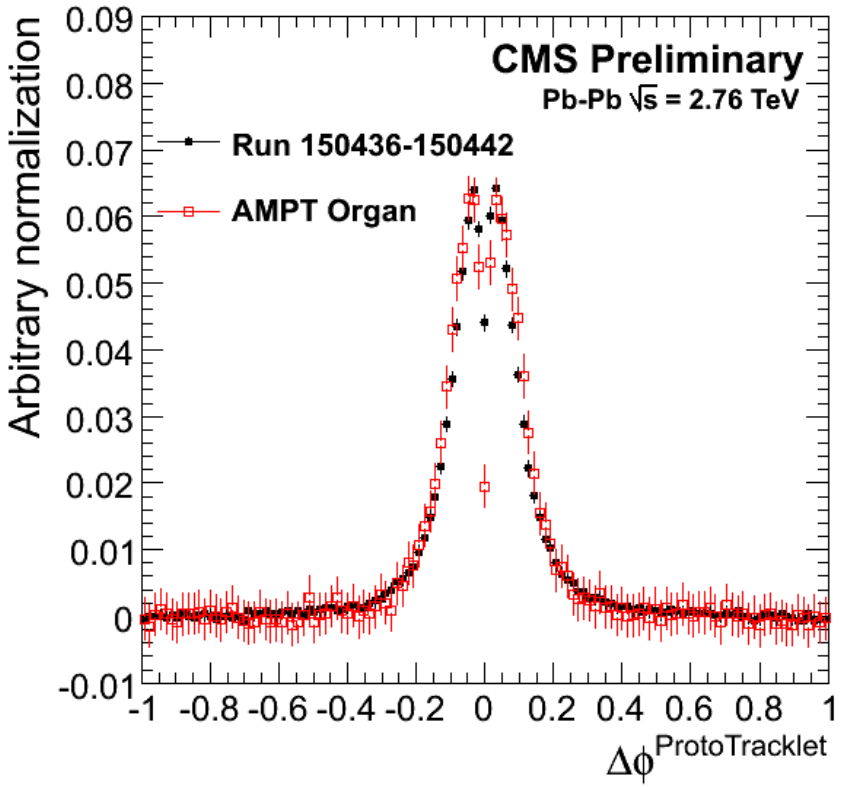
Summary: Pb-Pb

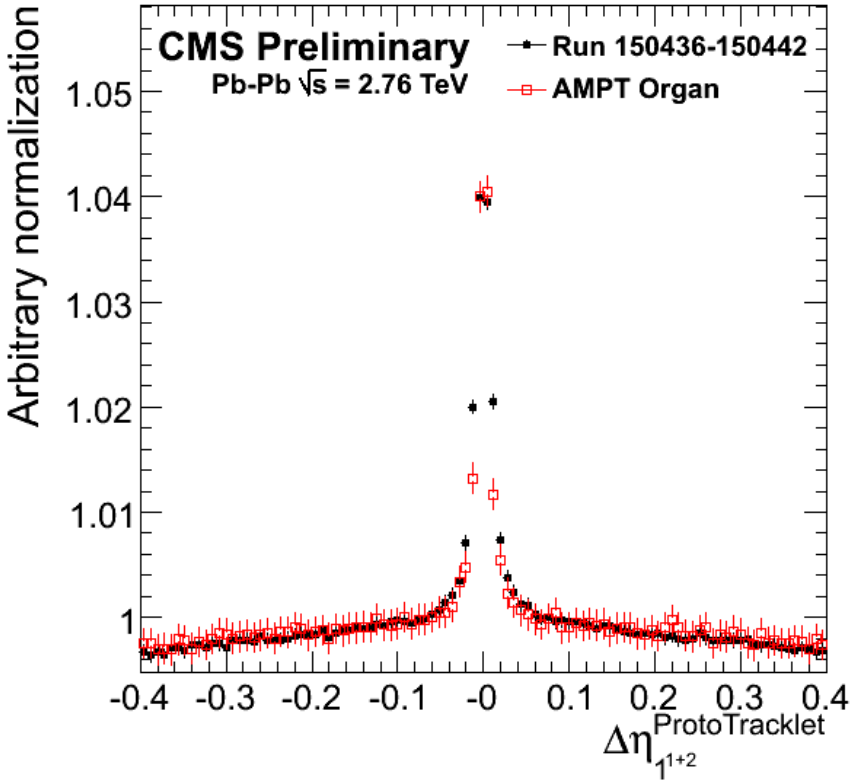
- CMS is doing well in recording data
- Has unique capabilities in many areas: large tracker, excellent muon detectors
- Direct observation of jet quenching
- Interesting prospects for heavy ion physics at CMS

Backup

Pixel detector

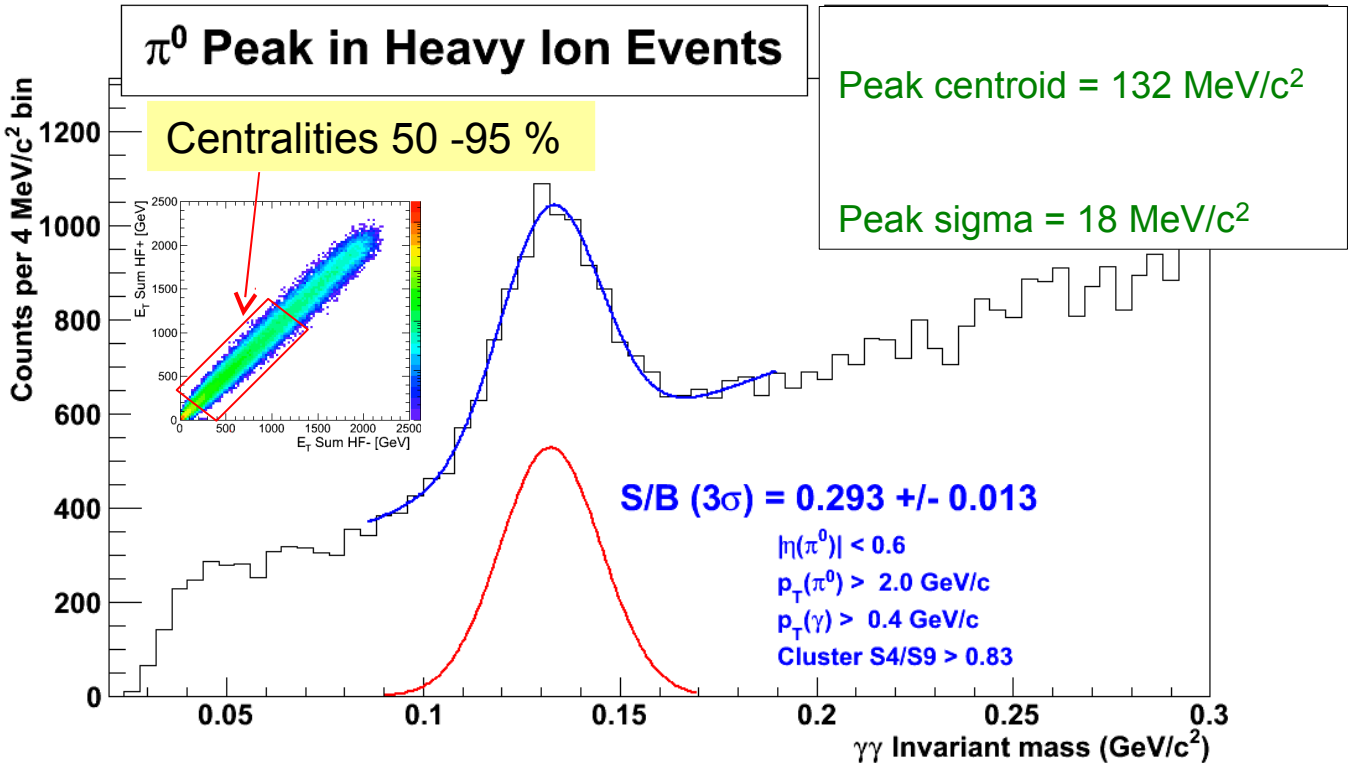
- Pixel “tracklets”





Pixel tracklets ΔΦ and Δη distribution is well reproduced by MC and similar to the ones seen in proton-proton collisions.

π^0



Despite a busier environment the π^0 looks good (small mass shift due to non-corrected selection bias)