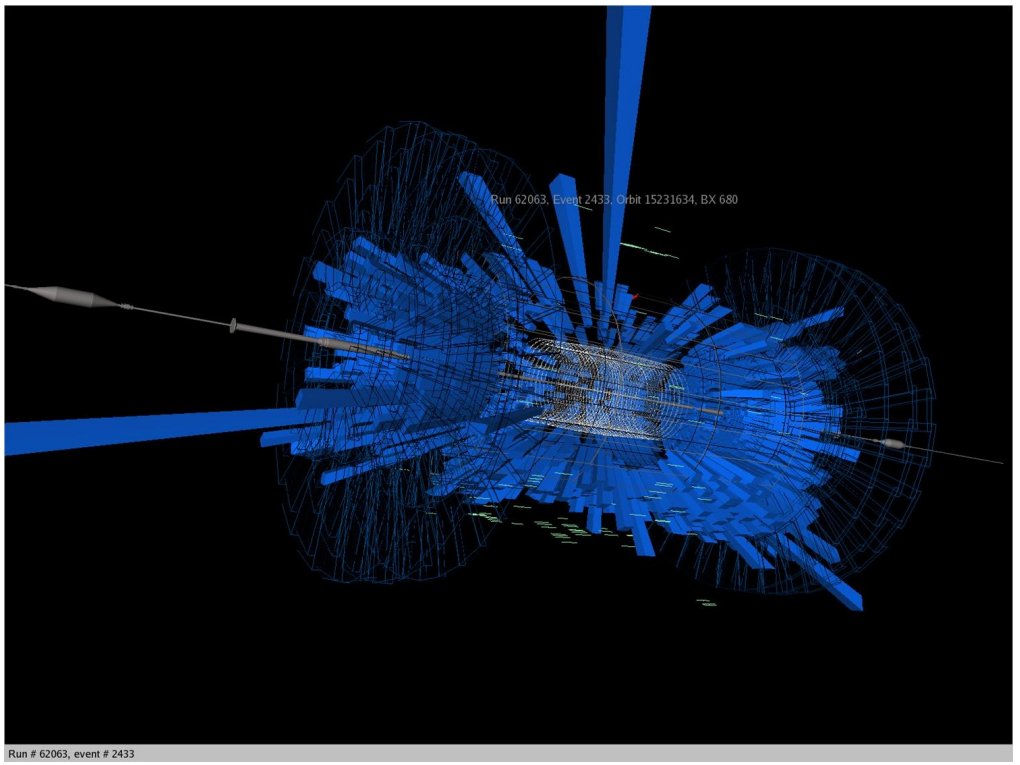
Charged particle spectra at CMS

Krisztián Krajczár for the CMS Collaboration

Eötvös University, Budapest



EPS HEP

Krakow, Poland, 2009

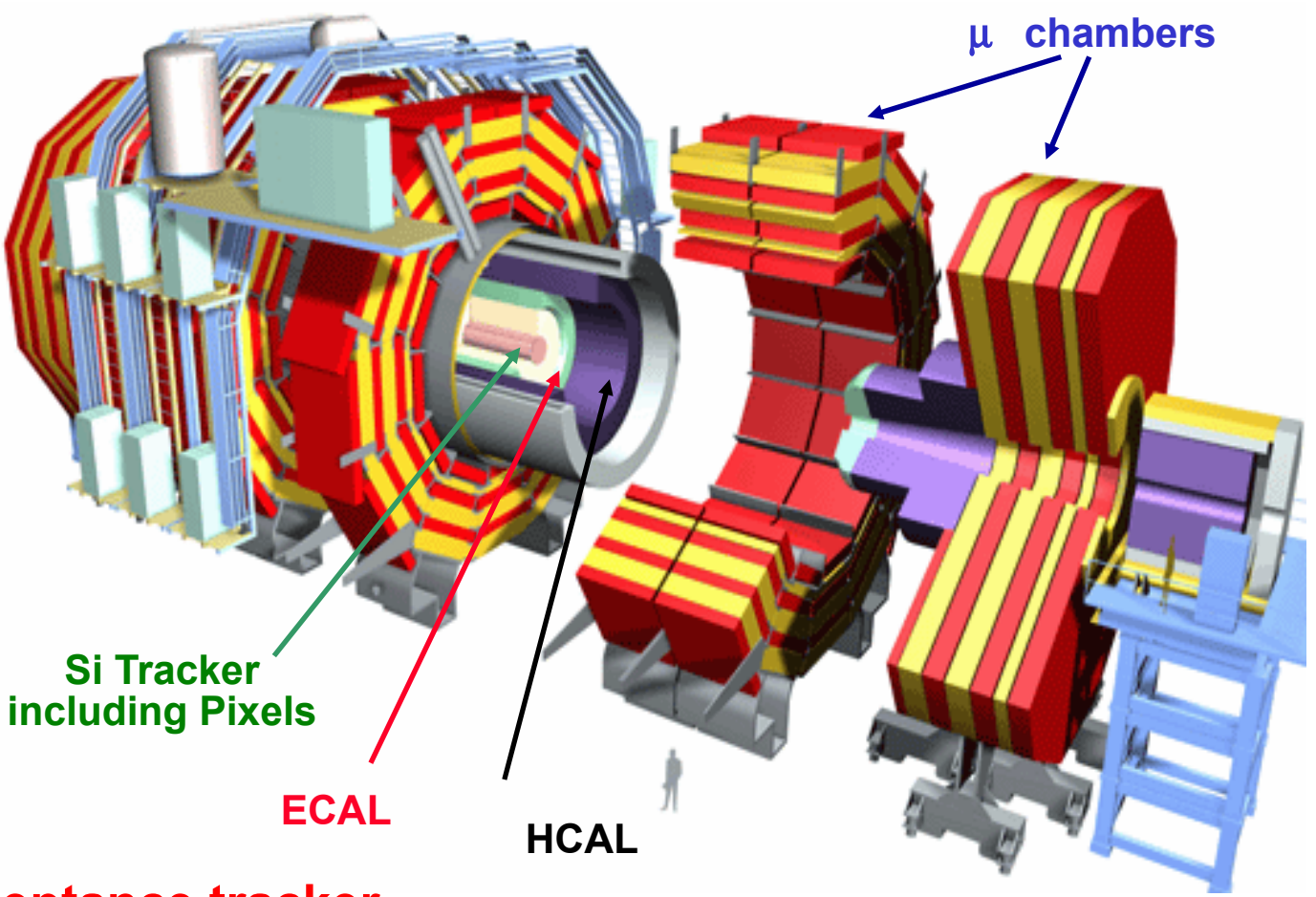
Charged particle spectra

- One of the first physics results from the LHC will be the measurement of charged hadron spectra in p-p collisions
- Provides information about the particle production mechanisms
- Charged particle spectra:
  - Integrate the differential cross section of charged particles:

$$\sim \frac{d^2 N}{dp_T d\eta} \longrightarrow \frac{dN}{dp_T}, \frac{dN}{d\eta}$$

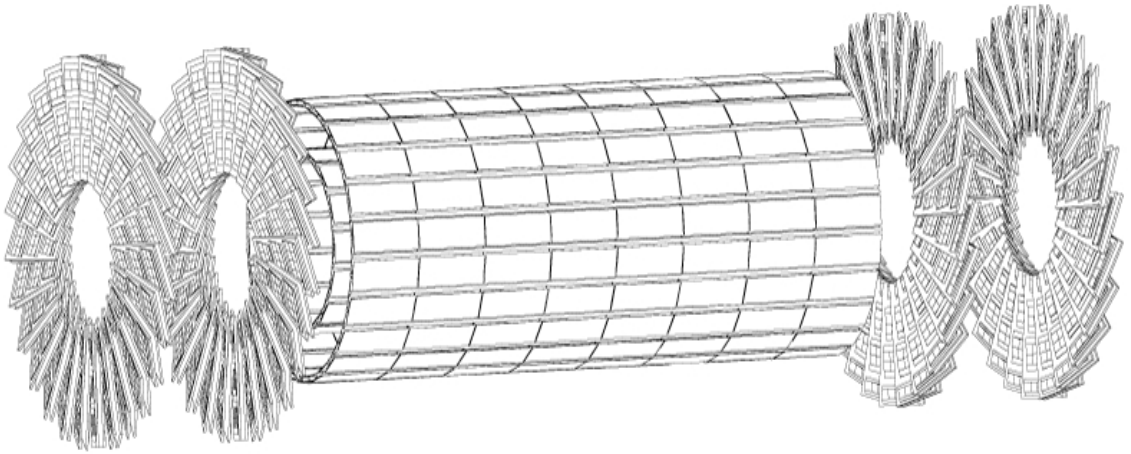
- LHC and CMS schedule:
  - CMS takes cosmic data from July, ready for beam in September
  - First beams in the LHC: in October
  - First collisions in the LHC: in November

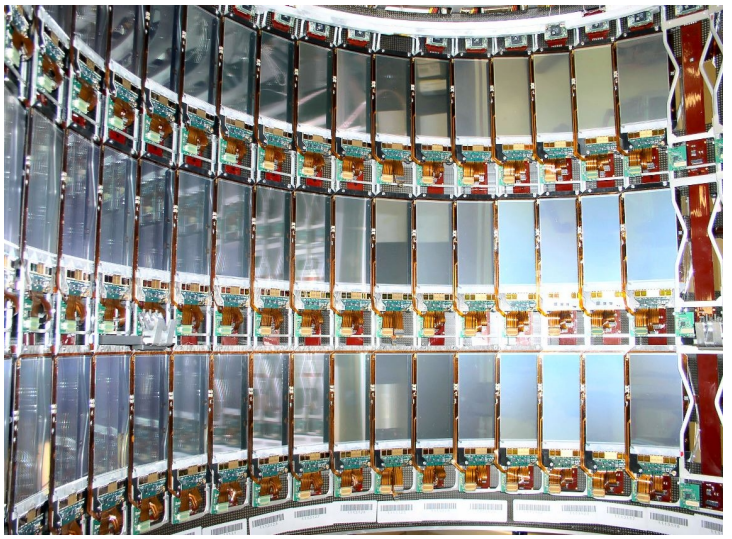
The CMS detector



- Large acceptance tracker
- Hermetic calorimetry
- Excellent muon spectrometer

Tracking system





- Silicon tracker including pixels and strips (|η|<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 (decrease) momentum resolution

The complete tracker layout in backup

Different approaches

- Aim:
  - Measure primary charged particles
  - Use various methods
- Different approaches to measure charged spectra:
  - Use all 3 pixel + strip layers (tracks): dN/dp_T, $dN/d\eta$
  - Use only 2 pixel layers (tracklets): $dN/d\eta$
  - Use only 1 pixel layer (clusters): $dN/d\eta$
- Each of them have their own pros and cons
- Common issues:
  - Triggering, event selection (which events to take)
  - Vertexing (where is the interaction point)

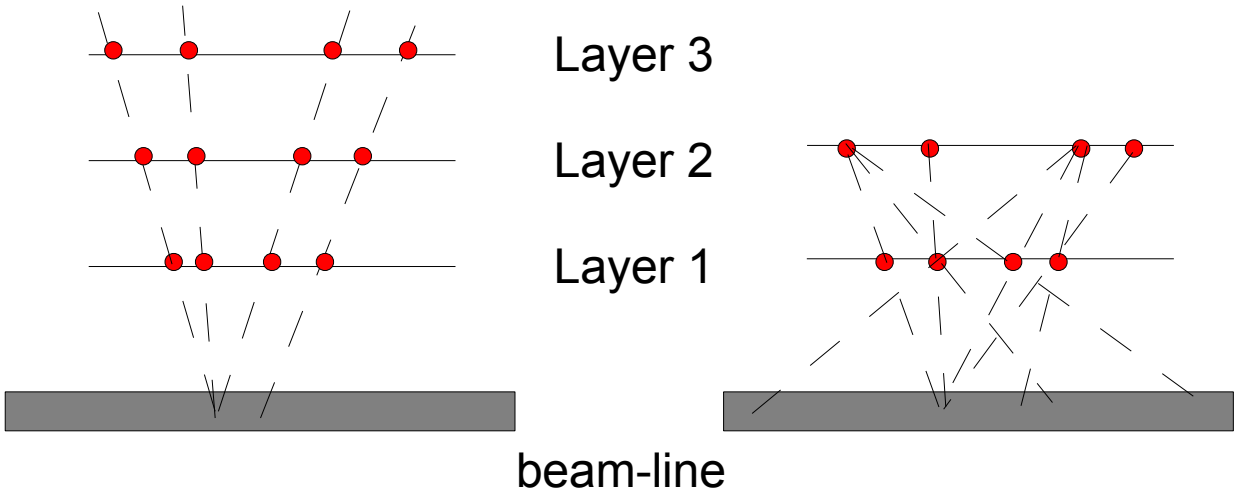
Common Issues

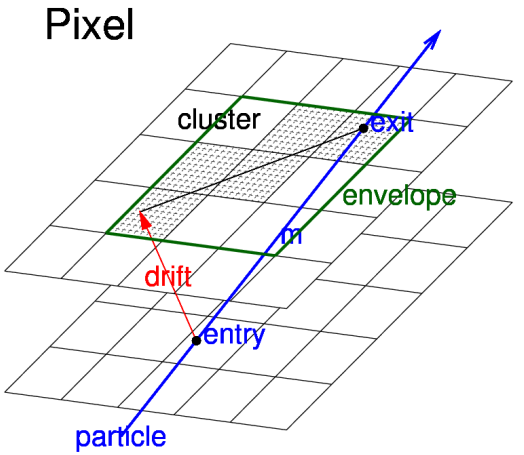
- Triggering:
  - Zero bias: filled bunch in both beams
  - Minimum bias: use forward detectors or reconstructed tracks
- Vertexing:

Tracks:
Try to clusterize tracks along the beam-line

Tracklets:
Try to clusterize tracklets along the beam-line

Clusters:
Use the shape of clusters

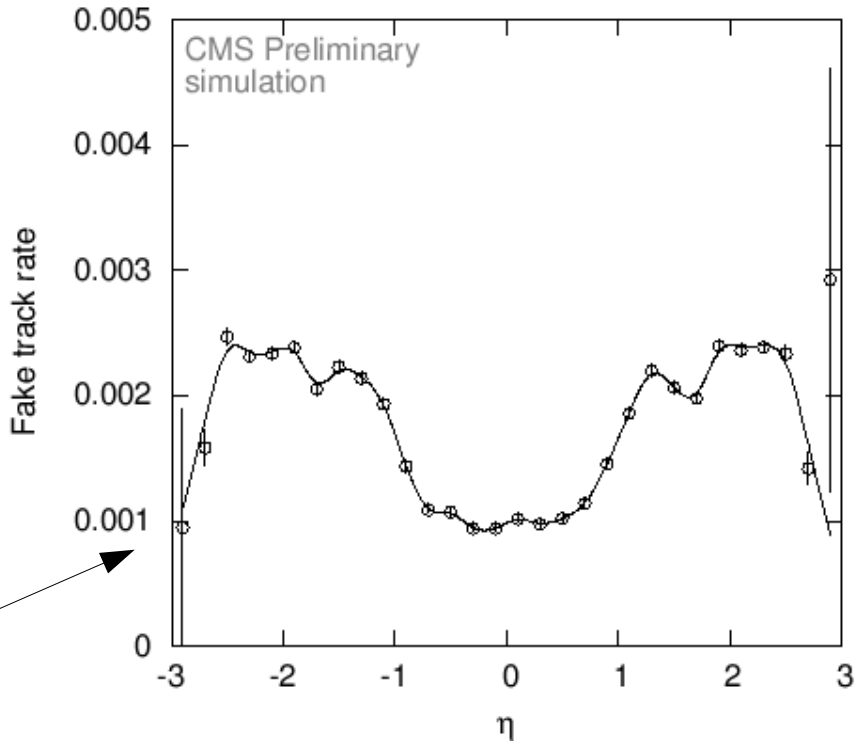




Tracks (I.)

- Use all 3 pixel layers to reconstruct tracks → form triplets
  → propagate the triplets to the strip layers
- Triplets can be cleaned by using the information present in clusters

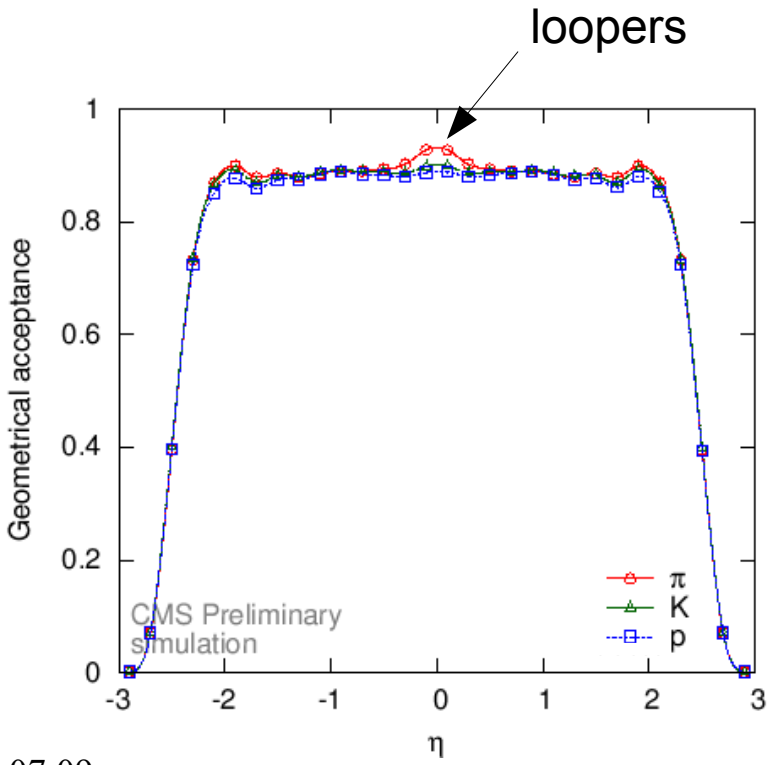
- Shape ~ direction
- Triplets with non-compatible clusters are to be removed
  ↓
- Fake tracks:
  not present on simulation level
- Fake track rate: per mille level

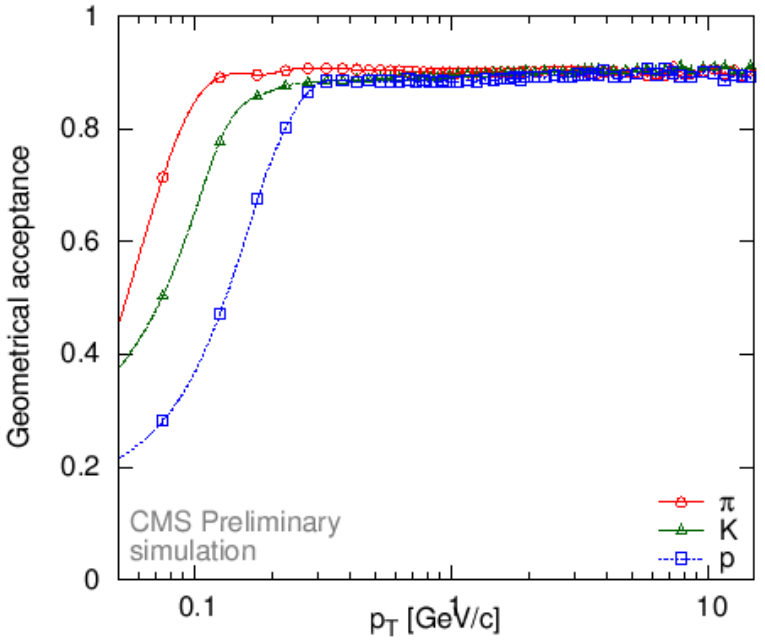


CMS PAS QCD-07-001

Tracks (II. Acceptance)

- Use all 3 pixel layers to reconstruct tracks → form triplets
- Performance:
  - Acceptance = fraction of the reconstructable primary particles



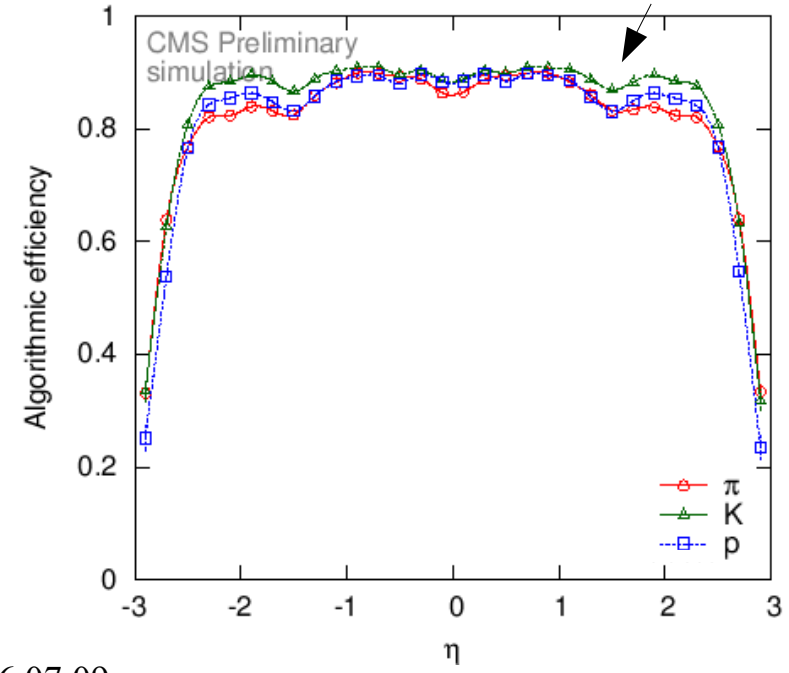


CMS PAS QCD-07-001

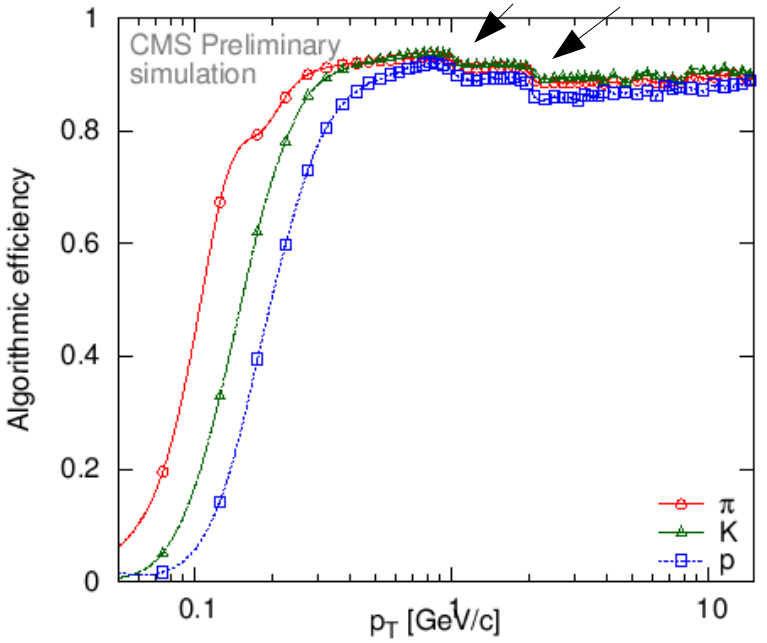
Tracks (II. Efficiency)

- Use all 3 pixel layers to reconstruct tracks → form triplets
- Performance:
  - Acceptance = fraction of the reconstructable primary particles
  - Efficiency = fraction of the reconstructed reconstructible particles

barrel → endcap



Additional hits are required

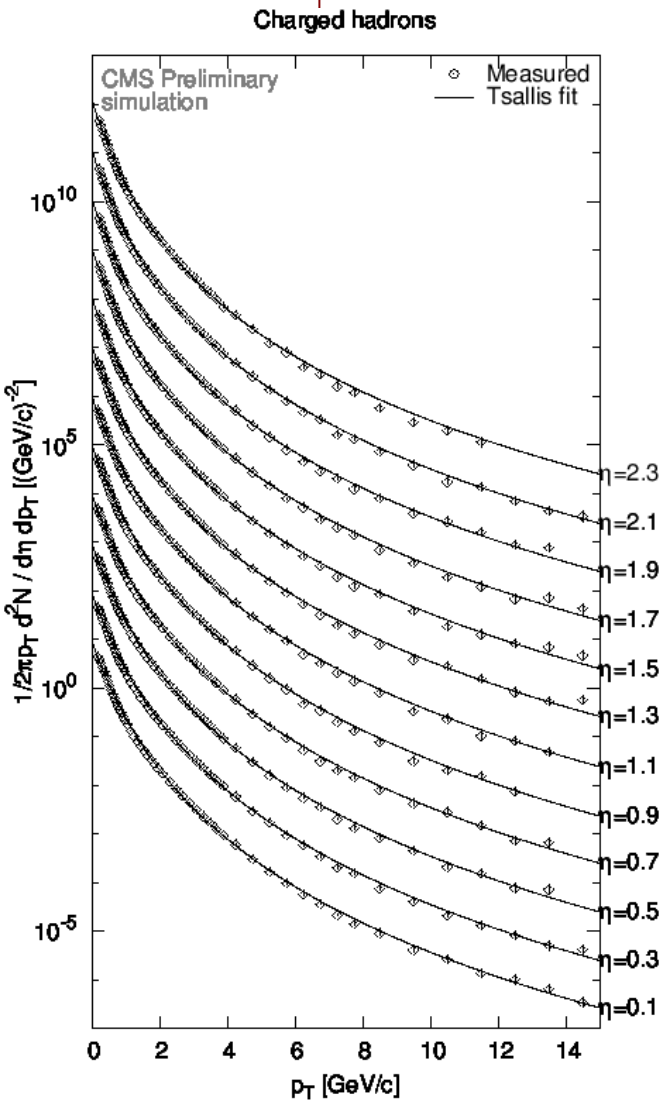


CMS PAS QCD-07-001

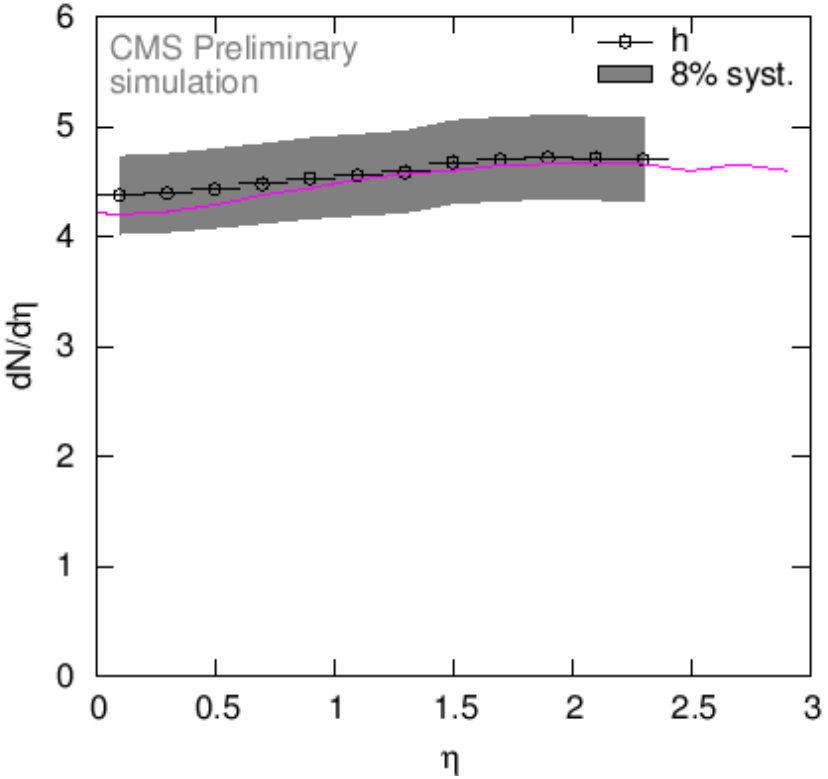
Tracks (III.)

- Results (on simulated events):

dN/dp$_T$ in η bins



dN/dη

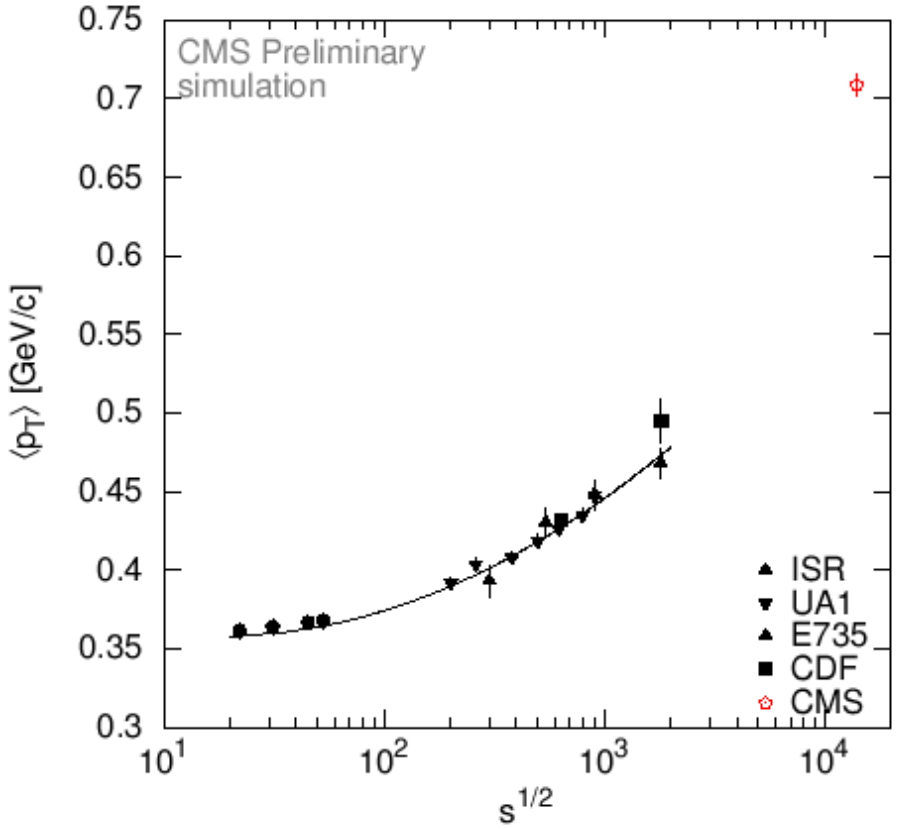


- p$_T$ reach: from 100 MeV/c!
- Larges source of syst.: trigger efficiency

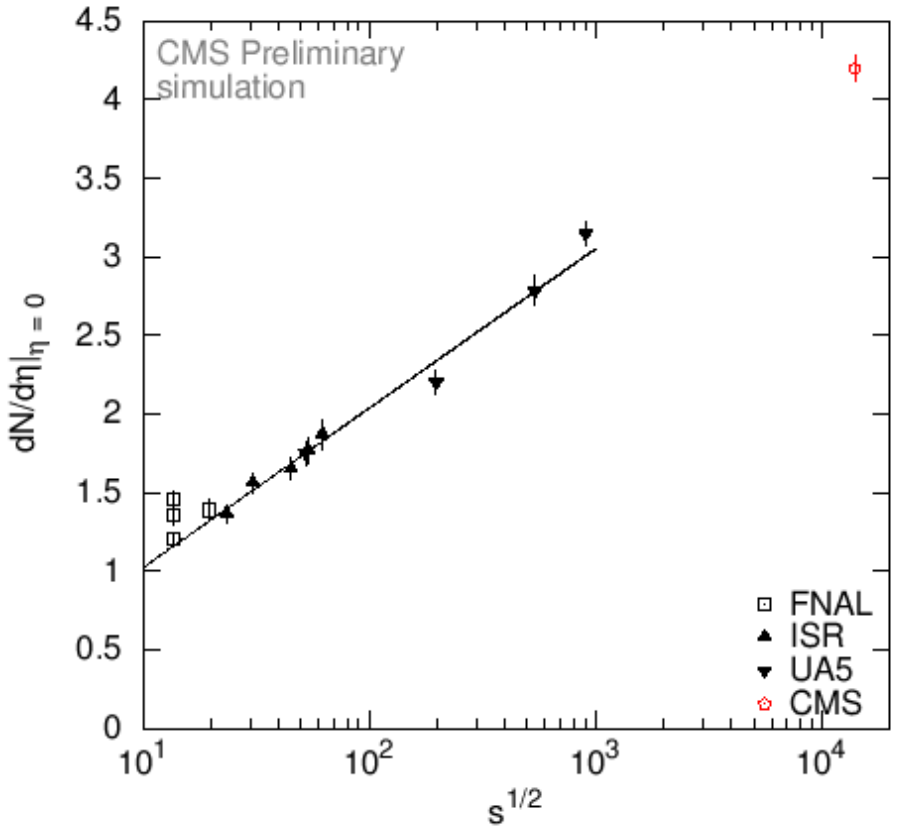
CMS PAS QCD-07-001

Tracks (IV.)

- Results (on simulated events):
  average p_T as a function of $s^{1/2}$



  $dN/d\eta|_{\eta=0}$ as a function of $s^{1/2}$



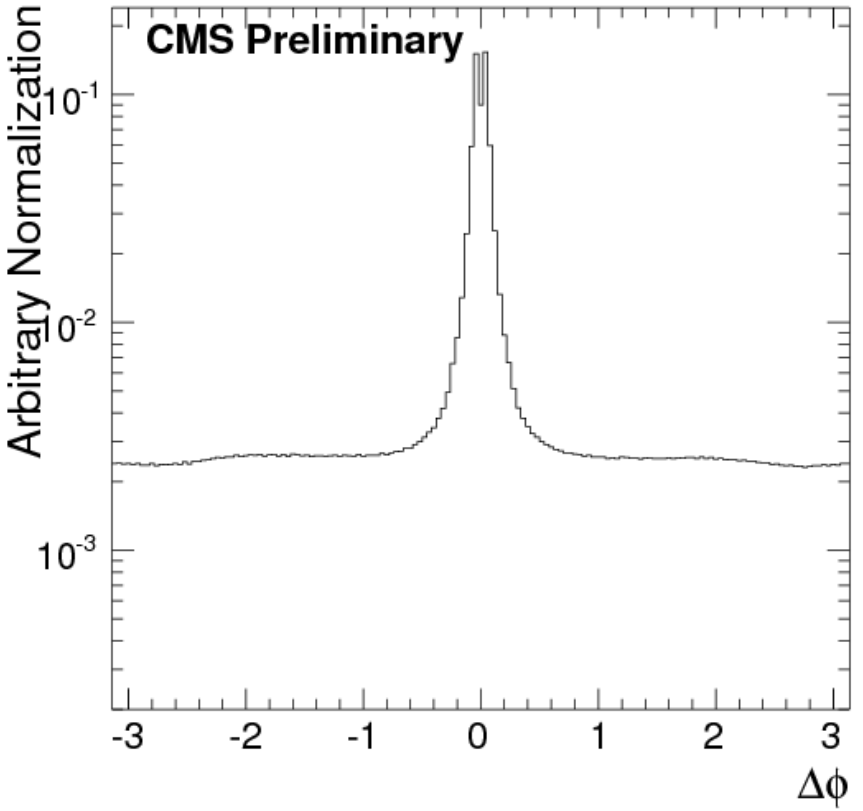
- CMS point: close to the top right corner

CMS PAS QCD-07-001

Tracklets (I.)

- Method: prepare pairs of hits, locate the vertex, reject background, rebuild tracklets
- Background rejection:
  - Use sidebands in ΔΦ
- Corrections:
  - Combinatorial background
  - Events with no particles in the tracker
  - Vertex correction
  - Dead channels
  - Tracklets to particles

Φ difference between the two hits

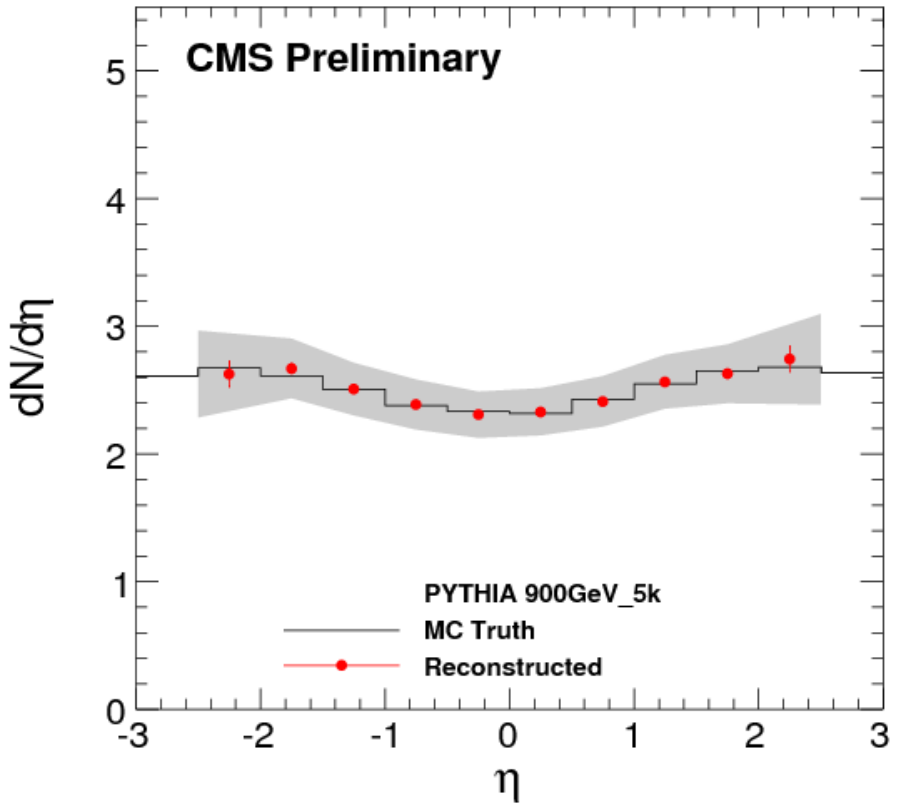


CMS PAS QCD-09-002

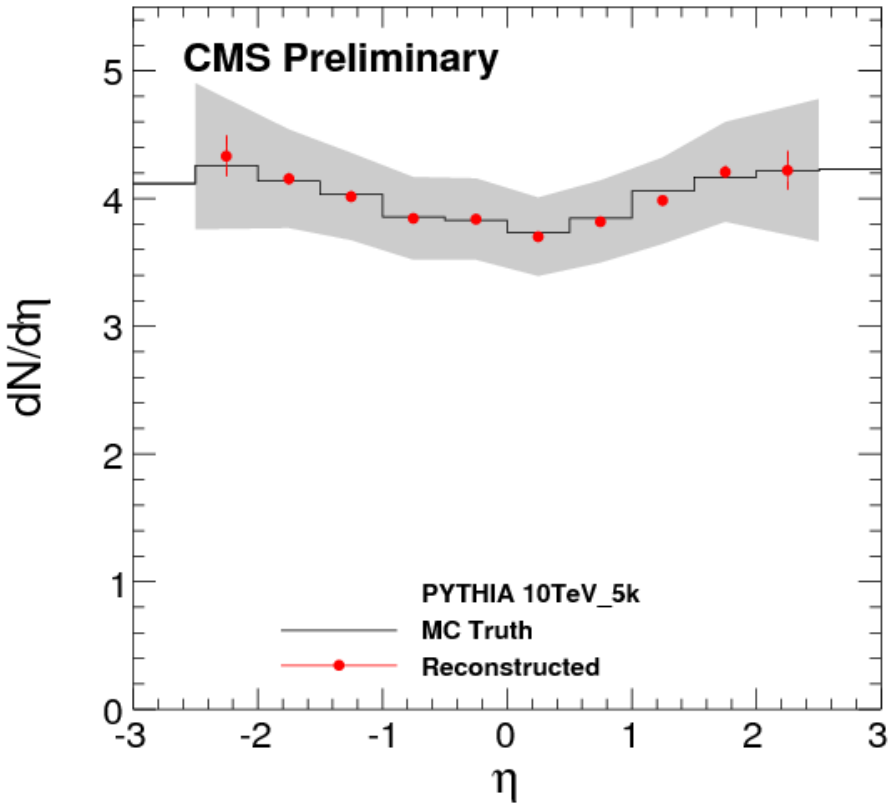
Tracklets (II.)

- Results (on simulated events):

dN/dη at 900 GeV



dN/dη at 10 TeV



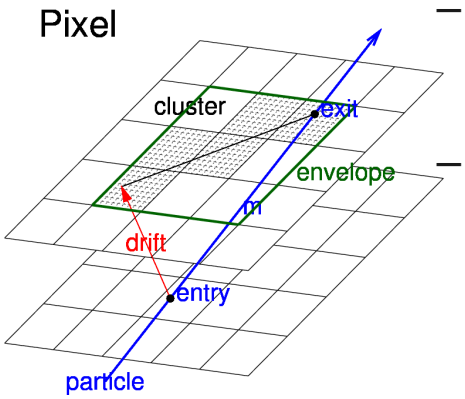
- Largest source of syst.: misalignment, fake vertices

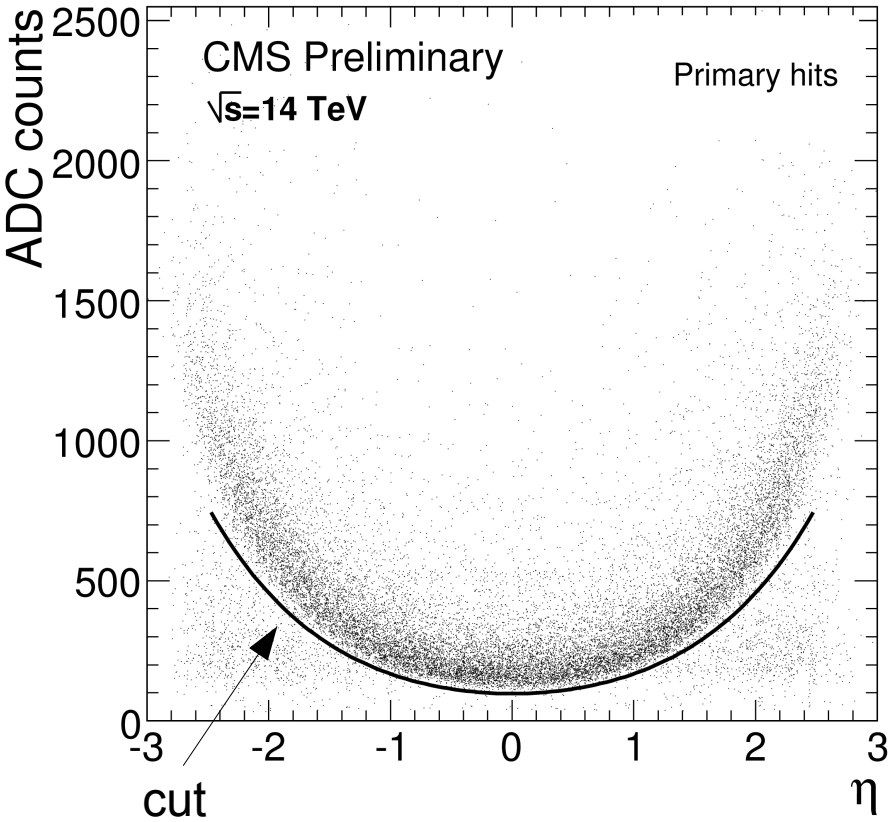
p_T reach: from 60 MeV/c!

CMS PAS QCD-09-002

Clusters (I.)

- Method: locate vertex, calculate the η of every cluster, reject background, count number of clusters on a single pixel layer
- Requires: understanding the various backgrounds (beam-halo muons, beam-gas collisions, …)
  - Background rejection:
    - ADC or cluster shape as a function of η
    - Special treatment of loopers:
      - particles bent back by the magnetic field
      - Cross the layer multiple time



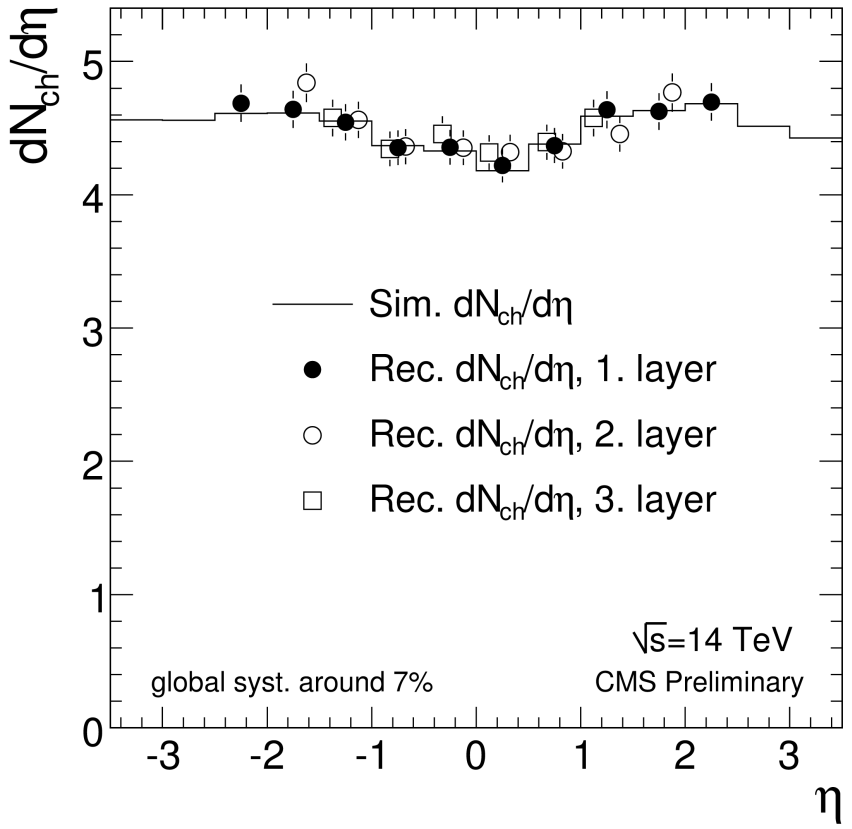


CMS PAS QCD-08-004

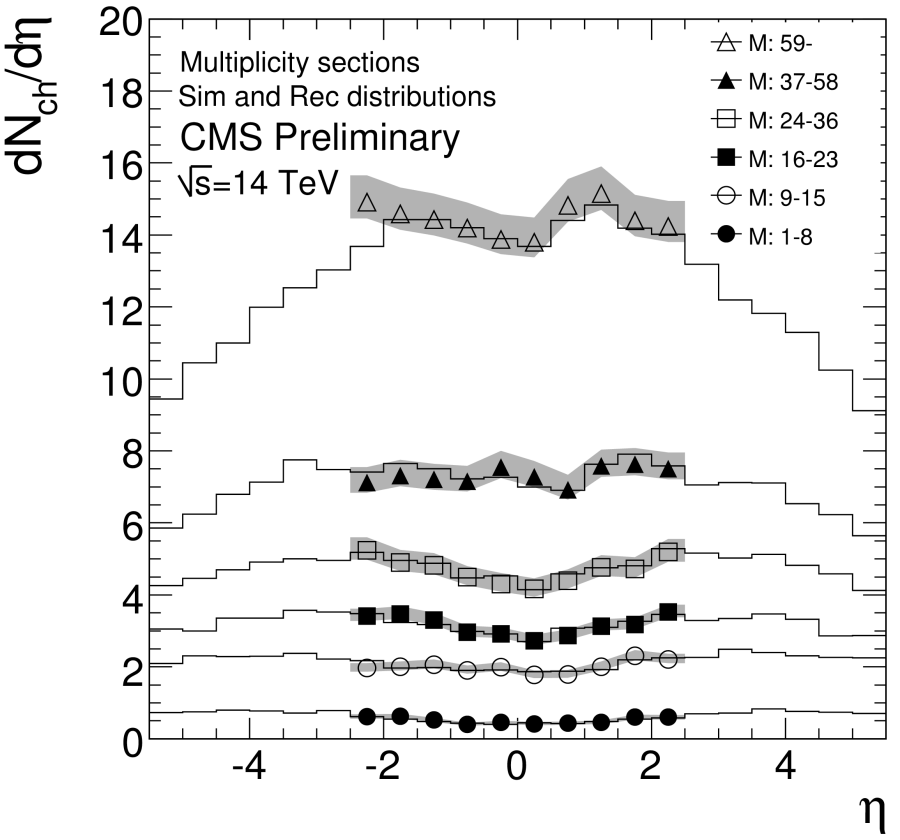
Clusters (II.)

- Results (on simulated events):

dN/dη



dN/dη in various multiplicity bins



- Largest source of syst.: background (beam-halo, etc.)

p_T reach: from 40 MeV/c!

CMS PAS QCD-08-004

Summary

- CMS has a set of well prepared analyses to measure charged hadron spectra:
  - Using tracks, tracklets, clusters
- They use different objects, have different systematics
  → can cross-check each other

CMS will be ready to extract charged particle spectra using various methods as the first collisions appear

- References (https://twiki.cern.ch/twiki/bin/view/CMS/PhysicsResults):
  - CMS PAS QCD-07-001
  - CMS PAS QCD-08-004
  - CMS PAS QCD-09-002

BACKUP SLIDES

Tracker layout