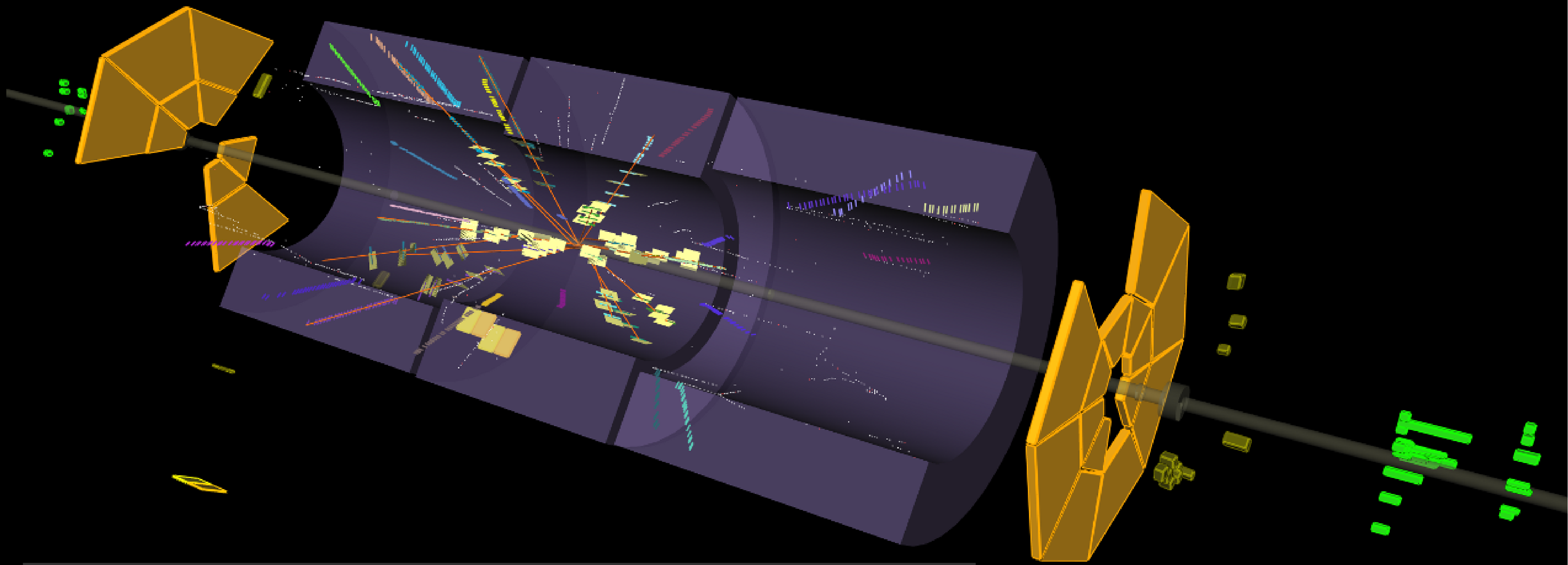


ATLAS Status Report

LHCC 17 February 2010

D Charlton (Birmingham), J Boyd (CERN)

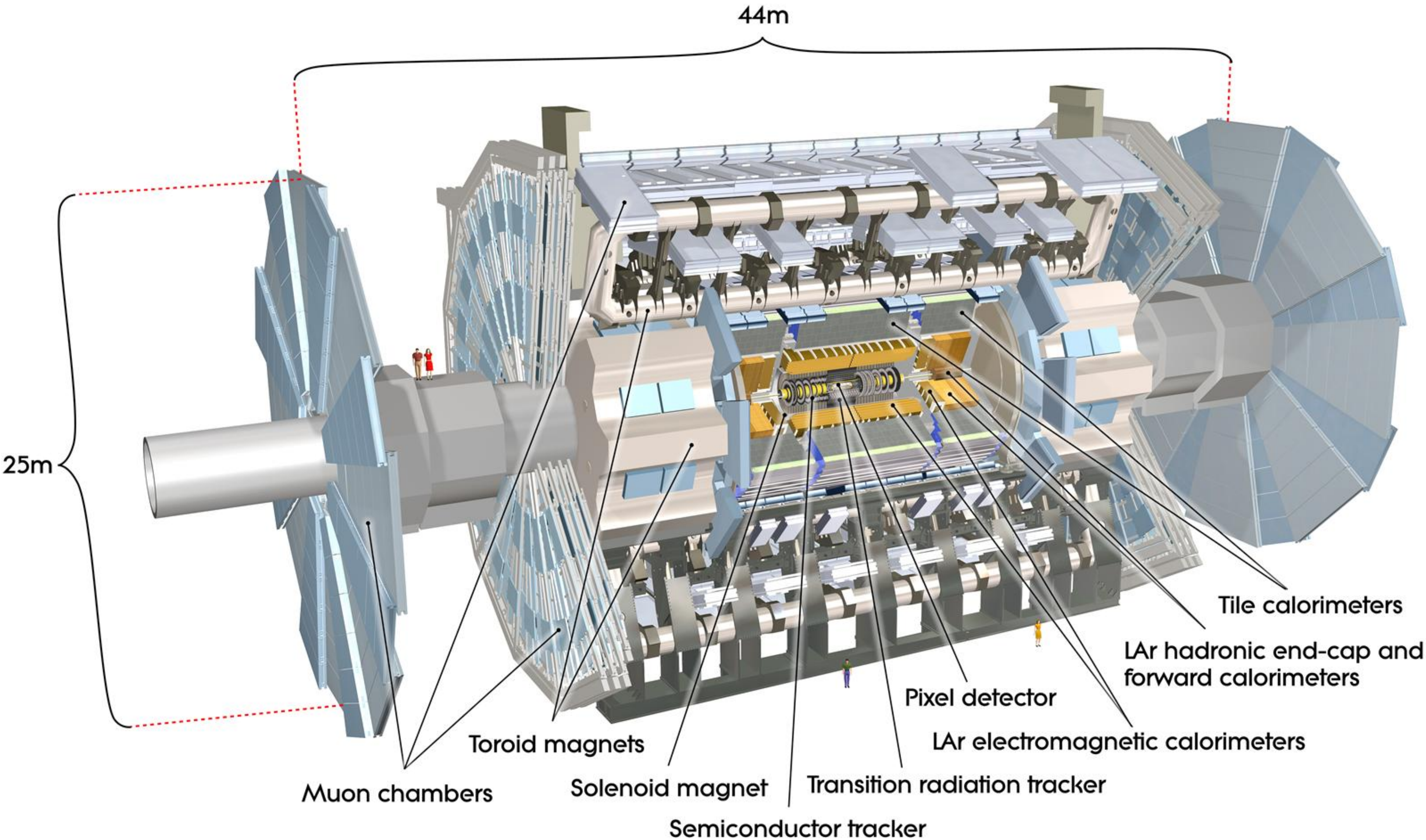
Technical Aspects were Covered in Pre-Meeting with Referees Yesterday

Data Taken, Detector & Trigger

Calorimetry, Jets & EM objects

Muons and Inner Detector Tracking

Minimum Bias Analysis


44m
25m
Tile calorimeters
LAr hadronic end-cap and
forward calorimeters
Pixel detector
LAr electromagnetic calorimeters
Toroid magnets
Muon chambers
Solenoid magnet
Transition radiation tracker
Semiconductor tracker

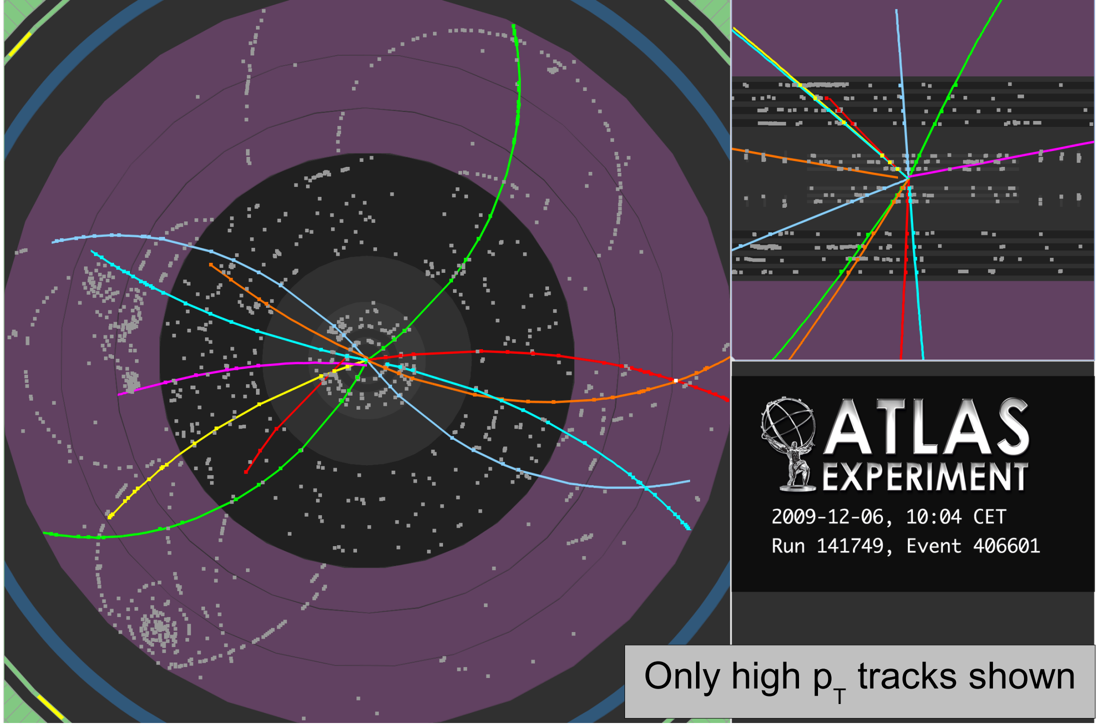
2009 Collision Data

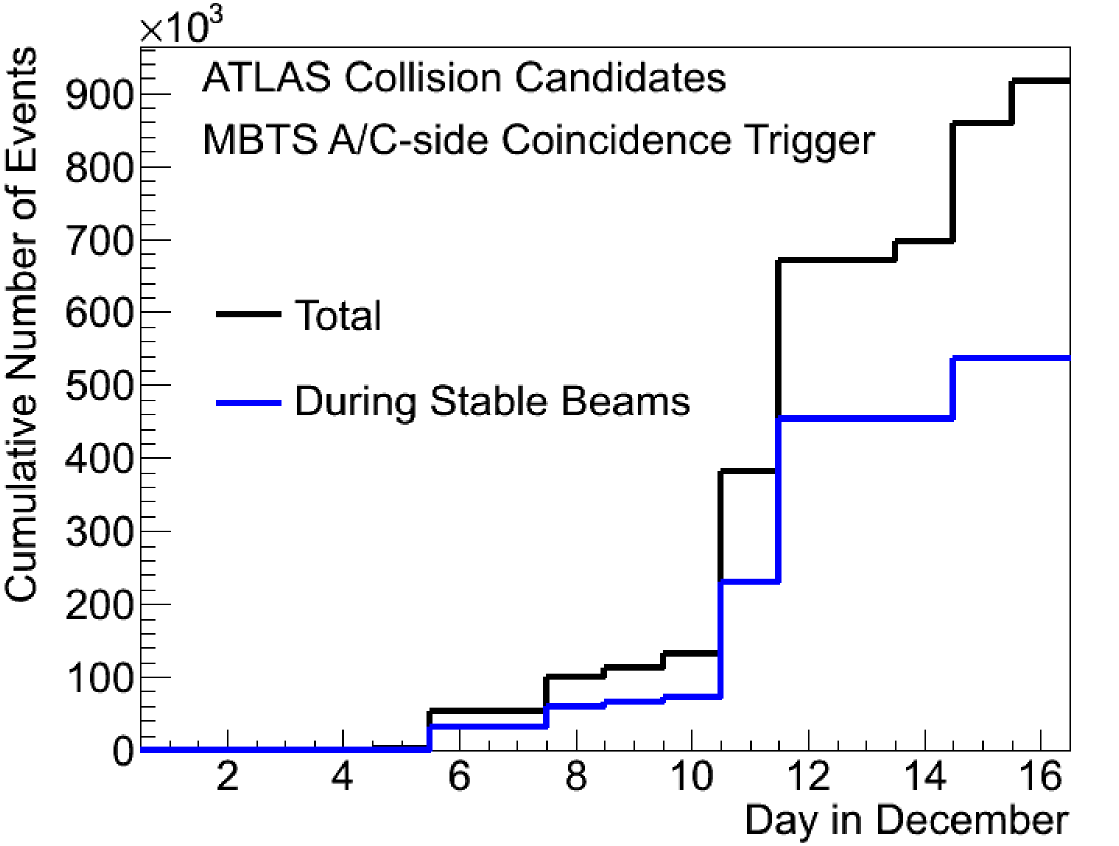
First collisions 23 November
First stable beams 6 December
2009 data complete 16 December

Total collision candidate events:
9.2×10^5, ~ 21 μb^{-1}
In stable beam conditions:
5.4×10^5, ~ 12 μb^{-1}
With ID+solenoid on, good data quality:
3.8×10^5, ~ 9 μb^{-1}

Short periods at 2.36 TeV
~ 34k collision events
(without stable beam conditions: ID not fully on)

Data-taking efficiency ~90%





Luminosity

Instantaneous luminosity $\mathscr{L}$ derived from:
Main 2009 measures:

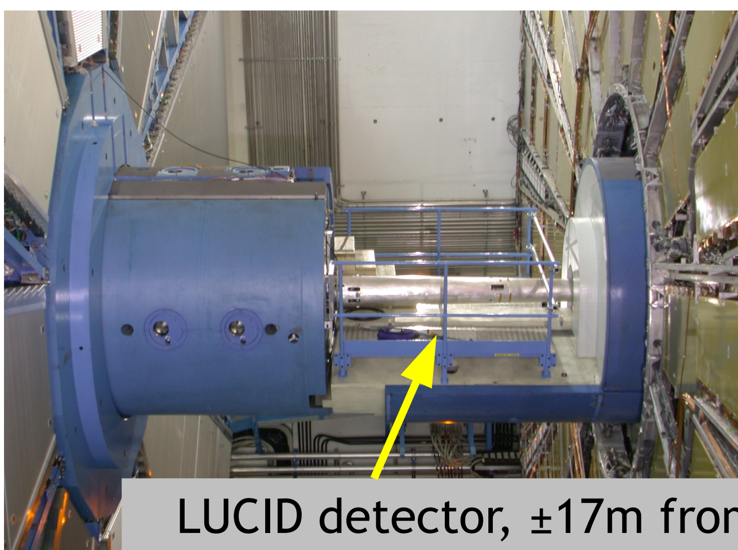
- MBTS two-side coincidence trigger rate
- LAr offline event selection (coincidence of in-time endcap E deposits)

Relative measurements also from:

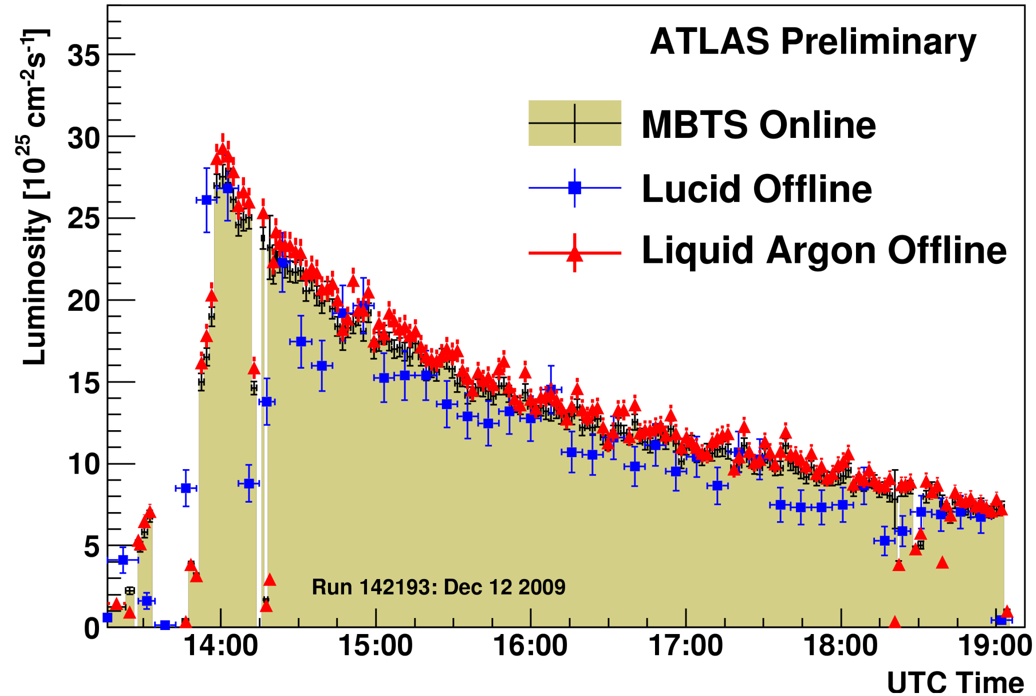
- Dedicated LUCID forward detectors
- FCal total energy measurement

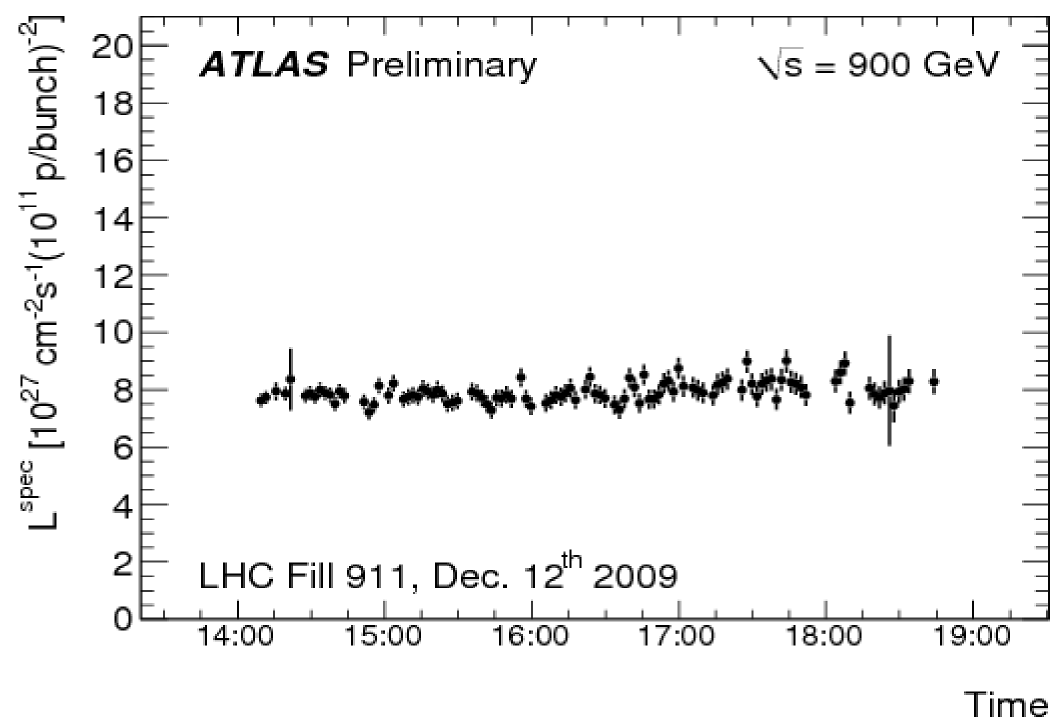
Overall $\mathscr{L}$ scale uncertainty ~ 30%

Specific luminosity ~ constant during stable fills, as expected



LUCID detector, ±17m from IP
Luminosity Cerenkov Integrating Detector





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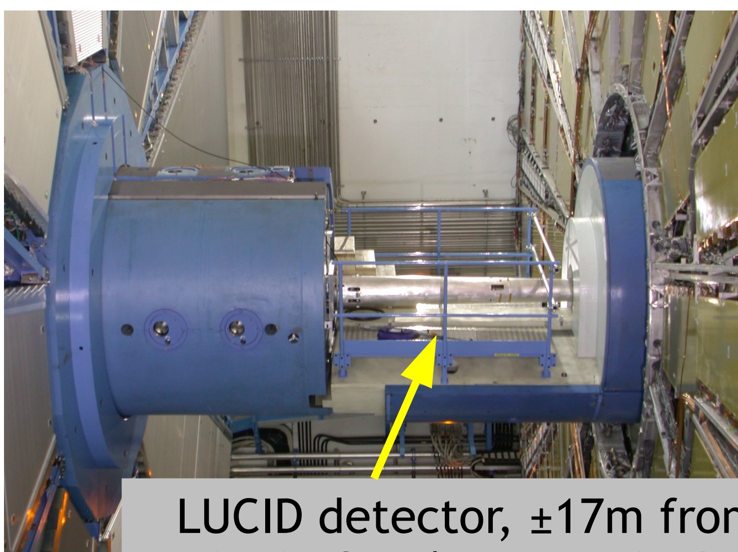
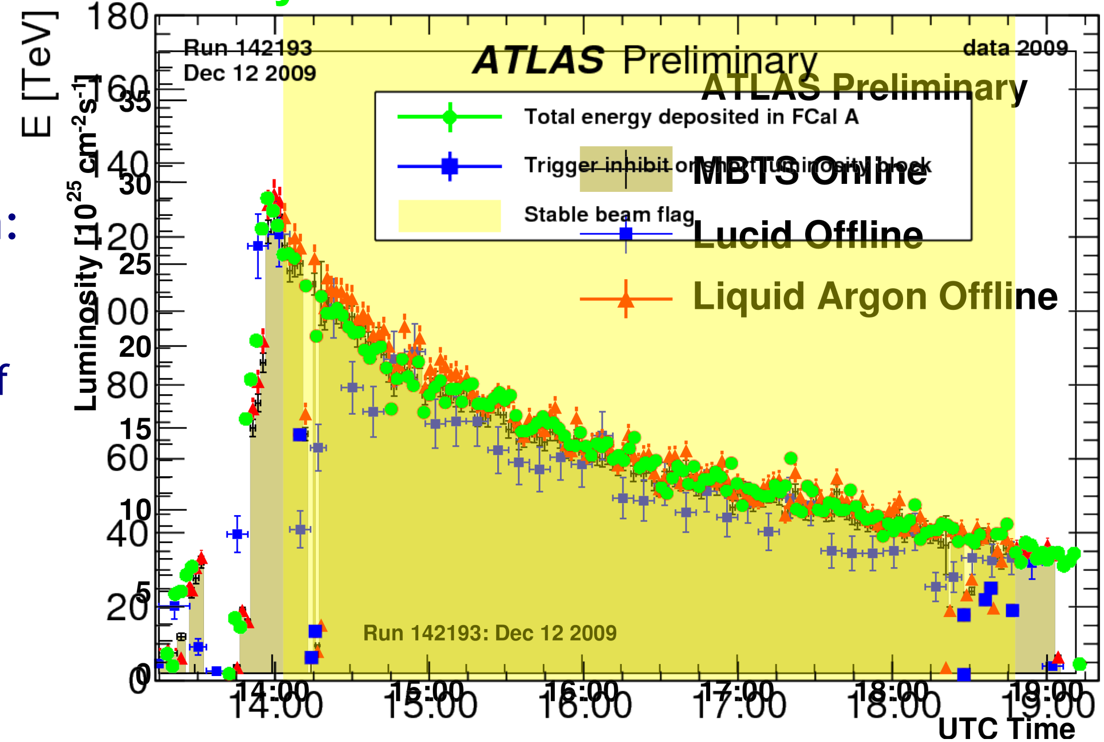
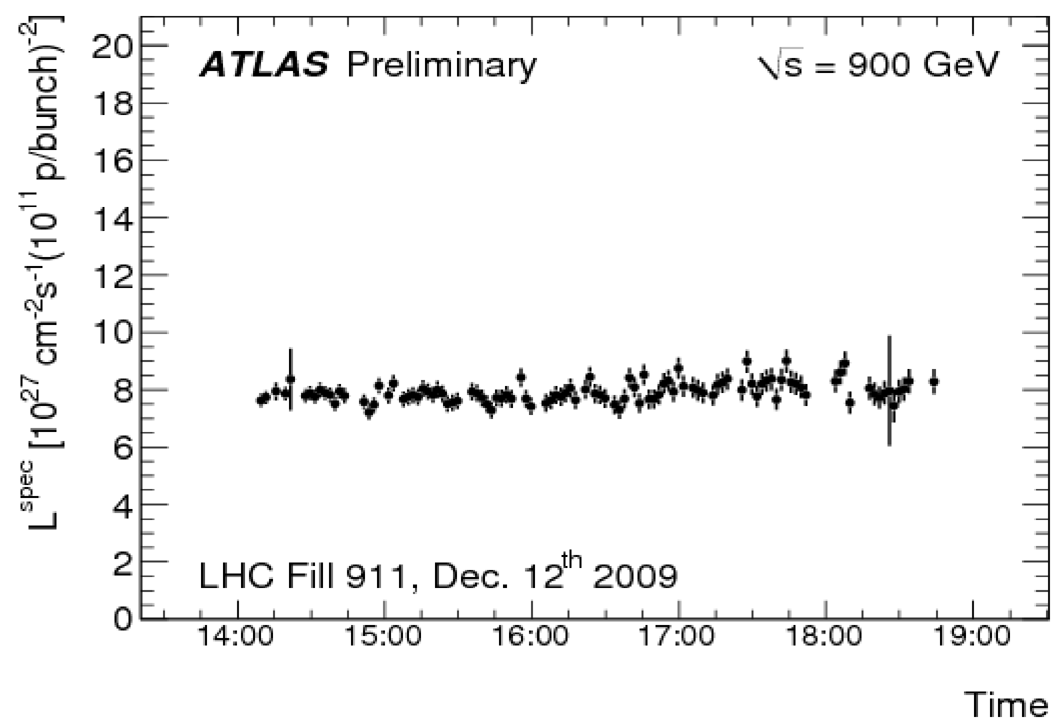


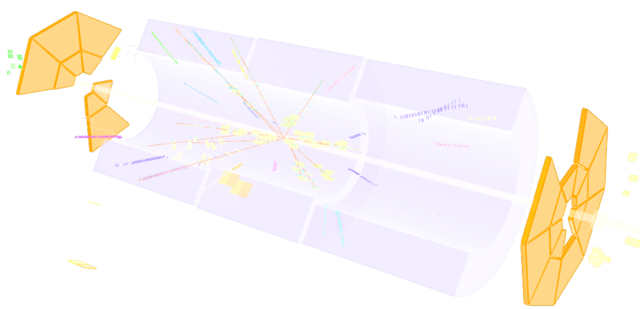
LUCID detector, ±17m from IP
Luminosity Cerenkov Integrating Detector

Overlay: Fcal total E measurement vs time





Level-1 Trigger



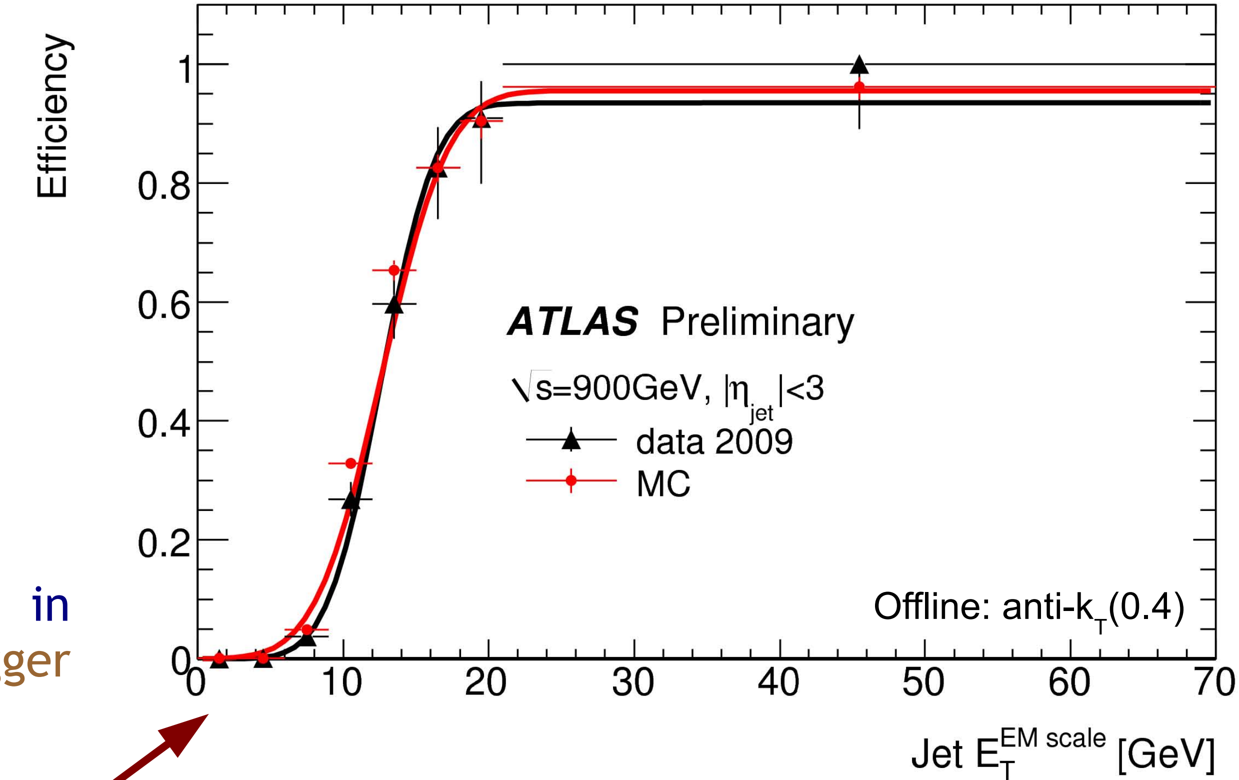
Main 2009 collision trigger: hit in *either* arm of minimum-bias trigger scintillators (MBTS) 2.09<|η|<3.84

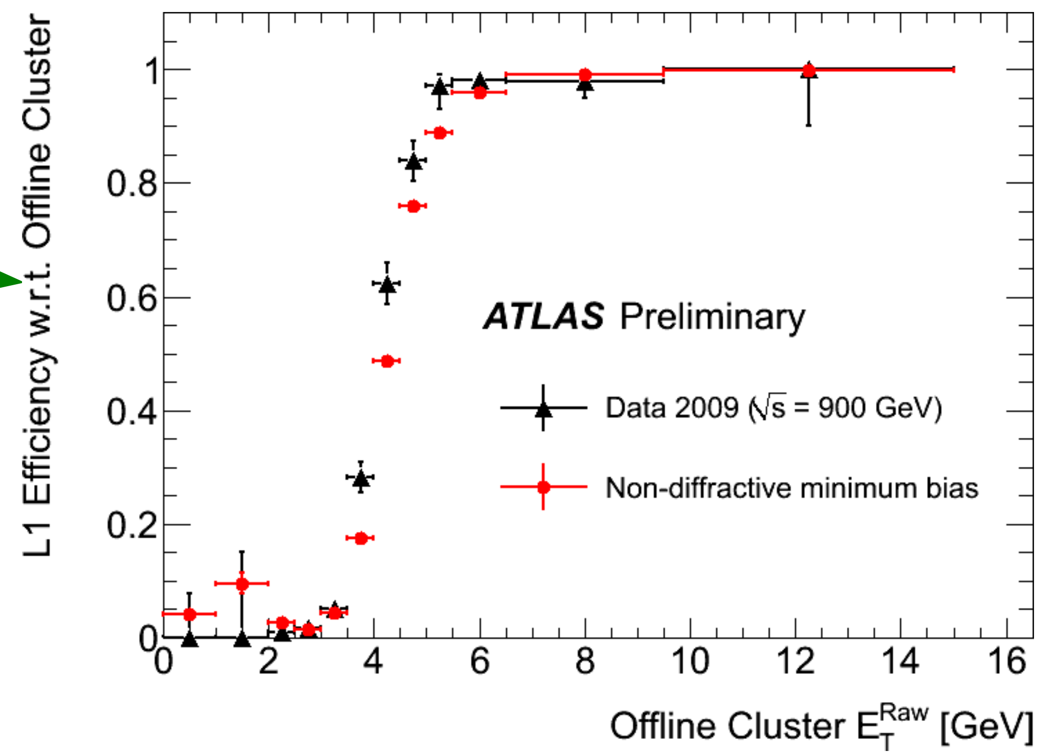
Higher E_T triggers also active, eg:

- Lowest threshold jet trigger in 0.4x0.4 ηxφ
- Lowest threshold EM trigger, on pairs of 0.1x0.1 ηxφ EM cells

L1calo algorithms use 1 GeV bit-step and in 2009 a tight noise suppression

L1 muon trigger active, statistics very low

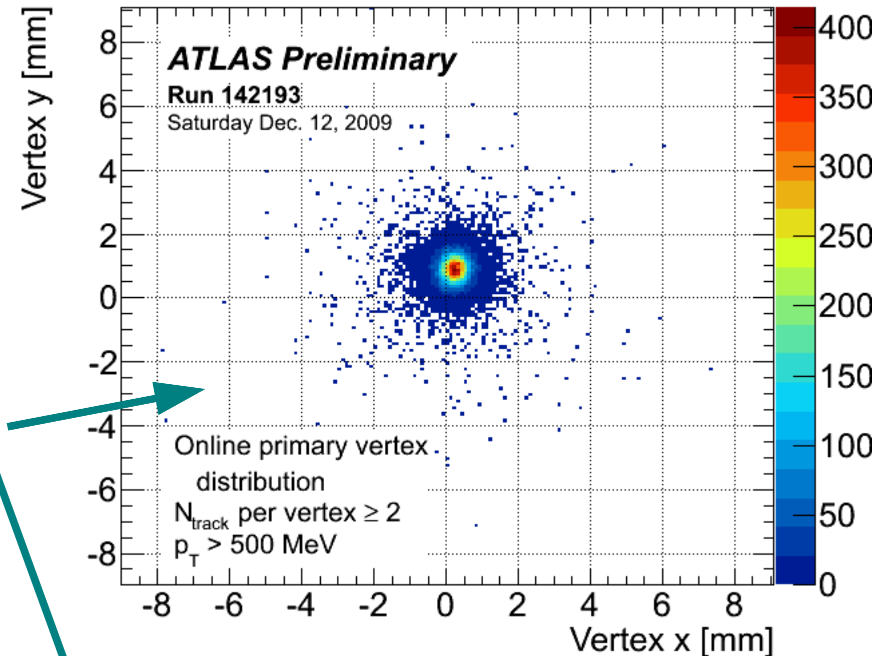


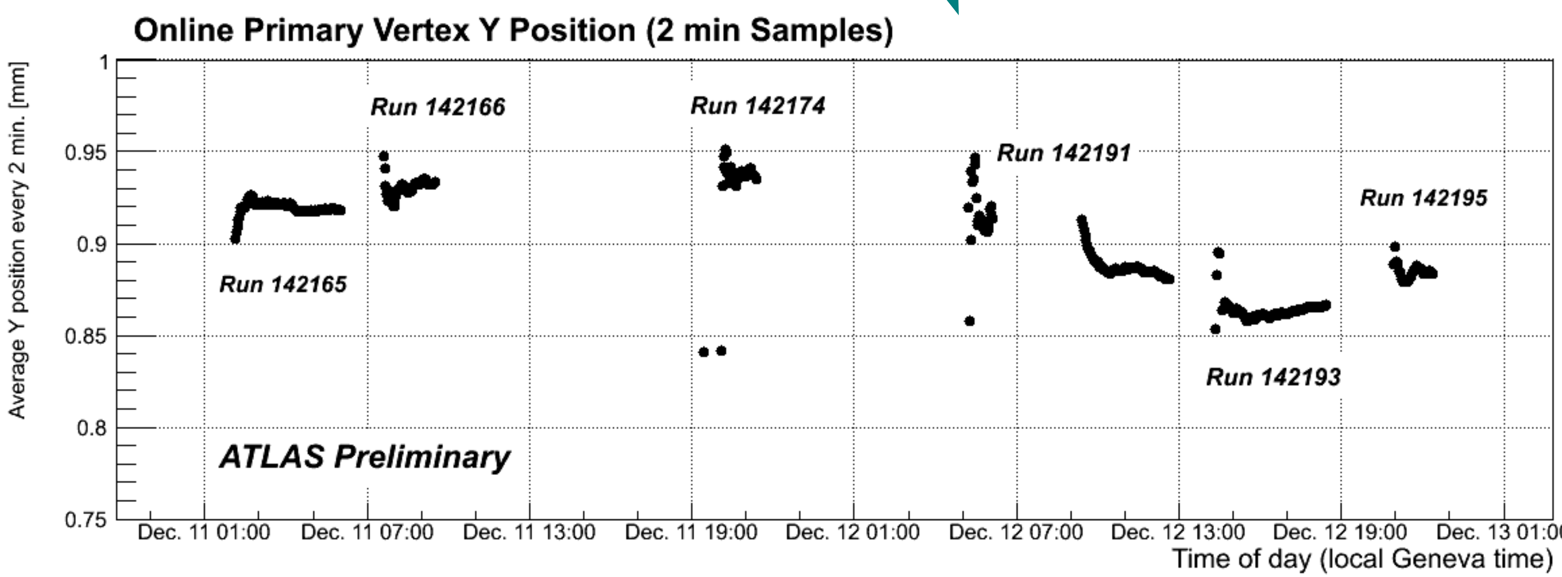


High-Level Trigger

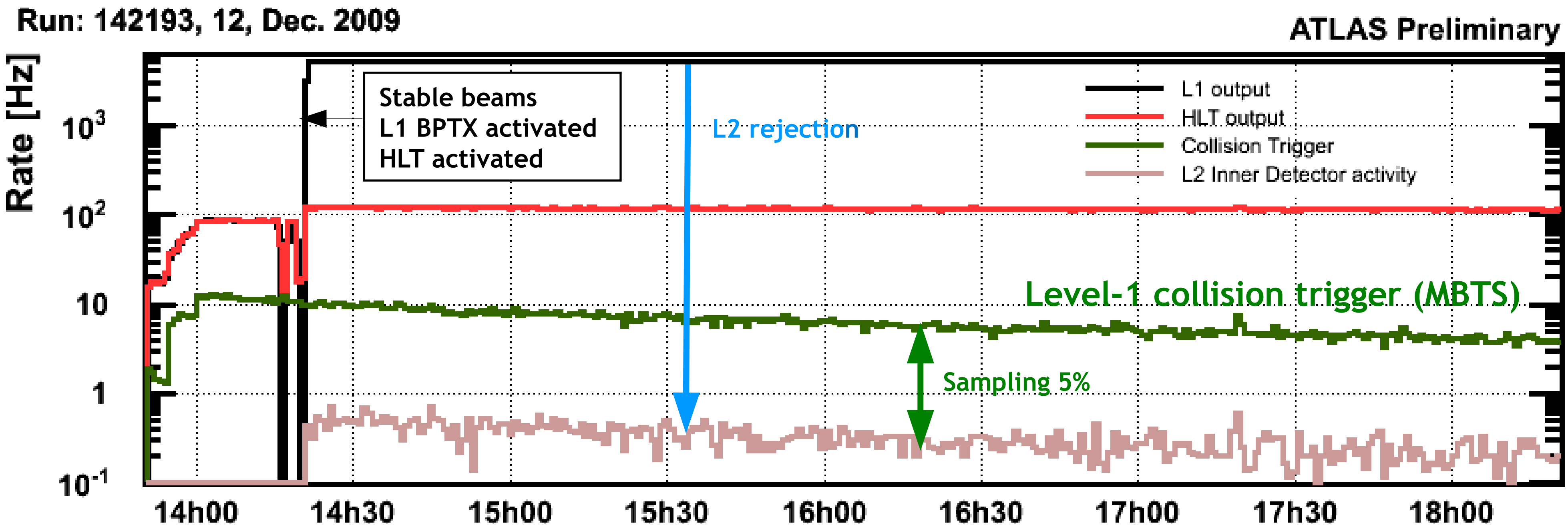
Rapid commissioning on collision data:

- Run systematically offline on data from 20 November (splashes) onwards
- HLT infrastructure run online from the start to provide event streaming
- Real HLT menu run online from 25 November in pass-through mode, e.g. online beamspot determination available from level-2
- Active event rejection started on 6 December for specific physics analysis requirement





High-Level Trigger Rejection



Active event rejection introduced at the HLT from 6 December

- beam pickup level-1 trigger (prescaled by 20)
- ID activity required at HLT (~10^4 rejection)

Provides a sample to measure MBTS efficiency

Further HLT commissioning will be required in 2010 for high-E_T object trigger signatures

Detector Readiness - Summary

High operational fractions of all detector systems

Minor repairs/maintenance during technical stop:

- Barrel toroid current lead repairs
- Solenoid cooling circuit cleaned
- Maintenance of cooling and gas systems
- Minor detector cabling fixes
- Additional supports installed for future install'n of more small EE muon chambers

CSC muon chamber readout continuing its commissioning

Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.5%
SCT Silicon Strips	6.3 M	99.3%
TRT Transition Radiation Tracker	350 k	98.2%
LAr EM Calorimeter	170 k	98.6%
Tile calorimeter	9800	98.0%
Hadronic endcap LAr calorimeter	5600	99.9%
Forward LAr calorimeter	3500	100%
MDT Muon Drift Tubes	350 k	99.7%
CSC Cathode Strip Chambers	31 k	98.5%
RPC Barrel Muon Trigger	370 k	99.5%
TGC Endcap Muon Trigger	320 k	100%
LVL1 Calo trigger	7160	99.5%

ATLAS is ready for 2010 data-taking

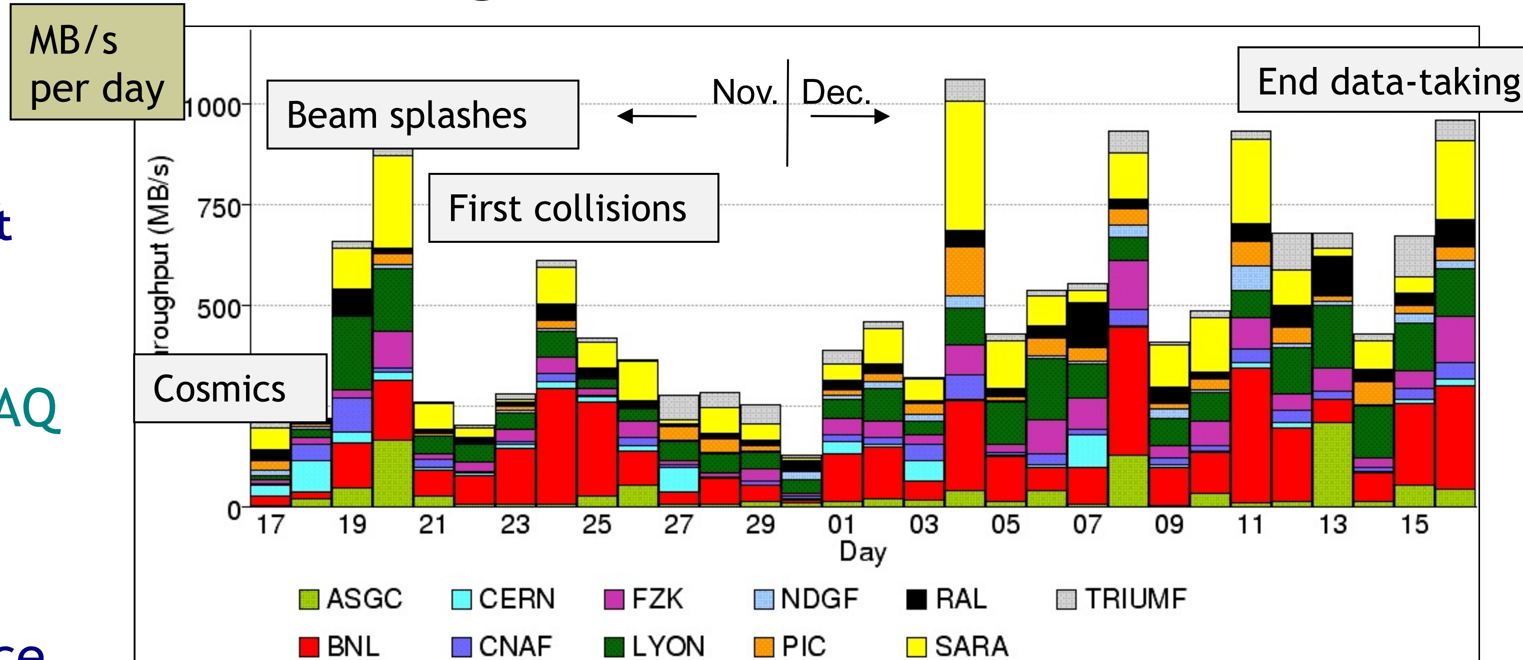
- Taking combined cosmic data since 2 February

Prompt Data Processing and Distribution

Data reconstructed & exported promptly

Typically ~4h from DAQ to Tier-2, including reconstruction time

Excellent performance of Tier sites for data processing and analysis



Total data throughput through the Grid (Tier0, Tier-1s, Tier-2s)

In steady-state 2010 operation, “calibration loop” will be introduced

- express-stream (~5%) reconstructed promptly at Tier-0
- wait ~36h for semi-automatic calibration updates before starting bulk reconstruction
  - e.g. beamspot, channel maps derived from express processing
- reconstructed bulk data available after ~48h, improved quality

Reprocessing

“Fast reprocessing” campaign started just after data-taking ended in December → most plots shown today

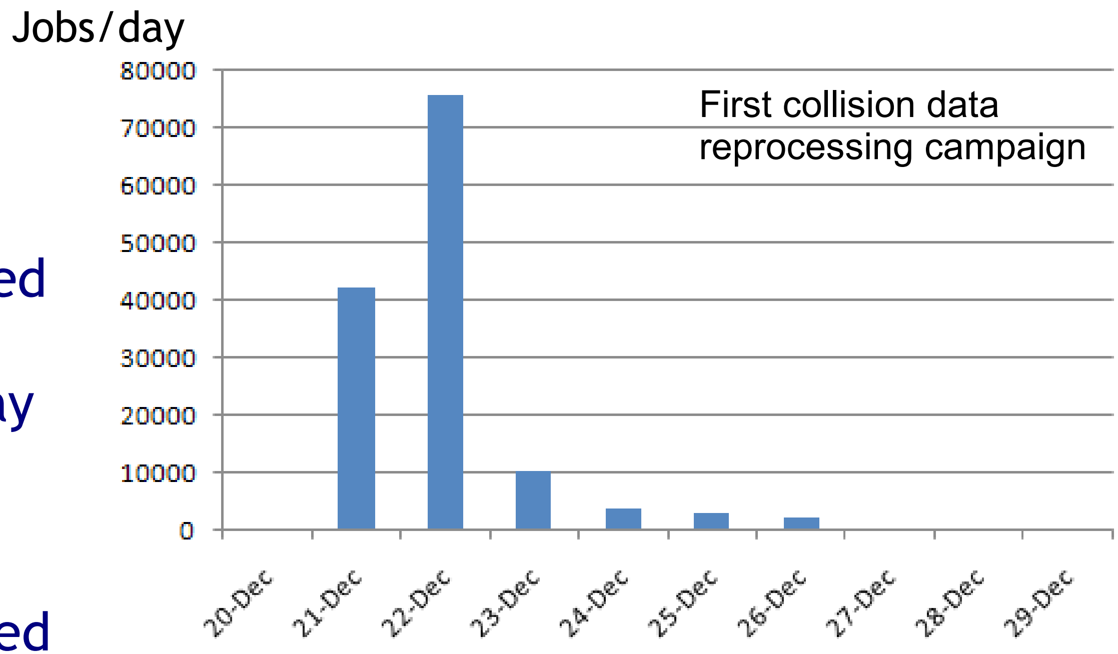
- consistent reconstruction code
- updated ID alignment constants…

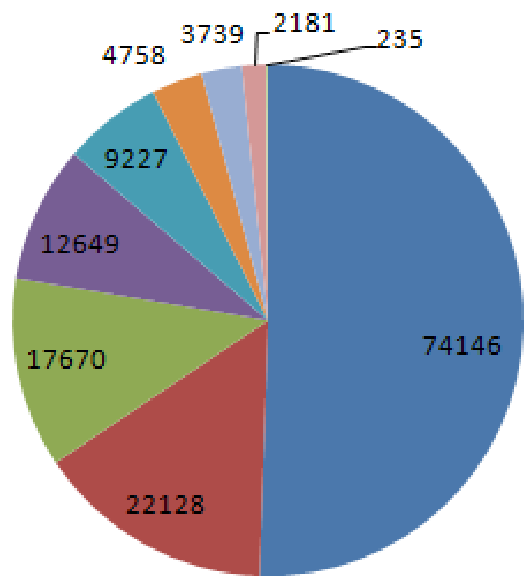
Monte Carlo samples also reprocessed with same reconstruction version

Reprocessing performed at Tier-1 sites according to the ATLAS computing model

A second reprocessing was started on Friday last week → now largely done

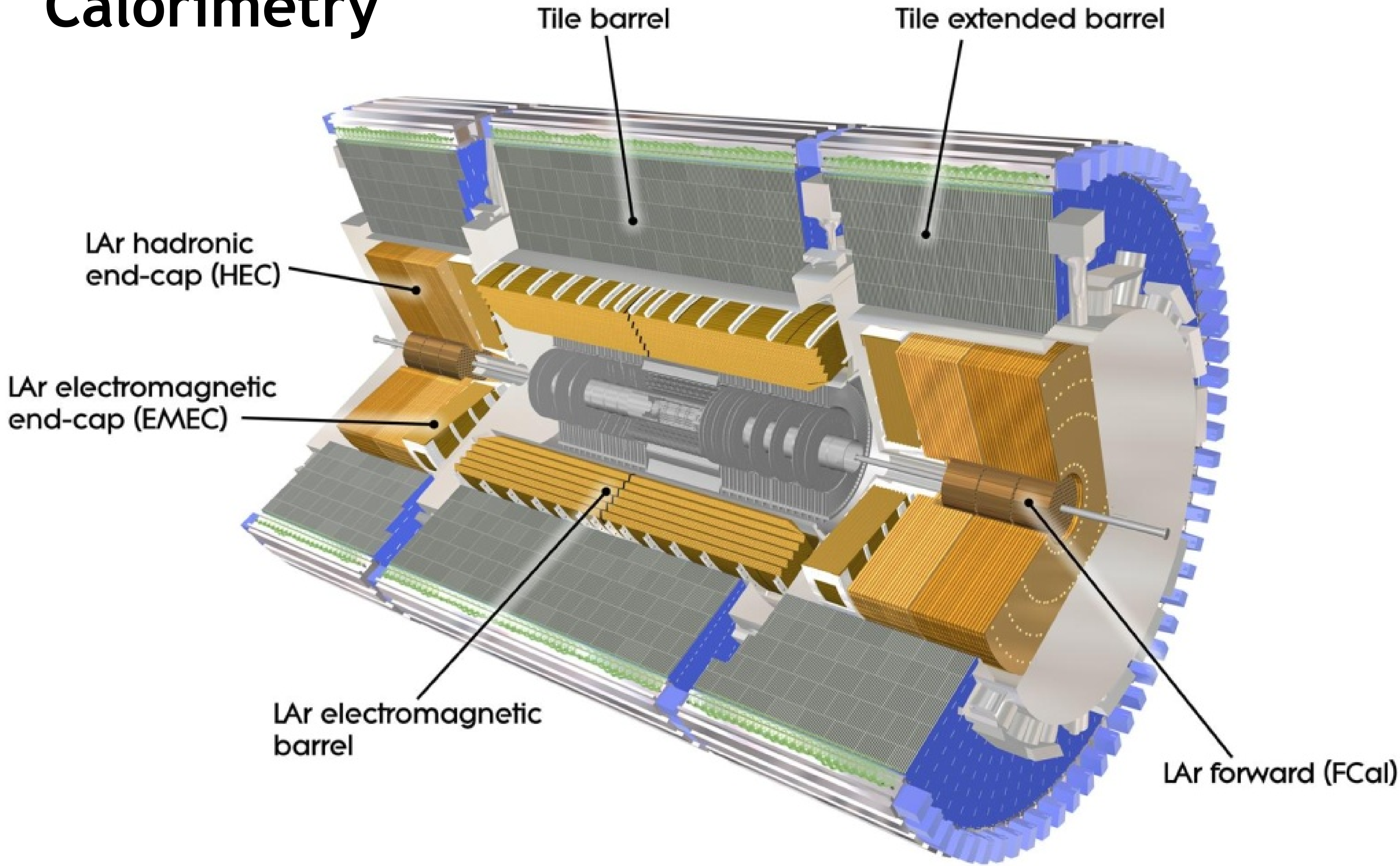
- Uses software version for first 2010 data-taking





Nine Tier-1s participating
Flexible re-allocation between Tier-1 sites possible

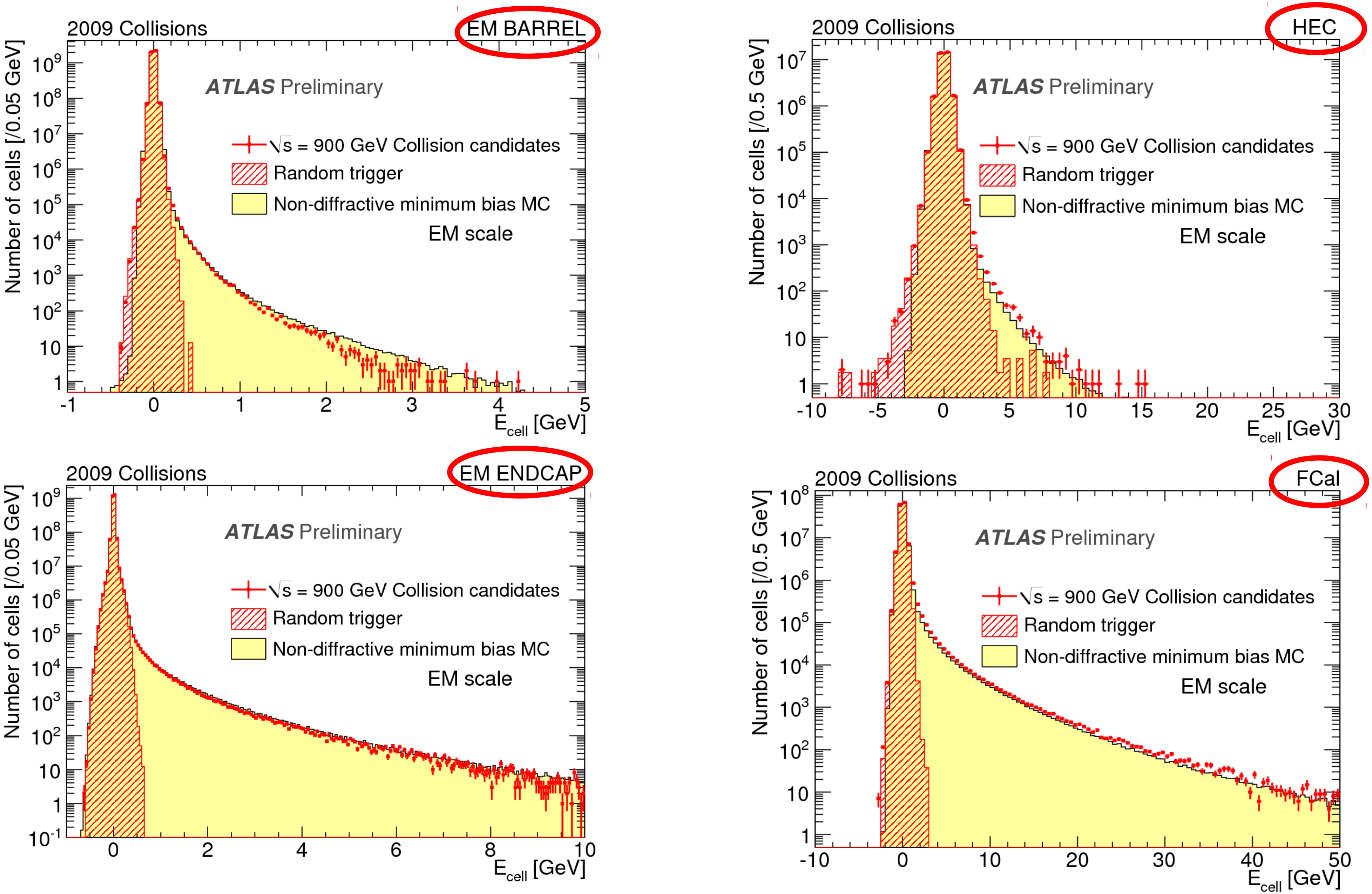
Calorimetry



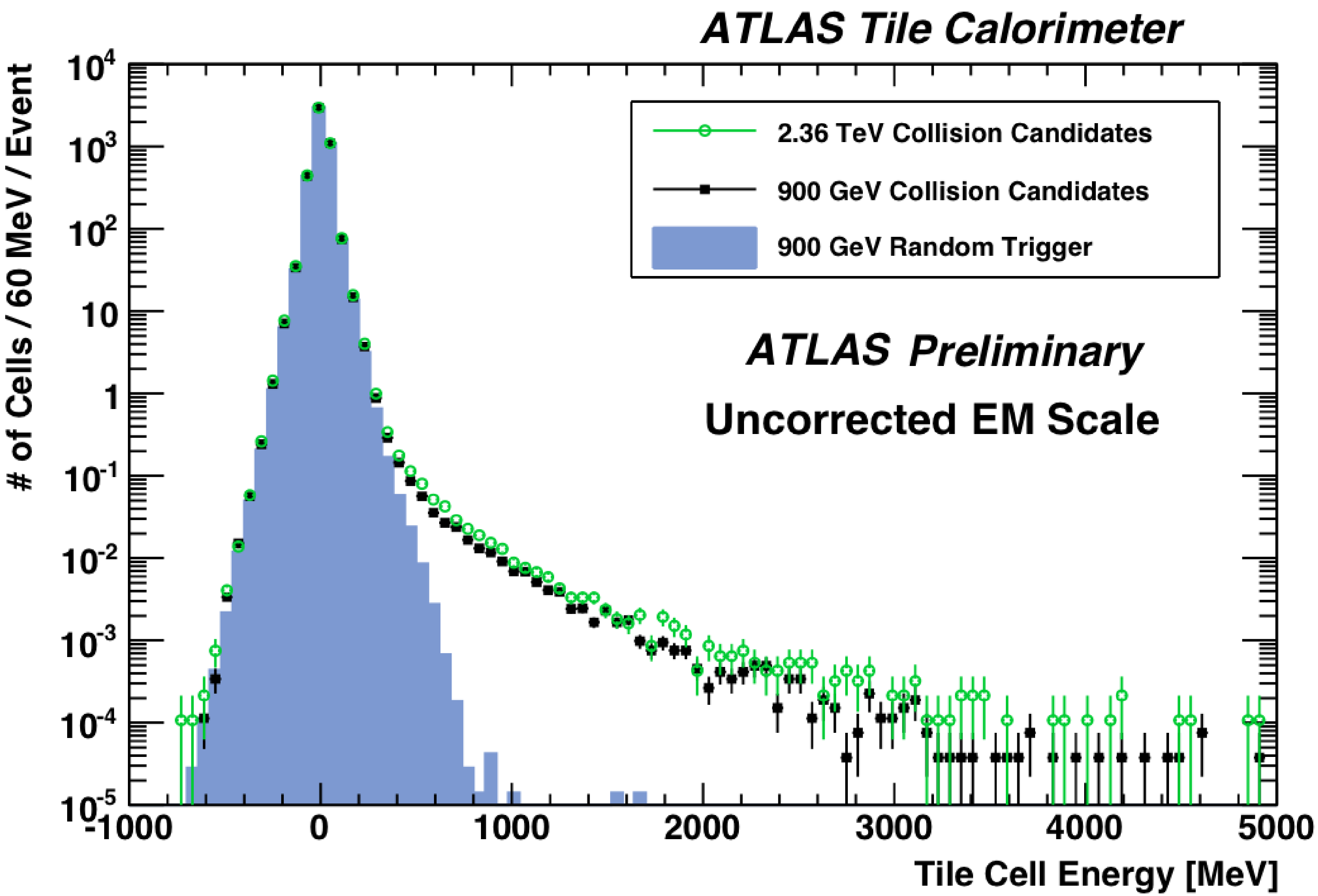
LAr Calorimeter

Raw cell energy distributions

- simulation quality is very good
- full angular range including FCal



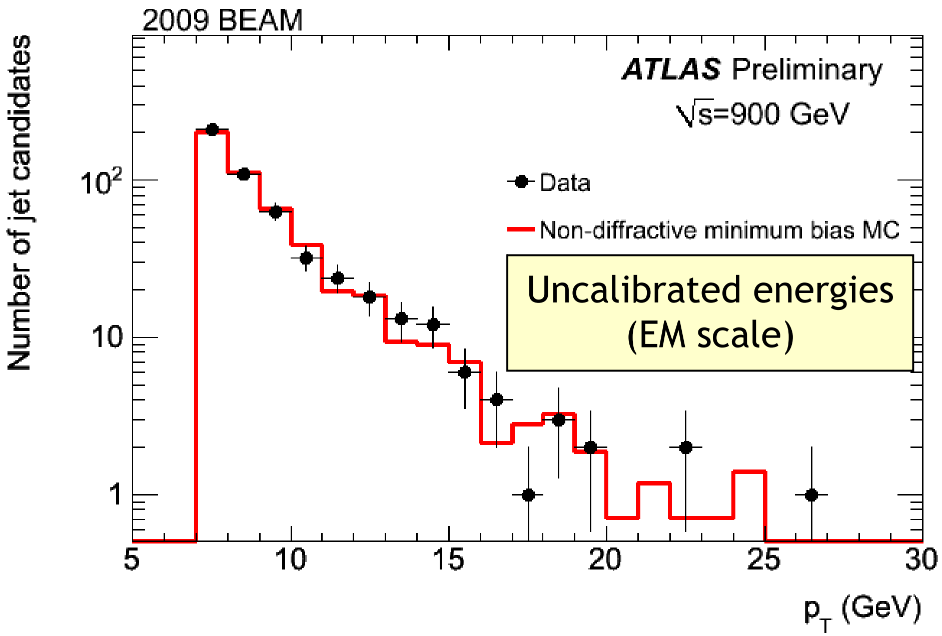
Tile Calorimeter

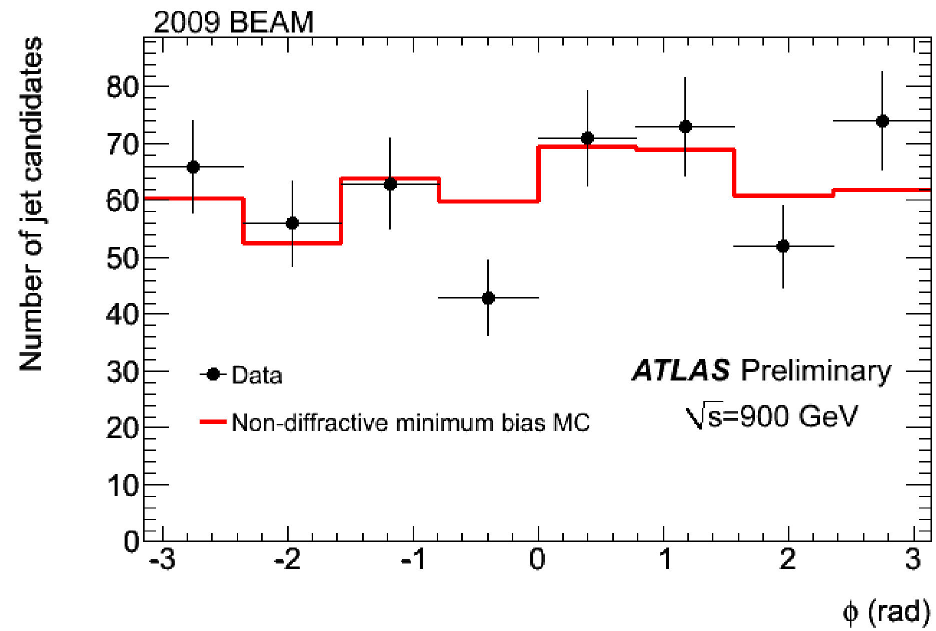


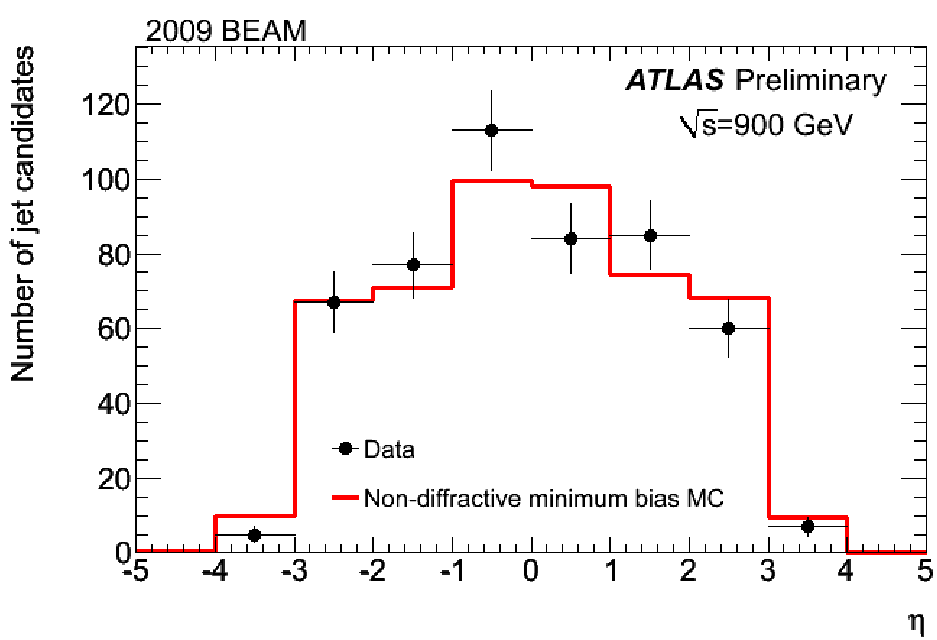
Raw cell energy distributions
Includes 2.36 TeV data

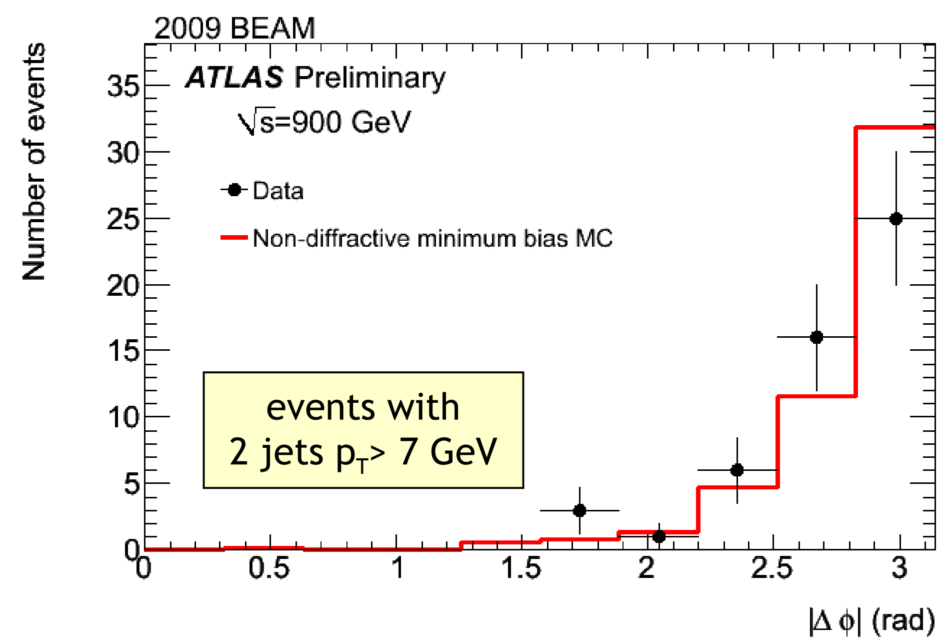
Jets

MBTS trigger (rather open)
Simulation normalised to data









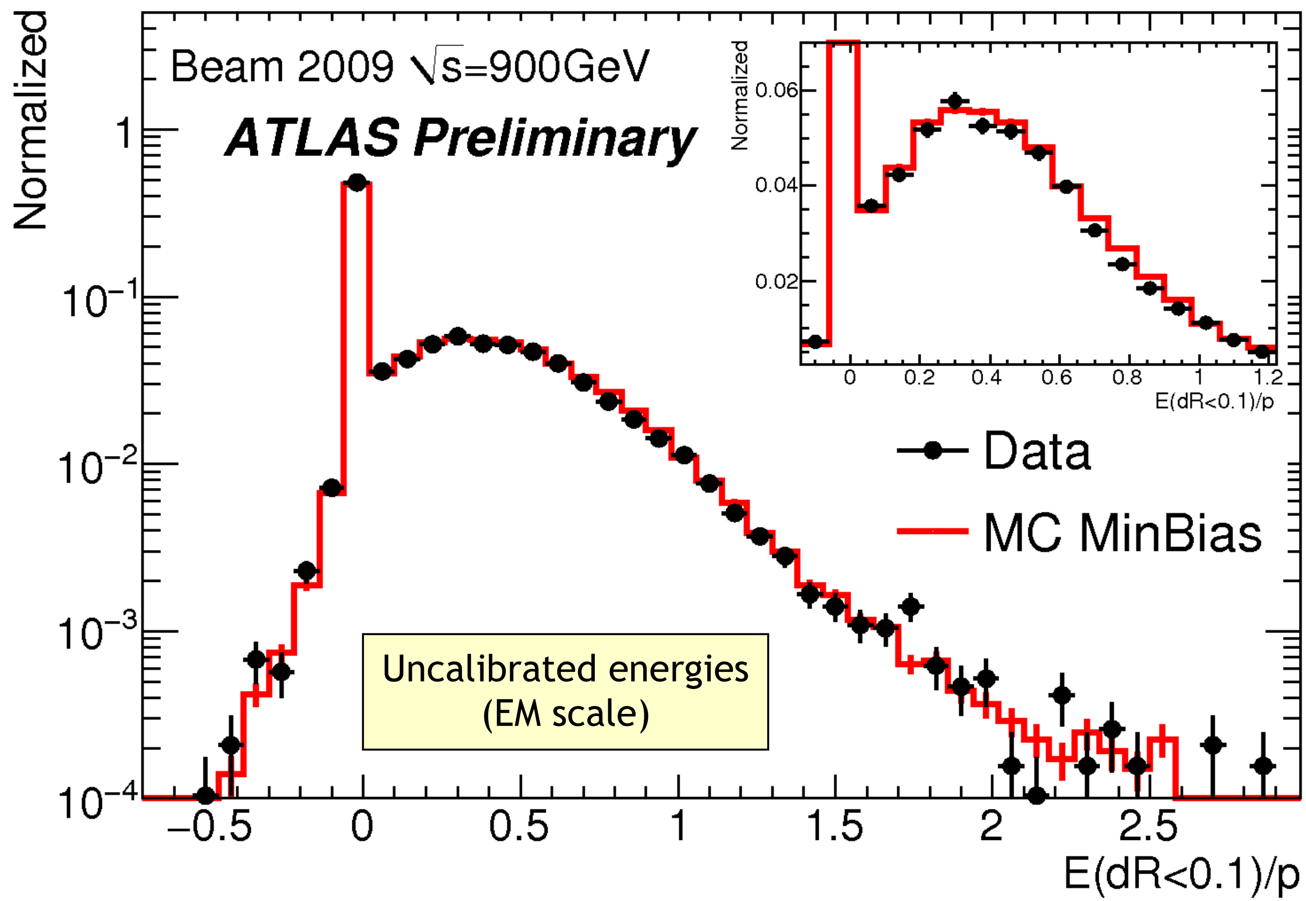
Calorimeter Response to Isolated Tracks

Sample of isolated hadrons

- $0.5<p_T<10$ GeV, $|\eta|<0.8$
- No track within $\Delta R=0.4$

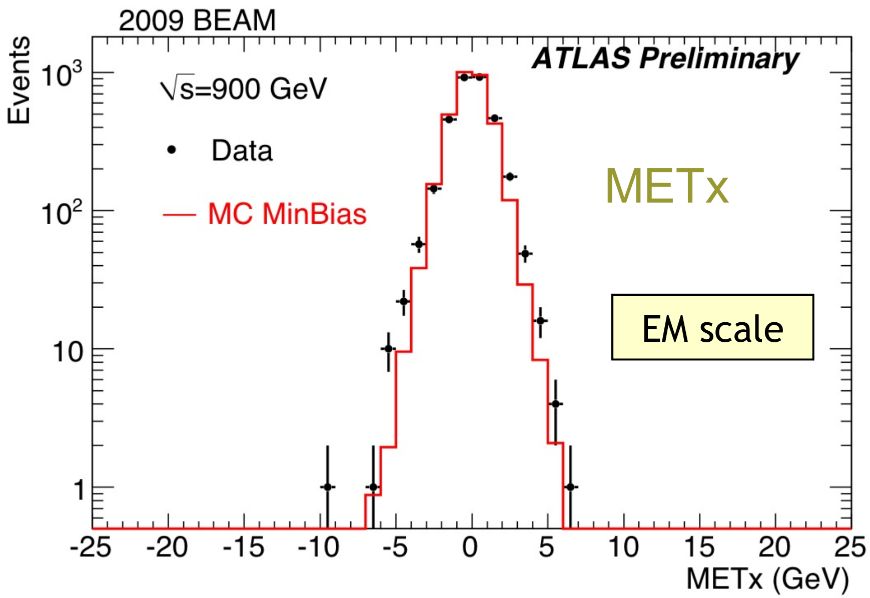
$E(\Delta R<0.1)/p$
a powerful tool to test simulation of calorimeter response to single hadrons

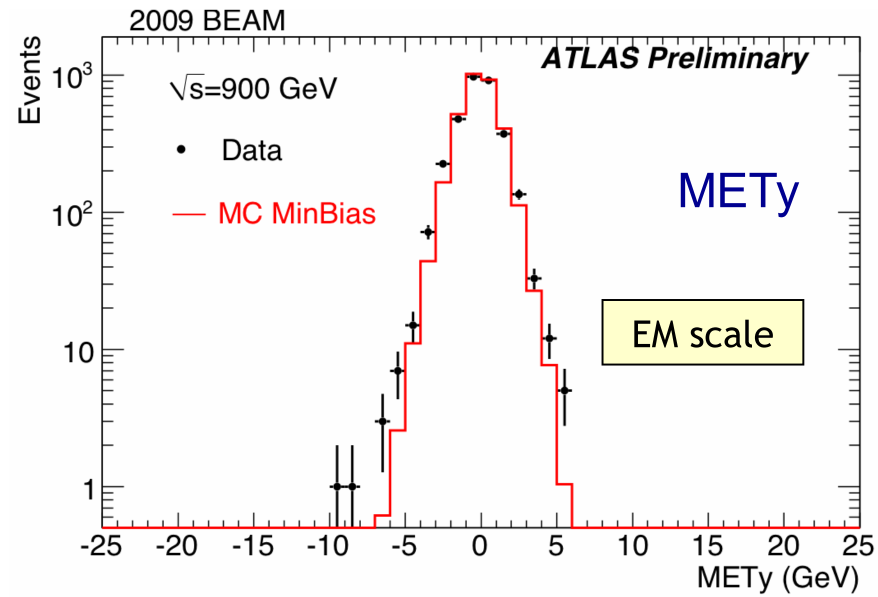
Remarkable quality of simulation: very promising for detailed understanding of jet energy calibration



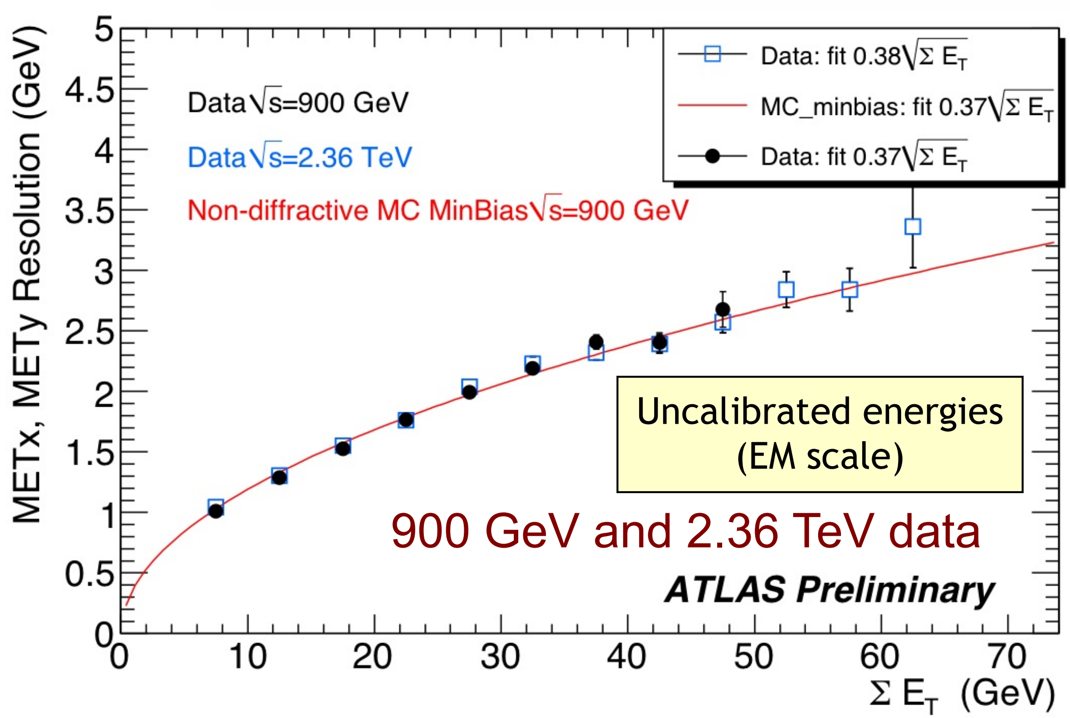
A pay-off from the many years of test-beam studies and detailed comparisons to G4 simulation (models, material, etc)

Missing-E_T





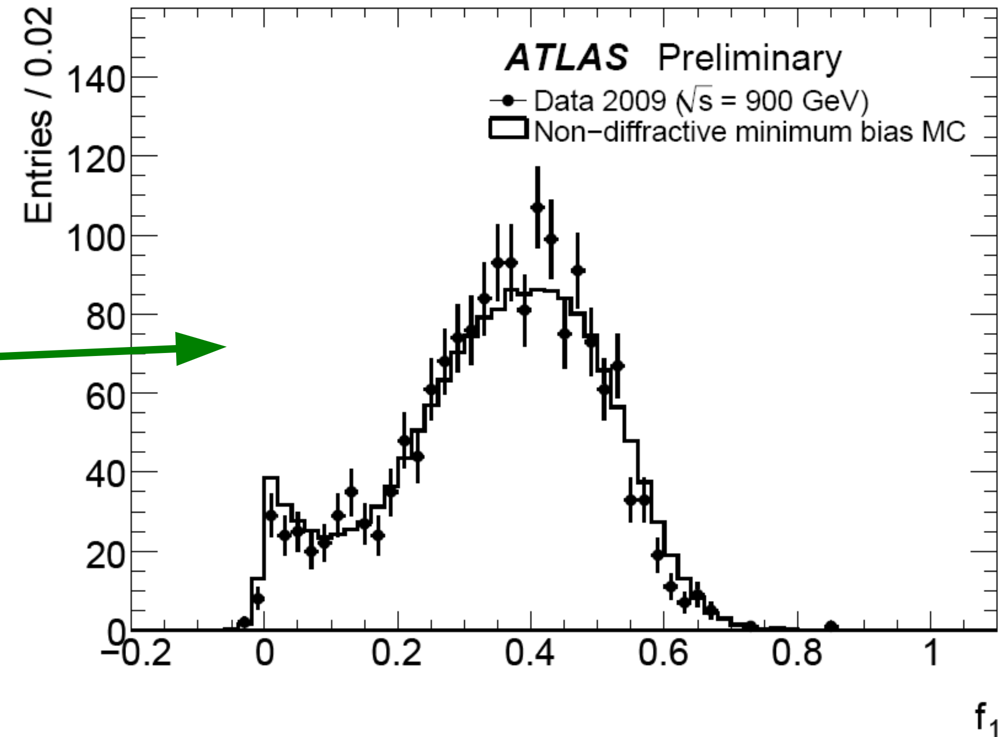
Resolution of the two components vs. total E_T sum

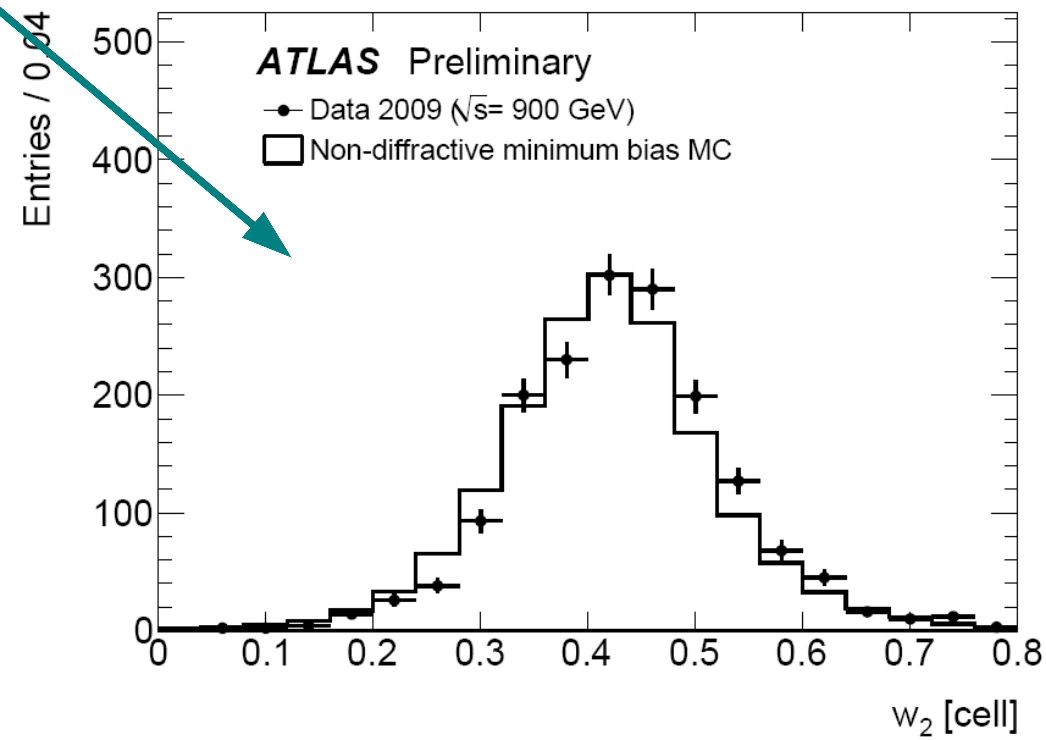


Calorimeter shower shape variables

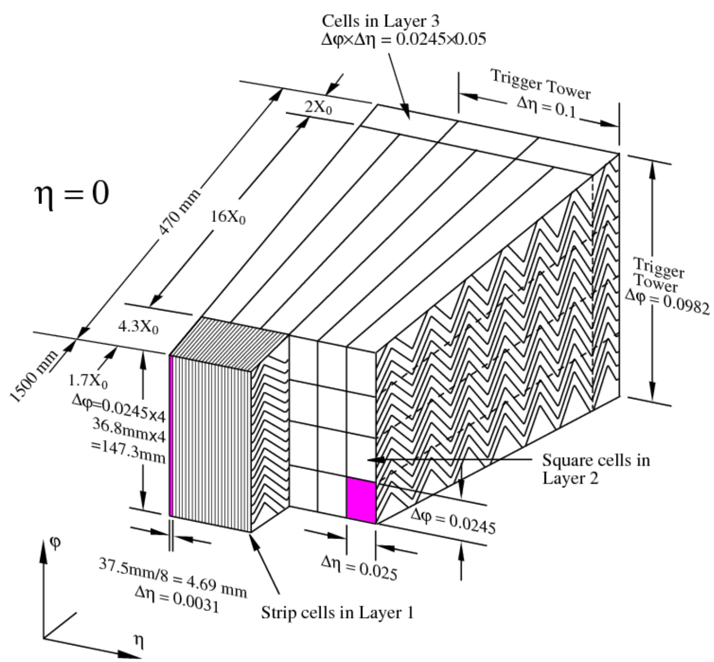
Photon candidates with p_T>2.5 GeV

- Fraction of energy in first layer, f_1 (longitudinal shower development)
- Lateral shower width in middle EM layer, w_2
- Average η profile in front-layer strips
- Shower width computed over three cells in first layer w_{s3}





Good description of the data both in depth and transverse profiles



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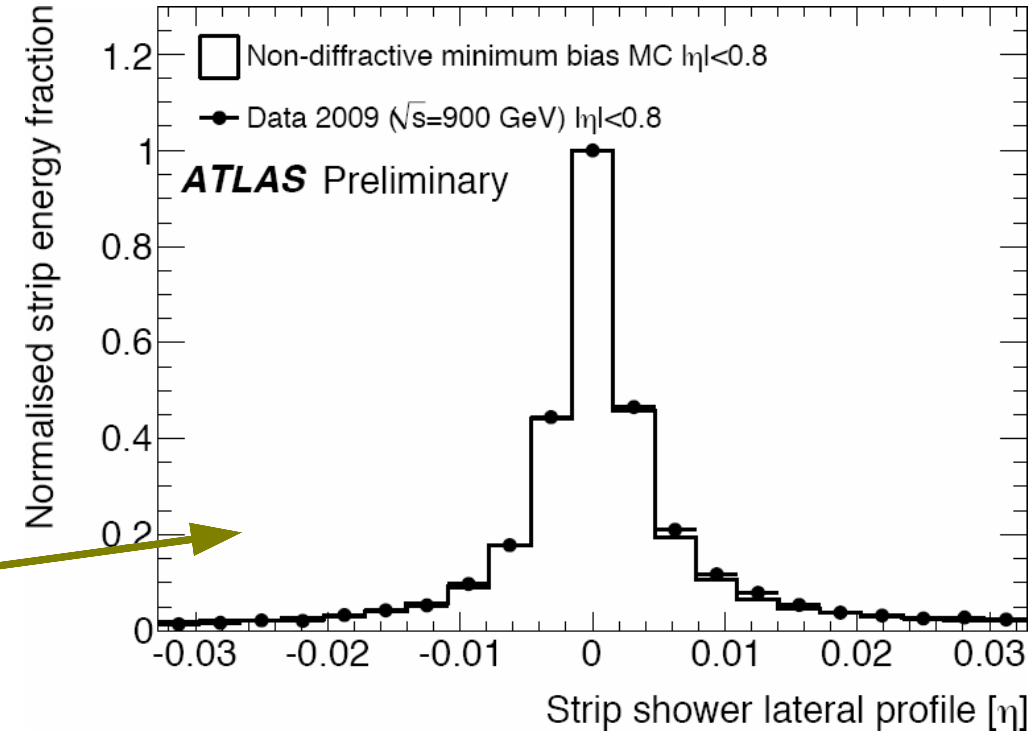
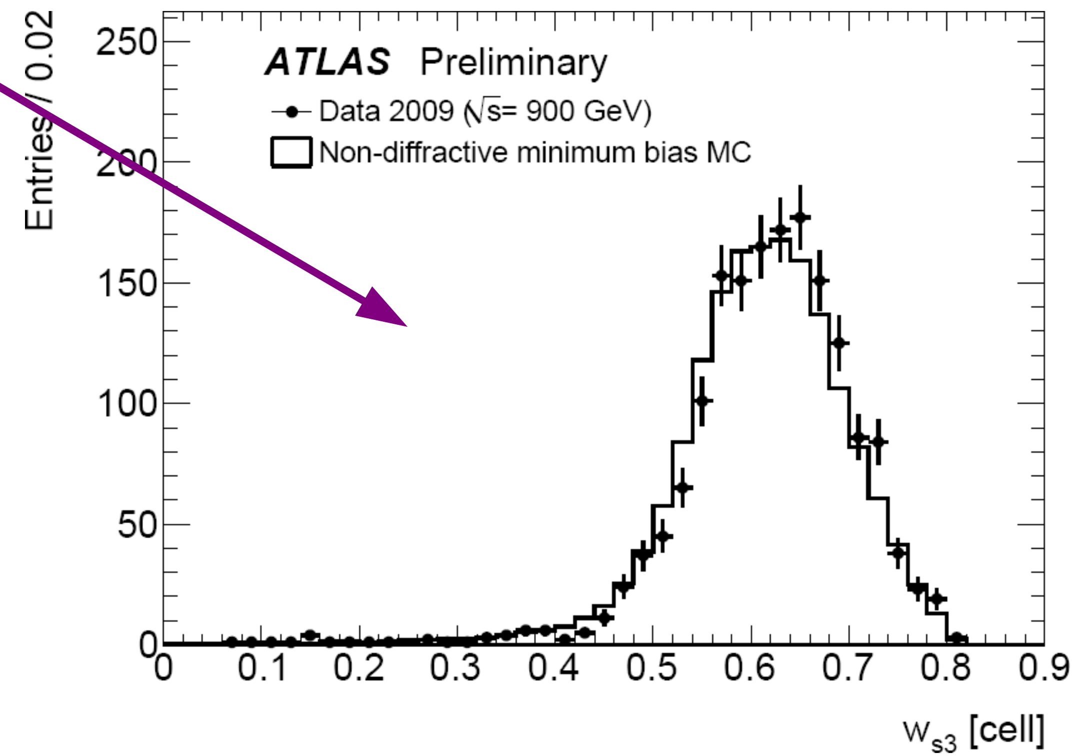
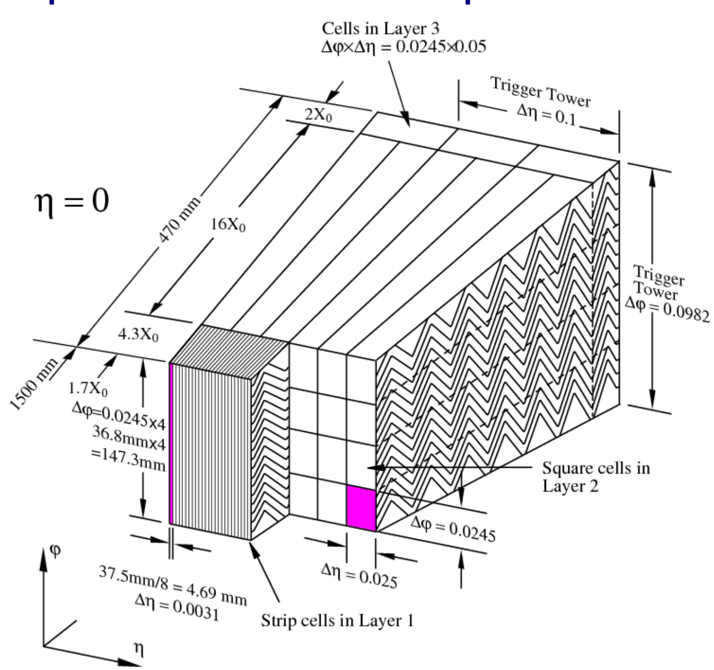


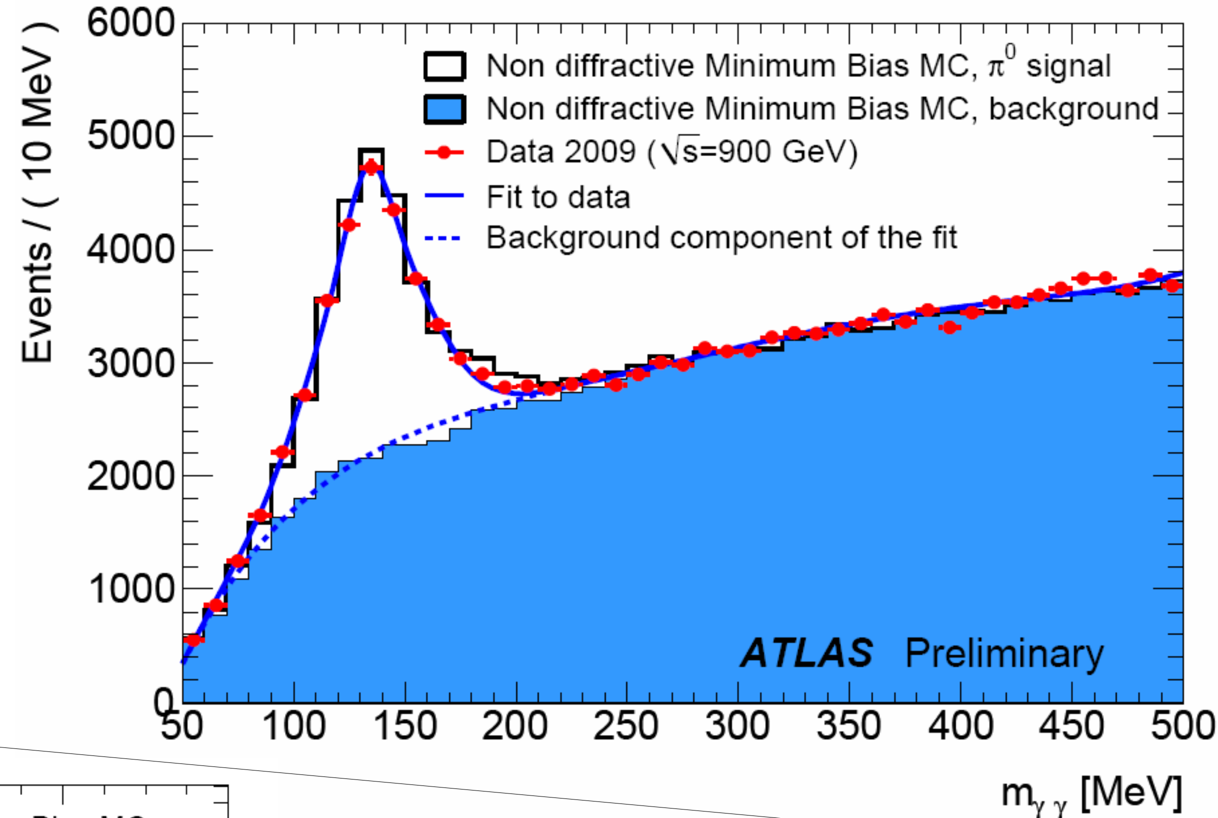


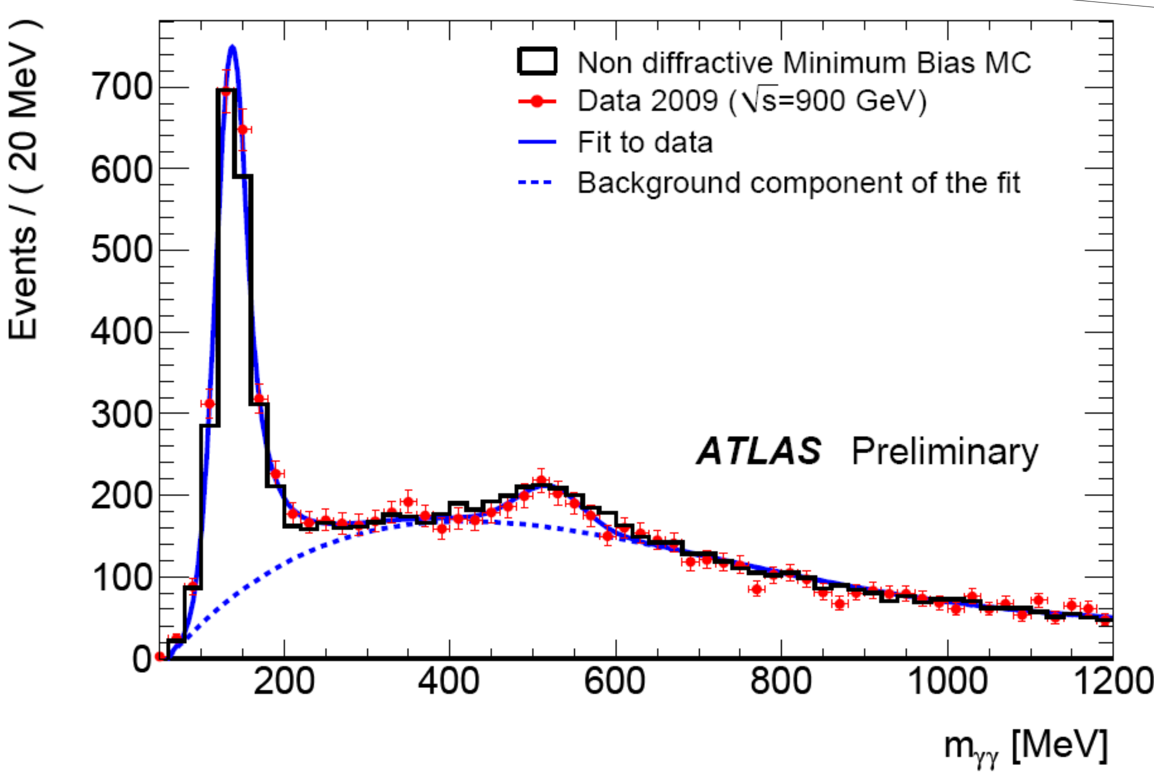


Diphoton Mass Distributions

Two photon candidates

- $p_T(\gamma)>0.4$ GeV, $p_T(\gamma\gamma)>0.9$ GeV
- Calibrated cluster energies





Tighter kinematic cuts, including:

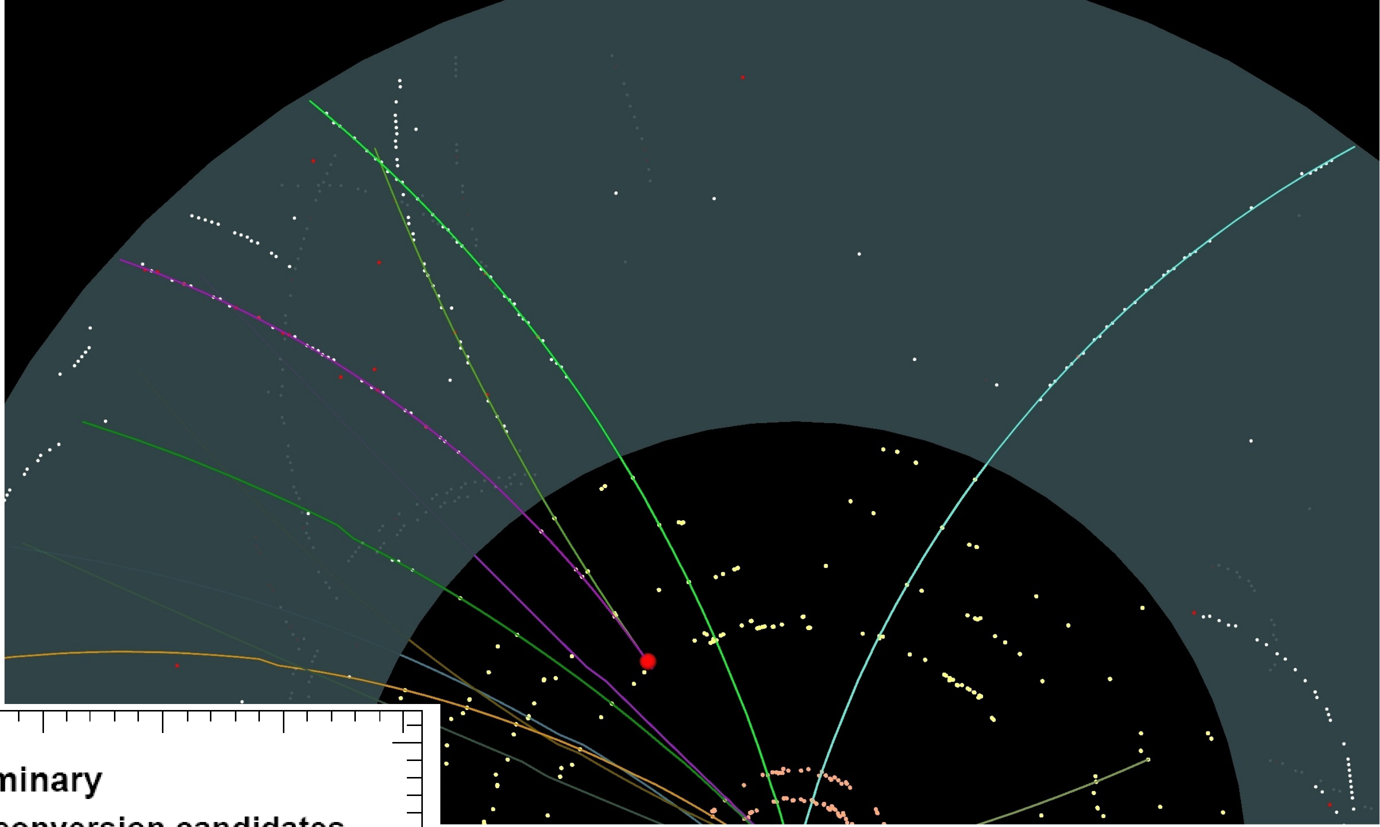
- $p_T(\gamma)>0.6$ GeV, $p_T(\gamma\gamma)>1.5$ GeV

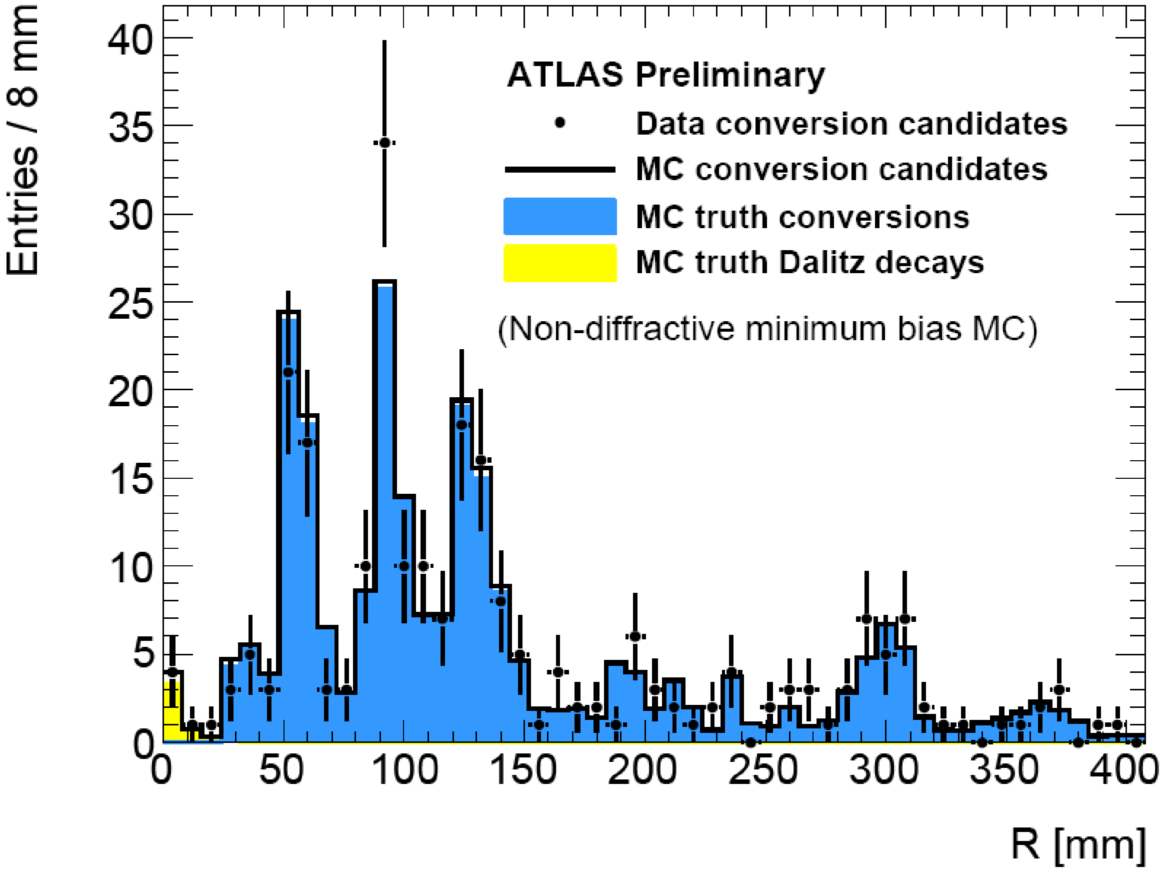
Remove clusters with matched tracks

Widths and positions well described by simulation

Conversions

Reconstruct here using tracks with hits in silicon detectors





Reconstructed conversion radius

- clean conversion sample
- Dalitz decays separable
- pay-off for detailed assay of ID material

Conversions

Reco
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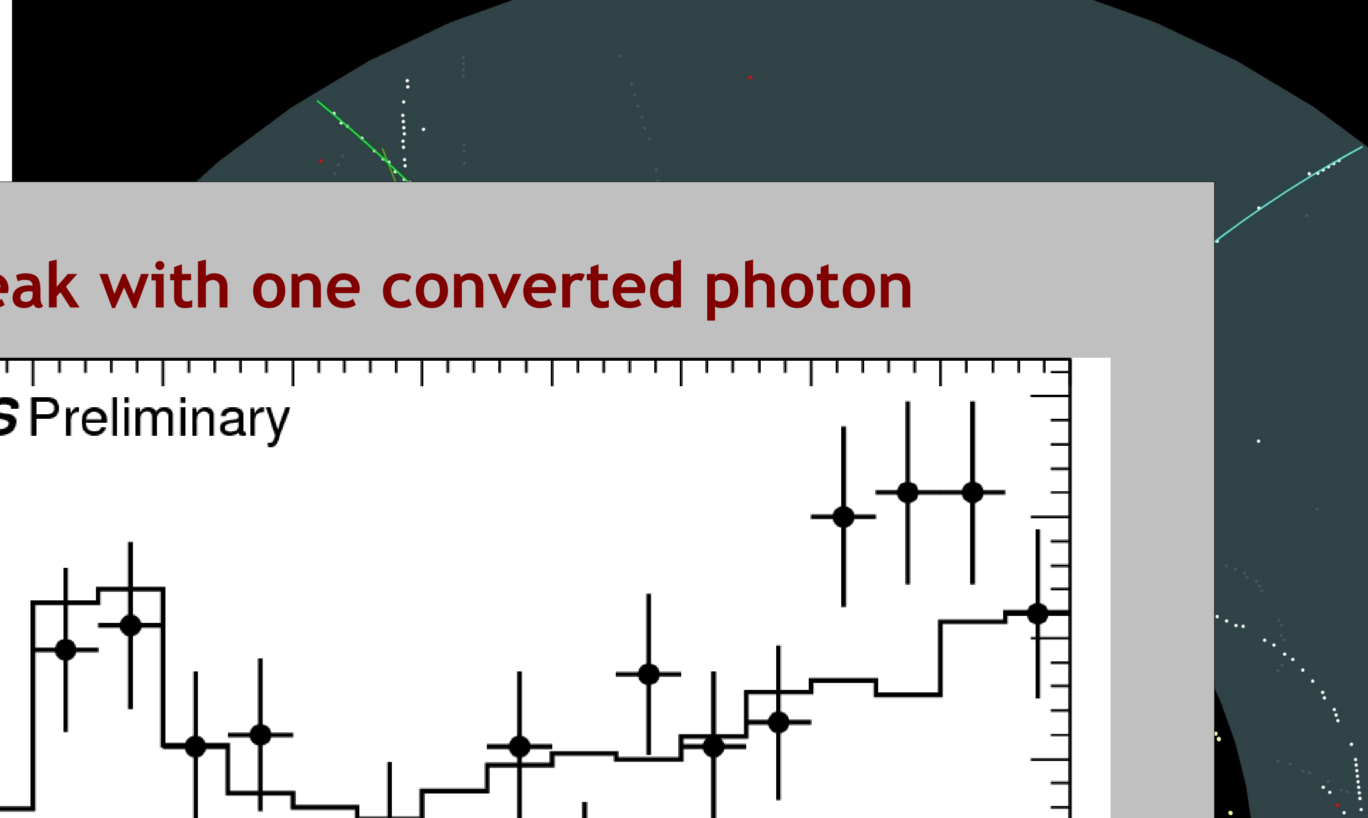
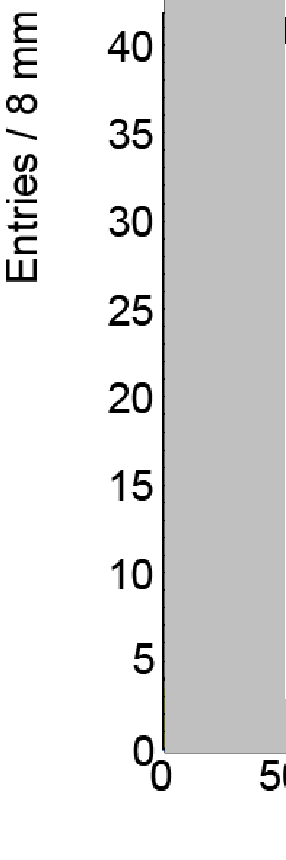
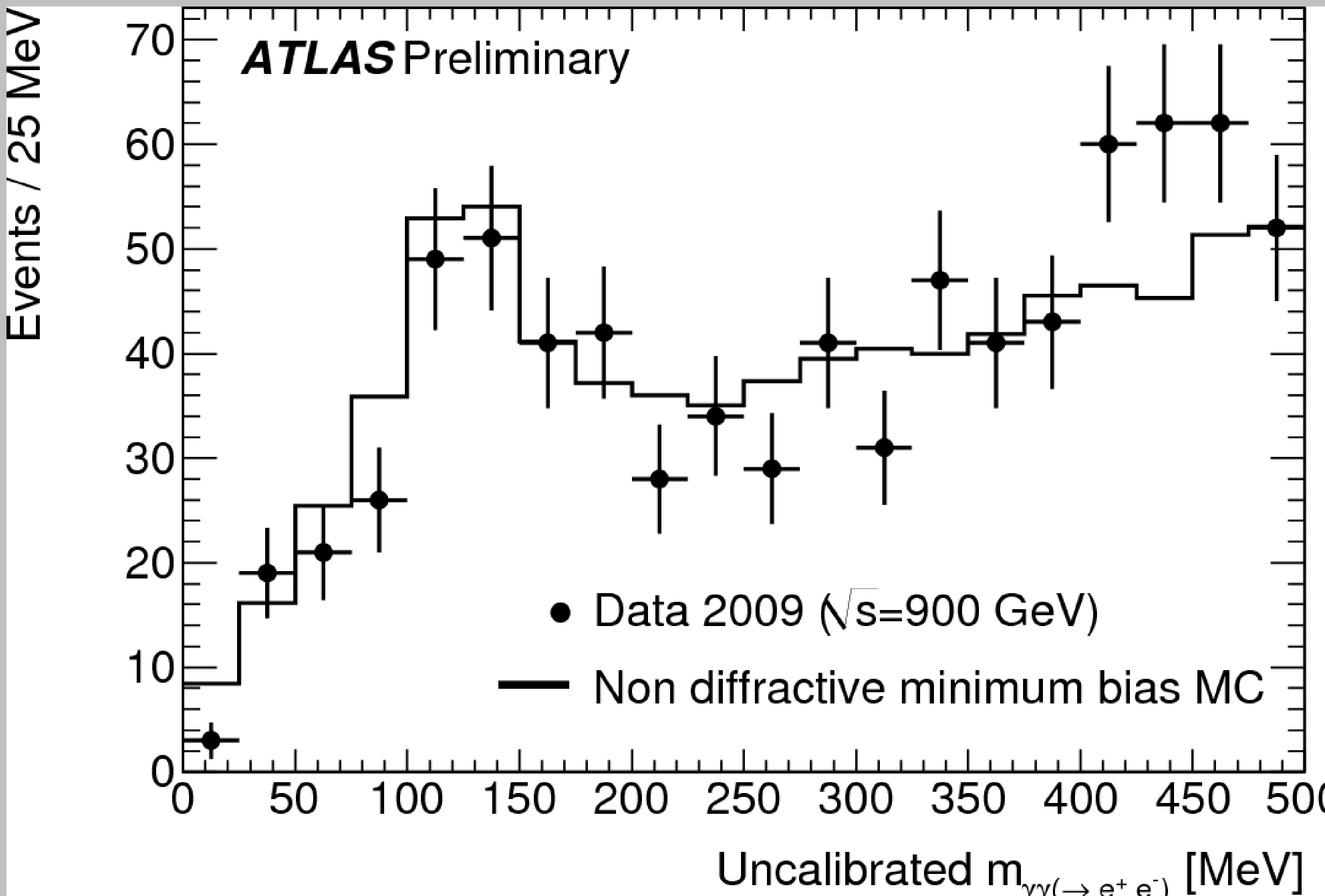
dete





π^0 mass peak with one converted photon

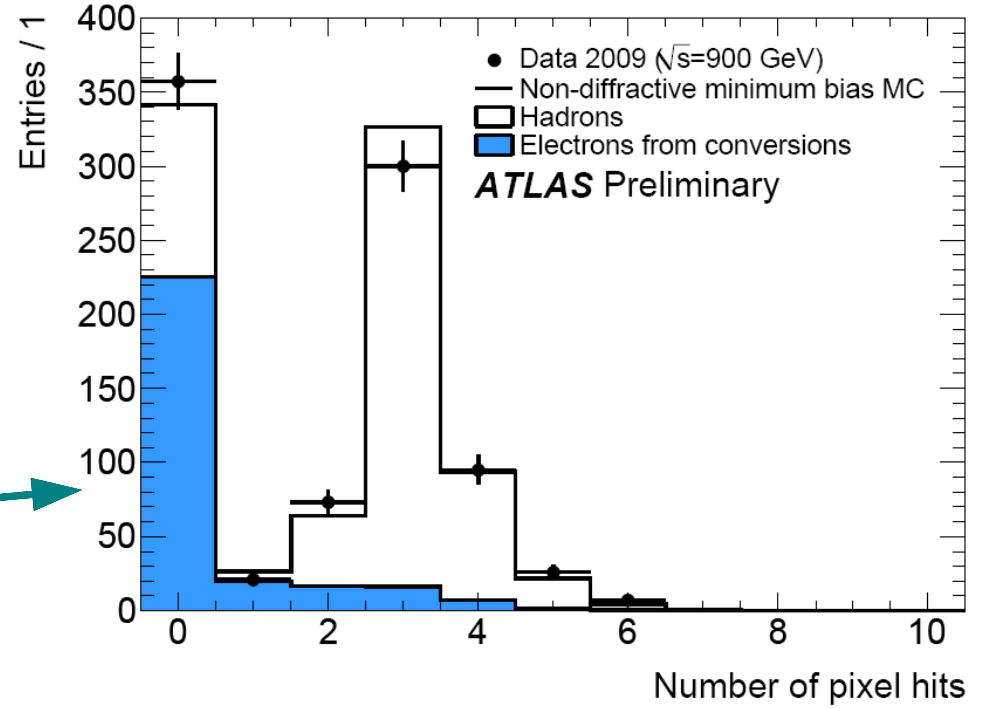


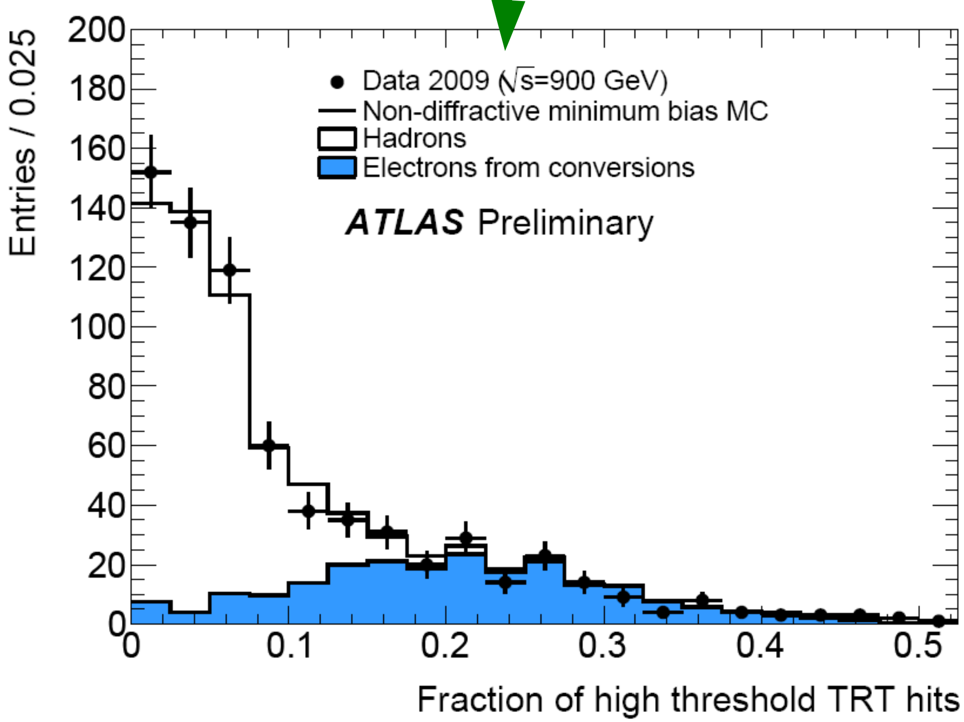
Electron Identification

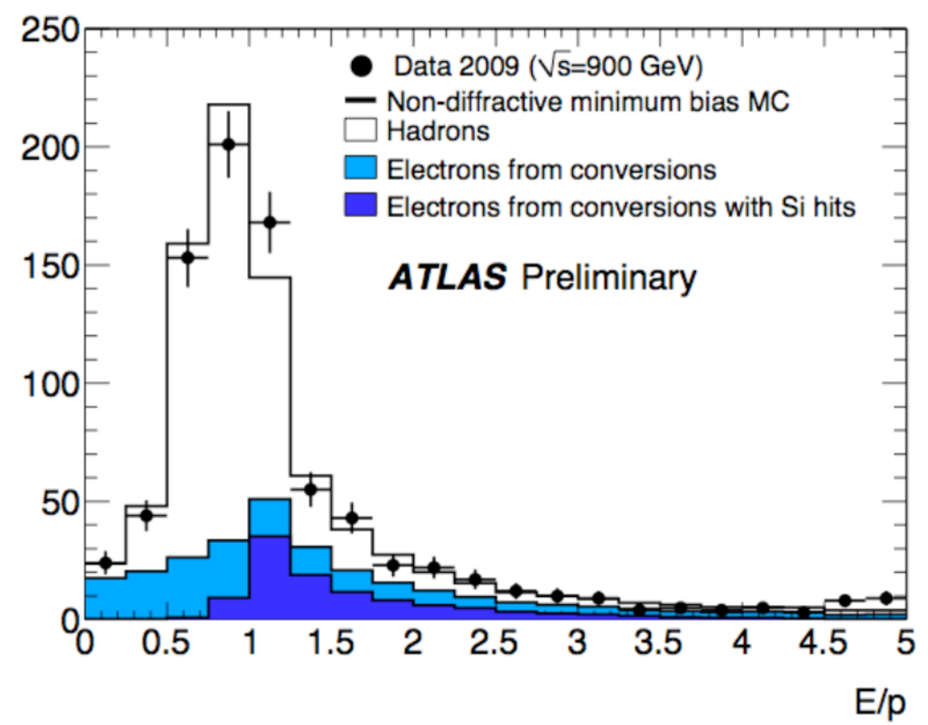
Electron candidates reconstructed from EM clusters with a matched track p_T>0.5 GeV

Track-based distributions well described by sum of hadron and conversion-electrons:

- few pixel hits on tracks
- Strong discrimination even at these low-p_T for transition radiation hits







Electron Identification

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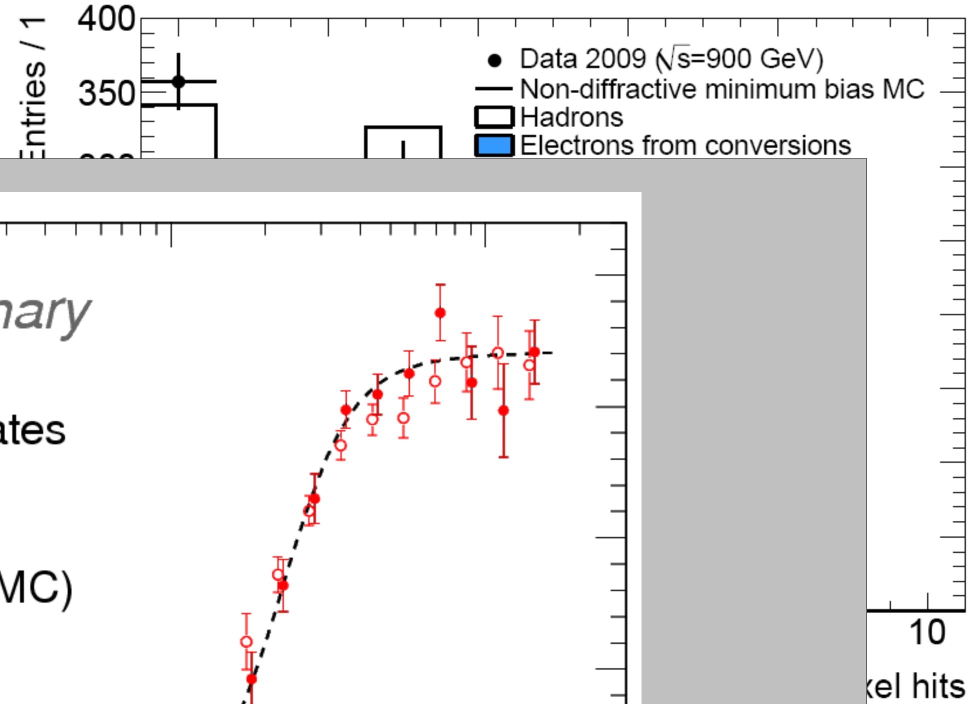
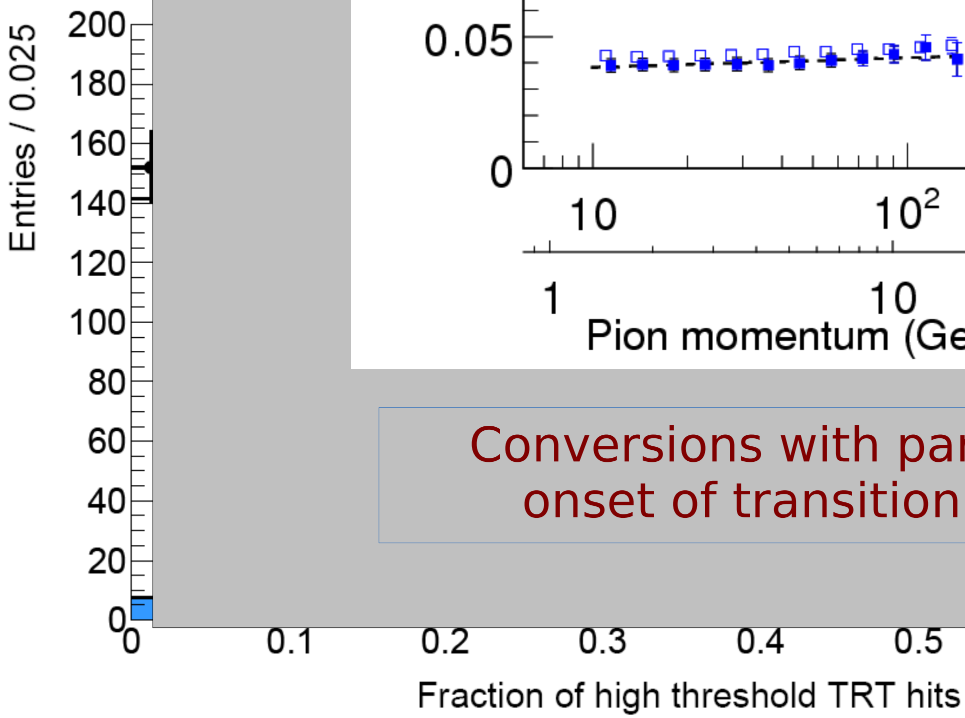
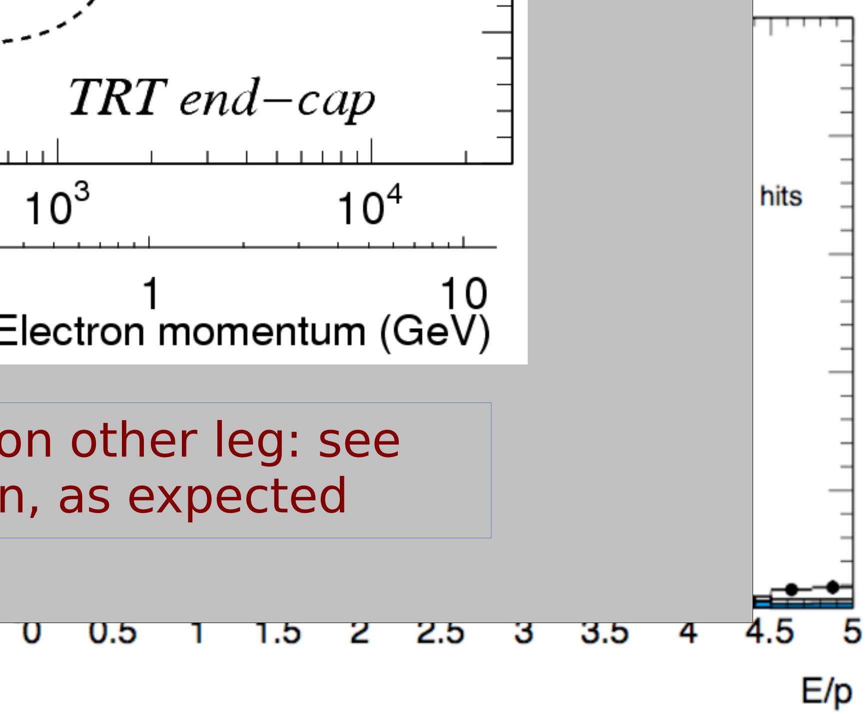
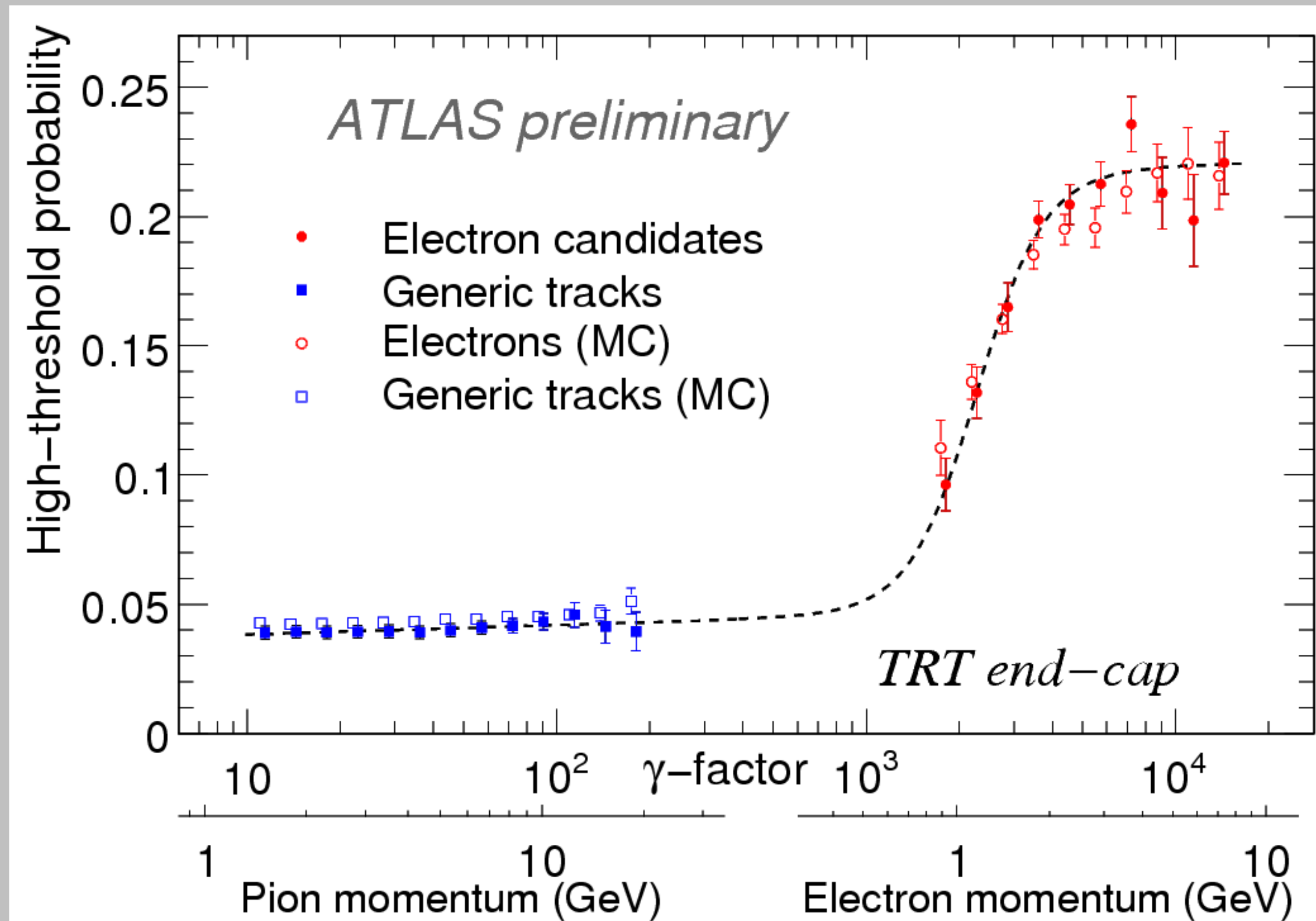








Conversions with particle ID on other leg: see onset of transition radiation, as expected

Electron Identification

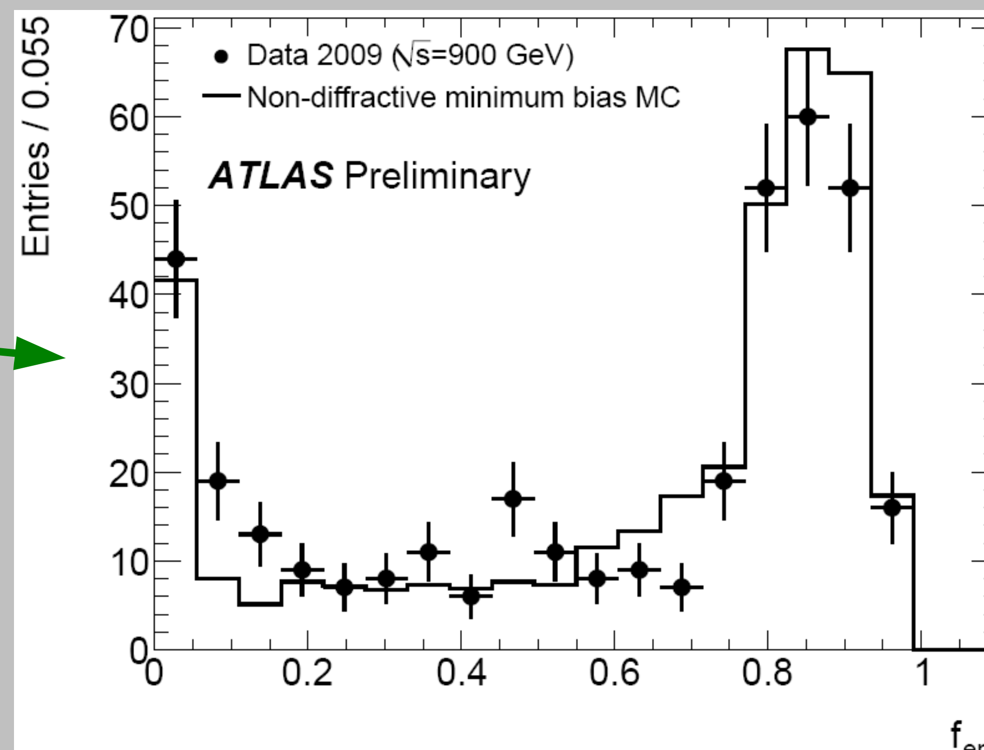
Looking to the future: starting to test forward electron selection

Beyond tracking acceptance:
$2.5 < |\eta| < 4.9$
(EMEC, HEC, FCal)

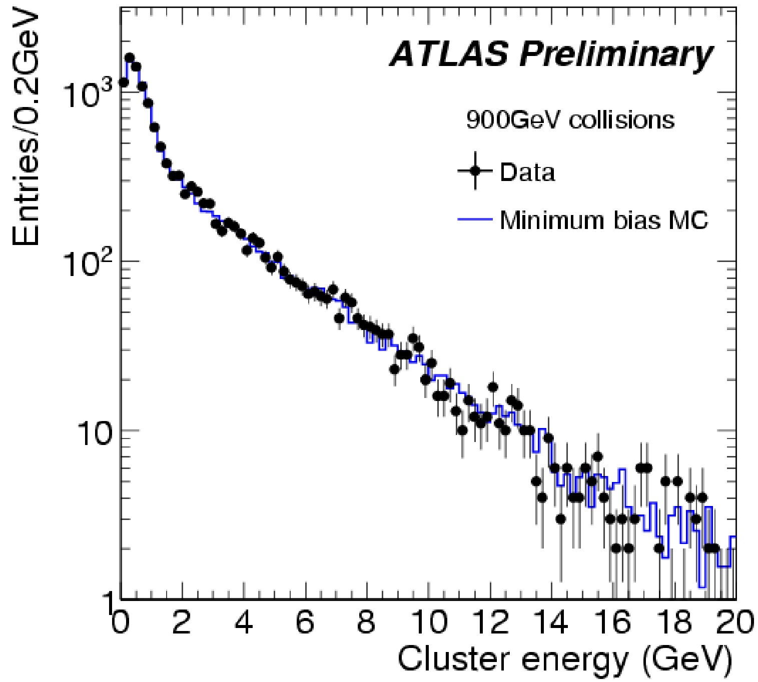
Fraction of energy, f_{em}, deposited in EM layers

Mainly photons at high f_{em}

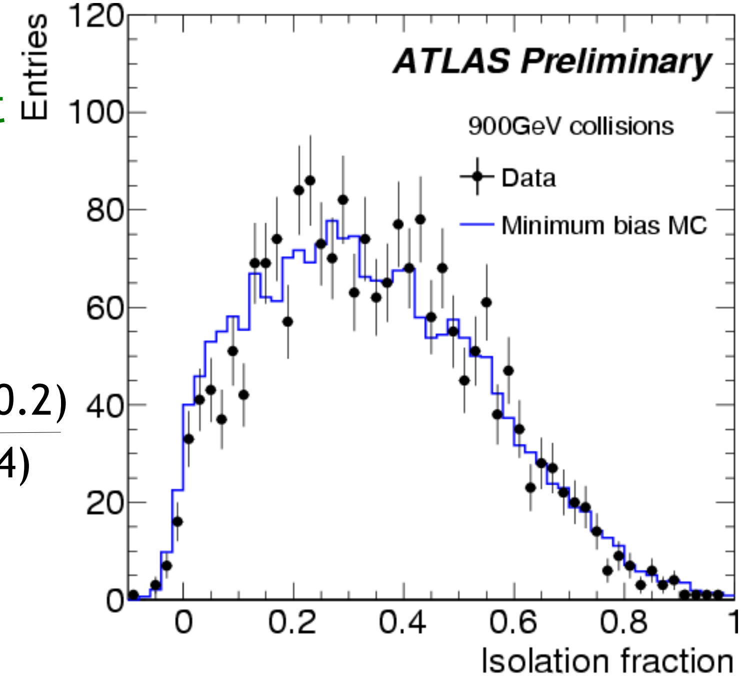
Towards an extended acceptance for $Z \rightarrow ee$ and $H \rightarrow eeee$…



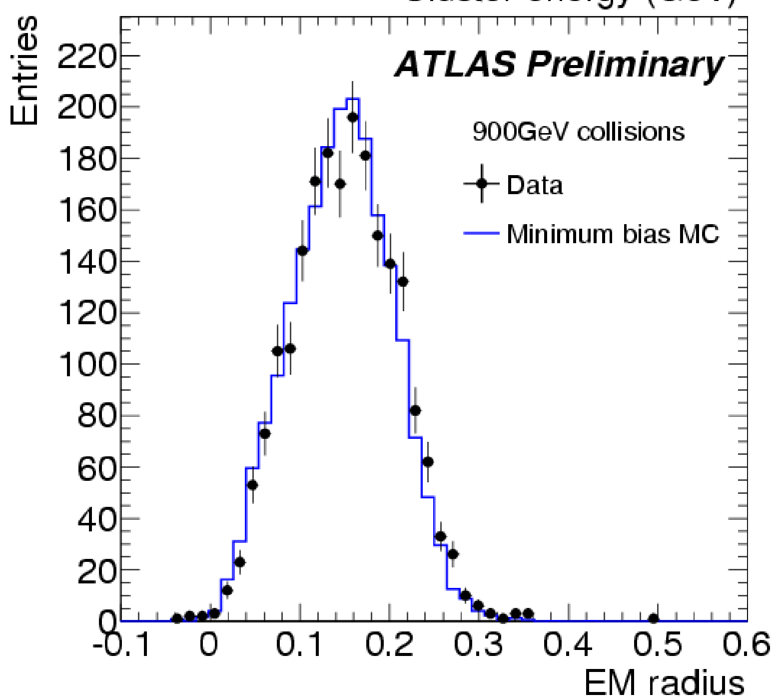
Towards Tau Identification



Pure background sample useful to test modelling of τ ID variables at low p_T

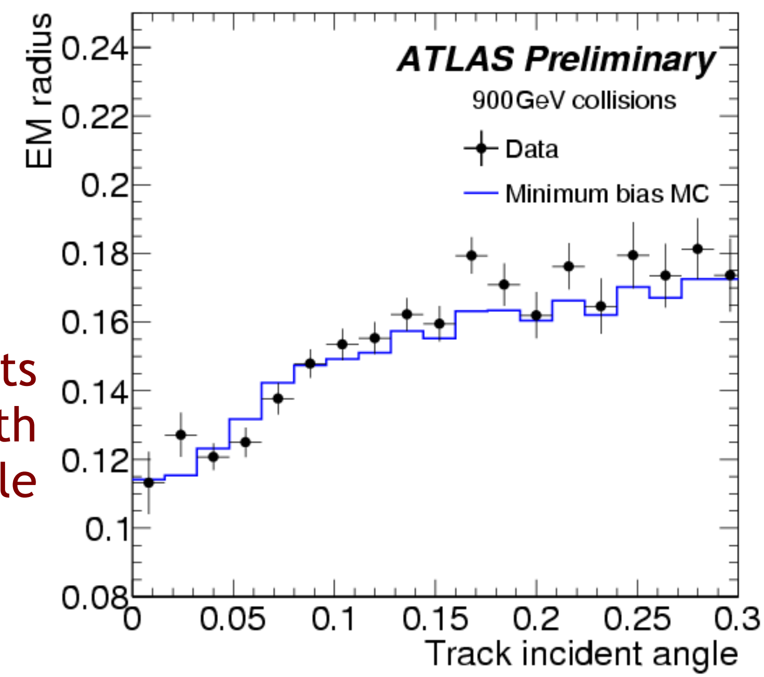


$$\frac{E_T^{core}\ (0.1<\Delta R<0.2)}{E_T^{core}\ (\Delta R<0.4)}$$

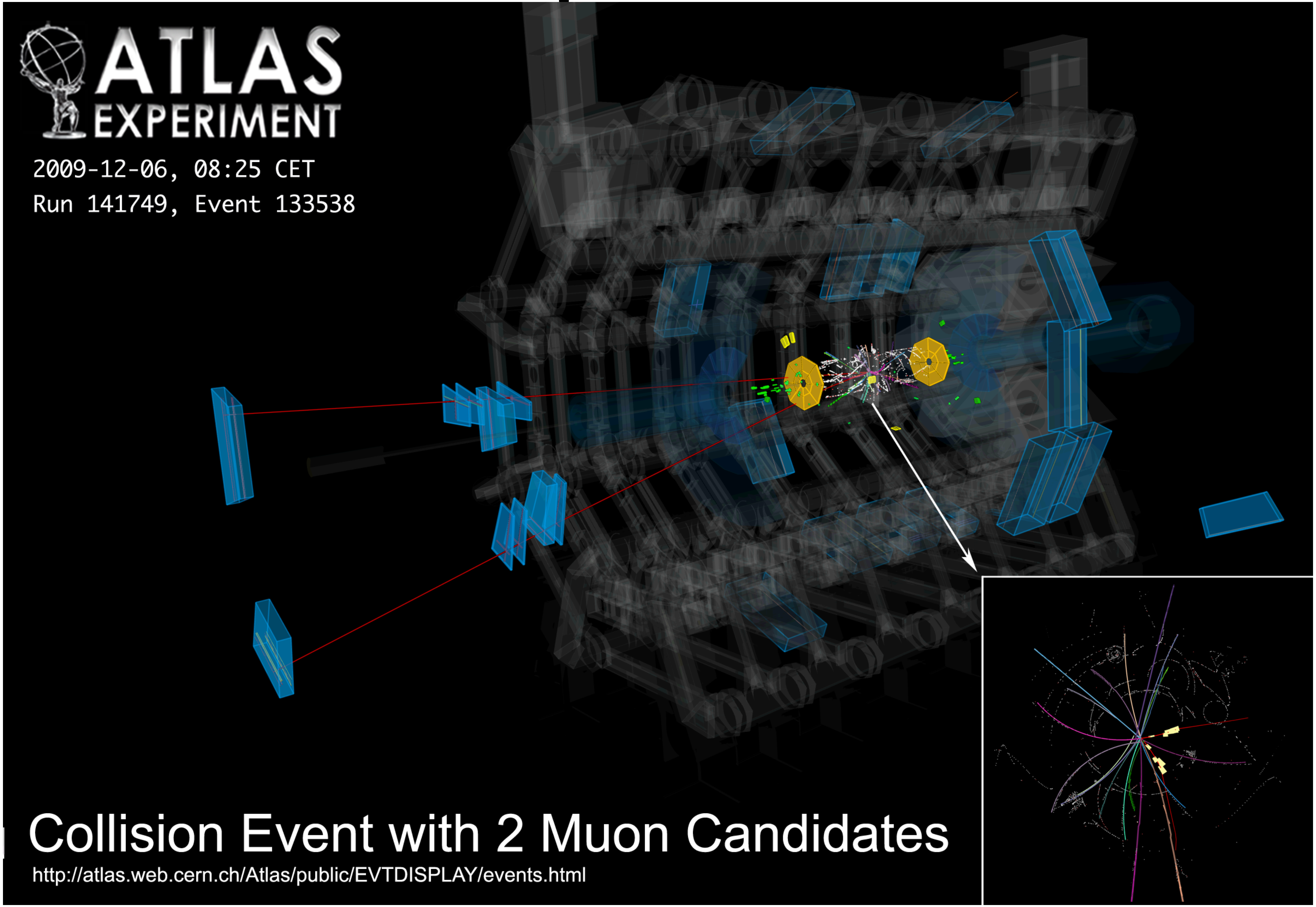


EM shower lateral radius

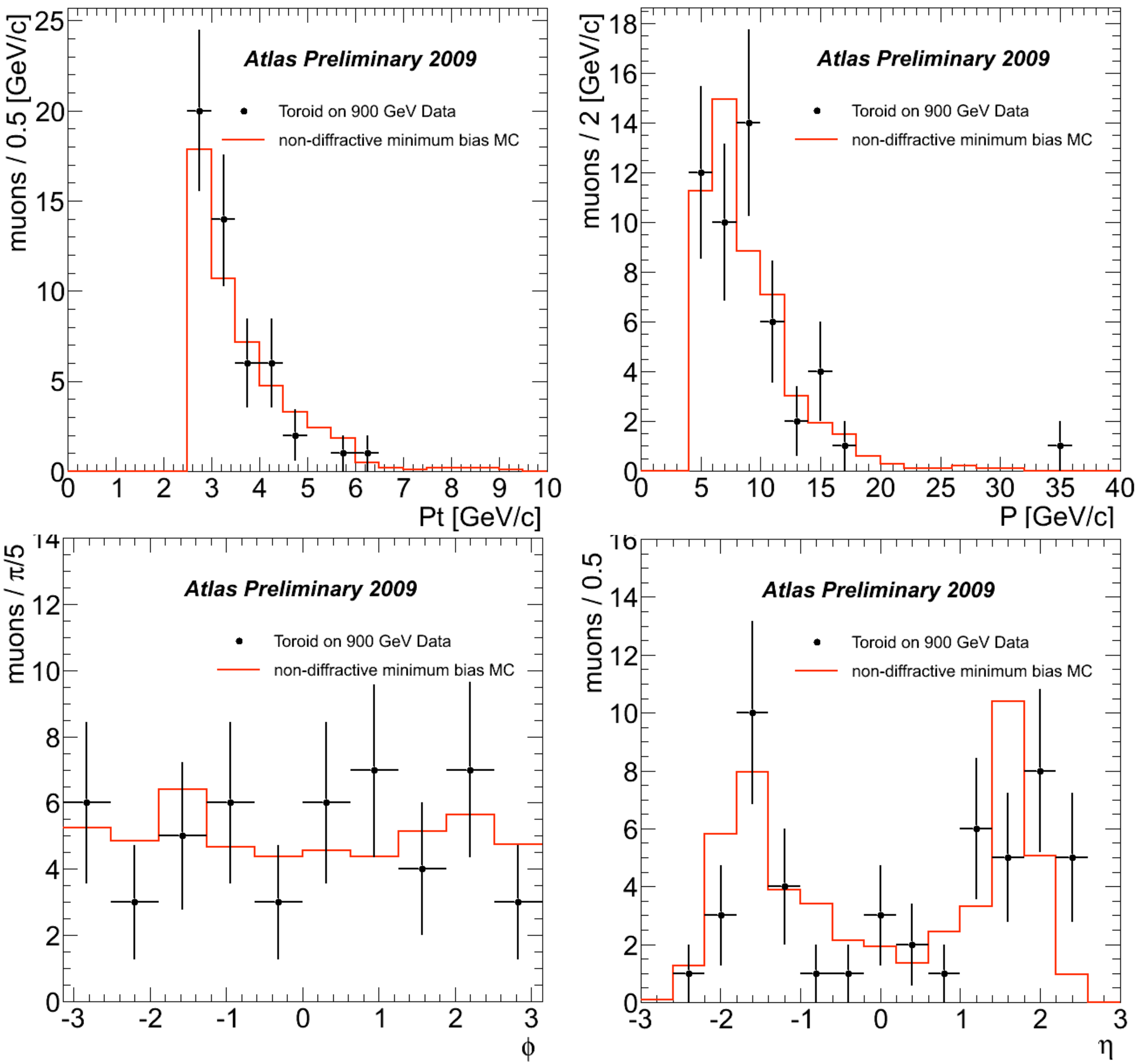
and evolution of its mean value with track incident angle



Muon Spectrometer



Muon candidates – data / MC comparisons

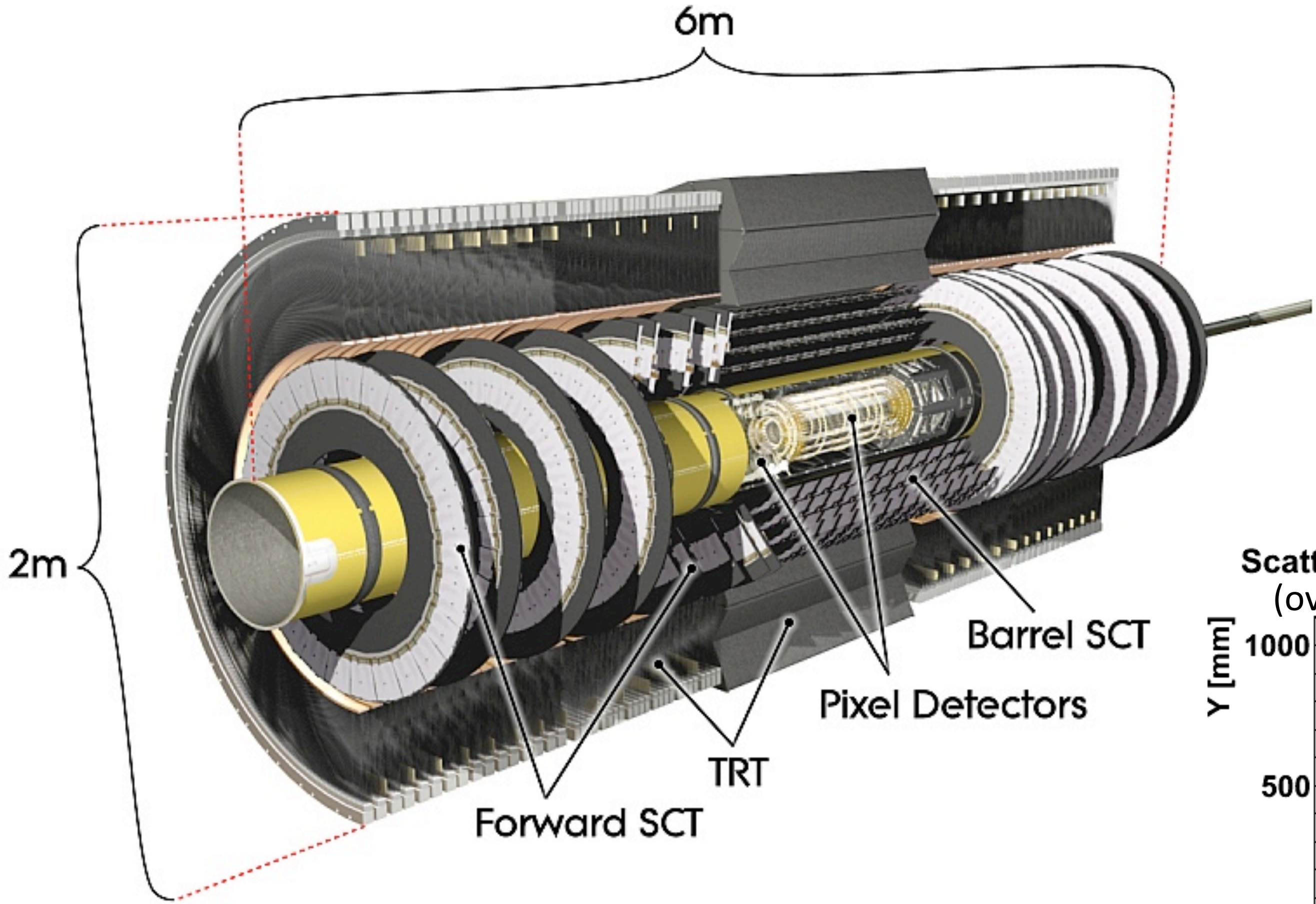


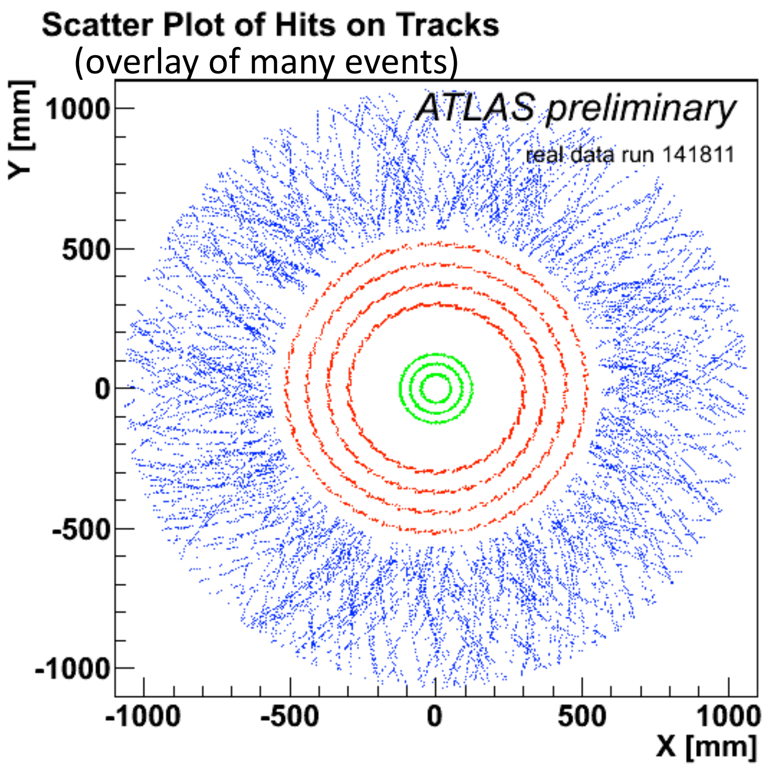
Muon candidates very forward and low momentum at 900GeV – threshold P_T >2.5 GeV.

Comparison of combined muon candidates (requiring tracking and muon spectrometer hits) between data and MC.

Nice agreement within the limited statistics (50 muon candidates).

The Inner Detector

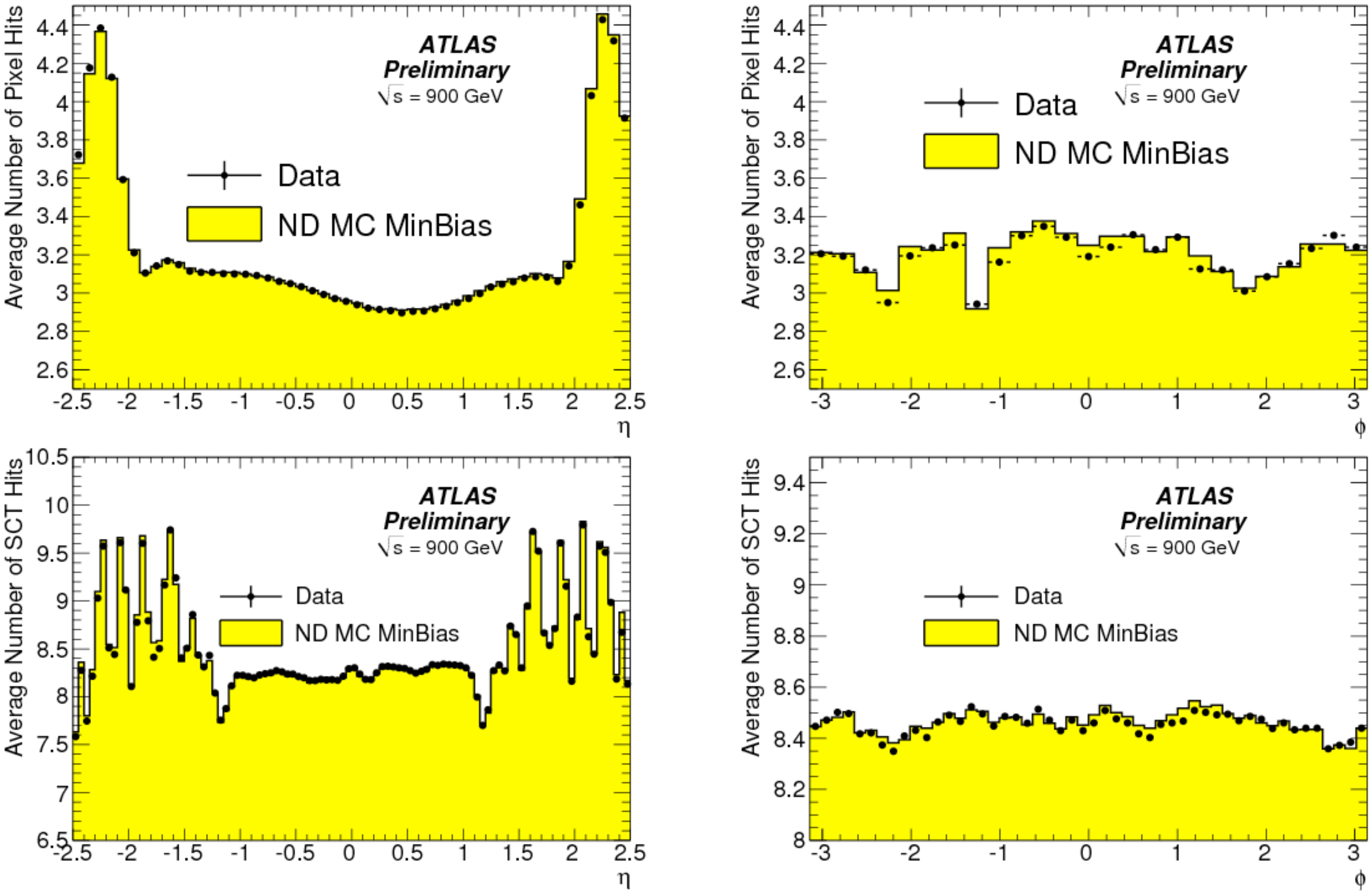




The 900 GeV data provides lots of low P_T tracks originating from the centre of the detector to commission the Inner Detector.

Tracking - data / MC comparisons

Excellent description of the data by the MC



Number of pixel hits on track versus η / ϕ

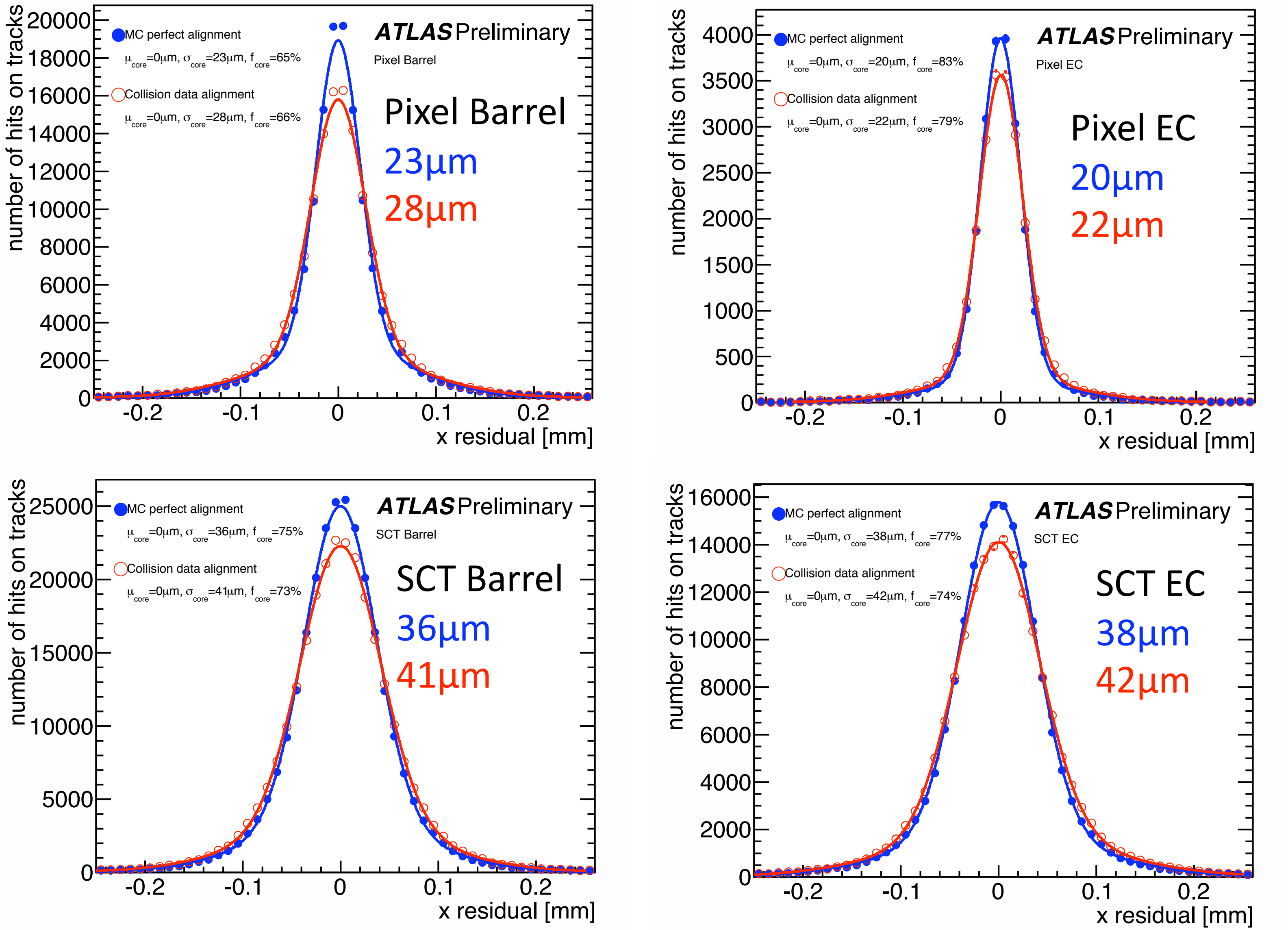
Number of SCT hits on track versus η / ϕ

- Correct MC for beamspot position and size
- Simulating the detector configuration as used in datataking

Unbiased Hit Residuals after Alignment

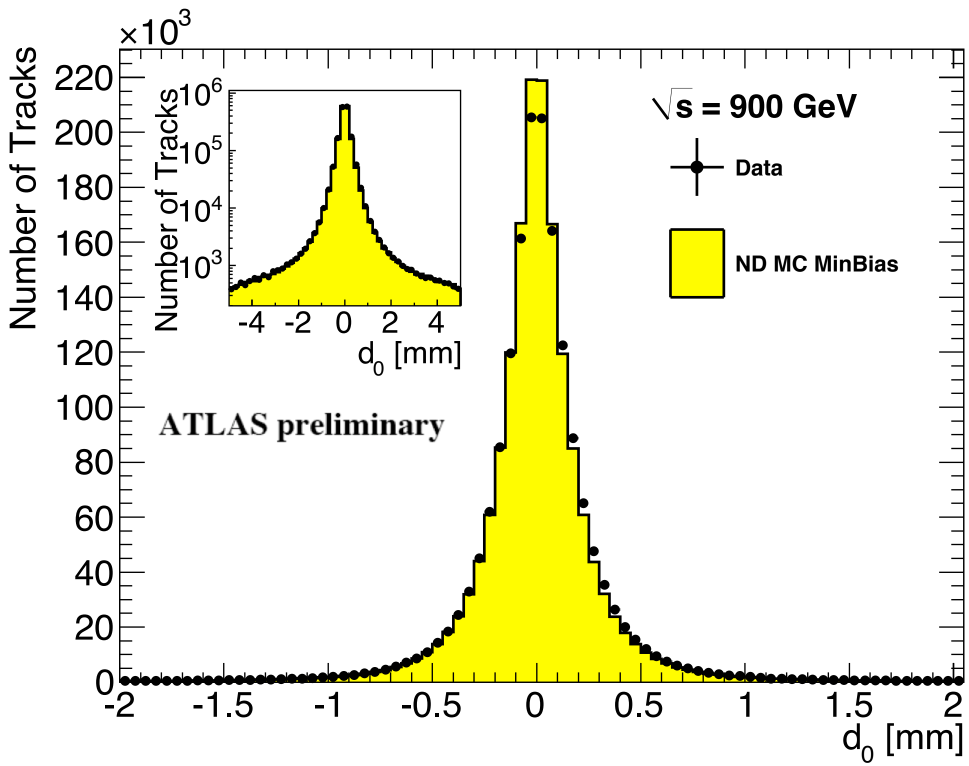
MC perfect alignment
Collision alignment

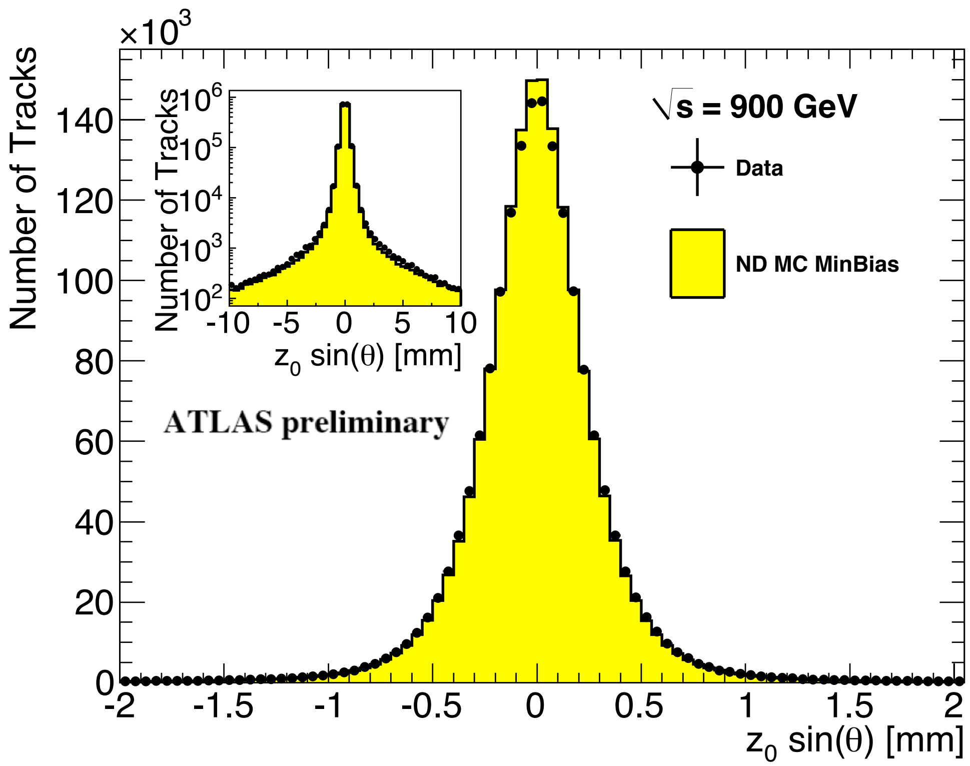
These residuals take into account alignment and intrinsic resolution - dominated by multiple scattering in this sample.



Big improvement in alignment with collision data especially for endcaps where cosmics are not so useful. Approaching the perfectly aligned MC residuals already! Final clustering strategy should improve widths further.

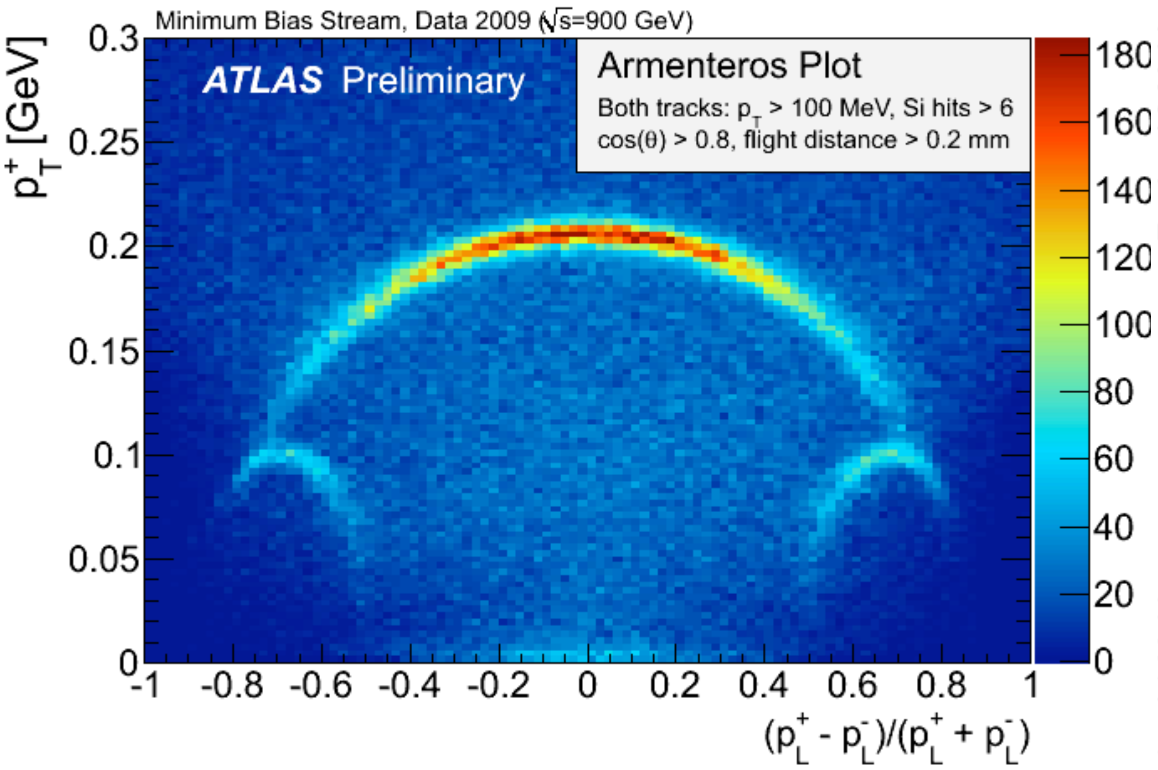
Impact parameters - data / MC comparisons

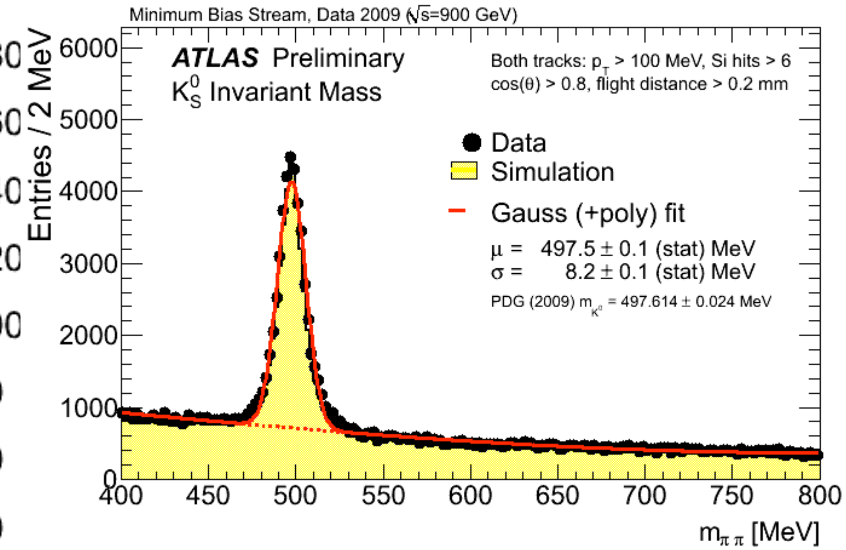


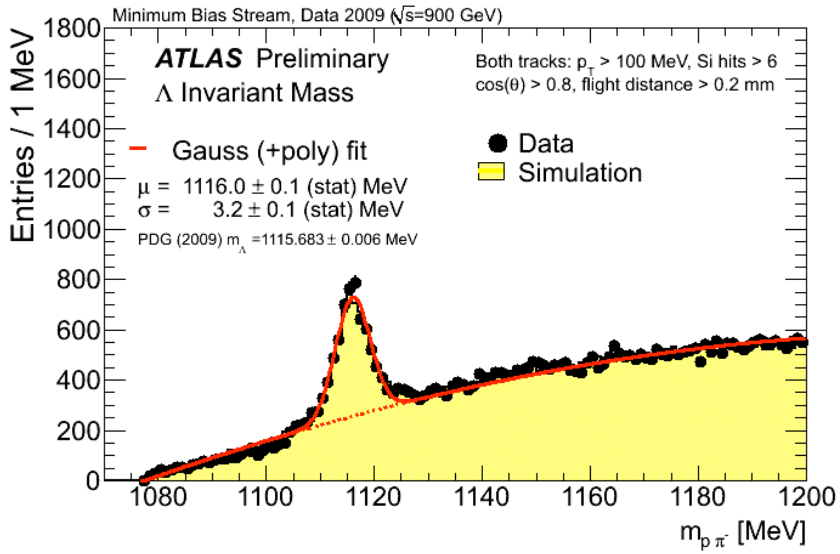


Good description of the data by the MC for the impact parameter distributions.

Tracking - strange particles



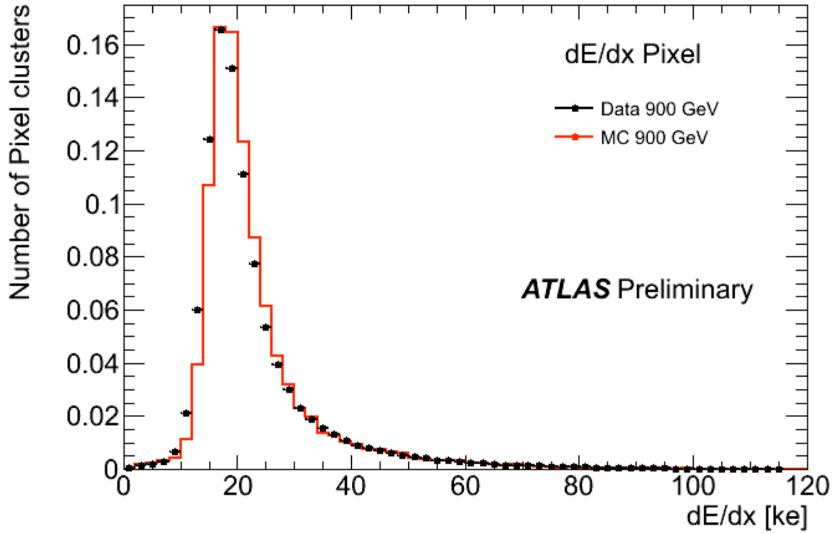


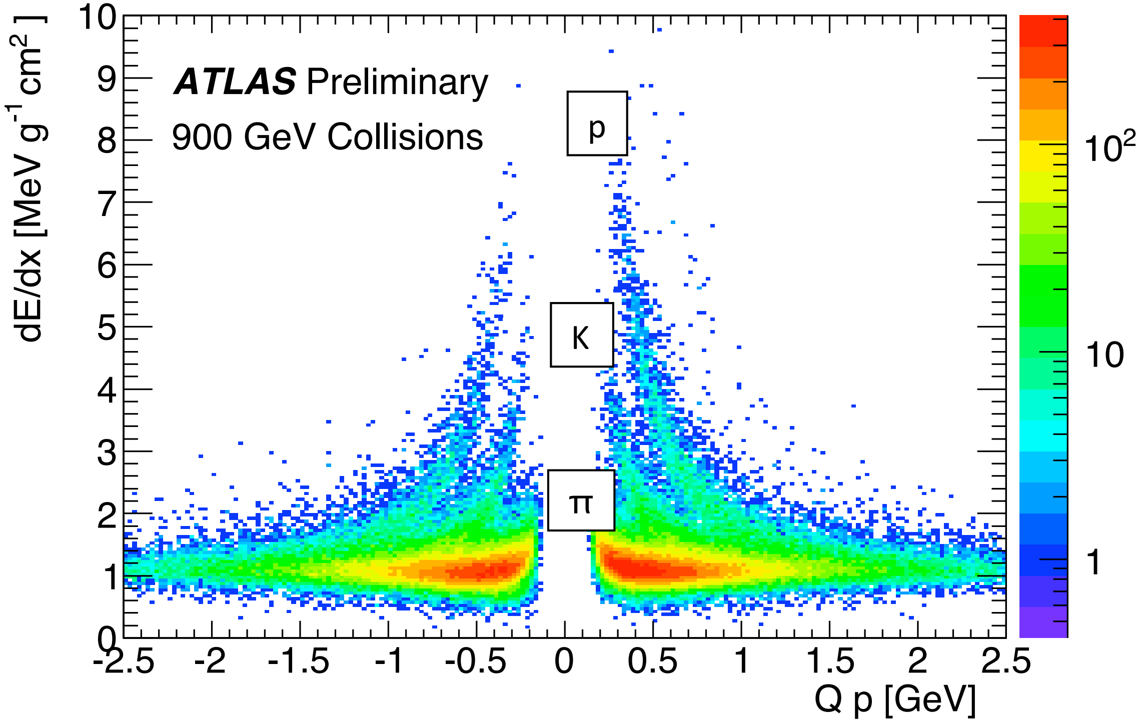


Detailed studies of tracking efficiency, momentum scale and momentum resolution ongoing using strange particle decays (K_S).

Pixel dE/dx

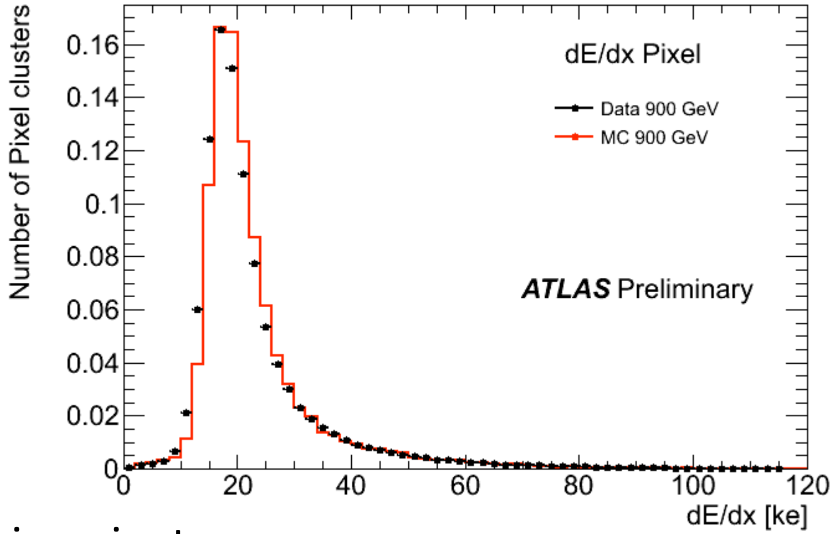
Using the particle ID features of the pixel detector.



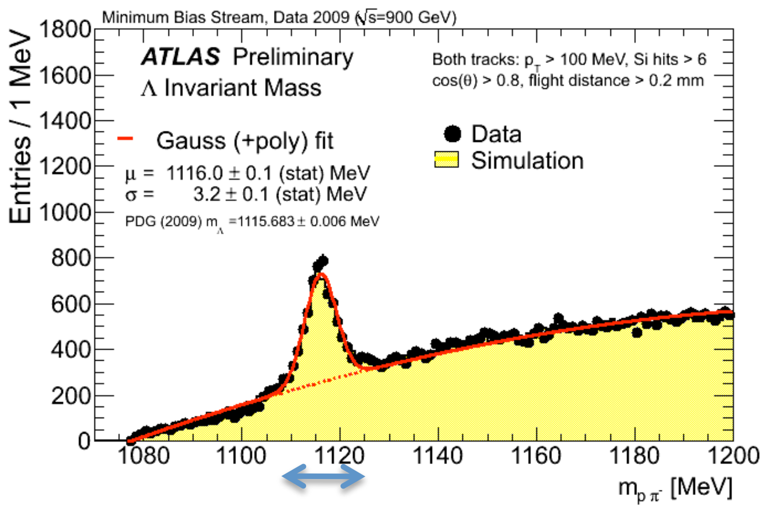


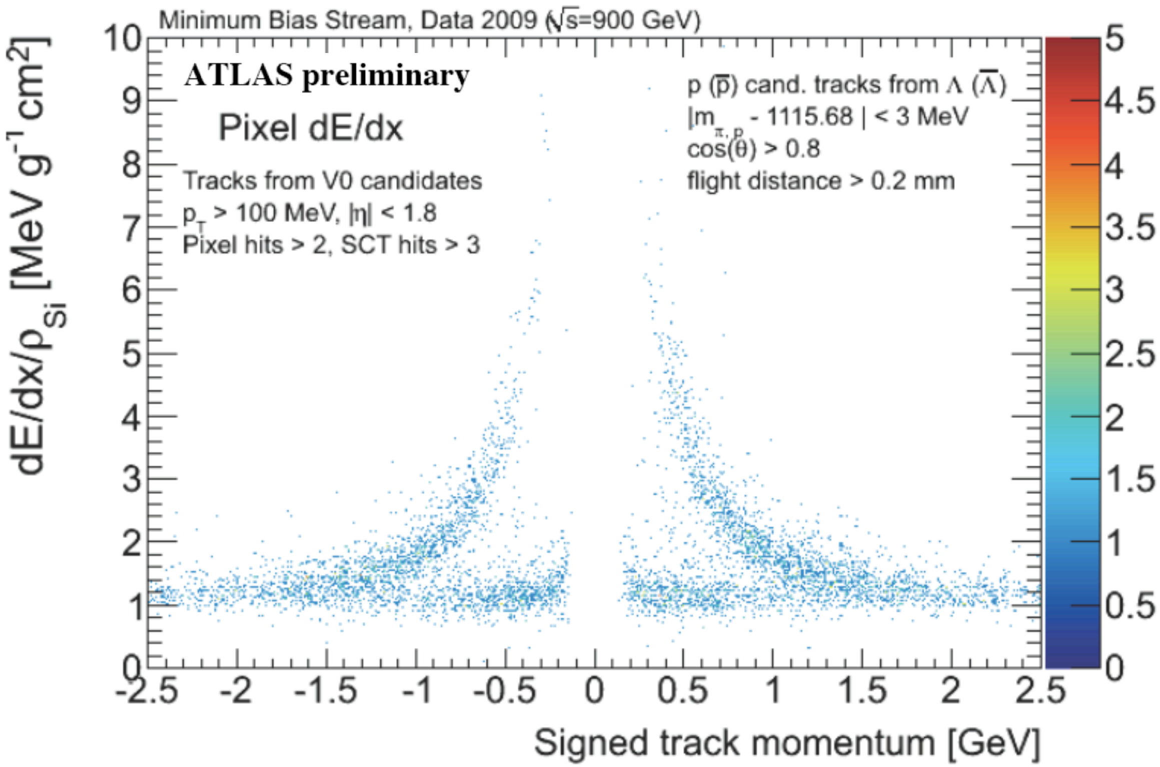
Pixel dE/dx

Using the particle ID features of the pixel detector.



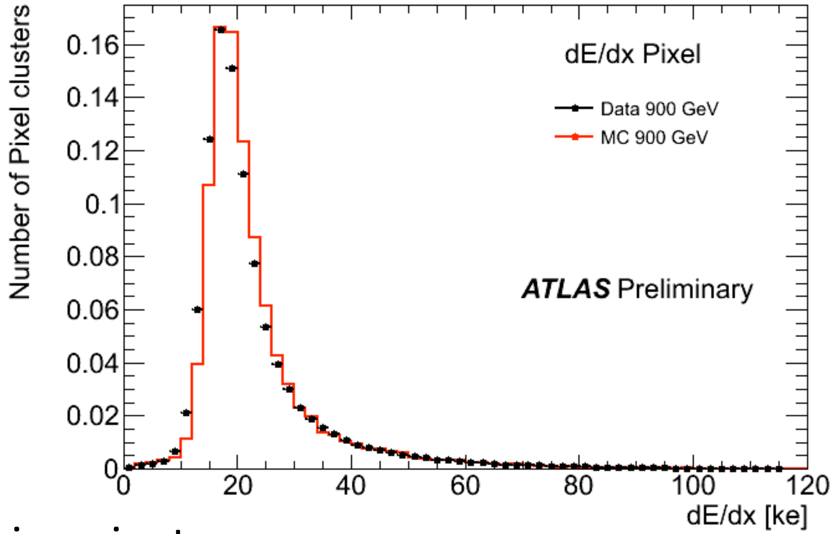
dE/dx for proton candidates selected using the Λ ($\bar{\Lambda}$) invariant mass.



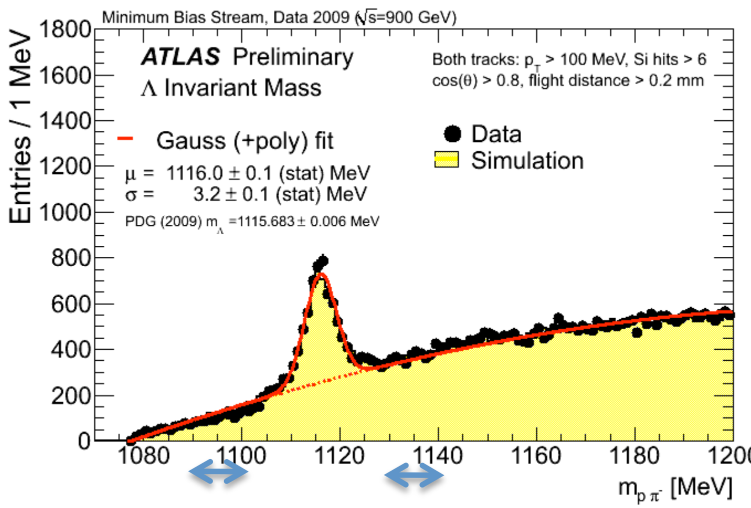


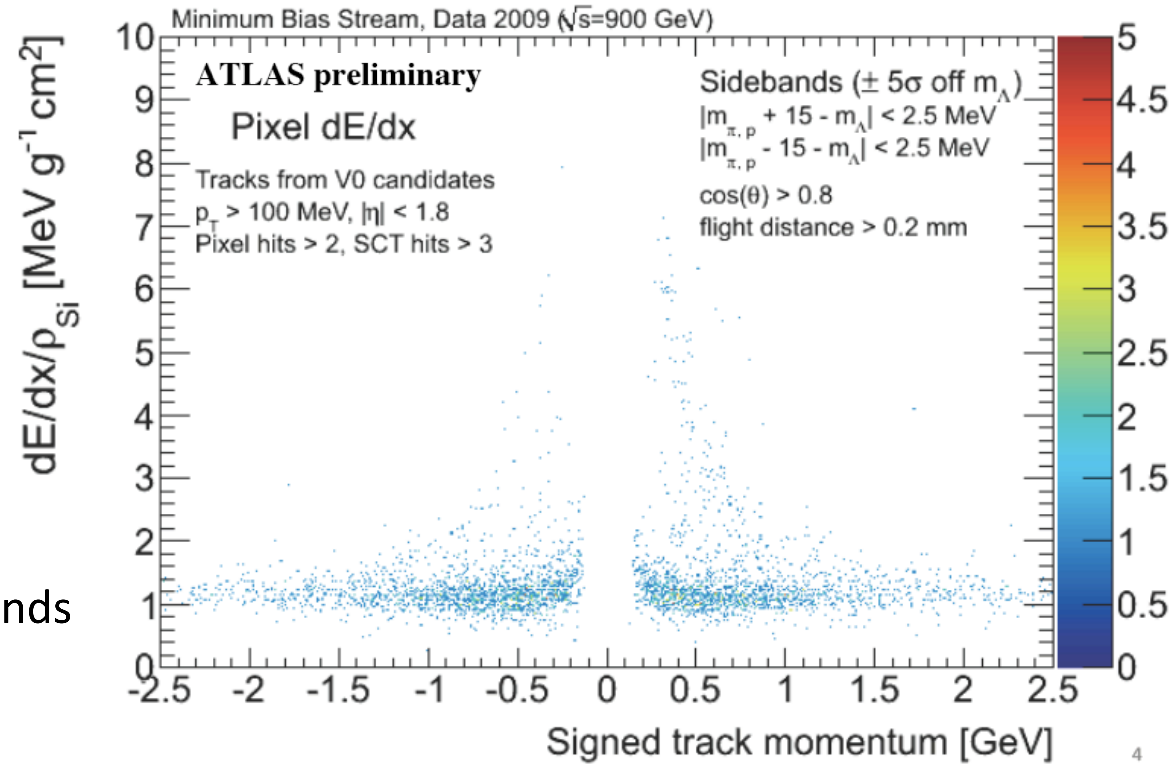
Pixel dE/dx

Using the particle ID features of the pixel detector.



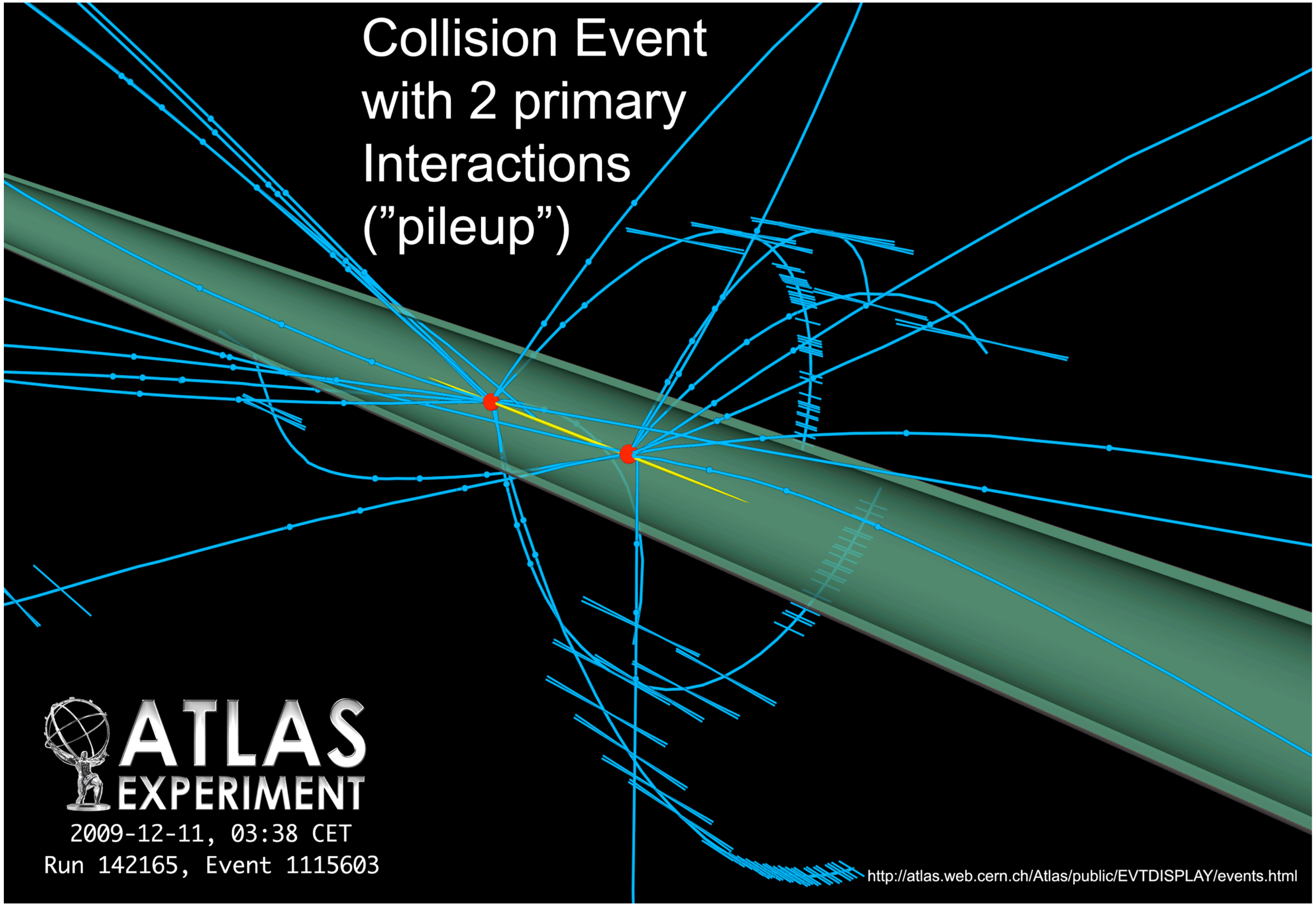
dE/dx for proton candidates selected using the Λ ($\bar{\Lambda}$) invariant mass.





dE/dx dominated by pions for sidebands

Event with Two Primary Vertices



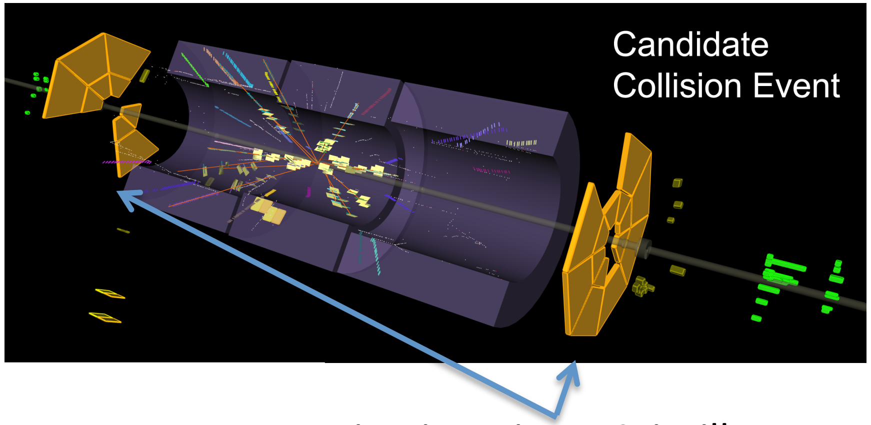
Charged particle multiplicity analysis

First public presentation of these results!

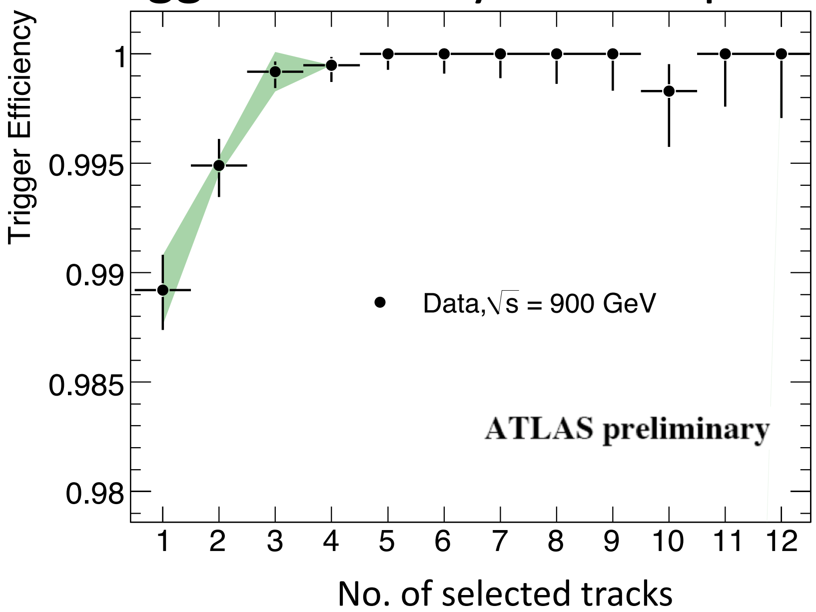
- Analysis overview
  - Use all 900 GeV data taken with stable beams and with trigger, tracking detectors, and solenoid operational
    - ~9μb^{-1} of data from 13 runs taken between Dec 6 - 15, 2009
  - Choose to measure primary charged particles in the phase space
    - P_T>500 MeV, $|\eta|$ <2.5
      - For analysis presented here we show for $|\eta|$<2.2 as we are still working on the final high η material corrections
  - Require events have at least one of these tracks and a reconstructed primary vertex
  - Select: 330k events / 1.9M tracks
    - Beam background estimated by looking at events taken in unpaired bunches to be <10^{-4} of selected events
- Within our phase space we measure fully inclusive inelastic distributions to avoid any model dependence
  - Facilitate direct comparisons with MC models
  - Correct for our trigger, vertexing & tracking efficiency to the hadron level
  - Do not correct for diffraction or extrapolate outside our phase space

Analysis overview - Trigger

- We use a dedicated Minimum Bias trigger
  - ±3.56m from IP (2.09 < |η| < 3.84)
  - 32 scintillating counters
  - Require >0 hits on either side (very inclusive)



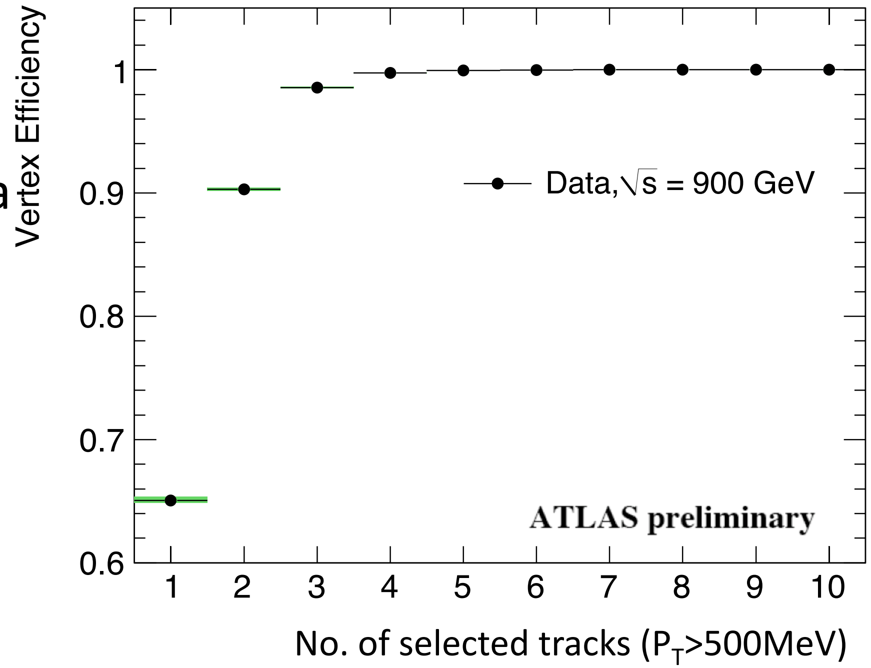
- Measure the trigger efficiency from data
  - Using an orthogonal trigger
  - Beam crossing signals from pickups at L1
  - Require Pixel/SCT hits and a loose track in Higher Level Trigger (looser than analysis requirement)
- Trigger Efficiency with respect to the analysis selection is extremely high



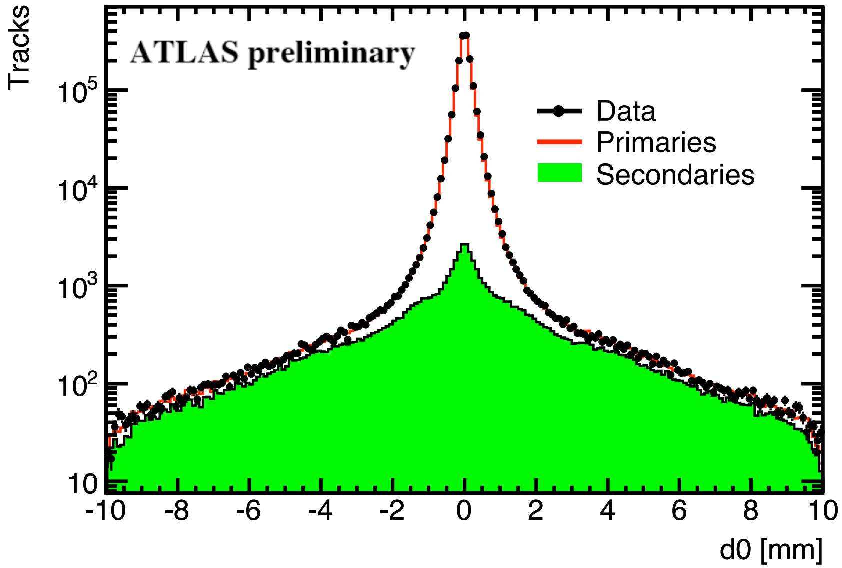
No biases w.r.t track η, P_T, …
Very low systematic uncertainty (<0.3%).

Analysis Overview - Vertexing & Secondaries

- Require a reconstructed primary vertex
  - Require >2 tracks in vertex (P_T>150MeV)
  - Vertexing efficiency measured from data
    - Systematic uncertainty <0.1%
  - ~100% for number of selected tracks >4

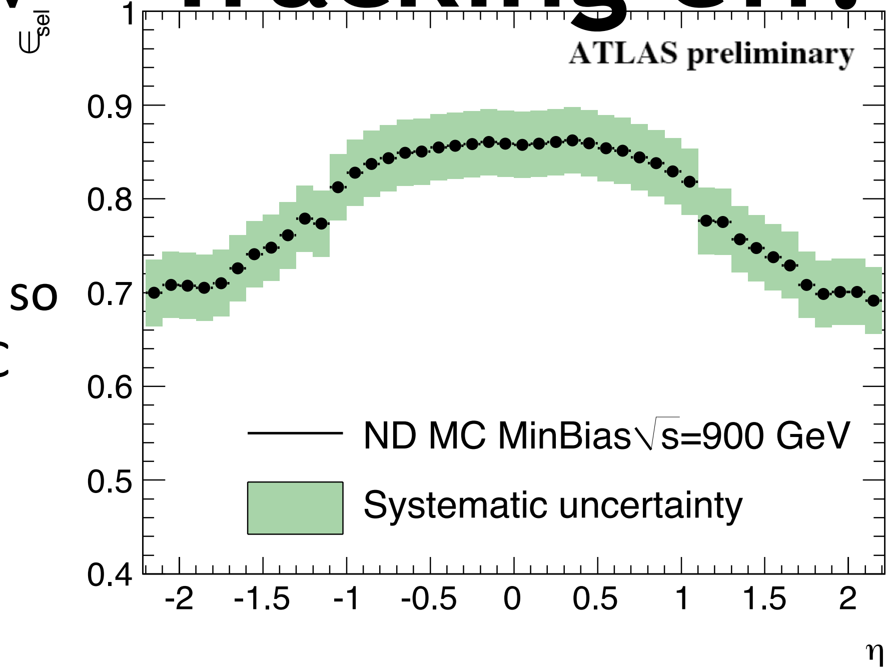


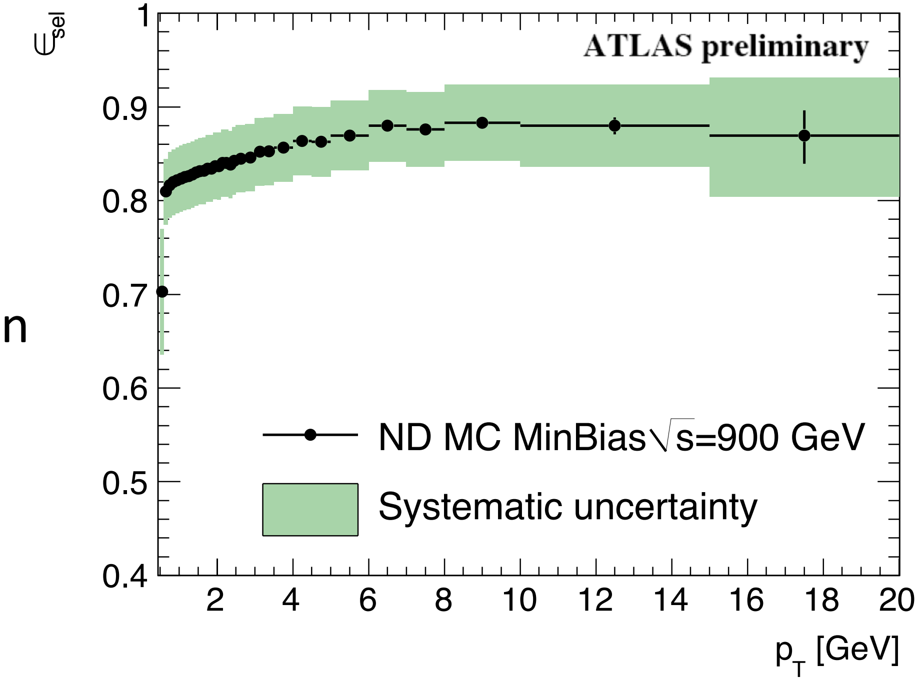
- To remove secondaries require:
  - $|d_0|$<1.5mm
  - $|z_0 \sin\theta|$<1.5mm
    - Both d_0, z_0 w.r.t primary vertex
- Remaining secondaries estimated using tails in the impact parameter distribution to be ~2% of selected tracks



Analysis Overview - Tracking eff.

- Tracks for analysis
  - P_T>500 MeV
- We see excellent description of data by MC so we can take the tracking efficiency from MC
  - No corrections to efficiency
  - Lots of effort has gone into assessing systematic uncertainty due to discrepancies between data/MC
    - Hit multiplicities (see earlier plots)
    - Individual system tracklet efficiencies (data/MC)
    - K_S studies in data/MC
  - Overall systematic ~3% in central region



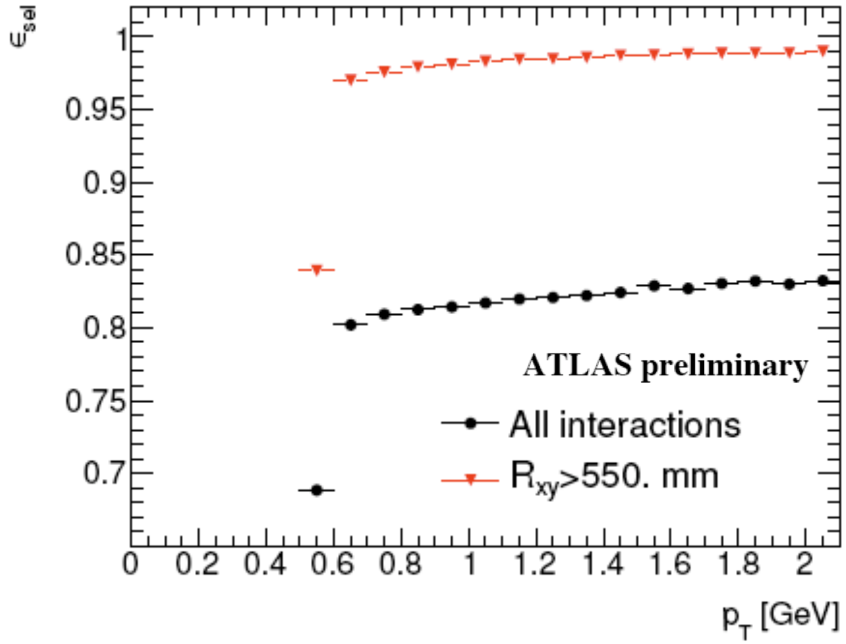


Analysis Overview - Material studies

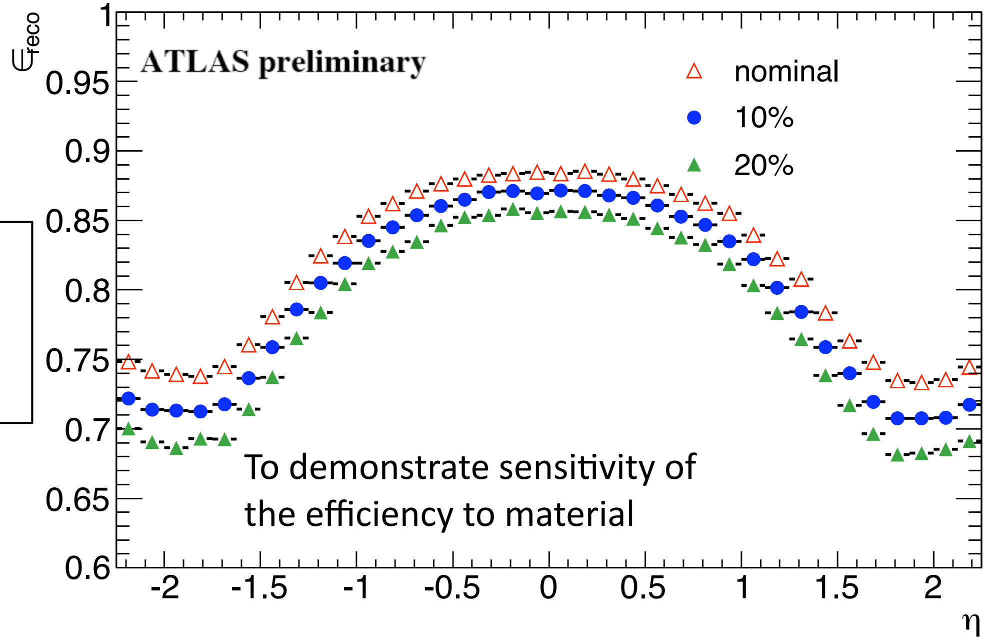
- -A lot of studies on understanding the detector material from data
  - -Investment for the future
- -Majority of tracking inefficiency from material interactions
- -Largest systematic on tracking efficiency from uncertainty on material in the simulation
- -Benefit from careful weighing of the tracking detector components before installation
- -Expect photon conversions to give us a detailed map of material
  - -Currently not enough data to give us required precision

All charged particles

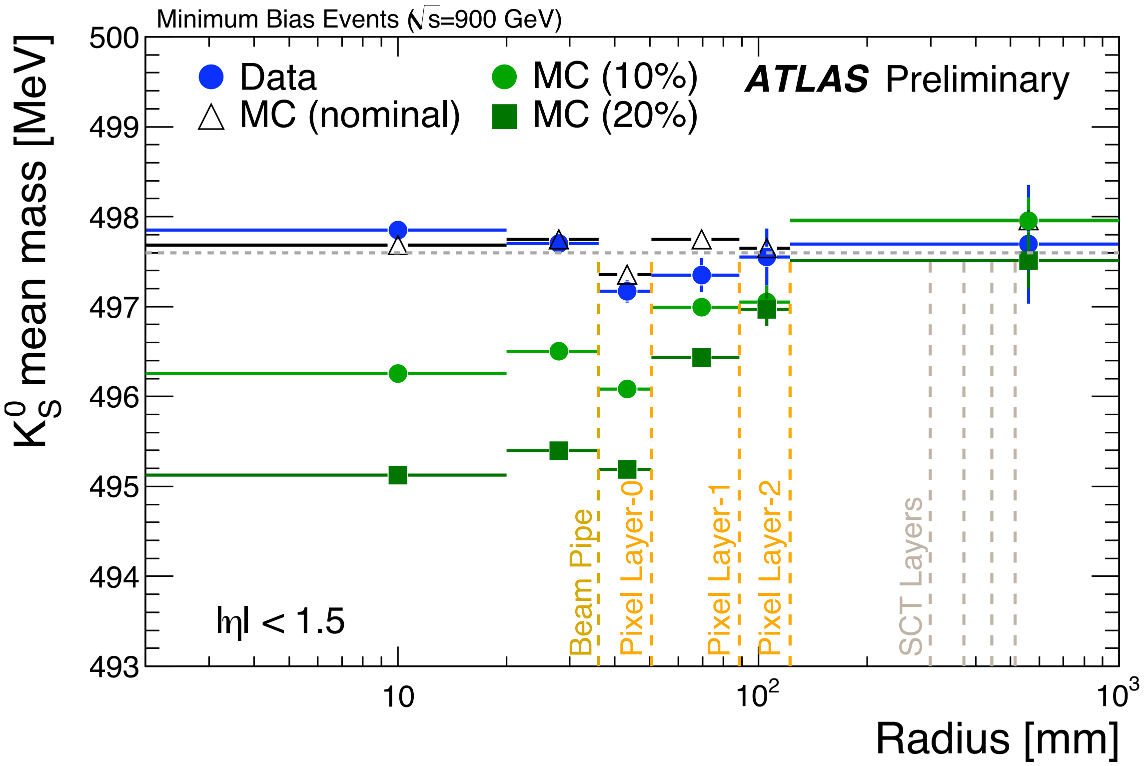
No material interactions in Si tracker



MC studies of the tracking efficiency with uniform scaling up of the material by 10 and 20% (in rad. length).

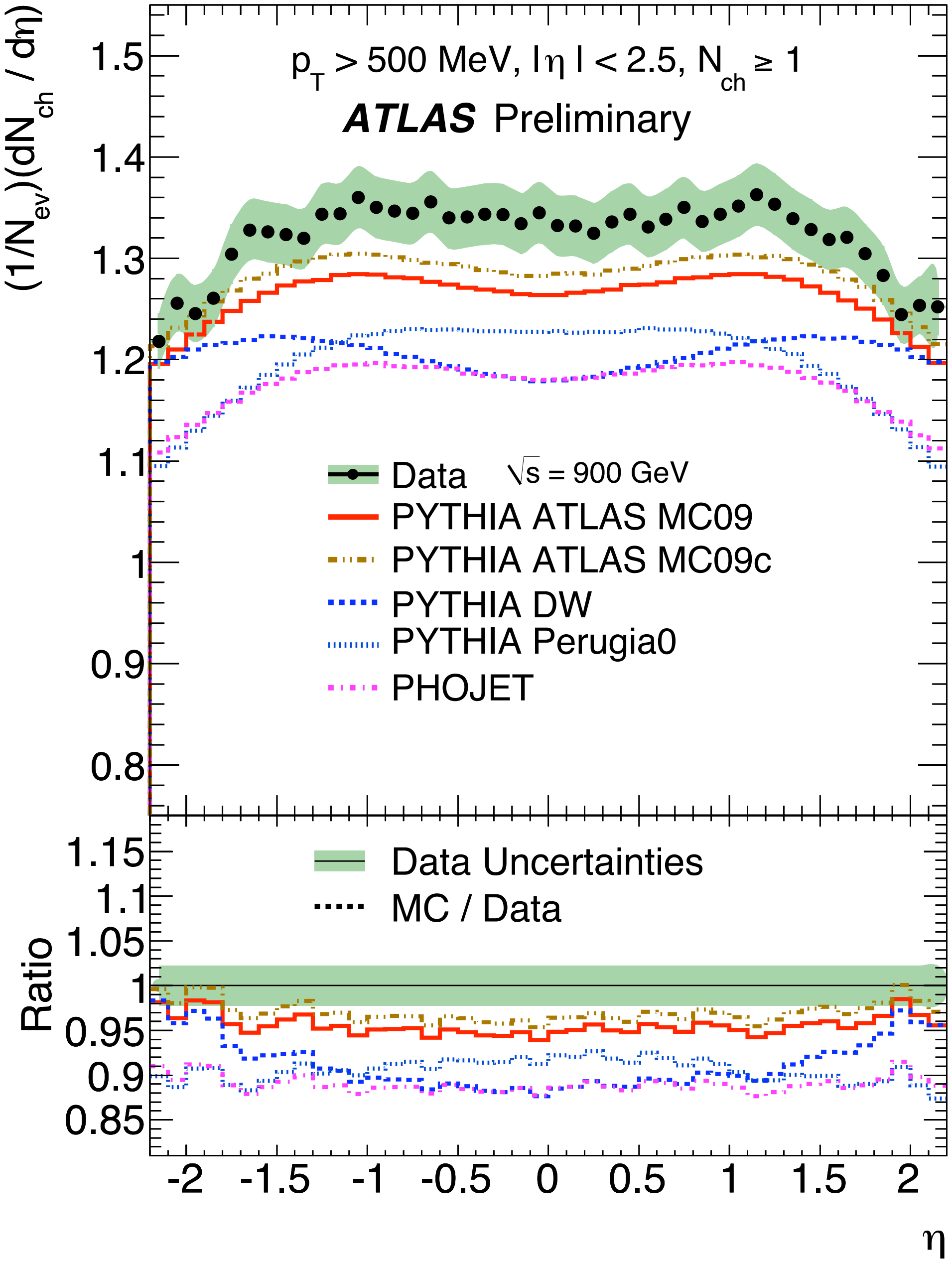


Analysis Overview - Material studies



- K_S studies to constrain the amount of material in the detector
- Data favours the nominal MC and is inconsistent with the MC with 10%, 20% additional material
- For systematic we currently take the largest difference in efficiency between nominal MC and the 10% additional material MC
    - Gives 3% systematic uncertainty on tracking efficiency
- Other studies give consistent results

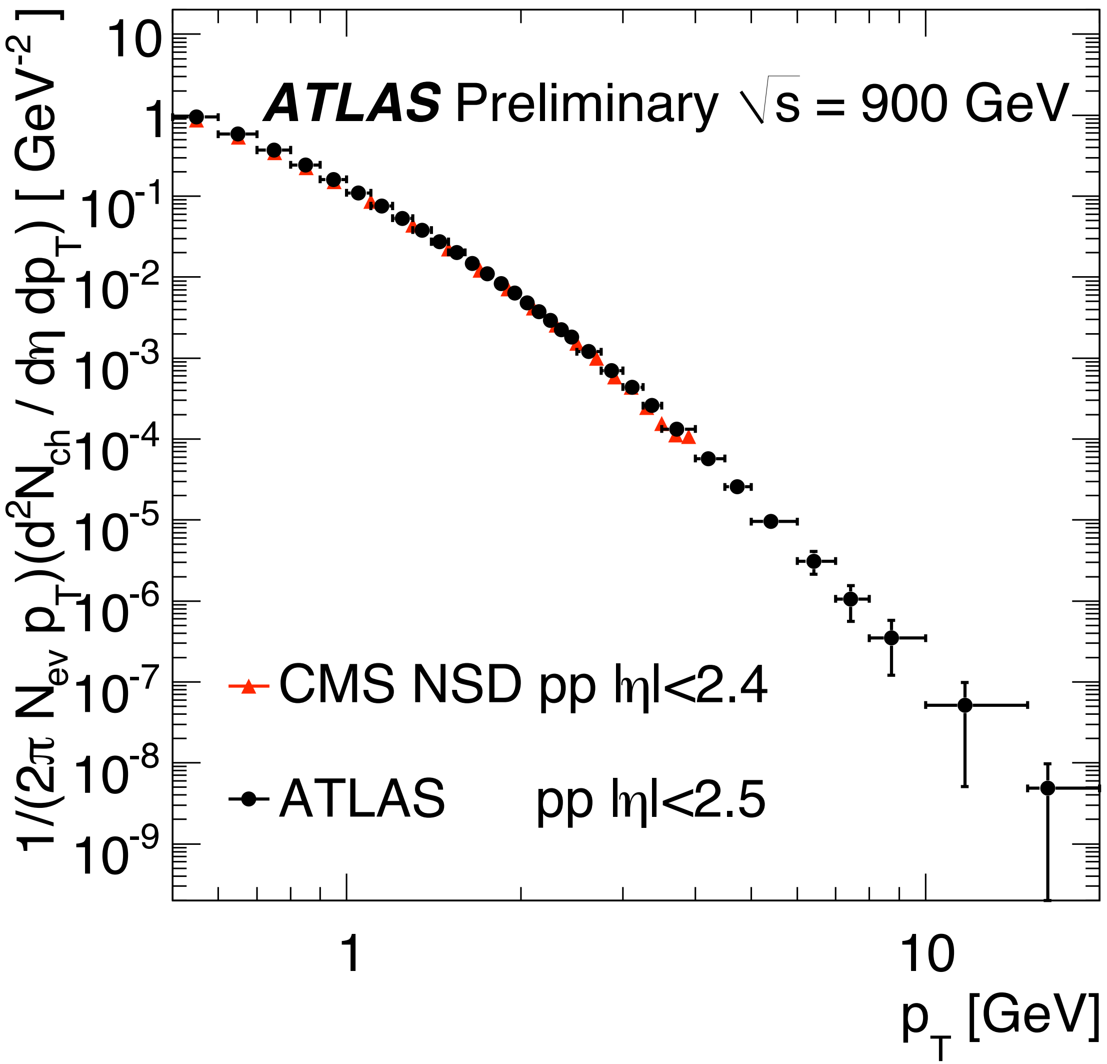
Analysis overview - Results



- dN/dη distribution
- Shape agrees well with some PYTHIA tunes
- ATLAS data shows higher value then all MCs
  - -MCs tuned in different region of phase space

Note suppressed 0 on y-axis

Analysis overview - Results



- Comparing P_T distribution with CMS data
  - -Thanks to CMS for making the data available (**arXiv:1002.0621v1**)
- ATLAS/CMS treat diffractive events in different ways

Summary

- During the first run ATLAS has been working very well from detector operation to data processing, distribution and analysis
- First collision data have shown that the detector performance is excellent and remarkably well described by the simulation (in the most difficult soft regime)
- Preliminary results on inclusive measurements of charged particle multiplicities at 900 GeV have been presented. A paper will be submitted soon.

ATLAS is very grateful to the LHC team for the excellent machine performance and looks forward to high energy data!