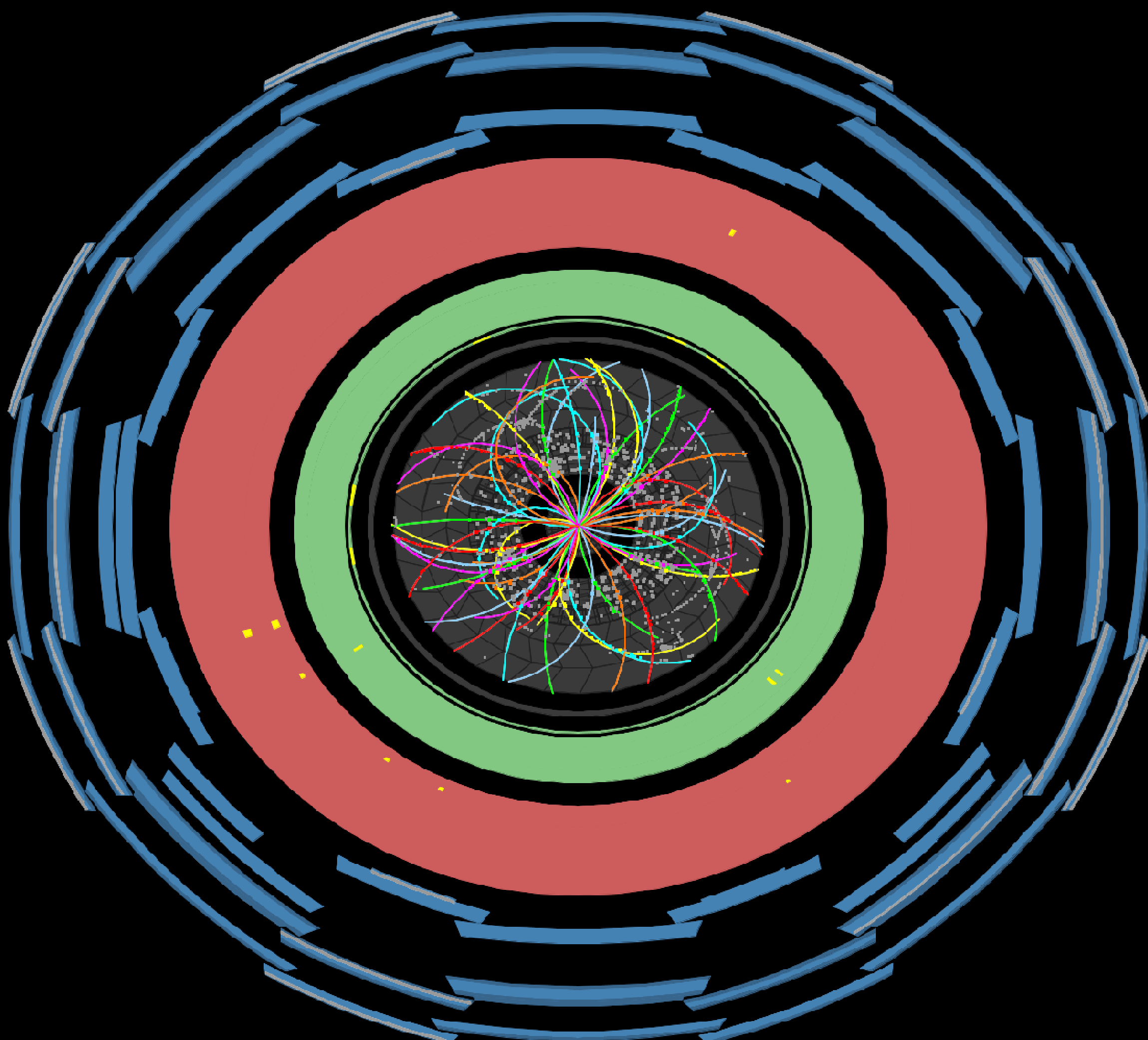
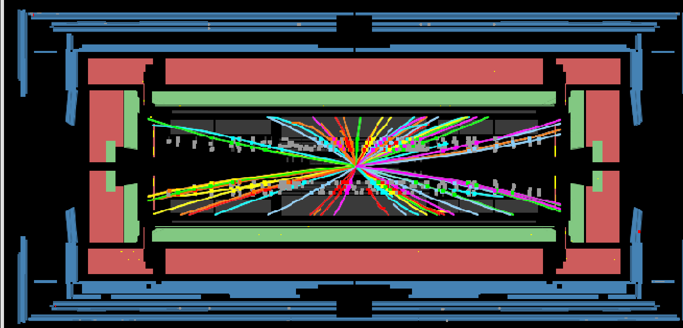
First results with ATLAS data

http://atlas.web.cern.ch/Atlas/public/EVTDISPLAY/events.html





ATLAS EXPERIMENT

Run Number: 152166, Event Number: 316199

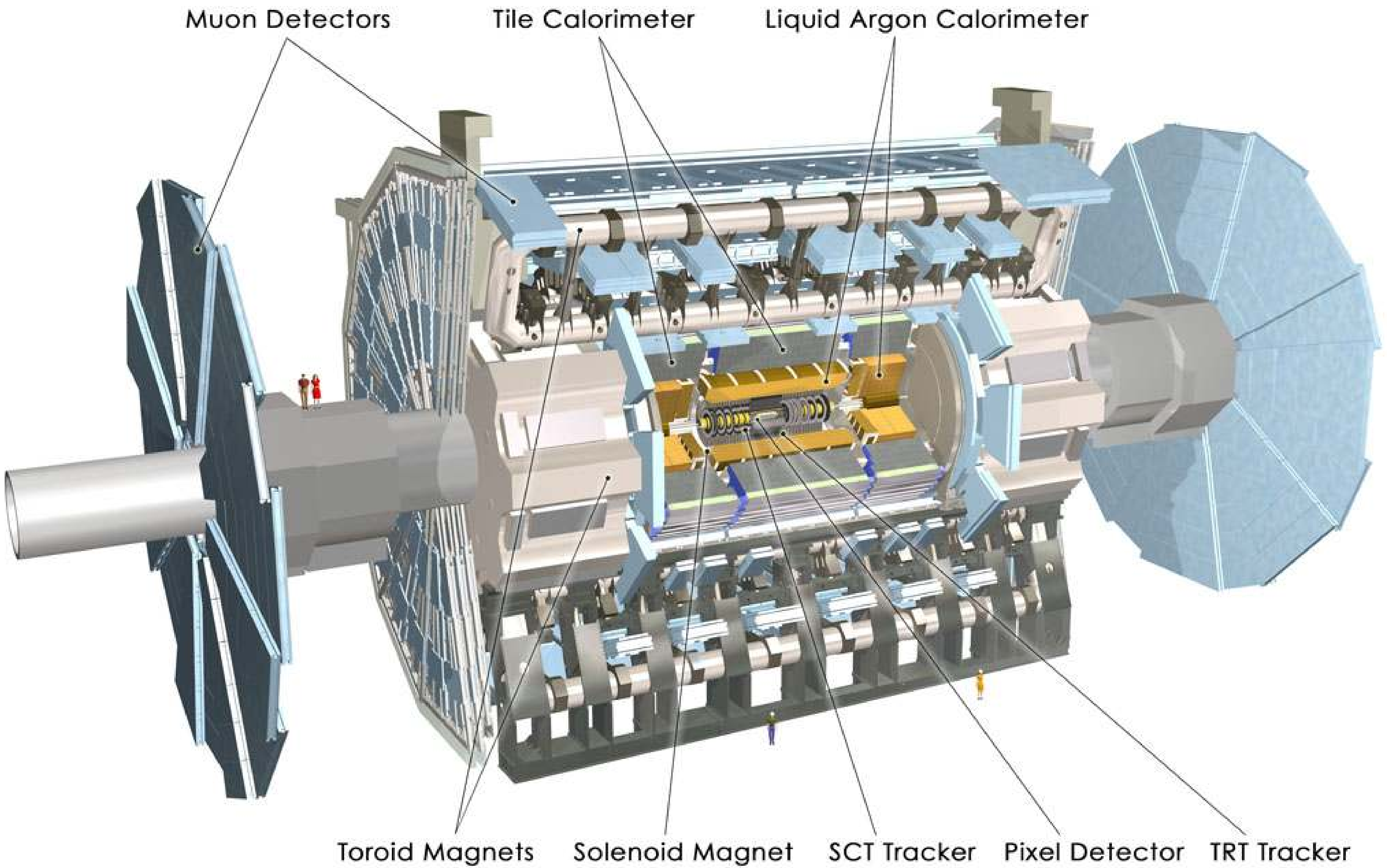
Date: 2010-03-30 12:58:23 CEST

Outline

- Introduction: data-taking
- Detector systems: Tracking , Calorimetry, Trigger
- Physics objects: e, γ, μ, jets, $E_{T,miss}$, b-jets
- Particles: π^0, η, K_S, φ, J/ψ, W
- Conclusion and Outlook

Warning: *all* plots in this presentation contain REAL DATA!

The ATLAS detector



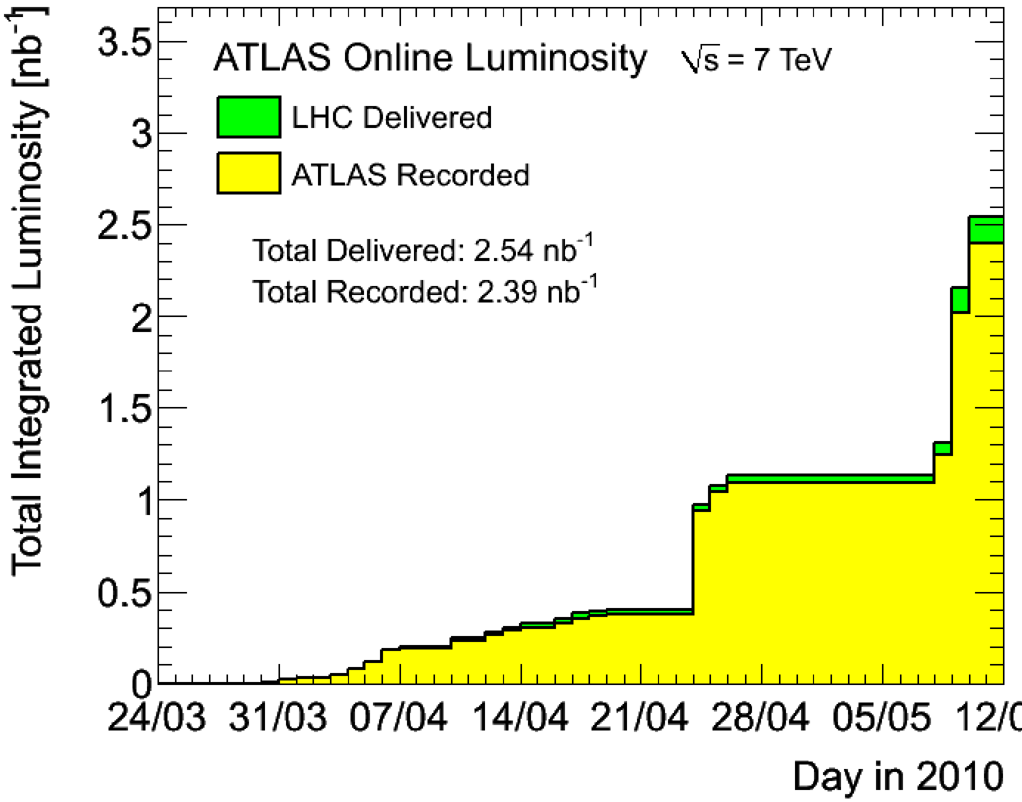
ATLAS detector status

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	98.0%
LAr EM Calorimeter	170 k	98.5%
Tile calorimeter	9800	97.3%
Hadronic endcap LAr calorimeter	5600	99.9%
Forward LAr calorimeter	3500	100%
LVL1 Calo trigger	7160	99.8%
LVL1 Muon RPC trigger	370 k	99.7%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.7%
CSC Cathode Strip Chambers	31 k	98.5%
RPC Barrel Muon Chambers	370 k	97.3%
TGC Endcap Muon Chambers	320 k	98.8%

High operational fractions for all detector systems

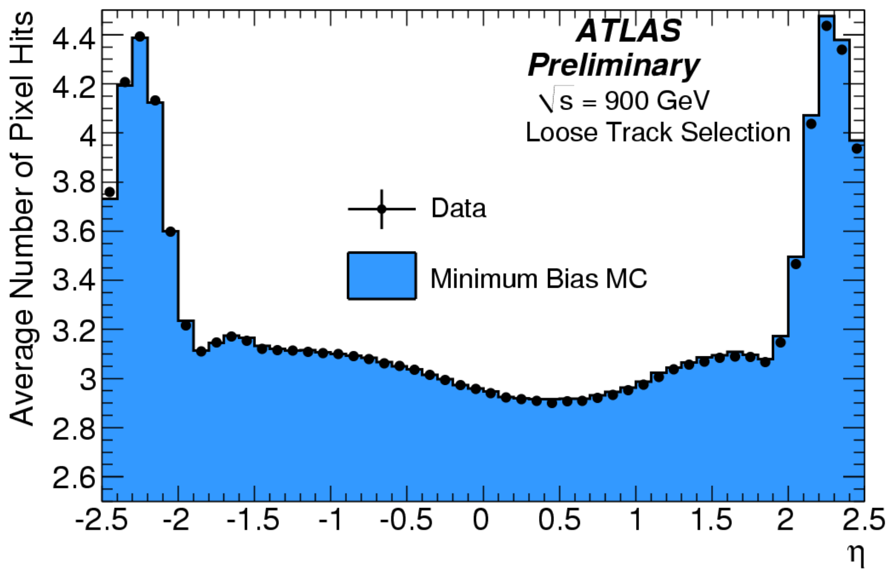
Data taking

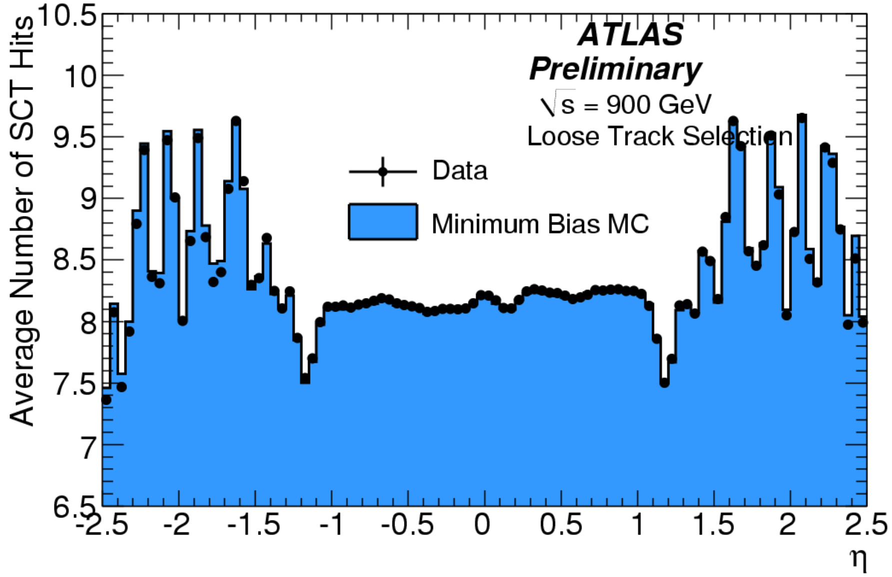
- Data collected at √s=900 GeV (and 2.36 TeV) in Dec. 2009: ~10/μb
- Since March 30, 2010: √s=7 TeV, collected ~2.4/nb,
  peak instantaneous luminosity ~10^{27}-10^{28}/cm^2/s (average of Ms evts/day)
- Recorded >95% of data delivered with stable beams
- commission detector + rediscover SM
- Many *detailed* studies completed
  (mostly on the 900 GeV data)
  Spring 2010: **26** ATLAS-CONF notes
- LHC delivering: rapidly increasing luminosity;
  reach 10^{30}/cm^2/s in early summer?
- Run to end 2011: expecting ~1/fb



Detector systems: tracking, calorimetry, trigger

Tracking – inner detector (Pixels, SCT, TRT)





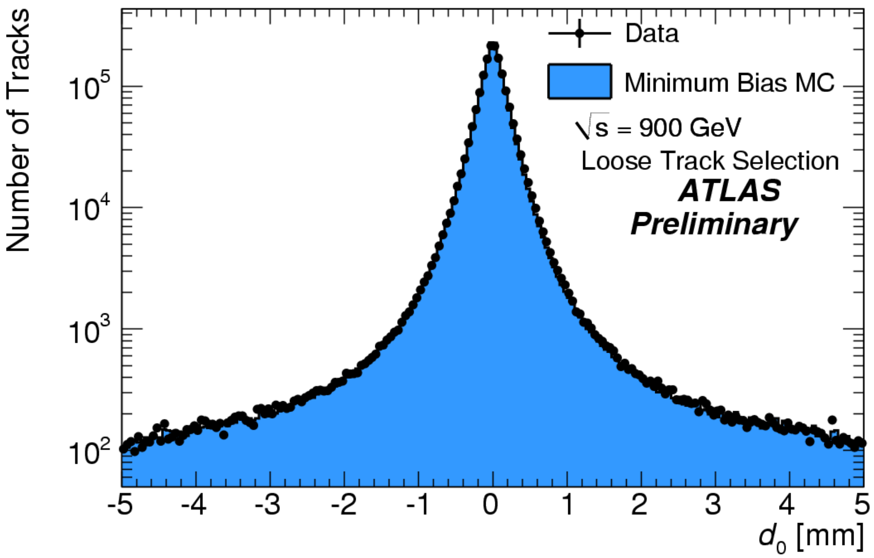
Excellent data/MC agreement in #hits/track overall

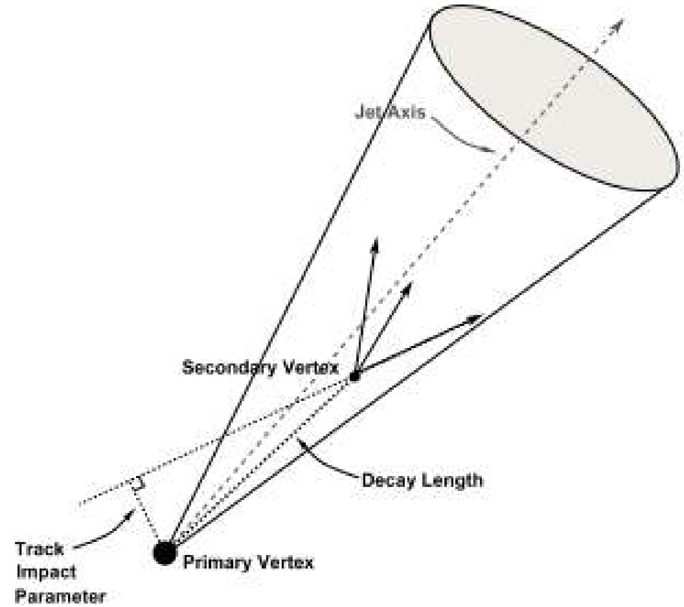
Include inactive Pix + SCT modules in simulation

Very good agreement in #hits/track as function of pseudorapidity (η), azimuthal angle (φ)

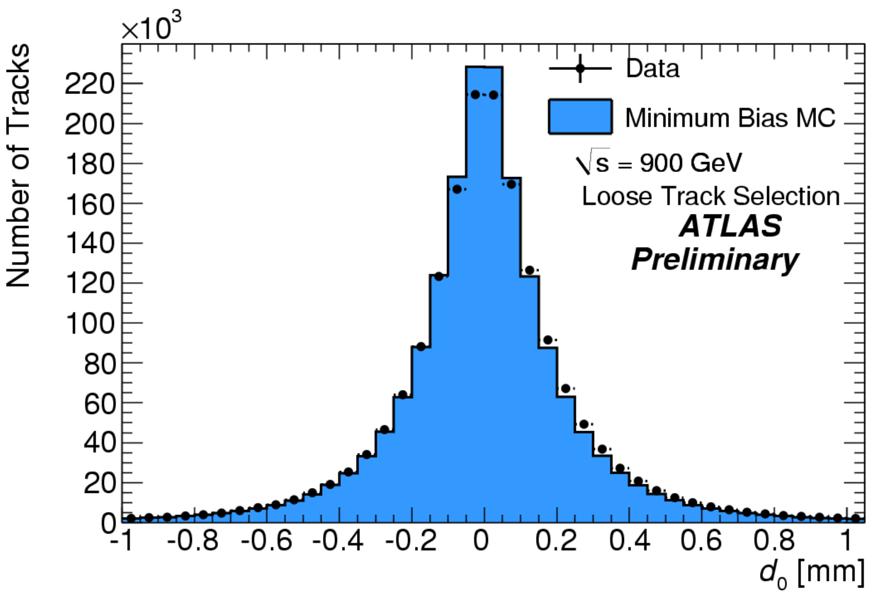
Small residual differences due to *transverse* beam position of beamspot being different in data and simulation.

Tracking – inner detector





Transverse impact parameter (d_0) distributions with respect to the primary *reconstructed* vertex in the event



Good data/MC agreement, especially in the tails

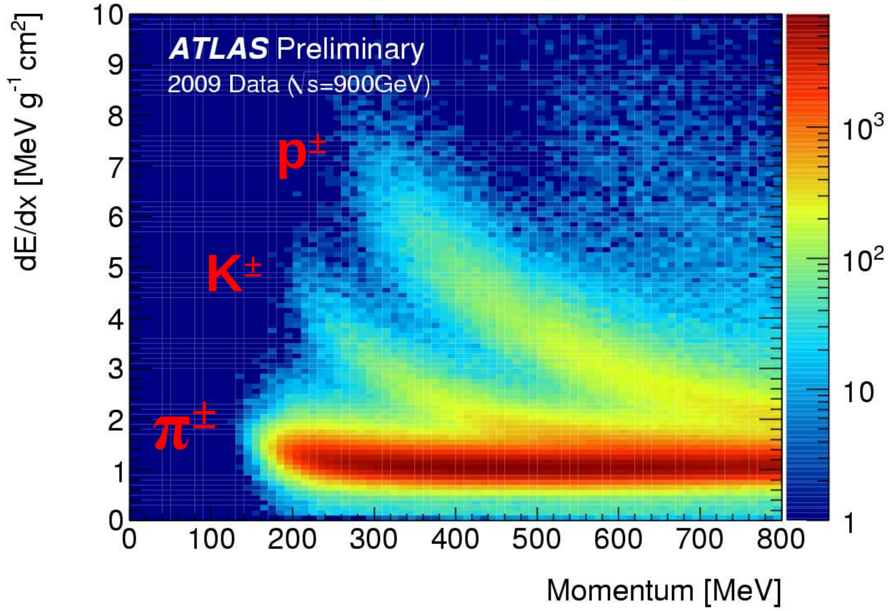
Difference in the core of the distribution is due to the better tracker alignment in the MC (as expected at this point in time).

Tracking – particle identification

Specific energy loss (dE/dx)

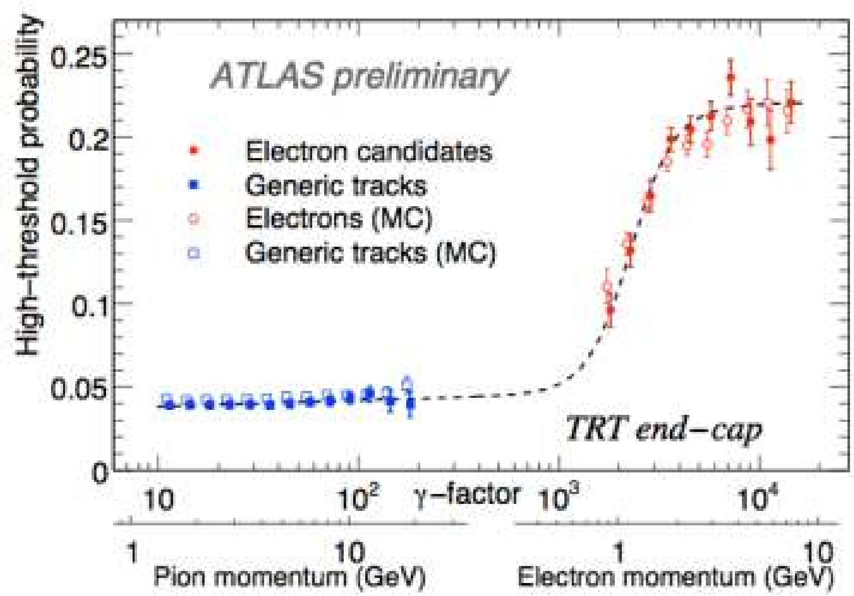
- measured in pixel detector sensors (each 250µm thick)
- Three clearly identifiable bands: dE/dx vs p

e.g. allow identification of low-momentum Kaons with reasonable efficiency and purity (<600 MeV/c ➔ $\varepsilon \geq 80\%$, pur$\geq 40\%$)



Transition Radiation Tracker

- Clear TR signal from electrons
- Fraction of high-threshold hits for electrons from conversions vs other tracks (good 900 GeV data/MC agreement)



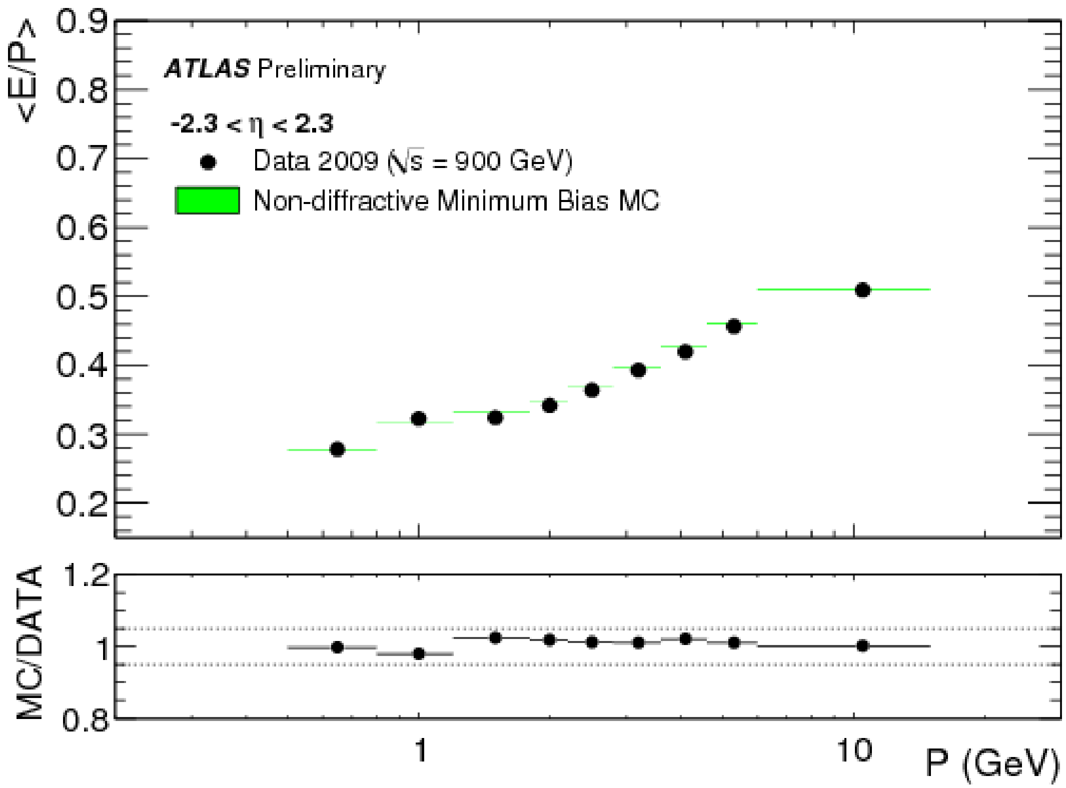
Calorimetry

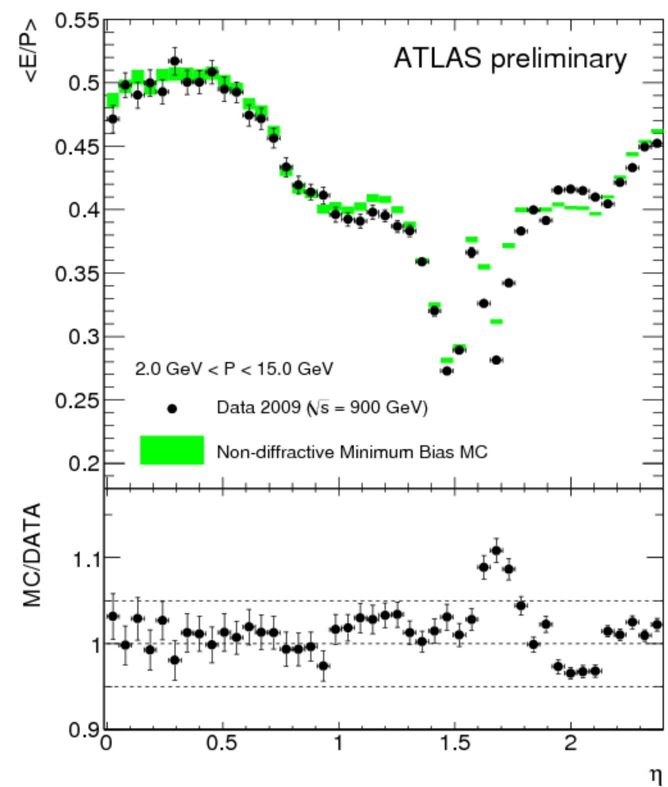
E/p, Energy response of the calorimeters to single isolated charged hadrons

- p: track momentum very precisely + accurately measured in tracker
- E: raw calorimeter energy associated with the isolated track

Calorimeter response well understood:

- very good agreement overall (within ±5%) between data and simulation
- worst agreement (~10%) is in the complicated barrel to end-cap transition region





Trigger

Three level trigger system:

L1
(hardware-based; coarse granularity calo + muon)

↓

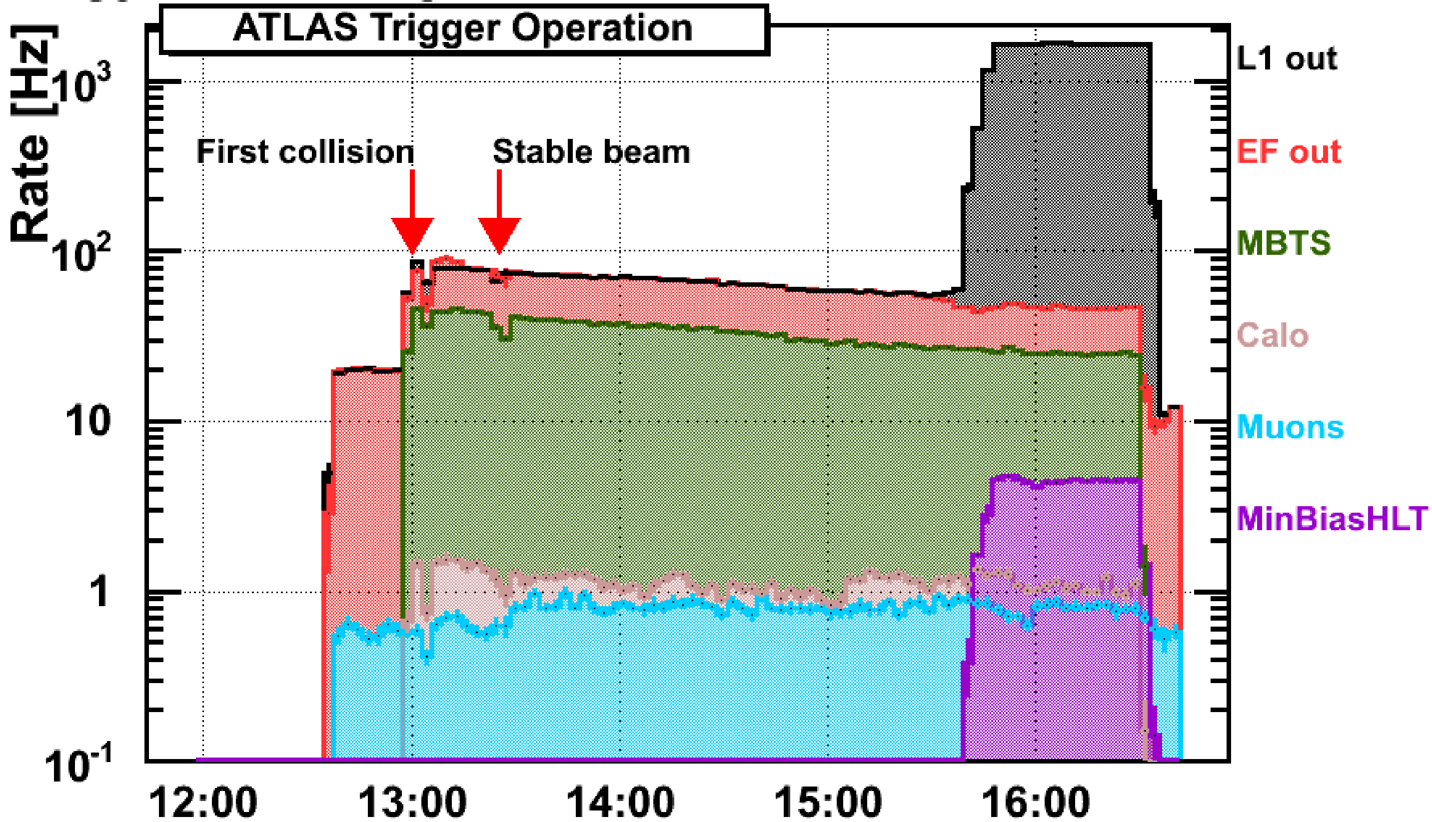
High Level Trigger
(software algorithms running on large computer farms)

L2

↓

EF (Event Filter)

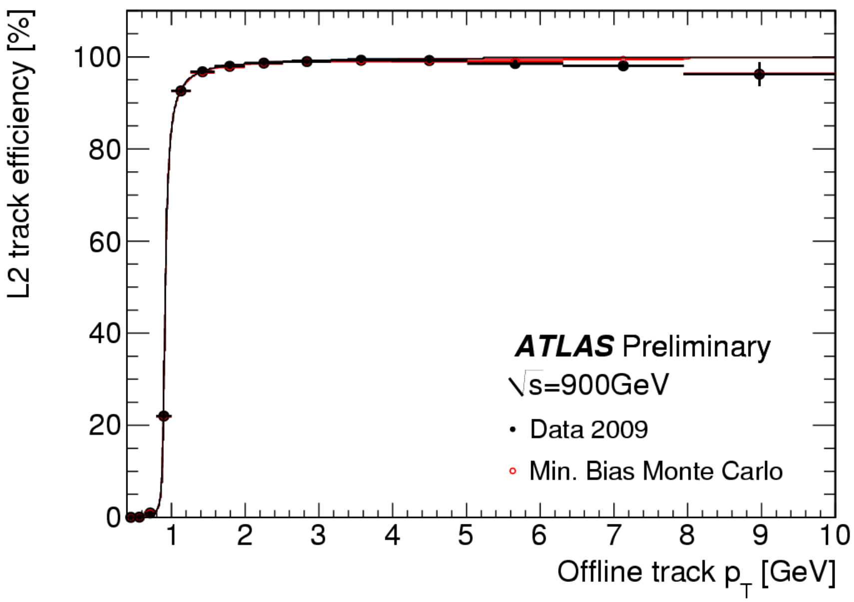
Trigger rates during first 7 TeV collisions



Trigger is being exercised, is stable and performance has been excellent overall!

- Online trigger rates during first 7 TeV collisions (30 March 2010)
- High Level Trigger initially inactive ("pass-through" mode)
- HLT selection activated within ~2.5 hours of first collisions

Trigger checks & performance

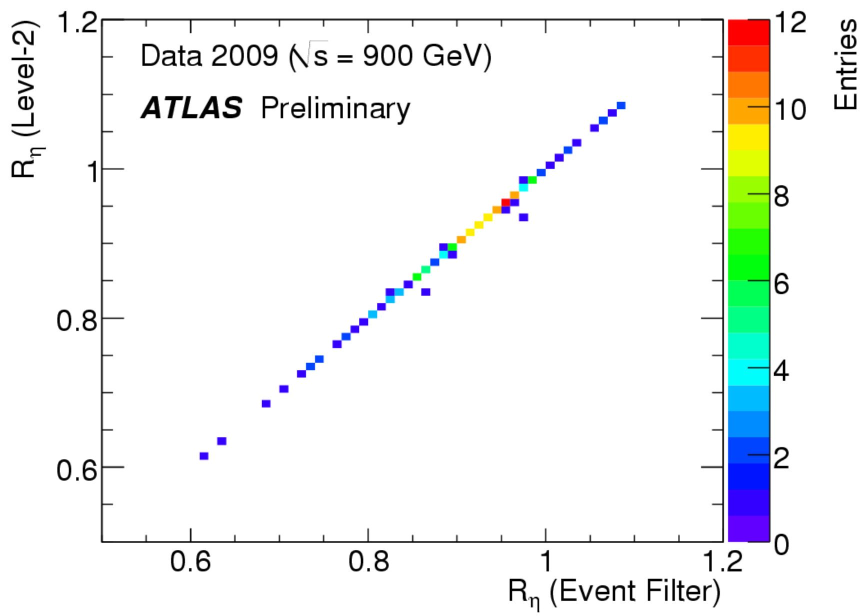


Detailed look at trigger variables, efficiencies, rates, stability, simulation, overall performance and robustness

L2 tracking

← efficiency: sharp threshold at p_T~1 GeV, reaching plateau of ~100% at 2 GeV (as required by eg B-physics triggers)

- very good data/MC agreement



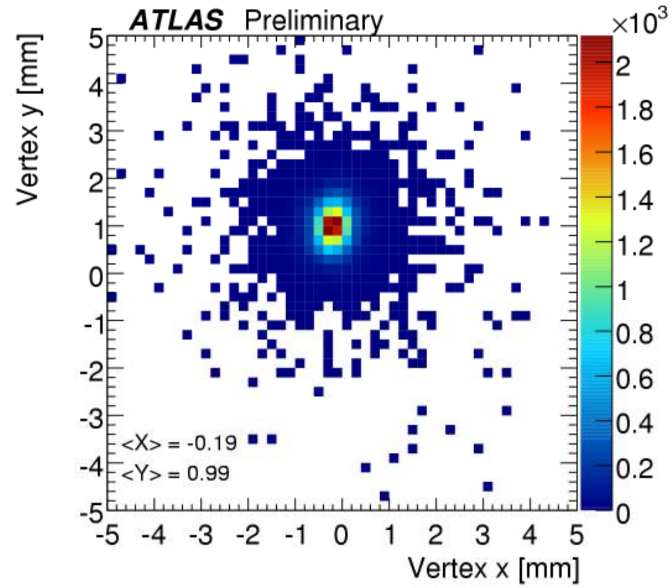
Ensure minimal trigger biases

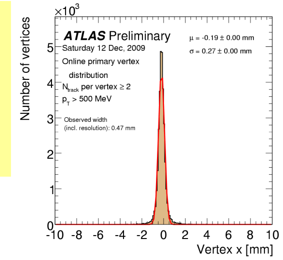
- eg compare e/γ triggering variables between L1/L2/EF and offline
- one of the steps of trigger commissioning

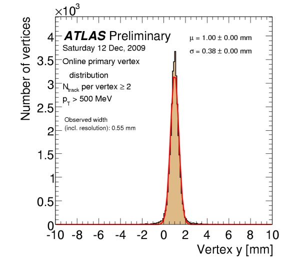
← L2 vs EF shower shape (transverse energy deposition)

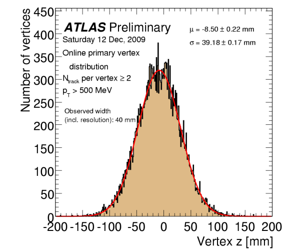
Trigger – online beamspot

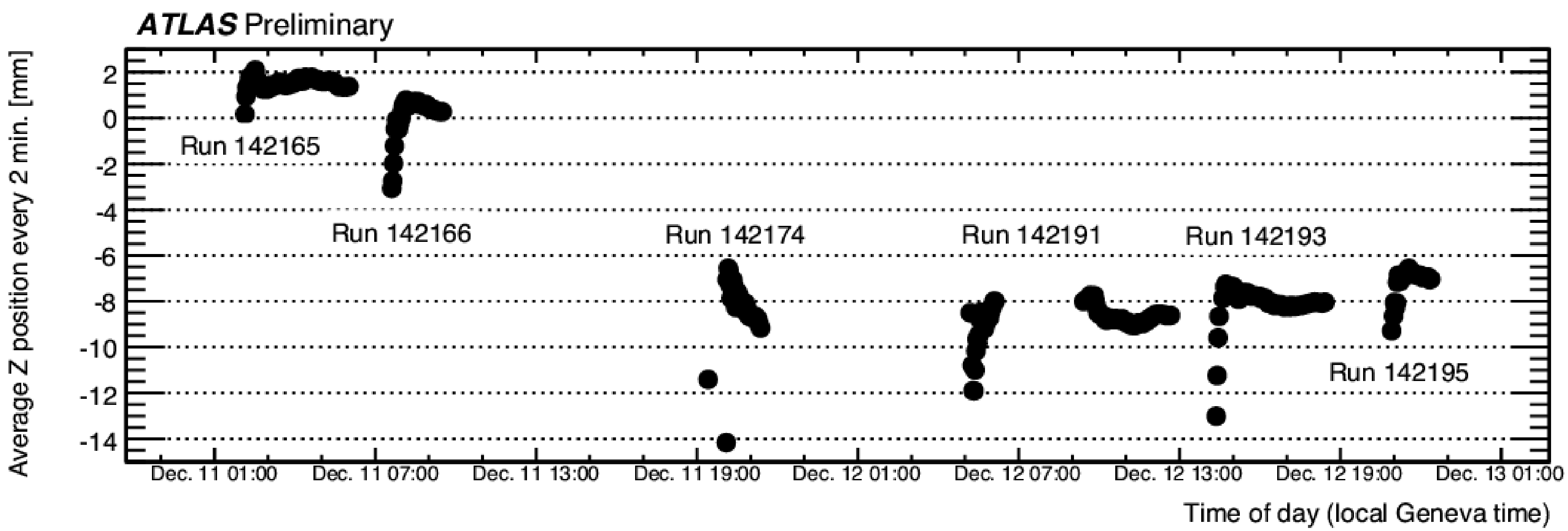
- Online measurement of beamspot using L2 fast tracking and vertexing algorithms
- L2 B-physics triggers rely on accurate beamspot position measurement
- Able to track beam spot position *in real time*; measurements confirmed by LHC
- Beam spot position fed back to L2 trigger algorithms, and to LHC operators











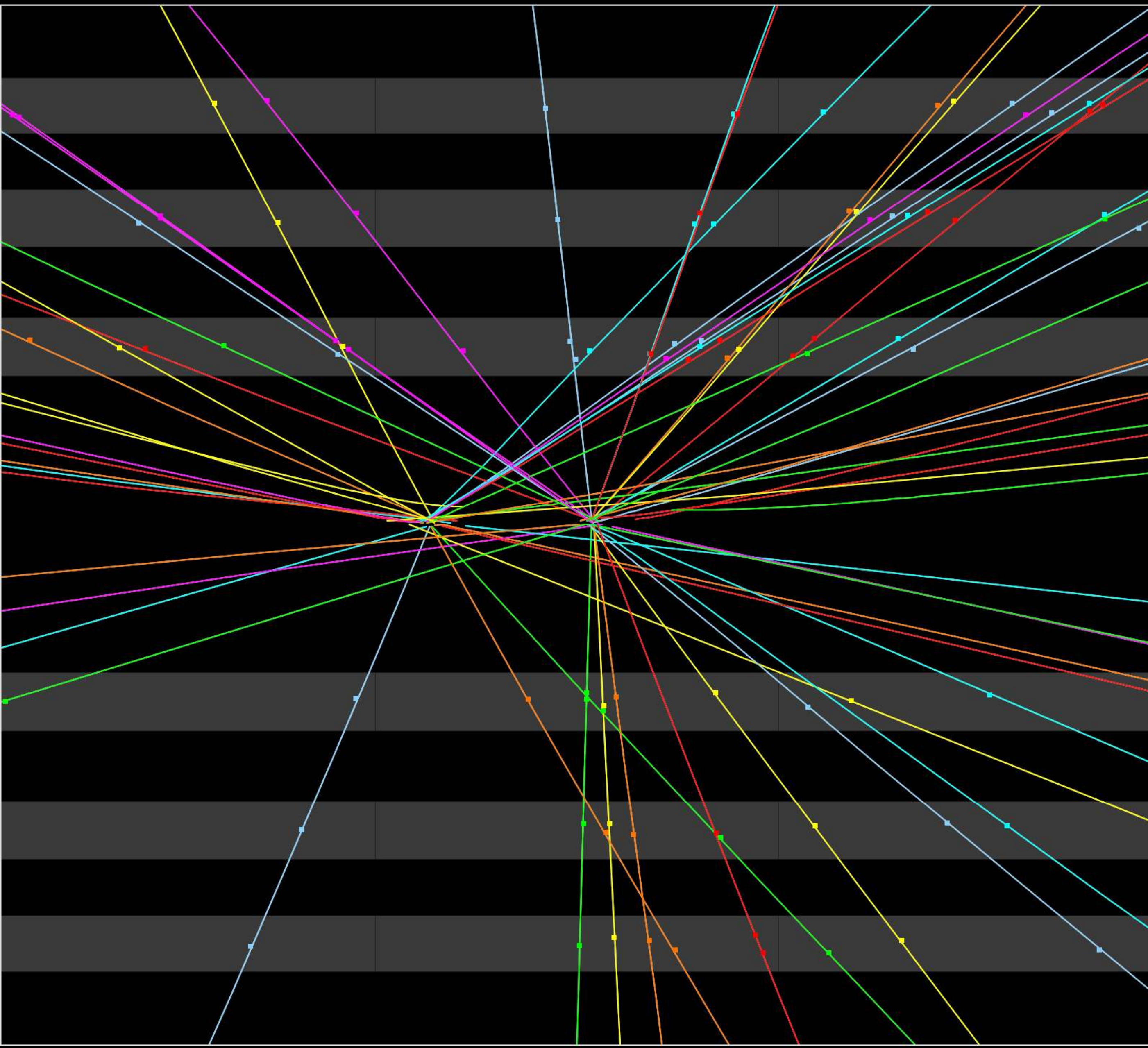
Charged particle multiplicities

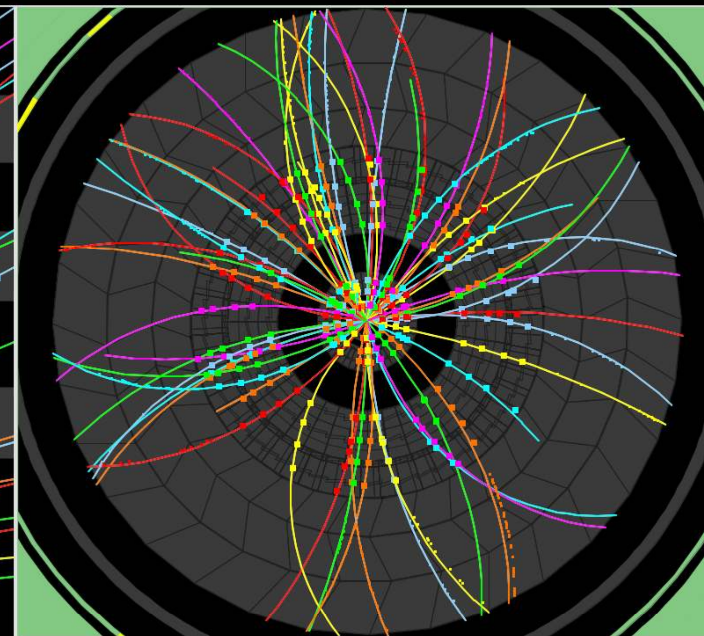
- Measurements of inclusive charged particle distributions at different $\sqrt{s}$ in hadronic colliders are used to
  - constrain models of soft hadronic interactions
  - predict event properties at higher $\sqrt{s}$

- $\sqrt{s}$=900 GeV analysis published (PLB **688** (2010) Issue 1, 21-42.)

- $\sqrt{s}$=7 TeV analysis now public
  - based on 6.8/μb of data (370k events collected on first 7 TeV run – 30/3/2010)
  - single-arm min. bias trigger
  - events with at least on charged track with p_T> 500 MeV/c and $|\eta|<2.5$
  - pile up! Non-negligible probability of a *second* pp interaction in *same* bunch-crossing (~1/1000, in this run). Such events (487) were removed.

Collision Event at 7 TeV with 2 Pile Up Vertices





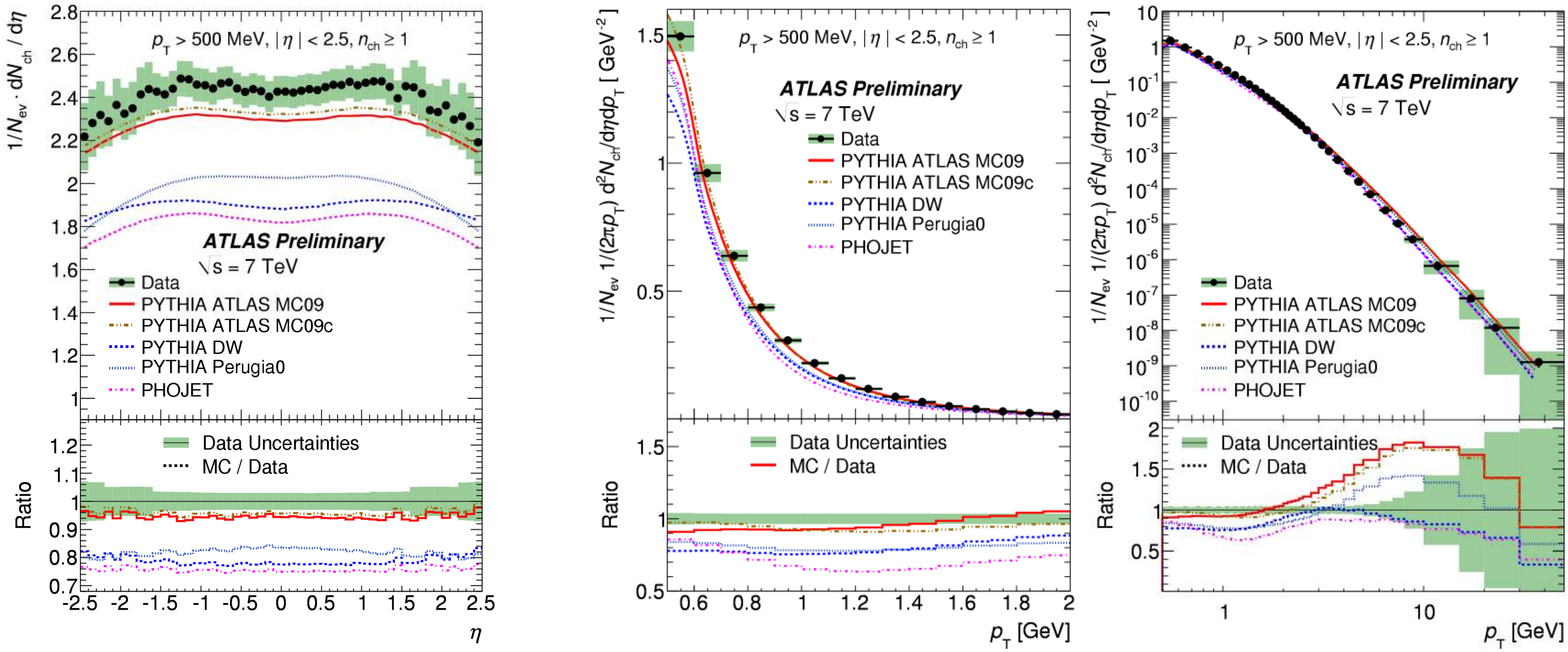
ATLAS EXPERIMENT

Run Number: 152166, Event Number: 467774

Date: 2010-03-30 13:31:46 CEST

http://atlas.web.cern.ch/Atlas/public/EVTDISPLAY/events.html

Charged particle multiplicities



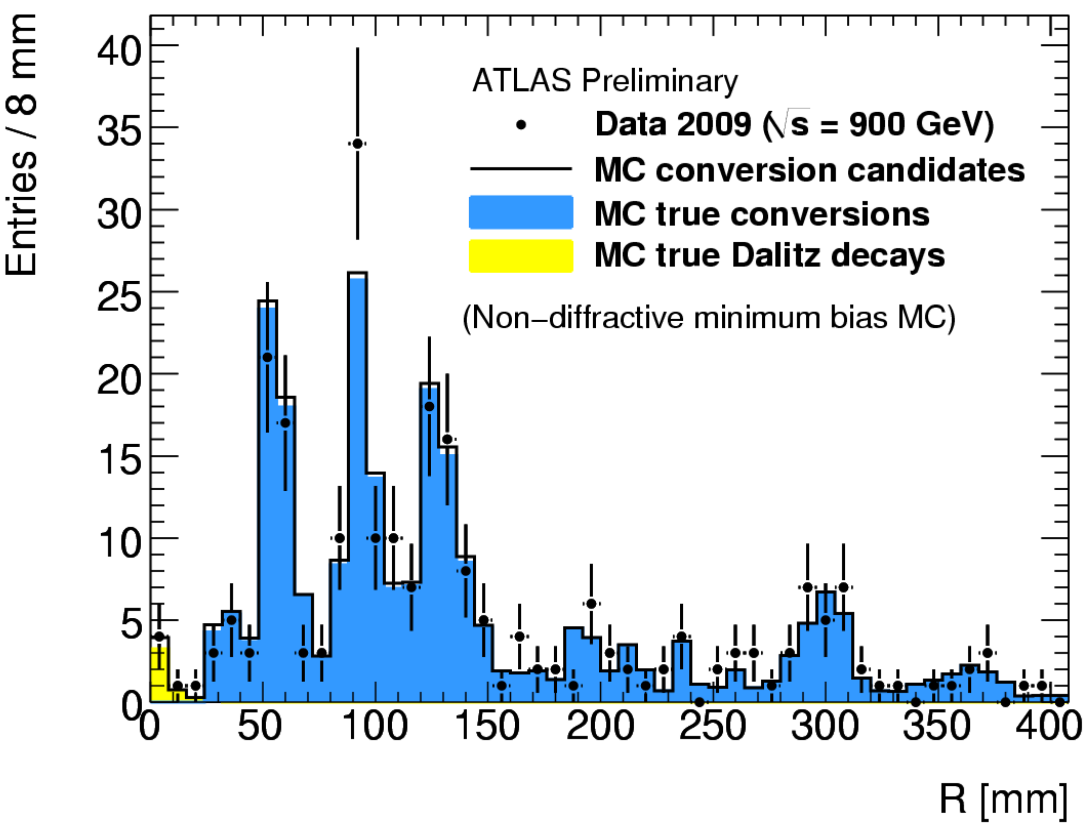
Charged particle density as function of η

- Overall: MC models are 5-20% lower than data
- Best description by PYTHIA ATLAS MC09c tune: same shape, 5% lower

Charged particle density as function of p_T

- Data covers more than 8 orders magnitude
- Good description up to 2 GeV, but significantly harder spectrum predicted above…

Investigate ATLAS tracker material with photon conversions

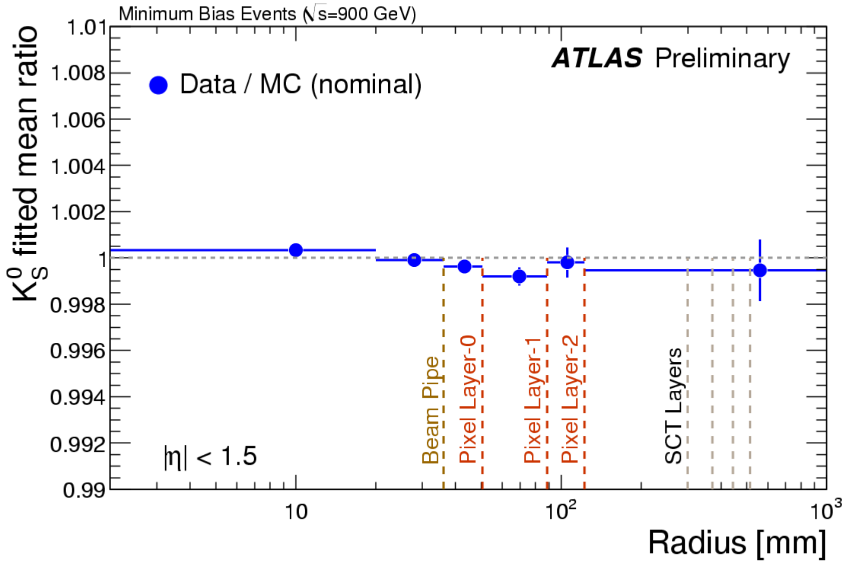


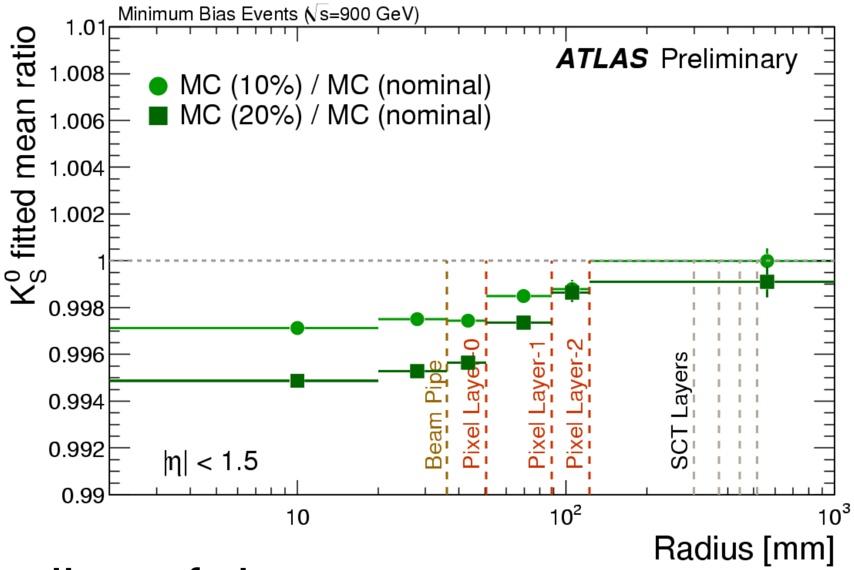
- Up to 50% of all photons convert ($\gamma \rightarrow e^+e^-$) before leaving the SCT
- Reconstruct conversion vertices: good performance of algorithm
- First cross-check (still low stats.) of tracker material: MC represents real detector well

Study of Inner Detector material budget with K_s decays

Measure $K_S \rightarrow \pi^+\pi^-$ invariant mass

- IF incorrect material modelling:
  → incorrect compensation of π's ionisation energy losses
  → biased p(π) reconstruction → biased $m(K_S)$ measurement





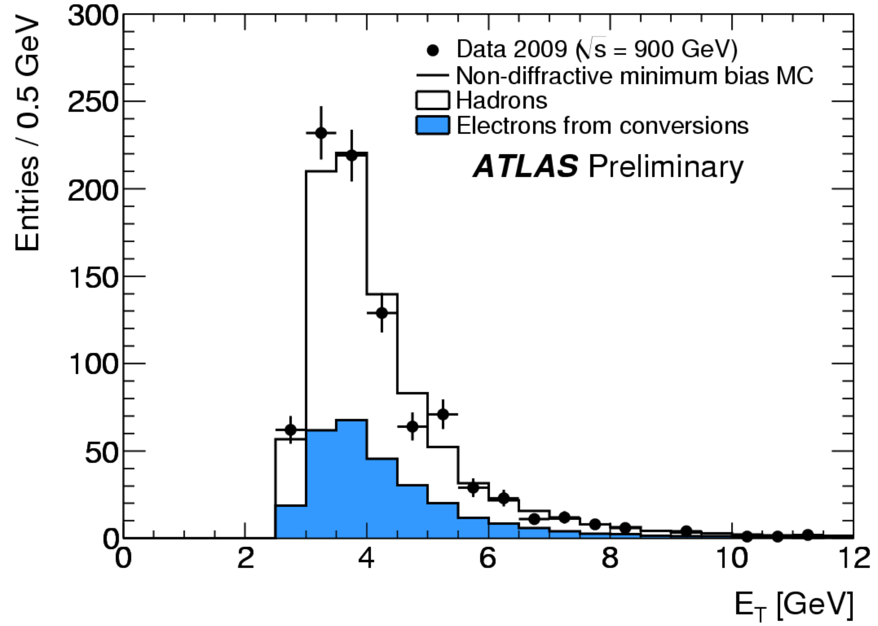
- Study detector material as function of radius of decay vertex (cτ=2.7cm)
- Excellent agreement between data and *nominal* MC
- Ruled out scenarios with 10%, 20% extra radiation lengths of material
- Estimate of extra radiation lengths of material in Pixel detector: (1.4 ± 1.5)%

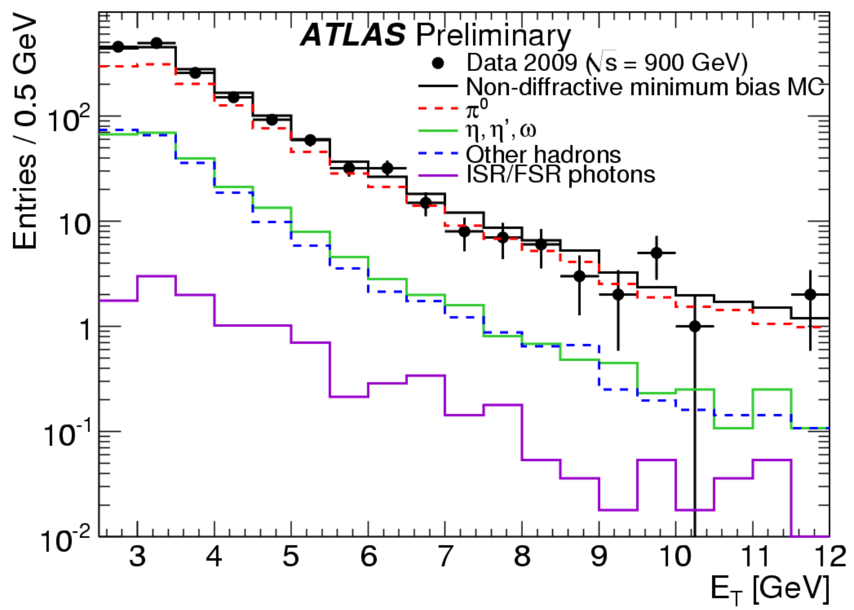
Physics objects: e, γ, μ, jets, $E_{T,miss}$, ...

Electrons, photons, muons…

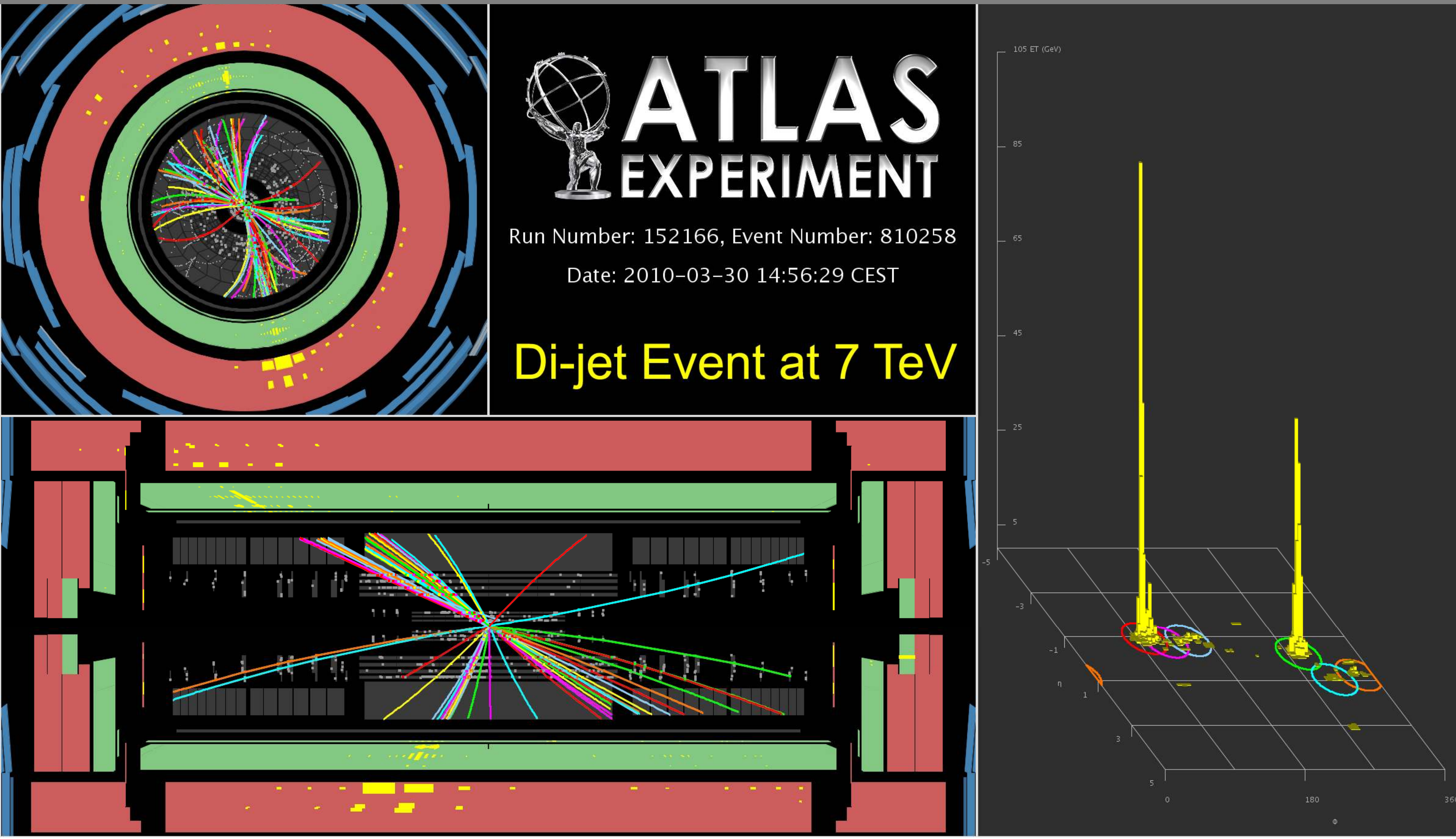
Small samples of Electron, Photon and Muon candidates selected

- In the $\sqrt{s}$=900 GeV run candidates are typically at low energy (E_T<10 GeV), for which the e/γ/μ selections are not optimal
- Nevertheless, good agreement with simulation, within the low statistics





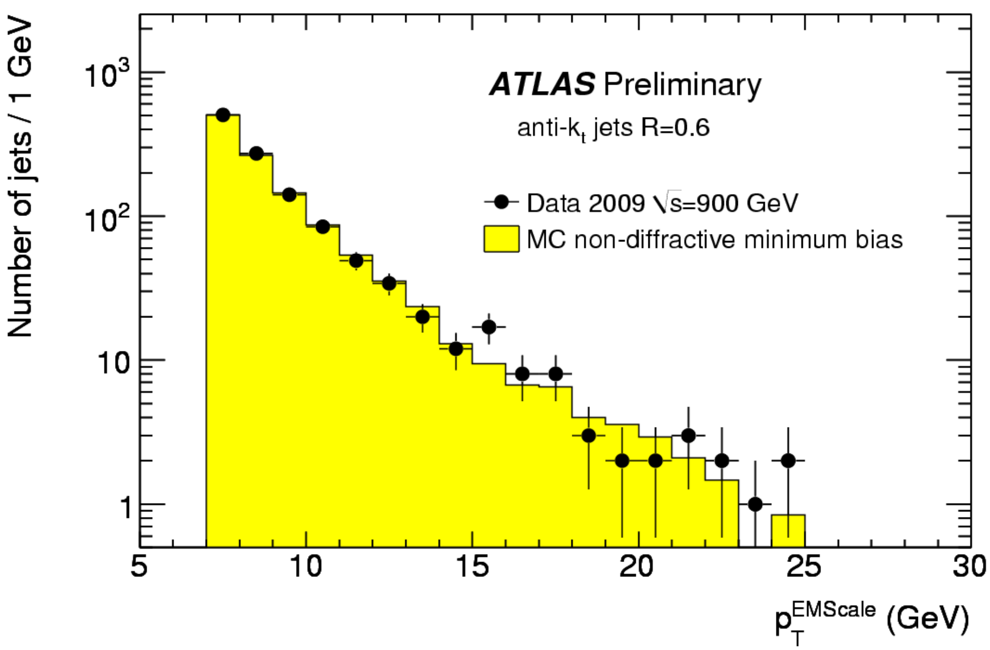
Jets!

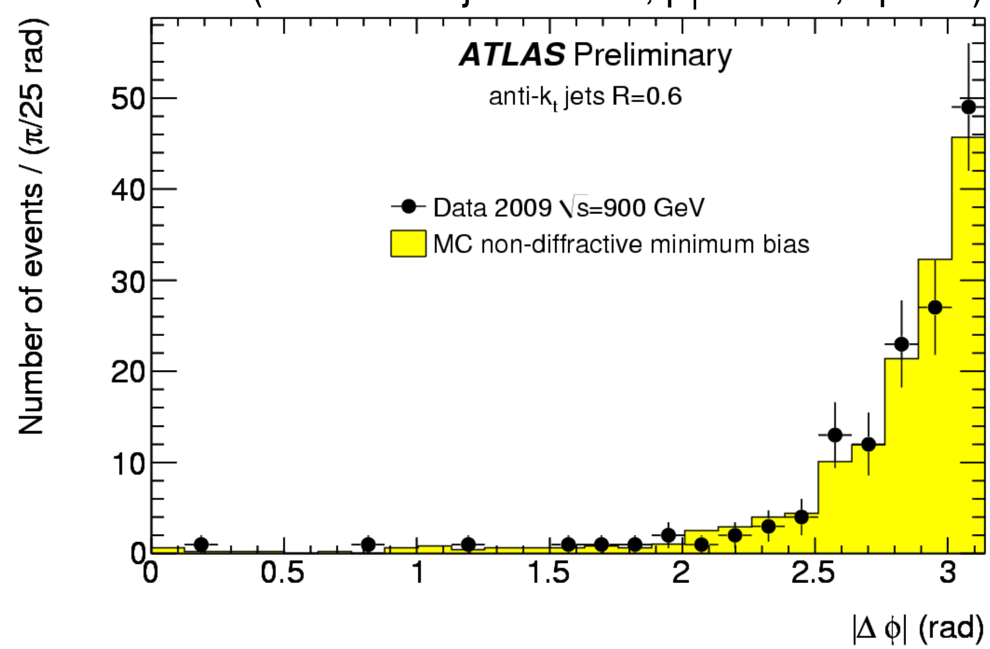

ATLAS EXPERIMENT
Run Number: 152166, Event Number: 810258
Date: 2010-03-30 14:56:29 CEST
Di-jet Event at 7 TeV
105 ET (GeV)
85
65
45
25
5
η
Φ
0
180
360

Jets seen...

- Jets reconstructed, using anti-k_T (R=0.6) algorithm: both calorimeter jets and track jets.
- One jet, and two jet (back-to-back) events observed
- For both calo/track jets: basic jet kinematics and topology (p_T, η, φ, $\Delta\varphi$) are well described in the simulation

(calorimeter jets shown; p_T>7 GeV; |η|<2.6)

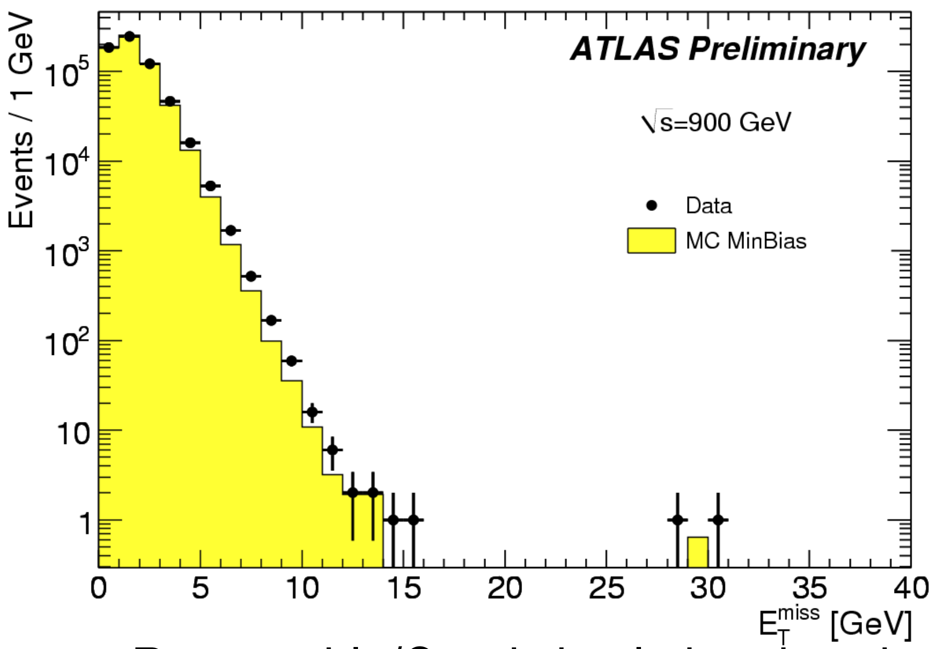


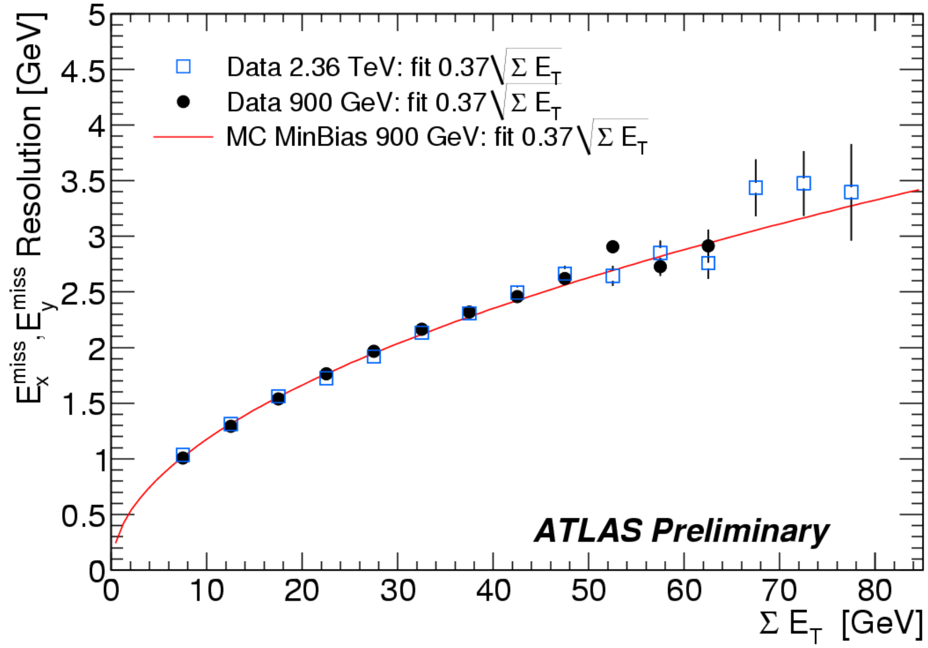


- Internal jet structure (charged part. multiplicities, width, profile!) also investigated

Missing transverse energy

- test performance of $E_{T,miss}$ reconstruction
- measured using topological clusters in the calorimeter; built-in noise suppression
- energies at the EM scale; not corrected for muons – as almost none in 900 GeV sample

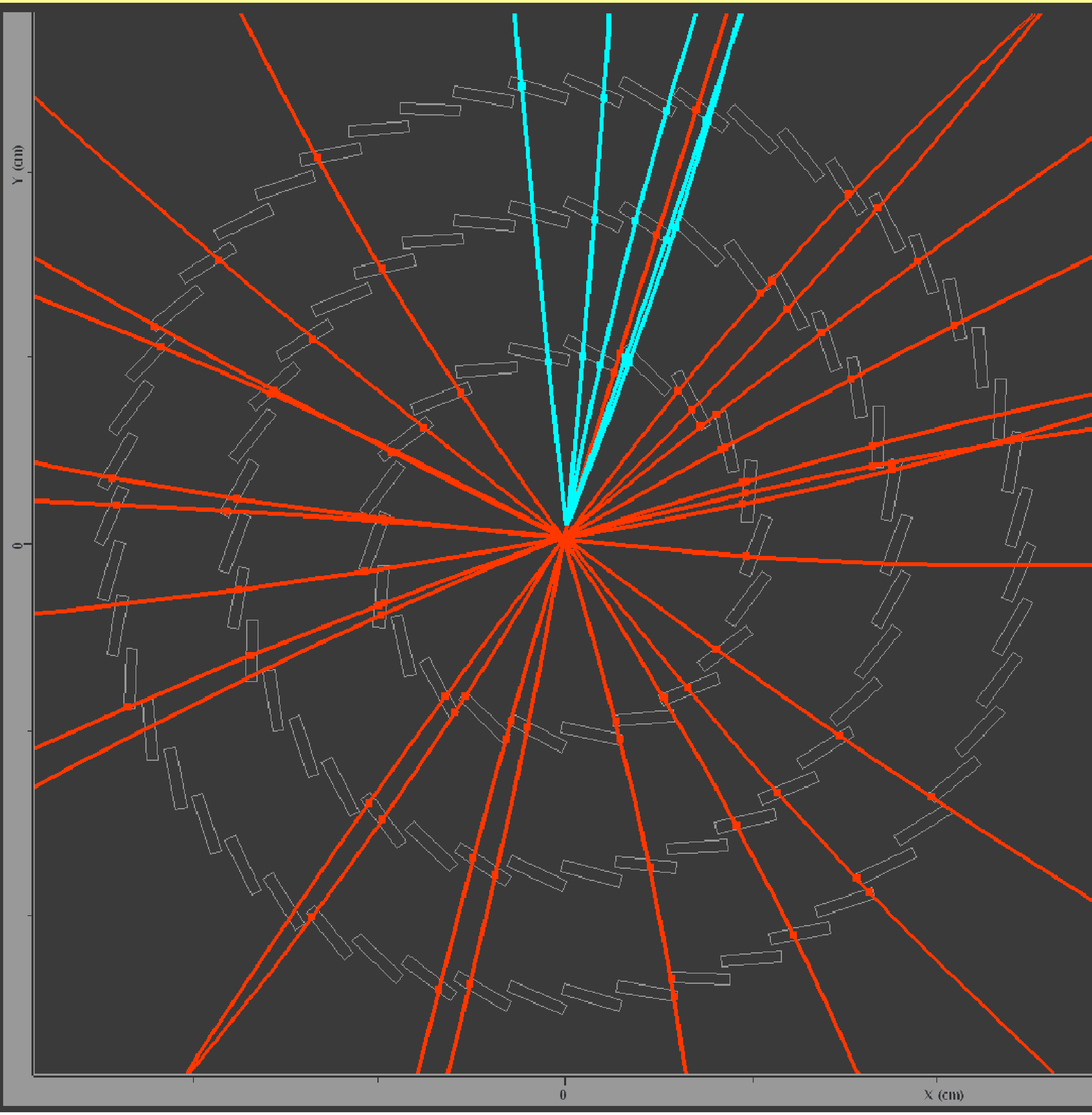




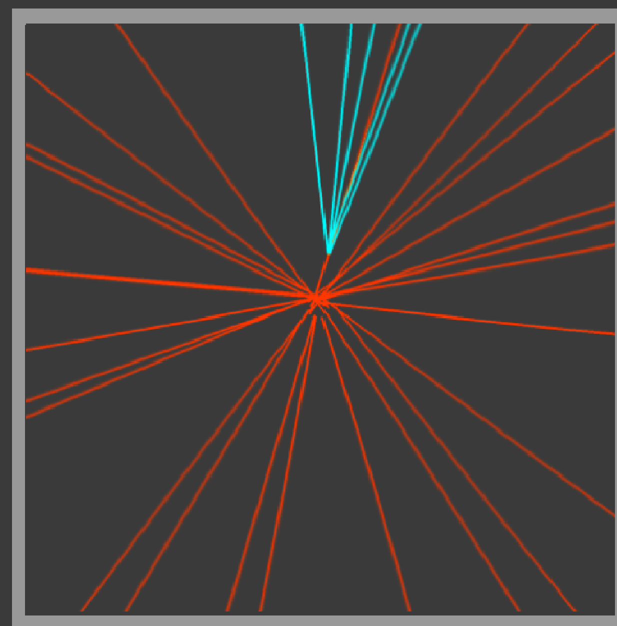
- Reasonable/Good simulation description

- Expect improvements next: $E_{T,miss}$ reconstructed with dedicated calibrations for each type of object (e/jet/τ, etc)

b-tagging (secondary vertex b-jet candidate)



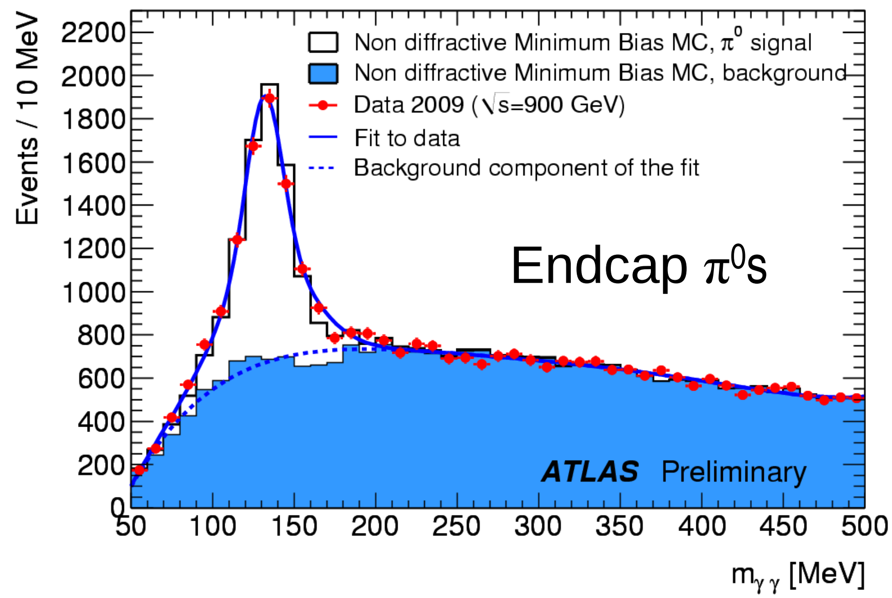
Decay length = 3.7 mm
Decay length signficance = 22
Lifetime = 3.1 ps
Vertex mass = 2.5 GeV
Number of tracks = 5

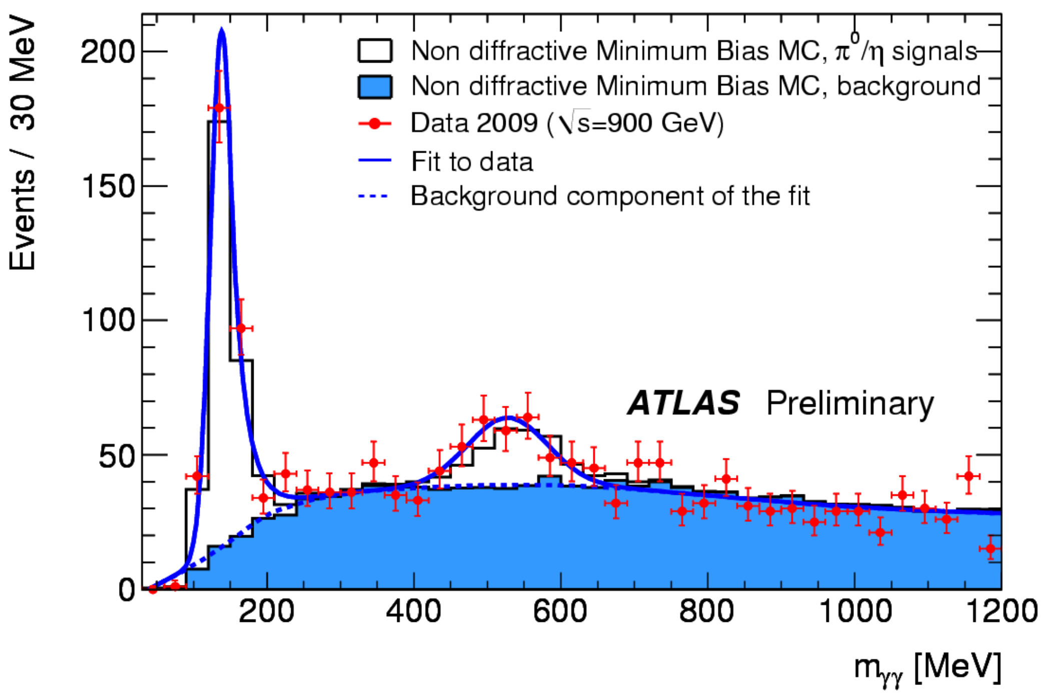


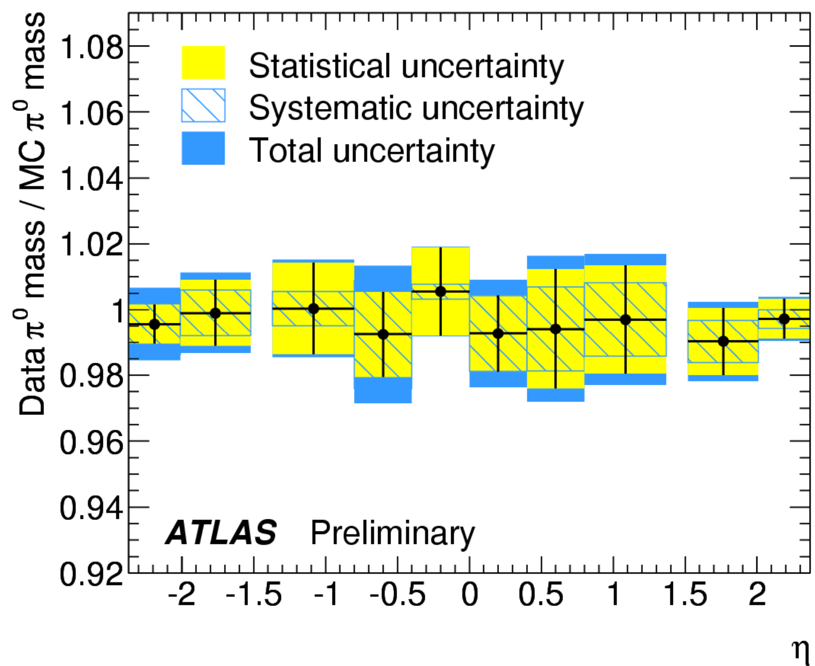
Particle reconstruction: π^0, η, K_S, φ, J/ψ, W, …

$\pi^0 \to \gamma\gamma$ and $\eta \to \gamma\gamma$

- Pi and eta signals extracted; fits in very good agreement with MC expectation
- Uniformity of EM calorimeter response better than ~2% (900 GeV run)



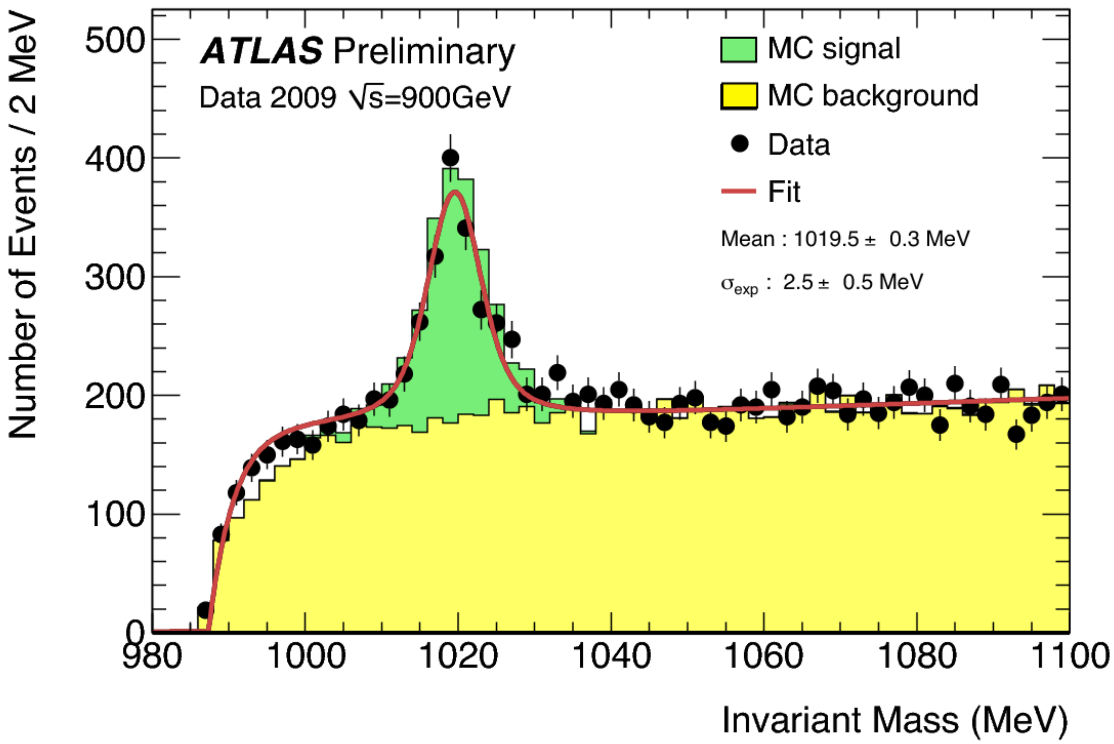




φ(1020)-meson production

Several thousand $\Phi \rightarrow K^+K^-$ reconstructed

- K identified via dE/dx, to reduce π background
- Tracks fitted under K (cf π) hypothesis, due to higher dE/dx → improved momentum
- Signal fits are in excellent agreement with world average
- Background mostly combinatorial → bgd level very sensitive to exact ch. part. mults.

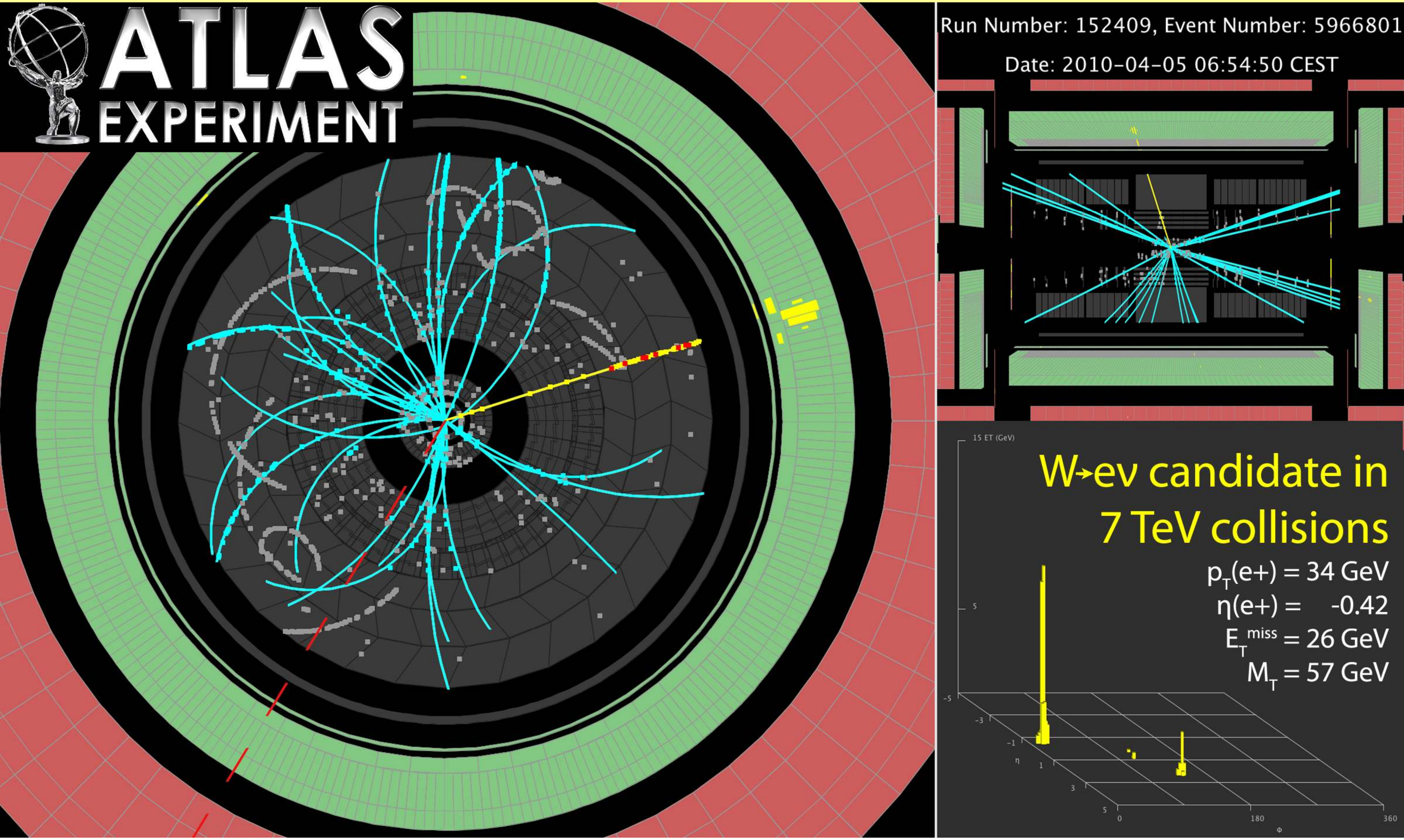


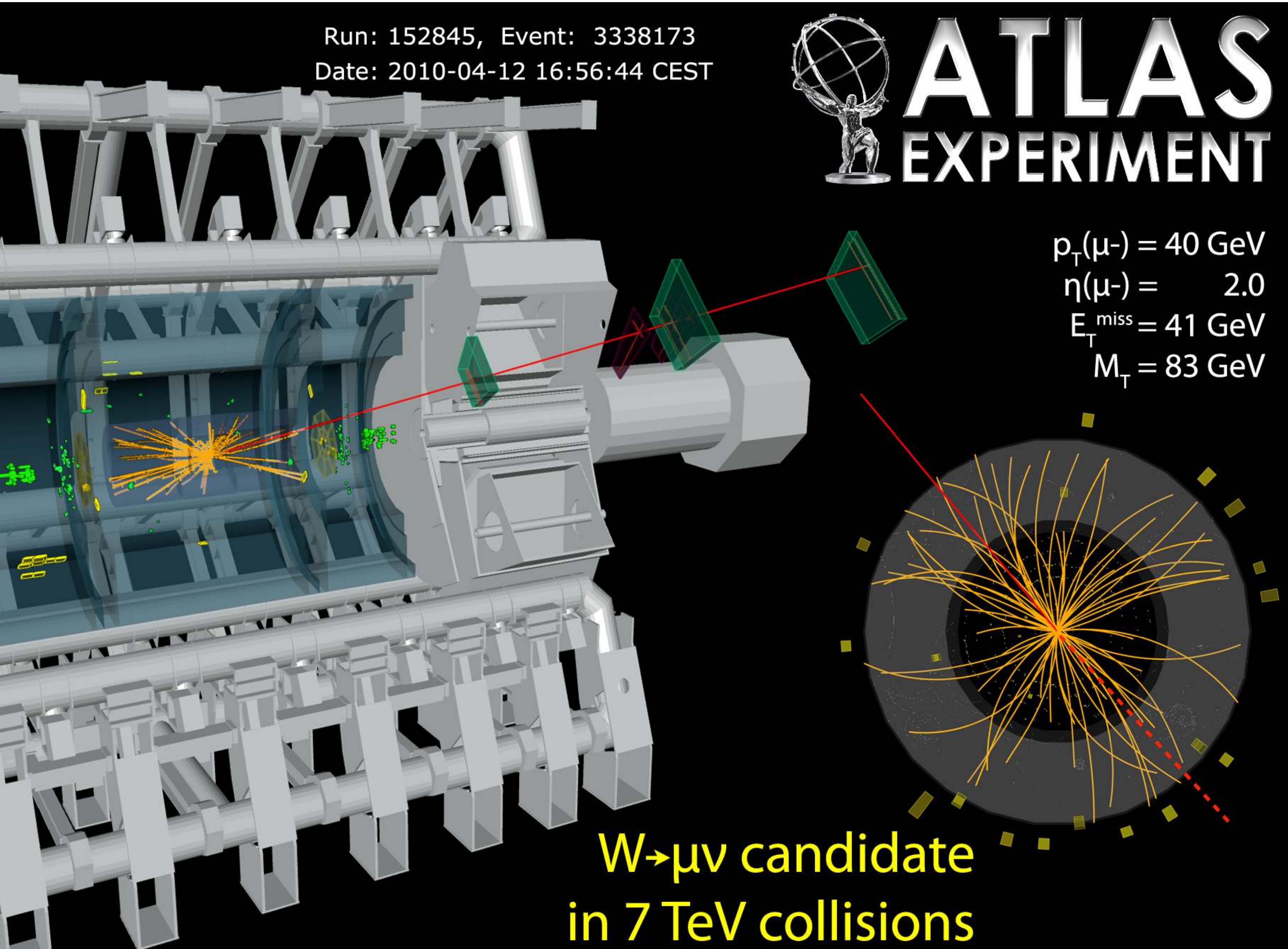
$m(\varphi) = 1019.5 \pm 0.3$ MeV

cf. world average:

$m(\varphi) = 1019.445 \pm 0.020$ MeV

$W \rightarrow e\nu$ / $\mu\nu$ candidates



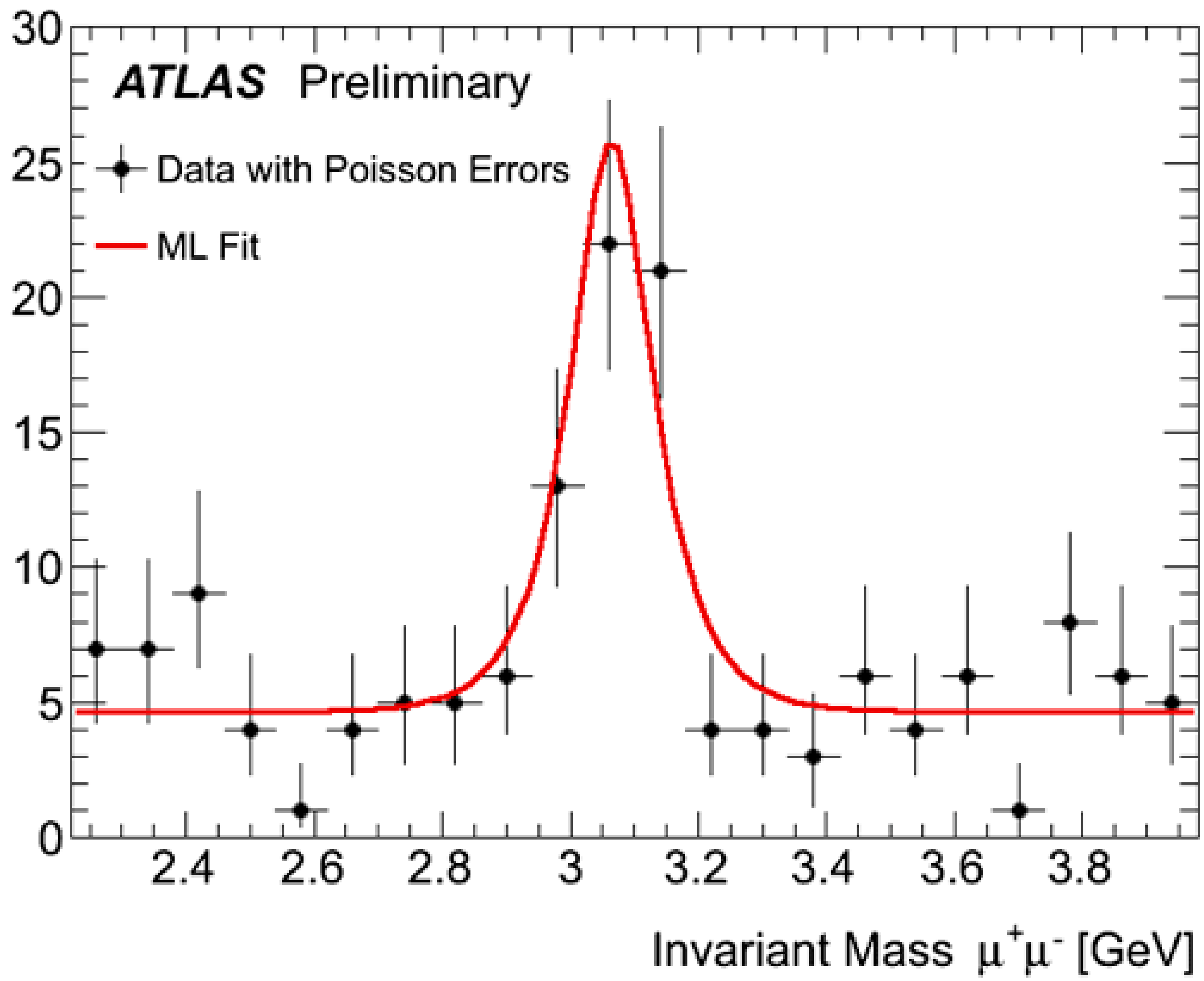

Run: 152845, Event: 3338173
Date: 2010-04-12 16:56:44 CEST
ATLAS
EXPERIMENT
$p_T(\mu-) = 40$ GeV
$\eta(\mu-) = 2.0$
$E_T^{miss} = 41$ GeV
$M_T = 83$ GeV
W→μν candidate
in 7 TeV collisions

Conclusion and Outlook

- Very successful detector operation and ongoing commissioning
- Very impressive and detailed effort to cross-check MC models, detector simulation & performance; implement improvements; extract first results.
- Extremely exciting to be starting off so well on this journey of discovery
- Looking forward to loads more data this summer and beyond…

Backup slides

$J/\psi \rightarrow \mu\mu$ ($\sqrt{s}$=7 TeV)



ATLAS H→WW→ℓνℓν sensitivity