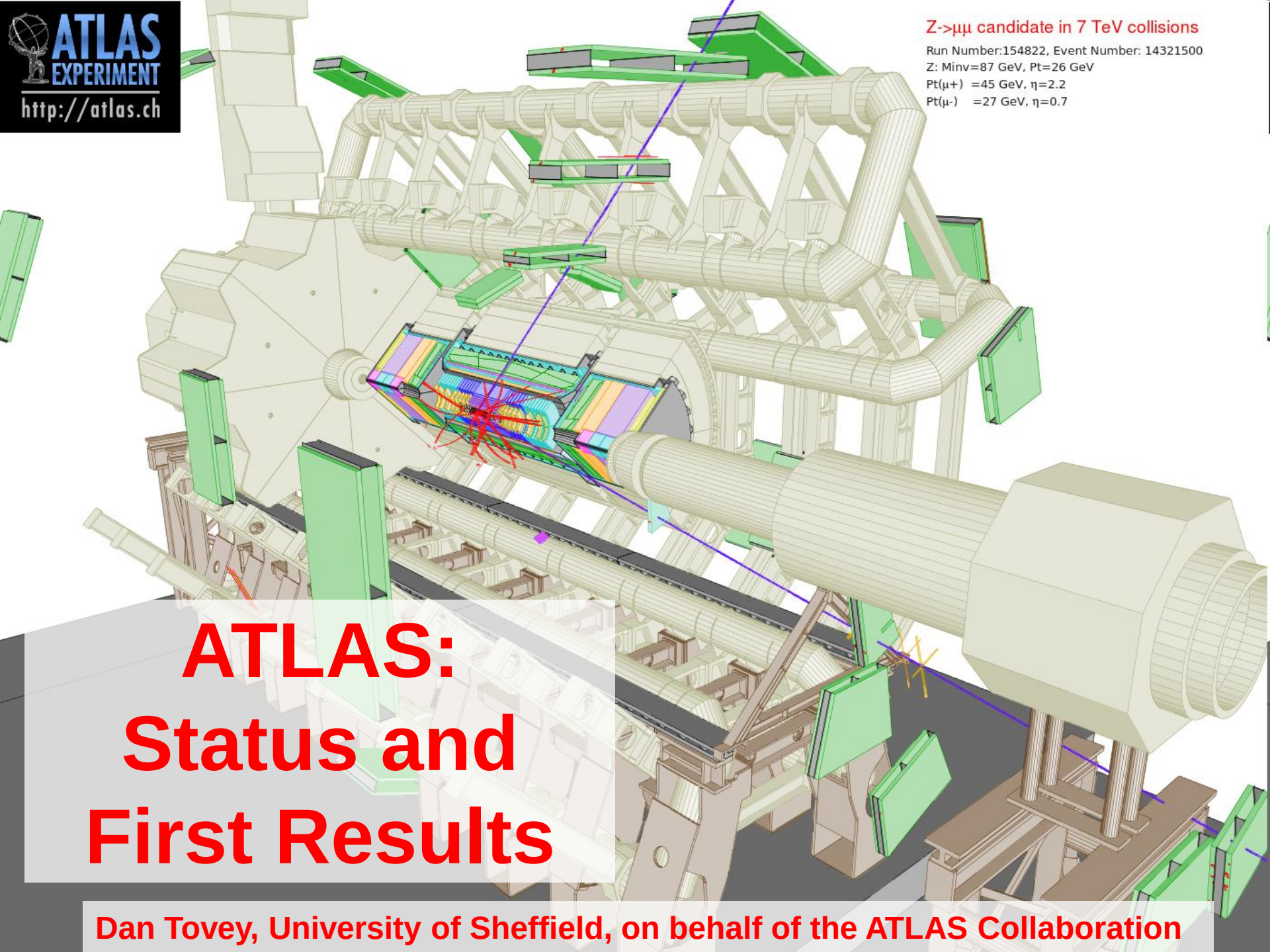
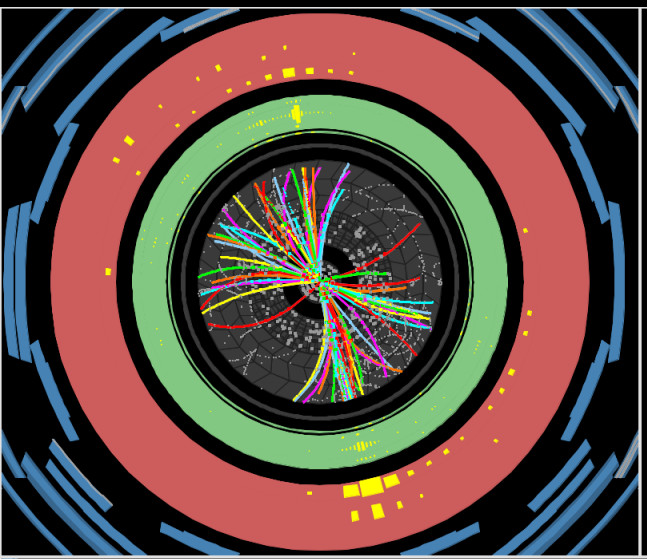


ATLAS: Status and First Results

Dan Tovey, University of Sheffield, on behalf of the ATLAS Collaboration

- Overview of the ATLAS detector
- Status of the experiment
- Performance and physics results in the first six months
- Future milestones

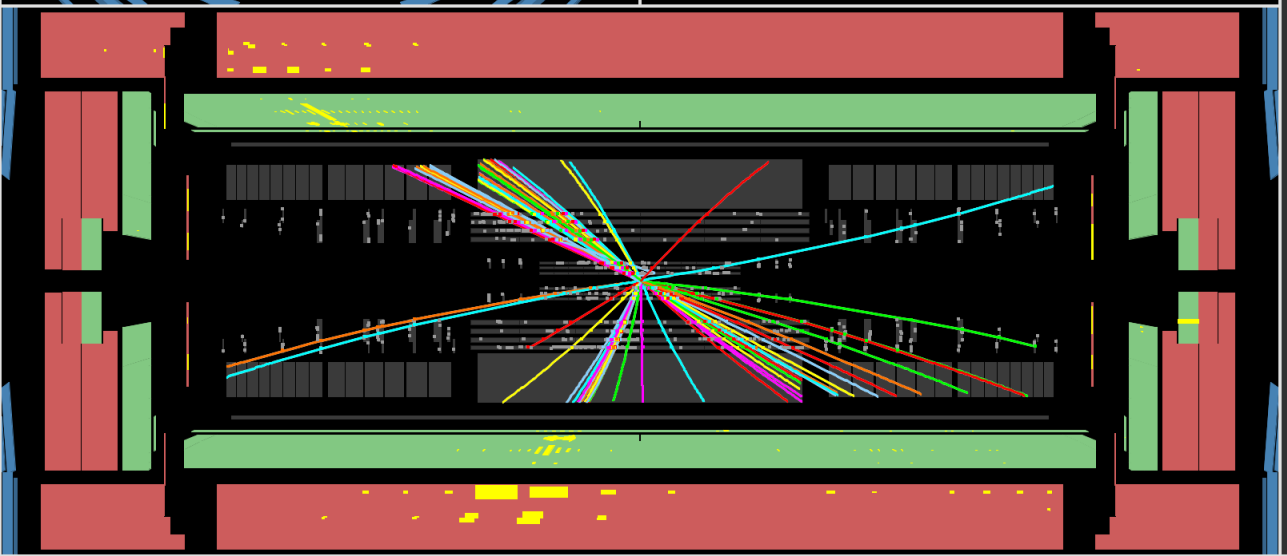


ATLAS EXPERIMENT

Run Number: 152166, Event Number: 810258

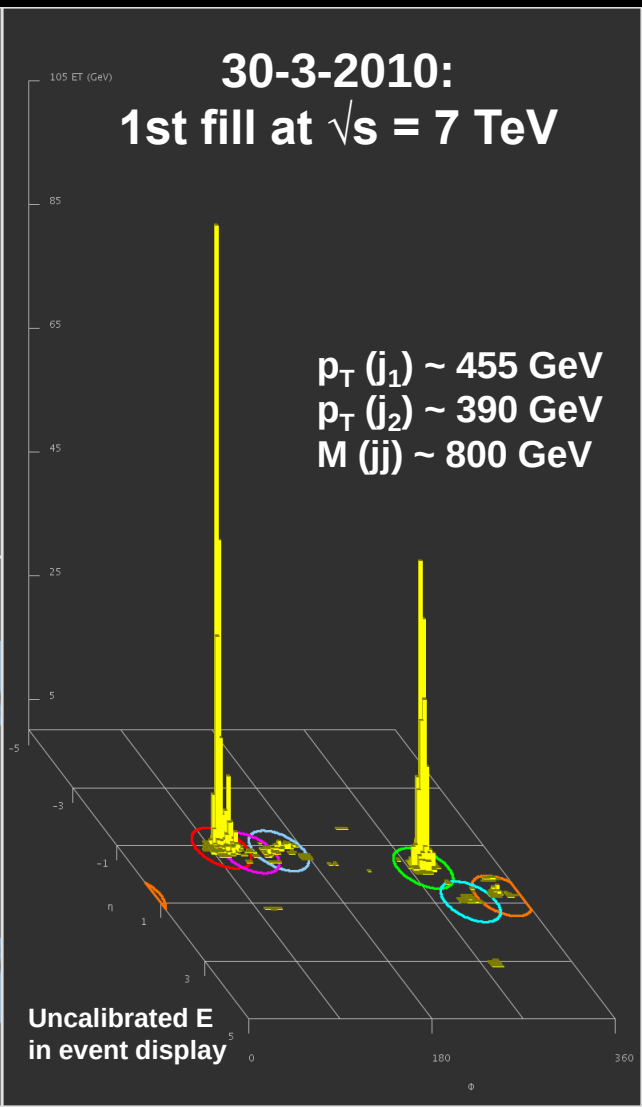
Date: 2010-03-30 14:56:29 CEST

Di-jet Event at 7 TeV

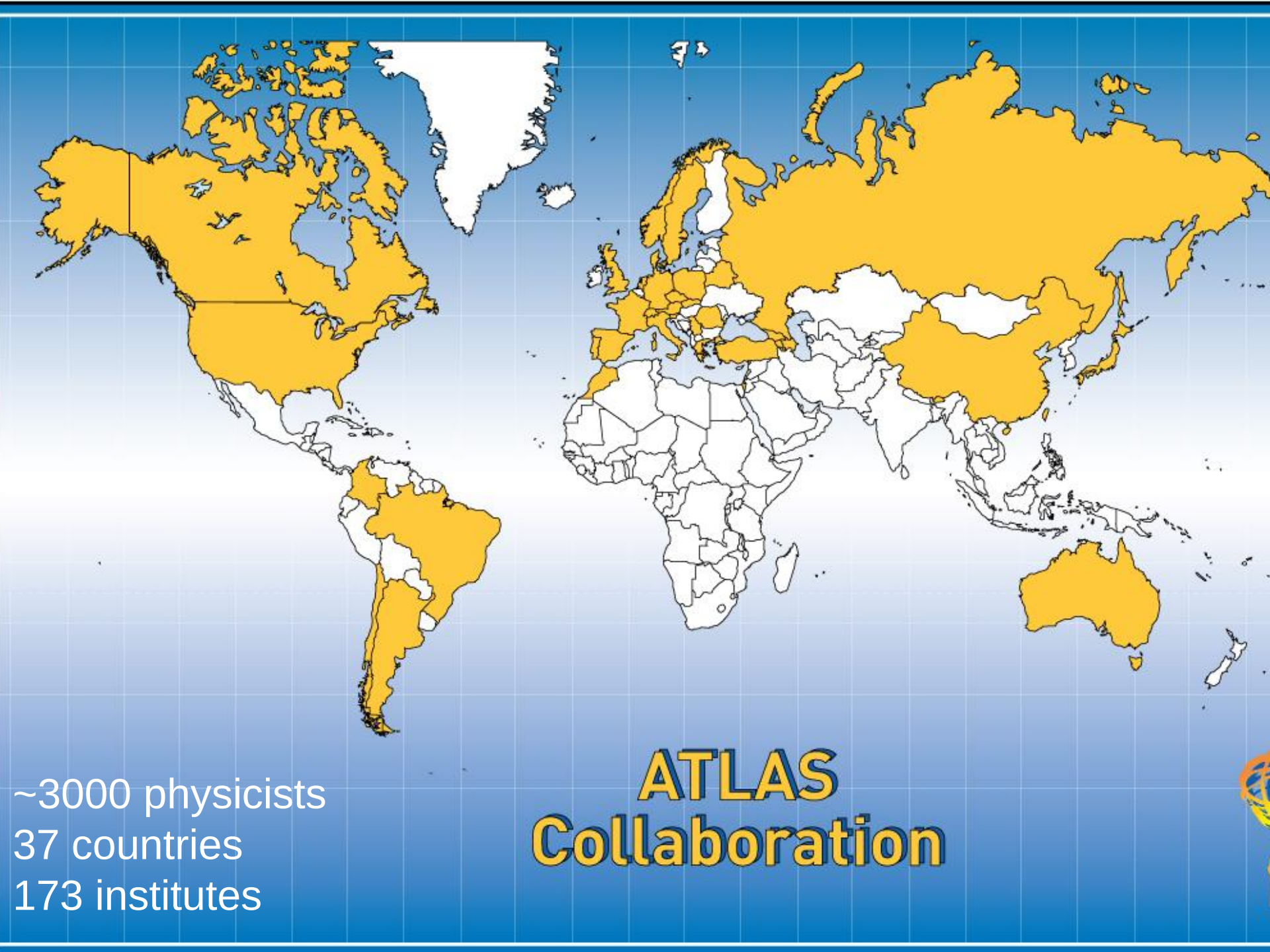


30-3-2010:
1st fill at $\sqrt{s}$ = 7 TeV

p_T (j_1) ~ 455 GeV
p_T (j_2) ~ 390 GeV
M (jj) ~ 800 GeV



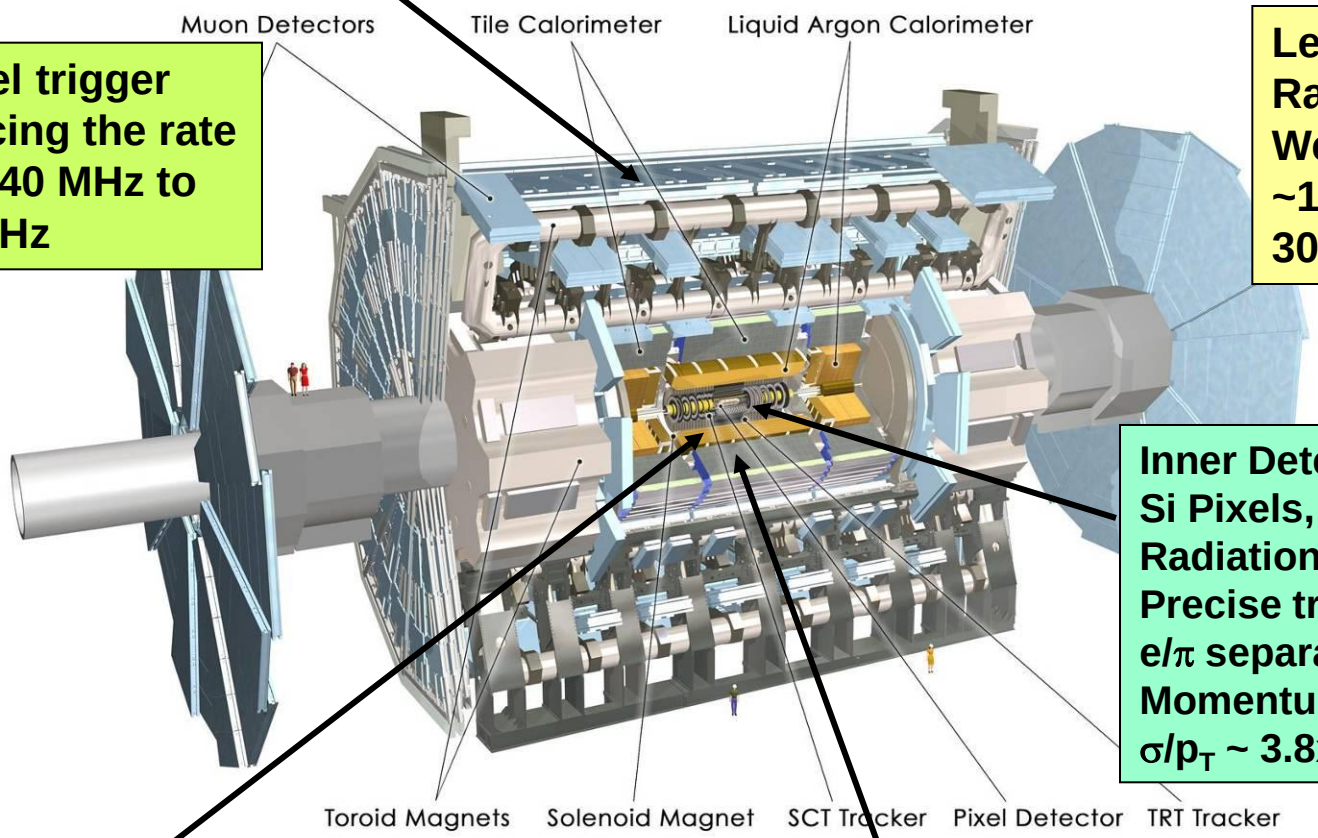
Uncalibrated E
in event display


~3000 physicists
37 countries
173 institutes
ATLAS
Collaboration

The ATLAS Detector

Muon Spectrometer ($|\eta|<2.7$) : air-core toroids with gas-based muon chambers
Muon trigger and measurement with momentum resolution < 10% up to $E_\mu \sim 1$ TeV

3-level trigger reducing the rate from 40 MHz to ~200 Hz



Length : ~ 46 m
Radius : ~ 12 m
Weight : ~ 7000 tons
~10^8 electronic channels
3000 km of cables

Inner Detector ($|\eta|<2.5$, B=2T):
Si Pixels, Si strips, Transition Radiation detector (straws)
Precise tracking and vertexing, e/π separation
Momentum resolution ($\eta=0$):
$\sigma/p_T \sim 3.8\times10^{-4}\ p_T\,(\text{GeV}) \oplus 0.015$

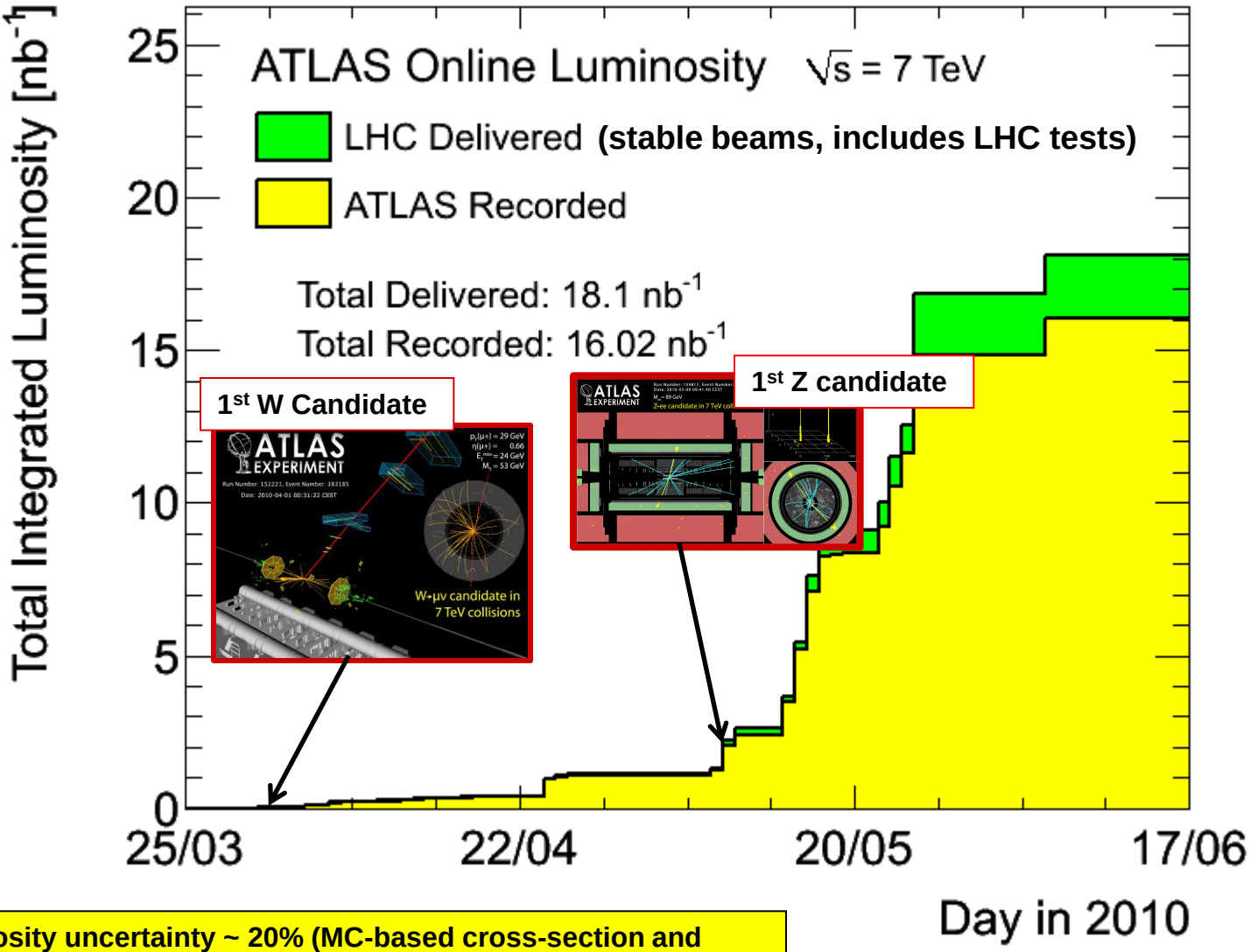
EM calorimeter: Pb-LAr Accordion
e/γ trigger, identification and measurement
E-resolution: $\sigma/E \sim 10\%/\sqrt{E}$

HAD calorimetry ($|\eta|<5$)
Fe/scintillator Tiles (central), Cu/W-LAr (fwd)
Trigger and measurement of jets and missing E_T
E-resolution: $\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$

First Six Months of Operation

- **20 Nov – 23 Dec :**
  - **First physics run at √s = 900 GeV (few hours √s = 2.36 TeV)**
  - **ATLAS recorded ~ 12 μb-1, 0.5M events**
- **16 Dec- 28 Feb:**
  - **Winter technical stop**
- **Since 30 March:**
  - **LHC running at √s = 7 TeV**

Data-Taking Status



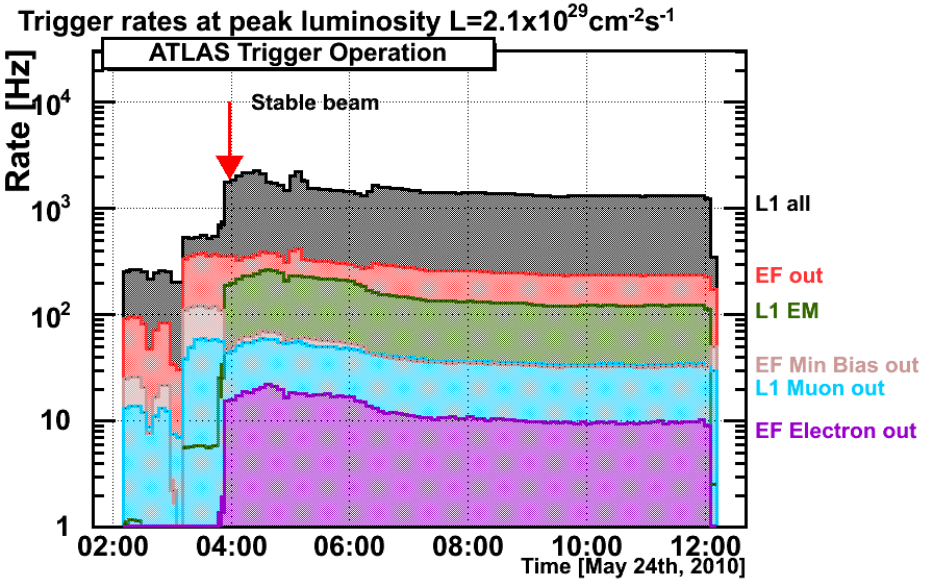
Absolute luminosity uncertainty ~ 20% (MC-based cross-section and acceptance of luminosity detectors) ➔ <10% soon (Van der Meer scans)

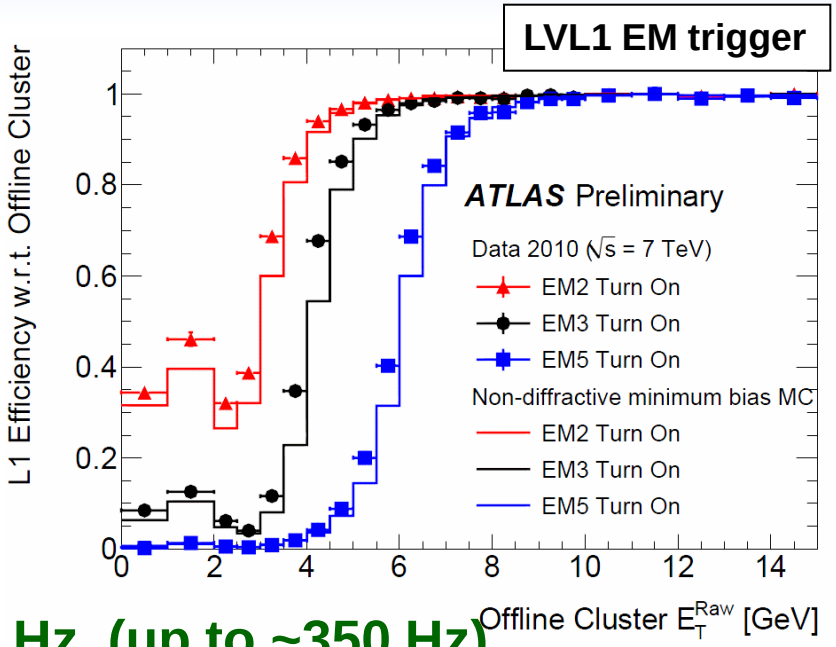
Detector Status

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%

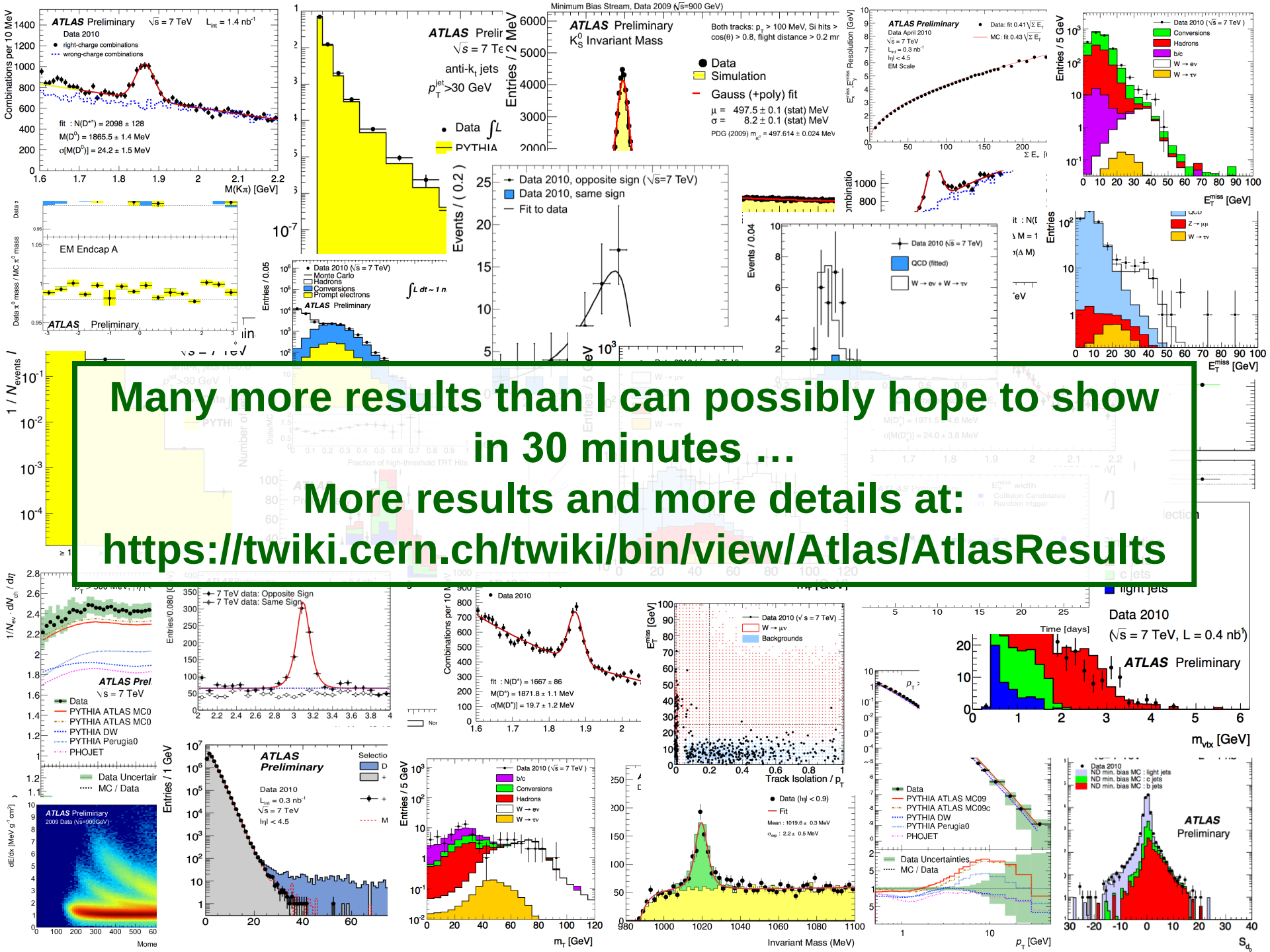
- **Overall data taking efficiency: ~ 92%**
- **Recorded with all detectors at nominal voltage (including Pixels): ~ 88 %**

Trigger Status





- **Trigger output rate: typically 200-300 Hz (up to ~350 Hz)**
- **L < few 10^{27} cm^{-2} s^{-1}:**
  - **(un-prescaled) minimum-bias LVL1 trigger based on hits in scintillator counters (MBTS) located at Z=± 3.5 m from collision centre**
  - **LVL1 muon and calo (EM, jets, ..) triggers also active**
  - **HLT (LVL2+EF) commissioned by running mostly in pass-through mode**
- **L > few 10^{27} cm^{-2} s^{-1} : MBTS trigger pre-scaled**
- **L > 10^{29} cm^{-2} s^{-1}: e/γ HLT chain activated in rejection mode to be able to run with lowest-threshold EM LVL1 item (3 GeV)**

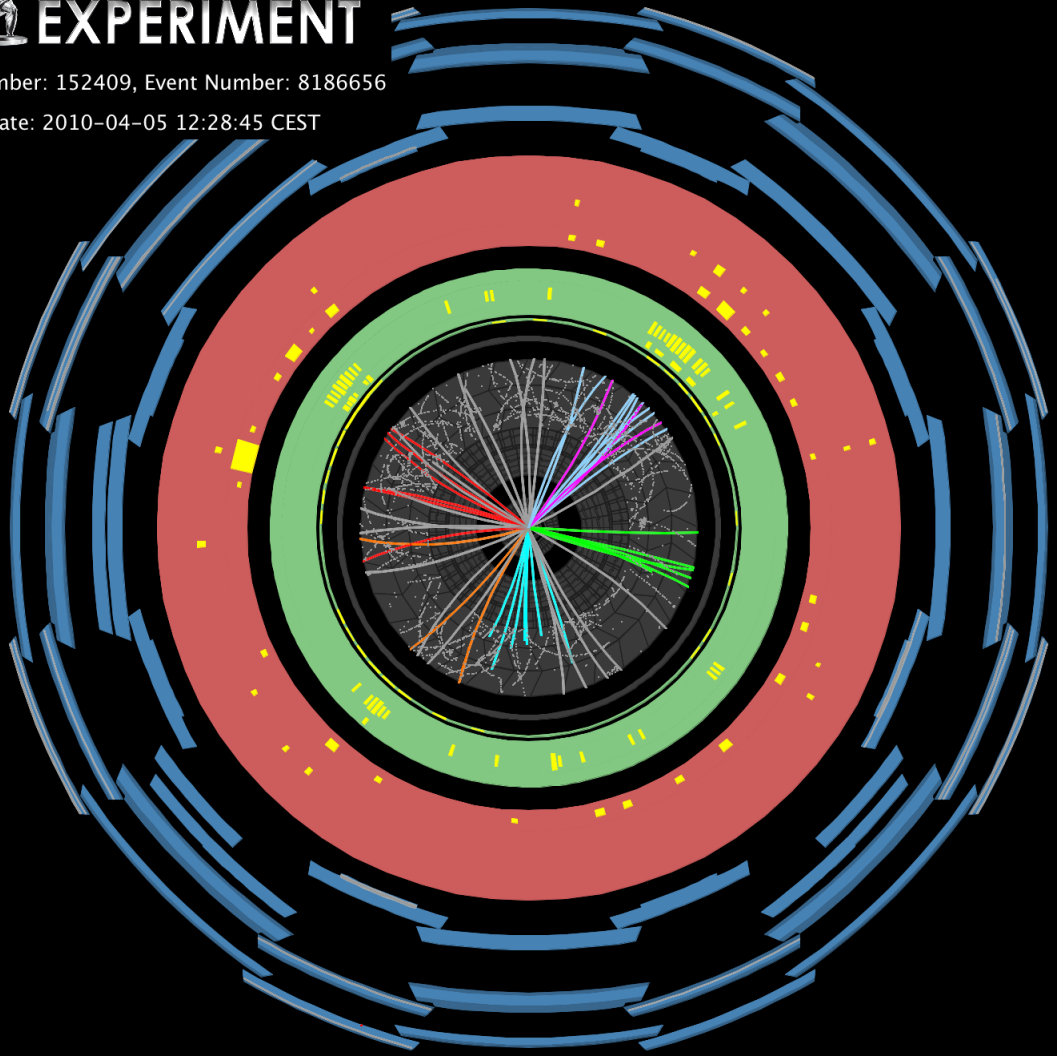

Many more results than I can possibly hope to show in 30 minutes …
More results and more details at:
https://twiki.cern.ch/twiki/bin/view/Atlas/AtlasResults

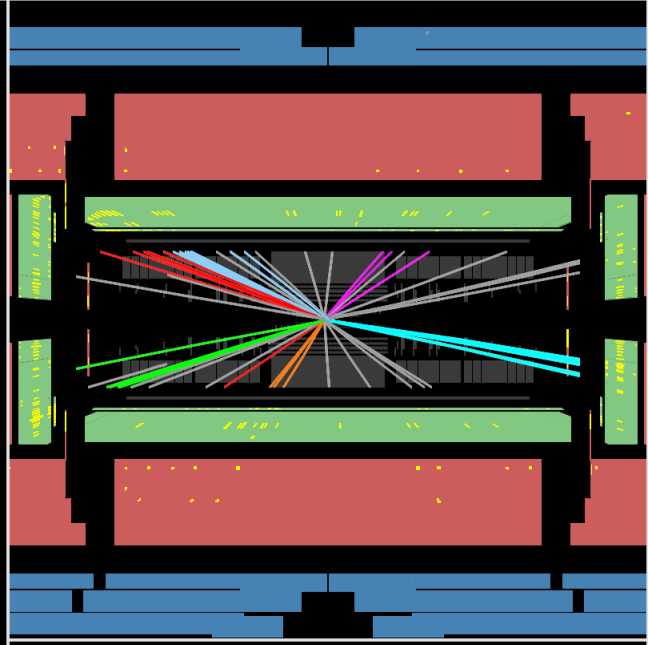
ATLAS EXPERIMENT

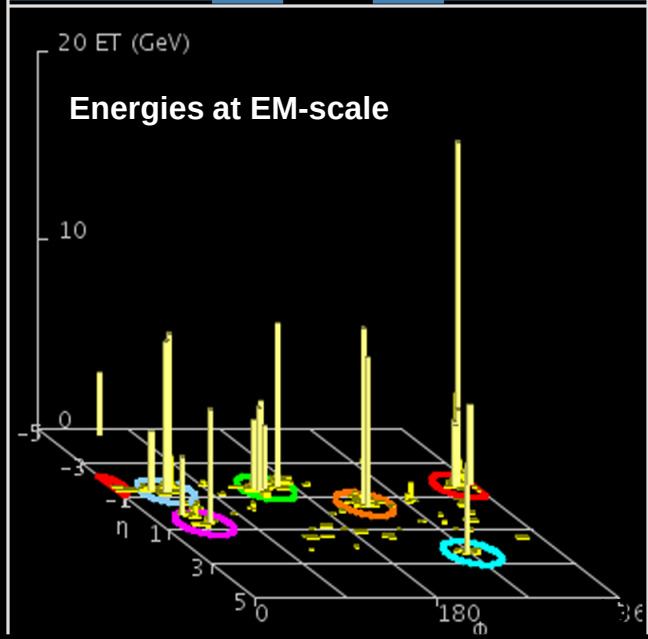
Run Number: 152409, Event Number: 8186656

Date: 2010-04-05 12:28:45 CEST

Maximum jet p_T 70 GeV





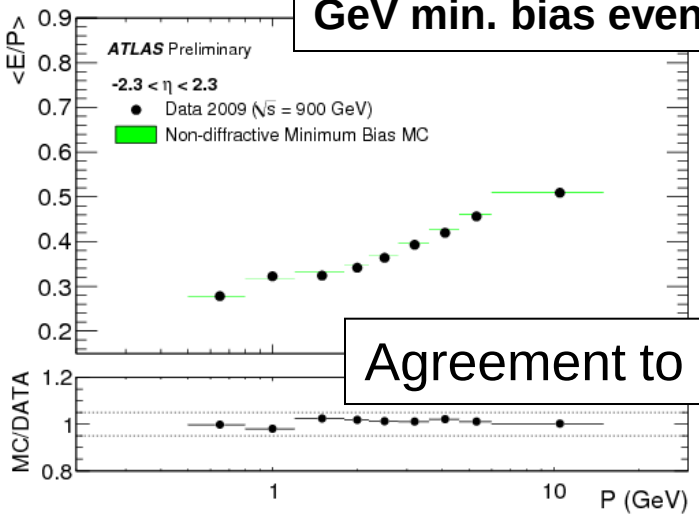


6 Jet Event in 7 TeV Collisions

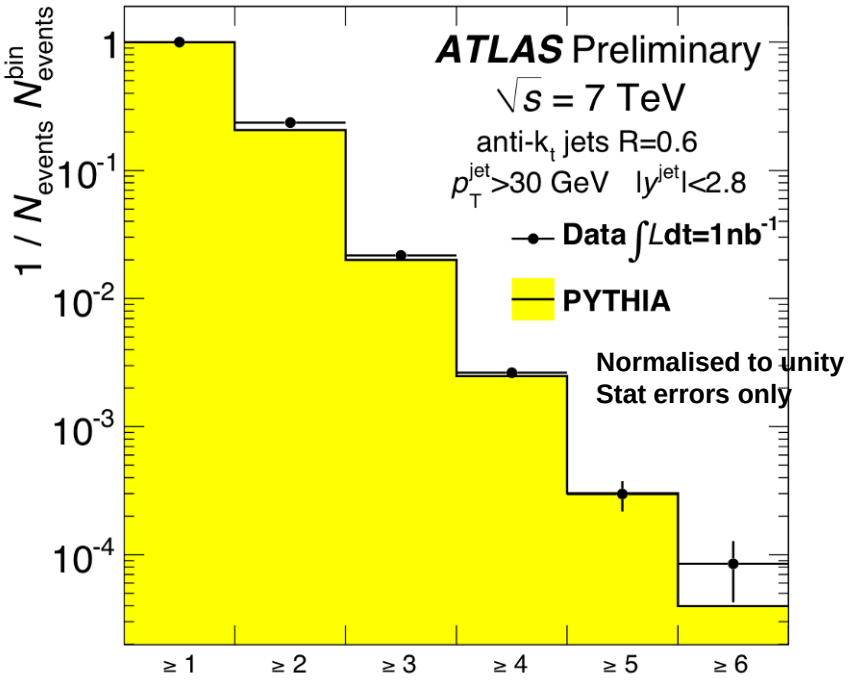
Jets

- Jets reconstructed with Anti-kT algorithm, calibrated with simple η/p_T-dependent corrections from test-beam, track E/p, MC ➔ 7% scale uncertainty
- Good agreement with LO+PS MC

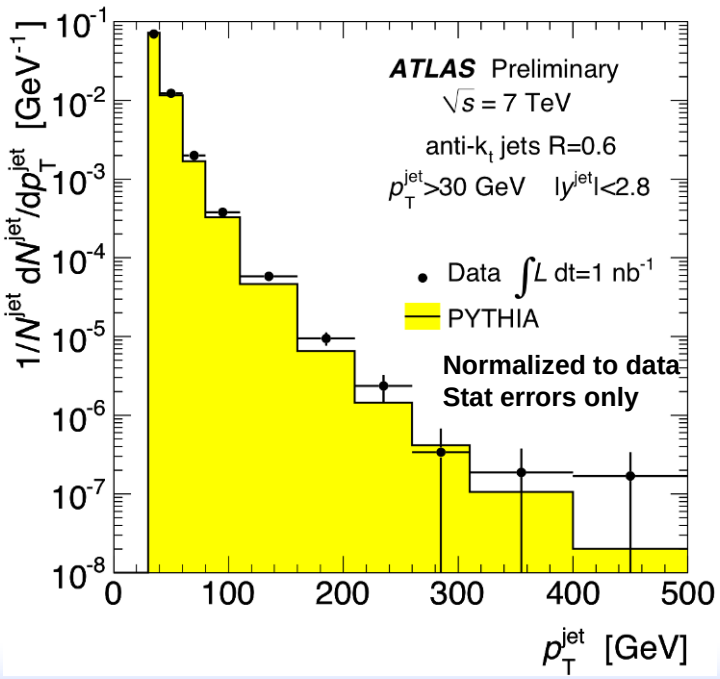
E/p for |η|<2.3 in 900 GeV min. bias events



Agreement to 5%

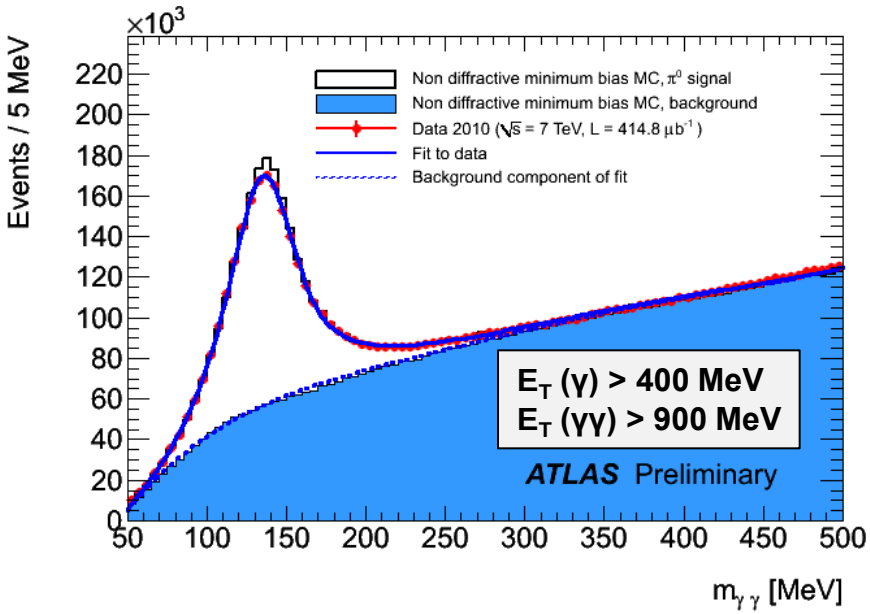


ATLAS-CONF-2010-043

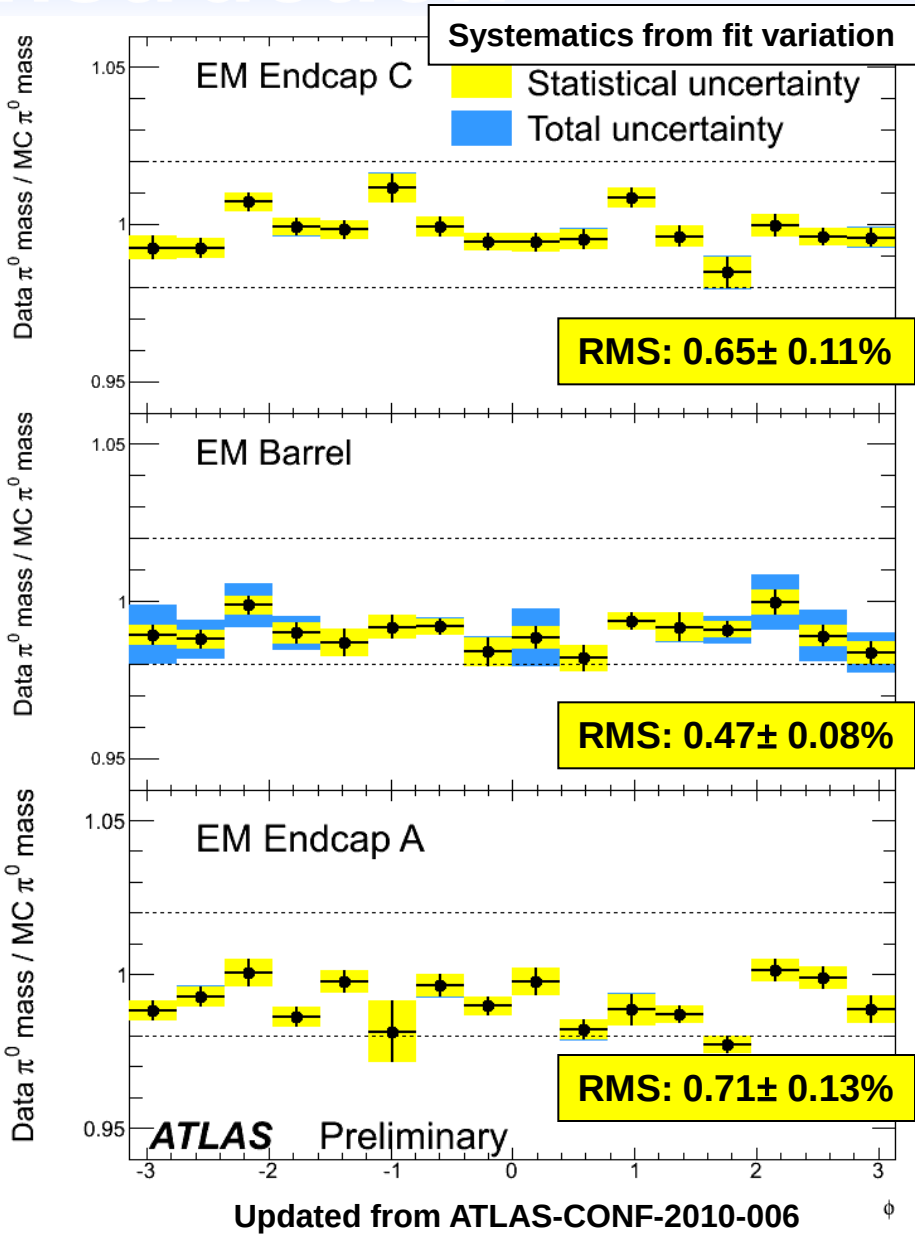


$\pi^0 \rightarrow \gamma\gamma$ Reconstruction

- **Key benchmark for EM reconstruction**
- **Tool for measuring calorimeter scale and uniformity**
- **Energy scale measured to ~2%**



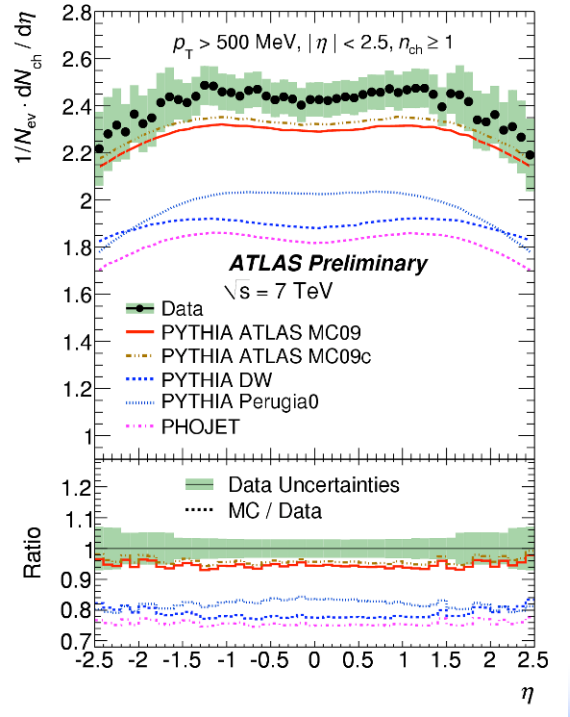
Mass peak: 135.05 ± 0.04 MeV (PDG: 134.98)
Width: ~ 20 MeV
Systematics: m: 1%; σ~ 10%

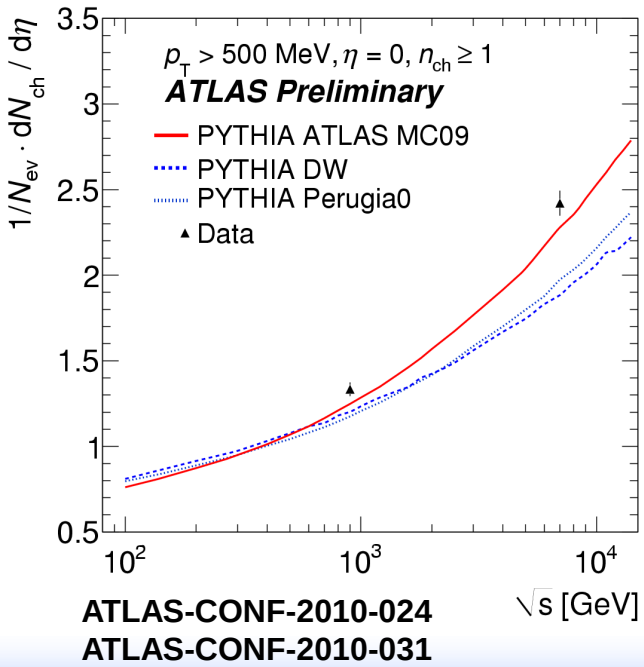


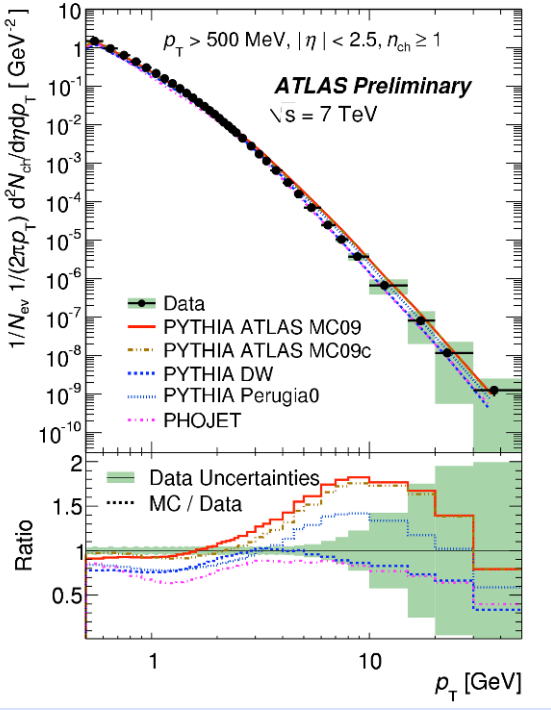
Updated from ATLAS-CONF-2010-006

Minimum Bias with Tracks

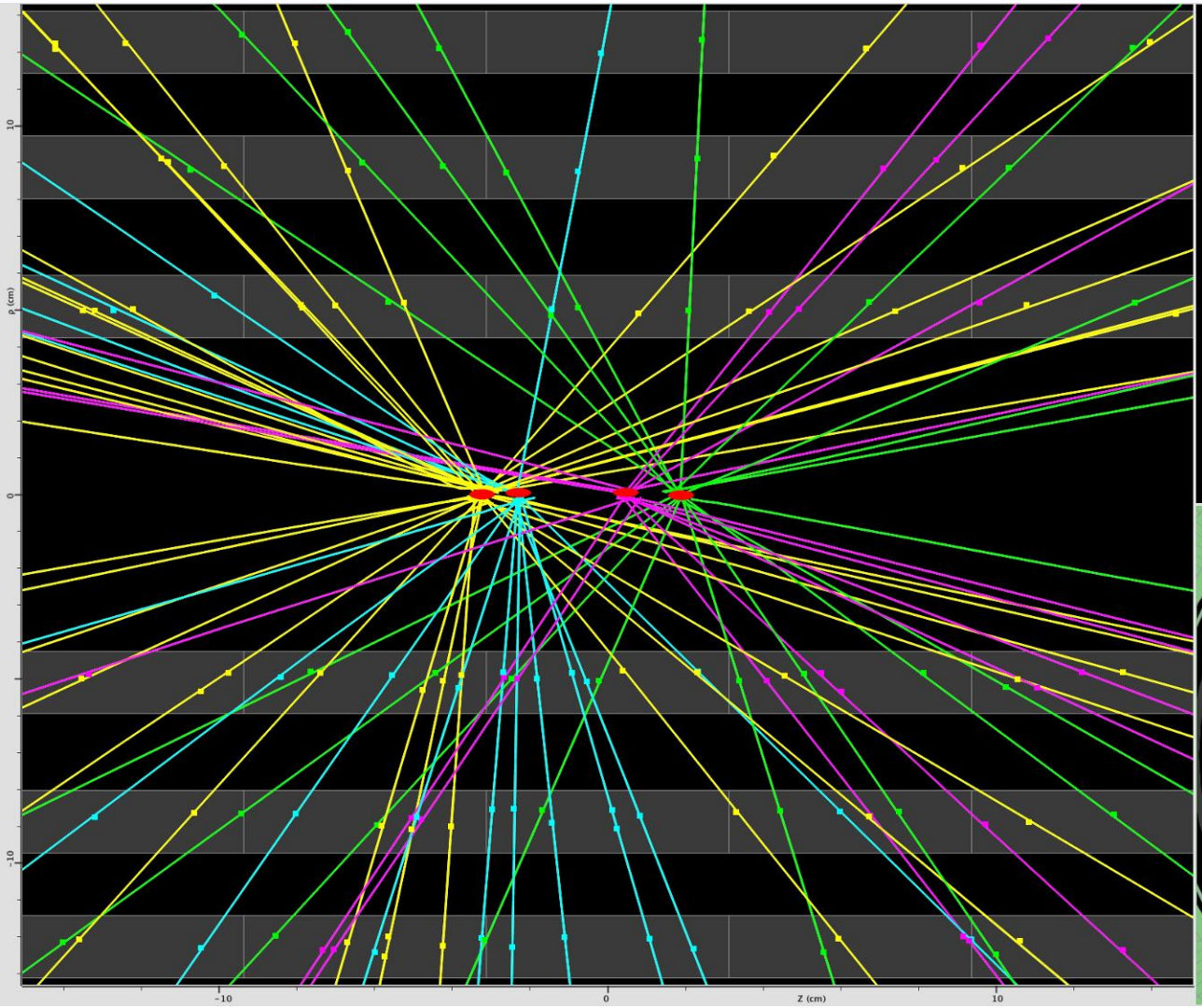
- **Inclusive, model-independent measurement from inelastic events:**
  - **Well-defined kinematic region: ≥ 1 charged particle p_T> 500 MeV, |η| <2.5**
  - **Single-arm scintillator trigger with high acceptance in above phase-space**
  - **No removal of single/double diffractive components**
  - **Distributions corrected back to hadron level**
- **Results at √s = 900 GeV published in Phys. Lett. B688 (2010) 1**
- **Excess above MC observed → new tune (ATLAS-CONF-2010-031)**

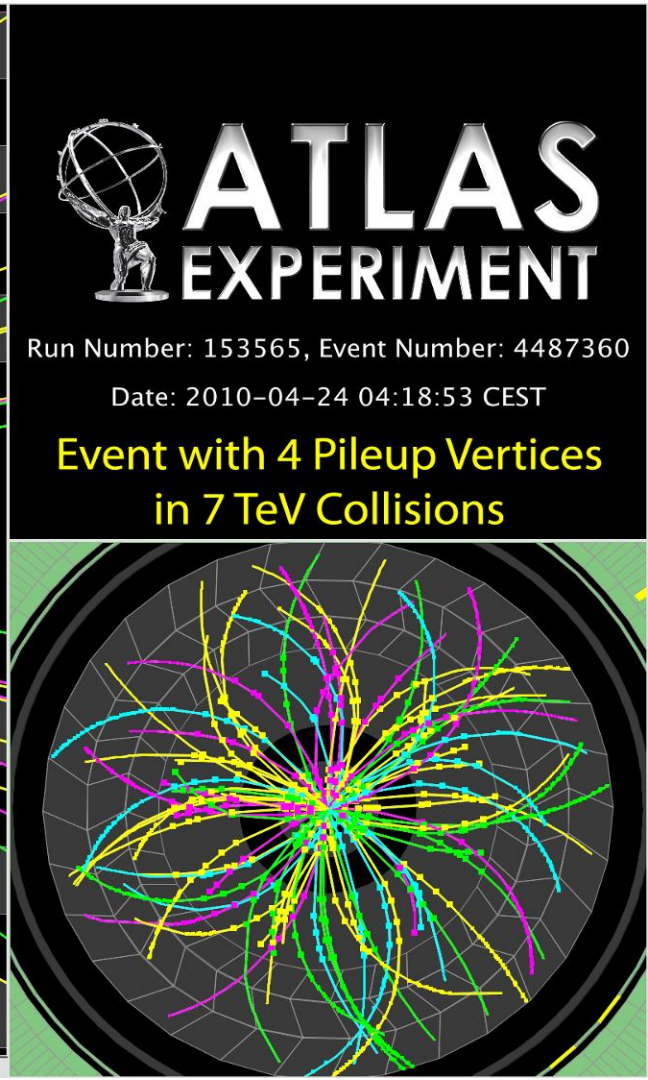






Primary Vertex Reconstruction





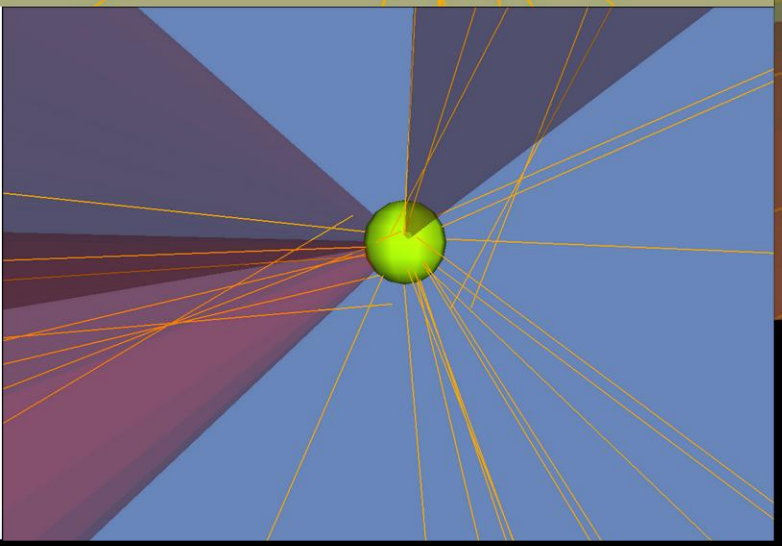
- ~ 10-45 tracks with p_T >150 MeV per vertex
- Vertex z-positions : −3.2, −2.3, 0.5, 1.9 cm (vertex z-resolution better than ~200 μm)
- Expect handful of 4-vertex events in this run

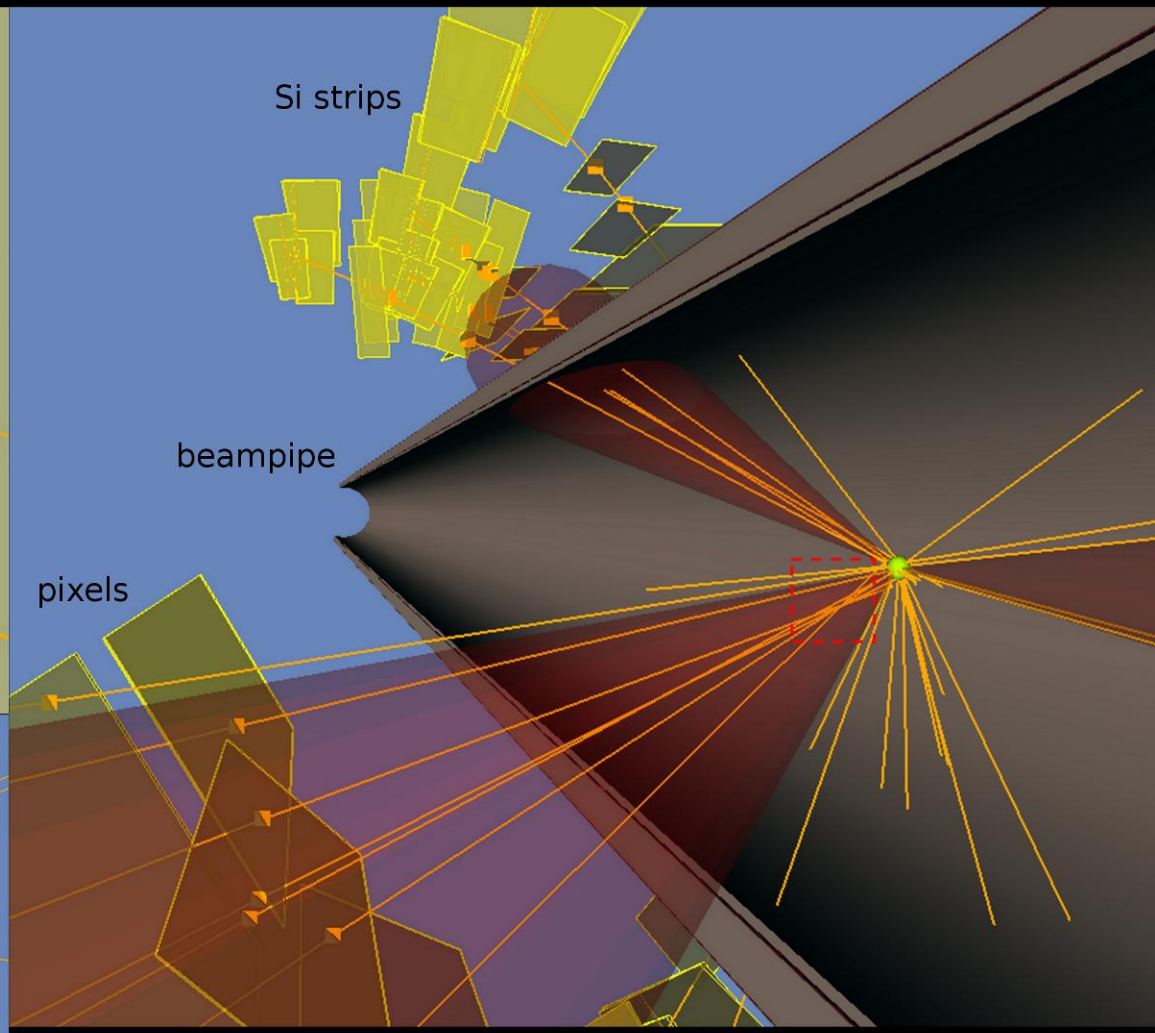
ATLAS EXPERIMENT

http://atlas.ch

Run 152166
Event 817271

b-tagged jet in 7 TeV collisions



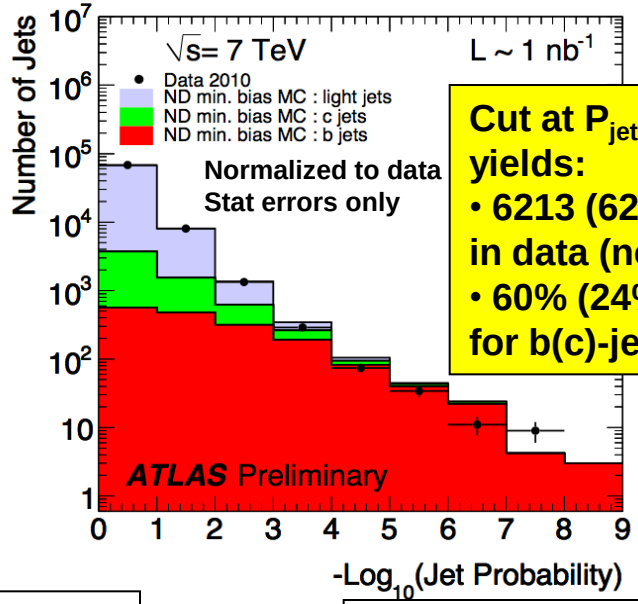


p_T^{jet} =19 GeV (measured at electromagnetic scale)

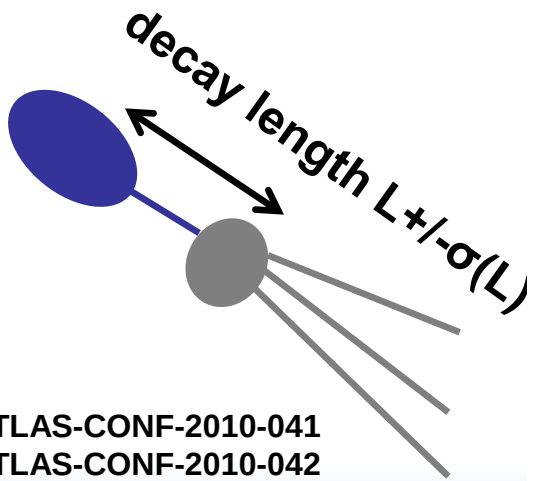
4 b-tagging quality tracks in the jet

Flavour Tagging

- Track counting: simple, robust
- Jet probability tagger:
  - Construct combined probability of tracks to be associated with PV
- Secondary vertex tagger:
  - Reconstruct SVX and cut on decay length significance
- Data/MC agreement very encouraging at such an early stage: bodes well for b-jet physics

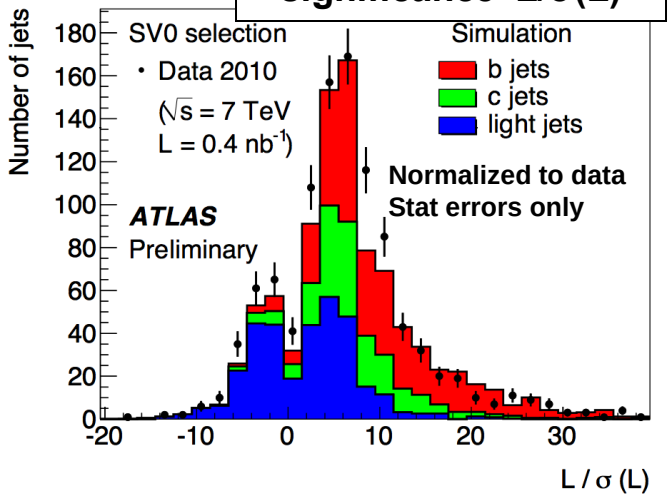


Cut at P_{jet}=0.055 yields:
- **6213 (6230) jets in data (norm MC)**
- **60% (24%) eff. for b(c)-jets in MC**

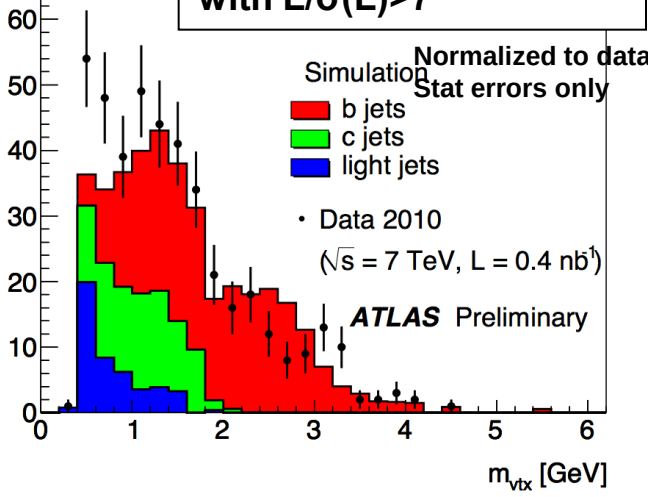


ATLAS-CONF-2010-041
ATLAS-CONF-2010-042

Decay length significance L/σ(L)

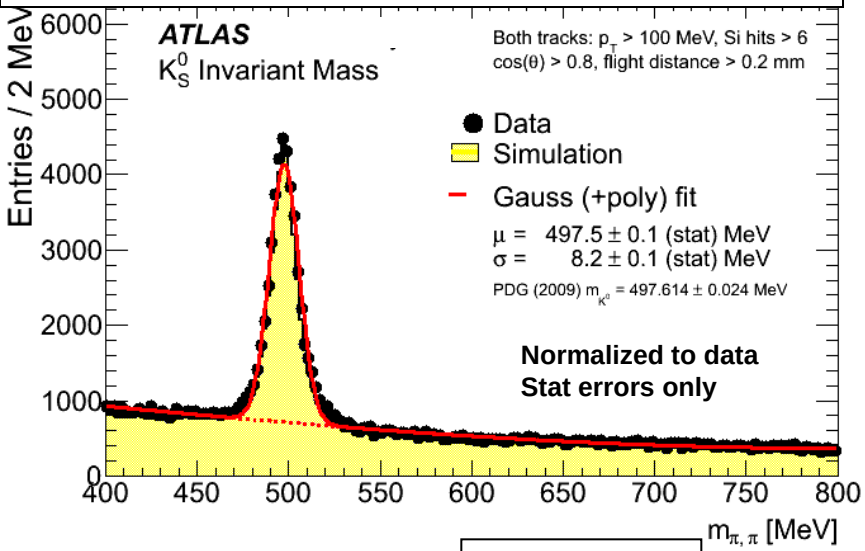


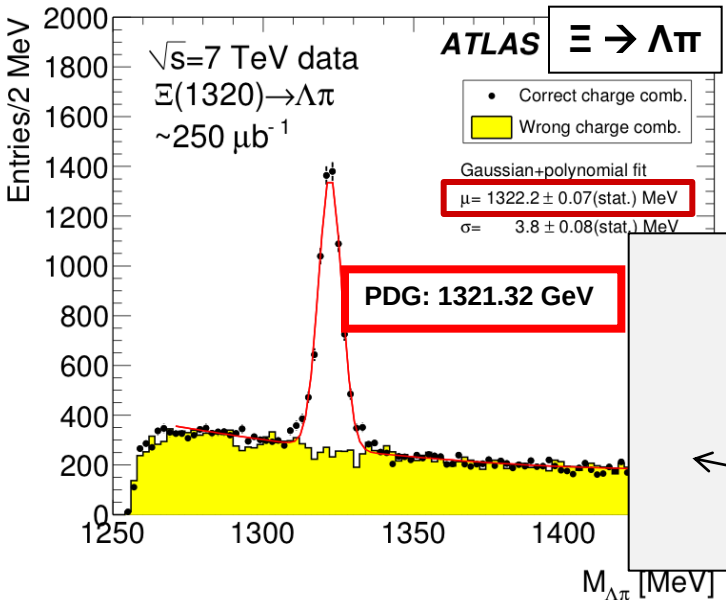
Vertex mass in events with L/σ(L)>7

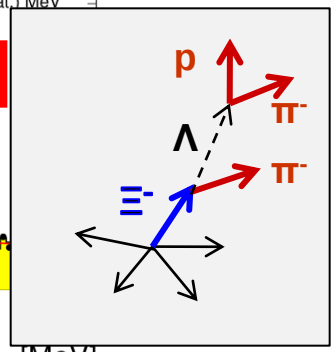


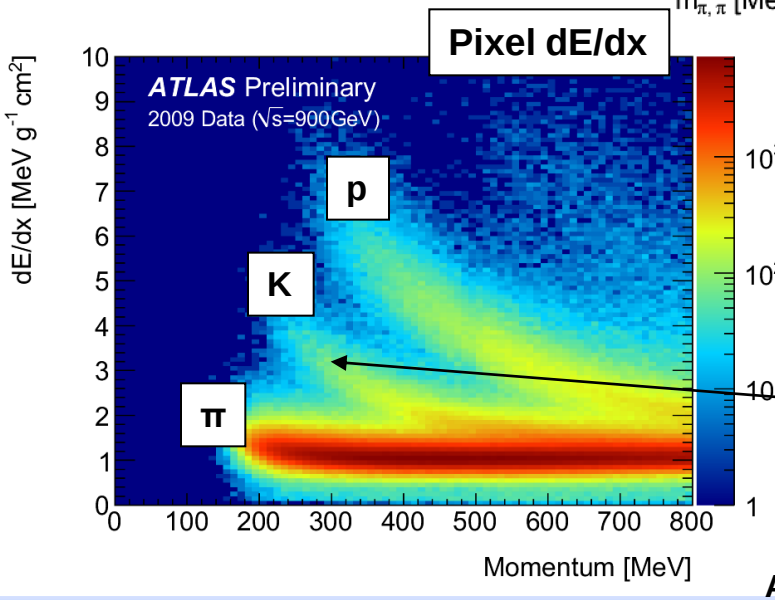
Hadron Spectroscopy

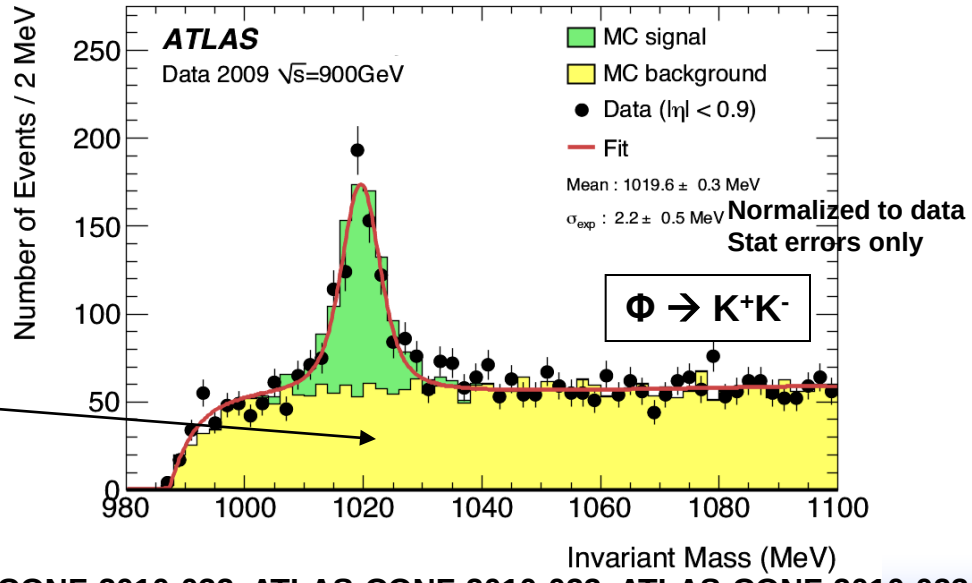
Early $K^0_s \rightarrow \pi^+\pi^-$ observed in Dec 2009, a few days after first collisions





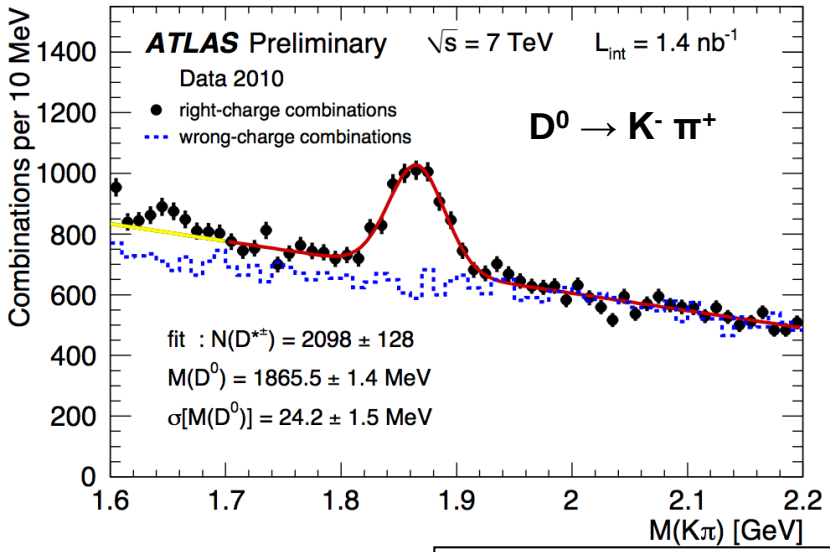


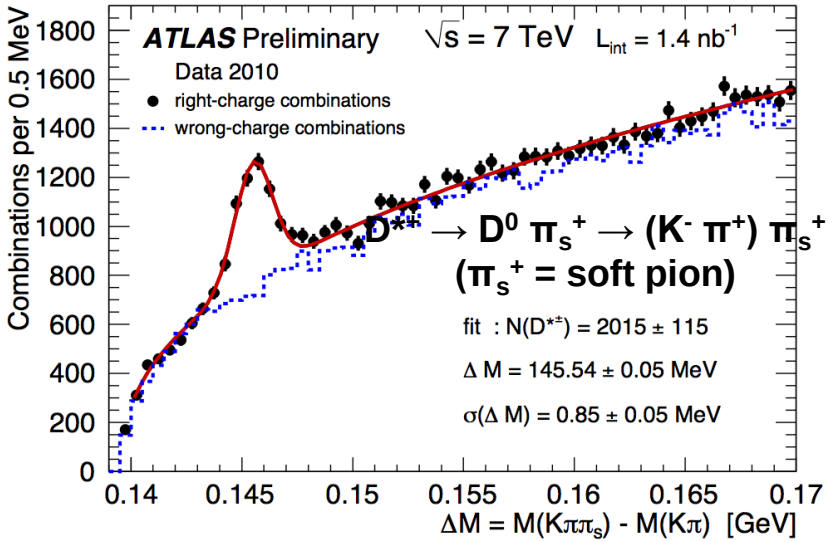




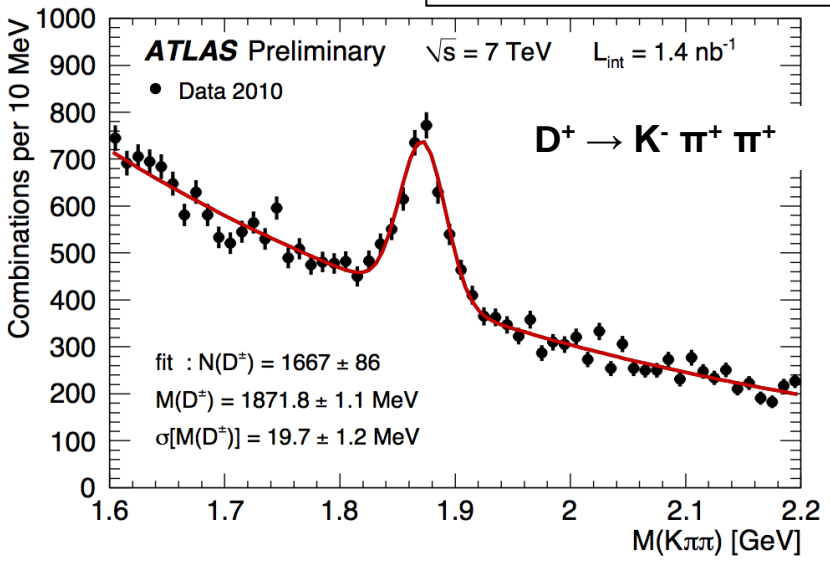
ATLAS-CONF-2010-032, ATLAS-CONF-2010-033, ATLAS-CONF-2010-023

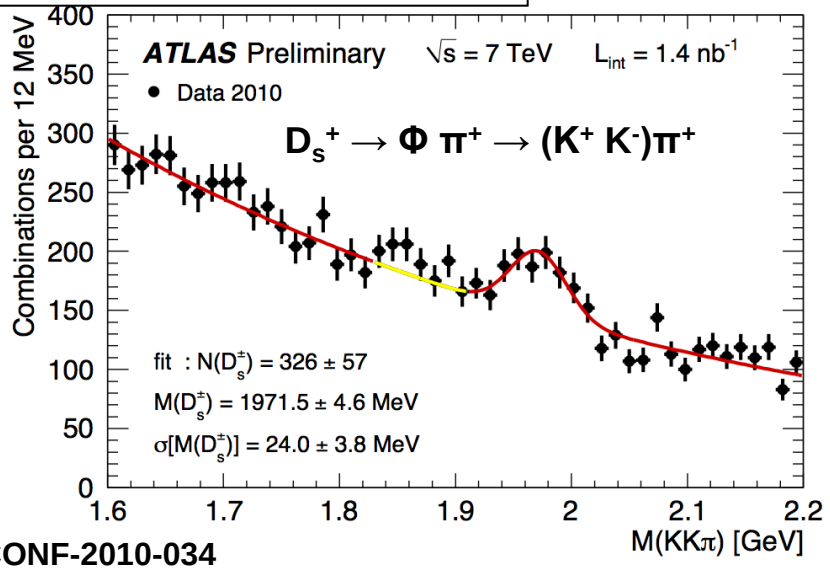
D(*) Meson Reconstruction





For more details see Eleni Mountricha's talk



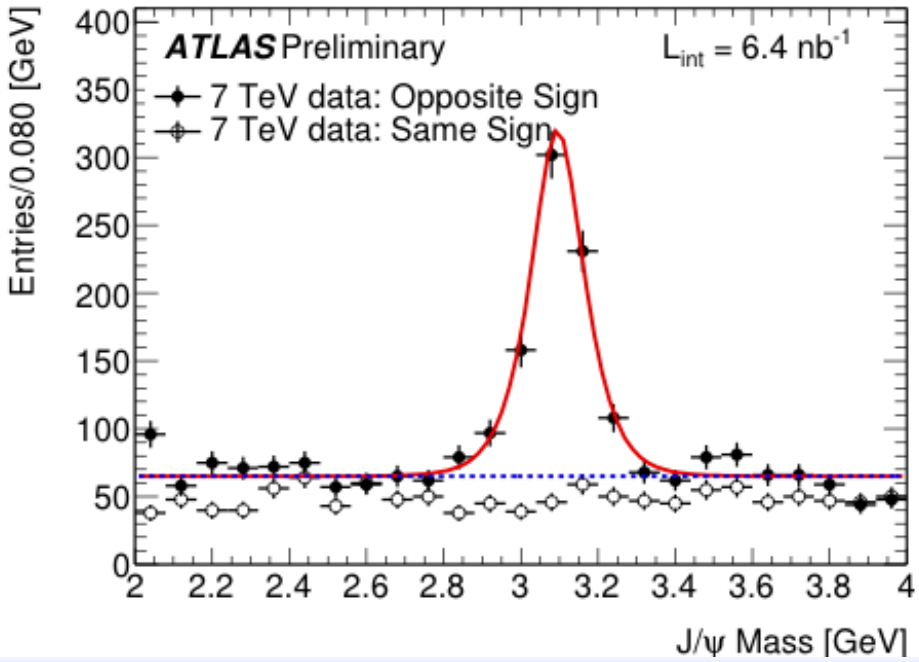


ATLAS-CONF-2010-034

$J/\psi \rightarrow \mu^+\mu^-$

ATLAS-CONF-2010-045

- **Key milestone for commissioning and physics**
  - **QCD test with J/ψ differential cross section, polarization...**
  - **Crucial to understand detector performance**
  - **Crucial for B-physics**
- **Makes use of matched ID and MS tracks**
- **Mass consistent with PDG, width well modelled by simulation**
- **For more details see Maria Smizanska's talk**



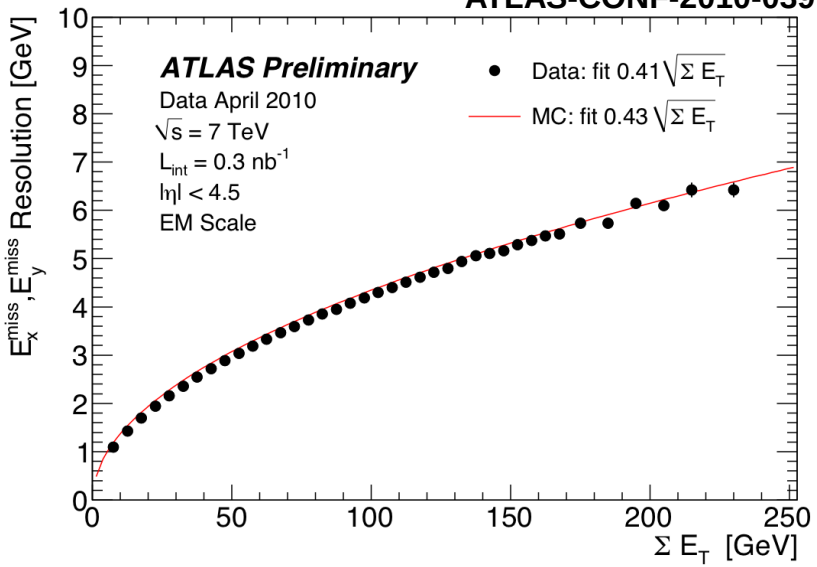
Very loose selections:
- **min-bias trigger at LVL1 plus HLT muon (→ sensitive to p_T (μ) as low as ~ 1 GeV)**
- **2 muons with opposite sign fitted to common vertex**
- **p_T (ID track) > 0.5 GeV**

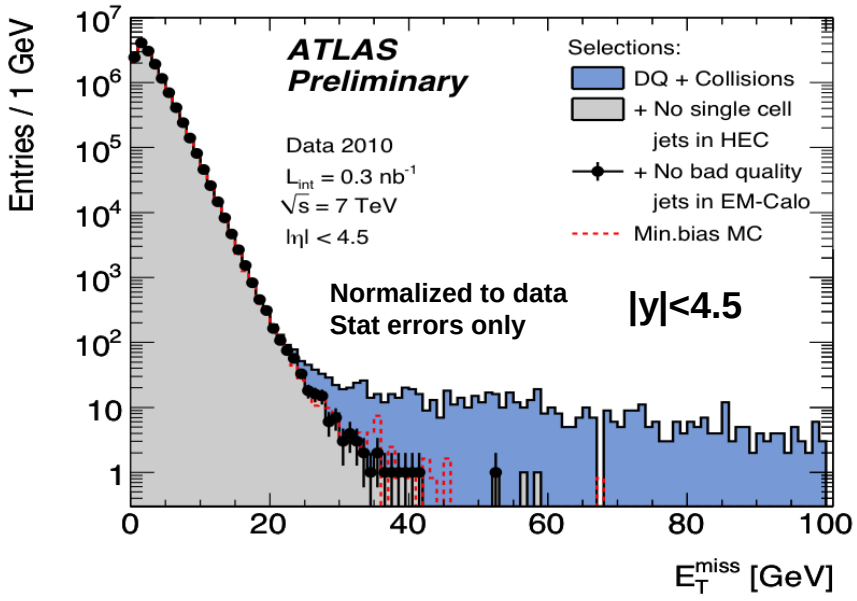
Signal : 612 ± 34 events
Background : 332 ± 9 events
Mass peak: 3.095± 0.004 GeV (PDG: 3.097)
Mass resolution: 82±7 MeV (MC: 74±0.4)

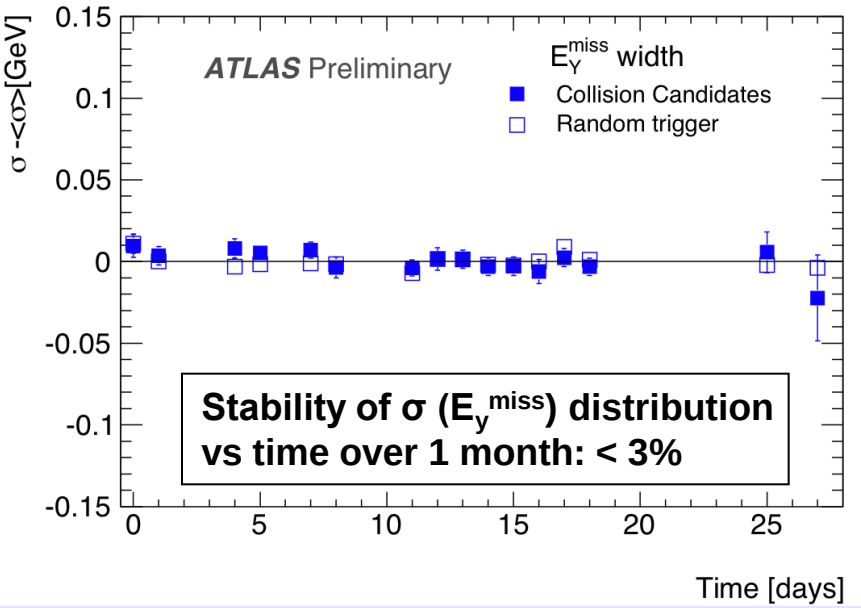
Missing Transverse Energy

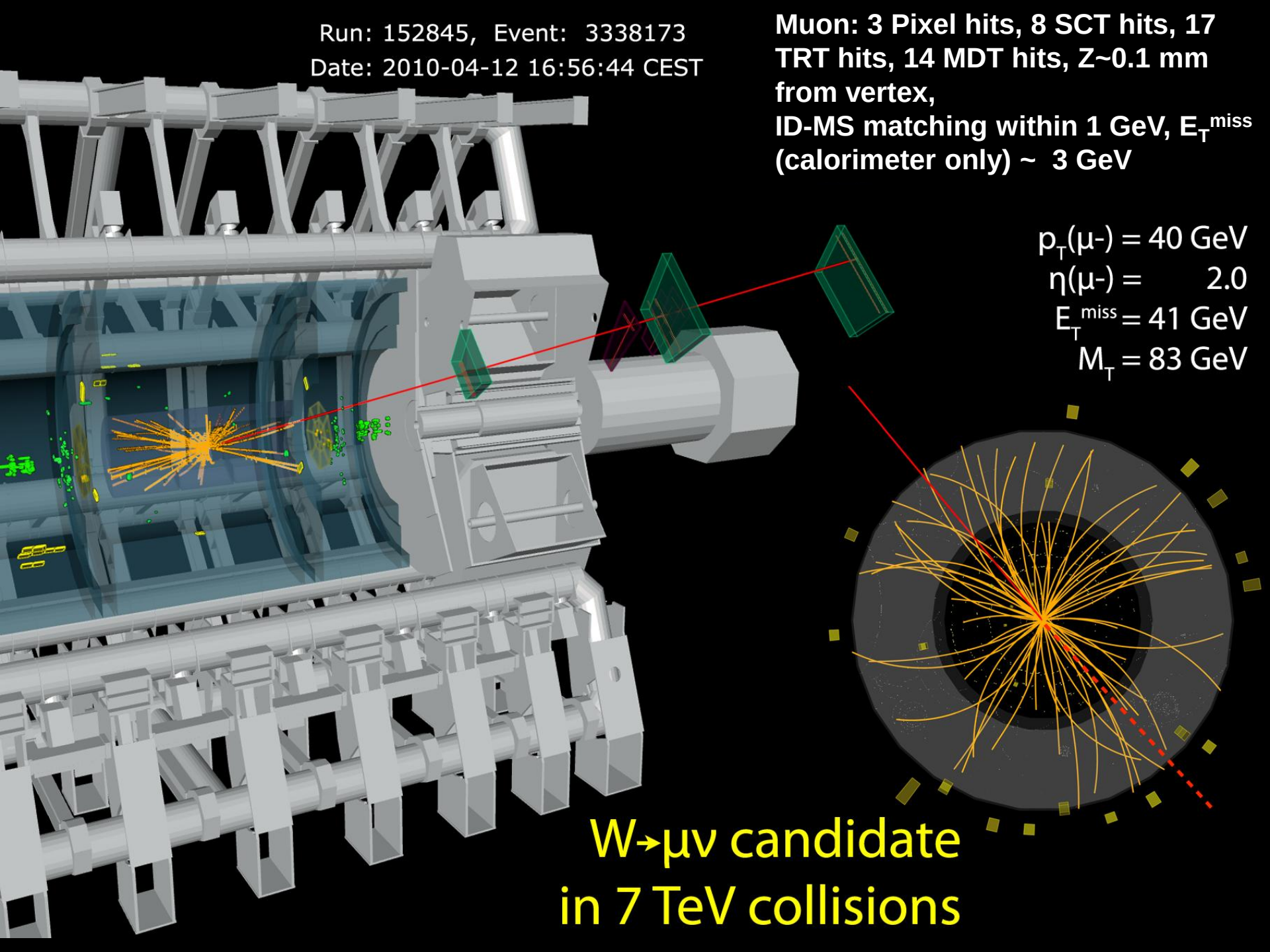
- **Sensitive to calorimeter performance (coherent noise, dead/hot cells, miscalibration, cracks etc.) and non-collision backgrounds ➔ strong test**
- **Calibrated at EM scale currently**
- **Clean and stable**

ATLAS-CONF-2010-039





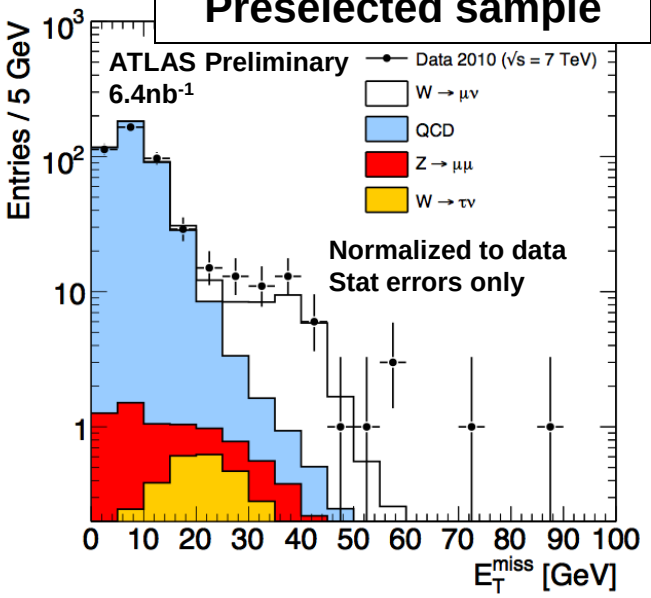



Run: 152845, Event: 3338173
Date: 2010-04-12 16:56:44 CEST
Muon: 3 Pixel hits, 8 SCT hits, 17 TRT hits, 14 MDT hits, Z~0.1 mm from vertex,
ID-MS matching within 1 GeV, E_T^{miss} (calorimeter only) ~ 3 GeV
$p_T(\mu-) = 40$ GeV
$\eta(\mu-) = 2.0$
$E_T^{miss} = 41$ GeV
$M_T = 83$ GeV
W→μν candidate
in 7 TeV collisions

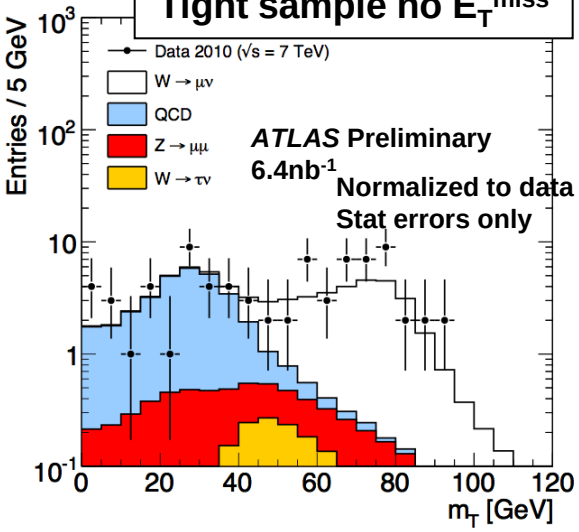
W→ μν Signal

- **Event Selection**
  - Level 1 muon trigger (no p_T threshold)
  - One PV with 3 tracks, consistent with BS
  - 1 combined MS+ID muon, p_T(combined)> 15 GeV, p_T(MS)>10 GeV
  - $|p_T(\text{combined})-p_T(\text{MS})|< 15$ GeV
  - $|z_\mu - z_{PV}|<1$cm, $|\eta|<2.4$
  - Any jets must pass quality cuts
- **Tight selection**
  - $p_T>20$ GeV and relative track isolation<0.2 in $\Delta R=0.4$

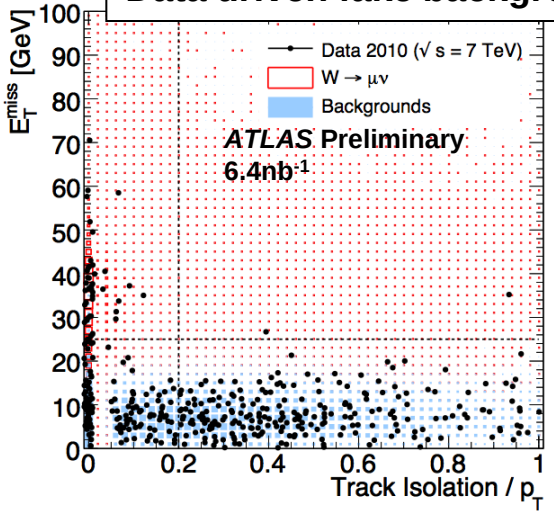
Preselected sample



Tight sample no E_T^{miss}



Data driven fake background



$\sigma^{NNLO}(W \rightarrow l\nu) = 10.45$ nb

$E_T^{miss} > 25$ GeV, $m_T > 40$ GeV

Observed	40
Expected	28.7±0.5(stat)±3.9(syst) ±5.7(lumi)
Signal	25.9±3.6(syst)±5.2(lumi)
Background	2.8±0.5(stat) ±0.8(syst)±0.6(lumi)

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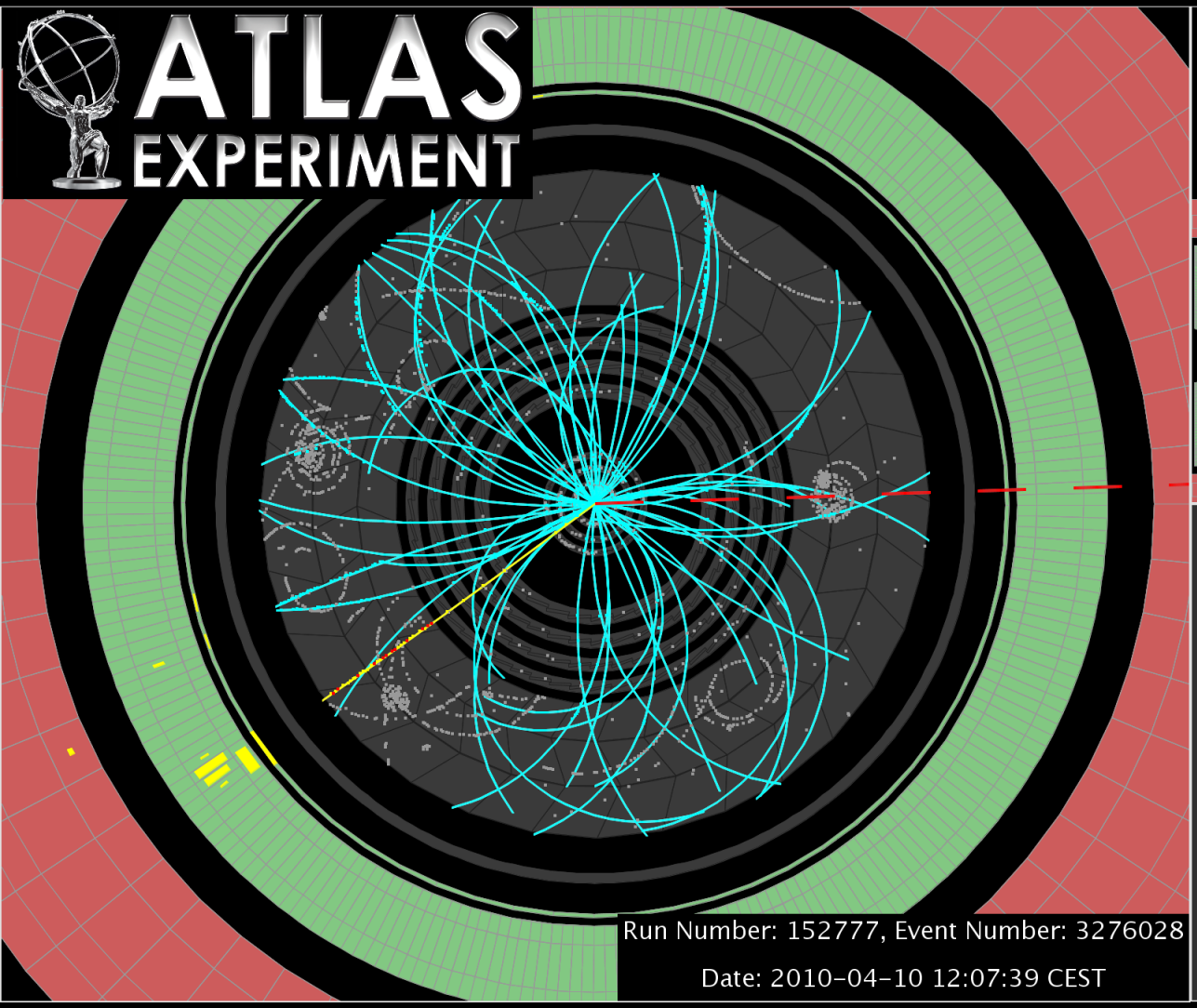
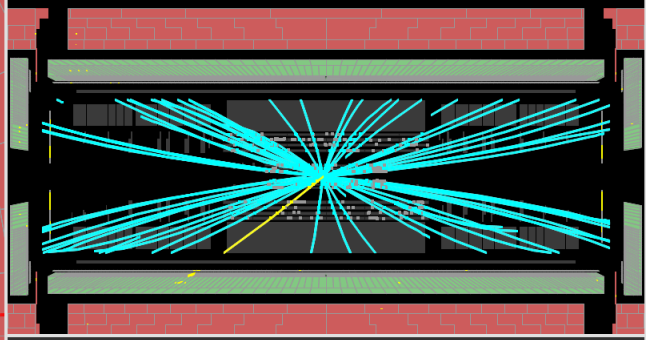
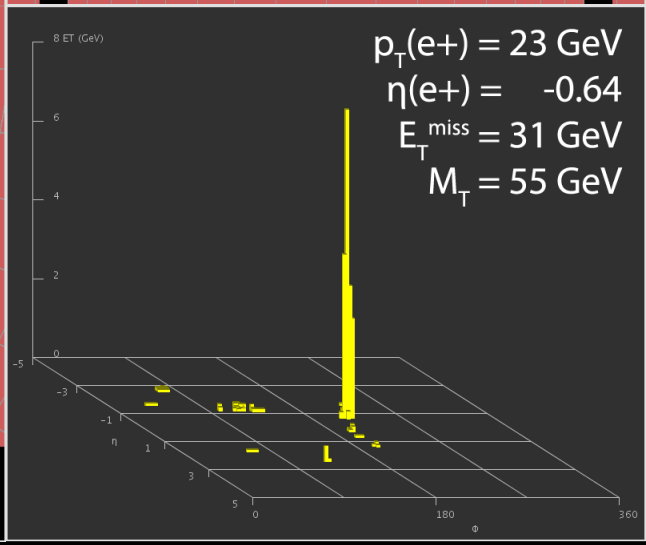


W→eν candidate in 7 TeV collisions

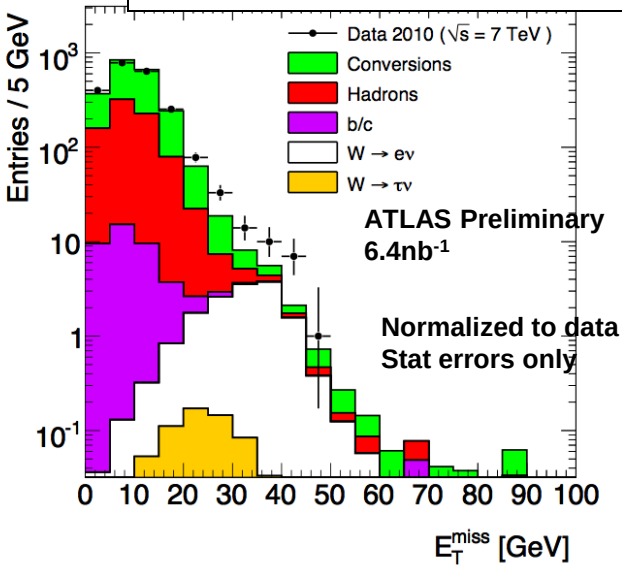




W→ eν Signal

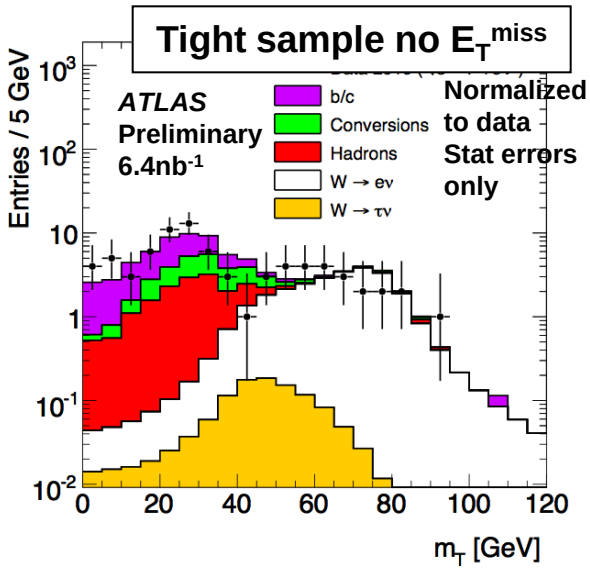
- **Event Selection**
  - Level 1 EM trigger (~ 2 GeV E_T threshold)
  - One PV with 3 tracks, consistent with beam spot
  - One loose electron with: ID track matching EM calo cluster, selection on the shower shape in the 2nd calo layer, energy in 1st had layer, cluster E_T>20 GeV
  - Any jets must pass quality cuts
- **Tight selection**
  - Full electron ID with TRT HT hits,
  - Conversion veto, detailed shower shape, impact parameter requirements

Preselected sample



$\sigma^{NNLO}(W \rightarrow l\nu) = 10.45$ nb

Tight sample no E_T^{miss}



$E_T^{miss} > 25$ GeV, $m_T > 40$ GeV

Observed	17
Expected	23.1±1.2(stat)±1.7(syst) ±4.6(lumi)
Signal	20.7±1.5(syst)±4.1(lumi)
Background	2.4±1.2(stat)±0.4(syst) ±0.5(lumi)

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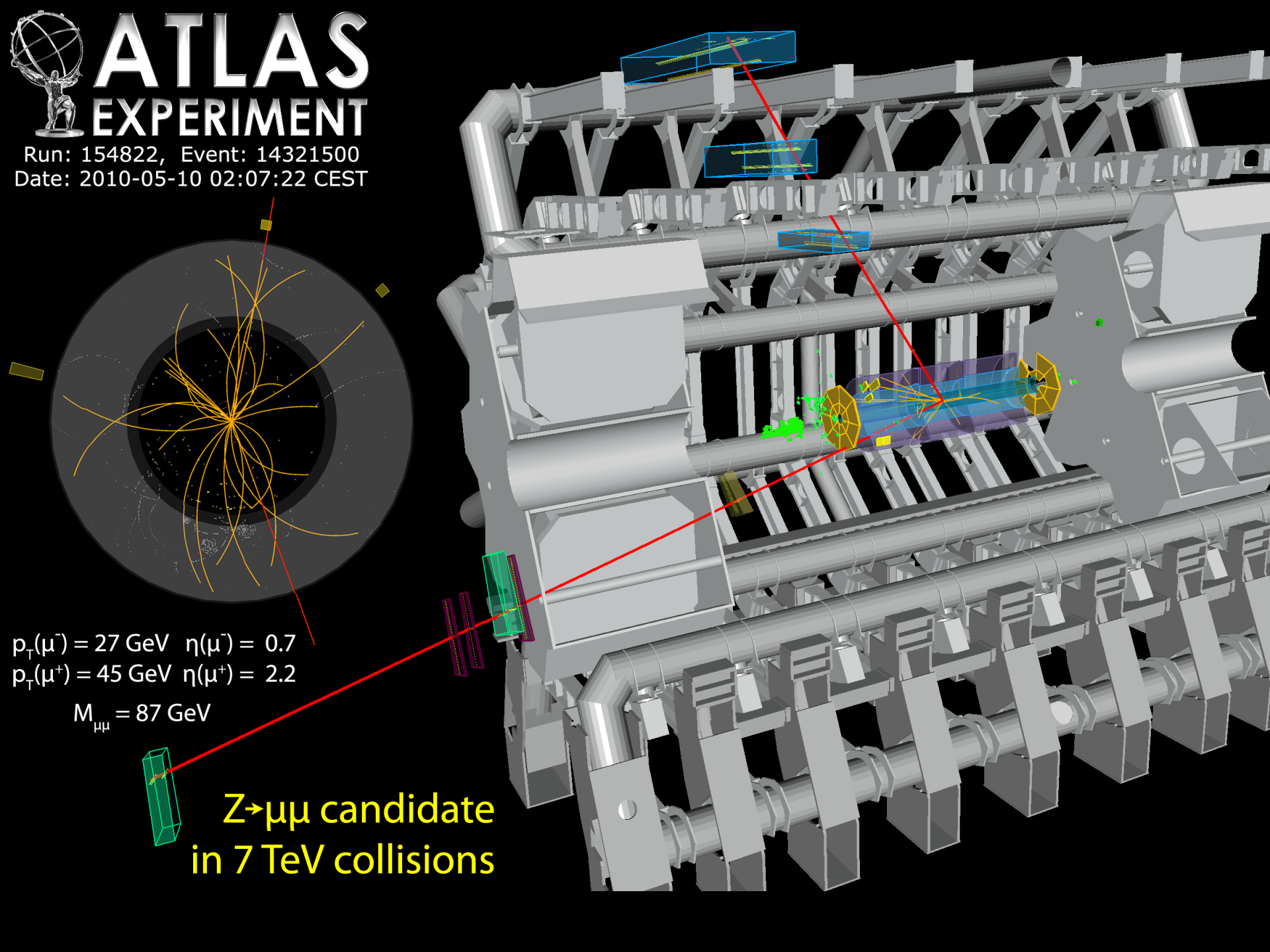
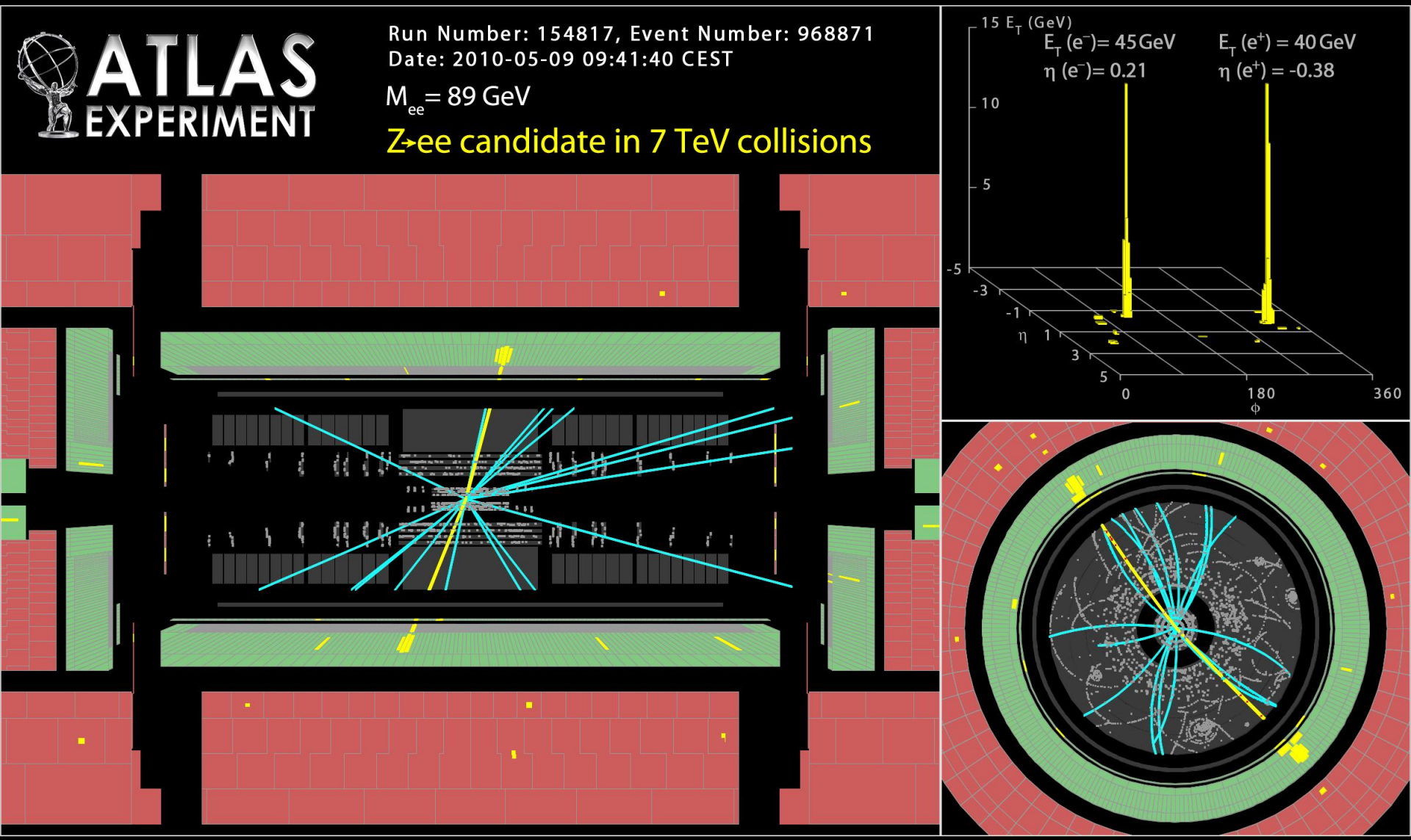

ATLAS
EXPERIMENT
Run: 154822, Event: 14321500
Date: 2010-05-10 02:07:22 CEST
$p_T(\mu^-) = 27$ GeV $\eta(\mu^-) = 0.7$
$p_T(\mu^+) = 45$ GeV $\eta(\mu^+) = 2.2$
$M_{\mu\mu} = 87$ GeV
Z→μμ candidate
in 7 TeV collisions


ATLAS
EXPERIMENT
Run Number: 154817, Event Number: 968871
Date: 2010-05-09 09:41:40 CEST
M_{ee} = 89 GeV
Z→ee candidate in 7 TeV collisions
15 E_T (GeV)
E_T (e^-)= 45 GeV
η (e^-)= 0.21
E_T (e^+) = 40 GeV
η (e^+) = -0.38
10
5
-5
-3
-1
η
1
3
5
0
180
360
ϕ

Z^0 Candidates

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$\sigma^{NNLO}(Z/\gamma^* \rightarrow ll) = 0.99$ nb

	$Z \rightarrow e^+e^-$	$Z \rightarrow \mu^+\mu^-$
Analysed Integrated Luminosity	$6.7nb^{-1}$	$7.9nb^{-1}$
Observed 80 GeV – 100 GeV	1	2
Observed outside 80 GeV – 100 GeV	0	1
Total expected	1.6 ±0.1(syst)±0.3 (lumi)	3.2 ±0.7(syst)±0.6 (lumi)
Background	<0.2 events From combination of MC and data driven technique	<0.01 events From Monte Carlo

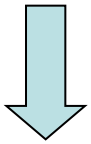
- **Main systematic uncertainties on prediction:**
  - **Luminosity (20%), Acceptance (5%), Trigger efficiency (4-7%), electron ID (5%), muon ID (10%)**

Prospects for 2010/11

In 2010/11 we expect to record up to 1fb^{-1} of integrated luminosity at 7 TeV

Standard Model

- W→*l*+ν (4M events)
- Z→*ll* (400k)
- ttbar→l+jets (6k)
- ttbar dilepton (2.5k)



Further Detector Commisioning
Standard Model measurements

Discovery Potential

- Susy 5σ discovery above Tevatron limit with a few 100pb^{-1}
- Z'→μμ : sensitive up to 1.5TeV
- Higgs: 3σ evidence in the mass range 145-180GeV

Conclusions

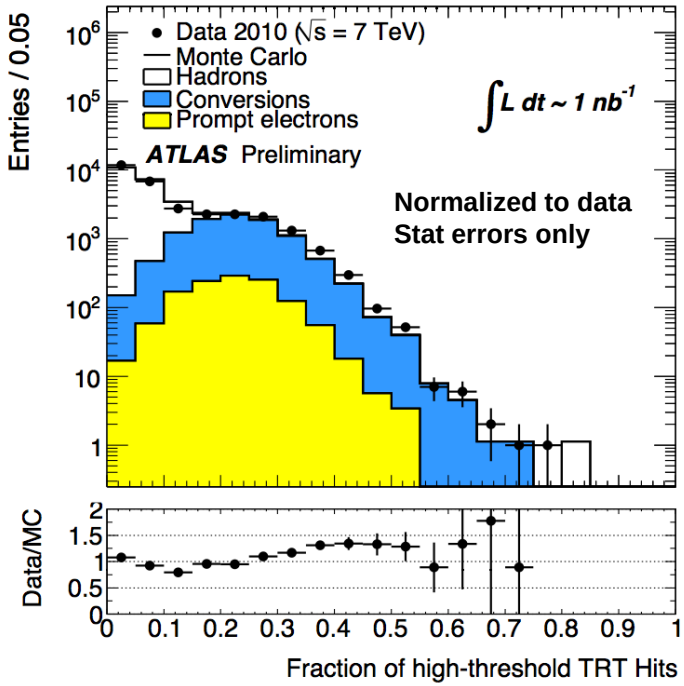
- ATLAS detector commissioning with 7 TeV data is ongoing
  - First 16 nb^{-1} of recorded luminosity.
  - Profound thanks to the machine for such rapid progress
- All detectors are performing remarkably well
  - Performance confirmed to match simulation in most cases
  - Excellent stability
- Physics analysis progressing to progressively heavier / more challenging signals
  - Min bias and underlying event studies
  - Resonances and hadron spectroscopy
  - J/ψ in electron and muon channels → flavour programme
  - First W and Z candidates in both electron and muon chanels
- ATLAS is ready for the exciting discoveries to come!

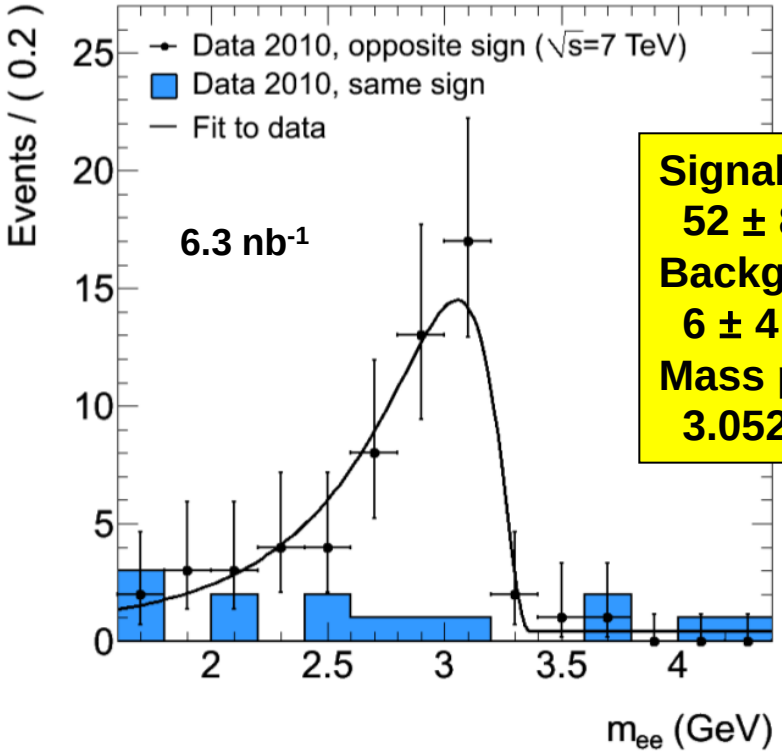
BACK-UP

$J/\psi \rightarrow e^+e^-$

- More challenging due to large background and signal electron bremsstrahlung
- Mass from tracks, currently uncorrected for brem effects
- For more details see Maria Smizanska's talk

Quite strong selections:
- LVL1 EM2 trigger (3 GeV threshold)
- p_T (clusters) > 4, 2 GeV
- 2 EM clusters matched to tracks
- Track quality, calo shower shapes
- Key handle: large transition radiation in TRT





Signal:
52 ± 8 events
Background:
6 ± 4 events
Mass peak:
3.052 ± 0.006 GeV