

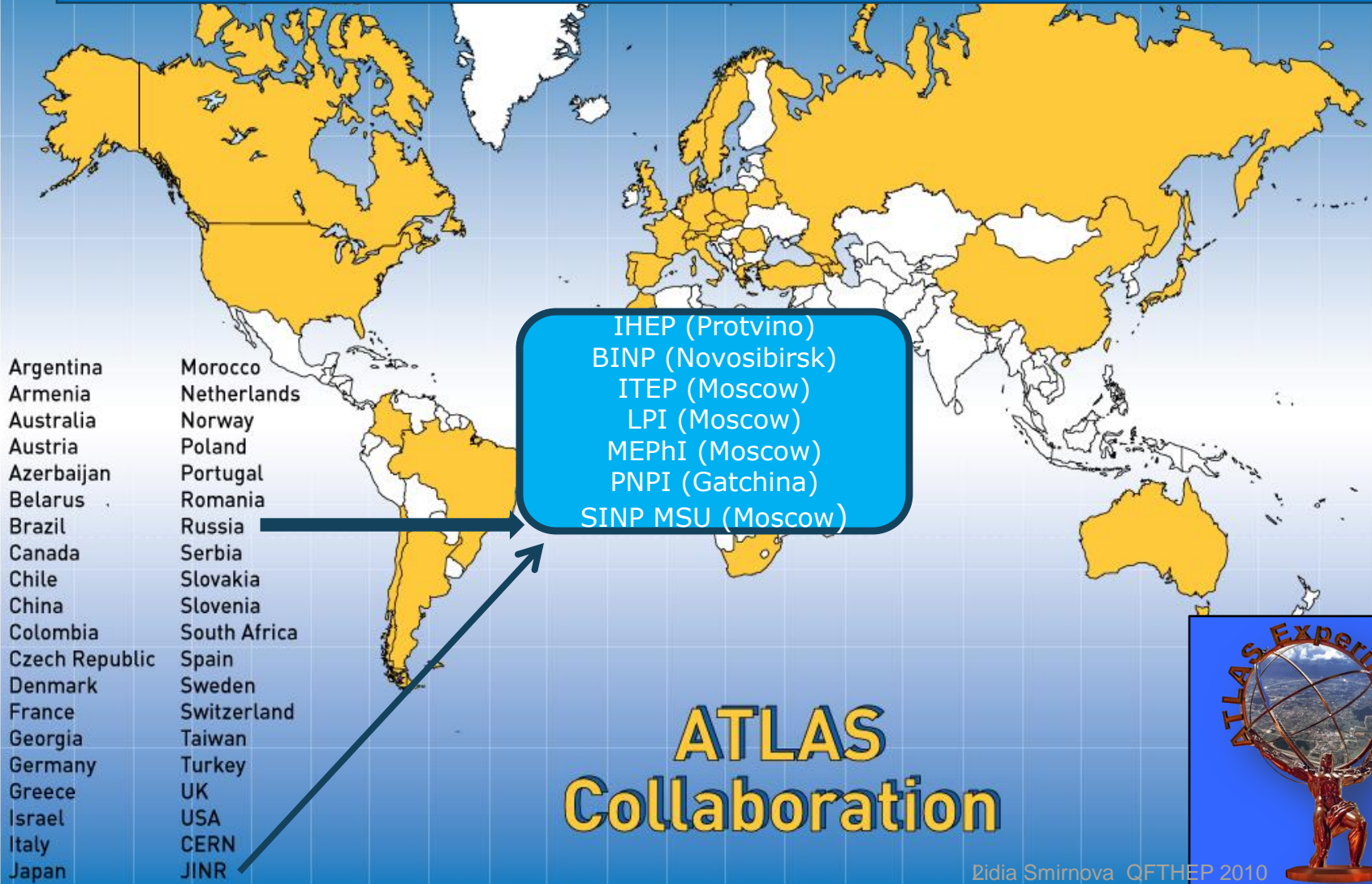
ATLAS status, operation and performance

Lidia Smirnova (SINP MSU)

On behalf of the ATLAS Collaboration

**QFTHEP'2010 , 14 September,
Golitsyno, Moscow, Russia**

~3000 scientists 174 Institutions and 38 Countries,
~1000 PhD students



ATLAS detector

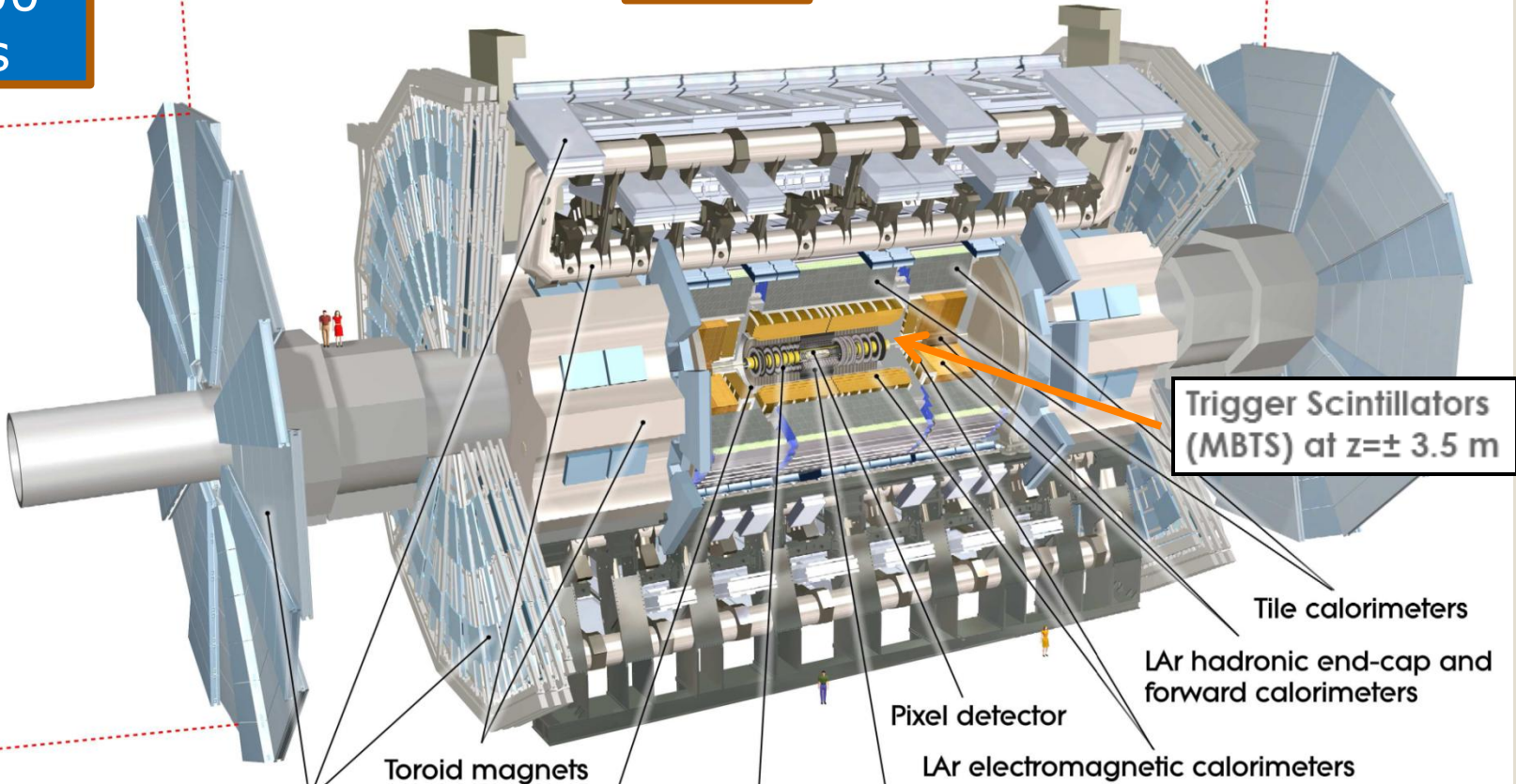
*Final installation
– August
2008*

JINST 3 (2008) S08003

~7000
tons

44 m

25 m



Trigger Scintillators (MBTS) at $z = \pm 3.5$ m

Tile calorimeters

LAr hadronic end-cap and forward calorimeters

Pixel detector

LAr electromagnetic calorimeters

Toroid magnets

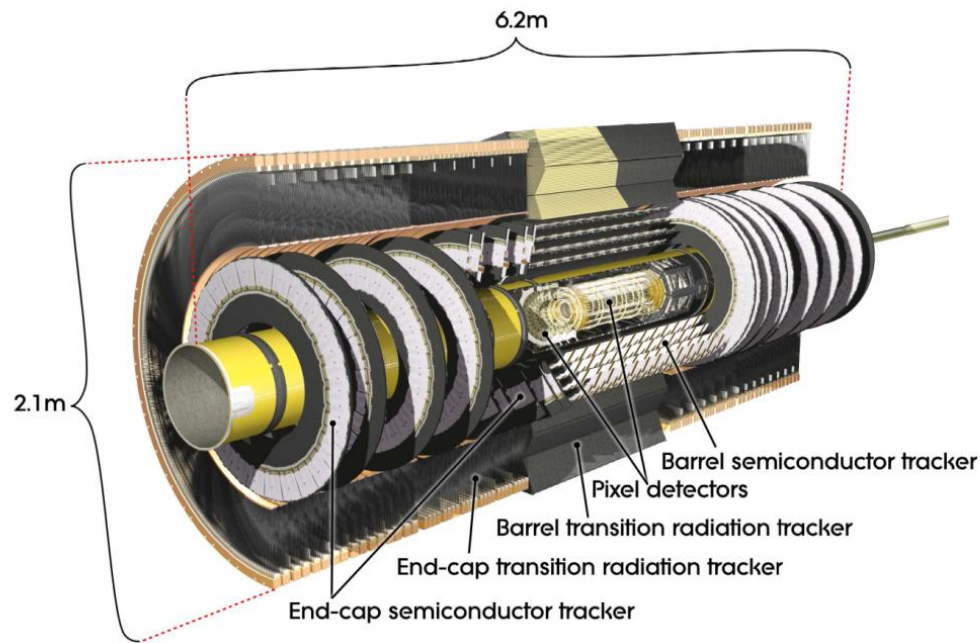
Solenoid magnet

Transition radiation tracker

Muon spectrometer

Inner Detector

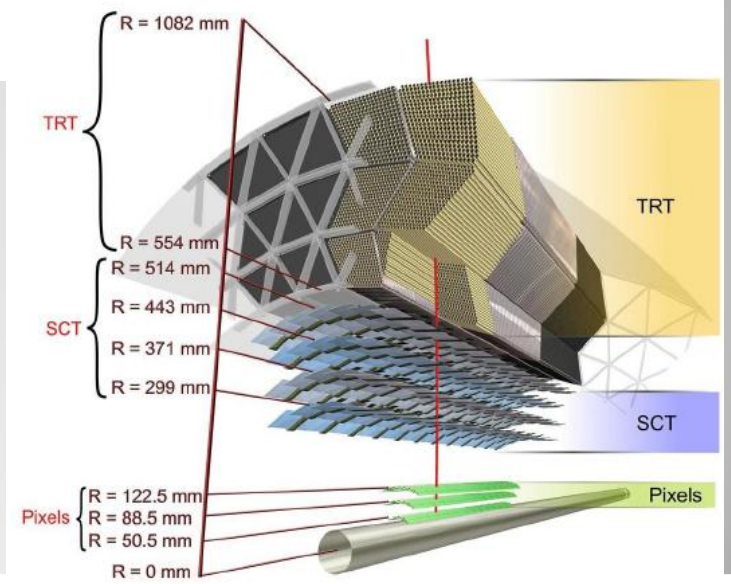
Calorimeters



- **Pixel detector**
 - 3 barrel layers, 2x3 disks
 - $\sigma(r\Phi) = 10 \mu\text{m}$, $\sigma(z) = 115 \mu\text{m}$
- **Silicon strip detector (SCT)**
 - 4 barrel layers, 2x9 disks
 - Pairs of single-sided sensors
 - $\sigma(r\Phi) = 17 \mu\text{m}$, $\sigma(z) = 580 \mu\text{m}$
- **Transition Radiation Tracker (TRT)**
 - $\sigma(r\Phi) = 130 \mu\text{m}$
- **Covers $|\eta| < 2.5$ (2.0 for TRT)**
- **2 T solenoidal field**

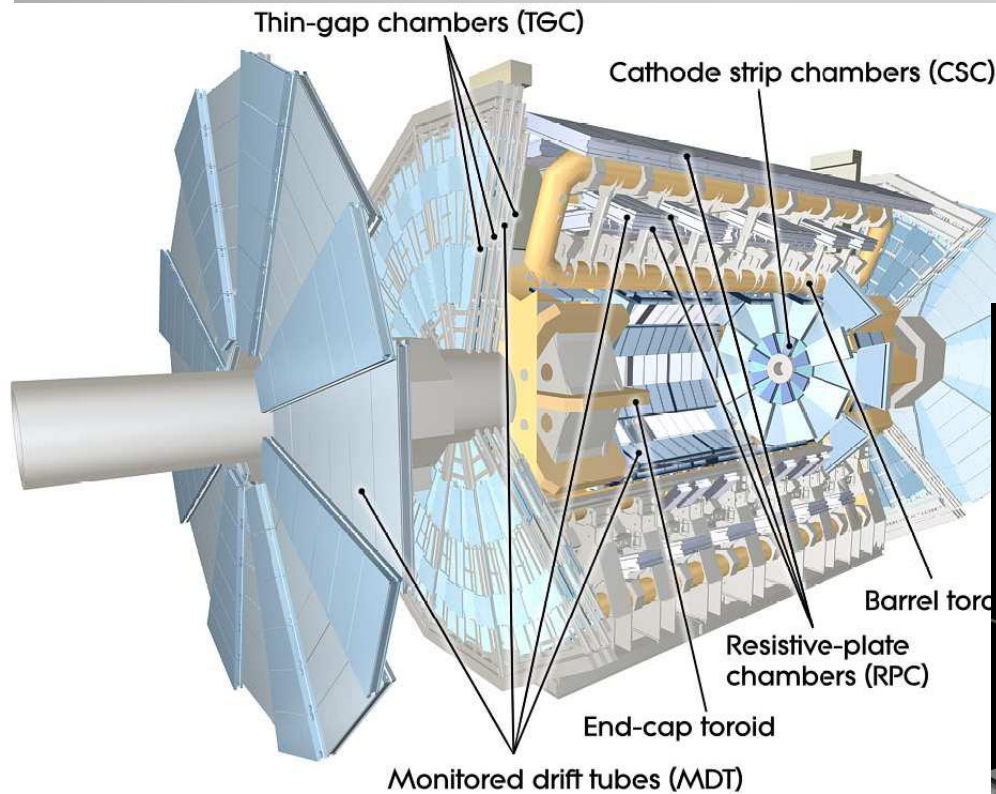
- Precise tracking and vertexing,
- e/π separation
- Momentum resolution:
 $\sigma/p_T \sim 3.8 \times 10^{-4} p_T \text{ (GeV)} \oplus 0.015$

Inner detector



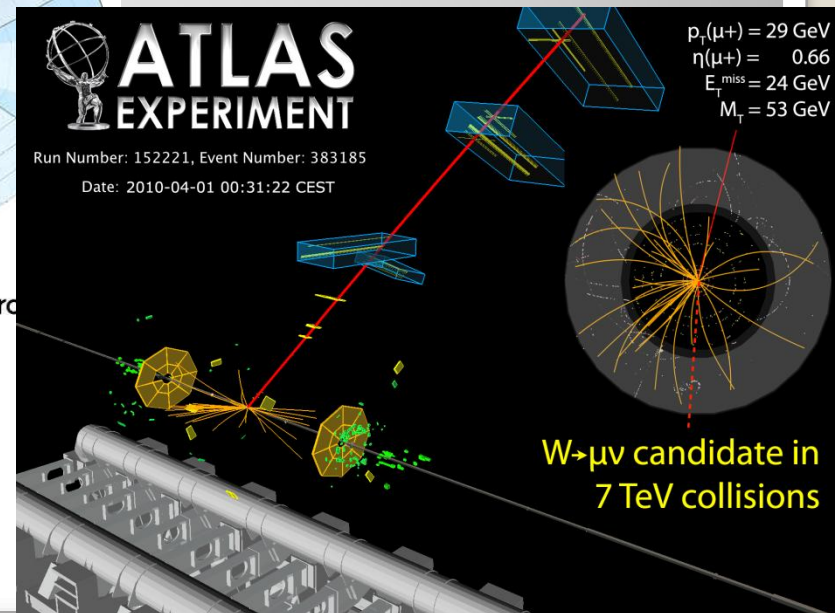
Muon spectrometer

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

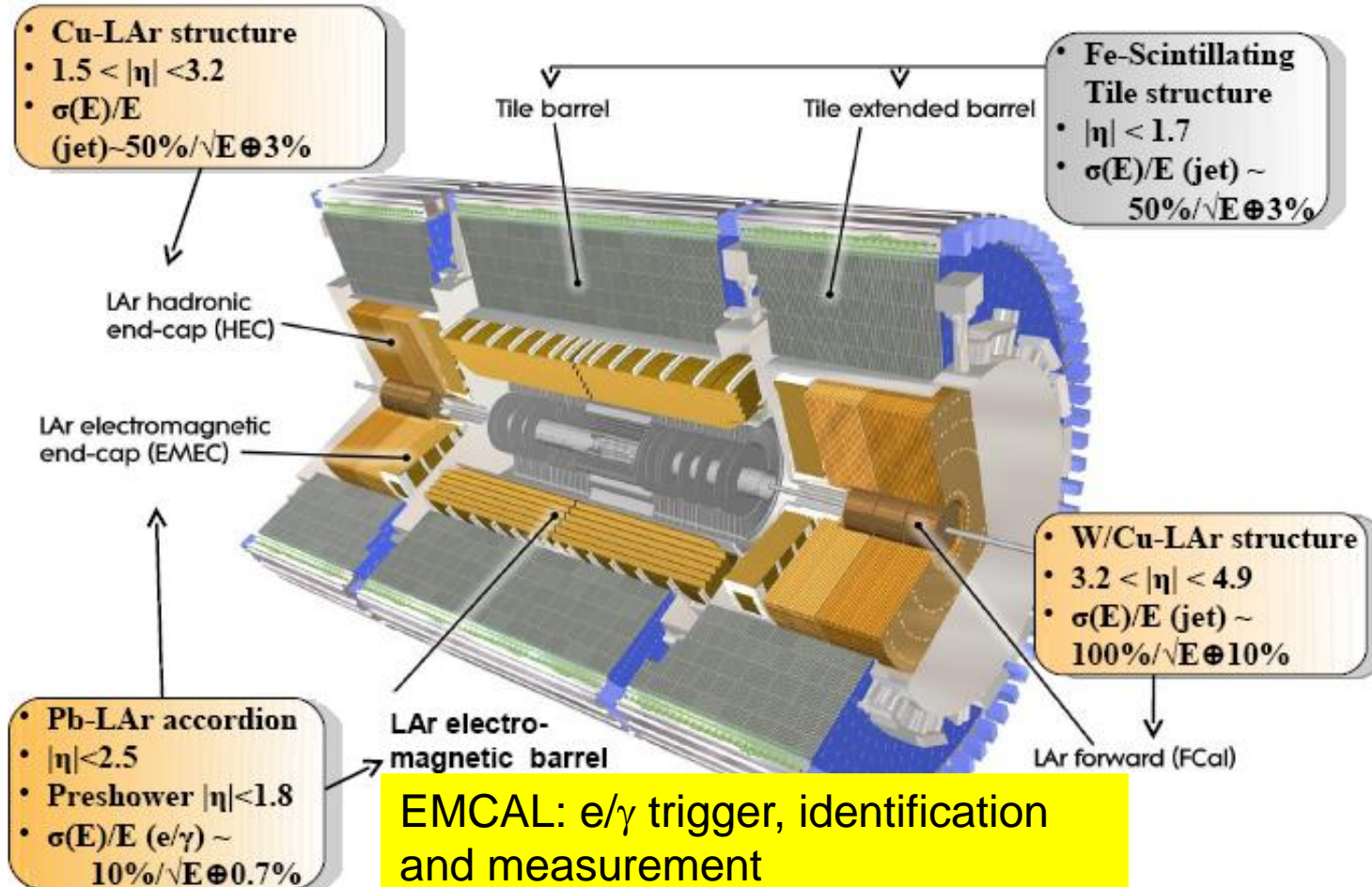


Trigger chambers:	RPC/TGC
Precision chambers:	MDT/CSC
Magnetic field:	~ 0.5 T
Bending power:	$\sim 2-5$ Tm
Coverage	$ \eta < 2.7$

W \rightarrow $\mu\nu$ candidate at 7 TeV \Rightarrow



Calorimeter System



EMCAL: e/γ trigger, identification and measurement
E-resolution: $\sigma/E \sim 10\%/\sqrt{E}$

Overall Detector Status

Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.4%
SCT Silicon Strips	6.3 M	99.2%
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	99.9%
LVL1 Muon RPC trigger	370 k	99.5%
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	97.0%
TGC Endcap Muon Chambers	320 k	98.6%

More than 97% of channels in operation

ATLAS status

Operation

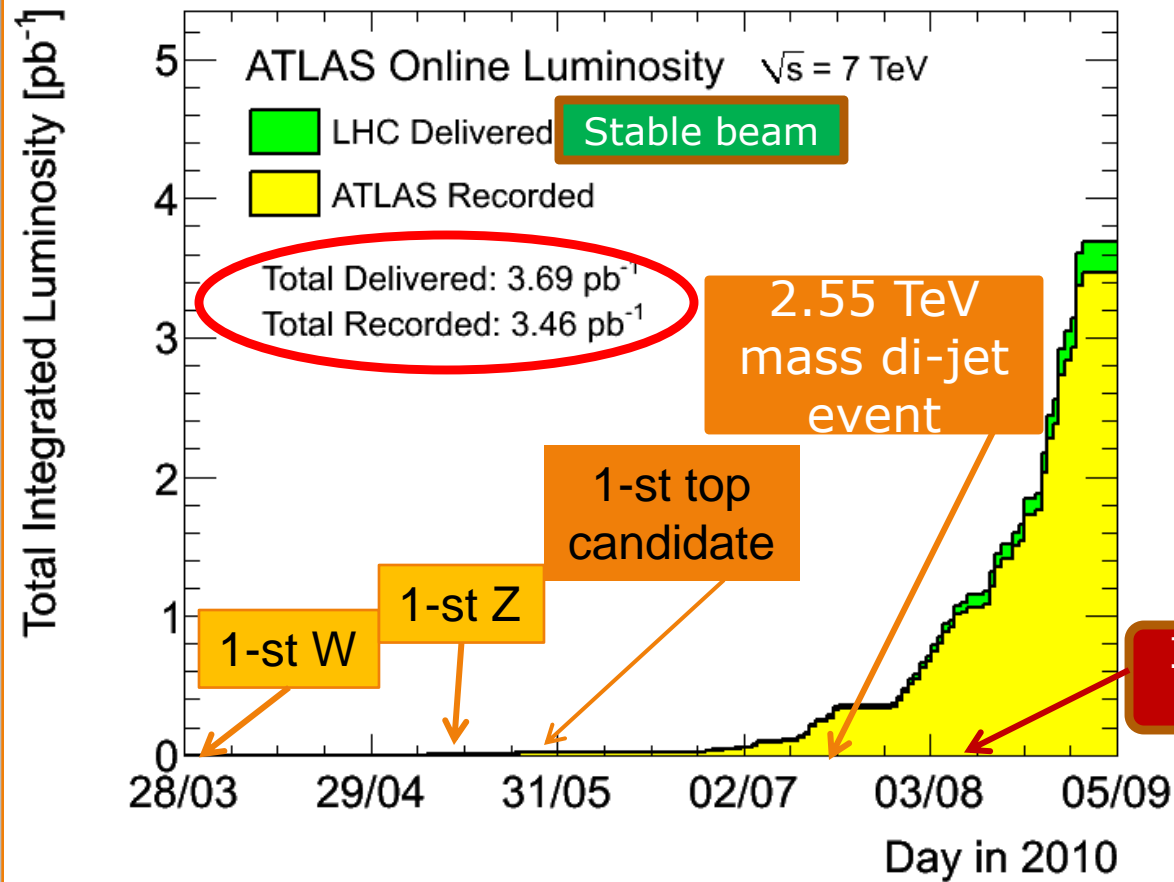
Data collected	Integrated luminosity	Time period
Cosmic rays		2008,2009
pp collisions at 900 GeV	$\sim 9 \mu\text{b}^{-1}$	Nov.-Dec.2009
pp collisions at 2.36 TeV	$\sim 0.7 \mu\text{b}^{-1}$	Dec.2009
pp collisions at 7 TeV	$\sim 3.4 \text{pb}^{-1}$	From 30 March 2010- up to now

Particle multiplicities and momentum spectra in pp minimum-bias events at 900 GeV (PhysLettB688:21,2010)

FIRST published results at 15 March

the latest presented at ICHEP2010 – 55 reports

ATLAS status



LHC milestones continue to be passed with satisfying regularity.

An inverse picobarn is a small step on the way to an inverse femtobarn

1-st inverse picobarn

Overall data taking efficiency 93.9%

ATLAS operation

Total fraction of good quality data (green "traffic light")

Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	TGC	CSC
97.7	96.4	100	94.4	98.7	99.3	99.2	98.5	98.3	98.6	98.3

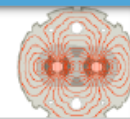
Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams at $\sqrt{s}=7$ TeV between March 30th and August 14th (in %)

Peak luminosity in ATLAS
 $L \sim 1.03 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$

ATLAS operation



Decided Scenario 2010-2011



ICHEP, July 26, 2010, Steve Myers report

Following the technical discussions in Chamonix (Jan 2010) the CERN management and the LHC experiments decided

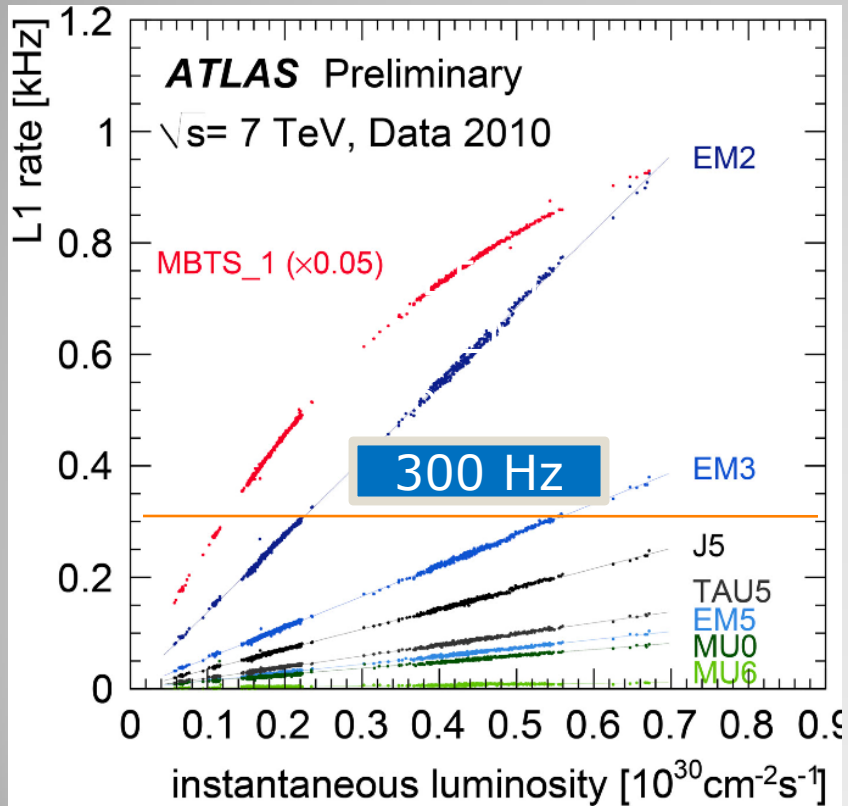
- Run at 3.5 TeV/beam up to a integrated luminosity of around 1fb^{-1} .
- Then consolidate the whole machine for 7TeV/beam (during a shutdown in 2012)
- From 2013 onwards LHC will be capable of maximum energies and luminosities

- requires a peak luminosity of $\geq 1 \times 10^{32} \text{ cm}^{-2}\text{s}^{-1}$ during 2011
- \rightarrow must reach $\sim 1 \times 10^{32} \text{ cm}^{-2}\text{s}^{-1}$ during 2010

ATLAS operation from LHC plan

Trigger commissioning and operation

ATLAS Trigger has 3 levels: LVL1, LVL2, Event Filter (EF)
High-Level-Trigger (HLT): LVL2 and EF



Typical L1 output 300 Hz in conditions:

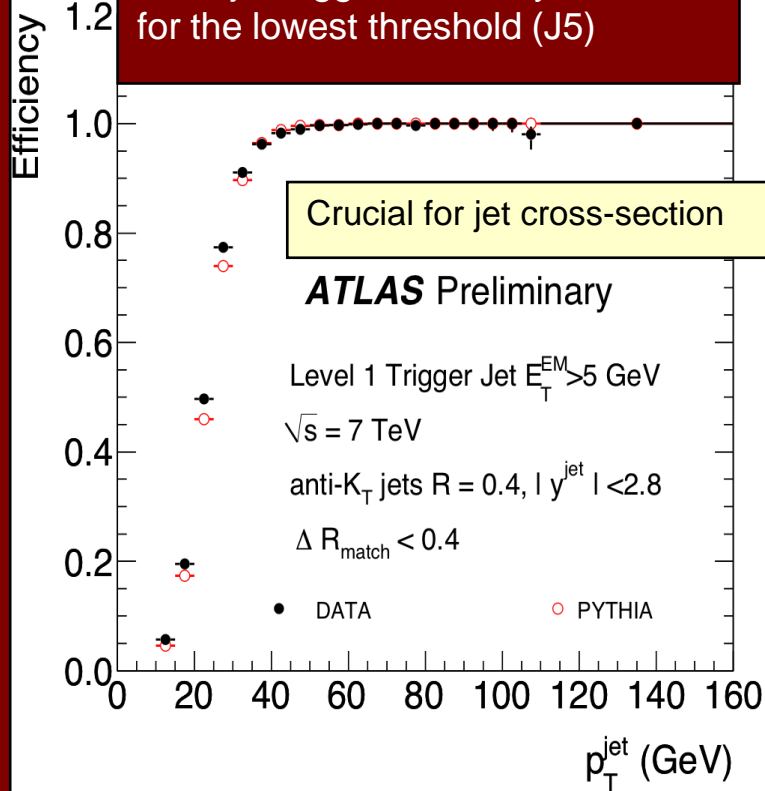
$L \sim 10^{29} \text{ cm}^{-2} \text{ s}^{-1}$:
start to activate HLT chains to cope with increasing rate while running with low LVL1 thresholds.
Jet items: lowest thresholds prescaled
(HLT rejection small)

Figure gives examples for L up to $7 \times 10^{29} \text{ cm}^{-2} \text{ s}^{-1}$

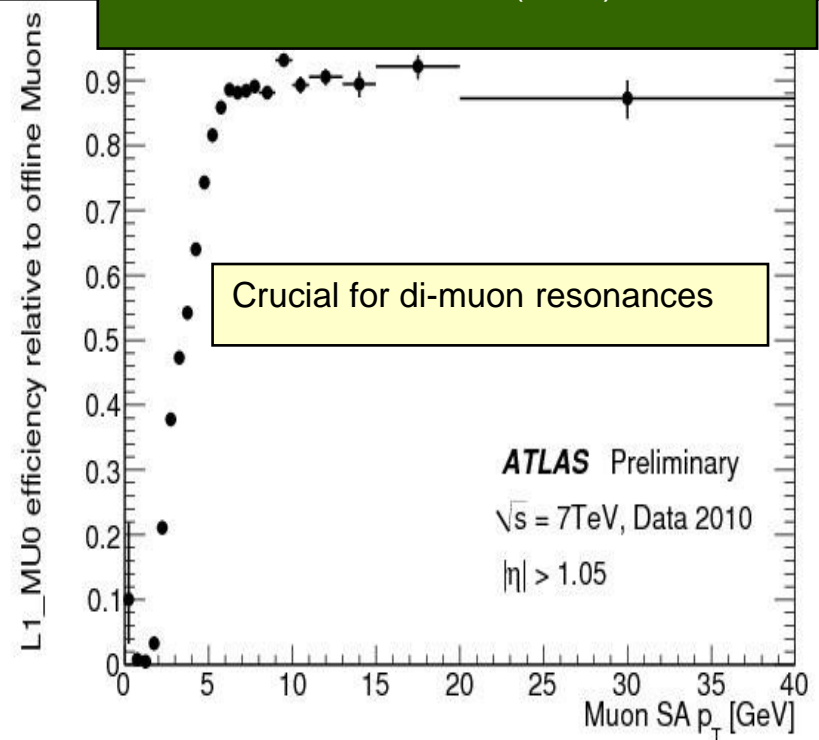
ATLAS operation

Trigger performance

LVL1 jet trigger efficiency for the lowest threshold (J5)



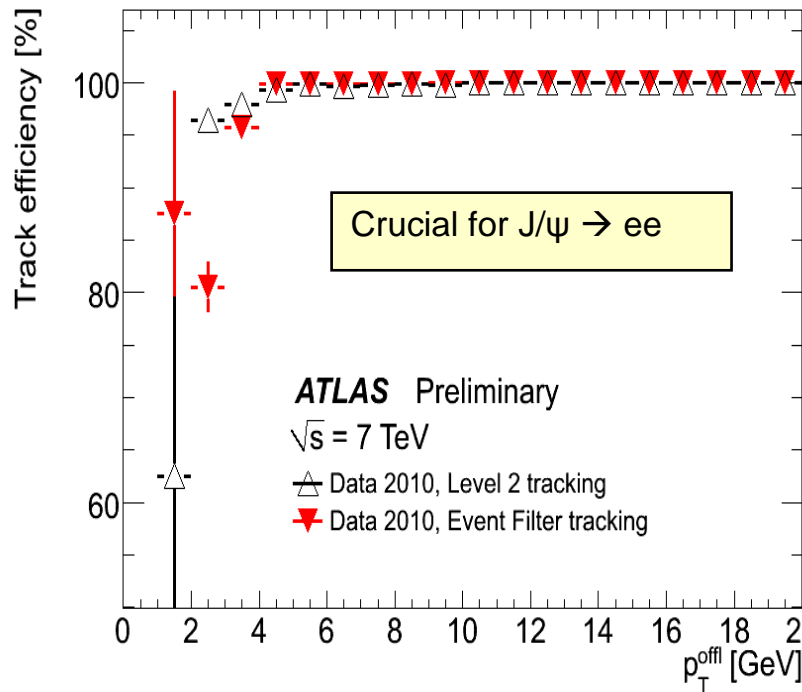
LVL1 forward muon trigger efficiency for the lowest threshold (MU0)



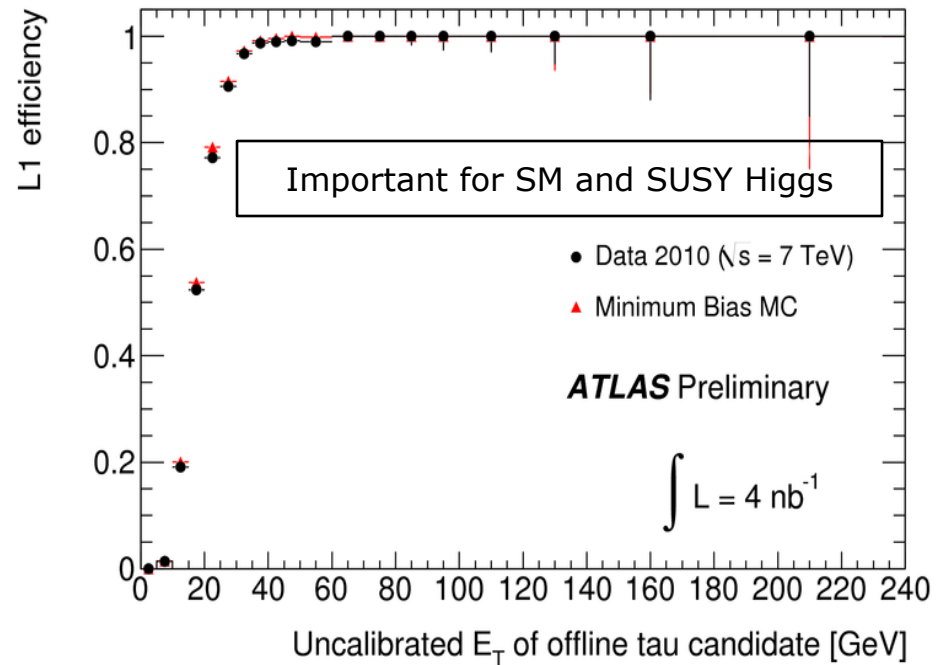
ATLAS operation

Trigger performance

Tracking efficiency at HLT for electron candidates with $E_T^{\text{off}}(\text{calo}) > 5 \text{ GeV}$



Tau L1 trigger efficiency
 $E_T > 5 \text{ GeV}$

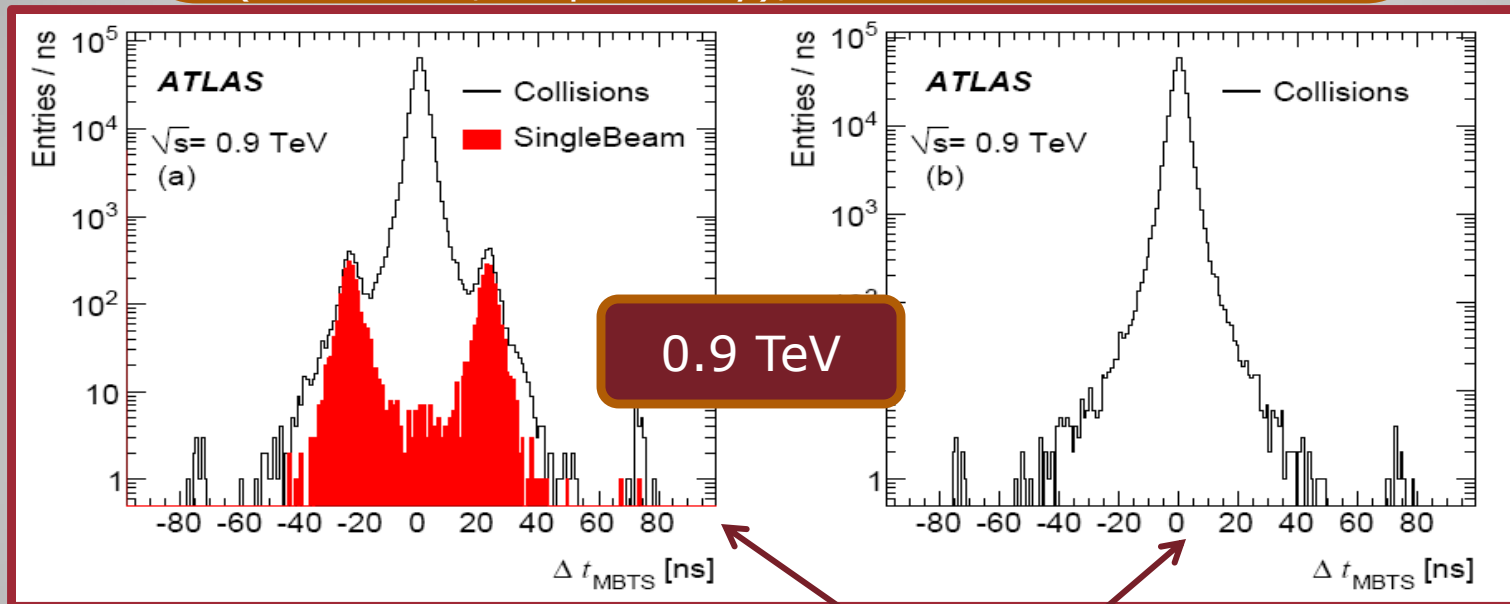


ATLAS operation

• Event selection

Primary vertex :

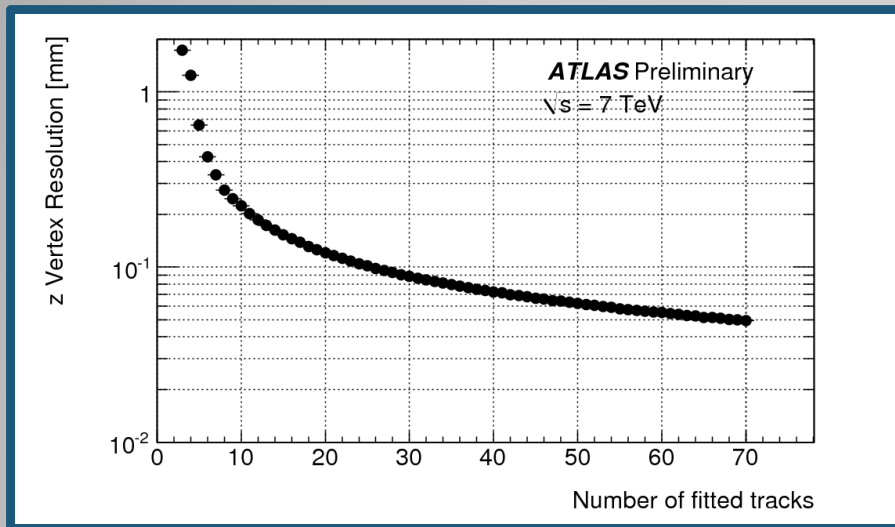
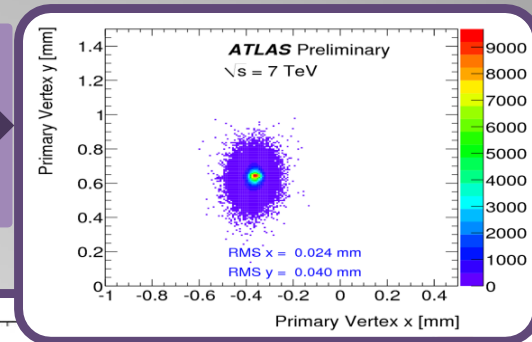
- 1) $n_{\text{track}} \geq 3$ ($p_t > 150$ MeV/c)
- 2) closest transverse distance to nominal interaction point
- 3) single hit in one or two MSTB wheels as trigger
- 4) selection on timing difference from EC or Fcal (5 or 10 ns, respectively), or two MSTB wheels



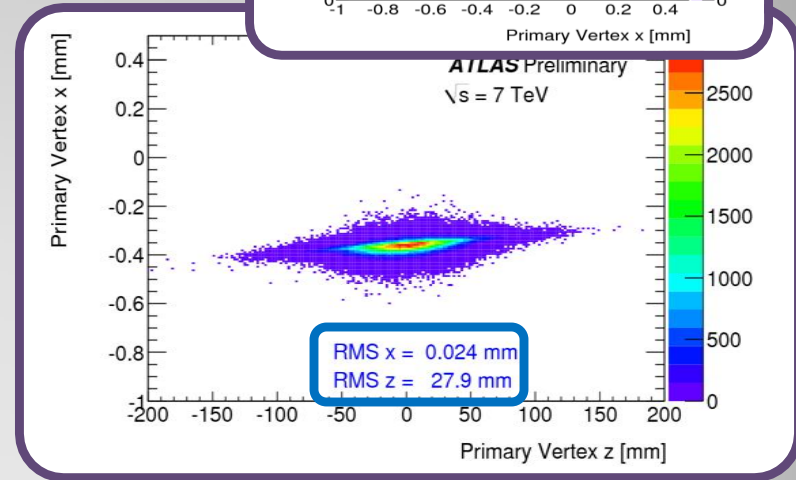
Time difference without any selection and with well reconstructed vertex

Primary Vertex reconstruction at 7 TeV

Primary vertices in the x-y plane, it shows beam spot: RMS = 0.024 and 0.04 mm
in x in y



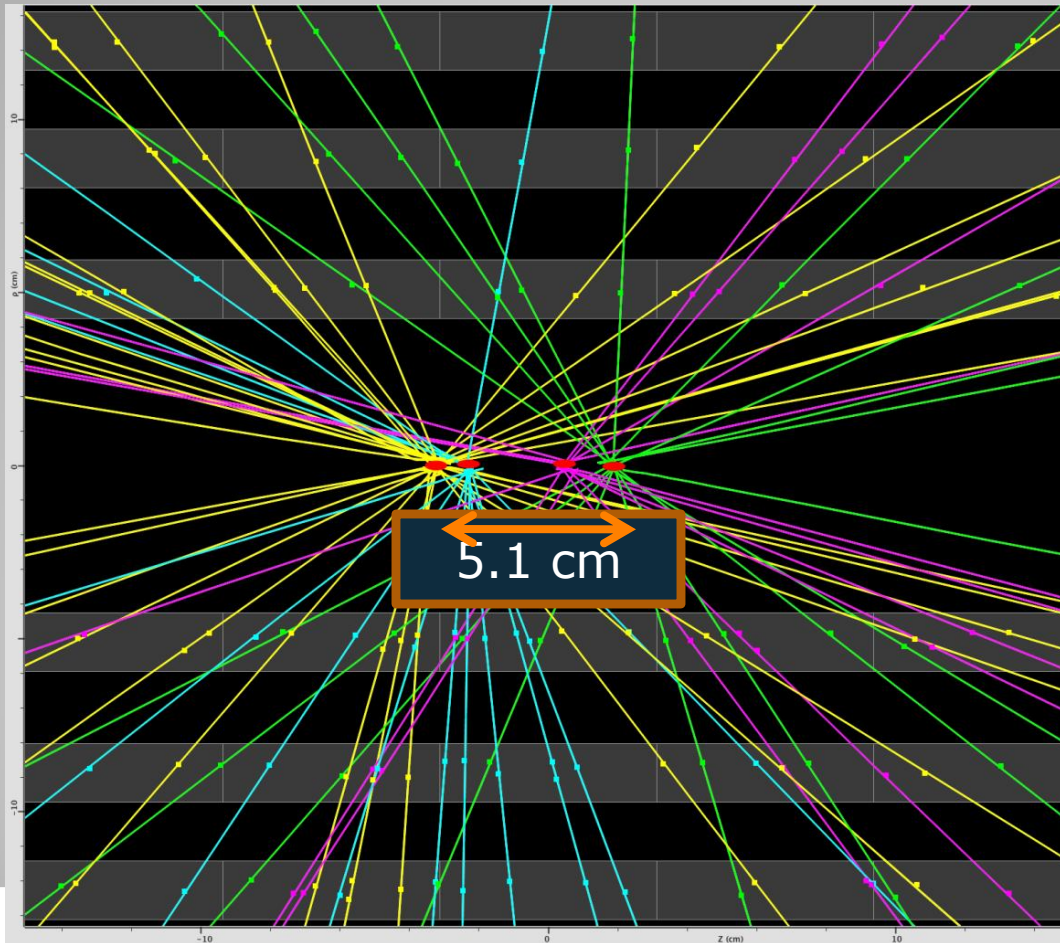
Estimated vertex resolution in 7 TeV data as a function of the number of tracks N .



Reconstructed primary vertices in the x-z plane as beam spot

Inner Detector performance

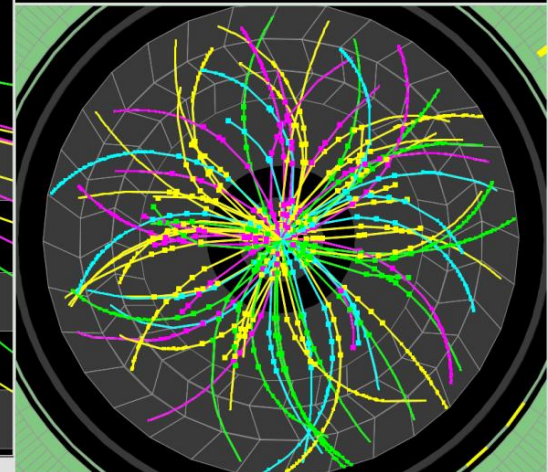
Event with four reconstructed primary vertices
the same beam-crossing
 $\sim 10\text{-}45$ tracks with $p_T > 150$ MeV per vertex



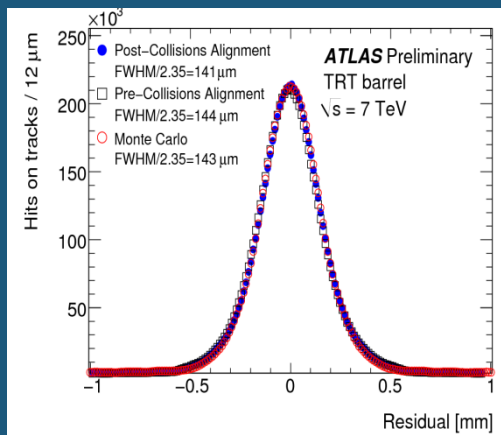
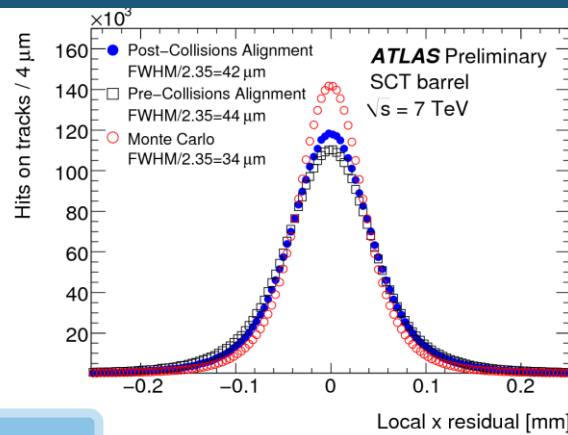
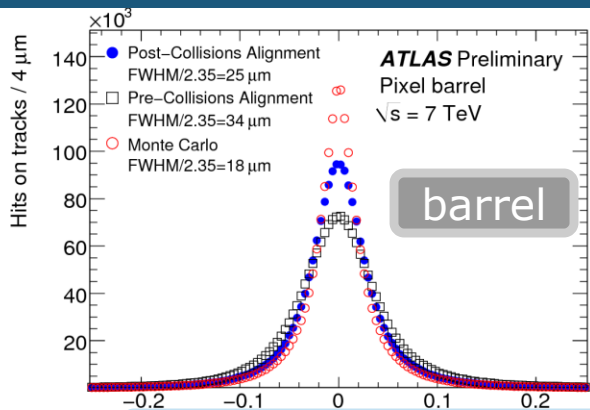
Run Number: 153565, Event Number: 4487360

Date: 2010-04-24 04:18:53 CEST

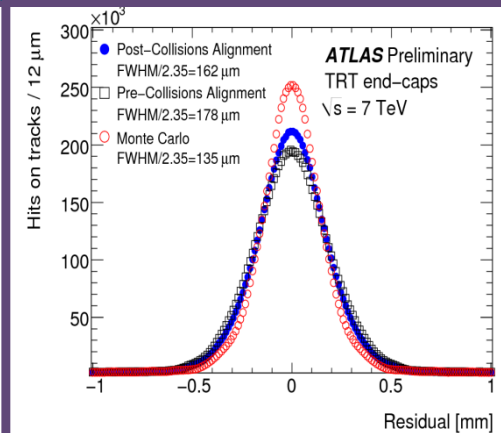
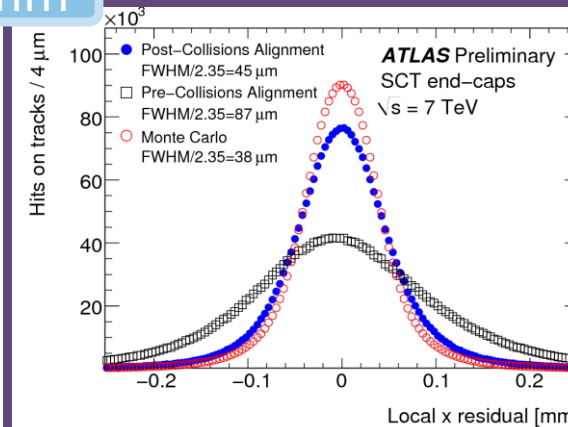
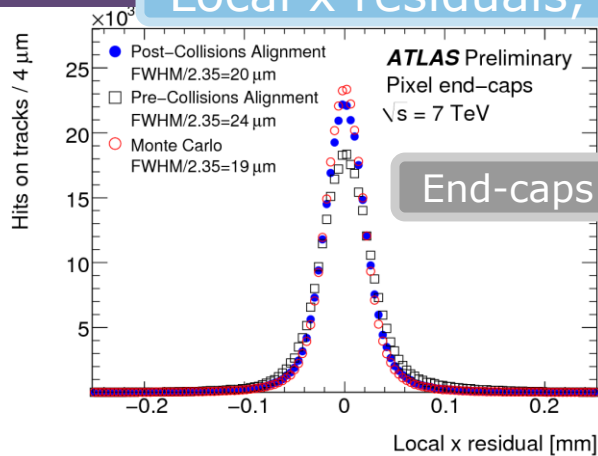
Event with 4 Pileup Vertices
in 7 TeV Collisions



ID Alignment pre-collisions and post-collisions



Local x residuals, mm



pixel

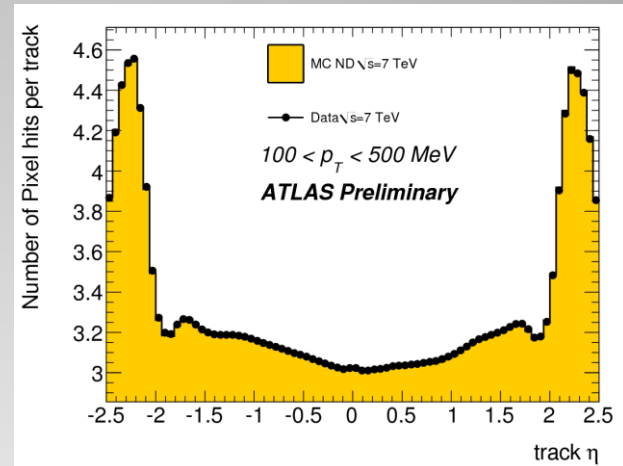
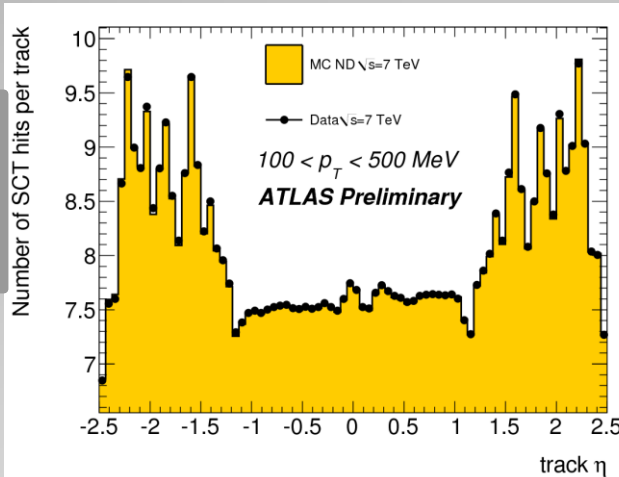
SCT

TRT

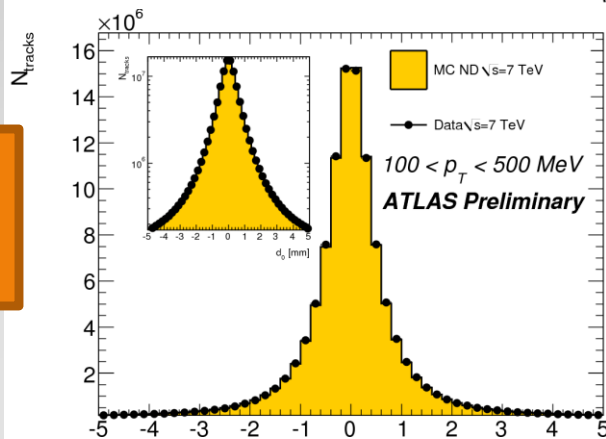
ID tracking performance $100 < p_T < 500$ MeV/c (similar to it for $p_T > 500$ MeV/c, relative to MC)

7 TeV

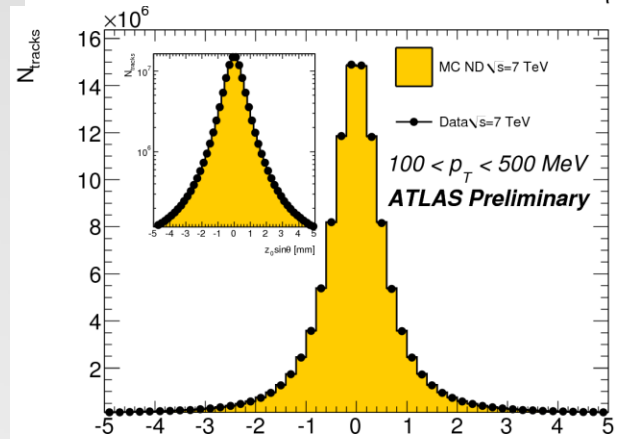
Numbers of hits in SCT and Pixel vs η



Track Impact parameters



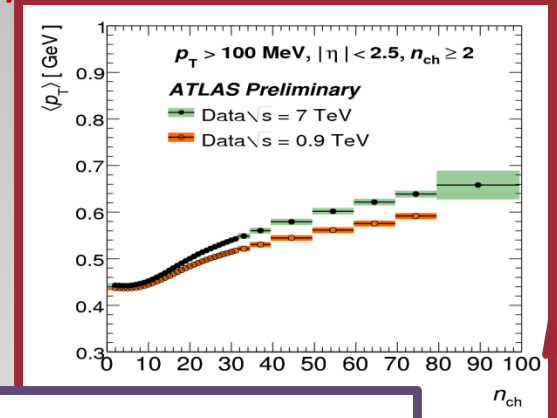
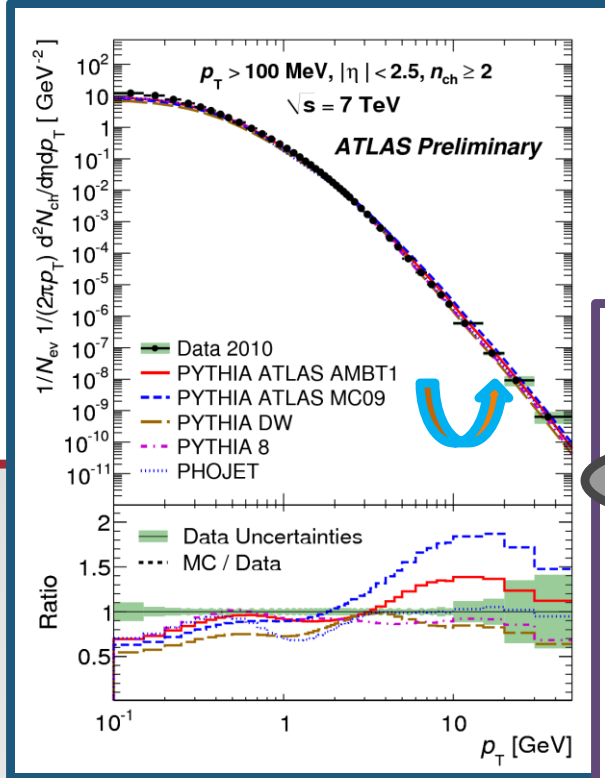
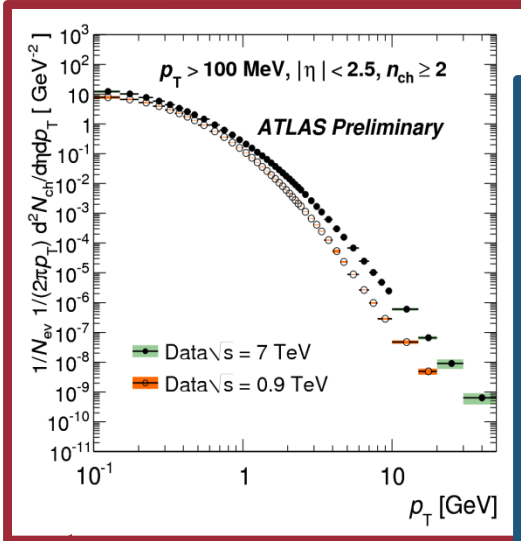
d_0 , mm



$Z_0 \sin \theta$, mm

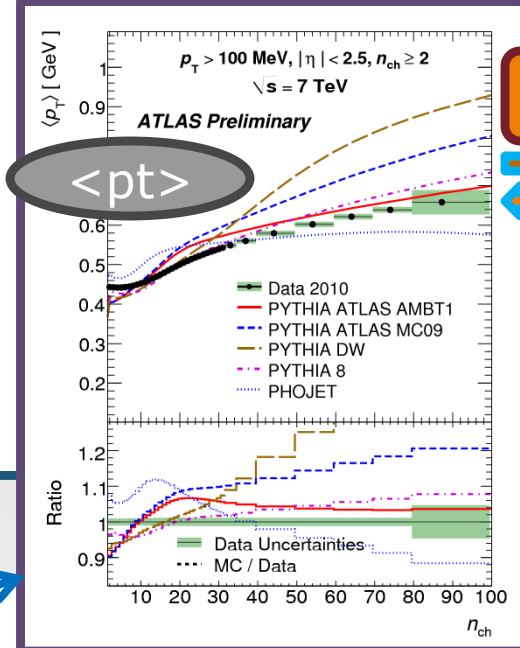
ATLAS performance

Pt measurements for charged particles with $p_T > 100 \text{ MeV}/c$ $|\eta| < 2.5$; $N_{ch} \geq 2$ at 0.9 and 7 TeV



Pt at 0.9 and 7 TeV

Pt at 7 TeV vs models



Nch at 0.9 and 7 TeV

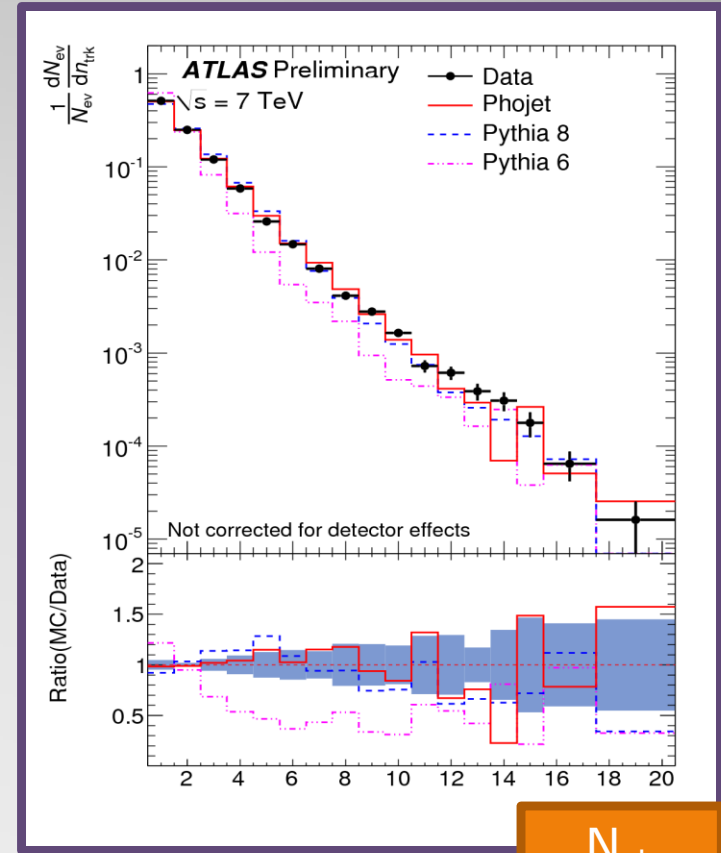
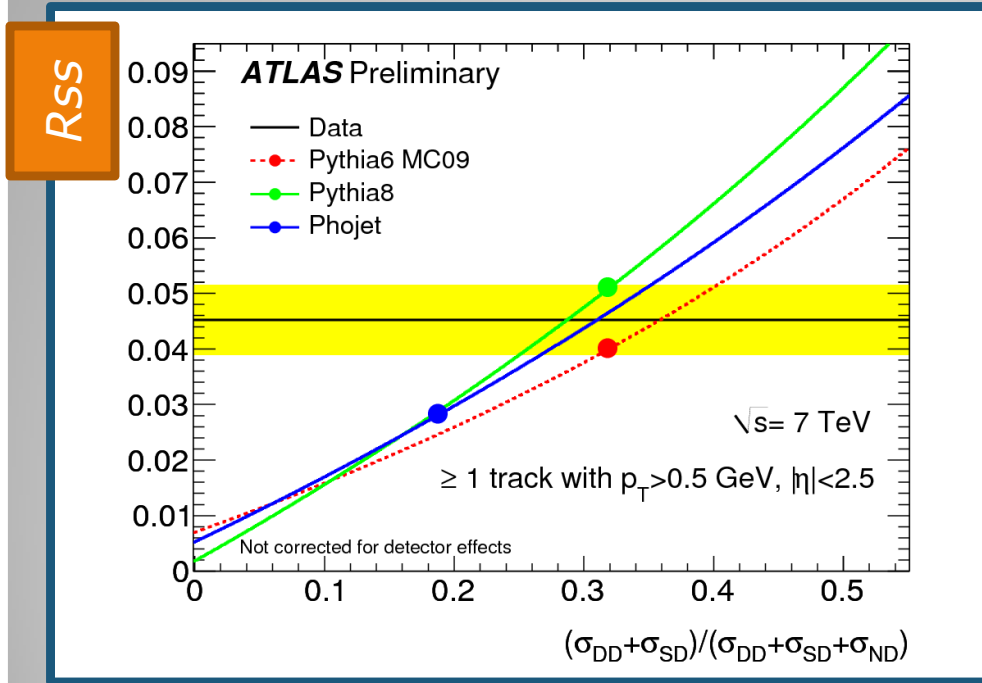
Nch

ATLAS performance and results

Data 7 TeV vs models

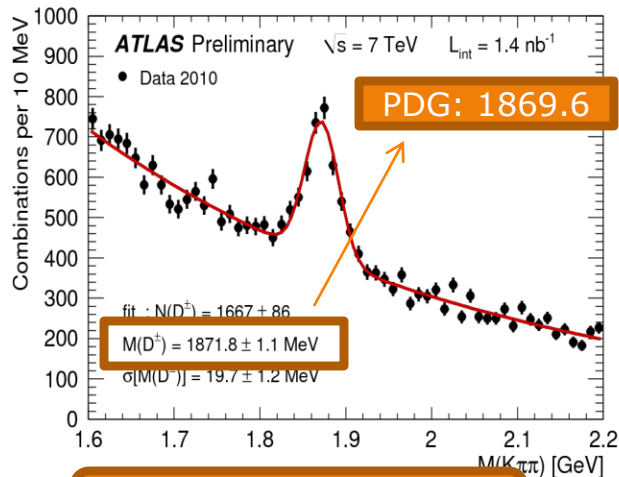
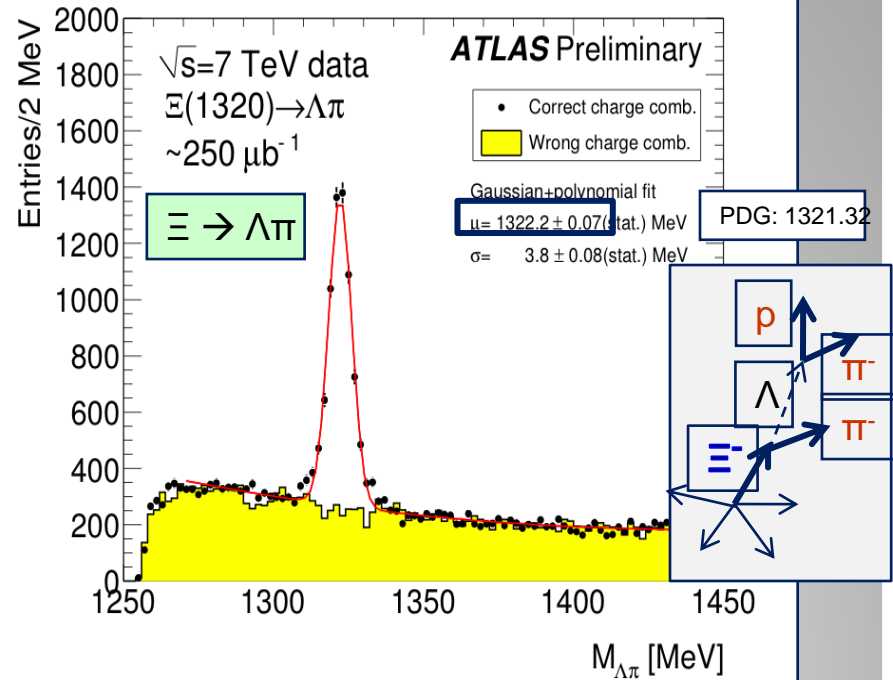
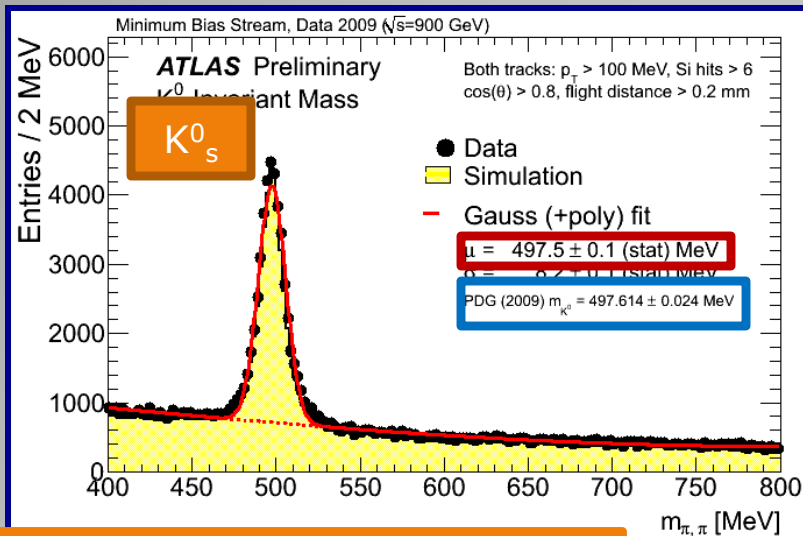
Diffraction enhanced events at 7 TeV

R_{SS} – The ratio of events with hits only on one side of the MBTS scintillators to events with any hits in the MBTS scintillators.



ATLAS performance and results

Secondary vertices and cascade decays

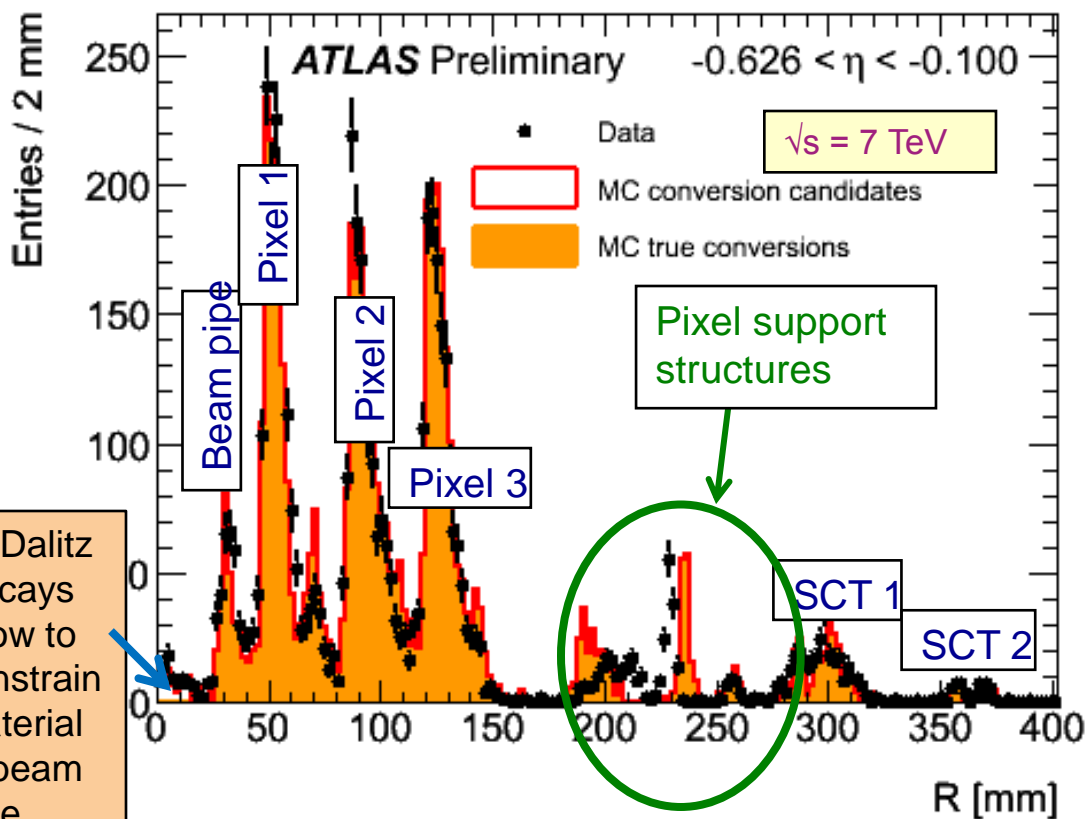


$D^\pm \rightarrow K\pi\pi$

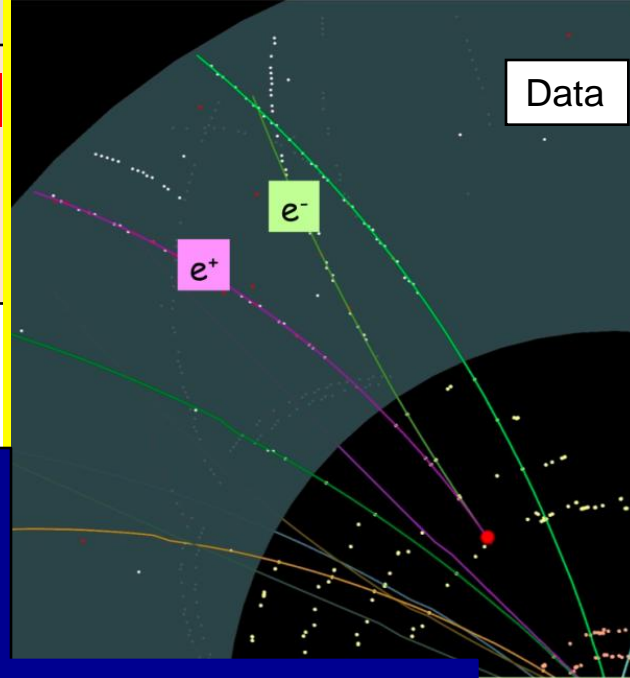
- $K_S^0, \Lambda, \Xi, \Omega, \phi, D, D^*$ mesons are reconstructed in Inner Detector
- Good agreement with MC
- Resolution as expected (dominated by multiple scattering)
- Fitted invariant masses agree with PDG values

Mapping the Inner Detector material with $\gamma \rightarrow e^+e^-$ conversions

Goal is to know material to better than 5%
(over-constraining with several methods)
Present understanding: at the level of $\sim 10\%$



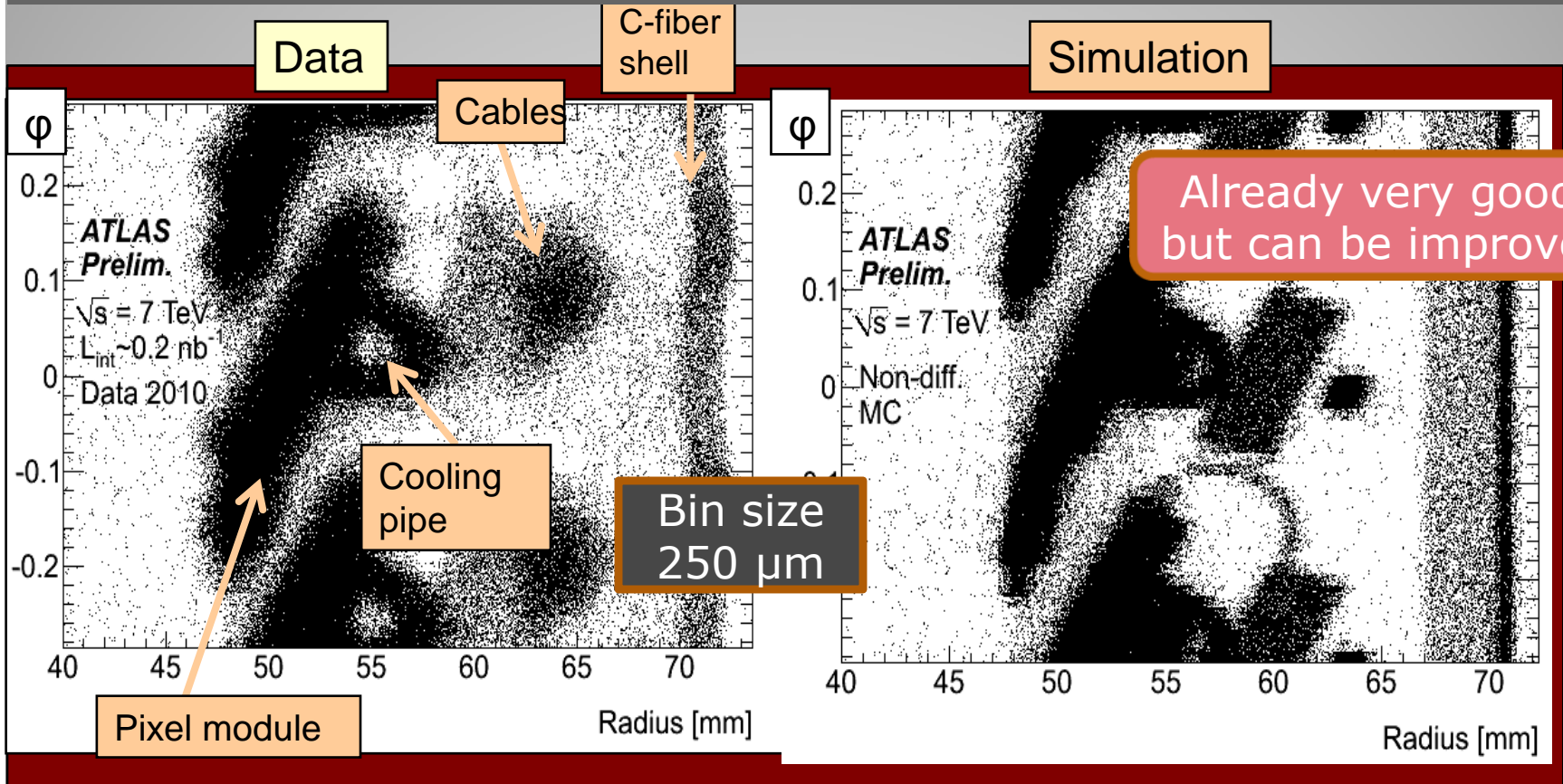
π^0 Dalitz Decays allow to constrain material in beam pipe



Reconstructed conversion point in the radial direction of $\gamma \rightarrow e^+e^-$ from minimum bias events (sensitive to X_0)

Data show that Pixel supports are displaced in the simulation \rightarrow to be fixed

Reconstructed secondary vertices due to hadronic interactions in minimum-bias events in the first layer of the Pixel detector
(sensitive to interaction length $\lambda \rightarrow$ complementary to γ conversion studies)

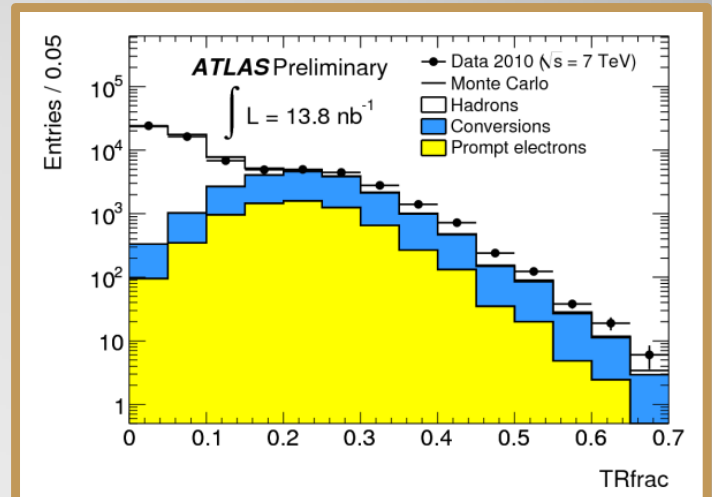
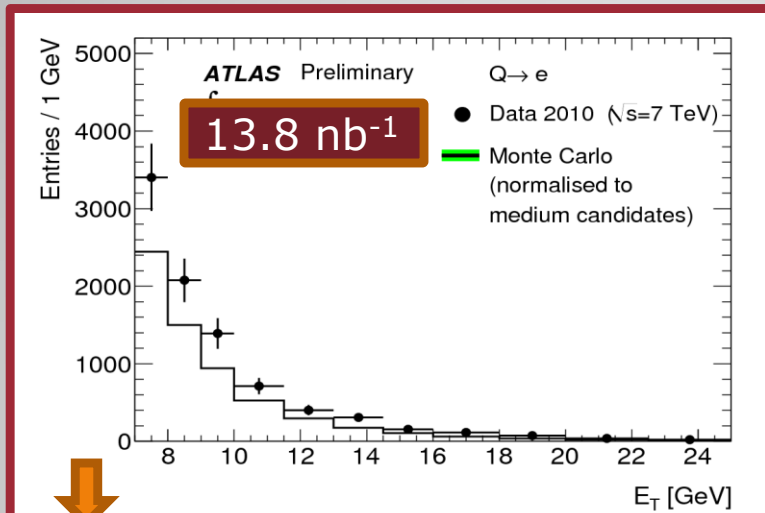
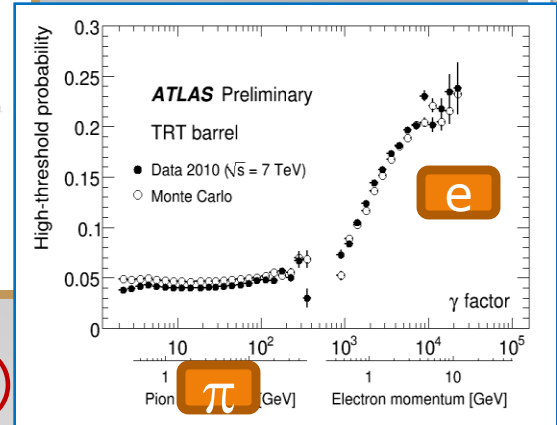
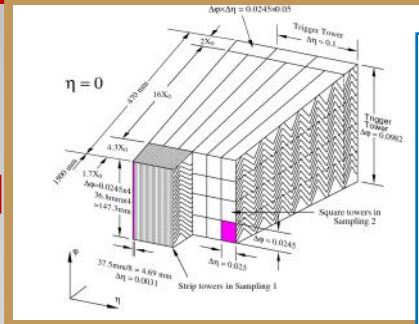


Mapping ID material with secondary hadronic interactions

e/γ reconstruction and identification

Based on:

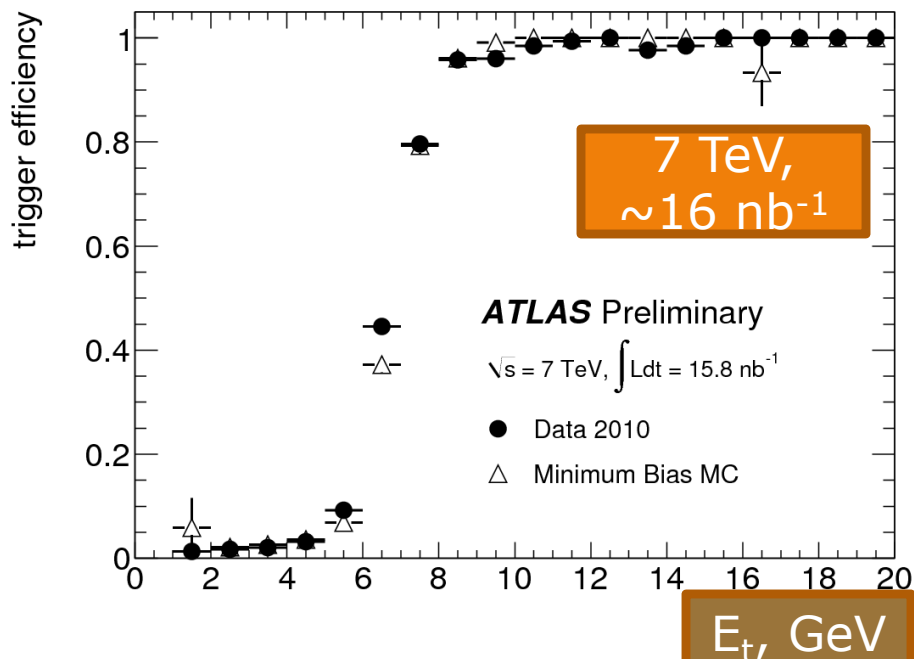
- Finest segmentation of EM
- Tracking performance
- TR measurements
- Hit on track in B-layer (select e from conversions)



Signal of $9920 \pm 160(\text{stat}) \pm 990(\text{syst})$ electrons predominantly from $b, c \rightarrow e$ is measured for $E_t > 7\text{GeV}$ and within $|\eta| < 2$

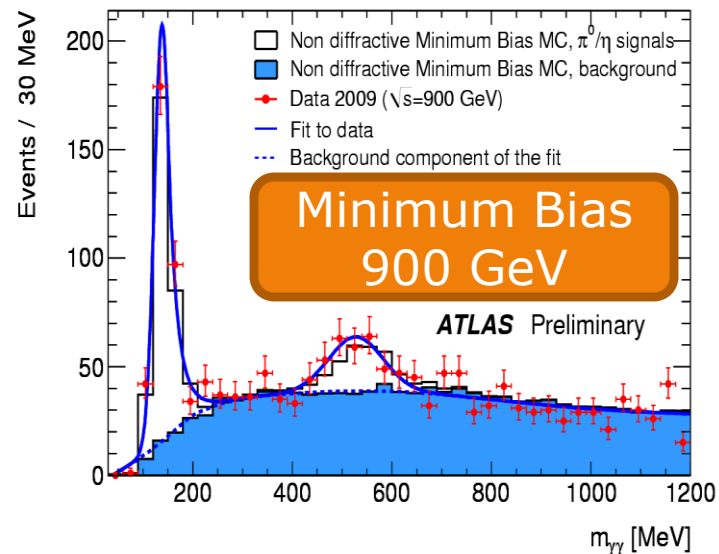
Decays to γ , prompt γ

Trigger efficiency for γ vs E_t

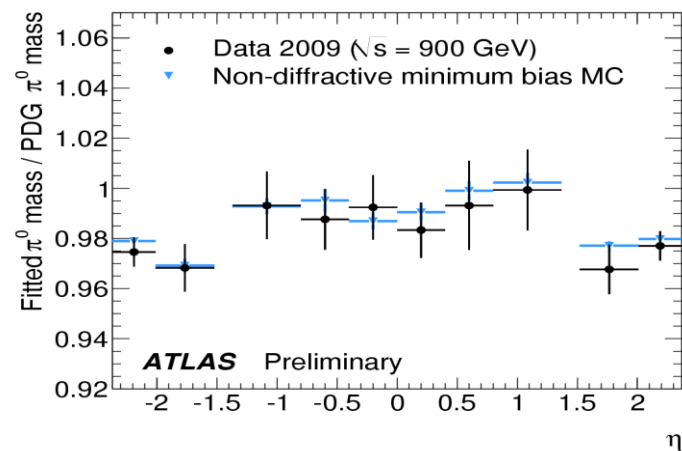


Efficiency $\geq 99.3\%$ for $E_t > 10 \text{ GeV}$
 Prompt photon purity for $E_t > 20 \text{ GeV}$
 $(72 \pm 7)\%$

e/γ performance



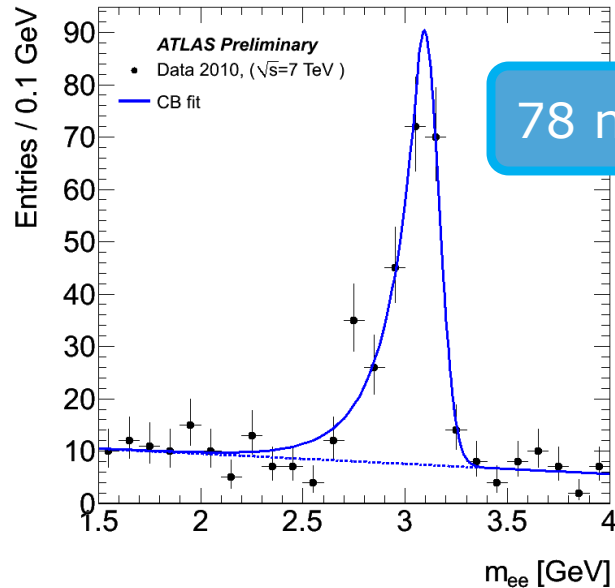
$M_{\gamma\gamma}$ with π^0 and η mesons signals, MeV



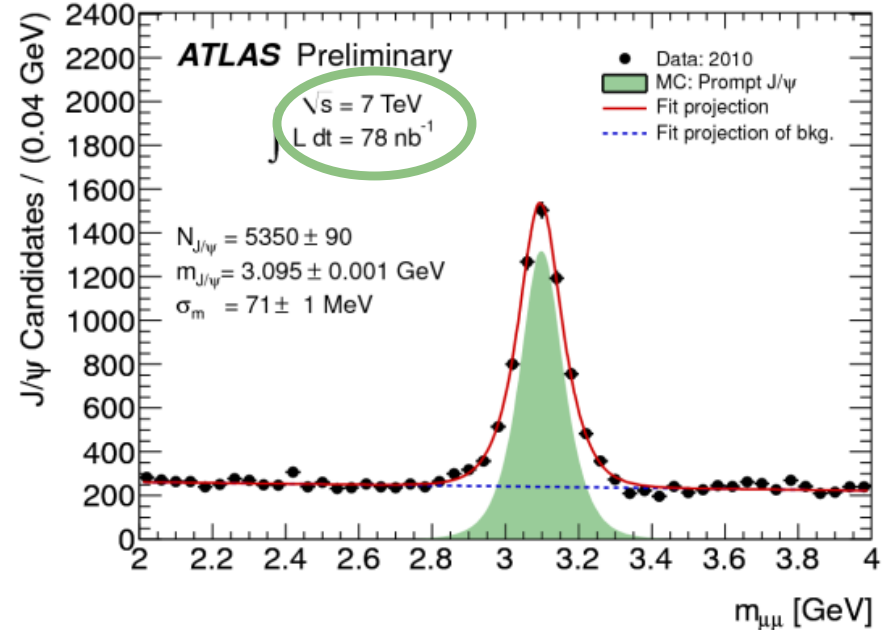
$J/\psi \rightarrow e^+e^-$

Signal : 222 ± 11 events
Background : 28 ± 2 events
Mass peak : 3.09 ± 0.01 GeV
Mass resolution : 0.07 ± 0.01 GeV

PDG:
3.0969



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



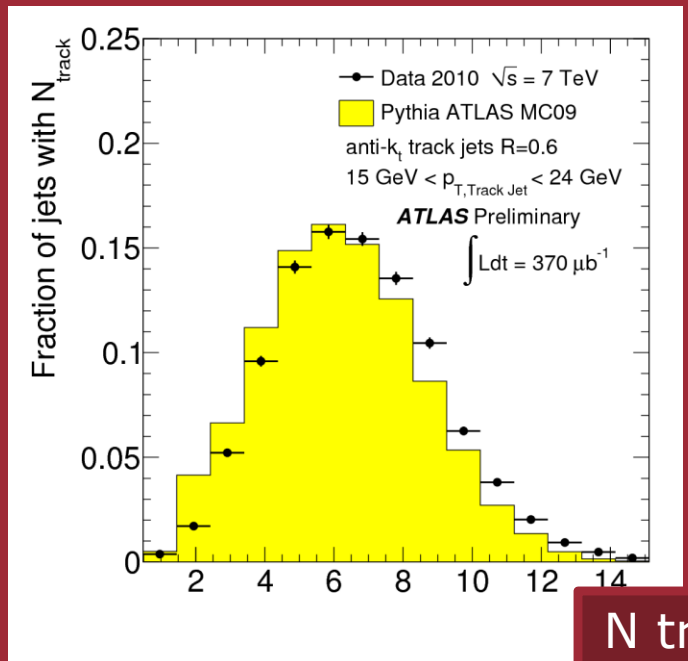
To extract signal from background:

- 2 EM clusters matched to tracks
- p_T (e^\pm tracks) $> 4, 2$ GeV
- track quality, calo shower shapes
- key handle: large transition radiation in TRT
- invariant mass from track parameters after
Brem recovery (GSF)

Measurements results
presented at this workshop by
K. Toms

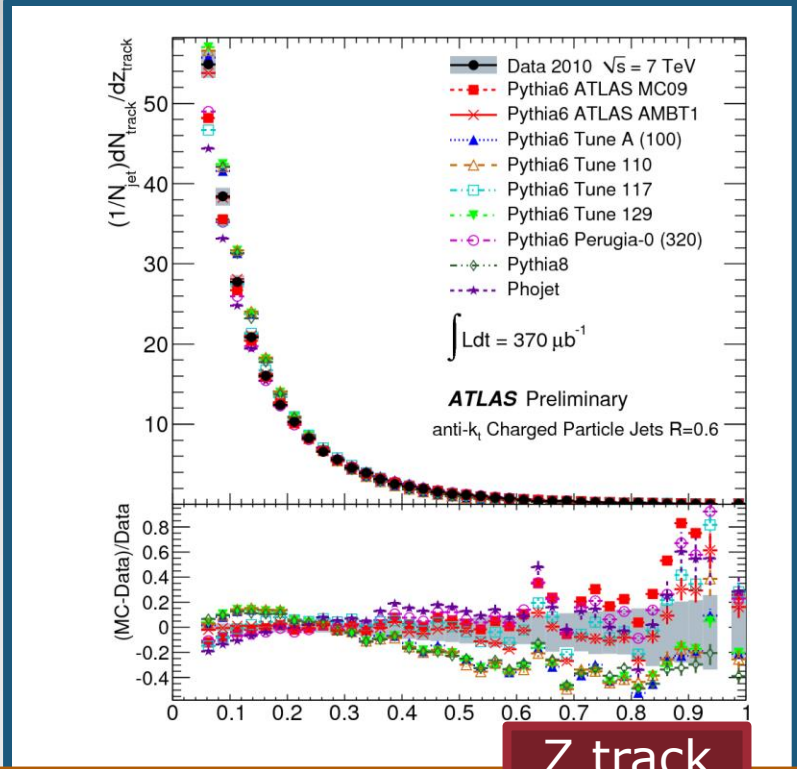
Inclusive jet measurements with ID: numbers of track distributions and fragmentation functions

7 TeV



N track

Number of tracks per jet with $R = 0.6$ for jet p_T from 15 GeV to 24 GeV. (Data are not corrected. Differences between data and Pythia MC09 are accounted for the fragmentation/underlying event systematic)

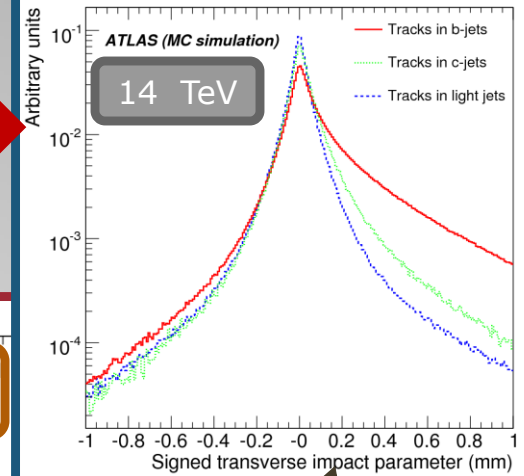
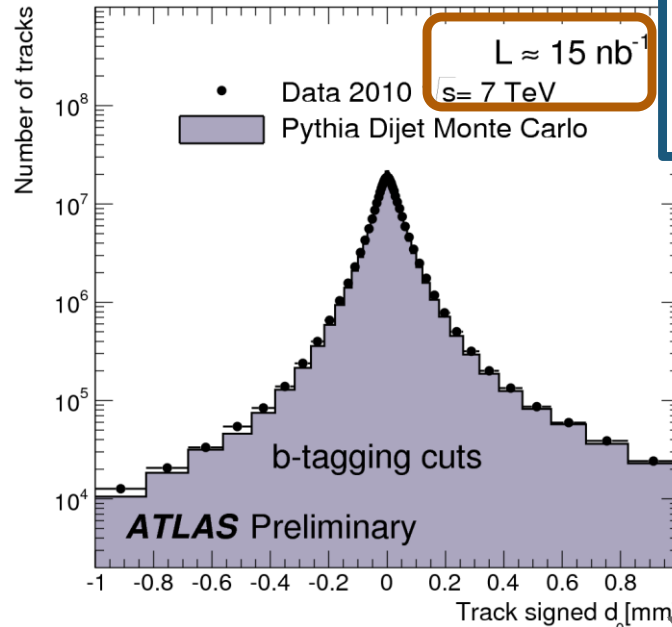
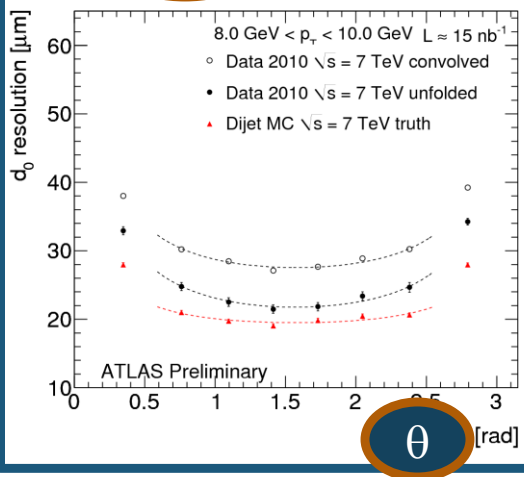
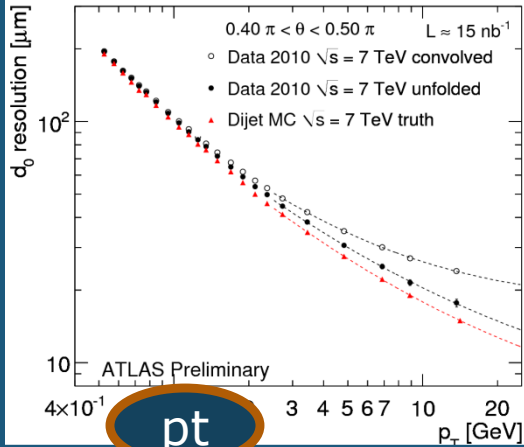


Z track

Corrected fragmentation function in anti- k_t jets with $R = 0.6$ for charged jet p_T from 15 - 24 GeV

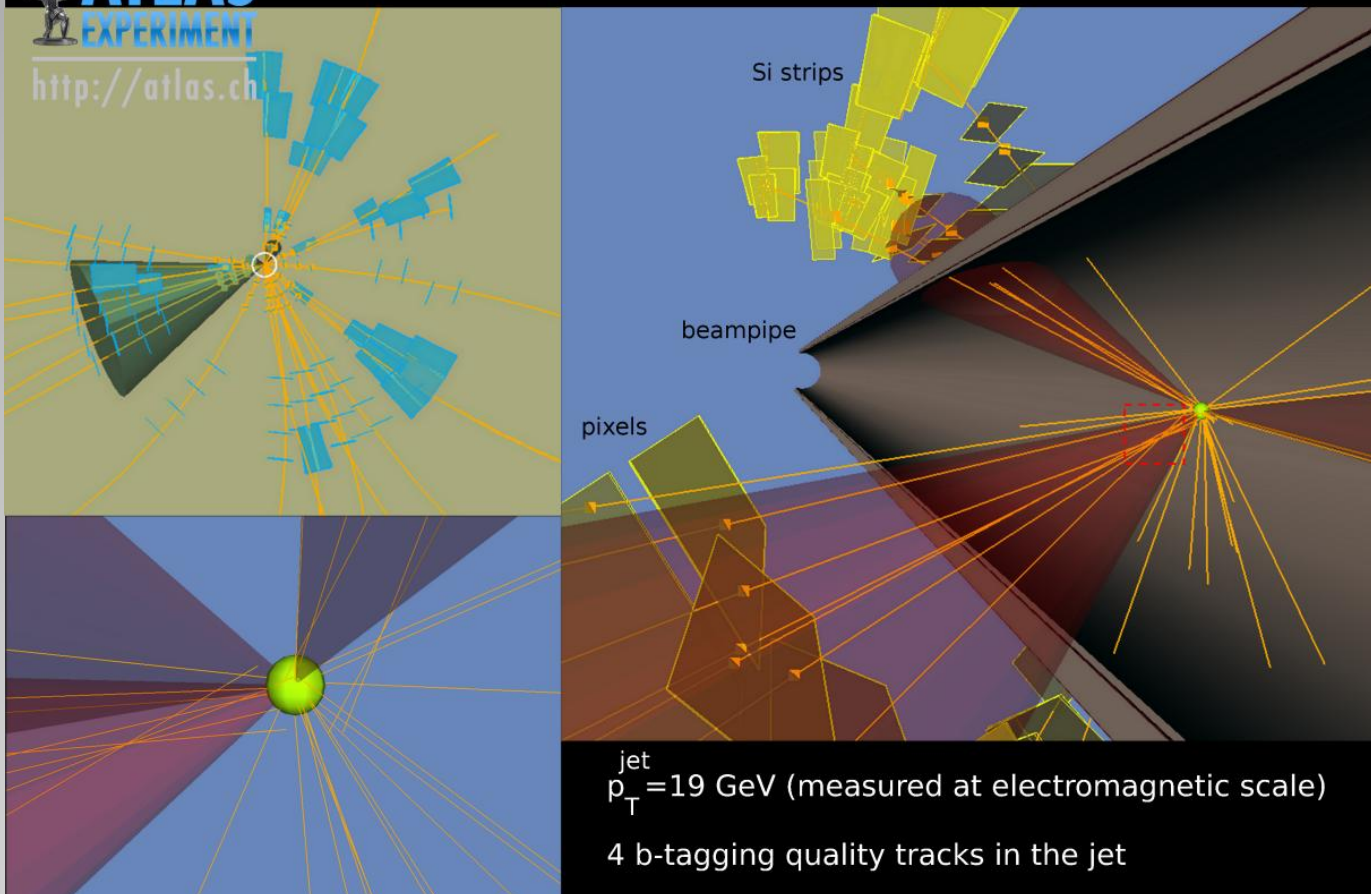
Important for TOP measurements

b-jet identification rely on:
Tracks impact parameters
Secondary vertex reconstruction



Signed transverse impact parameter for b, c and light jets in MC simulation and Data

Tracks impact parameter resolution vs Pt and θ

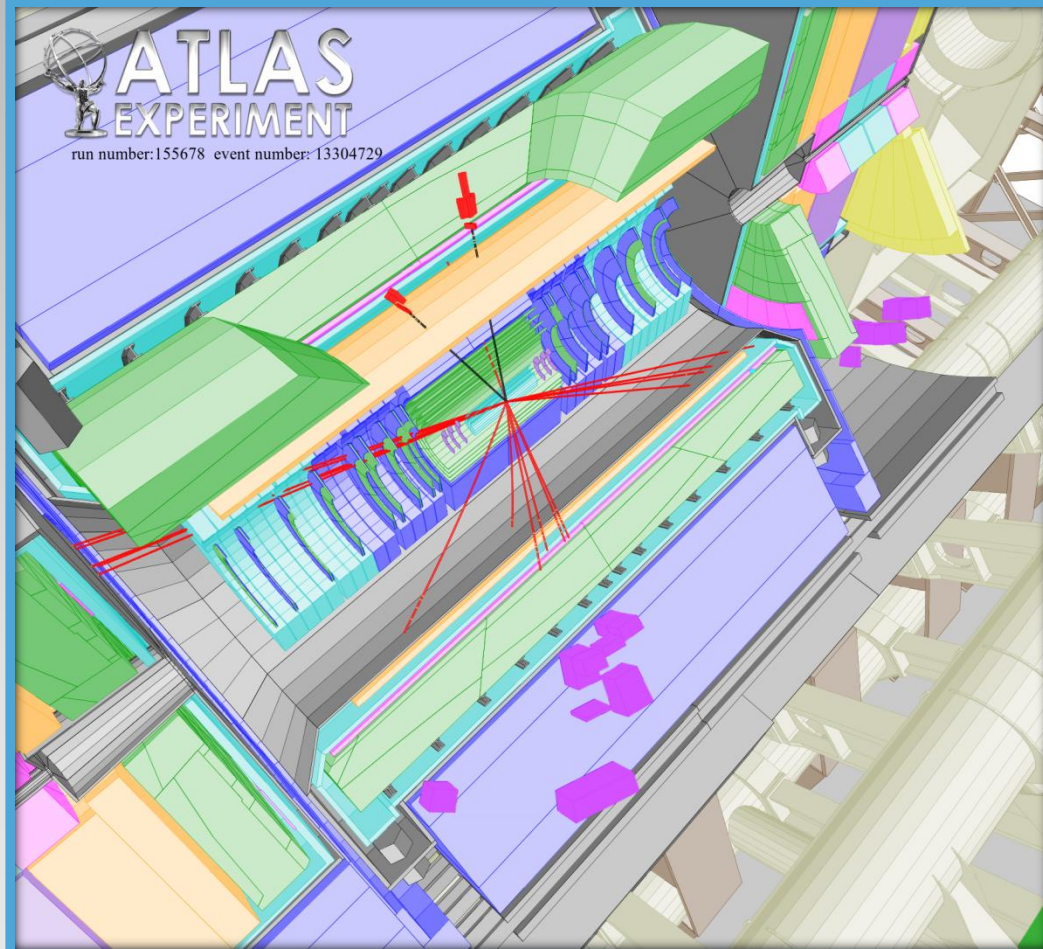


b-tagged jet in pp collisions at 7 TeV

One soft b-tagged jet in events with two electrons, passed cuts, at 7 TeV with int. luminosity 280 nb⁻¹

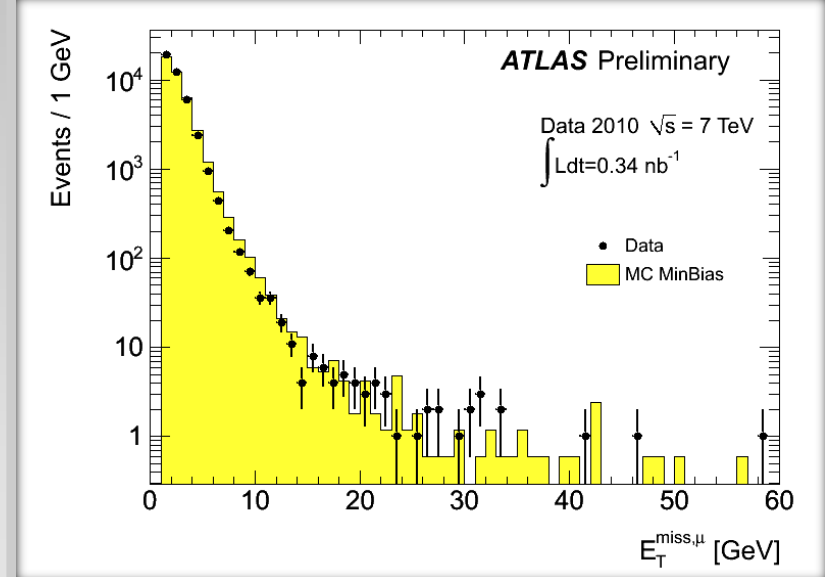
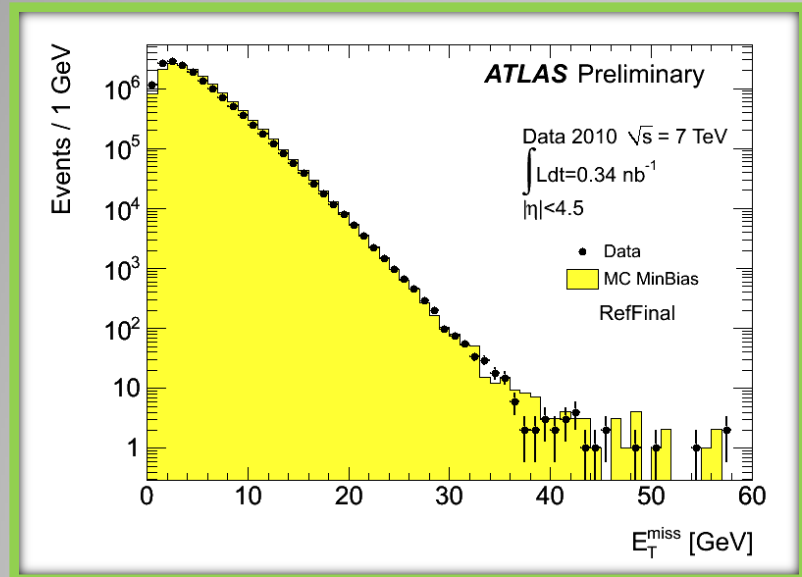
In GeV:
P_t of ee
55.2/40.6
E_t^{miss} 42.4;
H_t 271 GeV
#jets >20 GeV
- 3
b-tag jet -1

M_{ee} = 36.9 GeV



Top candidate

$E_{t \text{ miss}}$ performance

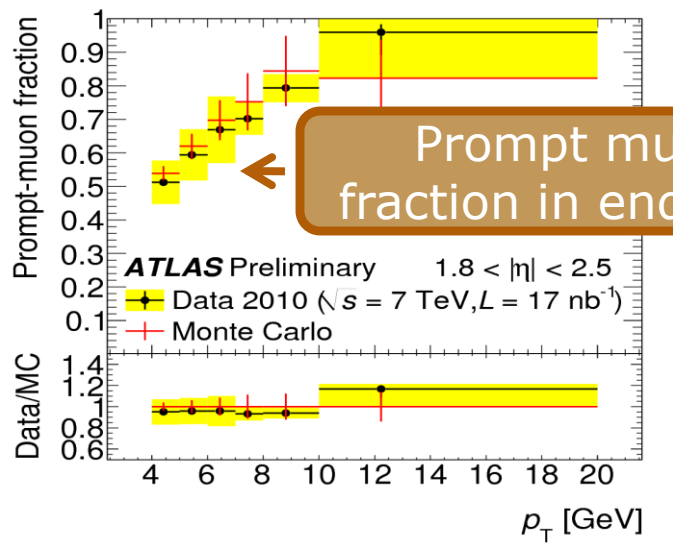
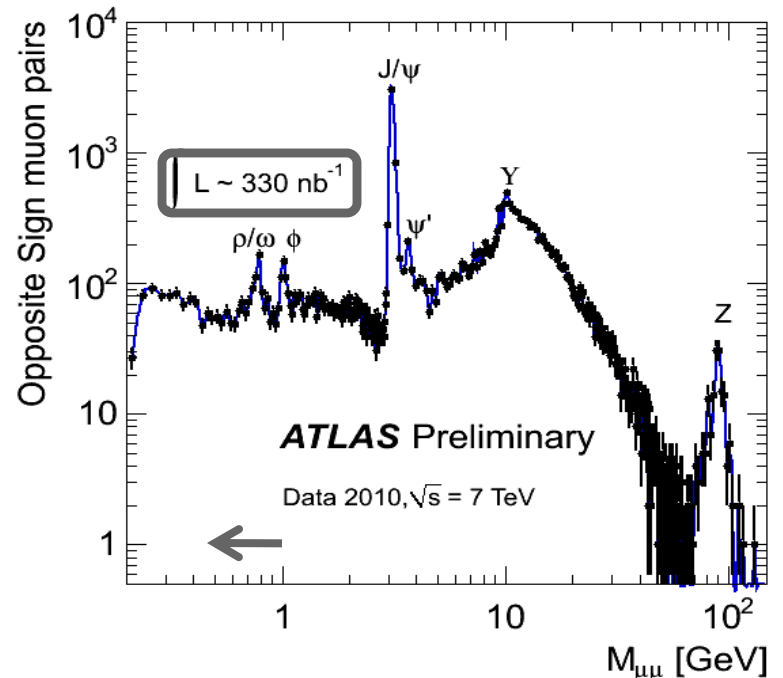
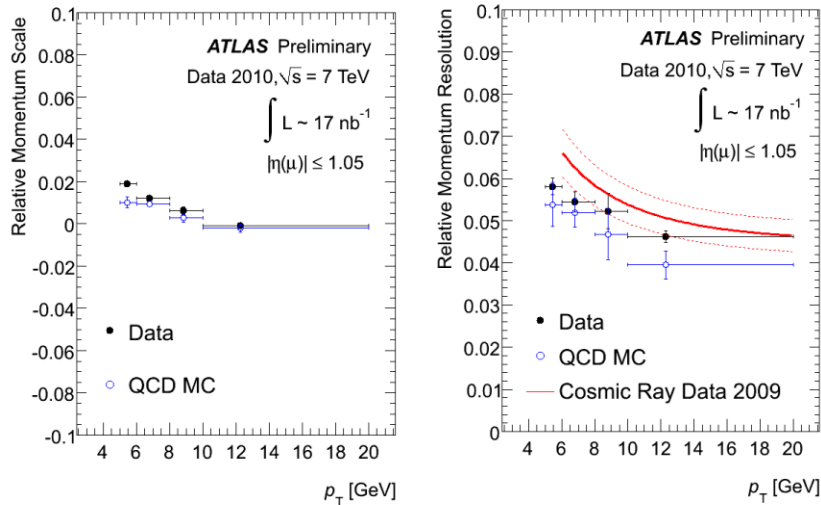


$E_{t \text{ miss}}$ in 15.2 million selected minimum bias events at 7 TeV, recorded in April 2010.

$E_{t \text{ miss}}$ in the events with at least one reconstructed muon at 7 TeV

Good agreement with MC simulations

P_T muon resolution from collisions



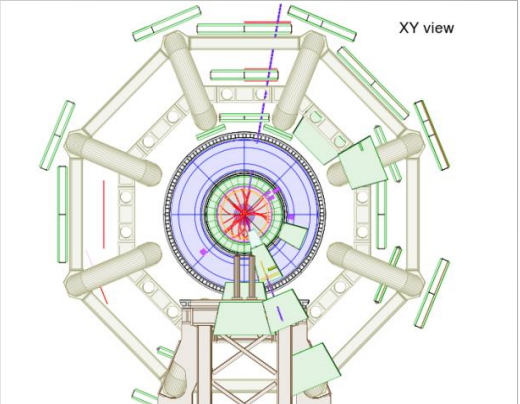
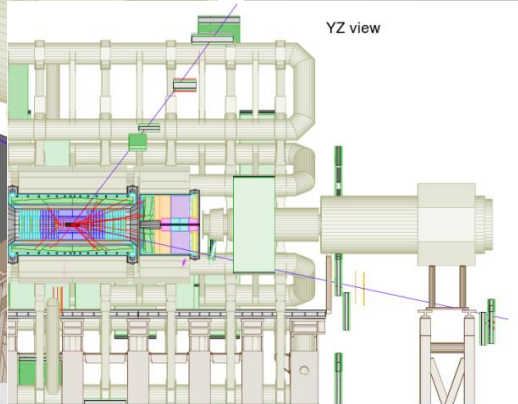
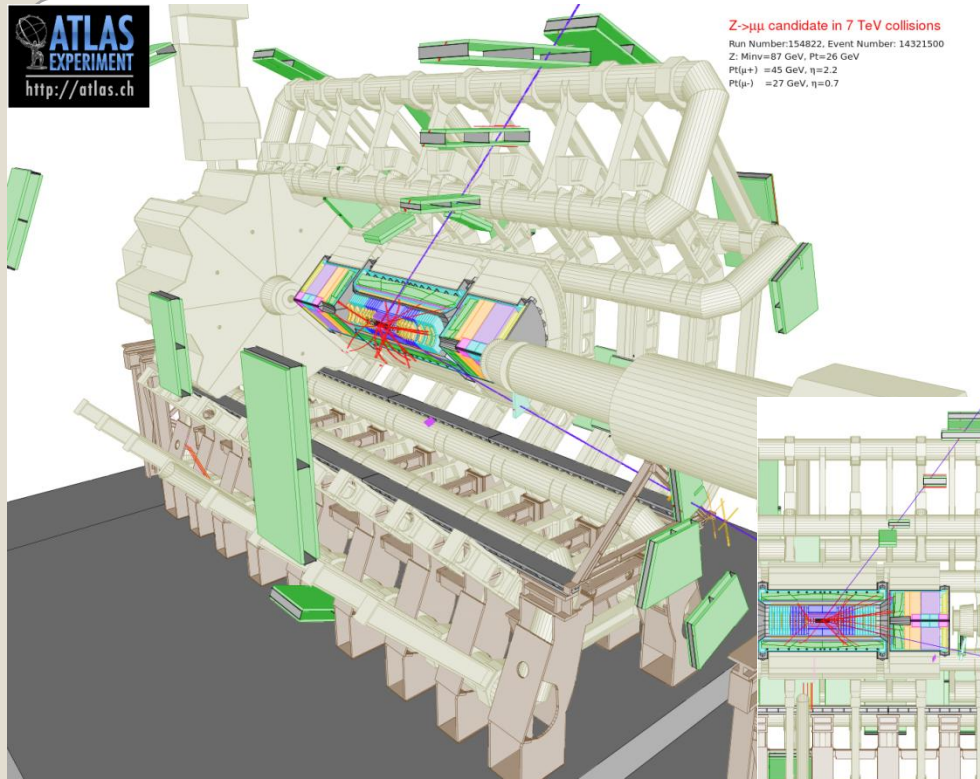
Prompt muon fraction in end-caps

- LVL1 muon trigger with $p_T \sim 6$ GeV threshold
- 2 opposite-sign muons reconstructed by combining tracker and muon spectrometer
- both muons with $|z| < 1$ cm from

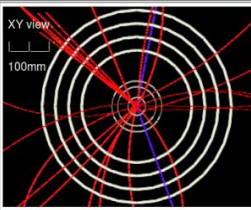
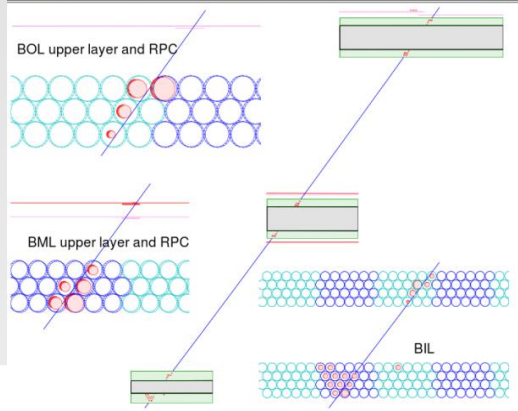
Muon performance

Z-> $\mu\mu$ candidate in 7 TeV collisions
Run Number: 154822, Event Number: 14321500
Z: Minv=87 GeV, Pt=26 GeV
Pt(μ^+) = 45 GeV, $\eta=2.2$
Pt(μ^-) = 27 GeV, $\eta=0.7$

Z-> $\mu\mu$ candidate (collected on 10 May)



Event properties: $p_T(\mu^+)$
= 45 GeV
 $\eta(\mu^+) = 2.2$
 $p_T(\mu^-) = 27$ GeV
 $\eta(\mu^-) = 0.7$
 $m_{\mu\mu} = 87$ GeV



Z-> $\mu\mu$ candidate in 7 TeV collisions
Run Number: 154822, Event Number: 14321500
Z: Minv=87 GeV, Pt=26 GeV
Pt(μ^+) = 45 GeV, $\eta=2.2$
Pt(μ^-) = 27 GeV, $\eta=0.7$

Conclusion

- *ATLAS successfully operate with beam collisions* - pp at 7 TeV from 30.03.2010
- Calibration, alignment, synchronization, reconstruction software and trigger on real data were realized and continued with improvements
- Good detector and reconstruction performance is achieved
- First physics results for Soft QCD are received
- Hard QCD and EW objects are observed (jets, W/Z, tau, b-jet)
- Information on results could be found on atlas.web.cern.ch in Public ATLAS Results

ATLAS status, operation and performance