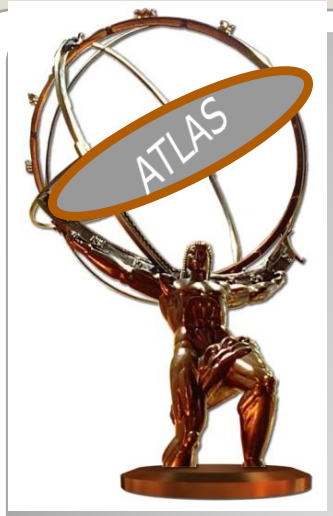
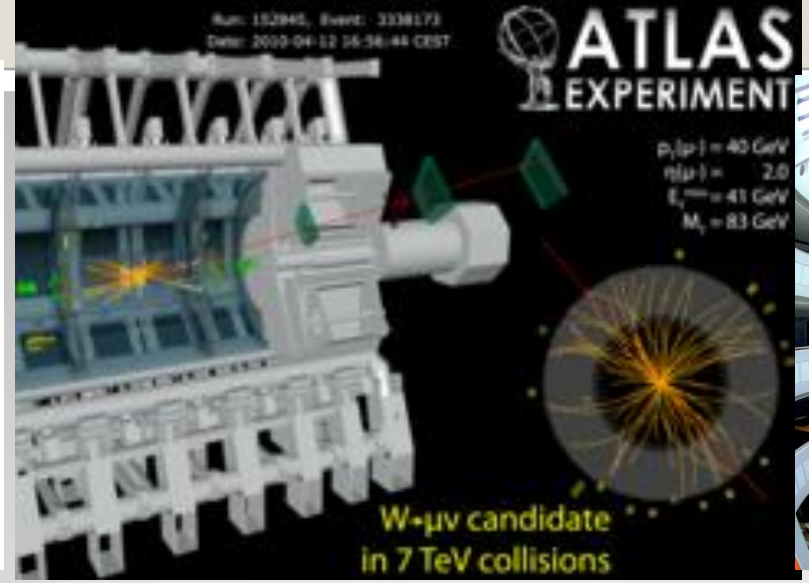




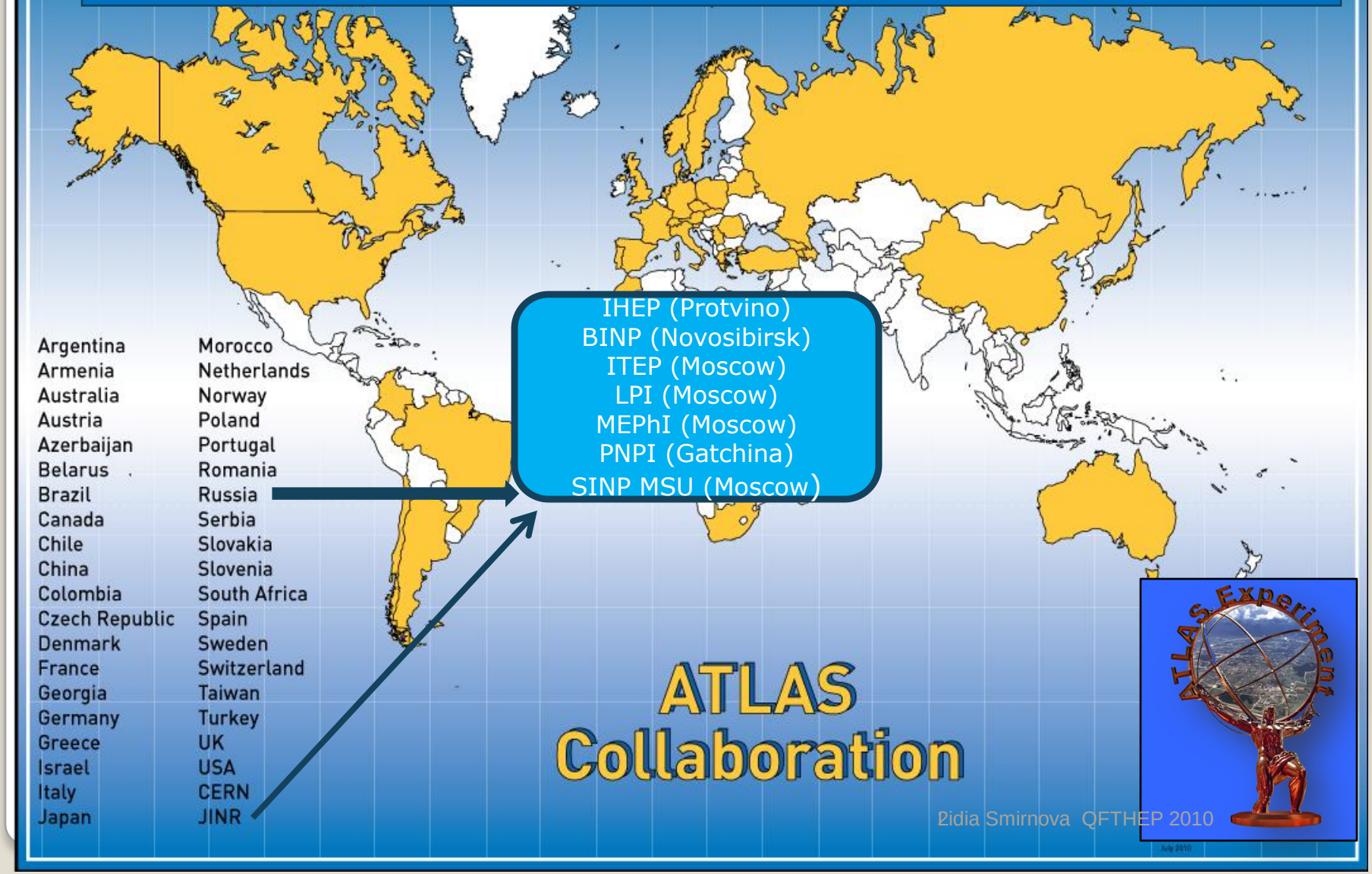
ATLAS status and operation

Lidia Smirnova

21.09.2010

SINP MSU

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



ATLAS detector

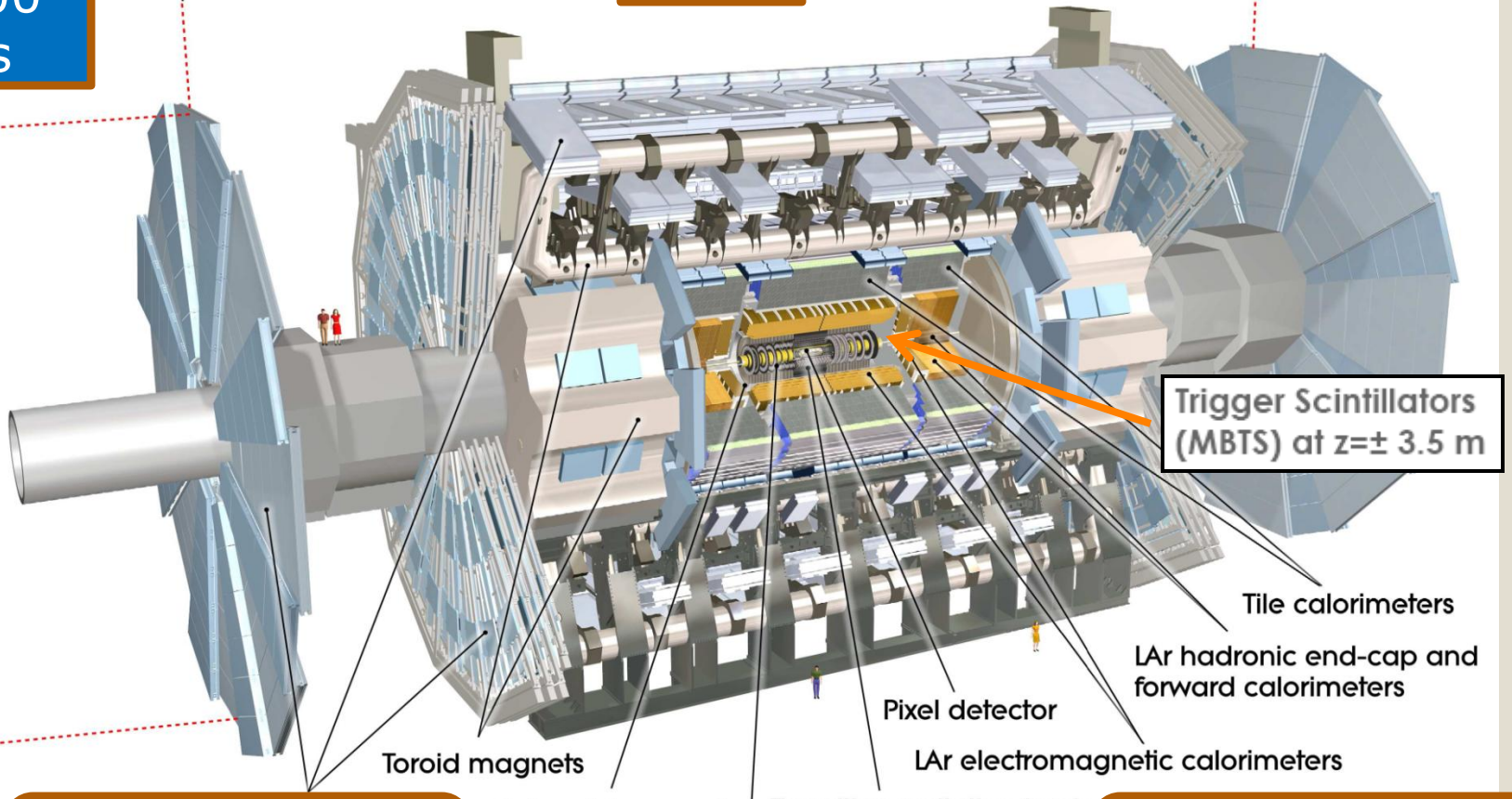
JINST 3 (2008) S08003

Final installation – August 2008

~7000 tons

44 m

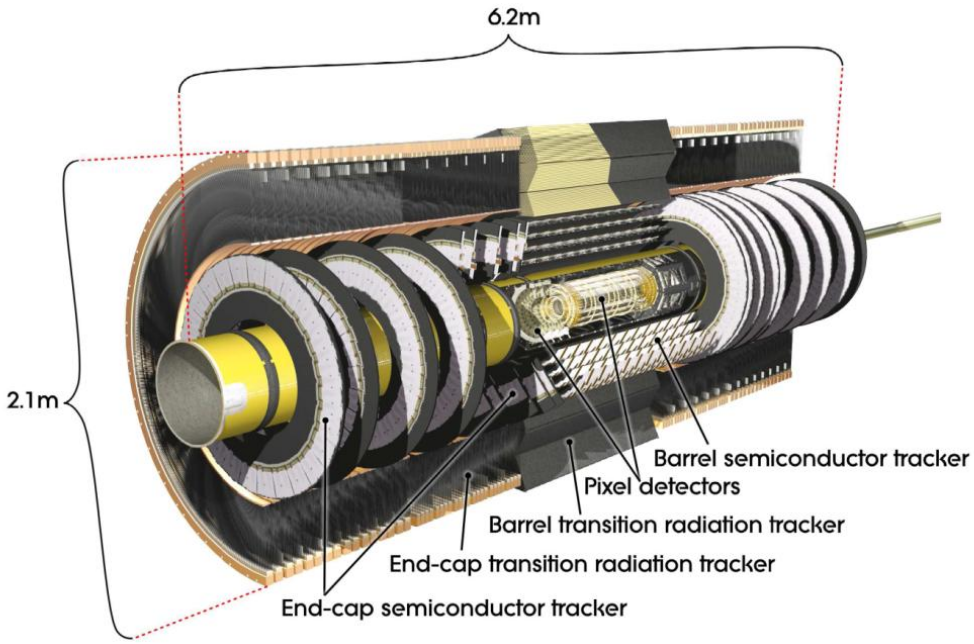
25 m



Muon spectrometer

Inner Detector

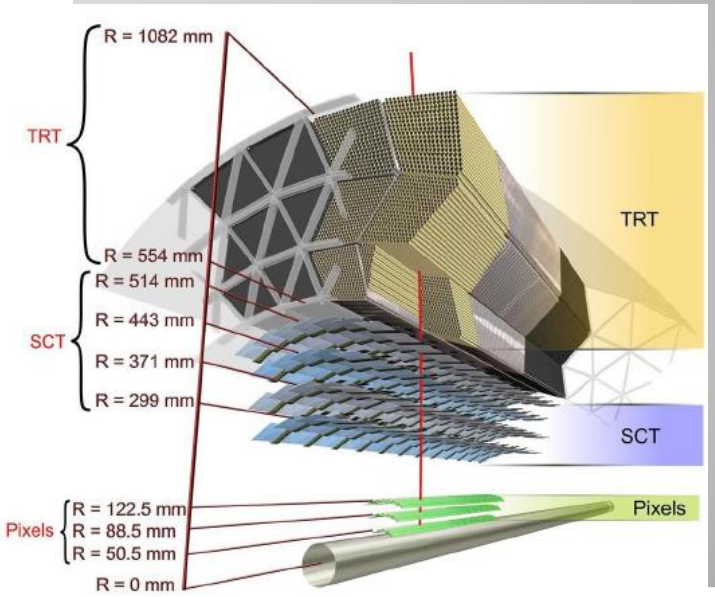
Calorimeters



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

- Precise tracking and vertexing,
- e/π separation
- Momentum resolution:

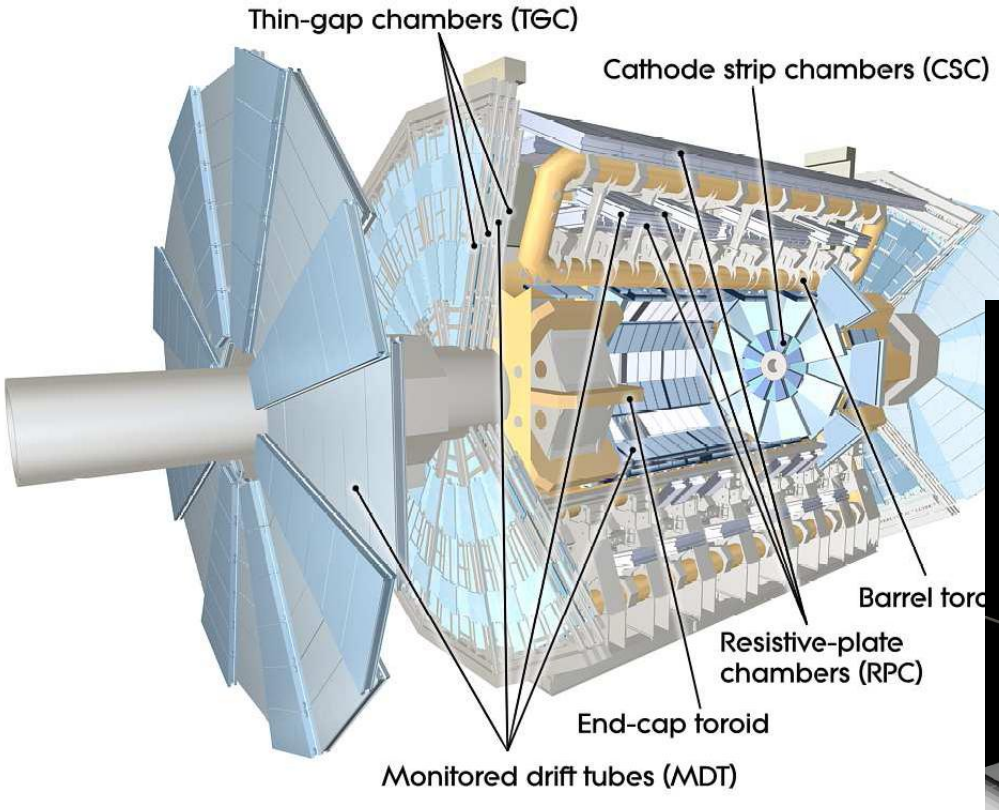
$\sigma/p_T \sim 3.8 \times 10^{-4}\, p_T\,(\text{GeV}) \oplus 0.015$



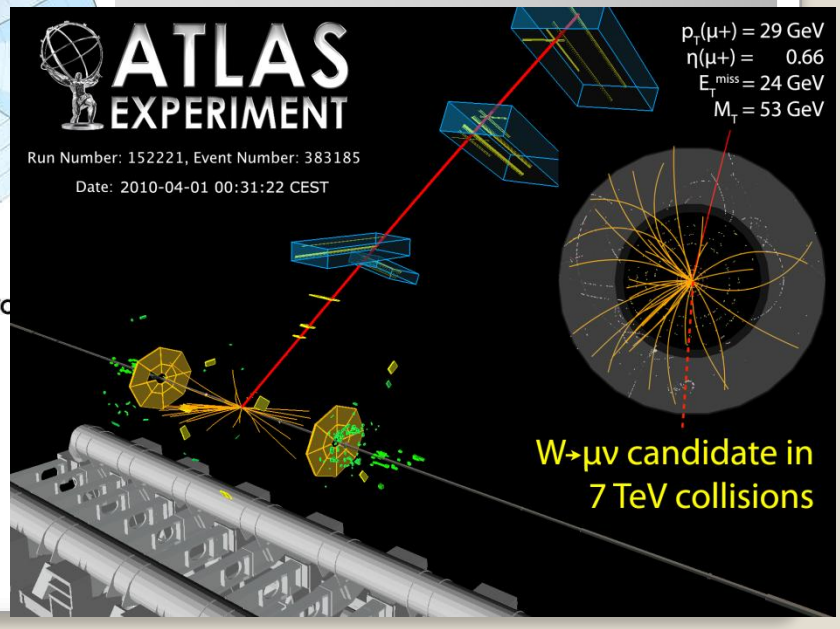
Inner detector

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

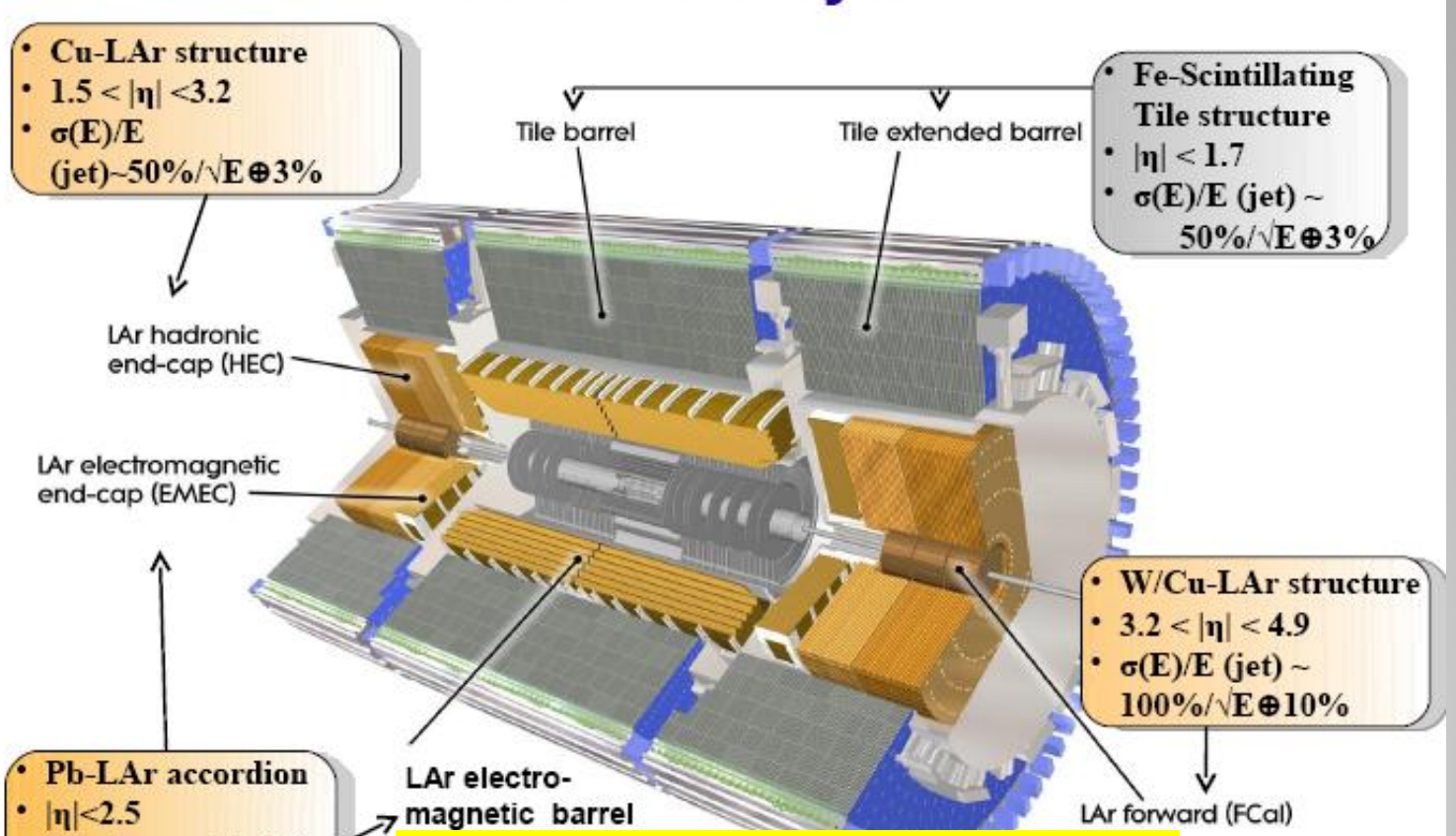


Trigger chambers:	RPC/TGC
Precision chambers:	MDT/CSC
Magnetic field:	~0.5 T
Bending power:	~2-5 Tm
Coverage	$\|\eta\| < 2.7$



W->μν candidate at 7 TeV

HAD calorimetry (|η|<5)
Trigger and measurement of jets and missing E_T E-resolution: $\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$



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

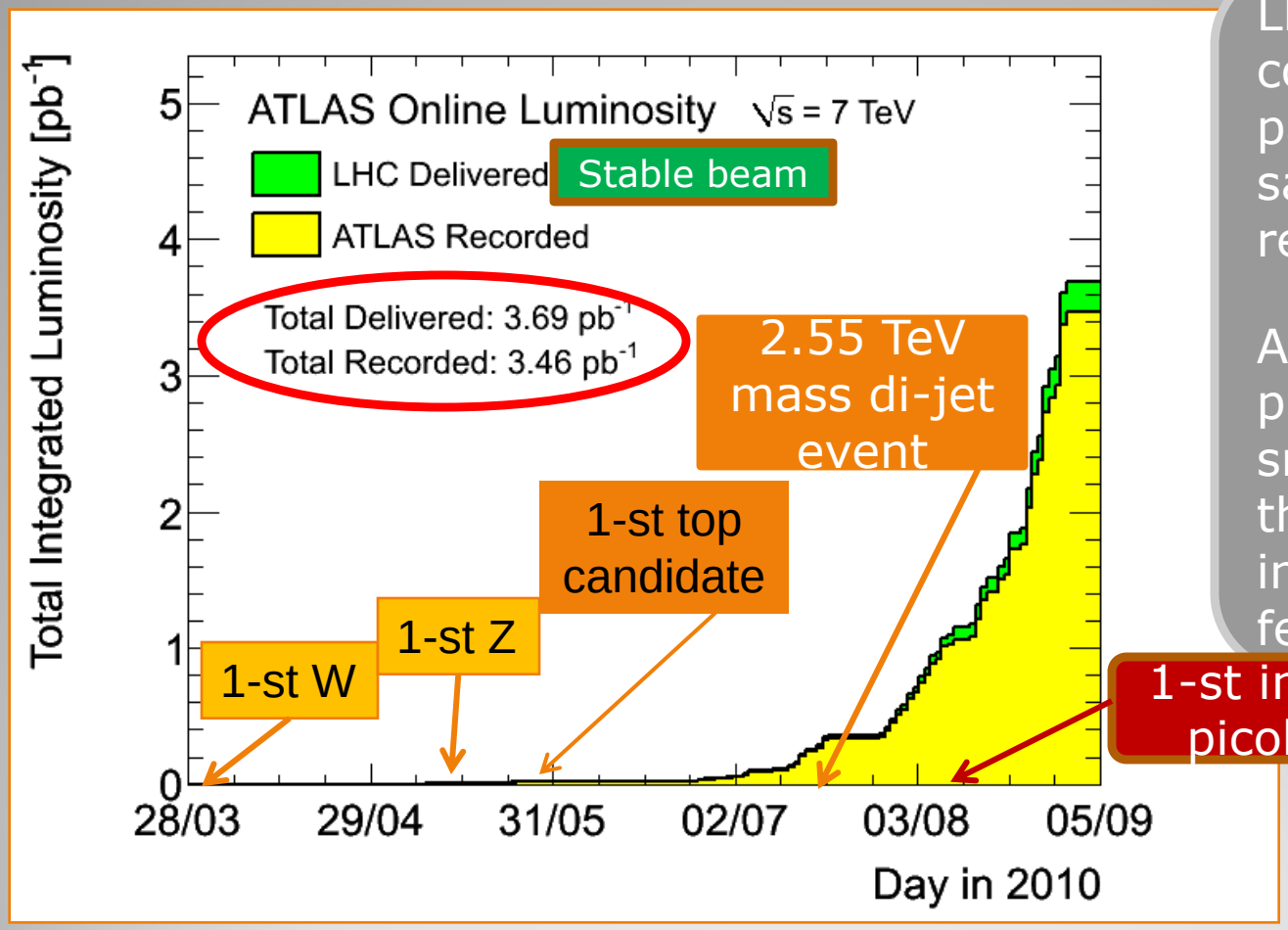
Data collected	Integrated luminosity	Time period
Cosmic rays		2008,2009
pp collisions at 900 GeV	~ 9 μb^{-1}	Nov.-Dec.2009
pp collisions at 2.36 TeV	~ 0.7 μb^{-1}	Dec.2009
pp collisions at 7 TeV	~ 3.46 pb^{-1} 247x10^9events	From 30 March 2010- up to now

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

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
$L \sim 1.03 \times 10^{31}\ cm^{-2}\ s^{-1}$

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

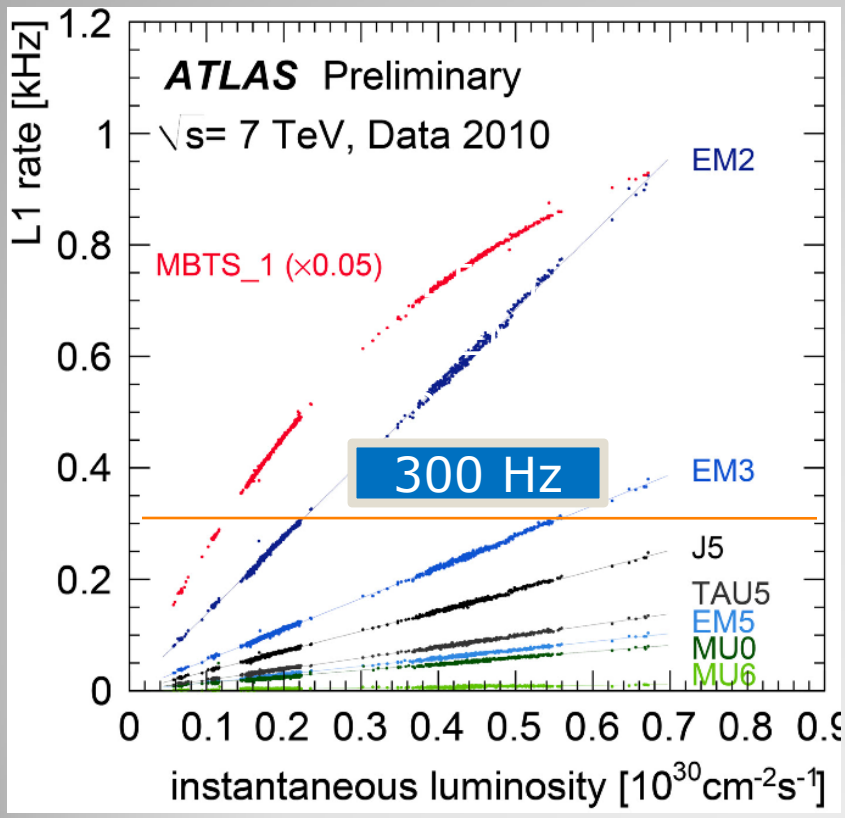
- requires a peak luminosity of $\geq 1x10^{32}$ $cm^{-2}s^{-1}$ during 2011
- → must reach ~1 $x10^{32}$ $cm^{-2}s^{-1}$ during 2010

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:

$L \sim 10^{29}$ cm^{-2} s^{-1}:
start to activate HLT chains to cope with increasing rate while running with low LVL1 thresholds.

Jet items: lowest thresholds prescaled

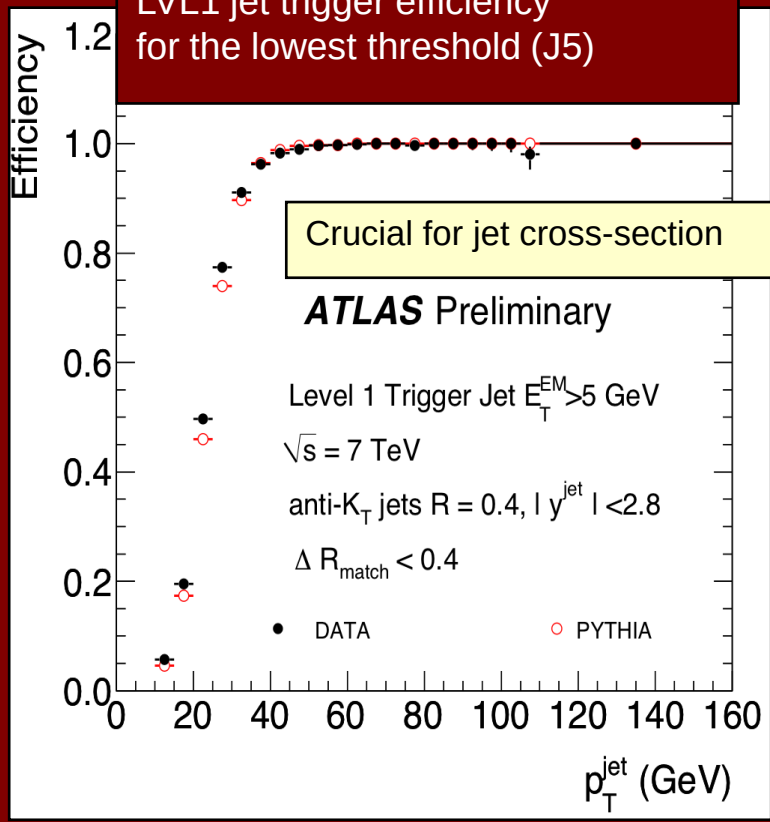
(HLT rejection small)

Figure gives examples for L up to 7×10^{29} cm^{-2} s^{-1}

ATLAS operation

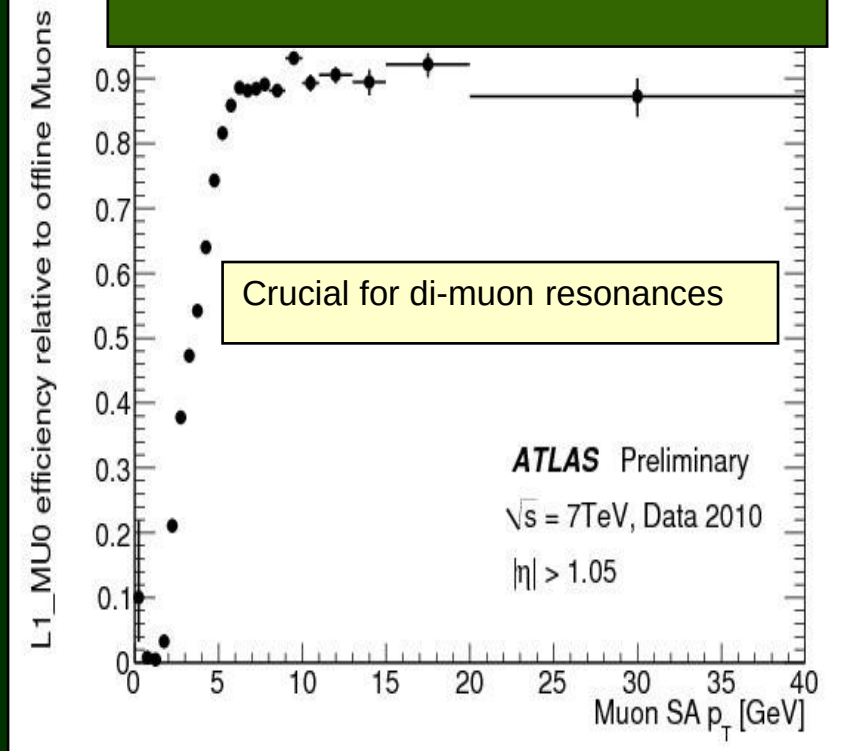
Trigger performance

LVL1 jet trigger efficiency for the lowest threshold (J5)



Crucial for jet cross-section

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

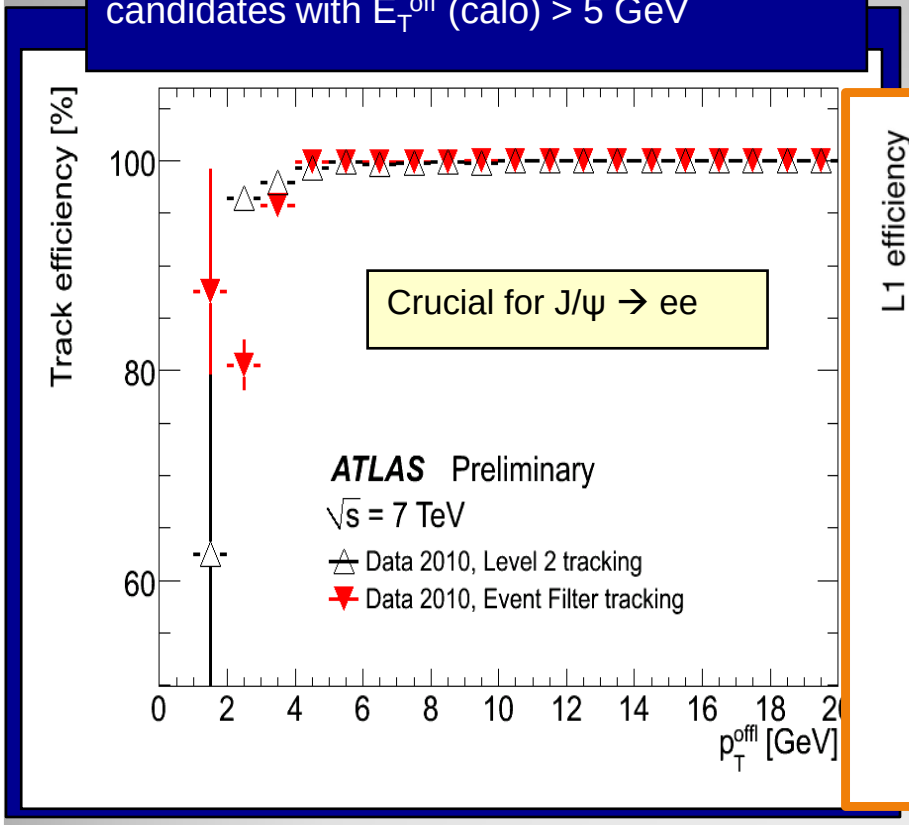


Crucial for di-muon resonances

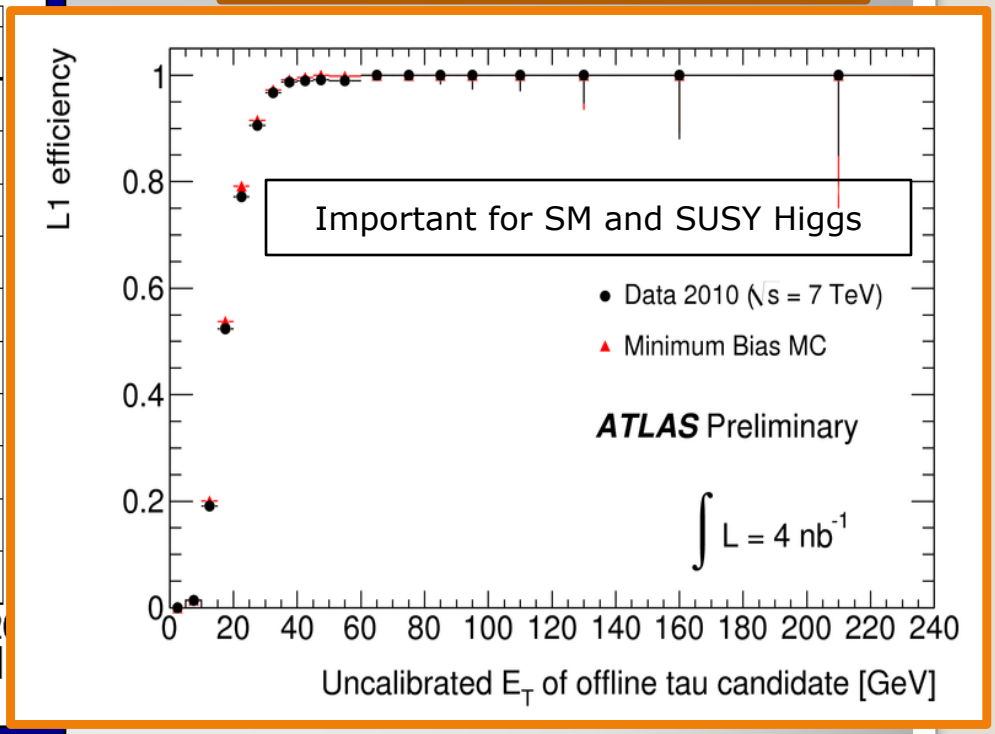
ATLAS operation

Trigger performance

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



Tau L1 trigger efficiency
Et > 5 GeV

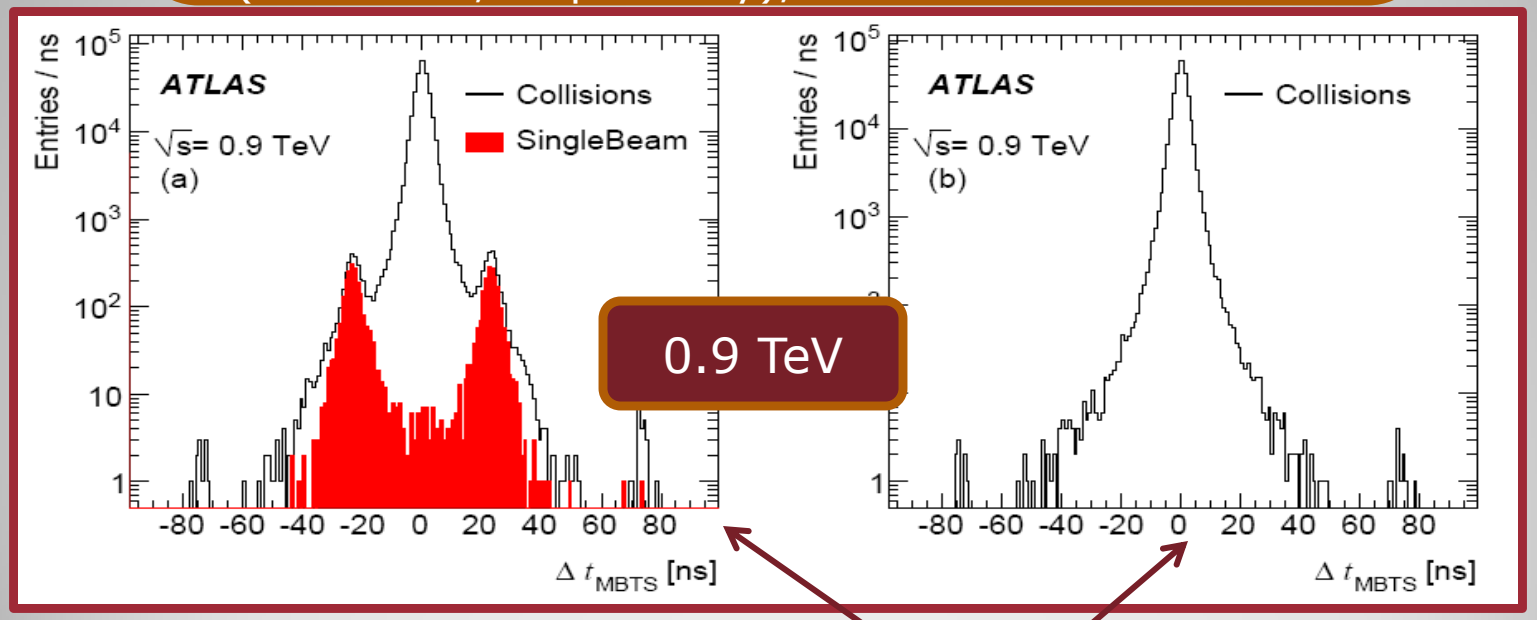


ATLAS operation

Event selection

Primary vertex :

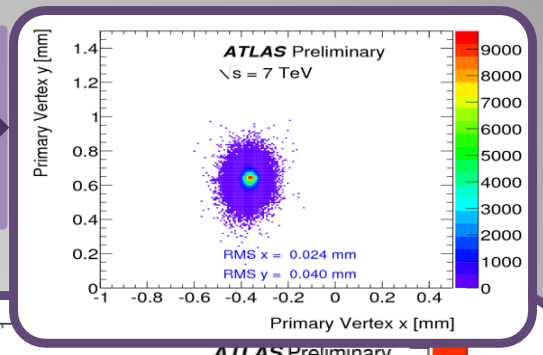
1) $n_{track} \geq 3$ ($p_t > 150$ MeV/c)
2) closest transverse distance to nominal interaction point
3) single hit in one or two MSTB wheels as trigger
4) selection on timing difference from EC or Fcal (5 or 10 nc, respectively), or two MSTB wheels

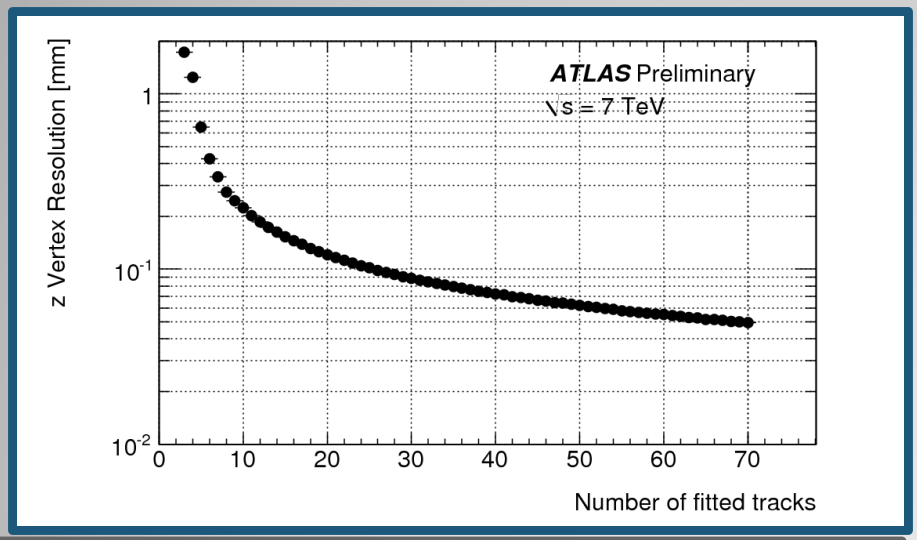


Time difference without any selection and with well reconstructed vertex

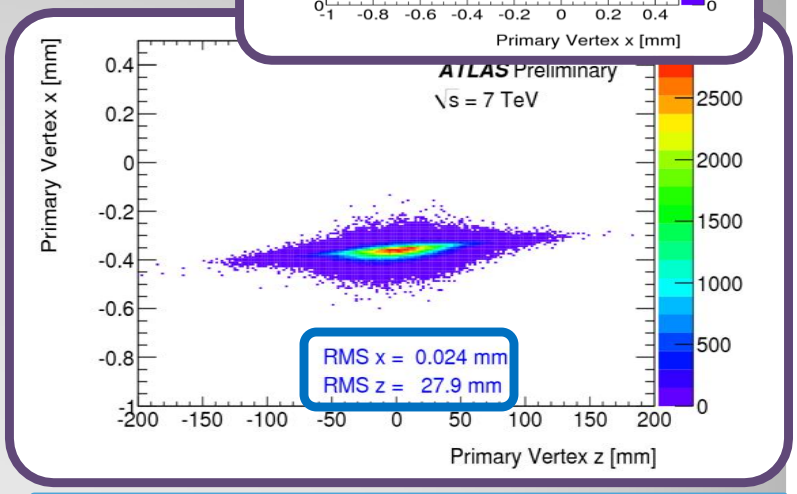
Primary Vertex reconstruction at 7 TeV

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 .



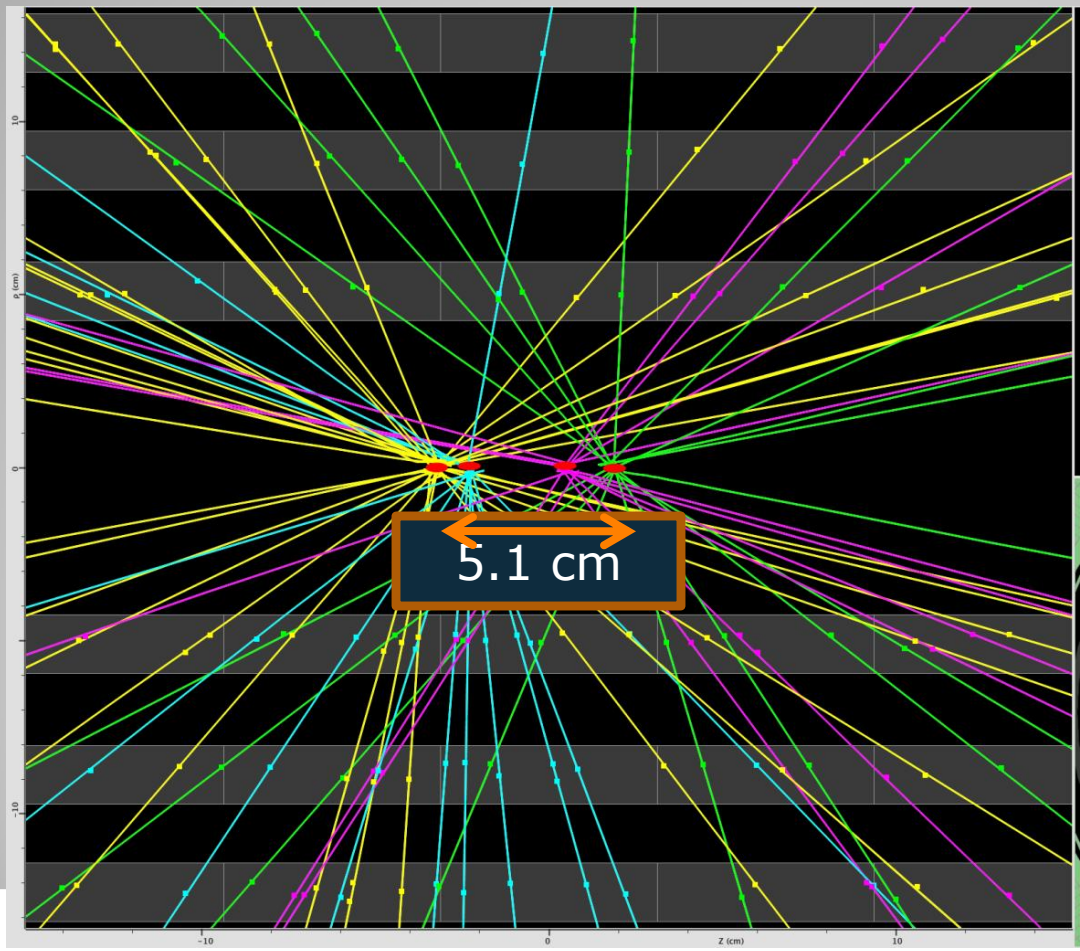
Reconstructed primary vertices in the x-z plane as beam spot

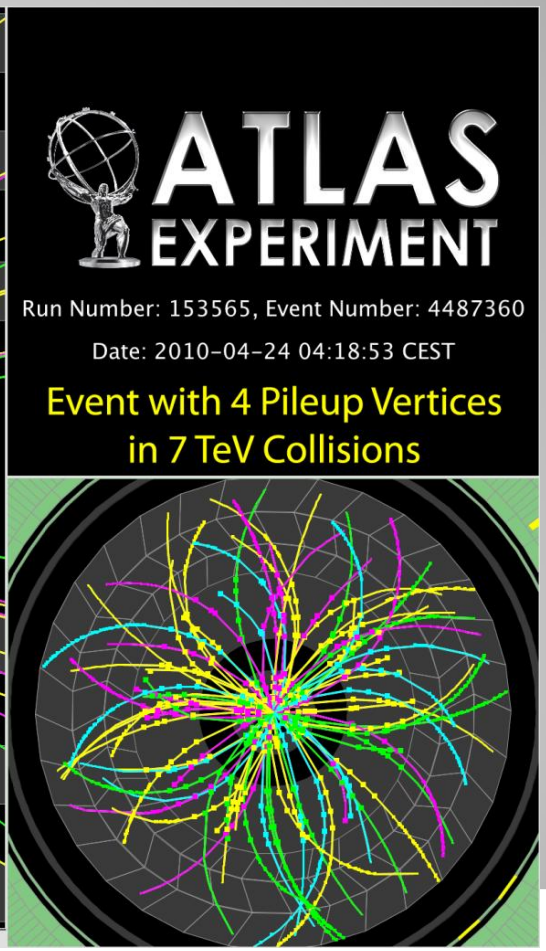
Inner Detector performance

Event with four reconstructed primary vertices

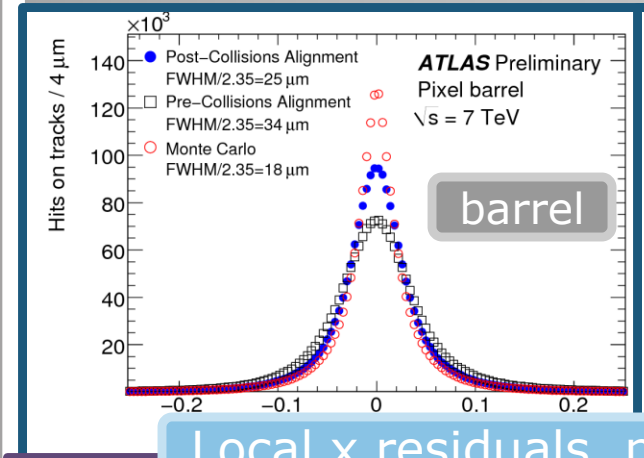
the same beam-crossing

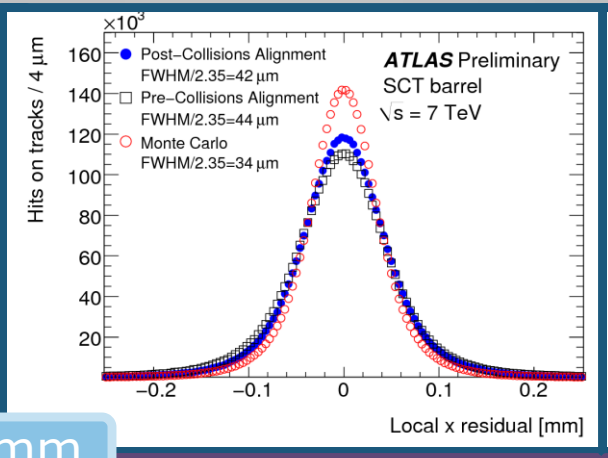
~ 10-45 tracks with p_T >150 MeV per vertex

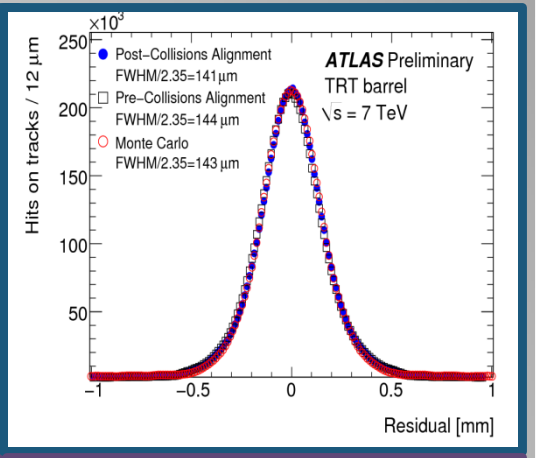




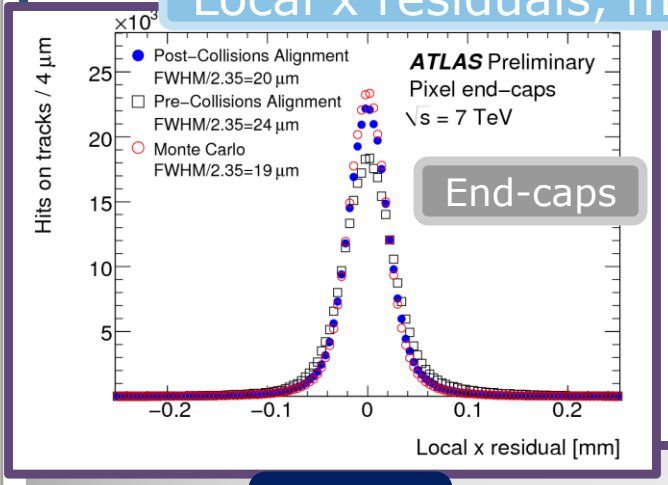
ID Alignment pre-collisions and post-collisions

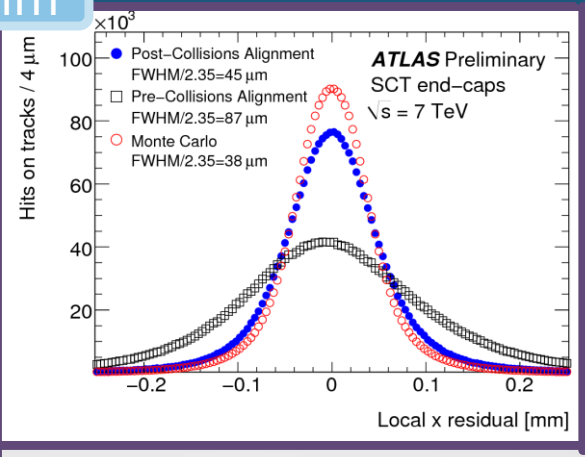


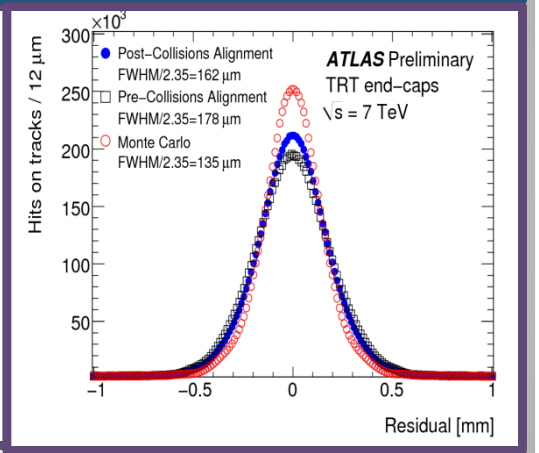




Local x residuals, mm







pixel

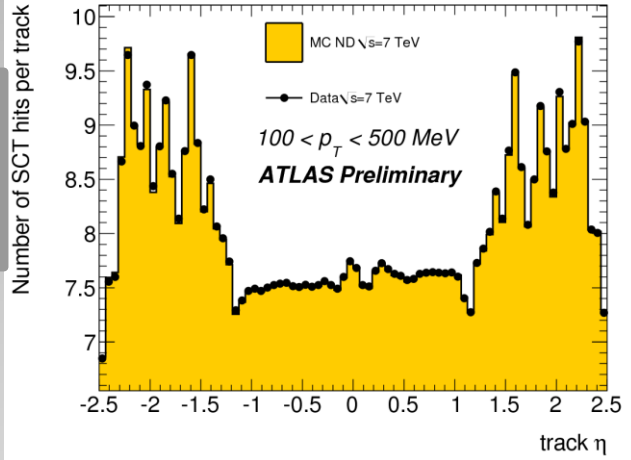
SCT

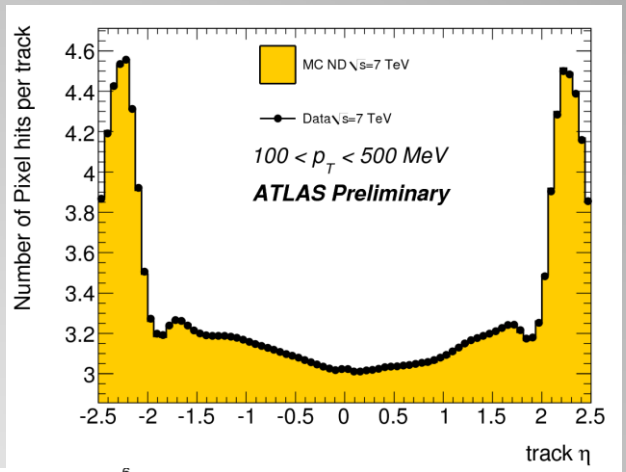
TRT

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

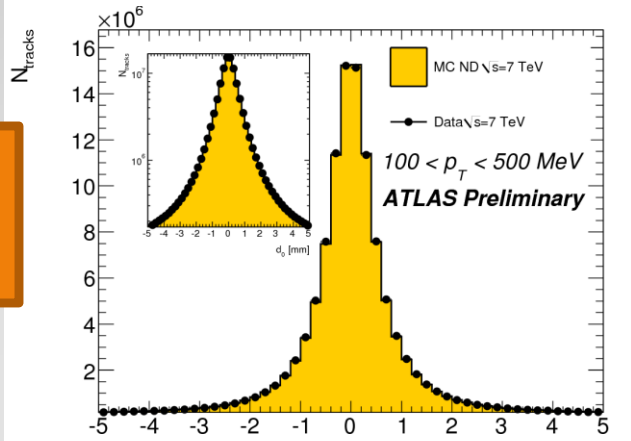
7 TeV

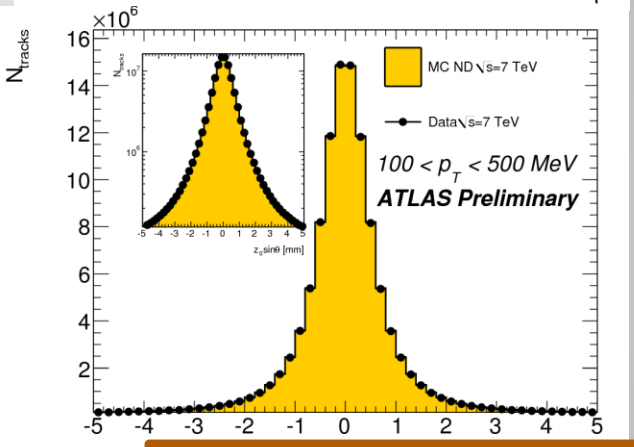
Numbers of hits in SCT and Pixel vs η





Track Impact parameters





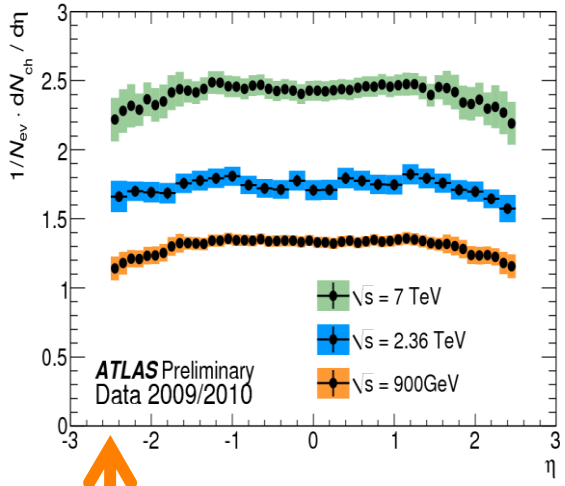
d_0, mm

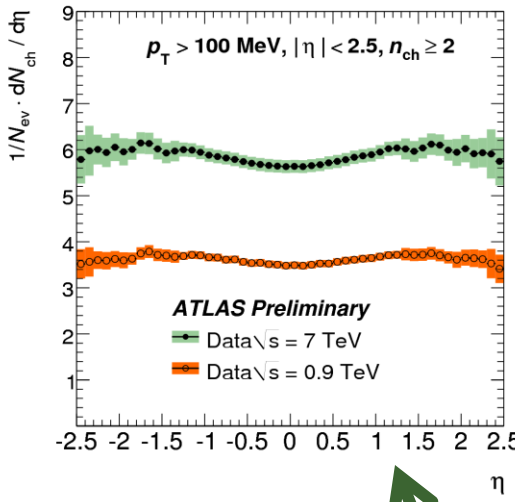
$Z_0 \sin\Theta$, mm

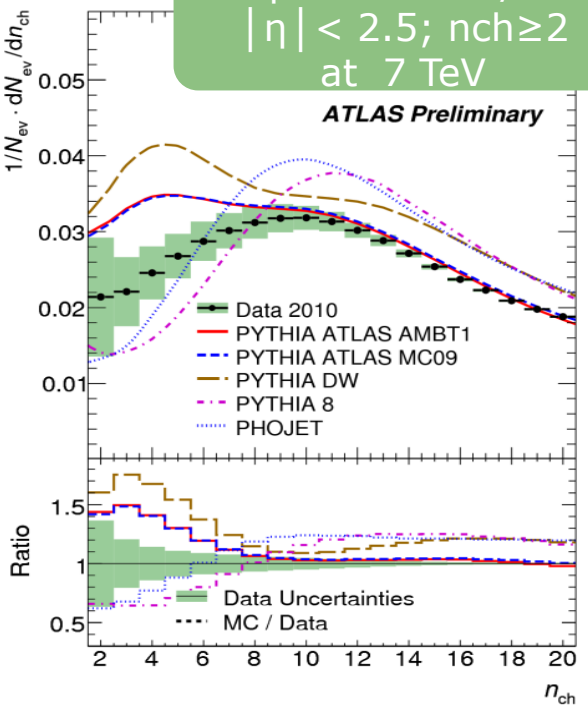
ATLAS performance

Particle multiplicities measurements

pt>100 MeV/c
$|\eta| < 2.5$; nch≥2
at 7 TeV

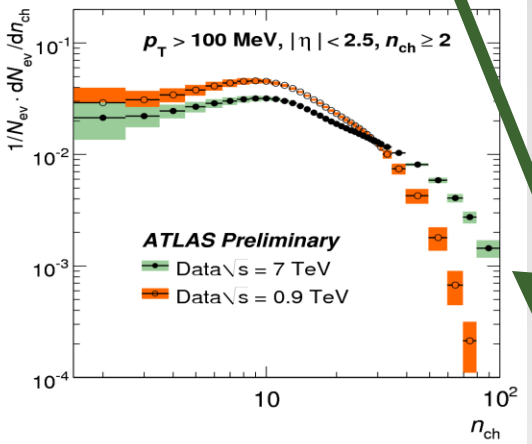






Charged particles with
pt>500 MeV/c
$|\eta| < 2.5$; nch≥1
at 0.9, 2.36 and 7 TeV

- No subtraction for single/double diffractive components
- Distributions corrected back to hadron level

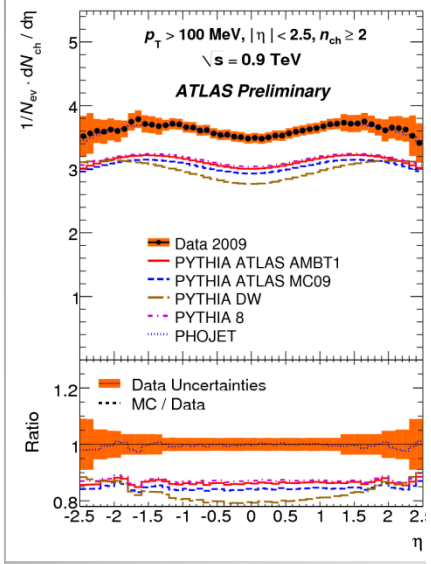


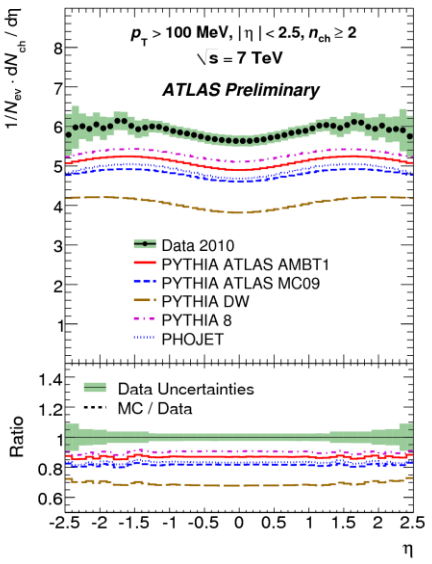
Charged particles with
pt>100 MeV/c
$|\eta| < 2.5$; nch≥2
at 0.9 and 7 TeV

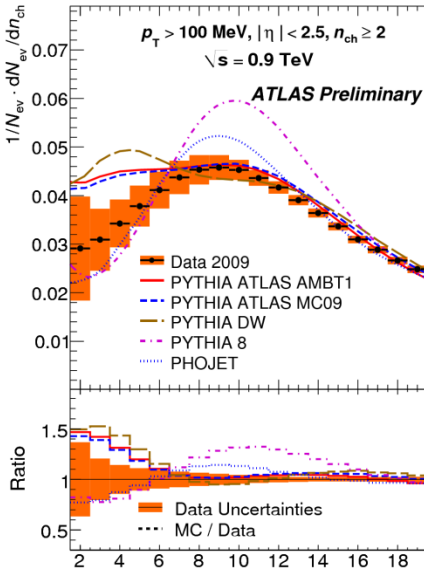
ATLAS performance and results

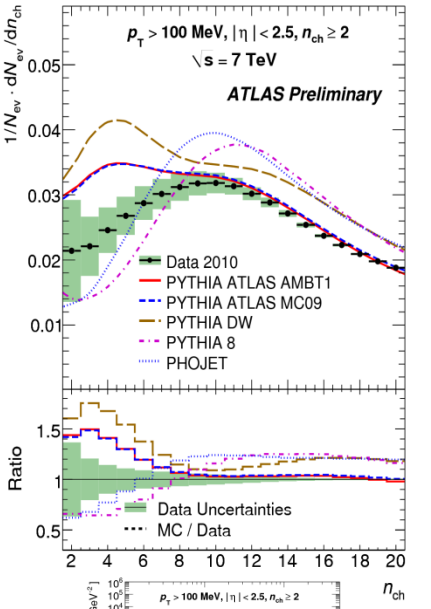
Particle Multiplicities at 0.9 and 7 TeV

on η and n(ch) for pt > 100 MeV/c and |η| < 2.5; n(ch) ≥2 with models predictions

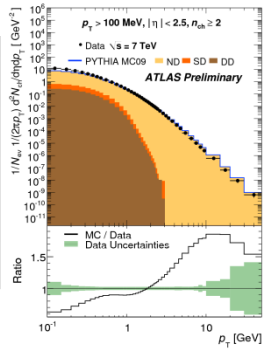




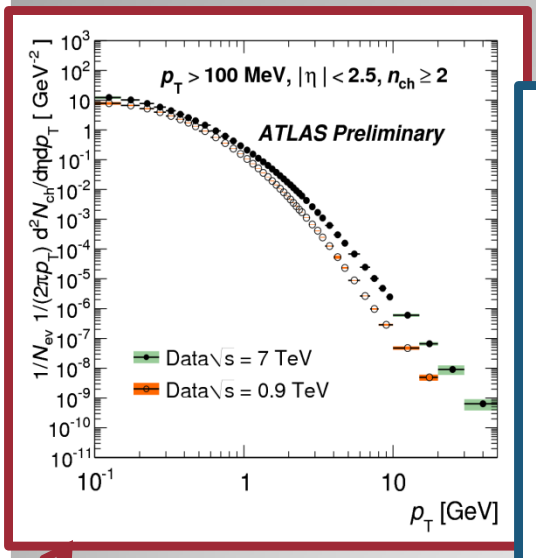




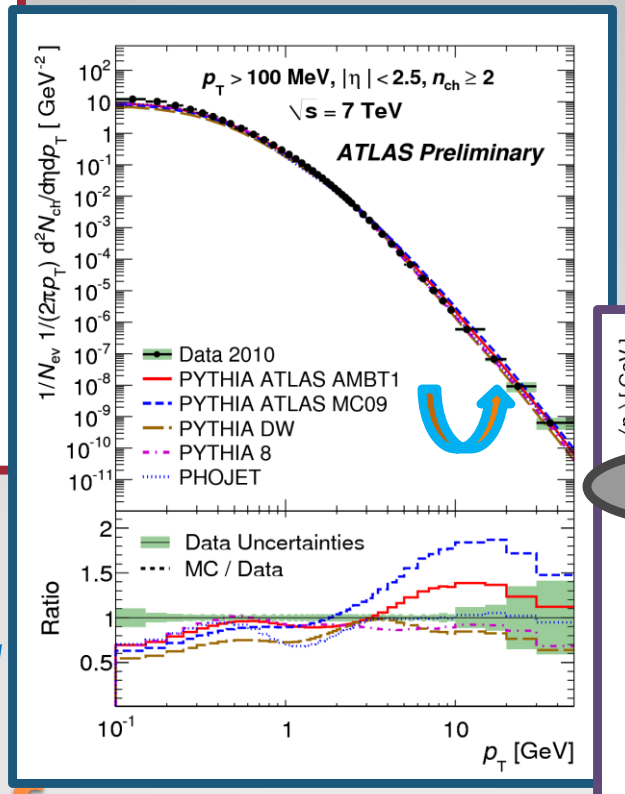
- Measured over a well-defined kinematic region
- No subtraction for single/double diffractive components
- Distributions corrected back to hadron level
- High-precision minimally model-dependent measurements
- Provide strong experimental constraints on MC models



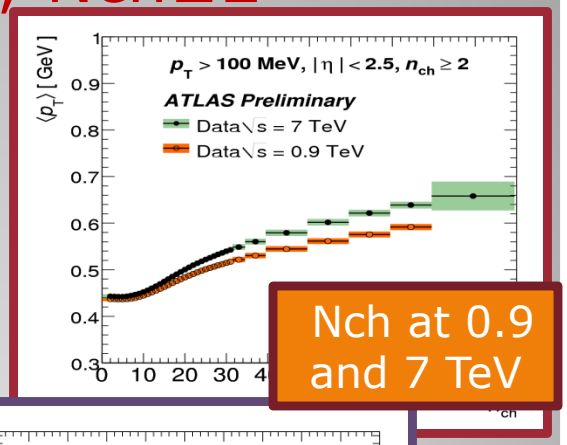
Pt measurements for charged particles with pt>100 MeV/c |η|< 2.5; Nch≥2 at 0.9 and 7 TeV



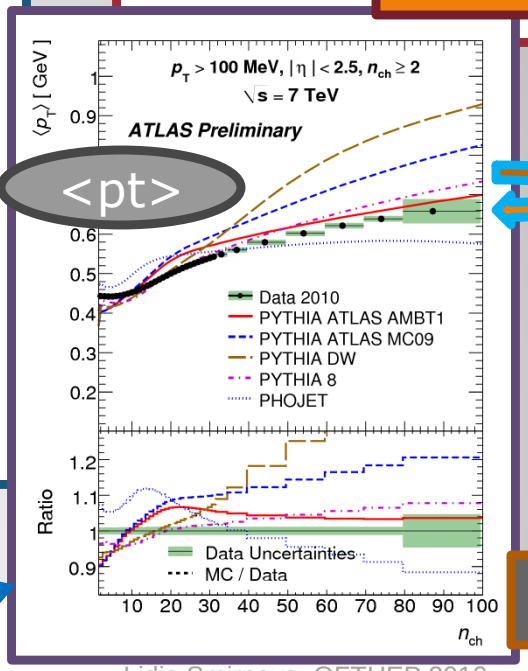
Pt at 0.9 and 7 TeV



Pt at 7 TeV vs models



Nch at 0.9 and 7 TeV



Nch

ATLAS performance and results

Data 7 TeV vs models

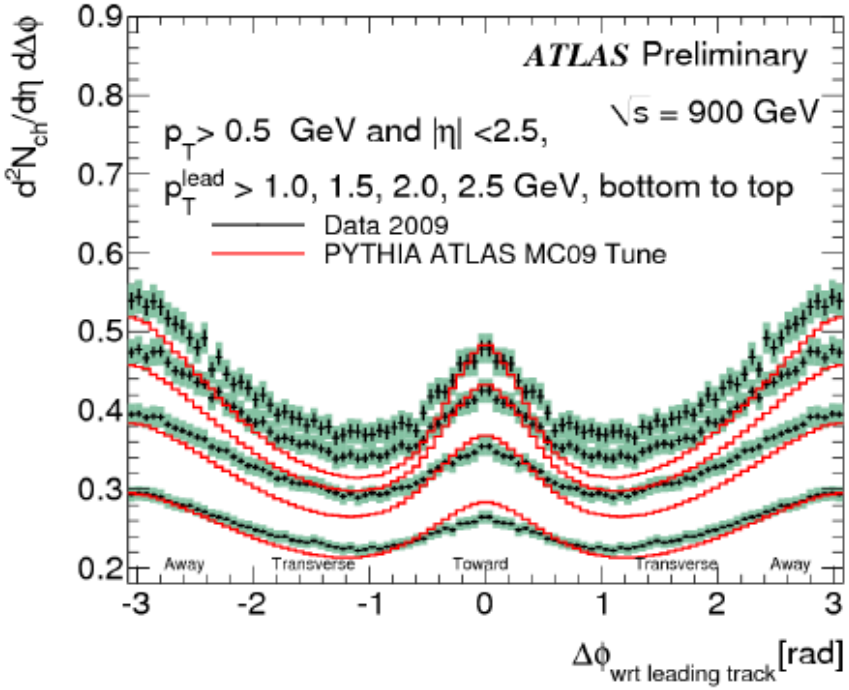
(1/Nev)Nch/dη at η = 0	Pt > 0 CMS	Pt > 100 MeV/c ATLAS Nch≥2	Pt > 500 MeV/c ATLAS Nch≥1
0.9 TeV	$3.48 \pm 0.02_{stat} \pm 0.13_{syst}$	$3.486 \pm 0.008_{stat} \pm 0.077_{syst}$	$1.333 \pm 0.003_{stat} \pm 0.040_{syst}$
2.36 TeV	$4.47 \pm 0.04_{stat} \pm 0.16_{syst}$		$1.739 \pm 0.019_{stat} \pm 0.058_{syst}$
7 TeV	$5.78 \pm 0.01_{stat} \pm 0.23_{syst}$	$5.635 \pm 0.002_{stat} \pm 0.149_{syst}$	$2.418 \pm 0.004_{stat} \pm 0.076_{syst}$

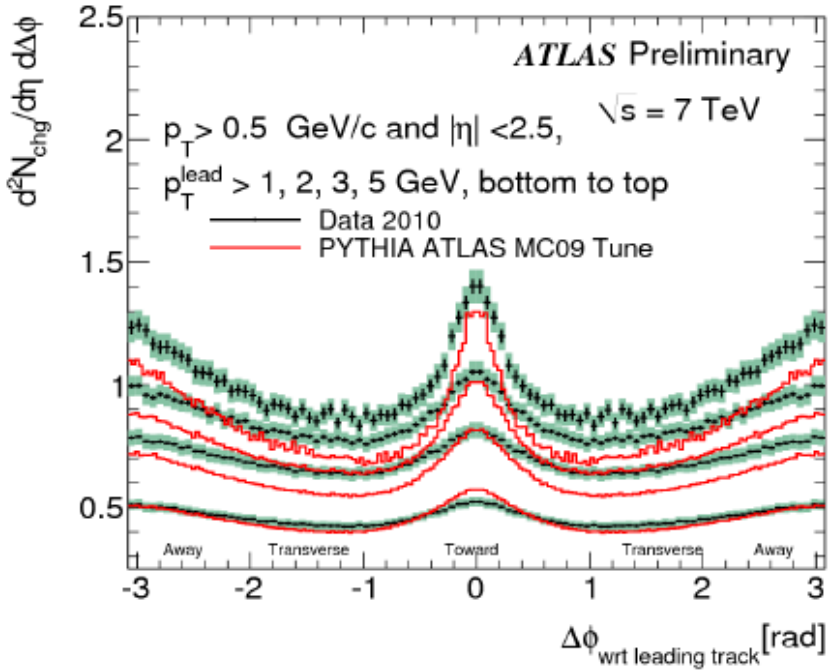
ATLAS and CMS data for charged particle multiplicities at η = 0

CMS: JHEP 02(2010)041; PRL 105, 022002(2010)

Particle Density Angular Correlation

- Define the event orientation by the azimuthal angle of the track with the highest p_T
- Plots are reflected about φ=0; highest p_T track is not included



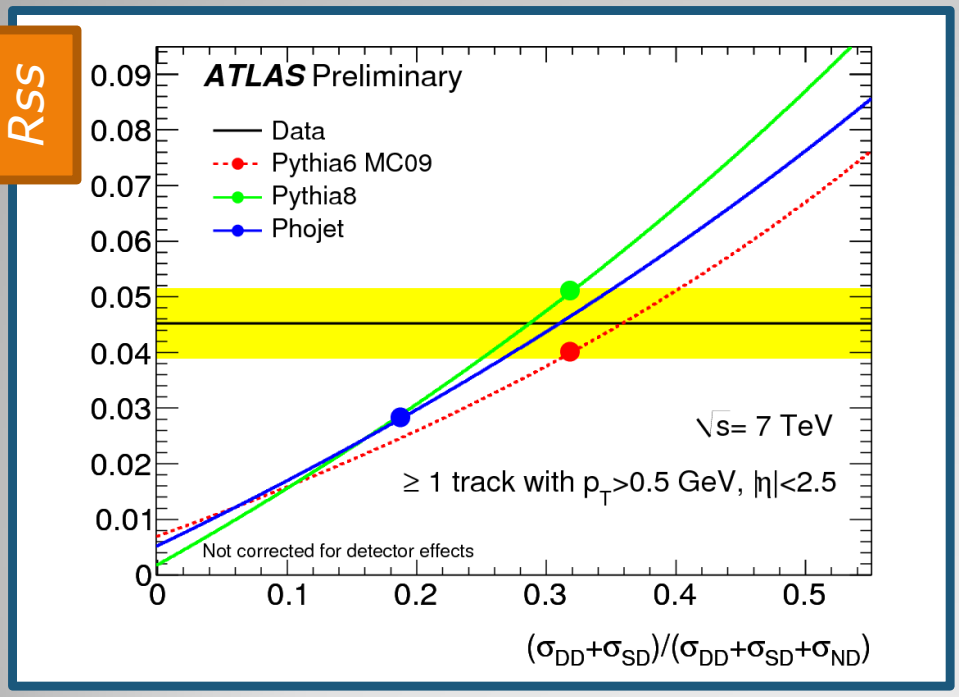


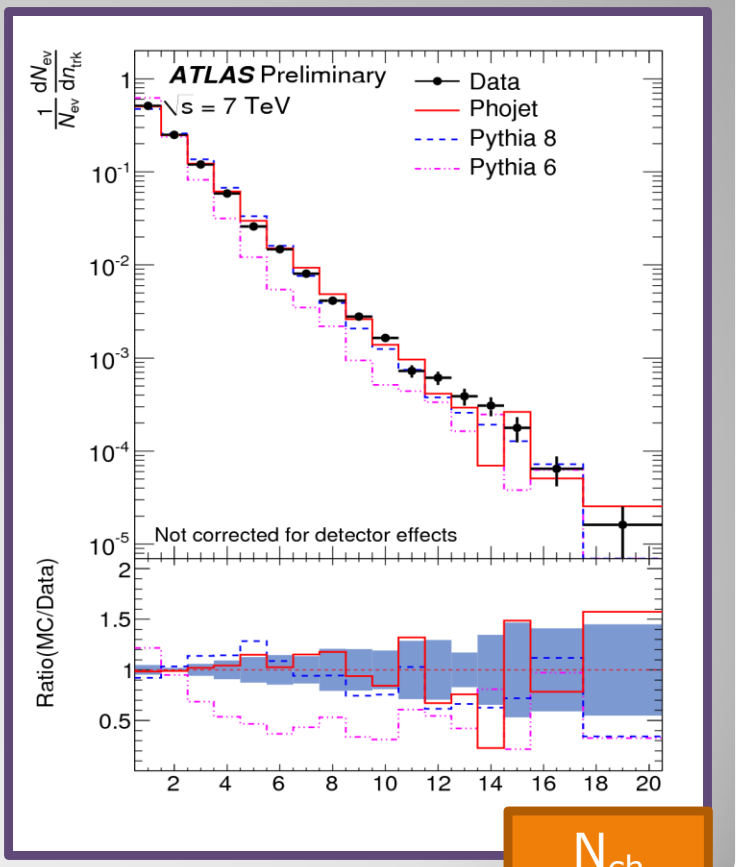
- Monte Carlo tunes only reproduce the general features
  - Disagreement in rates both in the transverse region (UE) and in the Toward and Away regions (MPI/Hard Core)

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.

Rss

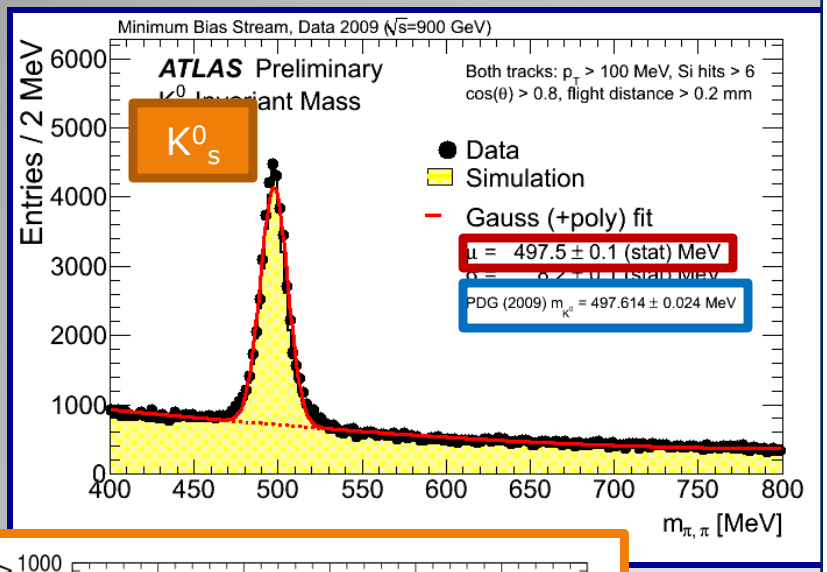


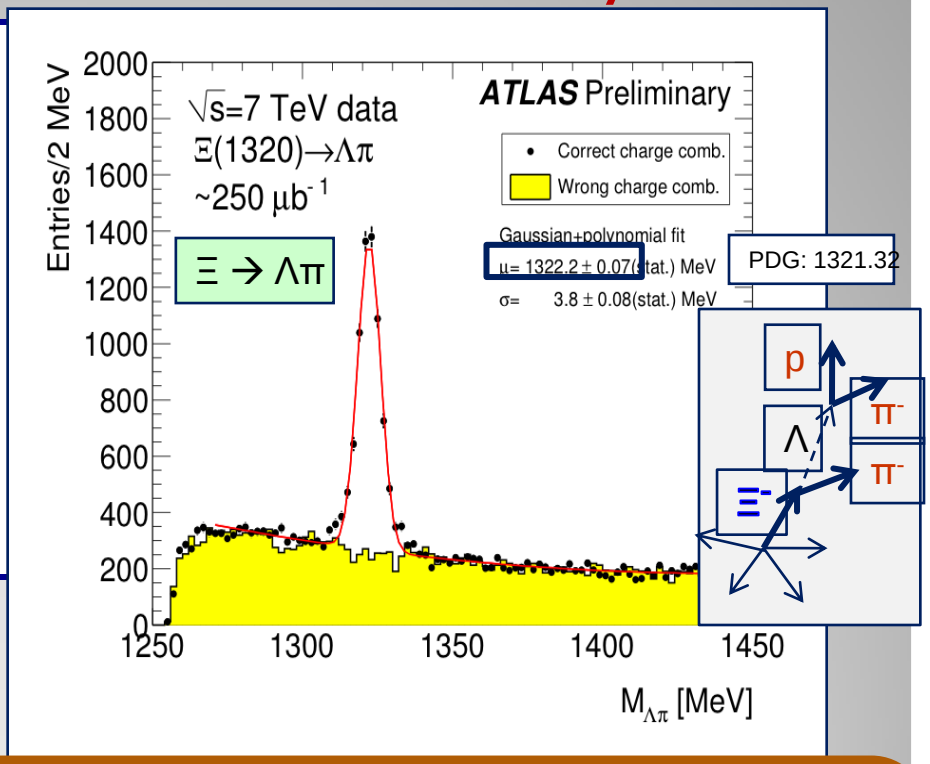


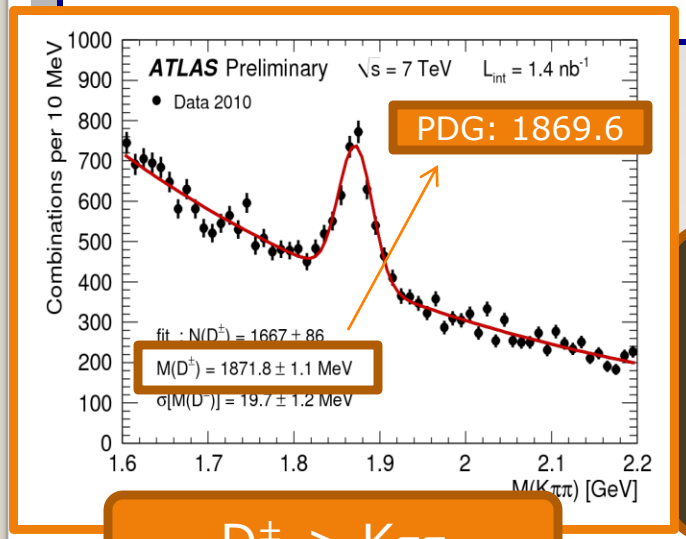
N_{ch}

ATLAS performance and results

Secondary vertices and cascade decays





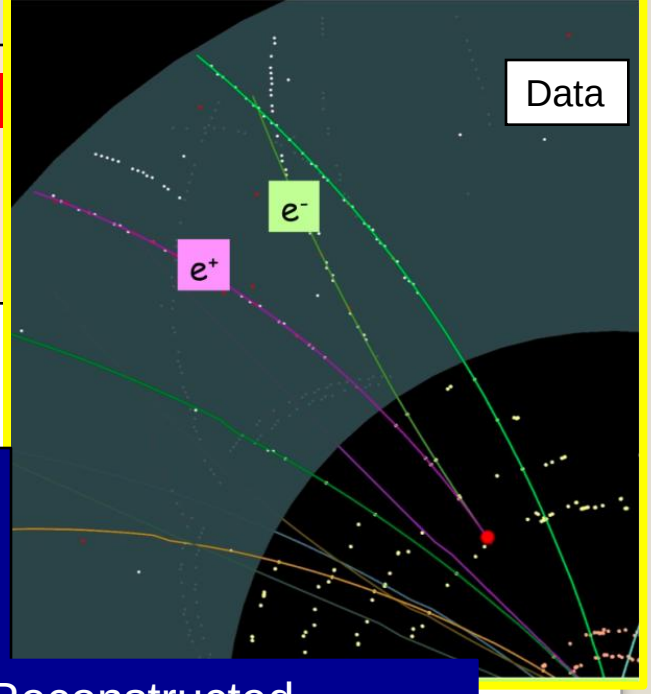


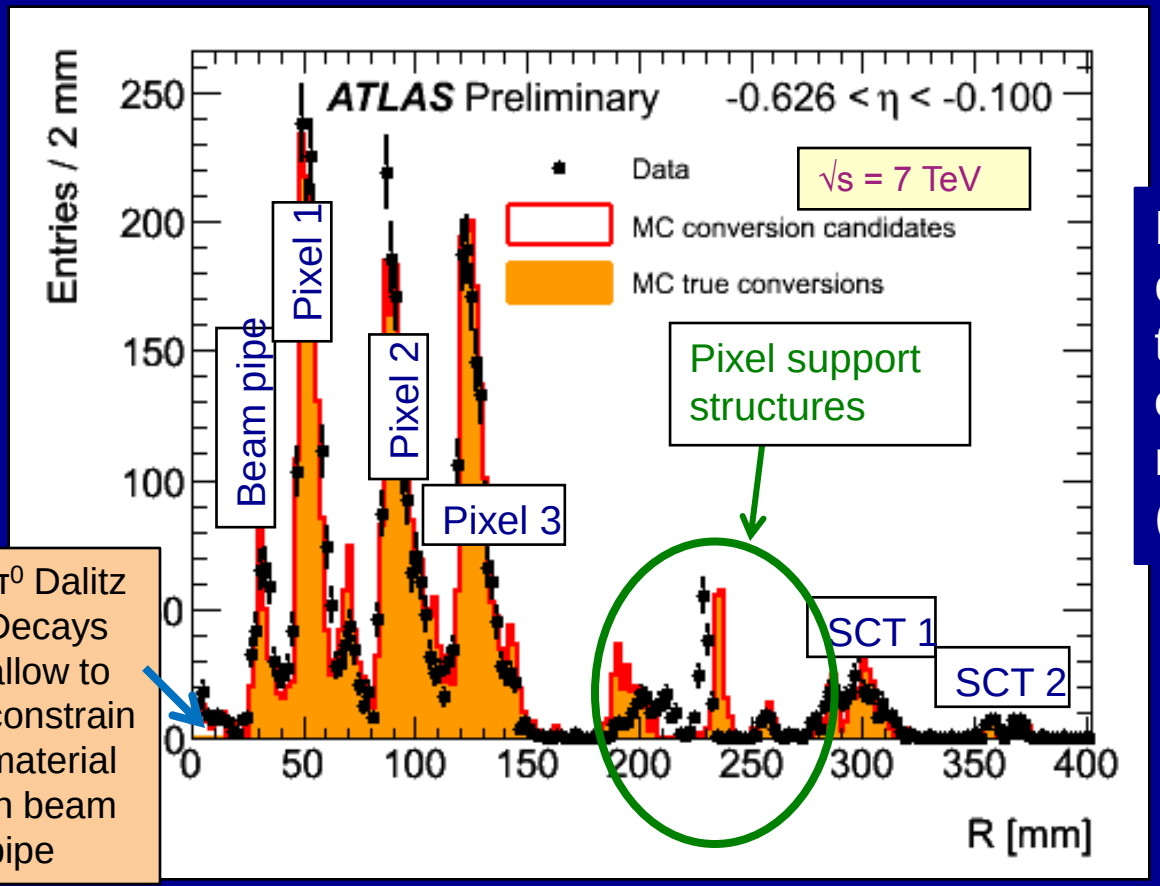
D±-> Kππ

- K0s, Λ, Ξ, Ω, φ, 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 ~ 10%



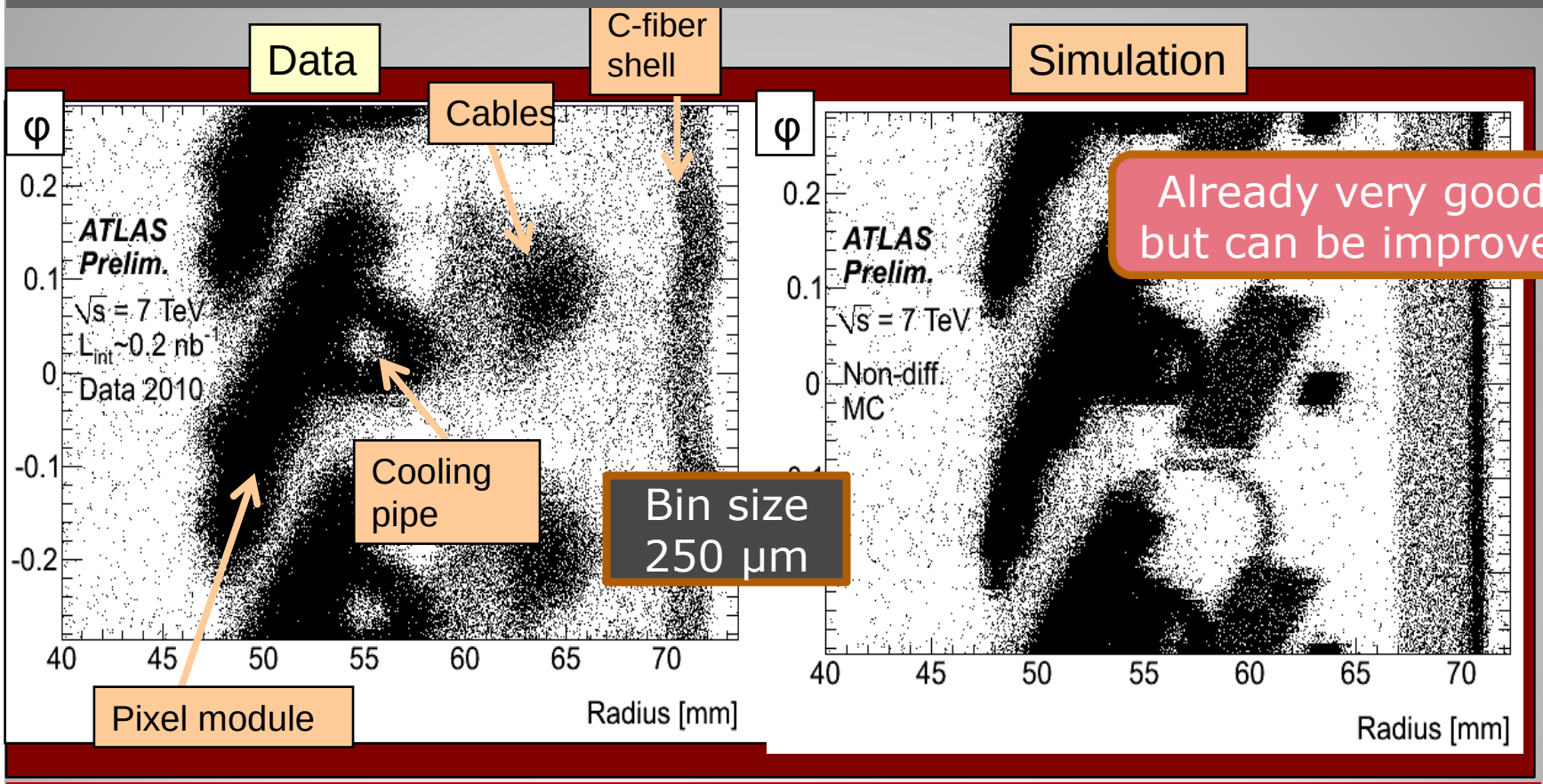


π^0 Dalitz Decays allow to constrain material in beam pipe

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

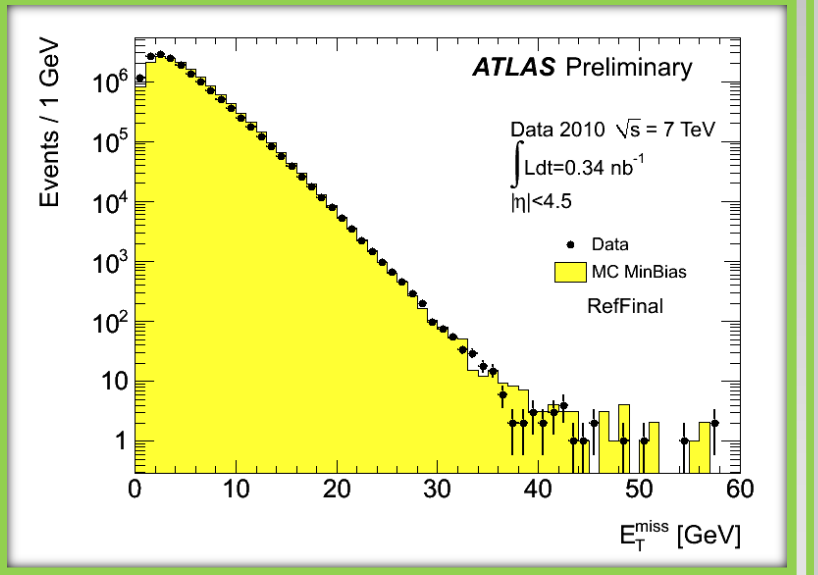
Data show that Pixel supports are displaced in the simulation → to be fixed

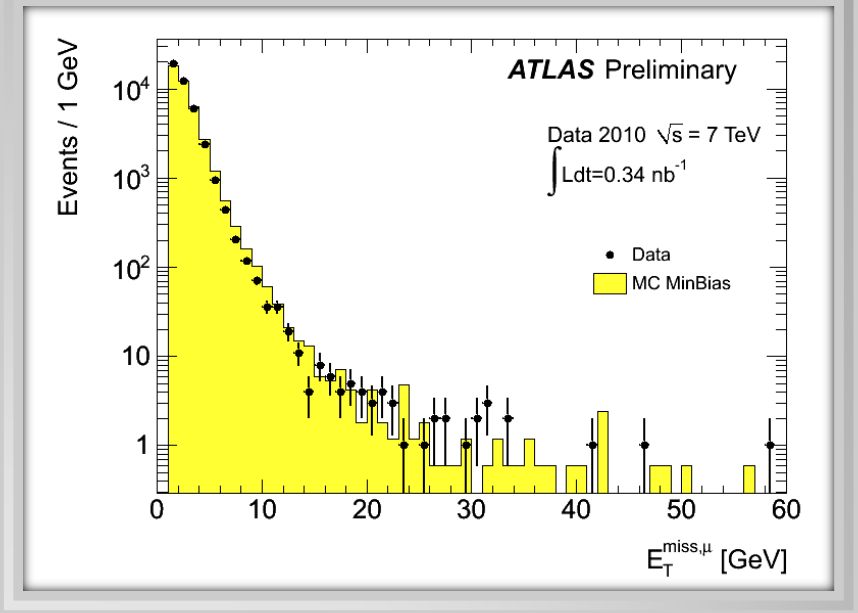
Reconstructed secondary vertices due to hadronic interactions in minimum-bias events in the first layer of the Pixel detector
(sensitive to interaction length λ → complementary to γ conversion studies)



Mapping ID material with secondary hadronic interactions

$E_{t\ miss}$ performance





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

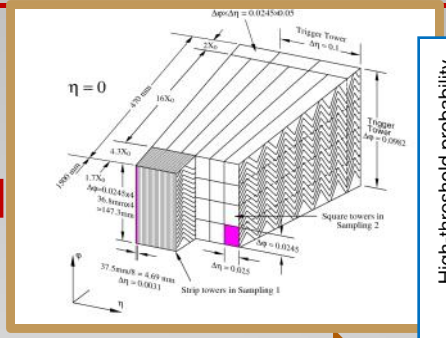
$E_{t\ miss}$ in the events with at least one reconstructed muon at 7 TeV

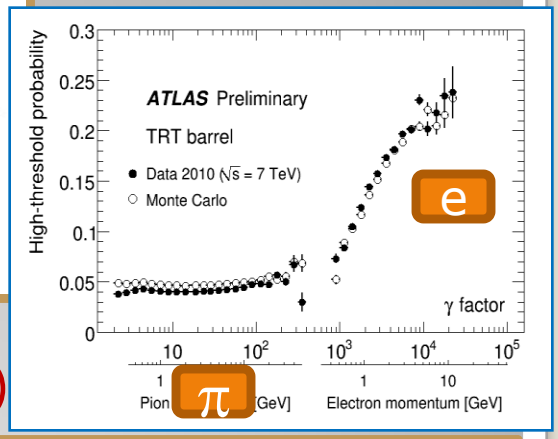
Good agreement with MC simulations

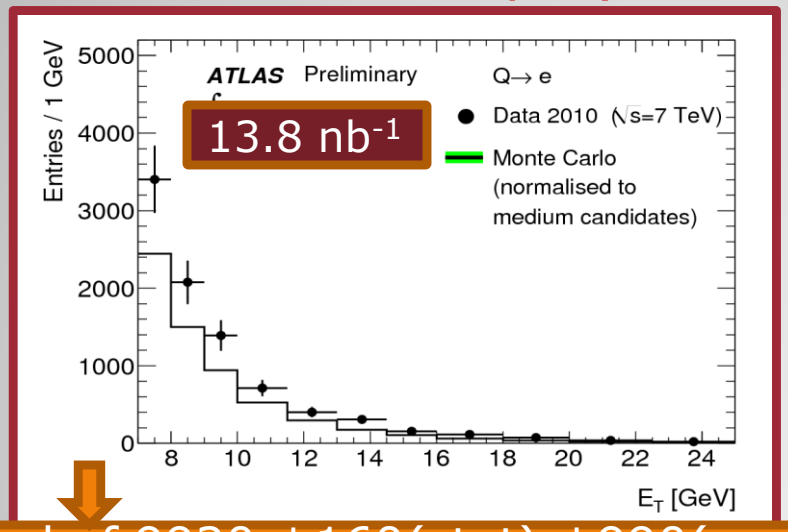
e/γ reconstruction and identification

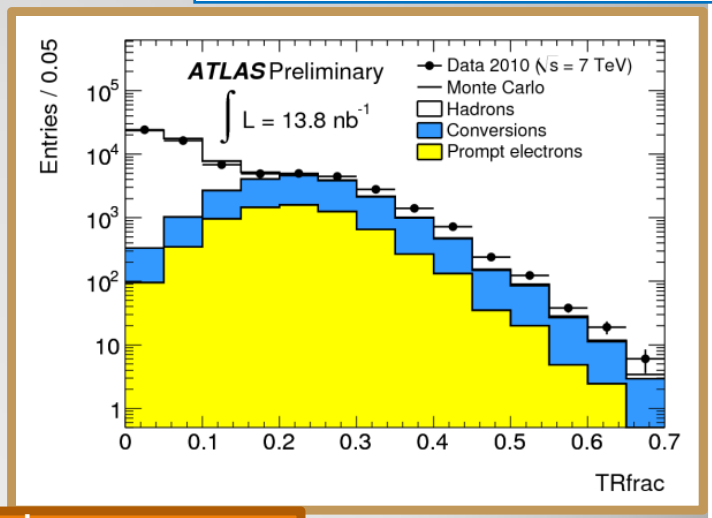
Based on:

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





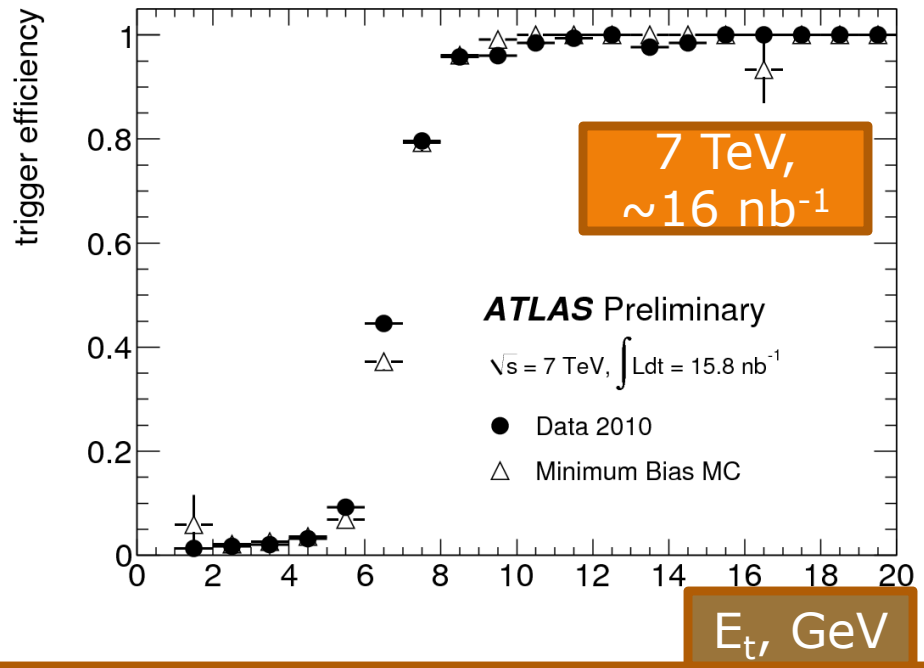




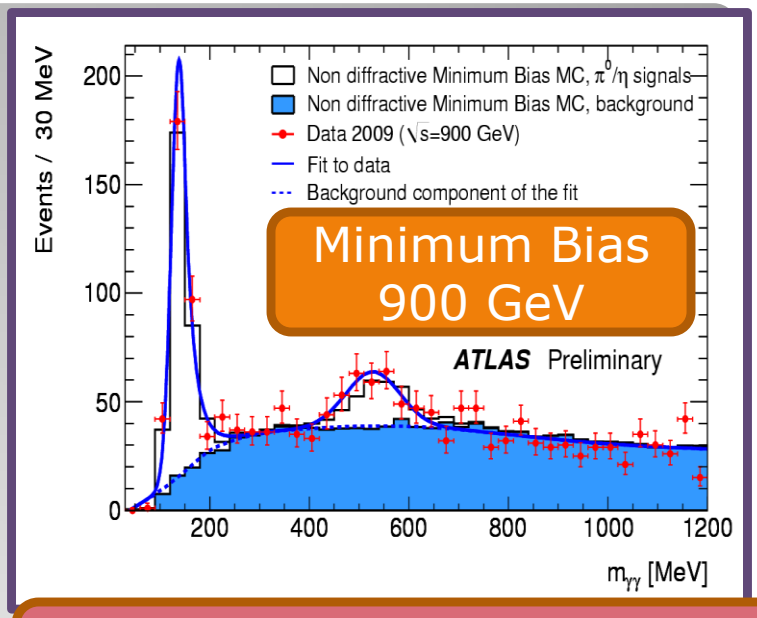
Signal of 9920 ±160(stat) ±990(syst) electrons predominantly from b,c->e is measured for E_t>7GeV and within |η|<2

Decays to γ, prompt γ

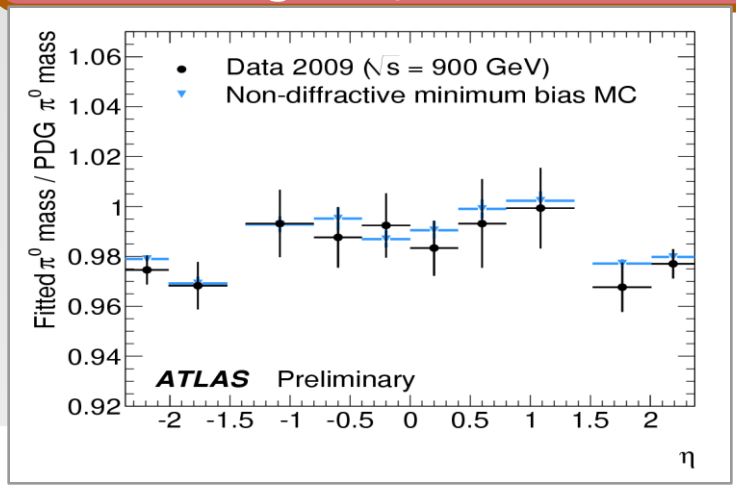
Trigger efficiency for γ vs E_t



Efficiency ≥ 99.3% for E_t > 10 GeV
Prompt photon purity for E_t > 20 GeV
(72±7)%



Mγγ with π^0 and η mesons signals, MeV

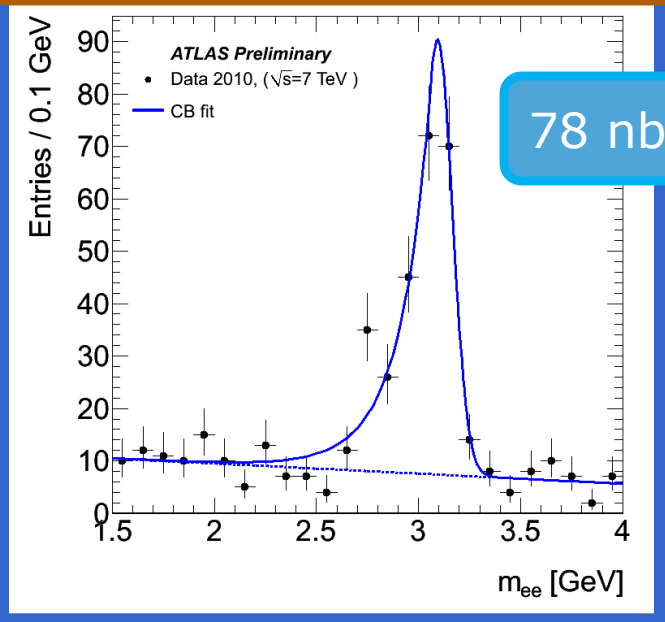


e/γ performance

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

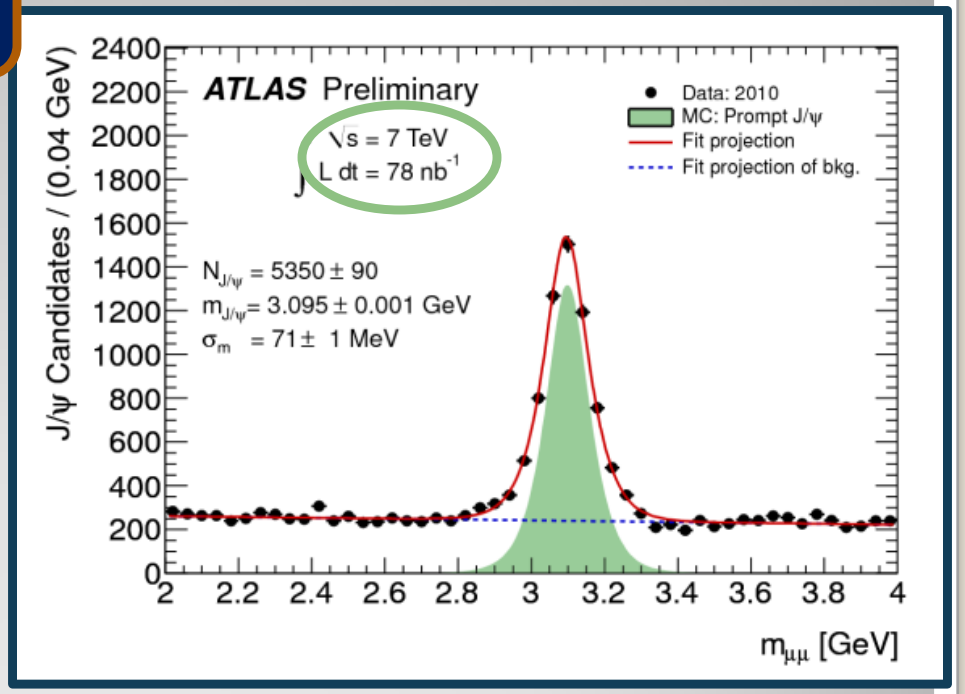
Signal : 222 ± 11 events
Background : 28 ± 2 events
Mass peak : 3.09± 0.01 GeV
Mass resolution : 0.07 ± 0.01 GeV

PDG: 3.0969



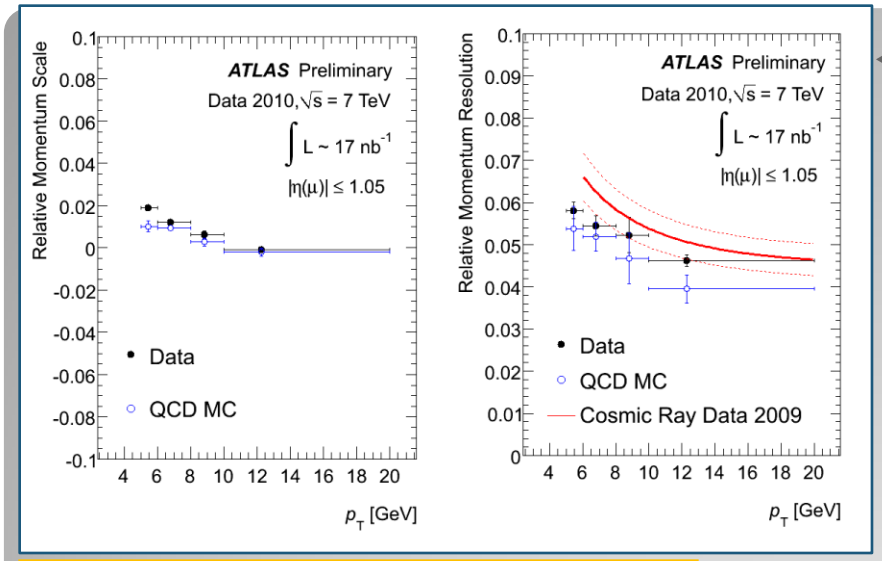
78 nb^{-1}

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

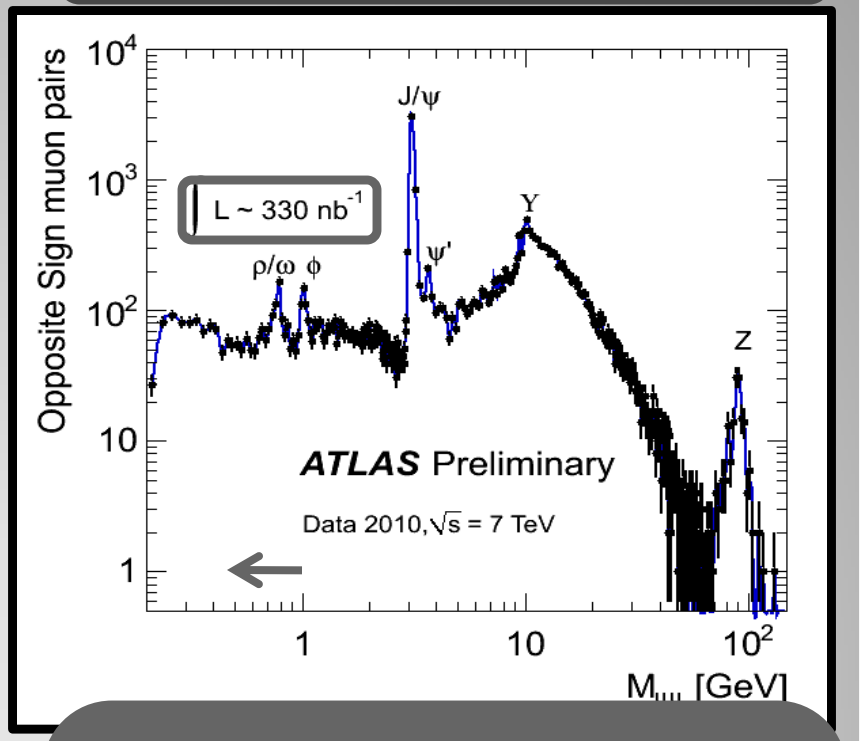


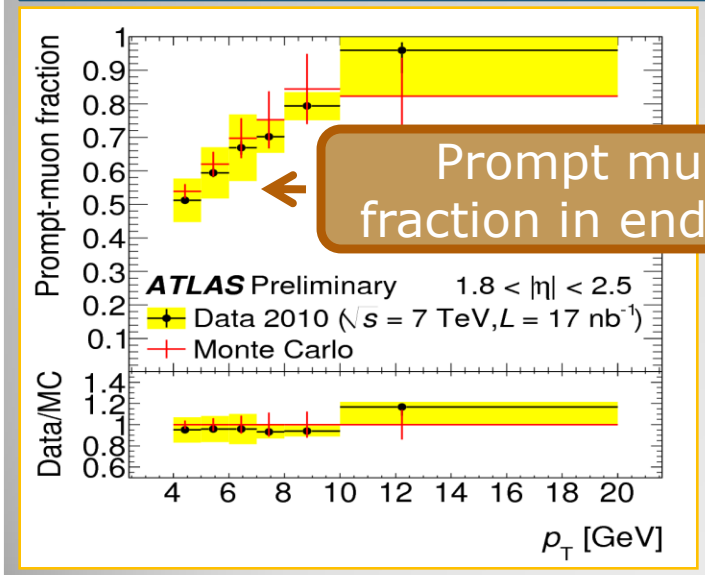
To extract signal from background:
- **2 EM clusters matched to tracks**
- **p_T ($e^\pm$ tracks) > 4, 2 GeV**
- **track quality, calo shower shapes**
- **<u>key handle: large transition radiation in TRT</u>**
- **invariant mass from track parameters after**
  - **Brem recovery (GSF)**

Measurements results presented at this workshop by K. Toms



P_T muon resolution from collisions

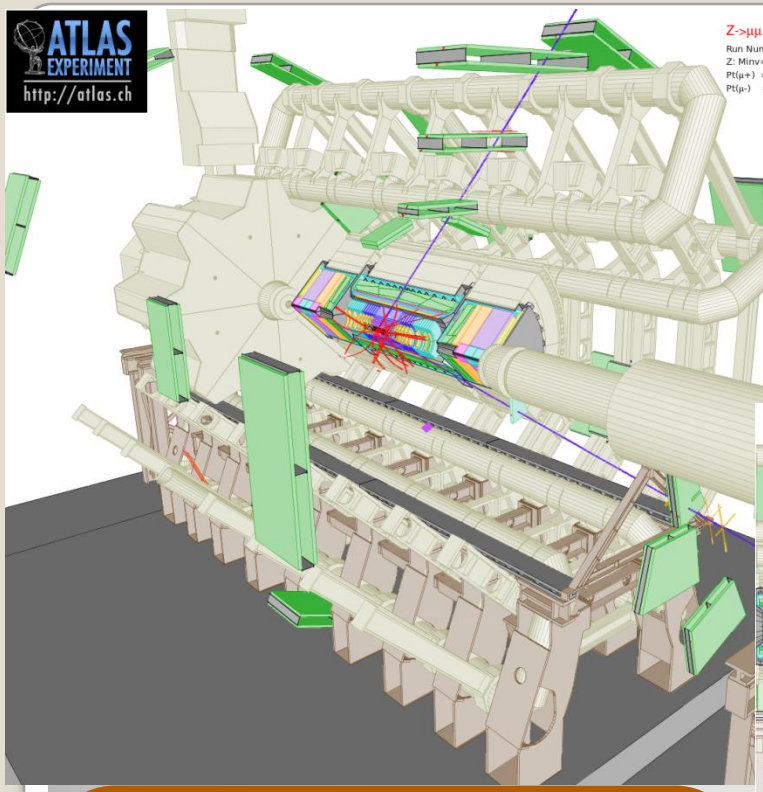




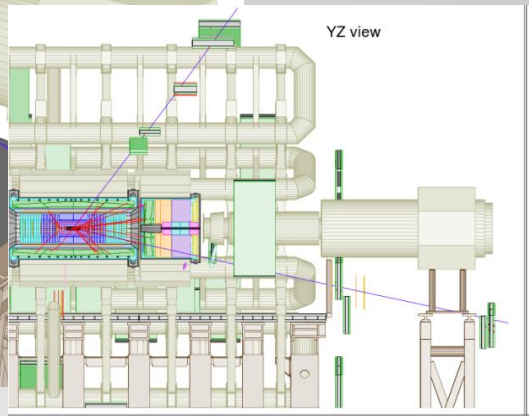
Prompt muon fraction in end-caps

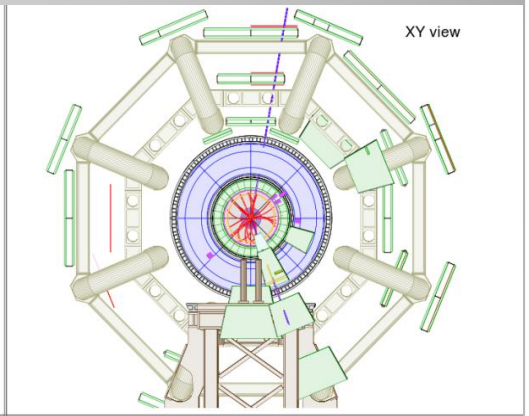
Muon performance

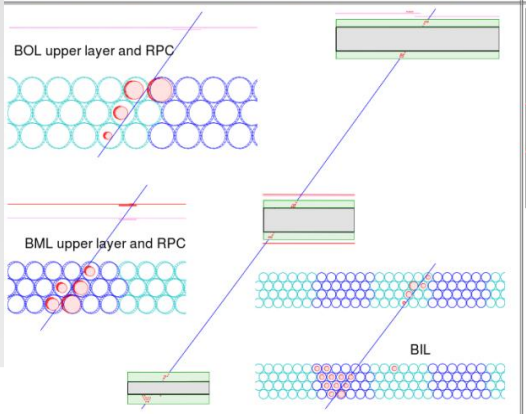
- LVL1 muon trigger with p_T ~ 6 GeV threshold
- 2 opposite-sign muons reconstructed by combining tracker and muon spectrometer
- both muons with |z|<1cm from primary vertex

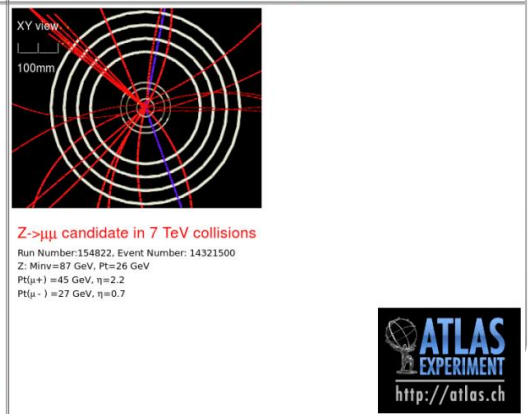


Z-> μμ candidate (collected on 10 May)





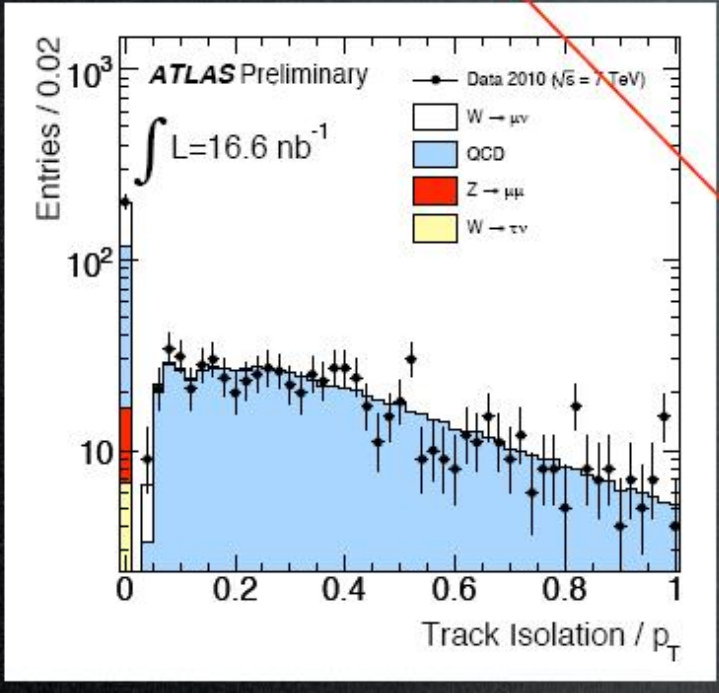


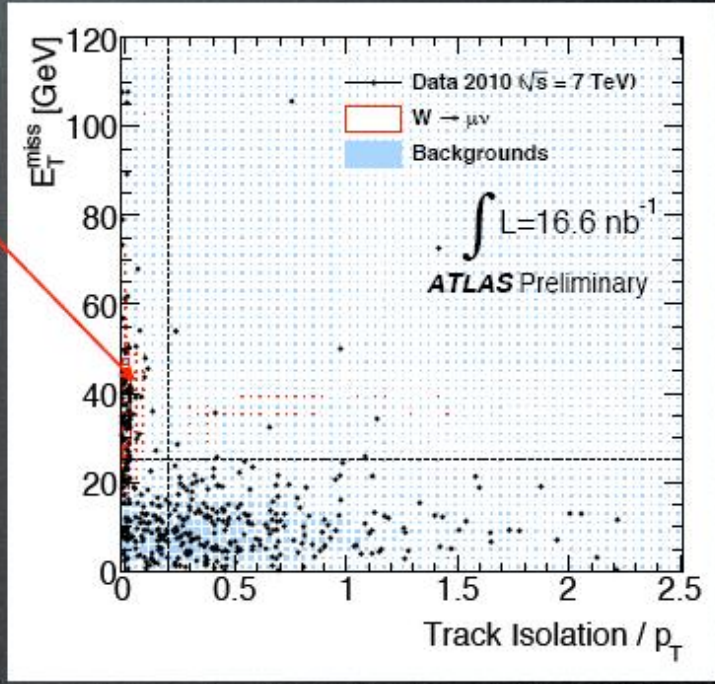


Event properties: $p_T(\mu^+)$ = 45 GeV
$\eta(\mu^+)$ = 2.2
$p_T(\mu^-)$ = 27 GeV
$\eta(\mu^-)$ = 0.7
$m_{\mu\mu}$ = 87 GeV

Background estimation: QCD, μ

- "ABCD" method to predict background in signal region from control regions dominated by bkg (jets, π/K decays)
- **Uncorrelated** variables: ME_T and track Isolation/p_T
- QCD in signal region: 0.9 ± 0.3 (stat) ± 0.6 (syst)





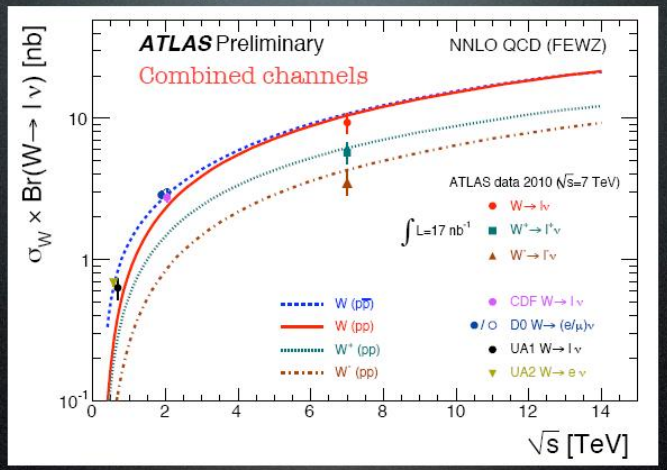
W cross-section

$L = 16.9\ nb^{-1}$	Estimated N(signal)	cross-section (nb)
W(eν)	46	8.5 ± 1.3 (stat) ± 0.7 (syst) ± 0.9 (lumi)
W(μν)	72	10.3 ± 1.3 (stat) ± 0.8 (syst) ± 1.1 (lumi)
Combined	118	9.3 ± 0.9 (stat) ± 0.6 (syst) ± 1.0 (lumi)

Theory:

$$\sigma^{NNLO}_{W\to\ell\nu} = 10.46\ \text{nb} \quad (\sigma^{NNLO}_{W^+\to\ell^+\nu} = 6.16\ \text{nb} \quad \text{and} \quad \sigma^{NNLO}_{W^-\to\ell^-\nu} = 4.30\ \text{nb})$$

First point at 7 TeV...



- Remarkable agreement with theory (4% theor. uncertainty not shown)
- $W^{+/-}$ asymmetry due to parton composition in protons observed

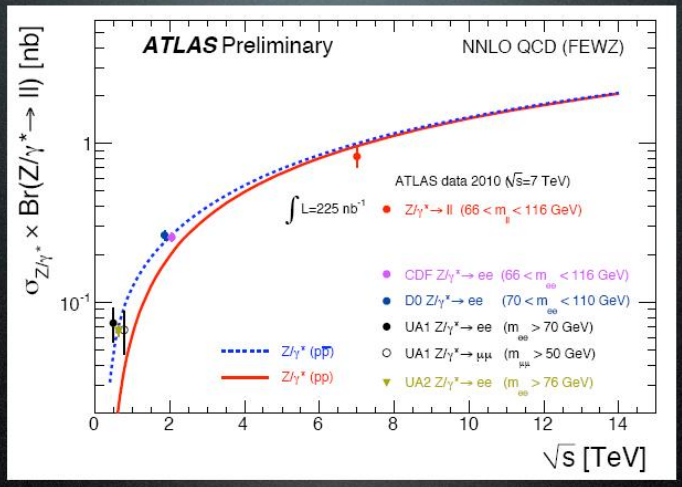
Z cross-section

$L = \sim 225\ nb^{-1}$	Estimated N(signal)	cross-section (nb)
Z(eν)	46	0.72 ± 0.11 (stat) ± 0.10 (syst) ± 0.08 (lumi)
Z(μν)	79	0.89 ± 0.10 (stat) ± 0.07 (syst) ± 0.10 (lumi)
Combined	125	0.83 ± 0.07 (stat) ± 0.06 (syst) ± 0.09 (lumi)

Theory:

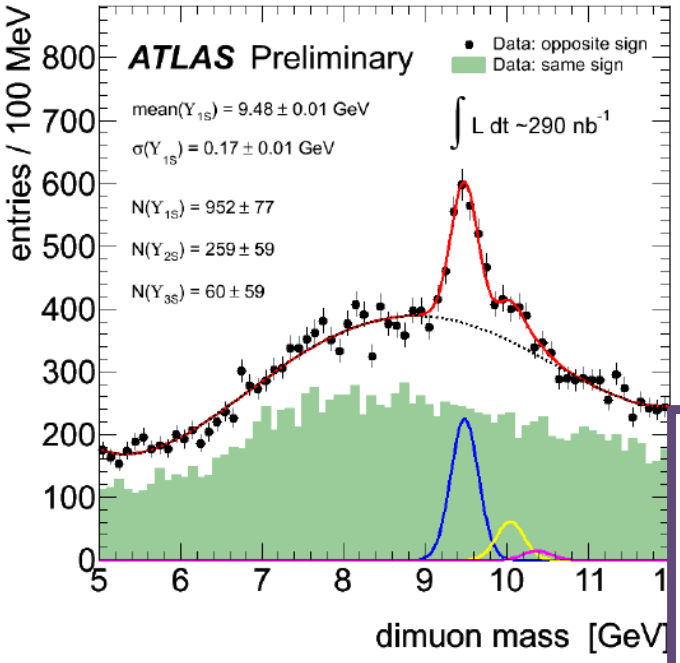
$$\sigma^{NNLO}_{Z/\gamma^*\to\ell\ell} = 0.99\ \text{nb}$$ (66 GeV < M(ll) < 116 GeV)

First point at 7 TeV...



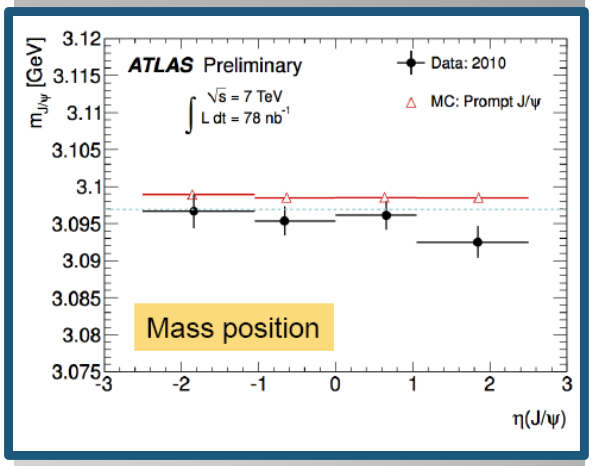
- Good agreement with theory
- 4% theoretical uncertainty not shown

$\Upsilon(1s,2s,3s)\rightarrow\mu\mu$ candidates



Level1 muon trigger with no p_T cut

Cuts on muons:
2.5 and 4 GeV



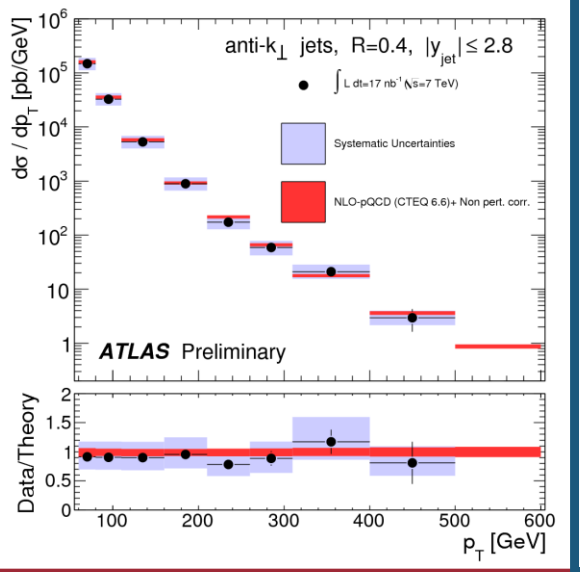
High mass quarkonia production

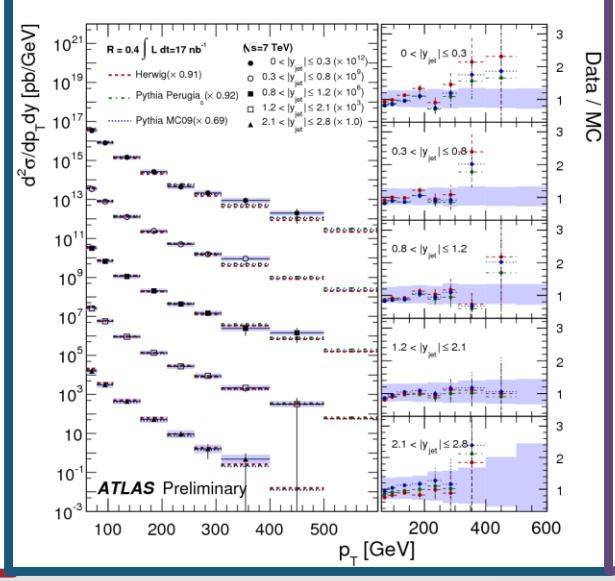
Open charm and Onia summary

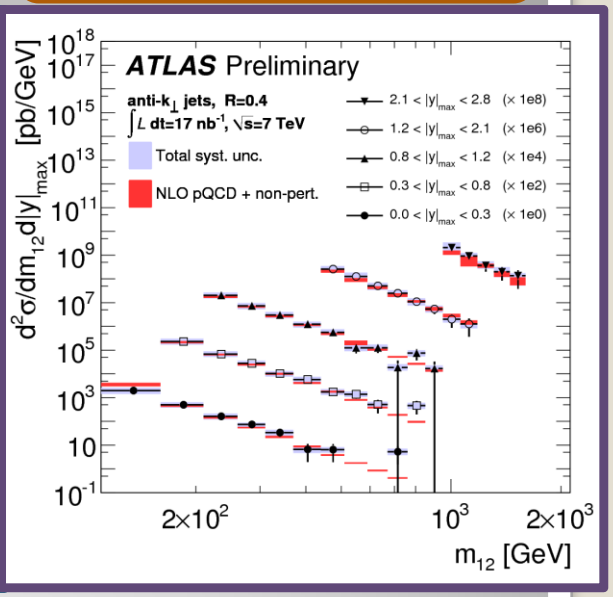
- Signals from $D^{*\pm}$, $D^{\pm}$ and $D_s^{\pm}$ observed by the ATLAS detector with 1.4 nb^{-1} integrated luminosity
  - Signal yields: $D^{*\pm}$ (2020±120); $D^{\pm}$(1667±86); $D_s^{\pm}$(326±57)
  - Good agreement with PDG in reconstructed mass position
- J/ψ signal has been observed
  - Excellent agreement with MC predictions and PDG mass position
  - Now have enough statistics (6820±90) in peak with 290 nb^{-1} data for performance studies
- Studies of these particles show tracking, vertexing and muon system working well, and in line with expectation
- Expect to be making first ratio and differential production cross-section measurements shortly, with a strong program of measurements into the charmonium production mechanism to follow

Jets performance and results

pp 7 TeV, 17 nb-1





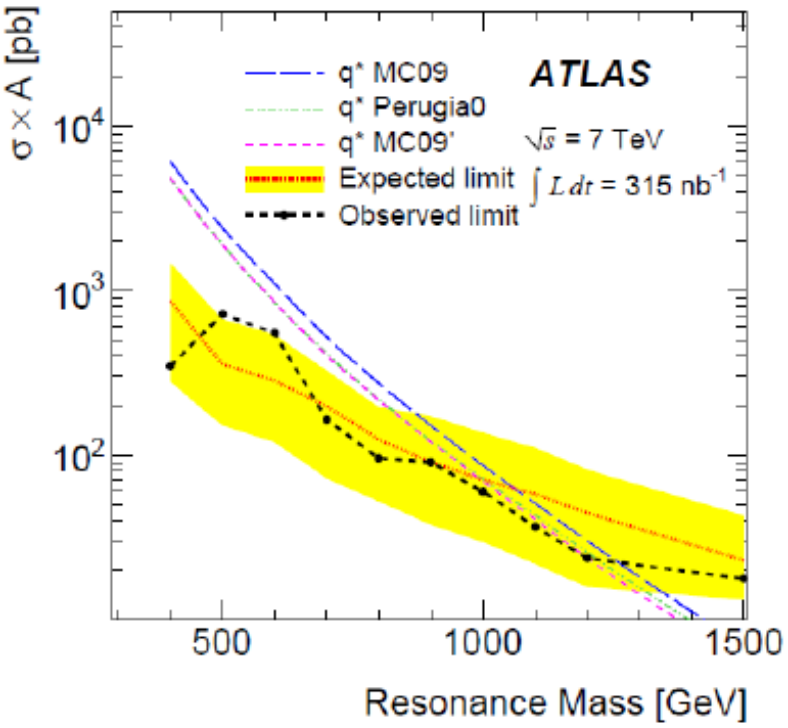


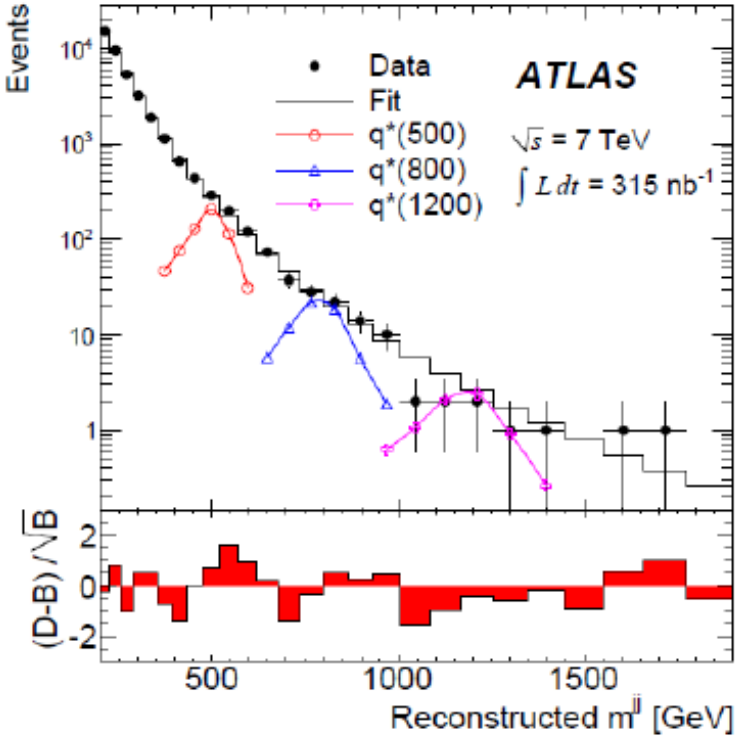
Measured Inclusive jet cross-section extended up to jet pt =500 GeV/c and dijet masses of 2 TeV

Data are well described by fixed-order NLO pQCD, corrected for non-perturbative effects

Search for new particles decaying in dijets

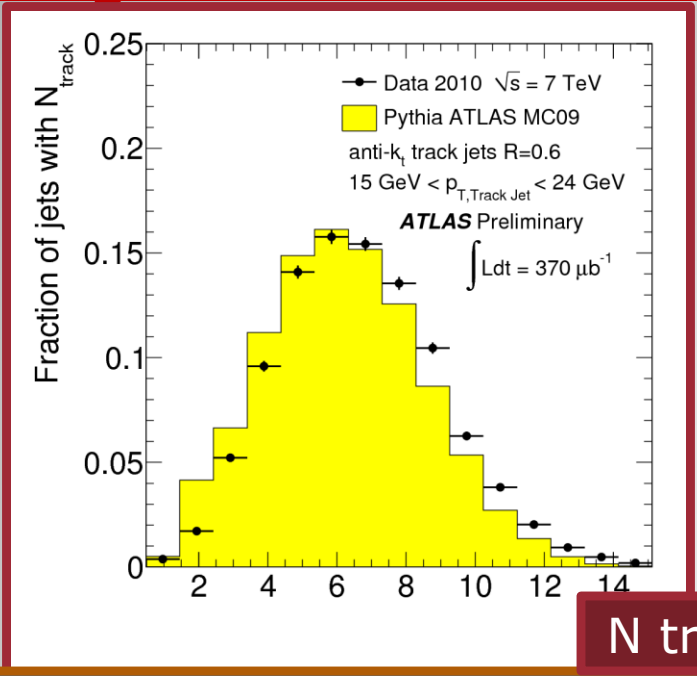
- Sensitive for possible new states in dijet resonances: excited quarks q*, Z', W', graviton and others
- Tevatron exclusion for q*: $260 < m_{q^*} < 870$ GeV @ 95% CL
- *New ATLAS limit:* $400 < m_{q^*} < 1290$ GeV @ 95% CL (more details here: http://arxiv.org/abs/1008.2461, paper submitted to PRL)





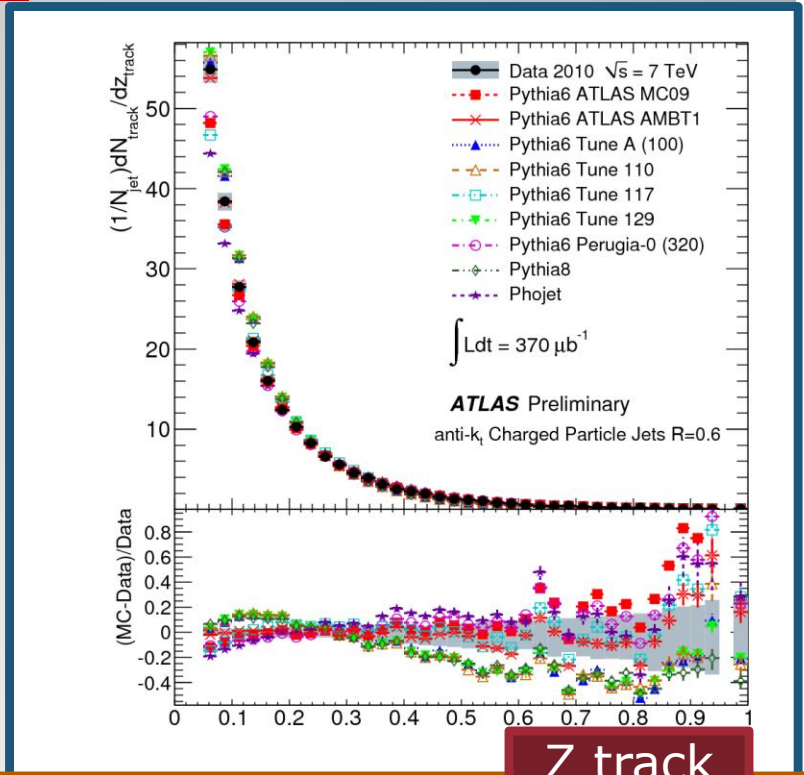
Inclusive jet measurements with ID: numbers of track distributions and fragmentation functions

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

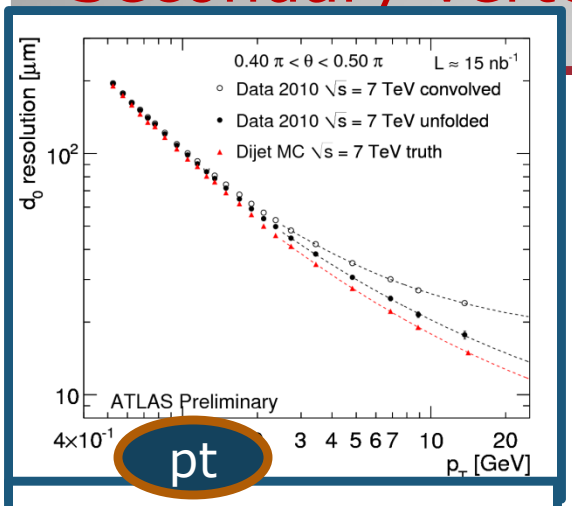
Corrected fragmentation function in anti-k_t jets with R = 0.6 for charged jet p_T from 15 - 24 GeV

Important for TOP measurements

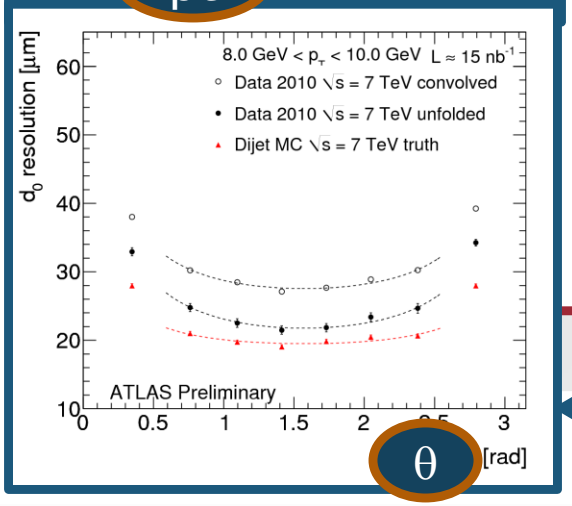
b-jet identification rely on:

Tracks impact parameters

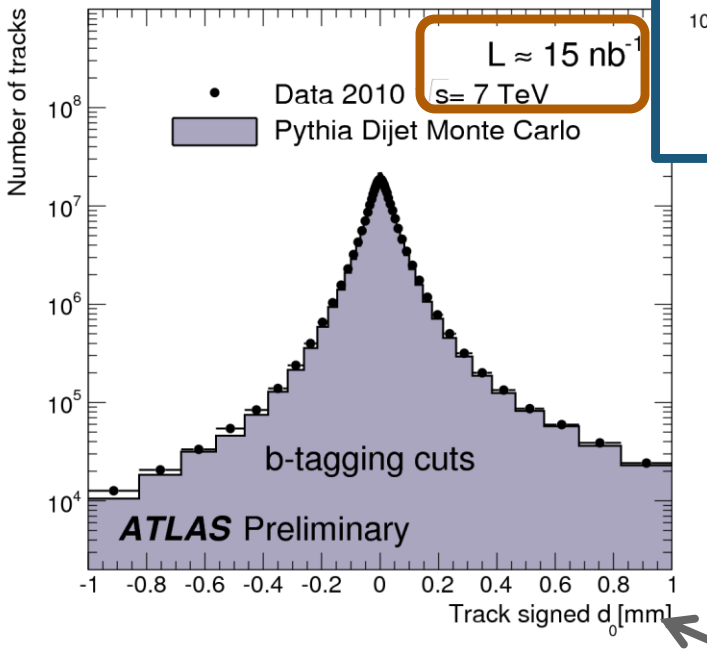
Secondary vertex reconstruction

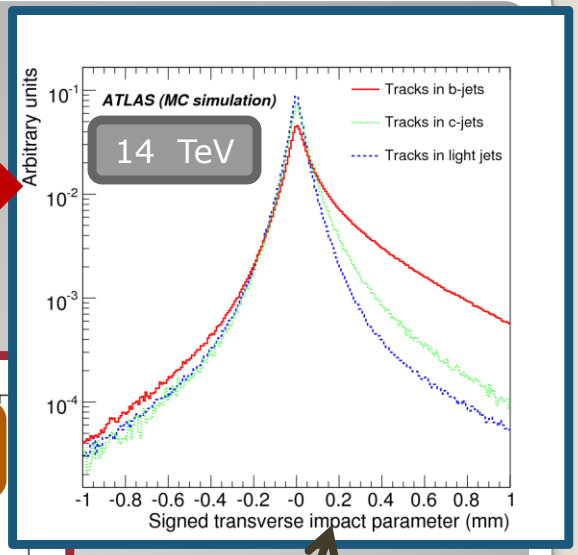


pt



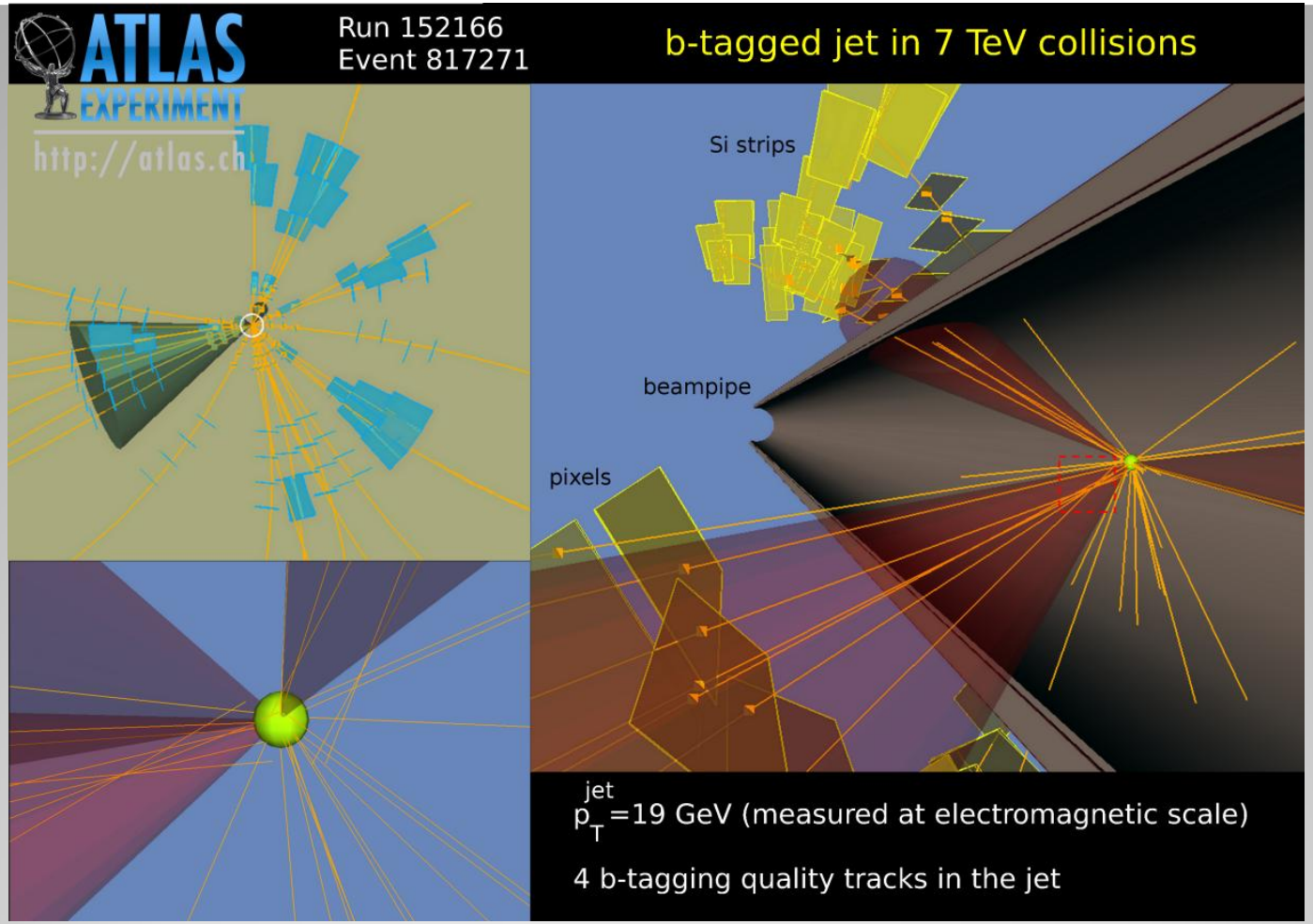
θ





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

Tracks impact parameter resolution vs Pt and θ

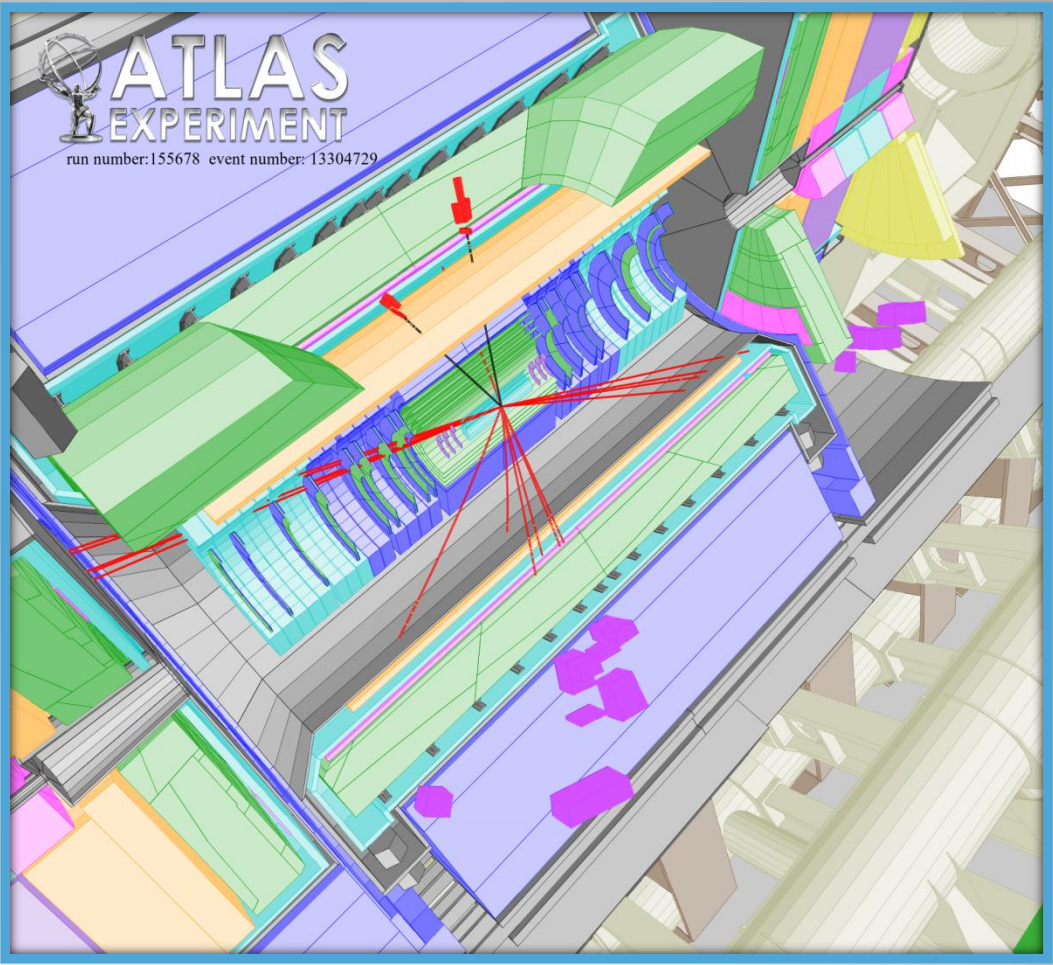


b-tagged jet in pp collisions at 7 TeV

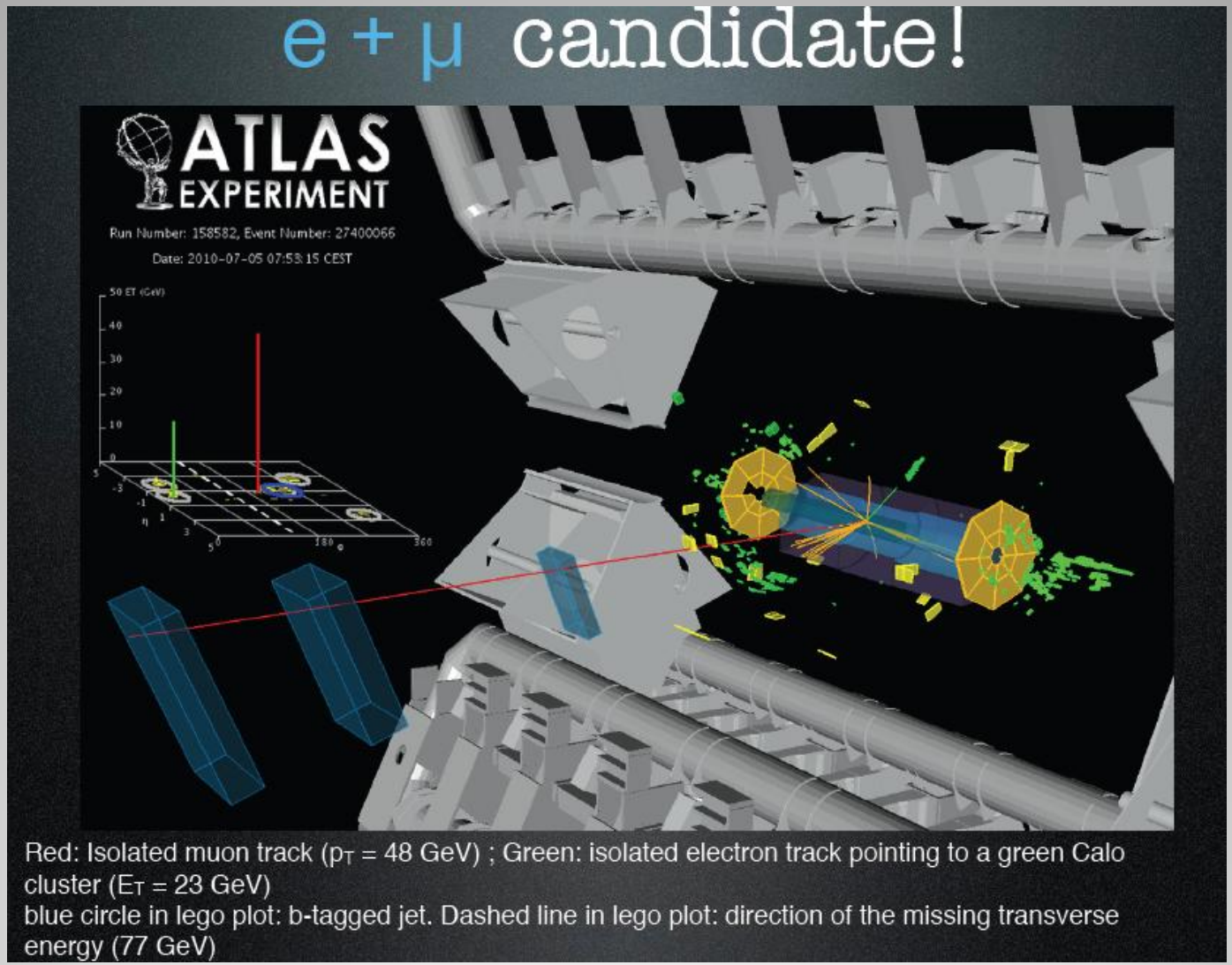
One soft b-tagged jet in events with two electrons, passed cuts, at 7 TeV with int. luminosity 280 nb^{-1}

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

M_{ee} = 36.9 GeV



Top candidate



TOP candidate

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