$J/\psi \rightarrow \mu^+\mu^-$ from 7 TeV pp collisions in ATLAS:

performance with the first data

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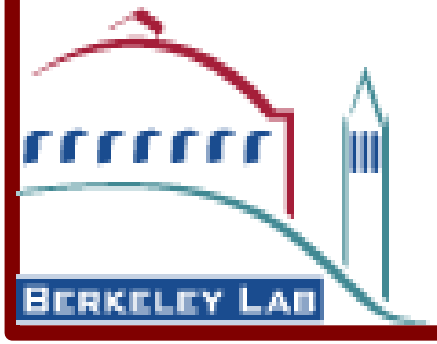
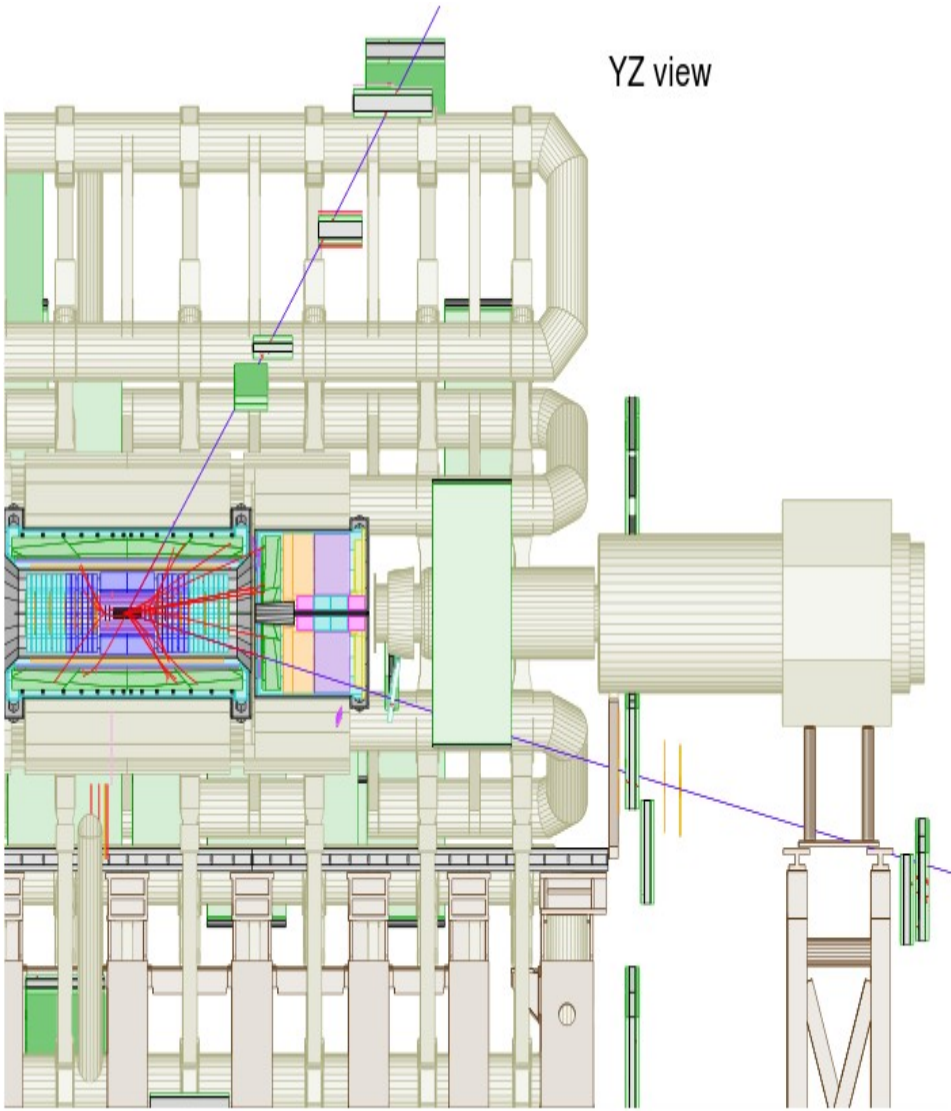
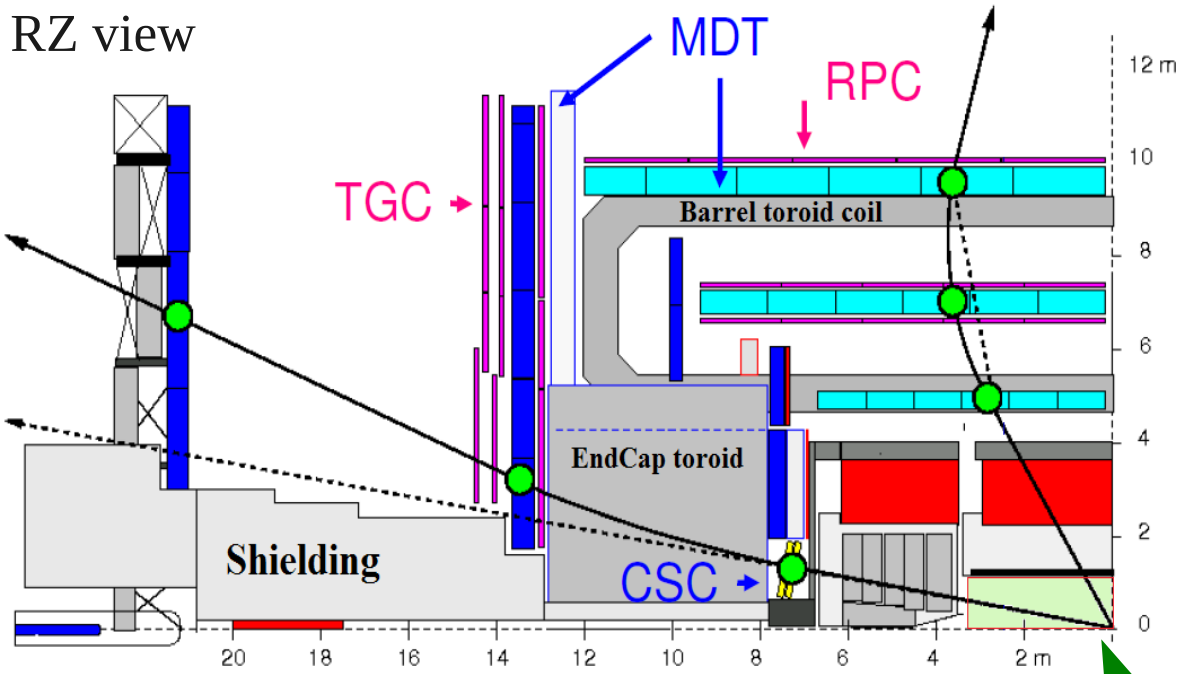


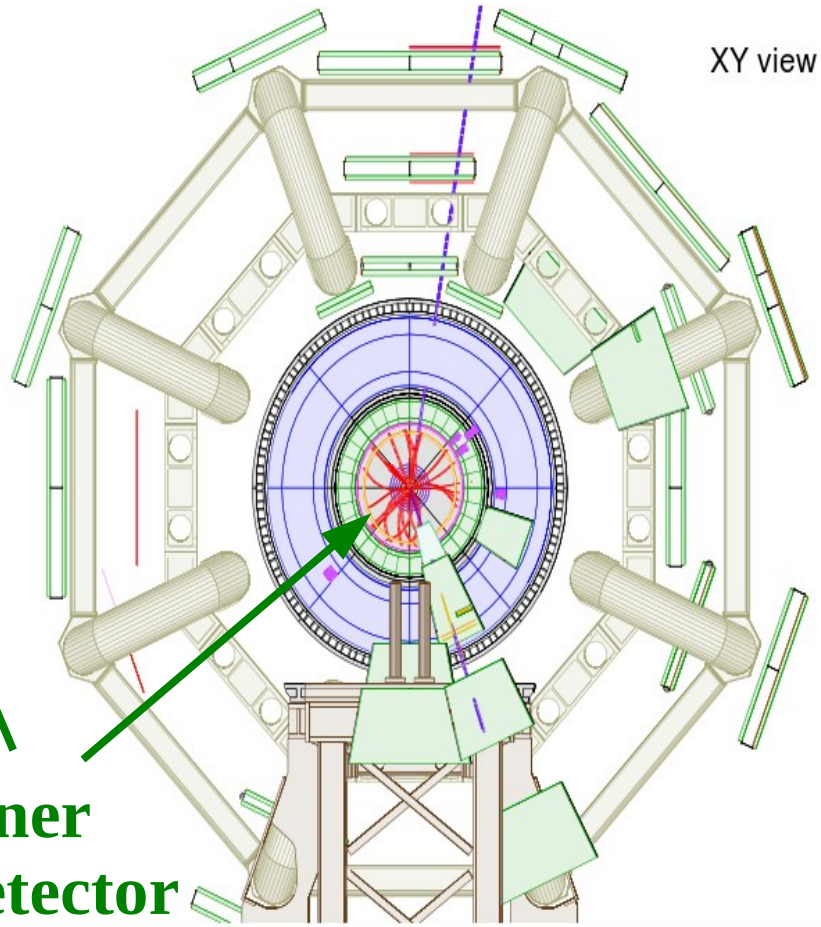
Introduction

- ATLAS is a general purpose Detector
- Muon Reconstruction combines Muon System and InnerDetector
- Muon system provides excellent resolution at high momentum: $\sigma(1\ \text{TeV}) \sim 10\%$
- At low momentum (< 100GeV), measurement dominated by Inner Detector tracking
- Di-muon resonances with known properties used as reference points to access Inner Detector performance



ATLAS: A Toroidal LHC ApparatuS





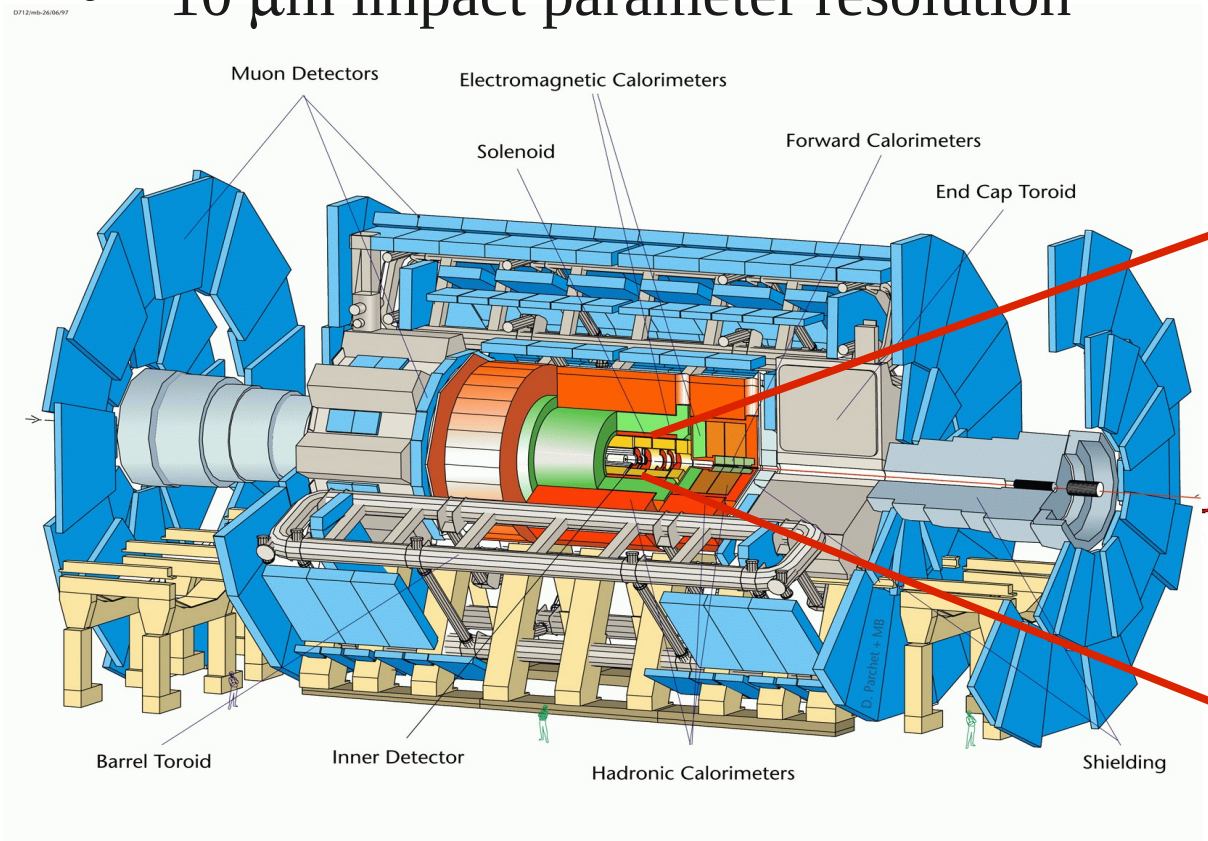
- Muon System: inside toroid
- Precision chambers
  - Monitored Drift Tubes (MDT)
  - Cathod Strip Chambers (CSC)
- Fast trigger layers
  - Resistive Plate Chambers (RPC)
  - Thin Gap Chambers (TGC)

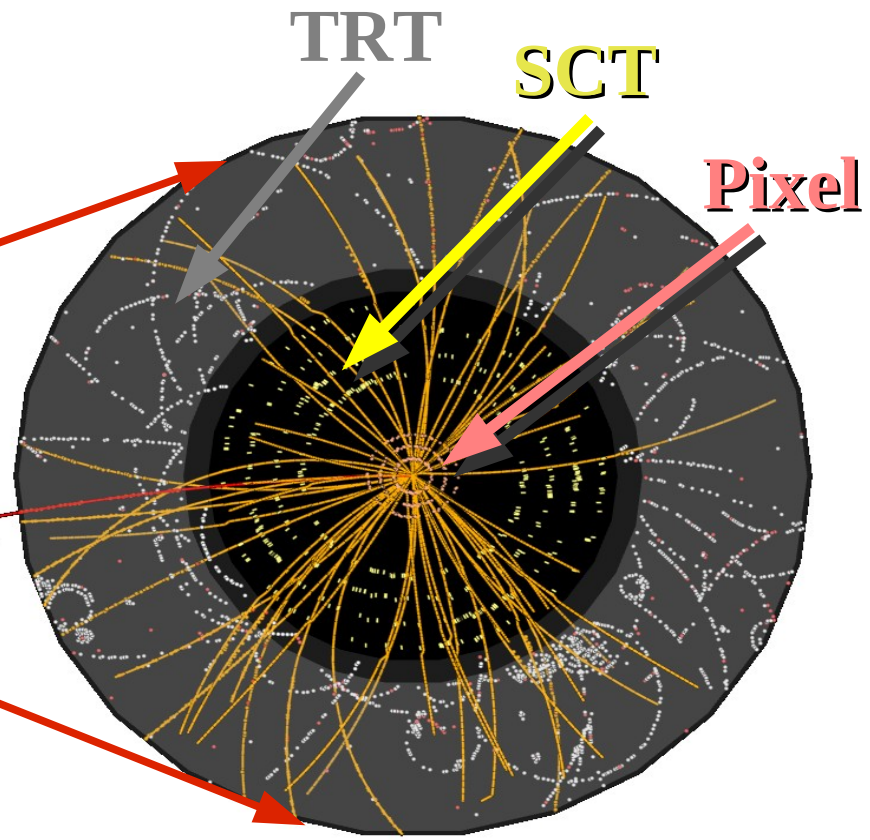
Inner Detector (inside:solenoid)

ATLAS Inner Detector

- 1.2m radius, 7m long
- 3 tracking technologies
- Inside 2T magnetic field
- σ_{Pt}/Pt ~0.05%Pt[GeV]⊕1.5%
- ~ 10 μm impact parameter resolution

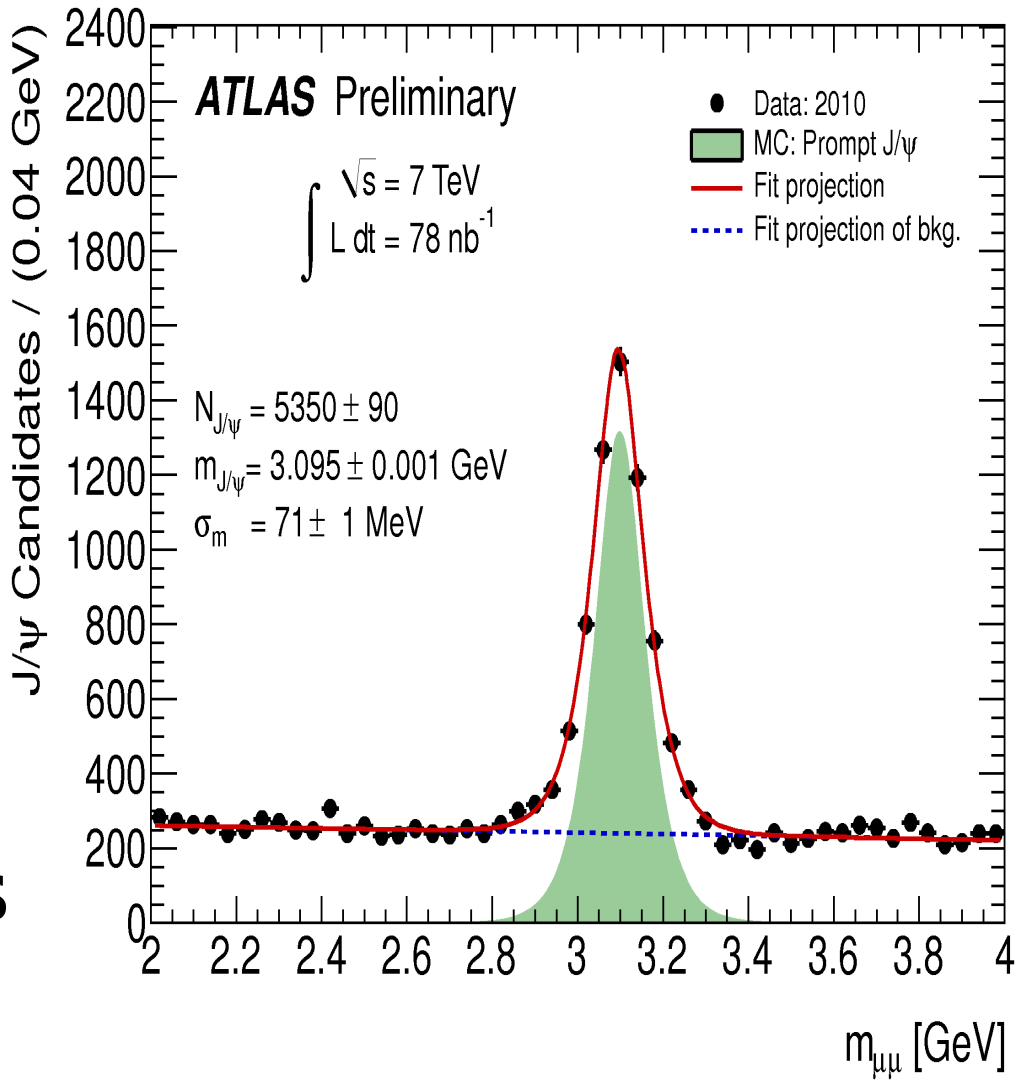
- Transition Radiation Tracker (TRT) : 73 layers of straws (36 hits on avarage)
- SemiConductor Tracker (SCT): 4 double layers
- Pixel Detector: 3 layers





J/ψ reconstruction

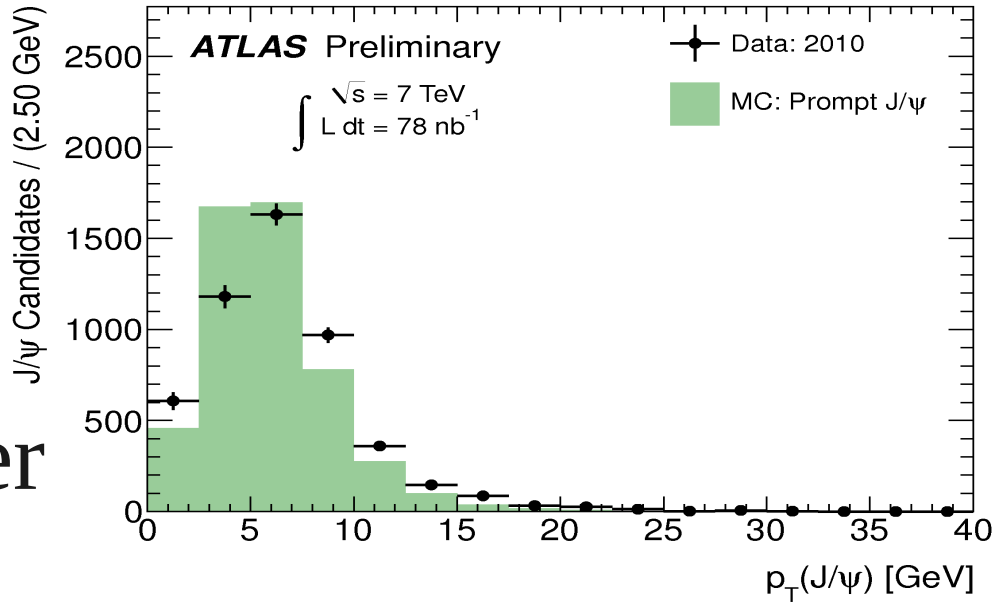
- Reconstruct:
  5350 $J/\psi \rightarrow \mu^+\mu^-$ decays in 78 nb^{-1} of data using:
  - Track quality cuts
  - $p(\mu) > 3$ GeV
  - Vertex fit
- $m_{J/\psi} = 3.095 \pm 0.001$ GeV (stat. uncertainty only)
- reconstructed mass agrees well with PDG (3.096916 ± 0.000011 GeV)

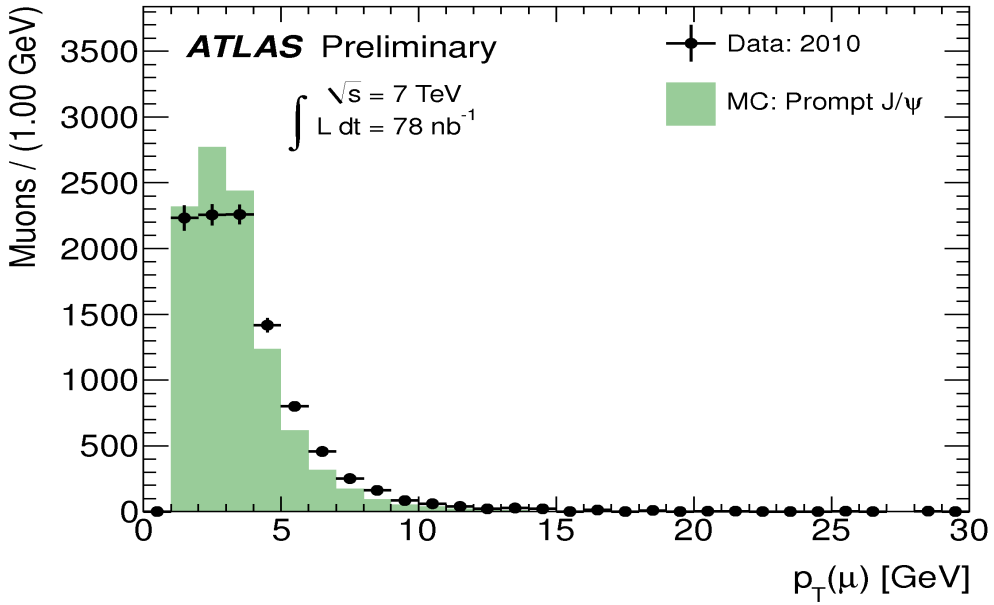


J/ψ and muon kinematics

- lower muon momenta accessible with triggers during commissioning

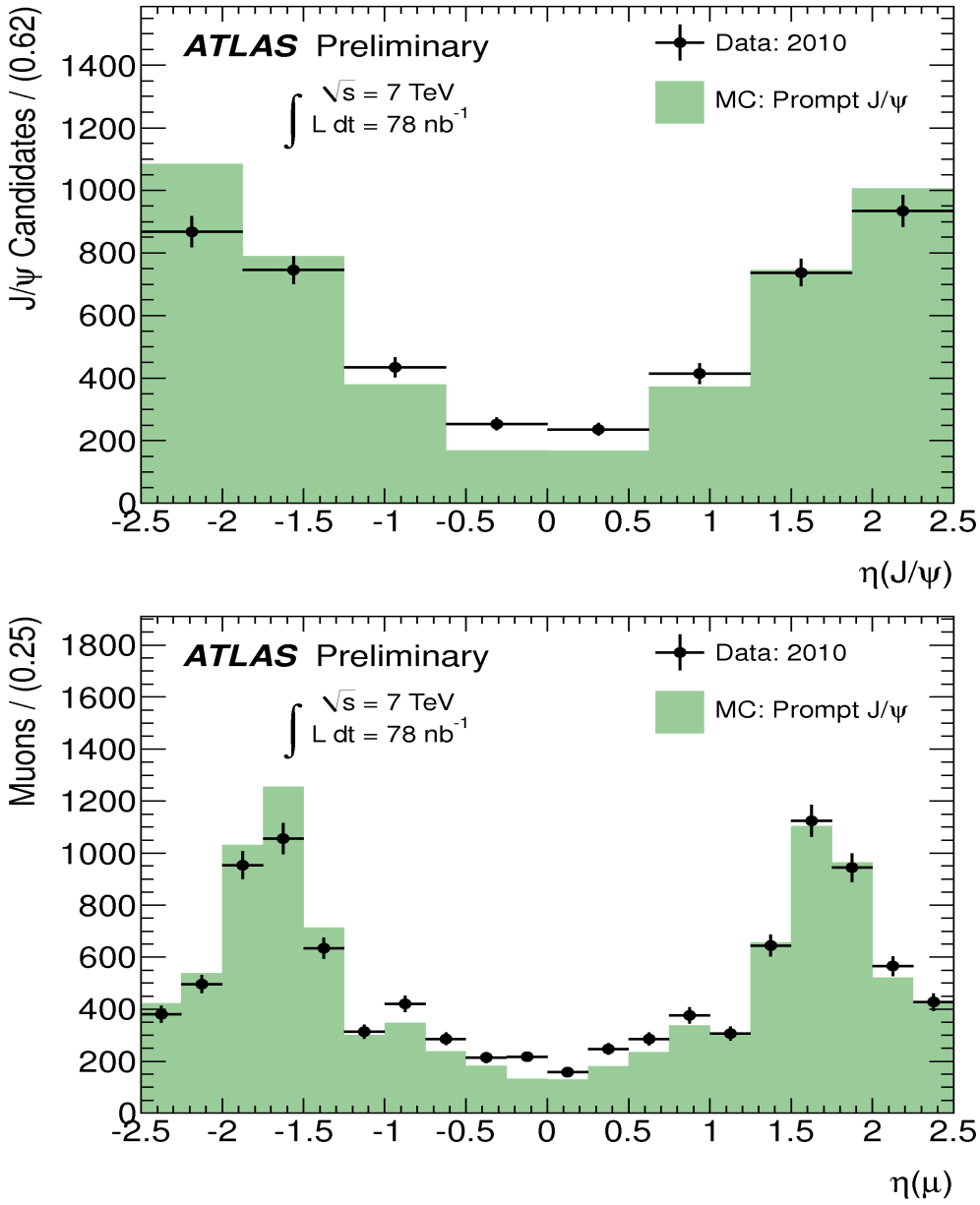
  → not available any longer due to prescales at higher luminosity!
- p_T spectrum not very well described by Pythia





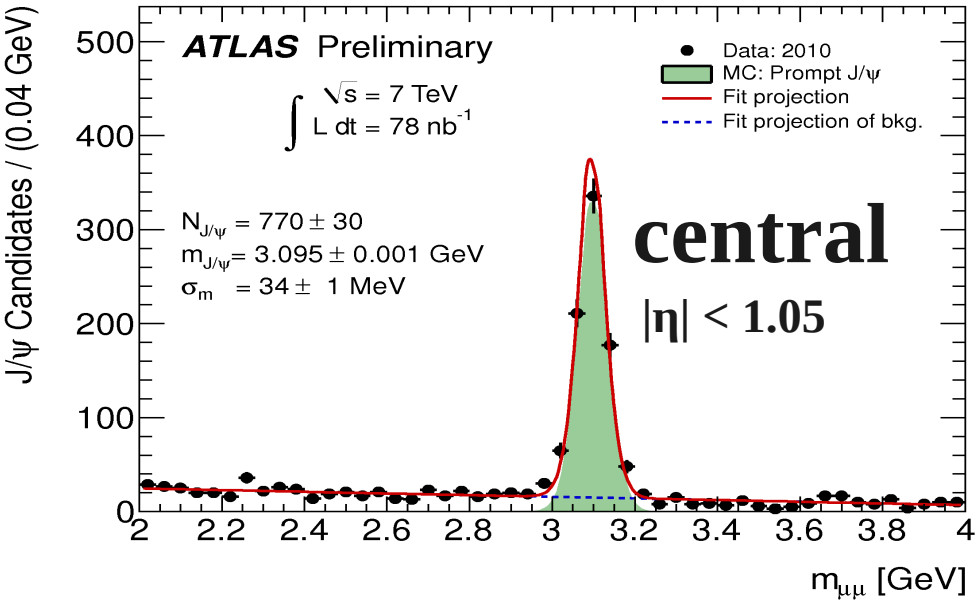
J/ψ and muon kinematics continued

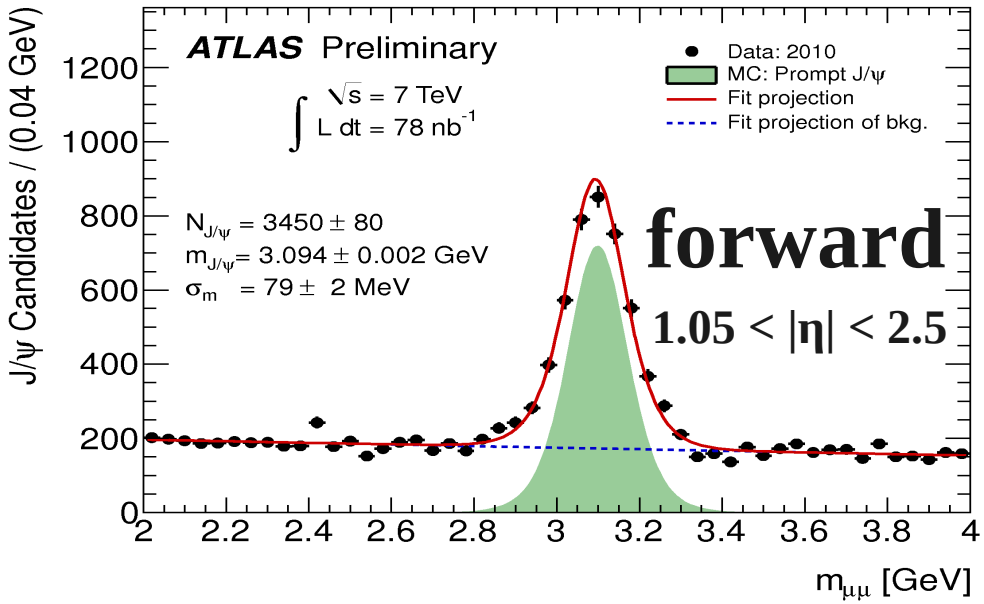
- Use full coverage of the Inner Detector $|\eta| < 2.5$
- Due to range-out, muons predominantly forward
- Monte-Carlo momentum modeling discrepancy propagates into the η distribution



J/ψ in different reconstruction regions

- Detector geometry and material varies
- Best resolution in central region: 34 ± 1 (stat.) MeV
- Resolution well described by the Monte Carlo

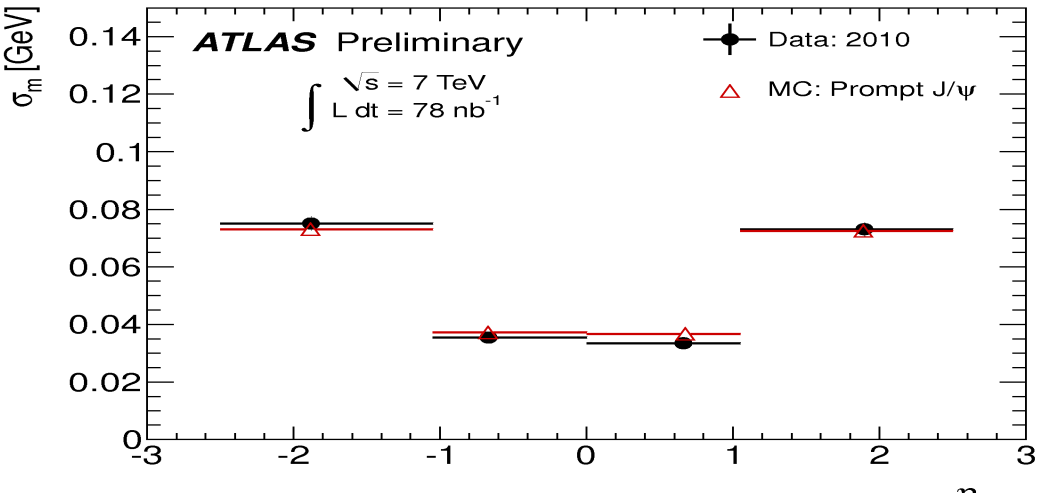




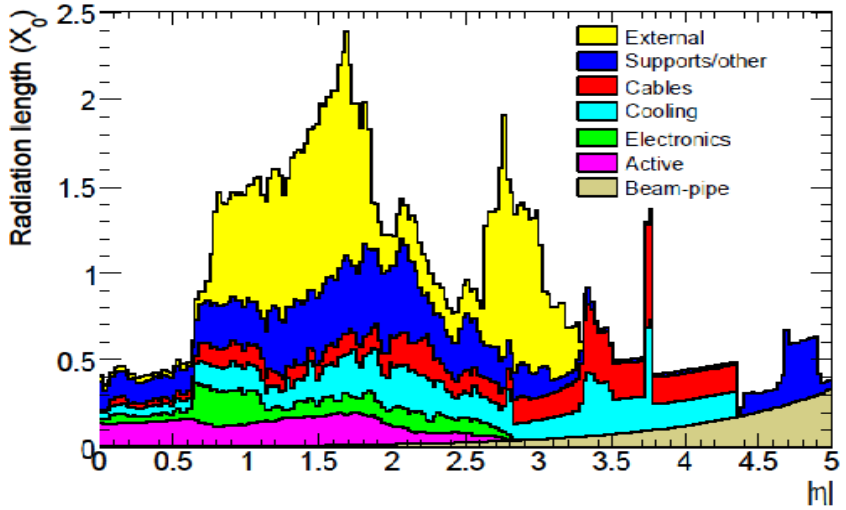
central	data	34	± 1	MeV
	MC	37.0	± 0.3	MeV
forward-central	data	58	± 2	MeV
	MC	52.9	± 0.3	MeV
forward	data	79	± 2	MeV
	MC	78.5	± 0.2	MeV

Mass resolution

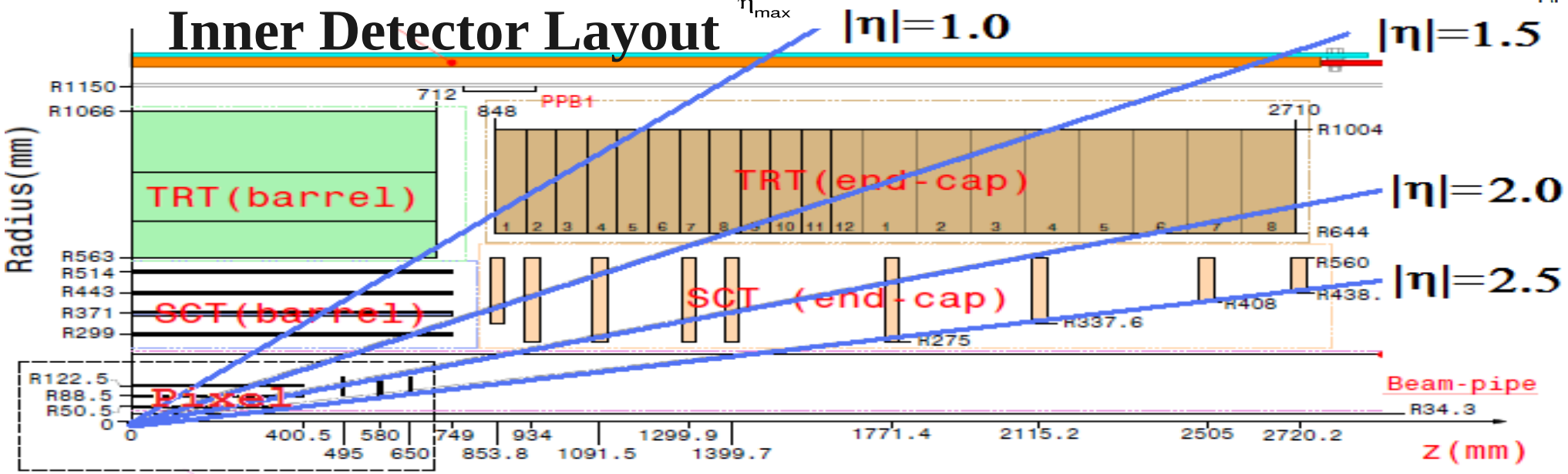
Measured mass resolution



Material distribution

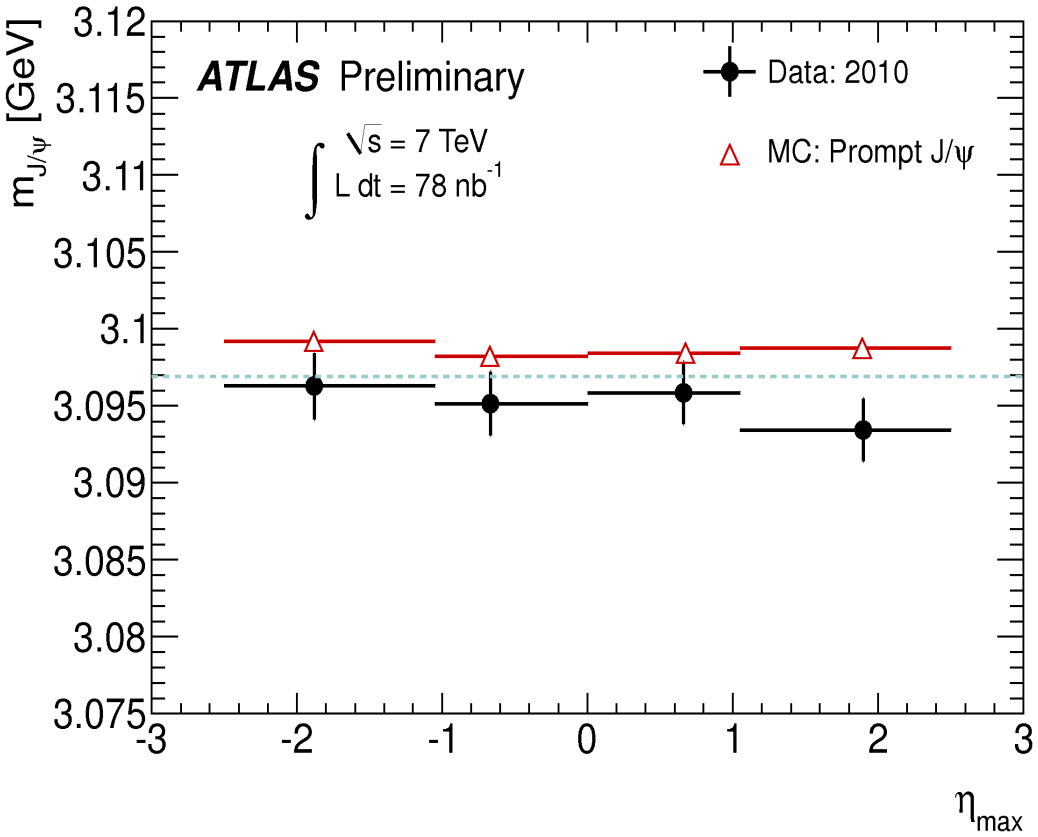


Inner Detector Layout



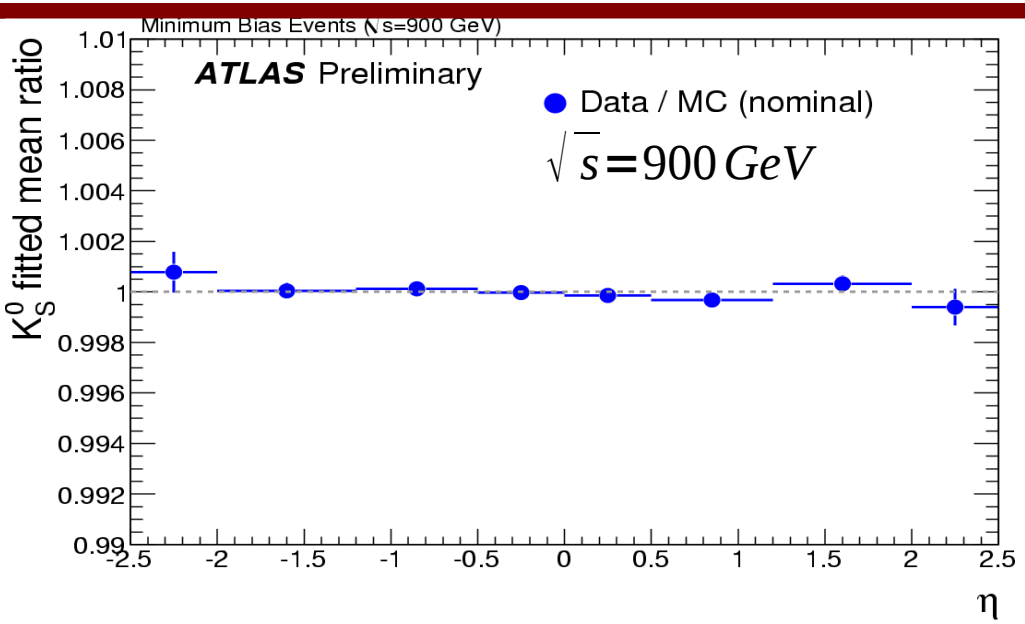
Detector Performance using J/ψ decays

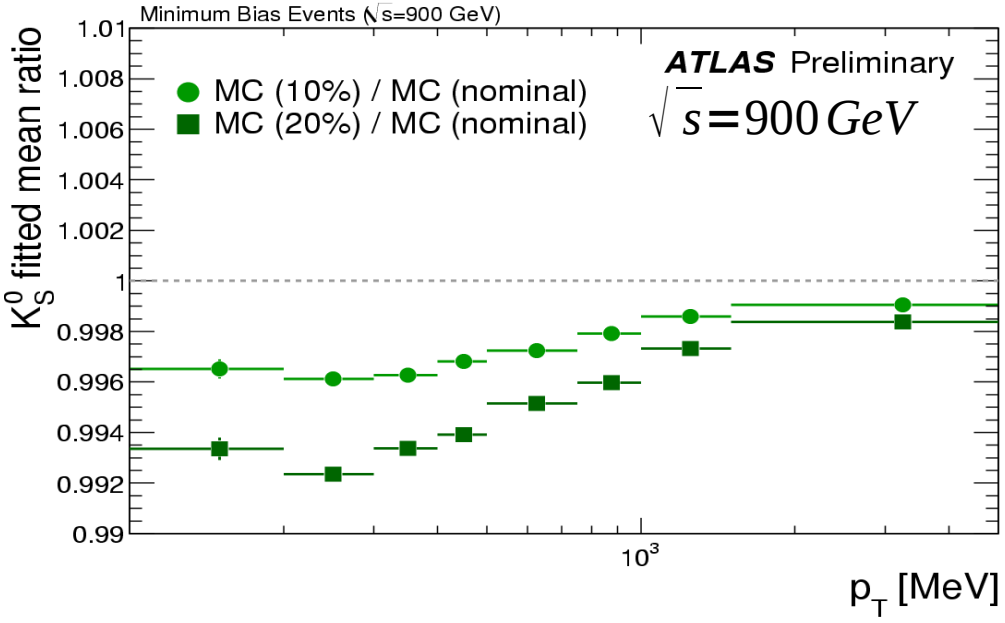
- J/ψ mass well known
  → "standard candle"
- Look for reconstruction bias in different regions
- Statistics still limited, but no bias observed
- Use information to
  - Align components
  - Calibrate material
  - Calibrate momentum and energy scale

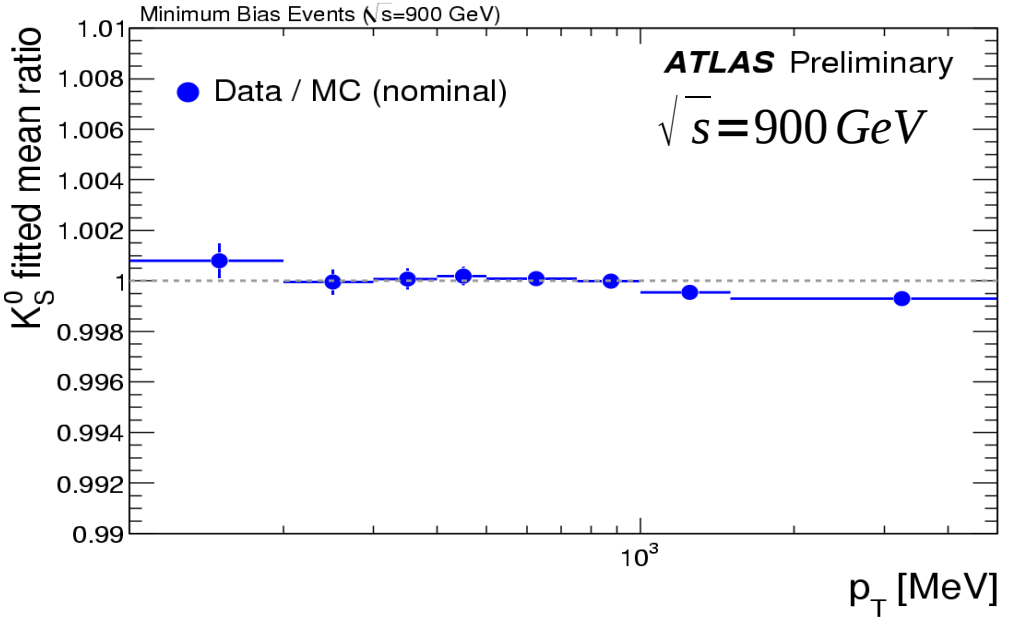


Extension from lower momenta

- $K_s \rightarrow \pi^+\pi^-$ decays already very abundant
- First tests of material and alignment
- But only very low momenta accessible

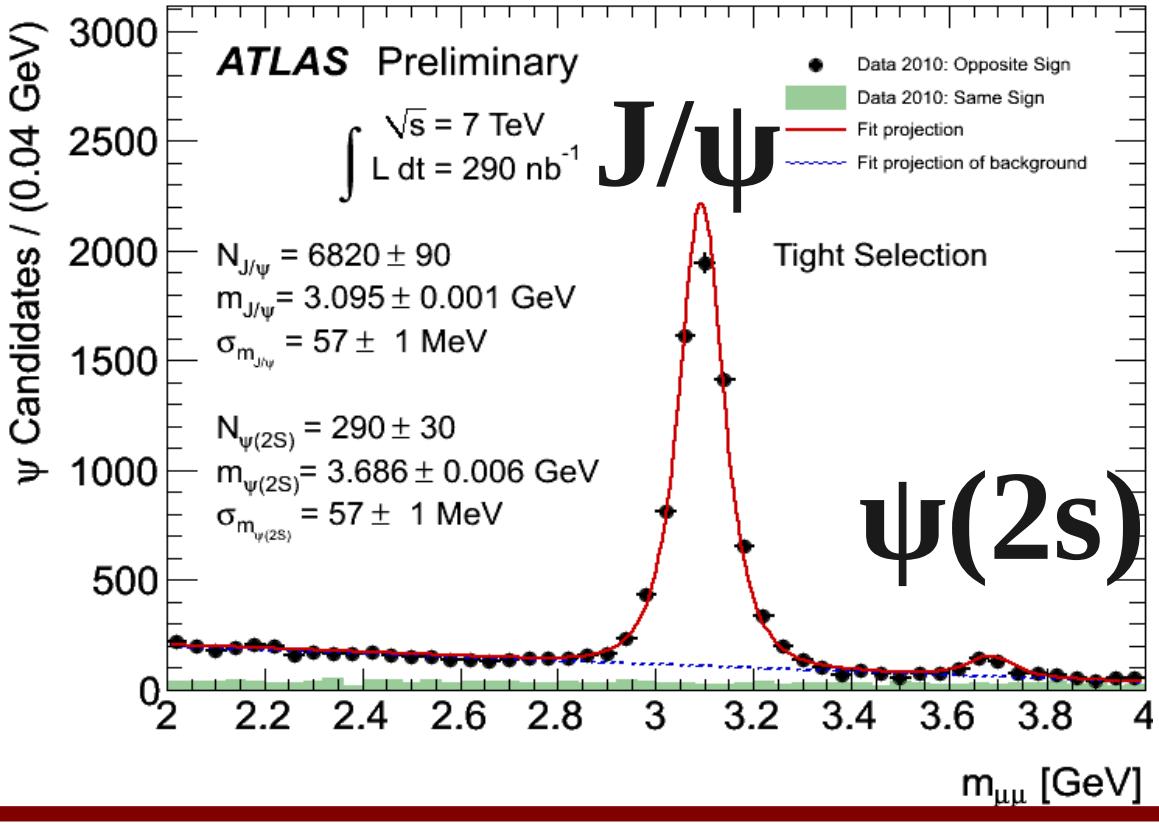


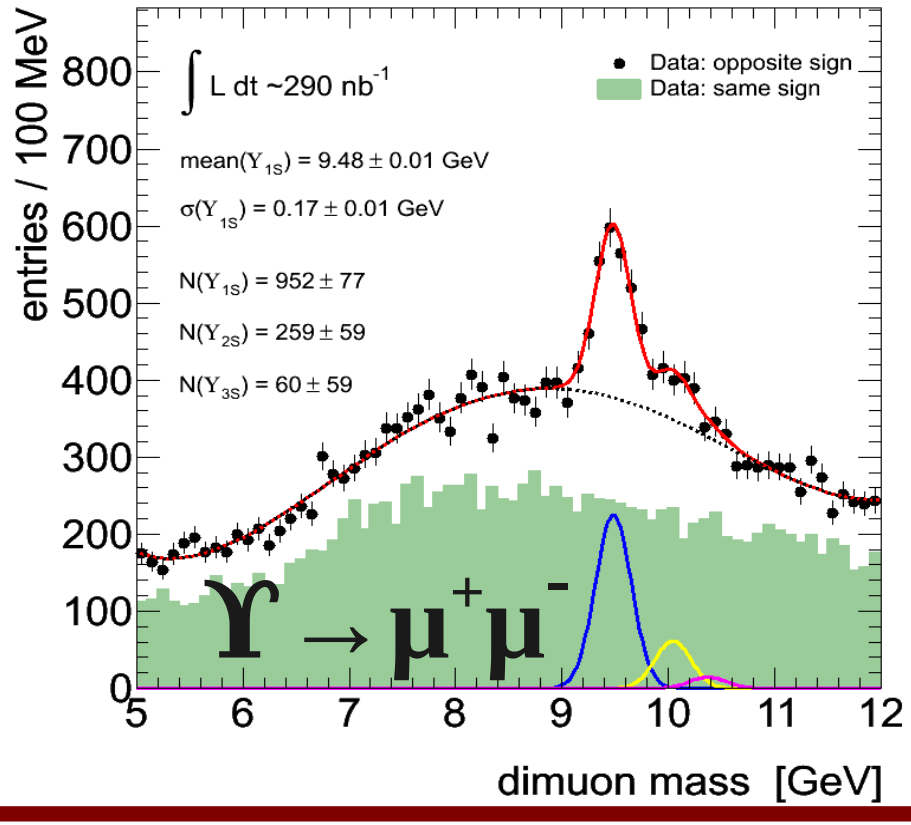




Higher mass resonances: Υ and $\Psi(2s)$

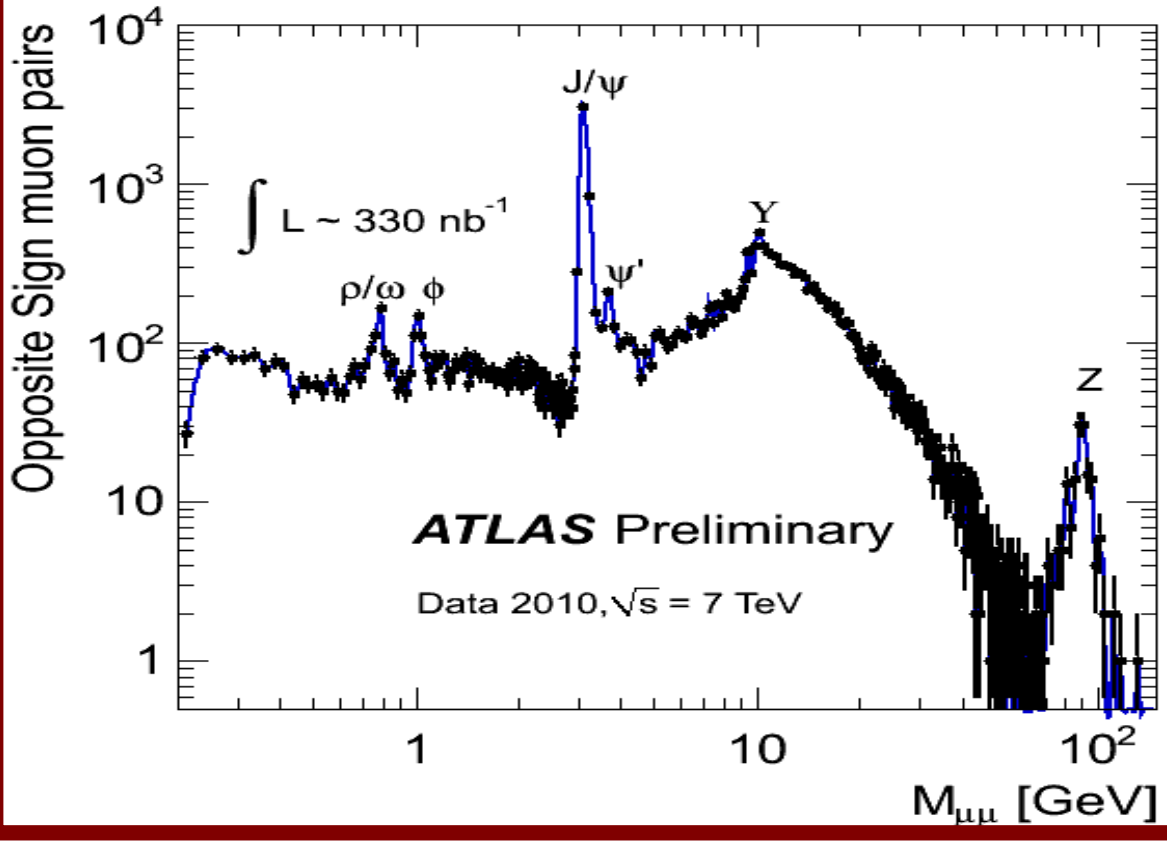
- Use other "standard candles": $\psi(2s)$, Υ, $Z \rightarrow ll$ to establish points along the momentum scale
- $m_{\psi(2s)} = 3686 \pm 6$ (stat.) MeV (PDG: 3686.09 ± 0.04 MeV)
- $m_{\Upsilon(1s)} = 9480 \pm 10$ (stat.) MeV (PDG: 9460.30 ± 0.26 MeV)

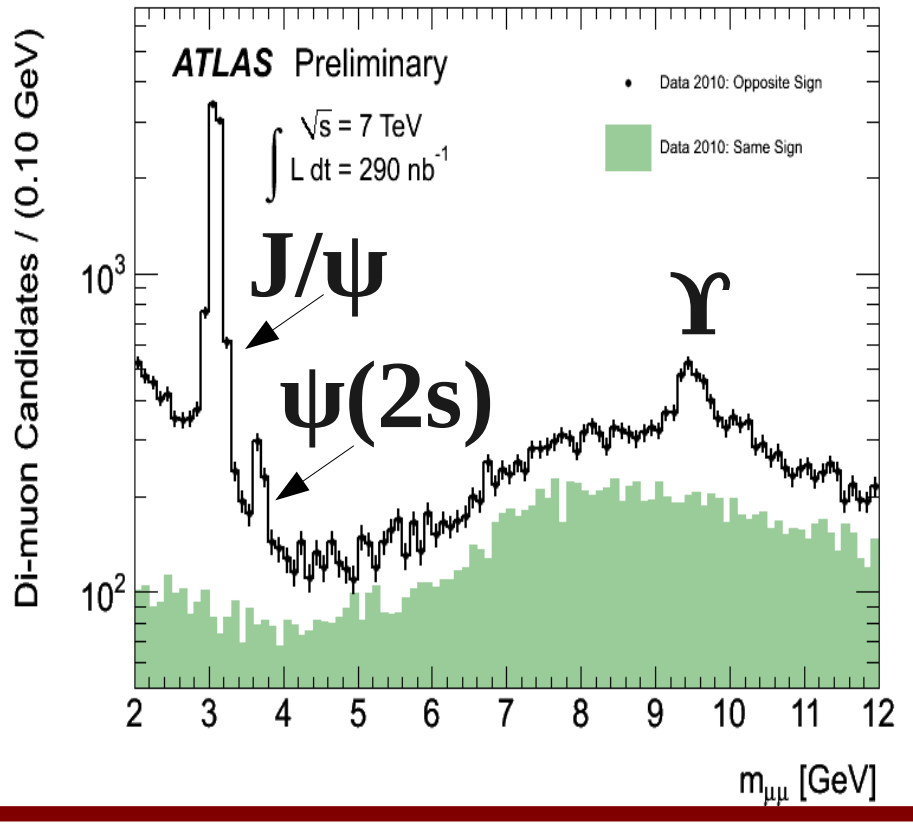




Higher mass resonances

- Use other "standard candles": $\psi(2s)$, Υ, $Z \rightarrow ll$ to establish points along the momentum scale
- A forest of resonances .....



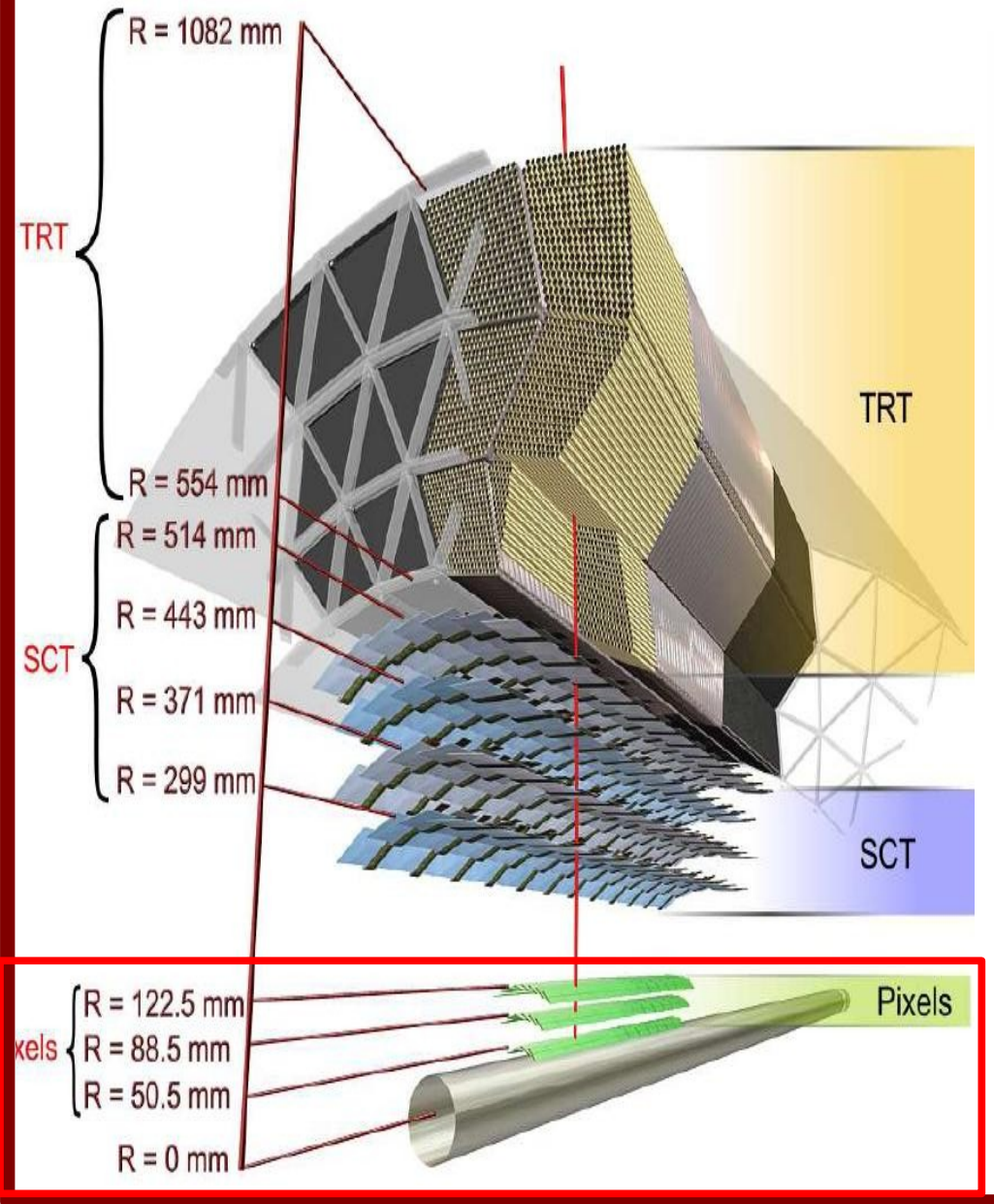


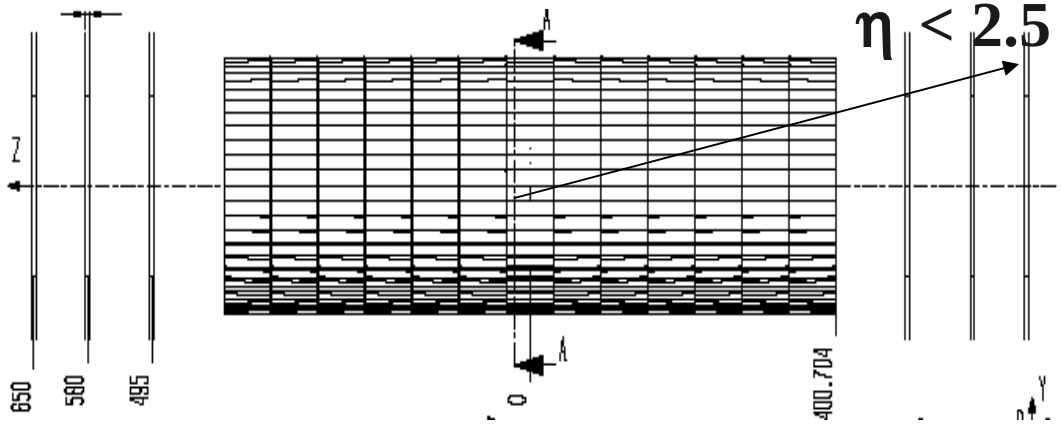
Conclusion

- ATLAS clearly observes di-muon resonances
- Already good detector performance
- good modeling of the detector in the Monte Carlo
- Further understanding of the ATLAS detector with increasing statistics on going
- ATLAS B-Physics program in its first steps (see e.g. Andy's talk next)
- Looking forward to precision physics and new discoveries with ATLAS

Bonus Slides

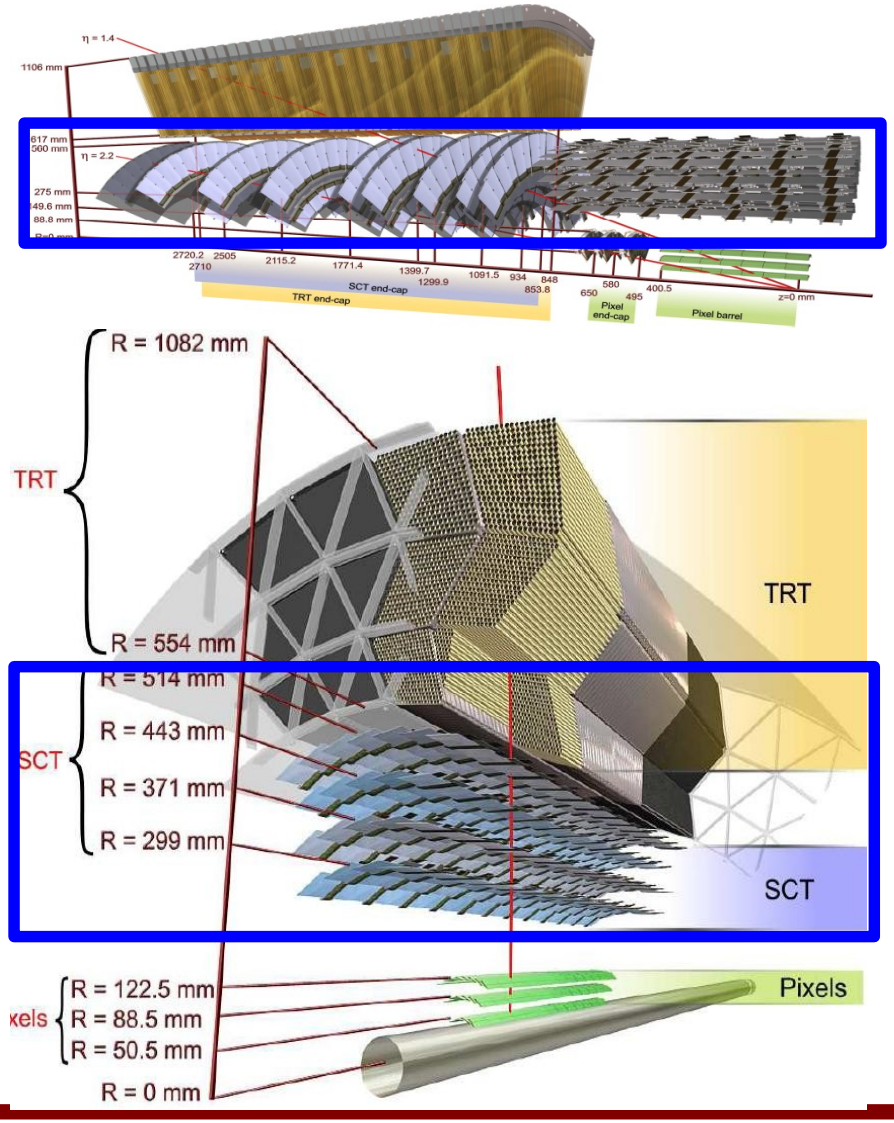
ATLAS Pixel Detector Overview



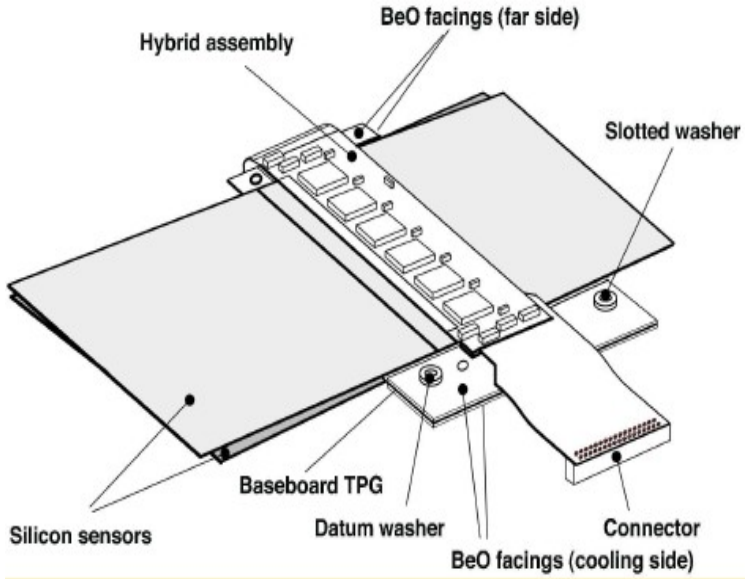


- 3 barrels, 3 disks at each end
- Total of 1744 modules, organized in staves and sectors
- 46080 channels per module, total ~80 million channels
- Minimize confusion during pattern recognition (occupancy 10^{-4}, noise $<10^{-9}$)
- B-layer at 5 cm ↔ good impact parameter resolution

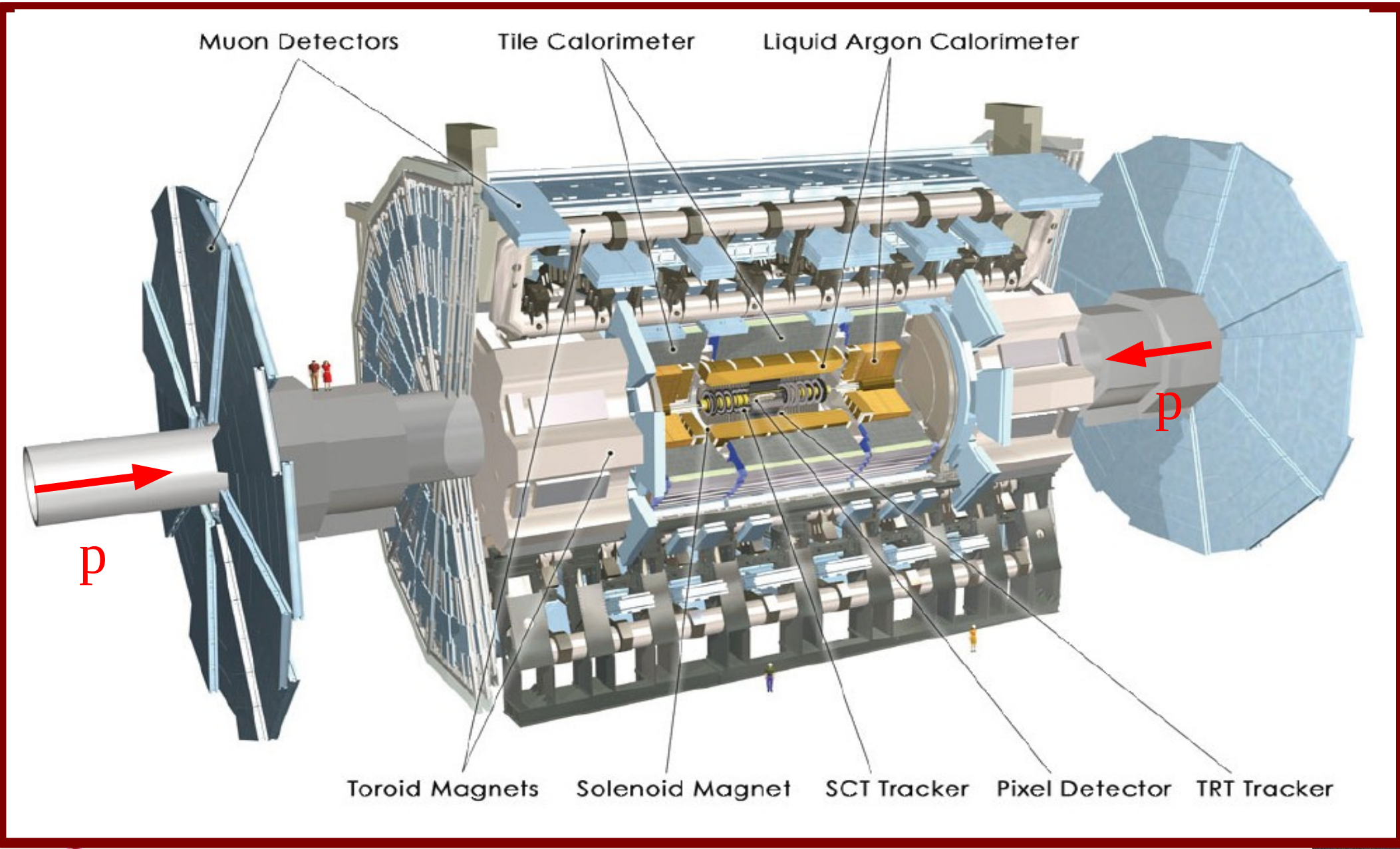
ATLAS SemiConductor Tracker



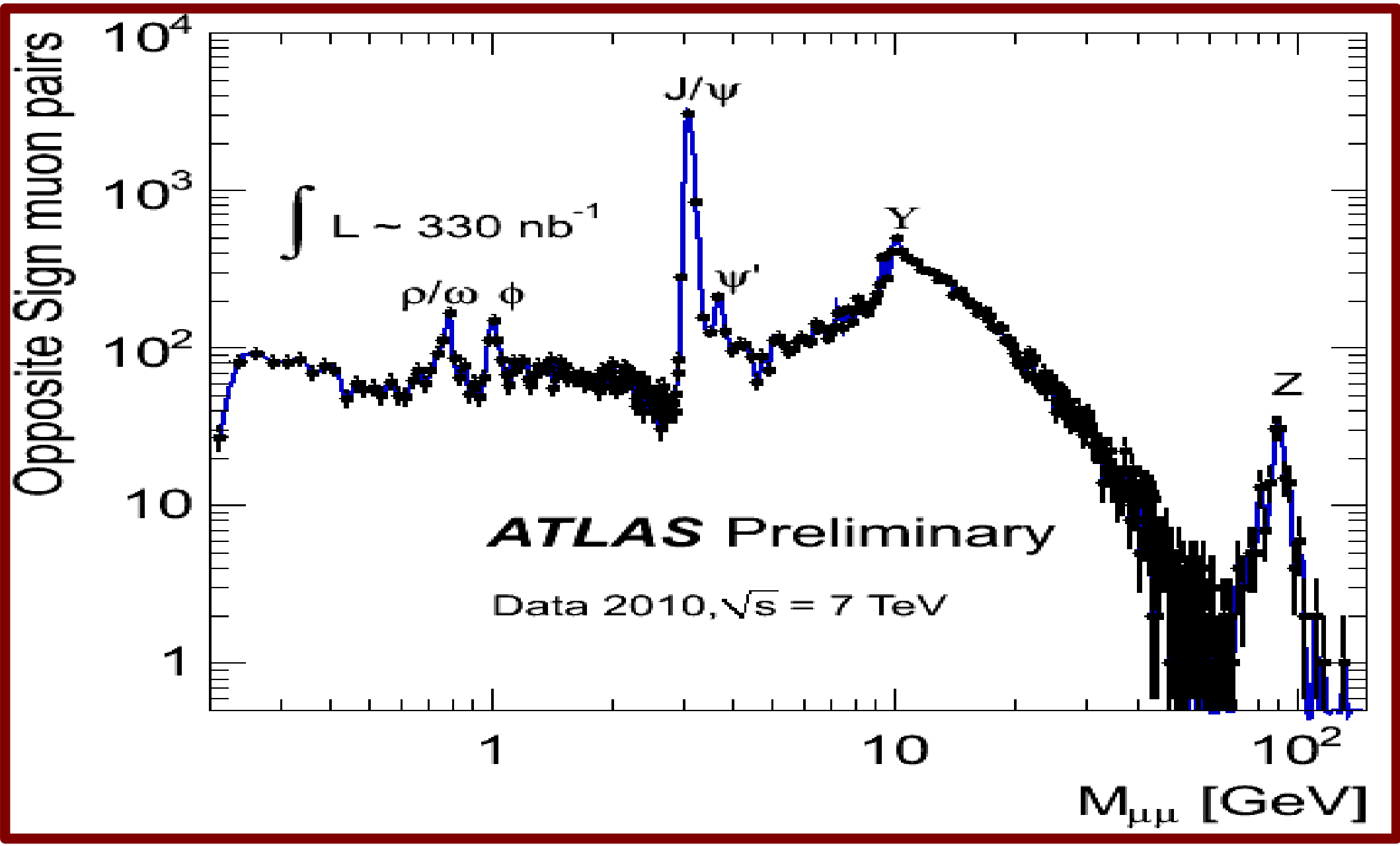
- Barrel: 80 µm silicon strips
- Endcap: 57-90 µm silicon strips
- 4088 modules
- 2 sides: 40 mrad stereo angle
- 2 x 768 channels per module
- 4 Barrels, 2x9 disks
- 6 million channels total
-



ATLAS: a particle detector

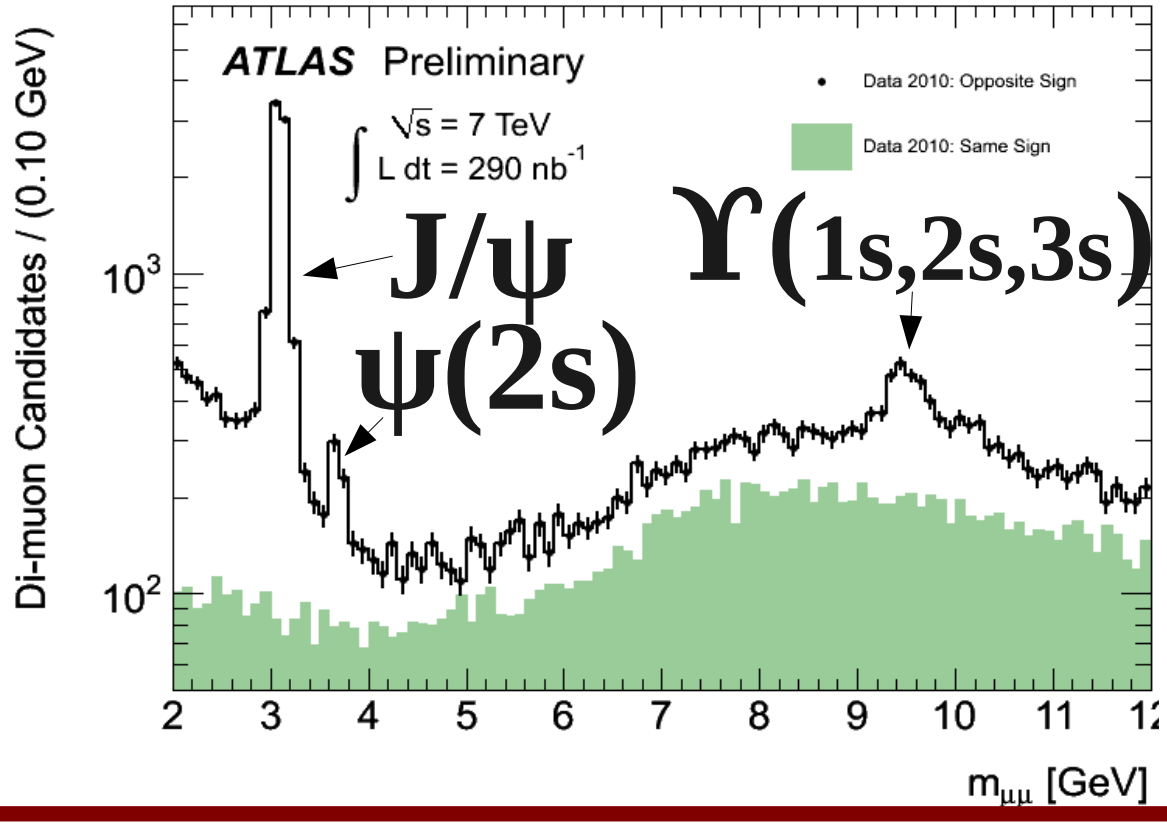


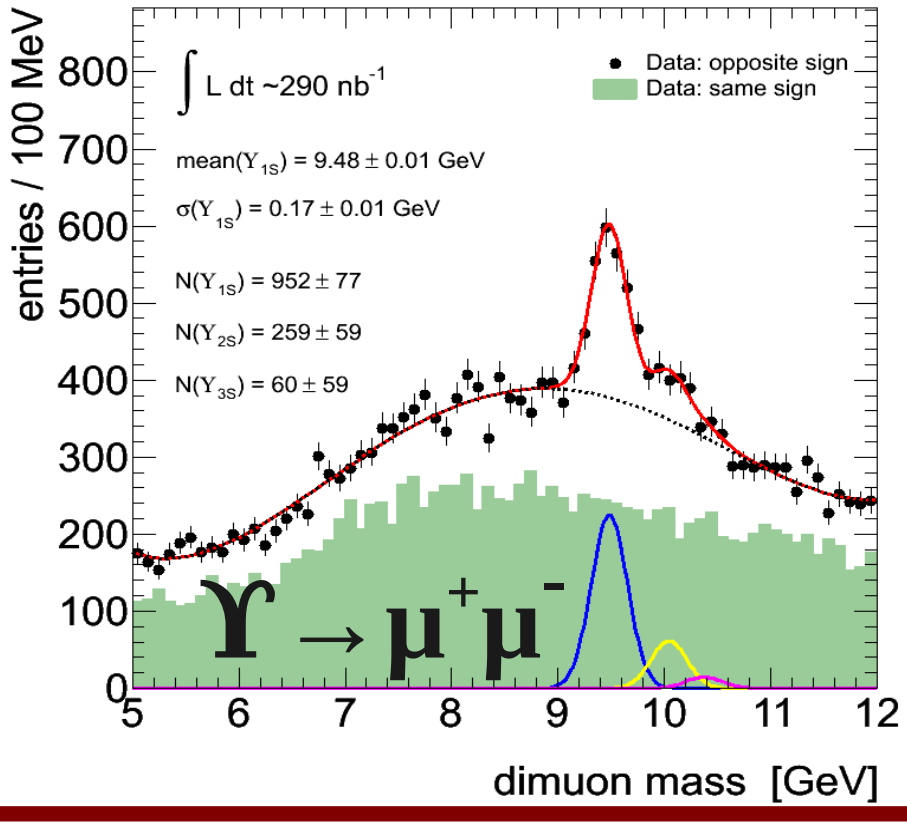
A forest of resonances



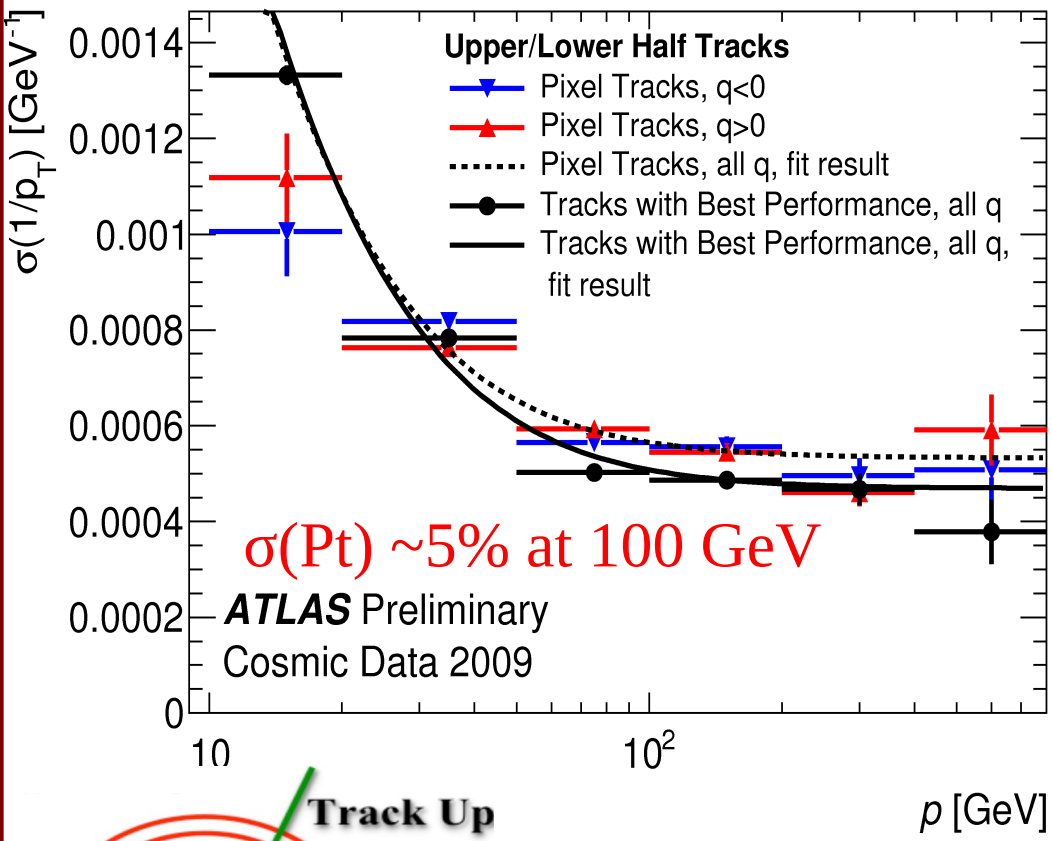
Higher mass resonances: ϒ and Ψ(2s)

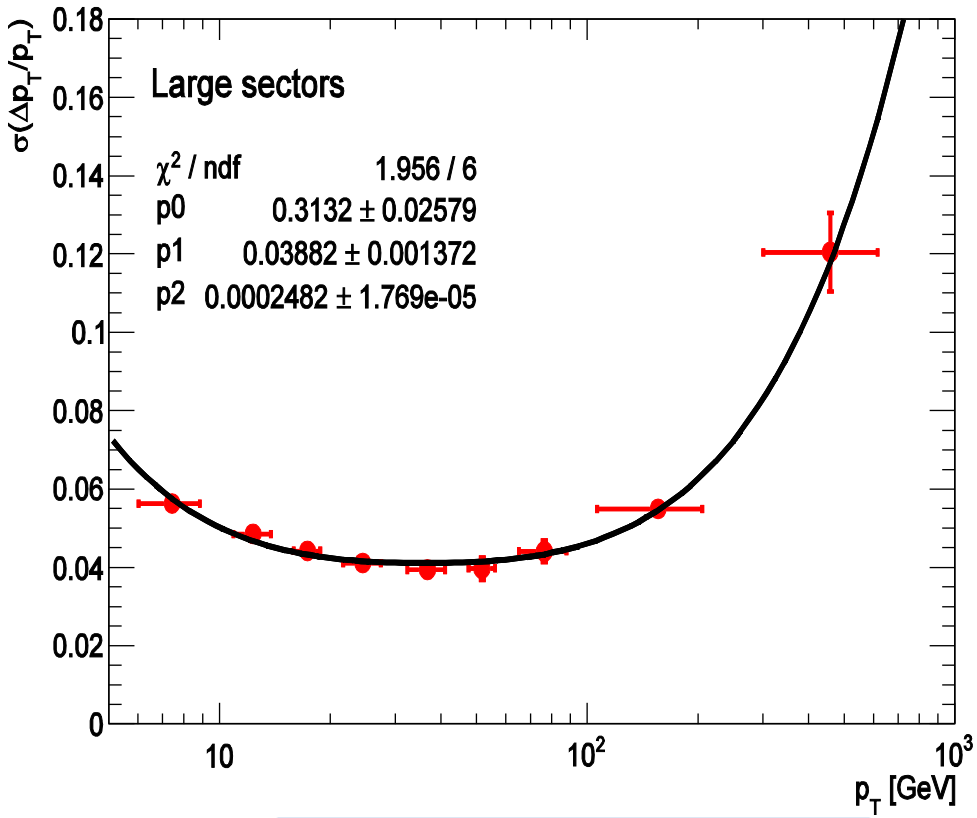
- Use other "standard candles"
  - ψ(2s), ϒ, Z → ll
- To establish points along the momentum scale

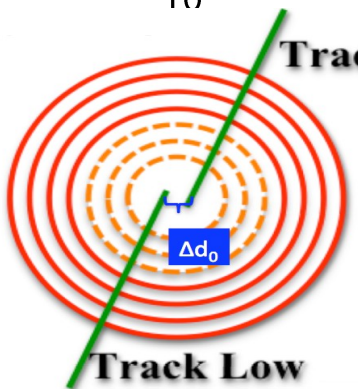




Resolutions from Cosmic Rays







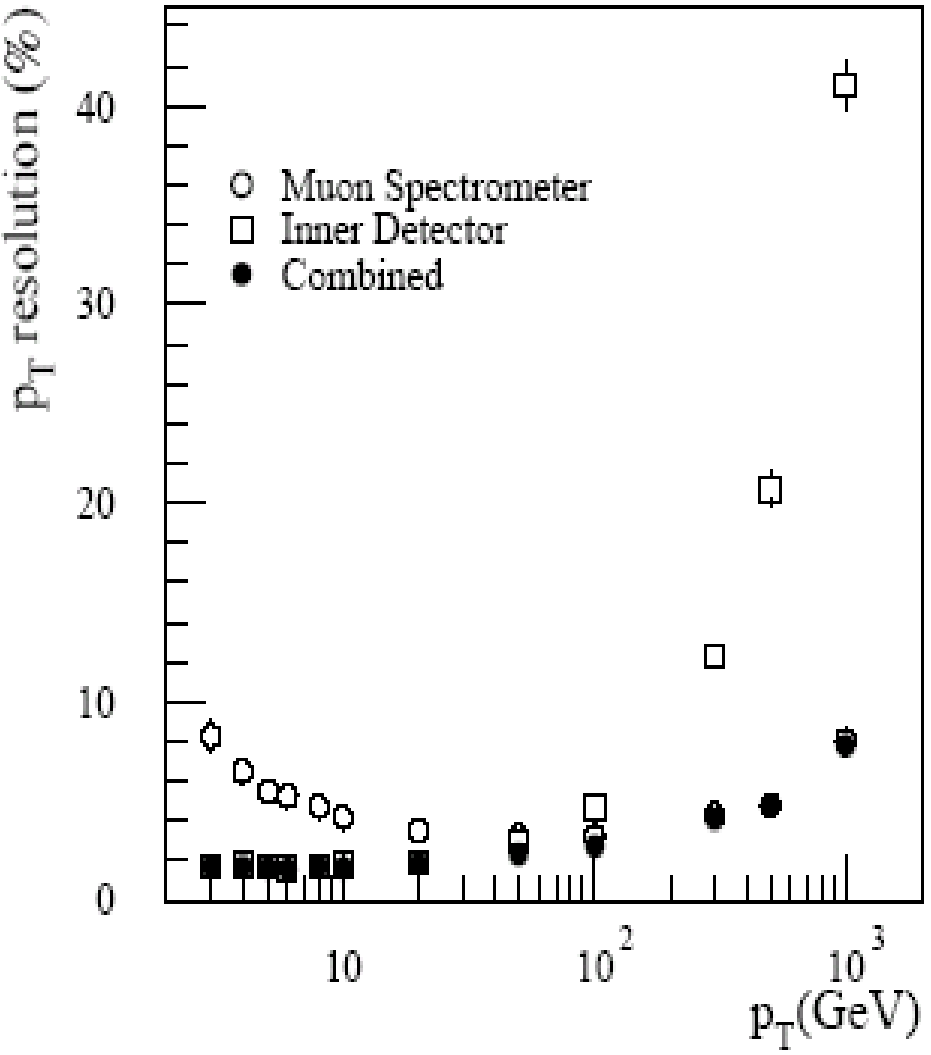
- Use half tracks
- Measure both halves independently
  → compare in order to measure resolution
- Already quite close to expected values

$$\frac{\sigma(p_T)}{p_T} = \sqrt{\left(\frac{p_0}{p_T}\right)^2 + (p_1)^2 + (p_2 \cdot p_T)^2}$$

p_0 : energy loss (0.35 expected)
p_1 : multiple scattering (3.5% expected)
p_2 : intrinsic resolution ($12 \cdot 10^{-5}$ expected)

Resolution

- MS dominates above 100 GeV
- MS only: 10% at 1 TeV
- ID: σ_{Pt}/Pt ~0.05%Pt[GeV]⊕1.5%



ATLAS material