Dimuon Measurements in Pb+Pb Collisions with the ATLAS Detector at LHC

Marzia Rosati
Iowa State University
for

the ATLAS Collaboration

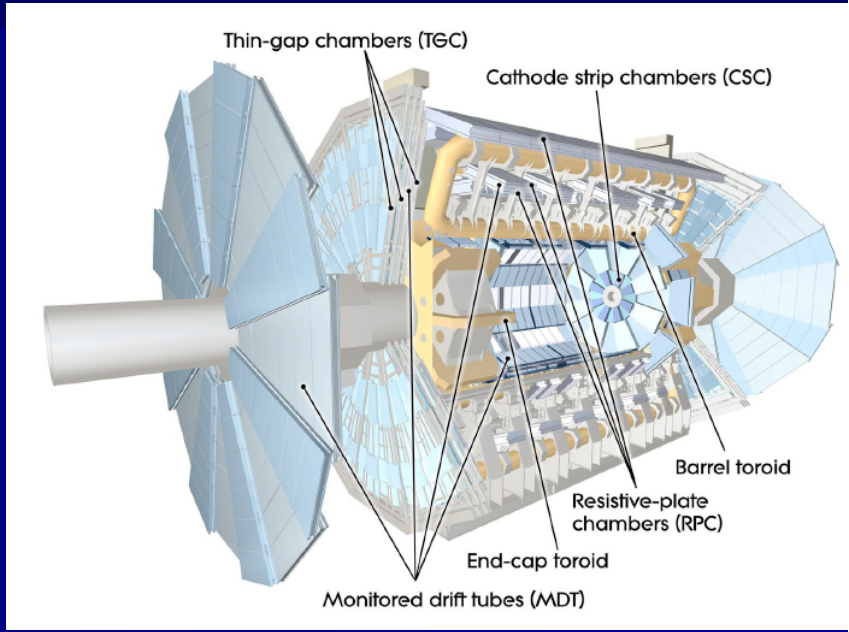
Quark Matter 2009
Knoxville, Tennessee
March 30th - April 4th, 2009

Outline

- ATLAS Muon Spectrometer
- Quarkonia measurement
  - J/Ψ's
  - Upsilon's
- Z boson measurement

The ATLAS Muon Spectrometer

- toroidal magnetic field:
  $\langle B \rangle = 4$ Tm
  $\Rightarrow$ high p_T resolution independent of the polar angle



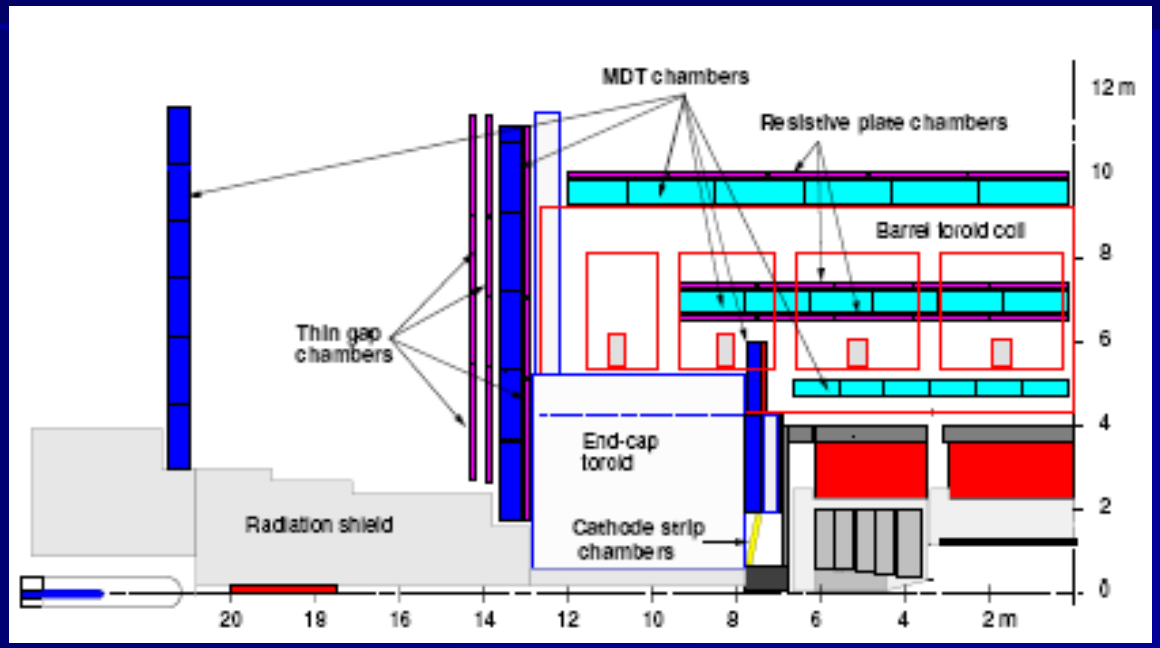
- air-core coils to minimize the multiple scattering
- 3 detector stations
  - cylindrical in barrel
  - wheels in end caps
- Clean in Pb+Pb central collisions

ATLAS Muon Spectrometer

Coverage:

$|\eta| < 2.7$

$p>3GeV/c$



Muon Chambers:

- Trigger Chambers
  - Resistive Plate Chambers (RPC) in Barrel
  - Thin Gap Chambers (TGC) in the Endcaps
- Momentum measurement chambers
  - Monitored Drift tubes (MDT) in most of the solid angle
  - Cathode Strip Chambers (CSC) in the forward Endcap region

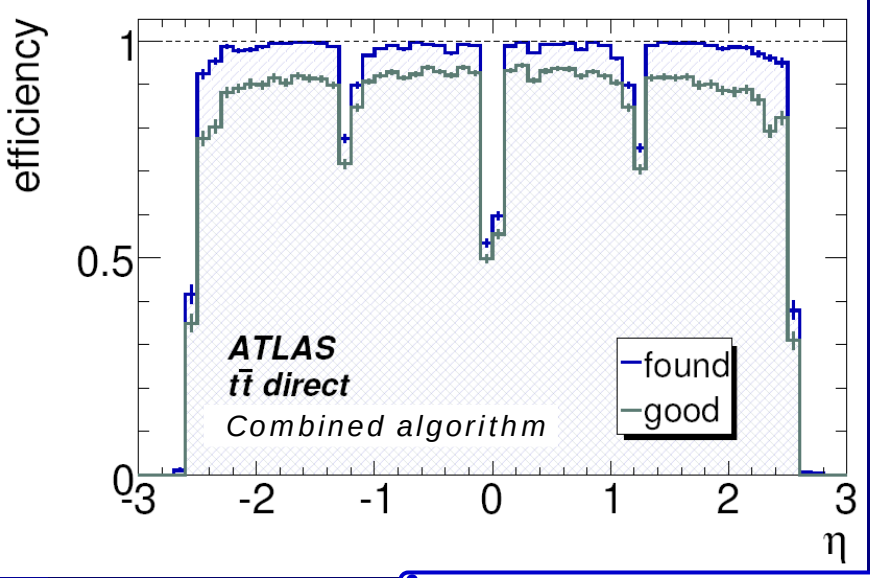
Muon Reconstruction Algorithms

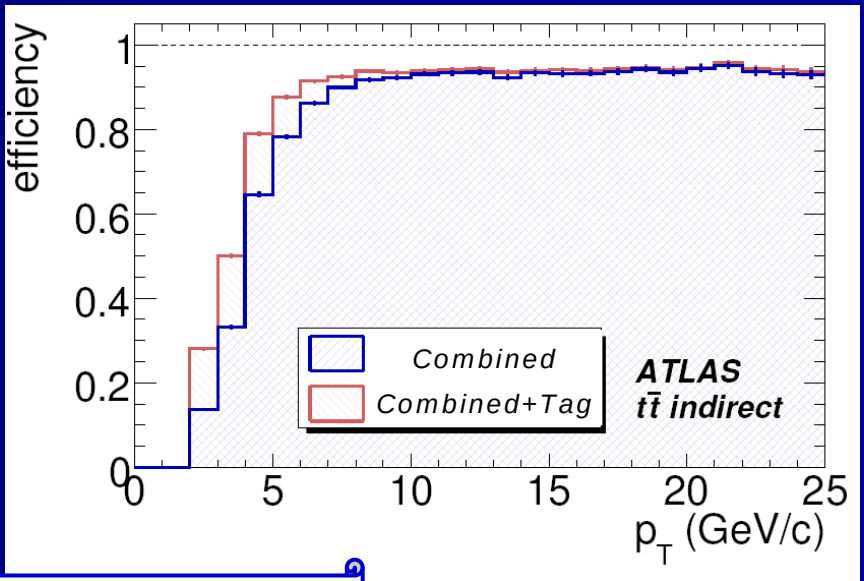
- Muon reconstruction and identification combines the Muon Spectrometer information with the information from the Inner Detectors (Si pixels and microstrips covering $|\eta|<2.5$)
  - Combined Algorithms:
    I. Reconstruct standalone muons by finding tracks in the muon spectrometer and then extrapolating these to the beam line.
    II. Muons are found by matching standalone muons to nearby inner detector tracks and then combining the measurements from the two systems.
  - Tagging Algorithms:

    Inner detector tracks are tagged as muons if a matching track segment in the first station of the muon spectrometer is found.

Single Muon Performance in p+p Collisions

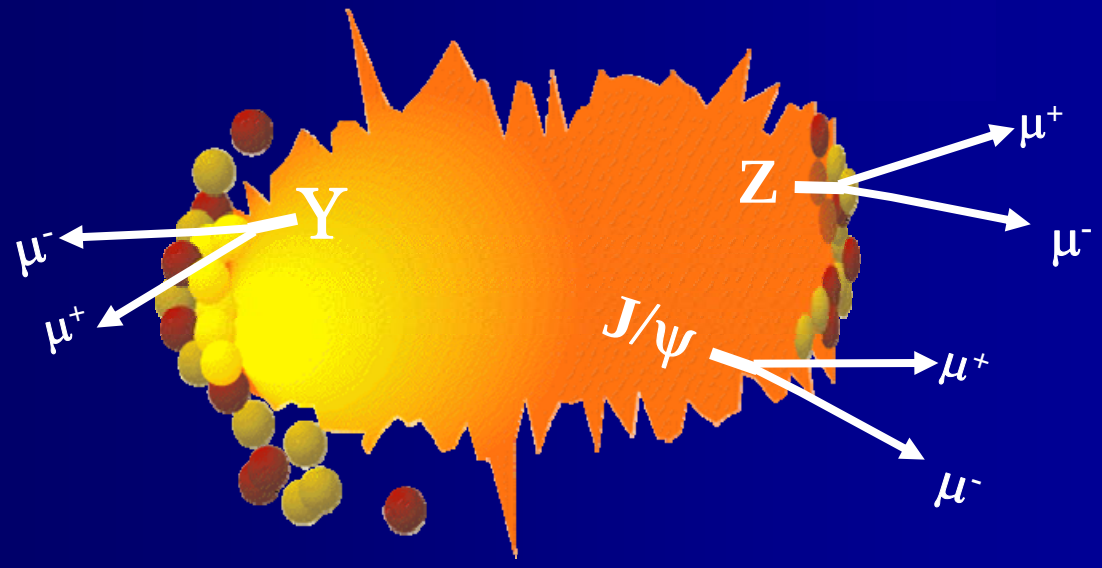
- Reconstruction efficiency >90% for p_T>6GeV/c
- Spectrometer Momentum resolution ~5% at p_T=10GeV/c
- Momentum resolution



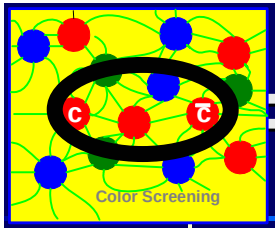


Expected Performance of the ATLAS Experiment
arXiv:0901.0512

Using Dimuons to Probe Nuclear Matter

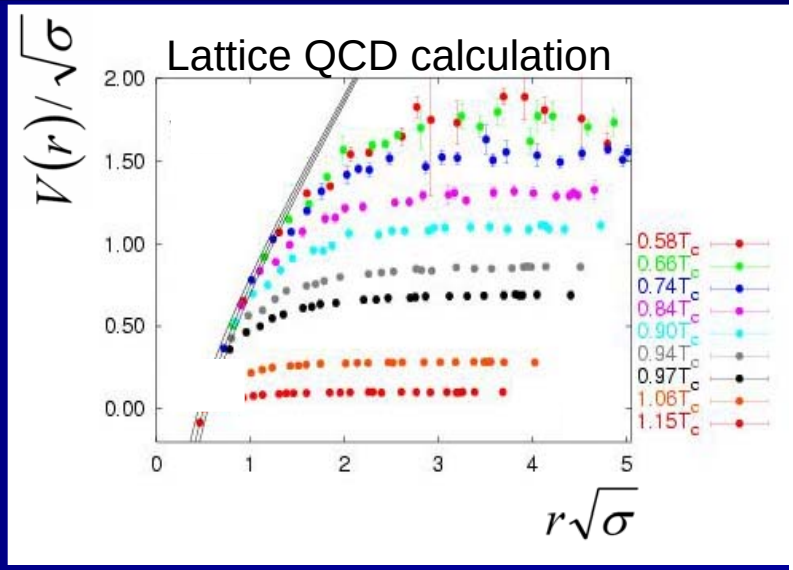


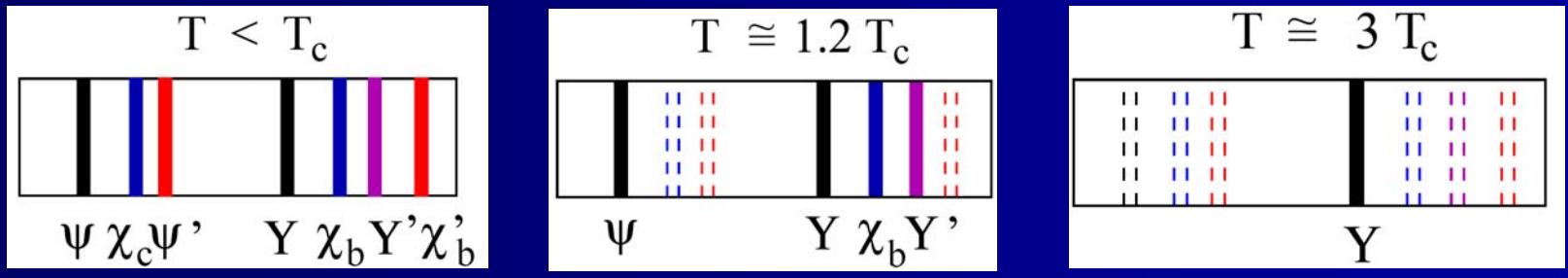
- ATLAS performance in Pb+Pb collisions to measure quarkonium and Z via di-muon channel was studied by merging single J/ψ, Υ and Z into Hijing Pb+Pb collisions at 5.5 TeV energy.



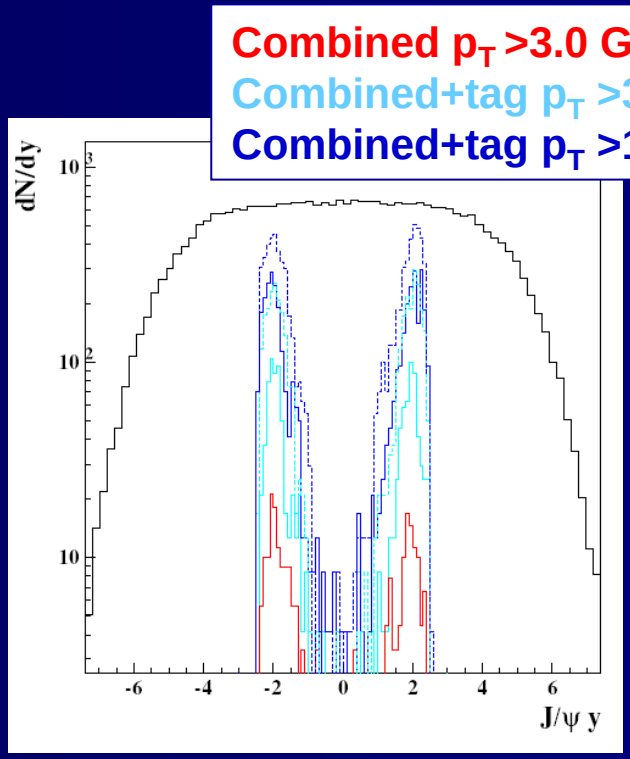
Probing Deconfinement with Quarkonia

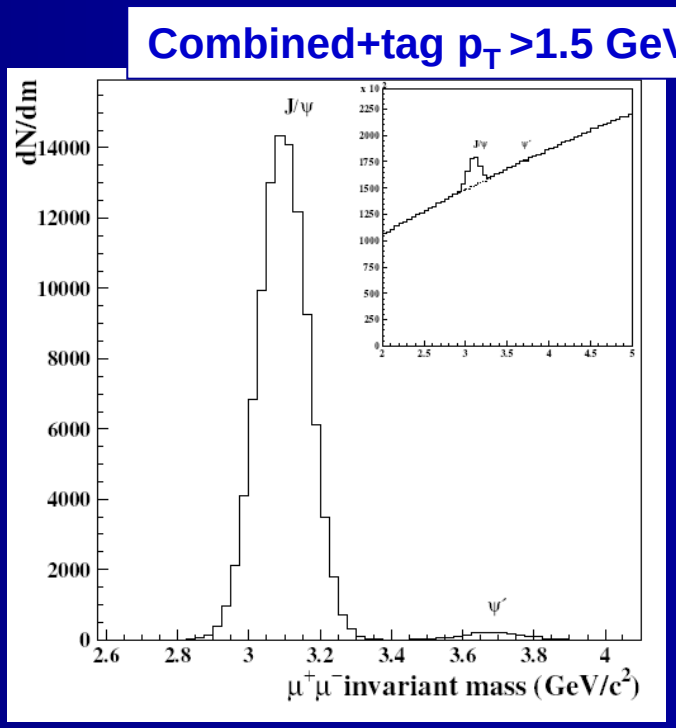
- Lattice QCD makes a clear prediction for the onset of deconfinement, different quarkonia states test the degree of color screening
- ATLAS has good capabilities to measure several $c\bar{c}$ and $b\bar{b}$ states to probe quarkonia deconfinement and other phenomena like dissociation by gluon and regeneration from heavy $q\bar{q}$ pairs





J/Ψ Acceptance and Invariant Mass Distribution

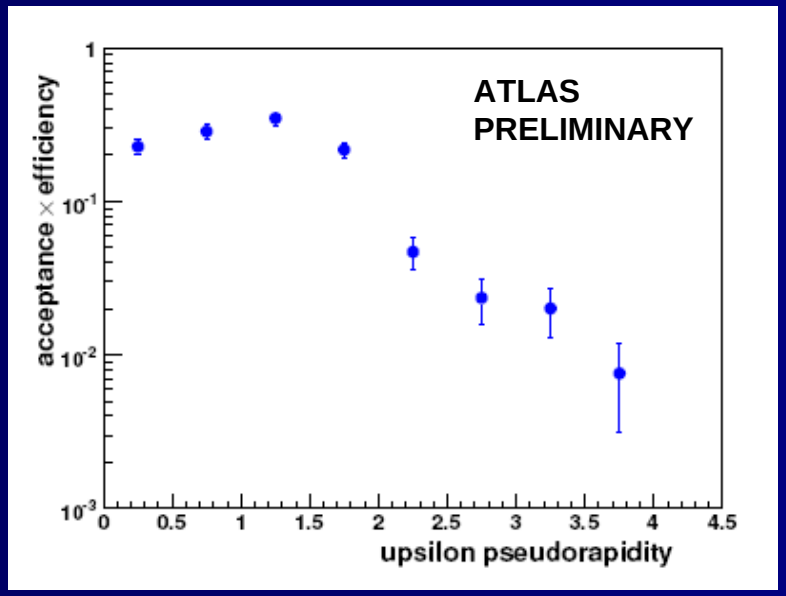


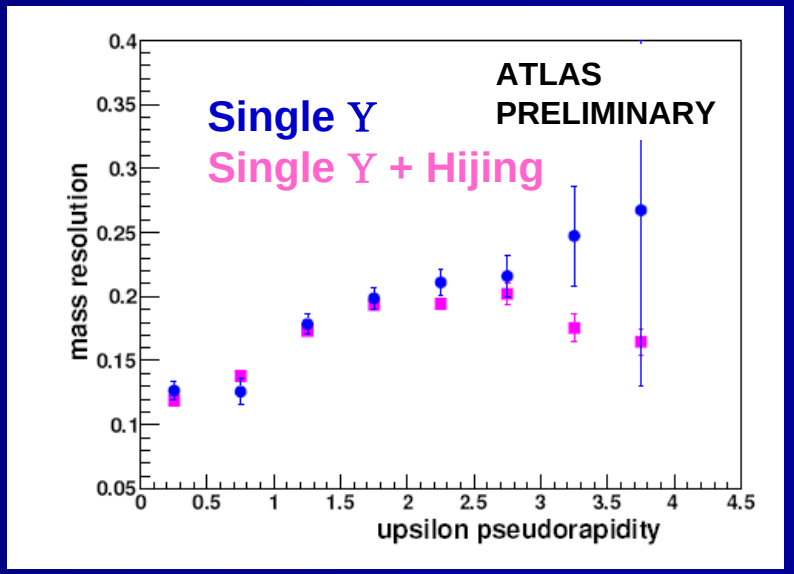


Using the Combined+tag algorithms with p_T>1.5 GeV:

- Acceptance x Reconstruction Efficiency= 0.53%
- J/ψ mass resolution ~ 70 MeV
- Signal/Background 3:20

Υ Acceptance and Mass Resolution

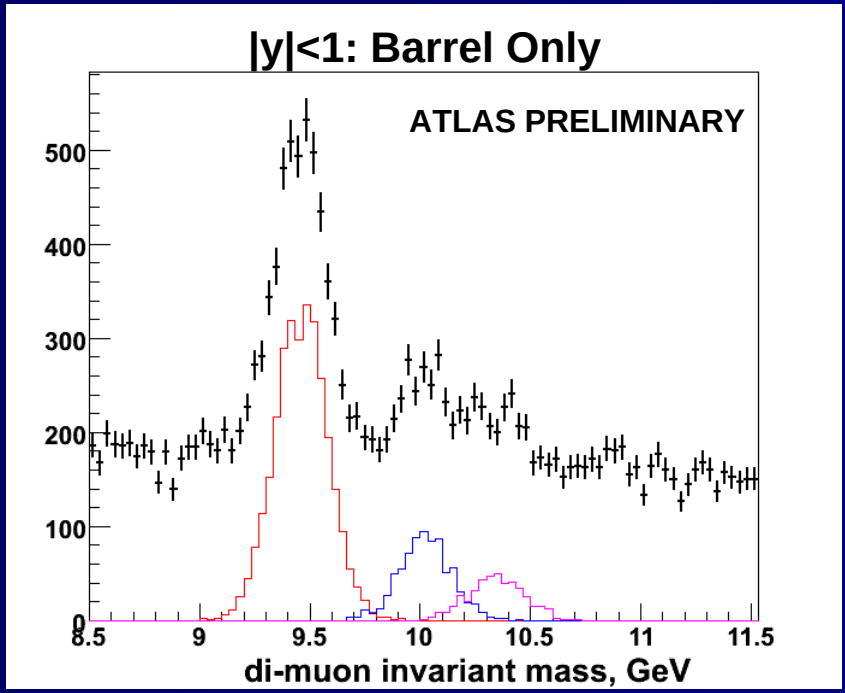




- Muons from Υ decays are more energetic and they can be reconstructed over a large Υ kinematic range
- Acceptance x Reconstruction Efficiency=13%
- Υ mass resolution 120-160 MeV

Upsilon Invariant Mass

- Invariant Mass Spectra are calculated assuming that both high p_T muons and Υ scale with number of binary collisions :
  - Use PYTHIA to get muons from charm/beauty leptonic decays
  - Run full simulation on single pions and kaons to extract muon spectrum from hadron decays
  - Add Υ's



Υ Mass Resolution 120 MeV
Signal/Background 4:10

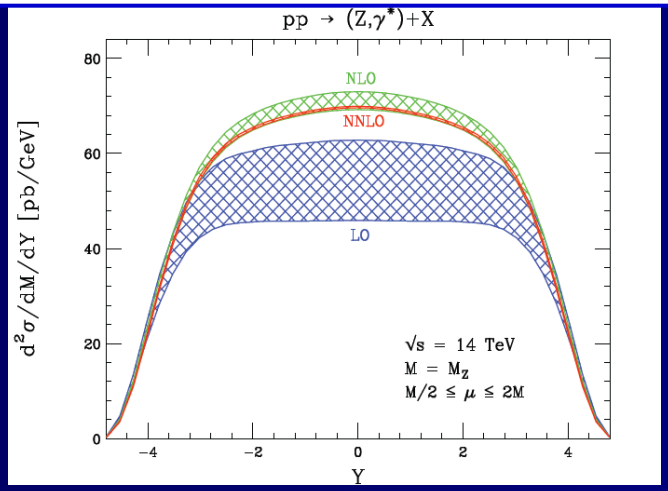
Quarkonia Performace and Rates

	J/ψ	Υ	Υ(|y|<1)
Acceptance x Efficiency	0.53%	12.5 %	4.7%
Mass Resolution (MeV)	68	160	120
Signal:Background	3:20	3:10	4:10
Rate/month	130,000	18,750	7,100

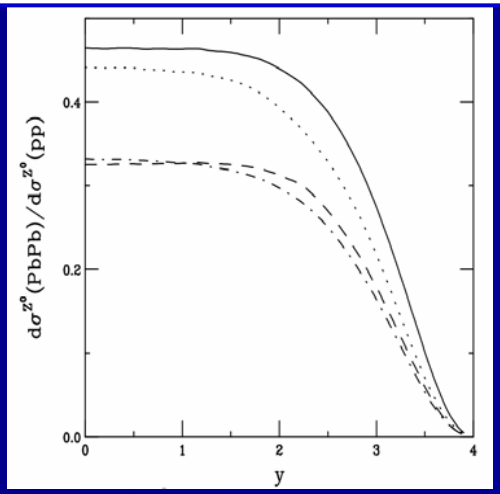
- Rates calculated for one month running at nominal luminosity with 50% machine+experiment efficiency equivalent to an integrated luminosity of 0.5nb^{-1}.

Probing PDF's with Z Boson

C. Anastasiou et al., Phys.Rev.D69:094008,2004



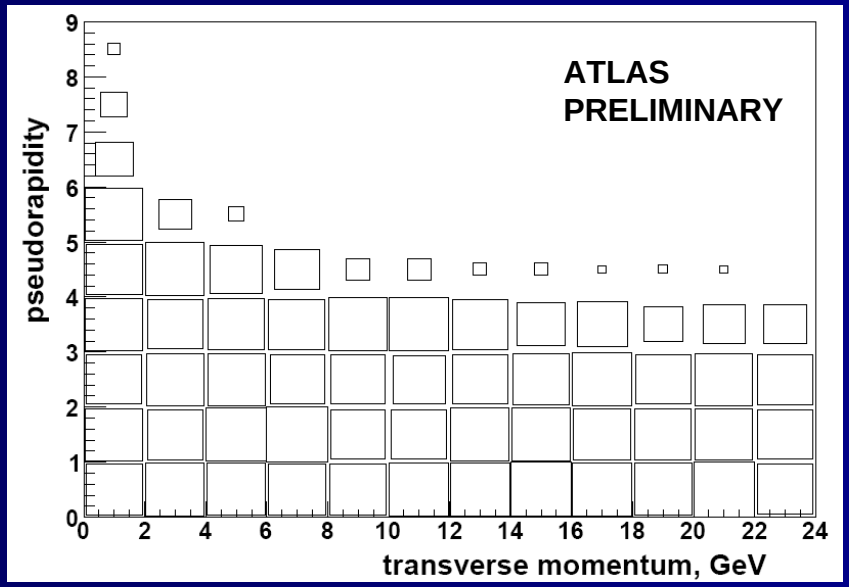
R.Vogt, Phys.Rev.C64:044901,2001

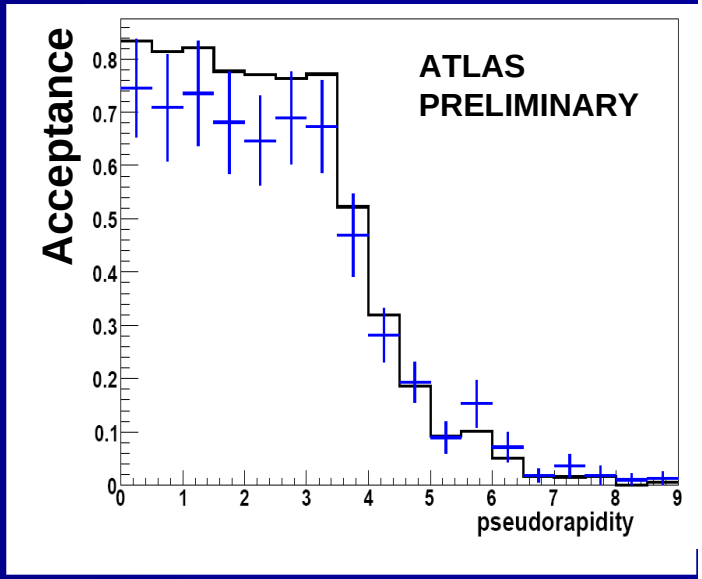


- Z production rate in p+p can be accurately calculated in NNLO pQCD therefore measuring production in Pb+Pb will provide a precise measurement of PDF's
  - We can determine x dependence of shadowing while measuring Z as a function of rapidity
  - Study centrality dependence while dividing into rapidity bins to restrict the x coverage
- Use Z as a reference for quarkonium suppression

Z Boson Acceptance

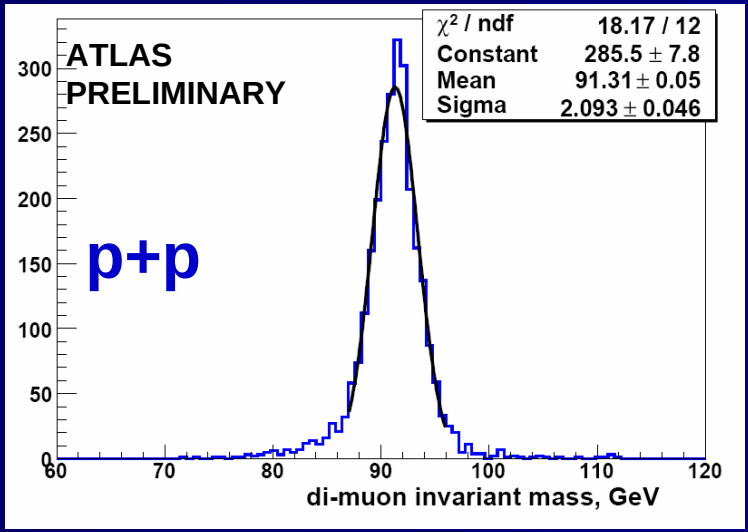
- Acceptance for Z boson was estimated by generating Z's with flat rapidity and transverse momentum distributions

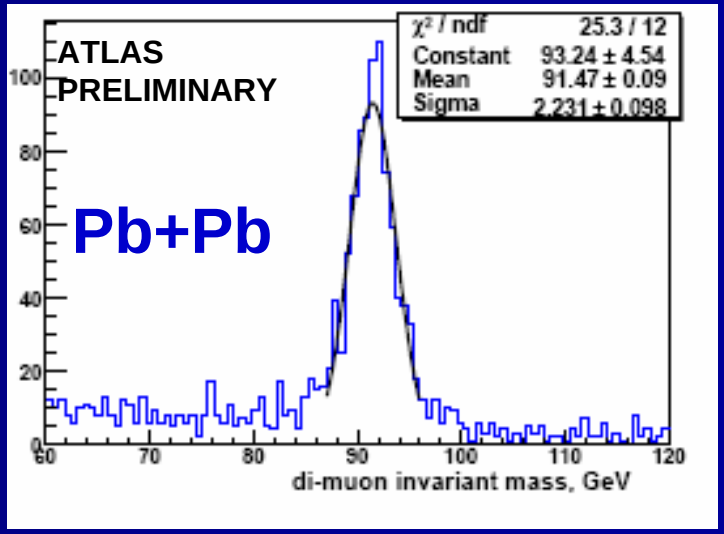




- Weighting the calculated acceptance with kinematic distributions predicted by NLO we derive:
  - Acceptance x Reconstruction Efficiency=60%

Z Mass Resolution





Acceptance x Efficiency	60%
Mass Resolution	2.2 GeV
Rate/year	8,000

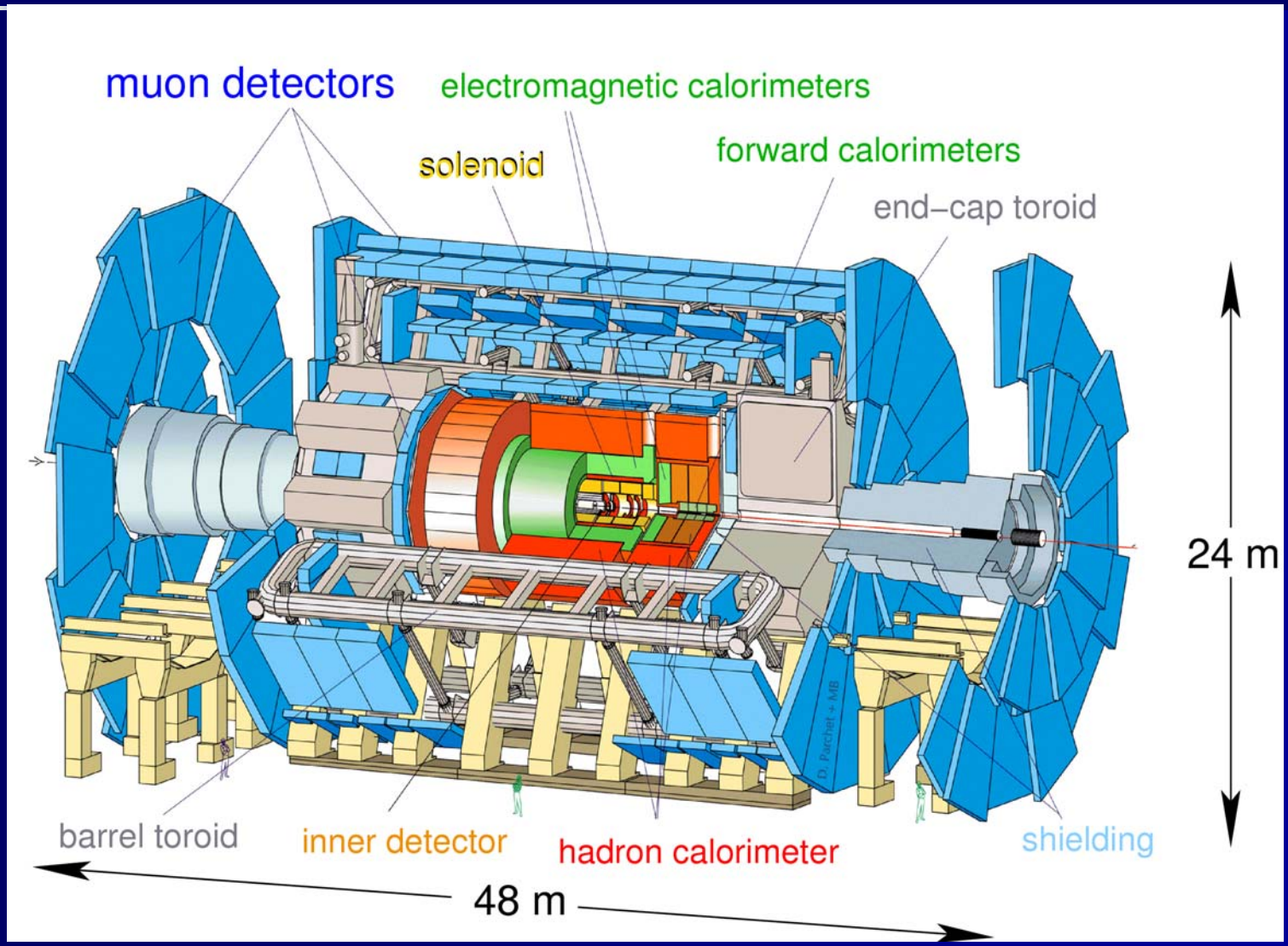
- Rates calculated for one month running at nominal luminosity with 50% machine+experiment efficiency equivalent to an integrated luminosity of 0.5nb^{-1}, using NLO kinematic distributions.

Conclusions

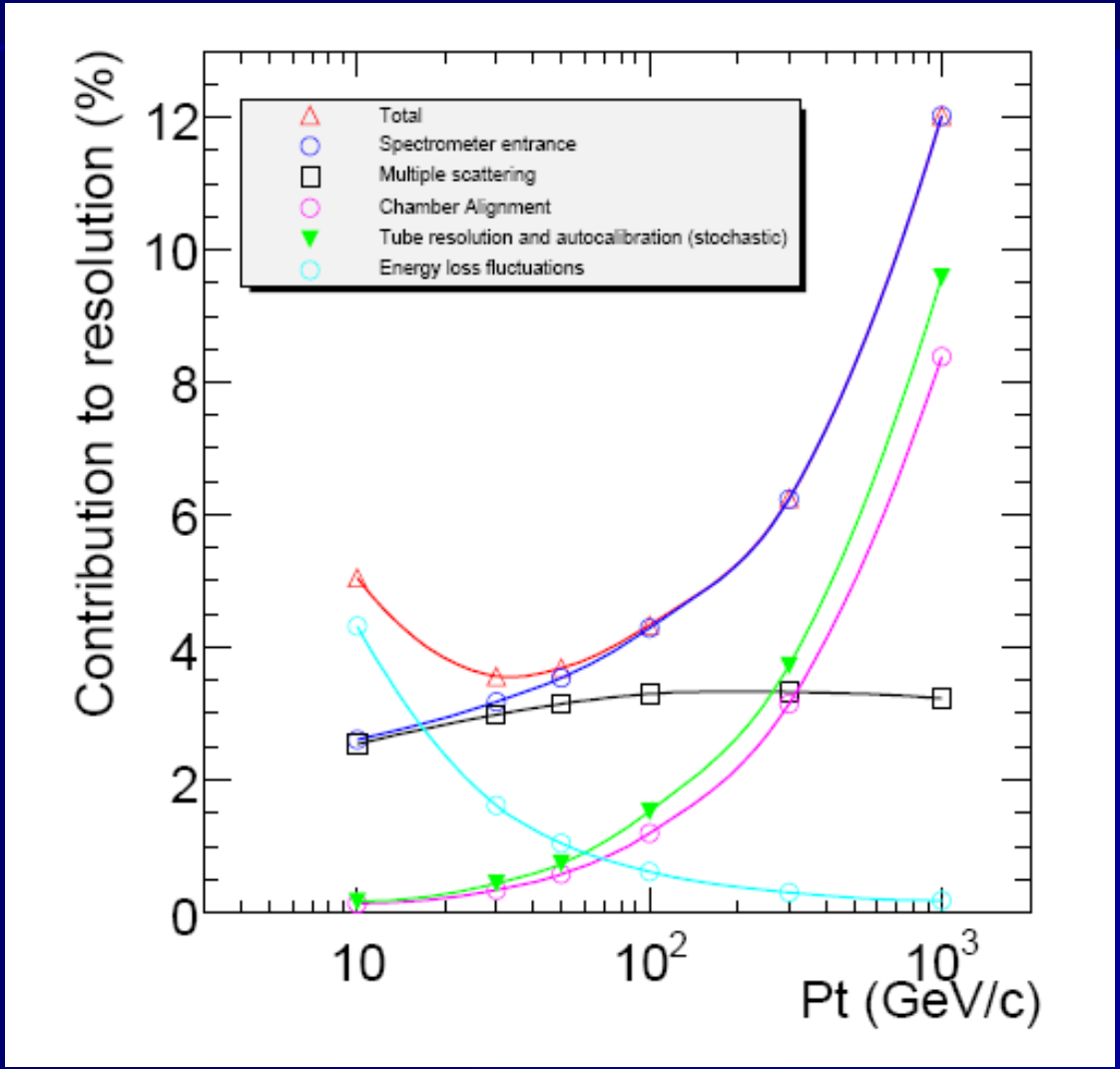
- ATLAS will make interesting measurements in dimuon channel probing Hot and Cold Nuclear Matter effects in Pb+Pb Collisions
- Excellent capability to measure
  1. J/ψ's
  2. Υ's
  3. Z^0's
  - Mass resolution is almost unaffected in PbPb collisions
  - Mass resolution is good enough to separate different Υ states in the barrel region
  - We should be able to see Υ and J/ψ peaks in a few weeks of running
- Currently studying the feasibility of e^+e^- channel

END

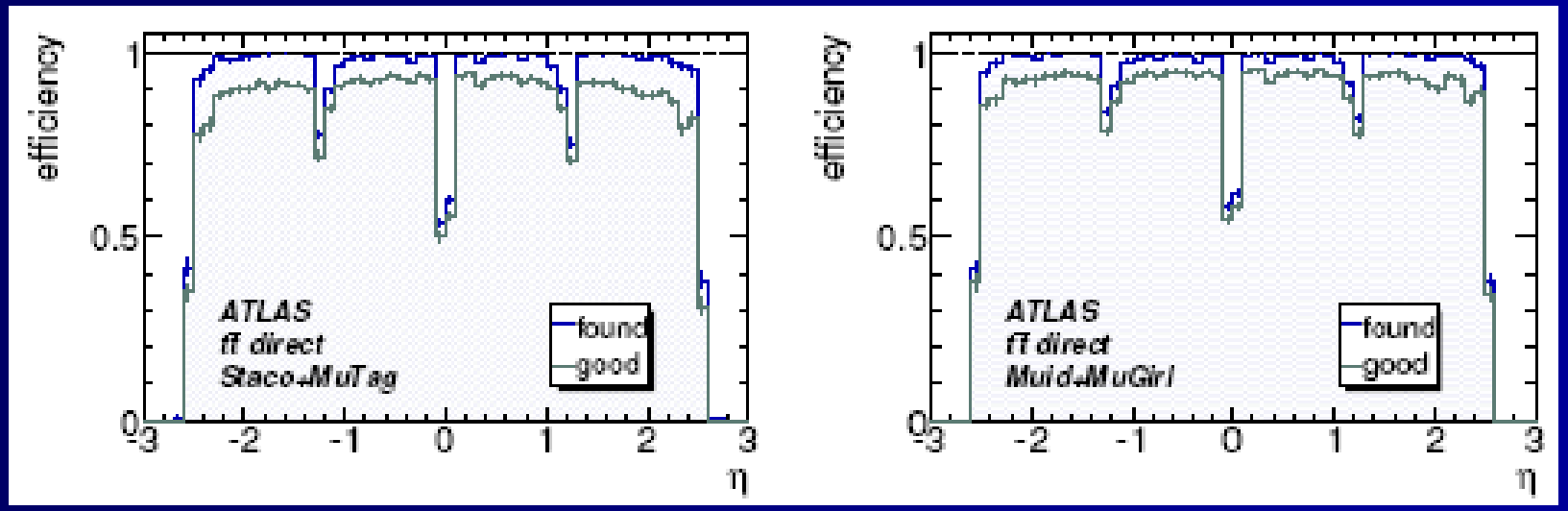
The ATLAS Detector

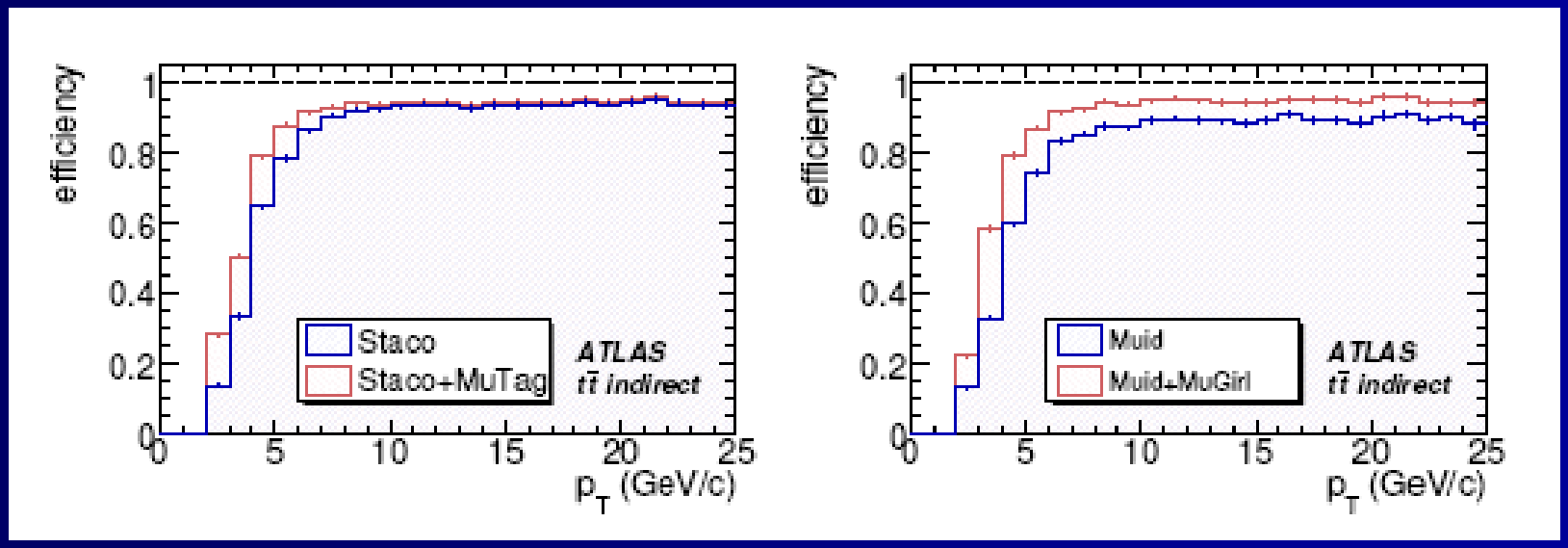


Contributions to Muon Momentum Resolution



Single Muon Performance





ATLAS Muon Spectrometer