Quarkonia Studies in PbPb Collisions by the ATLAS Experiment at LHC

Alexandre Lebedev, Iowa State University

for the ATLAS Collaboration

Why Quarkonia?

Quarkonium dissociation due to color screening is considered as a promising signature of QGP formation.

- Different quarkonia states are expected to “melt” at different temperatures.

Recent RHIC results point to importance of recombination of quarkonia in the later stages of the collisions.

- Also need to consider feed-down from higher resonances

Complicated picture:

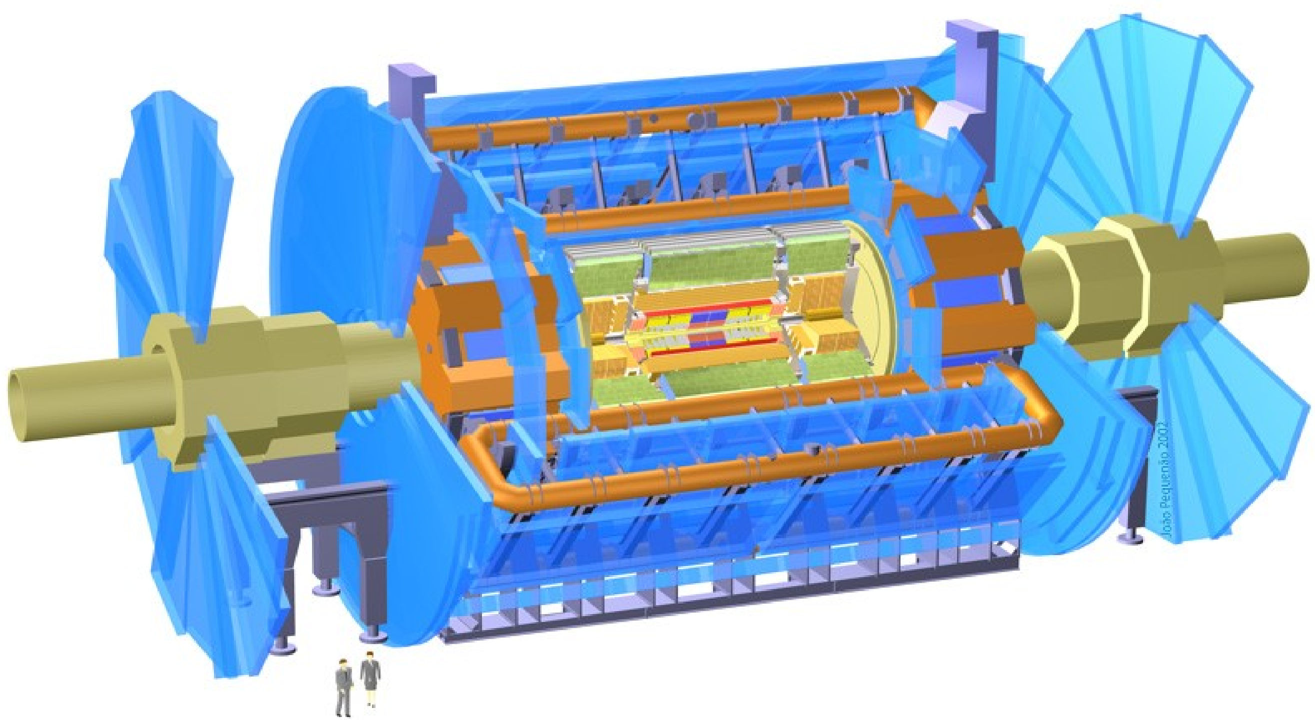
- It is important to measure simultaneously different quarkonia states in order to understand heavy ion collisions

In this talk we study possibility to measure charmonium (J/ψ) and bottonium (Υ) states via di-muon channel in PbPb collisions by the ATLAS experiment at LHC.

Measuring quarkonia in ATLAS

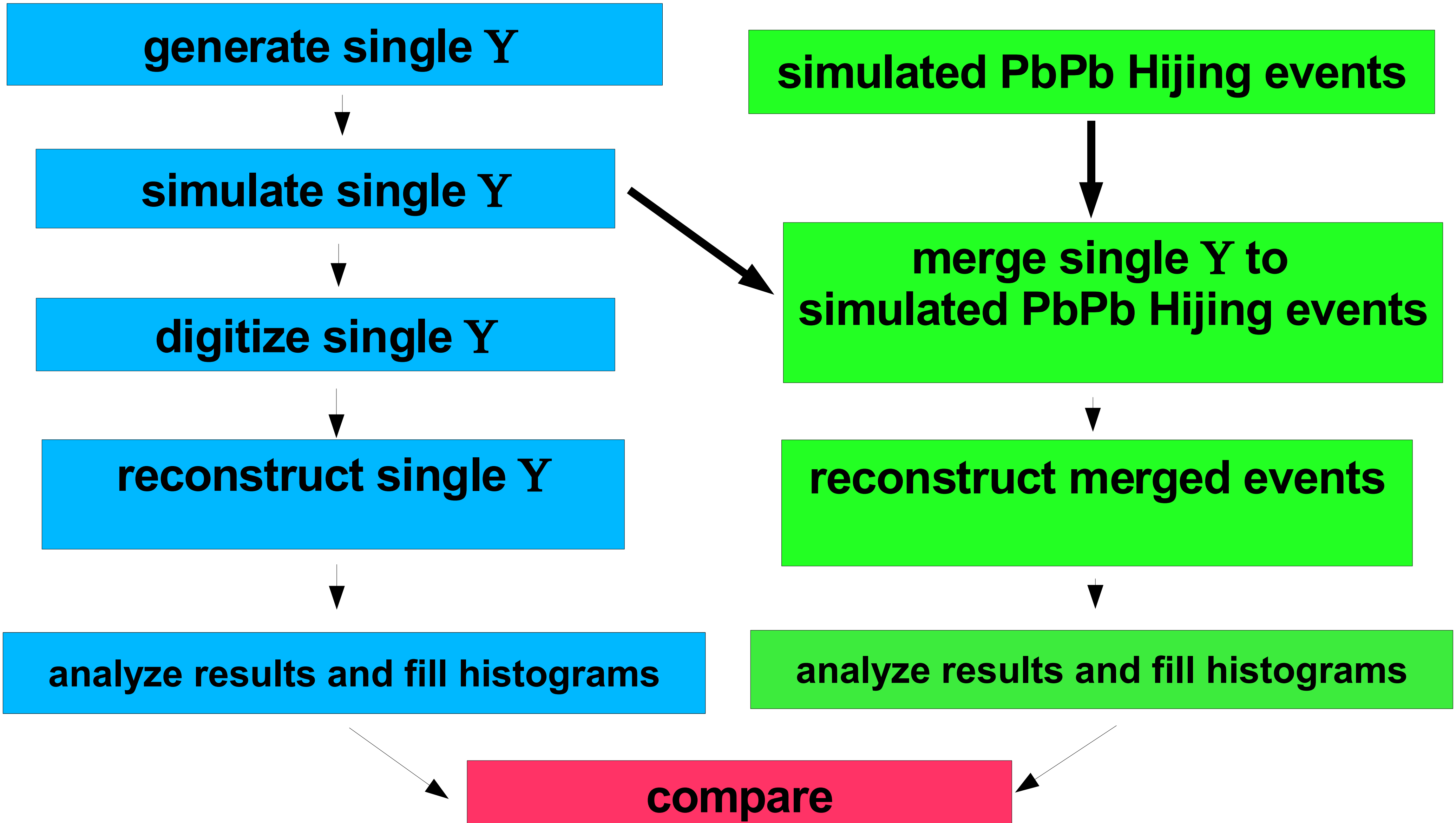
Quarkonia are measured in di-muon decay channel. ATLAS has excellent muon detection capabilities for $|\eta| < 2.6$ and $P_T > \sim 2.5$ GeV/c

MDT: Monitored drift tubes (barrel and endcaps)
CSC: Cathode strip chambers (endcaps)
RPC: Resistive Plates Chambers (barrel trigger)
TGP: Thin Gap Chambers (endcaps and barrel trigger)



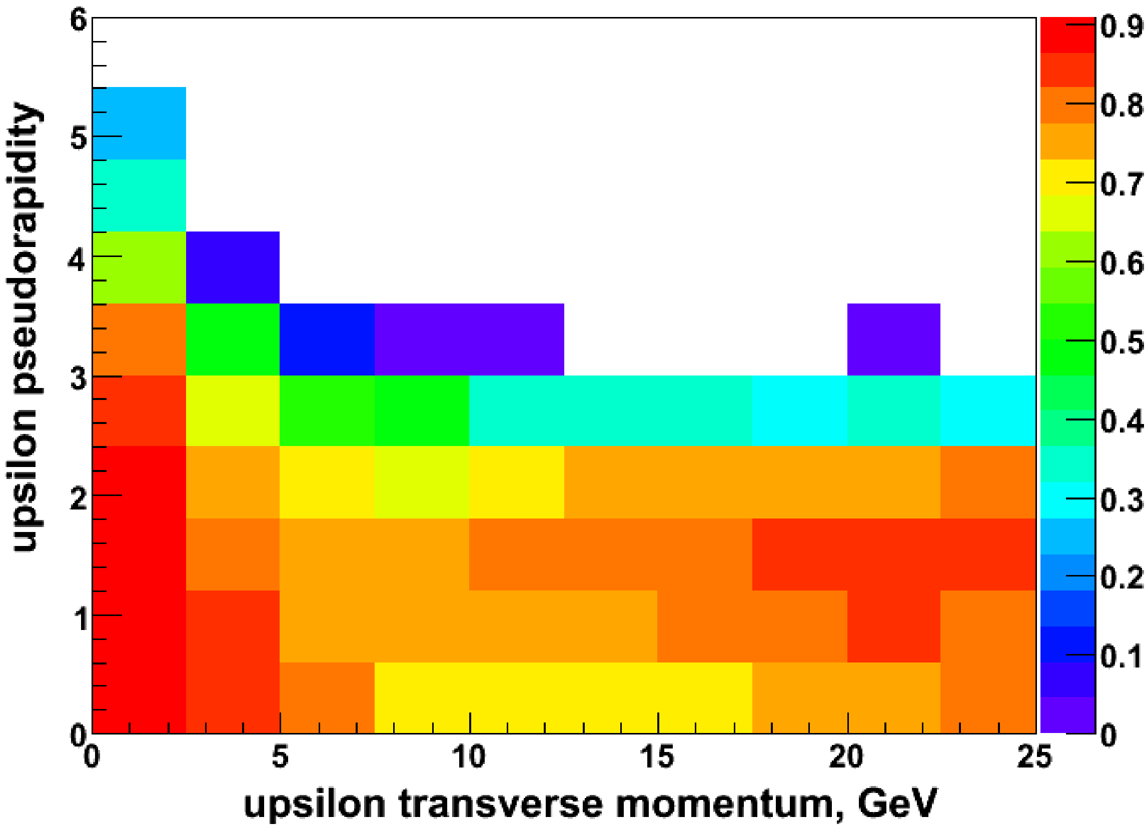
Algorithm

Υ with flat P_T and η distributions, weighted with Pythia distributions.

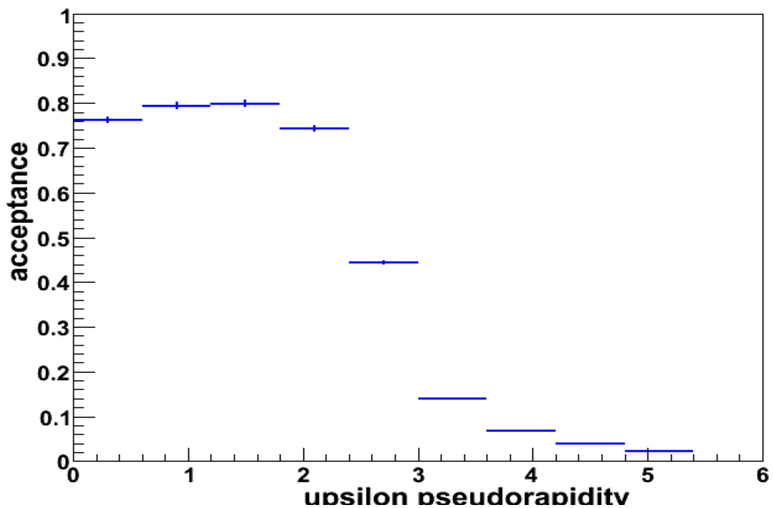


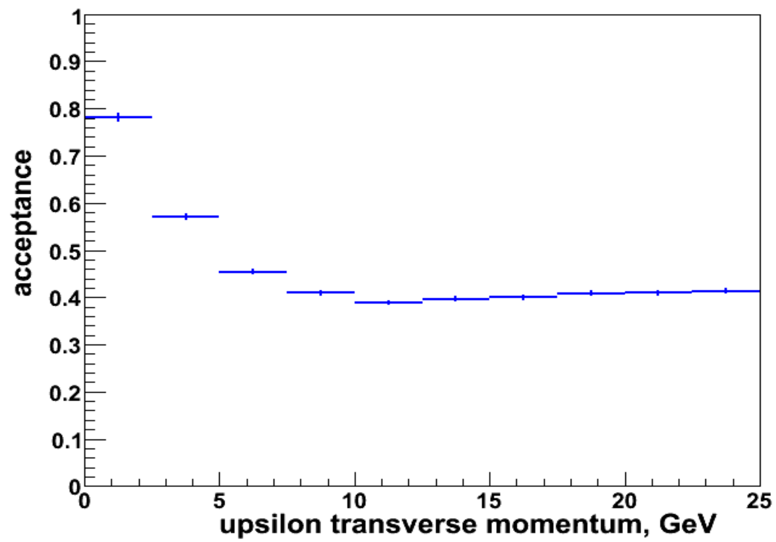
Υ acceptance (singles)

Υ was considered to be in acceptance if both muons produced hits in muon detector.



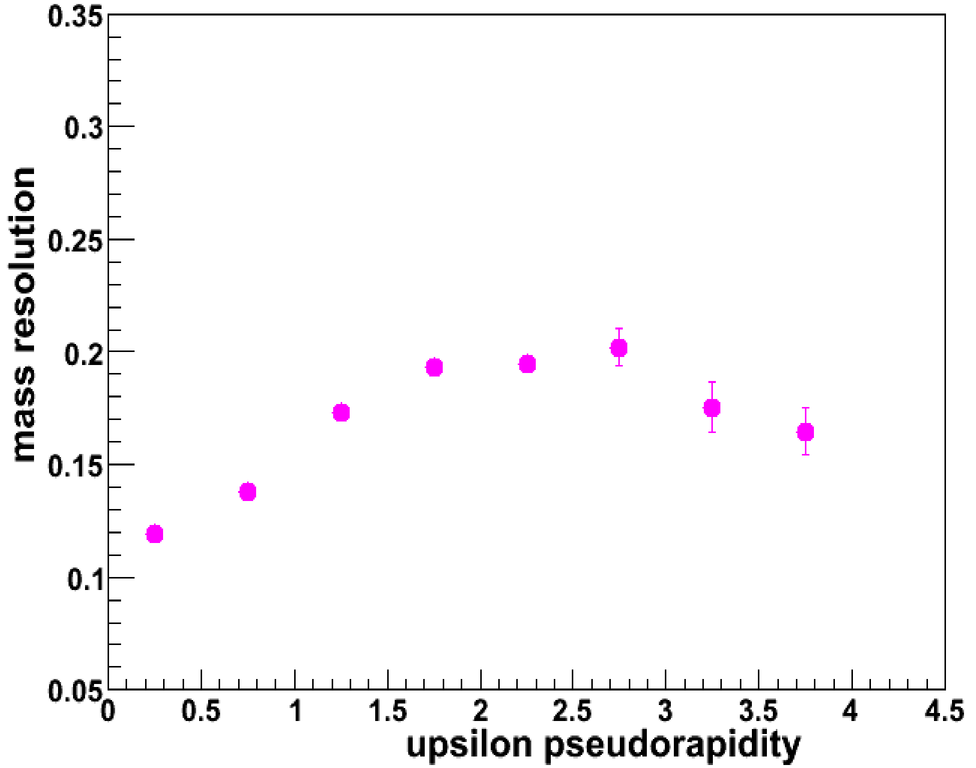
Projections are done with P_T and η distributions from pythia.

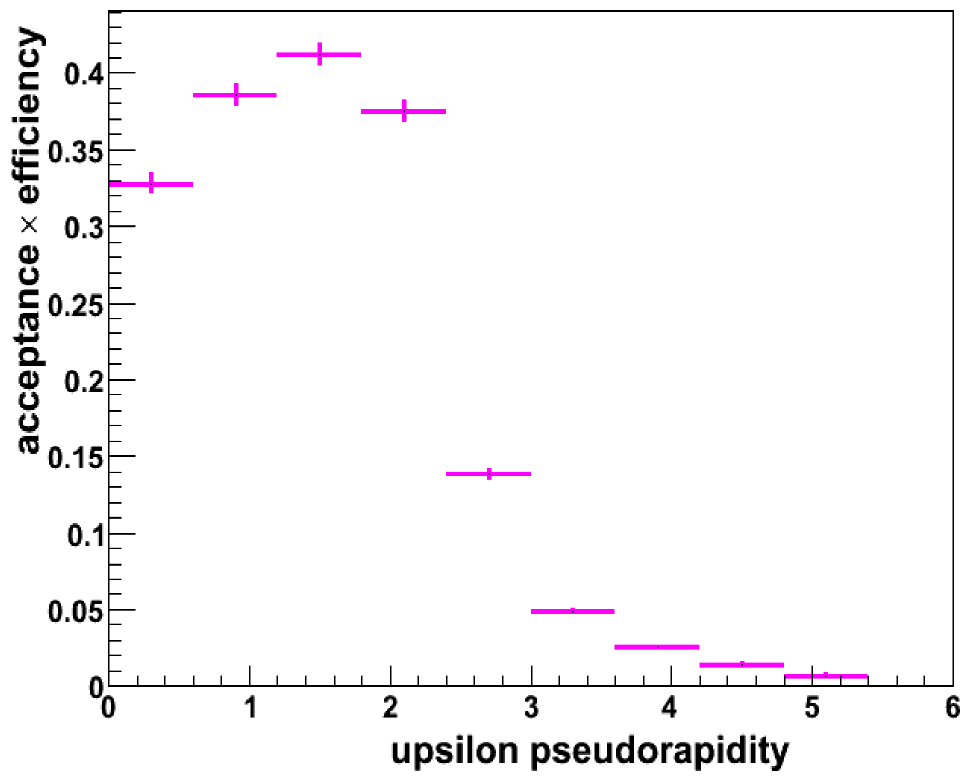




Single Υ (baseline for PbPb)

Integrated (over P_T and η) mass resolution is 177 MeV.
Integrated acceptance times efficiency is ~0.19



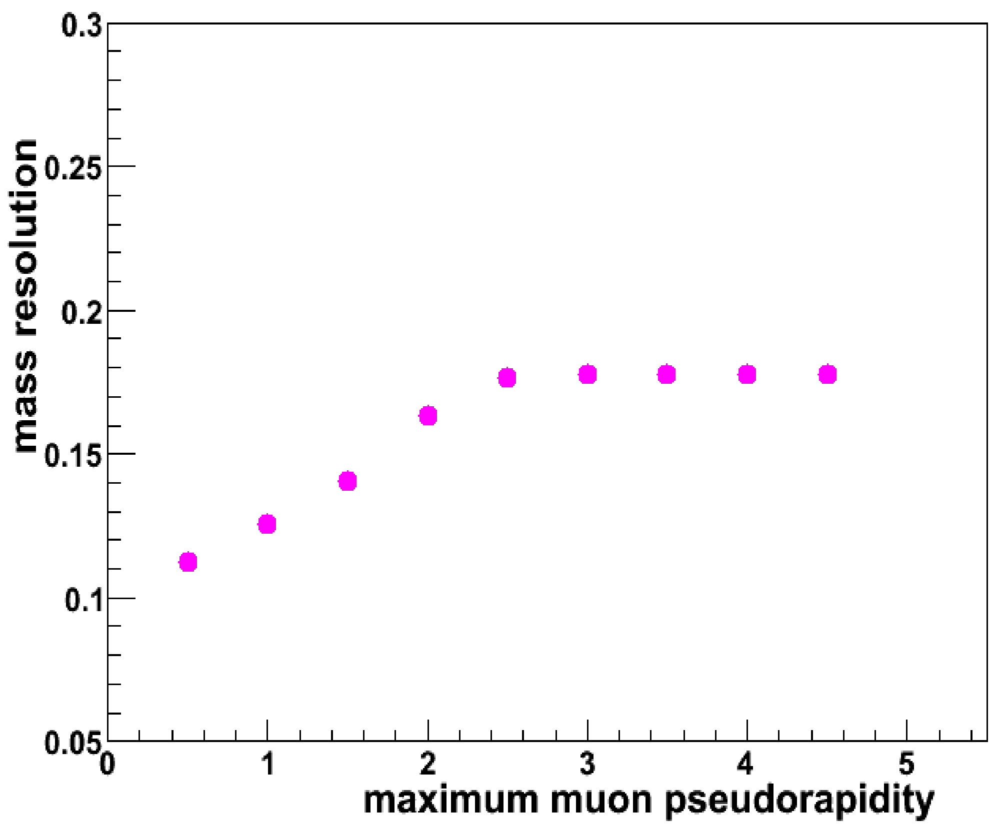


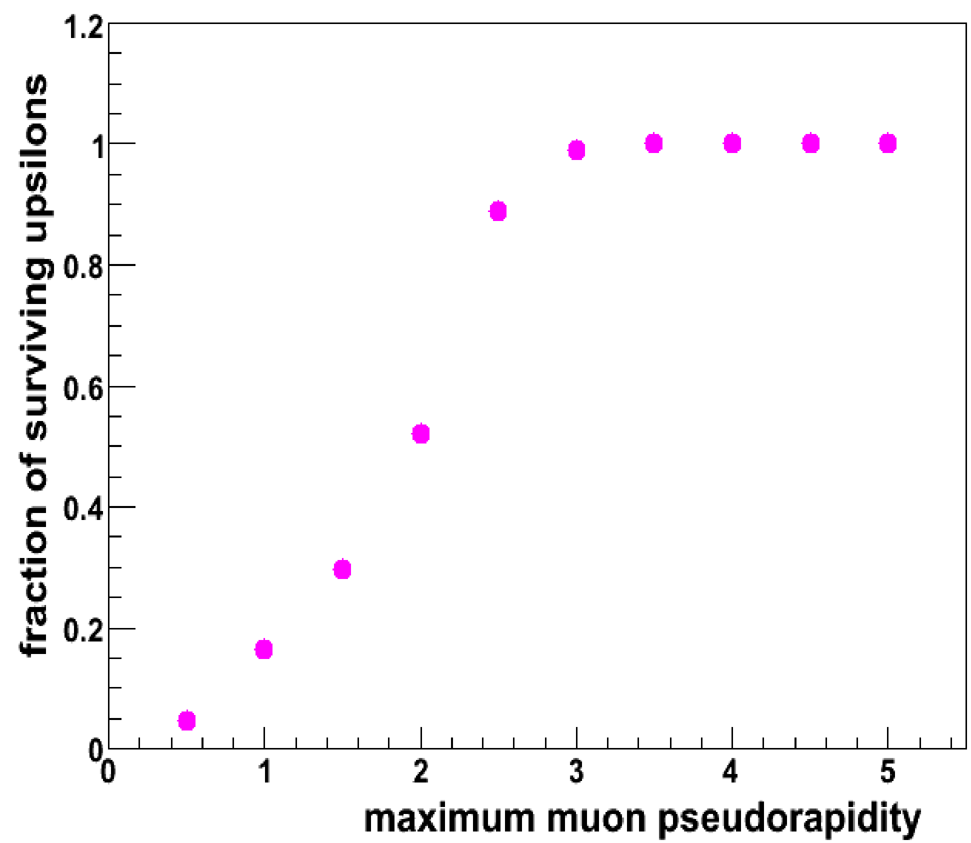
Improving mass resolution

Restrict muon pseudorapidity - but loose statistics.

Best mass resolution ~111 MeV (~10% improvement)

Tighter reconstruction cuts can slightly improve this number
- still further loss in statistics

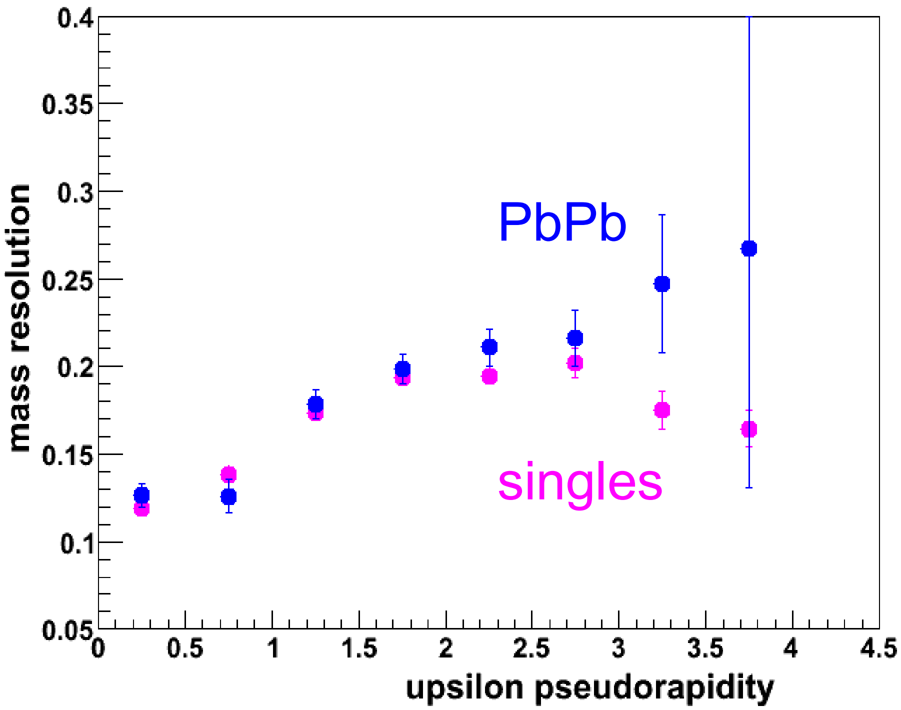


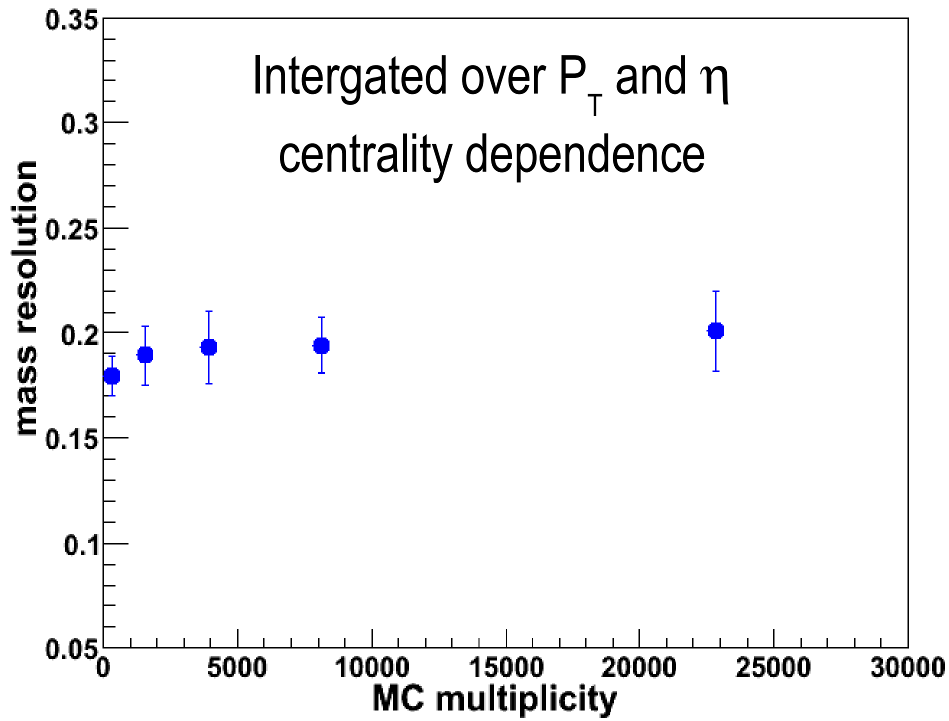


Mass resolution (PbPb)

Integrated (over P_T and η) mass resolution is 192 MeV

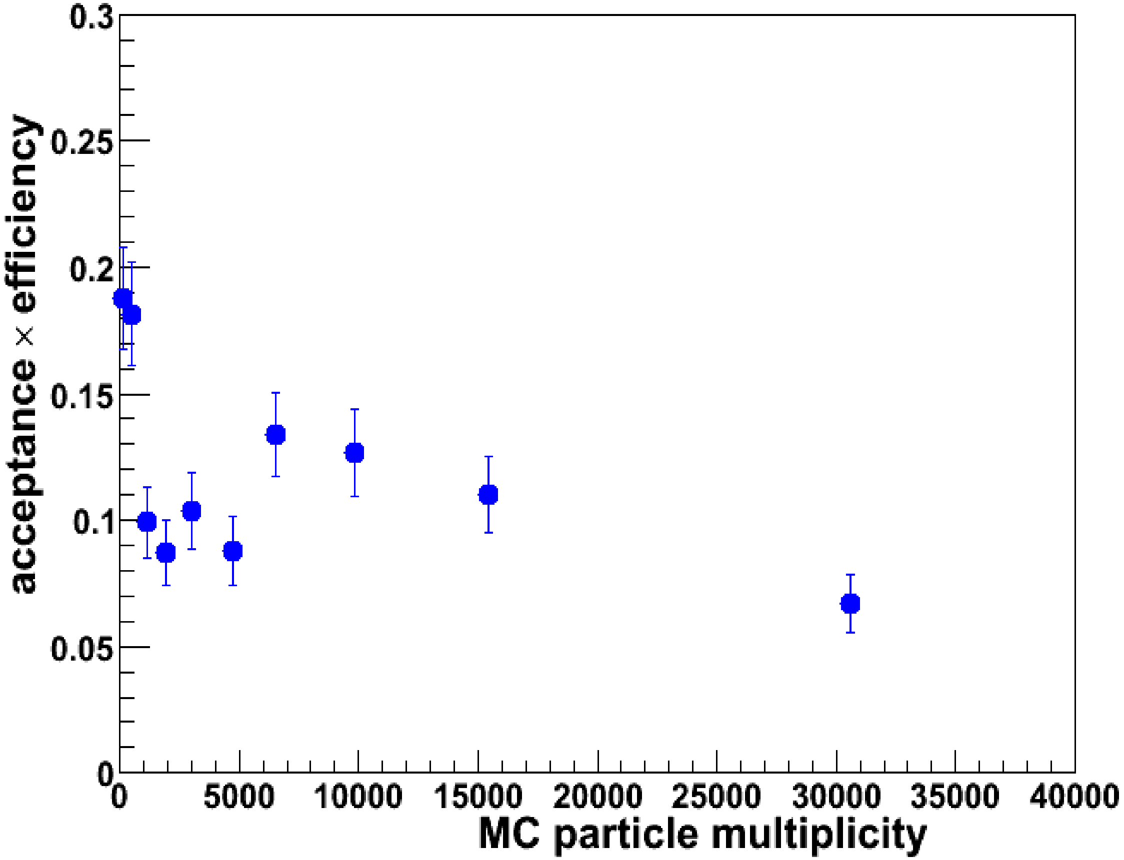
Weighted with P_T distribution from pythia

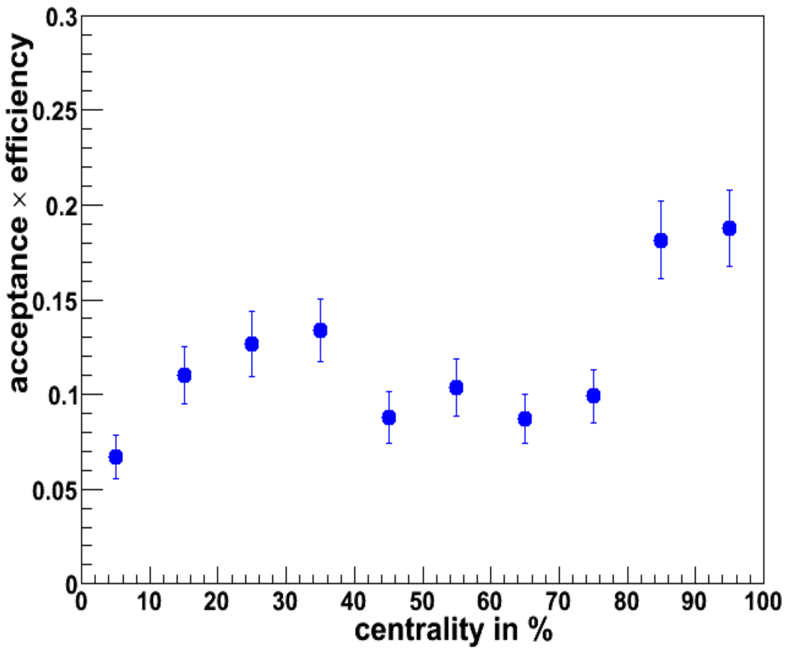




Reconstruction efficiency vs centrality

- Integrated (over P_T and η) acceptance times efficiency is 0.12
- Factor of ~2 loss in most central collisions





Muon triggers

ATLAS Trigger system:

- Level 1 (L1) – configurable hardware

Higher Level Triggers (HLT):

- Level 2 (L2) – software, relies on input from L1
- Event Filter (EF) – off-line algorithms and data model

In PbPb interaction rate is expected to be ~3kHz

Probably no need for L1 trigger for data taking

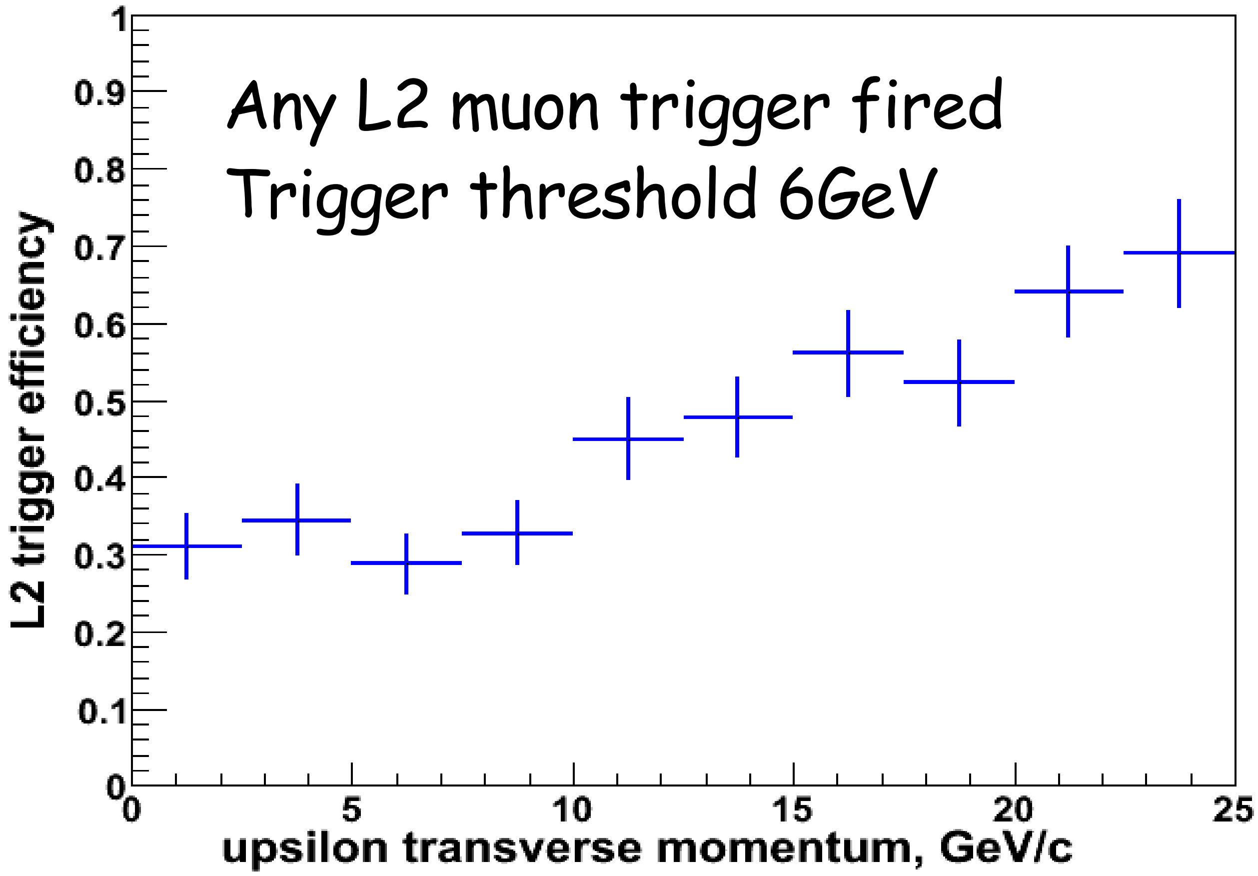
But need HLT for analysis

We studied L2 trigger efficiency using merged Upsilon/PbPb events, and fake rate using pure PbPb Hijing events.

Triggering on Upsilons

efficiency = (Υ reconstructed & muon trigger fired)/(Υ reconstructed)

No fakes in ~250 PbPb Min. Bias Hijing events (without Υ merging)



Background and yields (1/3)

Total pp cross-section at 5.5 TeV: ~100mb
bbar cross-section at 5.5 TeV: ~100μb
Υ cross-section: ~100nb

- Upsilon cross-section in pp collisions was studied using pythia:
  http://dprice.web.cern.ch/dprice/work/oniumvalidation-jun06.pdf
- 34nb with default trigger cuts, ~150nb with relaxed trigger cuts.

One Upsilon reconstructed in ~1M pp events

PbPb expected luminosity is 4 10^{26} $cm^{-2}s^{-1}$ (Letter of Intent)

- Interaction rate ~3000 Hz

from Glauber calculation (*David d'Enterria, nucl-ex/0302016*):

- Total PbPb cross-section: 7.7b
- Number of binary collisions: 400 (MB); 1670 (central)

Assume that both high pT muons and Υ scale with number of binary collisions. Then background will scale as a square of signal, and S/sqrt(B) ratio will be the same for pp and PbPb.

Background and yields (2/3)

Sources of background:
- a) charm
- b) beauty
- c) hadron decays (mostly pi & K)
- d) hadron punch-through

Calculating background:
- use pythia to get muons from charm/beauty (a and b)
- generate single pions and kaons, run full simulation, plot reconstructed muon spectrum (c and d)

This gives us muon spectra and multiplicities

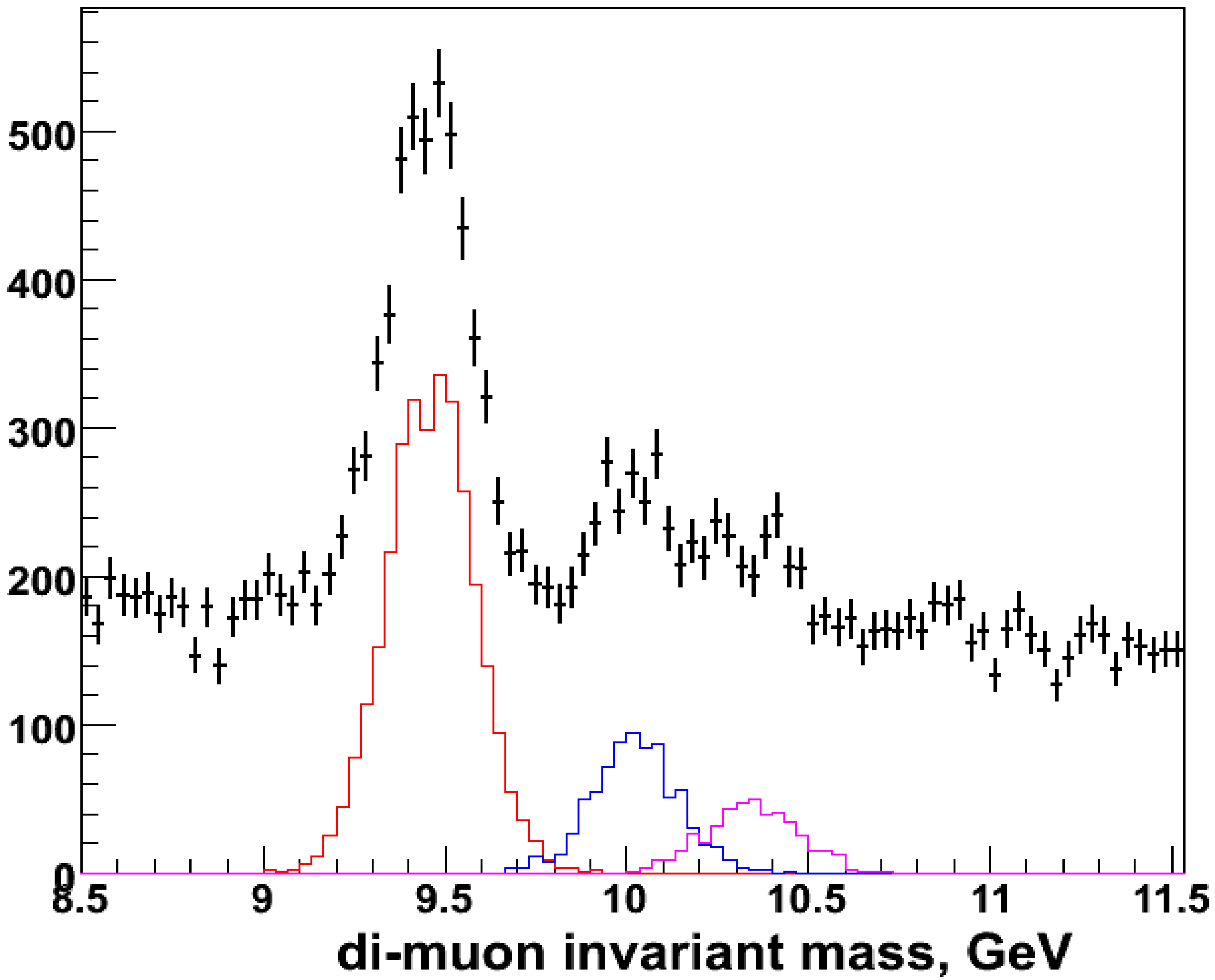
Add Upsilons to this mix.

Scale everything with number of binary collisions

Run MC simulation and produce di-muon invariant mass spectra.

Background and yields (3/3)

This plot corresponds to 24 days of running, at 3 kHz collision rate
Acceptance and efficiency corrected
Barrel only (|η|<1), 120 MeV Υ mass resolution



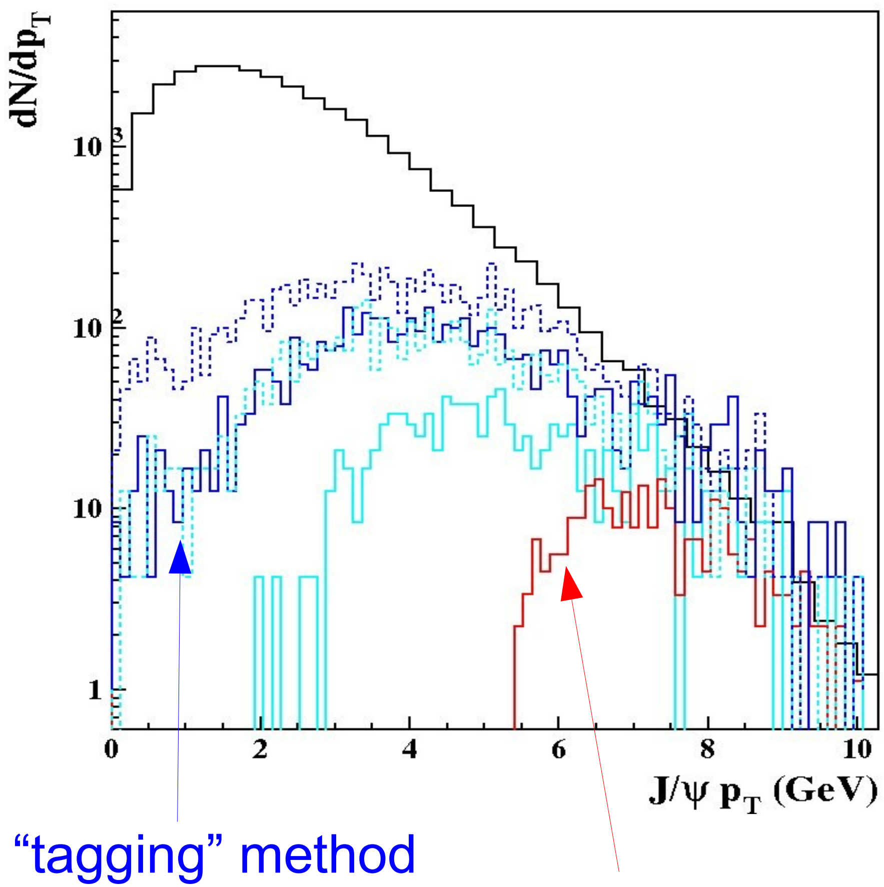
~15k reconstructed
Υ1S

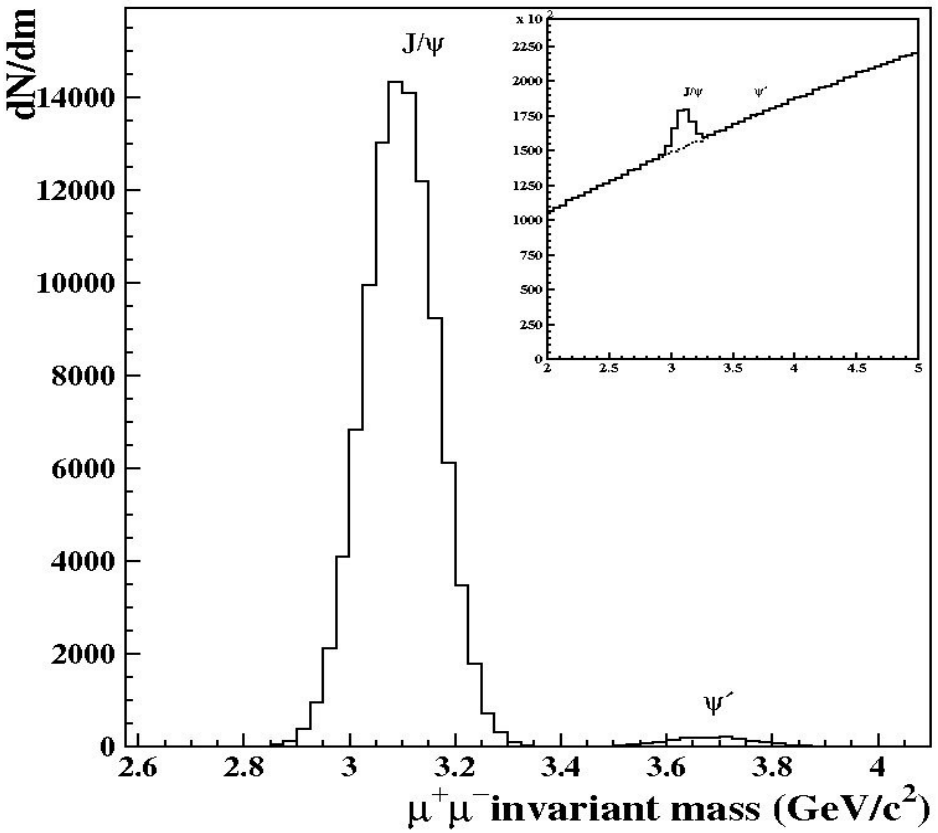
Charmonium (J/ψ)

Main problem: low acceptance due to minimum muon P_T ~2.5-3.0 GeV

Two methods considered:

- both muons fully reconstructed
- "tagging method" for one muon *(allows muon reconstruction down to 1.5GeV).*





Mass resolution 68 MeV

~100k J/ψ per month, tagging method

Conclusions and outlook

- Reconstruction efficiency is reasonably good even in most central PbPb events

- Mass resolution is almost unaffected in PbPb collisions

- Mass resolution is good enough to separate different Υ states at least in the barrel region

- We should be able to see Υ and J/ψ peaks in a few weeks of running

- Quarkonium study in e+e- channel is underway

- χ_C study is underway