

# Charmonium detection by p-N collisions at FAIR energies in CBM experiment

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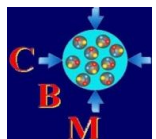
(On behalf of CBM Collaboration)

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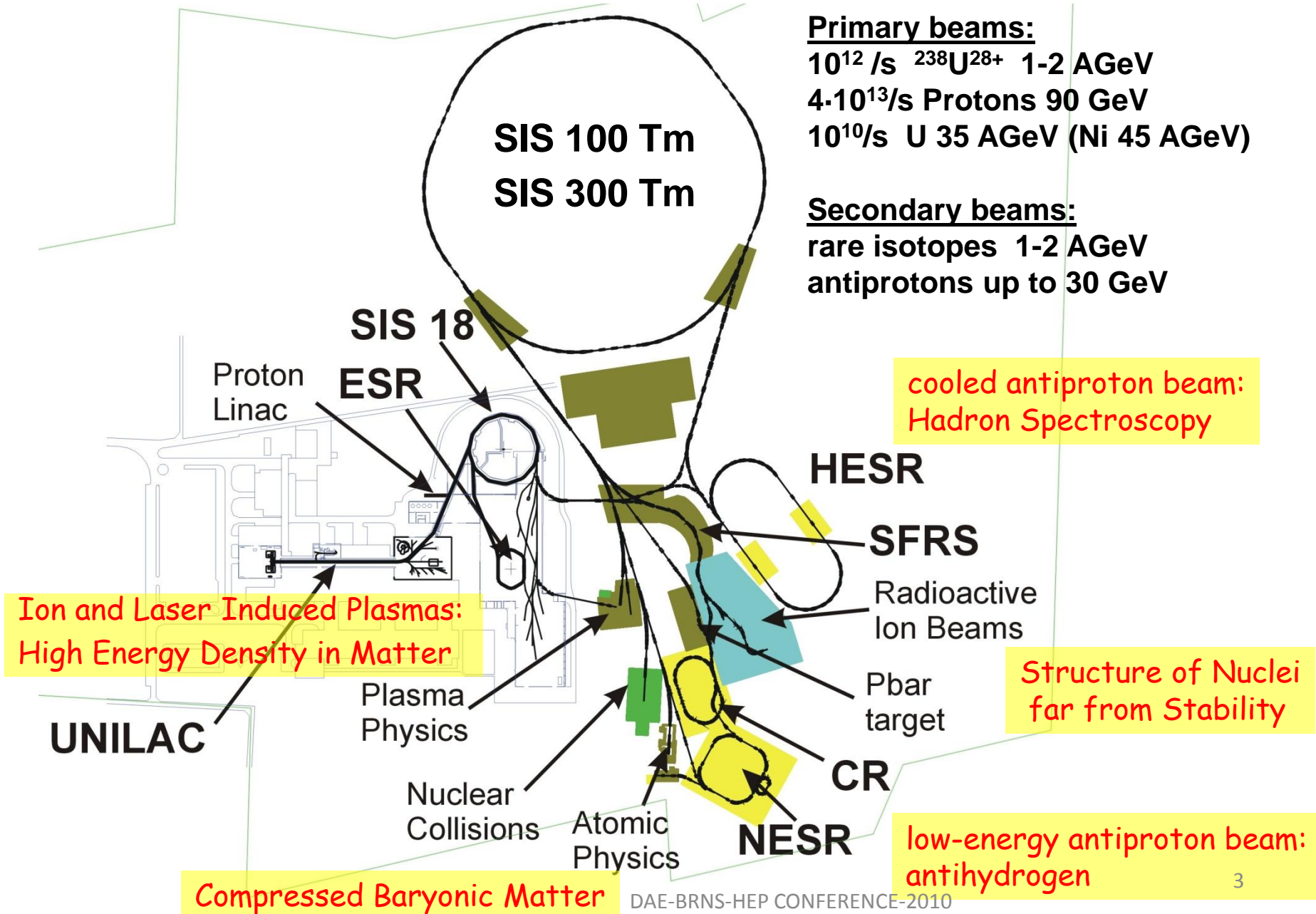
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# Outline

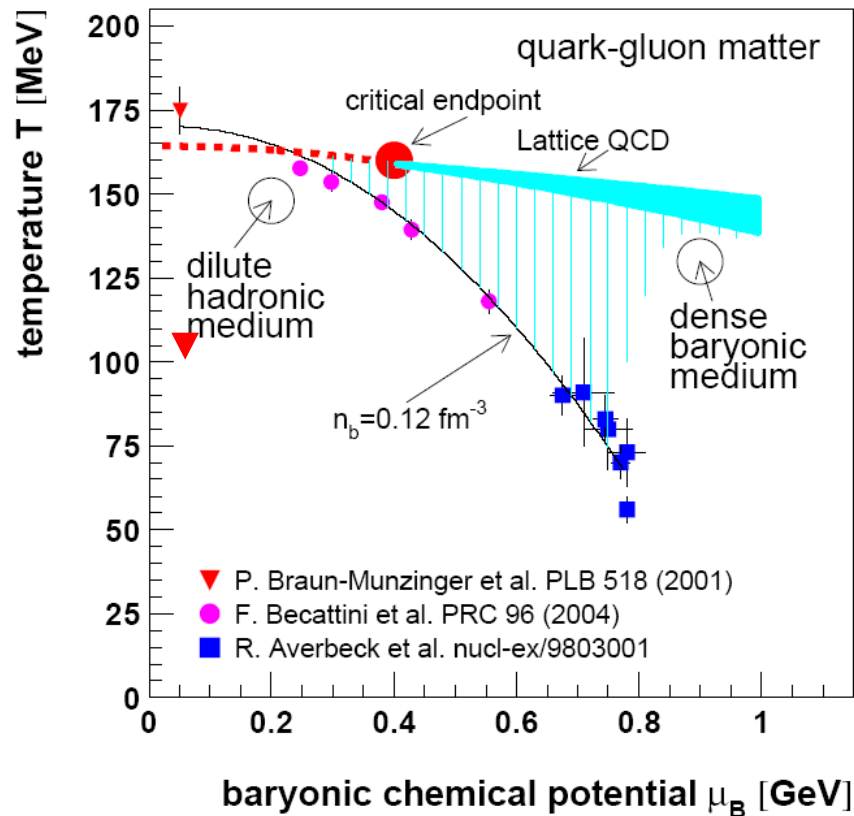
- Introduction
- Physics Motivation
- CBM Detector Concept
- Feasibility Studies
- Summary



# The future Facility for Antiproton and Ion Research (FAIR)



# Exploring the QCD Phase diagram



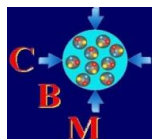
## High-energy heavy-ion collision experiments:

RHIC, LHC: cross over transition, QGP at high T and low  $\rho$

Low-energy RHIC: search for QCD-CP with bulk observables

NA61@SPS: search for QCD-CP with bulk observables

CBM@FAIR: scan of the phase diagram with bulk and rare observables



# What do we need to measure?

## The equation-of-state at high $\rho_B$

- collective flow of hadrons
- particle production at threshold energies (open charm?)

## Deconfinement phase transition at high $\rho_B$

- excitation function and flow of strangeness ( $K, \Lambda, \Sigma, \Xi, \Omega$ )
- *excitation function and flow of charm ( $J/\psi, \psi', D^0, D^\pm, \Lambda_c$ )*

## QCD critical endpoint

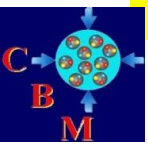
- excitation function of event-by-event fluctuations ( $K/\pi, \dots$ )

## Onset of chiral symmetry restoration at high $\rho_B$

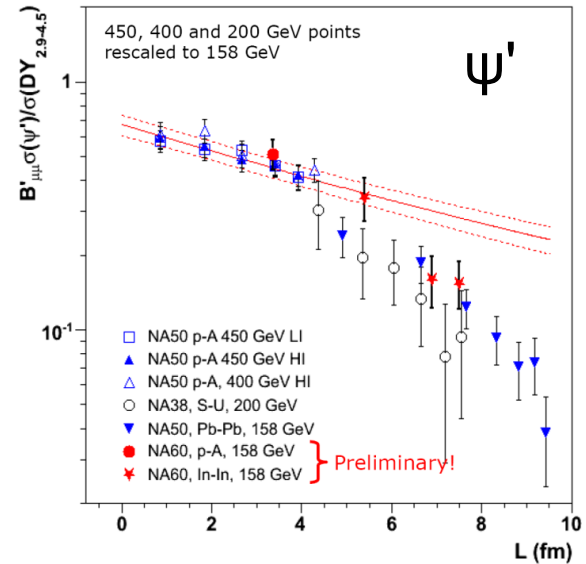
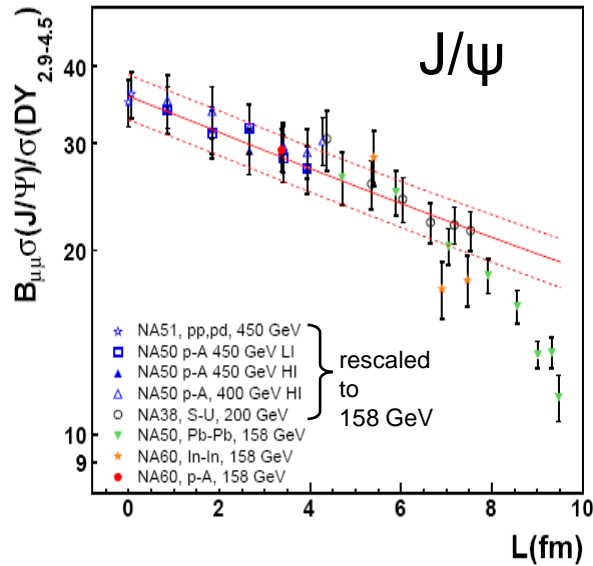
- *in-medium modifications of hadrons ( $\rho, \omega, \phi \rightarrow e^+e^-(\mu^+\mu^-), D$ )*

CBM: detailed measurement over precise energy bins (pp, pA, AA)

FAIR beam energy range 2-45 AGeV (protons 90 GeV)



# Probing the quark-gluon plasma with charmonium



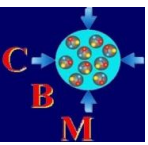
Quarkonium dissociation temperatures  
(Digal, Karsch, Satz)

state	$J/\psi(1S)$	$\chi_c(1P)$	$\psi'(2S)$	$\Upsilon(1S)$	$\chi_b(1P)$	$\Upsilon(2S)$	$\chi_b(2P)$	$\Upsilon(3S)$
$T_d/T_c$	2.10	1.16	1.12	> 4.0	1.76	1.60	1.19	1.17



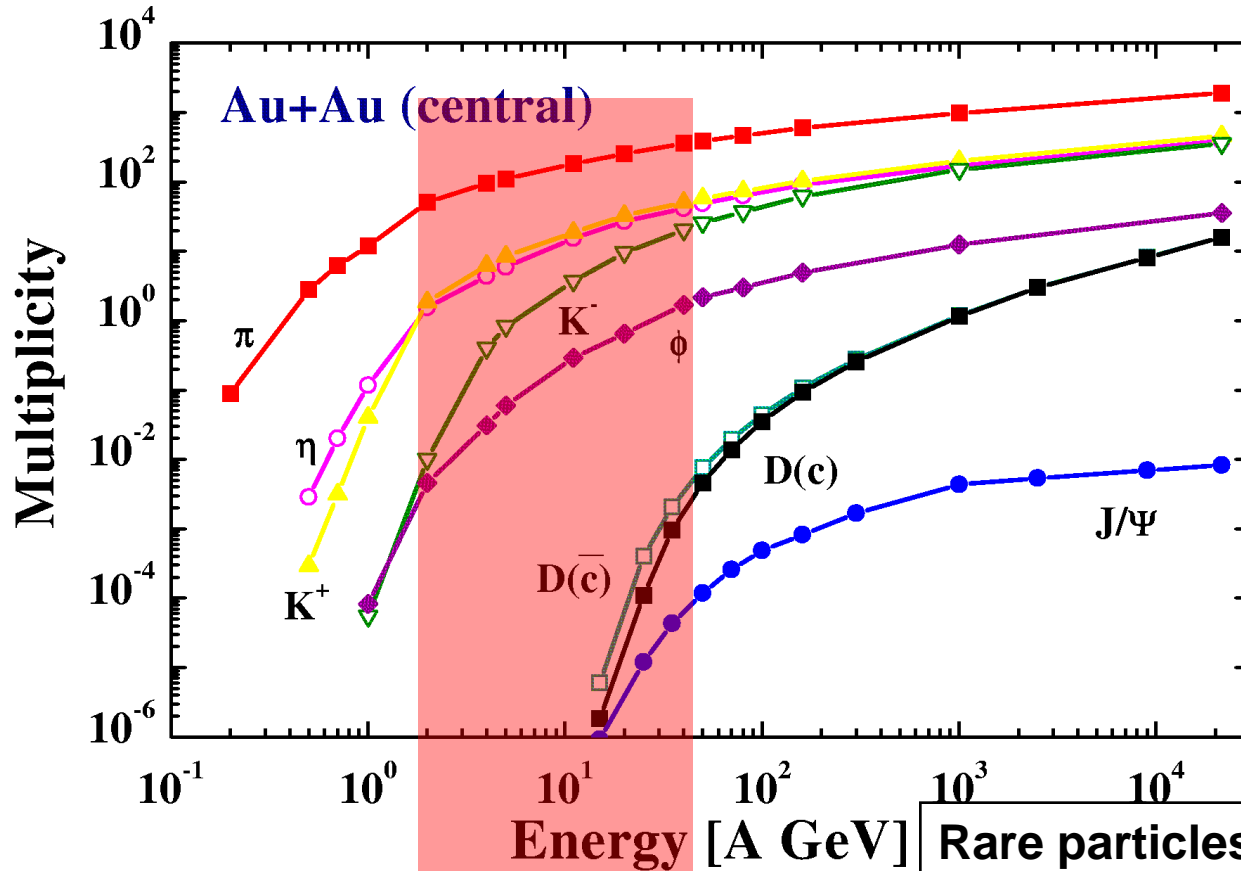
sequential dissociation?

Measure excitation functions of  $J/\psi$  and  $\psi'$  in p+p, p+A and A+A collisions !



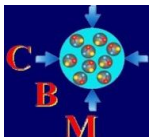
# Multiplicity in central Au+Au collisions

W. Cassing, E. Bratkovskaya, A. Sibirtsev, Nucl. Phys. A 691 (2001) 745

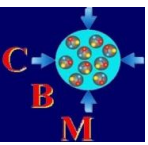
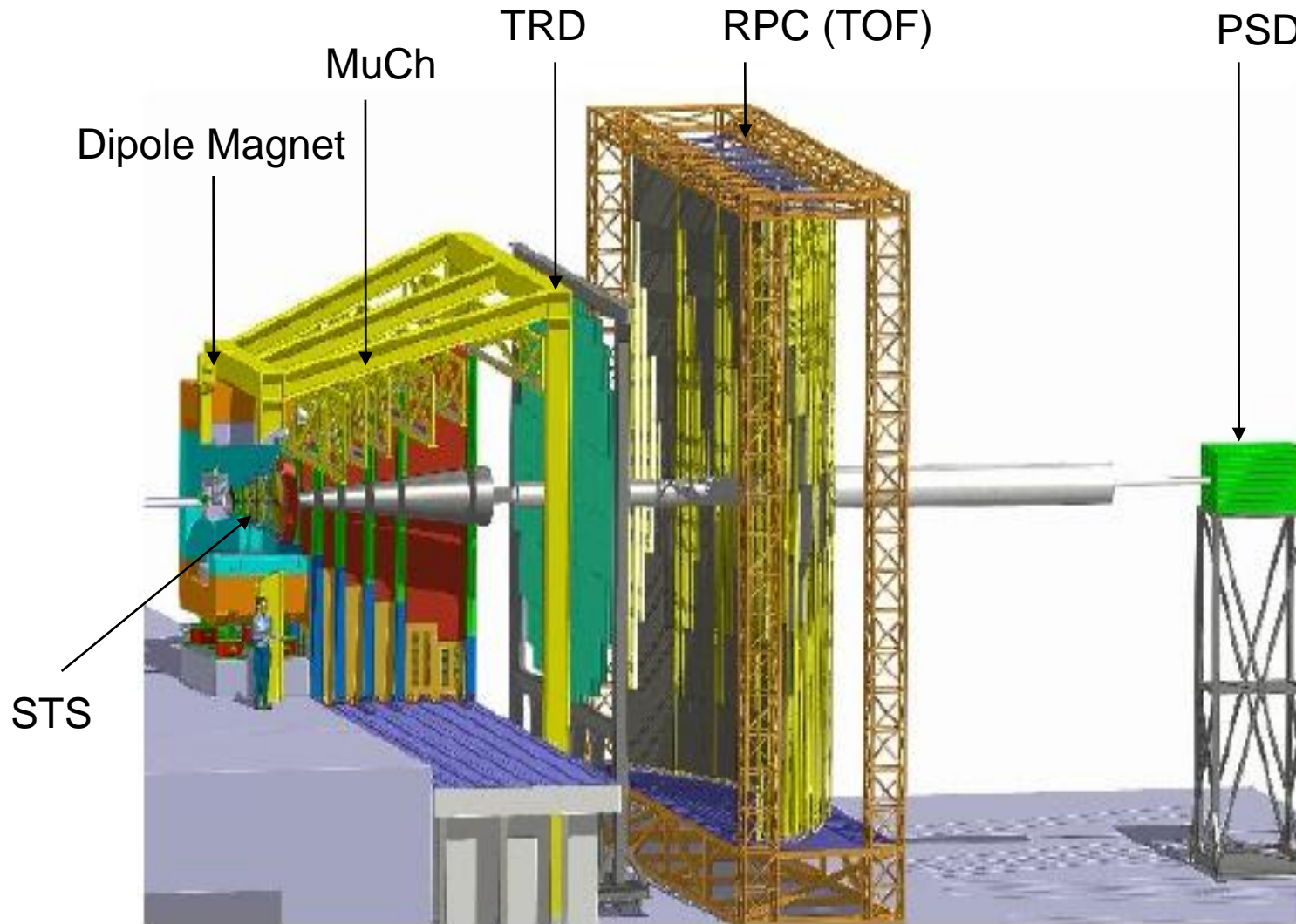


Rare particles with high statistics  
High beam intensity  
Interaction rate: 10 MHz  
Fast detectors/DAQ

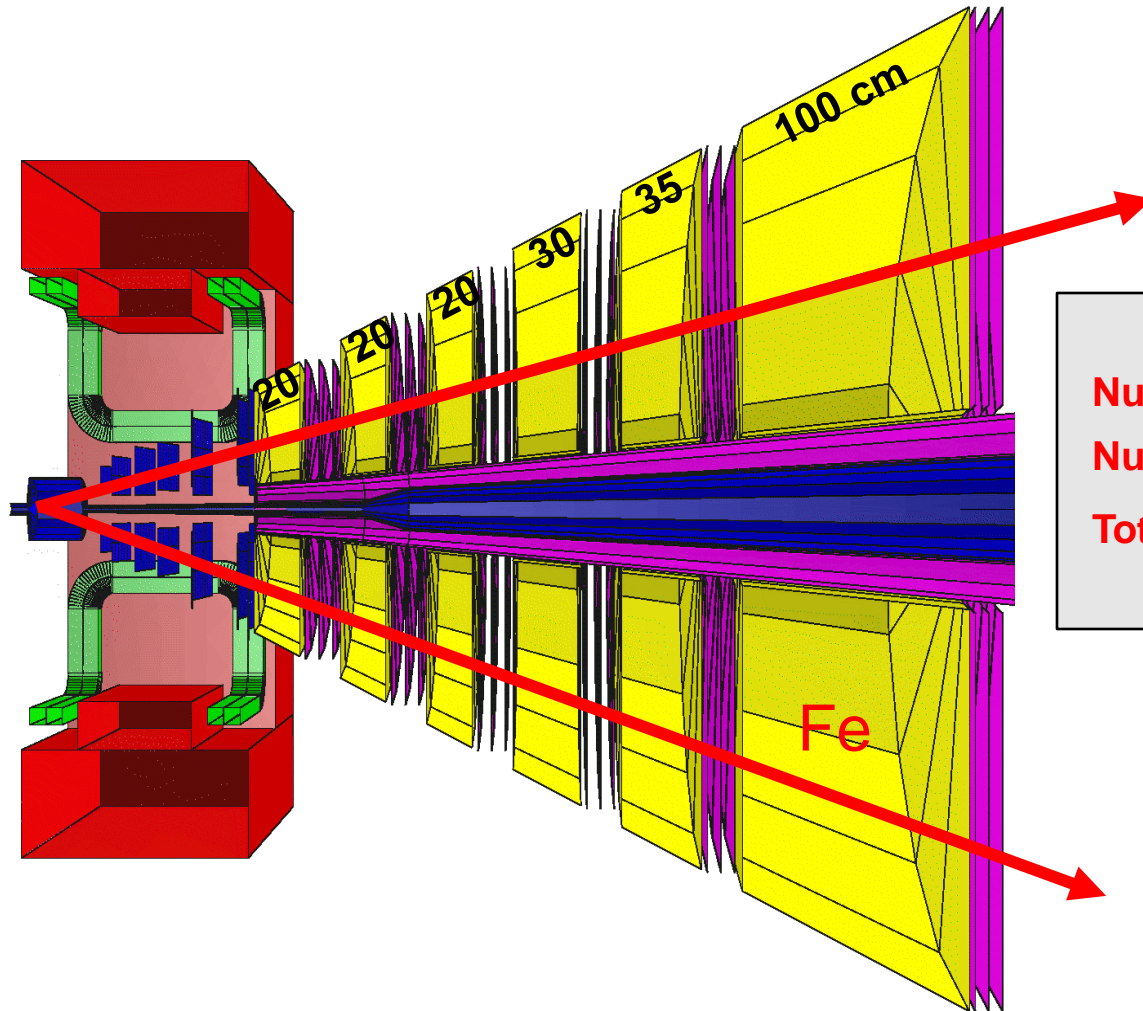
SIS  
100/300



# CBM experiment : Muon set up



# Muon Detection System: Standard Geometry



**Number of stations : 18**  
**Number of absorbers : 6**  
**Total absorber thickness:  $13.5 \lambda$**

# Motivation

- Proton-nucleus (p+A) collisions is a fundamental component of any heavy-ion physics programme
- **Defines the reference baseline relative to which we recognize HI specific phenomena**
- p+A collisions provide a measure of the nuclear effects – helps in disentangling the “QGP” effect from the “non-QGP” effects. Here there is no formation time for the “secondary” medium , hence such collisions provide as essential tool to correctly account for the effect of the nuclear medium initially present.
- **Charm propagation in cold nuclear matter & normal absorption.**

# The p-A System

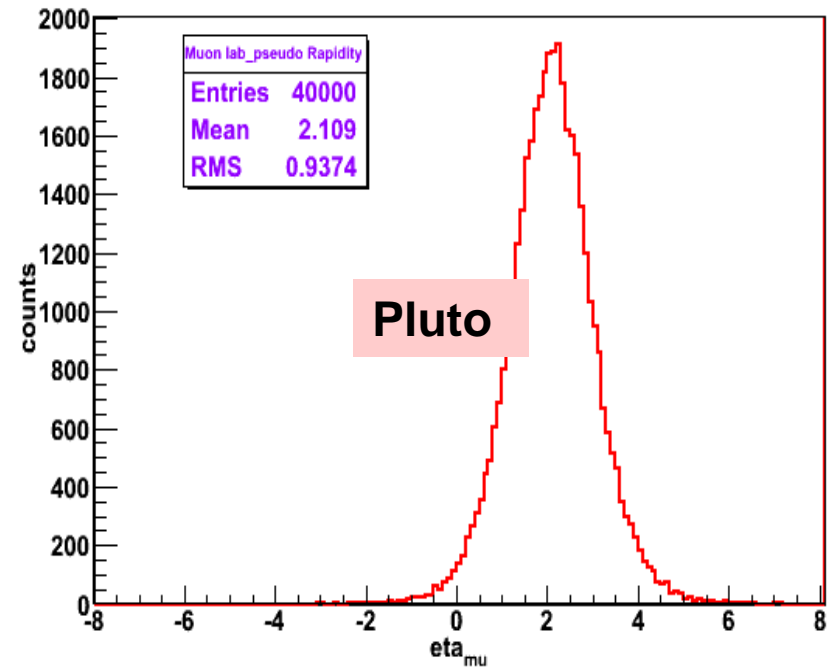
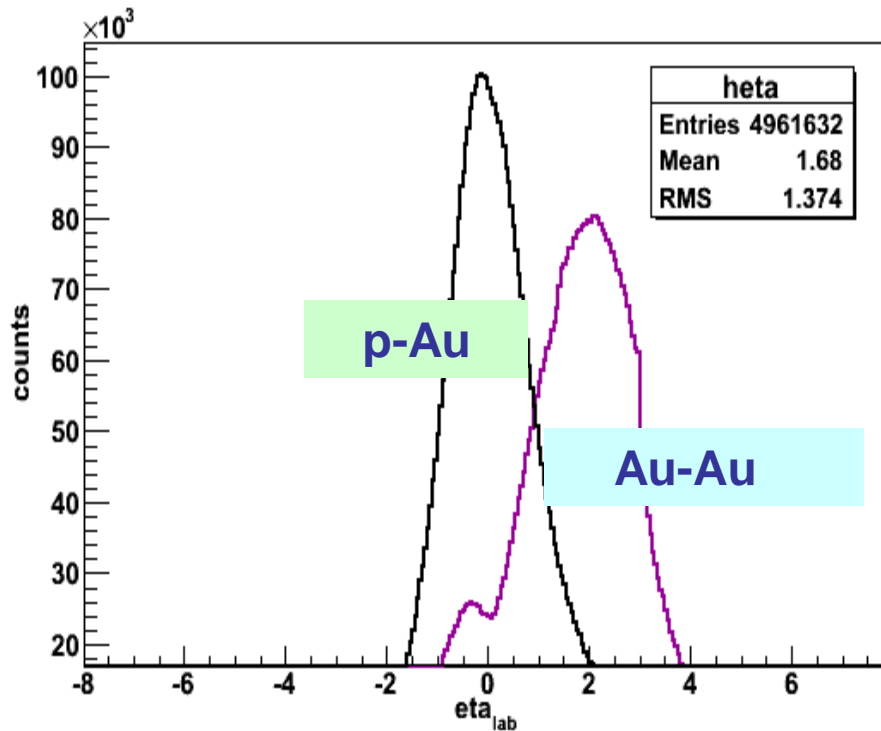
## The specifications of the system chosen are:

- Target : Au (79 , 197)
- Projectile : p (1, 1)
- Beam energy : 25 GeV
- Collision type : Minimum bias
- Event generator :
  - Background : UrQMD
  - Signal : Pluto ( $J/\psi \rightarrow \mu^+ + \mu^-$ )
- Events simulated : 10,000
- **Muon detection system : Standard Geometry, Start version Geometry**

**An extremely asymmetric system**

# Acceptance (system asymmetry)

MUCH Detector acceptance rejects background



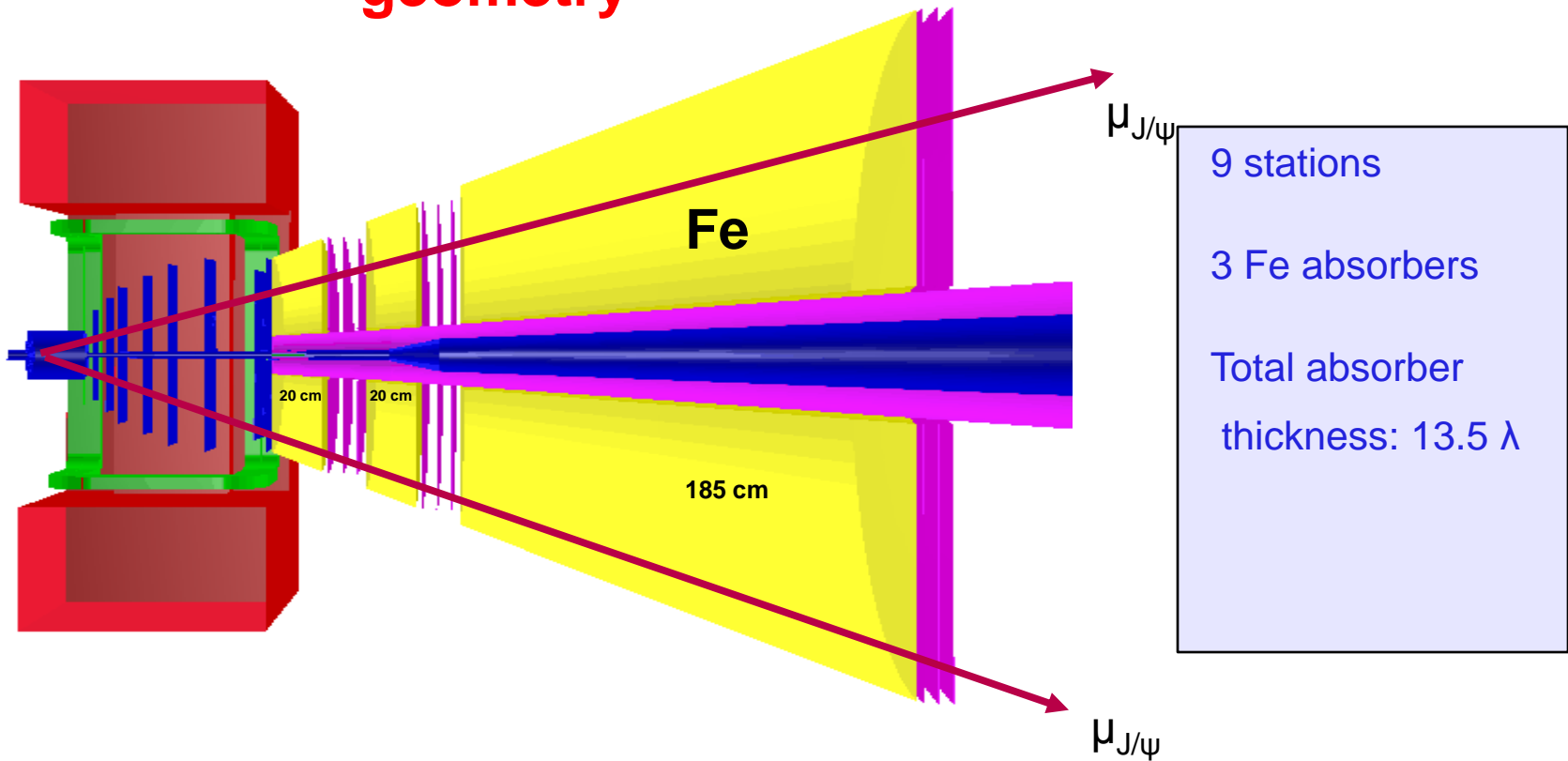
Detector coverage:

$\theta_{in} = 5.3$  degree     $\theta_{out} = 26.7$  degree

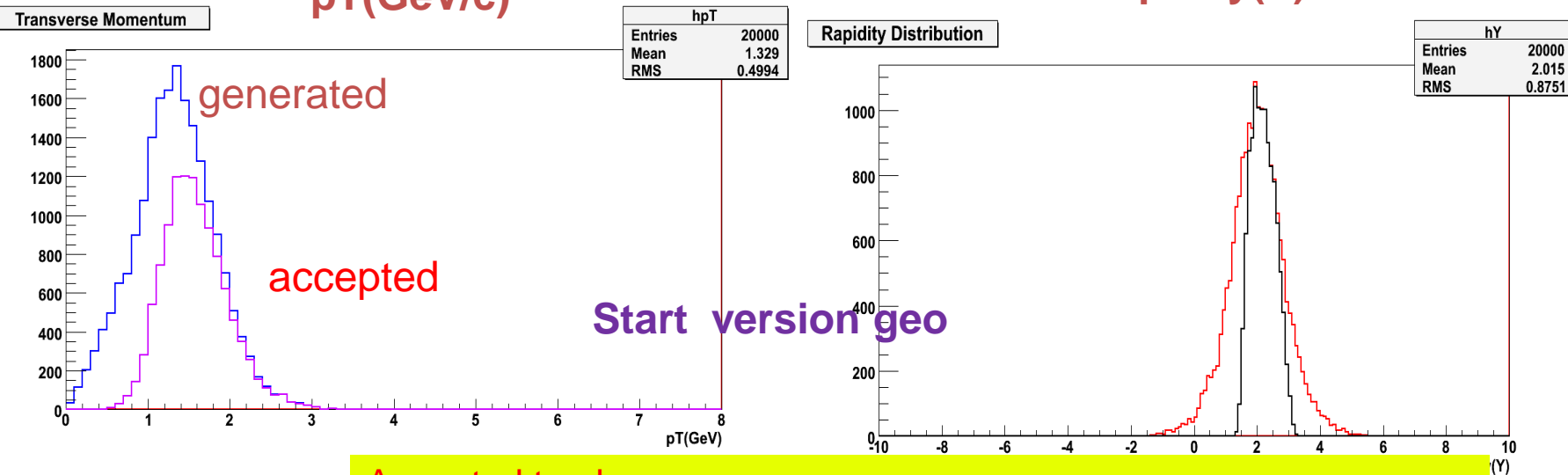
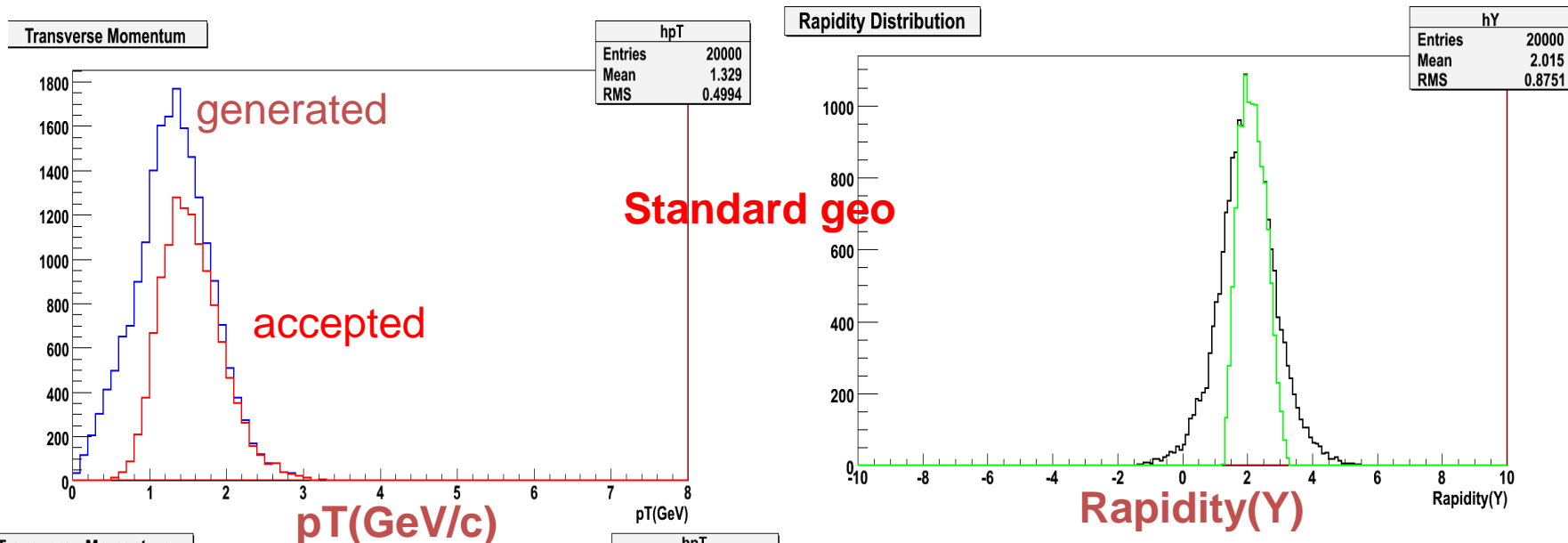
$\eta_{max} = 3.07$      $\eta_{min} = 1.44$

# New Geometry (Reduced Number of stations)

Start Version  
geometry

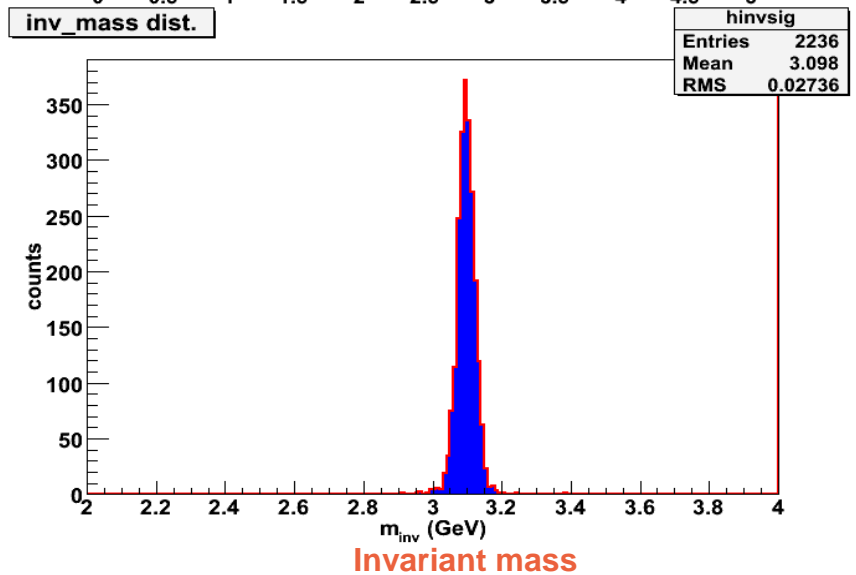
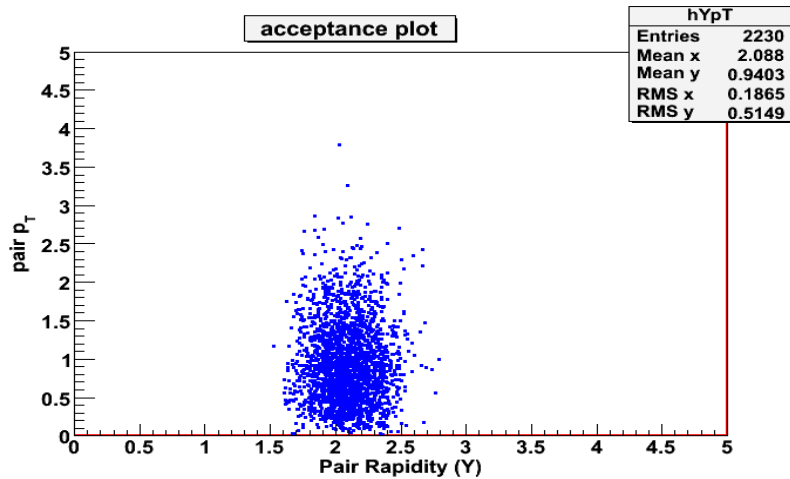
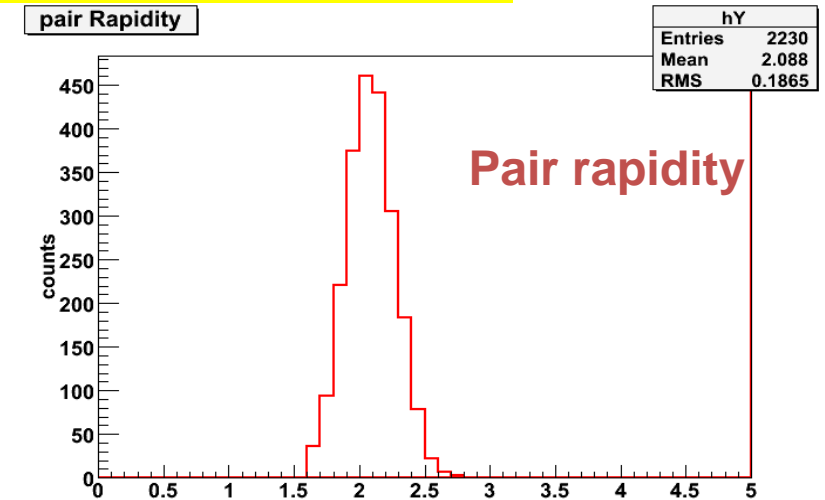
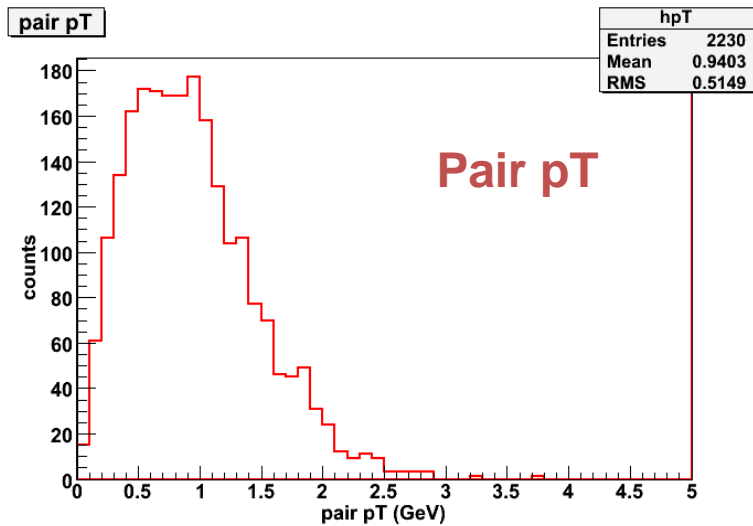


# Pluto (signal muons)



**Accepted tracks**  
 (STS points  $\geq 4$ , MUCH Points  $\geq 70\%$  of the total no. of muon detectors)

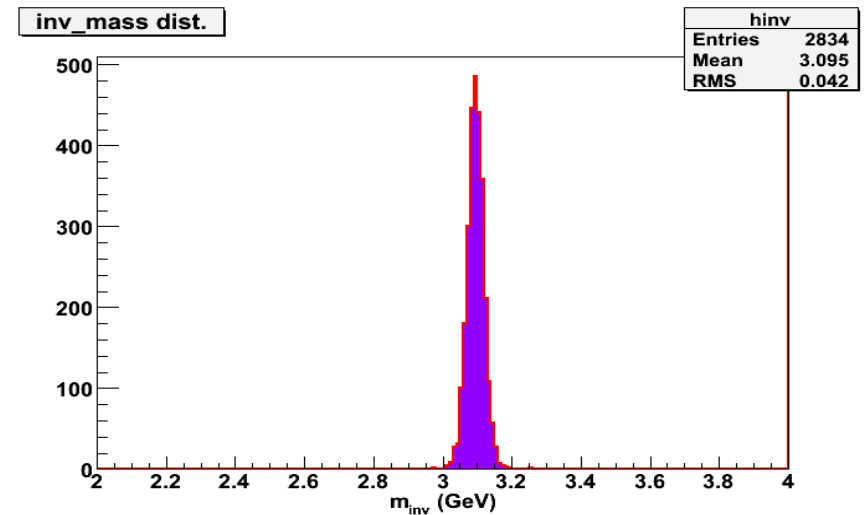
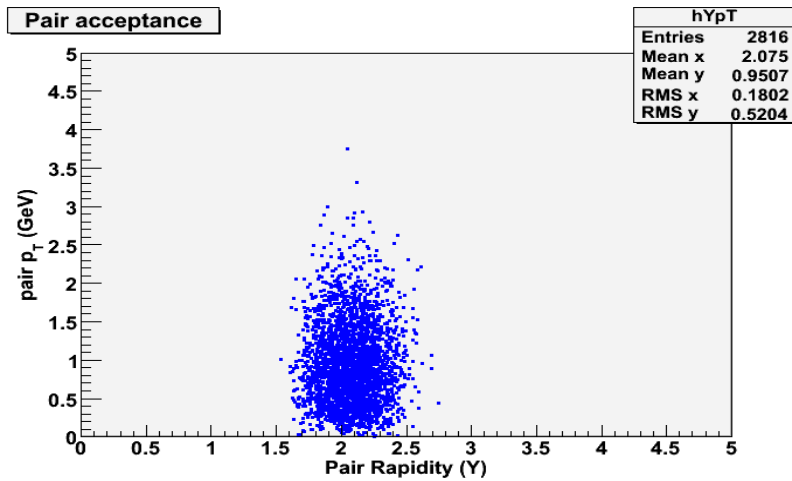
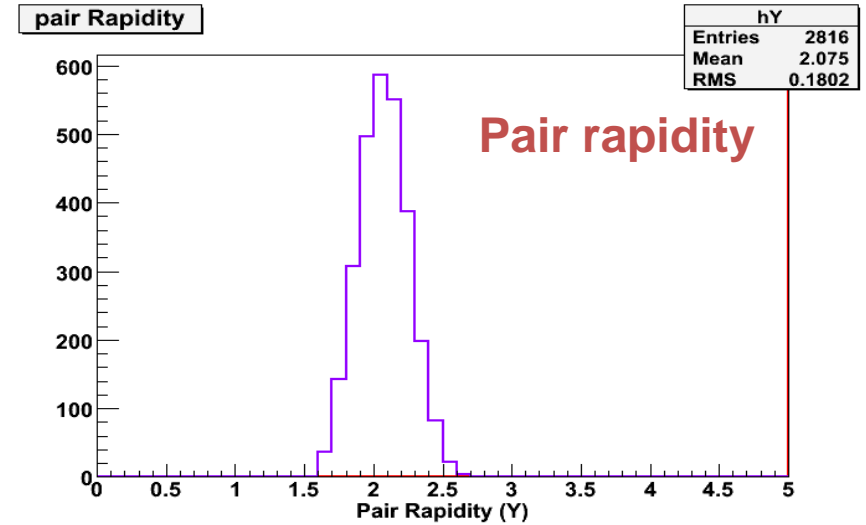
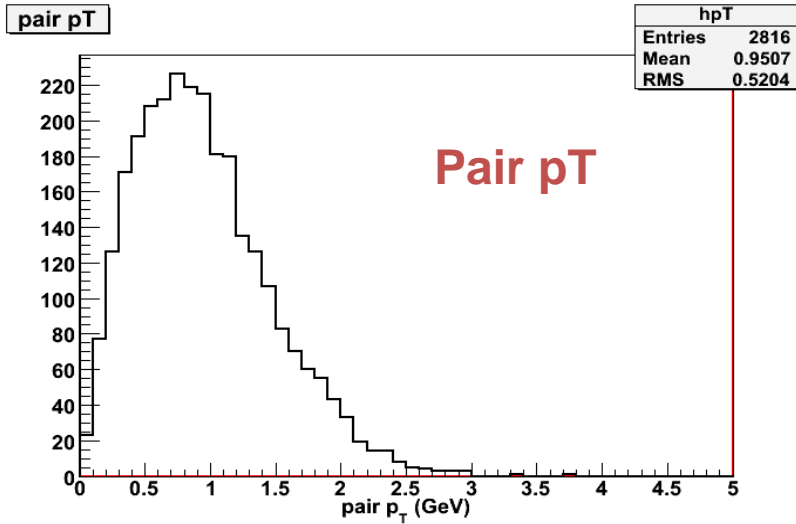
# Reconstructed $J/\psi$ Standard Geometry



Reconstruction efficiency : 22.3 %,  
(10 K embedded events, URQMD+PLUTO)

# Reconstructed $J/\psi$

## Start version Geometry



Reconstruction Efficiency : 28.16 %

# Summary & Future Plans

First estimates of reconstruction efficiency of  $J/\psi$  in SIS100 clearly shows the feasibility of measurement

Much less background in pA owing to the typical geometrical acceptance

A **START VERSION** geometry of MUCH with 9 stations implemented. preliminary comparison conveys similar reconstruction efficiency. More study underway.

Estimation of background & calculation of S/B ratio will be done

Transport models (HSD) will be implemented to include the system asymmetry in production of signal muons .