J/Ψ production in p+p and Au+Au @ 200 GeV as seen by the PHENIX experiment at RHIC

Raphaël Granier de Cassagnac
LLR – Ecole polytechnique

Topics in Heavy-Ions Collisions
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Physics motivation

- ## In AA collisions :
  - Quarkonia production expected to be modified in a Quark Gluon Plasma
  - Anomalous suppression seen at CERN →

- ## In pA (or dA) collisions :
  - Normal nuclear effects
  (Shadowing, Cronin, …)
  - Baseline for AA

- ## In pp collisions :
  - Cross section
  - Production mechanisms
  - Baseline for pA and AA
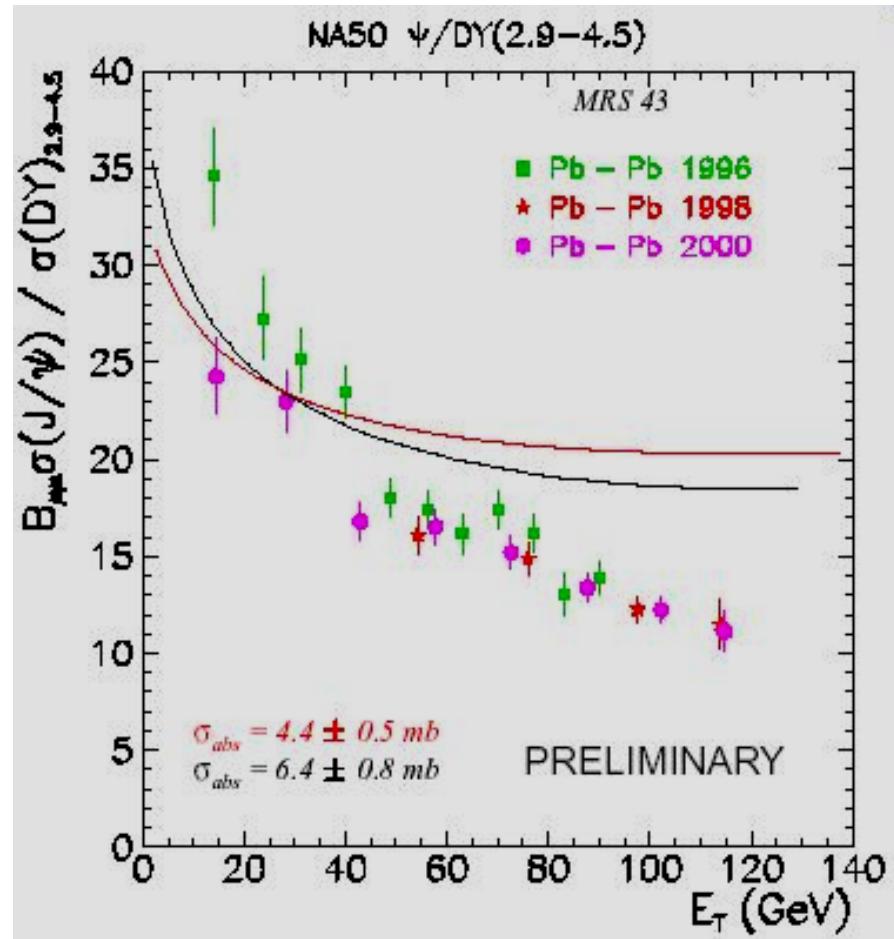
(NA50 from Quark Matter 2002)

How does PH✳ENIX see the J/Ψ ?
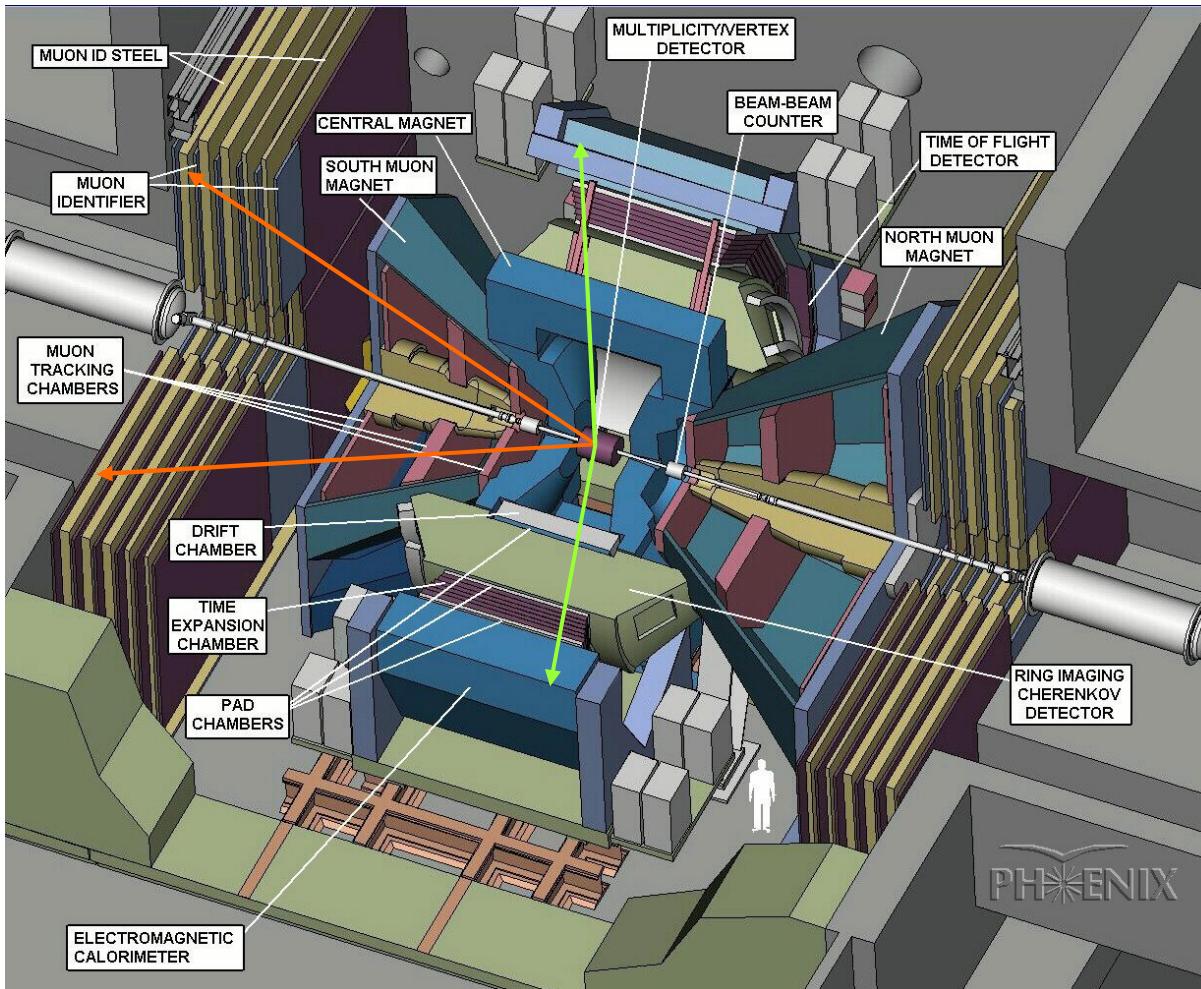
$J/\Psi \rightarrow e^+e^-$
identified in RICH
and EMCal
- $|\eta| < 0.35$
- $p > 0.2$ GeV

$J/\Psi \rightarrow \mu^+\mu^-$
identified in
two forward
spectrometers
- $\pi/\mu \sim 10^{-4}$
- $1.2 < |\eta| < 2.4$
- $p > 2$ GeV

Centrality and
vertex given by
global detectors

RHIC run history (and outline)

Year	Species	Energy	Luminosity	Detectors
2000	Au-Au	130 GeV	$1~\mu b^{-1}$	Central (electrons)
2001/2002	2. Au-Au	200 GeV	$24~\mu b^{-1}$	Central + 1 muon arm
	1. p-p	200 GeV	$0,15~pb^{-1}$	
2002/2003	3. d-Au	200 GeV	$2,74~nb^{-1}$	Central + 2 muon arms
	p-p	200 GeV	$0,35~pb^{-1}$	
2003/2004	Au-Au	200 GeV	? ? ?	! ready !

J/Ψ statistics in p + p

46 J/Ψ → ee   66 J/Ψ → μμ
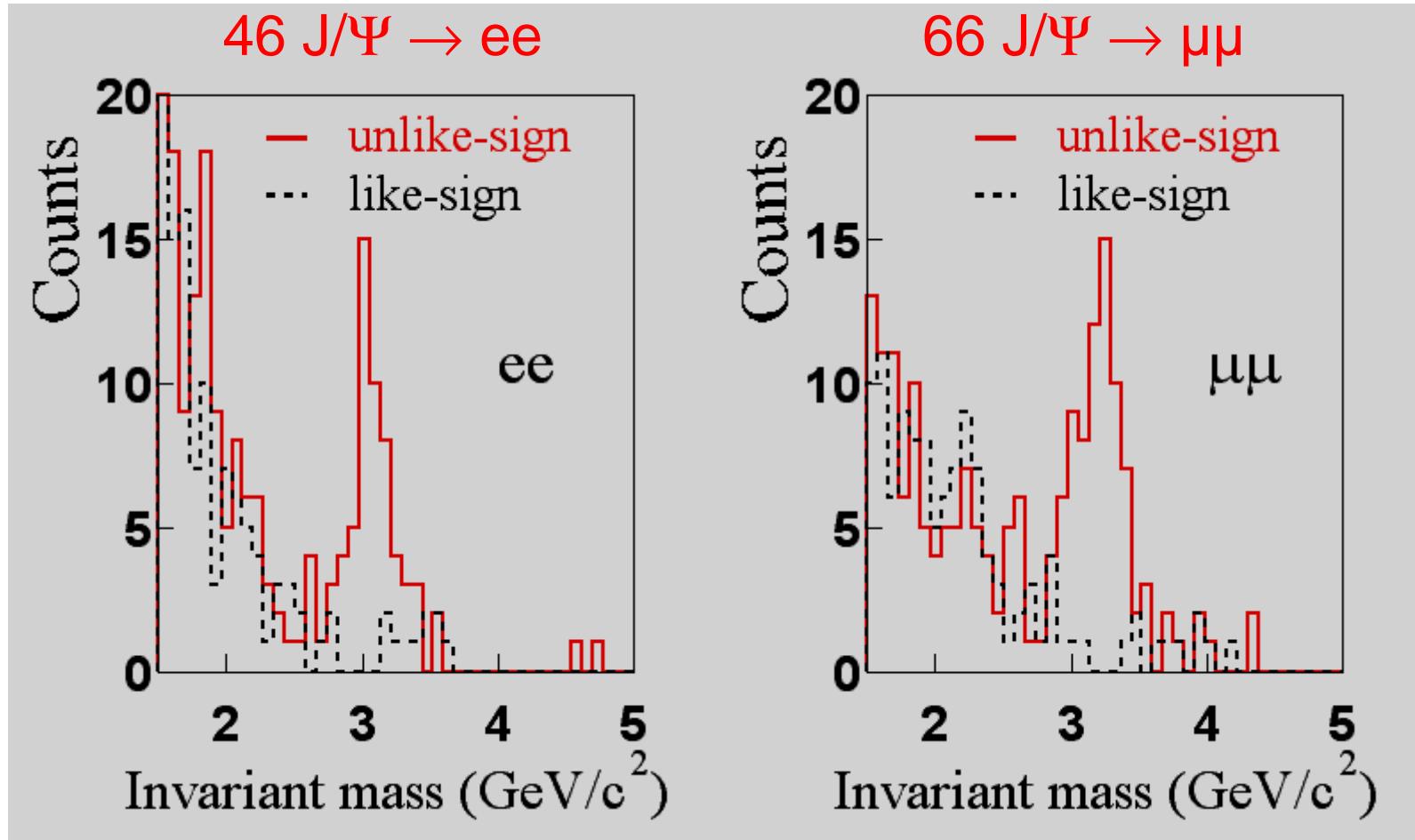
Resolutions agree with expectations

$\sigma_{ee} \sim 110$ MeV $\sigma_{\mu\mu} \sim 160$ MeV

J/Ψ transverse momentum
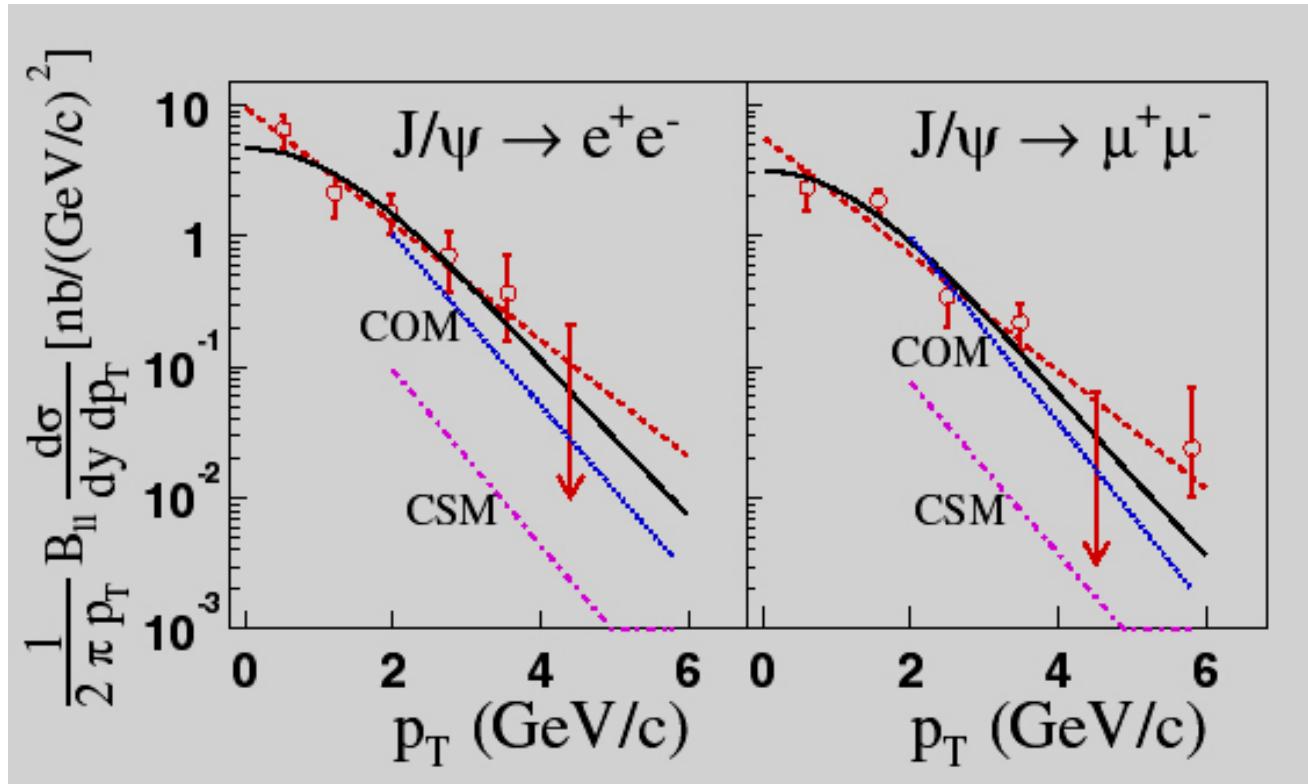
Color Singlet Model
Color Octet Model
(from Nayak et al.
hep/ph 0302095)

COM contribution is dominant, as for high p_T J/Ψ @ Tevatron

Phenomenological + exponential fits of dimuon and dielectron data give mean p_T :

<pT> = 1.80 ± 0.23 (stat) ± 0.16 (sys) GeV/c

J/Ψ cross section
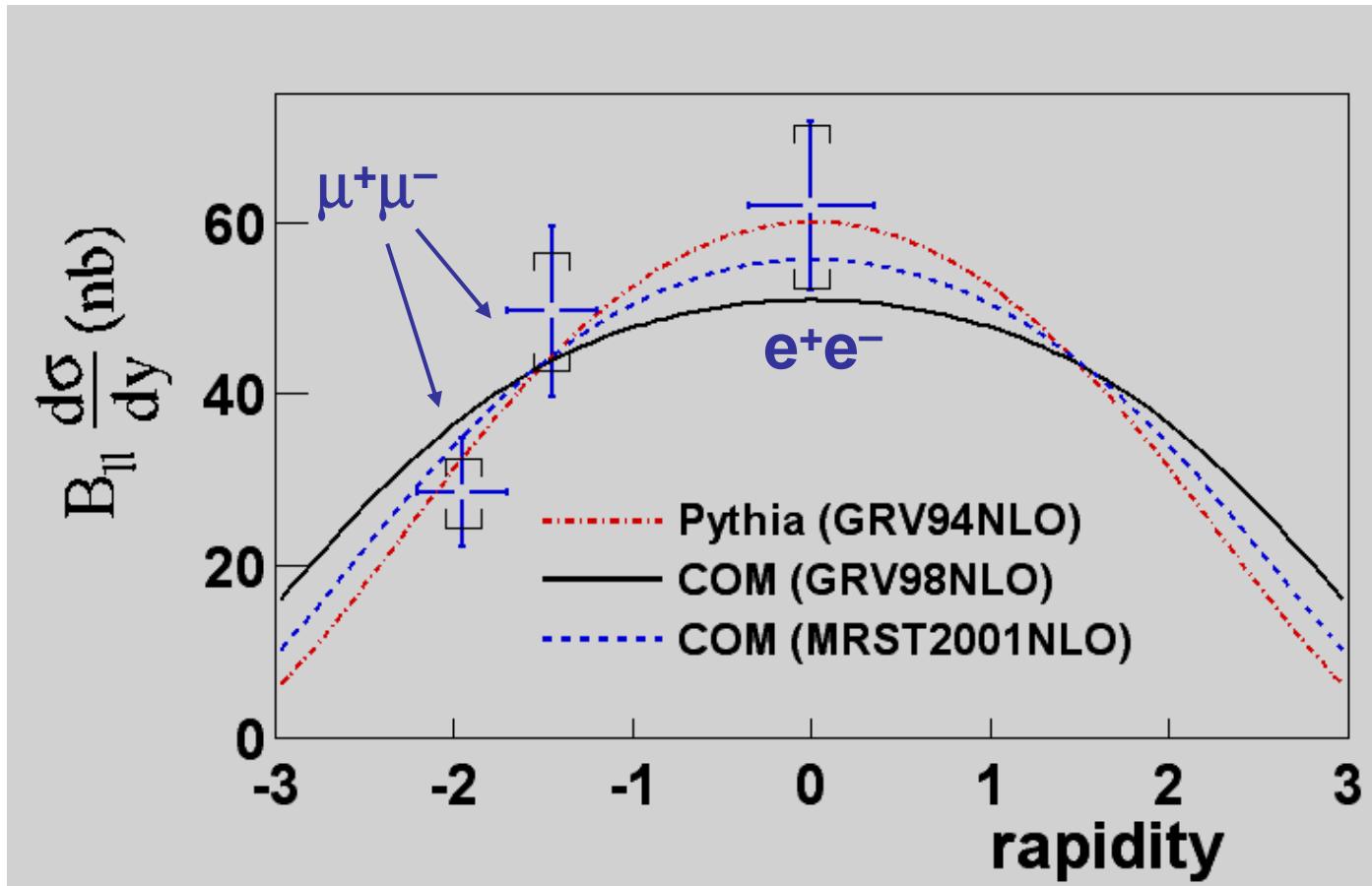
Results consistent with shapes from various models and PDF.

Take the PYTHIA shape to extract our cross-section

Error from absolute normalization

Integrated cross-section :

3.99 ± 0.61 (stat) ± 0.58 (sys) ± 0.40(abs) µb

Running with energy
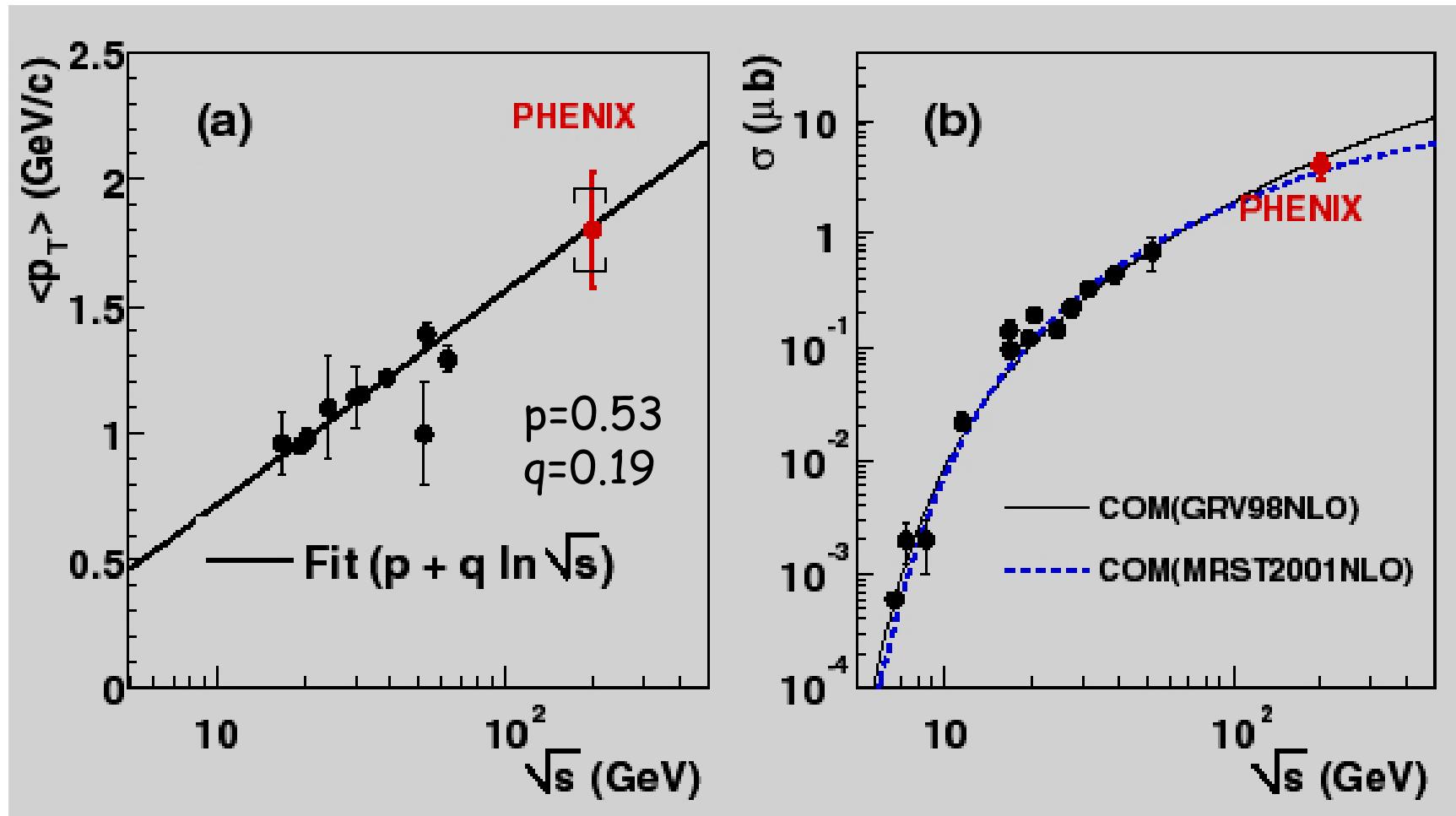
Cross section well described by *Color Octet Model*

J/Ψ statistics in Au+Au

- ## Di-muon statistics are marginal
  - One arm only, being commissioned…

- ## A few di-electron candidates
  - Divided in 3 centrality bins (0-20%, 20-40%, 40-90%)

For instance, in the 20 to 40 % centrality bin
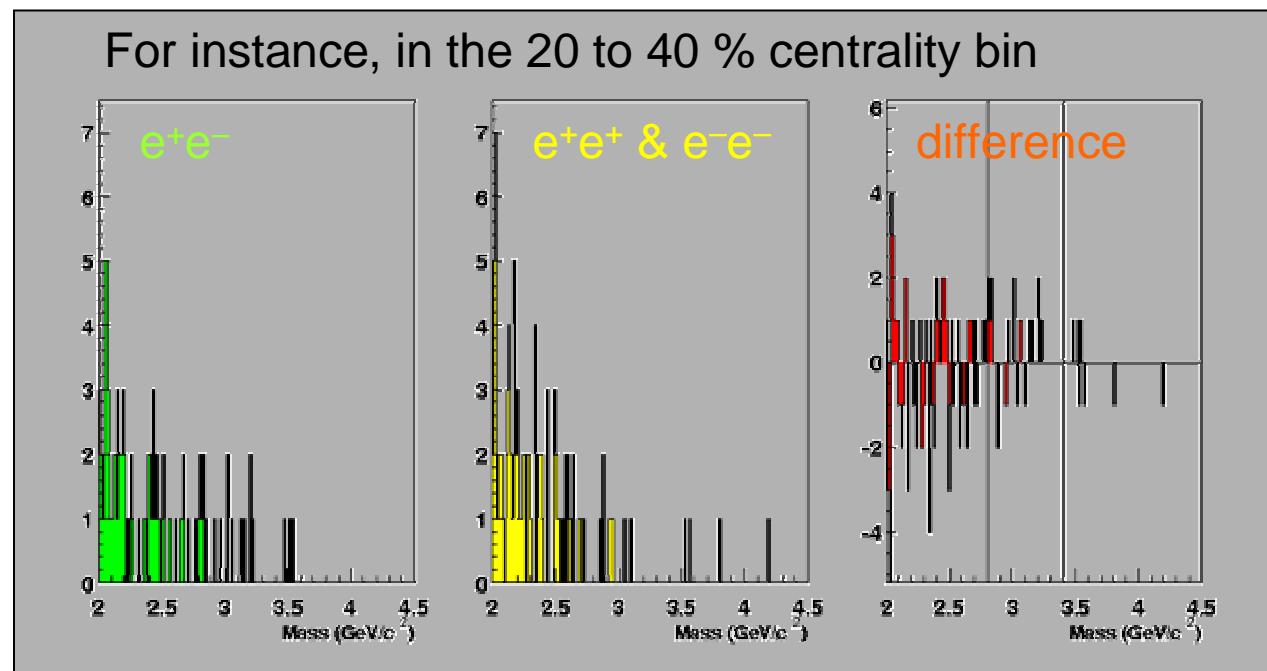
- Very low statistics !
- Extract signal expectation value from like sign and unlike sign likelihood distribs

J/Ψ versus centrality
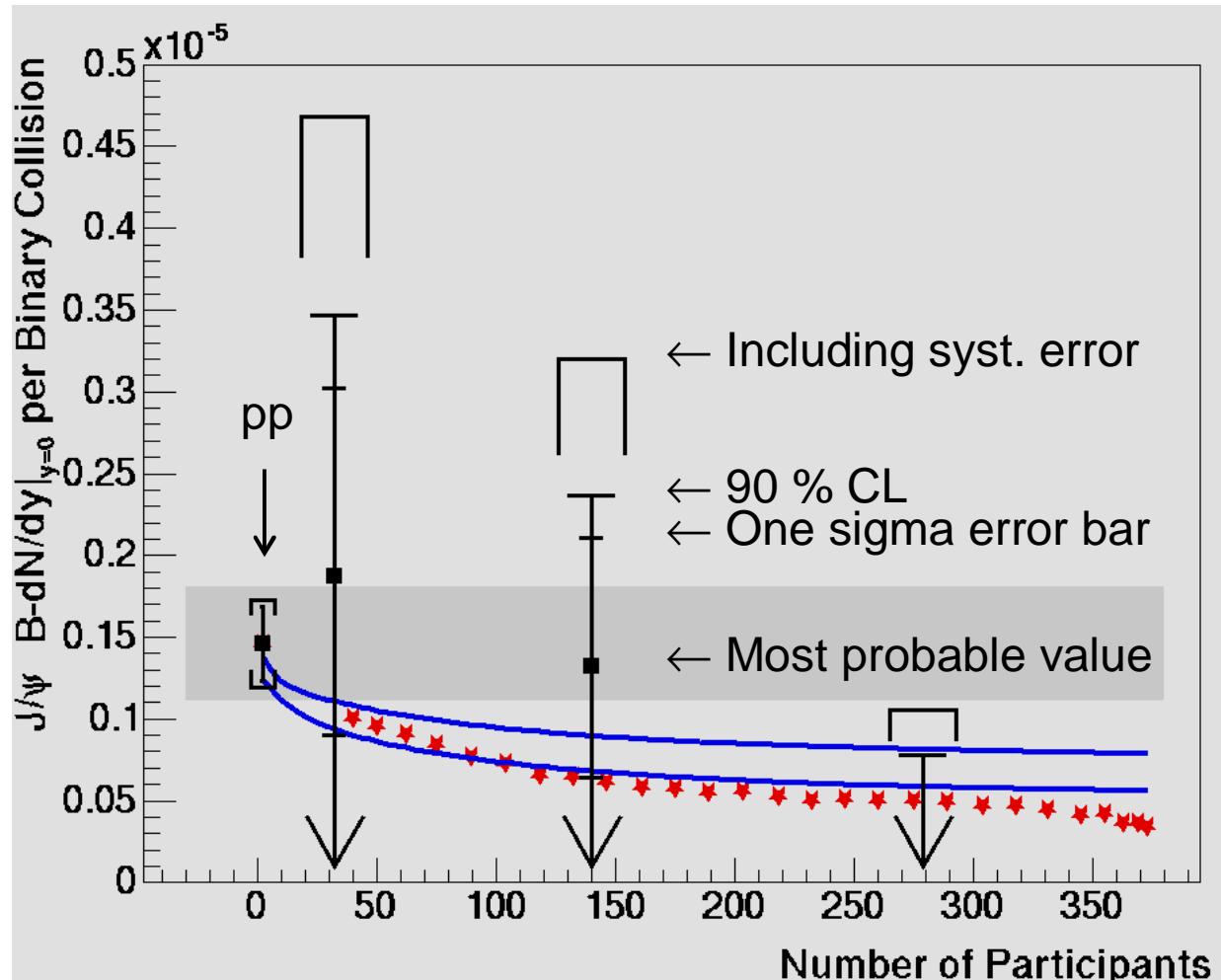
No event in most central bin.

Measurements are compatible with zero within 2σ.

← Binary scaling

← Nuclear absorption 4.4 and 7.1 mb

★ NA50 points normalized to pp for shape comparison

Available as nucl-ex/0305030, submitted to Phys. Rev. C

Comparison with models
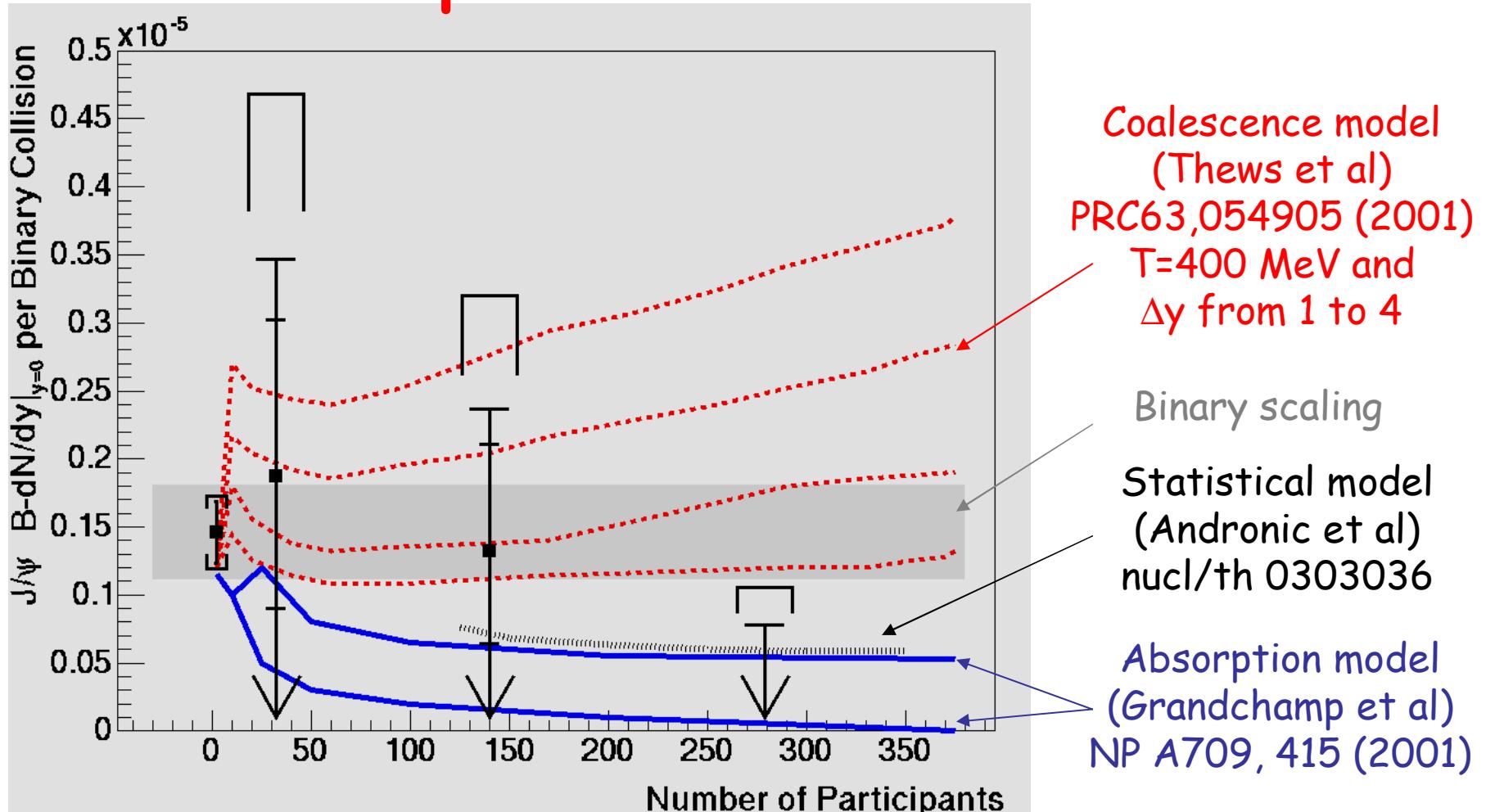
- ➢ Cannot distinguish between suppression models
- ➢ Disfavor strong enhancement wrt to binary scaling

J/Ψ in Deuteron + Gold

- Two muon arms fully commisioned !
- A partial analysis from subsets of data :
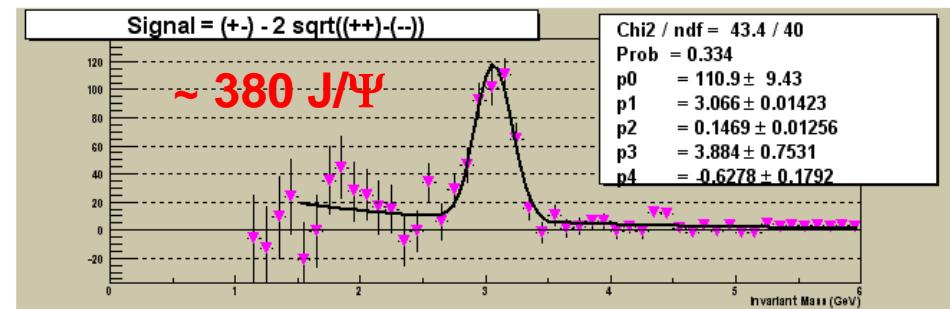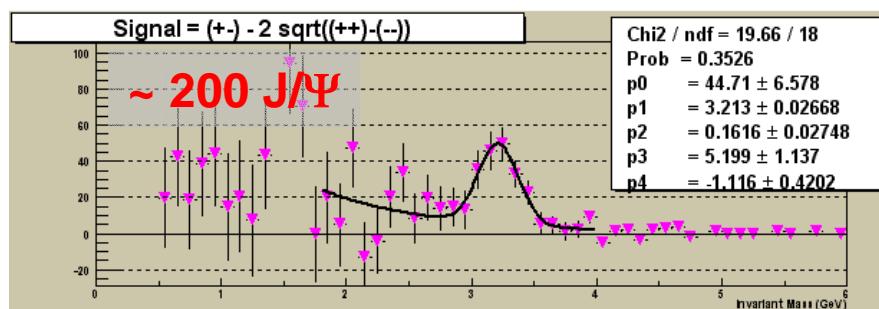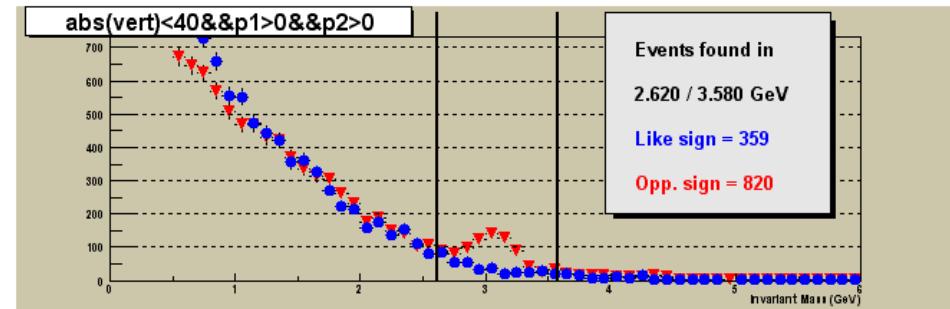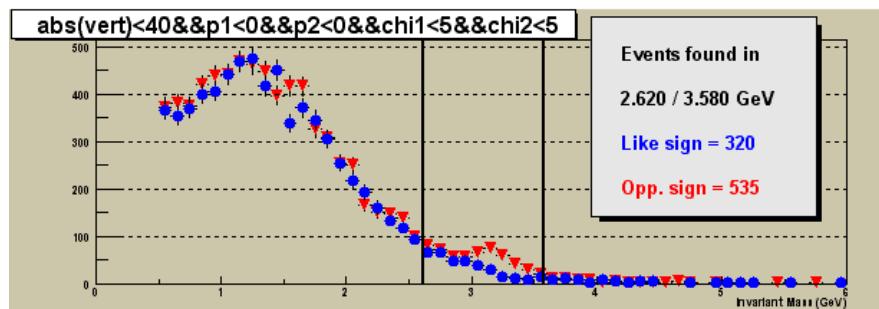
- Please, don't compare numbers !
  - Different cuts, no acceptance and efficiency corrections applied ! Analysis in progress...

Last run outcomes

d+Au expected statistics :

  ~ 1000 J/Ψ per muon arm

  ~ 400 J/Ψ in dielectron

Will give us valuable
information about
gluon shadowing.

Eskola, Kolhinen, Vogt
hep-ph/0104124
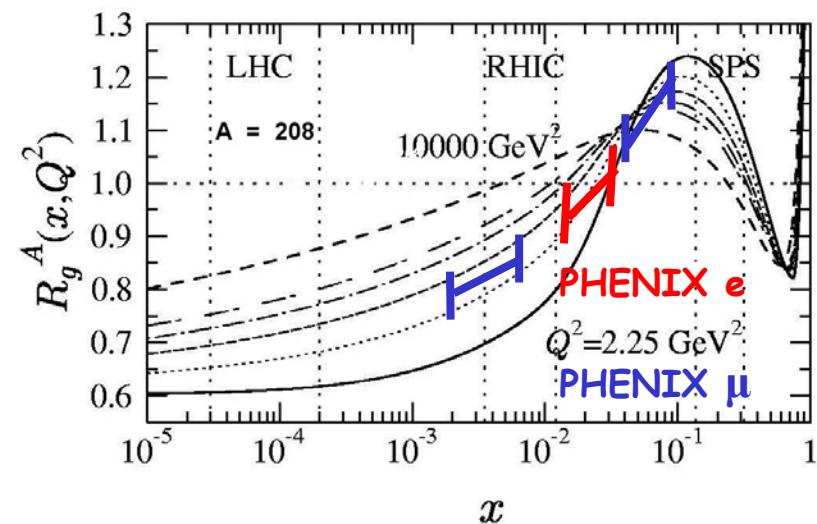
New p+p run should contain
a few hundred J/Ψ.
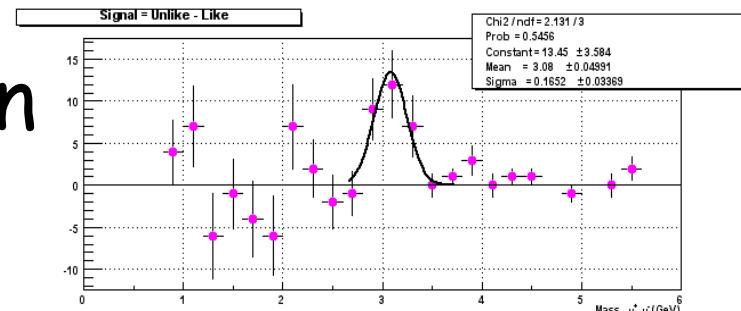
Conclusions

➢ p+p : J/Ψ cross section measured

    3.99 ± 0.61 (stat) ± 0.58 (sys) ± 0.40(abs) µb

    (to be submitted to PRL soon)

➢ Au+Au : High J/Ψ enhancement is disfavored.

    – We need more statistics !

➢ d+Au : Promissing statistics for gluon shadowing investigation…

➢ Au+Au run 4 should allow us to probe J/Ψ anomalous suppression !

    ~ Maybe 350 µb^{-1} effective luminosity

    ~ 3000 J/Ψ $\rightarrow$ µµ and 600 J/Ψ $\rightarrow$ ee (if not suppressed)

PHŒNIX

|	
Brazil	University of São Paulo, São Paulo
China	Academia Sinica, Taipei, Taiwan
	China Institute of Atomic Energy, Beijing
	Peking University, Beijing
France	LPC, University de Clermont-Ferrand, Clermont-Ferrand
	Dapnia, CEA Saclay, Gif-sur-Yvette
	IPN-Orsay, Universite Paris Sud, CNRS-IN2P3, Orsay
	LLR, Ecòle Polytechnique, CNRS-IN2P3, Palaiseau
	SUBATECH, Ecòle des Mines at Nantes, Nantes
Germany	University of Münster, Münster
Hungary	Central Research Institute for Physics (KFKI), Budapest
	Debrecen University, Debrecen
	Eötvös Loránd University (ELTE), Budapest
India	Banaras Hindu University, Banaras
	Bhabha Atomic Research Centre, Bombay
Israel	Weizmann Institute, Rehovot
Japan	Center for Nuclear Study, University of Tokyo, Tokyo
	Hiroshima University, Higashi-Hiroshima
	KEK, Institute for High Energy Physics, Tsukuba
	Kyoto University, Kyoto
	Nagasaki Institute of Applied Science, Nagasaki
	RIKEN, Institute for Physical and Chemical Research, Wako
	RIKEN-BNL Research Center, Upton, NY
	University of Tokyo, Bunkyo-ku, Tokyo
	Tokyo Institute of Technology, Tokyo
	University of Tsukuba, Tsukuba
	Waseda University, Tokyo
S. Korea	Cyclotron Application Laboratory, KAERI, Seoul
	Kangnung National University, Kangnung
	Korea University, Seoul
	Myong Ji University, Yongin City
	System Electronics Laboratory, Seoul Nat. University, Seoul
	Yonsei University, Seoul
Russia	Institute of High Energy Physics, Protovino
	Joint Institute for Nuclear Research, Dubna
	Kurchatov Institute, Moscow
	PNPI, St. Petersburg Nuclear Physics Institute, St. Petersburg
	St. Petersburg State Technical University, St. Petersburg
Sweden	Lund University, Lund

USA — Abilene Christian University, Abilene, TX
Brookhaven National Laboratory, Upton, NY
University of California - Riverside, Riverside, CA
University of Colorado, Boulder, CO
Columbia University, Nevis Laboratories, Irvington, NY
Florida State University, Tallahassee, FL
Georgia State University, Atlanta, GA
University of Illinois Urbana Champaign, Urbana-Champaign, IL
Iowa State University and Ames Laboratory, Ames, IA
Los Alamos National Laboratory, Los Alamos, NM
Lawrence Livermore National Laboratory, Livermore, CA
University of New Mexico, Albuquerque, NM
New Mexico State University, Las Cruces, NM
Dept. of Chemistry, Stony Brook Univ., Stony Brook, NY
Dept. Phys. and Astronomy, Stony Brook Univ., Stony Brook, NY
Oak Ridge National Laboratory, Oak Ridge, TN
University of Tennessee, Knoxville, TN
Vanderbilt University, Nashville, TN   *as of July 2002

12 Countries; 57 Institutions; 460 Participants*

Spare slides

Au+Au centrality
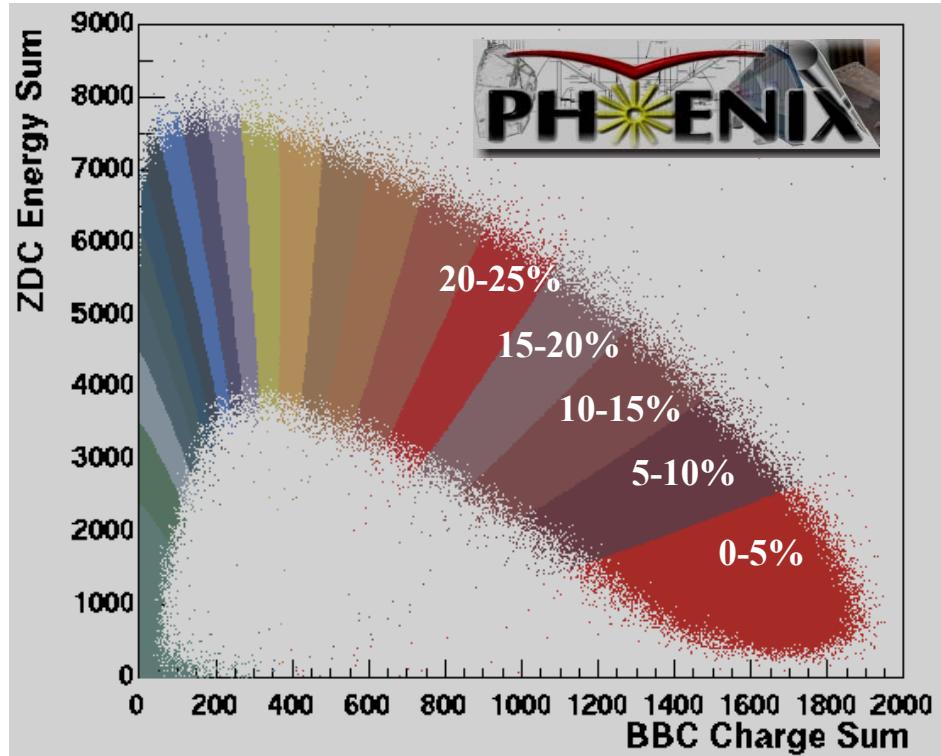
Centrality	N_{part}	N_{bin}
0-20 %	279	779
20-40 %	140	296
40-90 %	32	45
0-90 %	111	263

Au+Au signal determination

20-40 % centrality bin

- **Signal likelihood distribution from**
  - Unlike sign and
  - like sign counts

- **Renormalize to correct for unphysical negative values.**

- **Other contributions :**
  - J/Ψ from B decay : 1 to 4 %
  - Open charm : 0.02 to 0.1 signal events
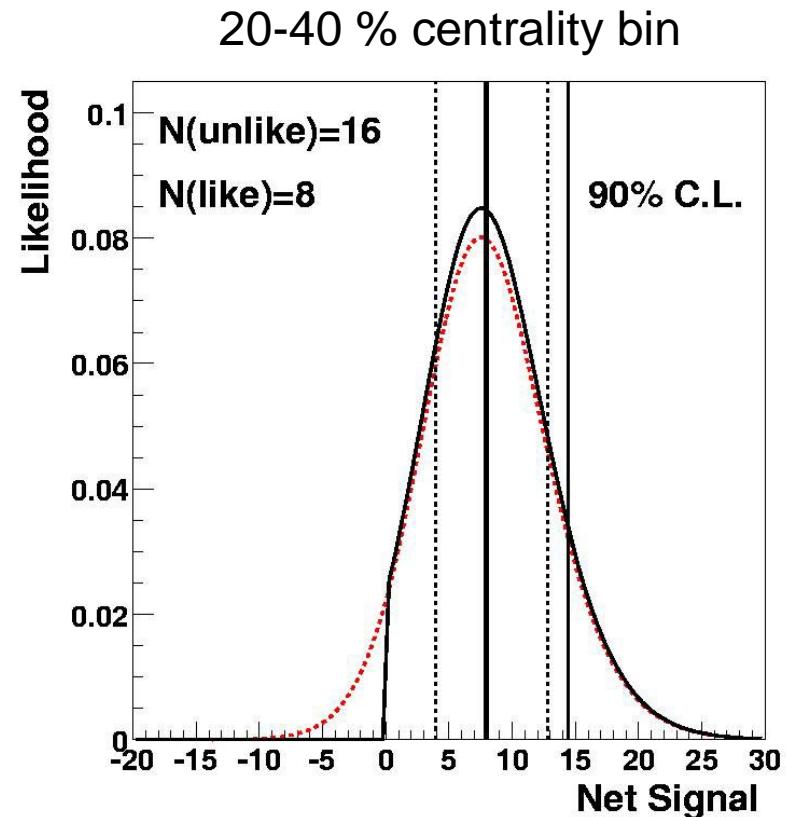
Au+Au yields

$$B \, dN/dy|_{y=0} \, (\times 10^{-4})$$

Centrality	Most likely value	90% C.L.U.L.
0-20 %	No counts	6.08 + 1.56 (sys)
20-40 %	$4.00^{+2.34}_{-2.01}{}^{+1.36}_{-1.60}$	7.19 + 2.43 (sys)
40-90 %	$0.86^{+0.52}_{-0.44}{}^{+0.29}_{-0.35}$	1.60 + 0.54 (sys)