Recent results on anomalous J/ψ suppression in Pb-Pb collisions at 158 GeV/c per nucleon

H. Santos, LIP-Lisbon, for the NA50 Collaboration

[1] Università del Piemonte Orientale, Alessandria and INFN-Torino, Italy [2] LAPP, CNRS-IN2P3, Annecy-le-Vieux, France [3] LPC, Univ. Blaise Pascal and CNRS-IN2P3, Aubière, France [4] IFA, Bucharest, Romania [5] Università di Cagliari/INFN, Cagliari, Italy [6] CERN, Geneva, Switzerland [7] LIP, Lisbon, Portugal [8] INR, Moscow, Russia [9] IPN, Univ. de Paris-Sud and CNRS-IN2P3, Orsay, France[10] Laboratoire Leprince-Ringuet, Ecole Polytechnique and CNRS-IN2P3, Palaiseau, France[11] Università di Torino/INFN, Torino, Italy[12] IPN, Univ. Claude Bernard Lyon-I and CNRS-IN2P3, Villeurbanne, France

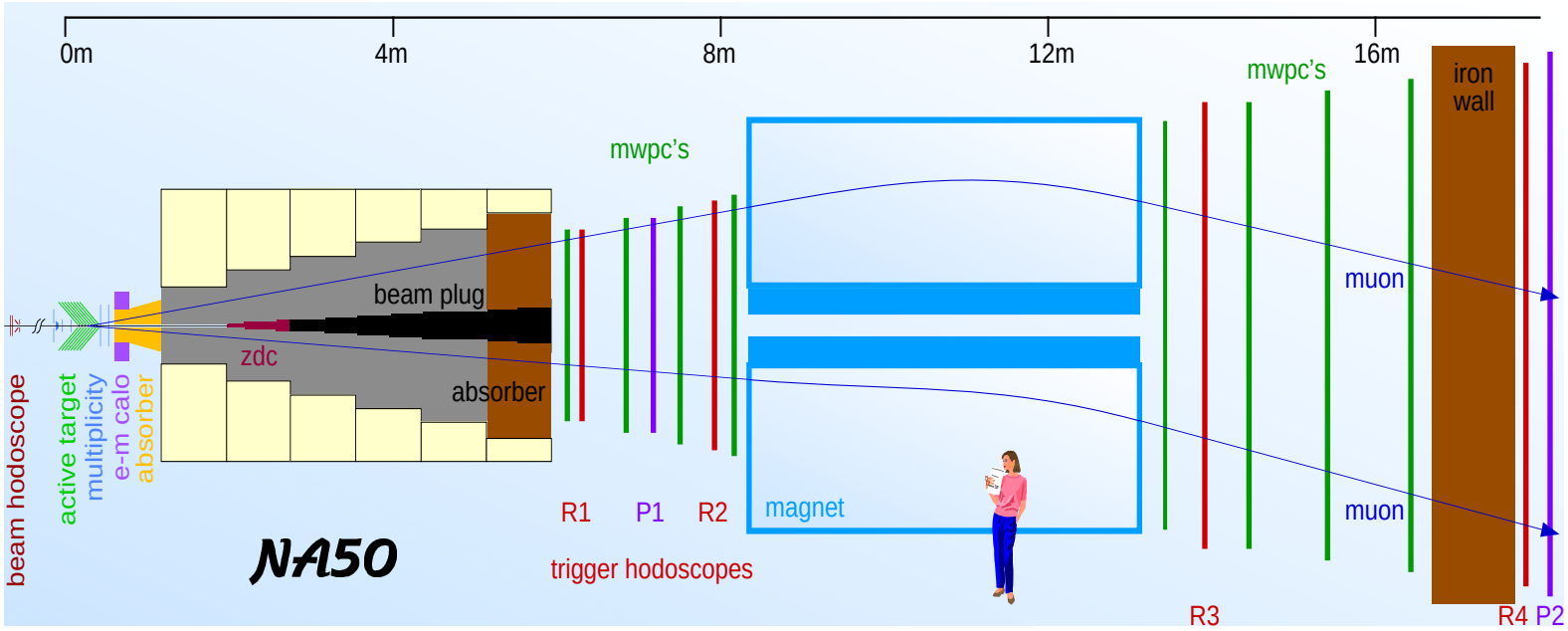
Outline

- NA50 Dimuon Spectrometer
- Before 2000 - The state of the art
- Goals of the Pb-Pb2000 data taking
- Standard Analysis Procedure
- Pb-Pb2000 Results
- Summary

The NA50 Experiment

The main goal is to measure J/ψ and Drell-Yan yields in order to search for the formation of the Quark Gluon Plasma

The Dimuon Spectrometer

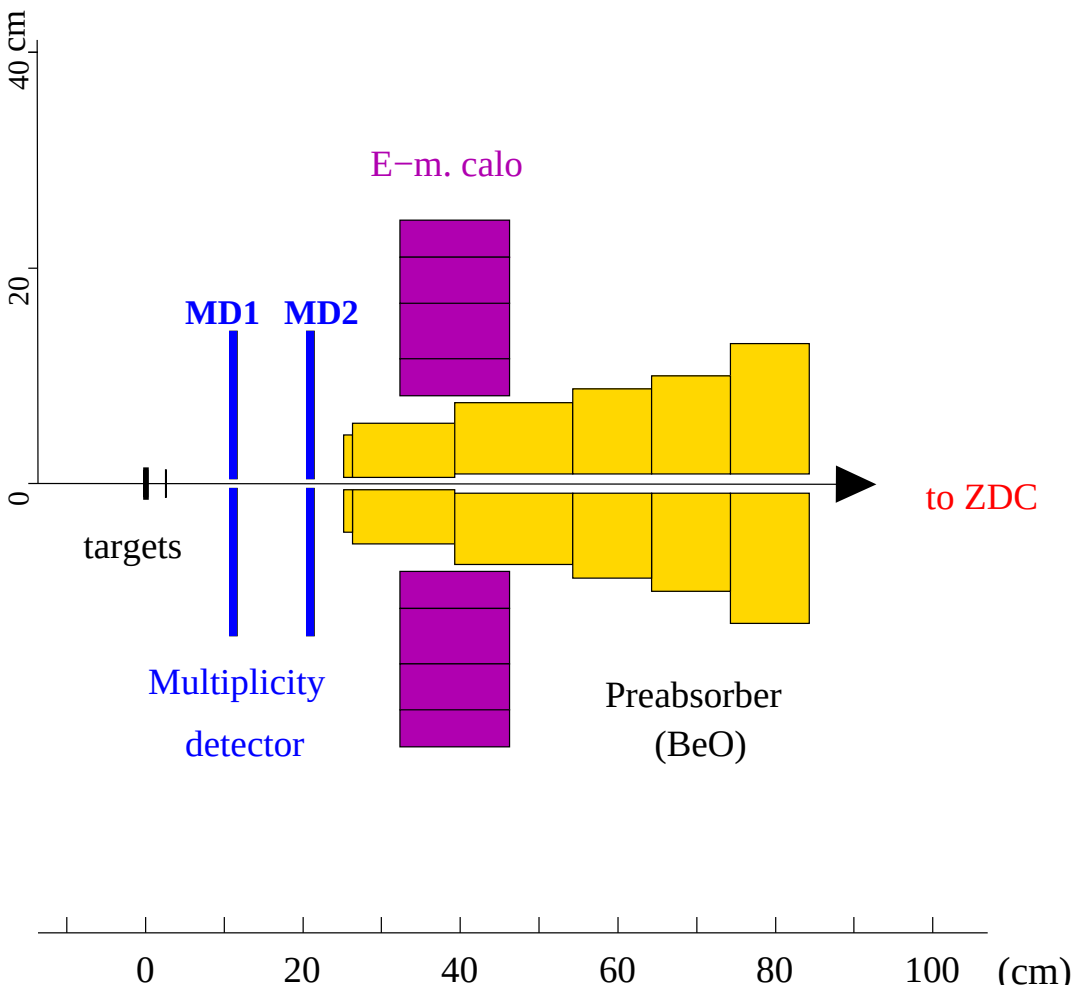


Kinematical Domain: $0 \leq y_{CM} < 1 \;\; (2.92 \leq y_{lab} < 3.92) \quad \mid cos\theta_{CS} \mid < 0.5$

Acceptances: $Acc(J/\psi) = 13.5\%$

$Acc(DY) = 14.5\%$ (in $2.9 \leq M_{\mu\mu} < 4.5\ GeV/c^2$)

Beam Hodoscope (BH): Identifies and counts the incoming ions



- **Centrality Detectors:**

◇ **E.M. Calorimeter**

$$1.1 \leq \eta_{lab} < 2.3$$

◇ **Zero Degree Calorimeter**

$$\eta_{lab} > 6.3$$

◇ **Multiplicity Detector**

$$1.5 \leq \eta_{lab} < 3.9$$

Collision centrality measured simultaneously by neutral transverse energy, forward energy and charged particle multiplicities

Before 2000 - The state of the art

NA50 is an upgrade of the NA38 spectrometer and uses proton and lead beams colliding on fix targets

Main improvements

◇ **Magnetic current increased from 4000A to 7000A**

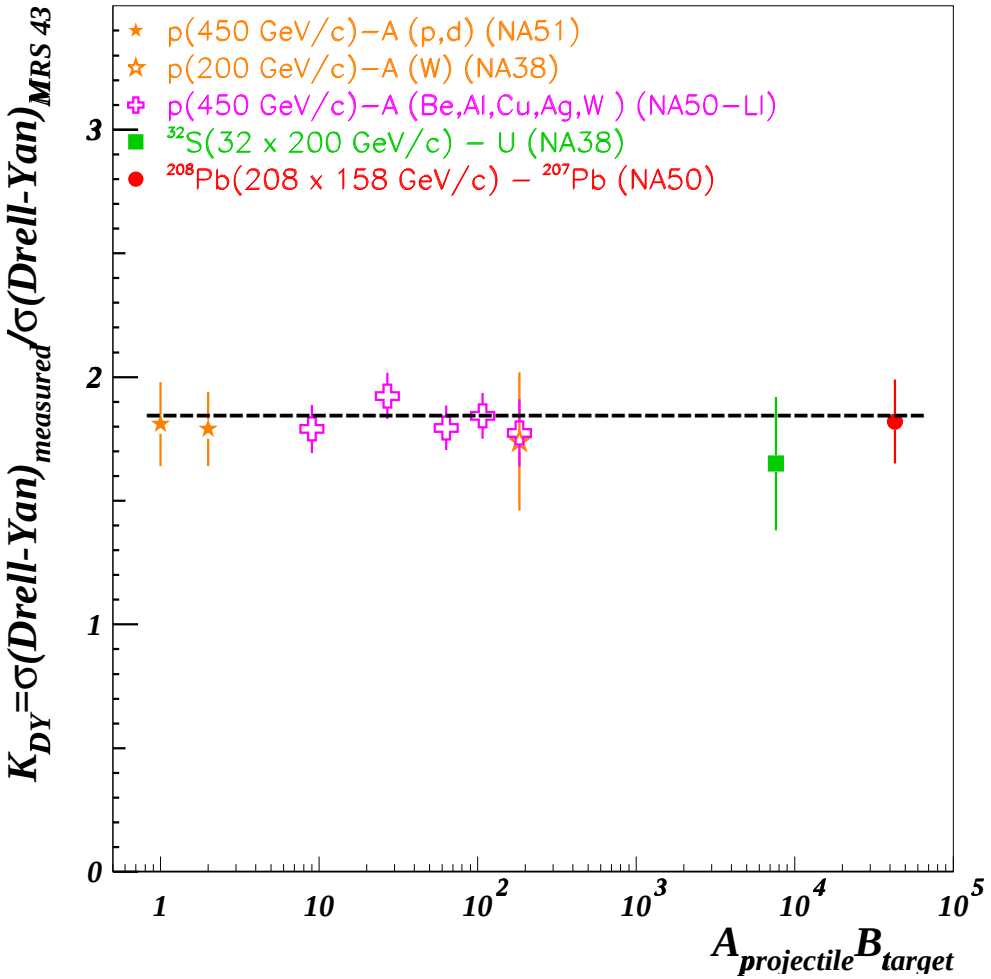
↪ **better mass resolution for high masses (3.3% for J/ψ)**

◇ **Additional centrality detectors: ZDC and MD**

data period	total target thickness	number of sub-targets	target region	beam intensity (ions/burst)	number of J/ψ
1995	17% λ_I	7	air	3×10^7	50000
1996	30% λ_I	7	air	5×10^7	190000
1998	7% λ_I	1	air	5.5×10^7	40000

Before 2000 - The state of the art (2)

Reference for J/ψ production: Drell-Yan

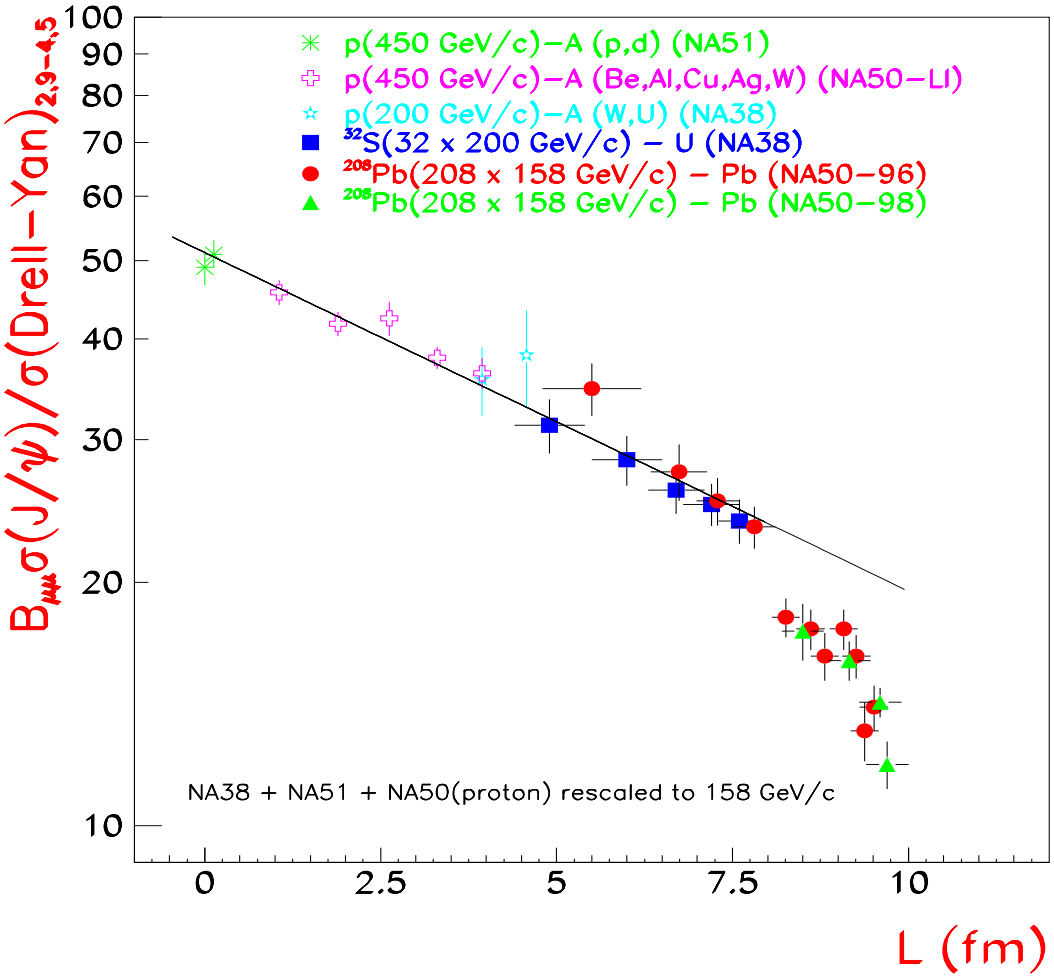


- σ**(DY) is proportional to the number of nucleon-nucleon collisions from p-p up to Pb-Pb**

$\hookrightarrow$ **Good normalization for** $\sigma(J/\psi)$

Before 2000 - The state of the art (3)

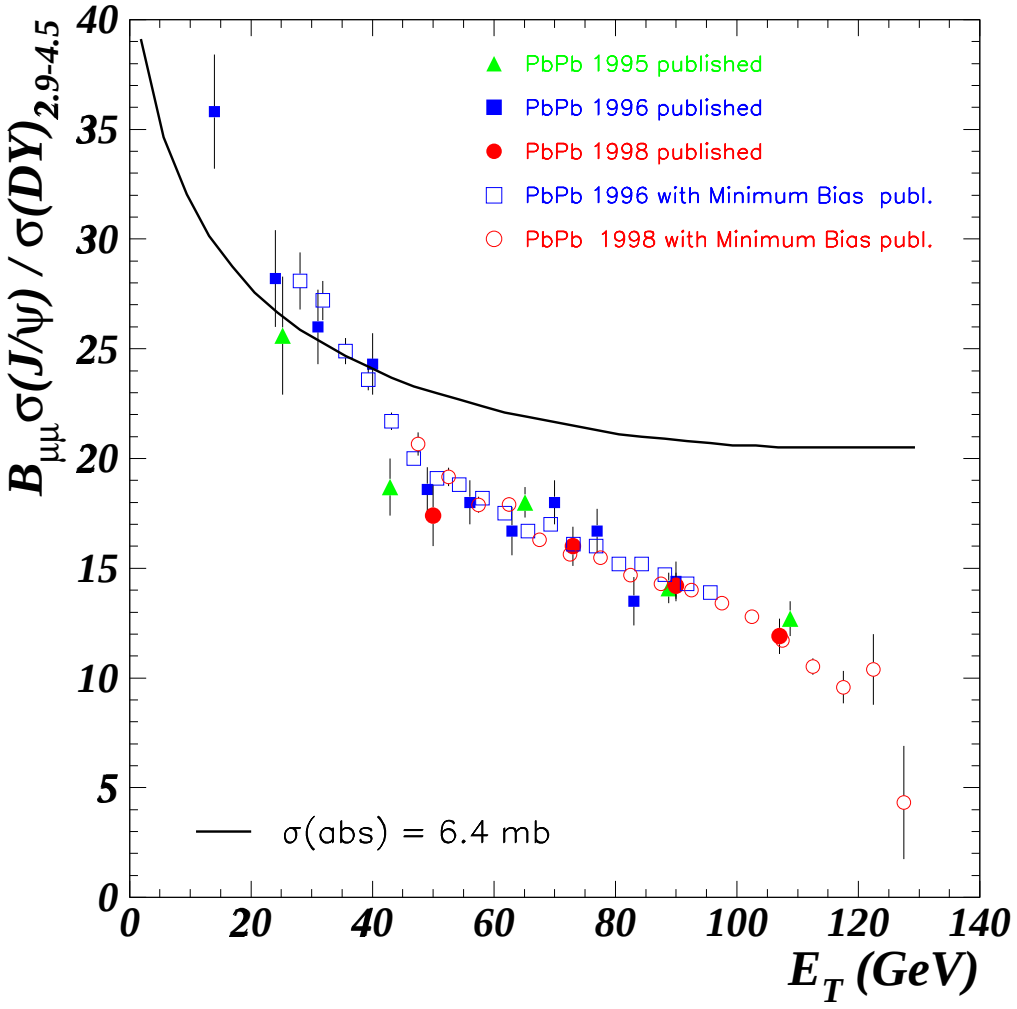
$J/\psi/DY$ as a function of L



- L **is the mean free path length crossed by the** $c\bar{c}$ **pair in the nuclear matter**
- **Clear departure of** $J/\psi/DY$ **from the absorption curve at** $L = 8 \ fm$

Before 2000 - The state of the art (4)

$J/\psi/DY$ as a function of E_T



- **The absorption curve fits our lighter systems: NA51 and NA38 p-A and S-U**
- **Sharp decrease of $J/\psi/DY$ at $\approx$ 40 GeV**
- **No saturation of $J/\psi/DY$ at high E_T**

The last 2000 data taking

- **Goal of Pb-Pb 2000 run:**

  To investigate peripheral Pb-Pb collisions

  $\hookrightarrow$ **The target region up to the pre-absorber (BeO) is placed in vacuum**

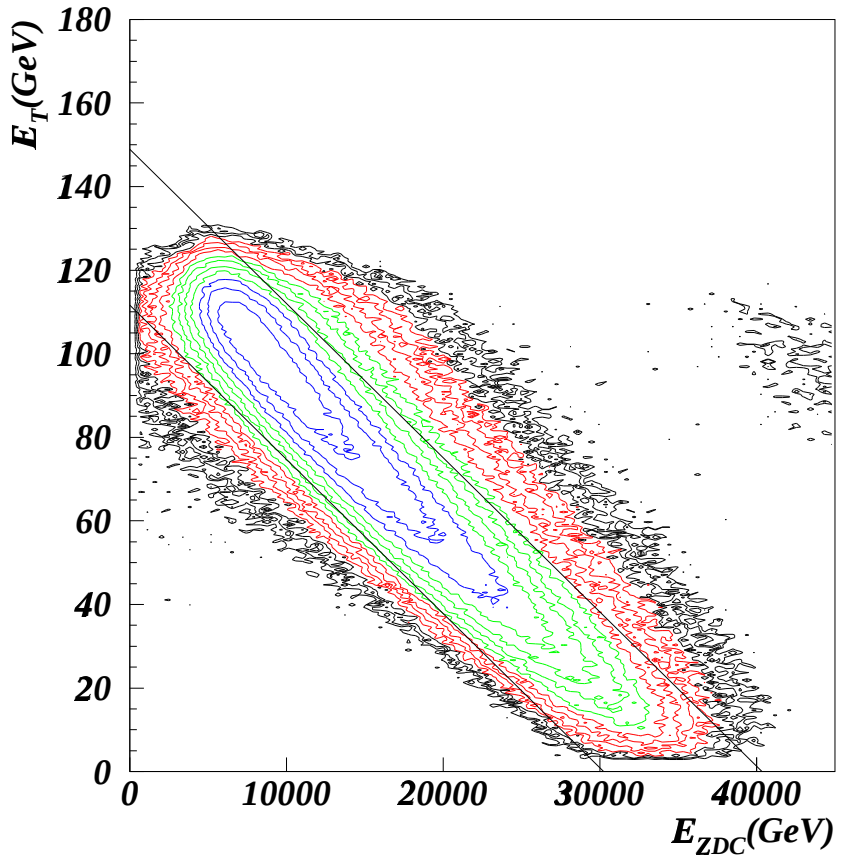
◇ **1 single target with 9.5%** λ_I **(in vacuum)**

◇ **Beam intensity =** 7×10^7 **ions/burst**

◇ $\approx$ **120000** J/ψ **collected**

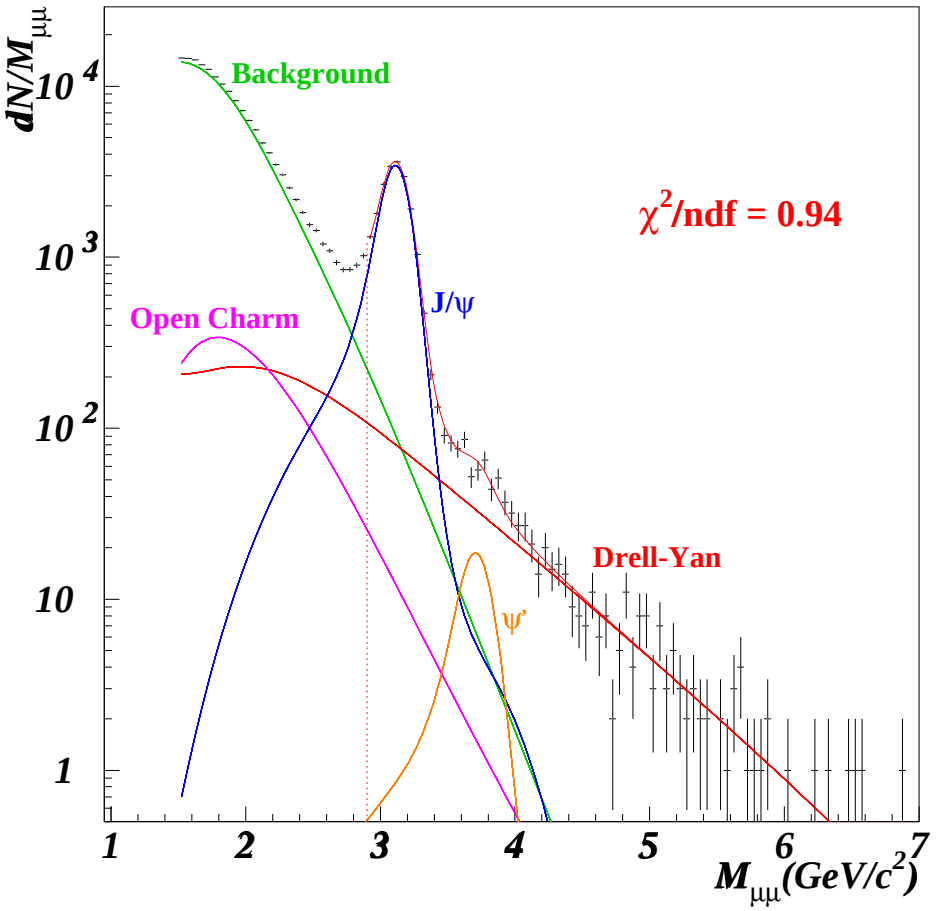
Pb-Pb00 - Data Selection

- Interactions in the Beam Hodoscope (BH) and upstream from the target are rejected by a BH interaction detector and Anti-halo counters
- Primary interaction location: Two planes of silicon microstrip detectors, MD1 and MD2, identify target interactions
- Residual pileup interactions are rejected by $E_T - E_{ZDC}$ correlation



Standard Analysis Procedure

$$\frac{dN^{+-}}{dM} = A_{J/\psi}\frac{dN_{J/\psi}}{dM} + A_{\psi'}\frac{dN_{\psi'}}{dM} + A_{DY}\frac{dN_{DY}}{dM} + A_{D\bar{D}}\frac{dN_{D\bar{D}}}{dM} + \frac{dN_{BG}}{dM}$$

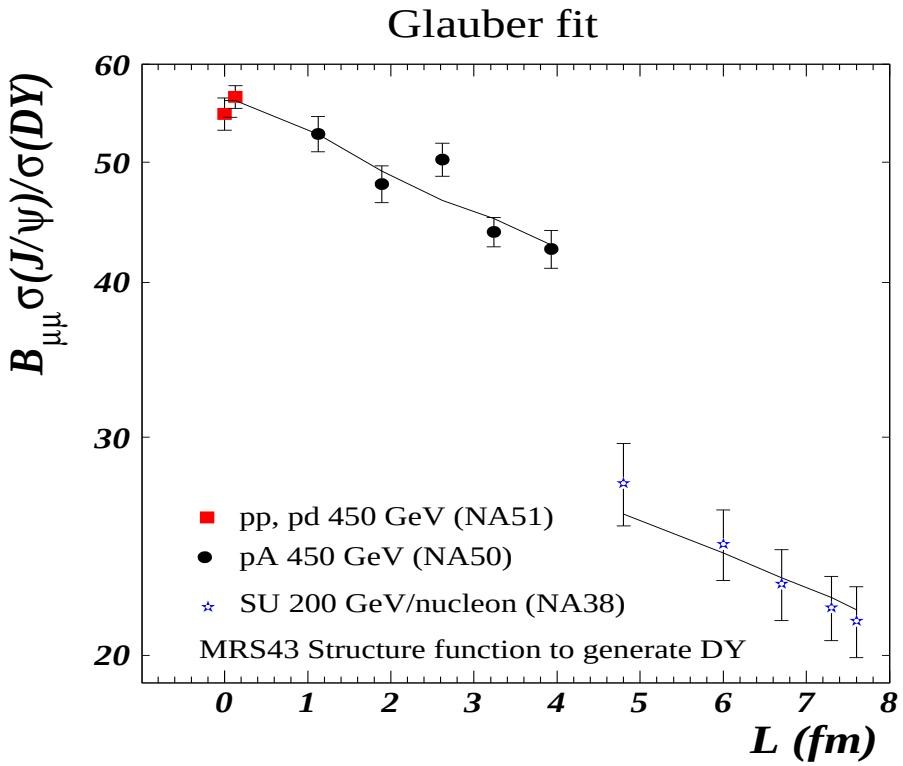


- **Final fit performed for** $M > 2.9\ GeV/c^2$
- J/ψ, ψ', DY **and** $D\bar{D}$ **shapes obtained by Monte Carlo**
- **Combinatorial background from pion and kaon decays is extracted from like-signs pairs, using:**

$$N_{BG} = 2\sqrt{N^{++}N^{--}}$$

The J/ψ normal absorption

New NA50 high statistics p-A data combined with reanalysis of NA38 S-U data constitutes a new baseline to check the behaviour of anomalous J/ψ suppression against normal nuclear absorption

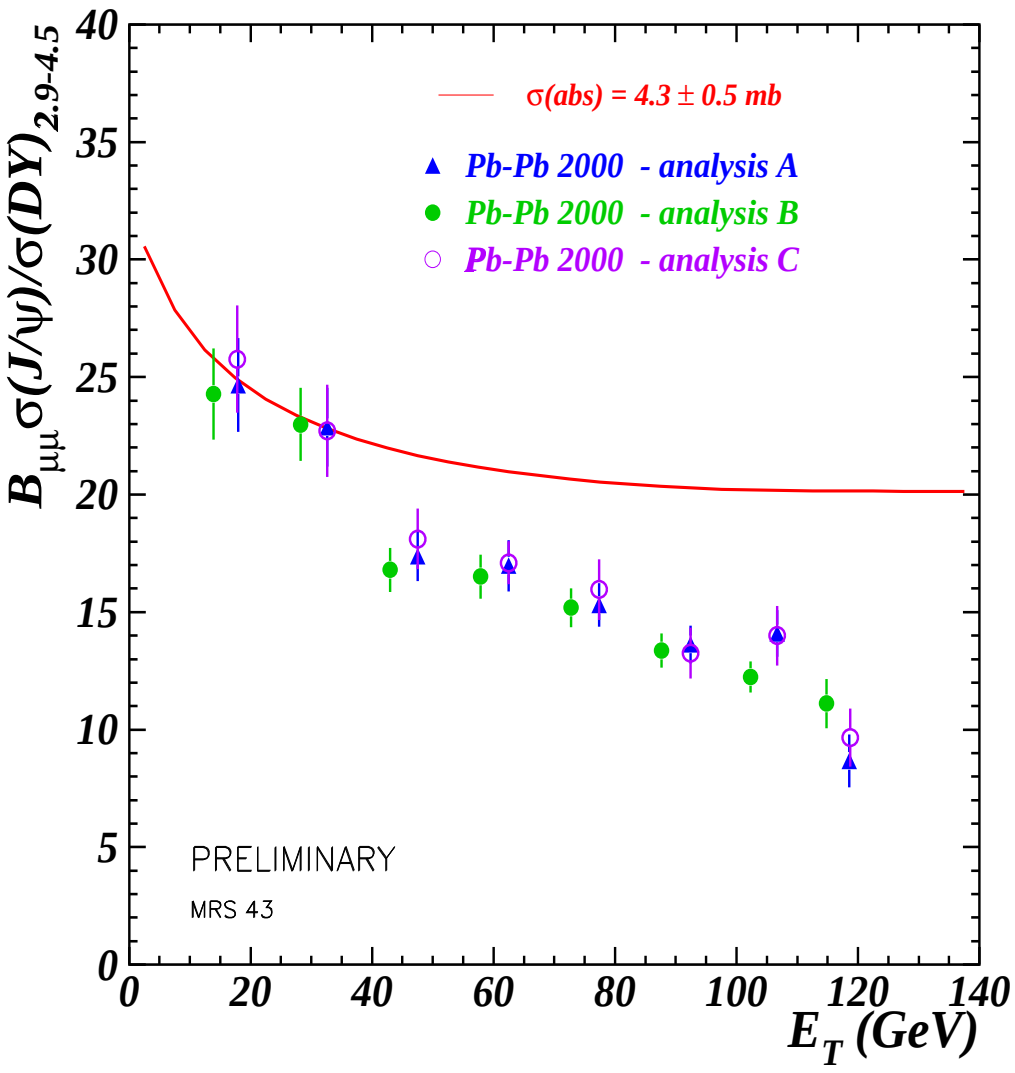


- **Using a Glauber model fit, the absorption cross-section for J/ψ obtained is**

$$\sigma_{abs} = 4.3 \pm 0.5 \ mb$$

Pb-Pb 2000 Results

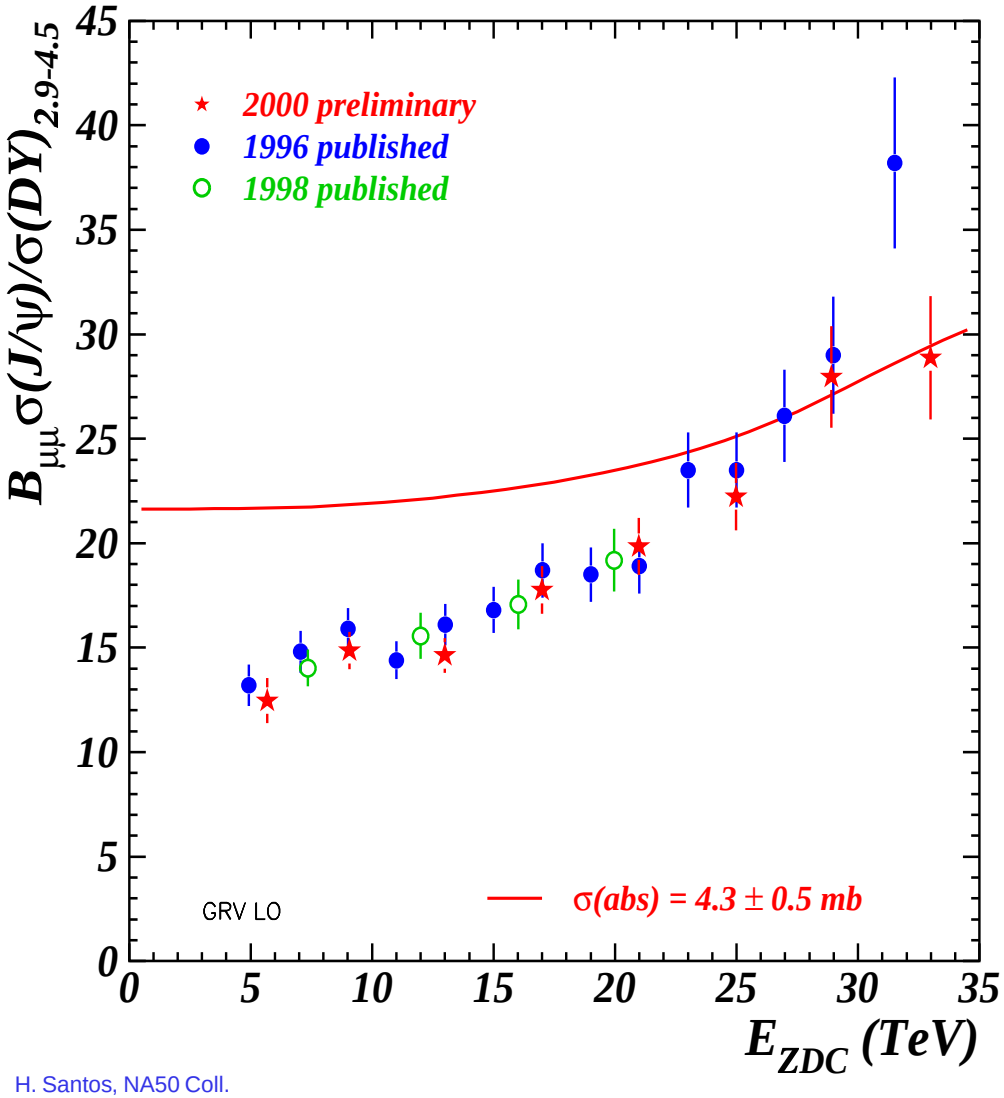
Transverse energy, E_T, used as the centrality collision estimator



- **Independent analyses from 3 Laboratories (different data selections and fit methods) agree within few percent**
- **Peripheral collisions are in agreement with the new absorption curve**
- **Departure of $J/\psi/DY$ at mid-centrality from the absorption curve**
- **No saturation at high E_T**

Pb-Pb 2000 Results (2)

Forward energy, E_{ZDC}, used as the centrality collision estimator

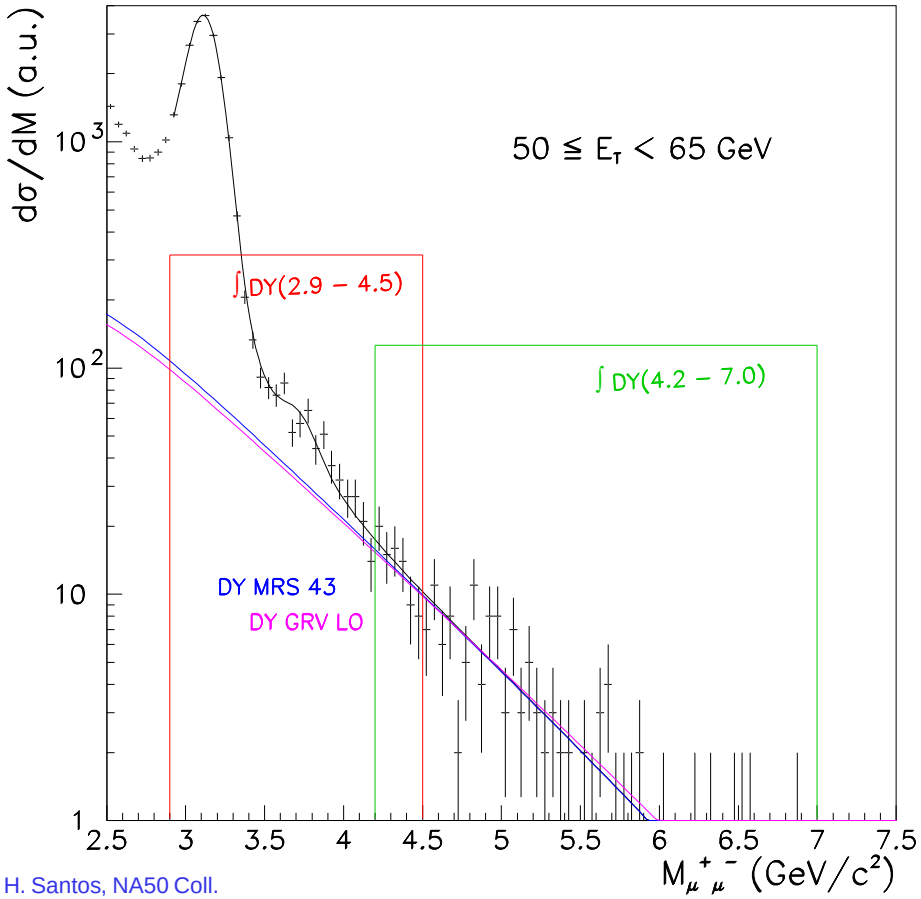


- **2000 data in good agreement with published analyses (except for most peripheral collisions, probably due to Pb-air interactions in 1996 setup conditions)**
- **Departure of $J/\psi/DY$ at mid-centrality from the absorption curve**
- **No saturation at low E_{ZDC}**

Pb-Pb2000 - New reference: Drell-Yan in 4.2-7.0 GeV/c^2

In the same invariant mass range (2.9-4.5 GeV/c^2) muons from J/ψ and Drell-Yan have similar features, namely acceptance and momentum.

Nevertheless, different structure functions chosen to generate Drell-Yan lead to different mass distributions



- σ_{DY}**(2.9-4.5) is determined by the measured** σ_{DY}**(4.2-7.0), but MRS 43 and GRV LO have different mass distributions**

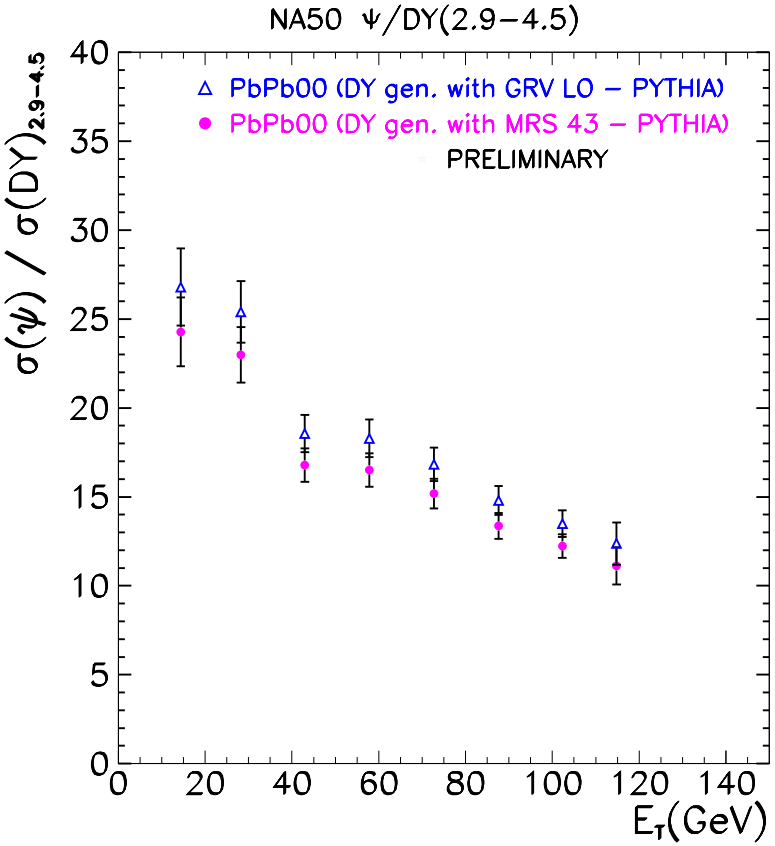
  $\Rightarrow$ **different** $J/\psi/DY_{2.9-4.5}$ **ratios**

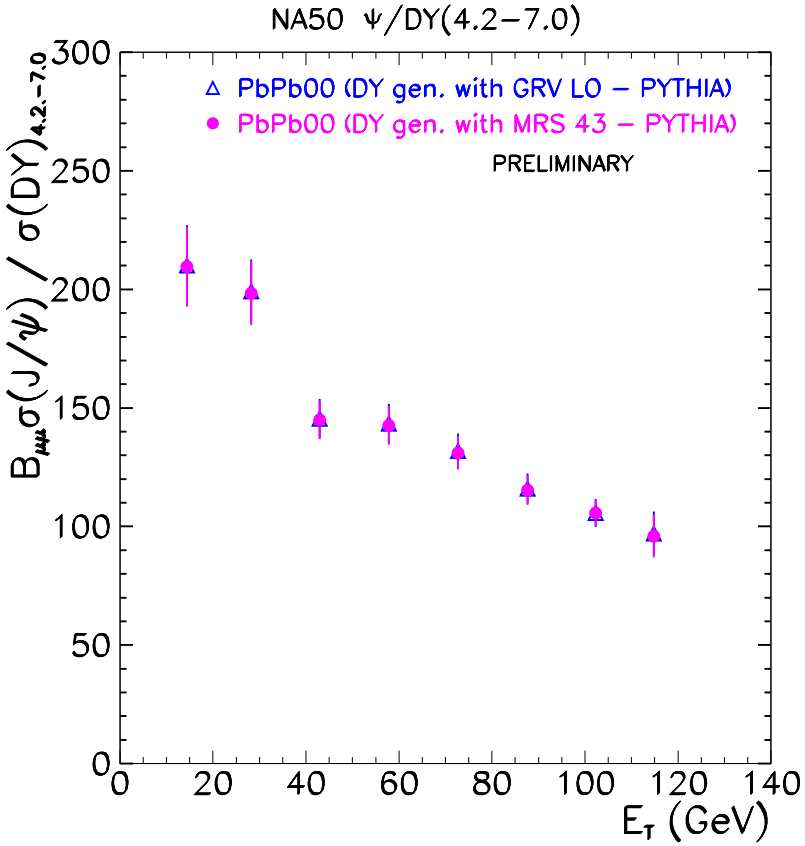
- **Both structure functions give the same** σ_{DY} **in the measured region: 4.2-7.0 GeV/c^2**

  $\Rightarrow$ **same** $J/\psi/DY_{4.2-7.0}$ **ratios**

Pb-Pb2000 - New reference: Drell-Yan in 4.2-7.0 GeV/c^2 (2)

Comparison between ψ/DY ratios fitted with Drell-Yan obtained with GRV LO and MRS 43 structure functions

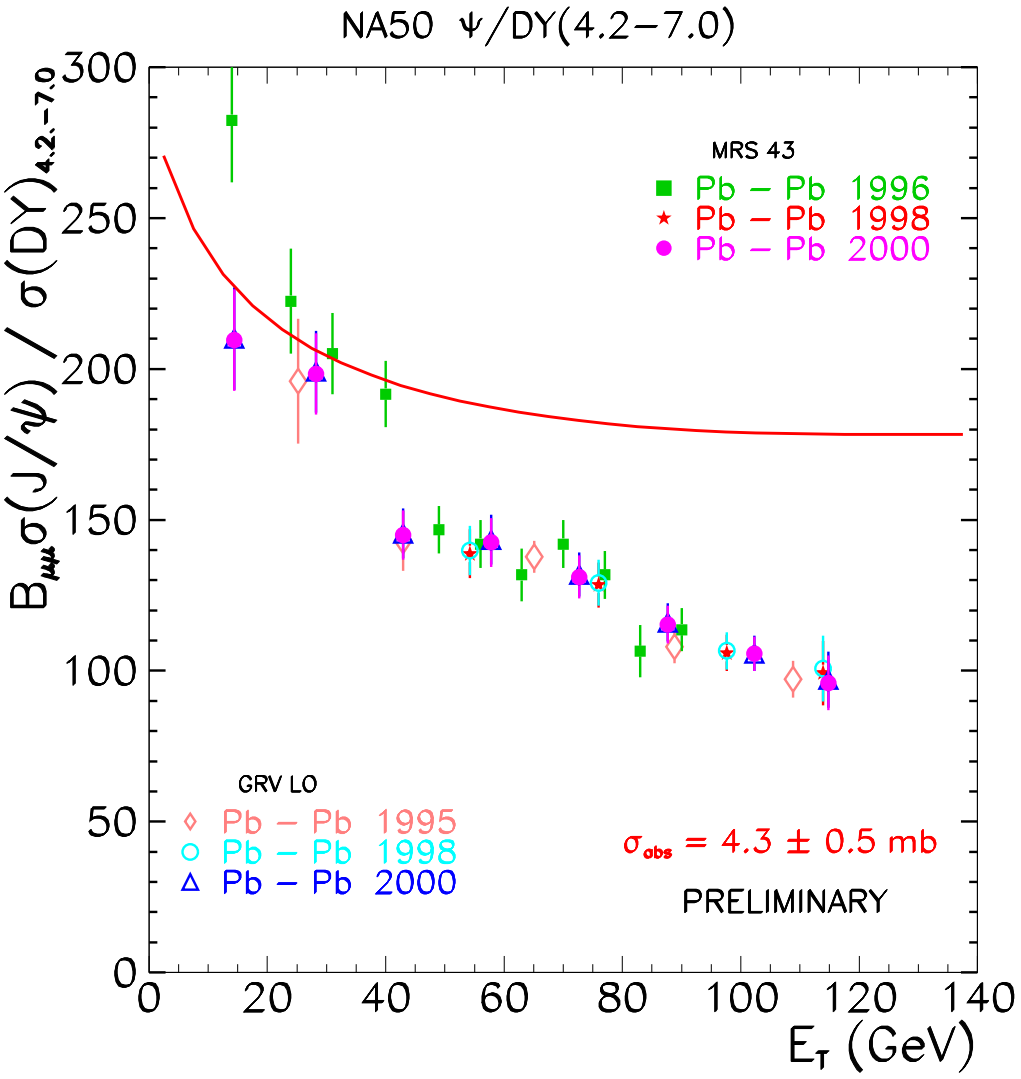




In 4.2-7.0 mass domain, the $J/\psi/DY$ ratio does not depend on parton distribution functions

Pb-Pb Results: DY(4.2-7.0)

Transverse energy, E_T, used as the centrality collision estimator



- $J/\psi/DY$ **ratios are independent on PDF chosen to generate Drell-Yan**
- **Comparison with previous data takings shows good agreement, (except for the most peripheral point in 1996)**

Summary

- **Before 2000, NA50 results for lead-lead collisions show an anomalous suppression of J/ψ as a function of L, E_T and E_{ZDC}**
- **The Pb-Pb 2000 data, with the target region placed in vacuum, shows:**
  - ◇ **The peripheral points are in agreement with the new absorption curve (our lighter systems)**
  - ◇ **Departure of $J/\psi/DY$ from the absorption curve at mid-centrality**
  - ◇ **No visible saturation of $J/\psi/DY$ ratio at high E_T**
- **A new Drell-Yan reference (not PDF dependent) is taken:**
  $4.2 - 7.0 GeV/c^2$
  ↪ **A good agreement is observed among all Pb-Pb data**