Latest results on J/ψ suppression

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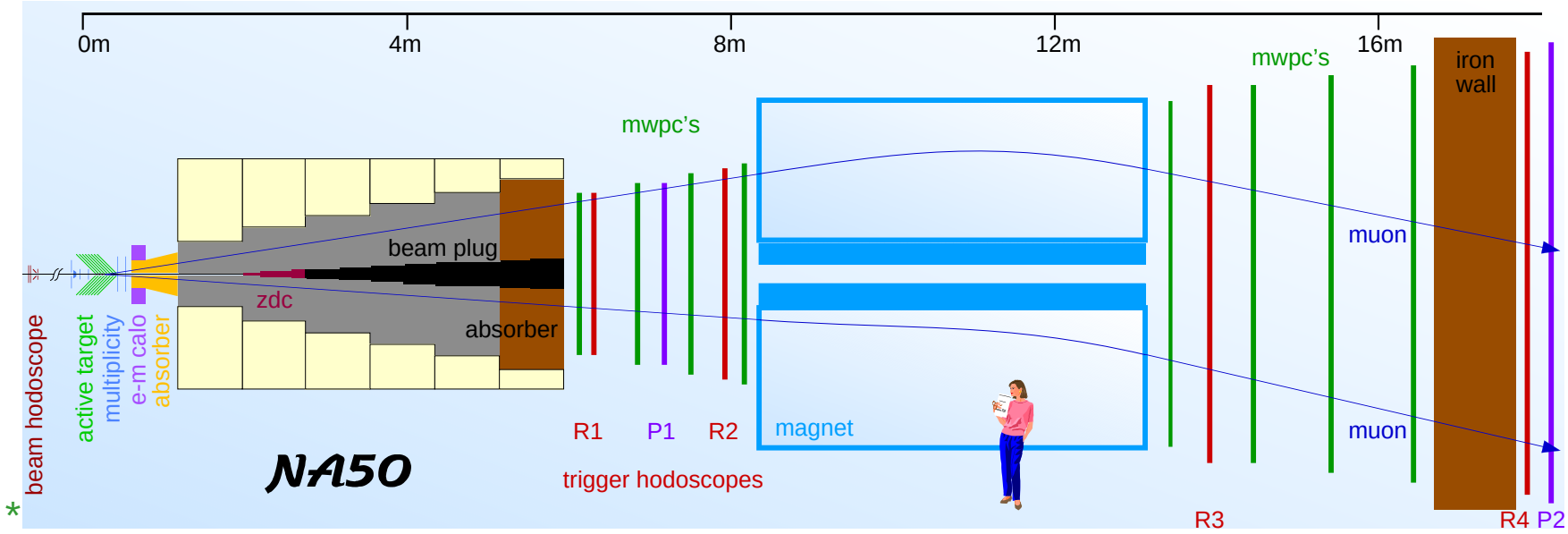
for the

NA50 Collaboration

Alessandria, Annecy, Aubière, Bucharest, Cagliari, CERN,

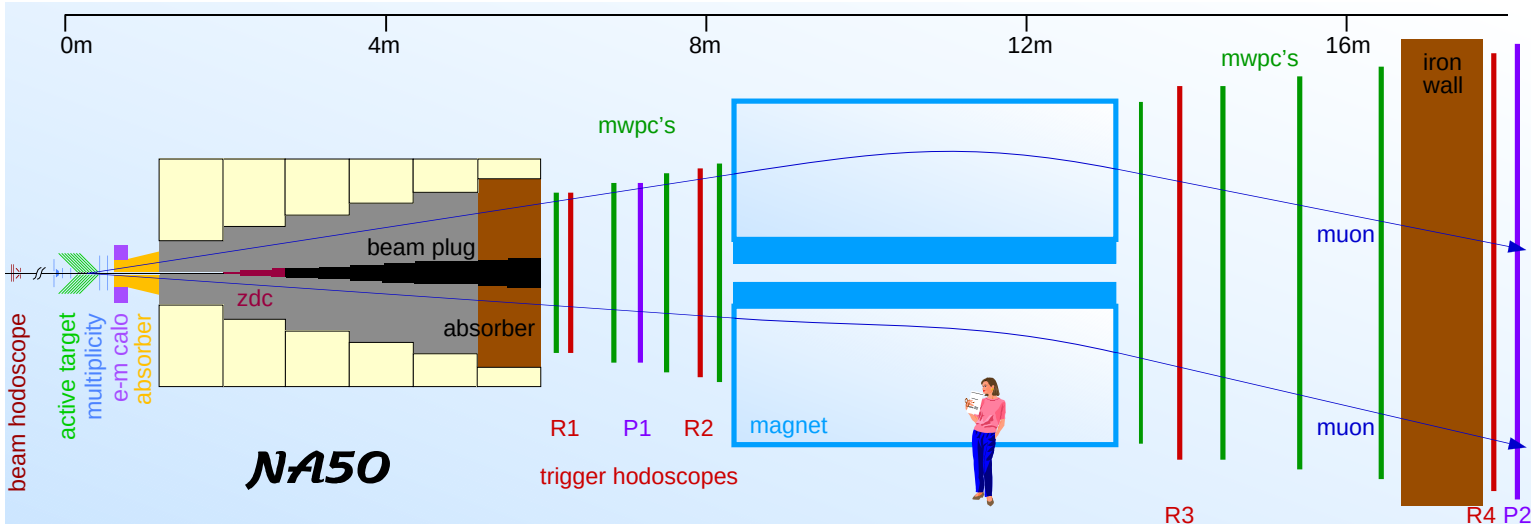
Lisbon, Moscow, Orsay, Palaiseau, Torino, Villeurbanne, Yerevan



Outline

- The experimental apparatus
  $\hookrightarrow$ Main detectors and kinematical domain
- Published NA50 results on charmonium
- Goals and tools for year 2000 run
- The Drell-Yan process: The reference
- J/ψ normal absorption: The baseline
- The anomalous J/ψ suppression as a function of:
  $\hookrightarrow$ The transverse energy (E_T)
  $\hookrightarrow$ The forward energy (E_{ZDC})
- Comparison with previous data takings
- Conclusions

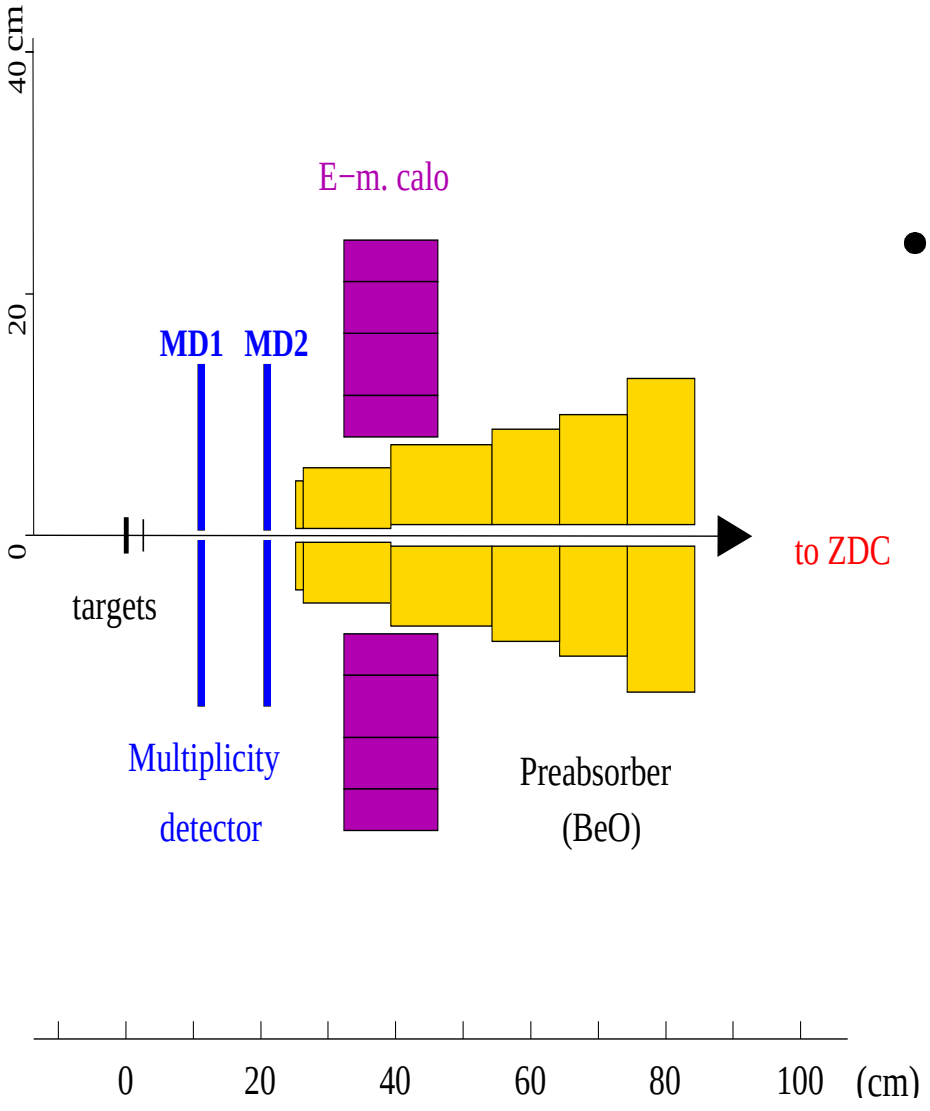
Experimental setup



J/ψ is detected via its decay into muon pairs $J/\psi \to \mu^+\mu^-$

- Dimuon detection in:
  - $\hookrightarrow 0 < y_{CM} < 1 \quad (2.92 < y_{Lab} < 3.92) \quad |\cos\theta_{CS}| < 0.5$
- Acceptances:
  - $\hookrightarrow \mathcal{A}_{J/\psi}$ = 13.5 %
  - $\hookrightarrow \mathcal{A}_{DY}$ = 14.5 % (in 2.9 < $M_{\mu\mu}$ < 4.5 GeV/c^2)
- Set of counters in beam line:
  - $\hookrightarrow$ Beam Hodoscope, Anti-Halo detectors, B.H. interaction detector

Experimental setup



- Active target with Čerenkov counting blades

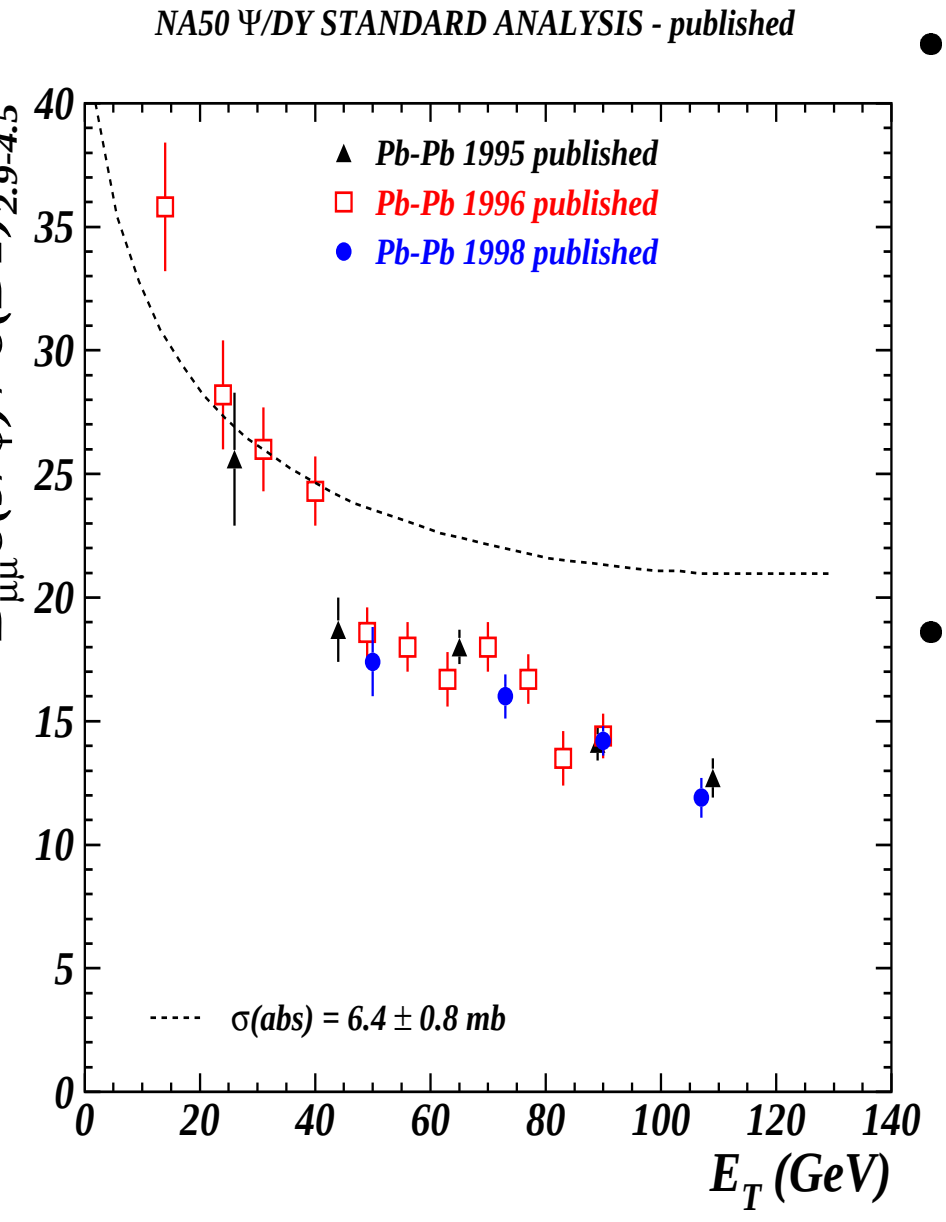
- Centrality detectors:

  ↪ Electromagnetic Calorimeter (EM) measures the neutral transverse energy of the collision in 1.1< η_{lab} <2.3

  ↪ Multiplicity Detector (MD) measures charged particles in 1.5< η_{lab} <3.9

  ↪ Zero Degree Calorimeter (ZDC) measures spectators energy in η_{lab} >6.3

$\frac{J/\psi}{DY}$ published results



- Feature
  - ↪ Sharp decrease at $E_T \sim 40$ GeV
  - ↪ No saturation of the ratio at high E_T
  - ↪ Normal absorption curve established using **our spectrometer** with p-p,p-d (NA51) and p-A,S-U interactions (NA38)
- A deeper understanding revealed:
  - ↪ Possible bias in peripheral PbPb collisions due to Pb-air contamination
  - ↪ Comparison with ordinary nuclear absorption limited by the low NA38 statistics

NA50 PbPb runs

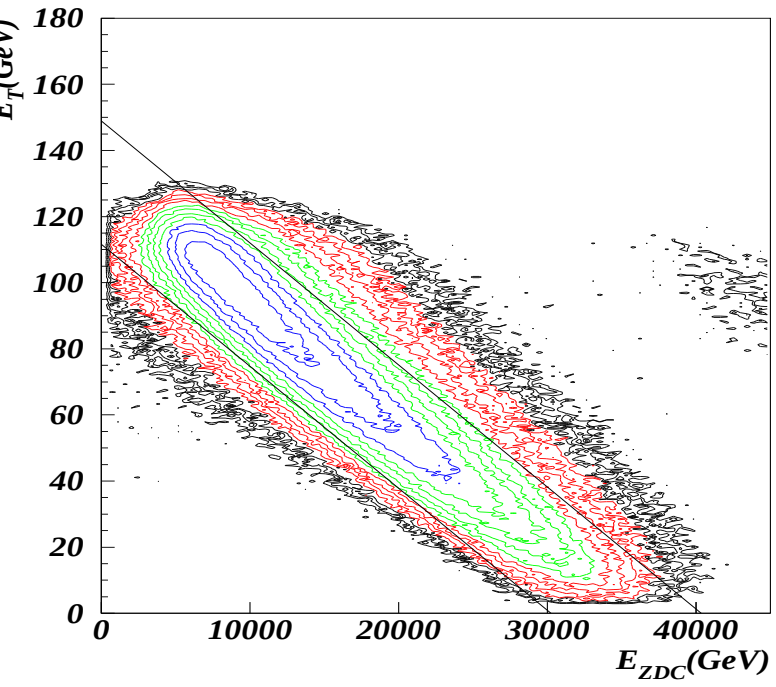
Data period	total target thickness	sub-targets	target region	beam intensity (ions/burst)	J/ψ number
1995	17% λ_I	7	air	3×10^7	50000
1996	30% λ_I	7	air	5×10^7	190000
1998	7% λ_I	1	air	5.5×10^7	40000
2000	9.5% λ_I	1	vacuum	7×10^7	120000

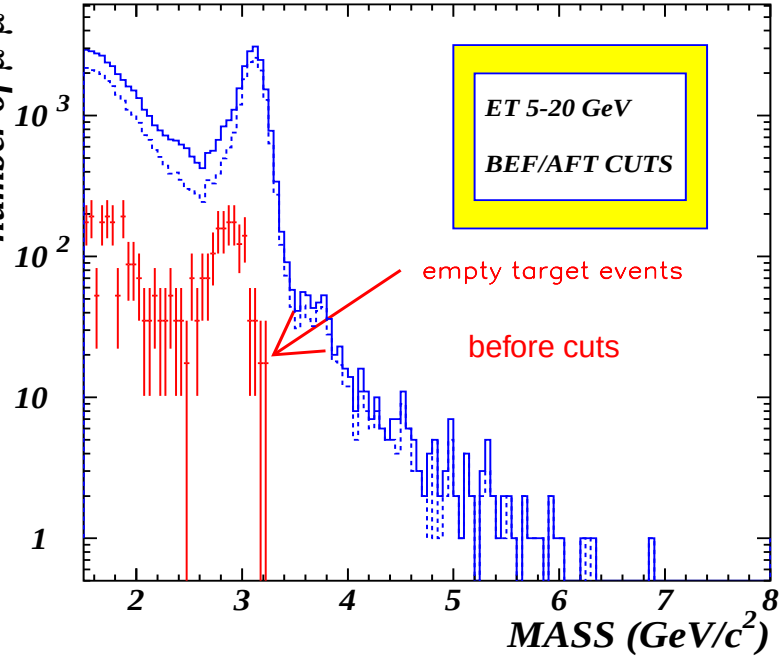
- Year 2000 was devoted to check if PbPb peripheral collisions were really compatible with lighter systems:

  $\hookrightarrow$ Target region was placed under vacuum up to the pre-absorber

  $\hookrightarrow$ More statistics on several p-A systems were collected to establish a more precise normal absorption curve

Data reduction





- Selection criteria:

  ↪ Rejection of parasitic interactions of the incoming Pb beam in the BH

  ↪ Rejection of double interactions via a temporal signal analysis in the EMC

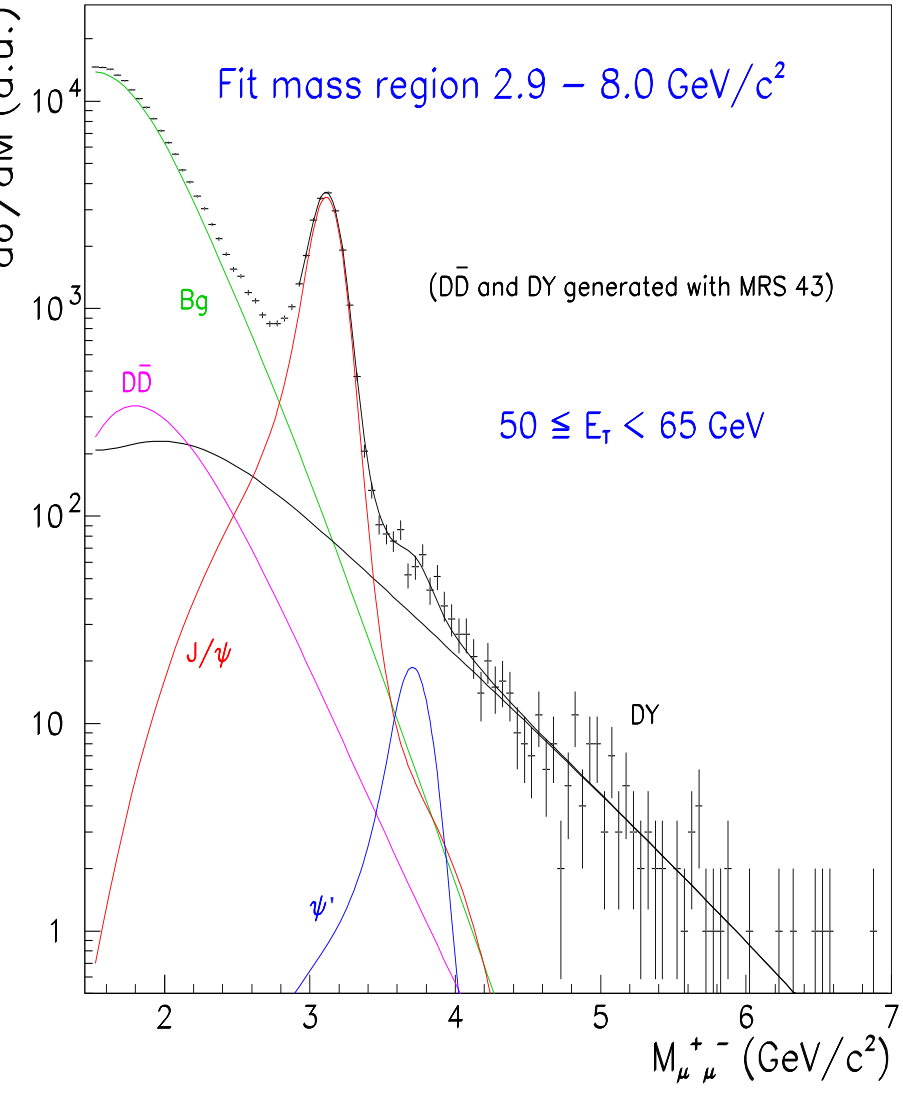
  ↪ Pile-up rejection based in a 2σ E_T-E_{ZDC} correlation.

  ↪ New algorithm for the location of the primary interaction was developed based in the MD

  ⇒ Higher efficiency for peripheral collisions than the usual target ID algorithm.

Fit method

$$\frac{dN}{dM} = N_{J/\psi}\frac{dN_{J/\psi}}{dM} + N_{\psi'}\frac{dN_{\psi'}}{dM} + N_{DY}\frac{dN_{DY}}{dM} + N_{D\bar{D}}\frac{dN_{D\bar{D}}}{dM} + \frac{dN_{BKG}}{dM}$$

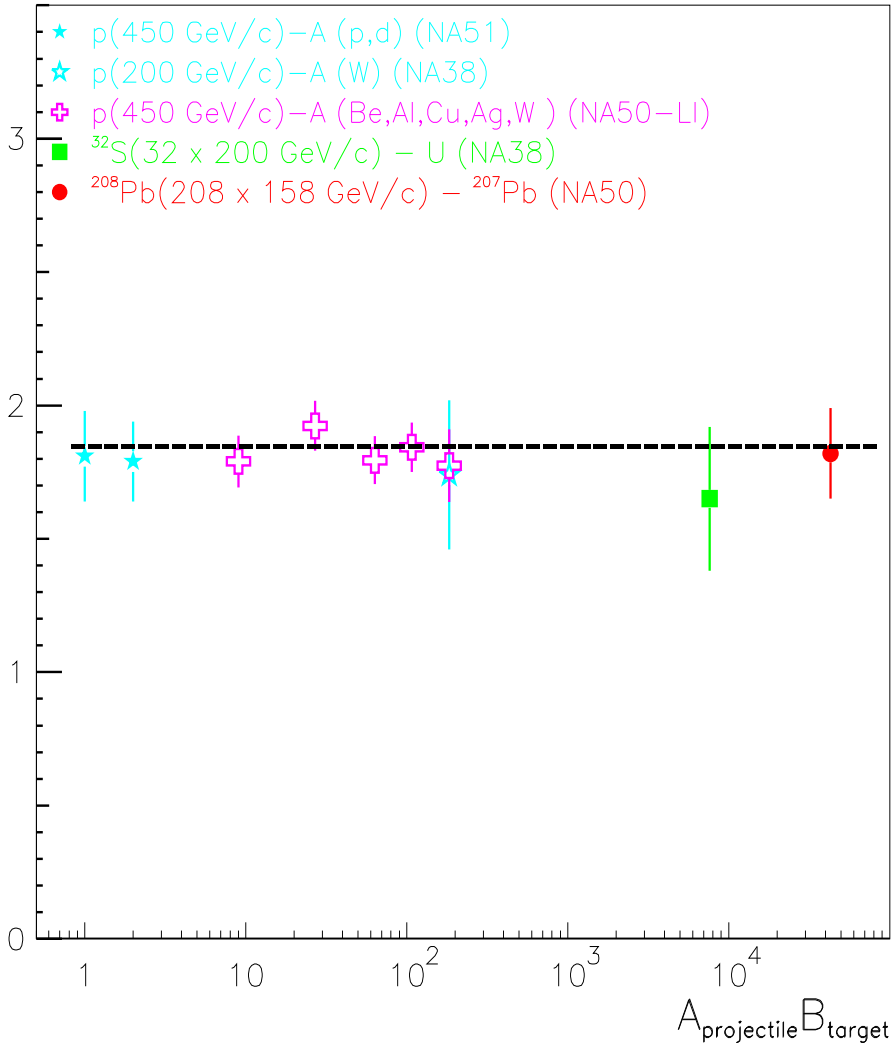


- Mass spectrum ingredients
  - ↪ J/ψ $\rightarrow$ $\mu^+\mu^-$
  - ↪ ψ' $\rightarrow$ $\mu^+\mu^-$
  - ↪ Drell-Yan
  - ↪ Semi-leptonic decay of open charm mesons
  - ↪ Background from $\pi^{\pm}, K^{\pm}$ decays

$$N^{+-}_{BKG} = 2R\sqrt{N_{++}N_{--}}$$

Acceptances and physical shapes determined via Monte Carlo and spectrometer simulation.

Drell-Yan : The reference for J/ψ analysis



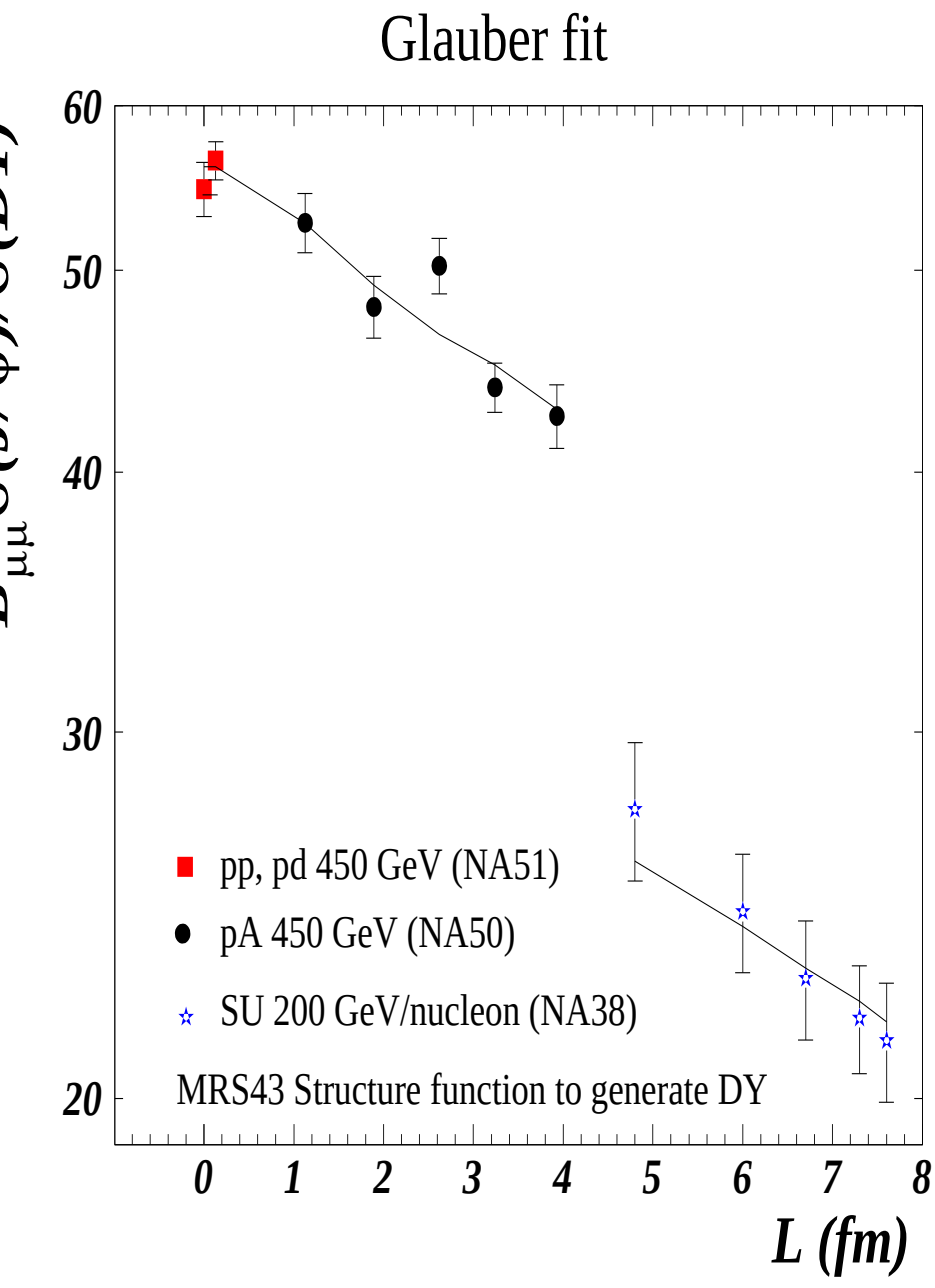
- Drell-Yan is proportional to the number of nucleon-nucleon collisions from p-p to Pb-Pb, as expected.

$$\sigma_{DY} \propto (AB)^{\alpha}, \text{ with } \alpha = 1$$

- Good normalization for J/ψ

  $\hookrightarrow$ Studying $\frac{J/\psi}{DY}$ as a function of centrality will give results free of systematic effects (same trigger)

J/ψ normal absorption



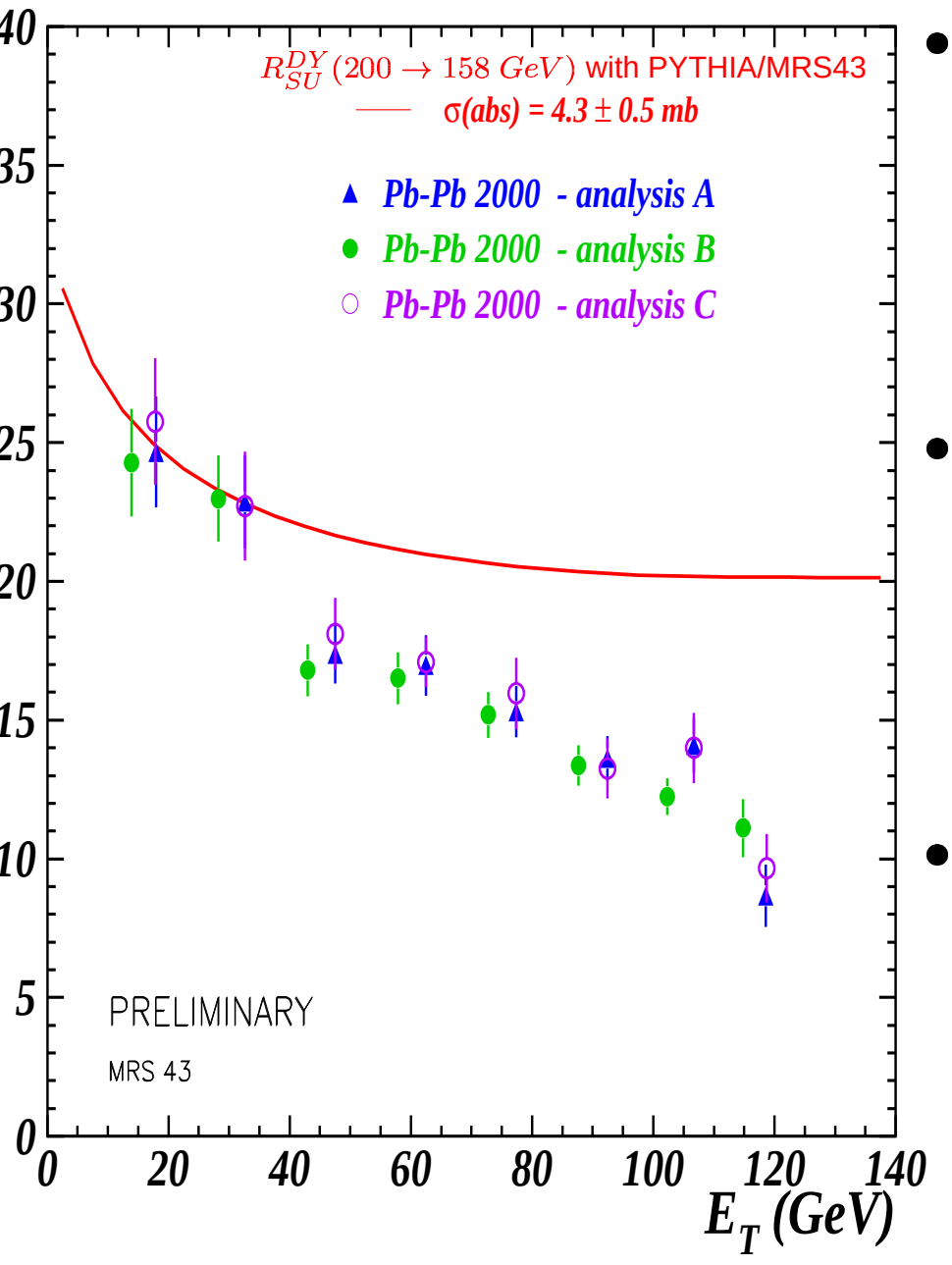
- Normal nuclear absorption of charmonium states is measured using the same spectrometer:
  ↪ NA51 p-p,p-d and NA38 S-U
  ↪ present NA50 p-A data

- From a Glauber fit:
  ↪ S-U still compatible with new NA50 p-A analysis.

$$\sigma_{\mathbf{abs}}^{\mathbf{J/\psi}}(\mathbf{pA, SU}) \;=\; \mathbf{4.3 \pm 0.5\ mb}$$

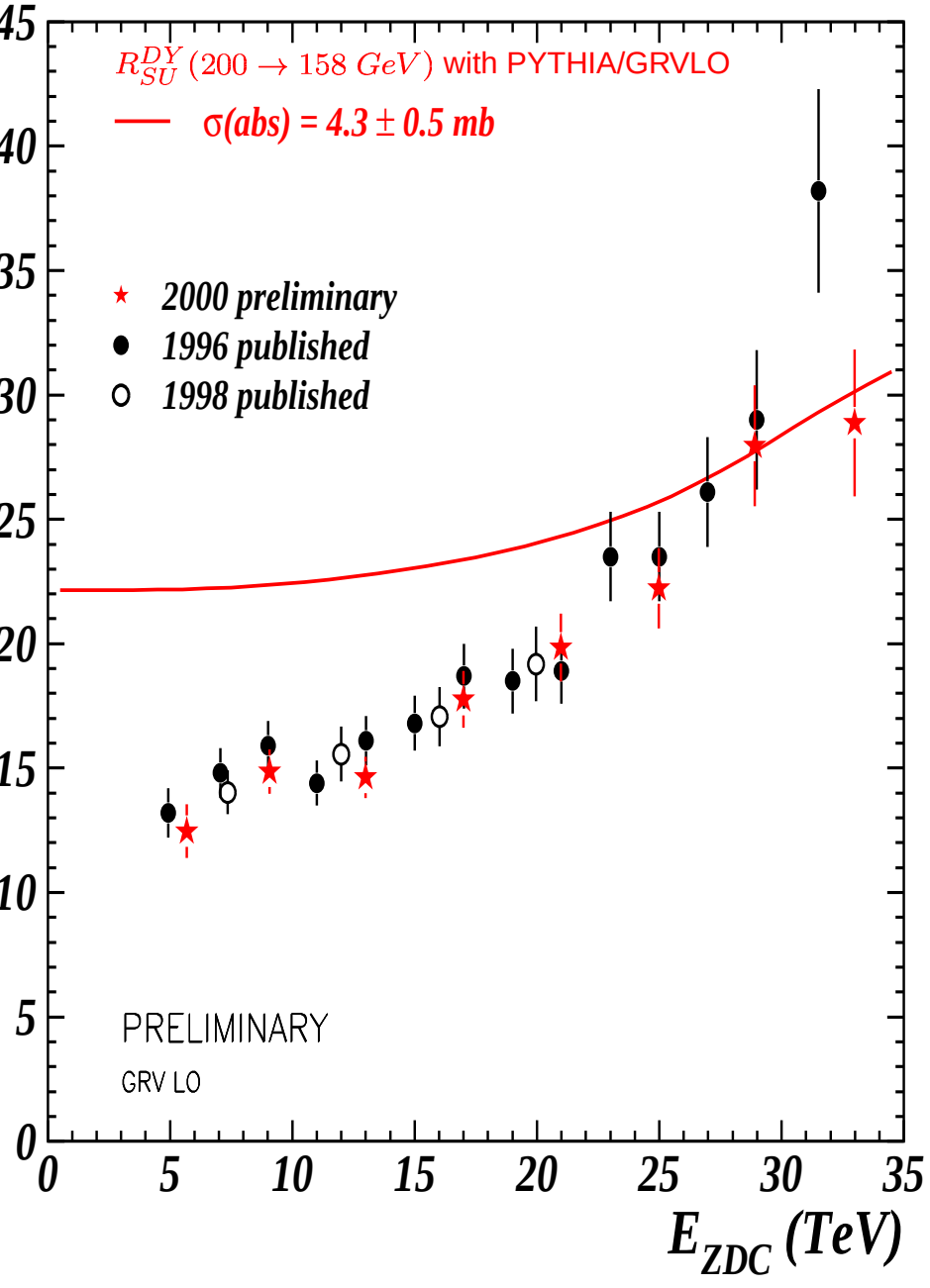
- Absorption curve is extrapolated to 158 GeV as a function of E_T:
  ↪ Normalization is given by SU data, rescaled from $200 \rightarrow 158\ GeV$
  ↪ There could be a 4% difference in the rescaling due to the involved theory

2000 results : $\frac{J/\psi}{DY_{2.9-4.5}}$ vs E_T



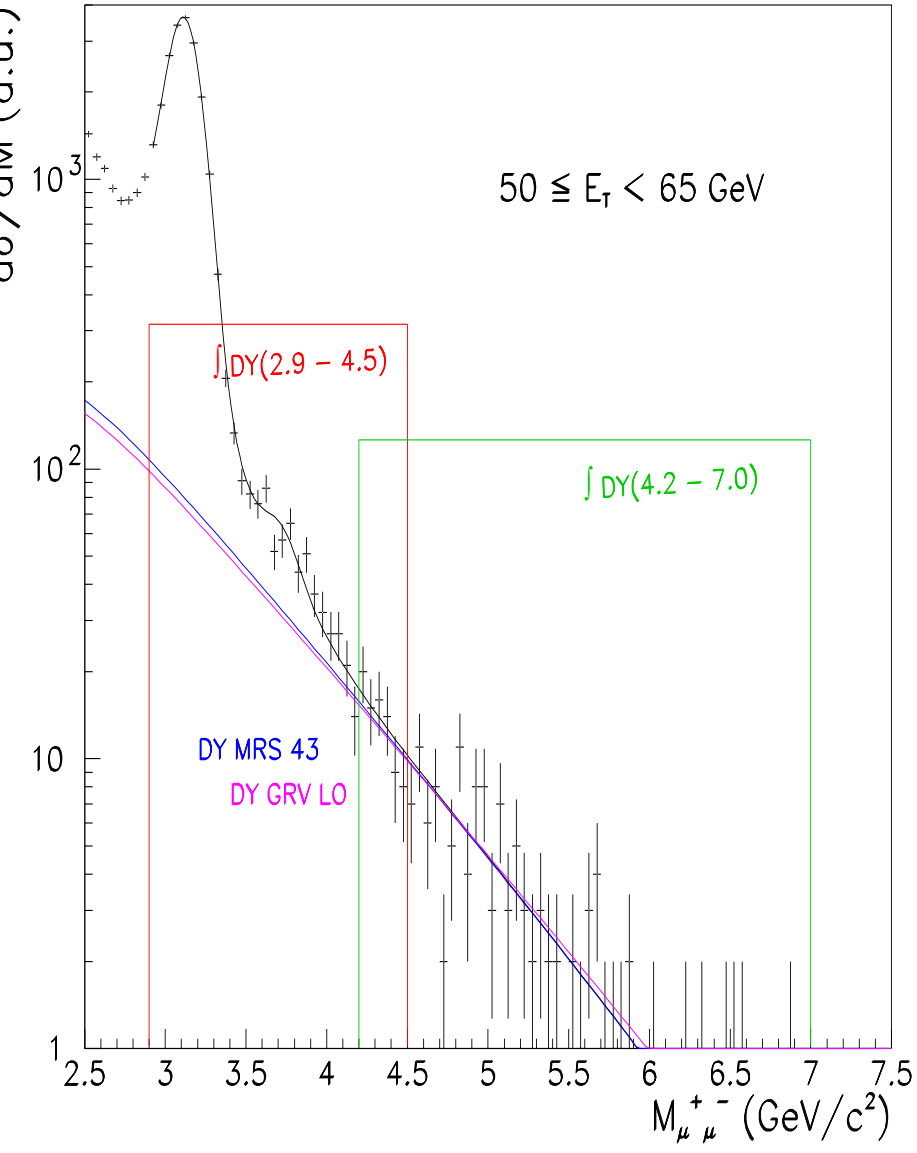
- 3 different analysis:
  - ↪ different labs and selection criteria
  - ↪ different fitting methods and E_T bins
  - ↪ Agreement within a few %
- Peripheral PbPb collisions:
  - ↪ Seem to follow the pattern of normal nuclear absorption as deduced from pA and SU collisions
- Stepwise pattern:
  - ↪ Departure from absorption curve at mid-centrality
  - ↪ No saturation at high E_T

PbPb $\frac{J/\psi}{DY_{2.9-4.5}}$ results vs E_{ZDC}



- Other centrality estimator E_{ZDC}:
  ↪ Forward energy of the spectators
- Comparisons:
  ↪ All published data in the same conditions as the preliminary 2000 data
  ↪ All data sets agree within a few $\%$ (except for most peripheral 96 data contaminated by Pb-air interactions)
- Same stepwise pattern as seen in E_T:
  ↪ Departure from absorption curve at mid-centrality
  ↪ No saturation at low E_{ZDC}

A new DY reference



- Results of $\frac{J/\psi}{DY_{2.9-4.5}}$:

  $\hookrightarrow \sigma_{DY}^{2.9-4.5}$ depends of $\frac{dN_{DY}}{dM}$ extrapolation from the mass region where it is directly measured

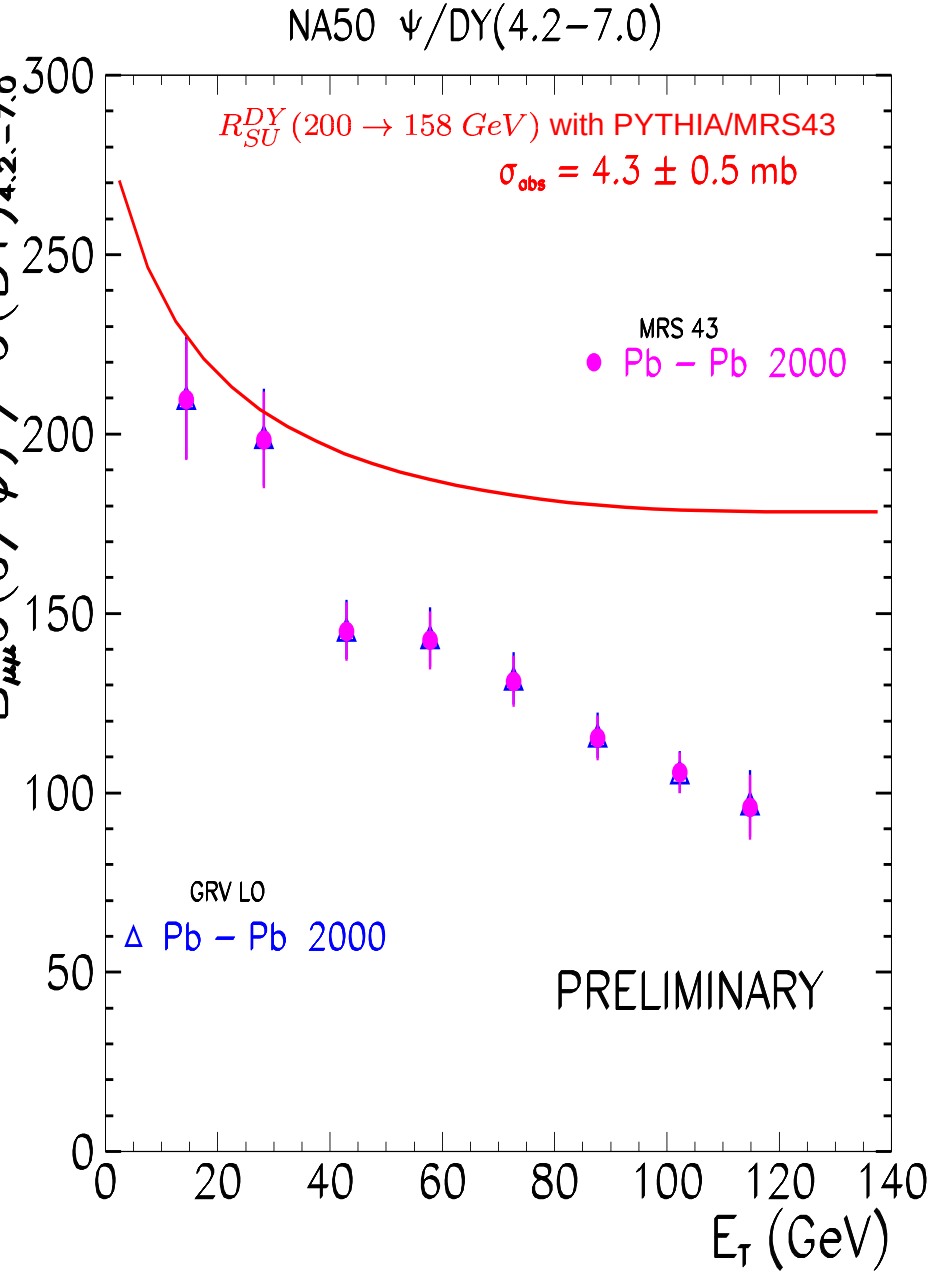
  $\hookrightarrow$ Different parton distributions lead to different results on $\frac{J/\psi}{DY_{2.9-4.5}}$

$$\frac{\sigma_{\mathbf{DY}}^{\mathbf{2.9-4.5}}|_{\mathbf{MRS43}}}{\sigma_{\mathbf{DY}}^{\mathbf{2.9-4.5}}|_{\mathbf{GRVLO}}} \sim \mathbf{10\%}$$

- Drell-Yan reference in a new mass region (4.2-7.0):

  $\hookrightarrow$ Using as reference the directly measured $\sigma_{DY}^{4.2-7.0}$ leads to an unique result

2000 PbPb results in $\frac{J/\psi}{DY_{4.2-7.0}}$



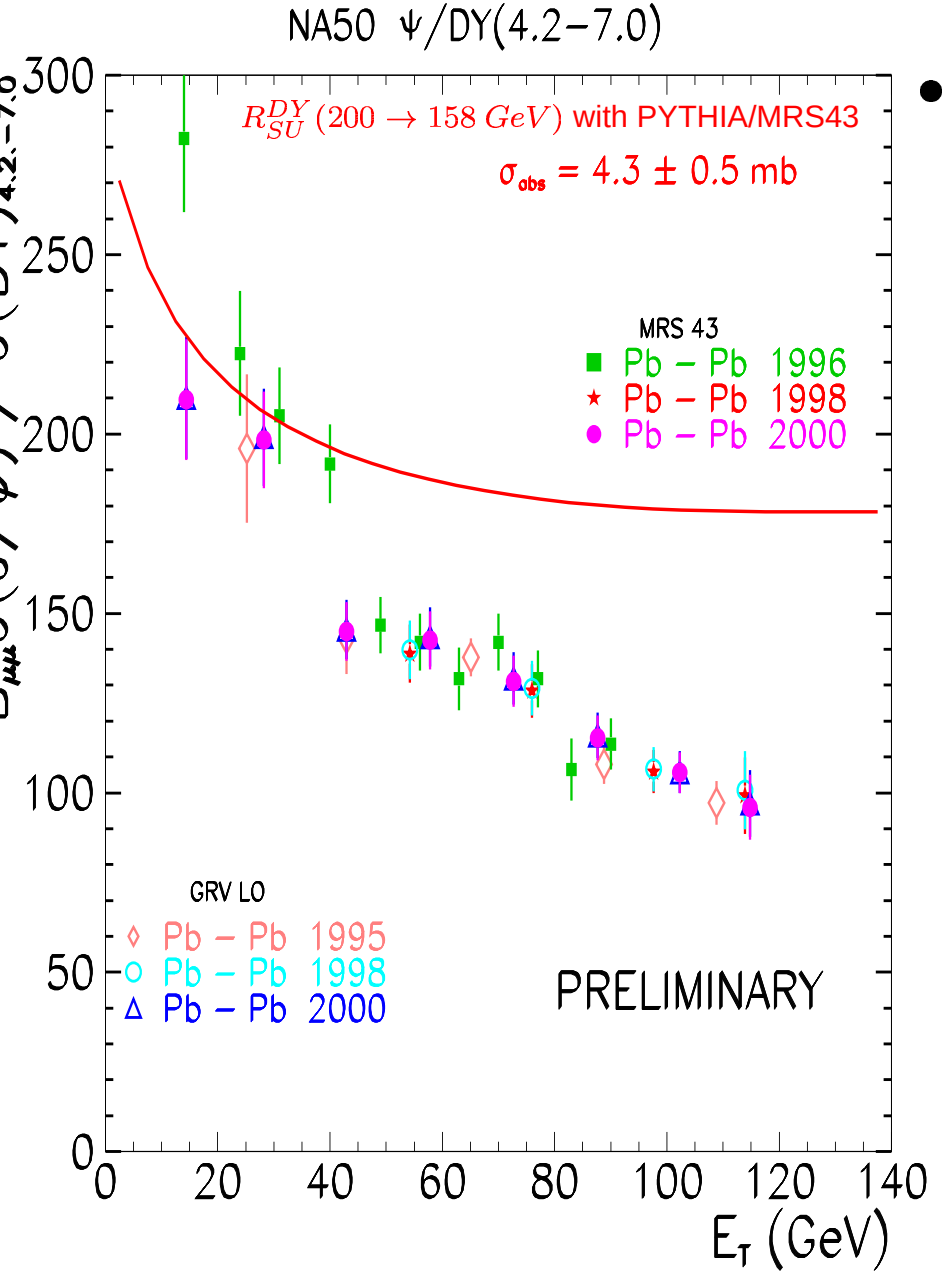
- PDF Independent results

  ↪ 2000 data analyzed with GRVLO and with MRS43 practically coincide

  ↪ $\frac{J/\psi}{DY_{4.2-7.0}}$ result does not depend anymore of the used structure functions

  ↪ The direct measured DY cross section is the same in both cases.

NA50 PbPb results in $\frac{J/\psi}{DY_{4.2-7.0}}$



- Comparison of year 2000 results with previous data

↪ Good compatibility between all data sets (except for 96 most peripheral points due to Pb-air contamination)

↪ A stepwise pattern of anomalous J/ψ suppression is seen in all Pb-Pb data:

★ Departure from the normal absorption curve at $E_T \sim 40$ GeV

★ Steady decrease of $\frac{J/\psi}{DY_{4.2-7.0}}$ observed for the most central PbPb collisions

Conclusions

Preliminary results from last PbPb NA50 run,with target in vacuum:

- Confirms the anomalous J/ψ suppression:
  $\hookrightarrow$ Agreement with previous analysis, using either E_T or E_{ZDC} as a centrality estimator
  $\hookrightarrow$ The same pattern as seen in previous NA50 results
  $\hookrightarrow$ No saturation at high E_T

- Confirms the departure from an improved normal nuclear absorption curve as determined from pA and SU interactions, all measured using the same spectrometer.

- Peripheral PbPb collisions seem to be compatible with the normal absorption coming from lighter systems.