

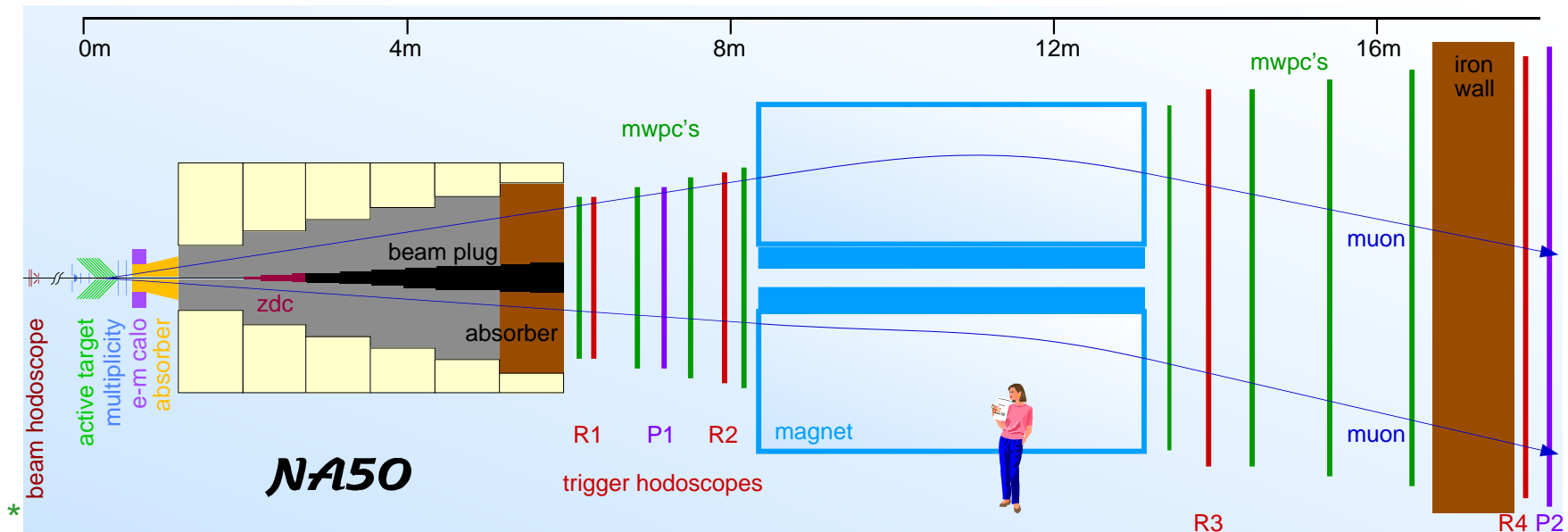
Latest results on J/ψ suppression

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for the

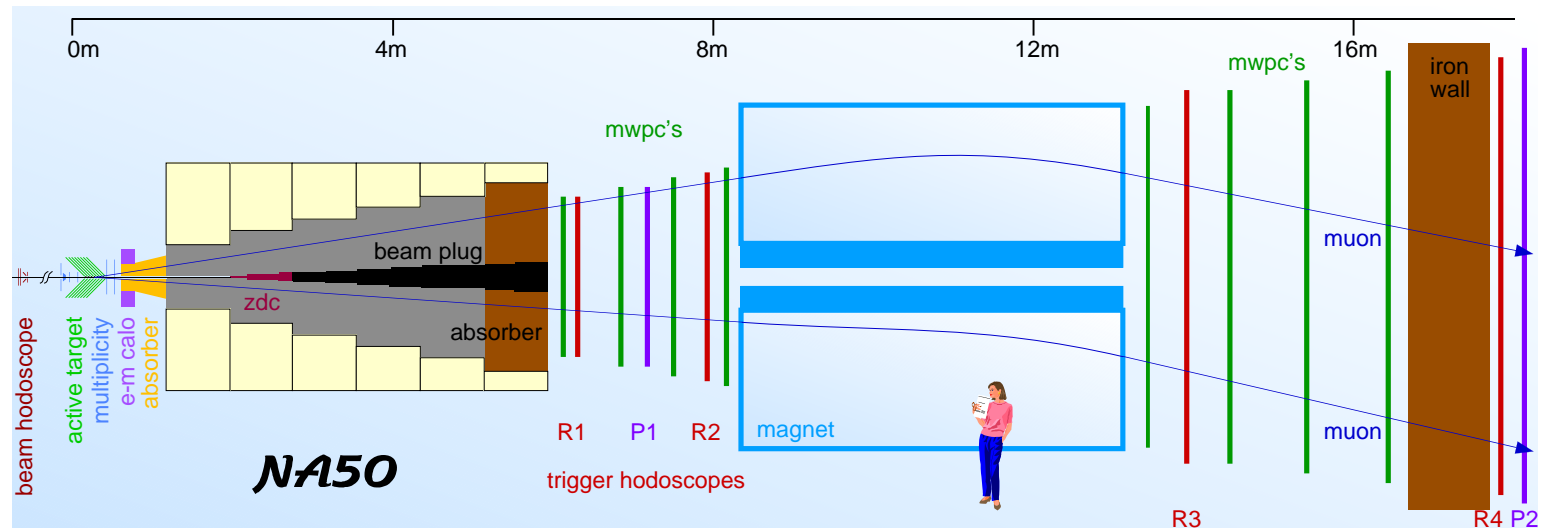
NA50 Collaboration

Alessandria, Annecy, Aubière, Bucharest, Cagliari, CERN,
Lisbon, Moscow, Orsay, Palaiseau, Torino, Villeurbanne, Yerevan



- The experimental apparatus
 - ↪ 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:
 - ↪ The transverse energy (E_T)
 - ↪ The forward energy (E_{ZDC})
- Comparison with previous data takings
- Conclusions

Experimental setup



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

- Dimuon detection in:

$$\hookrightarrow 0 < y_{CM} < 1 \quad (2.92 < y_{Lab} < 3.92) \quad |\cos \theta_{CS}| < 0.5$$

- Acceptances:

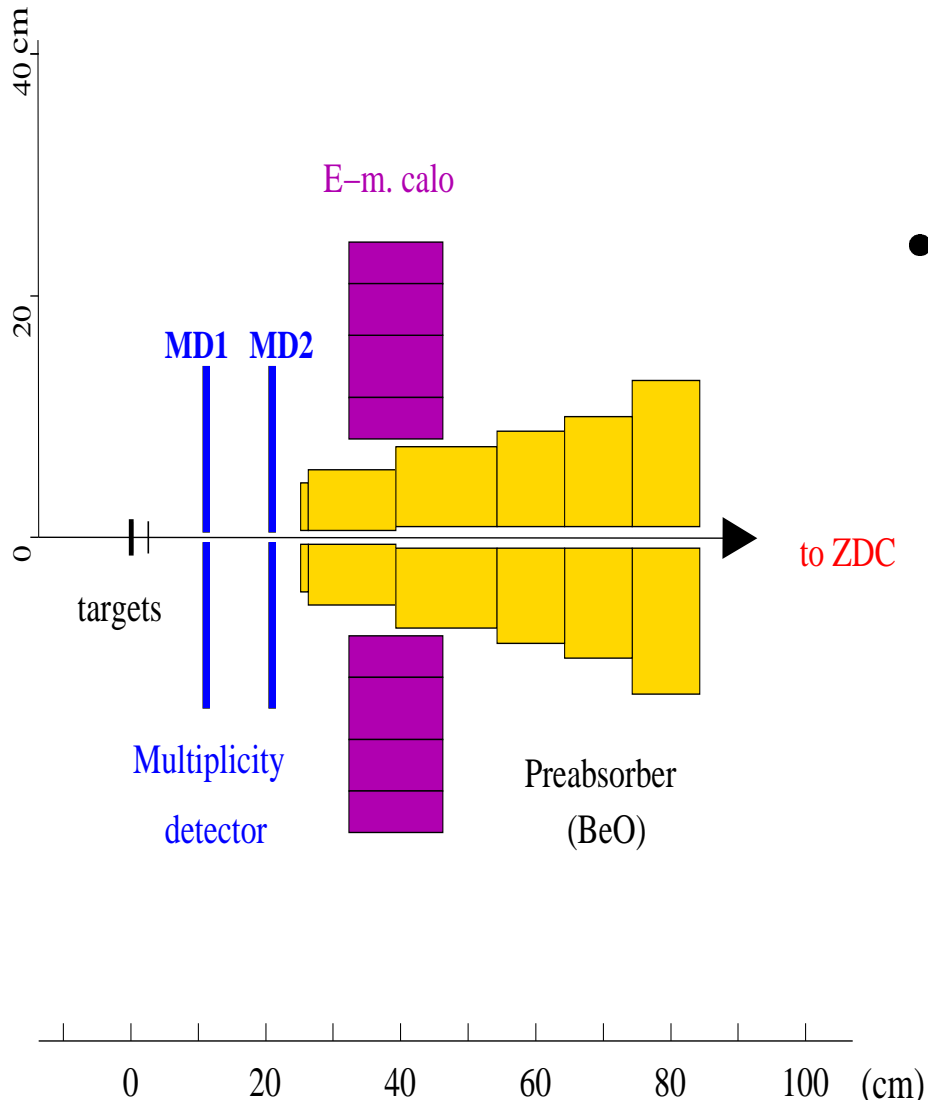
$$\hookrightarrow \mathcal{A}_{J/\psi} = 13.5 \%$$

$$\hookrightarrow \mathcal{A}_{DY} = 14.5 \% \quad (\text{in } 2.9 < M_{\mu\mu} < 4.5 \text{ GeV}/c^2)$$

- Set of counters in beam line:

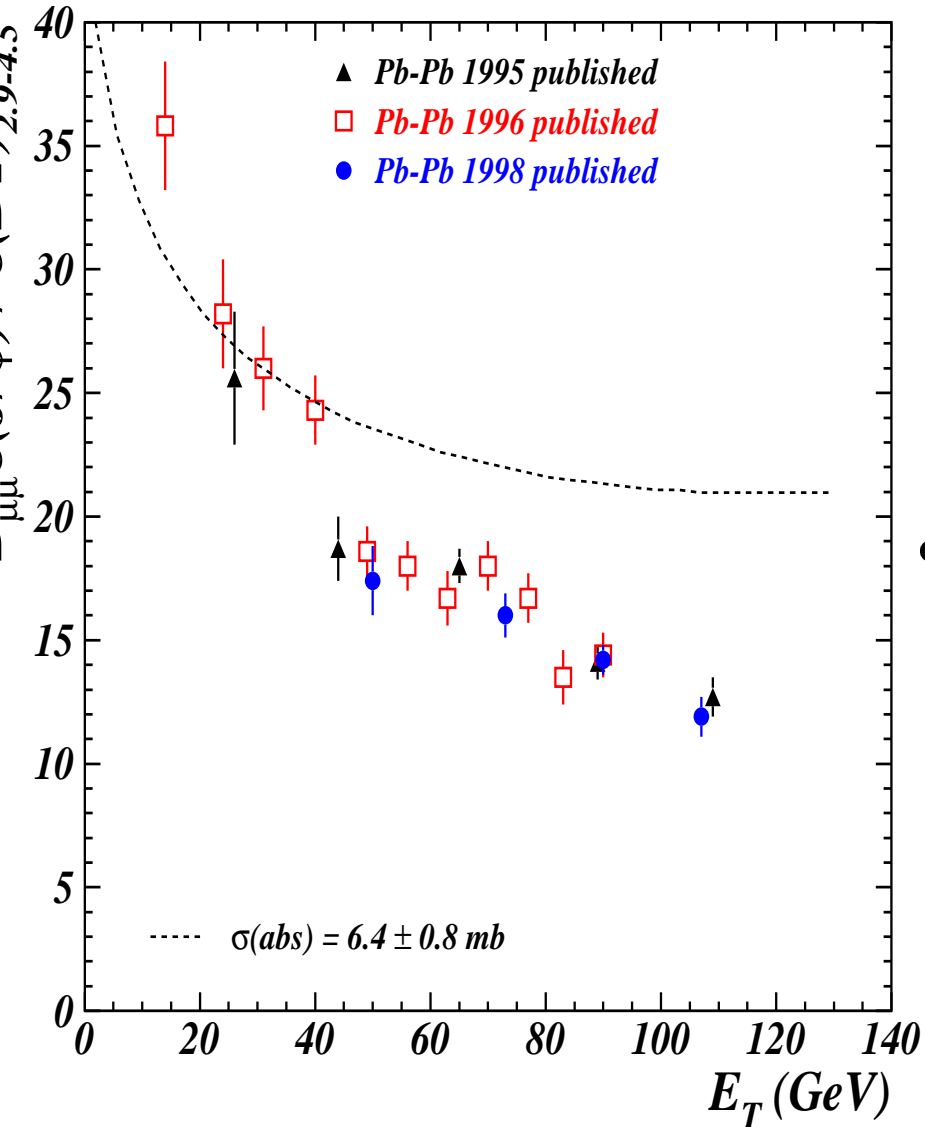
\hookrightarrow Beam Hodoscope, Anti-Halo detectors, B.H. interaction detector

Experimental setup



- Active target with Čerenkov counting blades
- Centrality detectors:
 - ↪ Electromagnetic Calorimeter (EM) measures the neutral transverse energy of the collision in $1.1 < \eta_{lab} < 2.3$
 - ↪ Multiplicity Detector (MD) measures charged particles in $1.5 < \eta_{lab} < 3.9$
 - ↪ Zero Degree Calorimeter (ZDC) measures spectators energy in $\eta_{lab} > 6.3$

NA50 Ψ/DY STANDARD ANALYSIS - published



- 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**

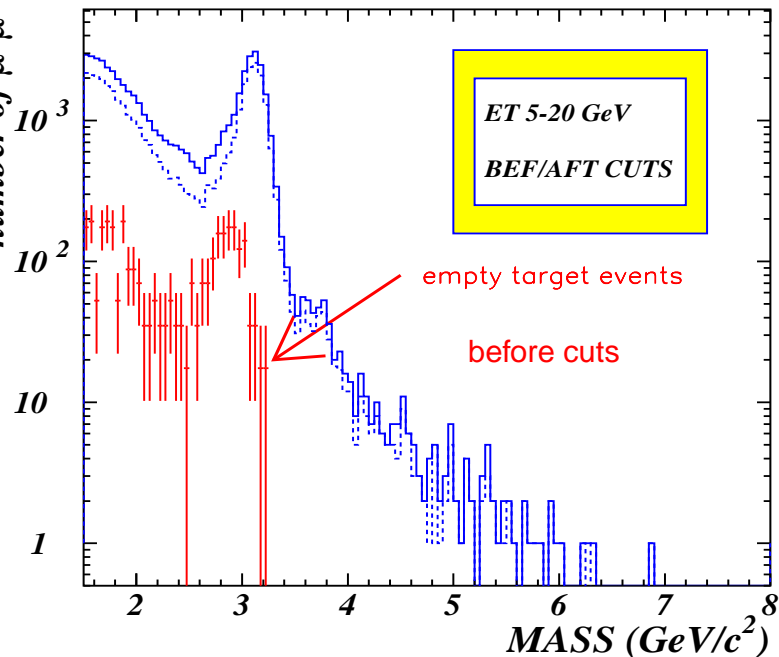
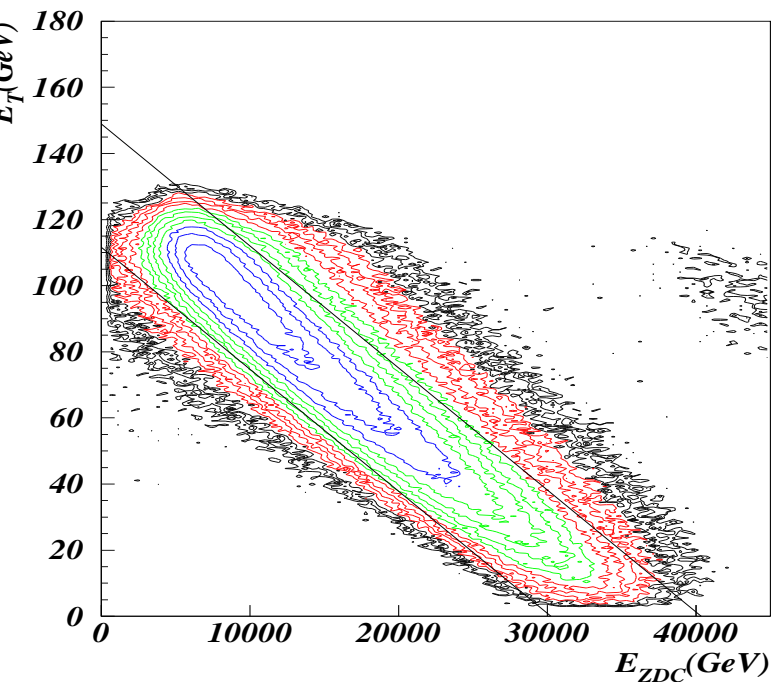
NA50 PbPb runs

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:

↪ **Target region was placed under vacuum** up to the pre-absorber

↪ **More statistics on several p-A systems** were collected to establish a more precise normal absorption curve



- Selection criteria:

- ↳ Rejection of **parasitic interactions** of the incoming Pb beam in the BH

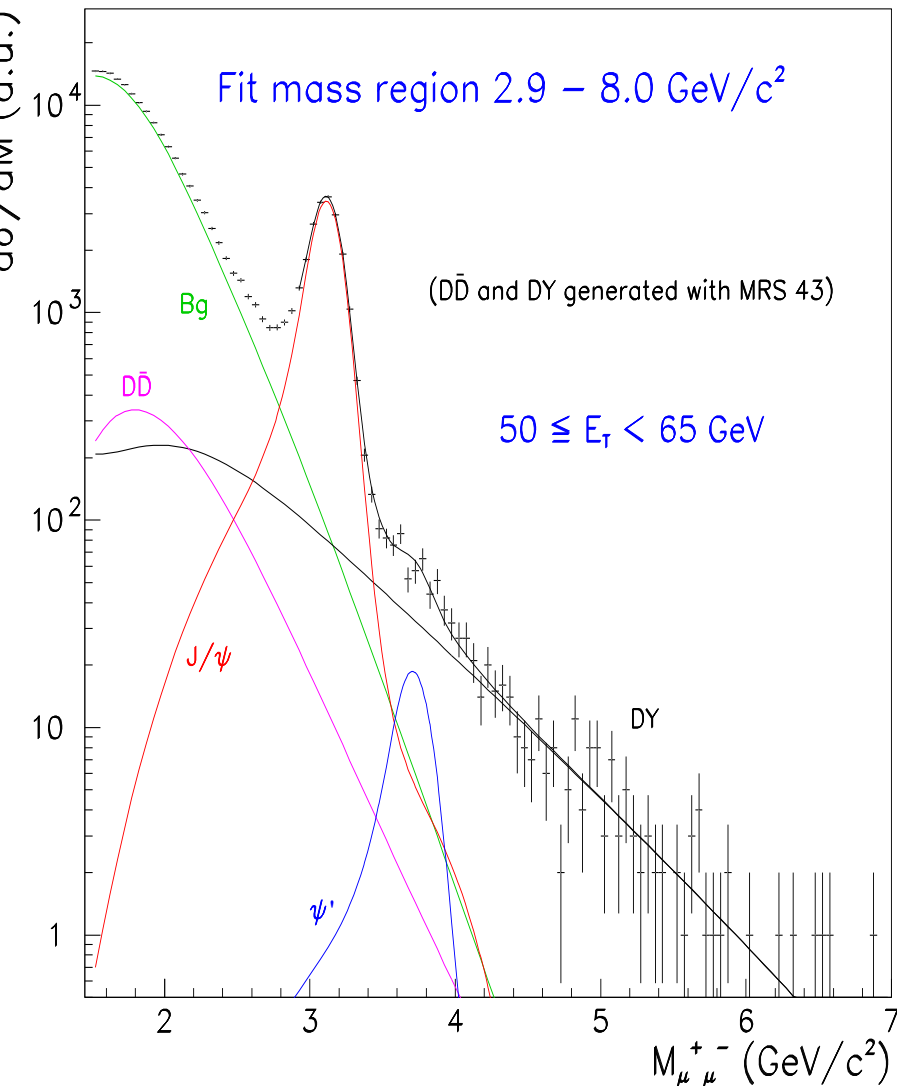
- ↳ Rejection of **double interactions** via a temporal signal analysis in the EMC

- ↳ **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.

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



- Mass spectrum ingredients

- ↪ $J/\psi \rightarrow \mu^+ \mu^-$

- ↪ $\psi' \rightarrow \mu^+ \mu^-$

- ↪ Drell-Yan

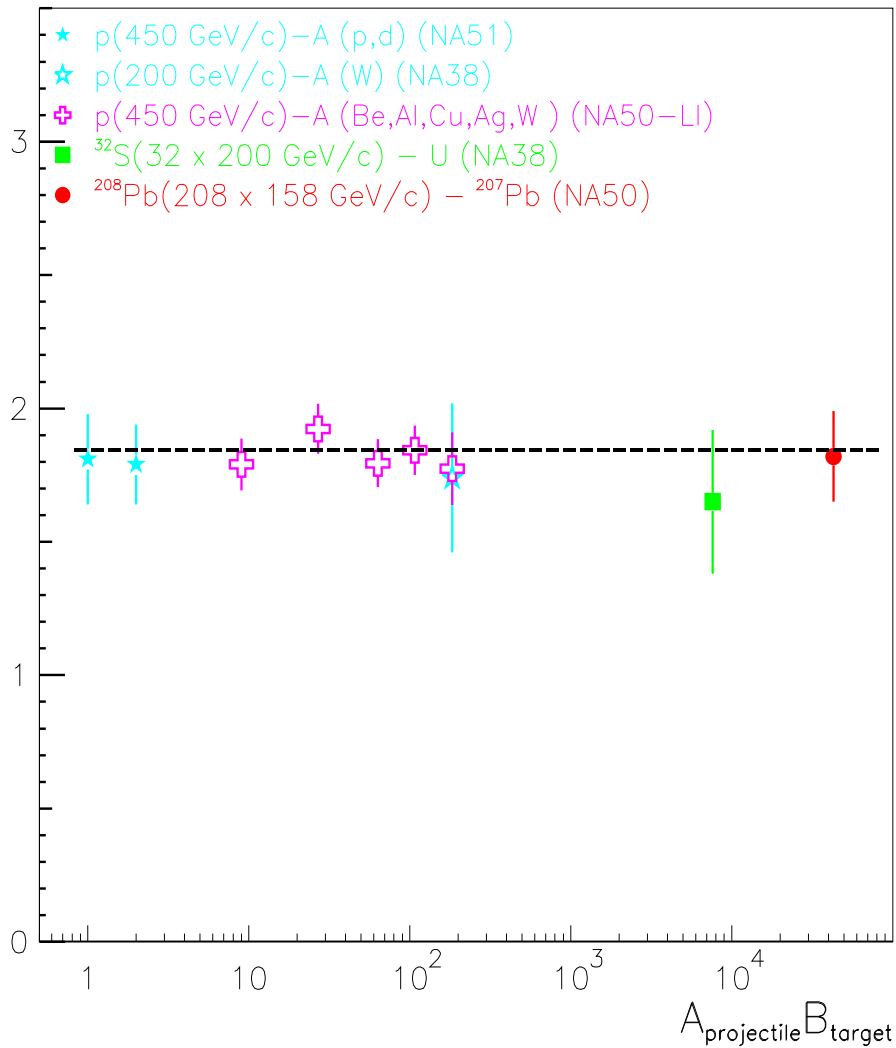
- ↪ Semi-leptonic decay of open charm mesons

- ↪ Background from π^\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

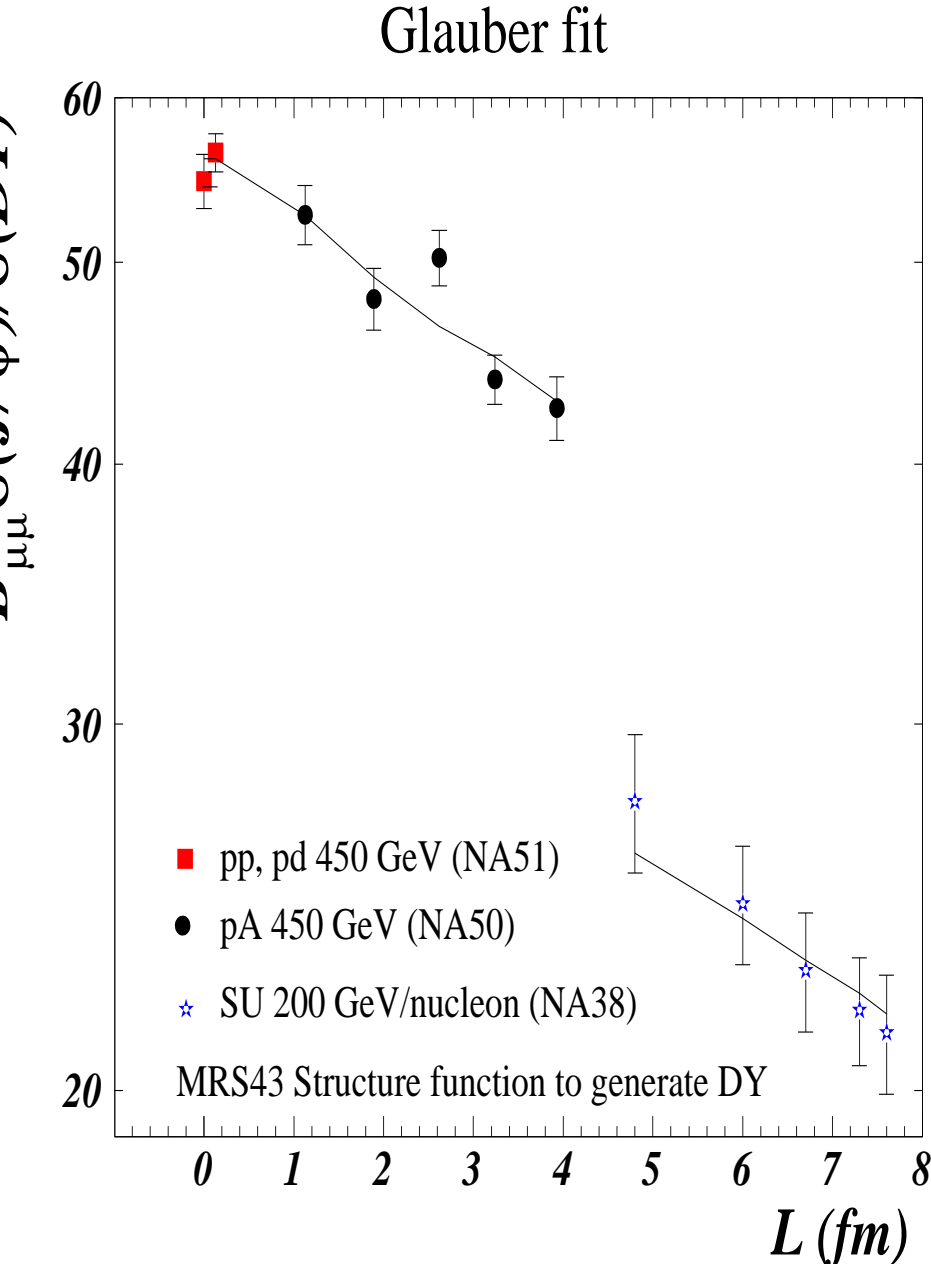


- Drell-Yan is proportional to the number of nucleon-nucleon collisions from p-p to Pb-Pb, as expected.

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

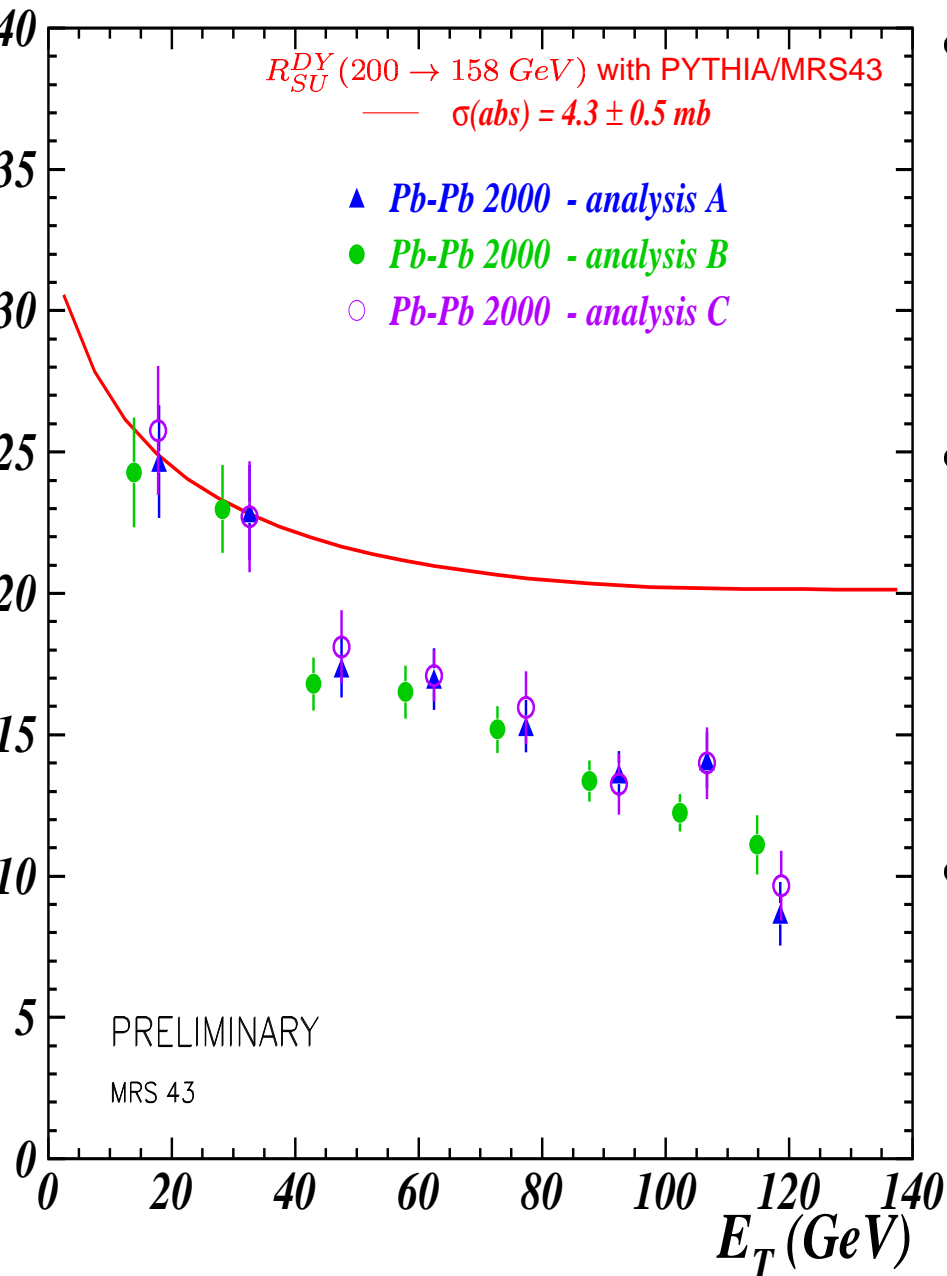
- Good normalization for J/ψ
 \hookrightarrow Studying $\frac{J/\psi}{\text{DY}}$ as a function of centrality will give results **free of systematic effects (same trigger)**

J/ψ normal absorption



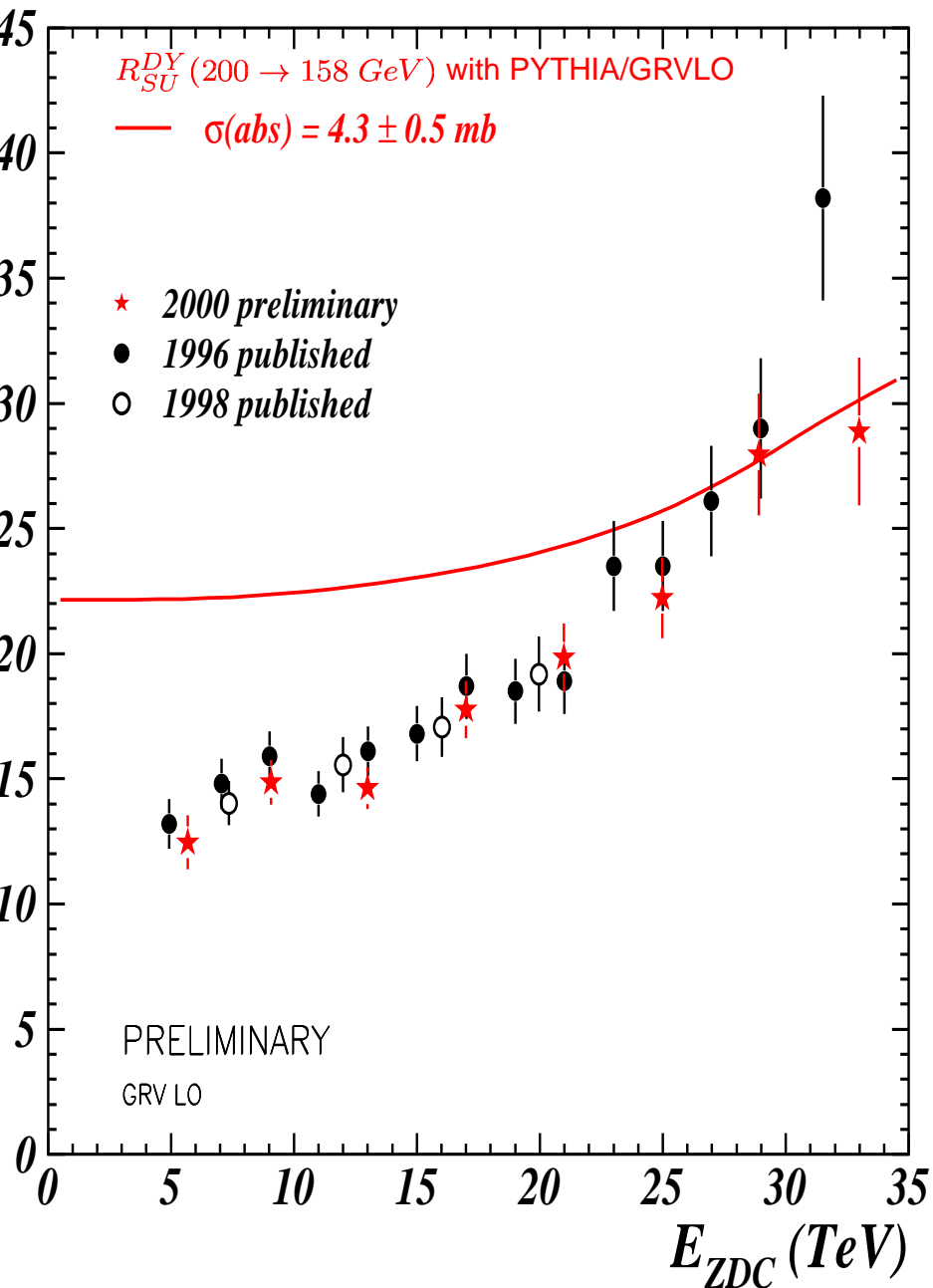
- Normal nuclear absorption of charmonium states is **measured** using the same spectrometer:
 - ↪ **NA51 p-p,p-d** and **NA38 S-U**
 - ↪ present NA50 p-A data
- From a Glauber **fit**:
 - ↪ S-U still compatible with new NA50 p-A analysis.
$$\sigma_{\text{abs}}^{J/\psi}(\text{pA}, \text{SU}) = 4.3 \pm 0.5 \text{ mb}$$
- 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



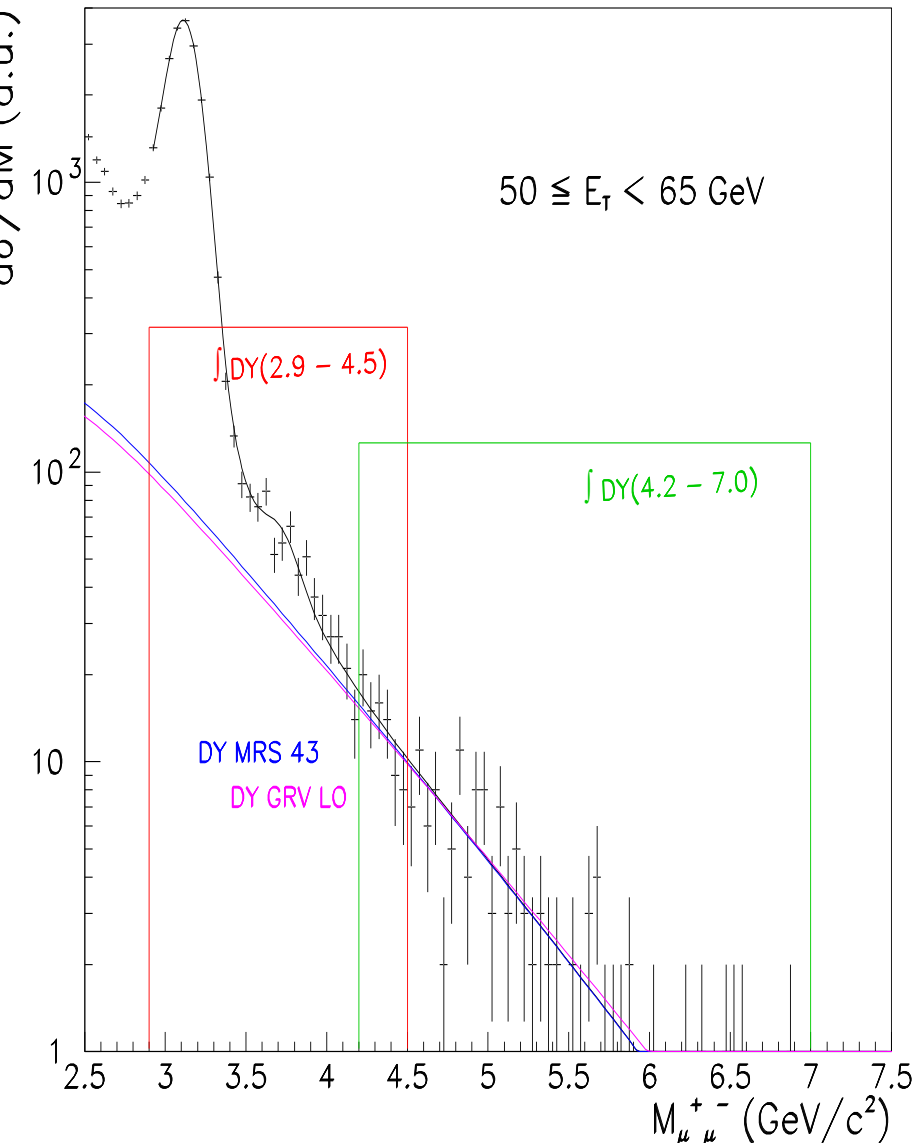
- 3 different analysis:
 - ↪ different labs and selection criteria
 - ↪ different fitting methods and E_T bins
 - ↪ Agreement within a few %
- Peripheral PbPb collisions:
 - ↪ **Seem to follow the pattern of normal nuclear absorption** as deduced from pA and SU collisions
- Stepwise pattern:
 - ↪ **Departure 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}



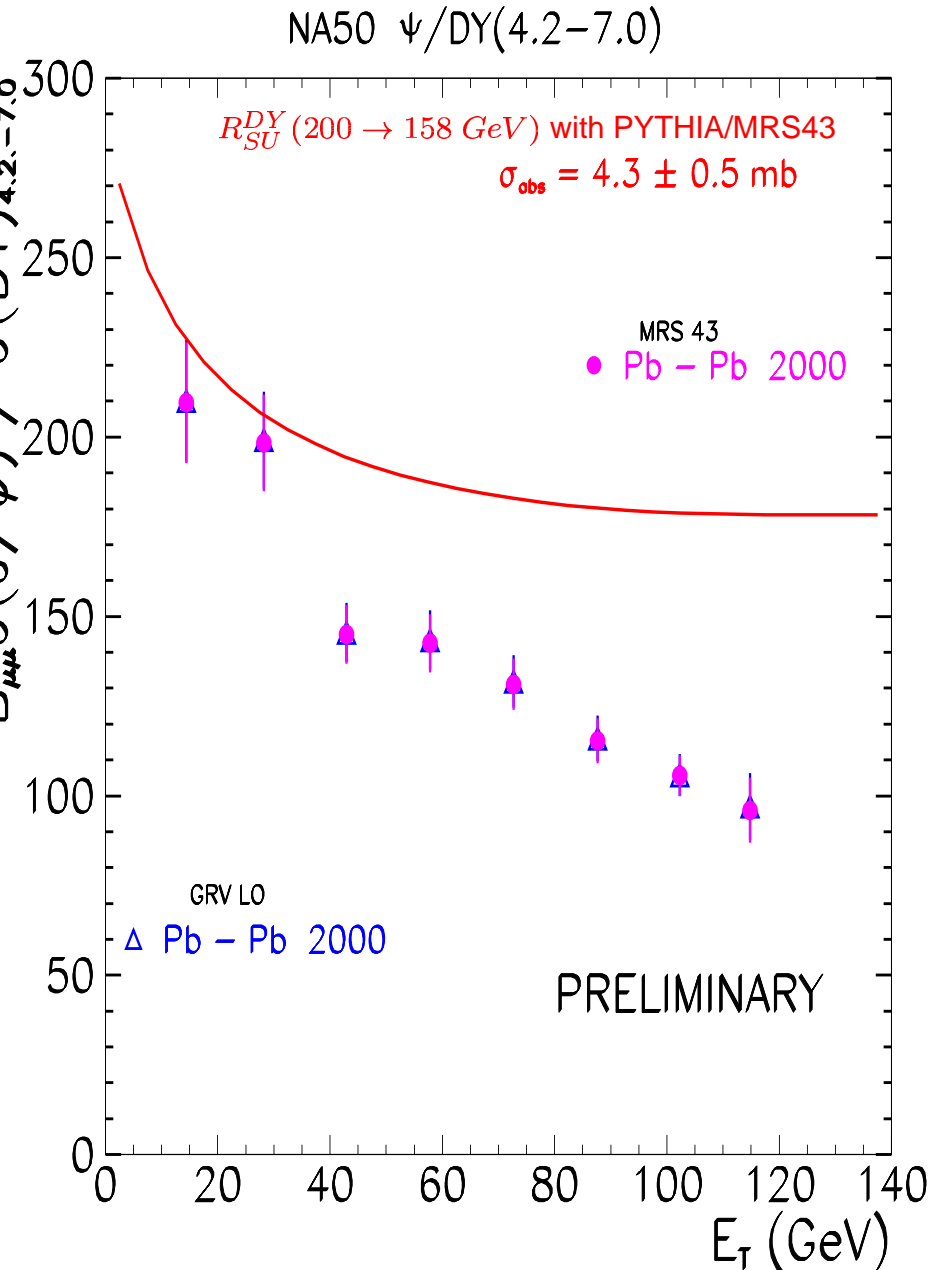
- Other centrality estimator E_{ZDC} :
 ⇨ Forward energy of the spectators
- Comparisons:
 ⇨ All published data in the same conditions as the preliminary 2000 data
 ⇨ All data sets agree within a few % (except for most peripheral 96 data contaminated by Pb-air interactions)
- Same stepwise pattern as 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 $\frac{J/\psi}{DY_{2.9-4.5}}$
$$\frac{\sigma_{DY}^{2.9-4.5} |_{\text{MRS43}}}{\sigma_{DY}^{2.9-4.5} |_{\text{GRVLO}}} \sim 10\%$$
- 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 $\frac{J/\psi}{DY_{4.2-7.0}}$



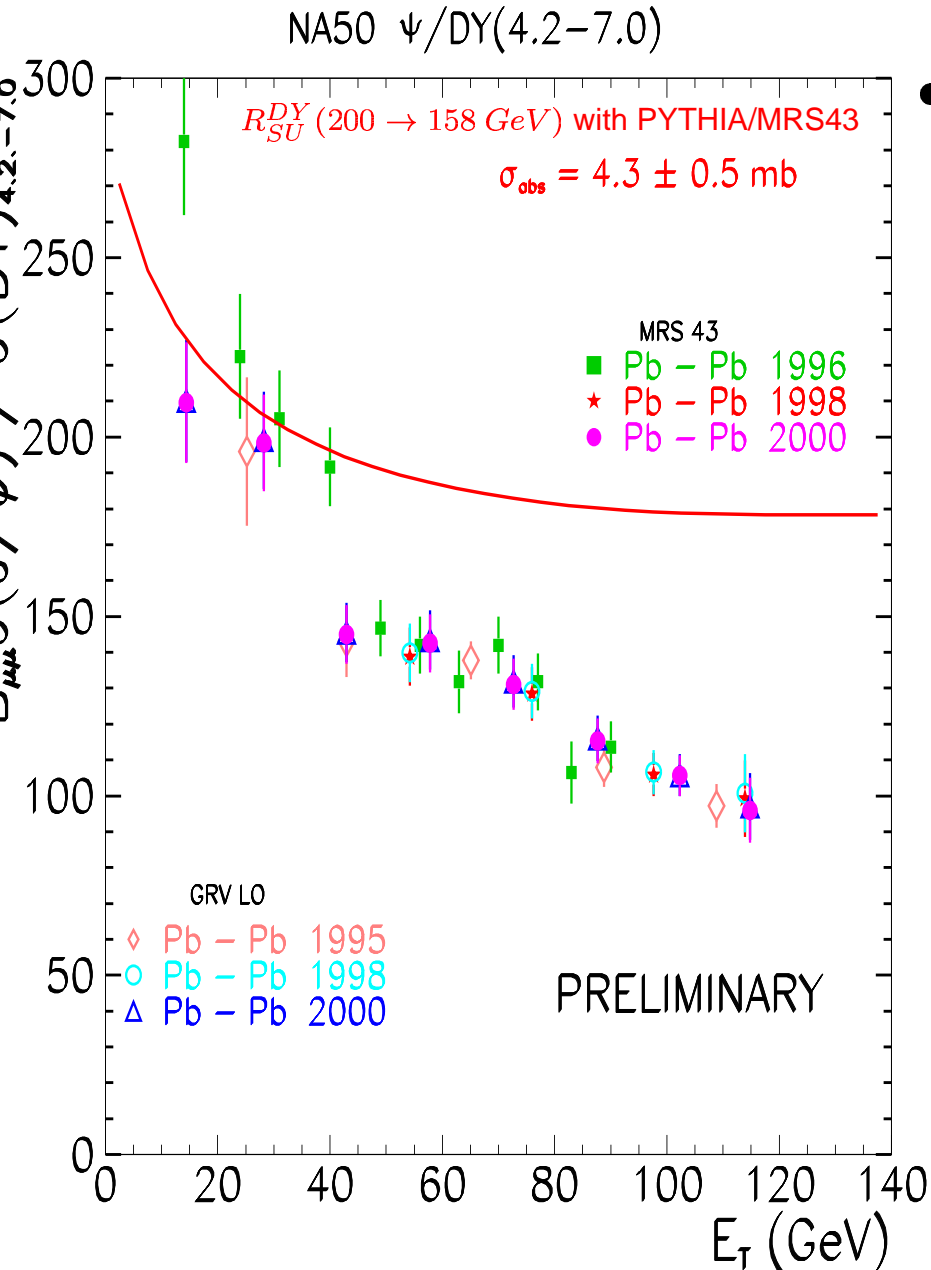
- PDF Independent results

↪ 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 $E_T \sim 40 \text{ GeV}$

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

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

- Confirms the anomalous J/ψ suppression:
 - ↪ **Agreement with previous analysis**, using either E_T or E_{ZDC} as a centrality estimator
 - ↪ **The same pattern** as seen in previous NA50 results
 - ↪ **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.