

# Recent results on anomalous $J/\psi$ suppression in Pb-Pb collisions at 158 GeV/c per nucleon

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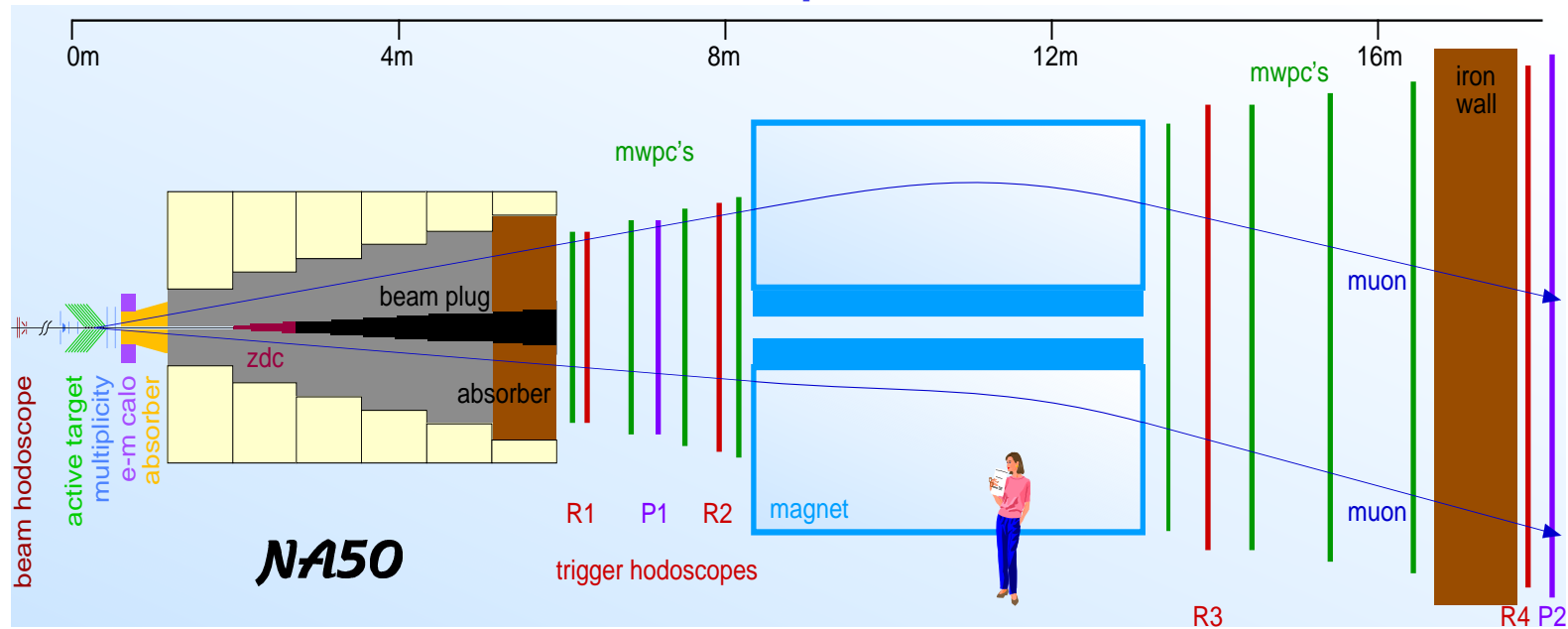
# Outline

- **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  $J/\psi$  and **Drell-Yan** yields in order to search for the formation of the **Quark Gluon Plasma**

## The Dimuon Spectrometer

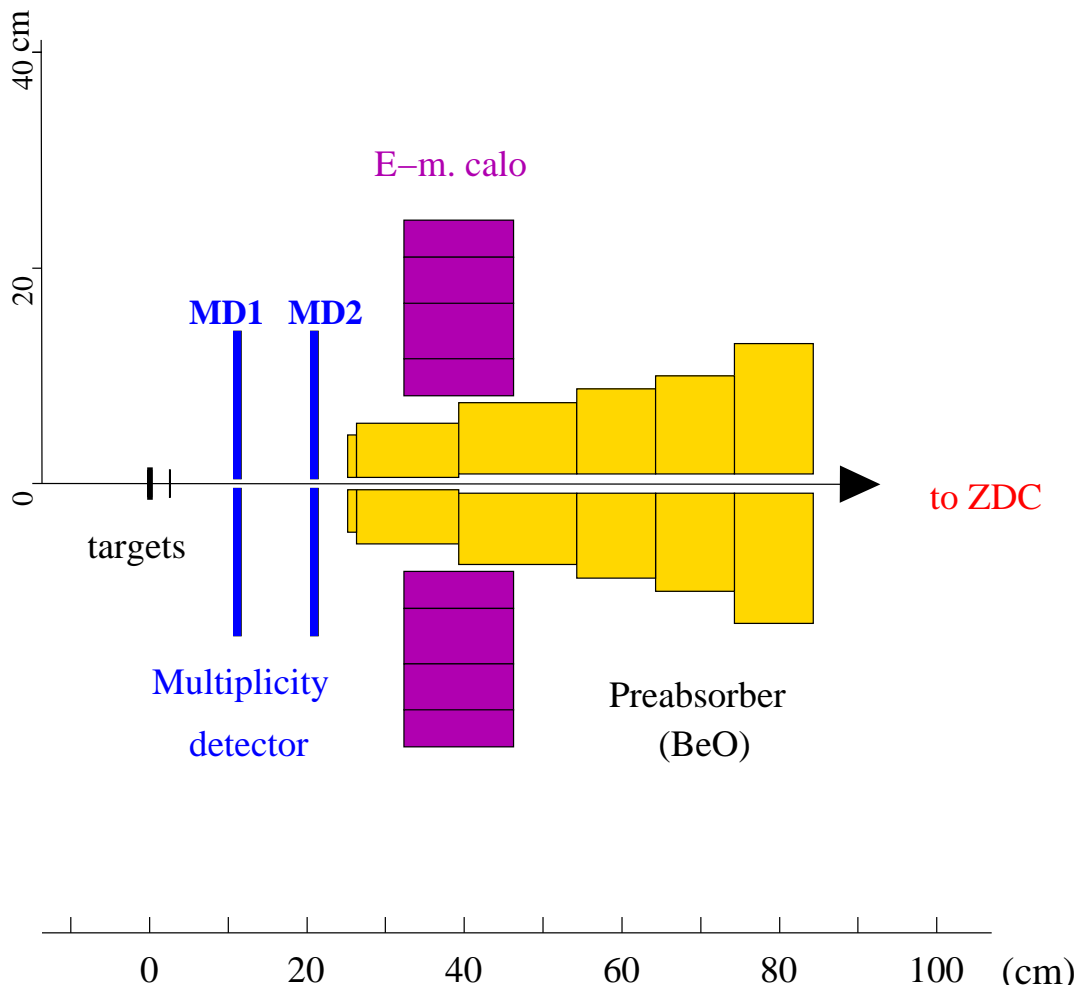


Kinematical Domain:  $0 \leq y_{CM} < 1$  ( $2.92 \leq y_{lab} < 3.92$ )  $|\cos\theta_{CS}| < 0.5$

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

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

**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

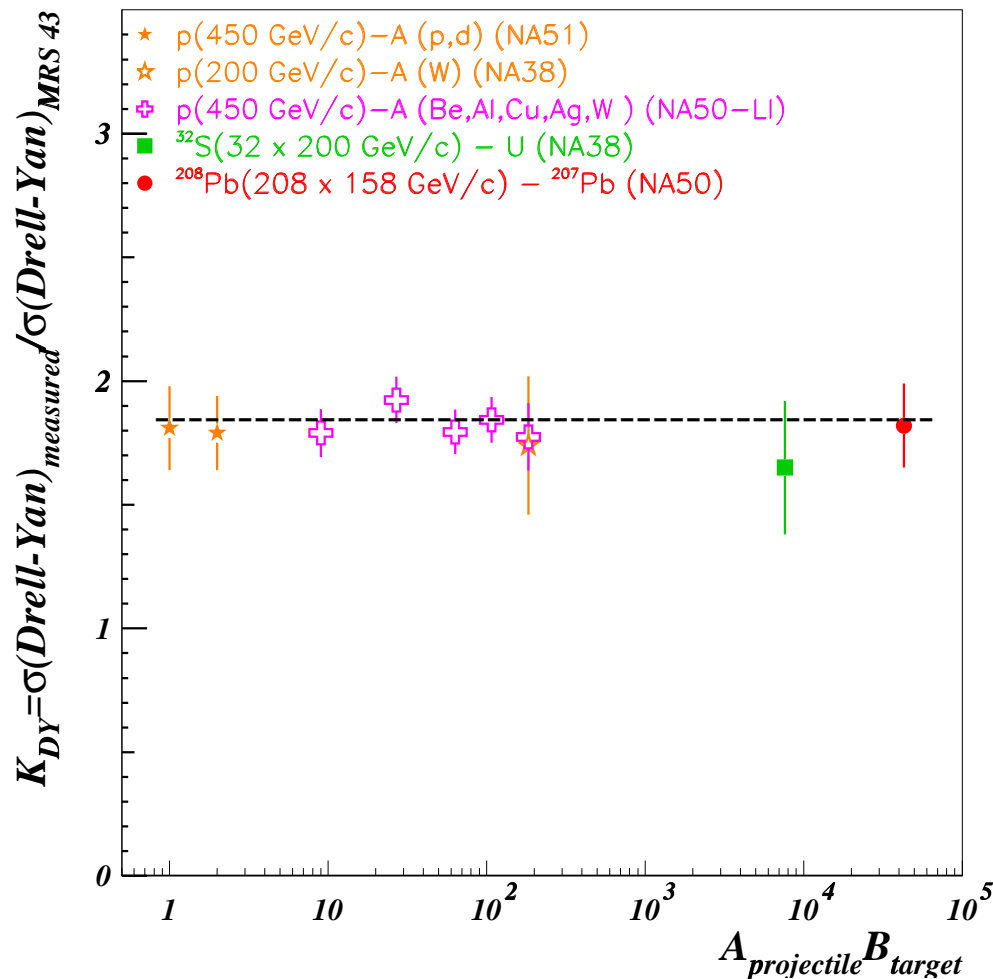
### Main improvements

- ◇ Magnetic current increased from 4000A to 7000A  
    ↪ better mass resolution for high masses (3.3% for  $J/\psi$ )
- ◇ Additional centrality detectors: ZDC and MD

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

## Before 2000 - The state of the art (2)

### Reference for $J/\psi$ production: Drell-Yan

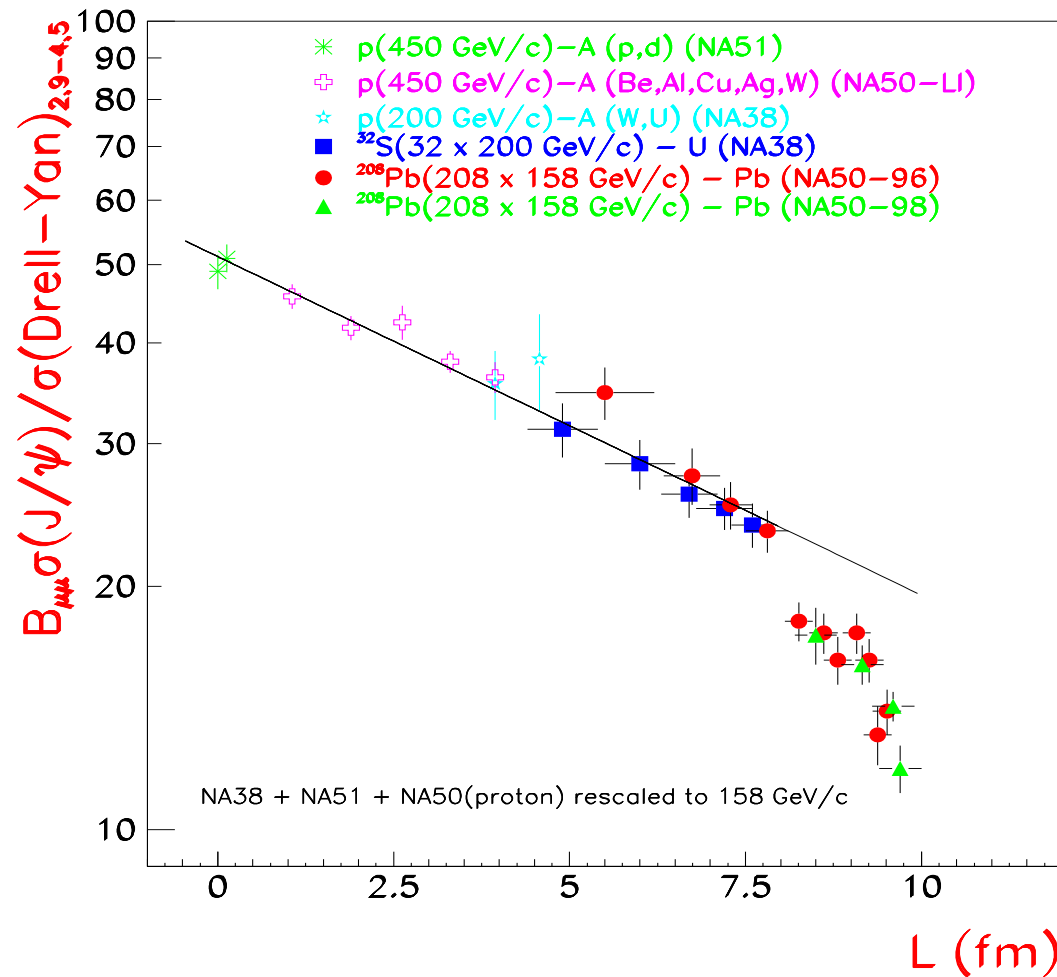


- $\sigma(\text{DY})$  is proportional to the number of nucleon-nucleon collisions from **p-p** up to **Pb-Pb**

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

## Before 2000 - The state of the art (3)

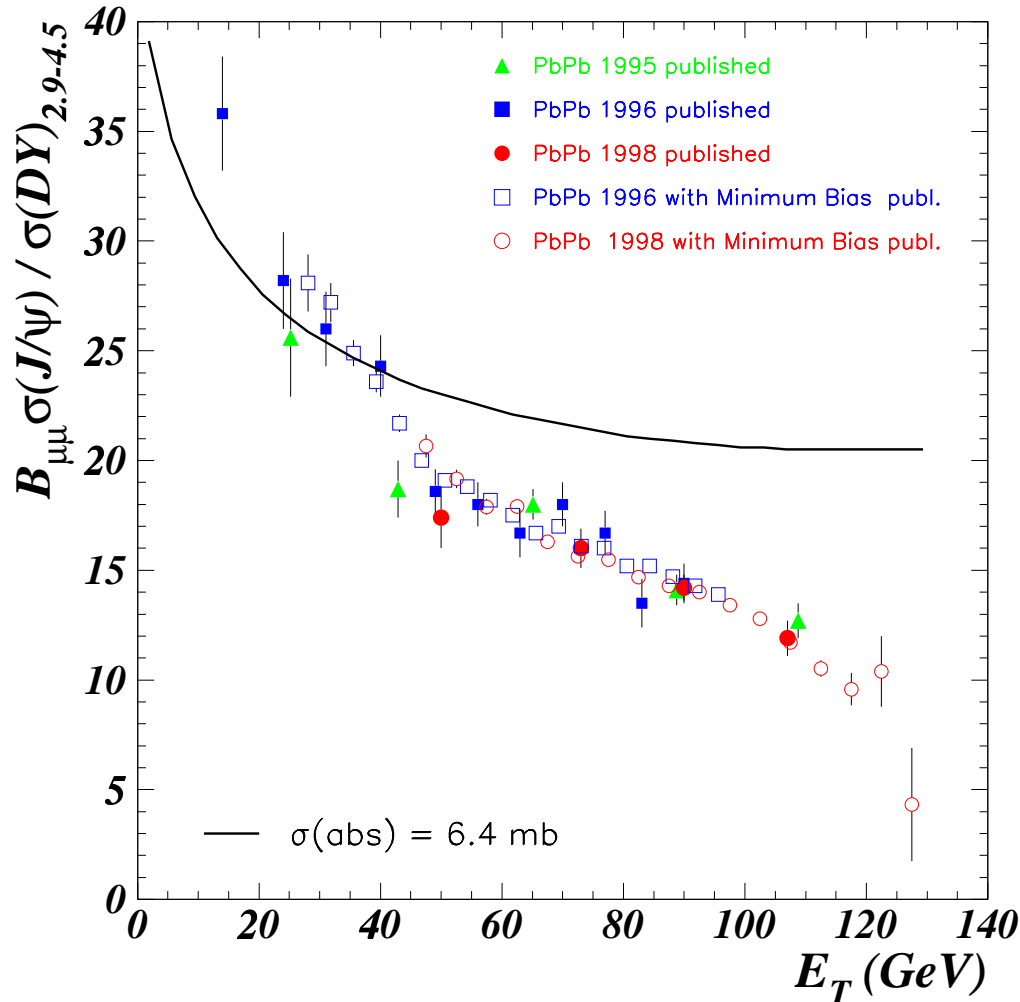
$J/\psi/DY$  as a function of  $L$



- $L$  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  $L = 8 \text{ fm}$

## 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  $\approx 40 \text{ GeV}$
- 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

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

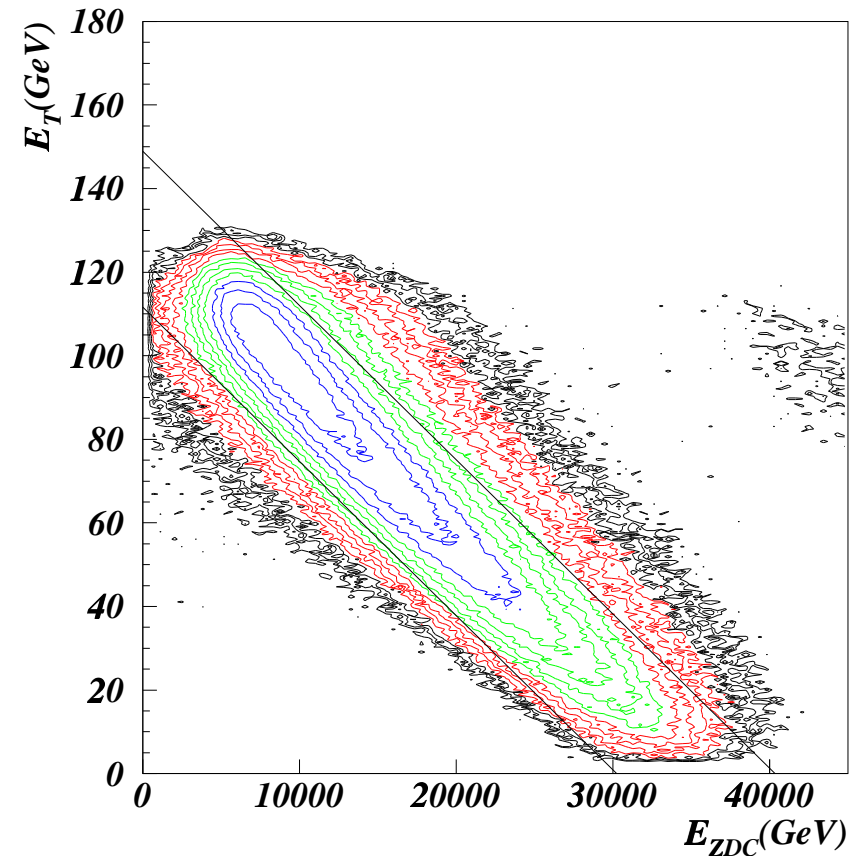
- ◇ 1 single target with 9.5%  $\lambda_I$  (in vacuum)

- ◇ Beam intensity =  $7 \times 10^7$  ions/burst

- ◇  $\approx 120000$   $J/\psi$  collected

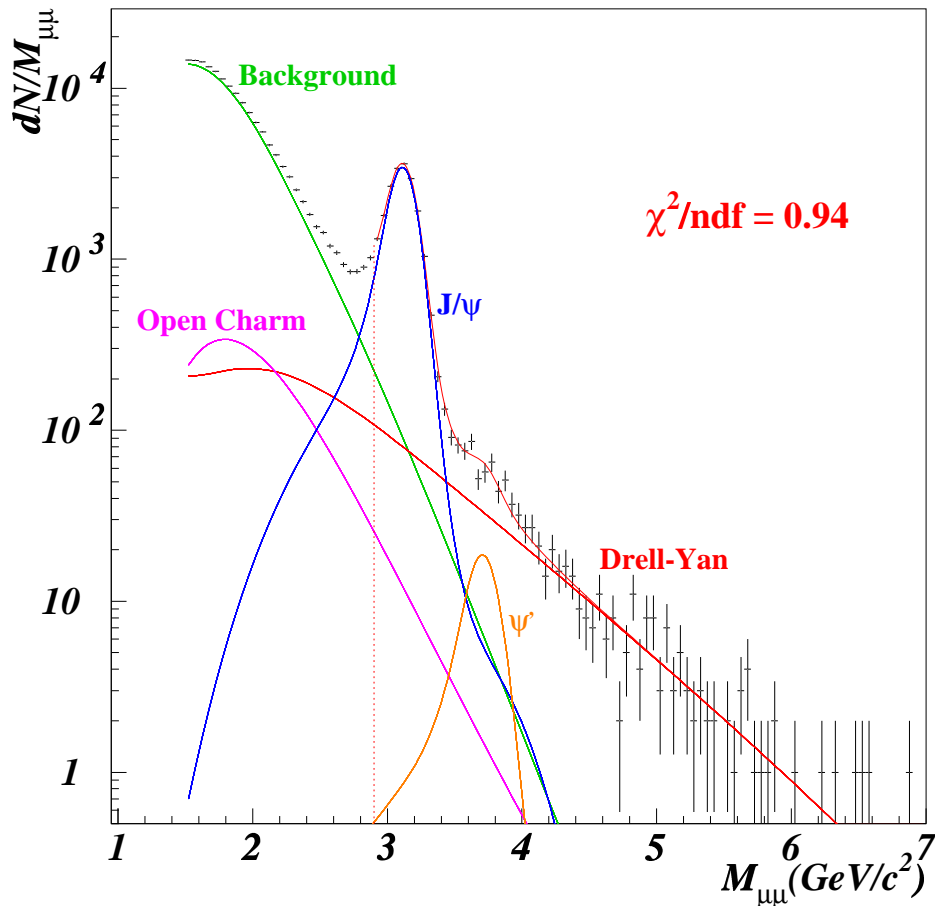
## Pb-Pb00 - Data Selection

- 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

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

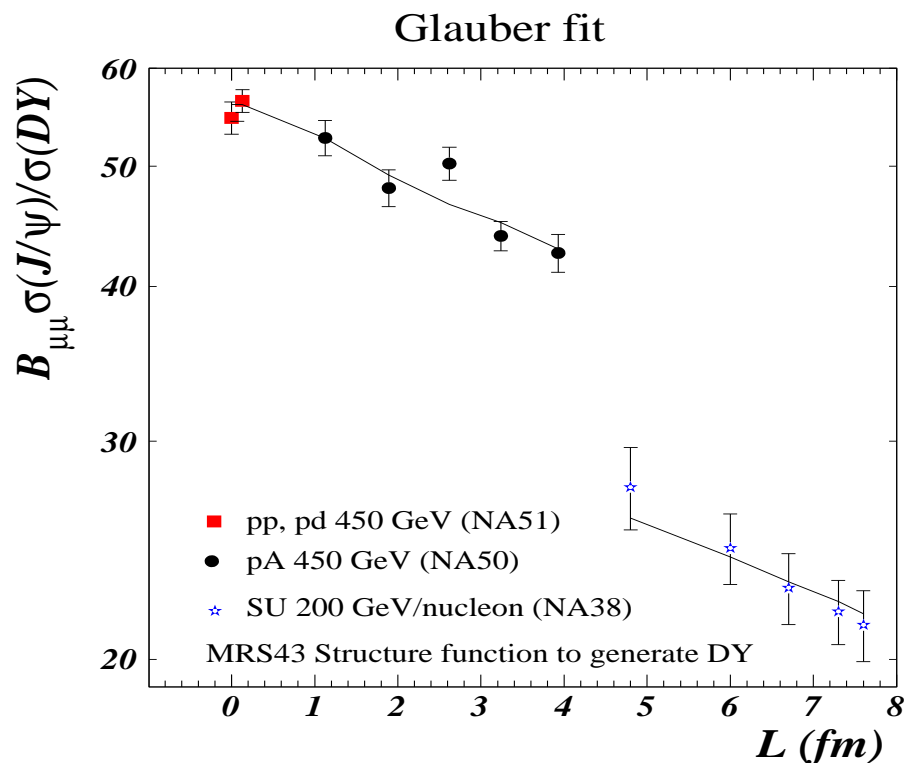


- Final fit performed for  $M > 2.9 \text{ GeV}/c^2$
- $J/\psi$ ,  $\psi'$ ,  $DY$  and  $D\bar{D}$  shapes obtained by Monte Carlo
- Combinatorial background from pion and kaon decays is extracted from like-signs pairs, using:

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

# The $J/\psi$ 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  $J/\psi$  suppression** against **normal nuclear absorption**

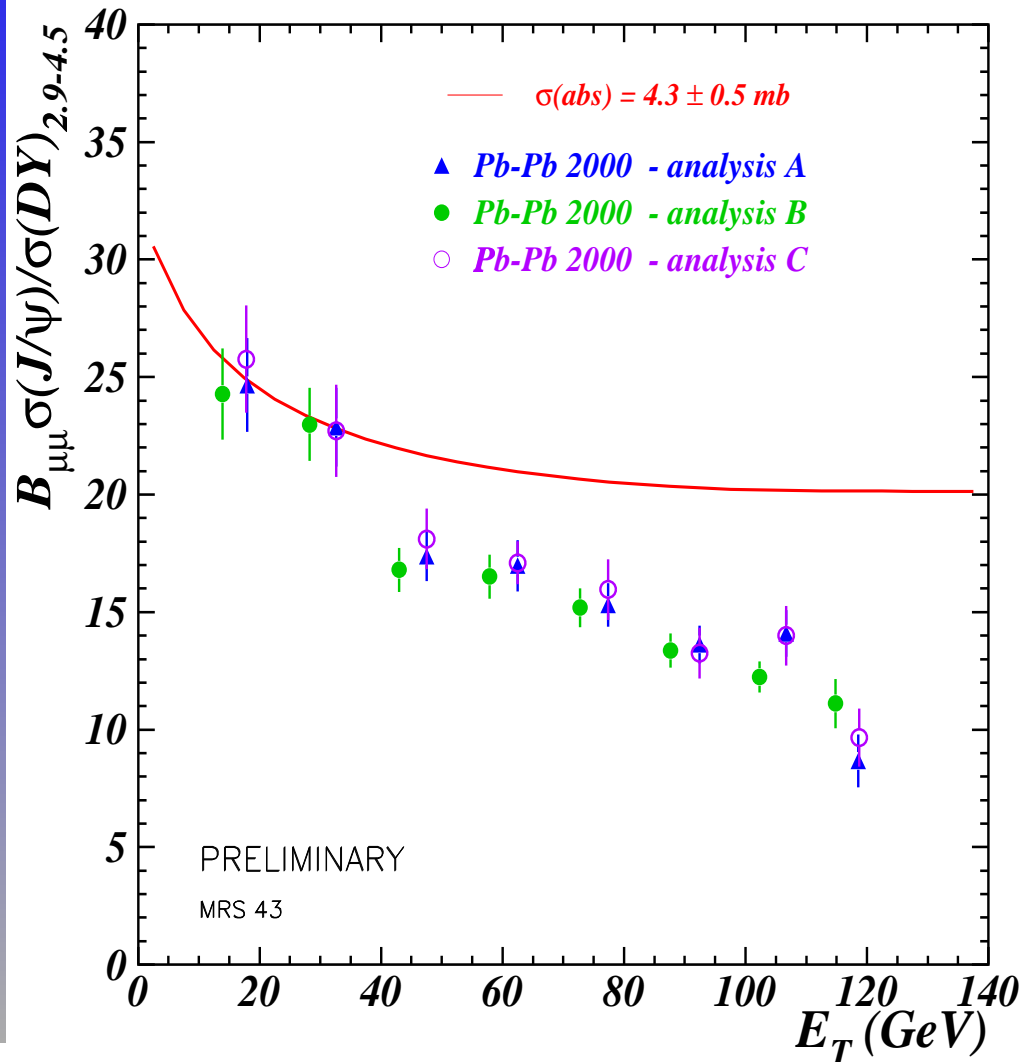


- Using a Glauber model fit, the **absorption cross-section** for  $J/\psi$  obtained is

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

# Pb-Pb 2000 Results

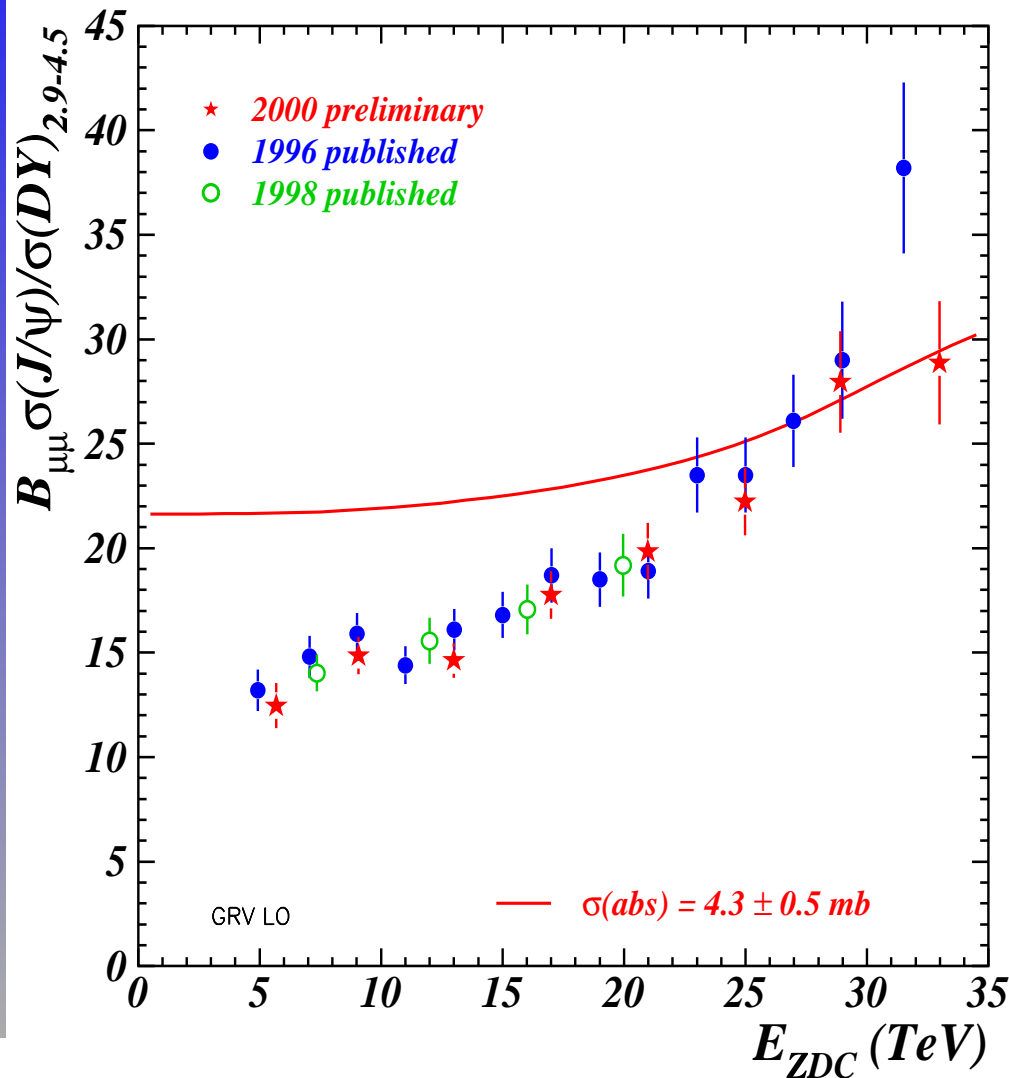
Transverse energy,  $E_T$ , used as the **centrality collision** estimator



- **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

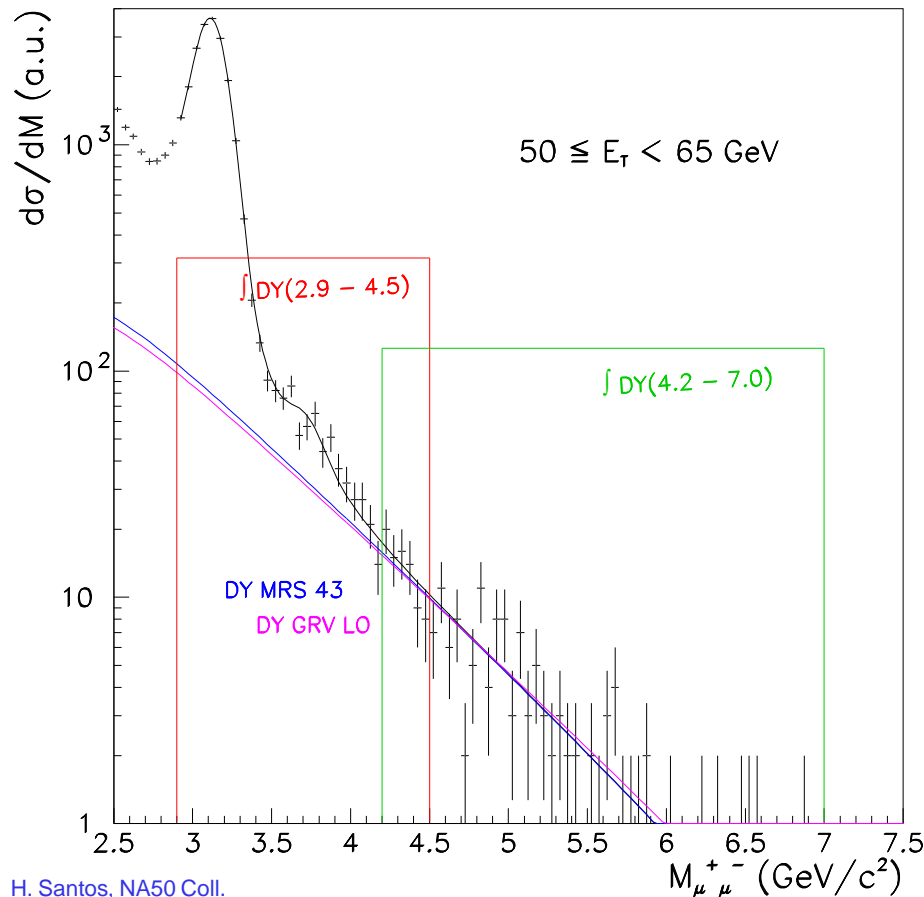


- **2000 data** in good agreement with published analyses (except for most peripheral collisions, probably due to Pb-air interactions in **1996** setup conditions)
- Departure of  $J/\psi/DY$  at mid-centrality from the absorption curve
- No saturation at low  $E_{ZDC}$

# Pb-Pb2000 - New reference: Drell-Yan in 4.2-7.0 GeV/c<sup>2</sup>

In the same invariant mass range (2.9-4.5 GeV/c<sup>2</sup>) muons from  $J/\psi$  and Drell-Yan have similar features, namely acceptance and momentum.

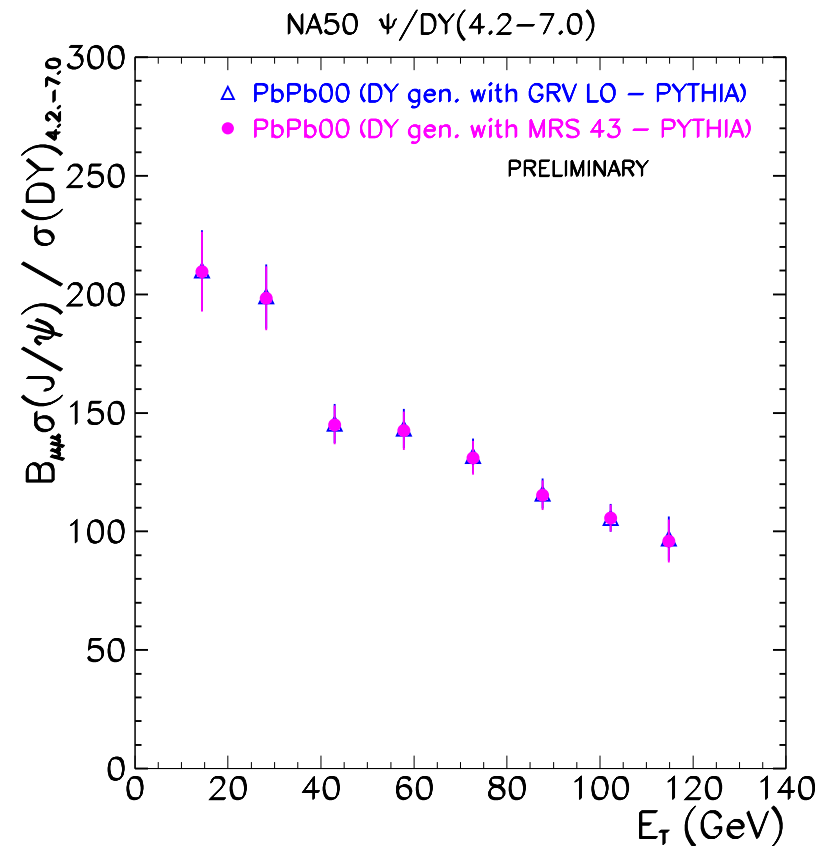
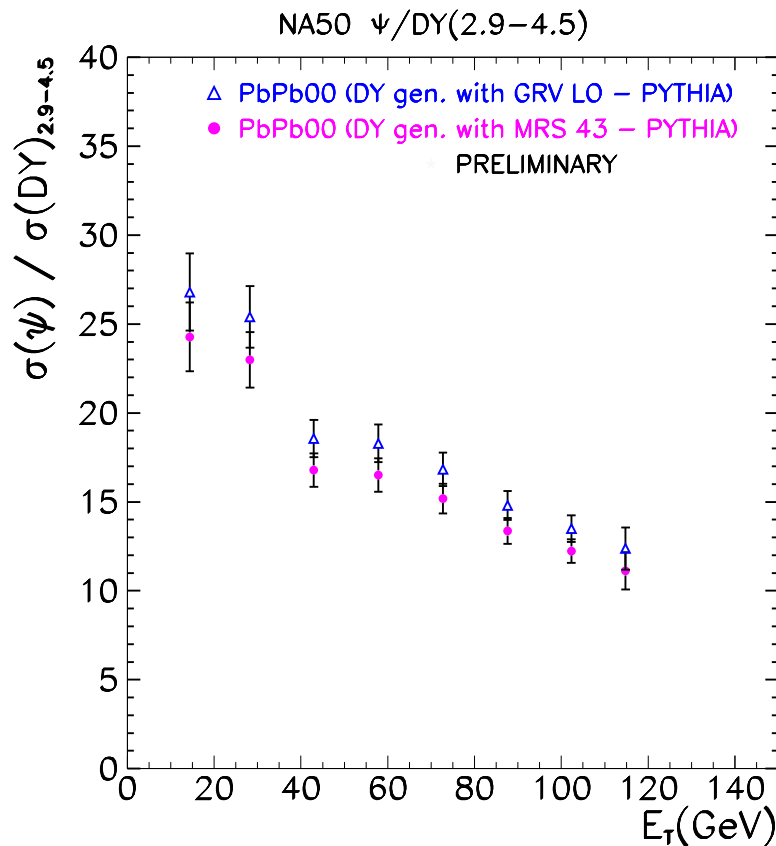
Nevertheless, different structure functions chosen to generate Drell-Yan lead to different mass distributions



- $\sigma_{DY}(2.9-4.5)$  is determined by the measured  $\sigma_{DY}(4.2-7.0)$ , 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  $\sigma_{DY}$  in the measured region: 4.2-7.0 GeV/c<sup>2</sup>  
 $\Rightarrow$  **same  $J/\psi/DY_{4.2-7.0}$  ratios**

# Pb-Pb2000 - New reference: Drell-Yan in 4.2-7.0 GeV/c<sup>2</sup> (2)

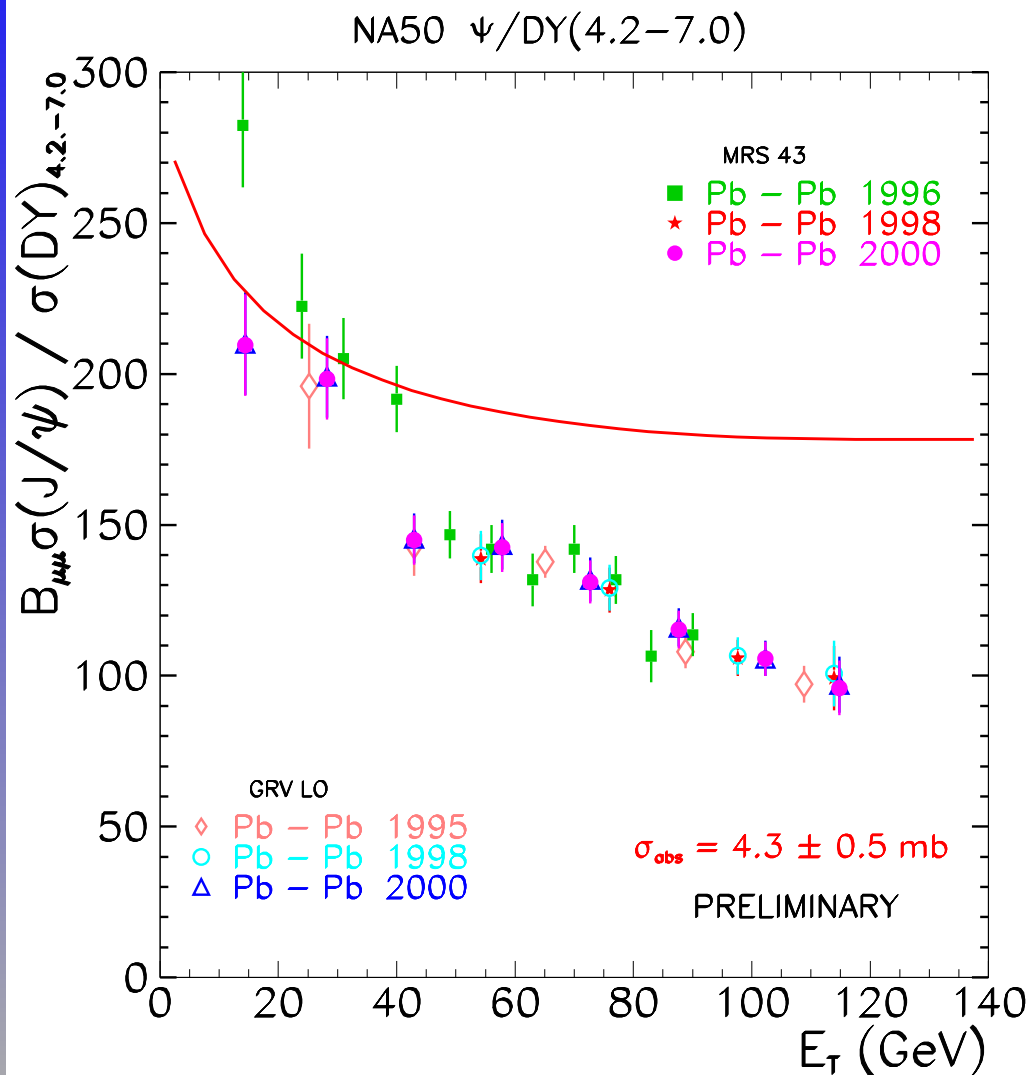
Comparison between  $\psi/DY$  ratios fitted with Drell-Yan obtained with  
**GRV LO** and **MRS 43** structure functions



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  $J/\psi$**  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