Charmonia absorption in p-A collisions at the CERN SPS: results and implications on Pb-Pb interactions

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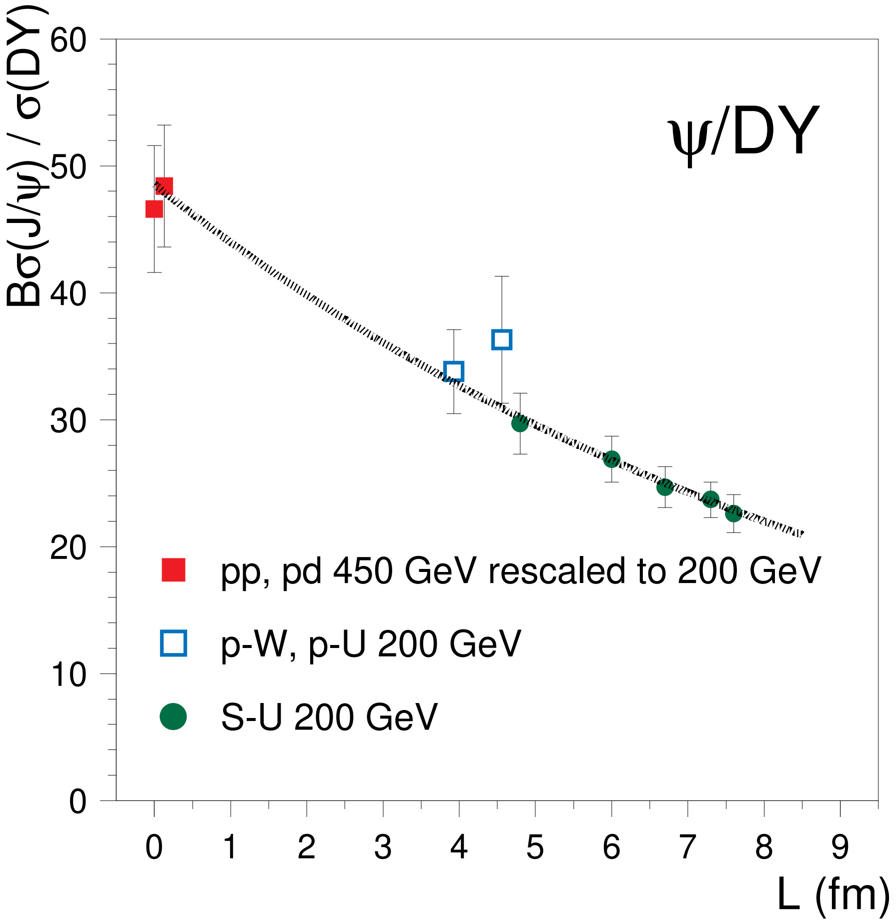
Summary

- The estimation of J/ψ nuclear absorption cross section in p-A and S-U collisions by NA38/NA51
- Results in p-A collisions at 450 GeV/c
  - Glauber fit to p-A data to extract $\sigma^{abs}_{\mathrm{J}/\psi}$ in ψN interactions
- Comparison of J/ψ production in p-A with S-U collisions
  - Compatibility between $\sigma^{abs}_{\mathrm{J}/\psi}$ in p-A and S-U data
  - Estimation of a common $\sigma^{abs}_{\mathrm{J}/\psi}$ from p-A and S-U data
- Estimation of the J/ψ normal nuclear absorption in Pb-Pb collisions

The J/ψ nuclear absorption measured by NA38/NA51



Study of $B_{\mu\mu}\sigma(\mathrm{J}/\psi)/\sigma(DY)$

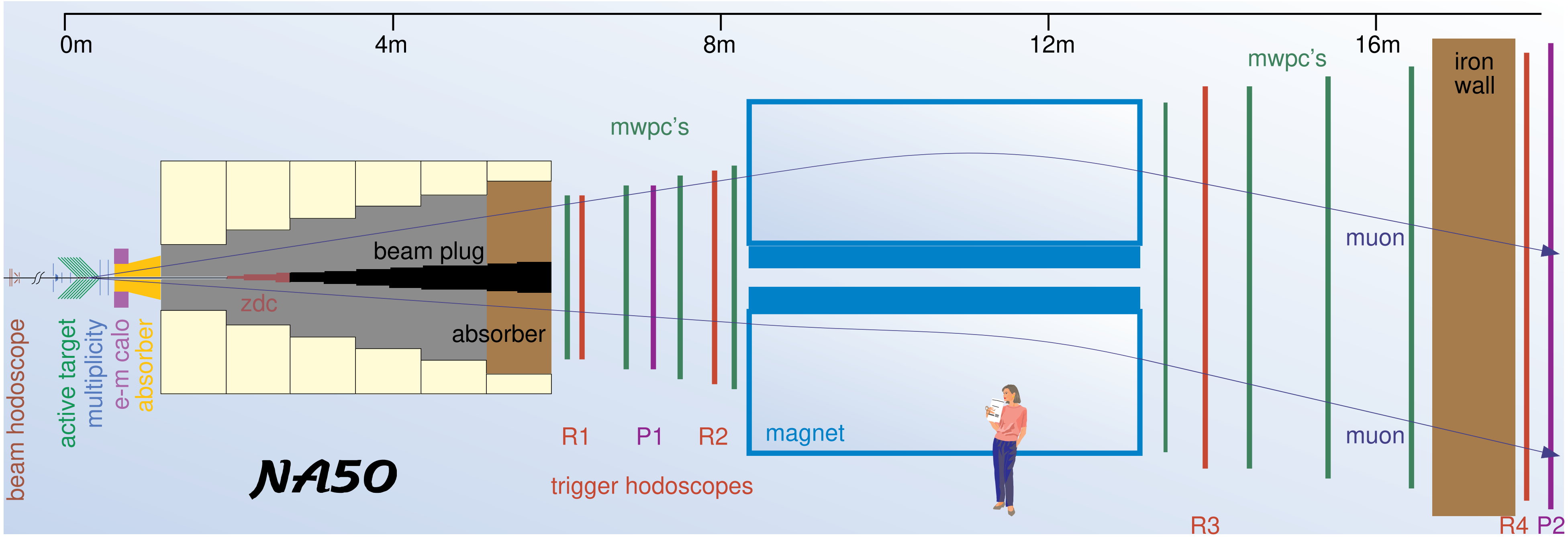
- direct normalization: Drell-Yan is proportional to the number of binary nucleon-nucleon collisions

- cancellation of most systematic errors (luminosity and detection efficiency)

Glauber fit to NA38/NA51 results
$\Rightarrow \sigma^{abs}_{\mathrm{J}/\psi} = 6.4 \pm 0.8$ mb

Need improved ψ/DY data in p-A collisions

The NA50 muon spectrometer: data taking conditions



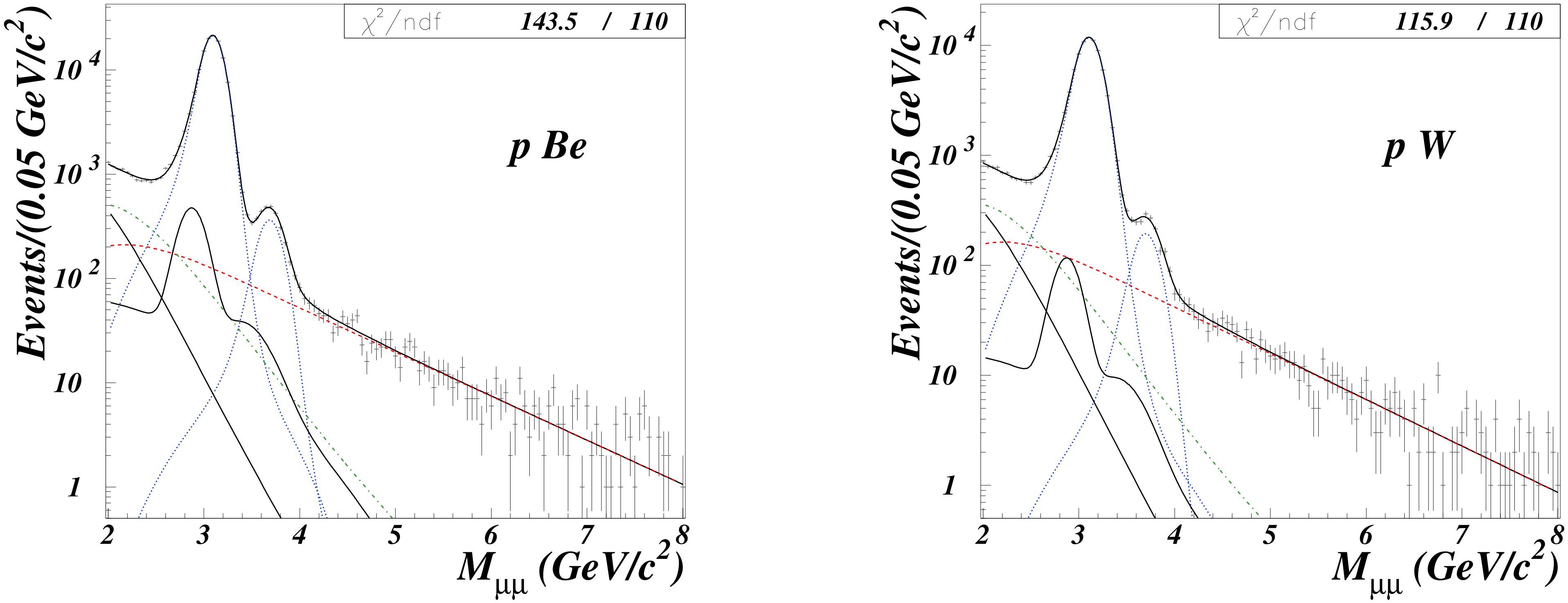
p beam at top SPS energy: 450 GeV

Acceptance: $-0.4 < y^* < 0.6$ and $|\cos\theta_{CS}| < 0.5$

5 targets: Be, Al, Cu, Ag and W with thicknesses between ∼0.3 and ∼0.5 λ_i

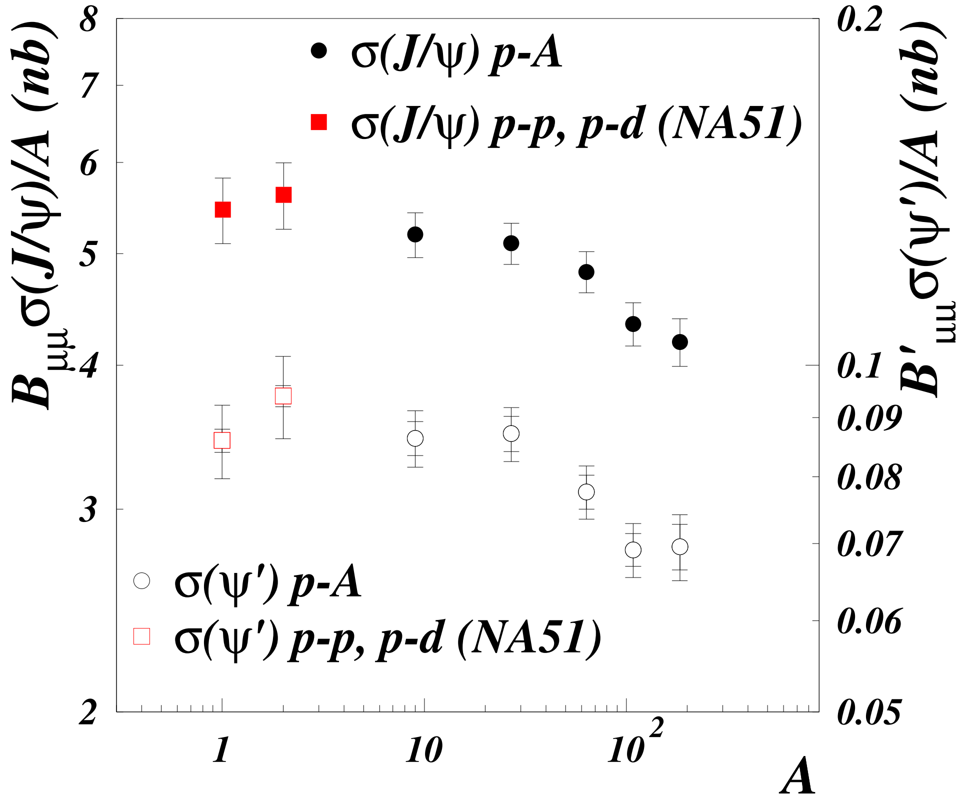
Fit to $\mu^+\mu^-$ invariant mass spectra

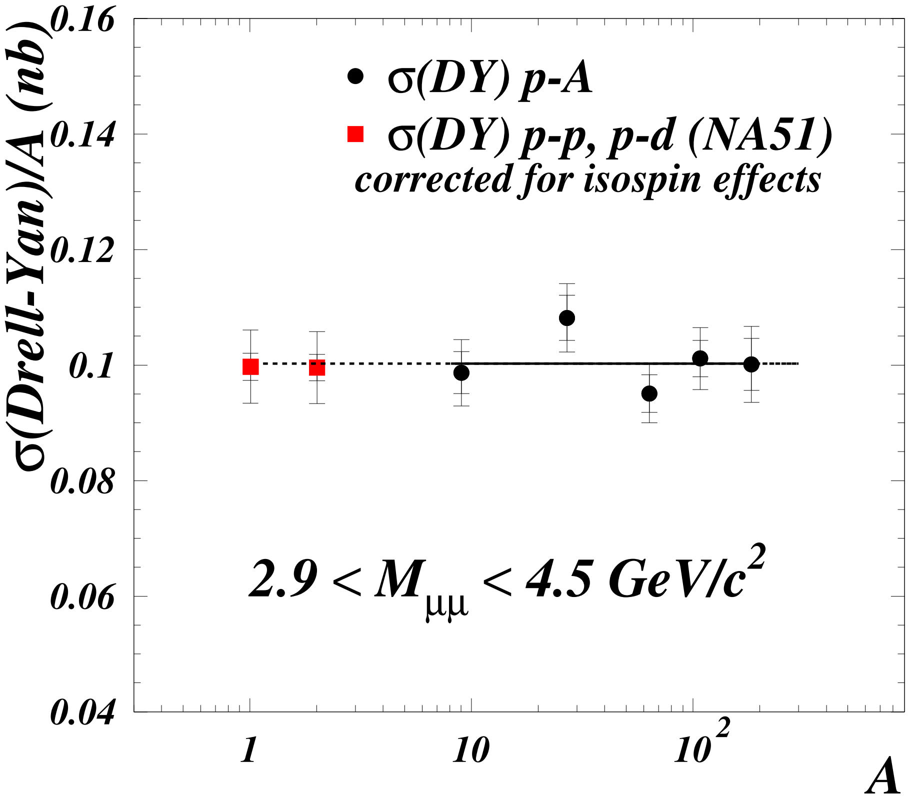
$$\frac{dN^{+-}}{dM} = n^{DY}\frac{dN^{DY}}{dM} + n^{J/\psi}\frac{dN^{J/\psi}}{dM} + n^{\psi'}\frac{dN^{\psi'}}{dM} + n^{D\overline{D}}\frac{dN^{D\overline{D}}}{dM} + R\frac{dN^{bck}}{dM} + \frac{dN^{out}}{dM}$$



$\frac{dN^i}{dM}$ determined by Monte-Carlo simulation for DY, J/ψ, ψ' and $D\overline{D}$
R factors calculated with a simulation based on VENUS 4.12
n^i are free parameters in the fit

The J/ψ, ψ' and Drell-Yan cross sections at 450 GeV

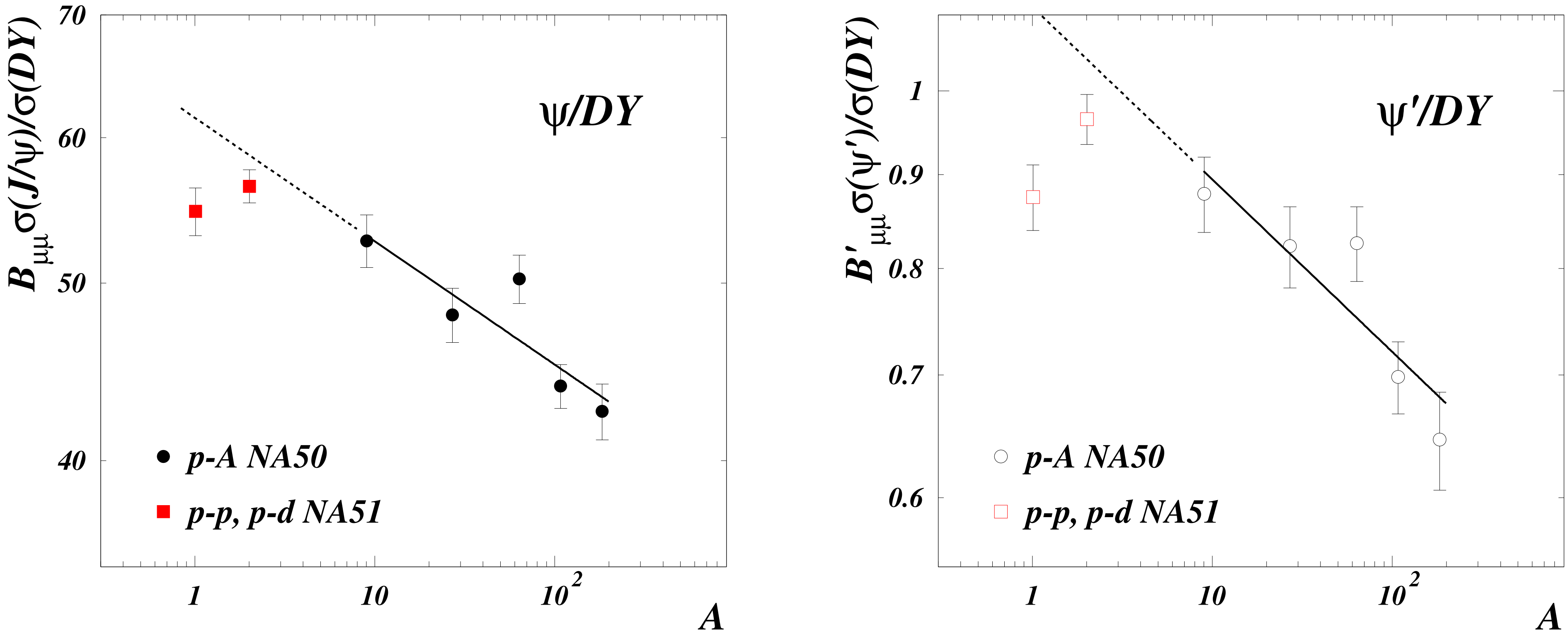




$\sigma_{DY}^{pA} = \sigma_{DY}^{pp} \cdot A^{\alpha}$ $\quad \Rightarrow \alpha_{DY}^{pA} = 0.995 \pm 0.016\ (\mathrm{stat}) \pm 0.019\ (\mathrm{syst})$

$\Rightarrow$ nuclear shadowing is negligible in the explored phase space

The J/ψ and ψ' interactions with nuclear matter



p-p and p-d results (NA51) are not included in the fit

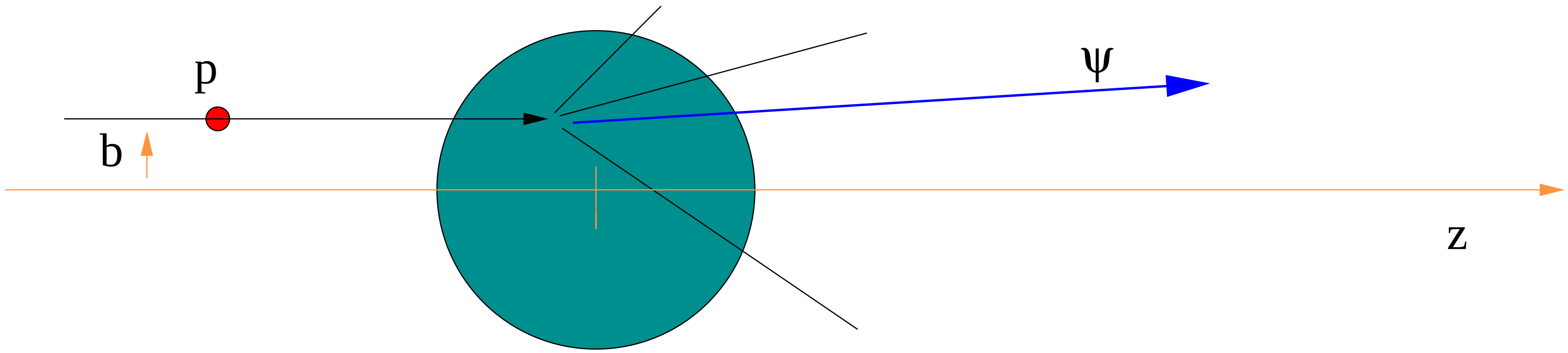
Results: $\alpha_{J/\psi} = 0.933 \pm 0.015$ and $\alpha_{\psi'} = 0.906 \pm 0.022$

$\Delta\alpha = \alpha_{J/\psi} - \alpha_{\psi'} = 0.028 \pm 0.014$

The Glauber approach

σ^{pA}_{DY} proportional to N_{coll}

$$\sigma^{pA}_{DY} = A \cdot \sigma^{pN}_{DY}$$

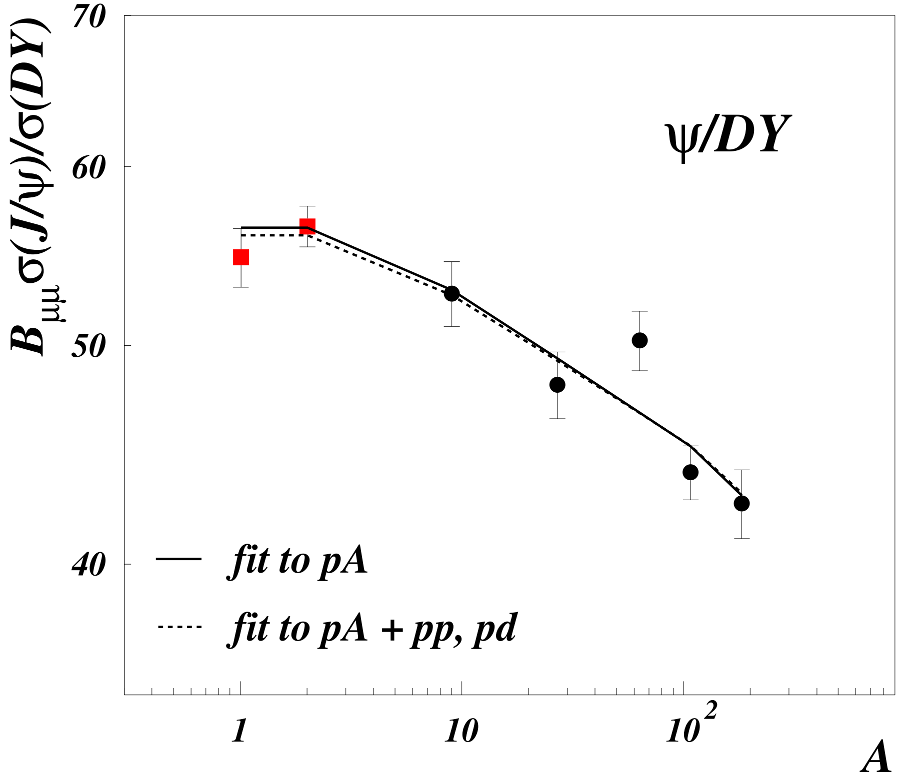


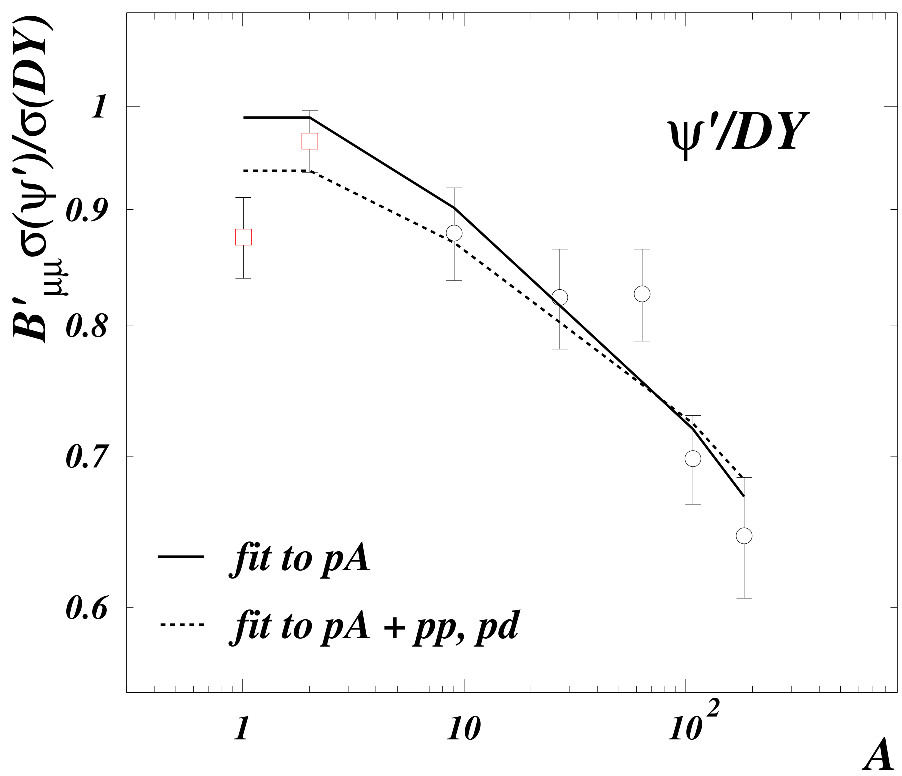
$\sigma^{pA}_{\mathrm{J}/\psi}$ proportional to N_{coll} convoluted with nuclear absorption

$$\sigma^{pA}_{J/\psi} = A \cdot \sigma^{pp}_{J/\psi} \cdot \frac{1}{(A-1)\sigma^{2}_{abs.}} \cdot \int d^2b(1 - e^{-(A-1)T_A(\vec{b})\sigma^{\mathrm{J}/\psi}_{abs}})$$

✔ Fit to ψ/DY results with 2 free parameters: $\left(\frac{\sigma_{J/\psi}}{\sigma_{DY}}\right)^{pp}$ and $\sigma^{\mathrm{J}/\psi}_{abs}$

Glauber fit to p-A

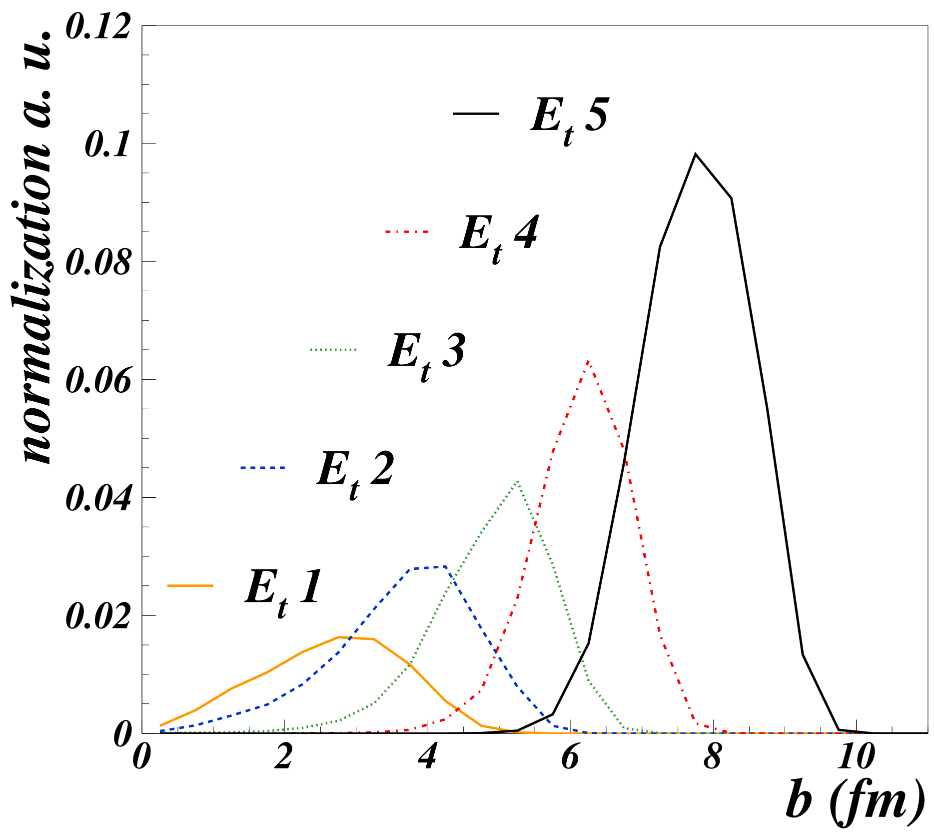




	$\sigma^{abs}_{J/\psi}$ (mb)	χ^2	$\sigma^{abs}_{\psi'}$ (mb)	χ^2	$\Delta\sigma = \sigma^{abs}_{\psi'} - \sigma^{abs}_{J/\psi}$ (mb)
p-A	4.4±1.0	2.4	6.4±1.5	1.5	2.2±1.0
p-A + pp + pd	4.2±0.5	1.6	5.1±0.8	1.9	0.9±0.6

J/ψ production in S-U

- NA38 $\Rightarrow$ centrality estimated by the transverse energy

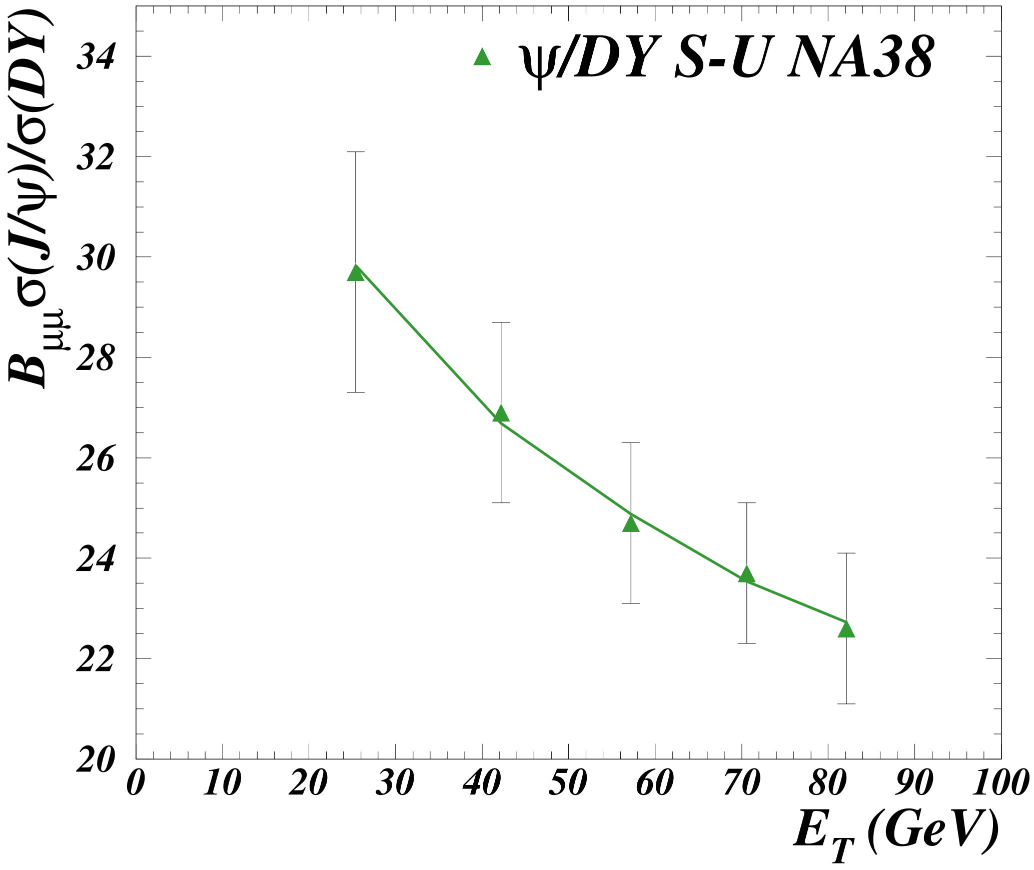


- From E_t to b $\Rightarrow$ Glauber fit

Take into account the resolution of the electromagnetic calorimeter

- $2\pi\, b\, db$ $\Rightarrow$ probability distribution

Glauber fit to S-U

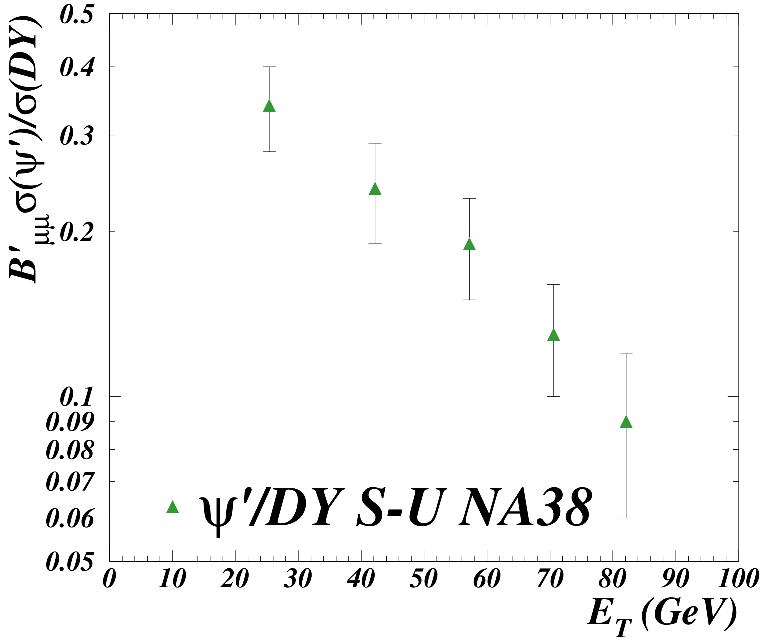


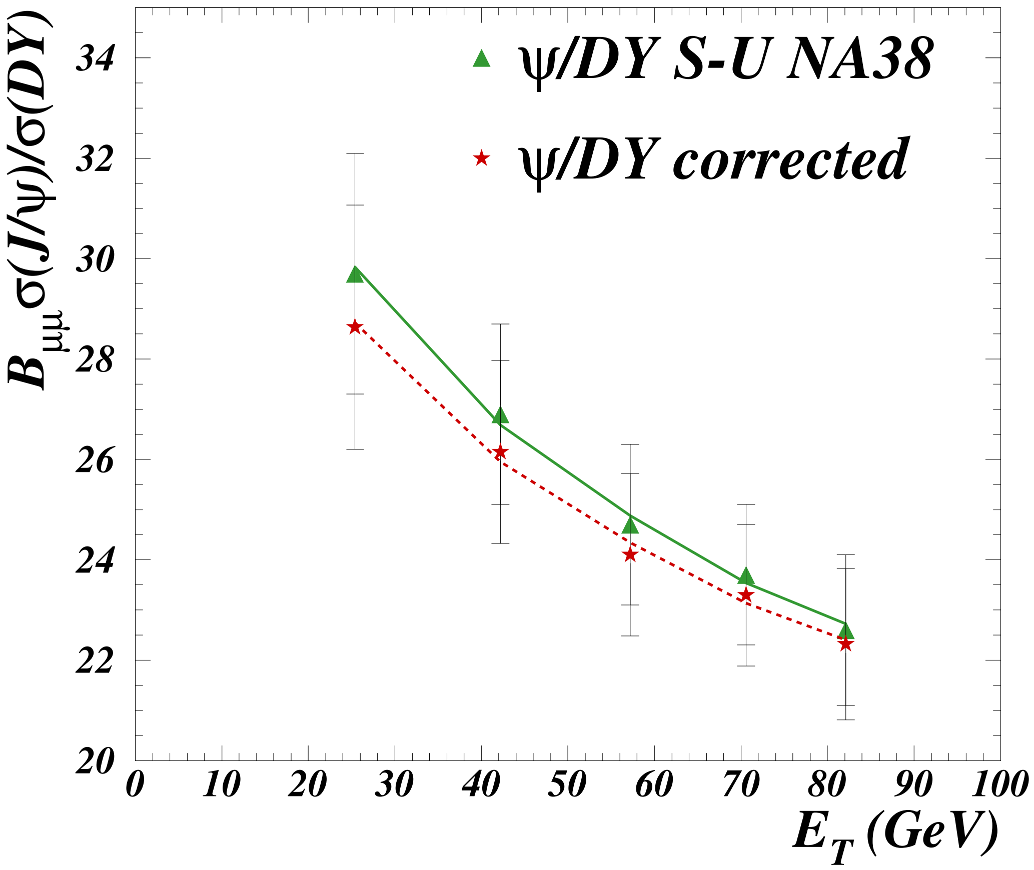
$$\sigma_{\mathrm{J}/\psi}^{abs,\,SU} = 7.1 \pm 3.0 \text{ mb}$$

error on S-U results and correlation between the fit parameters $\Rightarrow$ large error on σ^{abs}

J/ψ nuclear absorption compatible with p-A:
$$\sigma_{\mathrm{J}/\psi}^{abs,\,pA} = 4.2 \pm 0.5 \text{ mb}$$

The ψ' suppression in S-U





✘ ψ' decays feed the J/ψ sample mainly in peripheral events

$$\left(\frac{\mathrm{J}/\psi}{DY}\right)_{corrected} = \left(\frac{\mathrm{J}/\psi}{DY}\right) - \frac{B(\psi'\to\mu\mu)\cdot B(\psi'\to\mathrm{J}/\psi+\mathrm{X})}{B(\mathrm{J}/\psi\to\mu\mu)}\cdot\left(\frac{\psi'}{DY}\right)$$

Fit to corrected $\psi/DY \Rightarrow \sigma^{abs,\,SU}_{\mathrm{J}/\psi\ corrected} = 6.3 \pm 2.9$ mb

Comparing p-A and S-U data

- J/ψ absorption cross sections in p-A and S-U are compatible within errors

$\sigma^{abs,\,pA}_{\mathrm{J}/\psi} = 4.2 \pm 0.5$ mb $\qquad\qquad \sigma^{abs,\,SU}_{\mathrm{J}/\psi} = 7.1 \pm 3.0$ mb

- When the ψ' contribution is subtracted the compatibility is improved:

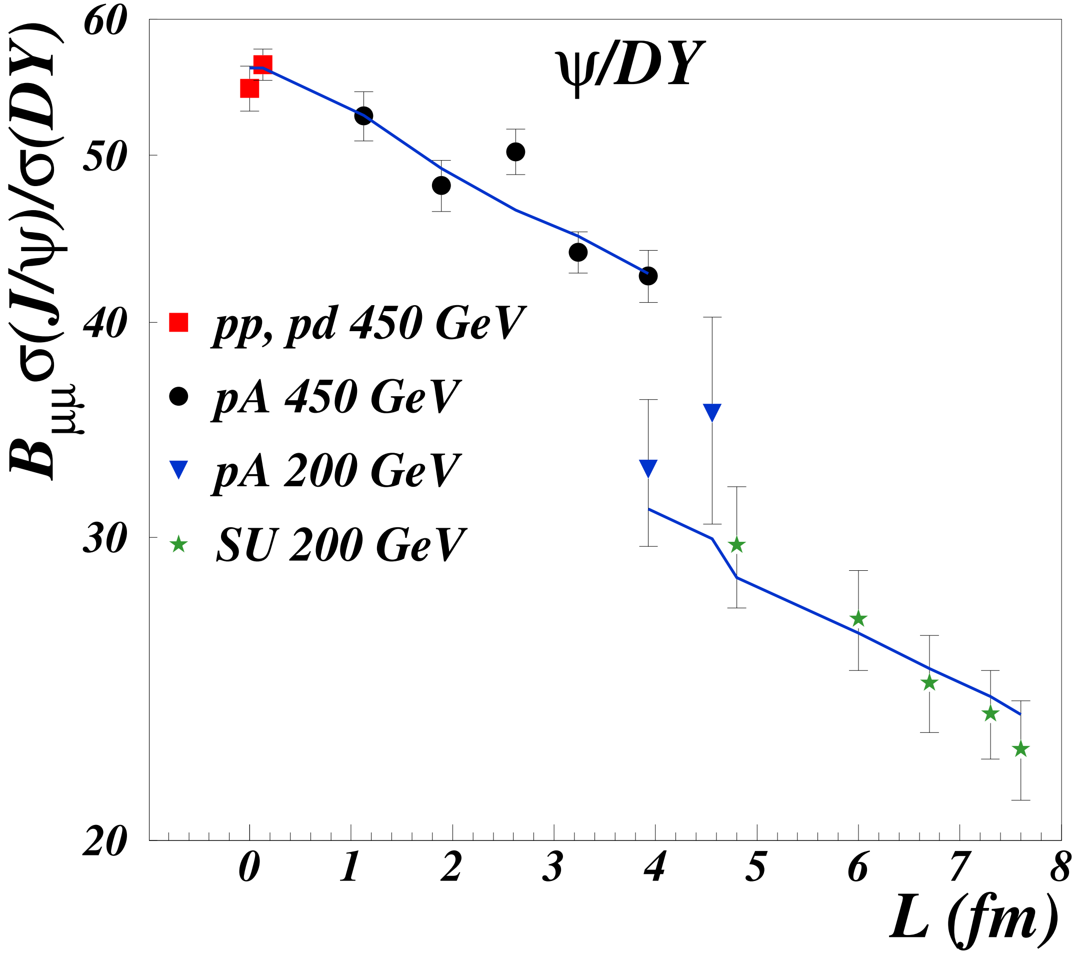
$\sigma^{abs,\,pA}_{\mathrm{J}/\psi\,corrected} = 4.1 \pm 0.6$ mb $\qquad\qquad \sigma^{abs,\,SU}_{\mathrm{J}/\psi\,corrected} = 6.3 \pm 2.9$ mb

- The two data sets can be fitted with a common J/ψ absorption cross section

Simultaneous fit to p-A and S-U with 3 free parameters:

1. $\sigma^{abs}_{\mathrm{J}/\psi}$
2. $\left(\frac{J/\psi}{DY}\right)^{pp}_{450\,GeV}$
3. $\left(\frac{J/\psi}{DY}\right)^{pp}_{200\,GeV}$

Glauber fit to p-A and S-U data (1)

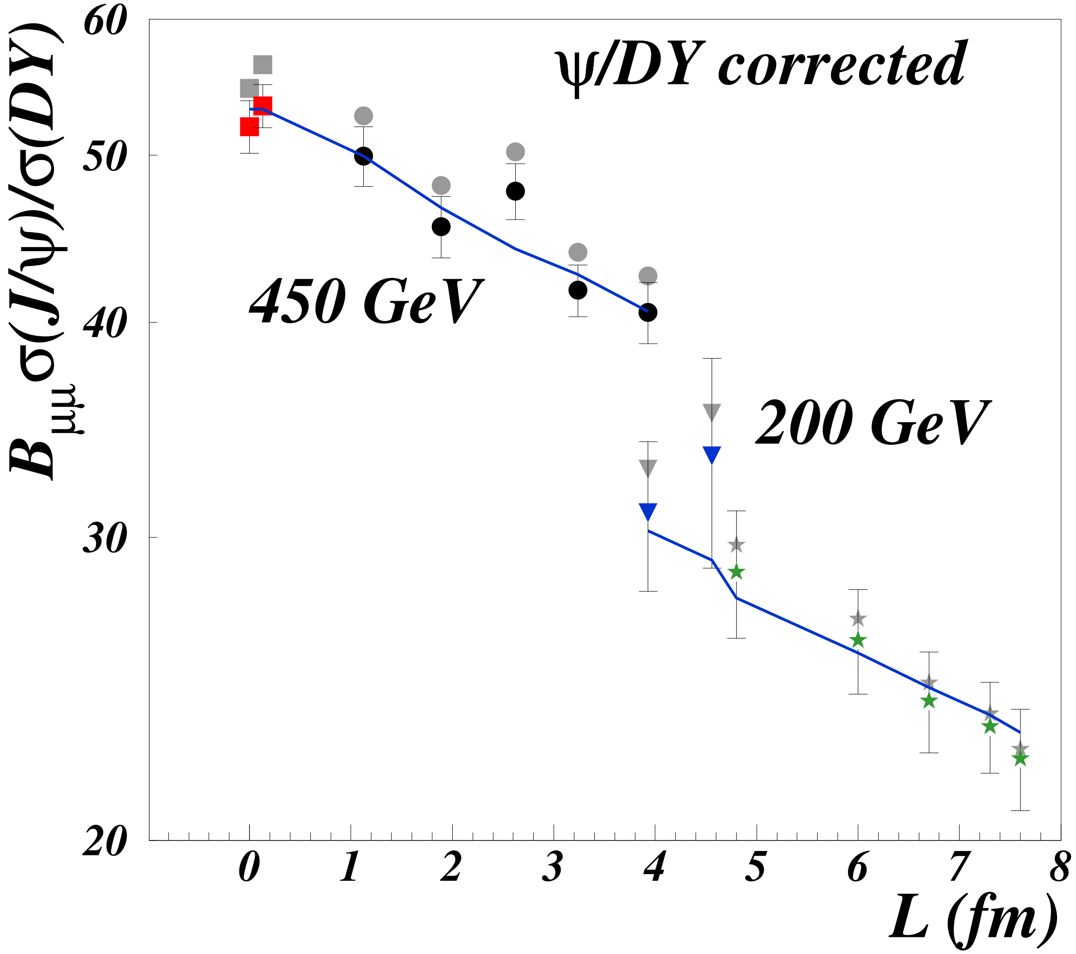


$$\sigma^{abs}_{J/\psi} = 4.4 \pm 0.5 \text{ mb}$$
$$(\chi^2 = 1.0)$$

$$(\psi/DY)^{pp}_{200\text{ GeV}}/(\psi/DY)^{pp}_{450\text{ GeV}} = 0.73 \pm 0.03$$

(consistent with expectation)

Glauber fit to p-A and S-U data (2)



$\sigma^{abs}_{J/\psi,\,corrected} = 4.3 \pm 0.6$ mb
$(\chi^2 = 0.6)$

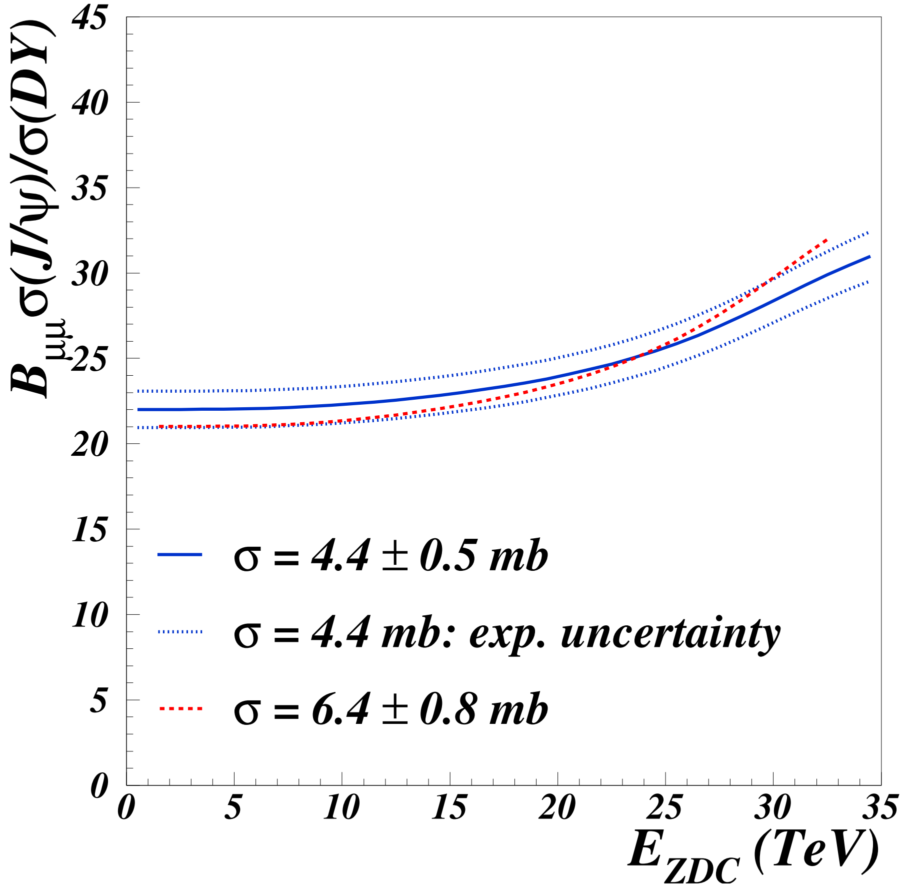
Subtract the ψ' contamination
$\Rightarrow$ no change on σ_{abs}.

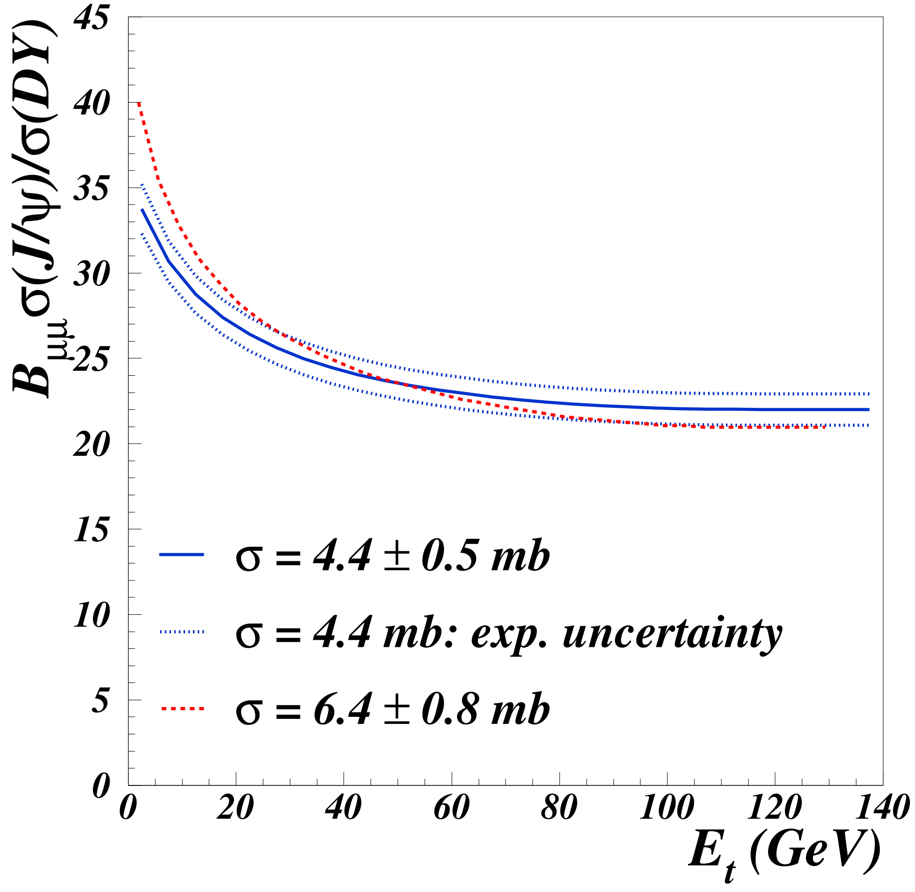
The quality of the fit improves!

Nuclear absorption for the J/ψ in Pb-Pb collisions

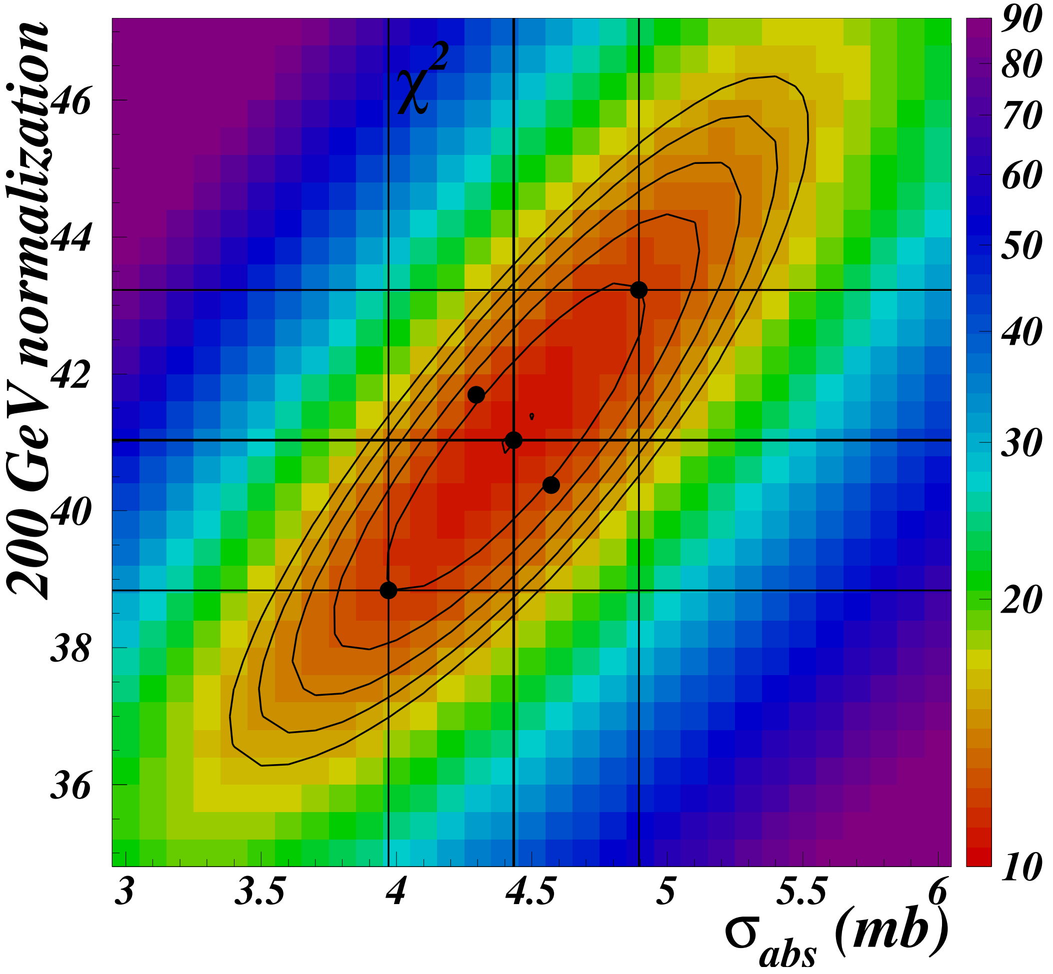
Rescaling the $\left(\frac{J/\psi}{DY}\right)^{SU}_{200\,GeV}$ to $\left(\frac{J/\psi}{DY}\right)^{PbPb}_{158\,GeV}$ $\Rightarrow$ scaling factor $= 1.051 \pm 0.026$

for the J/ψ using the "Schuler parametrization",
for DY with a Leading Order calculation with MRS A (Low Q^2) structure functions





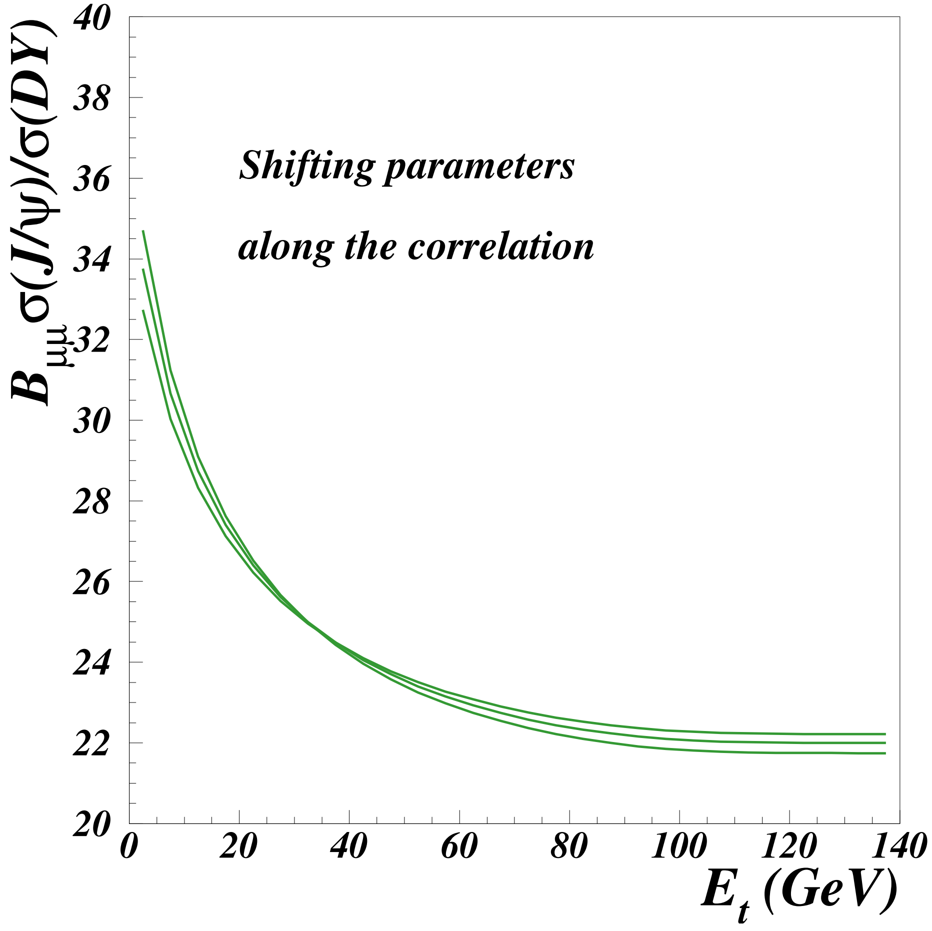
χ^2 in the simultaneous fit of p-A and S-U

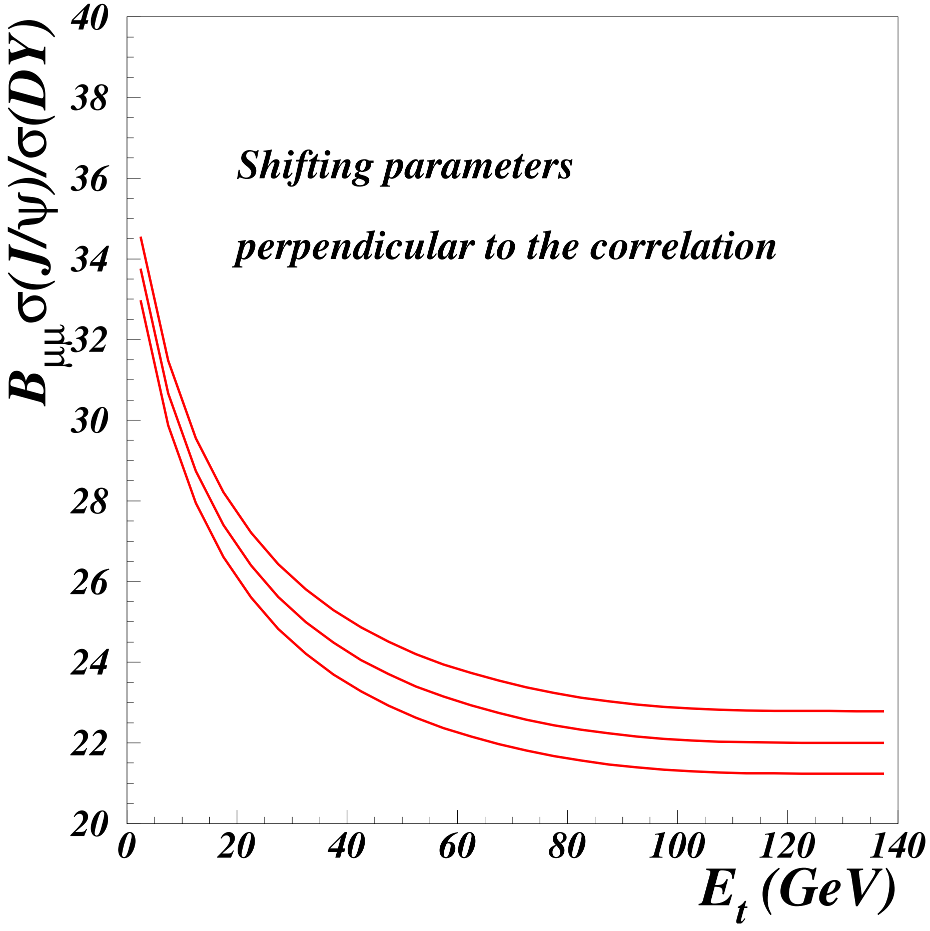


Correlation ≈ 0.85
between fit parameters: $\sigma^{abs}_{\mathrm{J}/\psi}$ and
normalization $\left(\frac{J/\psi}{DY}\right)^{pp}_{200\,GeV}$

$\Rightarrow$ increase of $\sigma^{abs}_{\mathrm{J}/\psi}$ is compensated
by a change in the normalization

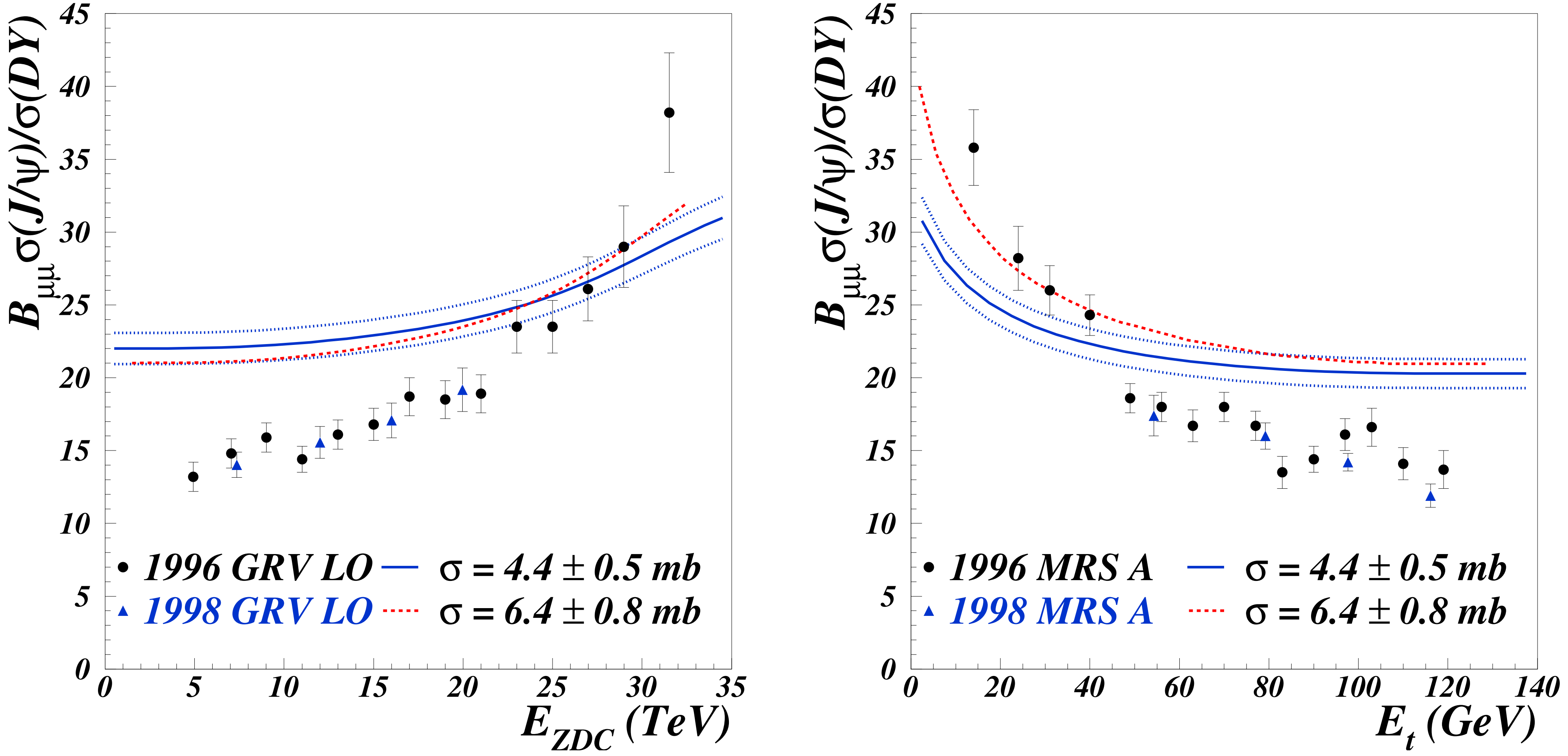
Uncertainty on the nuclear absorption in Pb-Pb





Combination of the two effects + error on rescaling
$\Rightarrow$ relative uncertainty of $\approx 4\%$ constant with centrality

Comparison with NA50 Pb-Pb data



More in the presentation by L. Ramello in the plenary session

Conclusions

✔ High statistics p-A data sets at 450 GeV incident energy were collected by NA50

⇒ study of ψ/DY and ψ'/DY on 5 nuclear targets
⇒ estimation of $\sigma^{abs}_{\mathrm{J}/\psi}$ in p-A in the framework of a Glauber model

✔ $\sigma^{abs}_{\mathrm{J}/\psi}$ extracted from p-A data compared with $\sigma^{abs}_{\mathrm{J}/\psi}$ in S-U

- results are compatible
- the agreement improves when the ψ' contamination is subtracted

✔ p-A and S-U data sets can be fitted with a common $\sigma^{abs}_{\mathrm{J}/\psi}$. From a simultaneous fit:

$$\sigma^{abs}_{\mathrm{J}/\psi} = 4.4 \pm 0.5 \text{ mb}$$

not corrected for ψ' contamination

✔ A new baseline for J/ψ suppression in Pb-Pb collisions has been estimated