Recent results on J/ψ from NA50

NA50 Collaboration

P. Bordalo – LIP-Lisbon

Stony Brook, January 15-20, 2001

NA50 COLLABORATION

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Outline

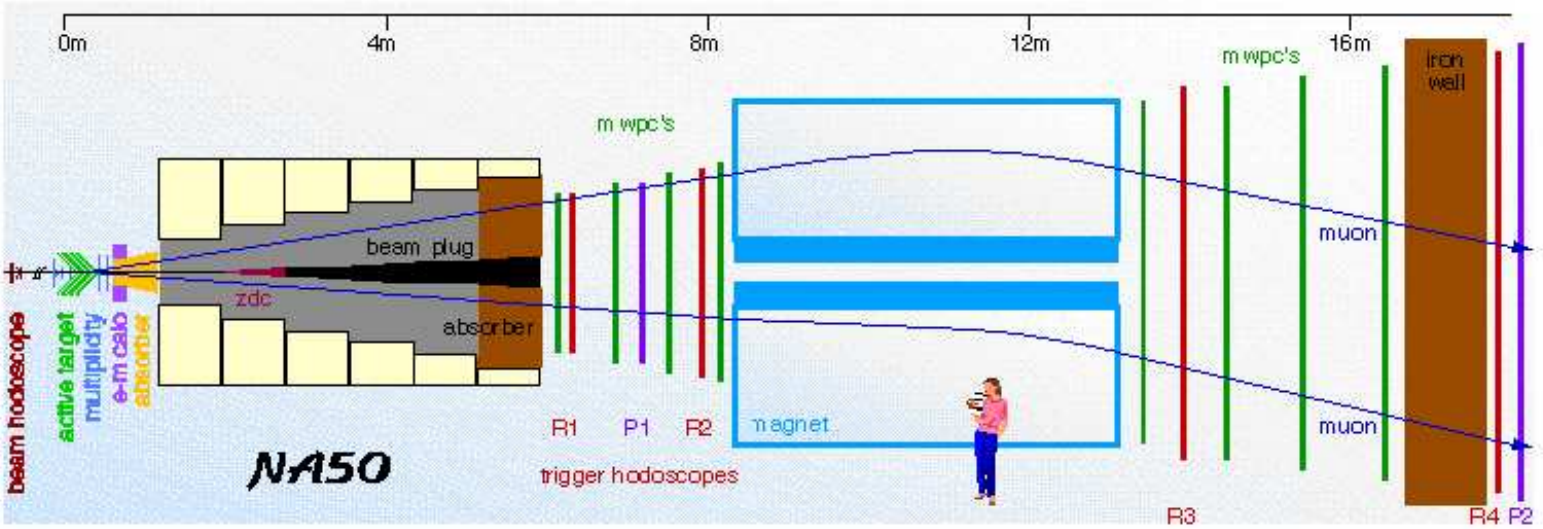
J/ψ Production:

- $J/\psi/DY$ as a function of E_T, L and ϵ
- New proton data
- Minimum Bias analysis
- ZDC analysis
- Comparision with models

J/ψ Transverse distributions:

- dN/dM_{T} distributions
- $\langle p_{\mathrm{T}} \rangle$ and $\langle p_{\mathrm{T}}^2 \rangle$ as a function of E_{T} and L
- Inverse slope parameter T
- dN/dp_{T} ratios for different centralities

Experimental Setup



The J/ψ is detected via its decay into muon pairs

- **Dimuon spectrometer:**

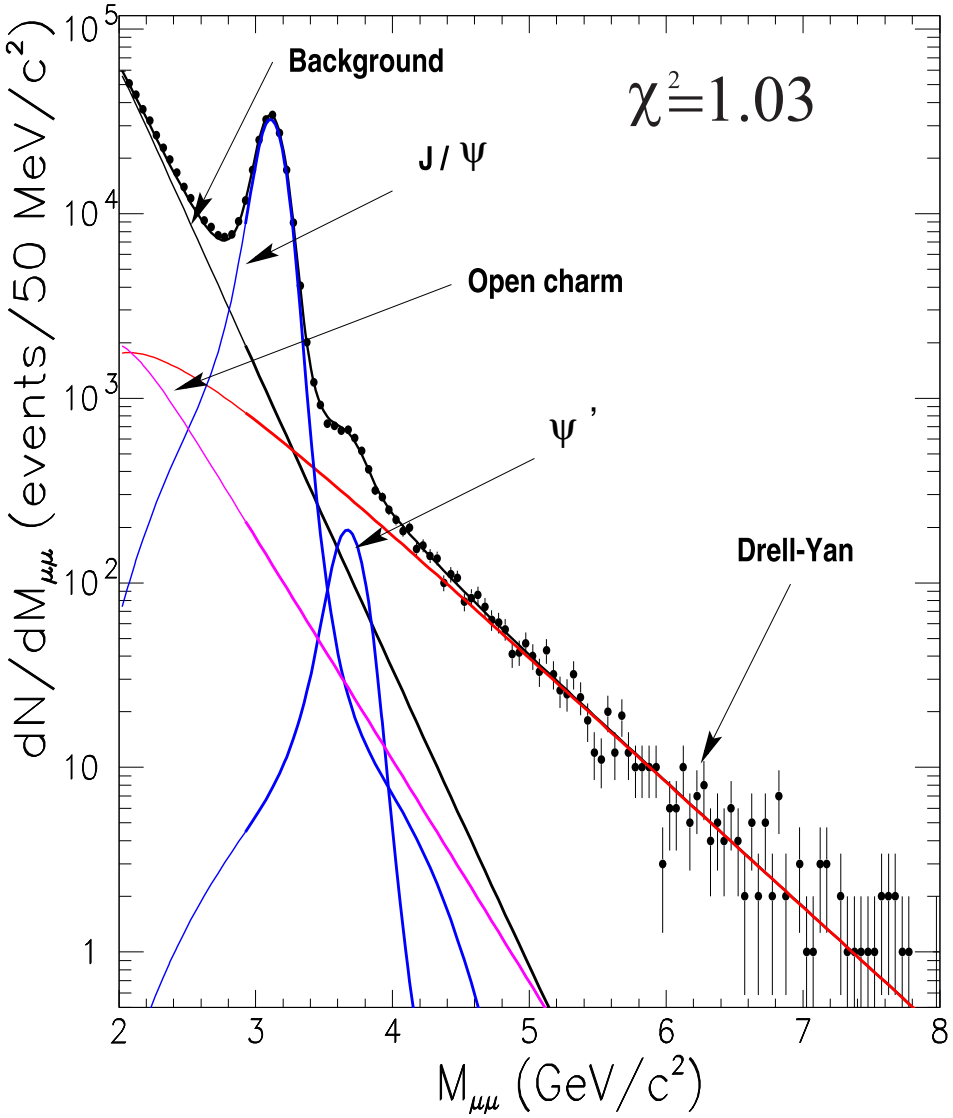
$0 < y_{CM} < 1 \quad (2.92 < y_{Lab} < 3.92) \quad |\cos\theta_{CS}| < 0.5$

Acceptance	J/ψ	13.5%
	DY$(2.9-4.5)$	15.1%
	DY $(2.9-8.0)$	15.4%

- **Active target:** Čerenkov counter blades
- **Centrality detectors:**
  - ▷ E.m. calorimeter $(1.1 < \eta_{lab} < 2.3)$
  - ▷ Zero Degree Calorimeter $(\eta_{lab} > 6.3)$
  - ▷ Multiplicity detector $(1.5 < \eta_{lab} < 3.5)$

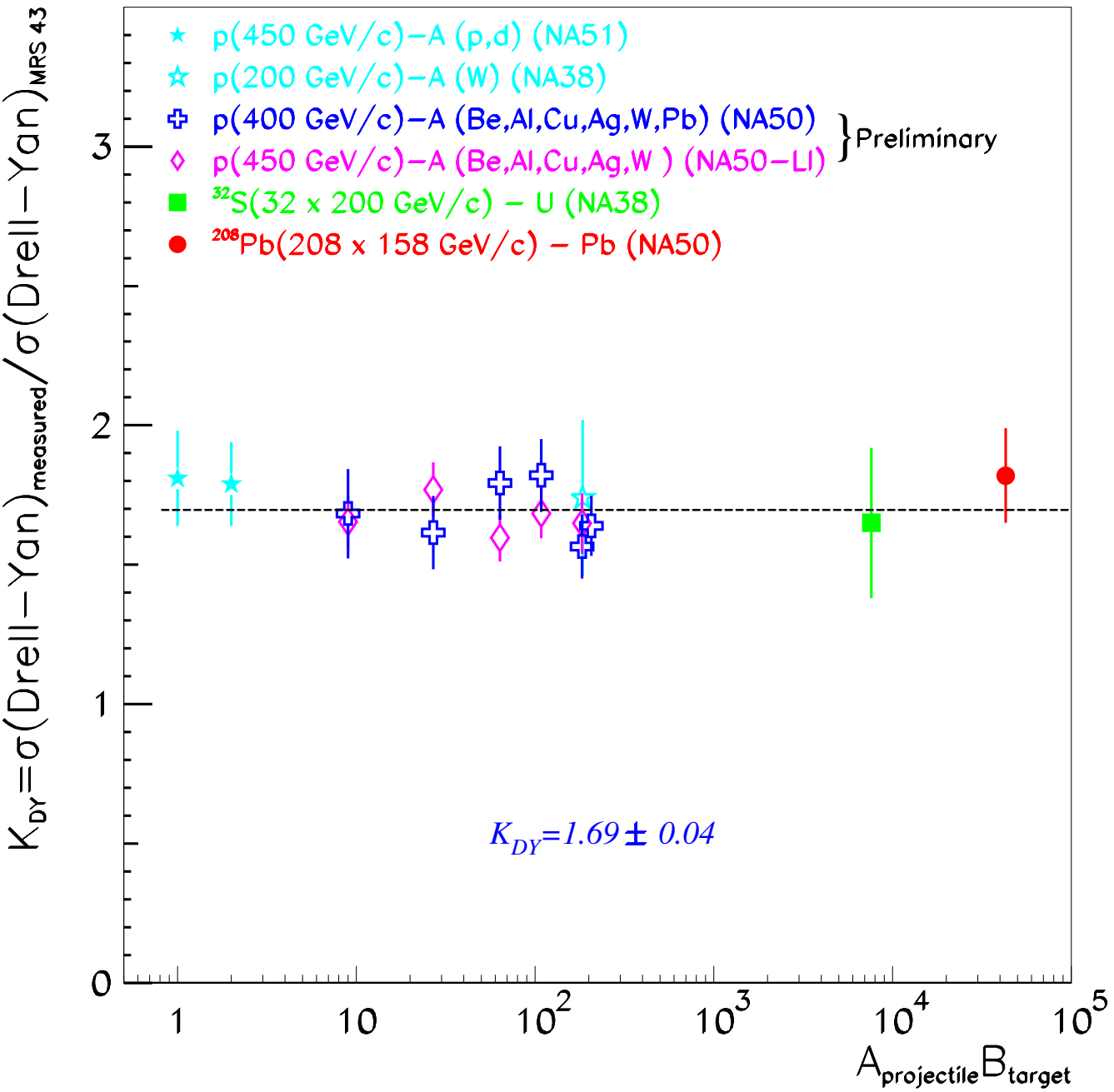
Fit to the mass spectrum

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



- Combinatorial background, due to π and K decays, is estimated from like-sign pairs: $N_{BG} = 2\sqrt{N^{++}N^{--}}$
- J/ψ, ψ', $D\bar{D}$ and Drell-Yan shapes from simulation and reconstructed chain

Drell-Yan: Experimental K factor



Drell-Yan is proportional to the number of collisions A·B, that is, it scales as expected:

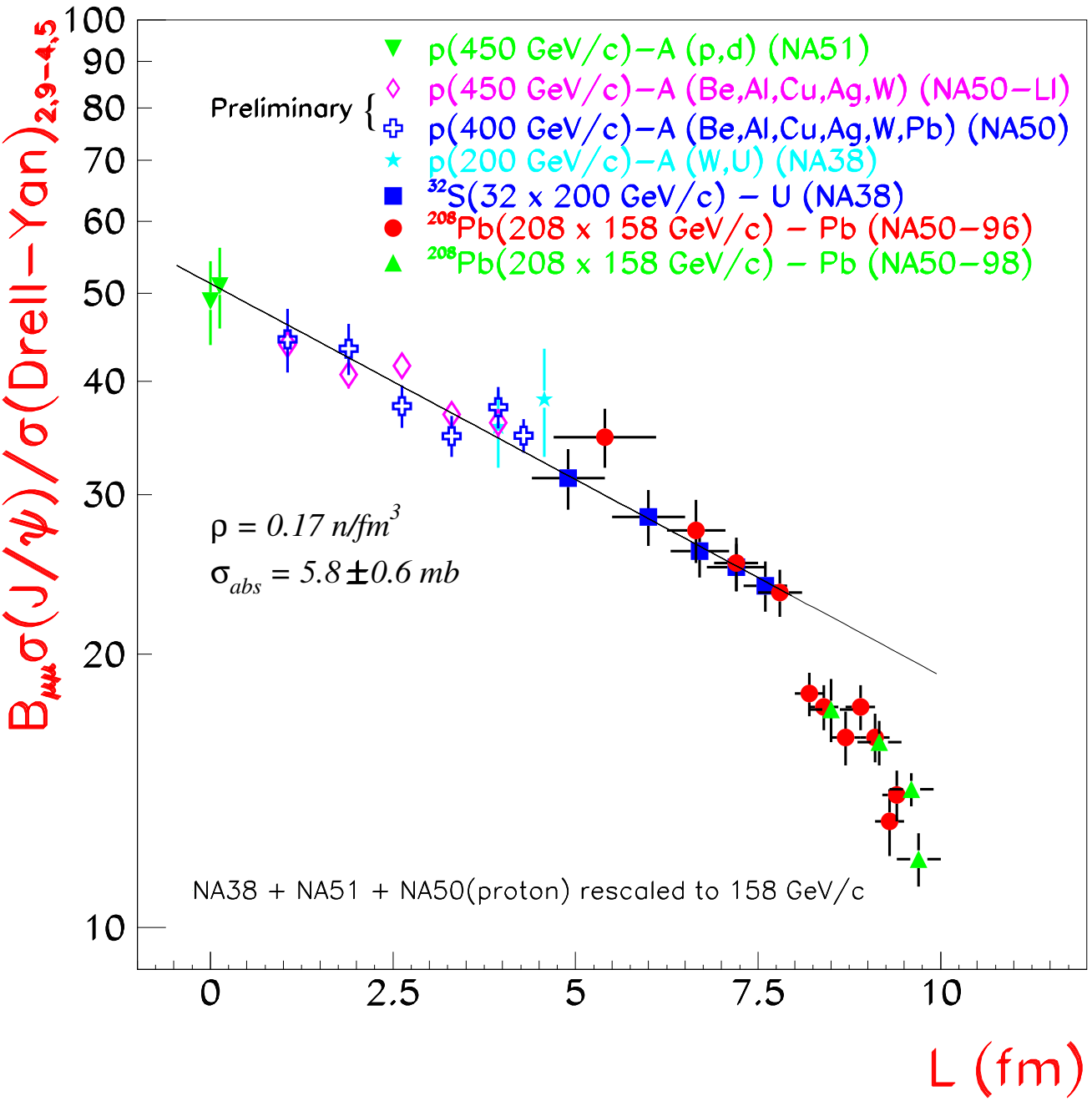
$$\sigma^{DY} \propto (A\ B)^{\alpha} \quad with \quad \alpha = 1$$

Previous K factor (excluding new proton data):

$$K_{DY} = 1.78 \pm 0.08$$

ψ/DY as a function of L

L - path length of the pre-resonant $c\bar{c}g$ state in nuclear matter

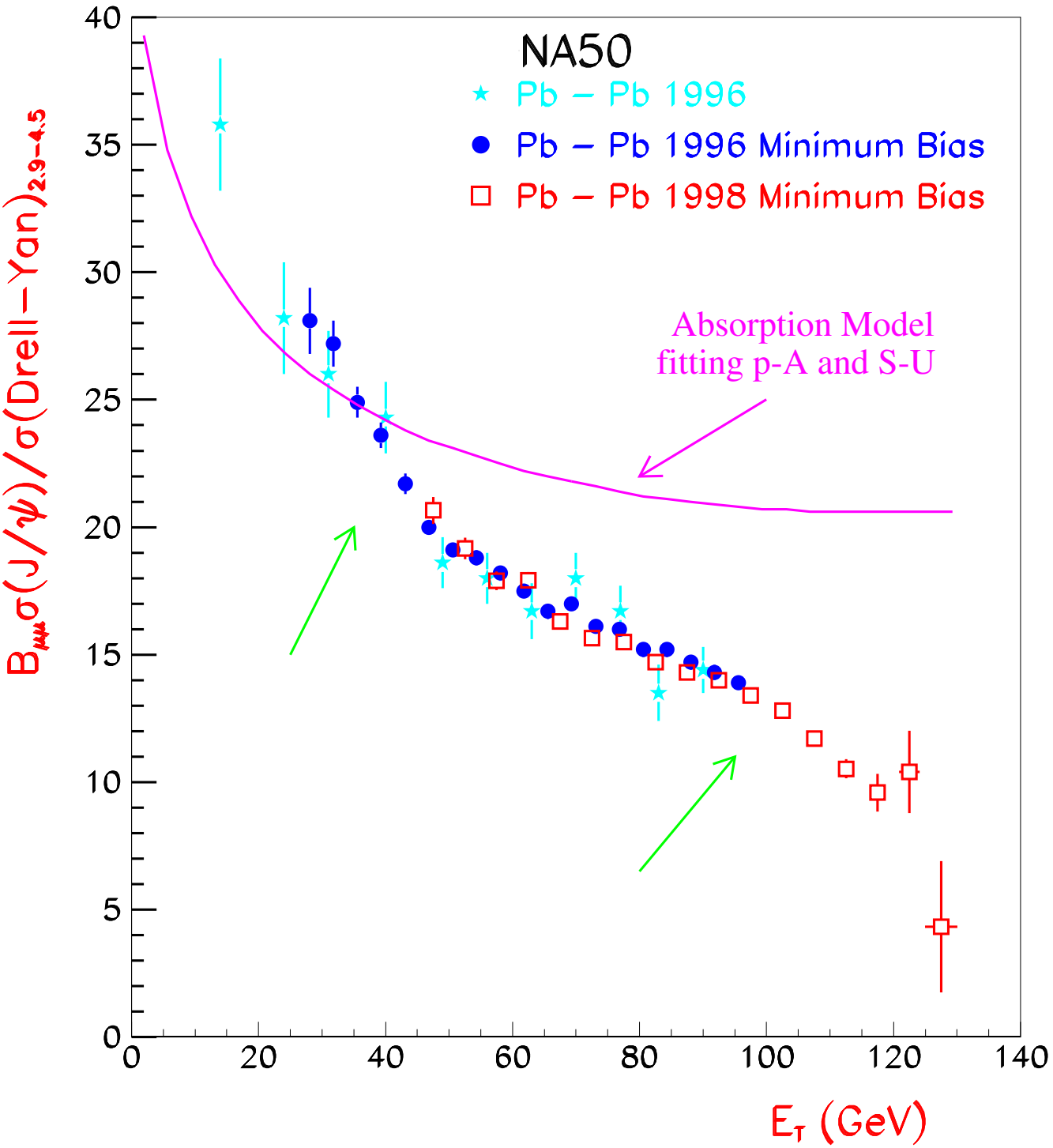


Fit including new proton data:

$$\frac{B_{\mu\mu}\sigma^{\psi}}{\sigma^{DY}} \propto e^{-\rho L \sigma_{abs}} \Rightarrow \sigma_{abs} = 5.4 \pm 0.4 \ mb$$

Sudden 20% drop at L = 8 fm

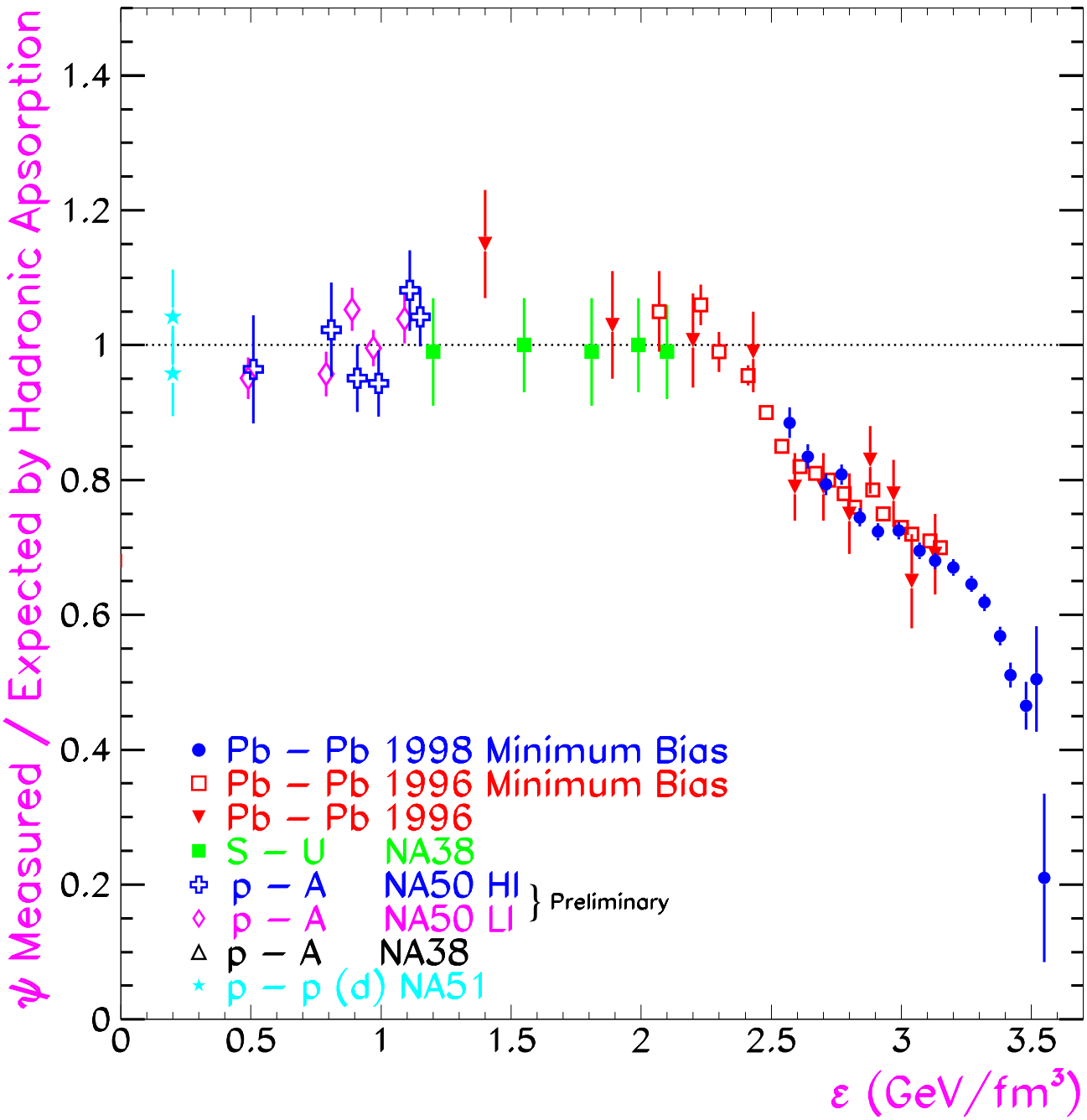
ψ/DY as a function of E_T



Solid line: exponential parametrization as obtained from fit to light systems (NA38 + NA51)

20% drop at 40 GeV and an inflexion point at 90 GeV followed by a steady steep decrease

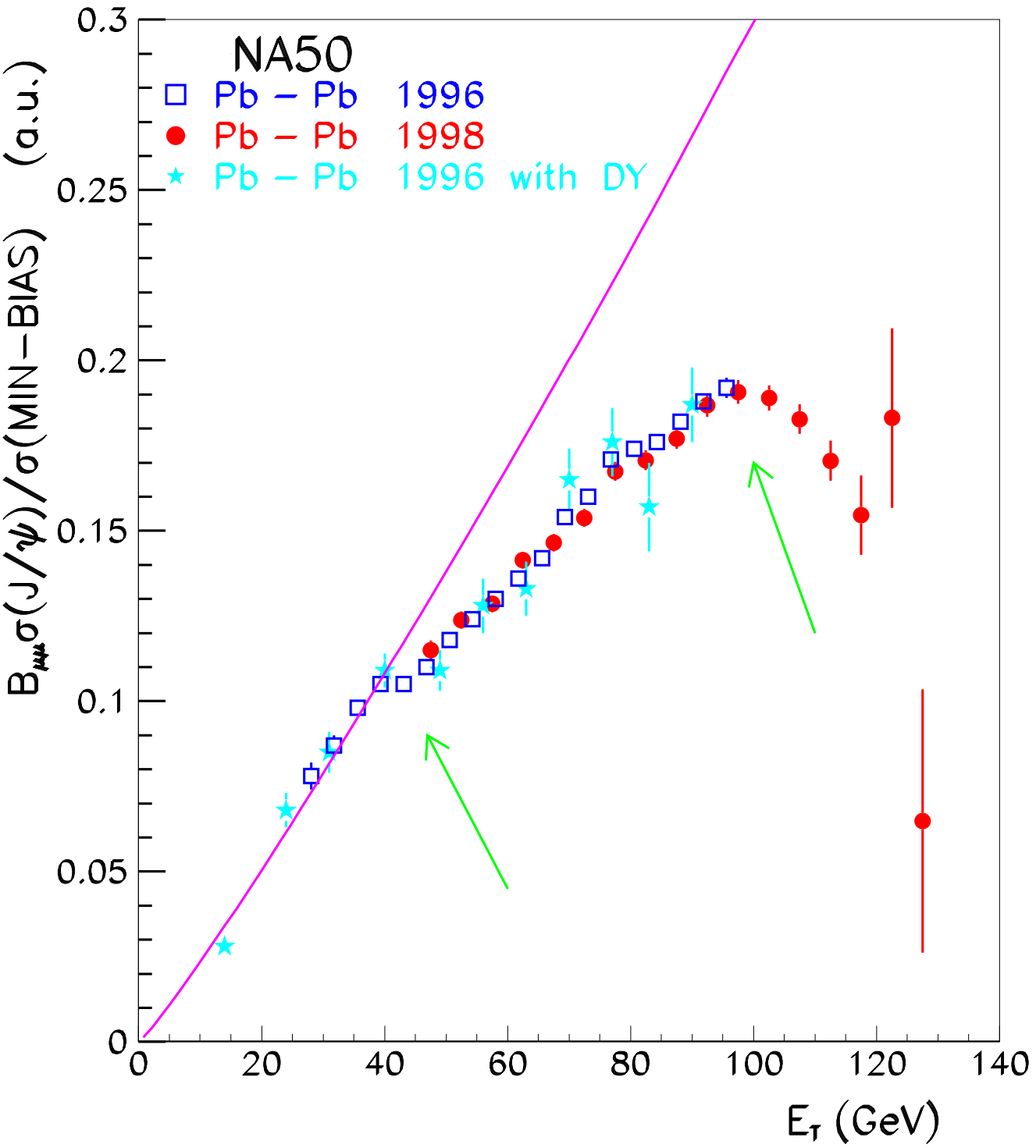
ψ Measured/Expected as a function of ϵ



Expected: **Absorption Model as obtained from fit to light systems (p-A and S-U)**

Stepwise Pattern: 2 threshold values for J/ψ suppression, $\simeq$ 2.4 and $\simeq$ 3.2 GeV/fm^3

ψ/Minimum Bias as a function of E_T

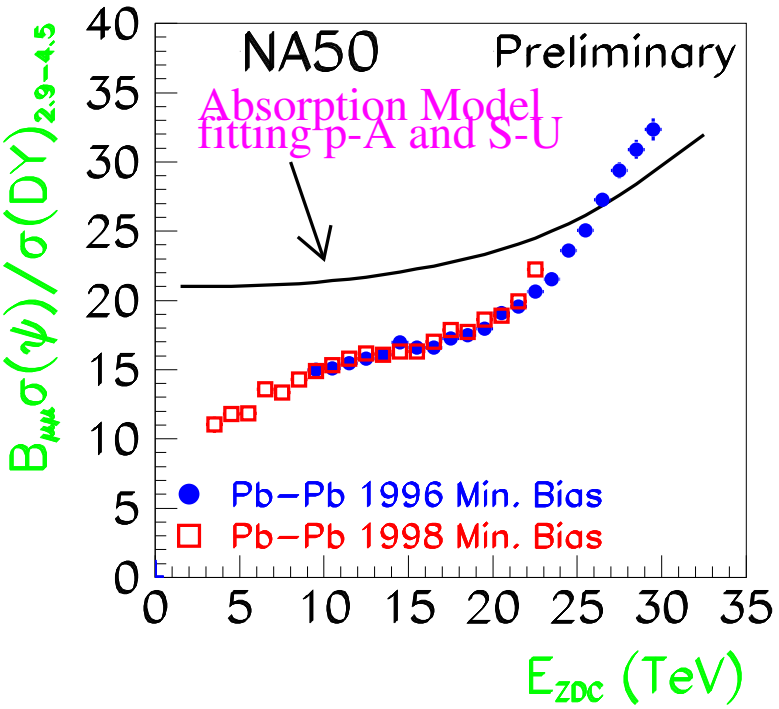


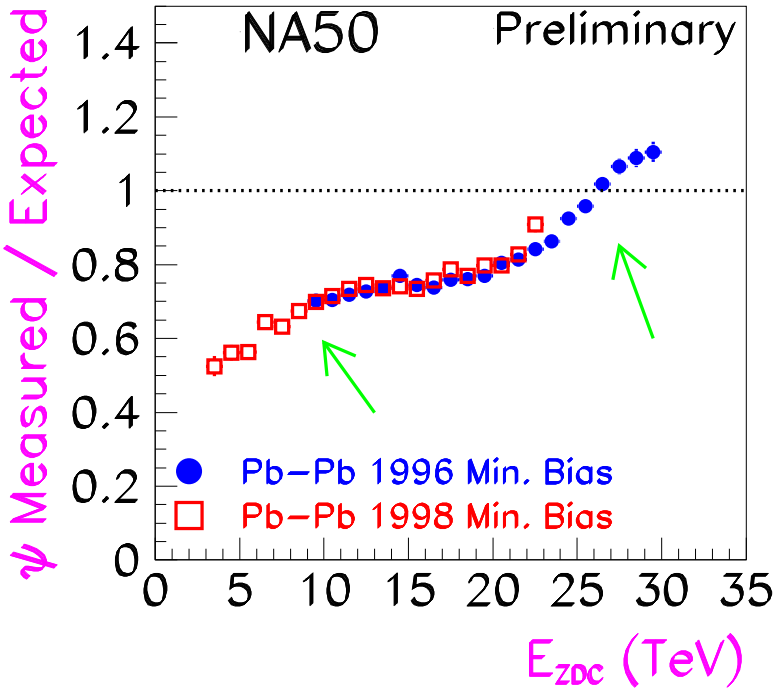
Solid line: Absorption Model with $\sigma_{abs} = 6.4 \pm 0.8\ mb$ **as obtained from fit to p-A and S-U data (NA38 + NA51) with full calculation**

Pattern exhibits 2 "accidents"

ψ/DY as a function of ZDC

Using another detector: ZDC, for centrality ψ studies



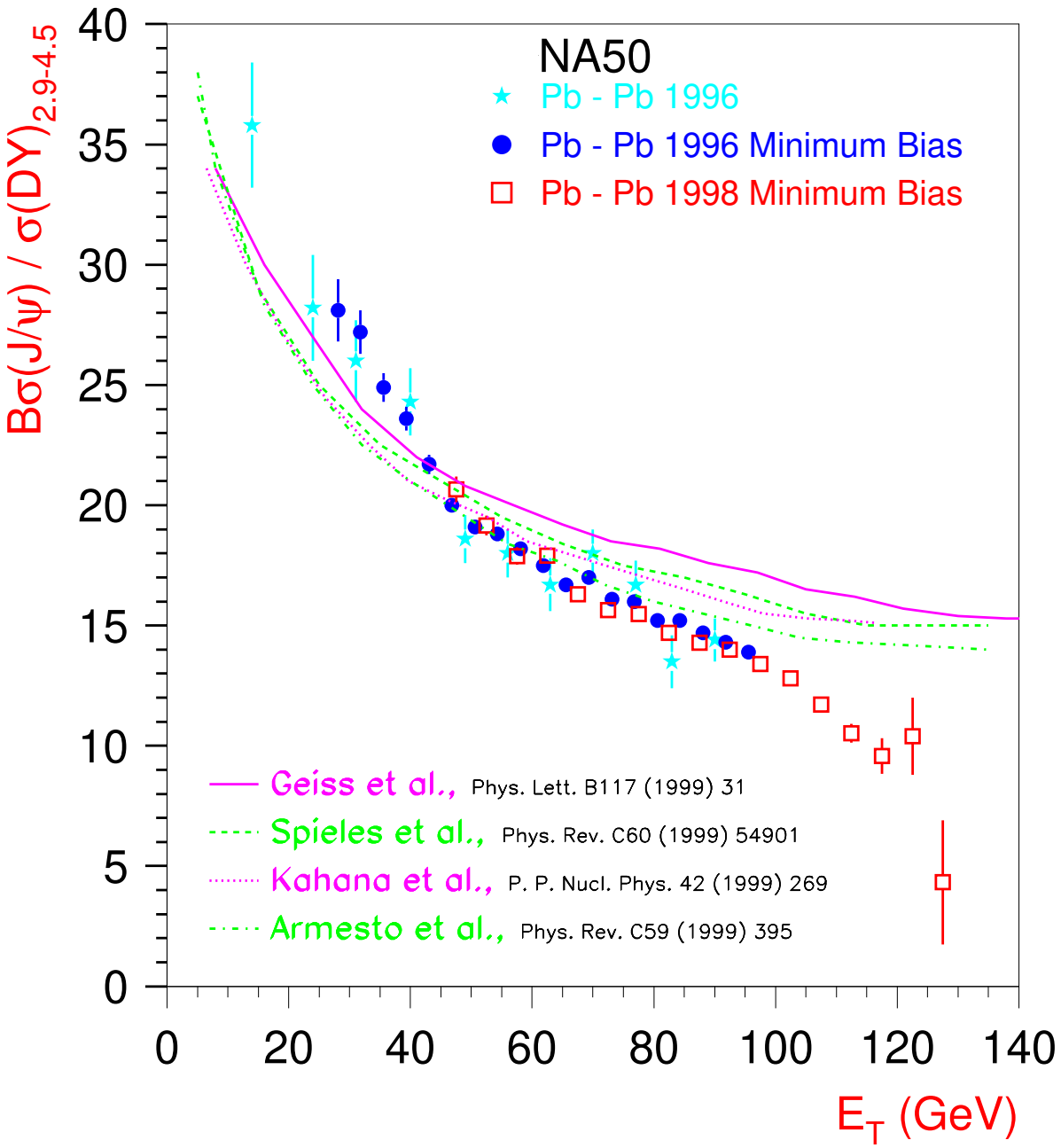


Solid line and Expected: Absorption Model as obtained from fit to light systems (p-A and S-U)

Observation of the 2 discontinuities in ψ suppression

ψ/DY as a function of E_T

Comparision with conventional (hadronic) models

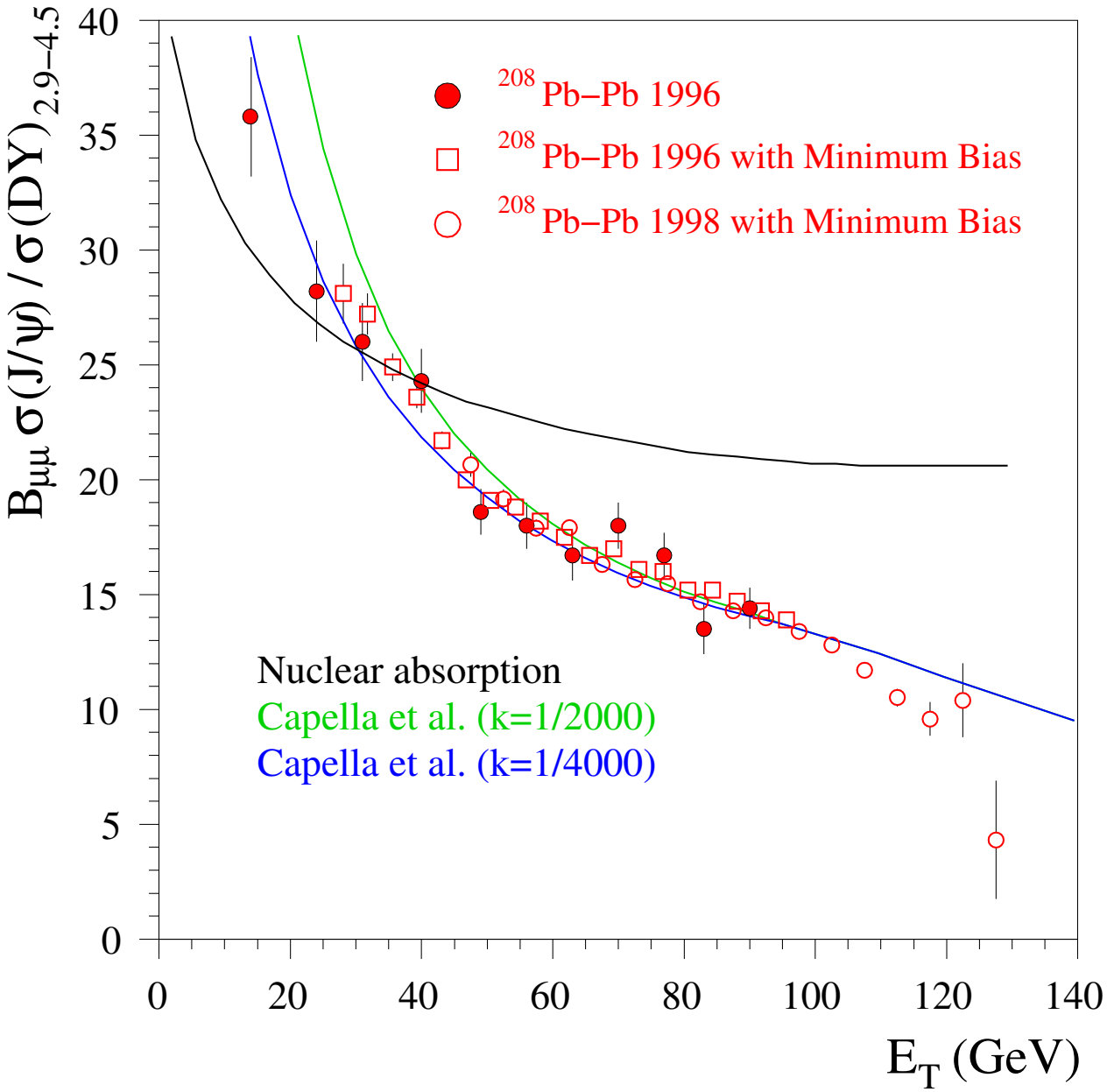


The stepwise suppression pattern rules out any of these conventional models

ψ/DY as a function of E_T

Comparision with modified Capella's hadronic model (E_T fluctuations included)

(Phys. Rev. Lett. 85 (2000) 2080)

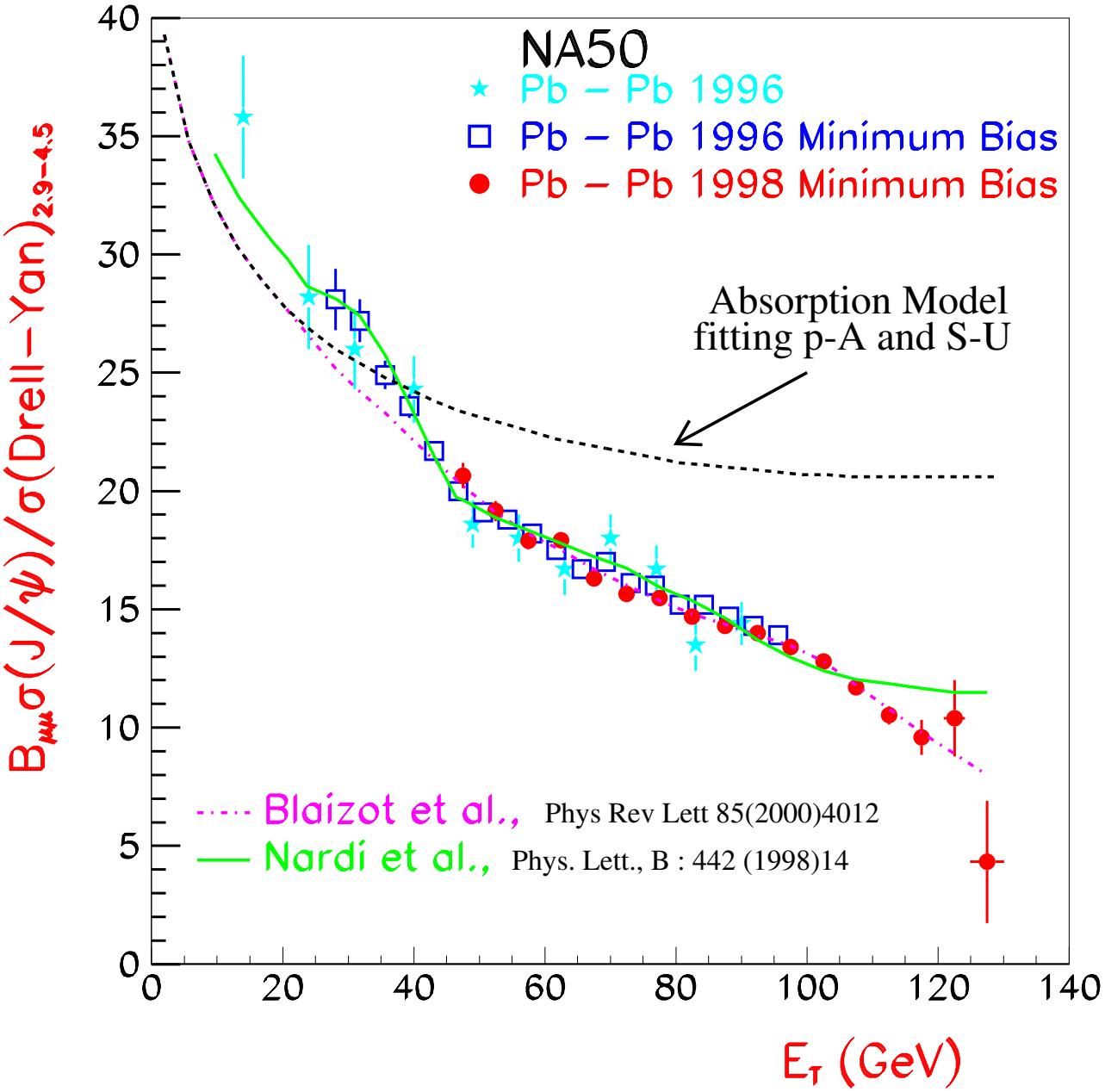


The model does not describe:

- ▷ **the normal absorption as observed in p-A and S-U interactions (black line)**
- ▷ **the steady decrease for central Pb-Pb collisions**

ψ/DY as a function of E_T

Comparision with models assuming QGP

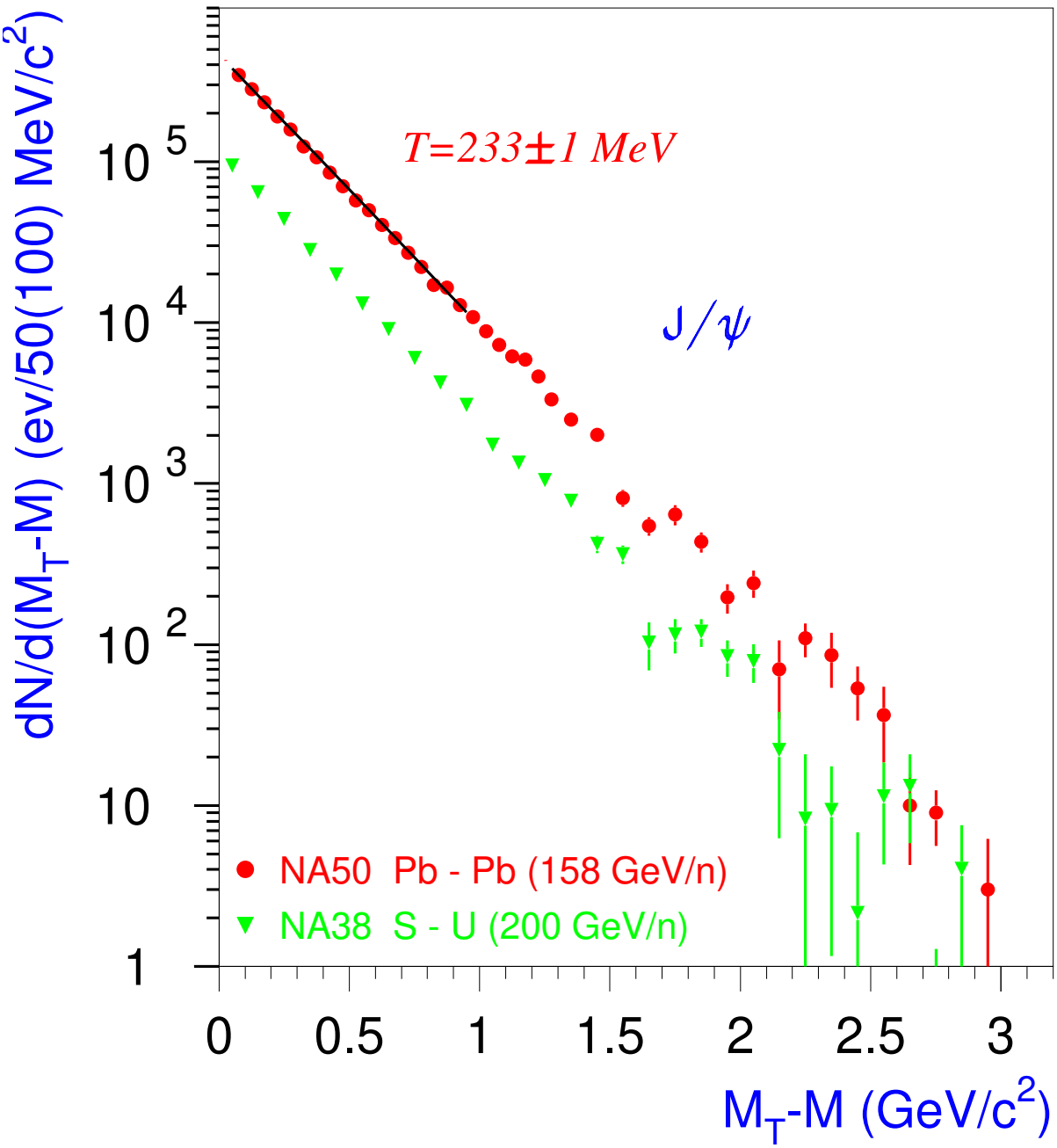


Magenta line: with gradual J/ψ suppression and E_T fluctuations

Green line: with two thresholds, corresponding to the χ and the J/ψ melting points, but no E_T fluctuations

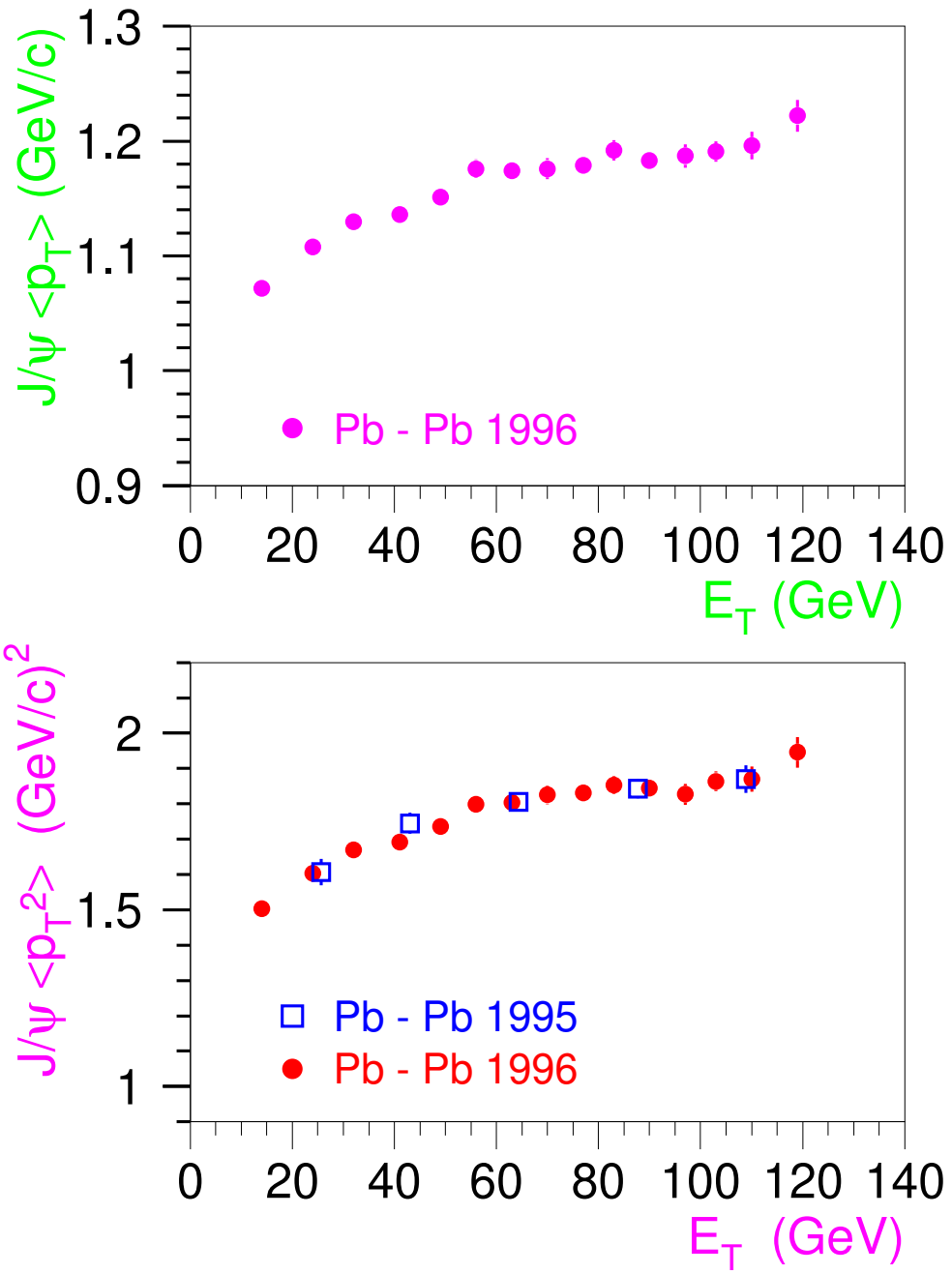
Quark and Gluon Deconfinement with 2 melting points plus E_T fluctuations seem necessary to describe the data

ψ Transverse Mass Distribution



Solid line: **Fit with modified Bessel Function gives an inverse slope parameter $T = 233 \pm 1\ MeV$ for Pb-Pb collisions at 158 GeV/nucleon**

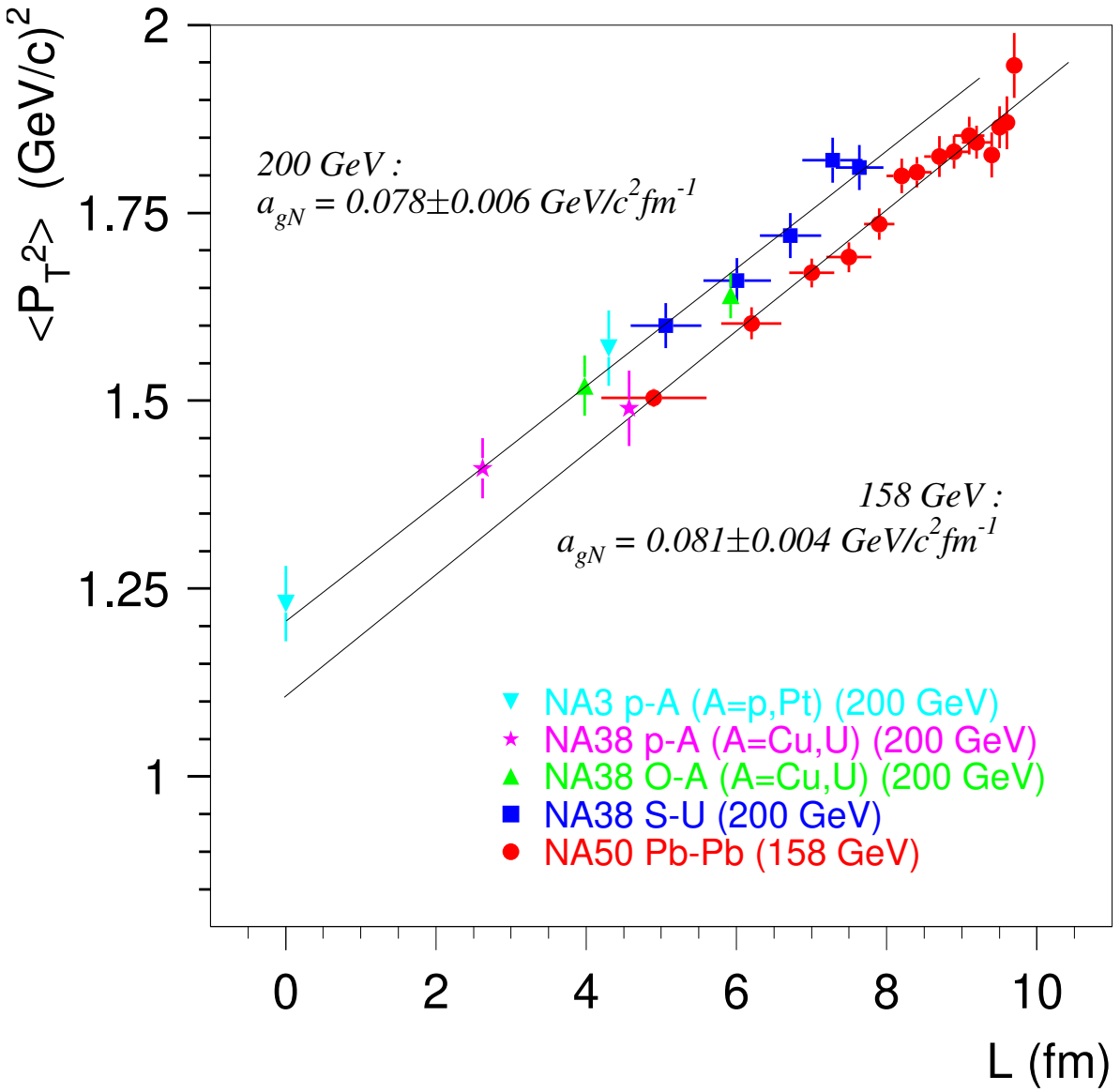
$\langle p_{\mathrm{T}} \rangle_{\psi}$ and $\langle p_{\mathrm{T}}^2 \rangle_{\psi}$ as a function of E_T



Both $\langle p_{\mathrm{T}} \rangle$ and $\langle p_{\mathrm{T}}^2 \rangle$ show an increase followed by a saturation

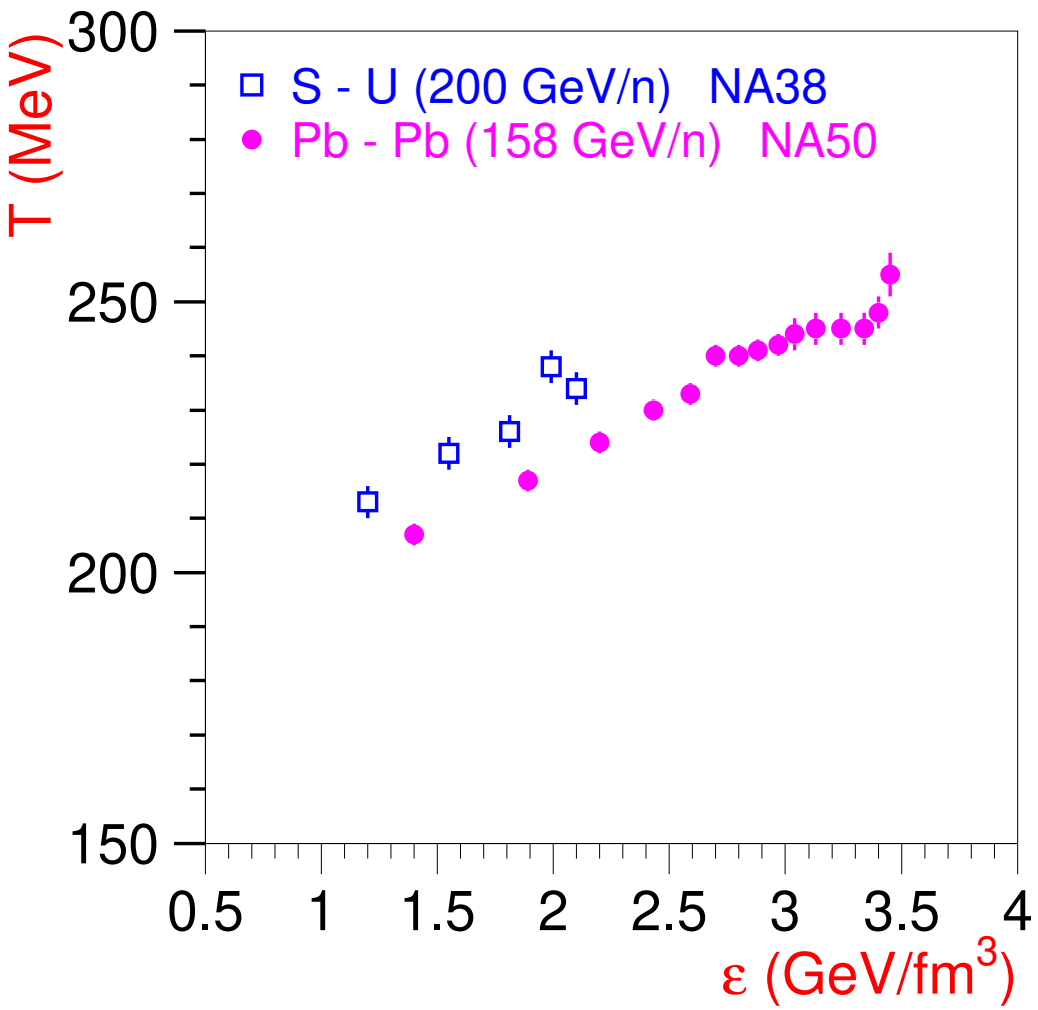
$\langle p_{\mathrm{T}}^2 \rangle_\psi$ as a function of L

Study of the initial state interactions effect: $\langle p_{\mathrm{T}}^2 \rangle$ as a function of L, the geometric length of matter crossed by the $c\bar{c}$ state



- **Fits according to: $\langle p_{\mathrm{T}}^2 \rangle (E_{\mathrm{T}}) = \langle p_{\mathrm{T}}^2 \rangle_{pp} + a_{gN}\ L(E_{\mathrm{T}})$ give compatible slopes for proton, Sulfur and Lead induced reactions. Fit with common slope: $a_{gN} = 0.080 \pm 0.003\ GeV^2/c^2 fm^{-1}$ with $\chi^2/ndf = 0.65$**
- **$\langle p_{\mathrm{T}}^2 \rangle$ depends on the beam energy**

T_ψ as a function of ϵ

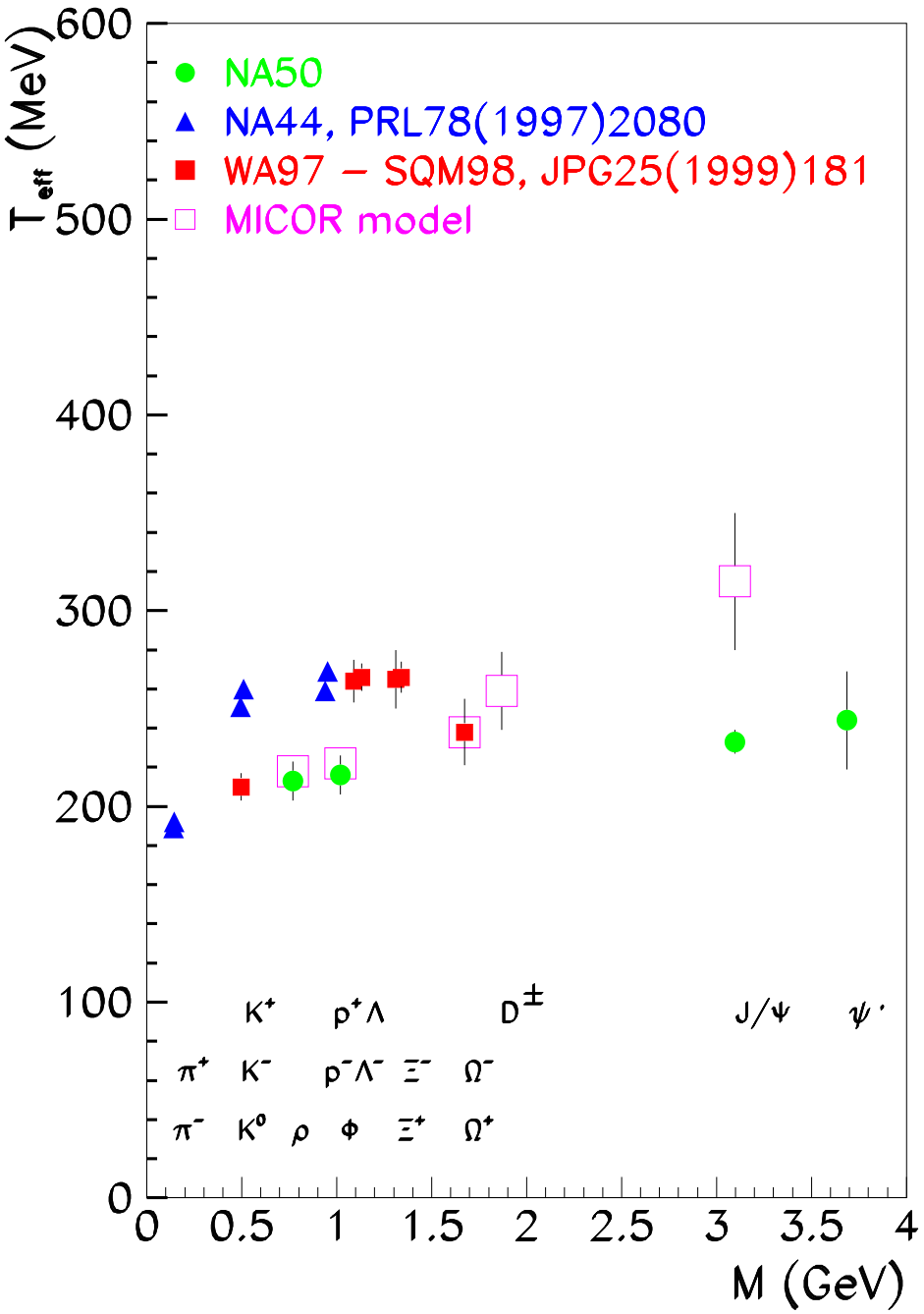


The inverse slope parameter T for Pb-Pb as a function of energy density shows an increase, followed by a saturation and a final increase(?)

The T parameter depends also on beam energy

T as a function of Particle Mass

Determining T parameter by fitting $d\sigma_{\rm part}/dM_T$ distributions with $M_T^{3/2} exp(-M_T/T)$

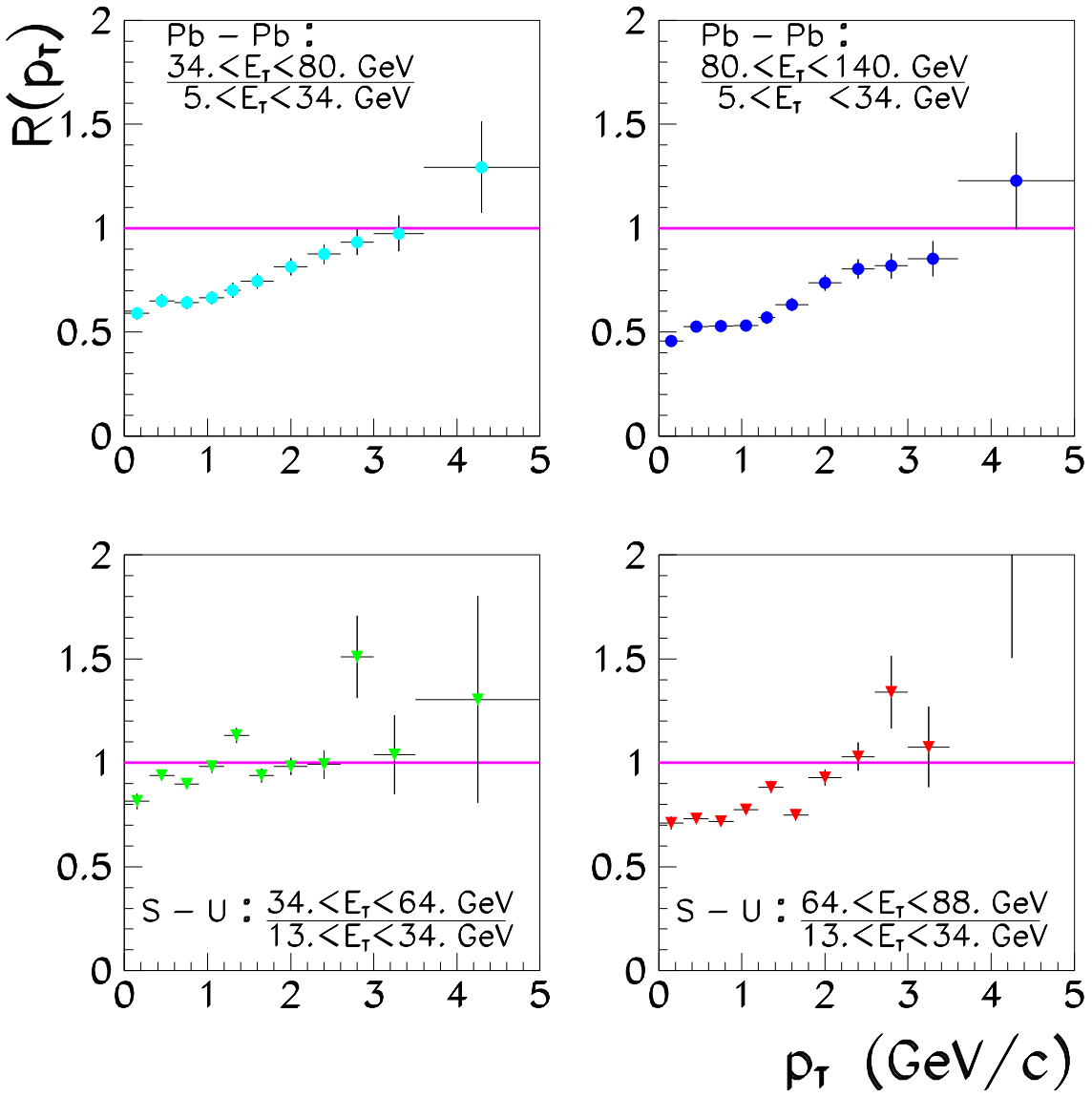


The rise of T with Particle Mass is smoother than the expected

Ratio $R(p_T)$

$R(p_T)$ is the ratio of ψ p_T distributions for a given E_T region with respect to the lowest E_T region, normalized to the ratio of the corresponding DY events:

$$R(p_T) \equiv \frac{\frac{dN_\psi}{dp_T}/N_{DY} \quad (high\ E_T)}{\frac{dN_\psi}{dp_T}/N_{DY} \quad (low\ E_T)}$$



In Pb-Pb central collisions $R(p_T)$ seems to saturate at high p_T

Conclusions

J/ψ Suppression:

- **Different analyses (E_T, MB, ZDC) agree with the observed stepwise pattern of the anomalous J/ψ suppression: a drop of about 20% and an inflexion point followed by a steady steep decrease**
- **This can be interpreted by successive melting of charmonium bound states (χ, J/ψ) as predicted by Quark-Gluon Deconfinement**

J/ψ Transverse Distributions:

- **J/ψ is more suppressed at low p_T**
- **p_T distributions of formed J/ψ studied as a function of centrality show a rise followed by a saturation**
- **In Pb-Pb central collisions the ratio $R(p_T)$ seems to saturate at high p_T**