DIMUON ENHANCEMENT IN NUCLEUS-NUCLEUS ULTRARELATIVISTIC INTERACTIONS

NA38/NA50 Collaboration

P. Bordalo – LIP-Lisbon

QUARK MATTER '99

Torino, May 10-15, 1999

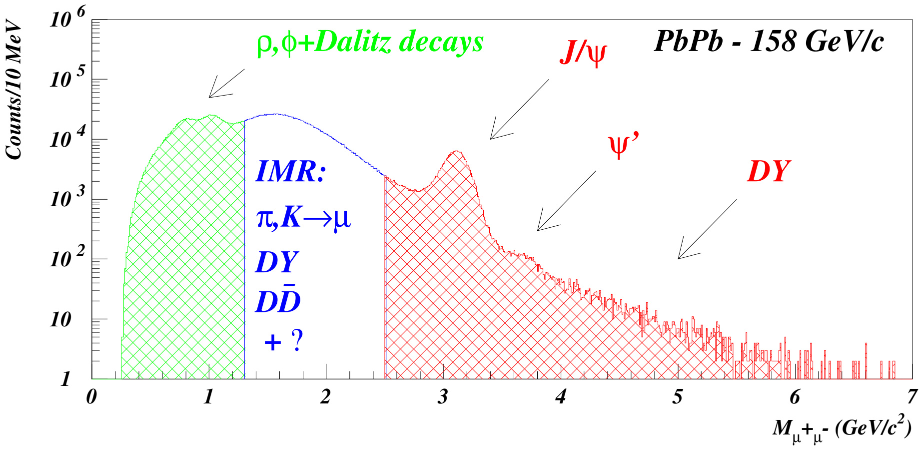
NA50 COLLABORATION

M.C. Abreu[7], B. Alessandro[12], C. Alexa[4], R. Arnaldi[12], J. Astruc[9], M. Atayan[14], C. Baglin[2], A. Baldit[3], M. Bedjidian[13], F. Bellaiche[13], S. Beolè[12], V. Boldea[4], P. Bordalo[7], A. Bussière[2], V. Capony[2], L. Casagrande[7], J. Castor[3], T. Chambon[3], B. Chaurand[10], I. Chevrot[3], B. Cheynis[13], E. Chiavassa[12], C. Cicalò[5], M.P. Comets[9], N. Constans[10], S. Constantinescu[4], J. Cruz[7], A. De Falco[5], N. De Marco[12], G. Dellacasa[1], A. Devaux[3], S. Dita[4], O. Drapier[13], L. Ducroux[13], B. Espagnon[3], J. Fargeix[3], S.N. Filippov[8], F. Fleuret[10], P. Force[3], M. Gallio[12], Y.K. Gavrilov[8], C. Gerschel[9], P. Giubellino[12], M.B. Golubeva[8], M. Gonin[10], A.A. Grigorian[14], J.Y. Grossiord[13], F.F. Guber[8], A. Guichard[13], H. Gulkanyan[14], R. Hakobyan[14], R. Haroutunian[13], M. Idzik[12,c], D. Jouan[9], T.L. Karavitcheva[8], L. Kluberg[10], A.B. Kurepin[8], Y. Le Bornec[9], C. Lourenço[6], P. Macciotta[5], M. Mac Cormick[9], A. Marzari-Chiesa[12], M. Masera[12], A. Masoni[5], S. Mehrabyan[14], M. Monteno[12], S. Mourgues[3], A. Musso[12], F. Ohlsson-Malek[13], P. Petiau[10], A. Piccotti[12], J.R. Pizzi[13], W.L. Prado da Silva[12], G. Puddu[5], C. Quintans[7], C. Racca[11], L. Ramello[1], S. Ramos[7], P. Rato-Mendes[12], L. Riccati[12], A. Romana[10], I. Ropotar[6], P. Saturnini[3], E. Scomparin[6], S. Serci[5], R. Shahoyan[7], S. Silva[7], M. Sitta[12], C. Soave[12], P. Sonderegger[6], X. Tarrago[9], N.S. Topilskaya[8], G.L. Usai[5], E. Vercellin[12], N. Willis[9].

[1] Univ. Piemonte Orientale, Alessandria and INFN-Torino, Italy.
[2] LAPP, CNRS-IN2P3, Annecy-le-Vieux, France.
[3] LPC, Univ. Blaise Pascal and CNRS-IN2P3, Aubière, France.
[4] IFA, Bucharest, Romania.
[5] Università di Cagliari/INFN, Cagliari, Italy.
[6] CERN, Geneva, Switzerland.
[7] LIP, Lisbon, Portugal.
[8] INR, Moscow, Russia.
[9] IPN, Univ. de Paris-Sud and CNRS-IN2P3, Orsay, France.
[10] LPNHE, Ecole Polytechnique and CNRS-IN2P3, Palaiseau, France.
[11] IRS, Univ. Louis Pasteur and CNRS-IN2P3, Strasbourg, France.
[12] Università di Torino/INFN, Torino, Italy.
[13] IPN, Univ. Cl. Bernard Lyon-I and CNRS-IN2P3, Villeurbanne, France.
[14] YerPhI, Yerevan, Armenia.

Intermediate Mass Region

NA50 opposite sign muon pair mass distribution in 158 GeV/nucleon Pb-Pb interactions (1996) :



The IMR – Intermediate Mass Region $(1.5 < M_{\mu\mu} < 2.5$ GeV/c$^2)$ description is the aim of this analysis

Known sources in pp and pA collisions:

- Drell-Yan : $q\bar{q} \rightarrow \gamma^* \rightarrow \mu^+\mu^-$
- Charmed meson semi-leptonic decays:

$D\bar{D}$

$\bar{D} \rightarrow \mu^- + X$

$D \rightarrow \mu^+ + X$

- Combinatorial background from π and K decays

Previous results in nucleus-nucleus interactions have shown an **excess in the IMR** when extrapolating from pA the above sources:

NA38 : C. Lourenço et al. Nucl.Phys.A566(1994)77c **SU**
NA50 : E. Scomparin et al. Nucl.Phys.A610(1996)331c **PbPb 95**
Helios-3 : A.S. Angelis et al., CERN-EP/98-92 **SW**

Event selection

- Data reduction: standard NA38/NA50 selection criteria
  - Two and only two fully reconstructed tracks pointing to the target;
  - Beam hodoscope $\rightarrow$ pile–up rejection;
  - Active target $\rightarrow$ vertex identification;
  - Phase space cuts:
    - $0<y_{cm}<1$ ($-0.52<y_{cm}<0.48$ for p–A runs)
    - $-0.5<\cos\theta_{CS}<0.5$
- Centrality selection
  - Use neutral transverse energy E_T;
  - S–U $\rightarrow$ 5 centrality classes;
  - Pb–Pb $\rightarrow$ 9 centrality classes;
  - Estimate of b and N_{part} $\rightarrow$ geometrical model + VENUS.

Present Analysis

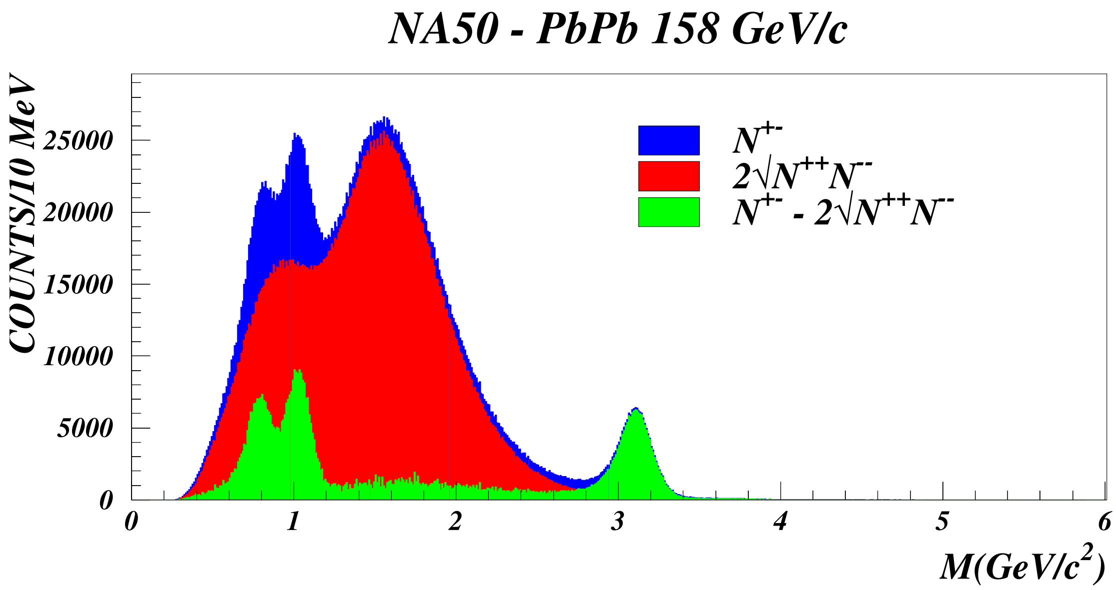
Data :

- PbPb at 158 GeV/nucleon (1996)
- SU at 200 GeV/nucleon (1992)
- pA (A=Al,Cu,Ag,W) at 450 GeV (1996-97)

Background subtraction :

- In the IMR the N^{bkg}/N^{+-} ratio is very high :

  $\sim$ 80% (pA)– 95% (PbPb)



$$\frac{dN^{bkg}}{dM} = 2R\sqrt{\frac{dN^{++}}{dM}\frac{dN^{--}}{dM}}$$

The background shape is smoother when obtained by the overall combination of muons (μ^+, μ^-) from the measured like-sign pairs

R is slighty different from 1, depending on multiplicity and charge correlation

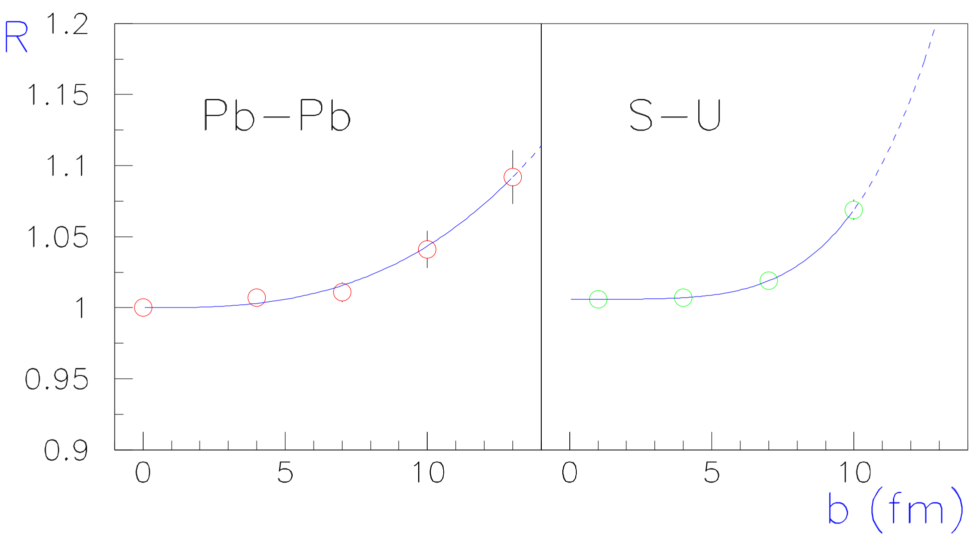
Background R factor

Charge correlation is estimated with VENUS simulation followed by π and K decays into muons and tracked through the setup

$$R_{sim} = \frac{N^{+-}_{sim}}{2\sqrt{N^{++}_{sim} N^{--}_{sim}}}$$

Agreement with experimental data
pW at 200 GeV/c , $\langle I \rangle \sim 10^7$ protons/burst :

- from 2 setups, with very different hadron absorber lengths, we measure $\rightarrow$ **R**=1.19±0.04
- from VENUS simulation $\rightarrow$ $\mathbf{R}_{sim} = 1.21 \pm 0.02$



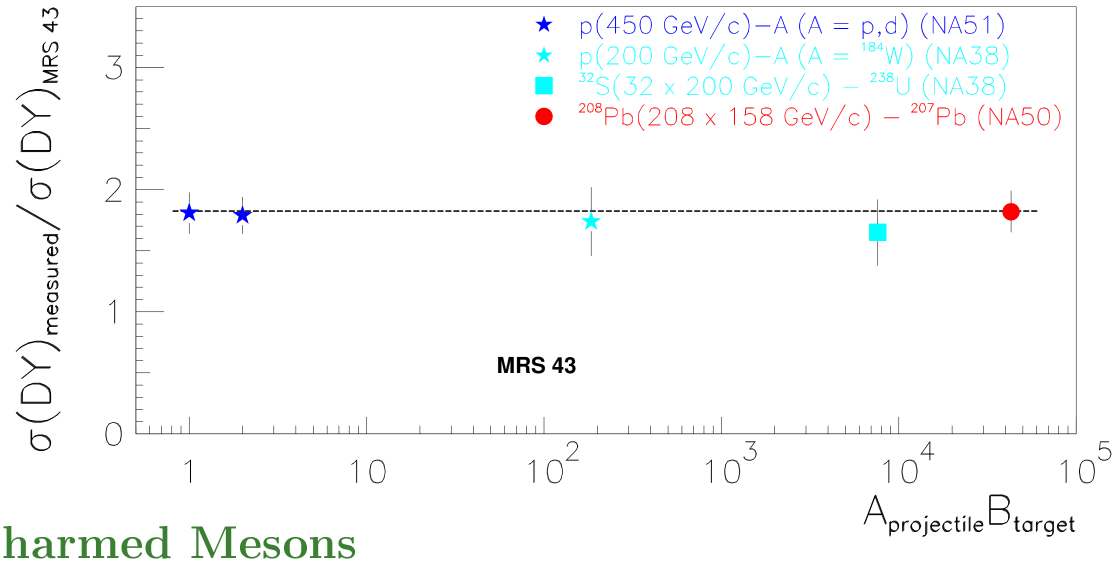
Variation of R with impact parameter b, used in the data background subtraction, is obtained with VENUS Monte-Carlo

Known Sources

Drell-Yan

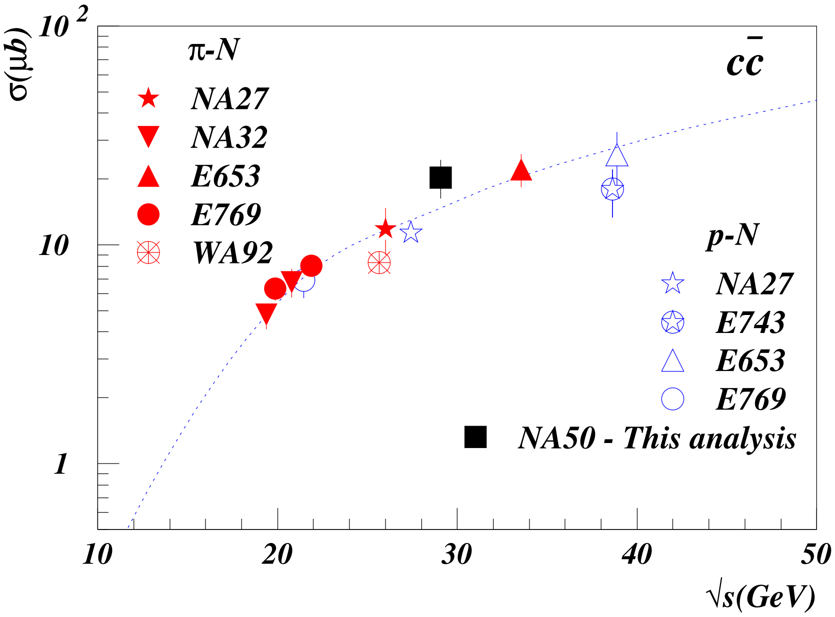
- calculated in LLA with a MRS set of parton density functions
- scales with AB : $\sigma_{AB}^{DY} = \sigma_{NN}^{DY} \cdot (AB)^{\alpha=1}$
- DY K-factor $\sim$ 1.8

$\rightarrow$ normalization is fixed with high mass events (M > 4.5 GeV/c^2)



Charmed Mesons

- calculated in LLA using PYTHIA with m_c=1.5 GeV/c^2
- in pA $D\bar{D}$ production scales with A$^{\alpha=1}$
- our preliminary pA (A=Al,Cu,Ag,W) measurement is in agreement with other experiments

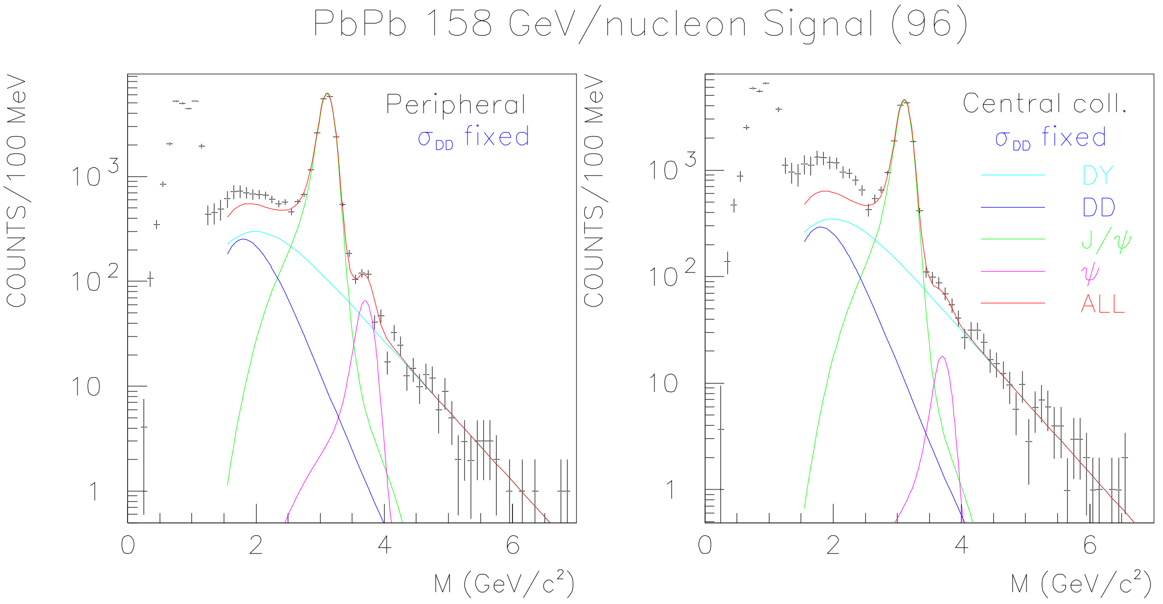


With $\alpha_{DY} = 1$ and assuming $\alpha_{D\bar{D}} = 1$

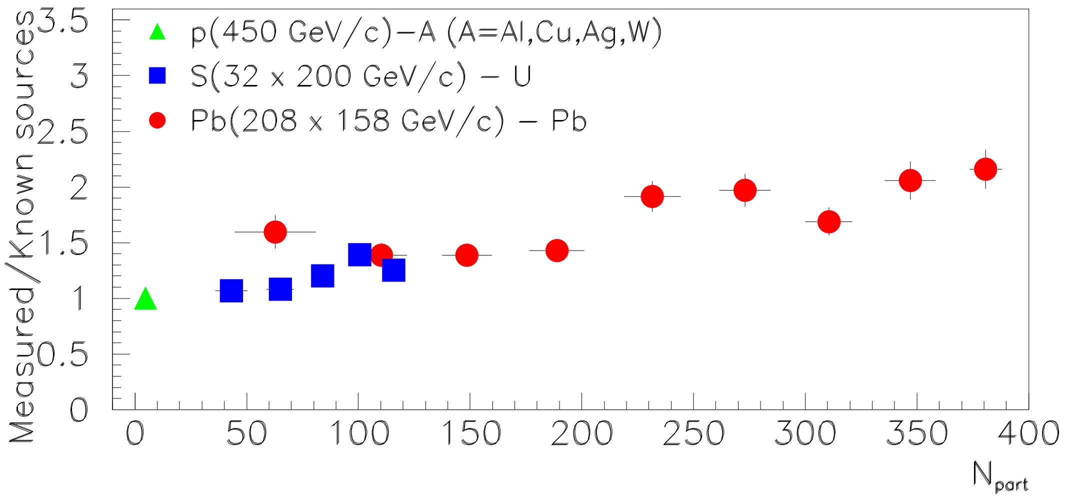
$\Rightarrow$ $D\bar{D}$/DY should be constant coming from pA to AB collisions

Signal Mass Fit With Known Sources

- R^{bkg}=F(b) fixed by VENUS
- DY normalization is fixed according to the high mass region
- $\sigma_{c\bar{c}}$ extrapolated from pA result with $\alpha_{D\bar{D}} = 1$



An excess is observed with respect to the known sources and it is bigger for central collisions



Ion data measured/known sources normalized to the same proton ratio increases with the number of participants

What Could Be The Excess ?

- **Thermal dimuons**

  $\Rightarrow$ **No generator available ...**

- **Bad background subtraction**

  $\Rightarrow$ **Tests with R free or R=1 give excess variations $\sim$ 20%**

  $\Rightarrow$ **The excess mass shape is not consistant with background mass shape**

- $D\bar{D}$ **final state rescattering**

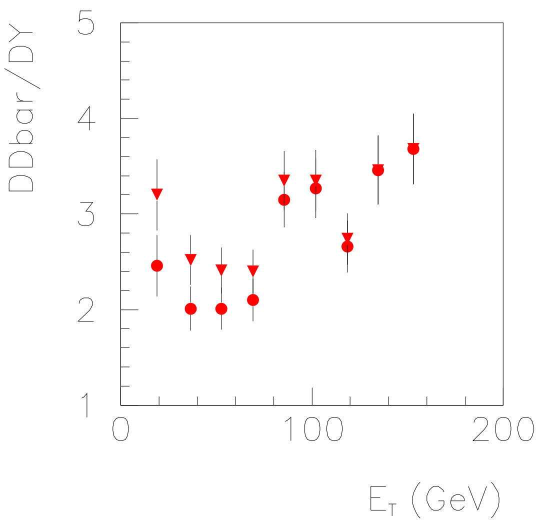
  $\Rightarrow$ **In P_T distributions there is some room for rescattering**

  $\Rightarrow$ **A strong rescattering (cf. Lin & Wang) accounts only for 20% of the excess**

- **Open charm enhancement**

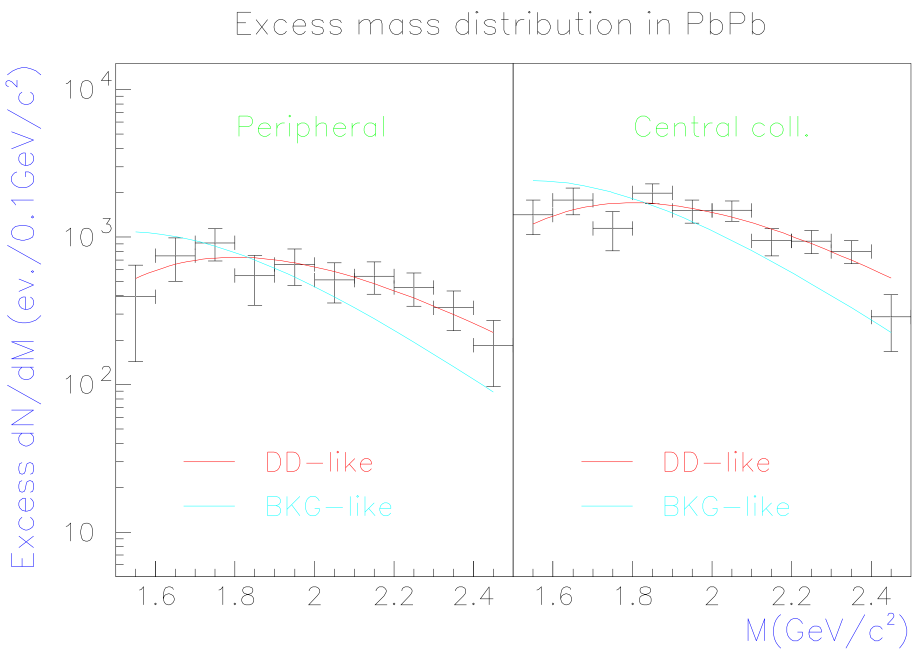
  $\Rightarrow$ **The dimuon excess mass yield has the same shape as the $D\bar{D}$ contribution**

Combinatorial Background Subtraction



with R fixed to 1 (triangle points) the ratio $(D\bar{D}$ + Excess)/DY changes by 20% for peripheral and less than 3% for central collisions

Excess = Data measured – Known sources



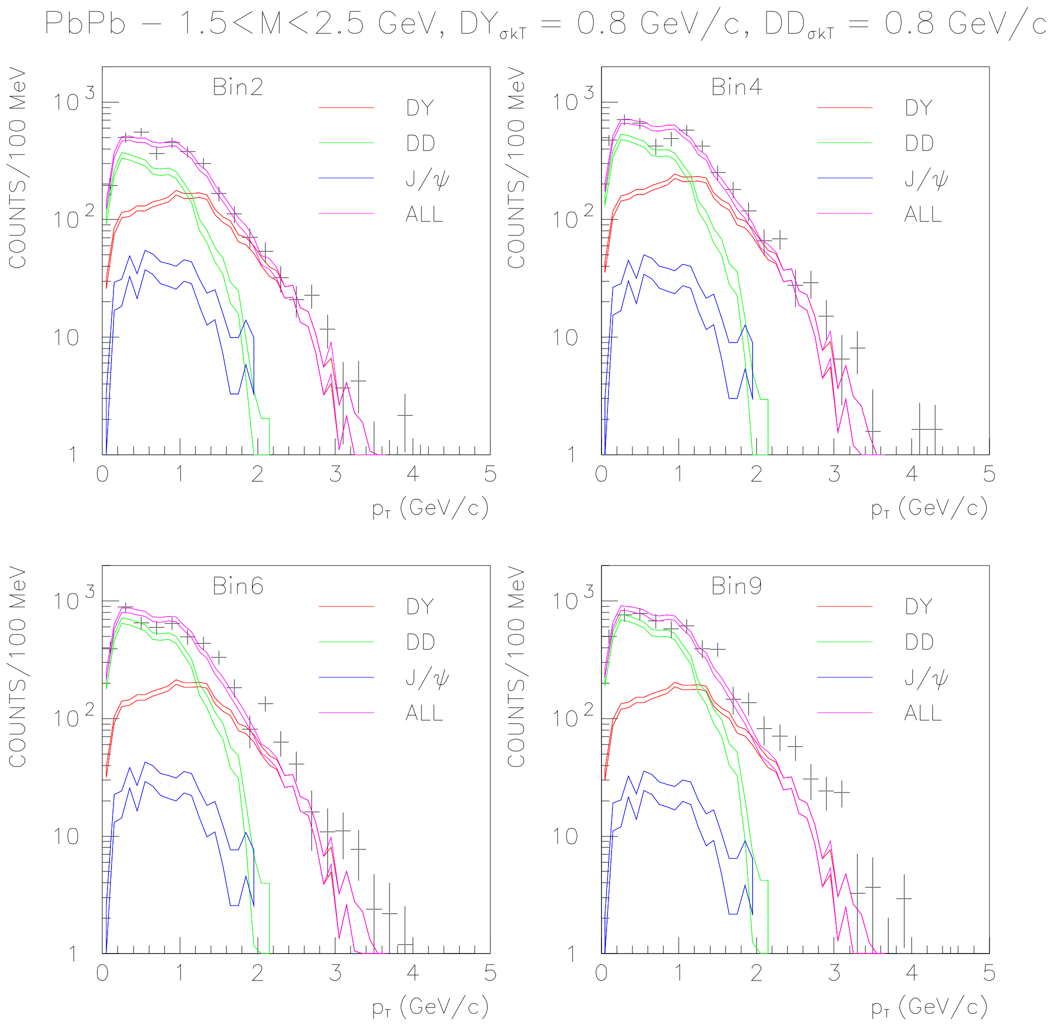
Free normalization of background and $D\bar{D}$ yields

The shape of excess mass distributions, both in peripheral and central collisions

- ⋆ are different from combinatorial background
- ⋆ agree with $D\bar{D}$ production

P_T Distributions

Signal P_T spectra in the IMR for 4 different centrality classes :



P_T distributions are reasonably described by known sources including in the $D\bar{D}$ component the excess obtained in the mass fit

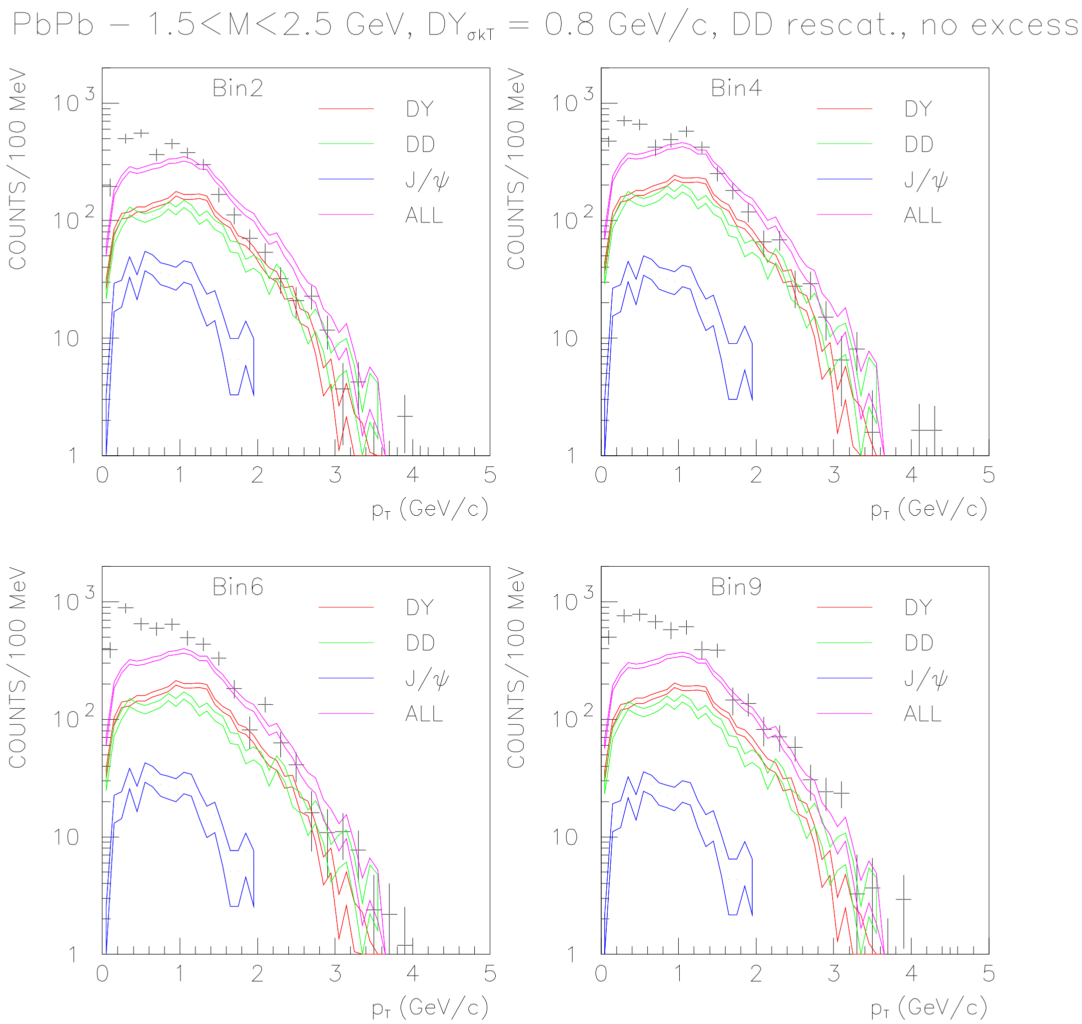
Assuming σ_{KT}=0.8 GeV/c, there is some room for D-meson rescattering in central collisions

The experimental rescattering magnitude depends on σ_{KT} assumptions introduced in DY and $D\bar{D}$ PYTHIA generators

D-meson rescattering

According to Z. Lin and X.N. Wang [Phys.Lett. B444(1998)] D-meson rescattering in nuclear matter can broaden the m_T spectrum

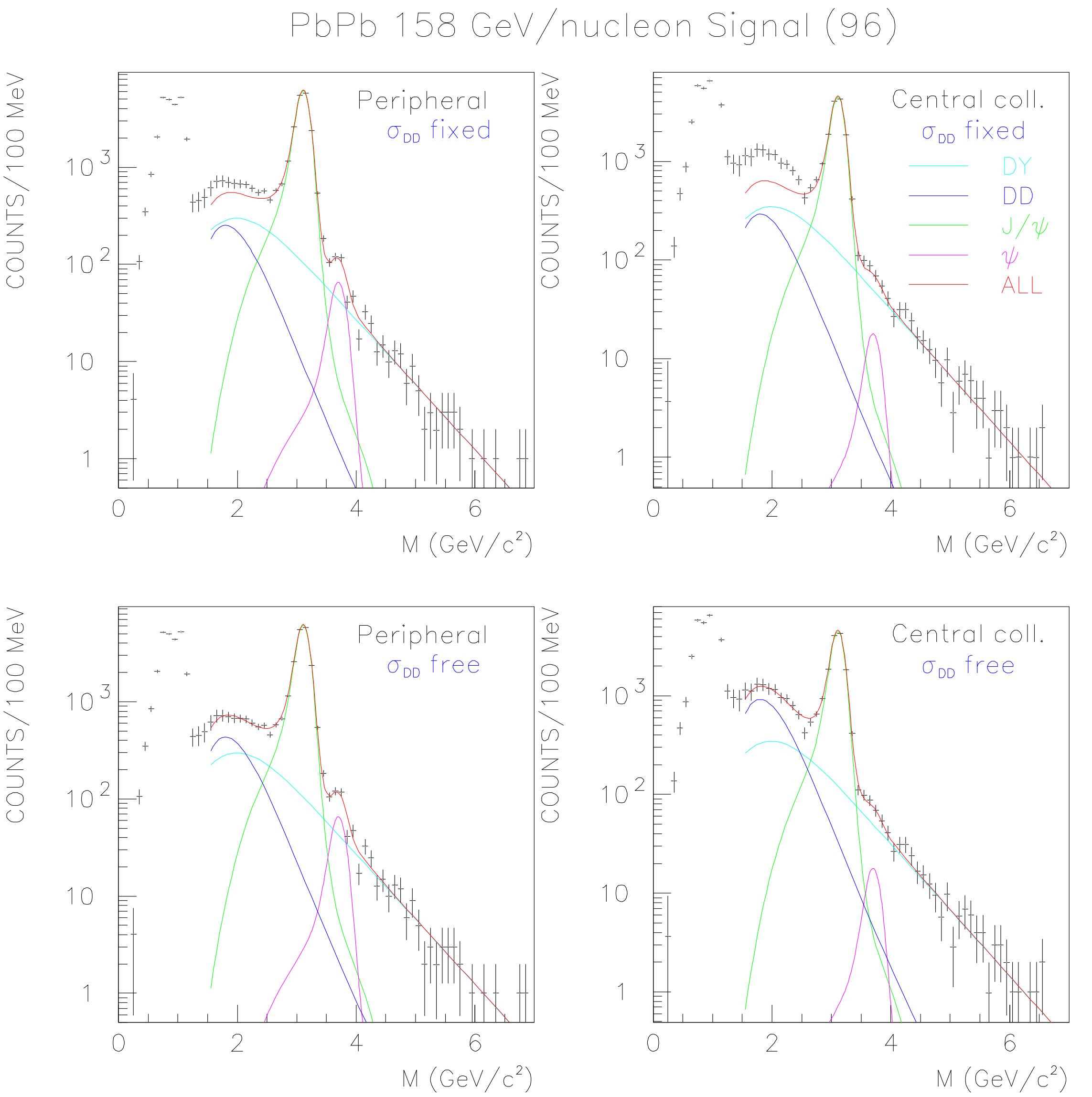
The P_T shape is obtained by simulation putting in the PYTHIA generator a $\sigma_{KT} = 3.0$ GeV for the $D\bar{D}$ component



• Even for the most central bin, this huge P_T broadening does not describe the data

$\Rightarrow$ **An excess is still present**

Mass Distribution Fit

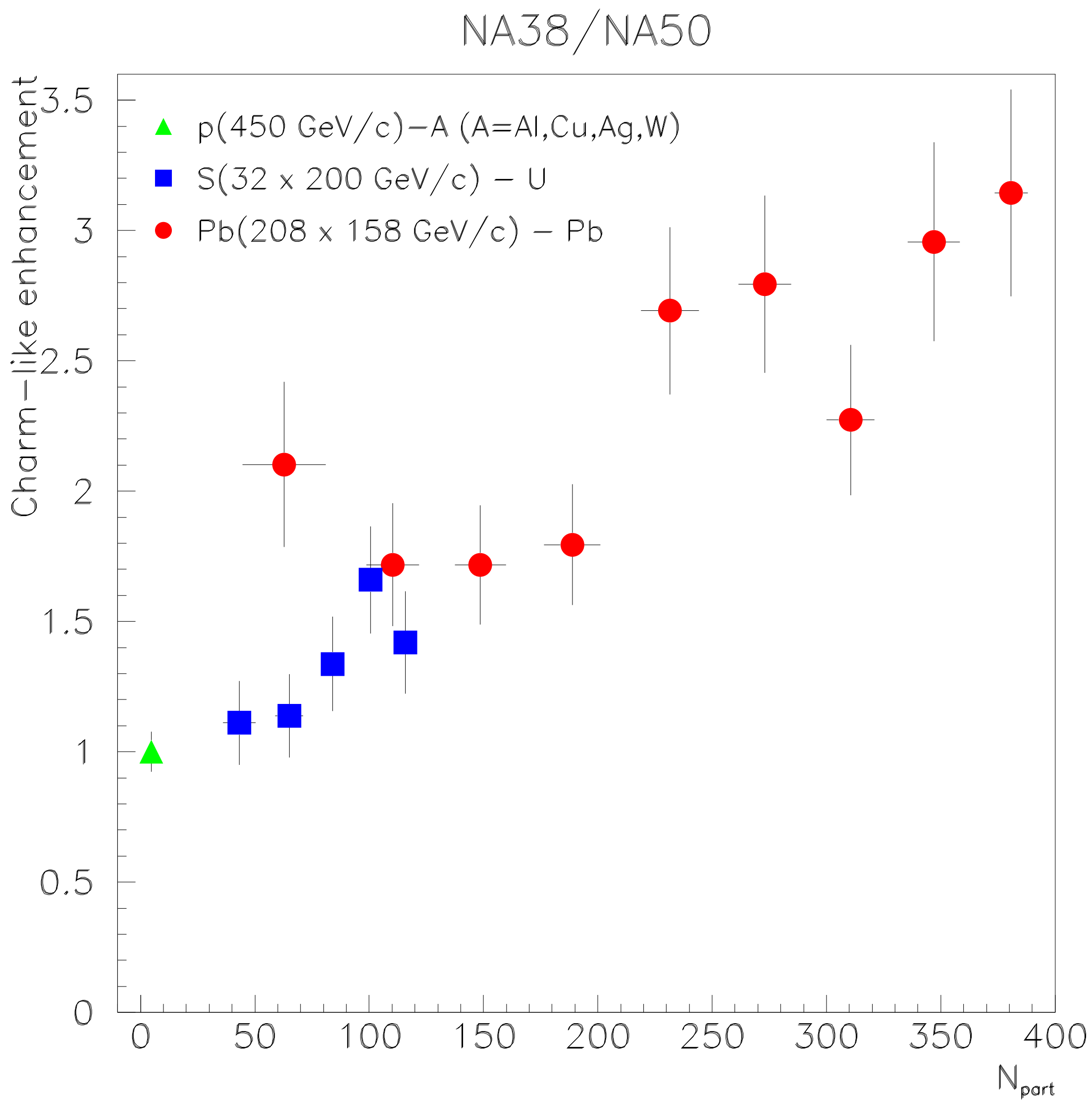


Fitting with $\sigma_{c\bar{c}}$ free the mass spectra is well described

⇒ **The excess is charm-like** (Exc$_{c.l.}$)

Charm-like Enhancement as a Function of N_{Part}

$$\frac{(D\bar{D}+Exc_{c.l.}\ /\ DY)^{AB}_{measured}}{(D\bar{D}\ /\ DY)^{AB}_{expected}} \Big/ \frac{(D\bar{D}/DY)^{pA}_{measured}}{(D\bar{D}/DY)^{pA}_{expected}}$$



⇒ **In central Pb-Pb collisions the charm-like enhancement is a factor of 3 with respect to proton induced reactions**

⇒ **The charm-like enhancement increases linearly with N_{Part}**

Conclusions

- **In nucleus-nucleus interactions an excess is observed in the intermediate mass region**
  - **The excess increases with N_{Part} up to a factor of 3 for the most central collisions**

- **Combinatorial background cannot account for the amount of the excess yield**

- **The dimuon mass shape of the excess is :**
  - **different from the combinatorial background**
  - **charm-like**

- **The charm-like excess is not explained by a broadening of the open charm P_T distribution due to its rescattering in matter**