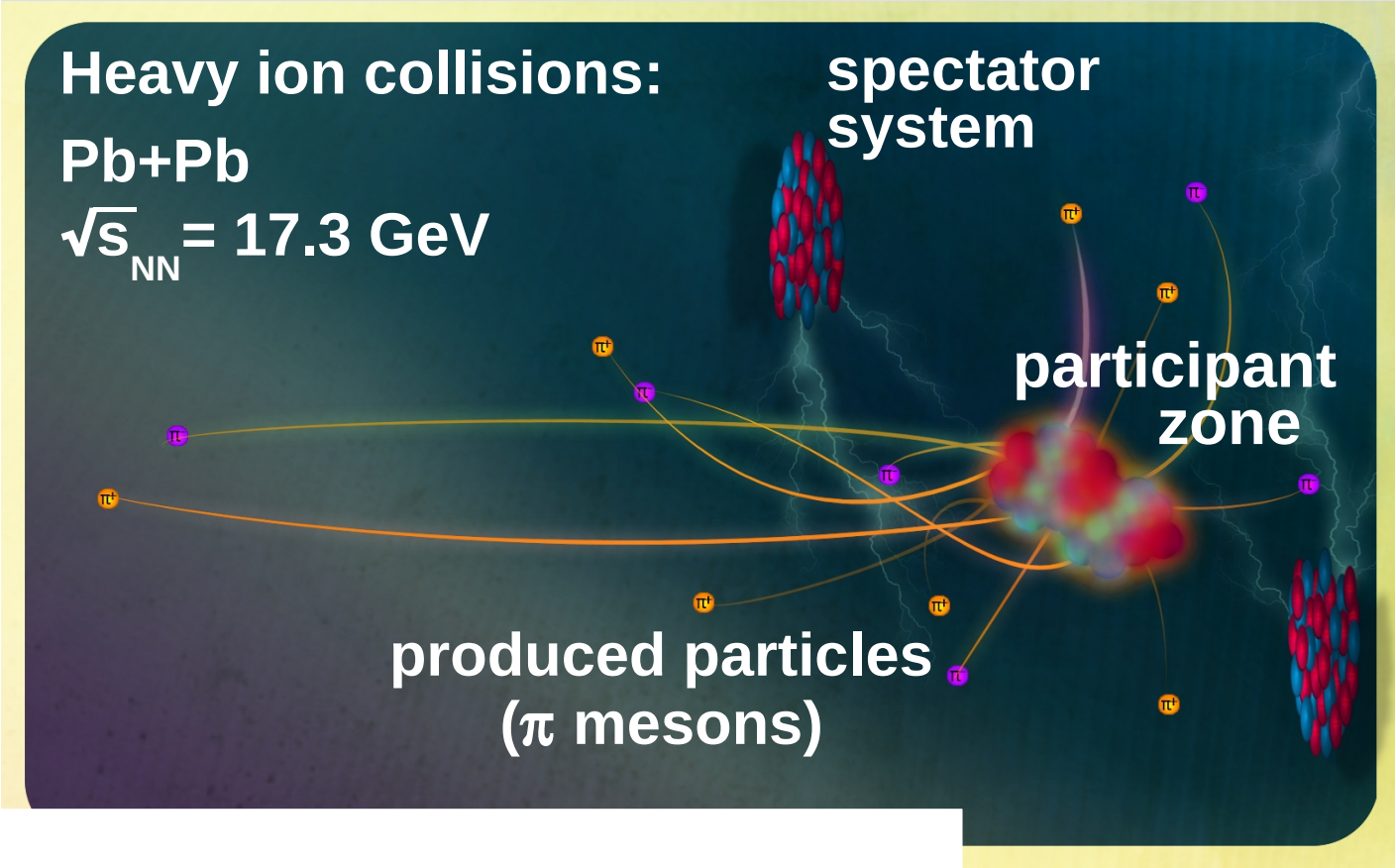
Electromagnetic effects on meson production: a new tool for studying the space-time evolution of heavy ion collisions.

Andrzej Rybicki
H. Niewodniczański Institute of Nuclear Physics
Polish Academy of Sciences

1) Introduction ;
2) EM effects in heavy ion collisions ;
3) Space-time evolution of the system ;
4) Summary & outlook.

work in collaboration with
Antoni Szczurek
Mariola Kłusek-Gawenda
Nikolaos Davis
Vitalii Ozvenchuk
Mirosław Kiełbowicz

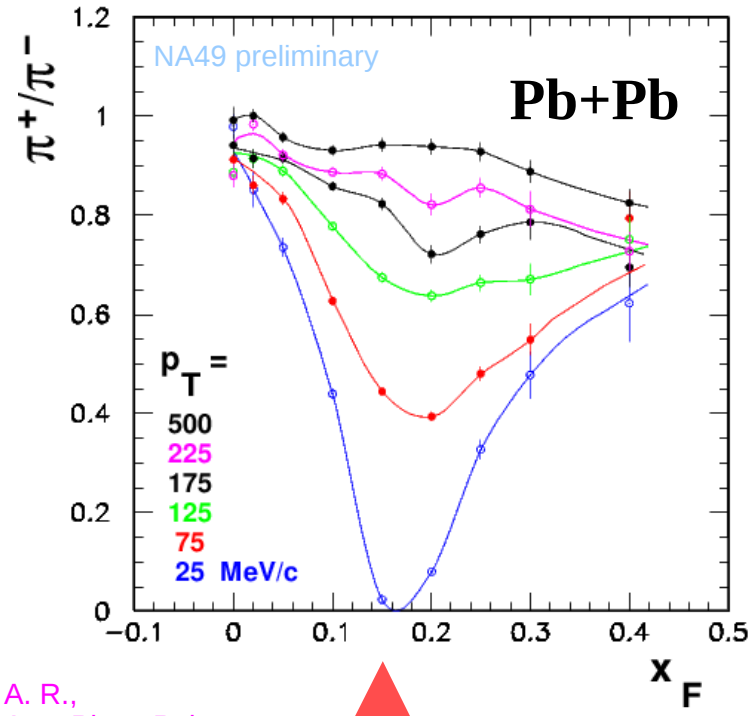
1) Introduction

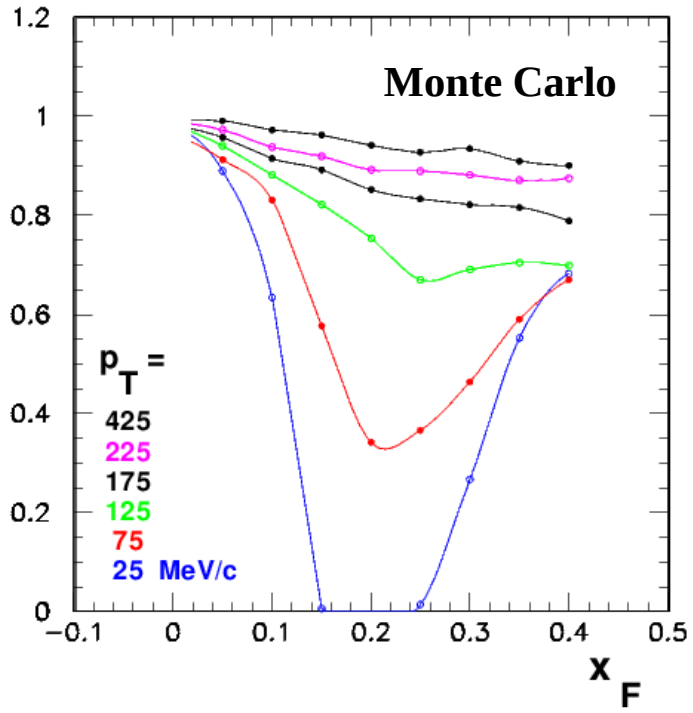


by I. Sputowska

- Charged spectators in non-central collisions generate electromagnetic fields.
- Can we use them as a new source of information on the space-time evolution of the system ?
- Can we use resonances ?

2) EM effects in heavy ion collisions





A. R.,
Acta Phys. Polon.
B42 (2011) 867

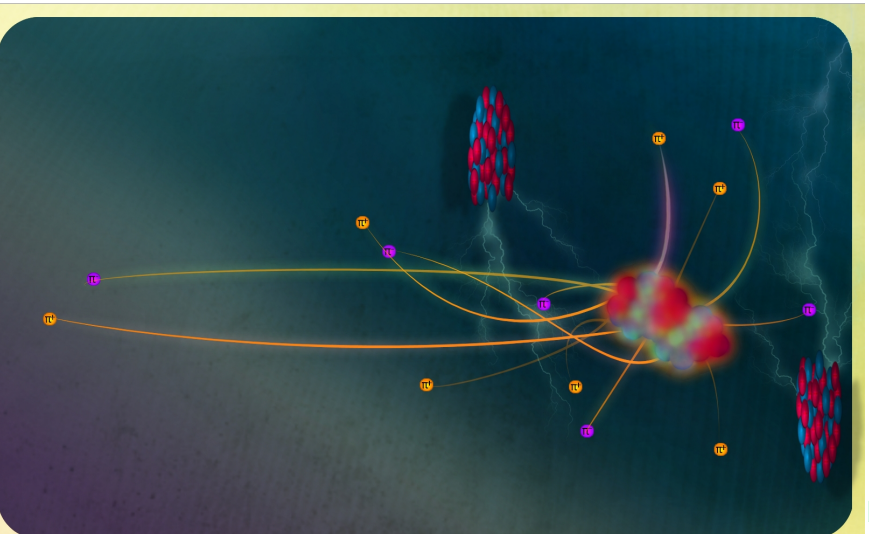
NA49,
$\sqrt{s_{NN}}$=17.3 GeV
Pb+Pb, peripheral

spectator velocity

$$x_F = \frac{p_L}{p_L^{beam}}$$

(c.m.s.)

$d_E \approx 0.75$ fm !



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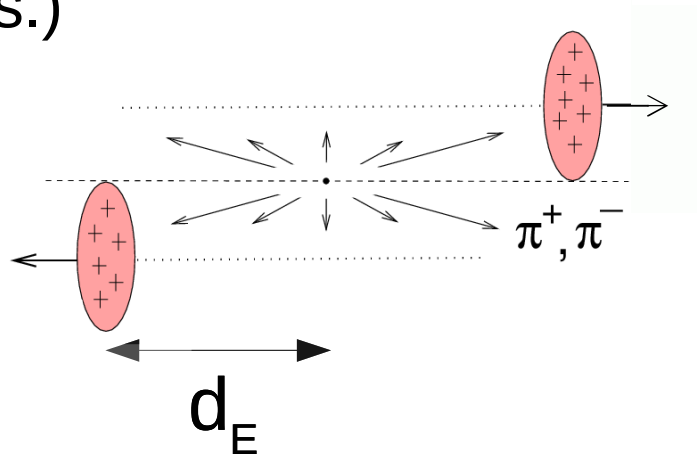

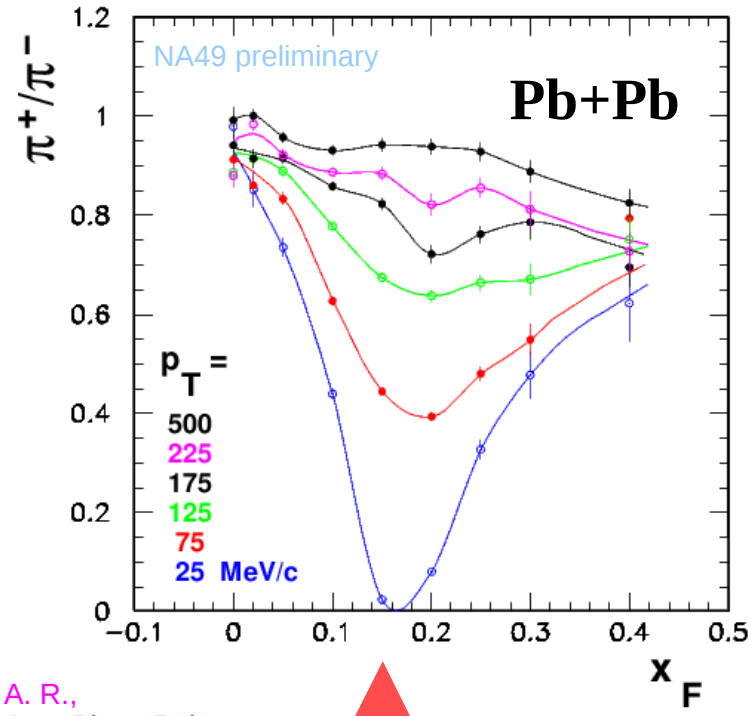

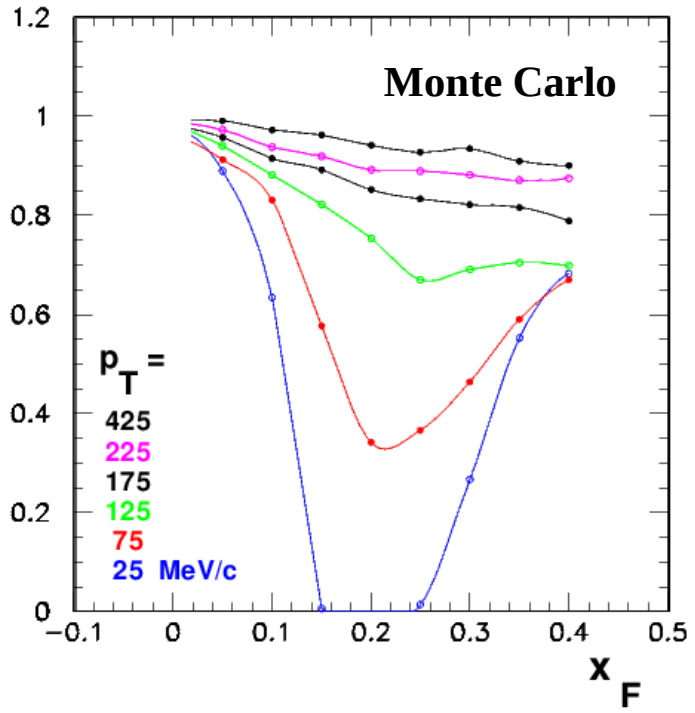

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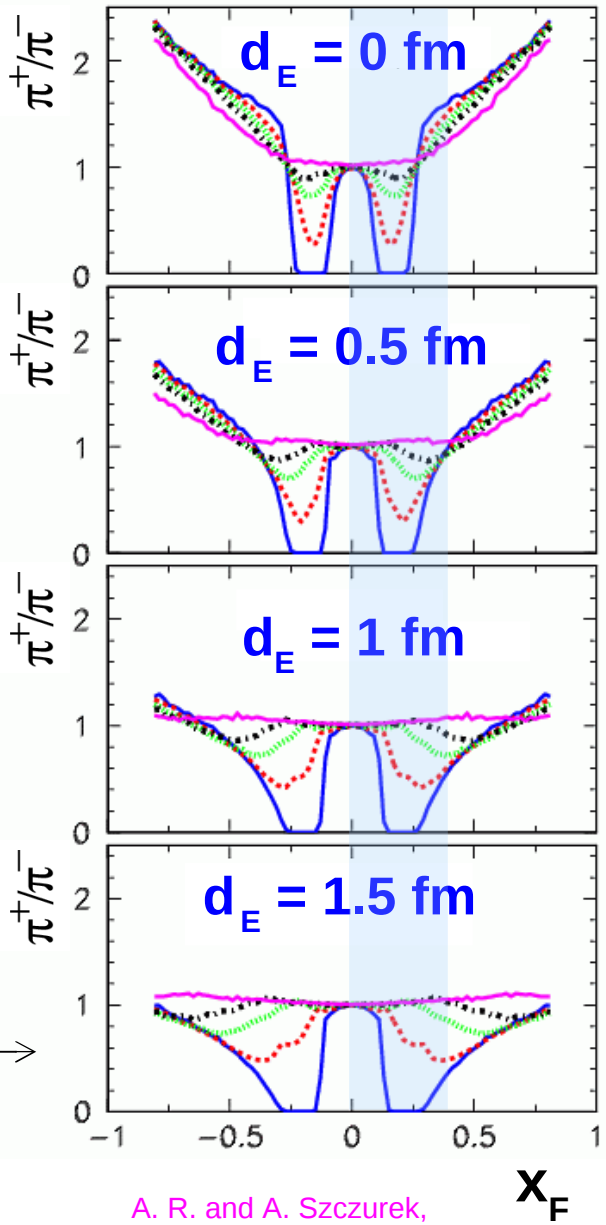
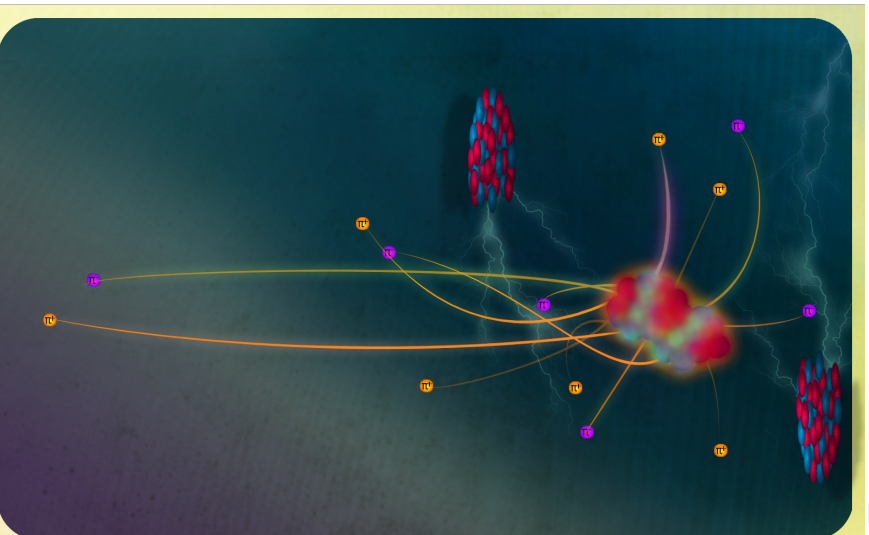


A. R. and A. Szczurek,
Phys. Rev. **C75** (2007)
054903



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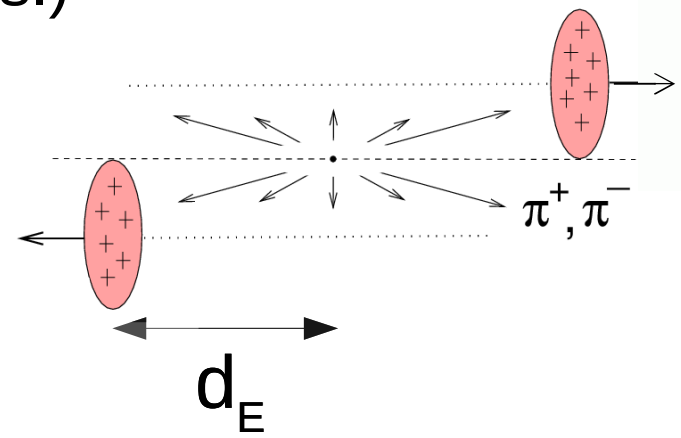

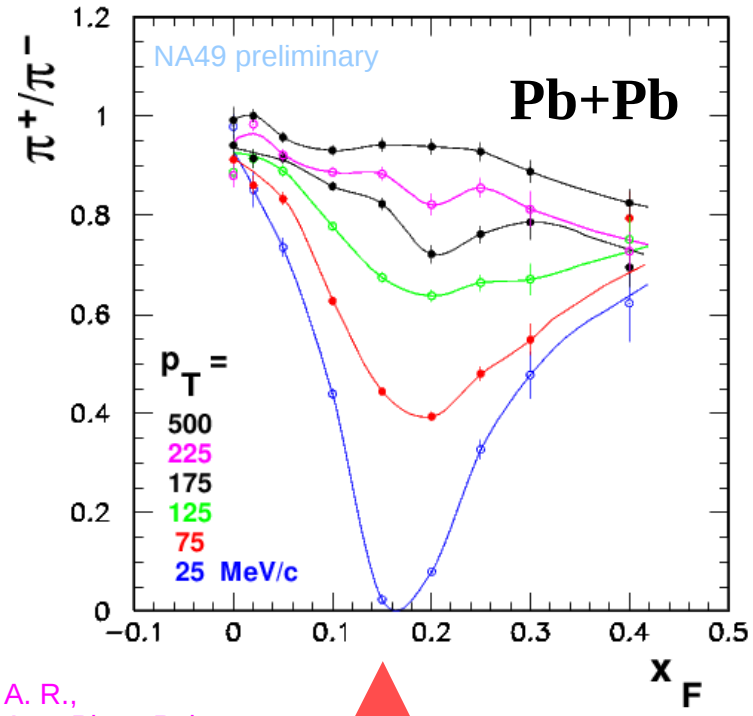

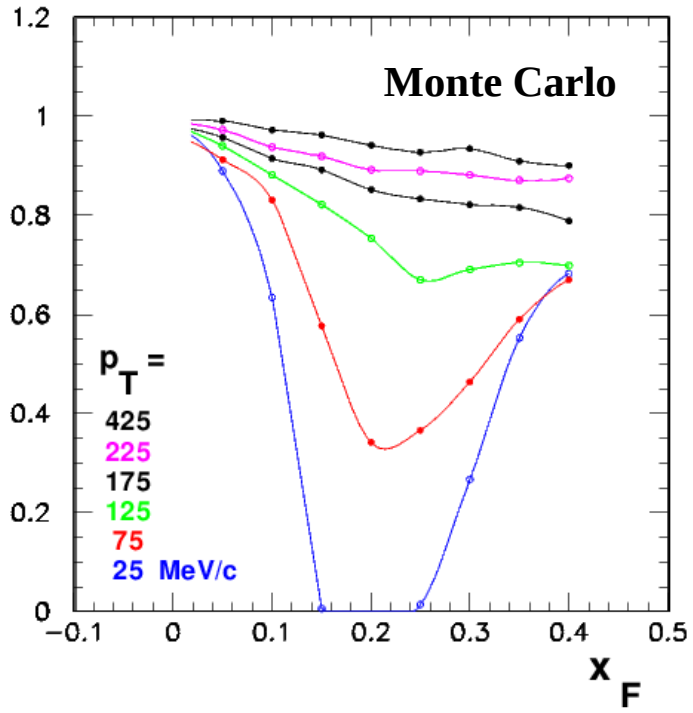

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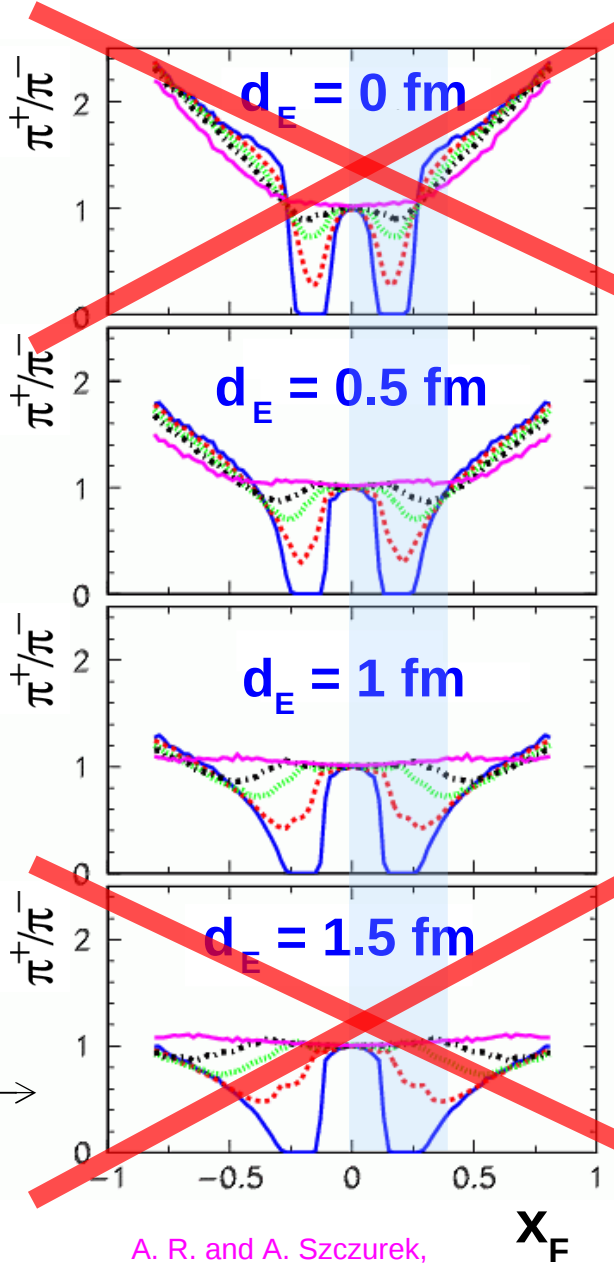

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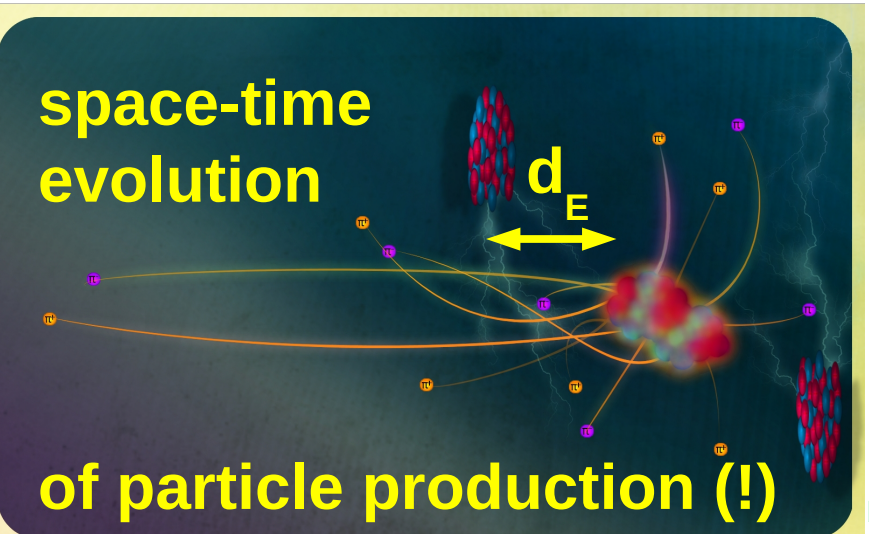

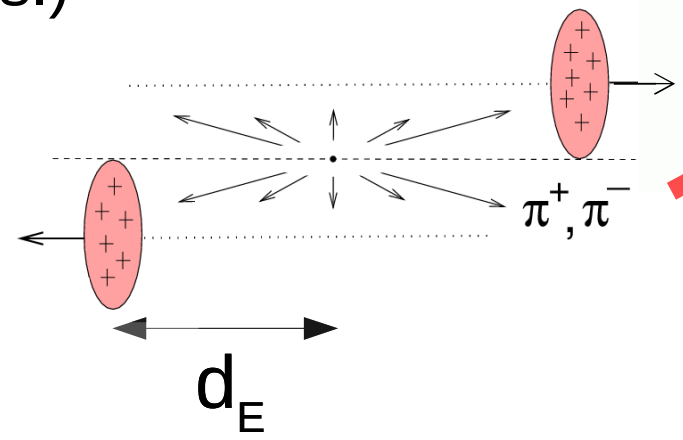

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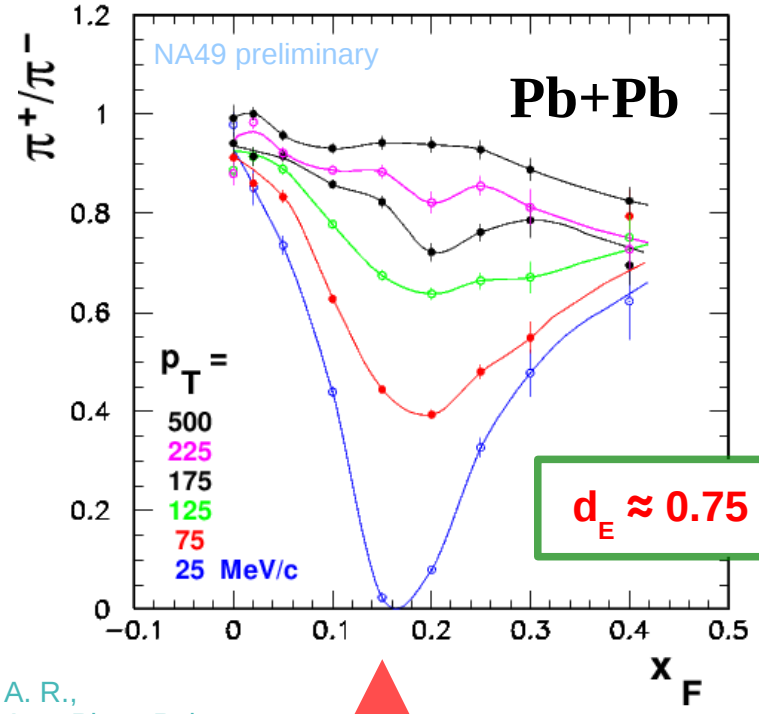

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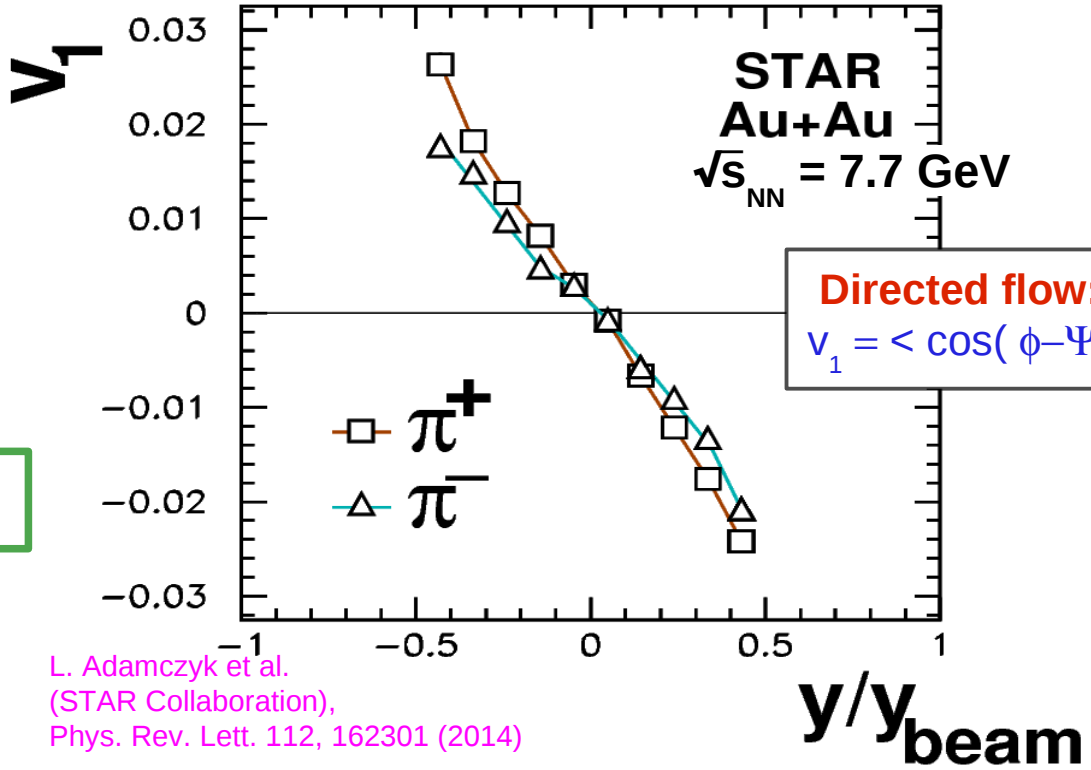
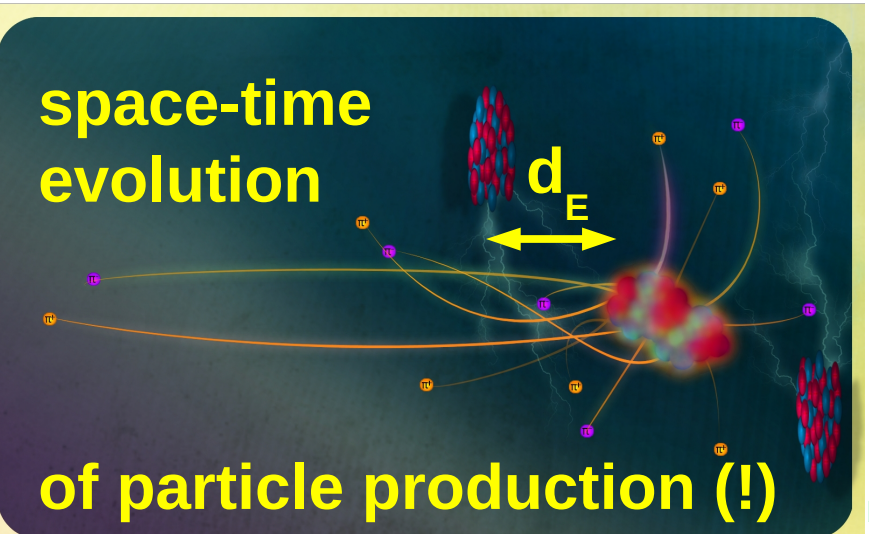


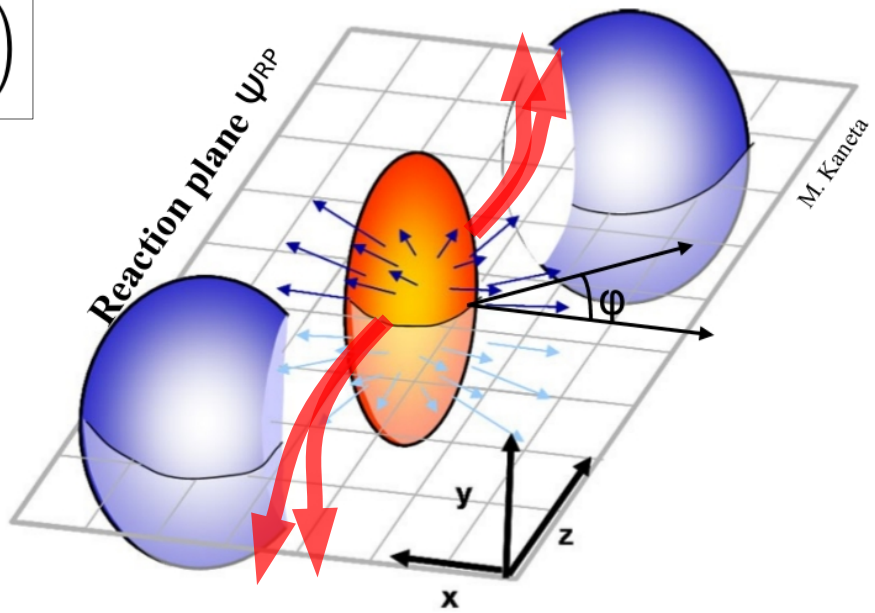
Directed flow:
$v_1 = \langle \cos(\phi - \Psi_{RP}) \rangle$

L. Adamczyk et al.
(STAR Collaboration),
Phys. Rev. Lett. 112, 162301 (2014)

$y = y_{beam}$

$$y = \frac{1}{2} \ln \left(\frac{E+p_L}{E-p_L} \right)$$





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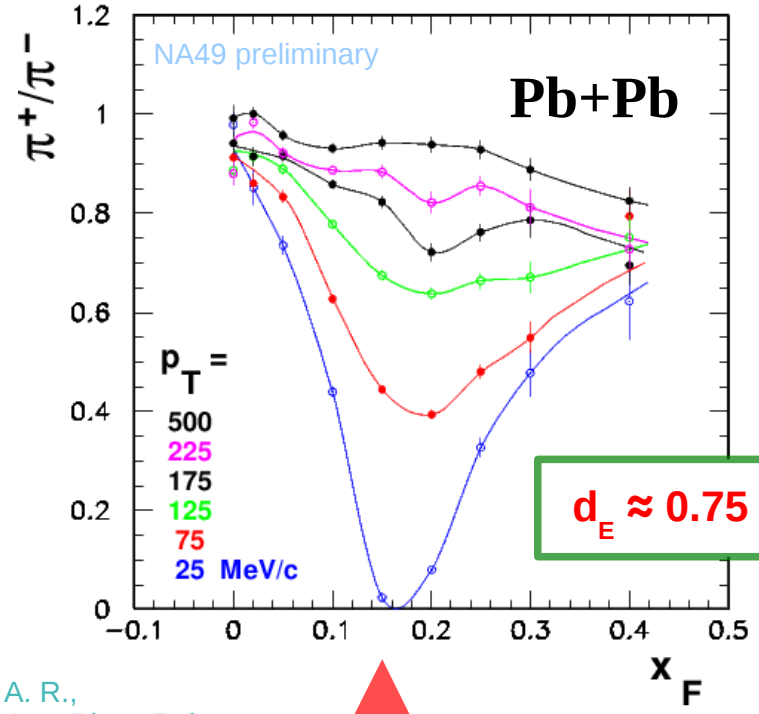

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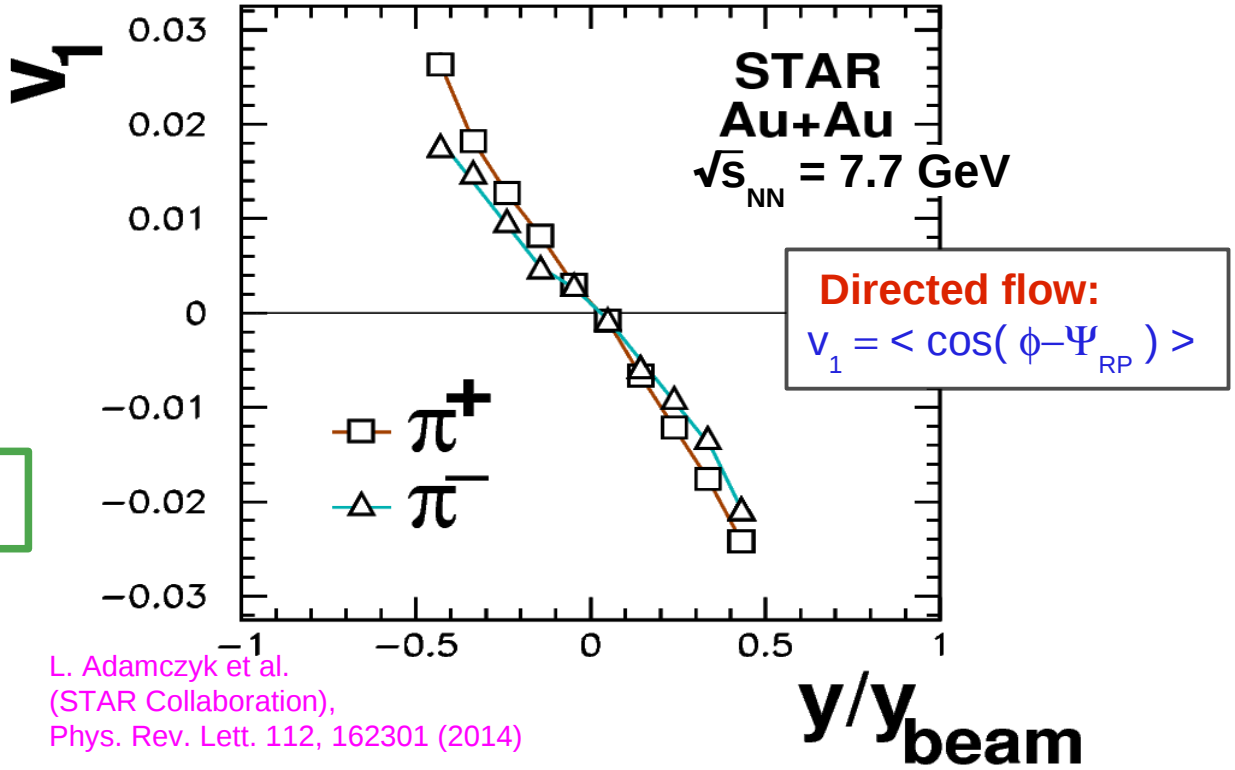

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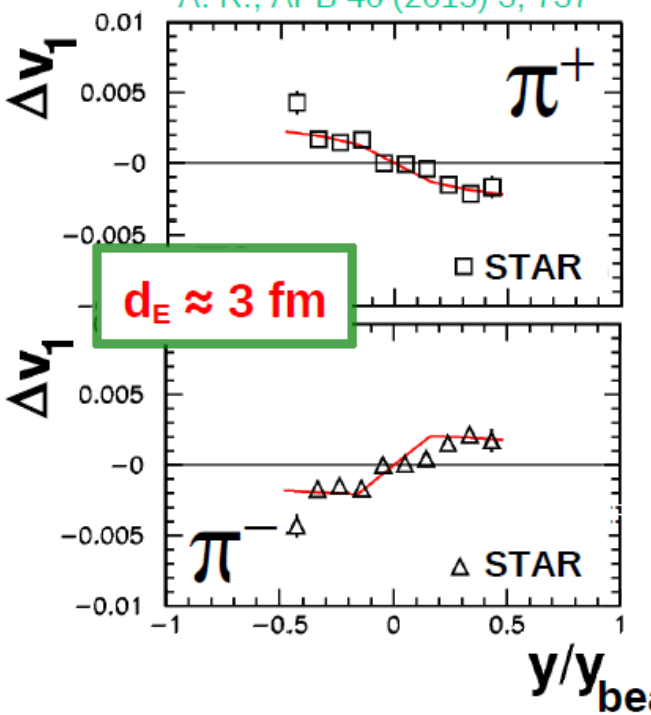
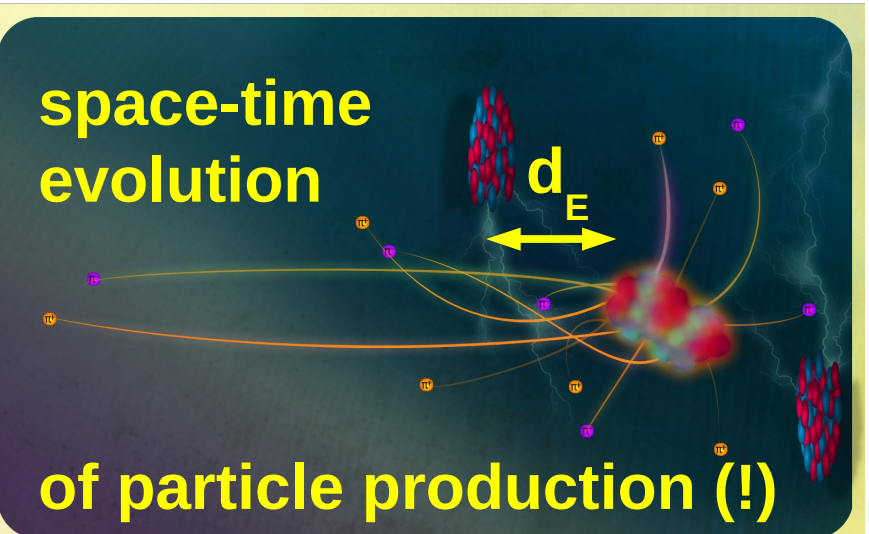
A. R., APB 46 (2015) 3, 737



$d_E \approx 3$ fm



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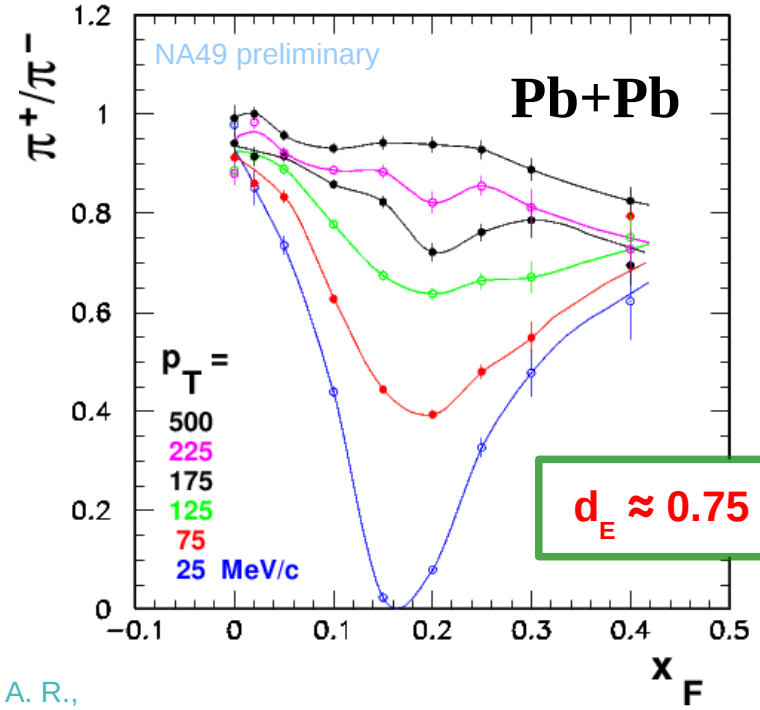

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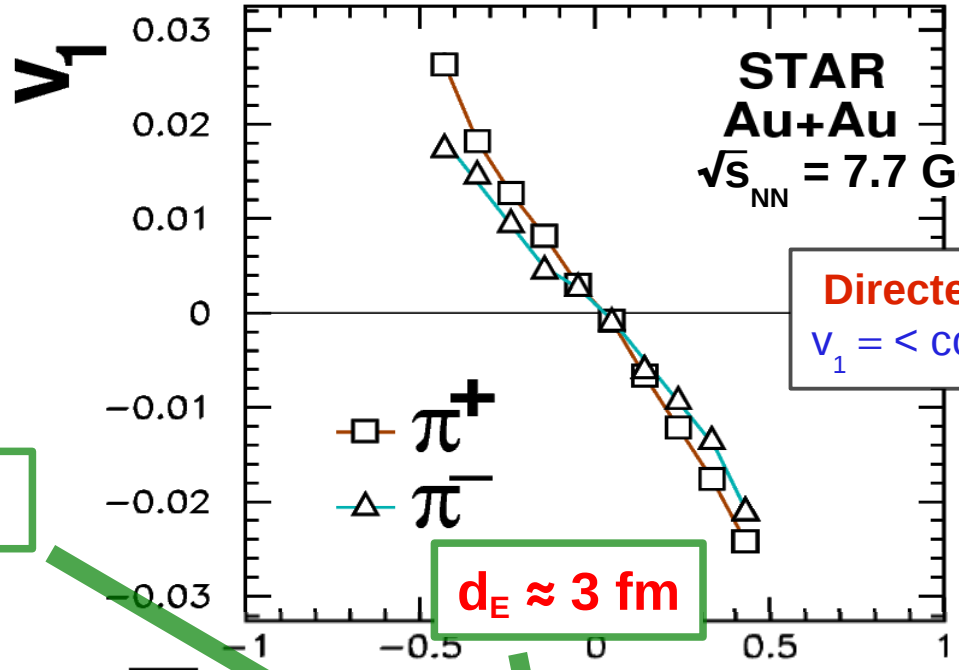

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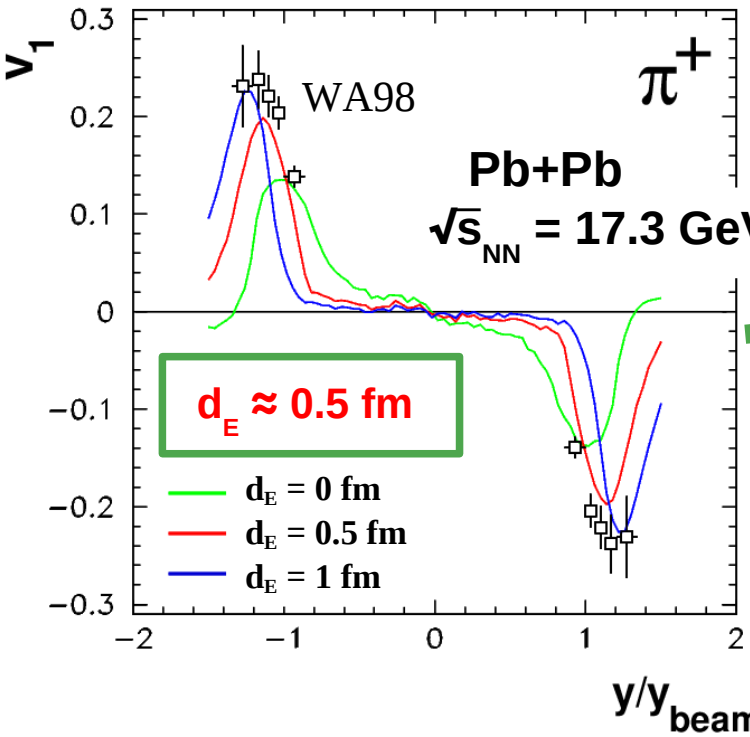
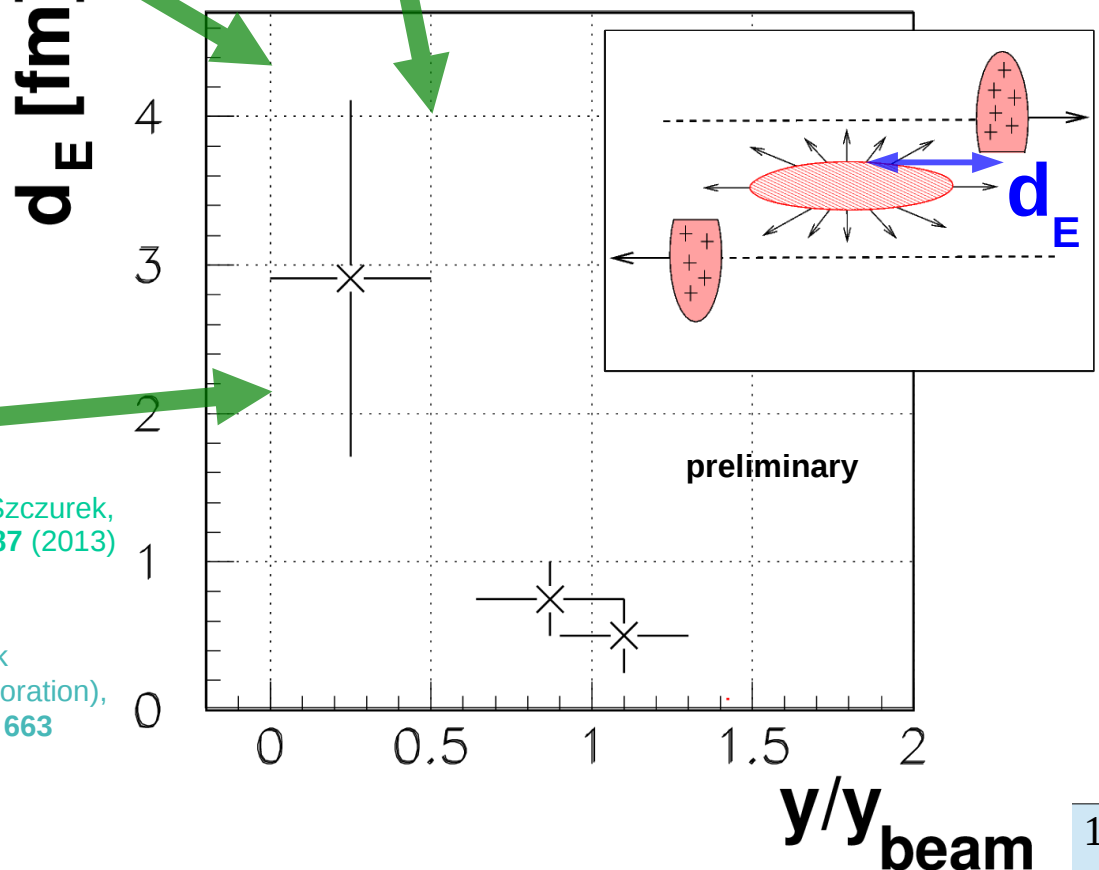
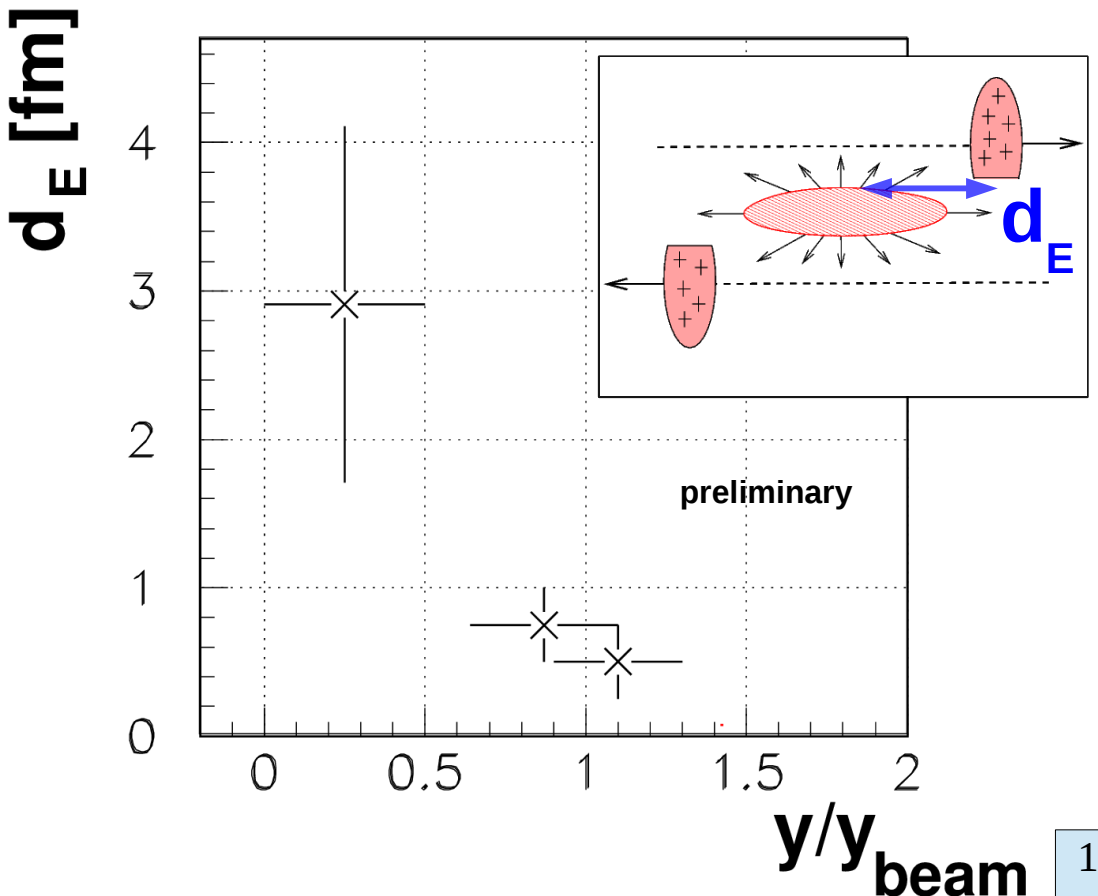


A. R. and A. Szczurek,
Phys. Rev. **C87** (2013)
054909.

H. Schlagheck
(WA98 Collaboration),
Nucl. Phys. A **663**
(2000) 725.



3) Space-time evolution of the system ...



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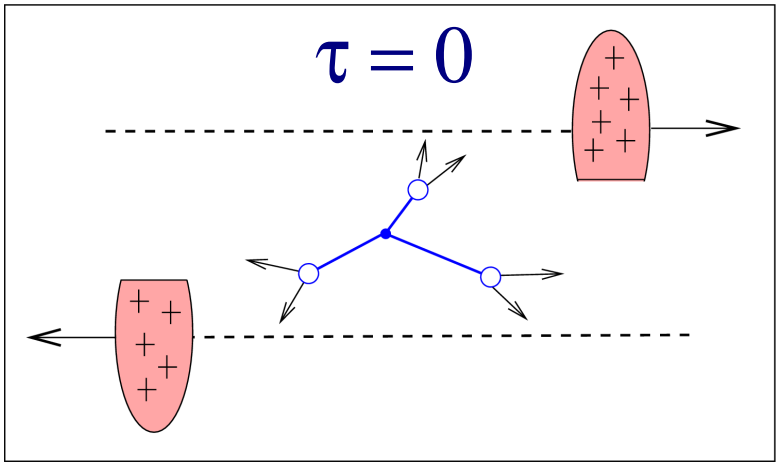
many thanks to
K. Redlich **M. Różańska**
L. Leśniak **H.G. Fischer**

Toy Monte Carlo model:

- pion production from resonances ;
- $\Delta \rightarrow p\pi$ and $\rho \rightarrow \pi\pi$;
- (y, p_T) spectra ~ known in p+p ;
- baryon stopping of the Δ ;
- Breit-Wigner's, lifetimes, etc.



Input:

- K.Fiałkowski, W.Kittel, Rept. Prog. Phys 46 (1983) 1283.
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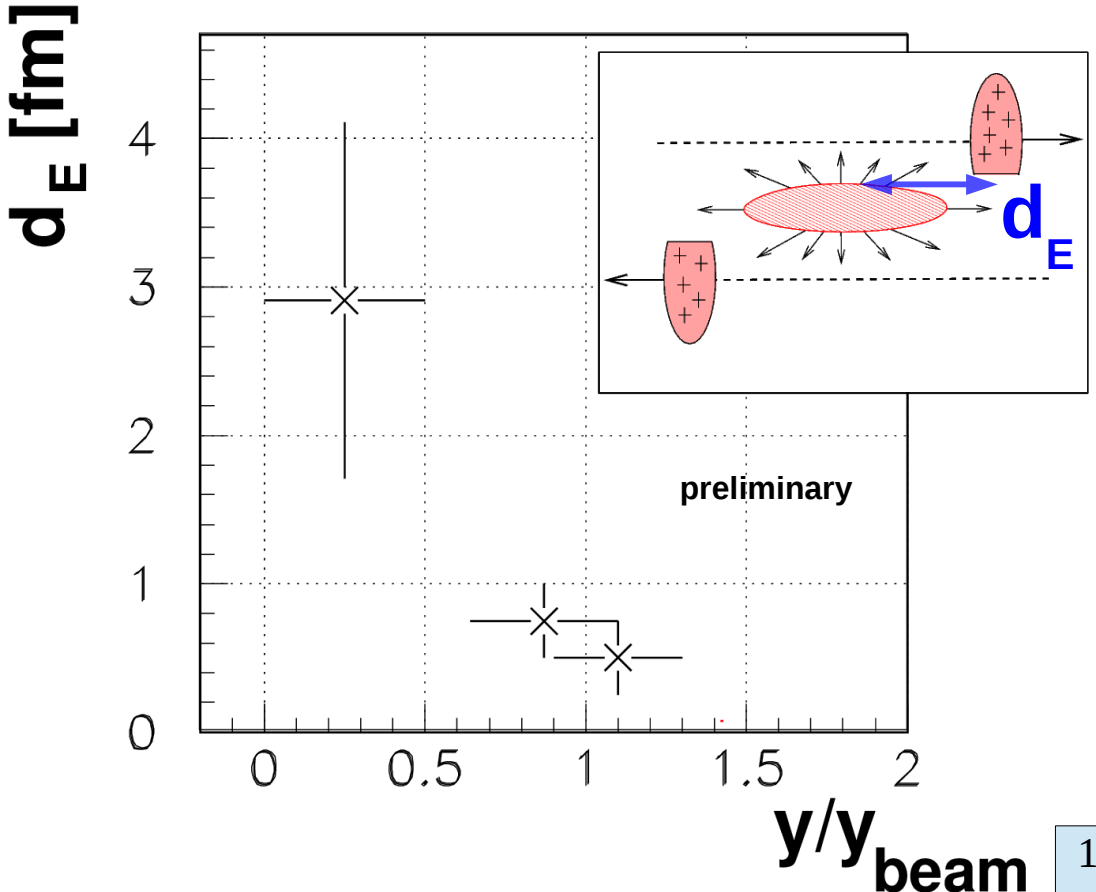
- A.R., CERN-THESIS-2003-005, and references therein.



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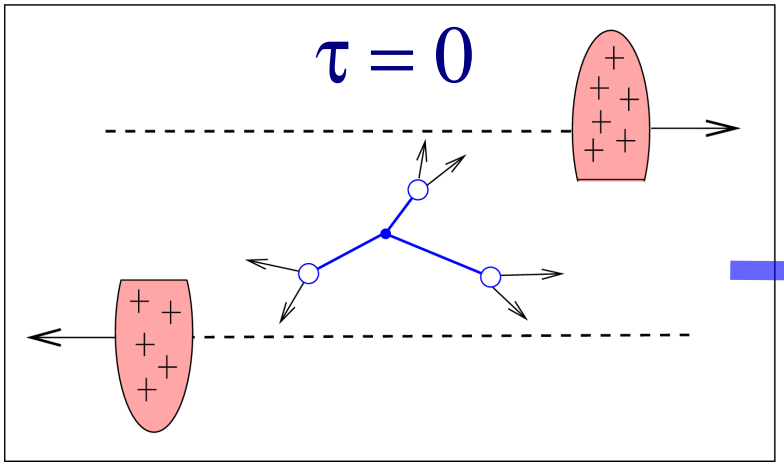

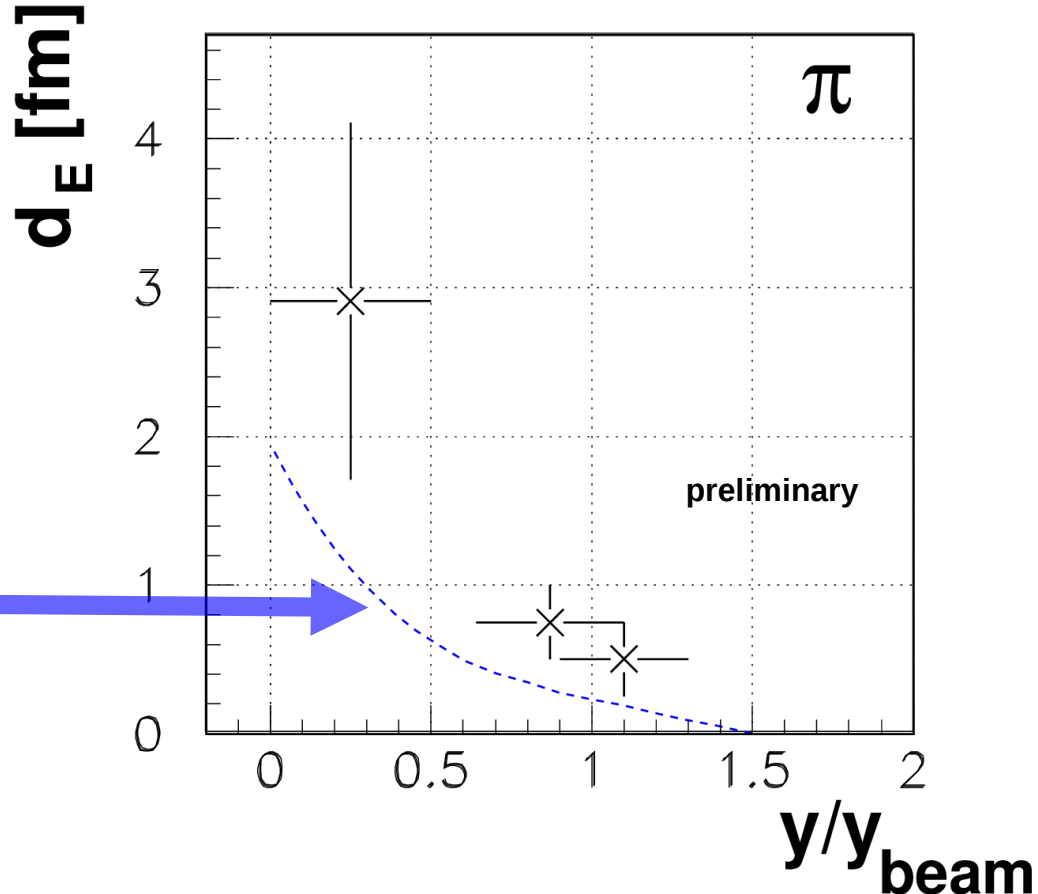

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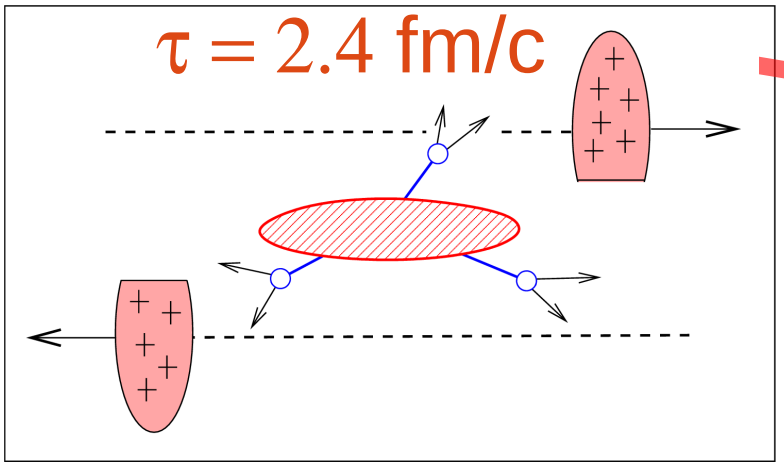

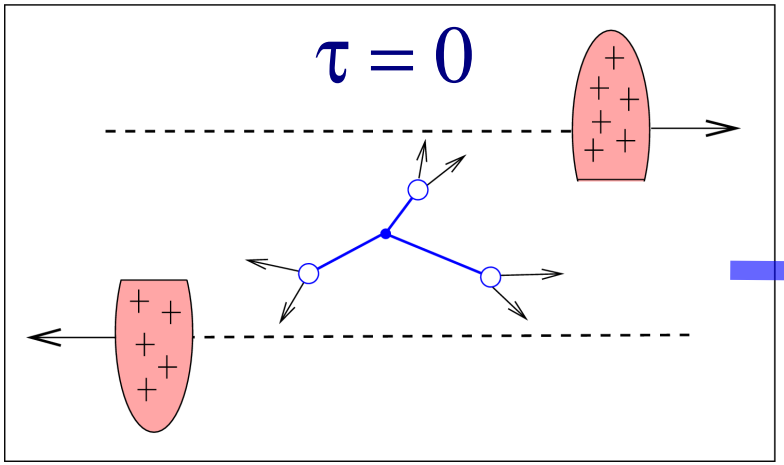

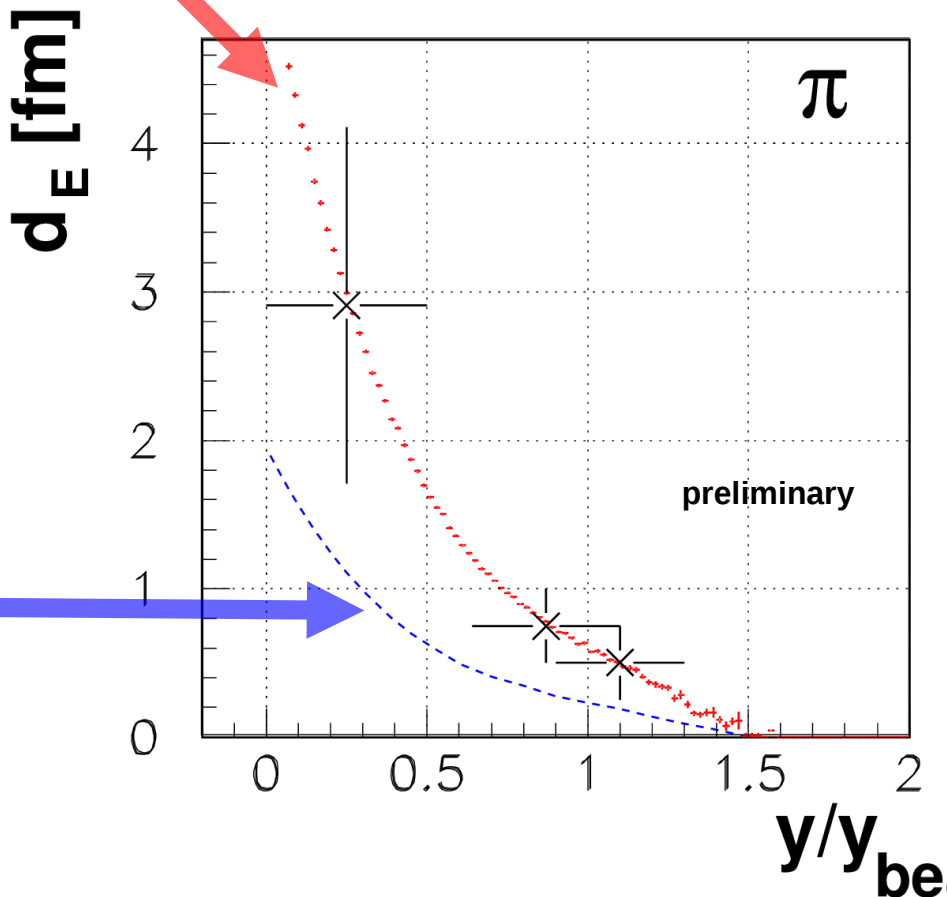

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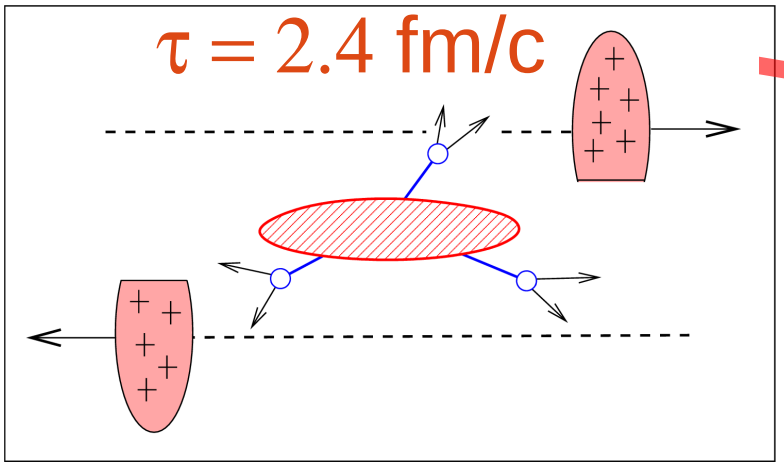

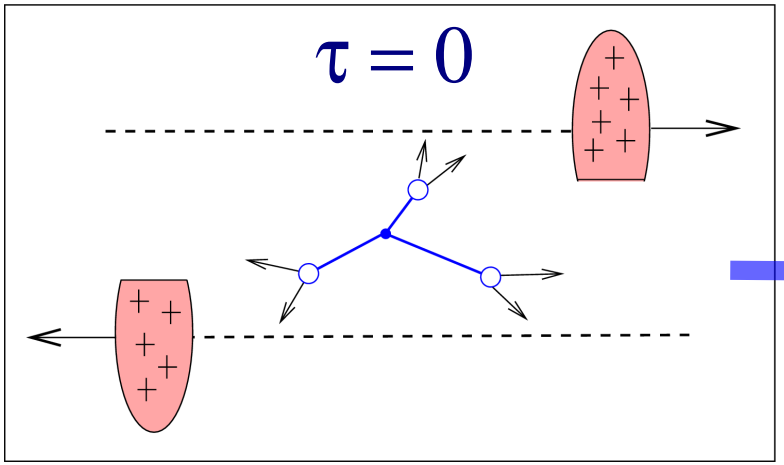

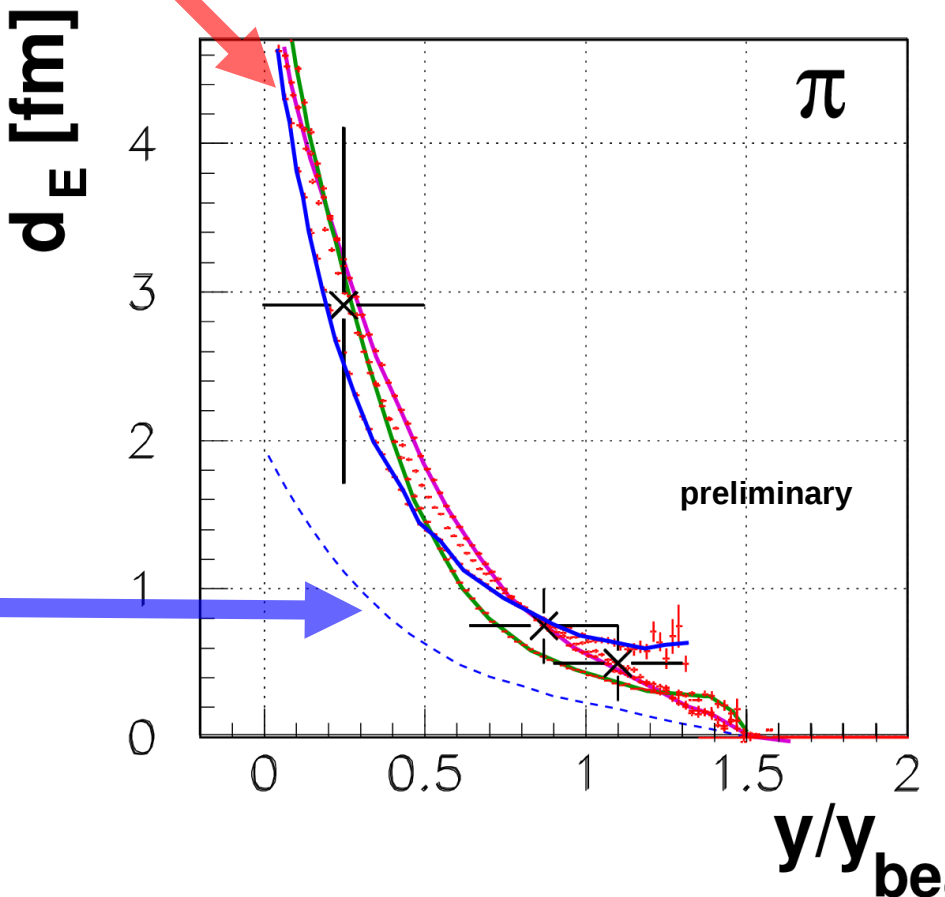

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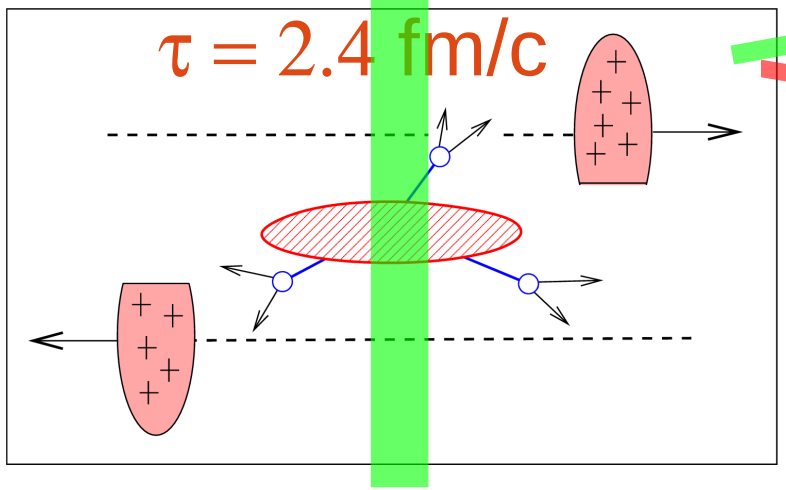
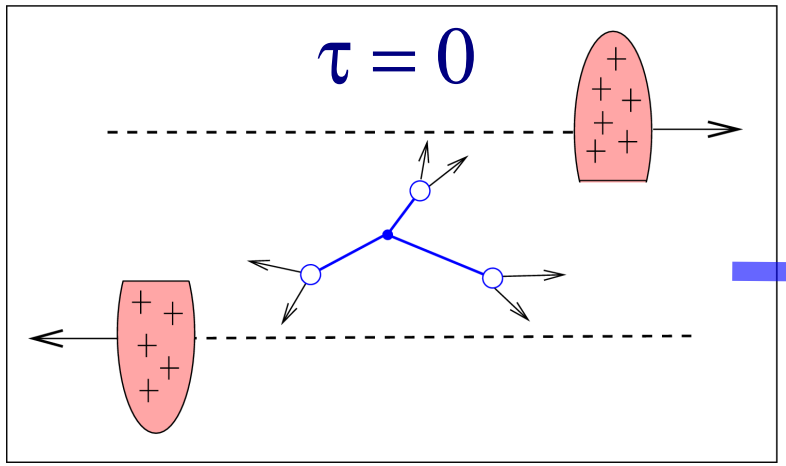
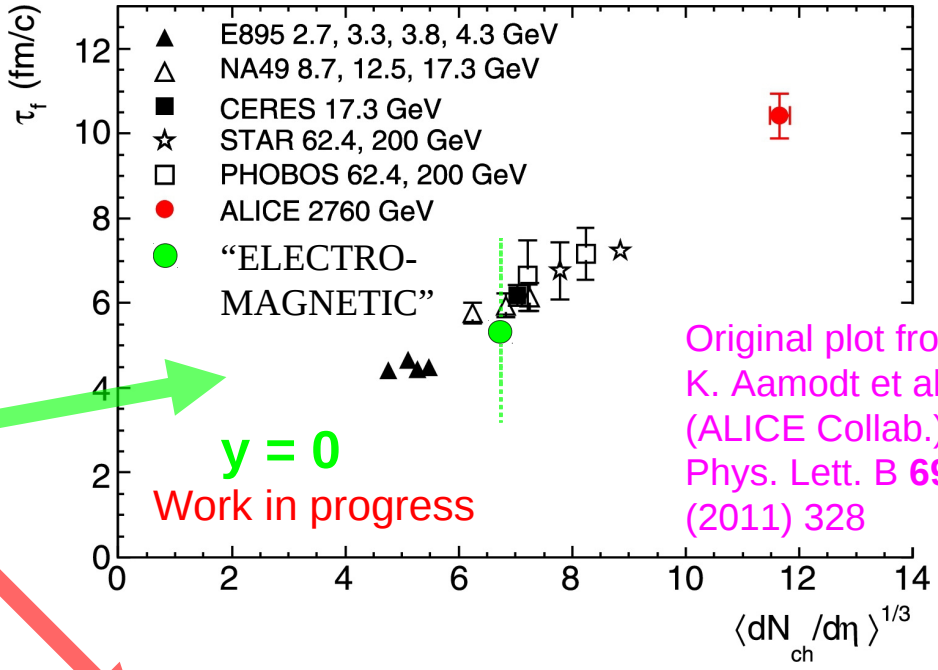
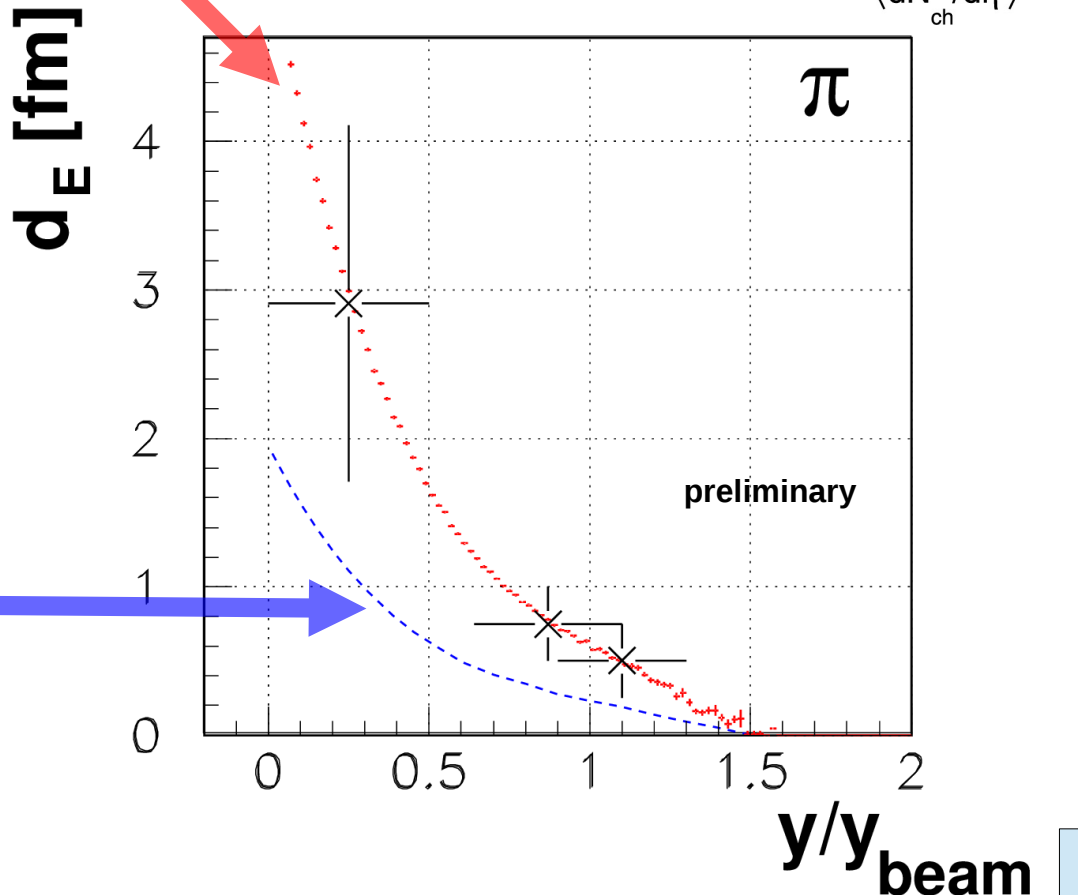






Original plot from: K. Aamodt et al. (ALICE Collab.), Phys. Lett. B **696** (2011) 328



4) Summary & outlook

EM effects in heavy ion collisions are sensitive to the distance d_E between the pion emission site and the spectator(s).

They can be used as a new source of information on the longitudinal space-time evolution of the system.

/ built up a group, joined NA61/SHINE @ CERN /

Plan (2015-2020):

1. to get more data on these effects
   (NA61/SHINE, SPSC-P-330-ADD-8, NICA, EPJA vol. 52 (2016)) ;

2. to clarify the situation at LHC.

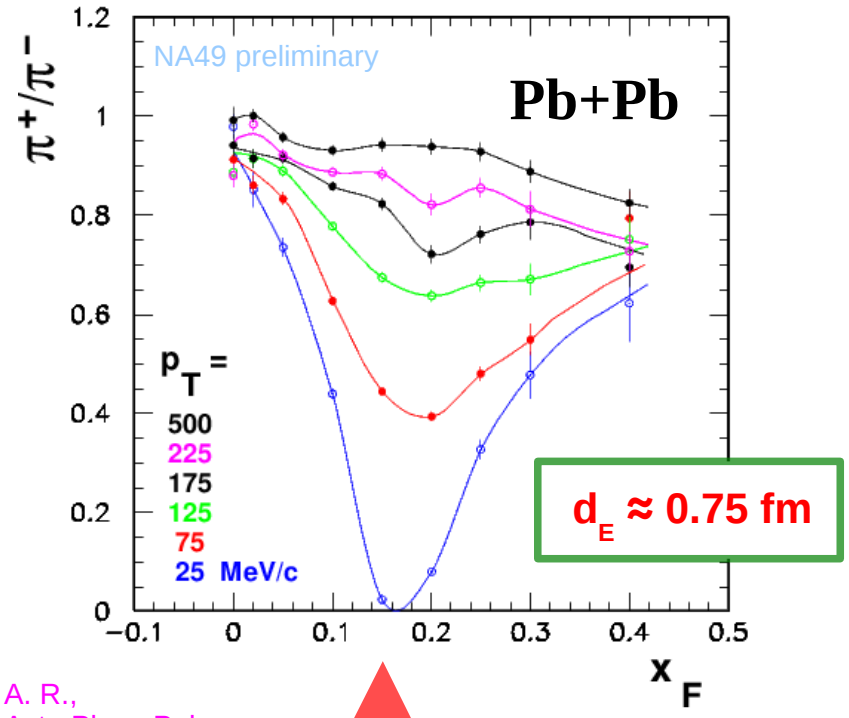
Help, advice and discussion are more than welcome.

Thank you !

Acknowledgments.

This work was supported by the National Science Centre, Poland (grant no. 2014/14/E/ST2/00018).

Extra slides



A. R.,
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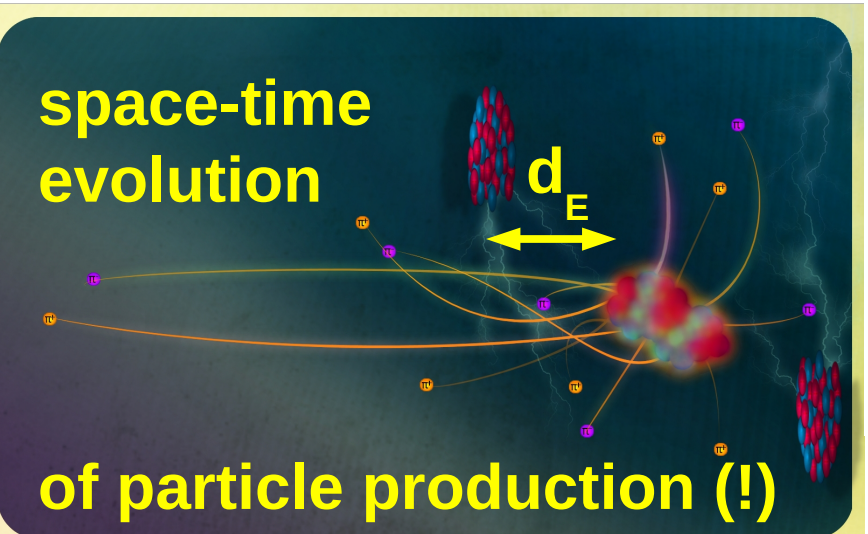

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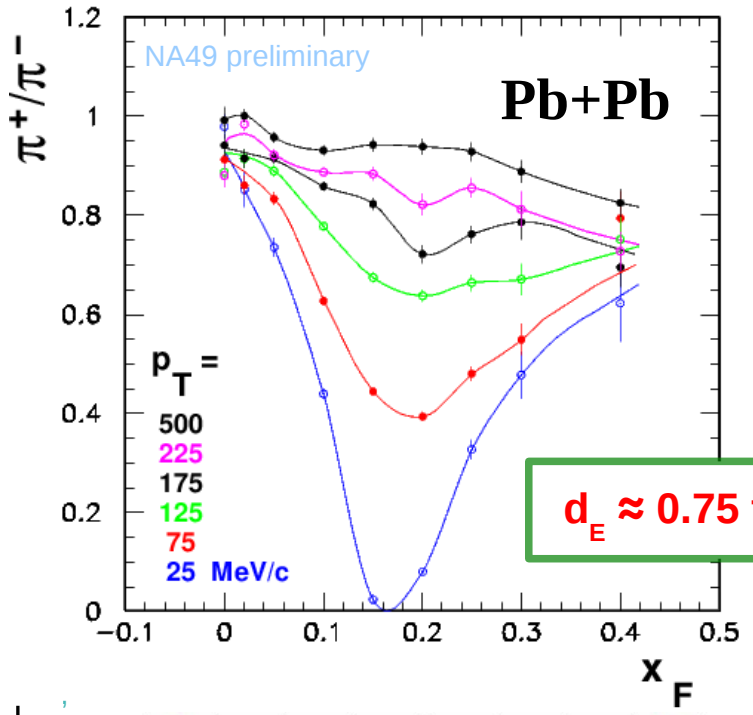

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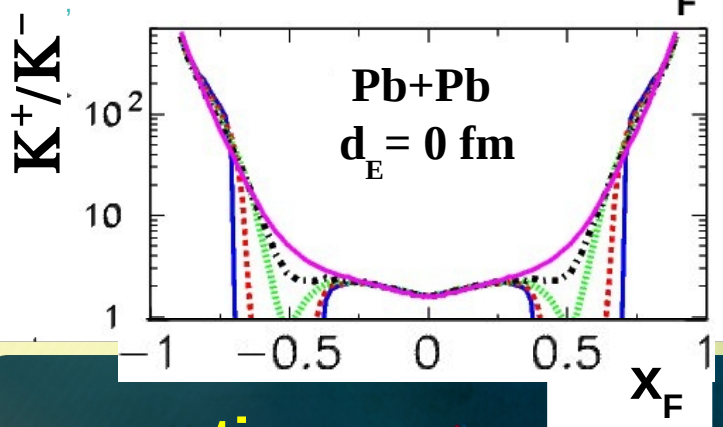
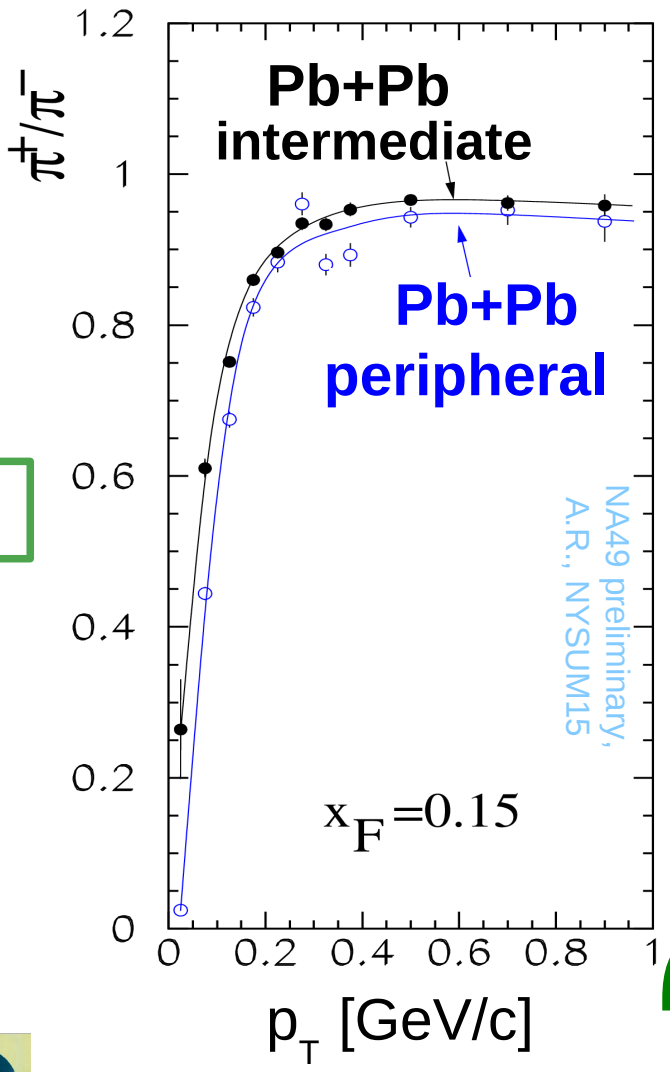


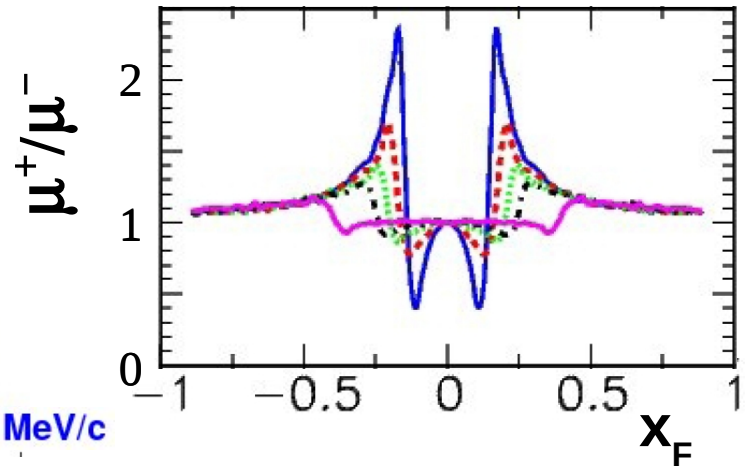


Pb+Pb, SPS, 17.3 GeV

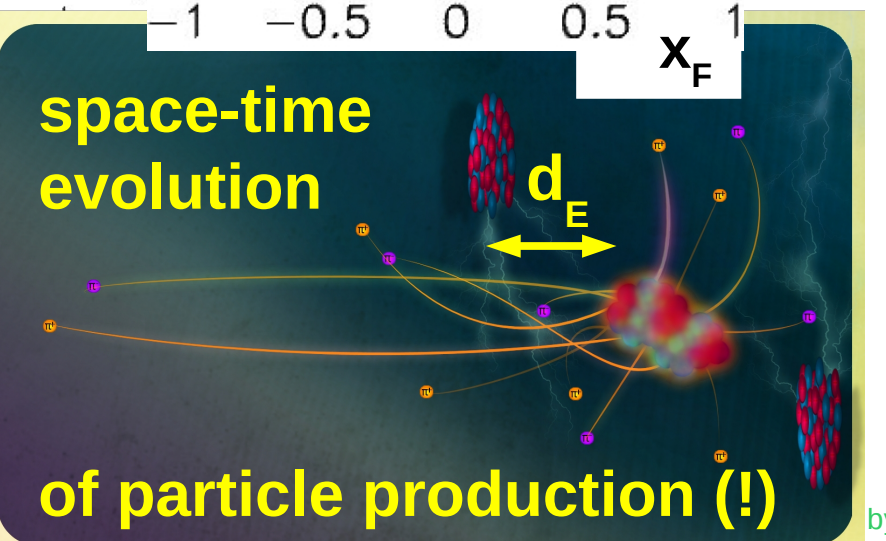
UPC, Au+Au, 200 GeV

($\gamma\gamma \rightarrow \mu^+\mu^-$)

b=112 fm, d_E = 0 fm

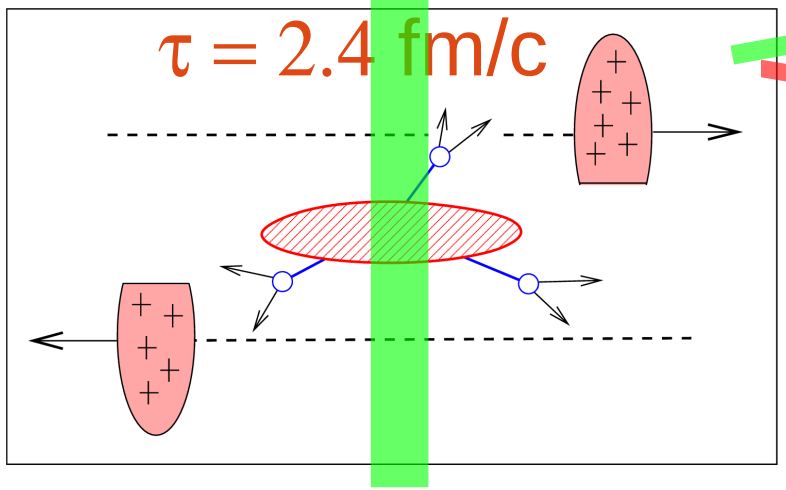


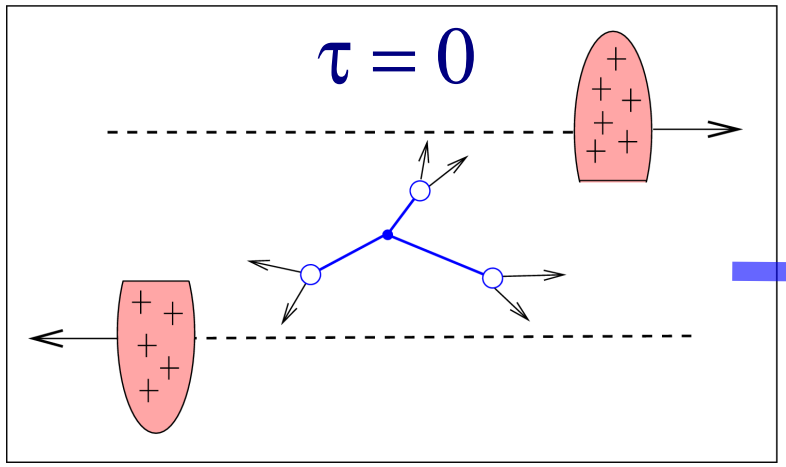
in progress

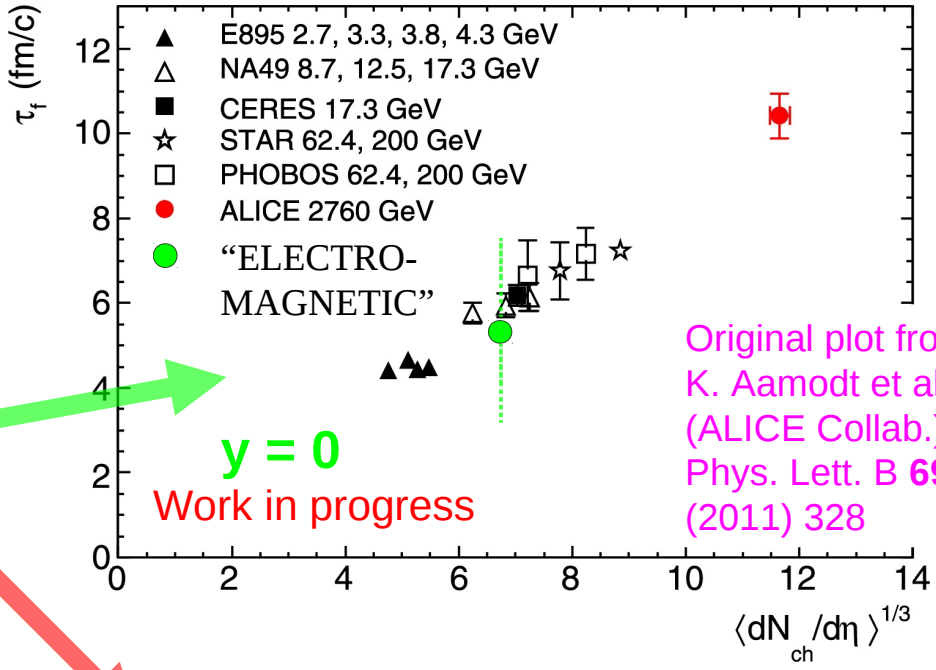


by I. Sputowska

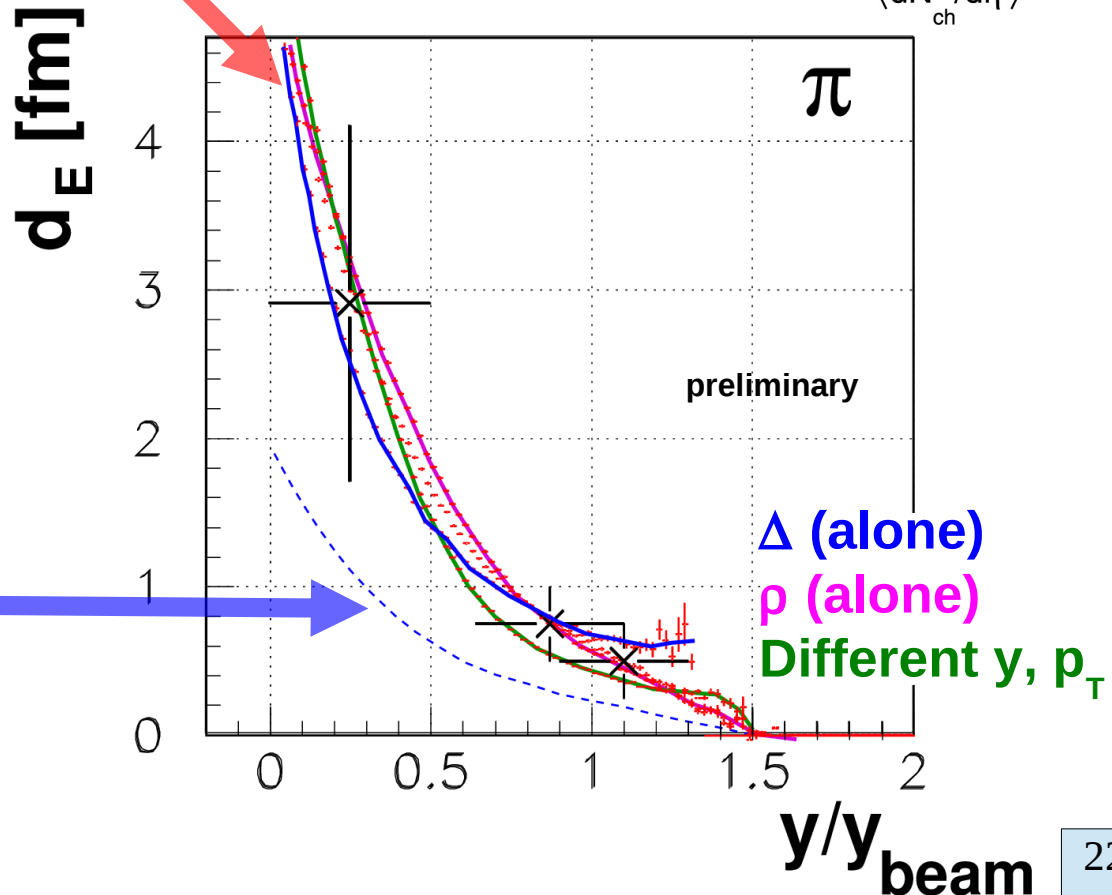
3) Space-time evolution



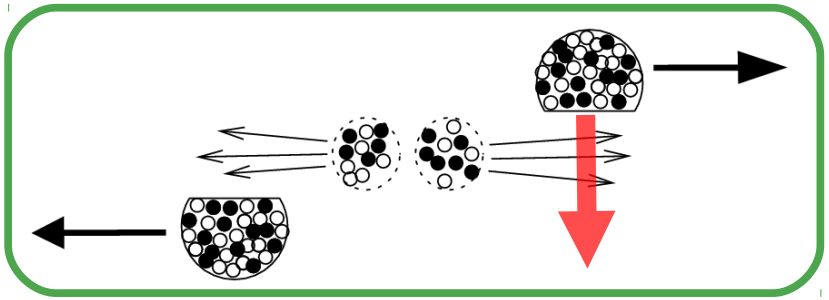




Original plot from: K. Aamodt et al. (ALICE Collab.), Phys. Lett. B **696** (2011) 328



NA49, 158 A GeV/c

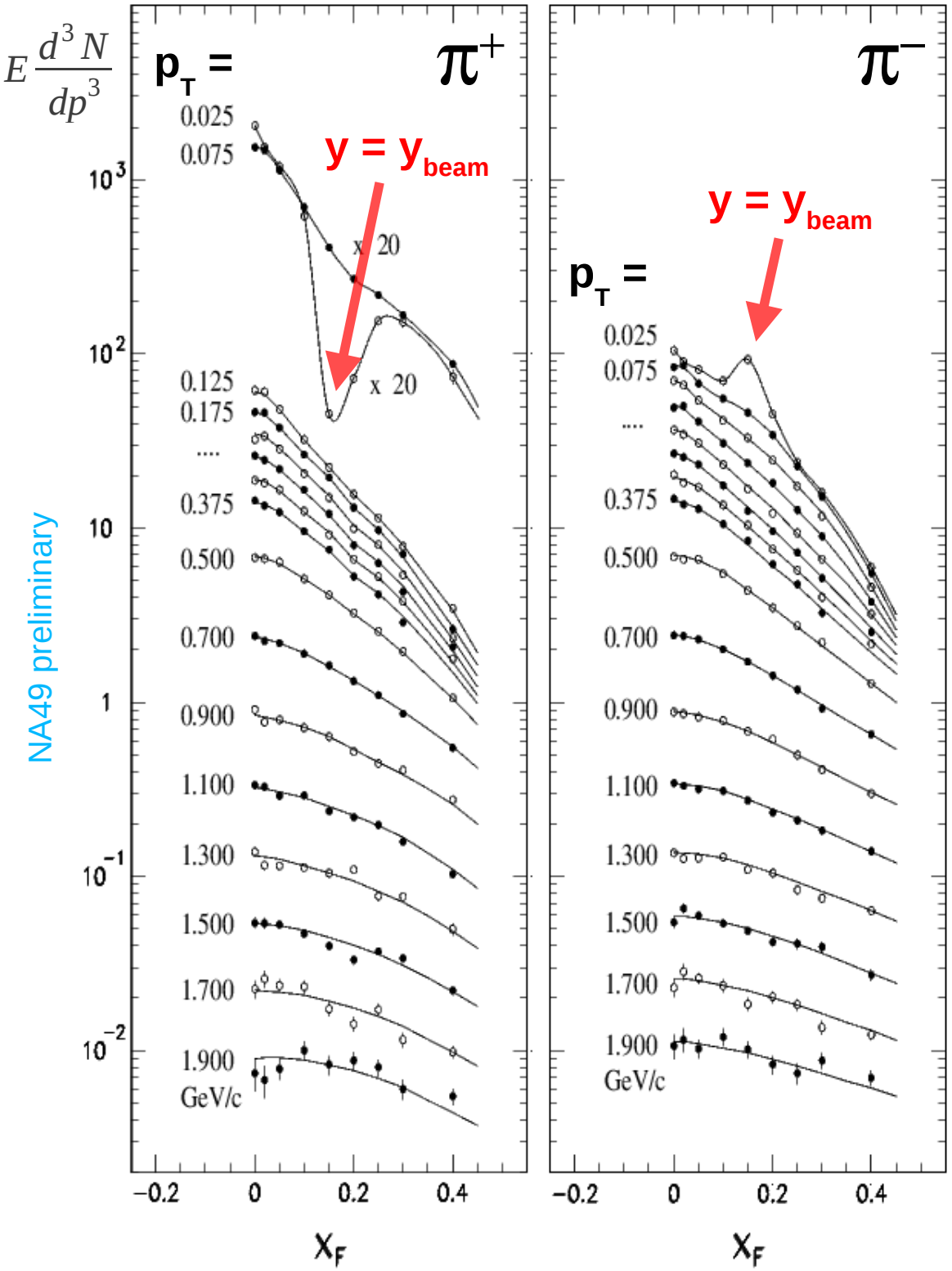


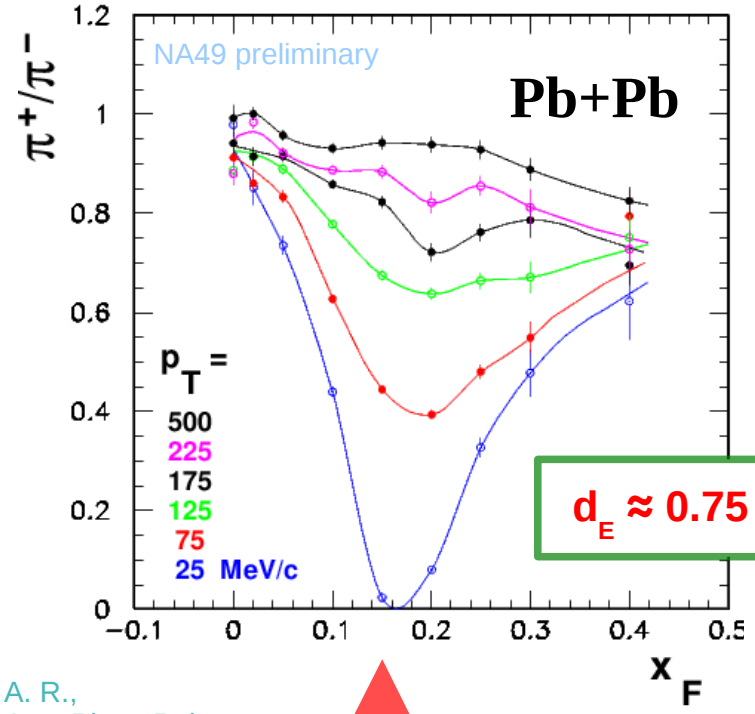
Repulsion (for π^+)
Attraction (for π^-)

$$x_F = \frac{p_L}{p_L^{beam}}$$

(c.m.s.)

Pb+Pb, peripheral

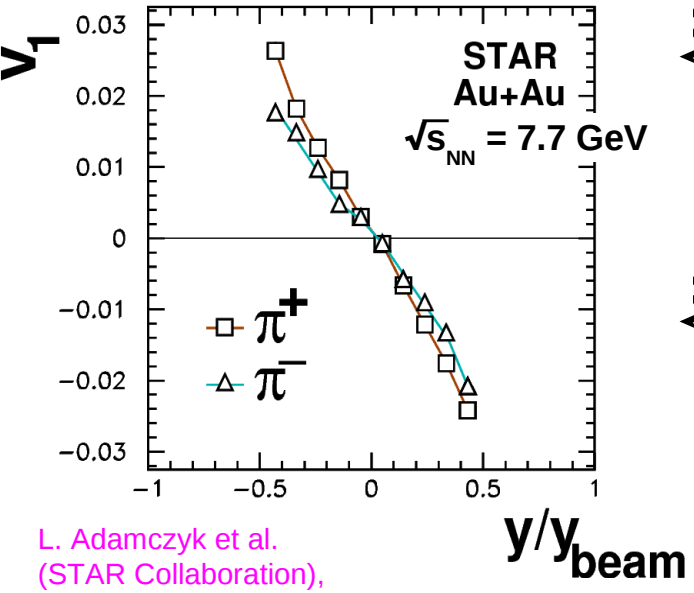




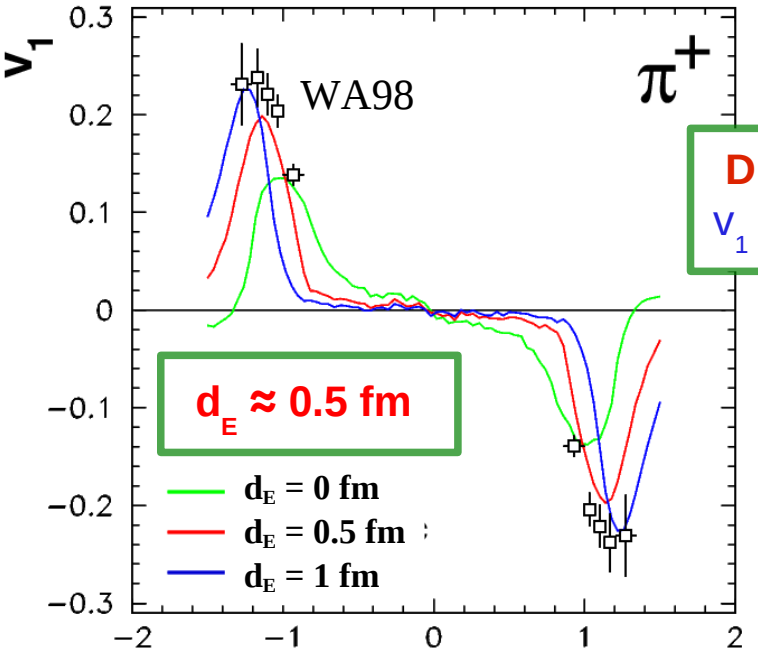
$d_E \approx 0.75$ fm

A. R.,
Acta Phys. Polon.
B42 (2011) 867

$y = y_{beam}$



L. Adamczyk et al.
(STAR Collaboration),
Phys. Rev. Lett. 112, 162301 (2014)



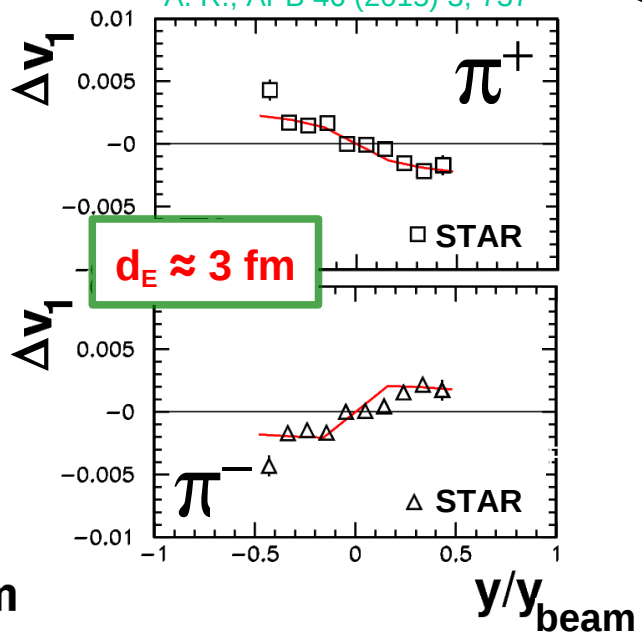
$d_E \approx 0.5$ fm

Directed flow:
$v_1 = \langle \cos(\phi - \Psi_{RP}) \rangle$

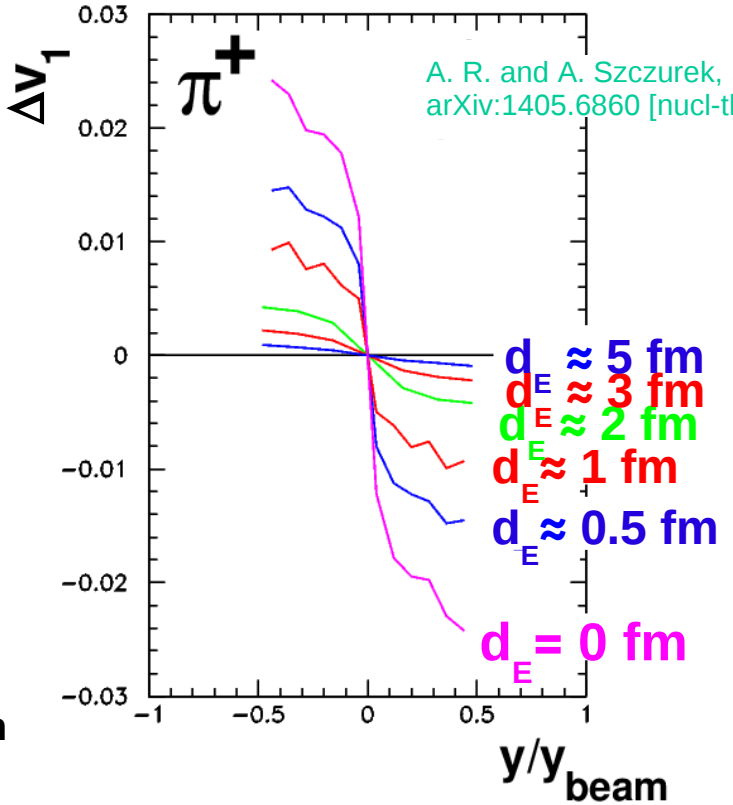
A. R. and A. Szczurek,
Phys. Rev. **C87** (2013)
054909.

H. Schlagheck
(WA98 Collaboration),
Nucl. Phys. A **663** (2000)
725.

A. R., APB 46 (2015) 3, 737



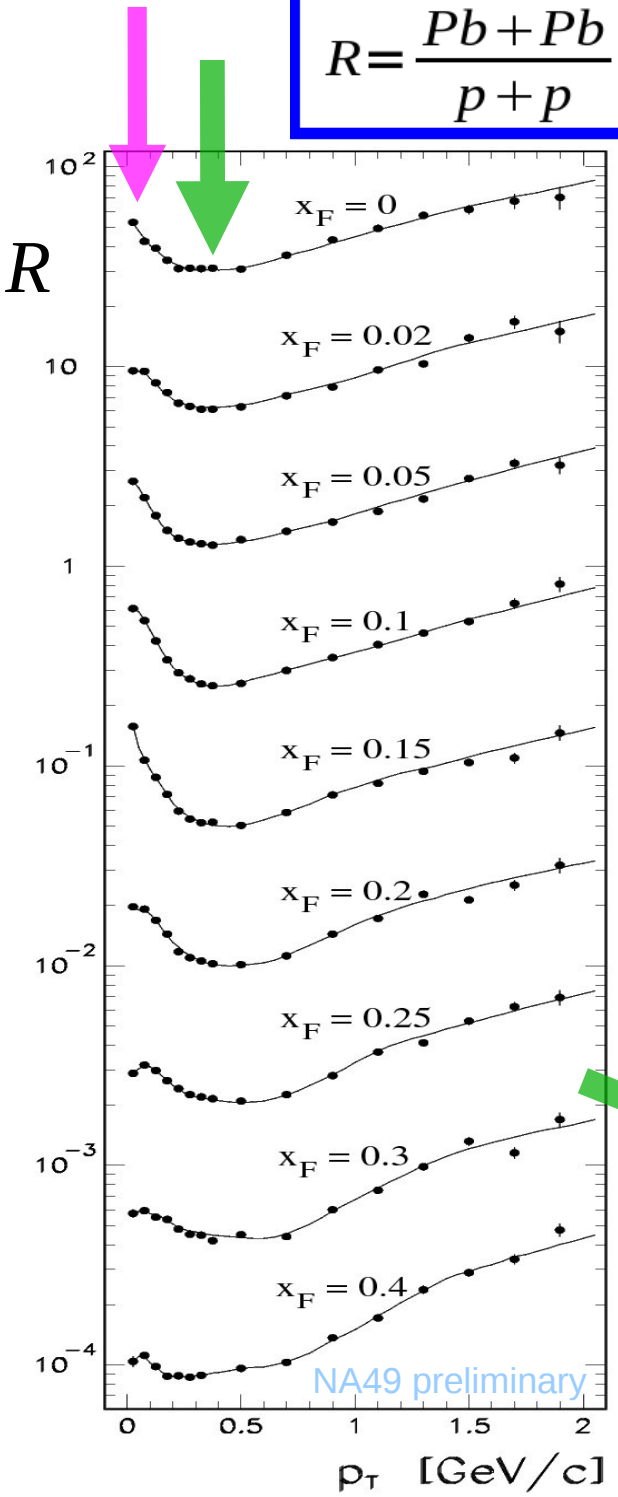
$d_E \approx 3$ fm

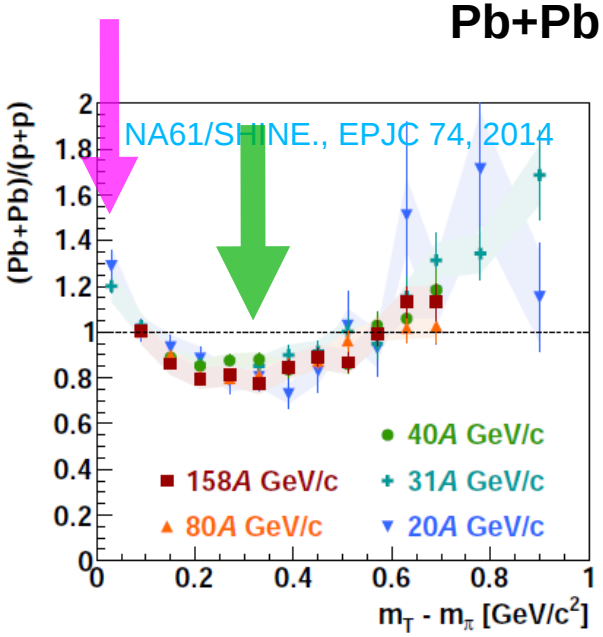


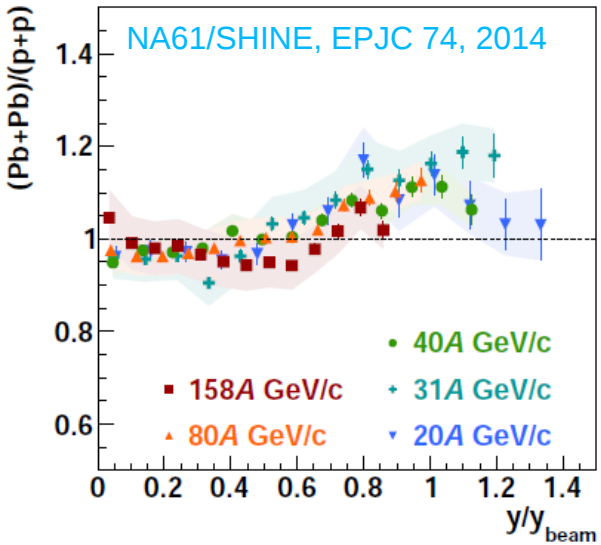
A. R. and A. Szczurek,
arXiv:1405.6860 [nucl-th].

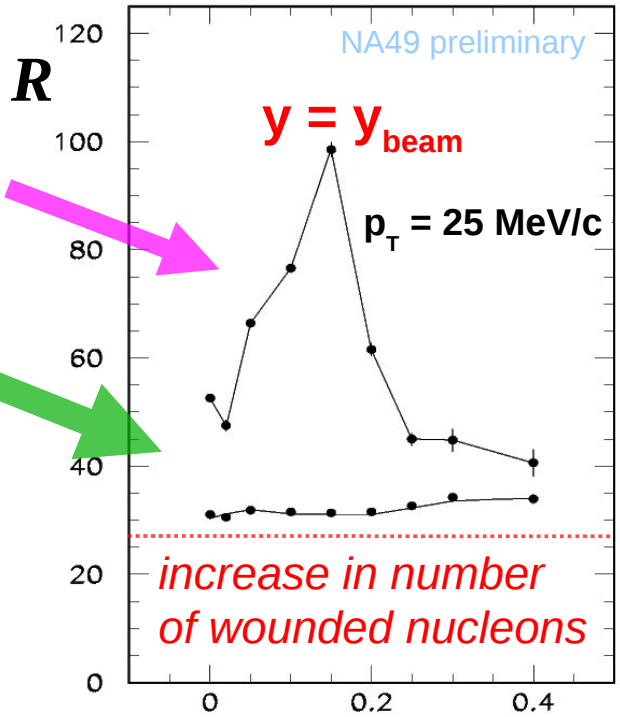
$$R = \frac{Pb+Pb}{p+p}$$

- NA49: $(\pi^+ + \pi^-)/2$; **Pb+Pb peripheral.**
- NA61/SHINE: π^- only; **Pb+Pb CENTRAL.**



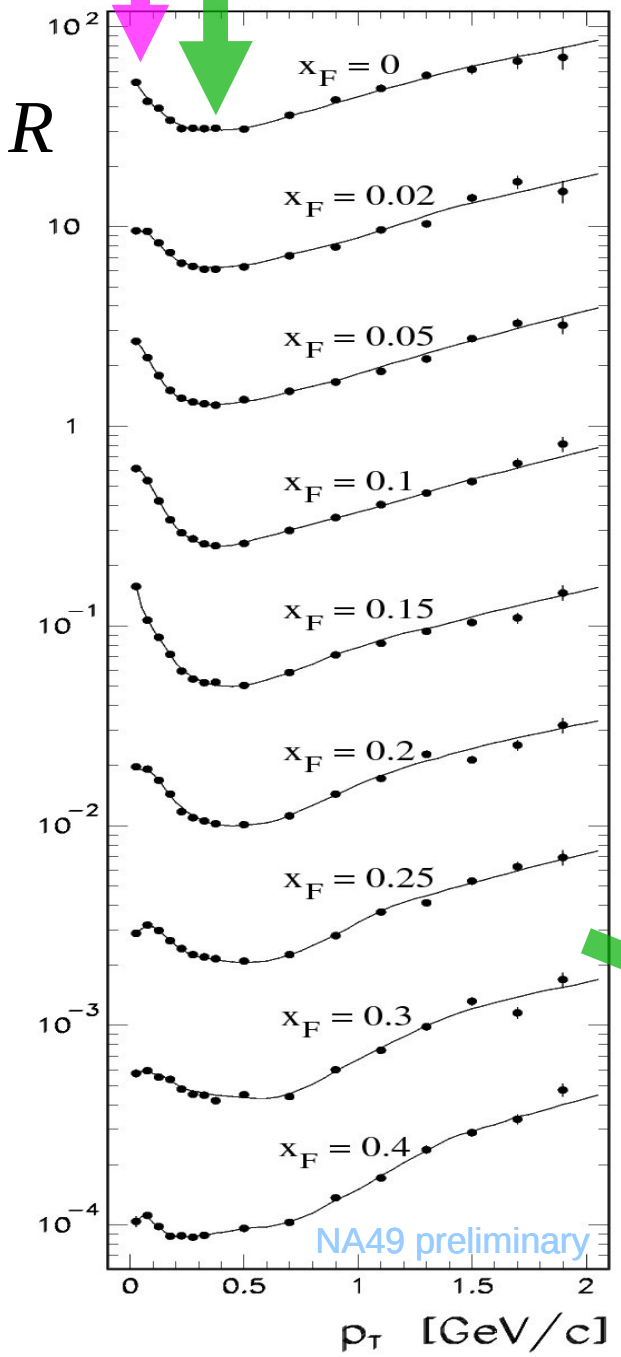


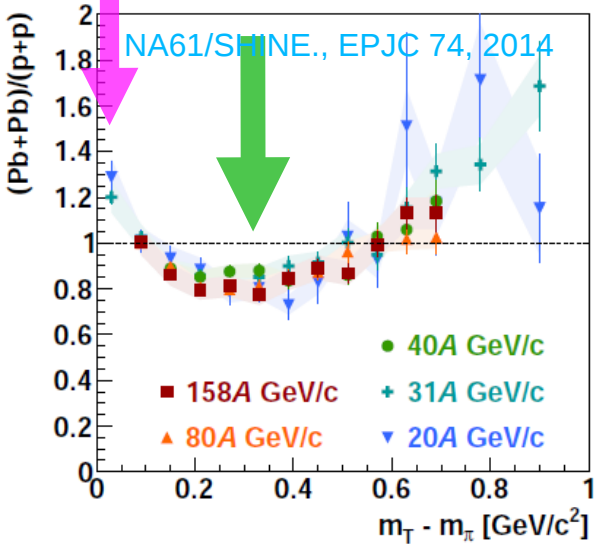


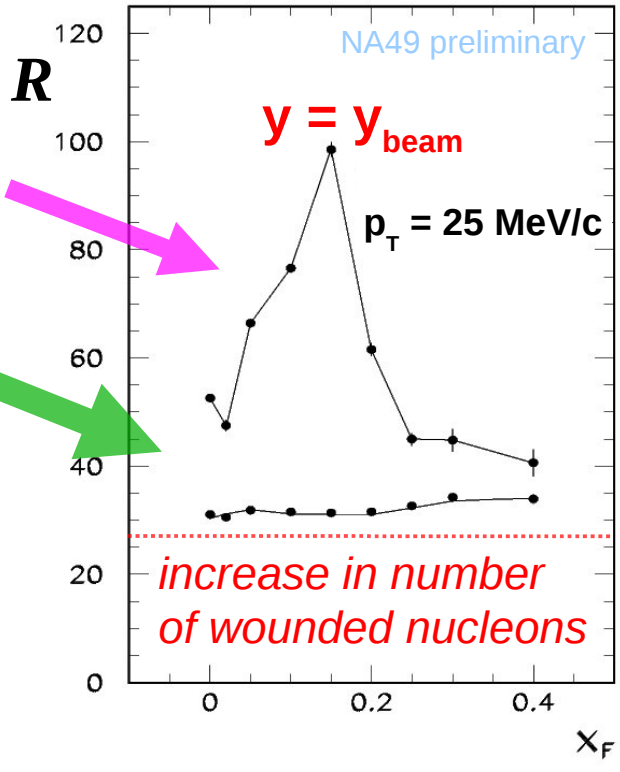


$$R = \frac{Pb+Pb}{p+p}$$

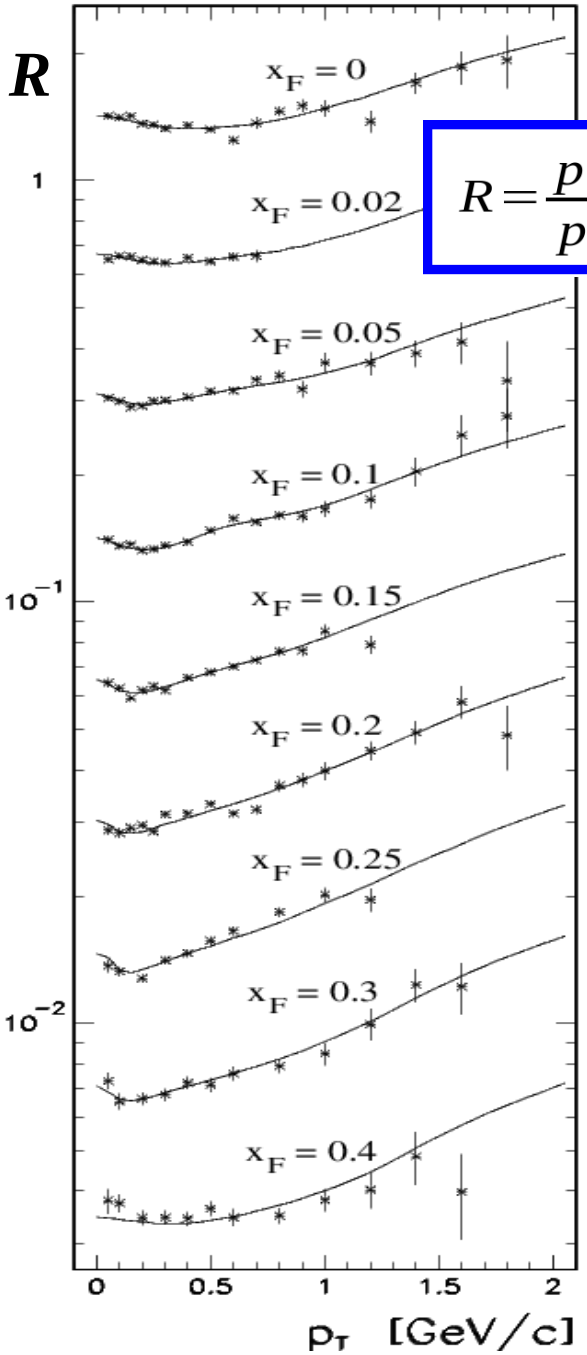
- NA49: $(\pi^+ + \pi^-)/2$; **Pb+Pb peripheral.**
- NA61/SHINE: π^- only; **Pb+Pb CENTRAL.**





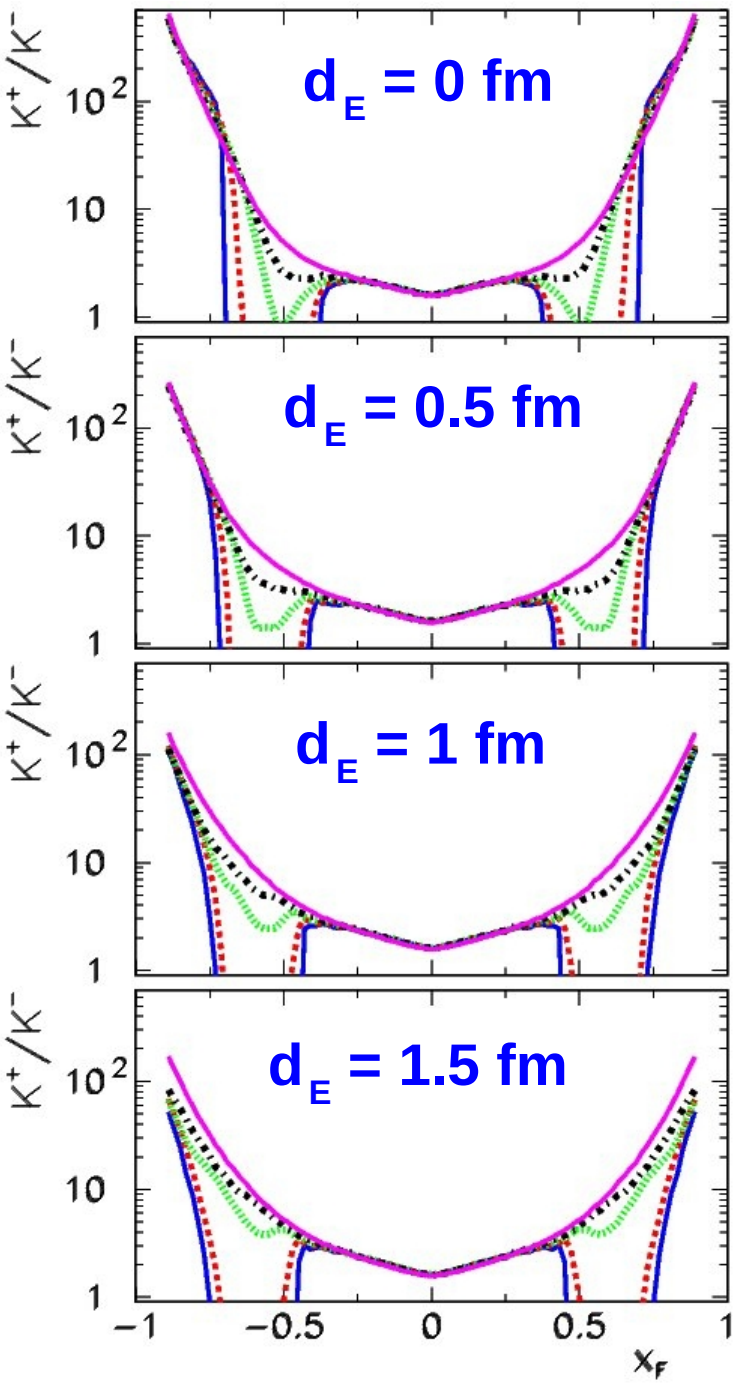


$$R = \frac{p+C}{p+p}$$

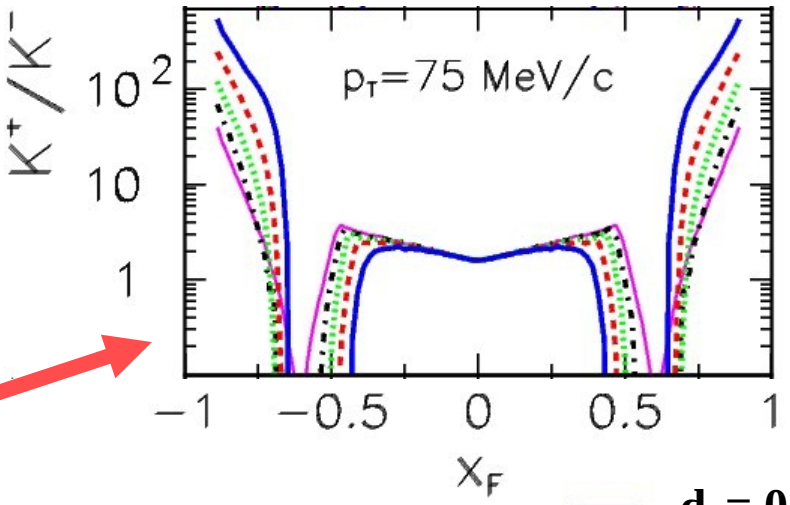


Based on: C. Alt et al., EPJC 49, 2007

A.R., Acta Phys. Pol. B42, 2011



Acta Phys.Polon.Supp. 5, 2012



d_E = 0 fm
d_E = 0.5 fm
d_E = 1 fm
d_E = 1.5 fm
d_E = 2 fm

p_T =
25 MeV/c
75 MeV/c
125 MeV/c
175 MeV/c
325 MeV/c

- Large effect above x_F=0.5.
- Dependence on initial conditions.
- **Very high x_F**