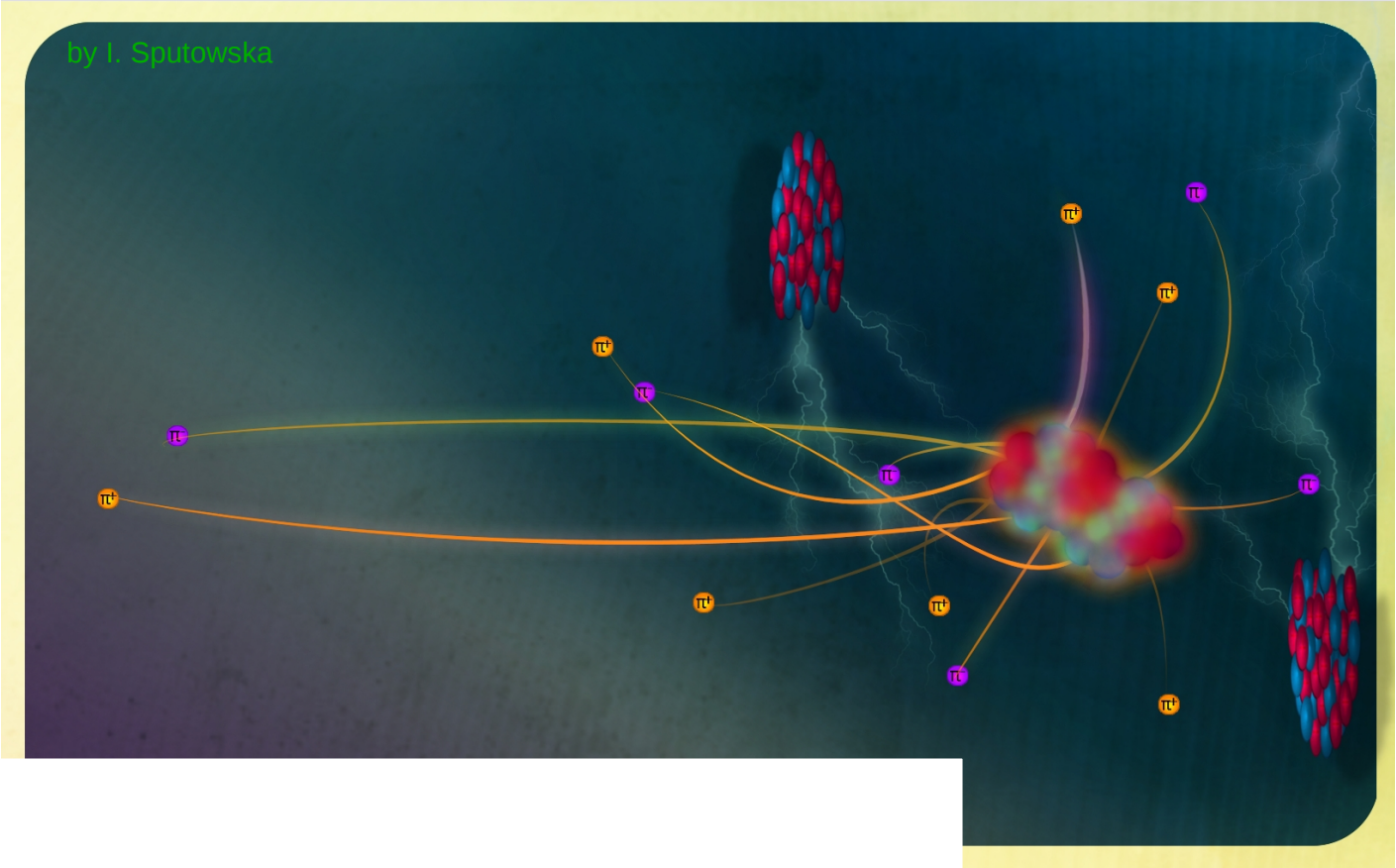
Can we obtain a “new femtoscopy” on the basis of electromagnetic effects ?

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

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

work in collaboration with
Antoni Szczurek

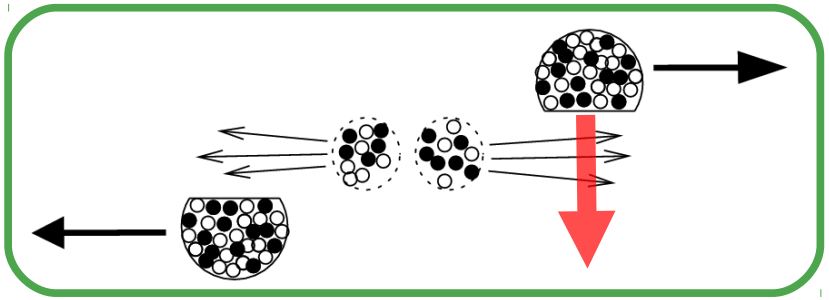
1) Introduction



- 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 hope this information to be (reasonably) model-independent?

2) EM effects

NA49, 158 A GeV/c

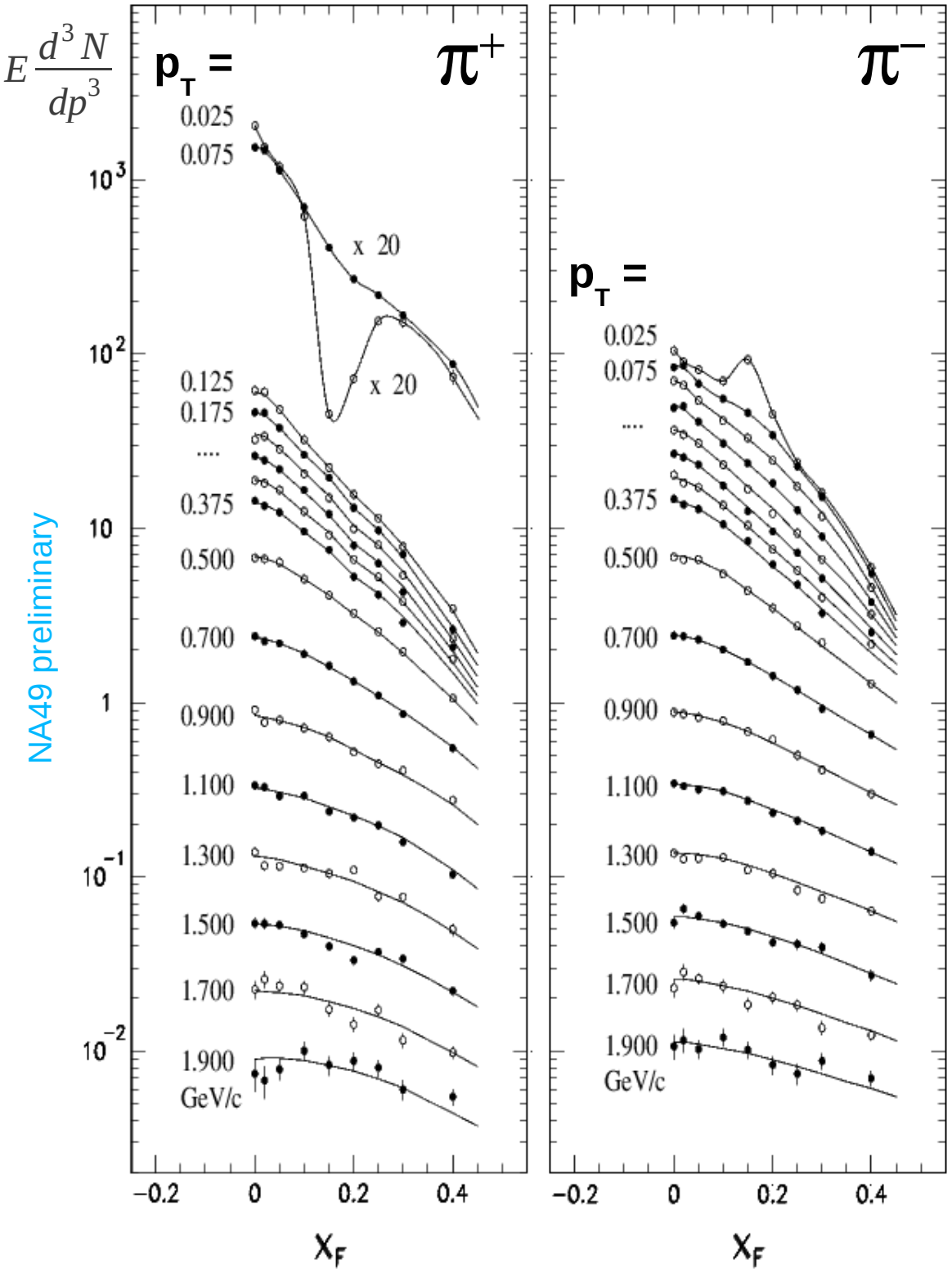


Repulsion (for π^+)
Attraction (for π^-)

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

(c.m.s.)

Pb+Pb, peripheral



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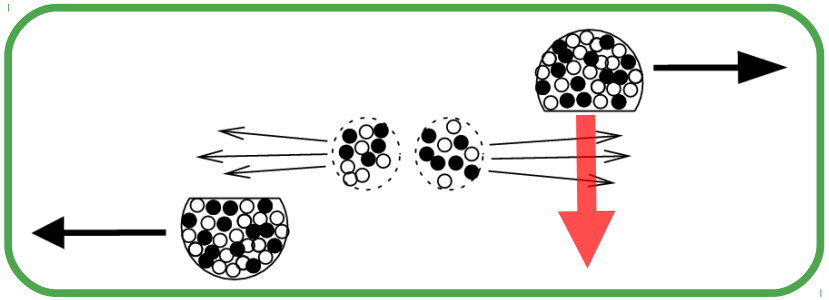

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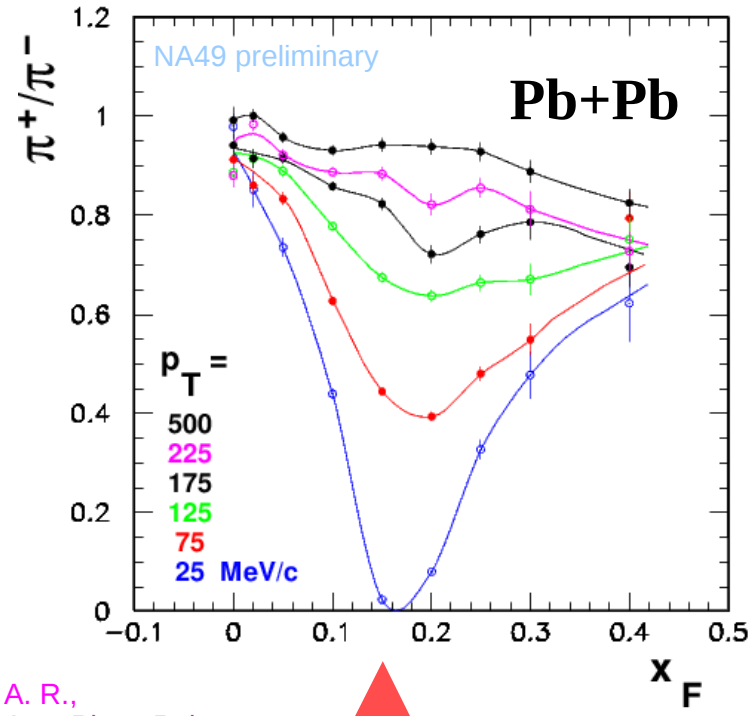

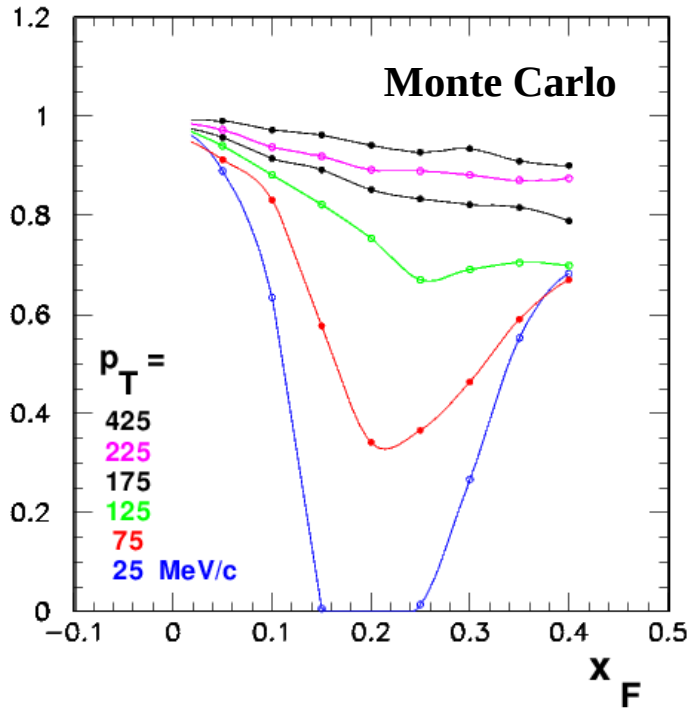

A. R.,
Acta Phys. Polon.
B42 (2011) 867

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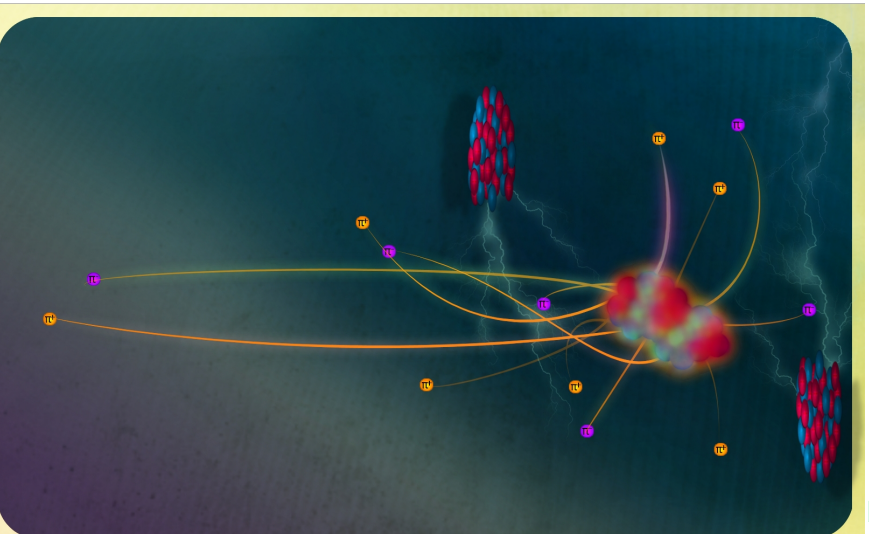
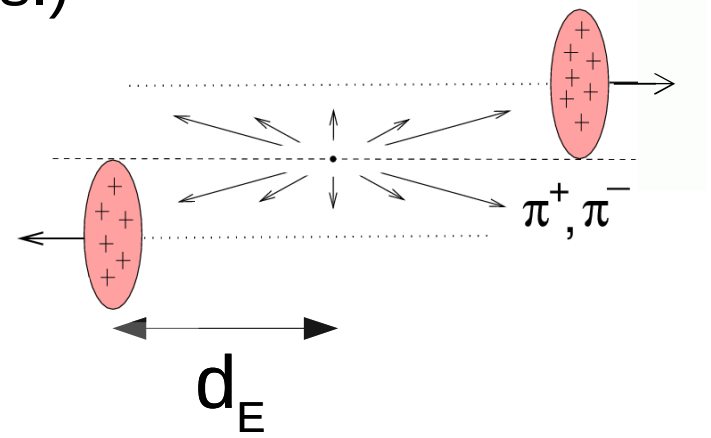
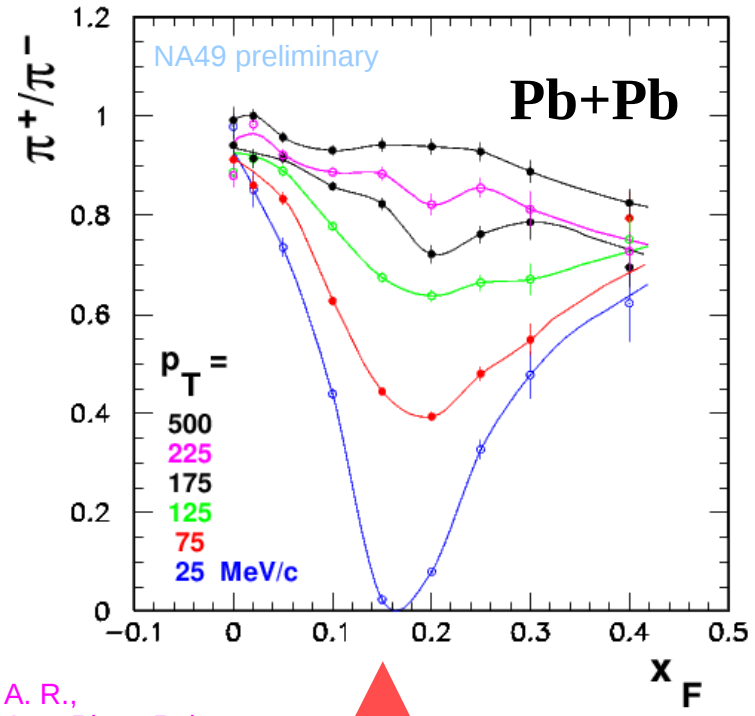
(c.m.s.)

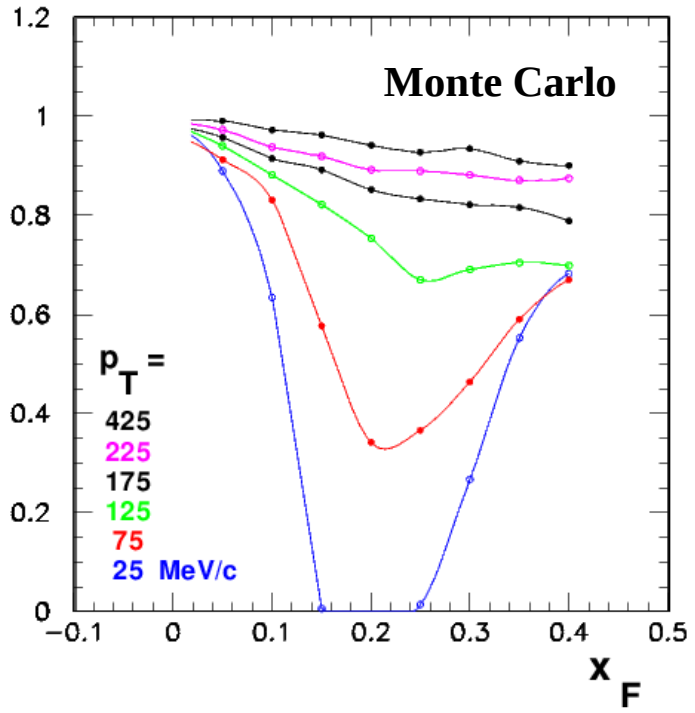
$d_E \approx 0.75$ fm !





by I. Sputowska





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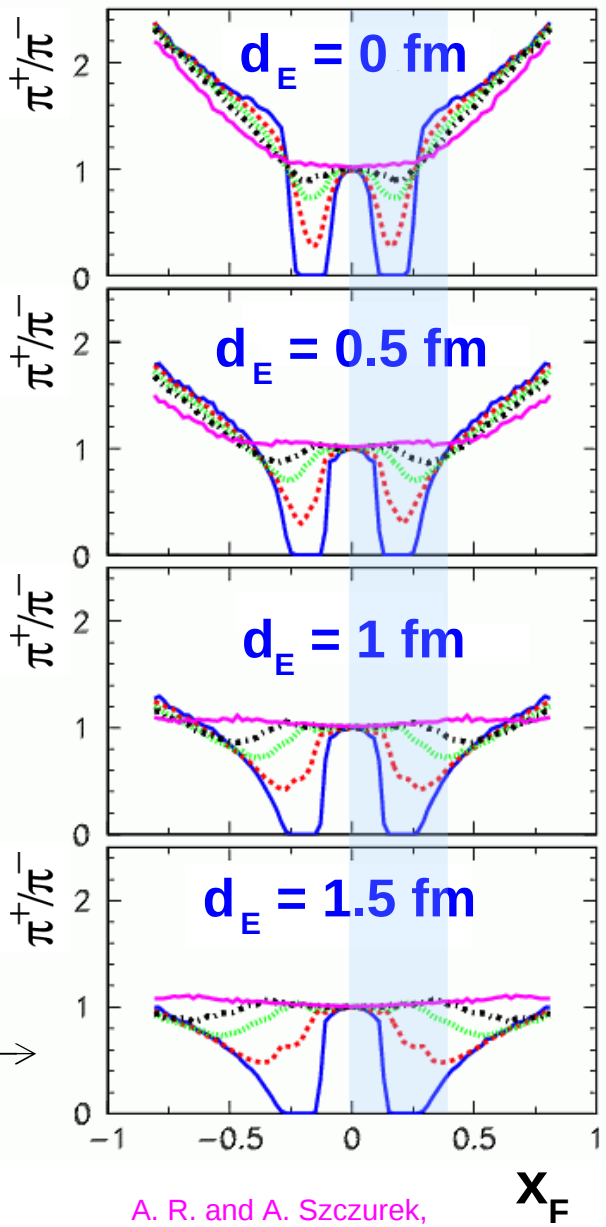
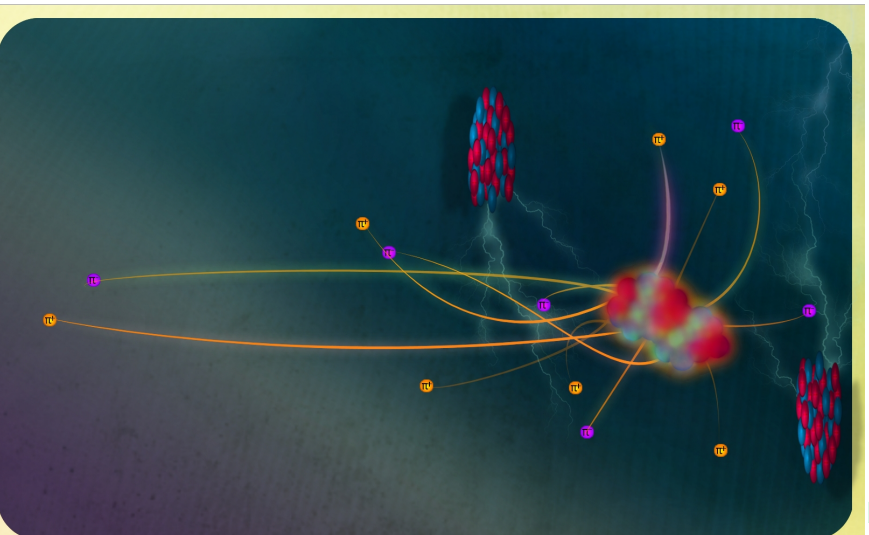
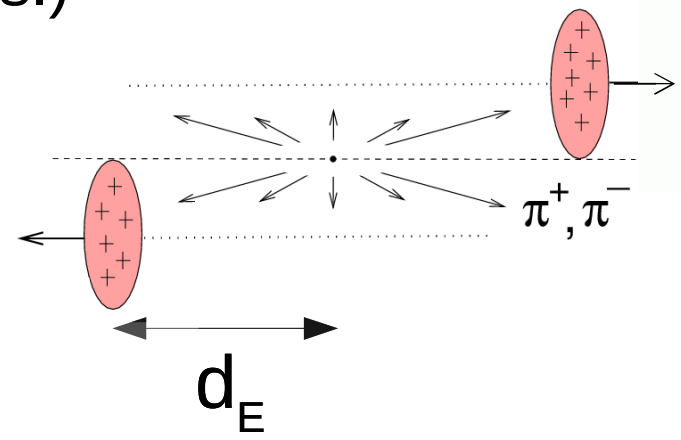


A. R. and A. Szczurek,
Phys. Rev. **C75** (2007)
054903





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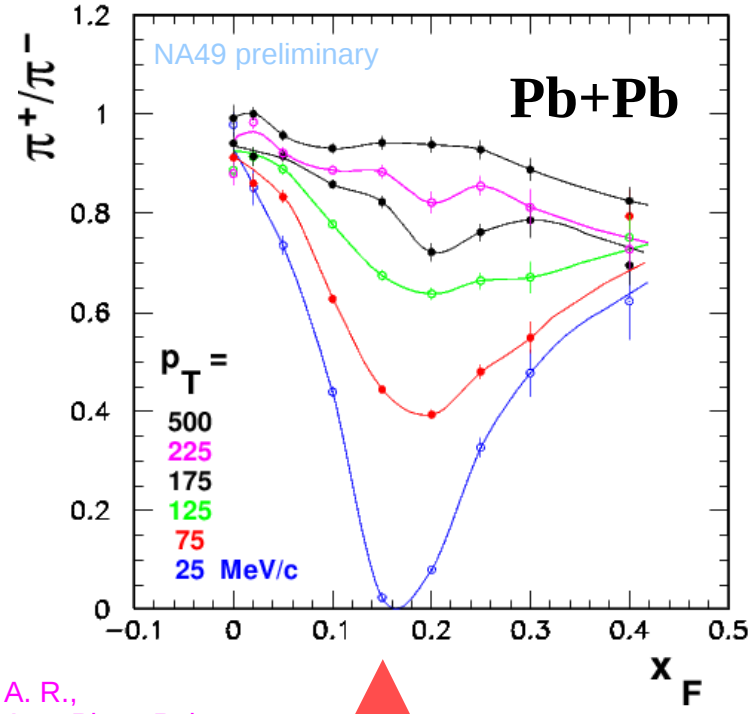

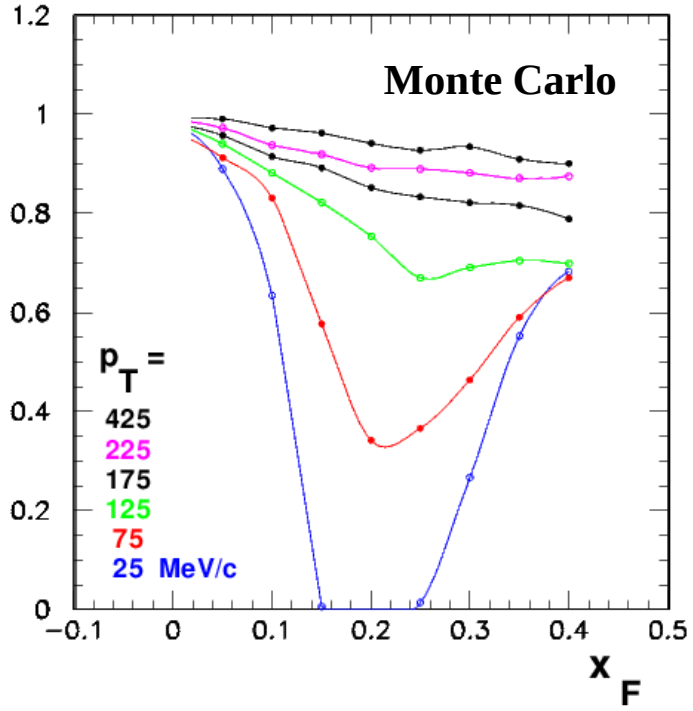

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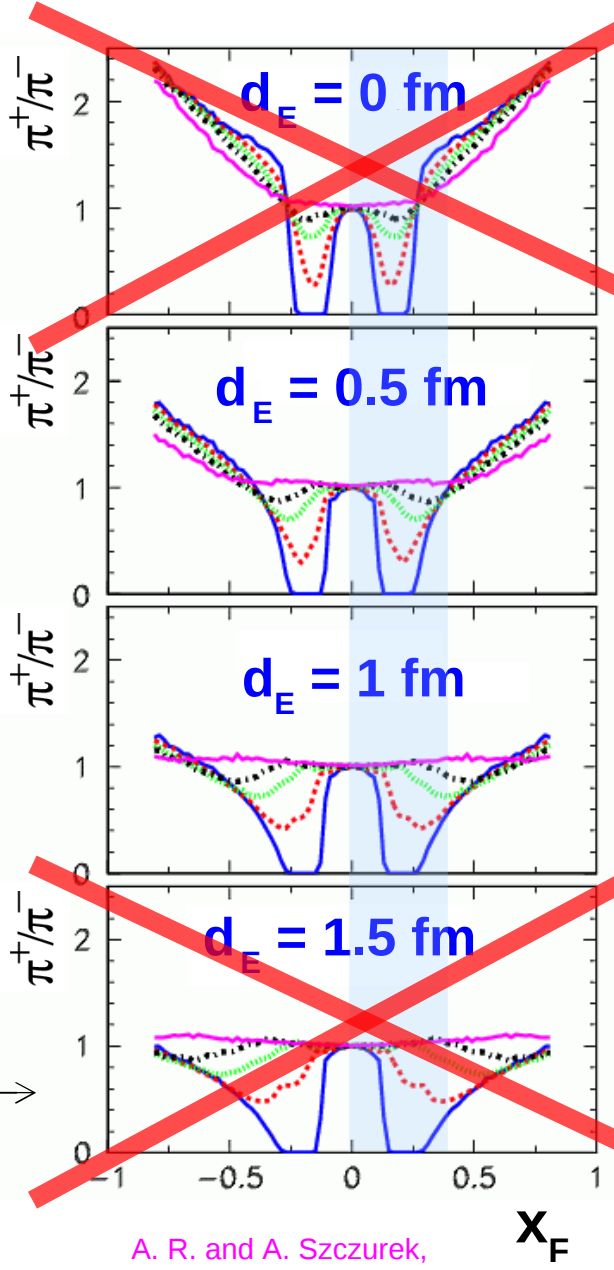

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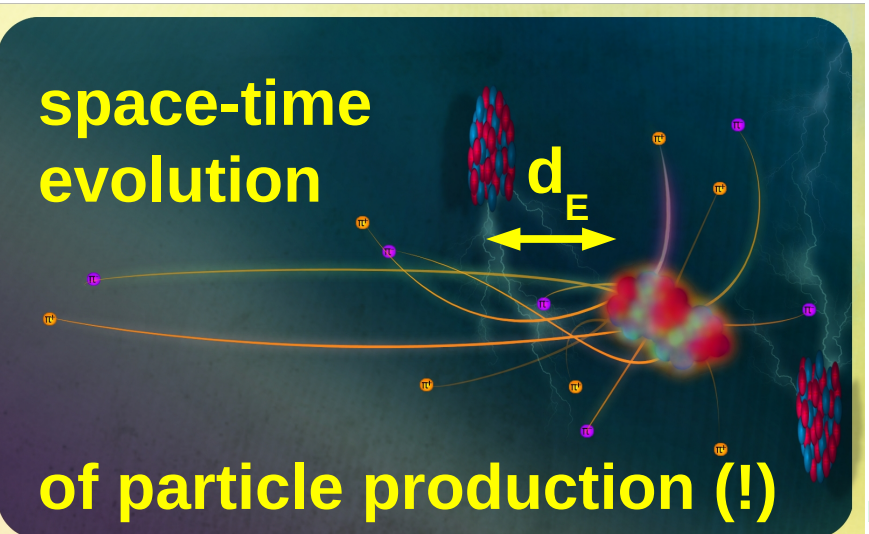

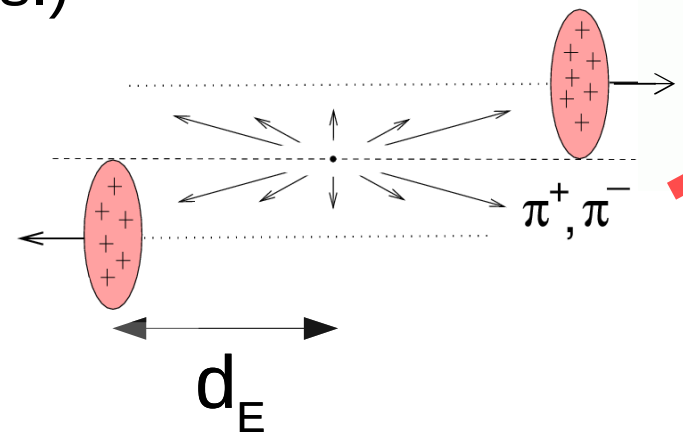

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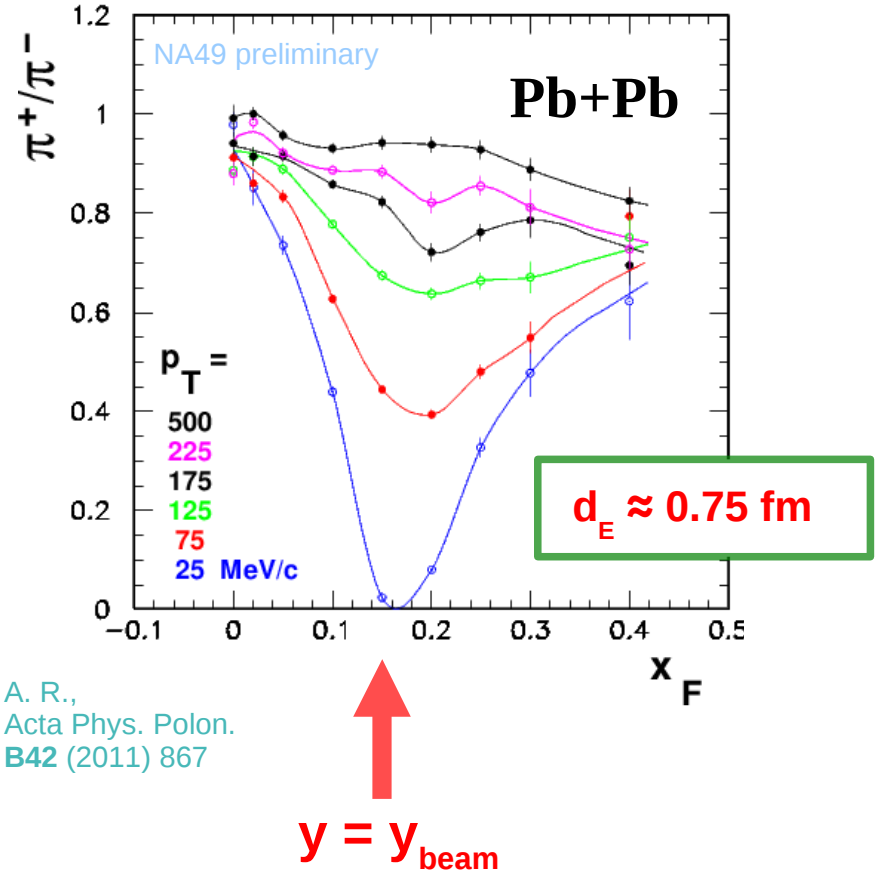

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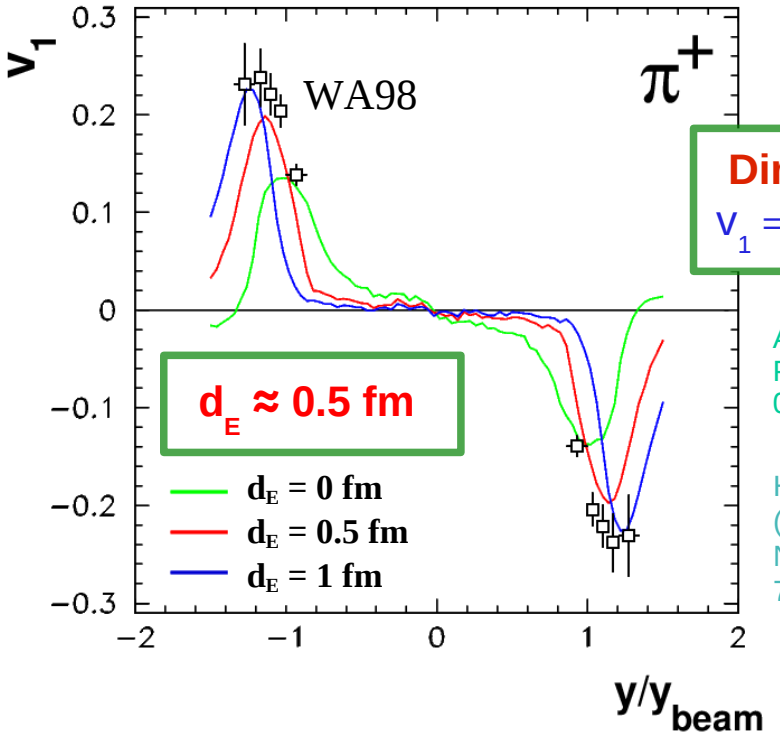

Directed flow:
$v_1 = \langle \cos(\phi - \Psi_{RP}) \rangle$

A. R. and A. Szczurek,
Phys. Rev. **C87** (2013)
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H. Schlagheck
(WA98 Collaboration),
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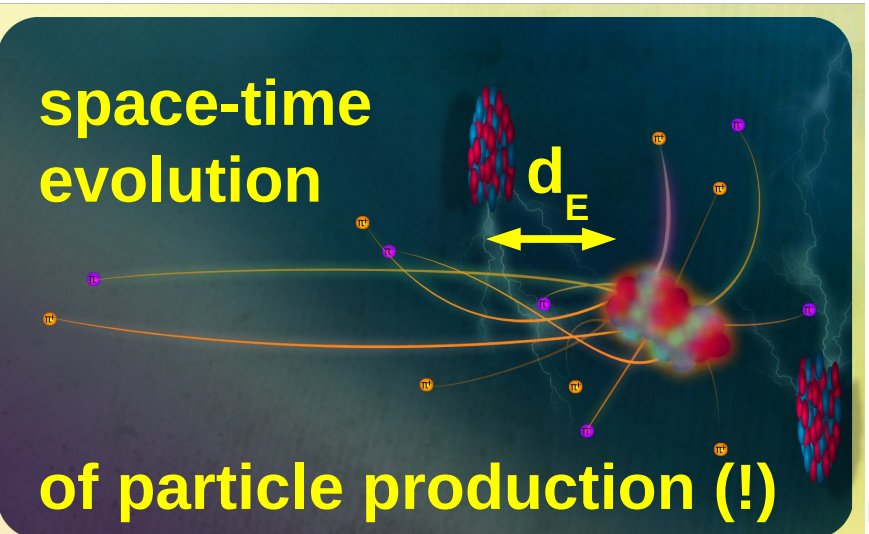

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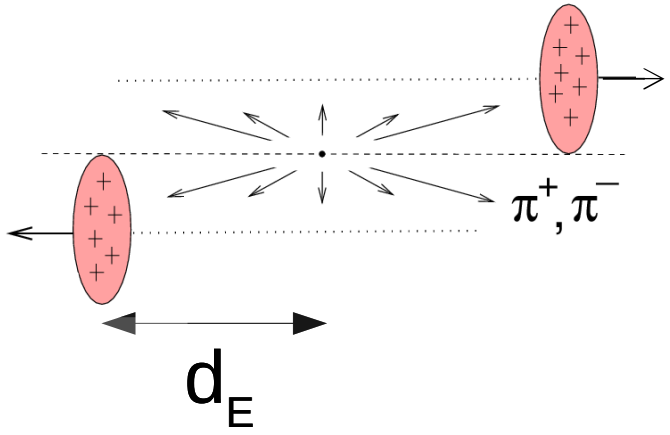

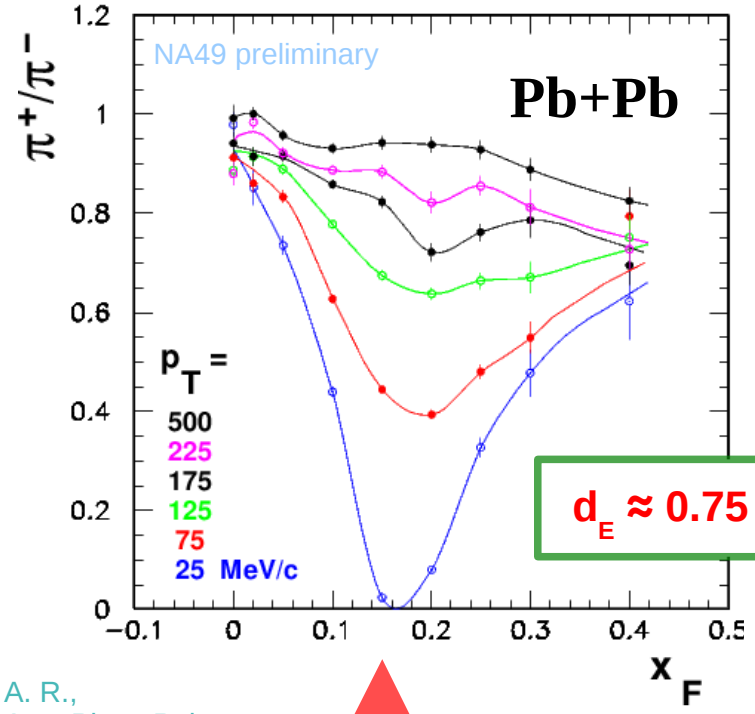

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Acta Phys. Polon.
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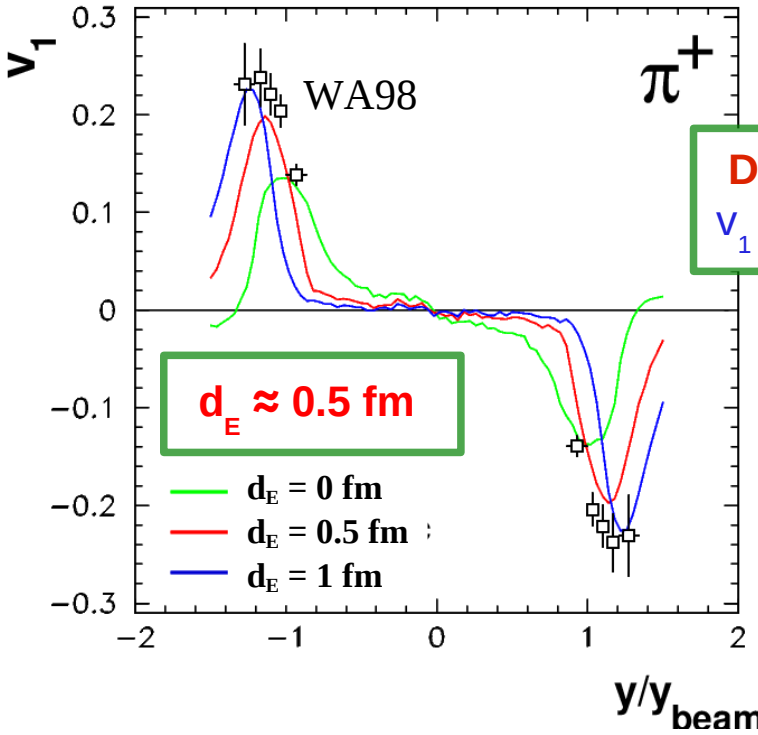

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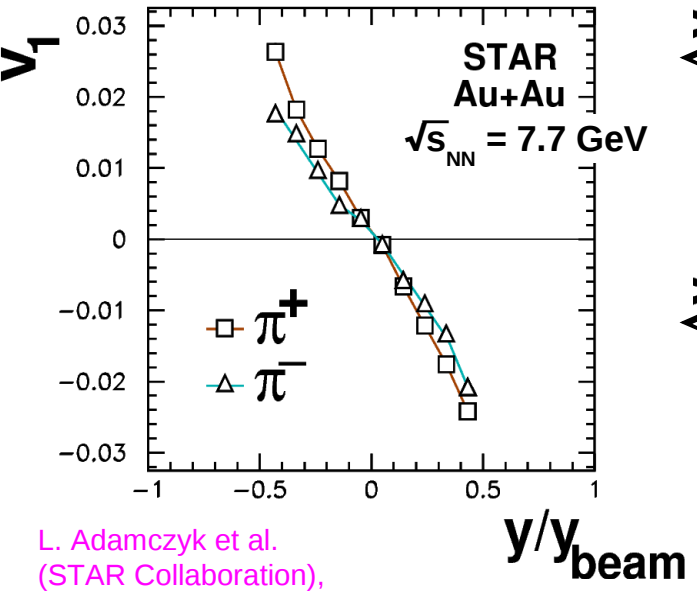
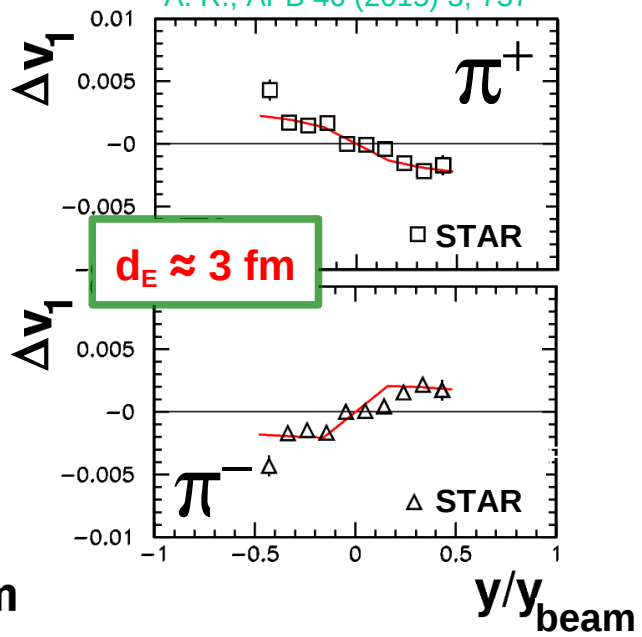
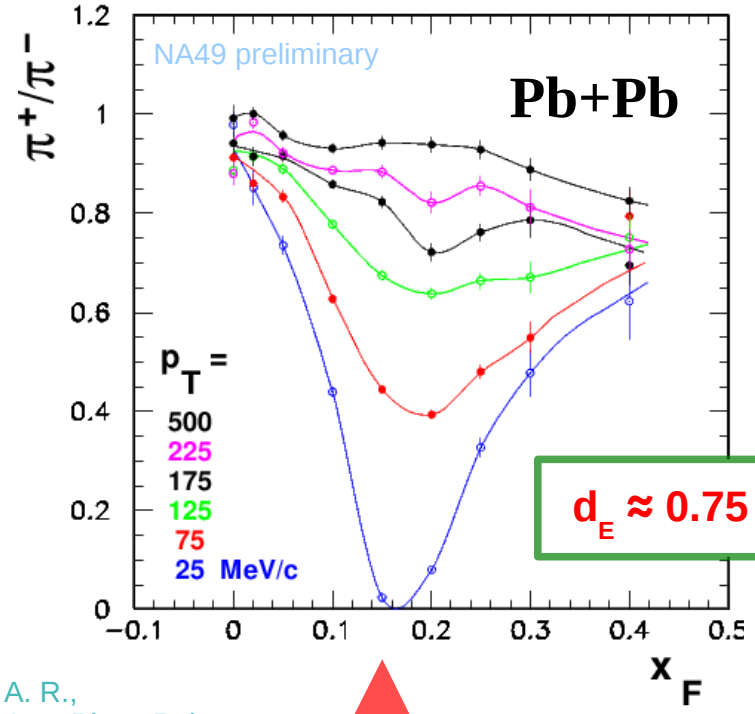


L. Adamczyk et al.
(STAR Collaboration),
Phys. Rev. Lett. 112, 162301 (2014)

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



$d_E \approx 3$ fm



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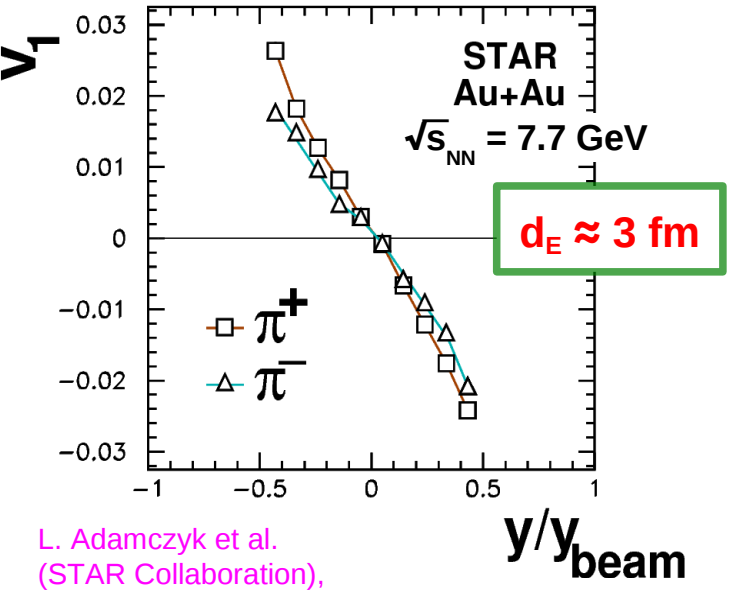

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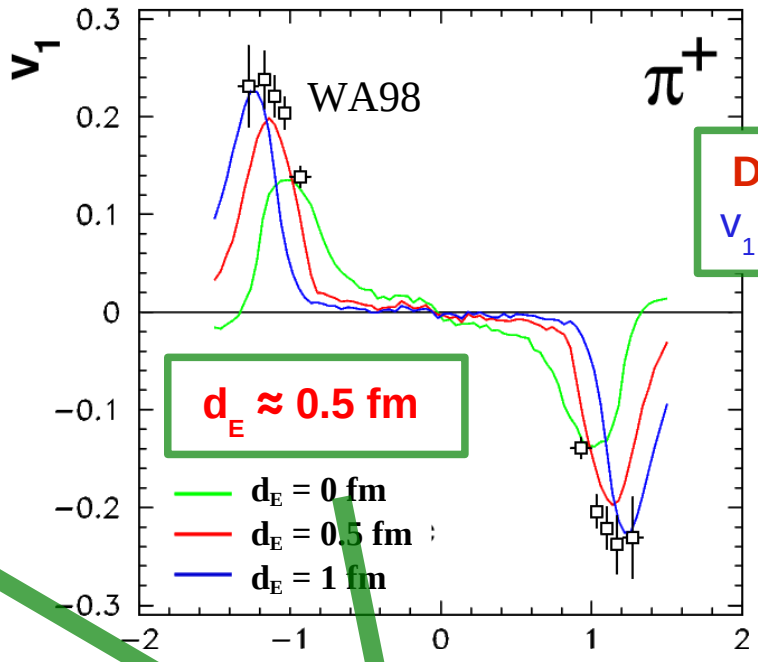

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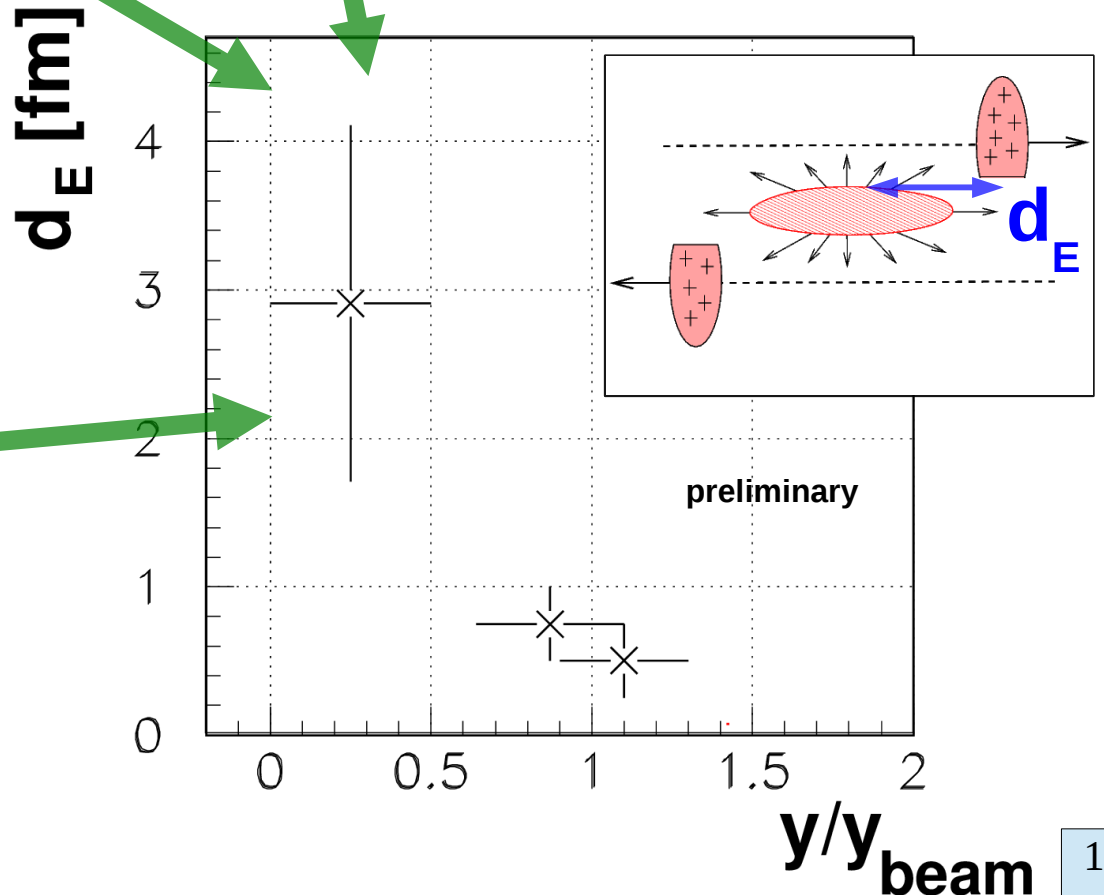
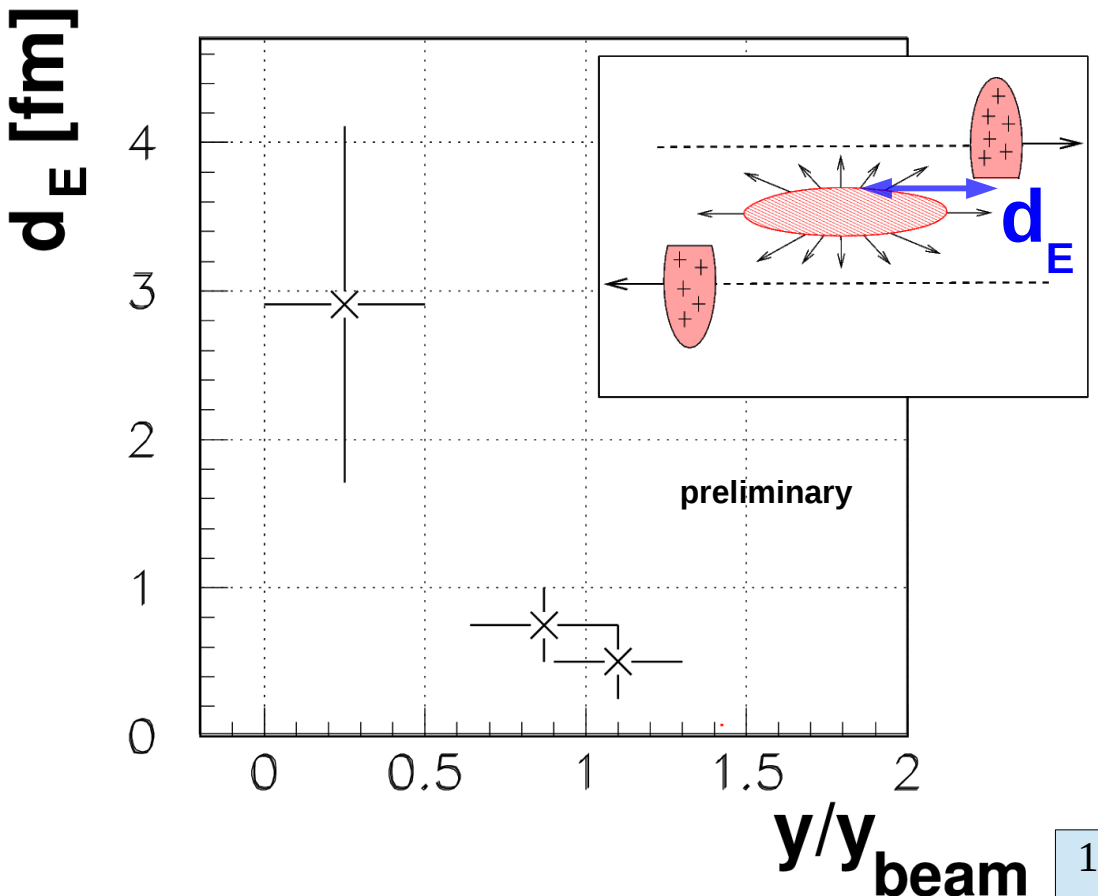


3) Space-time evolution of the system ...



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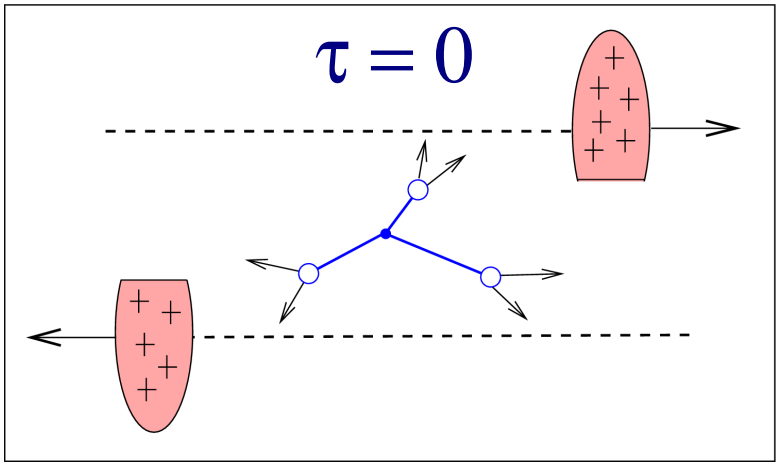
many thanks to
K. Redlich M. Różańska
L. Leśniak H.G. Fischer

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:

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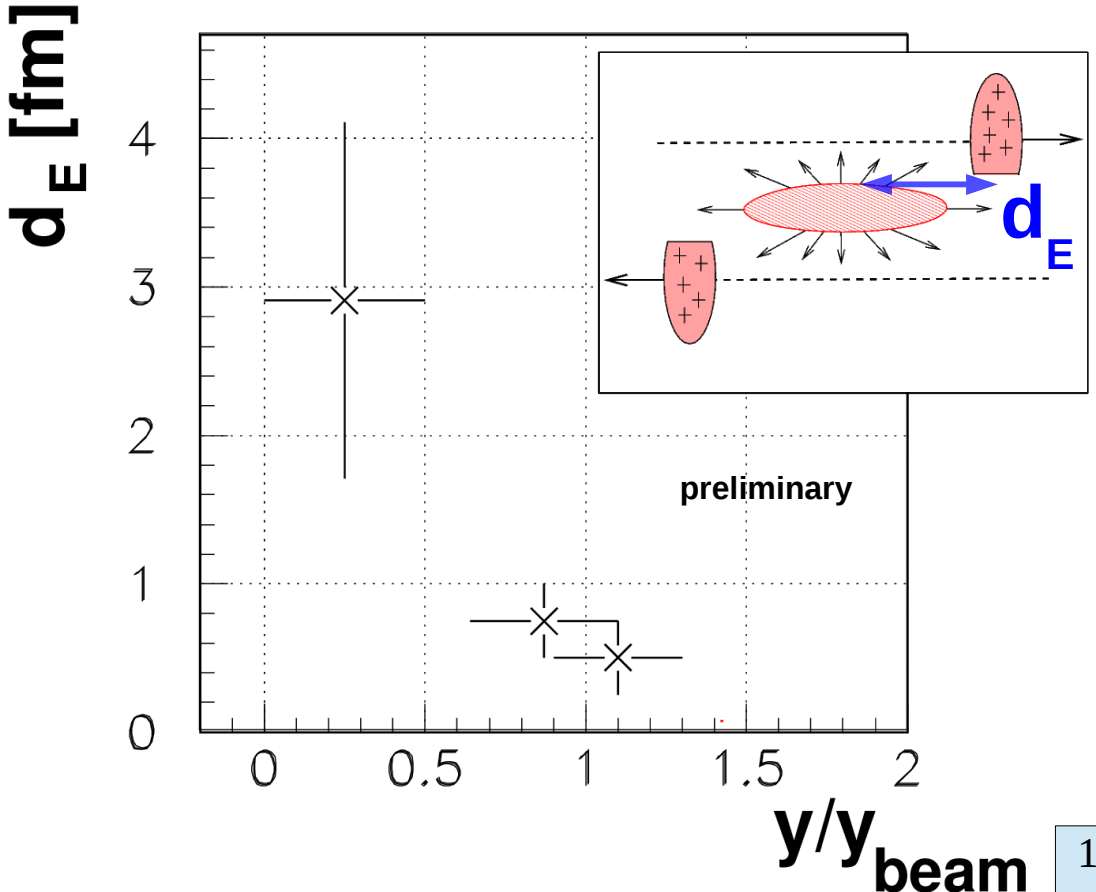

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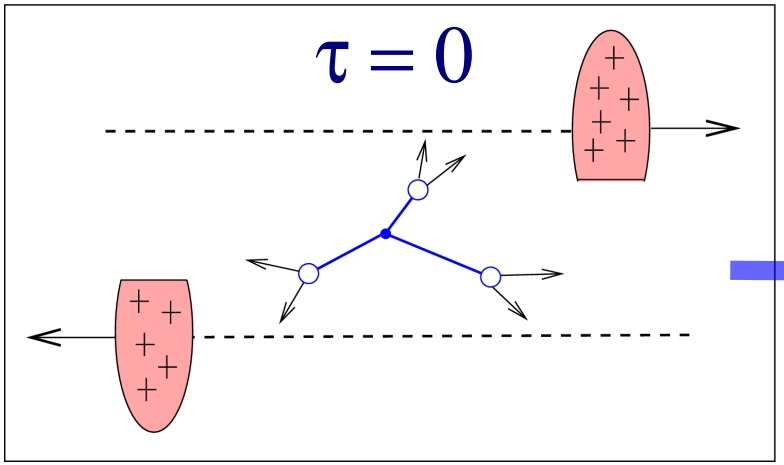

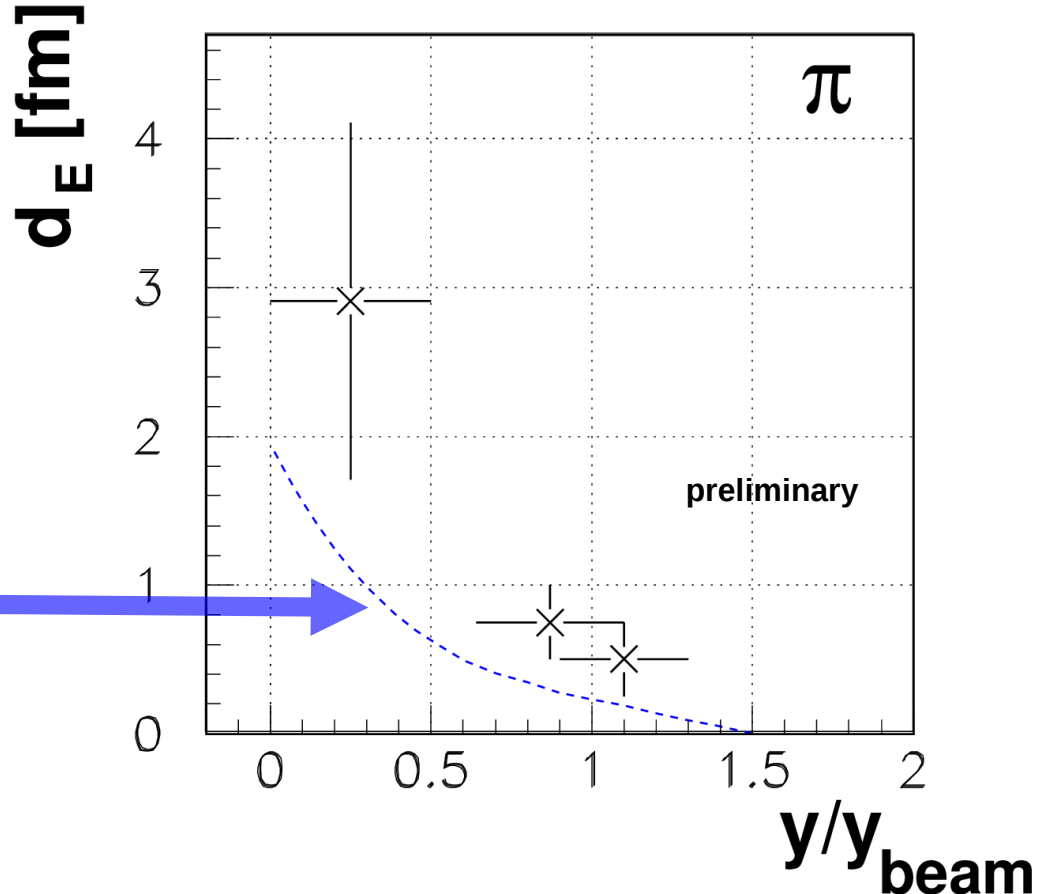

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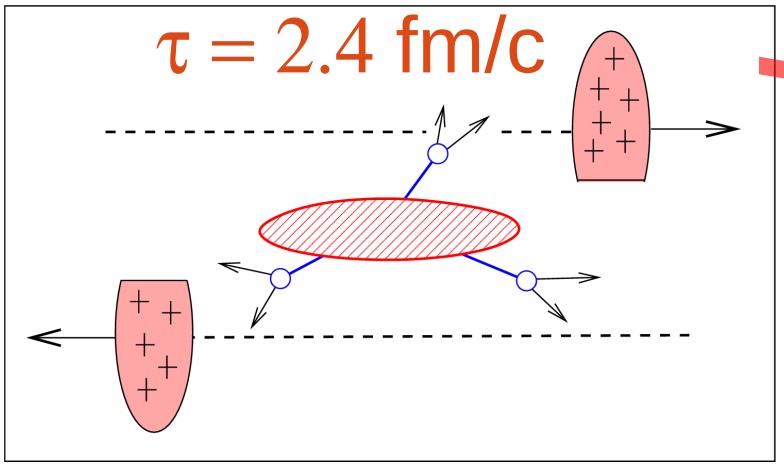

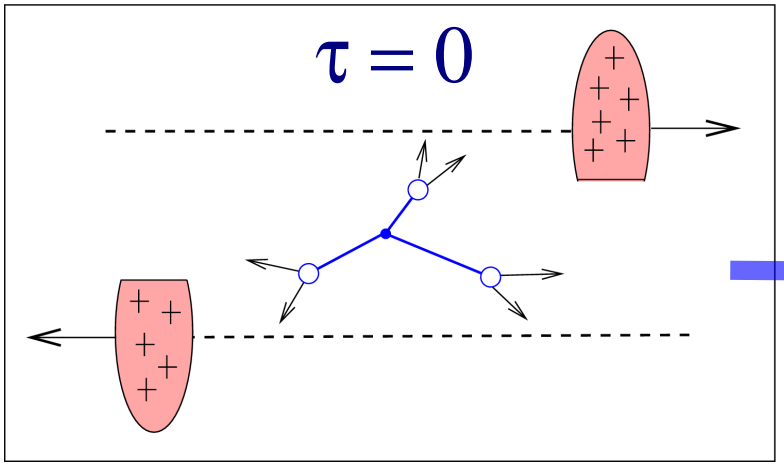

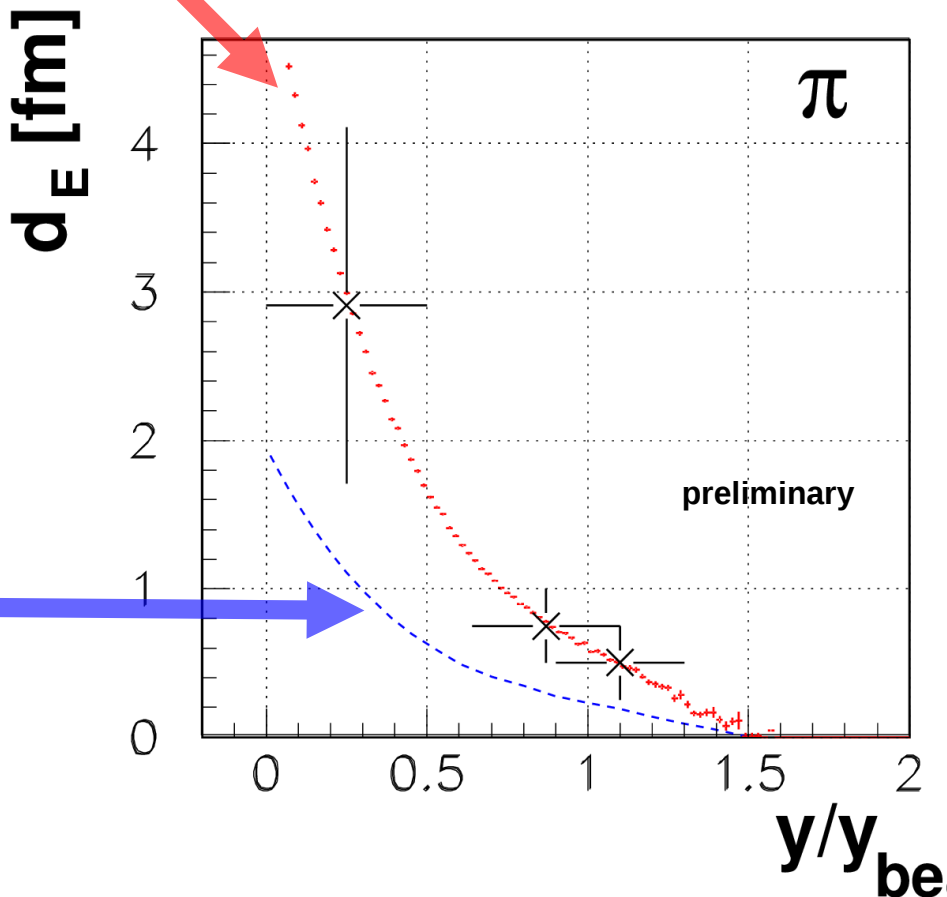

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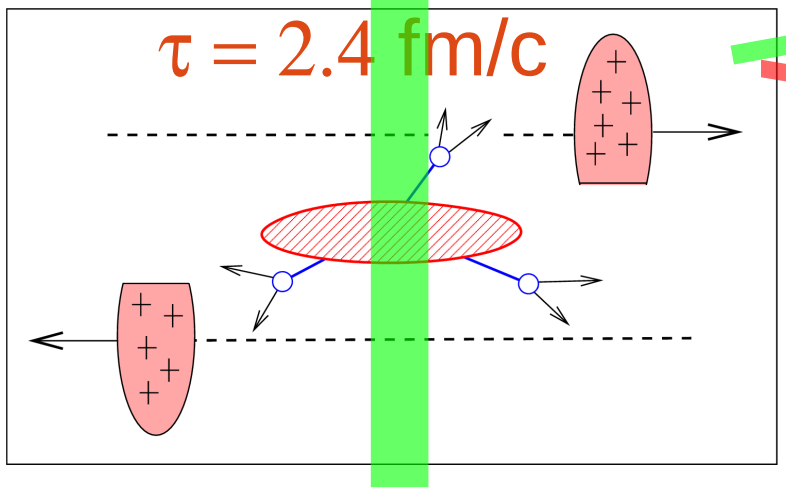
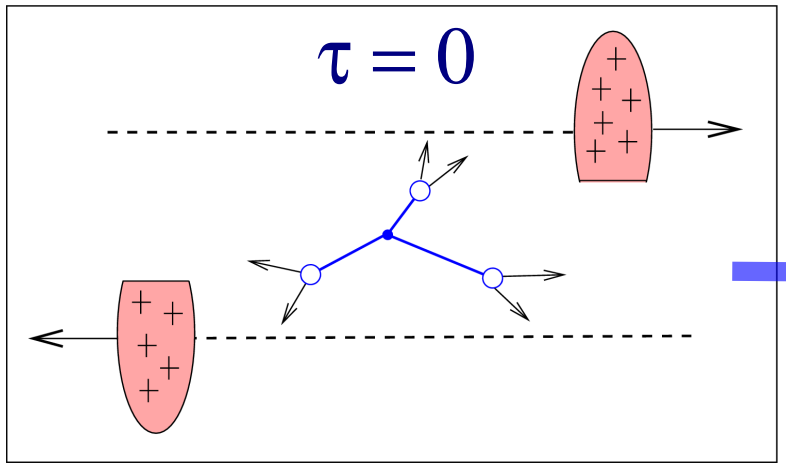
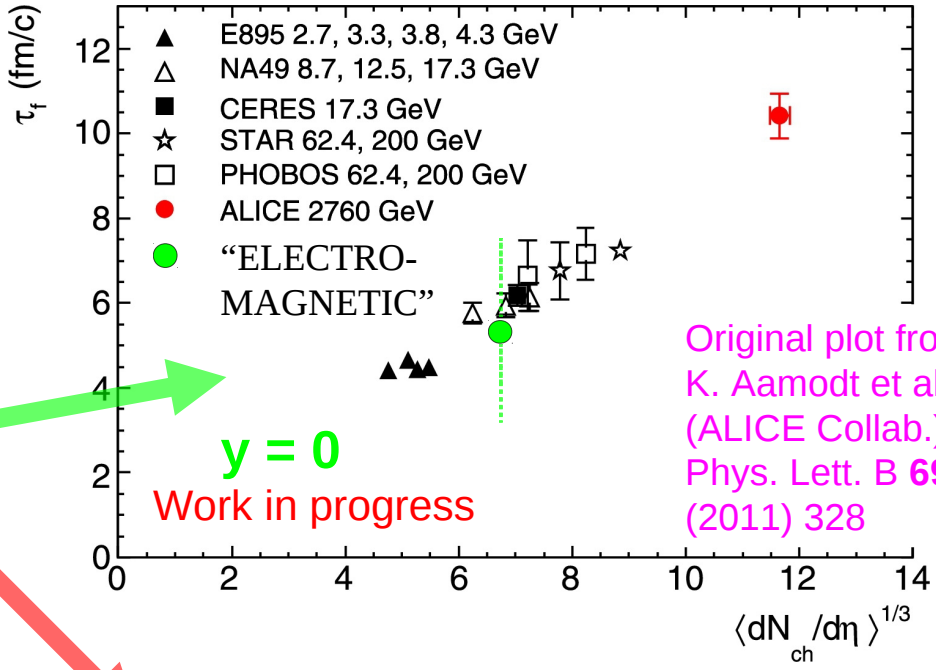
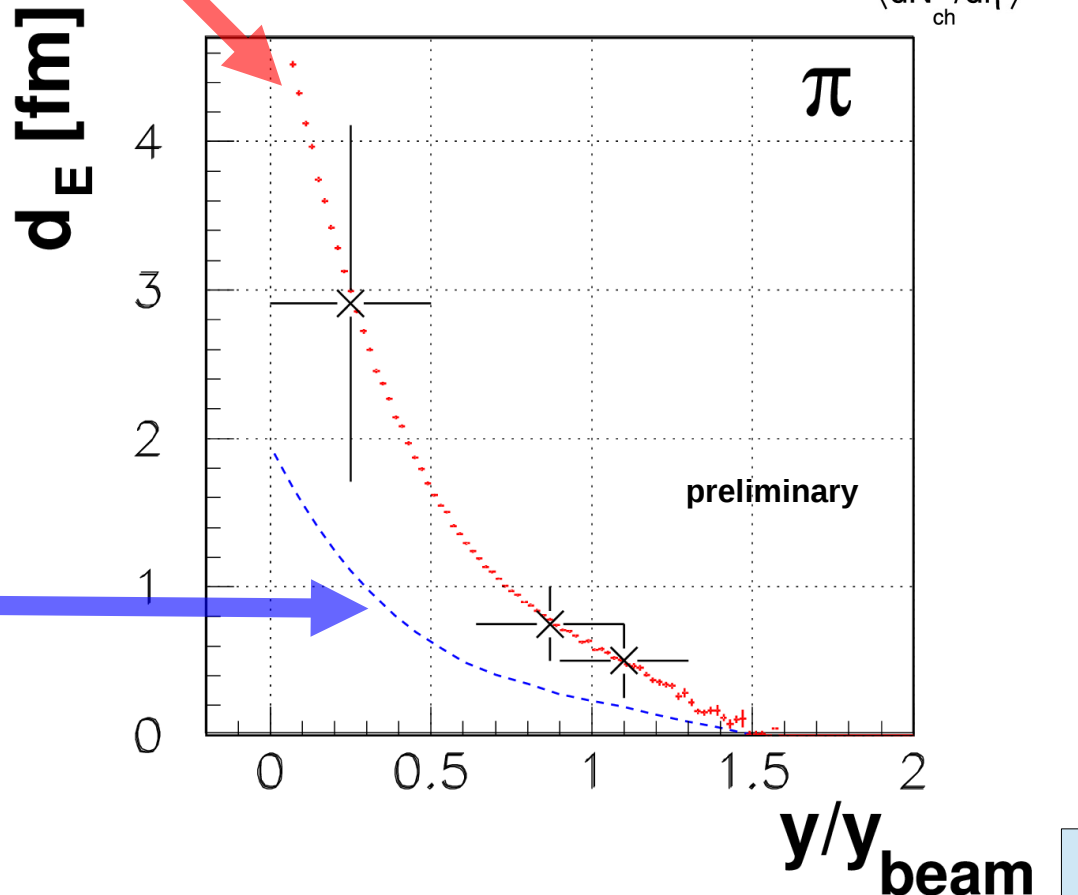






Original plot from: K. Aamodt et al. (ALICE Collab.), Phys. Lett. B **696** (2011) 328



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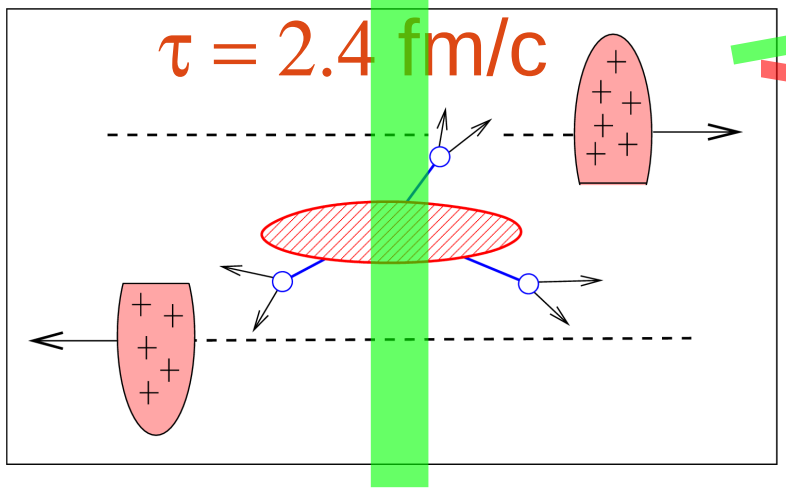

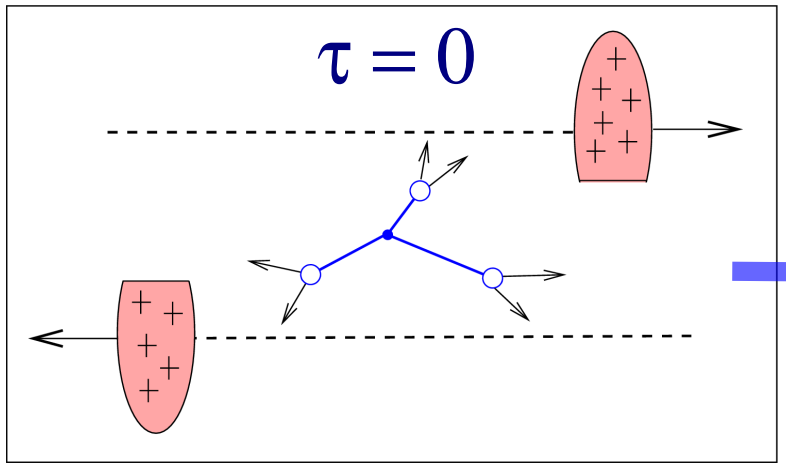

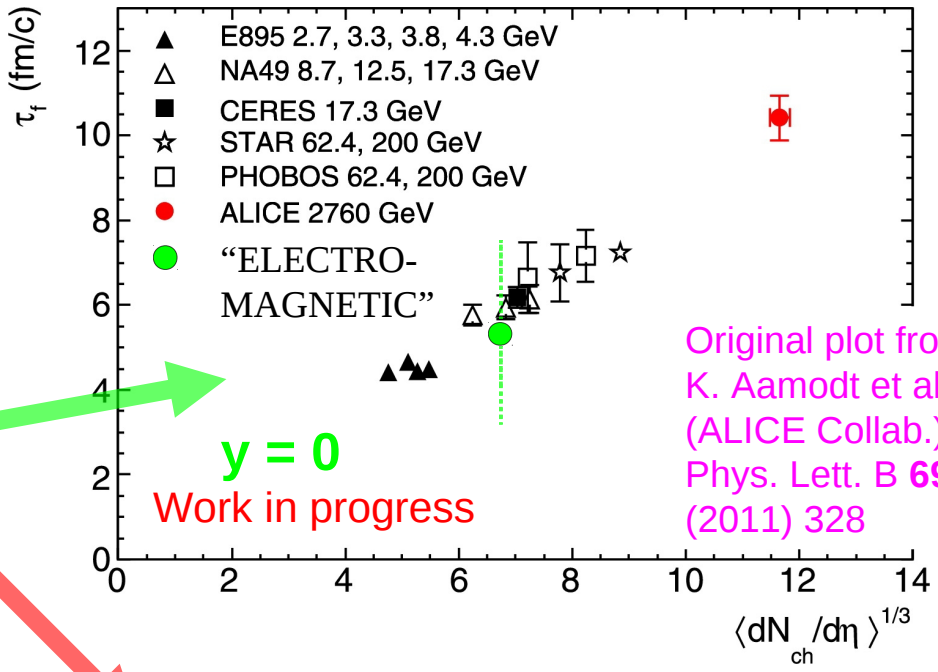

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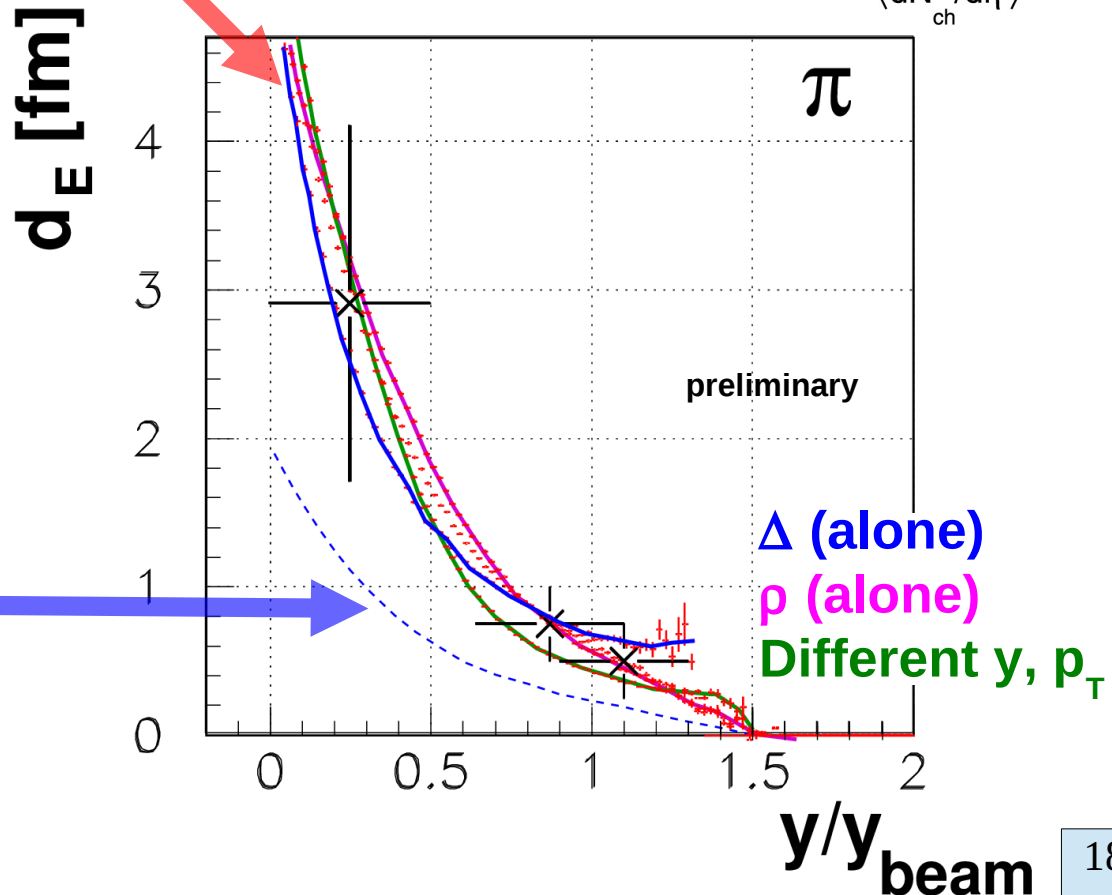

Δ (alone)
ρ (alone)
Different y, p_T

3) Summary & outlook

The presence of EM fields in the heavy ion collision results in charge-dependent effects on various observables.

These effects 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.

Plan (2015-2020): / group under construction /

1. to get more data on these effects
   (NA61/SHINE, SPSC-P-330-ADD-8, NICA, EPJA vol. 52 (2016)) ;
2. to provide a more realistic phenomenological description ;
3. to clarify the situation at LHC ;

Help, advice and discussion are more than welcome.

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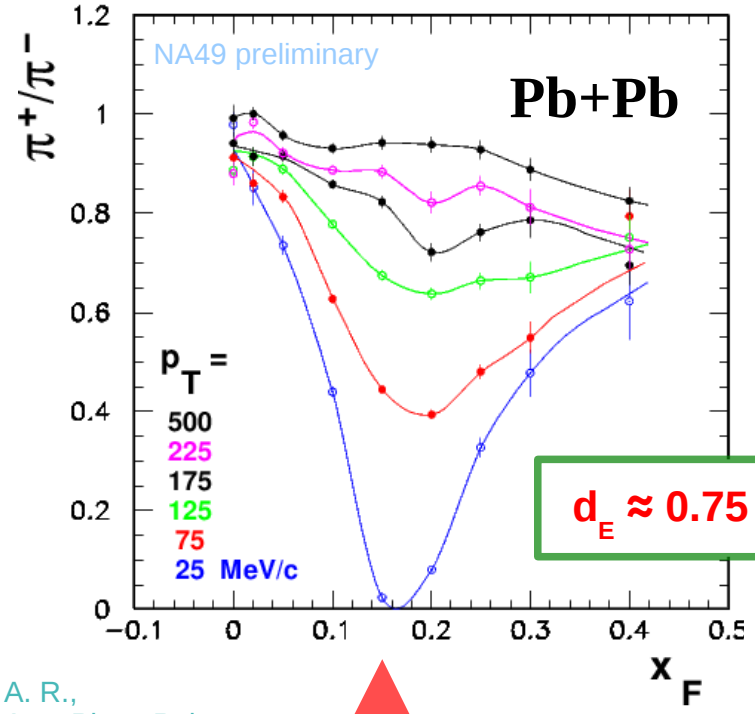
Acknowledgments.

This work was supported by the National Science Centre, Poland

(grants no. 2011/03/B/ST2/02634 and 2014/14/E/ST2/00018).

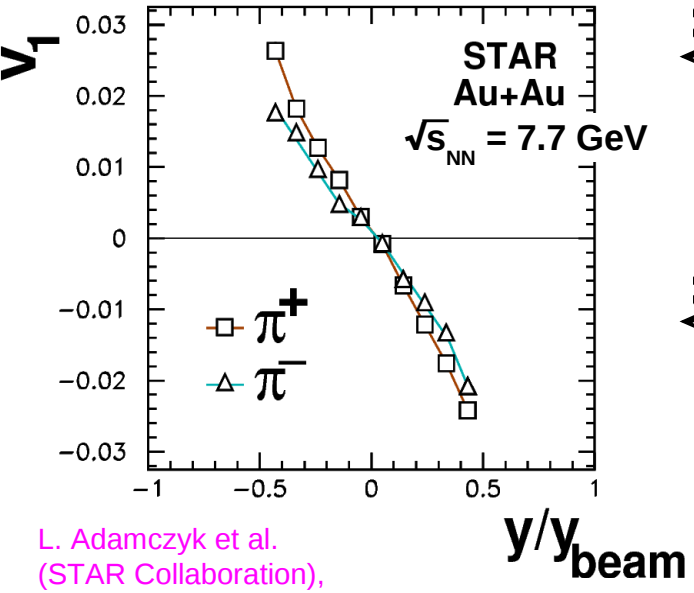
Extra slides



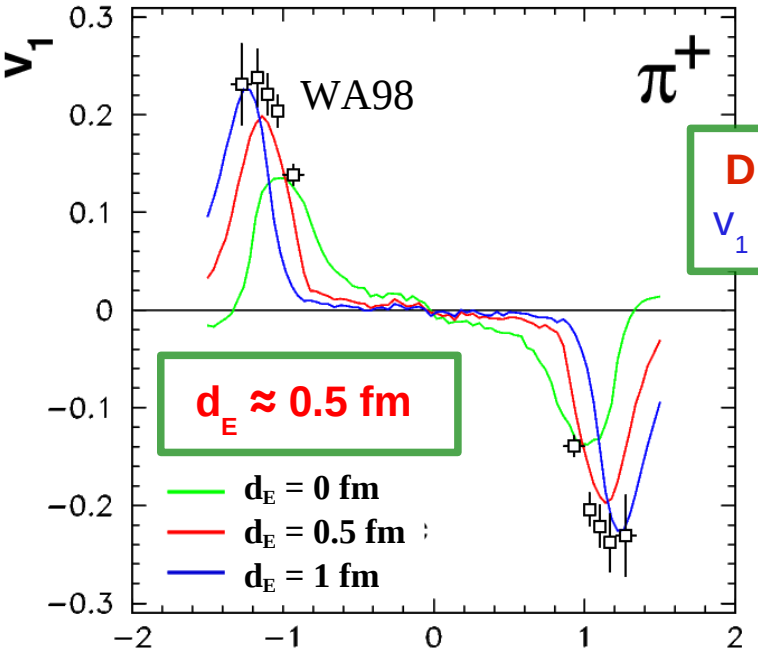
$d_E \approx 0.75$ fm

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

$y = y_{beam}$



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



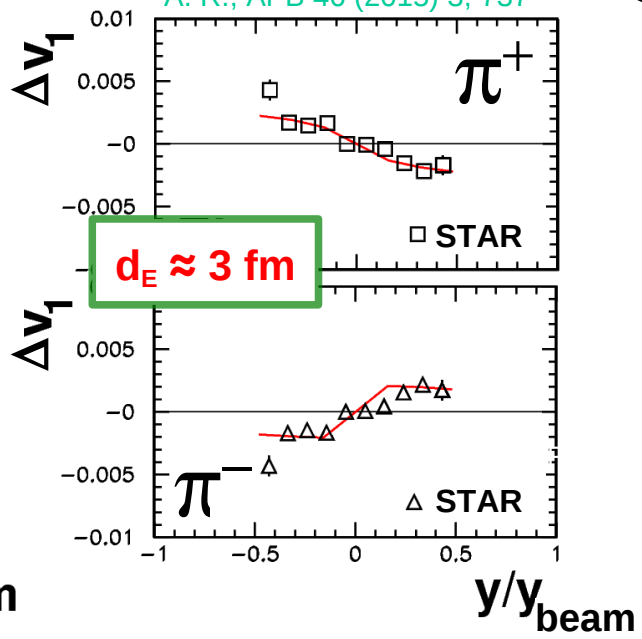
$d_E \approx 0.5$ fm

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

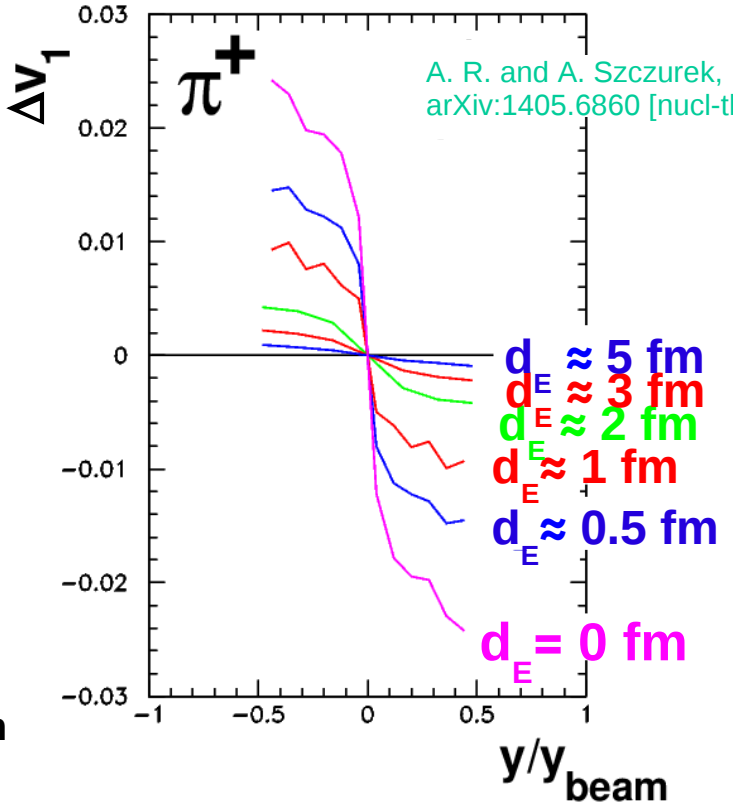
A. R. and A. Szczurek,
Phys. Rev. **C87** (2013)
054909.

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

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



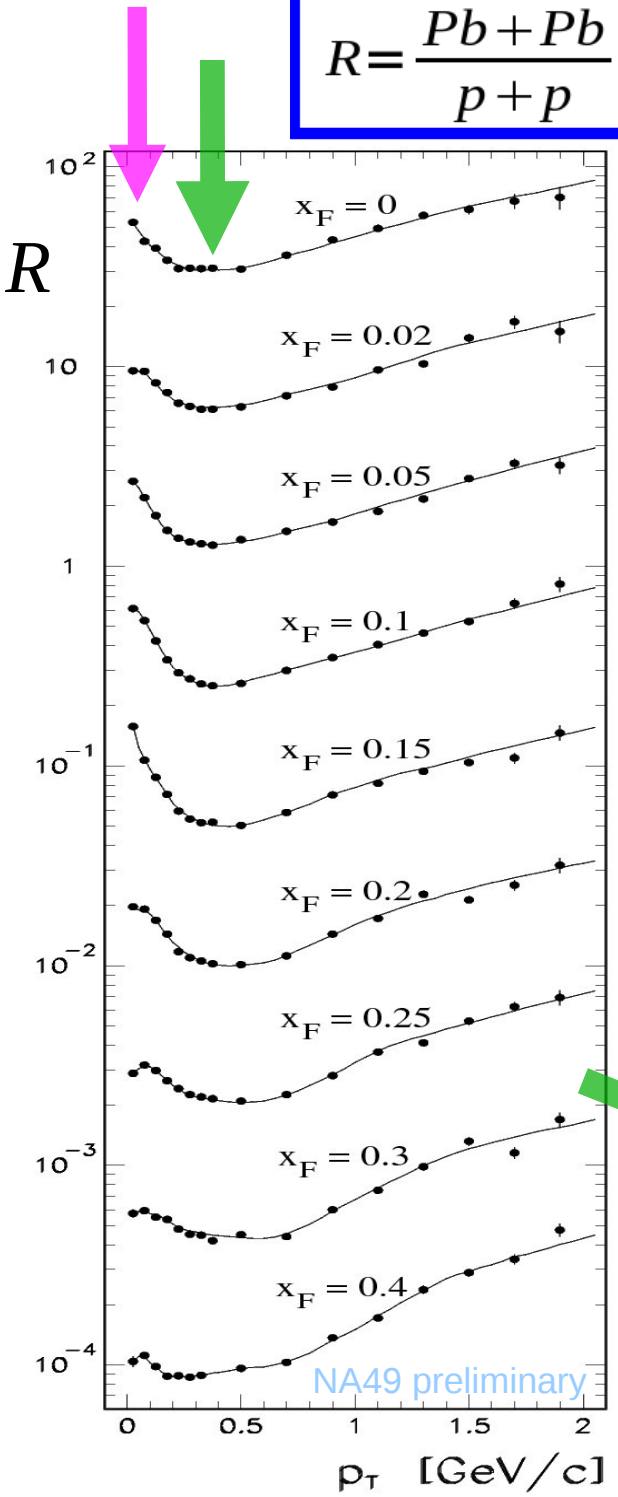
$d_E \approx 3$ fm

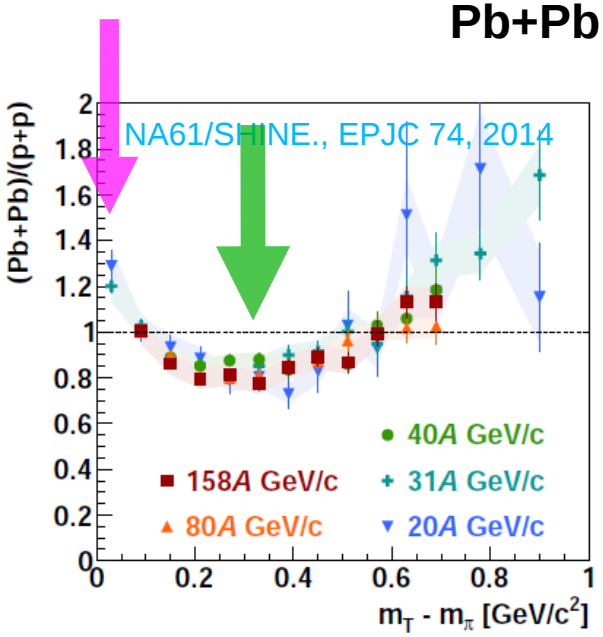


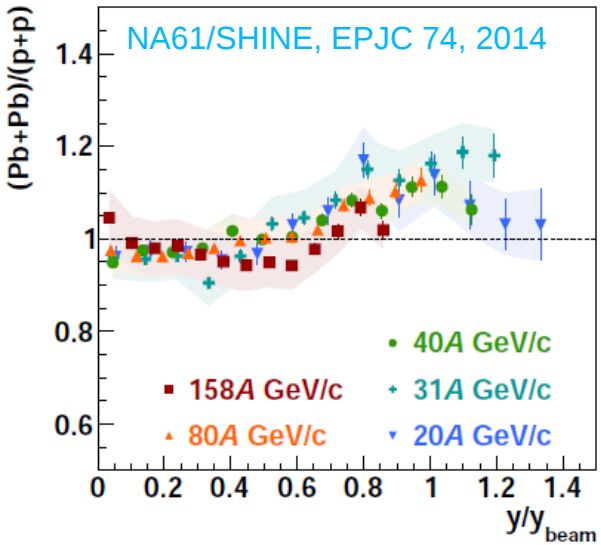
A. R. and A. Szczurek,
arXiv:1405.6860 [nucl-th].

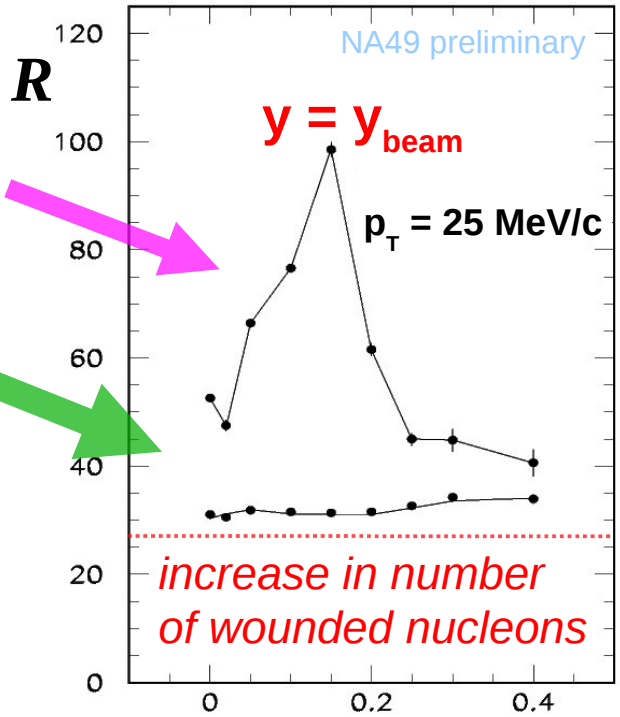
$$R = \frac{Pb+Pb}{p+p}$$

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



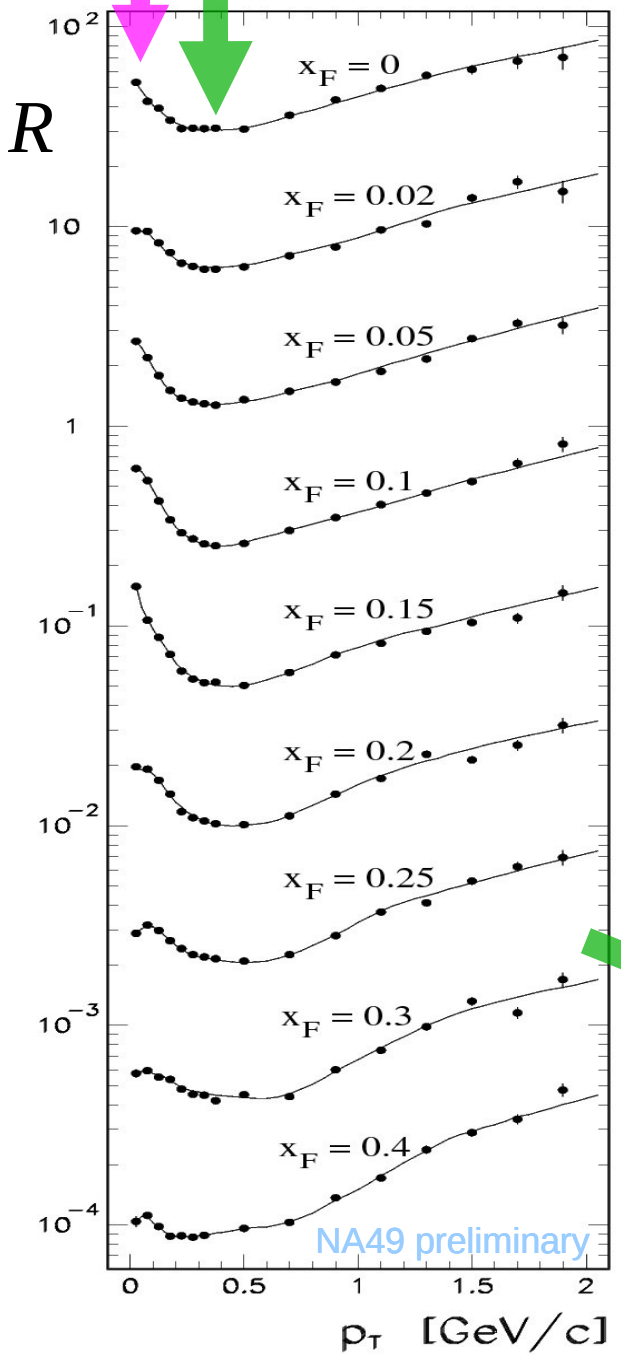


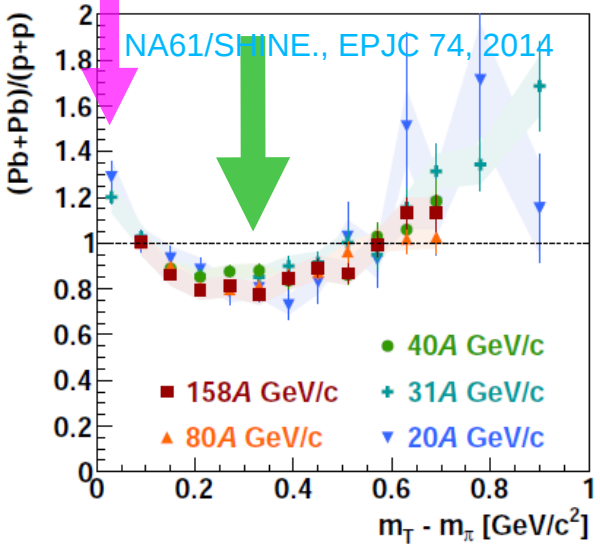


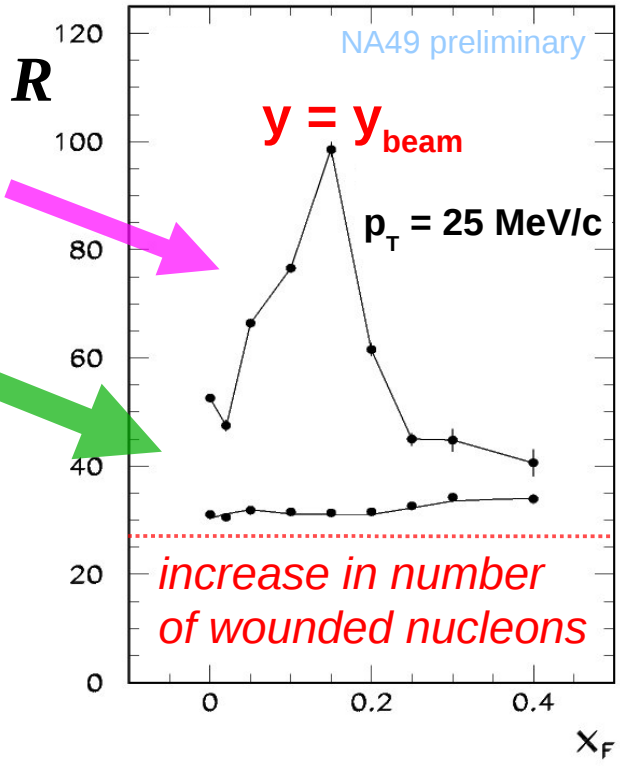


$$R = \frac{Pb+Pb}{p+p}$$

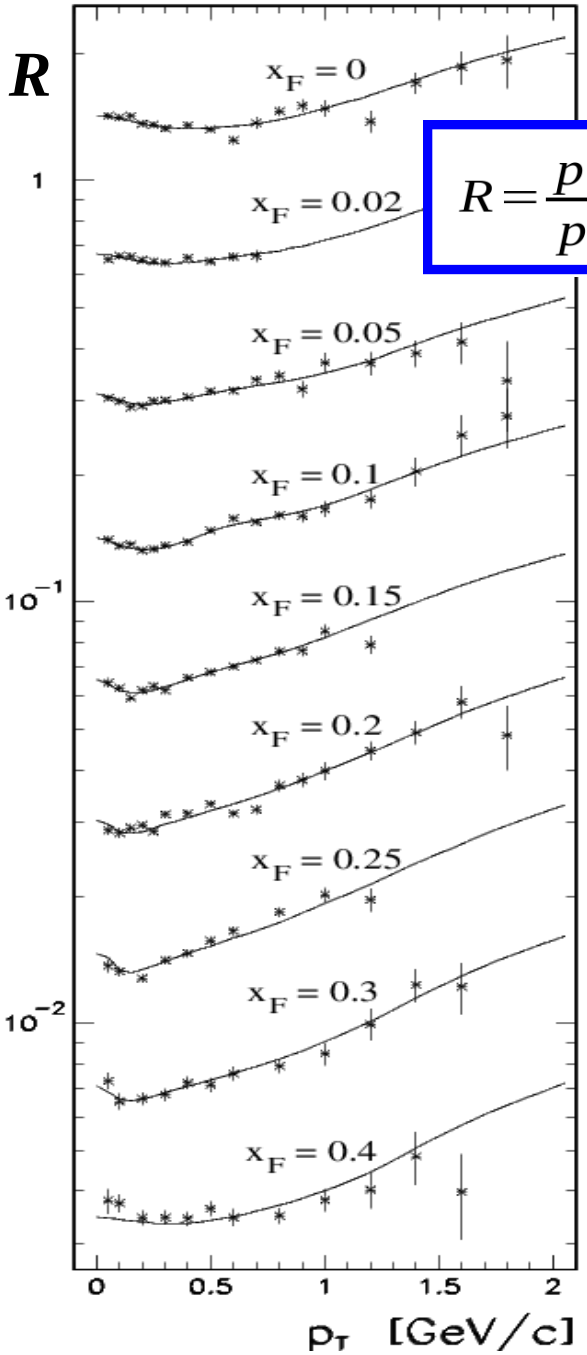
- NA49: $(\pi^+ + \pi^-)/2$; **Pb+Pb peripheral.**
- NA61/SHINE: π^- only; **Pb+Pb CENTRAL.**







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



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