Spectator induced electromagnetic effects in heavy-ion collisions and space-time-momentum conditions for pion emission

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in collaboration with

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Initial Stages 2021

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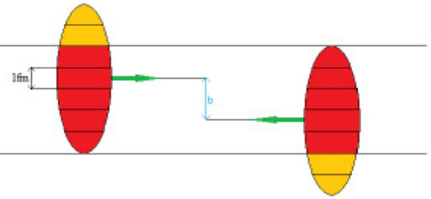
Our model: PRC 95 (2017) 2, 024908; PRC 99 (2019) 2, 024908;
EM part: PRC 102 (2020) 1, 014901

The model

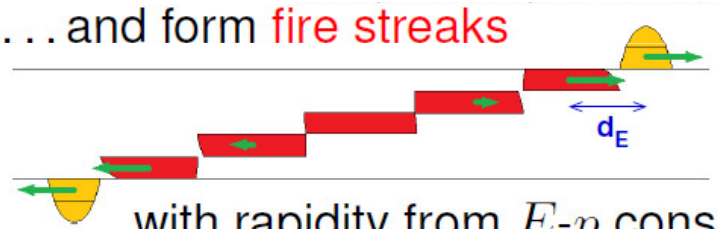
A. Szczurek, A. Rybicki, M. Kiełbowicz, Phys. Rev. C **95**, 024908 (2017); data points from: T. Anticic et al., Phys. Rev. C **86**, 054903 (2012)

Bricks collide . . .

1x1 fm^2



. . . and form fire streaks



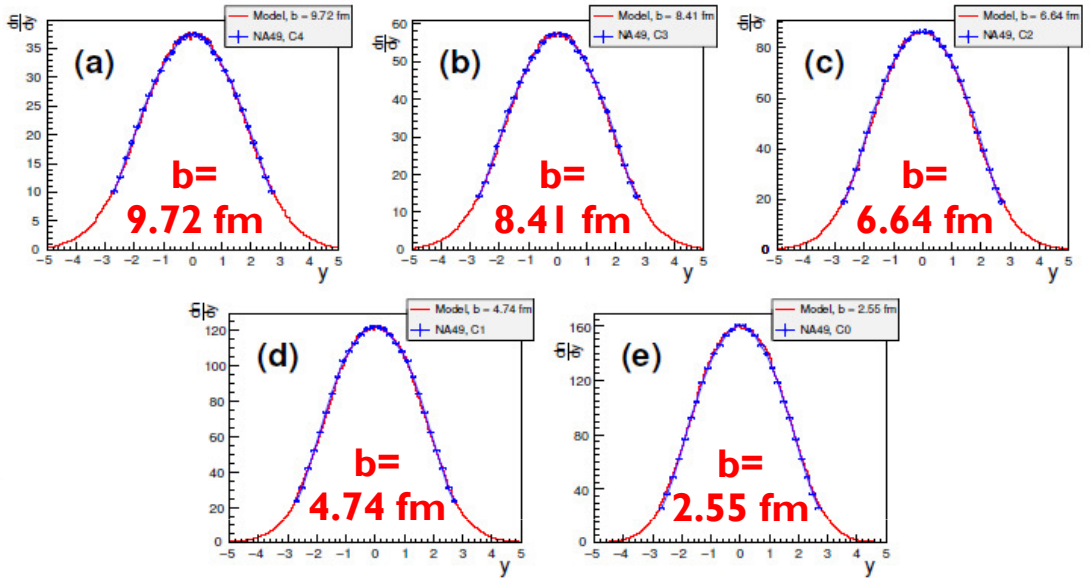
with rapidity from E-p conservation

Each fire streak fragments independently in pions

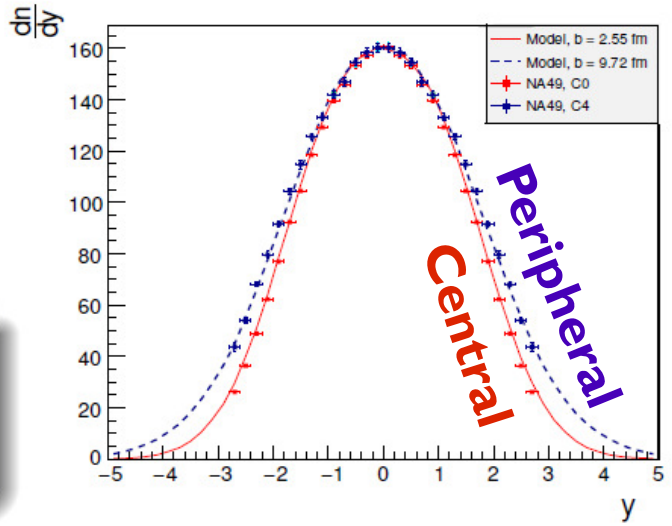
available energy **fire streak rapidity**

$$\frac{\mathrm{d}n}{\mathrm{d}y} \sim A \cdot (E_s^* - m_s) \cdot \exp\left(- \frac{\left[(y - y_s)^2 + \epsilon^2 \right]^{\frac{n}{2}}}{n \sigma_y^n} \right)$$

total fire streak energy sum of brick masses



π^- in NA49 Pb+Pb @ 158 GeV

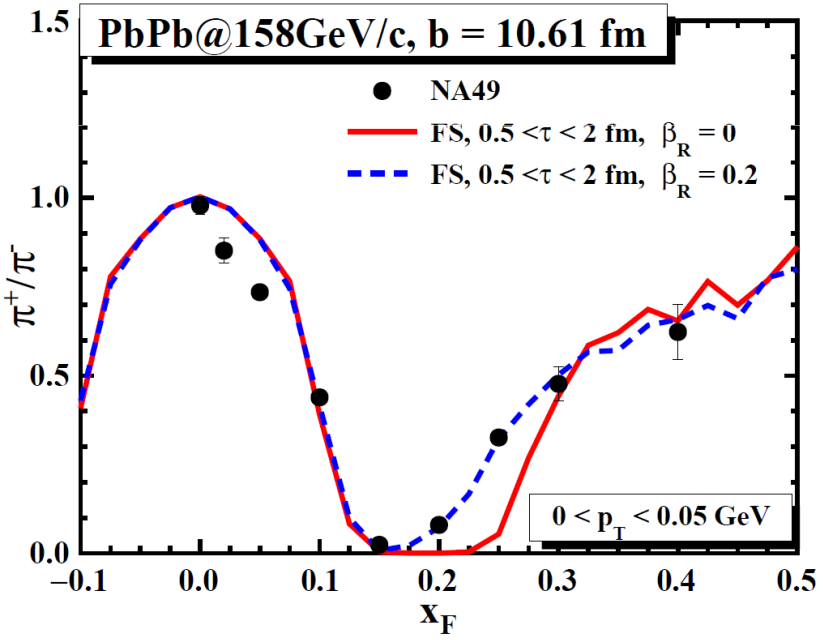


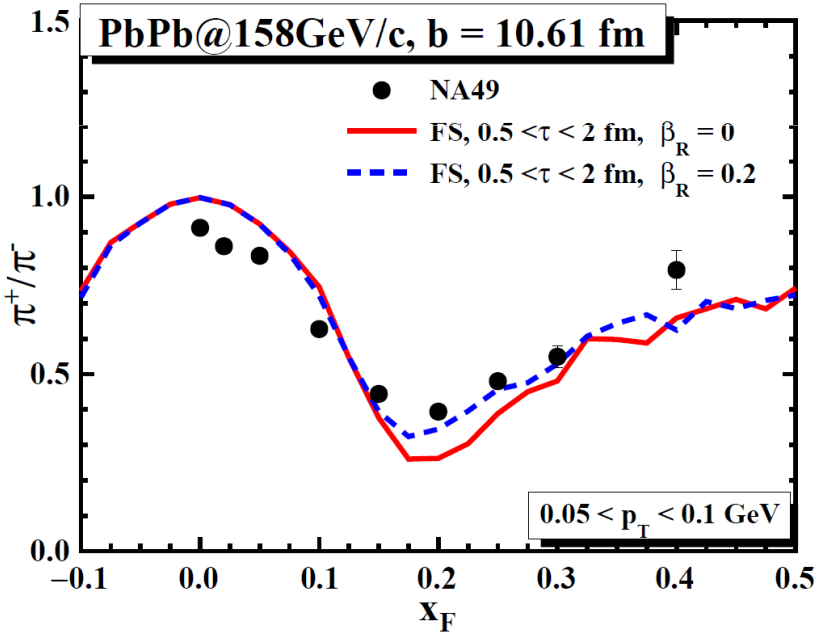
Results

- We fix the pion emission time from the fire streaks and initial position of the pion relative to the spectator

- We assume that the pion creation time increases with the excitation energy of the fire streak, we take:

$$\tau = a(E_s^* - m_s) + \tau_0$$





- The configuration with the expanding spectator ($\beta_R = 0.2$) gives the best description K.Mazurek, A.Szczurek *et al.*, PRC 97, 024604 (2018)

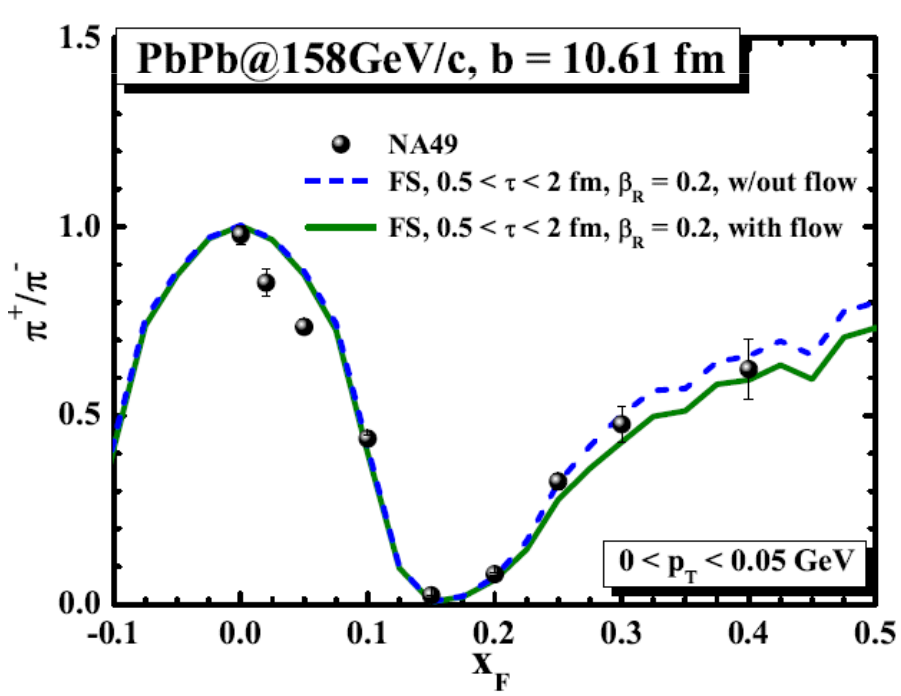
Particle flow in momentum space (results)

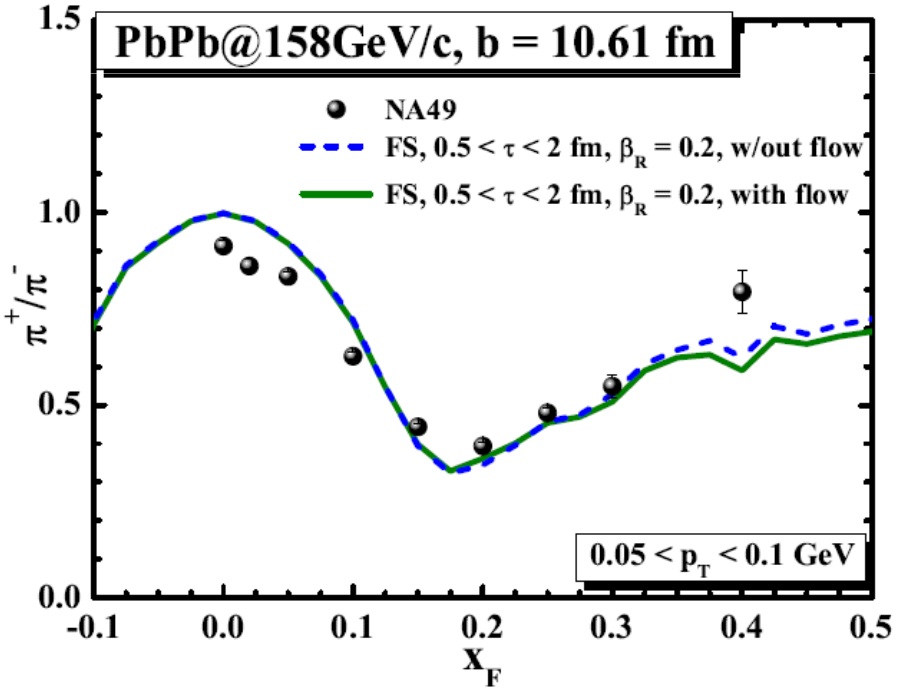
- **We fit NA49 and WA98 experimental data for v_1 and v_2 and include them to the initial conditions of the system**

NA49 data:
C. Alt *et al.*, PRC 68, 034903 (2003)

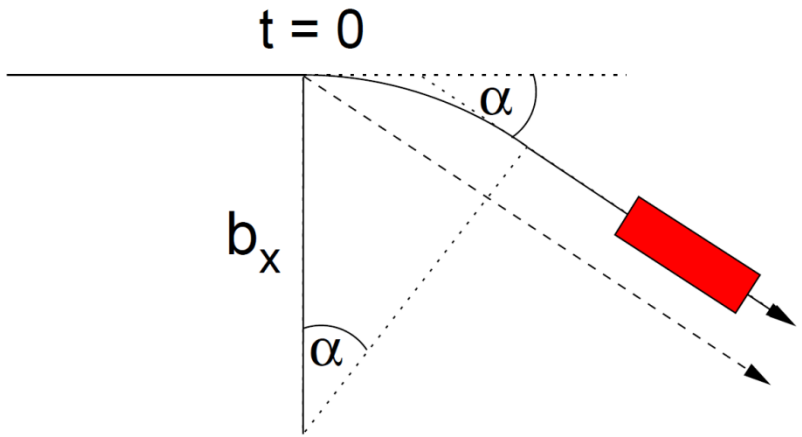
WA98 data:
H. Schlagheck, NPA 663, 75 (2000)

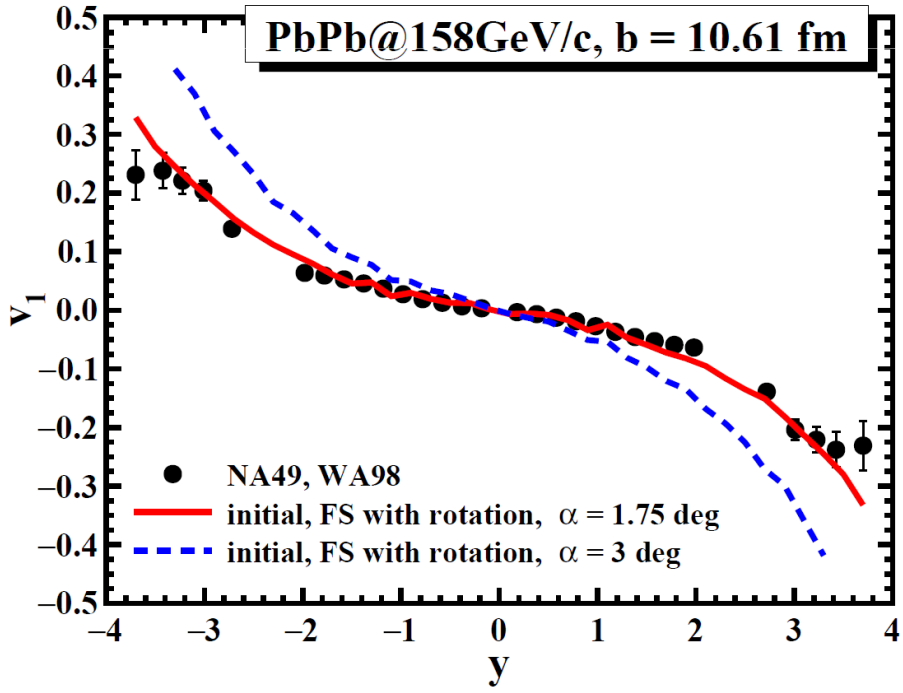
- **We find no effect for v_2 but a non-negligible effect for v_1:**





Vorticity of fire streaks





- Fire streaks rotate for a given small angle α
- After rotation the fire streak follows its modified trajectory until pions are emitted from the fire streak
- The pion emission point is shifted in transverse and longitudinal direction with respect to the case with no rotation
- The size of the shift increases with increasing α and τ
- Rotation by α = 1.75 deg gives a good description of the experimental data on v_1 (!)

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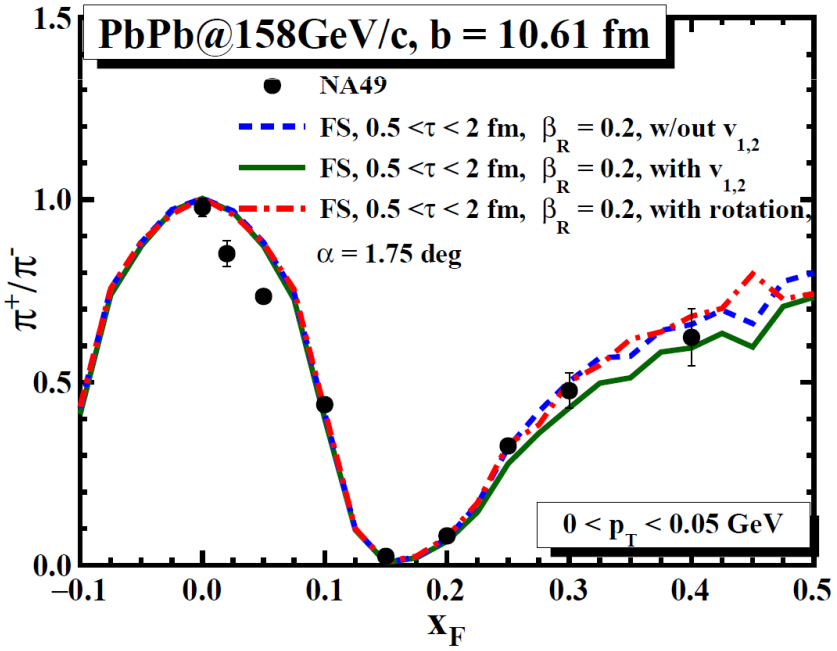
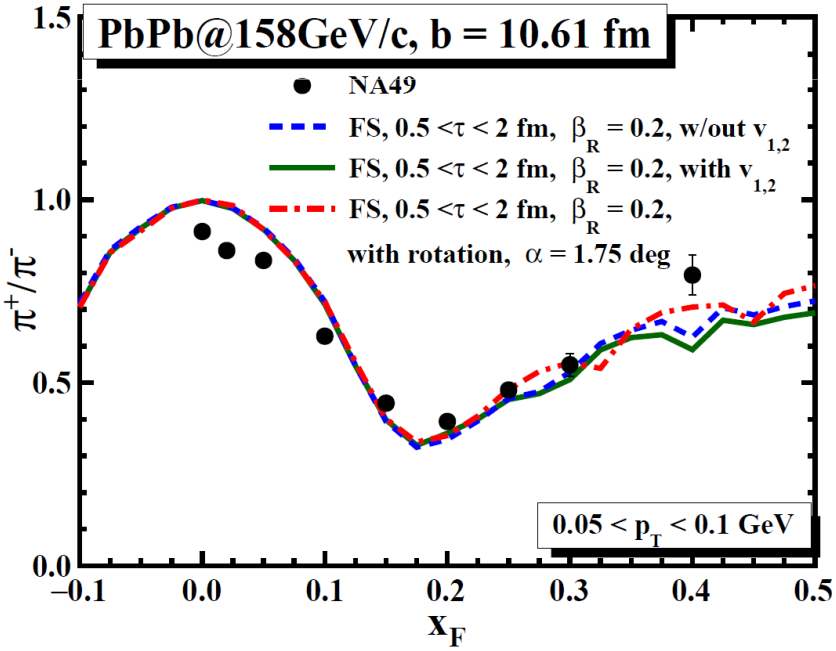
Vorticity (results)

- **No significant change is visible with respect to the case with no rotation**

- **Due to the small total angle allowed by the experimental data on v_1, vorticity includes only a small displacement of the pion emission points**





Summary

- We introduced the model of the longitudinal evolution of the system, which
  - explains the centrality dependence of pion yields and rapidity spectra in Pb+Pb collisions

- We implemented the initial conditions for pion production provided by our model to study the electromagnetic effects in peripheral Pb+Pb collisions
  - rather small pion creation times have been necessary to describe the data on electromagnetic effects, which concern faster pions ($0.5<\tau<2$ fm/c)
  - configuration with the expanding spectators gives the best description of the data
  - inclusion of directed flow gives a non-negligible effect, whereas elliptic flow shows no effect
  - vorticity of fire streaks results in the presence of directed flow (*see PRC 102 (2020) 1, 014901 for more details*), but has little effect on the electromagnetic distortion of pi+/pi- ratios

Thank you!

Acknowledgments:
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