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Strangeness production and long-range correlations in pp collisions in string fusion approach

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JOINT INSTITUTE FOR NUCLEAR RESEARCH
Strangeness in Quark Matter
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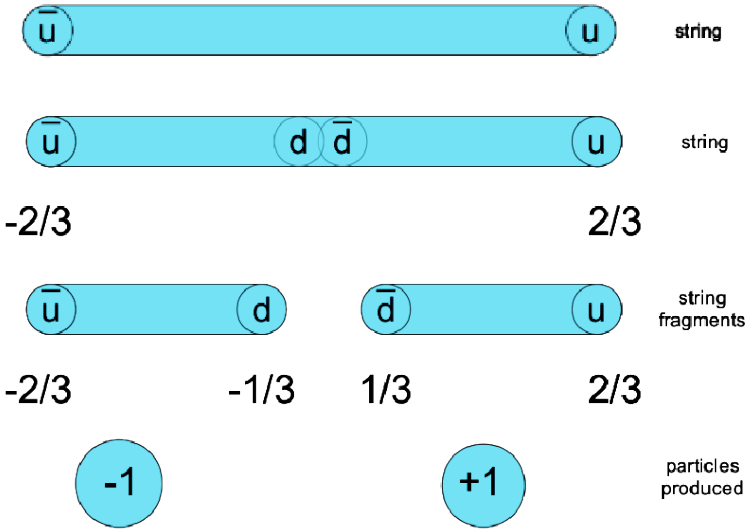
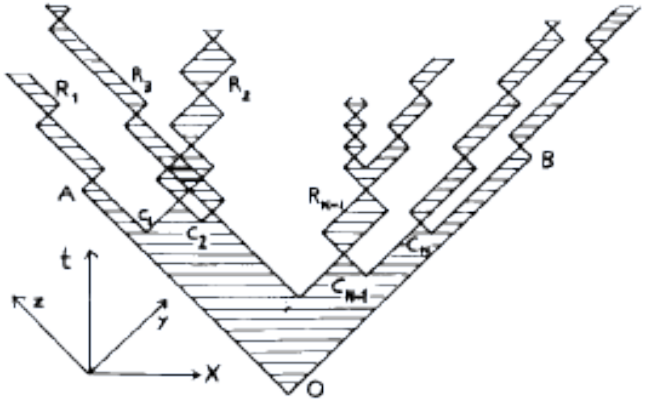
Overview

- The soft QCD processes is not described by usual perturbation theory
- The model of quark-gluon strings, stretched between projectile and target partons
  – semiphenomenological approach to the multiparticle production



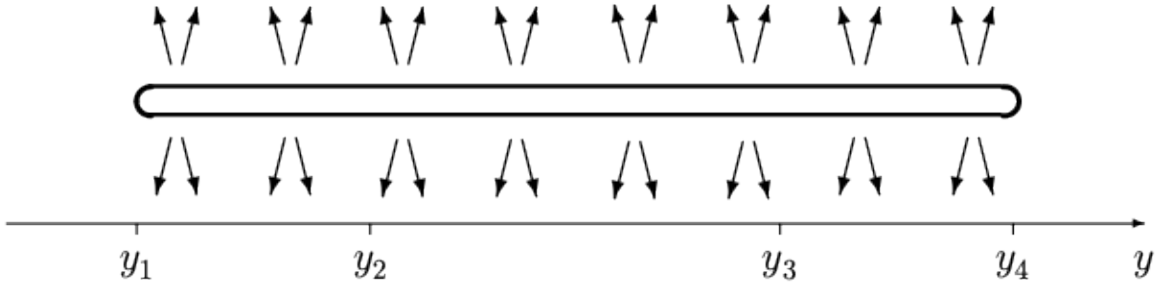


X. Artru and G. Mennessier, Nucl Phys B 70 (1974) 93
"String Model and Multiproduction",

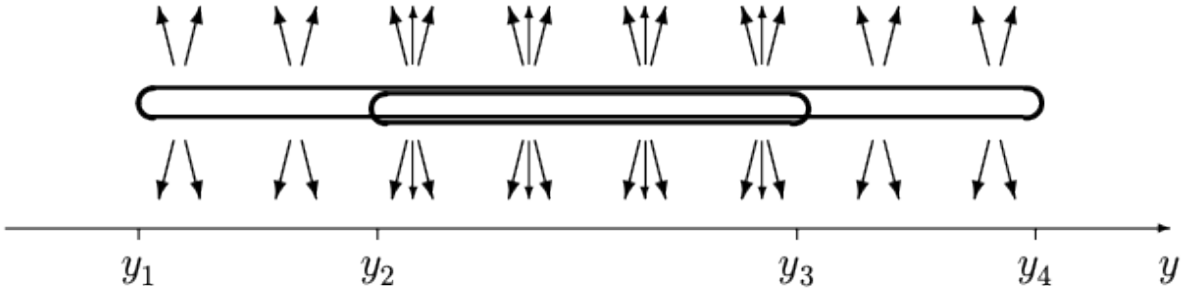
- Correlations play crucial role:
  – causality requires appearance of long-range correlations – if they exist – at the very early stages between particles detected in separated rapidity intervals

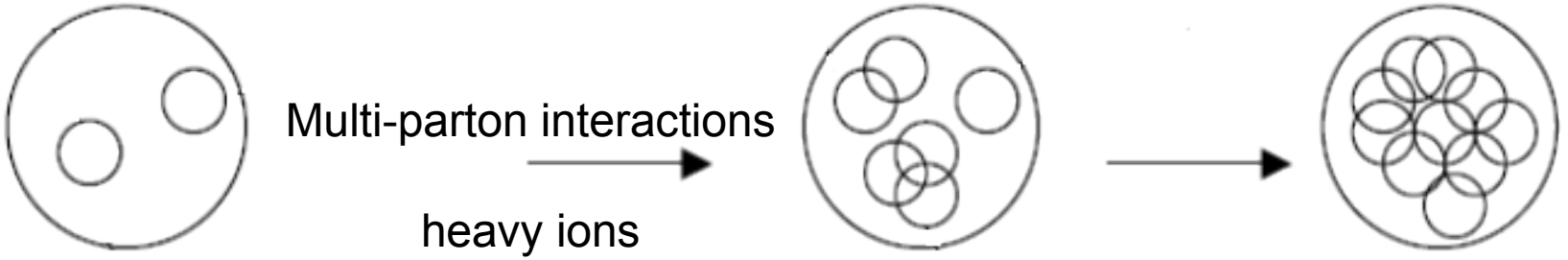
String in rapidity space

- Uniform distribution of particles from y_{min} to y_{max}



- Can study string overlaps:





–>>> sqrt(s) increases –>>> –>>> –>>>

String fusion

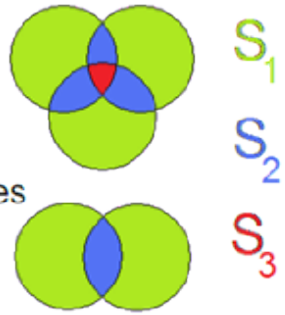
$$Q^2(n) = \left(\sum_{i=1}^{n} \vec{Q}_i(1) \right)^2 = \sum_{i=1}^{n} Q_i^2(1) + \sum_{i \neq j} \vec{Q}_i(1) \cdot \vec{Q}_i(1)$$

$$\left\langle Q^2(n) \right\rangle = nQ^2(1)$$

SFM

$C = \{S_1, S_2, \ldots\}$

S_k – area covered k-times

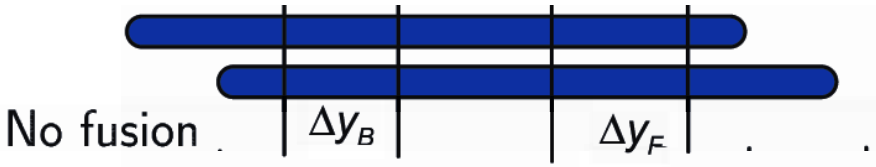


$$\langle \mu \rangle_k = \mu_0 \sqrt{k} \frac{S_k}{\sigma_0} \qquad \langle p_t^2 \rangle_k = p_0^2 \sqrt{k} \qquad \langle p_t \rangle_k = p_0 \sqrt[4]{k}$$

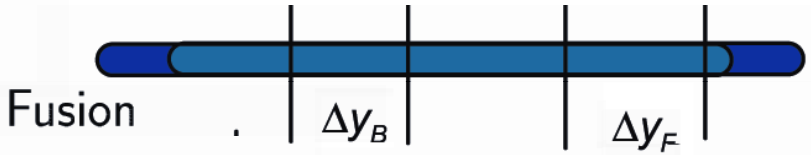
S_k – area, where k strings are overlapping, σ_0 single string transverse area,
μ_0 and p_0 – mean multiplicity and transverse momentum from one string

M. A. Braun, C. Pajares, Nucl. Phys. B 390 (1993) 542.
M. A. Braun, R. S. Kolevatov, C. Pajares, V. V. Vechernin, Eur. Phys. J. C 32 (2004) 535.
N.S. Amelin, N. Armesto, C. Pajares, D. Sousa, Eur.Phys.J.C22:149-163 (2001), arXiv:hep-ph/0103060
G. Ferreiro and C Pajares J. Phys. G: Nucl. Part. Phys. 23 1961 (1997)

- String fusion in separated rapidity windows:

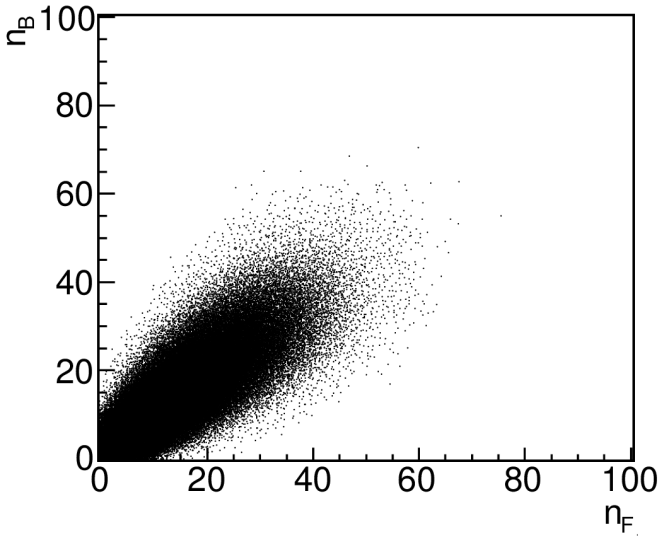


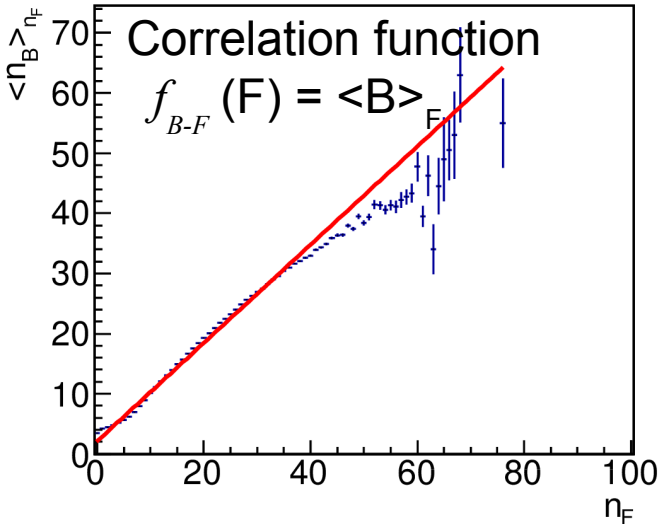
$$\langle n_F \rangle = 2\mu_0, \quad \langle p_{tB} \rangle = \overline{p}$$

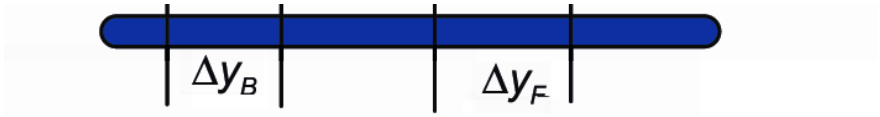


$$\langle n_F \rangle = \sqrt{2}\mu_0, \quad \langle p_{tB} \rangle = \sqrt[4]{2}\overline{p}$$

Long-range (forward-backward) correlations







Correlation coefficient: $\mathbf{b}_{B\text{-}F}$

$f_{B\text{-}F}$ (F) = a + $\mathbf{b}_{B\text{-}F}$ F

Observables F, B could be:

- n – number of charged particles in given rapidity window
- pt – mean event transverse momentum of charged particles in given window
- S – fraction in the event of strange charged particles

NEW

Types of correlations:

n-n, pt-n, pt-pt

S-n, S-pt, S-S

Monte Carlo model

- Partonic picture based on dipole interaction
- Energy and angular momentum conservation in the initial state
- The interaction probability amplitude it terms of transverse coordinates:

$$f = \frac{\alpha_s^2}{2} \ln^2 \frac{|\vec{r}_1 - \vec{r}_1'||\vec{r}_2 - \vec{r}_2'|}{|\vec{r}_1 - \vec{r}_2'||\vec{r}_2 - \vec{r}_1'|}$$

- The **hardness** of the elementary collisions by transverse size of dipoles:

$$d_{1i} = |\vec{r}_1 - \vec{r}_2|, \; d_i' = |\vec{r}_1' - \vec{r}_2'|$$

- Transverse momentum of a cluster of strings:

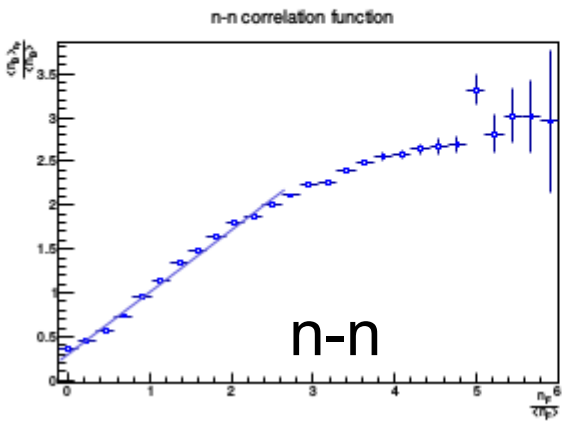
$$p_1^4 = \sum_i^k p_{Tstri}^4, \quad p_{Tstri}^2 = \frac{1}{d_i^2} + \frac{1}{d_i'^2} + p_0^2$$

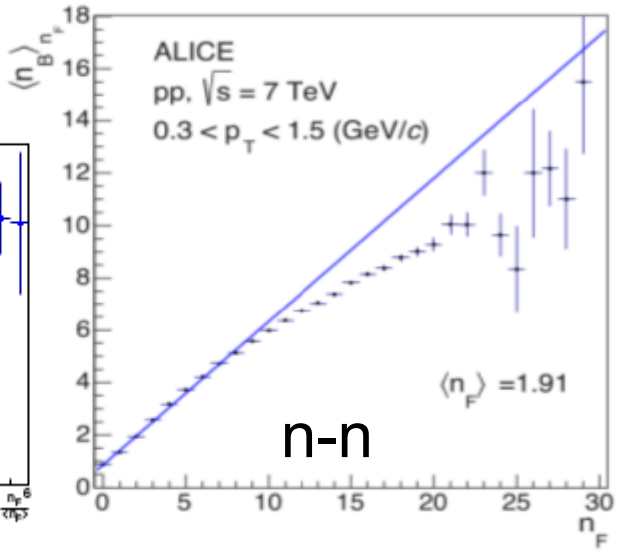
- Parameters of the model are fixed using inelastic cross section and multiplicity in wide energy range in pp, and also p-Pb and Pb-Pb collisions

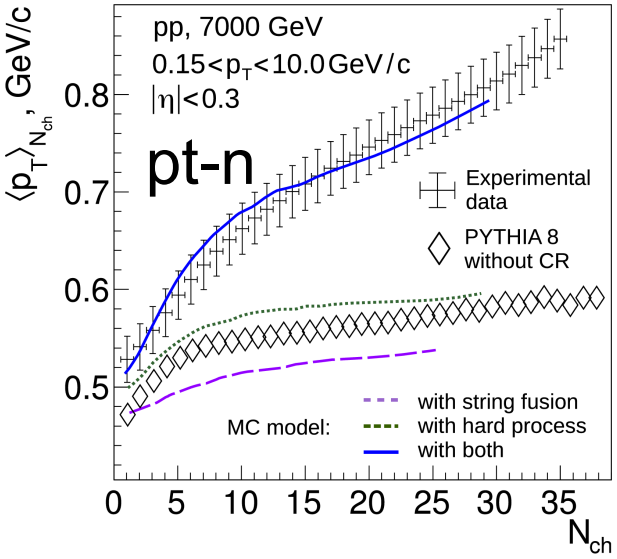
V. N. Kovalenko. Phys. Atom. Nucl. 76, 1189 (2013), arXiv:1211.6209 [hep-ph]; V. Kovalenko, V. Vechernin, PoS (Baldin ISHEPP XXI) 077, arXiv:1212.2590 [nucl-th], 2012; V. Kovalenko, V. Vechernin, DESY Conf. Proc. 2014-04, 82 (pp. 691-694), DOI:10.3204/DESY-PROC-2014-04/82, arXiv:1410.3884 [hep-ph] (2014)

Forward-backward correlations

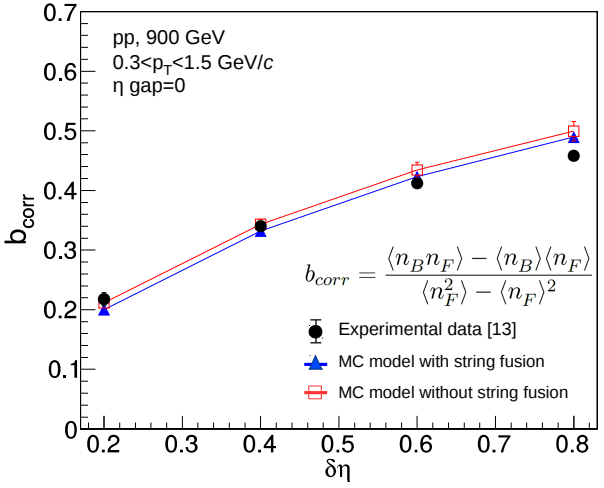
Correlation functions

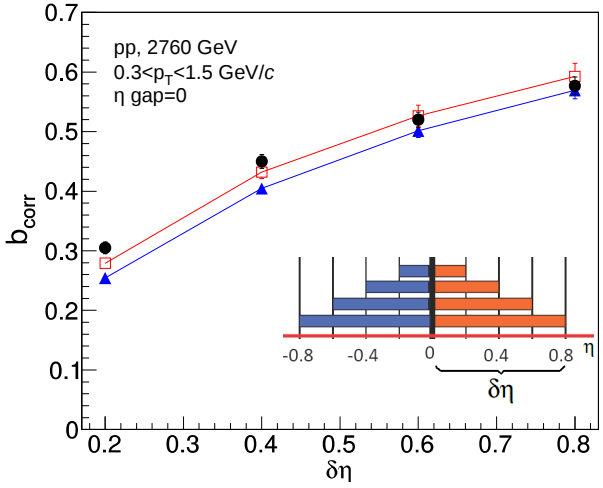


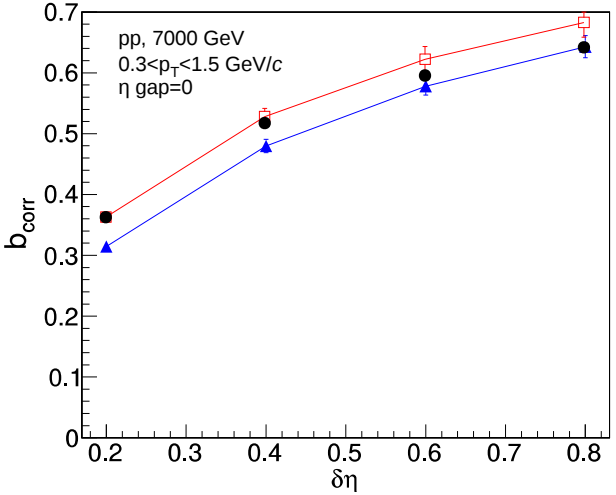




Correlation coefficients (n-n)







Particles differentiation

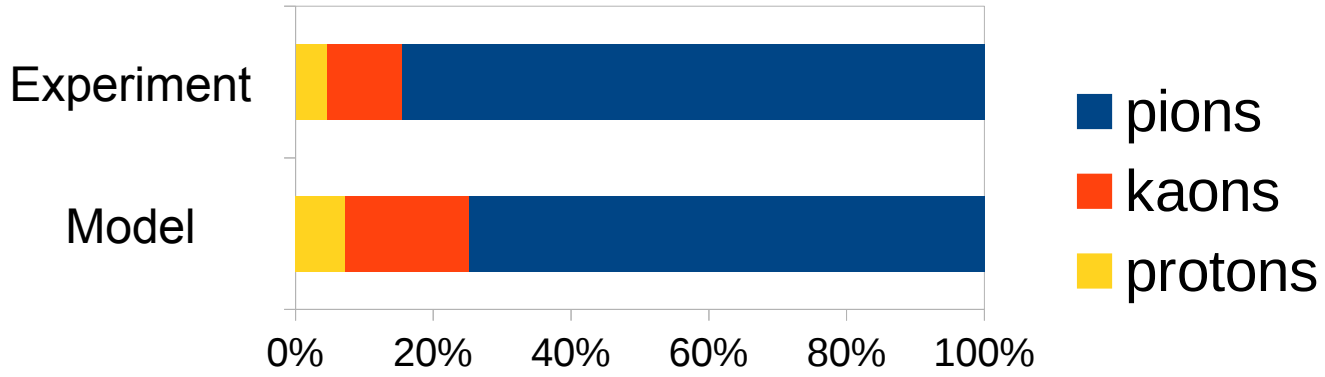
- Schwinger mechanism of particle production [4]:

$$Y_{\nu} \sim \exp\left(\frac{\pi\left(p_t^2 + m_{\nu}^2\right)}{t}\right)$$

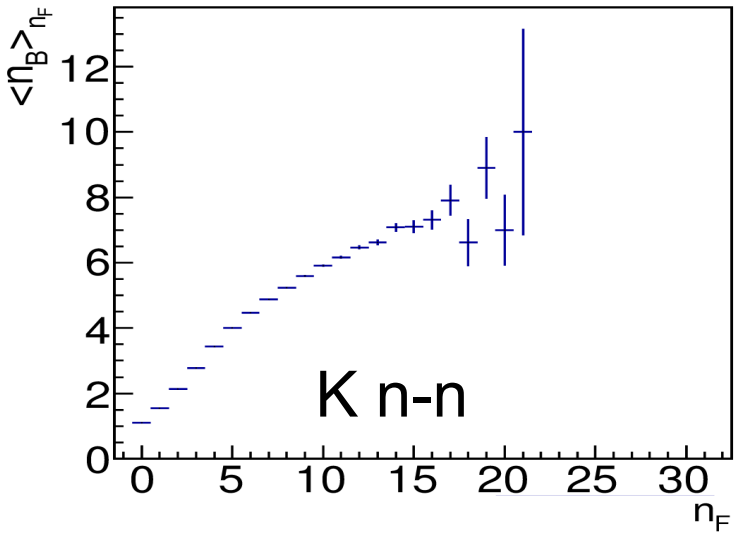
[4] J. Schwinger // Phys. Rev. 1951. V. 82, P. 664; T. S. Biro, H. B. Nielsen, and J. Knoll // Nucl. Phys. B. 1984, V. 245, P. 449.

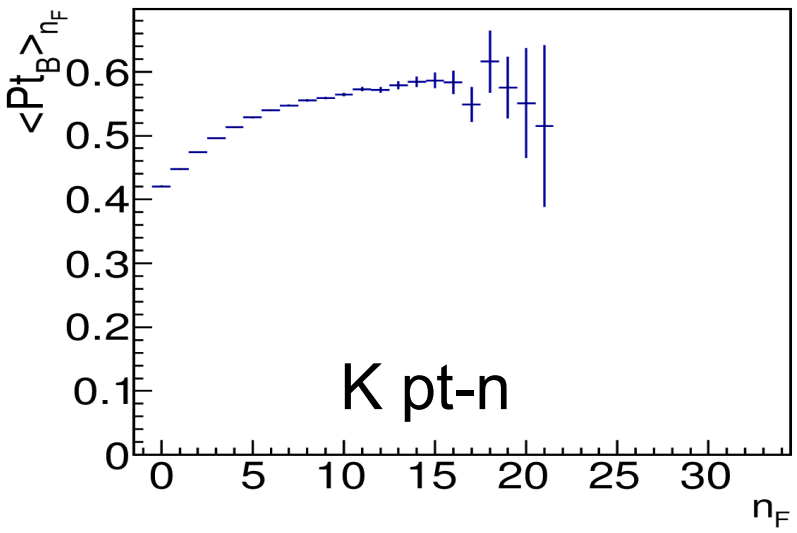
- In **string fusion** model the string tension of η overlapped strings is given by $t = \sqrt{\eta}\, c_N\, p_0^2$
- Major particles are taken: pions, kaons, protons
- rho-meson: decays into pions: $\rho^0 \rightarrow \pi^+ + \pi^-$, $\rho^{\pm} \rightarrow \pi^{\pm} + \pi^0$

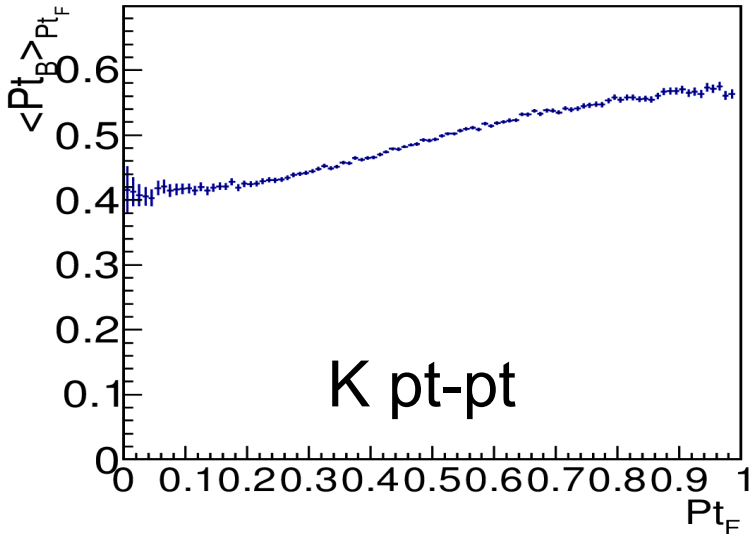
  added with a factor of 3 to pions

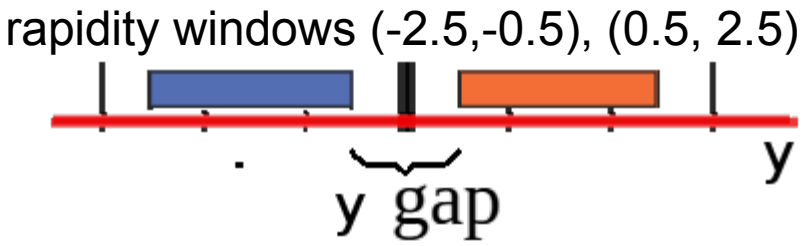


Results: n-n, pt-n, pt-pt correlation functions for kaons

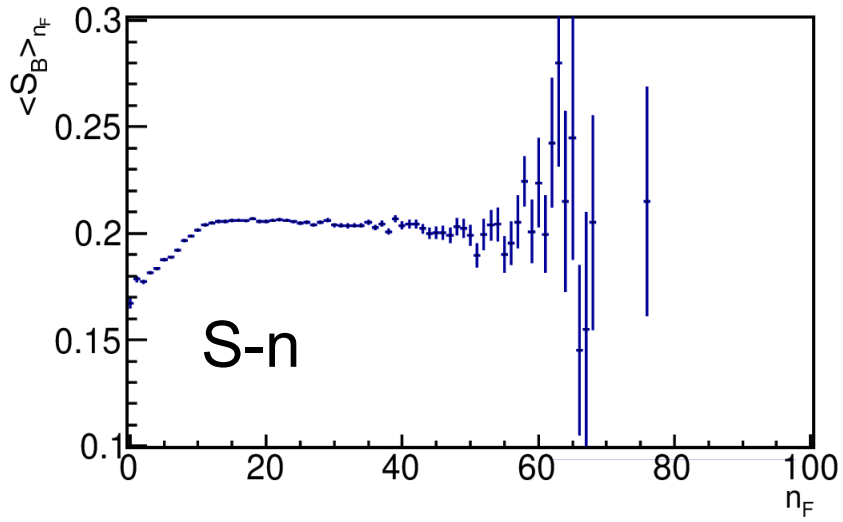


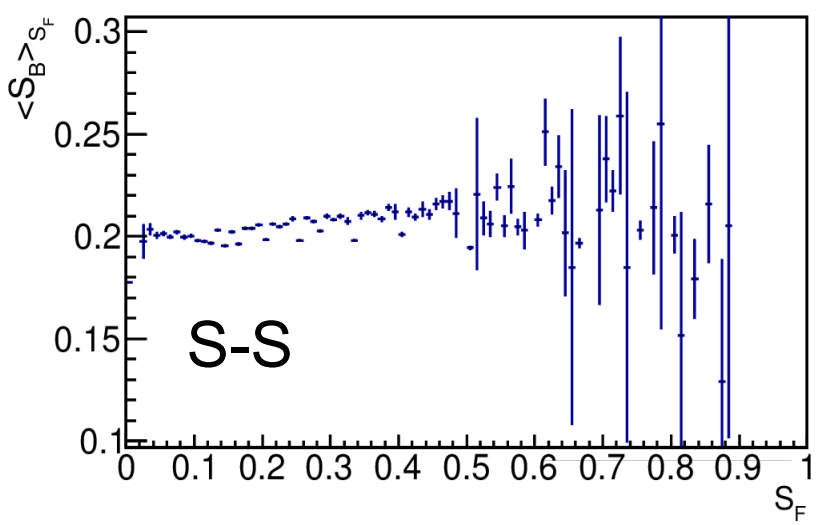


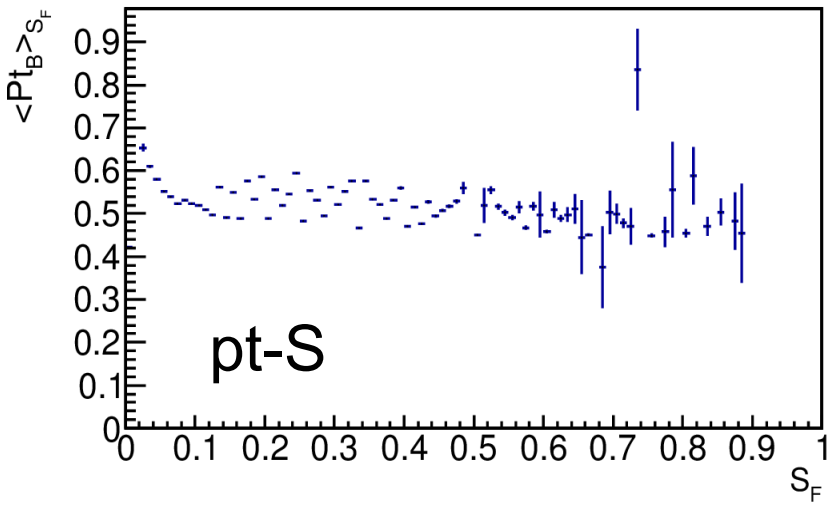


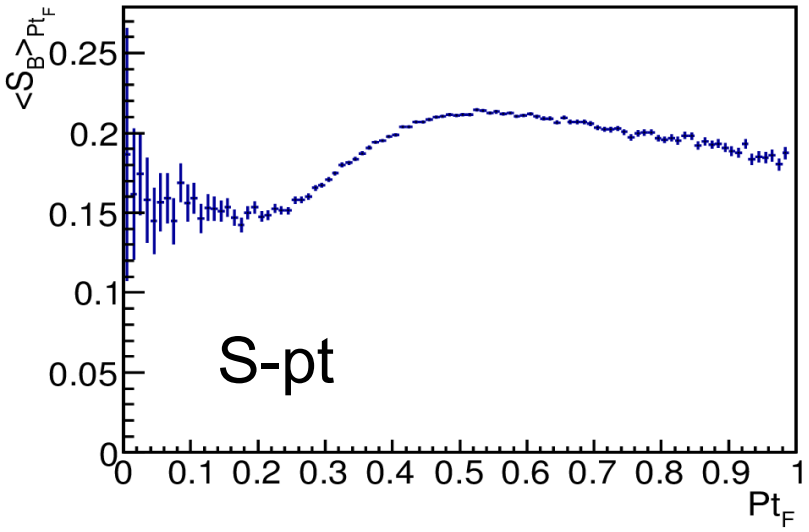


Results: correlations for mean event strangeness









rapidity windows (-2.5,-0.5), (0.5, 2.5)

Conclusions

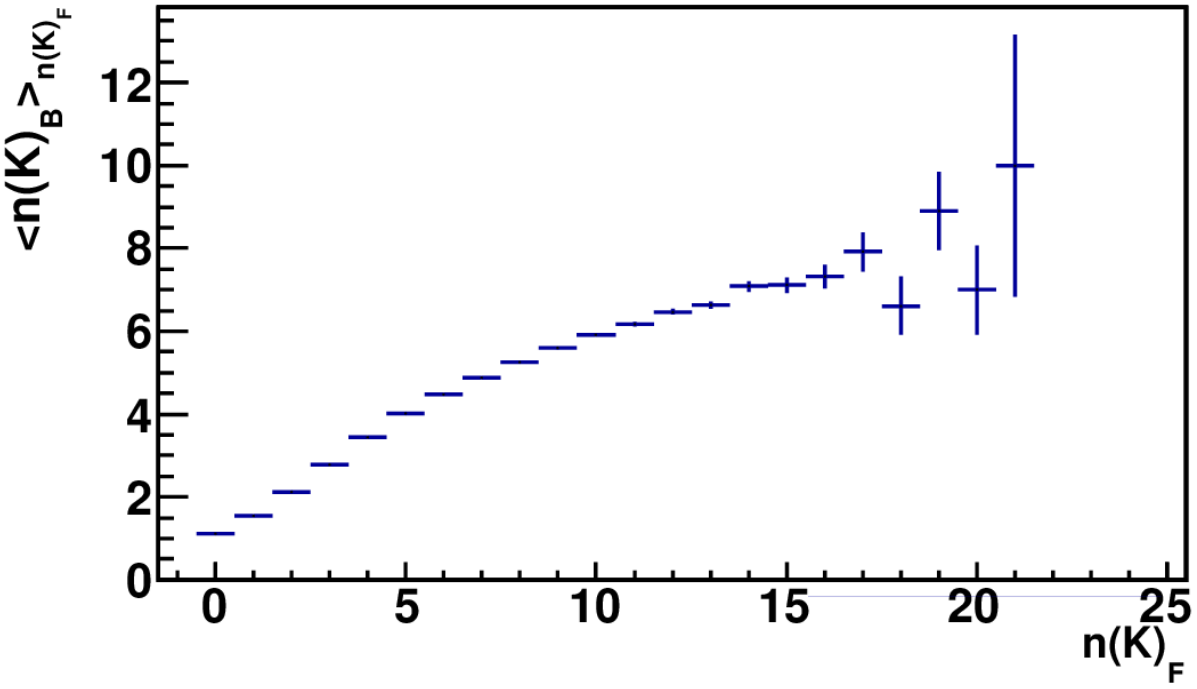
- Production of strange particles in the framework of string fusion model is implemented according to Schwinger mechanism
- Forward-backward correlations in separated rapidity windows are studied taking into account strangeness
- New types of long-range correlations are introduced:
  – S-n, S-S, S-pt
- Mean event strangeness, as well as mean event pt is an intensive variable → useful also in p-A and AA collisions

The End

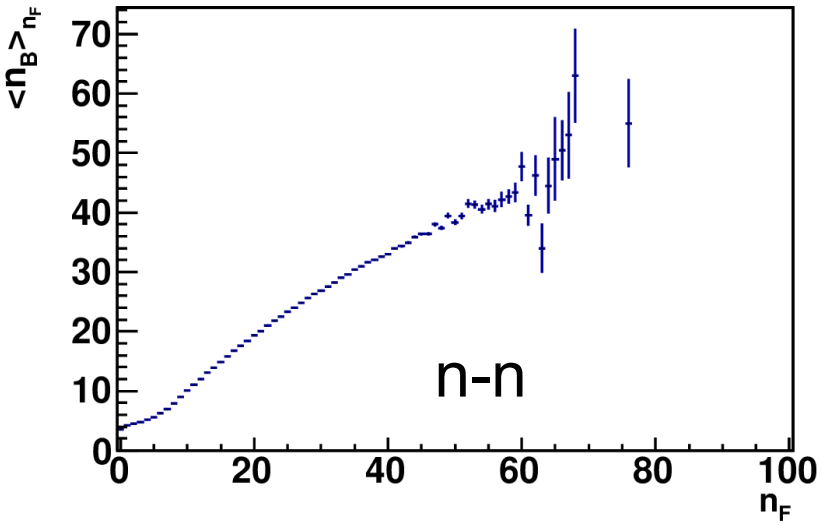
- Thank you!

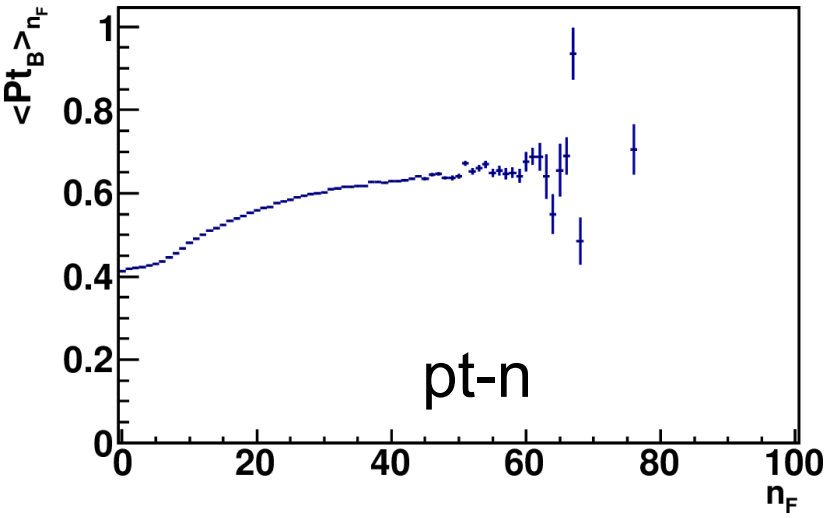
Backup

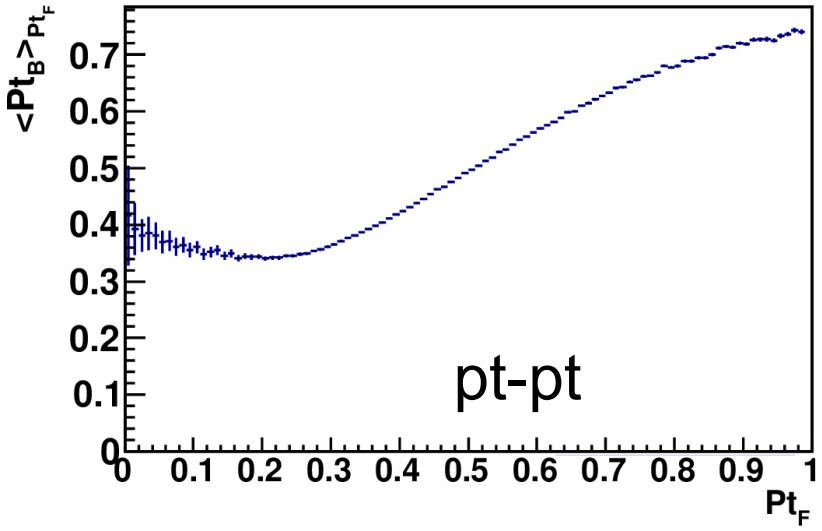
Kaon-kaon multiplicity correlation function

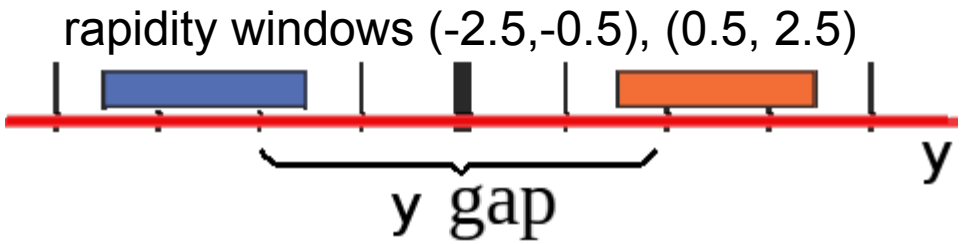


Results: n-n, pt-n, pt-pt correlation functions all charged









Conclusions

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