New results on the *pp* - scattering simulation for the Beam-Beam Counter at NICA SPD

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Abstract.

The results on the pp-scattering simulation at collision energies up to 27 GeV for the Beam-Beam Counter at SPD are presented. The simulation has been performed using the Pythia8 generator under SPDRoot framework. The estimations of the magnetic field influence on the inclusive charged particles production asymmetries and on the Beam-Beam Counter loads are shown here.

TDR design 2023

BBC - detector

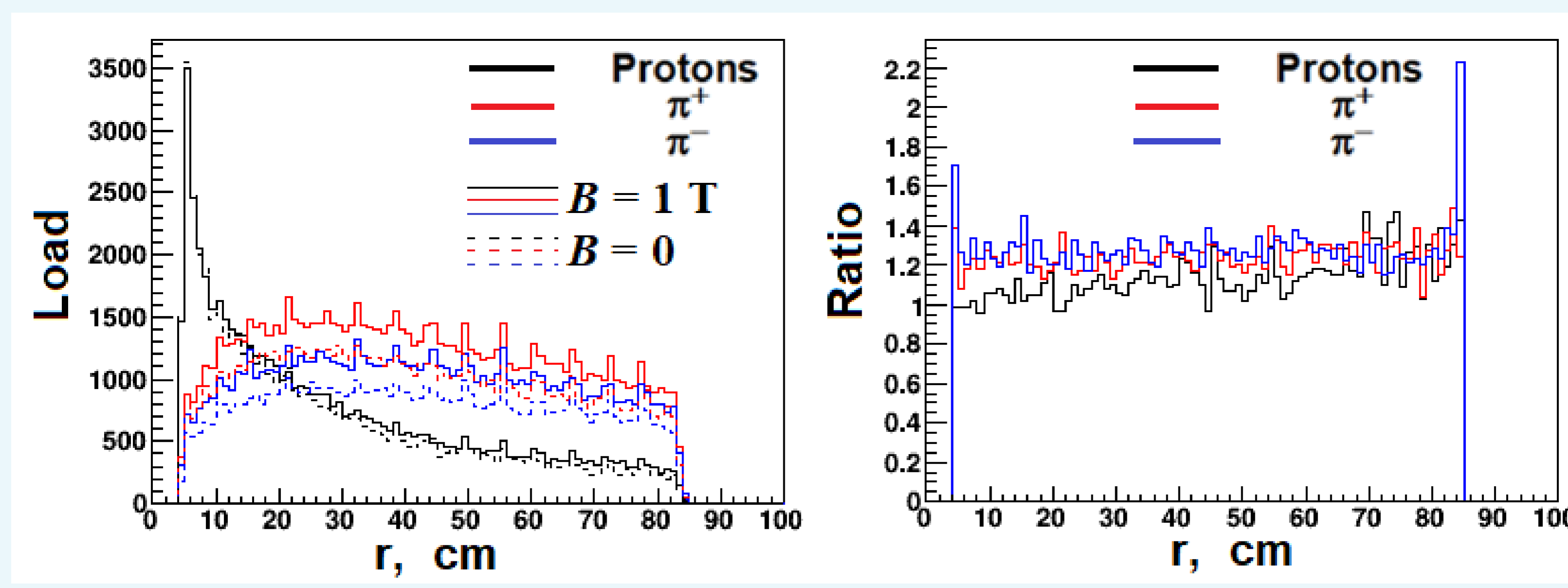
The SPD will include two BBCs. Each BBC will consist of 416 scintillation tiles. It will be divided into 14 concentric layers with 16 azimuthal sectors each. The distance between tiles ***is*** 1 mm. The tile thickness is 10 mm. The diameter will be 1650 mm. The distance between each BBC from the SPD center is 1716 mm. This configuration will cover a range of the scattering angle θ up to 25°-30°. The uncertainty of the interaction point is expected to be 300 mm.

The simulation of the *pp*-scattering

Energy : $\sqrt{s}$ up to 27 GeV. Generator: Pythia8.

I. The estimation of the magnetic field influence on the BBC load.

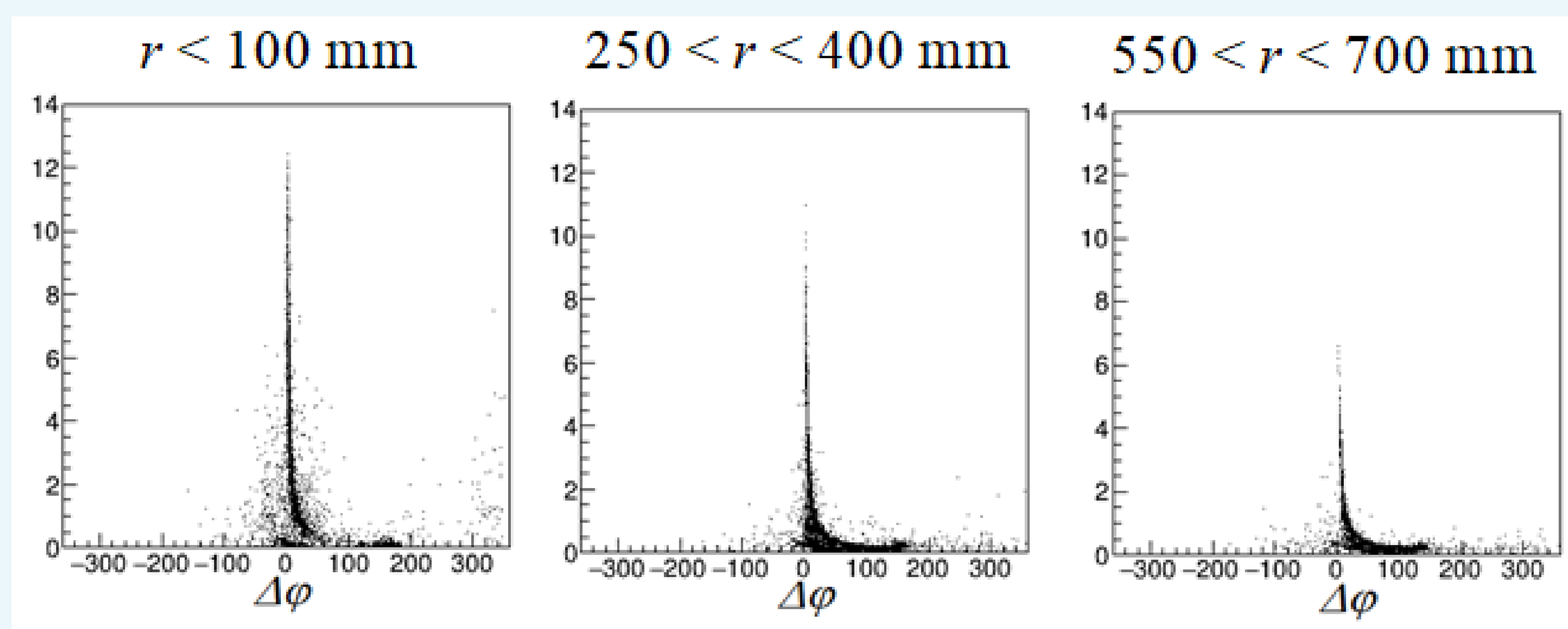
The radial dependence of the charged particles loads were obtained for one of BBC modules for cases when the magnetic field is turned on (solid line) and off (dashed line). One can see, the magnetic field presence increases the BBC load. This increase is observable for all radii for π^+ and π^-. For protons, the influence of the magnetic field is observed more prominently at large radii.



Left: loads of the BBC for B = 1T and B = 0 for one of BBCs. **Right**: ratio of loads

II. Track rotation in the magnetic field.

The magnetic field changes particle trajectory. The rotation angle $\Delta\varphi$, depends on magnetic field as well as particle momentum and charge. The correlation of the $\Delta\varphi$ and p for each particle shows that the smear of the $\Delta\varphi$ – distribution increases with the increase of BBC radius r. For pions, large deviations ($\Delta\varphi >$ 50°) is corresponds to the momentum range $p <$ 0.4 GeV/c. The particles with the small longitudinal momentum (and large transverse momentum $p\perp$) pass to the upper BBC layers. The simulation at 3, 10 and 27 GeV shows that the particles number with the $\Delta\varphi >$ 50° is increased with the energy increasing. It is due to the increasing fraction of particles with large transverse momentum with increasing collision energy.



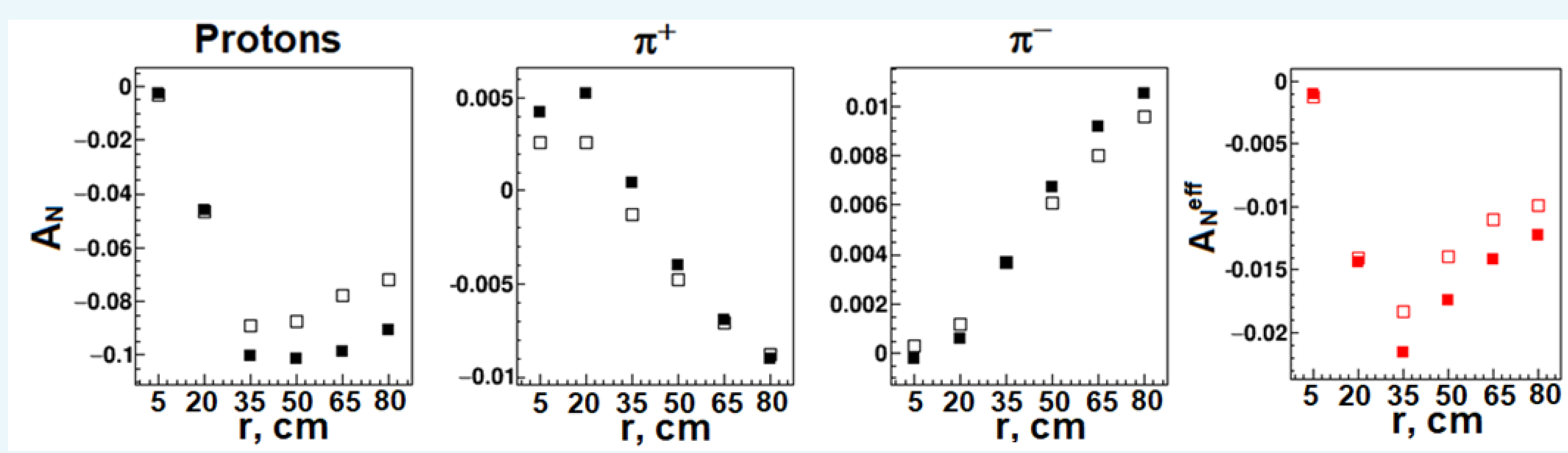
$\Delta\varphi$: p – correlation for pions in dependence of the BBC radius

III. The magnetic field influence on the inclusive charged particle production asymmetries.

The presence of the magnetic field leads to a change of the loads as the function of x_F and p_t up to 20% and 10%. The analyzing powers A_N have been calculated by the Abramov V. V. [1] for inclusive reaction within the framework of the phenomenological model for chromomagnetic polarization of quarks (CPQ). Also the effective analyzing power A_N^{eff} have been calculated for two cases: B = 0 and B = 1T. The presence of the magnetic field leads to a change of the A_N^{eff} up to 22%.

$$A_N^{eff} = \frac{A_N^p N_p + A_N^{\pi^+} N_{\pi^+} + A_N^{\pi^-} N_{\pi^-}}{N_p + N_{\pi^+} + N_{\pi^-}}$$

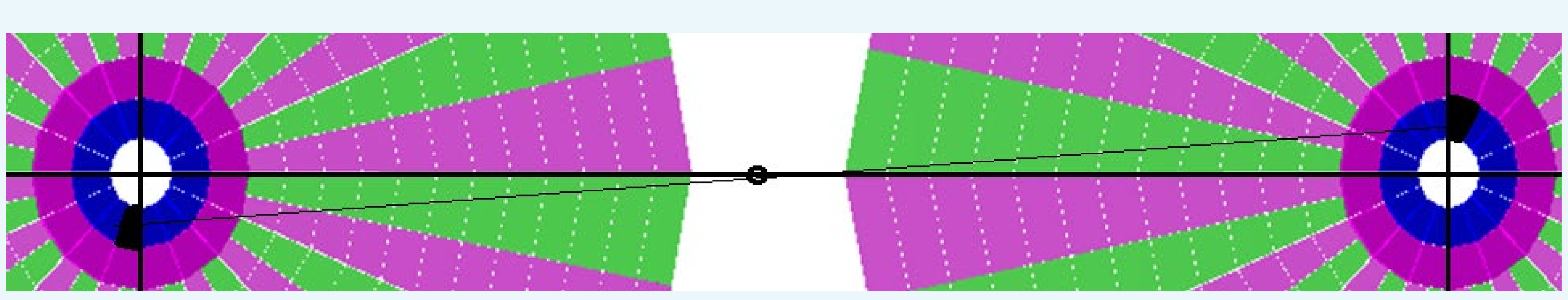
N_p - , $N_{\pi+}$ - *and* $N_{\pi-}$ - number of protons and pions in each BBC layer.



A_N as a function from the BBC radius for B = 0 (■) and B = 1T (□).

IV. *PP* – elastic scattering selection

Elastic scattering of protons can be used for polarimetry control of the colliding beams. Also elastically scattered protons have large momentum and therefore small rotation angle $\Delta\varphi$ in the magnetic field. Preliminary analysis shows [2] that the elastic scattering plays a significant role at all BBC layers at the energies $\sqrt{s}$ < 10 GeV. The comparison of the proton and pion analyzing powers A_N [2] show that the behavior of A^{eff}_N is dominated by the A^{proton}_N. Therefore, the selection of the elastic channel is of interest to estimate its contribution to the behavior of A^{eff}_N. The timing information for each hit in the kinematically corresponding tiles can be used for this purpose. Two corresponding tiles of the BBC first layers have been selected in the figure below as an example. The time distributions of the hits which are present simultaneously in the both BBCs have been obtain. In this way, elastic scattering events can be pre-selected. Also the estimation of the background is necessary. The simulation of the *pp*-interaction with and without of the elastic channel must be performed for this purpose.



Two corresponding tiles of the BBC first layers.

[1] Abramov V. V. JPS Conf.Proc. 37 (2022) 020901

[2] Terekhin A.A. Phys. of Atomic Nuclei, V 87, № 2, p. 44 (2024)