Simulation of the pp - scattering for the Beam-Beam Counter at SPD at NICA

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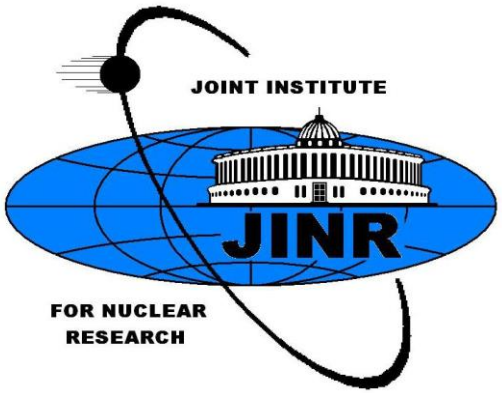
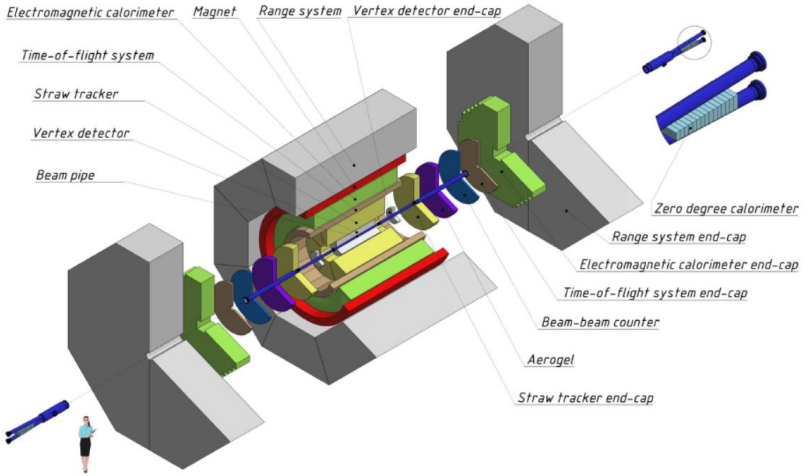


Spin Physics Detector (SPD)

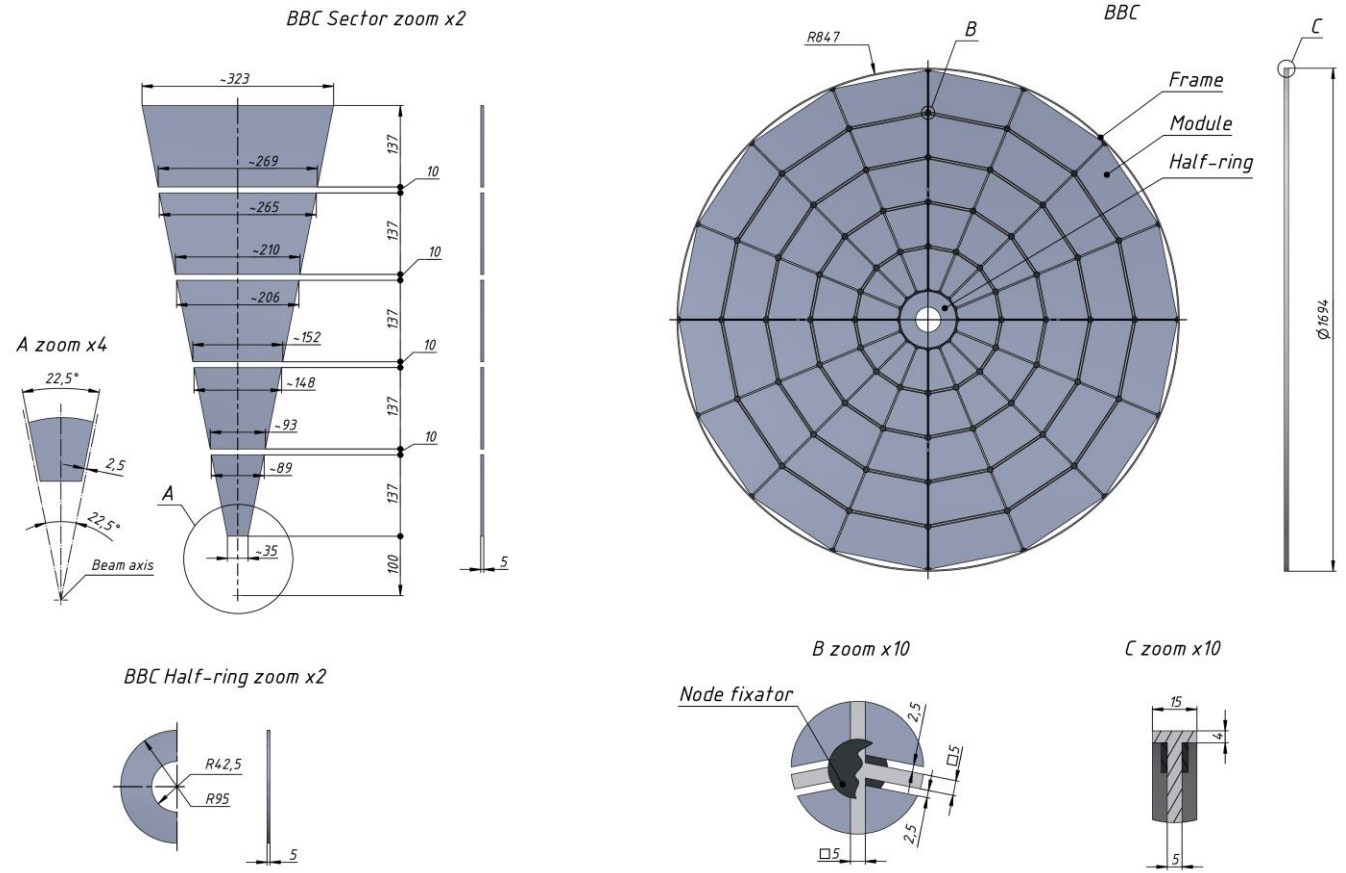
The SPD detector is being created as a universal setup for the comprehensive study of gluons in protons and deuterons the centre-of-mass energy up to 27 GeV and luminosity of up to 10^{32} cm^{-2} s^{-1}. This setup is being planned to be placed in one of the two beam collision points of the NICA collider and includes the vertex detector, straw-tube based tracking system, time-of-flight system, aerogel-based Cherenkov detector, electromagnetic calorimeter, muon (range) system, pair of beam-beam counters and zero-degree calorimeters.

Pair of beam-beam counters are designed to perform the local polarimetry of the transverse polarized protons and to control the luminosity of the beam collision.



BBC - detector

The SPD will be include the two BBC. In the current design (TDR version) the BBC consist of ~ 80-100 scintillation segments. 16 segments are formed one ring sector. BBC consist of the 6 sectors. The diameter will be equal about 1700 mm. The distance between each detector and point interaction equal Z = 1716 mm. Such configuration will be allowed to cover of the angle scattering range up to θ =25^{o}-30^{o}. The uncertainty of location of the point interaction is expected to be $\Delta Z \sim \pm 300$ mm.



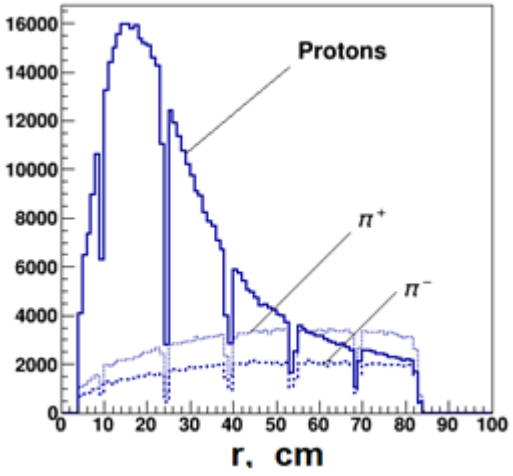
The simulation of the *pp*-scattering

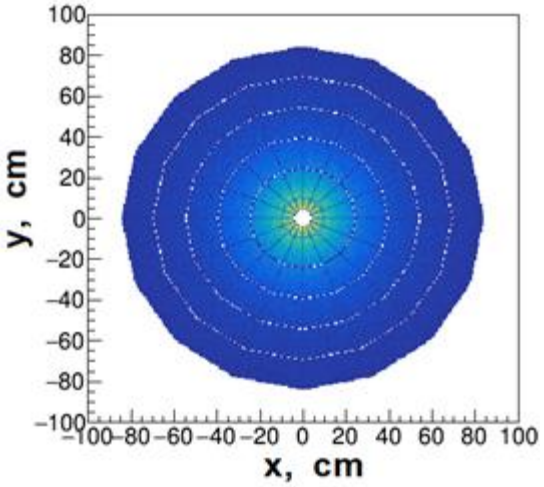
The TDR geometry with small modifications was used for simulation of the pp-scattering. The first sector was divided to the 16 segments. It was done to the obtain the statistical data for the 1/16 part of BBC, which consist from 6 segments.

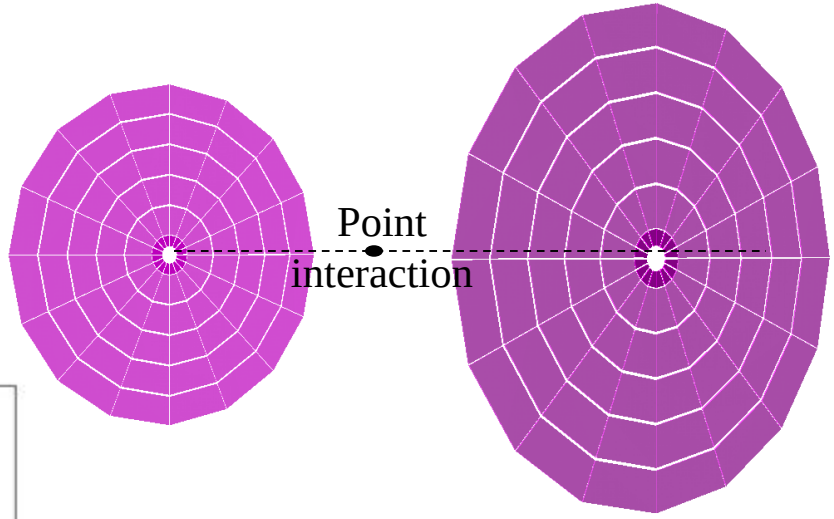
The simulation of the pp-scattering at energies $\sqrt{s}$ = 6.2, 10 and 23.5 GeV have been performed by using the FTF and Py8 generators.

The distributions in the dependence from the BBC radius for protons, π^+ , and π^- particles and the coordinate profiles of events in BBC have been obtained. Analogous distributions have been obtained at 10 and 23.5 GeV.

$\sqrt{s}$ = 6.2 GeV, N_{total} = 1*10^6 events



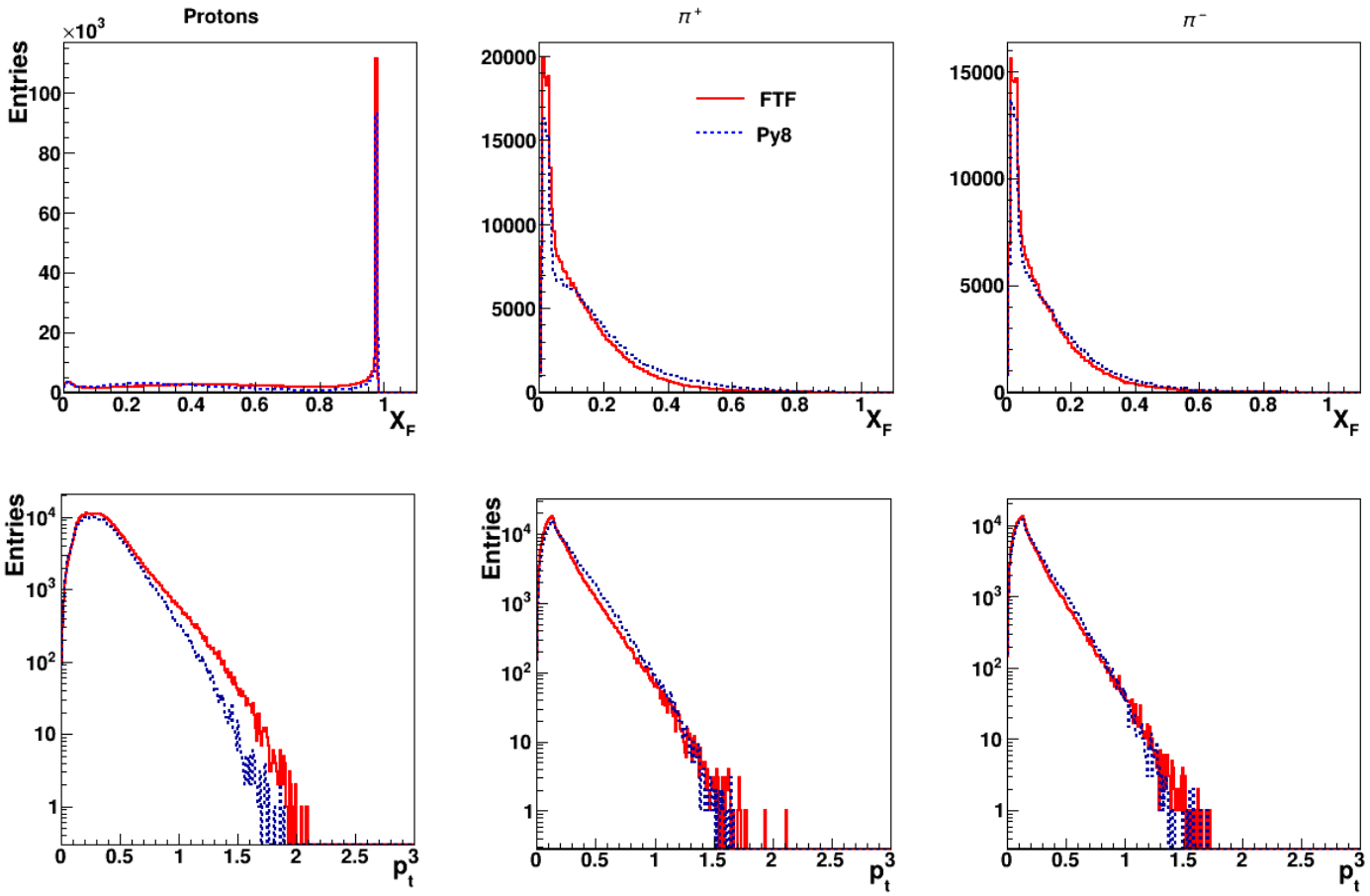




The simulation of the *pp*-scattering by the FTF and Py8 generators

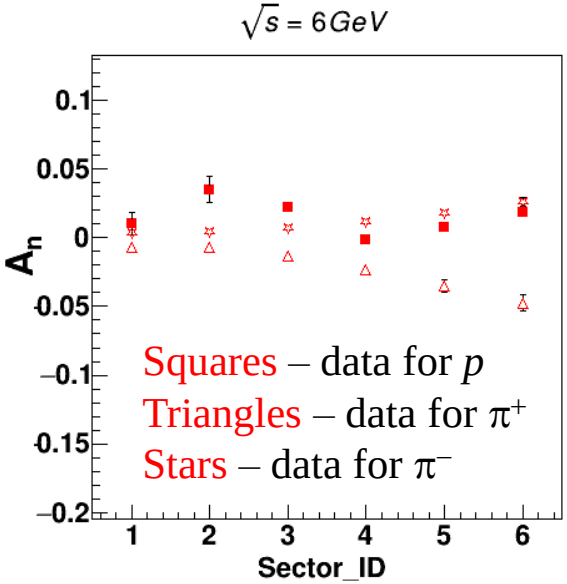
The simulation by using two generators have been performed for 10 and 23.5 GeV. The comparison of the X_F and p_t - distributions is presented for simulation by the FTF and Py8 generators.

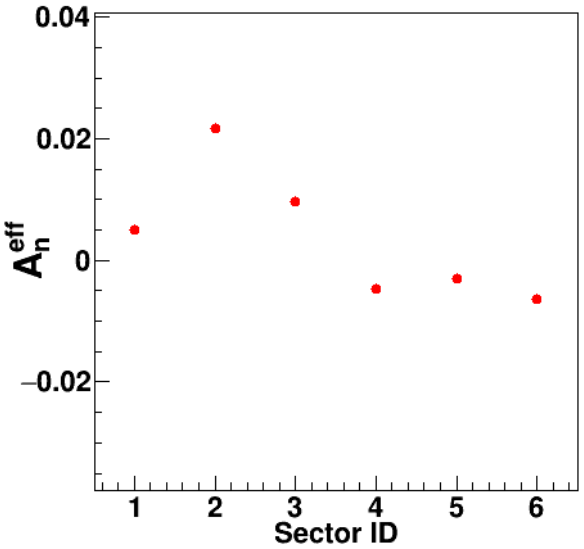
$\sqrt{s}$ = 10 GeV, N_{total} = 1*10^6 events



The single scattering asymmetry in the inclusive pp-interaction

The analyzing powers A_n have been calculated by the Abramov V. V. [1] for inclusive reaction within the framework of the phenomenological model chromomagnetic polarization of quarks (CPQ).





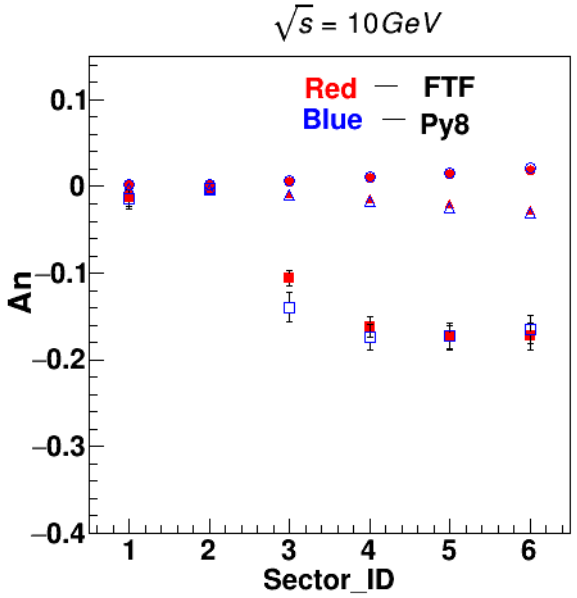
The effective analyzing powers A^{eff}_n have been estimated for these A_n data. The scale of asymmetry is insignificant due to the small values of X_F and p_t in this kinematic area. The non zero value for second (and third) sector is due to the A^{proton}_n (elastic or inelastic scattering) .

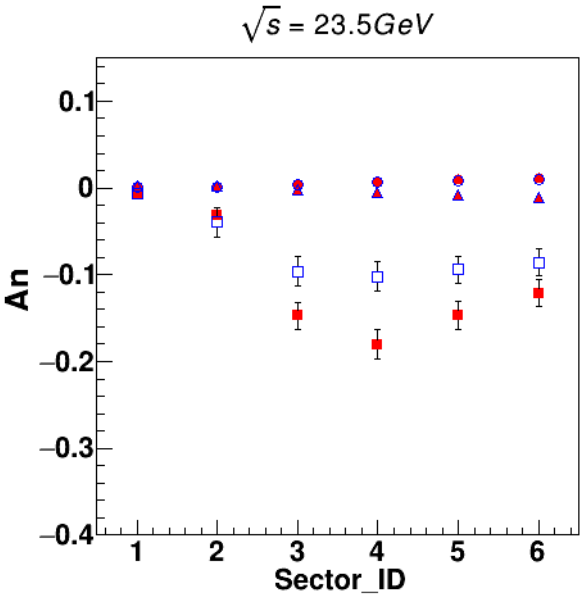
$$A_n^{eff} = \frac{A_n^p N_p + A_n^{\pi^+} N_{\pi^+} + A_n^{\pi^-} N_{\pi^-}}{N_{\text{ch}}}$$

N_{ch} - total charged particles number.

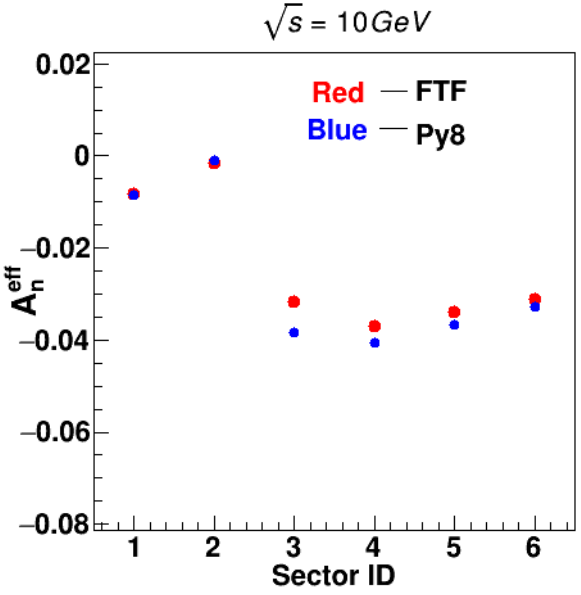
[1] Abramov V. V. JPS Conf.Proc. 37 (2022) 020901

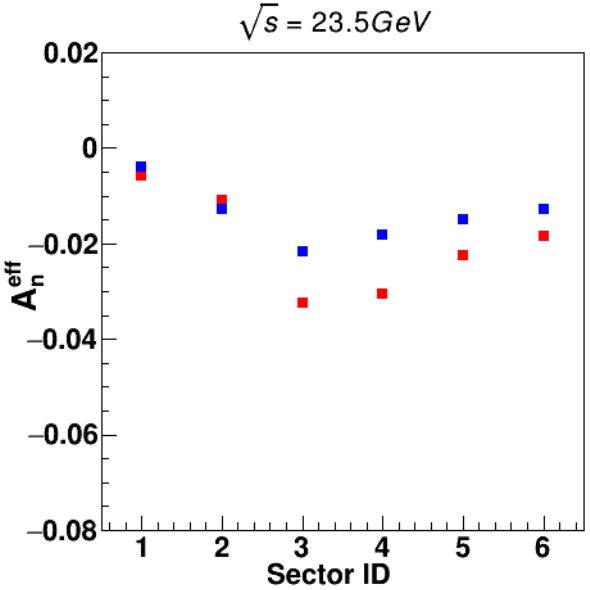
The single scattering asymmetry in the inclusive pp-interaction





Squares – data for *p*
Triangles – data for π^+
Circles – data for π^-



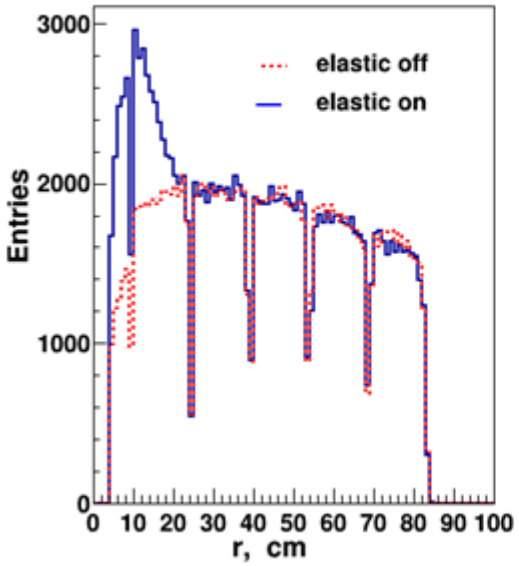


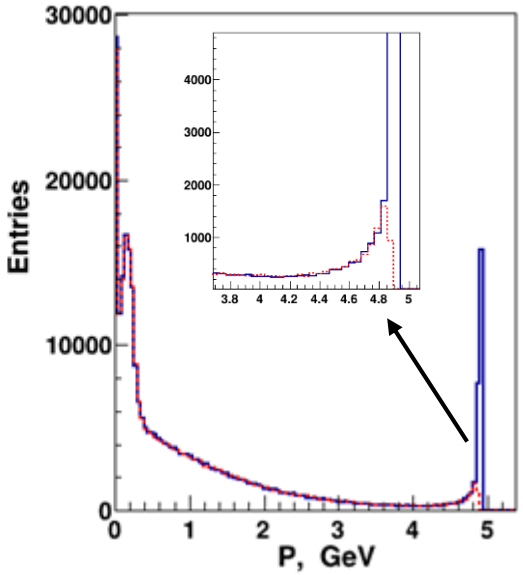
The analogous results have been obtained for 10 and 23.5 GeV. At $\sqrt{s}$>10 GeV the A^{eff}_n has the non zero values for SectorID >2.
It is necessary to selected the elastic channel to estimate the contribution of this channel to the behavior of A^{eff}_n.

The simulation of the *pp*-scattering by the FTF and Py8 generators

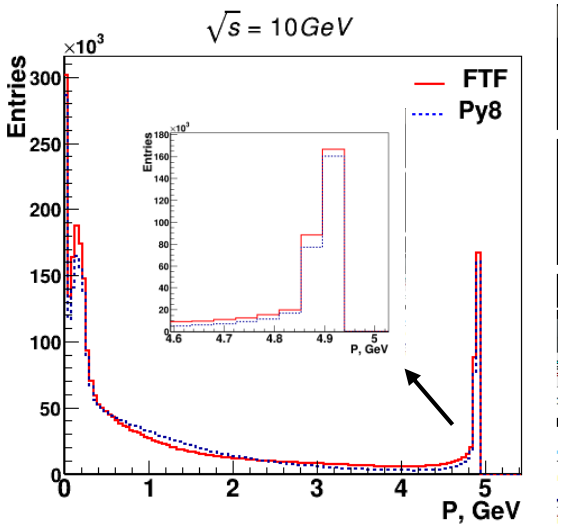
$\sqrt{s}$ = 10 GeV

The turning on and off of the pp-elastic scattering in the Pythia generator.



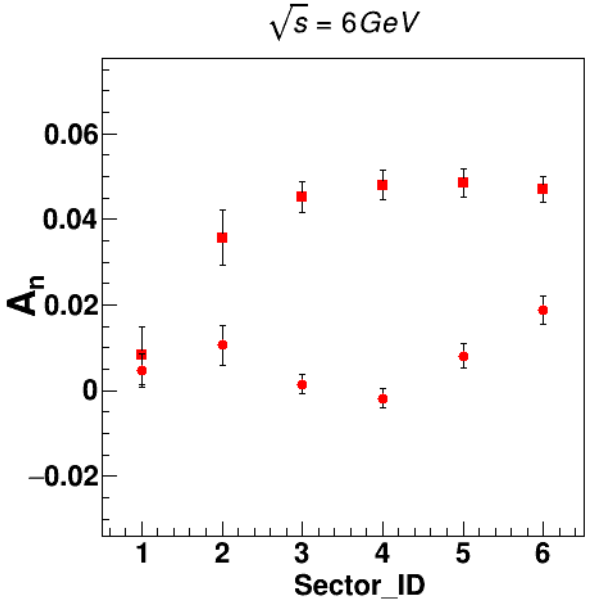


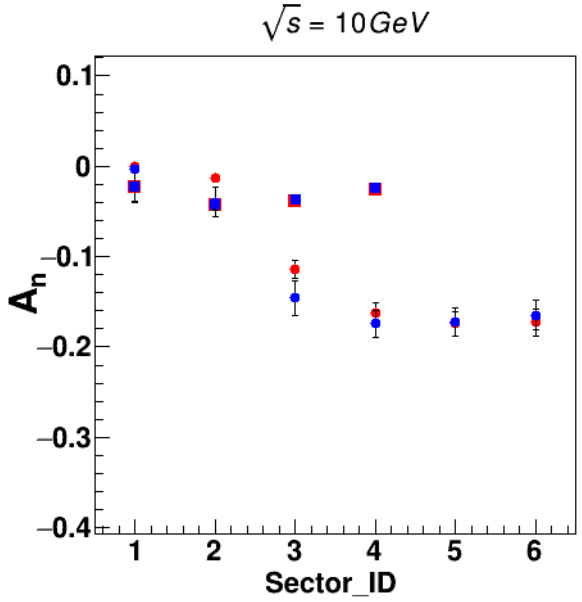
One can see, the elastic events are concentrated at the $P > \sim 4.85$ GeV/c. The comparison of the results from FTF anf Py8 generators is shown that this criterion can be use for FTF generator also.

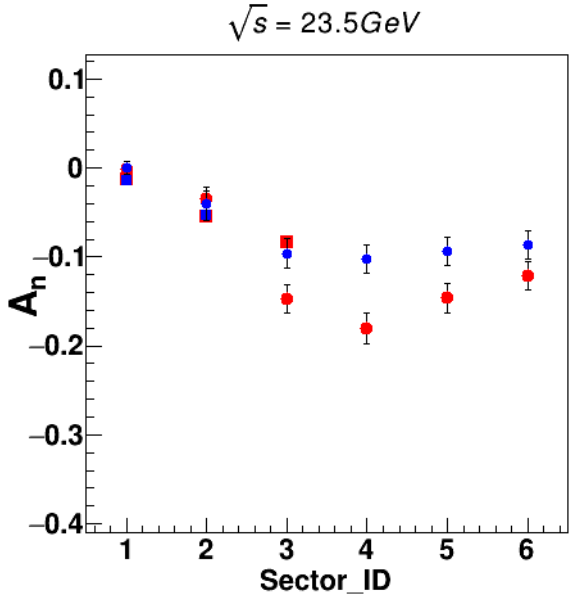


The single scattering asymmetry in the elastic and inelastic pp-interaction

The analyzing powers A_n have been calculated at three energies for elastic and inelastic scattering. One can see, that elastic scattering is significant at the $\sqrt{s} < 10$ GeV. The inelastic scattering, on the contrary, is significant at the $\sqrt{s} > 10$ GeV.







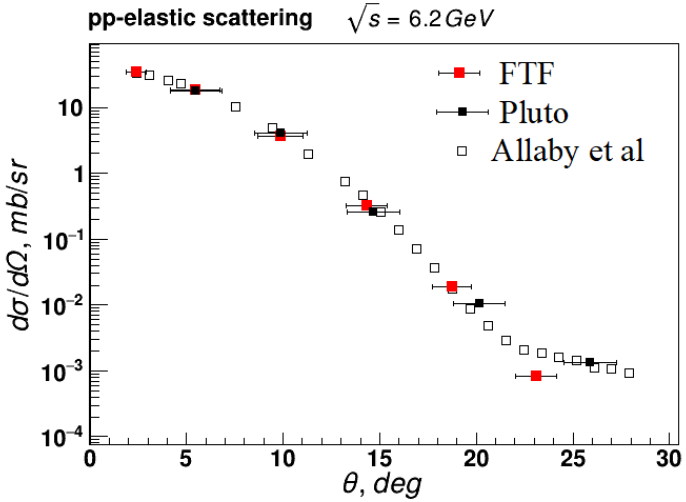
Squares – data for *pp*-elastic scattering
Circles – data for *pp*-inelastic scattering

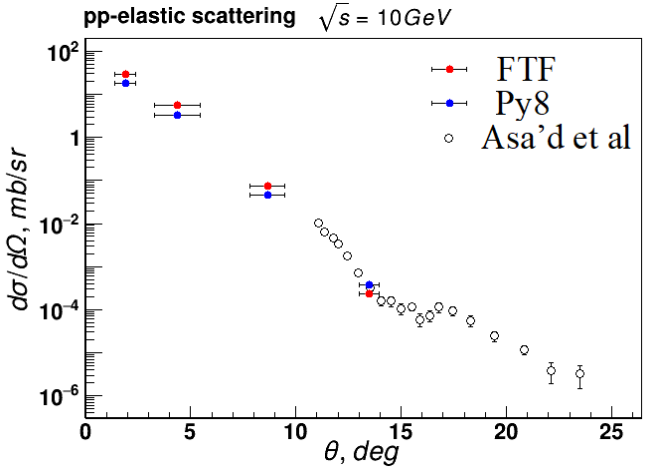
Red – FTF
Blue – Py8

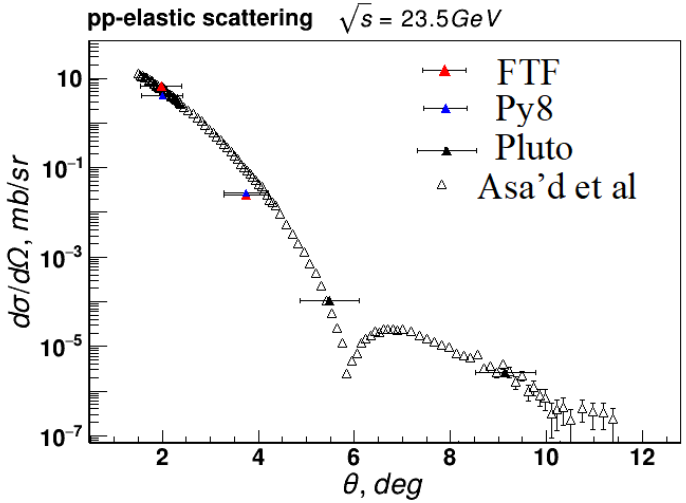
The simulation of the *pp*-scattering by the FTF generator

$\sqrt{s}$ = 6.2, 10 and 23.5 GeV, N_{total} = 1*10^6 events

The angle dependence of the normalized elastic scattering events have been compared with the differential cross section. The simulation results are in agreement with the experimental data and with the results of the simulation by the Pluto generator which was performed early.





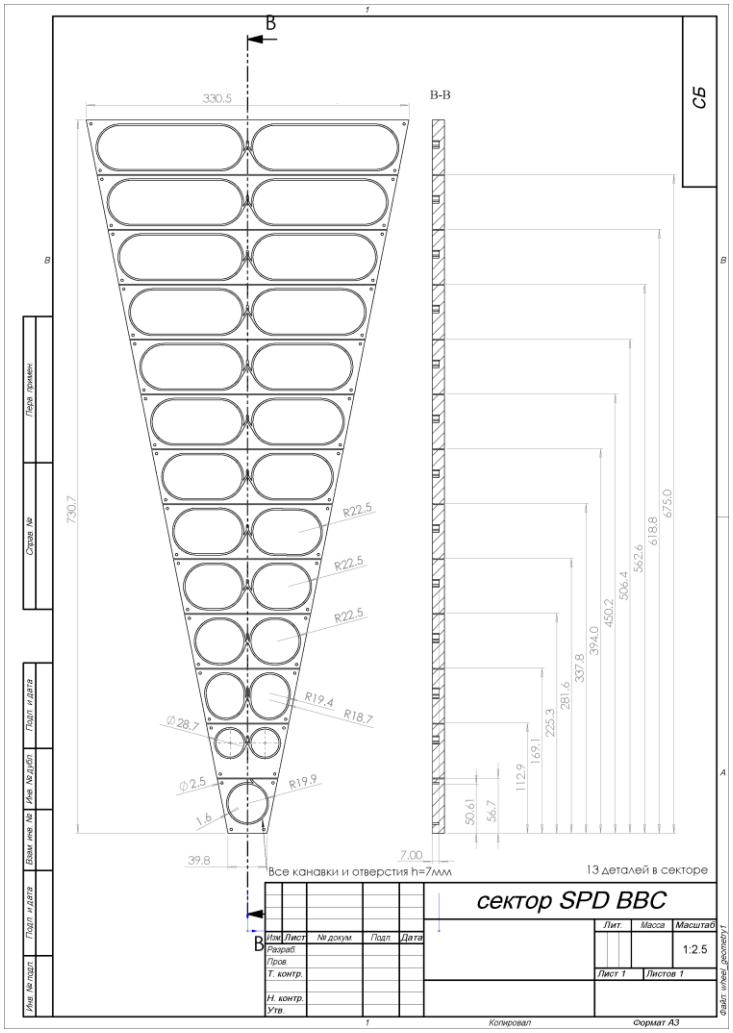


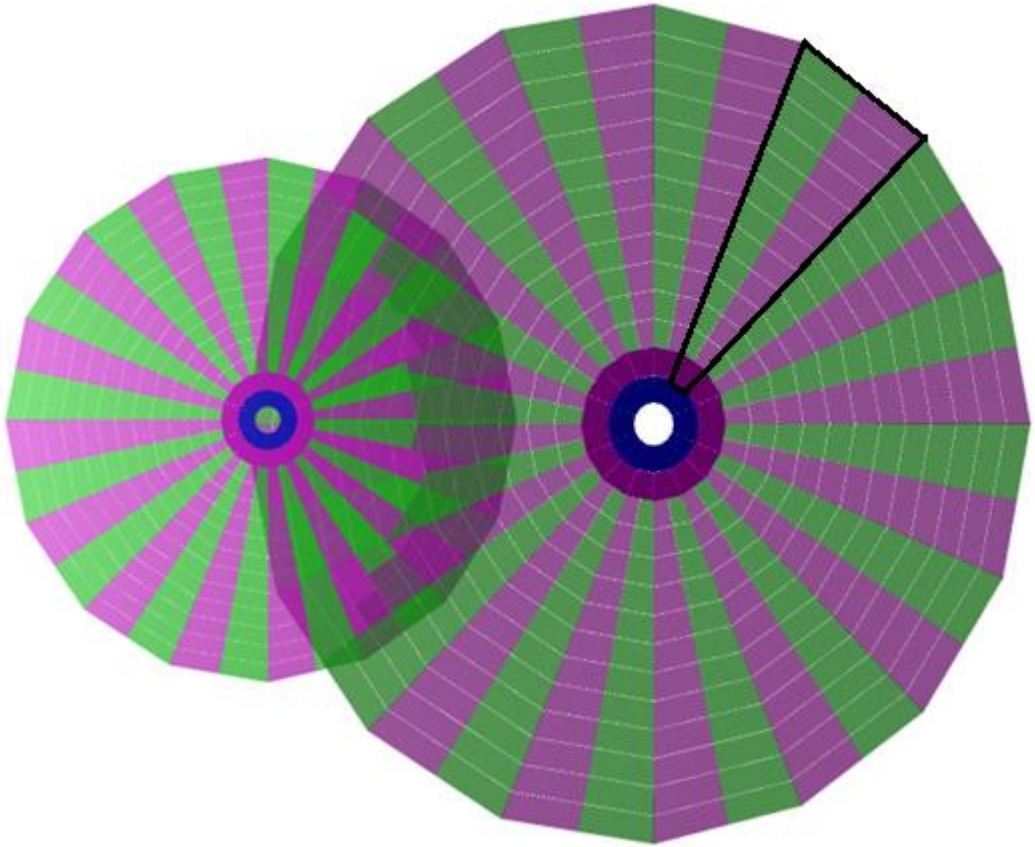
J.V. Allaby et al., Phys. Lett. B. 28, 67 (1968)

Z. Asa'd et al., Phys Lett B. 108, 51 (1982)

New BBC geometry

The new BBC geometry was proposed with an increased number of segments. The new geometry has was implemented within SPDroot framework.

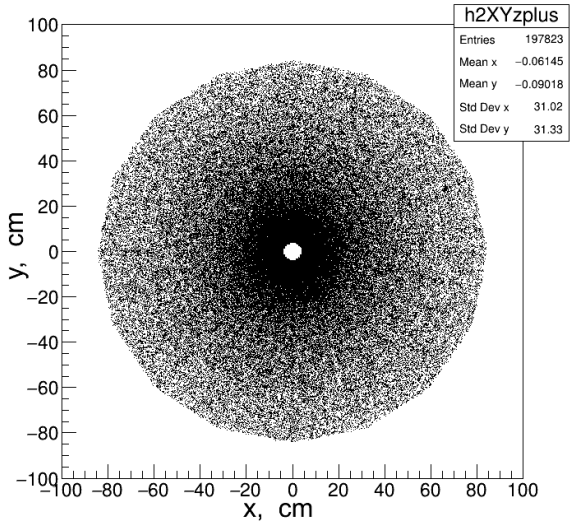


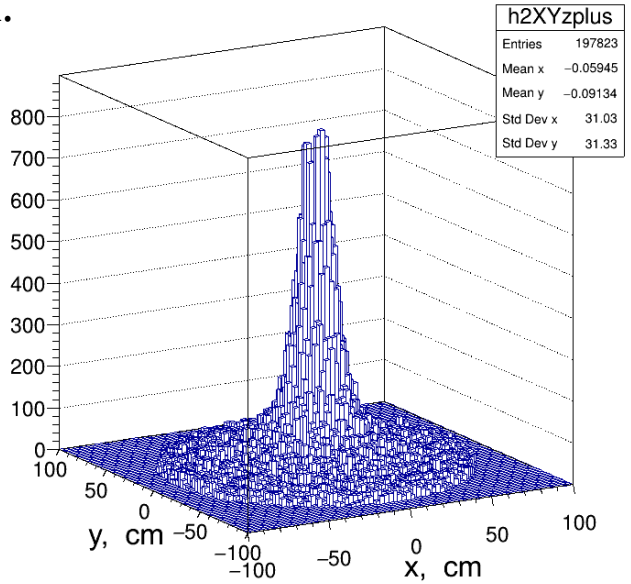


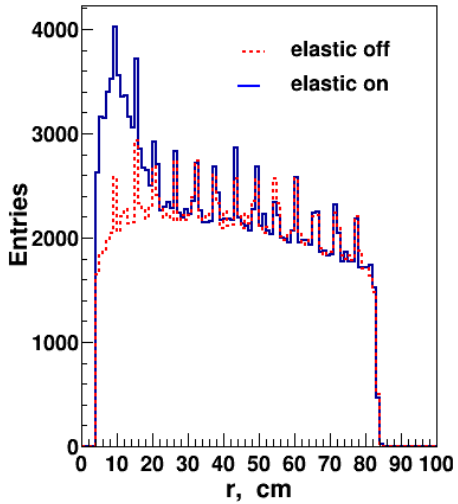
Simulation with the new BBC geometry

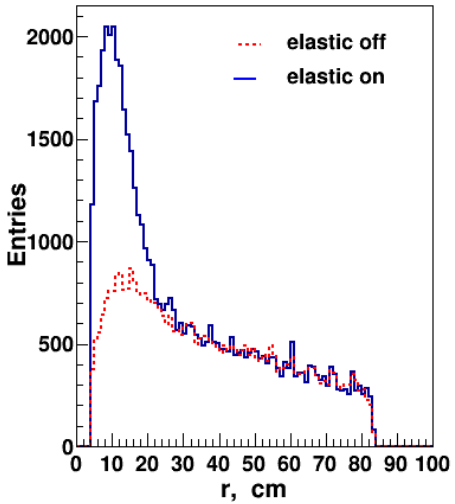
PP – interaction, √s = 10 GeV

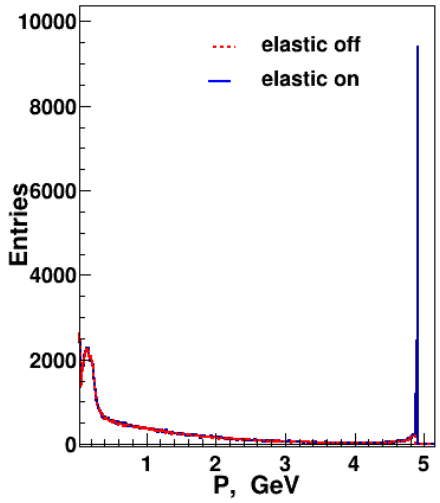
The coordinate profiles of events in BBC and distributions in the dependence from the BBC radius *r* and from momentum *P* have been obtained.











Conclusion

-The first stage of the simulation of the *pp* - scattering at energies $\sqrt{s} < 27$ GeV has been performed for SPD BBC using the FTF, Py8 and Pluto generators within SPDroot framework.

-The effective analyzing powers A_n have been estimated for inclusive reaction at $\sqrt{s}$ = 6.2, 10 and 23.5 GeV within the framework of the phenomenological model chromomagnetic polarization of quarks (CPQ).

-The role of the pp-elastic scattering has been researched. Is shown that the elastic channel gives the significant contribution to the effective asymmetry at the energies $\sqrt{s} < 10$ GeV. The inelastic channel, on the contrary, gives the significant contribution at the energies $\sqrt{s} > 10$ GeV.

-The comparison of the simulation results with the differential cross section experimental data have been performed. The data are in agreement.

-The work with the new highly granular design of the BBC is started.