Towards the ideal detector for fluctuation/correlation measurements at NICA

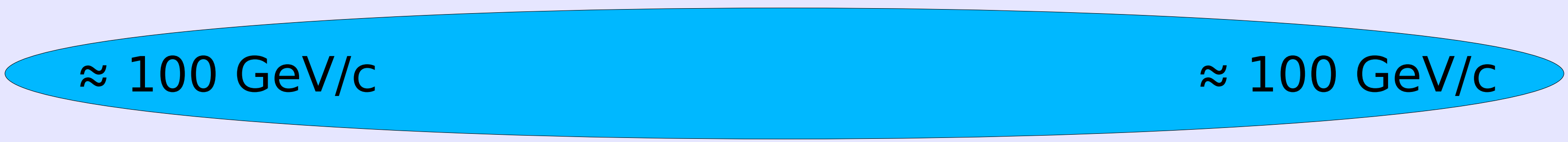
M.G., Dubna, November 1, 2013

The physics priority of ion programme at NICA is a precision study of event-by-event fluctuations and correlations.
This requires measurements of hadron production properties in a large acceptance as well as a low background caused by secondary interactions in the detector material and off-time interactions.

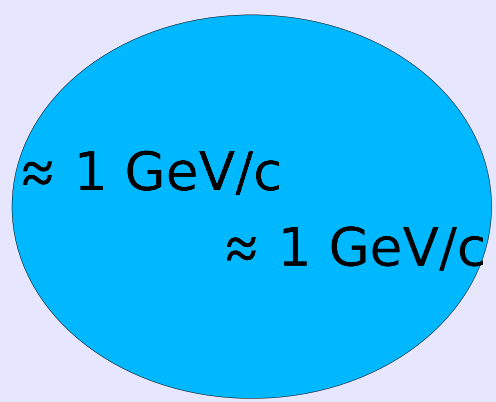
Thus the ideal NICA detector:

- has 4π acceptance,
- is massless and
- runs at a relatively low collision rate (Δt ≈ 10 μsec).

The MPD design resembles closely the set-up of STAR and ALICE detectors. They are determined by the topology of very high energy nucleus-nucleus collisions, namely the majority of hadrons is emitted in two narrow and dense forward-backward jets with a typical hadron momentum of about 100 GeV/c:



The topology of a typical low energy nucleus-nucleus collision at NICA is very different. The hadron distribution is significantly more isotropic, particle multiplicity and density are moderate and typical momenta are only about 1 GeV/c



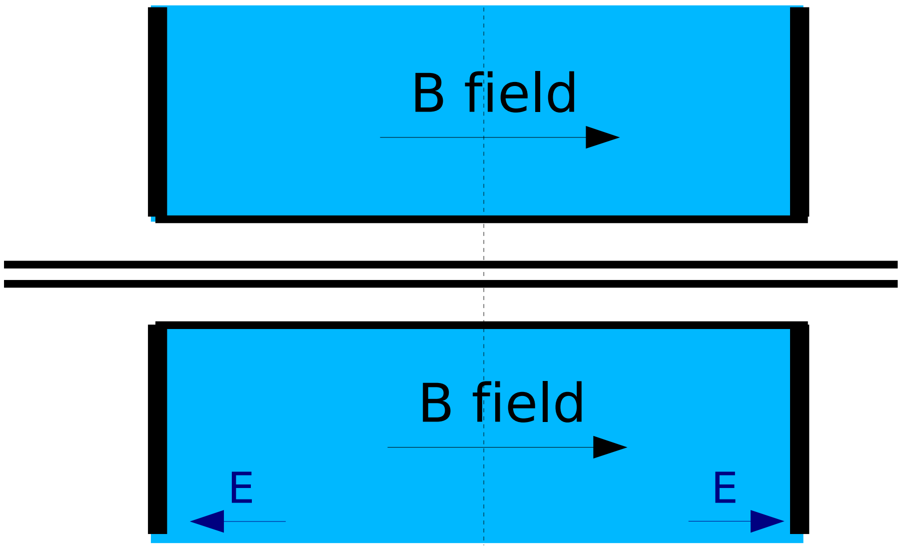
This suggests that the optimal set-up for a detector at NICA may be different than the ALICE and STAR ones.

Due to the topology of very high energy events and physics goals the ALICE and STAR TPCs are cylindrical with the inner cylinder being not instrumented.
The magnetic field is along the beam direction.

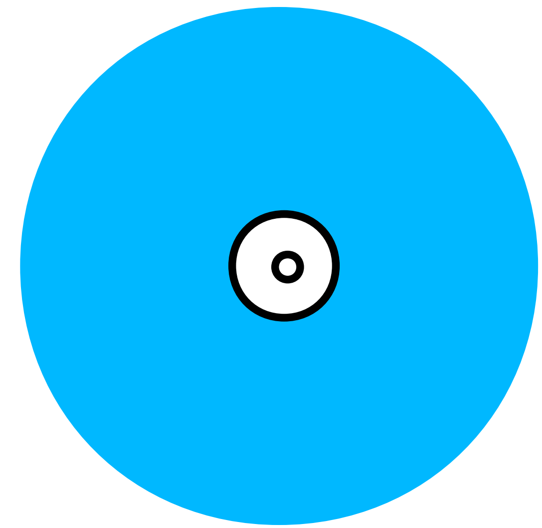
This allows to measure transverse momentum spectra at mid-rapidity in the medium and high p_T domains, as well as correlations in p_T and azimuthal angle in the acceptance.

At the low collision energies, the event topology and particle multiplicity allow to measure particle production in a broad acceptance in the fixed target experiments, e.g., NA49 and NA61/SHINE.
The magnetic field is perpendicular to the beam direction.
This configuration should lead even to a better acceptance in the case of collider experiments.

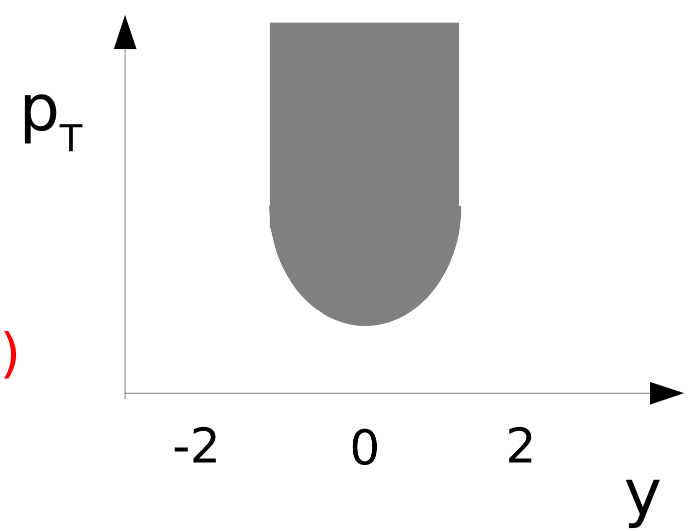
The ALICE-like solution:



central TPC



TPC acceptance

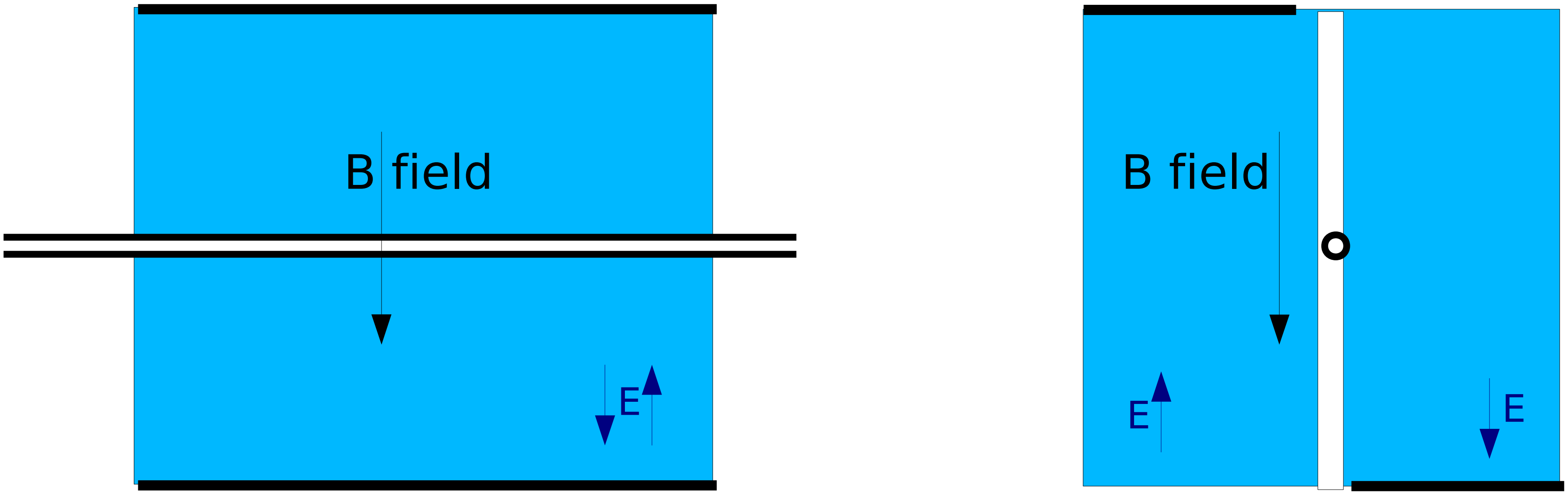


Advantage:
- rotational symmetry

Disadvantages:
- significantly limited y-p_T acceptance,
- material in the TPC acceptance (inner walls) and in the acceptance of side detectors (read-out end caps)

The 2xNA61-like solution:

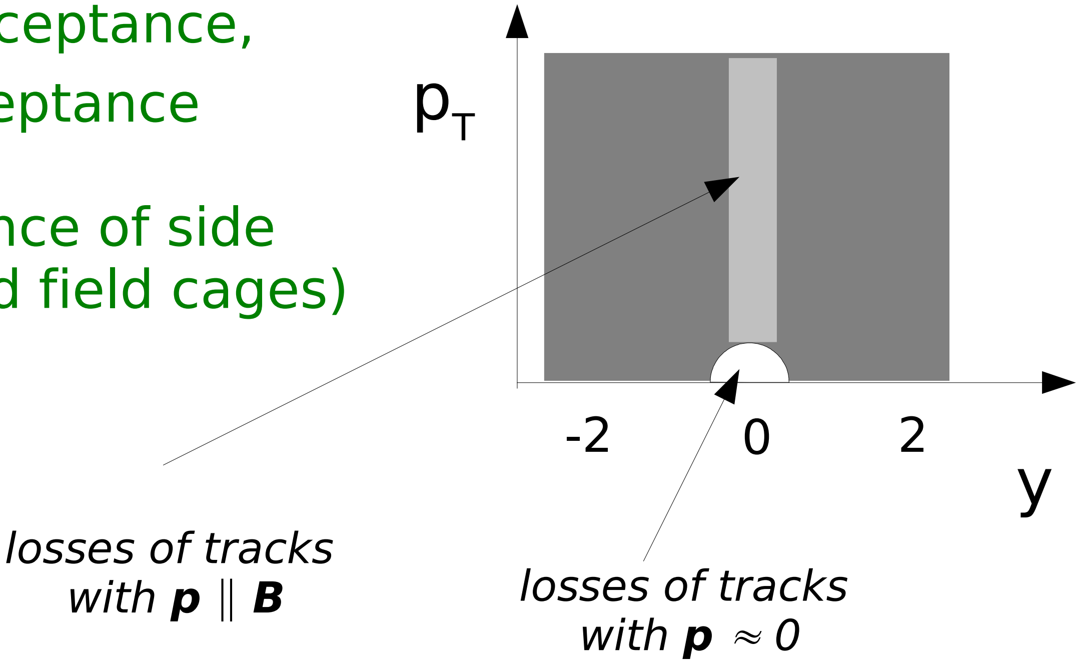
central TPC



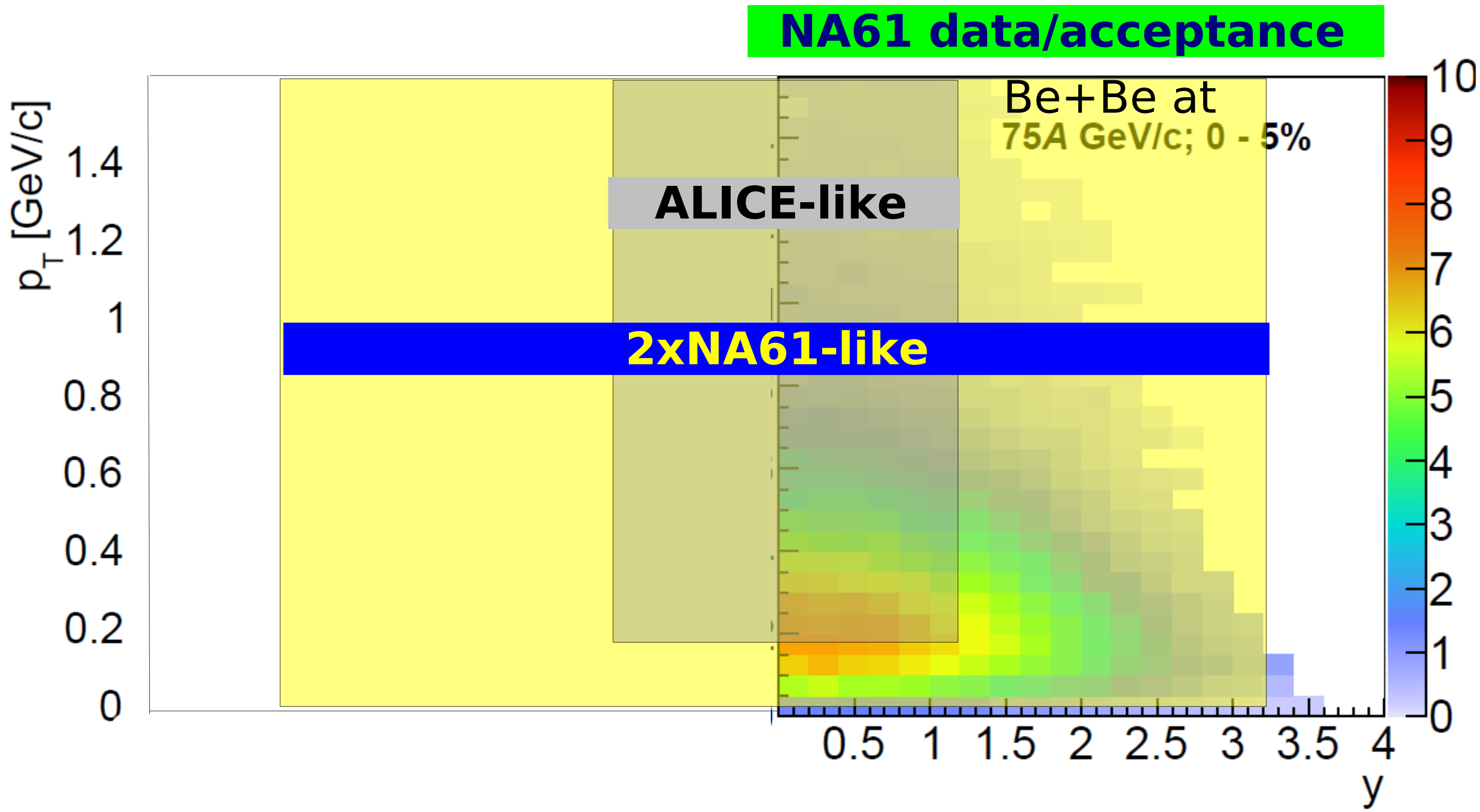
Advantages:
- probably almost complete y-p_T acceptance,
- minimum material in the TPC acceptance (beam pipe only)
- minimum material in the acceptance of side detectors (only foils of the gas and field cages)

Disadvantage:
- no rotational symmetry

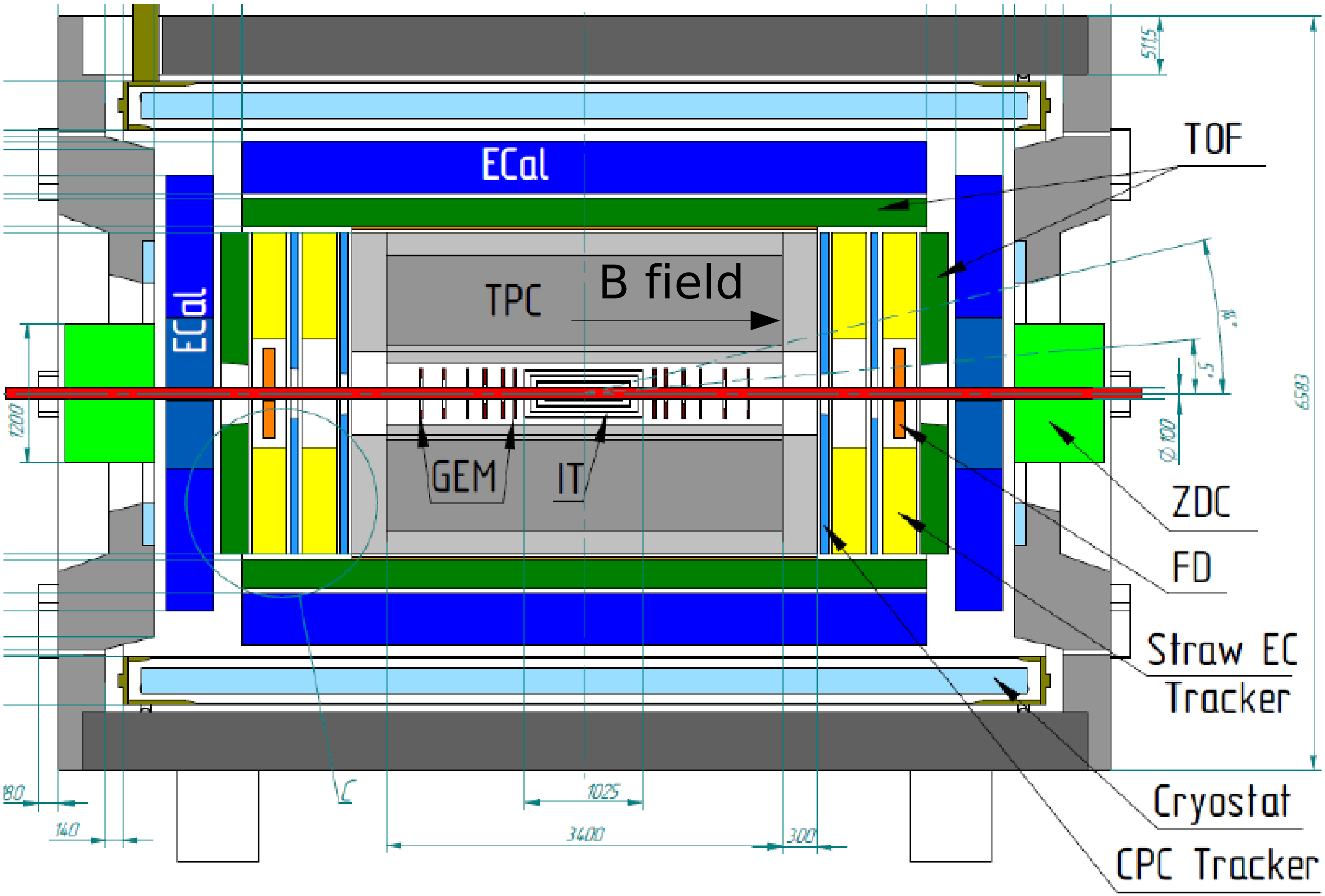
TPC acceptance



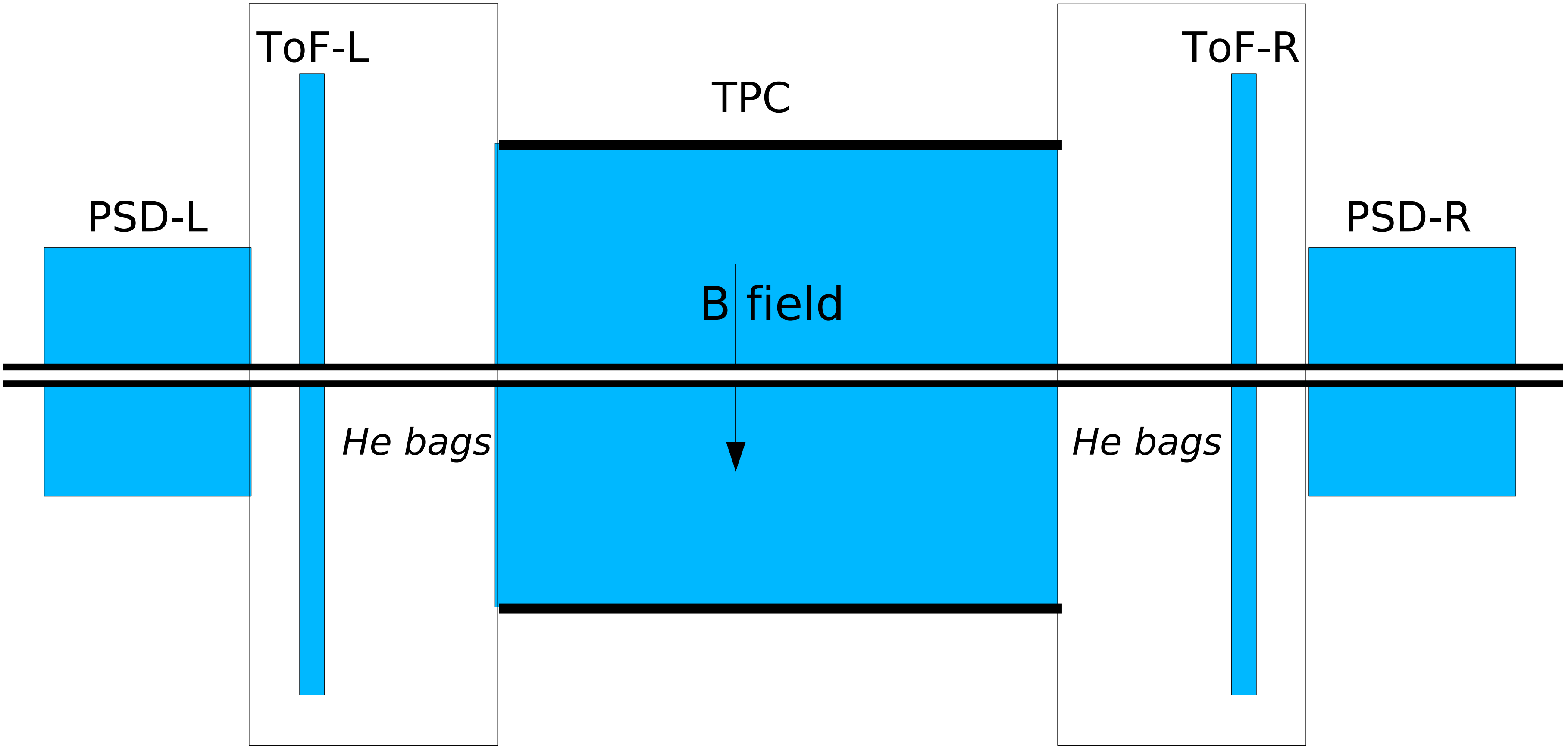
Schematic comparison of TPC acceptances for negatively charged pions at about 11 GeV:



The ALICE-like MPD detector for NICA:



The 2xNA61-like detector for NICA:



Questions to the 2xNA61-like solution
and comments by Rainer Renfordt and Christoph Blume:

- clearly the qualitative argumentation presented here should be first verified by a simple simulation

- beams will be deflected by the B field: how the collider should be modified? *(check the solution used by LHCb)*

- tracks will spiral in all directions: a pixel GEM-based read-out is needed *(check the TPC prototype with the GEM pixel read-out developed for PANDA)*

- a new concept of tracking should be developed: *(check developments for the PANDA TPC at TUM Munich)*

- what to do with the design of the selenoid magnet for MPD *(consider possible use for SPD where di-muons can be measured also in A+A collisions)*