Target fragments detector

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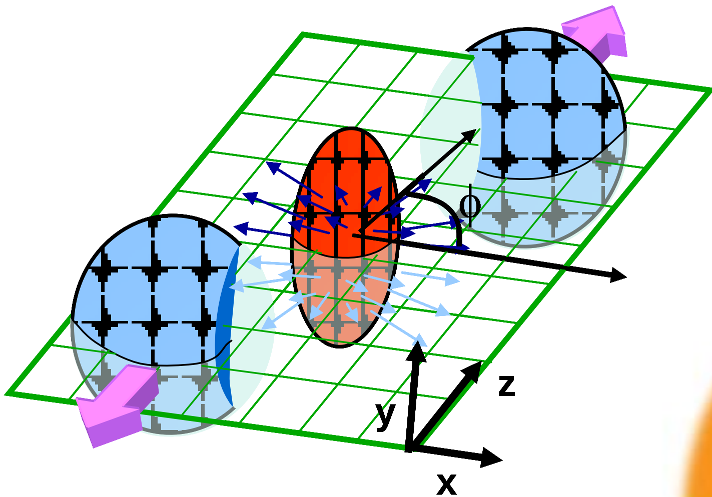
Outline

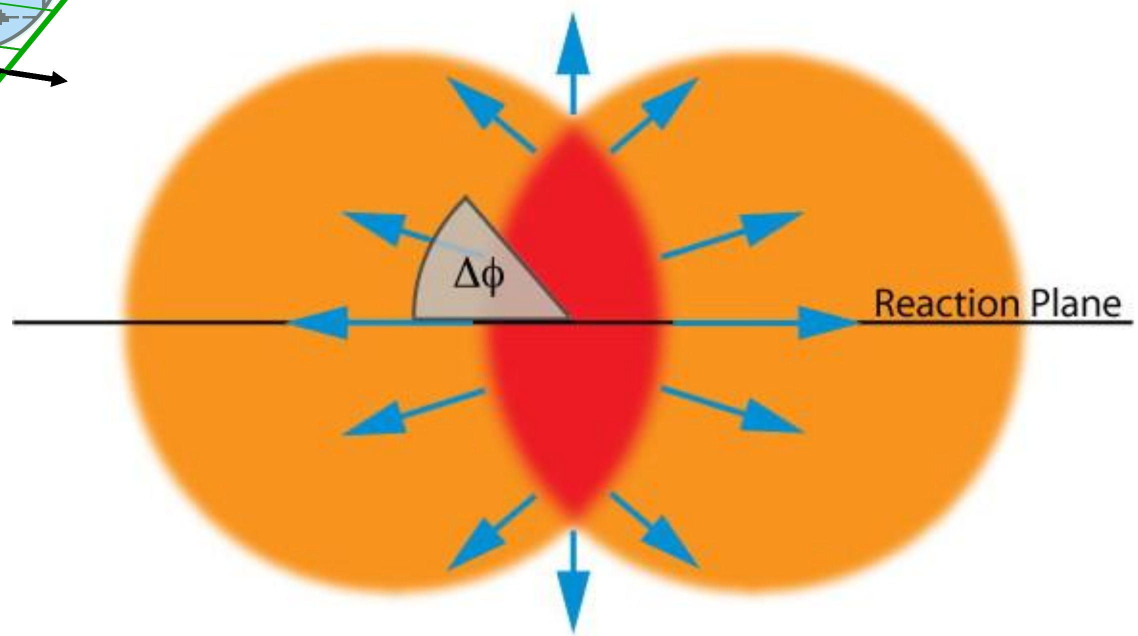
- Physics motivation for TFD
- Observables in relativistic nuclear collisions
- Concept of the nuclear fragments detector

Why fragments of colliding nuclei are important?

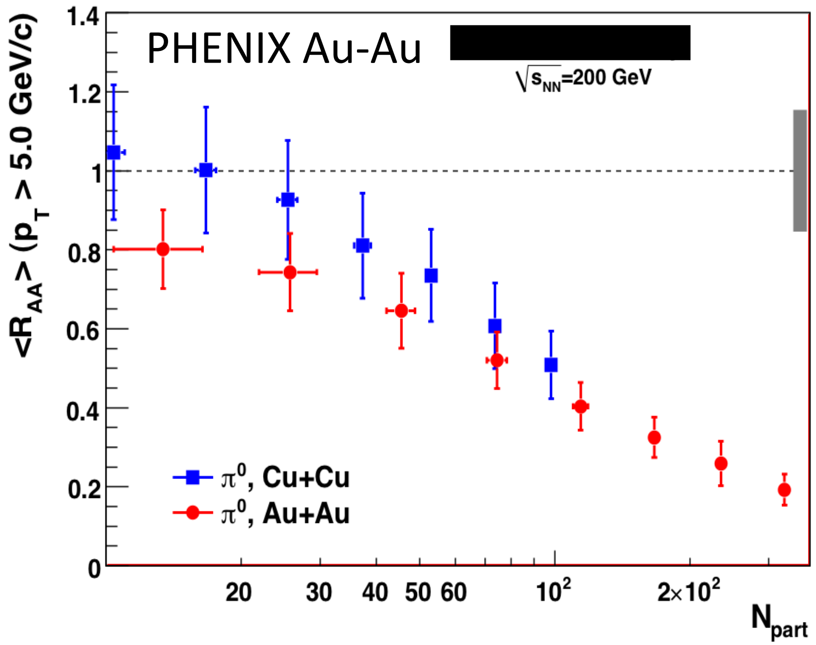
- Nucleus is an extended object with $R=1.2A^{1/3}$ [fm]
  - Carbon: R=2.7 fm
  - Copper: R=4.8 fm
  - Lead: R=7.1 fm
- Centrality of the collision related directly to the number of nucleons participating in reaction, and, thus, to the energy density in the overlapped region
- In peripheral collisions ($b \sim R_1+R_2$) a part of colliding nuclei remains intact , and their nuclear fragments fly almost along the beam direction in C.M.S.
  - Presence of nuclei fragments in the region if high rapidity is a signature of peripheral collisions.
- In the most central collisions (b=0) all nucleons participate in reactions
  - Absence of nuclei fragments at high y reflects the central collisions.
- Azimuthal anisotropy of nuclei fragments is a direct measurement of the collision plane.

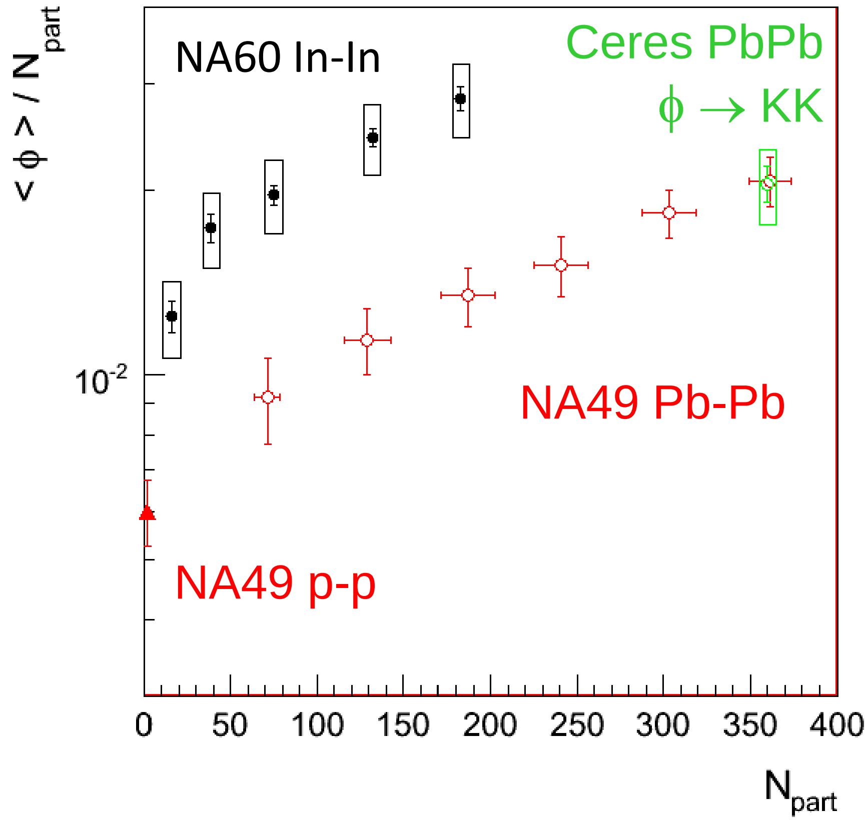
Collision centrality and reaction plane



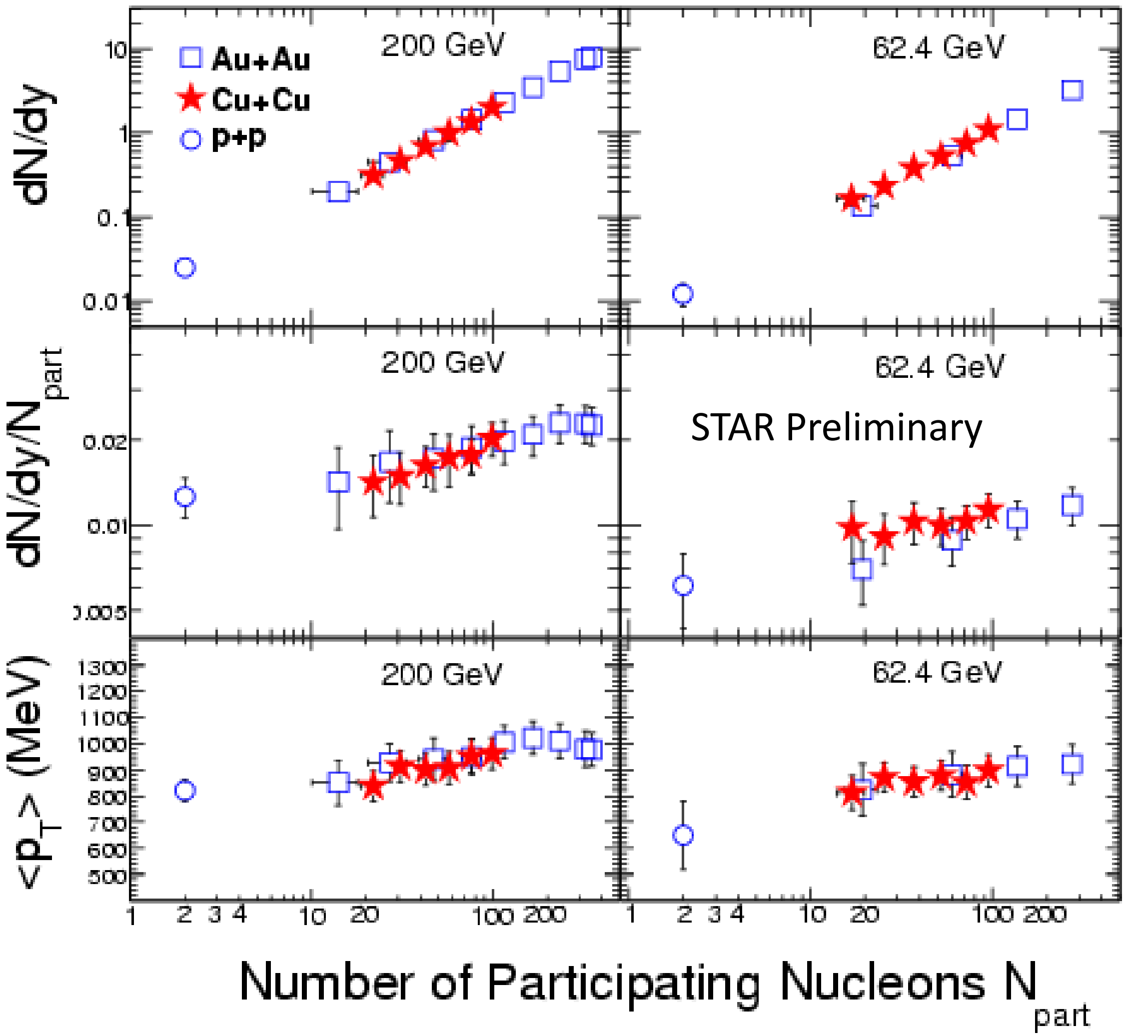


Observables in nuclei collisions and their dependence in centrality





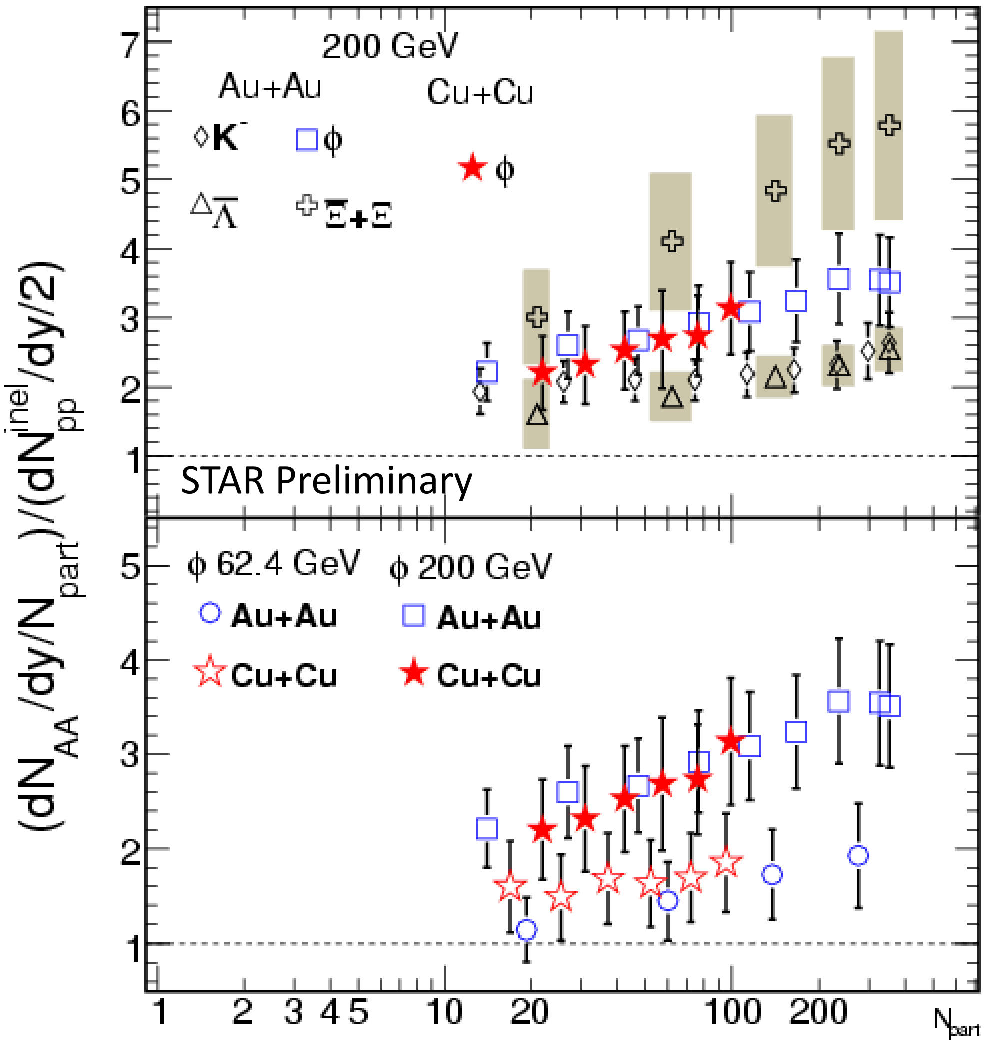
ϕ dN/dy and $<p_T>$



– The dN/dy and $<p_T>$ are similar for Cu+Cu and Au+Au at similar N_{part} bin for the same collisions energy.

– ϕ yields from Au+Au and Cu+Cu collisions depend on the number of participant nucleons only, unlike Kaon and hyperons.

Strangeness enhancement @ STAR

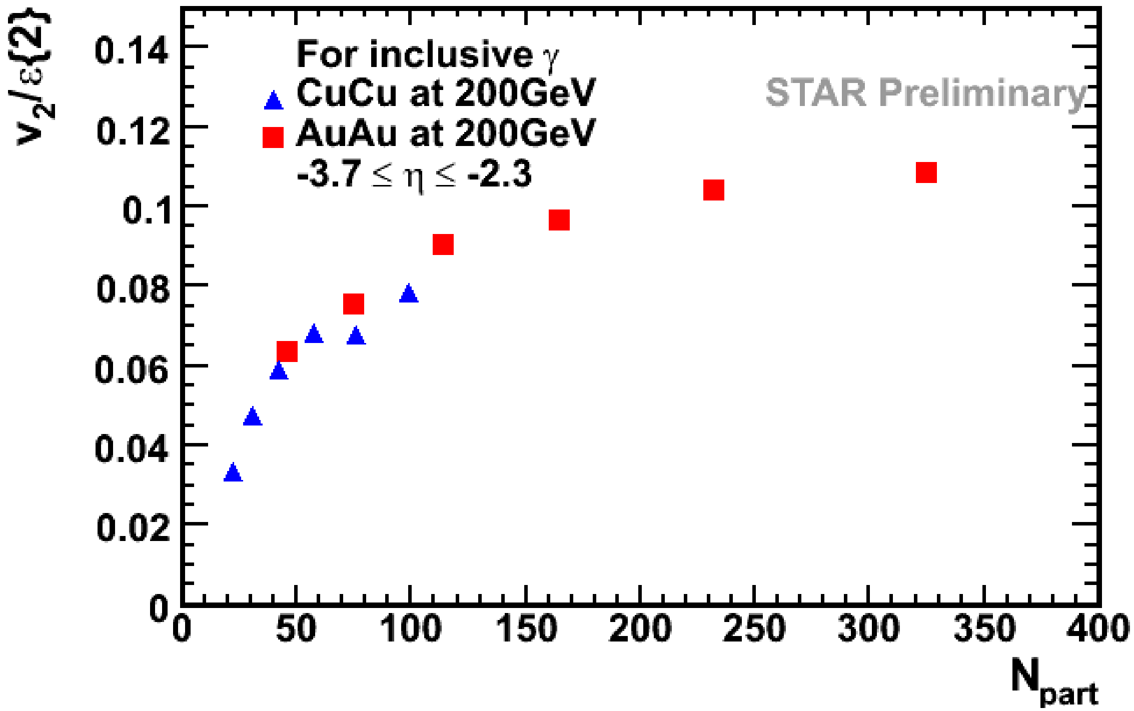


ϕ-meson enhancement shows a distinct collision centrality and energy dependence.

The enhancement factor of the ϕ-meson production (yield per Npart) lies between those of K/Λ and Ξ, and decreases from 200 GeV to 62.4 GeV data unlike hyperons.

Forward Inclusive γ v_2

from Cu+Cu and Au+Au collisions at 200 GeV



STAR PMD Detector used in the analysis

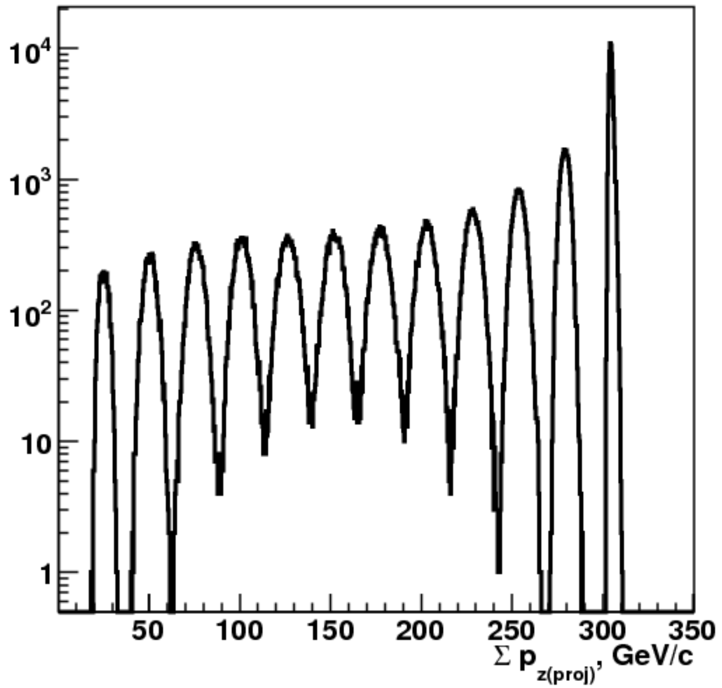
1) v_2 scaled with eccentricity increase with centrality: reflects the strength of collective expansion.

2) For large values of N_{part}, scaled v_2 tends to saturate, as expected in an equilibrium scenario.

Concept of the target fragments detector for Hyperon@U70

- Ion beam of momentum equivalent to 50-GeV protons can be delivered to the beam line 18 after some redesign (rf. to the talk of Yu.Chesnokov).
- UrQMD v2.3 has been used for nuclei collisions: C+C, C+Cu, C+Sn, C+Pb.
- Final state contains stable hadrons (π,K,p,n)
- Wounded nucleons can be identified at off-mass-shell protons and neutrons, but they are not combined to nuclei (d,t,He, etc)

C+C at 25A GeV/c: Total p_z of beam fragments in lab system

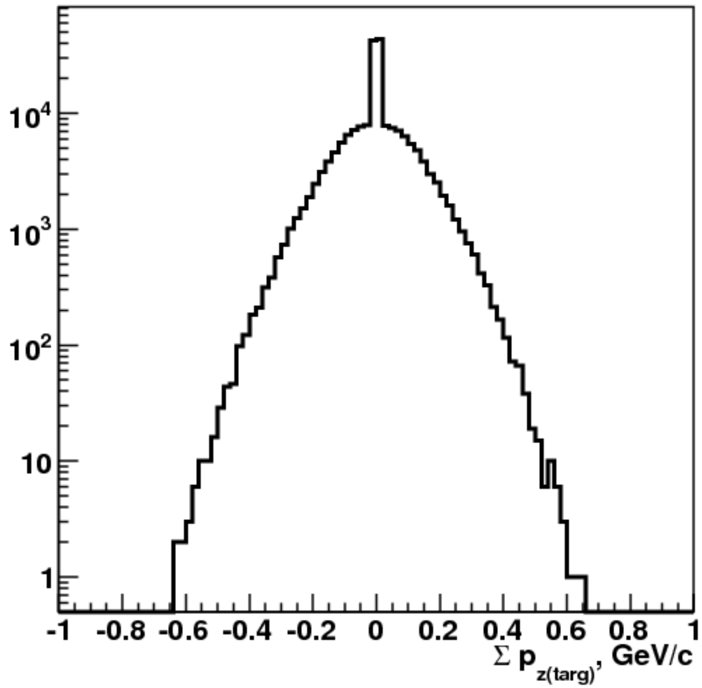


Pro: very clean signal if the total energy is measured by hadron calorimeter installed in the forward region.

Contra: the hadron calorimeter should be installed very far downstream and very close to the beam, which might be not always possible

Rf. A.Sadovsky talk.

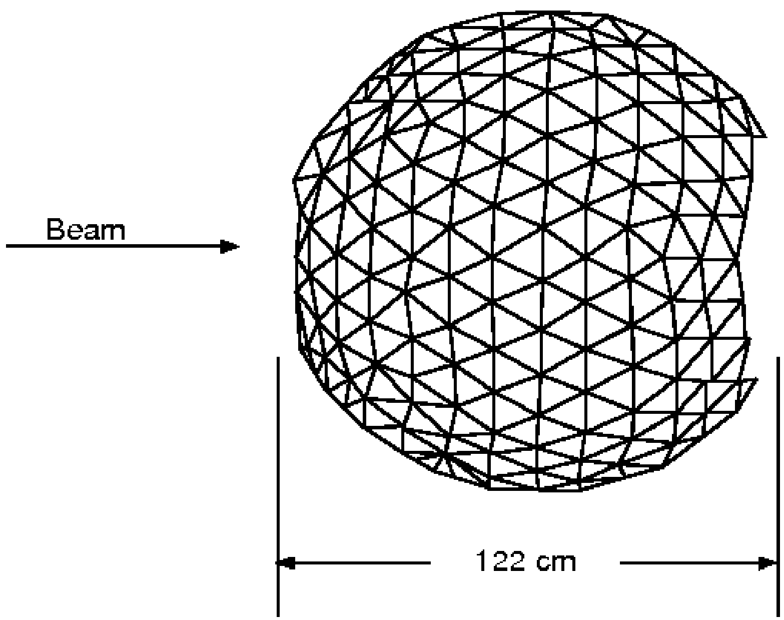
C+C at 25A GeV/c: Total p_z of target fragments in lab system

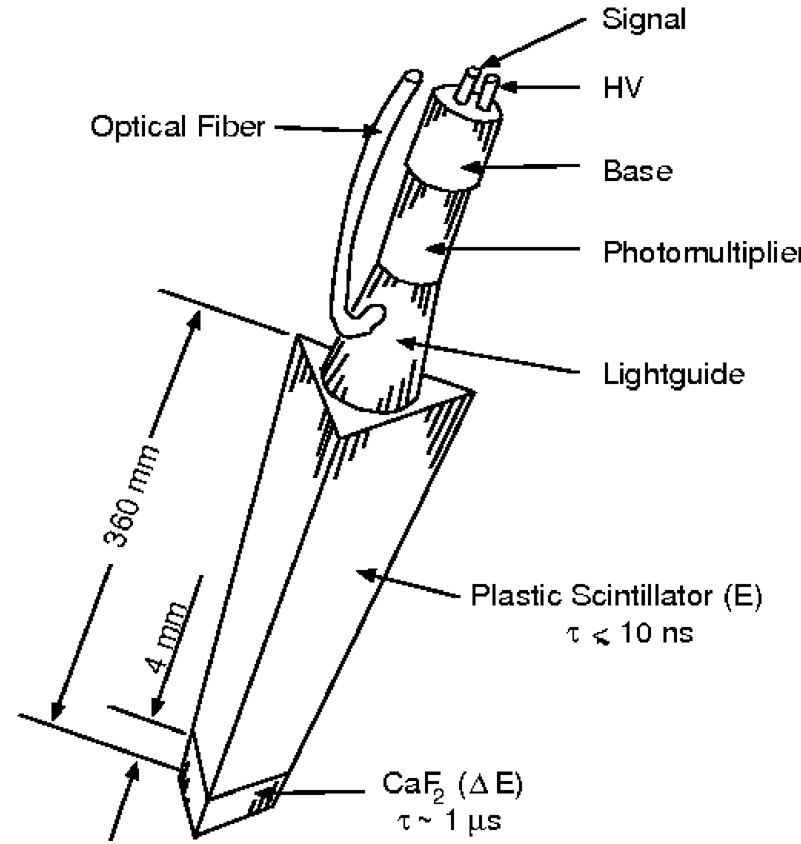


Contra: the target nuclear fragments are very soft and their energy cannot be measured.

Pro: very wide range of the scattering angles of target fragments in lab system. The number of the target fragments can be counted by scintillator detectors surrounding the target

WA98 plastic ball



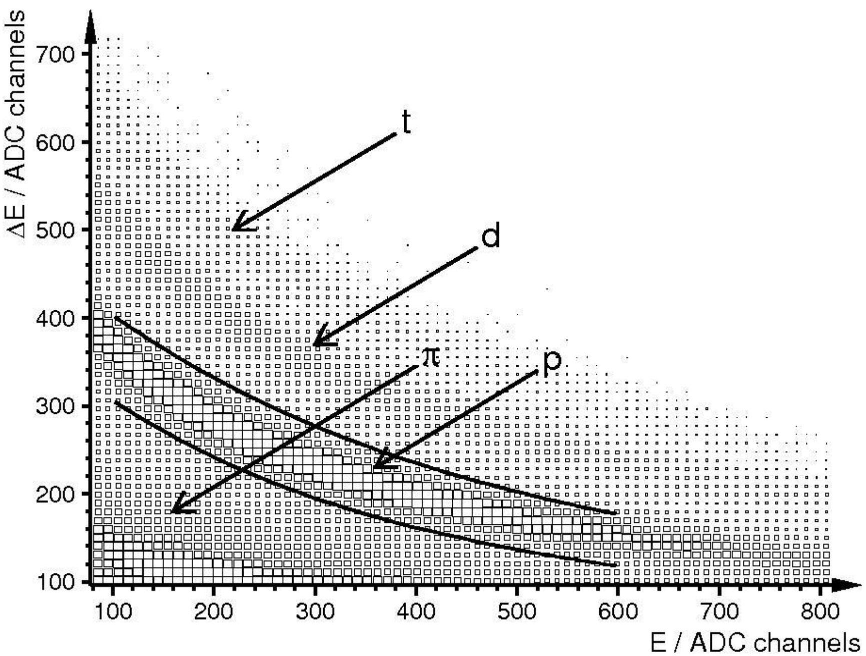


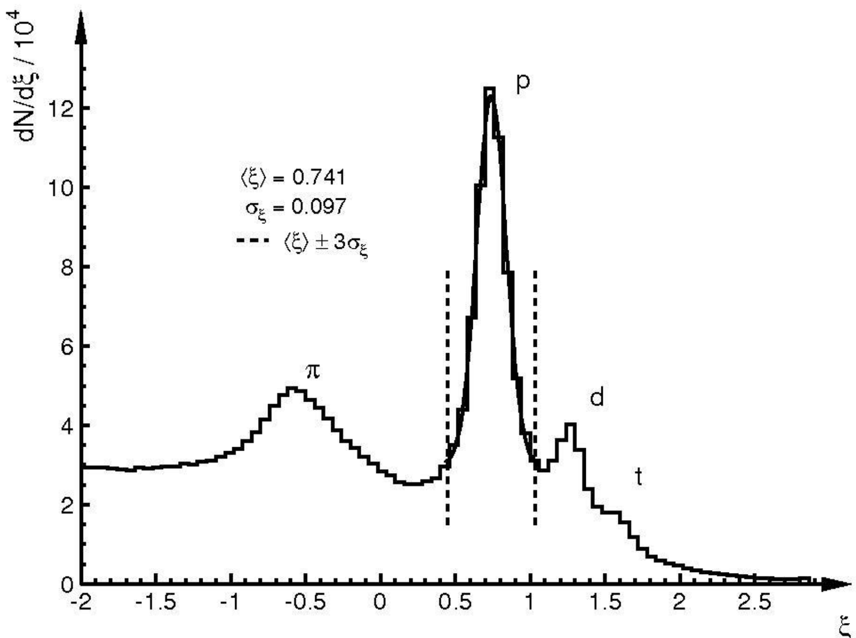
Plastic ball covered 30<θ<160°. It consisted of 655 detectors. Particle ID via ΔE-E.

WA98 plastic ball: PID

- Each module consists of two scintillators with different timing:
  - ΔE is measured by 4-mm think Eu-doped CaF_2 with τ=1 μs. Protont up to 40 MeV are stopped.
  - E is measured by 356-mm think plastic scintillator with τ=10 ns. Protons up to 240 MeV are stopped.
- ΔE is integrated over 1.5-μs after 240-ns delay
- Charged pions are identified by their decays

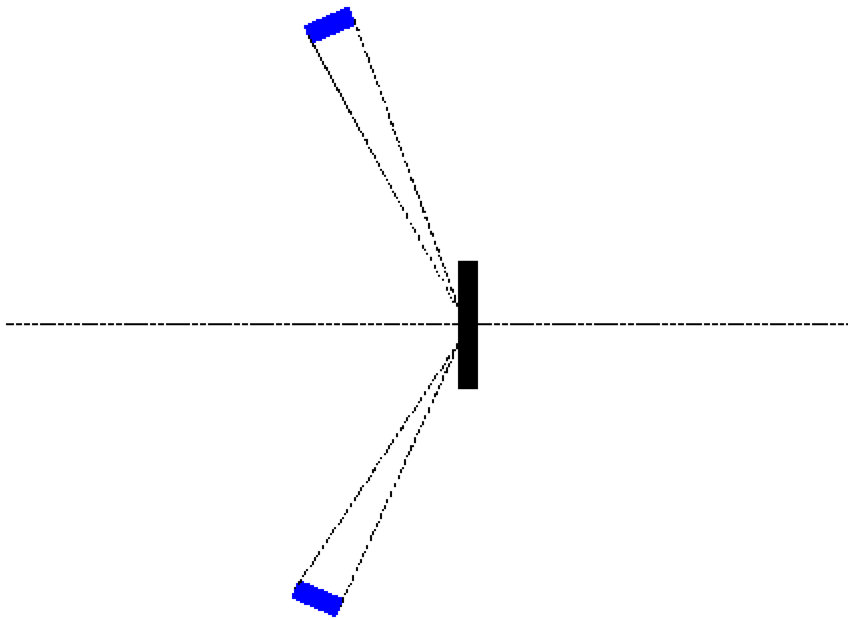
WA98 plastic ball: ΔE-E



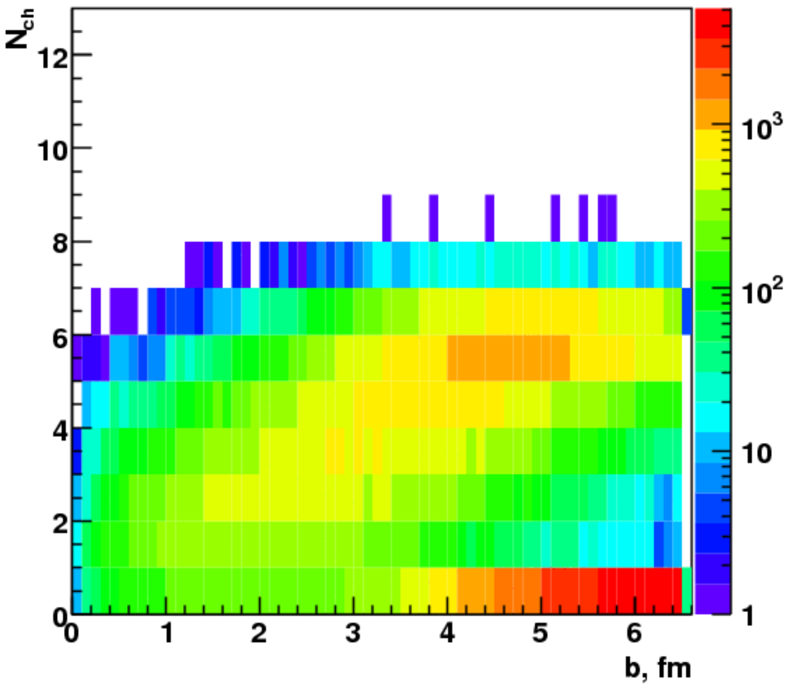


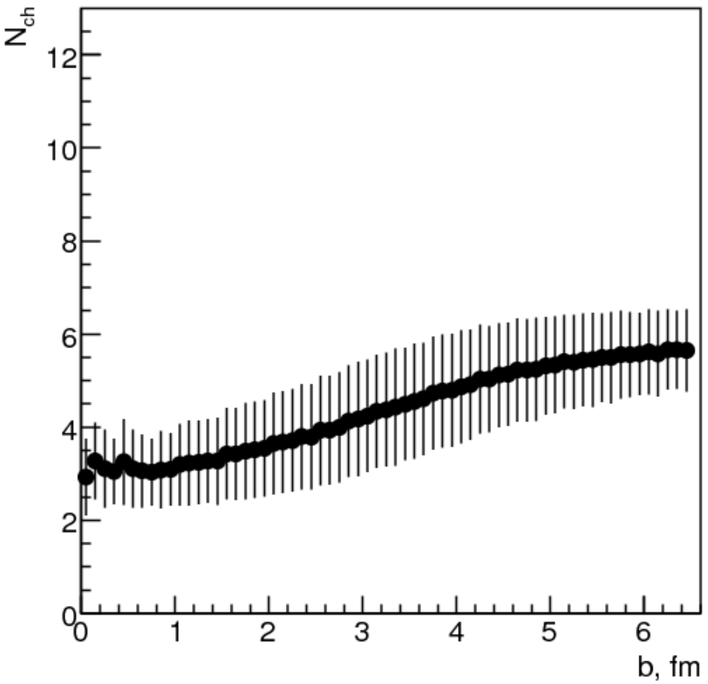
$$\xi = \log(1.95\Delta E) + 0.95(E + 0.5\Delta E) - 11.226$$

Target fragments detector

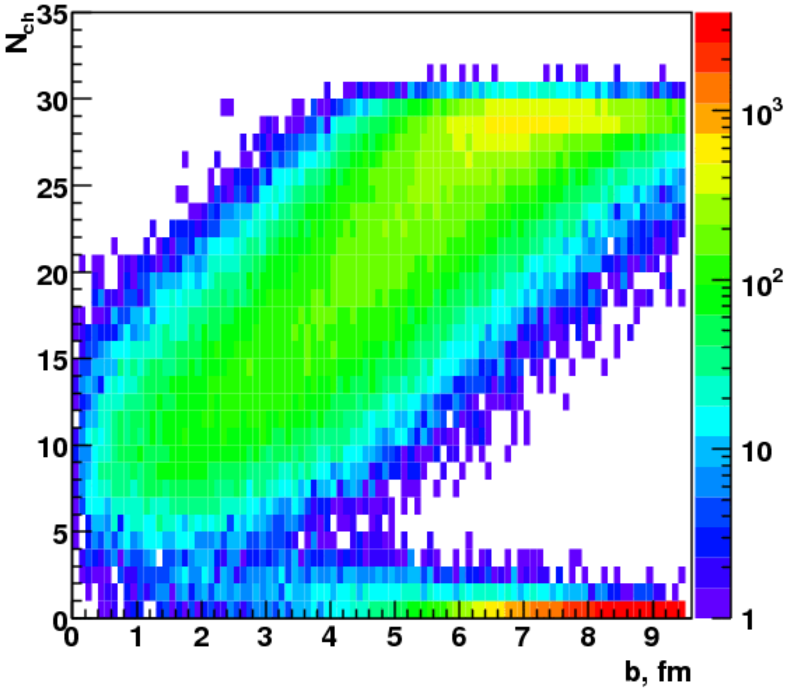


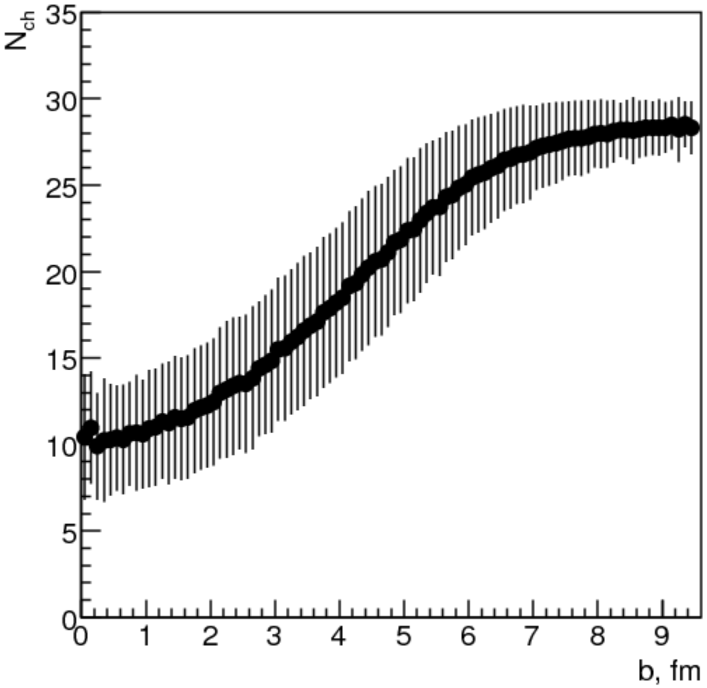
C+C at 25A GeV/c
110<θ<120°



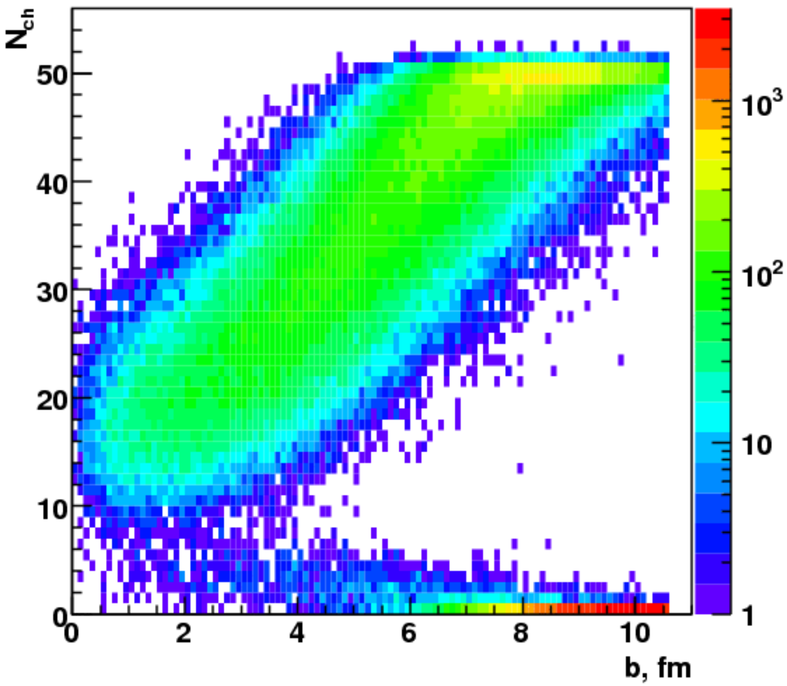


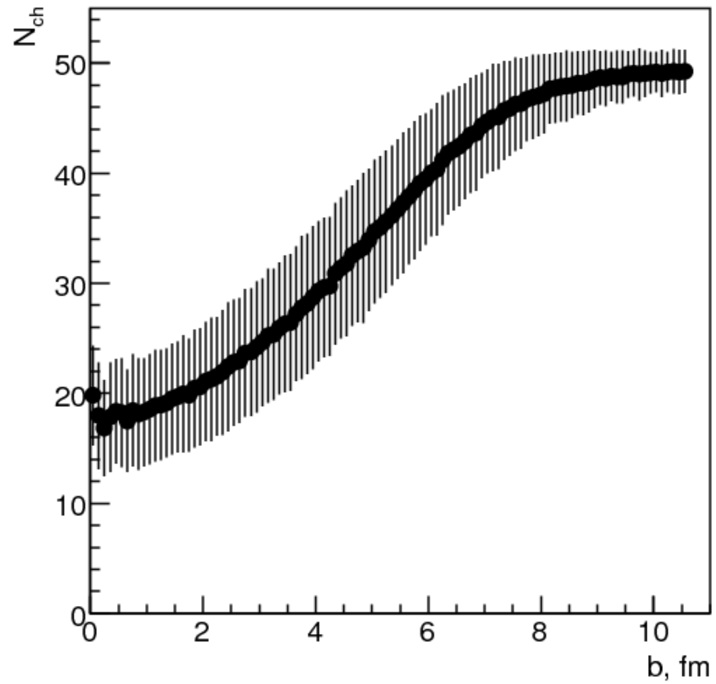
C+Cu at 25A GeV/c
$110<\theta<120°$



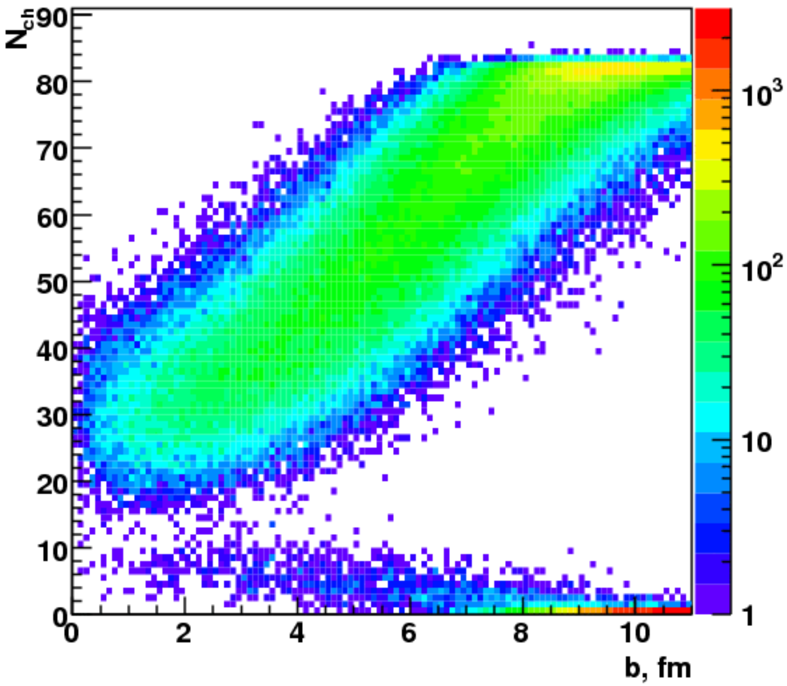


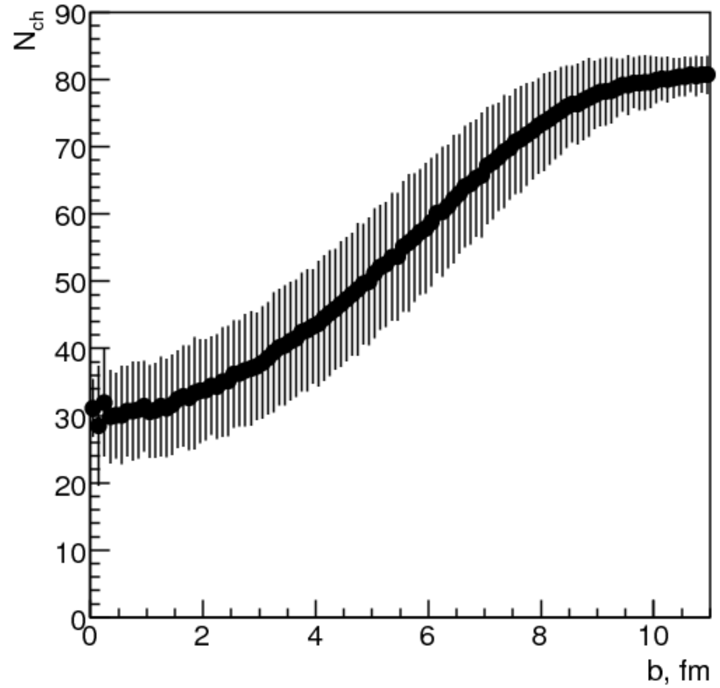
C+Sn at 25A GeV/c
110<θ<120°





C+Pb at 25A GeV/c
110<θ<120°





Summary

- Centrality measurement is indispensable for nucleus-nucleus collision experiments
- Many physics observables depends on centrality: RAA, particle yields, mean pT, flow
- In fixed target experiments centrality can be measured indirectly via beam or target fragments
- Target fragmentation detectors should count MIPs in the backward hemisphere
- UrQMD is a good event generator to study collisions centrality, but needs for nuclei fragments construction.
- For light nuclei the dependence of the signal in TFD on centrality is weak
- For heavy nuclei this dependence is more prominent