# Update on net charge and hadron ratio fluctuations measurement with MPD in BiBi @9.2 GeV

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# Motivation, physic interest

- Probe the QGP phase; Non-monotonic behavior in fluctuations as a function of beam energy are proposed as signatures of the QCD critical point.
  J.Phys.G34:S437,2007; Phys. Rev. Lett. 81, 4816 (1998)

D-measure: $4\frac{\langle \delta Q^2 \rangle}{\langle N_{ch} \rangle}$ $\quad D = \begin{cases} 4\,, \text{HG} \\ 3\,, \text{HRG} \\ 1 - 1.5\,, \text{QGP} \end{cases}$

S. Jeon, V. Koch, Phys. Rev. Lett. **85**, 2076
S. Jeon, V. Koch, arXiv:hep-ph/0304012

Dynamical fluctuation variable **ν:**

$$\nu_{dyn}[+,-] = \frac{\langle N_+(N_+-1)\rangle}{\langle N_+\rangle^2} + \frac{\langle N_-(N_--1)\rangle}{\langle N_-\rangle^2} - 2\frac{\langle N_+N_-\rangle}{\langle N_+\rangle\langle N_-\rangle}$$

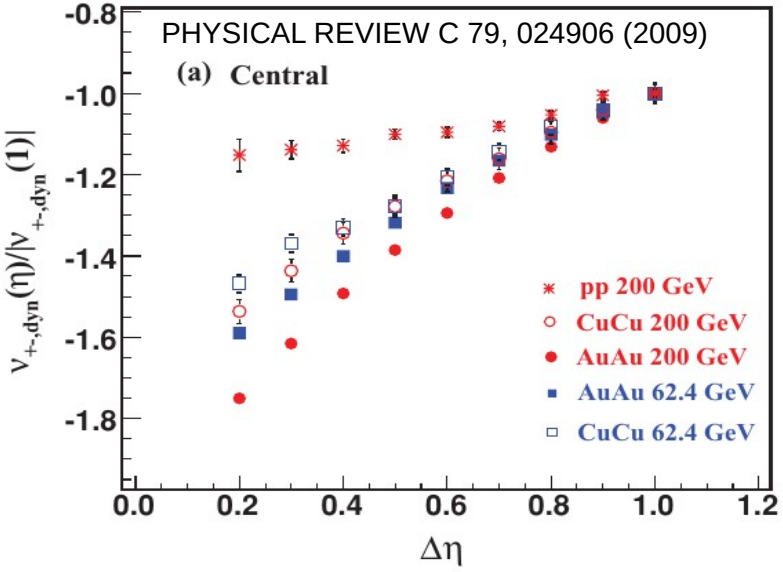
- $\nu_{dyn} < 0$ → (opposite charge) correlations dominate
- $\nu_{dyn} > 0$ → (same charge) fluctuations dominate
- $\nu_{dyn} = 0$ → independent particle production

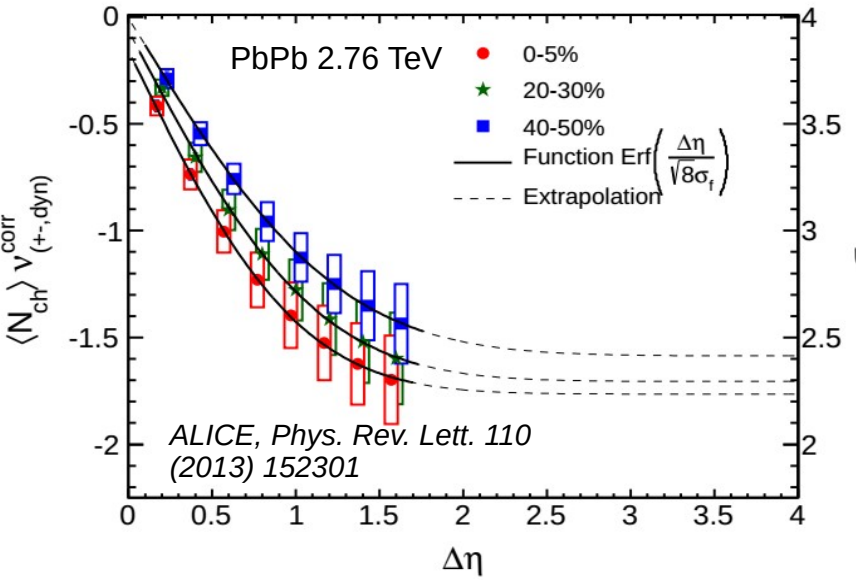
For $\langle N_+ \rangle \approx \langle N_- \rangle$:

$$D = 4\frac{\langle \delta Q^2 \rangle}{\langle N_{ch} \rangle} \approx \langle N_{ch} \rangle \langle \nu_{dyn} \rangle + 4$$

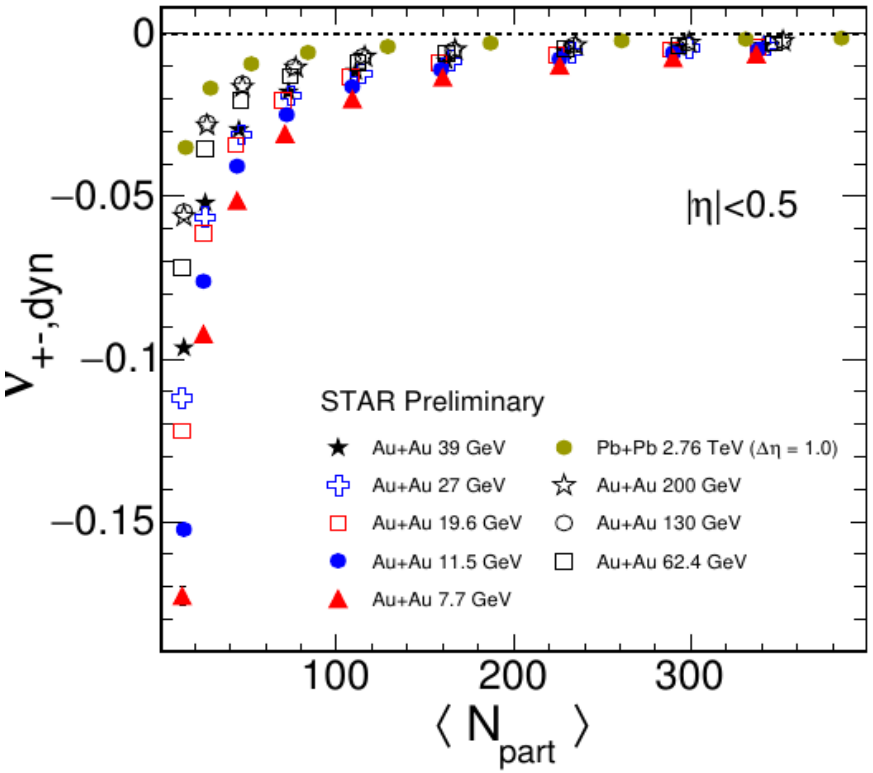
# Experimental data on net-charge fluctuations

## η-phase window dependence

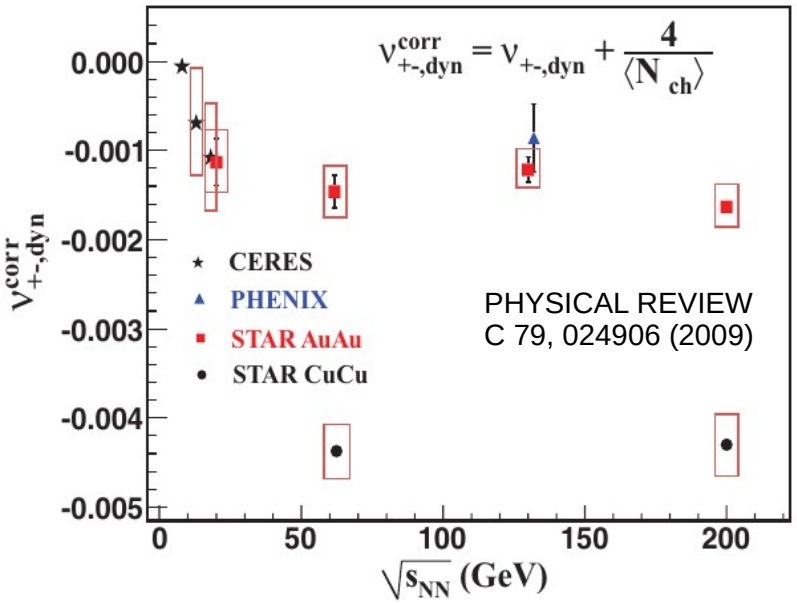


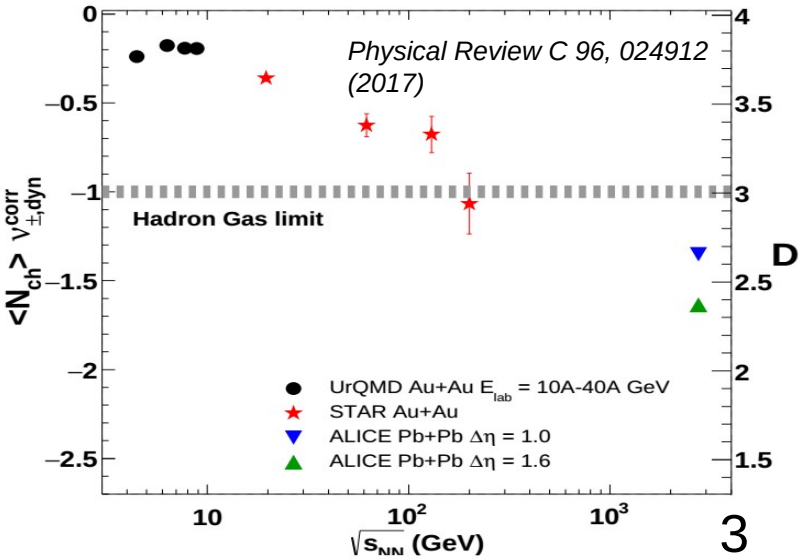




## Centrality dependence



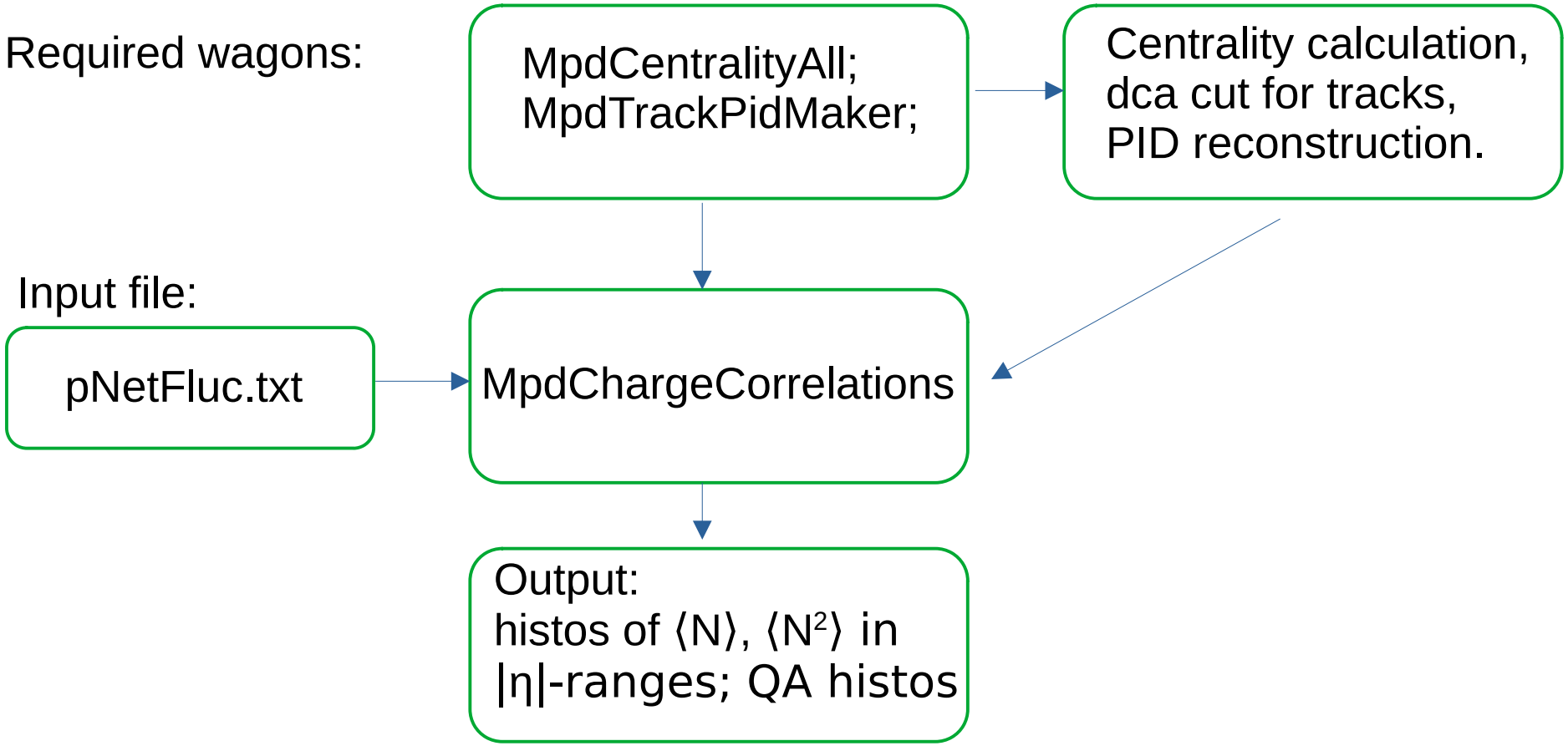

## Collision energy dependence



# Analysis wagon

To be placed in *mpdroot/physics/chargeCorrelations/*



# Input file for the current analysis

```
#-------Parameters used for analysis------
# Event selection:
mIsMC    true  #  MC-reco analysis
mZvtxCut 30 #  cut on vertex z coordinate
mRvtxCut 2  #  cut on vertex transverse coordinate
# Track selection:
mNofHitsCut   15  # minimal number of hits to accept track
mEtaCut      1.  # maximal pseudorapidity accepted
mPtminCut    0.1  # minimal pt used in analysis
mPtmaxCut    3.0  # maximal pt used in analysis
mDcaCut      2.0  # maximal DCA accepted


# PID cuts
mPIDsigTPC  3.0
mPIDsigTOF  3.0
```

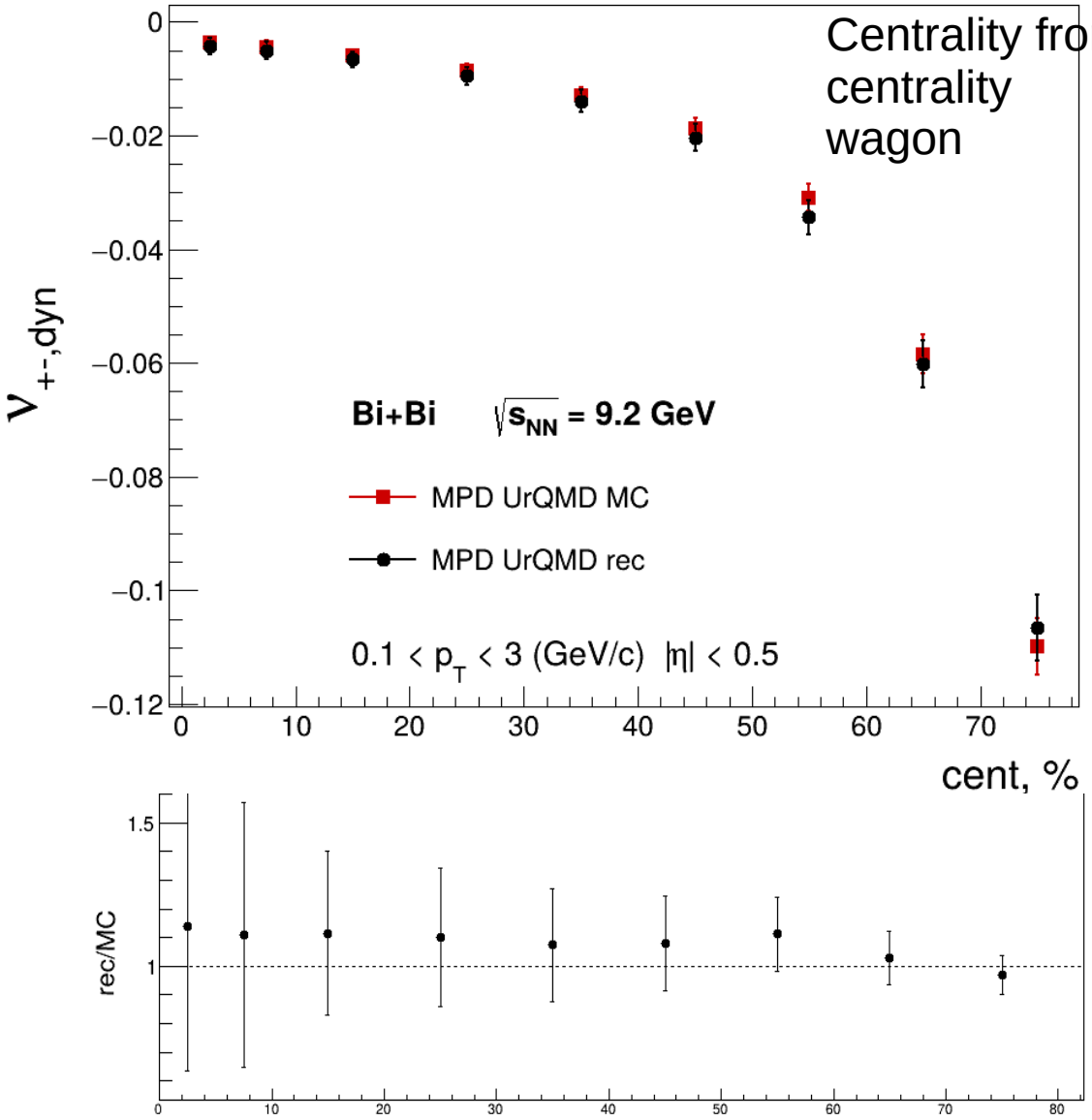
pNetFluc.txt

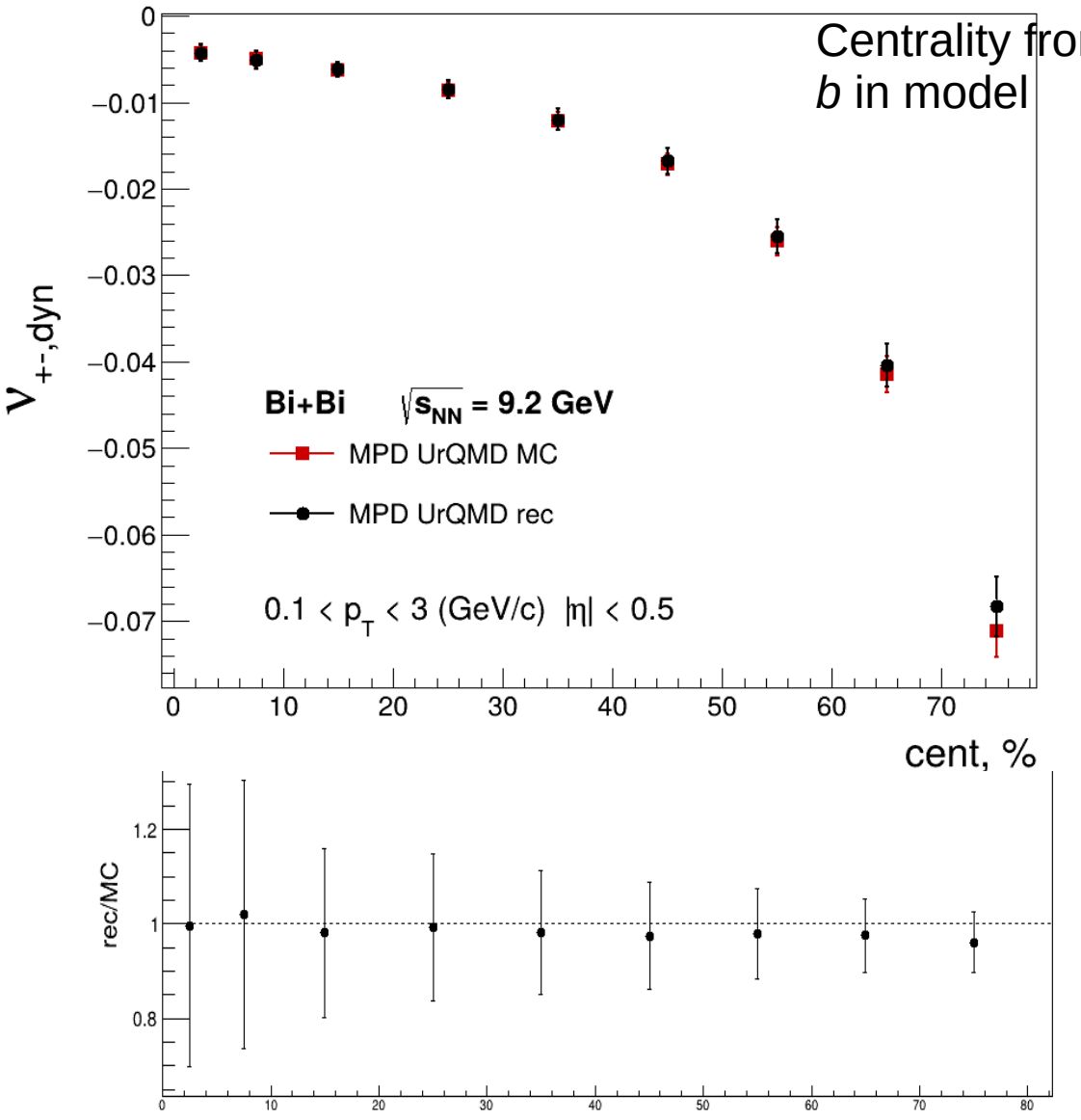
REC tracks: Global tracks

MC tracks: (p,K,π) from primary vertex ($\sqrt{(MCHeader->GetX() - trackMC->GetStartX())^2 + .. } < 1e\text{-}6$)

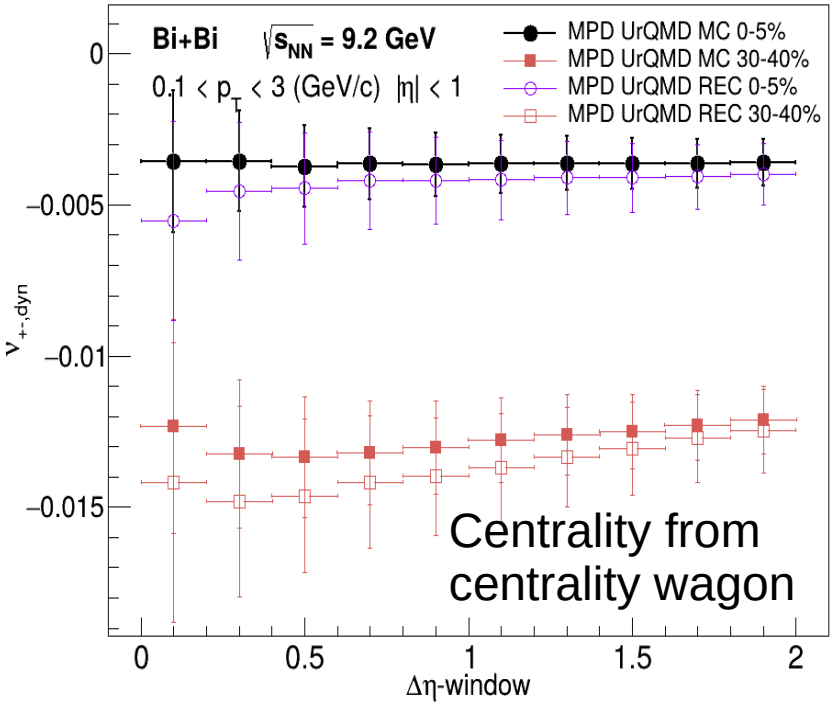
# UrQMD MC vs REC

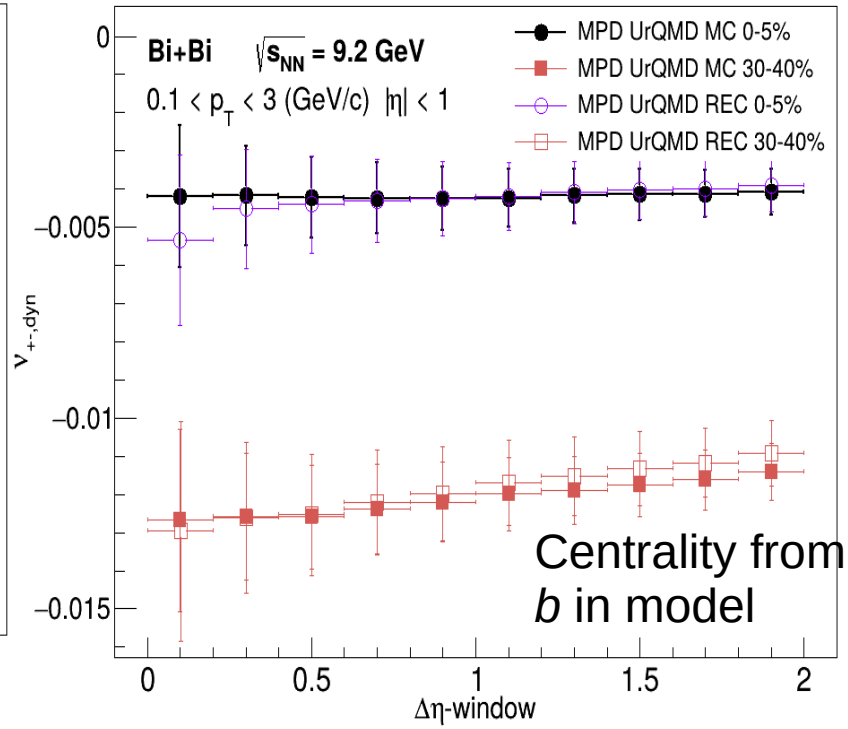
Data set: /eos/nica/mpd/sim/data/exp/dst-BiBi-09.2GeV-mp07-22-500ev-req25/BiBi/09.2GeV-mb/urqmd/BiBi-09.2GeV-mp07-22-500ev-req25/0,1,..

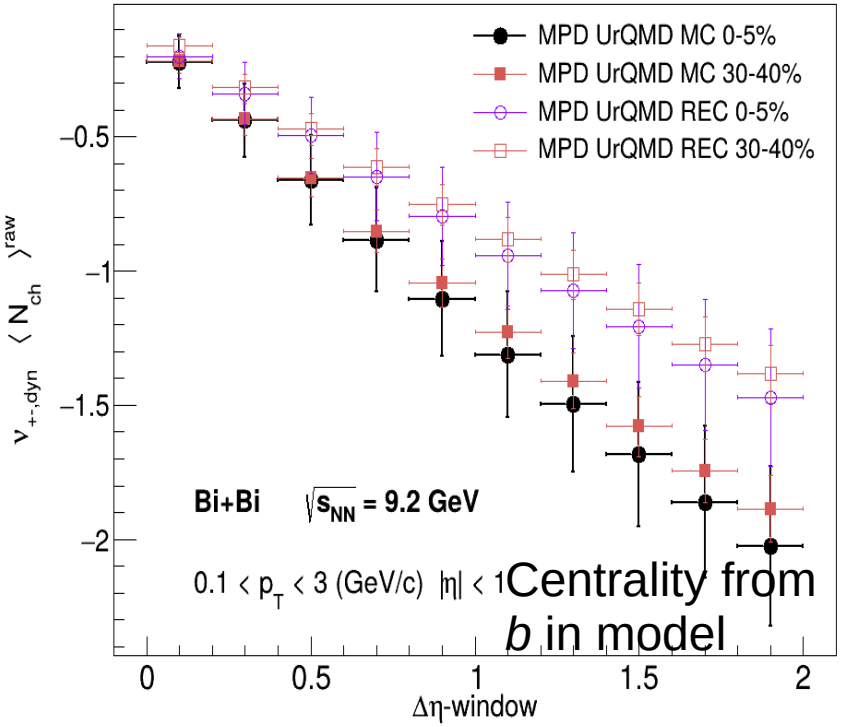


# UrQMD MC vs REC




- ν observable is robust against random efficiency losses.
  - Holds only if efficiency is independent on multiplicity
    C. Pruneau, S. Gavin, S. Voloshin, Phys. Rev. C 66, 044904 (2002).
- Good MC-rec agreement.
- $\nu\langle N_{ch}\rangle$ observable has to be corrected for the efficiency.

*Final results have to be corrected for the global charge conservation effect,* $\nu \rightarrow \nu + 2/\langle N_+ \rangle$

# Particle Ratio Fluctuations

| p/π | K/π | K/p |
|---|---|---|
| $(p^+ + p^-)/(\pi^+ + \pi^-)$ | $(K^+ + K^-)/(\pi^+ + \pi^-)$ | $(K^+ + K^-)/(p^+ + p^-)$ |

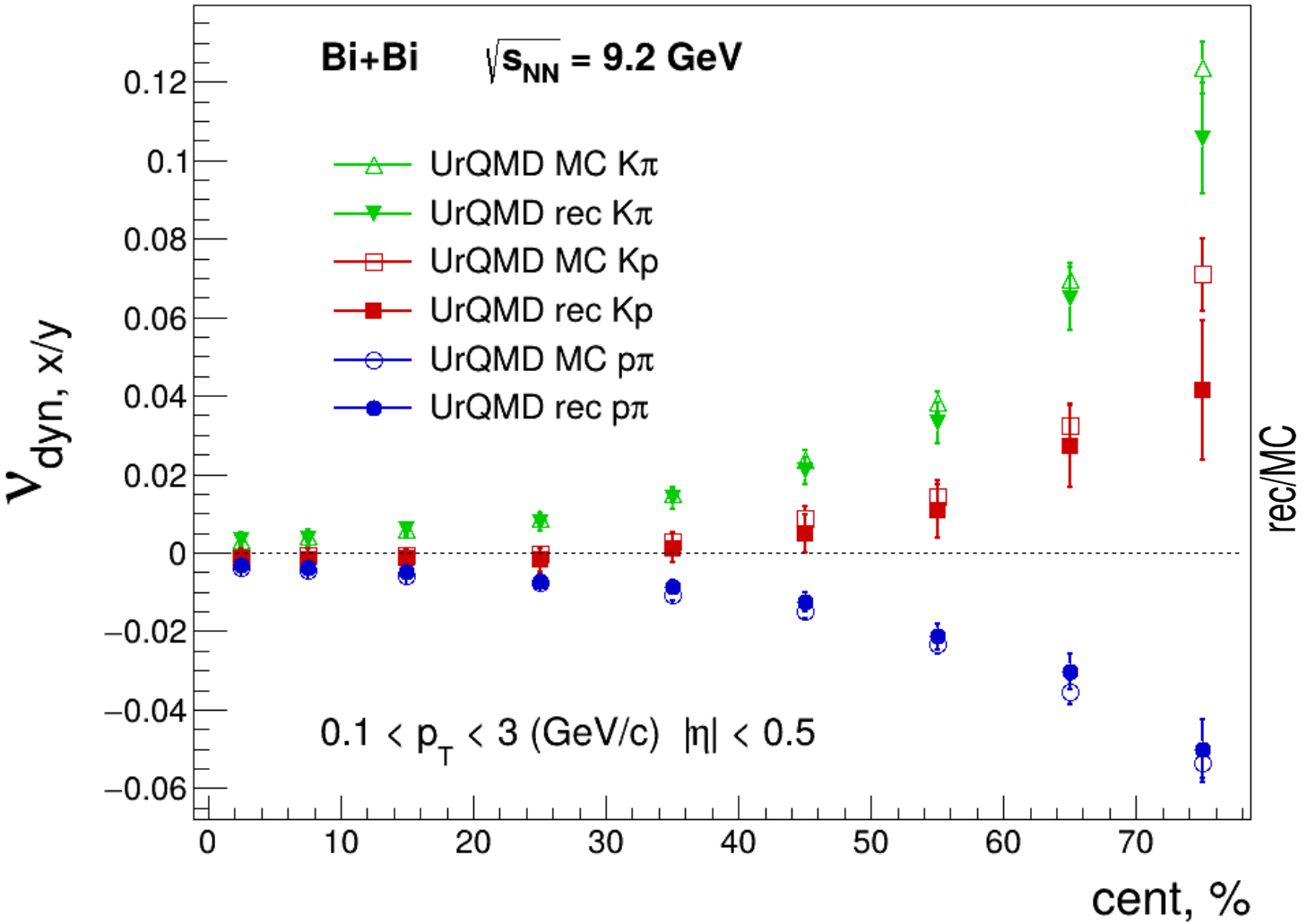
- Non-monotonic behavior of the K/π yield ratio at $\sqrt{s_{NN}} \sim 7.6$ GeV at SPS for central Pb+Pb collisions is observed and is supposed to be a signature of phase transition.
  S. V. Afanasiev et al. (The NA49 Collaboration), Phys. Rev. C 66 054902 (2002)

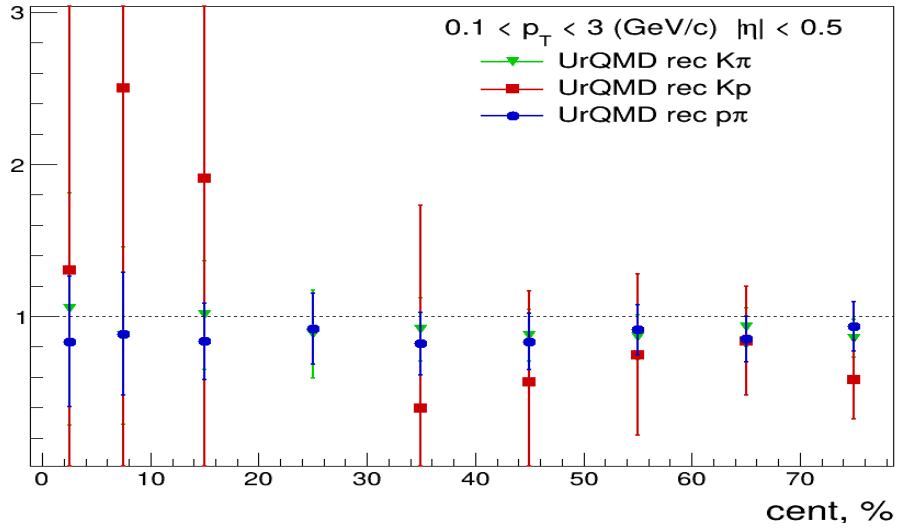
- At SPS $\sigma_{dyn}$ observable was used.
- STAR uses $\nu_{dyn}$

$$\nu_{\mathrm{dyn},K\pi} = \frac{\langle N_K(N_K - 1)\rangle}{\langle N_K\rangle^2} + \frac{\langle N_\pi(N_\pi - 1)\rangle}{\langle N_\pi\rangle^2} - 2\frac{\langle N_K N_\pi\rangle}{\langle N_K\rangle\langle N_\pi\rangle}$$

- $\nu_{dyn} < 0 \rightarrow$ (Kπ) correlations dominate
- $\nu_{dyn} > 0 \rightarrow$ (KK), (ππ) fluctuations dominate or anticorrelation (Kπ)

# Particle Ratio Fluctuations



# Summary

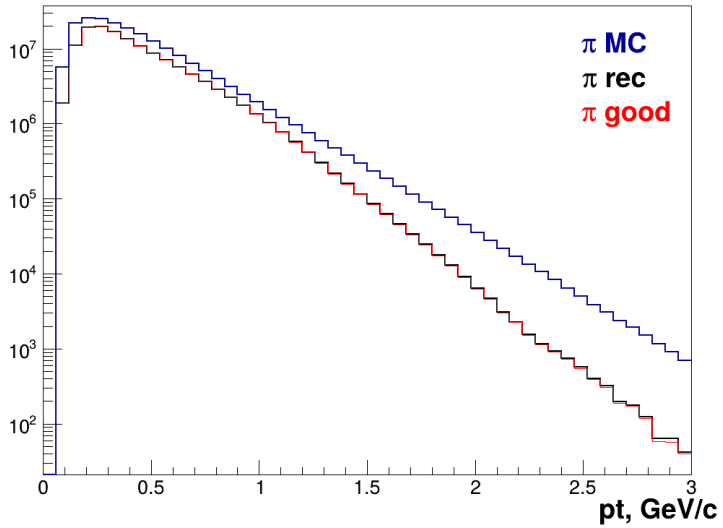
- Analysis wagon is prepared for net charge and particle ratio fluctuation measurements.
- Net charge fluctuations $\nu$ and $\nu\langle N_{ch}\rangle$ were calculated in BiBi collisions at 9.02 GeV with UrQMD model at MC and REC levels.
  - A good agreement between MC and REC for $\nu_{dyn}$ is achieved with the current track selection and the the independent (not track-based) centrality calculation (e.g. *b*-parameter).
  - Reconstructed $\nu_{dyn}$ values are close to the generated ones (but the difference increases with event centrality up to ~14% for most central collisions) with centrality estimated from centrality wagon.
  - $\nu\langle N_{ch}\rangle$ onservable has to be corrected for the tracking efficiency (to be done).
- Particle ratio fluctuations were calculated using $\nu$ observable at MC and REC levels.
  - Performance of reconstruction has to be studied further.

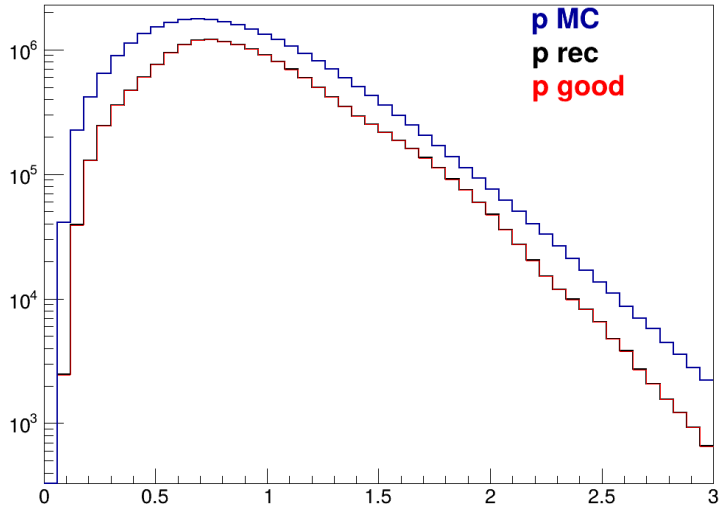
# Backup

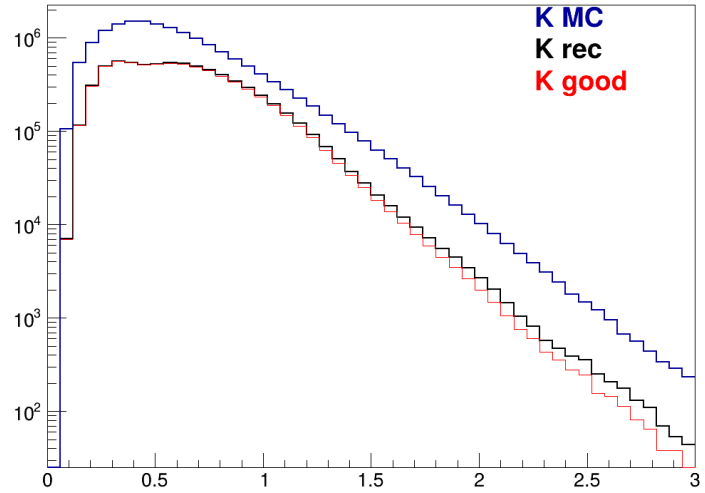
# PID with pid wagon

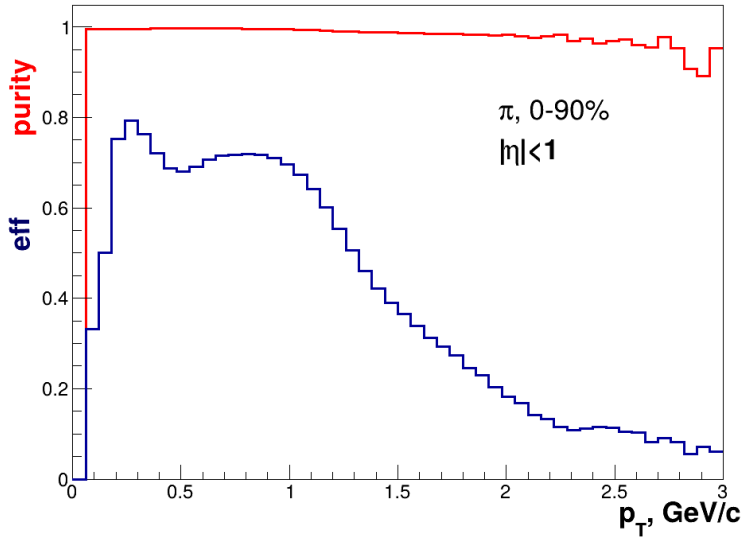
n-sigma cut
TPC, TOF = 3

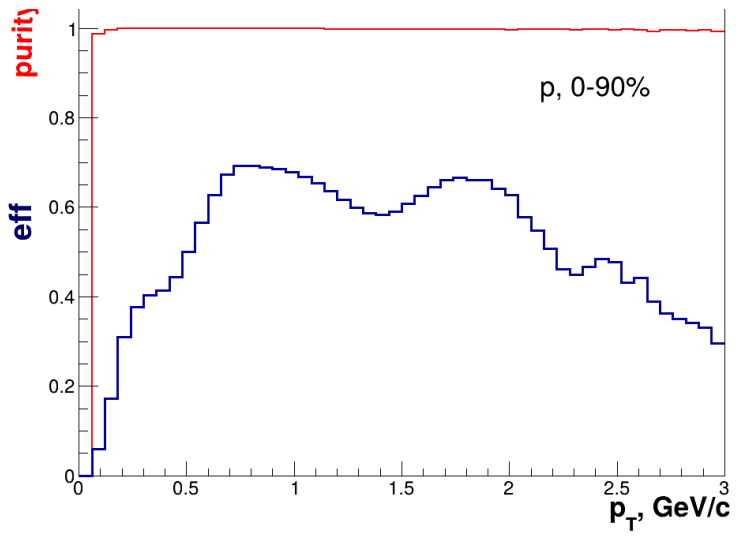
- *p,K,π,e* are considered.
- both TPC and TOF n-sigma cut is used if(track->GetTofFlag() == 2 || track->GetTofFlag() == 6)
- Only TPC -n-sigma cut if no TOF
- If several particles pass the cut → no PID

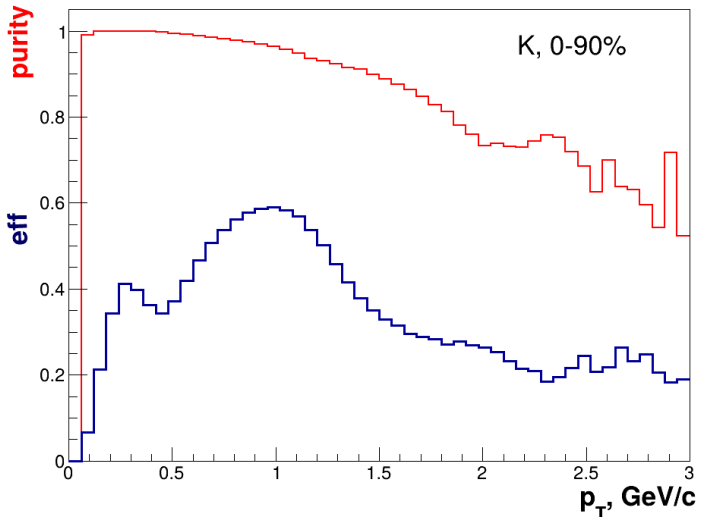


# Efficiency correction

Both $\nu_{dyn,+-}$ $\nu_{dyn,x/y}$ are independent of experimental efficiency ε.

Holds: if the ε is independent of multiplicity.
The dependence on ε would arise if the Gaussian approximation is not valid, e.g. if the detector response functions differ markedly from Binomial or Gaussian functions.

Let the probability of detecting each particle be ε and the probability of missing it be (1 − ε).
For a binomial distribution the average number of measured particles is: $\langle N \rangle_{\rm exp} = \epsilon \langle N \rangle$

while the average square is: $\langle N^2 \rangle_{\rm exp} = \epsilon^2 \langle N^2 \rangle + \epsilon(1-\epsilon)\langle N \rangle$

*Cancels out for ν.*

More details in : C. Pruneau, S. Gavin, S. Voloshin, Phys. Rev. C 66, 044904 (2002).