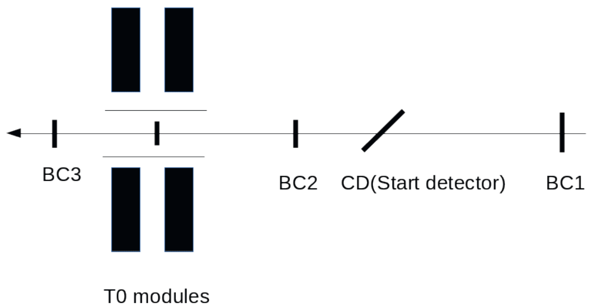
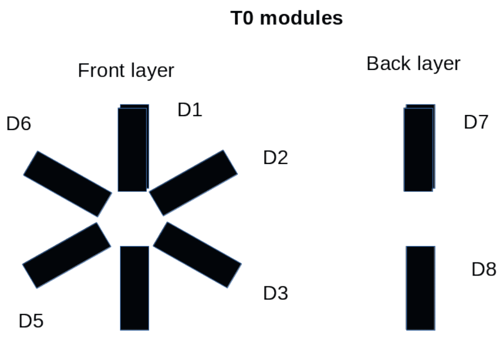
Применение идентити метода расчета флуктуаций множественности идентифицированных частиц в ядро-ядерных взаимодействиях на установке STAR

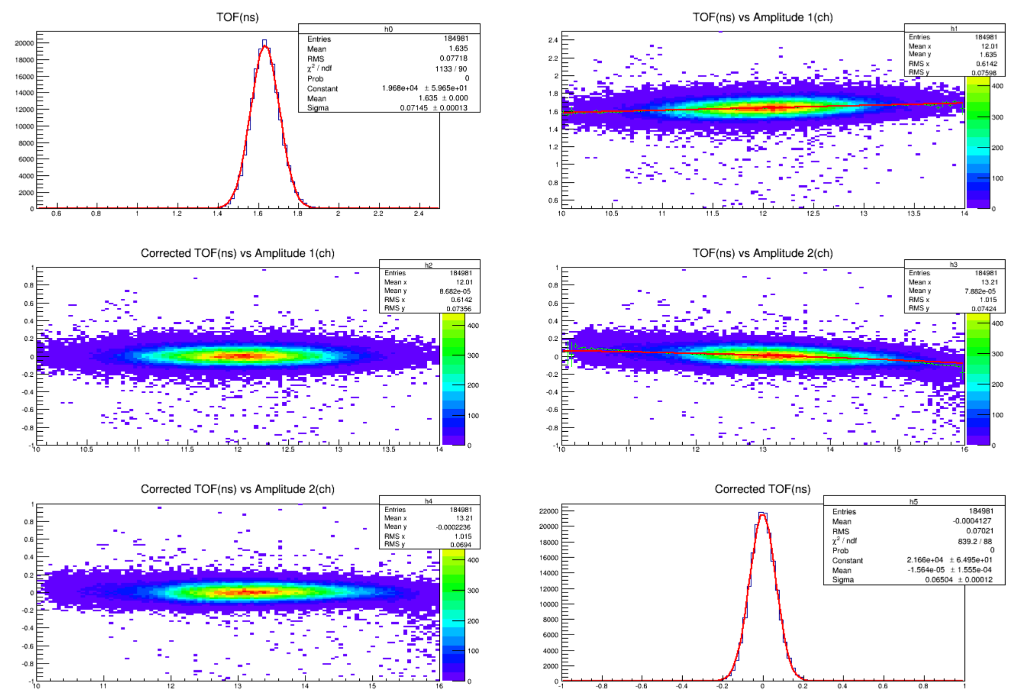
Агакишиев Гейдар

- Отчет за 5 лет:
  - STAR – применение identity метода
  - BM&N – обработка данных с триггерных детекторов
  - HADES – разработка программы быстрого поиска прямых треков в детекторах с линейными датчиками
  - Образовательная программа – обучение студентов методам анализа данных с физических детекторов в пакете ROOT

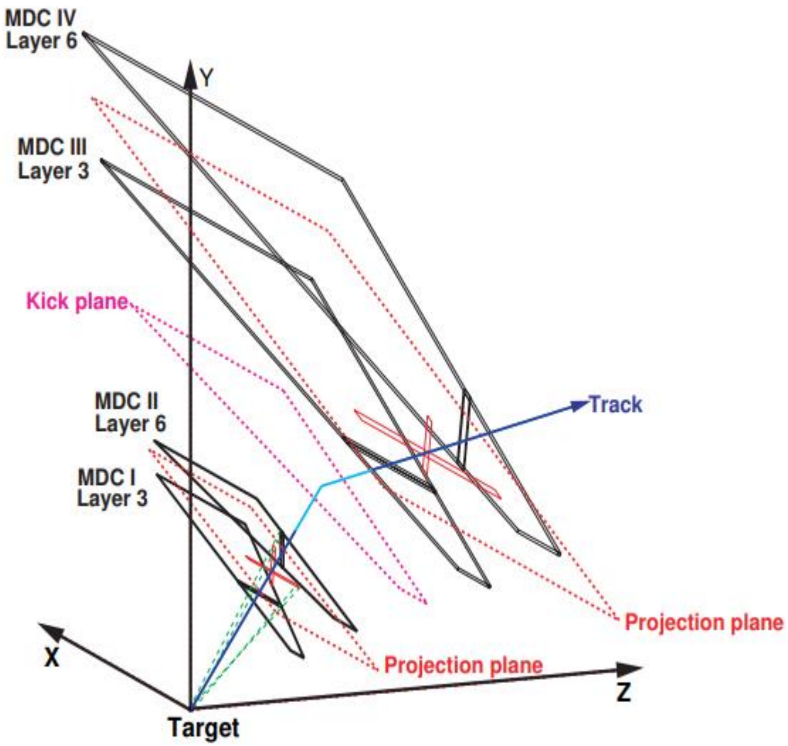
BM&N – обработка данных с триггерных детекторов

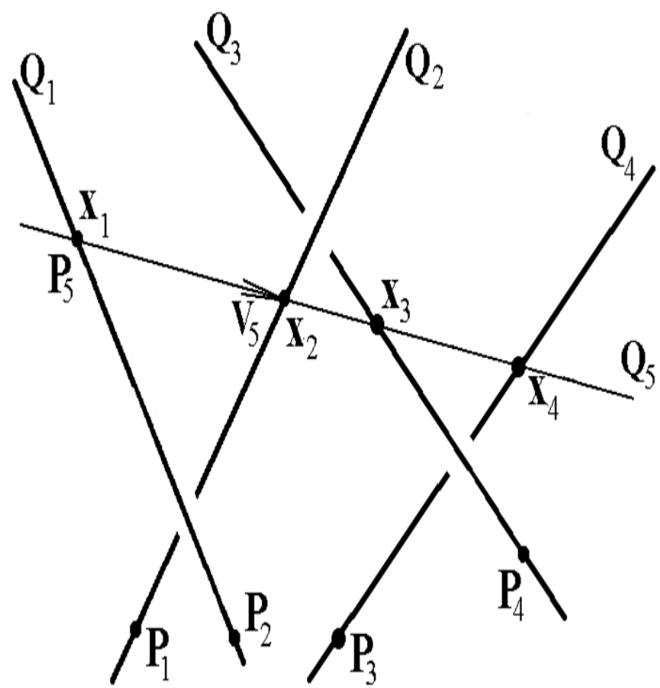






HADES – разработка программы быстрого поиска прямых треков в детекторах с линейными датчиками





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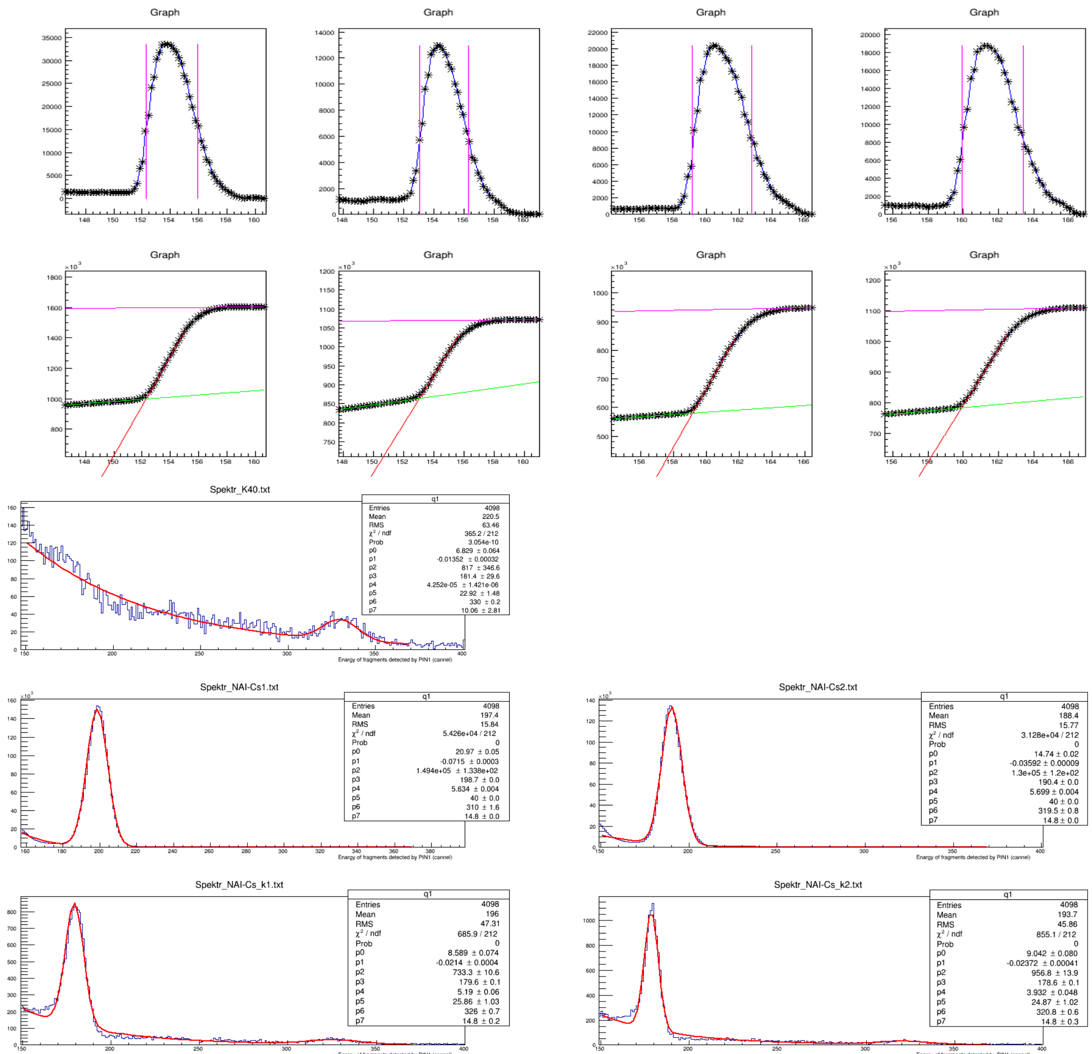
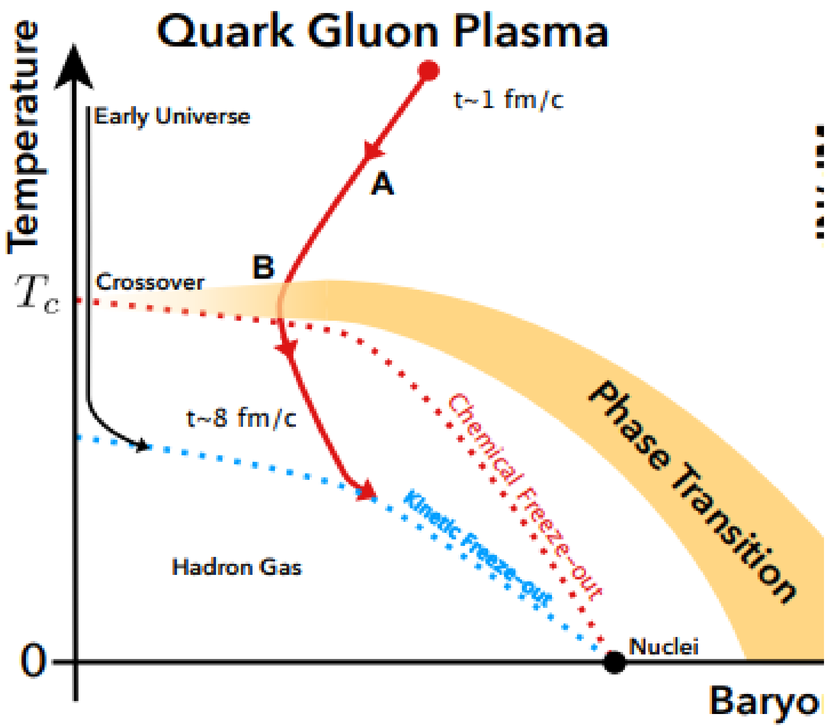
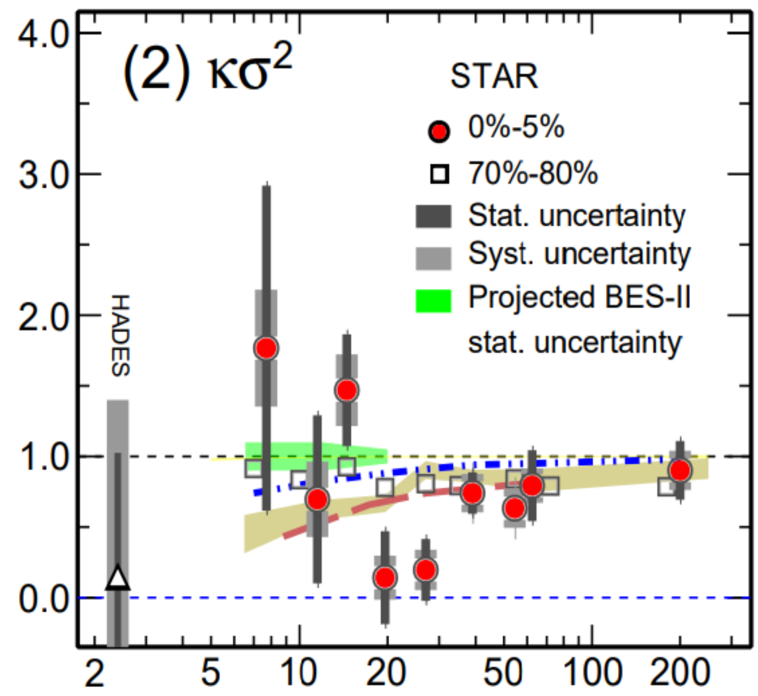
Образовательная программа – обучение студентов методам анализа данных с физических детекторов в пакете ROOT



STAR – применение identity метода

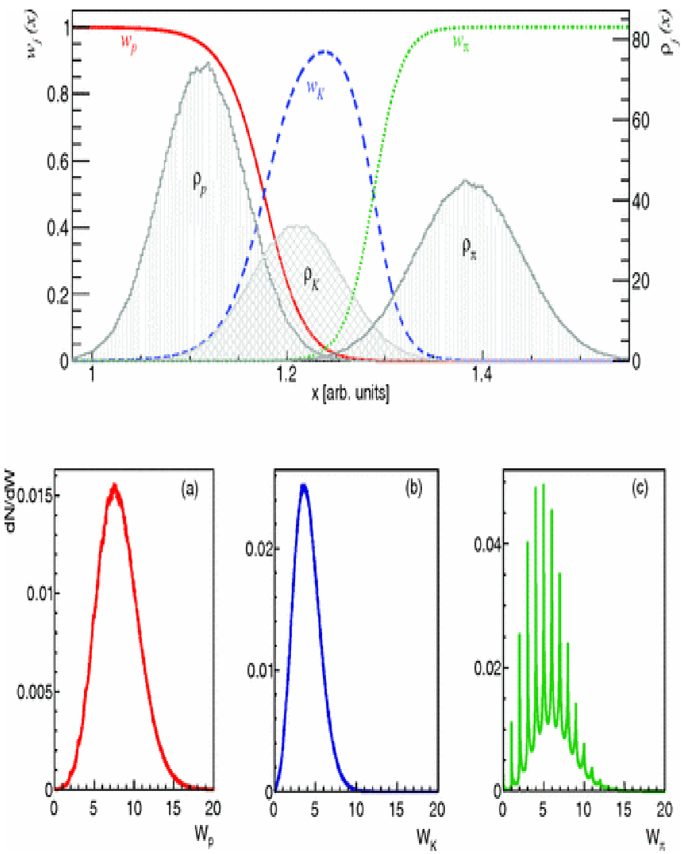




The value of cumulants is very sensitive to purity of selected events and particles. Published results based on particle identifications by fixed cut on TPC dE/dx and TOF measurements.

Identity method, defining the problem

Images



- Available information:
  - Inclusive dE/dx spectra
  - Mean multiplicities
    - $< N_P > = \int \rho_p(m) dm$
    - $< N_k > = \int \rho_k(m) dm$
  - dE/dx value for every track

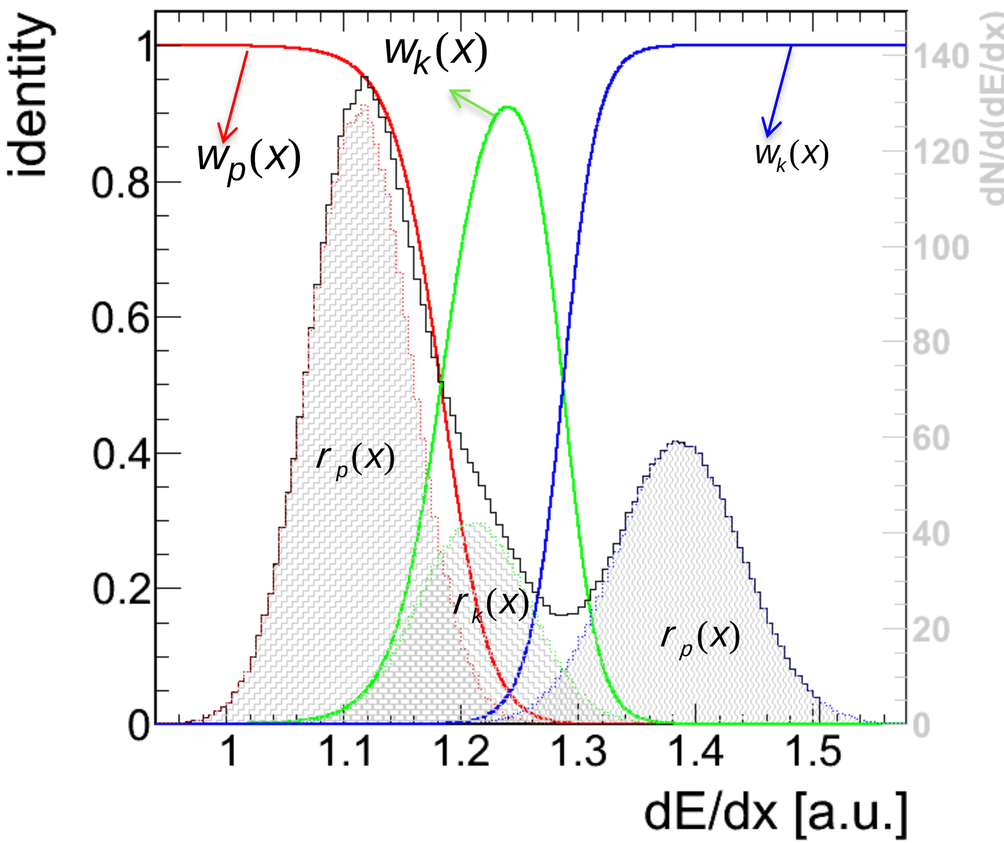
Given this information we want to estimate moments of the unknown multiplicity distributions

Identities (3-particle example)

$$w_p(x) = \frac{\rho_p(x)}{\rho_p(x) + \rho_\pi + \rho_k(x)}$$

$$w_\pi(x) = \frac{\rho_\pi(x)}{\rho_p(x) + \rho_\pi + \rho_k(x)}$$

$$w_K(x) = \frac{\rho_K(x)}{\rho_p(x) + \rho_\pi + \rho_k(x)}$$



$$W_p = \sum w_p$$

$$W_\pi = \sum w_\pi$$

$$W_K = \sum w_k$$

Calculated for each event

Identity method, second moments

Main idea is to find a relation between known moments of the W quantities and unknown moments of multiplicity distributions. For example in case of 2 particle types (p, k)

$$\begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix} \begin{pmatrix} \langle N_p^2 \rangle \\ \langle N_k^2 \rangle \\ \langle N_p N_k \rangle \end{pmatrix} = \begin{pmatrix} \langle W_p^2 \rangle - f_1(\langle N_1 \rangle, \langle N_2 \rangle, \rho_1, \rho_2) \\ \langle W_k^2 \rangle - (\langle N_1 \rangle, \langle N_2 \rangle, \rho_1, \rho_2) \\ \langle W_p W_k \rangle - (\langle N_1 \rangle, \langle N_2 \rangle, \rho_1, \rho_2) \end{pmatrix}$$

Known in term of inclusive dE/dx distributions

Phys. Rev. C 83, 054907 (2011)
Phys. Rev. C 84, 024902 (2011)
Phys. Rev. C 86, 044906 (2012)
arXiv:2409.09814 [hep-ex]

Identity method, second moments

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↓

Known in term of inclusive dE/dx distributions

Phys. Rev. C 83, 054907 (2011)
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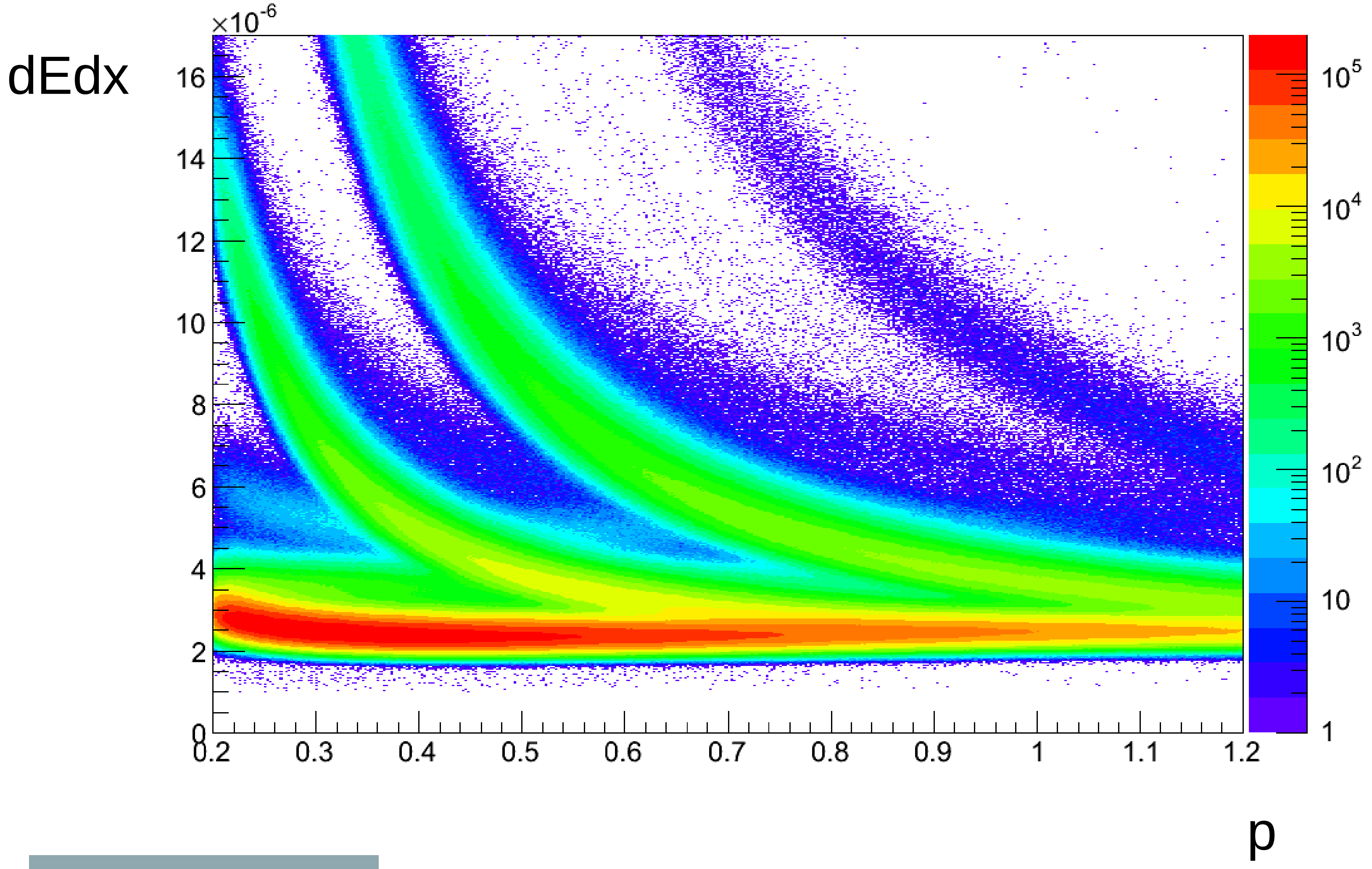
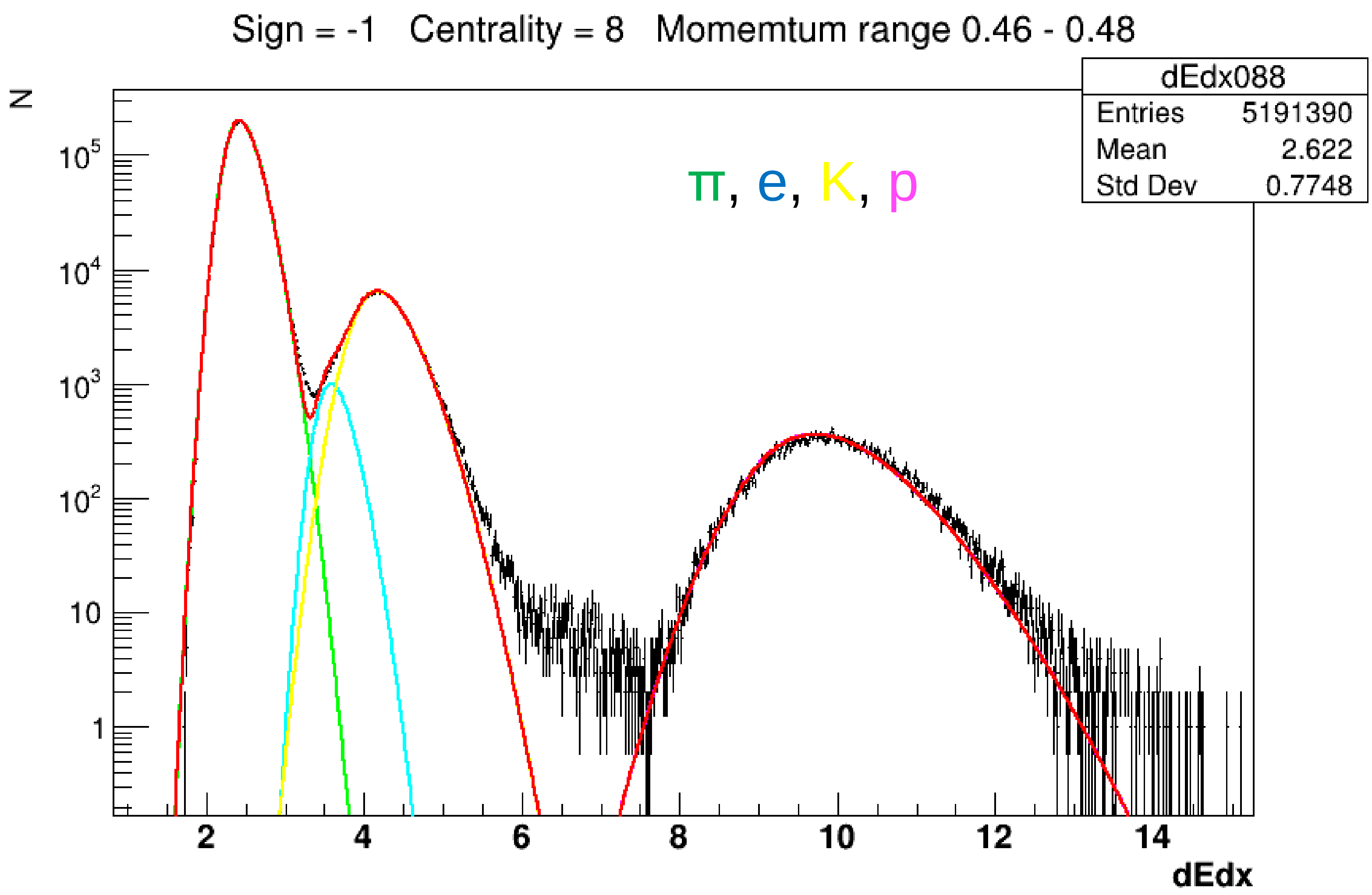
arXiv:2409.09814 [hep-ex]

dEdx vs p AuAu 39 GeV



All tracks



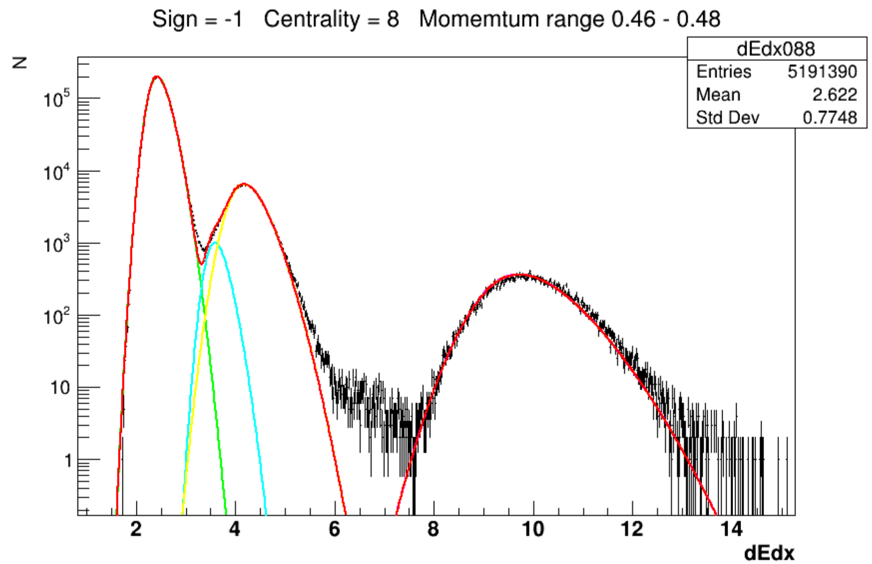
Sign = -1   Centrality = 8   Momemtum range 0.46 - 0.48
dEdx088
Entries 5191390
Mean 2.622
Std Dev 0.7748
π, e, K, p
N
10⁵
10⁴
10³
10²
10
1
2
4
6
8
10
12
14
dEdx

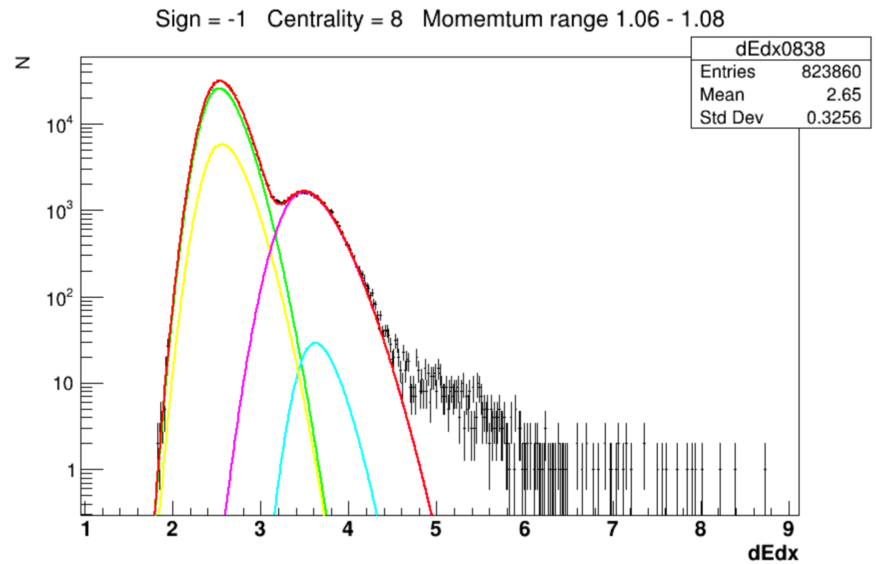
Fit function

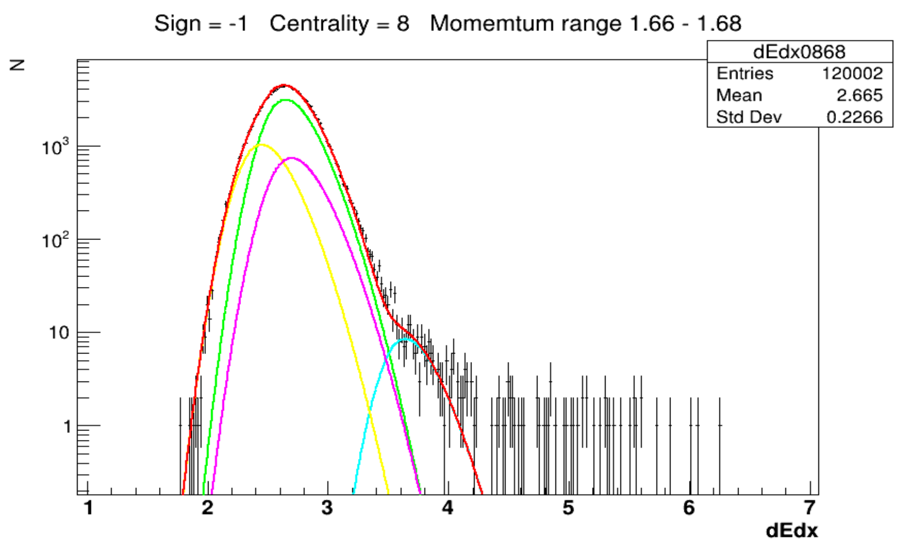
- Generalized Gauss Function:

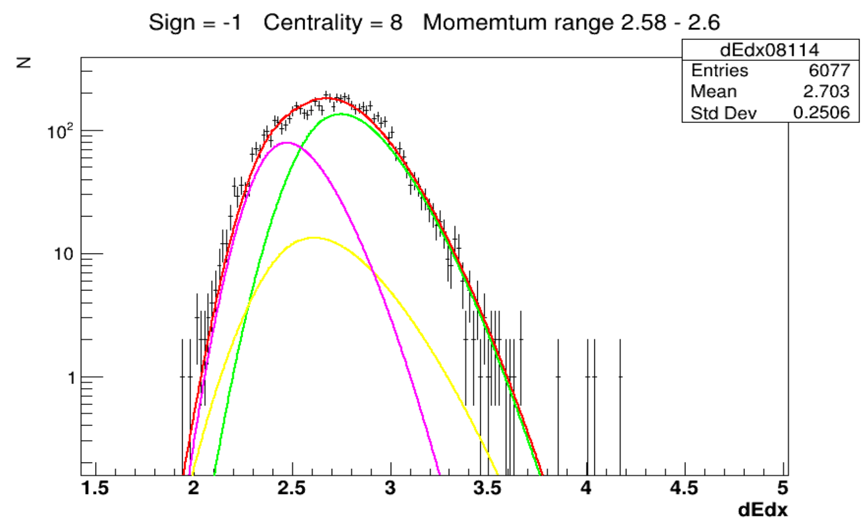
$$Ae^{-(|x-\mu|/\sigma)^{\kappa}}(1+Erf(S(x-\mu)/\sigma\sqrt{2}))$$

Fit examples

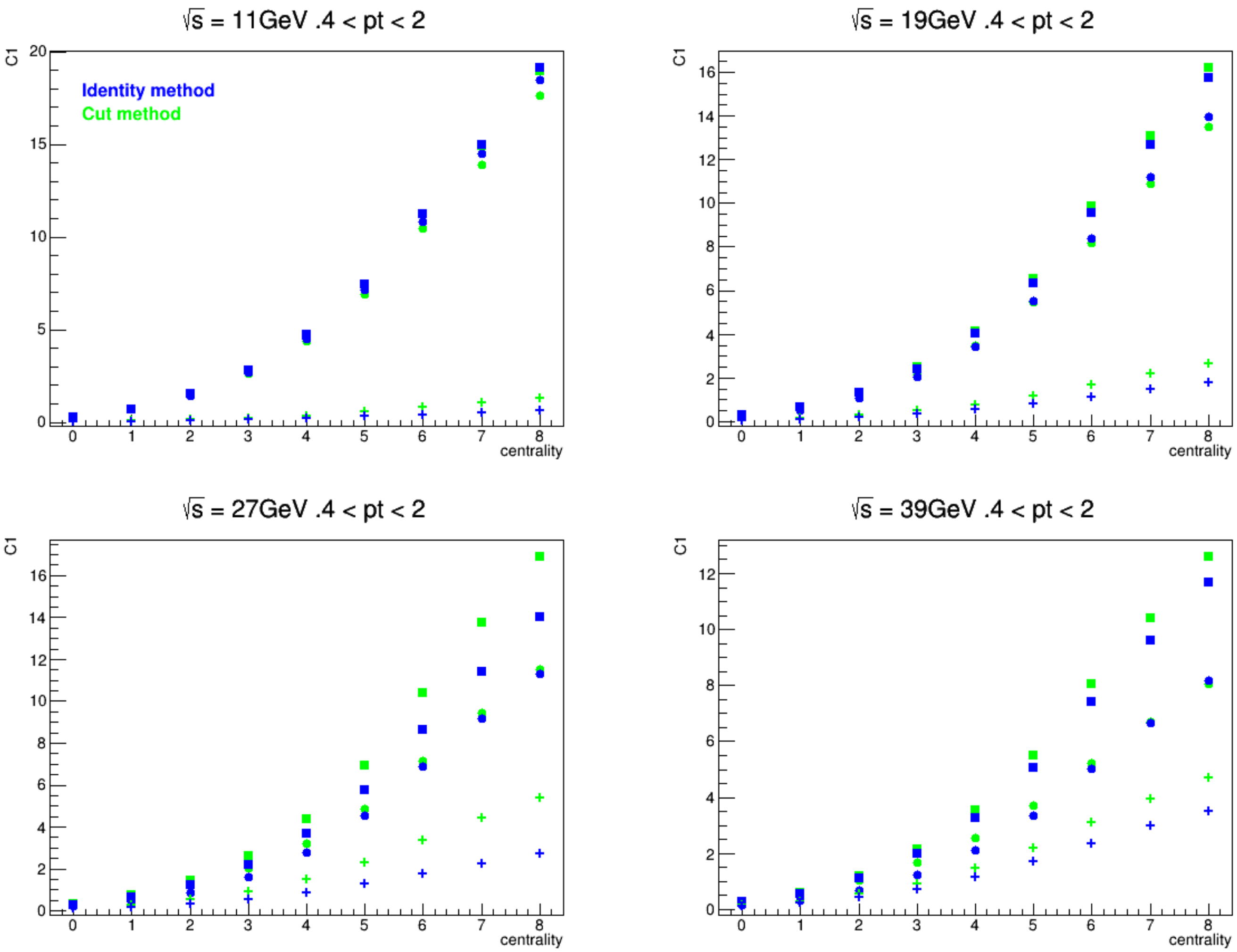




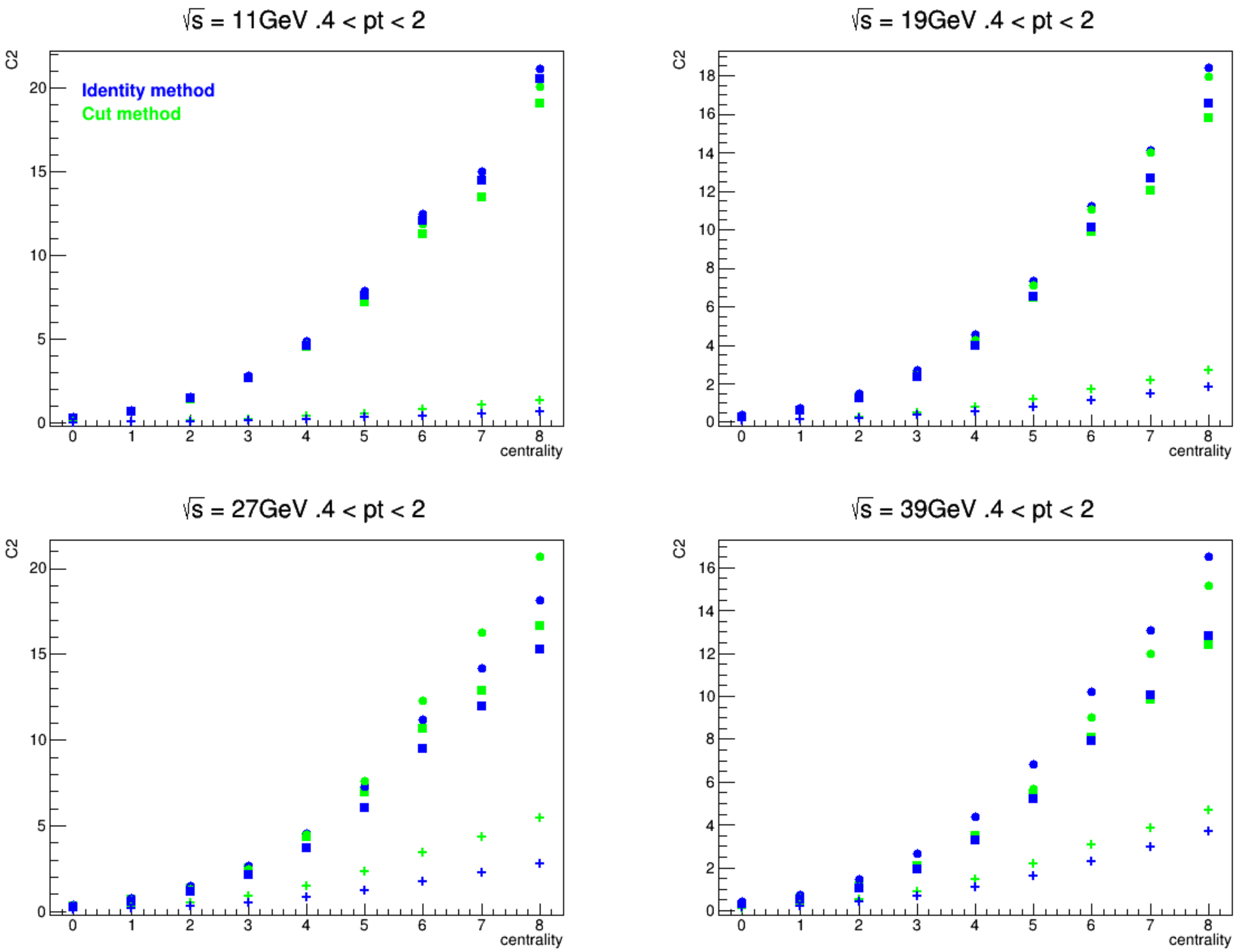




C1 vs centrality 0.4<pt<2GeV



C2 vs centrality 0.4<pt<2GeV



Планы на будущее

- Получить функции отклика TPC после модернизации для всех энергий BES II получить моменты распределения по множественности нет-протонов в identity подходе и сравнить с методом катов
- Продолжить участие в наборе и анализе данных с триггерных детекторов BM@N
- Подготовить и опубликовать полный алгоритм поиска прямых треков в детекторах с линейными датчиками.
- Продолжить развитие образовательных программ анализа экспериментальных данных в физике высоких энергий.

Backup slides

Introduction

- Transition from hadronic matter to QGP at fixed μ_B predicted to be first order. This also mean existence the critical point. Several theoretical model predict irregular behavior of net-barion density around the critical point. STAR experiment demonstrate the non-monotonic beam energy dependence of ratio of cumulants C_4/C_2 of net-proton multiplicity distribution in AuAu central collisions at BES I energy.
- The value of cumulants is very sensitive to purity of selected events and particles. Published results based on particle identifications by fixed cut on TPC dE/dx and TOF measurements.

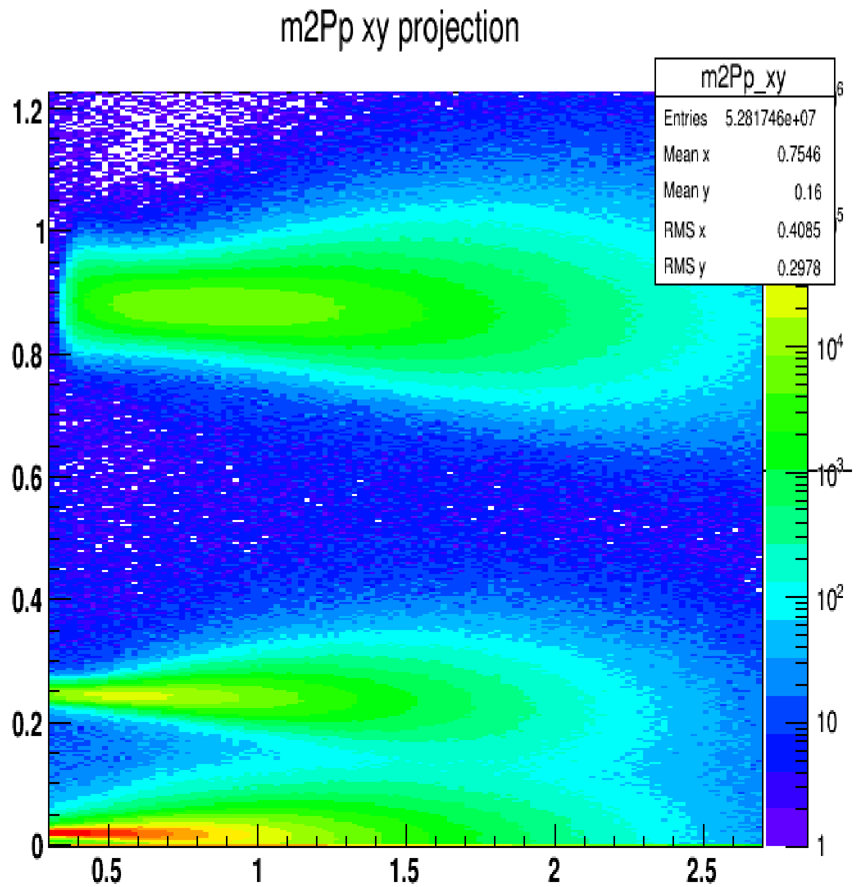
Introduction

- The purity of particle samples can be skewed due to overlaps in dEdx and TOF distribution of different spices of particles. Therefore it will be useful to get same results by different identification methods.
- We are trying to use for this aim the identity method developed in NA49 experiment. In frame of this approach one can calculate the particle momentum distribution cumulants from TPC dE/dx response functions.
- To get detail dE/dx response functions the high statistics data is needed.
- We are planning do it using the BES II data collected by collaboration during 2020-2022 years.
- The software for this analysis is already created and tested at BES I data.

Event & Track selection

- Event selection
  - AuAu 11,19,27,39 GeV Run10 ~ 7, 16, 31, 29 million events
  - Only good runs selected
  - Ref2 centrality bin
  - $-30 < z < 30$cm
  - Vertex radius < 2cm
- Track selection
  - $-.5 < \eta < .5$
  - $p_t > .2$GeV
  - DCA < 1cm
  - $N_{hits} > 6$
  - $N_{hitsfit} > 21$
  - $N_{hitsfit} / N_{hitsposs} > 0.521$

Clean sample selection



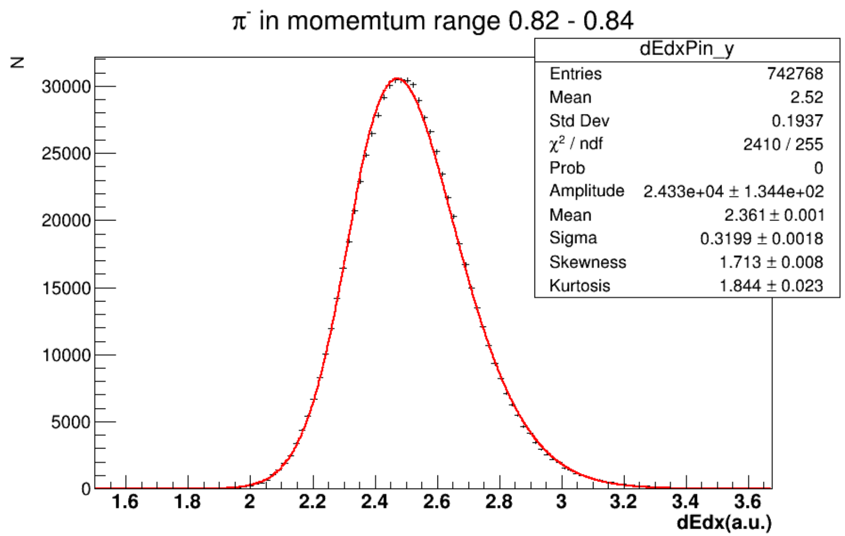
p 0.80 < m2 < 0.93

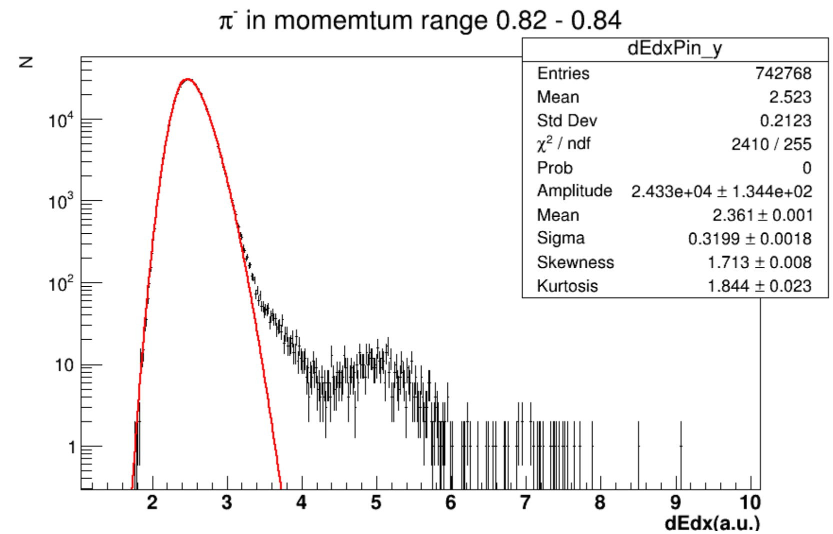
K 0.17 < m2 < 0.29

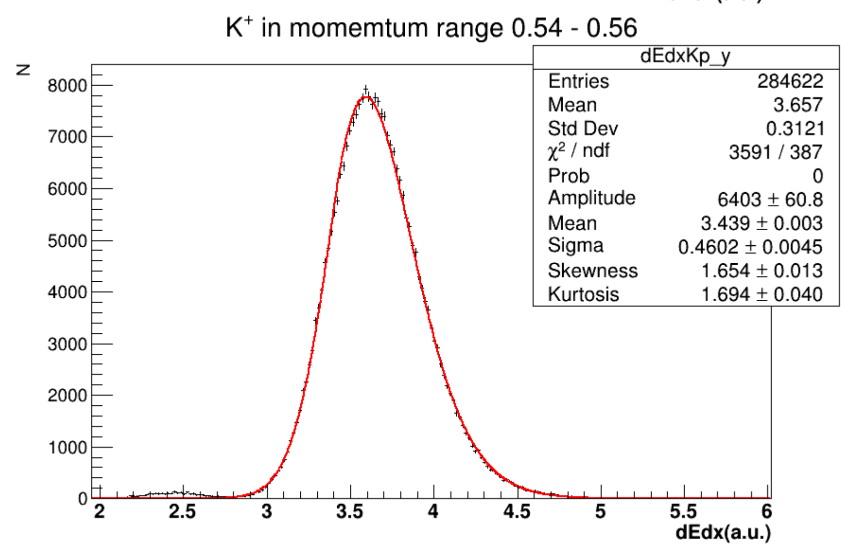
π 0.005 < m2 < 0.07

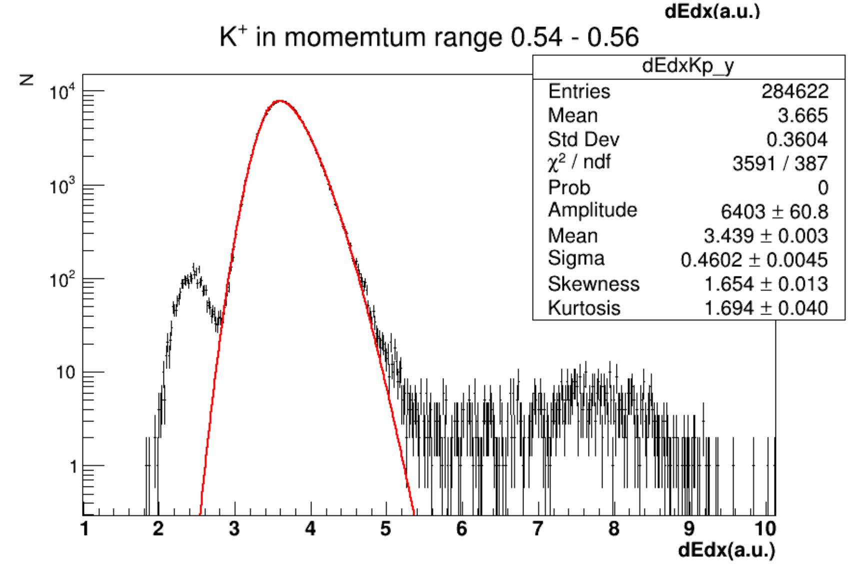
e 0.004 < m2 < 0.005

Clean sample examples

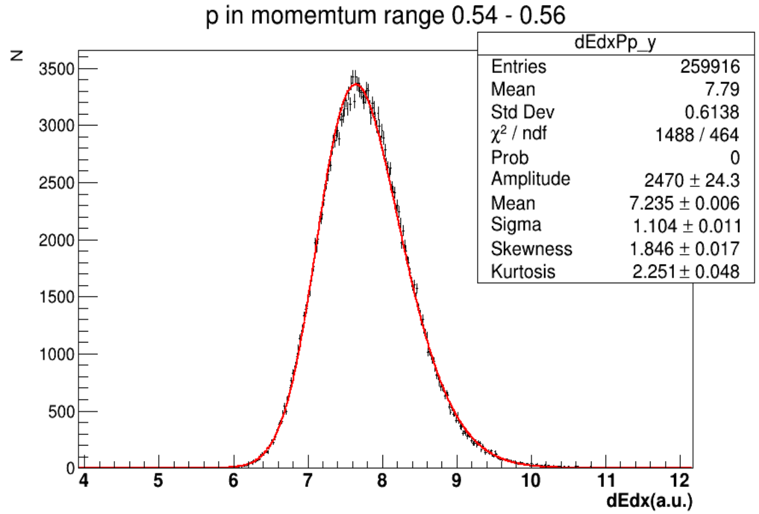


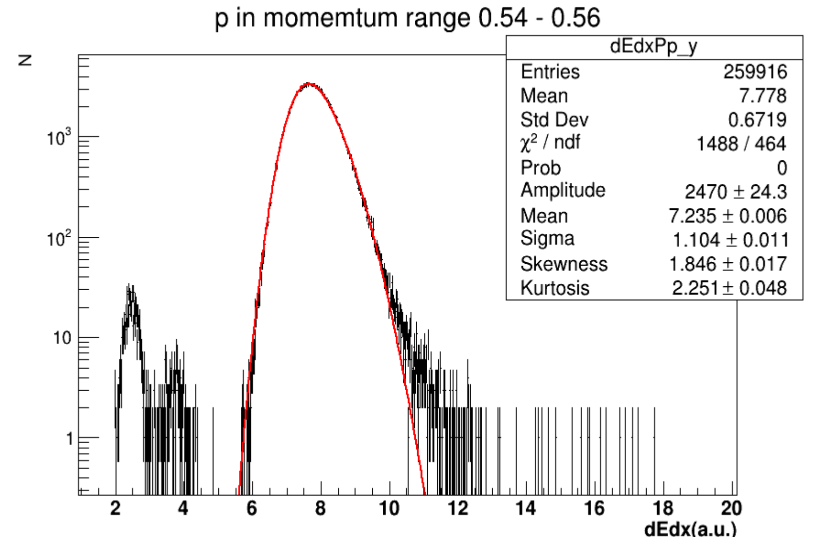


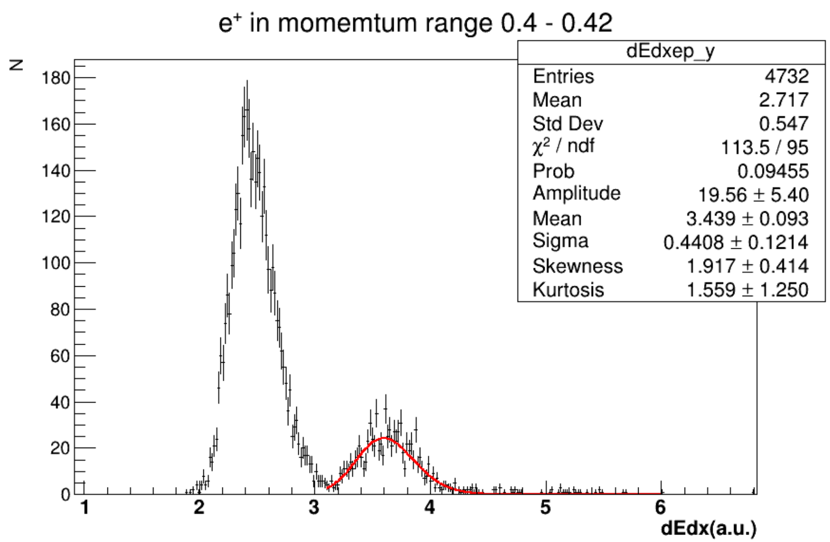


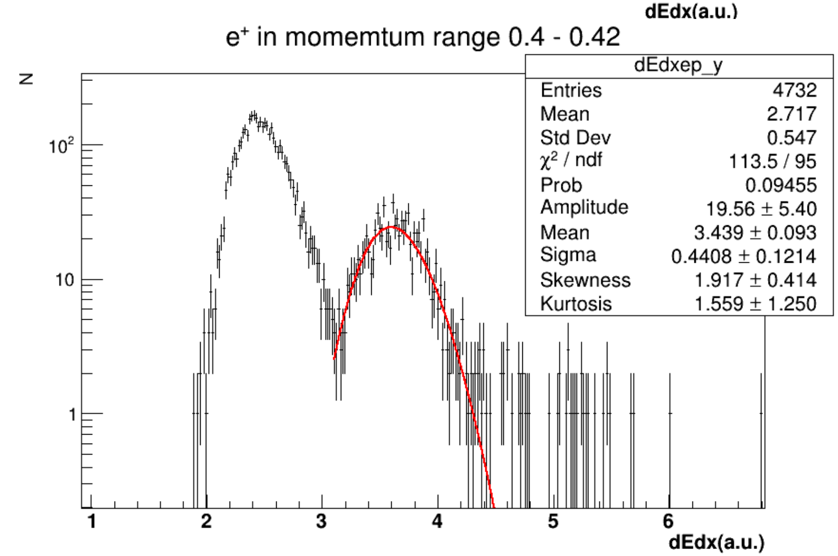


Clean sample examples

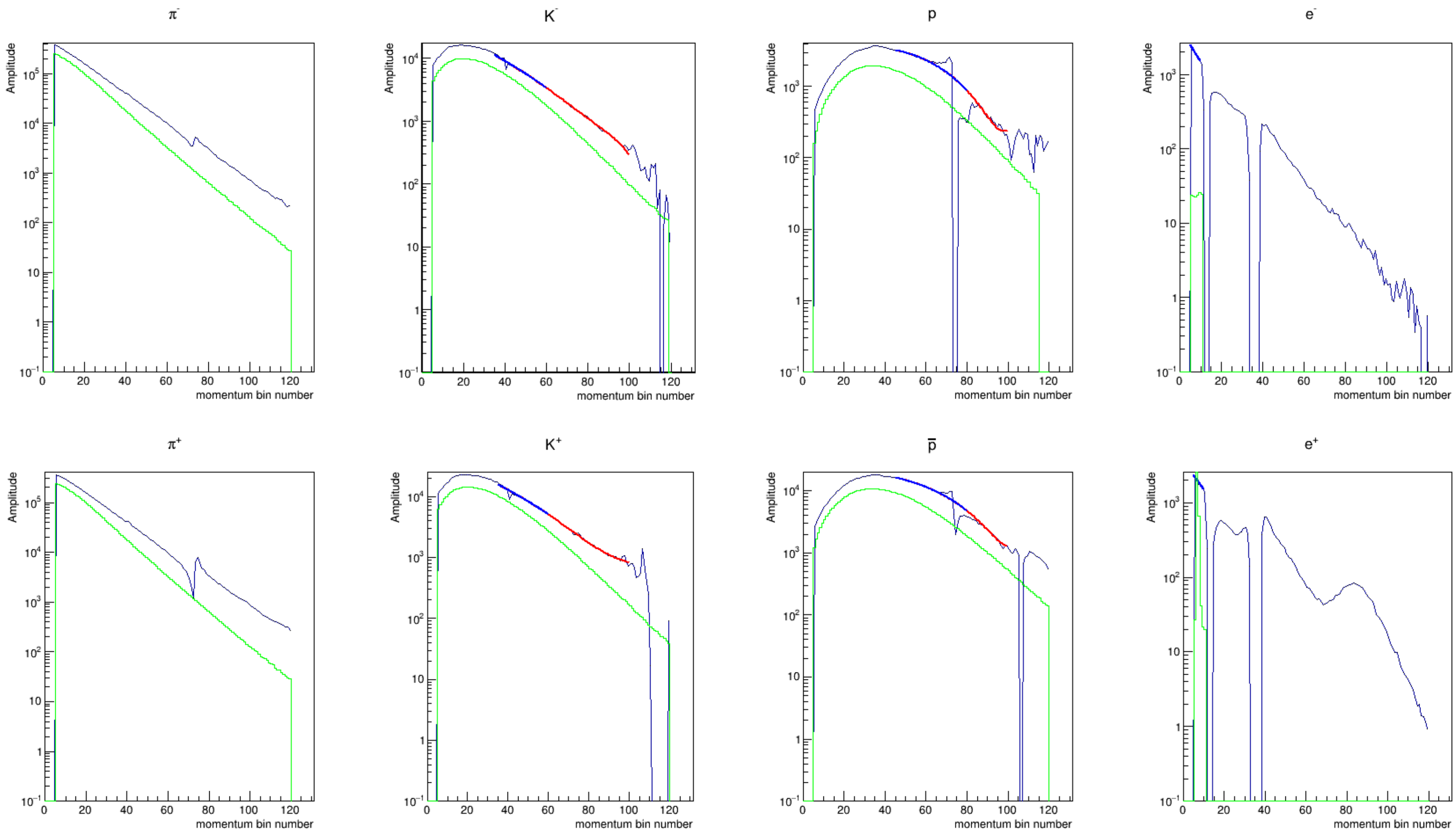








Parameter correction



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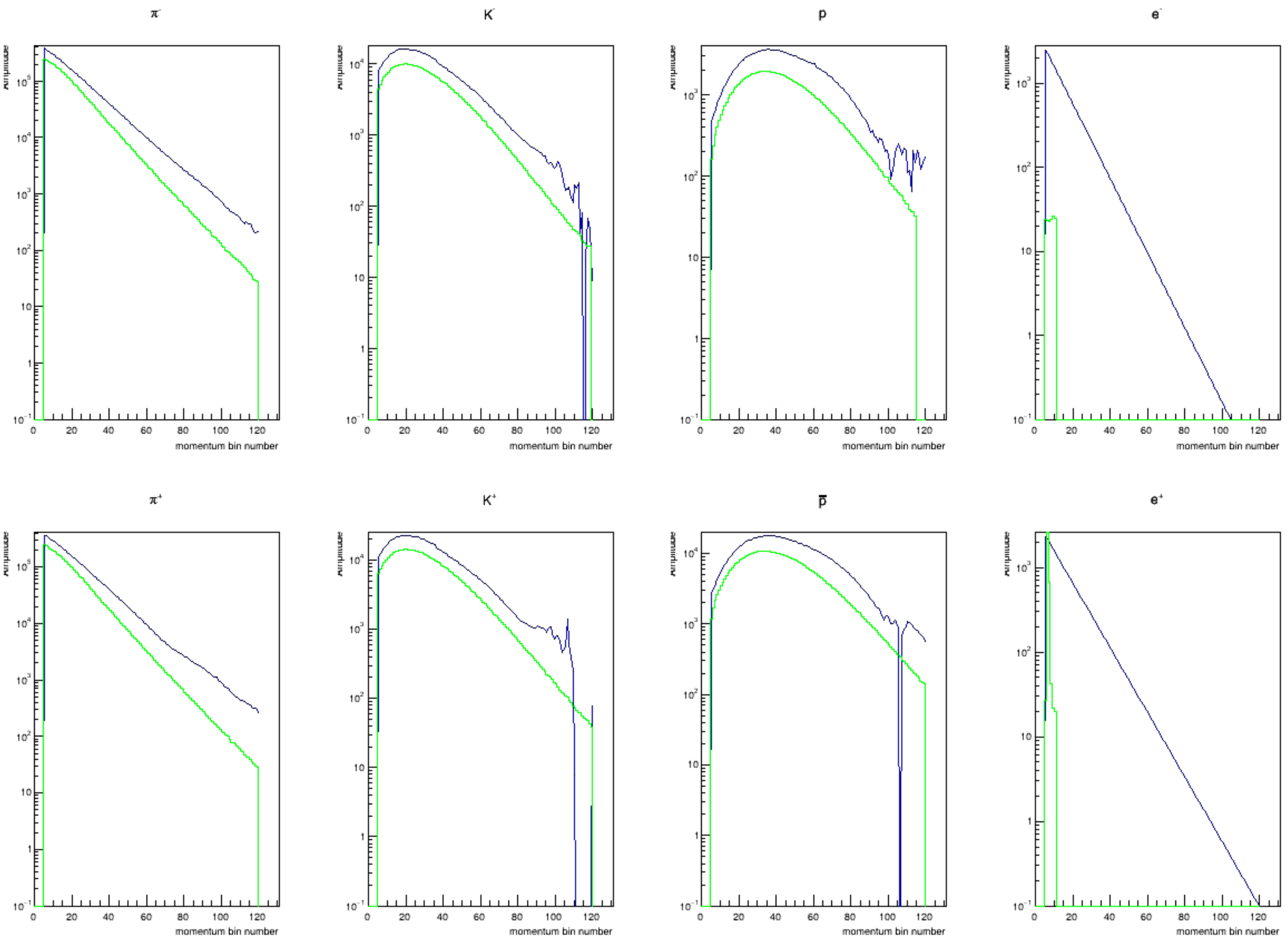
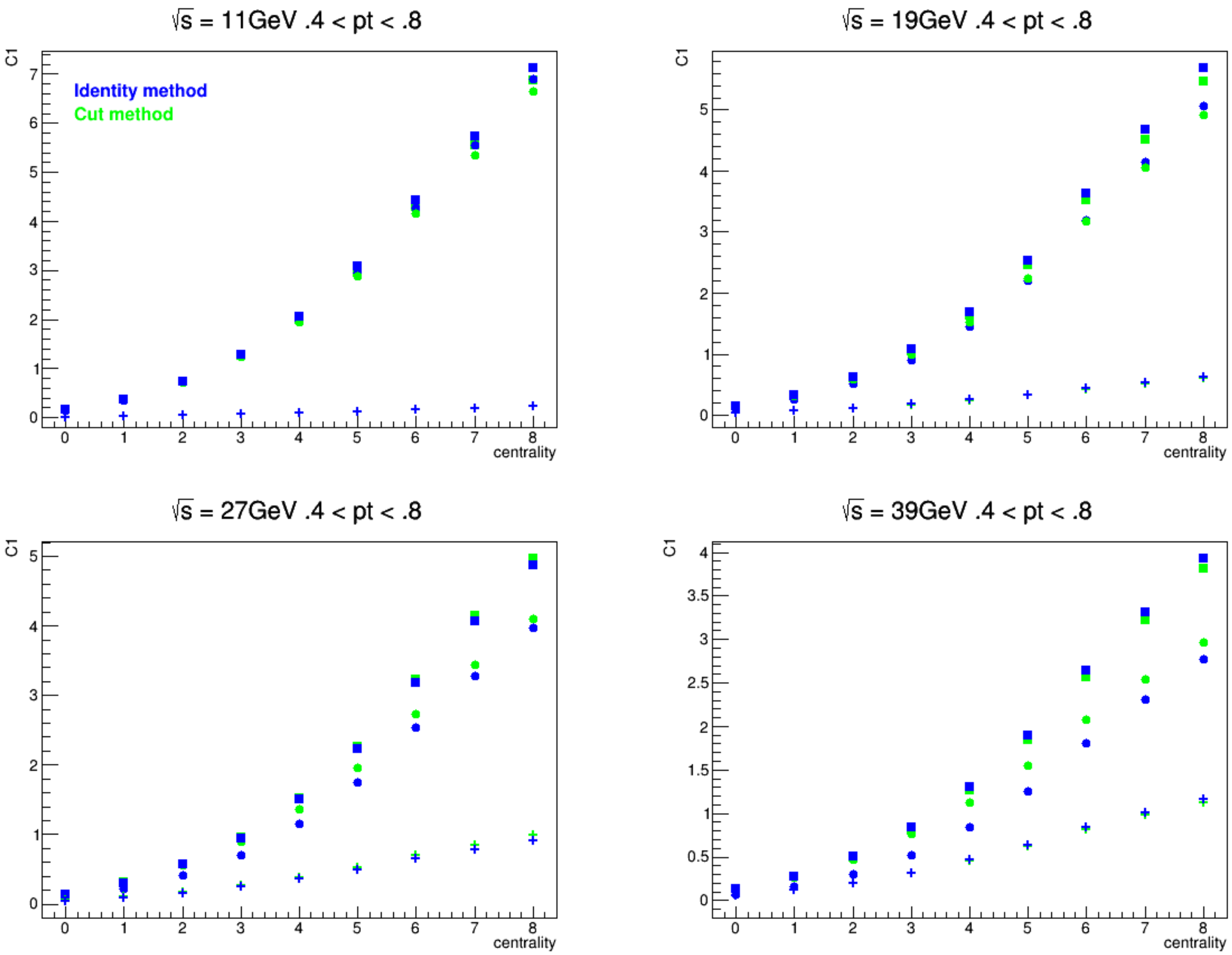


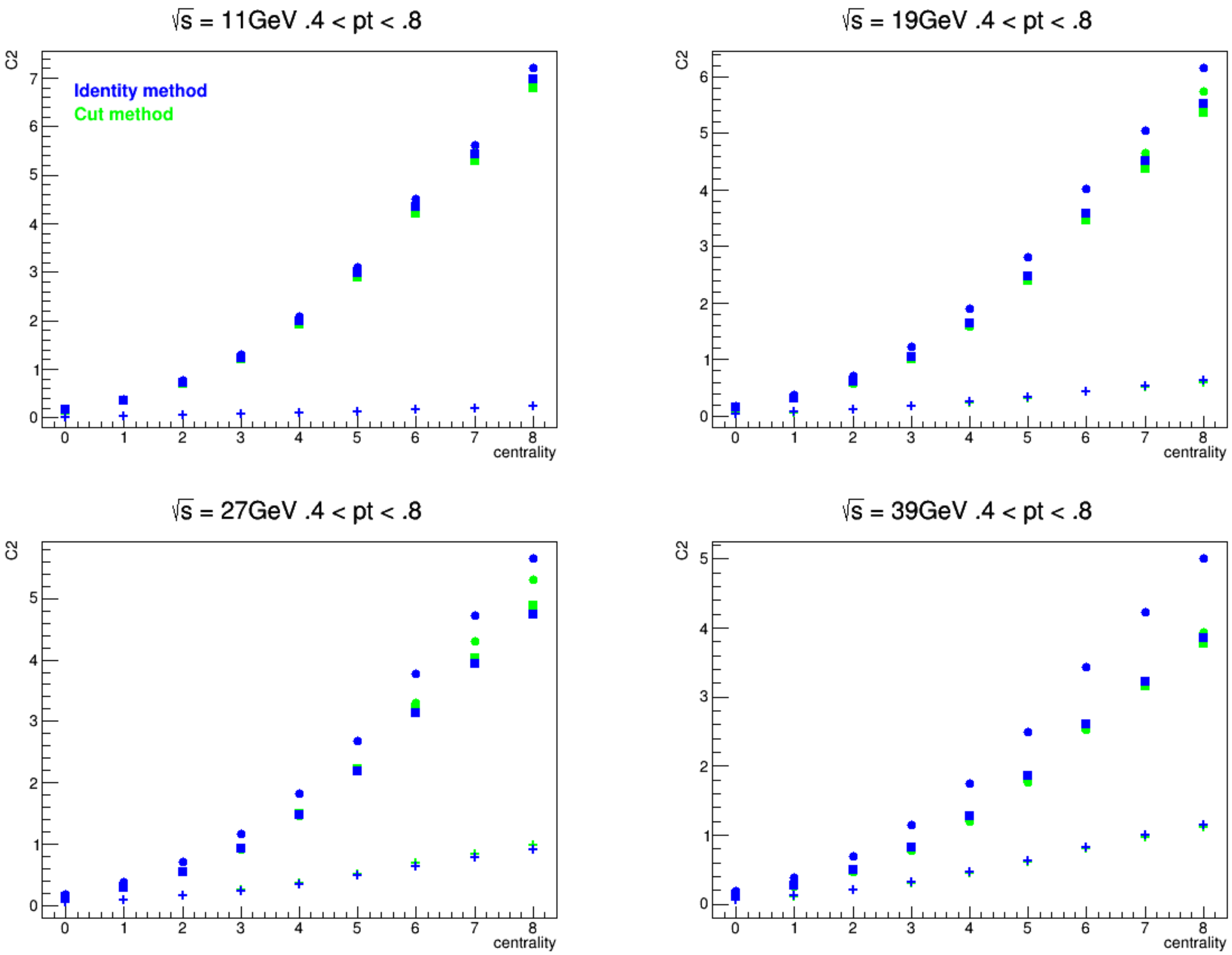
Proton Cuts

- For 0.4 < pt < 0.8GeV interval
  - Nsigma < 2
- For 0.8 < pt < 2.0GeV interval
  - Nsigma < 2
  - 0.6 < m2 < 1.2
  - m2<-0.4

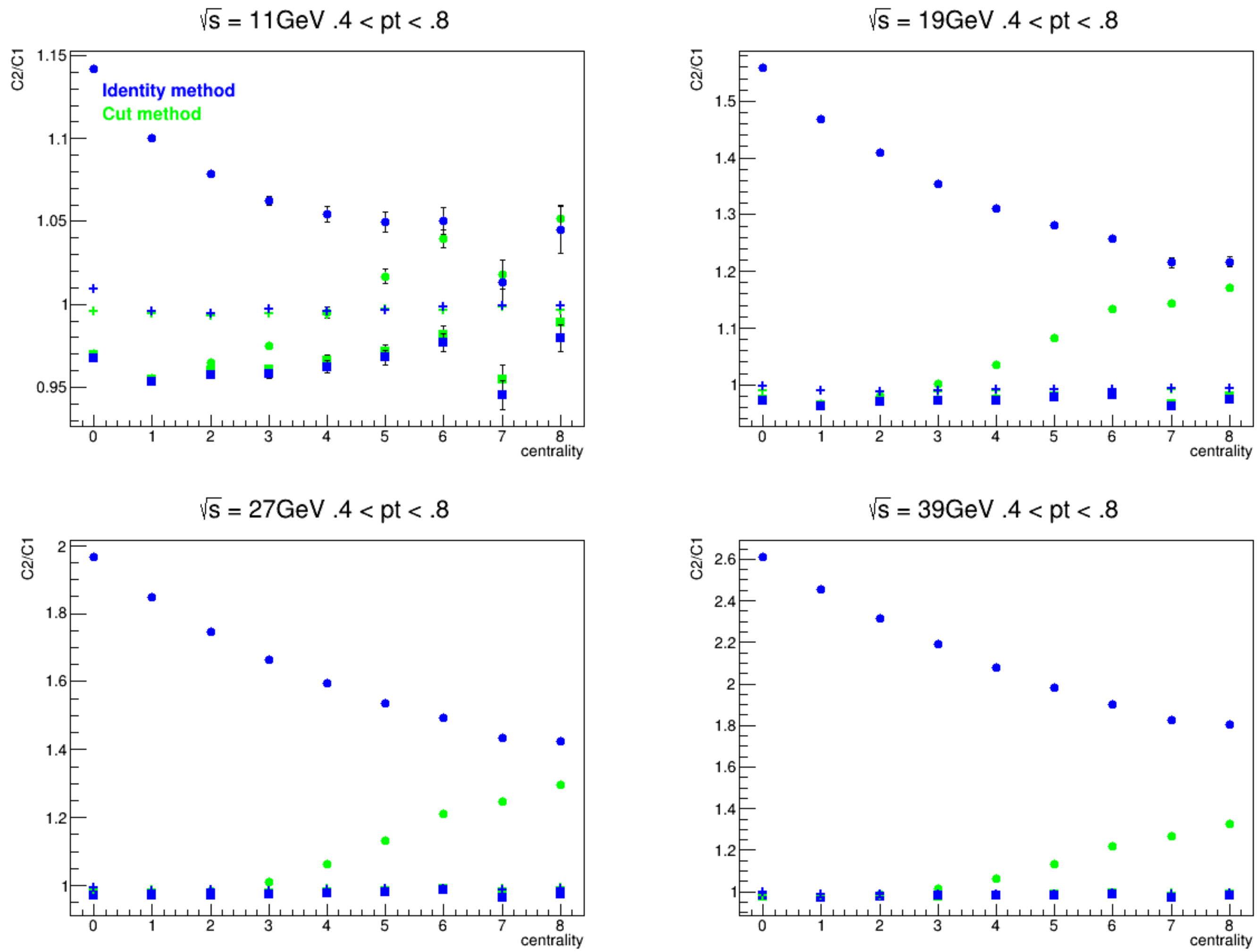
C1 vs centrality 0.4<pt<0.8GeV



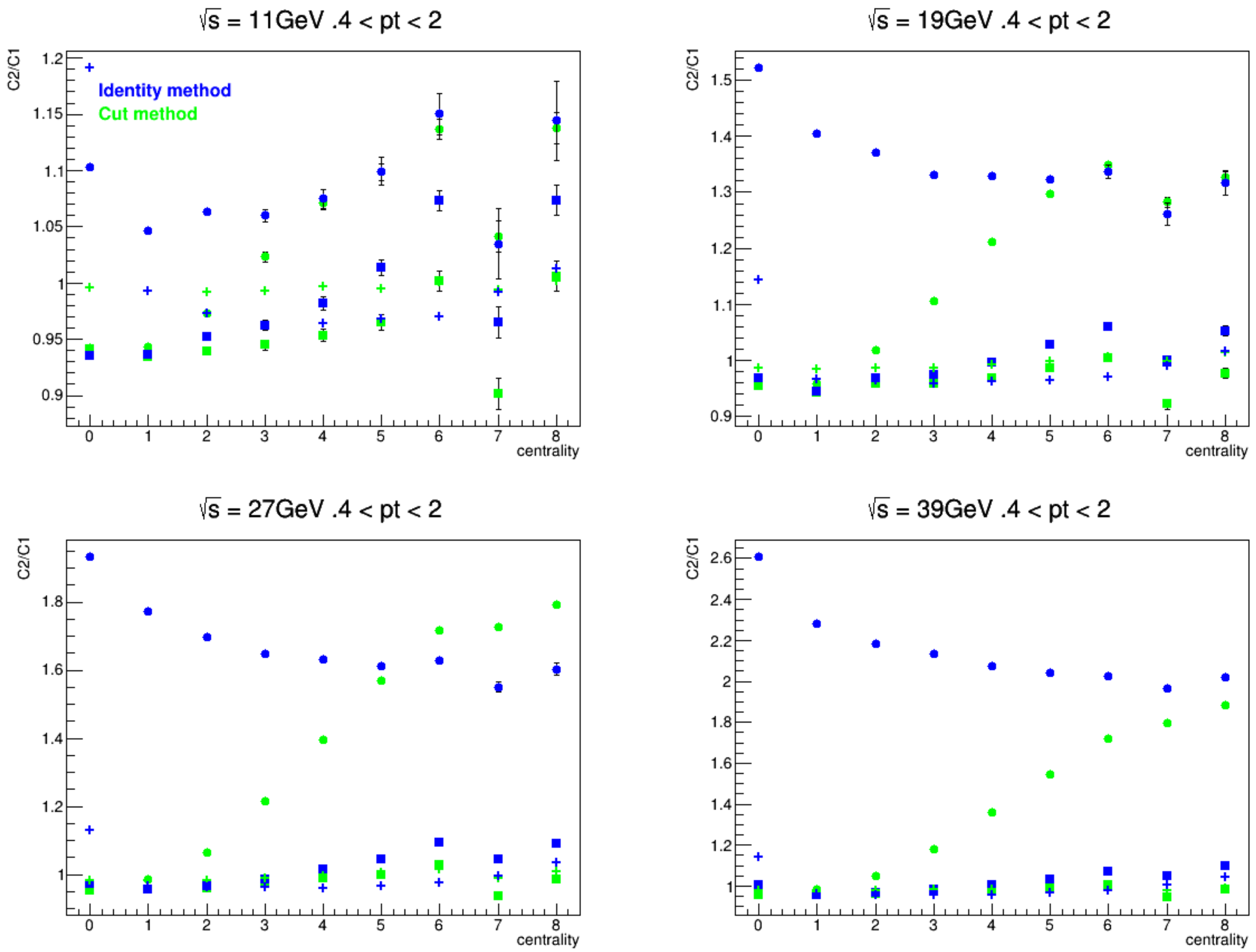
C2 vs centrality 0.4<pt<0.8GeV



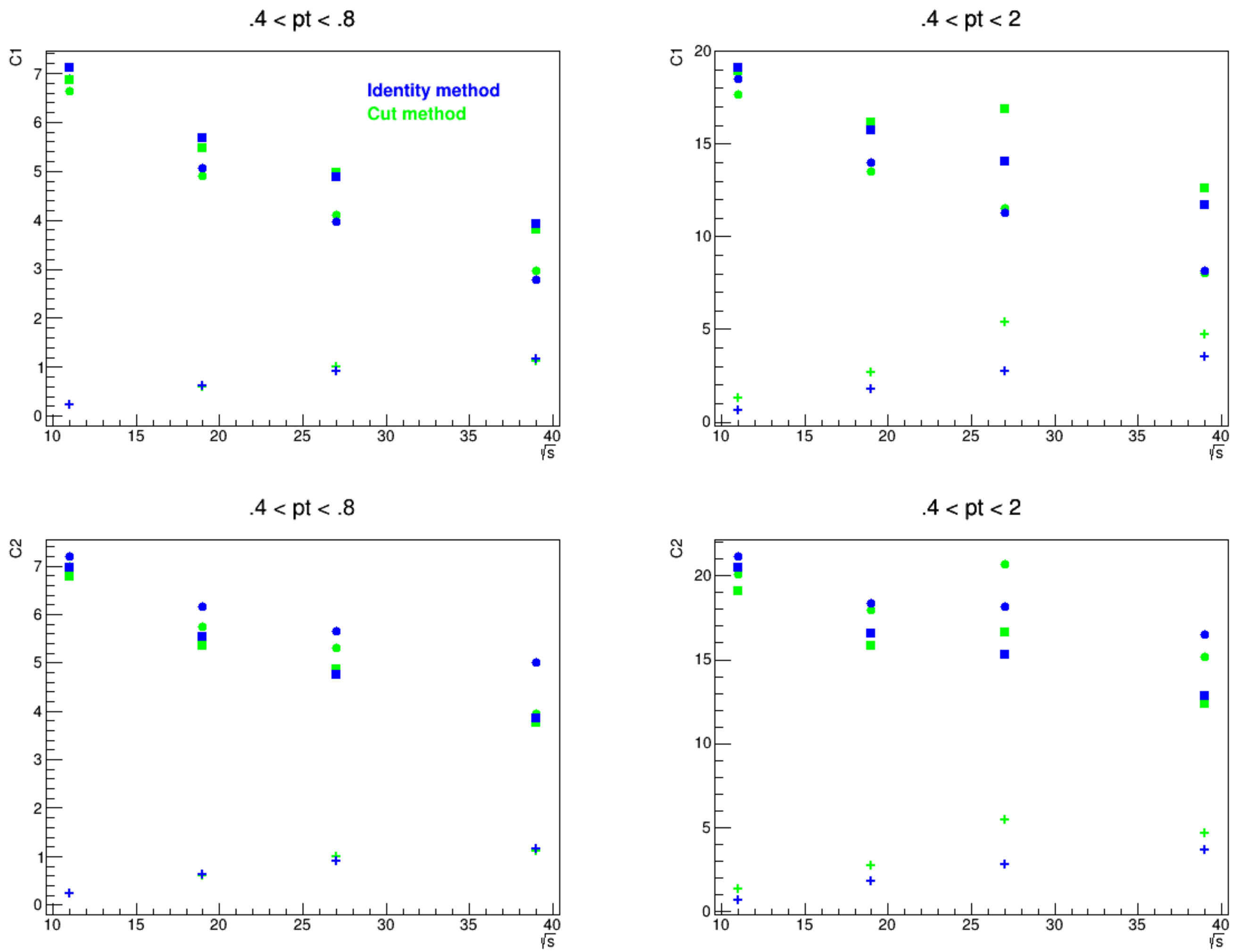
C2/C1 vs centrality 0.4<pt<0.8GeV



C2/C1 vs centrality 0.4<pt<2GeV



C1 & C2 vs √s (centrality 5%)



C2/C1 vs √s (centrality 5%)