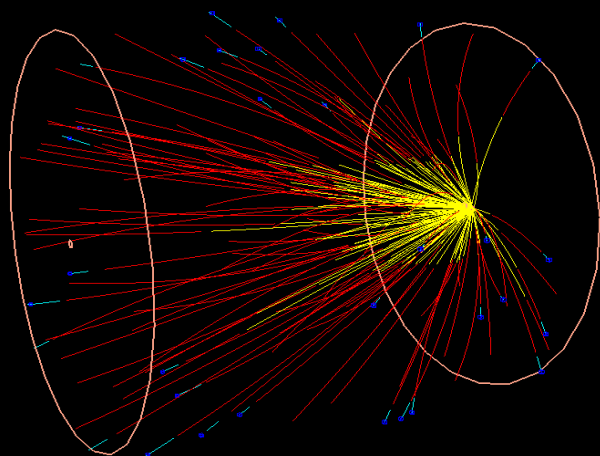


Fixed-Target Proton Measurements Au + Au $\sqrt{s_{NN}} = 3.0$ GeV collisions

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University of California-Davis
for the STAR Collaboration



UC DAVIS₁

RHIC

(Relativistic Heavy Ion Collider)

STAR

EBIS &
LINAC

Booster

AGS

Signatures of a QCD phase transition

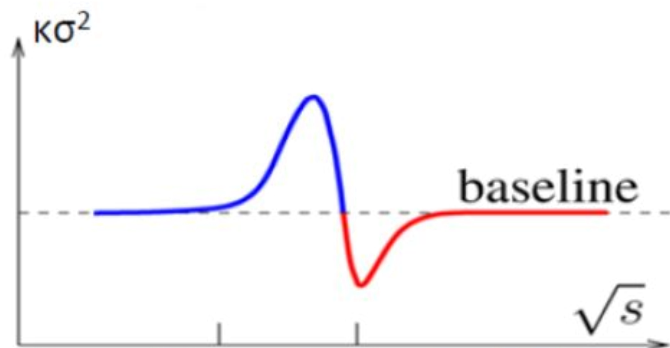
Probing non-gaussian fluctuations

Fluctuations manifest as event-by-event observables
(multiplicities, mean transverse momenta)

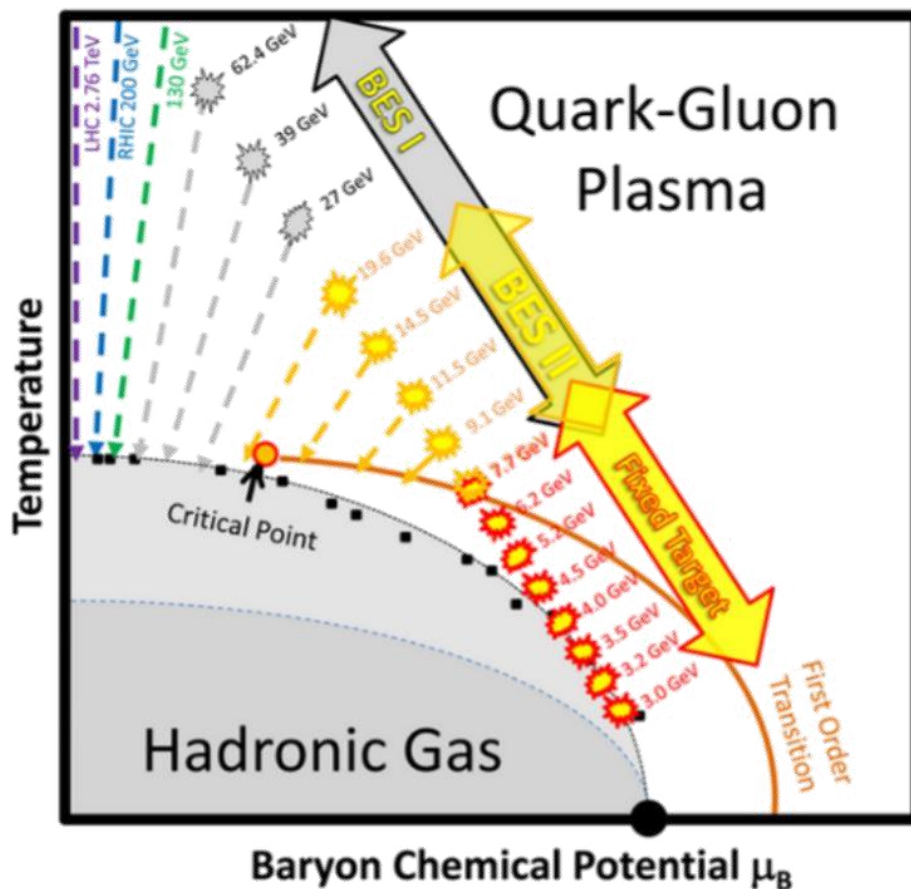
Net Baryon Density fluctuation sensitivity to
Correlation length ξ :

$$\xi^{4.5} \sim S\sigma$$

$$\xi^7 \sim \kappa\sigma^2$$



M. Stephanov. J. Physics G.: Nucl. Part. Phys. **38** (2011) 124147



Moments and Susceptibilities of the System

QCD Thermodynamics on the lattice (QCD Partition Function)

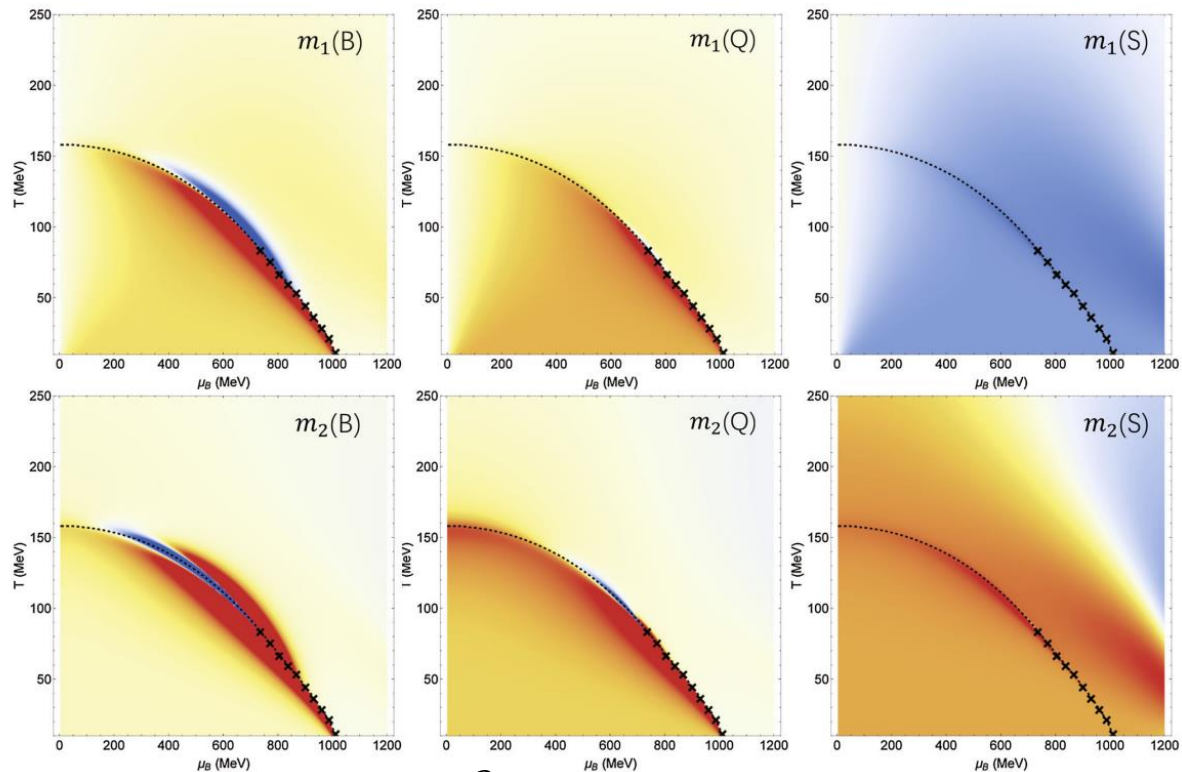
$$\frac{P}{T^4} = \frac{1}{VT^3} \ln[Z(V, T, \mu_B, \mu_Q, \mu_S)]$$

$$\chi_{ijk}^{BQS} = \frac{\partial^{i+j+k} [P/T^4]}{\partial \hat{\mu}_B^i \partial \hat{\mu}_Q^j \partial \hat{\mu}_S^k}$$

$$\frac{\chi_q^4}{\chi_q^2} = \frac{C_4}{C_2} = \kappa \sigma^2$$

$$\frac{\chi_q^3}{\chi_q^2} = \frac{C_3}{C_2} = s \sigma$$

NJL Model

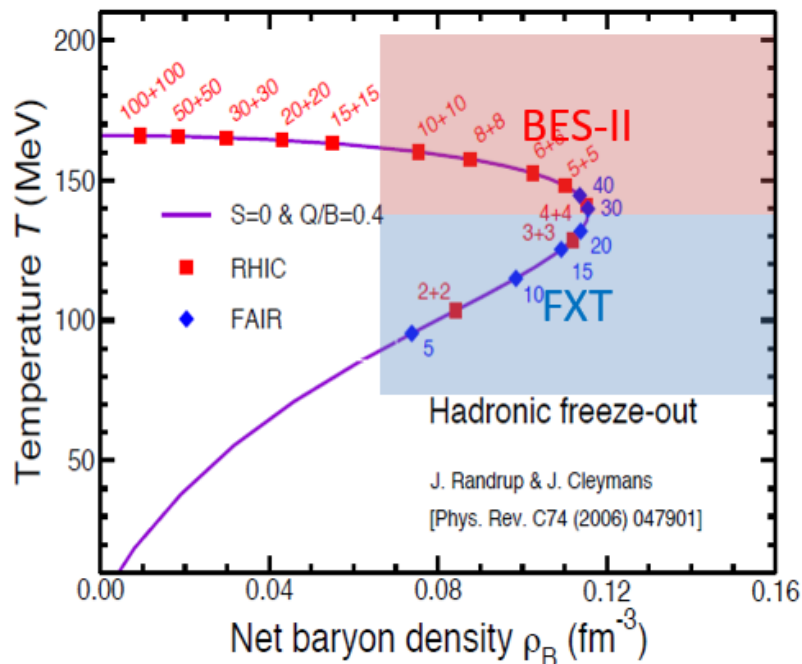


$$m_1 = \frac{\chi^3}{\chi^2}$$

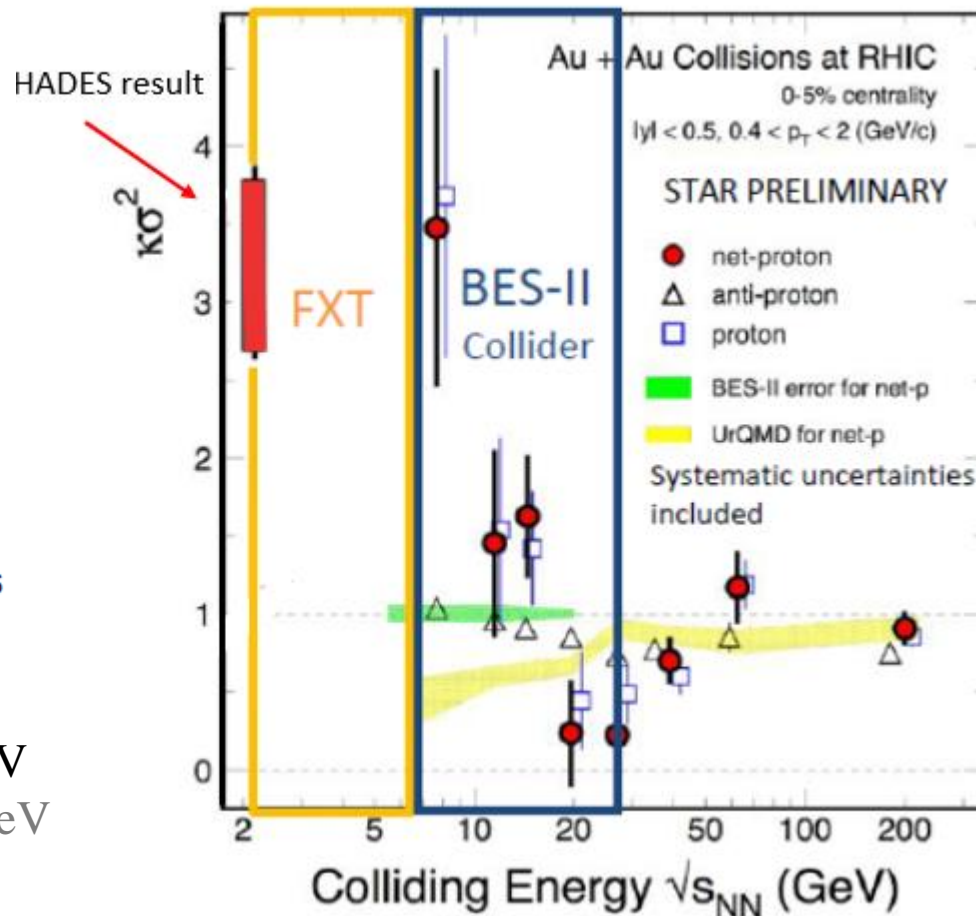
$$m_2 = \frac{\chi^4}{\chi^2}$$

Luo, X. & Xu, N. NUCL SCI TECH (2017) 28: 112. <https://doi.org/10.1007/s41365-017-0257-0>

BES-II and Fixed Target



BES-II: 7.7, 9.2, 11.5, 14.6, 19.6 GeV
 Fixed Target: 3.0, 3.2, 3.9, 7.2 7.7 GeV



Overview of Fixed Target Program

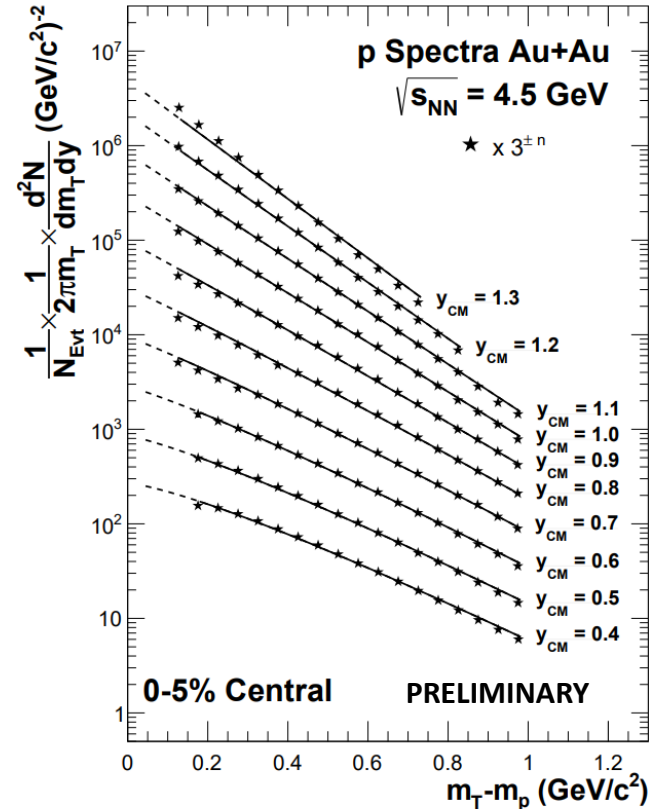
2018

Single Beam Energy (GeV)	Fixed Target $\sqrt{s_{NN}}$ (GeV)	Good Triggers
3.85	3.0	360 M

2019

Single Beam Energy (GeV)	Fixed Target $\sqrt{s_{NN}}$ (GeV)	Good Triggers
31.2	7.7	50 M
7.4	3.9	53 M
4.59	3.2	200 M
3.85	3.0	3.7 M

2015 Fixed Target Test Run

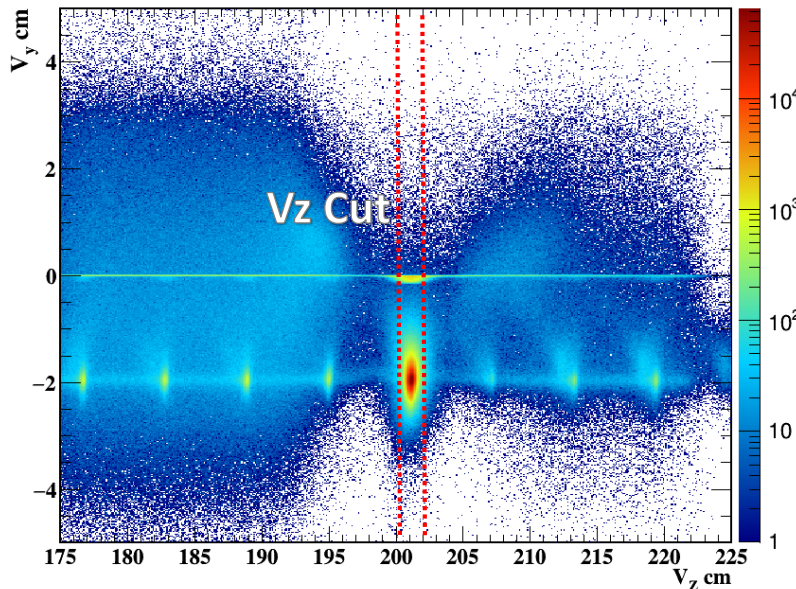
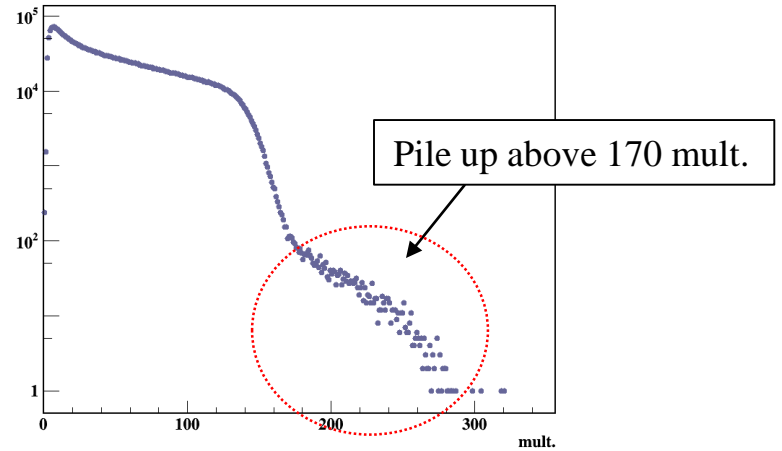
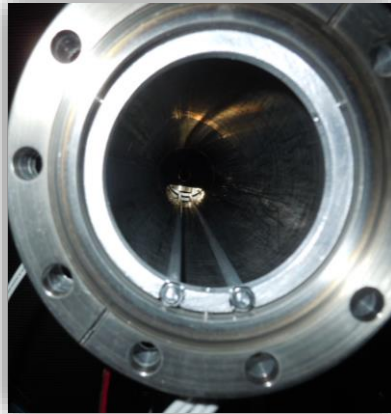
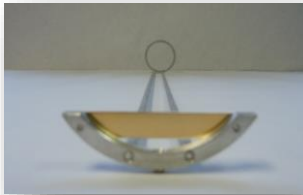


STAR Fixed Target

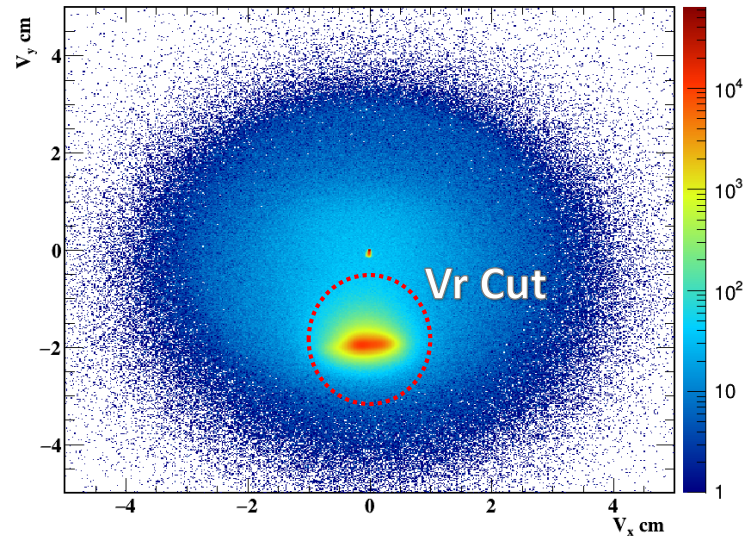
Vertex Cuts

$200 \text{ cm} < V_z < 202 \text{ cm}$

$V_r < 1 \text{ cm}$ around $(0, -2)$

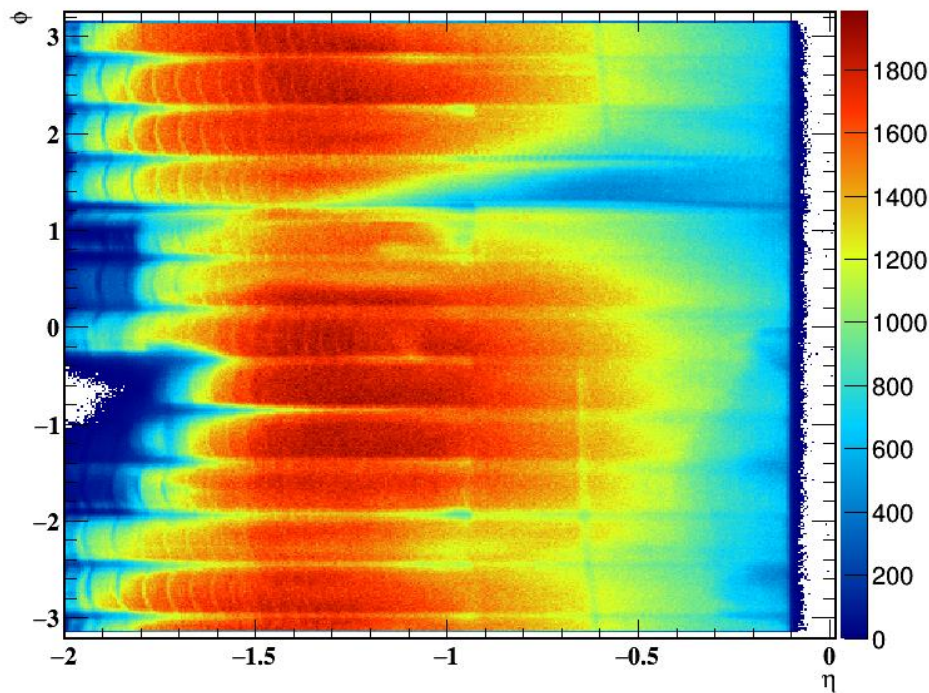


Reconstructed Vertex

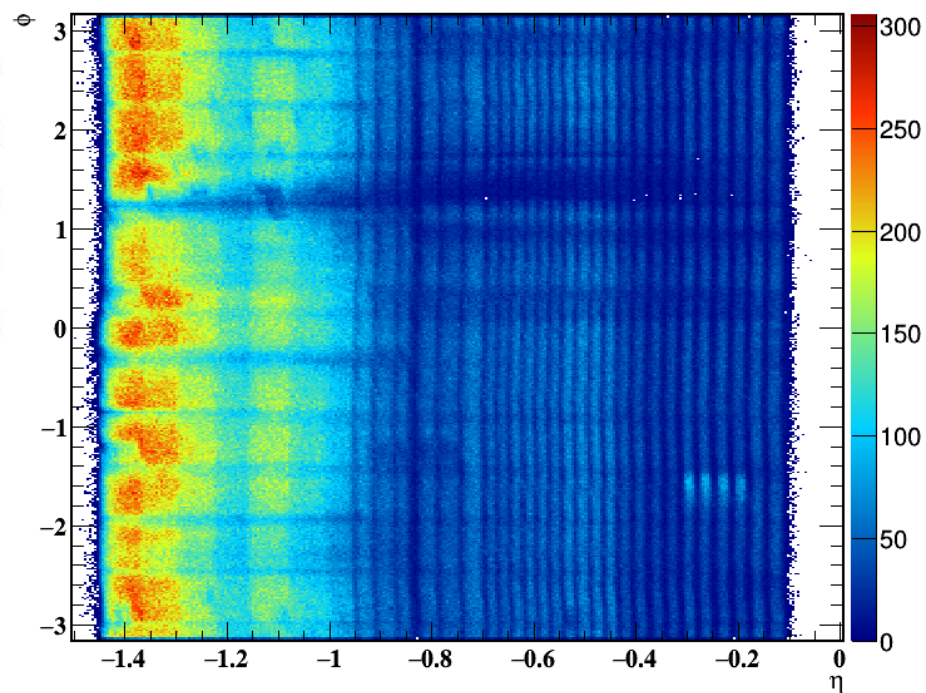


Reconstructed Vertex

TPC Performance



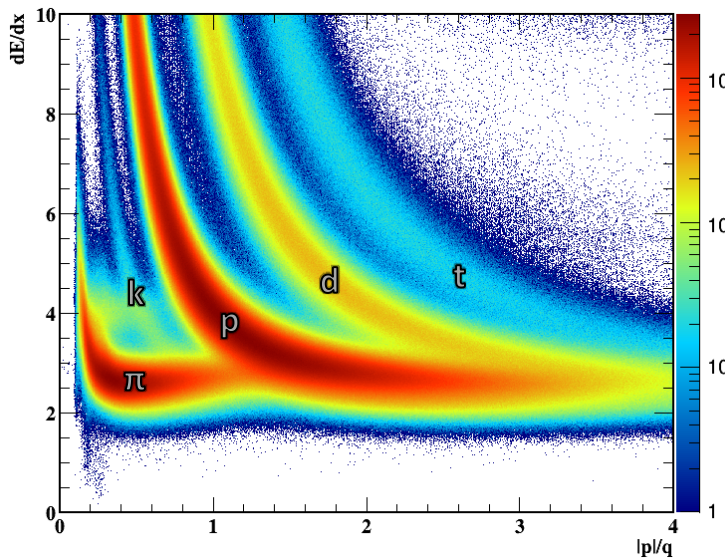
All TPC Tracks



TPC with Time of Flight Hit Required

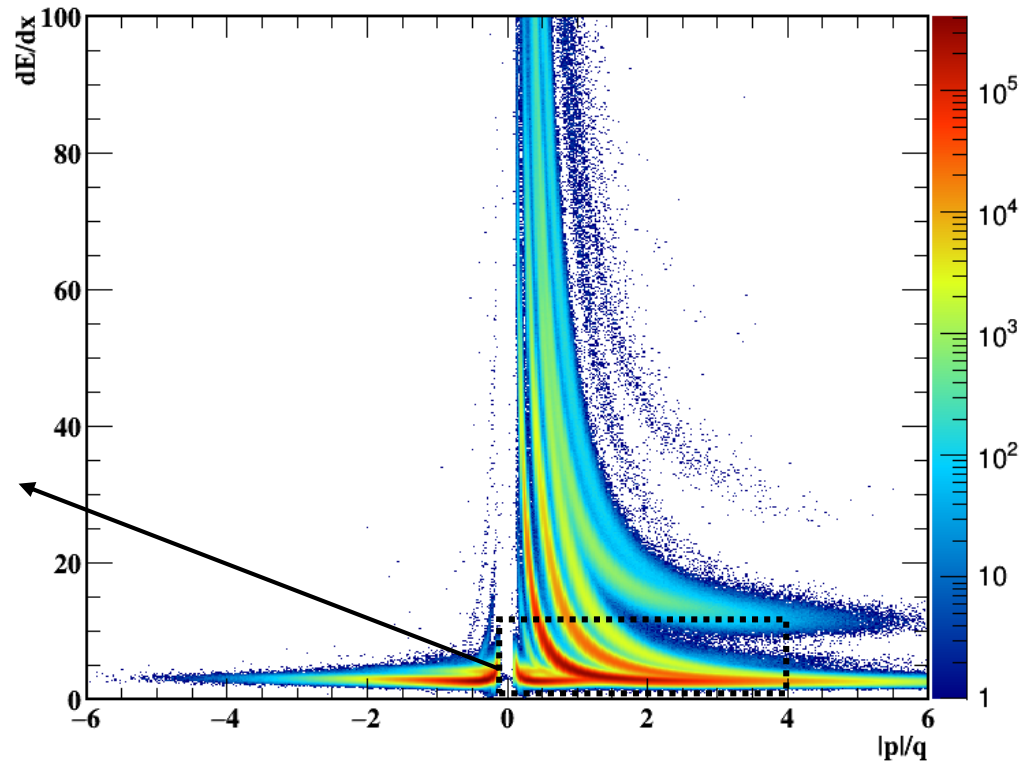
Particle Identification

Particle bands are well separated at $\sqrt{S_{NN}} = 3.0$ GeV

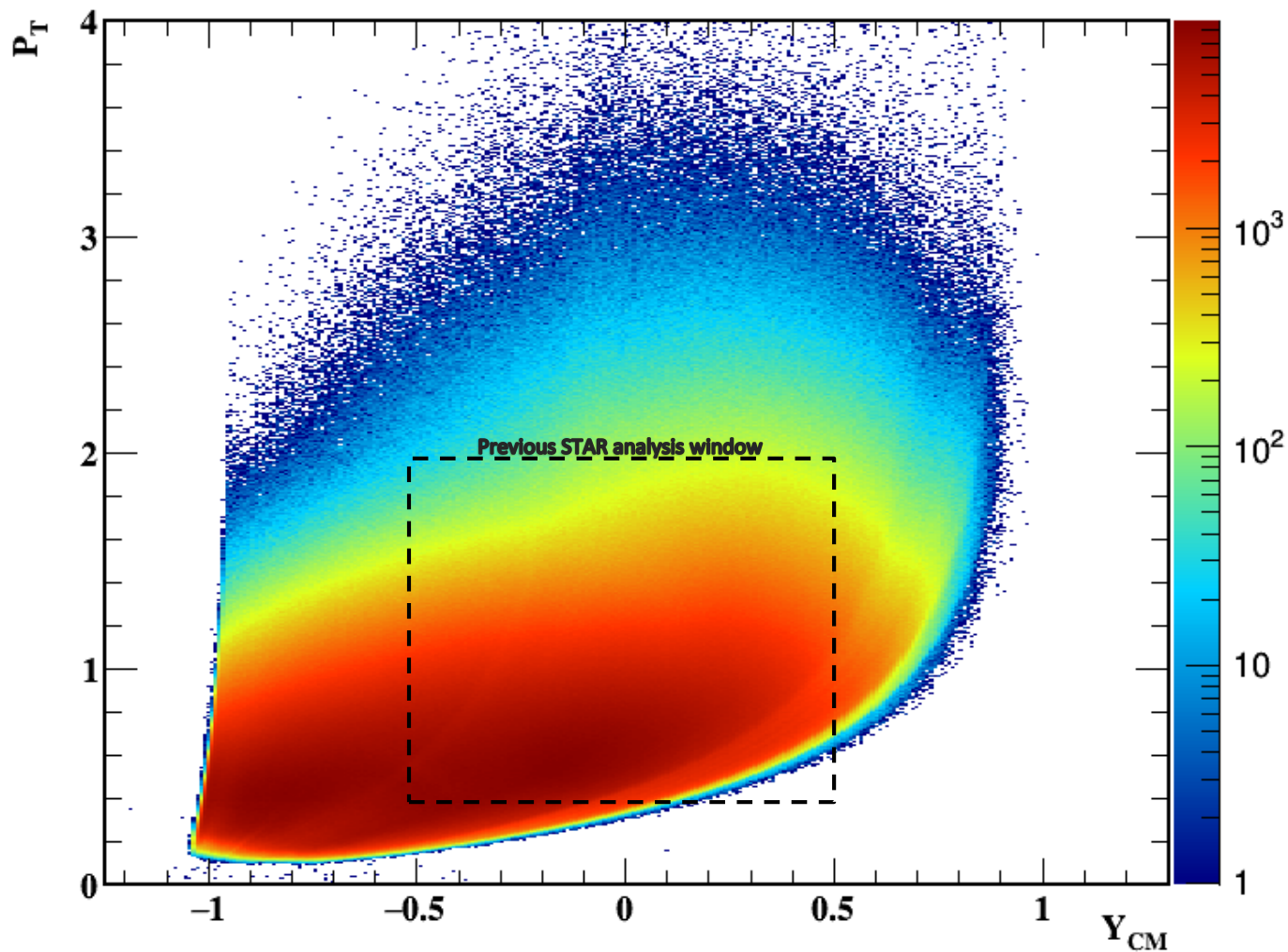


Protons will not require additional detector identification below ~ 2.3 GeV

Energy Loss in the Time Projection Chamber



Proton Acceptance



Almost full coverage of STAR's previous analysis window

Summary

- Study the phase transition of Hadron Gas to Quark Gluon Plasma
- Cumulants of net-proton measured from 200 GeV down to 7.7 GeV Au+Au collisions
- Fixed Target extends STAR's energy range to 3.0 GeV
- Good proton acceptance at 3.0 GeV to probe the phase space of previous STAR analysis