Low p_T non-photonic electron production in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV

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(PIP2015)

Outline

- Motivation I : Heavy flavor in HIC
- Motivation II : Recent NPE results
- Status of low p_T NPE analysis in detail
  - Inclusive electrons
  - Reconstruction of photonic electrons background
  - Partner finding efficiency
- Summary

Outline

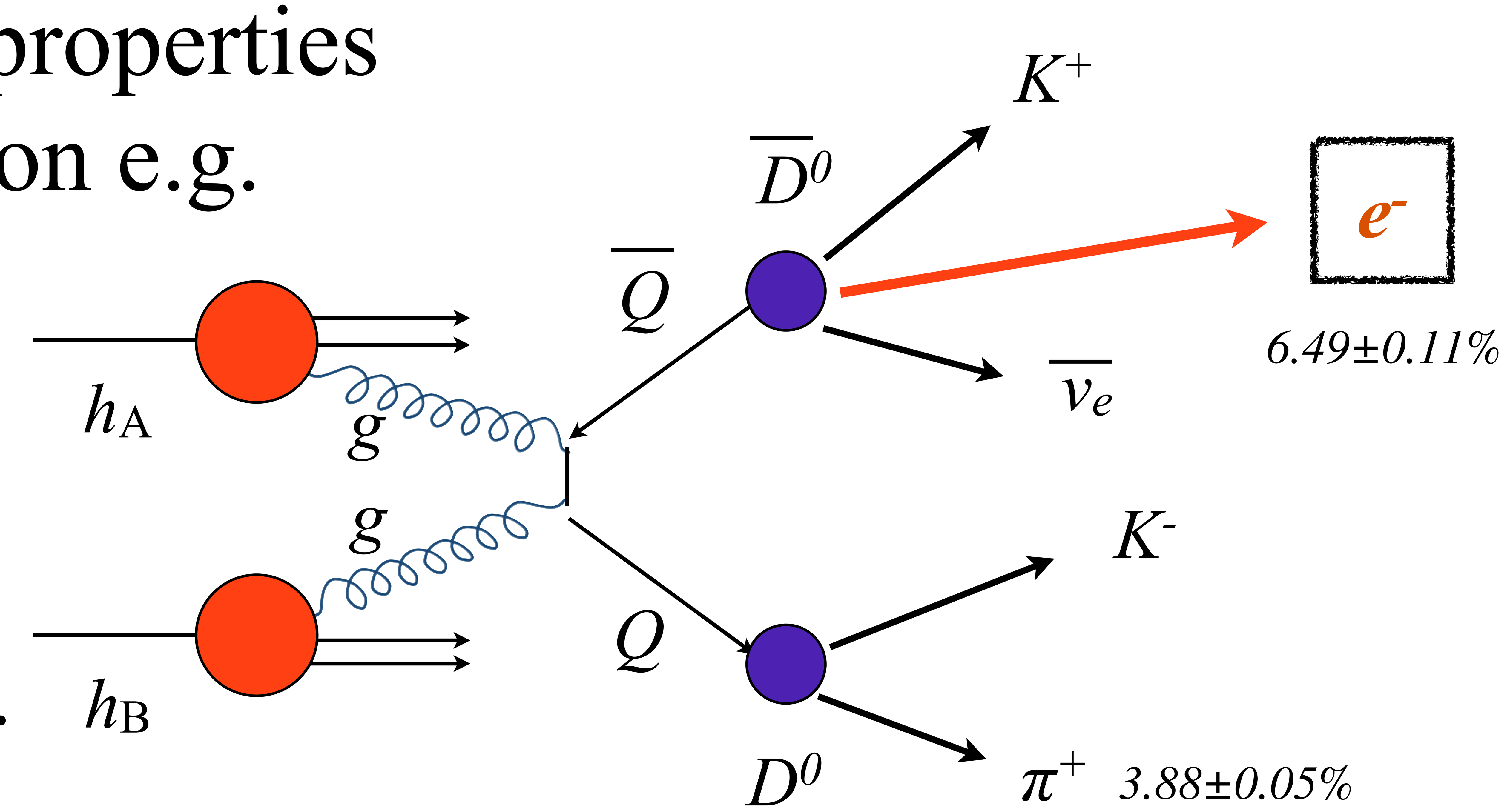
- Motivation I : Heavy flavor in HIC
- Motivation II : Recent NPE results

Analysis Technique!

- Status of low p_T NPE analysis in detail
  - Inclusive electrons
  - Reconstruction of photonic electrons background
  - Partner finding efficiency
- Summary

Motivation

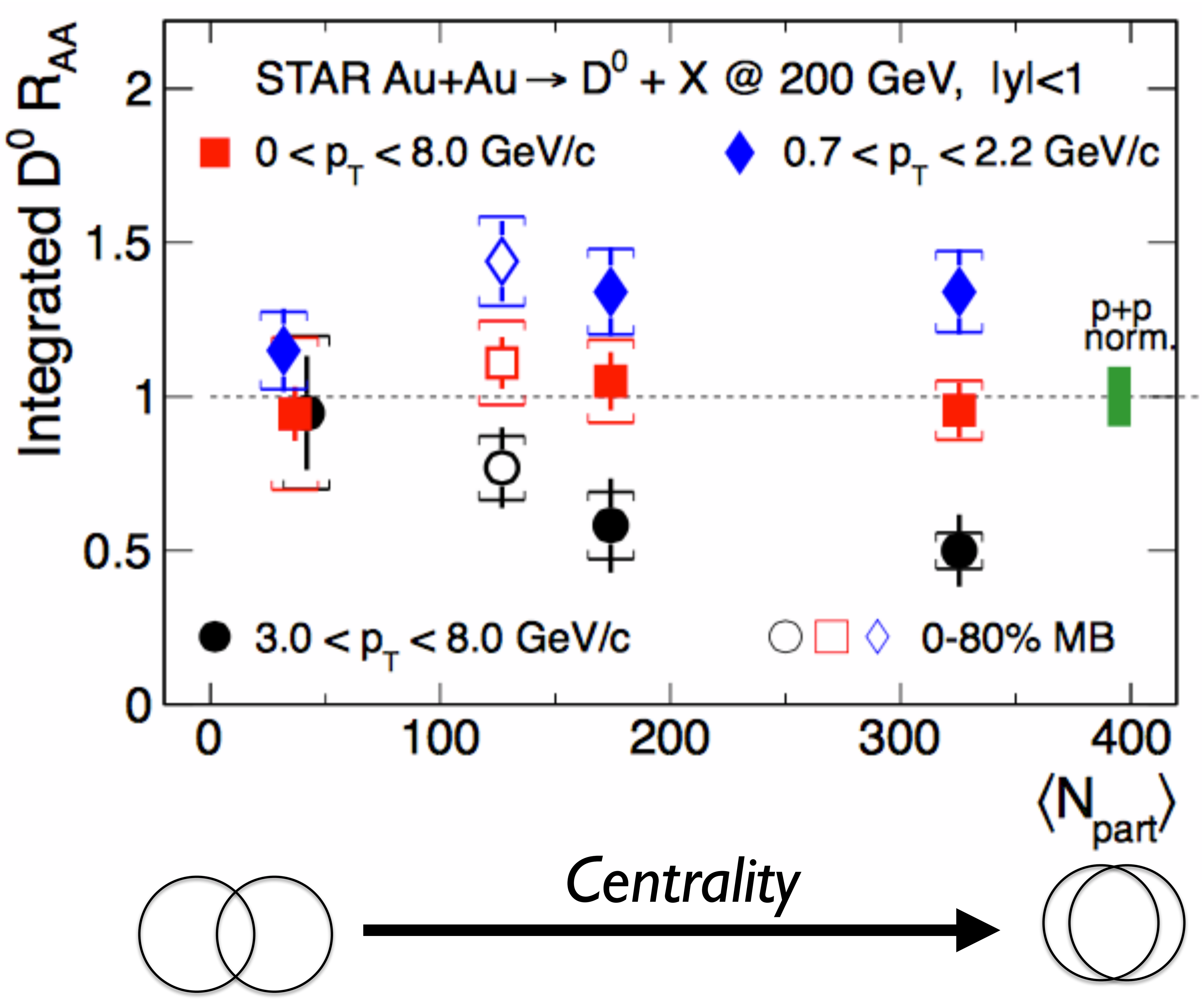
- **Heavy Flavor** in heavy-ion collisions
  - HF quarks are primarily produced in **initial hard scattering**, and are exposed to the evolution of **the hot nuclear matter** created at RHIC.
  - Using the HF as a probe to study properties of the QGP and their dependence on e.g. system size and energy.

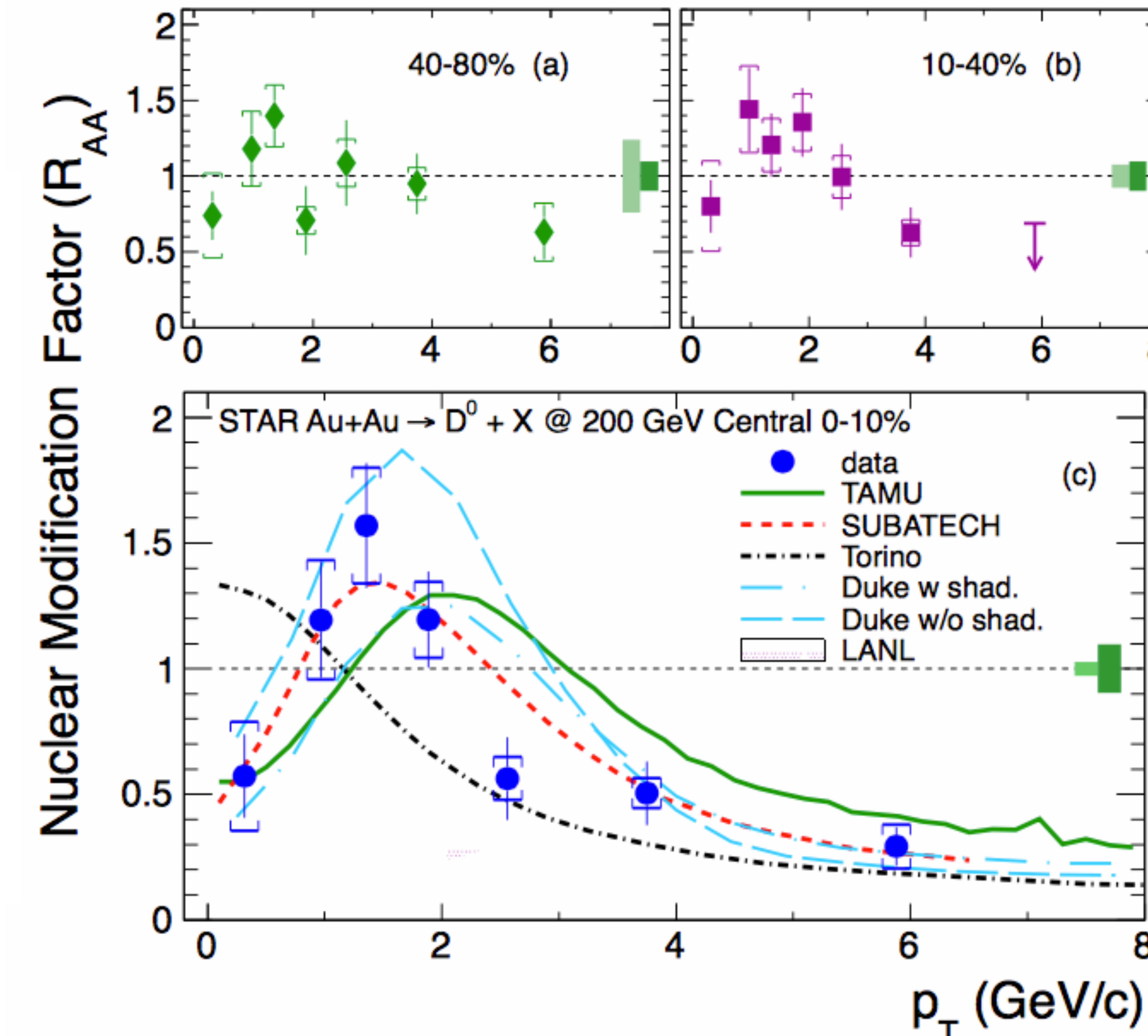


- **Non-photonic electrons (NPE)**
  - *Semileptonic channel* has high B.R. of *open heavy flavor mesons.*
  - *Easy for triggering and identification.*
  - Comparable with direct reconstructed open heavy flavor mesons.

Recent D meson results

arXiv:1404.6185

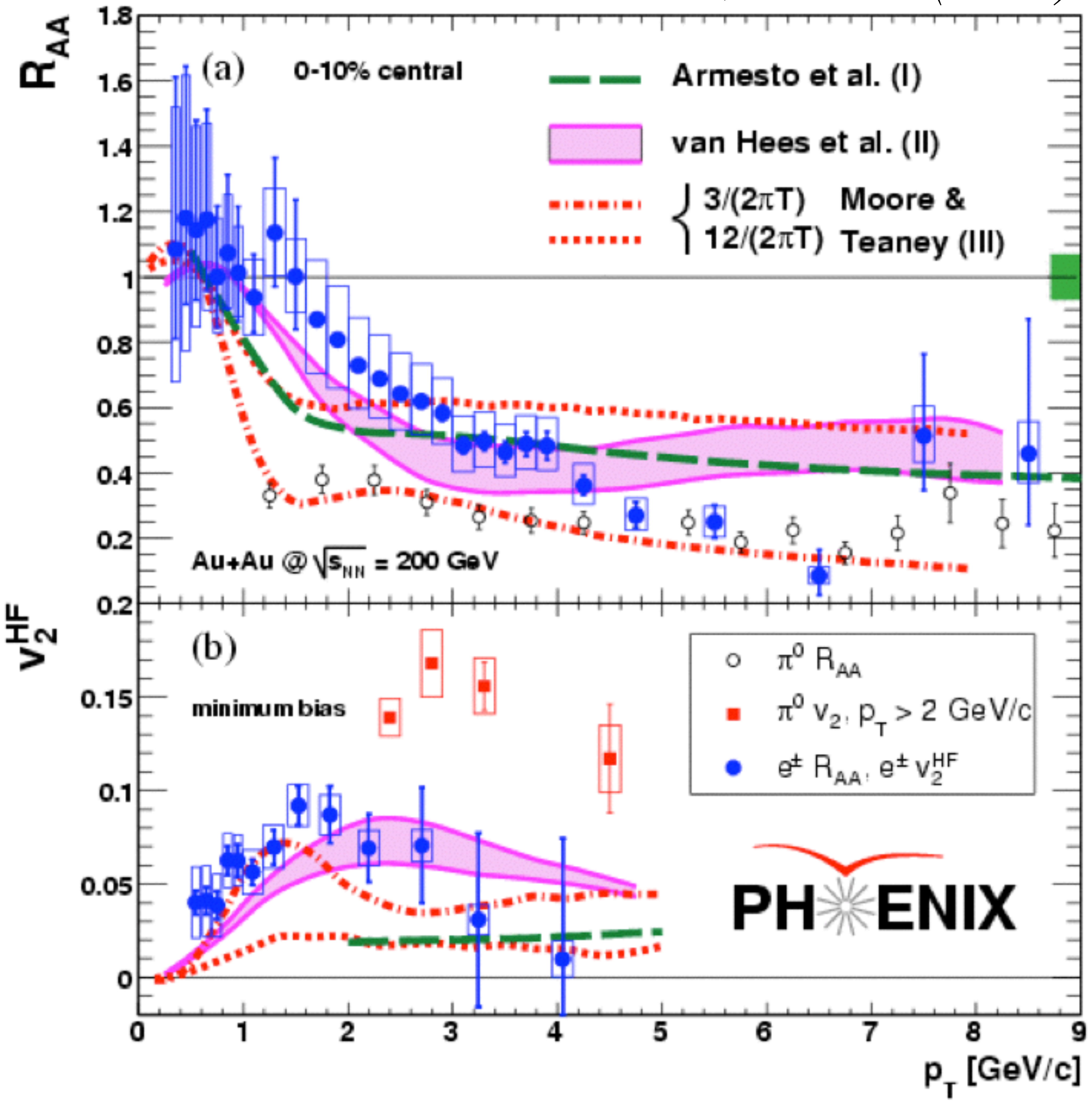




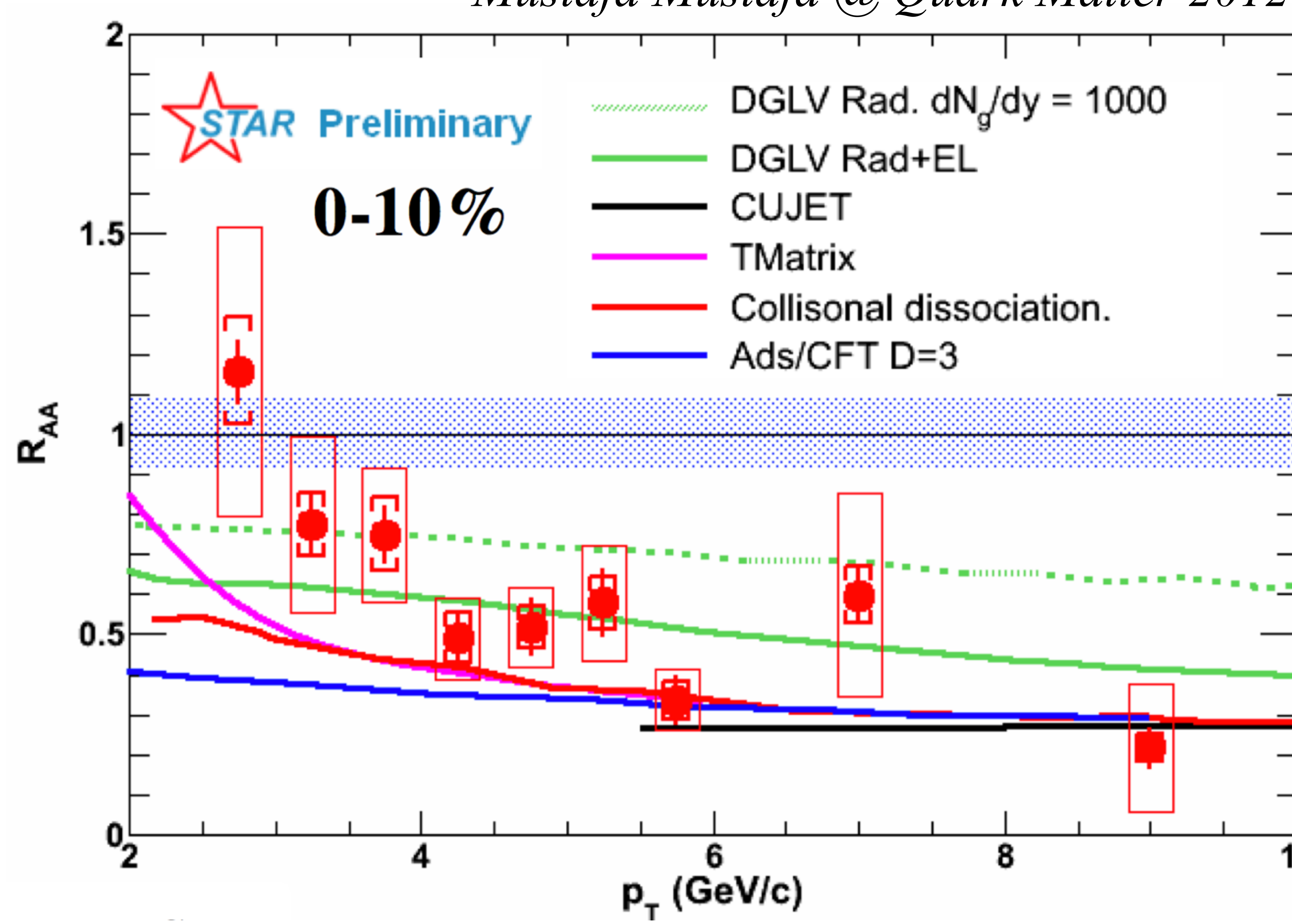
- Strong suppression is observed at high p_T.
  - Indication of enhancement p_T~0.7-2.2GeV/c, described by models with charm quarks coalescence with light quarks. → *Low p_T NPE also?*

Recent NPE results

PRL ***98****, 172301 (2007)*



Mustafa Mustafa @ Quark Matter 2012



- Production of NPE suppressed at high p_T.
  - Large systematic errors in PHENIX low p_T result.
  - Low p_T NPE measurement is important for total charm quark cross section measurements.

The Solenoid Tracker At RHIC (STAR)

- ★ Full azimuthal coverage
- ★ $-1 < \eta < 1$ coverage
- ★ Uniform acceptance for all beam energies
- ★ Full TOF barrel (Run10)
- ★ Low material budget in the tracking volume

by Maria & Alex Schmah

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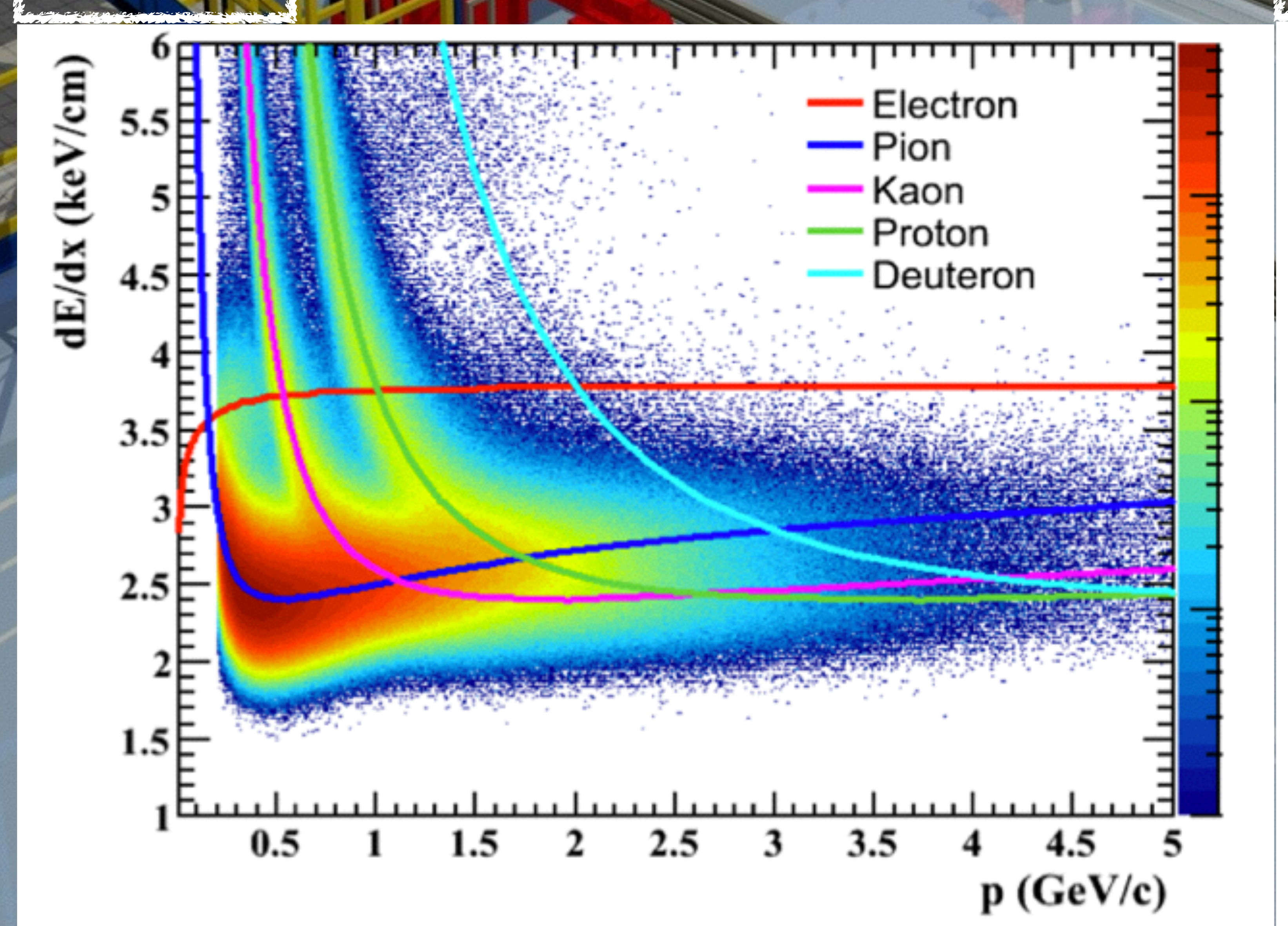
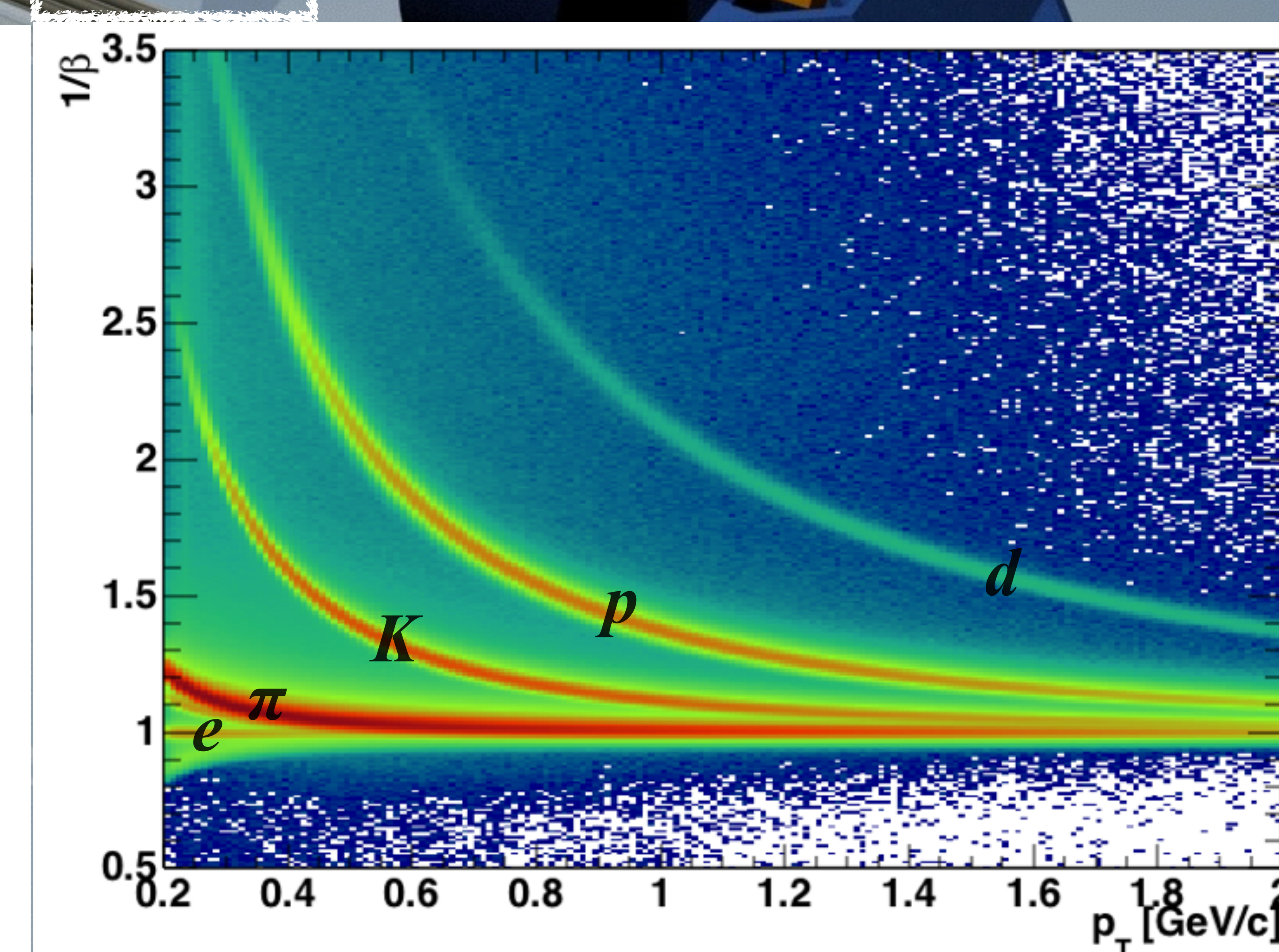




by Maria & Alex Schmah

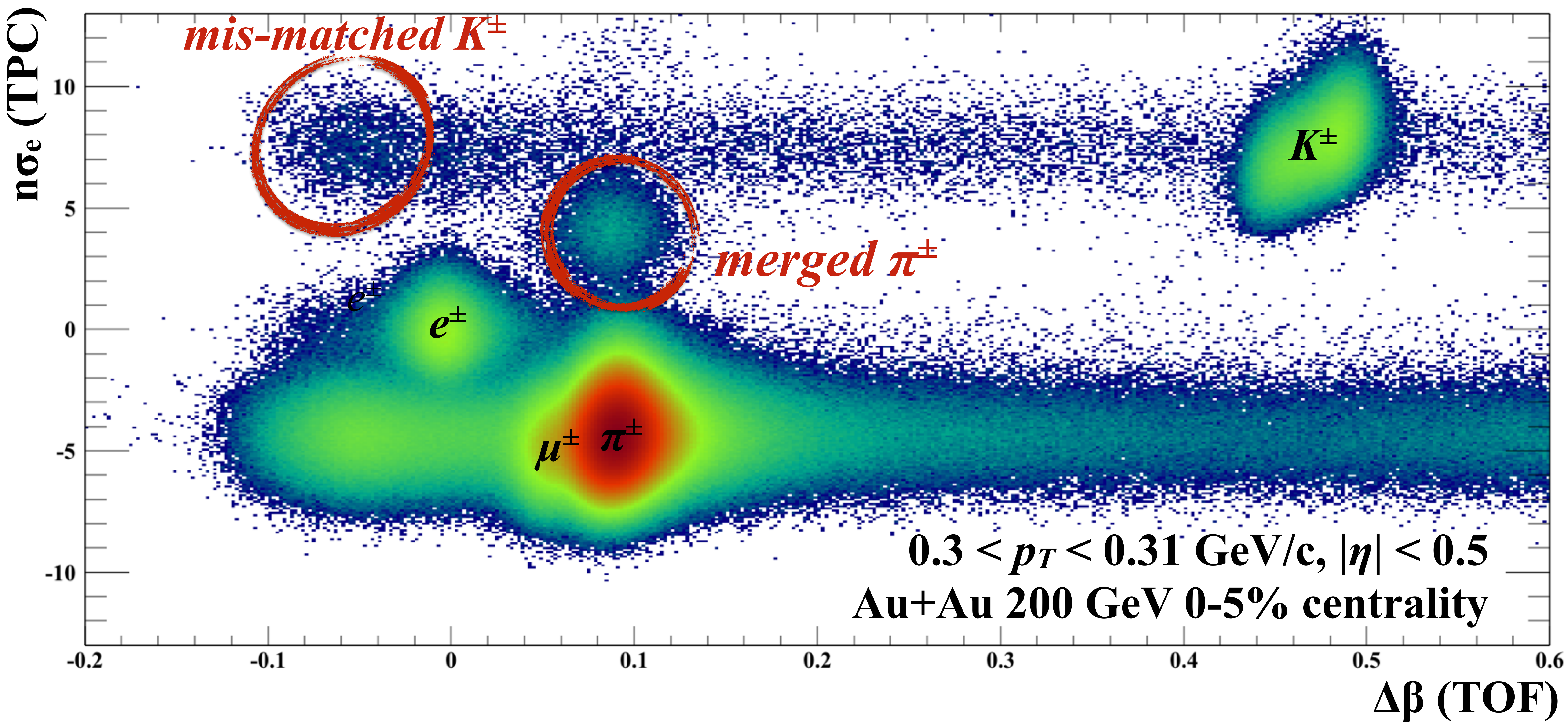
Low p_T NPE analysis

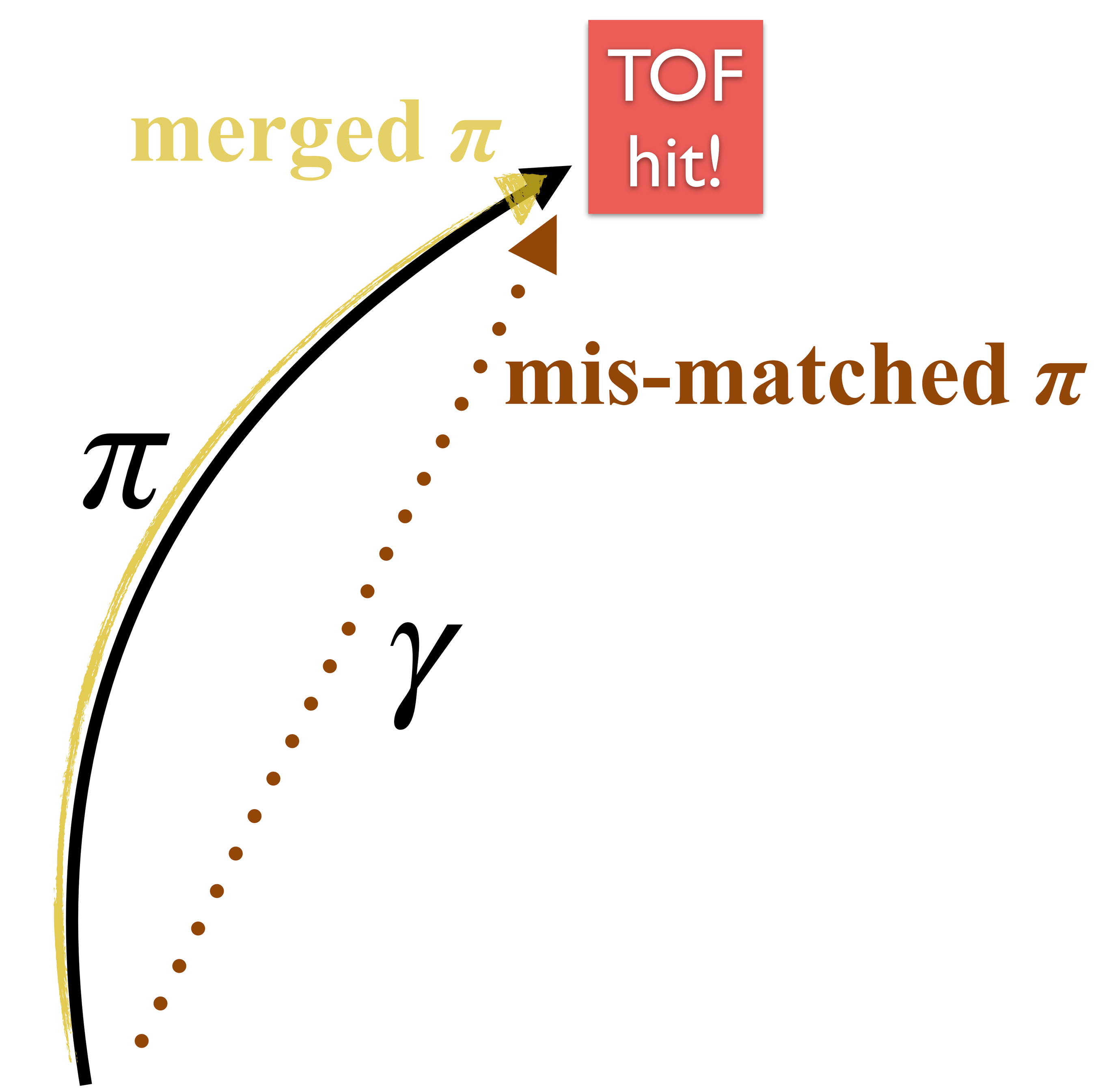
Non-photonic electrons(NPE) = Inclusive electrons (after electron PID) − *Photonic electrons(PE)*

$D^0, D^{\pm}, B, \Lambda_c$ ... γ, π^0, η^0 ...

- Inclusive electrons: Electron identification with TPC + TOF at low p_T.
- Photonic electrons :
  - Statistical subtraction by inclusive electrons.
  - Reconstruction method.
  - Photonic electron reconstruction efficiency :
    - Embedding simulation for γ and π^0 Dalitz decay for reconstruction efficiency estimation.
- Non-photonic electrons :
  - Single electron reconstruction efficiency corrected.
  - Number of binary collision corrected.

Inclusive electrons



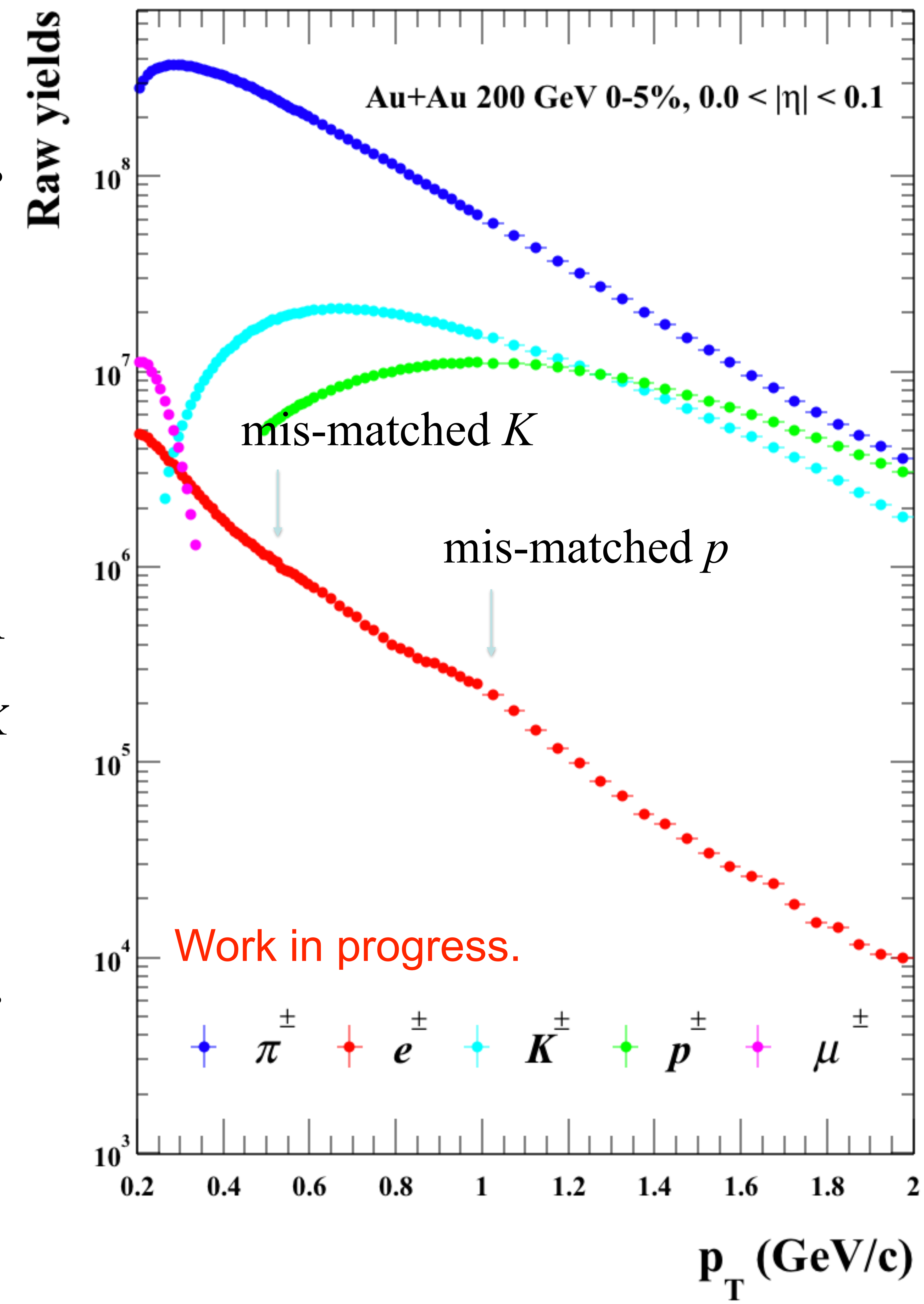


- Au+Au 200 GeV 0-80% VPDMinBias dataset : ~200M events
- Inclusive electron is identified by **TOF+TPC**
  - There are many ***mis-identified particles*** in central collisions with high multiplicity.
    - Mis-matched particle : Very fast particle make TOF hit instead of TPC hit particle.
    - Merged particle : In the same path, there are 2 particles and measured double value of spcific energy loss in TPC.

Inclusive electrons

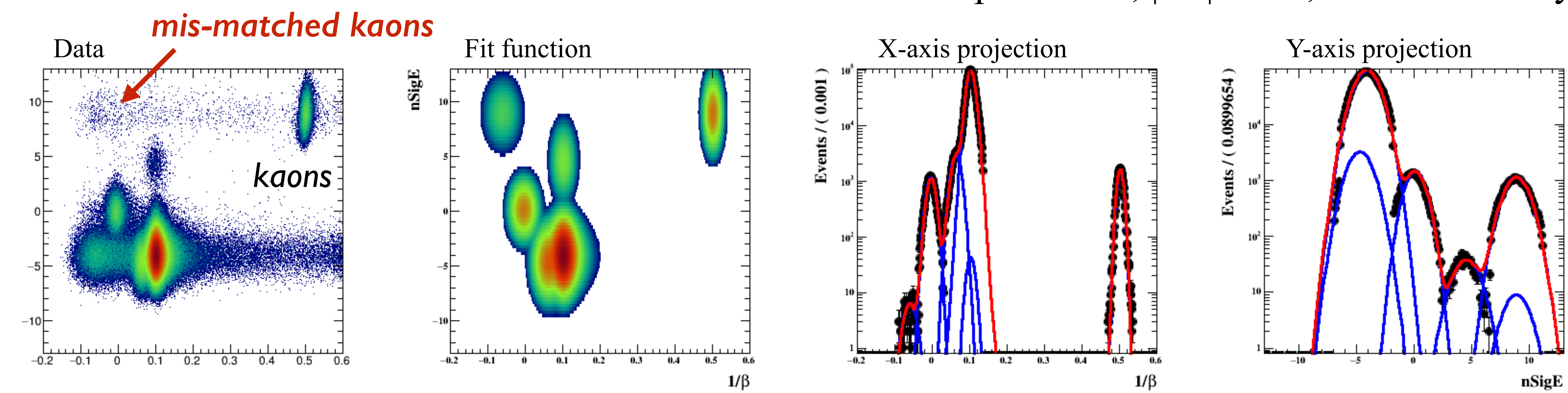
How to estimate electron yield in Trash box.

1. Fill 2D histograms by eta, p_T and centralities.
2. Estimate *pure electron* sample to fix electron shape through conversion electrons.
3. Fix π, K, p shape with 2D fitting.
4. Fit the mis-matched kaons and protons at well separated momentum regions and fix N_{misK}/N_K and N_{misp}/N_p.
5. Fit all particles, electron, merged pion, mis-matched kaons, protons, to obtain their yields.



examples

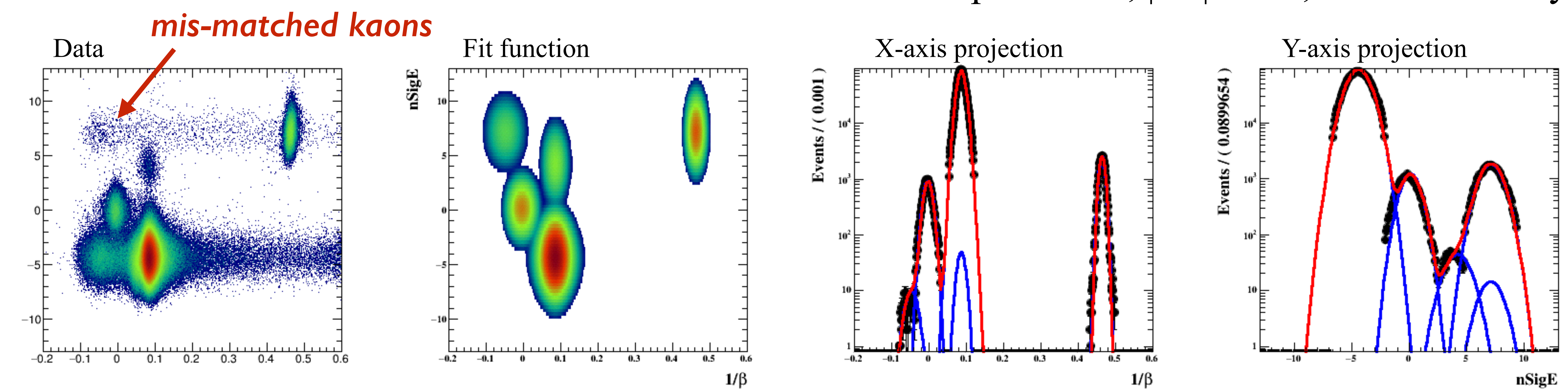
$0.28 < pT < 0.29$, $|eta| < 0.1$, 0-5% centrality



Toy MC

examples

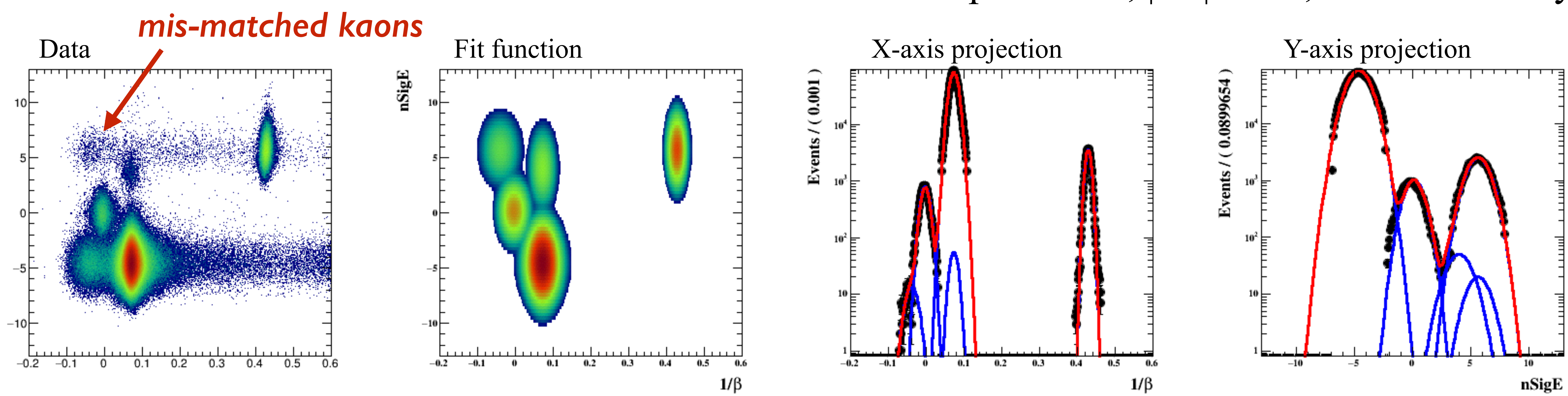
0.31 < pT < 0.32, |eta| < 0.1, 0-5% centrality



Toy MC

examples

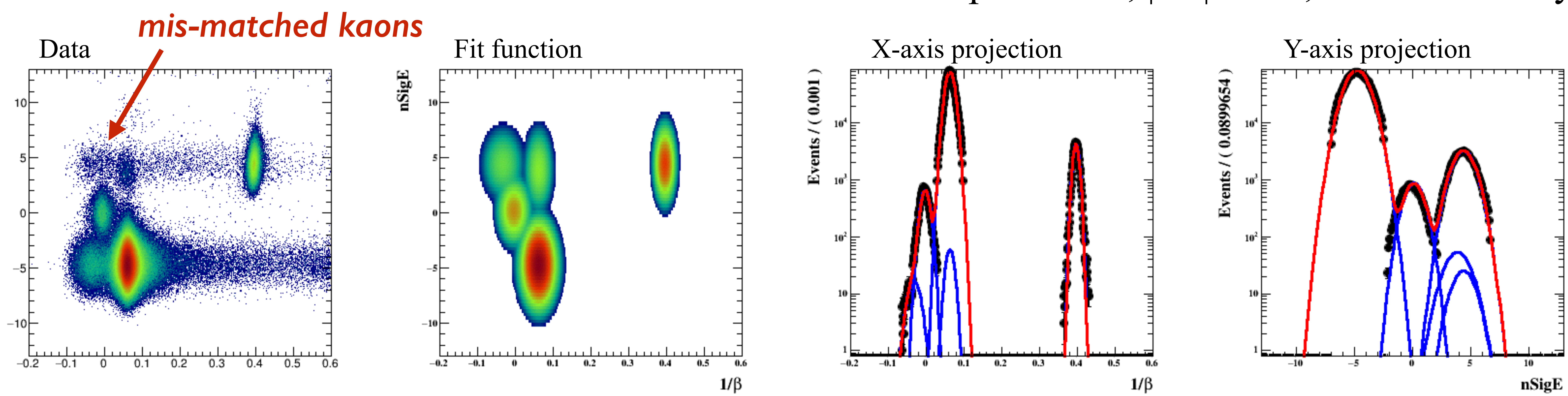
0.34 < pT < 0.35, |eta| < 0.1, 0-5% centrality



Toy MC

examples

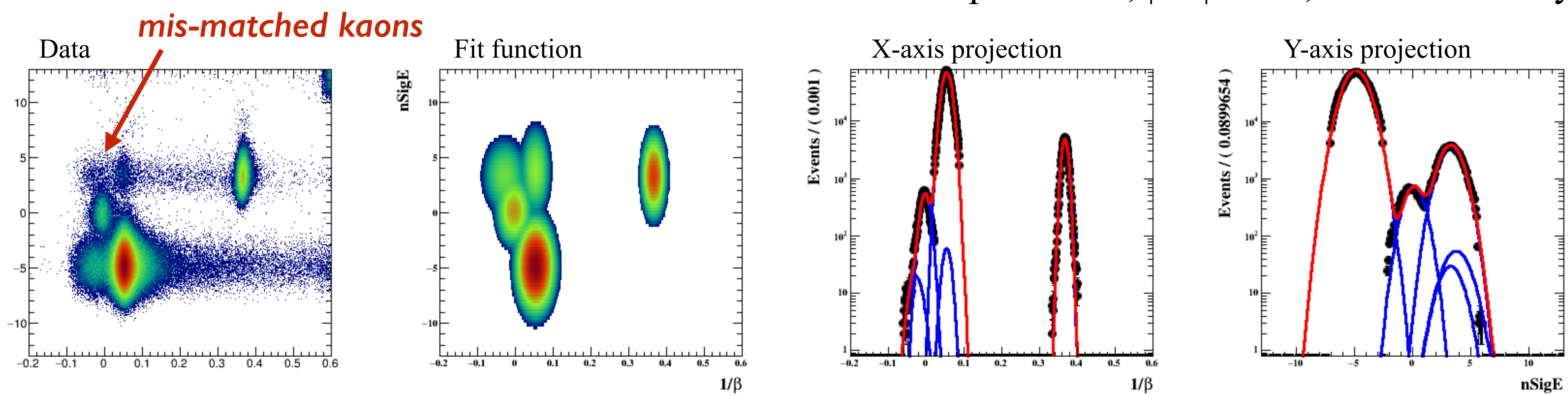
0.37 < pT < 0.38, |eta| < 0.1, 0-5% centrality



Toy MC

examples

0.40 < pT < 0.41, |eta| < 0.1, 0-5% centrality



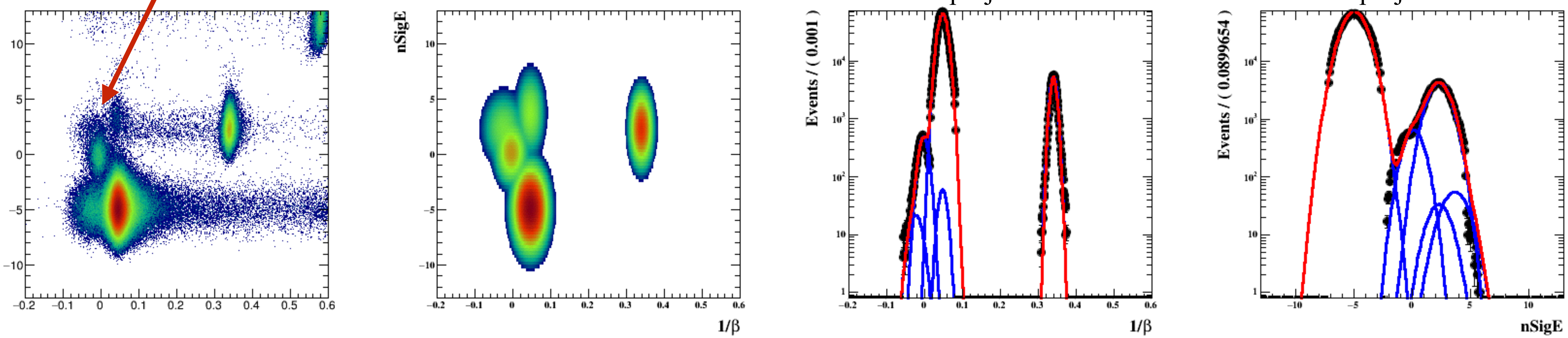
Toy MC

examples

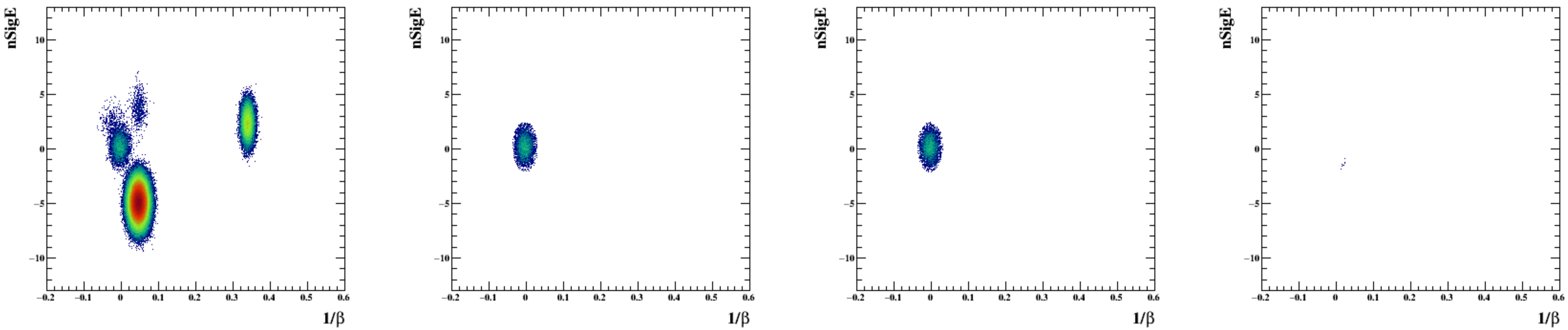
0.43 < pT < 0.44, |eta| < 0.1, 0-5% centrality

mis-matched kaons

Data | Fit function | X-axis projection | Y-axis projection



before PID cut | after PID cut | after PID cut electron | after PID cut others

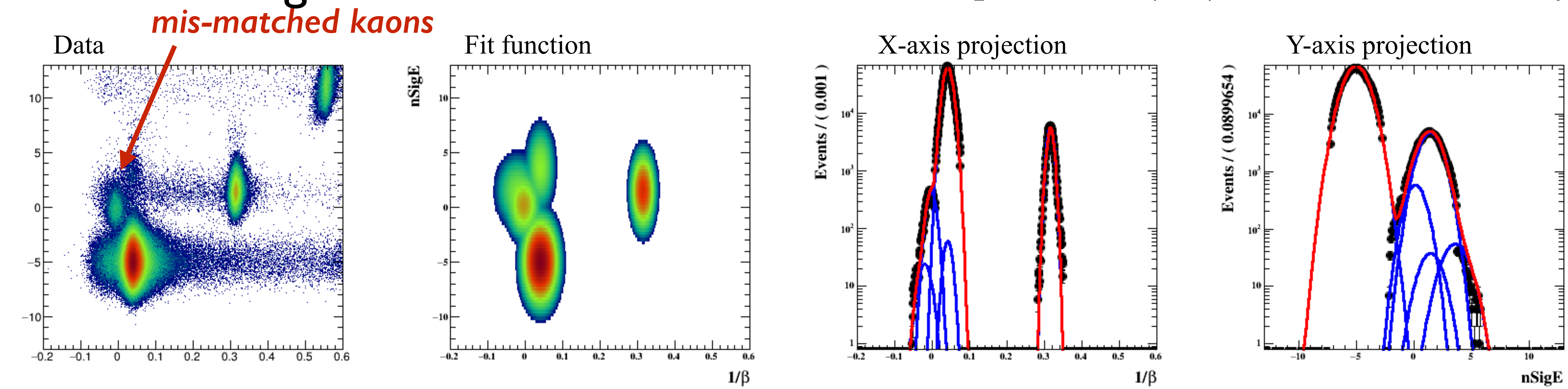


Toy MC

examples

Crossing over electron !

0.46 < pT < 0.47, |eta| < 0.1, 0-5% centrality



Toy MC

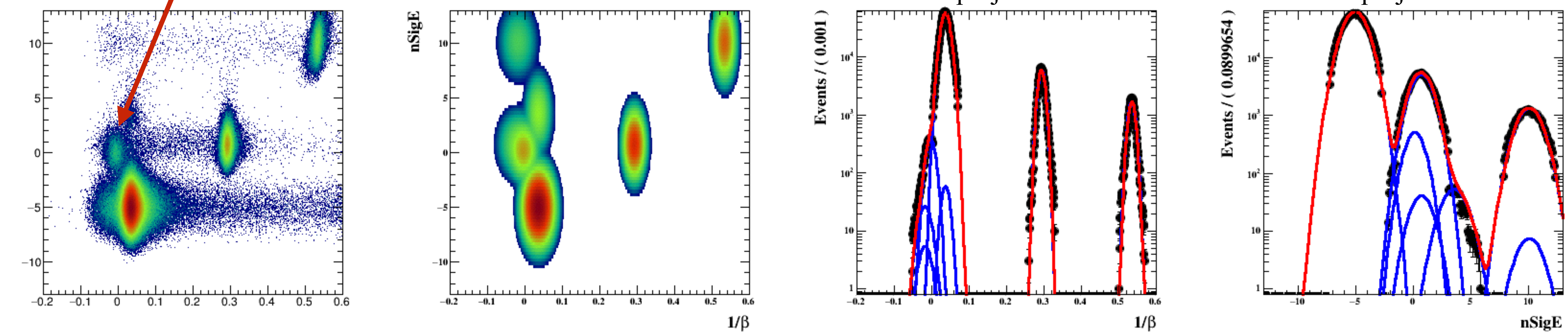
examples

Crossing over electron !

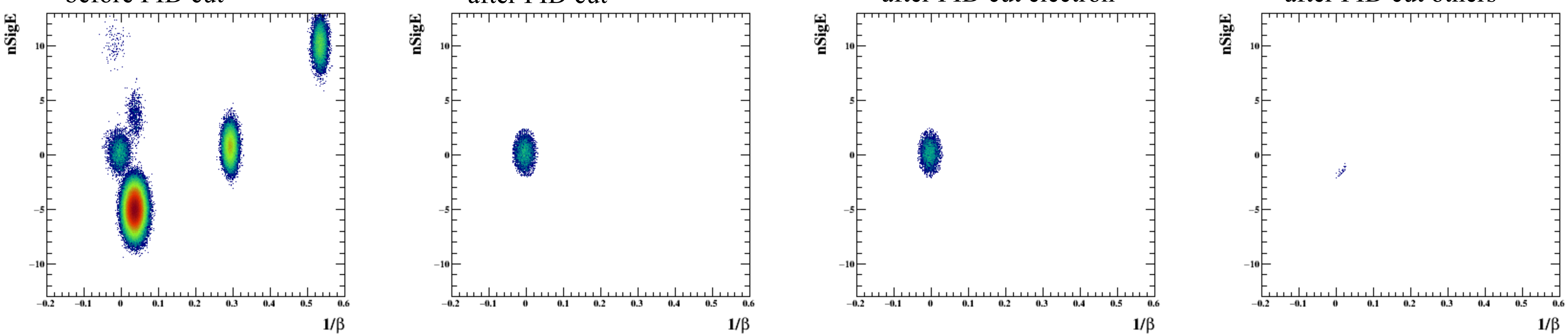
0.49 < pT < 0.50, |eta| < 0.1, 0-5% centrality

mis-matched kaons

Data | Fit function | X-axis projection | Y-axis projection



before PID cut | after PID cut | after PID cut electron | after PID cut others

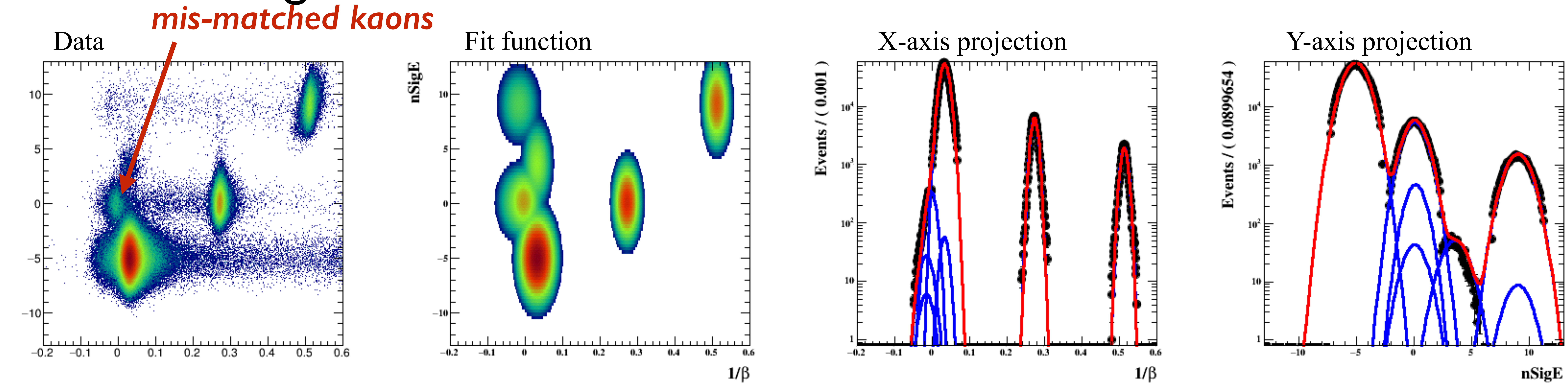


Toy MC

examples

Crossing over electron !

0.52 < pT < 0.53, |eta| < 0.1, 0-5% centrality



Toy MC

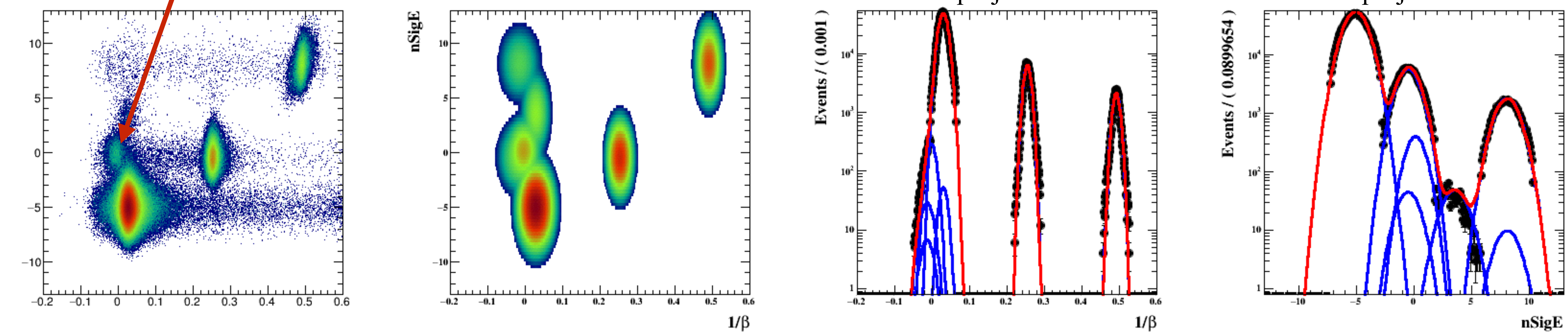
examples

Crossing over electron !

$0.55 < pT < 0.56$, $|eta| < 0.1$, 0-5% centrality

mis-matched kaons

Data | Fit function | X-axis projection | Y-axis projection



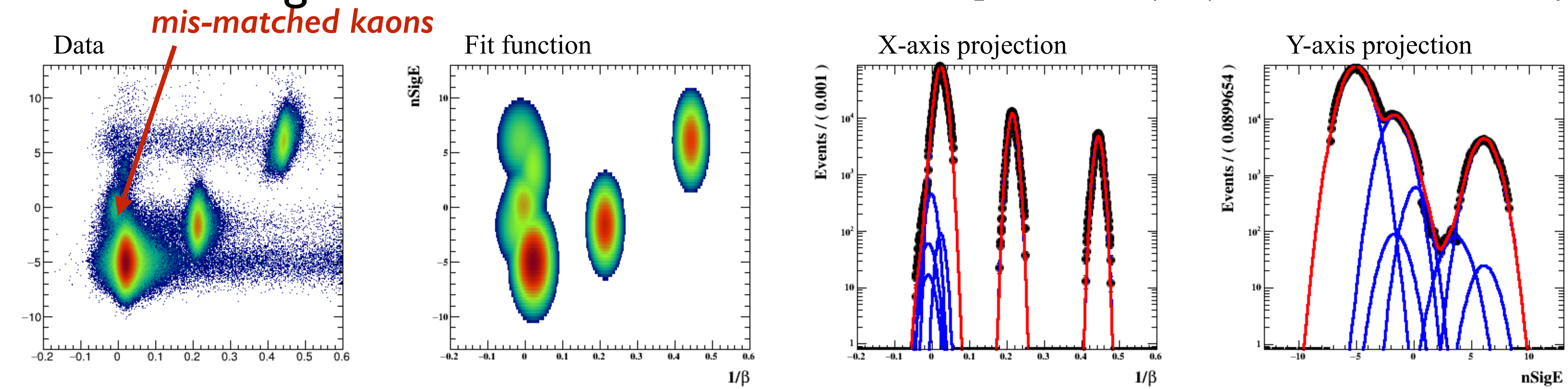
before PID cut | after PID cut | after PID cut electron | after PID cut others

Toy MC

examples

Crossing over electron !

0.62 < pT < 0.64, |eta| < 0.1, 0-5% centrality



Toy MC

*It is very tough job that inclusive electron estimation in **central collisions**.*

Inclusive electrons

How to estimate electron yield in Trash box.

1. Fill 2D histograms by eta, p_T and centralities.
2. Estimate *pure electron* sample to fix electron shape through conversion electrons.
3. Fix π, K, p shape with 2D fitting.
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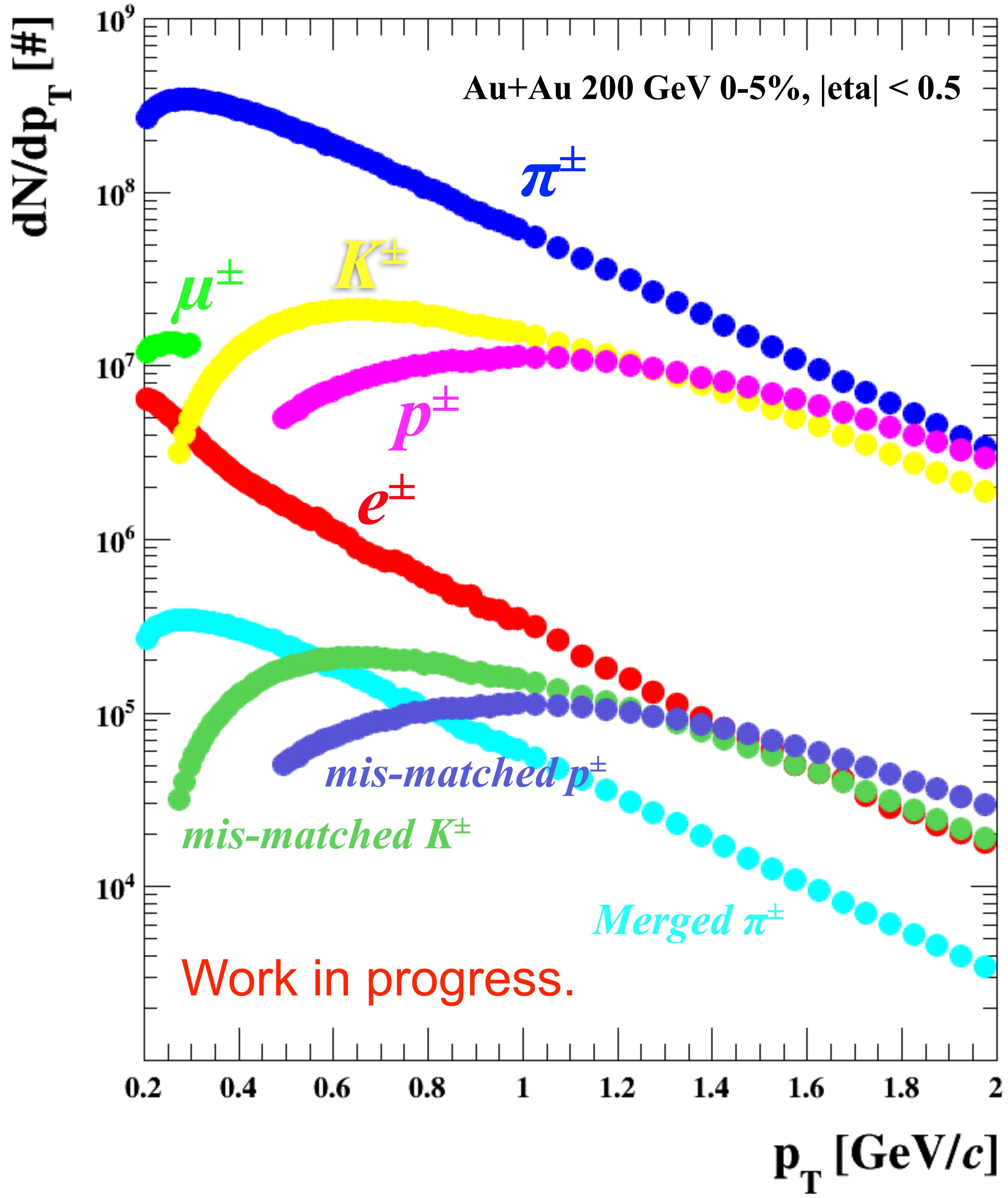

Inclusive electrons

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1. Fill 2D histo
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   separated mo
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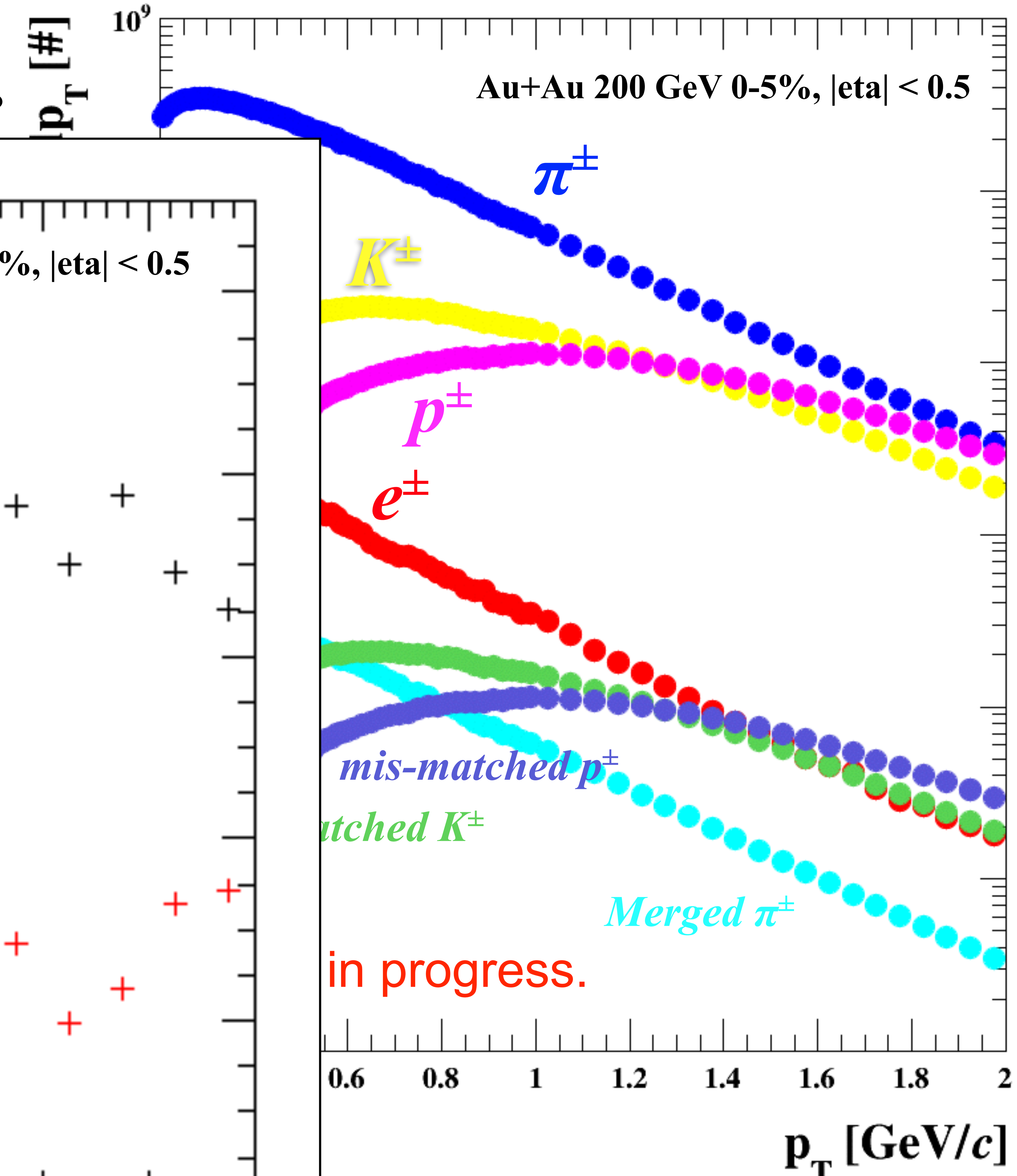
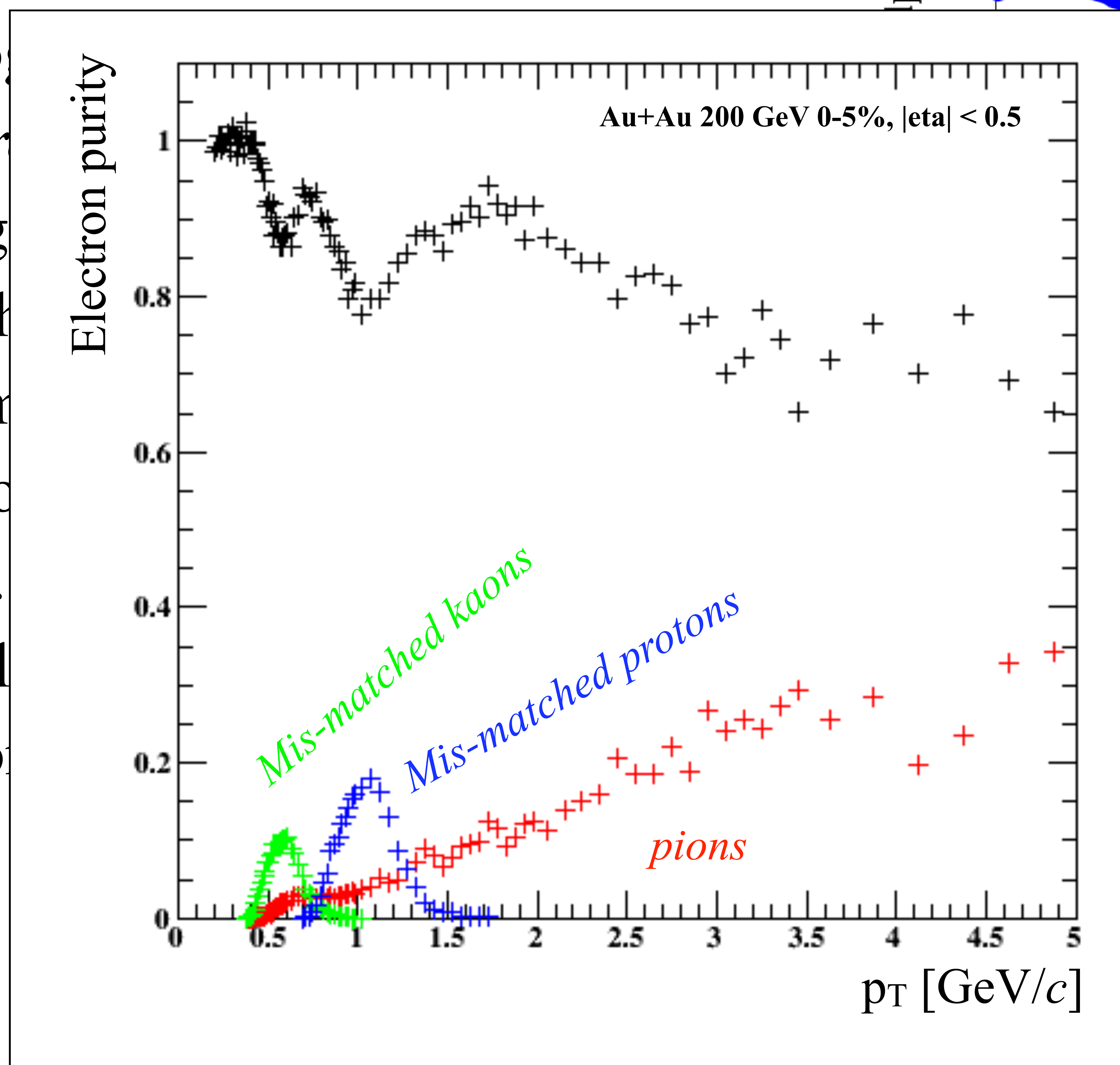
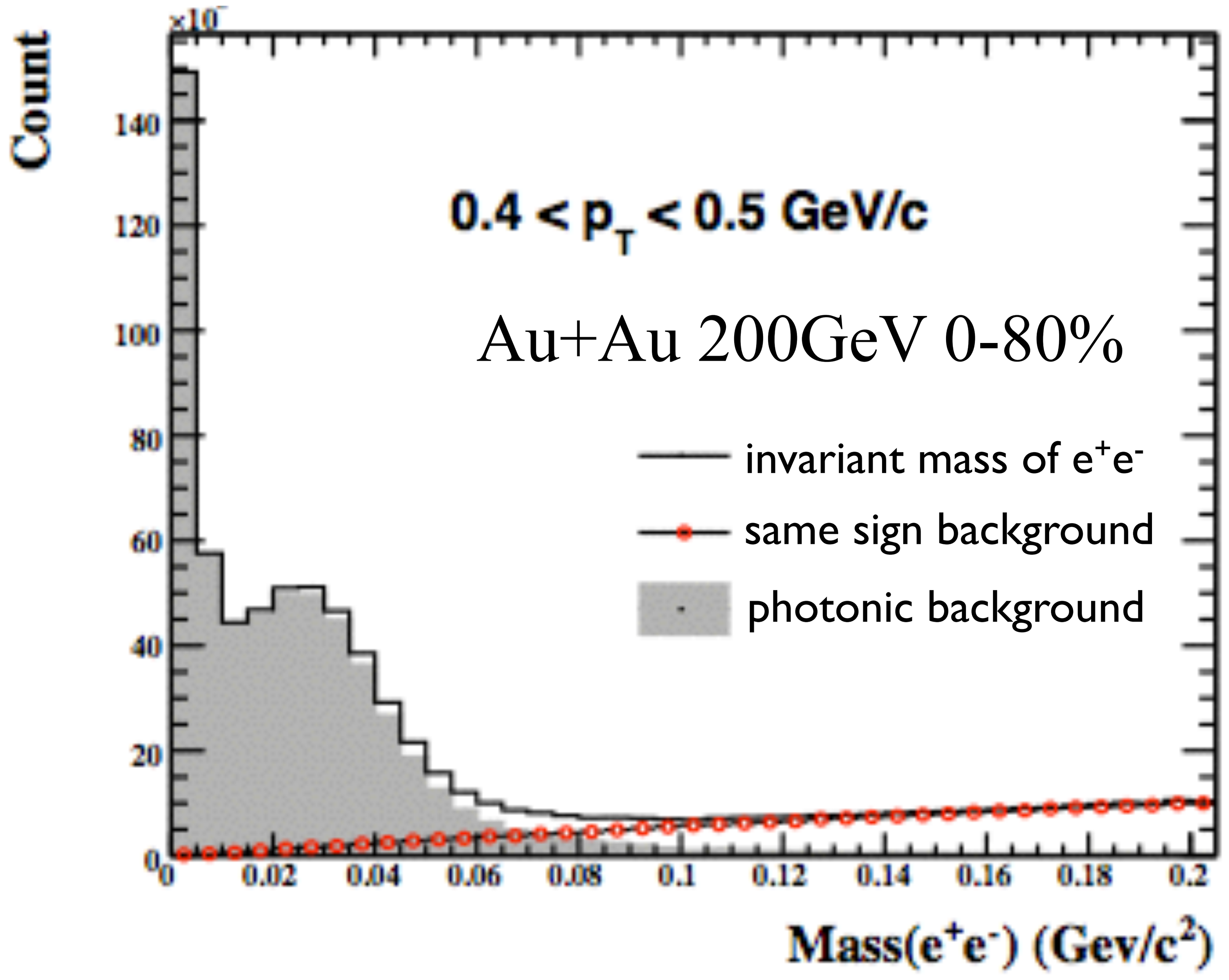
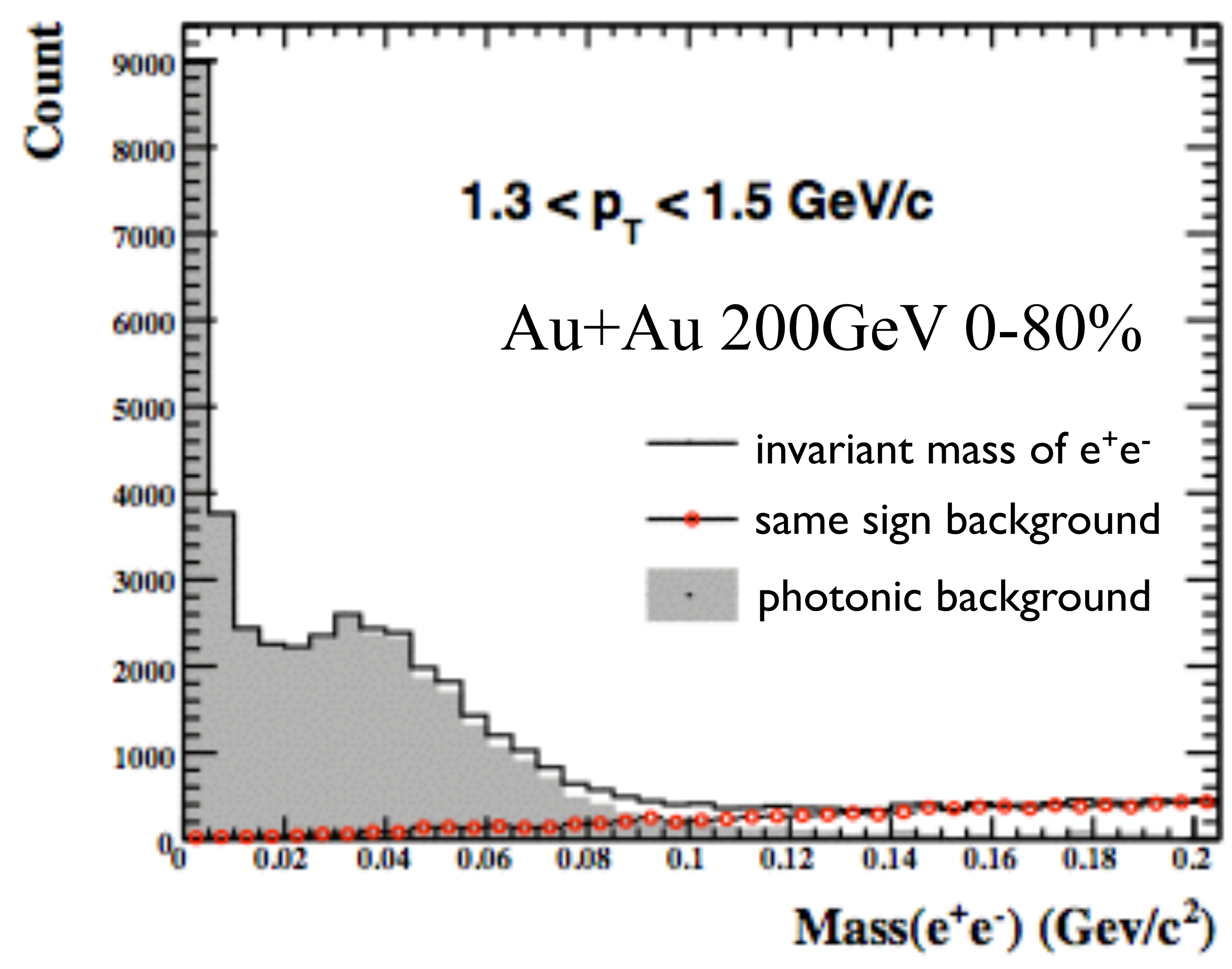
5. Fit all particl
   matched kao

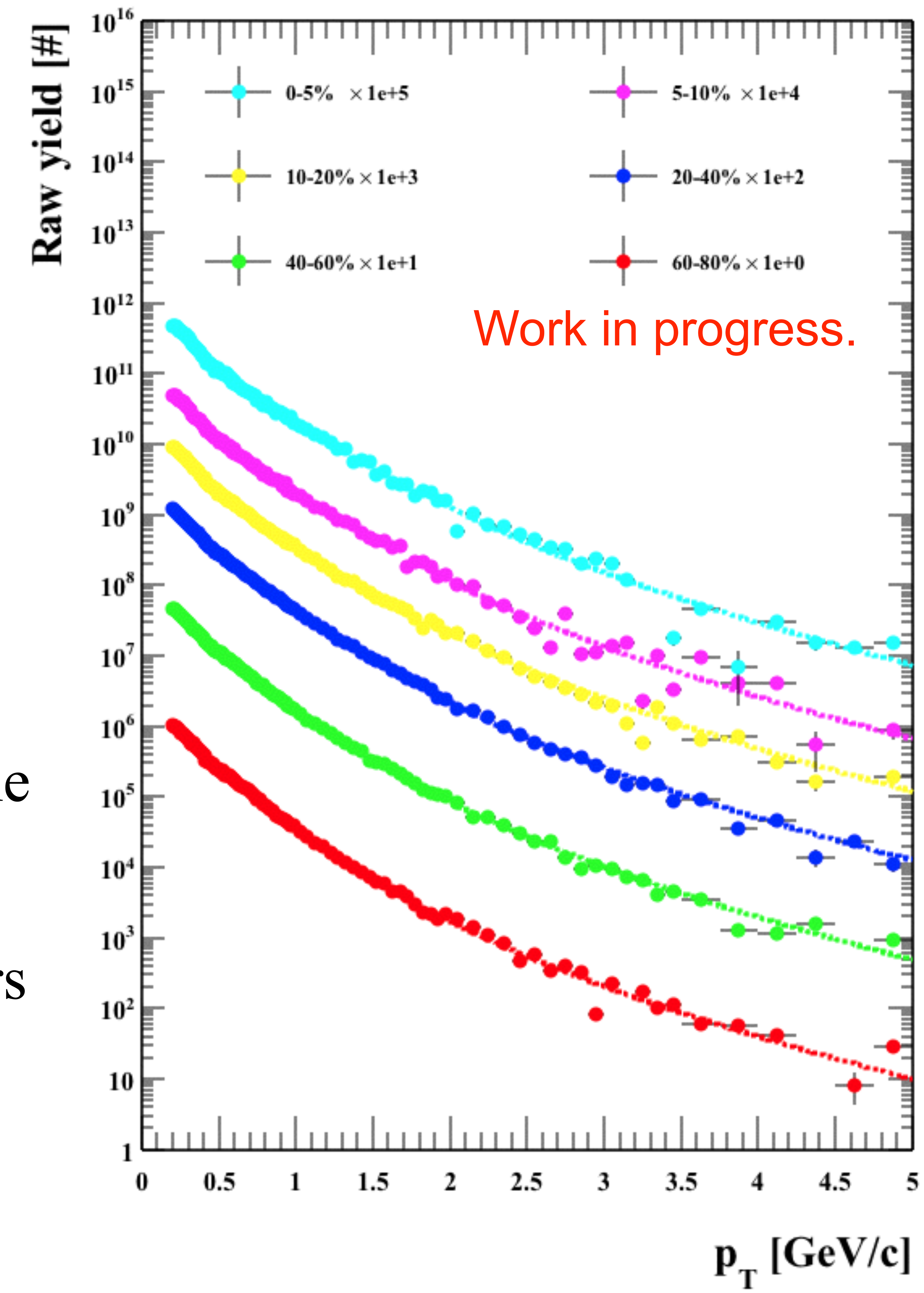




Photonic electrons

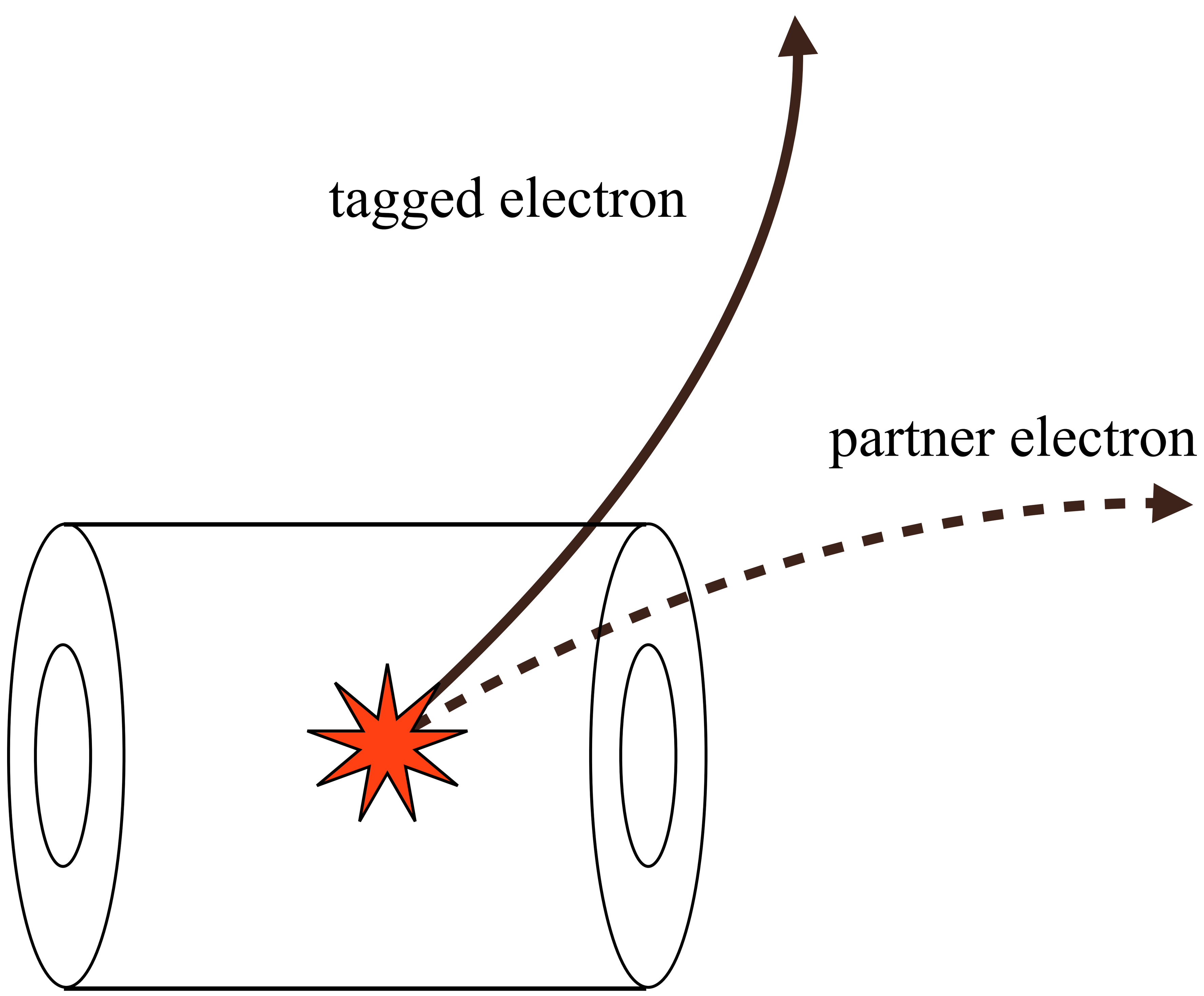




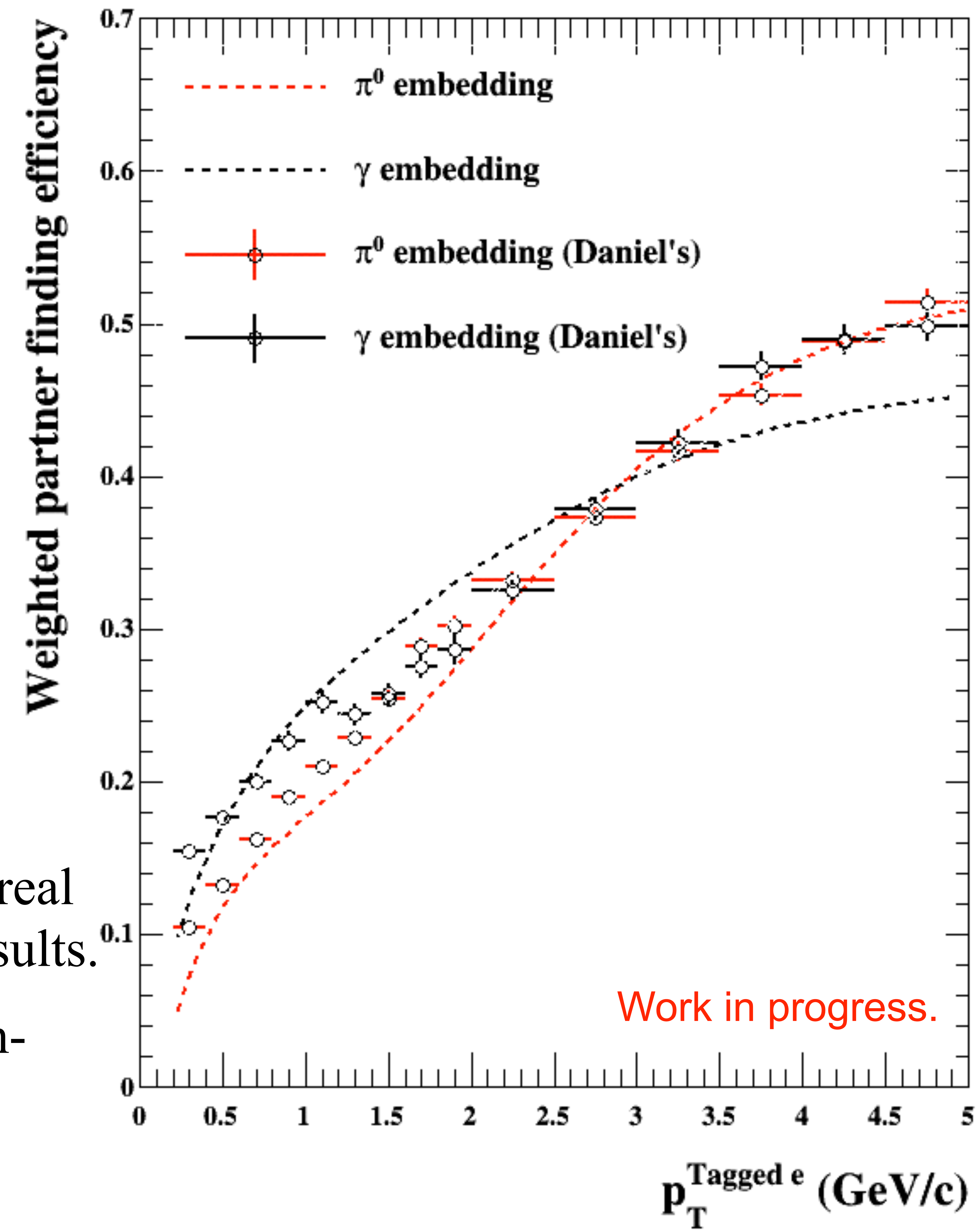


- I used the "**reconstruction method**" to statistically subtract the contribution of photonic electrons to inclusive electrons.
- We estimate the photonic electron contribution using e+e- pairs with invariant mass < 0.05 GeV/c^2 in real data
  - $\gamma \rightarrow e^+ e^-$ photon conversion in the material in STAR detector.
  - $\pi^0 \rightarrow \gamma e^+ e^-$ (B.R. = 1.174 ± 0.035)%
  - $\eta^0 \rightarrow \gamma e^+ e^-$ (B.R. = 0.70 ± 0.07)%
- Photonic electrons need partner finding (photonic electrons reconstruction) efficiency correction.

Partner finding efficiency



Sometimes, we cannot identify or detect the partner electron. (geometry, efficiency...)



- Monte-Calo π^0 and γ embedding simulation with real π^0 and γ distribution from PHENIX and STAR results.
- Partner finding efficiency is 10~40% in minimum-bias Au+Au collisions.

Summary

- ***Summary :***
  - Low p_T non-photonic electron production in heavy-ion collisions is being studied.
  - Inclusive electron estimation method (2D fitting). → Fitting optimisation is on going.
  - Photonic electron yield estimation with Rec. method and corrected with π^0 and γ embedding simulation.

- **Outlook :**
  - Systematic error study for low p_T NPE
  - η and $K \rightarrow \pi^0 e^+ \nu_e$ embedding study
  - The new HFT detector is installed : Measurement of $B \rightarrow e$ and $D \rightarrow e$ spectra separately.