Low p_T NPE analysis
from *Run10 Au+Au 200 GeV*

Kunsu OH 오근수
Pusan National University

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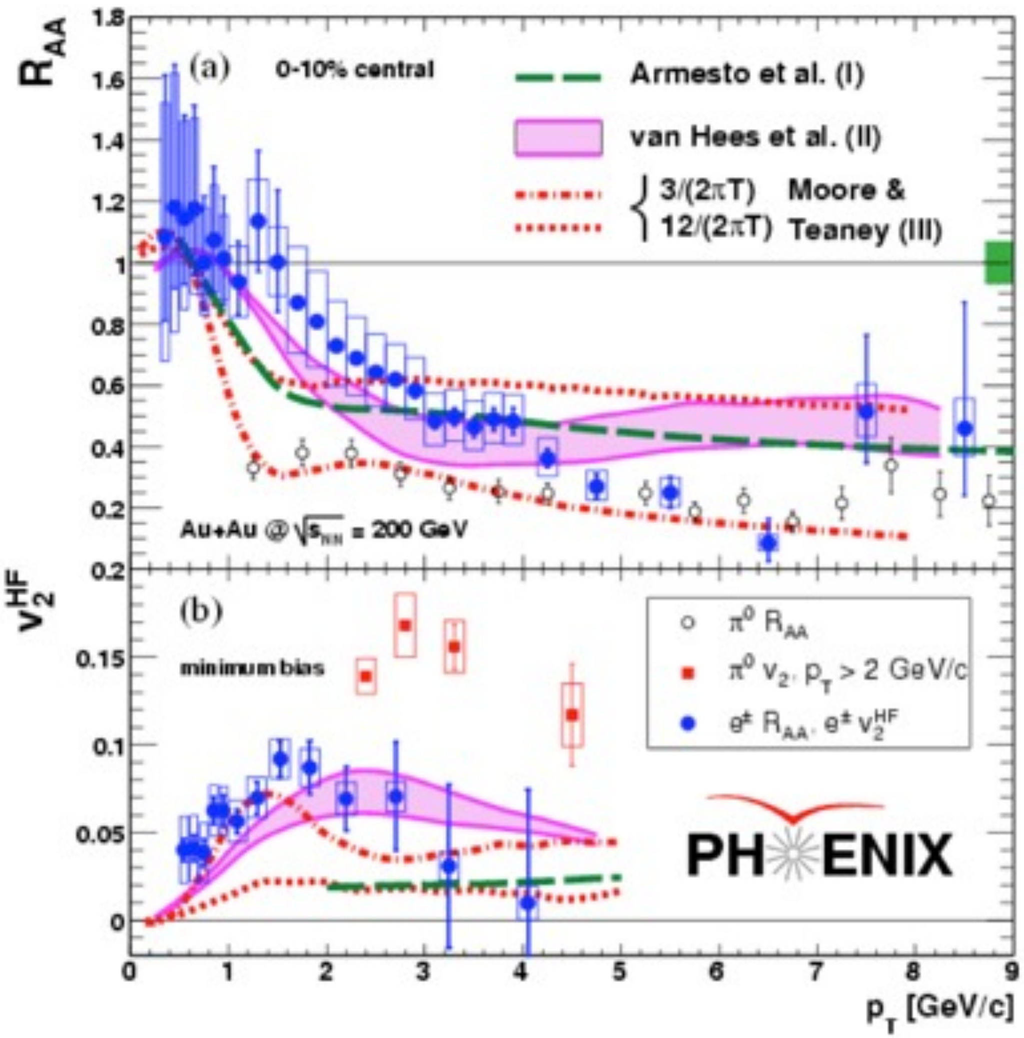
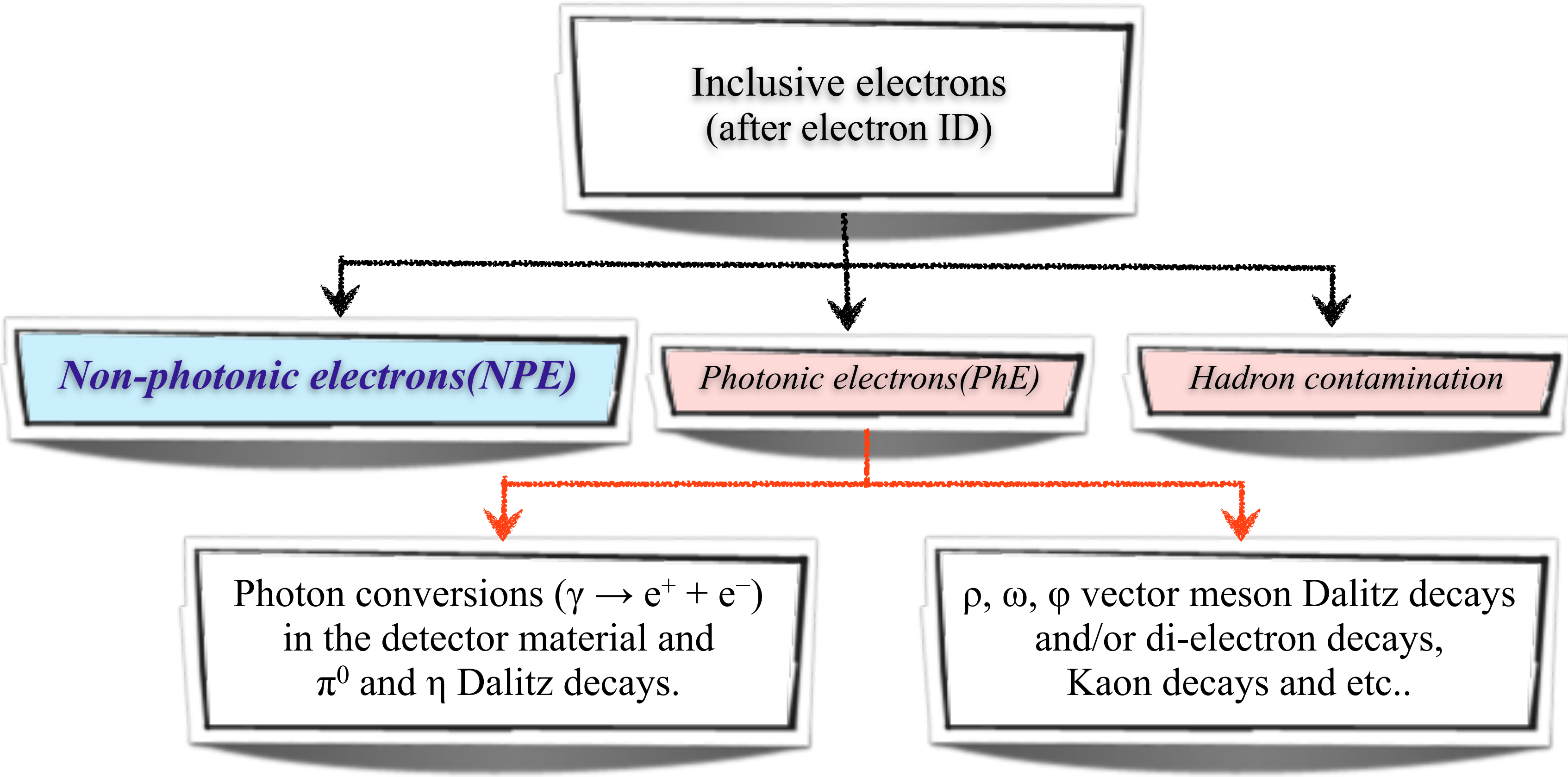
Motivation

- Non-photonic electron
  - heavy-flavor semileptonic decays
  - to study heavy flavor production.
- PHENIC non-photonic electron results.



$c \rightarrow e^+ + \textit{anything}(9.6\%)$ $B \rightarrow e^+ + \textit{anything}(10.86\%)$ PDG2010

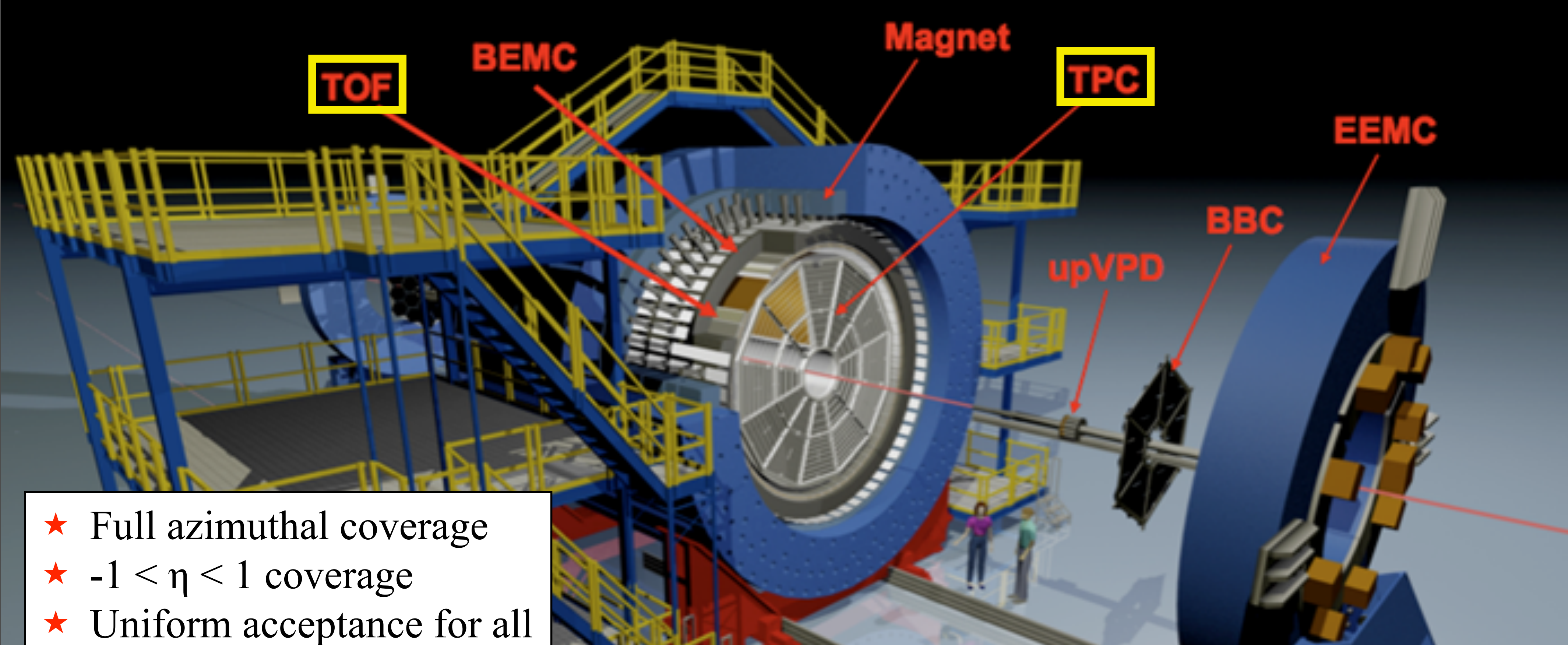
NPE Analysis Scheme



The **invariant mass** of electron-positron pairs from **photon conversions** or **Dalitz decays** will be **very small**.

Contributions from all **other sources** of photonic background combined are **only a few percent of the total background** and can be ignored when compared to systematic uncertainties.

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

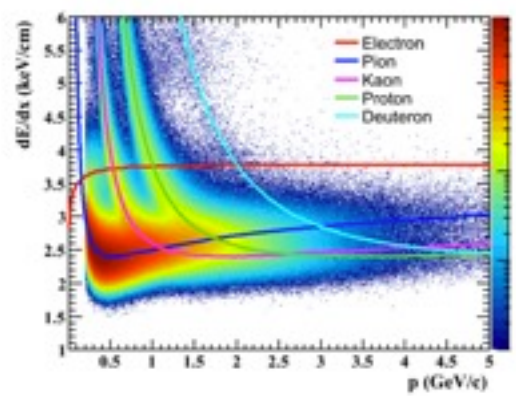


그림 3.2: Cu+Cu 200GeV 충돌에서의 운동량에 따른 dE/dx 분포 및 이론적 예측값[31].

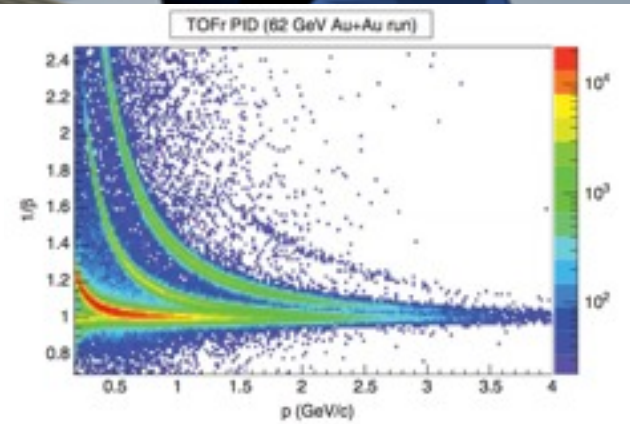


그림 3.3: Au+Au 62GeV 충돌에서의 운동량에 따른 $1/\beta$ 분포[33].

Run10 Au+Au 200GeV MinBias

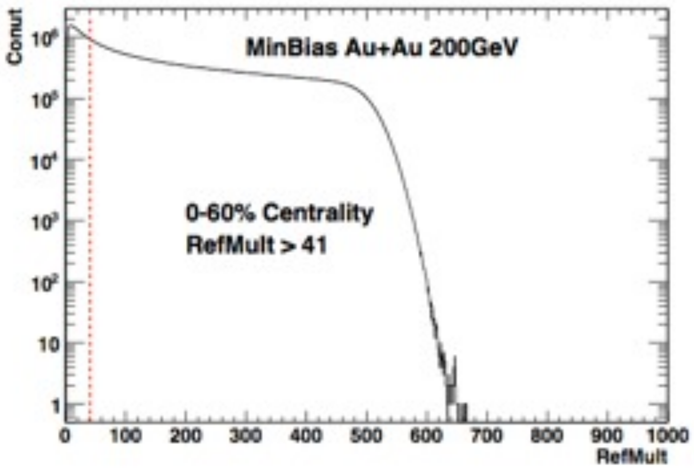


그림 3.7: 검출된 대전 입자 개수 분포

Trigger: MinBias	Cut	Events size
Total		226M
Vz [cm]	(-40, 40)	218M
vpdVz - Vz [cm]	(-3, 3)	200M
Centrality(refmult) [%(#)]	0-60(> 41)	154M

표 3.1: 이벤트 선택 조건

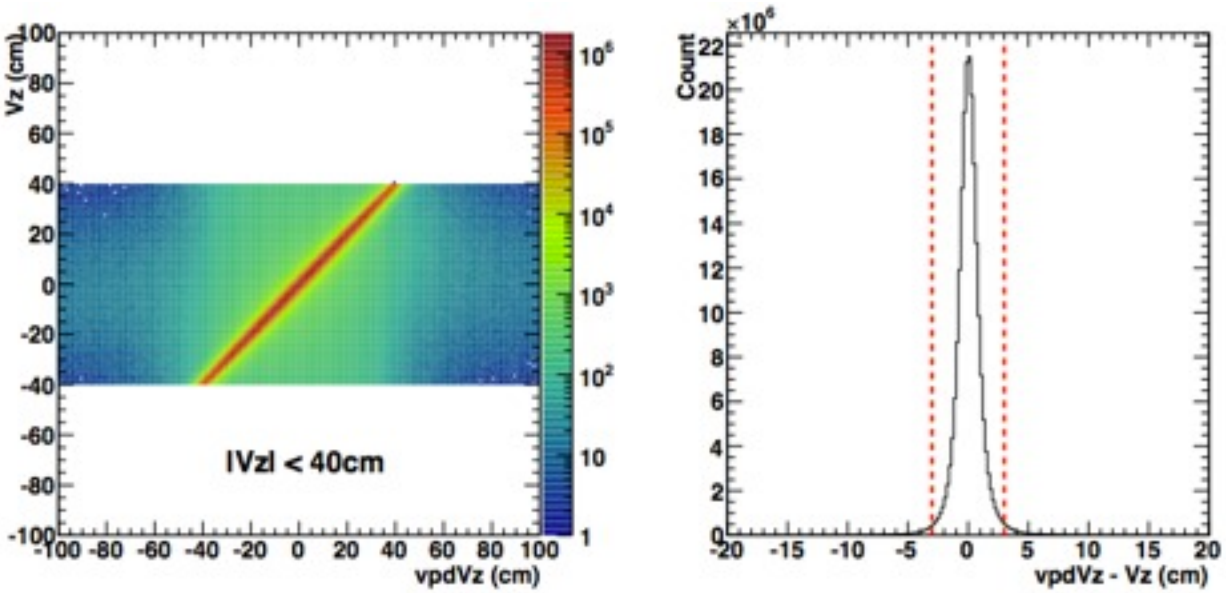


그림 3.6: Vertex Z와 vpd Vertex Z의 차이

Primary track?	yes
TOF hits matched?	yes
global DCA [cm]	≤ 1.0
nFitPts [#]	≥ 20
nFitPts/nMax	≥ 0.52
ndEdxFitPts [#]	≥ 15
$1/\beta - 1$	(-0.025, 0.025)
rapidity	(-0.5, 0.5)
p_T [GeV/c]	(0.2, 20)

표 3.2: 생성된 모든 전자 전자 선택 조건

Electron identification

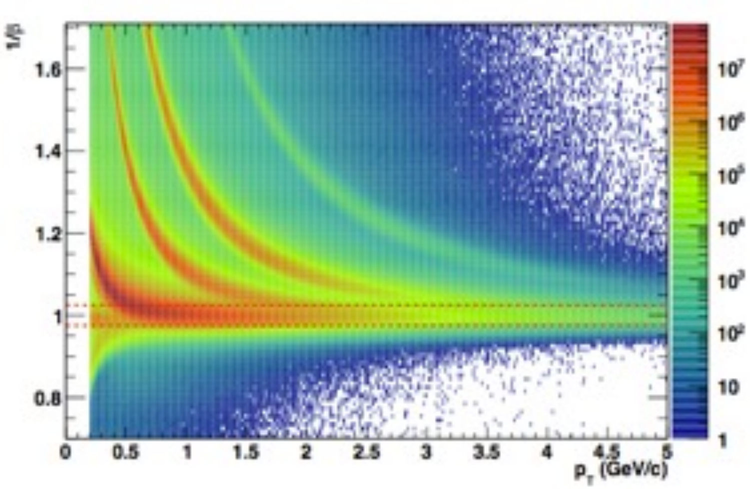


그림 3.9: 횡방향 운동량에 따른 입자 속도(1/β) 분포(TOF)

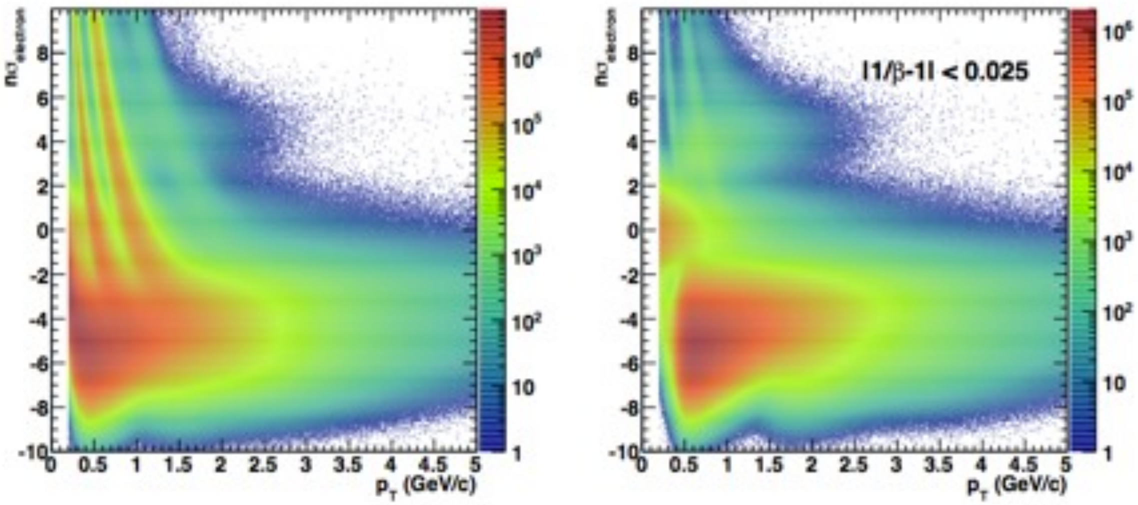


그림 3.8: 횡방향 운동량에 따른 n$\sigma_{electron}$ 분포(TPC)

- TOF 검출기로 부터 얻어진 1/beta 값이 1에 가까운(|1/beta-1| < 0.025) 경우, 질량이 매우 가벼운 입자이므로 1차적으로 전자를 골라냄.
- TPC 검출기로 부터 얻어진 dE/dx의 정보를 바탕으로 전자 식별.
- 횡운동량에 따른 dE/dx → n$\sigma_{electron}$분포로 나타냄.

pure Hadron's sample

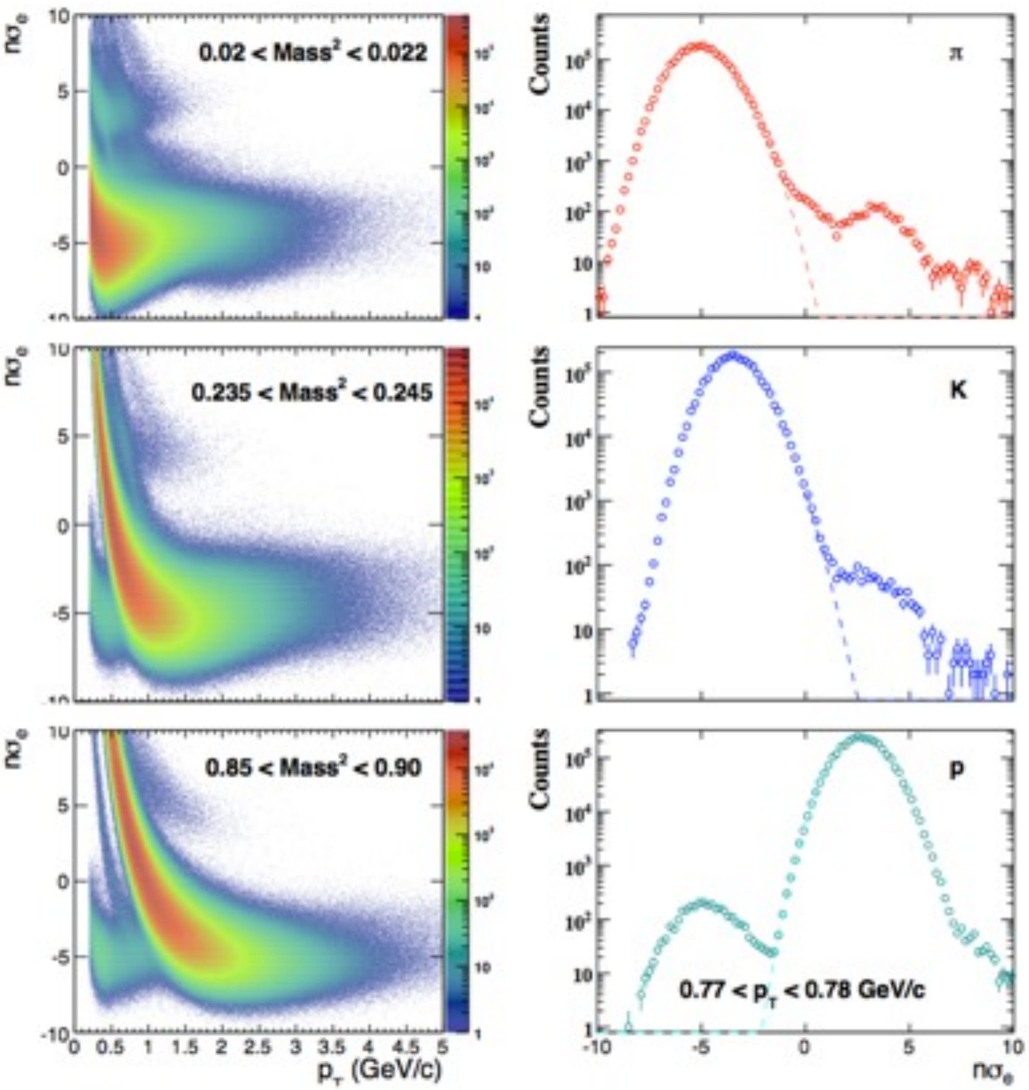


그림 3.10: High purity hadron sample

- 강입자들의 분포는 가우시안이 아니므로 그들의 개수를 산출 하기 매우 힘듬.
- TOF 검출기로 부터 얻어진 $Mass^2$ 정보를 이용해서 순수한 강입자 모양을 이용해서 전자의 개수를 산출 하는데 사용.

pure Electron sample

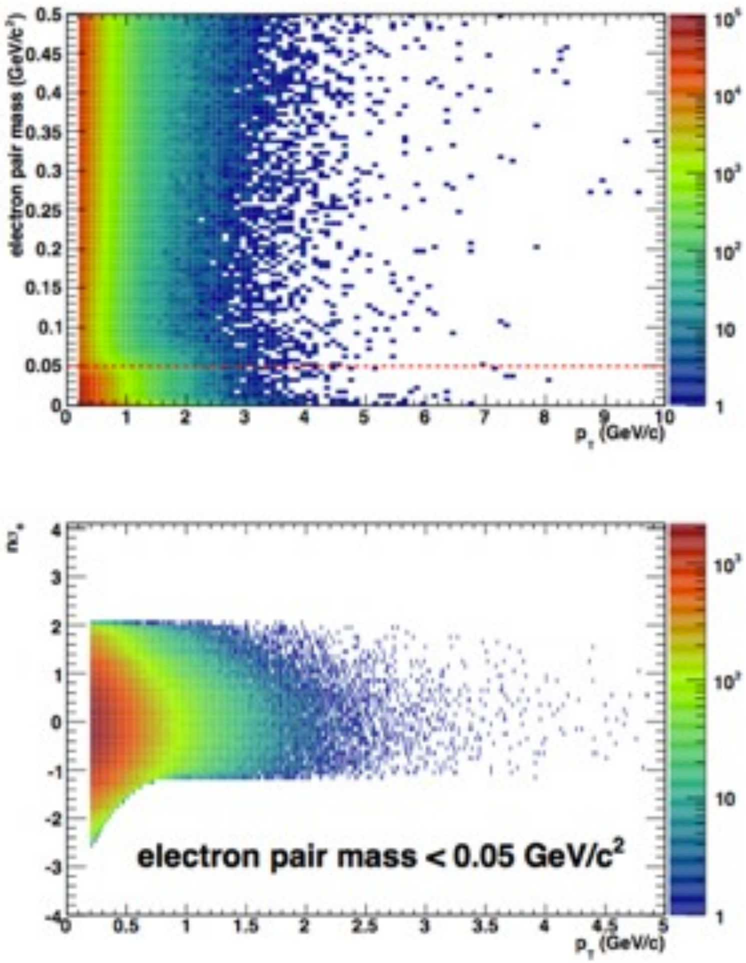


그림 3.11: Invariant mass of electron pair Vs. p_T and pure electron $n\sigma_e$ Vs. p_T distribution.

- 원칙적으로 $n\sigma_{electron}$에서 전자의 횡운동량에 대한 $\sigma = 1$, mean = 0인 가우시안 분포를 가져야 하지만, 실제로는 약간 차이가 있음.
- 측정된 모든 전자들 중,
  각각의 이벤트 내에서 전자쌍을 만들고 그들중 불변질량이 0에 가까운 전자쌍을 이용해서 순수한 전자의 분포를 이용.

Electron identification

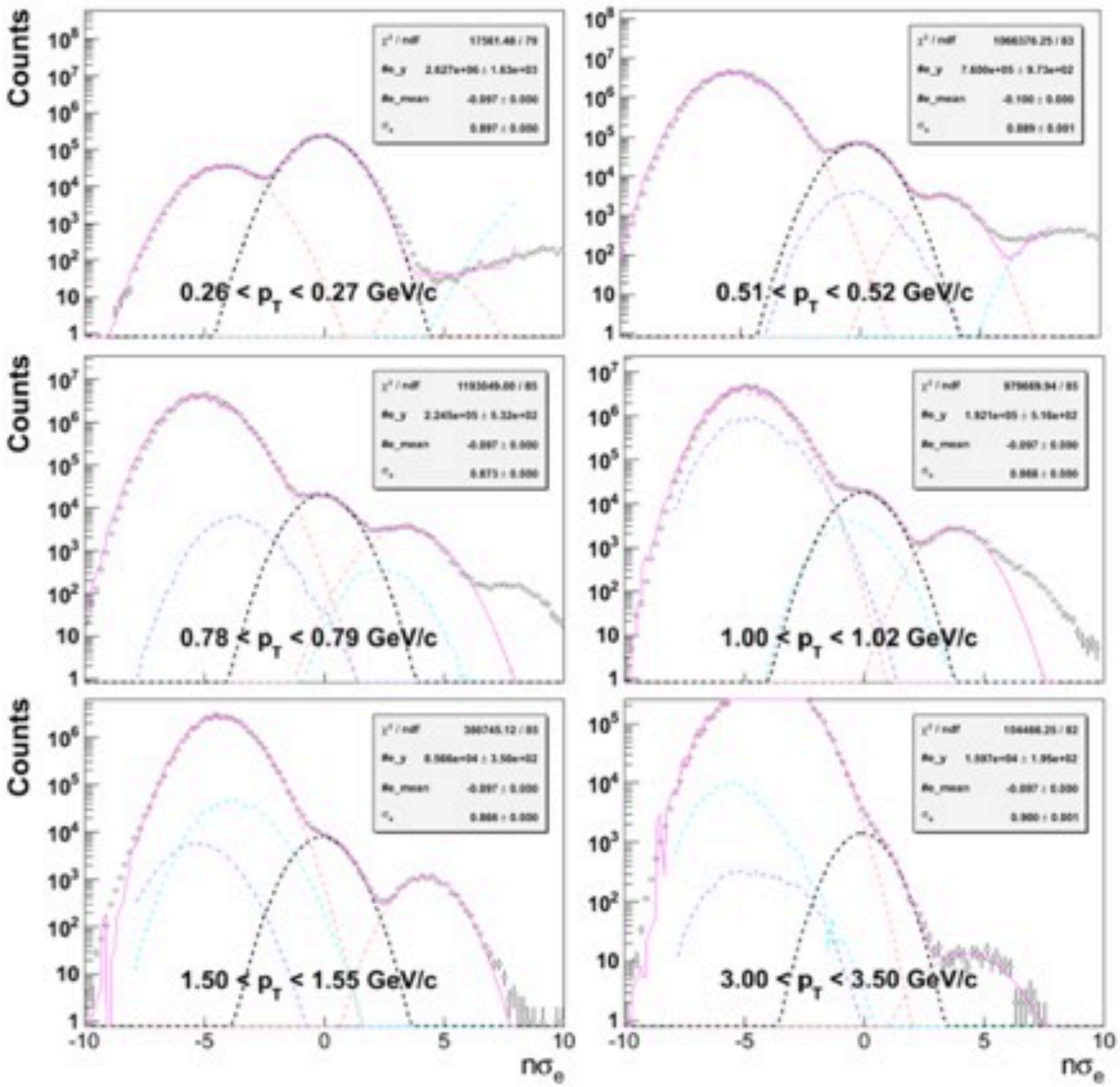


그림 3.12: $n\sigma_e$ fit for inclusive electron raw yield extraction

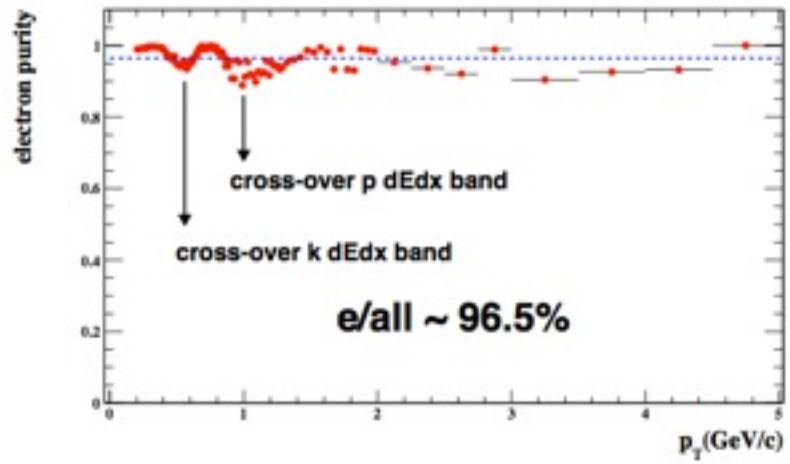


그림 3.13: Estimate electron purity

- 순수한 강입자의 분포와 순수한 전자의 분포를 이용해서 각각의 횡운동량에 따른 전자의 개수를 산출.
- 이때, 전자의 순수도는 약 96%

Efficiencies correction

TPC Tracking Efficiency - track reconstruction efficiency and TPC acceptance efficiency

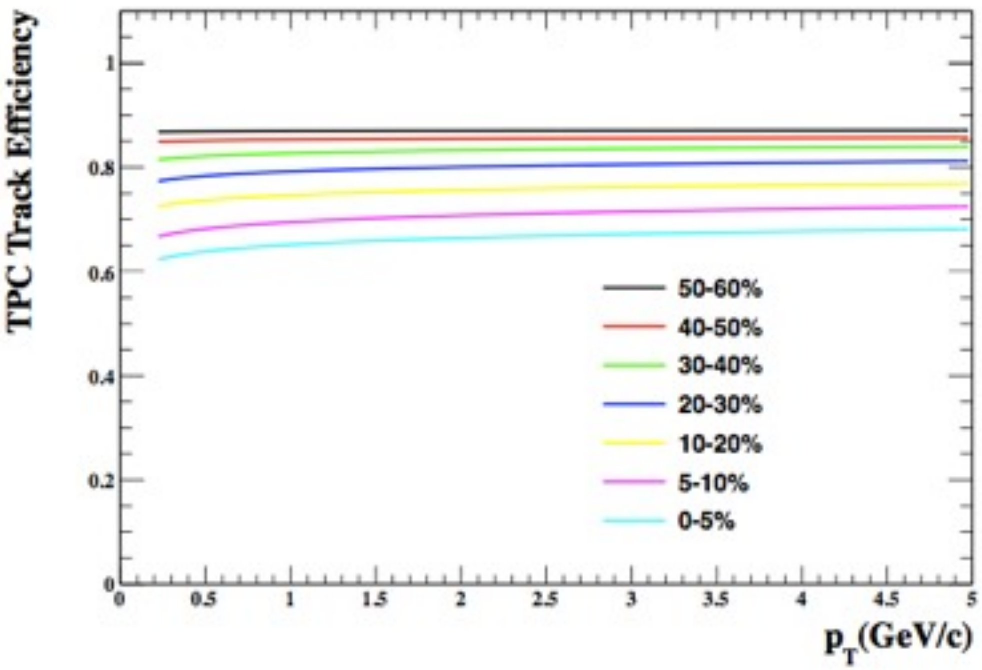


그림 3.14: TPC Tracking Efficiency for each centrality

- TPC tracking efficiency depend on centrality (Reference multiplicity).
- Positron embedding study
- same cut applied with real data analysis

Efficiencies correction

TOF matching efficiency - TPC track and TOF hit matching efficiency and TOF matching efficiency

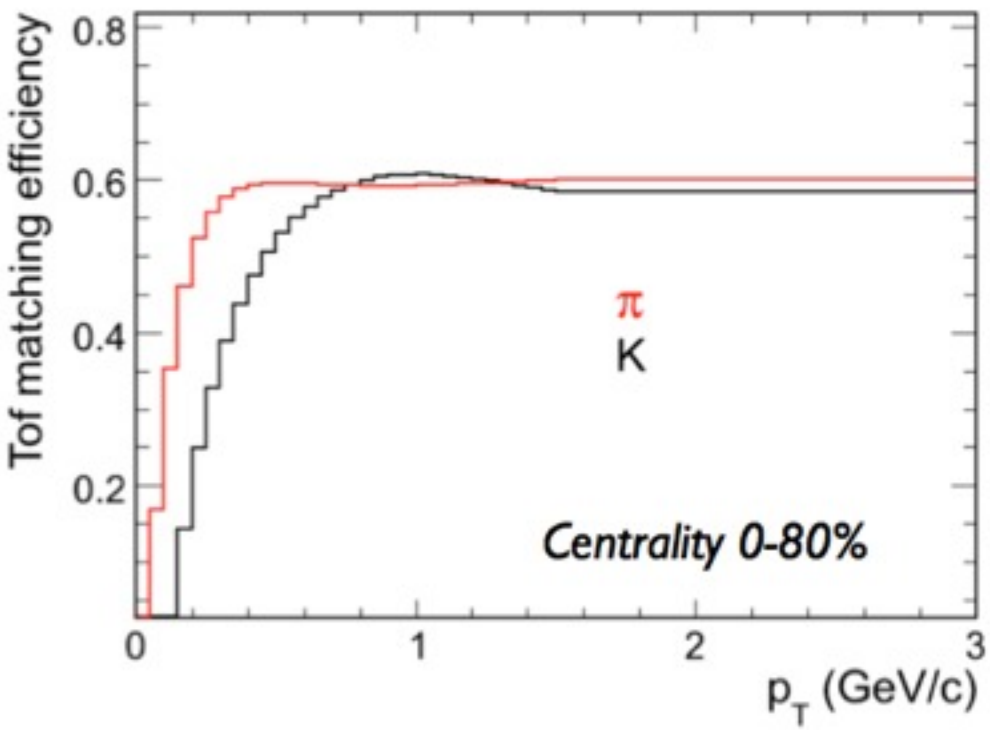


그림 3.15: TOF Matching Efficiency

- TOF matching efficiency depend on particle momentum.
- We expect p_T dependency will be small effect for low mass particle (electron).
- From π and K efficiency, we decide TOF matching efficiency for electron is 60%.

Efficiencies correction

ndEdxFitPts(number of dE/dx fit points) cut efficiency.

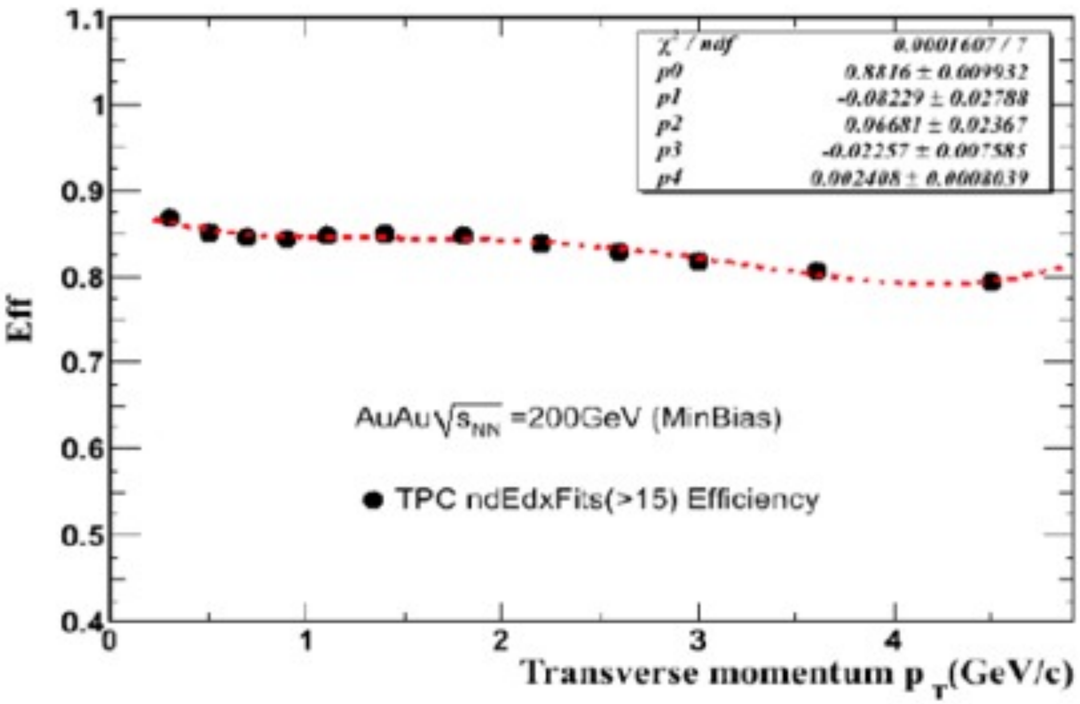


그림 3.16: *ndEdxFitPts* cut efficiency

- ndEdxFitPts (number of dE/dx fit points) cut efficiency is not included TOF tracking efficiency technically.
- We obtained to compare w/ ndEdxFitPts cut and w/o ndEdxFitPts cut in real data.

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Efficiencies correction

|1/β−1| cut efficiency.

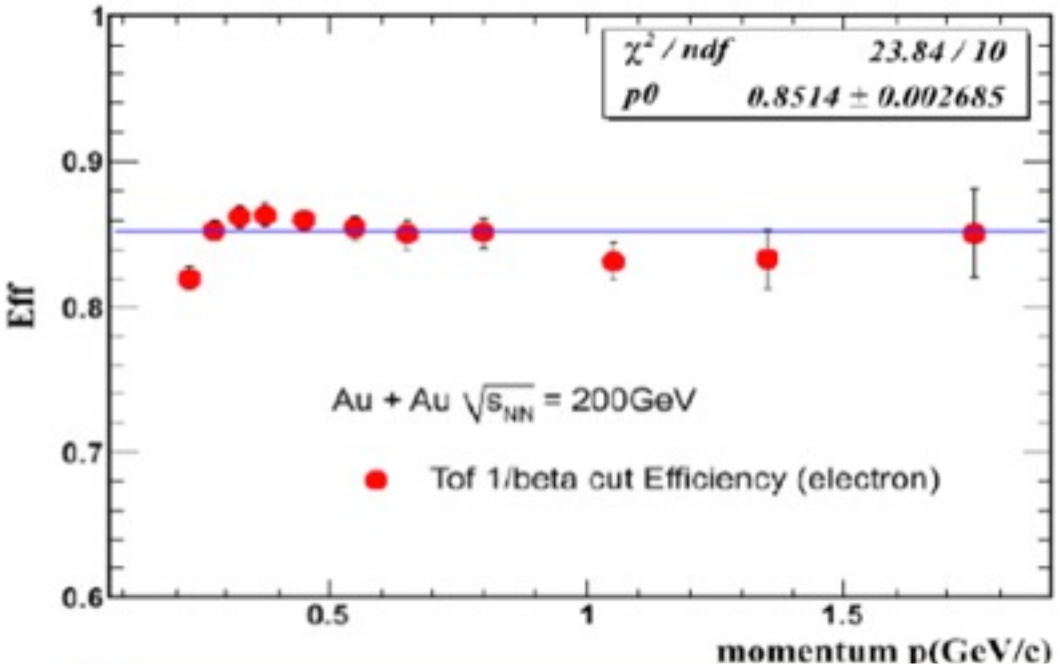


그림 3.17: $|1/\beta - 1|$ cut efficiency

- |1/β−1|조건 효율은 PID에서 |1/β−1| 조건에 의해서 생김.
- ndEdxFitPts 조건 효율과 비슷한 방법으로 얻을 수 있다.

Photonic Background

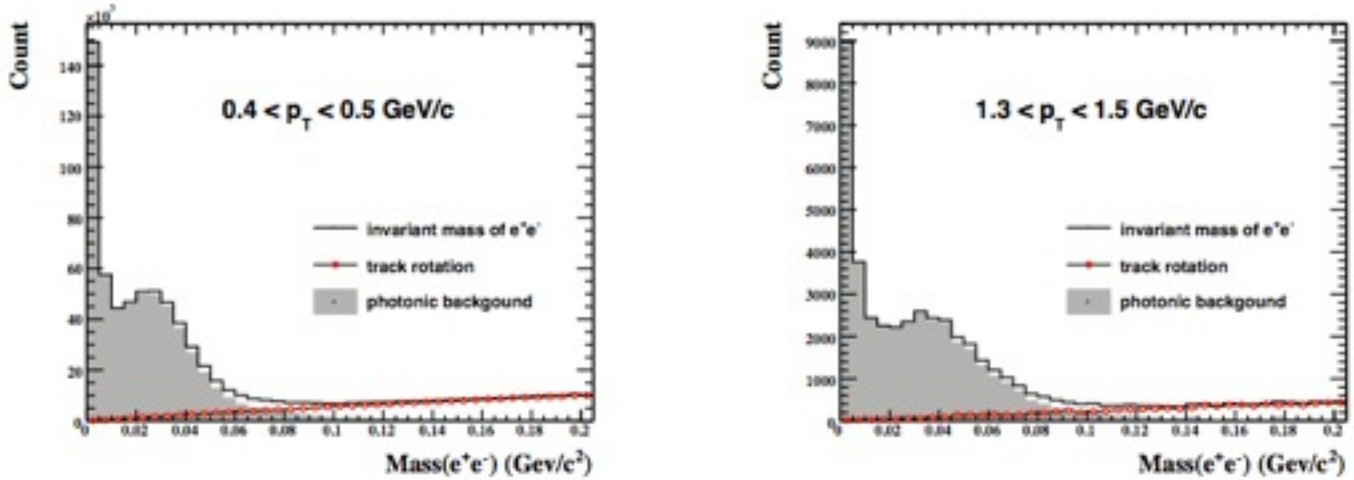


그림 3.19: 광자에 의한 배경

- We obtained ***photonic electron yield*** by **electron pair invariant mass < 0.15 GeV/c^2**.
  - $\gamma \rightarrow e^+e^-$ photon conversion in the material in STAR detector.
  - $\pi0 \rightarrow \gamma e^+e^-$ (1.174 ± 0.035)%
  - $\eta \rightarrow \gamma e^+e^-$ (0.70 ± 0.07)%
- Photonic electron needed partner finding efficiency.

Partner Finding Efficiency

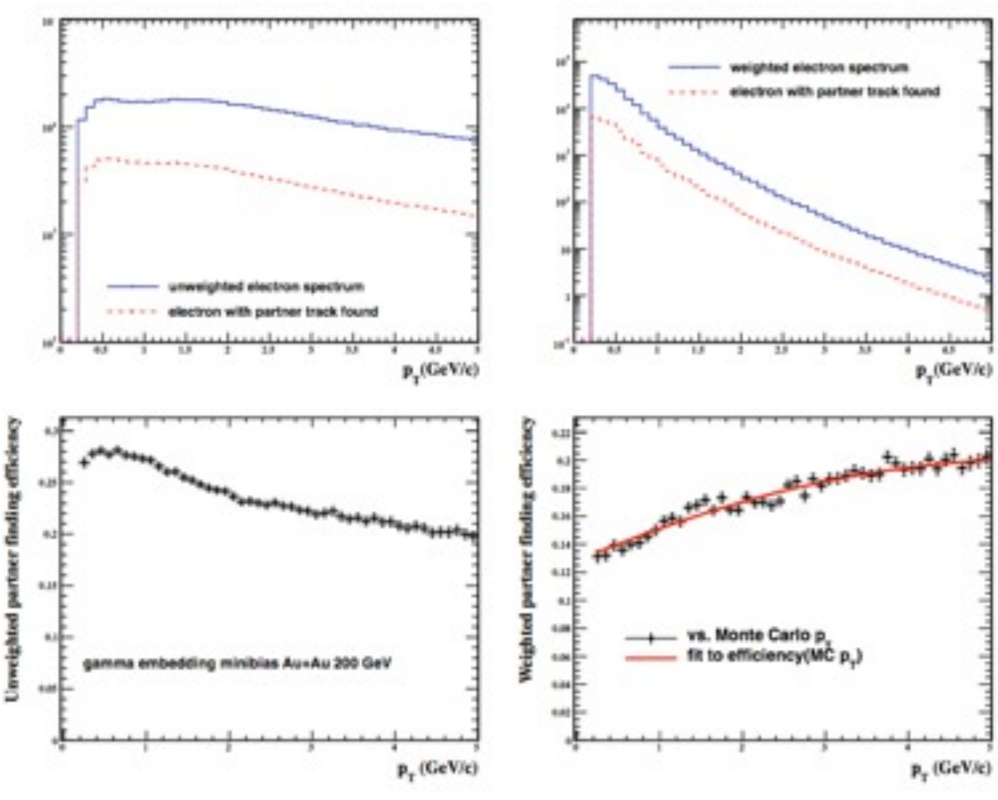


그림 3.20: Partner finding efficiency

- 짝찾기 효율 얻고 이를 보정 함으로서 실제 생성된 광자에 의한 배경을 얻을 수 있음.
- 모의 광자를 실제 실험 결과에 끼워 넣어 (gamma embedding) 계산 할 수 있음.
- 끼워 넣은 모의 광자는 균일한 횡운동량의 분포를 가지고 있기 때문에 실제 광자의 분포 로 보정(weighting)이 필요.

NPE p_T Distribution

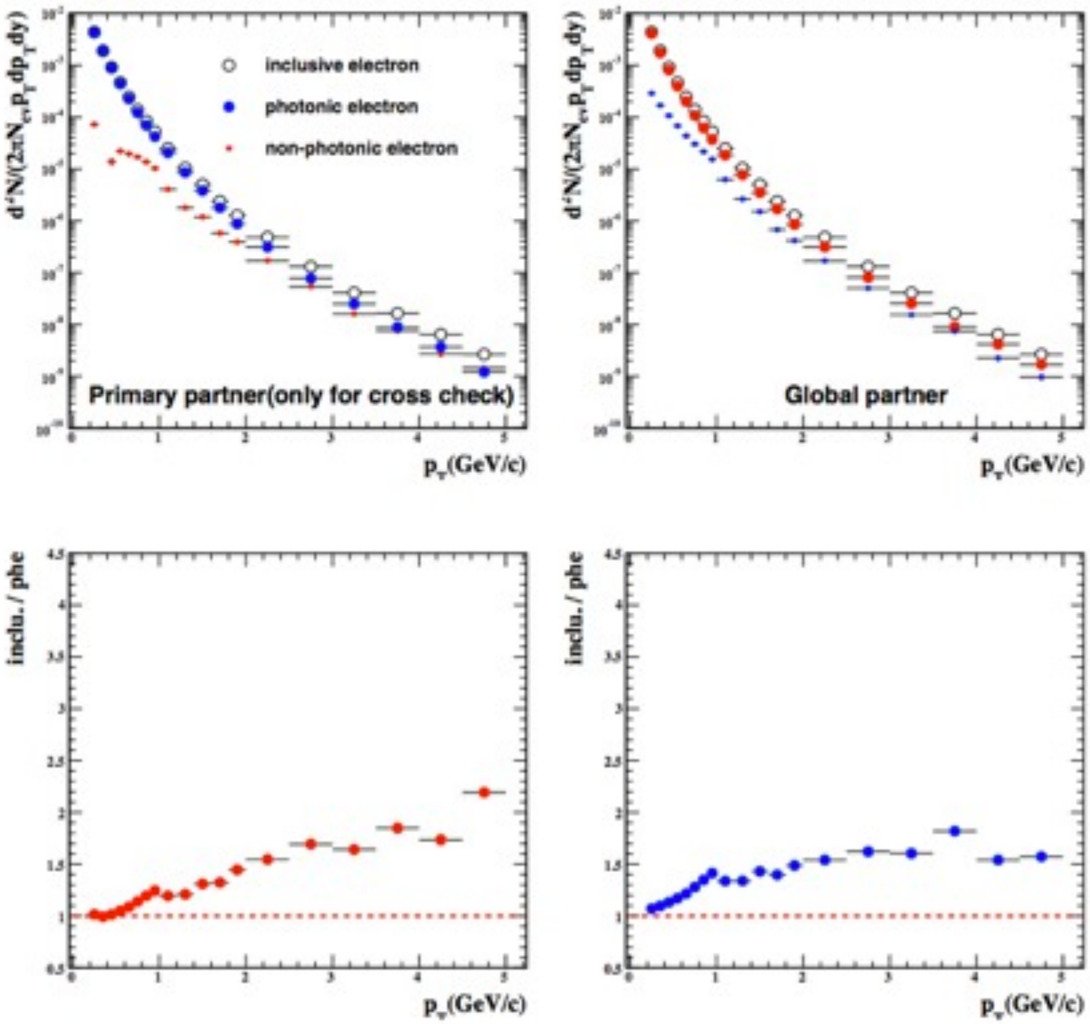


그림 3.21: inclusive electron and photonic electron spectra with global/primary partner

- Global track
  - reconstructed from TCP information only
- Primary track
  - reconstructed from TPC + vertex position bias.
  - Low partner finding efficiency (~5%)

- In principle, it will be same with global and primary partner.
  - primary partner finding efficiency is too low, small fluctuation will be make large difference.
  - global partner will be better. Also, we need investigate study for global partner.

Summary

- I obtained *non-photonic electron* yield in 200 GeV Au+Au collisions.
  - (*new*) PID method using TPC and TOF
  - low p_T NPE yield
- To-do
  - investigate study for backgrounds
    - photonic backgrounds
    - hadron contamination
    - light vector meson di-electron/ Daliz decay
    - ...

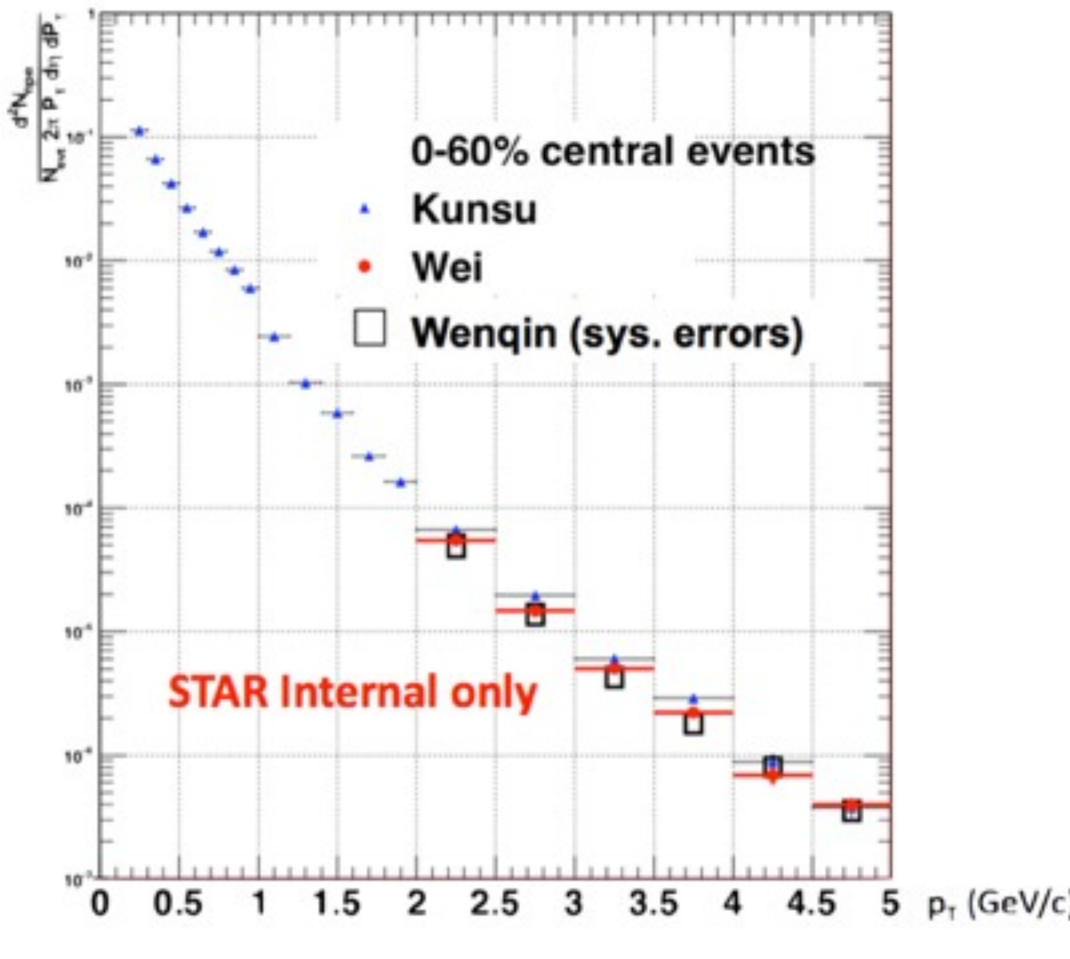


그림 4.1: Non-photonic electron spectra with Wie's and Wenqin's result

Thank you for attention.

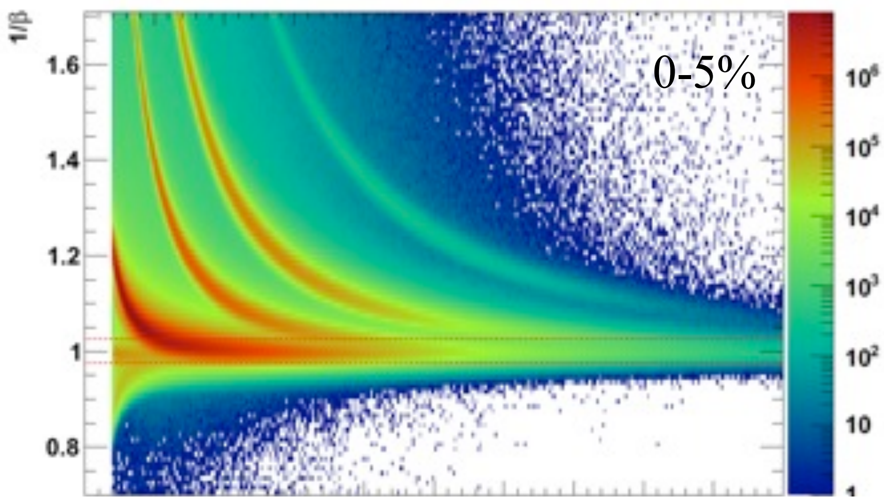
Backup

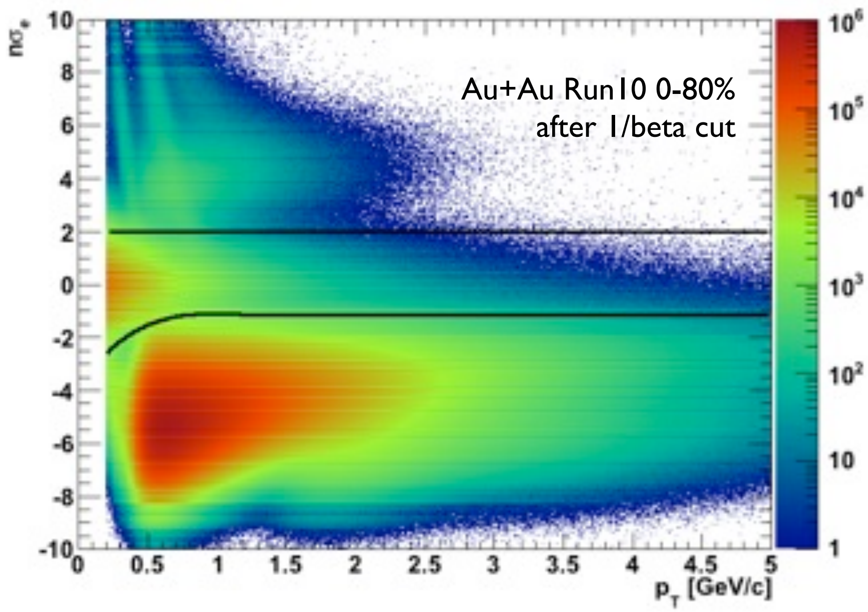
In the STAR environment, the inclusive electron sample consists of several sources of electrons:

- Photon conversions ($\gamma \longrightarrow e+ + e-$) in the detector material between the inter- action point and the TPC. There are several sources for the conversion photons: direct photons, photons from $\pi0$, η decays, etc.
- $\pi0$, η, etc. scalar meson Dalitz decays. $\pi0 \longrightarrow e+ +e- +\gamma$ (1.198±0.032)% $\eta \longrightarrow e+ +e- +\gamma$ (0.60±0.08)%
- ϱ, ω, ϕ vector meson Dalitz decays and/or di-electron decays.
- Kaon decays
- Heavy quark (charm and bottom) hadron semi-leptonic decays.
- Other possible contributions such as Dell-Yan, heavy quarkonium decay, thermal electrons, etc.

*Reference: **Xiaoyan Lin**'s PhD Thesis for STAR collaboration*

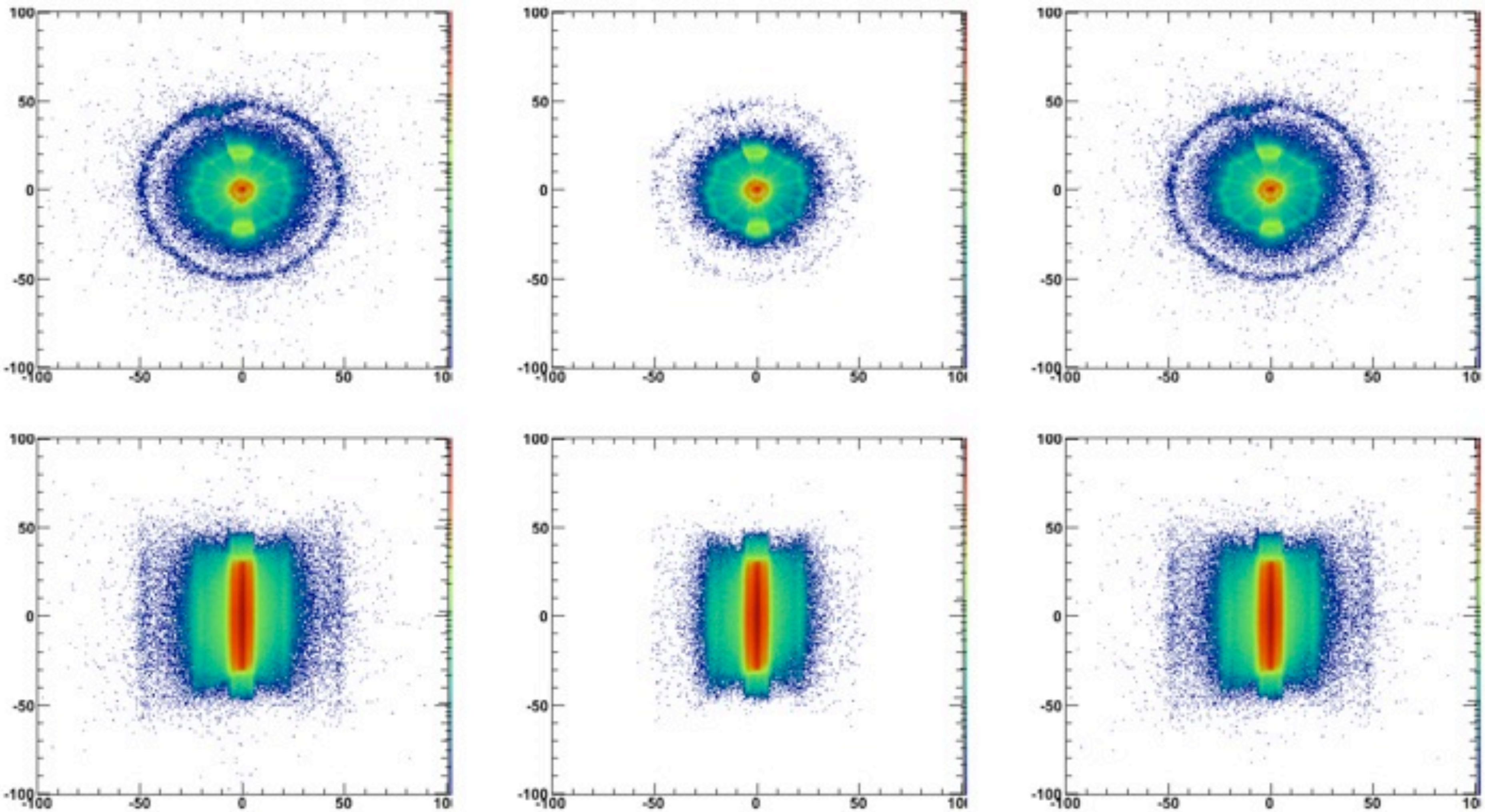
Track cuts



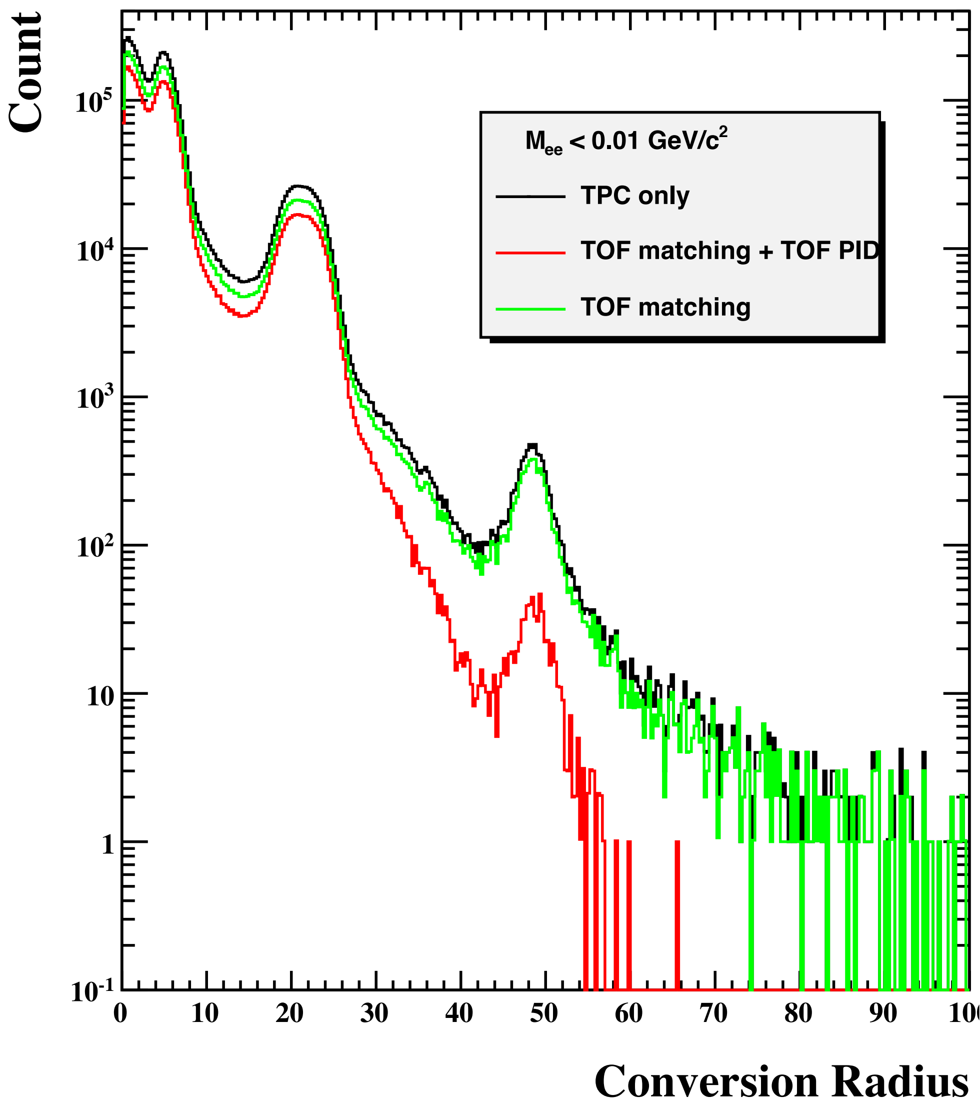


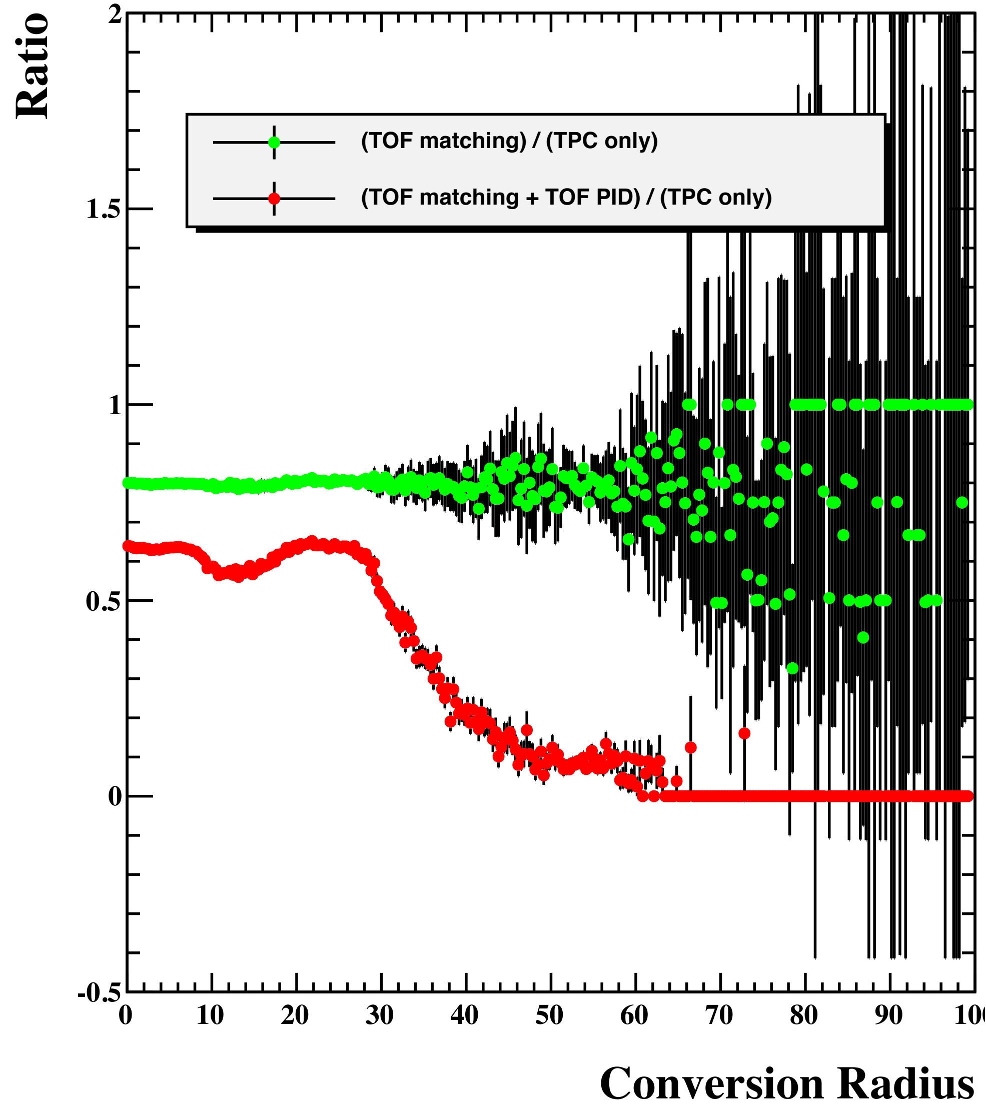
Cuts	*Tagged e* / *Primary partner*	*Global partner 1*	*Global partner 2*	*Global partner 3*
Primary track?	yes	no		
TOF hits matched?	yes	no	yes	
ylocal	(-1.9, 1.9)	-	(-1.9, 1.9)	-
zlocal	(-3.2, 3.2)	-	(-3.2, 3.2)	-
global DCA [cm]	≤ 1.0	-	-	-
nFitPts [#]	≥ 20			
nFitPts/nMax	> 0.52			
ndEdxFitPts [#]	≥ 15			
p_T [GeV/c]	(0.2, 20)			
pseudo-rapidity	(-0.7, 0.7)	(-1, 1)		
1/beta - 1	(-0.025, 0.025)	-	(-0.025, 0.025)	-
nSigE	⬅	(-1, 2)		

Conversion Position



Conversion Position

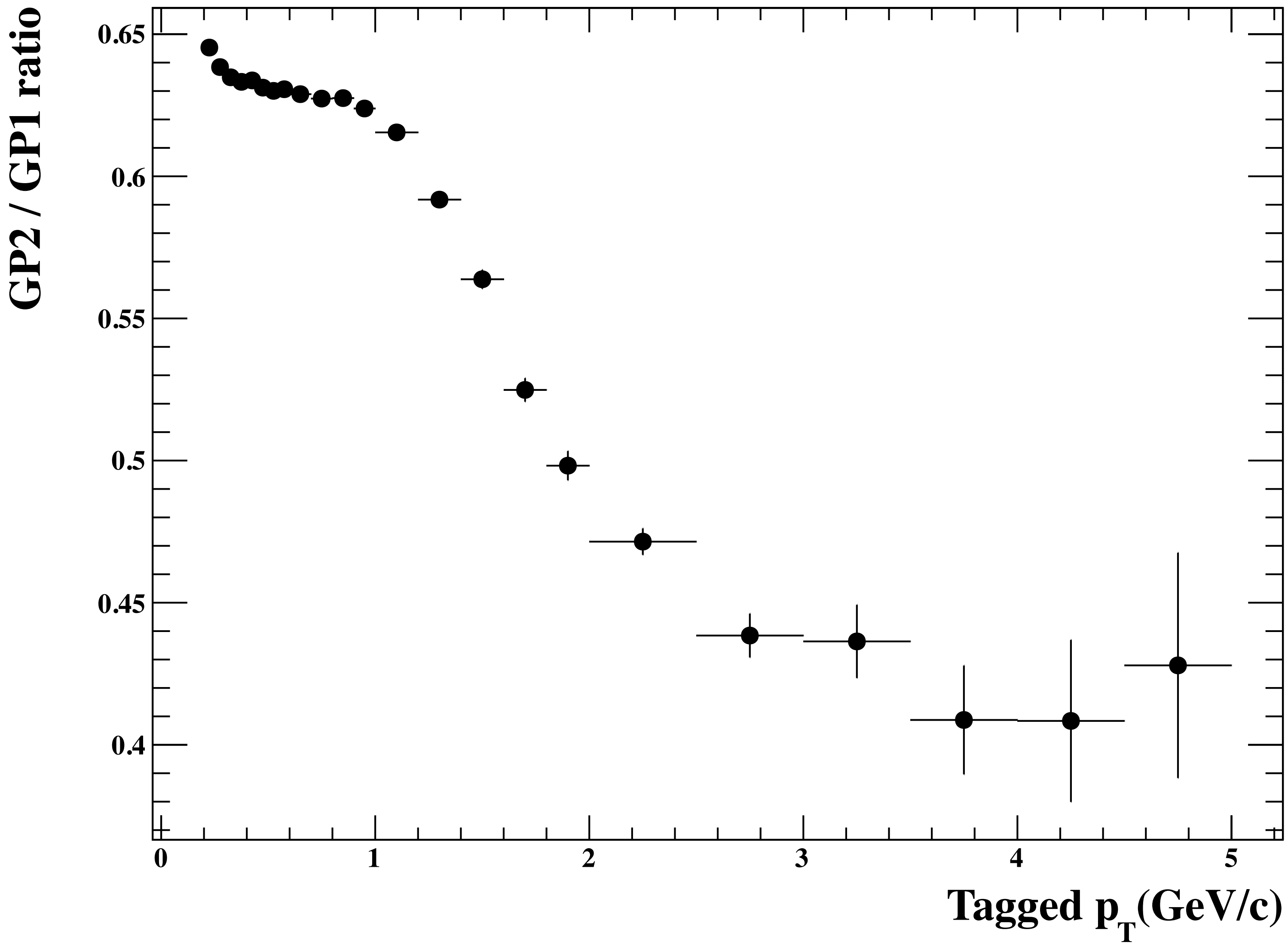




TPC only

GP2 / GP1 ratio

TPC + TOF matching + TOF PID



TPC only

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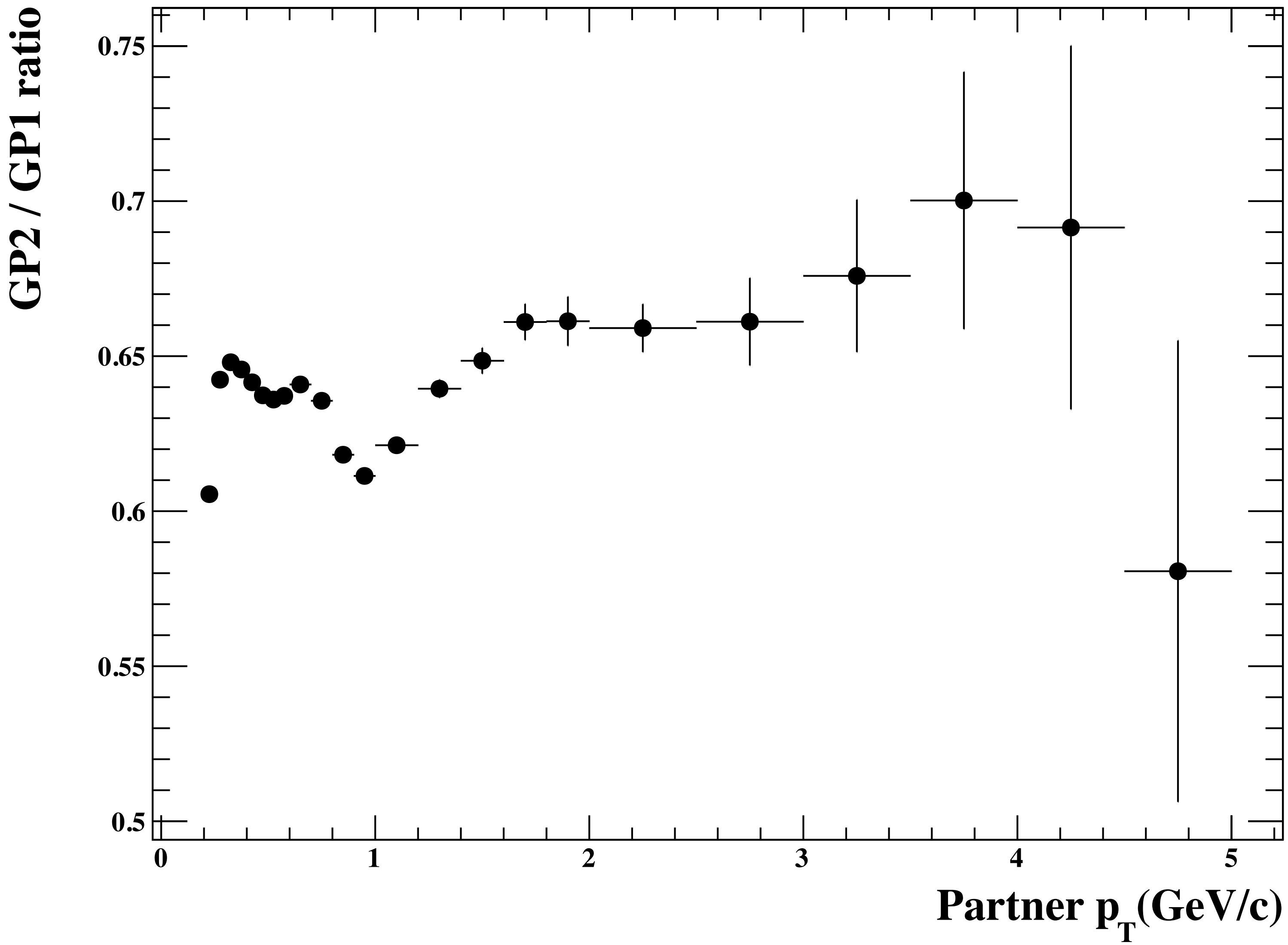
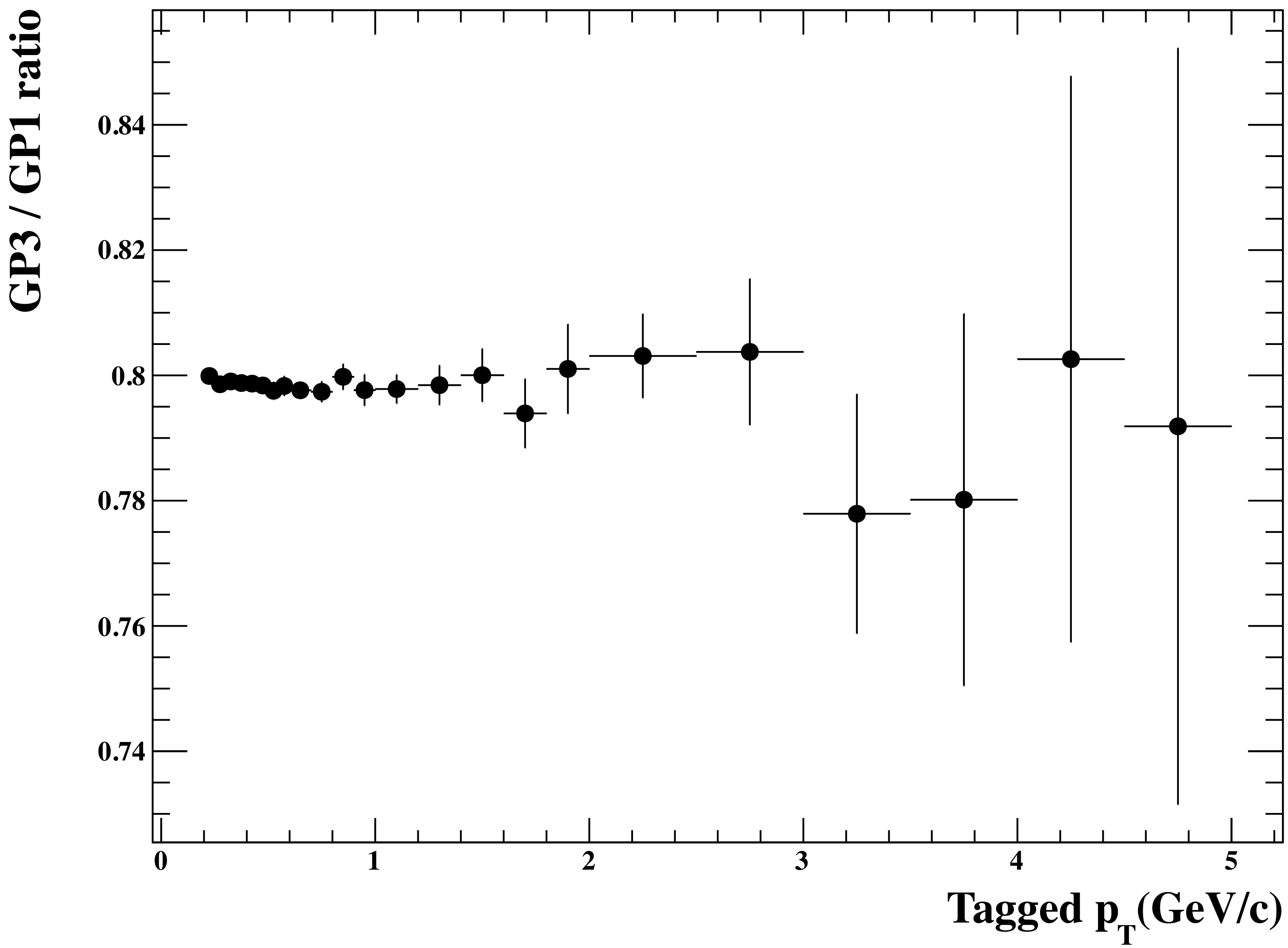


TPC only

GP3 / GP1 ratio

TPC + TOF matching



TPC only

GP3 / GP1 ratio

TPC + TOF matching