Transverse Physics

Kinematics studies for eRHIC

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EIC Collaboration Meeting

Catholic University of America, 29th July 2010

Overview

- Q^2 vs. x and p_T vs. z coverage
- Acceptance
- gmc_trans: monte carlo generator
- Torino parameterisations

Transverse SIDIS

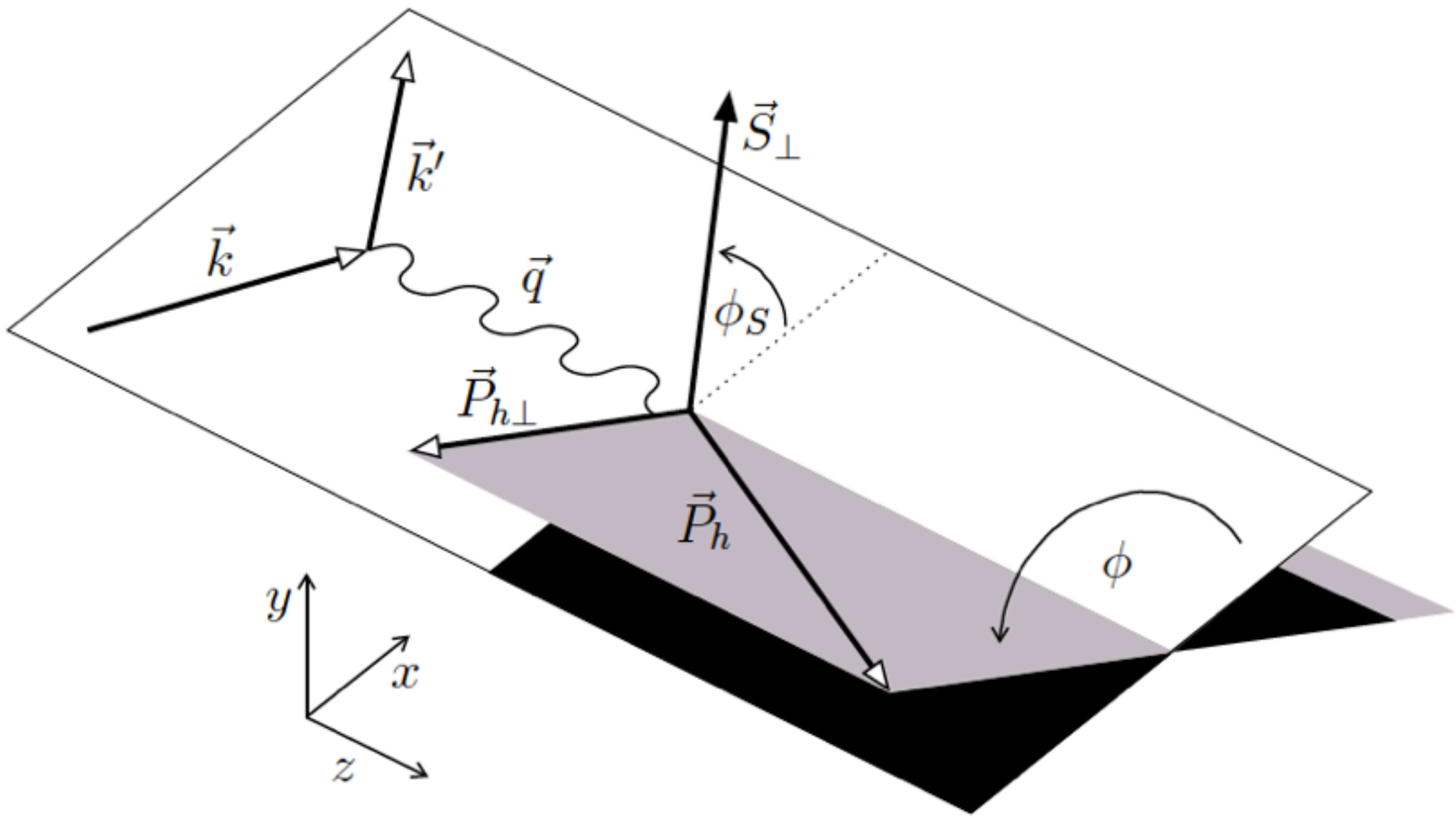
- Excellent tool for studying transverse spin

  ➡ control of event kinematics

- Disentangle contributions via different angular dependencies

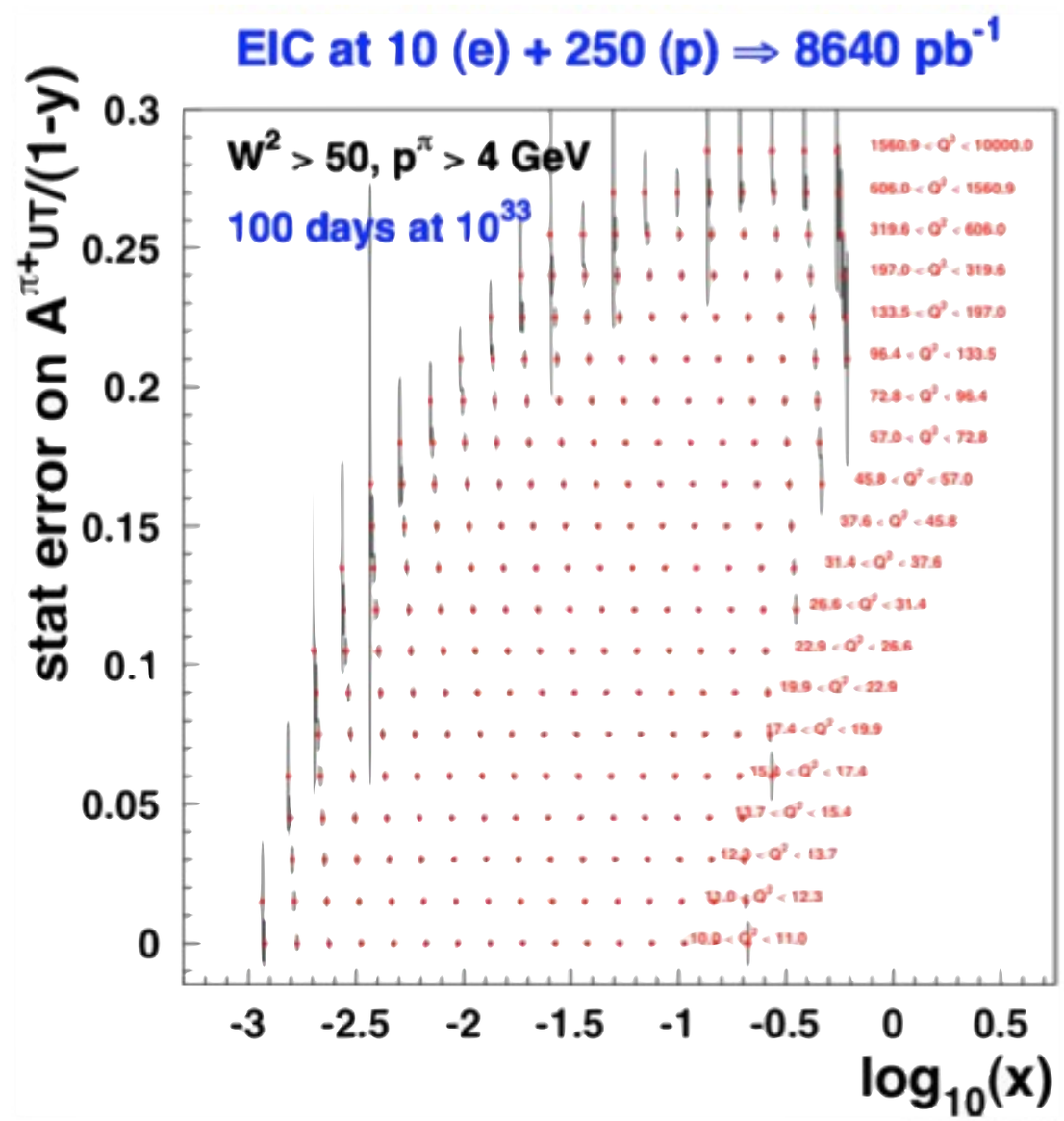
  ➡ Sivers & Collins @ HERMES, COMPASS

Transverse SIDIS

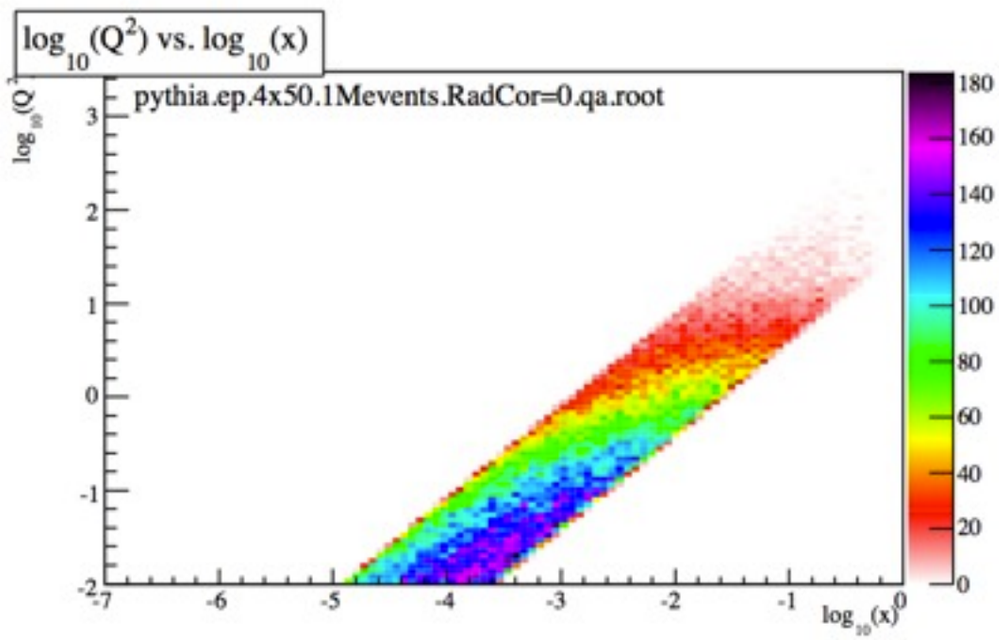


Kinematics

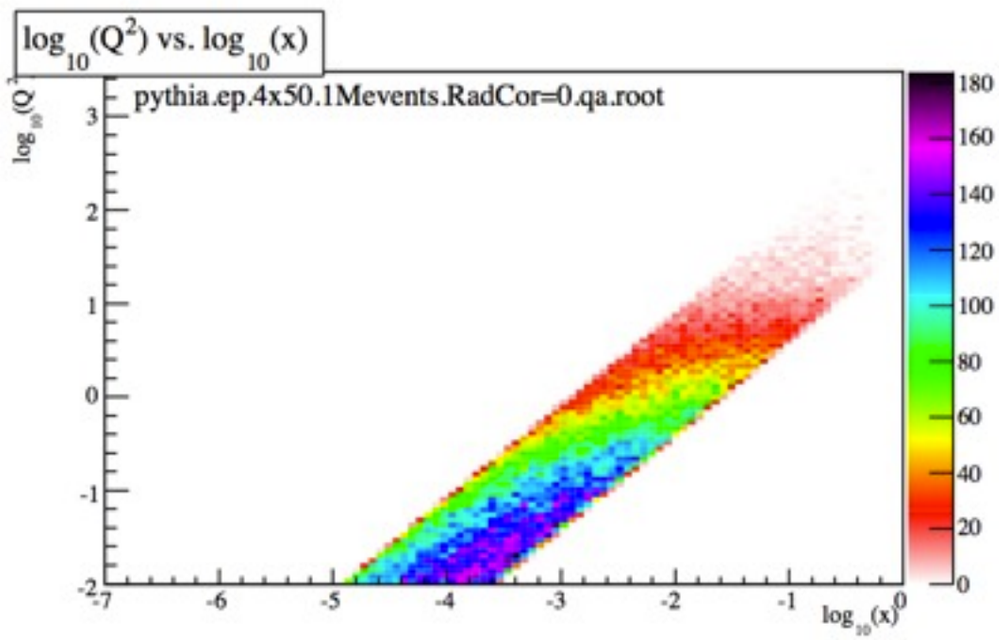
- EIC luminosity:
  - Enables multi-dimensional analysis
- To map TMDs, want wide kinematics coverage
  - Wide Q2 'lever arm' at given x
  - Coverage in z and particle pT



Q^2 vs. x


log10(Q2) vs. log10(x)
pythia.ep.4x50.1Mevents.RadCor=0.qa.root
log10(Q2)
log10(x)
3
2
1
0
-1
-2
-7
-6
-5
-4
-3
-2
-1
0
180
160
140
120
100
80
60
40
20
0

Q^2 vs. x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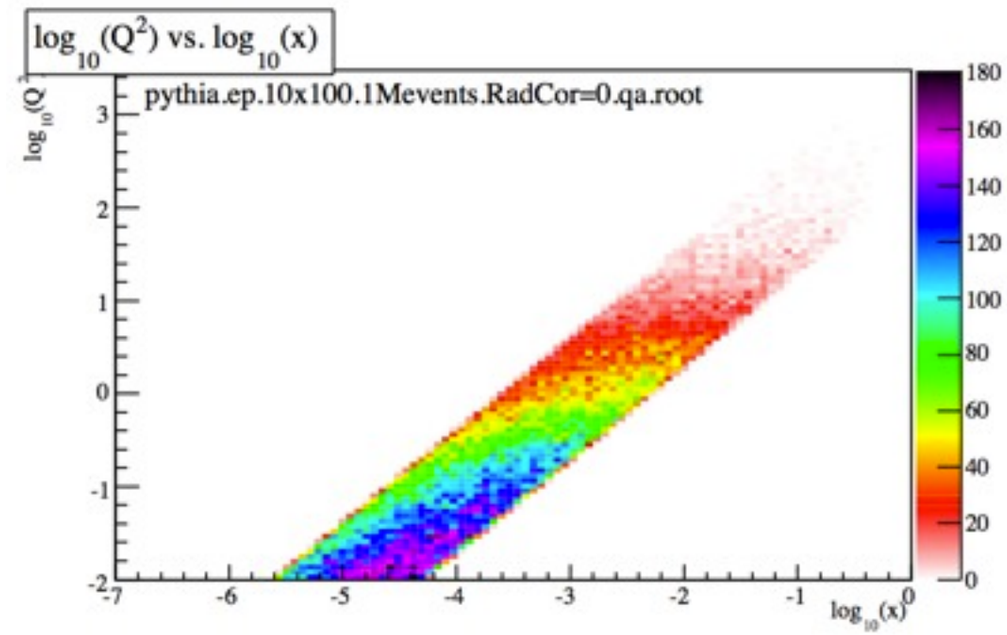
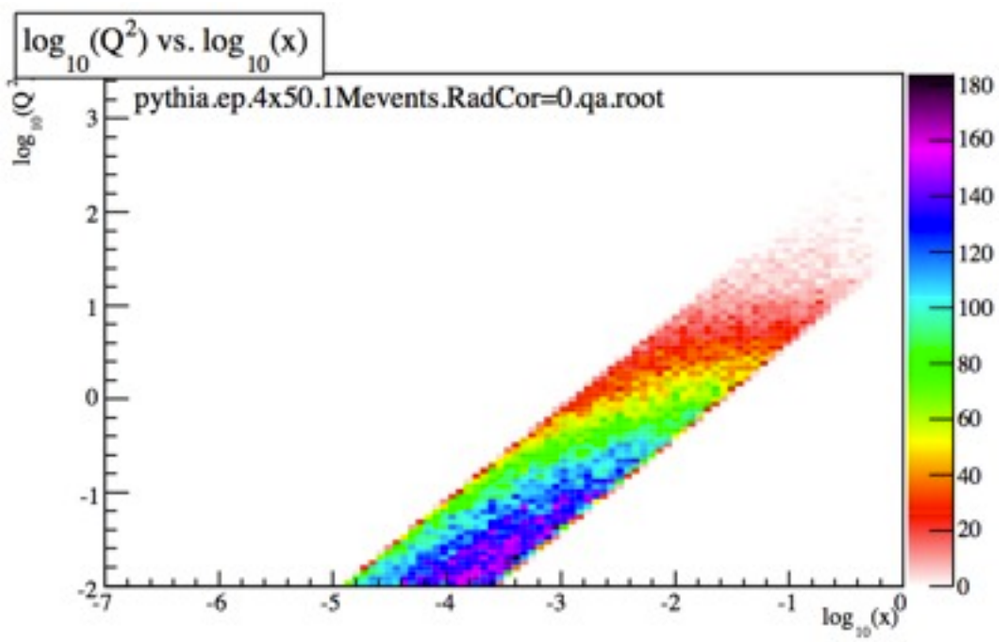

log10(Q2) vs. log10(x)
pythia.ep.10x100.1Mevents.RadCor=0.qa.root
log10(Q2)
log10(x)

Q^2 vs. x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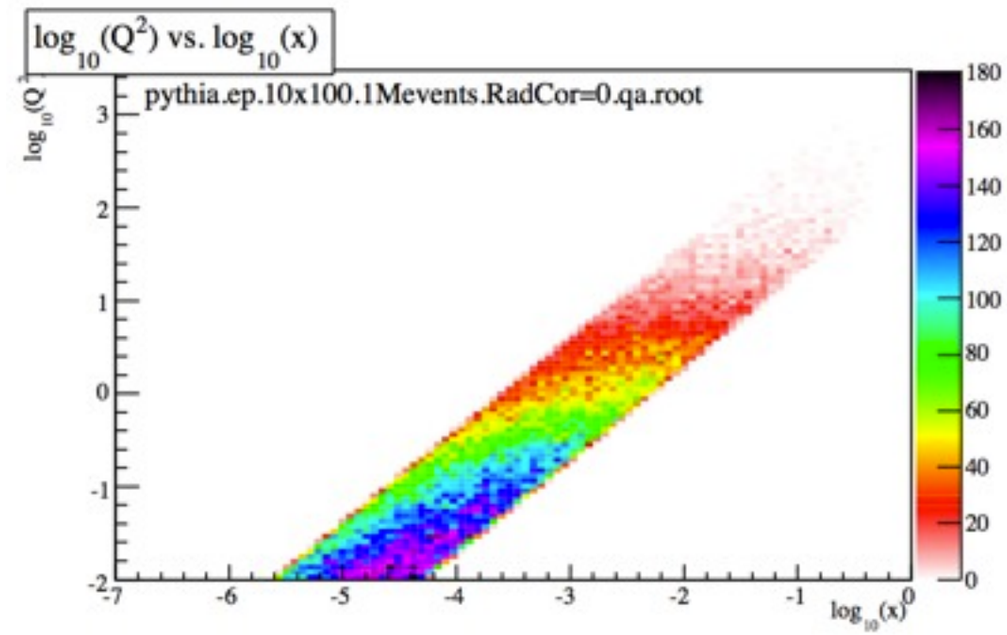
log10(x)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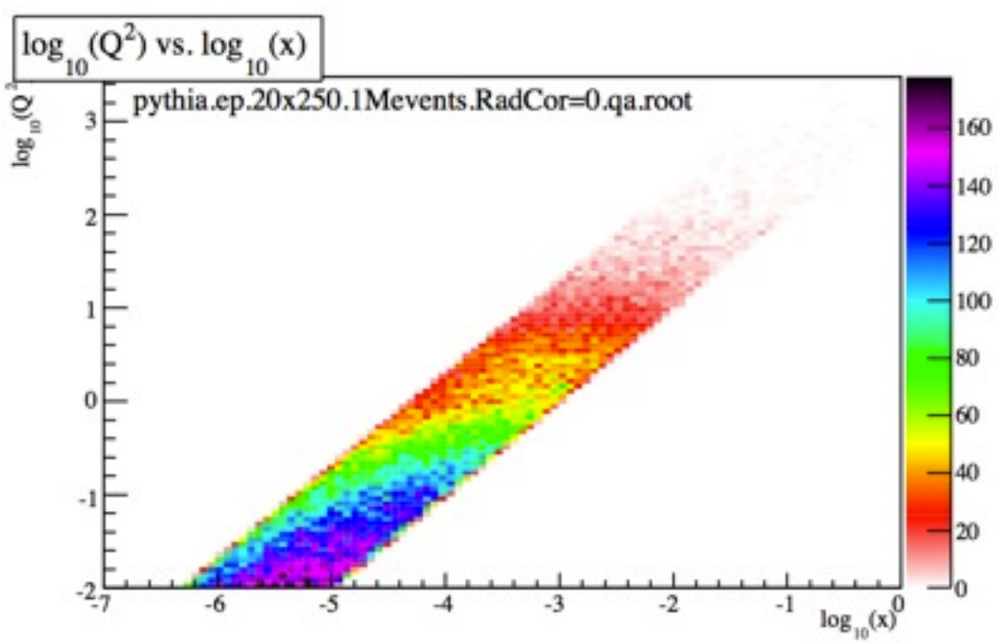
log10(x)


log10(Q2) vs. log10(x)
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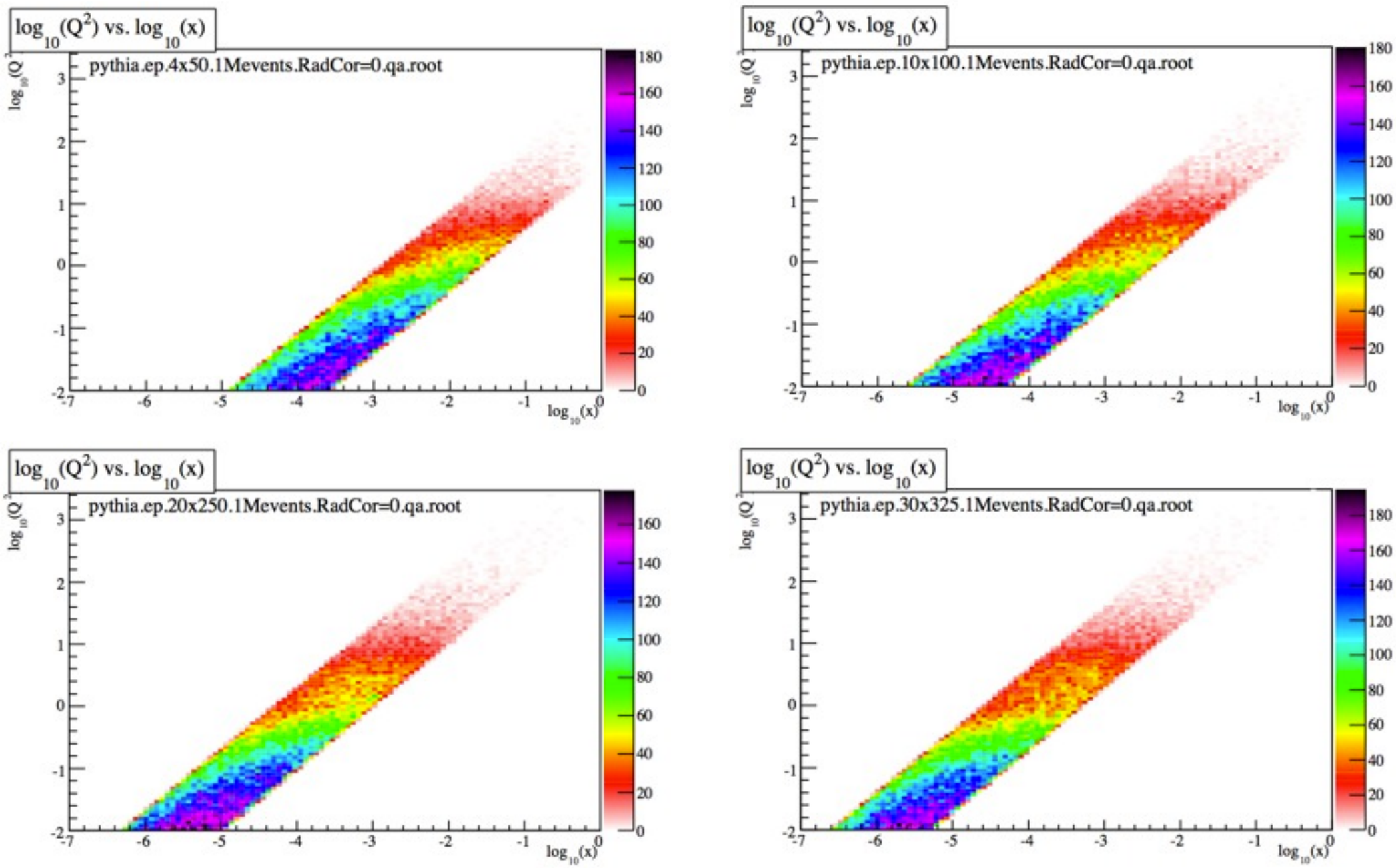
log10(Q2)
log10(x)

Q^2 vs. x


log10(Q2) vs. log10(x)
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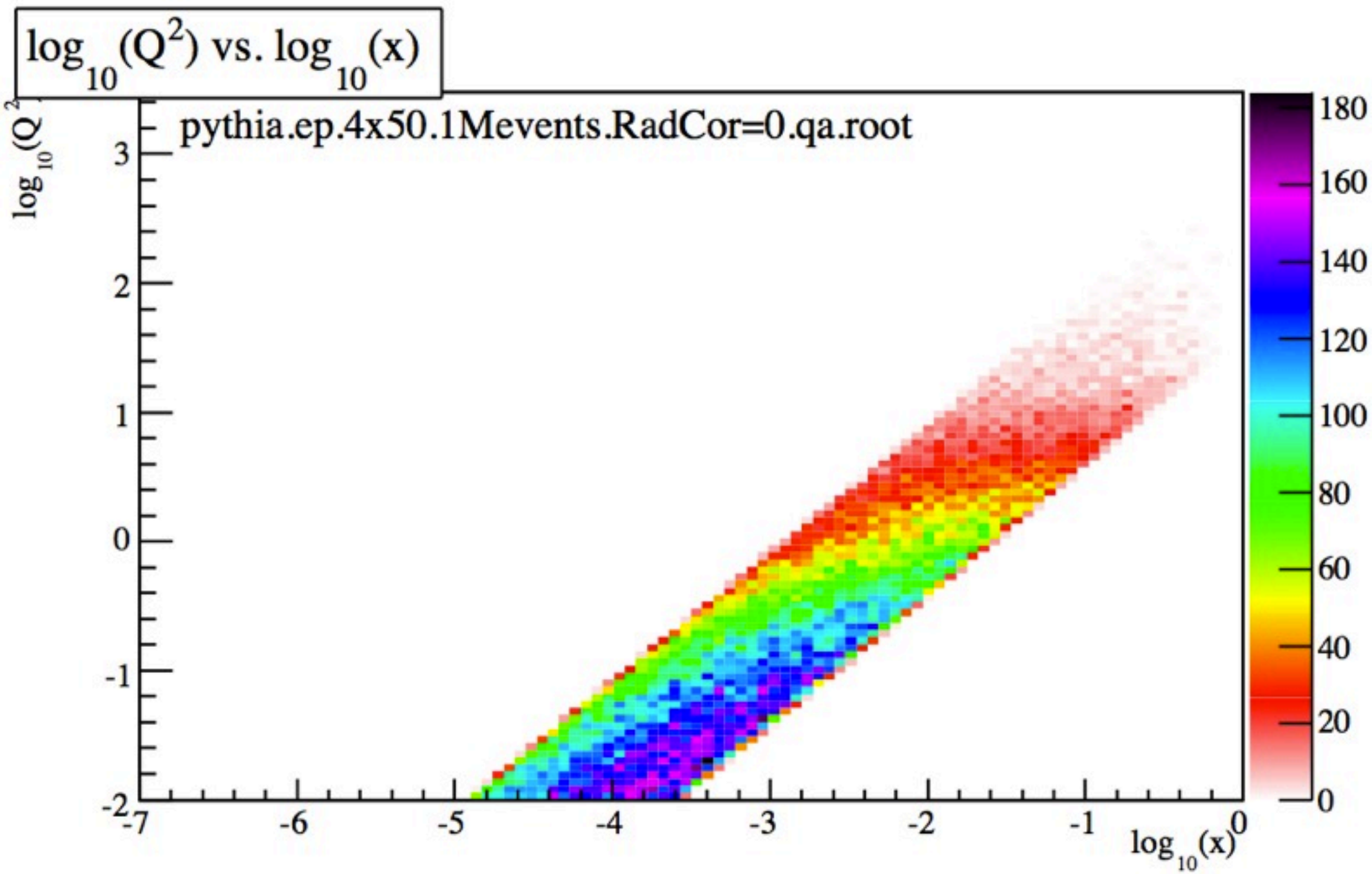
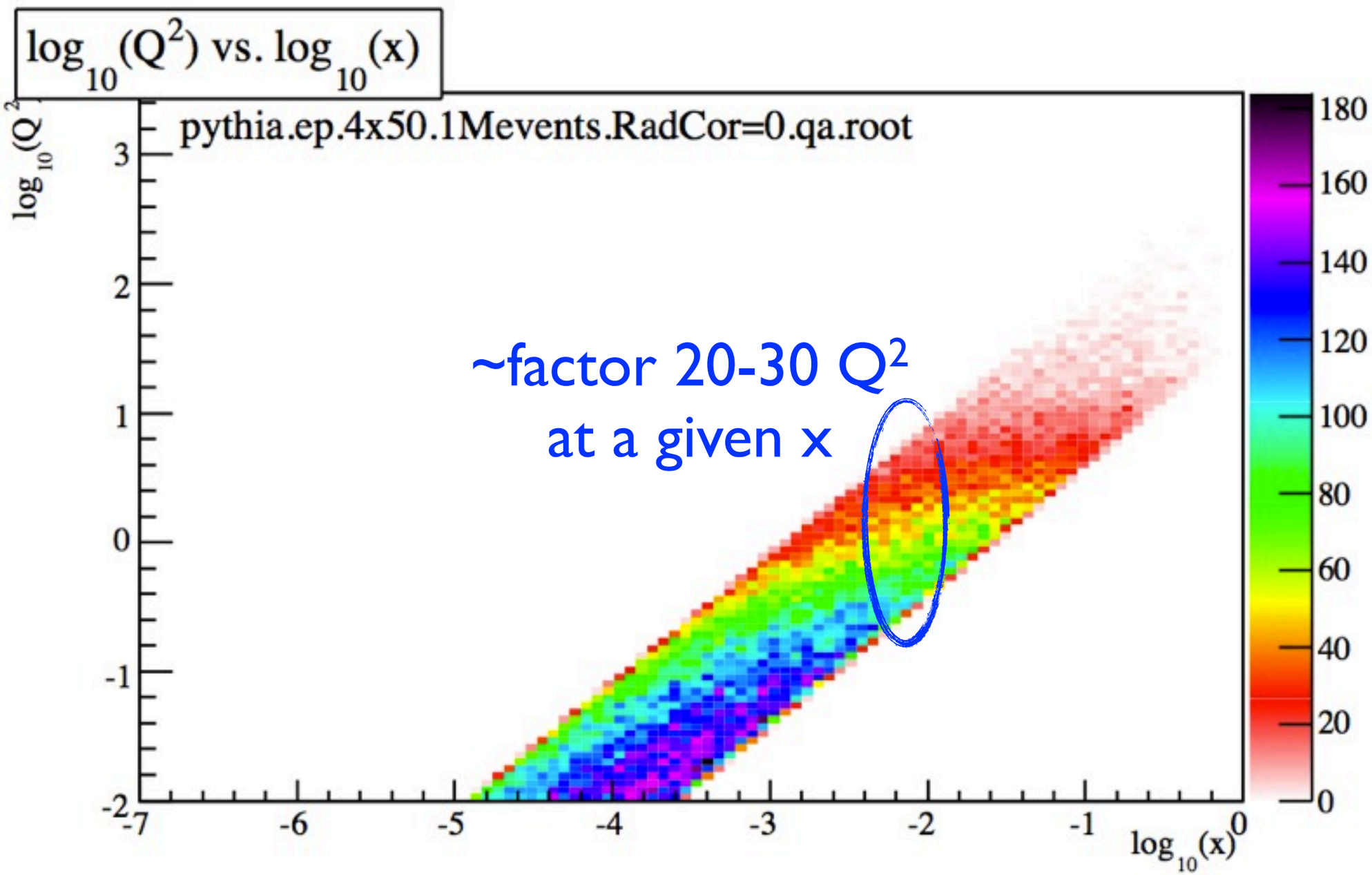
log10(Q2) vs. log10(x)
pythia.ep.10x100.1Mevents.RadCor=0.qa.root
log10(Q2) vs. log10(x)
pythia.ep.20x250.1Mevents.RadCor=0.qa.root
log10(Q2) vs. log10(x)
pythia.ep.30x325.1Mevents.RadCor=0.qa.root
log10(x)
log10(Q2)

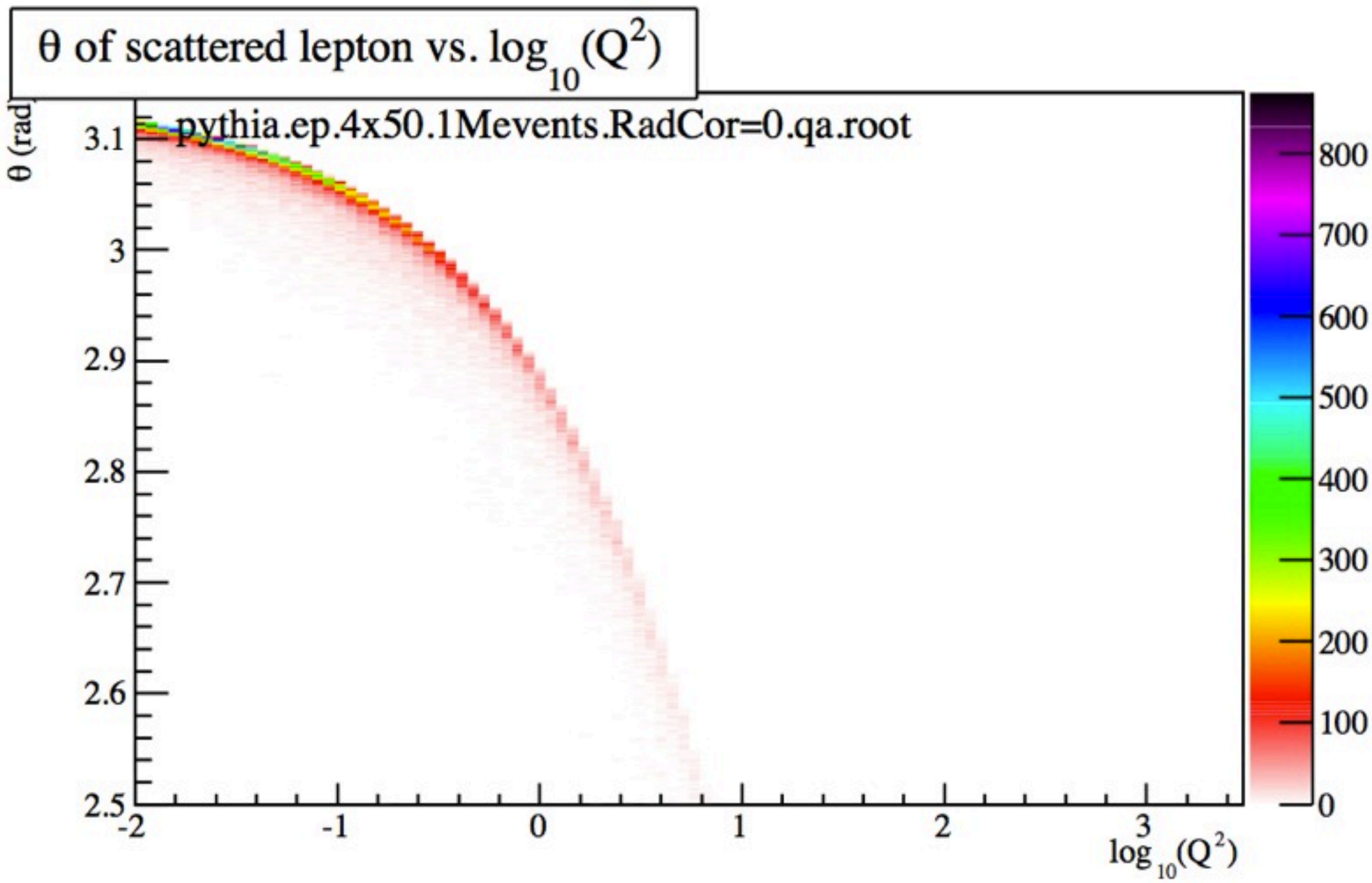
Q^2 vs. x


log10(Q2) vs. log10(x)
pythia.ep.4x50.1Mevents.RadCor=0.qa.root
log10(Q2)
log10(x)
3
2
1
0
-1
-2
-7
-6
-5
-4
-3
-2
-1
0
180
160
140
120
100
80
60
40
20
0

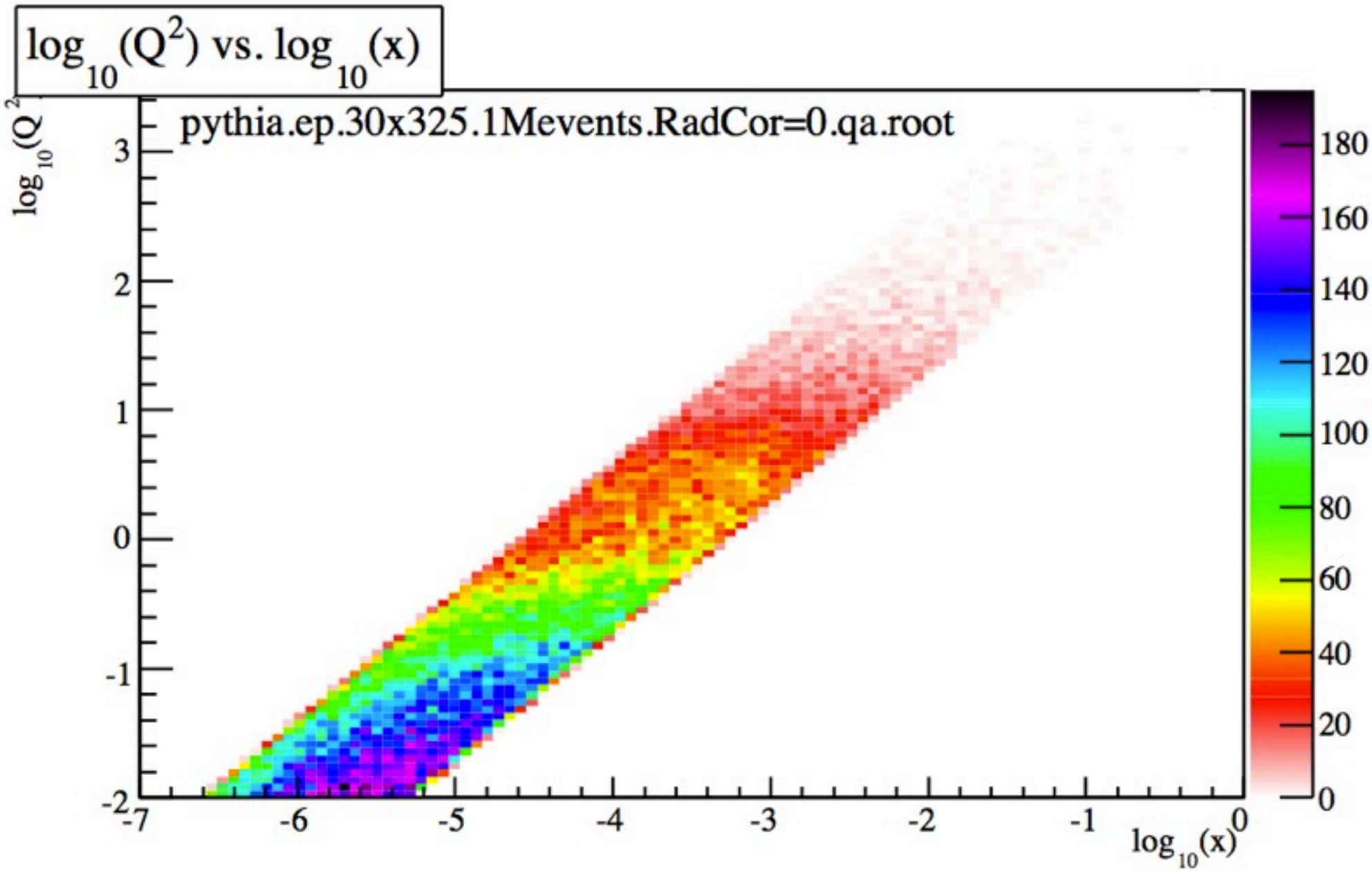
Q^2 vs. x


log10(Q2) vs. log10(x)
pythia.ep.4x50.1Mevents.RadCor=0.qa.root
~factor 20-30 Q2
at a given x
log10(Q2)
log10(x)
3
2
1
0
-1
-2
-7
-6
-5
-4
-3
-2
-1
0
180
160
140
120
100
80
60
40
20
0

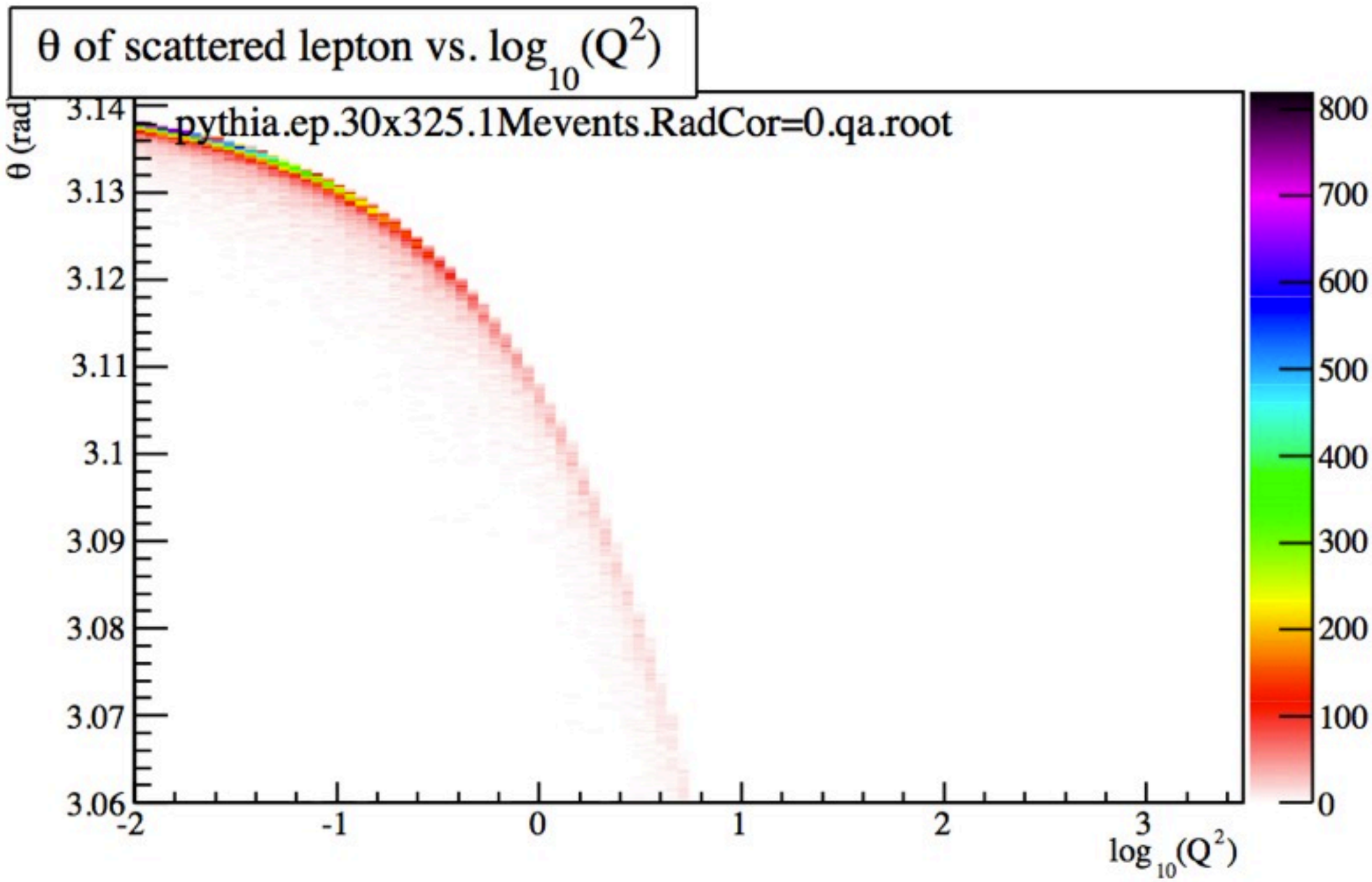
Q^2 vs. x


θ of scattered lepton vs. log10(Q2)
pythia.ep.4x50.1Mevents.RadCor=0.qa.root
θ (rad)
3.1
3
2.9
2.8
2.7
2.6
2.5
-2
-1
0
1
2
3
log10(Q2)
800
700
600
500
400
300
200
100
0

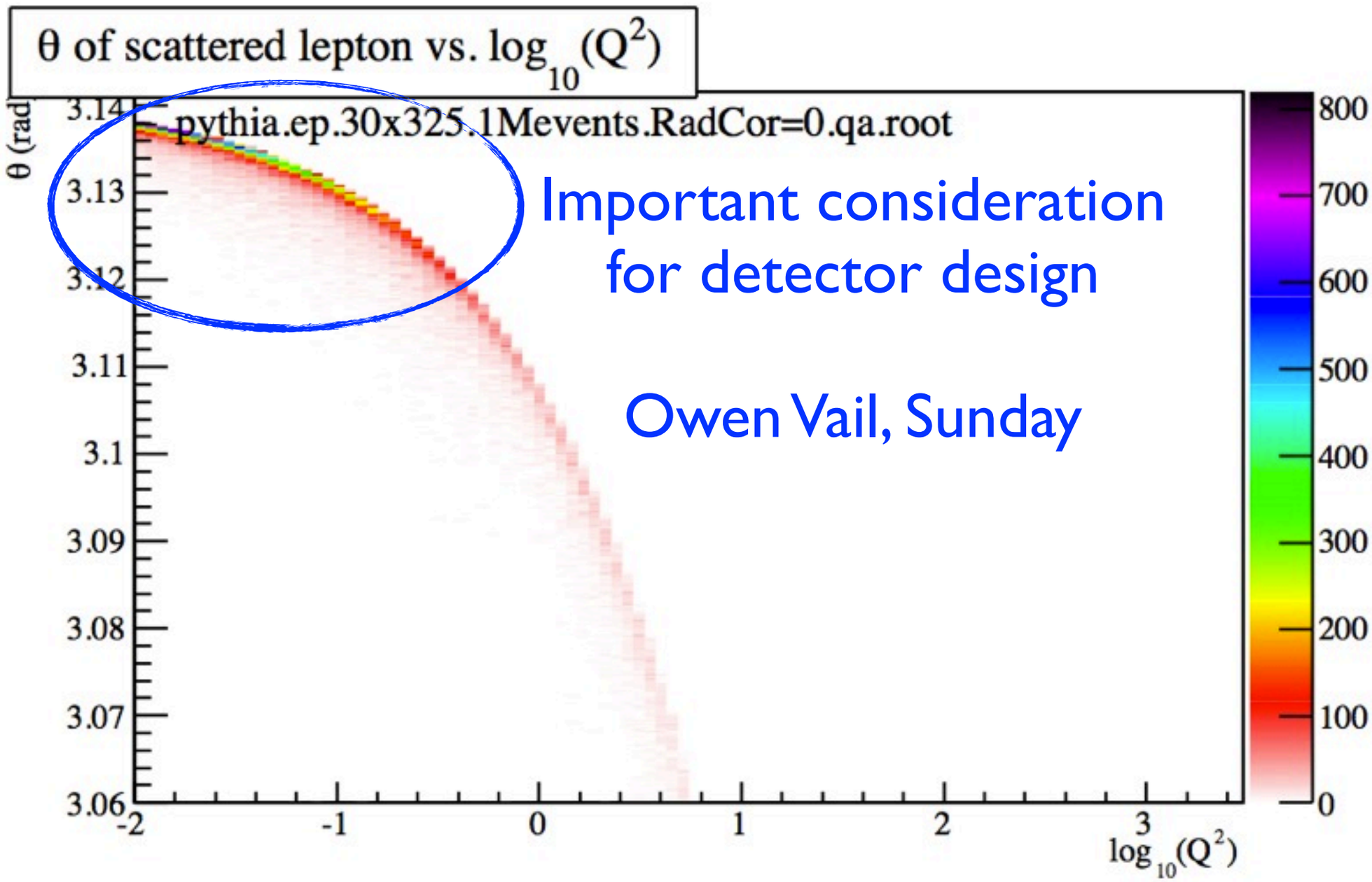
Q^2 vs. x


log10(Q2) vs. log10(x)
pythia.ep.30x325.1Mevents.RadCor=0.qa.root
log10(Q2)
log10(x)
3
2
1
0
-1
-2
-7
-6
-5
-4
-3
-2
-1
0
180
160
140
120
100
80
60
40
20
0

Q^2 vs. x


θ of scattered lepton vs. log10(Q2)
pythia.ep.30x325.1Mevents.RadCor=0.qa.root
θ (rad
3.14
3.13
3.12
3.11
3.1
3.09
3.08
3.07
3.06
-2
-1
0
1
2
3
log10(Q2)
800
700
600
500
400
300
200
100
0

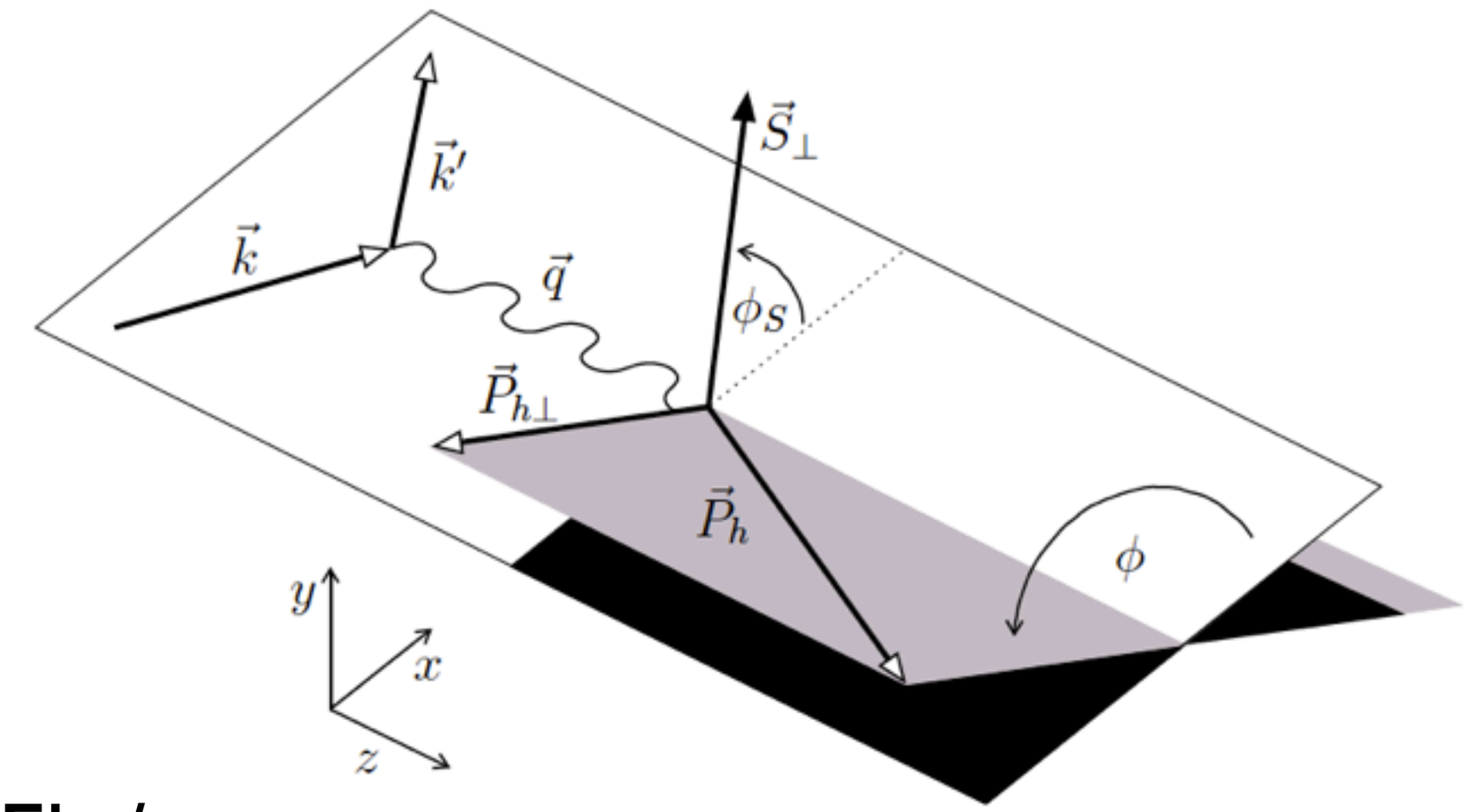
Q^2 vs. x



Important consideration for detector design

Owen Vail, Sunday

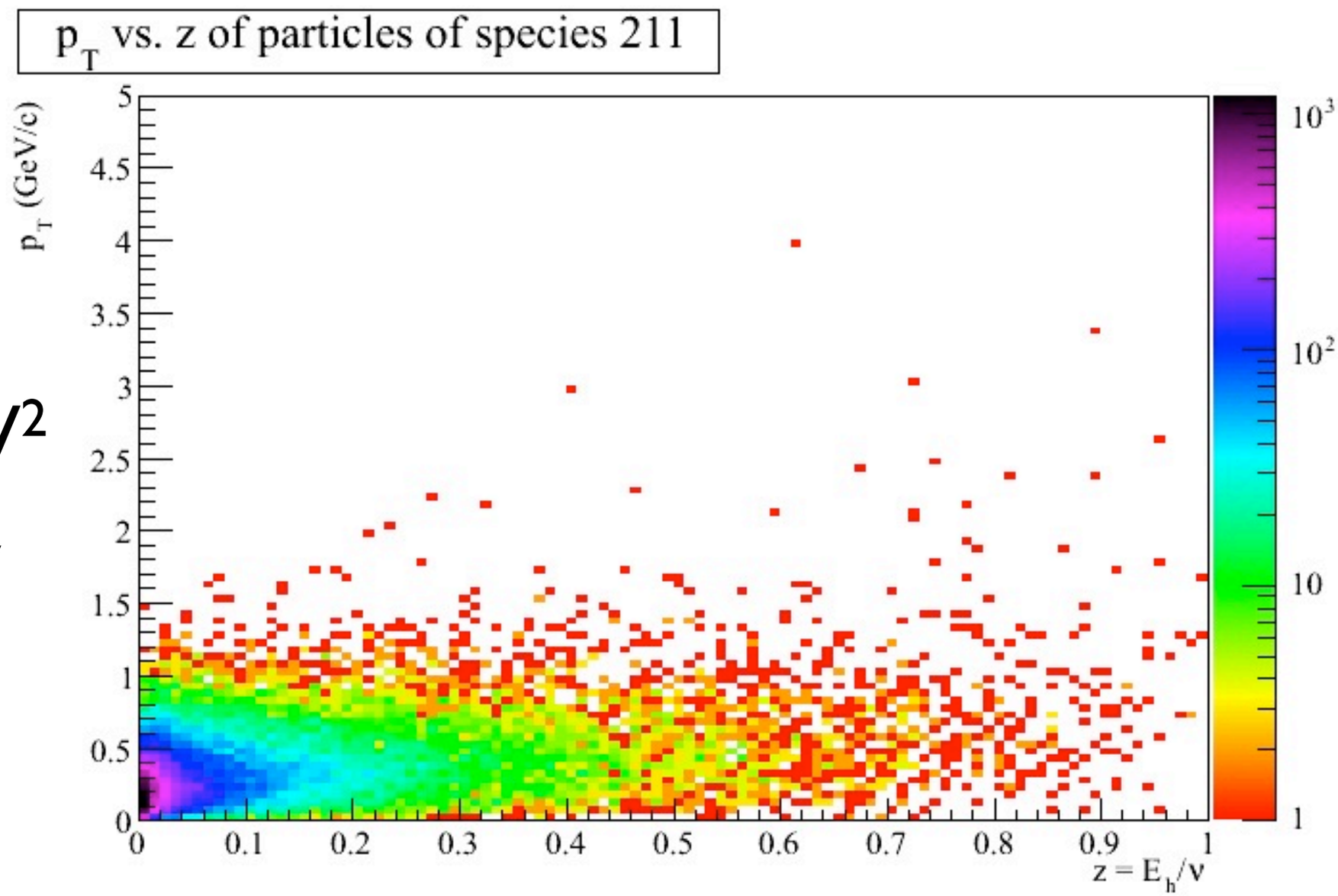
z vs. p_T

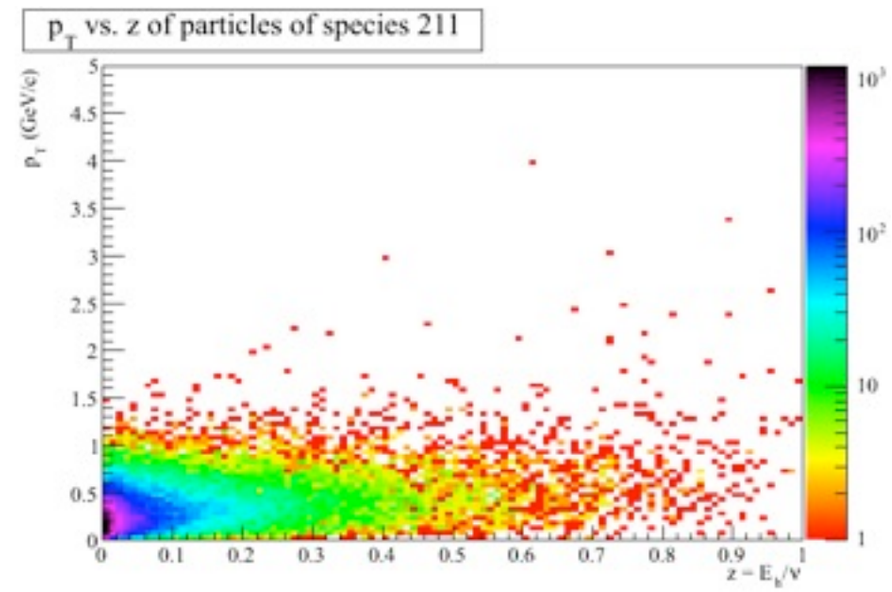


- p_T w.r.t. to γ^*
- $z = P.P_h / P.q = E_h / \nu$

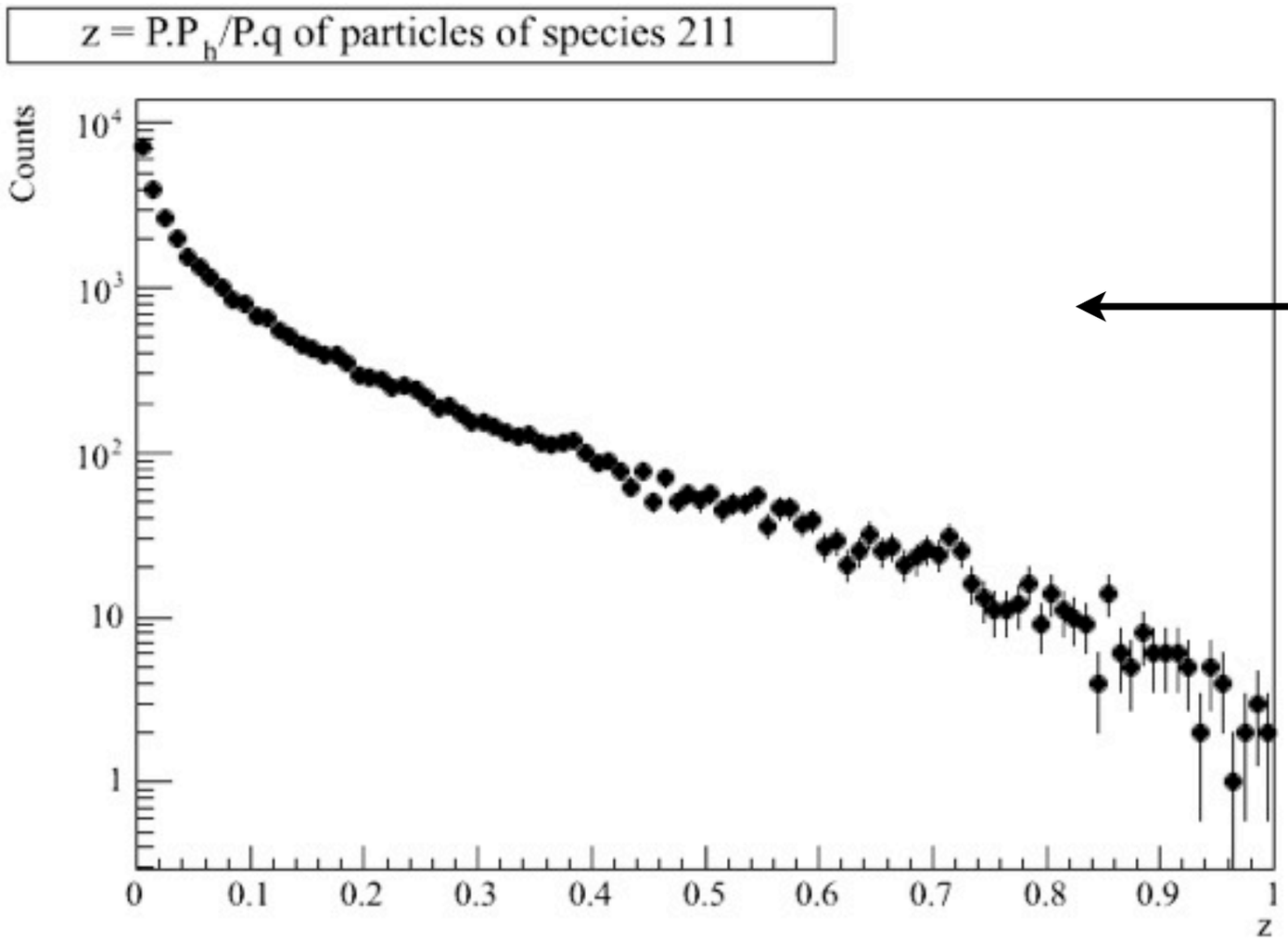
z vs. p_T

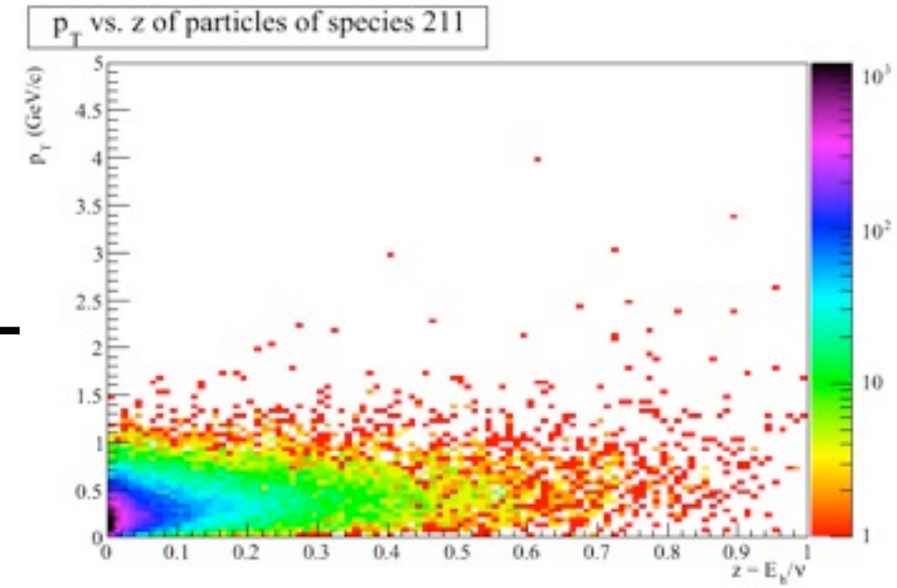
- π^+
- $Q^2 > 1\ GeV^2$
- 4 x 50 GeV



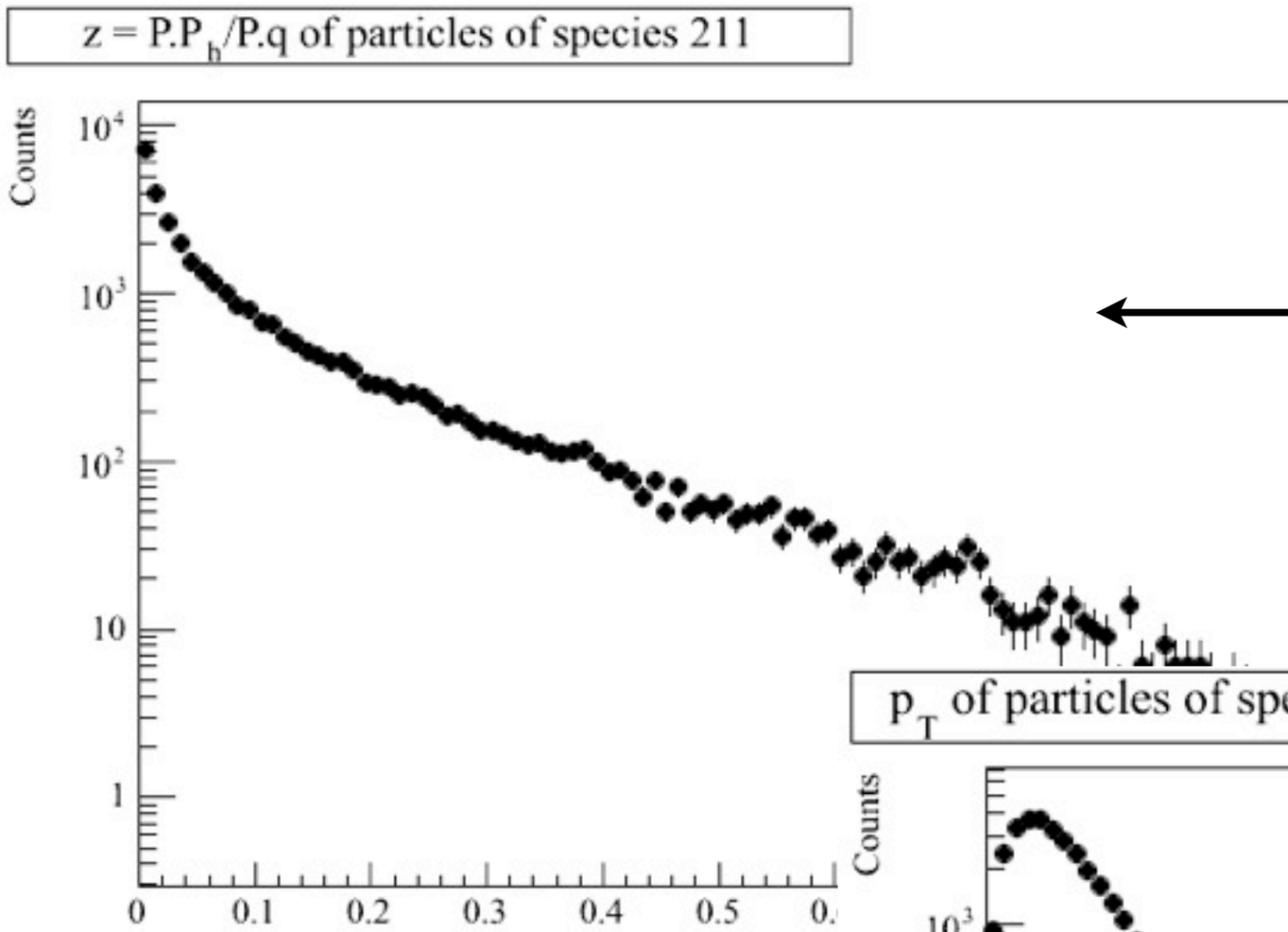


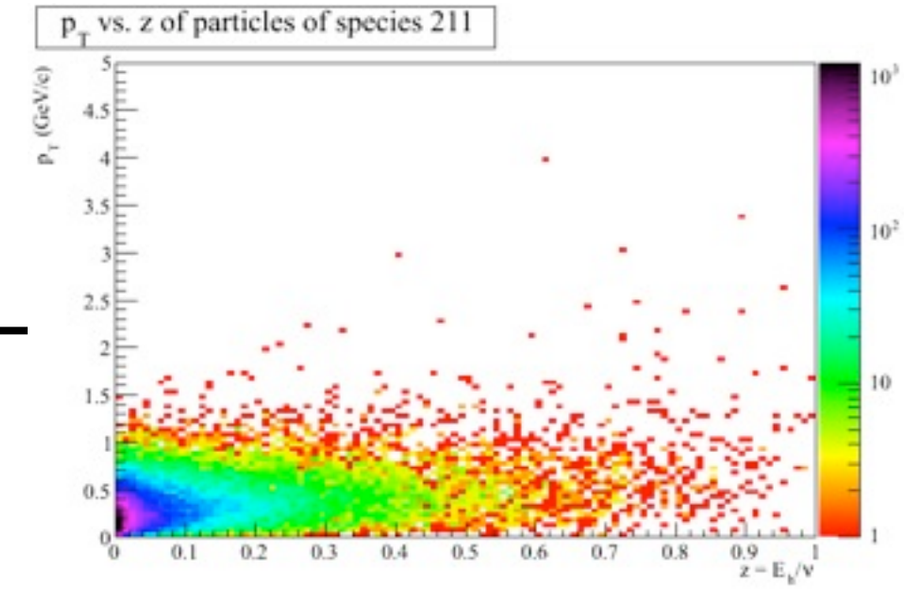
- π^+
- $Q^2 > 1\ \mathrm{GeV}^2$
- 4 x 50 GeV

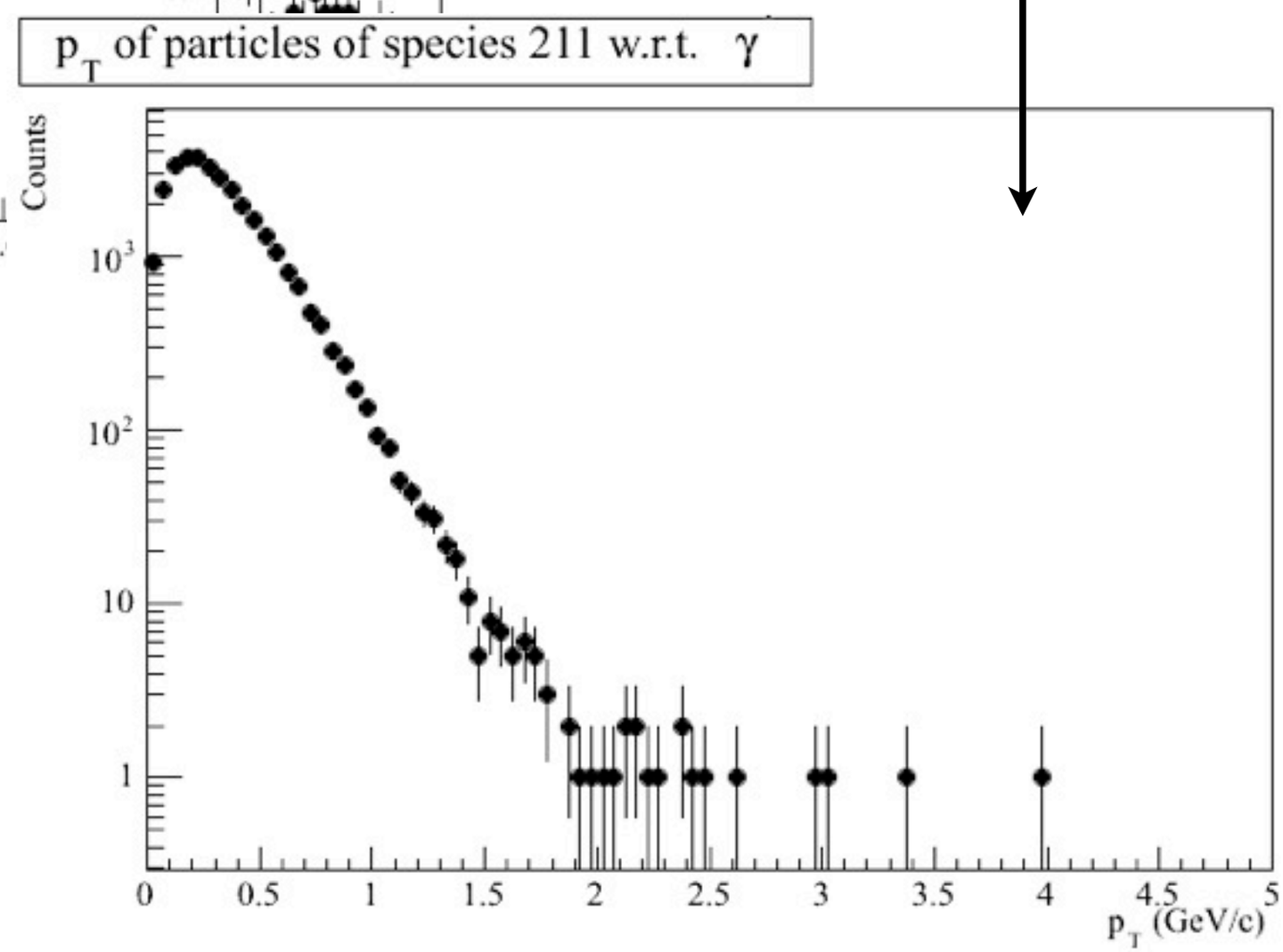

z = P.P_h/P.q of particles of species 211
Counts
z


p_T vs. z of particles of species 211
p_T (GeV/c)
z = E_h/ν

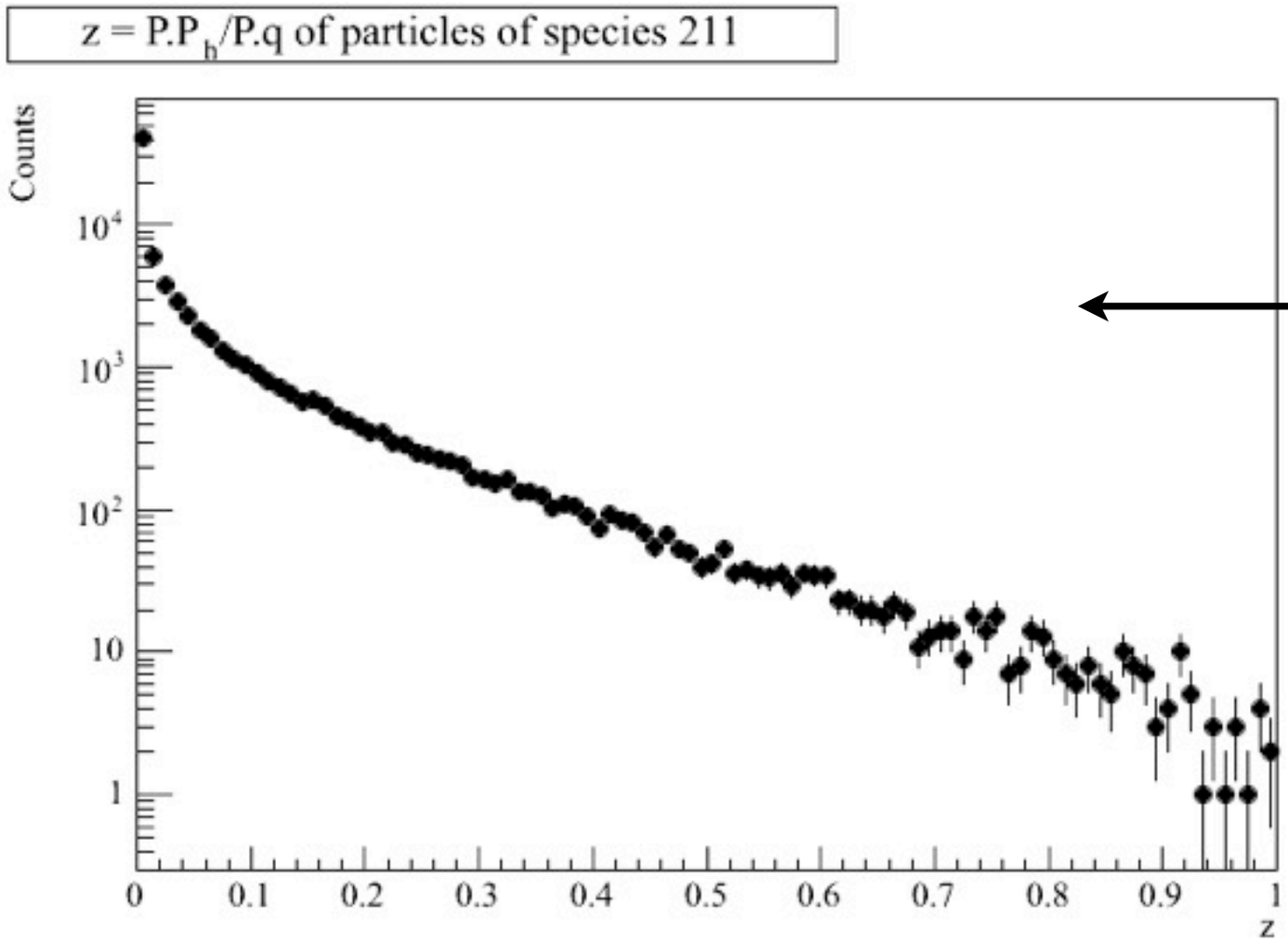
- 4 x 50 GeV

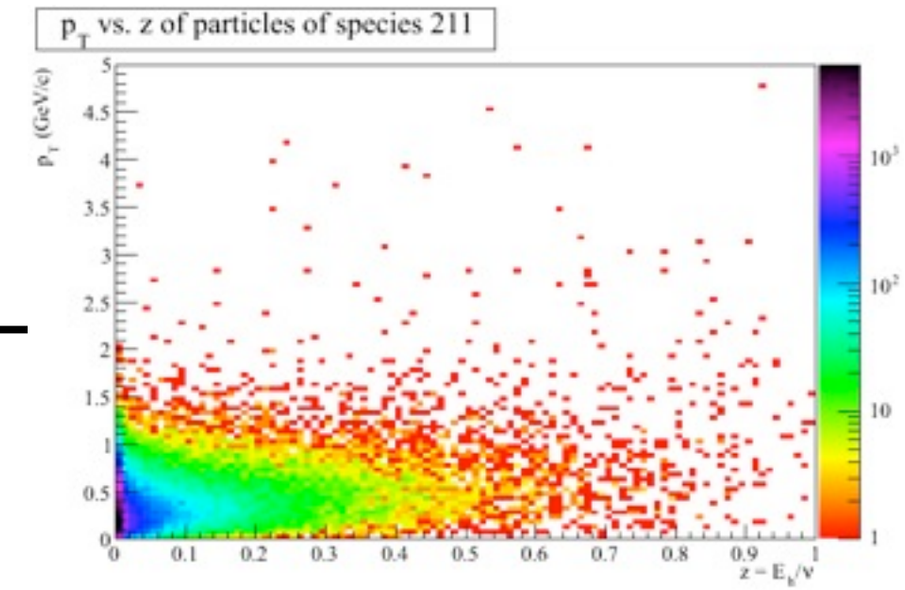

z = P.P_h/P.q of particles of species 211
Counts


p_T vs. z of particles of species 211
p_T (GeV/c)
z = E_h/ν

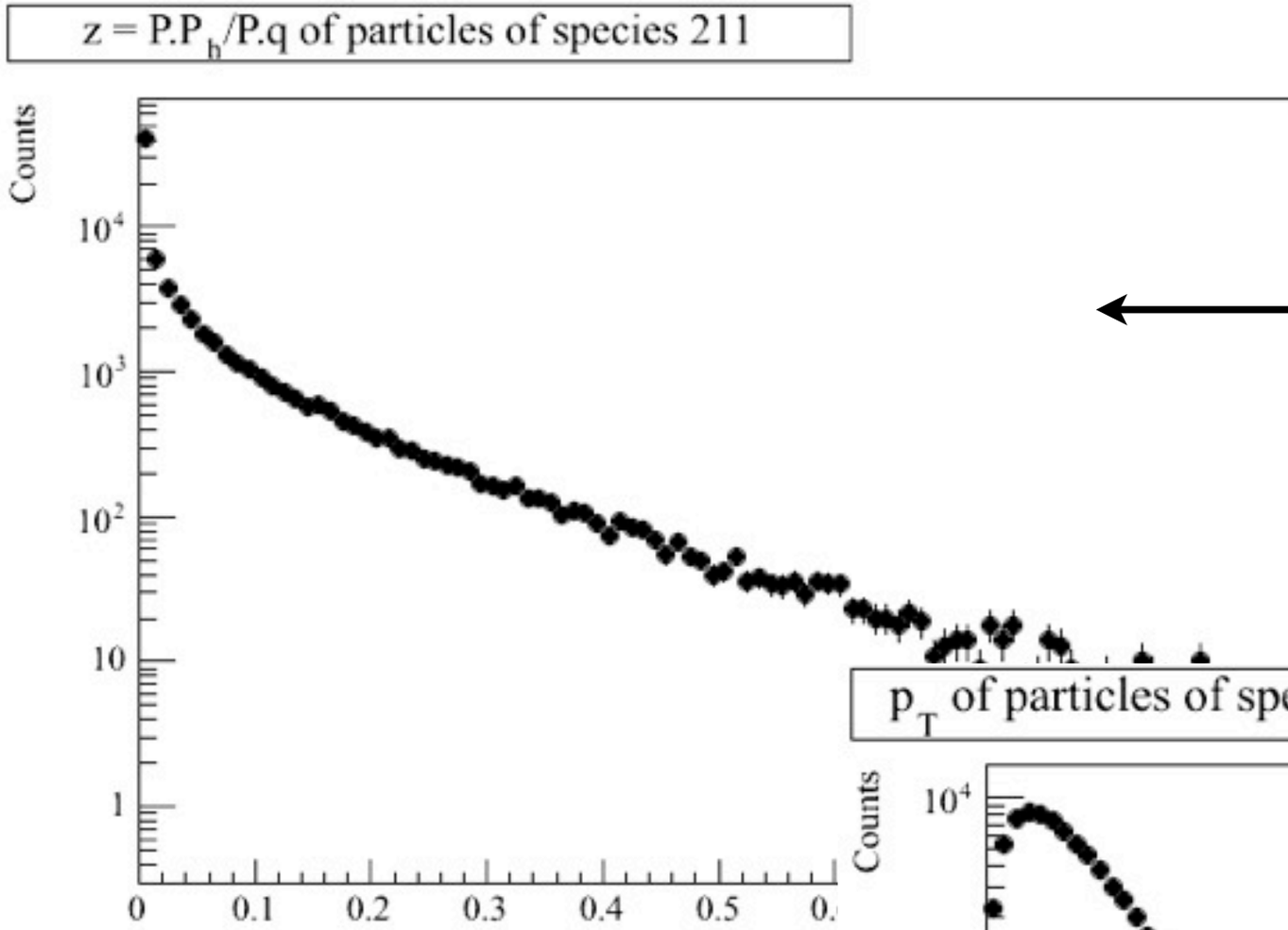

p_T of particles of species 211 w.r.t. γ
Counts
p_T (GeV/c)

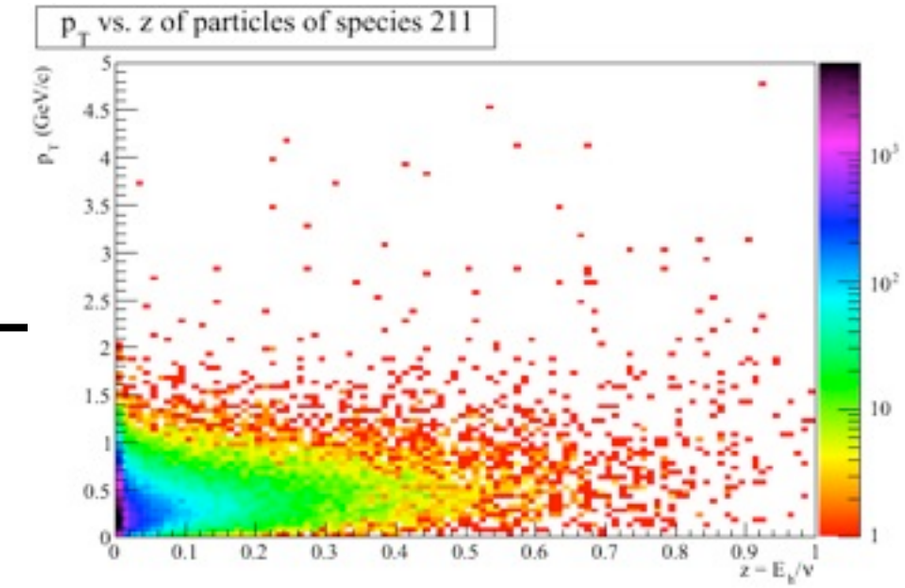
- 4 x 50 GeV

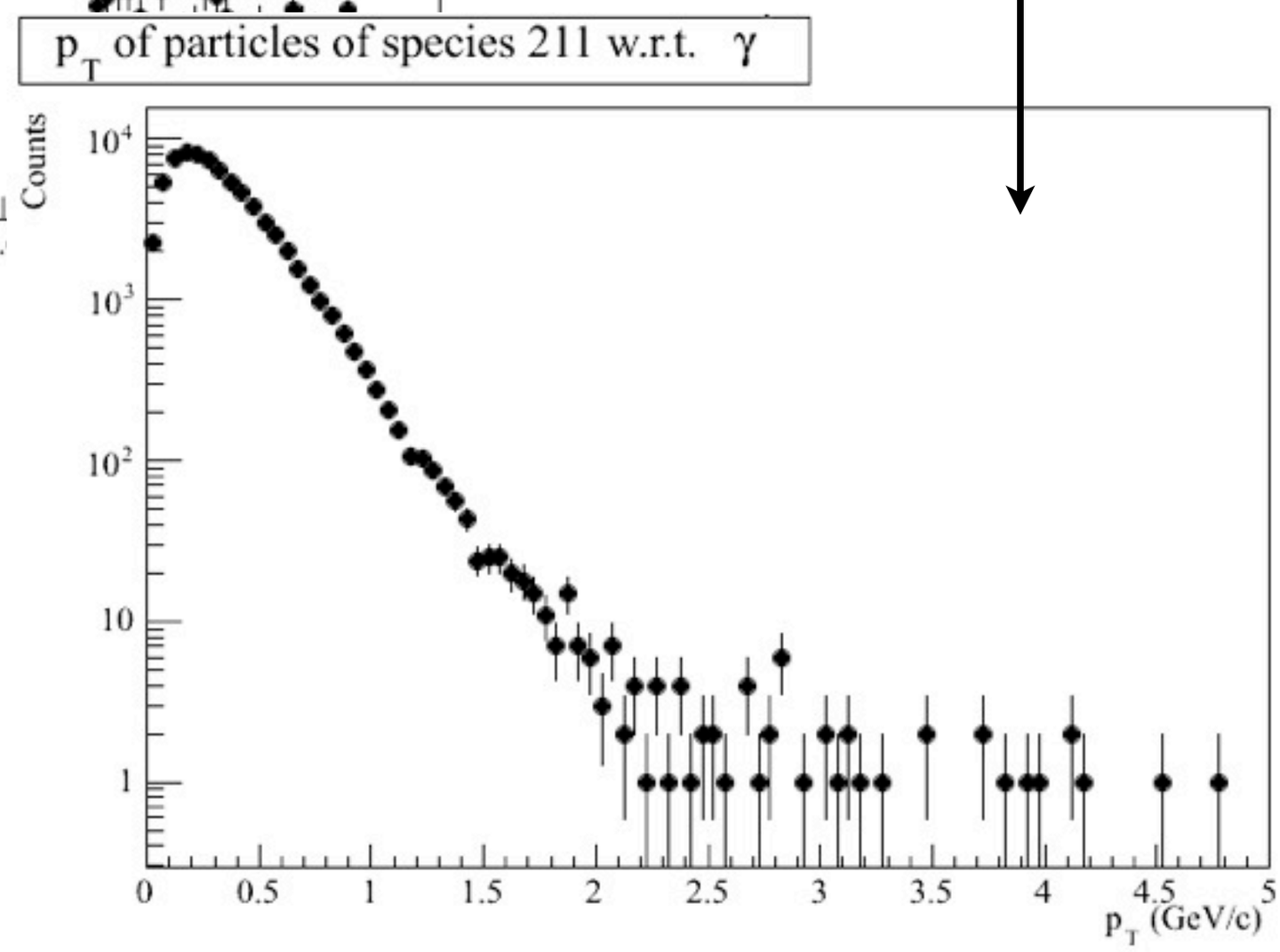

z = P.P_h/P.q of particles of species 211
Counts
z


p_T vs. z of particles of species 211
p_T (GeV/c)
z = E_h/ν

- 30 x 325 GeV


z = P.P_h/P.q of particles of species 211
Counts


p_T vs. z of particles of species 211
p_T (GeV/c)
z = E_h/ν


p_T of particles of species 211 w.r.t. γ
Counts
p_T (GeV/c)

- 30 x 325 GeV

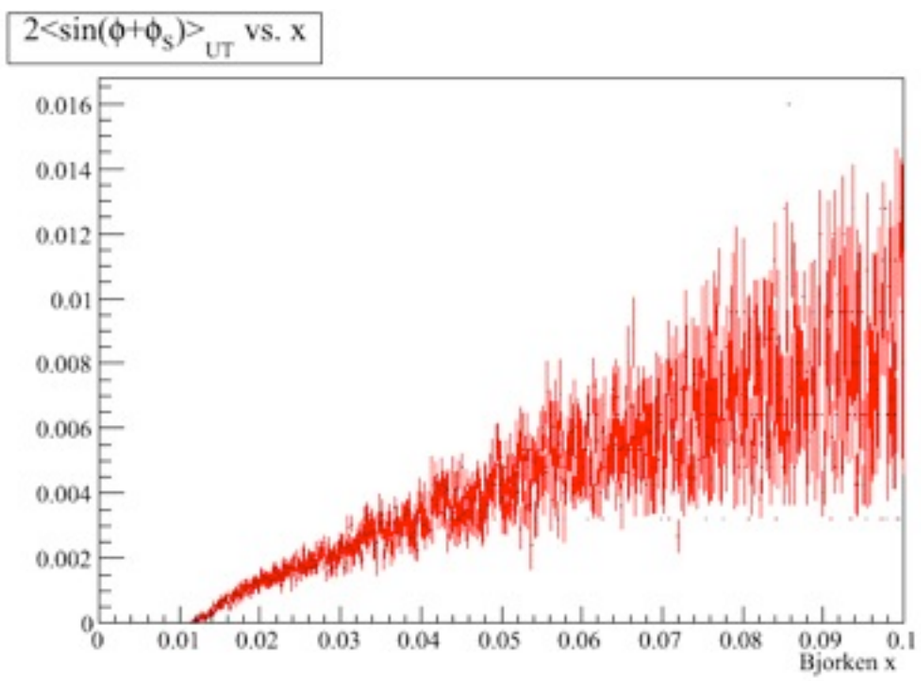
gmc_trans

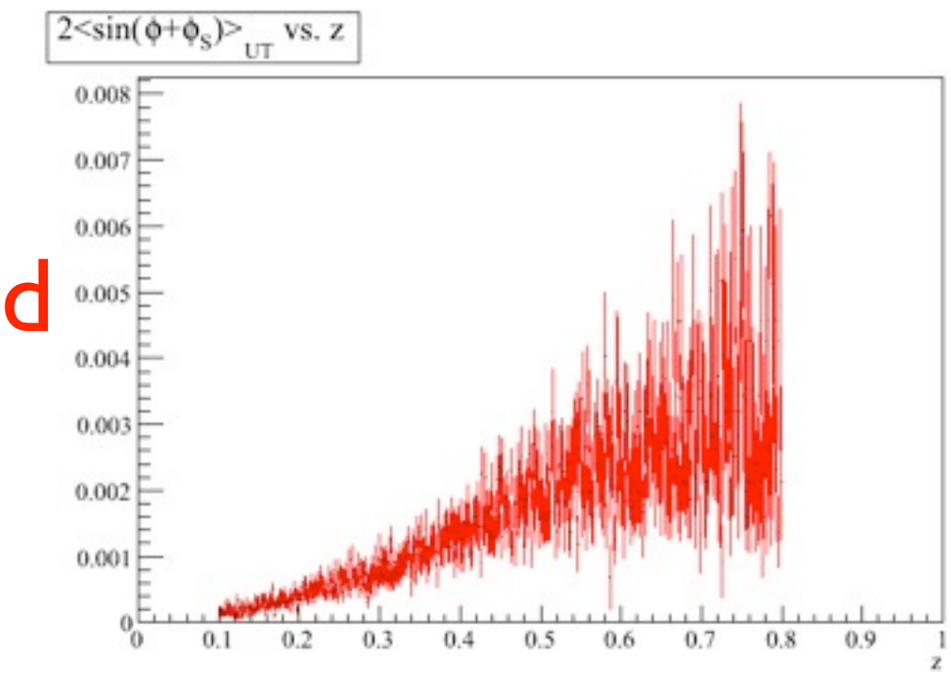
- Monte Carlo generator developed at HERMES
- Generates SIDIS events:
  - $\pi^{+,-,0,}$ $K^{+,-}$ production
- Various distribution parameterisations:
  - Transversity, Sivers, Collins, Boer-Mulders
- Originally fixed target
  - Modified for collider kinematics

gmc_trans

- Test setup:
  - $0.1 < z < 0.8$
  - $W^2 > 10\ \mathrm{GeV}^2$
  - $1 < Q^2 < 1000\ \mathrm{GeV}^2$
  - $0.0001 < x < 0.1$
  - DSS fragmentation functions
  - Anselmino et al. Collins and transversity

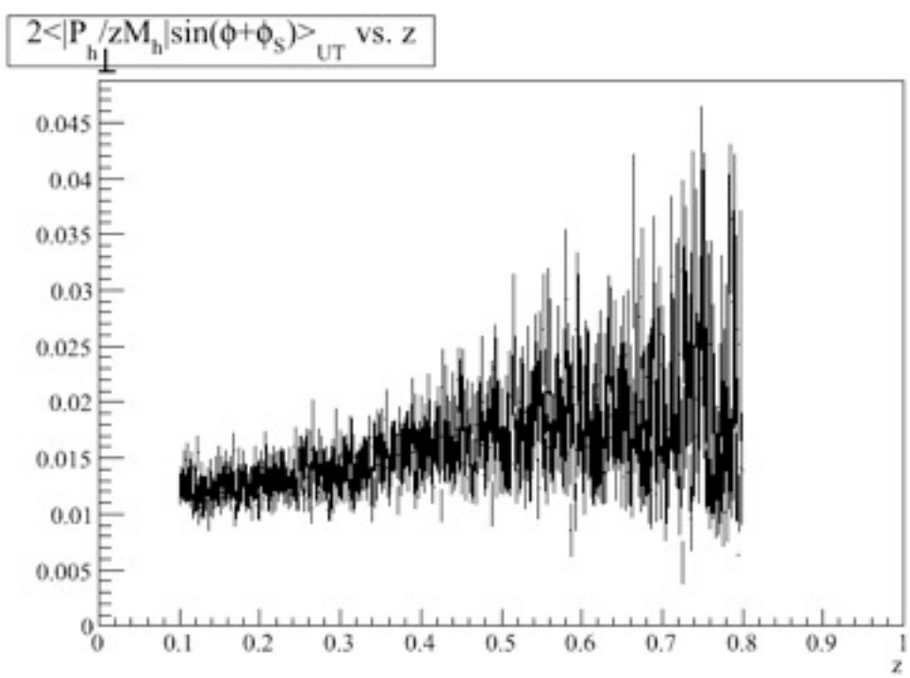
gmc_trans: collins



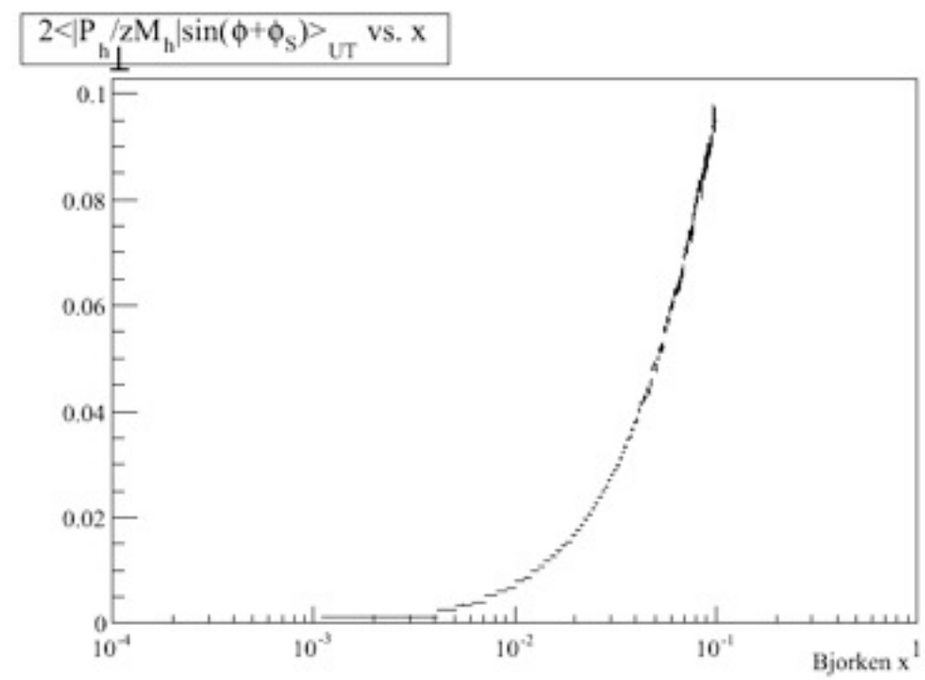


Unweighted

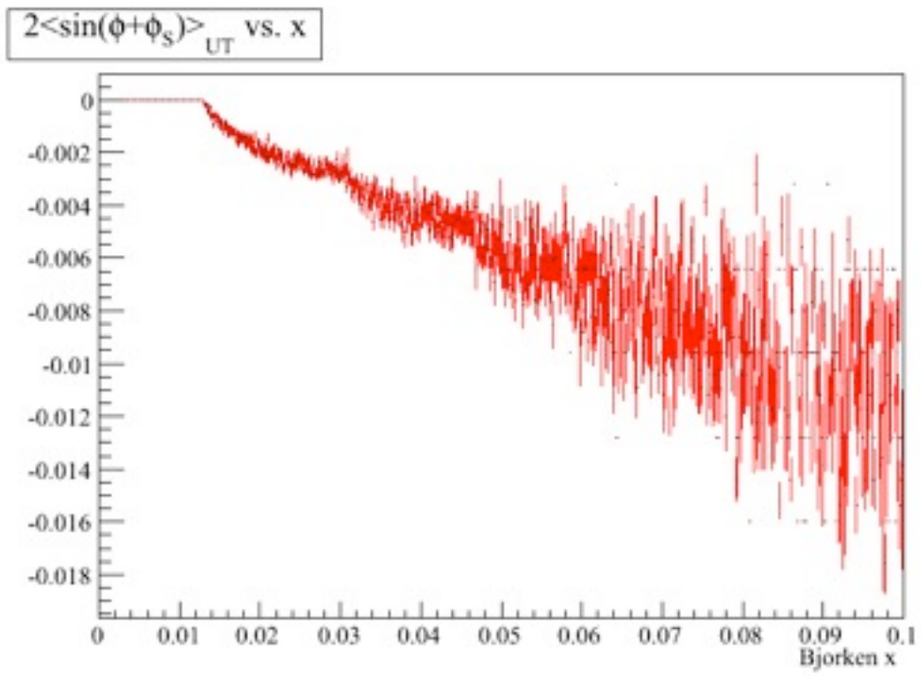
4 x 50
π^+

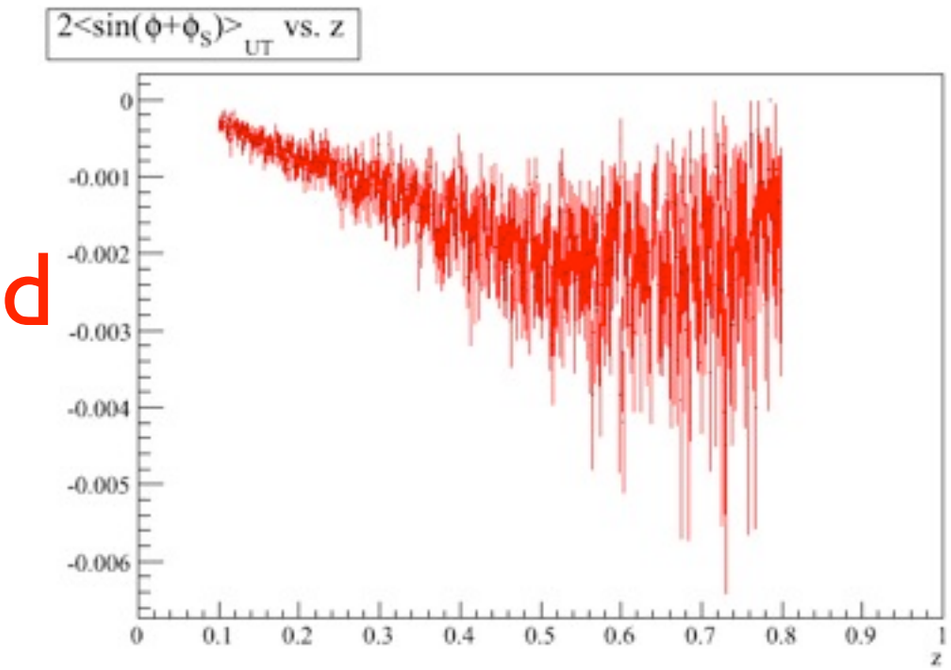


Weighted



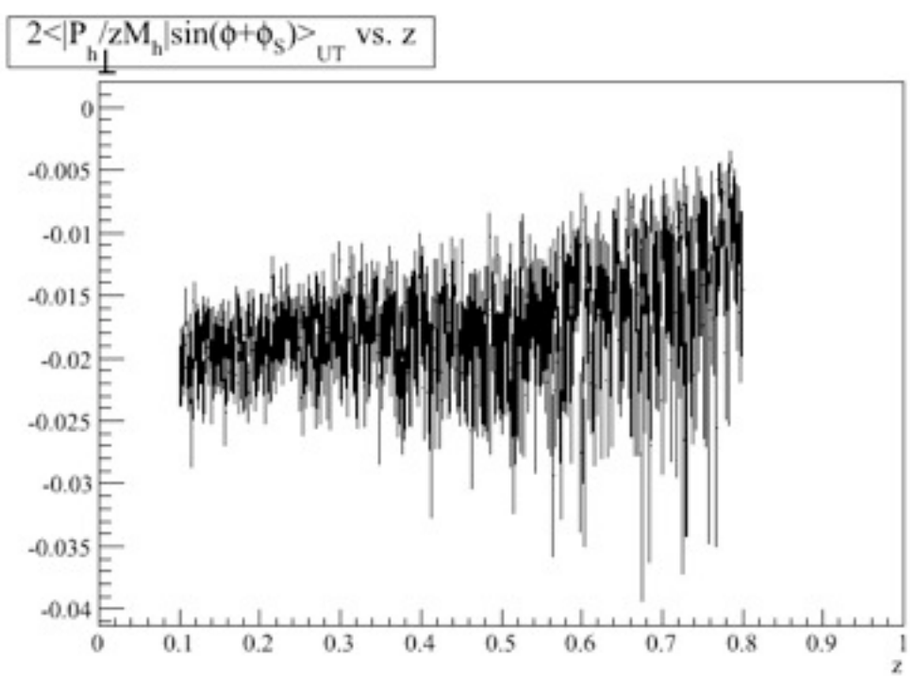
gmc_trans: collins



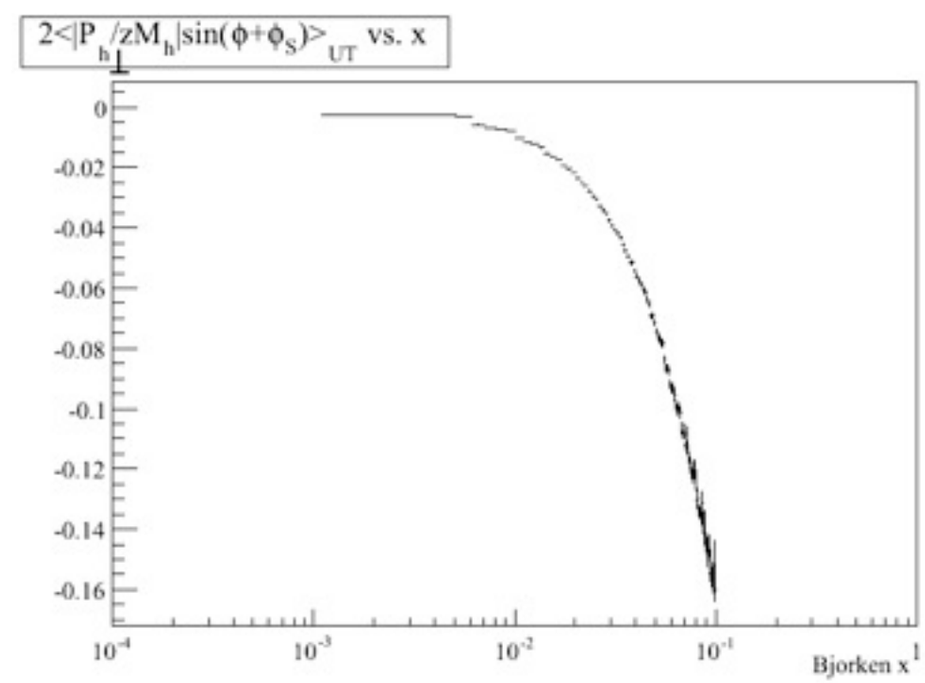


Unweighted

4 x 50
π^-

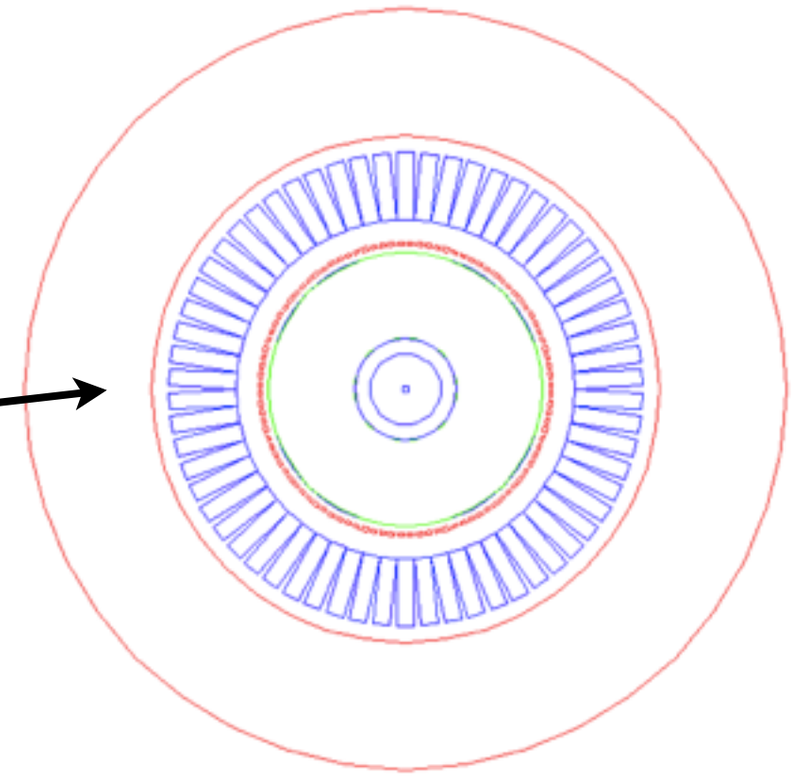


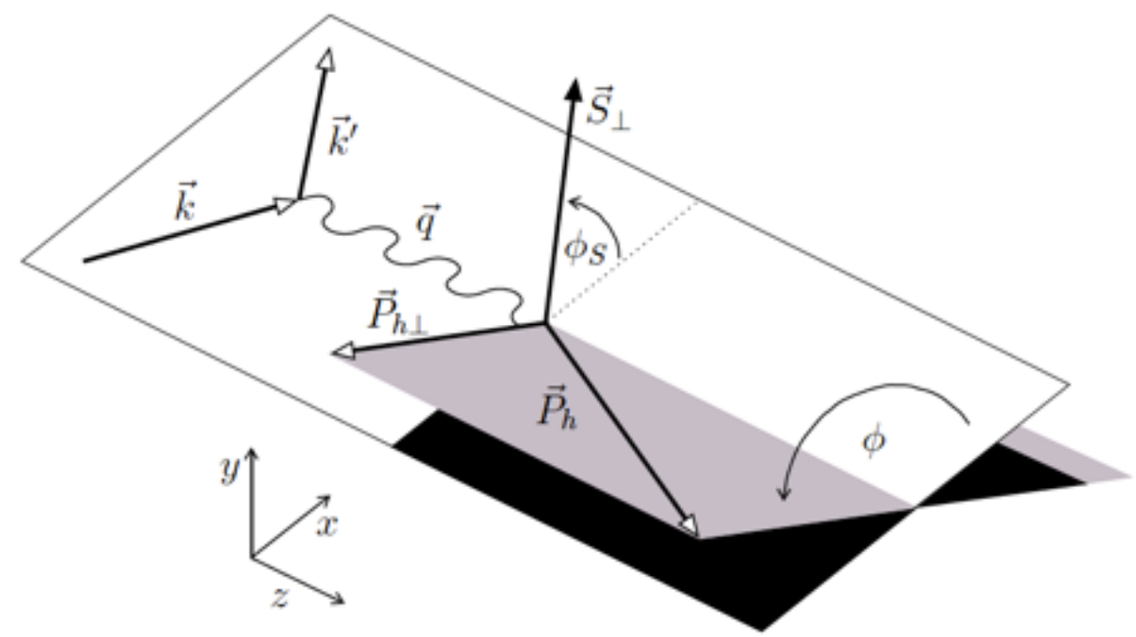
Weighted



Acceptance

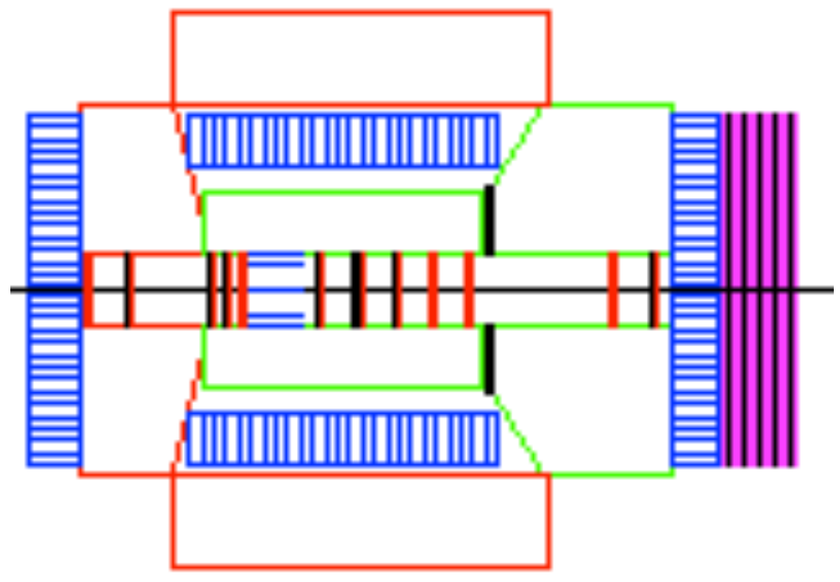
- Detector design is
  - uniform in ϕ
  - as close to hermetic as possible
- What is the acceptance around γ^*?



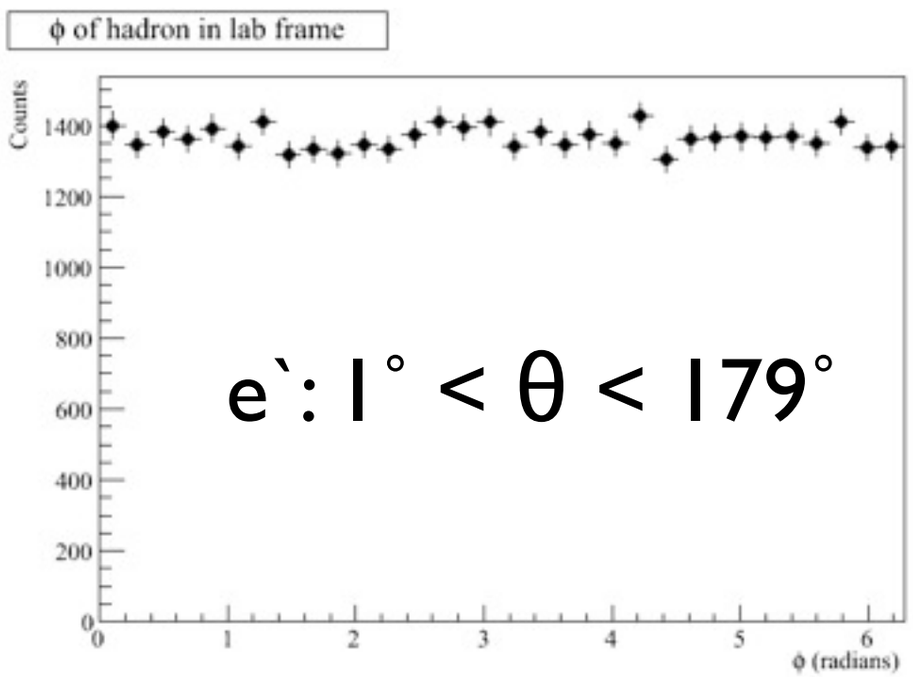


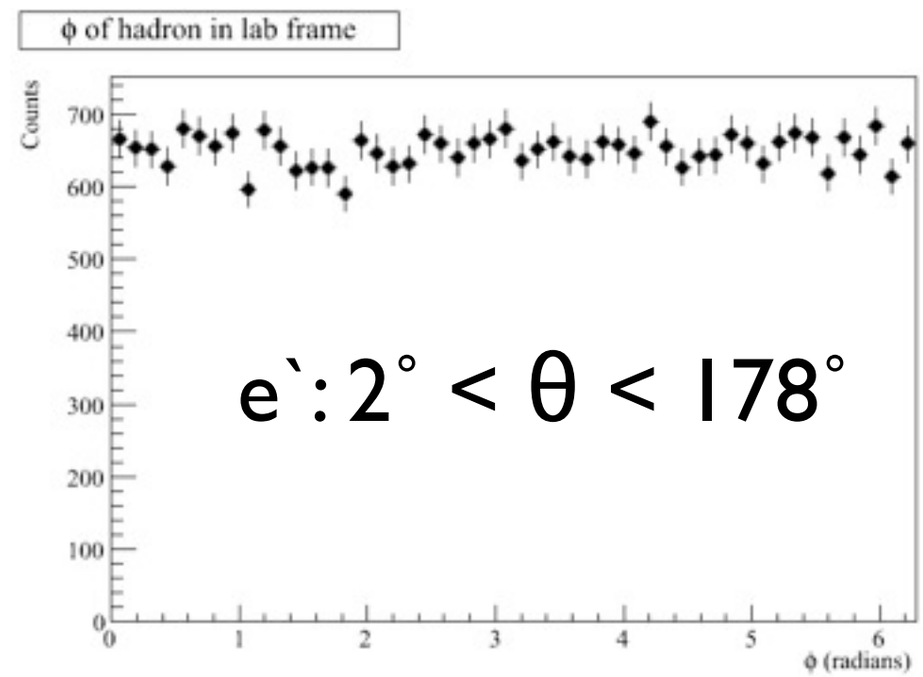
Acceptance

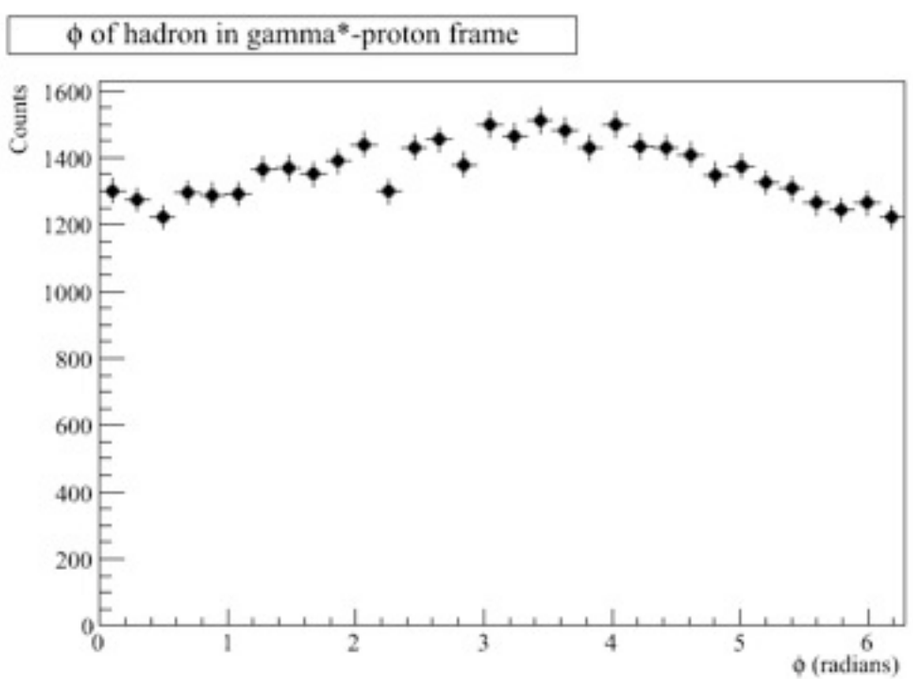
- Approximation of detector acceptance:
  - hadron: $p_T > 100$ MeV
  - hadron: $5 < \theta < 130^\circ$
  - e`: $1(2)^\circ < \theta < 179(178)^\circ$

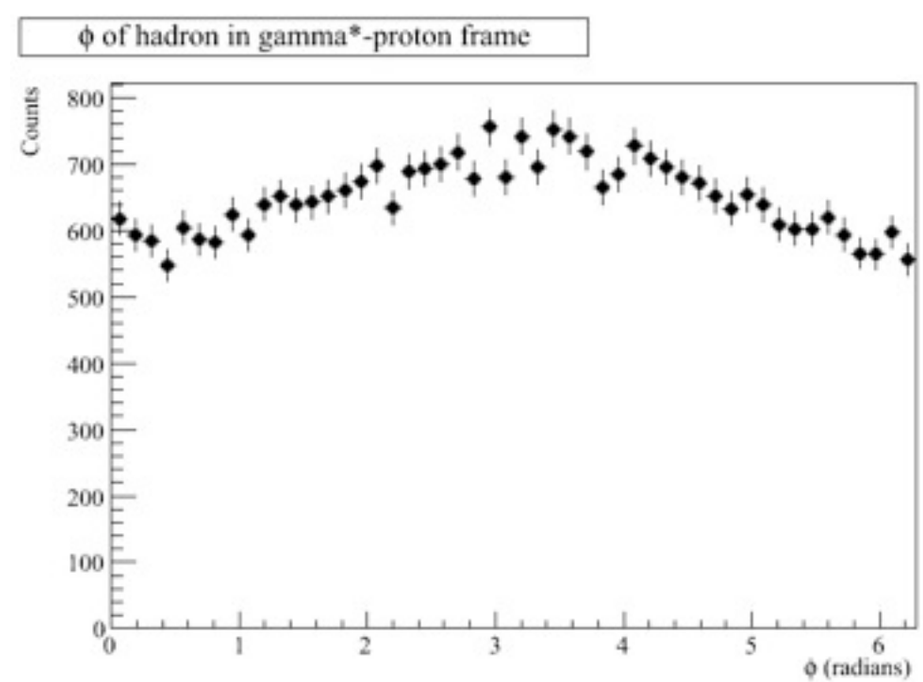


4 x 50 GeV

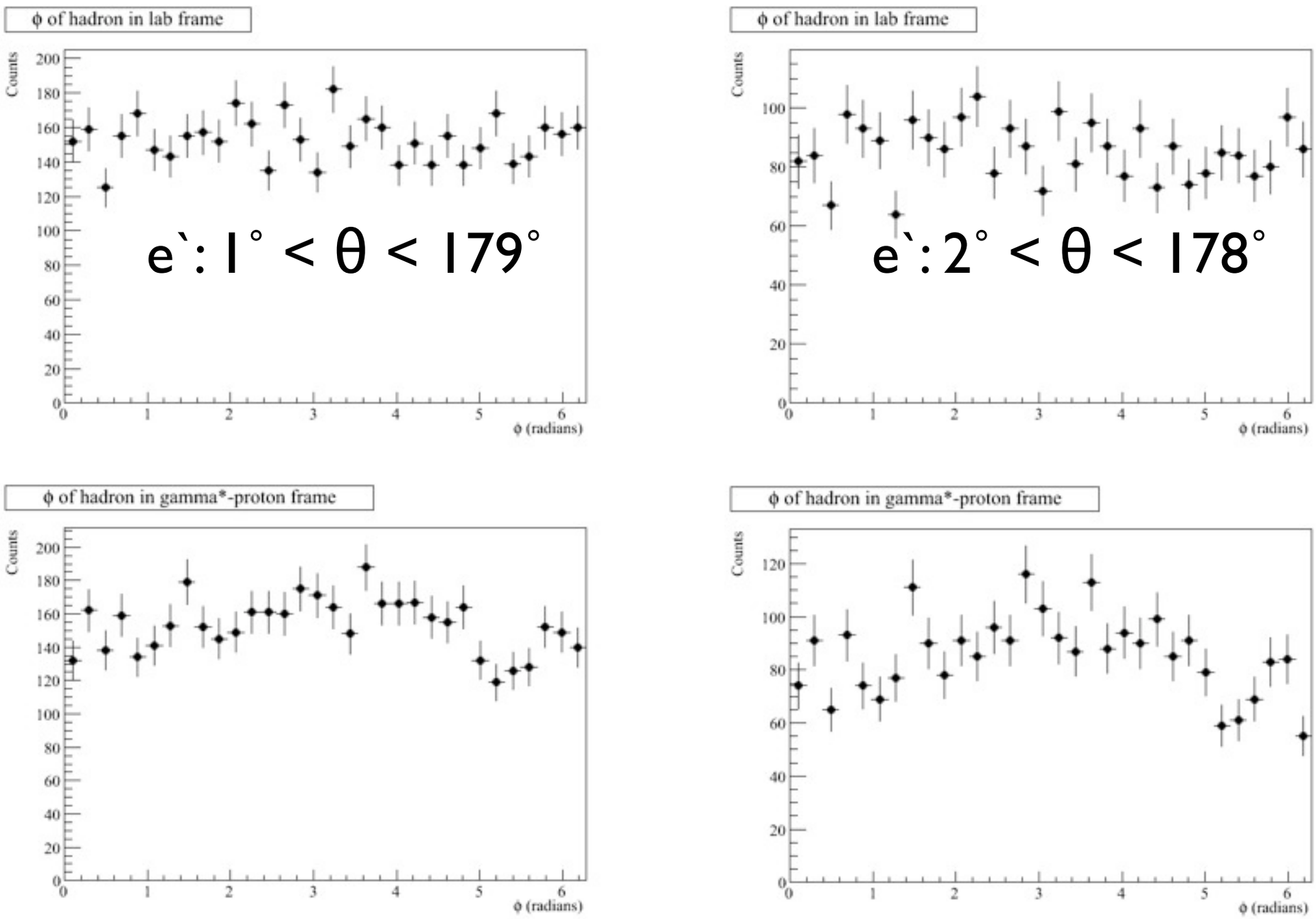

ϕ of hadron in lab frame
Counts
ϕ (radians)
e`: 1° < θ < 179°


ϕ of hadron in lab frame
Counts
ϕ (radians)
e`: 2° < θ < 178°


ϕ of hadron in gamma*-proton frame
Counts
ϕ (radians)


ϕ of hadron in gamma*-proton frame
Counts
ϕ (radians)

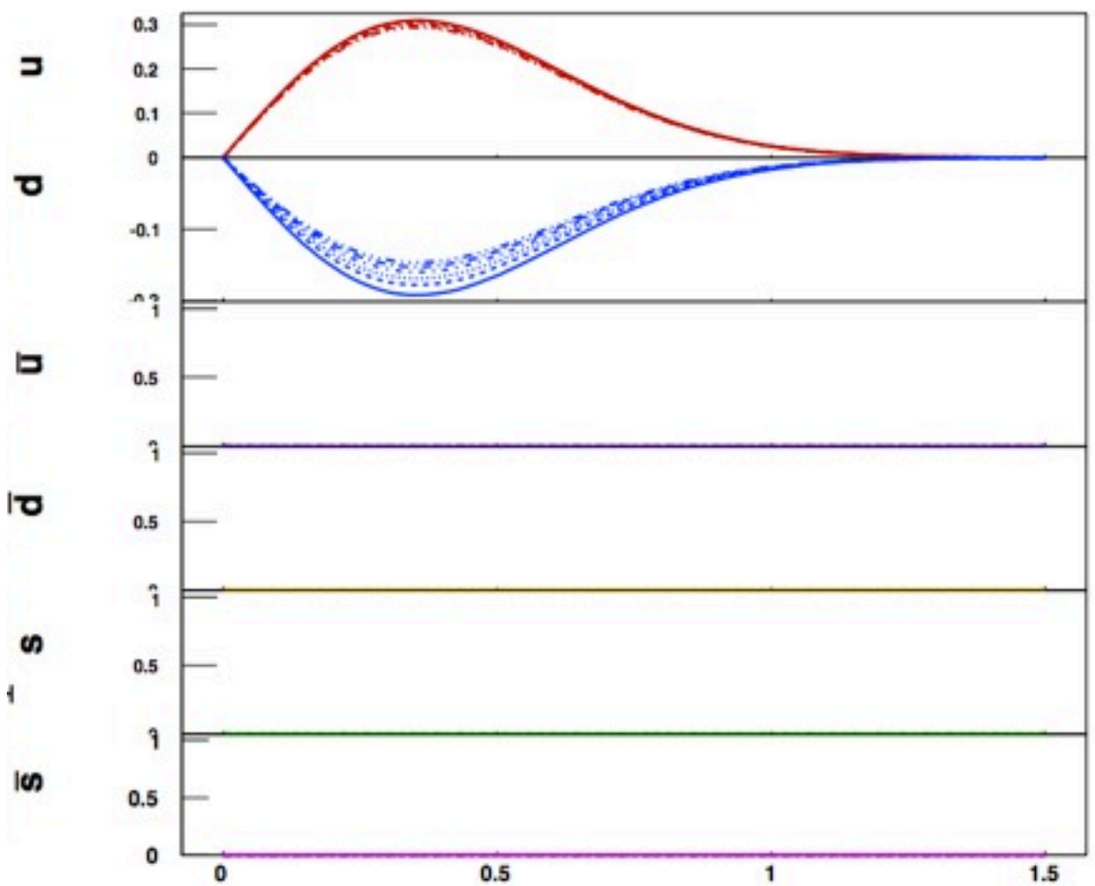
20 x 250 GeV


ϕ of hadron in lab frame
Counts
ϕ (radians)
e`: 1° < θ < 179°
ϕ of hadron in lab frame
Counts
ϕ (radians)
e`: 2° < θ < 178°
ϕ of hadron in gamma*-proton frame
Counts
ϕ (radians)
ϕ of hadron in gamma*-proton frame
Counts
ϕ (radians)

Parameterisations

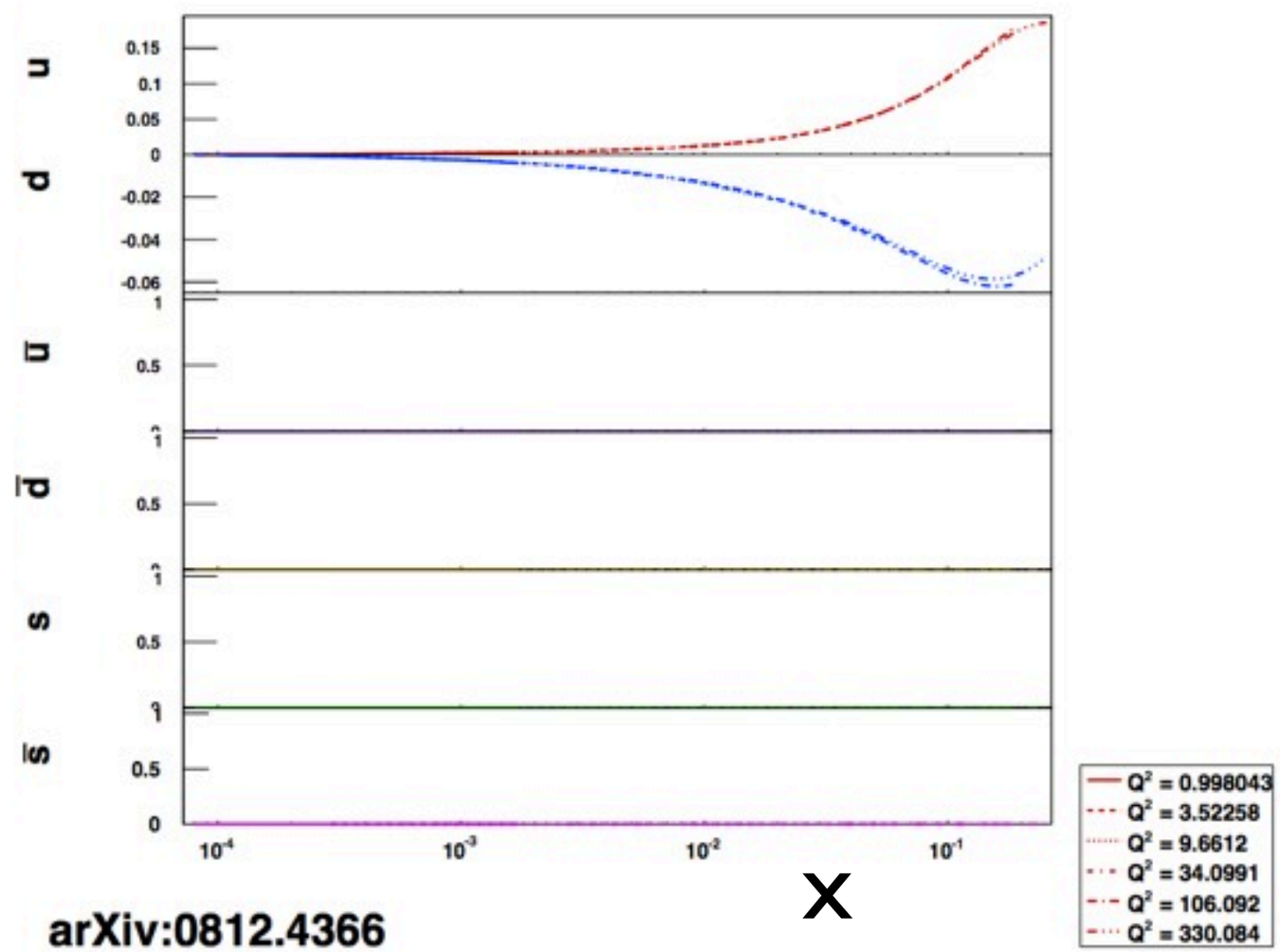
- Code from Alexei Prokudin
- Torino group parameterisations:
  - Sivers, Collins and Transversity
- Plotted as functions of x(z) and k_T
- Use Q^2/x ranges from PYTHIA for eRHIC kinematics
- guide expectations for sizes of effects visible at eRHIC

Transversity



arXiv:0812.4366

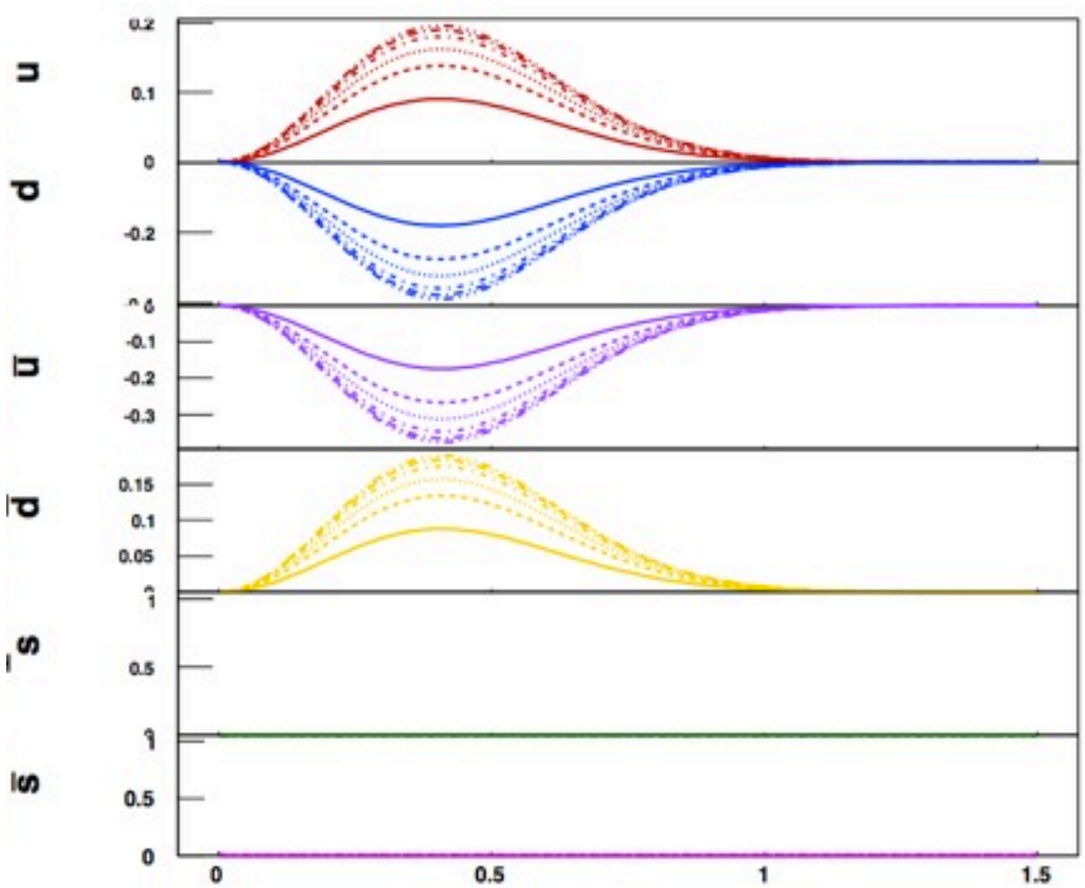
k_T



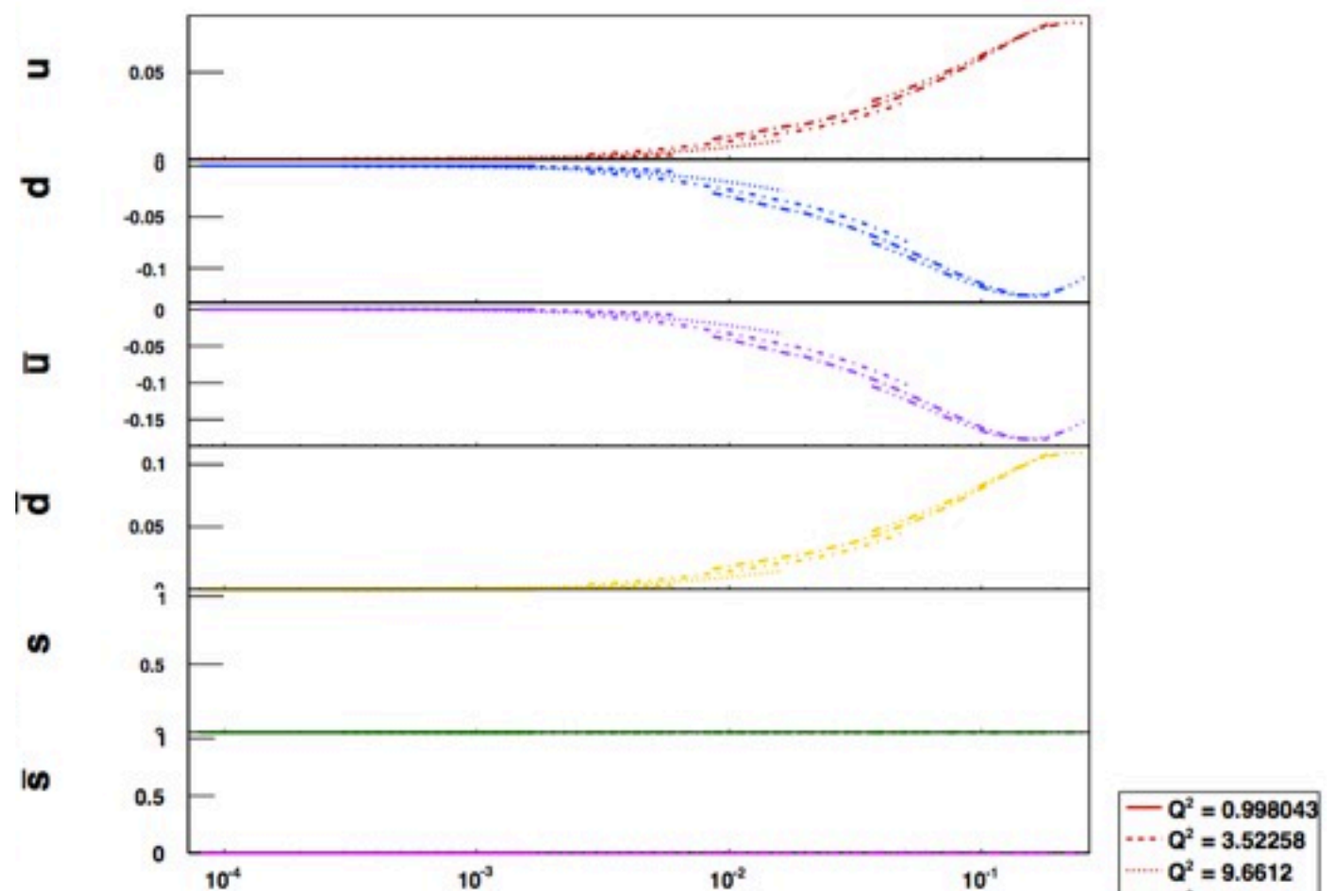
arXiv:0812.4366

x

Collins

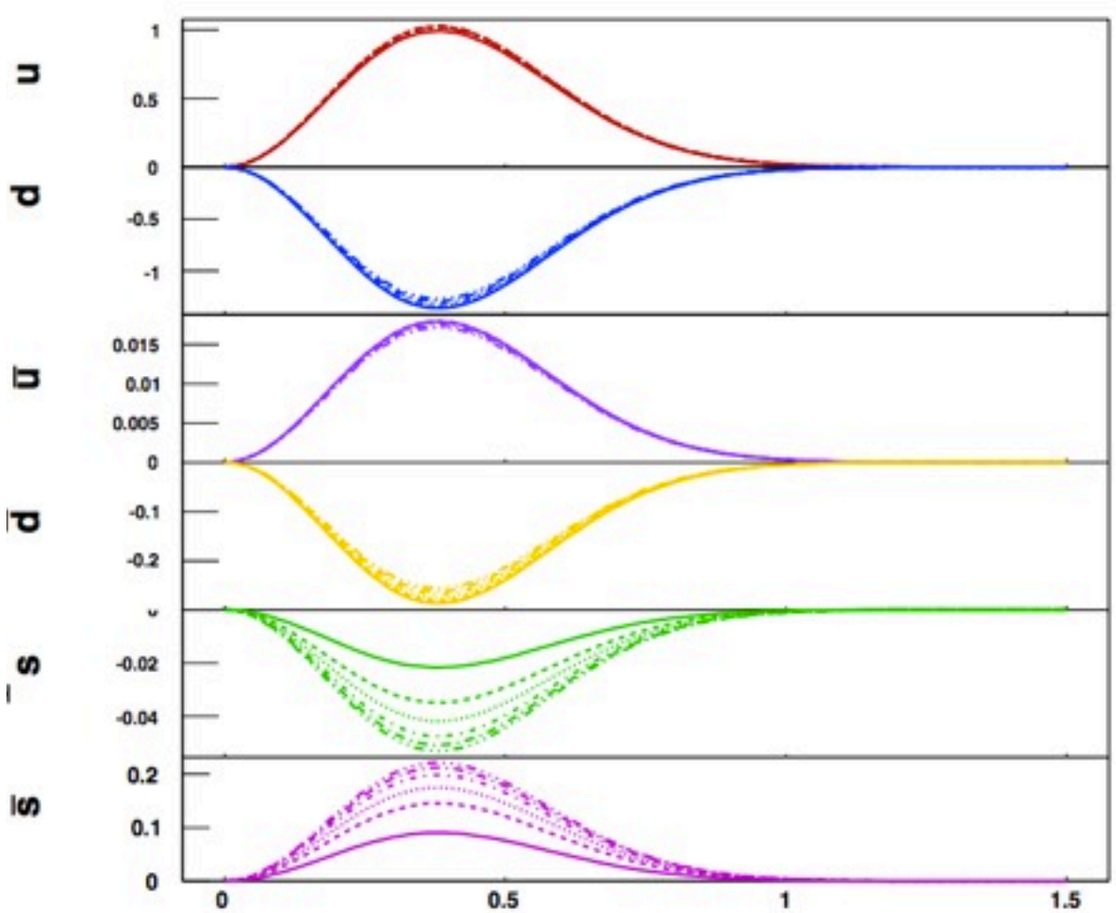


arXiv:0812.4366 quark --> π^+ k_T



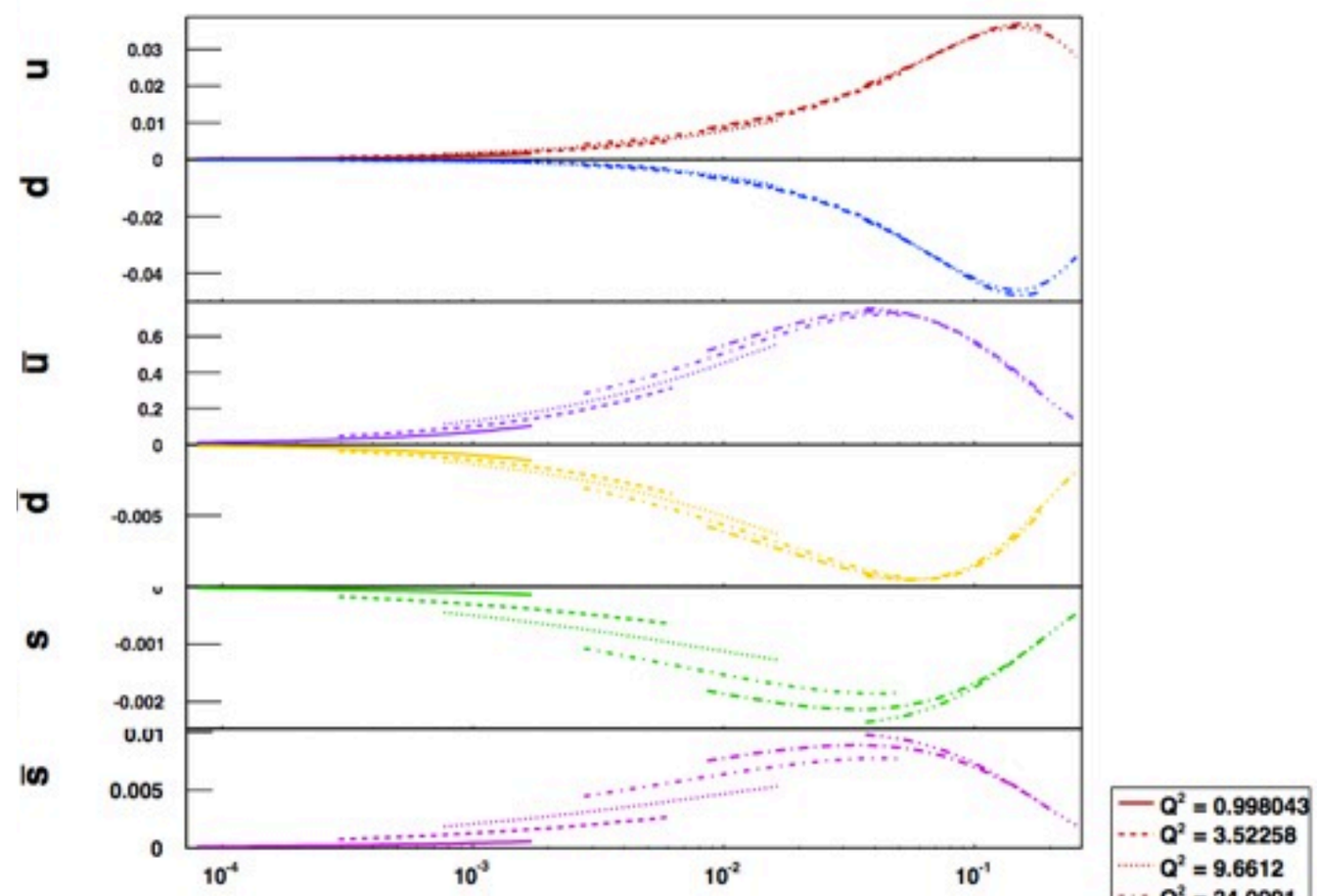
arXiv:0812.4366 quark --> π^+ z

Sivers



Eur.Phys.J.A39:89-100,2009

k_T

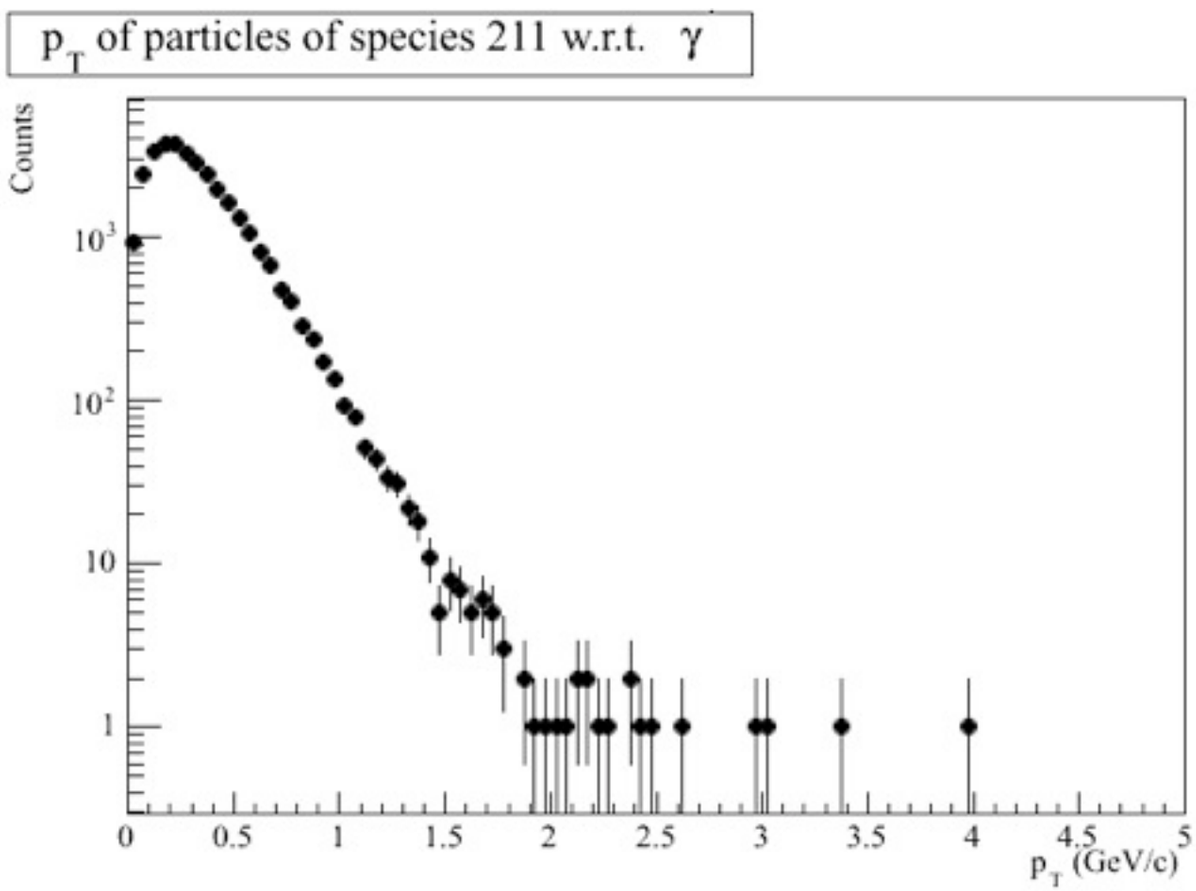


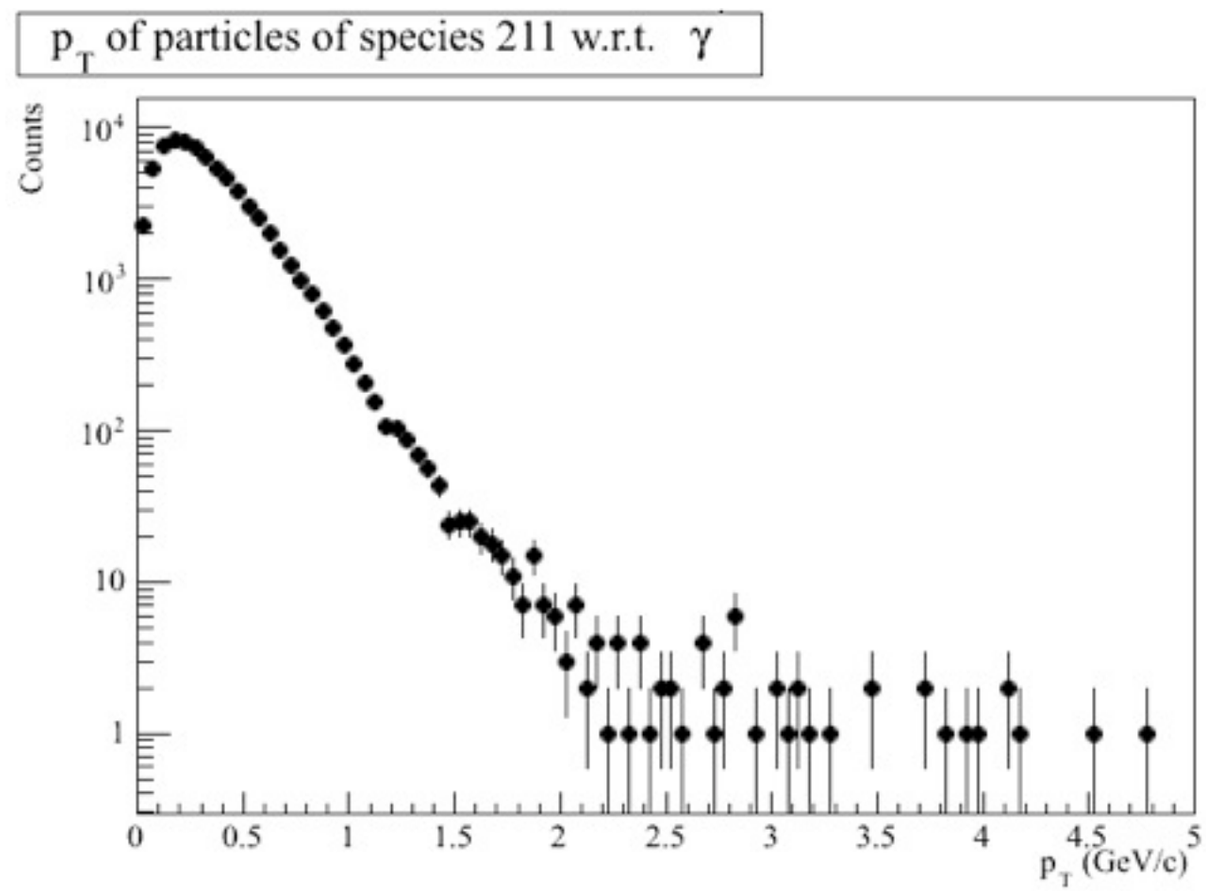
Eur.Phys.J.A39:89-100,2009

x

Summary

- Undertaking kinematics studies
- Implementing monte carlo for eRHIC
- Detector acceptance/resolution
- Aim to present further results at INT


p_T of particles of species 211 w.r.t. γ
Counts
10^3
10^2
10
1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
p_T (GeV/c)


p_T of particles of species 211 w.r.t. γ
Counts
10^4
10^3
10^2
10
1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
p_T (GeV/c)

Parameterisations

- Intend to investigate e.g. size of asymmetries allowed by e.g. maximal sea sivers vs. zero sivers - what error bars needed to distinguish?
- Want plots in time for INT.