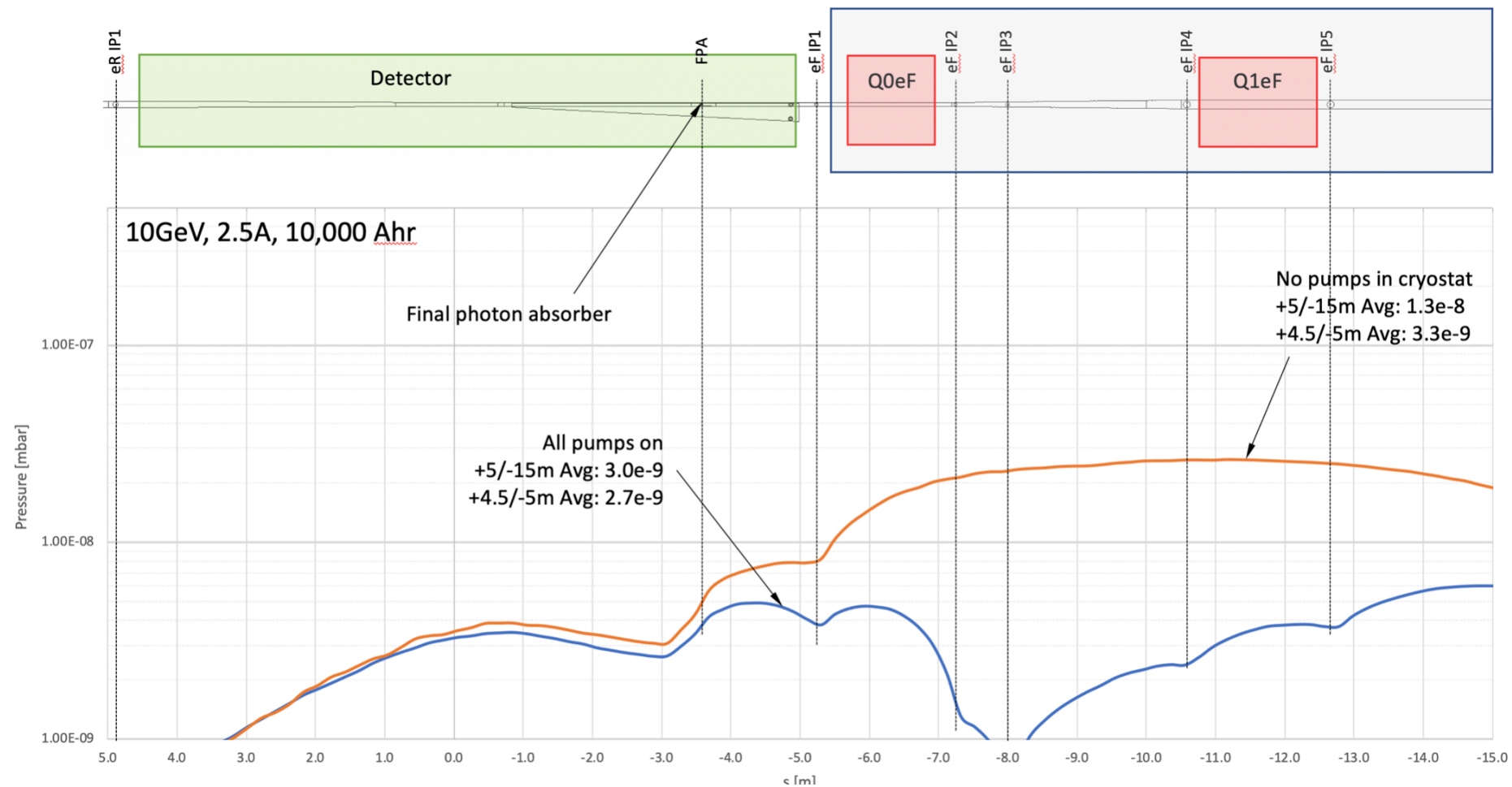

Proton beam gas background

Zhengqiao Zhang
BNL

Introduction

- We use Charles Hetzel's vacuum simulation after 10000Ahr (All pumps on);
- We use the Pythia8 fixed target events including beam effects (cross angle, crab cavity, beam energy spread, angular beam divergence, bunch length) for our simulation;
- $-5.5\text{m} < s < 5\text{m}$ beam gas is considered;



Beam parameters and collision rate

Species Energy (GeV)	Proton 275	Proton 100	Proton 41
RMS Emittance h/v (nm)	18/1.6	20/2.7	44/10
β^* h/v (cm)	80/7.1	63/5.7	90/7.1
RMS $\Delta\theta$ h/v (μ rad)	150/150	220/220	220/380
RMS Bunch length (cm)	6	7	7.5
RMS Δ/p (10^{-4})	6.8	9.7	10.3

PM = dRT;

R = 0.0821 atm/mol;

P = 2.63032e-09 mbar = 2.63032e-09 * 0.000986923 atm = 2.5959e-12 atm

T = 293k;

M = 1.00794g/mol (molar mass)

Density = 1.0877e-13g/L = 6.4991e7 molecules/cm³

Background collision rate = $L_{bg} * \sigma_{pH^2}$;

Luminosity of background = (beam current) * (average gas density) * (length);

Current = (1.0C/s) * (protons/1.6e-19C) = 6.3e18 protons/s;

Length = 10.5m;

σ_{pH^2} = 39.27mb * 2 (Pythia8);

Background collision rate =

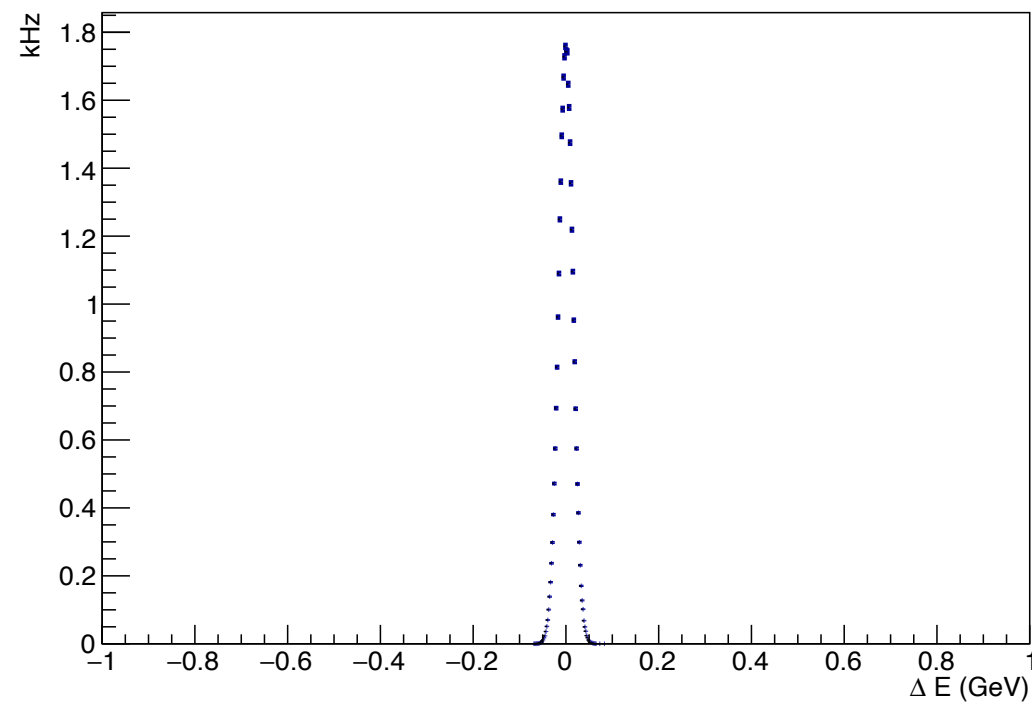
6.33e18(s-1) * 6.4991e7(cm-3) * 1050(cm) * 39.27 * (1.0e-27cm²) * 2 = **33.93kHz**; //275GeV

33.16kHz; // 100GeV

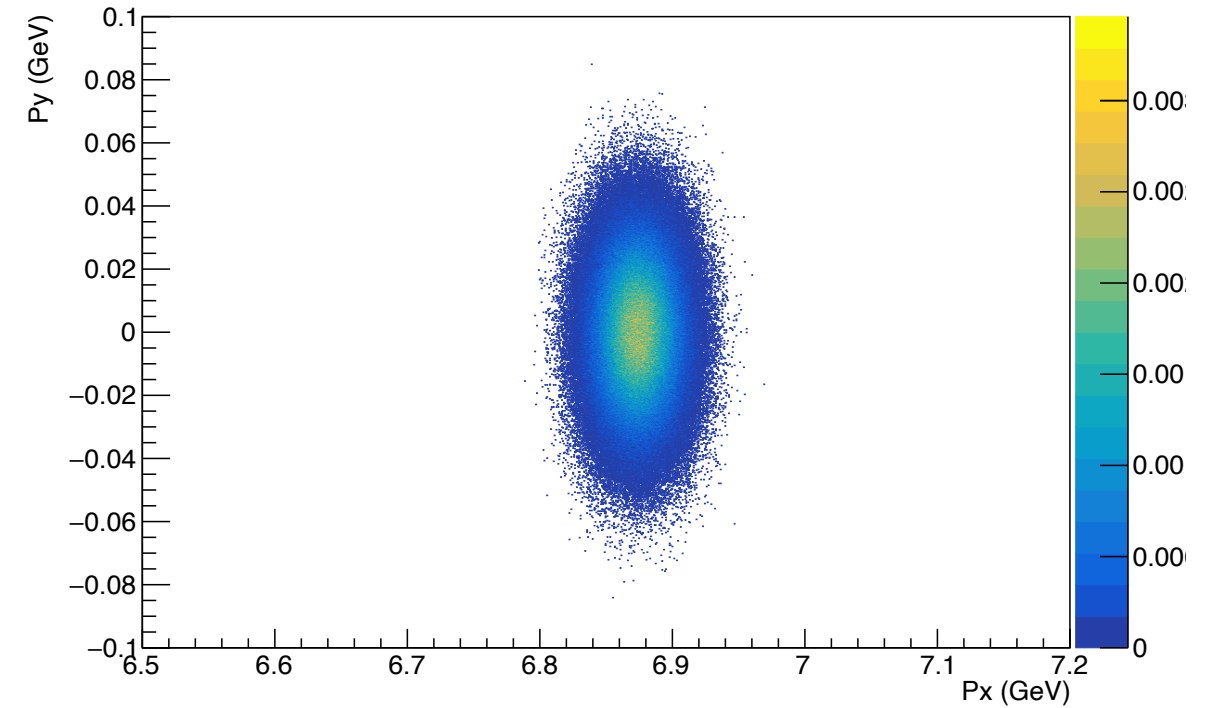
33.40kHz; // 41GeV

Events QA plots

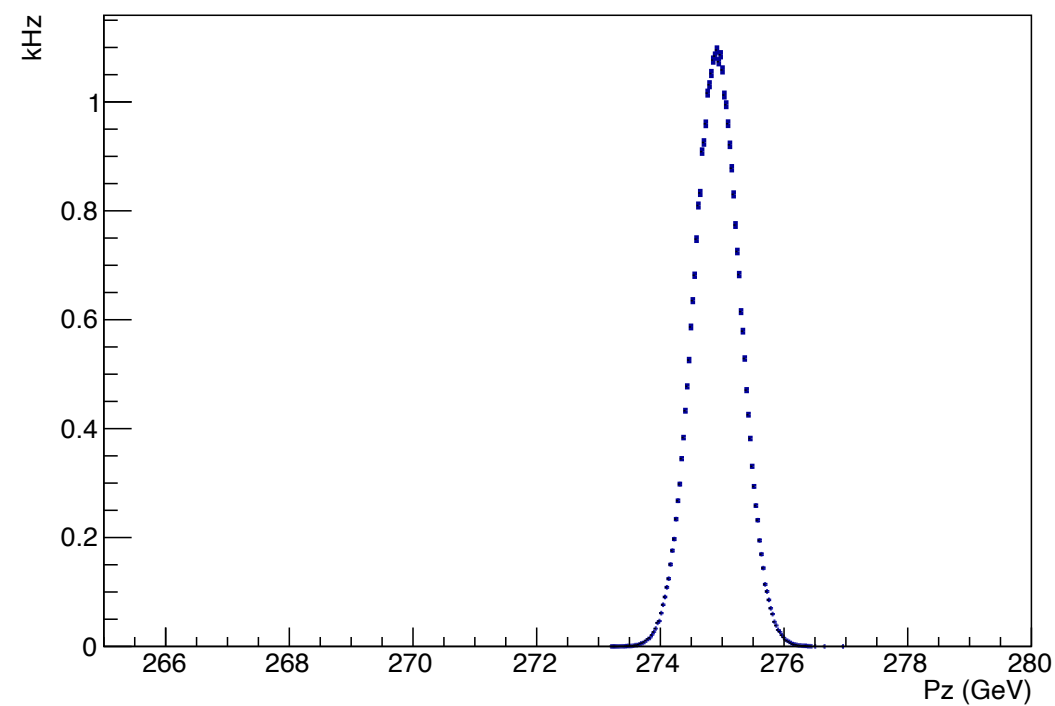
Modified - Nominal CM Energy



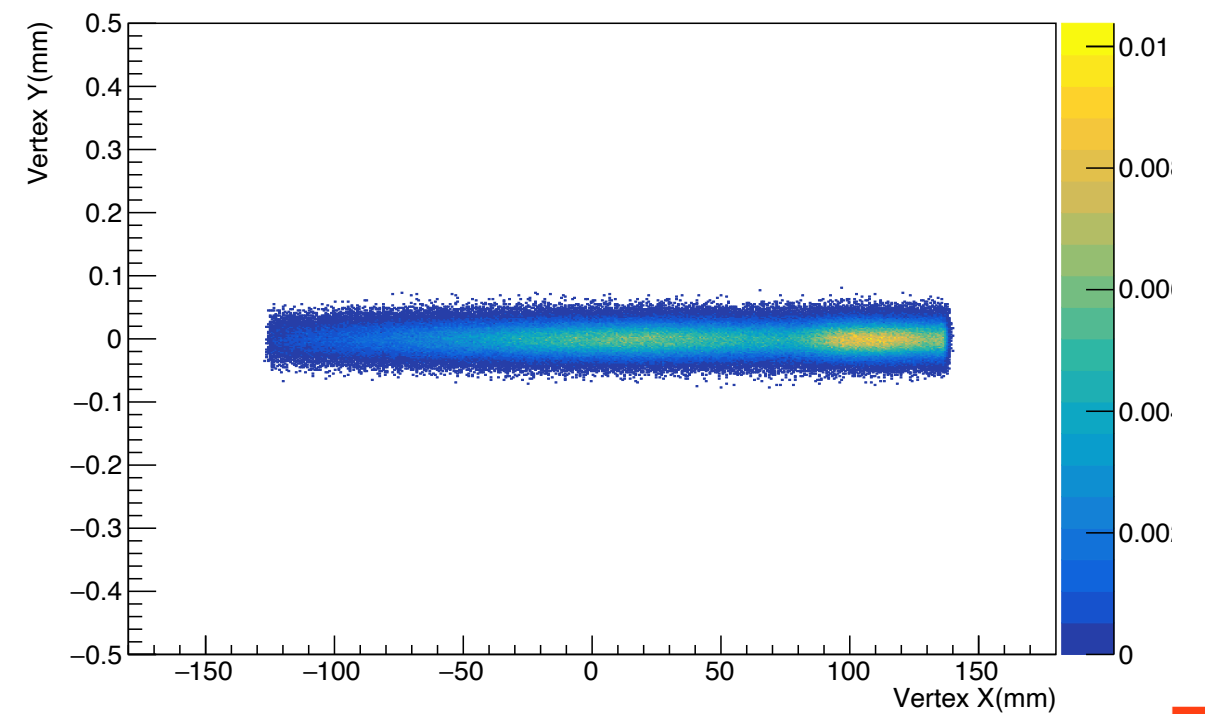
Hadron Beam Py Vs Px



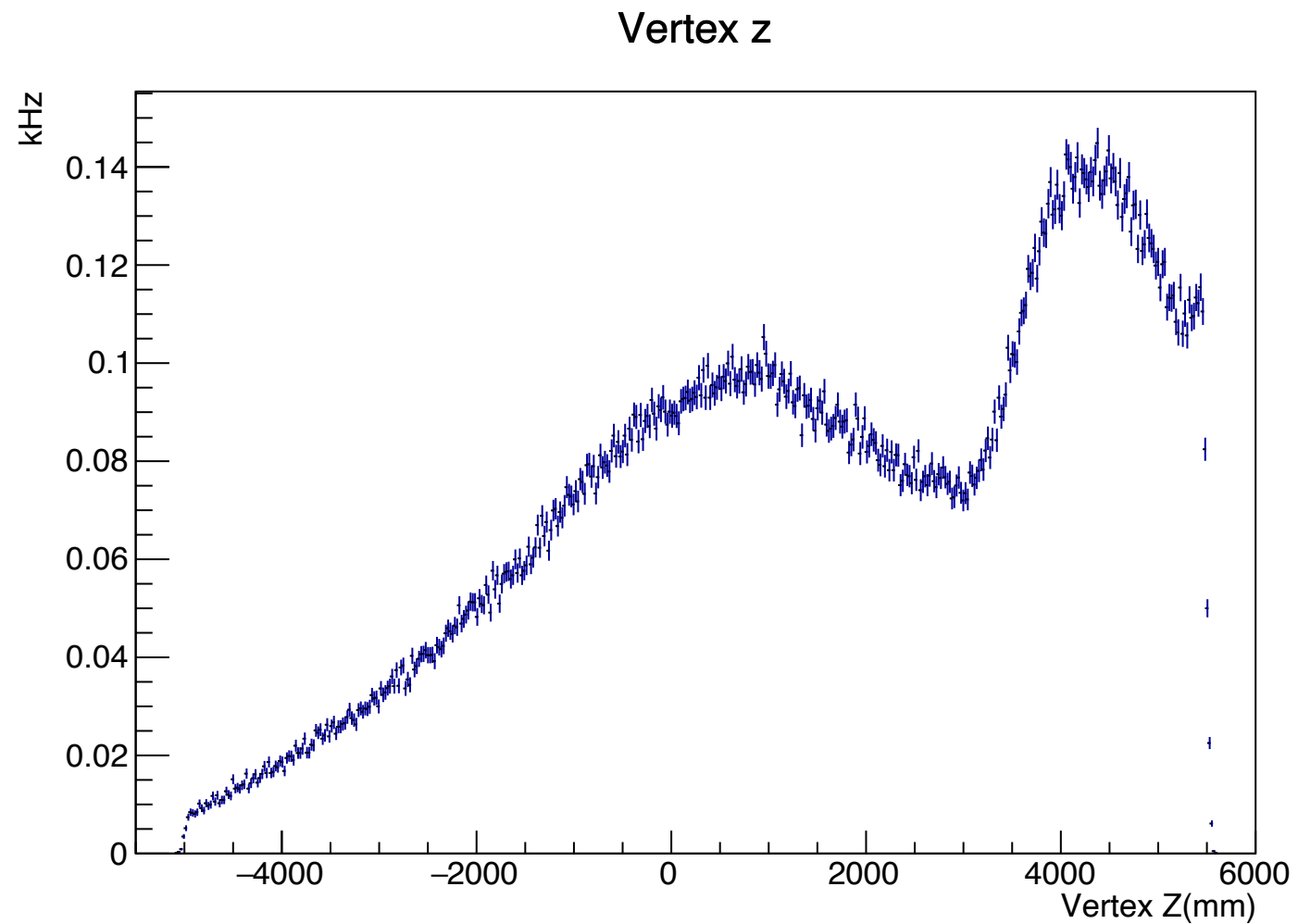
Hadron Beam Pz



Vertex Y vs X

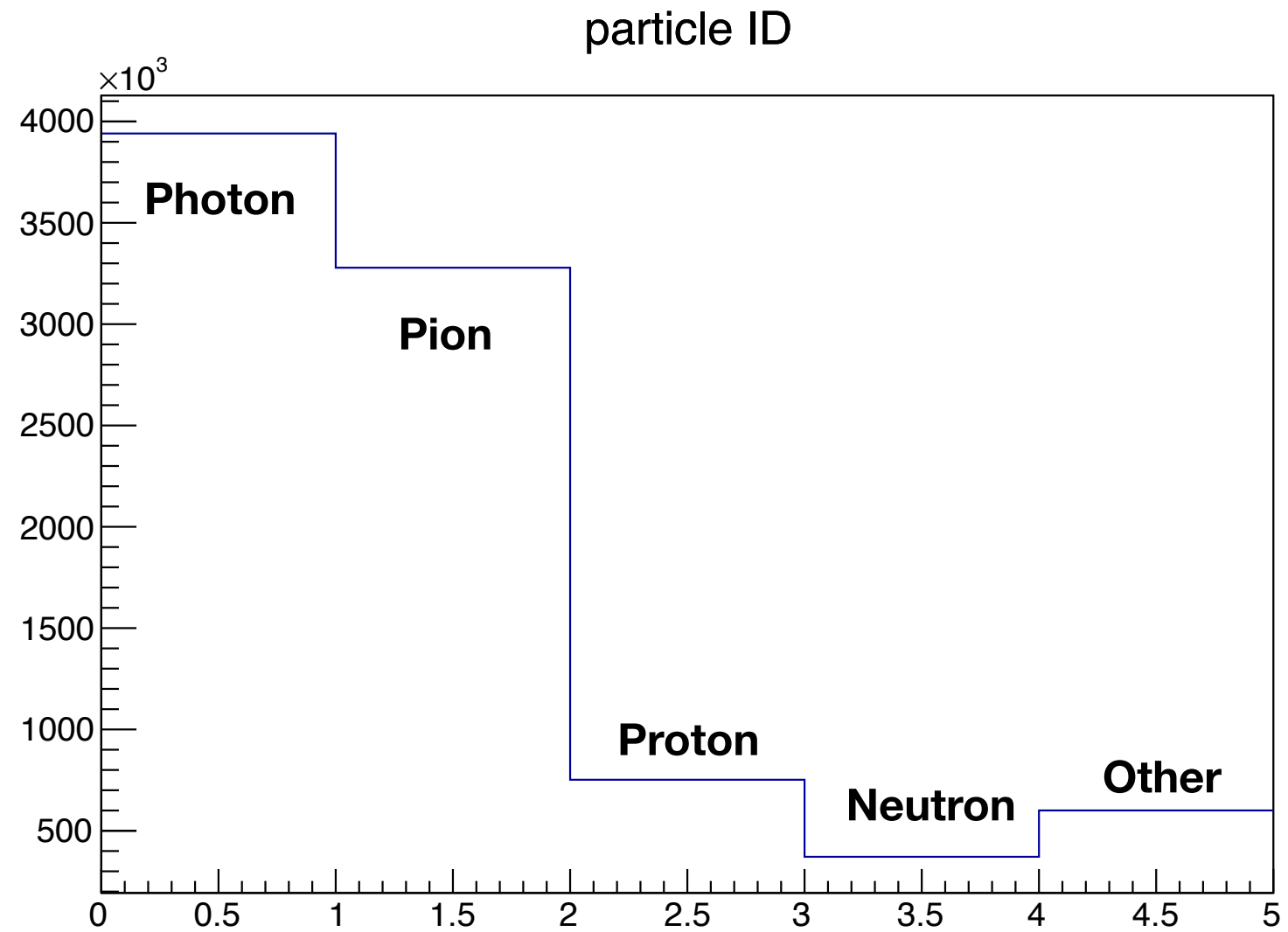


Events QA plots



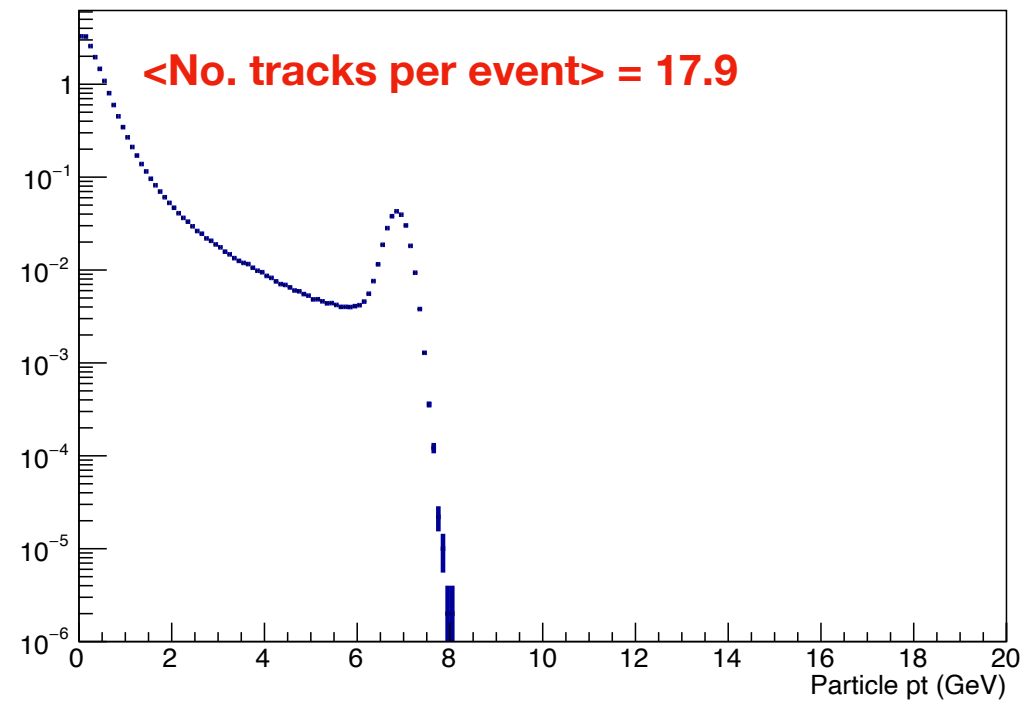
- Total collision rate = 33.93kHz in $-5.5\text{m} < s < 5\text{m}$;

Beam gas produced particle ID

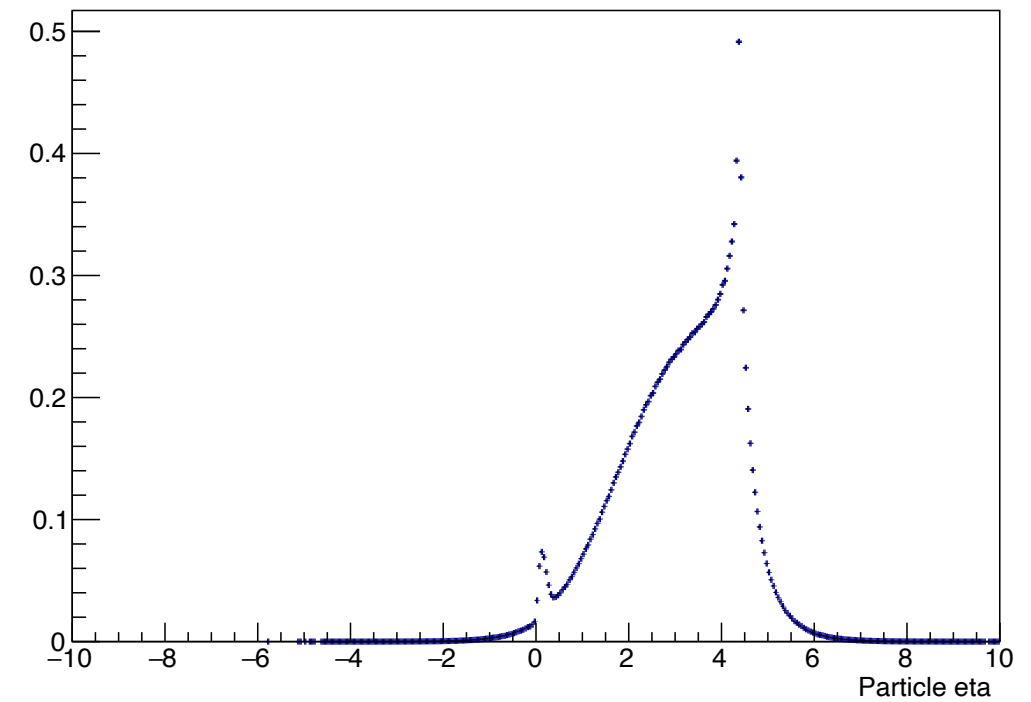


QA plots per event

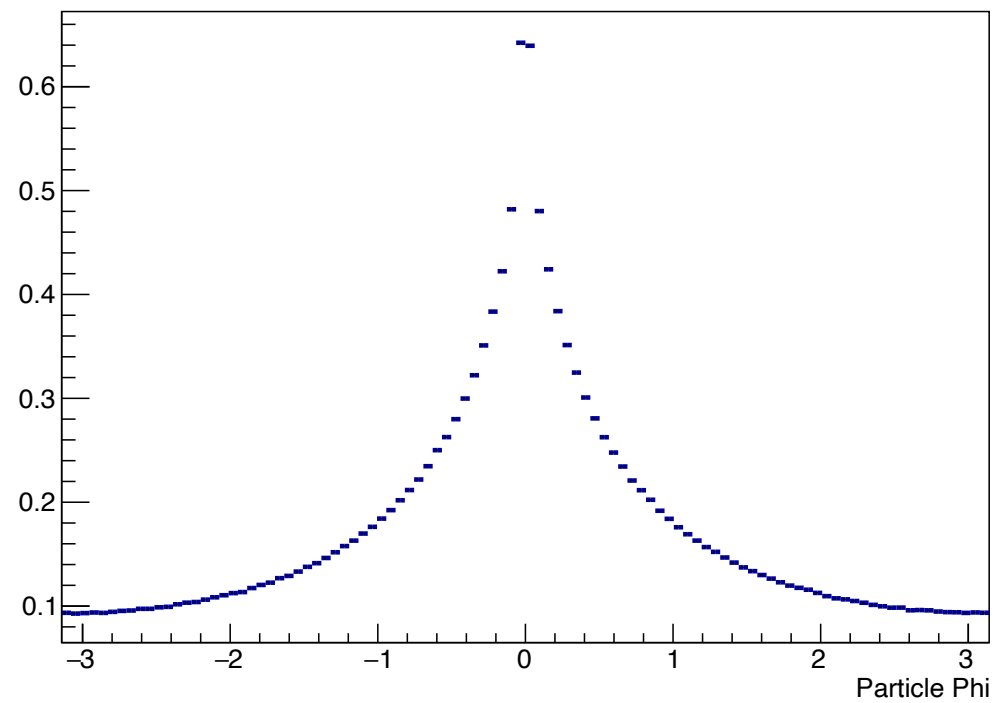
Final State Particle Pt per event



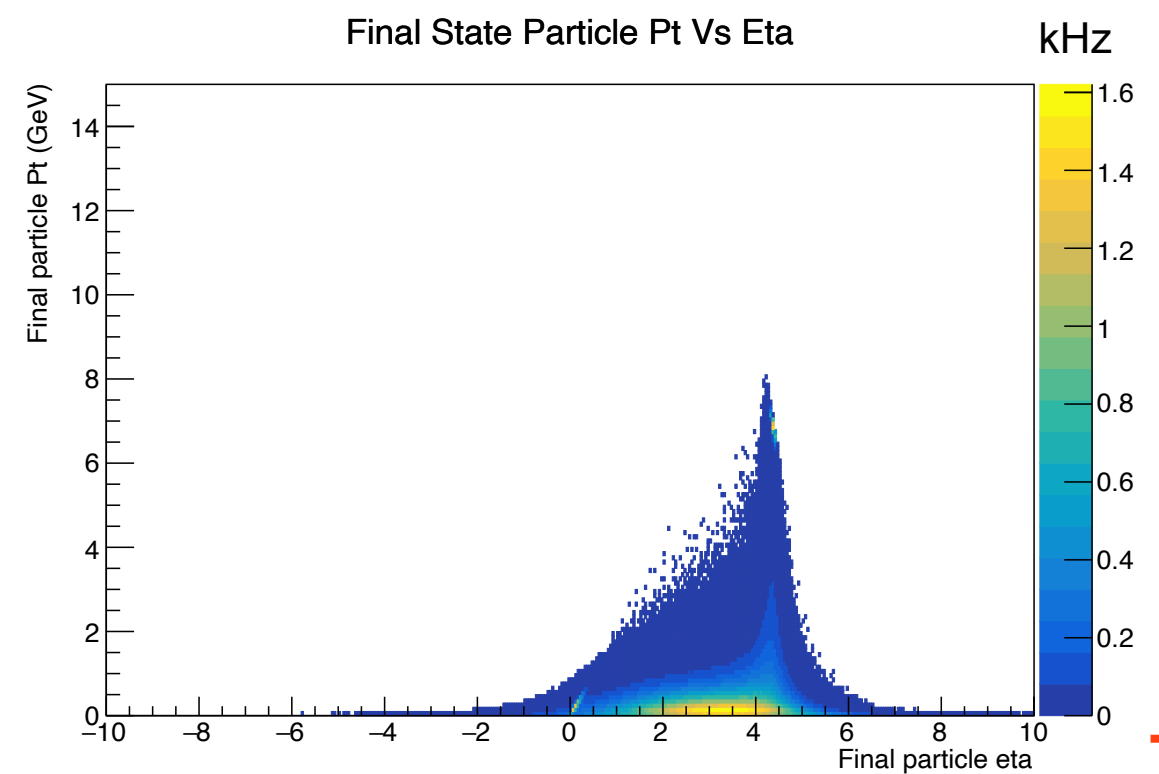
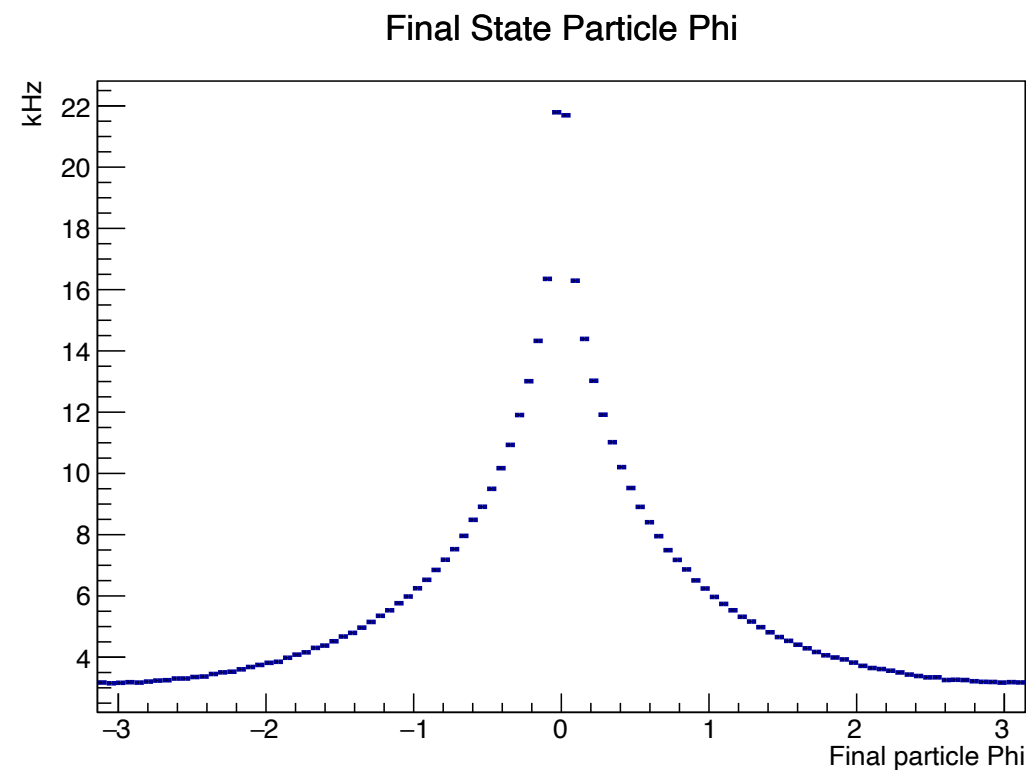
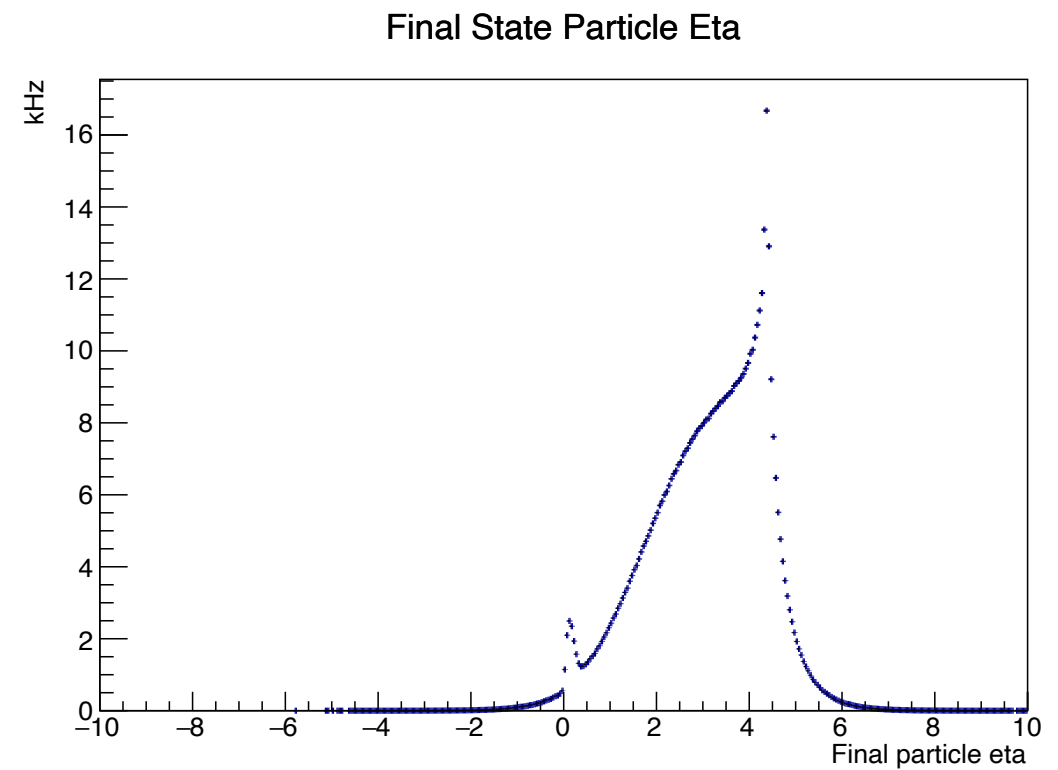
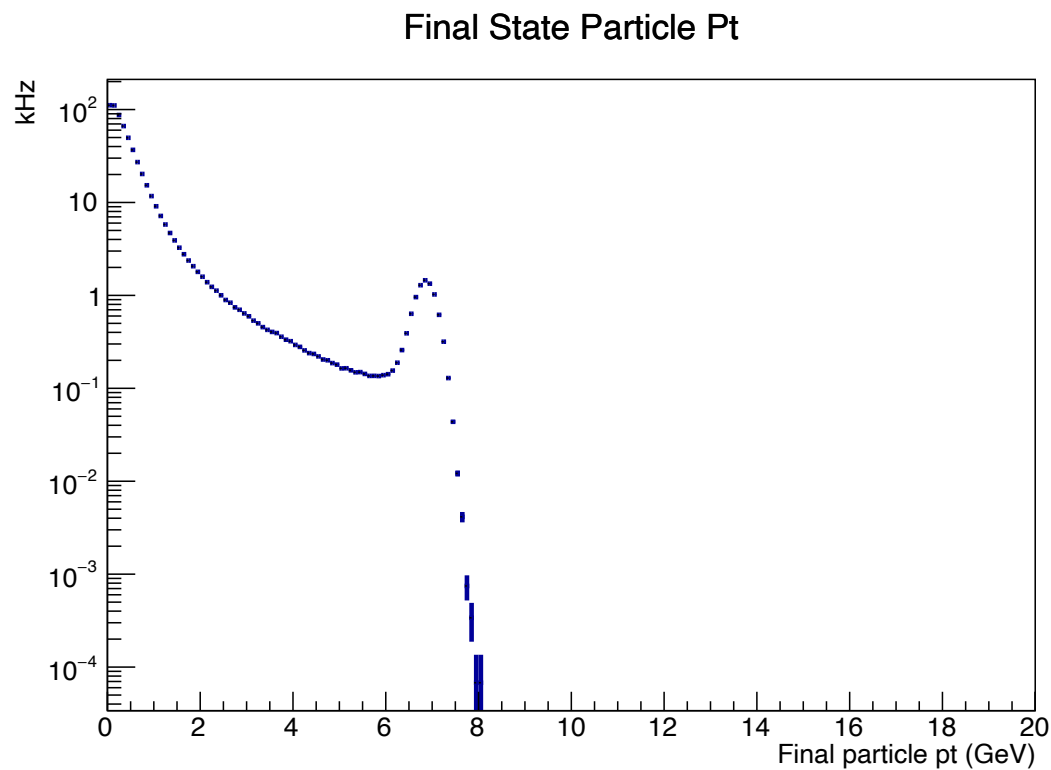
Final State Particle Eta per event



Final State Particle Phi per event



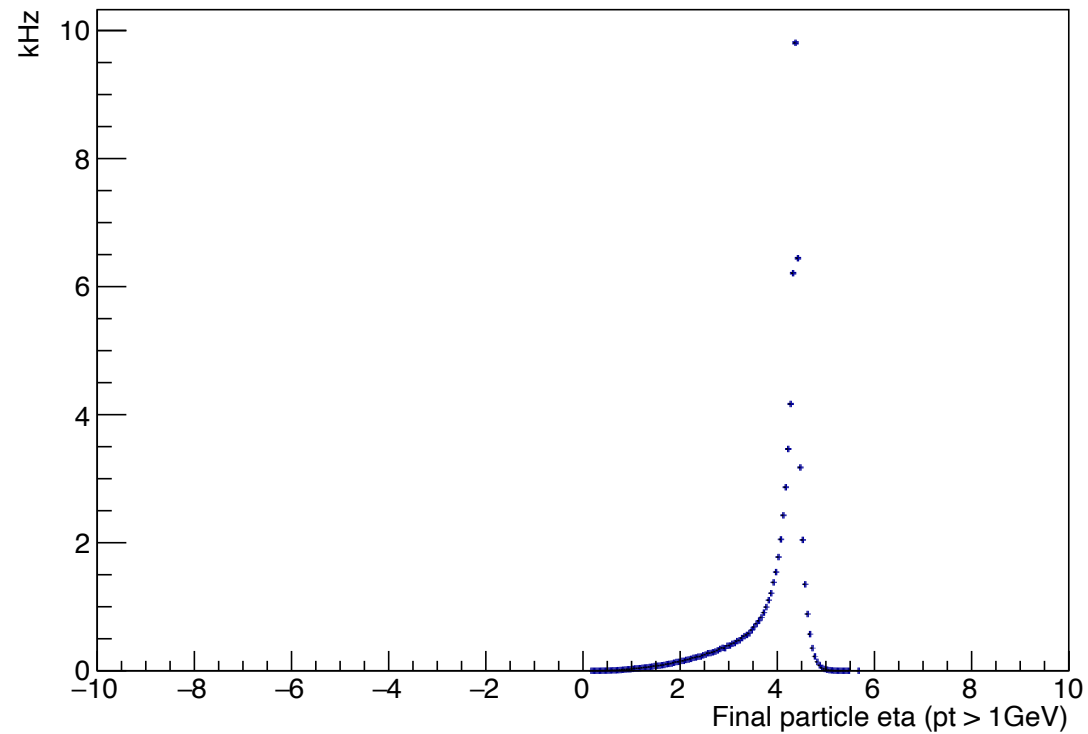
QA plots per event



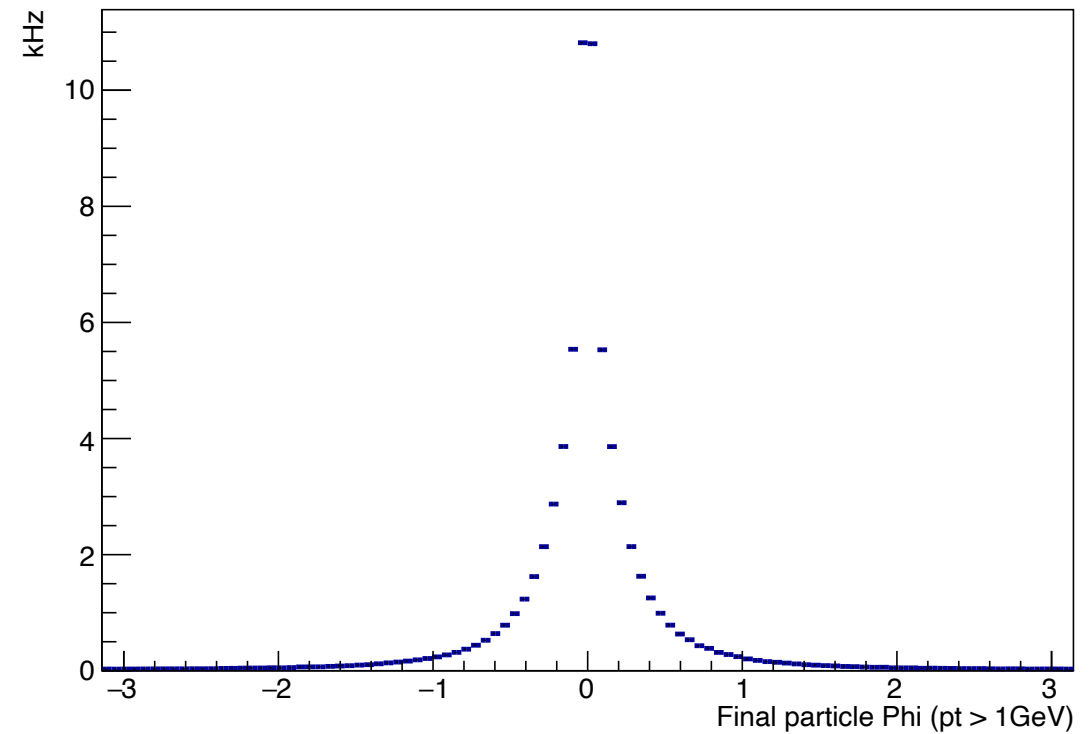
- Total produced tracks rate = 606.8 kHz in $-5.5m < s < 5m$;

Events QA plots

Final State Particle Eta (Pt > 1 GeV)

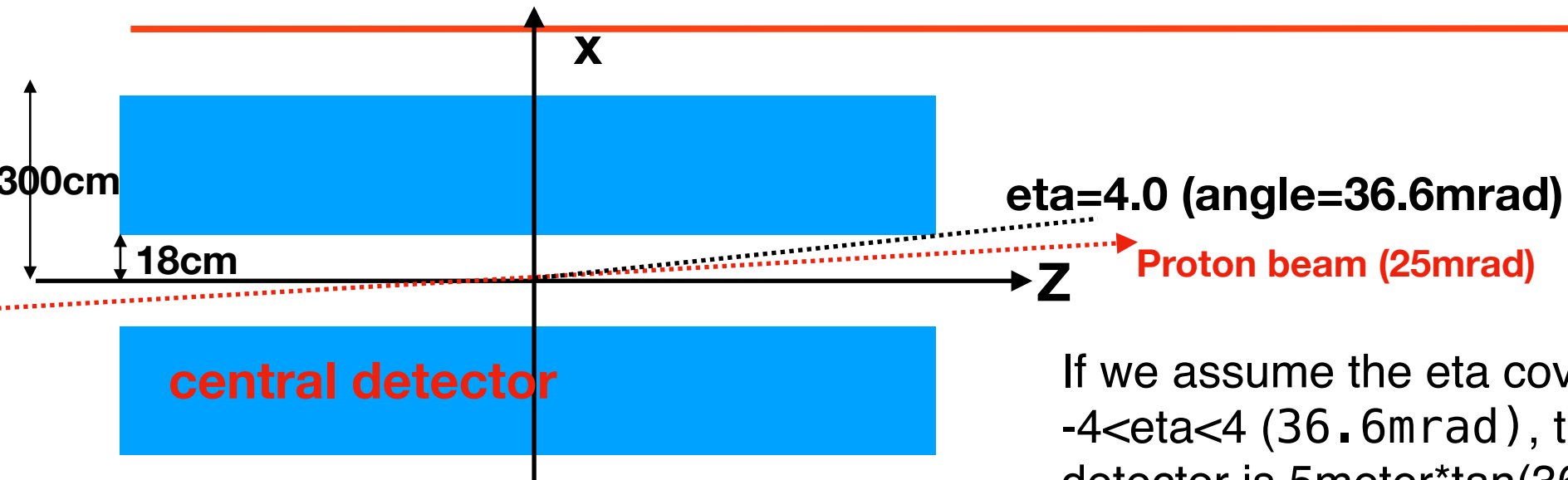


Final State Particle Phi (Pt > 1 GeV)



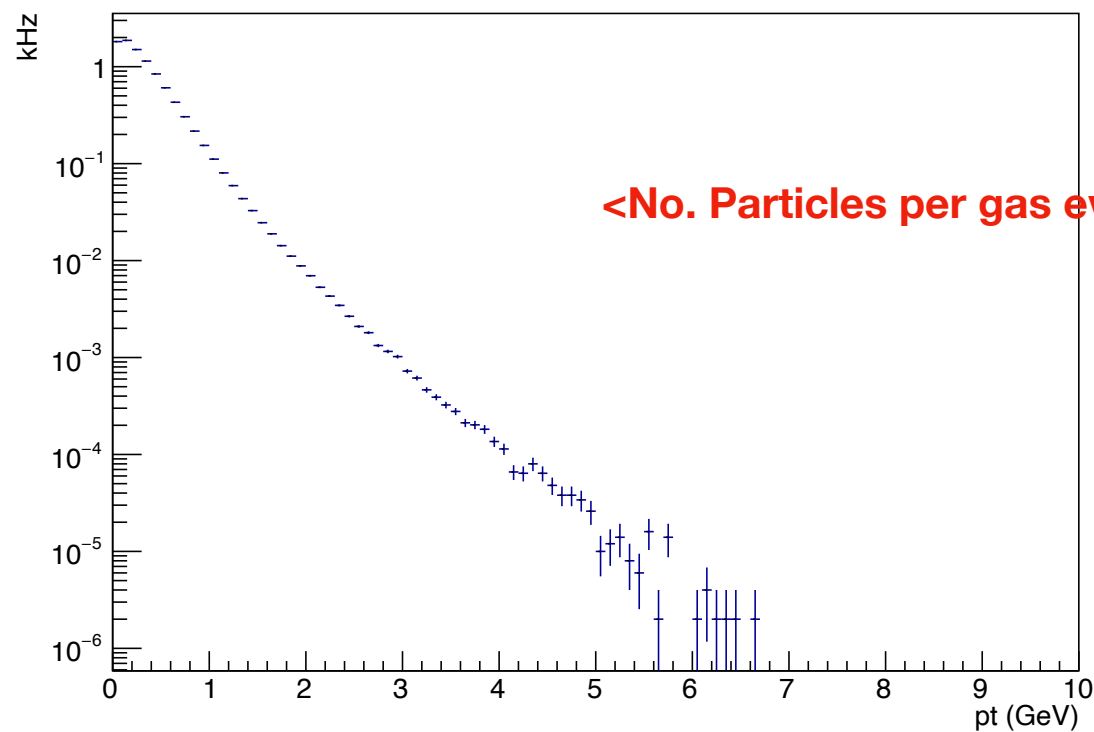
- Total produced high pt tracks rate = 70.1 kHz in $-5.5\text{m} < s < 5\text{m}$;

Particles that hit central detector per event

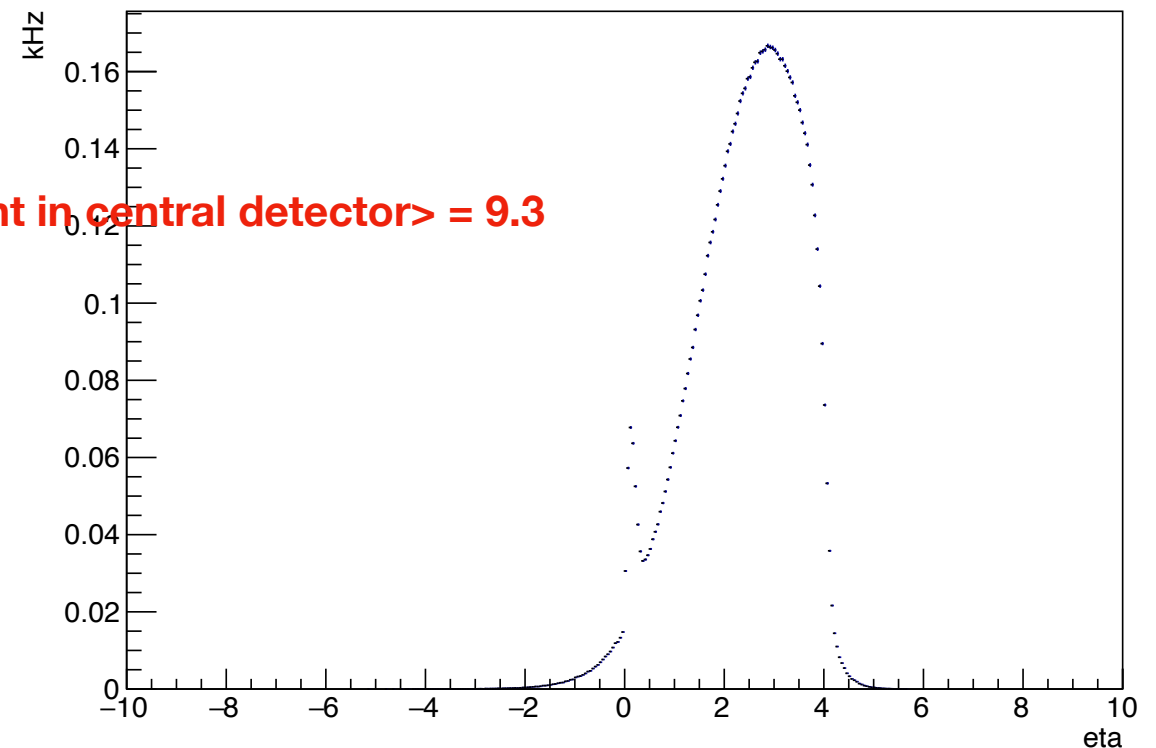


If we assume the eta coverage for the central detector is $-4 < \eta < 4$ (36.6mrad), then the inner radius of the detector is $5\text{meter} \cdot \tan(36.6\text{mrad}) = 18\text{cm}$; So here “hit the central detector” means the particle hits the blue parts ($18\text{cm} < r_{xy} < 300\text{cm}$);

Pt of Particle enter central detector

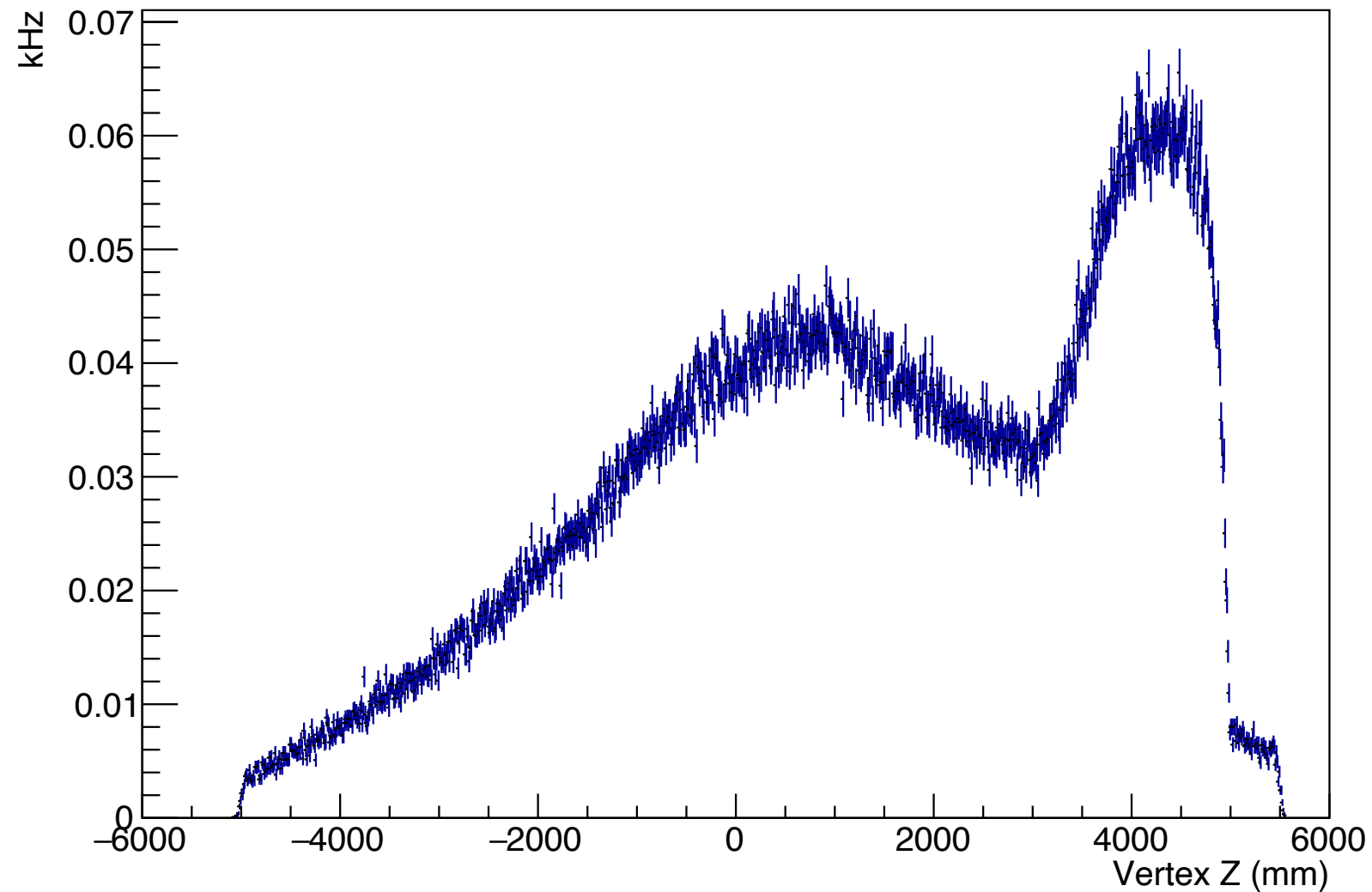


Eta of Particle enter central detector



Events with particles in central detector

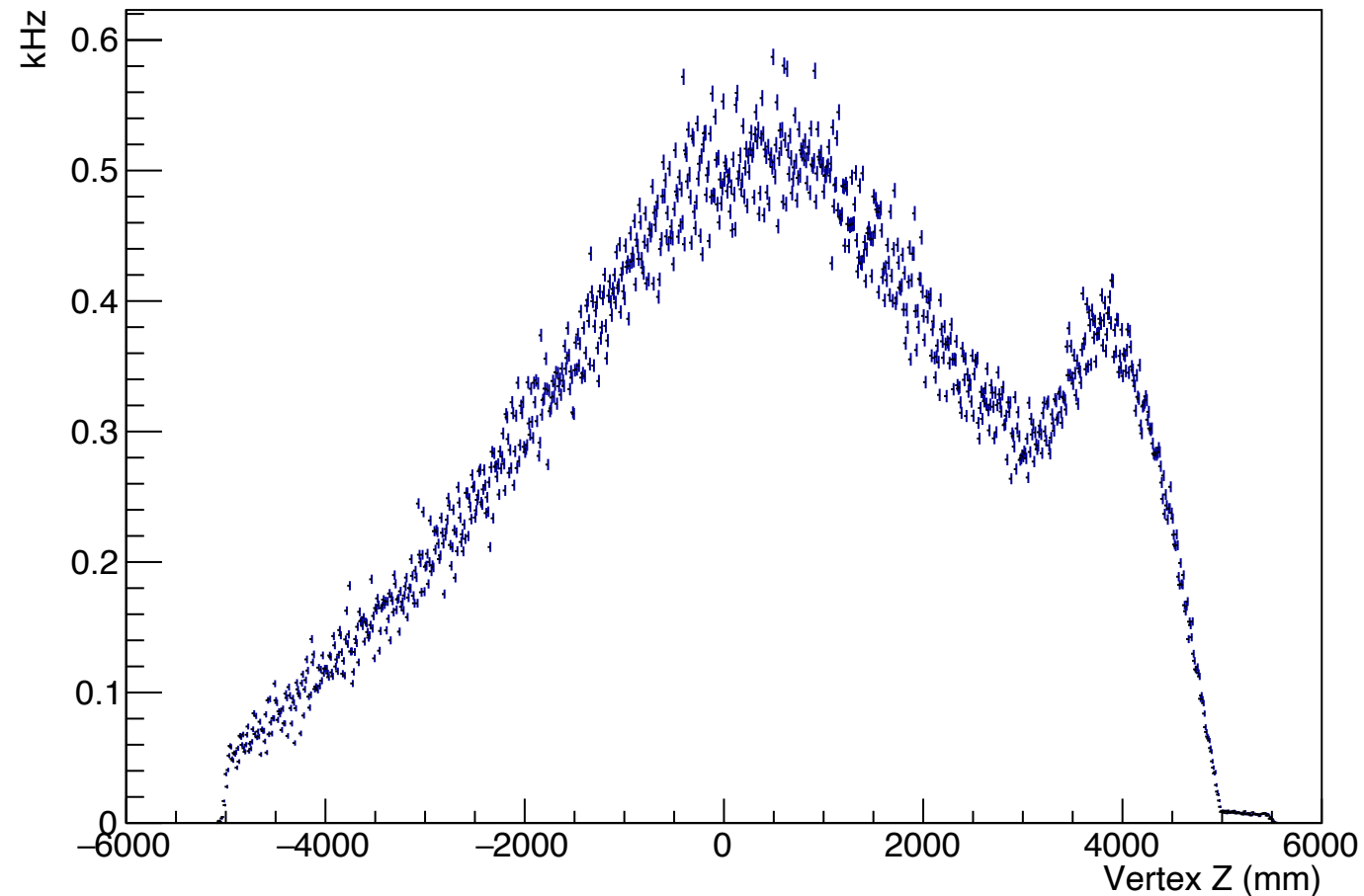
event rate with particle in main detector



- Total gas event rate that has particle in the central detector = 31.33kHz from beam gas in $-5.5\text{m} < s < 5\text{m}$;

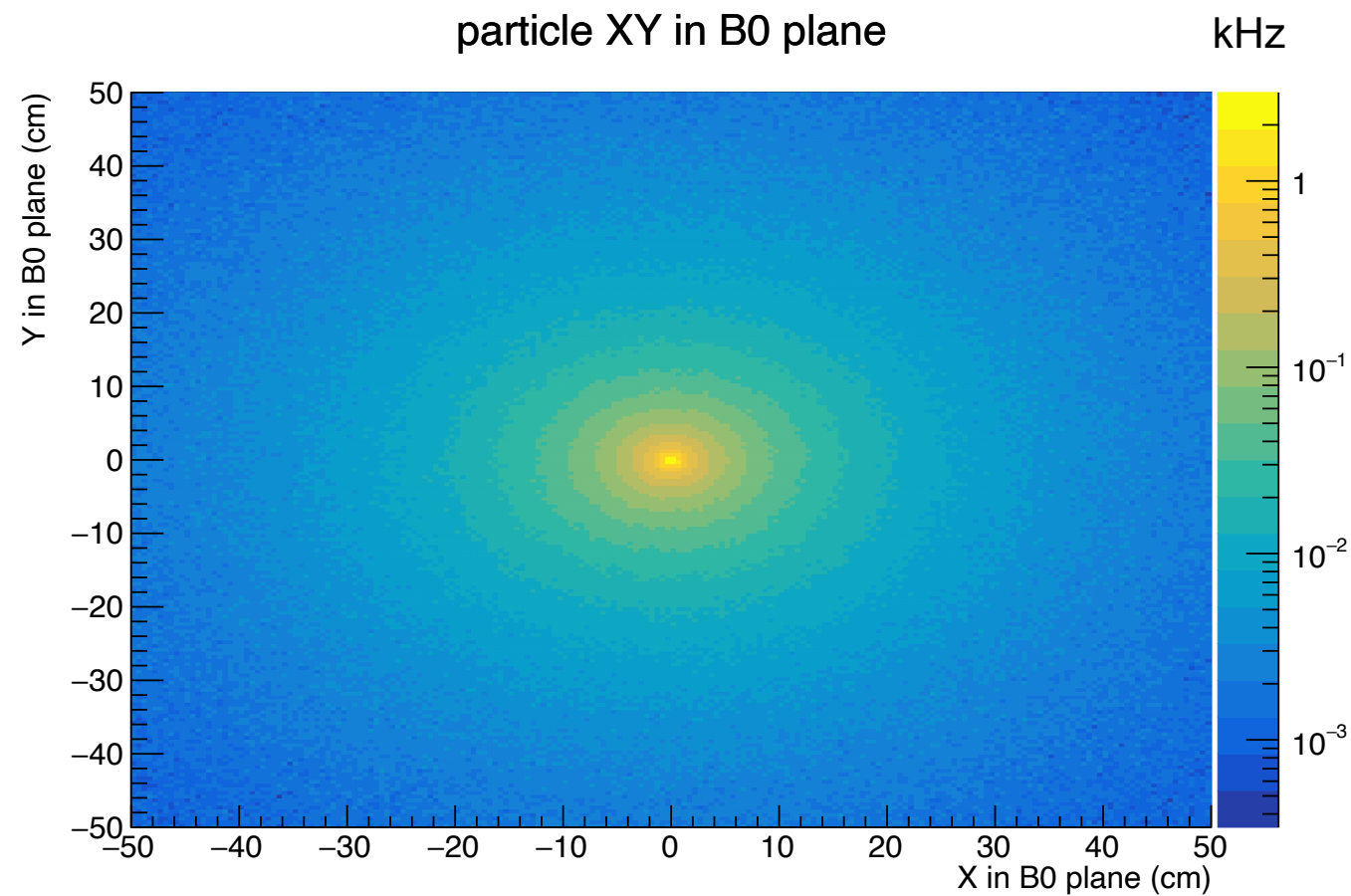
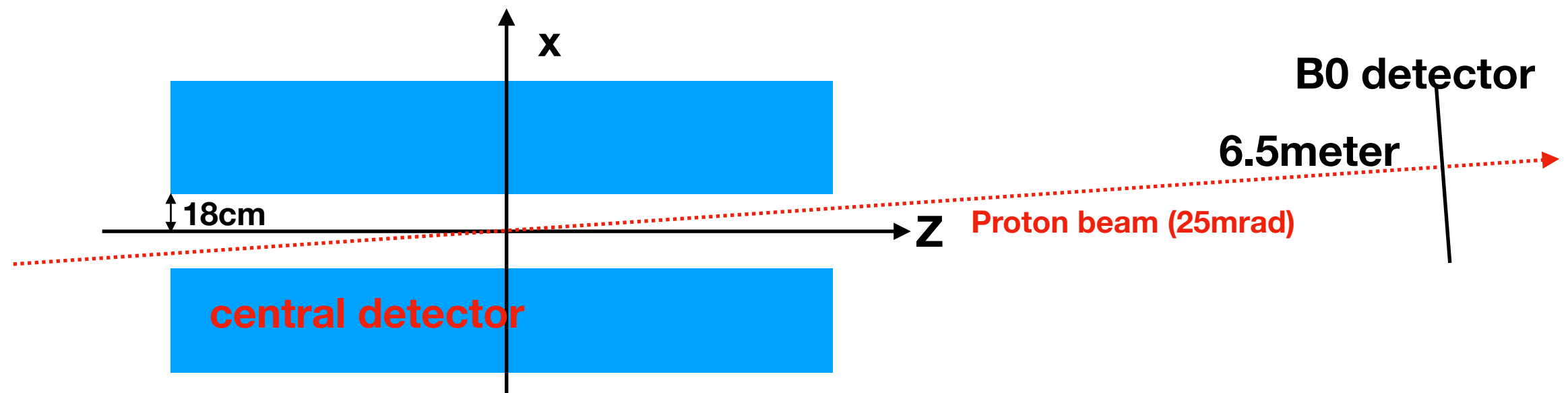
Particle rate in central detector

particle rate in main detector vs. Vertex Z

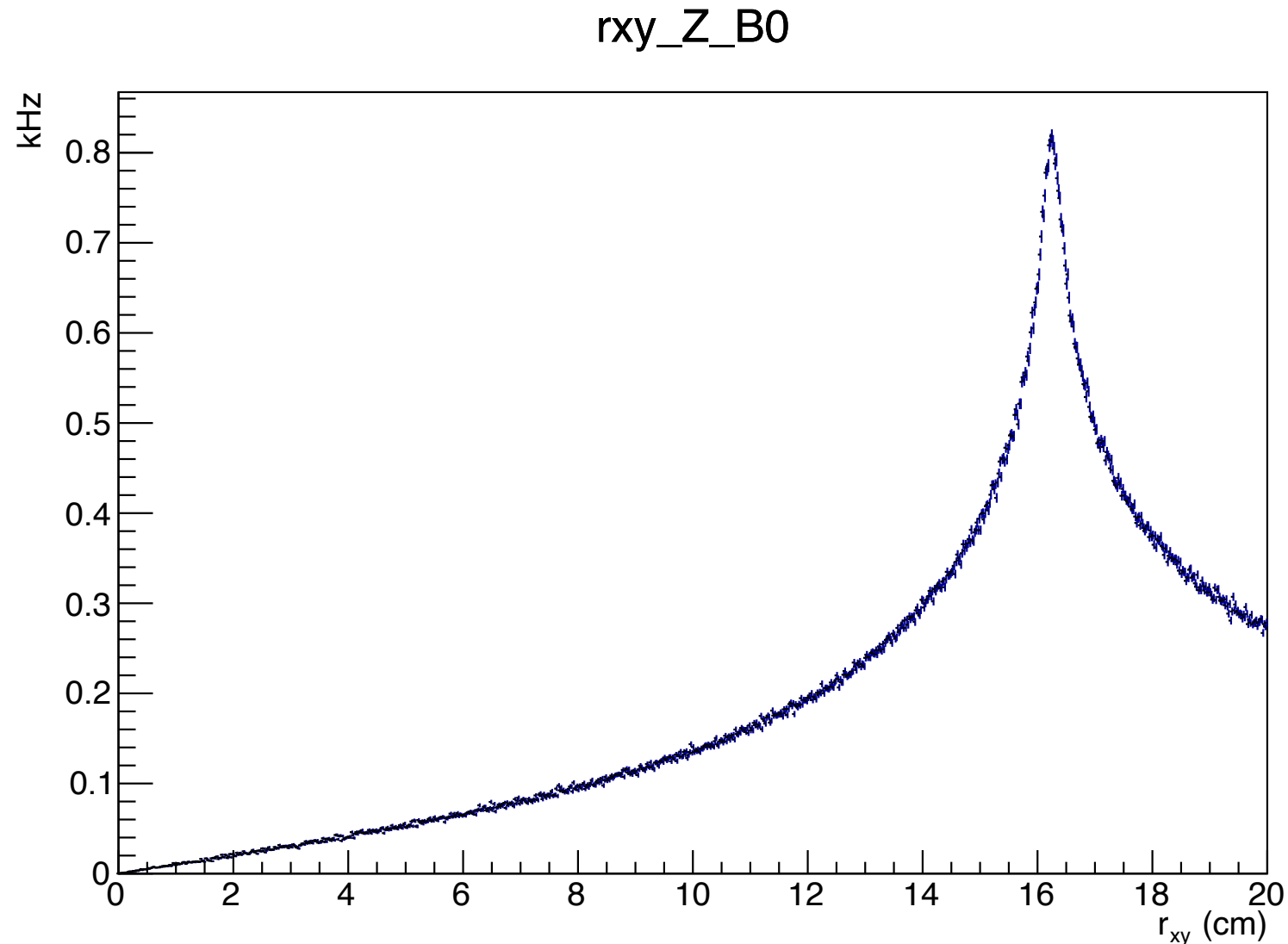


- Final particle and $-10.0 < \text{particle eta} < 10.0$;
- Total produced particle rate in central detector = 316.14 kHz from beam gas in $-5.5\text{m} < s < 5\text{m}$;

XY distribution for beam gas produced particle in the B0 plane



r_{xy} distribution in the B0 plane (Z=6.5m)



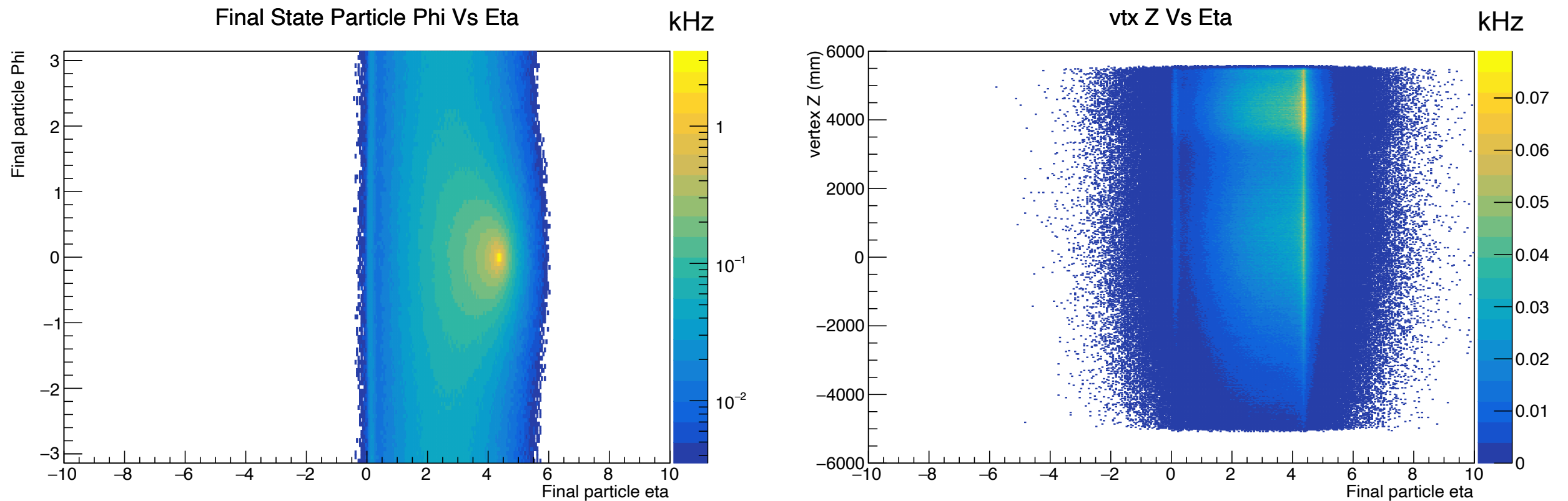
- We assume the B0 coverage is from 5mrad to 20mrad;
- The particle rate for $3.6\text{cm} < r_{xy} < 13.0\text{cm}$ is 52.6kHz;
- About 1.55 particles per gas event hit B0;

Summary

- The background collision rate for different proton beam energy is estimated based on Pythia8 model;
- All proton beam effects (cross angle, crab cavity, beam energy spread, angular beam divergence, bunch length) are added in our simulation;
- Beam gas events are stored in HepMC3
 - ➡ `/gpfs/mnt/gpfs02/eic/zhangzq/pythia8/beameffect/BeamGas/BeamGasEvents`

Backup

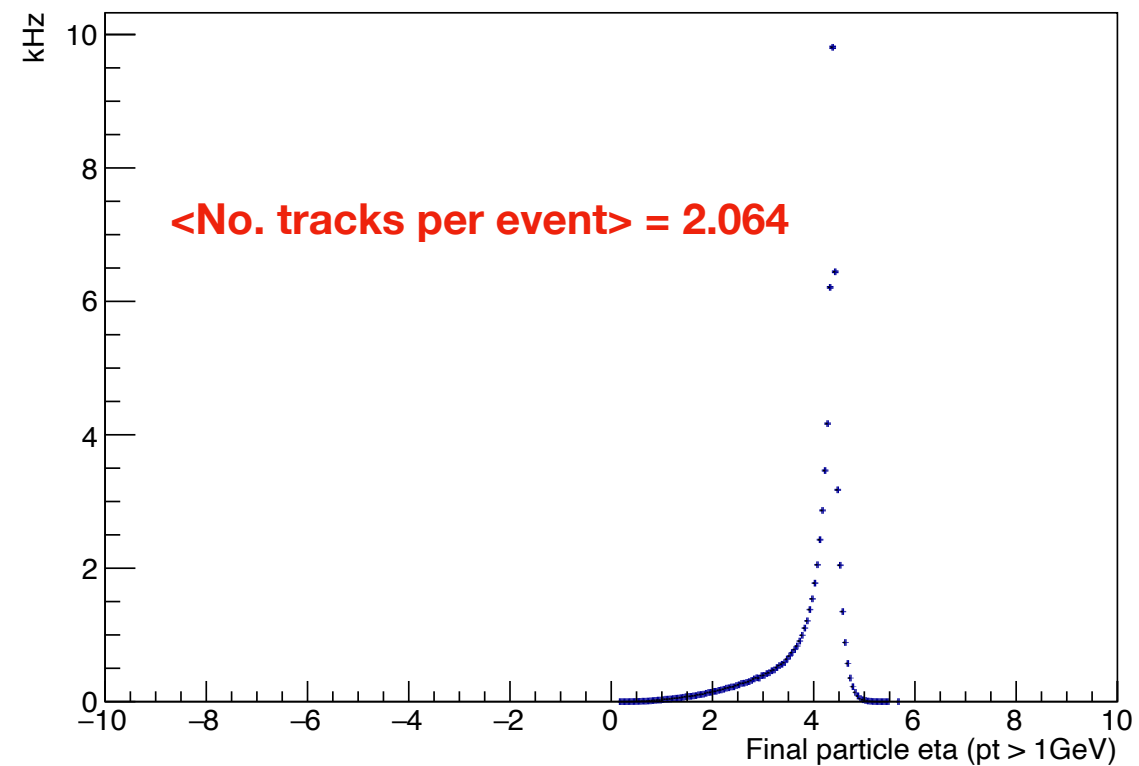
Events QA plots



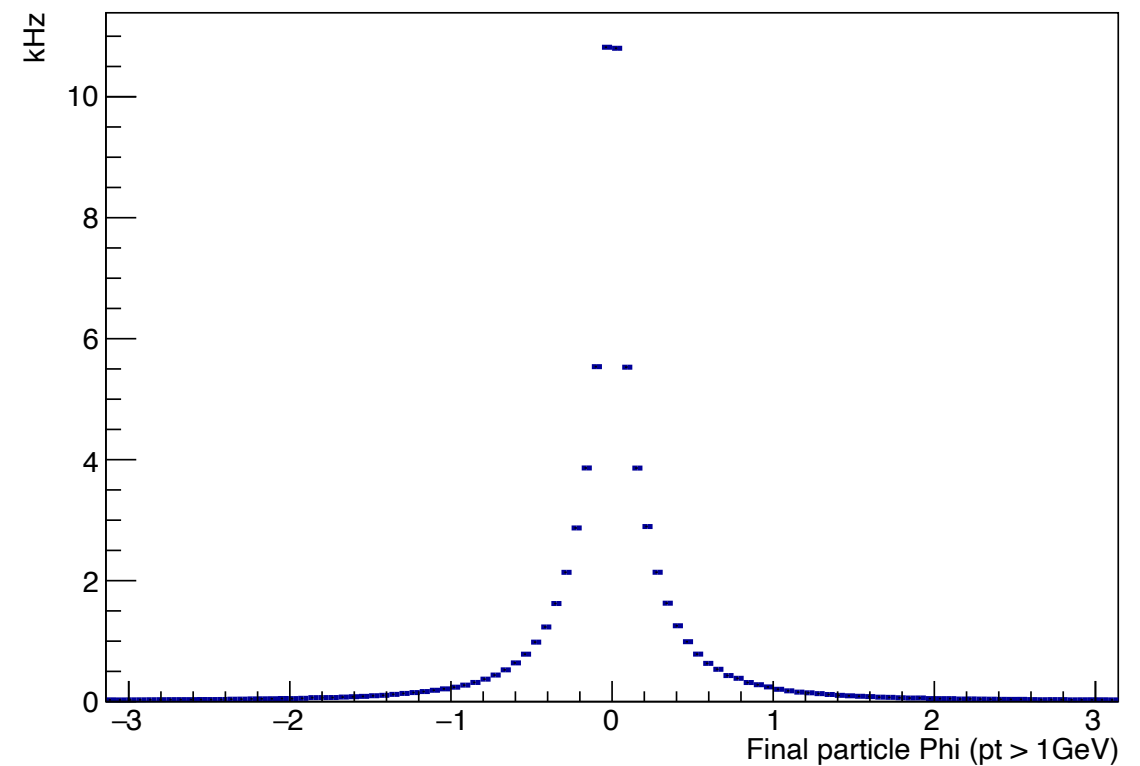
- Total produced tracks rate = 606.8 kHz in $-5.5\text{m} < s < 5\text{m}$;

QA plots per event (pt > 1GeV)

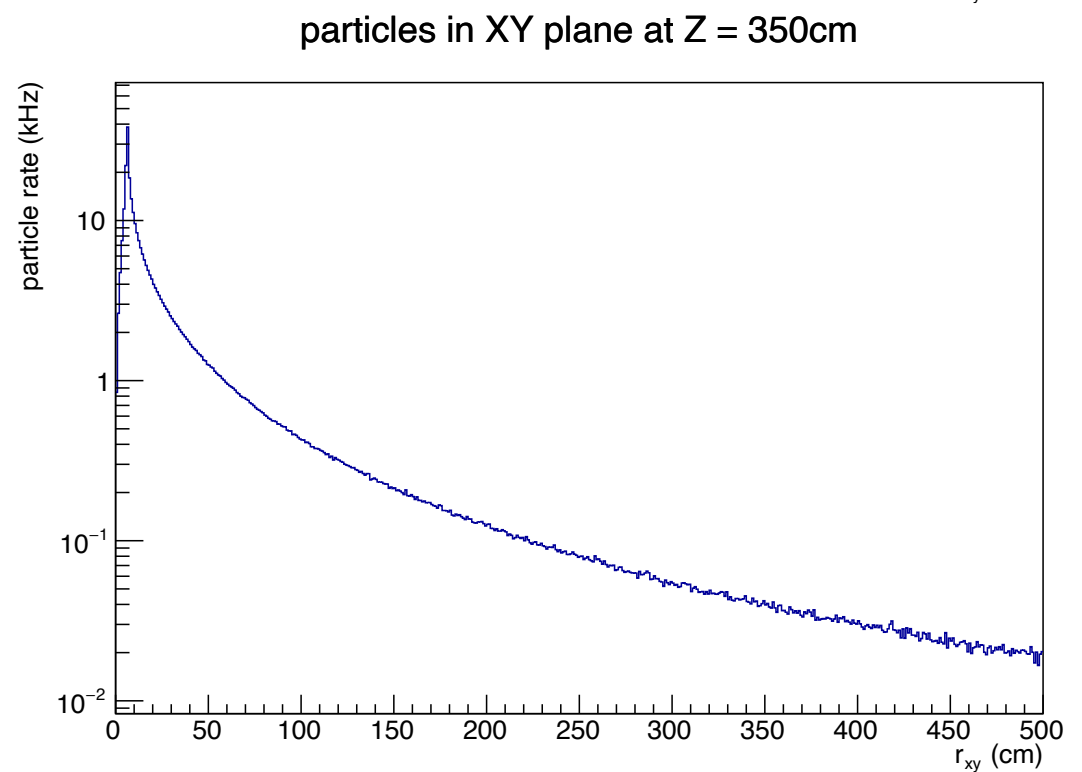
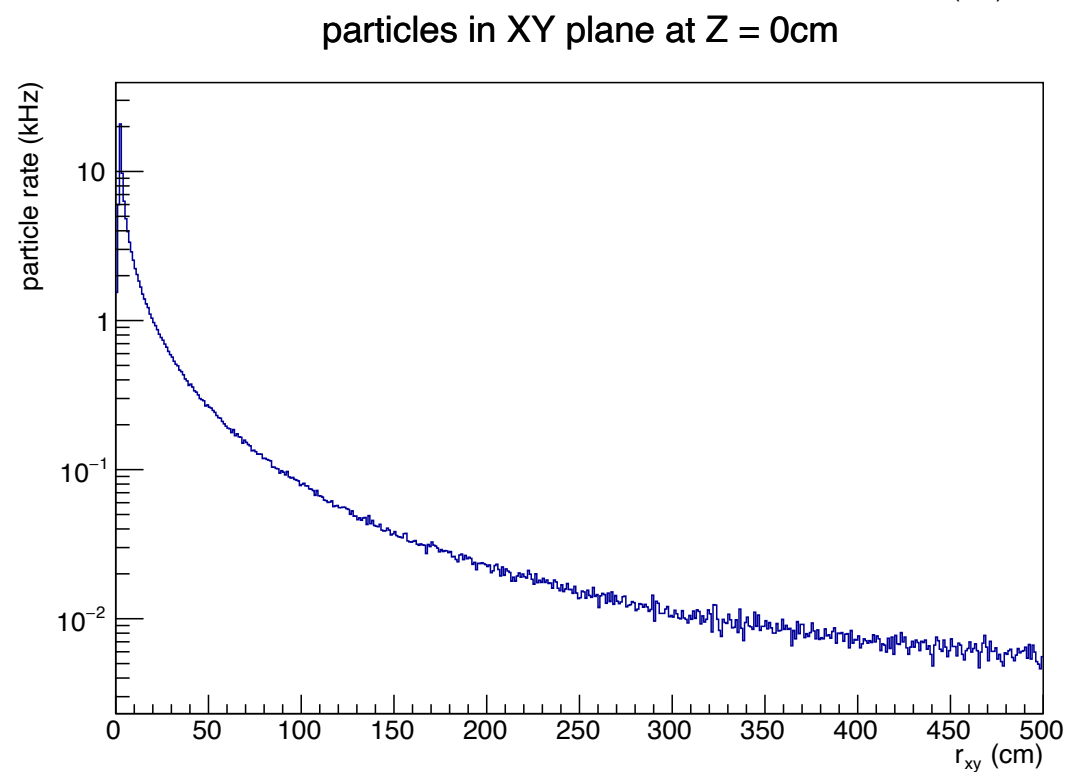
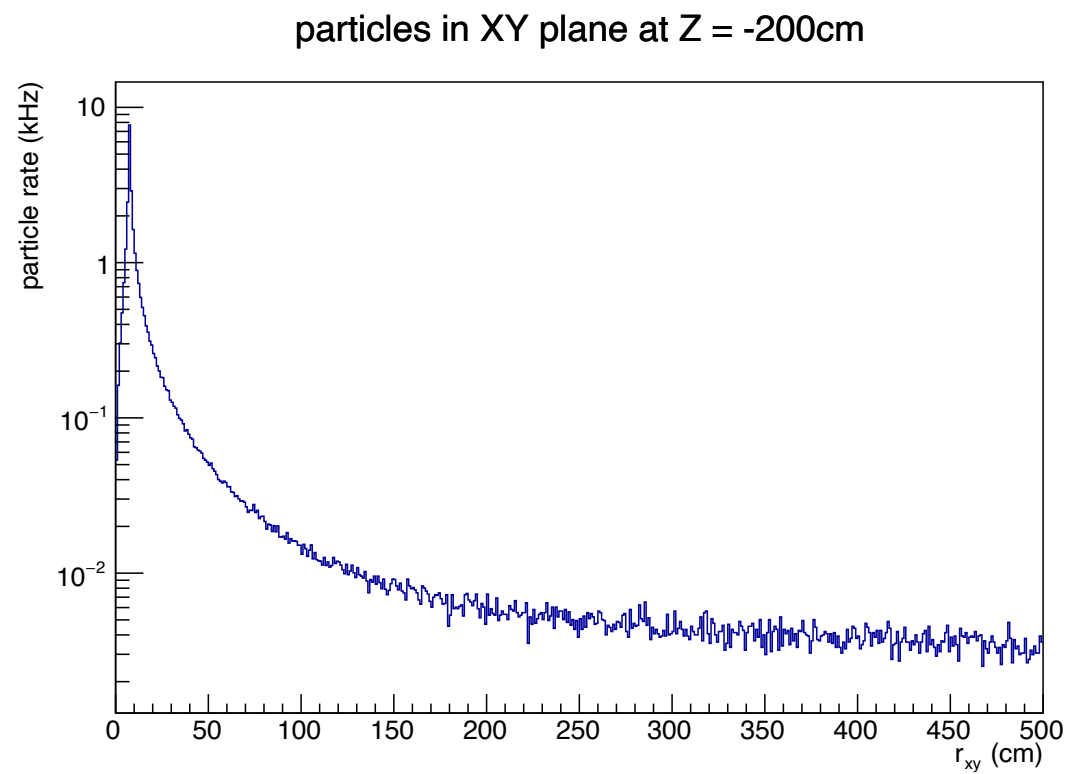
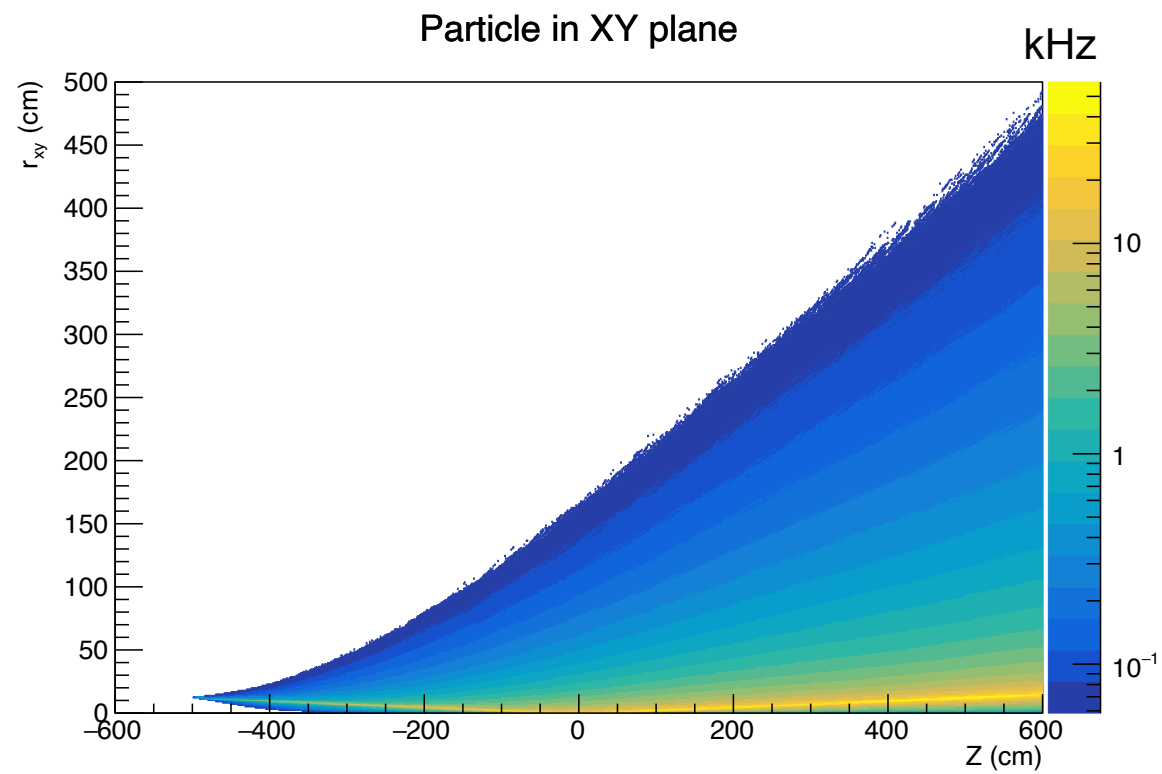
Final State Particle Eta (Pt > 1 GeV)



Final State Particle Phi (Pt > 1 GeV)



Events QA plots



Particle rate vs. Z

