
Proton beam gas background for EPIC

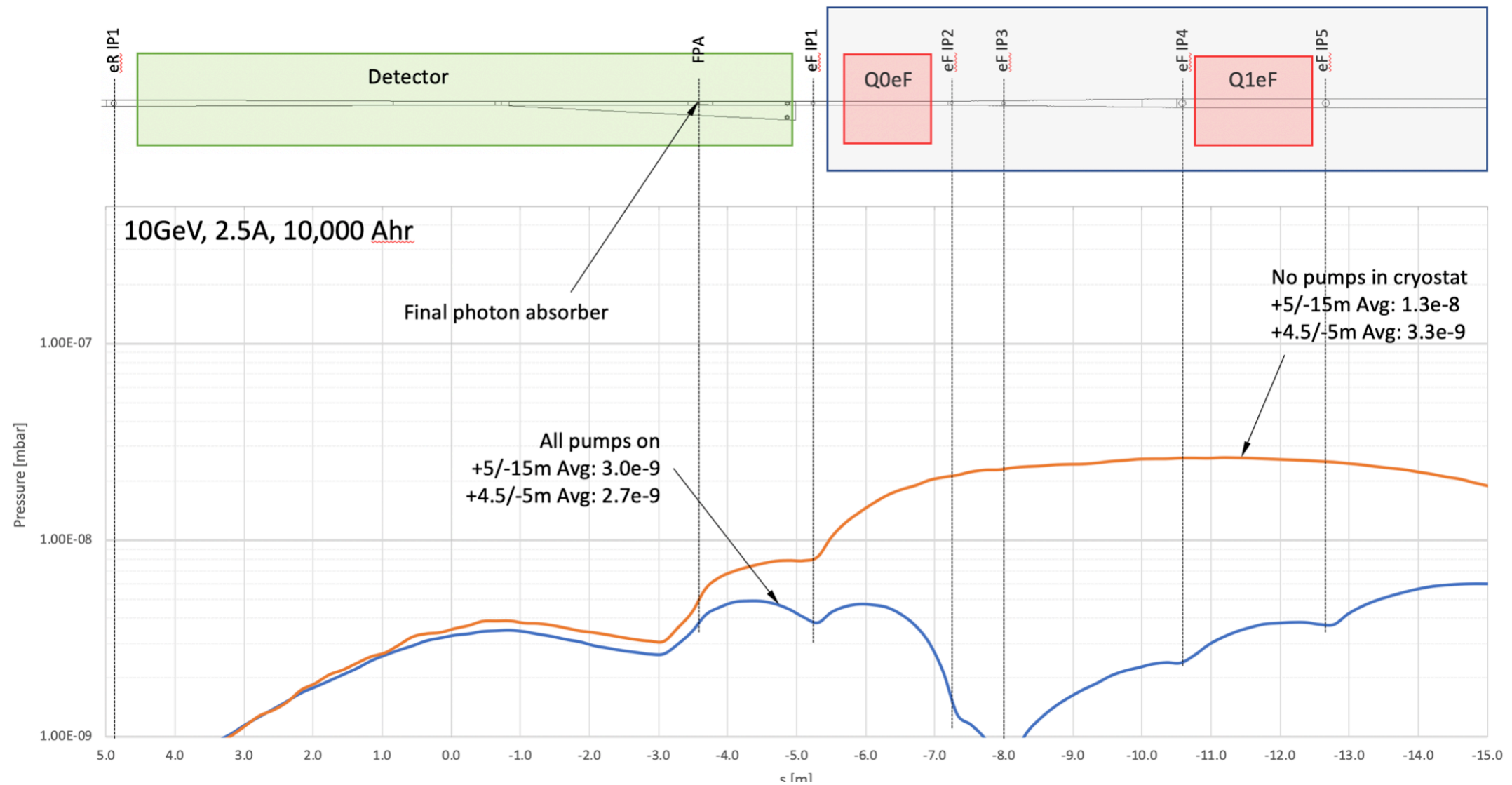
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Introduction

- 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 = 2.560254e-09 mbar = 2.560254e-09 * 0.000986923 atm = 2.5267736e-12 atm

T = 293k;

M = 1.00794g/mol (molar mass)

Density = 1.0587422e-13g/L = 6.326e7 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;

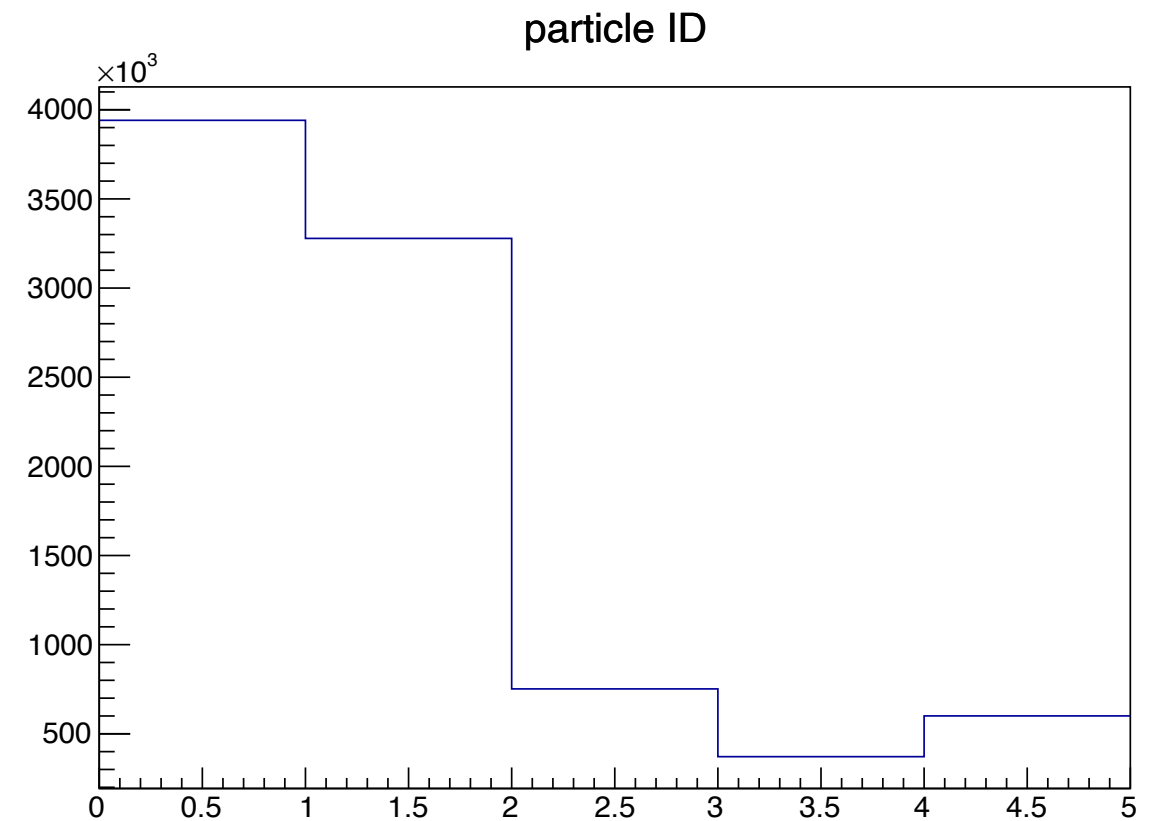
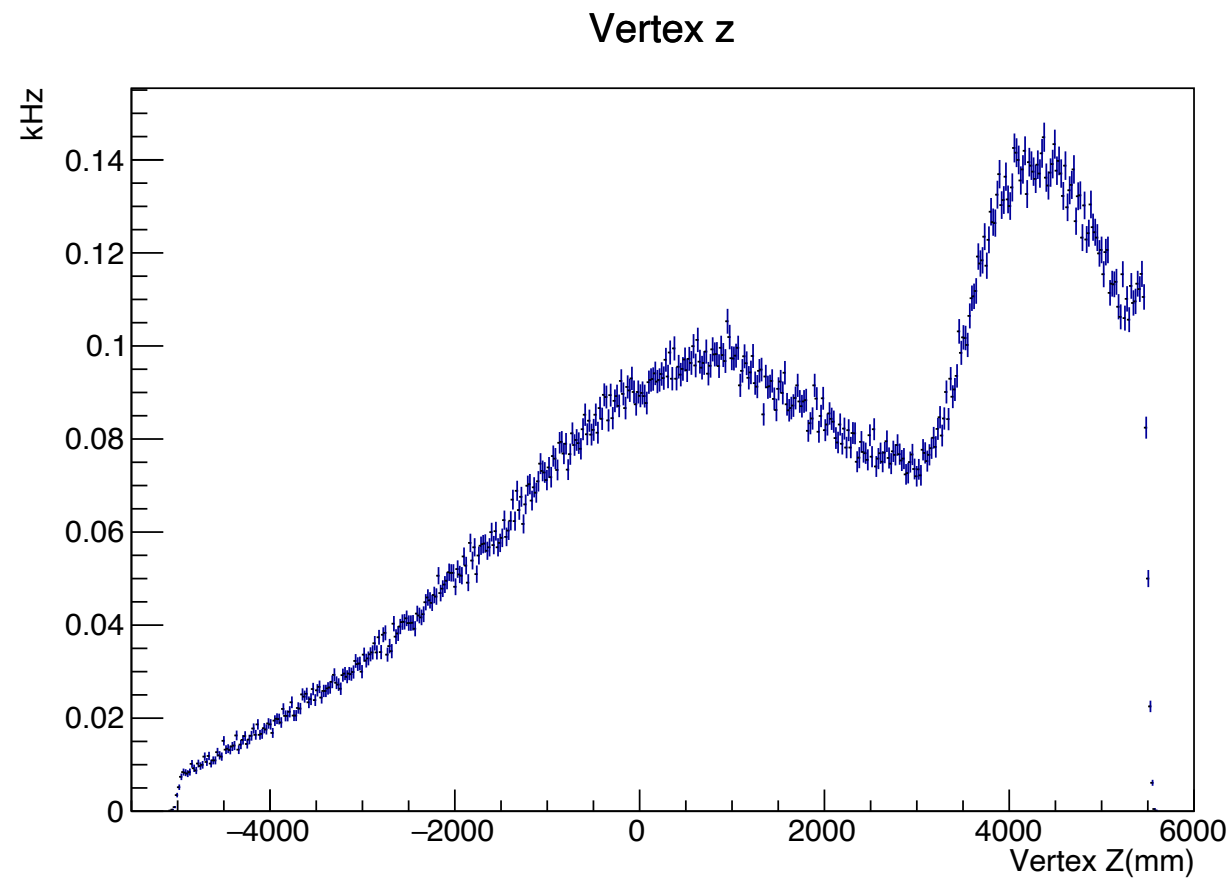
Length = 10m;

σ_{pH2} = 39.27mb *2 (Pythia8);

Background collision rate =

6.33e18(s-1)*6.326e7(cm-3)*1000(cm)*39.27*(1.0e-27cm²) *2 = **31.45kHz**; //275GeV
 30.74kHz; // 100GeV
 30.96kHz; // 41GeV

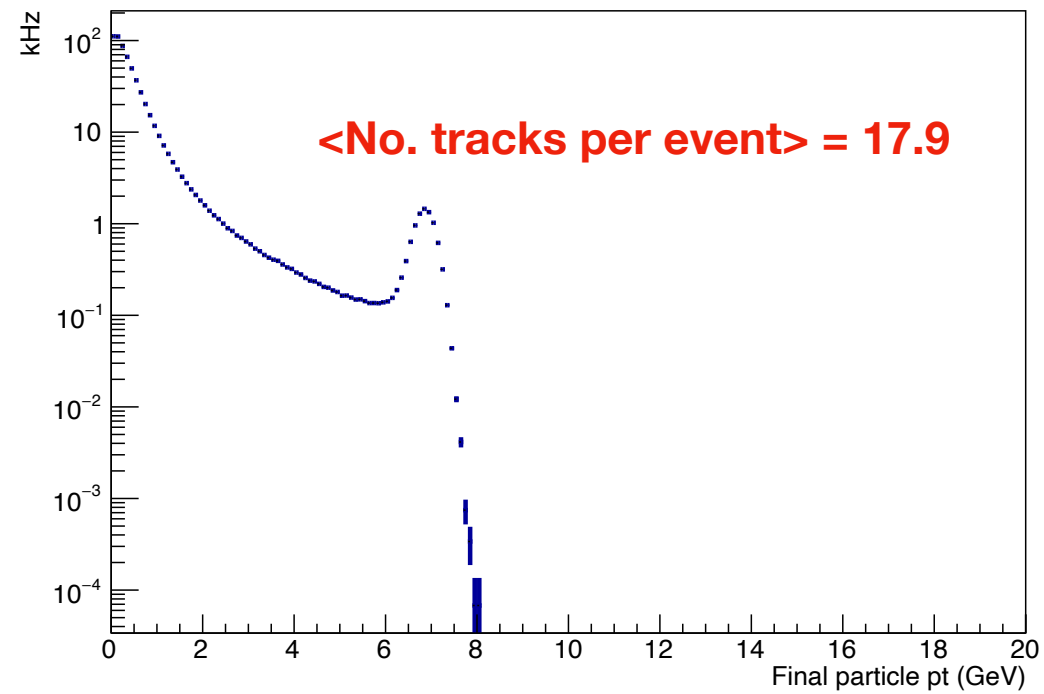
Events QA plots



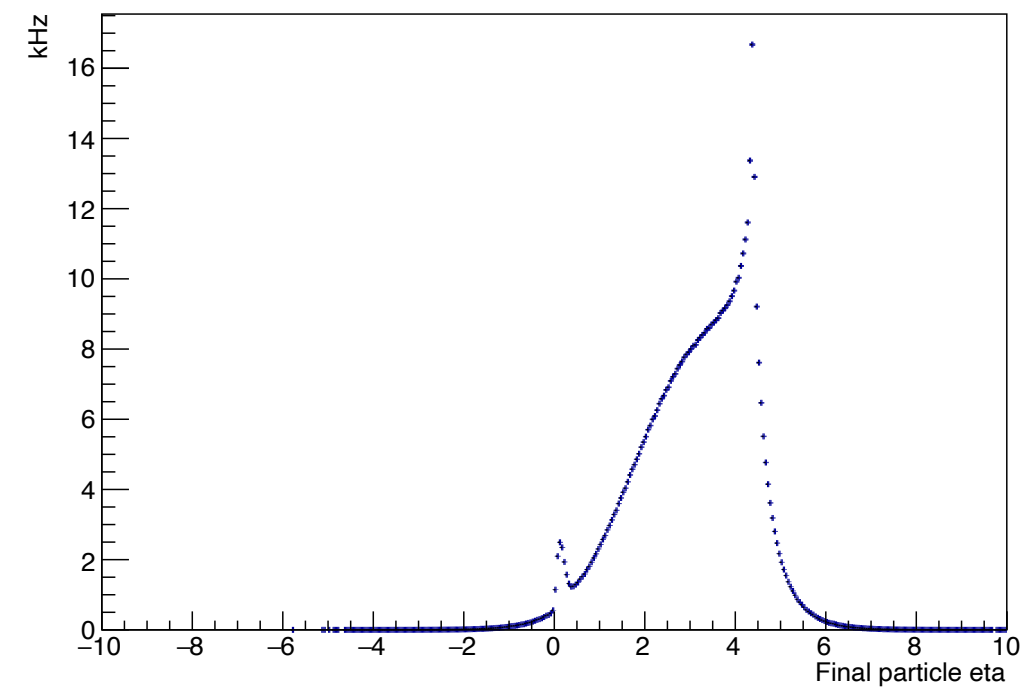
- Total collision rate = 33.93kHz in $-5.5\text{m} < s < 5\text{m}$;
- HepMc3 files can be found in /gpfs/mnt/gpfs02/eic/zhangzq/EPIC/eic/protonBeamGasEvents_Pythia8;

QA plots per event

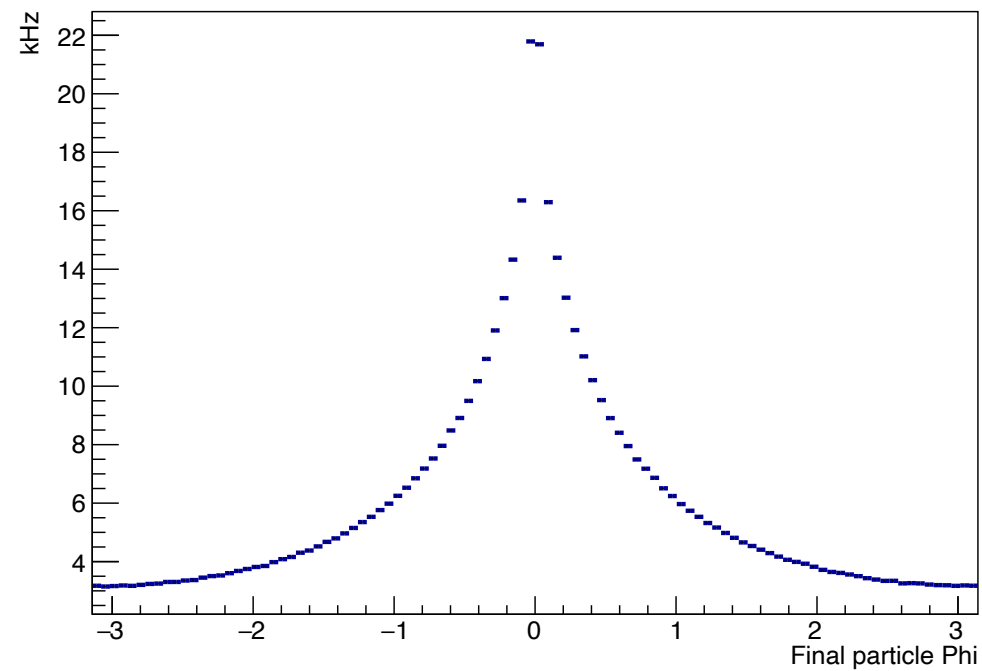
Final State Particle Pt



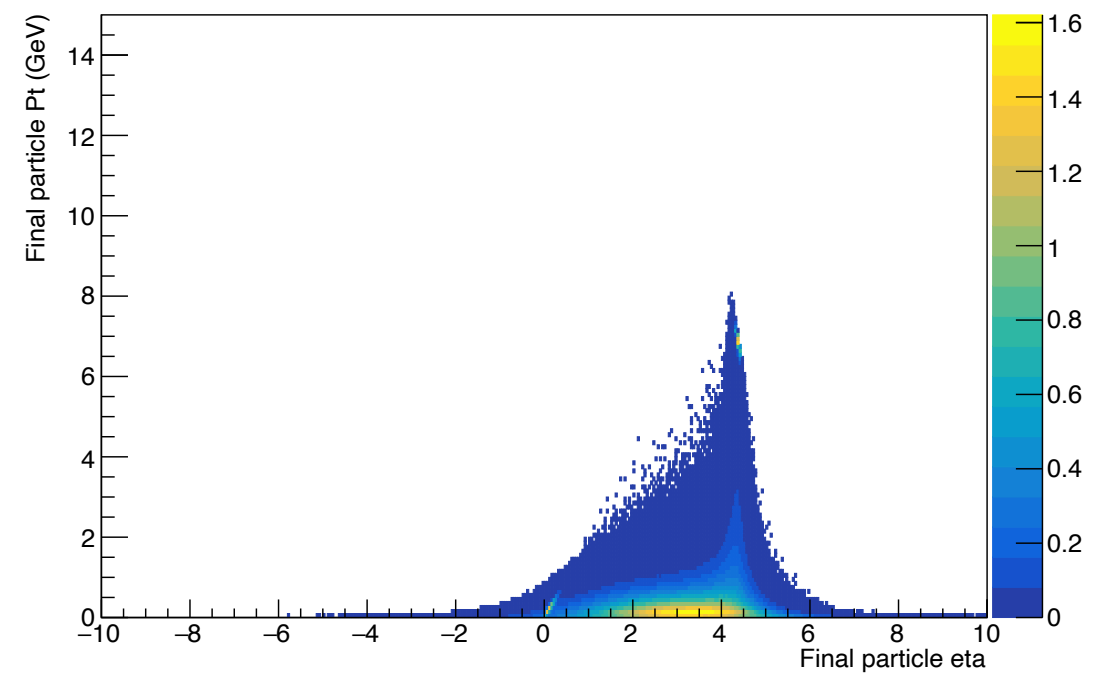
Final State Particle Eta



Final State Particle Phi



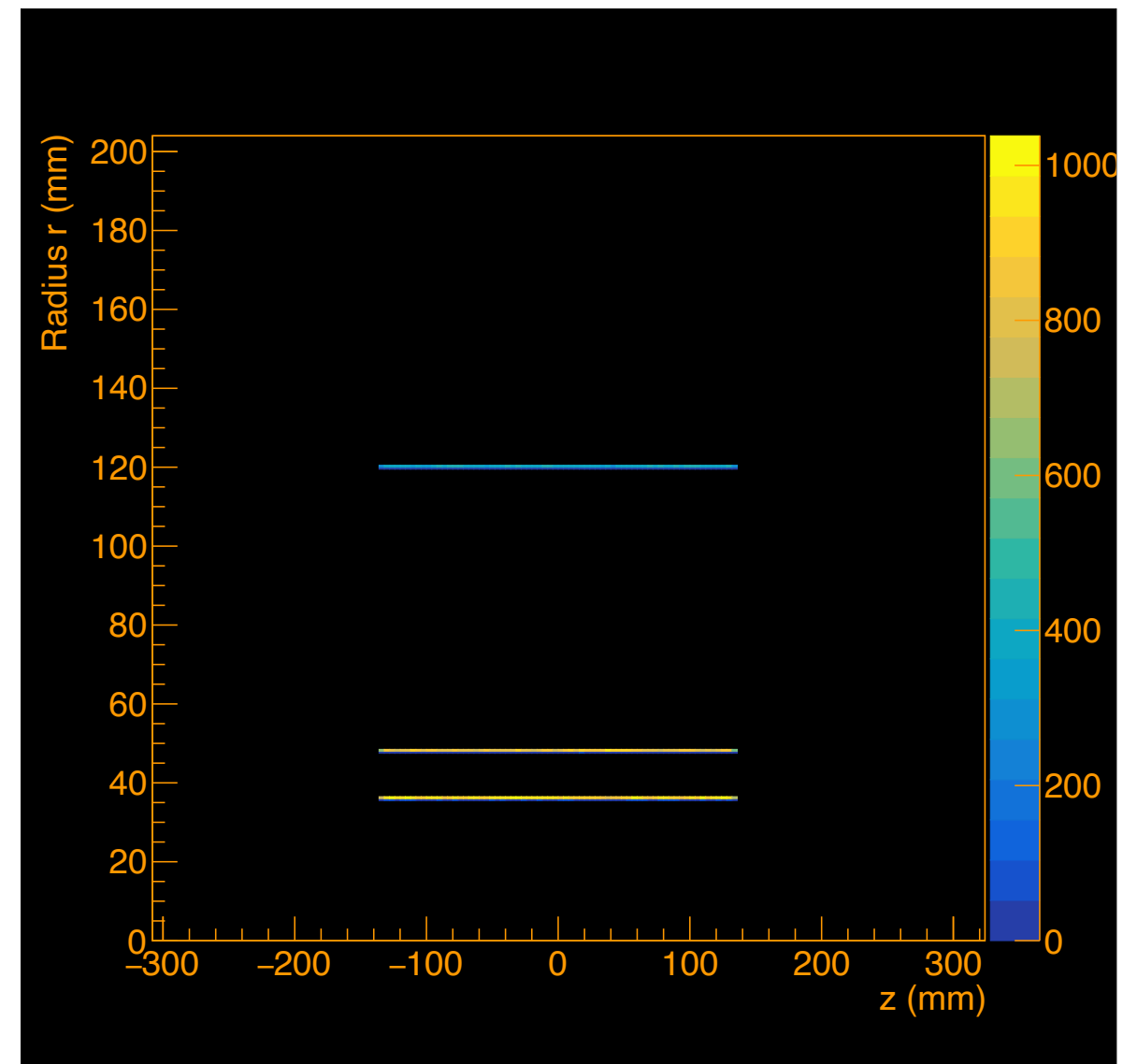
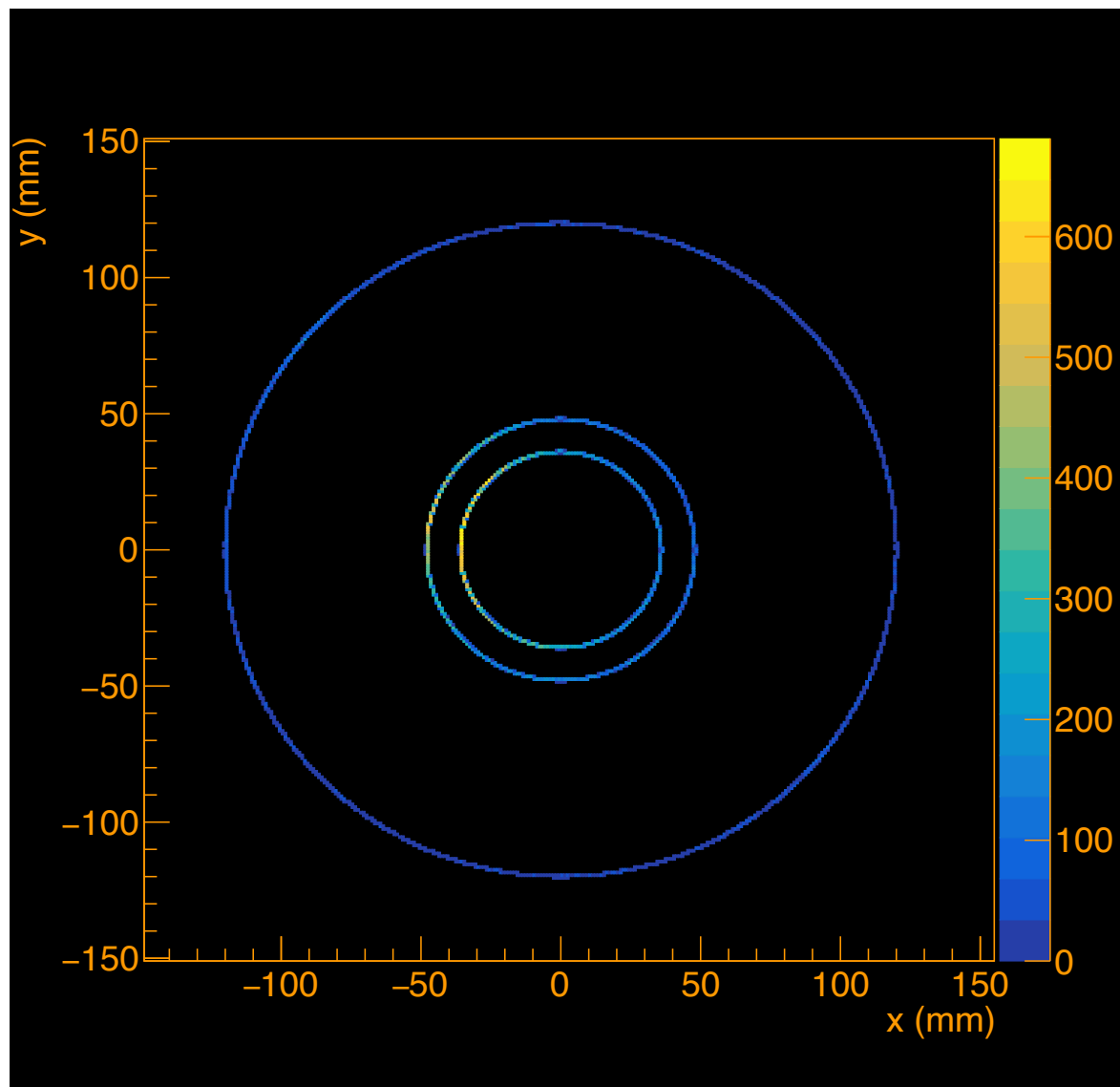
Final State Particle Pt Vs Eta



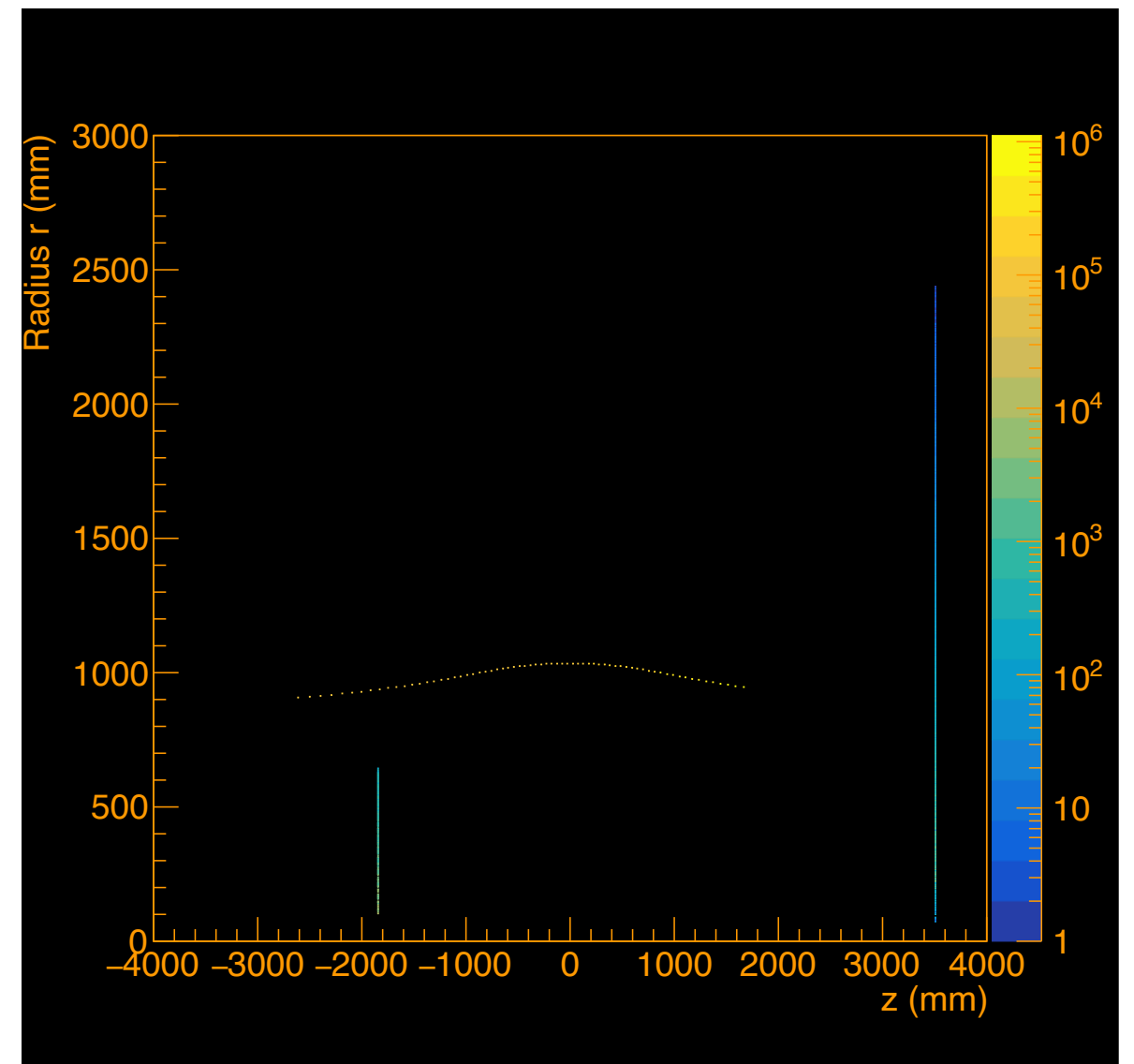
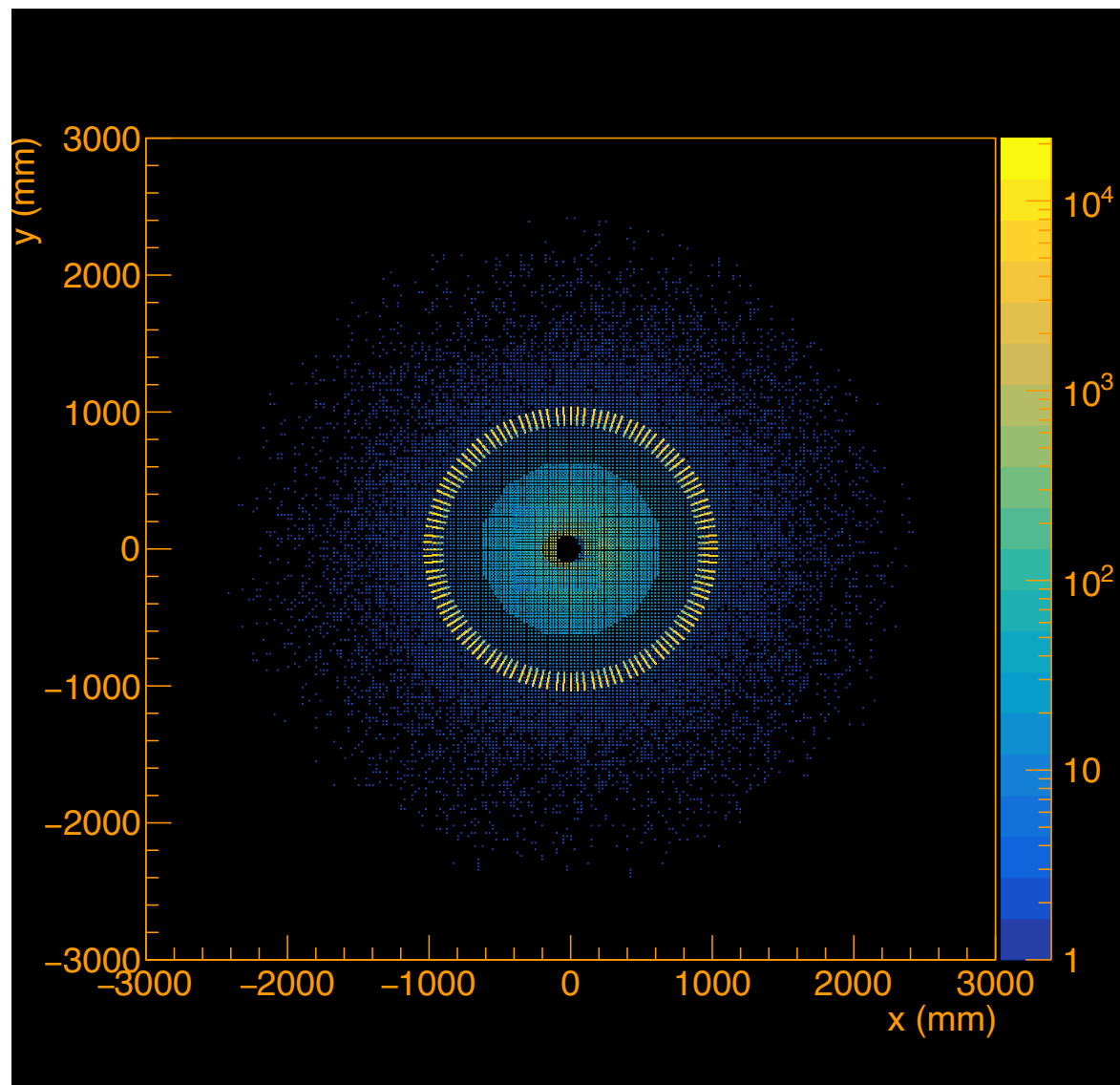
HepMc3 files

- HepMc3 files produced by Pythia8 can be found in **/gpfs/mnt/gpfs02/eic/zhangzq/EPIC/eic/protonBeamGasEvents_Pythia8**
- `source /opt/detector/setup.sh`
- `ddsim --compactFile $DETECTOR_PATH/$DETECTOR_CONFIG.xml --numberOfEvents 5000 --inputFiles /gpfs/mnt/gpfs02/eic/zhangzq/pythia8/beameffect/BeamGasEvents/275_HiAc_25mrاد_Asciiv3_1.hepmc --outputFile 275_HiAc_25mrاد.edm4hep.root`
- We can get the hits information in all sub detectors;
- The events (20k) produced by dd4hep can be found in **/gpfs/mnt/gpfs02/eic/zhangzq/EPIC/eic/protonBeamGasEvents_dd4hep**

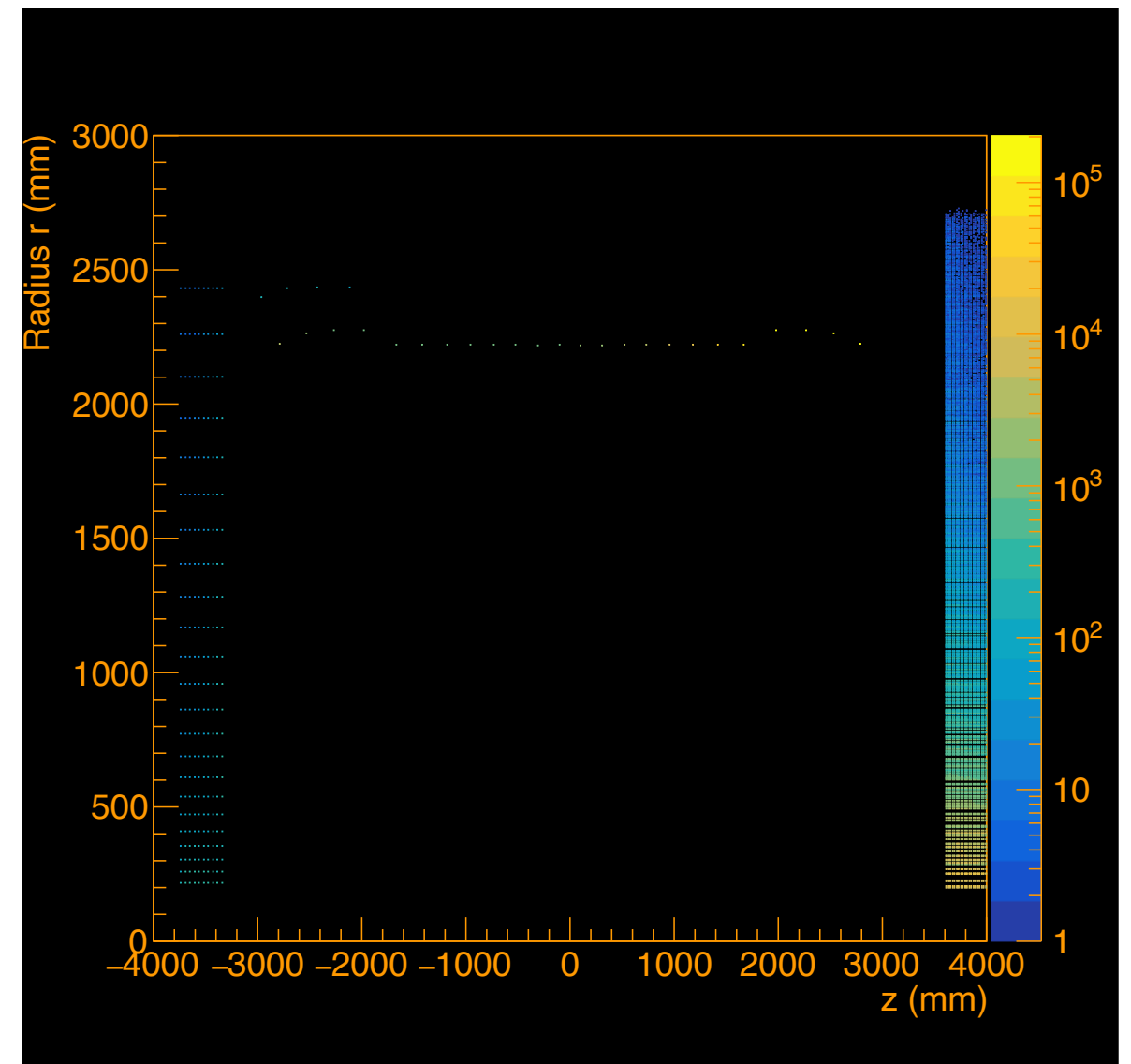
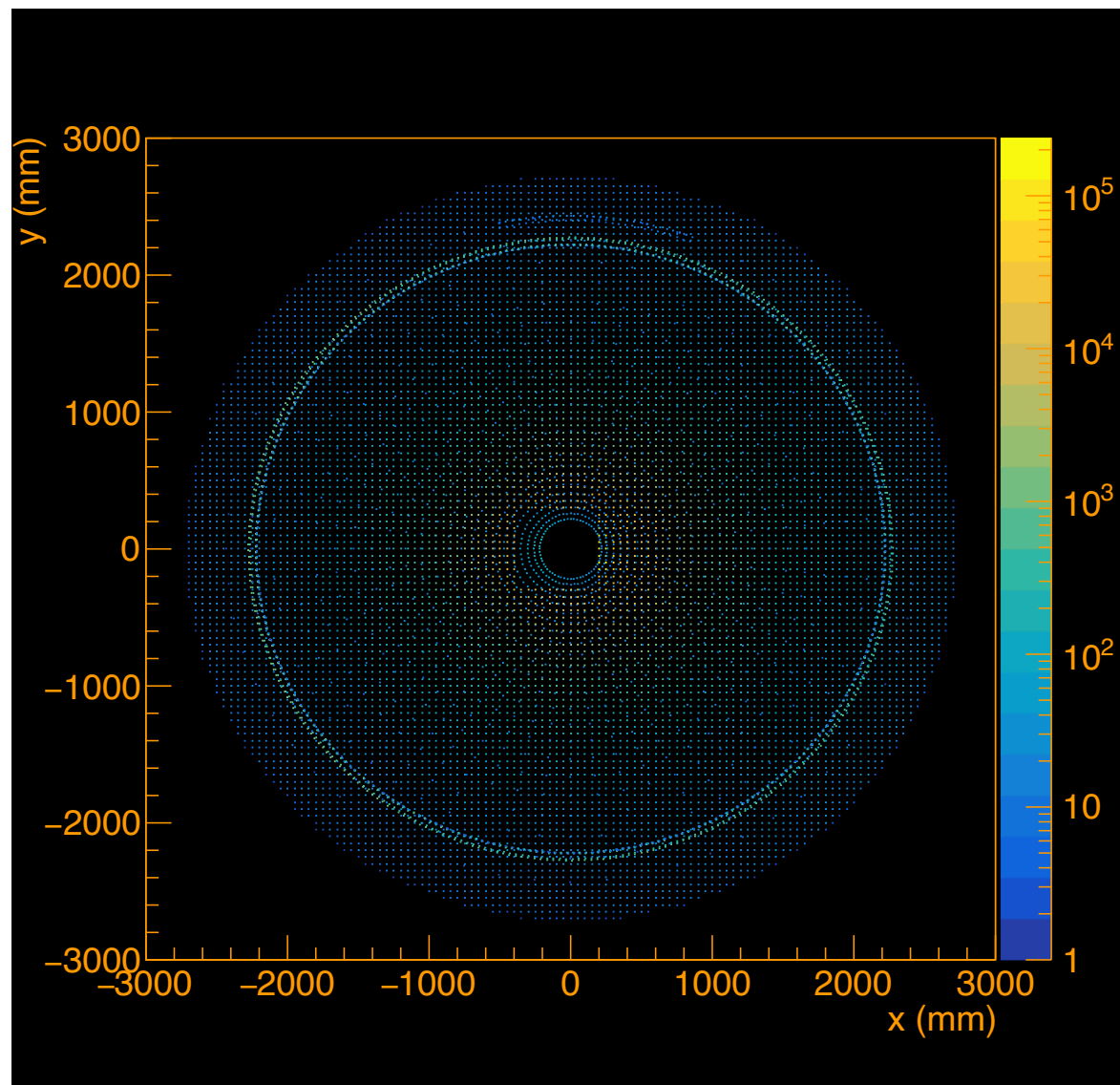
VertexBarrel Hits Distribution



Electromagnetic calorimeters, EcalBarrelSciGlass+EcalEndcapP + EcalEndcapN +EcalEndcapPInsert



Hadron calorimeters, HcalBarrel + HcalEndcapN + HcalEndcapP

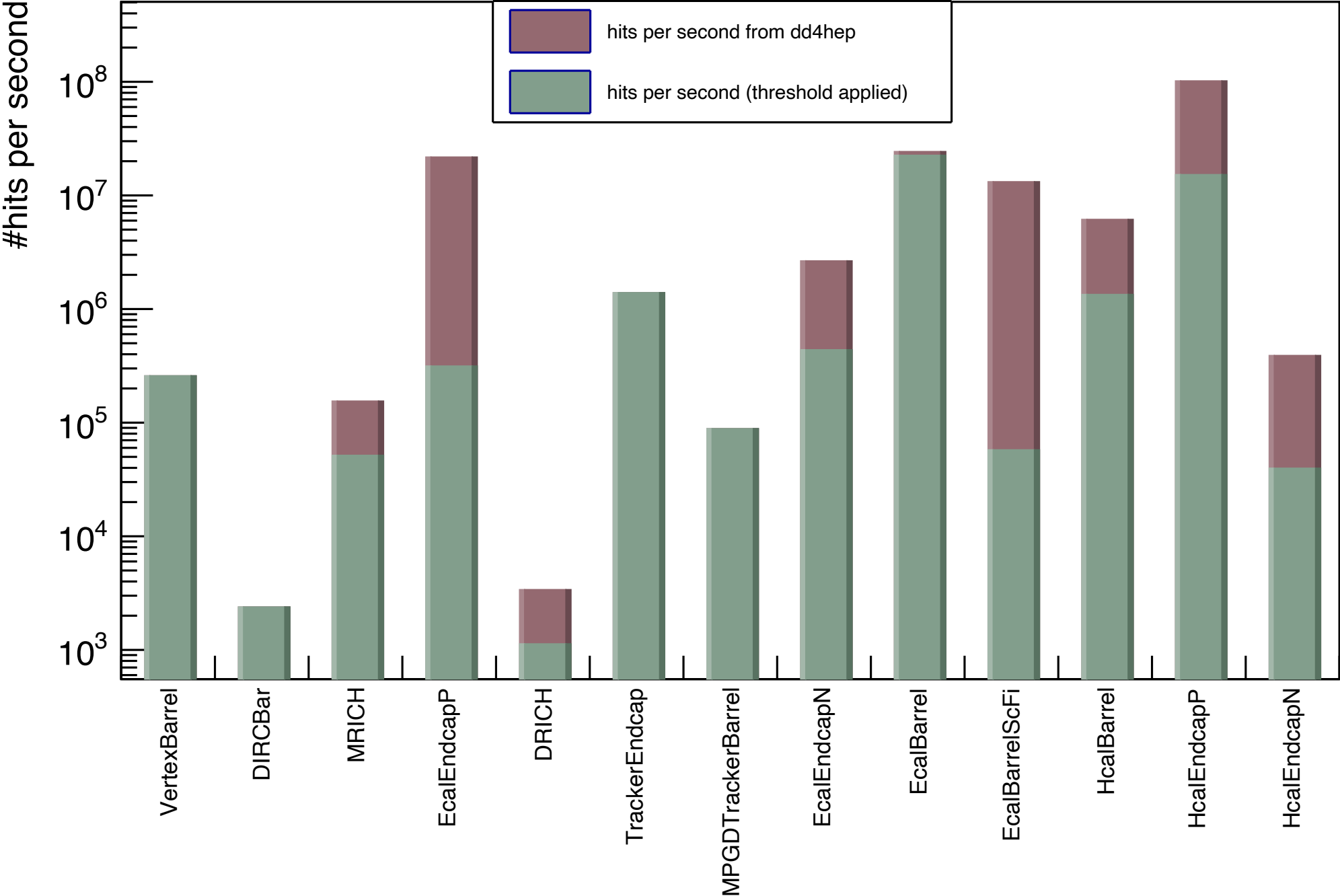


Hits Rate and Threshold

	readout	no. hits per	Threshold	after threshold
VertexBarrel	0.010mm*0.010mm	2.27E+05	0.4keV	2.27E+05
DIRCBar	3.0mm*3.0mm	4.40E+06		4.4E+06
ERICH	3.2mm*3.2mm	4.81E+05	divided by 3	1.60E+05
EcalEndcapP	1 fiber (20.5mm*20.5mm)	3.58E+07	5 MeV	7.34E+05
DRICH	3.2mm*3.2mm	8.05E+06	divided by 3	2.68E+06
TrackerBarrel	0.010mm*0.010mm	1.33E+05	0.4 keV	1.33E+05
TrackerEndcap	0.010mm*0.010mm	1.61E+06	0.4 keV	1.61E+06
MPGDTrackerBarrel	0.52mm*0.52mm	5.75E+05	0.2 keV	5.31E+05
GEMTrackerEndcap	0.17mm*0.87mm	1.14E+06	0.2 keV	1.03E+06
EcalEndcapN	1 fiber (20.5mm*20.5mm)	9.43E+05	2.5 MeV	8.47E+04
EcalBarrel	0.5mm*0.5mm	8.02E+05	0.4 keV	7.71E+05
B0Preshower		4.13E+04		4.13E+04
EcalBarrelScFi	1 fiber	2.06E+07	2.5 MeV	8.19E+04
HcalBarrel	100.0mm*100.0mm	6.63E+06	0.1 MeV	1.29E+06
HcalEndcapP	100.0mm*100.0mm	3.36E+07	300 MeV	2.36E+05
HcalEndcapN	100.0mm*100.0mm	9.34E+04	0.1 MeV	2.04E+04
B0Tracker		1.86E+05		1.86E+05
ForwardOffMTracker		2.11E+03		2.11E+03
ffiZDCSi		4.36E+03		4.36E+03
ffiZDCWSciFi		2.03E+05		2.03E+05
ffiZDCSiPb		1.91E+05		1.91E+05
ForwardRomanPot		1.35E+05		1.35E+05
ffiZDCScint		5.03E+03		5.03E+03

For EPIC, I used 0.1MeV (single layer) threshold for Hcal, a similar threshold like Athena case may need to be studied;

Hits rate in each detector



Summary

- HepMc3 files produced by Pythia8 can be found in **/gpfs/mnt/gpfs02/eic/zhangzq/EPIC/eic/protonBeamGasEvents_Pythia8**
- The events (20k) produced by dd4hep can be found in **/gpfs/mnt/gpfs02/eic/zhangzq/EPIC/eic/protonBeamGasEvents_dd4hep**
- Wiki page is updating for proton beam gas background: **<https://wiki.bnl.gov/EPIC/index.php?title=Background>**

THANK YOU!
