Transverse Single Spin Asymmetry (A_N) of Neutral Pions at Intermediate Rapidities using the EEMC in Run15 200 GeV pp Collisions at STAR

For the STAR PWG Meeting, December 2024

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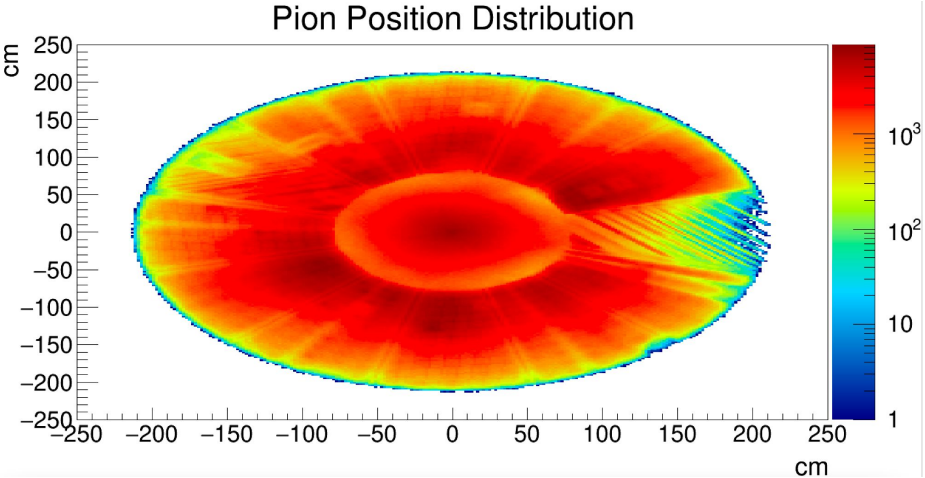
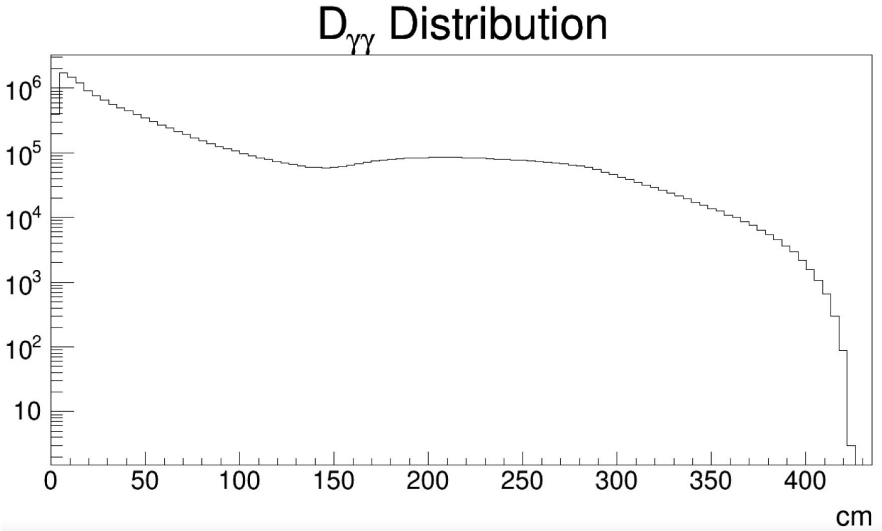
QA plots - Pion Position Distribution and D Distribution

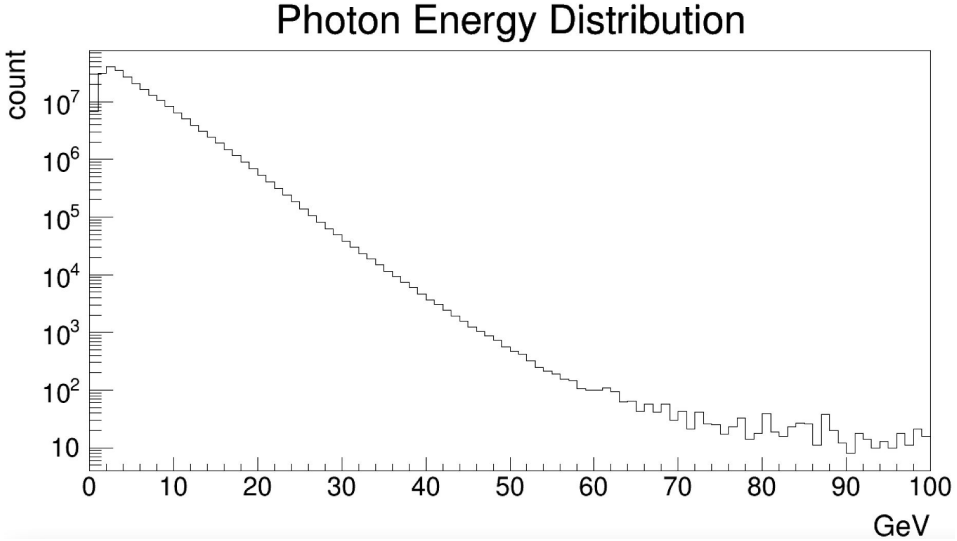


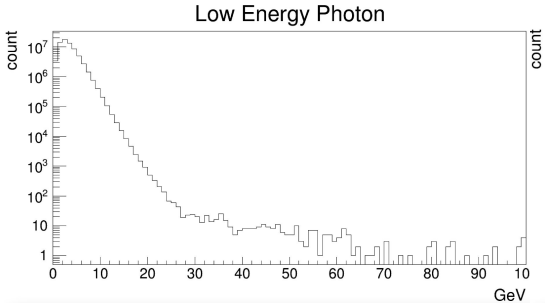


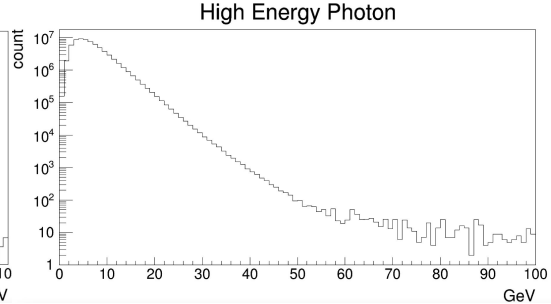
$$\mathrm{Pos}_{\pi^0} = \frac{1}{2}(\mathrm{Pos}_{\gamma_1} + \mathrm{Pos}_{\gamma_2})$$

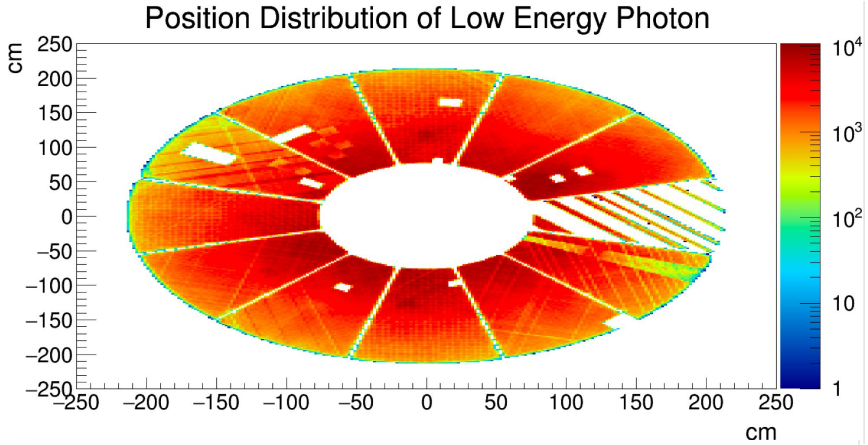
$$\mathrm{D}_{\pi^0} = |\mathrm{Pos}_{\gamma_1} - \mathrm{Pos}_{\gamma_2}|$$

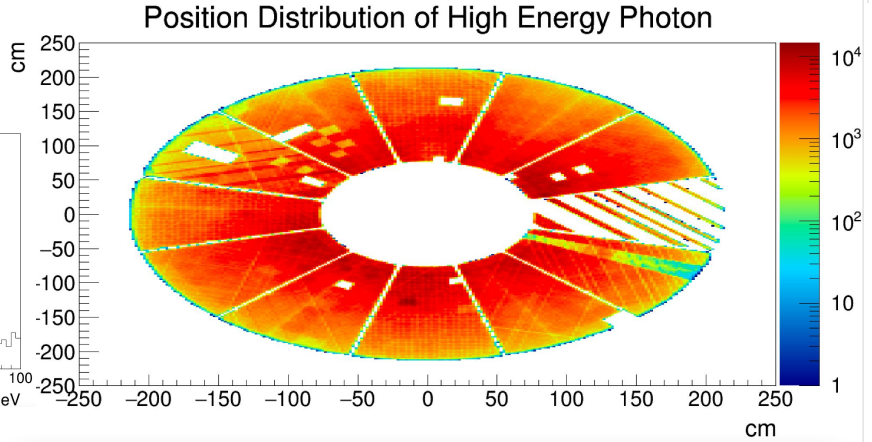
QA plots - Photon Energy Distribution & Position Distribution





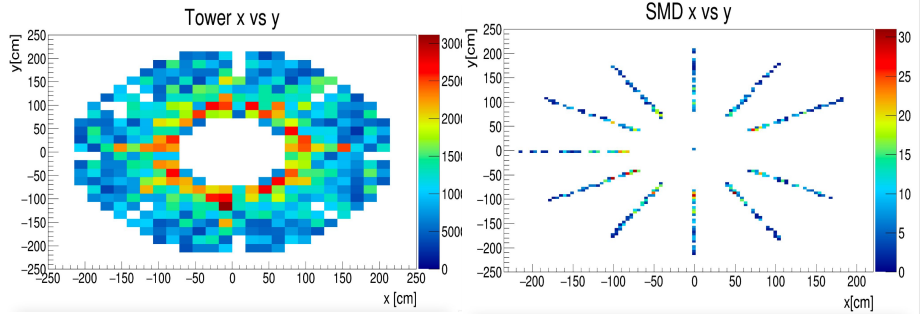




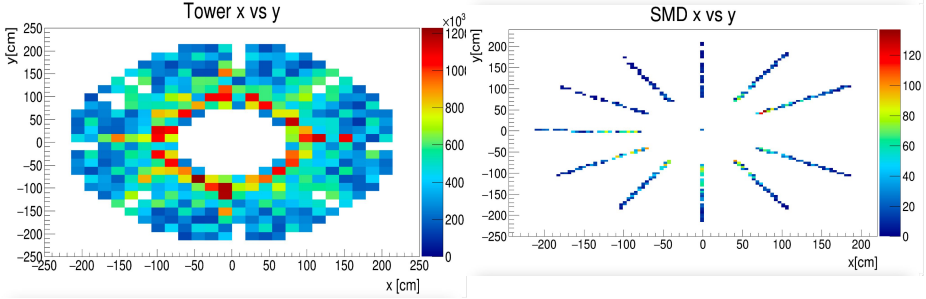


Recap : EEMC Data for Run15

-π/12 to π/12 sector is bad , Avoid phi bins 11 and 12 in analysis

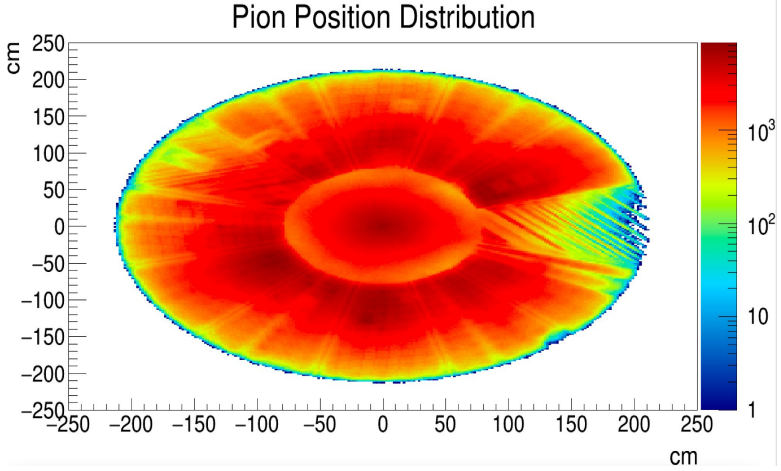


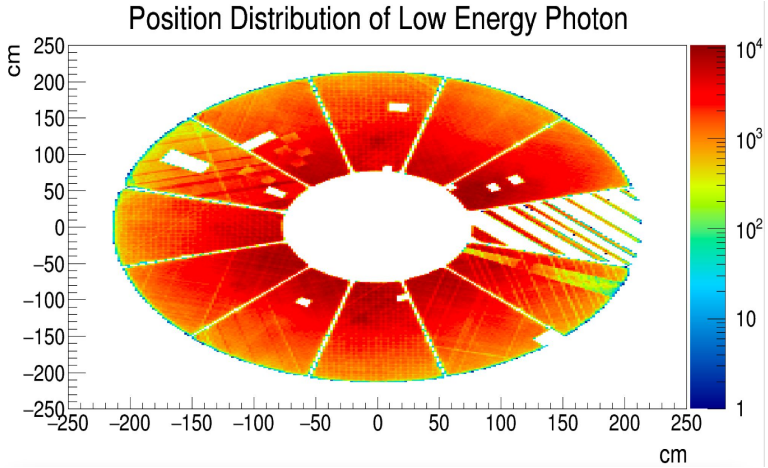
Run: 16064077



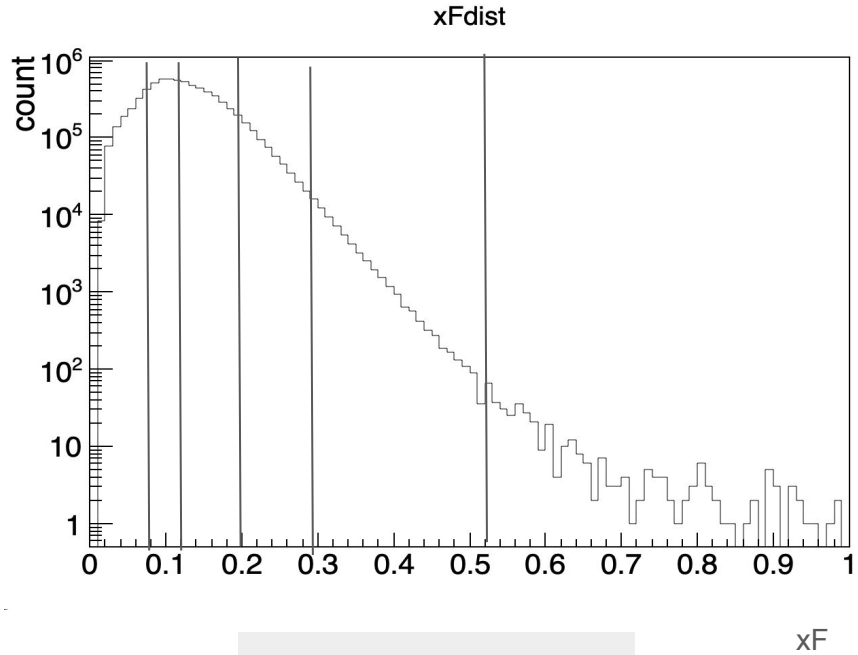
Run: 16090026

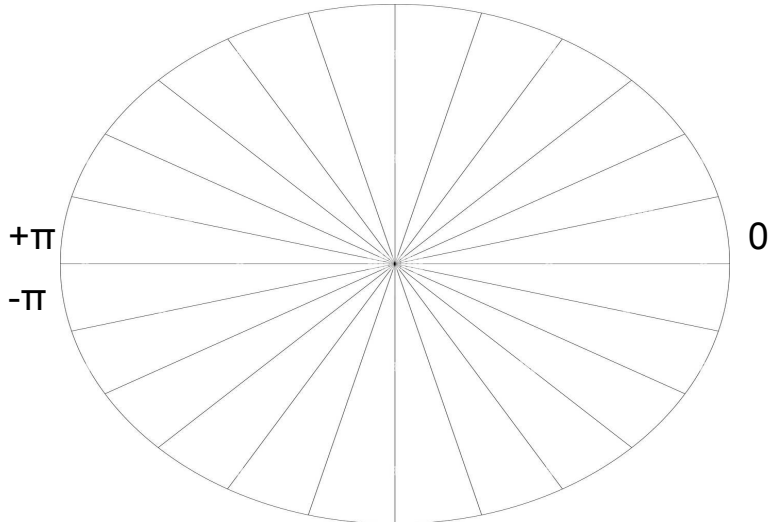
Run-by-run analysis of EEMC tower hits and SMD towers





xF and phi bins





xF Bins:
0.08 < xF < 0.12
0.12 < xF < 0.20
0.20 < xF < 0.30
0.30 < xF < 0.54

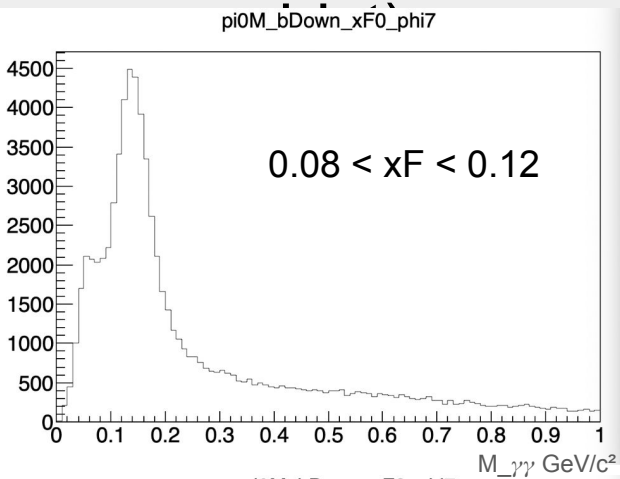
Phi Bins:
24 bins : 0 - 2pi
1 bin : 15 deg, π/12

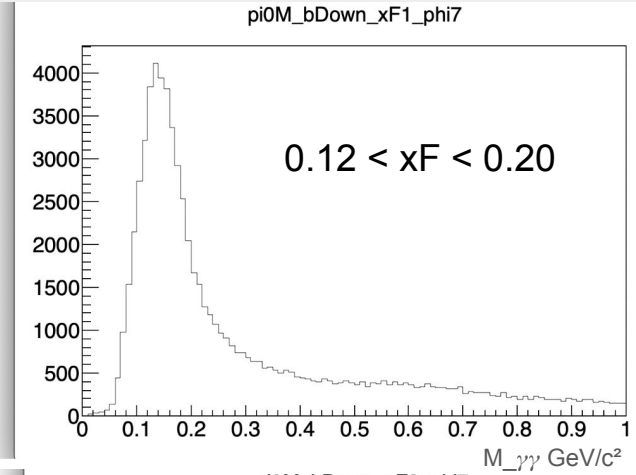
Blue Beam - Pi0 Invariant Mass plots for xF and phi bins (96)

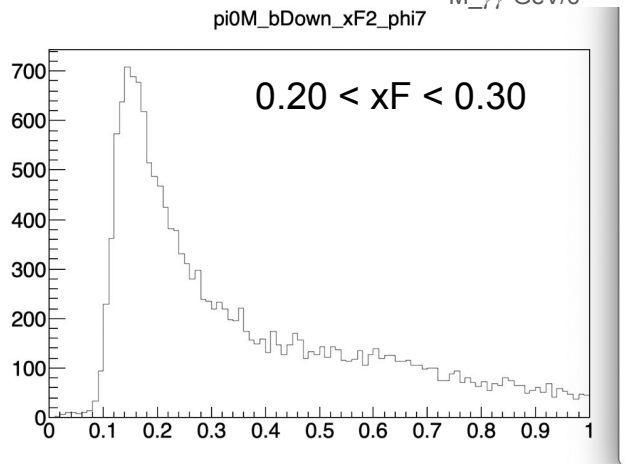
xF Bins:
0.08 < xF < 0.12
0.12 < xF < 0.20
0.20 < xF < 0.30
0.30 < xF < 0.54

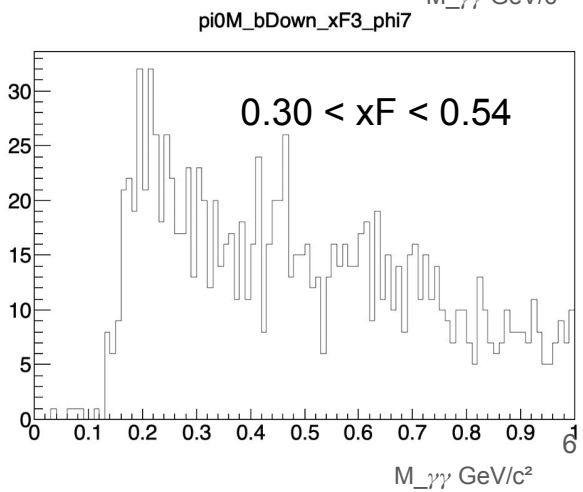
$$x_F = \frac{E_{\pi^0}\tanh(\eta)}{\text{Beam Energy}\ (100\ \text{GeV})}$$

Phi Bins:
24 bins : 0 - 2pi
1 bin : 15 deg, pi/12

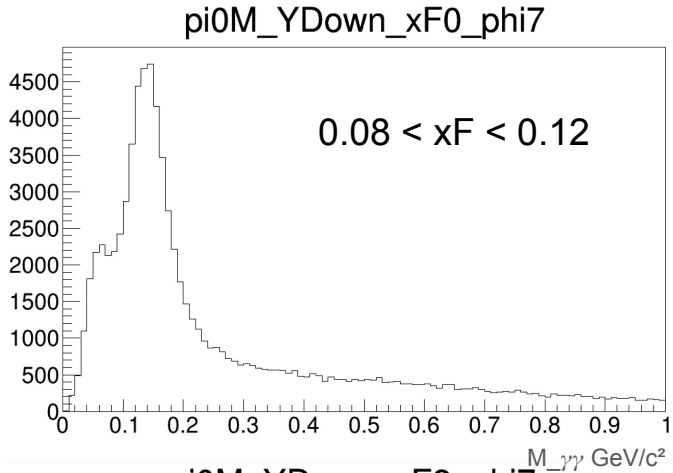


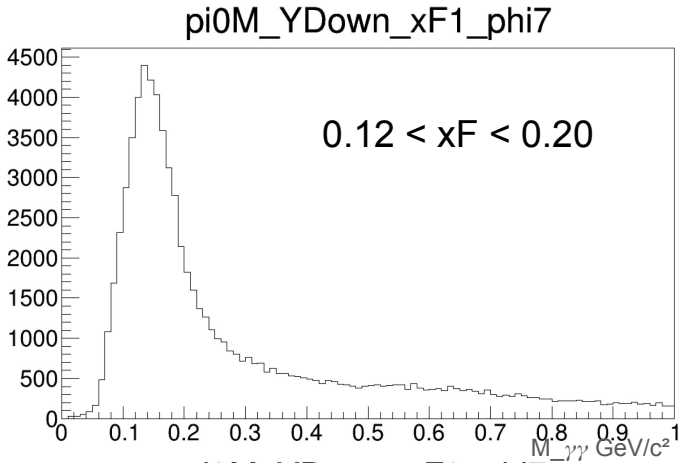


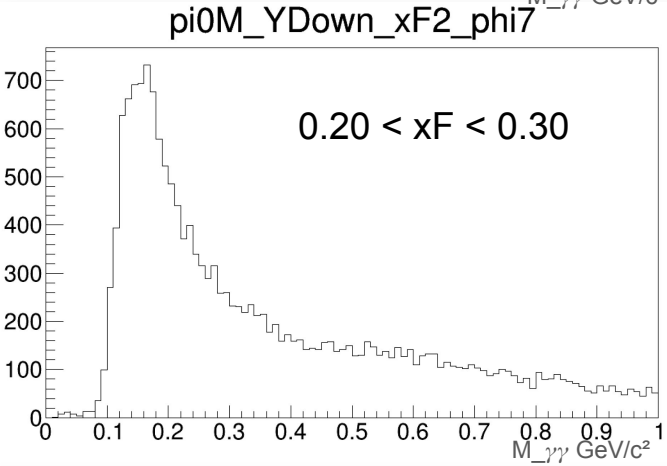


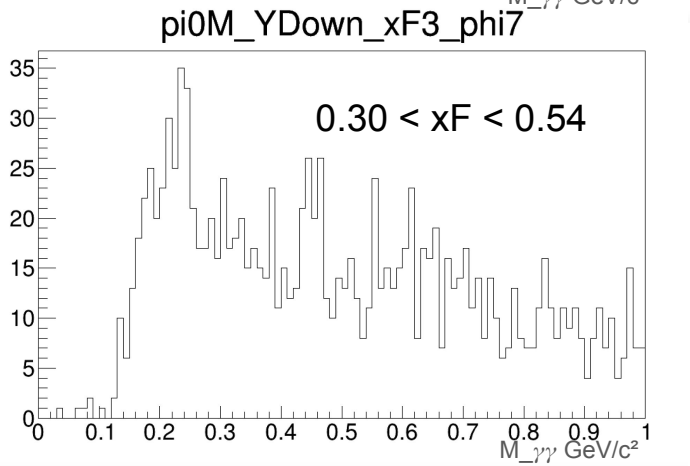


Pi0 invariant mass plots using the Yellow Beam





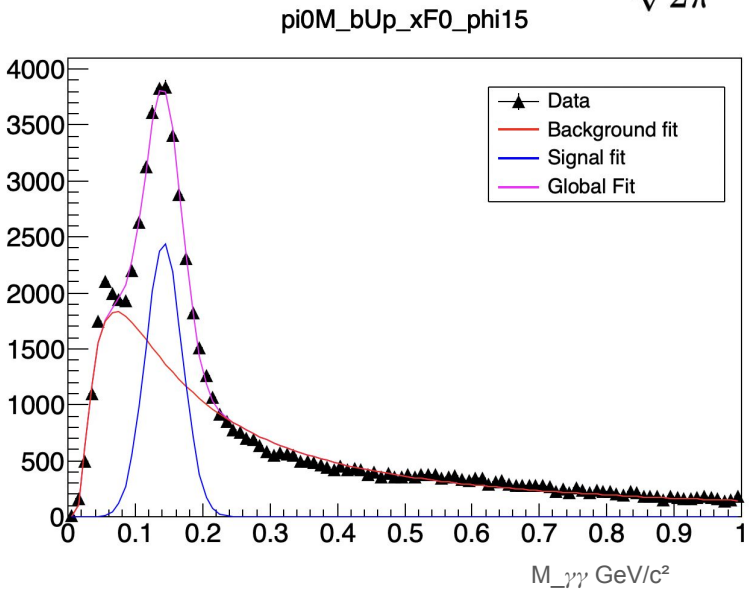


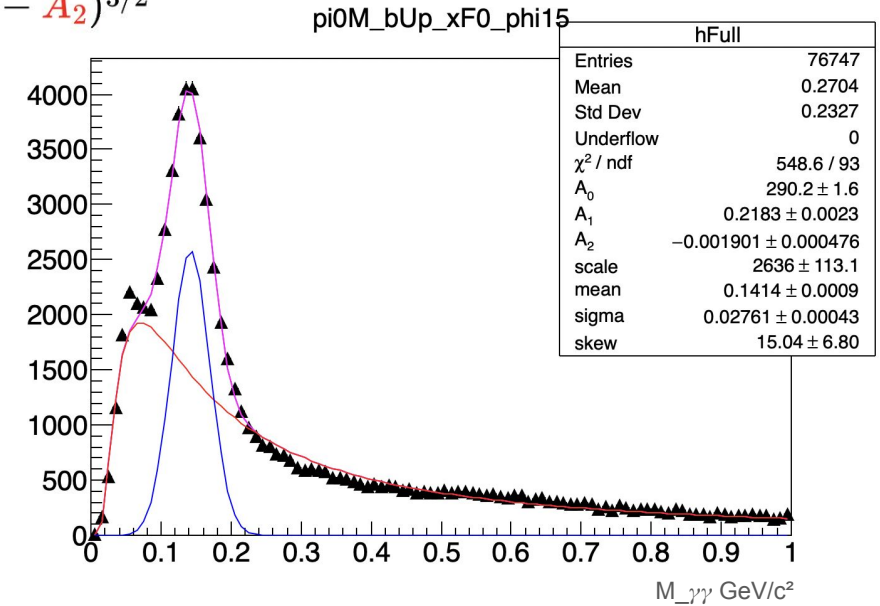


Fits for pi0 invariant mass plots for 1st xF bin i.e. 0.08 < xF < 0.12

Signal Fit : Skewed Normal Distribution : Scale * Gaus(Mean, Sigma) * CDF(skewness)

Background Fit : Levy Distribution : $\frac{A_0}{\sqrt{2}\pi} e^{\frac{-A_1}{2(x-A_2)}} \frac{1}{(x-A_2)^{3/2}}$





Calculate pi0 yields (N); Calculate raw A_N for signal and sideband regions using :

$$\frac{1}{P}\frac{N_\uparrow(\phi) - RN_\downarrow(\phi)}{N_\uparrow(\phi) + RN_\downarrow(\phi)} = B + A_N \cos\phi,$$

Using Embedding sample to estimate the background function

Run15 pp200 Transverse Embedding Request

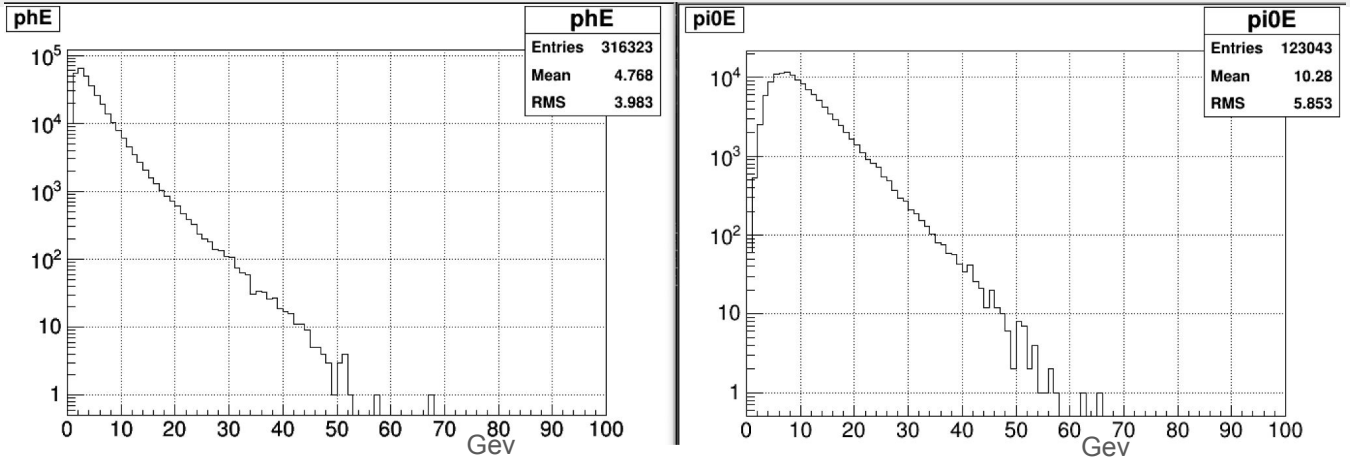
Ting Lin

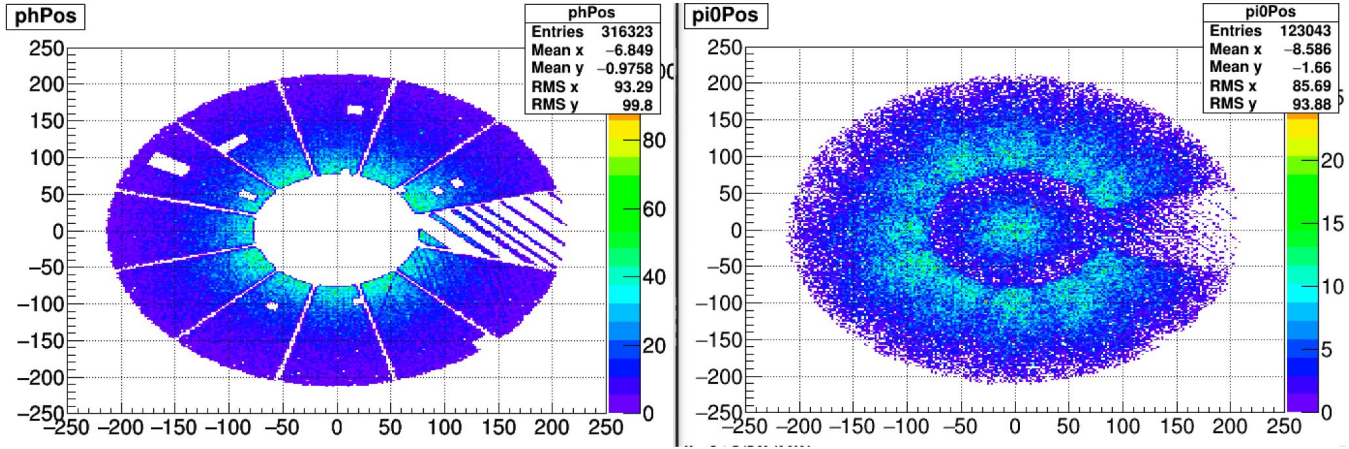
Simulation Setting:

1. Type of simulations request: Standard Embedding
2. Number of events: 7.74M
3. Magnetic Field: Reversed Full Field, -5.0 T
4. Collision Type: pp 200 GeV
5. Data Production: P16id
6. Geometry: y2015c
7. STAR Library for simu: SL16d
8. STAR Library for reco: SL16d_embed
9. BFC tags
    a. DAQ: in, magF, tpcDb, NoDefault, TpxRaw, -ittf, NoOutput, useXgeom
    b. FZD: fzin, gen_T, geomT, sim_T, TpcRS, -ittf, -tpc daq, nodefault, ry2015c
    c. MIX: DbV20160418 DbV20191105_EMC_Calibrations DbV20190702_EEMC_Calibrations DbV20190702_TRG_Calibrations pp2015c btof Sti mtd mtdCalib pp2pp fmsDat fmsPoint fpsDat BEmcChkStat -evout CorrX OSpaceZ2 OGridLeak3D -hitfilt TpxClu -VFMinuit VFPPVnoCTB beamLine TpcMixer, GeantOut, MiniMcMk, McAna, -in, NoInput, useInTracker ry2015c, emcSim, EEfs
10. Vertex option: Leave vertex to be reconstructed vertex, and use VFPPVnoCTB with beamline constraints
11. Pile-up option: No
12. Detectors set for simulation reco: TPC, BEMC, EEMC

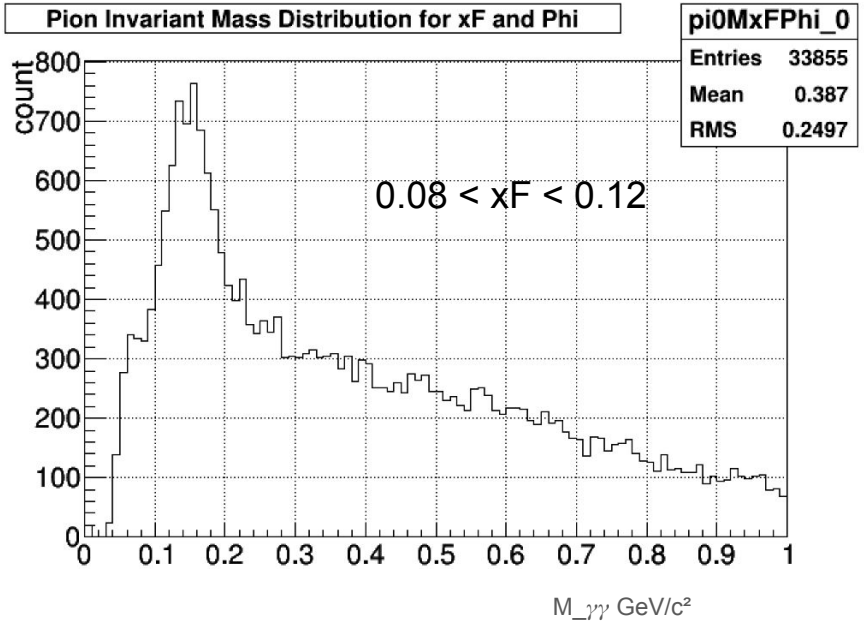
Available in HPSS

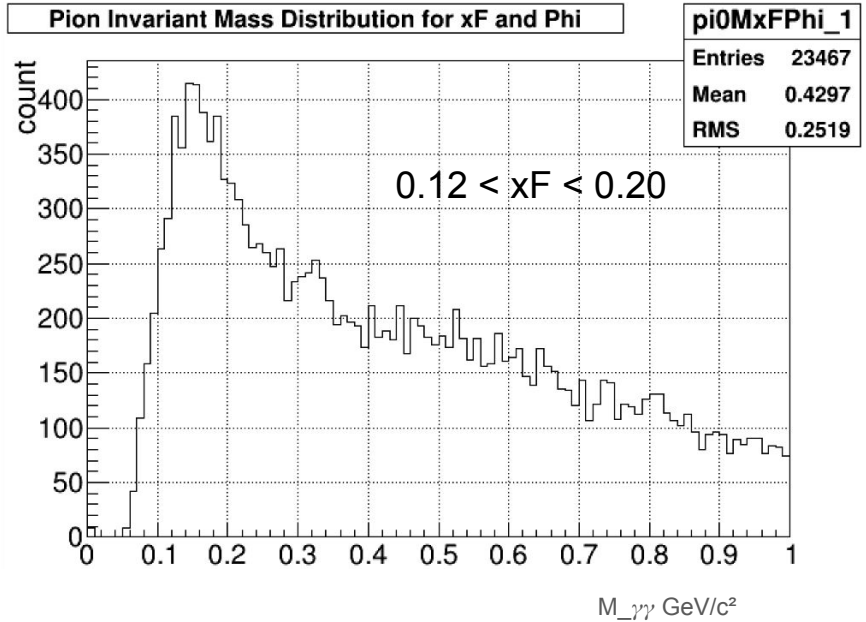
Embedding QA plots



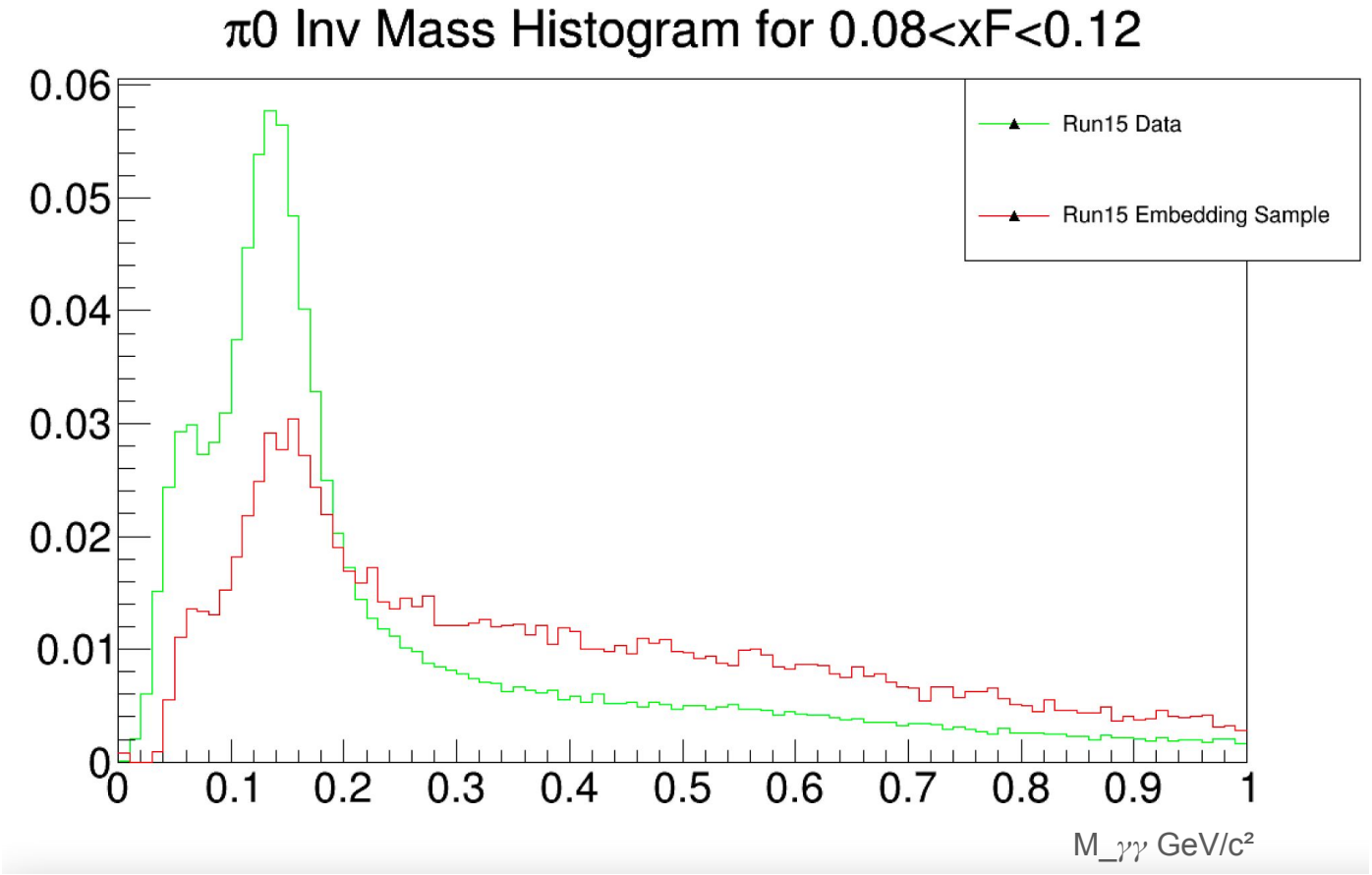


Embedding Sample





Comparison between Embedding and Data

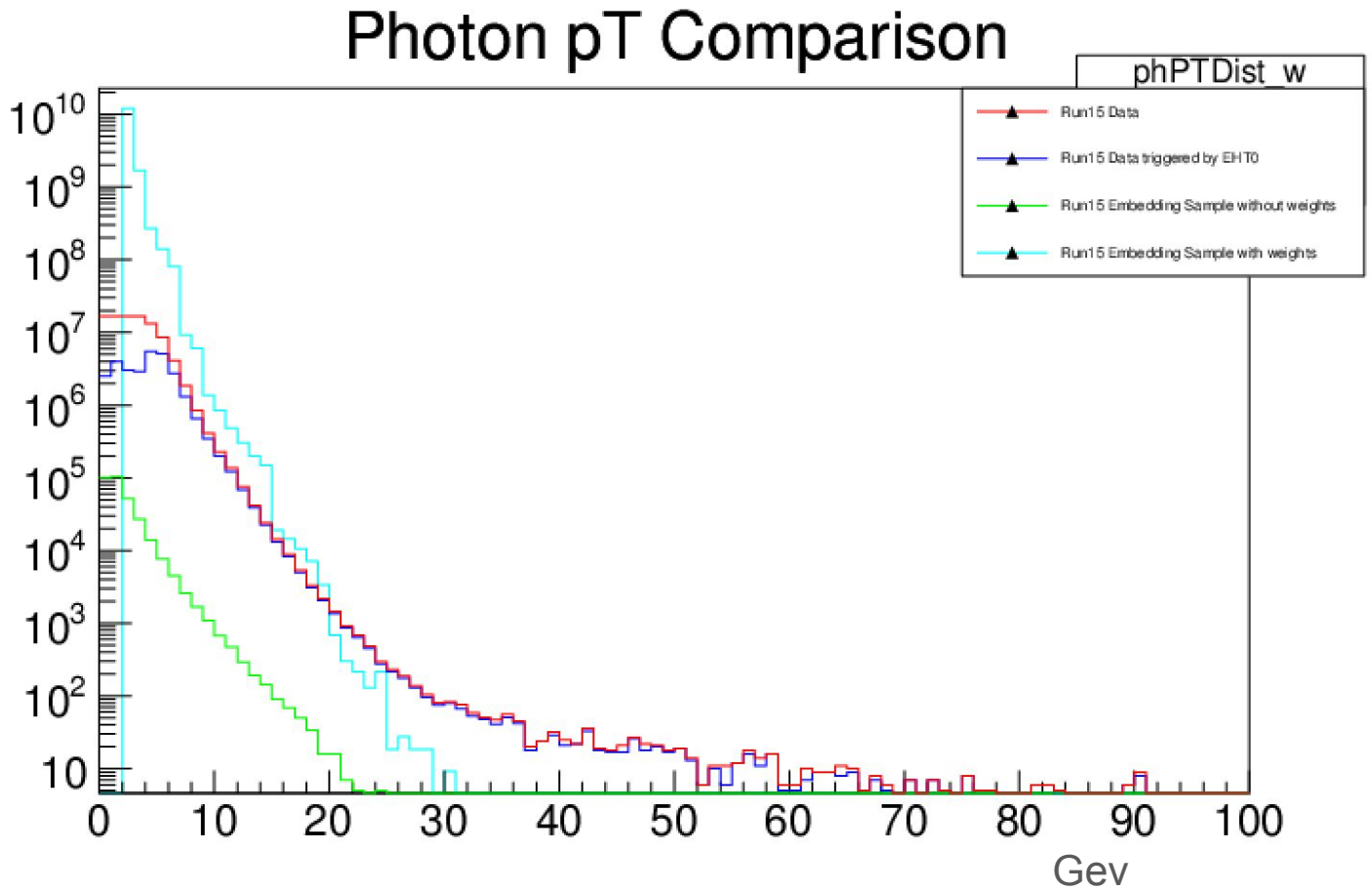


Weights from Ting's Analysis Note

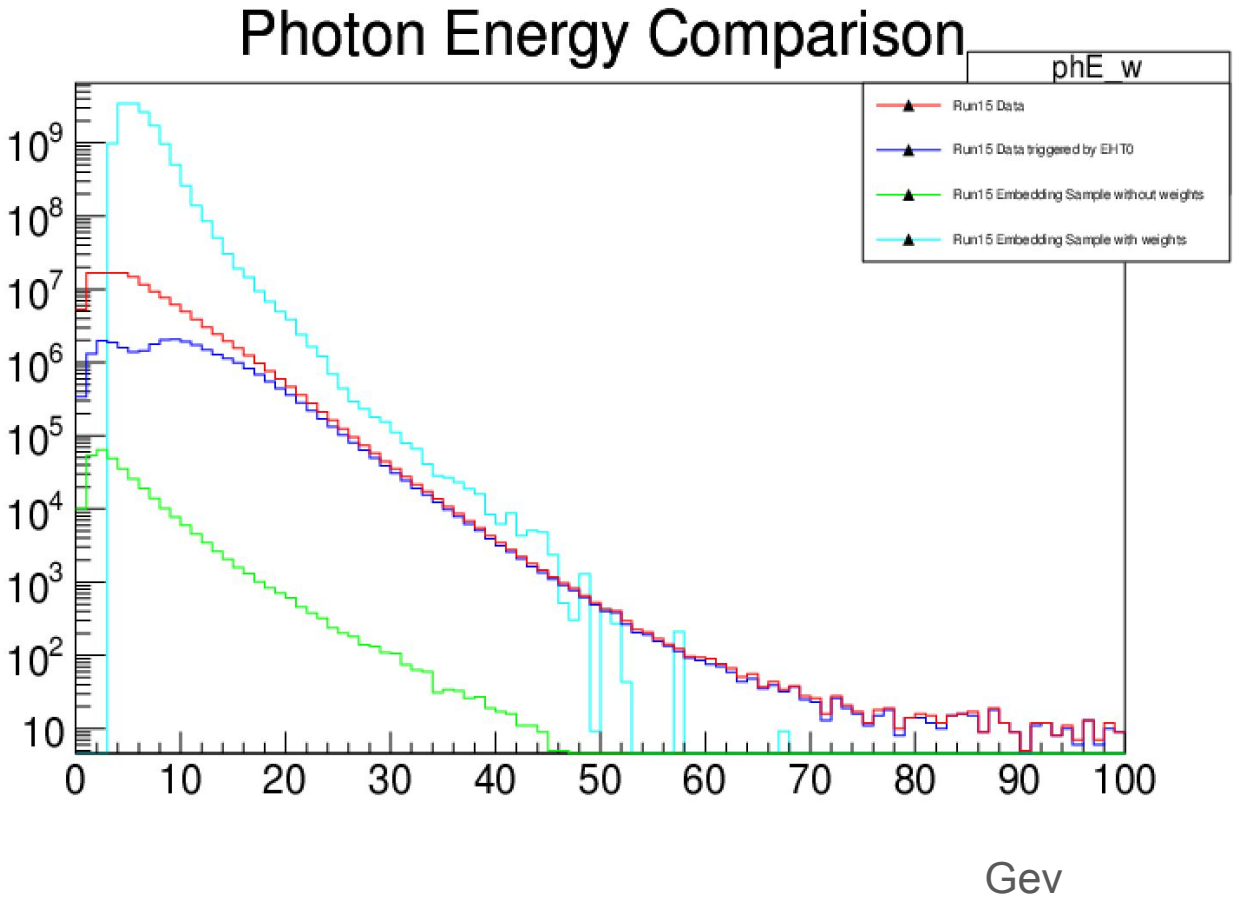
Partonic $\hat{p}_T$	Final Weight	PYTHIA Events
2-3	233830.00	12103343
3-4	62493.5	7862602
4-5	19213.9	6739219
5-7	18150.3	3078767
7-9	3581.99	2564991
9-11	1249.17	1727538
11-15	1032.87	826204
15-20	210.284	601778
20-25	43.072	391613
25-35	9.175	391613
35-∞	1.0	183386

Table 1.1: Generated Pythia simulation events and weight factors.

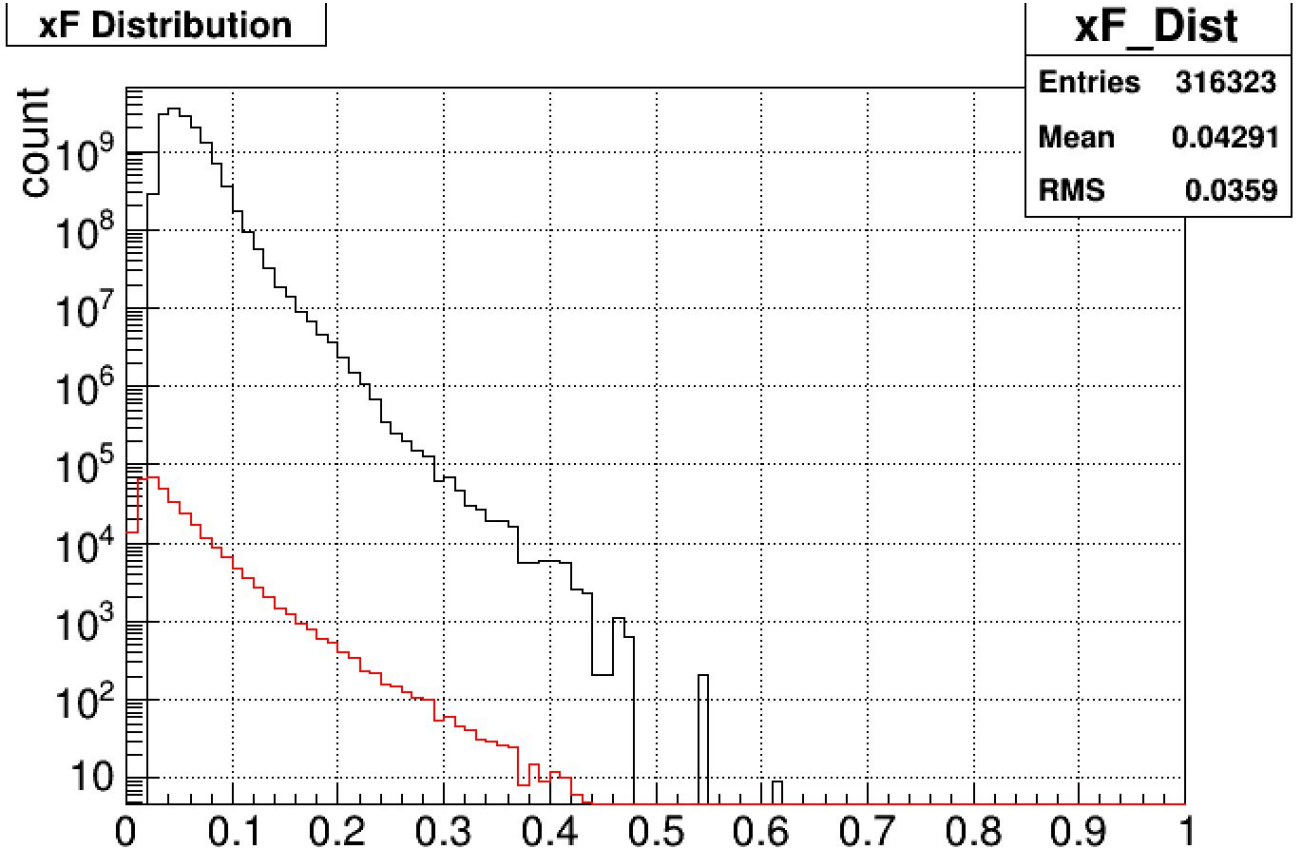
Photon pT Comparison



Photon Energy Comparison



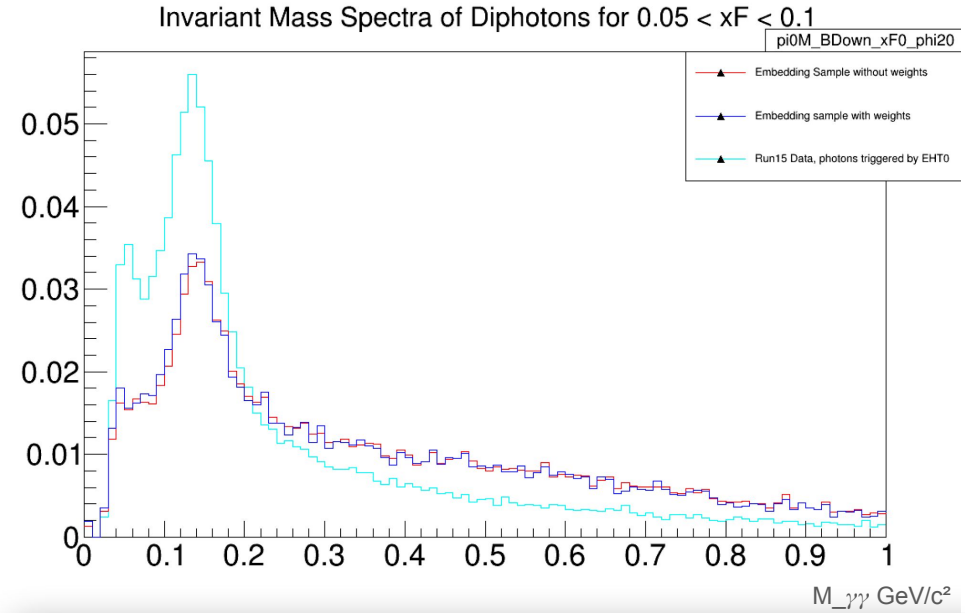
Photon xF Distribution for Embedding sample

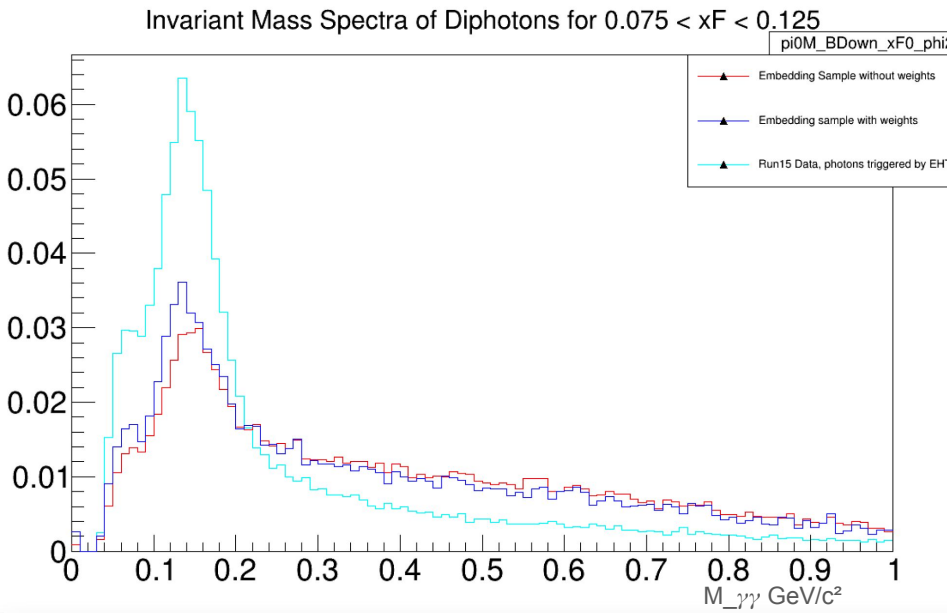


Rearranged xF bins to have the upper limit at 0.5

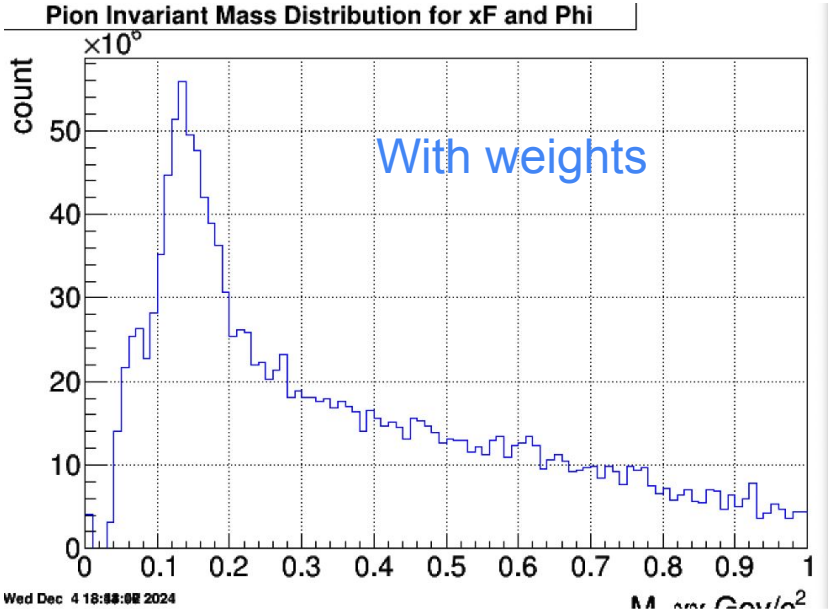
- With weights
- Without weights

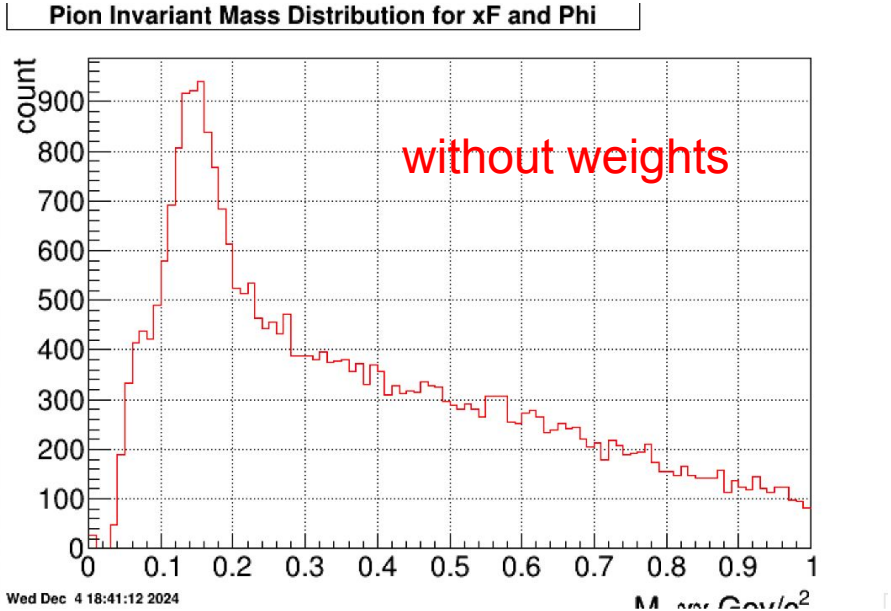
Pion Invariant Mass Spectra Comparison (Normalized)



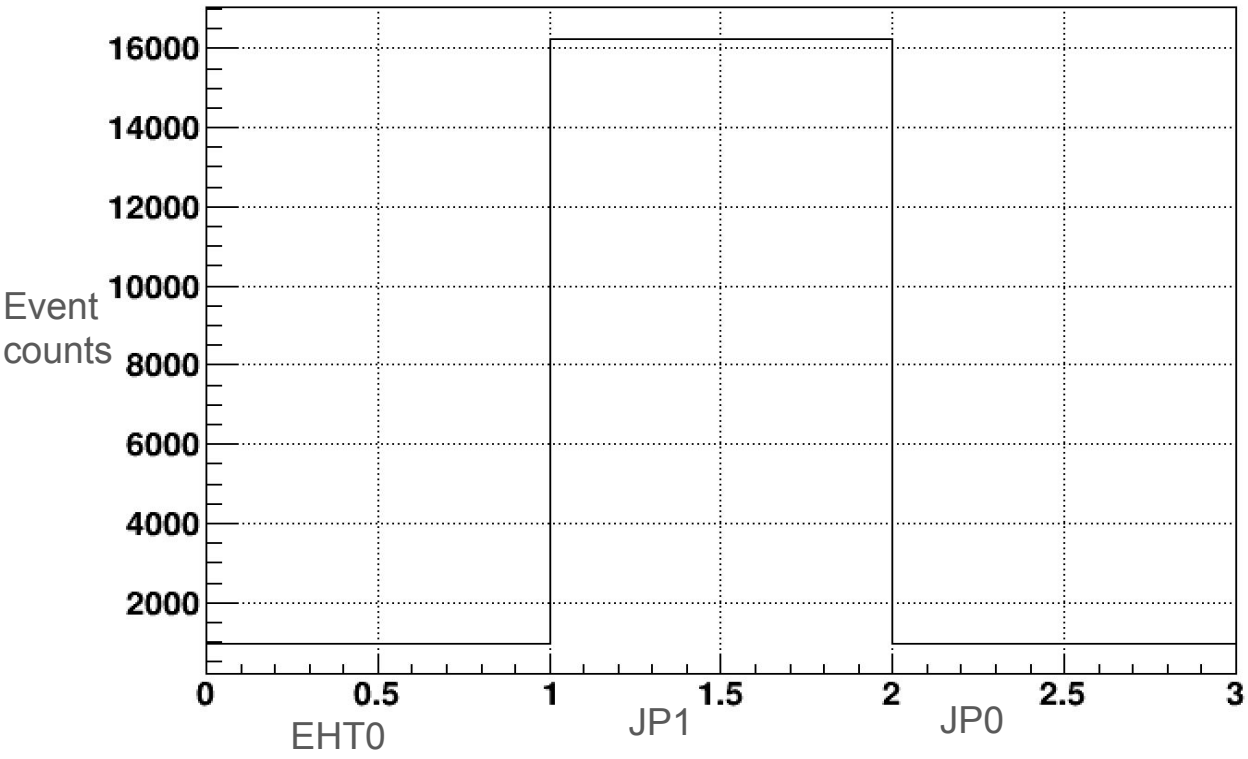


Pion Invariant Mass Spectra Comparison 0.075<xF<0.125 of Embedding Sample (Unnormalized)





Information from Trigger Simu Maker on Embedding



Events: Embedding Sample Runs 16065*

Total Events : 53473
Events Triggered by JP1 : 16253
Events Triggered by EHT0 : 981

Only ~ 2% EHT0 triggered events vs. 30% JP1 triggered events

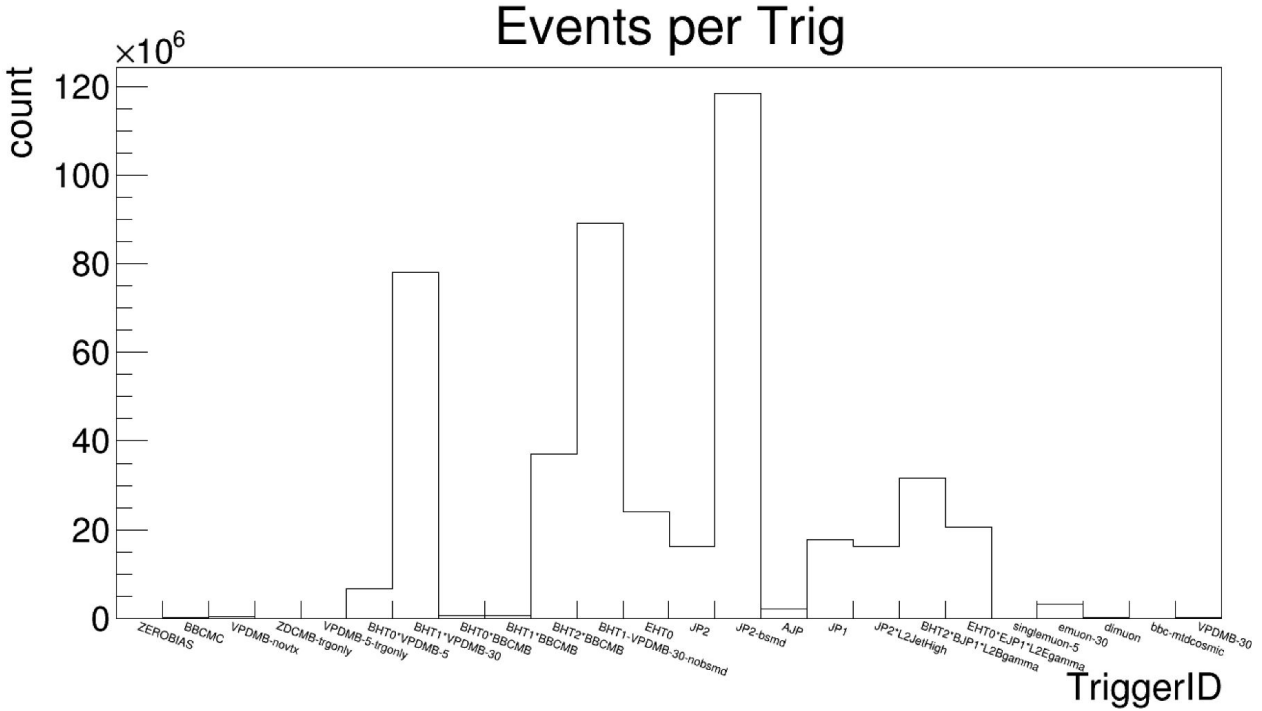
Qs : Is this Embedding sample a good comparison?

Thank You!
Looking forward to hear your comments/suggestions

Back-up Slides : Trigger EHT0 threshold calculation

Trigger Threshold ADC value for Run15 pp 200 trans system : 18 (from RunLog Browser)

0.236 × (ADC − 5). 18 ADC counts equal to 3.1 GeV.



Calculation of Raw A_N

The transverse spin asymmetry is computed by binning with respect to φ, the angle between the azimuthal angles of the pi0 and the spin polarization vector. The raw cross ratio ε(φ) is computed per φ bin:

$$\frac{1}{P}\frac{N_{\uparrow}(\phi) - RN_{\downarrow}(\phi)}{N_{\uparrow}(\phi) + RN_{\downarrow}(\phi)} = B + A_N \cos\phi$$

where, N = pi0 yields

↑ = Beam spin polarised vertically upward in the lab frame

↓ = vertically downward

P = average Polarisation

R = Relative Luminosity

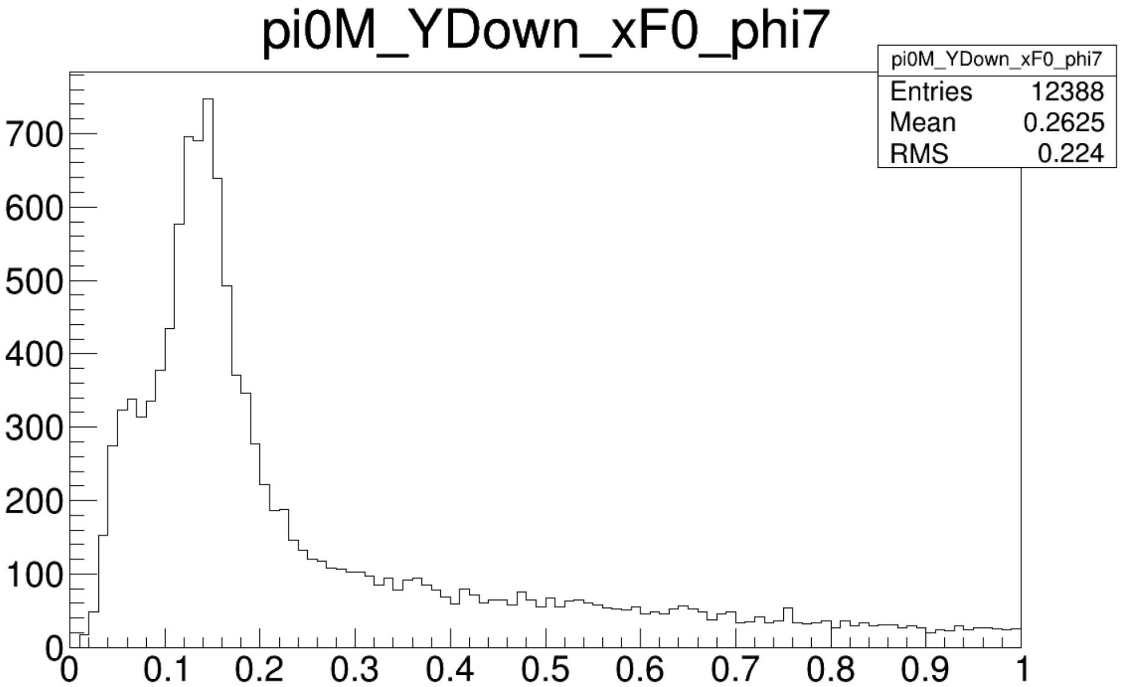
This gives the raw A_N. The asymmetry for neutral pions, A_N(pi0) is calculated as :

$$A_N^{\mathrm{raw}_{sig}} = f_{\mathrm{sig}_{sig}} * A_N^{\pi^0} + (1 - f_{\mathrm{sig}_{sig}}) * A_N^{bkg}$$

$$A_N^{\mathrm{raw}_{sb}} = f_{\mathrm{sig}_{sb}} * A_N^{\pi^0} + (1 - f_{sig_{sb}}) * A_N^{bkg}$$

Where signal (sig) and sideband (sb) regions will be defined in the pi0 invariant mass plots

Pion Invariant Mass with 3.1 GeV Energy Cut



Levy Distribution for Background Fits