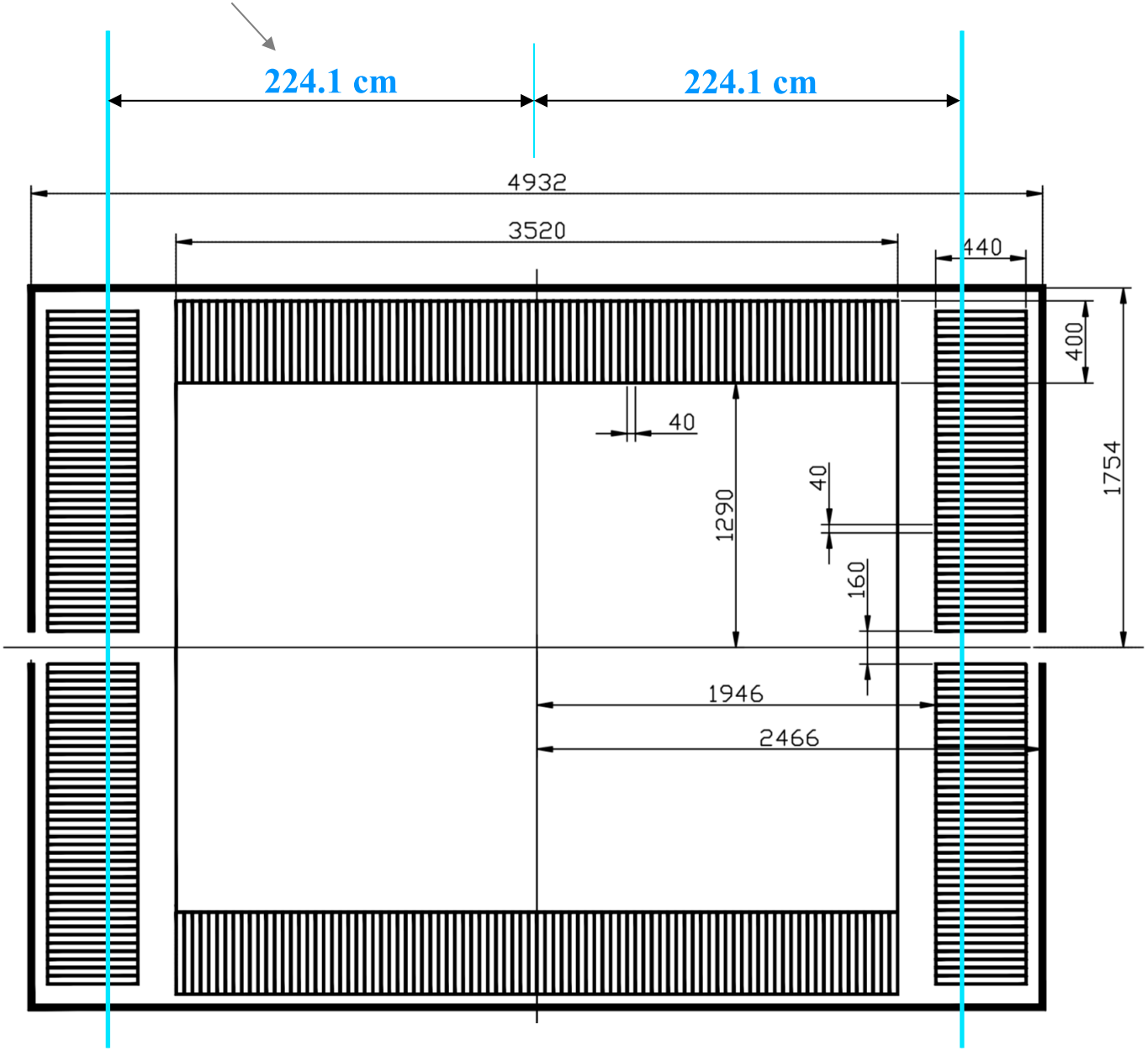
Reconstruction of π^0 in SPD ECAL endcaps (SPDRoot)

$$pp \to \pi^0 X$$

Position of the photon impact in the Ecal (hit position), from SpdEcalRCParticle



$$p + p \rightarrow \pi^0 + X$$

$$\gamma\gamma$$

SpdRoot

$\sqrt{s} = 27\ GeV$

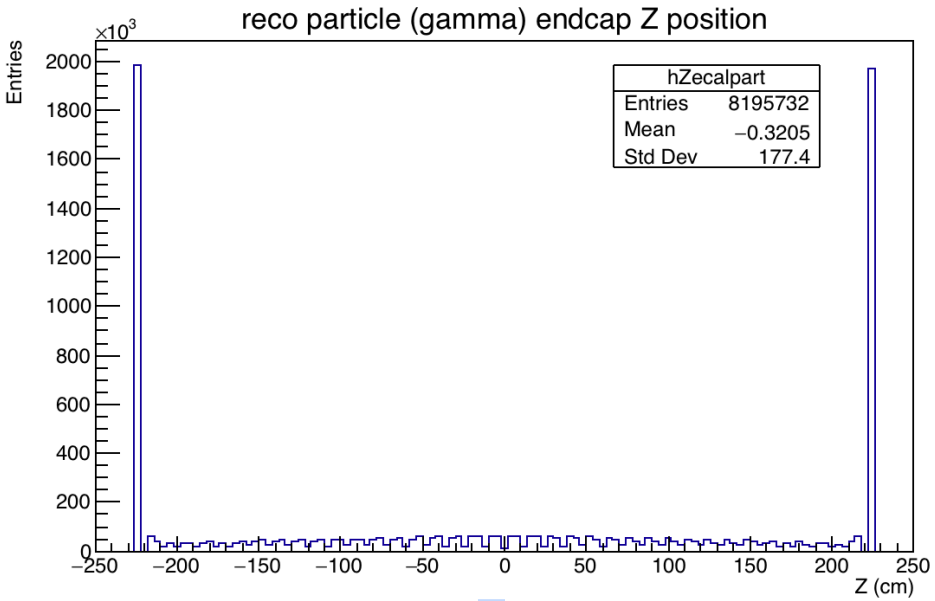
10^6 events

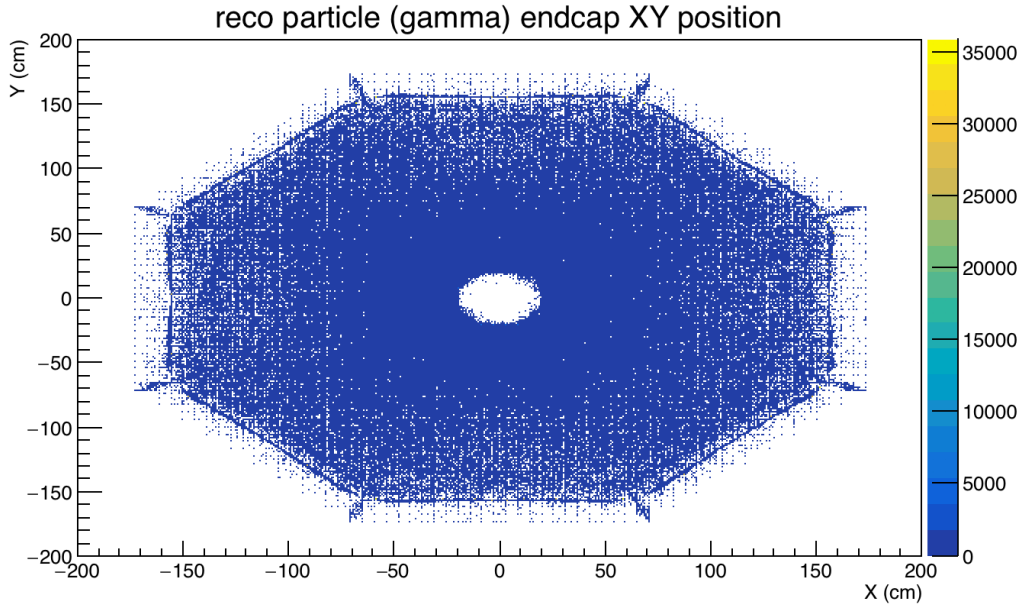
$E^{\gamma}_{min} = 400$ MeV

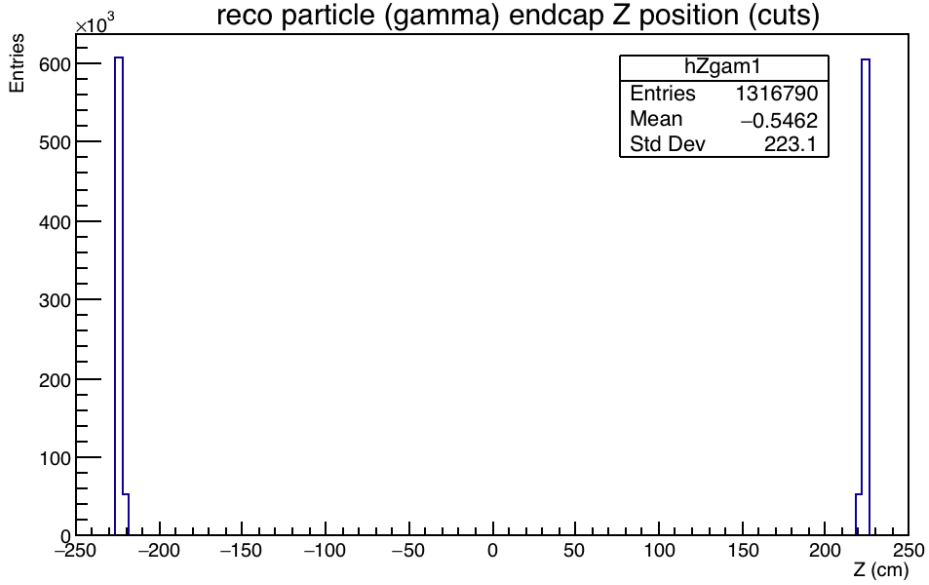
$p_T > 0.5$ GeV/c

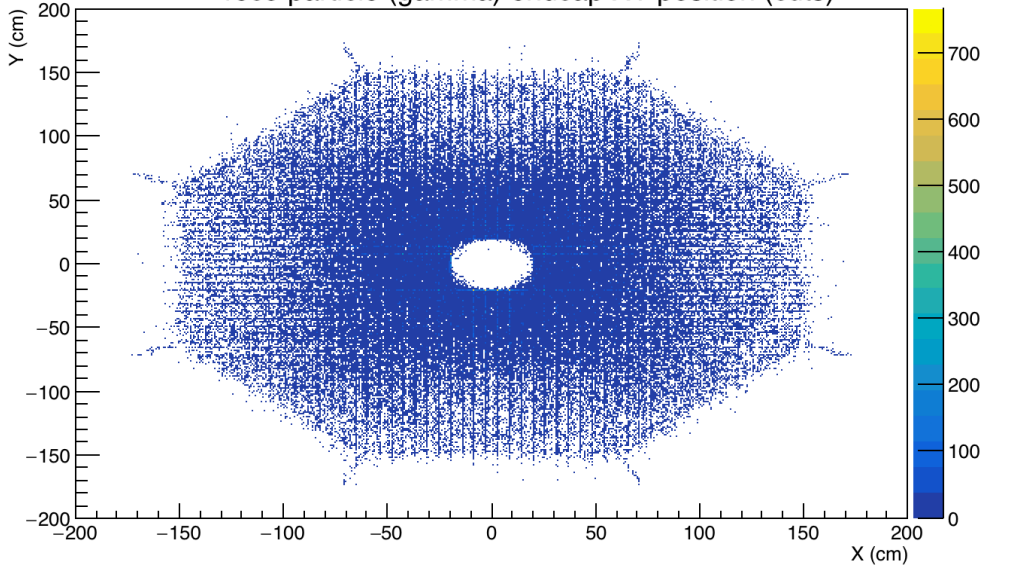
Pythia8 generator

Position distribution in the ECAL endcaps

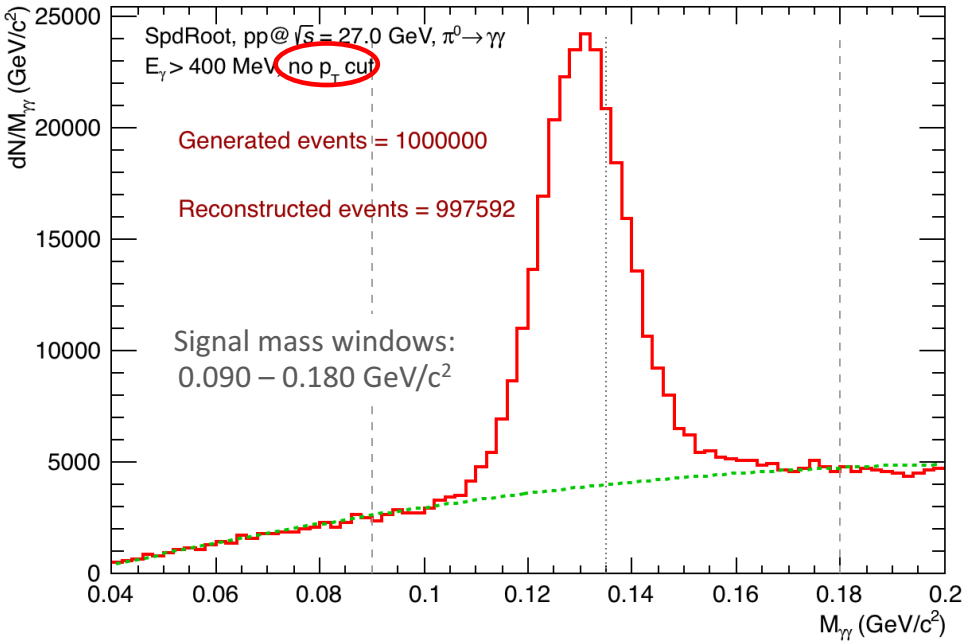


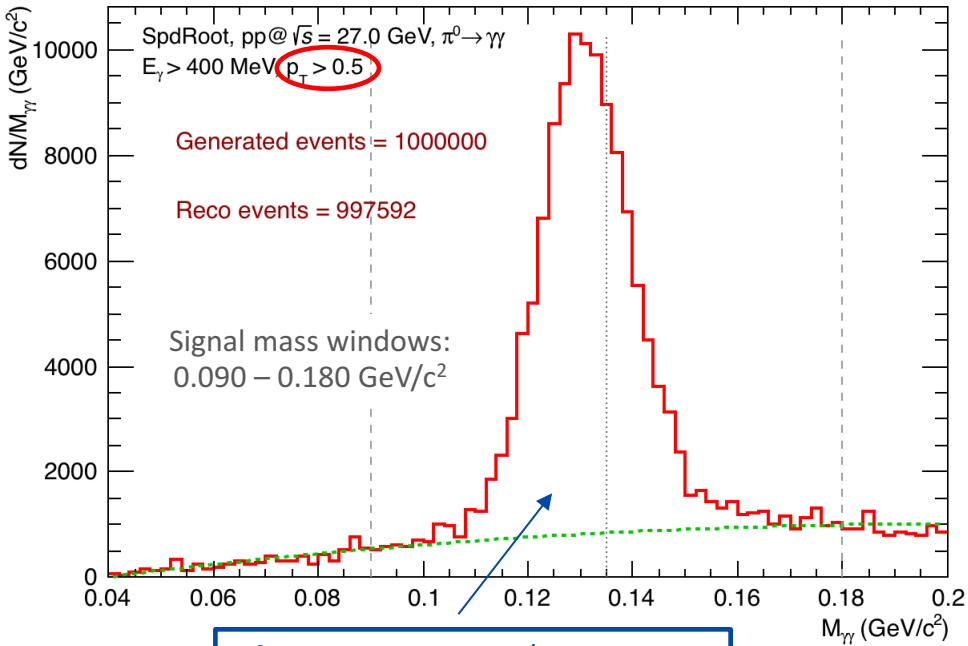






Cut on p_T

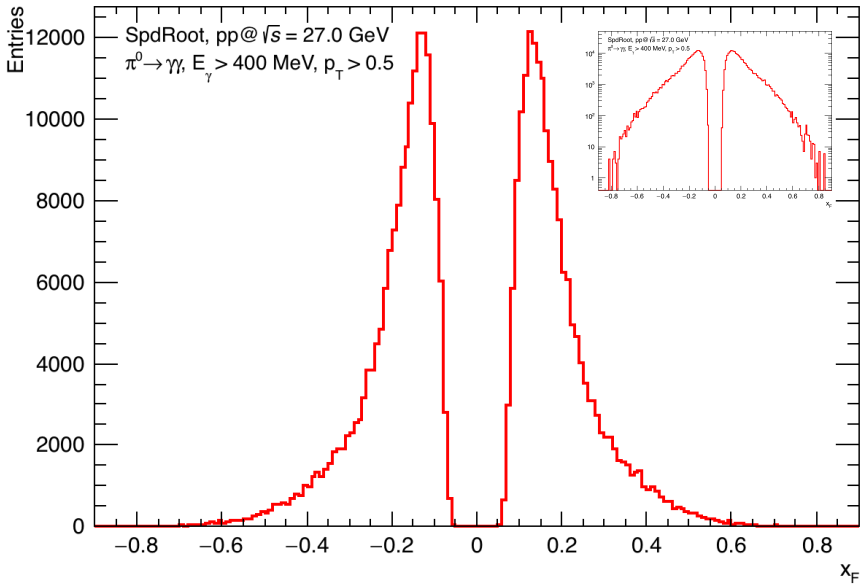


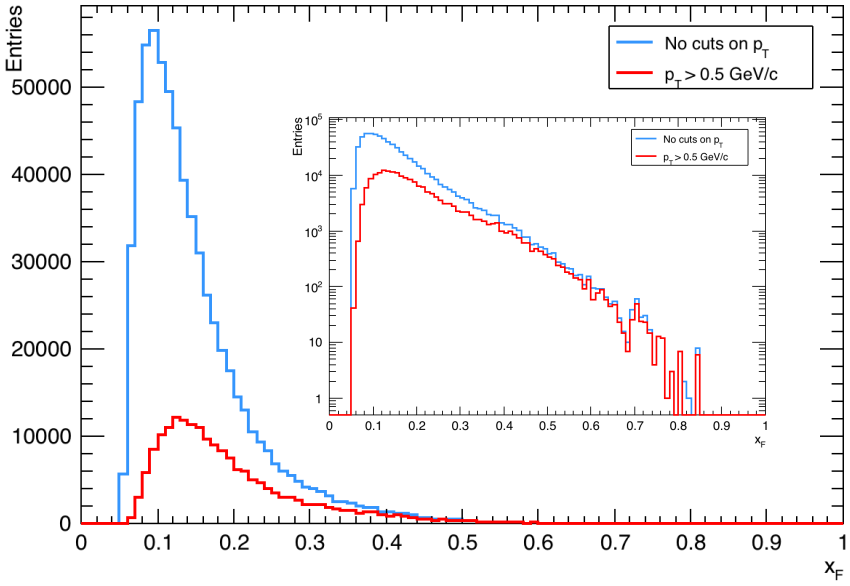


The mass peak in SpdRoot is obtained shifted from the π^0 mass!

After cut: $p_T > 0.5$ GeV/c:

- The yield is reduced **2.74** times
- The S/B ratio improves **1.7** times





Extraction of A_N

$p^{\uparrow} + p \rightarrow \boldsymbol{\pi^0} + X \qquad \phi = 2\pi$

The cross section of hadron production in polarized $p^{\uparrow} + p$ collisions, is modified in azimuth.

$$\frac{d\sigma}{d\phi} = \frac{d\sigma}{d\phi_0}(1 + \underbrace{P \cdot A_{\mathrm{N}} \cdot \cos\phi}_{\text{Azimuthal cosine modulation}})$$

$$N_{\boldsymbol{\pi^0}}(\phi) = A(1 + B\cos\phi)$$

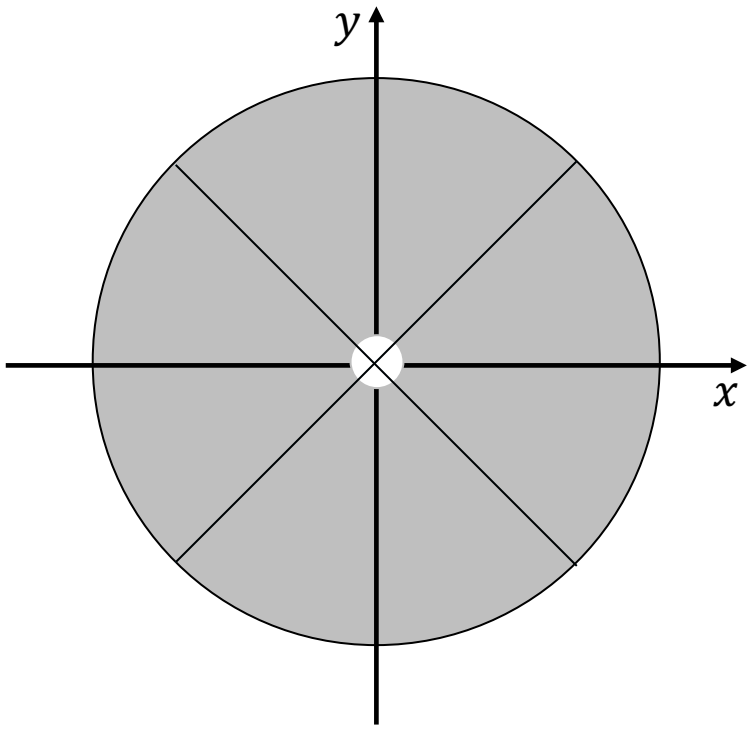
$$A_N = \frac{B}{P}$$

$N_{\boldsymbol{\pi^0}}(\phi)$: Yield of π^0

P: Beam polarization

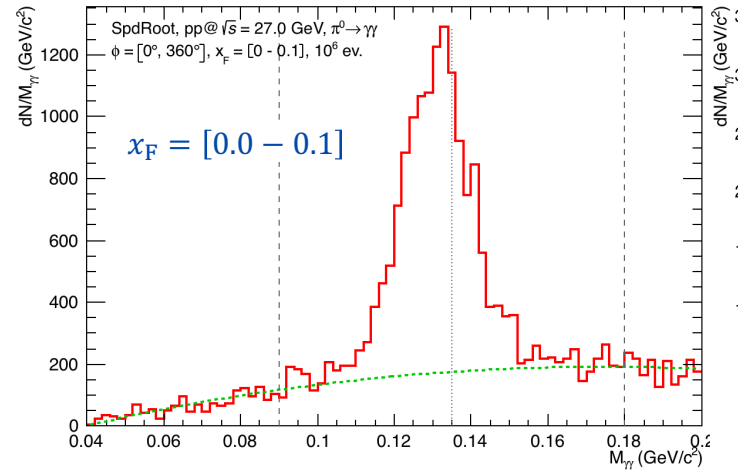
- P ~ 0.7 was assumed

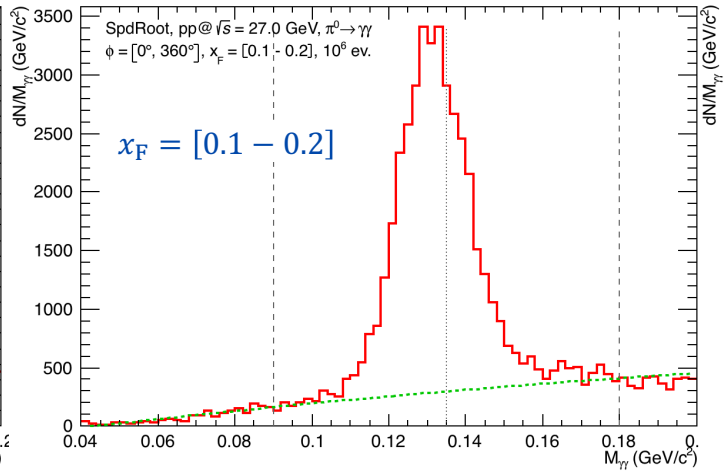
8 azimuthal bins

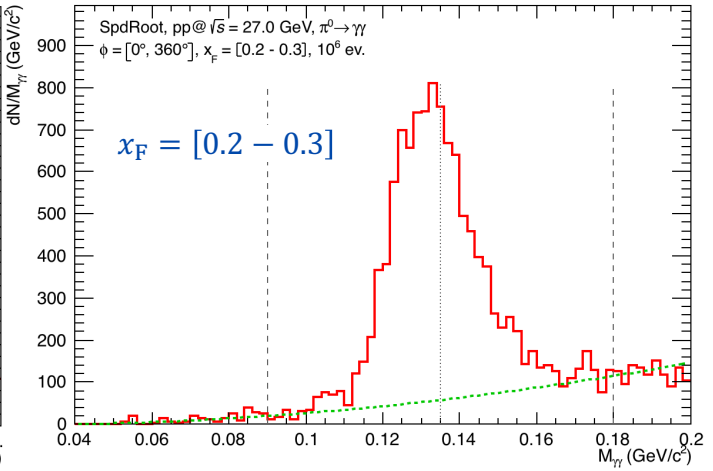


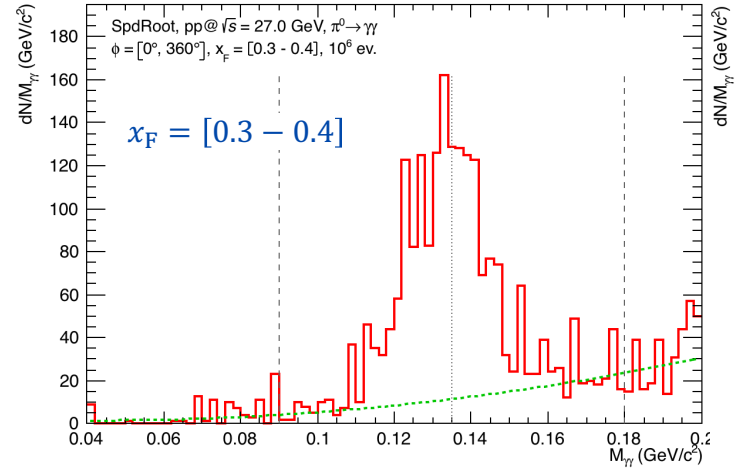
- The spin dependent π^0 yields for each bin are extracted from the invariant mass spectra in different x_{F} sub-ranges for each ϕ bin.
- The invariant mass was fitted with a **polynomial** function for the background and a **normalized Gaussian** distribution representing the signal peak.

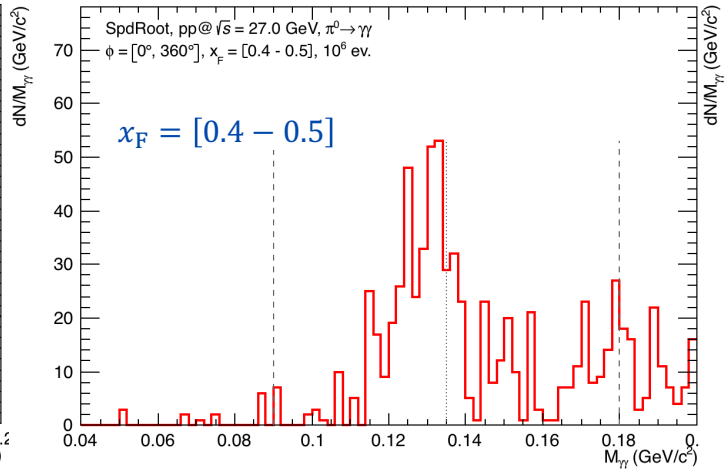
Invariant mass in x_F intervals, $\phi = [0 - 360]$ degrees

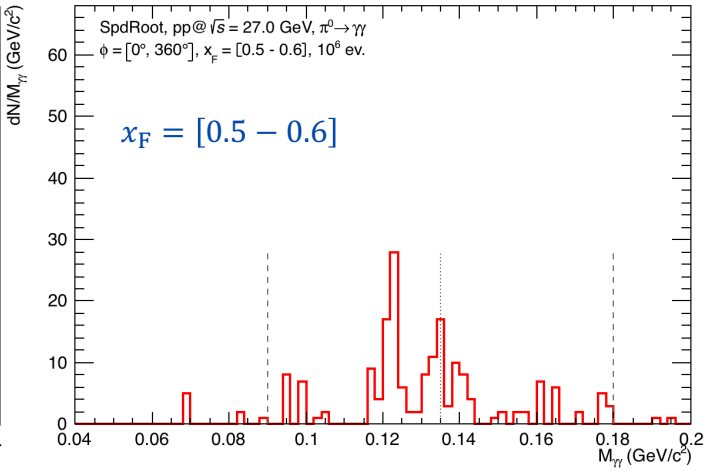


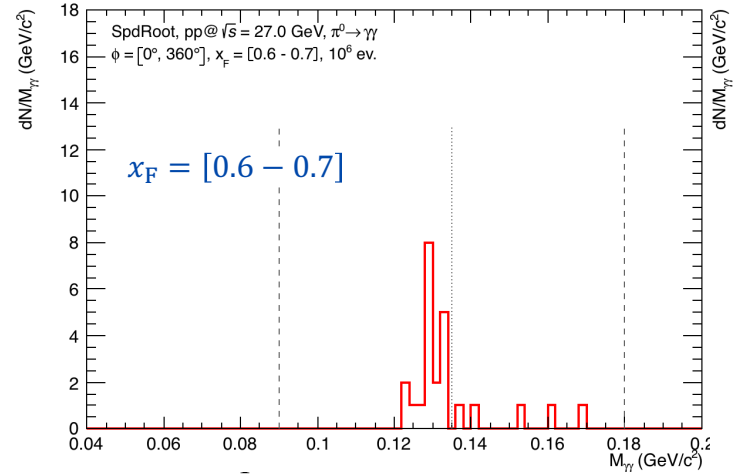


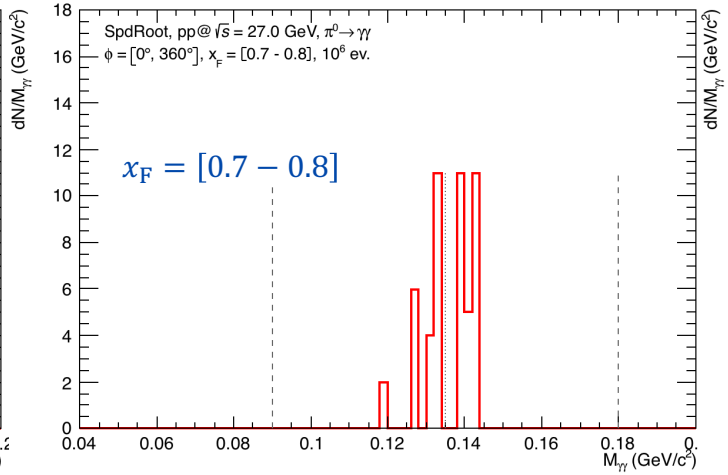


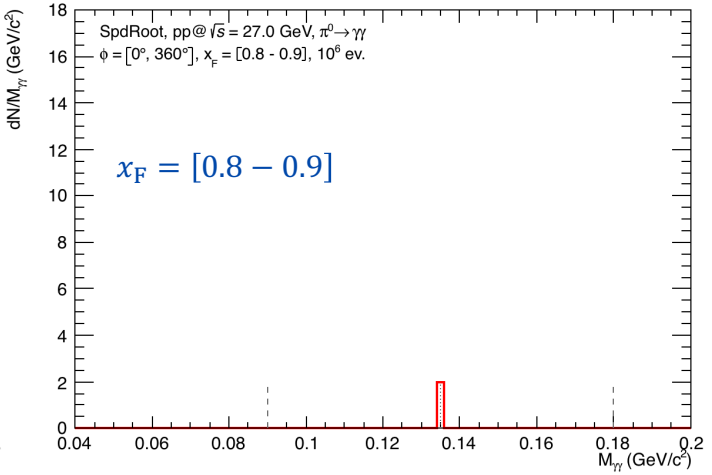




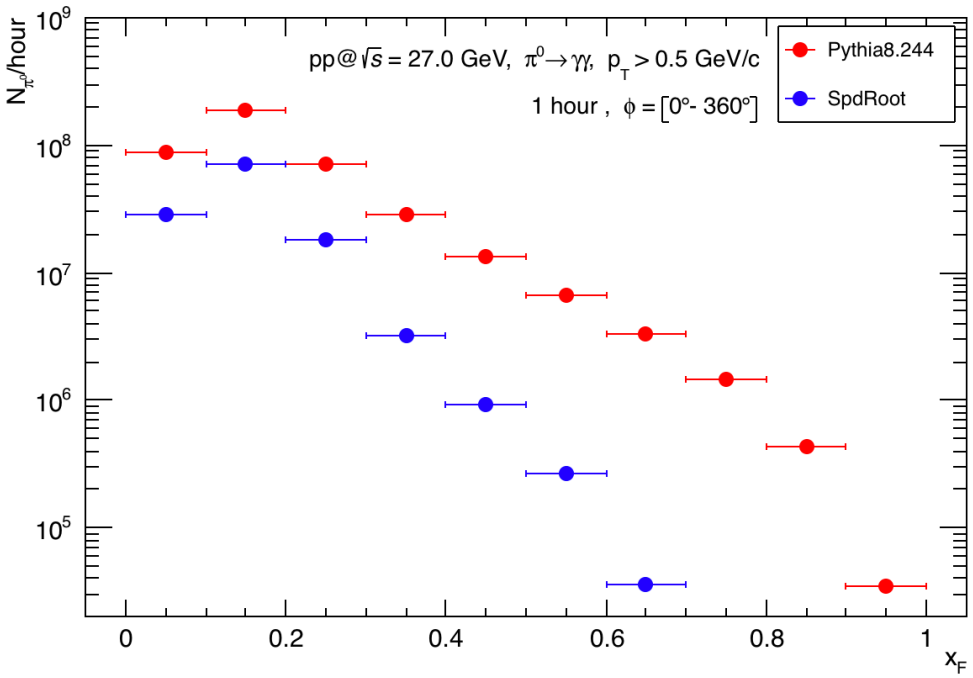


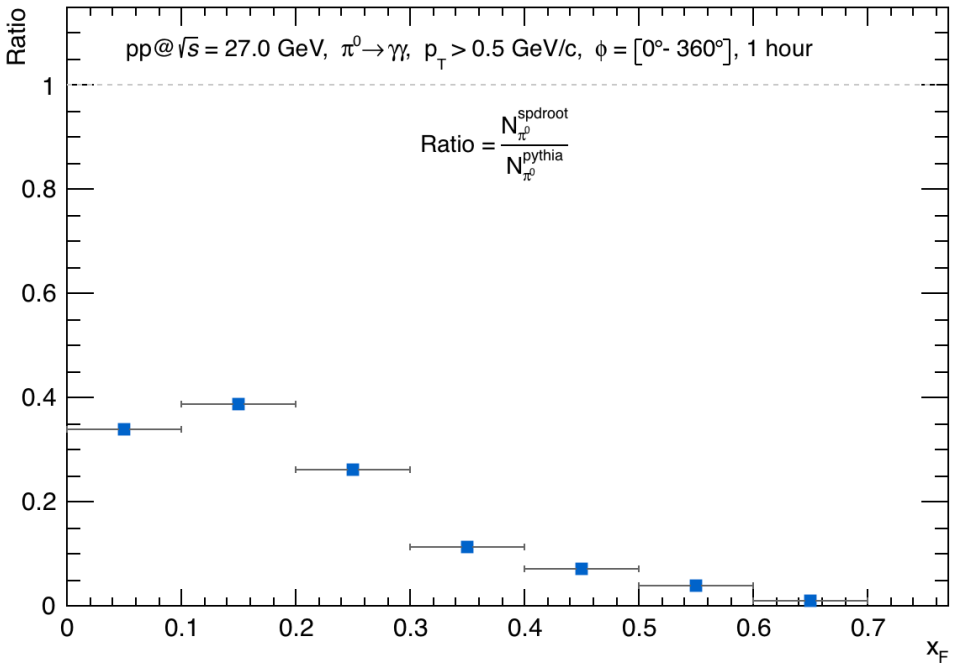






Estimation of π^0 yield in the ECAL endcaps





Expected in 1 hour at a reaction rate $4 \cdot 10^6 s^{-1}$

Expected number of π^0 in 1 hour assuming the SPD reaction rate of $4 \cdot 10^6 s^{-1}$, calculated from the invariant mass spectra ($\pi^0 \to \gamma\gamma$) in $0° < \phi < 360°$:

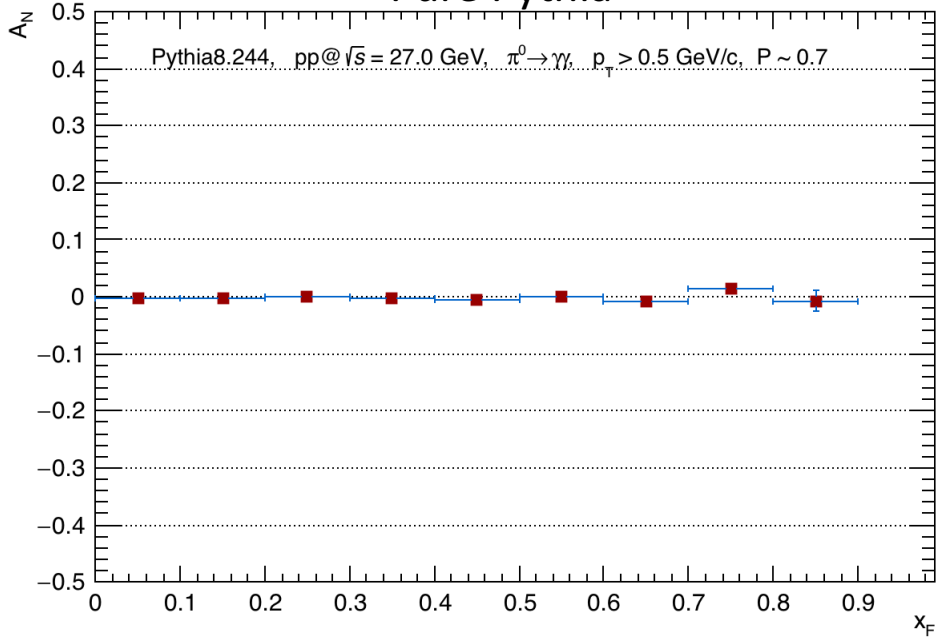
$$N_{\pi^0}(pythia) = (4.0131 \cdot 10^8 \pm 46987)\ \text{hour}^{-1}$$

$$N_{\pi^0}(spdroot) = (1.2337 \cdot 10^8 \pm 21907)\ \text{hour}^{-1}$$

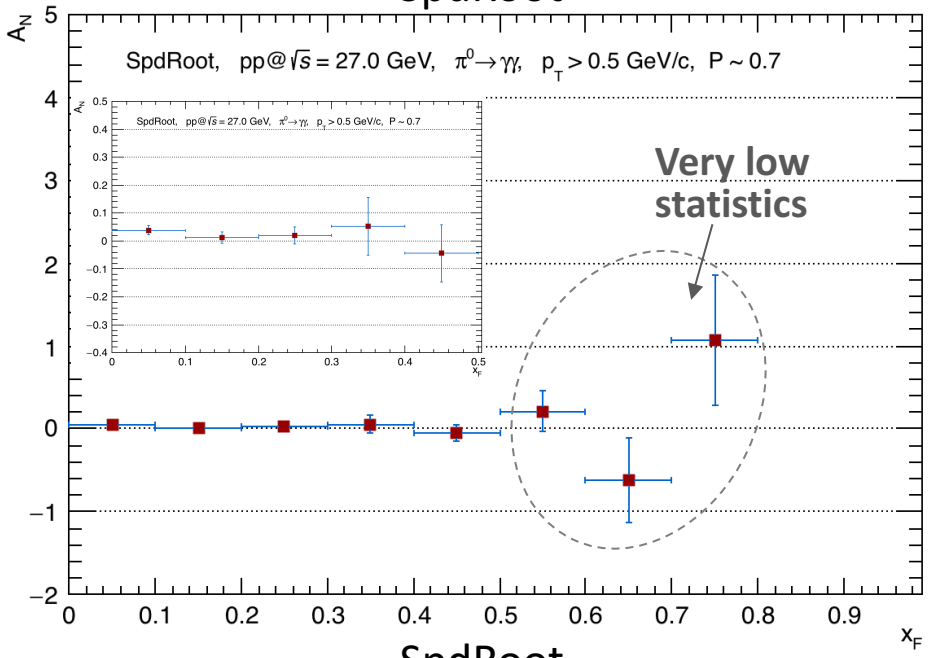
x_F	N_{π^0}(pythia)	N_{π^0}(spdroot)
0.0 – 0.1	8.71623e+07 ± 9336	2.88889e+07 ± 5374
0.1 – 0.2	1.89277e+08 ± 13757	7.17679e+07 ± 8471
0.2 – 0.3	7.05884e+07 ± 8401	1.81456e+07 ± 4259
0.3 – 0.4	2.90411e+07 ± 5388	3.26321e+06 ± 1806
0.4 – 0.5	1.34162e+07 ± 3662	9.34335e+05 ± 966
0.5 – 0.6	6.60482e+06 ± 2569	2.62667e+05 ± 512
0.6 – 0.7	3.27958e+06 ± 1810	3.56159e+04 ± 188
0.7 – 0.8	1.46884e+06 ± 1211	7.41998e+04 ± 272
0.8 – 0.9	4.37768e+05 ±661	2967.99e ± 54
0.9 – 1.0	3.43149e+04 ± 185	-

A_N in the ECAL endcaps

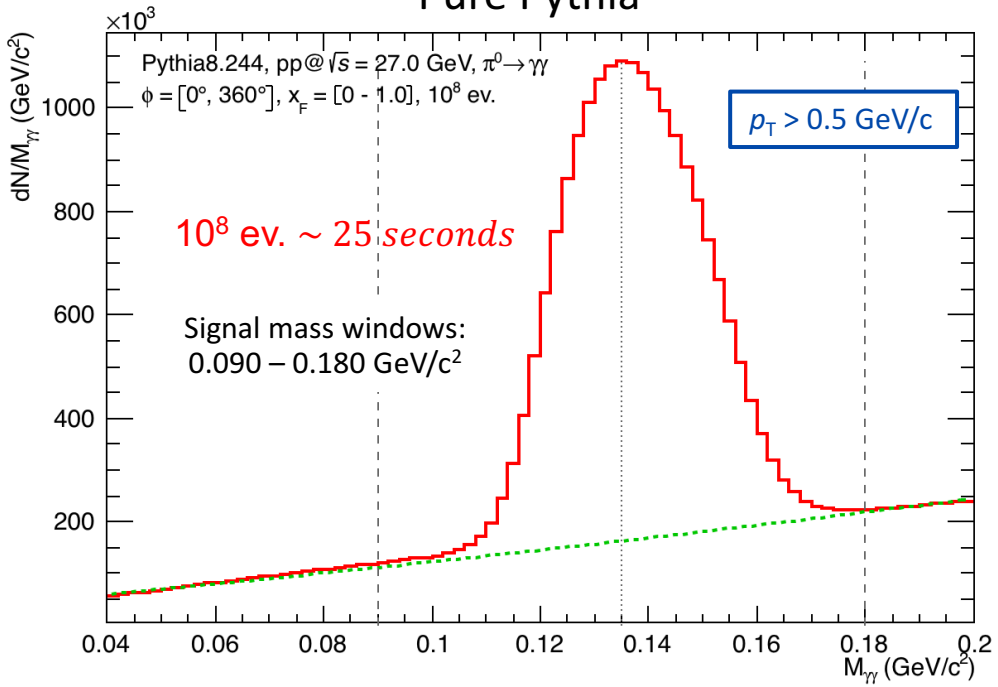
Pure Pythia



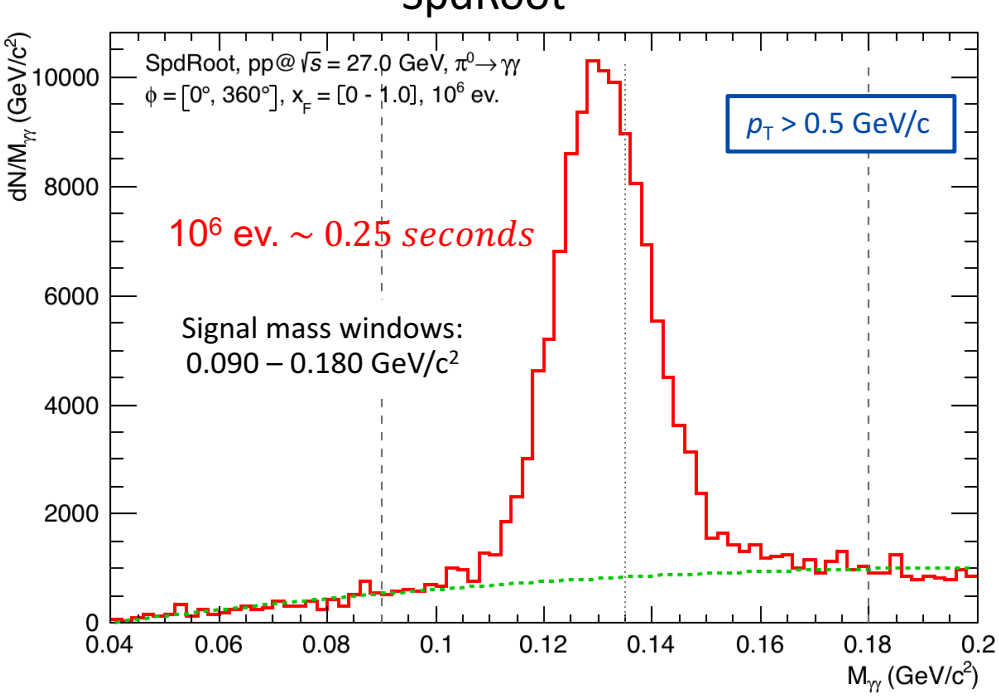
SpdRoot



Pure Pythia

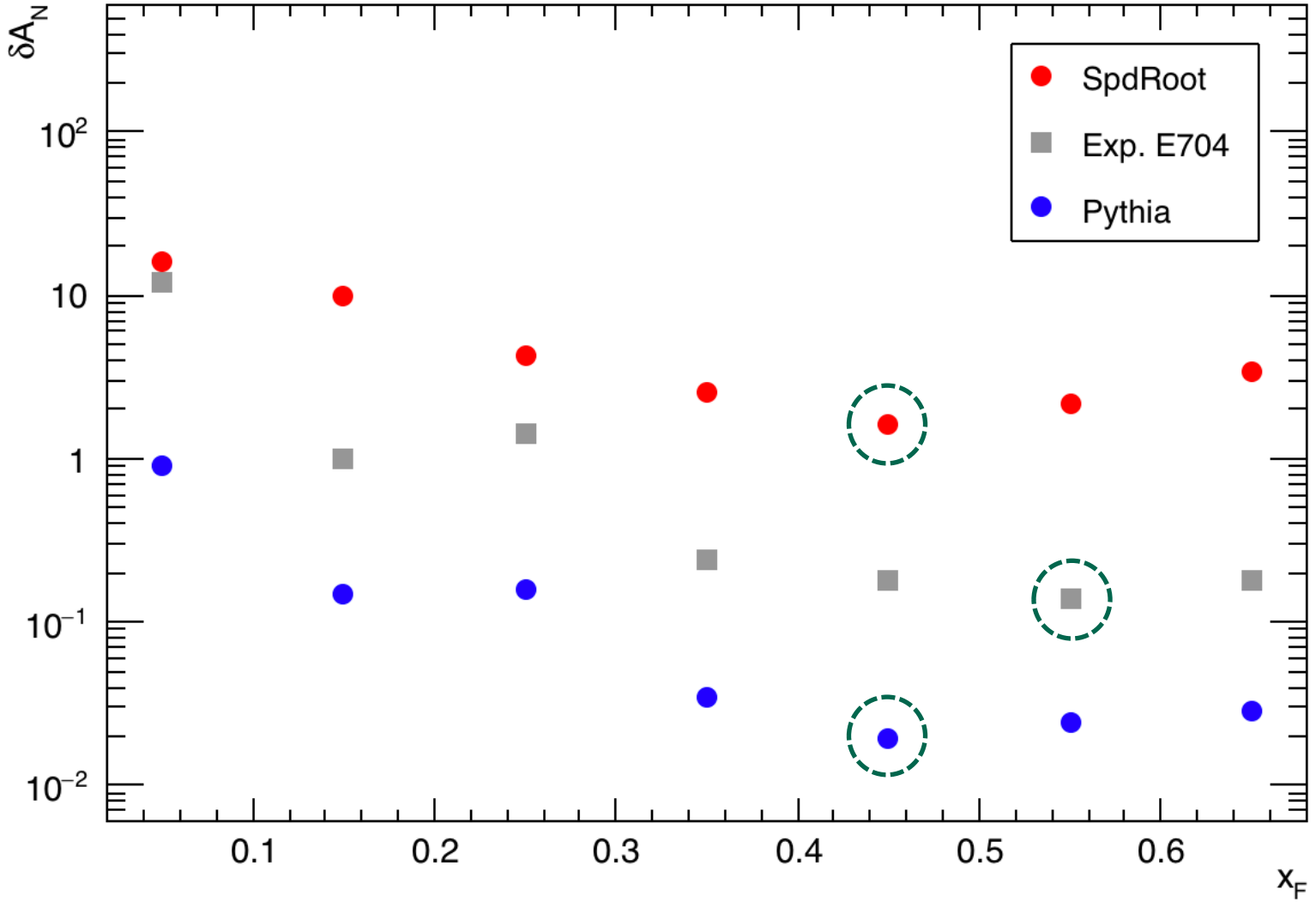


SpdRoot



By using the measured A_N from the E704 experiment at $\sqrt{s} = 19.4$ GeV, we can estimate the relative error of δA_N *vs* x_F

$$\frac{dA_N}{A_N} \sim \frac{dP}{P}$$



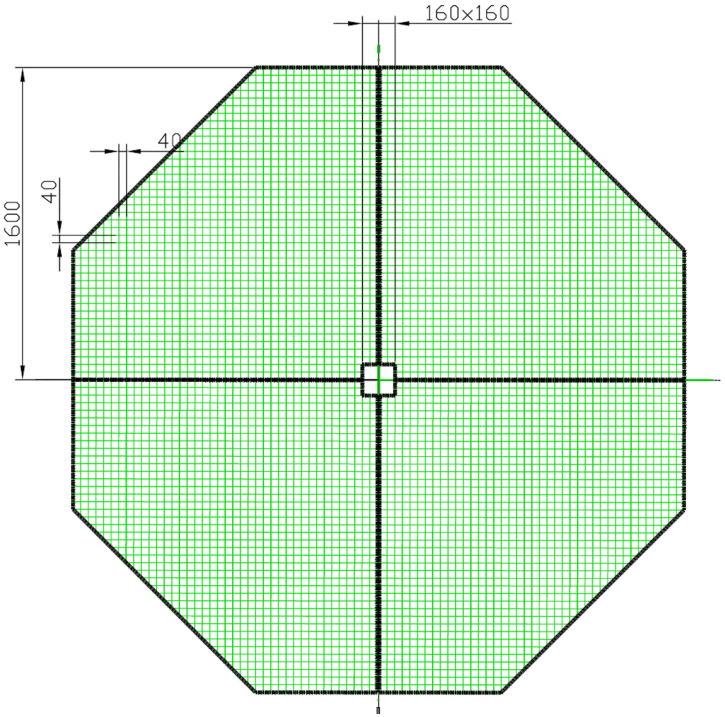
$$\delta A_N = \frac{dA_N}{A_N}$$ SpdRoot / E704

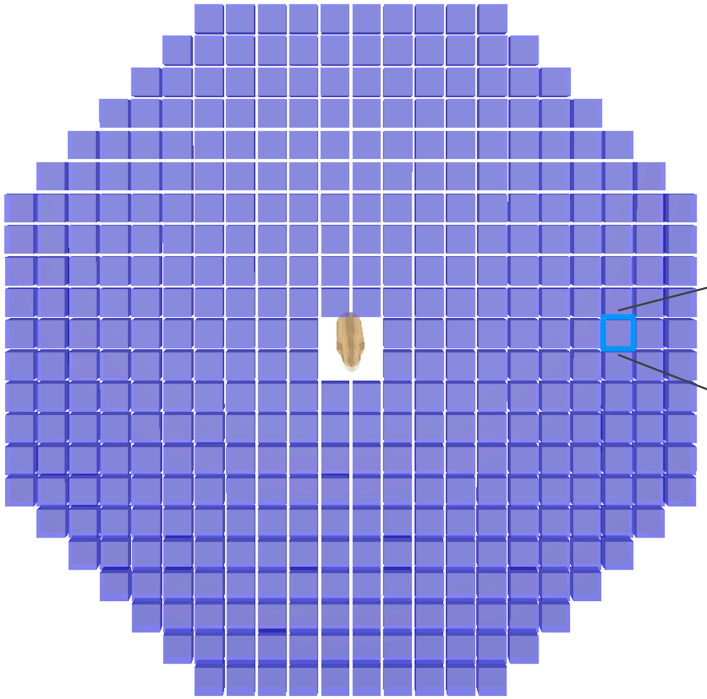
$$\delta A_N = \frac{dA_N}{A_N}$$ E704 / E704

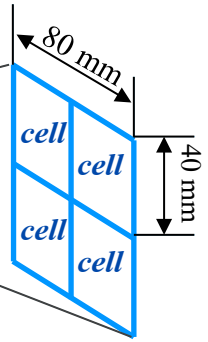
$$\delta A_N = \frac{dA_N}{A_N}$$ Pythia / E704

The determination of the polarization is expected to be precise for $0.4 < x_F < 0.6$.

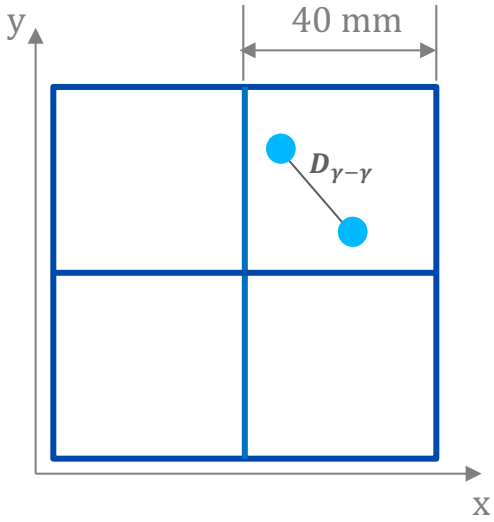
Geometrical considerations



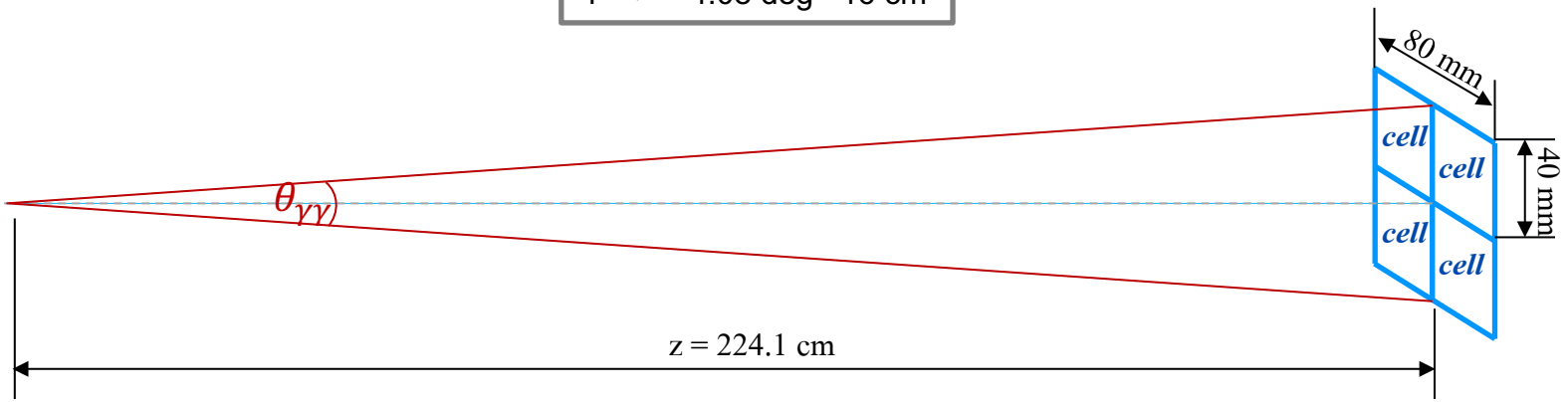




# cells	$\theta_{\gamma\gamma}$	d_{ij}
1 ->	1.02 deg	4 cm
2 ->	2.04 deg	8 cm
3 ->	3.06 deg	12 cm
4 ->	4.08 deg	16 cm

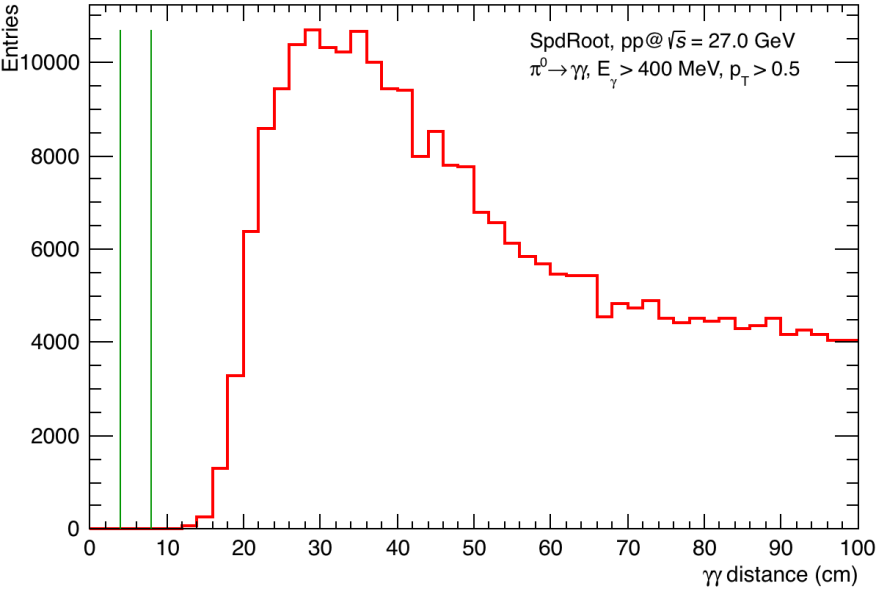


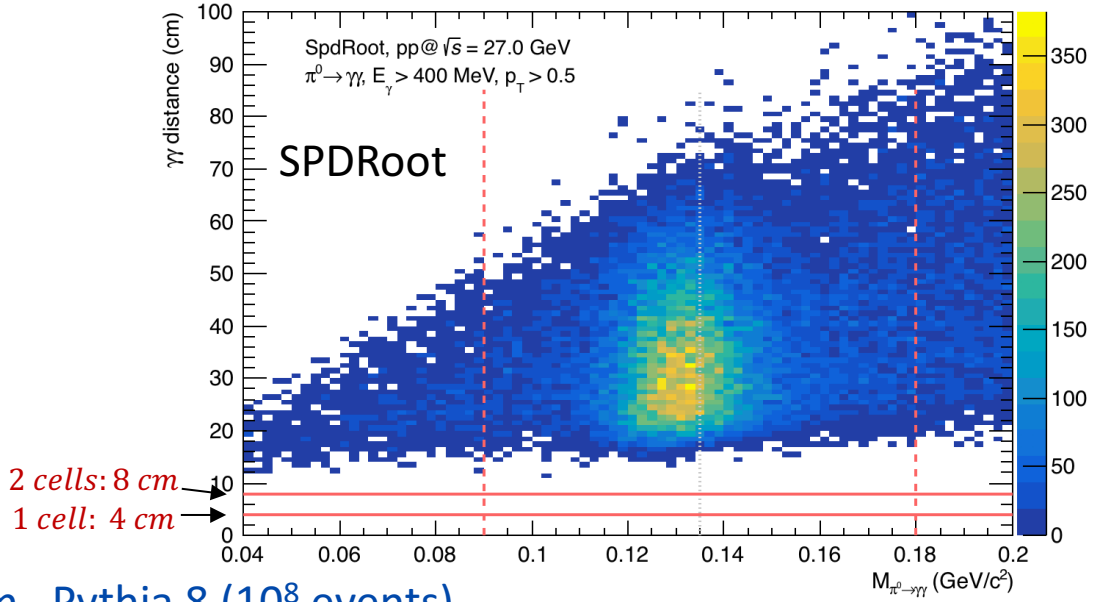
$$D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$



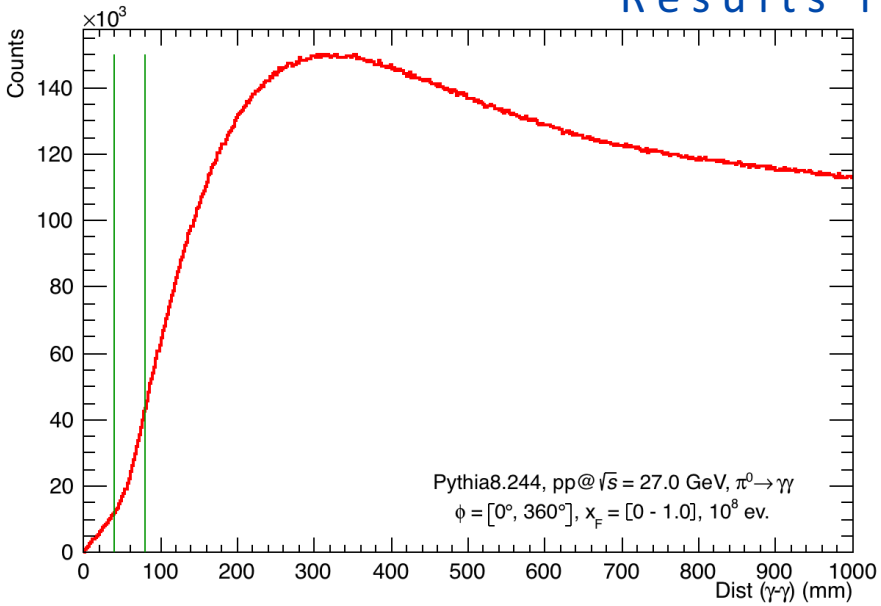
Distance between impact of $\gamma\gamma$ pairs registered in the ECAL endcaps ($z = \pm 224.1\ cm$)

Results from SpdRoot (10^6 events)

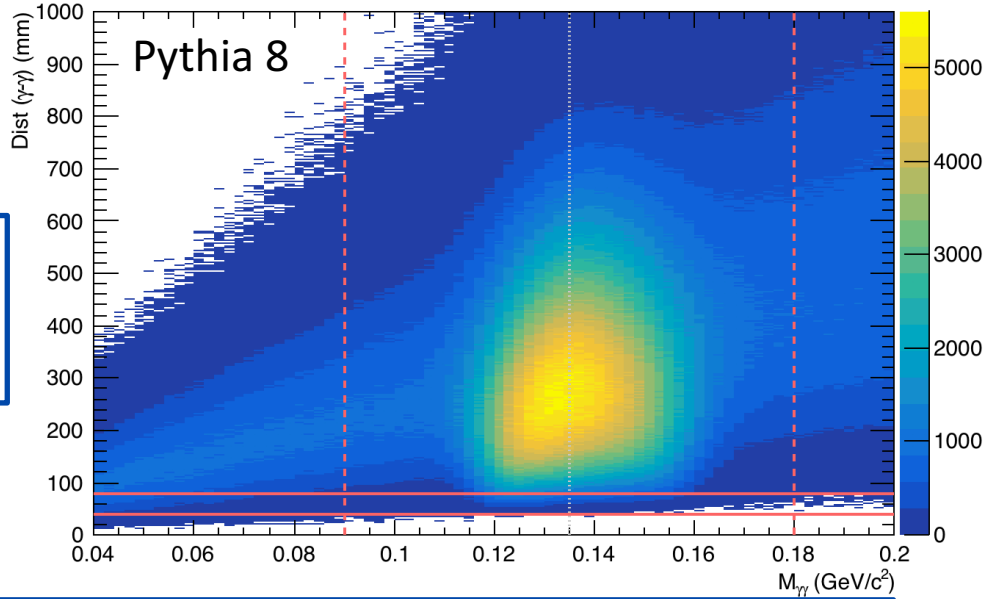




Results from Pythia 8 (10^8 events)



# cells	$\theta_{\gamma\gamma}$
1 ->	1.02 deg
2 ->	2.04 deg
3 ->	3.06 deg
4 ->	4.08 deg



- The opening angle of $\gamma\gamma$ pairs decayed from π^0 should be ~2.05° in order to be detected in one module at z = 224.1 cm.
- **No π^0 is reconstructed from $\gamma\gamma$ pairs with angle $< 2.05°$** (2 cells)

Some remarks

- The determination of the polarization is expected to be precise for $0.4 < x_F < 0.6$.

- The reconstruction efficiency should be better estimated, not using pure pythia, but the MC truth information for ECAL.

- The implementation of a better separation algorithm inside SpdRoot is needed (… machine learning algorithm?)

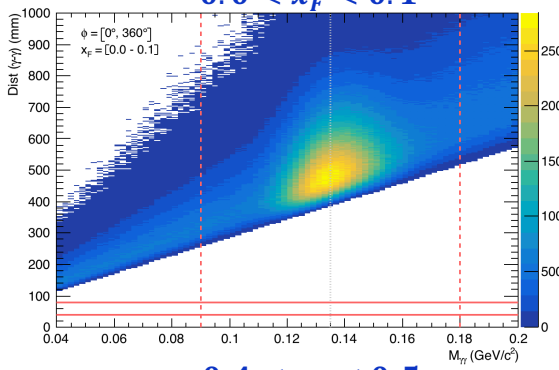
- No π^0 is reconstructed (SPDRoot) from $\gamma\gamma$ pairs in the endcap module/cell size range (within a distance of 4 cm or 8 cm)

- Pythia simulation gives rise to π^0 with few statistics in the endcap module/cell size range

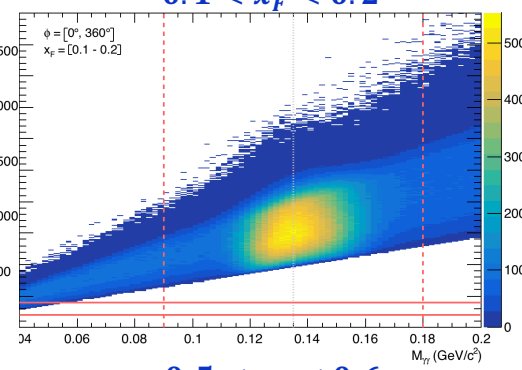
Distance “XY” plane (endcap) of the two photons vs. Invariant Mass

$$x_F - depencence\ , 0° < \phi < 360°$$

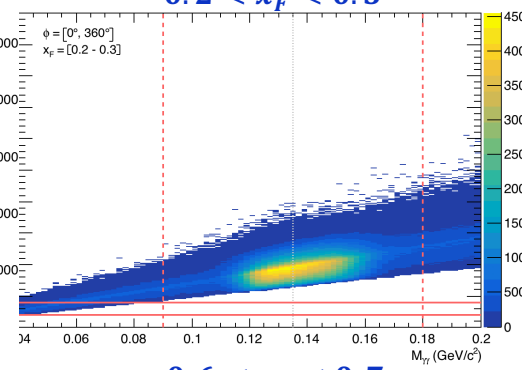
$0.0 < x_F < 0.1$



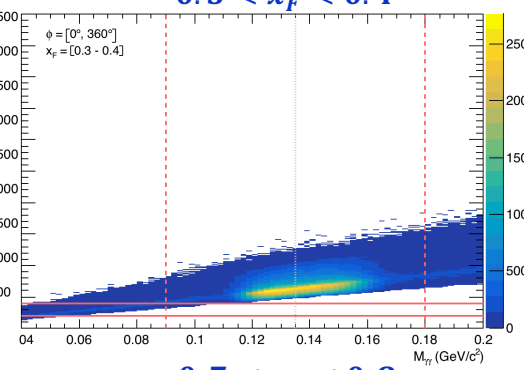
$0.1 < x_F < 0.2$



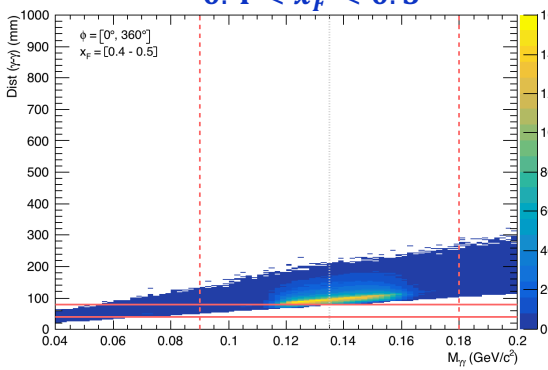
$0.2 < x_F < 0.3$



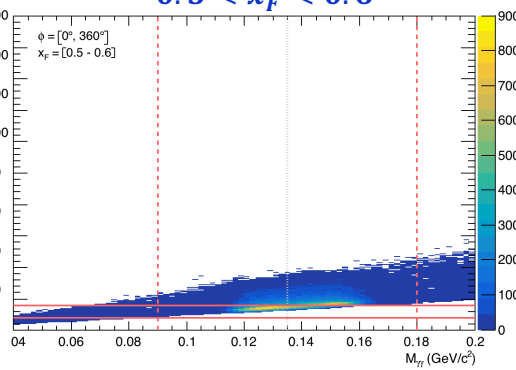
$0.3 < x_F < 0.4$



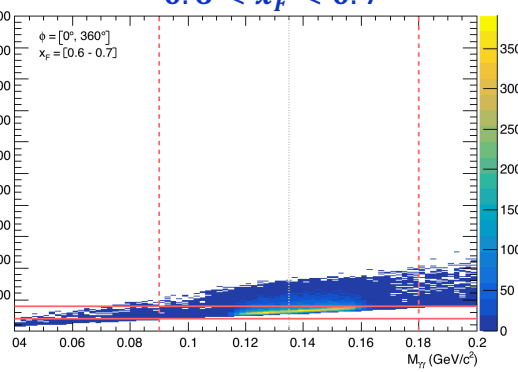
$0.4 < x_F < 0.5$



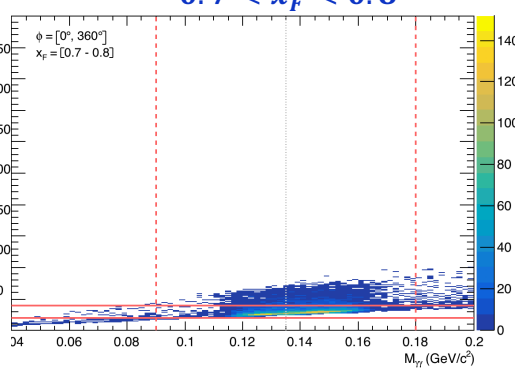
$0.5 < x_F < 0.6$



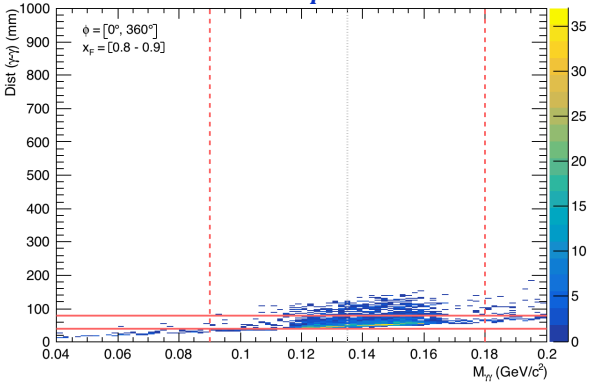
$0.6 < x_F < 0.7$



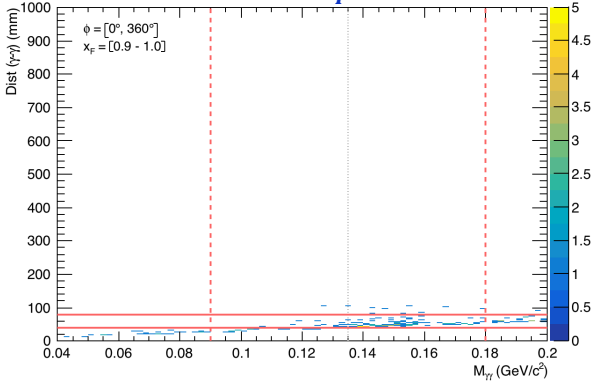
$0.7 < x_F < 0.8$



$0.8 < x_F < 0.9$



$0.9 < x_F < 1.0$



$0.0 < x_F < 1.0$