Inclusive π^0 for polarimetry: comparison between two approaches

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Simulation

- SpdRoot version 4.1.5.1
- pp @ $\sqrt{s} = 27$ GeV
- Particle generator: Pythia 8 (number of events: ~100M)
- Minimum Bias
- Vertex assumed at (0, 0, 0) → Gaussian smeared: $\sigma_z = 30\ cm$ and $\sigma_{x,y} = 0.1\ cm$

Analysis

Two cases

1. Realistic reconstruction
2. MC-truth based

1 Based on realistic reconstruction

data branches

```
IT → ActivateBranch("RCVertices");
IT → ActivateBranch("MCTracks");
IT → ActivateBranch("RCEcalParticles");
IT → ActivateBranch("RCEcalClusters");
IT → ActivateBranch("MCParticles");
```

data pointers

```
rcvertices        = IT → GetVerticesRC();
mctracks          = IT → GetTracks();
rcecalparticles = IT → GetEcalParticlesRC();
rcecalclusters   = IT → GetEcalClustersRC();
mcparticles       = IT → GetParticles();
```

1 Based on realistic reconstruction

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rcecalclusters  = IT → GetEcalClustersRC();
mcparticles     = IT → GetParticles();
```

Get reconstructed vertex (vtxPos)

⇩

Check track fit parameters (extrapolate to the ecal)

⇩

Loop over the “ecal” reconstructed particles

Getting:
- Cluster ID, to which *rcecalparticle* belongs
- **Particle position and energy from cluster**

⇩

Ensure that we are dealing with photons (pdg = 22)

⇩

Select clusters belonging to the endcaps of ECAL

⇩

Fill 4-momenta of photons

⇩

Look for candidates to π^0
(Create all possible combinations of $\gamma\gamma$ in the endcaps)

Two cases

1 Based on realistic reconstruction

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mcparticles     = IT → GetParticles();
```

2 MC-truth based

```
IT → ActivateBranch("RCVertices");
IT → ActivateBranch("MCTracks");
IT → ActivateBranch("RCEcalParticles");
IT → ActivateBranch("RCEcalClusters");
IT → ActivateBranch("MCParticles");
IT → ActivateBranch("MCEcalParticles");
IT → ActivateBranch("MCEcalClustersInfo");
```

```
rcvertices      = IT → GetVerticesRC();
mctracks        = IT → GetTracks();
rcecalparticles = IT → GetEcalParticlesRC();
rcecalclusters  = IT → GetEcalClustersRC();
mcparticles     = IT → GetParticles();
ecalparticlesmc      = IT → GetEcalParticlesMC();
ecalclustersmcinfo = IT → GetEcalClustersMCInfo();
```

- Position of the reconstructed vertex is not taken into account!
- Track fit parameters are not checked!
- Do not look at the ECAL reco particle!

2 MC-truth based

```
IT → ActivateBranch("RCVertices");
IT → ActivateBranch("MCTracks");
IT → ActivateBranch("RCEcalParticles");
IT → ActivateBranch("RCEcalClusters");
IT → ActivateBranch("MCParticles");
IT → ActivateBranch("MCEcalParticles");
IT → ActivateBranch("MCEcalClustersInfo");
```

```
rcvertices        = IT → GetVerticesRC();
mctracks          = IT → GetTracks();
rcecalparticles   = IT → GetEcalParticlesRC();
rcecalclusters    = IT → GetEcalClustersRC();
mcparticles       = IT → GetParticles();
ecalparticlesmc   = IT → GetEcalParticlesMC();
ecalclustersmcinfo = IT → GetEcalClustersMCInfo();
```

Loop over the "ecal" reconstructed clusters

Get the list of the "ecal rc-clusters with mc-info" *ecalclustersmcinfo*

⇩

Associate each cluster with the corresponding MC particles

⇩

Loop over the MC "ecal" particles from *ecalclustersmcinfo*

Create set of "ECAL particles" *ecalparticlesmc* from MC true info

⇩

Ensure that particles are created before ECAL, transported in the ECAL volume and deposited energy in the ECAL material

⇩

Extrapolation to ECAL assuming linear trajectories. Position (x,y) is recorded. Z coordinate – is fixed)

⇩

The energy of the MC "ecal" particles is collected

⇩

Position and energy: smeared to the resolution for the endcaps

⇩

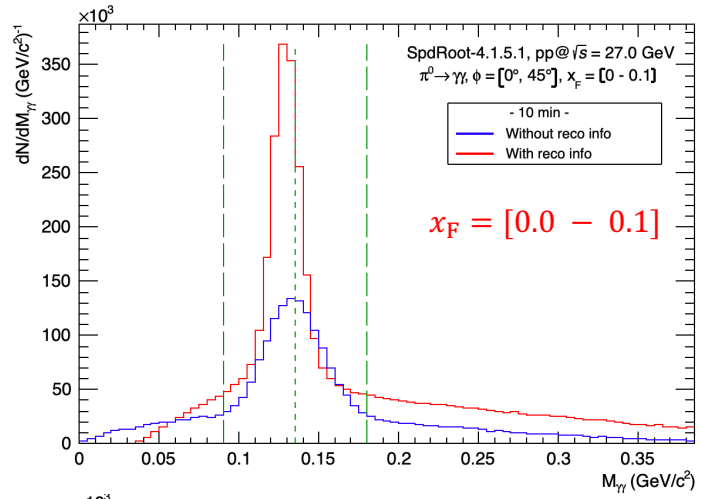
Fill 4-momenta of photons

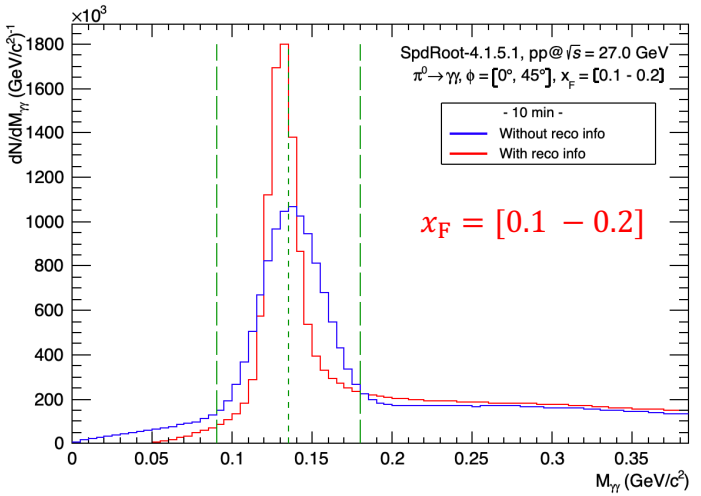
⇩

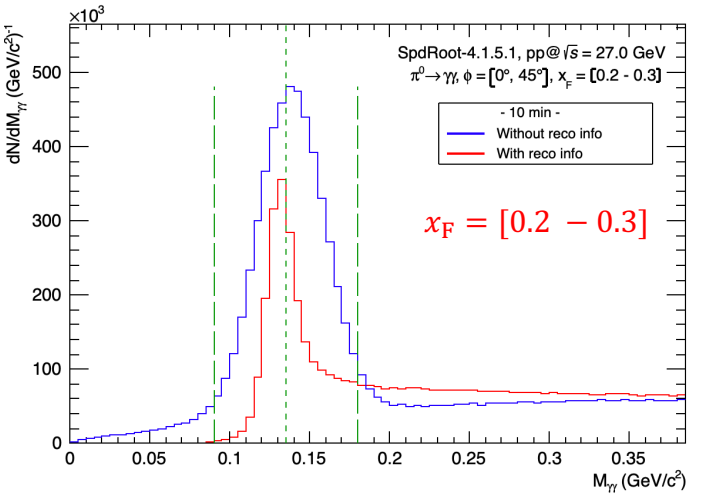
Look for candidates to π^0
(Create all possible combinations of $\gamma\gamma$ in the endcaps)

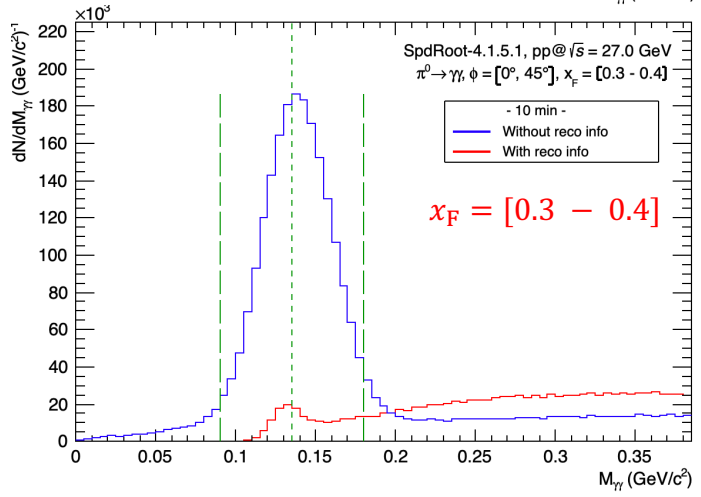
Inv. mass spectra in one azimuthal sector, $\Delta\phi = [0 - 45] deg$

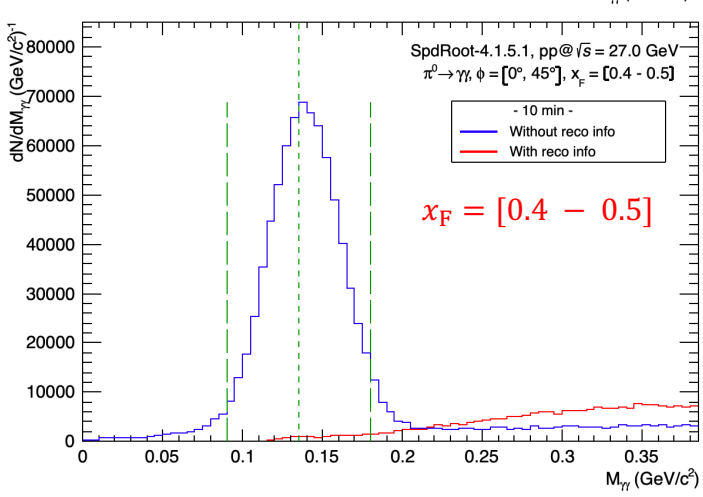
Mass windows: (0.09 ÷ 0.18) GeV/c^2

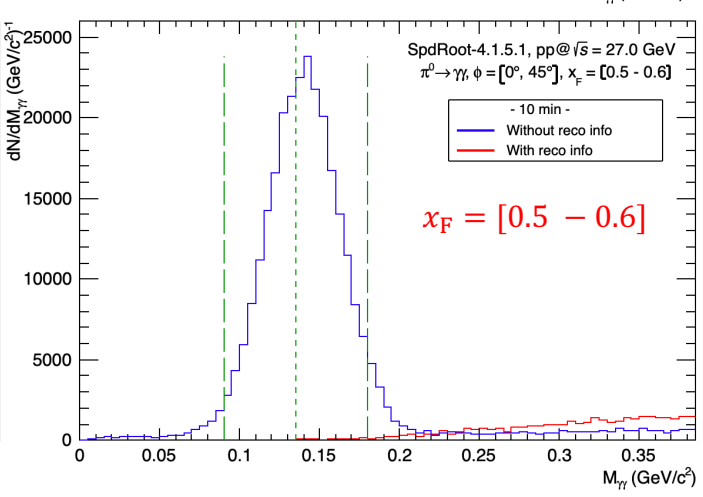


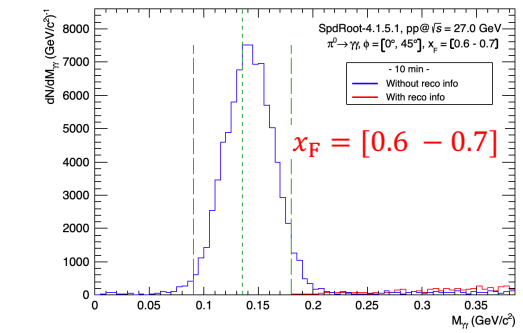


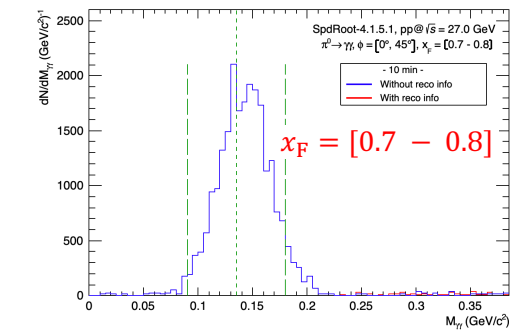


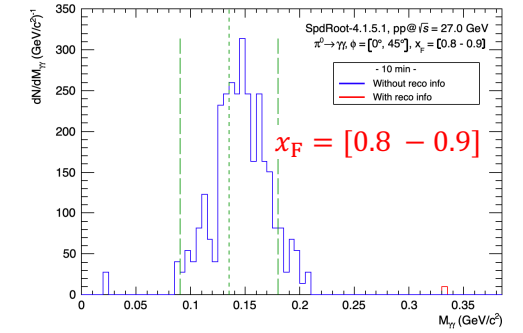


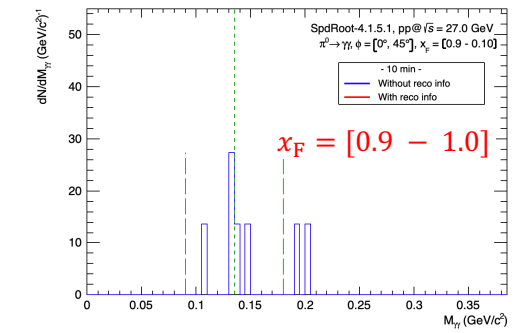




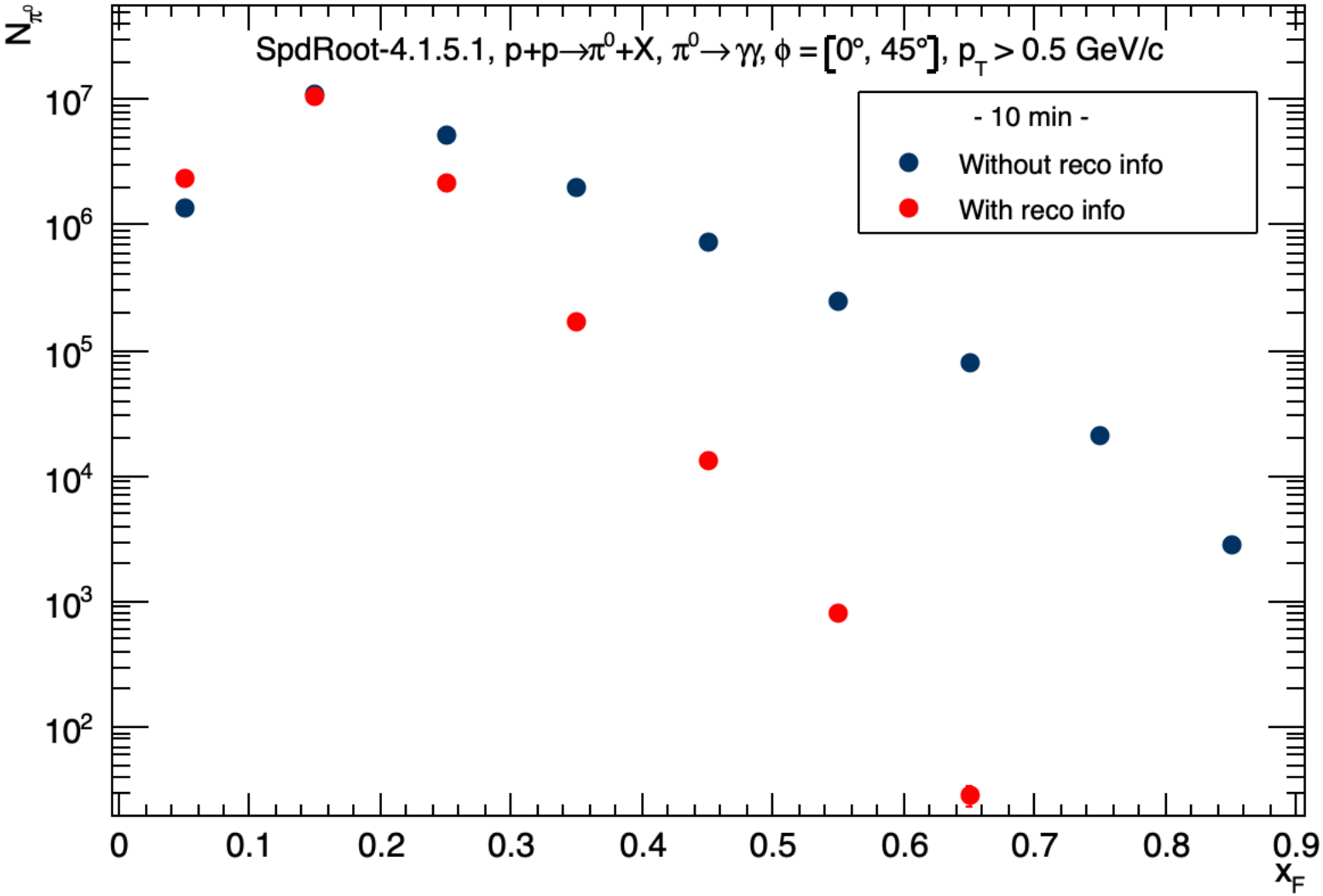






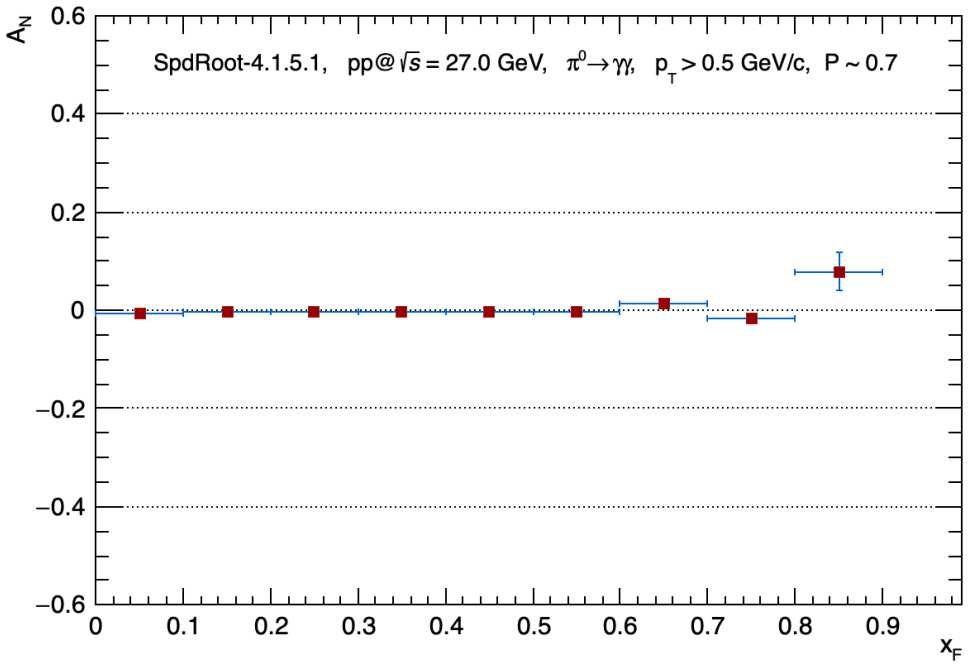


Yield N_{π^0} $vs.$ x_F in one azimuthal sector $\Delta\phi = [0 - 45] deg$

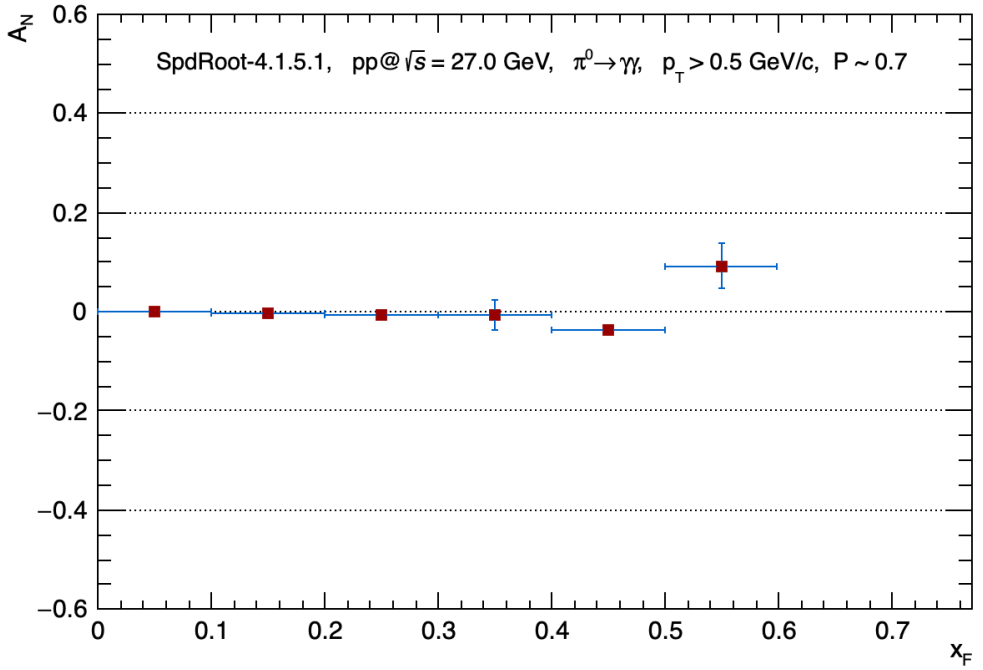


A_N *vs.* x_F

MC – truth

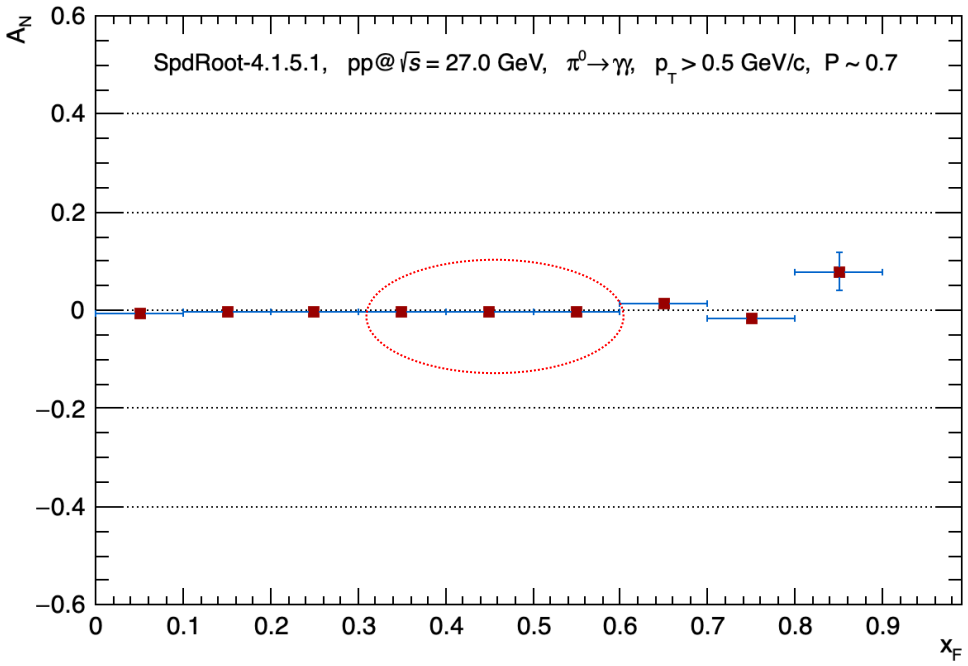


Realistic reco

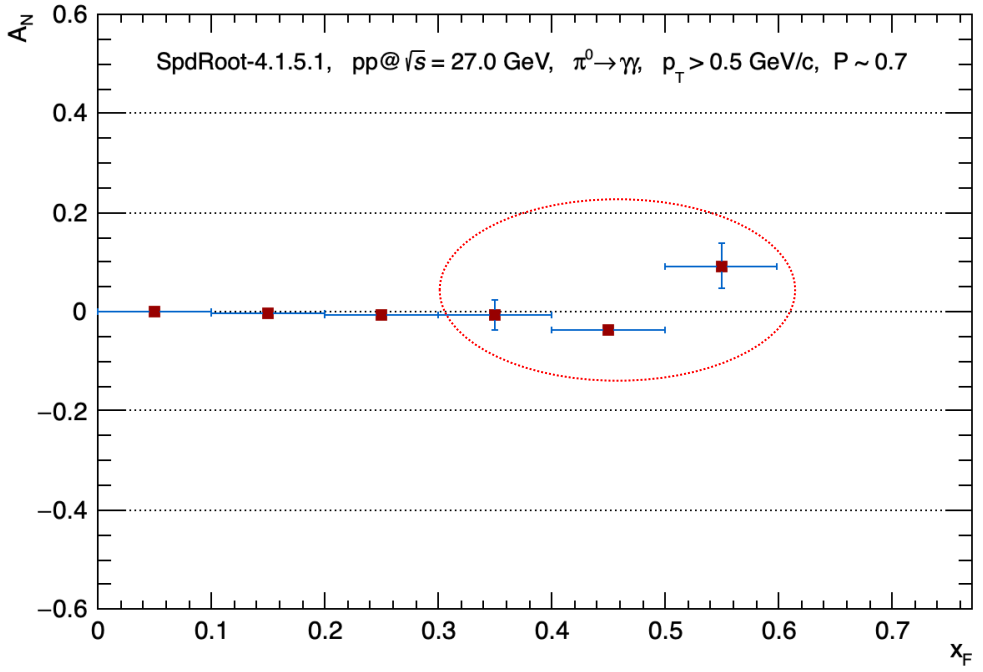


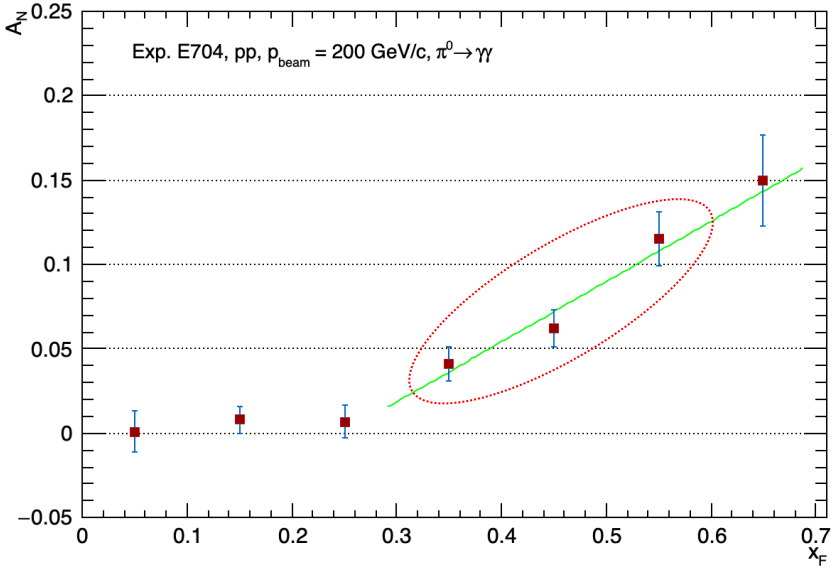
A_N *vs.* x_F

MC – truth



Realistic reco





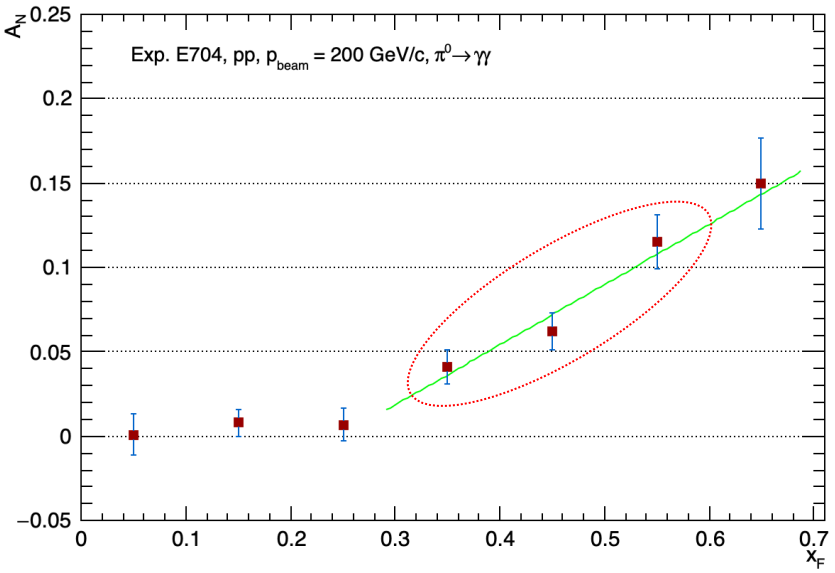
$\frac{\Delta A_N}{A_N}$ → SpdRoot; A_N → E704

$$\frac{\Delta A_N}{A_N} \sim \frac{\Delta P}{P}$$

Estimated relative error of the polarization

$$\frac{\Delta A_N}{A_N} \sim \frac{\Delta P}{P}$$

$$\frac{\Delta P}{P} = \frac{1}{\sqrt{\sum_i \left(\frac{A_{N_i}}{\Delta A_{N_i}}\right)^2}}$$



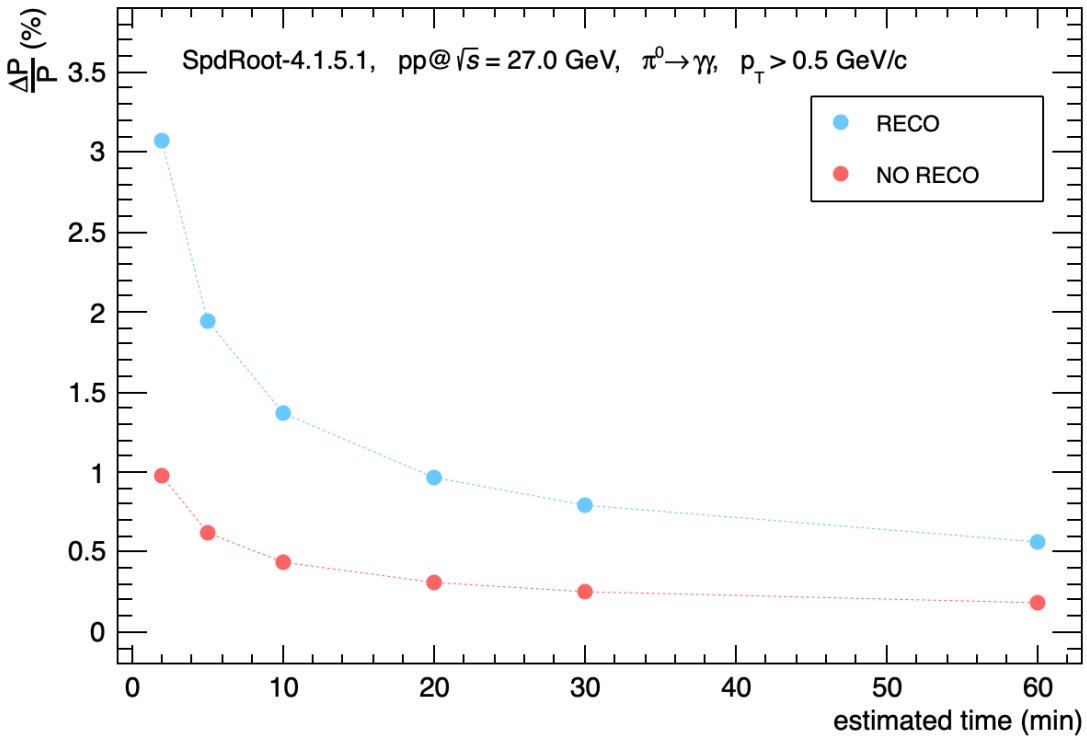
Taking three experimental 3 points ($0.3 \leq x_F < 0.6$): $\frac{\Delta P}{P} = 0.0998 \rightarrow 9.9\ \%$ (Experiment E704)

*The error of the beam polarization in the experiment **E704** is estimated in **10%***

(FERMILAB-Pub-91/15-E[E581,E704])

Estimation of the statistical accuracy of the beam polarization measurement, with $pp \to \pi^0 X$ at $\sqrt{s} = 27$ GeV, in SPD ECAL endcaps.

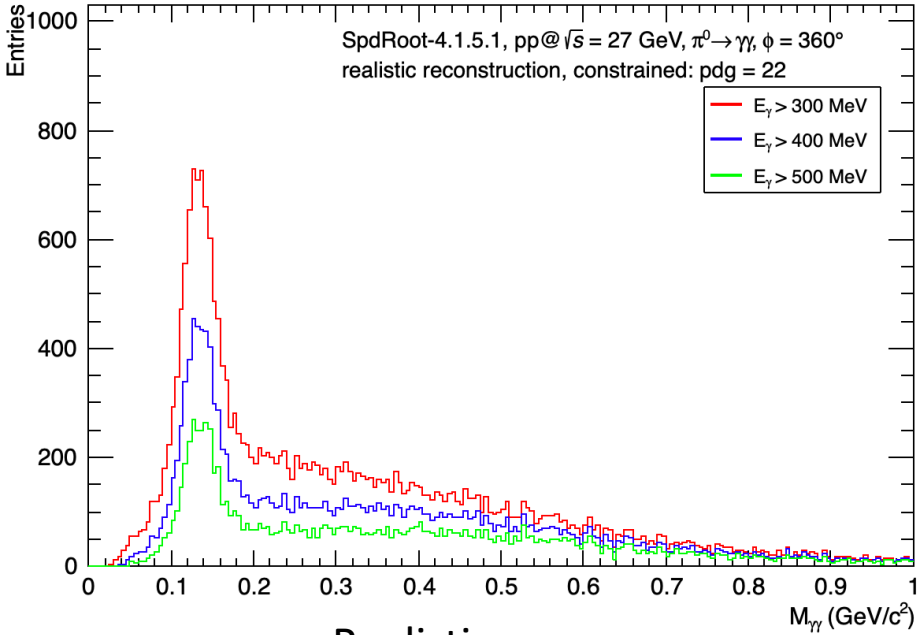
Estimated time	$\frac{\Delta P}{P}$	
	$MC - thuth$	$RECO$
2 min	0.97 %	3.07 %
5 min	0.61 %	1.94 %
10 min	0.43 %	1.37 %
20 min	0.30 %	0.97 %
30 min	0.25 %	0.79 %
1 h	0.18 %	0.56 %



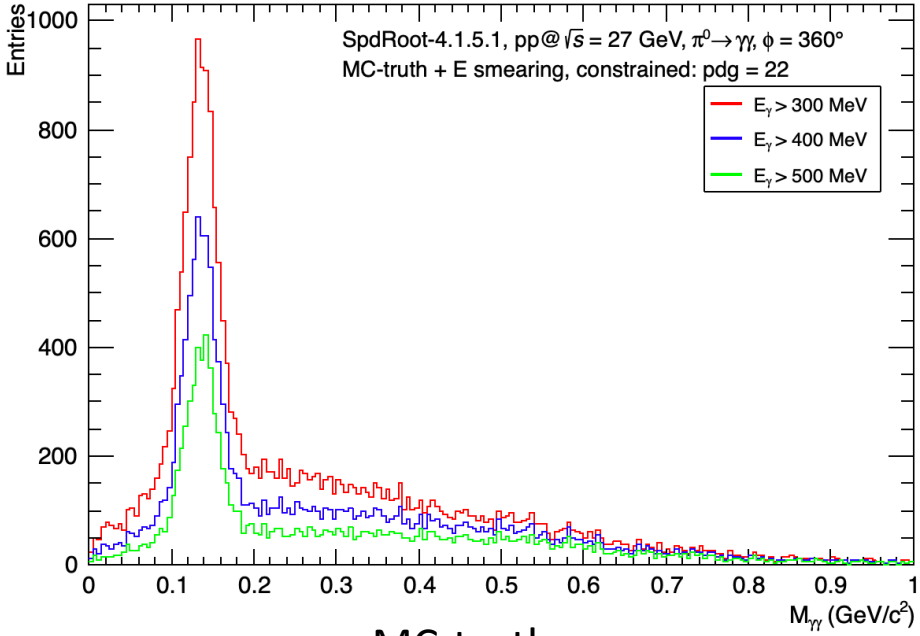
E_γ thresholds

number of events: ~280 000

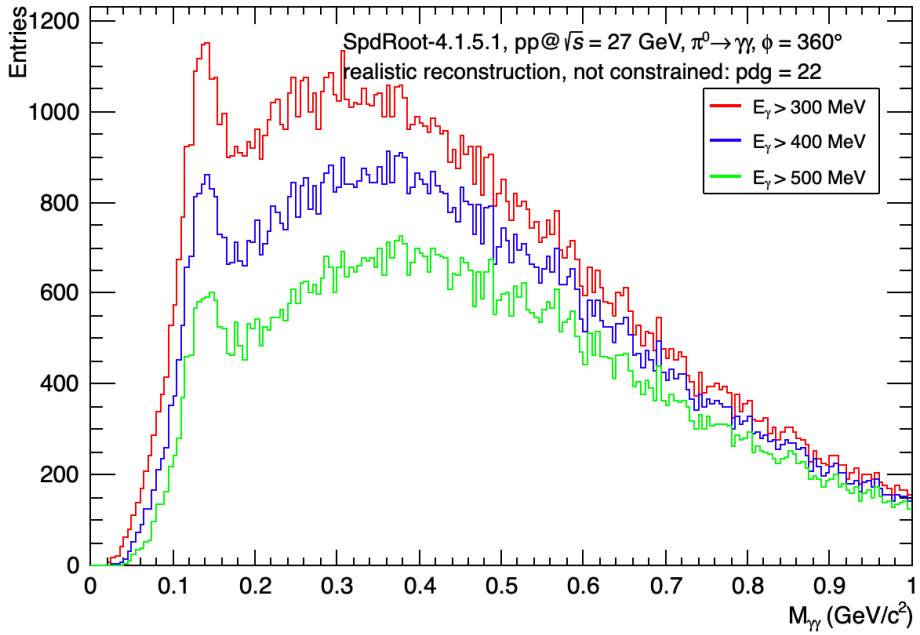
Realistic reco



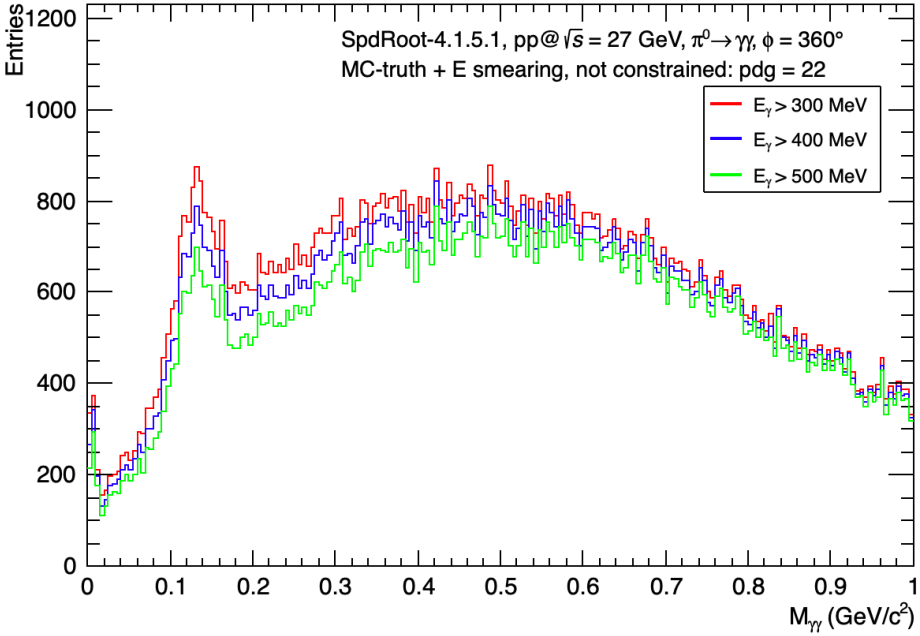
MC-truth



Realistic reco

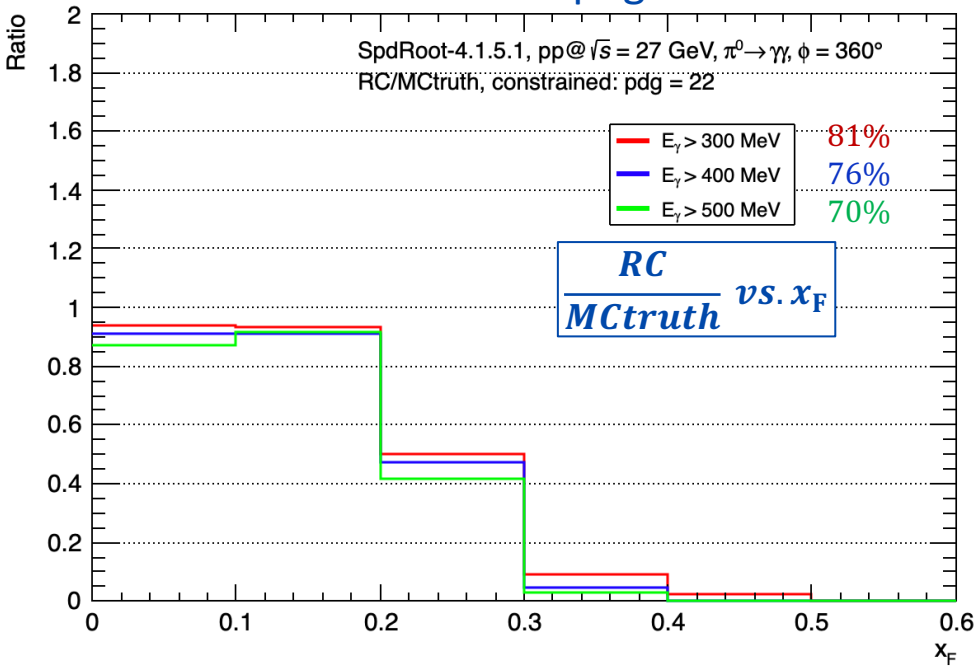


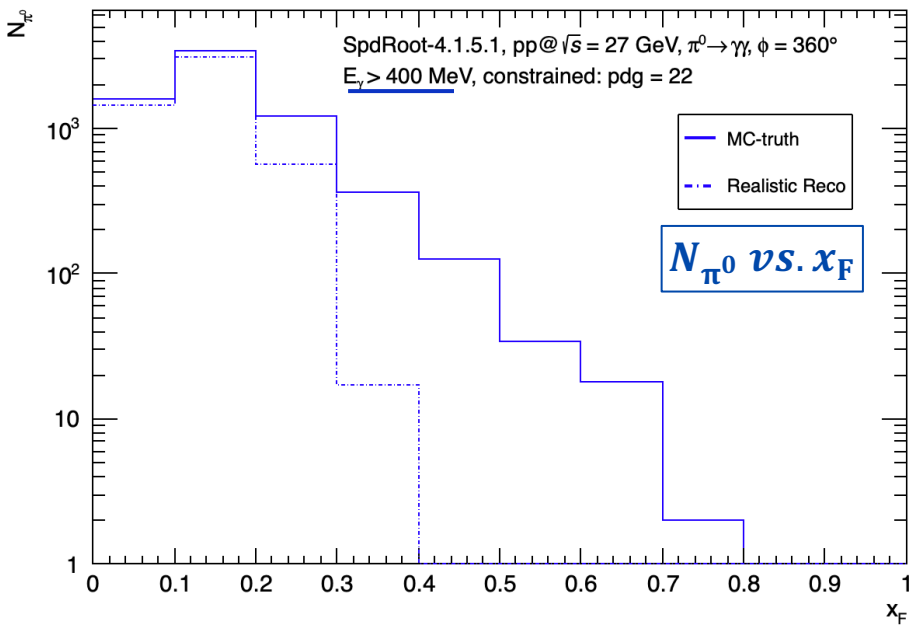
MC-truth



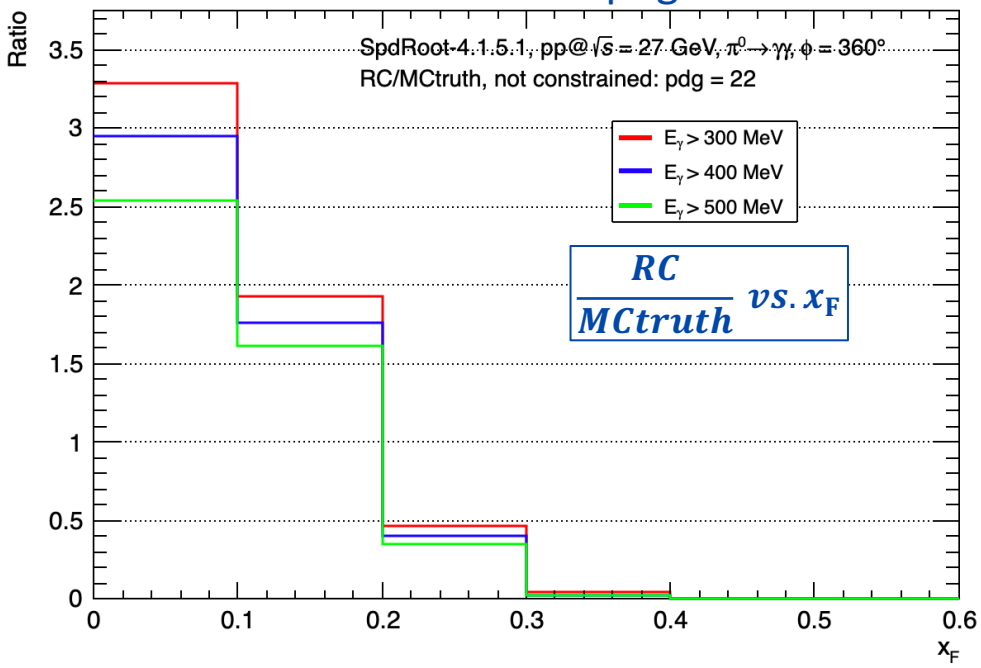
number of events: 280 000

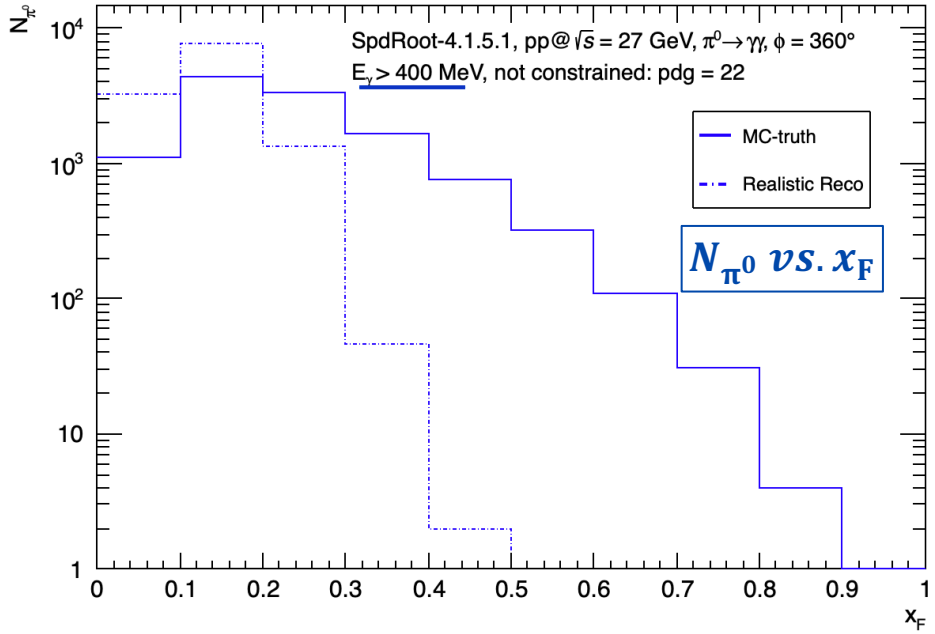
With constraint: pdg = 22





Without constraint: pdg = 22





Summary

- The accuracy of the beam polarization have been estimated with two approaches: one based on the realistic reconstruction of photons from the clusters in SpdRoot, and the other is based in MC-truth + energy smearing.

- More statistics needs to be collected in order to finished the comparison between both approaches and estimate better the expected accuracy of the polarimetry based on the inclusive π^0 in the ECAL-endcaps.