Update on the inclusive π^0 analysis for online polarimetry on the ECAL endcaps

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Simulation

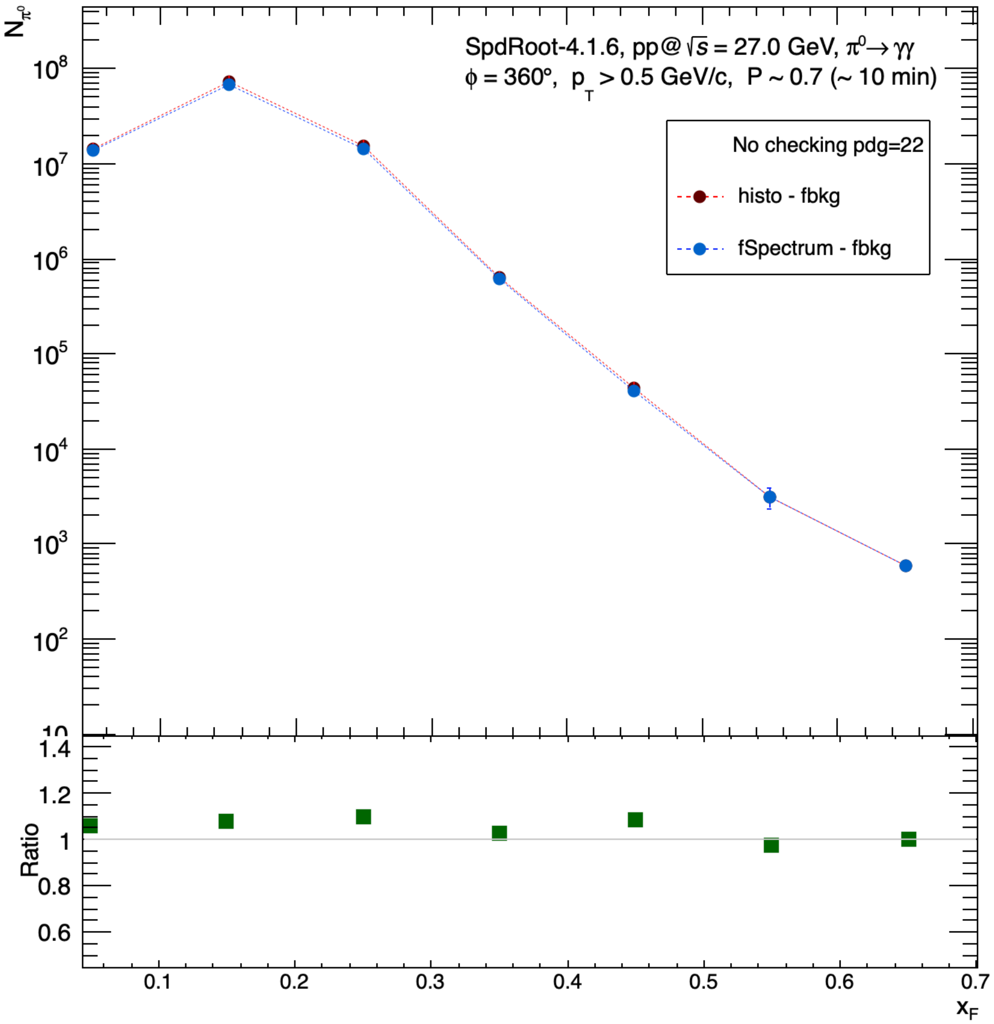
Generation

- ☐ SpdRoot version 4.1.6
- ☐ pp @ $\sqrt{s} = 27$ GeV
- ☐ Particle generator: Pythia 8 (number of events: $\sim 200\text{M}$) ← using DIRAC platform
- ☐ Minimum Bias
- ☐ Vertex assumed at (0, 0, 0) → Gaussian smeared: $\sigma_z = 30\ cm$ and $\sigma_{x,y} = 0.1\ cm$

Realistic reconstruction

- ☐ Focus on the “ECAL” reconstructed particle
- ☐ Identified the cluster to which the particle belongs
- ☐ Position and energy taken from cluster
- ☐ Selected clusters that belong to the ECAL endcaps
- ☐ **No especial constraint is applied to select photons (i.e. pdg code)**
- ☐ Candidates to π^0 selected from all possible $\gamma\gamma$ combinations (invariant mass)

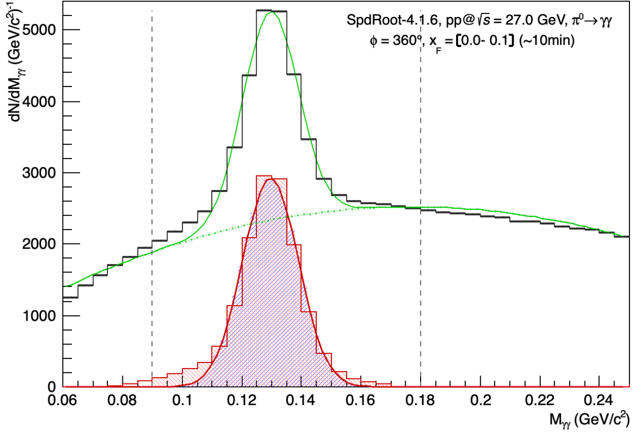
Yield N_{π^0} $vs. x_F$, $\Delta\phi = 360\ deg$



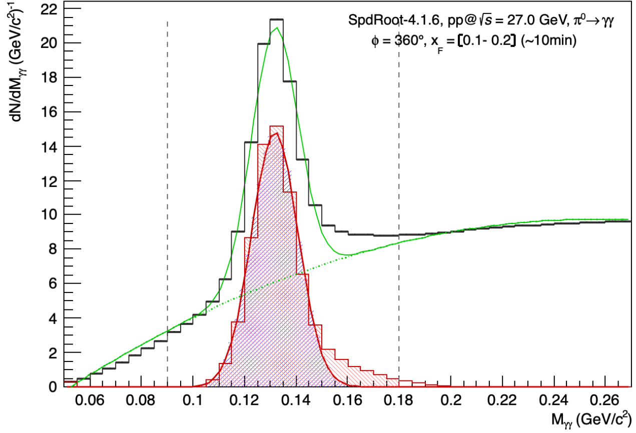
$$f(x) = [p0] \cdot exp(-0.5 \cdot ((x - [p1])/[p2]) \cdot ((x - [p1])/[p2]))/(sqrt(2\pi) \cdot [p2]) + [p3] + [p4] \cdot x + [p5] \cdot pow(x, 2)$$

Inv. Mass $vs. x_F$, $\Delta\phi = 360\ deg$

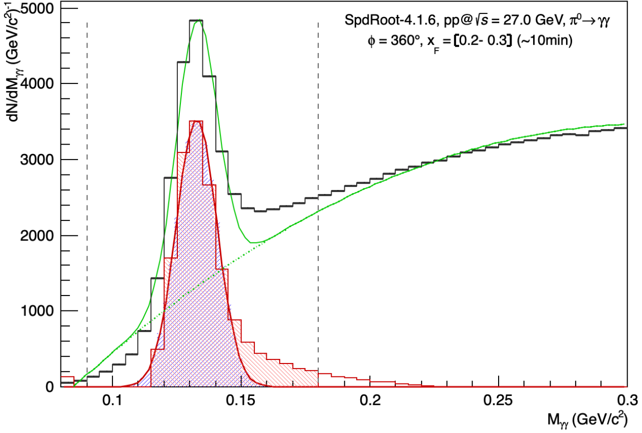
$x_F = [0.0 - 0.1]$



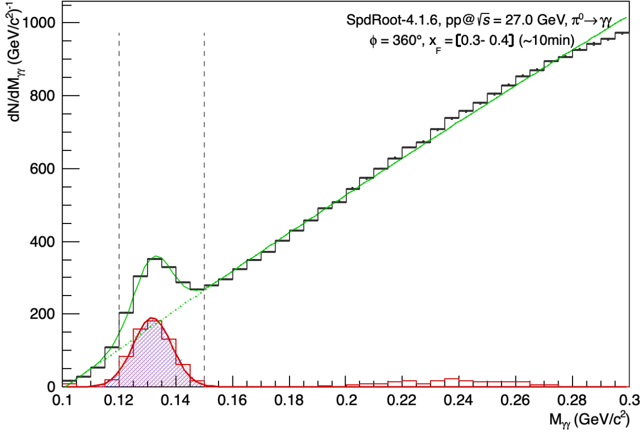
$x_F = [0.1 - 0.2]$



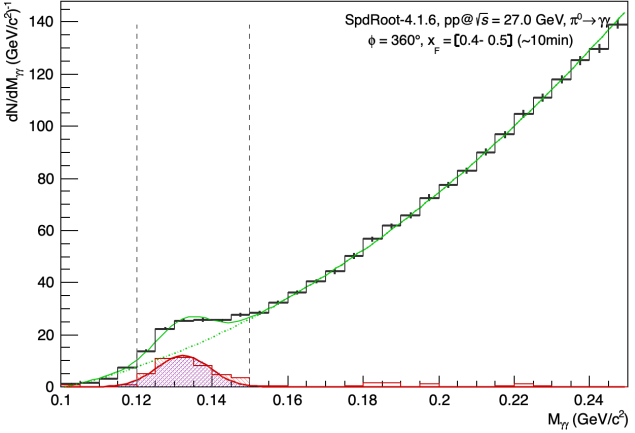
$x_F = [0.2 - 0.3]$



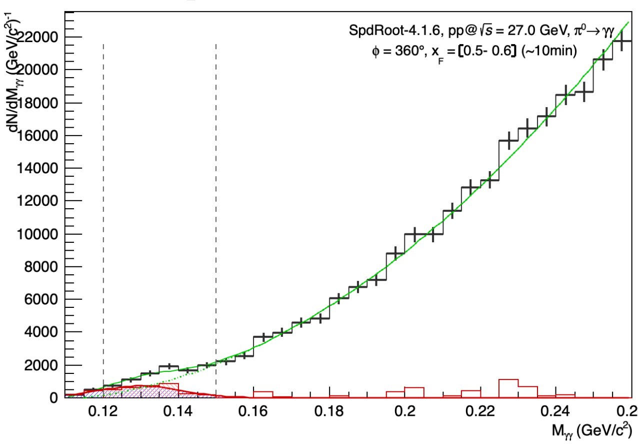
$x_F = [0.3 - 0.4]$



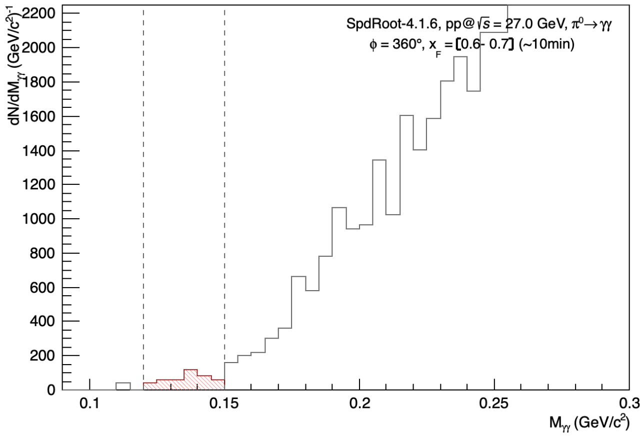
$x_F = [0.4 - 0.5]$



$x_F = [0.5 - 0.6]$



$x_F = [0.6 - 0.7]$

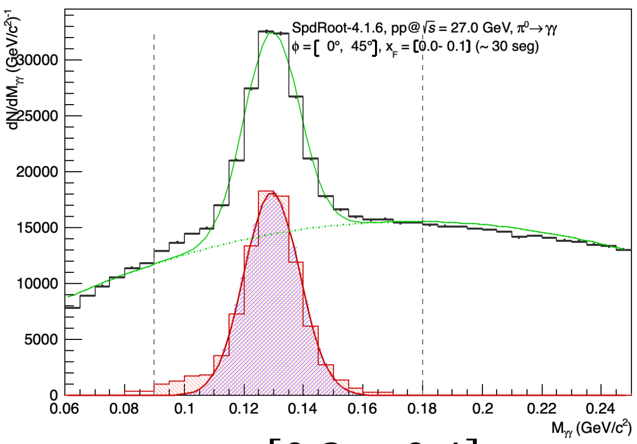


$Fit: gausn + pol2$

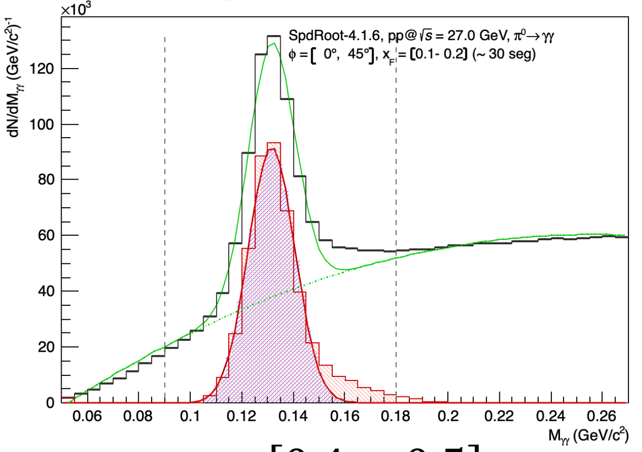
$$f(x) = [p0] \cdot exp(-0.5 \cdot ((x - [p1])/[p2]) \cdot ((x - [p1])/[p2]))/(sqrt(2\pi) \cdot [p2]) + [p3] + [p4] \cdot x + [p5] \cdot pow(x, 2)$$

Inv. Mass $vs. x_{\mathrm{F}}$, $\Delta\phi = 0 \; - 45 \; deg$

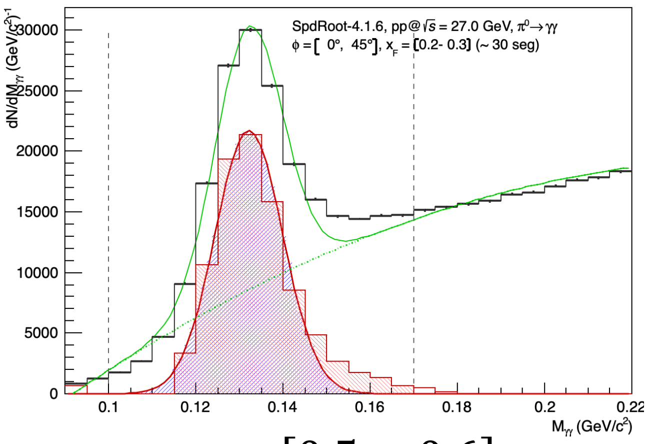
$x_{\mathrm{F}} = [0.0 - 0.1]$



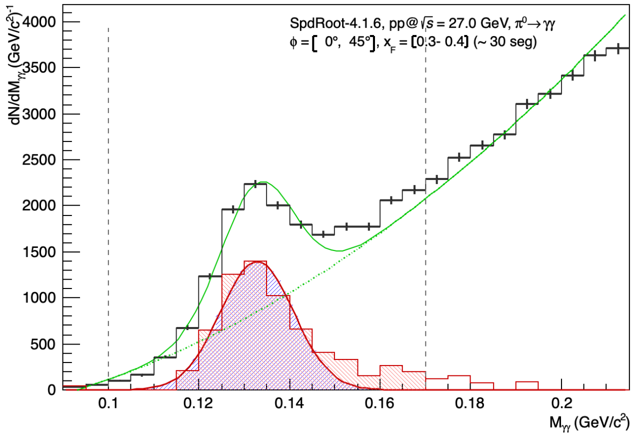
$x_{\mathrm{F}} = [0.1 - 0.2]$



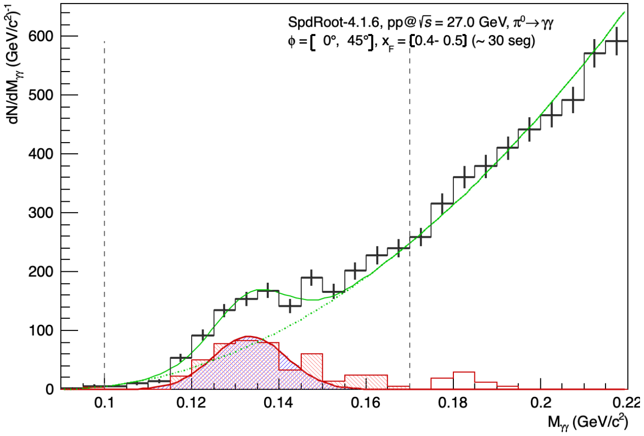
$x_{\mathrm{F}} = [0.2 - 0.3]$



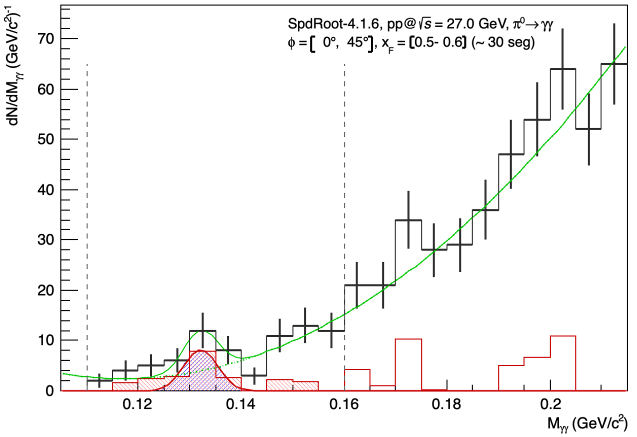
$x_{\mathrm{F}} = [0.3 - 0.4]$



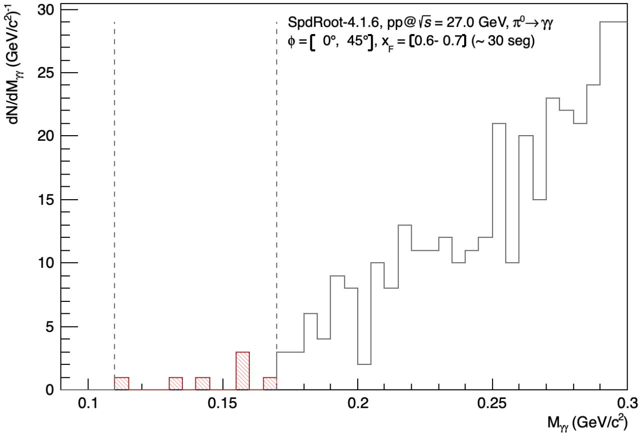
$x_{\mathrm{F}} = [0.4 - 0.5]$



$x_{\mathrm{F}} = [0.5 - 0.6]$



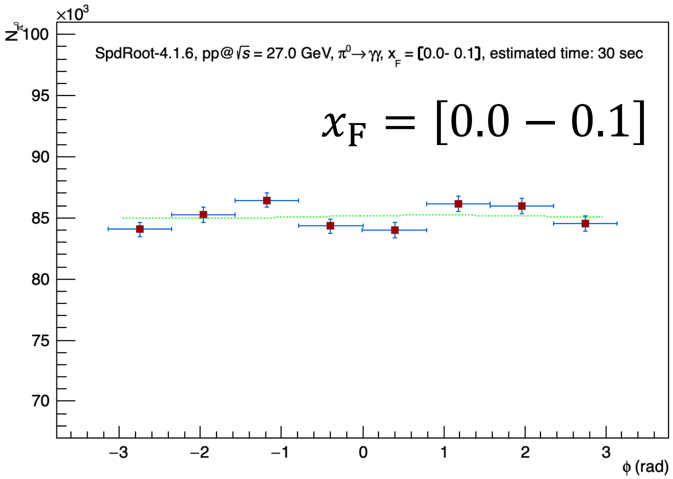
$x_{\mathrm{F}} = [0.6 - 0.7]$

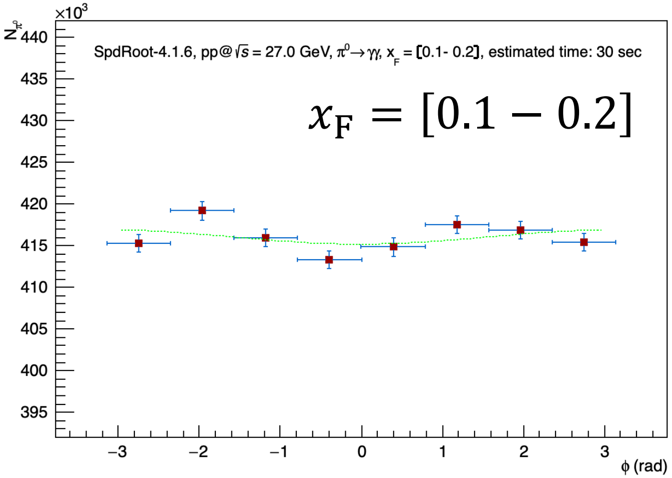


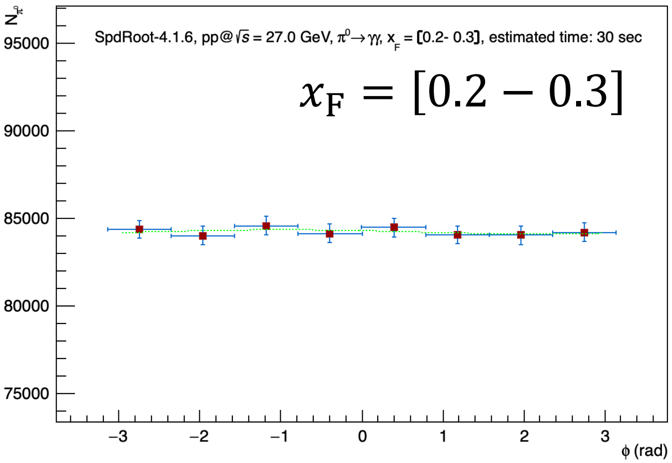
$Fit: gausn + pol2$

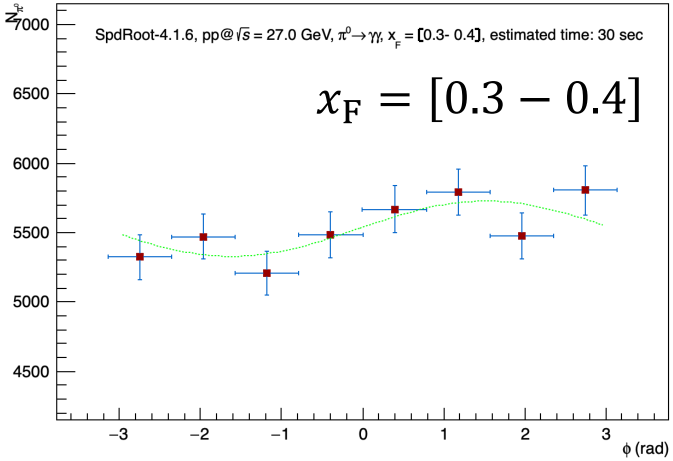
$$f(x) = [p0] \cdot exp(-0.5 \cdot ((x - [p1])/[p2]) \cdot ((x - [p1])/[p2]))/(sqrt(2\pi) \cdot [p2]) + [p3] + [p4] \cdot x + [p5] \cdot pow(x, 2)$$

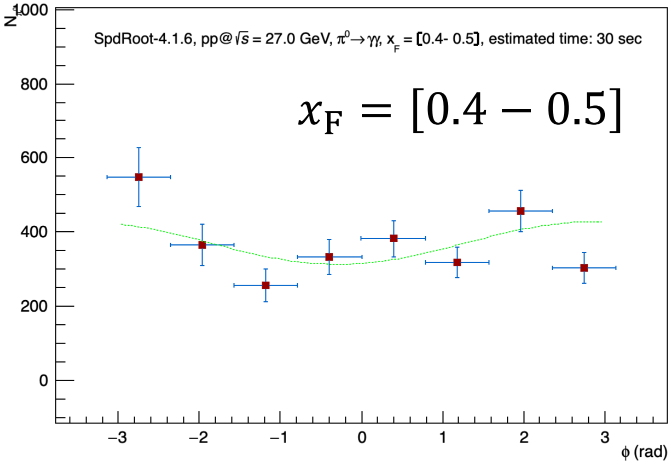
Azimuthal cosine modulation of π^0 yields in x_F intervals

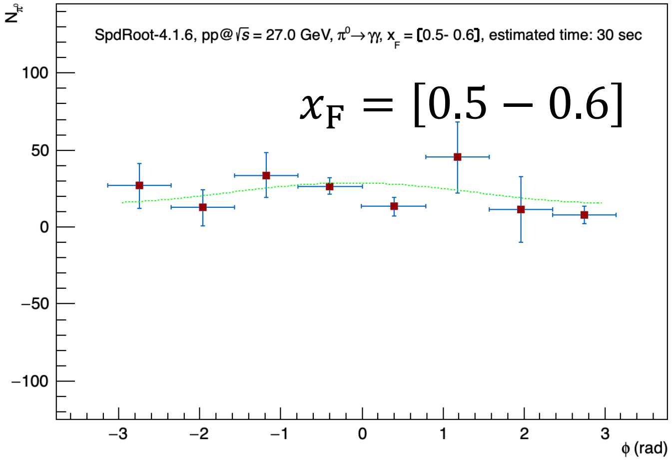


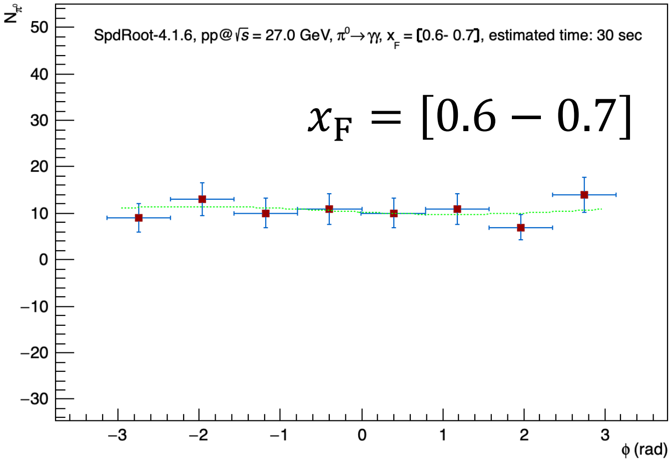












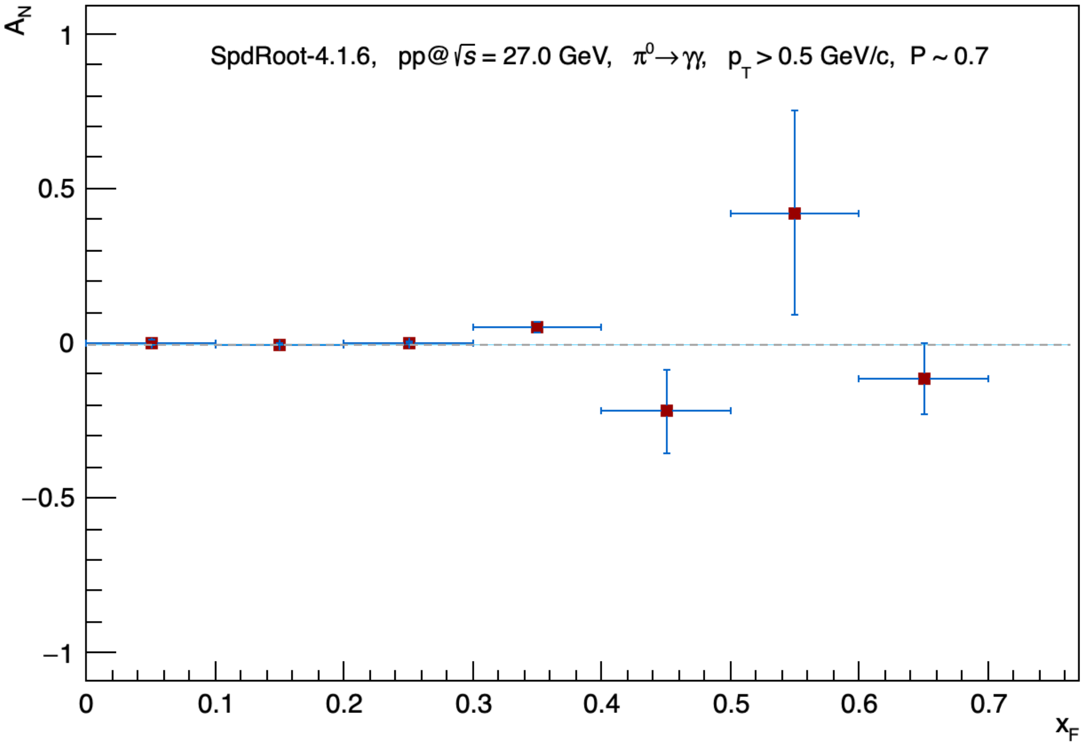
Azimuthal cosine modulation:

$$[p0] \cdot (1 + \underbrace{[p1]}_{P \cdot A_N} \cdot \cos([p2] + x))$$

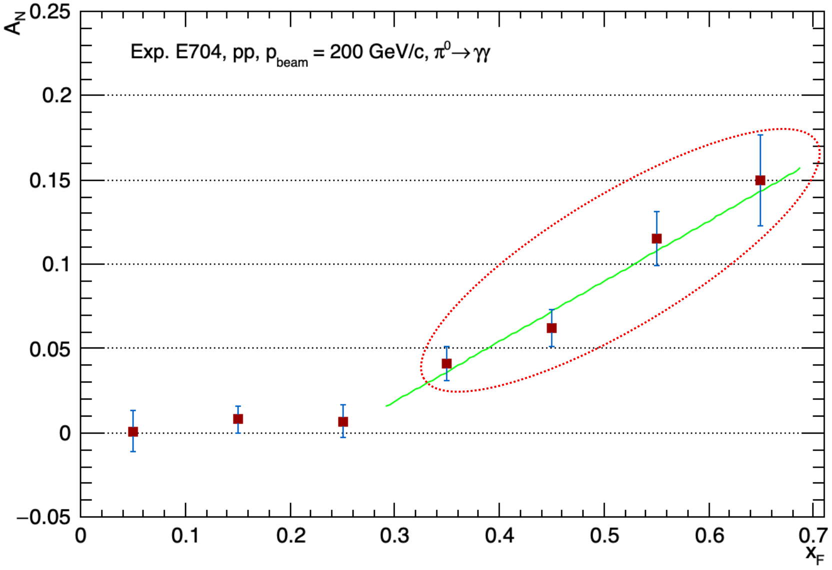
$(P{\sim}0.7)$

A_N in the ECAL endcap

A_N vs. x_F (spdroot)



Experiment E704 (1991)



$$\frac{\Delta A_N}{A_N}$$

ΔA_N → SpdRoot

A_N → E704

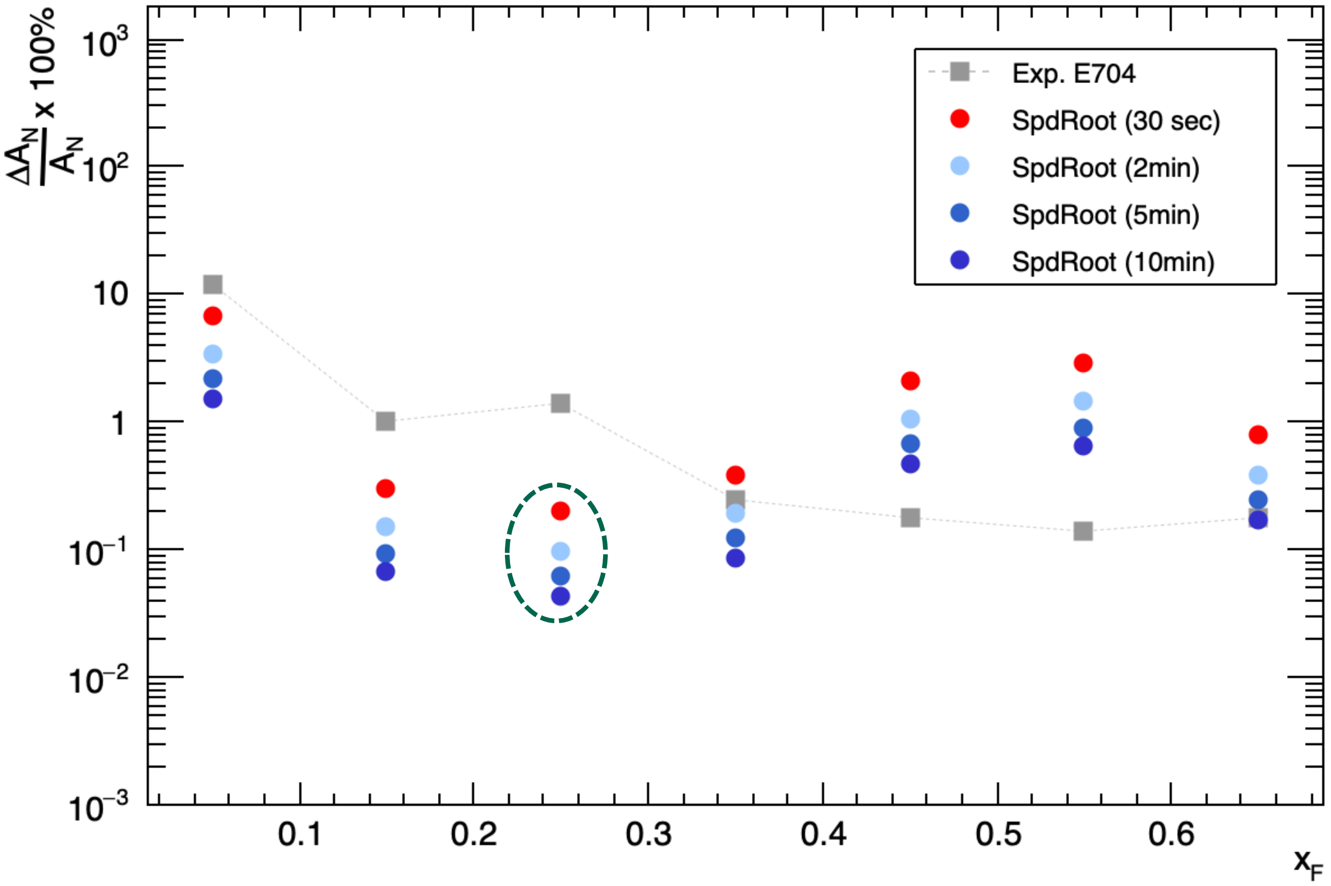
$$\frac{\Delta A_N}{A_N} \sim \frac{\Delta P}{P}$$

Relative error for A_{N}, pp @ $\sqrt{s} = 27$ GeV

$\frac{\Delta A_{\mathrm{N}}}{A_{\mathrm{N}}}$ ***vs.*** x_{F}

$$\frac{\Delta A_{\mathrm{N}} \rightarrow \text{SpdRoot}}{A_{\mathrm{N}} \rightarrow \text{E704}}$$

$$\frac{\Delta A_{\mathrm{N}}}{A_{\mathrm{N}}} \sim \frac{\Delta P}{P}$$

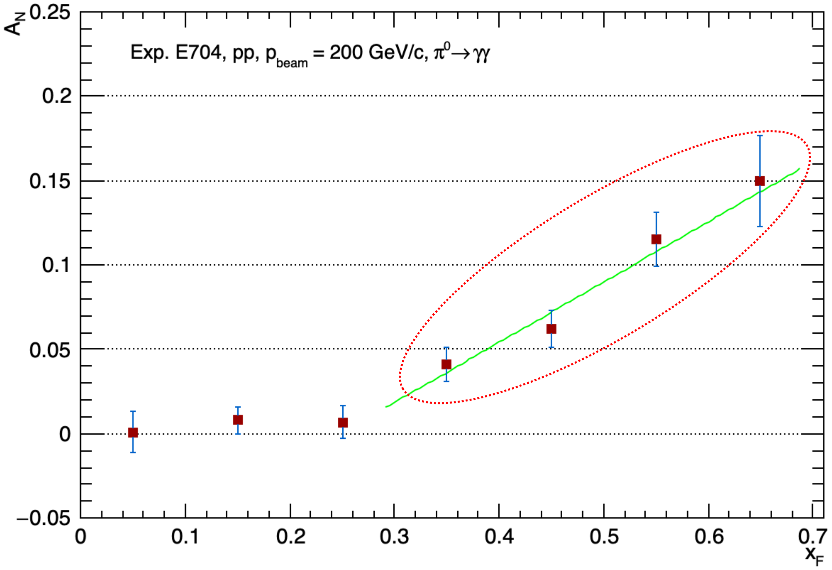


Better precision of the polarization measurement expected at:
$0.2 < x_F < 0.3$ ($\sqrt{s} = 27$ GeV)

Estimated relative error of the polarization

$$\frac{\Delta A_{\mathrm{N}}}{A_N} \sim \frac{\Delta P}{P}$$

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



Taking three experimental 4 points ($0.3 \leq x_F < 0.7$): $\frac{\Delta P}{P} = 0.0998$ → 9.9 % (Experiment E704)

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

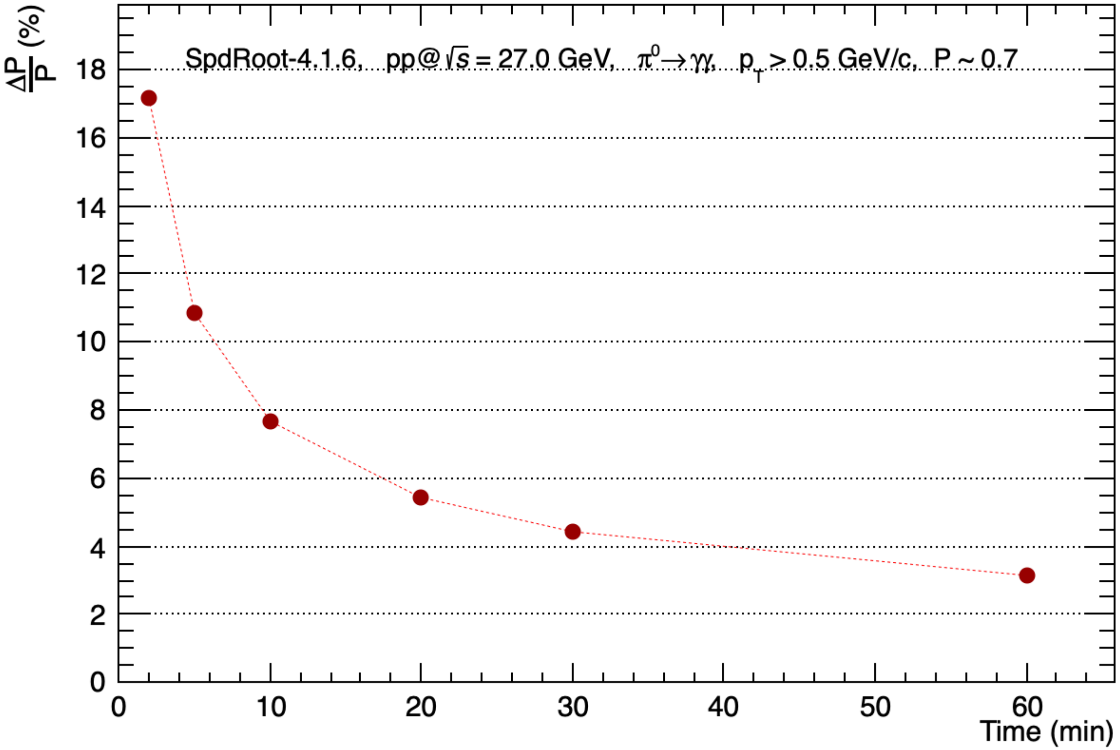
(FERMILAB-Pub-91/15-E[E581,E704])

Estimated relative error of the polarization

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

Realistic reconstruction

Estimated time	$\frac{\Delta P}{P}$
	Fitting and substracting bkg
2 min	17.14 %
5 min	10.84 %
10 min	7.67 %
20 min	5.42 %
30 min	4.43 %
1 h	3.13 %



TODO

- ✓ Explore the possibility of including skewed Gaussian functions.
- ✓ Identify photons originating from the same π^0 to better elucidate the π^0 signal, mostly at high x_F.