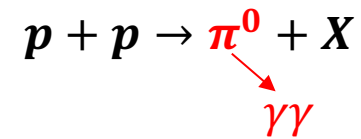


# Inclusive $\pi^0$ production for online polarimetry in SPD (SpdRoot-4.1.5)

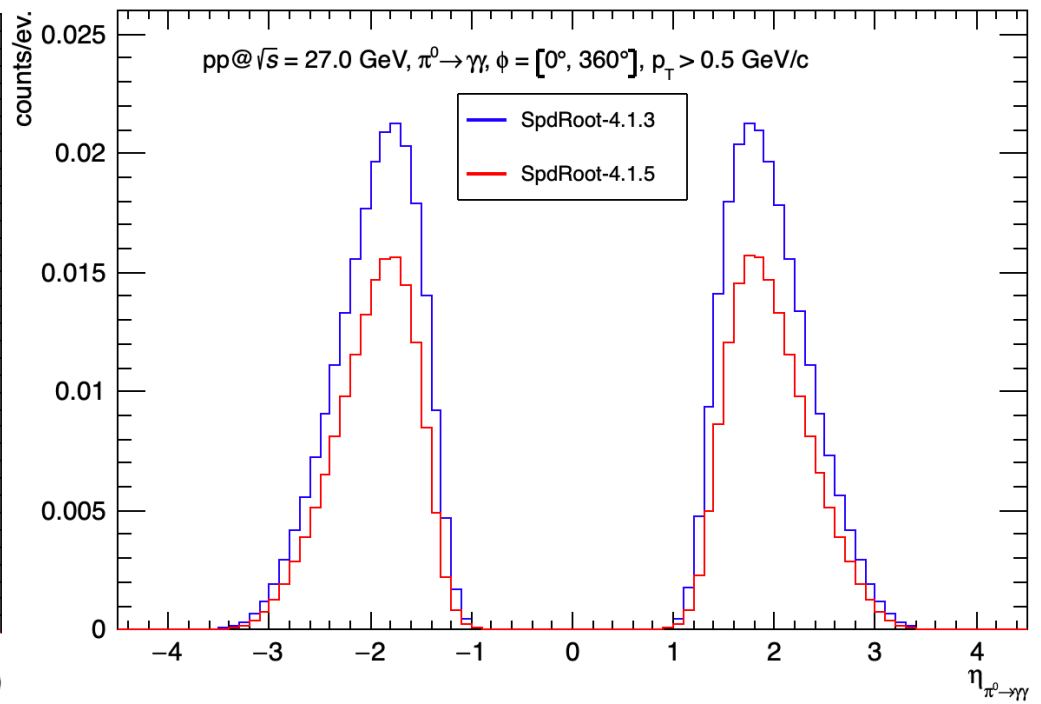
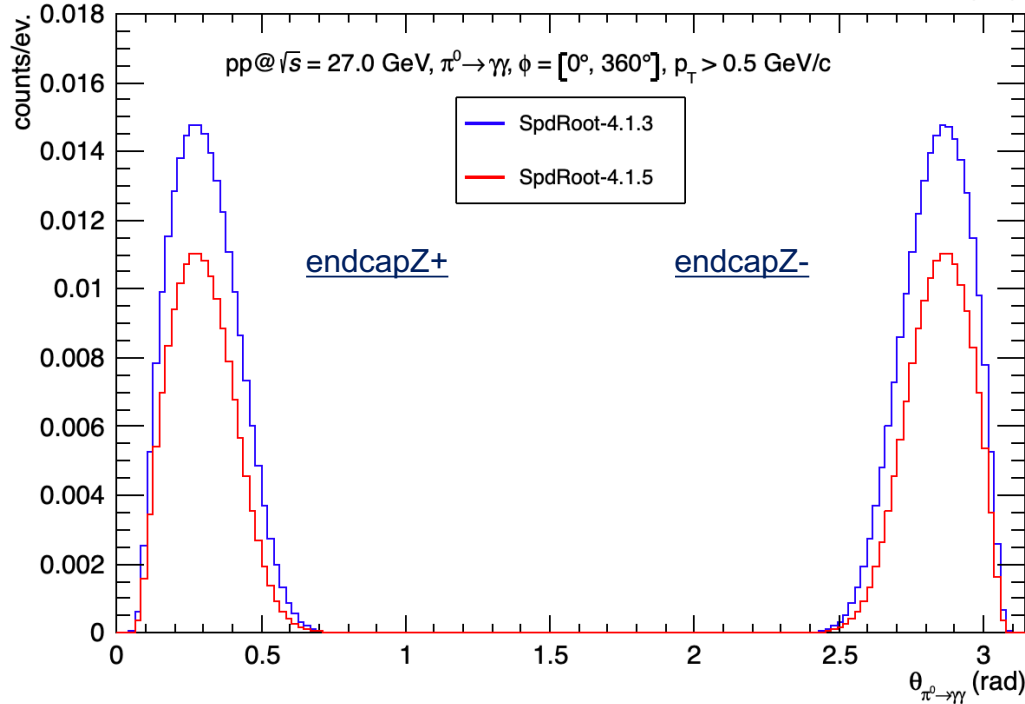
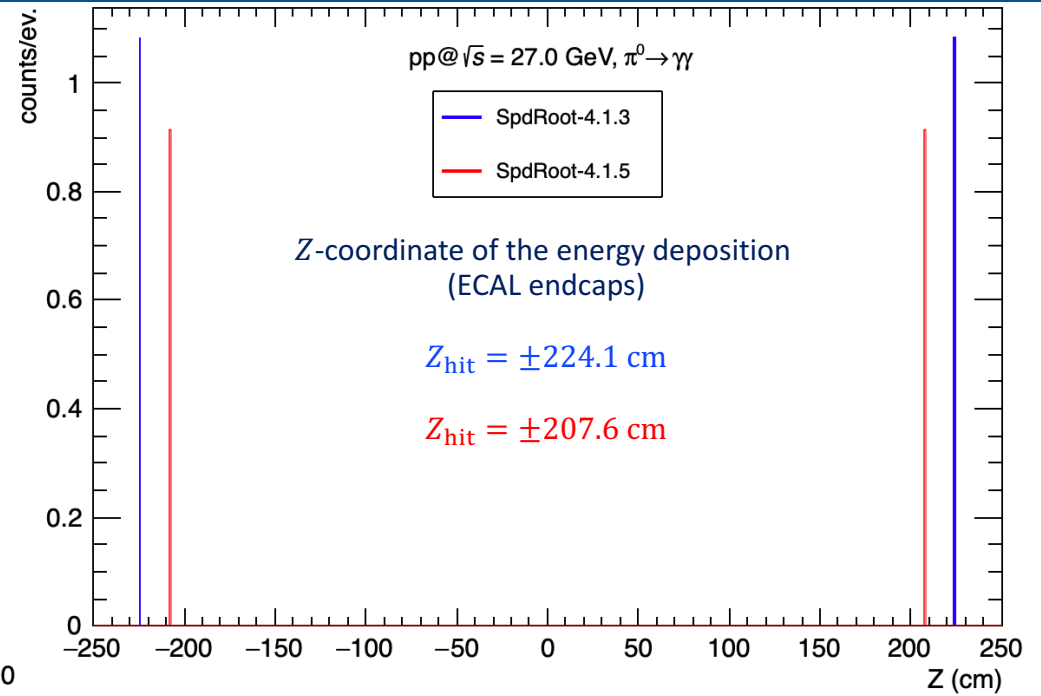
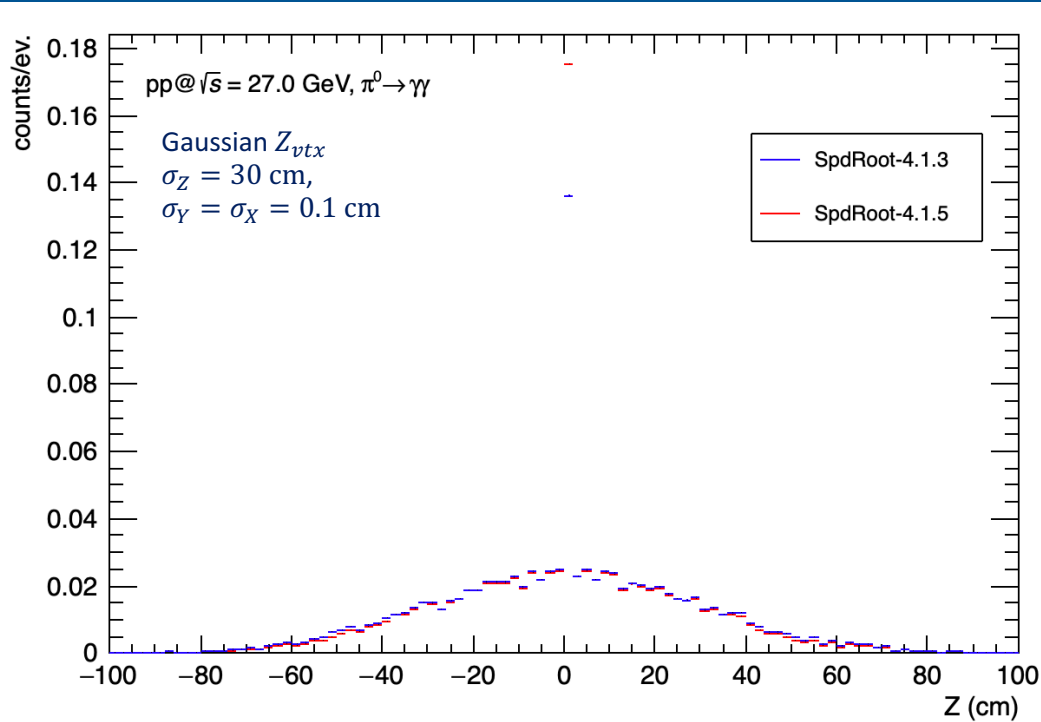
Katherin Shtejer Díaz

SPD Collaboration Meeting  
22.02.2023

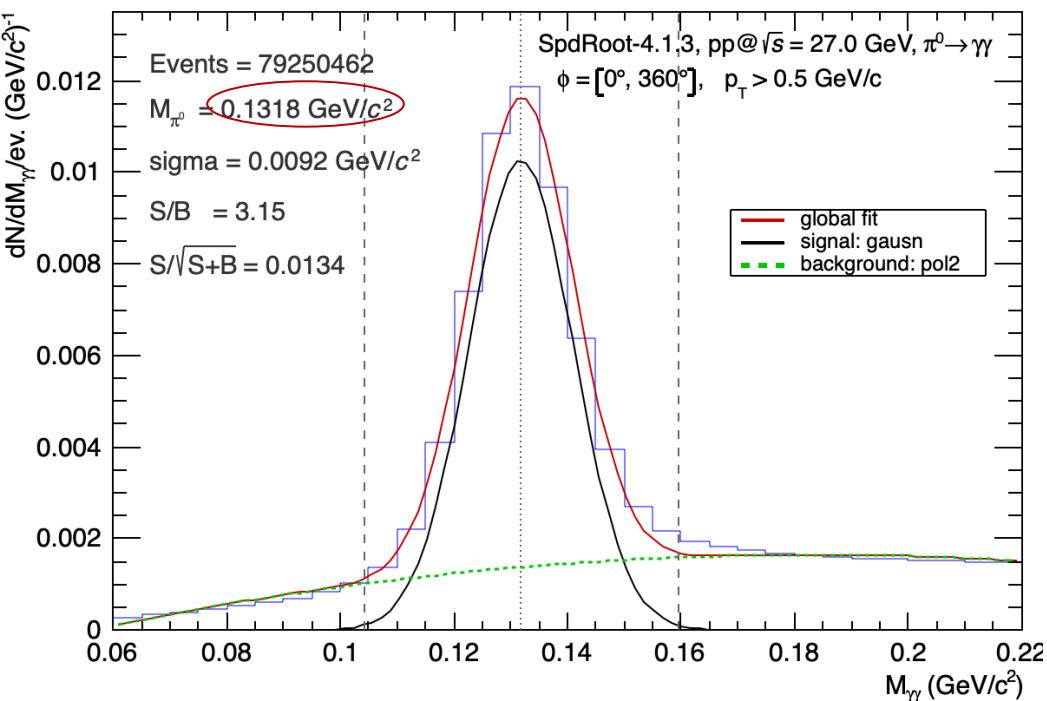


- ❑ SpdRoot version 4.1.5
- ❑  $pp @ \sqrt{s} = 27 \text{ GeV}$
- ❑ Particle generator: Pythia 8 (number of events:  $\sim 100\text{M}$ )
- ❑ Minimum Bias: *SoftQCD:inelastic*
- ❑ Smeared vertex in  $\Delta Z = \pm 30 \text{ cm}$  (Gauss)
- ❑  $E_{min}^\gamma = 400 \text{ MeV}$  ( $\gamma$  : reconstructed particle)
- ❑ Reconstructed photons detected in the ECAL Endcaps
  - detId = 1 (endcapZ+)     $Z = +207.6 \text{ cm}$
  - detId = 0 (endcapZ-)     $Z = -207.6 \text{ cm}$
- ❑ Cell size =  $4 \text{ cm}$
- ❑  $\pi^0$  are reconstructed from the  $M_{inv}$  of  $\gamma$  pairs

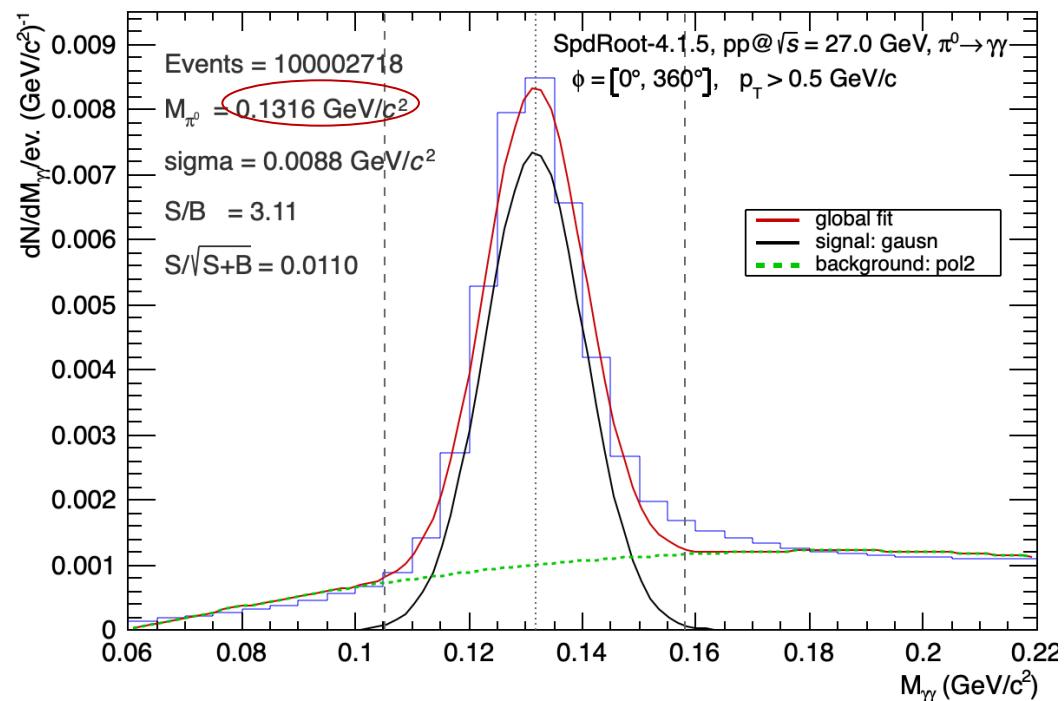
# General characteristics



## SpdRoot – 4.1.3

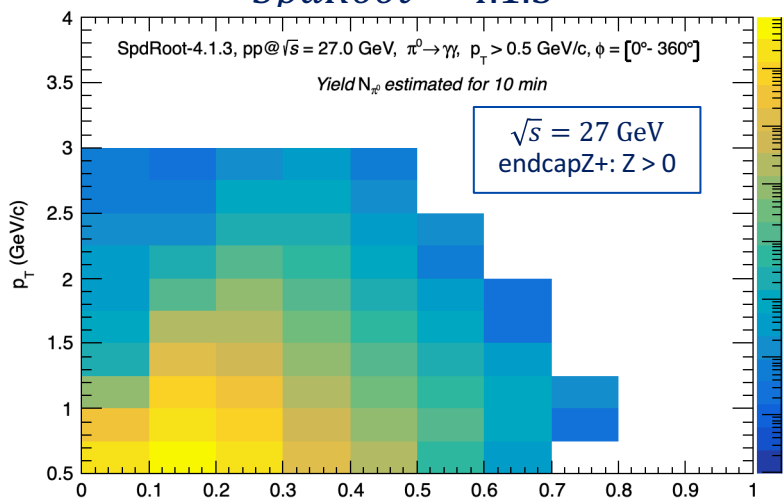


## SpdRoot – 4.1.5

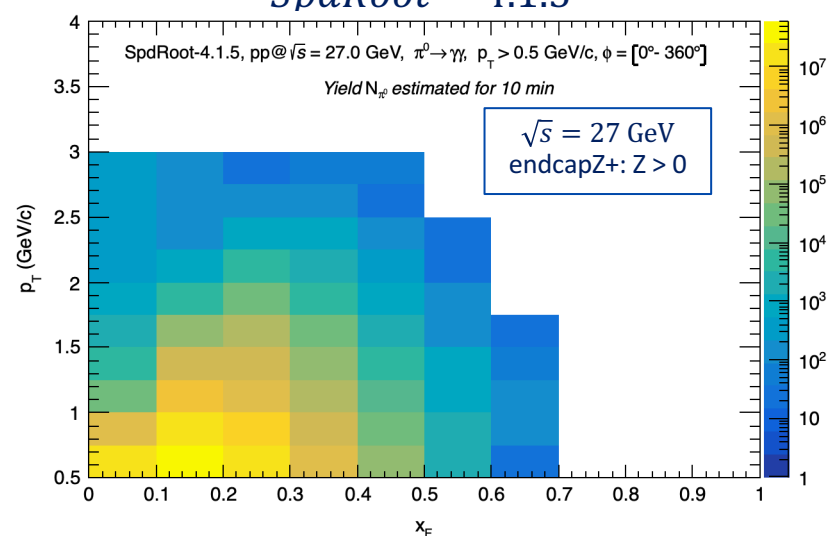


$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right] + p_1 + p_2x + p_3x^2$$

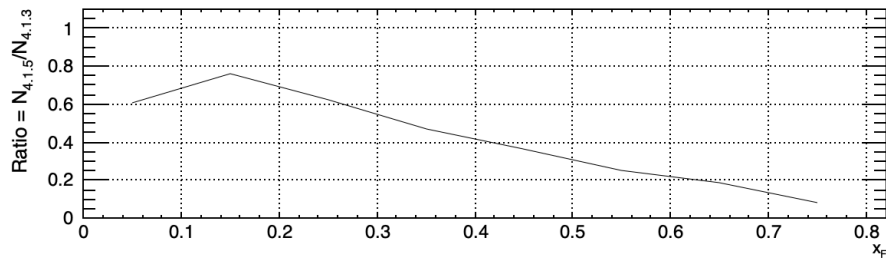
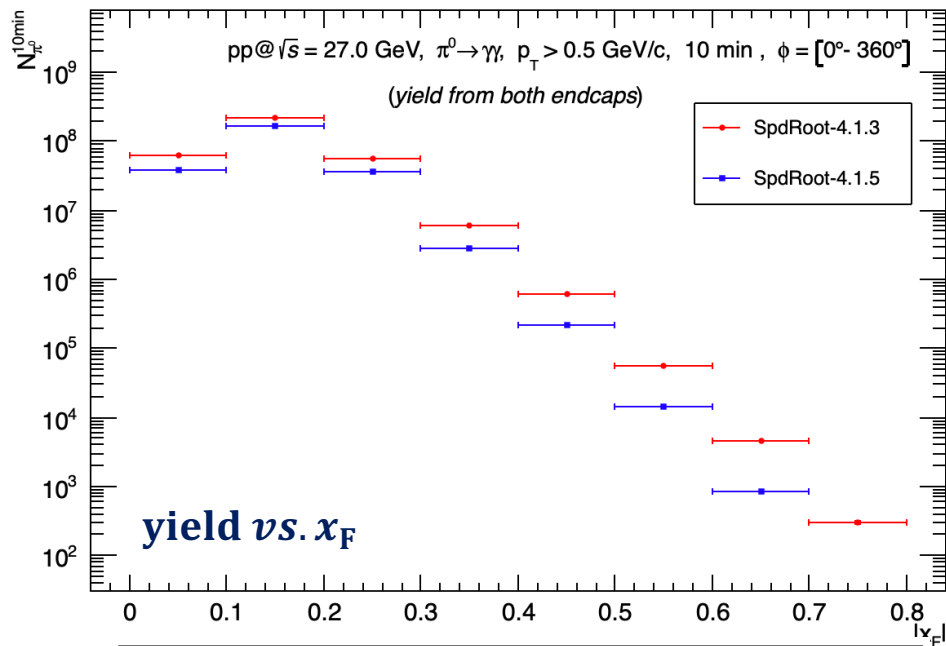
## SpdRoot – 4.1.3



## SpdRoot – 4.1.5

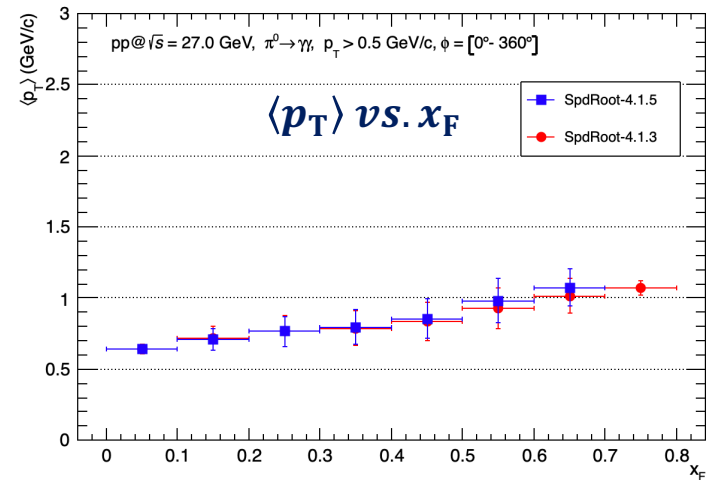
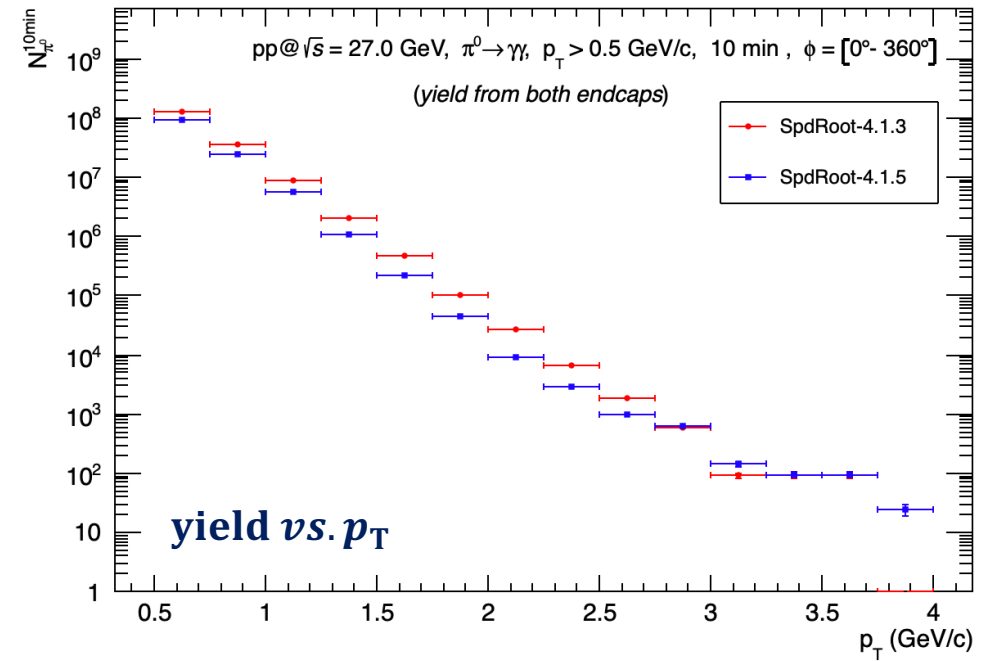


# Estimation of $\pi^0$ yield in the ECAL endcaps



Expected yield for 10 min at  
reaction rate  $4 \cdot 10^6 s^{-1}$  ( $\sqrt{s} = 27$  GeV)

SpdRoot	$N_{\pi^0}$ (10 min)	$\sigma_{stat}$ (%)
4.1.3	$3.4783e+08$	0.0054
4.1.5	$2.4519e+08$	0.0064



$$p^\uparrow + p \rightarrow \pi^0 + X \quad \phi = 2\pi$$

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

$$\frac{d\sigma}{d\varphi} = \frac{d\sigma}{d\varphi_0} [1 + \underbrace{P \cdot A_N \cdot \cos(\varphi + \varphi_0)}_{\text{Azimuthal cosine modulation}}]$$

Azimuthal cosine modulation

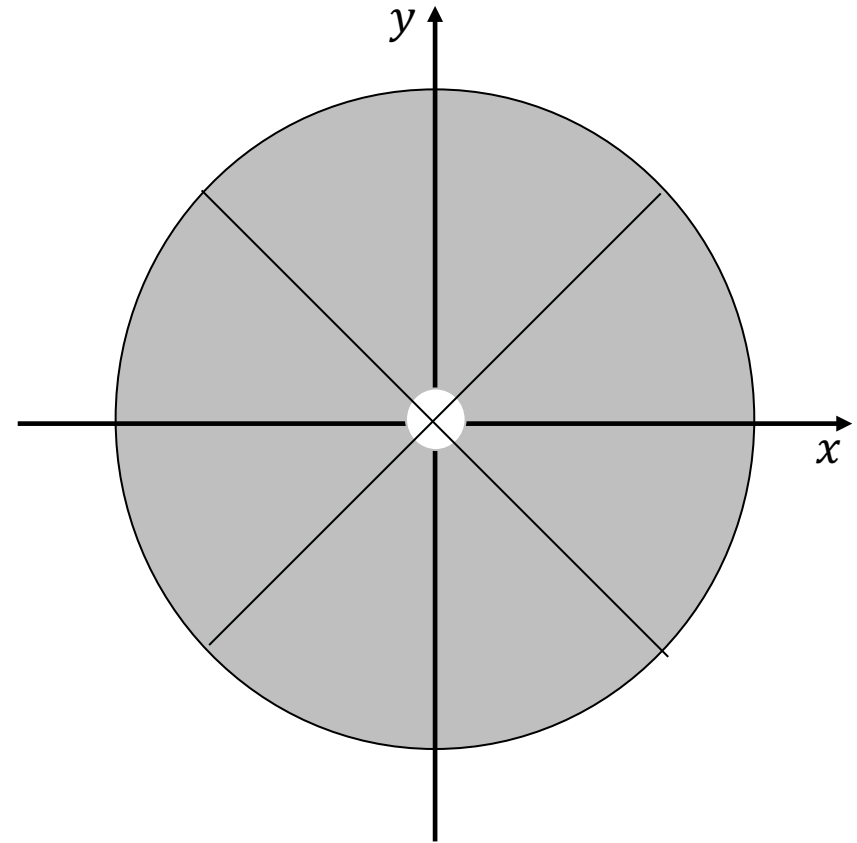
$$N_{\pi^0}(\varphi) = A[1 + P \cdot A_N \cdot \cos(\varphi + \varphi_0)]$$

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

$N_{\pi^0}(\varphi)$ : Yield of  $\pi^0$

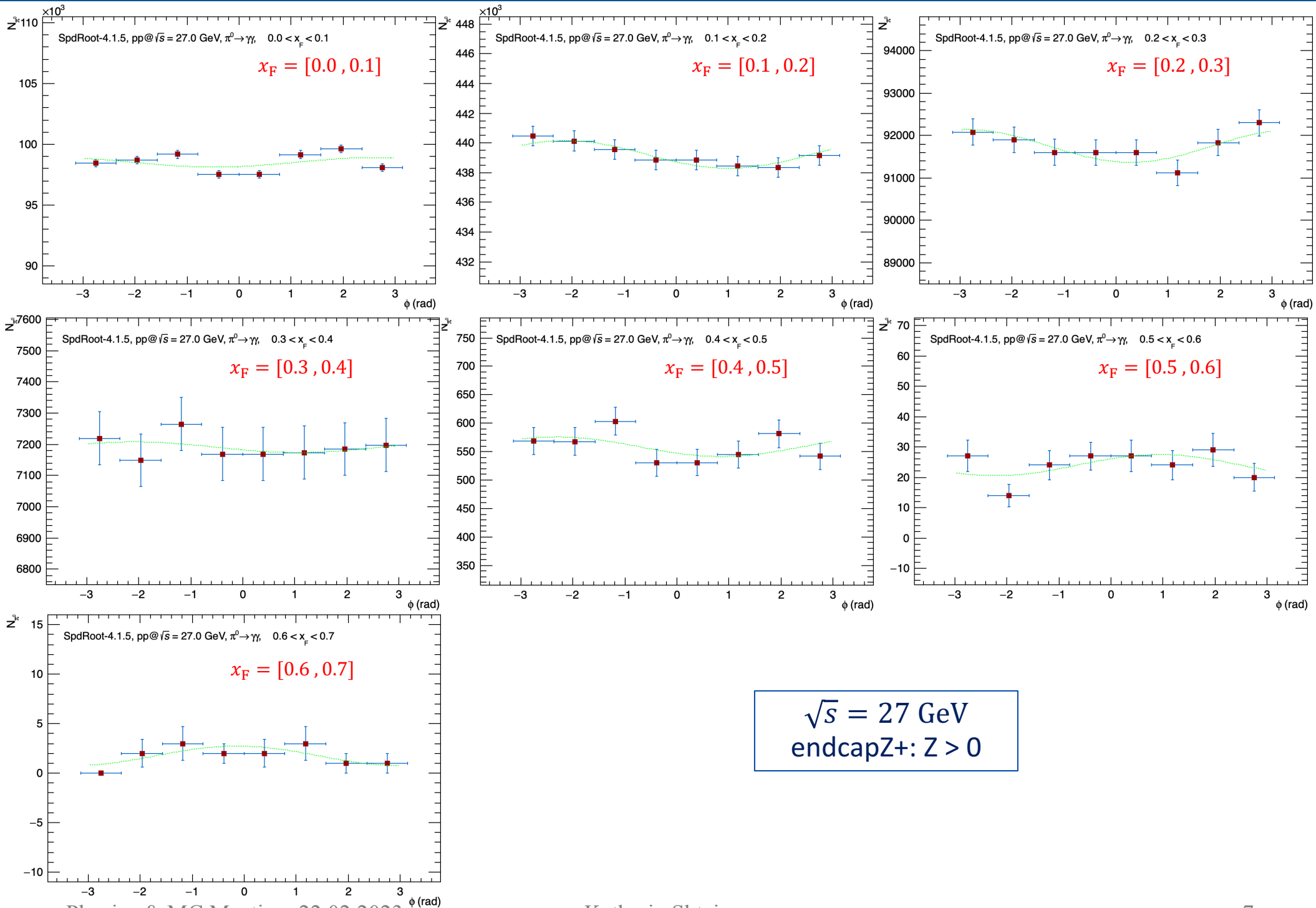
$P$ : Beam polarization

- $P \sim 0.7$  was assumed

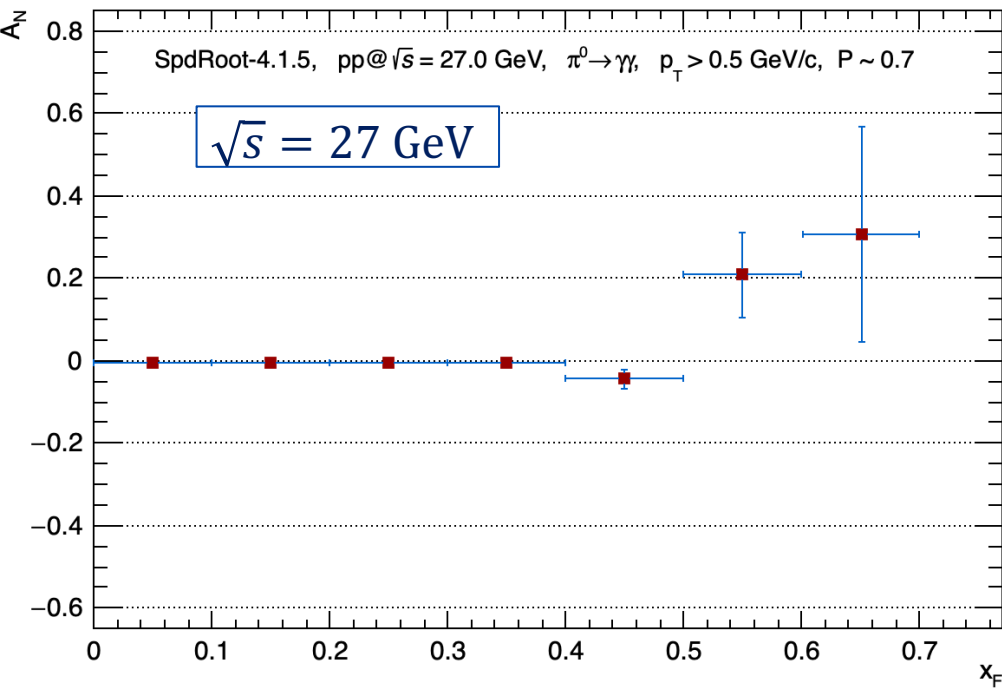


- The cosine modulation fittings were performed for two cases:
  - 1- pure cosine function, 2- adding a free phase
- The spin dependent  $\pi^0$  yields for each bin are extracted from the invariant mass spectra in different  $x_F$  sub-ranges for each  $\varphi$  bin.

# Azimuthal cosine modulation of $\pi^0$ yields in $x_F$ intervals, $A(1 + B \cos(\varphi + \varphi_0))$



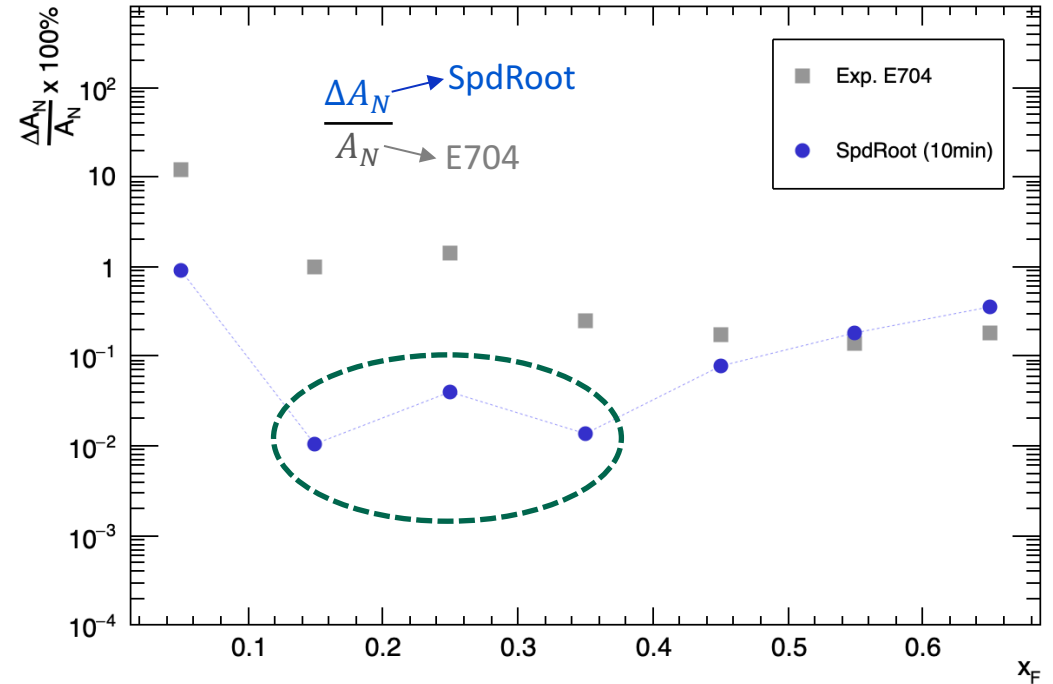
## $A_N$ in $x_F$ intervals



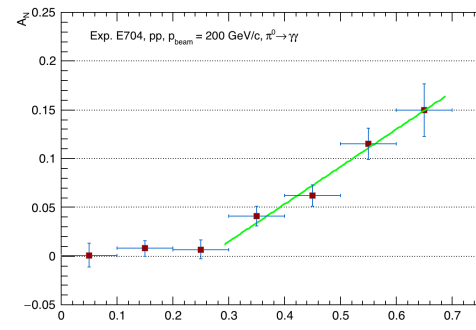
SpdRoot estimation of the statistical accuracy of the beam polarization measurement, with  $pp \rightarrow \pi^0 X$  @  $\sqrt{s} = 27$  GeV, in SPD ECAL endcaps.

Estimated time	$\frac{\Delta P}{P}$	
	SpdRoot – 4.1.3	SpdRoot – 4.1.5
2 min	4.59 %	3.05 %
5 min	2.90 %	1.93 %
10 min	2.05 %	1.37 %

## Estimated rel. error $\frac{\Delta A_N}{A_N}$ vs. $x_F$



The error of the beam polarization in the experiment **E704** is estimated in **10%**, as reported in FERMILAB-Pub-91/15-E[E581,E704]



Taking the last 4 points ( $0.3 \leq x_F < 0.7$ ):

**8.7%** (Experiment E704)

$$\frac{\Delta P}{P} \approx 0.0873$$



- In the release SpdRoot 4.1.5 the  $\pi^0$  yield decreased 1.4 times with regards to analysis based on the the previous version 4.1.3.
- The accuracy of the beam polarization have been estimated for pp @ 27 GeV, and is **~1%** lower with the last version SpdRoot-4.1.5.
- From the asymmetry determination, based on SPDRoot simulations, the statistical accuracy of the beam polarization is estimated in:

$$\sqrt{s} = 27 \text{ GeV}$$

$$\text{➤ 2 minutes: } \frac{\Delta P}{P} \sim \mathbf{3.05\%}$$

$$\text{➤ 5 minutes: } \frac{\Delta P}{P} \sim \mathbf{1.93\%}$$

$$\text{➤ 10 minutes: } \frac{\Delta P}{P} \sim \mathbf{1.37\%}$$

- TODO: Simulations with more statistics (at least  $\sim 10^9$ ) should be carried out in order to estimate better the asymmetry errors at  $x_F > 0.6$