# Initial Belle II $\tau \to \pi\nu$ Selection for Tau Polarimetry

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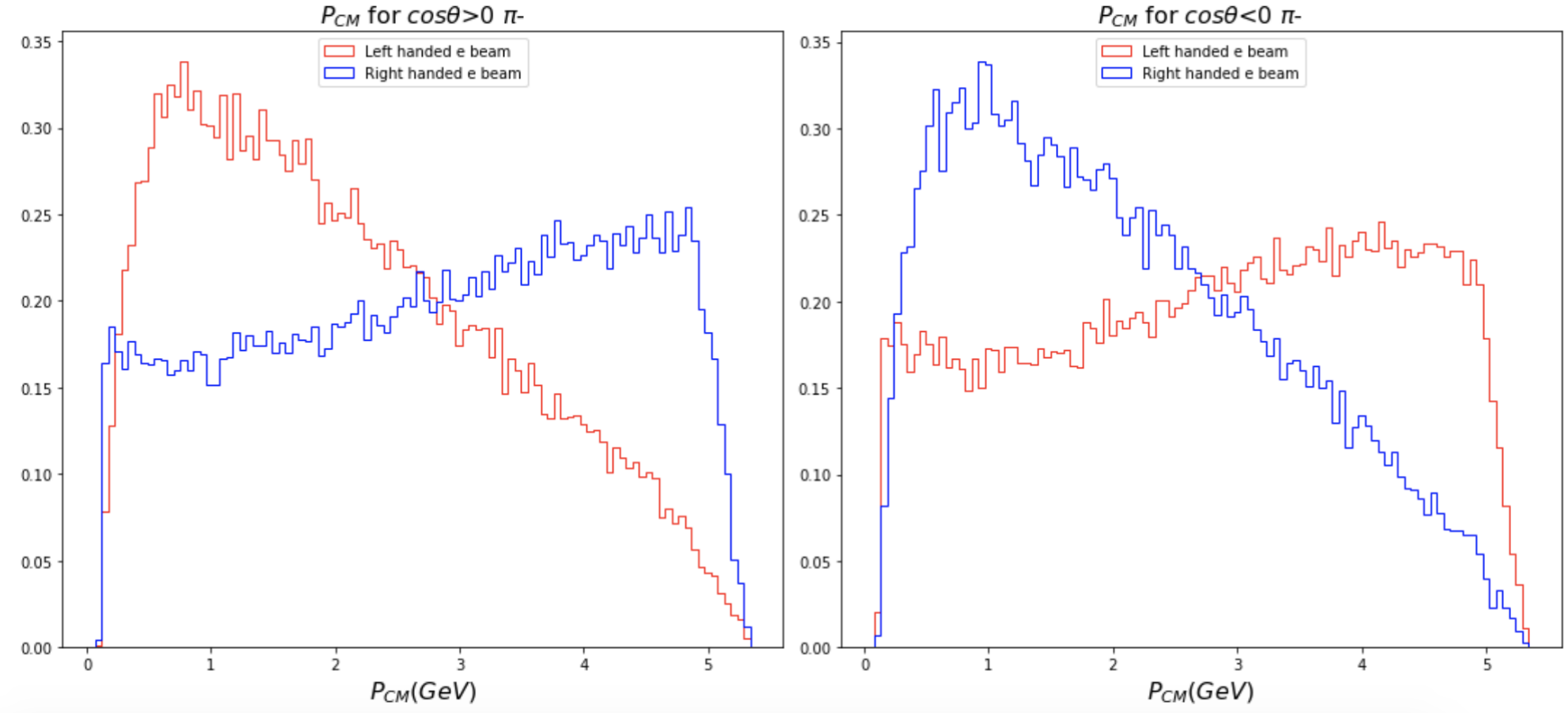
# Pion Momentum, Polarization Sensitivity

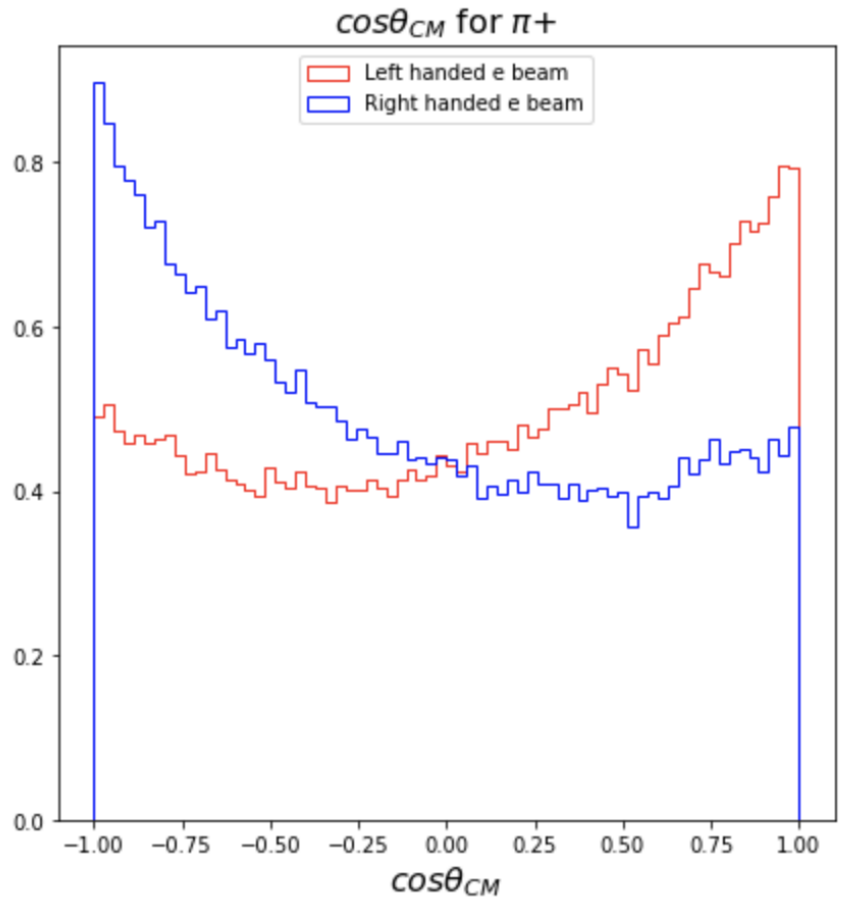
- Polarization sensitivity is mirrored between the forward and backward region of the detector
- Theta is defined as the angle between the pion and the electron beam direction

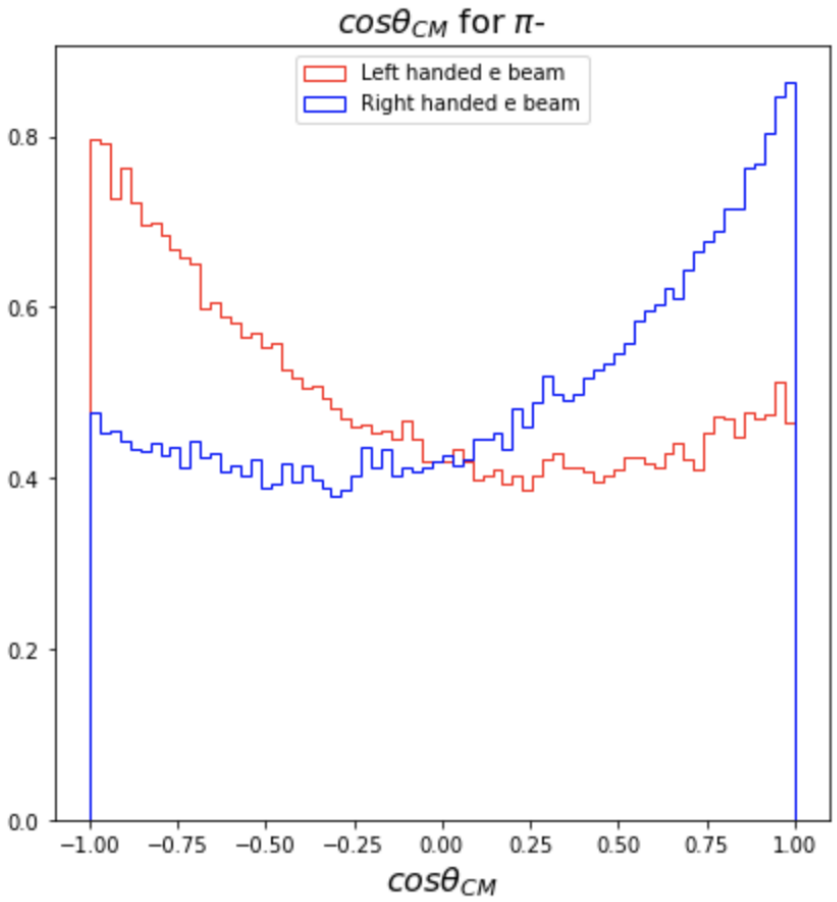



Red: Left-Handed $e^-$ beam, Blue: Right-Handed $e^-$ beam

# Pion Angular Distribution, Polarization Sensitivity

- Using momentum and cosθ gives together improves sensitivity



# Polarization Fit

- We employ the Barlow&Beeston[1] template fit methodology
- MC and data is binned in 2D histograms of momentum vs cosθ
- Polarized tau MC is used for each beam state in order to be sensitive to the polarization
- The data (or data-equivalent MC) is fit as a linear combination of the templates

$$D = a_l L + a_r R + a_b B + a_m M + a_u U + a_c C$$

$$\sum a_i \equiv 1$$

$$\langle P \rangle \equiv a_l - a_r$$

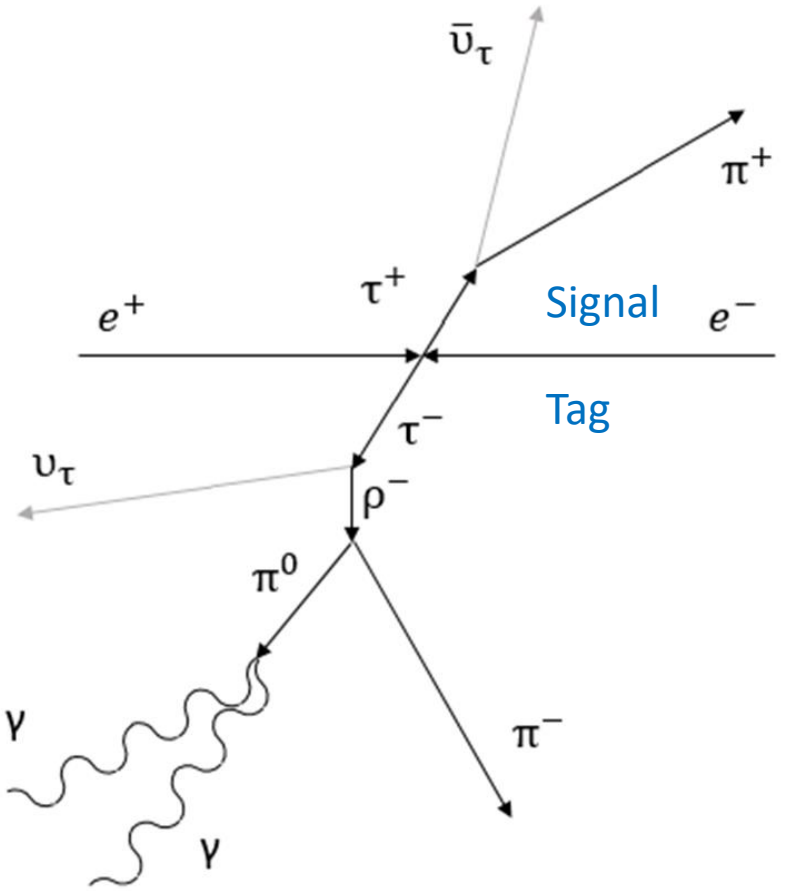
L=Left Polarized Tau MC, R=Right Polarized Tau MC, B=Bhabha($e^+e^-$),M=μμ, U=uds, C=c$\bar{c}$

[1] R. Barlow, C. Beeston; Computer Physics Communications, Volume 77, Issue 2, 1993, Pages 219-228, https://doi.org/10.1016/0010-4655(93)90005-W

# Belle II initial selection

## Analysis cuts

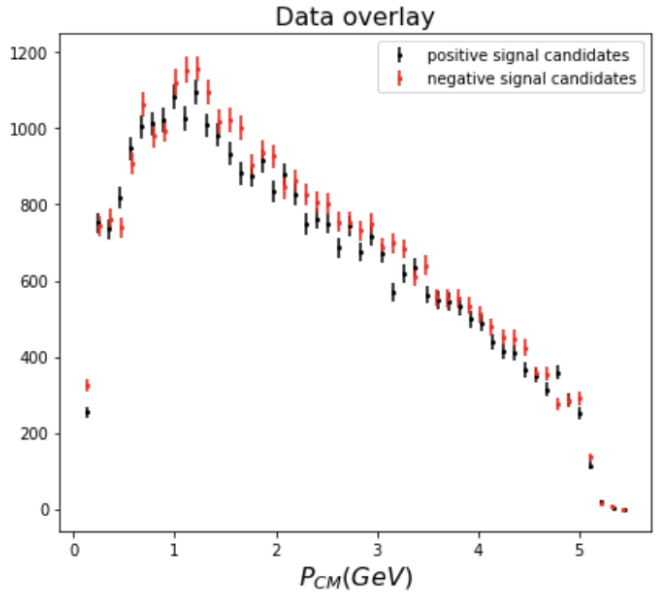
- trackCuts = 'dr <= 1.0 and -5.0 <= dz <= 5.0 and nCDCHits > 0’
- gammaCuts = 'E > 0.200 and -0.8660 < cosTheta < 0.9563’
- No. of tracks==2 & no. of photons ==2
- Signal and tag particles on opposite side of event
- pi0 invariant mass window of (0.08, 0.2) GeV
- piIDCuts = 'electronID <= 0.5 and muonID <= 0.5’
- Tauskim on Data (partial on MC)



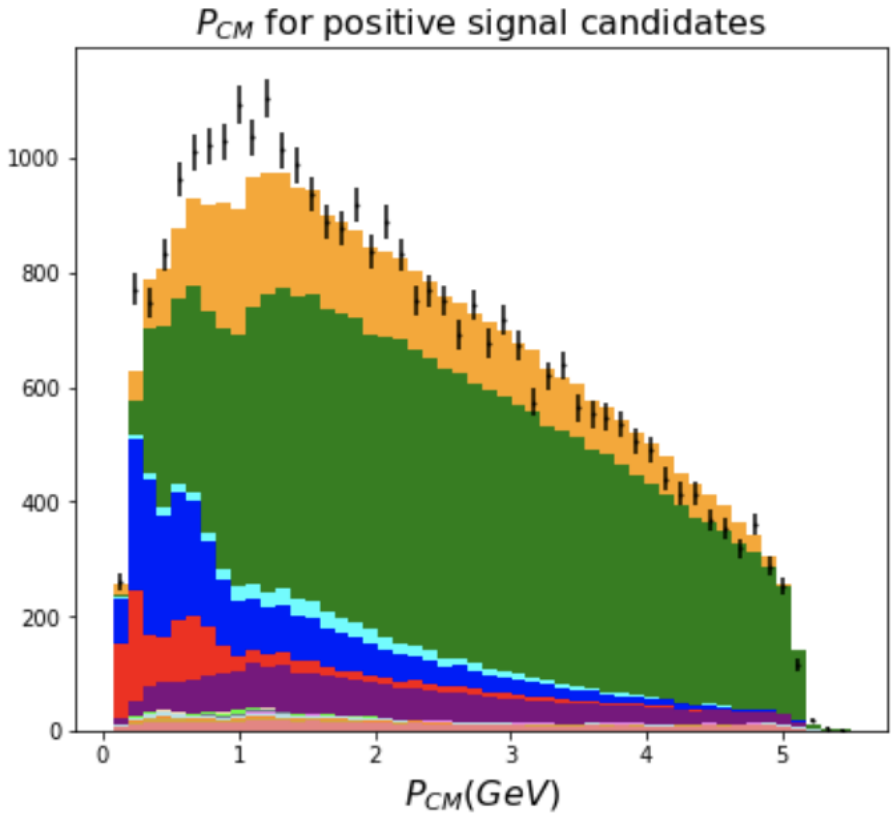

## Scaling

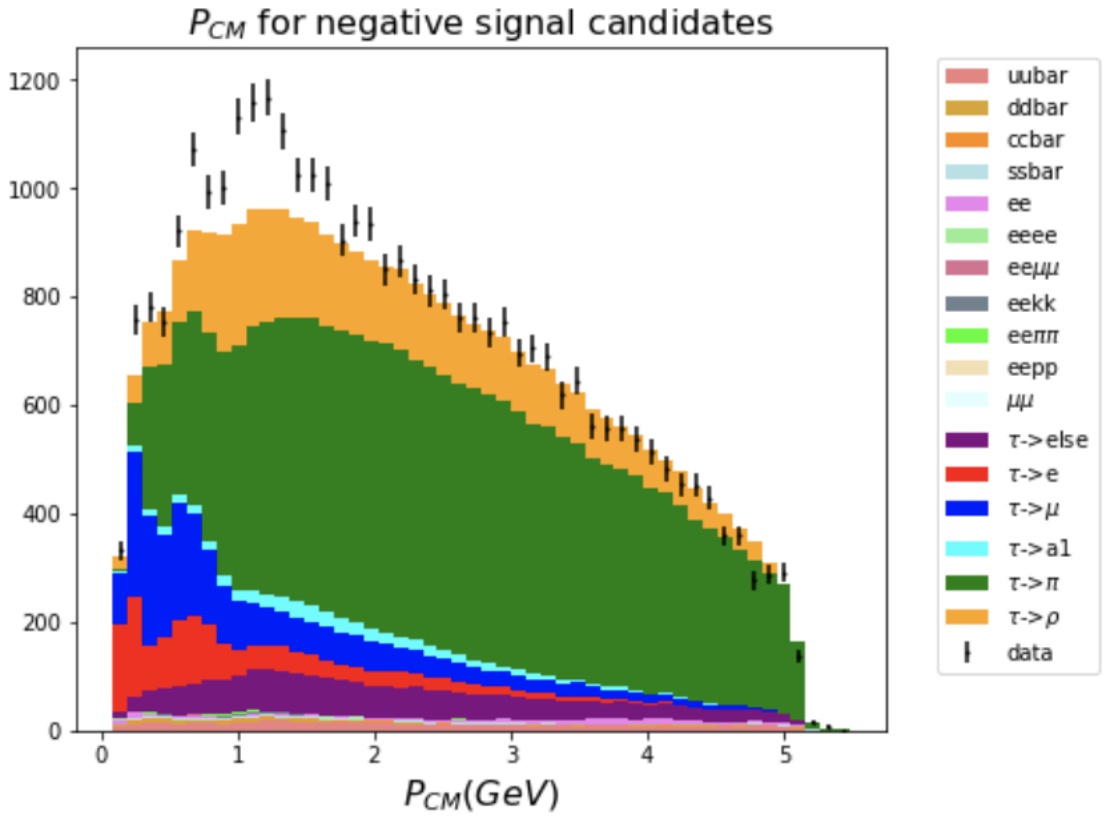
- MC13a : 100 $fb^{-1}$ of MC types
  - “Generic”: qqbar, taupair (B mesons not included at this stage)
  - “Lowmulti”: eeee,eeμμ, μμ(50$fb^{-1}$),ee(10 $fb^{-1}$), 1$ab^{-1}$ of: eepipi, eeKK, eepp
- proc10: exp7+8 tauskim about 5$fb^{-1}$
- All MC scaled to 100$fb^{-1}$ and then scaled down to 4$fb^{-1}$ to produce the plots shown
  - 4$fb^{-1}$ was chosen arbitrarily to bring data/mc near 1 and partially account for some failed data runs on the grid

# CMS momentum

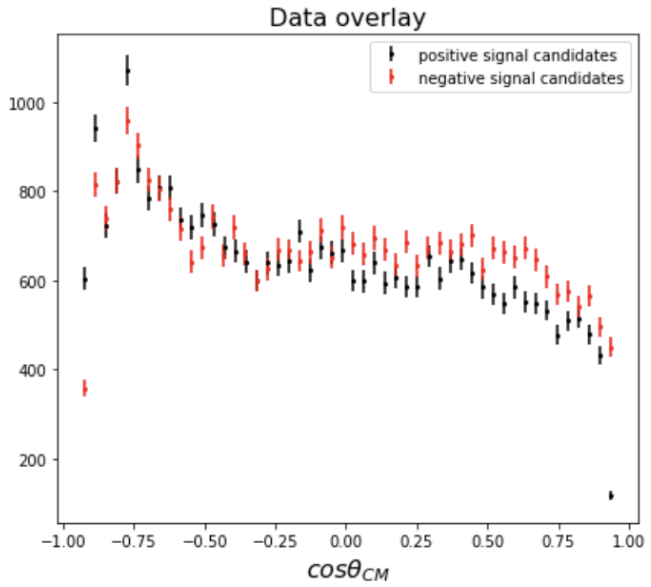



***Data and MC scaled arbitrarily for shape comparison. Not yet luminosity scaled***



# CMS cosTheta

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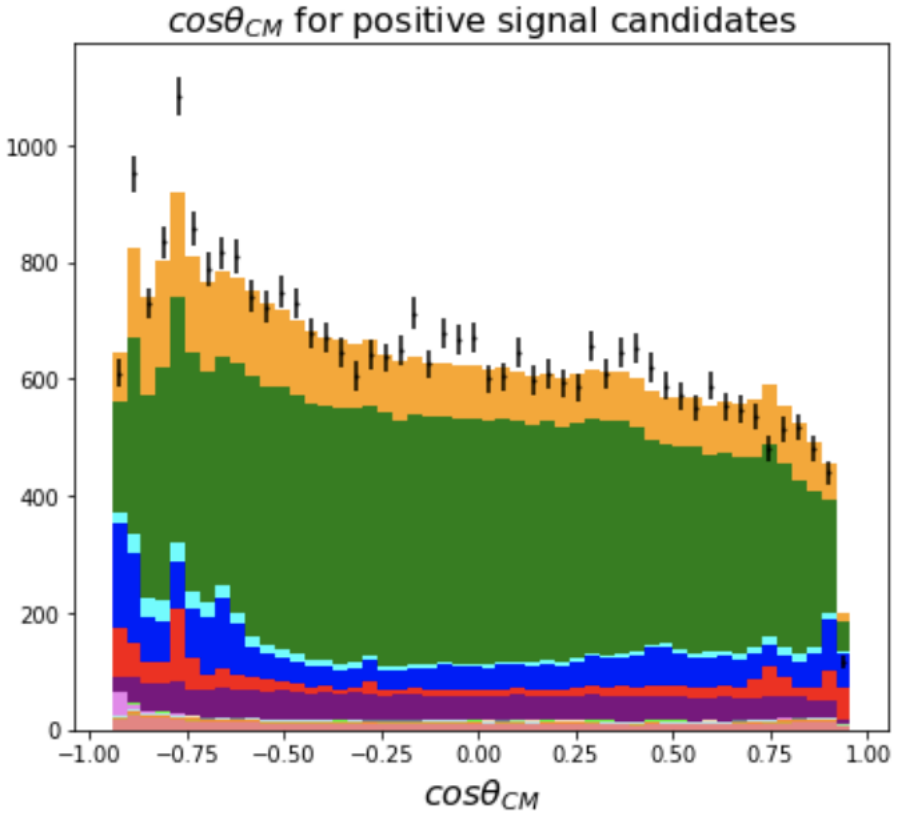
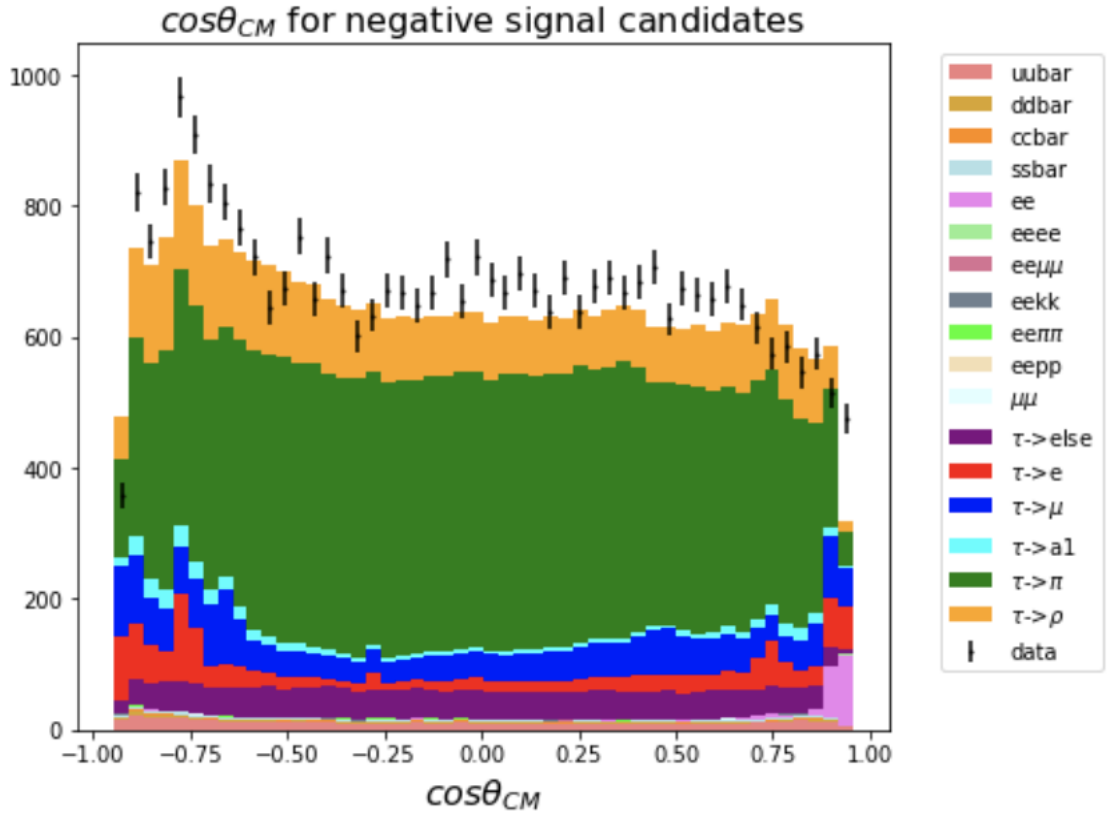
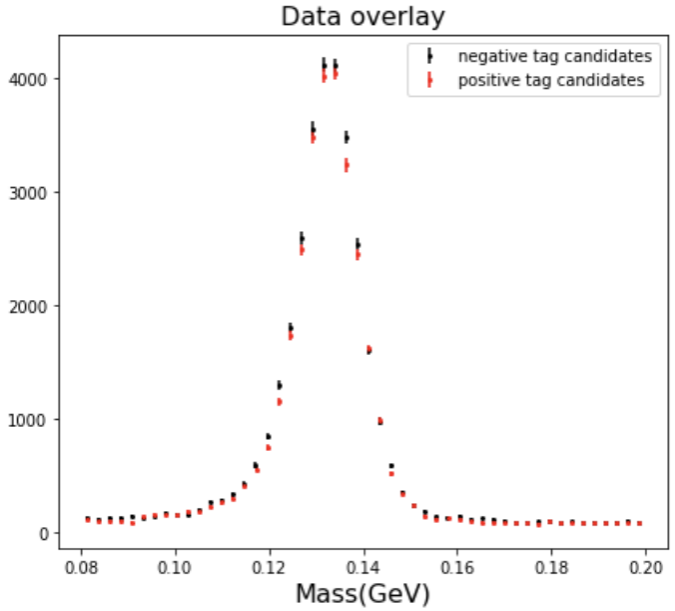
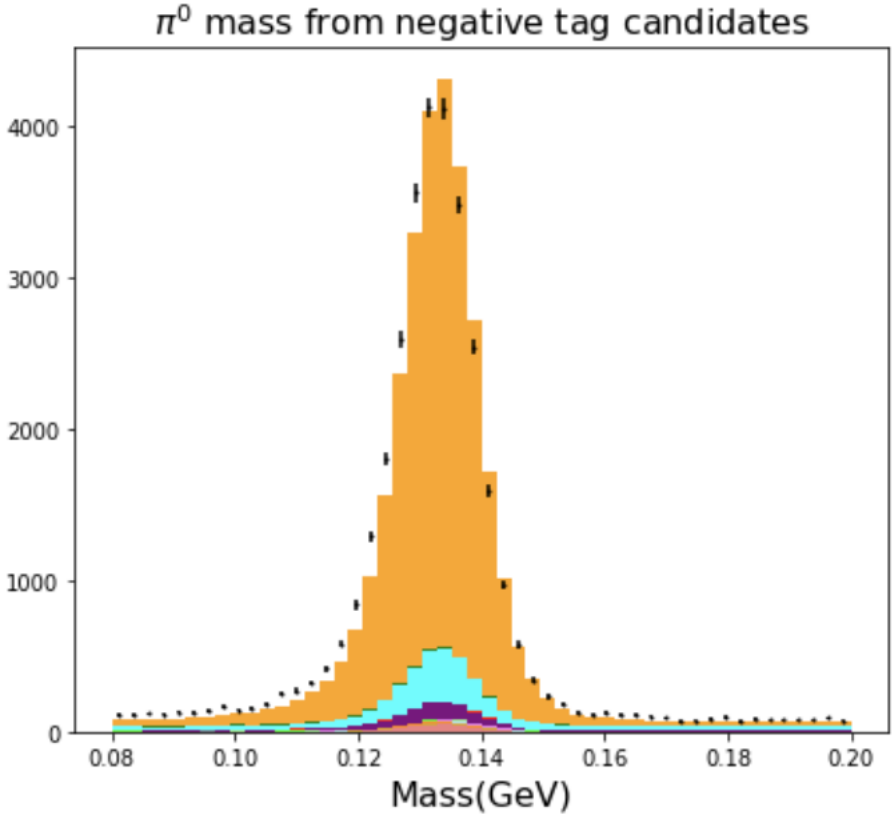


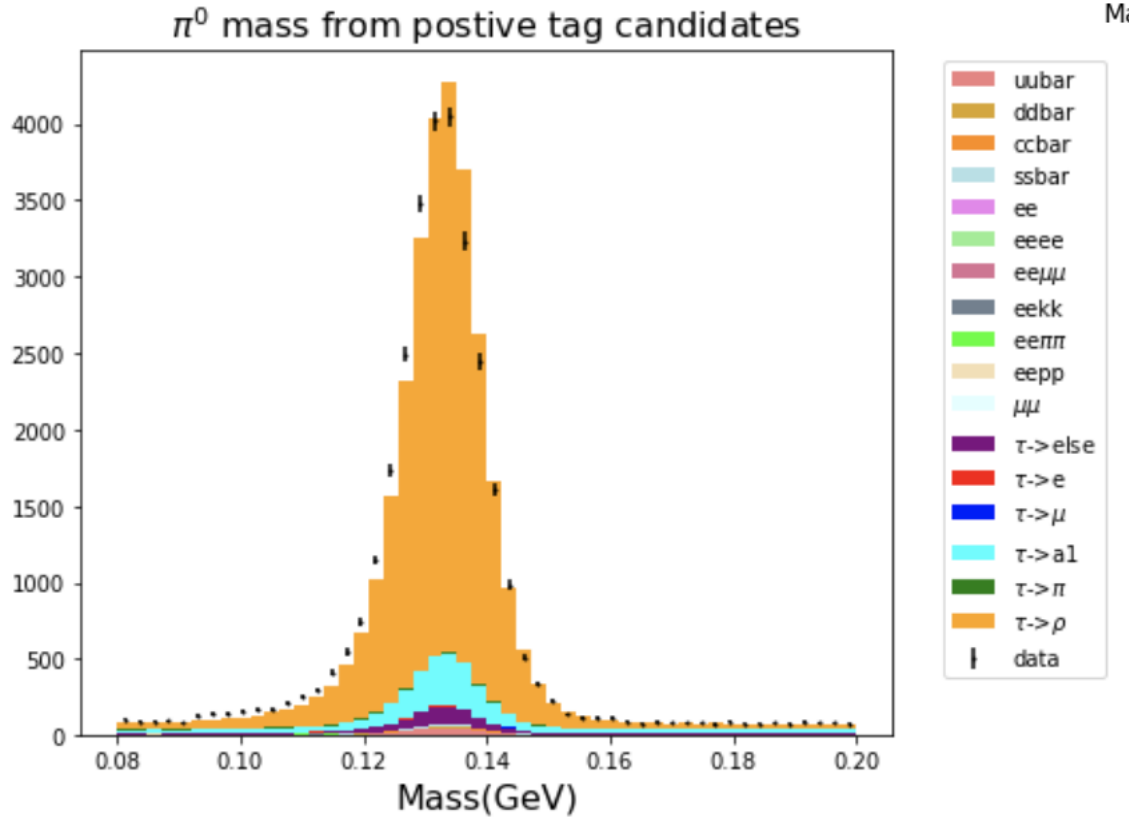



# $\pi^0$ mass

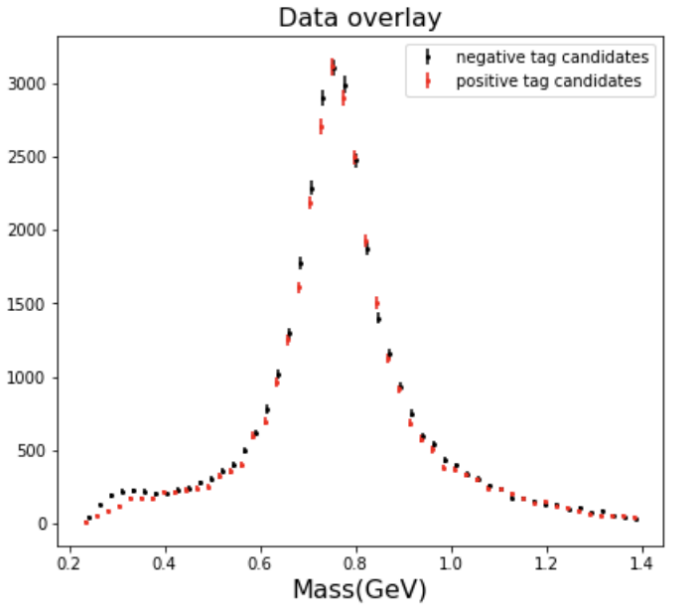



***Data and MC scaled arbitrarily for shape comparison. Not yet luminosity scaled***



# $\rho$ mass

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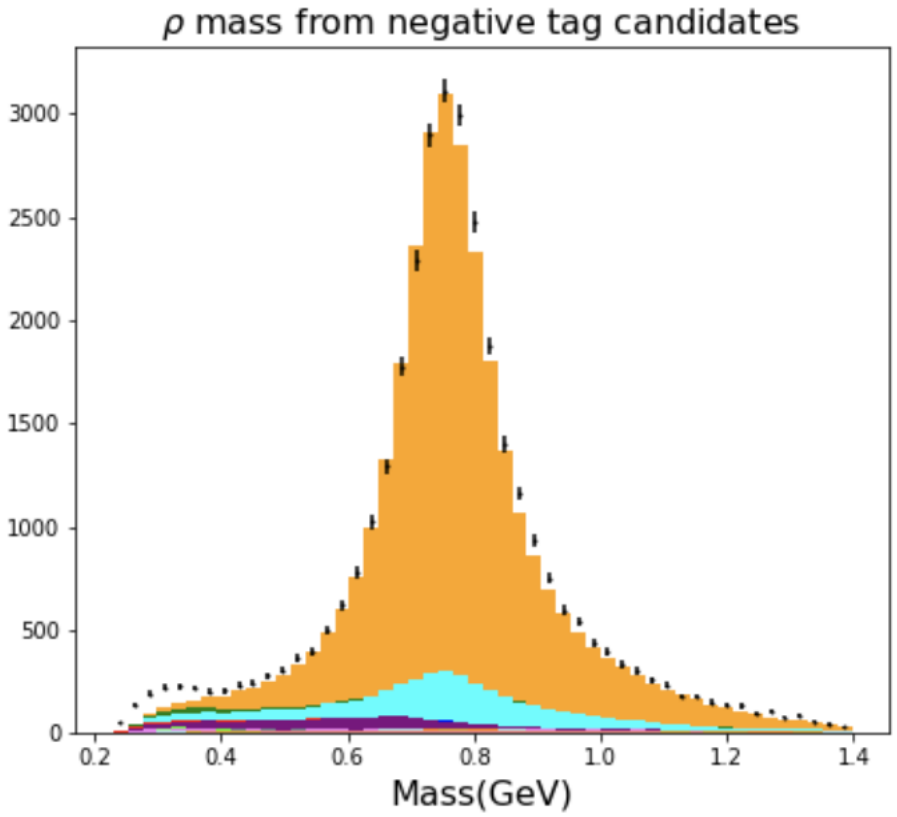


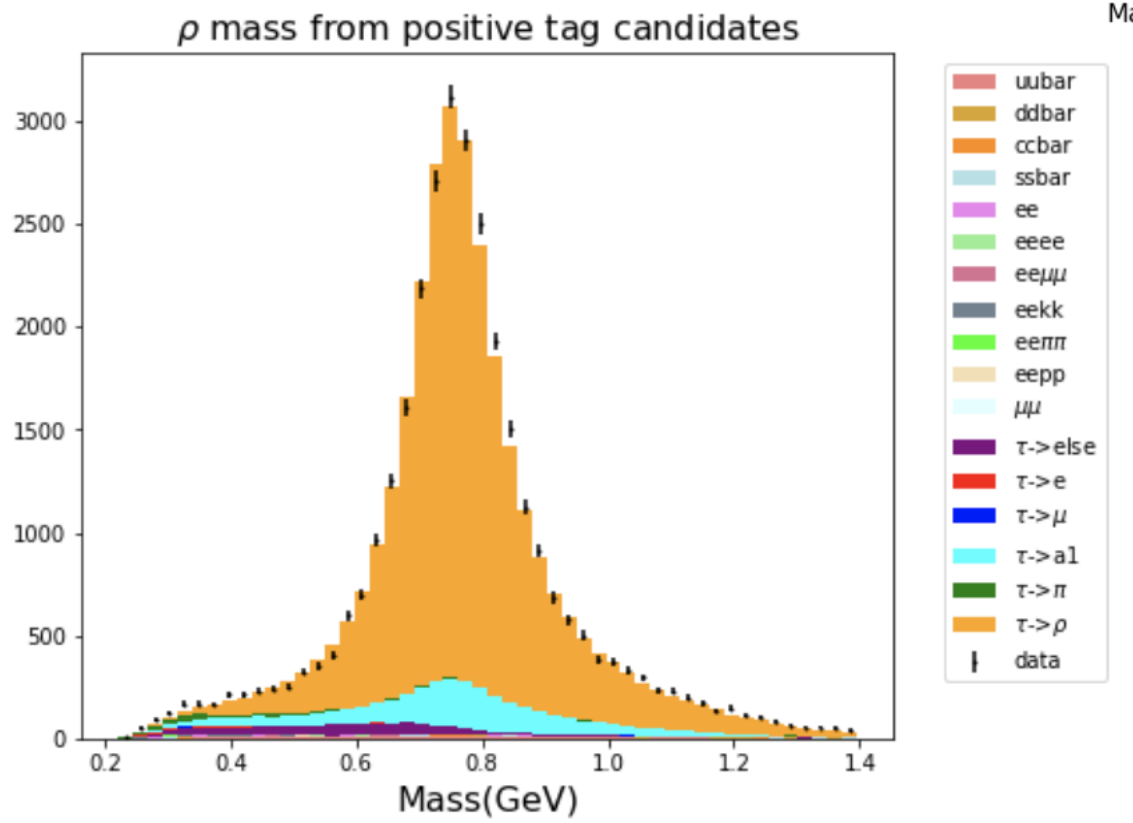

# Next Steps

- Adding tauskim,HLT,L1 flags to analysis ntuples
- Adding ECL energy analysis ntuples
- Upgrading from MC13 to MC14
- Upgrading from proc10 to proc11
  - proc12-chunk1 is listed as ready but no LFNs listed
- Requested 200fb$^{-1}$ tau MC for each polarized beam state
- Working to understand the discrepancies in the MC and data