



Physics Studies for ND280 Upgrade

New dials for Spectral Function model

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Introduction to fitter code

In order to reduce the systematic uncertainty for the neutrino oscillation parameters, we need to know better the neutrino-nucleus interaction model, and obtain better precision for interaction modes (CCQE, 2p2h, other)

- We have developed a fitter and a model of systematics uncertainties in order to quantify the impact of the use of Single Transverse Variables in the ND280 upgrade in order to reduce systematics uncertainties

Fitter goals

Before

Value and precision of

- 2p2h_c1 0-600MeV
- 2p2h_c2 (>600MeV)
- CCQE_c1 0-150MeV
- CCQE_c2 150-300MeV
- CCQE_c3 300-450MeV
- CCQE_c4 450-600MeV
- CCQE_c5 600-750MeV
- CCQE_c6 750-900MeV
- pion Absorption FSI norm
- pion Background FSI norm
- norm syst
- proton FSI
- Hydrogen interaction norm
- Eb/25 (for easy plot since other parameter values are 1)

After

Value and precision of

All are the same except for the replacement of CCQE parameters by new Spectral Function dials

- P Shell and S Shell interaction
- Mean Field (MF) and Short Range Correlation (SRC)

Missing Energy and missing momentum

For antineutrinos:

Missing energy $E_m = (E_{\bar{\nu}} + m_p) - E_{\mu} - E_n - T_{rem}$

Missing momentum $\vec{p}_m = \vec{p}_{\bar{\nu}} - \vec{p}_{\mu} - \vec{p}_n$

$$T_{rem} = \sqrt{|\vec{p}_{11B}|^2 + M_{11B}^2} - M_{11B}$$

For neutrinos:

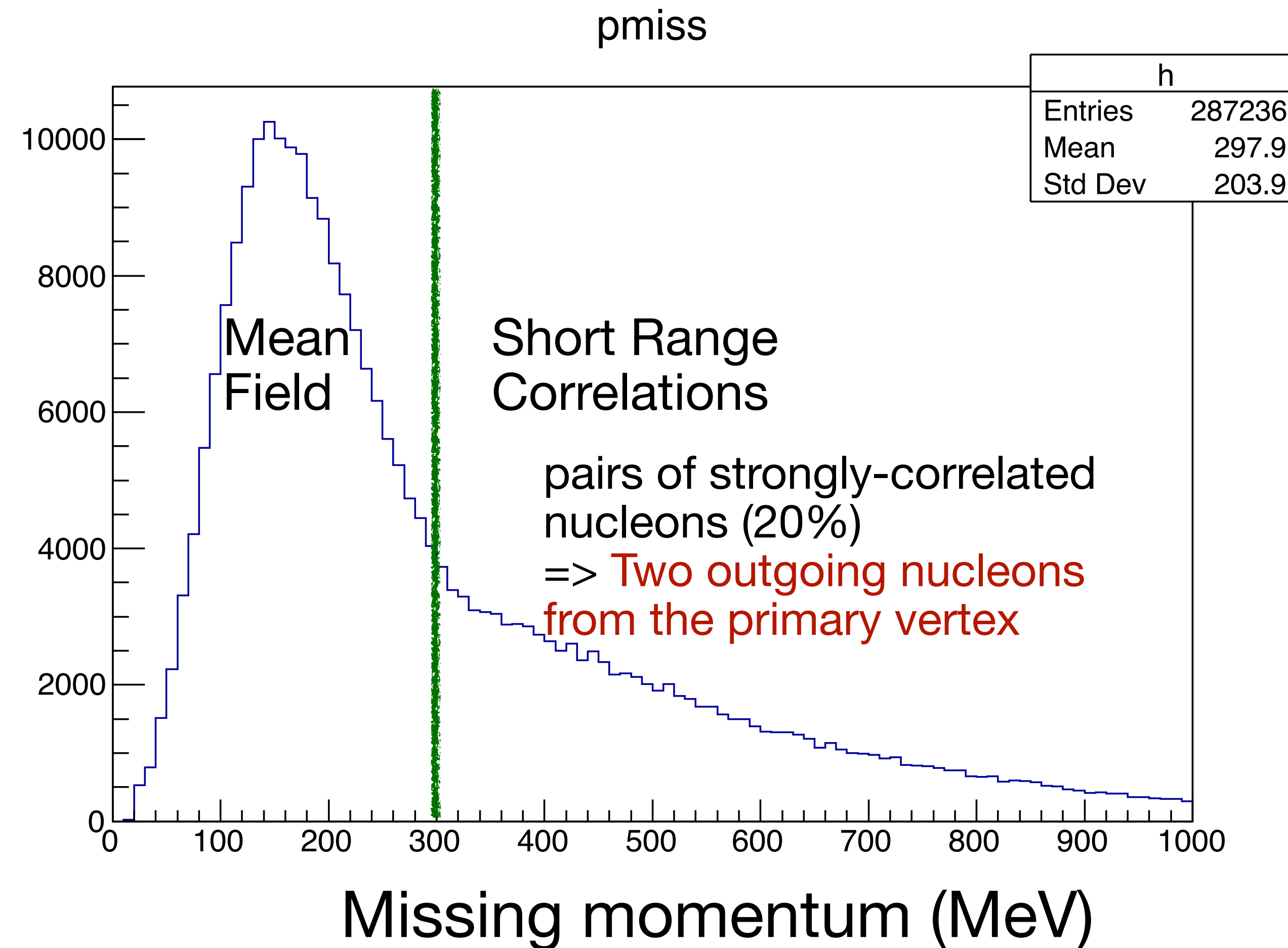
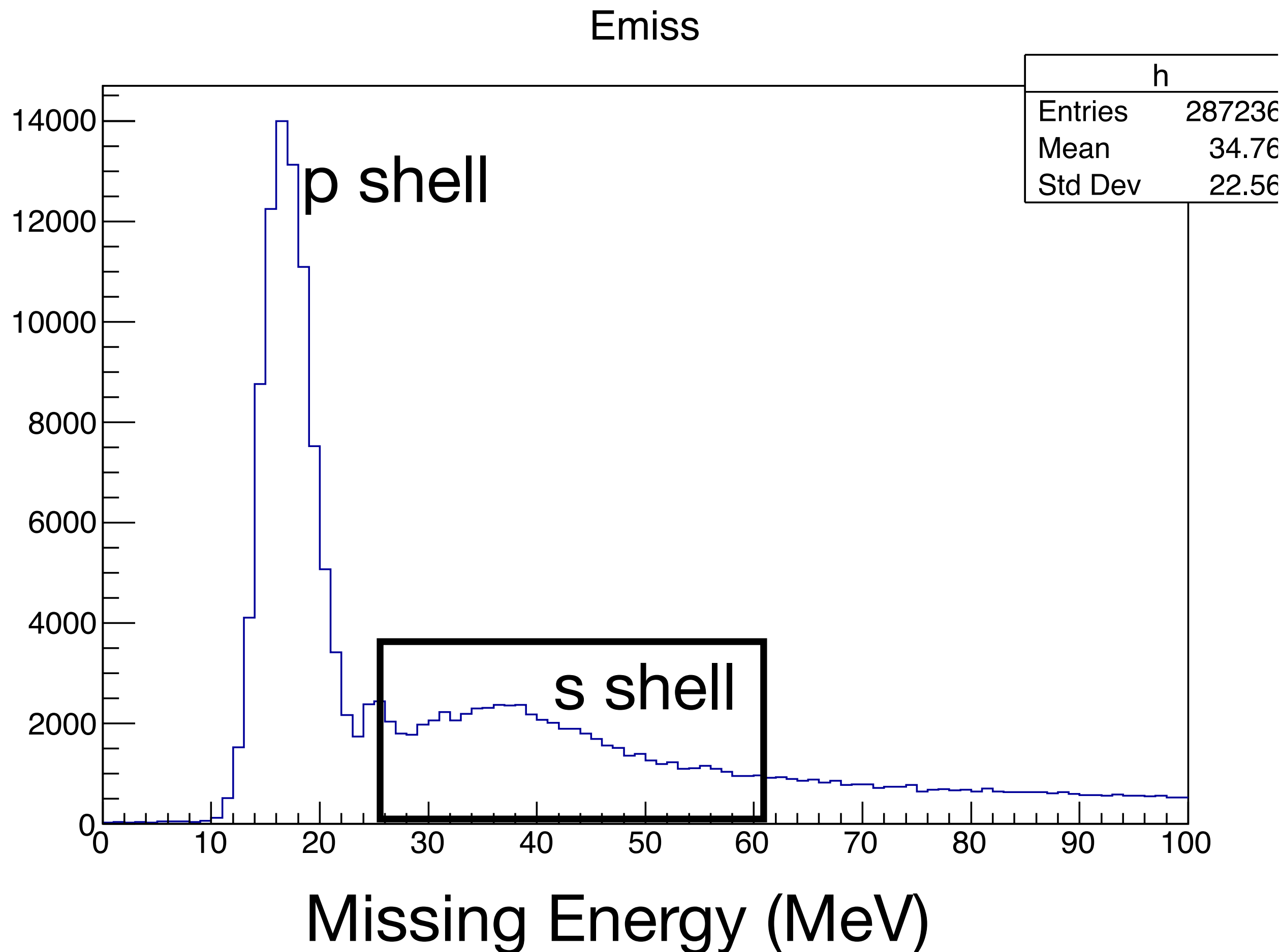
Missing energy $E_m = (E_{\nu} + m_n) - E_{\mu} - E_p - T_{rem}$

Missing momentum $\vec{p}_m = \vec{p}_{\nu} - \vec{p}_{\mu} - \vec{p}_p$

$$T_{rem} = \sqrt{|\vec{p}_{11C}|^2 + M_{11C}^2} - M_{11C}$$

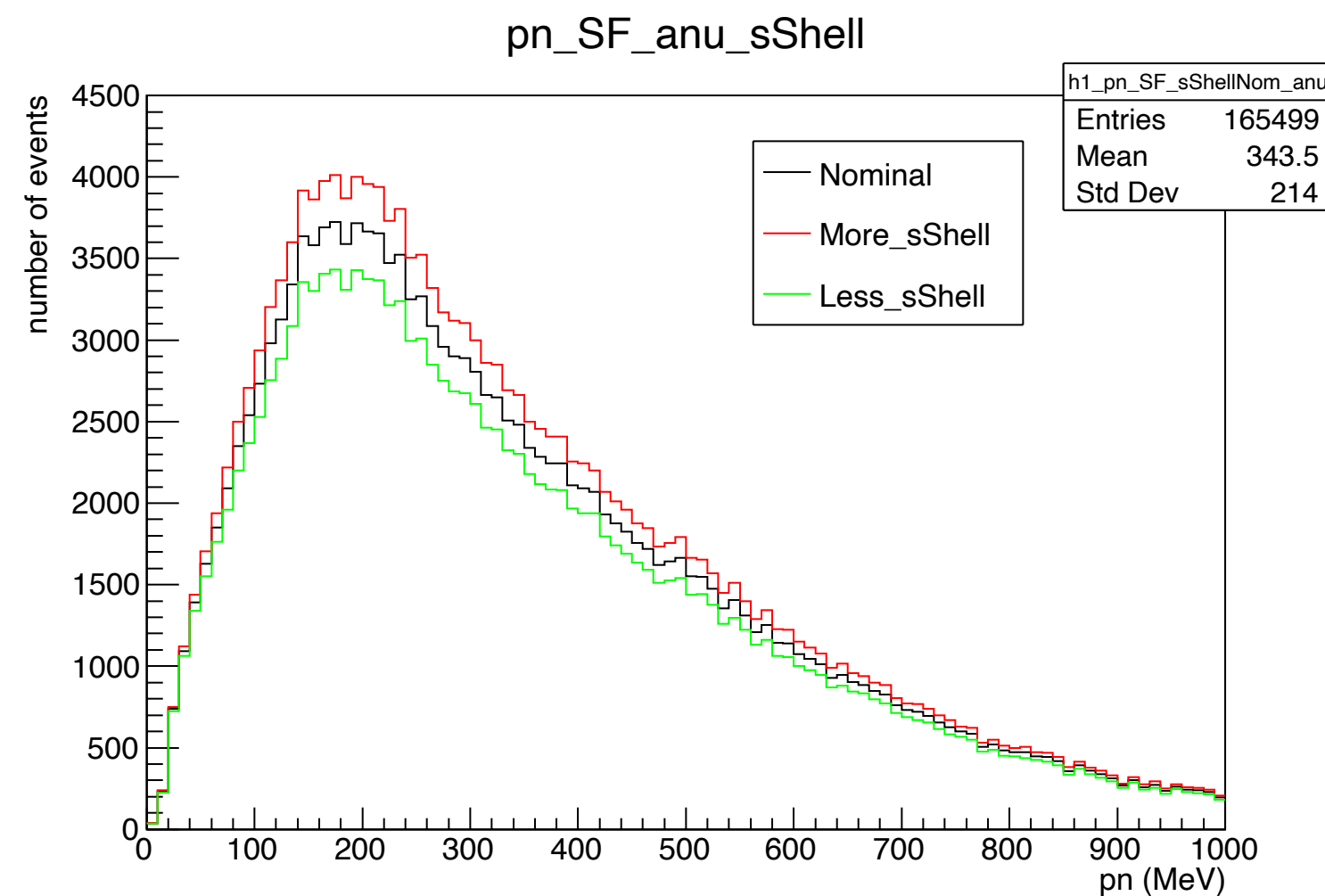
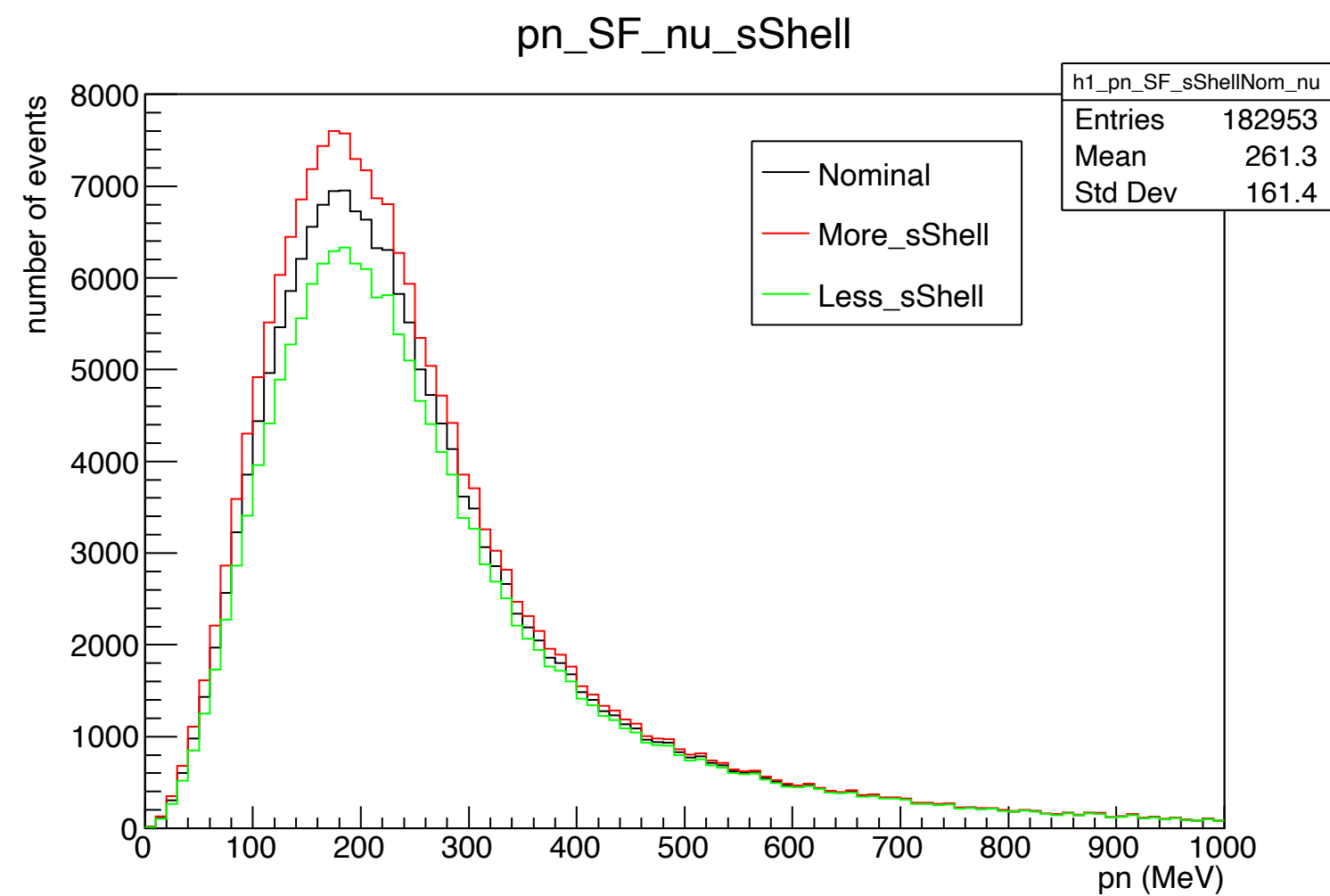
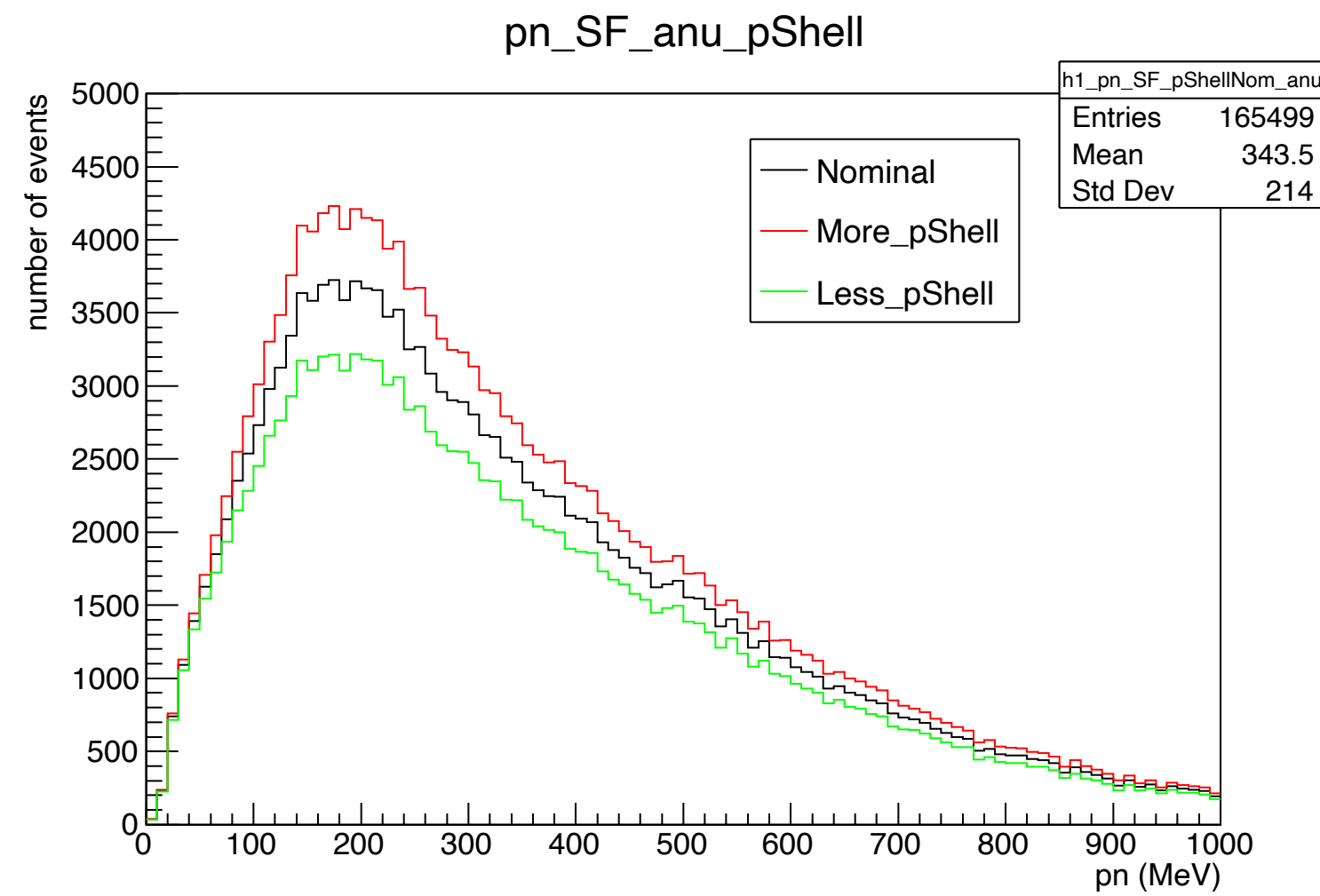
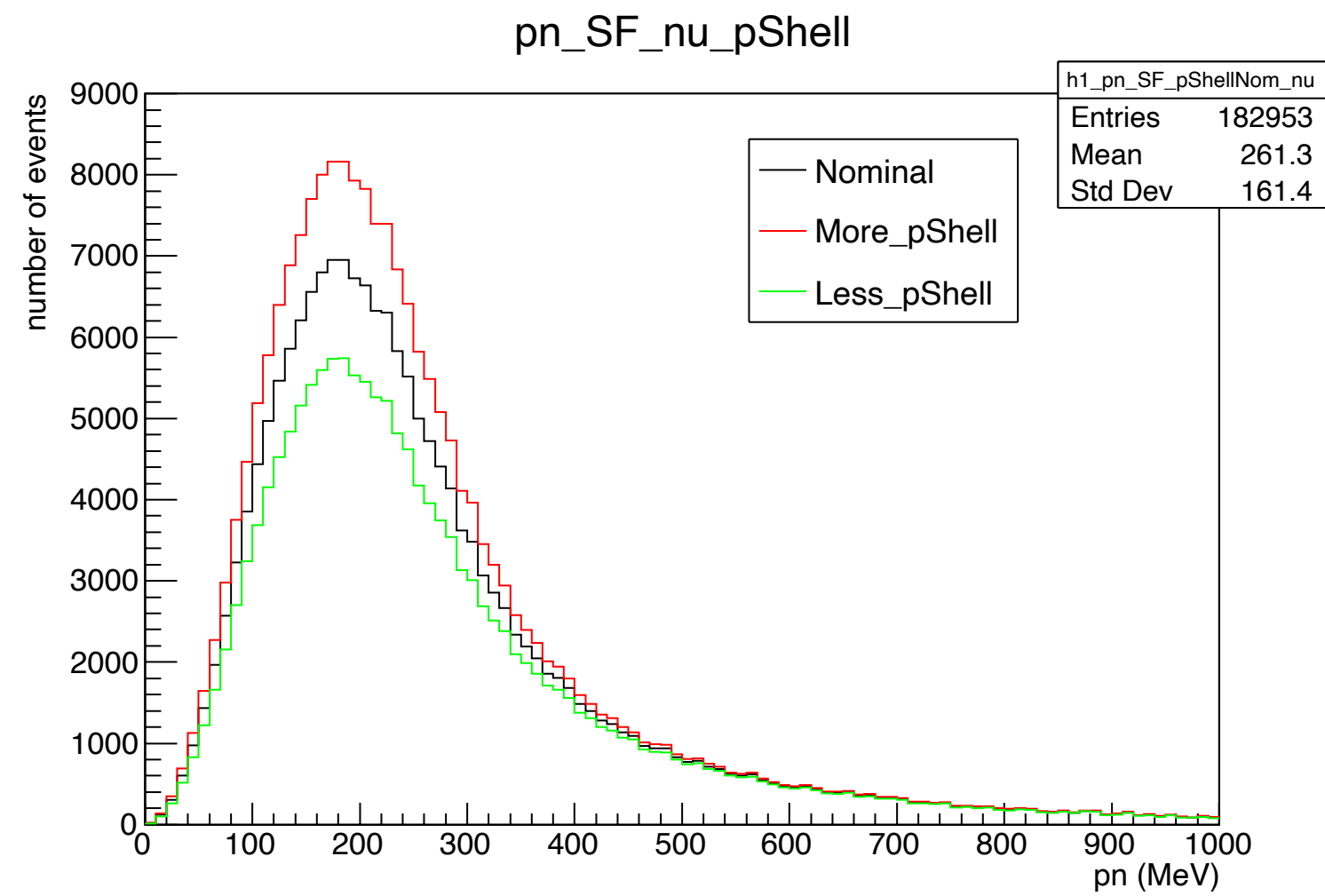
Missing Energy and missing momentum for (SF, nu) case

Mean Field: Independent nucleons, moving in a mean-field potential within the shell-model picture => **One outgoing nucleons from the primary vertex**



We can create for example pShellNorm, pShellMore, pShellLess histogram

Fermi momentum distribution



P Shell

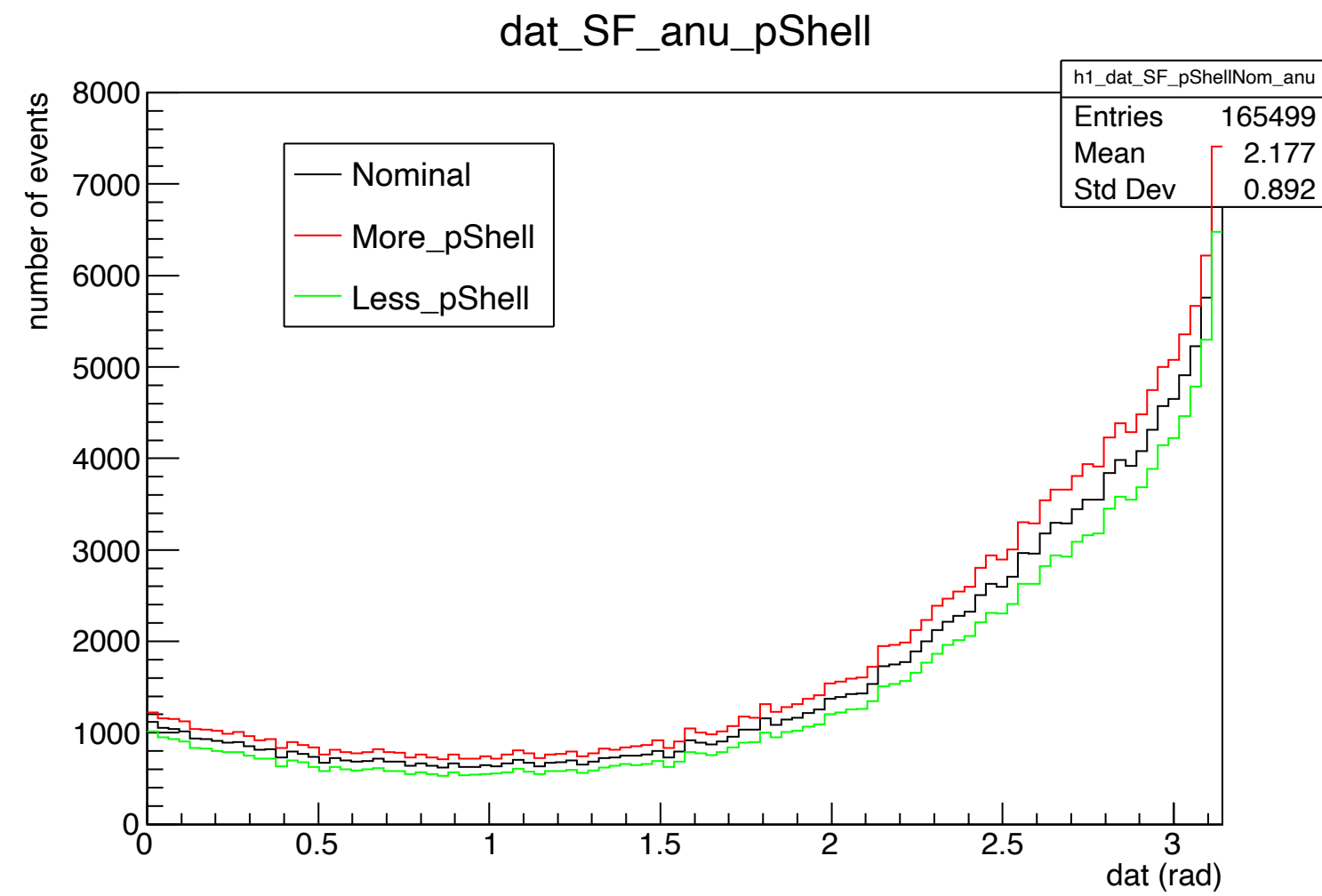
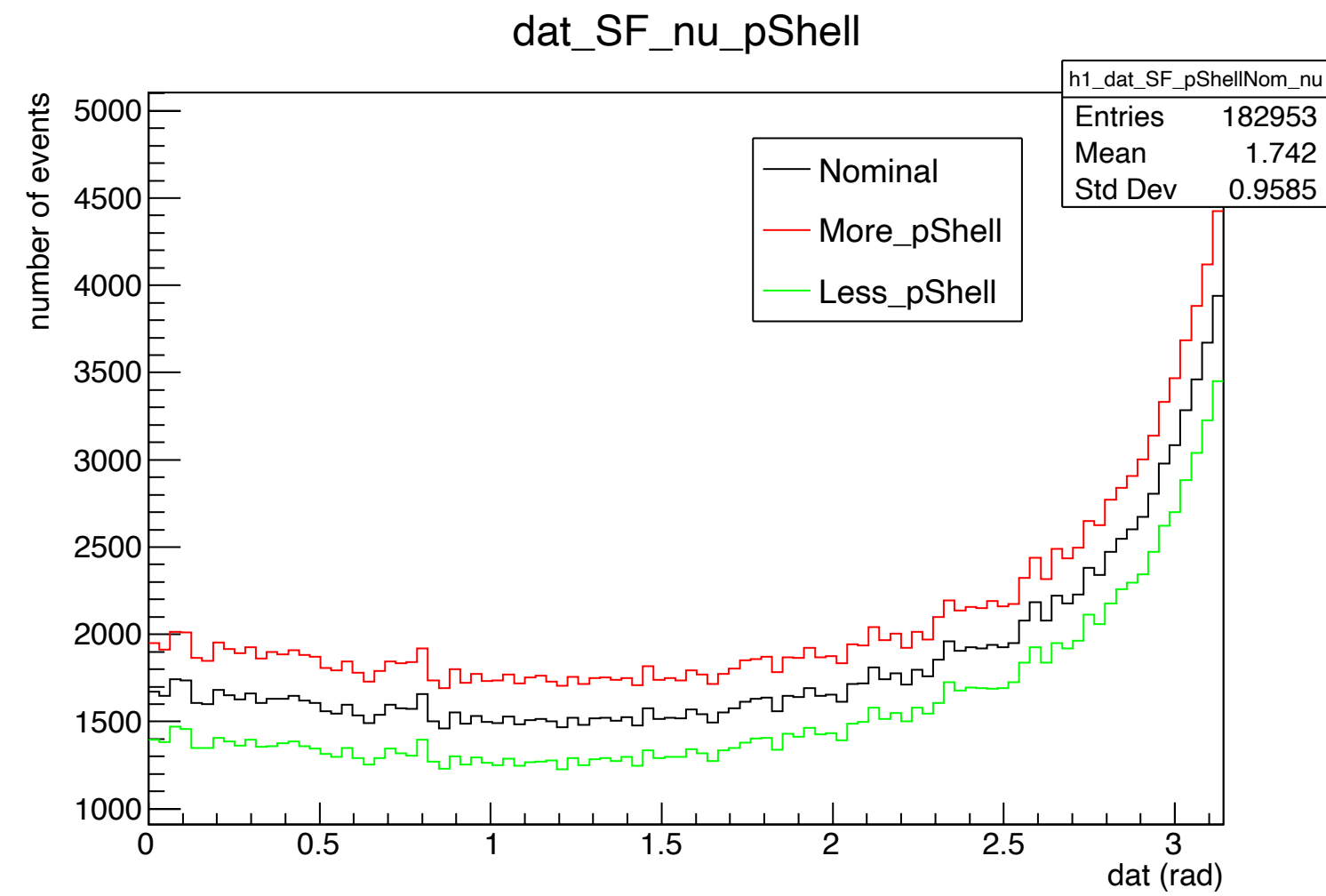
More = reweight(Nom,1.3)
Less = reweight(Nom,0.7)

S Shell

Neutrino

Anti-Neutrino

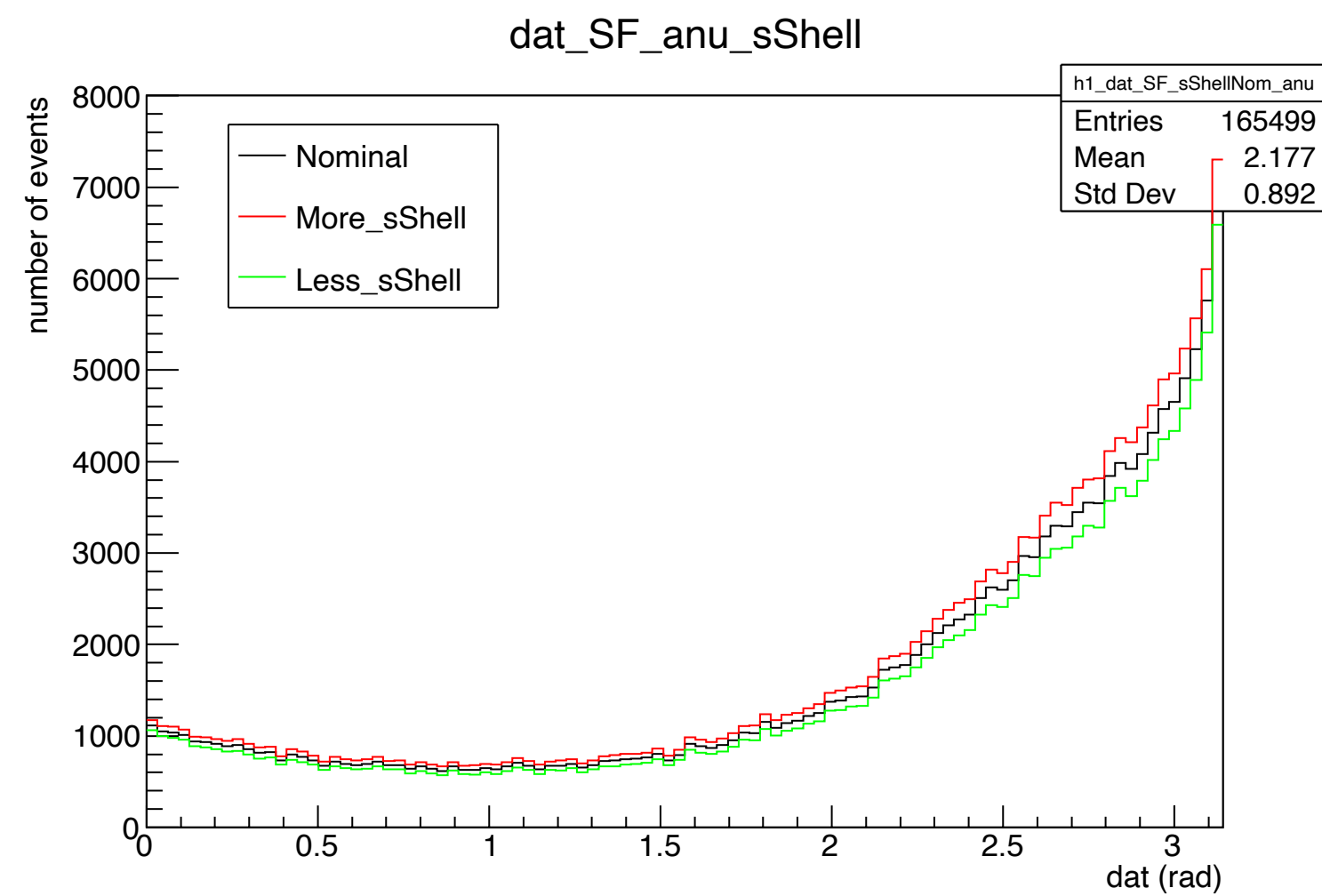
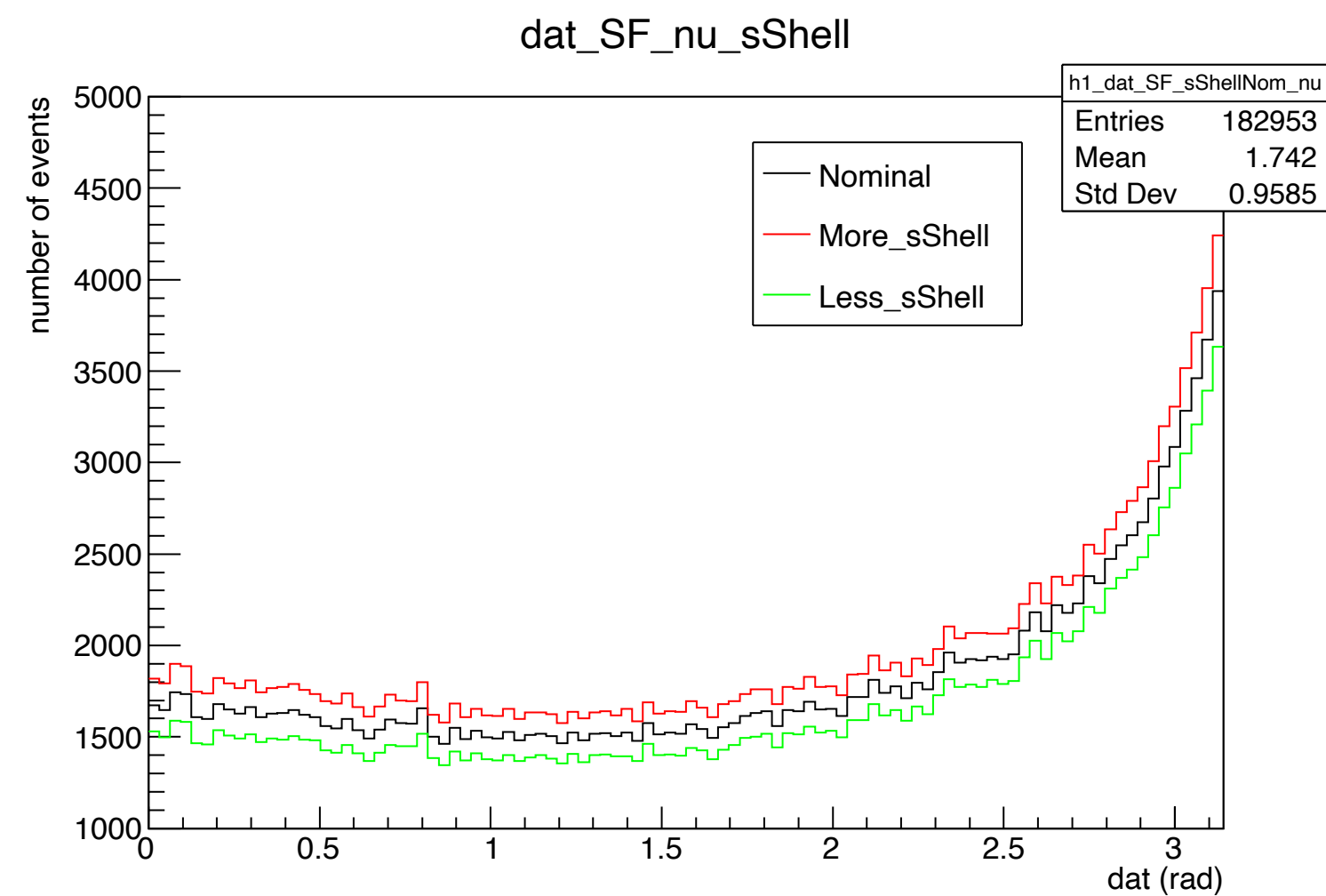
Delta alpha T distribution



P Shell

More = reweight(Nom, 1.3)

Less = reweight(Nom, 0.7)



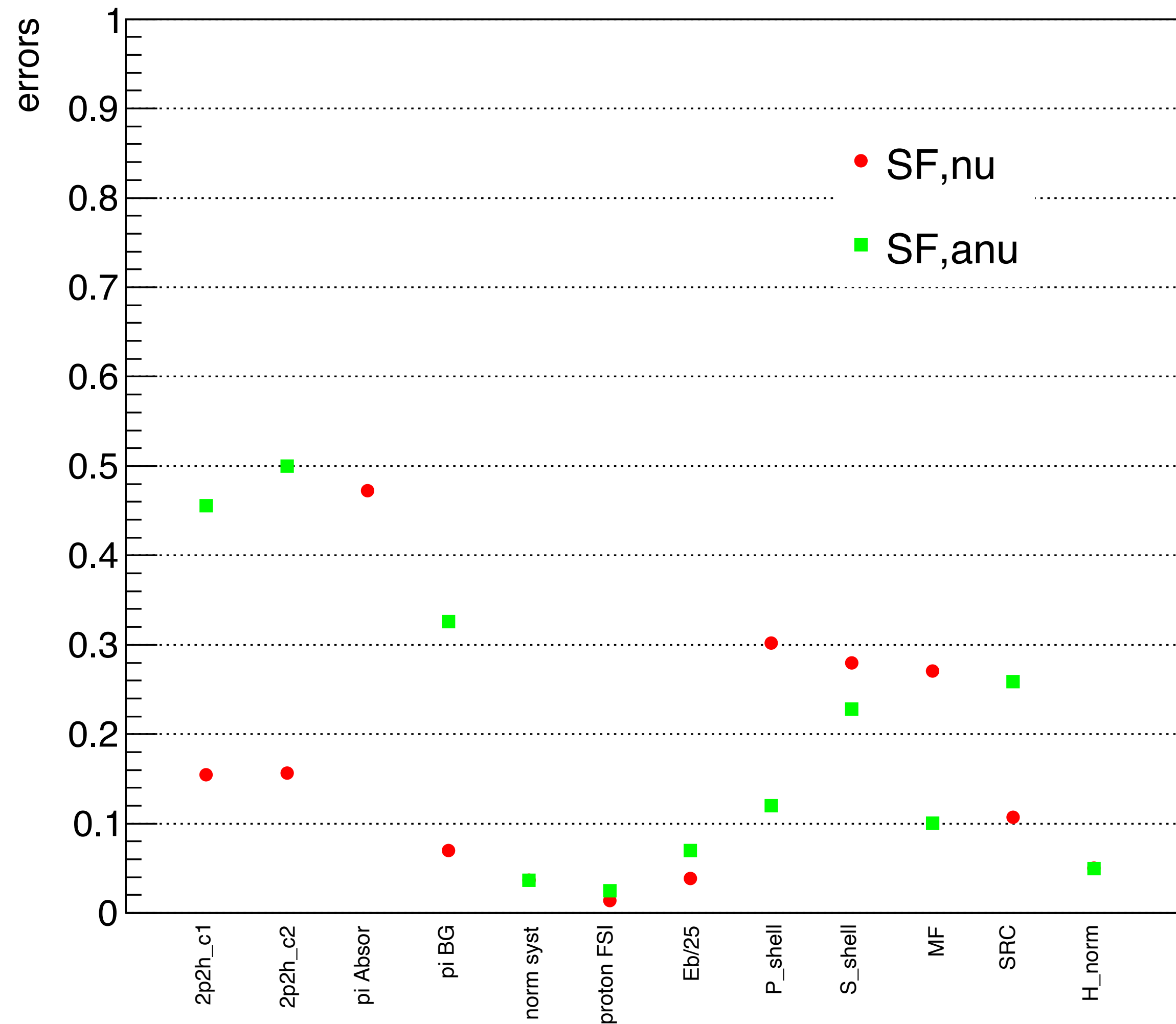
S Shell

Neutrino

Anti-Neutrino

Results after fit

Parameters' errors with different model



Good constraint for p Shell, s Shell, MF and SRC
=> precision below 4%

We expect to have better uncertainties for nu case
=> under investigation

Summary

- First step to obtain good constraints for new Spectral Function dials

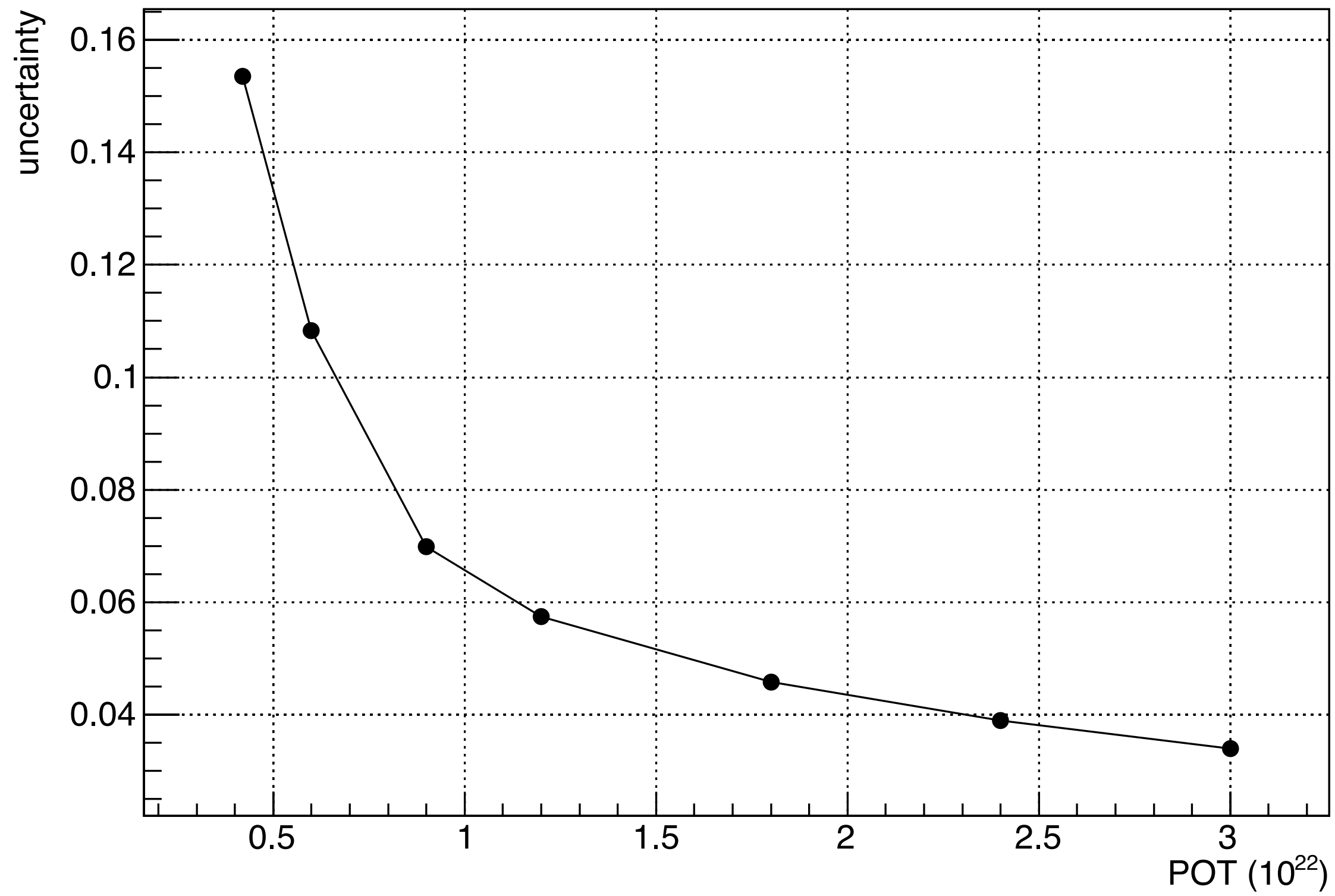
NEXT

- Continue studying more properties of these new dials
- Compare 2p2h event generated from NEUT and NuWro
- Just start working with Marco table. In near future I will convolute Marco differential cross section to T2K neutrino flux.

Thank you!

P_shell and S_shell uncertainties wrt POT

P_Shell dat_pn



S_Shell dat_pn

