NEUTRINO Group meeting
Physics Studies for ND280 Upgrade

NGUYEN Quoc Viet

LPNHE, Paris

21/04/2020

Introduction to simple fitter code

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

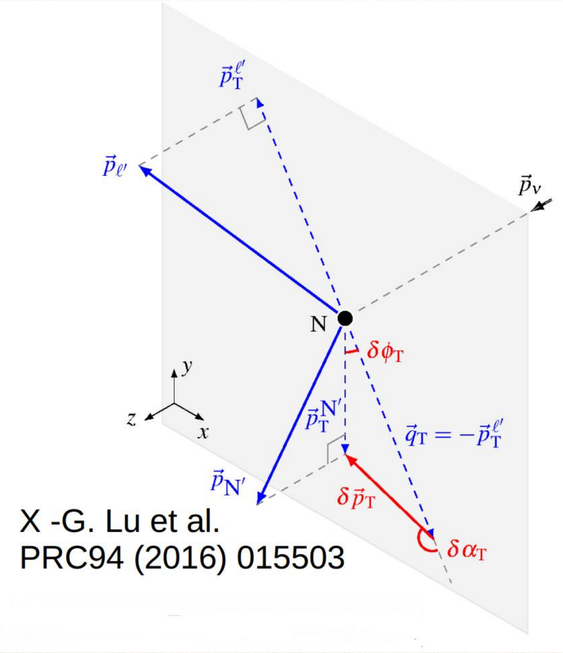
- The fitter code helps us with this. It minimises the chi square of the Monte Carlo and the data to figure out the fraction of all interaction mode components. We are using the fake data, so we don't care much about values, but the errors of CCQE, 2p2h,…

- The Monte Carlo is generated from 3 models: Relativistic Fermi Gas (RFG), Local Fermi Gas (LFG) and Spectral Function (SF).

Input, output

Input

- 2D histograms of Single Transverse Variables dalphaT and dpT or dalphaT and nucleon fermi momentum (pn)
- These are pseudo-reconstructed variables



X -G. Lu et al.
PRC94 (2016) 015503

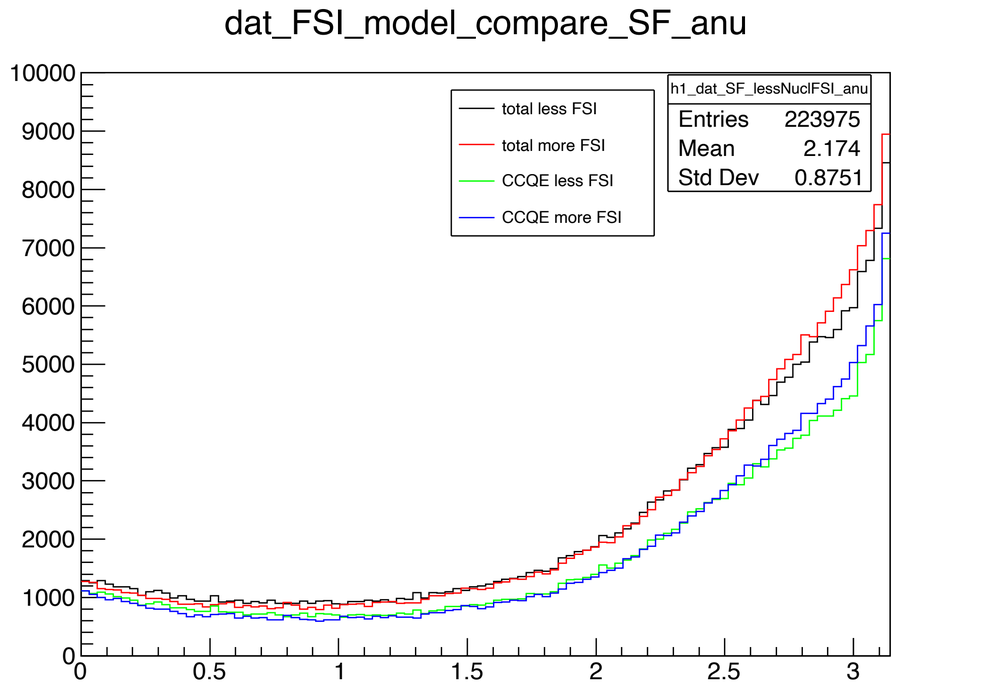
Fitter code

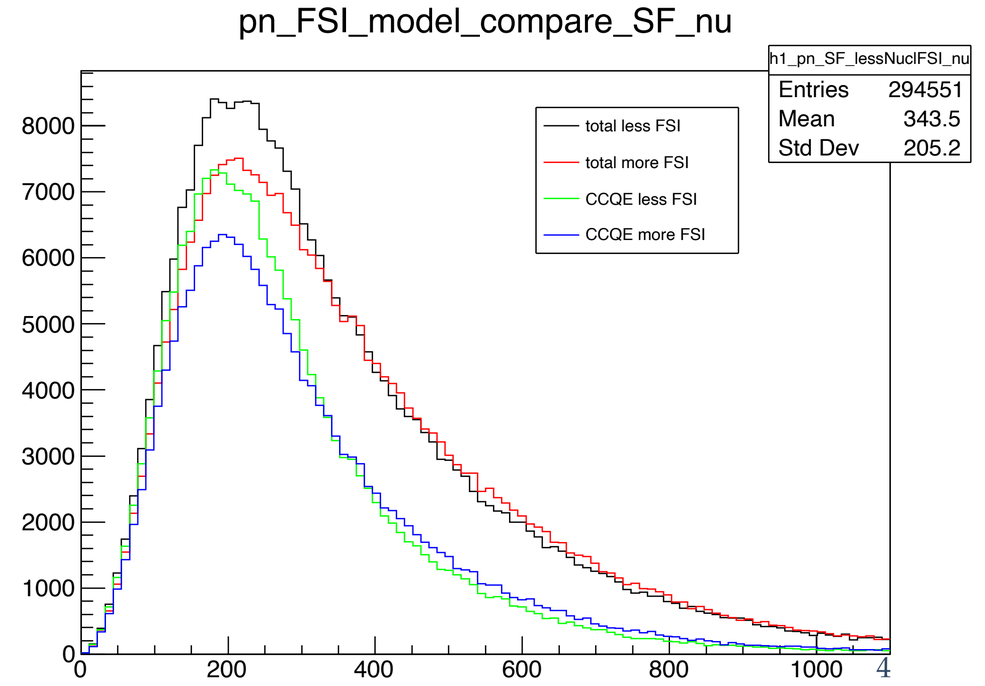
Output
Value and precision of

- 2p2h_c1 0-600MeV
- 2p2h_c2 (>600MeV)
- CCQE_c1 0-100MeV
- CCQE_c2 100-200MeV
- CCQE_c3 200-300MeV
- CCQE_c4 300-500MeV
- pion Absorption FSI norm
- pion Background FSI norm
- norm syst
- proton FSI
- Eb/25 (for easy plot since other parameter values are 1)

Input for fitter

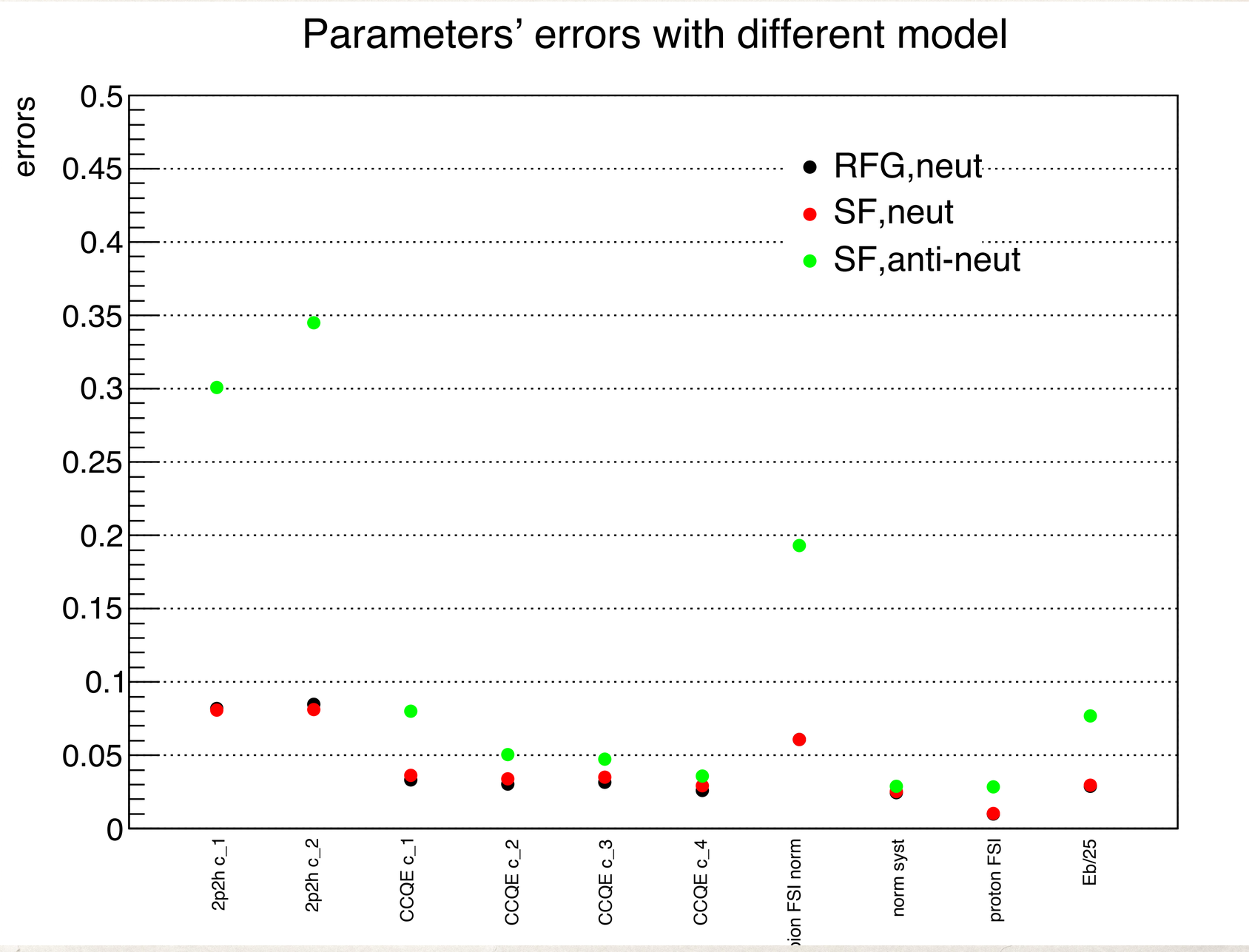
- In initial nucleon momentum (pn) distribution, less FSI has higher peak and lower tail compared to more FSI
- In my previous talk, I've given some explanation for daT distribution in my opinion.





Results after the fit for key parameters

- rescale =1 for nu;
- rescale = 0.276 for anu
- The scales for all cases are modified to have the same POT.
  => the anti-neutrino precision is worse than the rest.
- CCQE give the better precision compared to 2p2h and PionFSI
- Similarity for RFG and SF

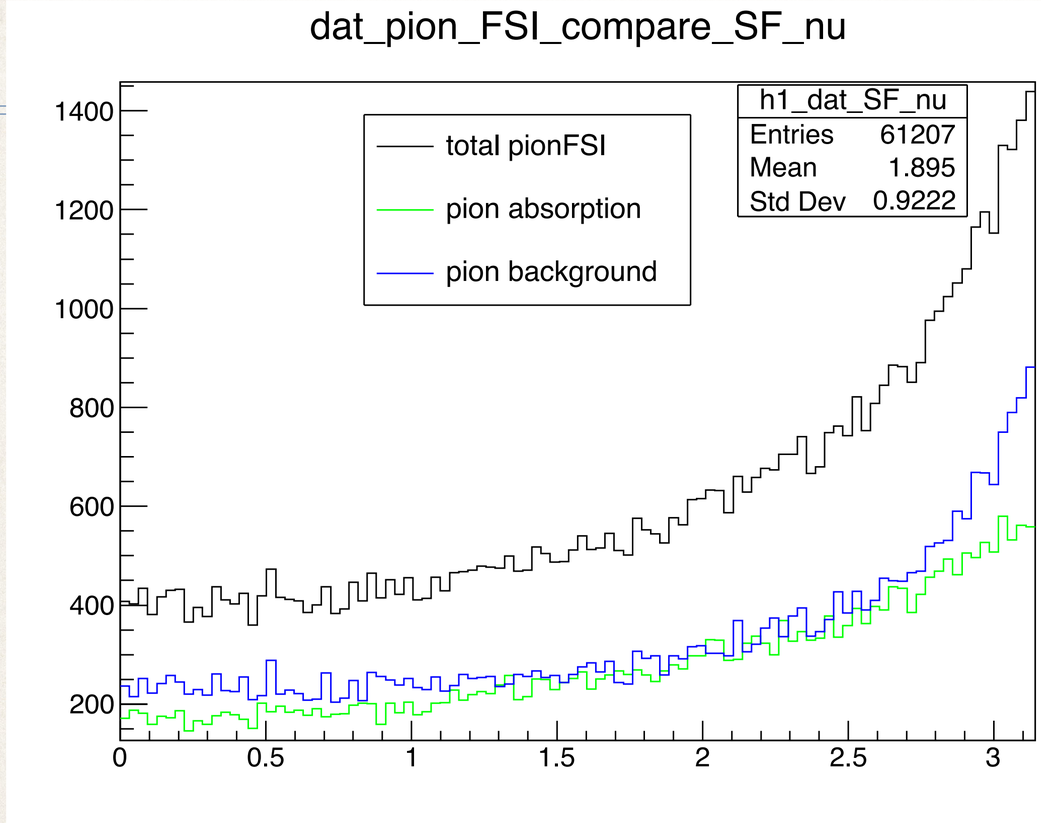


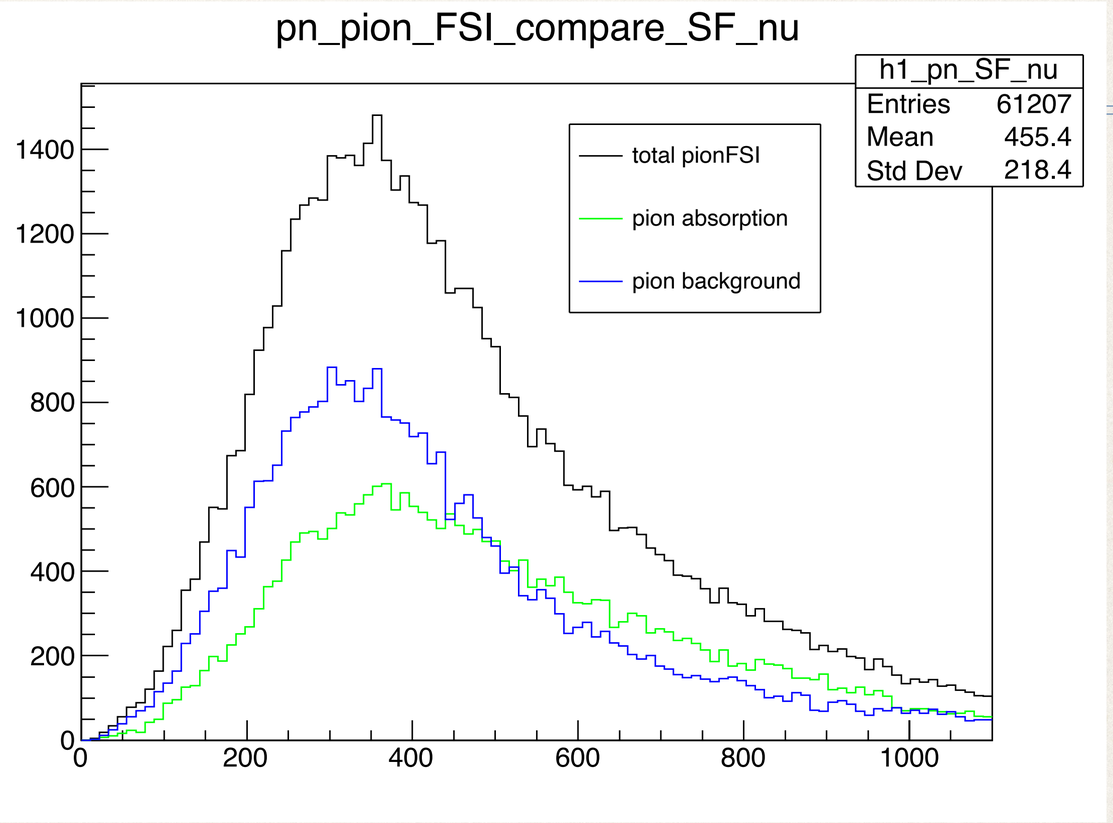
Pion FSI new parameters

- Before: Pion_FSI parameter

- After: Pion FSI is divided into 2 new parameters:
  - Pion Absorption: mode > 2, flagCC0pi=1 (pion production events)
  - Pion Background: mode > 2, flagCC0pi=0 (pion was below detection threshold)
  Notice that all of them are CC0pi by reconstruction.

Pion absorption and pion background distribution
Spectral Function, neutrino



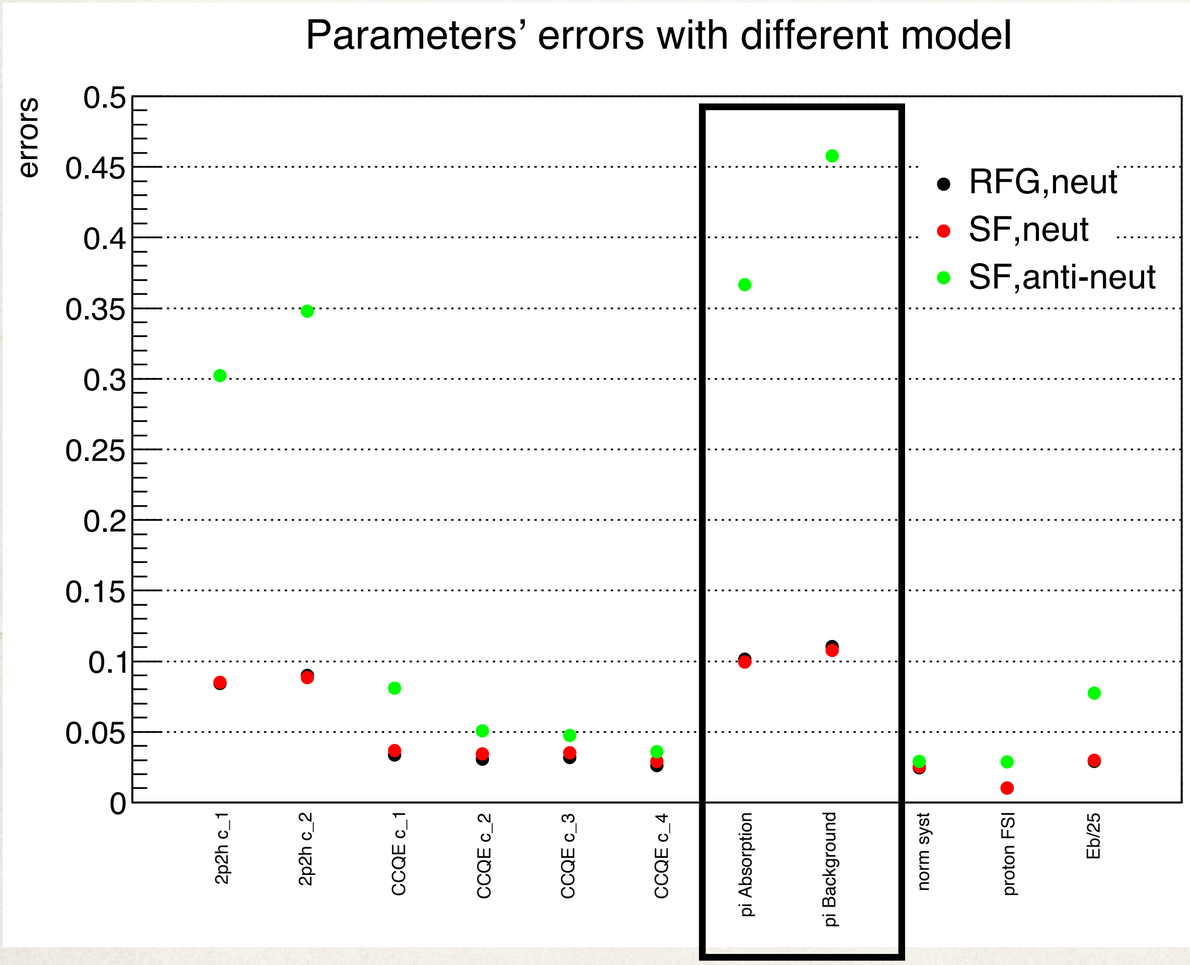


delta_alpha_T:
Pion absorption is lower pion background in general

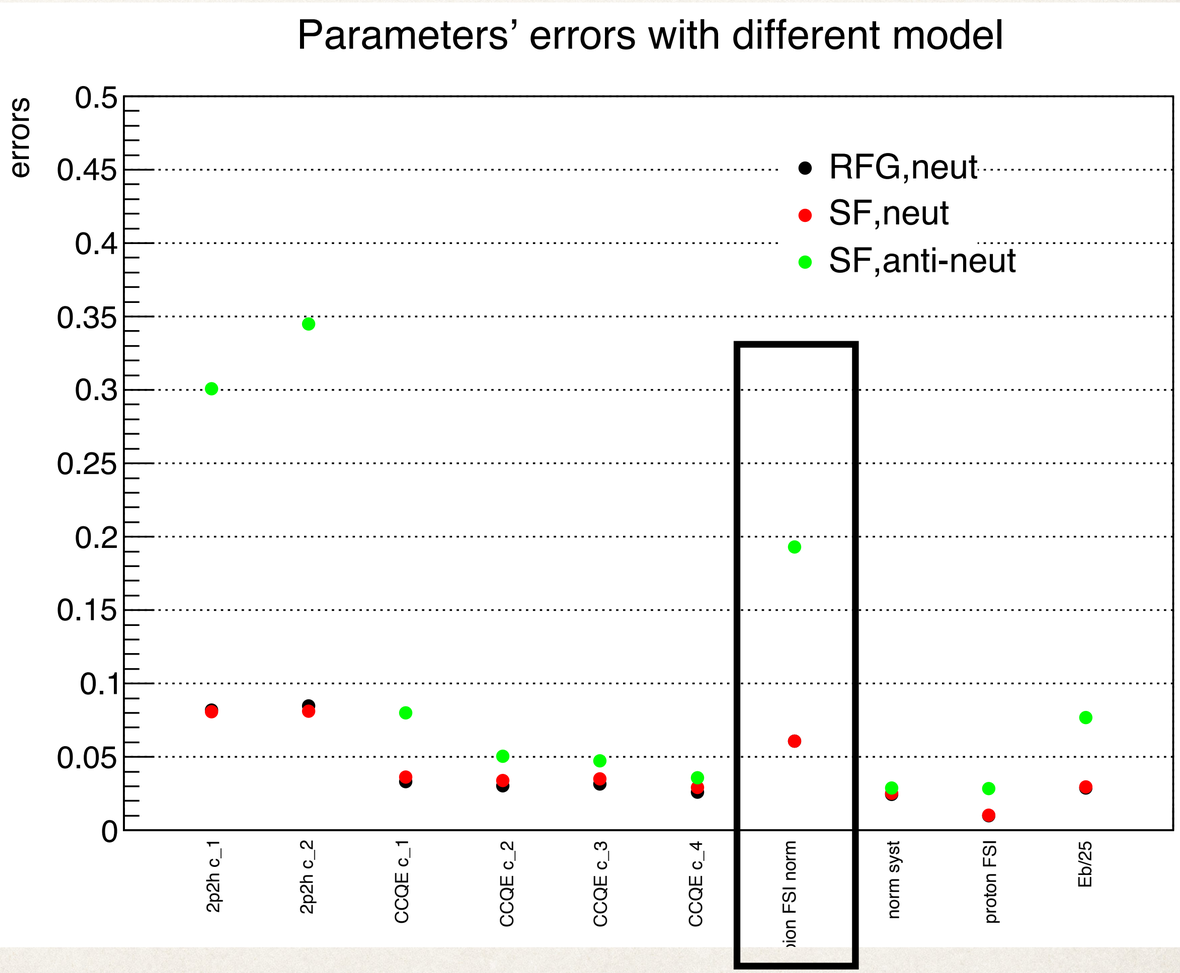
Pion background is below detection threshold, so the initial nucleon is more likely to have low momentum
=> The tail of pion background is lower

7

Results after the fit
Compare 1 and 2 parameters of Pion FSI

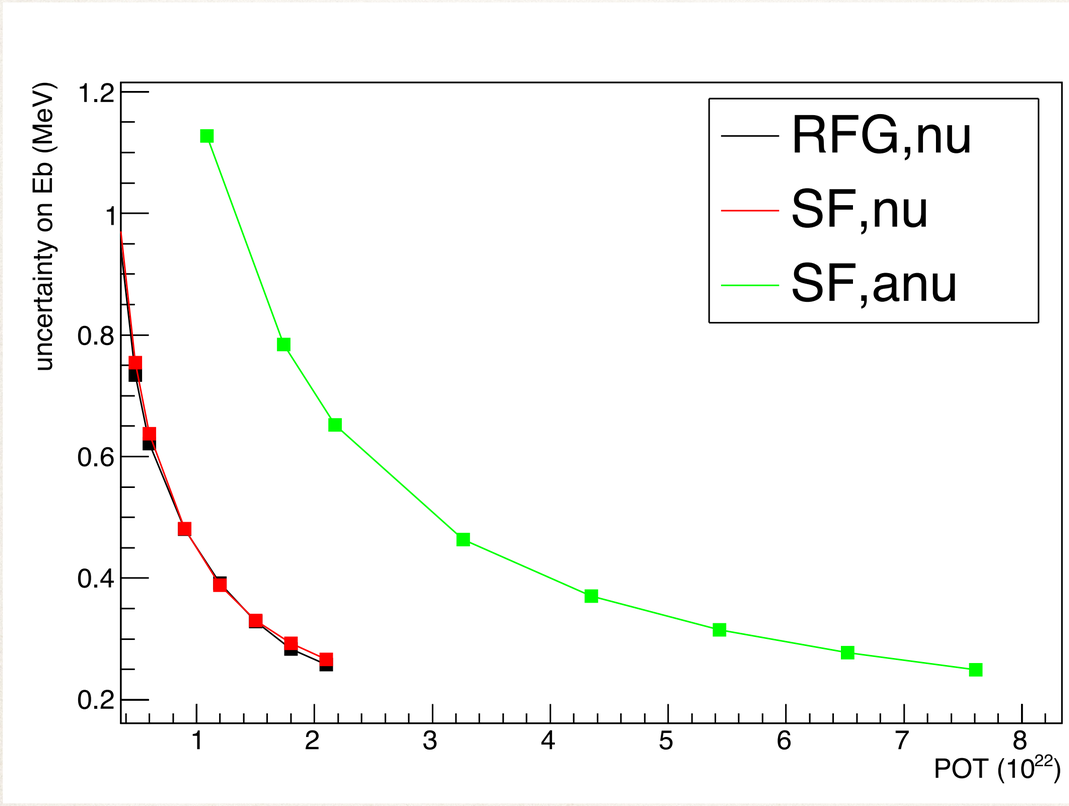


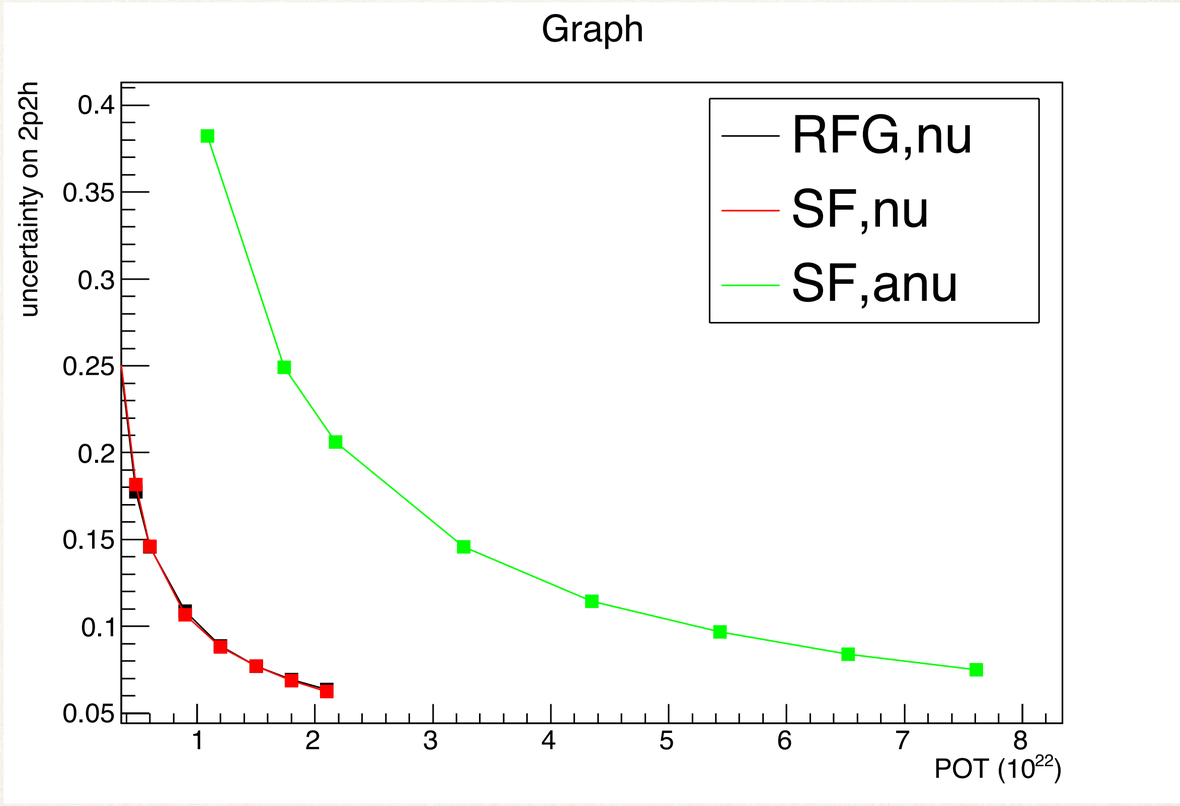
2 pion FSI parameters



1 pion FSI parameter

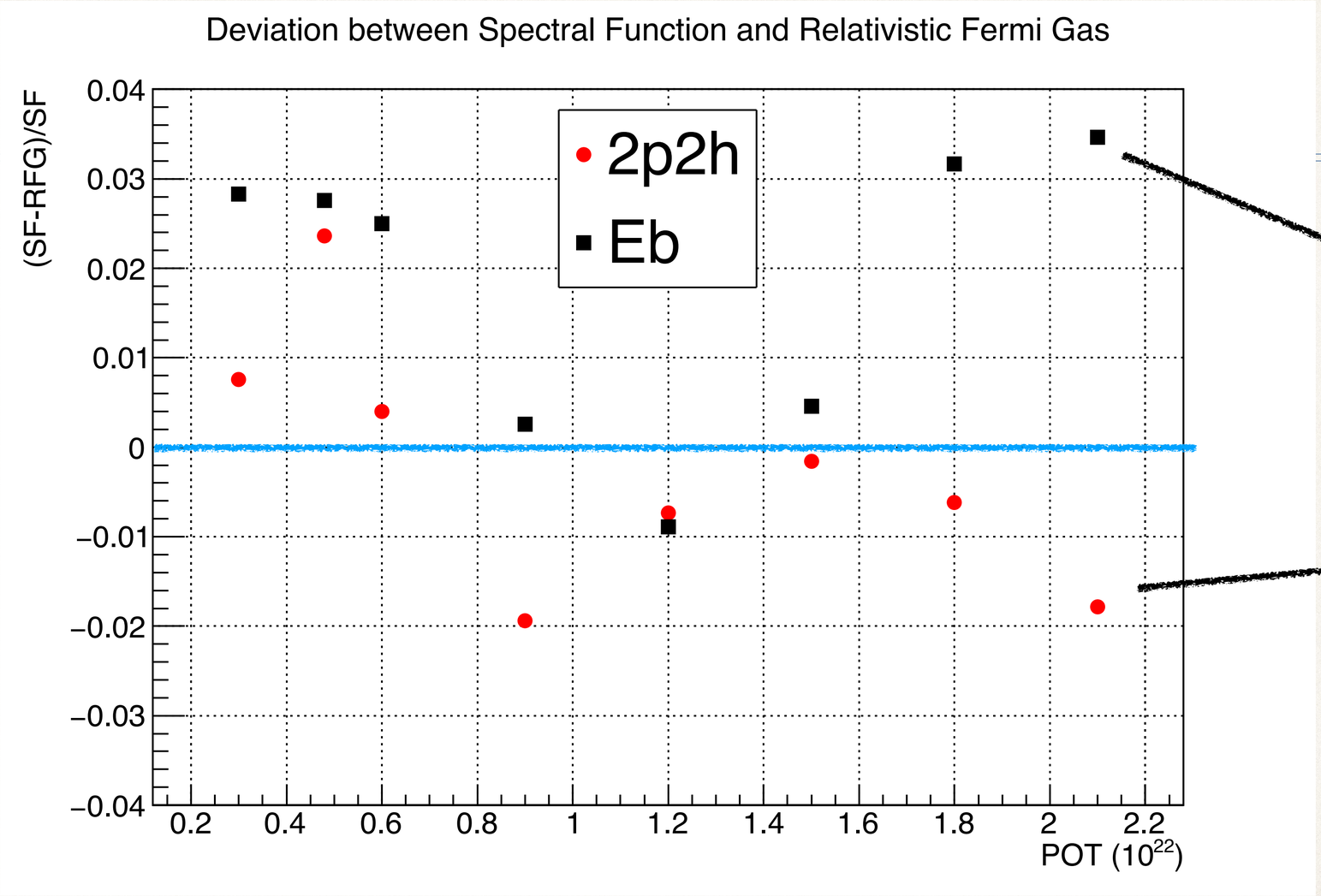
Uncertainty on Eb (left) and 2p2h (right)





The behaviours of RFG,nu and SF,nu are similar. While for anu we need more POT to reach the same level of precision. But anyway both Eb and 2p2h precisions are much improved with the fitter

SF and RFG comparison for 2p2h, Eb precision



RFG better

SF better

(uncert_SF-uncert_RFG)/uncert_SF
Neutrino case

Summary

- While studying the fitter code, I understand more the neutrino-nucleus interaction models (RFG, LFG, SF) and statistic methods.
- Most of the time I study the quantitative sensitivities to neutrino-nuclei interaction modes. And I obtained expected and good precision for key parameters.

Thank you!