UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES

T2K

νPRISM 2nd workshop

νPRISM in antineutrino mode

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UniGe

Introduction

Now that the mixing angle and the magnitude of mass differences of the PMNS matrix are accurately known, what remains to be determined is the mass hierarchy and the CP-violating phase δ_{CP}.

T2K has a good sensitivity to constrain δ_{CP} and ran in anti-ν mode last June.

The anti-ν mode is mandatory to determine the CP violation by observing a difference of oscillating events between ν and anti-ν :

$$A = P(\nu_\mu \rightarrow \nu_e) - P(\bar{\nu}_\mu \rightarrow \bar{\nu}_e)$$

$$A = \cos(\theta_{13})\sin(2\theta_{12})\sin(2\theta_{23})\sin(2\theta_{13})\sin(\delta)\sin^2\left(\frac{\Delta m^2_{31} L}{4 E_\nu}\right)\sin\left(\frac{\Delta m^2_{21} L}{4 E_\nu}\right)$$

If we build νPRISM, it will need to run in anti-ν mode : a good characterisation of the flux is mandatory to extract the physics quantities of our interest !

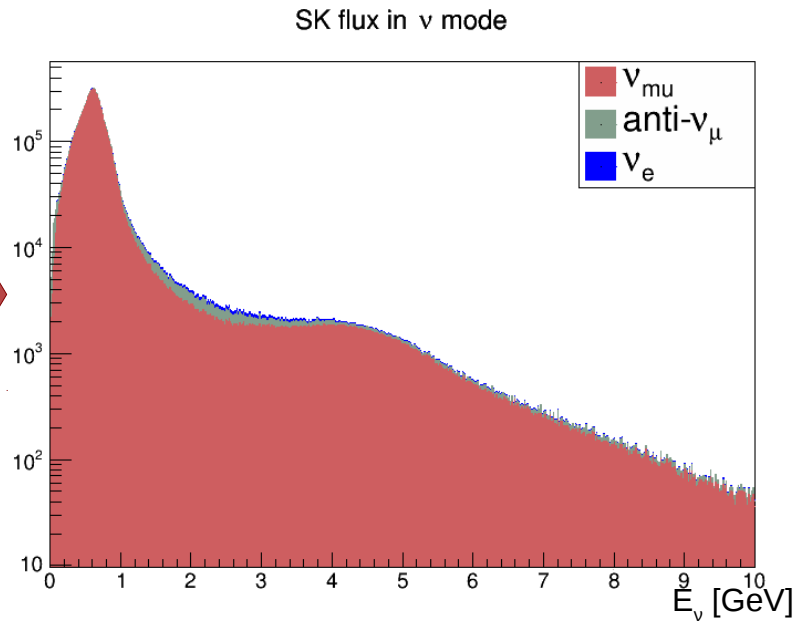
disclaimer : the plots I will show are done processing files make by M. Scott and M. Hartz. More a “what I think I will do” than a “what I have done” talk.

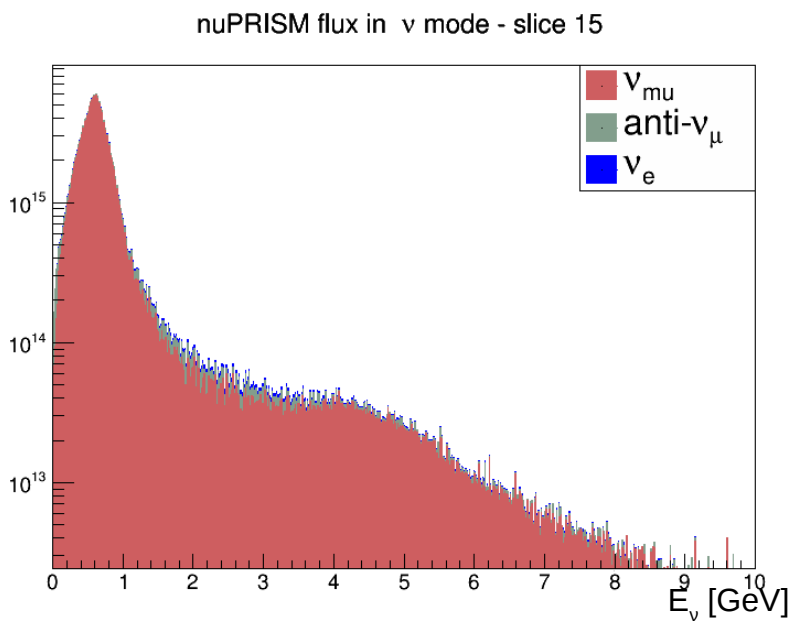
νPRISM VS Super-Kamiokande flux

Super-K flux

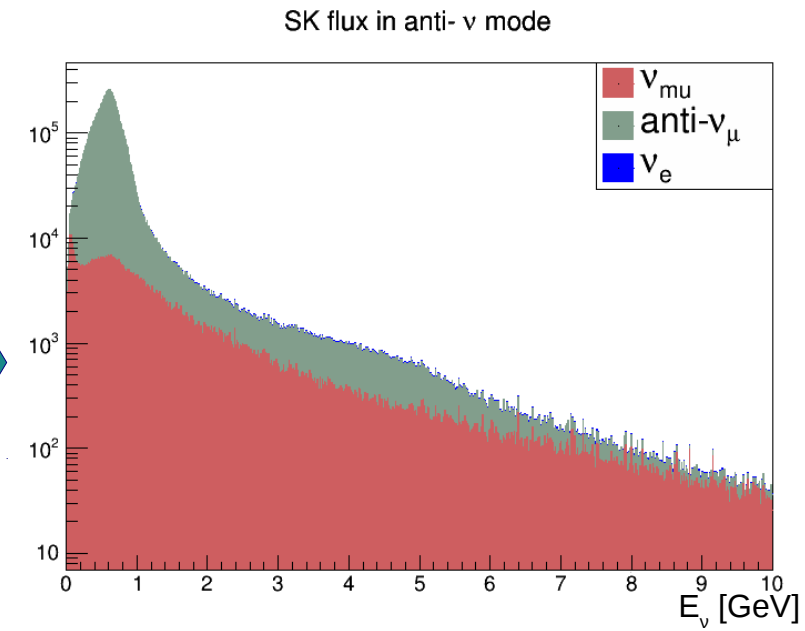
νPRISM flux (2.4°)

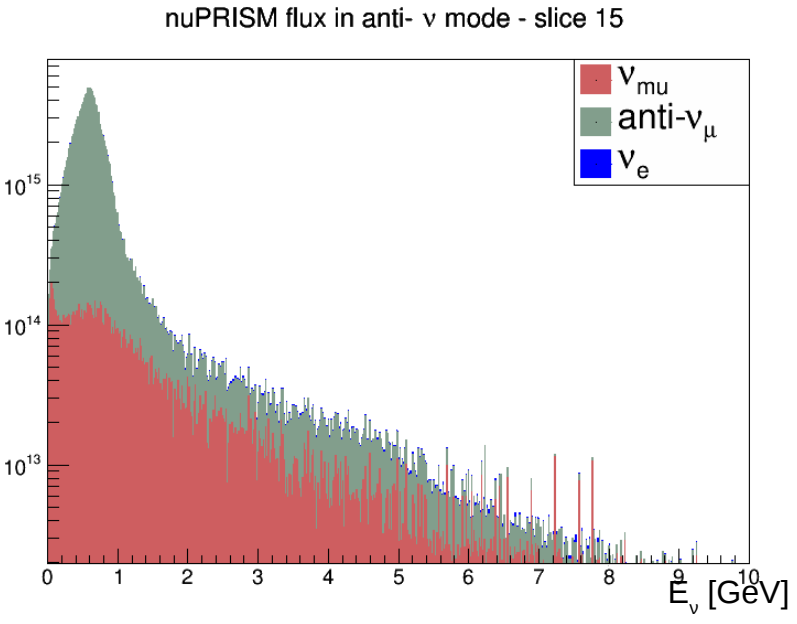
ν mode





anti-ν mode





(flux stored in the nuprism_spectra.root file)

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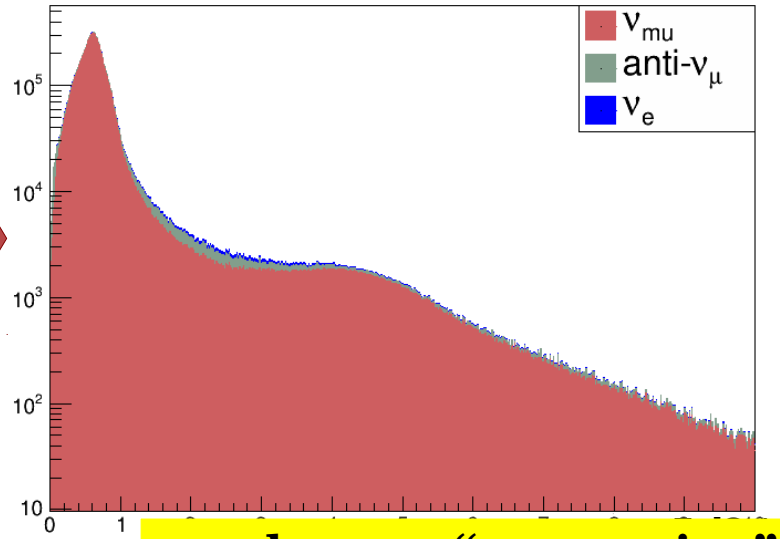
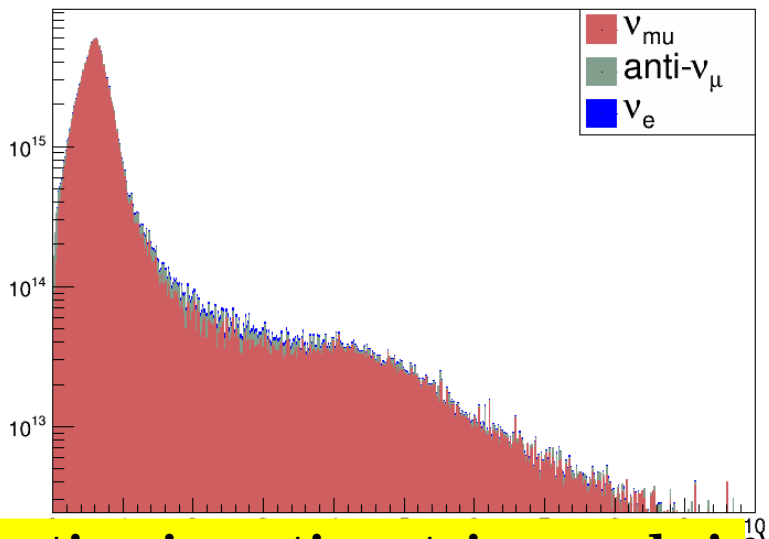
Super-K flux

νPRISM flux (2.4°)

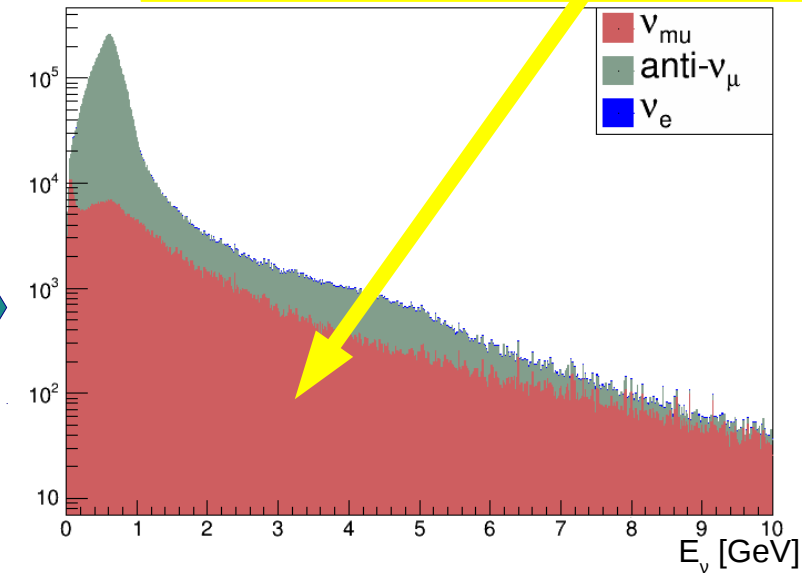
ν mode

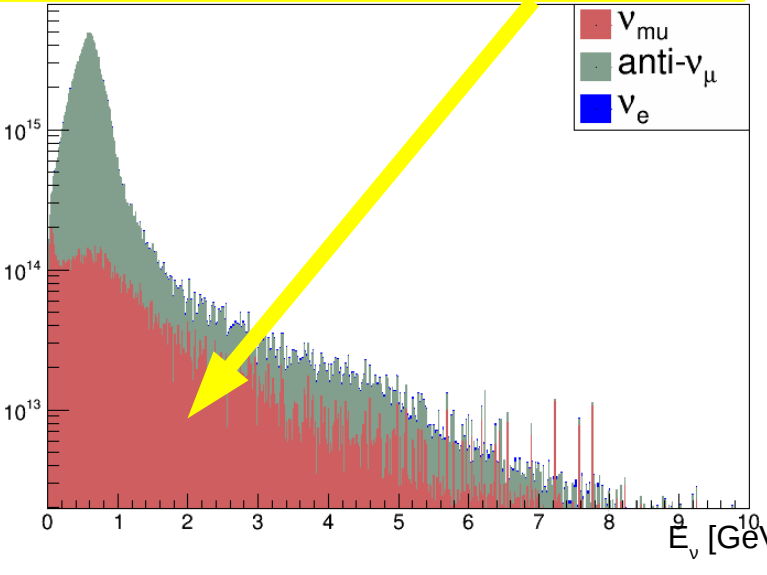
anti-ν mode





much more "wrong sign" contamination in antineutrino mode !
(mind the log scale in Y)

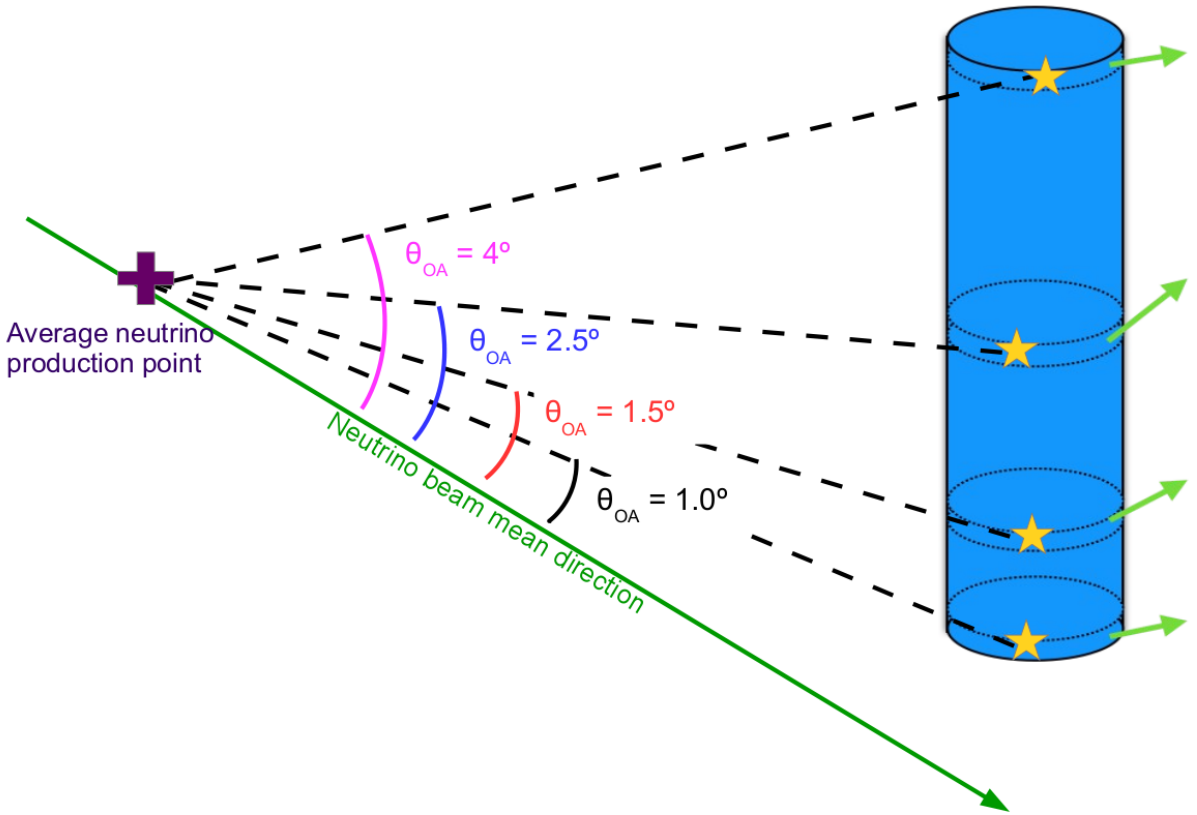


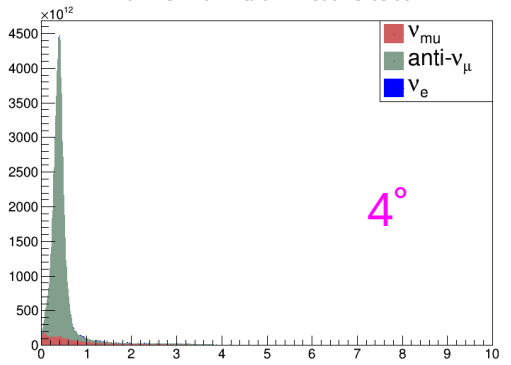


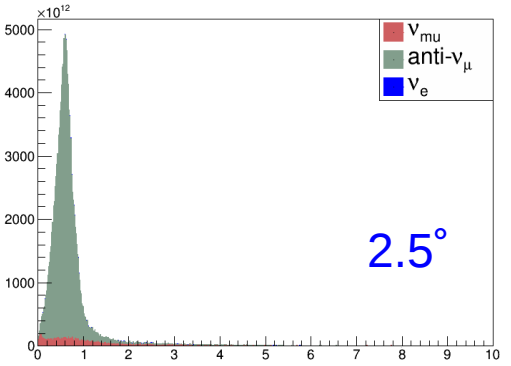
(flux stored in the nuprism_spectra.root file)

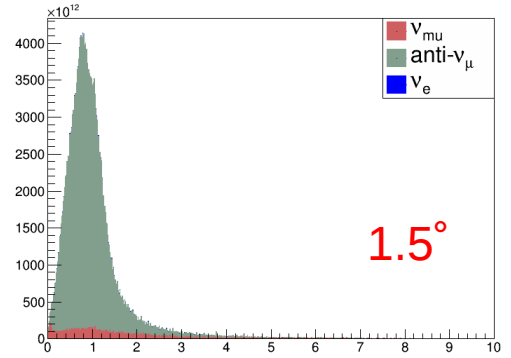
νPRISM in anti-ν mode

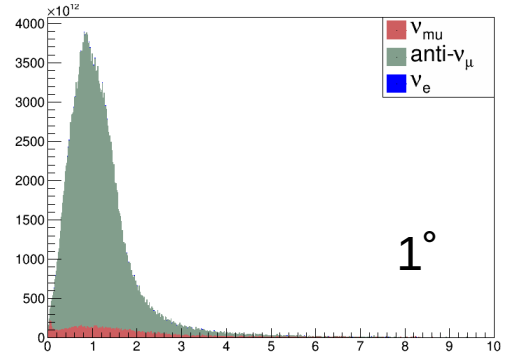
I only saw those plots for ν mode so here there are for the anti-ν mode.











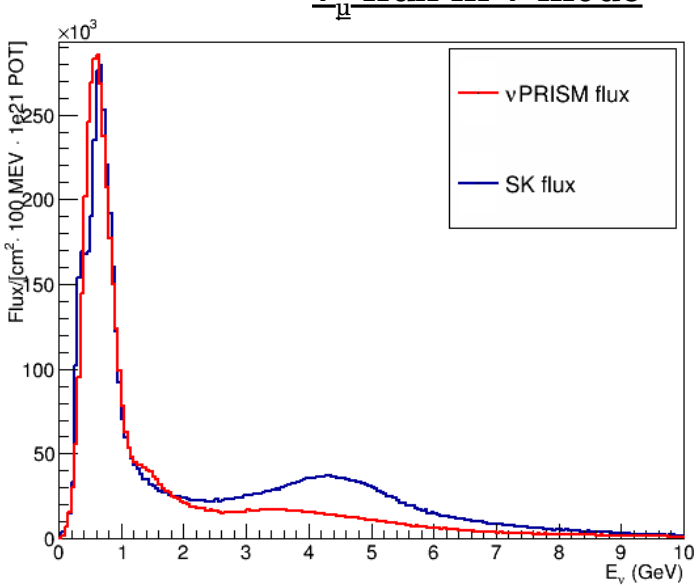
fitting the anti-ν mode flux

So now we need to fit 30 angles slices (spanning 3° from 1° to 4°) and assign a coefficient to each off-axis angle "bin" in order to model the Super-K (oscillated) flux.

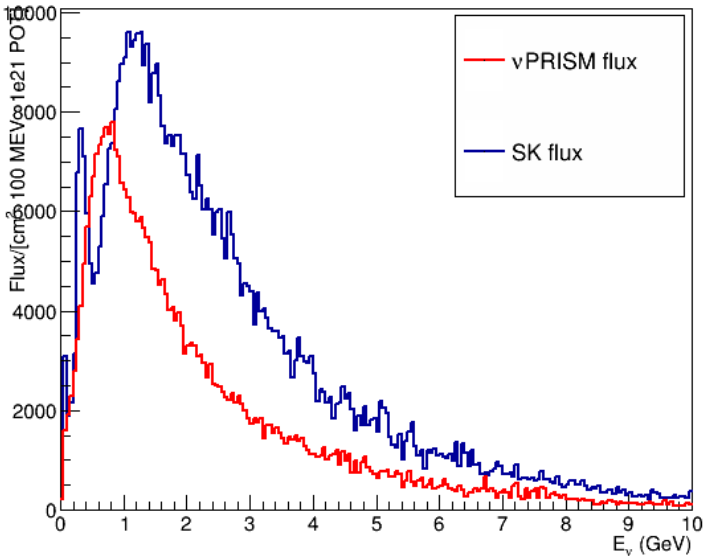
Contrarily to what has been done for the flux in ν mode, we cannot neglect the background in anti-ν mode : we need to subtract the ν_μ content before we fit the anti-ν_μ νPRISM flux.

A parenthesis : here is the output I get from the macro fitting the ν_μ content of the beam in ν mode and applies the determined coefficients to the ν_μ and the anti-ν_μ νPRISM flux bins. I am not sure we can say it works well for both, neither do I get why the oscillation peak only appear for the anti-ν_μ.

ν_μ flux in ν mode



anti-ν_μ flux in ν mode



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Contrarily to what has been done for the flux in ν mode, we cannot neglect the background in anti-ν mode : we need to subtract the ν_μ content of the beam before we fit the anti-ν_μ νPRISM flux.

In steps :

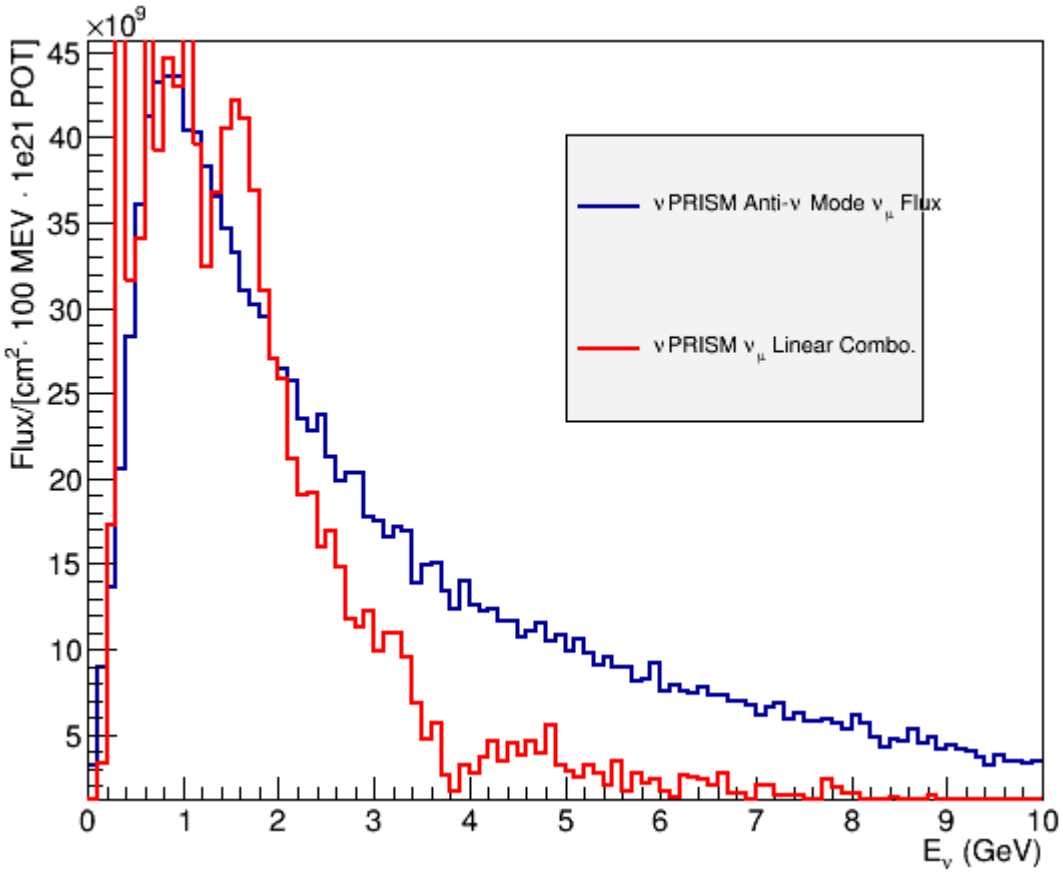
1. fit of the νPRISM ν_μ contamination in anti-ν mode with a linear combination of the νPRISM ν_μ content in forward-current mode (ν mode)
2. fit of the Super-K anti-ν_μ content in reversed-current mode with a linear combination of the νPRISM anti-ν_μ content in reversed-current mode (anti-ν mode)
3. fit of the Super-K ν_μ contamination in reversed-current mode with a linear combination of the νPRISM ν_μ content in forward-current mode

fitting the anti-ν mode flux

1. fit of the νPRISM ν_μ contamination in reversed-current mode with a linear combination of the νPRISM ν_μ content in forward current mode
2. fit of the Super-K anti-ν_μ content in reversed-current mode with a linear combination of the νPRISM anti-ν_μ content in reversed-current mode
3. fit of the Super-K ν_μ contamination in reversed-current mode with a linear combination of the νPRISM ν_μ content in forward-current mode

on the plot, output of the macro : fit_spectrum_Wrongsign.cc

Can we make it better ? Should we use ND280 as an input ?



fitting the anti-ν mode flux

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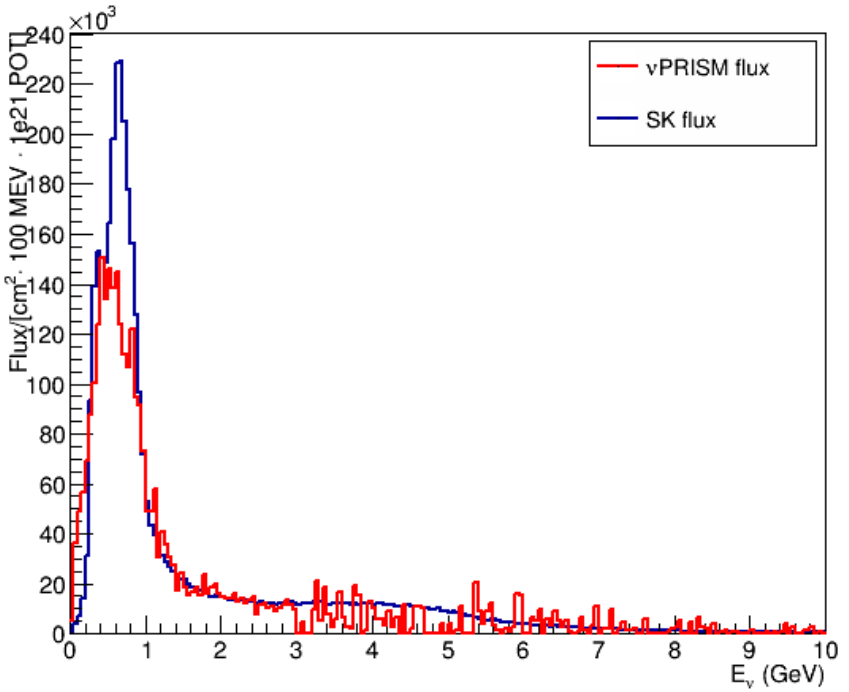
I managed to get some results, but the fit fails to correctly recover the peak.

The distribution is not smooth, but the introduction of a penalty term in the χ^2 makes the fit totally unable to resolve the peak.

I need to improve the fit.

anti-ν_μ flux in reversed-current mode



fitting the anti-ν mode flux

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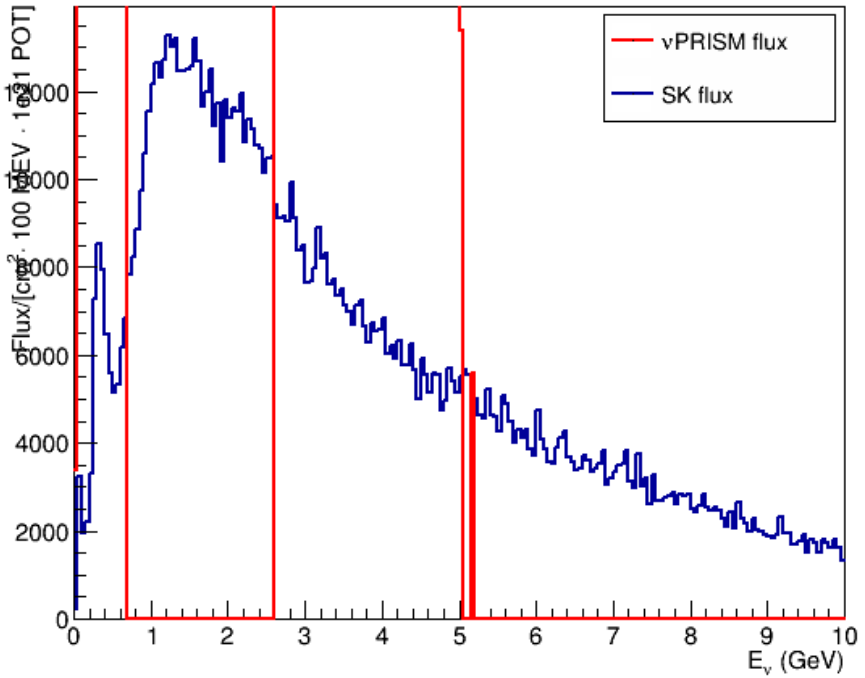
A parenthesis : it really does not work to fit the ν_μ flux content with the same parameters.

ν_μ flux in reversed-current mode



fitting the anti-ν mode flux

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3. fit of the Super-K ν_μ contamination in reversed-current mode with a linear combination of the νPRISM ν_μ content in forward-current mode

Not done yet... May need to think how to scale the ν_μ content determined in ν mode to the ν_μ content in anti-ν mode ? Or will it happens naturally in the fit ?

To be tried soon...

and after...

Summary of the fit of the νPRISM flux in anti-ν mode :

1. fit of the νPRISM ν_μ contamination in anti-ν mode with a linear combination of the νPRISM ν_μ content in forward-current mode → done
2. fit of the Super-K anti-ν_μ content in reversed-current mode with a linear combination of the νPRISM anti-ν_μ content in reversed-current mode → in progress
3. fit of the Super-K ν_μ contamination in reversed-current mode with a linear combination of the νPRISM ν_μ content in forward-current mode → to do

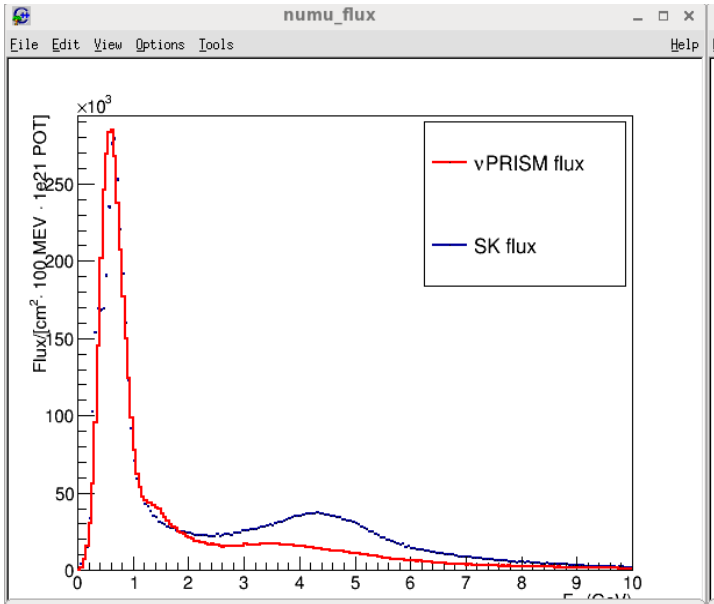
Then there will be many studies similar to the ν mode that will probably be needed :

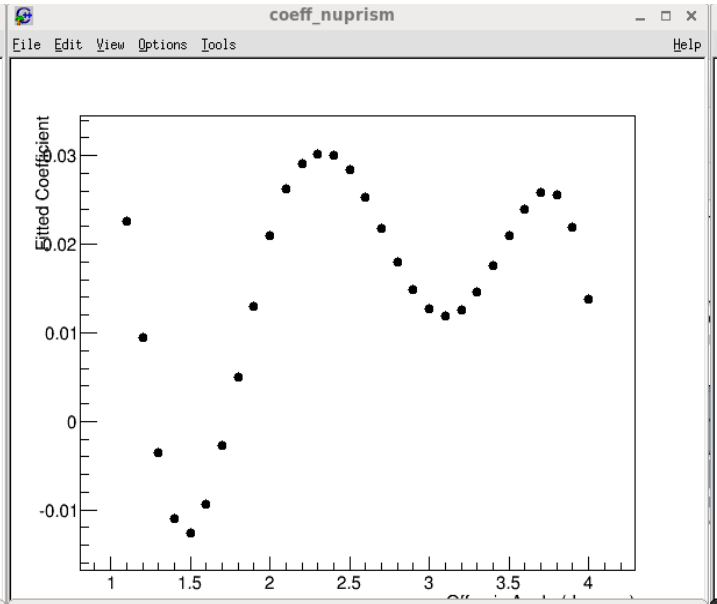
- e+ background sources
- cross-section ratio $\frac{\sigma(\bar{\nu}_e)}{\sigma(\bar{\nu}_\mu)}$
- cross section on water (CCQE, NC...)

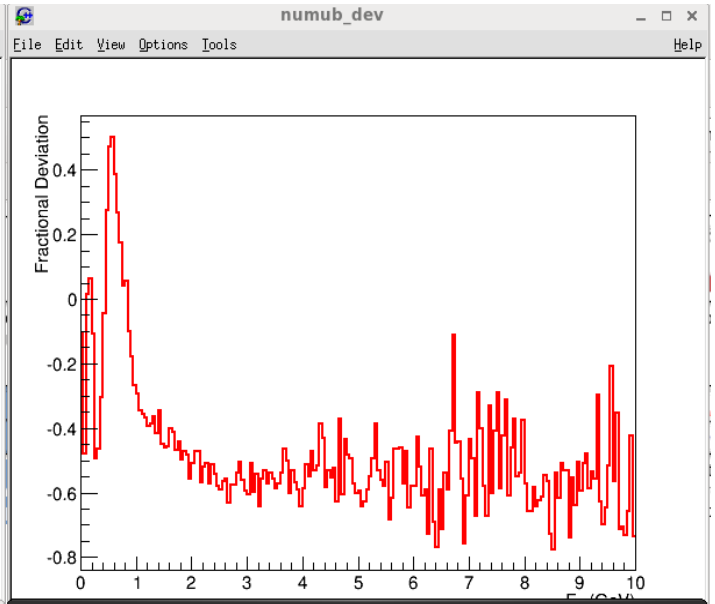
Stay tuned, and thanks for your attention !

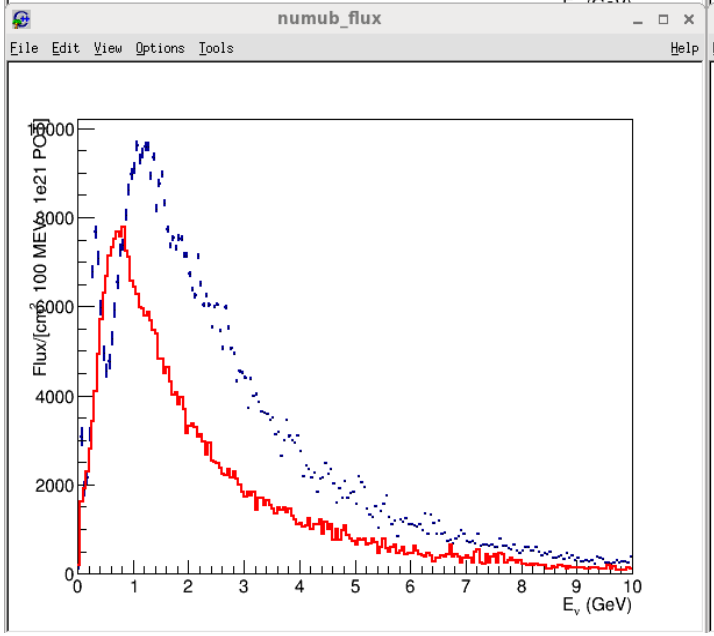
backup

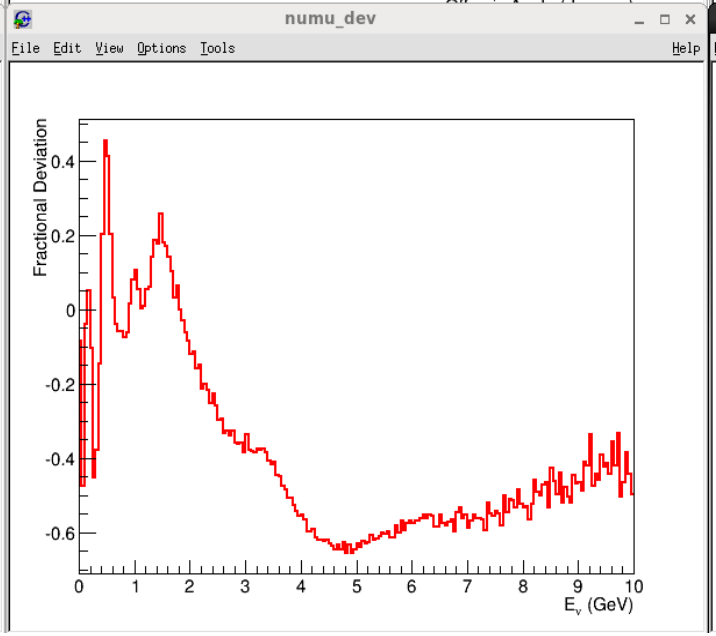
ν mode flux fit output

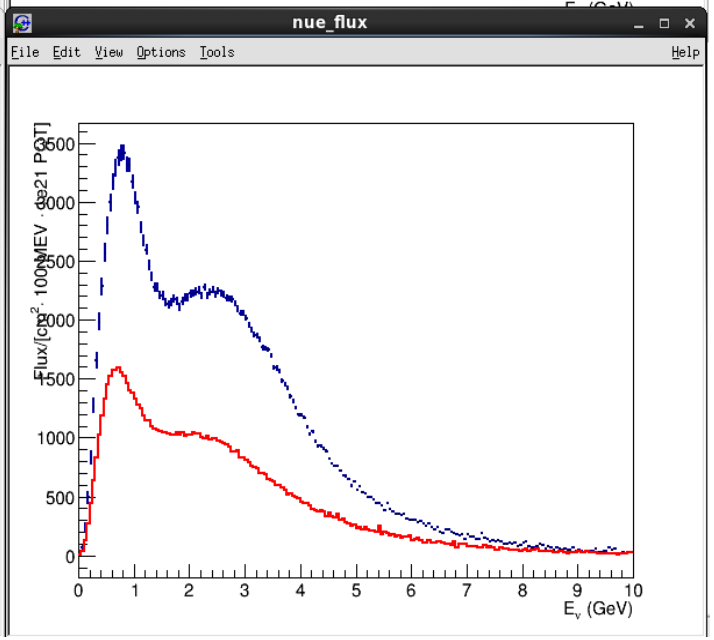












anti-ν mode flux fit output