Tools for physics analysis

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Introduction

- Tools developed for the studies of CPV/MH sensitivity:
  - Simple CP fitter based on GLOBES
    - Relatively quick
  - Custom made fitter (more involved analysis) ← used in the EOI, SPSC review, and other studies
    - Not-so-quick

Analysis with GLOBES

- Inputs:
  - Neutrino interaction cross sections
    - Computed w/ GENIE by Silvestro (http://laguna.ethz.ch:8080/Plone/work/genie_cross_sections/xsec_ar40)
  - "Migration" matrices: $E_\nu^{True} \rightarrow E_\nu^{Rec}$
    - Provided by Silvestro
  - Neutrino fluxes for +"ve" and –"ve" horn polarities
- Event normalization (flux norm, detector mass, POT …) set via @norm command in input card
- Fit rec energy spectrum shape

Example of GLOBES @norm calculation

- Assume the fluxes are given as /100MeV/100m2/2300km/3.75E+20 POT
- Assume the cross-sections are given per atom (not per nucleon as in GLOBES files, in that case remove 39.948)

$$\text{@norm} = \frac{1}{5.2}\left(\frac{\text{GeV}}{\Delta E}\right)\left(\frac{\text{cm}^2}{A}\right)\left(\frac{L}{\text{km}}\right)^2\left(\frac{\tau}{m_u}\right) \times 10^{-38} \times \left(\frac{\mathcal{L}_u}{\mathcal{L}}\right)$$

Applicable only for GLOBES version < 3.0

1/0.1 (for 100 MeV bin)

1E-6 (for 100 m2)

2300^2

6.022/39.948 x 10^{23} x 10^9 (Ar atoms/kT)

SPS POT/y / 3.75 (POT/y)
SPS POT/y = 1.4E+20 (dedicated mode)
SPS POT/y = 1E+20 (shared mode)

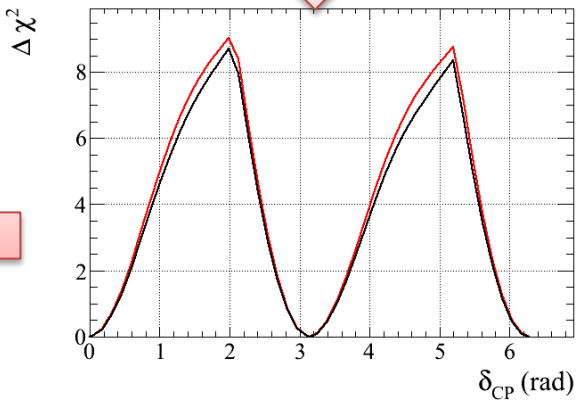
$$@norm = 10 \times 10^{-6} \times 2.3^2 \times 10^6 \times \frac{6.022}{39.948} \times 10^{32} \times 10^{-38} \times \frac{SPSPOT(1/10^{20})}{3.75}$$

$$@norm = 2.127 \times 10^{-6} \times SPSPOT(1/10^{20})$$

Optimization flow chart

ν flux in GLOBES format for a given optimization

Calculate CP sensitivity with GLOBES fitter

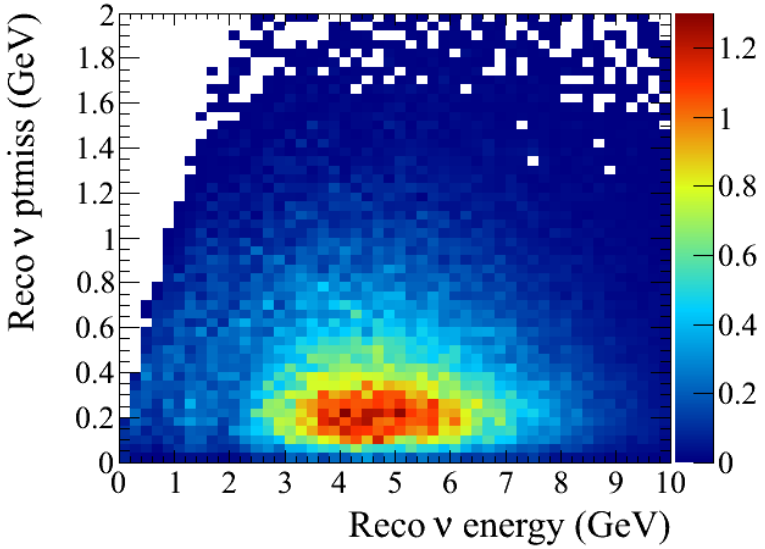


Calculate a single number to rank a given configuration:

- Integral under the curve
- Coverage at a given significance level

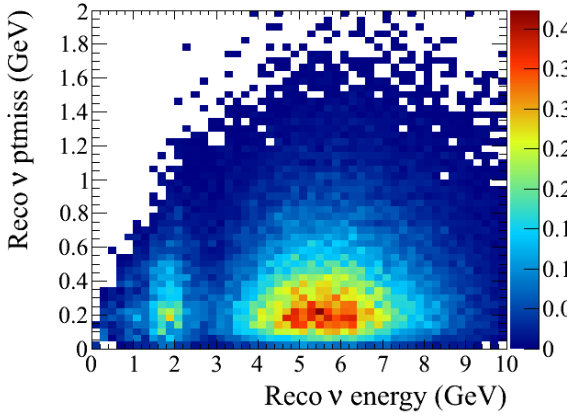
LBNO fitter “myFitter”

All e-like (PHF)

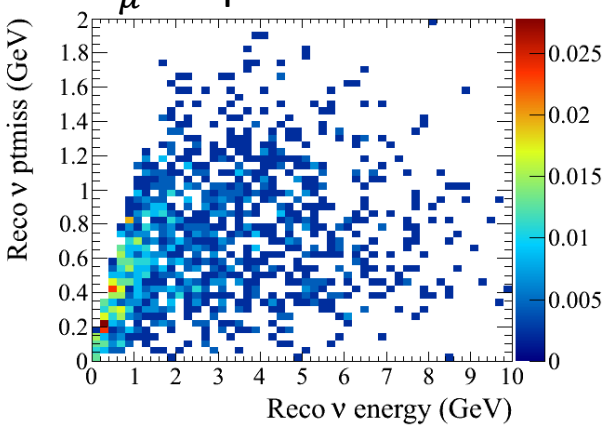


- Fit two dimensional samples
- Better constrain on backgrounds

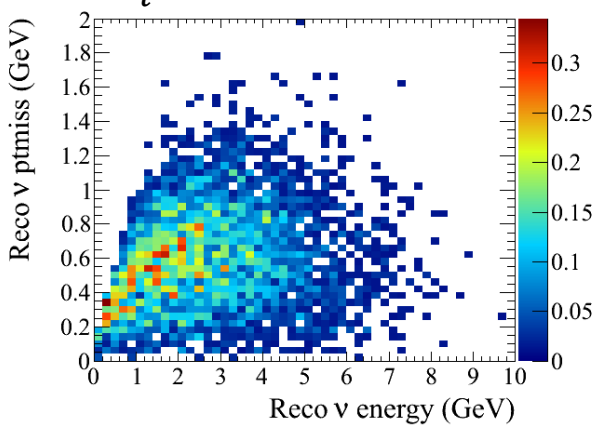
ν_e signal CC



ν_μ NC pi0



ν_τ CC $\tau \rightarrow$ e



Simulation of ν interactions in LAr

- GLACIER files produced with GENIE (R. Terry)

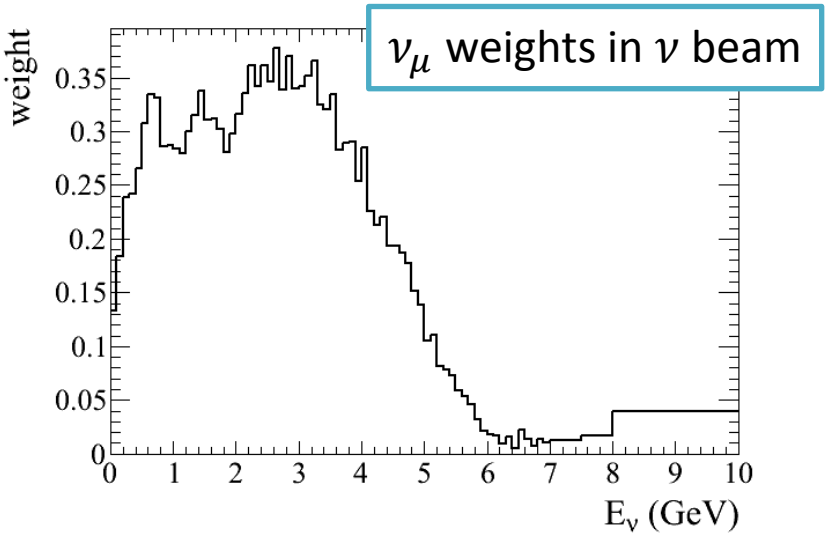
http://laguna.ethz.ch:8080/Plone/work/wp5.2.3-glacier/data-storage-for-glacier-wp5.2.3-files/data-storage-on-irods-for-glacier

- Neutrino flux is the one by A. Longhin

→ Need to perform energy based re-weighting for different fluxes

To account for differences in energy spectra between a given optimization fluxes and the ones used to produce MC files

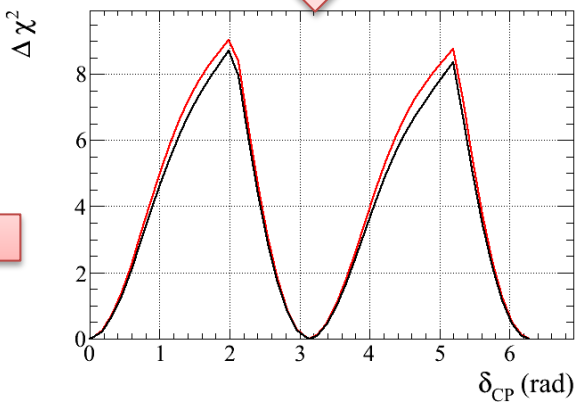
- 8 weight histograms in total
  - 2 horn polarities x 4 nu flavours



Optimization flow chart

Ratios of fluxes for a given optimization and HPPS fluxes by A. Longhin

Calculate CP sensitivity with LBNO fitter



Calculate a single number to rank a given configuration:

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Summary

- There are two tools to study physics performance
  - Simple GLOBES based analysis could be used in the first rounds of optimization (quick output → fast rejection of bad configuration parameters)
  - More refined analysis with LBNO fitter: slower, so use it in the latter stages to get a more realistic evaluation of physics reach
- All the necessary code for analysis exists just need some script “glue” to make it run automatically in the optimization cycles