Response function for NumuOA

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Setting

- Skimmed SKMC : SKMC 11c after 10a Numu cut
  - Weighting by using latest tuned flux (11b v3.1)
- Oscillation parameters → Right Table
- Response function calculated with T2KReWeight (by Murakami)
  - version : v1v15p1
- Binning for True Enu & Recon Enu → later
- Interaction category → later

Parameter	Value
Δm^2_{21}	$7.6 \times 10^{-5}\mathrm{eV}^2$
Δm^2_{32}	$2.4 \times 10^{-3}\mathrm{eV}^2$
$\sin^2 2\theta_{12}$	0.8704
$\sin^2 2\theta_{23}$	1.0
$\sin^2 2\theta_{13}$	0.1 (or 0)
δ_{CP}	0
Mass hierarchy	Normal
ν travel length	295 km
Earth density	$2.6\mathrm{g/cm}^3$

Binning for response function

True Enu binning : Same as BANFF flux bing

ν_μ, ν_μ-bar: 0.0-0.4, 0.4-0.5, 0.5-0.6, 0.6-0.7, 0.7-1.0, 1.0-1.5, 1.5-2.5, 2.5-3.5, 3.5-5.0, 5.0-7.0, 7.0-30.0 GeV

ν_e: 0.0-0.5, 0.5-0.7, 0.7-0.8, 0.8-1.5, 1.5-2.5, 2.5-4.0, 4.0-30.0 GeV

ν_e-bar: 0-2.5, 2.5-30 GeV

Recon Enu binning : fine (41 bins)

{ 0.00, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, 1.00, 1.10, 1.20, 1.30, 1.40, 1.50, 1.60, 1.70, 1.80, 1.90, 2.00, 2.10, 2.20, 2.30, 2.40, 2.50, 2.60, 2.70, 2.80, 2.90, 3.00, 3.5, 4.0, 5.0, 7.0, 10., 30. }; (GeV)

Interaction modes used in NEUT

```
########## NEUTRINO MODE ##########
      ***** CHARGED CURRENT *****
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```
   -- ELASTIC --
1 : NEU,N --> LEPTON-,P
```

ccqe

```
   -- SINGLE PI FROM DELTA RESONANCE --
11 : NEU,P --> LEPTON-,P,PI+
12 : NEU,N --> LEPTON-,P,PI0
13 : NEU,N --> LEPTON-,N,PI+
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ccpi

```
16 : NEU,O(16) --> LEPTON-,O(16),PI+
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cccoh

```
   -- SINGLE GAMMA FROM DELTA RESONANCE --
17 : NEU,N --> LEPTON-,P,GAMMA

   -- MULTI PI (1.3 < W < 2.0 GeV) --
21 : NEU,(N OR P) --> LEPTON-,(N OR P),MULTI PI

   -- SINGLE ETA FROM DELTA RESONANCE --
                (added 97/12/01 J.Kameda)
22 : NEU,N --> LEPTON-,P,ETA0

   -- SINGLE K FROM DELTA RESONANCE --
                (added 98/02/25 J.Kameda)
23 : NEU,N --> LEPTON-,LAMBDA,K+

   -- DEEP INELASTIC (2.0 GeV < W , JET set) --
26 : NEU,(N OR P) --> LEPTON-,(N OR P),MESONS
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ccoth

```
      ***** NEUTAL CURRENT *****

   -- SINGLE PI FROM DELTA RESONANCE --
31 : NEU,N --> NEU,N,PI0
32 : NEU,P --> NEU,P,PI0
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ncoth

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33 : NEU,N --> NEU,P,PI-
34 : NEU,P --> NEU,N,PI+
```

ncpi

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36 : NEU,O(16) --> NEU,O(16),PI0

   -- SINGLE GAMMA FROM DELTA RESONANCE --
38 : NEU,N --> NEU,N,GAMMA
39 : NEU,P --> NEU,P,GAMMA

   -- MULTI PI (1.3 GeV < W < 2.0 GeV) --
41 : NEU,(N OR P) --> NEU,(N OR P),MULTI PI

   -- SINGLE ETA FROM DELTA RESONANCE --
                (added 97/12/01 J.Kameda)
42 : NEU,N --> NEU,N,ETA0
43 : NEU,P --> NEU,P,ETA0

52 : NEU,N --> NEU,N
   -- SINGLE  K  FROM DELTA RESONANCE --
                (added 98/02/20 J.Kameda)
44 : NEU,N --> NEU,LAMBDA,K0
45 : NEU,P --> NEU,LAMBDA,K+

   -- DEEP INELASTIC (2.0 GeV < W , JET set) --
46 : NEU,(N OR P) --> NEU,(N OR P),MESONS

   -- ELASTIC --
51 : NEU,P --> NEU,P
```

Parameter List for Response function

variable name	Center value (absolute)	Fraction 1σ error (absolute)
MA_QE (maqe)	x 1 (1.21)	0.198 (0.24)
MA_RES (mares)	x 1 (1.21)	0.083 (0.1)
CC other shape (ccothshp)	x 0	0.4
Spectral function (sf)	x 1	1
EB (for Oxygen) → Not used	x 1 (27)	0.33 (9)
pF (pf) (for Oxygen)	x 1 (225)	0.133 (30)
W shape (mdel)	x 1 (87.8)	0.52 (45.7)
pionless delta decay (pdd)	x 0	0.2
MB 1pi shape (pishp)	x 0	0.5

Param# vs Affected Interaction Category

○: affected

param# \ int. cate.	0 CCQE	1 CCPI	2 CCCoh	3 CCOth	4 NCPI	5 NCOth
0 MAQE	○					
1 MARES		○		○	○	○
2 CC other Shape				○		
3 Spec Function	○					
4 EB						
5 pF	○					
6 W-shape		○		○	○	○
7 Pi-less delta decay		○			○	○
8 MB 1Pi shape		○				○

MC files

- The place of MC files

http://www-he.scphys.kyoto-u.ac.jp/~akira.m/nuosc/work/response/plot/

- NumuOA Skimmed MC
  - File name : mtuple_sk11c_flx11bv31_(flavor).root
- Corresponding weights tree
  - File name : t2krew_wgt(flavor).root
- Spline function based on these inputs
  - spl_numuoa_sk11c_flx11bv31_(flavor).root
  - Spline name : spl_(xsec param)_(int. cate.)_enu(true enu bin#)_erec(erec bin#)
    - xsec param = “maqe”,“mares”,“ccothshp”,“sf”,“pf”,“mdel”,“pdd”, “pishp”
    - Int. cate. = “ccqe”,“ccpi”,“cccoh”,“ccoth”,“ncpi”,“ncoth”

Response function plots

The place of plots :

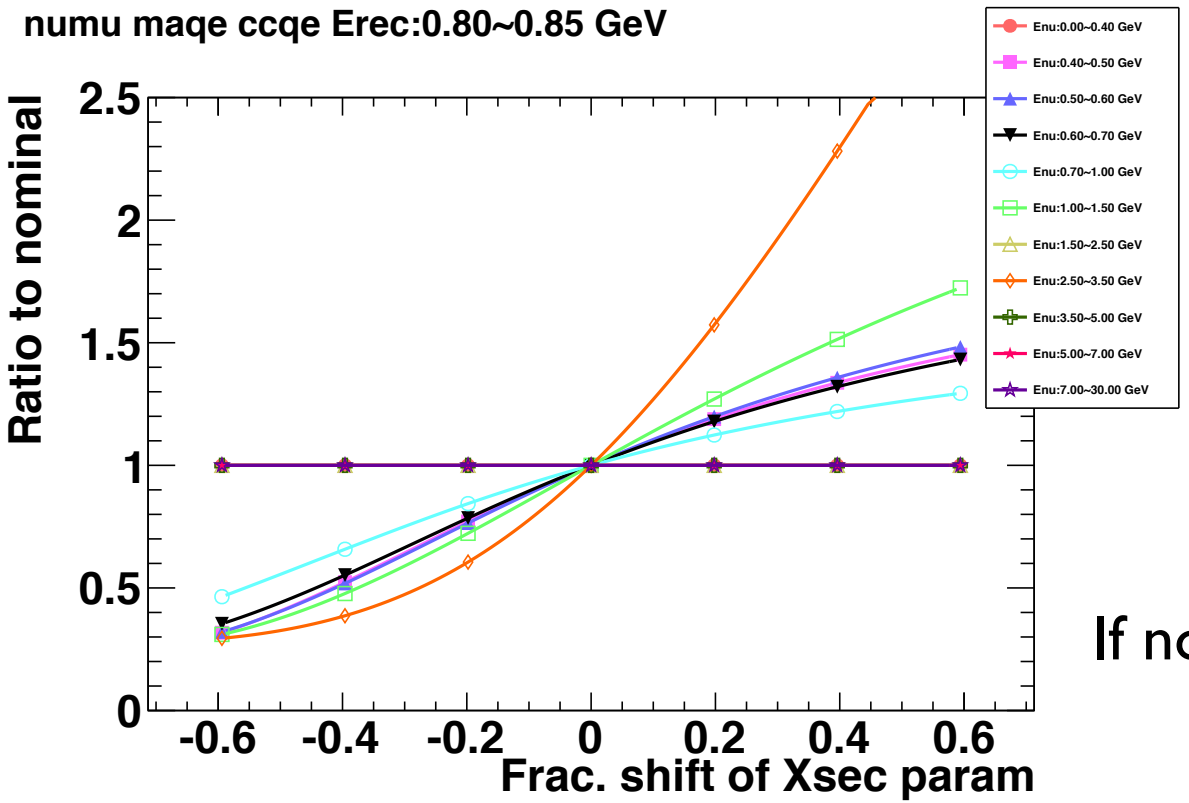
http://www-he.scphys.kyoto-u.ac.jp/~akira.m/nuosc/work/response/plot/

File name indicates:

res_spl_(flavor)_(parameter)_(int. cate.)_41bins.pdf

- flavor : numu, numubar, nue, nuebar
- parameter : p.5
- int. cate. : p.6

Example of response function



x axis is corresponding to
-3, -2, -1, 0, +1, +2, +3
sigma of xsec param.

y axis is the ratio to nominal

If no events, the response is set to 1

Overlapping all true Enu bins