ORCA4 oscillation analysis using MONA

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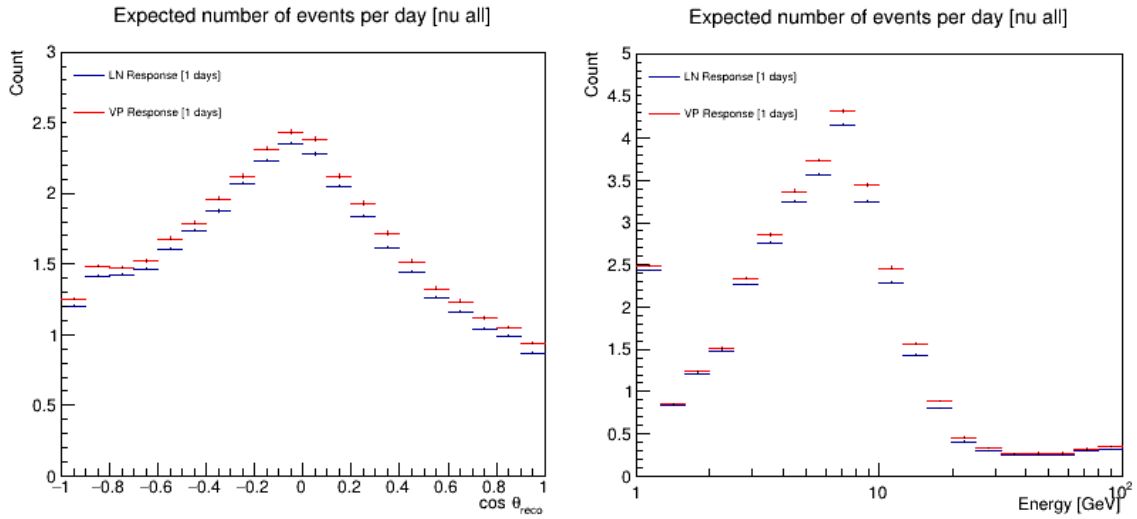
Considerations

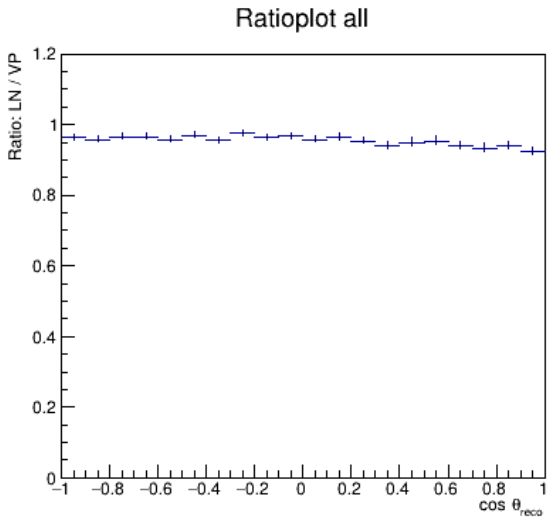
- Comparison:
  - Lodewijk (LN) and Valentin (VP) response functions
  - MONA and data

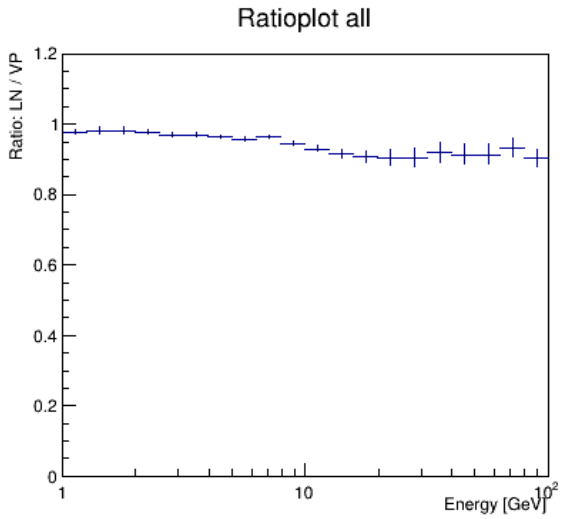
- MONA calculates flux and oscillations per bin with (20,20) binning in (E, cosTh) at bincenter. This is fast and needed for fitting.
- Weighting scheme used by VP calculates flux and oscillations per event at exact (E, cosTh). This gives a more precise result.
- Is this the reason for the discrepancy?

Neutrino response comparison

LN vs VP
All neutrino flavors
Using aanet flux
Normal ordering
Events per day





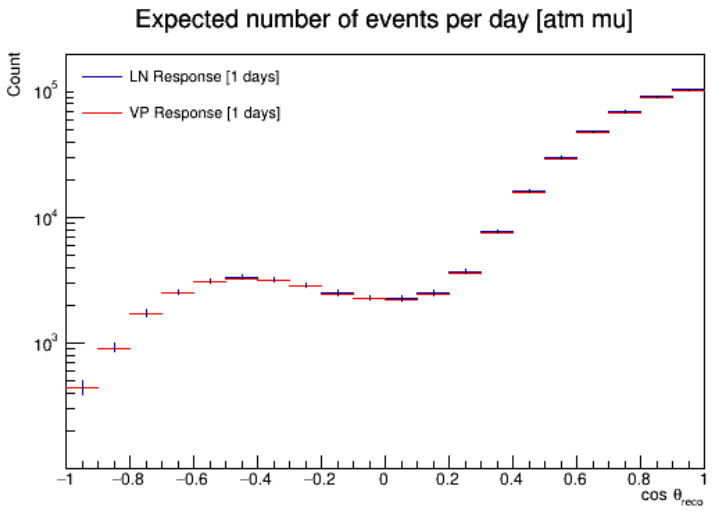


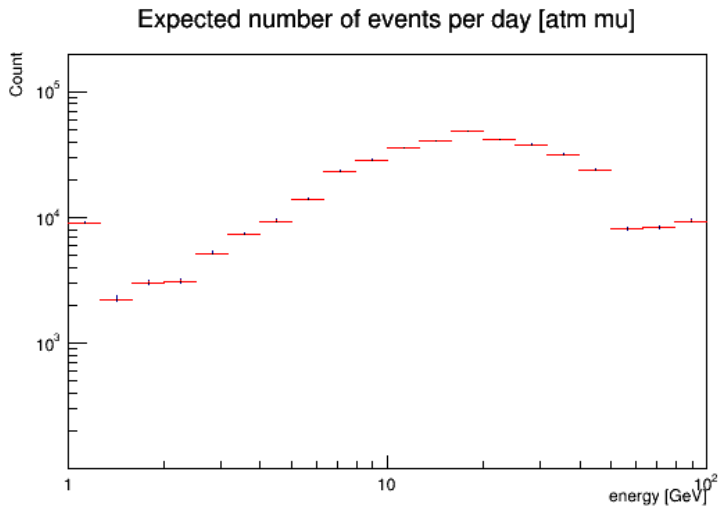
NB: per flavor in backup

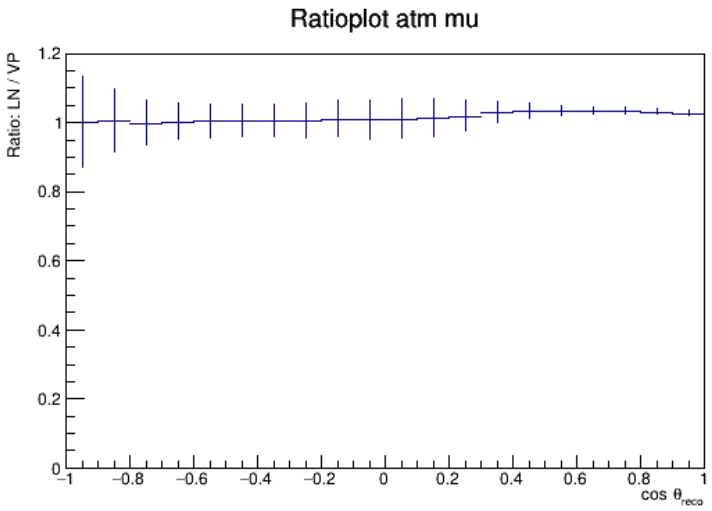
Atmospheric muon response

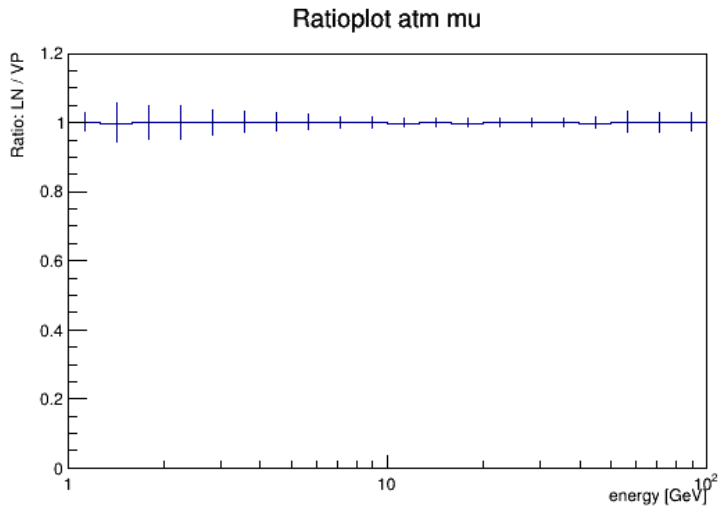
LN vs VP

Events per day
Almost exactly 1 to 1!



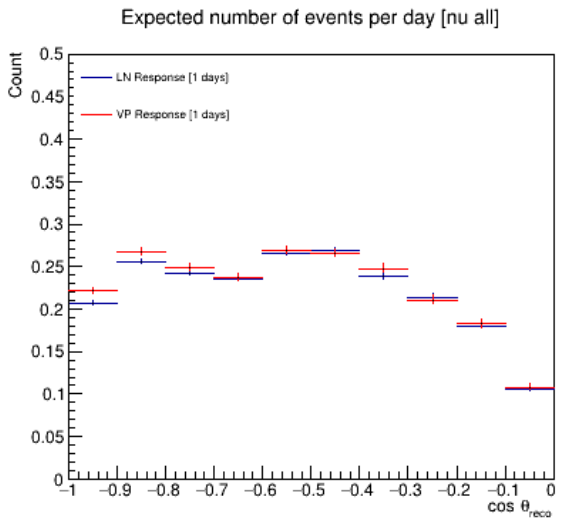


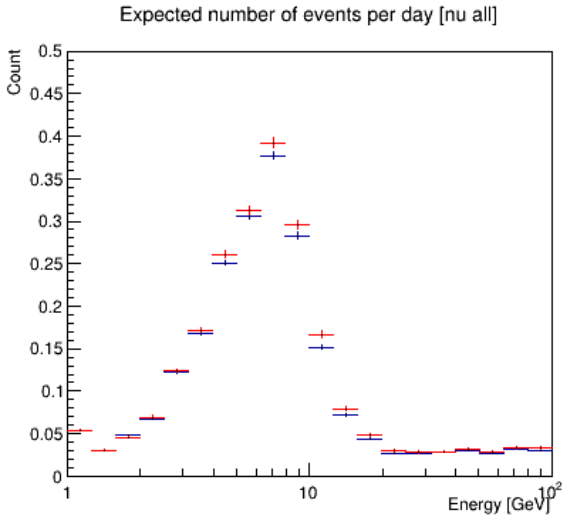


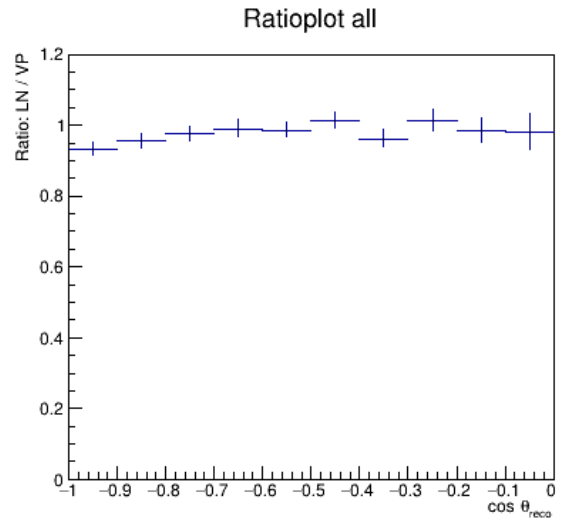


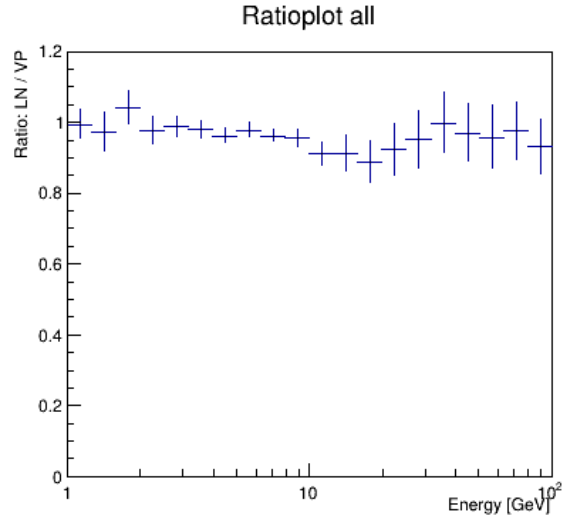
Neutrino response comparison
Cuts applied

LN vs VP
All neutrino flavors
Using aanet flux
Normal ordering
Events per day
Janniks cuts applied









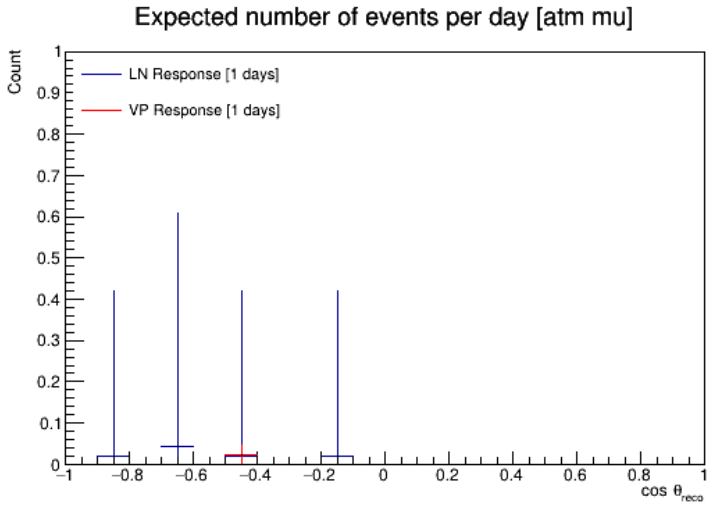
Atmospheric muon response
Cuts applied

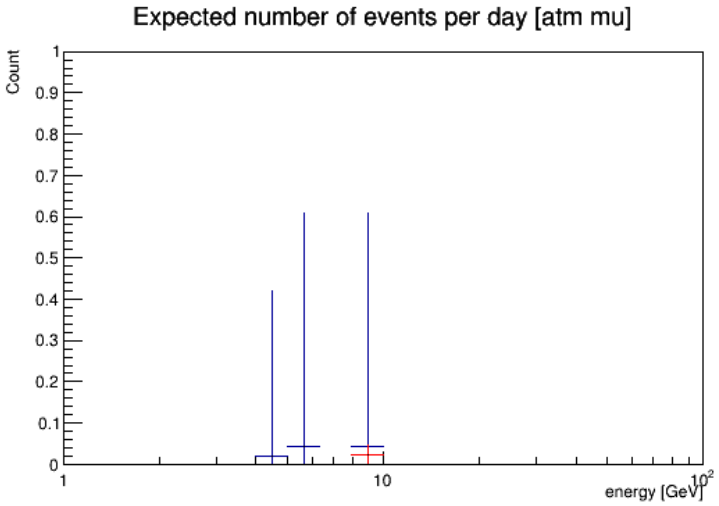
LN vs VP

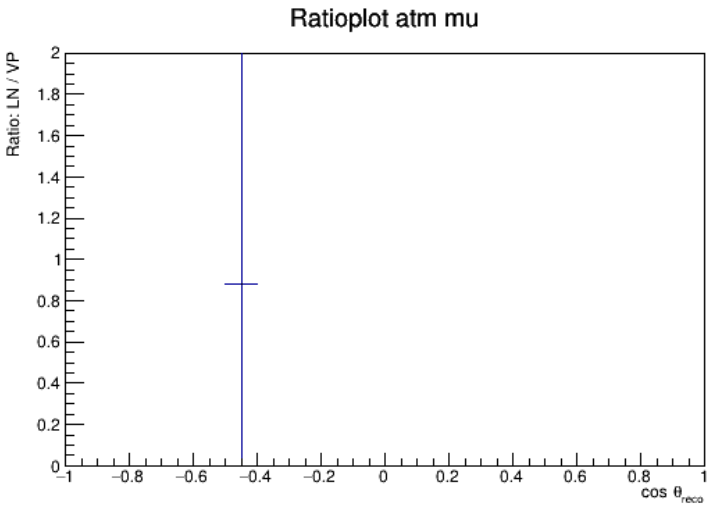
Events per day
Jannik cuts applied

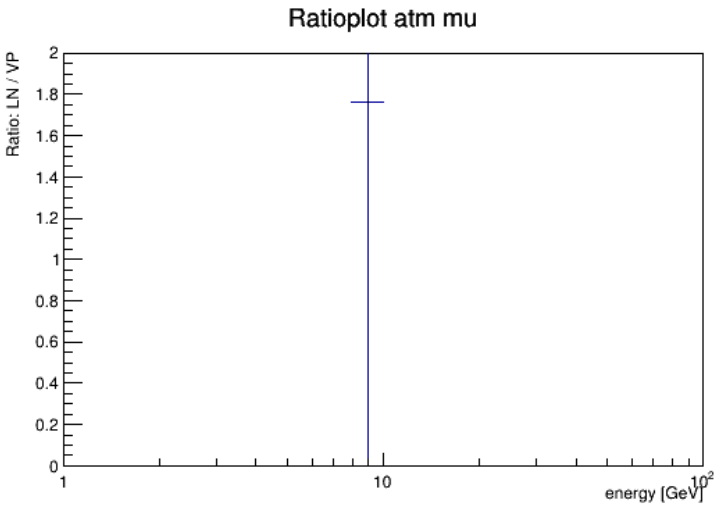
5 events for LN
1 event for VP

Errors on LN response?







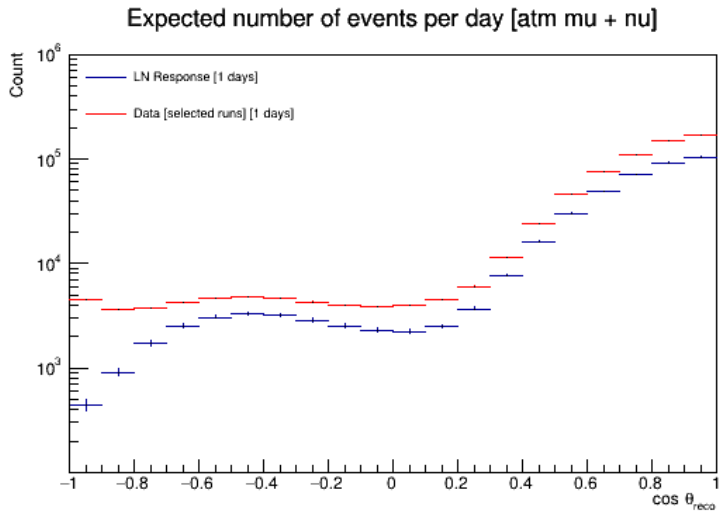


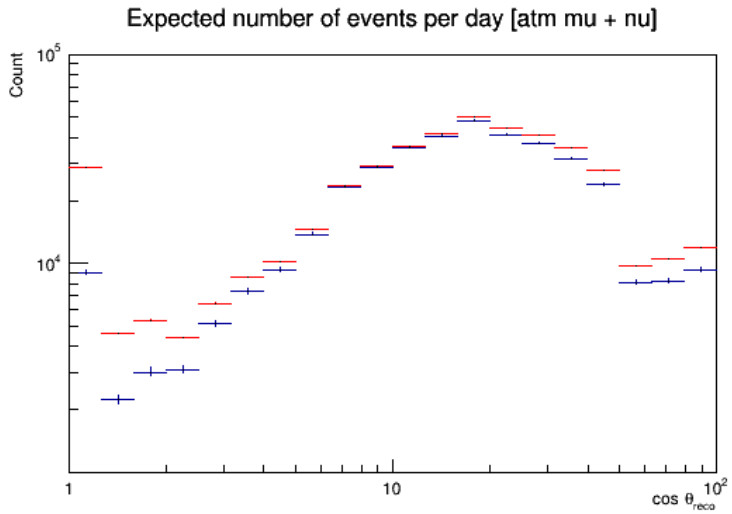
MONA response vs. Data

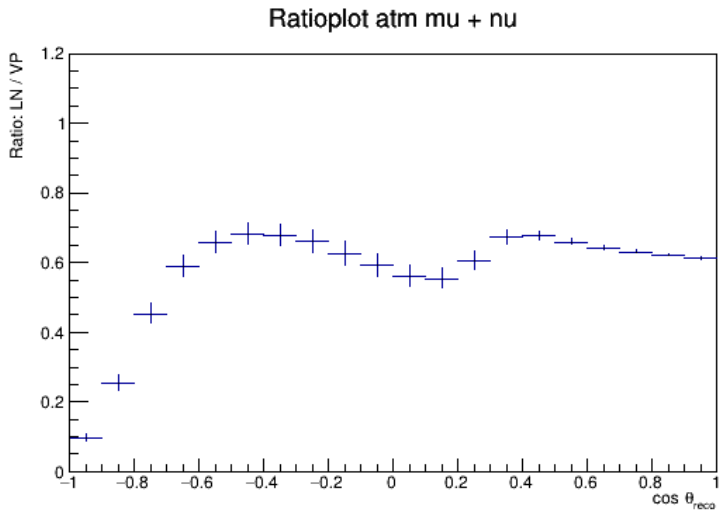
MONA vs Data

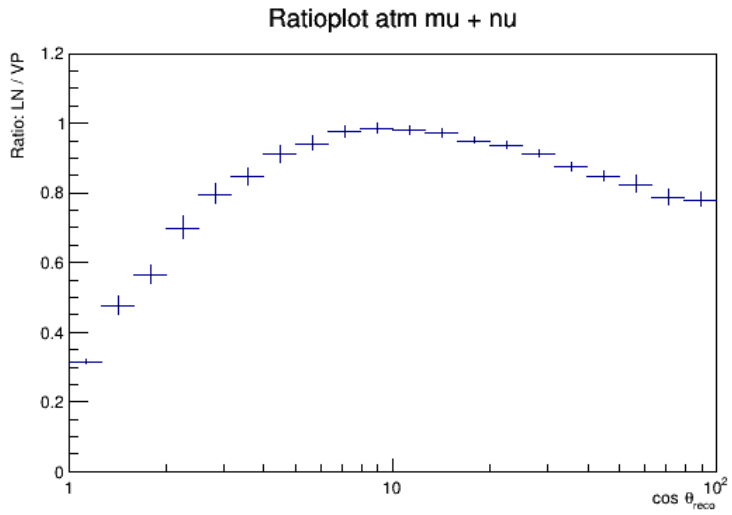
117 days of data
Response uses normal ordering

How good is the data/MC for mupage?







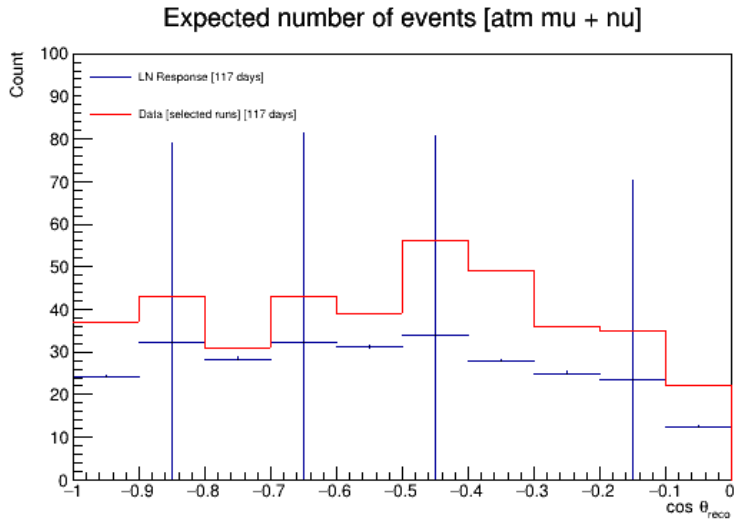


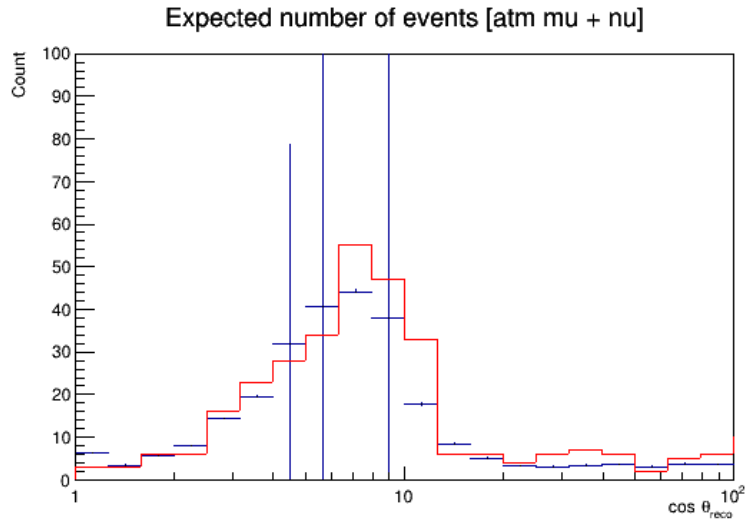
MONA response vs. Data
Cuts applied

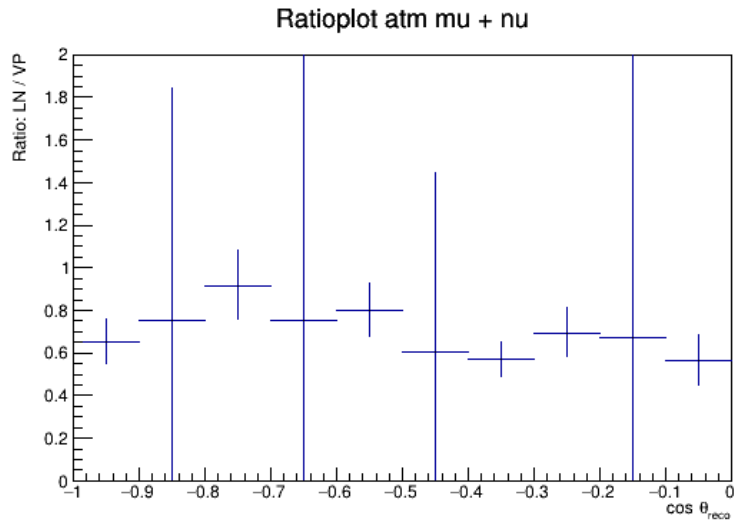
MONA vs Data

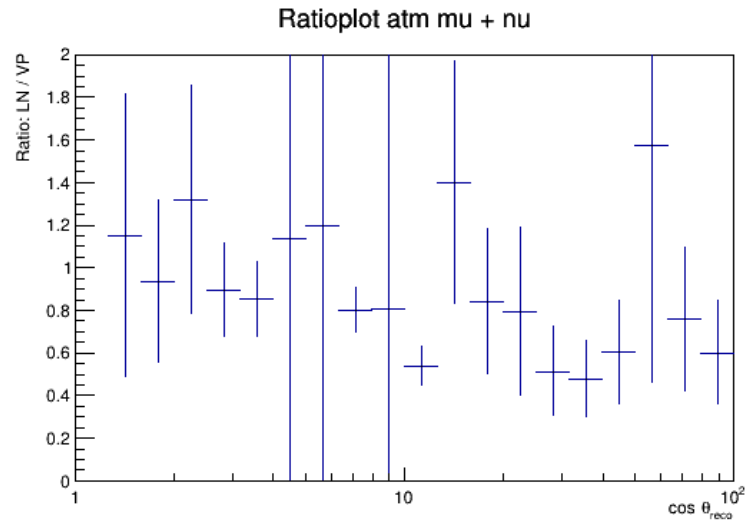
117 days of data
Response uses normal ordering
Jannik cuts applied
Run selection applied

Large errors: muons
Does MONA use proper time? [117d]









“First” fit of ORCA4 data in MONA

- Just for fun (and to see what happens)
- Free fit: all oscillation parameters let free
- No systematics included

At boundary

No sensitivity

```
*********Fit result comparison*****************************
sinsq_th12 fitted: 0.354          bounds: (0.25, 0.297, 0.354)
sinsq_th13 fitted: 0.0190001      bounds: (0.019, 0.0215, 0.024)
sinsq_th23 fitted: 0.503935       bounds: (0.381, 0.425, 0.615)
dm21       fitted: 7.25415e-05    bounds: (6.93e-5, 7.37e-5, 7.96e-5)
dm31       fitted: 0.00269        bounds: (2.45e-3, 2.56e-3, 2.69e-3)
dcp        fitted: 1.22506        bounds: (-0.5, 1.38, 2.5)
```

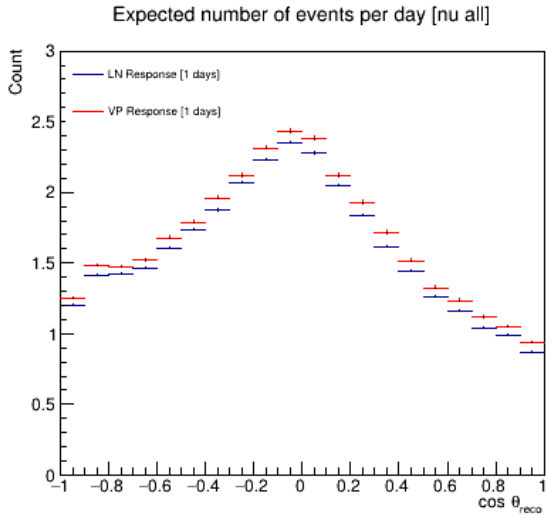
- Needs lots of investigating:
  - What binning to use, energy cuts on response, parameter fixing, systematics, further cross checks with MC models & data, no noise included

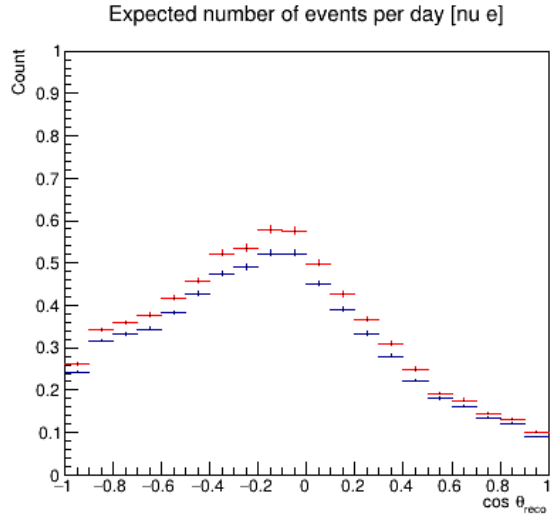
Conclusion

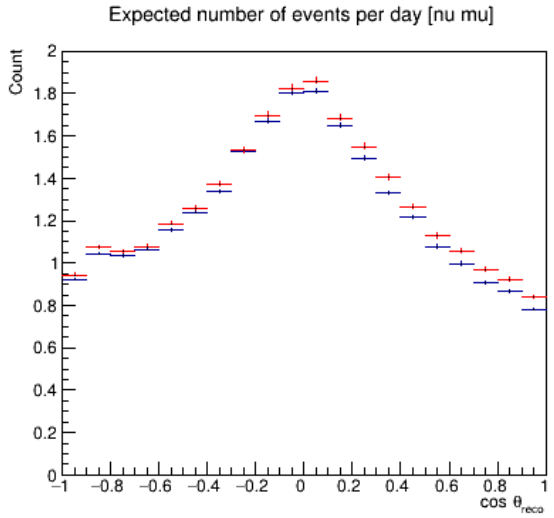
- Response and data need more investigating
  - Is MUPAGE properly tuned?
  - MONA stat. errors on muons is excessively large
- Can MONA binning explain difference LN&VP? Not sure!
- Fitting is just getting started
  - Investigate all the things!

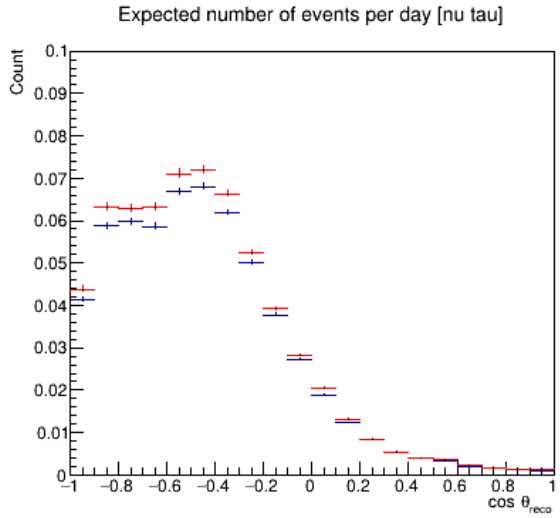
Backup

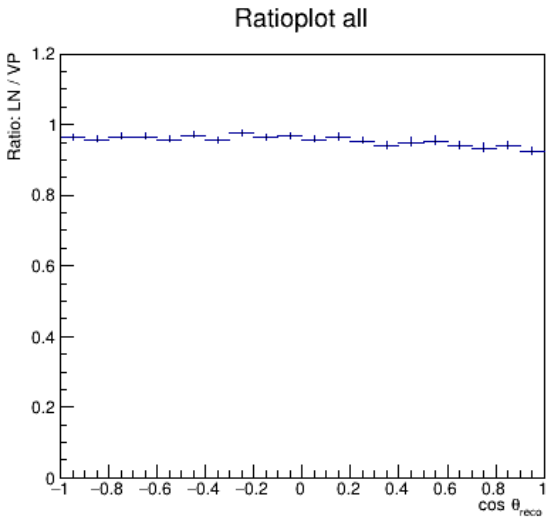
Overview of responses: LN vs VP
EvtResp, AANET FLUX, RespRange [1,1000]GeV
CosTh, NO [same osc params] in LN plot used, 1 days runtime

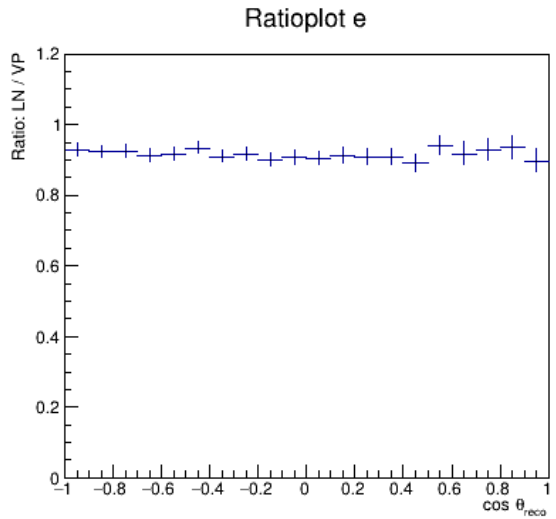


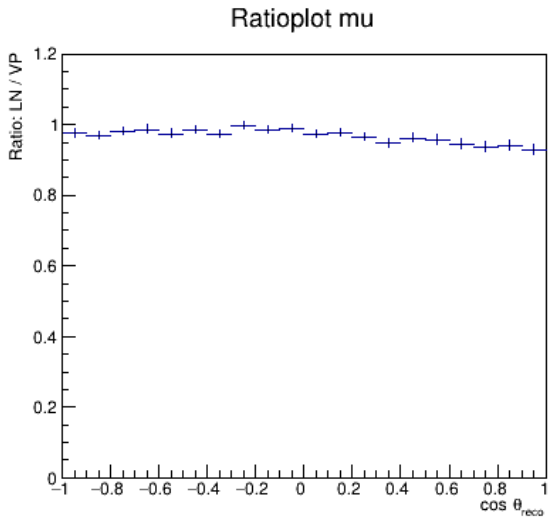


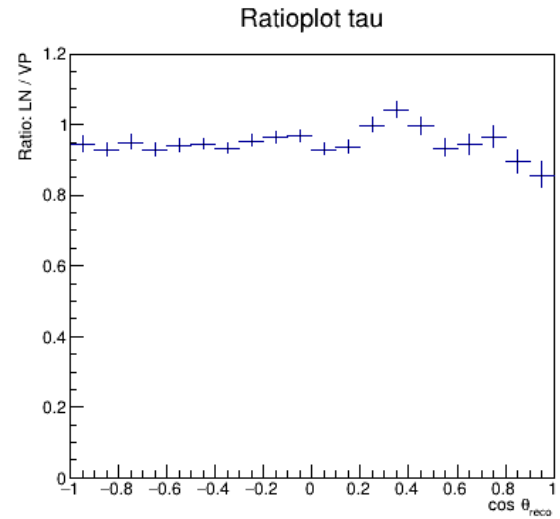












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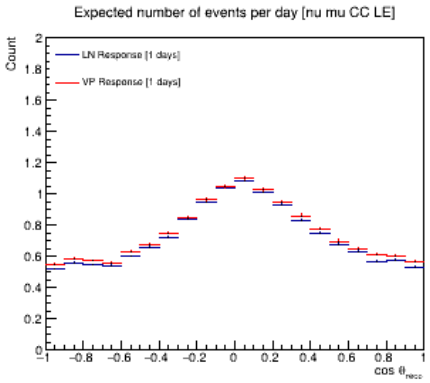

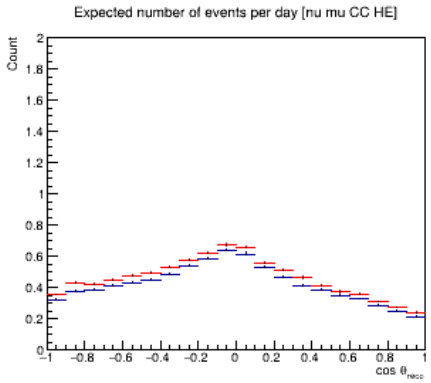

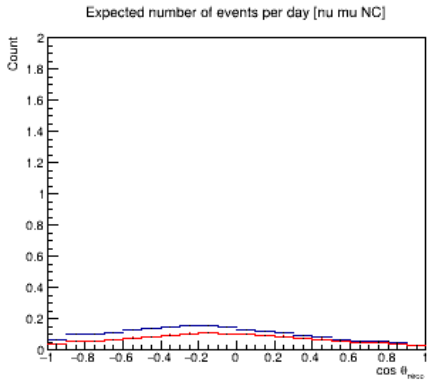

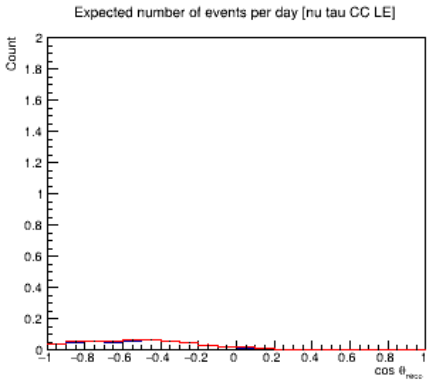

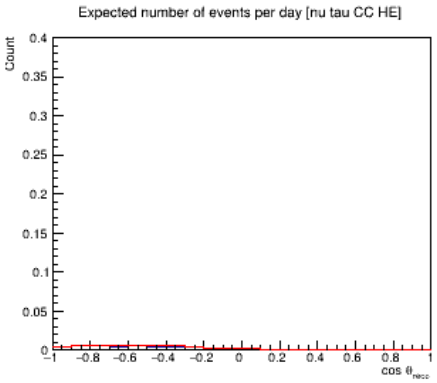

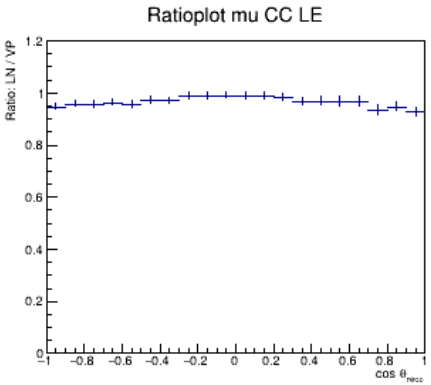

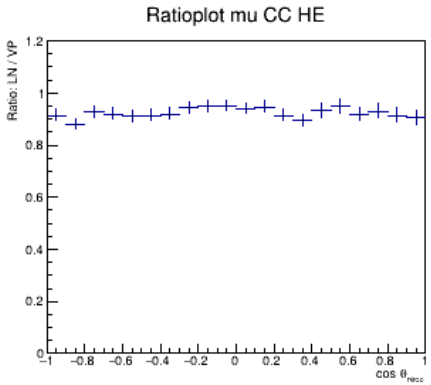

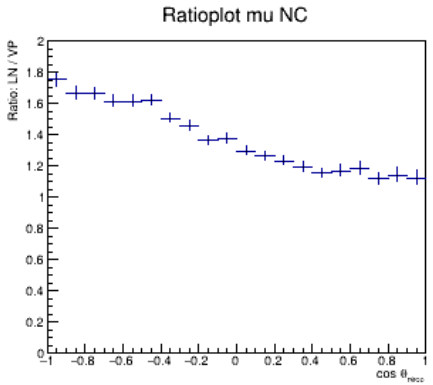

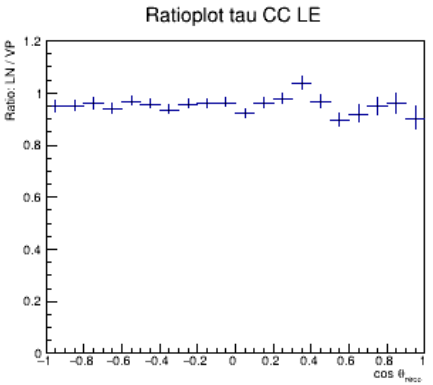

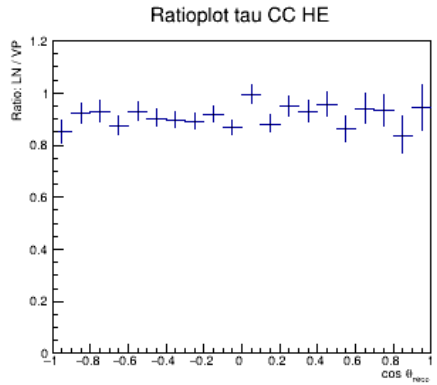

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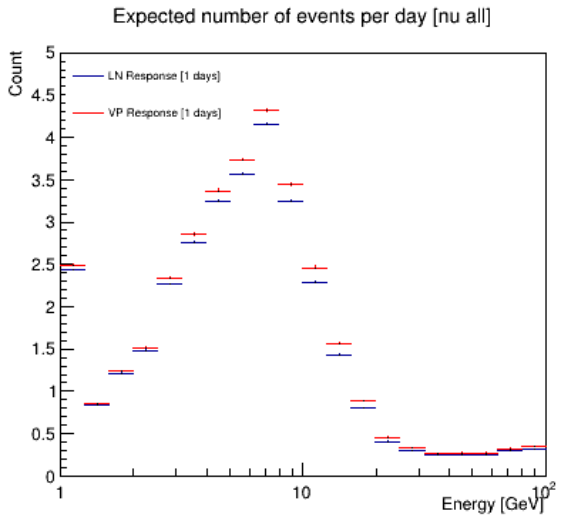
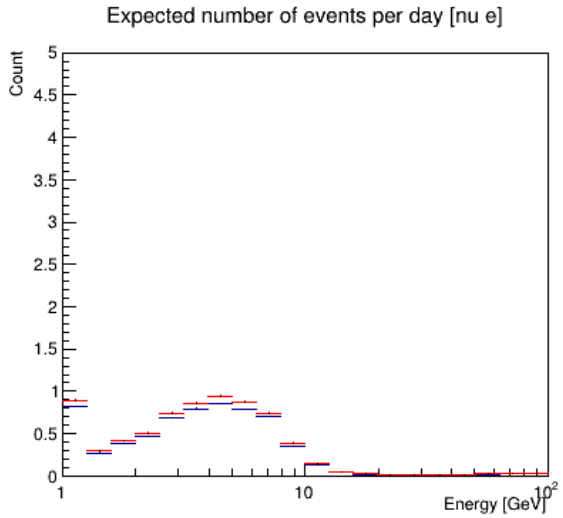
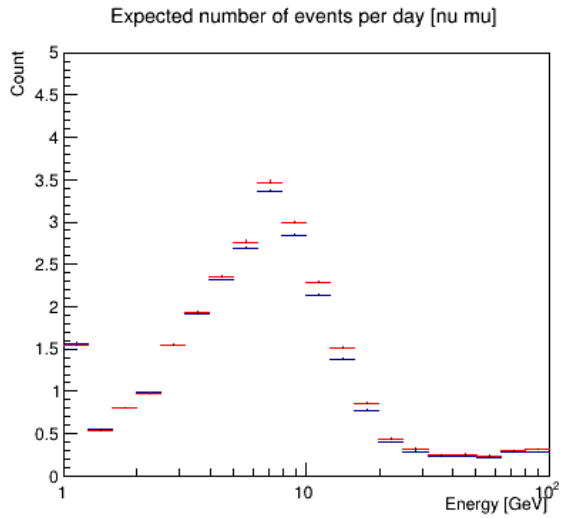
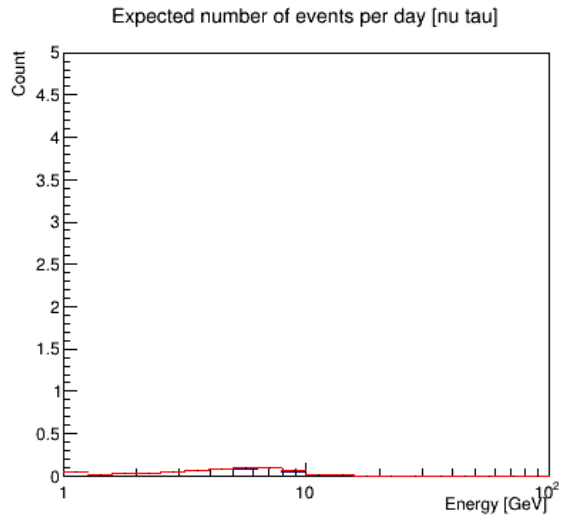
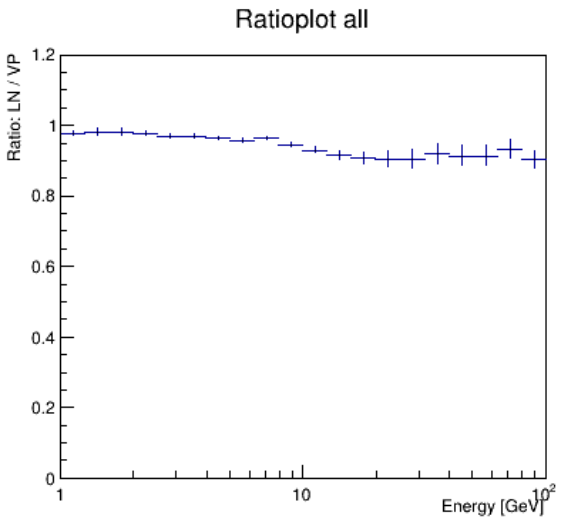
EvtResp, AANET FLUX, RespRange [1,1000]GeV
E, NO, 1 days runtime

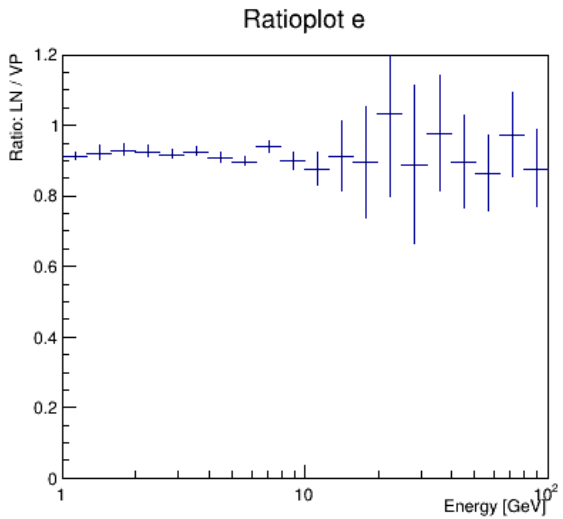


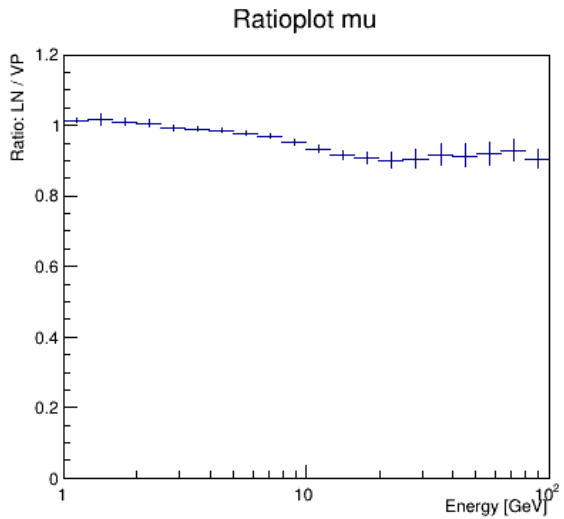


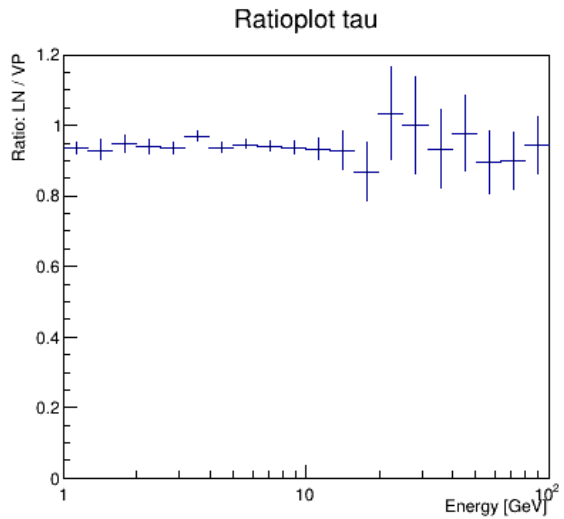












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