ORCA4/6 analysis meeting

2020-10-16

Outlook

- Identified cuts that were missing / wrong -> same events as Valentin/Jannik

- Made acceptance plots, cut distributions, observable distributions (many 100s of plots)
https://www.nikhef.nl/~ljnauta/acceptance_document.pdf
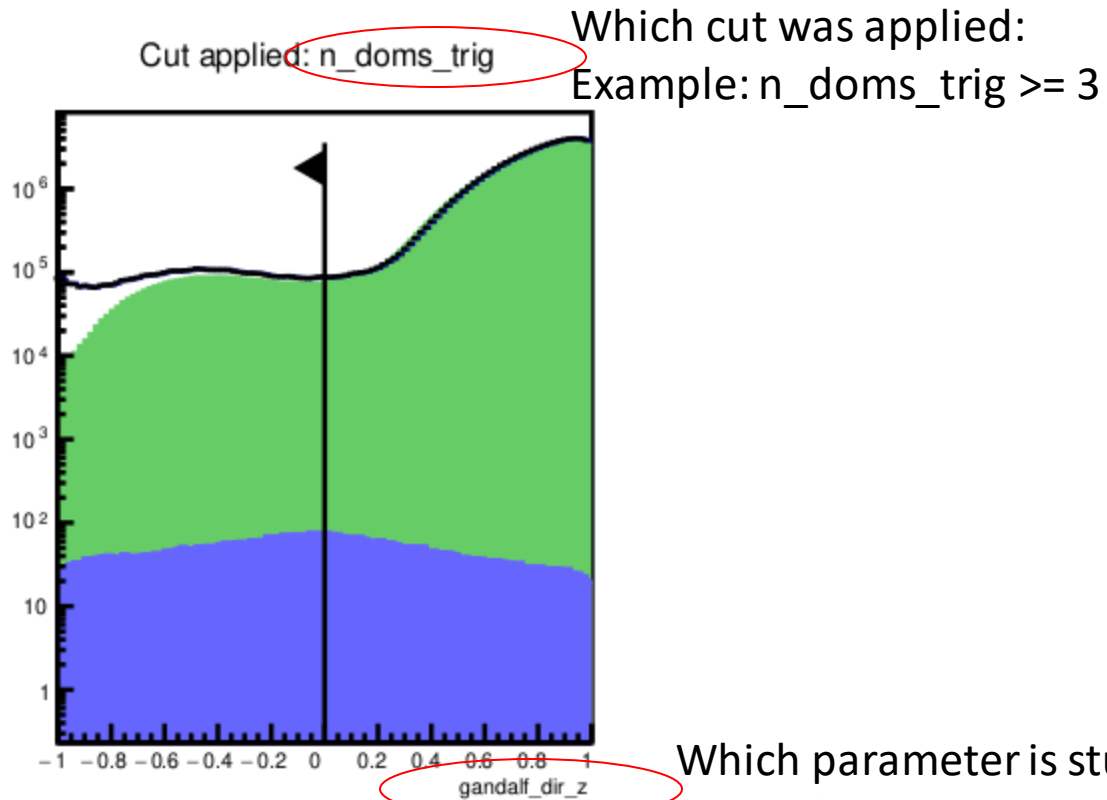https://www.nikhef.nl/~ljnauta/cut_distributions.pdf
https://www.nikhef.nl/~ljnauta/observables.pdf

Explanation of stacked histograms

Every slide shows the impact of 1 cut on all 15 other cut distributions in terms of passed nu/mu

Cut applied: n_doms_trig

Which cut was applied:
Example: n_doms_trig >= 3

- Data

Muons (weighted)

Neutrinos (weighted)

Which parameter is studied:
gandalf_dir_z is reconstructed angle

Arrow: what the cut on gandalf_dir_z
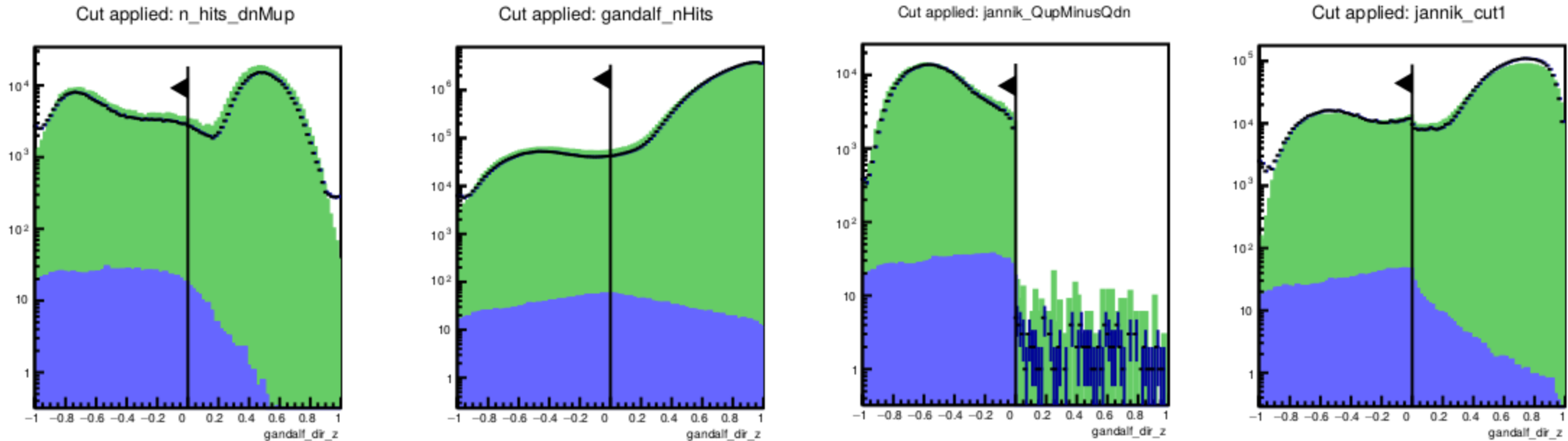would do to the distribution.
Arrow: part to keep

Rejected | Accepted

Cuts

- There are 15 cuts (see backup for definitions)
- Which cuts are important?
  - BG suppression
  - Physics
  - Remove bad events (for example huge events that have time>255ns, etc)
- Which cuts are not important?
  - Remove no muons
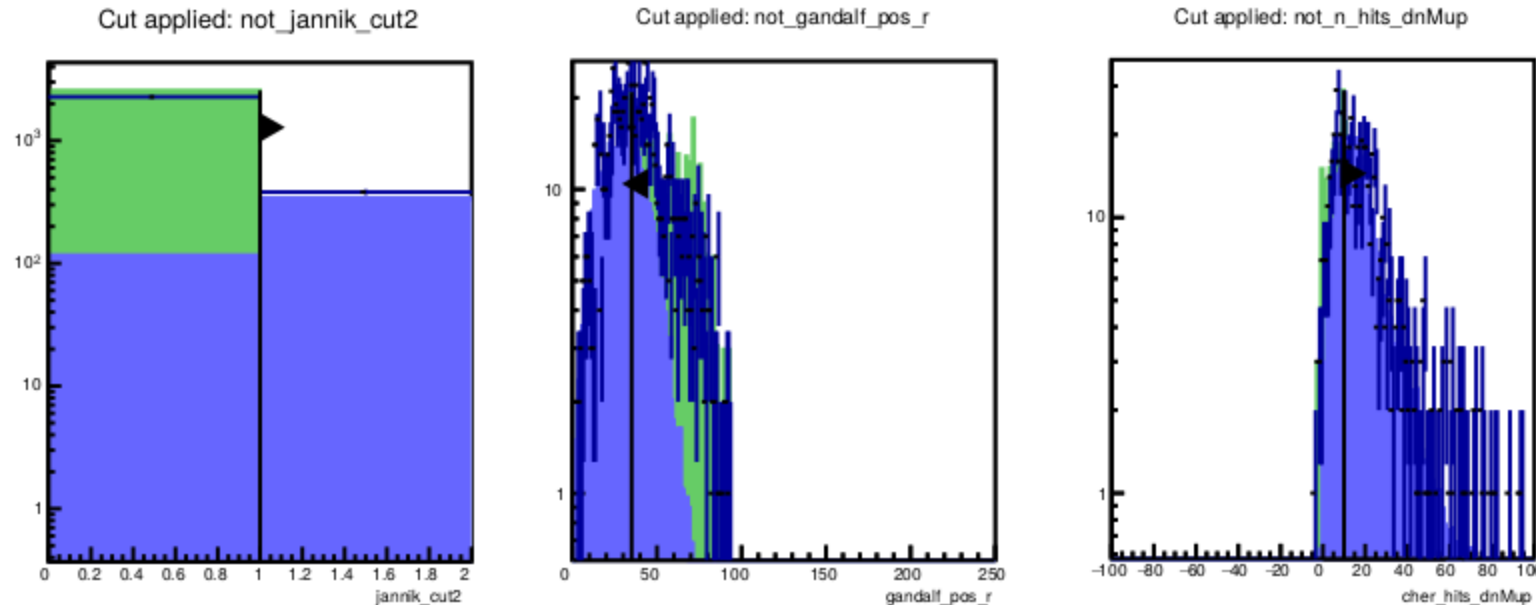 - Have similar effect as other cuts

Find which cuts remove noise BG

- By studying what happens at the tail @ CT = -1, identify cuts that remove BG.
- 4 Cuts important when suppressing noise: n_hits_dnMup, nHits, QupMinusQdn, 'cut1'

Which cuts are important for muon removal?
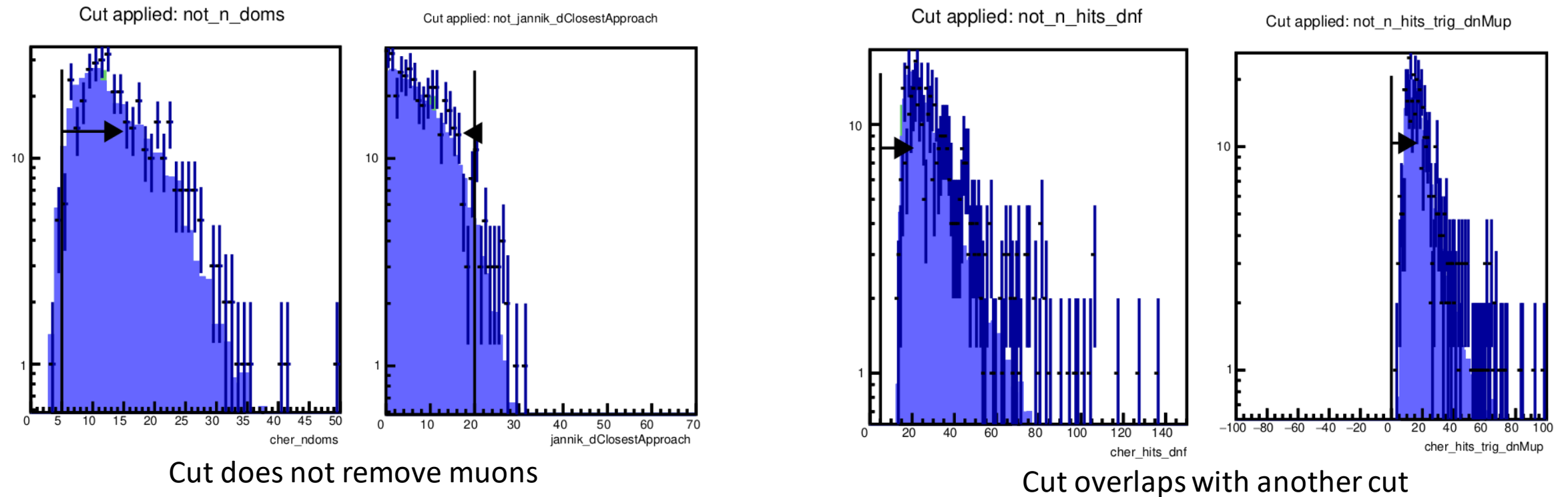
- Do muons appear when removing this cut?

The binning is not optimal
Plots show the parameter itself
and where the muons are in the
phase-space when cutting.

- 'Cut2', pos_r, n_hits_dnMup
  are important when it comes to removing last muons

Which cuts are not important?

- Removing this cut does not affect the passing of muons (much)

Cut applied: not_n_doms

Cut applied: not_jannik_dClosestApproach

Cut applied: not_n_hits_dnf

Cut applied: not_n_hits_trig_dnMup

cher_ndoms

jannik_dClosestApproach

cher_hits_dnf

cher_hits_trig_dnMup

Cut does not remove muons

Cut overlaps with another cut

- n_doms, n_doms_trig, n_hits_dnf, n_hits_trig_dnMup, dClosestApproach are not important: 4 of these 5 are "cherenkov conditions"

Conclusion on cuts

- Based on shown plots (and more in the documents)
- Important for BG removal:
  n_hits_dnMup, nHits, QupMinusQdn, cut1
- Important for muon acceptance:
  Cut2, pos_r, n_hits_dnMup
- Important for physical reasons:
  dir_z, maxToT
- Not imporant, these do not add muons when removed:
  n_doms, n_doms_trig, n_hits_dnf, n_hits_trig_dnMup, dClosestApproach
- Not clear:
  earlyTrigHits

S/B under different cut combinations

- 15 cuts (all)
  S/B according to MC is: 244.43/2.78108 = 87
- 10 cuts, gone: n_doms, n_doms_trig, n_hits_dnf, n_hits_trig_dnMup, jannik_dClosestApproach
  S/B according to MC is: 263.442/2.78108 = 97.4
- 9 cuts, gone: maxToT
  S/B according to MC is: 263.442/2.78108 = 97.4
- 8 cuts, gone: earlyTrigHits
  S/B according to MC is: 264.425/8.34325 = 31.65

- The last 2 cuts may affect the data, but not MC: usage may be adivesed

Correlation matrix for cut parameters

Correlation matrix of "cut parameters" shows that the parameters identified as not good are strongly correlated with one-another and other parameters that do cut muons

|	chercond_n_doms	chercond_n_doms_trig	chercond_n_hits_dnf	chercond_n_hits_dnMup	chercond_n_hits_trig_dnMup	maxToT_trig	gandalf_dir_z	gandalf_pos_r	gandalf_nHits	jannik_earlyTrigHits	jannik_QupOvernHits	jannik_QupMinusQdn	jannik_dClosestApproach	jannik_cut1	jannik_cut2
chercond_n_doms	1	0.936581	0.712037	-0.751024	-0.7434	0.524421	-0.330573	0.00131729	0.8318	0.293447	-0.251463	-0.82124	-0.0021203	-0.0829687	0.267134
chercond_n_doms_trig	0.936581	1	0.772083	-0.734839	-0.770563	0.569715	-0.231832	0.00163311	0.874676	0.345221	-0.180774	-0.825515	-0.00250684	-0.00560926	0.210993
chercond_n_hits_dnf	0.712037	0.772083	1	-0.380392	-0.428186	0.685616	-0.00954852	0.00393487	0.870904	0.417818	-0.0191521	-0.695822	-0.00235629	0.267286	0.0585555
chercond_n_hits_dnMup	-0.751024	-0.734839	-0.380392	1	0.978458	-0.439455	0.421913	0.00402228	-0.714524	-0.226723	0.32106	0.778559	0.00173343	0.286977	-0.318667
chercond_n_hits_trig_dnMup	-0.7434	-0.770563	-0.428186	0.978458	1	-0.45973	0.36803	0.00327759	-0.742129	-0.251592	0.274679	0.783636	0.00185982	0.238478	-0.267457
maxToT_trig	0.524421	0.569715	0.685616	-0.439455	-0.45973	1	-0.0877972	0.000462559	0.664607	0.281477	-0.0788338	-0.607641	-0.00203484	0.111259	0.0988631
gandalf_dir_z	-0.330573	-0.231832	-0.00954852	0.421913	0.36803	-0.0877972	1	0.00507502	-0.19389	0.0132311	0.456669	0.350267	0.000508831	0.40546	-0.343224
gandalf_pos_r	0.00131729	0.00163311	0.00393487	0.00402228	0.00327759	0.000462559	0.00507502	1	0.0015499	0.00193567	0.222499	0.00162394	0.999801	0.3143	-0.00389575
gandalf_nHits	0.8318	0.874676	0.870904	-0.714524	-0.742129	0.664607	-0.19389	0.0015499	1	0.499605	-0.160168	-0.781595	-0.0019104	0.0673757	0.182406
jannik_earlyTrigHits	0.293447	0.345221	0.417818	-0.226723	-0.251592	0.281477	0.0132311	0.00193567	0.499605	1	-0.0164967	-0.165763	0.000417193	0.13582	0.0476656
jannik_QupOvernHits	-0.251463	-0.180774	-0.0191521	0.32106	0.274679	-0.0788338	0.456669	0.222499	-0.160168	-0.0164967	1	0.362055	0.0390809	0.765078	-0.442049
jannik_QupMinusQdn	-0.82124	-0.825515	-0.695822	0.778559	0.783636	-0.607641	0.350267	0.00162394	-0.781595	-0.165763	0.362055	1	0.00315504	0.313932	-0.306356
jannik_dClosestApproach	-0.0021203	-0.00250684	-0.00235629	0.00173343	0.00185982	-0.00203484	0.000508831	0.999801	-0.0019104	0.000417193	0.0390809	0.00315504	1	0.0382146	-0.000108378
jannik_cut1	-0.0829687	-0.00560926	0.267286	0.286977	0.238478	0.111259	0.40546	0.3143	0.0673757	0.13582	0.765078	0.313932	0.0382146	1	-0.395961
jannik_cut2	0.267134	0.210993	0.0585555	-0.318667	-0.267457	0.0988631	-0.343224	-0.00389575	0.182406	0.0476656	-0.442049	-0.306356	-0.000108378	-0.395961	1

Comparison of all 15 cuts and 10 cuts
(removed dnf, trig_dnMup, doms_trig, closestA, n_doms)

All 15 cuts
S/B according to MC is: 244.43/2.78108 = 87

"only" 10 cuts
S/B according to MC is: 263.442/2.78108 = 97.4
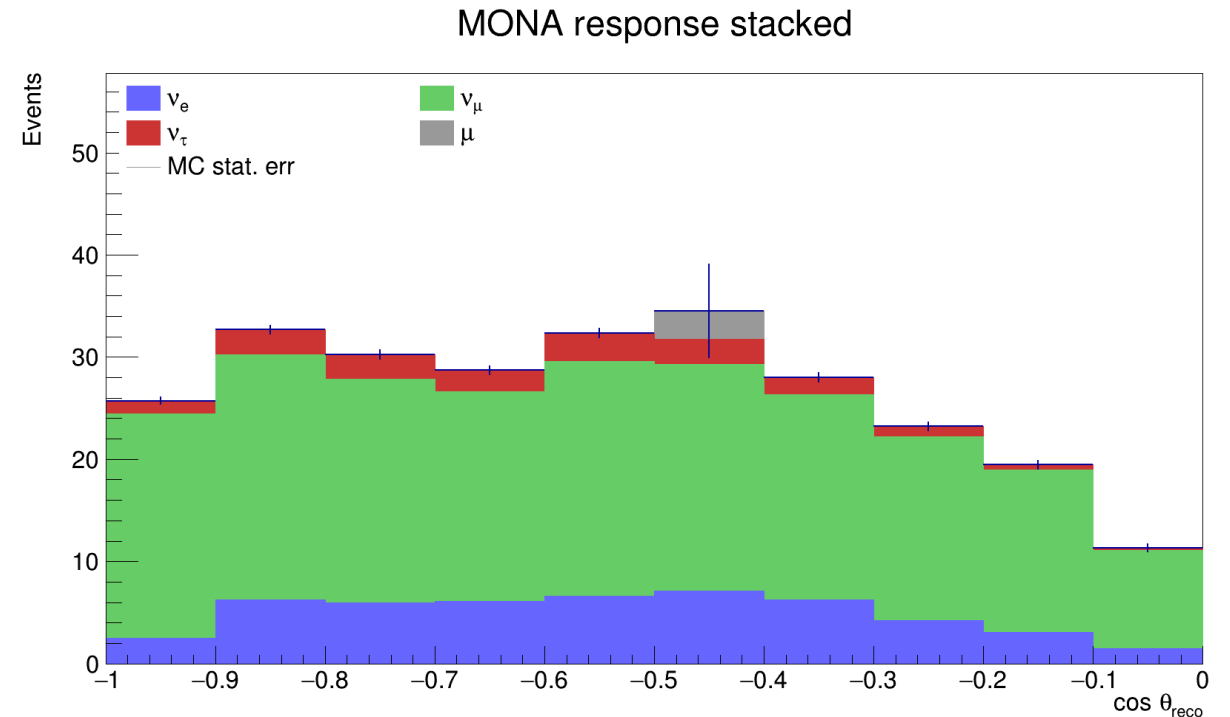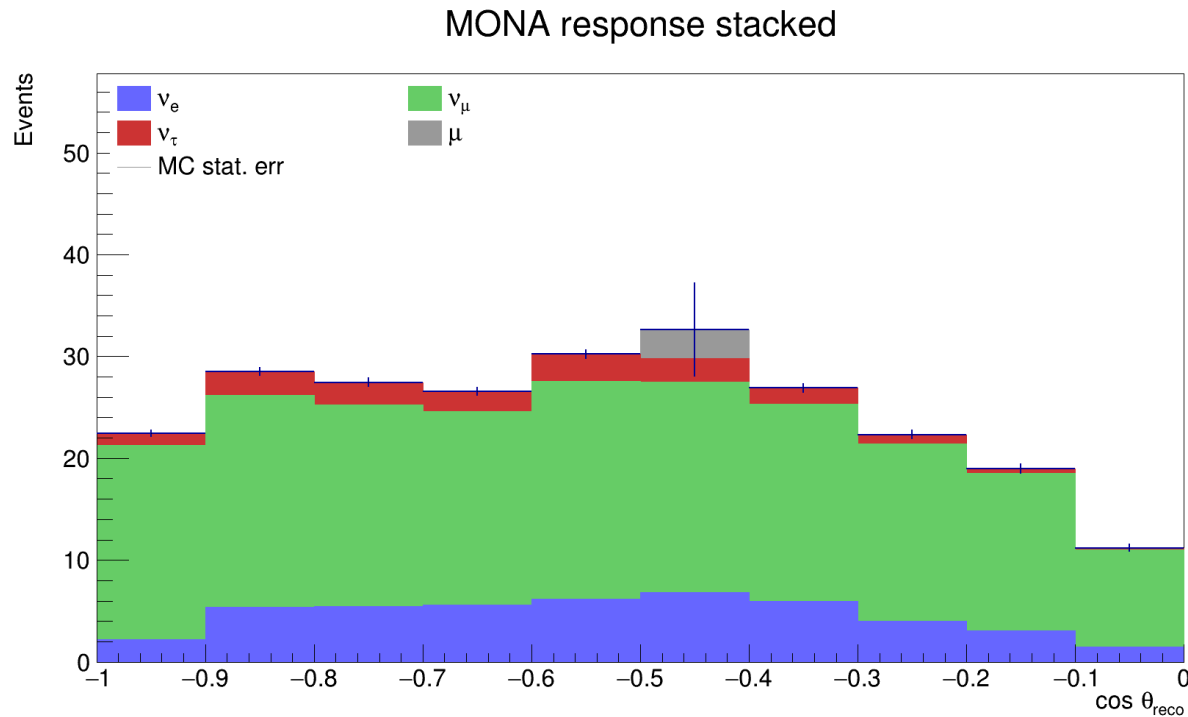
Miscellaneous

- Updated error propagation in MONA to sumw2.
  question: where does the sumw2 method come from? Cannot find.

- Moved all ORCA6 files to /dcache:
  ~1000 runs reconstructed, 300 muon runs, no neutrino files at all

- Tested JOscProb (for unbinned fits), it works but not tested if it converges to proper values.

- Sent Detector/calib chapter to Daan

Next steps

- Cuts... not sure if more needs to be done
  - Optimize cuts, come up with different cuts?
  - Need to inspect observable distributions
- Is a constant (small) muon background preferable over no muons?
  - This needs more muon statistics
- Started looking into systematics
  - LoI values, definitions from papers/theses
  - Implementation in MONA
- ORCA6 far from ready for oscillation analysis

Cut definitions

- Containment cuts:
gandalf_pos_r < 35
Vertex position from mean DU position is < 35m
Interpretation: the mean DU position is the center of the detector. 35m from the center.

- Physics cuts:
gandalf_dir_z < 0
Events are reconstructed as upward going
1 < gandalf_energy < 100
Reconstructed energy in range 1-100 GeV

- Cherenkov conditions (CC) are defined as:
Hit time <= 15ns from expected hit time
Hit distance closest approach < 100m

  chercond_n_doms >= 5
Number of DOMs in CC >= 5
chercond_n_doms_trig >= 3
Number of triggered DOMs in CC >= 3
chercond_n_hits_dnf >= 5
Number of hits on downward facing PMTs on all?? DOMs in CC
chercond_n_hits_dnMup >= 10
Number of hits on downward facing PMT – upward facing PMT on all?? DOMs in CC
chercond_n_hits_trig_dnMup >= 0
Number of triggered hits on downward facing PMT – upward facing PMT on DOMs in CC

- Reconstruction & BG suppression cuts:
maxToT < 240
Largest ToT in set of hits that caused a trigger is < 240

  L_up/nHits > 2
Quality of best upgoing / number of hits used in reconstruction > 2

  L_up / L_down > 40
Quality of best up / quality of best downgoing reconstruction > 40

  d_closest < 20
Distance of closest hit to reco track is < 20m

  "cut1": L_up * (1./nHits + 0.045) > 5
Adjusted reco quality cut...

  "cut2": (((meanZhitTrig - lowest_dom_z) > 25) || ((gandalf_pos_r < 20.) && (meanZhitTrig - lowest_dom_z > 15.))) > 1
Mean z position of triggered hits is 25m higher than lowest hit DOM OR distance from mean DU position is < 20m AND mean z position of triggered hits is 15m higher than lowest hit DOM
Interpretation of cut2: event is somewhere in the middle of the detector, not too low, not too far from center