burn sample vs mc check

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To evaluate the muon energy threshold for self-veto effect in cascade analysis, we compared pass2 MC (muon gun + nugen) and pass2 11 year burn sample data ($E_{reco} > 10$TeV). Due to low statistics of down-going cascades in the data, we used 3 cos(zenith) bins (as in published 6yrs cascade analysis): [-1, 0.2, 0.6, 1] to evaluate the best matching muon threshold value of 1 TeV. In addition we show comparisons between data and MC in fine energy and cos(zenith) bins for different values of muon energy thresholds.

CONTENTS

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I. INTRODUCTION

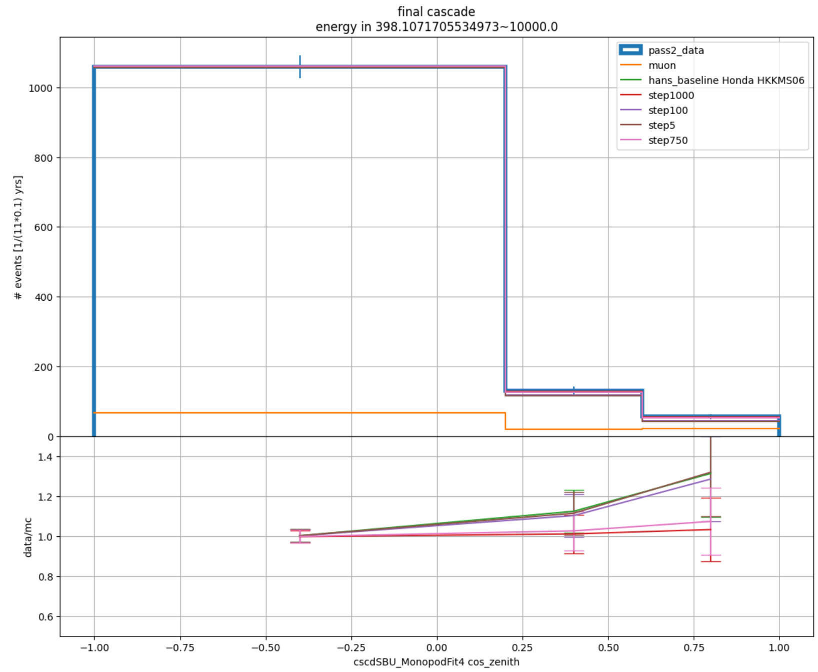

FIG. 1: The cos(zenith) distribution of all low energy events from cascade sample. Blue line show low energy events from 11 year burn sample. Green line are MC events weighted with pass1 baseline conventional neutrino flux (Honda HKKMS06) and old self veto passing rate. To compare with green line, other lines are weighted with same conventional neutrino flux and the only change among them is self veto. They use new self veto software to calculate passing rate and the muon energy threshold is indicated by the label in unit of GeV. The red line (step1000) gives the best data/mc agreement (chi2 values (p-value) are 0.06(0.97) for 1000 GeV, 0.27(0.87) for 750 GeV, 3.03(0.22) for 100 GeV and 3.64(0.16) for 5 GeV), so we proposed to use 1000 GeV as muon energy threshold.

Pure neutrino simulated by nugen and neutrino with muon accompanying have different passing rate to cascade filter. Self veto is a software to correct the passing rate of nugen simulation. "Muon energy threshold" is a parameter that used by self veto to tune to match down going atmospheric neutrinos in Monte Carlo with data.

We proposed to use new self veto software to calculate the neutrino passing rate. See my wiki for detailed information of old and new self veto. According to figure 1, we proposed to use 1 TeV as the muon energy threshold, which is a parameter in new self veto. But the reviewer (Shigeru) concerned about the self veto and wanted to see more detailed study of self veto. Here we present the results of this study.

II. UNCERTAINTY FROM SELF VETO MUON ENERGY THRESHOLD

In this section, we show the effect of different self-veto muon energy thresholds on final cascade sample. We use Honda HKKMS06 as conventional atmospheric neutrino flux model and GaisserH4a as muon flux with a scaling factor of 1.4, which is previous fitting result. And the events are reconstructed by Monopod with spice 3.2.1 as icemodel.

A. cos zenith distribution

Figure 2 shows the cos(zenith) distribution of cascade sample in a finer binning. Down-going events are more sensitive to self-veto, which is understood. But since there is large statistical uncertainty for down-going events and limited angular resolution, we can not decide the proper muon energy threshold from this plot. So the best way to decide muon energy threshold is still using the original cos(zenith) bins as figure 1. We also split figure 2 into energy (figure 3)and vertex depth (figure 4) bin, but again there is very large uncertainty for down-going events and it is hard to tell the best self veto muon energy threshold value.

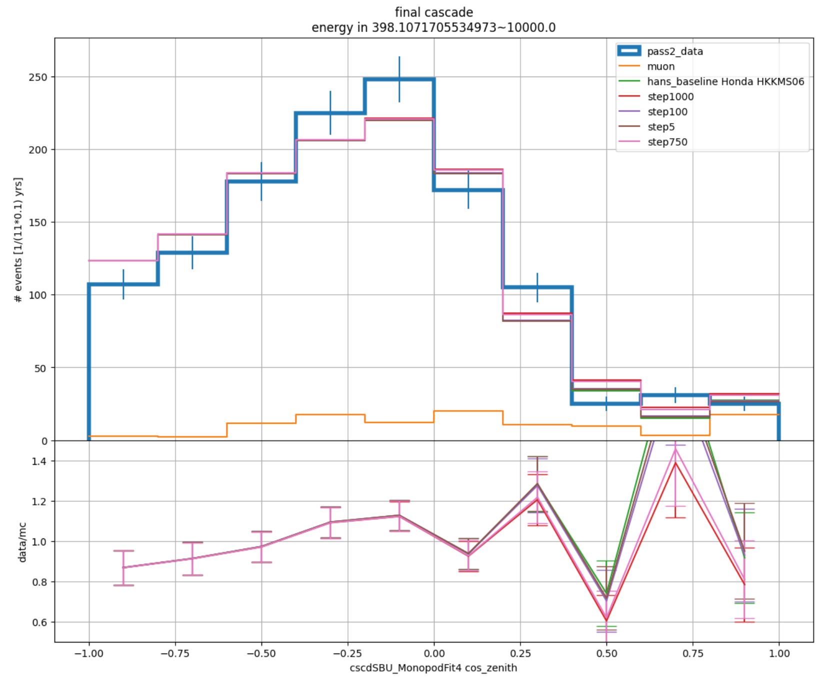

FIG. 2: Cos(zenith) distribution for all low energy (below 10 TeV) cascade sample. Statistical uncertainty is very large at self veto sensitive region.

We also split figure 1 into energy bins as shown in figure 5. Because we know there is no significant difference between events above and below dust layer from figure 4, we did not split figure 1 into vertex depth bins.

B. energy distribution

The energy distributions with different muon energy thresholds is presented in this section. Figure 6 shows the energy distribution of **all events** from cascade sample. Muon energy threshold has a larger effect at relatively high energy part. Because a lot of up-going events are contained in this plot, we split it into cos(zenith) bins to show the effect from self veto in figure 7. Self veto does not have visible effect for events from -1 to -0.2. For events from 0.2 to 0.6, 1 TeV muon energy works best. For event from 0.6 to 1, the statistic is too low to get any conclusion. Energy distribution is also split into depth bins. According to figure 8, events below and above dust layer show similar sensitivity to muon energy threshold of self-veto.

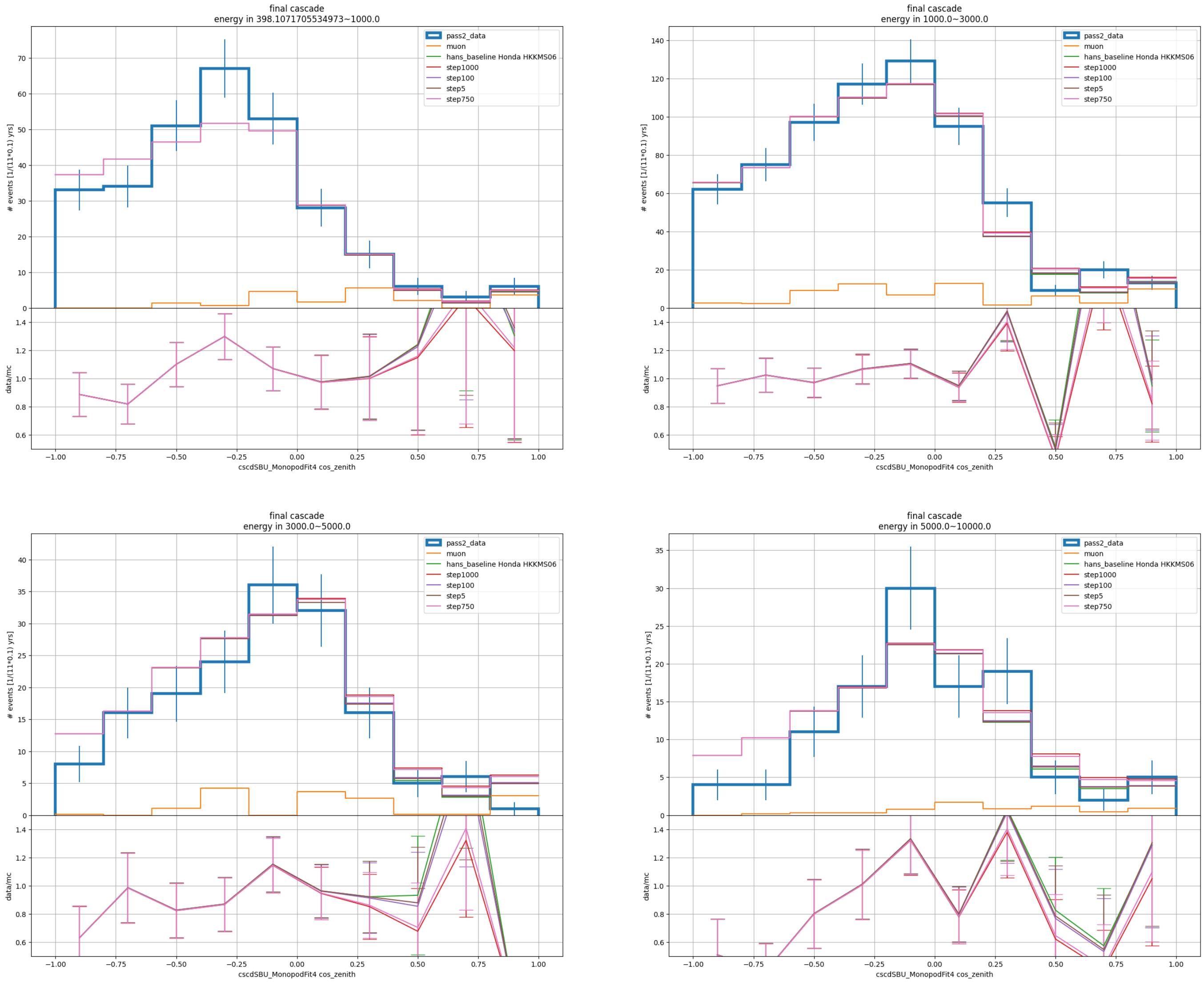

FIG. 3: Cos(zenith) distribution is split into different energy bins. The energy range is shown in the title of each subplot.

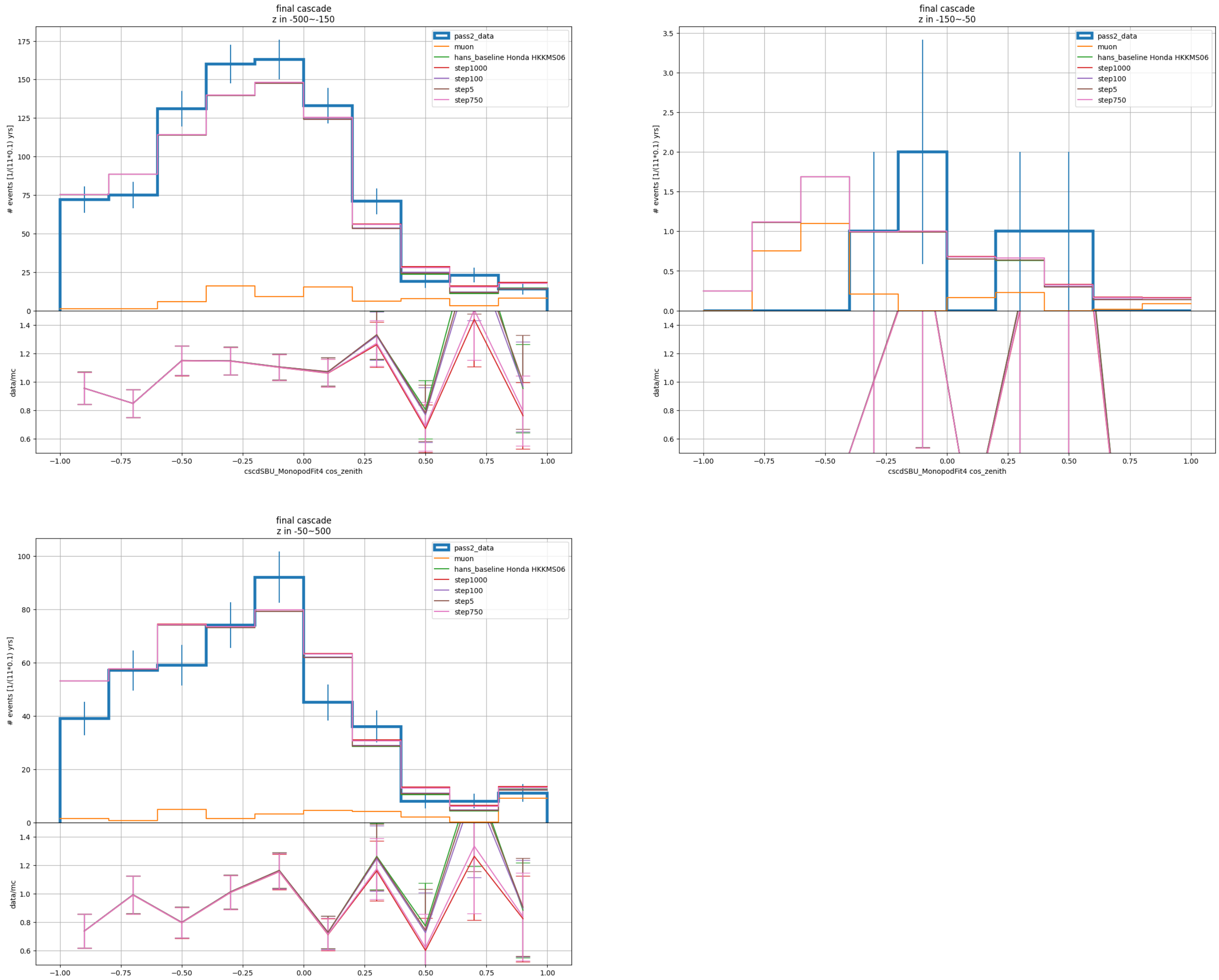

FIG. 4: Cos(zenith) distribution is split into different vertex depth bins. Because of statistics, I only split it into three parts: below, within and above dust layer. Events below dust layer has a slightly better data/mc agreement, but this is not significant.

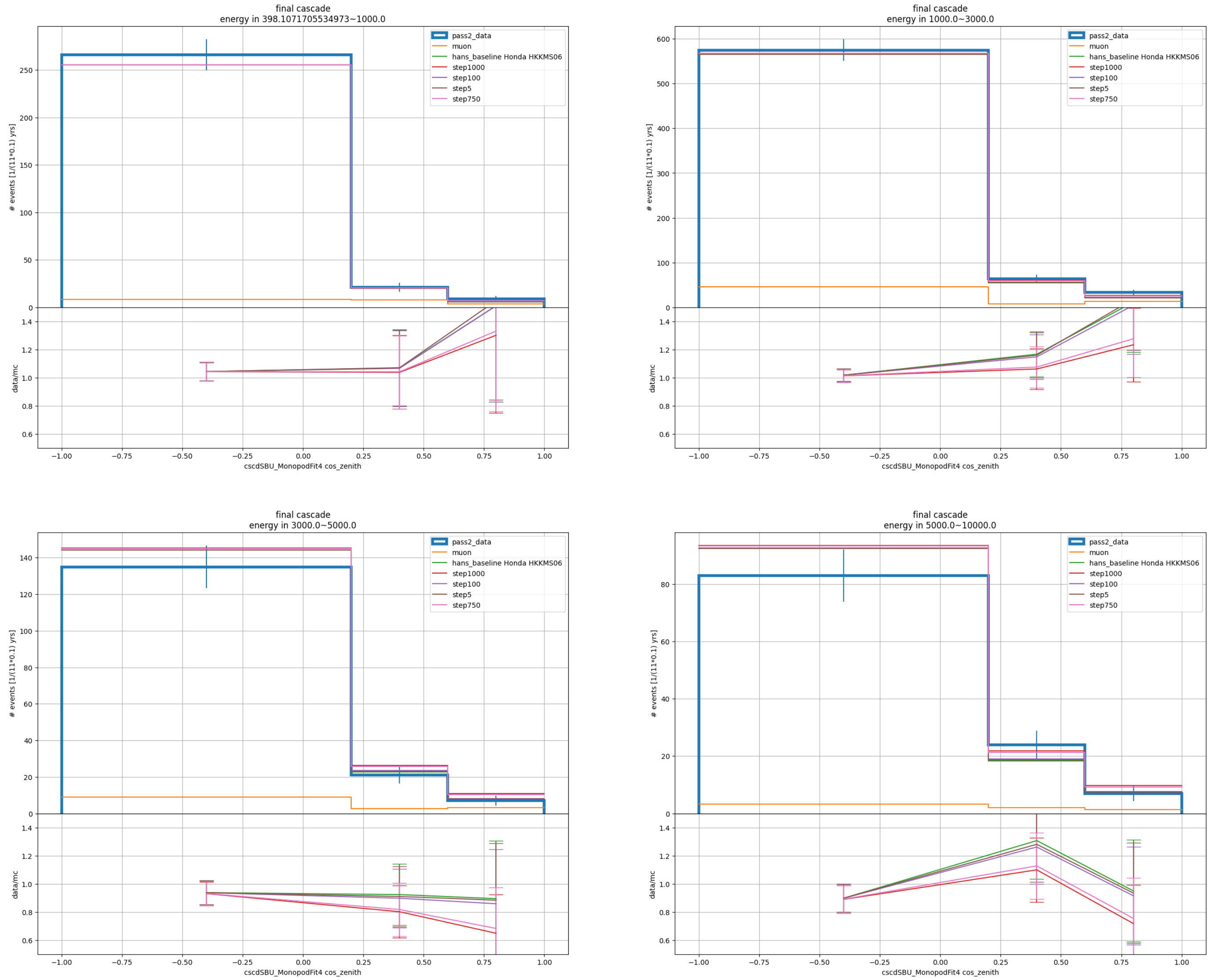

FIG. 5: Cos(zenith) distribution is split into different energy bins. 1 TeV muon energy threshold performs best.

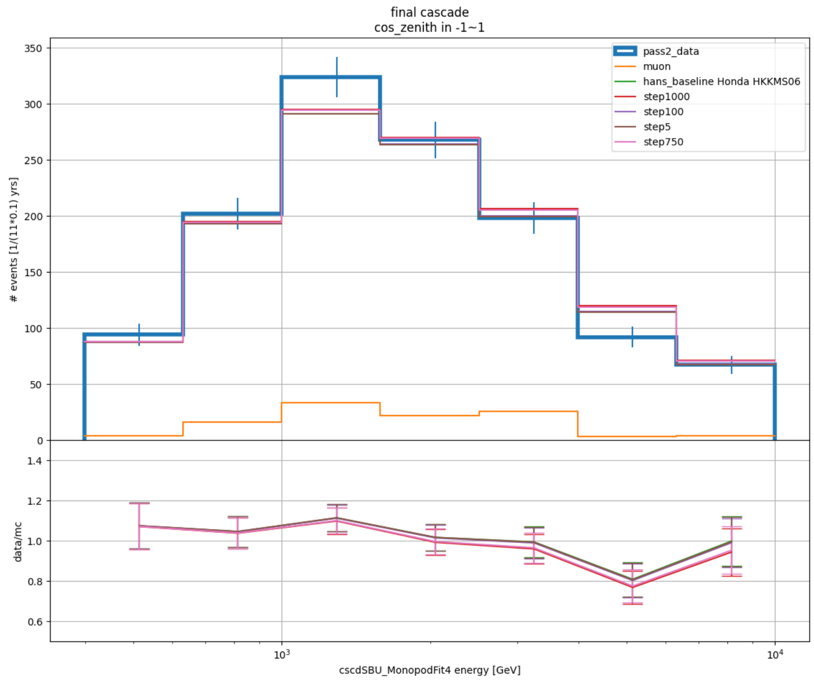

FIG. 6: The energy distribution of all events from cascade sample.

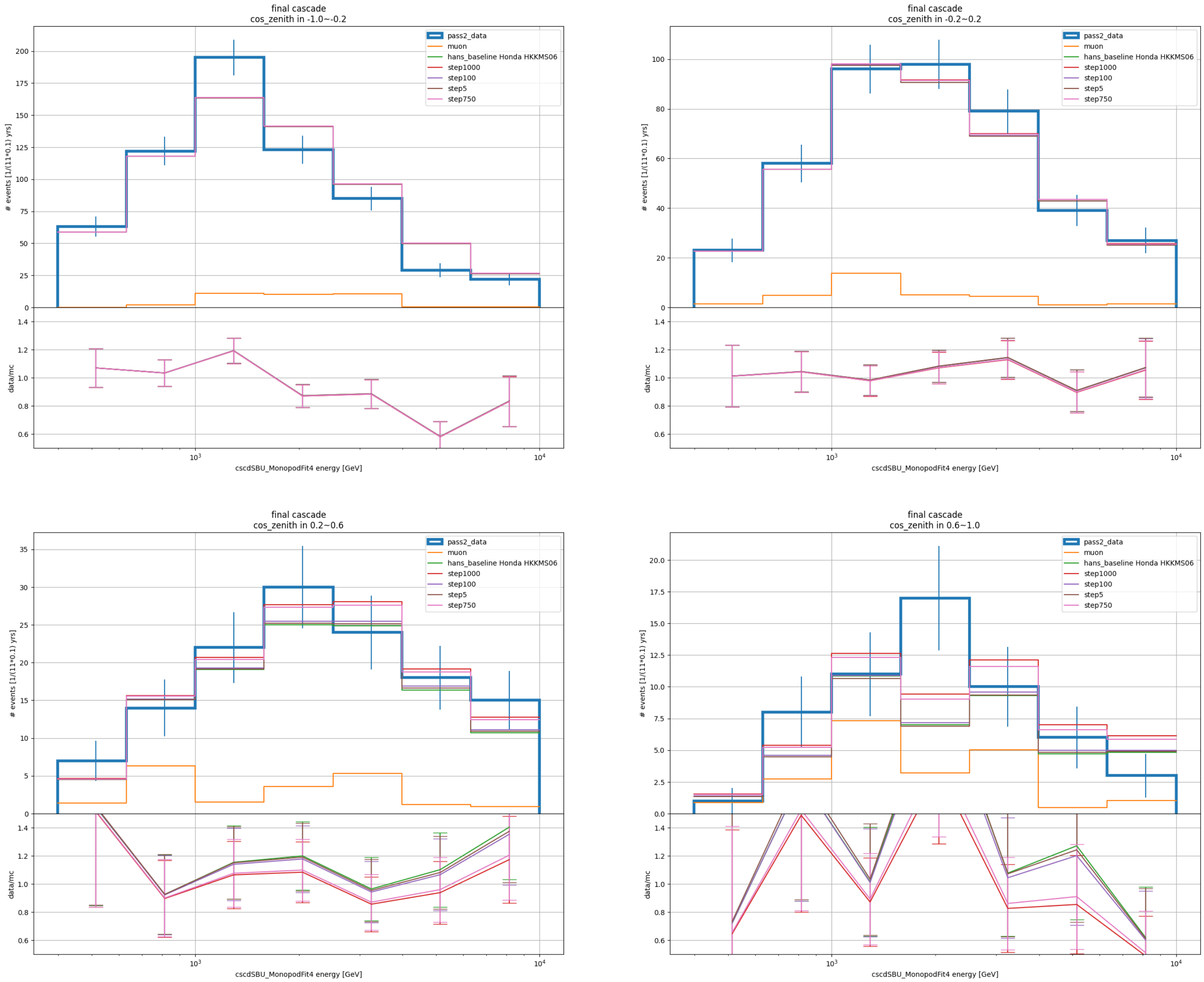

FIG. 7: The energy distribution is split into cos(zenith) bins. Events with cos(zenith) from 0.2 to 0.6 (lower left subplot) gives most of the information because the we still have enough statistic in this bin and it is sensitive to self veto. According to this plot, 1 TeV muon energy threshold gives the best data/mc agreement. (chi2 values(p-value) are 1.95(0.92) for 1000 GeV, 1.98(0.92) for 750 GeV, 2.83(0.83) for 100 Gev and 3.04(0.80) for 5 GeV.)

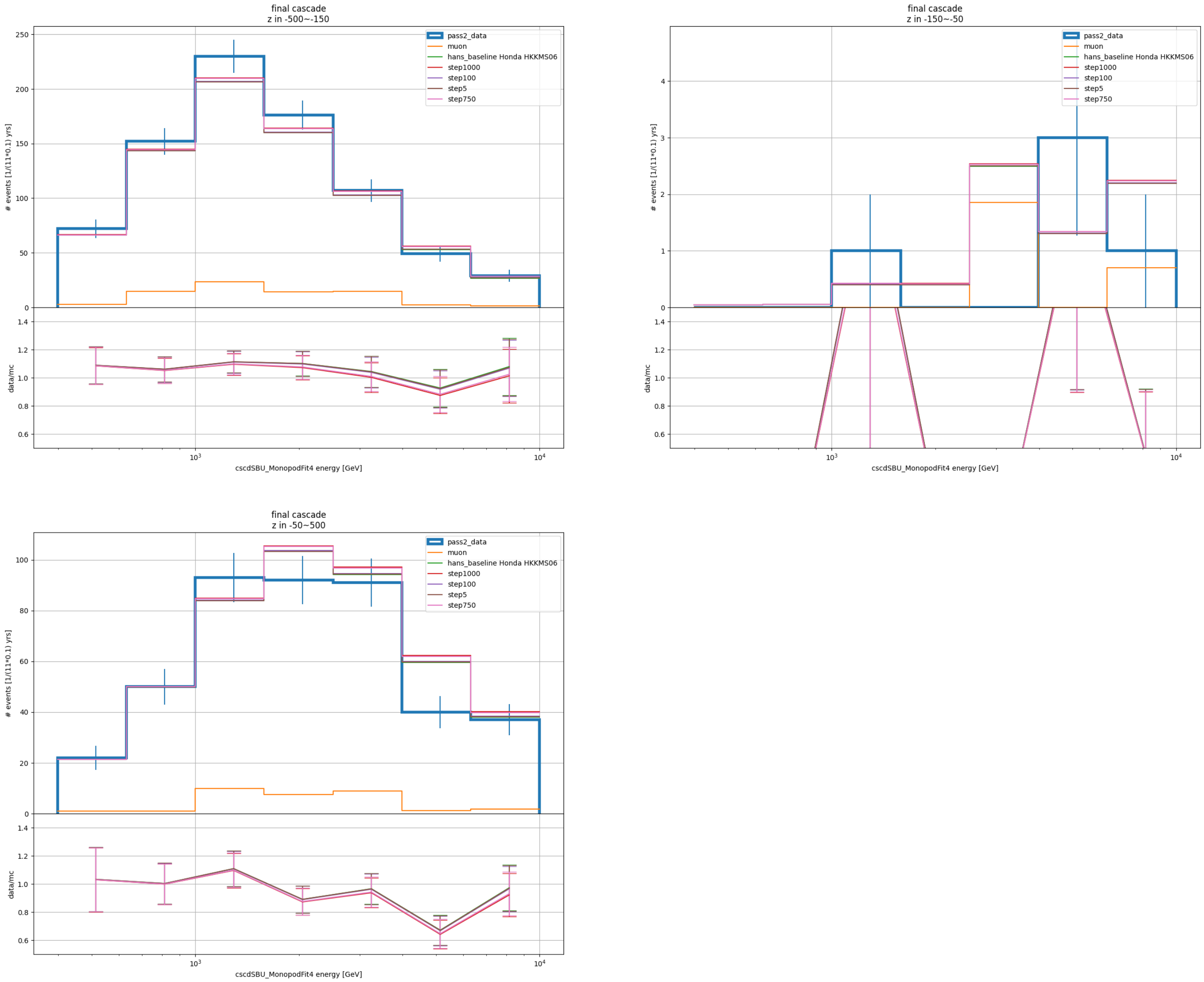

FIG. 8: The energy distribution is split into vertex depth. Events below dust layer has a slightly better data/mc agreement. But we can not decide muon energy threshold of self veto from these plots.

III. APPENDIX

For reference, the energy and cos(zenith) distributions of hybrid samples are attached in the appendix. These samples are not as sensitive to self veto as cascade sample and we did not see any indication of a potential problem with 1 TeV muon energy threshold.

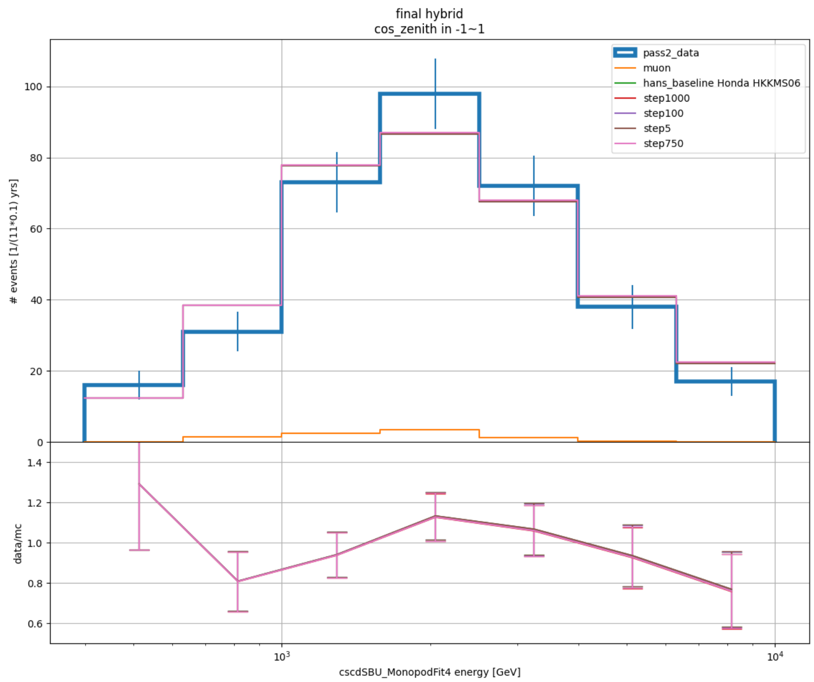

FIG. 9

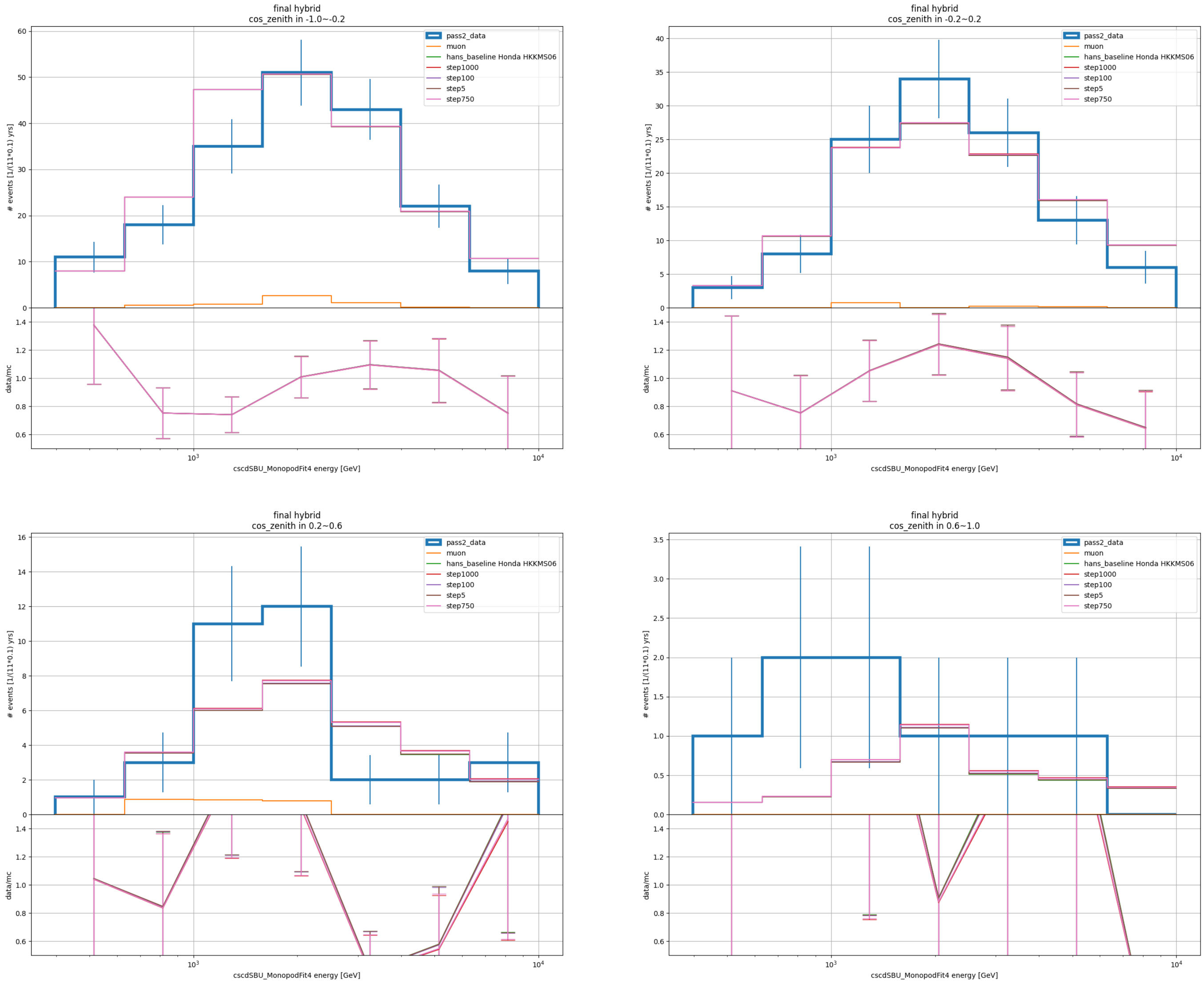

FIG. 10: The energy distribution in different cos(zenith) bins. Note that we loose statistics for down going events.

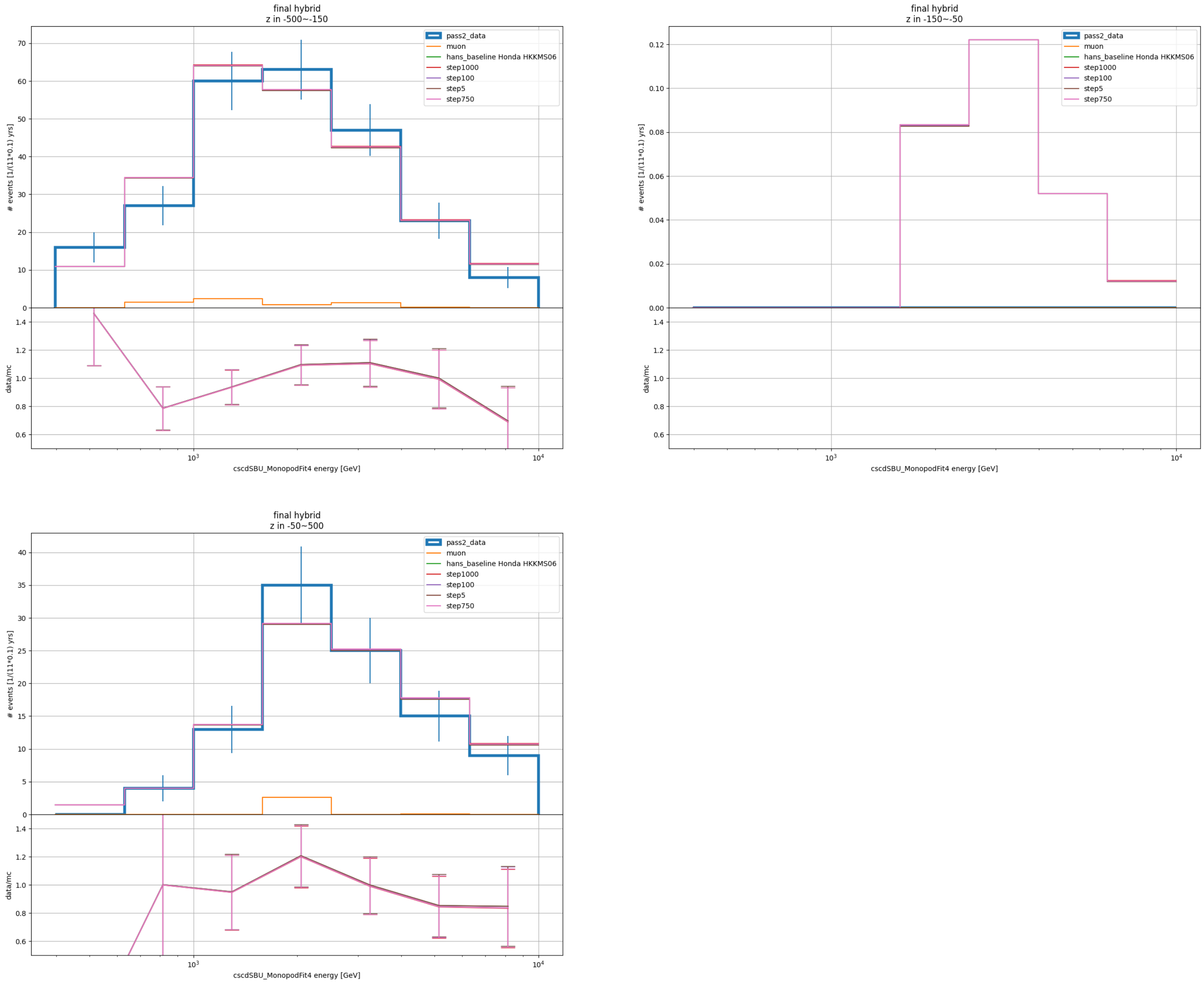
final hybrid
z in -500~-150
final hybrid
z in -150~-50
final hybrid
z in -50~500
pass2_data
muon
hans_baseline Honda HKKMS06
step1000
step100
step5
step750
events [1/(11*0.1) yrs]
data/mc
cscdSBU_MonopodFit4 energy [GeV]

FIG. 11

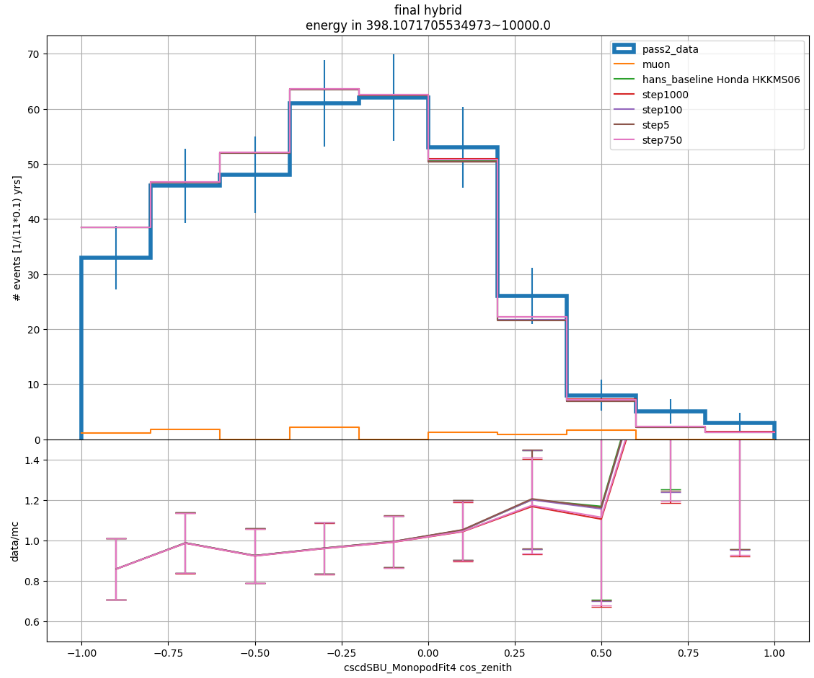
final hybrid
energy in 398.1071705534973~10000.0
pass2_data
muon
hans_baseline Honda HKKMS06
step1000
step100
step5
step750
events [1/(11*0.1) yrs]
data/mc
cscdSBU_MonopodFit4 cos_zenith

FIG. 12

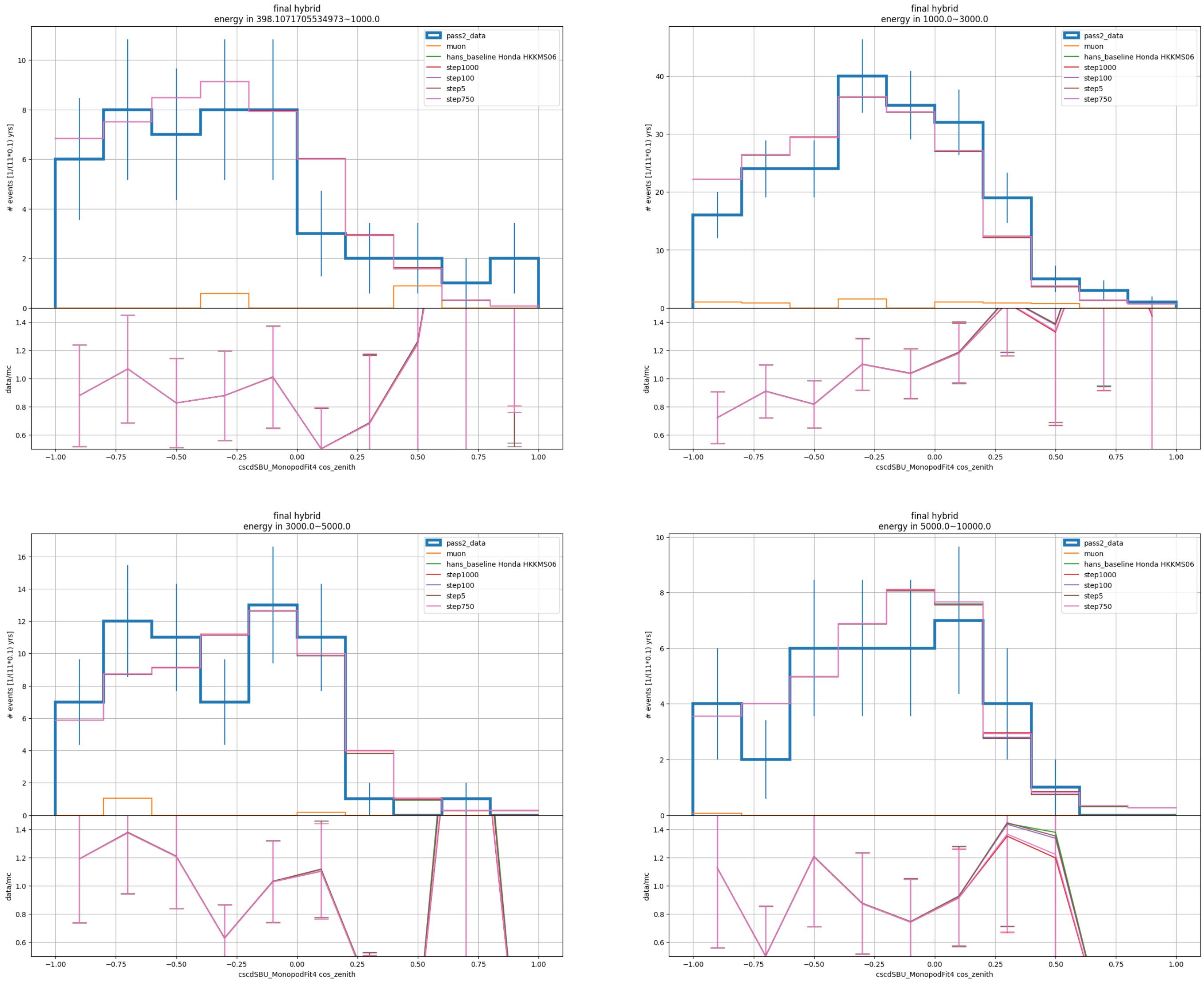
final hybrid
energy in 398.1071705534973~1000.0
final hybrid
energy in 1000.0~3000.0
final hybrid
energy in 3000.0~5000.0
final hybrid
energy in 5000.0~10000.0
pass2_data
muon
hans_baseline Honda HKKMS06
step1000
step100
step5
step750
events [1/(11*0.1) yrs]
data/mc
cscdSBU_MonopodFit4 cos_zenith

FIG. 13

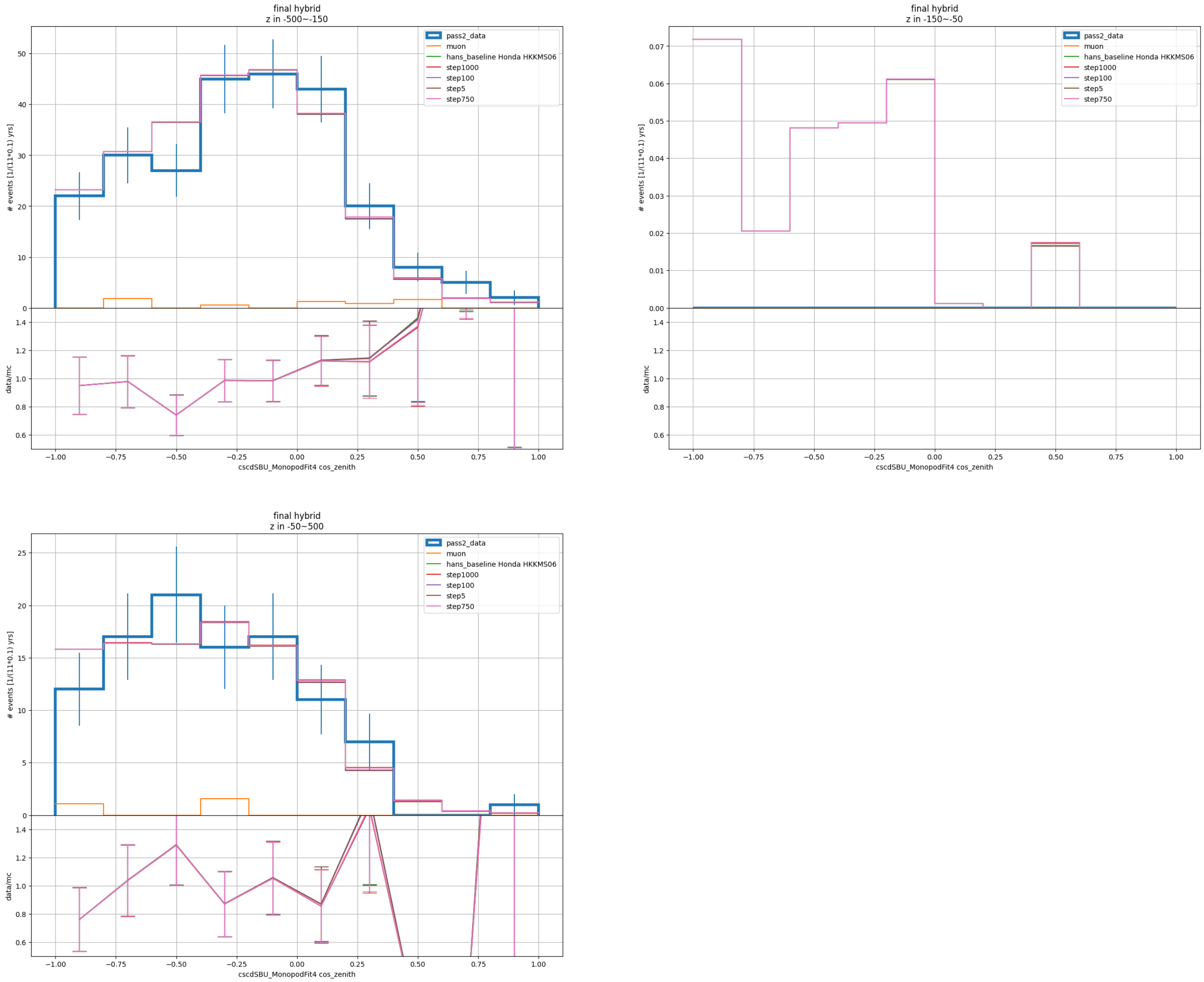
final hybrid
z in -500~-150
pass2_data
muon
hans_baseline Honda HKKMS06
step1000
step100
step5
step750
events [1/(11*0.1) yrs]
data/mc
cscdSBU_MonopodFit4 cos_zenith
final hybrid
z in -150~-50
pass2_data
muon
hans_baseline Honda HKKMS06
step1000
step100
step5
step750
events [1/(11*0.1) yrs]
data/mc
cscdSBU_MonopodFit4 cos_zenith
final hybrid
z in -50~500
pass2_data
muon
hans_baseline Honda HKKMS06
step1000
step100
step5
step750
events [1/(11*0.1) yrs]
data/mc
cscdSBU_MonopodFit4 cos_zenith

FIG. 14