



UNIVERSITY OF
TORONTO

ν_e CCQE/CC1 π^+ Selection Studies

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 ν_e CCQE/CC1 π^+ Meeting
June 26, 2019

Notes on Bug from Last Week

- Reminder: 1 problematic merged event in MC sample (out of 38934 merged MC sample events)
- **APfit error** when reaching this event
- **superscan error** when trying to view this event
- Likely due to the fact that this e event was extremely energetic (e-like momentum $> 20 \text{ GeV}/c$)
- Spent some time last week trying to fix this error
 - I was unsuccessful
- Decided to remove the problematic e-like event from elike-mc.list so it is not used in matching/merging steps
 - This e-like event was used in 8 matched events
- While trying to fix this, found a bug in my own code – accidentally used μ -like momentum of atmospheric e-like events instead of e-like momentum – FIXED

Summary of ν_e CC1 π^+ Hybrid Sample

Selected Atmospheric and T2K Events

Atmospheric e-like Events

- Atmospheric Data: /disk01/atmpd5/sk4_dst/sep16/fc_dst/ntuple_fQv5r0/apfit_run0??_fQv5r0.root
- Atmospheric MC: /disk01/atmpd5/sk4_dst/apr16/fc_mc/ntuple/mar16sk4.reduc.020?_fQv5r0.root
- Cuts:
 - $n_{hitac} < 16$ && $evis > 30$
 - $n_{ring} == 1$ && $ip[0] == 2$
 - $evis > 50$ *** will be removed
 - $n_{mue} == 0$
 - $agood > 0.6$
 - $pi0mass[0] < 100$ *** concerns from Mine-san that POLFIT has not been validated recently – check to see whether data/MC distributions agree
- **6905** selected e-like atmospheric data events
- **9313** selected e-like atmospheric MC events (then equalized to 6905)

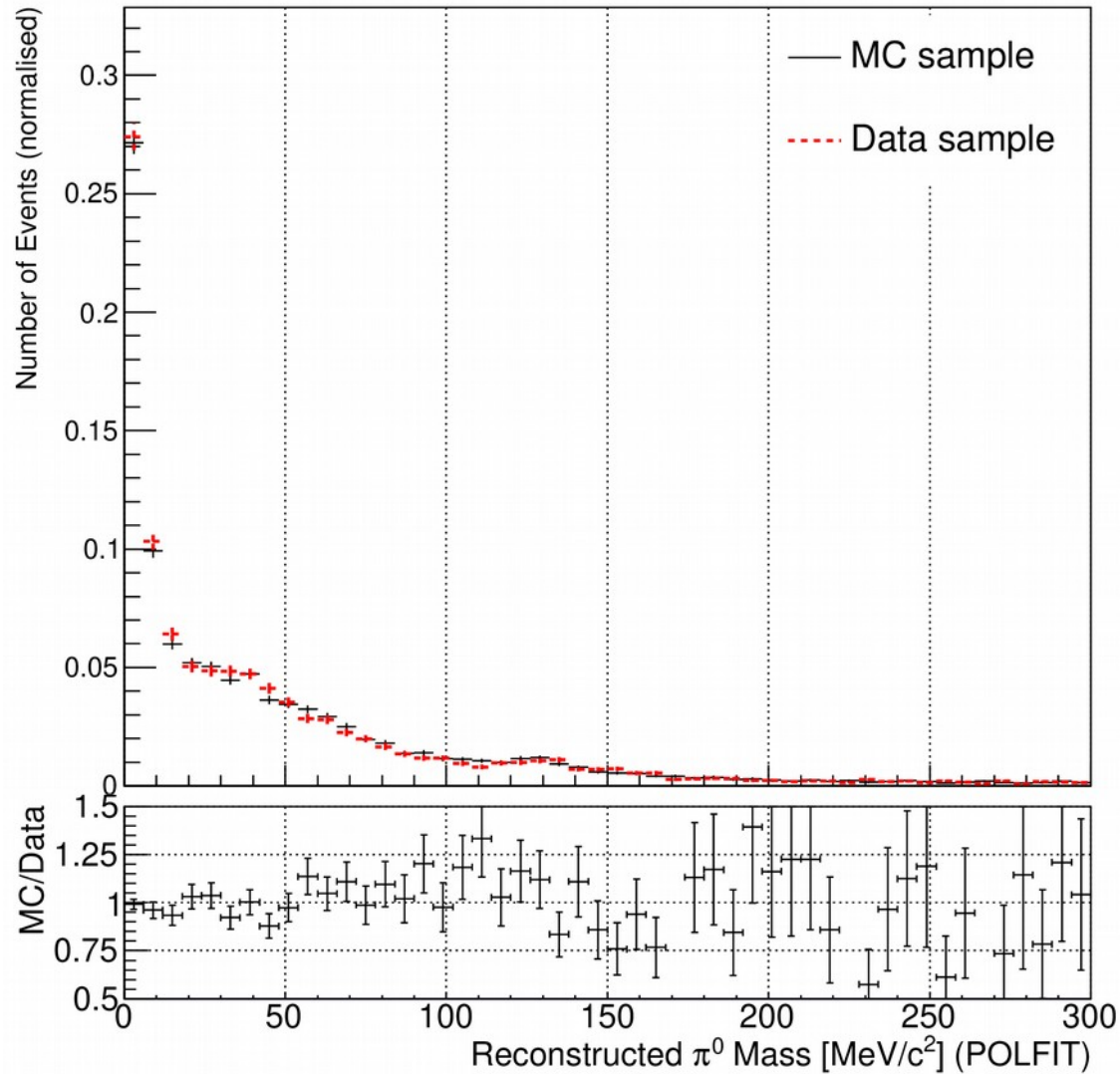
T2K MC $e\pi^+$ events

- T2K MC:
 - /disk01/sklb2/t2kmc/t2kmc_14c/t2k_14a_root/nu-mode/numu_x_nue/root
 - /disk01/sklb2/t2kmc/t2kmc_14c/t2k_14a_root/nu-mode/nue_x_nue/root
- **38934** selected $e\pi$ T2K MC events

POLFIT π^0 Mass Distributions

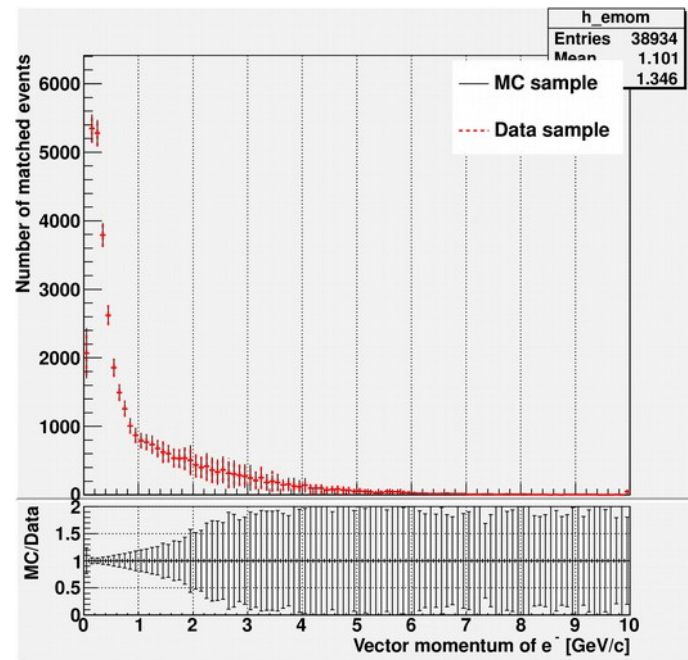
$$m_{\pi^0} < 100 \text{ MeV}/c^2$$

Atmospheric e-like Events (no π^0 cut)

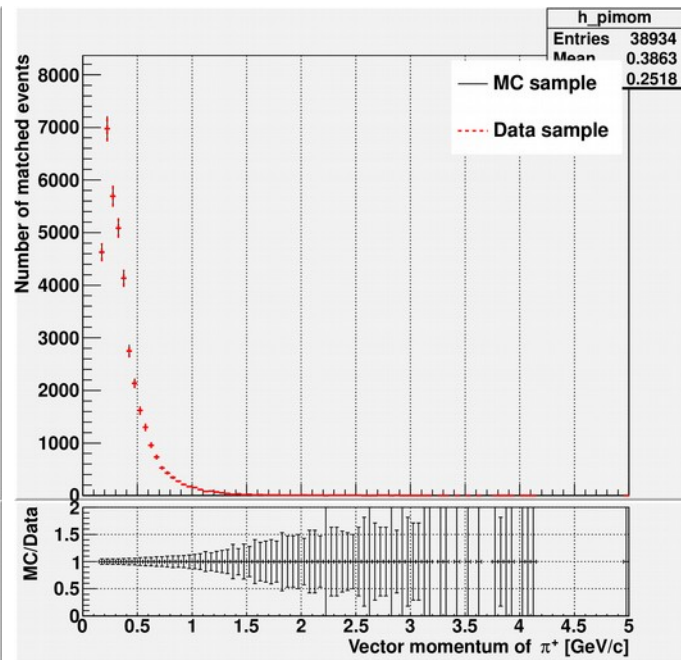


Kinematics of Matched Events

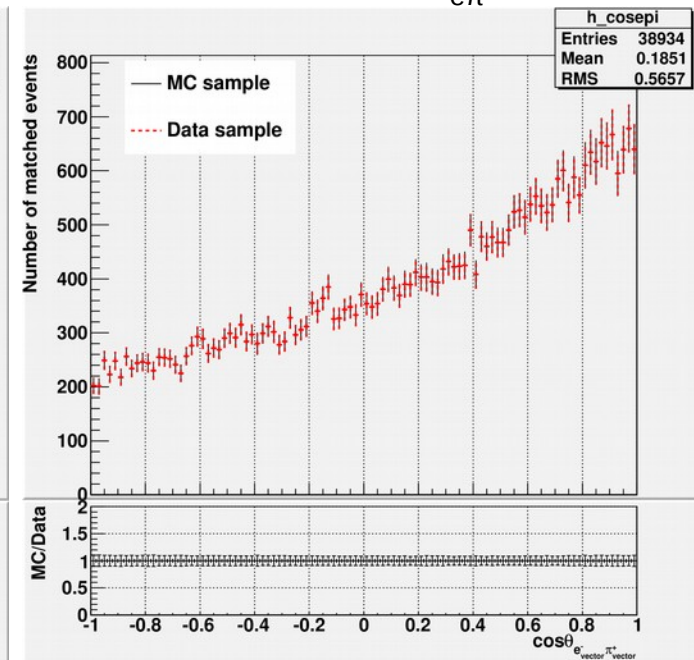
True e^- momentum



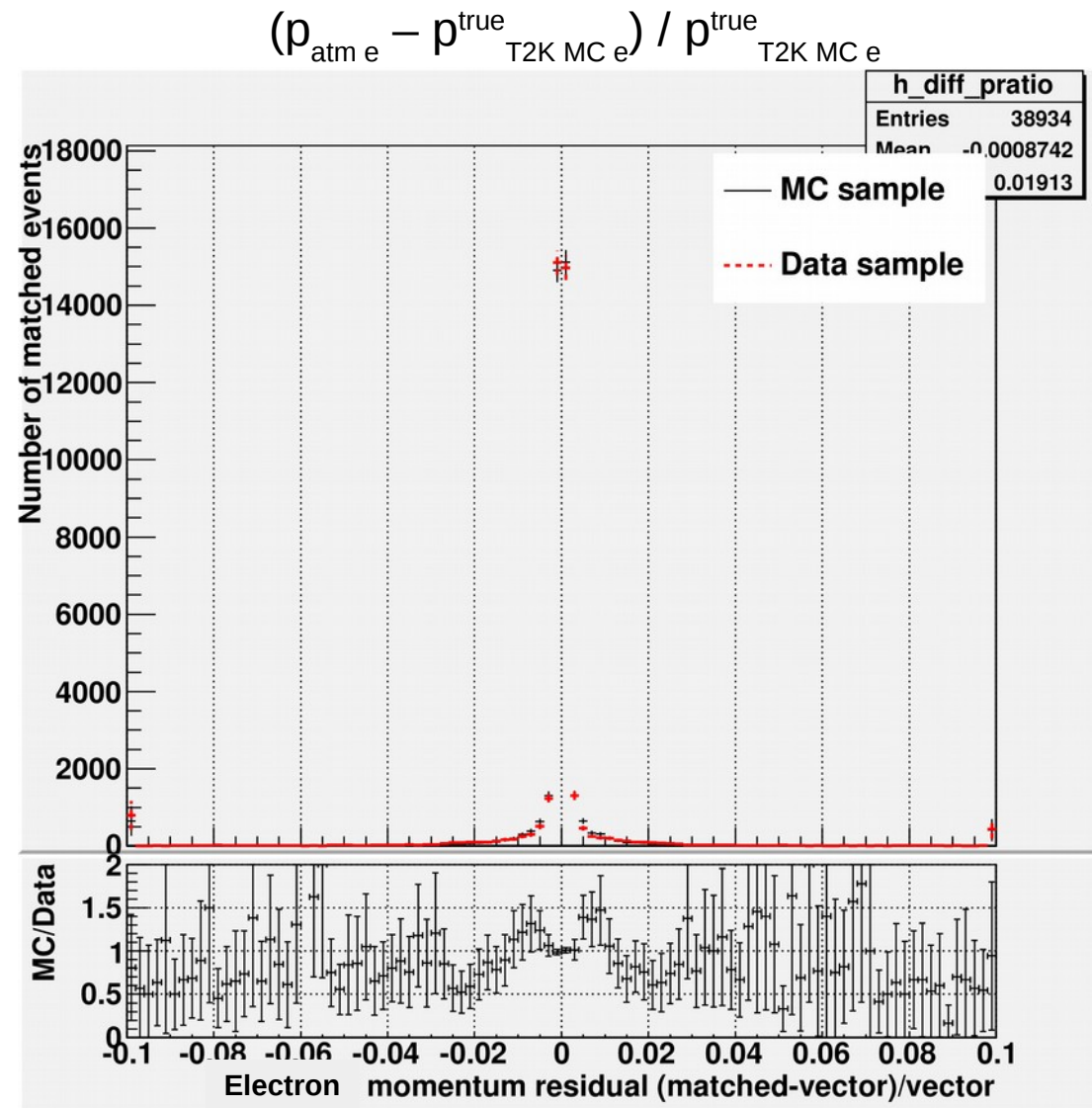
True π^+ momentum



True $\cos(\theta_{e\pi})$

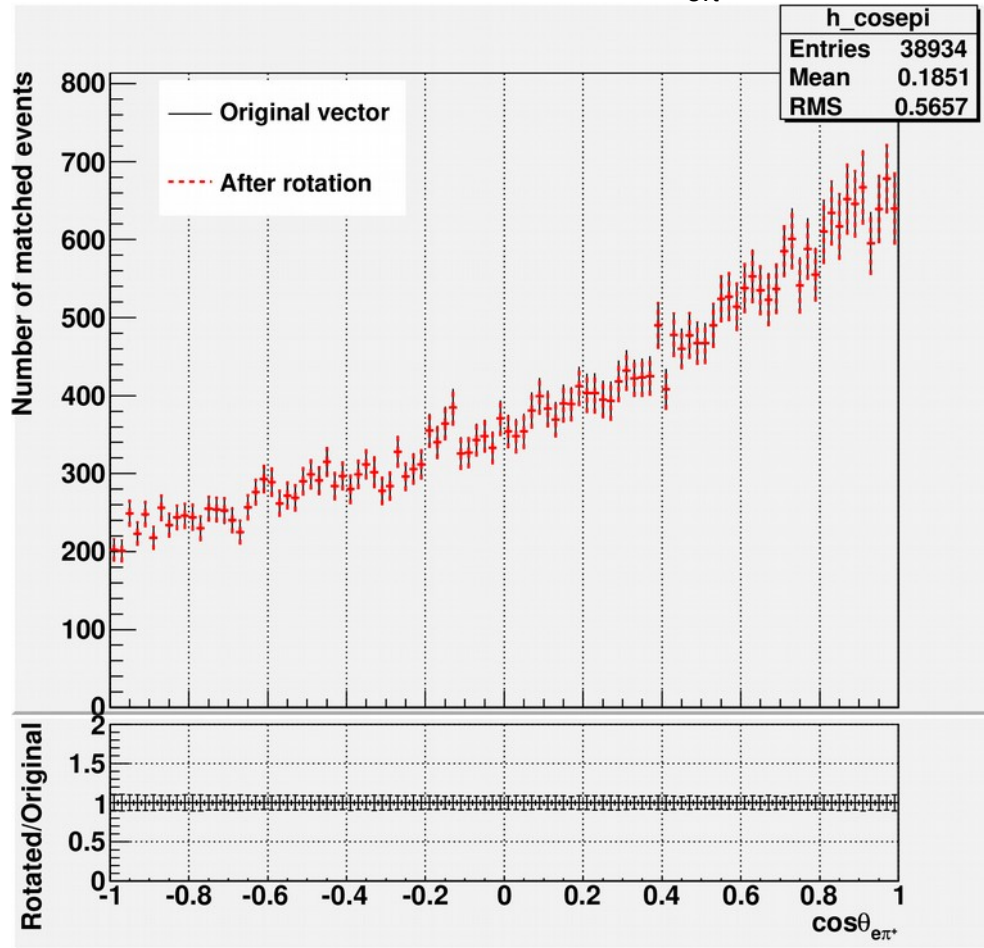


Matched e Momentum Difference

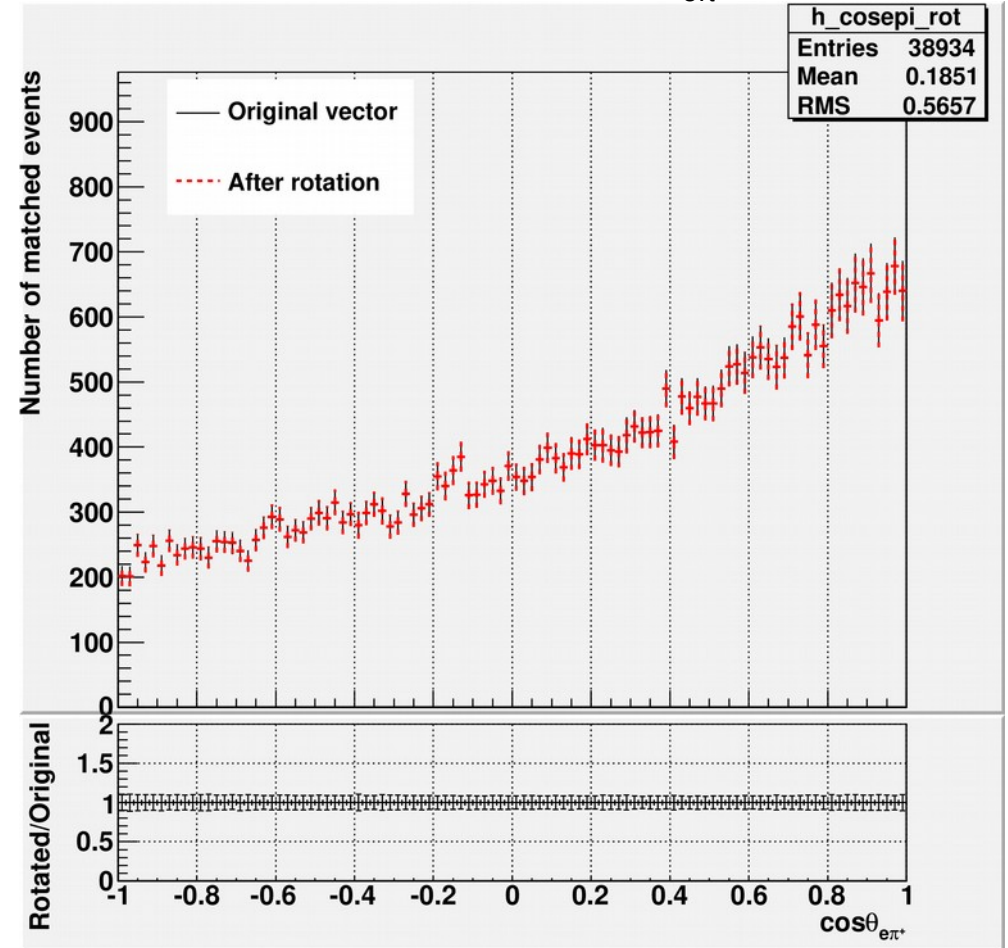


Rotation

Data Sample: $\cos(\theta_{e\pi})$



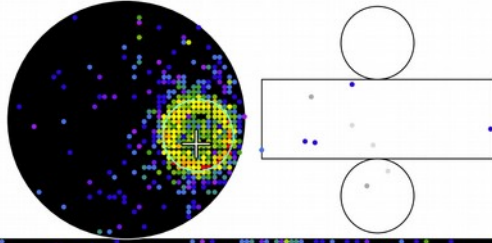
MC Sample: $\cos(\theta_{e\pi})$



Data Sample Event Display

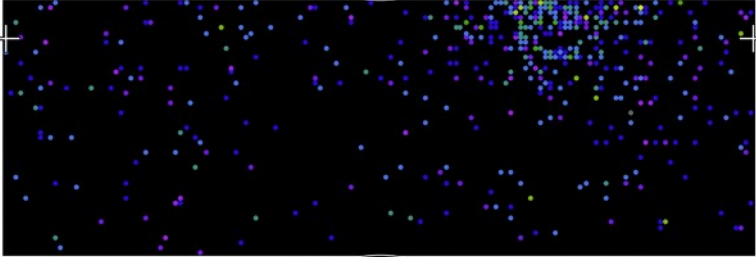
Super-Kamiokande IV

Run 61790 Sub 17 Event 3626885
08-10-20:19:04:12
Inner: 894 hits, 3017 pe
Outer: 5 hits, 5 pe
Trigger: 0x1000007
D_{wall}: 542.7 cm
Evis: 302.0 MeV
e-like, p = 302.0 MeV/c

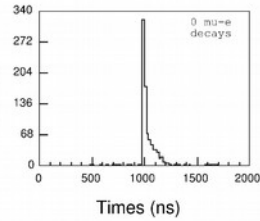
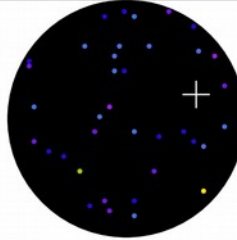


Charge (pe)

- >26.7
- 23.3-26.7
- 20.2-23.3
- 17.3-20.2
- 14.7-17.3
- 12.2-14.7
- 10.6-12.2
- 8.0-10.0
- 6.2- 8.0
- 4.7- 6.2
- 3.3- 4.7
- 2.2- 3.3
- 1.3- 2.2
- 0.7- 1.3
- 0.2- 0.7
- < 0.2

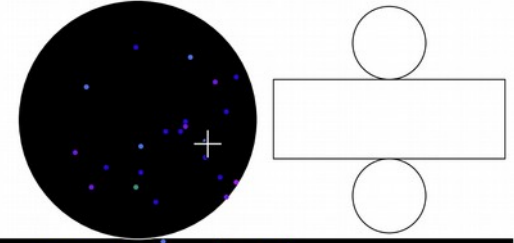


e



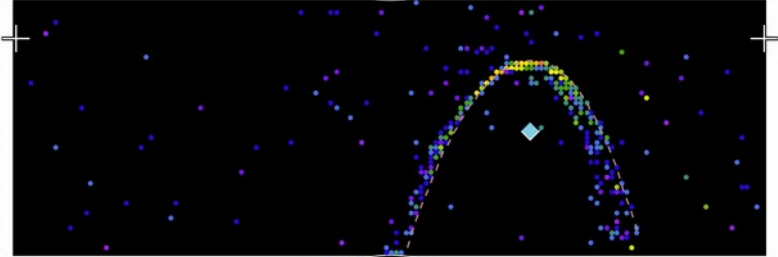
Super-Kamiokande IV

Run 999999 Sub 0 Event 1
19-06-22:10:56:44
Inner: 388 hits, 873 pe
Outer: 0 hits, 0 pe
Trigger: 0x07
D_{wall}: 542.7 cm
Evis: 0.0 MeV

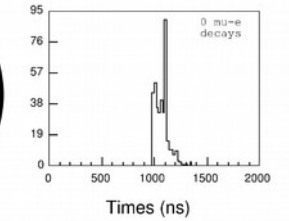
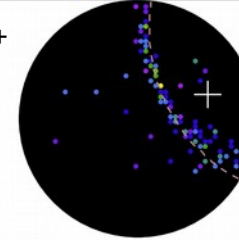


Charge (pe)

- >26.7
- 23.3-26.7
- 20.2-23.3
- 17.3-20.2
- 14.7-17.3
- 12.2-14.7
- 10.6-12.2
- 8.0-10.0
- 6.2- 8.0
- 4.7- 6.2
- 3.3- 4.7
- 2.2- 3.3
- 1.3- 2.2
- 0.7- 1.3
- 0.2- 0.7
- < 0.2

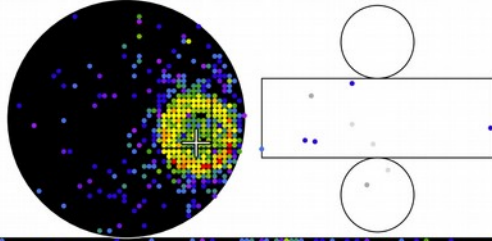


π^+



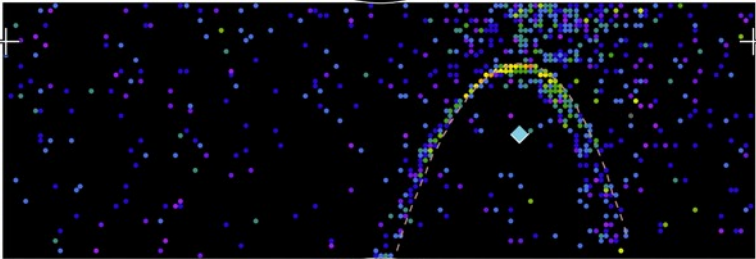
Super-Kamiokande IV

Run 999999 Sub 0 Event 1
19-06-22:10:56:44
Inner: 1244 hits, 3890 pe
Outer: 5 hits, 5 pe
Trigger: 0x07
D_{wall}: 542.7 cm
Evis: 0.0 MeV

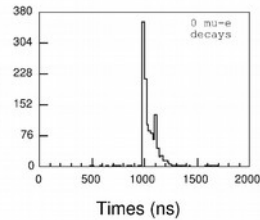
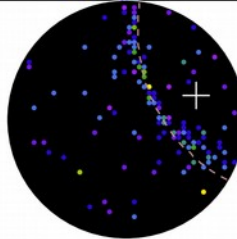


Charge (pe)

- >26.7
- 23.3-26.7
- 20.2-23.3
- 17.3-20.2
- 14.7-17.3
- 12.2-14.7
- 10.6-12.2
- 8.0-10.0
- 6.2- 8.0
- 4.7- 6.2
- 3.3- 4.7
- 2.2- 3.3
- 1.3- 2.2
- 0.7- 1.3
- 0.2- 0.7
- < 0.2

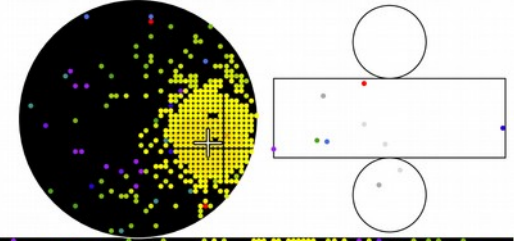


merged
charge



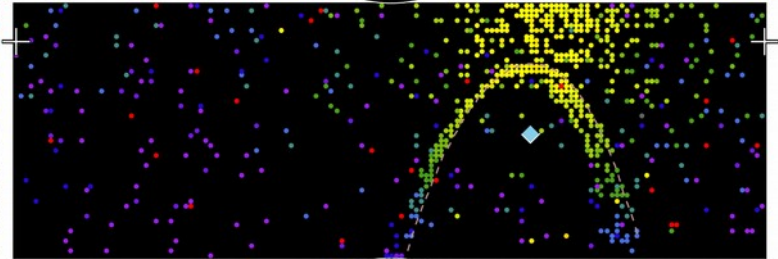
Super-Kamiokande IV

Run 999999 Sub 0 Event 1
19-06-22:10:56:44
Inner: 1244 hits, 3890 pe
Outer: 5 hits, 5 pe
Trigger: 0x07
D_{wall}: 542.7 cm
Evis: 0.0 MeV

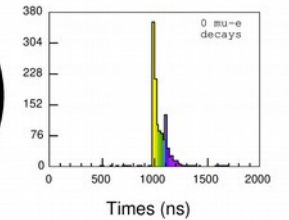
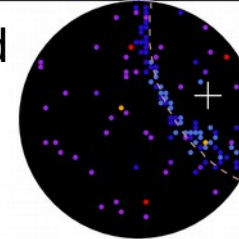


Time (ns)

- < 913
- 913- 929
- 929- 945
- 945- 961
- 961- 977
- 977- 993
- 993-1009
- 1009-1025
- 1025-1041
- 1041-1057
- 1057-1073
- 1073-1089
- 1089-1105
- 1105-1121
- 1121-1137
- >1137



merged
time

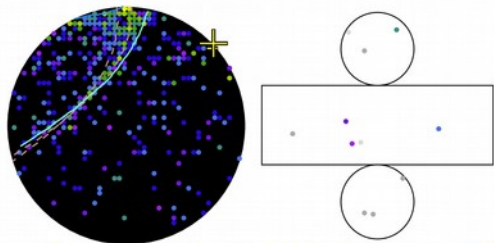


/CC1p

MC Sample Event Display

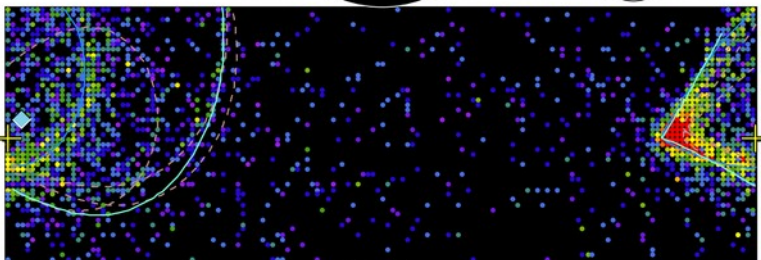
Super-Kamiokande IV

Run 999999 Sub 201 Event 8
16-03-10:19:06:31
Inner: 2329 hits, 9204 pe
Outer: 4 hits, 4 pe
Trigger: 0x07
D_{wall}: 0.3 cm
Evis: 589.8 MeV
e-like, p = 589.8 MeV/c

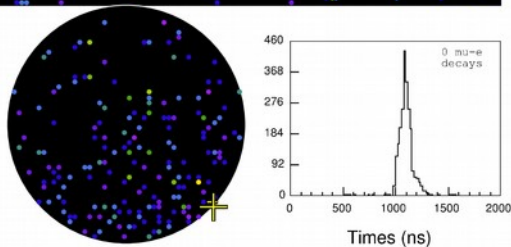


Charge (pe)

- >26.7
- 23.3-26.7
- 20.2-23.3
- 17.3-20.2
- 14.7-17.3
- 12.2-14.7
- 10.6-12.2
- 8.0-10.0
- 6.2- 8.0
- 4.7- 6.2
- 3.3- 4.7
- 2.2- 3.3
- 1.3- 2.2
- 0.7- 1.3
- 0.2- 0.7
- < 0.2

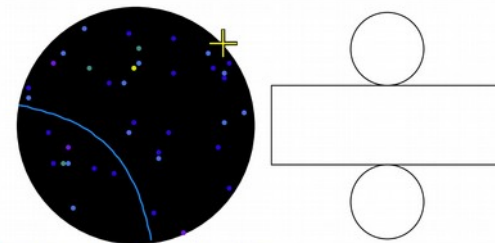


e



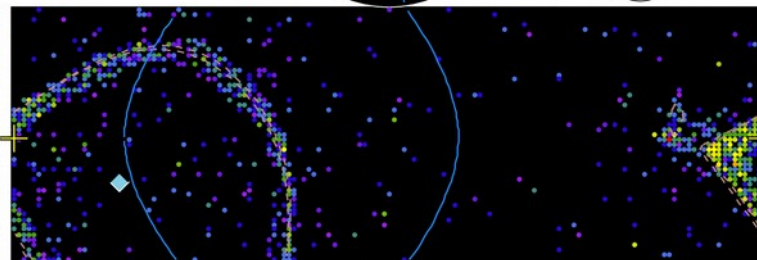
Super-Kamiokande IV

Run 999999 Sub 0 Event 1
19-06-22:10:57:52
Inner: 965 hits, 2210 pe
Outer: 0 hits, 0 pe
Trigger: 0x07
D_{wall}: 0.3 cm
Evis: 0.0 MeV

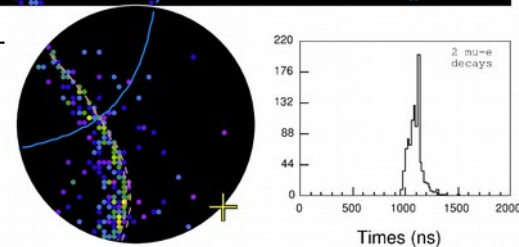


Charge (pe)

- >26.7
- 23.3-26.7
- 20.2-23.3
- 17.3-20.2
- 14.7-17.3
- 12.2-14.7
- 10.6-12.2
- 8.0-10.0
- 6.2- 8.0
- 4.7- 6.2
- 3.3- 4.7
- 2.2- 3.3
- 1.3- 2.2
- 0.7- 1.3
- 0.2- 0.7
- < 0.2

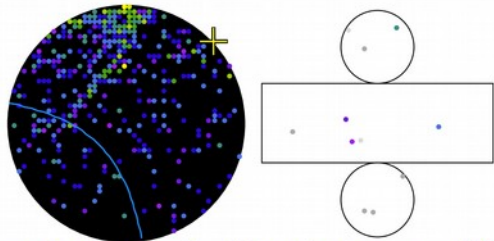


π^+



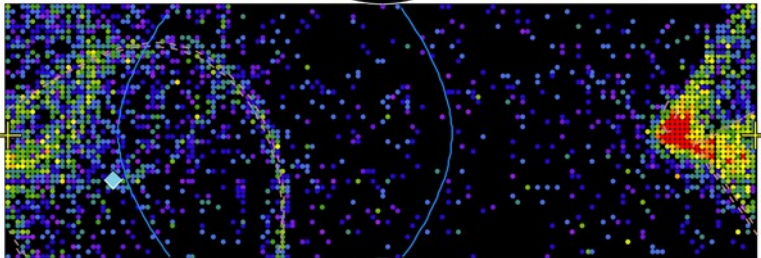
Super-Kamiokande IV

Run 999999 Sub 0 Event 1
19-06-22:10:57:52
Inner: 2914 hits, 11415 pe
Outer: 4 hits, 4 pe
Trigger: 0x07
D_{wall}: 0.3 cm
Evis: 0.0 MeV

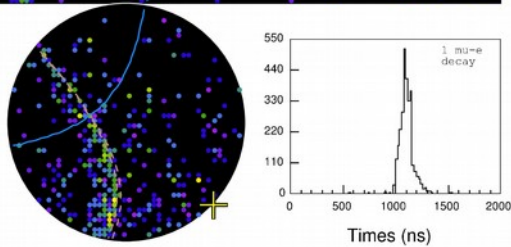


Charge (pe)

- >26.7
- 23.3-26.7
- 20.2-23.3
- 17.3-20.2
- 14.7-17.3
- 12.2-14.7
- 10.6-12.2
- 8.0-10.0
- 6.2- 8.0
- 4.7- 6.2
- 3.3- 4.7
- 2.2- 3.3
- 1.3- 2.2
- 0.7- 1.3
- 0.2- 0.7
- < 0.2

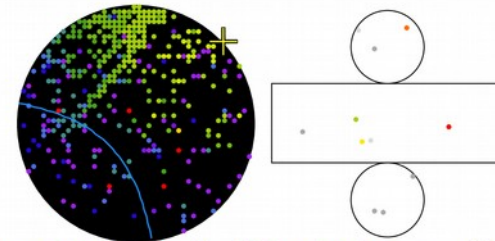


merged
charge



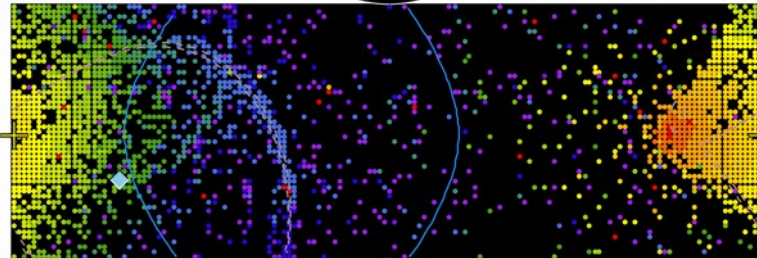
Super-Kamiokande IV

Run 999999 Sub 0 Event 1
19-06-22:10:57:52
Inner: 2914 hits, 11415 pe
Outer: 4 hits, 4 pe
Trigger: 0x07
D_{wall}: 0.3 cm
Evis: 0.0 MeV

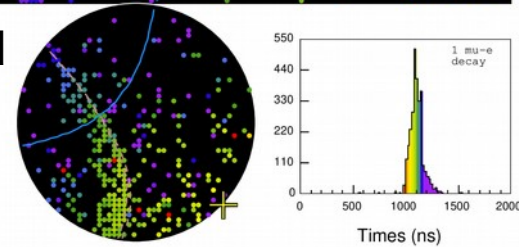


Time (ns)

- < 995
- 995-1008
- 1008-1021
- 1021-1034
- 1034-1047
- 1047-1060
- 1060-1073
- 1073-1086
- 1086-1099
- 1099-1112
- 1112-1125
- 1125-1138
- 1138-1151
- 1151-1164
- 1164-1177
- >1177



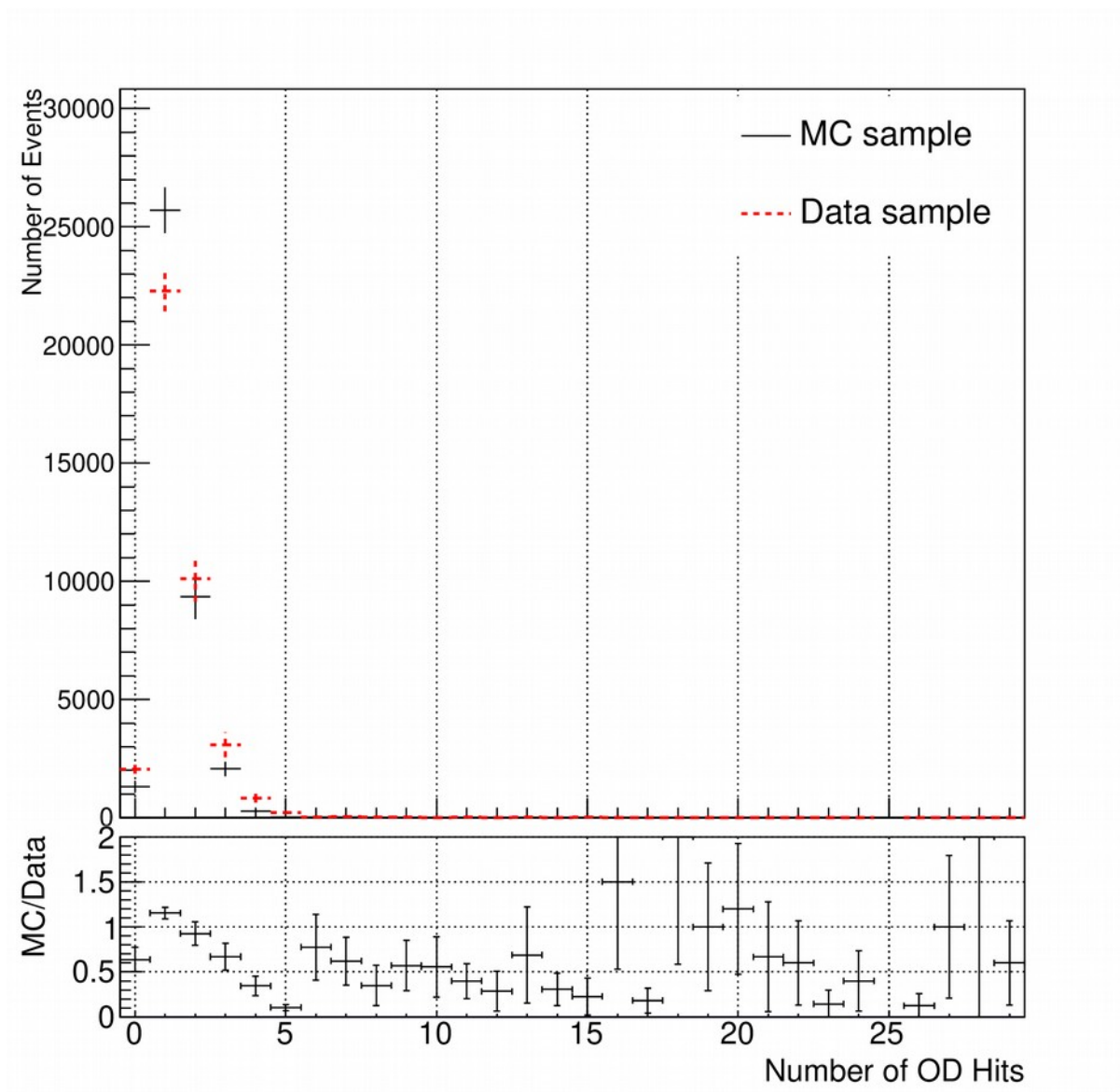
merged
time



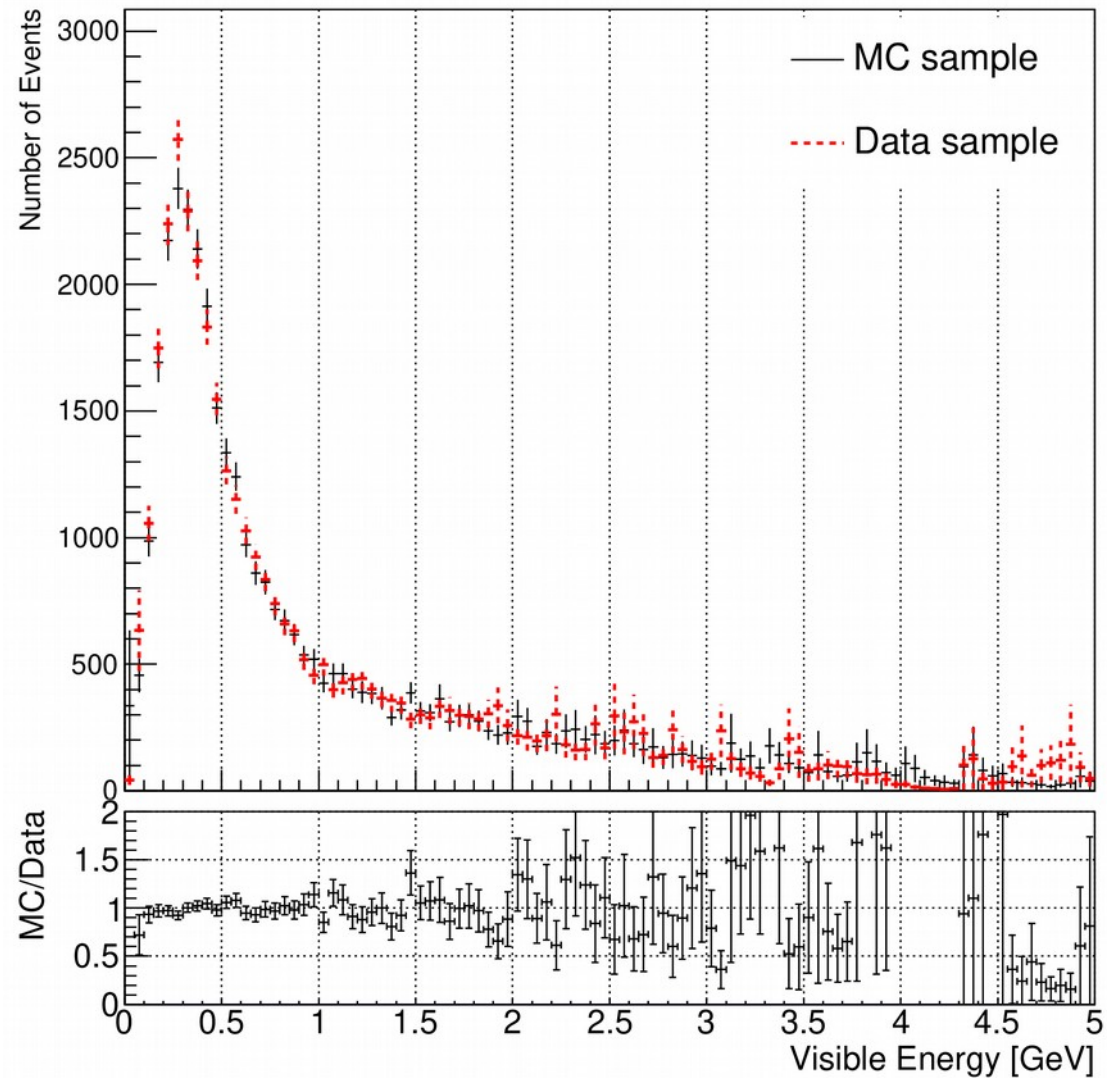
Hybrid Sample Selection

(Work In Progress)

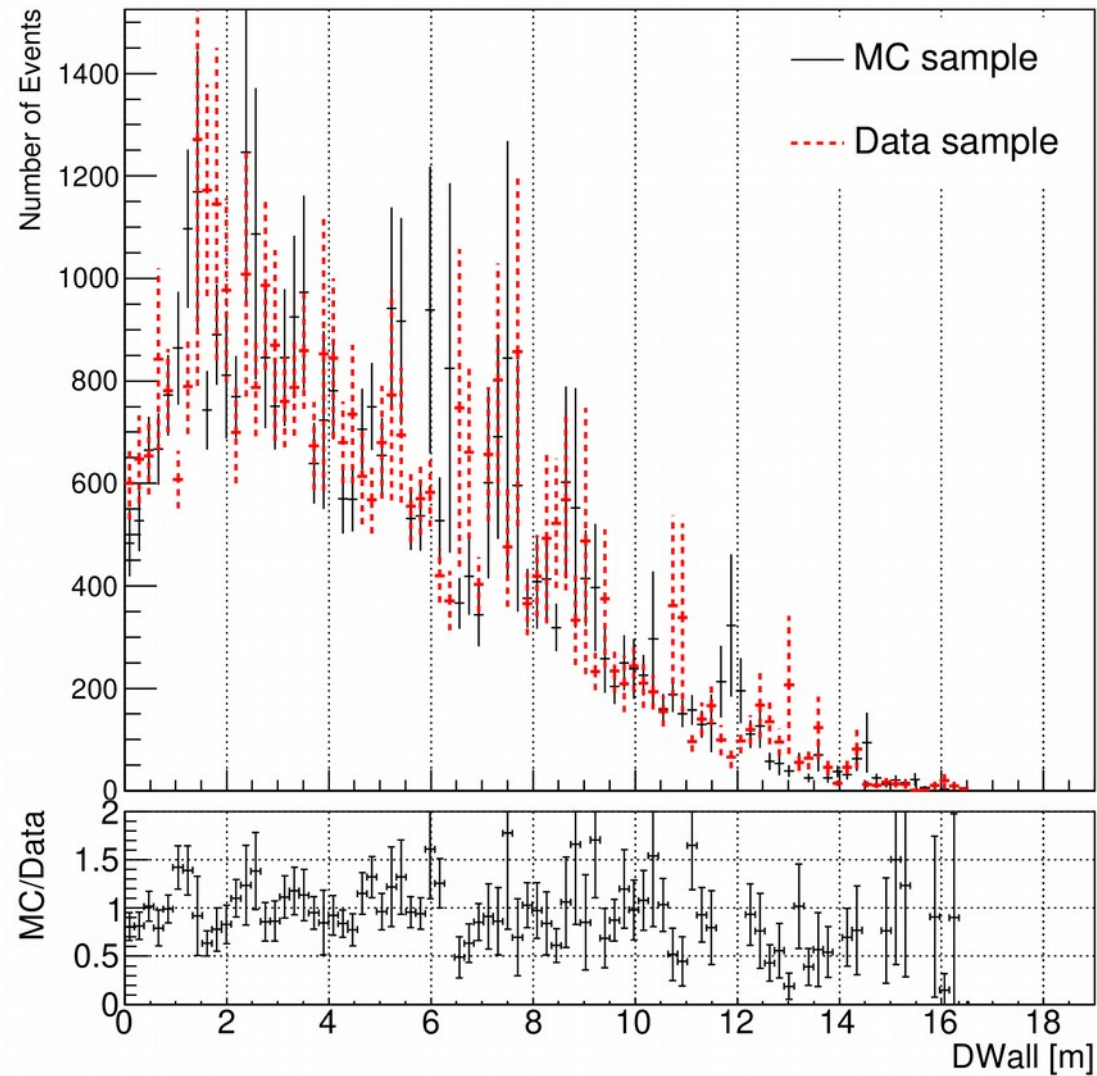
$n_{hitac} < 16$



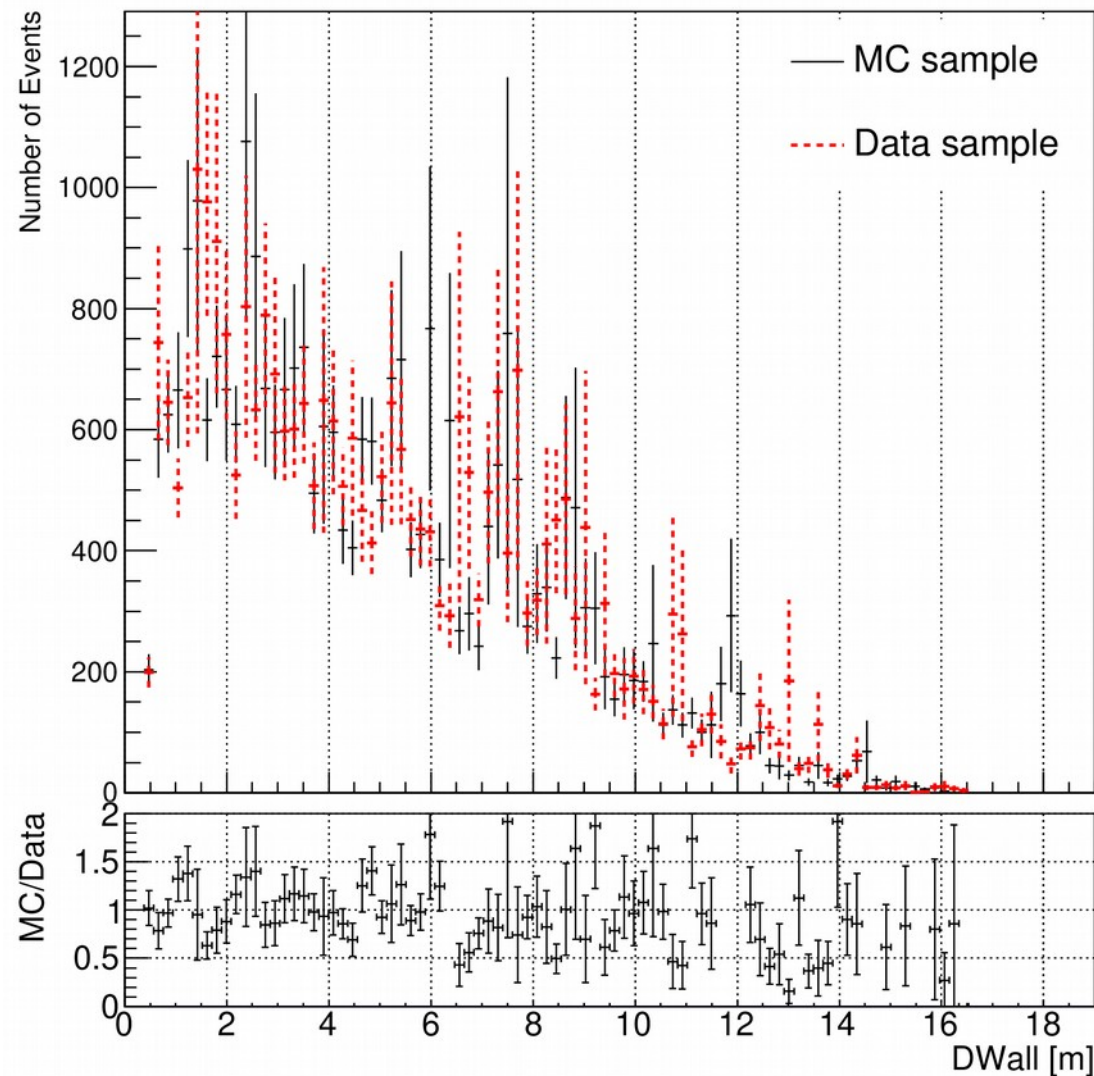
$$E_{\text{vis}} > 30 \text{ MeV}$$



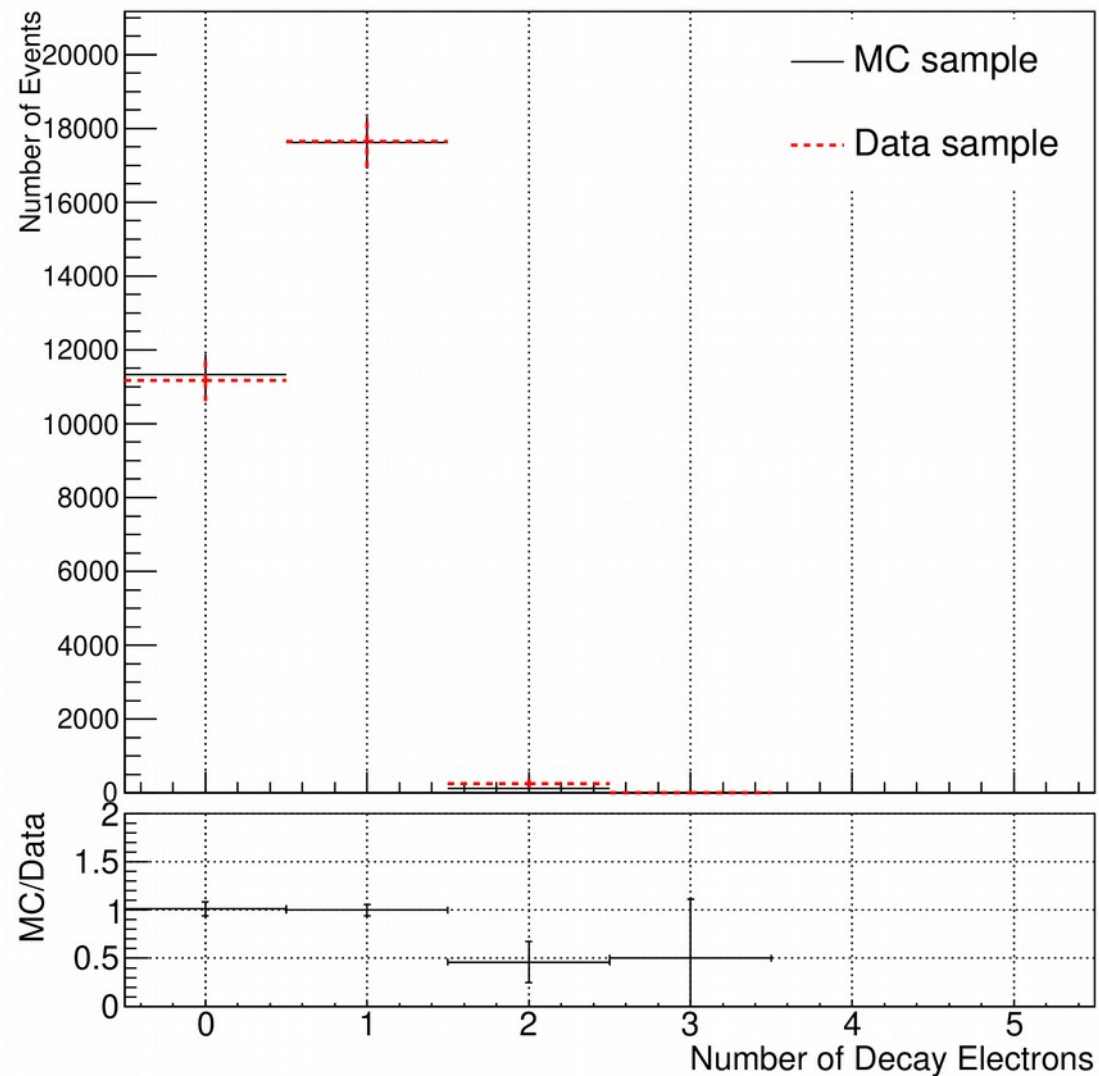
Wall > 50 cm



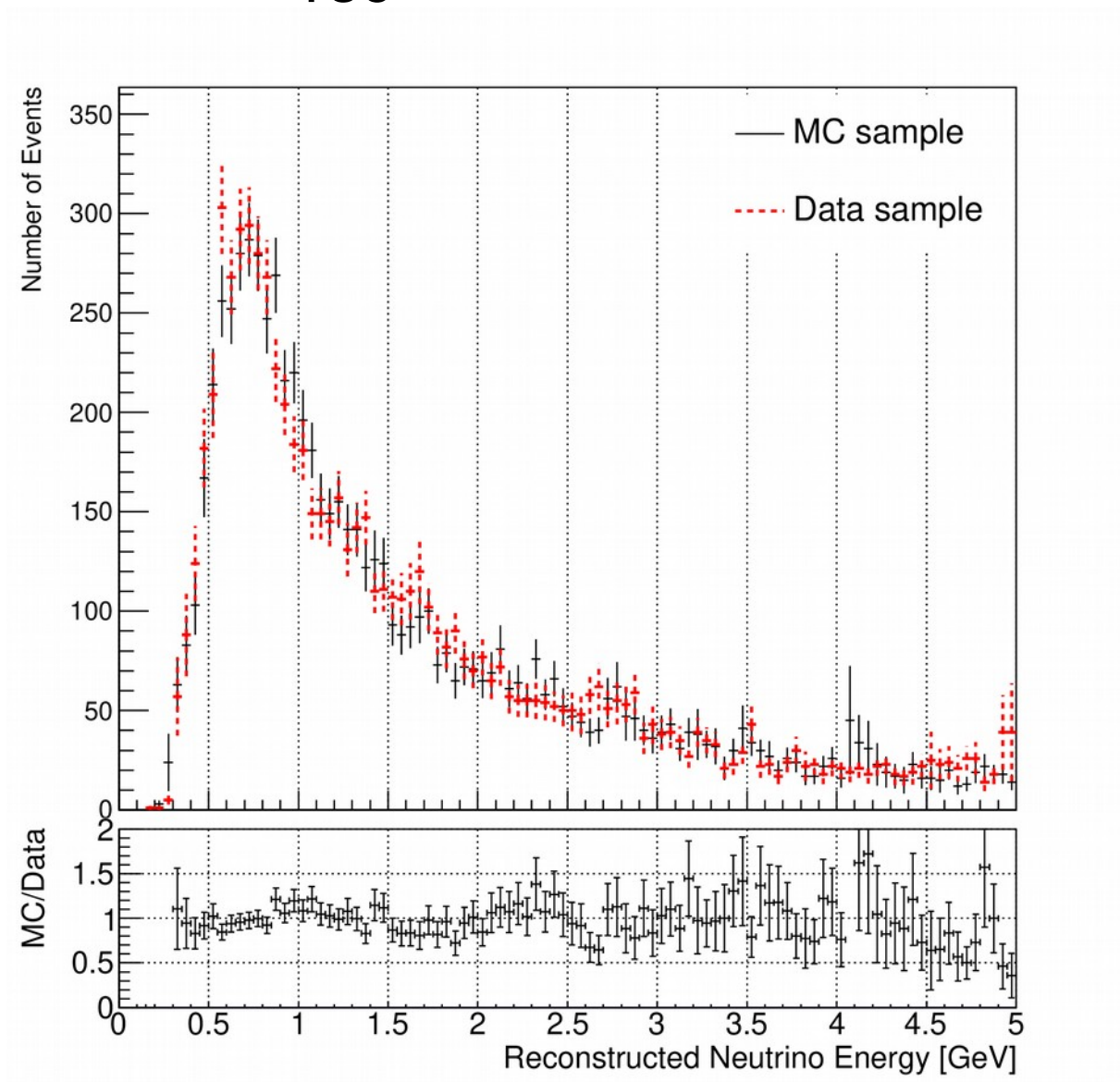
Not 1Re-like (TN319)



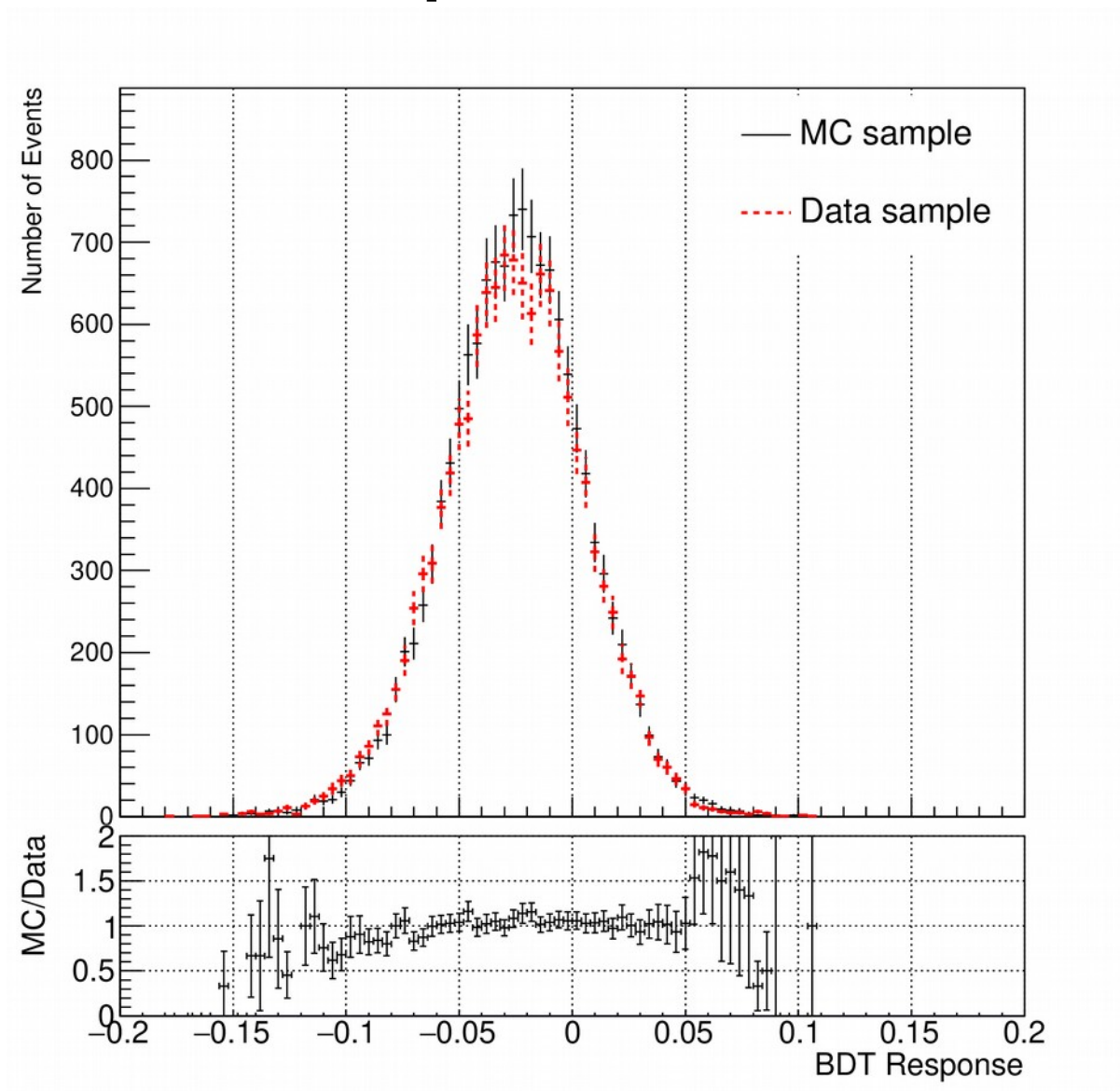
1 Decay Electron



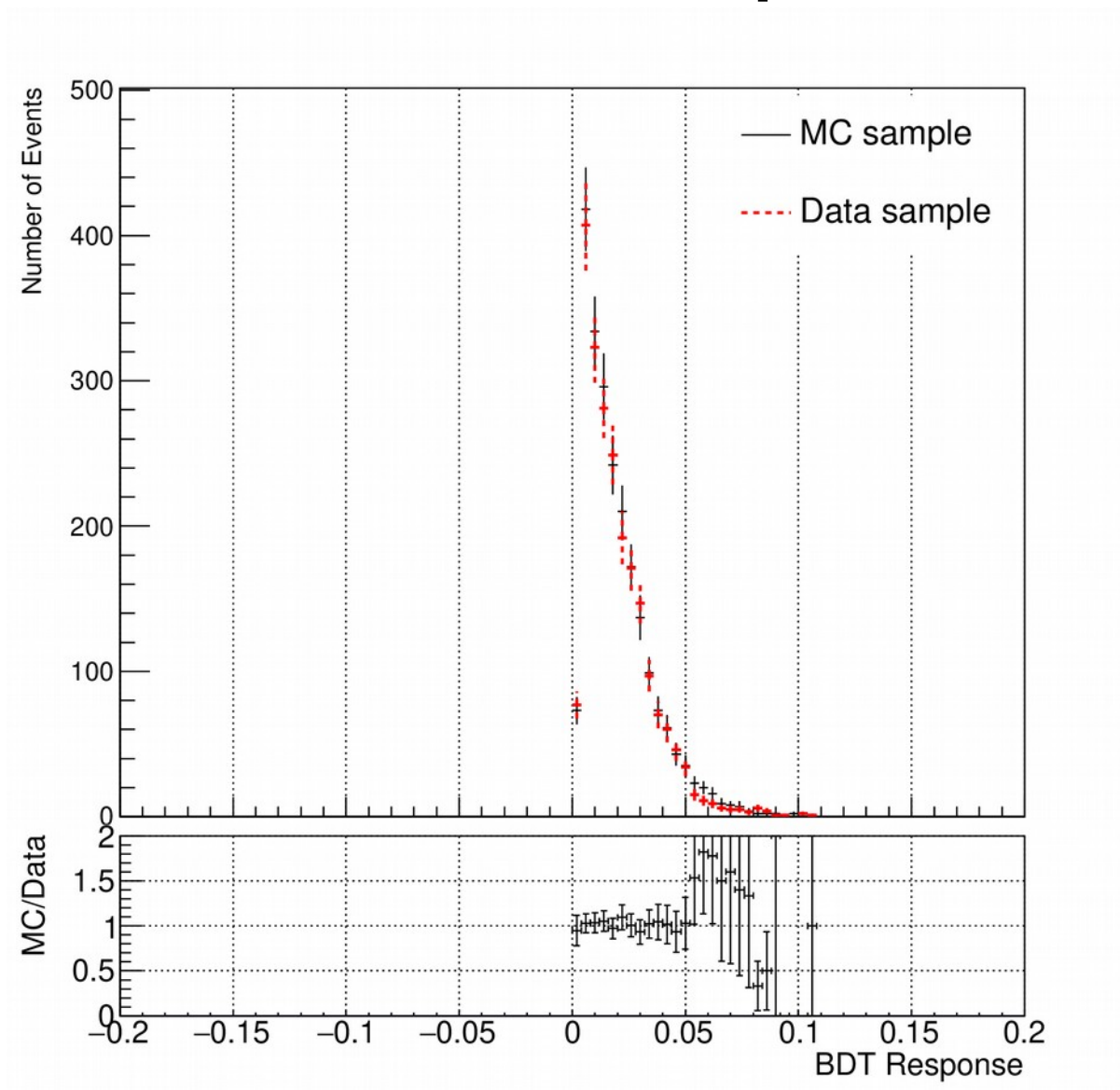
$$E_{\text{rec}} < 1.5 \text{ GeV}$$



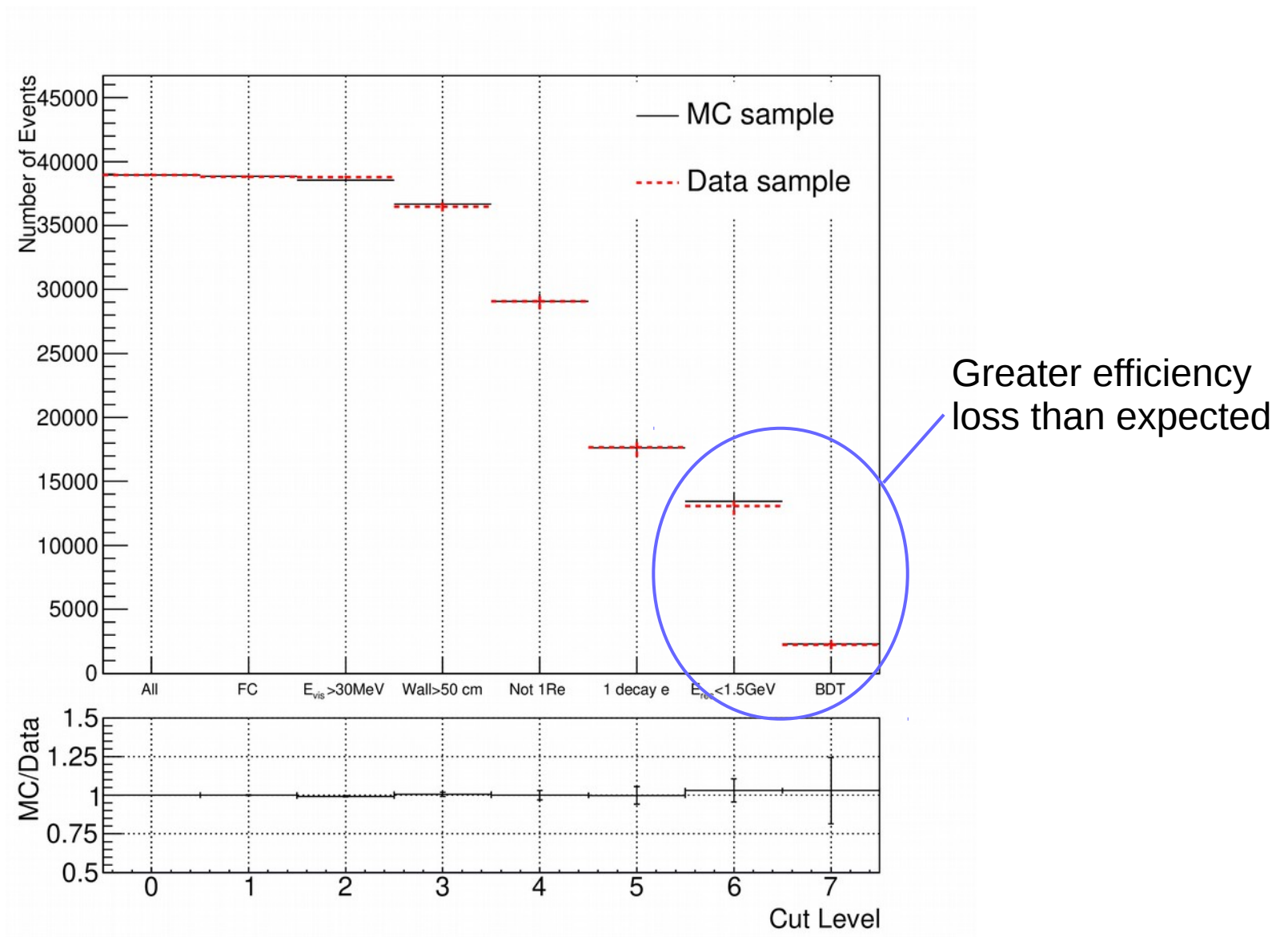
BDT Response > 0.0034



Final Sample



Cut Flow



Notes and Future Work

- Good agreement between data and MC samples is promising
- More plots of variables that aren't explicitly used in the selection are available
 - APFit electron momentum, “true” pion momentum
 - fiTQun momenta of 1st and 2nd rings
 - fiTQun PIDs of 1st and 2nd rings
- All plots are available *at each cut level*
- To-Do:
 - Draw arrows on plots to indicate cut value
 - Investigate efficiency discrepancy between hybrid sample and T2K-SK MC
 - Produce similar plots for APFit variables
 - No APFit-exclusive selection exists – will make a simple set of cuts with APFit variables