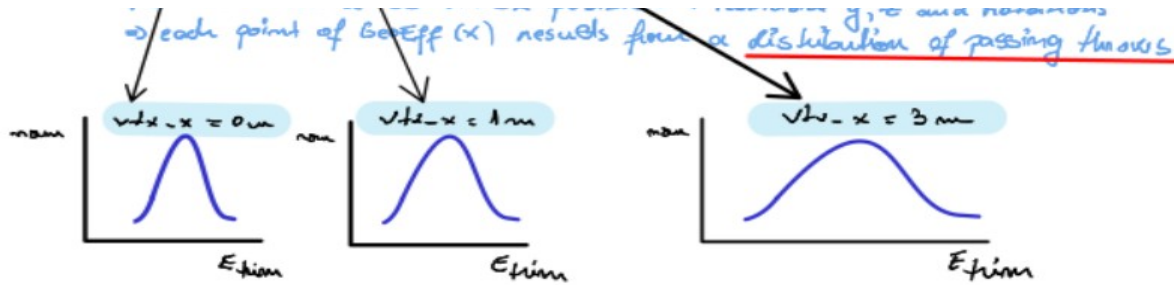


Geometric Efficiency Correction – UPDATE

January 22nd, 2024

Ioana Caracas

Geometric Efficiency within PRISM framework

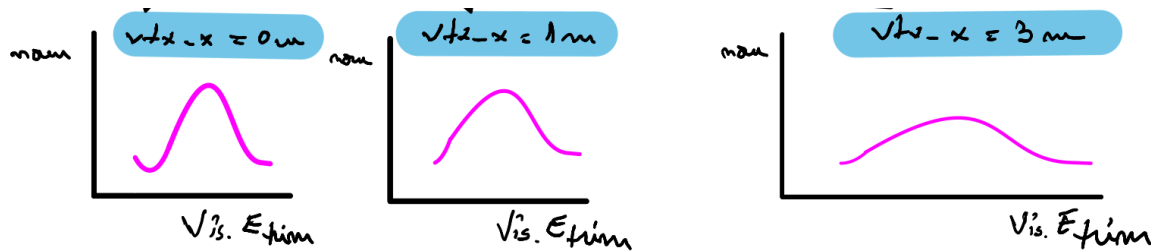


↳ Integral of each of these E_{trim} histograms = Geometric efficiency at the given $\sqrt{r^2 - x^2}$!

Each entry in these histograms = passing throw (rotation, y, z) for **hadronic cut**

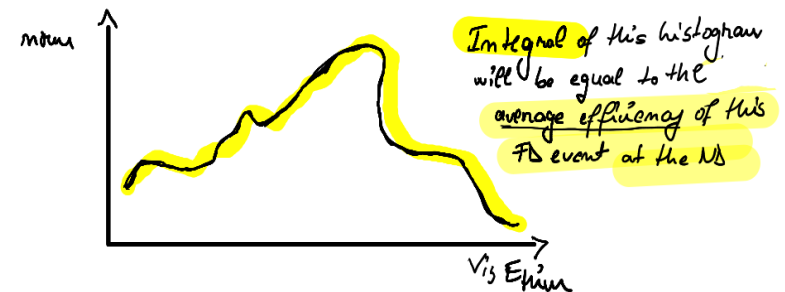
– each passing throw has a corresponding **muon geometric efficiency**: probability muon contained

→ apply this probability: $N(E_{trim}, throw) * P(E_{mu}, throw)$



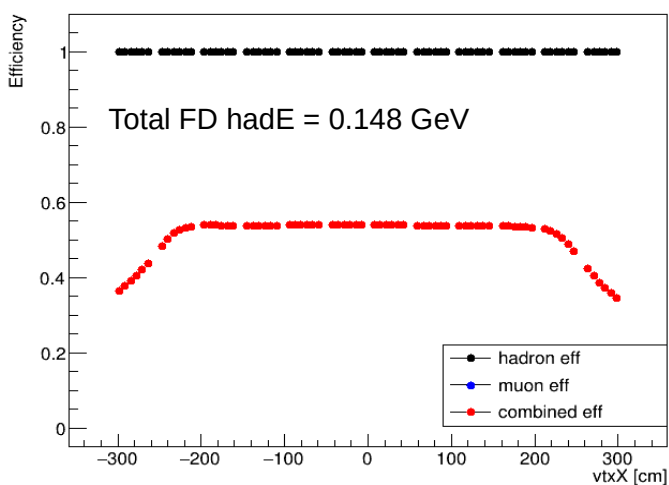
- To get the **average geometric efficiency of a FD event at the ND**: add all VisEtrim ($E_{trim} + E_{mu}$) histograms and linearly combine them

Add together all $Vis. E_{trim}$ histograms (all $\sqrt{r^2 - x^2}$, all OA) and apply the off-axis coefficients: $\sum_{OA} E_{trim}(OA) \cdot Coeff(OA)$

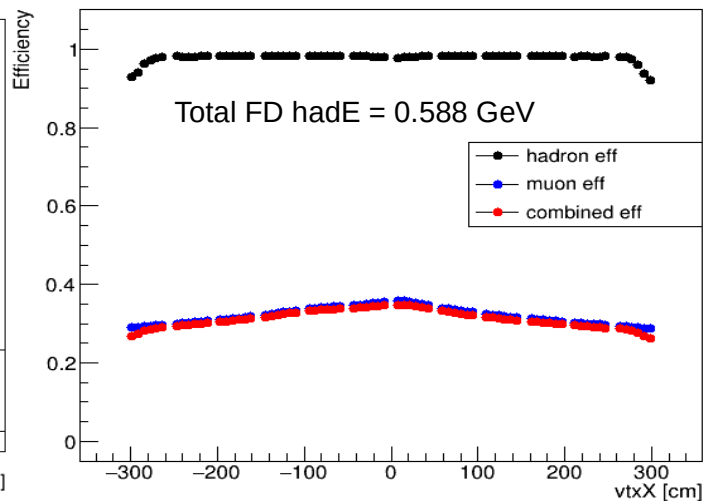


Muon, Hadron and Combined Efficiency correction

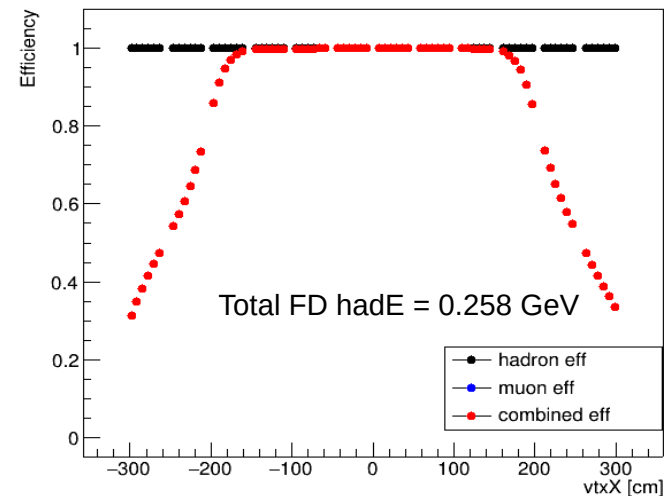
Event_0 $E_\nu=0.945272$ LepMom=0.750464



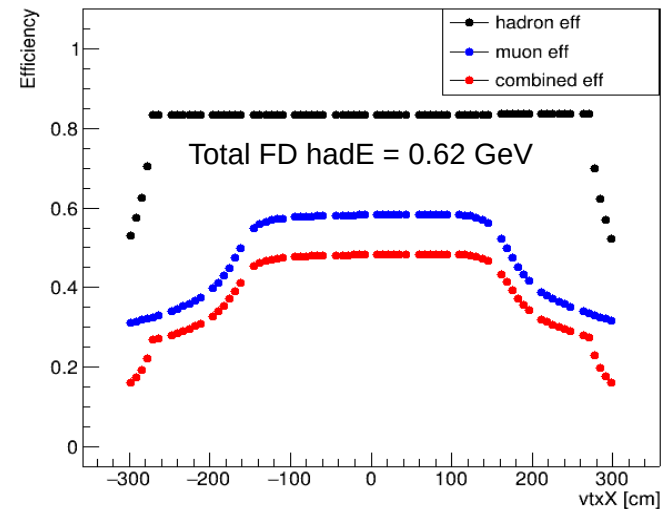
Event_1 $E_\nu=2.685058$ LepMom=1.969871



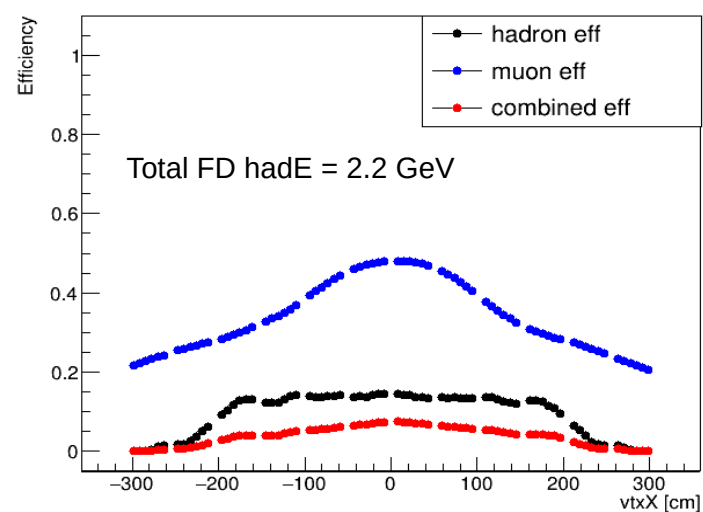
Event_2 $E_\nu=4.342554$ LepMom=3.923329



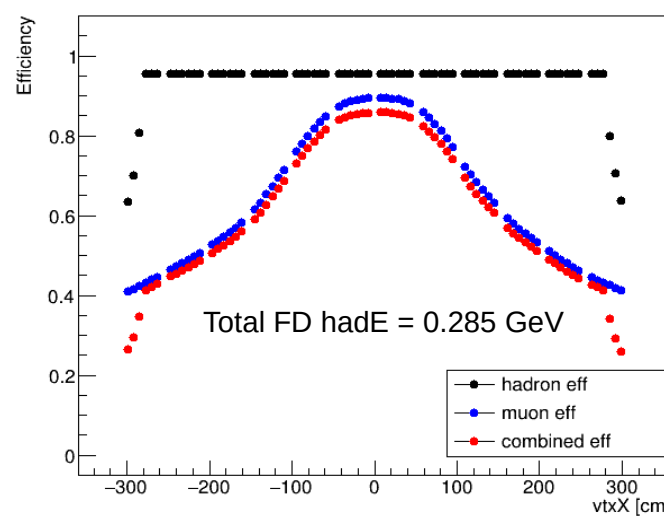
Event_3 $E_\nu=1.326016$ LepMom=0.658158



Event_4 $E_\nu=4.390517$ LepMom=1.381705

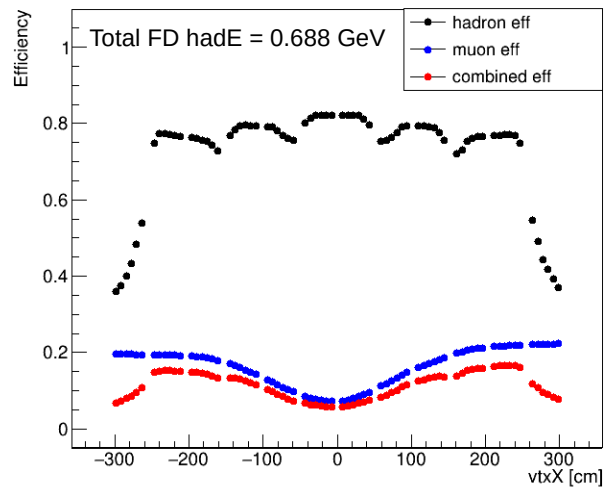


Event_5 $E_\nu=3.240887$ LepMom=2.915287

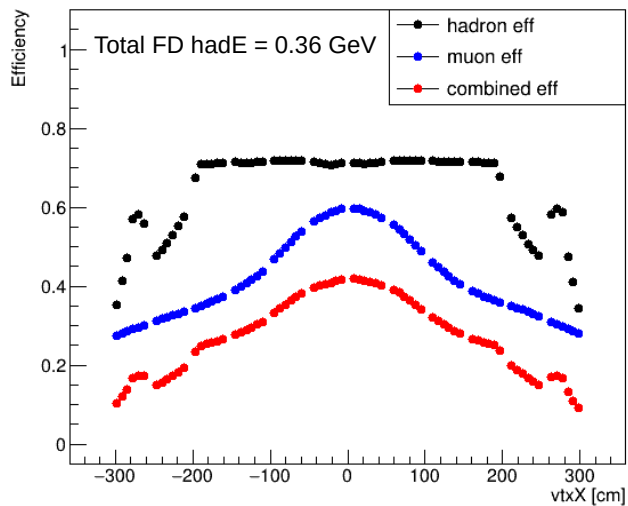


Muon, Hadron and Combined Efficiency correction

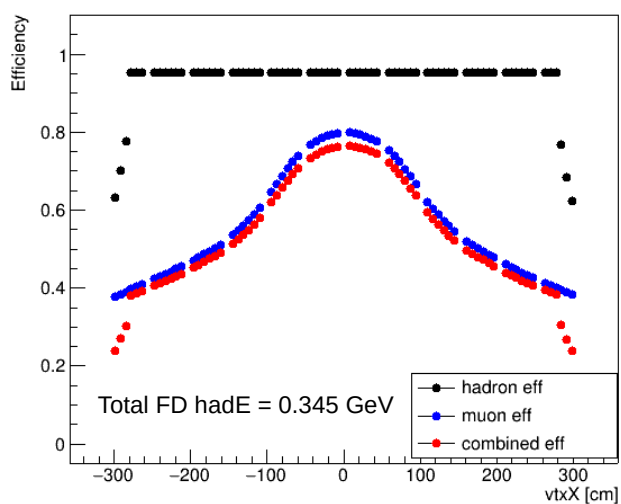
Event_6 $E_\nu=3.059191$ LepMom=2.009178



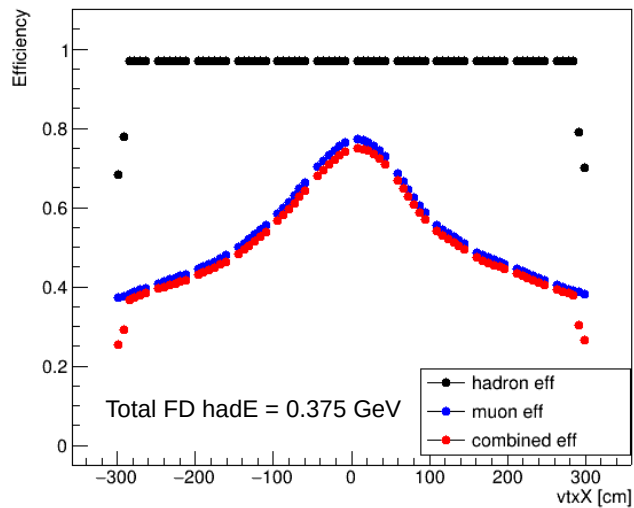
Event_7 $E_\nu=1.902728$ LepMom=1.527531



Event_8 $E_\nu=2.408426$ LepMom=1.911331

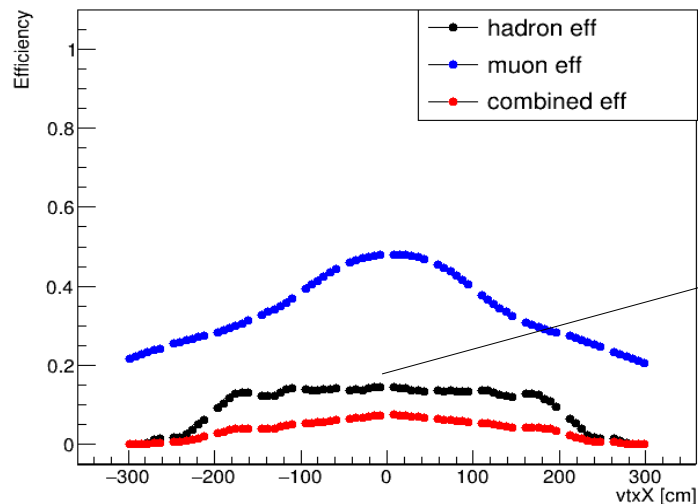


Event_9 $E_\nu=3.728254$ LepMom=3.294829

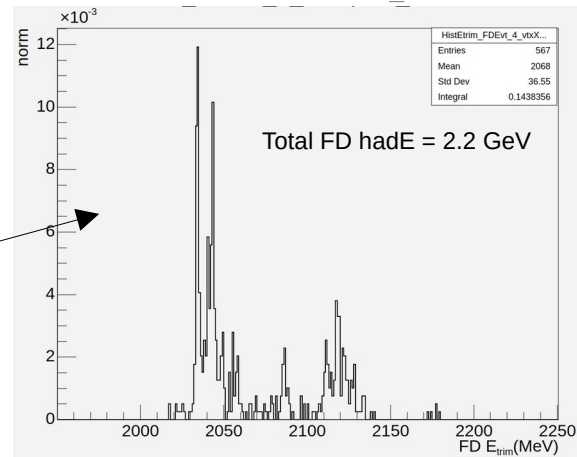


Muon, Hadron and Combined Efficiency correction

Event_4 $E_\nu=4.390517$ LepMom=1.381705



HadE trim distribution of throws that pass hadronic veto cut at $vtx_x = -14.75$



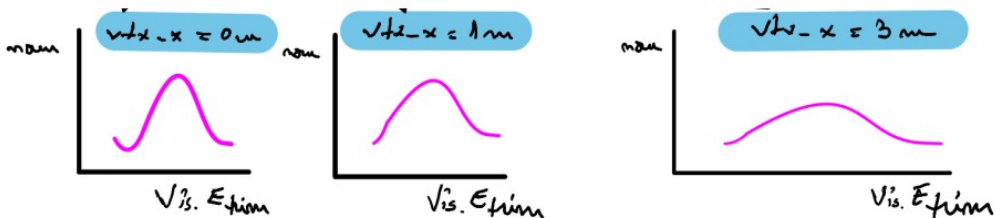
Each entry in these histograms = passing throw (rotation, y, z) for **hadronic cut**

– each passing throw has a corresponding **muon geometric efficiency**: probability muon contained

→ apply this probability: $N(E_{trim}, throw) * P(E_{mu}, throw)$

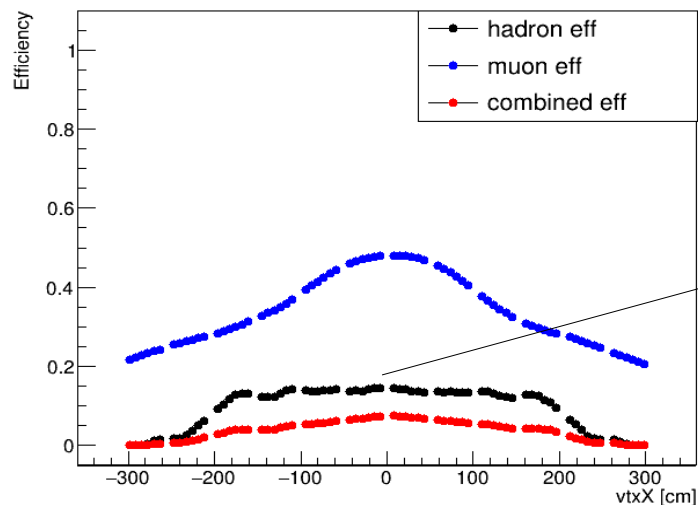
1. Take the muon probability and apply it to each entry in the histogram

- different distribution (I.e if $P_{mu} = 0 \rightarrow$ no event in the histo)
- visEtrim (= hadE_trim + E_mu) distribution of FD events that would be seen (both hadronic veto and muon) by the ND at a given vtx_x

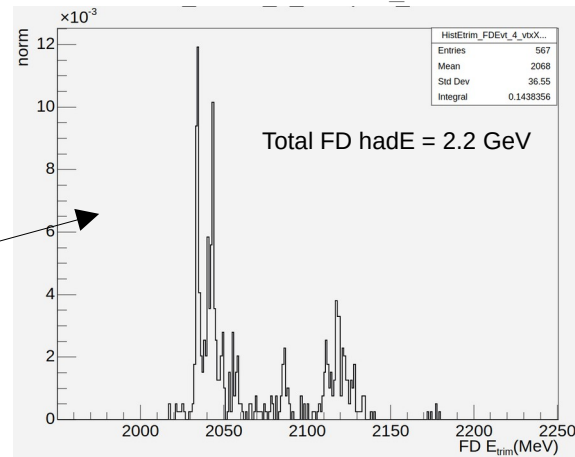


Muon, Hadron and Combined Efficiency correction

Event_4 $E_\nu=4.390517$ LepMom=1.381705



HadE trim distribution of throws that pass hadronic veto cut at $vtx_x = -14.75$



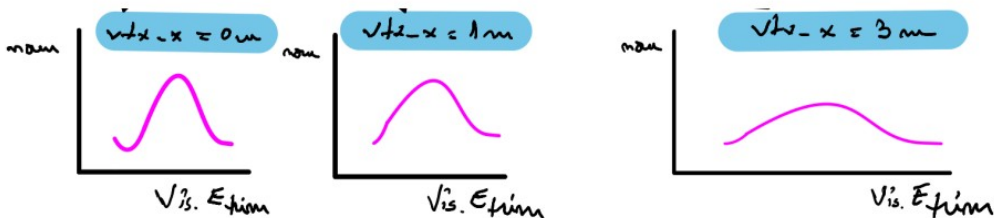
Each entry in these histograms = passing throw (rotation, y, z) for **hadronic cut**

– each passing throw has a corresponding **muon geometric efficiency**: probability muon contained

→ apply this probability: $N(E_{trim}, throw) * P(E_{mu}, throw)$

1. Take the muon probability and apply it to each entry in the histogram

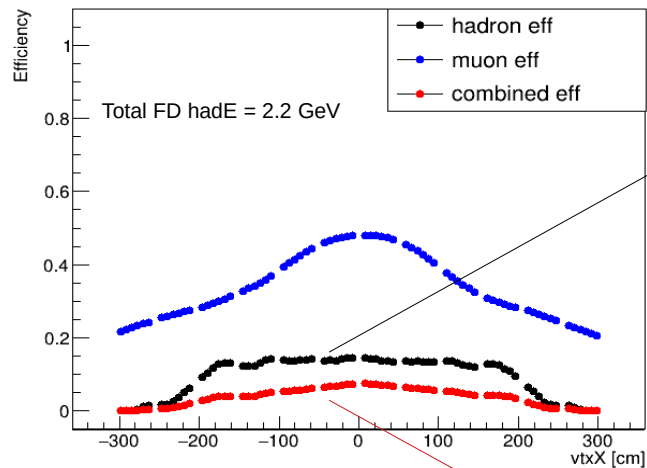
- different distribution (I.e if $P_{mu} = 0 \rightarrow$ no event in the histo)
- visEtrim (= hadE_trim + E_{mu}) distribution of FD events that would be seen (both hadronic veto and muon) by the ND at a given vtx_x



THEN: proceed as before (apply OA coeffs and add together all visEtrim histograms → **distribution of FD events that would be seen** (both hadronic veto and muon) **by the ND** – compare to the **linear combination of (ND data - bkg)**

Muon, Hadron and Combined Efficiency correction

Event_4 $E_{\nu}=4.390517$ LepMom=1.381705



HadE trim distribution of throws that pass hadronic veto cut at $vtx_x = -14.75$

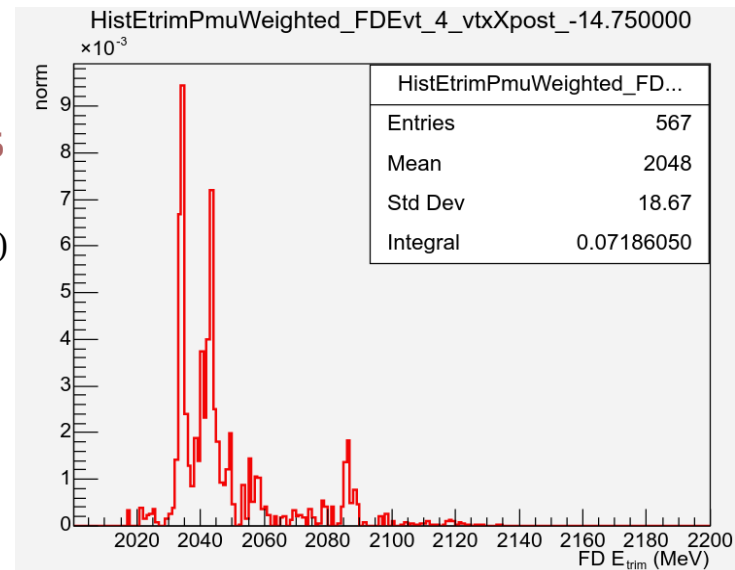
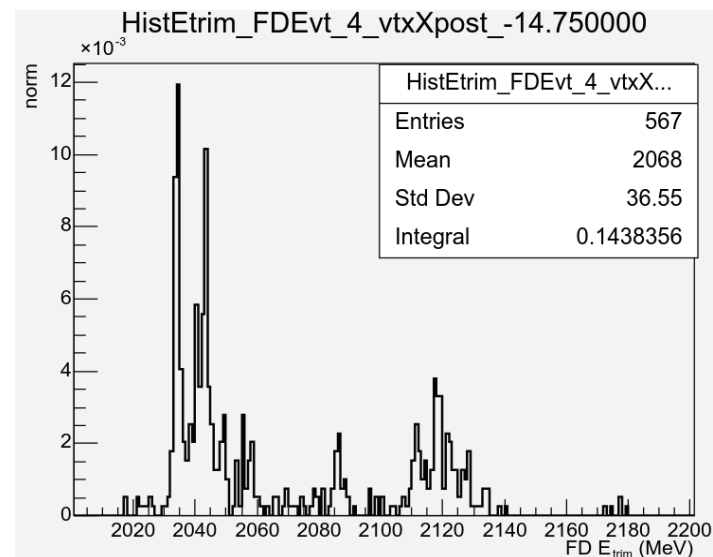
- integral = 0.14 (HaddEff(-14.75))
- entries = 567 (passing throws)

Integral of this histogram = hadron geo eff at $vtxX$

HadE trim distribution of throws that pass hadronic veto cut and muon (contained || tracker) cut at $vtx_x = -14.75$

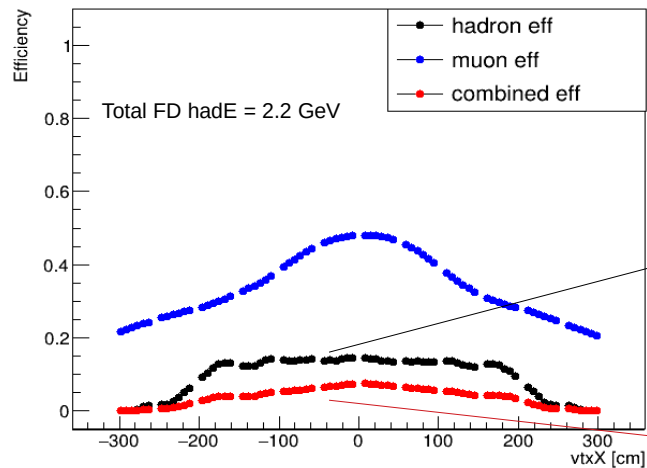
- integral = 0.07 (Combined Eff(-14.75))
- entries = 567 (passing throws)

Integral of this histogram = ND (had + mu) geo eff at $vtxX$

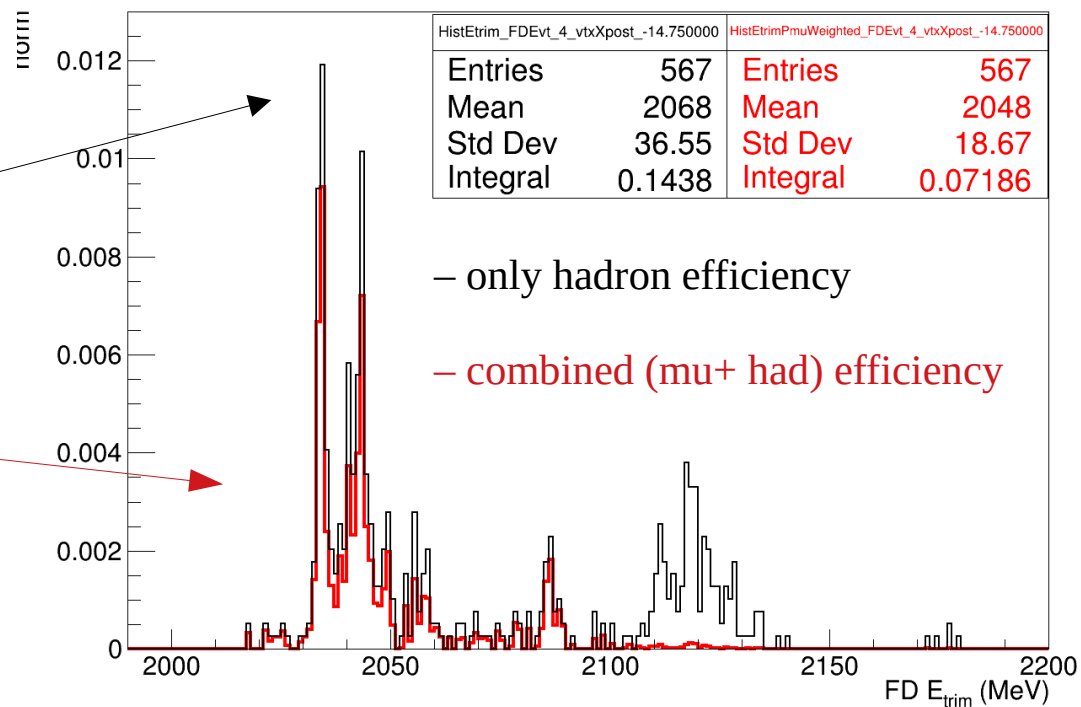


Muon, Hadron and Combined Efficiency correction

Event_4 $E_\nu=4.390517$ LepMom=1.381705



$vtx_x = -14.75$



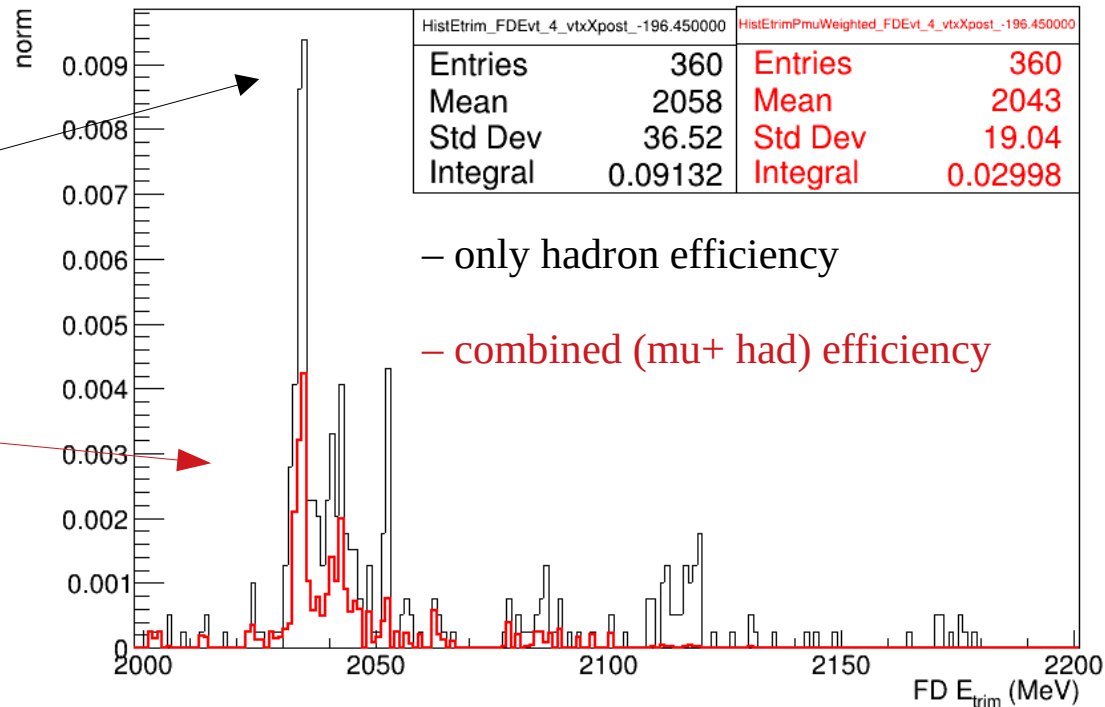
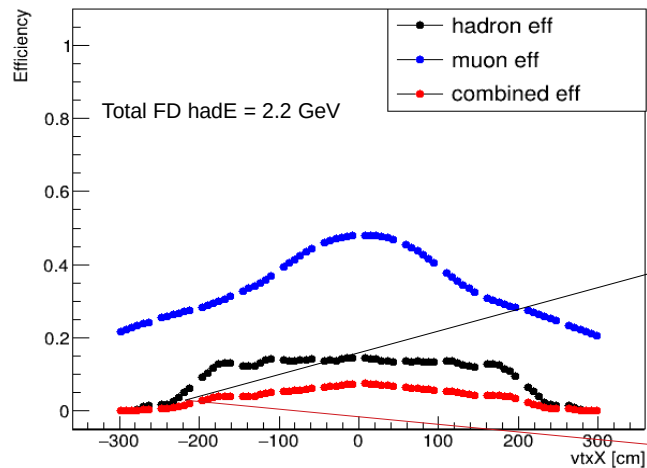
*Integral of this histogram
= hadron geo eff at $vtxX$*

*Integral of this histogram
= ND (had + mu) geo eff at $vtxX$*

Muon, Hadron and Combined Efficiency correction

Event_4 $E_{\nu}=4.390517$ LepMom=1.381705

$vtx_x = -196.45$



*Integral of this histogram
= hadron geo eff at vtxX*

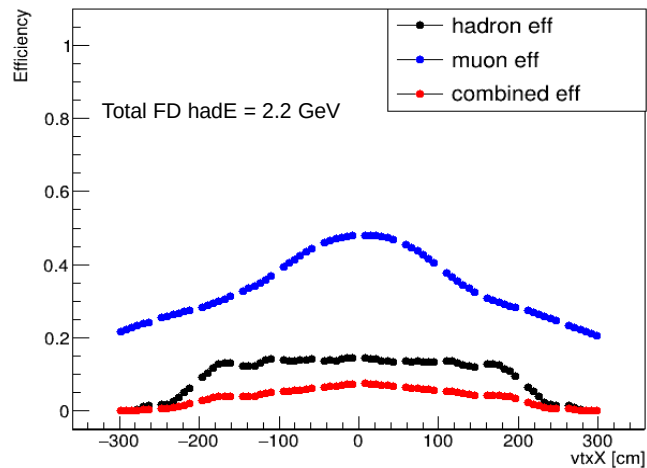
*Integral of this histogram
= ND (had + mu) geo eff at vtxX*

Muon, Hadron and Combined Efficiency correction

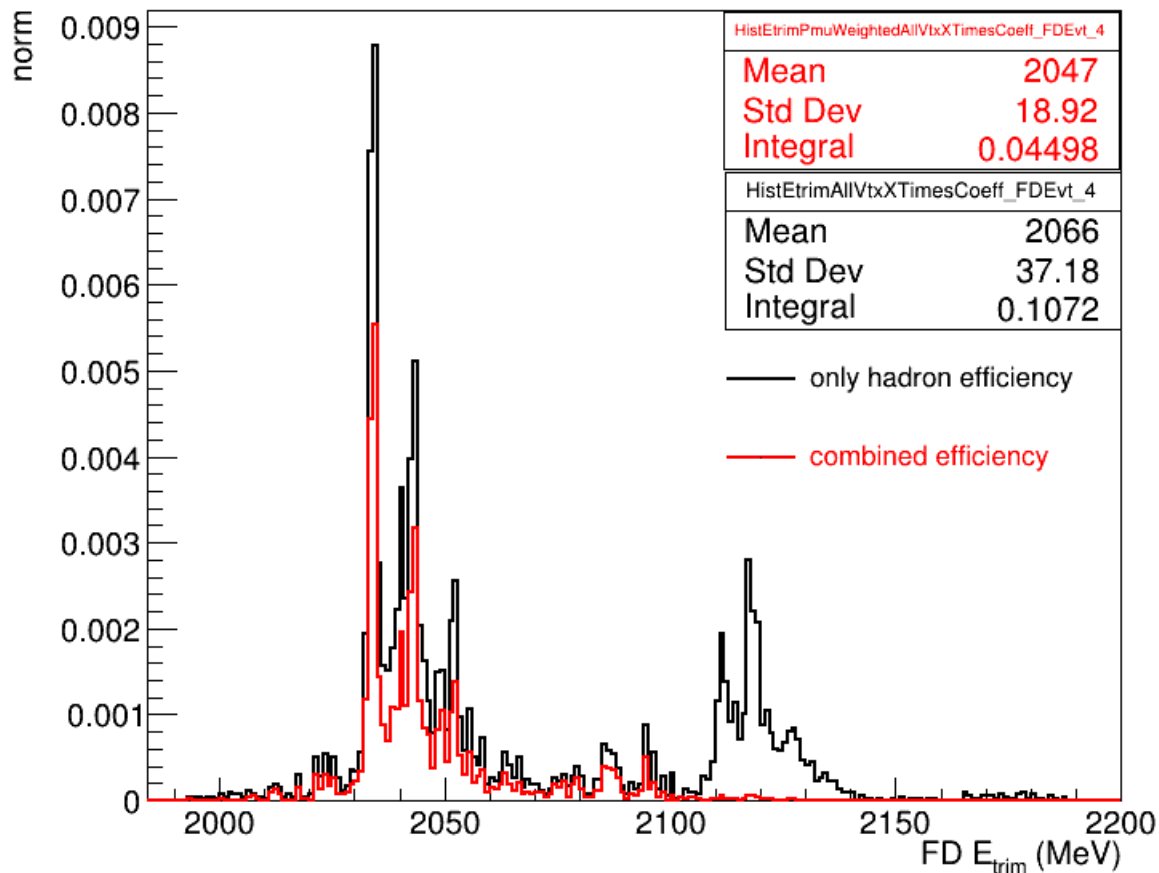
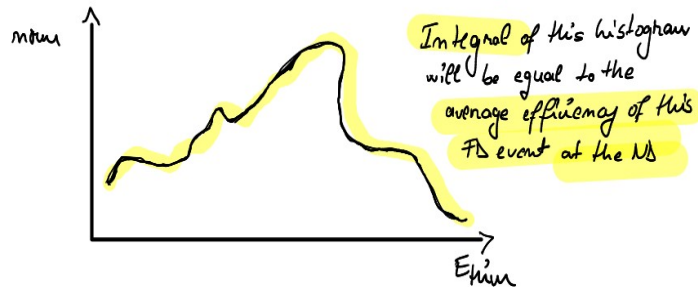
Event_4 $E_{\nu}=4.390517$ LepMom=1.381705

– sum over all vtxX and apply the coefficients (assume efficiency same at all det pos):

TotalFD Energy = 2209.36 MeV

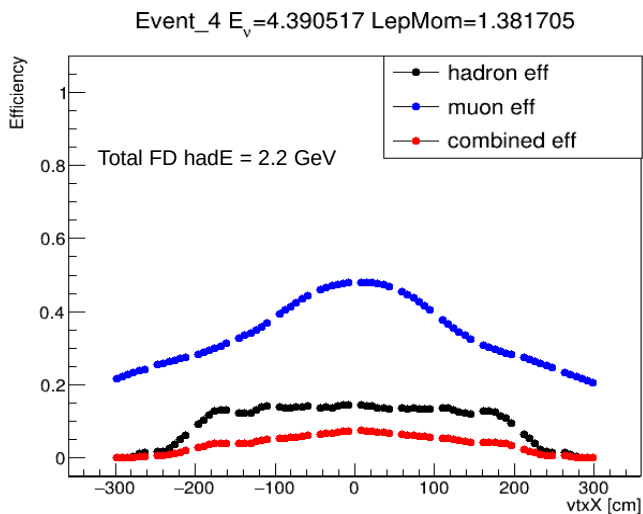


Add together all E_{trim} histograms (all vtx-x, all OA)
and apply the off-axis coefficients: $\sum_{OA} E_{\text{trim}}(OA) \cdot \text{coeff}(OA)$



Muon, Hadron and Combined Efficiency correction

– sum over all vtxX and apply the coefficients (assume efficiency same at all det pos):

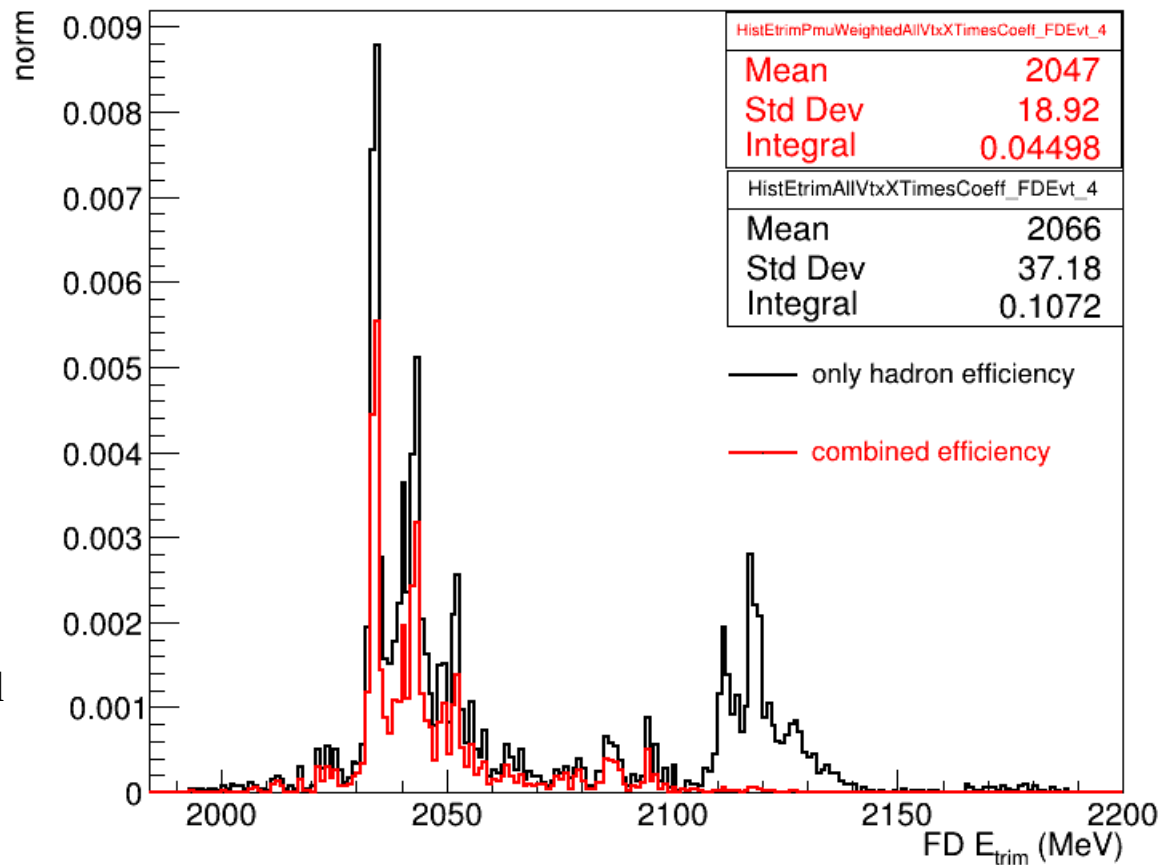


FD Event:

- E_{ν} = 4.39 GeV
- LepMom = 1.38 GeV
- total FD hadron energy = 2.2 GeV

- this event would be seen as 0.045 events in the ND if both hadron + muon efficiency accounted for (0.107 when only hadron efficiency)

Distribution in HadEtrim (hadron energy deposited in ND-LAr) of 1 FD Event as seen in the ND



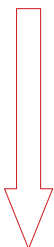
Distribution of all FD events as seen in the ND (hadron efficiency corrected)

- 10 FD events selected and translated to the ND
 - calculate the final ND Etrim distribution for each of the events and add them together to see their distribution in the ND
 - detector position sampling same as the ND CAFs

– 10 events in FD



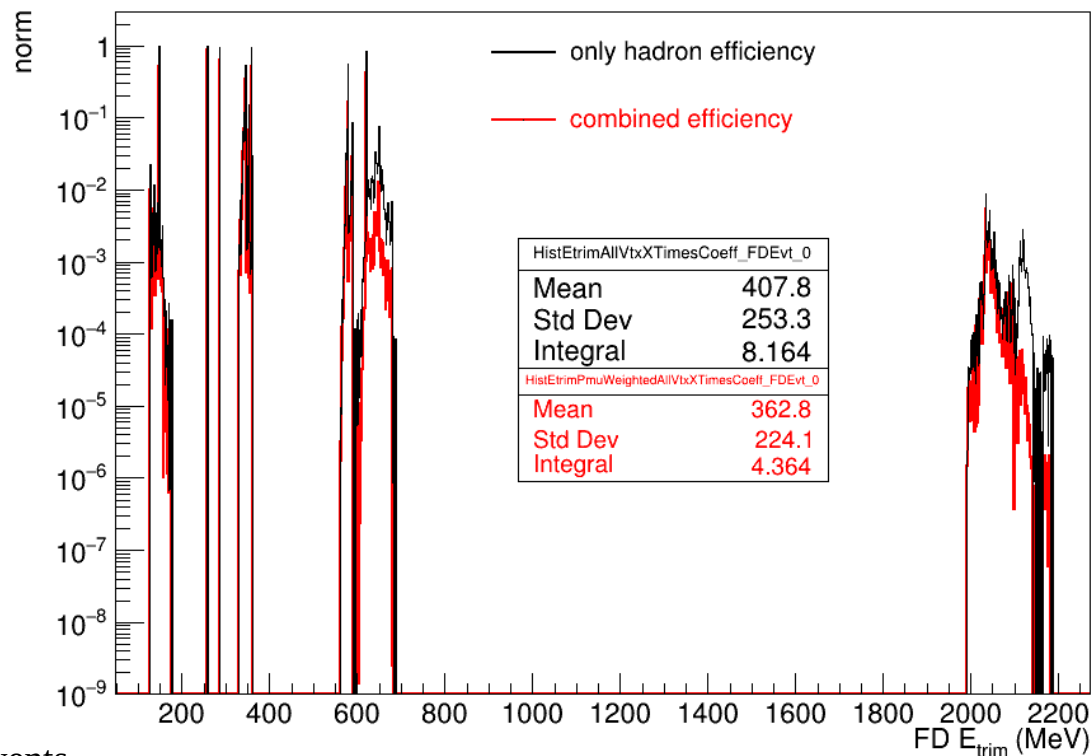
– 8.164 events seen in the ND (hadron eff only)



– 4.364 events seen in the ND (hadron+mu eff)

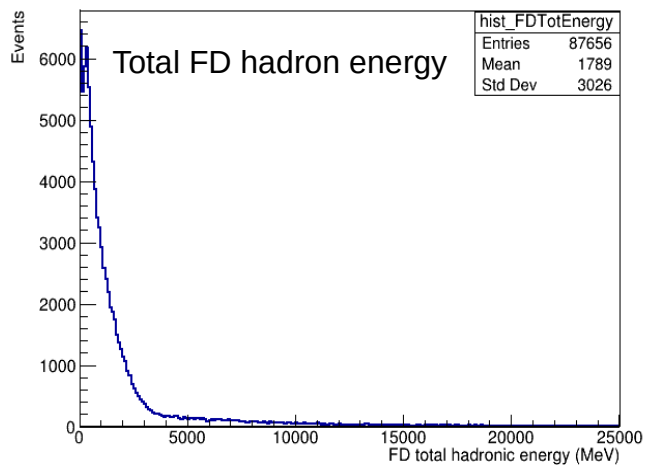
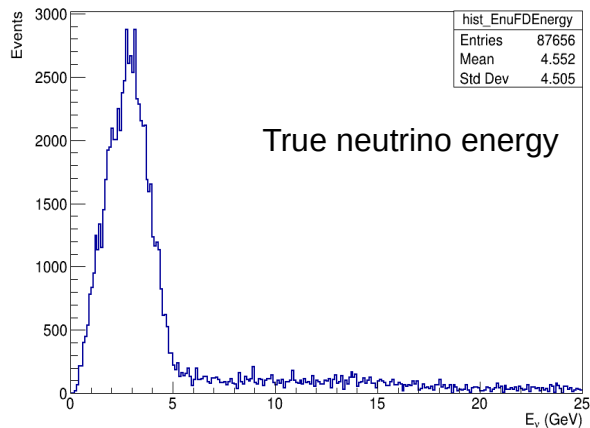
- * highest FD total energy = 2.2 GeV
- expecting less events seen by the ND for higher energy events

ND Events distribution of FD Events as seen in the ND (efficiency corrected)



Geometric efficiency – first results with higher statistics

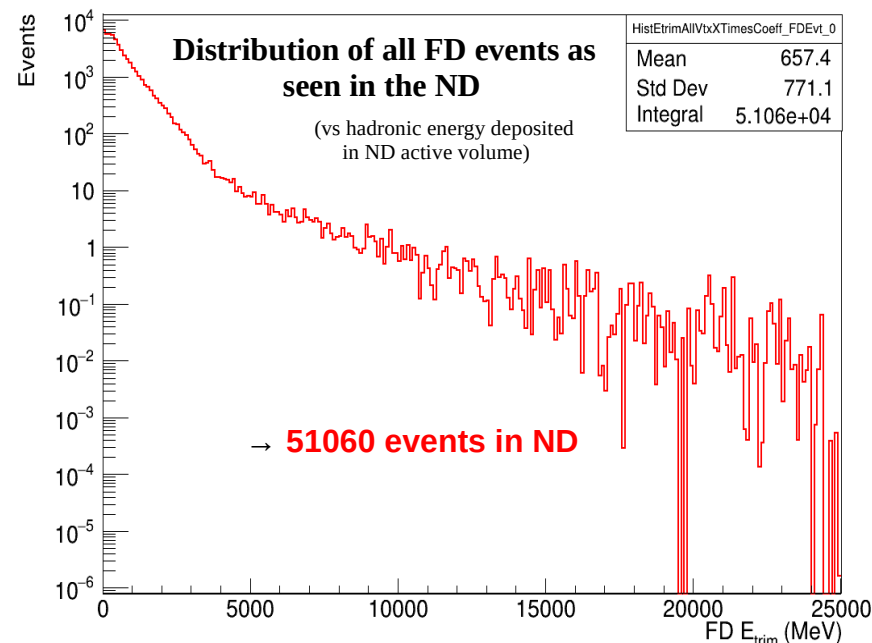
→ 87 656 FD events selected and translated to the ND (~ 10 % of simulated FD events pass selection)



Translated to ND
→
only hadron efficiency
applied so far !

Selection Cuts:

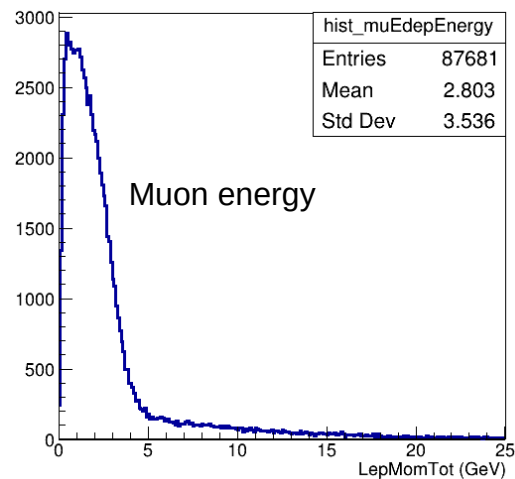
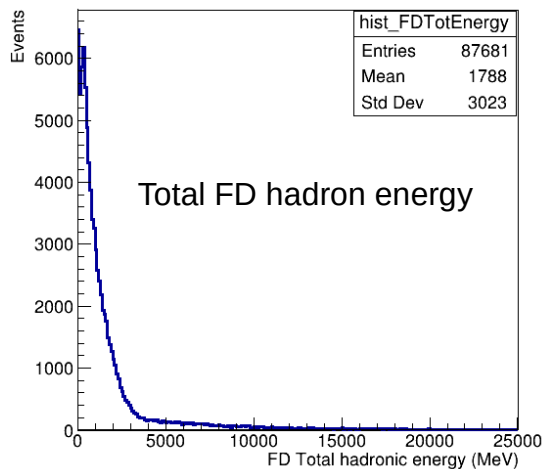
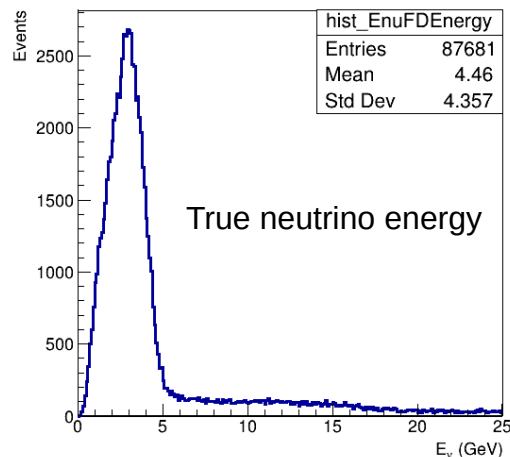
- event has to have muon/hadronic energy deposits
- CC events
- muon as final state lepton
- event vertex inside FD FV



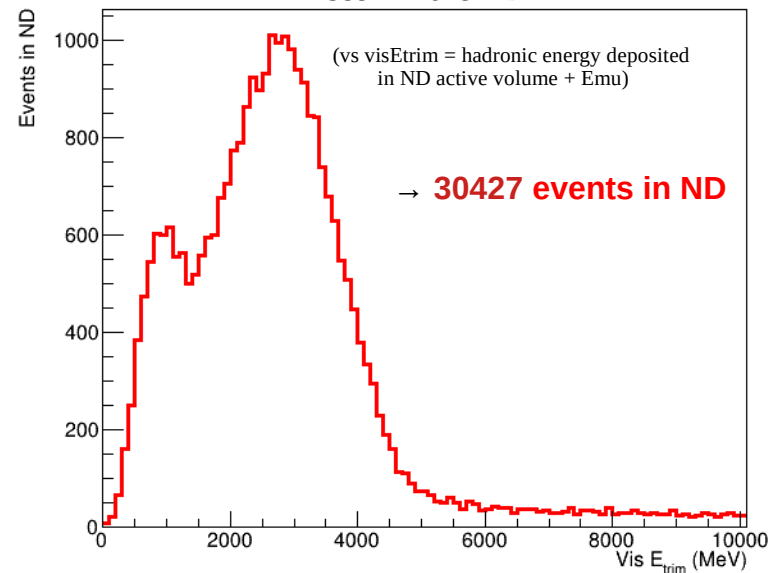
These events have to further be muon efficiency corrected and translated to ND visEtrim = E_{mu} + E_{trim}

Geometric efficiency – first results with higher statistics: μ + hadron combined

→ 87 656 FD events selected and translated to the ND ($\sim 10\%$ of simulated FD events pass selection)



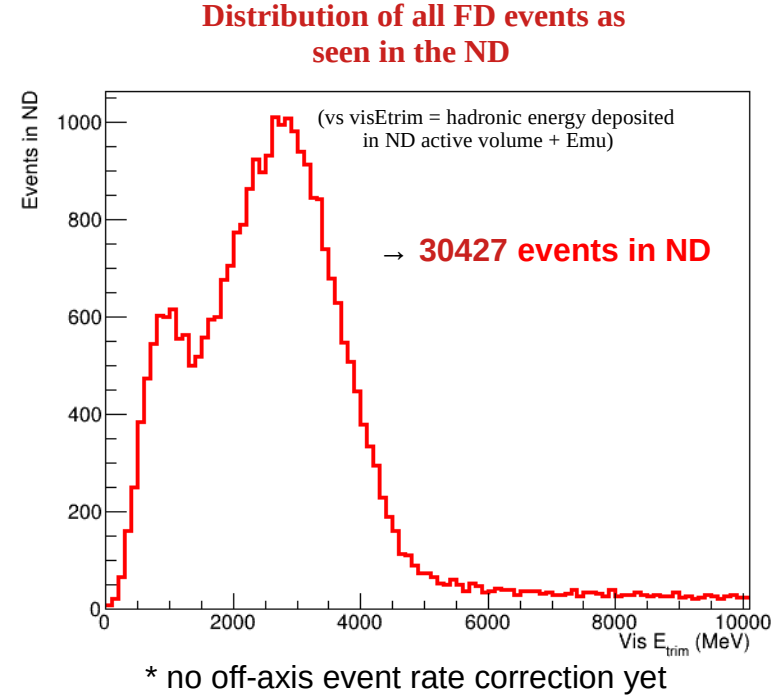
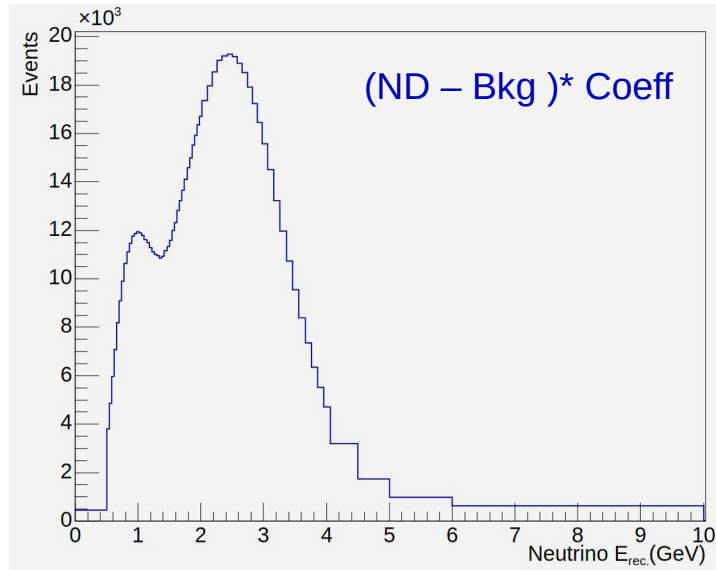
Distribution of all FD events as seen in the ND



* no off-axis event rate correction yet

Geometric efficiency – first results with higher statistics: mu + hadron combined

→ 87 656 FD events selected and translated to the ND ($\sim 10\%$ of simulated FD events pass selection)



– final fit / comparison between (ND - Bkg) * Coeff and Distrib of all FD Events as seen in the ND