External Background Rejection In KLOE-STT

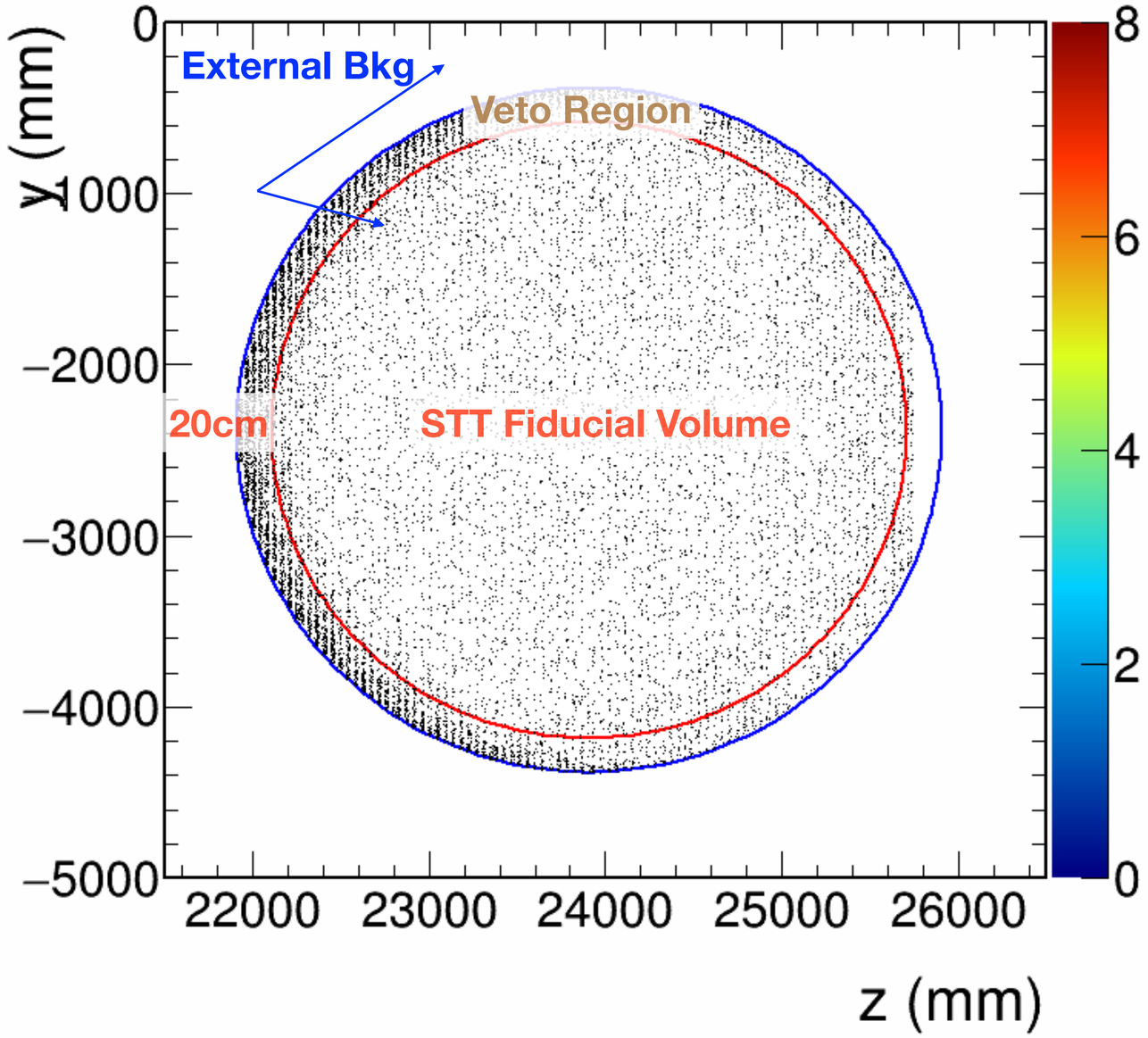
Duyang

Introduction

- External bkg is important for SAND especially because of the massive magnet.
- Study of ECAL-STT's ability to reject external backgrounds from ECAL and magnet.
- Based upon a GENIE-GEANT4 (Edepsim) simulation
  - 7.7 M CC, 4.8 M NC (normalized to 3:1) including STT, ECAL and magnet interactions.
- **Signal Definition**: CC events in STT fiducial volume.
- **Background Definition**: all external events from ECAL/Magnet.

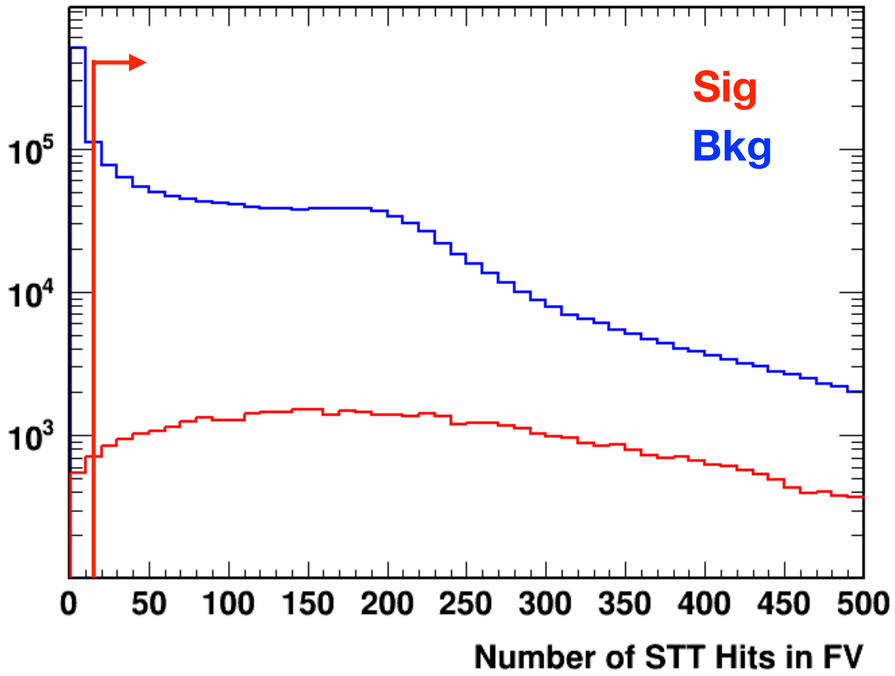
Fiducial Volume Definition

- Define a **fiducial volume** **20 cm** from STT-ECAL boundary.
  - In principle if shrink the FV and/or shift FV to downstream it could be even easier to reject external bkg, but I keep this “standard” FV definition to maintain statistics and for the needs of other analysis.
- Use the region between FV and ECAL as a “**veto region**”.

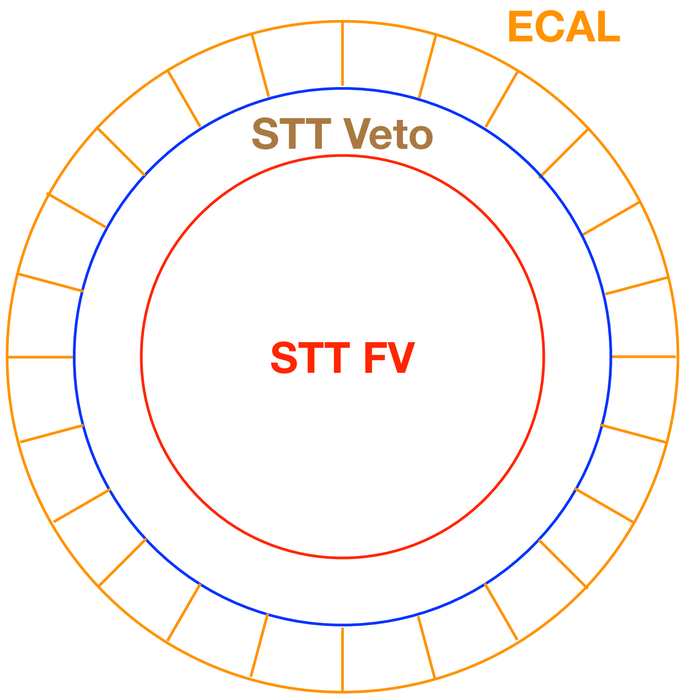


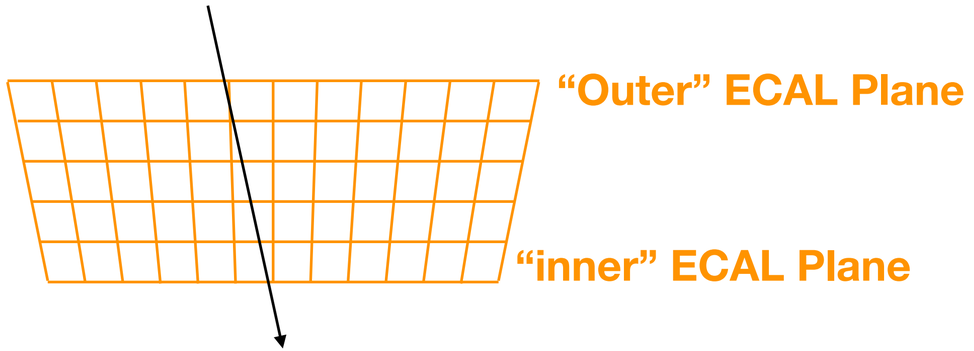
Pre-selection Cut

- Some loose pre-selection cuts on number of hits to reduce some obvious backgrounds.
  - Use STT hit energy threshold of 250 eV
  - ECAL raw cell hit energy threshold of 0.5 MeV.
- Smear time of STT and ECAL cell hits:
  - STT hits: **1 ns**
  - ECAL hits: **0.054/sqrt(E/GeV) + 0.05 ns** (E is the calibrated cell energy)



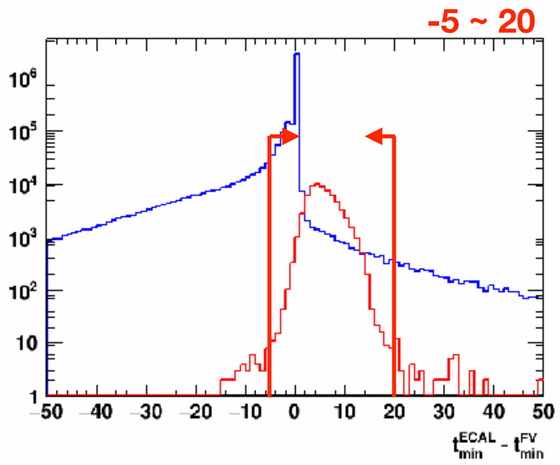
NN Inputs

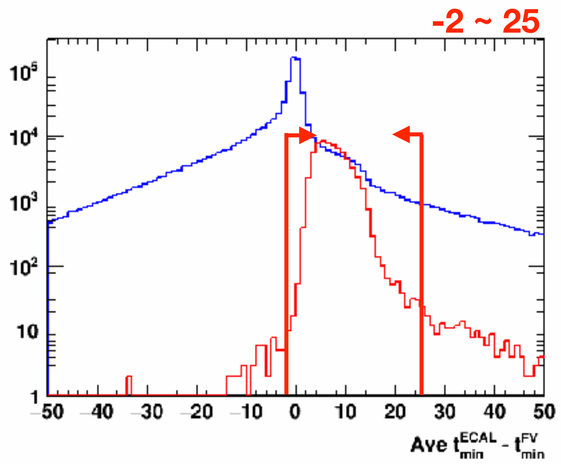


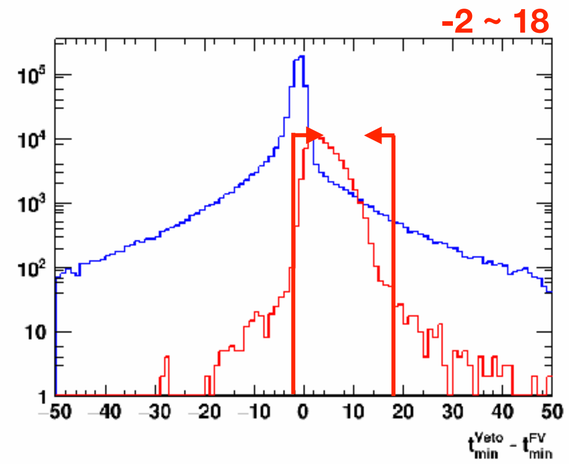


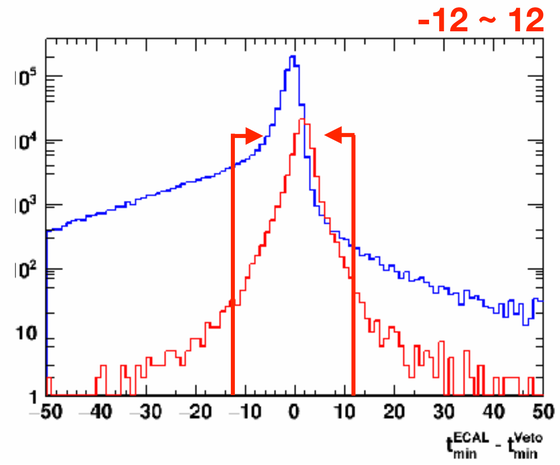
- Difference in the time of the earliest hits between:
  1. ECAL and STT FV
  2. STT Veto and FV
  3. ECAL and STT Veto
  4. Outer ECAL plane (the most outside ECAL plane with hits) and inner ECAL plane (the most inner ECAL plane with hits)
  5. Outer ECAL plane and STT FV
  6. Outer ECAL plane and STT Veto
  7. Average over ECAL planes and STT FV
- 7 variables used as input to an Artificial Neural Network.

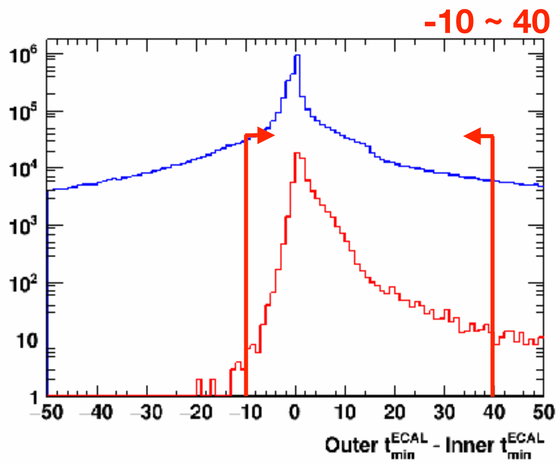
NN Inputs

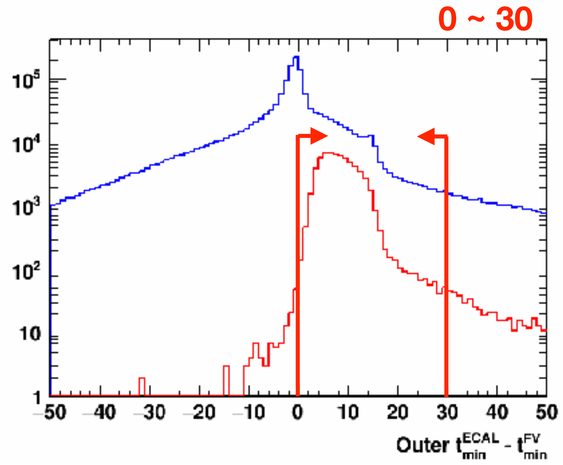


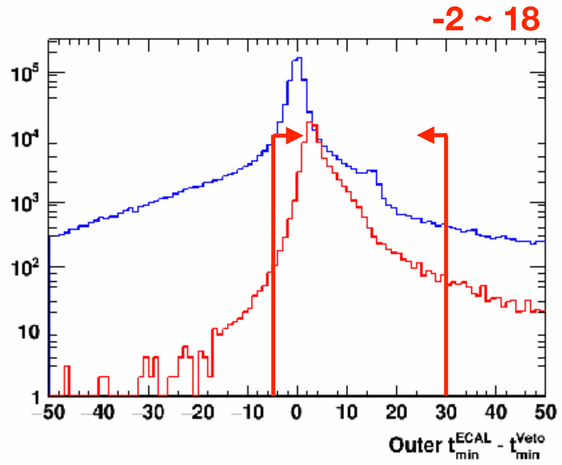






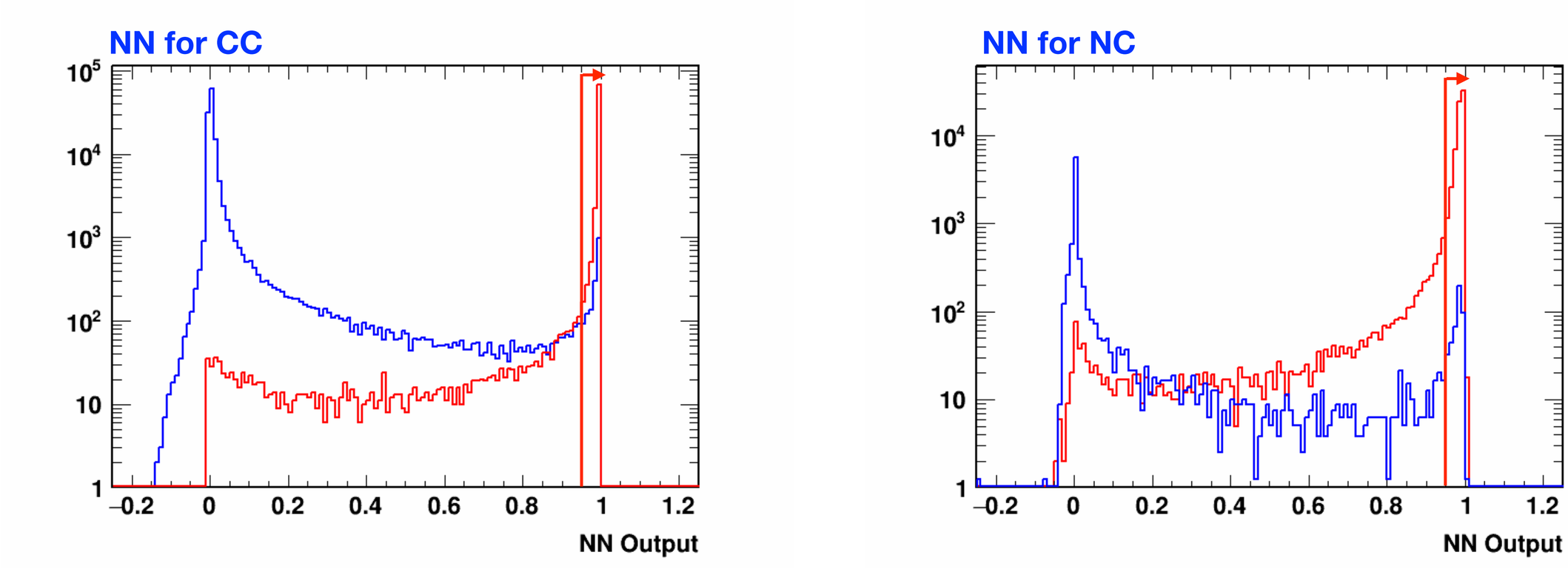






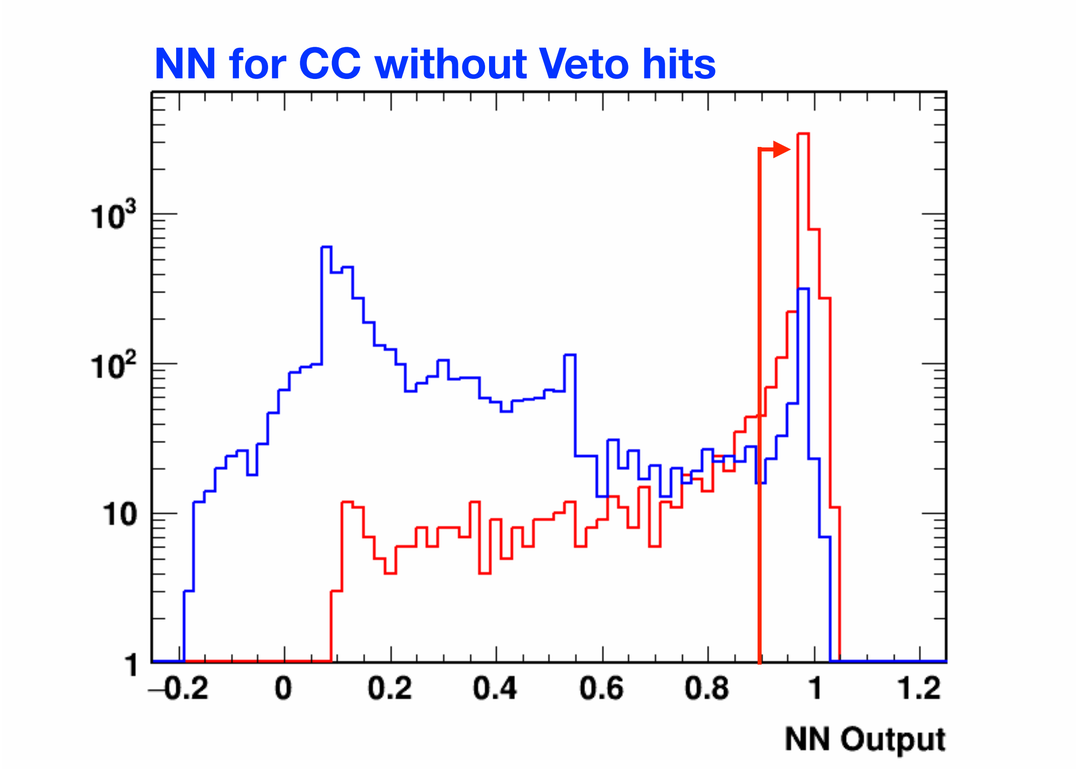
- Use timing informations as inputs to NN.
- Some loose pre-selection cuts on the NN input variables to reject obvious backgrounds before feed into NN.

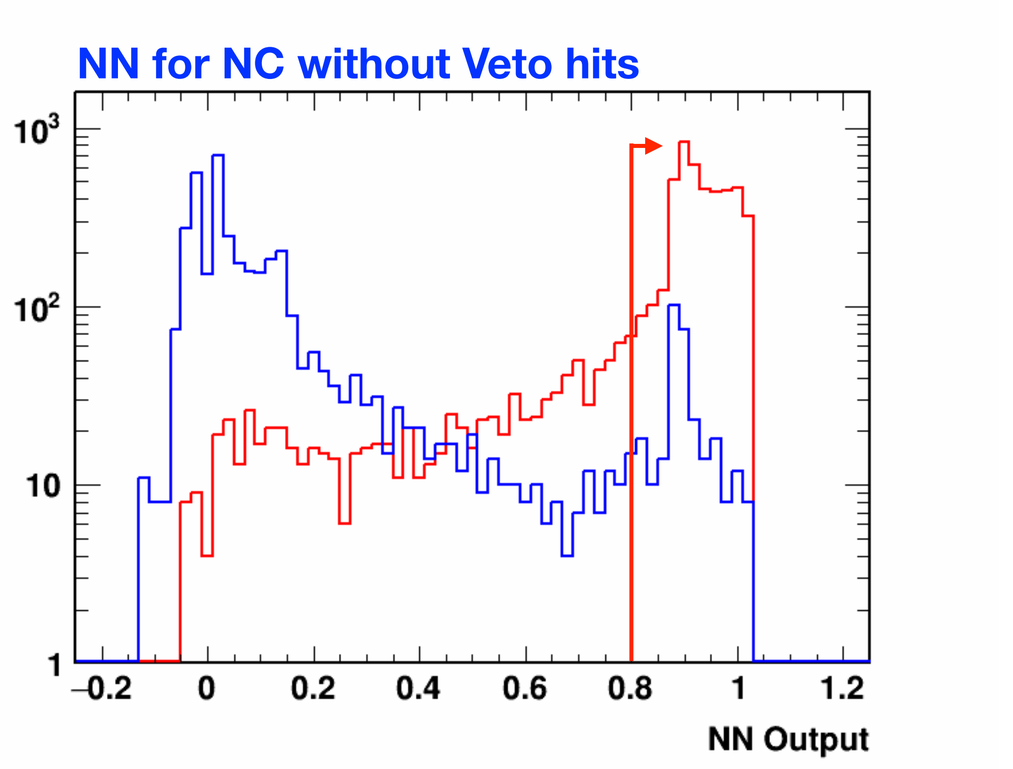
NN Outputs (for Events with Veto Hits)



- Slightly better result if train separate NNs for rejecting CC and NC backgrounds.
- NNo (CC) > 0.95 && NNo (NC) > 0.95.

NN Outputs (for Events with no Veto Hits)





- For small portion of events (~9% of signal) without veto hits, remove the inputs based upon veto hit timing and train separate NNs (with 4 inputs).
- NNo (CC, no Veto hit) > 0.9 && NNo (NC, no Veto hit) > 0.8.

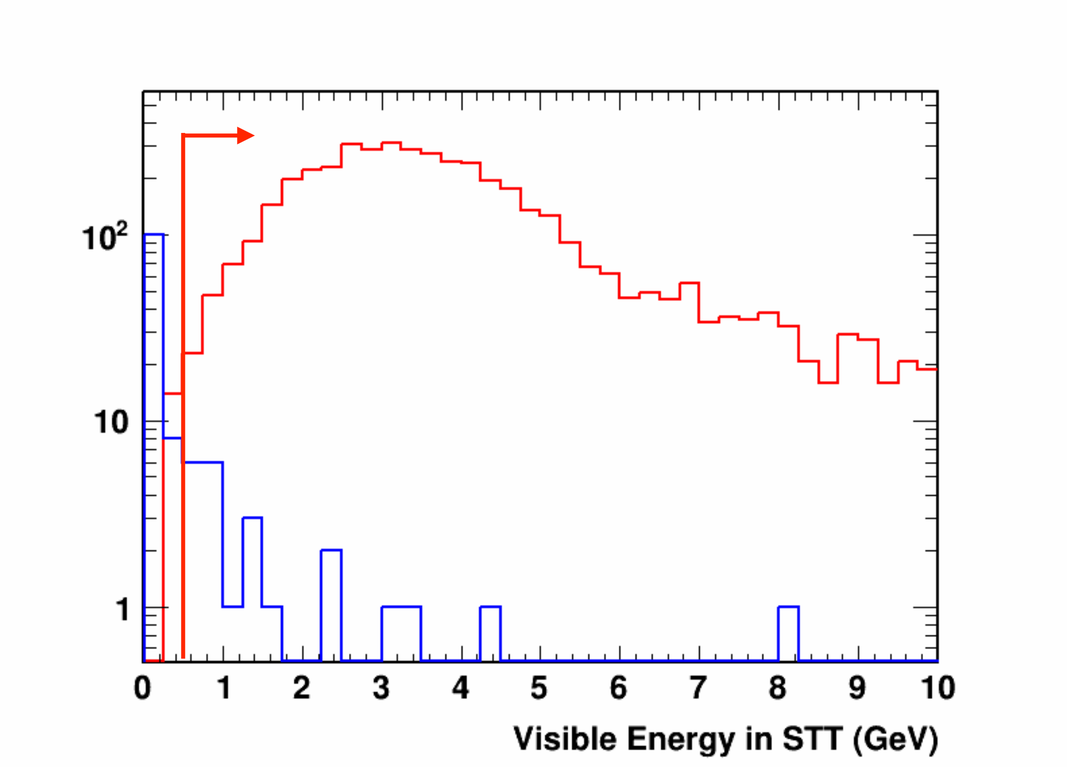
Cut Flow Table

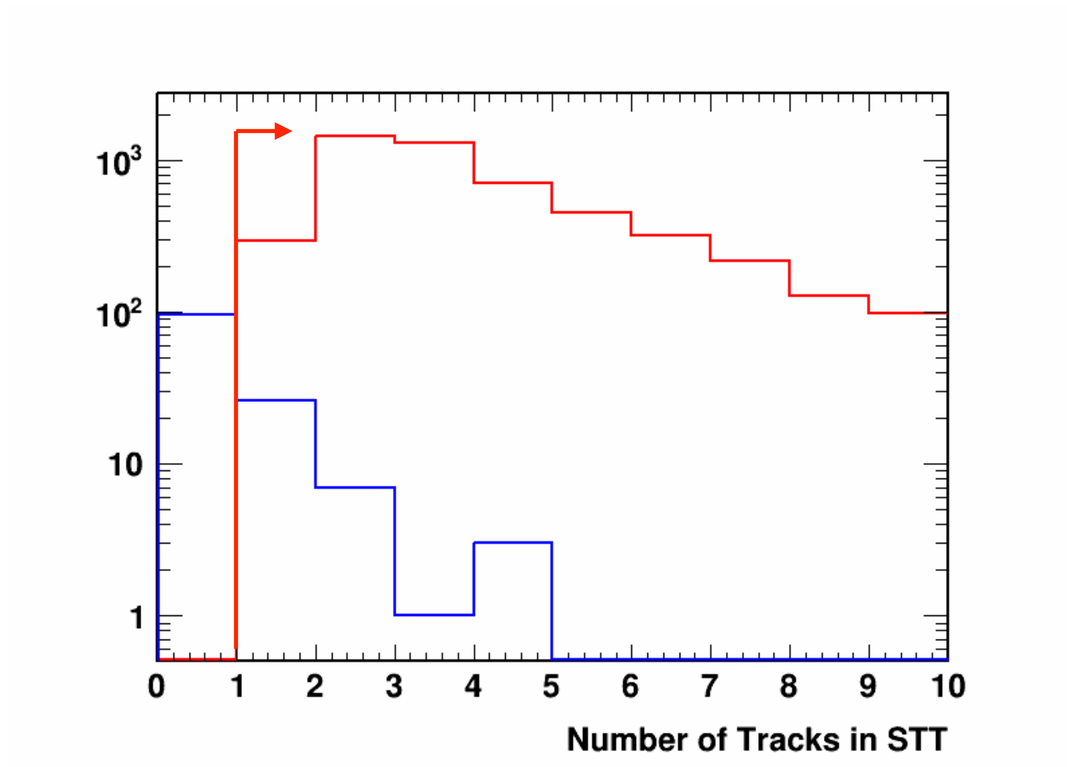
Cut	Sig Eff	Bkg Eff	Bkg Eff	Bkg Eff	Purity
1	0.98419	0.08723	0.02719	0.07218	0.09714
2	0.98141	0.07360	0.01641	0.05926	0.11558
3	0.97638	0.06840	0.01436	0.05485	0.12316
4	0.97531	0.06153	0.01254	0.04925	0.13516
5	0.97459	0.06140	0.01236	0.04911	0.13540
6	0.96430	0.05959	0.01135	0.04750	0.13808
7	0.95847	0.02190	0.00492	0.01765	0.30001
8	0.95760	0.02188	0.00489	0.01762	0.30019
9	0.93067	0.00027	0.00031	0.00028	0.96357
10	**0.89395**	0.00016	0.00021	0.00017	**0.97595**

Overall 89% efficiency and 98% purity with only hits and timing information

- 1. STT FV hit number > 15
- 2. Range of Tmin difference between Ecal and FV
- 3. Range of Tmin difference between Ecal average over planes and FV
- 4. Range of Tmin difference between Veto and FV (for events with veto hits only)
- 5. Range of Tmin difference between Ecal and Veto (for events with veto hits only)
- 6. Range of Tmin difference between most outer Ecal plane and most inner Ecal plane
- 7. Range of Tmin difference between the most outer ECAL plane and FV
- 8. Range of Tmin difference between the most outer ECAL plane and Veto.
- 9. NN for CC
- 10. NN for NC

“Higher Level” Reconstruction Cuts





- Using the STT smearing made by Bing.
  - Visible energy in STT > 0.5 GeV
  - Number of reconstructed tracks >= 1 in STT (minimal 4 YZ hits).

Complete Cut Flow Table with Reco Cuts

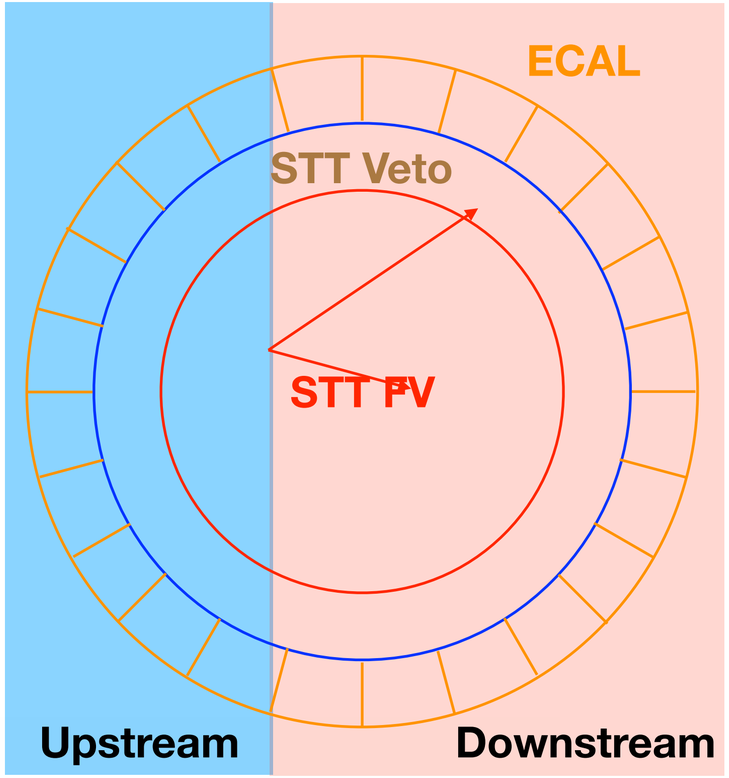
Cut	Sig Eff	Bkg Eff	Bkg Eff	Bkg Eff	Purity
1	0.98419	0.08723	0.02719	0.07218	0.09714
2	0.98141	0.07360	0.01641	0.05926	0.11558
3	0.97638	0.06840	0.01436	0.05485	0.12316
4	0.97531	0.06153	0.01254	0.04925	0.13516
5	0.97459	0.06140	0.01236	0.04911	0.13540
6	0.96430	0.05959	0.01135	0.04750	0.13808
7	0.95847	0.02190	0.00492	0.01765	0.30001
8	0.95760	0.02188	0.00489	0.01762	0.30019
9	0.93067	0.00027	0.00031	0.00028	0.96357
10	0.89395	0.00016	0.00021	0.00017	0.97595
11	**0.89186**	0.00006	0.00002	0.00005	**0.99367**

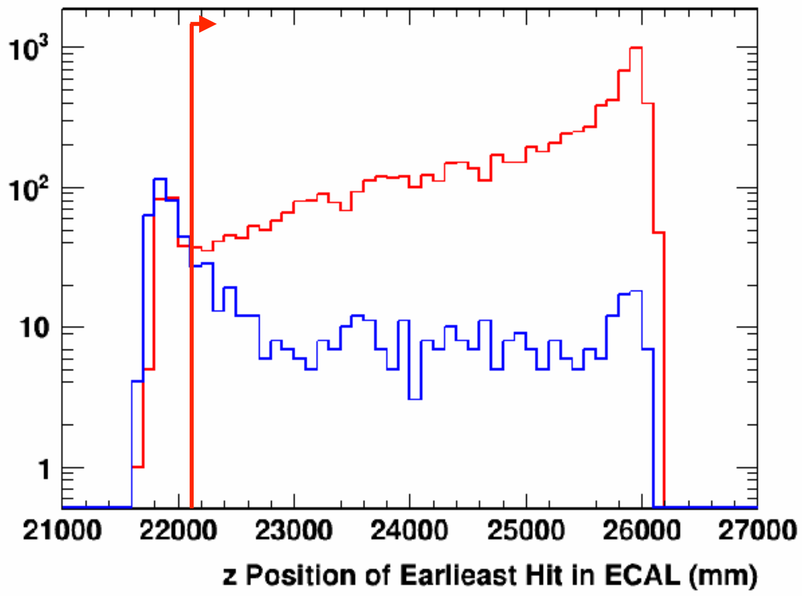
Overall 89% efficiency and >99% purity with reco cuts

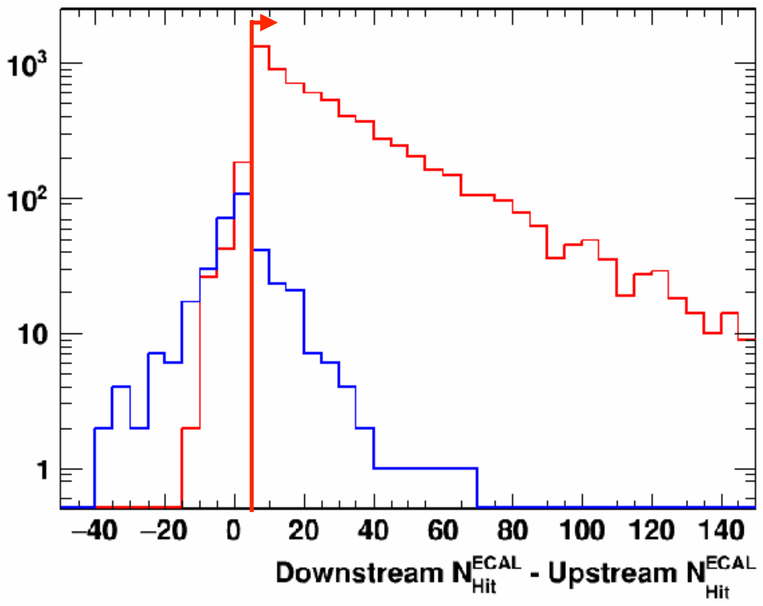
- 1. STT FV hit number > 15
- 2. Range of Tmin difference between Ecal and FV
- 3. Range of Tmin difference between Ecal average over planes and FV
- 4. Range of Tmin difference between Veto and FV (for events with veto hits only)
- 5. Range of Tmin difference between Ecal and Veto (for events with veto hits only)
- 6. Range of Tmin difference between most outer Ecal plane and most inner Ecal plane
- 7. Range of Tmin difference between the most outer ECAL plane and FV
- 8. Range of Tmin difference between the most outer ECAL plane and Veto.
- 9. NN for CC
- 10. NN for NC
- 11. Evis>0.5 GeV, Number of tracks >=1

ECAL Topology Information

- Adding some topology information from ECAL:
  - Z postion of the earliest ECAL hit
  - Difference between number of upstream/ downstream ECAL (relative to the earliest hit in STT) within 20 ns from the earliest hit in STT.







Cut-Based Analysis

Cut	Sig Eff	CC Bkg Eff	NC Bkg Eff	Bkg Eff	Purity
1	0.98319	0.08750	0.02756	0.07242	0.09969
2	0.97279	0.00863	0.00326	0.00728	0.52165
3	0.94288	0.00443	0.00195	0.00381	0.66897
4	0.93415	0.00396	0.00136	0.00331	0.69733
5	0.92145	0.00097	0.00081	0.00093	0.89003
6	0.88949	0.00050	0.00063	0.00053	0.93158
7	0.83673	0.00014	0.00021	0.00015	0.97780
8	**0.83596**	0.00002	0.00001	0.00002	**0.99755**

Overall 84% efficiency and >99% purity with cut-based analysis

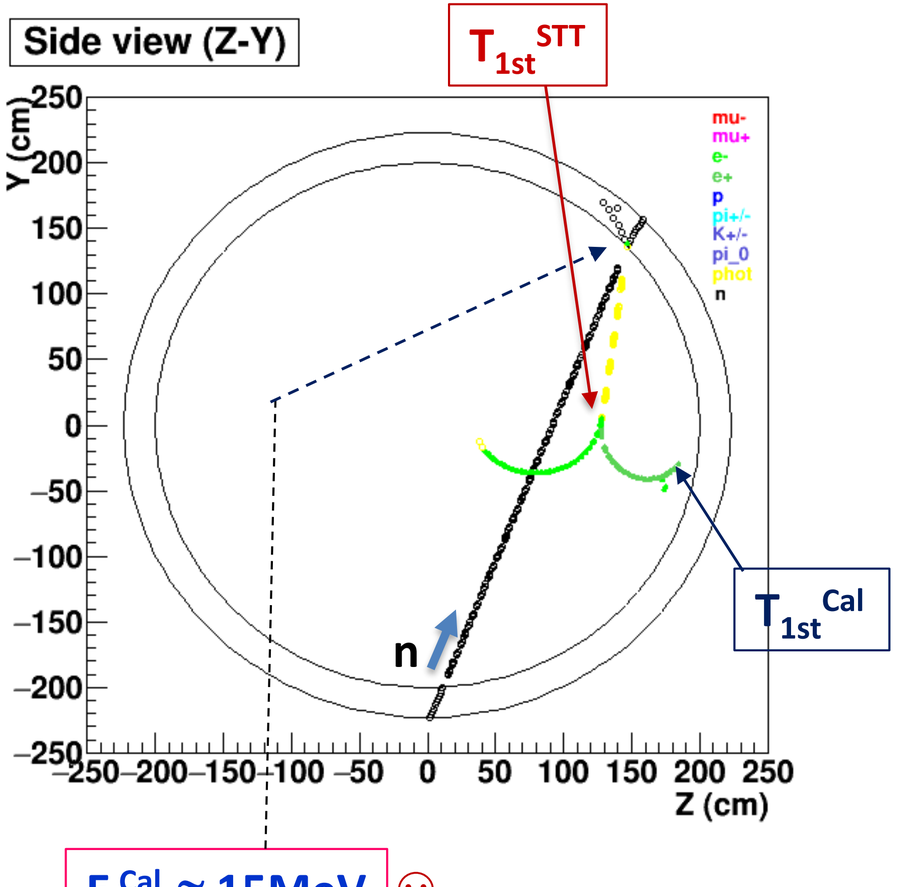
- 1. STT FV hit number > 15
- 2. Tmin difference between Ecal and FV > 0
- 3. Tmin difference between Veto and FV (for events with veto hits only) > 0
- 4. Tmin difference between most outer Ecal plane and most inner Ecal plane > -5
- 5. Tmin difference between the most outer ECAL plane and FV > 2
- 6. Z position of earliest ECAL hit > 22210 (10cm downstream from the upstream boundary of FV)
- 7. Number of downstream (relative to earliest FV hit, within 20 ns window) ECAL hits - upstream ECAL hits > 5;
- 8. N track >=1 && Evis >= 0.5 GeV

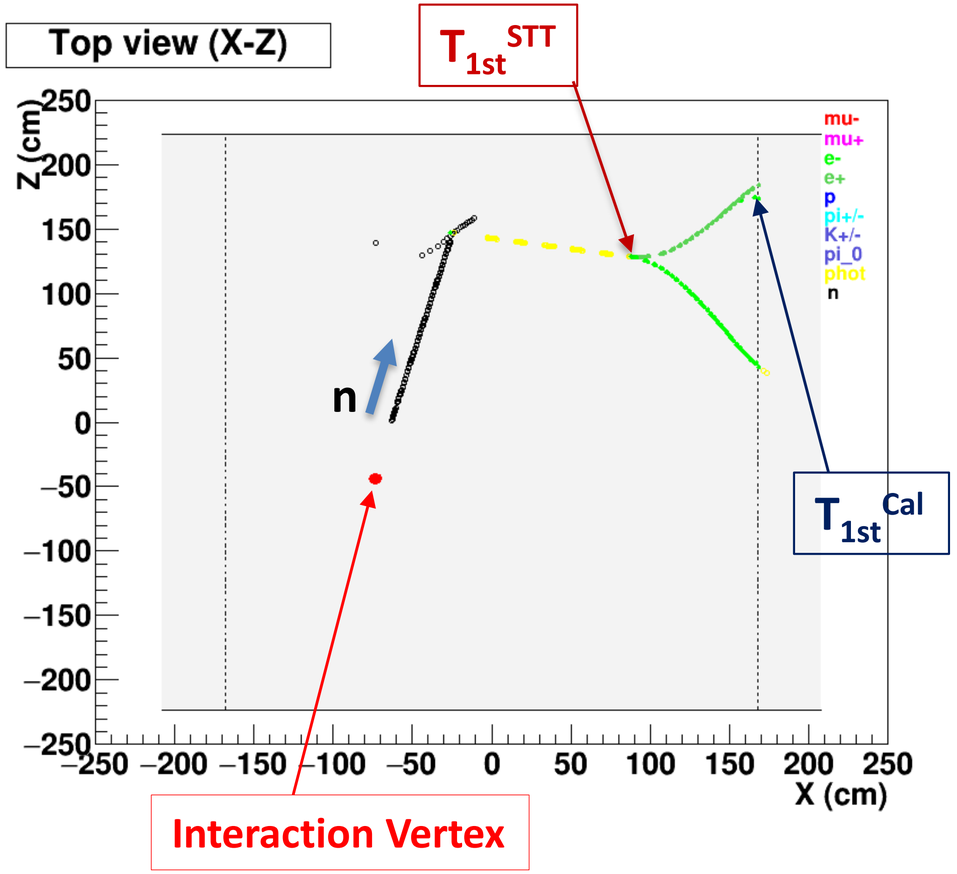
Summary

- The preliminary study shows that ECAL-STT rejects external bkg quite well.
- Further improvements:
  - NN analysis with ECAL topology information.
  - Optimize cuts.
  - Scan the remaining backgrounds.

Backup Slides

Event Display by Fluka





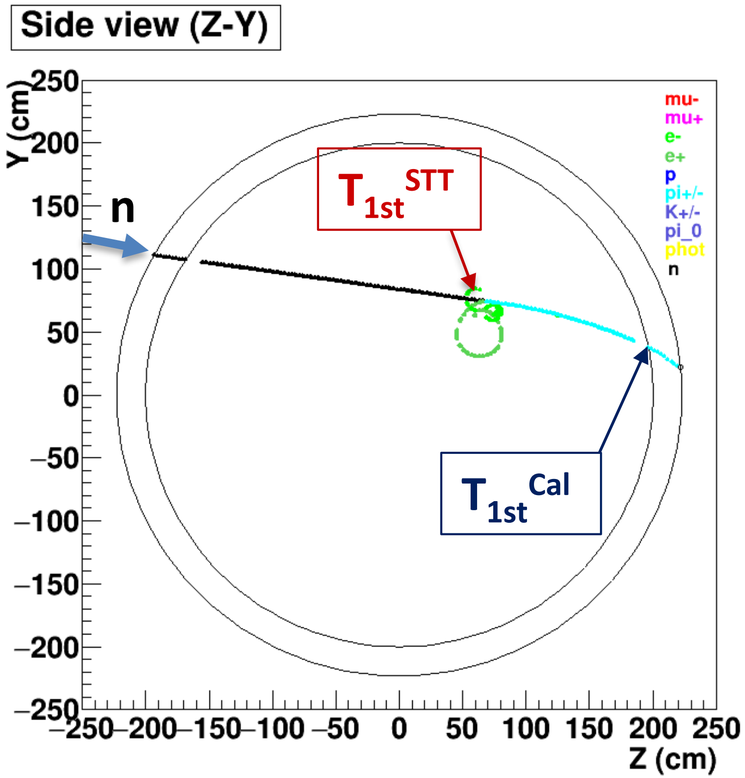
$E_i^{Cal} \cong 15MeV$ ☹

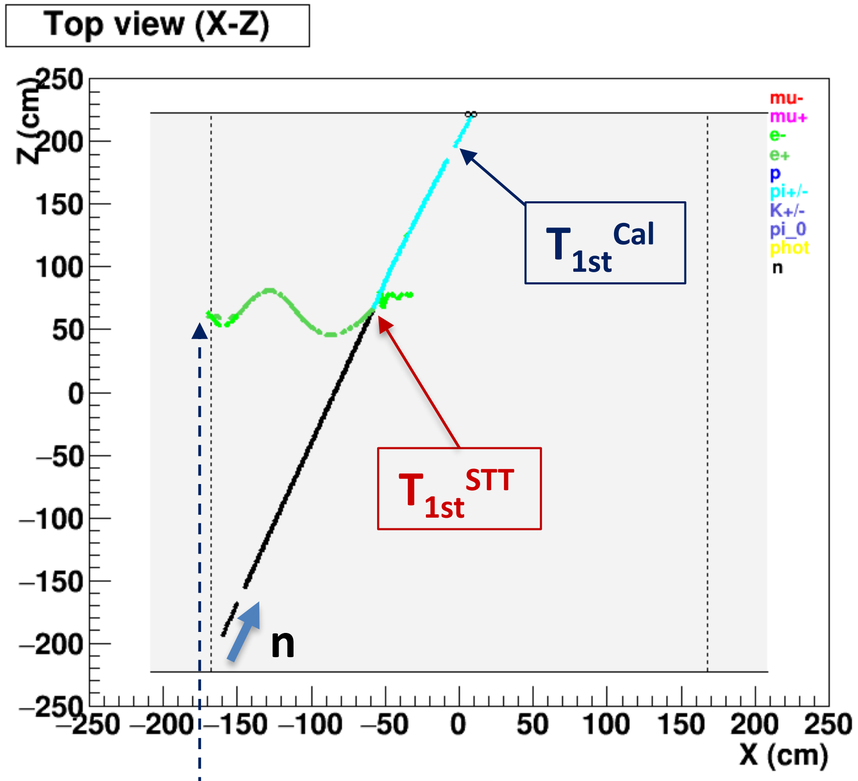
$T_i^{Cal} < T_{1st}^{STT}$! ☺

- Neutron crosses ECal (without hits), enters STT (producing some delayed hits), then crosses again ECal releasing >20 MeV in a cell

Fluka simulation and EVD by P. Bernarnidi and A. Surdo

Event Display by Fluka





- Neutron crosses ECal without giving hits and enters STT (where some prompt hits and tracks are produced)

$E_i^{Cal} < 10MeV$ ☹

$T_i^{Cal} > T_{1st}^{STT}$ ☹

Fluka simulation and EVD by P. Bernarnidi and A. Surdo