External Background Rejection In KLOE-STT Updates

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Introduction

- Study of ECAL-STT's ability to reject external backgrounds from ECAL and magnet.

- Based upon GEINIE-GEANT4 (Edepsim) simulation produced by Bing.

  - 7.7 M CC, 4.8 M NC (normalized to 3:1) including STT, ECAL and magnet interactions.

- **Signal Definition**: CC events in STT FV.

- **Background Definition**: all external events from ECAL/Magnet.

- Strategy: develop variables based upon:

  - Timing information.

  - Topology information (in ECAL).

  - Reconstruction-level information.

- Report both a cut-based result and a NN result.

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".
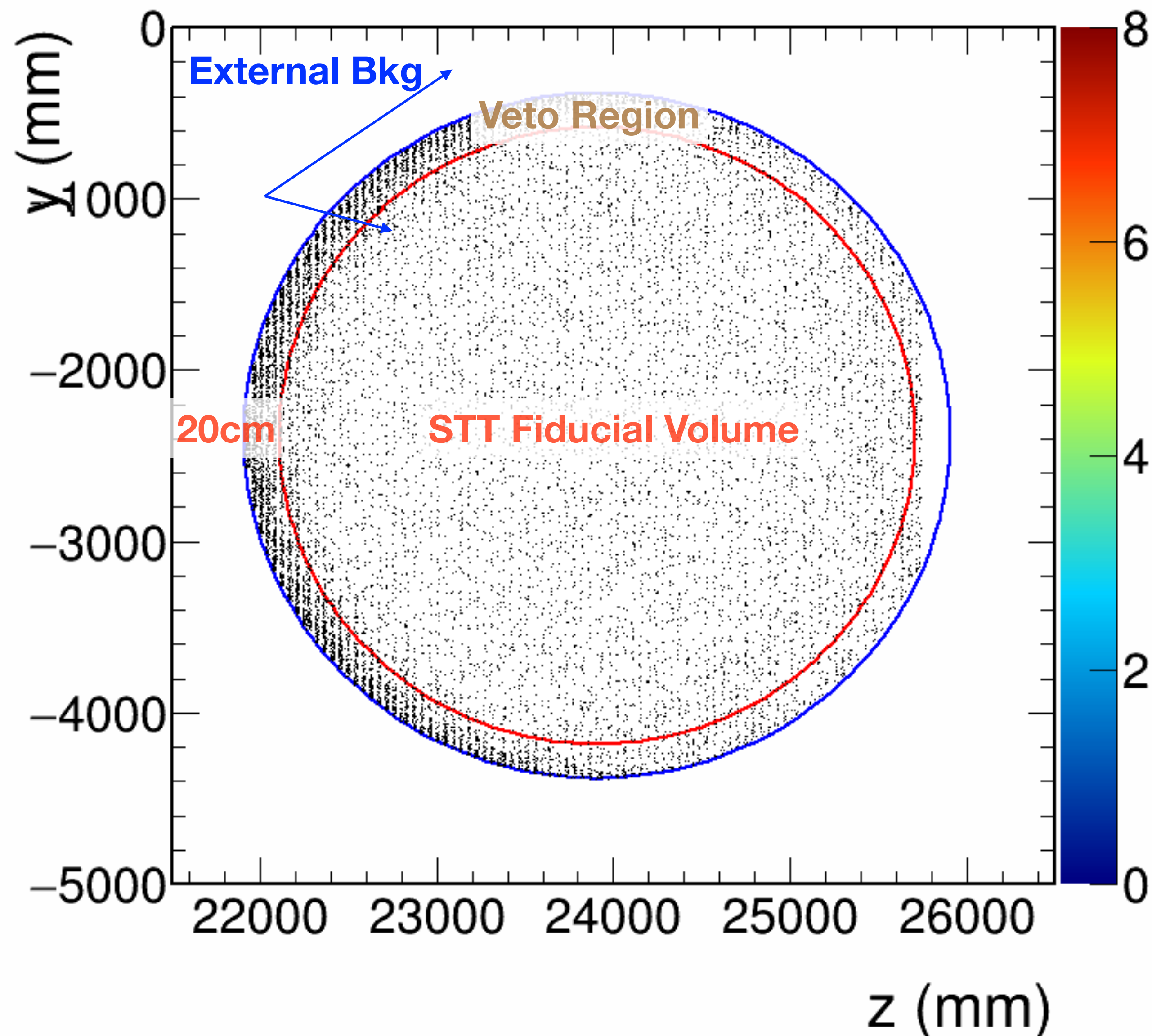
Threshold and Smearing

- Thresholds:
  - STT hit energy threshold: 250 eV
  - ECAL raw cell hit energy threshold: 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)
- Loose pre-selection cut on number of FV hits (>15) to reduce some obvious backgrounds.

Number of STT Hits in FV
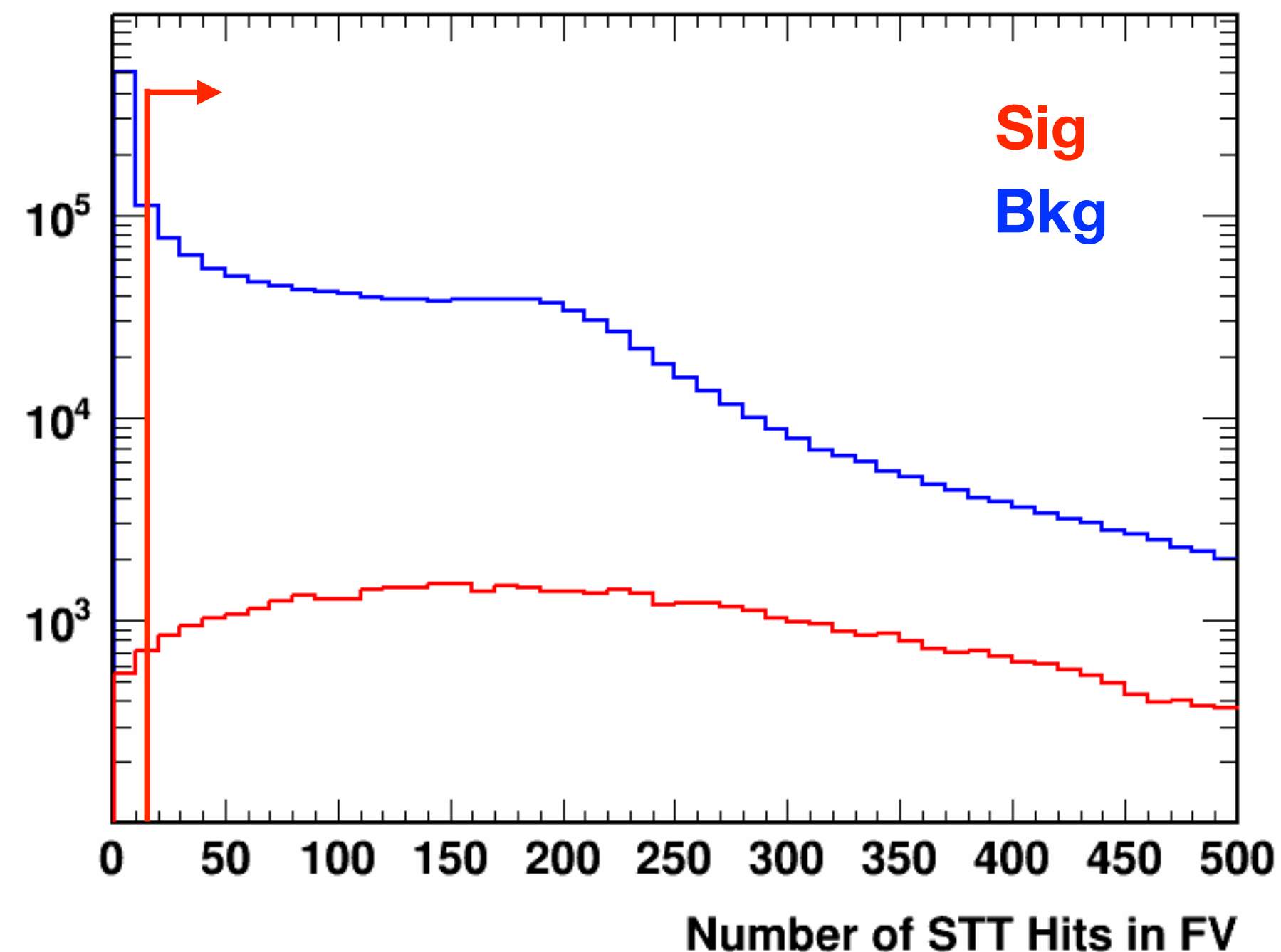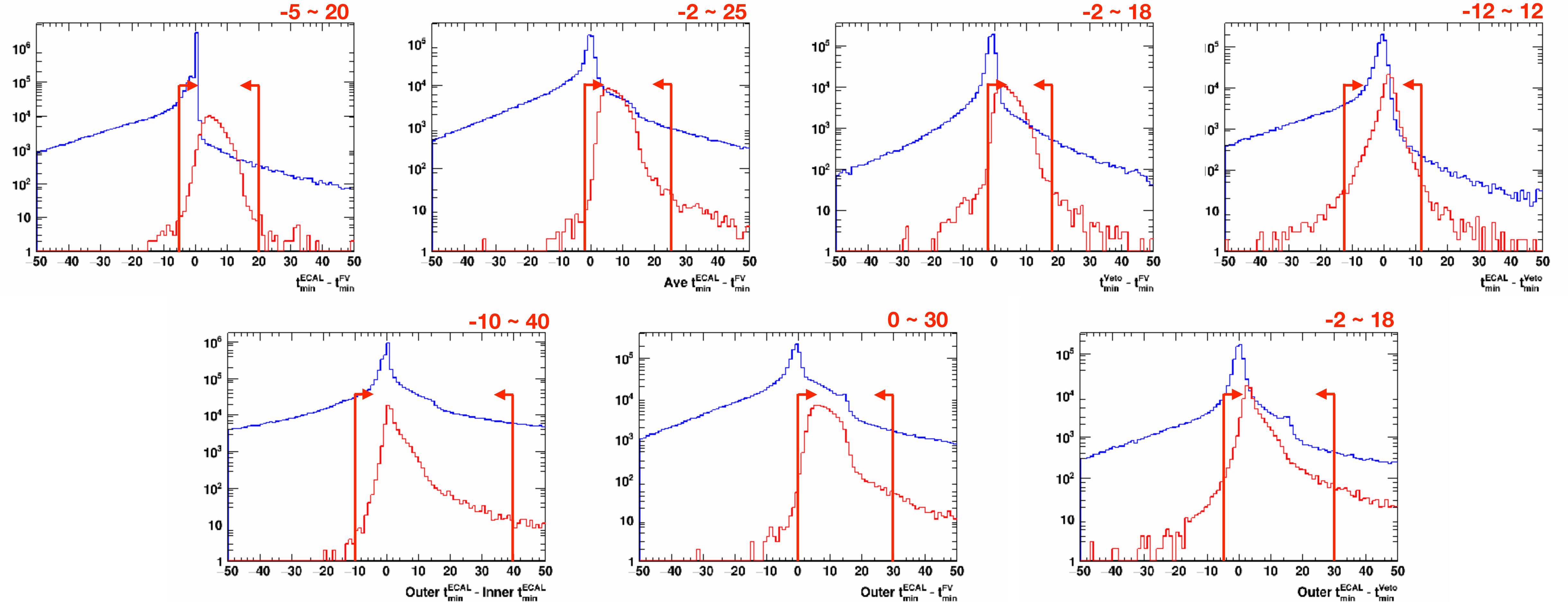
Timing Infomations
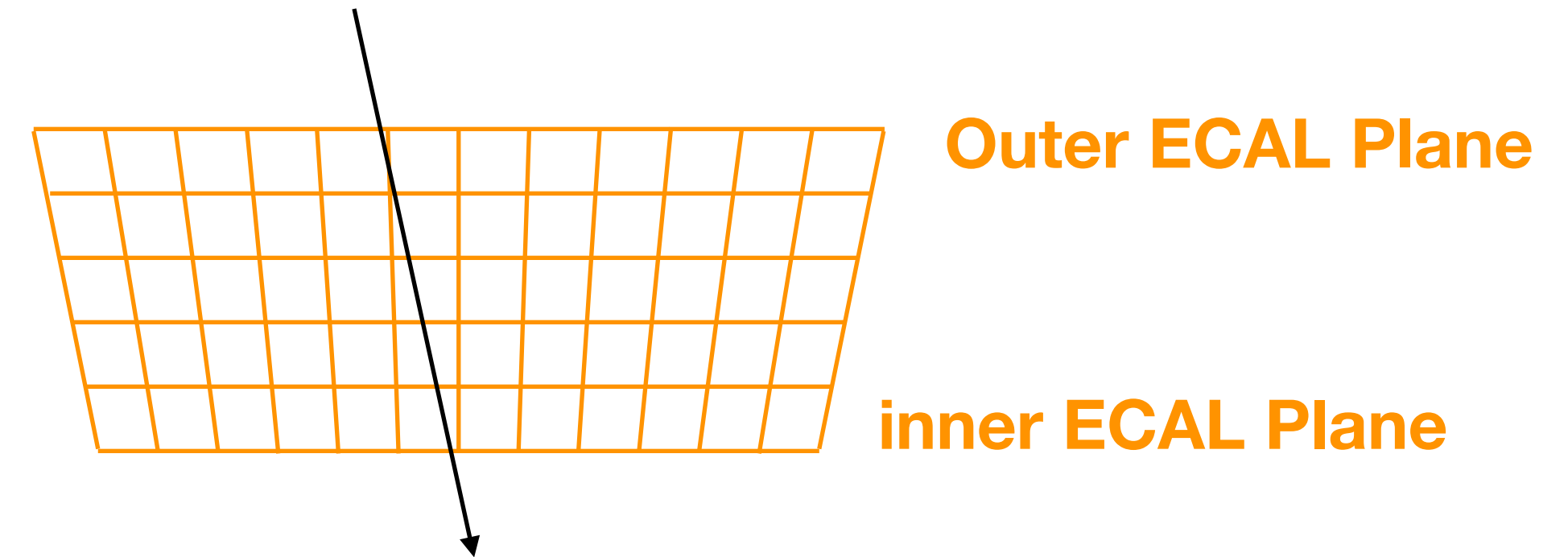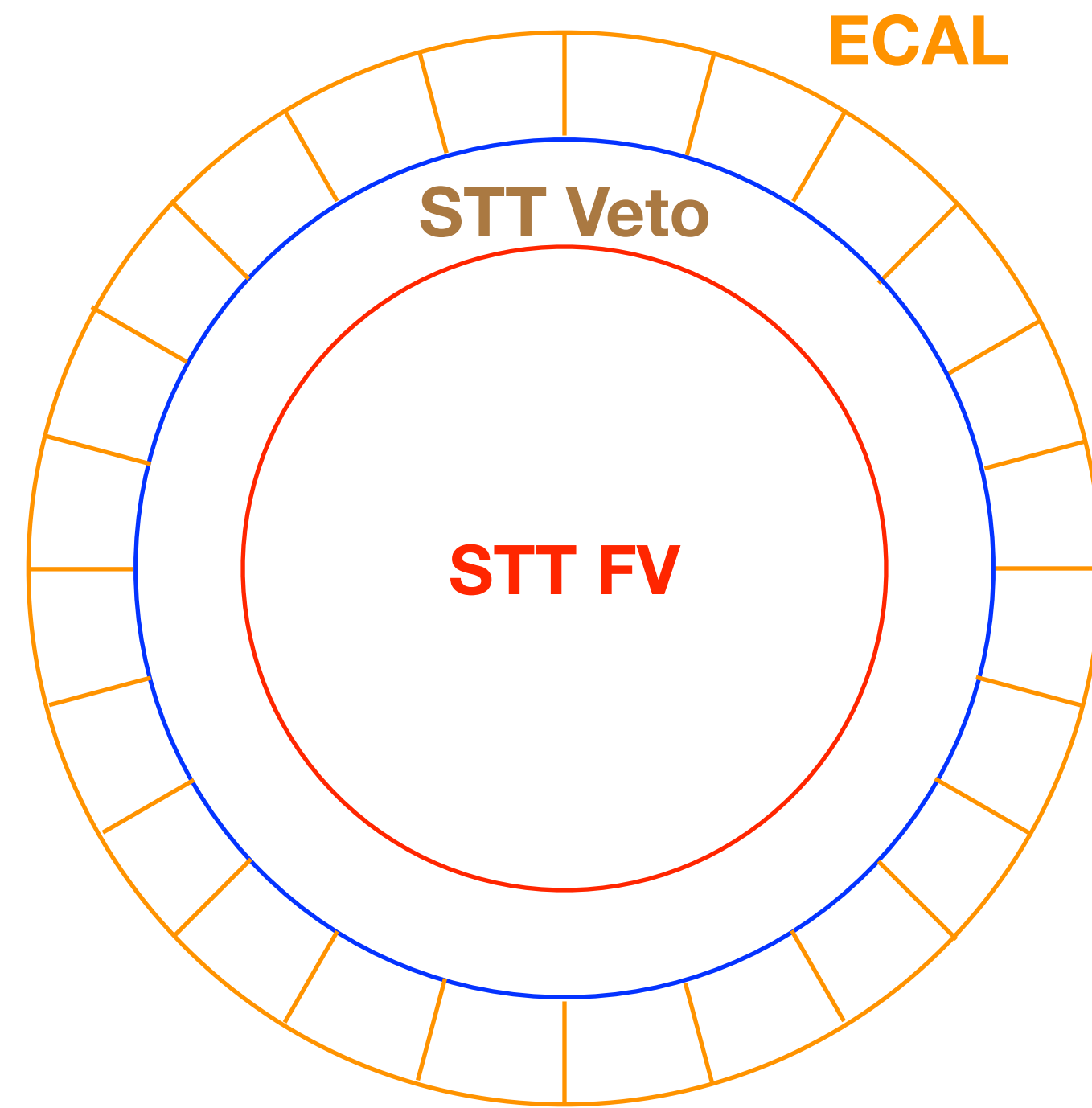
- Difference in the time of the earliest hits between:

    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

Timing Infomations

- 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.

ECAL Topological 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.
  - Difference in energy deposition between outer/inter upstream ECAL layers.
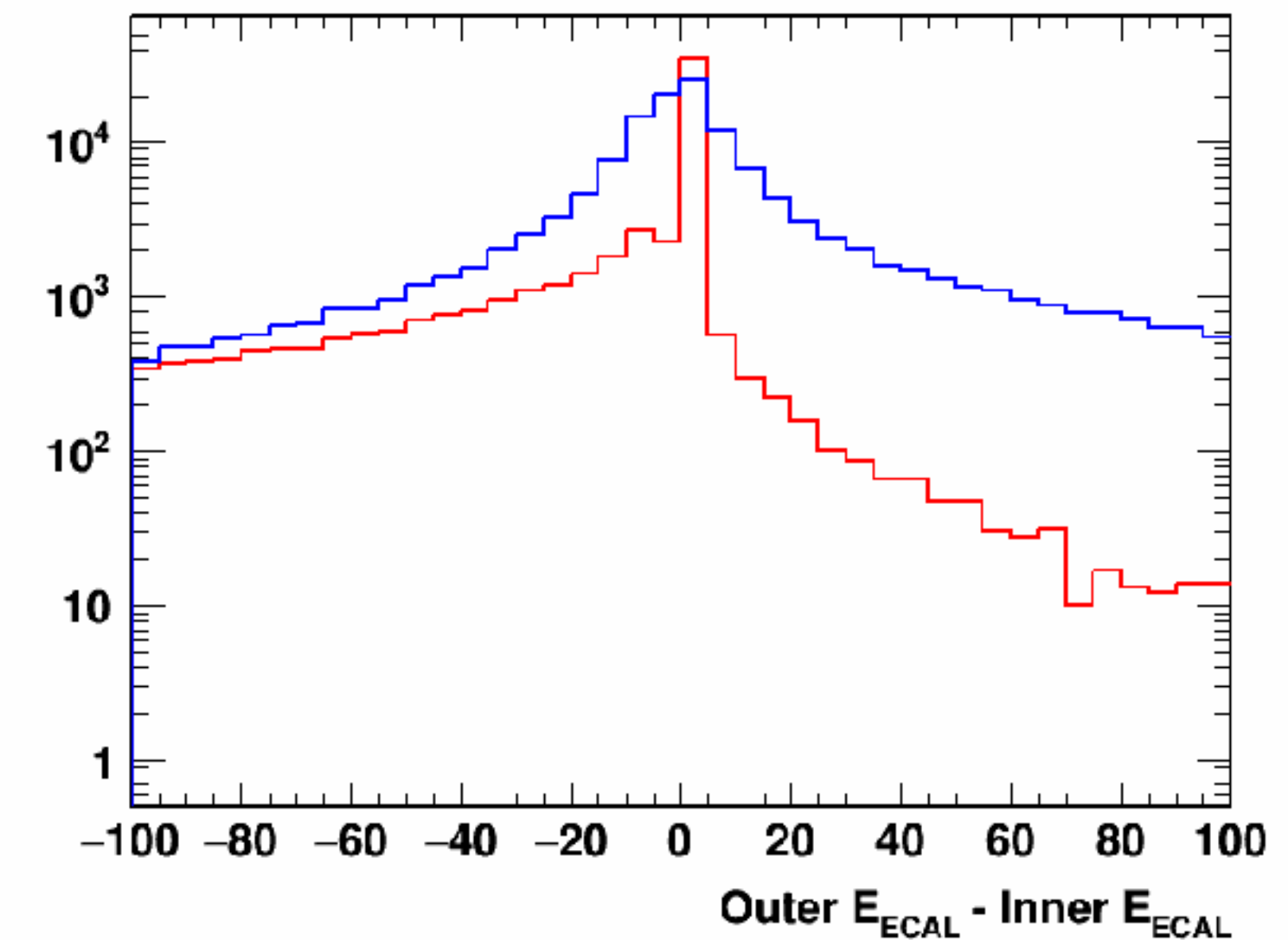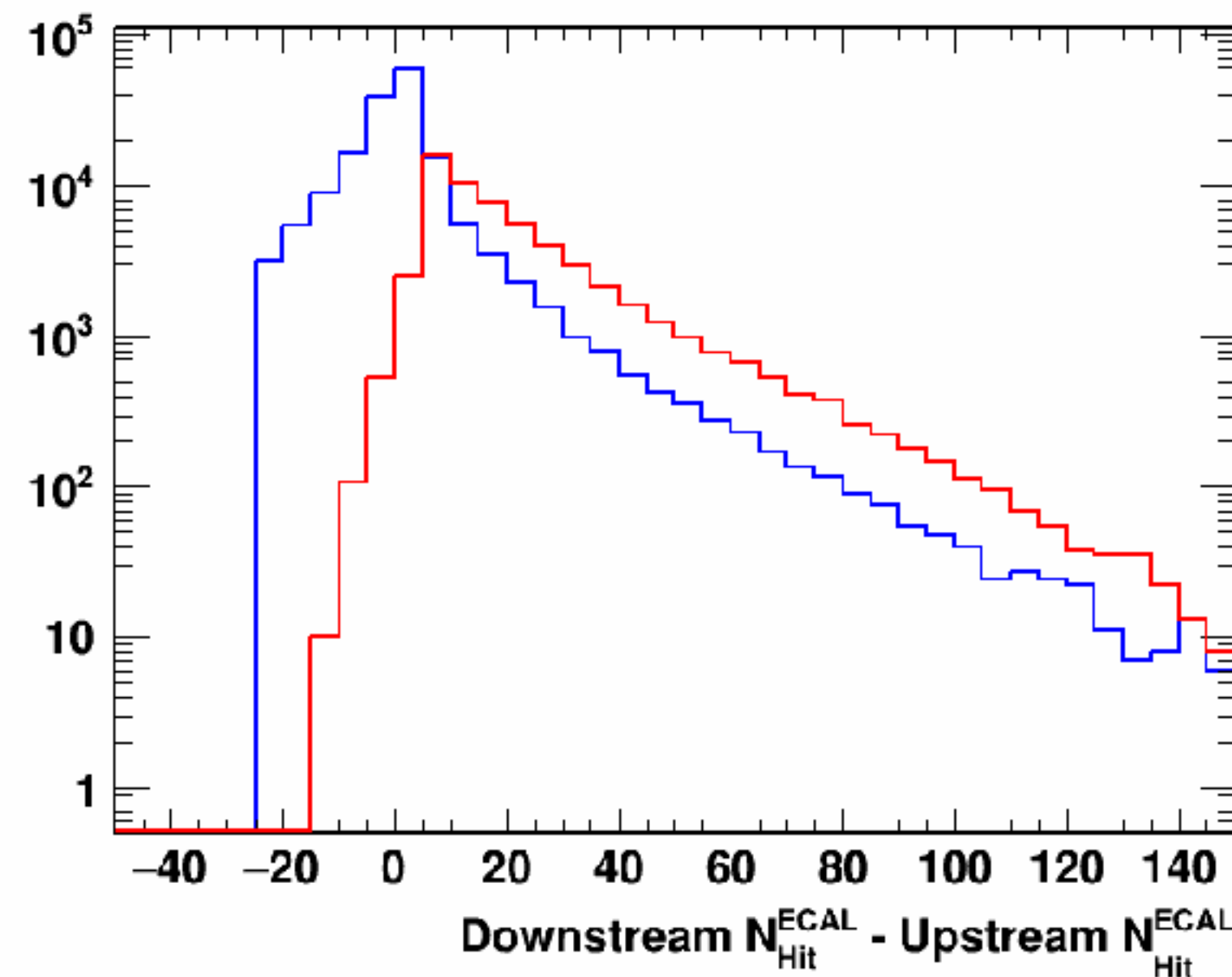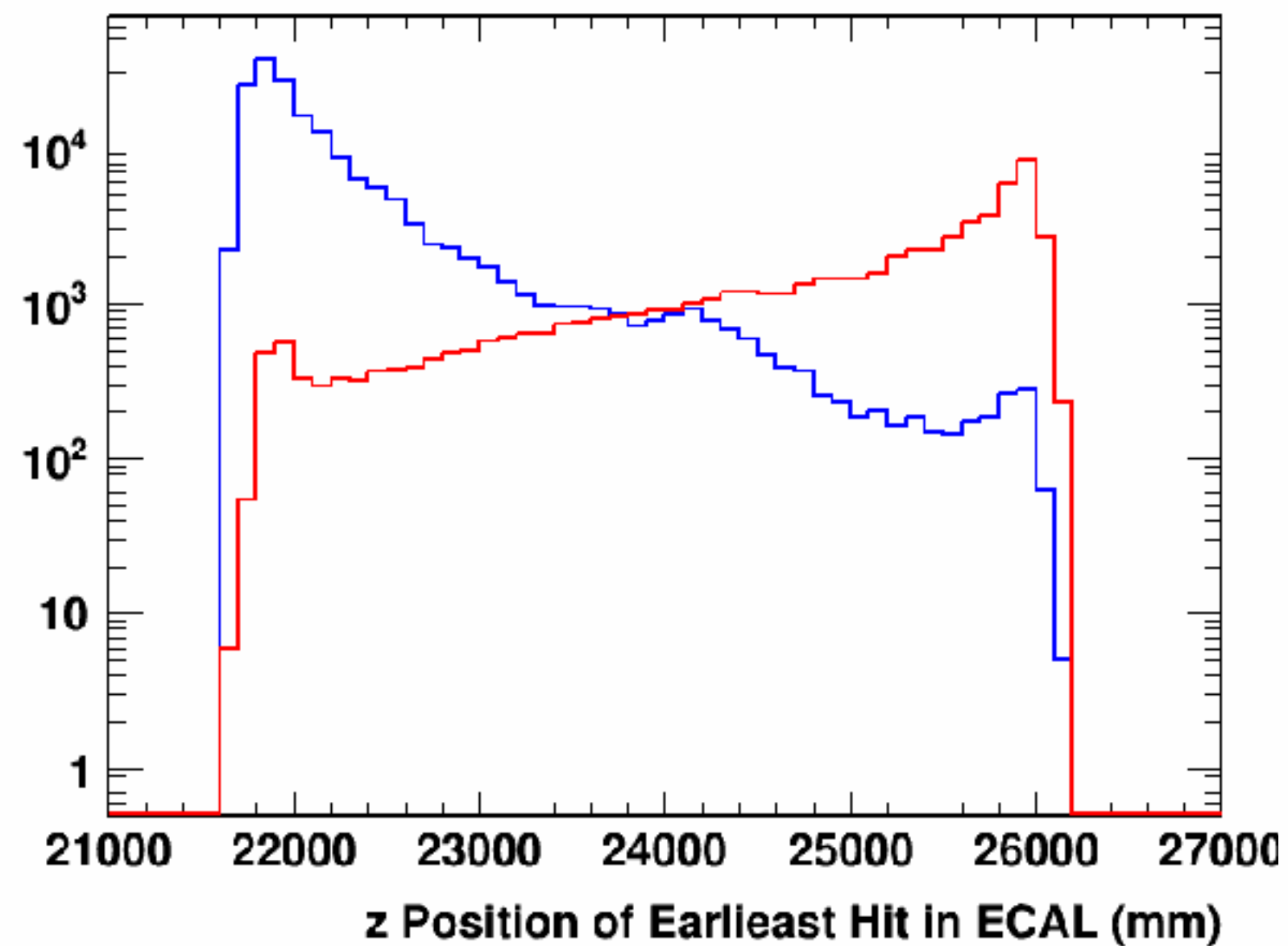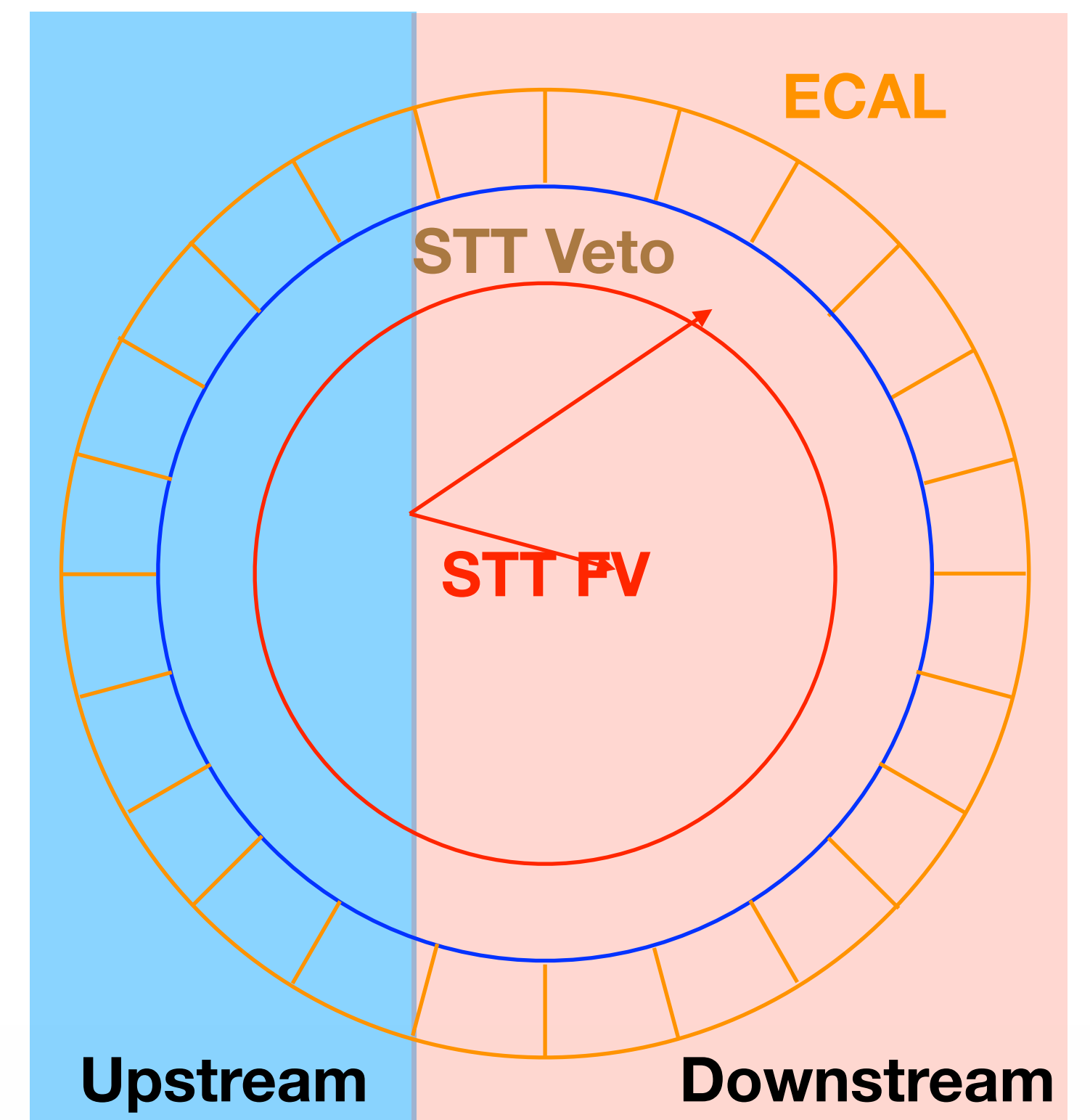
NN Output
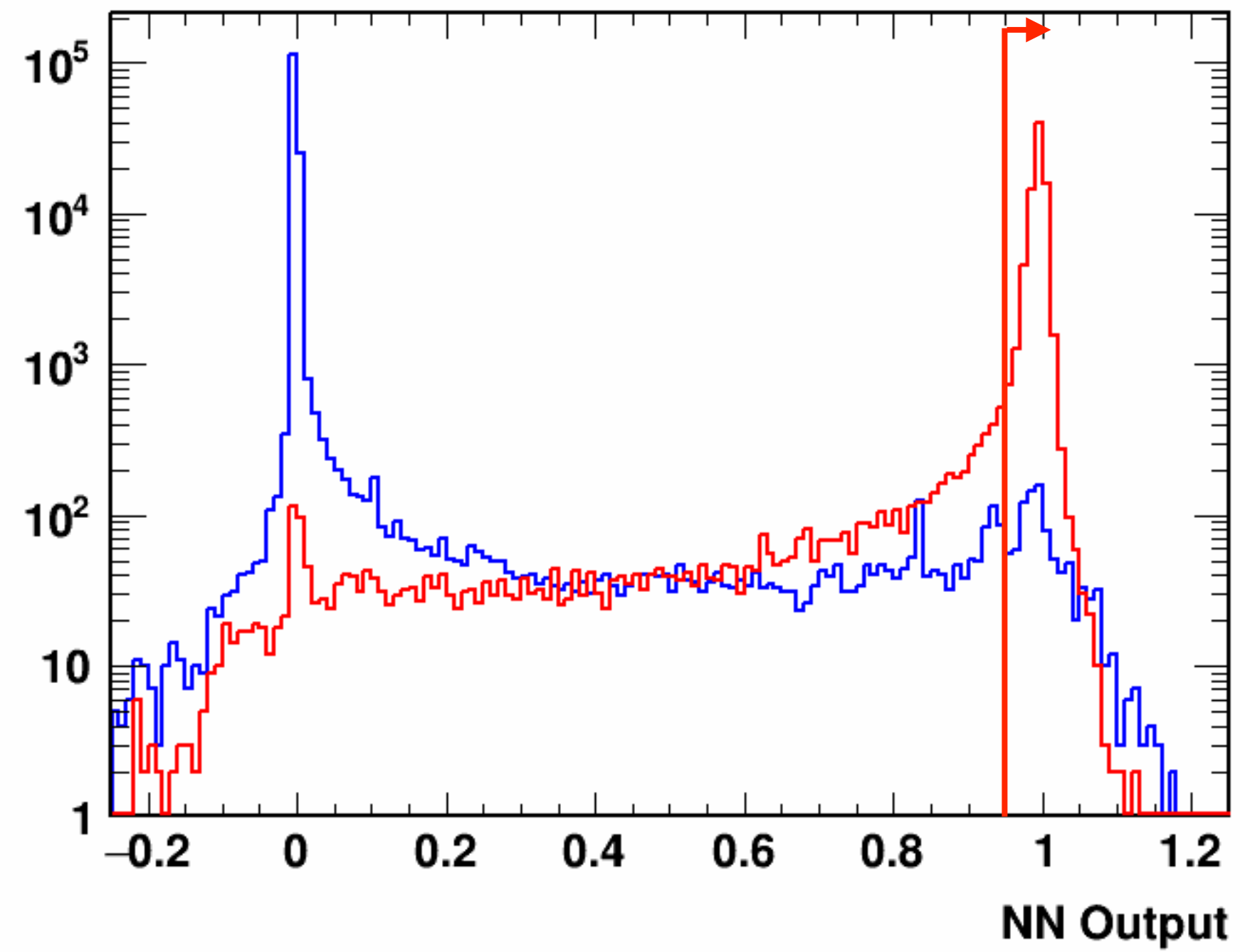
- NN with 7 timing variables and 3 ECAL-topology variables.
- One NN for rejection of both CC and NC backgrounds.

Cuts on Higher Level Reconstruction

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

Cut Flow Table
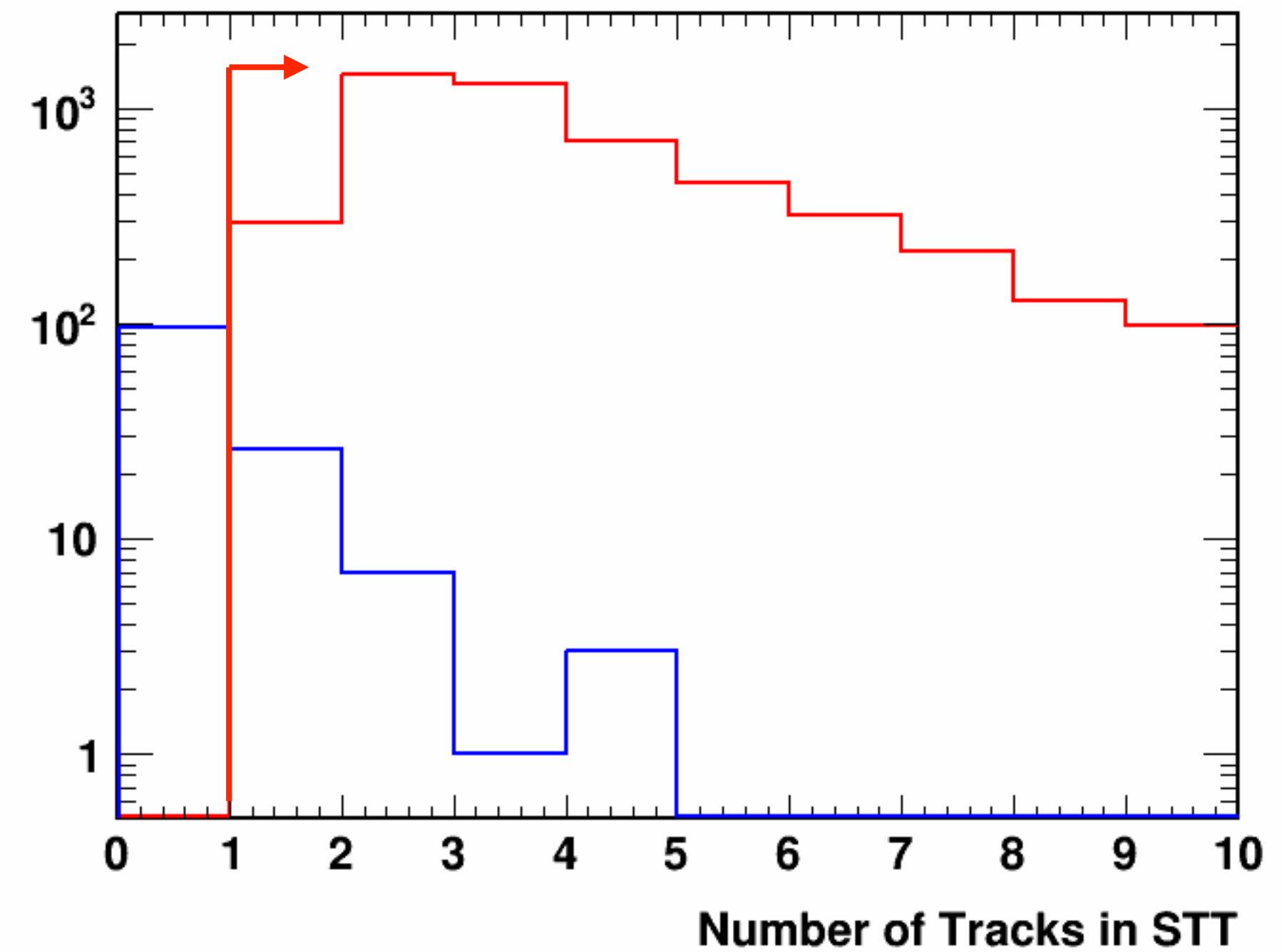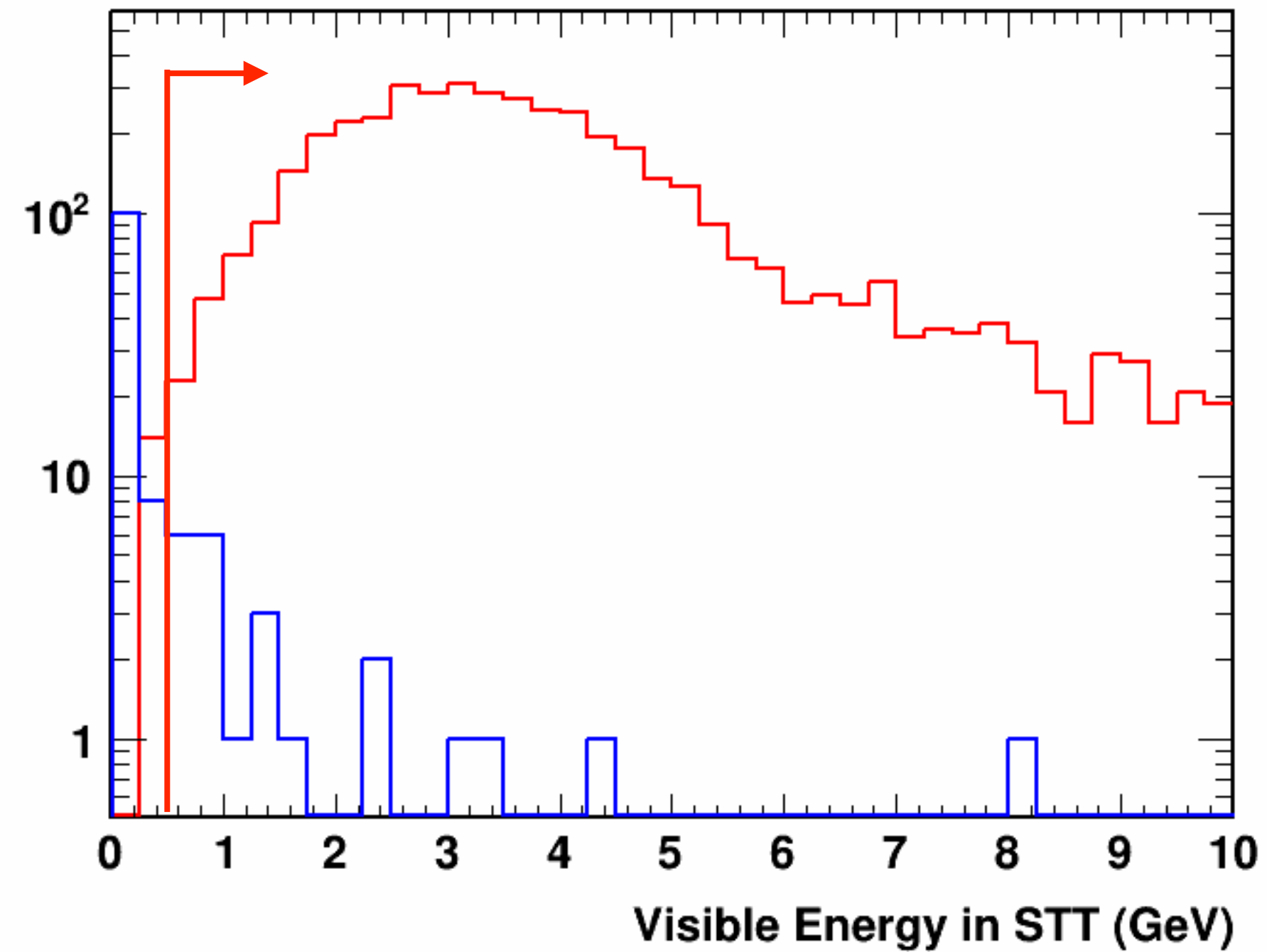
Cut	Sig Eff	CC Bkg Eff	NC Bkg Eff	Tot Bkg Eff	Purity
1	0.98319	0.08750	0.02719	0.07238	0.09984
2	0.97869	0.08045	0.01867	0.06496	0.10955
3	0.97587	0.07373	0.01487	0.05897	0.11904
4	0.97048	0.06919	0.01354	0.05524	0.12546
5	0.96958	0.06152	0.01146	0.04897	0.13918
6	0.96855	0.06125	0.01125	0.04871	0.13968
7	0.96316	0.06076	0.01098	0.04828	0.14008
8	0.95354	0.02554	0.00508	0.02041	0.27614
9	0.95315	0.02550	0.00503	0.02037	0.27649
10	0.95315	0.02451	0.00429	0.01944	0.28592
11	0.92889	0.00014	0.00020	0.00015	0.98009
12	0.9271	0.00003	0.00001	0.00003	0.99648

Pre-sel cuts (Cuts 1–10)

NN cut (Cut 11)

Reco cut (Cut 12)

Overall 93% efficiency and >99% purity with NN analysis

- 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 Veto.
- 8. Range of Tmin difference between the most outer ECAL plane and FV
- 9. Range of z of earliest ECAL hit.
- 10. Range of difference between downstream/upstream ECAL hits.
- 11. NN output > 0.95
- 12. Evis>0.5 GeV, Number of tracks >=1

Cut-Based Result

Cut	Sig Eff	CC Bkg Eff	NC Bkg Eff	Tot Bkg Eff	Purity
1	0.98414	0.08721	0.02733	0.07220	0.09708
2	0.98007	0.01312	0.00421	0.01089	0.41519
3	0.95075	0.00612	0.00235	0.00518	0.59167
4	0.93965	0.00534	0.00174	0.00443	0.62565
5	0.93355	0.00163	0.00103	0.00148	0.83242
6	0.90563	0.00072	0.00081	0.00074	0.90561
7	0.86298	0.00019	0.00022	0.00020	0.97212
8	0.85628	0.00018	0.00021	0.00019	0.97302
10	**0.85488**	0.00005	0.00001	0.00004	**0.99411**

Timing Cuts

ECAL Topology Cuts

Reco cut

Overall 85% 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. Difference in energy deposition between outer/inter upstream ECAL layers < 10;

- 9. N track >=1 && Evis >= 0.5 GeV

Conclusion

- Both cut-based study and NN study show that ECAL-STT rejects external background quite well.
  - Cut-based: **85%** efficiency and **>99%** purity
  - NN: **93%** efficiency and **>99%** purity

Backup Slides