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FD event selection and data quality cuts for the 1e20 analysis

Abstract

This short note describes the algorithm used to select beam neutrino candidates in the far detector, and the data quality cuts that are applied to exclude periods of bad data.

1 Event selection

Event selection is performed on the reconstucted "sntp" Far Detector spill ntuples. First the data is passed through a filter to select out only snarls that are in coincidence with beam spills (using the SpillTimeND entries in the spill database). Secondly, only snarls that contain at least one reconstucted event are considered (the vast majority of spill trigger snarls in the FD are empty). This filtering process passes through around 2000 snarls that can be subsequently used for scanning or event selection.

The event selection algorithm that I use (method 2 in [1]) then proceeds as follows:

1. *Timing cut:* The difference between the time of the reconstructed event and the SpillServer prediction (which is obtained from the database by means of the Spill-Timing class) is required to be greater than -20μs and less than 30μs. Here the reconstructed event time is the snarl trigger time plus the time of the earliest digit in the reconstructed event. This correction therefore locates the event within the spill trigger window. See figure 1 for the distrinution of this quantity for all Spill events and the final selected sample.

2. *Track cut:* The event must contain at least one reconstructed track (this selection algorithm is intended for CC events, although a significant fraction of NC events also contain a reconstructed track)

3. *Track vertex fiducial cuts:* The following cuts are placed on the reconstructed track vertex:

   - *Radial cut:* $x^2 + y^2 < 14$ m^2
   - *Longitudinal cut:* $0.5 < z < 14.3$ m OR $16.2 < z 28$ m. A cut of 0.2 m on z was initially proposed, but vertex reconstruction errors can cause uncontained events (rock muons, cosmics) to pass this cut. Figure 2 shows the z-vertex distribution for FD events in the hidden sample that pass all other cuts. The excess of events below $z = 0.5$ is clearly evident.

4. *Track direction cut:* The direction cosine between the reconstructed track and the beam direction should be greater than 0.6

The efficiency of these cuts on Monte Carlo is calculated to be 63% See table /reftab:cuts for a breakdown of the various inefficiencies and figure 3 for the distributions of these cut variables for data and MC events..

Cut	ν_μ CC	NC	ν_e CC
None	82968	22849	1223
Ntrack>0	82436 (99.4%)	13331 (58.3%)	974 (79.6%)
Track vertex $r^2 < 14$ m^2	66170 (80.3%)	11001 (82.5%)	787 (80.8%)
Track z vertex cuts	59491 (89.9%)	9886 (89.9%)	724 (92.0%)
Track beam dirn. cosine > 0.6	58386 (98.1%)	9070 (91.7%)	698 (96.4%)
LI topology cuts	58196 (99.7%)	9067 (99.97%)	698 (100%)
Total efficiency	70.1%	39.7%	57.1%

Table 1: Efficiency of FD selection cuts on Monte Carlo neutrino events for true ν_μ CC, NC and ν_w CC interactions. The effieiency of each cut is shown in parentheses.

2 Rejection of LI events

LI events are rejected using the following criteria:

- Events with an in-time trigger PMT hit (evthdr.litime in the standard ntuple) are rejected.
- In order to tag LI events that do not have a trigger PMT hit associated with them, the following topological cuts are applied:
  - The snarl is rejected if it contains a reconstucted shower and has total raw pulse height greater than 1e6 ADC counts
  - The snarl is rejected if the event header start and end planes coincide with readout crate boundaries (this cut was inspired by the FilterLI package written by C. Andreopoulos)

  The efficiency of these cuts for rejecting LI events was tested by applying them to events with an in-time trigger PMT hit (using the "fake" spill sample). Of the 11313 spills thus selected, 11306 were tagged as LI by this method - i.e. the efficiency is $> 99.9\%$. The rejection of true neutrino events is calculated from Monte Carlo to be 0.2%

3 Rejection of secondary events

Very occasionally (few % probability), neutrino interactions will be split into multiple events by the reconstruction. Typically, there is one "large" event which contains the primary track/shower, and one or more "small" events which are small tracks/showers that are reconstructed from a small number of digits (often cross-talk). These events are removed by only considering the largest event in each snarl. Here size is determined by the summed (sigcor ADC) pulse height of the event.

4 Beam monitoring cuts

The standard cuts are applied (using the BDSpillAccessor class):

1. maximum time difference between spill and nearest beam monitoring data < 1 second
2. $0.5 \times 10^{12} <$ tortgt $< 50 \times 10^{12}$ protons on target
3. -200 kA $<$ horn current < 155 kA
4. X-position of beam at target: $-2.0 < x < 0.0$ mm
5. Y-position of beam at target: $0 < y < 2.0$ mm
6. Horizontal width of beam at last profile monitor before target: $0.1 < x_{RMS} < 1.5$ mm
7. Vertical width of beam at last profile monitor before target: $0.1 < y_{RMS} < 1.5$ mm

Note that the lower limit on the horn current has been lowered from -163 kA to -155 kA to accommodate the special horn current runs that were taken in late-July and early August. The inefficiency of these cuts on LE-10 data is approximately 2%.

5 Data quality cuts

Data quality cuts are applied using the following criteria:

- *Magnet coil trips:* Coil trips are defined as those periods when either the coil current for SM1 or SM2 falls outside the range 80.0 ± 0.2 A. The raw DCS data (RawDcs-MagnetMonitorBlock) is used to determine these periods.
- *HV trips:* The raw TPSingles summary blocks are used to search for HV trips during physics runs. A HV trip is defined as a period in which the singles rate from any of the readout crates drops below 20kHz (nominal rate is 50kHZ).
- *GPS timing errors:* Periods where the uncetrainty on the GPS timestamps is large are flagged by reading the SpillServer monitoring blocks in the raw data and cutting periods where the maximum GPS uncertainty is greater than 1μs (nominal uncertainty is 200ns).

The inefficiency of these cuts on the FD LE-10 dataset is approximately $0,6\%$. A simple C function has been written which contains the start and end times of periods of "bad" data (where an additional window of ± 60 s is applied to HV trips and ± 360 s is applied to magnet trips and GPS timing problems). The function ("passfail") takes as input the trigger time of the snarl (in UNIX time) and returns either zero or one based on whether the event does (does not) fall within one of these periods (here 1 is pass and 0 is fail). The function can be downloaded from http://www.physics.umn.edu/~petyt/cc/dataqual/

References

[1] D. Petyt, FD data checks position paper, MINOS-doc-1273

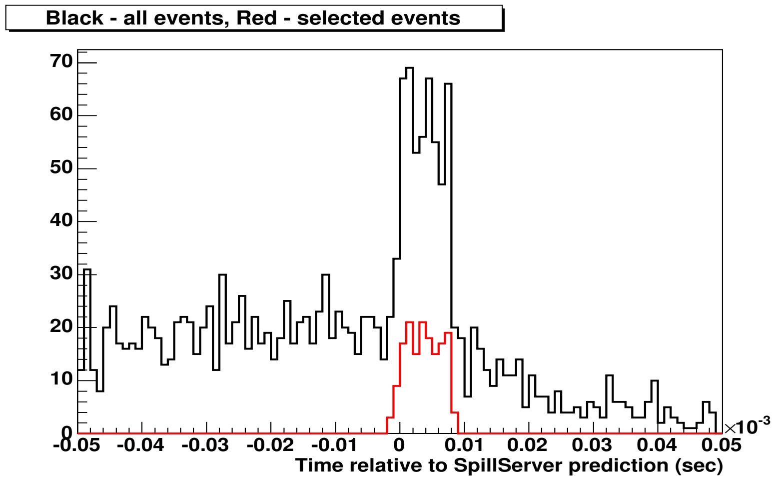

Figure 1: Distribution of event times relative to the SpillServer prediction for Spill events in the open dataset. The black histogram is for all events and includes neutrinos, rock muons and background events and the red histogram is for the final contained vertex candidate neutrino sample.

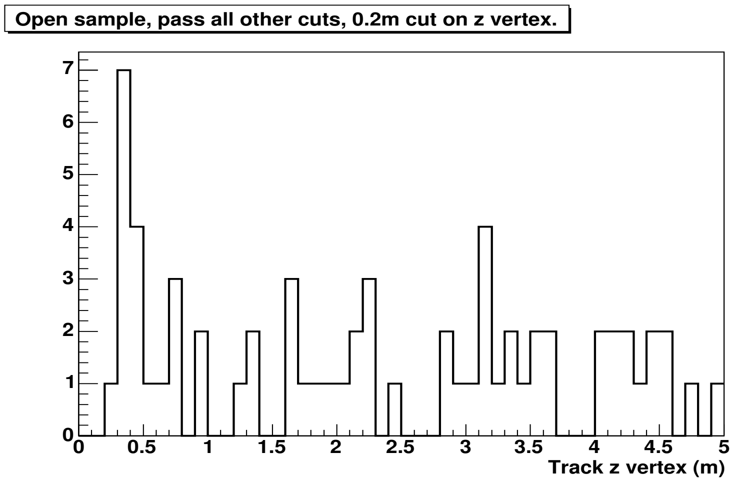

Figure 2: Distribution of reconstructed track vertex z positions for selected events in the hidden dataset with a cut of $z > 0.2$ m. The excess of events below $z = 0.5$ m is clearly seen.

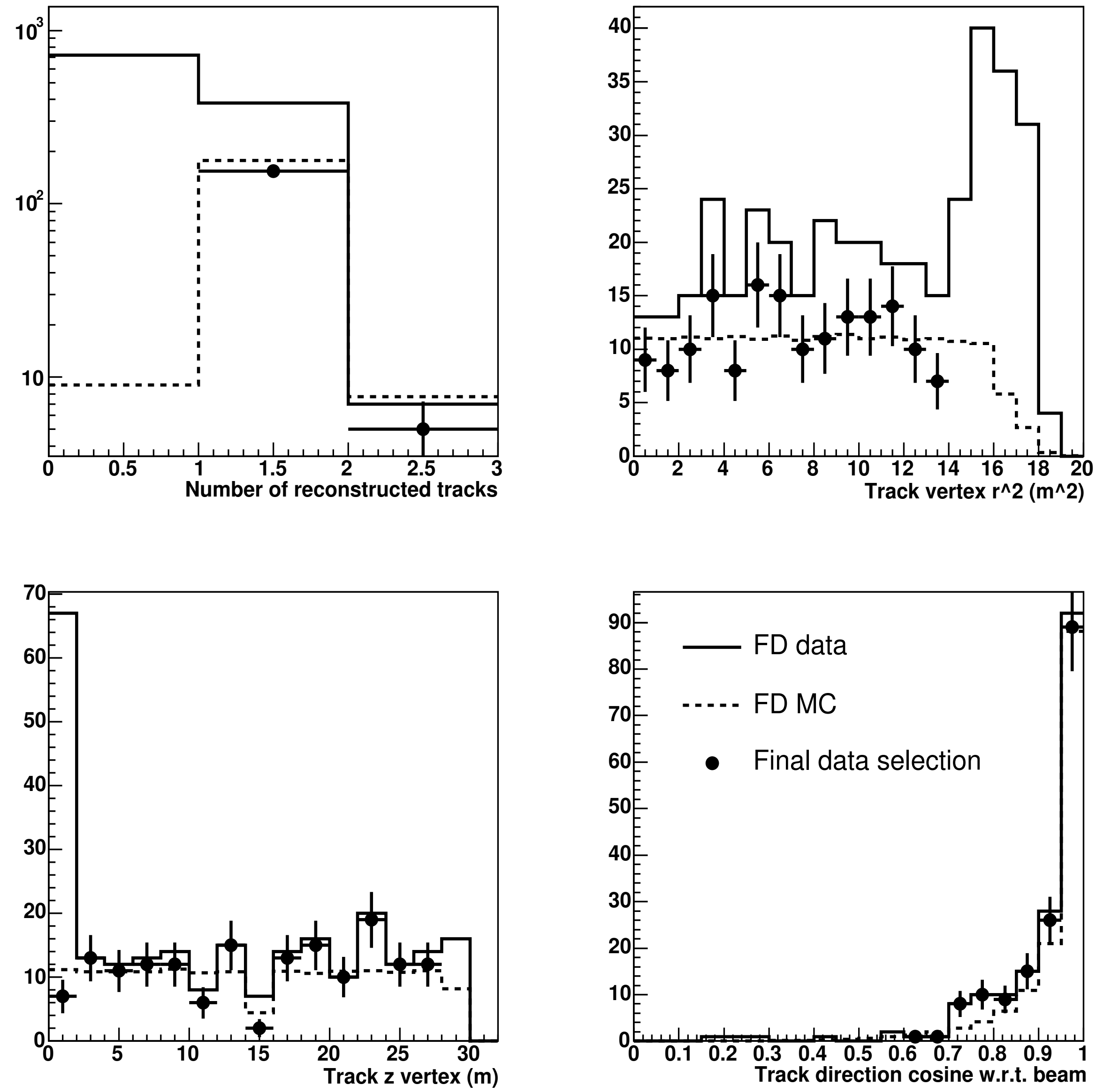

Figure 3: Distribution of variables that are used to isolate FD neutrino candidates. The FD spill events are shown by the solid histograms and MC event distributions are denoted by dashed histograms. The effect of the selection cuts (detailed in the text) on these distributions is cumulative. The final FD data sample is shown by the points with error bars.