This document describes how to analyze scifi neutrino data. The following is a content of this script.

(0) make run lists used for the scifi analysis (1) select neutrino candidate events from re-processed data

(2) analyze the selected events and make ntuple file for analysis

(3) make various figures (muon energy spectrum, etc.)

(4) get final sample of neutrino events

(0) Creation of run lists used for the scifi analysis

source files :

`/home/ishino/swork/scifi/dataquality/..`

`/home/ishino/swork/scifi/runtable/..`

`/home/ishino/swork/scifi/calc_totpot/..`

First of all, a run list used for the scifi analysis is made. Though, the start point of data reduction is re-processed data, at which data with bad beam and/or FG detector condition are removed, the data set may include undesirable run to use, for example, some IIT may had died without being noticed. In order to check the scifi data quality, please go to a directory `./dataquality`. A procedure to obtaining histograms which show the scifi data quality is written in `README`. `./dataquality/make_runlist.sh` will make a kumac file `proc.kumac` by looking the directory where ntuple files created by the re-process are located. When you execute this shell script, please rewrite run numbers in the file for which you want to update or re-analze. The kumac file `proc.kumac` will analyze the ntuple file for each sub run, calculate mean value of number of pixel hits for each IIT and write the value to a data file `dataquality.dat`. `dataquality.kumac` will read the data file and make plots by which you can check scifi data quality (i.e. IIT condition). If you find strange performance of IIT(s), please identify the run numbers.

Next, please go to the directory `/home/ishino/swork/scifi/runtable` Again `README` shows how to proceed and to make a run table containing only good runs which are usable to analyze scifi data. And then in the directory `/home/ishino/swork/scifi/calc_totpot/`, `r_stat.sh` will calculate total cumulated p.o.t in the selected runs by reading the `goodruntable.?????.`
and make a list of data file `selected_runlist.?????.dat` which is used for a next step.

(1) Selection of neutrino candidate events from re-processed data

source files :

`/home/ishino/swork/scifi/select/dataselect/*.F ,.c`

In this step, first reduction cuts are applied to the re-processed data and neutrino candidate events are selected. The cut criteria are as follows;

1. Timing cut : In order to select on-spill timing events, timing information of VETO scintillation counters is used. When at least one hit whose TMC count is in a timing window ranging from 1000 to 2750 counts ($\sim$1.4μsec) exists, the event remains.

2. Scifi track and Muon chamber (MUC) hit matching : We require at least one Scifi track matching with MUC hits. The matching condition is defined as;

$$|\Delta x|, |\Delta y| \leq 65\text{cm} \tag{1}$$

where $|\Delta x(y)|$ is a minimum distance between extrapolated Scifi track positions and the MUC hit positions in x(y) plane. The MUC hits are also required to be at least three hit coincidence in X and Y planes, i.e. XXY, XYY or XXYY hit patterns have to be satisfied. And further, the MUC hits must be associated with a track in MUC detector.

The shell script `proc.sh` will execute `select1.sh` which performs the above selection and makes neutrino candidate data sets named `nucand_runxxxxxx.xxxxxx` with log files (`select1_logxxxxxx.xxxxxx`) to check the performance.

For MC, same analysis method is applied. Programs carrying out the reduction are located in a directory;

`/home/ishino/swork/scifi/select/mcselect/*.F, .c`

This will also make data sets of "neutrino candidate events".

(2) Analysis of the selected events and creation of ntuple file for analysis

source files :

`/home/ishino/swork/scifi/fit.1224/*`

A detailed analysis of the scifi neutrino candidate events is carried out by a shell script `./dataanl/fitproc.sh`. It will execute `fit.sh` which makes ntuple files used for the scifi analysis. The contents of the ntuple file is listed in `./dataanl/fit_hbook.inc`. The produced ntuple files for many sub-runs are merged to one ntuple file by executing as follows;

% `cd ./hbook`
% `data_make_hbooklist.sh` (after you edit as you like)
% `paw -b data_merge` (making the merged file `data_fit.hbook`)
% `cd ..`

For MC, `./mcanl/mcfitproc.sh` will make same type ntuple files (please see `./macanl/mcfit_hbook.`
and the manipulation to make a merged ntuple file is follows;

% `cd ./hbook`
% `mc_make_hbooklist.sh` (after you edit as you like)
% `paw -b mc_merge` (making the merged file `mc_fit.hbook`)
% `cd ..`

Original information of all MC events will be also handled. The information is filled in a ntuple file created by `./mcpin/proc.sh`, which has contents defined in `./mcpin/mcpin_hbook.inc`.

(3) Production of various figures (muon energy spectrum, etc.)

The analysis is carried out by kumac files in `./kumac/fit.kumac`. The kumac file opens the merged ntuple file of data (`data_fit.hbook`), of MC (`mc_fit.hbook`) and the ntuple file (`mcpin.hbook`) containing original MC information, which is used to estimate detection efficiency, etc. `./kumac/fit.kumac` will execute `./kumac/reduction.kumac` that makes various histograms with various cuts determined by its two arguments. For details, please see the source kumac file. The selection criteria of further neutrino event selection are as follows (please see `./kumac/reduction_def.kumac`);

1. Fiducial volume cuts :

- **(a)** $z_{str} > -5$cm (from 2nd layer of Scifi) and $|x(y)_{str}| < 110$cm (10cm from detector edge)
- **(b)** $z_{stp} > 145$cm (19 or 20 layer)
- **(c)** $|X(Y)_{stp}| < 360$cm (20cm from detector edge)

where the subscript of $str(stp)$ means track start(end) and the small(capital) letter of x(X) means Scifi(MUC) detector position. Purposes of those cuts are; (a)eliminating induced muons from upstream side and comic ray muons, (b)rejecting muons missing MUC detector, (c)removing muons escaping from MUC detector. The fiducial volume cuts reduce target mass from 8.28tons of total Scifi detector volume to 5.94tons of fiducial volume.

2. Scifi and MUC track correlation : This cut rejects accidental track matching events such like (a noise track in Scifi) + (a track in MUC detector of a muon coming from 1kt or wall of experimental hall directory). The cut criterion is $\theta_{track} < 50$degree, where θ_{track} is angle between the Scifi and MUC track. However, this criterion is rather loose. In the near future, a more tight cut considering muon momentum dependence with additional parameters, i.e. distance between the tracks etc, have to be applied.

3. Veto cut: This final cut removes induced muons which do not hit first scintillation fiber layer due to inefficiency caused by the noise cut. Correlations of the muon track and hit timing and position information of veto scintillation counters are used for that purpose. Cut criteria are $0 < T_{down} - T_{up} < 20$nsec and $|\Delta y| < 20$cm, where $T_{up(down)}$ is hit timing of a up(down)stream counter which are nearest to a Scifi track and Δy is minimum distance between the Scifi track and hit counters. The threshold values were optimized using induced muon event sample selected by an eye scan.

(4) get final sample of neutrino events

source files :

`/home/ishino/swork/scifi/fit.1224/kumac/eventdump.kumac`

`/home/ishino/swork/scifi/select/reform/reform.sh`

`/home/ishino/swork/scifi/select/finalselect/finalselect.sh`

An event list of finally selected events are obtained using `eventdump.kumac`. This kumac file will create `event_select2.dat` containing run number, sub-run number, spill number, event type and number of track. However, this file includes many empty areas. `reform.sh` will eliminate the space and make new file `finalsample_list.dat`. `finalselect.sh` will make a final sample data set of neutrino events with `finalsample_list.dat`.