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Double beta decay sensitivity code

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1 Introduction

This document summarizes version 0 of the code which is used by the double beta decay group for the sensitivity studies. The method used in the current version of this code is described extensively in [1]. A set of known background MC distributions are used to derive fake data. Background and signal MC distributions are then fitted to the fake data using a likelihood fitter in ROOT. The fitted number of $0\nu\beta\beta$ events and its uncertainty are then used to define a neutrinoless double beta decay limit at a required confidence level. For example the exclusion limit of 90% CL result is defined as: fitted number of events+1.6$\times$ uncertainty of the fit.

2 Code structure

Currently, the code is using a header file "DBDanalysisTest.hh" which consists of several functions. The functions are as follow:

- **smearPDF(int numback,int numsig,double smearvalue)**: this can be used to smear the histograms. The "smearvalue" corresponds to the (energy, position) resolution of the detector. If reconstructed distributions are used and therefore no smearing is needed the smearvalue should be initialized to be 1. Note that at this version in order for the code not to break the user must use this function. This bug is going to be fixed for the next version. The variables numback and numsig are the number of background and signal histograms that are going to be smeared.

- **smearData(int numback,int numsig,double smearvalue)**: is defined similar to smearPDF. The purpose of this function is to produce another copy of the smeared histograms in order to be used later to create fake data.

- **MakeFakeData(int numback, int numsig)**: creates fake data using Poisson statistics.

- **FitData(TF1* func,TVirtualFitter* fitter)**: Fits fake data to MC histograms. This uses the ROOT function (Fit(func,"L") to perform likelihood fits. This maybe modified in the future.

The sensitivity code is in-bedded in **SingleLiveTimeTest(analysis *ana,const char path[500])**. This function uses the ROOT TF1 and TVirtualFitter classes to fit data to background and signal MCs. Within a loop performed "ensemble_size" times, fake data is generated and a subsequent fit is performed on this fake data, resulting in total of ensemble_size data sets and fits. Each fit result and the error on the fit are stored in histograms and a Gaussian fits are performed in order to find the mean and width of the fit results.

3 Compilation and Running the code

The code is provided with the RAT package and stored in:

snocave/sasquatch/DB/tools/DBDcode/

You can copy this anywhere in your working area and use it independantely from RAT. A Makefile is written in order to compile the code. The steps to compile the code is given below:

- make (or gmake). In case of having problems compling it in your machine please contact me.

The compilation creates an executables called DBDanalysis_mainTest.exe. To run this program one needs to be given a dat file as an argument. Thus to run:

- ./DBDanalysis_mainTest.exe Listoffiles.dat

The format of each line in the Listoffiles.dat file is: [type (B/S for background/signal)] [rootfile path] [item name] background rate [evt/year]. An example of Listoffiles.dat is provided with the tar ball as well as below:

B data/Tl208_spec.root Tl208 606

B data/Bi214_spect.root Bi214 7942.81

B data/2nbbex_spec.root excited 912392.93

B data/2nbb_spec.root 2nbb 13359441.5

B data/withosc_b8.root B8 1639

S data/0nbb_spec.root 0nbb 0

Note that one can include to 30 backgrounds and 10 signals in the dat files.

User is encouraged to look at the structure of DBDanalysis_mainTest.C to underestad the detailed structure of the code.

4 The code's output

If SingleLiveTimeTest(analysis *ana,const char path[500]) is called inside the main. Running the executable will give the limits on the half-life, effective neutrino mass and the fitted number of events. The resulting sensitivities are output in a latex format and can be inserted in to a latex document to produce a table.

5 Plans for the next release

The plans for the next release are:

- Cleaning up any existing bug(s): ie smearPDFs and smearData need to be called in order to FitData function to work.
- Add functions which are going to use log-likelihood ratio test statistic for signal extractions [2].
- Functions which gives us abilities to constrain certain backgrounds.

References

[1] Alex Wright's PhD thesis.

[2] Tom Junk, Confidence level computation for combining searches with small statistics. Nucl. Instr. Meth. , A434:435, 1999.