Fitting of ADC distribution for MIP Analysis

2024 INTT Work Shop

NWU B4

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Introduction

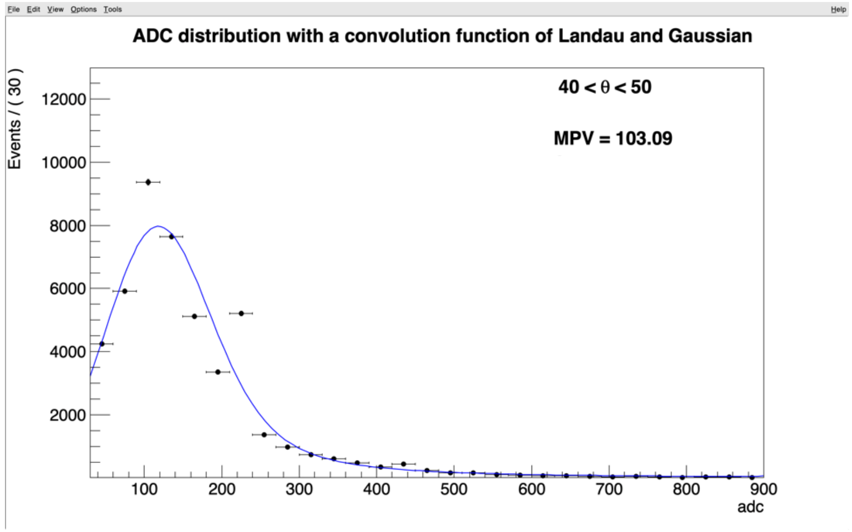
Why Fitting of ADC distribution for MIP Analysis?

- The goal is to improve the fitting accuracy so that we can accurately determine the ADC value of the MIP peak.

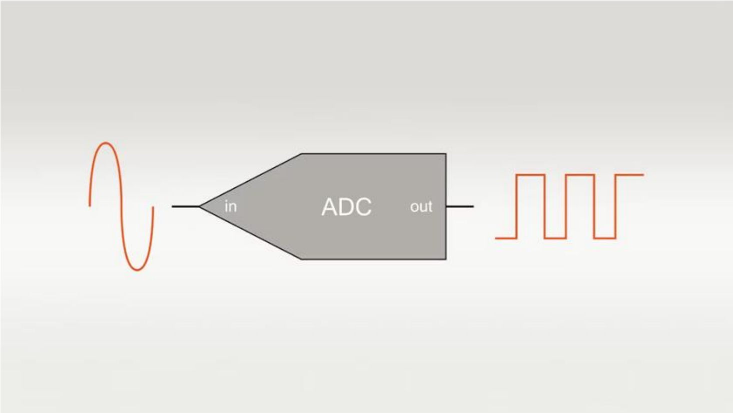
- The MIP peak value can be used to examine changes in the performance of the detector.

example of ADC distribution

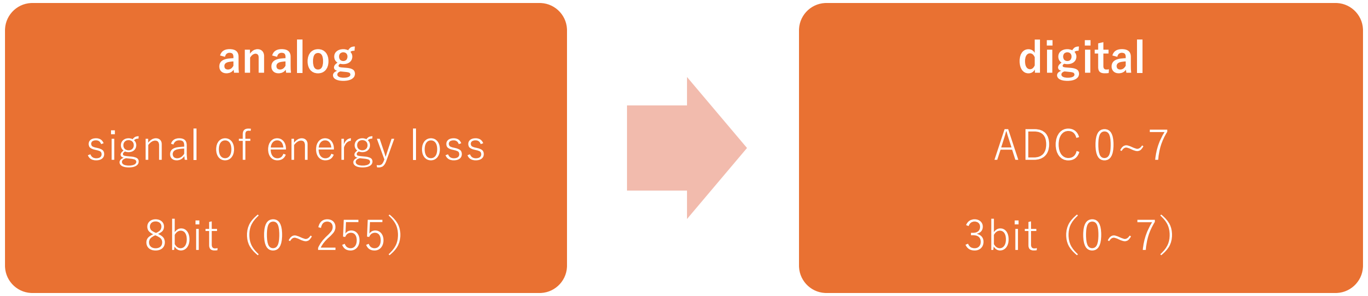
MPV : Most Probable Value of MIP peak



What is ADC distribution?



- **ADC** is **Analog Digital Converter**



analog

signal of energy loss

8bit（0~255）

digital

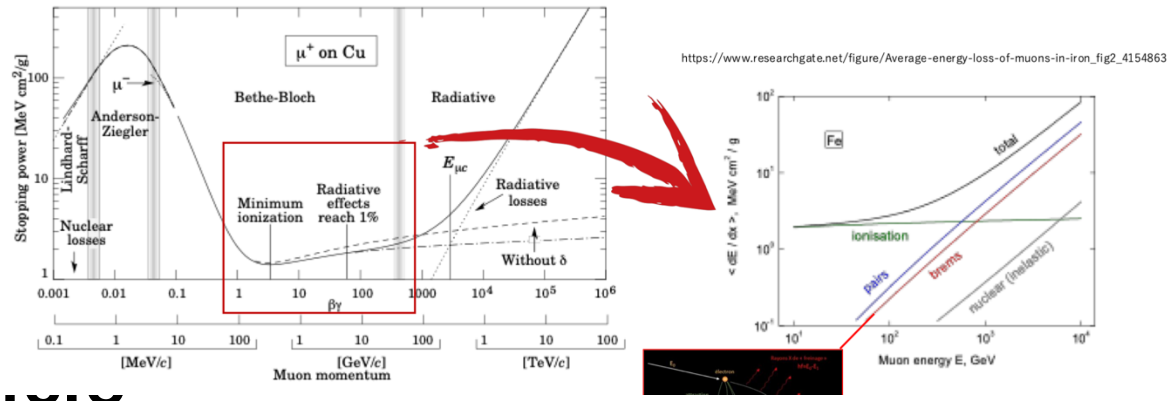
ADC 0~7

3bit（0~7）

- When multiple hits are detected within a single event, we can get many ADC values.
- These values are represented as a histogram, which is the ADC distribution.

ADC	DAC
0	15~30
1	30~60
2	60~90
3	90~120
4	120~150
5	150~180
6	180~210
7	210~

What is MIP ?



https://www.researchgate.net/figure/Average-energy-loss-of-muons-in-iron_fig2_4154863

quote from Mr. Nakagawa's slide (2024/11/18)

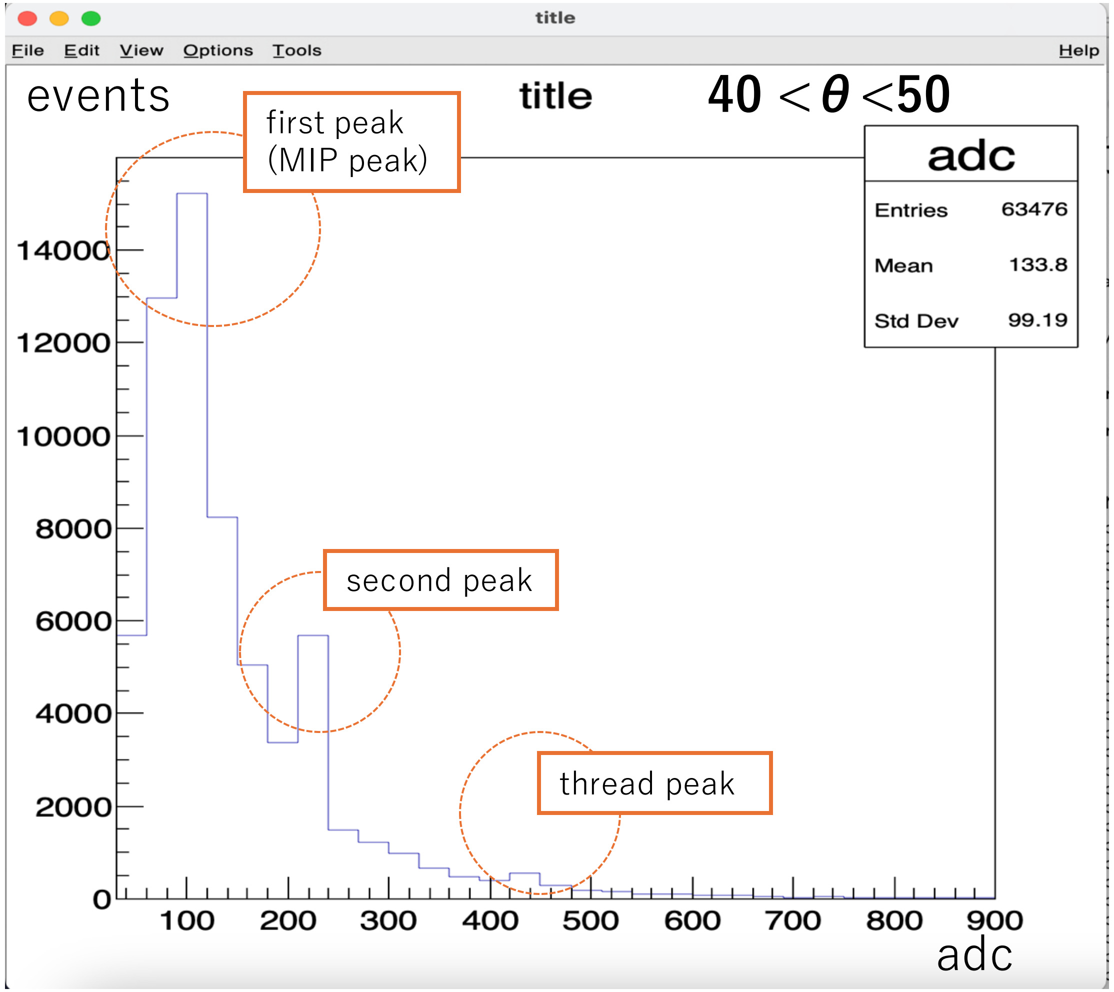
- **MIP** is **Minimum Ionization Particle**

- It refers to the energy loss of a particle that is minimized according to the Bethe-Bloch equation.
- The ADC distribution shows the energy loss, from which the MIP peak can be observed.
- The energy range typically studied in high-energy physics is between 1 and 10 GeV/c
- The range is included energy of MIP

result

The initial histogram

- The initial histogram contained two additional peaks besides the MIP peak.



adc	
Entries	63476
Mean	133.8
Std Dev	99.19

Correction of Fitt

What we had already been doing:

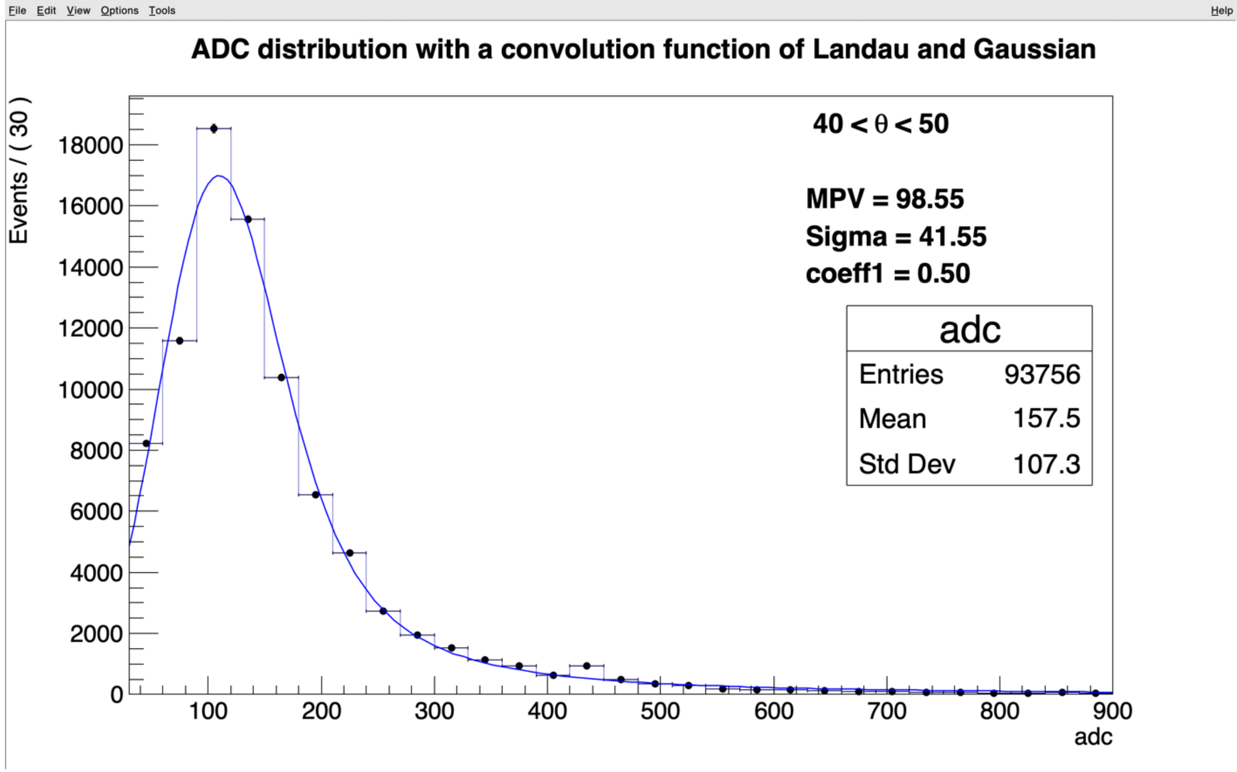
- I had applied cuts based on the angle (theta) range."

What I did newly:

- I applied a correction to the bins with DAC values ranging from 210 to 240 and from 420 to 450.

ADC distribution

theta $40 < \theta < 50$



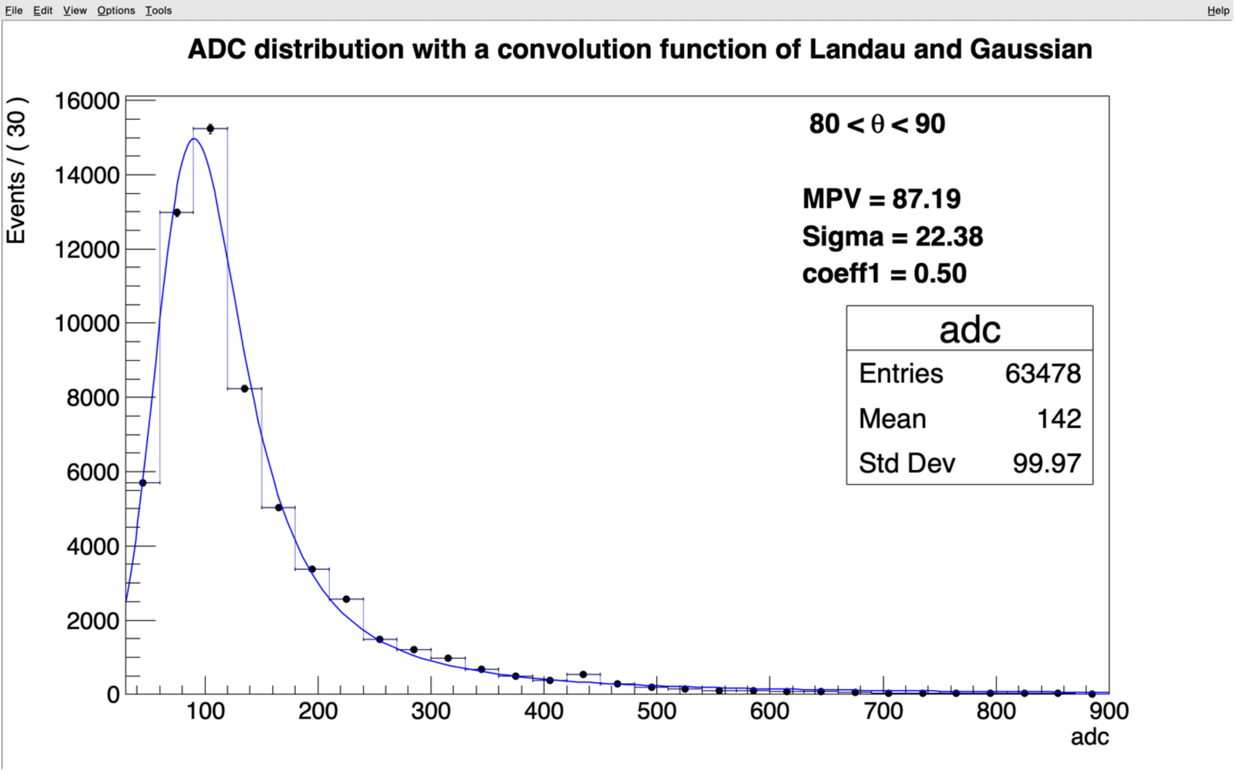
ADC distribution with a convolution function of Landau and Gaussian

$40 < \theta < 50$

MPV = 98.55
Sigma = 41.55
coeff1 = 0.50

adc	
Entries	93756
Mean	157.5
Std Dev	107.3

theta $80 < \theta < 90$



ADC distribution with a convolution function of Landau and Gaussian

$80 < \theta < 90$

MPV = 87.19
Sigma = 22.38
coeff1 = 0.50

adc	
Entries	63478
Mean	142
Std Dev	99.97

Summary

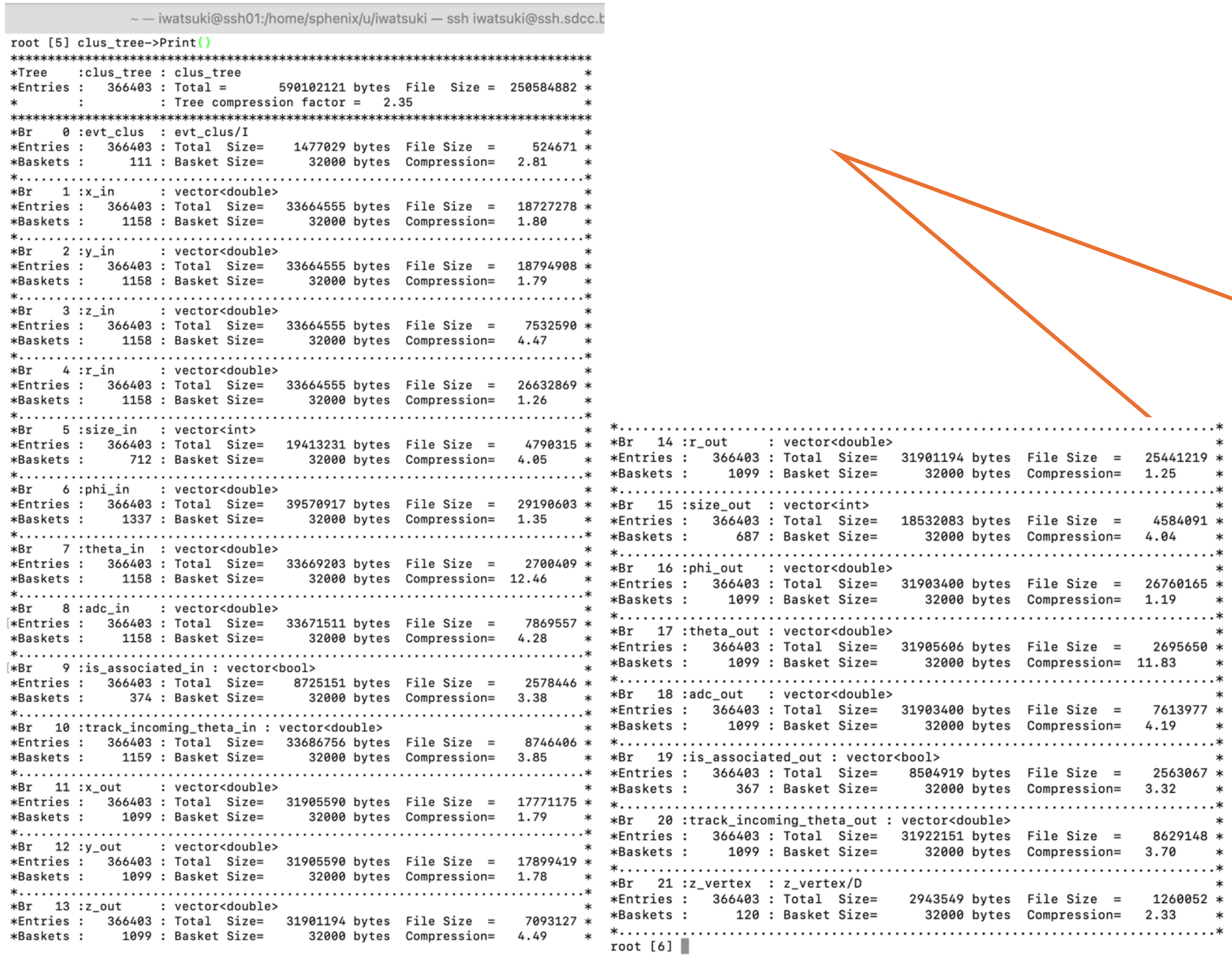
- **What I Learned**
- for me to study about ADC and MIP analysis
- to reduce noise at DAC 210~240 and DAC 420~450
- improve the fitting to better match the histogram.

- **Future Work**
- considering to handle ADC 7 data
- to improve the fitting accuracy

Back Up

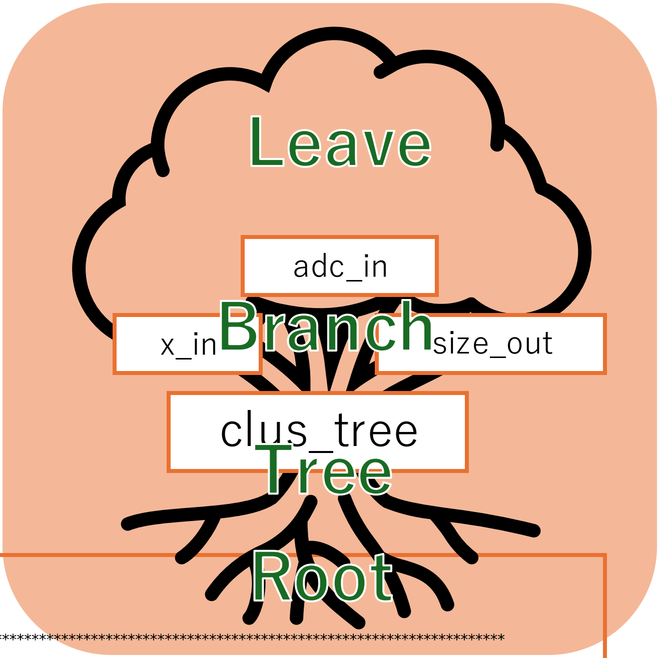
used data (root file)

root tracking_run50889.root



~ — iwatsuki@ssh01:/home/sphenix/u/iwatsuki — ssh iwatsuki@ssh.sdcc.b

```
root [5] clus_tree->Print()
******************************************************************************
*Tree    :clus_tree : clus_tree                                              *
*Entries :   366403 : Total =       590102121 bytes  File  Size =  250584882 *
*        :          : Tree compression factor =   2.35                       *
******************************************************************************
*Br    0 :evt_clus  : evt_clus/I                                             *
*Entries :   366403 : Total  Size=    1477029 bytes  File Size  =     524671 *
*Baskets :      111 : Basket Size=      32000 bytes  Compression=   2.81     *
*............................................................................*
*Br    1 :x_in      : vector<double>                                         *
*Entries :   366403 : Total  Size=   33664555 bytes  File Size  =   18727278 *
*Baskets :     1158 : Basket Size=      32000 bytes  Compression=   1.80     *
*............................................................................*
*Br    2 :y_in      : vector<double>                                         *
*Entries :   366403 : Total  Size=   33664555 bytes  File Size  =   18794908 *
*Baskets :     1158 : Basket Size=      32000 bytes  Compression=   1.79     *
*............................................................................*
*Br    3 :z_in      : vector<double>                                         *
*Entries :   366403 : Total  Size=   33664555 bytes  File Size  =    7532590 *
*Baskets :     1158 : Basket Size=      32000 bytes  Compression=   4.47     *
*............................................................................*
*Br    4 :r_in      : vector<double>                                         *
*Entries :   366403 : Total  Size=   33664555 bytes  File Size  =   26632869 *
*Baskets :     1158 : Basket Size=      32000 bytes  Compression=   1.26     *
*............................................................................*
*Br    5 :size_in   : vector<int>                                            *
*Entries :   366403 : Total  Size=   19413231 bytes  File Size  =    4790315 *
*Baskets :      712 : Basket Size=      32000 bytes  Compression=   4.05     *
*............................................................................*
*Br    6 :phi_in    : vector<double>                                         *
*Entries :   366403 : Total  Size=   39570917 bytes  File Size  =   29190603 *
*Baskets :     1337 : Basket Size=      32000 bytes  Compression=   1.35     *
*............................................................................*
*Br    7 :theta_in  : vector<double>                                         *
*Entries :   366403 : Total  Size=   33669203 bytes  File Size  =    2700409 *
*Baskets :     1158 : Basket Size=      32000 bytes  Compression=  12.46     *
*............................................................................*
*Br    8 :adc_in    : vector<double>                                         *
*Entries :   366403 : Total  Size=   33671511 bytes  File Size  =    7869557 *
*Baskets :     1158 : Basket Size=      32000 bytes  Compression=   4.28     *
*............................................................................*
*Br    9 :is_associated_in : vector<bool>                                    *
*Entries :   366403 : Total  Size=    8725151 bytes  File Size  =    2578446 *
*Baskets :      374 : Basket Size=      32000 bytes  Compression=   3.38     *
*............................................................................*
*Br   10 :track_incoming_theta_in : vector<double>                           *
*Entries :   366403 : Total  Size=   33686756 bytes  File Size  =    8746406 *
*Baskets :     1159 : Basket Size=      32000 bytes  Compression=   3.85     *
*............................................................................*
*Br   11 :x_out     : vector<double>                                         *
*Entries :   366403 : Total  Size=   31905590 bytes  File Size  =   17771175 *
*Baskets :     1099 : Basket Size=      32000 bytes  Compression=   1.79     *
*............................................................................*
*Br   12 :y_out     : vector<double>                                         *
*Entries :   366403 : Total  Size=   31905590 bytes  File Size  =   17899419 *
*Baskets :     1099 : Basket Size=      32000 bytes  Compression=   1.78     *
*............................................................................*
*Br   13 :z_out     : vector<double>                                         *
*Entries :   366403 : Total  Size=   31901194 bytes  File Size  =    7093127 *
*Baskets :     1099 : Basket Size=      32000 bytes  Compression=   4.49     *
*............................................................................*
*Br   14 :r_out     : vector<double>                                         *
*Entries :   366403 : Total  Size=   31901194 bytes  File Size  =   25441219 *
*Baskets :     1099 : Basket Size=      32000 bytes  Compression=   1.25     *
*............................................................................*
*Br   15 :size_out  : vector<int>                                            *
*Entries :   366403 : Total  Size=   18532083 bytes  File Size  =    4584091 *
*Baskets :      687 : Basket Size=      32000 bytes  Compression=   4.04     *
*............................................................................*
*Br   16 :phi_out   : vector<double>                                         *
*Entries :   366403 : Total  Size=   31903400 bytes  File Size  =   26760165 *
*Baskets :     1099 : Basket Size=      32000 bytes  Compression=   1.19     *
*............................................................................*
*Br   17 :theta_out : vector<double>                                         *
*Entries :   366403 : Total  Size=   31905606 bytes  File Size  =    2695650 *
*Baskets :     1099 : Basket Size=      32000 bytes  Compression=  11.83     *
*............................................................................*
*Br   18 :adc_out   : vector<double>                                         *
*Entries :   366403 : Total  Size=   31903400 bytes  File Size  =    7613977 *
*Baskets :     1099 : Basket Size=      32000 bytes  Compression=   4.19     *
*............................................................................*
*Br   19 :is_associated_out : vector<bool>                                   *
*Entries :   366403 : Total  Size=    8504919 bytes  File Size  =    2563067 *
*Baskets :      367 : Basket Size=      32000 bytes  Compression=   3.32     *
*............................................................................*
*Br   20 :track_incoming_theta_out : vector<double>                          *
*Entries :   366403 : Total  Size=   31922151 bytes  File Size  =    8629148 *
*Baskets :     1099 : Basket Size=      32000 bytes  Compression=   3.70     *
*............................................................................*
*Br   21 :z_vertex  : z_vertex/D                                             *
*Entries :   366403 : Total  Size=    2943549 bytes  File Size  =    1260052 *
*Baskets :      120 : Basket Size=      32000 bytes  Compression=   2.33     *
*............................................................................*
root [6]
```



example

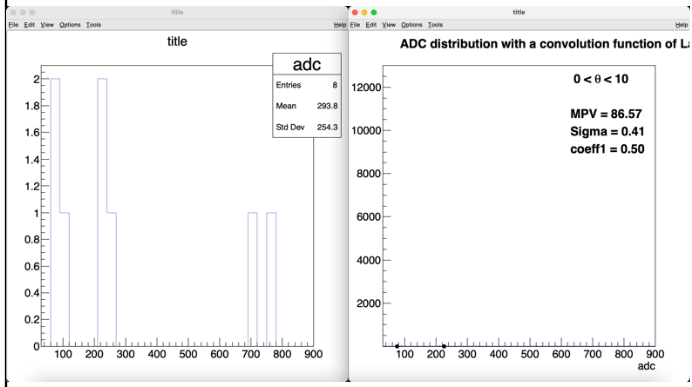
```
•  *************************************************************************************************************************
•  *    Row   * Instance * evt_clus. *      x_in *      y_in *      z_in *      r_in *   size_in *    phi_in *  theta_in *
•  *************************************************************************************************************************
•  *        0 *        0 *        0 *           *           *           *           *           *           *           *
•  *        1 *        0 *        1 * -1.854868 * 6.8333139 * 6.8275494 * 7.0805872 *         1 * 1.8358544 *       nan *
•  *        2 *        0 *        2 * -2.193175 * 6.7397770 * 17.627550 * 7.0876382 *         1 * 1.8853969 *       nan *
•  *        2 *        1 *        2 * 4.9518714 * 5.3587865 * 13.627549 * 7.2964117 *         1 * 0.8248431 *       nan *
•  *        3 *        0 *        3 * -5.488491 * -5.339135 * 17.627550 * -7.657016 *         1 * 2.1212896 *       nan *
•  *        3 *        1 *        3 * -4.668805 * 6.2500052 * -4.572450 * 7.8013019 *         1 * -2.119875 *       nan *
•  *        3 *        2 *        3 * 3.6296293 * 6.9063963 * 8.4275493 * 7.8020843 *         2 * -2.369987 *       nan *
•  *        3 *        3 *        3 * -4.056153 * 6.6084361 * 21.627550 * 7.7539543 *         1 * 2.2123799 *       nan *
•  *        3 *        4 *        3 * -4.313020 * -7.049278 * 13.627549 * -8.264046 *         1 * 1.0869213 *       nan *
•  *        3 *        5 *        3 * 3.0588078 * 6.5546646 * -12.57245 * 7.2332519 *         1 * 2.1212896 *       nan *
•  *        3 *        6 *        3 *           *           *           *           *           * -2.119875 *           *
•  *        3 *        7 *        3 *           *           *           *           *           * 1.1341736 *           *
•  *        4 *        0 *        4 * 2.2861161 * 6.7599639 * -9.372450 * 7.1360661 *         2 * 1.2446859 *       nan *
•  *        4 *        1 *        4 * -7.348895 * -1.740813 * -9.372450 * -7.552264 *         1 * -2.908998 *       nan *
•  *        4 *        2 *        4 * -7.201226 * -2.290732 * -7.772450 * -7.556792 *         1 * -2.833611 *       nan *
•  *        4 *        3 *        4 * 5.7743282 * -5.095060 * -2.972450 * -7.700812 *         1 *  1.366674 *       nan *
•  *        4 *        4 *        4 * 7.3226037 * 1.5412036 * -18.57245 * 7.4830363 *         2 * 2.4907673 *       nan *
•  *        4 *        5 *        4 * 1.4455783 * 6.9832892 * -14.57245 * 7.1313410 *         1 * -2.807869 *       nan *
•  *        4 *        6 *        4 * -5.805932 * 4.4212613 * -22.57245 * 7.2976985 *         1 * -2.807869 *       nan *
•  *        4 *        7 *        4 * -5.702480 * 4.5273790 * -18.57245 * 7.2811704 *         1 * -2.369478 *       nan *
•  *        4 *        8 *        4 * -7.150654 * -2.479060 * -18.57245 * -7.568196 *         1 * 2.5752178 *       nan *
•  *        4 *        9 *        4 * -7.469255 * -1.292592 * -16.57245 * -7.580275 *         2 * -3.119746 *       nan *
•  *        4 *       10 *        4 * -5.485737 * -5.341897 * -16.57245 * -7.656969 *         2 * -2.020879 *       nan *
•  *        4 *       11 *        4 * -5.937296 * -4.888926 * -14.57245 * -7.691104 *         2 * -2.059469 *       nan *
•  *        4 *       12 *        4 * -6.978711 * -3.119376 * 2.0275495 * -7.644143 *         1 * -2.059469 *       nan *
```

macro_roofit2.cc

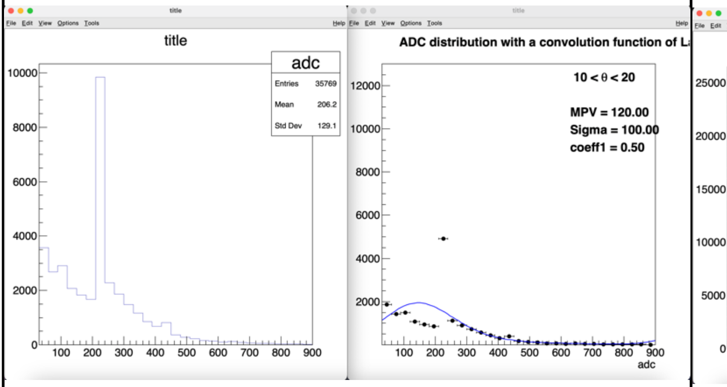
- histogram of adc_in+adc_out
- cut angle both adc_in and adc_out

Left side: number of adc_in+adc_out
right side: number of adc_in

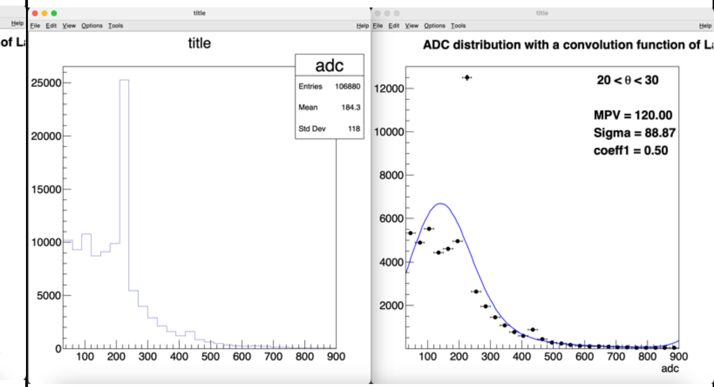
Theta:0-10



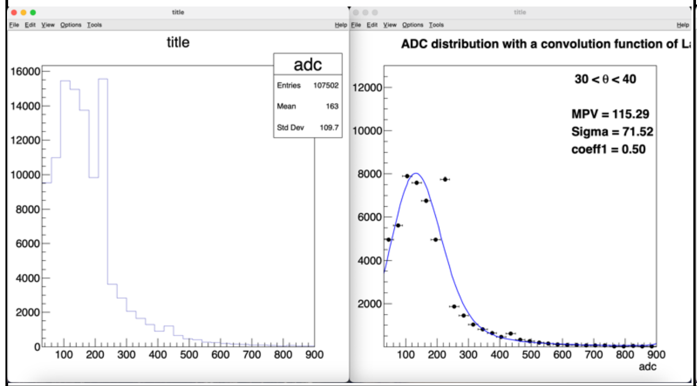
10-20



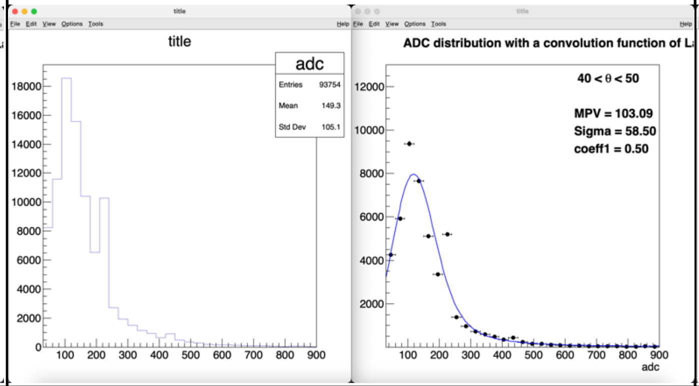
20-30



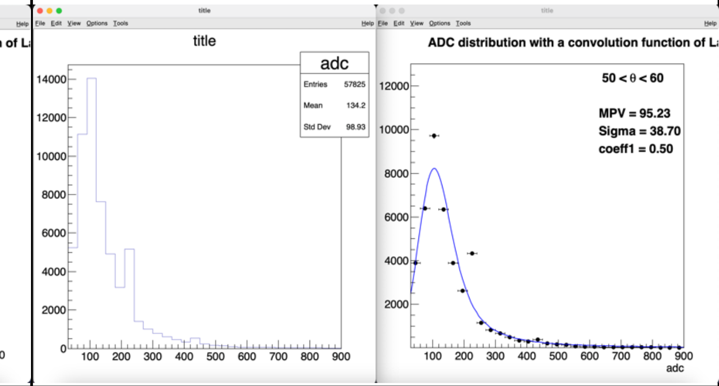
30-40



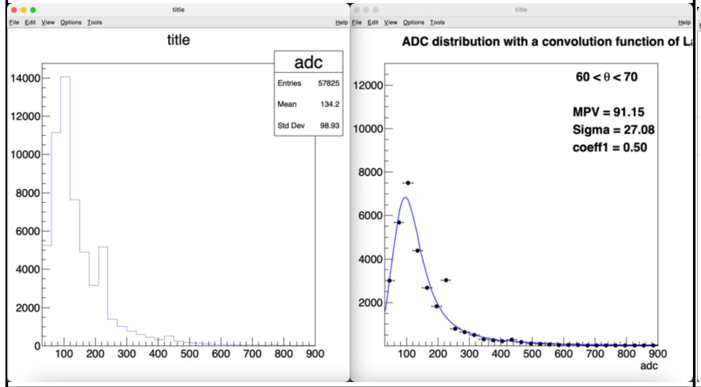
40-50



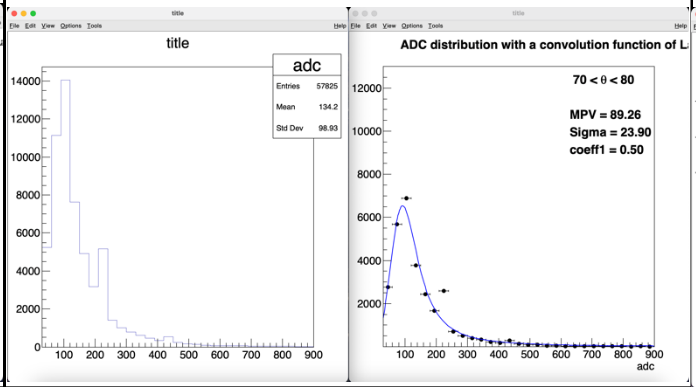
50-60



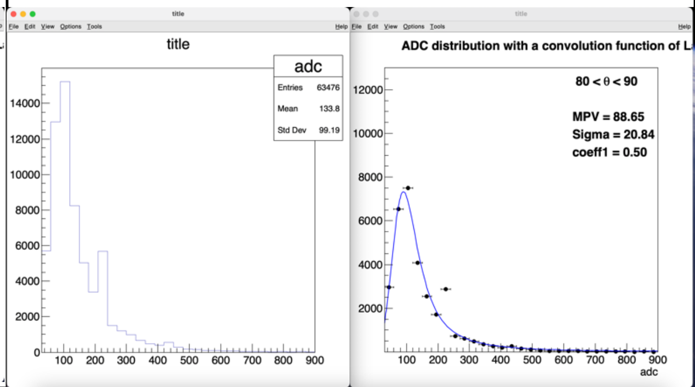
60-70



70-80



80-90



macro_roofit5.cc

macro_roofit2.ccからの変更点

```
ana->Loop(theta_min , theta_max);

 // xframe->SetMaximum(13000); // 最大値を8000に設定
   // xframe->SetMinimum(1); // 最小値を1に設定

ana->hist_adc->Draw("same");
```

.h

```
 virtual void     Loop(double theta_min, double theta_max);
```

.C

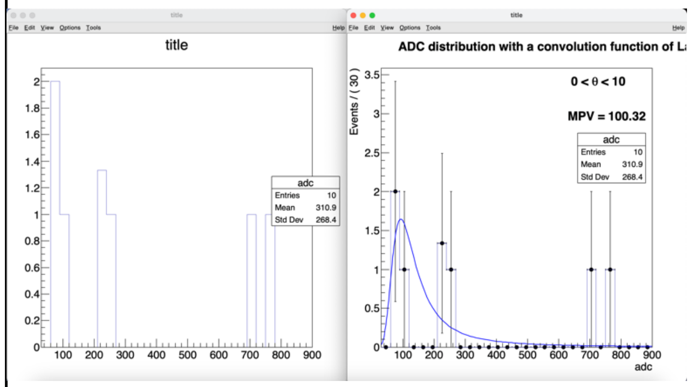
```
void analyzer::Loop( double theta_min , double theta_max )
```

変更ポイント

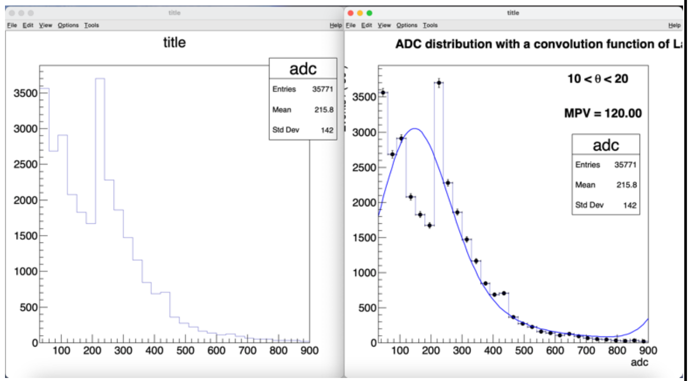
thetaカットをソースファイルを超えて連動させた

ヒストグラムを重ね書きするようにし、見やすくなった

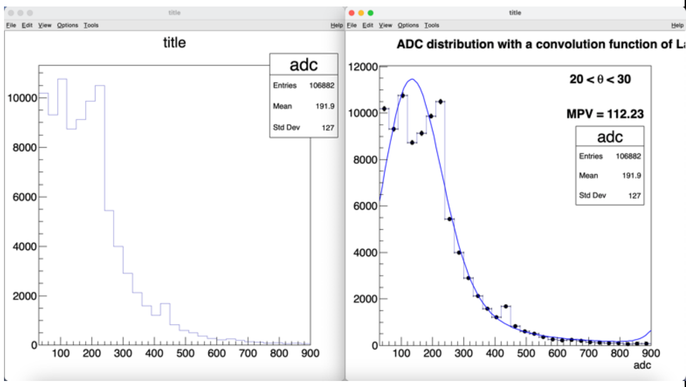
Theta:0-10



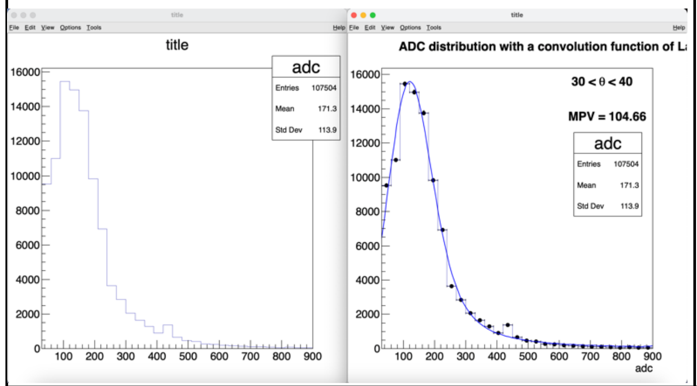
10-20



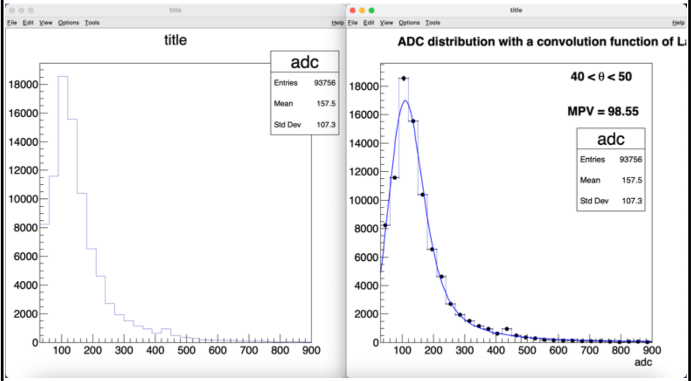
20-30



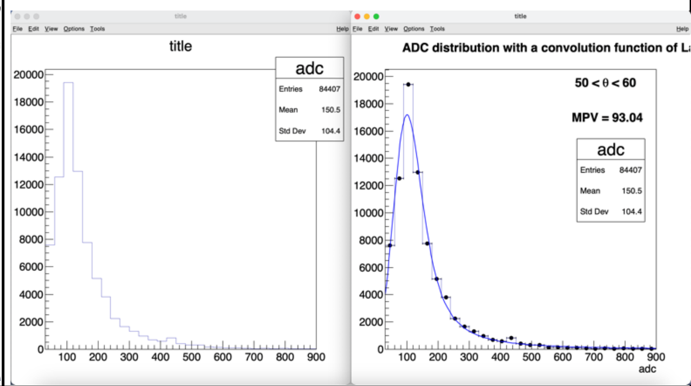
30-40



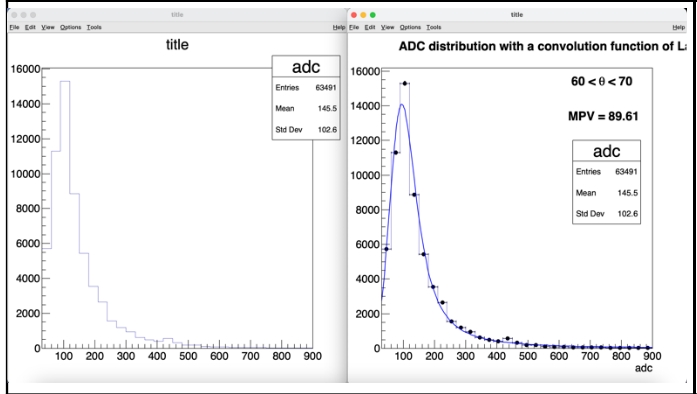
40-50



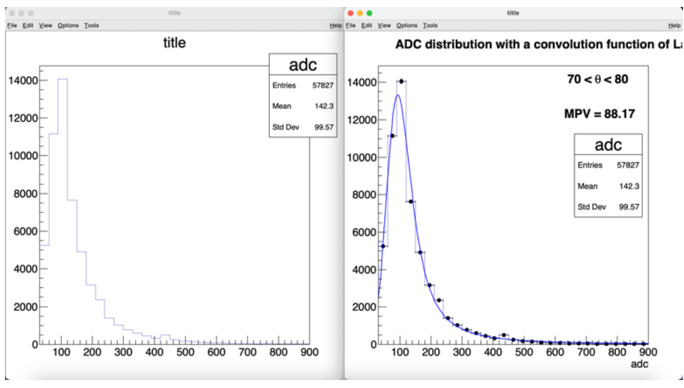
50-60



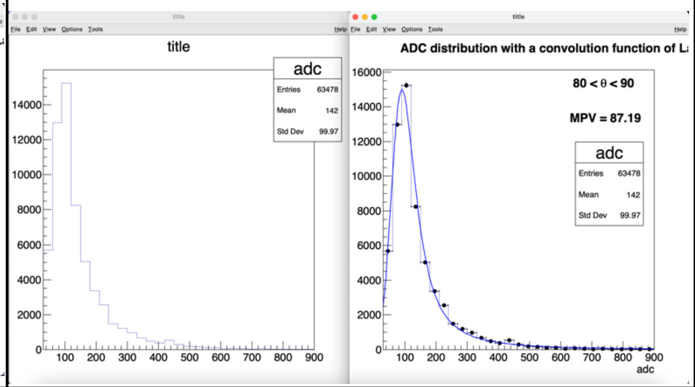
60-70



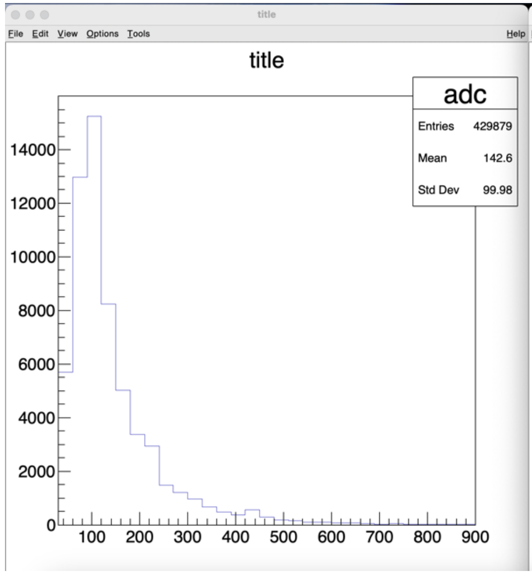
70-80

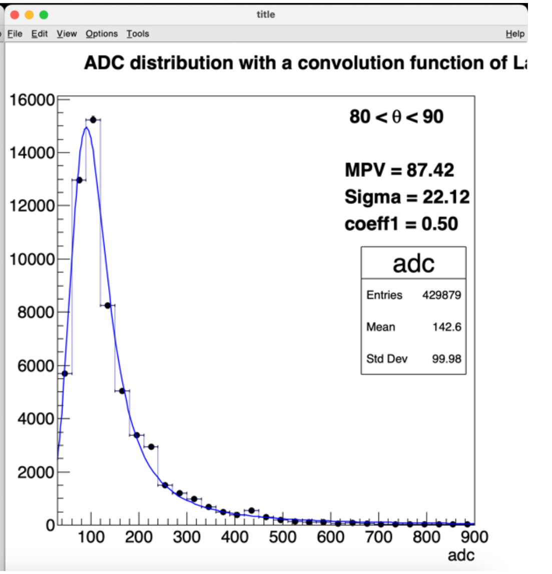


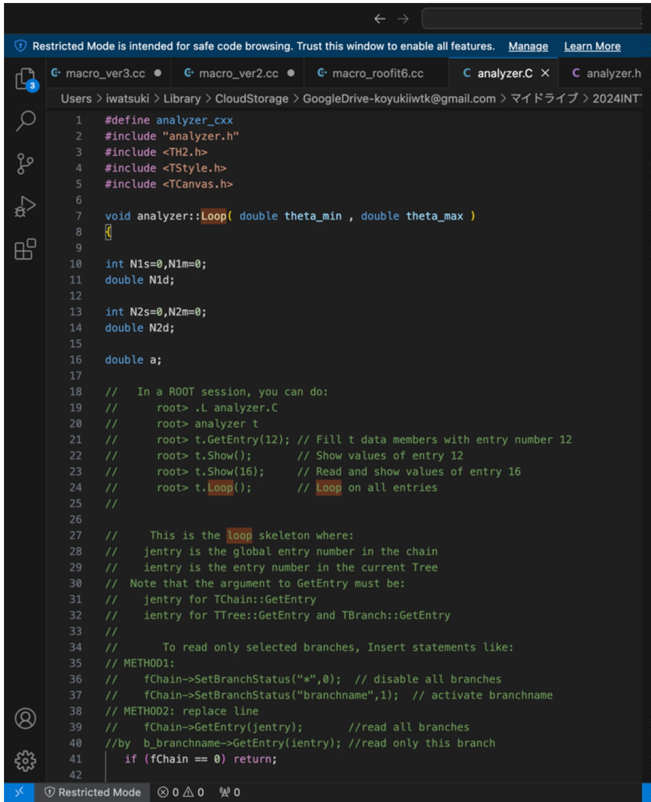
80-90



after changing analyzer.C

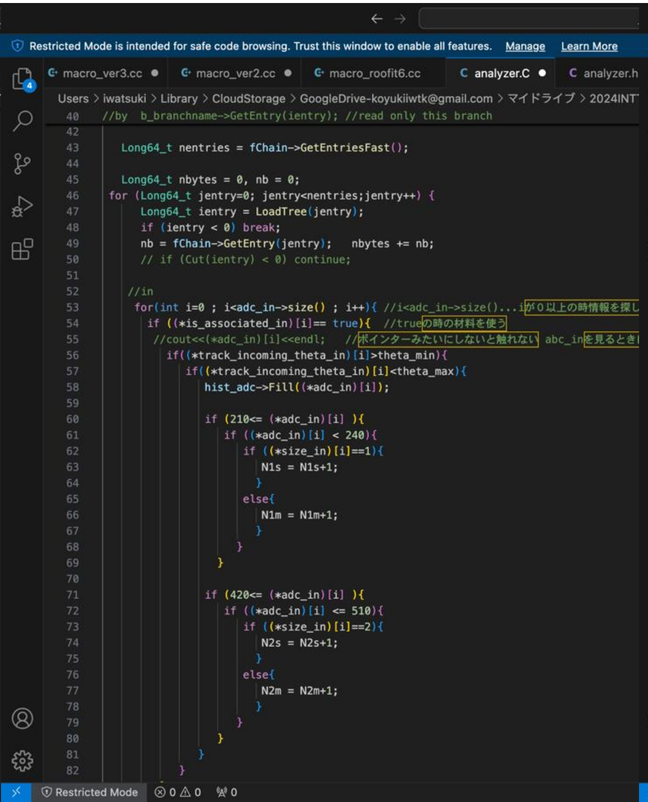





macro_ver3.cc
macro_ver2.cc
macro_roofit6.cc
analyzer.C
analyzer.h
Users > iwatsuki > Library > CloudStorage > GoogleDrive-koyukiiwtk@gmail.com > マイドライブ > 2024INT
Restricted Mode

Restricted Mode is intended for safe code browsing. Trust this window to enable all features. Manage Learn More

```
#define analyzer_cxx
#include "analyzer.h"
#include <TH2.h>
#include <TStyle.h>
#include <TCanvas.h>

void analyzer::Loop( double theta_min , double theta_max )
{

int N1s=0,N1m=0;
double N1d;

int N2s=0,N2m=0;
double N2d;

double a;

//   In a ROOT session, you can do:
//      root> .L analyzer.C
//      root> analyzer t
//      root> t.GetEntry(12); // Fill t data members with entry number 12
//      root> t.Show();       // Show values of entry 12
//      root> t.Show(16);     // Read and show values of entry 16
//      root> t.Loop();       // Loop on all entries
//

//     This is the loop skeleton where:
//    jentry is the global entry number in the chain
//    ientry is the entry number in the current Tree
//  Note that the argument to GetEntry must be:
//    jentry for TChain::GetEntry
//    ientry for TTree::GetEntry and TBranch::GetEntry
//
//       To read only selected branches, Insert statements like:
// METHOD1:
//    fChain->SetBranchStatus("*",0);  // disable all branches
//    fChain->SetBranchStatus("branchname",1);  // activate branchname
// METHOD2: replace line
//    fChain->GetEntry(jentry);       //read all branches
//by  b_branchname->GetEntry(ientry); //read only this branch
   if (fChain == 0) return;

```


macro_ver3.cc
macro_ver2.cc
macro_roofit6.cc
analyzer.C
analyzer.h
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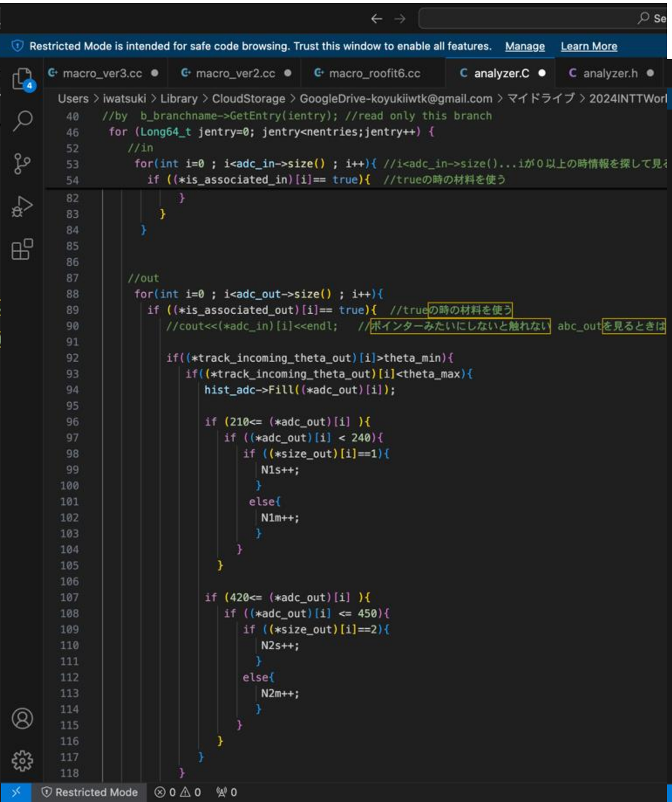
```
//by  b_branchname->GetEntry(ientry); //read only this branch

   Long64_t nentries = fChain->GetEntriesFast();

   Long64_t nbytes = 0, nb = 0;
  for (Long64_t jentry=0; jentry<nentries;jentry++) {
     Long64_t ientry = LoadTree(jentry);
     if (ientry < 0) break;
     nb = fChain->GetEntry(jentry);   nbytes += nb;
     // if (Cut(ientry) < 0) continue;

    //in
     for(int i=0 ; i<adc_in->size() ; i++){ //i<adc_in->size()...iが0以上の時情報を探し
      if ((*is_associated_in)[i]== true){  //trueの時の材料を使う
       //cout<<(*adc_in)[i]<<endl;   //ポインターみたいにしないと触れない abc_inを見るとき
         if((*track_incoming_theta_in)[i]>theta_min){
            if((*track_incoming_theta_in)[i]<theta_max){
               hist_adc->Fill((*adc_in)[i]);

               if (210<= (*adc_in)[i] ){
                  if ((*adc_in)[i] < 240){
                     if ((*size_in)[i]==1){
                        N1s = N1s+1;
                     }
                     else{
                        N1m = N1m+1;
                     }
                  }
               }

               if (420<= (*adc_in)[i] ){
                  if ((*adc_in)[i] <= 510){
                     if ((*size_in)[i]==2){
                        N2s = N2s+1;
                     }
                     else{
                        N2m = N2m+1;
                     }
                  }
               }
            }
         }
```


macro_ver3.cc
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macro_roofit6.cc
analyzer.C
analyzer.h
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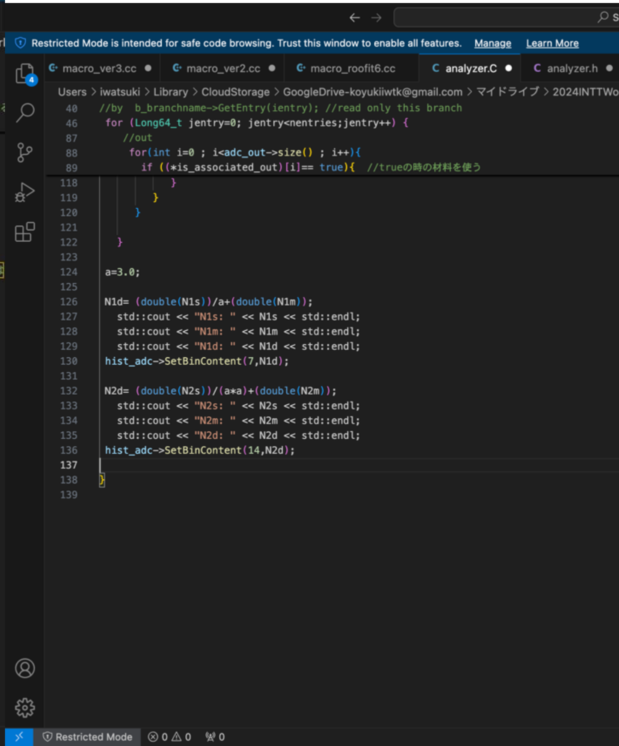
```
//by  b_branchname->GetEntry(ientry); //read only this branch
  for (Long64_t jentry=0; jentry<nentries;jentry++) {
    //in
     for(int i=0 ; i<adc_in->size() ; i++){ //i<adc_in->size()...iが0以上の時情報を探して見る
      if ((*is_associated_in)[i]== true){  //trueの時の材料を使う
         }
       }
     }


    //out
     for(int i=0 ; i<adc_out->size() ; i++){
      if ((*is_associated_out)[i]== true){  //trueの時の材料を使う
       //cout<<(*adc_in)[i]<<endl;   //ポインターみたいにしないと触れない abc_outを見るときは

         if((*track_incoming_theta_out)[i]>theta_min){
            if((*track_incoming_theta_out)[i]<theta_max){
               hist_adc->Fill((*adc_out)[i]);

               if (210<= (*adc_out)[i] ){
                  if ((*adc_out)[i] < 240){
                     if ((*size_out)[i]==1){
                        N1s++;
                     }
                      else{
                        N1m++;
                     }
                  }
               }

               if (420<= (*adc_out)[i] ){
                  if ((*adc_out)[i] <= 450){
                     if ((*size_out)[i]==2){
                        N2s++;
                     }
                     else{
                        N2m++;
                     }
                  }
               }
            }
         }
```


macro_ver3.cc
macro_ver2.cc
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```
//by  b_branchname->GetEntry(ientry); //read only this branch
  for (Long64_t jentry=0; jentry<nentries;jentry++) {
    //out
     for(int i=0 ; i<adc_out->size() ; i++){
      if ((*is_associated_out)[i]== true){  //trueの時の材料を使う
         }
       }
     }

   }

a=3.0;

N1d= (double(N1s))/a+(double(N1m));
  std::cout << "N1s: " << N1s << std::endl;
  std::cout << "N1m: " << N1m << std::endl;
  std::cout << "N1d: " << N1d << std::endl;
hist_adc->SetBinContent(7,N1d);

N2d= (double(N2s))/(a*a)+(double(N2m));
  std::cout << "N2s: " << N2s << std::endl;
  std::cout << "N2m: " << N2m << std::endl;
  std::cout << "N2d: " << N2d << std::endl;
hist_adc->SetBinContent(14,N2d);

}

```