Neutron Detector Array NAND Lesson 3

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Series of video lectures about ROOT analysis of pre-fission neutrons from the NAND Array at IUAC, New Delhi

All the files used here are available at http://www.ambar-chatterjee.com

Questions?

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Getting the files you need

Website: http://www.ambar-chatterjee.com

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Work:

- Bhabha Atomic Research Centre, Mumbai (Retd.)
- MS Univ of Baroda
- Inter University Accelerator Centre, New Delhi

Websites:

- LAMPS Data Acquisition
- AIWCF Chess Server

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Videos

NAND Lesson 1	MWPC Slicing, Angle Calculations	Click
NAND Lesson 2	Structured ROOT programs	Click
NAND Lesson 3	Building Neutron Spectra	Click

Support Files

NAND Lesson 1	nand01.tgz	
NAND Lesson 2	IUAC_NAND_data.001	nand02.tgz
NAND Lesson 3	nand03.tgz	

Building Neutron Energy Spectra

There will be NDet x NSlices spectra.
In my example data NDet = 73
I will consider 12 slices.
No of spectra = 73 x 12 = 876

The program will be structured so that it can deal with

- Any number of slices
- Each slice can have arbitrary X1,X2,Y1,Y2
- We can even have one large slice in the centre
- Any number of Neutron detectors

The program will output all the spectra (without any normalisation) into a single text file NeutronSpectra.txt
This file would be read later for moving source fit
We will also need the number of fission events, NFis in each slice

Gates to be applied:
CutT1_T2 which we saved in Work.root in the previous lesson
Neutron selection cuts CutN[DetNo] for each neutron detector
Conditions on X1,X2,Y1,Y2 for slicing

In most experiments MWPC1 is the forward angle fission detector
However, in our sample data MWPC2 was placed at forward angle.
When you use my program to analyse your data, do not forget to change the parameter numbers according to which MWPC is at forward angle. Slicing is for the forward angle MWPC.

In every experiment, the MWPCs need to be calibrated for position.
This is done by placing a mask in front of the MWPC
The numbers:

```
double Mx=7.71e-03,Cx=0.0;
double My=7.83e-03,Cy=-0.1;
```

that you will see in this lesson are these calibration numbers
Change these numbers according to your experiment.
The size of the MWPC could also be different.
Here MWPC2 was 20cm (horizontal) x 10cm (vertical)

Before writing the final program (Prog007.cpp), we are going to write two preliminary programs to help us understand the data

Program	Purpose
Prog005.cpp	Display the 2d position spectrum of the forward angle MWPC
Prog006.cpp	Display slices of the forward angle MWPC
Prog007.cpp	Builds neutron energy spectra for each MWPC slice

In addition to your list mode data, the following additional files are required in the same directory where these programs will be run. You need to edit these files according to your experiment and your decision about how you want to slice the forward angle MWPC.

File	Purpose
FileList.txt	List of files for the analysis (see Lesson 2)
gPos.txt	Saved position of gamma ray peaks (see Lesson 2)
ParaList.txt	List of parameters (see Lesson 2)
SliceData.txt	Geometry of MWPC slices (explained in this Lesson)
Work.root	Saved cuts from Lesson 2

Prog005.cpp

Here we calculate the position of detected fragment in the forward angle MWPC inside the event loop. For the sample data I am using MWPC2 was placed at the forward angle. Accordingly,

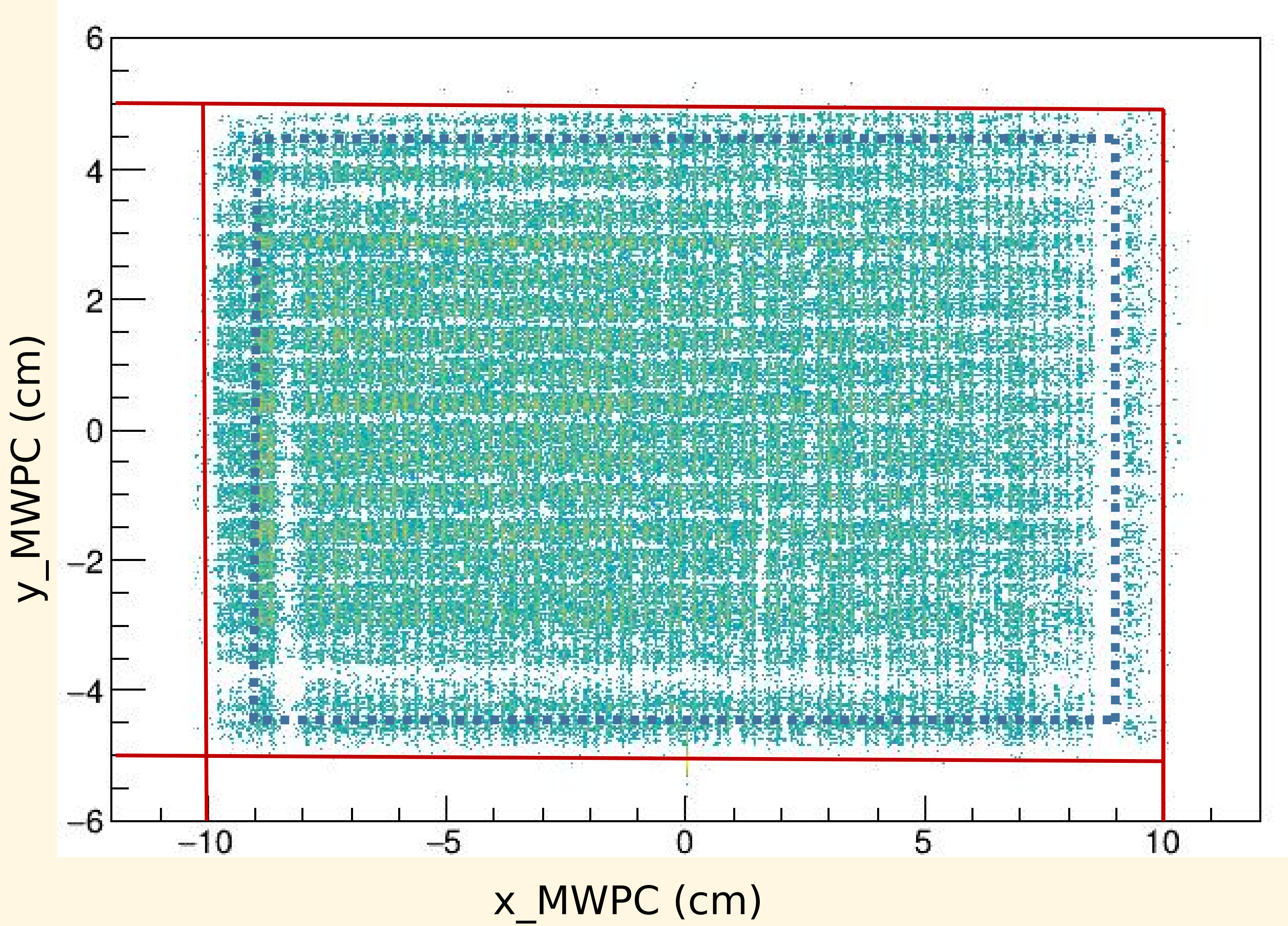
x_MWPC = Mx * (MWPC2_XL - MWPC2_XR) + Cx
y_MWPC = My* (MWPC2_YU - MWPC2_YD) + Cy

and in terms of our parameter numbering (ParaList.txt):

```
x_MWPC=Mx*(P[6]-P[7])+Cx;
y_MWPC=My*(P[8]-P[9])+Cy;
```

In case MWPC1 is at forward angle, you will have to change the above two lines in the code.

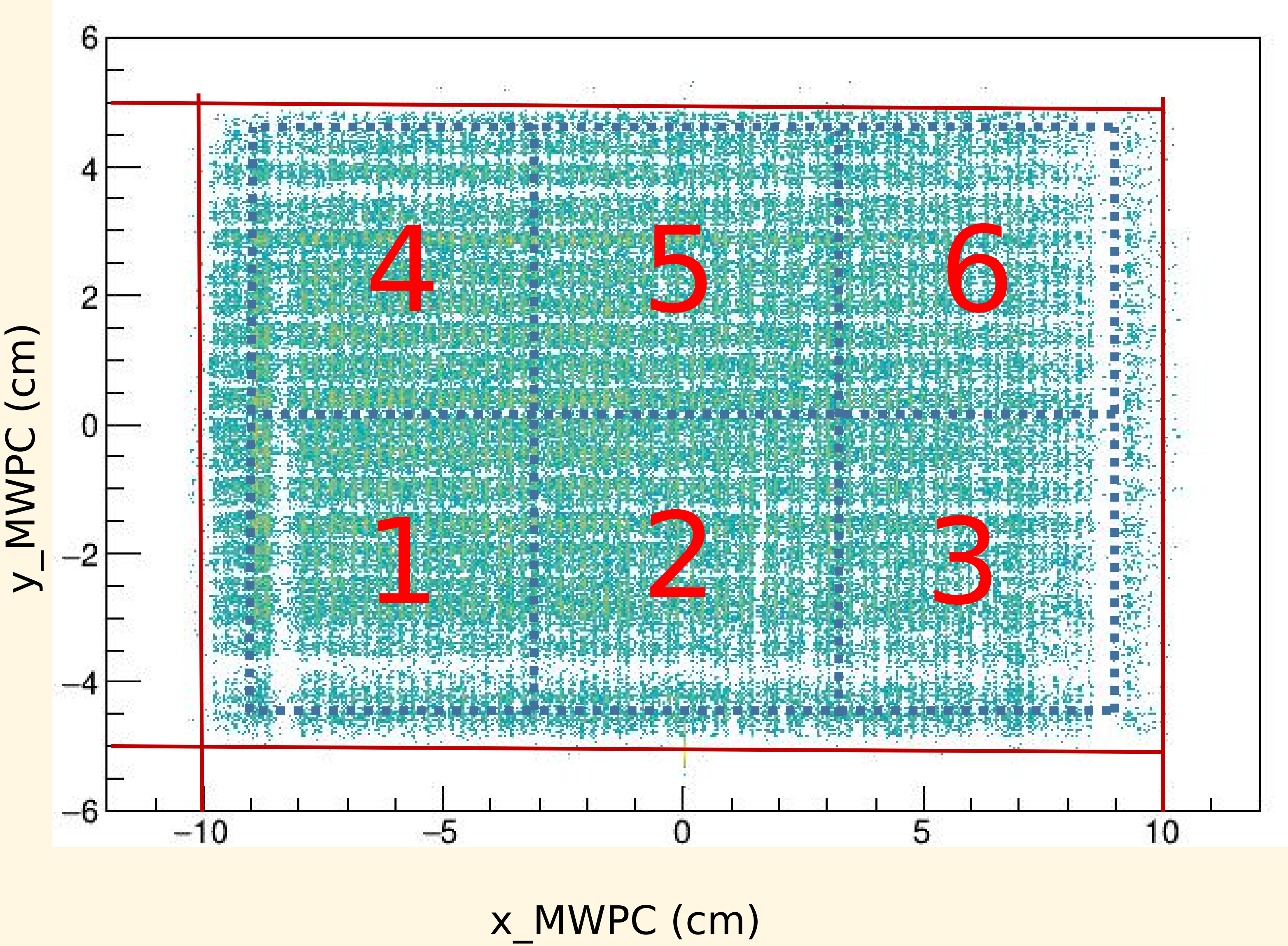
Calibrated 2d Histogram of Fission Events in **MWPC2** 20cm (X) x 10cm (Y)



Avoid edges where signals may not be proper.

Take as full acceptance:
-9cm < X < 9cm
-4.5cm < Y < 4.5cm

Try dividing into 6 slices 3x2



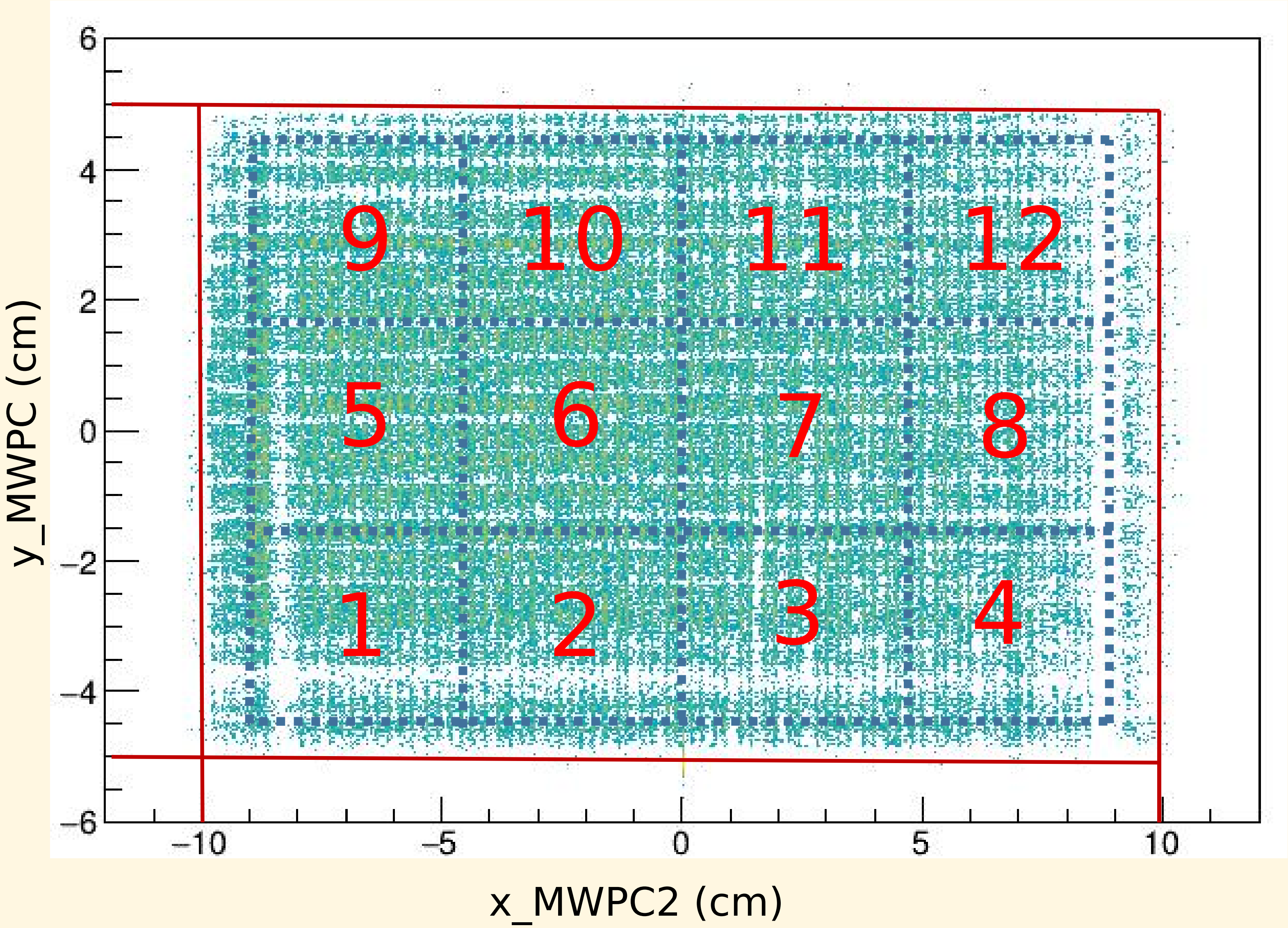
Slice data for 6 slices

Slice 1: -9<x<-3, -4.5<y<0
Slice 2: -3<x<3, -4.5<y<0
Slice 3: 3<x<9, -4.5<y<0

Slice 4: -9<x<-3, 0<y<4.5
Slice 5: -3<x<3, 0<y<4.5
Slice 6: 3<x<9, 0<y<4.5

Put these numbers in SliceData.txt

We will demo dividing into 12 slices 4x3



Slice data for 12 slices

Slice 1: -9<x<-4.5, -4.5<y<-1.5
Slice 2: -4.5<x<0, -4.5<y<-1.5
Slice 3: 0<x< 4.5, -4.5<y<-1.5
Slice 4: 4.5<x< 9, -4.5<y<-1.5

Slice 5: -9<x<-4.5, -1.5<y<1.5
Slice 6: -4.5<x<0, -1.5<y<1.5
Slice 7: 0<x< 4.5, -1.5<y<1.5
Slice 8: 4.5<x< 9, -1.5<y<1.5

Slice 9: -9<x<-4.5, 1.5<y<4.5
Slice 10: -4.5<x<0, 1.5<y<4.5
Slice 11: 0<x< 4.5, 1.5<y<4.5
Slice 12: 4.5<x< 9, 1.5<y<4.5

Put these numbers in SliceData.txt

Prog006.cpp

Lets take a look at SliceData.txt and see how we can slice the forward angle MWPC in any way we want

Slices

Decide on the slices and put this information in SliceData.txt
You can specify as many slices as you want of any size and position
You can even run with just 1 large slice in the centre
You can repeat the analysis with different number of slices

- The slices need to be small because the Watt expression is sensitive to angles
- The angles involved depend on the detector position, and on the emission direction of both fragments
- Some experiments have anaysed with only one slice (restricted in size) and even restricted the number of detectors
- Perhaps they think that it is “difficult” to analyse the full data
- Here we show that with well structured code it is easy
- With more slices, the statistics for each slice is reduced
- Since we will analyse ALL the data the overall statistics is not reduced
- I do not recommend analysing only part of your valuable data!

More about Slices

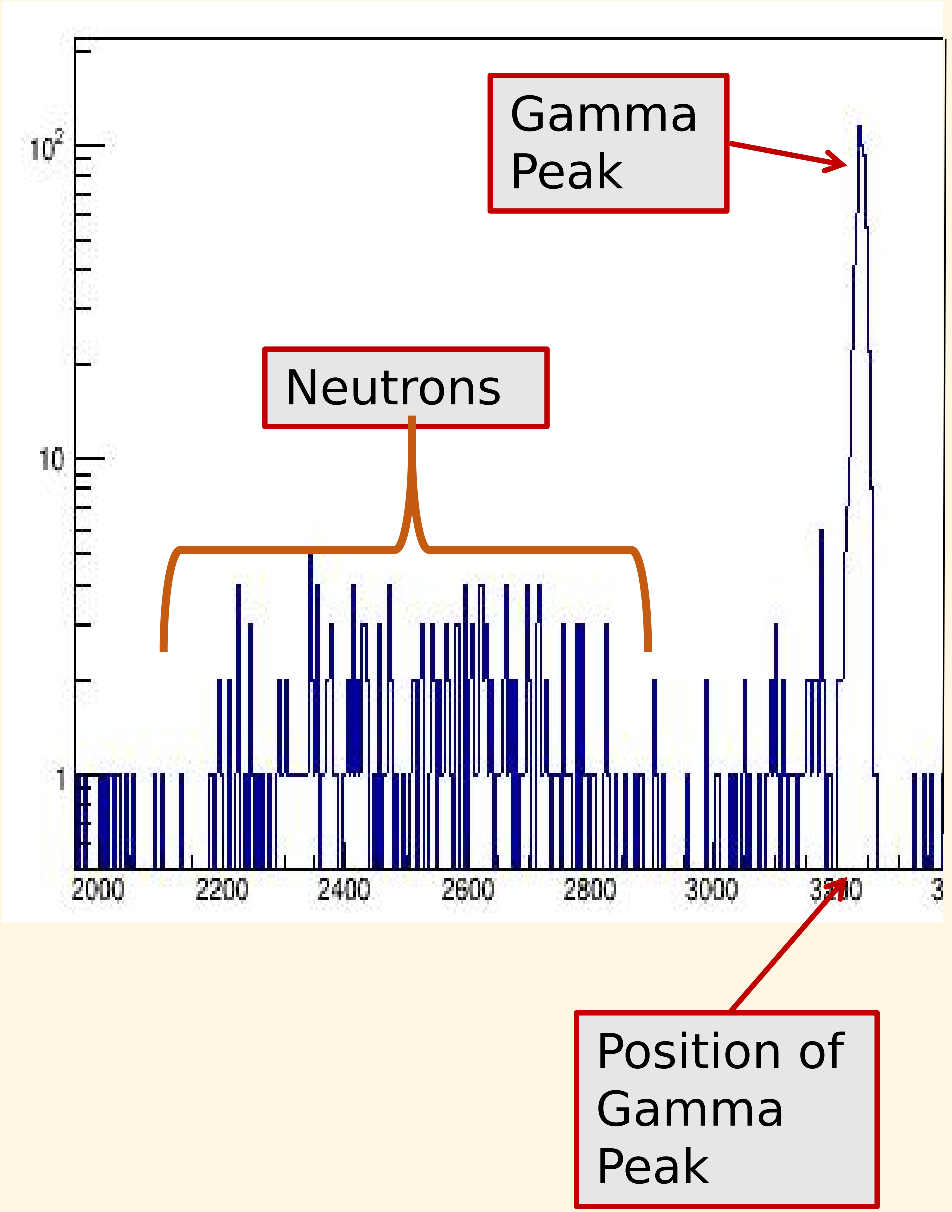
In today's Lesson we will see that with will structured code one can analyse the full data set generating e.g. spectra for 73 detectors x 12 slices

- How many slices are necessary?
- What is the error introduced if slices are large?
- How can we make a simultaneous Moving Source fit with so many slices?
- If we require so many slices (12 slices is not enough) will it be practical?
- How can we present so many spectra, that too with low statistics, to convince our audience about the goodness of our fit?

I will take up these questions in subsequent Lessons

Today I have only a very small demo data file but I show you how to write a ROOT code of only 174 lines to analyse the complete data with no compromises on detctors and as many slices as you want.

Calculating neutron energy



Approx TDC calibration 500ns/4096 = 0.122 ns/ch
Use accurate individual calibration if available

Velocity of light, c=29.979 cm/ns

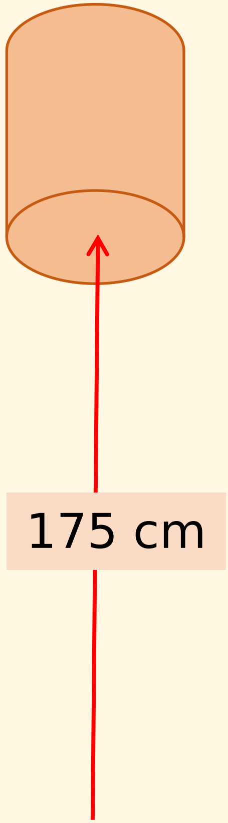
$$T(ns) = 0.122 \times (G - P) + \frac{175}{29.979}$$

Many people leave out the second term

$$T(ns) = 0.122 \times (G - P + 47.84)$$

$$E_n = \frac{1}{2} m_n v^2 = 0.5 \frac{939.56}{29.979^2} \left(\frac{175}{T}\right)^2$$

$$E_n = \frac{1.076e6}{(G - P + 47.84)^2} MeV$$



Prog007.cpp

Now I demonstrate the final program Prog007.cpp
We will produce (NDet x NSlices) neutron spectra
and save them in an ascii file for subsequent Moving
Source fit