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Update to the chain finder

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g4SBS EPC

**2M events (protons)
fine step**

Rachel's digitization

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**200 files
10k events/file**

`/w/halla-
scshelf2102/sbs/rmontgom/mTPC
/EPC180222`

ASCII to ROOT

`/w/halla-scsshelf2102/sbs/gayoso/g4sbs-
analysis/racheldataroot`

**Event (int)
Momentum (double)
theta (double)
phi (double)
zvertex (double)
NoHits (int)
TimeofArrival (vector double)
ADC (vector double)
ring (vector int)
pad (vector int)
plane (vector int)
ZtoGEM (vector double)
XHitPos (vector double)
YHitPos (vector double)
ZHitPos (vector double)**

Rachel's data output structure

Event	0								
0.391797		56.63	-95.11	0.0532					
1128.22	5.12029e-07	0	91	6	0.0361991	0.000277426	-0.0500013	0.0861991	
1145.36	3.79636e-07	0	91	6	0.036749	0.000360927	-0.0508323	0.086749	
1162.5	2.13527e-07	0	91	6	0.037299	0.000446939	-0.0516631	0.087299	
1179.64	1.38157e-07	0	91	6	0.0378489	0.000535465	-0.0524936	0.0878489	
1196.78	1.3457e-07	0	91	6	0.0383989	0.000626495	-0.0533238	0.0883989	
1213.92	1.05379e-07	0	91	6	0.0389488	0.000720043	-0.0541538	0.0889488	
1231.06	1.0527e-07	1	90	6	0.0394988	0.000816089	-0.0549834	0.0894988	
1248.21	1.54814e-07	1	90	6	0.0400487	0.00091463	-0.0558128	0.0900487	
1265.35	1.70296e-08	1	90	6	0.0405987	0.00101567	-0.0566418	0.0905987	
1282.49	1.07147e-07	1	90	6	0.0411487	0.00111922	-0.0574705	0.0911487	
1299.63	3.50869e-07	1	90	6	0.0416987	0.00122528	-0.0582989	0.0916987	

Sort the data pool

Following the notes from the presentation of [September 21, 2021](#):

G4 data enter in the data pool as first produced, first event → inner to outer

<https://userweb.jlab.org/~gayoso/file.gif>

Sorting (making use of Tvector and Quick Sort algorithm

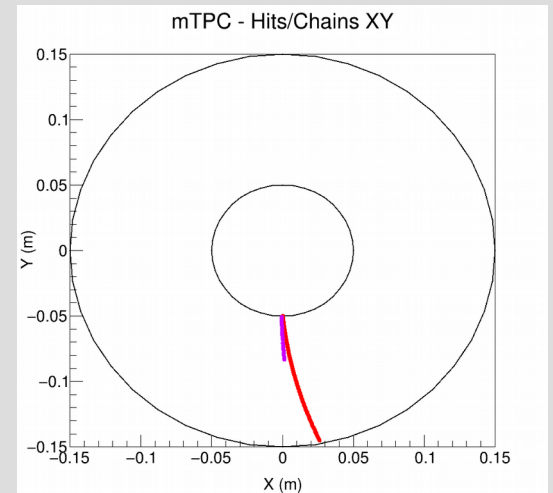
<http://www.algolist.net/Algorithms/Sorting/Quicksort>

→ outer to inner

https://userweb.jlab.org/~gayoso/file_01.gif



Gif animations of these two events showing the data pool sorted (before and after)

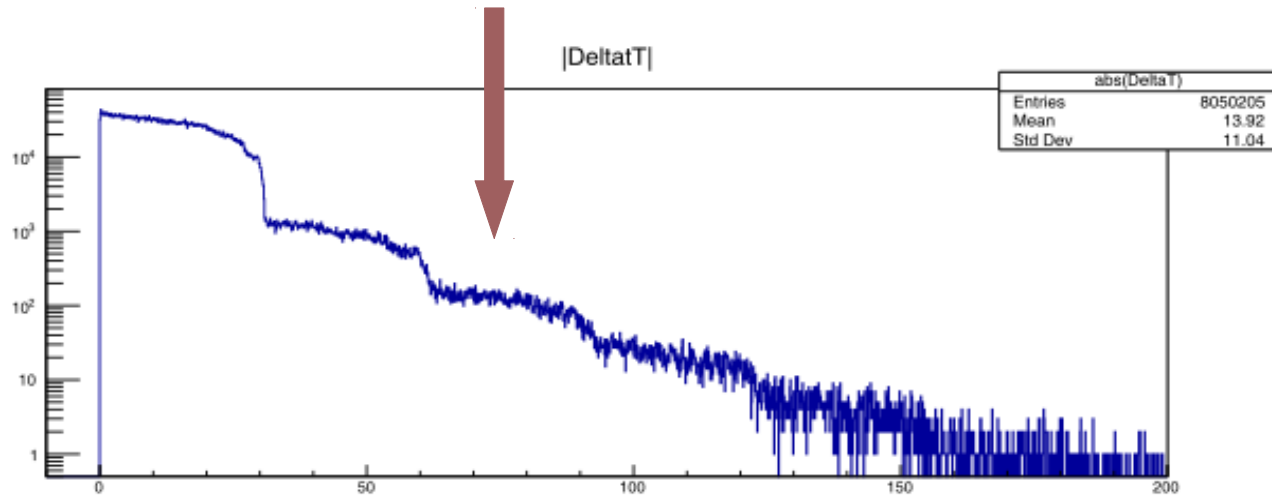
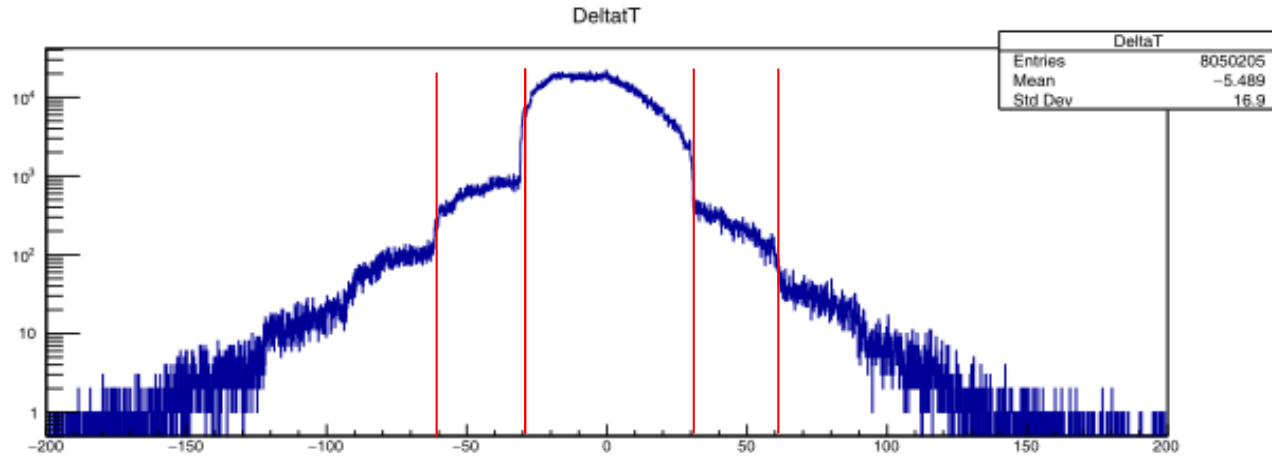


Use of time

Following the notes from the presentation of [September 21, 2021](#):

- The chain finder makes use of the spatial coordinates (now directly the g4sbs output)
- Make use of time difference between hits could help to select hits
 - It is assumed that different tracks will have different TDC timing hits within the time slot.
- But first I need to understand the data

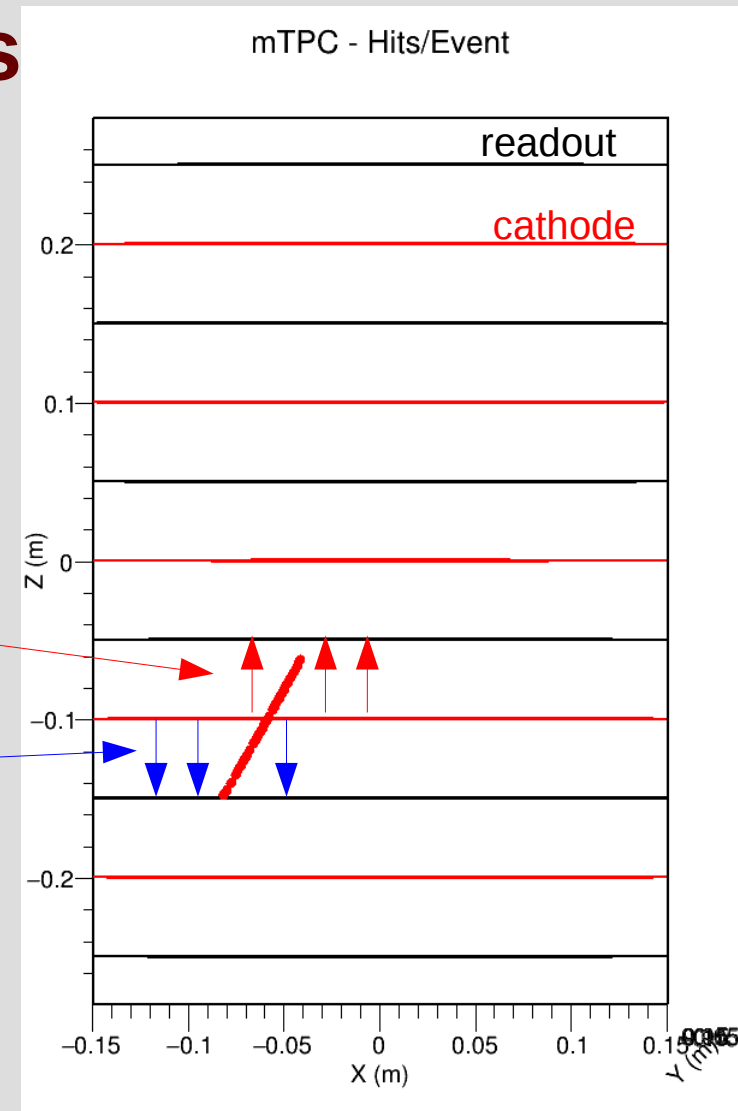
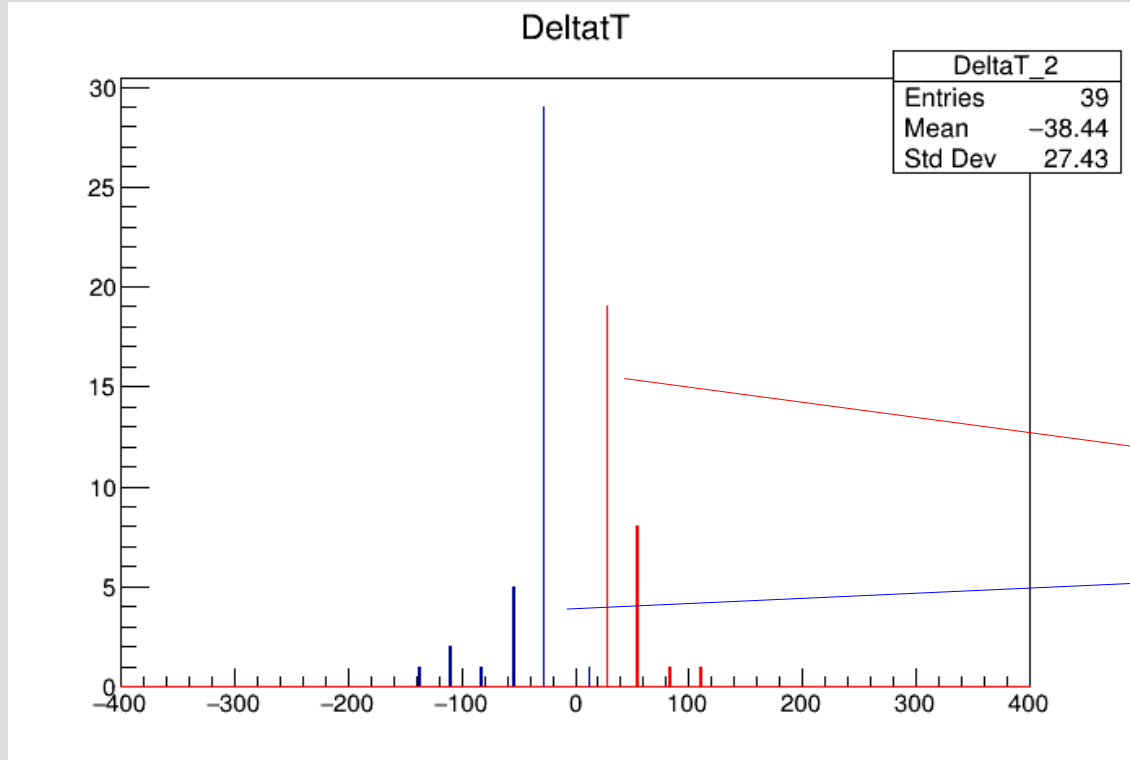
Time difference (Δt)



100k events
 $\Delta t = t_{\text{hit}_i} - t_{\text{hit}_{(i-1)}}$

30 ns structure
(SAMPA sampling)

Event analysis

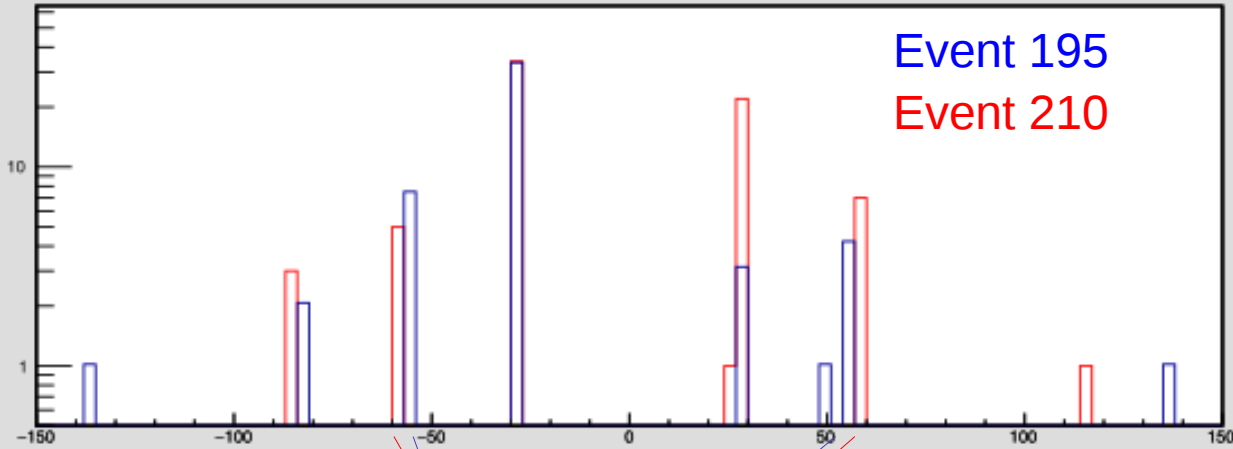


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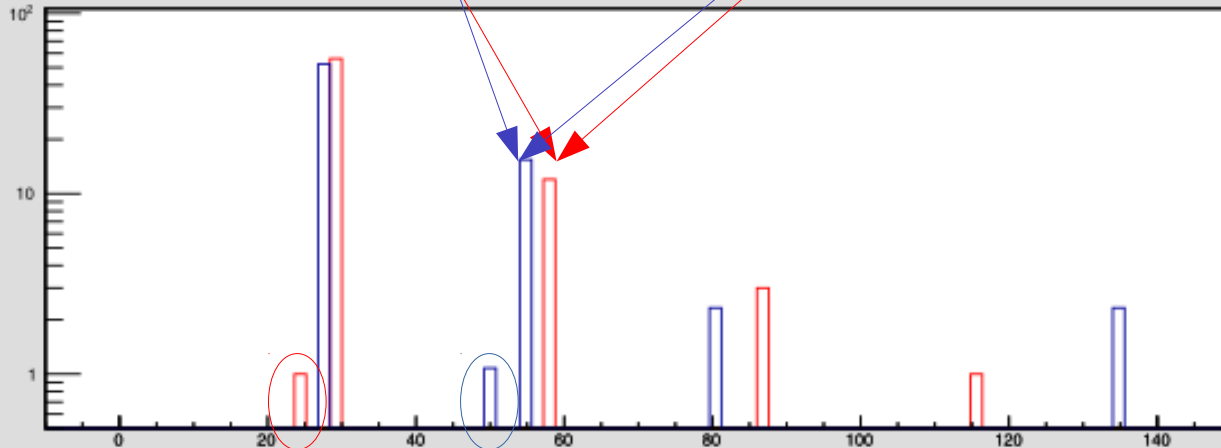
Event Analysis

DeltatT



Events at both sides of readout/cathode have $\sim |\Delta t|$

|\Delta t|



- The hits time is close of a multiple of shorter Δt
- Some events present some challenging to understand:
 - Events (in circle) are effect of the Geant4 engine and not accomplish the previous rule

Geant4 'effect'

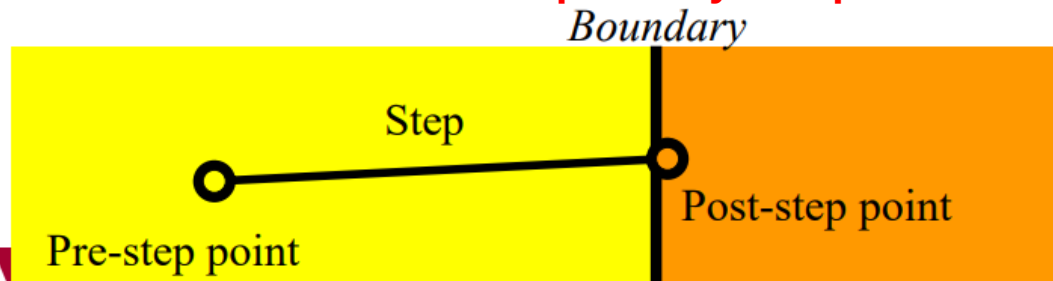
Step in Geant4

SLAC

```
Plane (bef): 1
deltat: 54.12
Plane (aft): 1
Plane (bef): 1
deltat: 27.05
Plane (aft): 1
Plane (bef): 1
deltat: 54.12
Plane (aft): 1
Plane (bef): 1
deltat: 27.05
Plane (aft): 1
Plane (bef): 1
deltat: 49.9
Plane (aft): 0
Plane (bef): 0
deltat: -27.04
Plane (aft): 0
```

- Step has two points and also “delta” information of a particle (energy loss on the step, time-of-flight spent by the step, etc.).
- Each point knows the volume (and material). In case a step is limited by a volume boundary, the end point physically stands on the boundary, and it **logically belongs to the next volume**.
 - Because one step knows materials of two volumes, boundary processes such as transition radiation or refraction could be simulated.
- **G4SteppingManager** class manages processing a step, a step is represented by **G4Step** class.
- **G4UserSteppingAction** is the optional user hook.

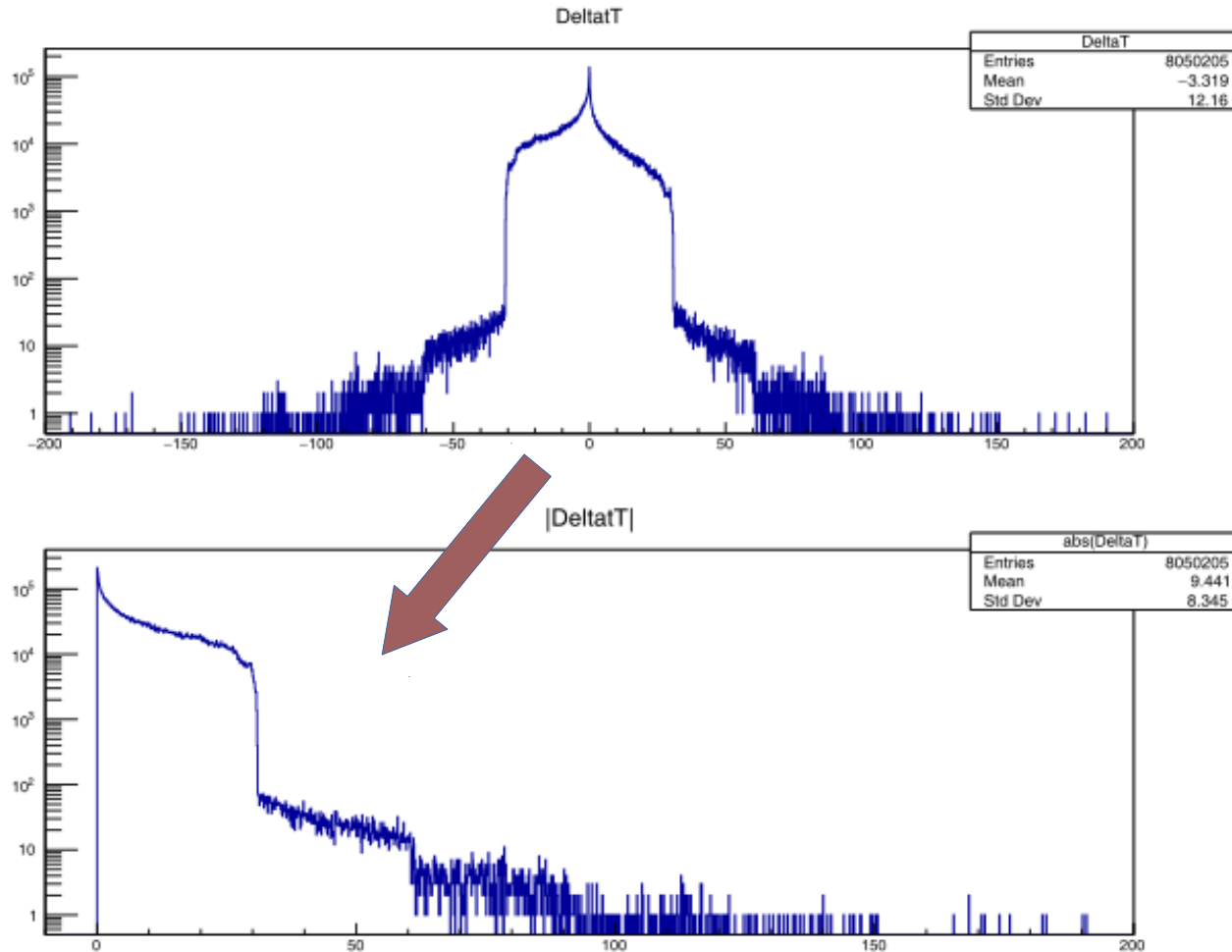
Steps always stop at volume boundary



Using the time to select hits

1. From the first hit (1), search the nearby hit (2) and calculate the time difference $\Delta t_{12} = \text{RAW } t_2 - \text{RAW } t_1$
 - Keep that time difference ($\Delta t_{\text{tmp}} = \Delta t_{12}$)
2. Search the next nearby hit (3) and calculate the Δt_{23}
3. Calculate the ratio and round up $\rightarrow \text{int}_t = \text{round}(\Delta t_{23} / \Delta t_{\text{tmp}})$
4. Then calculate the reduced time minus the previous one ($\Delta t_{23} / \text{int}_t - \Delta t_{\text{tmp}}$)
 - If such a difference is $<$ tolerance \rightarrow good hit to the chain
 - Keep the new time difference $\Delta t_{\text{tmp}} = \Delta t_{23} / \text{int}_t$
5. Repeat from 2.

Reduced time distribution

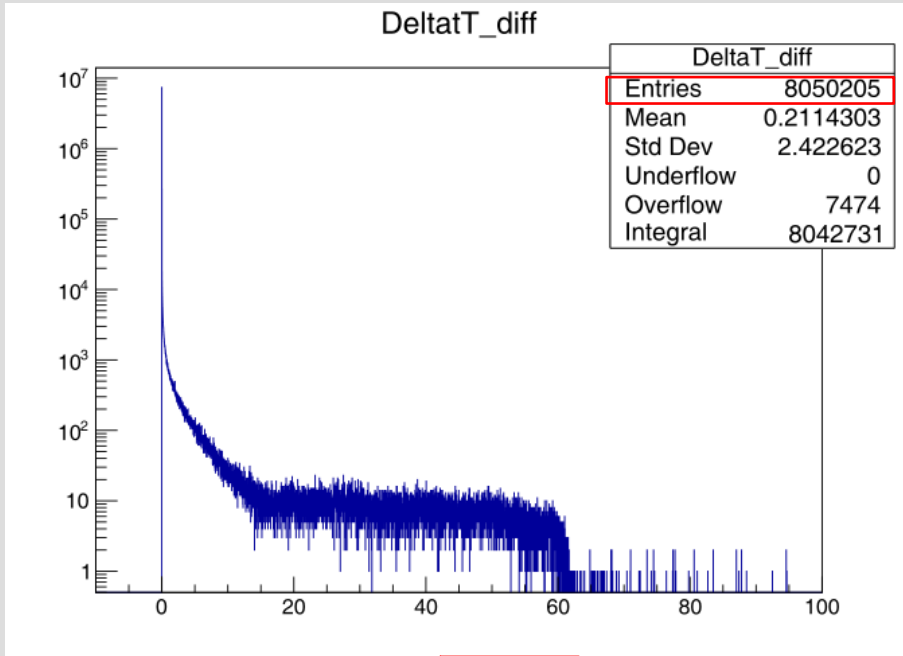


In principle, all the time differences should be comprised to the range <30 ns.

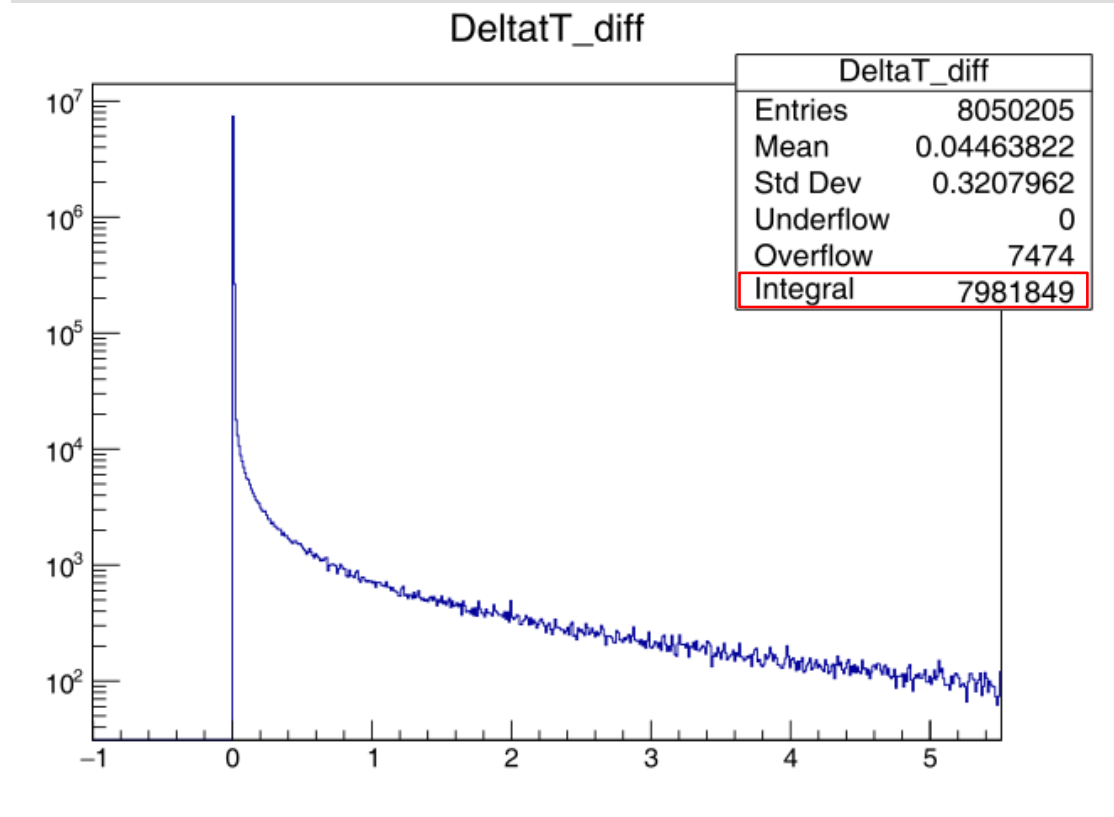
$\Delta t > 30$ ns:

- Initial hits which the first Δt is not the basic multiple of the track.
- G4 'effect'
- Those hits represent $\sim 1\%$ of the total data pool.

Time difference distribution



Cutting at $t_{diff} < 5.5$ ns remove less than 1% of all the hits



This could be a good criteria to use time to select hits

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Next steps

- Implement the time difference as a selection criteria in the chain finder algorithm
- Combine several events in one super-event
- Make efficiency studies
- ...