清華大學
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Deadtime and Efficiency

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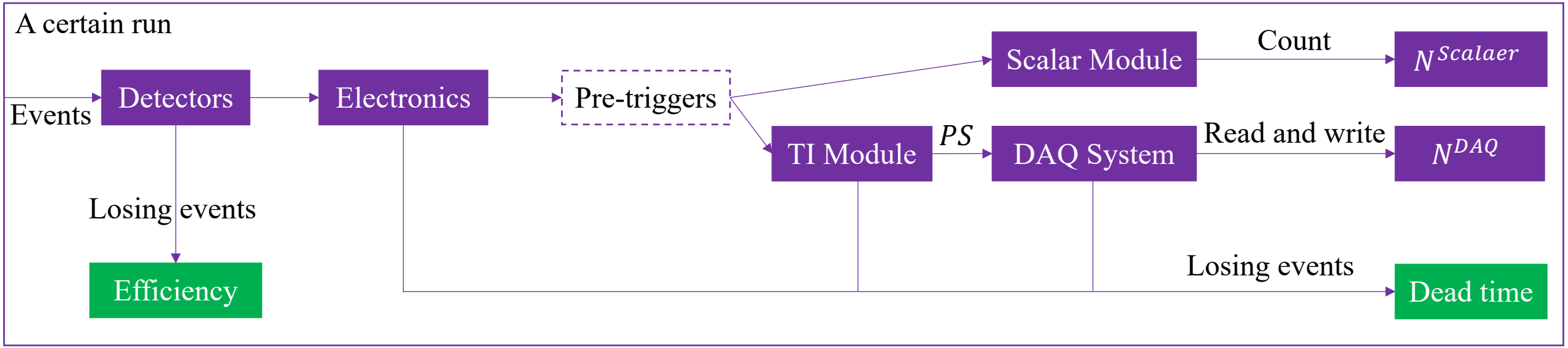
NPS Collaboration Meeting 07/18/2024

Overview

Deadtime and Efficiency



So, for a certain run, the average dead time for the *i*th trigger can be expressed as:

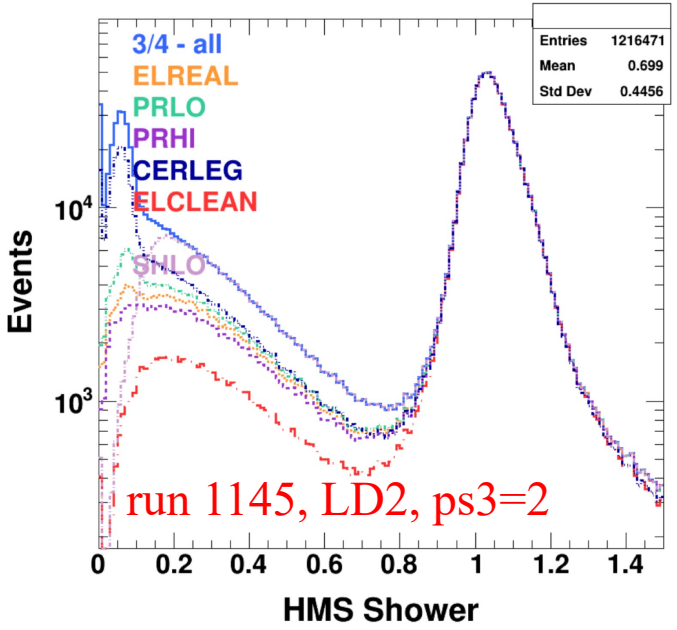
$$DT_i = 1 - \frac{PS_i \cdot N_i^{DAQ}}{N_i^{Scalar}}$$

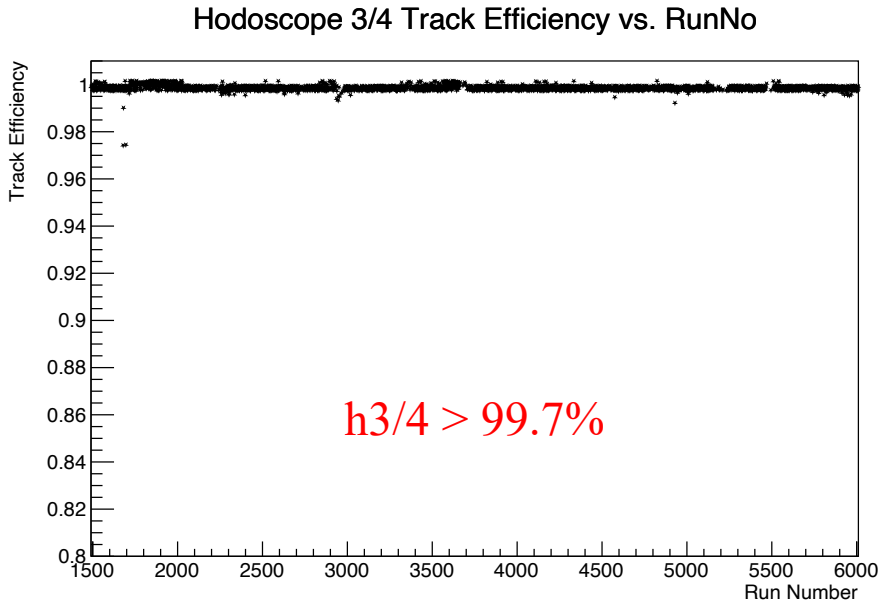
Dead time | Pre-scale factors | Counts

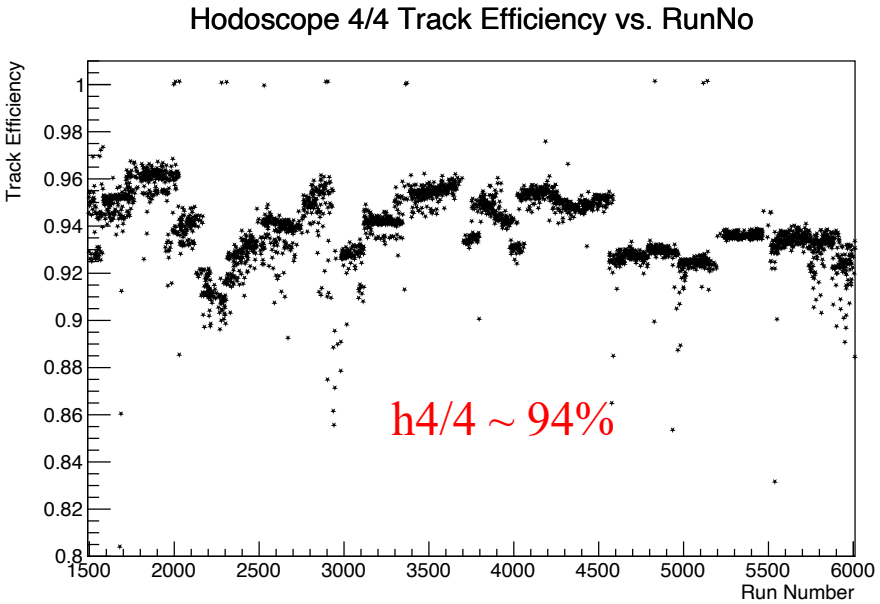
Efficiency

Pre-trigger List

- T1: NPS cluster trigger (VTP 1 Cluster OR VTP 2 Cluster OR delayed EDTM)
- T2: NPS cosmic (NPS cosmic OR LED)
- T3: HMS h3/4
- T4: HMS hEL-REAL
- T5: (T1) AND (T3)
- T6: (T1) AND (T4)





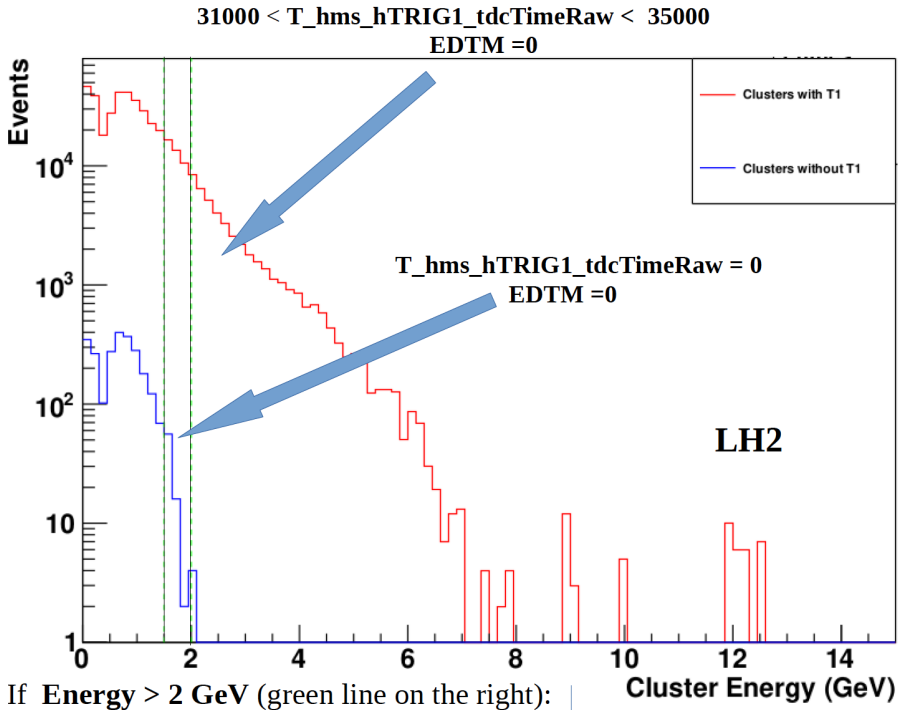


Efficiency

NPS T1 efficiency

Credit to Wassim

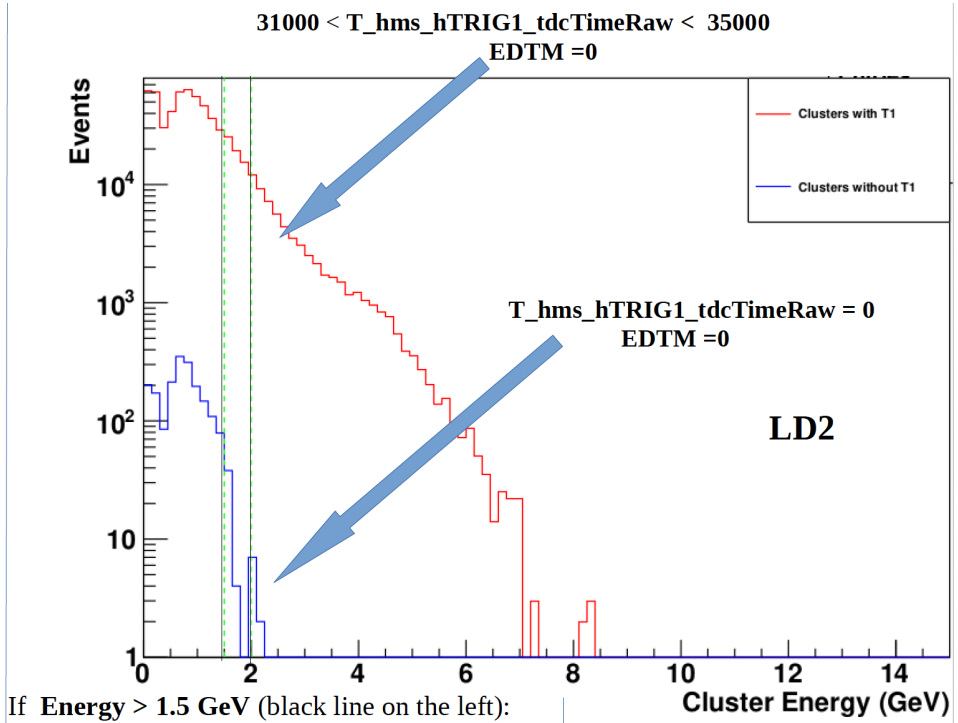
- Kinematics : Kin_x50_4 (HMS momentum : -5.253, HMS = 16.917 deg, SHMS = 31.747 deg and NPS = 14.447)
- Taking in account only the highest energy cluster in each event



If **Energy > 2 GeV** (green line on the right):
- **14097** events **with T1**
- **1** events **without T1**
- EFFICENCY = **99.9929 % ± 0.0084**

If **Energy > 1.5 GeV** (Black line on the left):
- **30016** events **with T1**
- **46** events **without T1**
- EFFICENCY = **99.8469 % ± 0.0057**

No cuts on energy :
- **405614** events **with T1**
- **2491** events **without T1**
- EFFICENCY = **99.3896 % ± 0.0015**



If **Energy > 1.5 GeV** (black line on the left):
- **37283** events **with T1**
- **25** events **without T1**
- EFFICENCY = **99.9329% ± 0.0051**

If **Energy > 2 GeV** (green line on the right):
- **16945** events **with T1**
- **1** event **without T1**
- EFFICENCY = **99.9940% ± 0.0076**

No cuts on energy :
- **610466** events **with T1**
- **1918** events **without T1**
- EFFICENCY = **99.6867% ±0.0012**

- 13 runs on LH2
- 12 runs on LD2
- Trigger: T3 (h3/4)

Deadtime

Several ways to estimate the deadtime

1. EDTM deadtime
    - TI / Computer deadtime
    - Electronics (discriminator) deadtime
2. Event time difference distribution
    - TI / Computer deadtime
3. TI live time (already exists in the report files)
    - TI / Computer deadtime

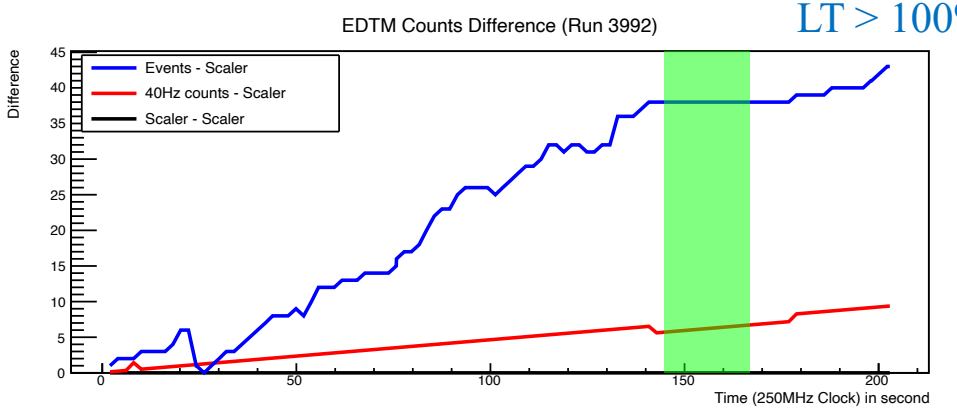
The deadtime for NPS part is not estimated yet.

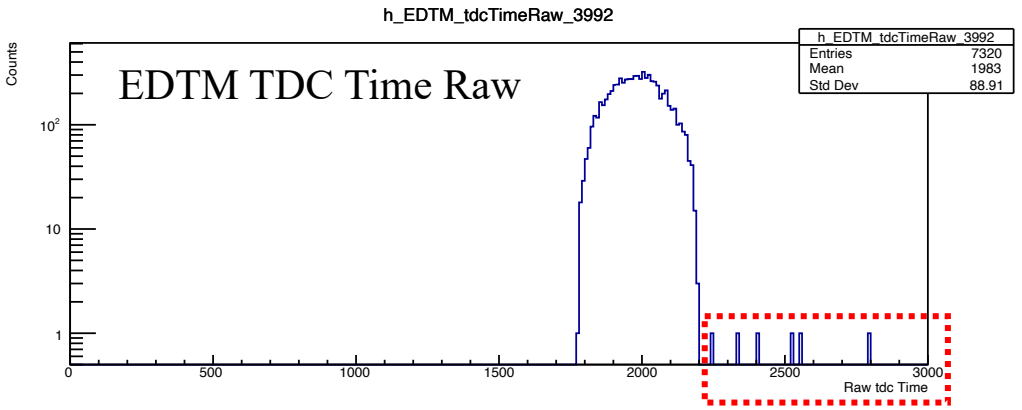
EDTM Deadtime

- **TDC noise needs to be considered**

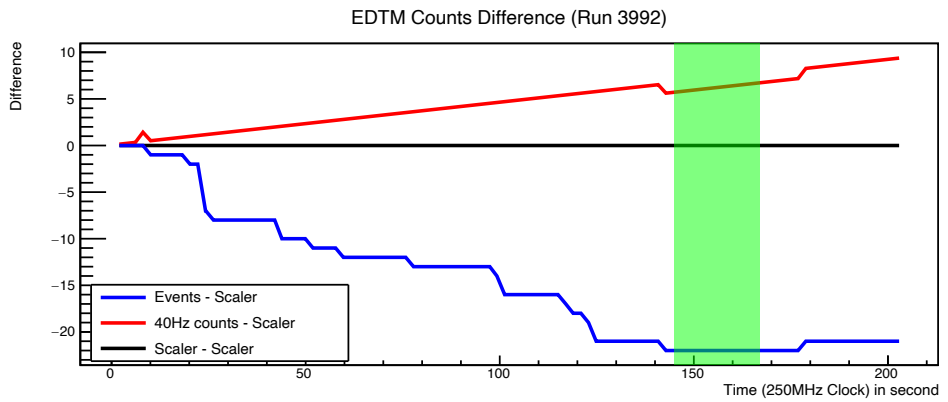
EDTM TDC Time Raw > 1

LT > 100%

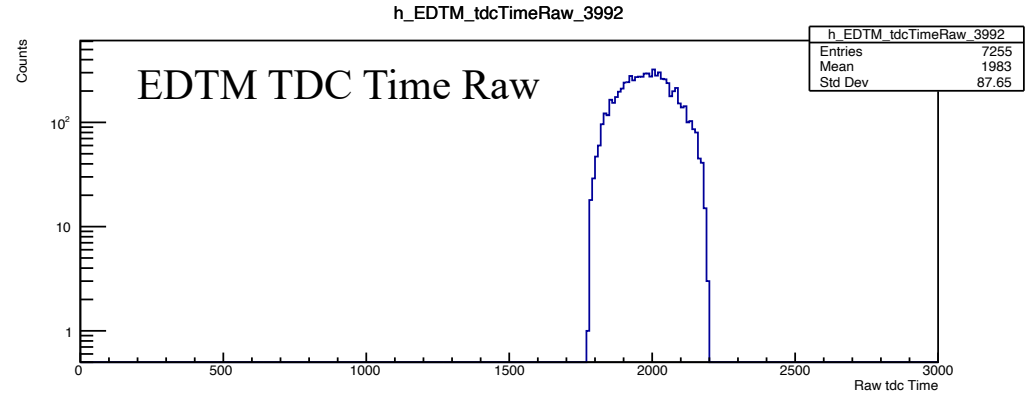




EDTM TDC Time Raw∈ [1770,2200]

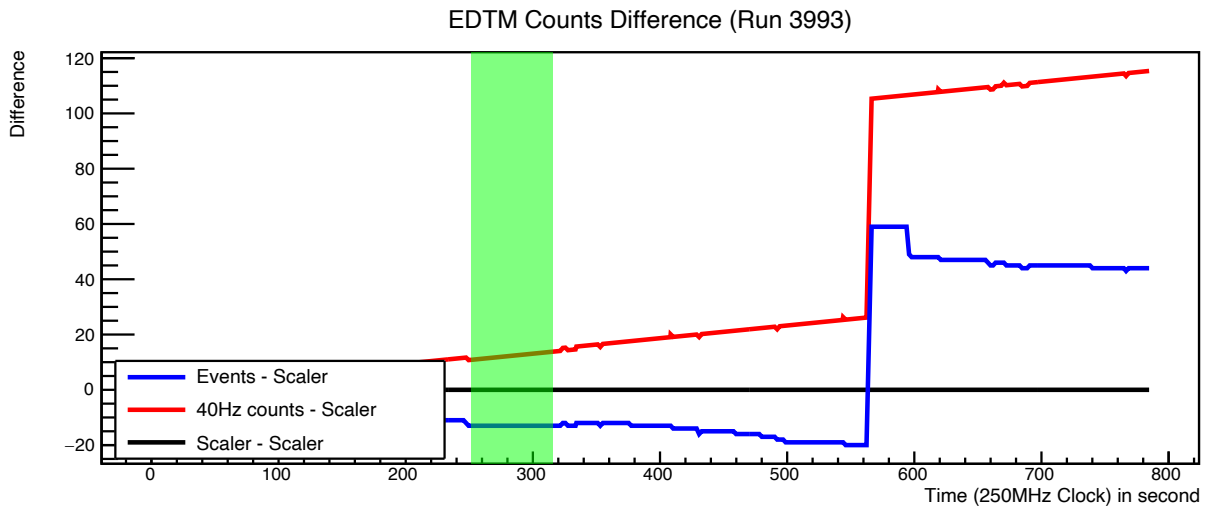


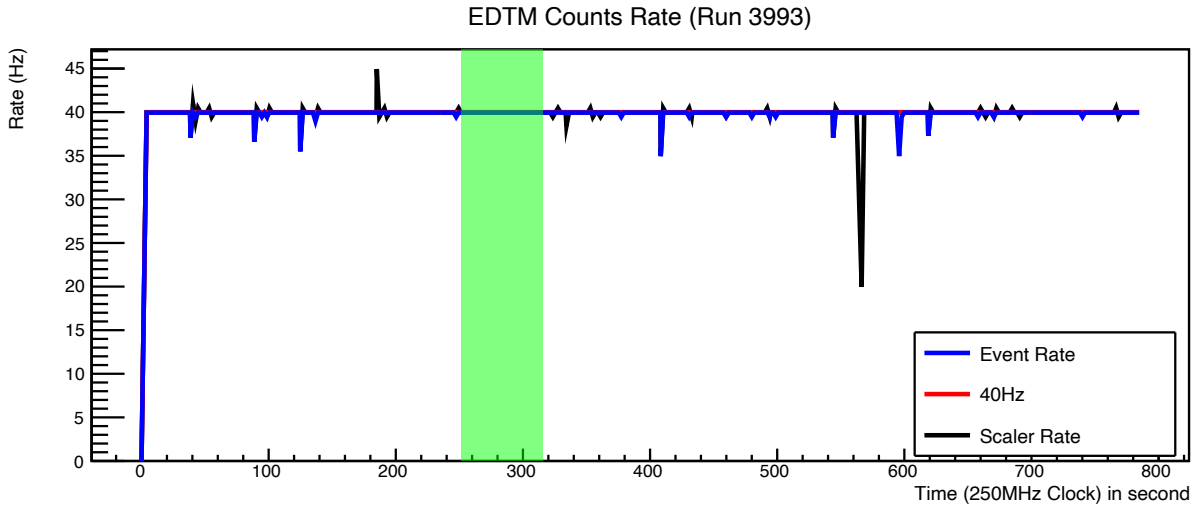
LT < 100%



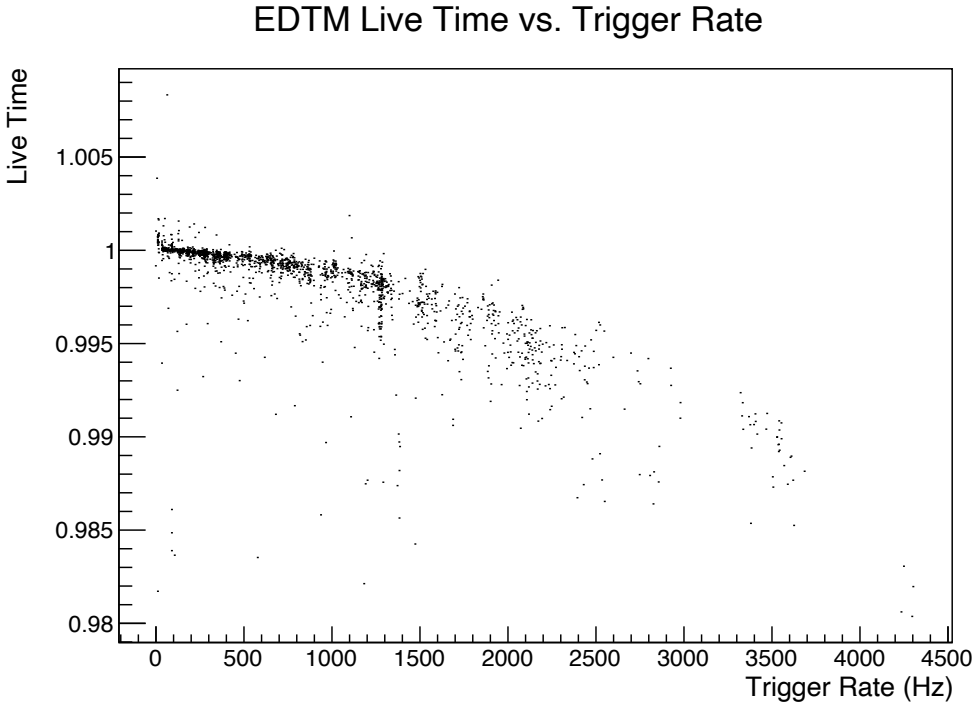
EDTM Deadtime

Other considerations





- Sudden EDTM scaler rate drop
  - It needs to be corrected
- Beam trips
  - The beam trips should be removed when calculating the EDTM deadtime



Events Time Difference Distribution

Other ways to estimate the deadtime

Dead time

Method 1

hccoda@hcvme01:~/hms/hcvme01/hcvme01.c

```
tiSetTriggerHoldoff(1,10,0);   /* 1 trigger in 10*16 nsec */  Rule 1
tiSetTriggerHoldoff(4,7,1);    /* 4 trigger in 7*3840 nsec (26.99 usec) */ Rule 4
```

- 1D histogram for time interval between adjacent events
- The minimum of the time interval is T_{dead}
- N events, total time T
- DT = $\frac{N \times T_{dead}}{T}$ ***Percentage of the time***

Method 2

hccoda@hcvme01:~/hms/hcvme01/hcvme01.c

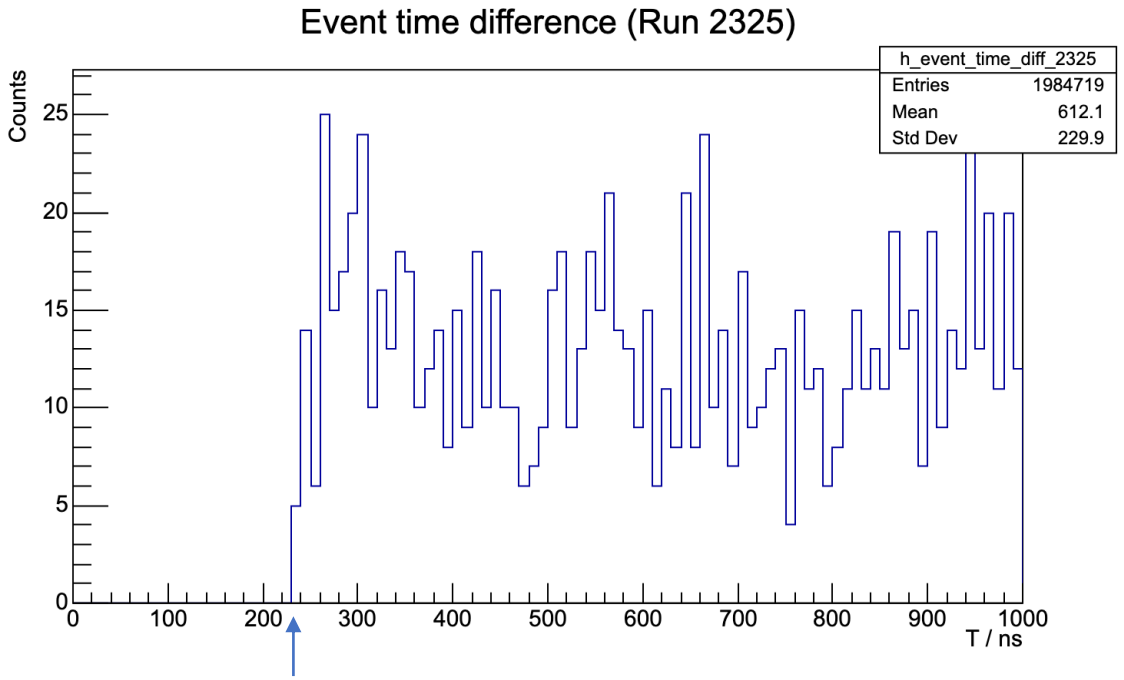
```
unsigned int V1190_TW_OFF = 3970;//changed from 3400(2023/08/23)
unsigned int V1190_TW_WID = 3600;//changed from 3200(2023/08/23)
```

- We can have multiple TDC hits for a single event
- Only the first hit was recorded as an event
- Poisson distribution: $P(N(t) = k) = \frac{e^{-\lambda t}(\lambda t)^k}{k!}$
- Exponential distribution: $P(T > t) = P(N(t) = 0) = e^{-\lambda t}$
- 1D histogram for time interval between adjacent hits
- Fit the histogram to get the λ
- Mathematical expectation: $E\big(N(t)\big) = \lambda t$
- DT = $1 - \frac{1}{\lambda t+1} = \frac{\lambda t}{\lambda t+1}$ ***Percentage of the event counts***

Events Time Difference Distribution

Other ways to estimate the deadtime

Method 1

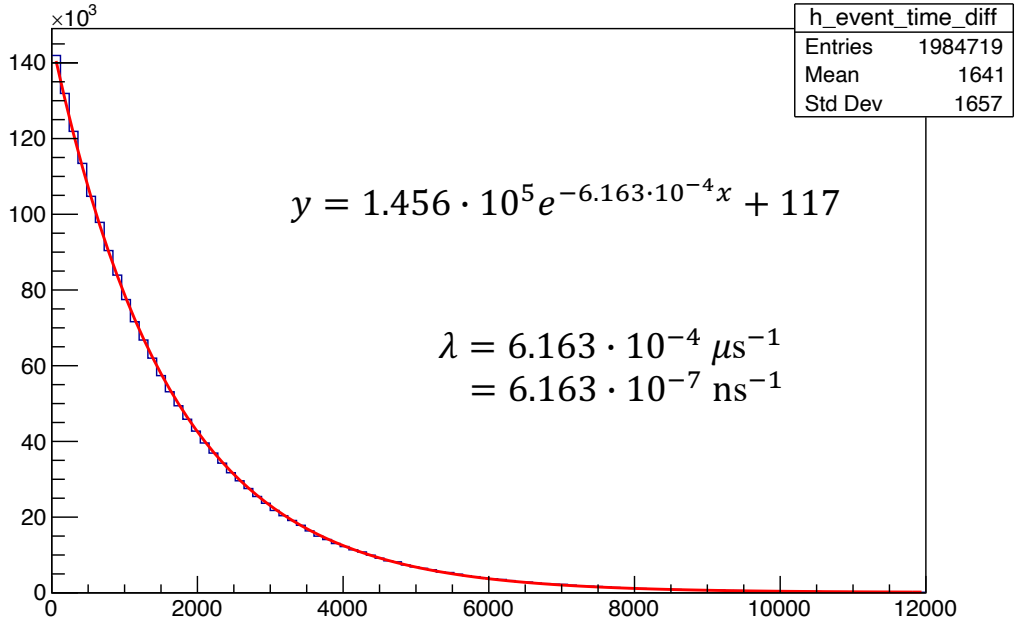


$T_{dead} = 230\ ns$

```
Total events: 2128022
Without EDTM events: 1984720
Total time: 3581.55 second
Dead time per event: 230 ns
Total dead time =  1984720 * 230 / 1e9 = 0.456486 second
Live time (percentage): 99.9873 %
```

$$\mathrm{LT} = 1 - \frac{N \times T_{dead}}{T} = \frac{1984720 \times 230\ ns}{3581.55\ s} = 99.9873\%$$

Method 2



$$\mathrm{LT} = \frac{1}{\lambda t + 1} = 99.9858\%$$

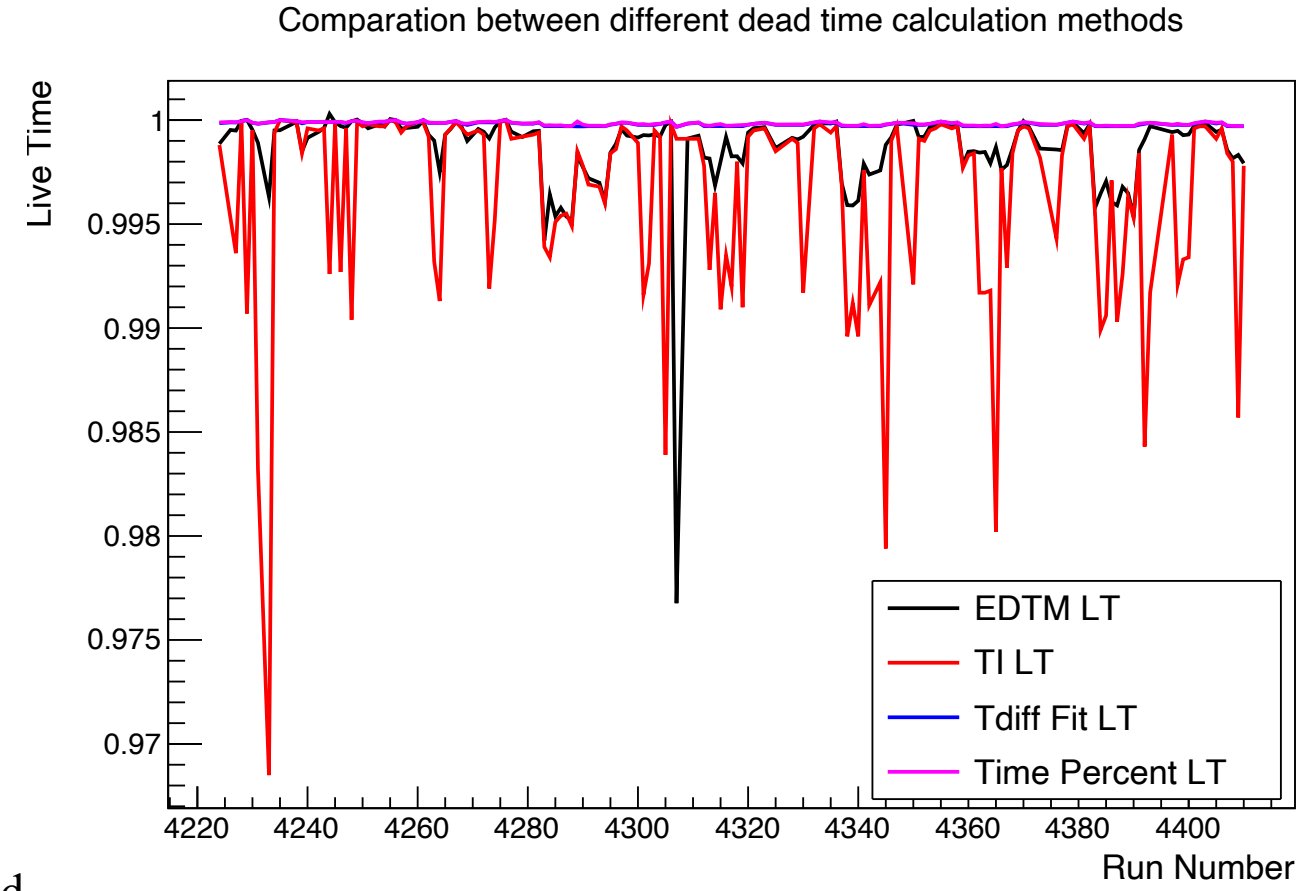
Comparison

Comparison between different methods

- EDTM deadtime
- Events time difference distribution (Method 1&2)
- TI live time (already exists in the report files)

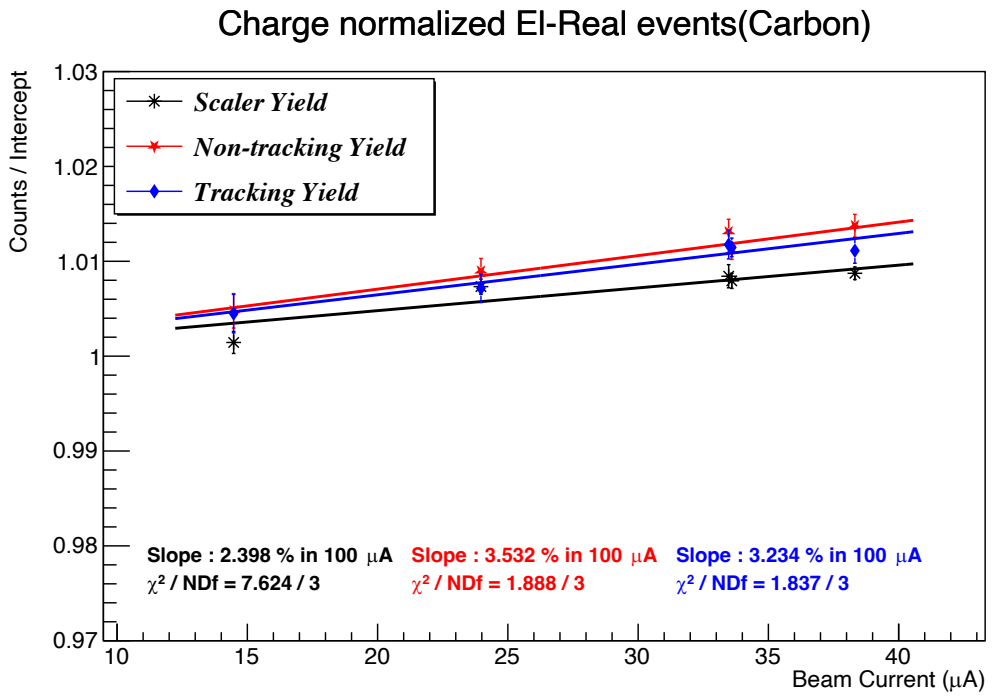
Conclusions

- Blue and pink lines are close to 100%
  - Theoretically TI Rule1&4 gives little dead time at our data taken rate (2kHz ~ 0.046%)
- EDTM and TI live time makes more sense
  - TI was not always working perfectly
- TI live time is much lower than EDTM LT
  - The TI LT in report files needs to be improved (see also next page)

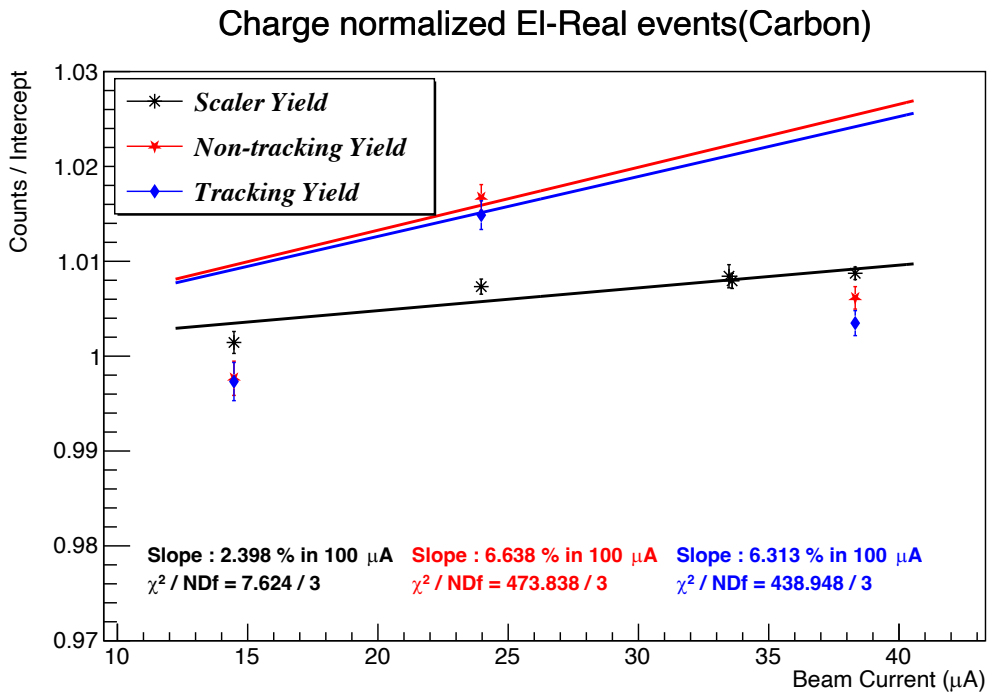


Improved TI LT Calculation

- **The TI LT in the root files are not reliable**



$$\mathrm{LT} = \frac{\#\ \text{of events}}{\mathrm{scaler\_htrig4} - \mathrm{scaler\_edtm}} \times \text{ps-factor}$$



LT from the report file
("HMS TRIG4 Computer Live Time")

- The left formula is exactly what we want
- TI LT in the report file doesn't match with the calculation

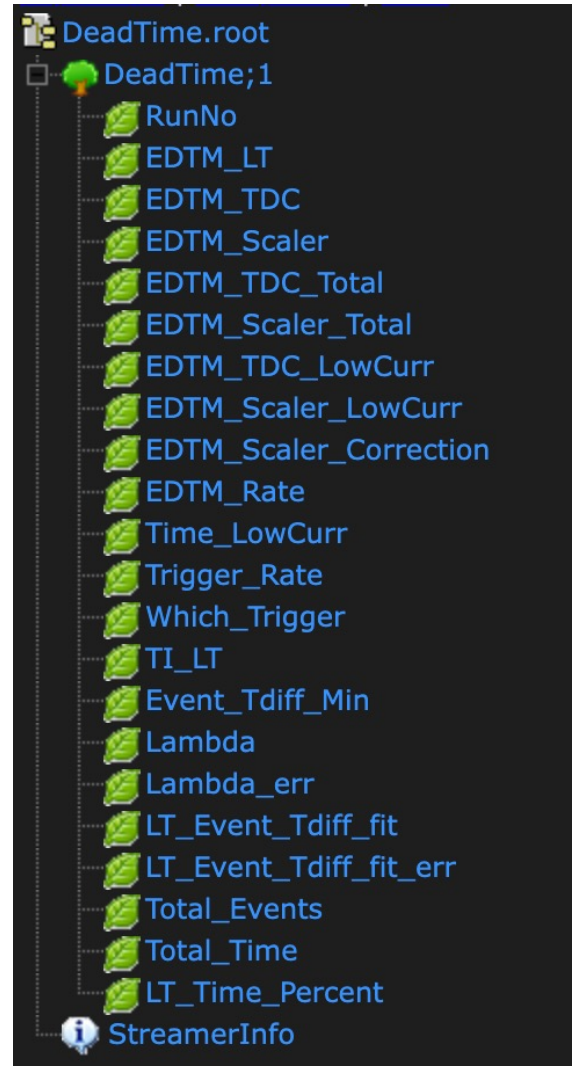
Summary

What is done now:

/group/nps/yaopeng/Analysis/Deadtime/DeadTime.root

I calculated the deadtime for runs from 1500 to 5000 (03/02/2024)

- EDTM deadtime
- Events time difference distribution
- TI live time (already exists in the root files)



Need to do next:

- Improve algorithm for EDTM deadtime calculation
- Calculate the LT using the formula: $LT = \frac{\#\ \text{of events}}{\text{scaler\_htrig4} - \text{scaler\_edtm}} \times \text{ps factor}$
- Generate the "DeadTime.root" for all the runs

Questions:

- Do we need (have chance) to estimate the NPS deadtime?
- There is some clue for the NPS deadtime
- As Julie suggested, I prepared some slides about luminosity analysis and helicity, may I continue to show them?

NPS Deadtime

Slope Table

KinC_x	LH2 Yield vs Trigger1 rate Slope (10^{-5} %/kHz)	Maximum Trigger1 Rate (kHz)	Runs (More than 5)
36_3	0.79	800	20
36_5	-3.03	2200	13
50_4	-2.43	1800	25
50_4’	-3.30	2000	35
60_3	-3.32	1100	11
50_1	-2.79	1000	9
36_5’ (Calibrated)	-3.07	2200	8
60_4a (Calibrated)	-2.22	2200	14
60_4b	-2.13	1200	19

- For LD2, the slope varies a lot (can be positive and also negative)
- For LH2, if the maximum hTRIG1 rate is larger than 800 kHz, the slope is always negative [-2, -3]e-5

THANKS!

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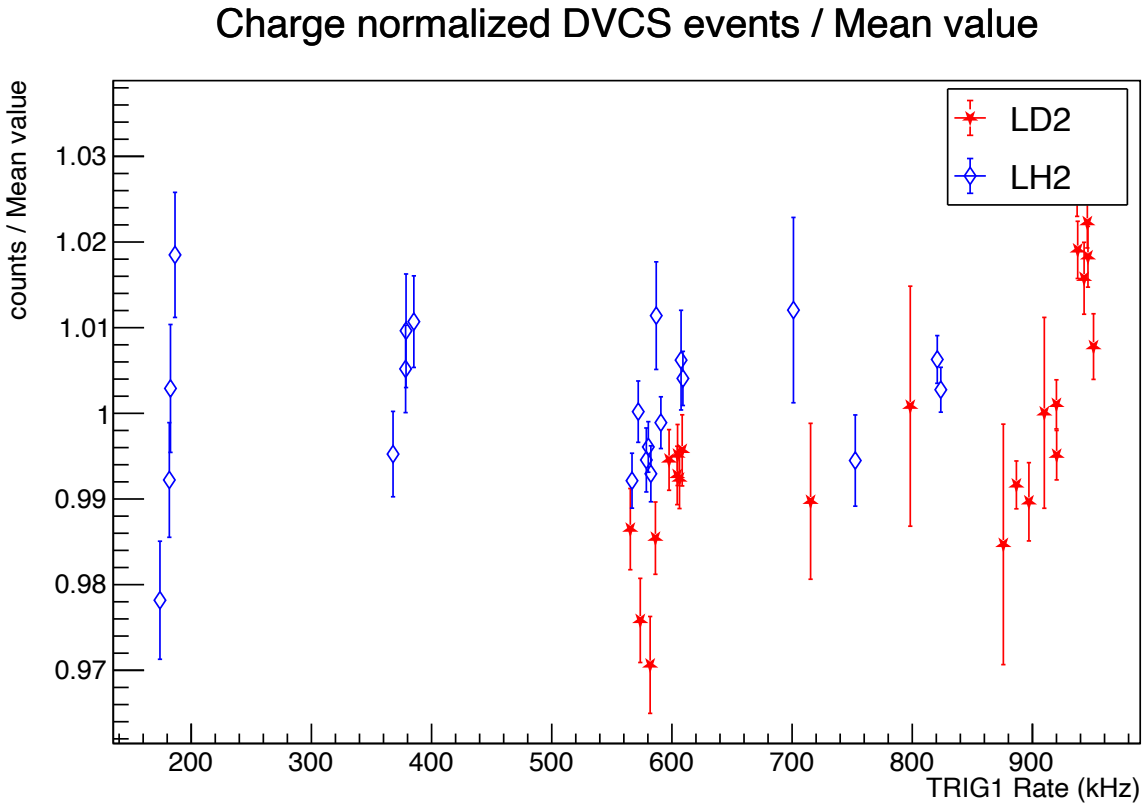
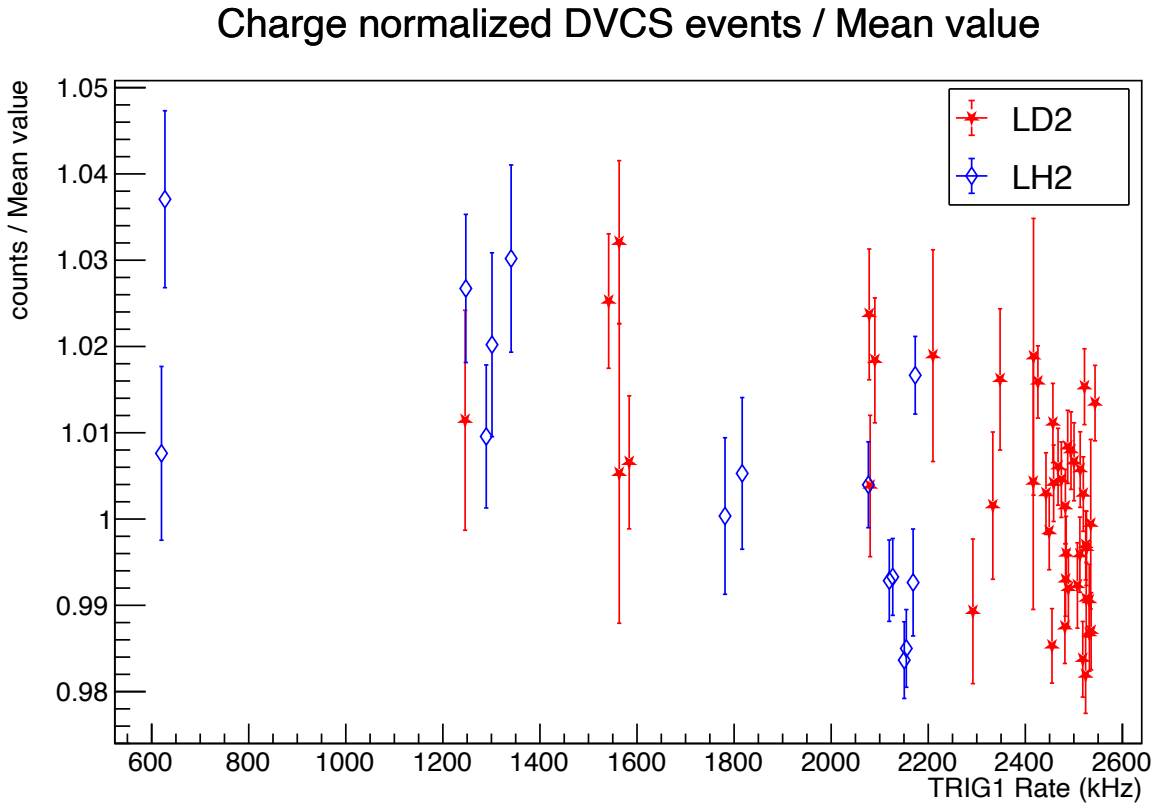
Appendix

Slope Table



KinC_36_3



KinC_x60_4a