19th April 2021

- Pushed the new module to git lab
  - Added UPM pulse & S1, S2 spectra plots
  - Added new algorithms (tested locally), added some PREM main code for test on PREM webpage
  - Added comments, titles, plotting options to JSON

Added PREM Algorithms

- Fraction:
  - Define a “box”, x, y cuts → # entries in that “box” / # total entries

```
void entriesFraction(std::string histName, float xlow, float xhigh, float ylow, float yhigh, float low2, float low1, float high1, float high2);
```

  - # entries for different situation / # total entries → plot hist with RQ cuts in main PREM code

```
void S1Fraction(std::string histCut, std::string histName, float low2, float low1, float high1, float high2);
void S2Fraction(std::string histCut, std::string histName, float low2, float low1, float high1, float high2);
void MPEFraction(std::string histCut, std::string histName, float low2, float low1, float high1, float high2);
void SPEFraction(std::string histCut, std::string histName, float low2, float low1, float high1, float high2);
void SEFraction(std::string histCut, std::string histName, float low2, float low1, float high1, float high2);
```

  - Compare the overlapping fraction between two hists → to check the similarity between two plots

```
void AlgsRLM_TPC_PREM::fractionVol(std::string refhist, std::string histName, float low2, float low1, float high1, float high2)
```

1. Hard coded in the function?
2. Also add ”box” cut?

- For S1 & S2 spectra plots
  - Calculate the mean with x cuts

```
void thresholdMean(std::string histName, float xlow, float xhigh, float low2, float low1, float high1, float high2);
```

- For R2 vs. Drift plot
  - Calculate the slope, y-intercept of the linear fit function to the Tprofile plot with x cuts (fiducial volume) → check the uniform distribution across bins

```
void slope(std::string histName, float xlow, float xhigh, float low2, float low1, float high1, float high2);
void y_intercept(std::string histName, float xlow, float xhigh, float low2, float low1, float high1, float high2);
```

  - Count the # bins that have the StD greater than a certain value (defined in the function) with x cuts;

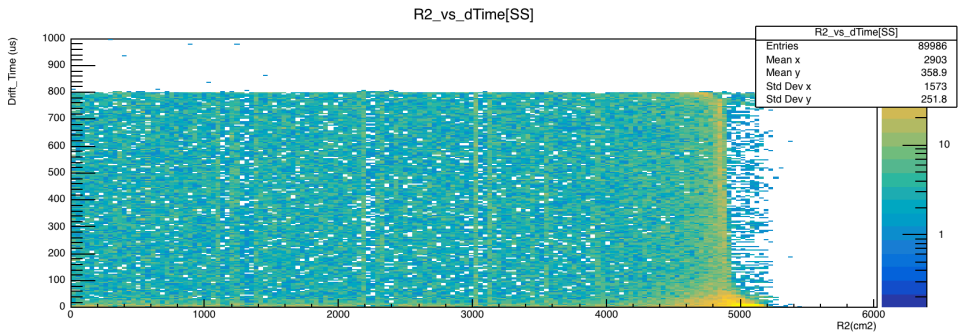
```
void errorCount(std::string histName, int Num, float xlow, float xhigh, float low2, float low1, float high1, float high2);
```

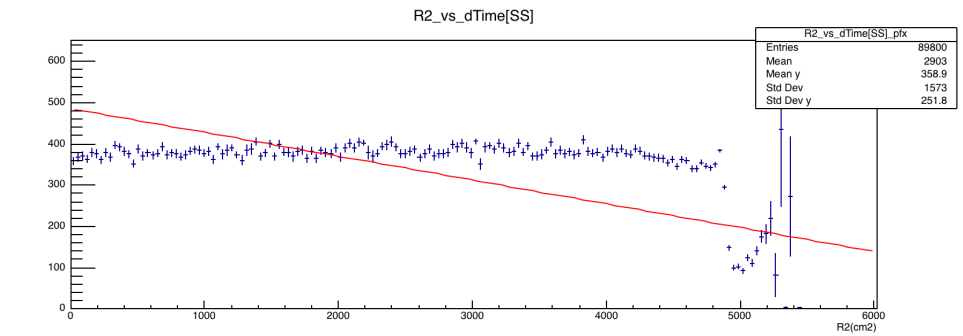
7th April 2021

- Checked two algorithms locally:
  - Mean values within a threshold (TH1)
  - Fraction of entries within an area over total entries (TH2)
- Mostly questions:
  - 1. Trying to develop algorithms to calculate fraction of entries for S1, S2, MPE, SPE, SE over the total entries, how does `GetEntries()` work with RQ cuts.

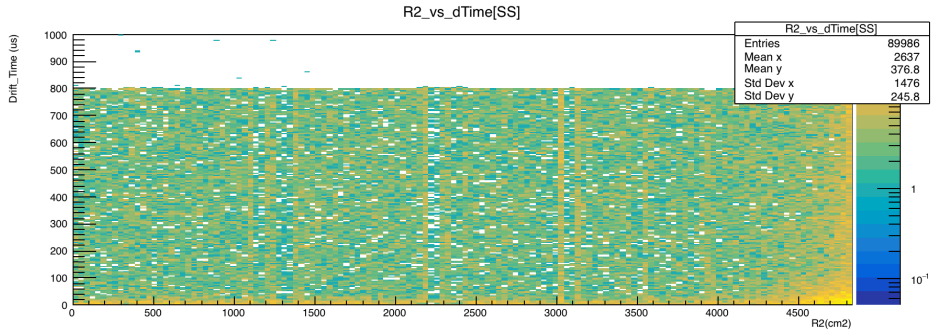
Uniform distribution check

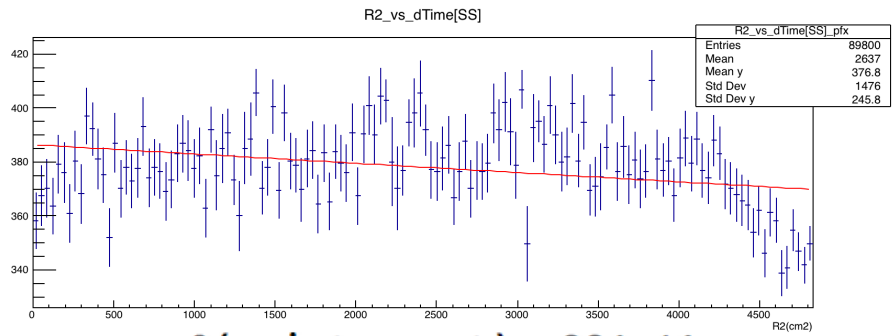
R2 cut at 4800cm2





p0(y-intercept): 485.641
p1(slope): -0.0576966
count(y-error bar>20): 5





p0(y-intercept): 386.41
p1(slope): -0.00343092
count(y-error bar>20): 0

- 94% decrease in |p1 value|
- Decrease in #count

Population shift & shape check

- Volume overlapping fraction:
  - Fraction = overlapping volume / reference volume.
  - Overlapping volume = x * y * z = xbin_width[i] * ybin_width[k] *#entries[i,k]
  - Since we are using the same bin size and x,y range, xbin_width[i] * ybin_width[k] term will be canceled out → fraction will only depend on the difference of entries from different plots.
  - **Idea:** loop through each x, y bin, use `min(entries1, entries2)` , and sum up the output from min() function.
  - Test on the same plot with two different LZAP version (501 vs 470): 0.803034
  - Test on the same plot with the same LZAP version (501 vs 501): 0.99924
  - **Question: how to write the comparison plot as a variable in the PREM algorithm?**

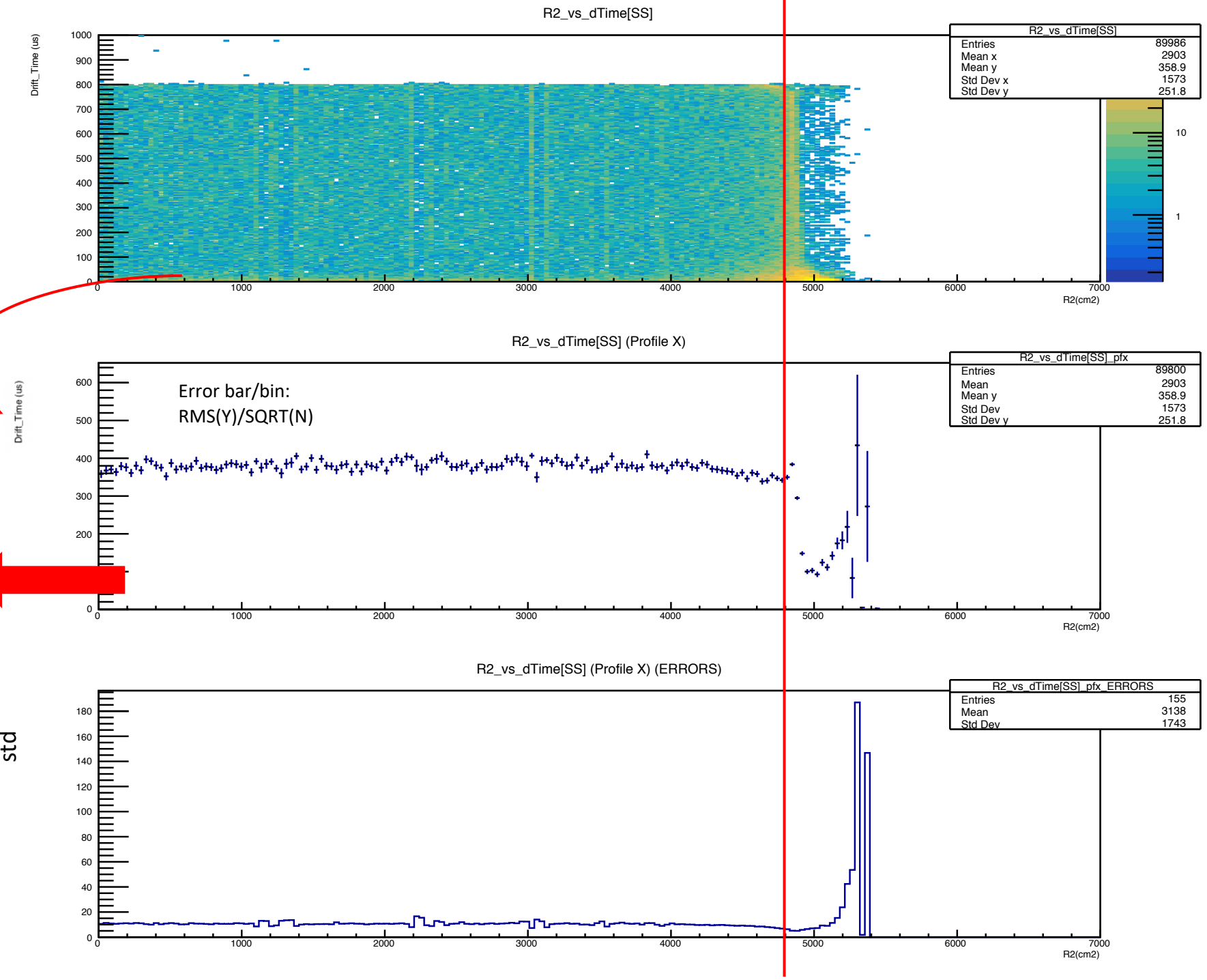
1st April 2021

- Algorithm for PREM (need to check the output on PREM website):
  - Mean within a threshold
  - Fraction for different cases
- Some thoughts for checking:
  - 1. uniform distribution (R2 vs dTime plot)
  - 2. shift of population & new appearance and disappearance of a new population (pulse parameter plots)

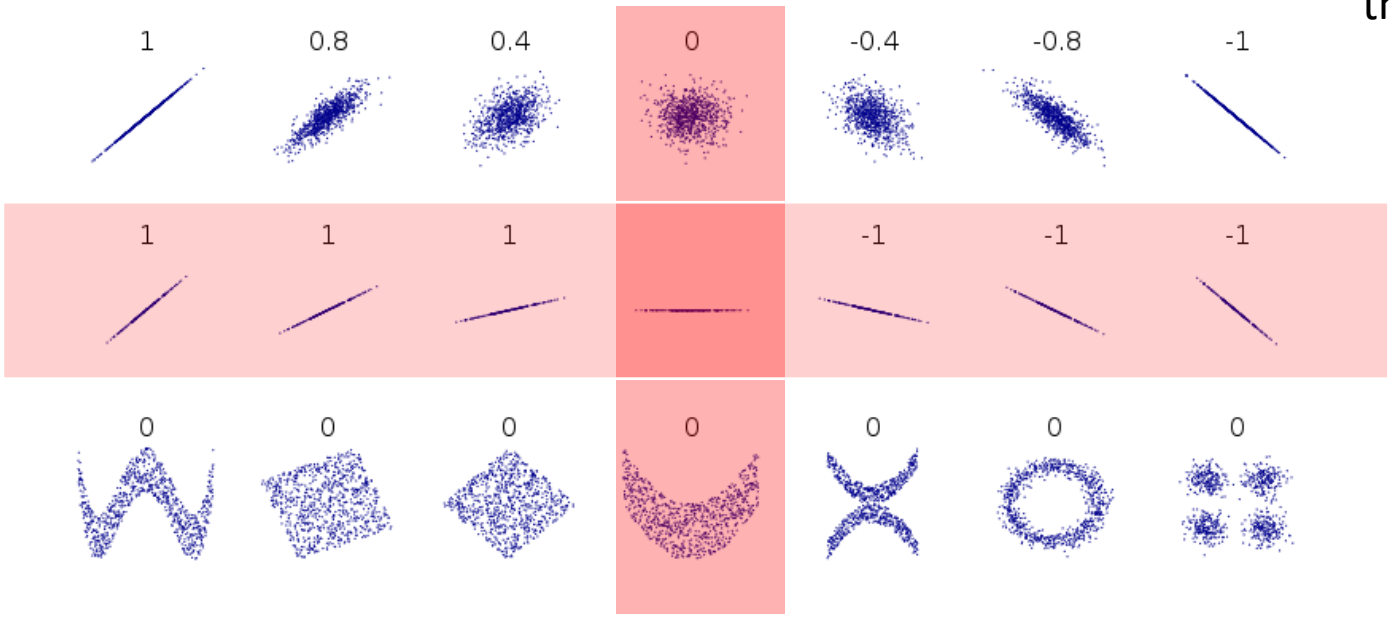
Profile the plot
→keep both x, y-axis information

Within the fiducial volume cut:

1. Create a reference distribution with mean and std → check each bin in the sample distribution



Correlation



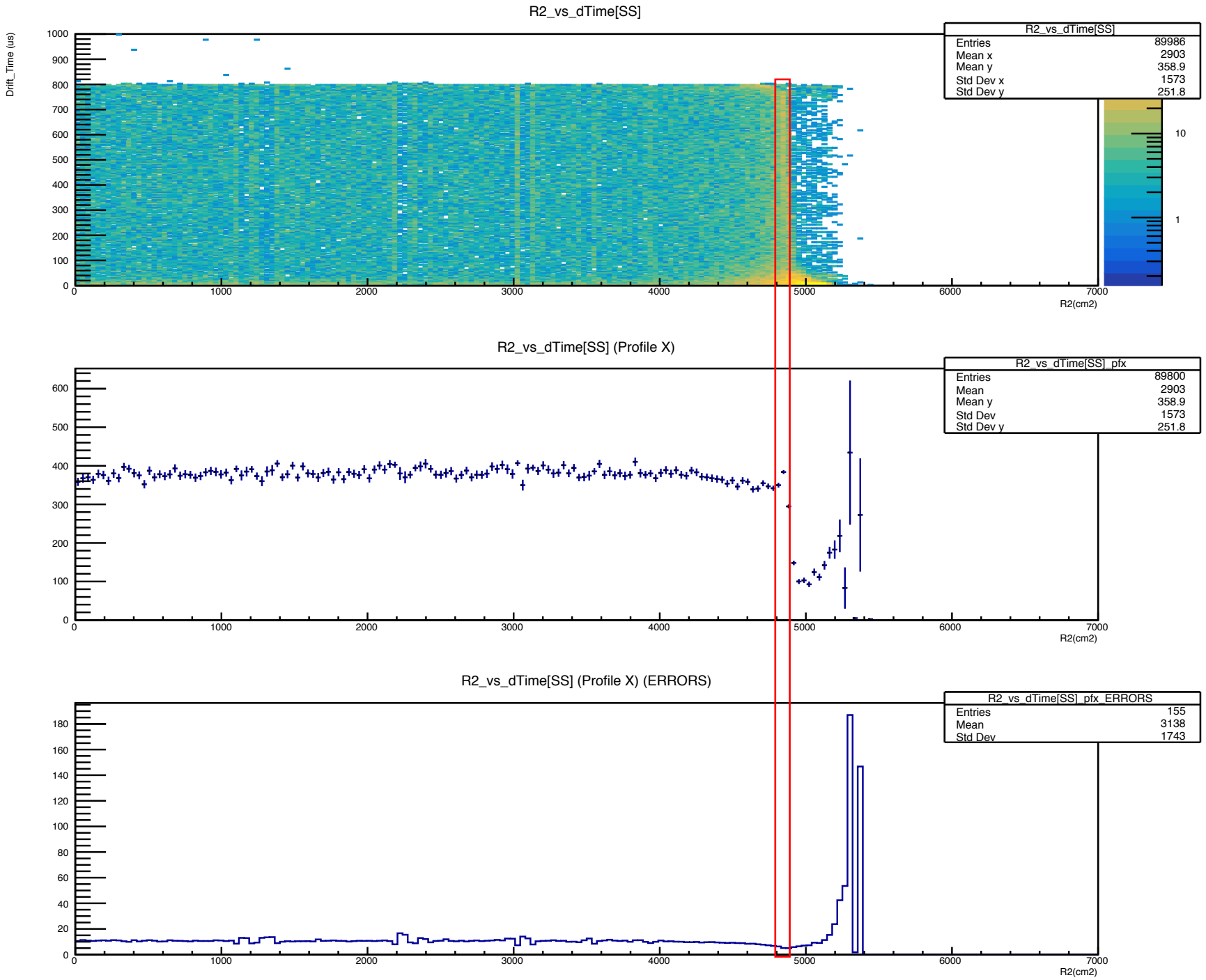
If uniform distribution → flat line + low error bar:

1. Correlation coefficient → 0 → data is random `GetCorrelationFactor()`
2. Y StD is small → uniform along the X-axis
3. Low Y Error Bar → uniform along the Y-axis

	correlation	StD
Within the red line cut	-0.167	14.318
+1 extra point at Y = 100	-0.210	27.541

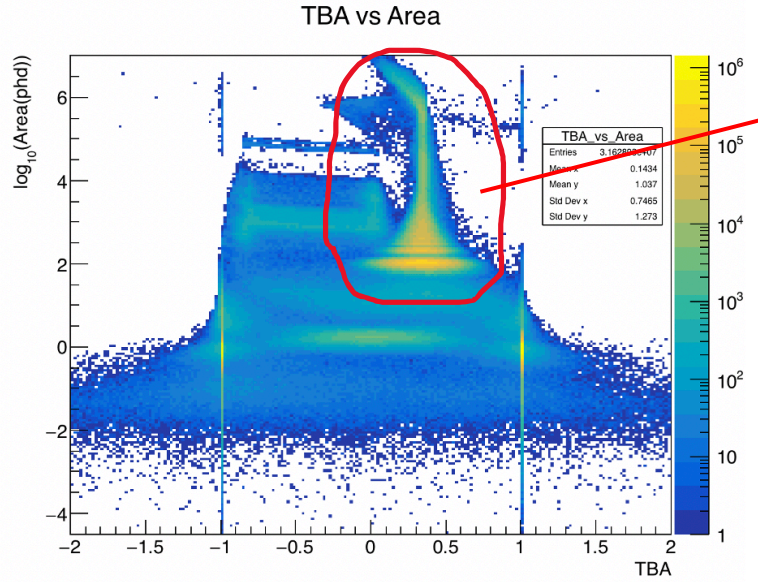
Concern: it won't detect if there is an increase uniformly along the Y-axis (as shown in the red region) → check #entries/bin

Or if this is unlikely to happen……



CDF

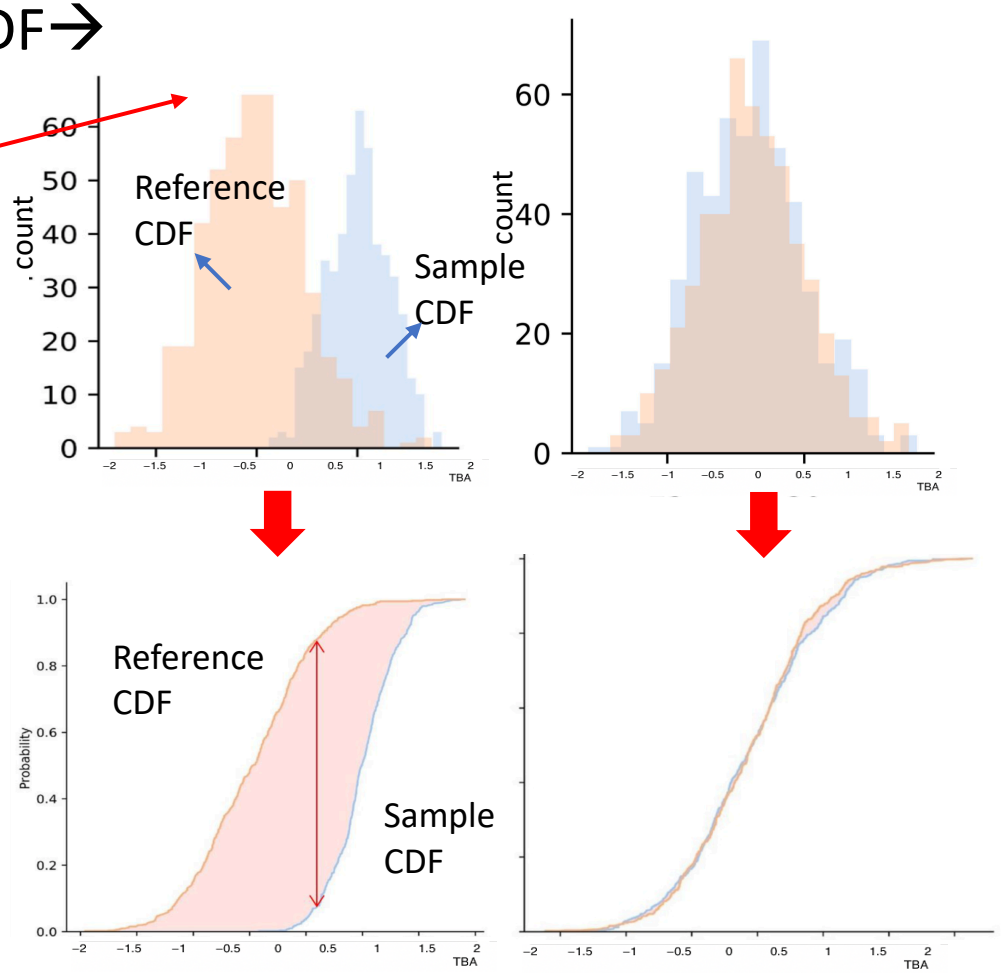
- 1st Goal → compare two distribution (sample vs. reference) → the distance between two CDF→ notice the shift of population



These are just to show the idea, not the real distribution from PREM plot

- Normalized the distribution for a population

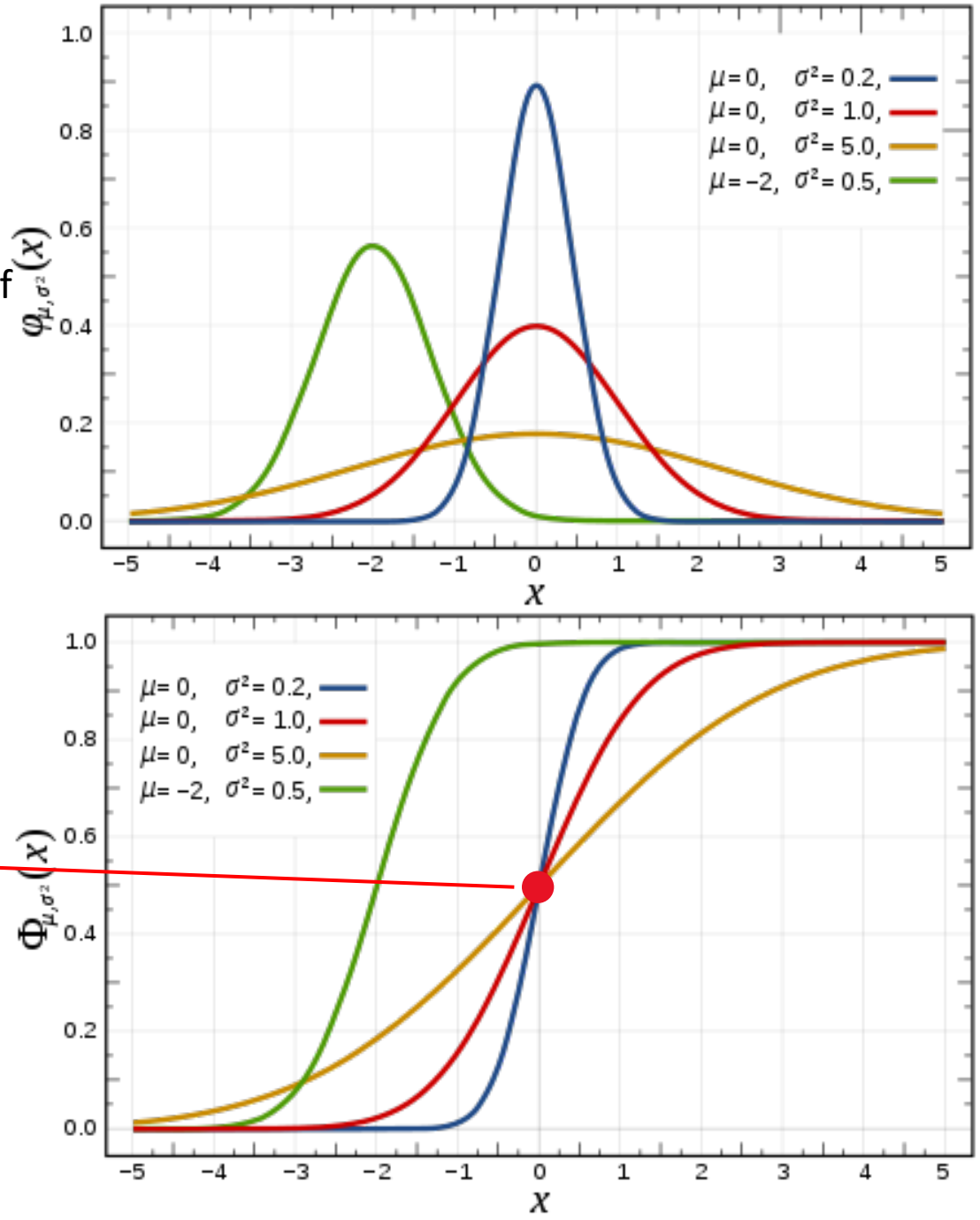
- Create Two CDFs: x, y
- For each interval, define what is a good number for distance



CDF

- 2nd Goal→ appearance/disappearance of a part of the population → shape of the CDF
  - Change of amplitudes in PDFs
  - In the CDF, there will be an intersection of two distributions

y-axis: percentage of total entries



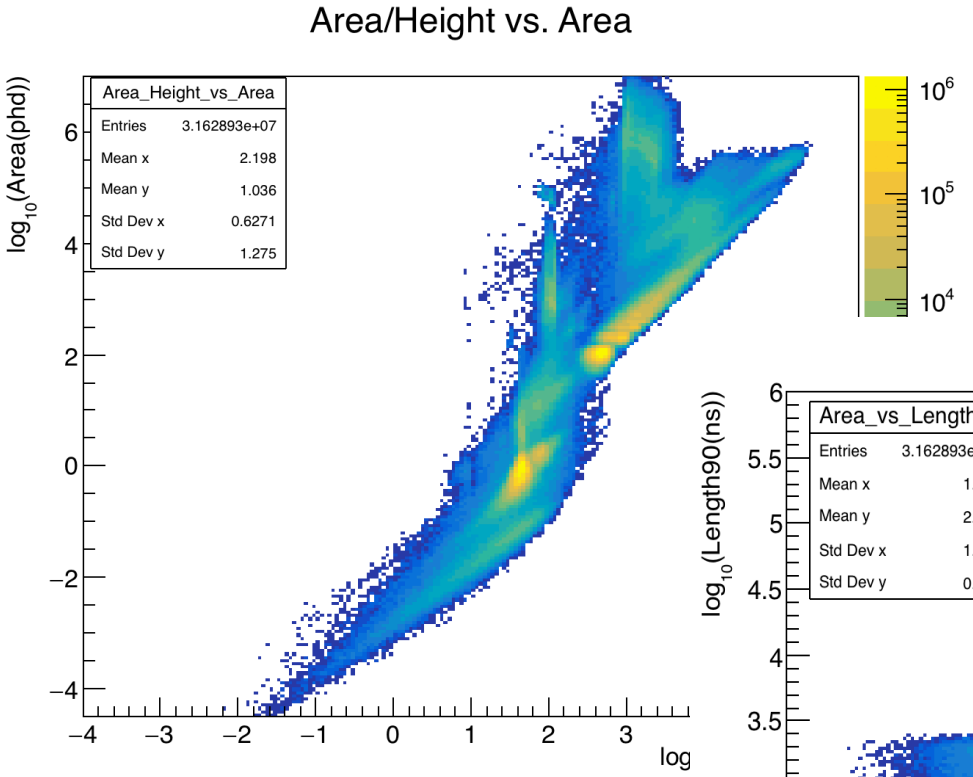
25^{th} March 2021

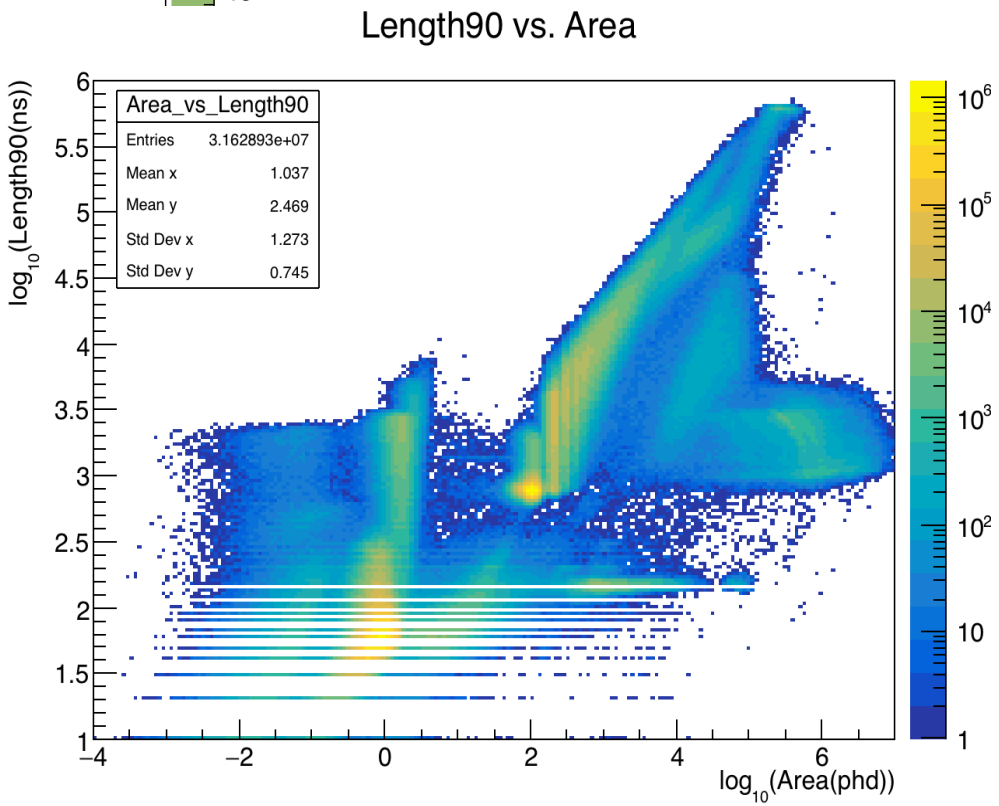
- Make algorithms for PREM_TPC plots.
  - Fraction of entries for different cases (3D pulse parameter plots)
  - Mean within a range (S1, S2 spectrum)
  - Fraction/entries below a certain threshold (drift time)

Fraction

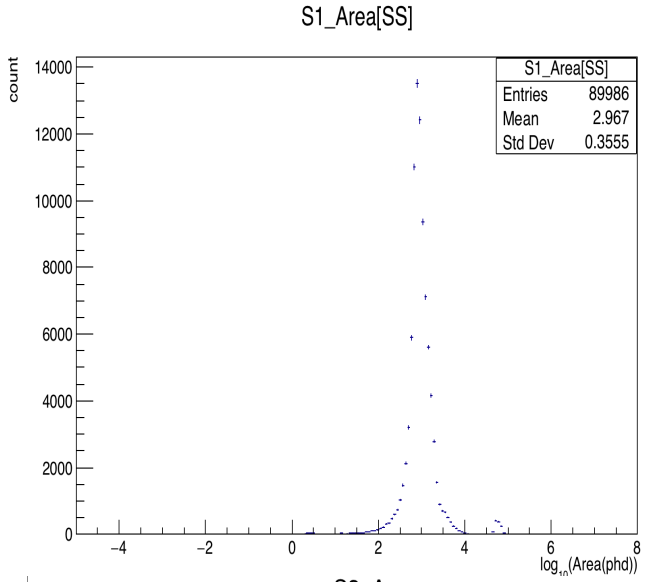
$$\text{Fraction} = \frac{\#\ entries\ of\ different\ events\ (S1,S2,SPE\ldots\ldots)}{\#\ total\ entries}$$

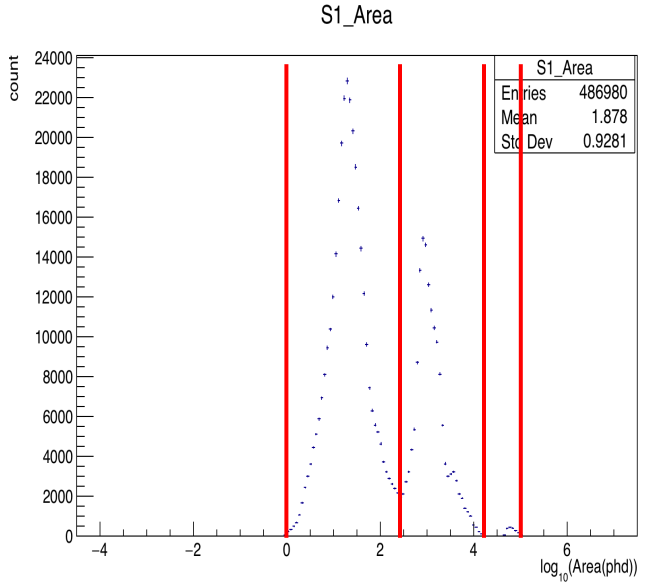
Shifter will look through the fraction

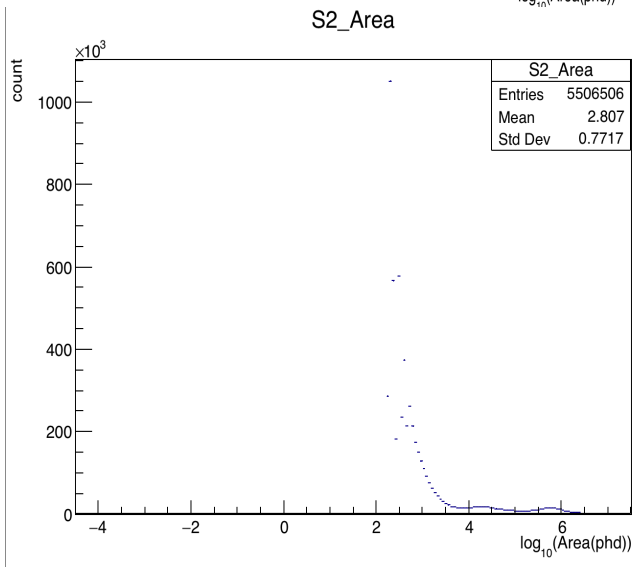


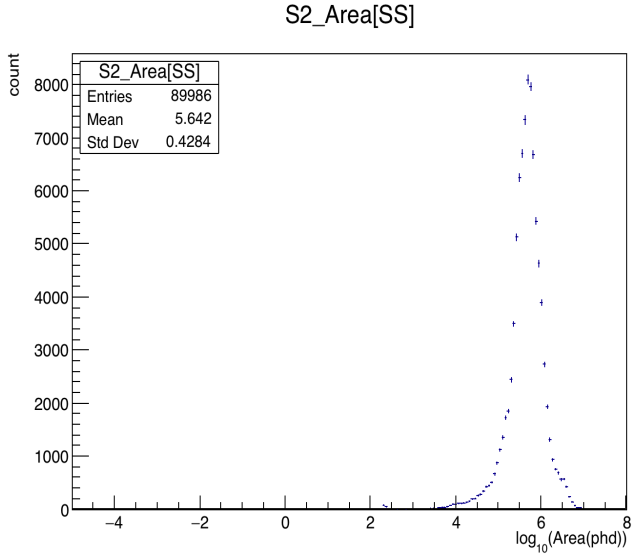


Mean



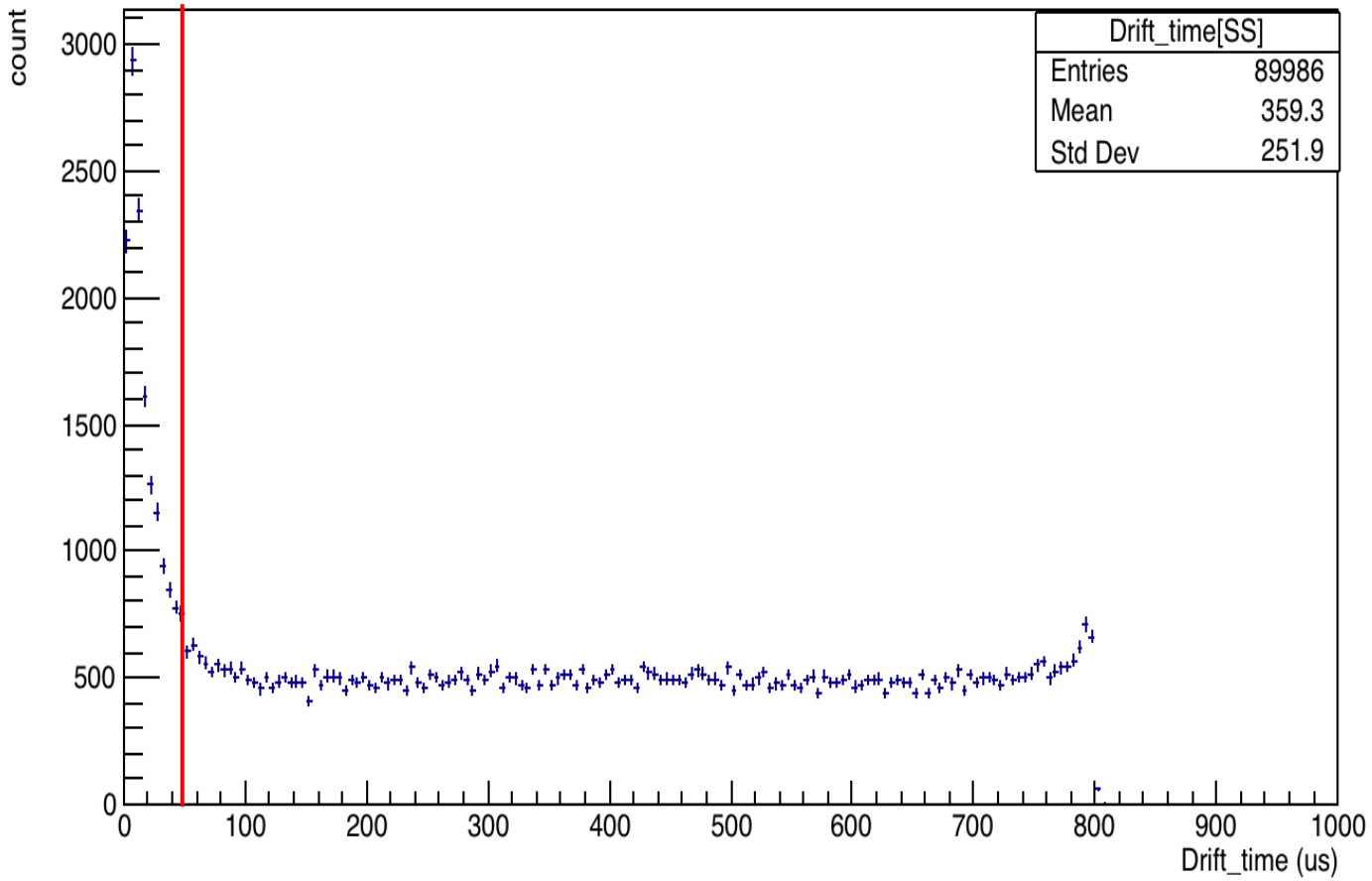






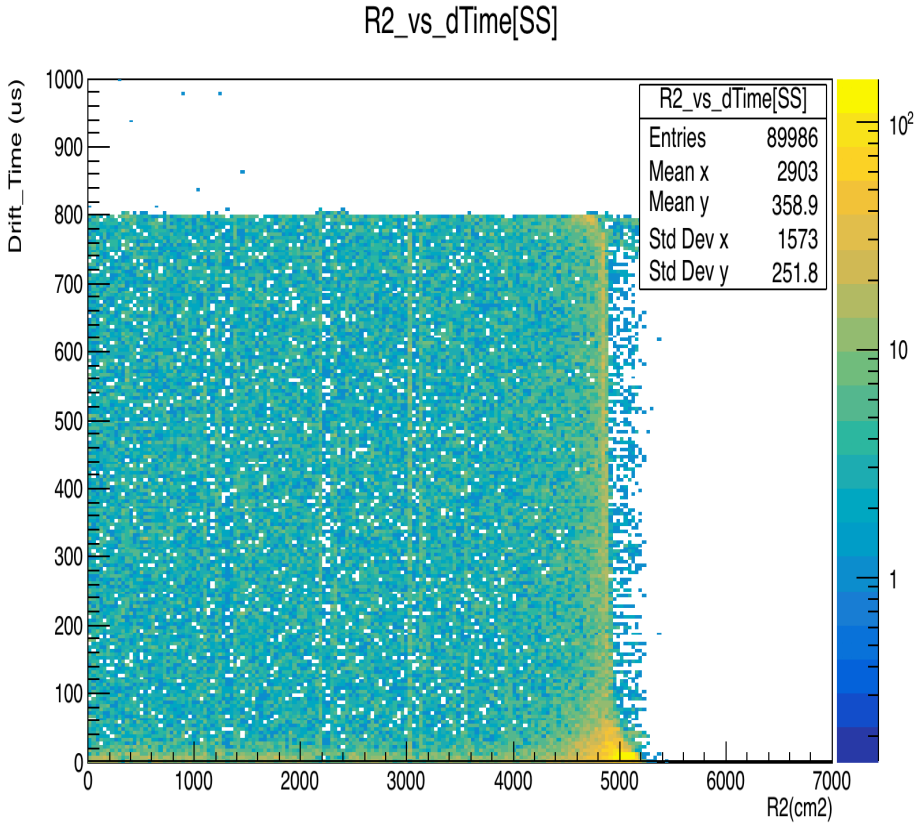
- Multiple spikes
- Define a threshold (lower bound, upper bound)
- Calculate the mean within that threshold

Drift time$_{\text{Drift_Time[SS]}}$

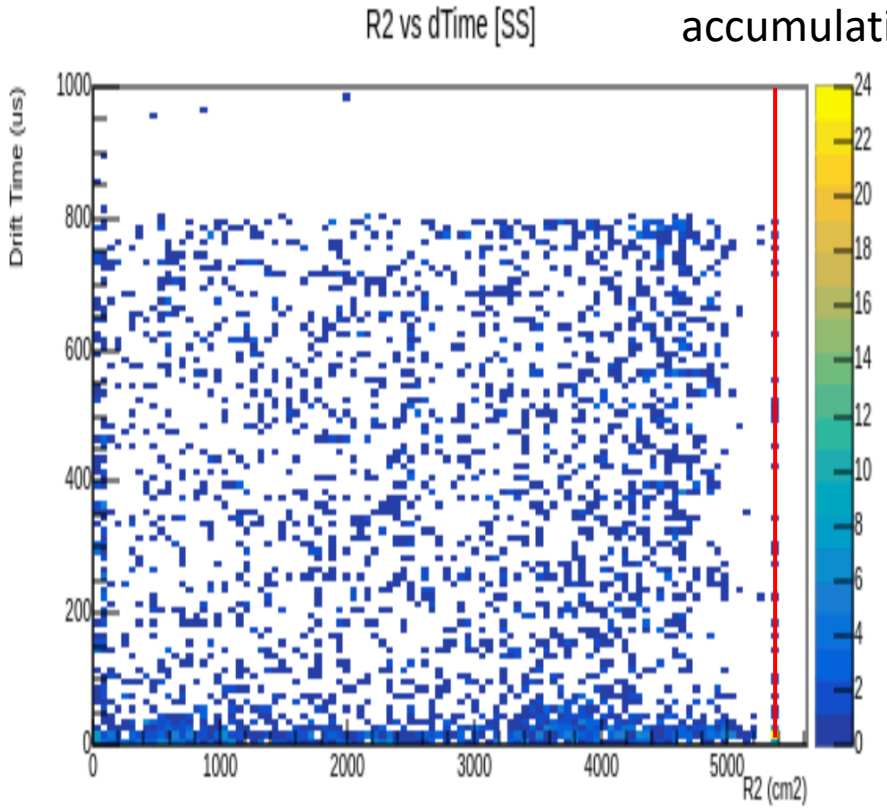


- **Main concern:** for very low drift_time, some S2 signals are created by the electrons emitted by the top gate
- **Algorithm:** for drift_time < threshold (50?) → get the #entries or the fraction

R2 vs Drift Time



PREM



UPM

Possible algorithm:

- Check the #events at the boundary of the TPC → don't want electron accumulation there

11th March 2021

- Extreme value of TBA (TBA > 50 or TBA < -50)
  - Check the RQ name for TBA
    - Calculated TBA from scratch, TBA = (T-B)/(T+B)
    - The output graph is exactly the same
  - The rate:
    - In total 14 + 18 = 32 out of 800,000 ~0.004% (1 LZap4.7.0 root file)
  - Event types:
    - Plot TBA vs Area for different conditions → **others**
  - Learned to use Event Viewer (pretty cool!)
    - Use event viewer to look at their pulses
    - From the raw root file:
      - Get **EventID**, **Run ID**
    - From the Lzap root file:
      - Get **PulseID**
  - Plot x vs. y positions of these events

Extreme TBA value

- $T - B > a\,(T + B)$
  - $T > 0 \rightarrow B < 0 \;\&\&\; |B| > T$
  - $T < 0 \rightarrow$
    - $B < 0$
    - $B > 0 \;\&\&\; |B| << |T|$ or $a >> 1$
  - $T = 0 \rightarrow B < 0$
  - $B = 0 \rightarrow T < 0$

- $T - B < -a\,(T + B)$

  $= B - T > a\,(T + B)$
  - $B > 0 \rightarrow T < 0 \;\&\&\; |T| > B$
  - $B < 0 \rightarrow$
    - $T < 0$
    - $T > 0 \;\&\&\; |T| << |B|$ or $a >> 1$
  - $T = 0 \rightarrow B < 0$
  - $B = 0 \rightarrow T < 0$

Pulse

PREM output:

```
TBA: 74.5369
/global/cfs/cdirs/lz/data/MDC3/background/BACCARAT-4.11.0_DER-8.5.13/20180401/lz_201804010002_000172_035738_raw.root,172,3873653,10
```

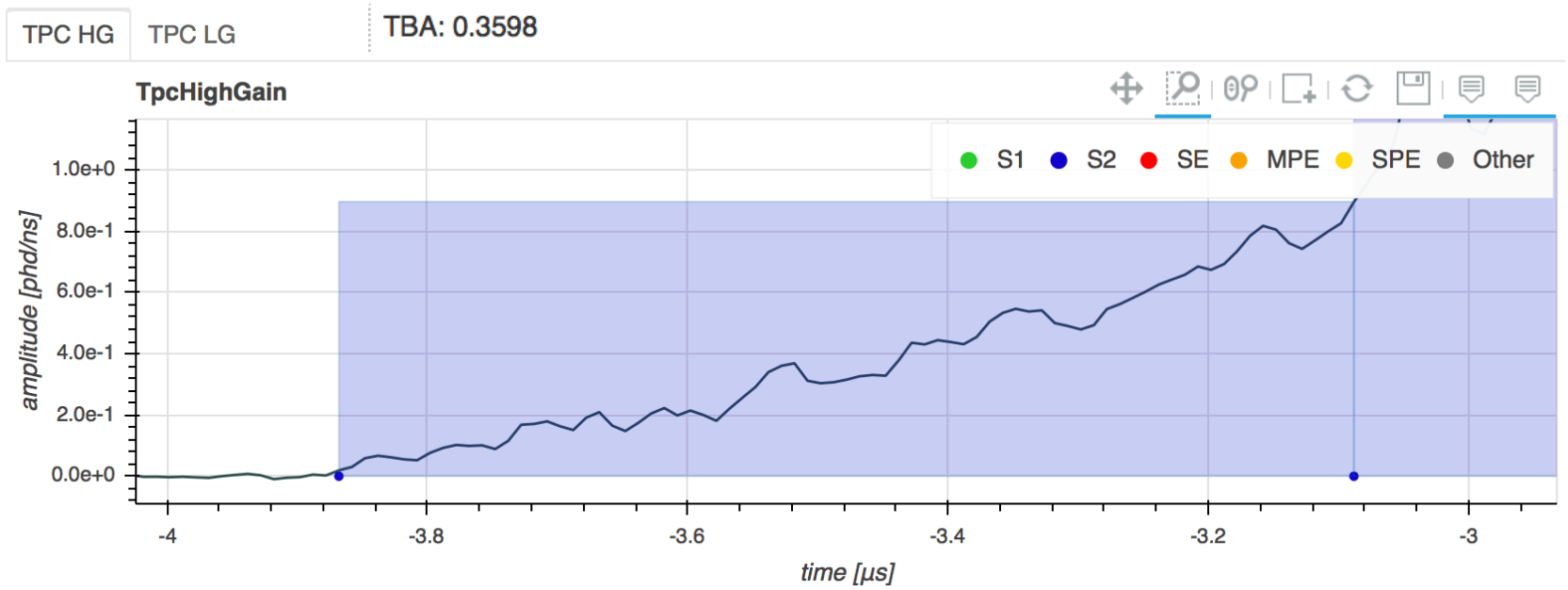
eventID

raw root file

runID

pulseID

Event Viewer output:



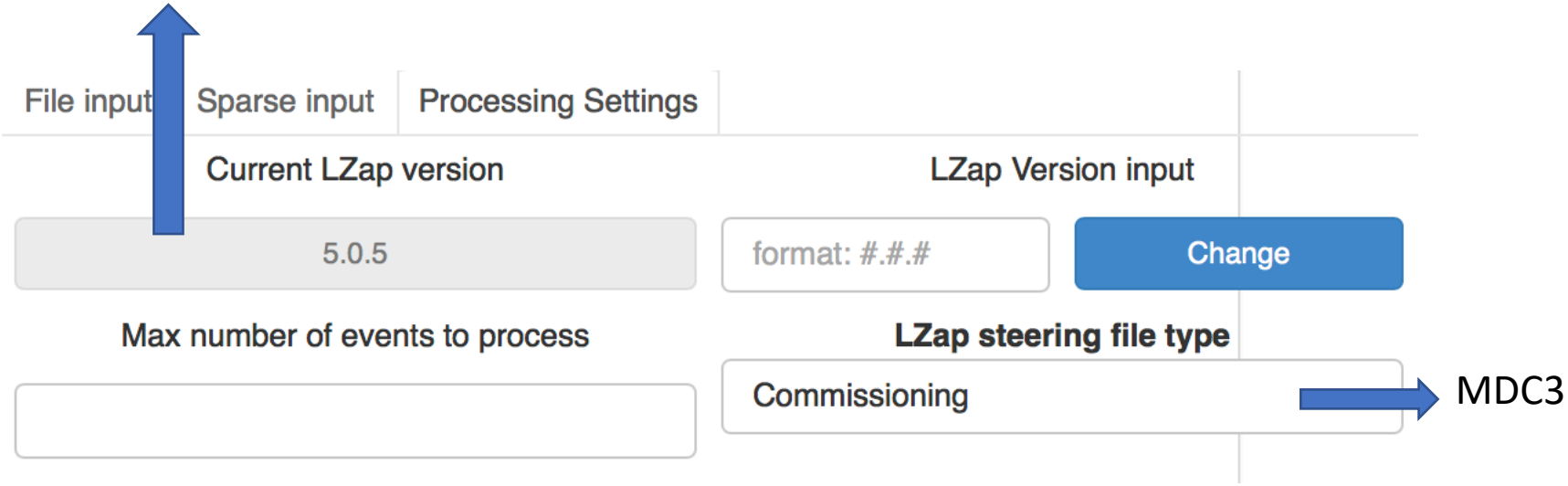
Does not match

1. Pulse type
2. TBA value

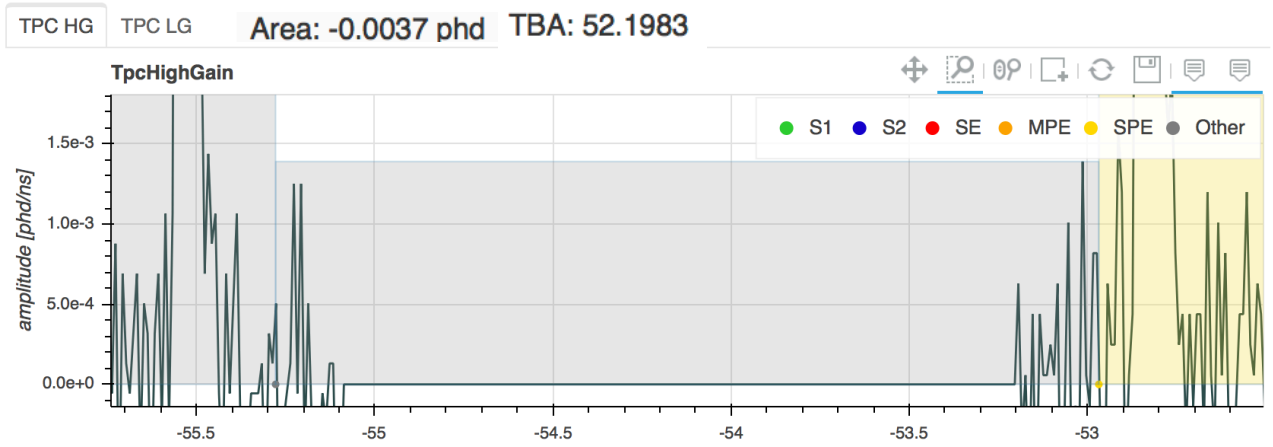
LZap 4.7.0

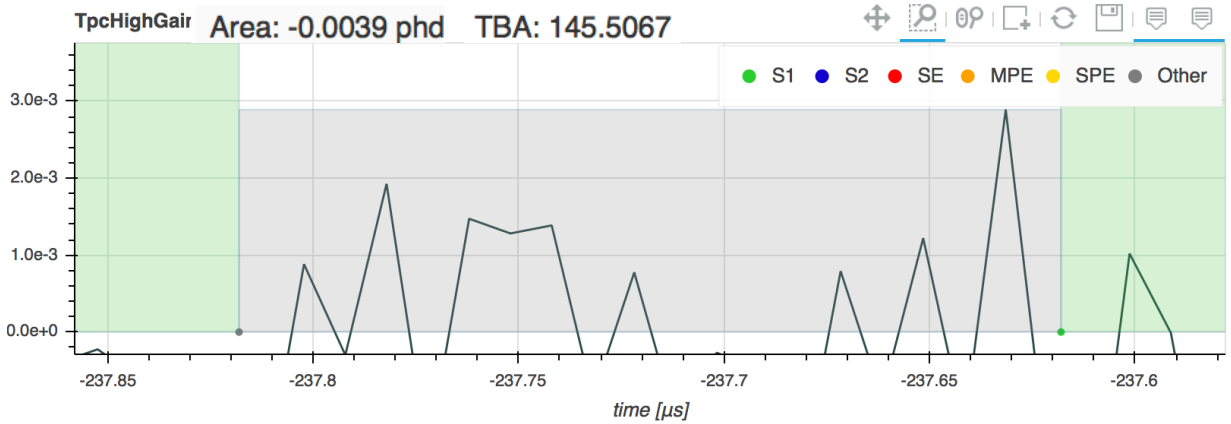
- Check the processing setting
- PREM input data file: using the root file from LZAP-4.7.0

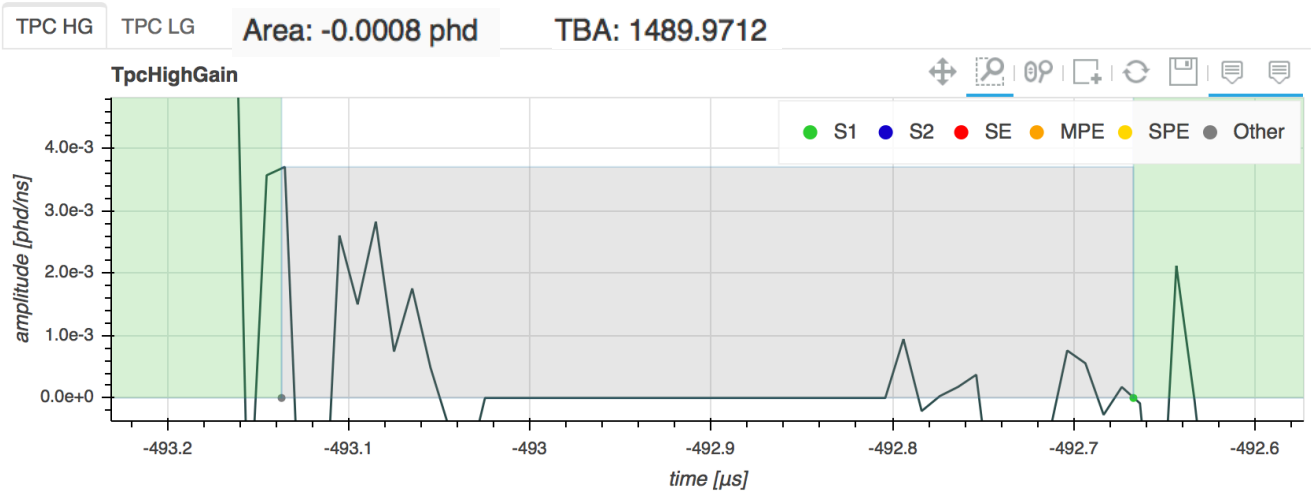
→ Default LZap version on Event Viewer: 5.0.5 → Event Viewer will process the raw root file with this LZap version
→ Change to 4.7.0

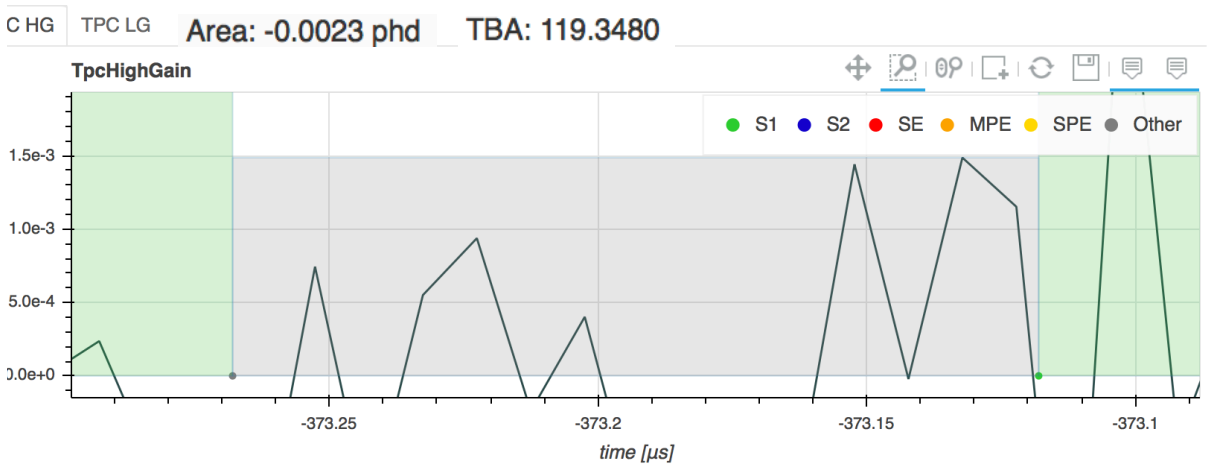


All the problems appear →







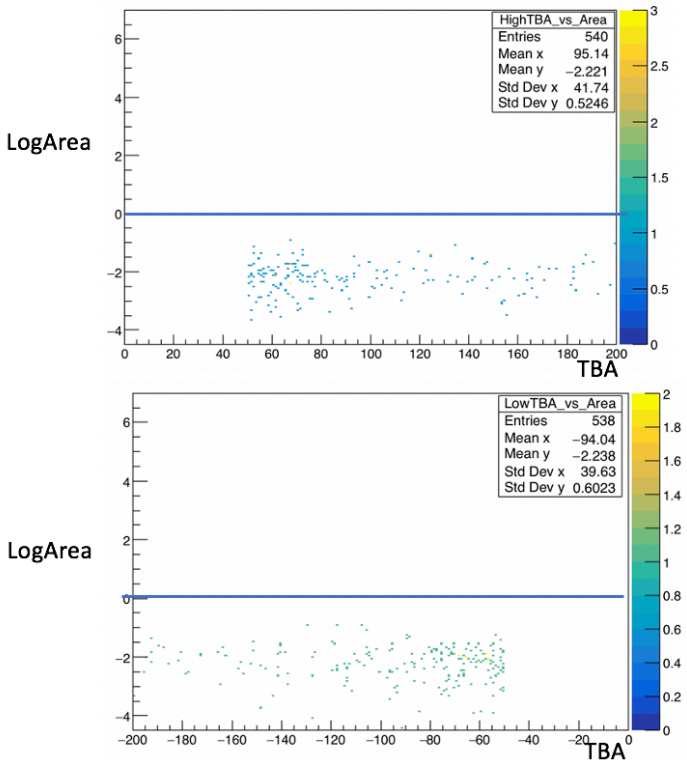


Problems with LZap version: 4.7.0

LZap 5.0.1

- Changed the input root data file to LZap 5.0.1, on the same date of root data file (20180401)
  - #Extreme TBA values decreased to 2+1 = 3 for 1 LZap data file

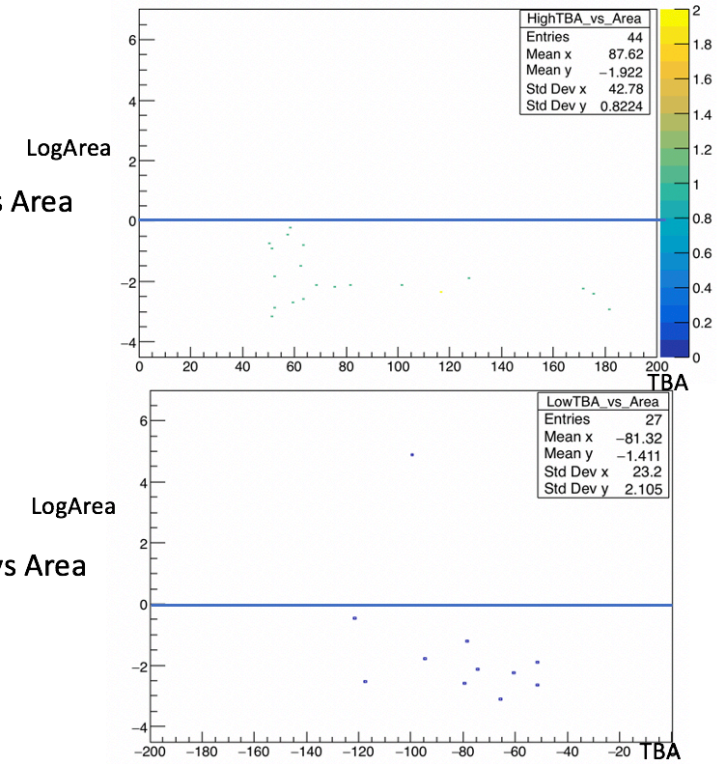
LZap 4.7.0



TBA > 50 vs Area

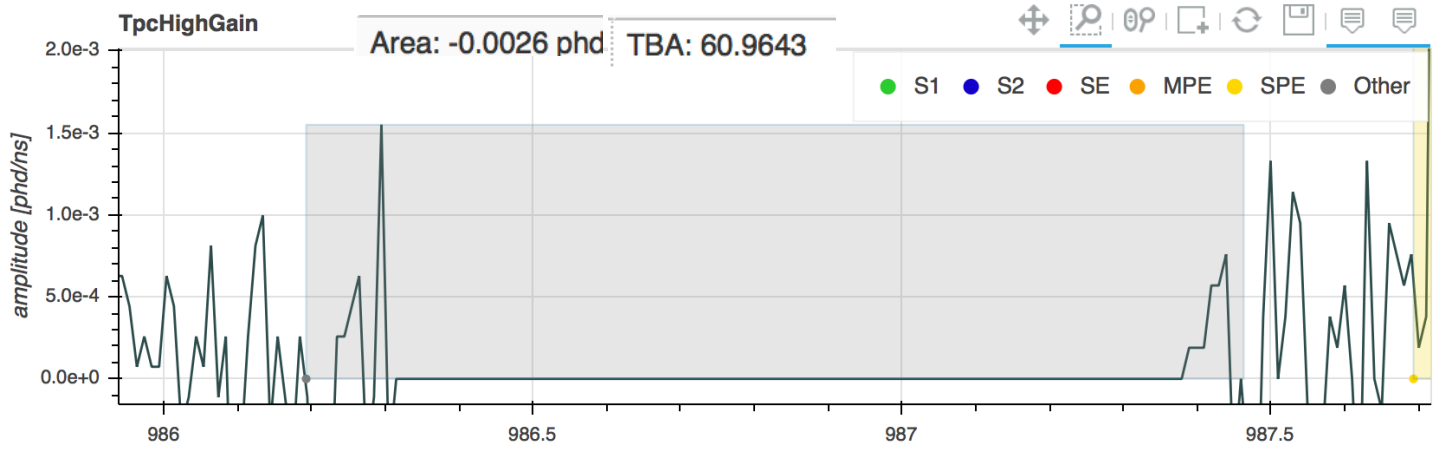
TBA < -50 vs Area

LZap 5.0.1

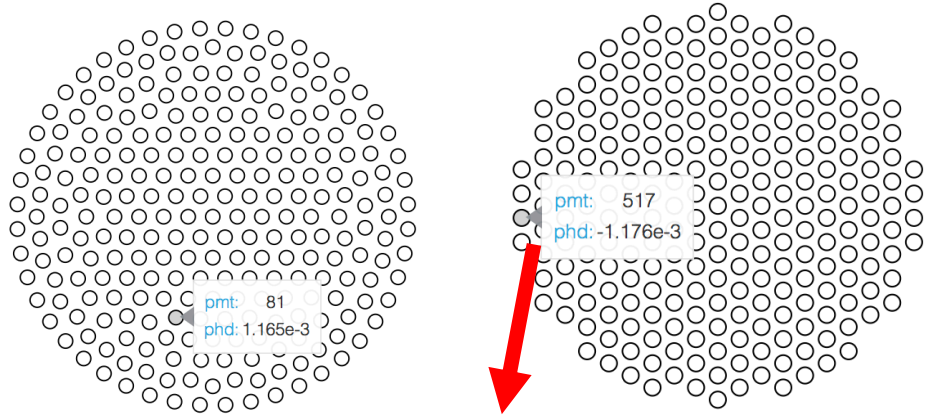


1. 8h data
2. A fraction of pulse area, < 1

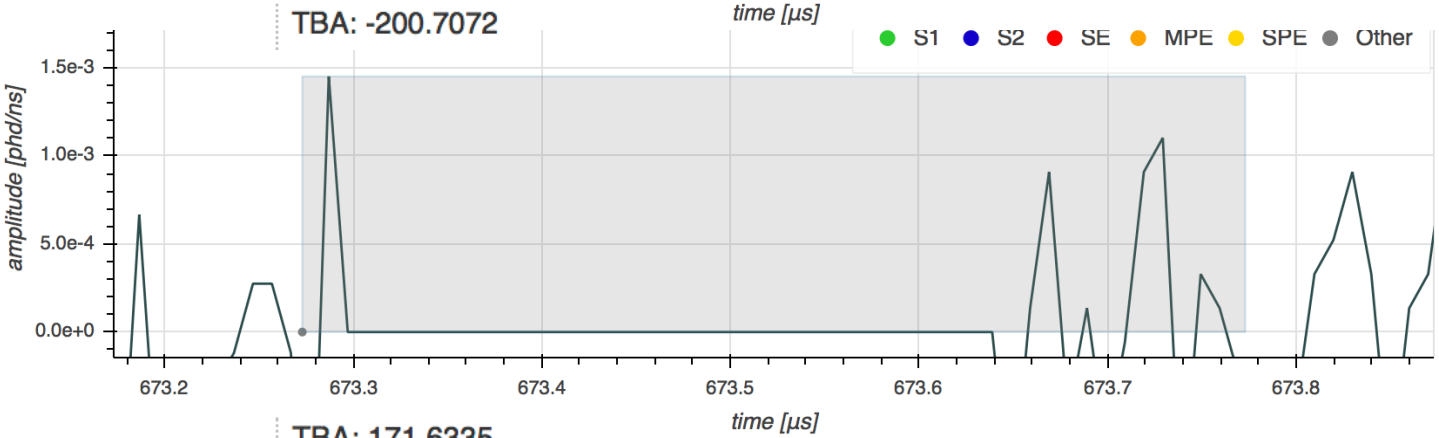
Just out of curiosity……



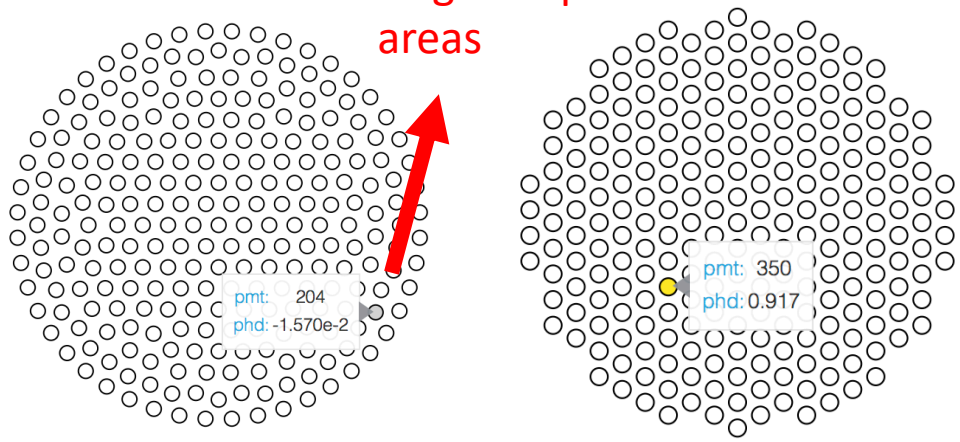
97

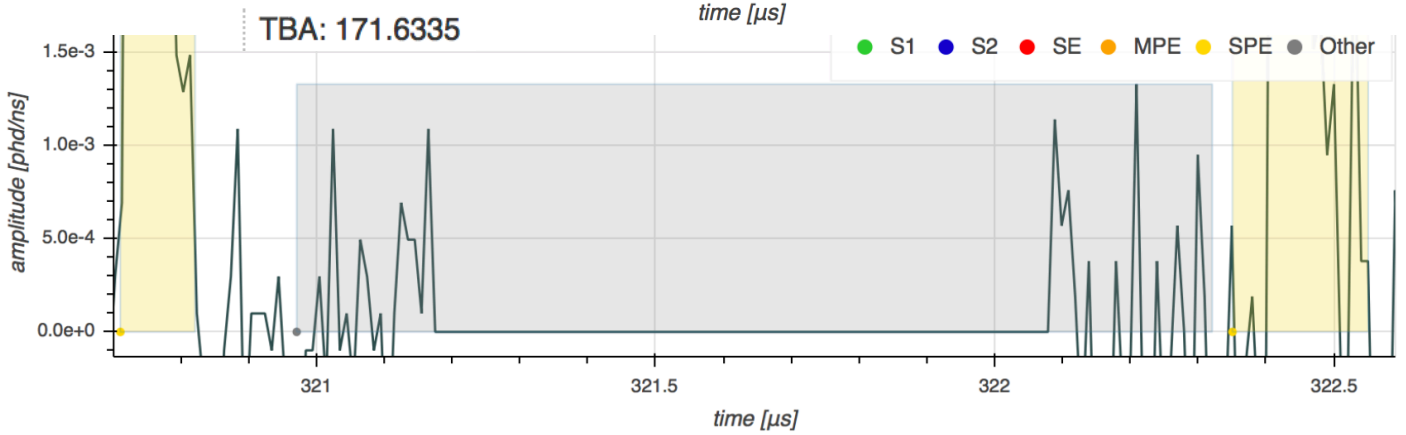


Negative pulse areas

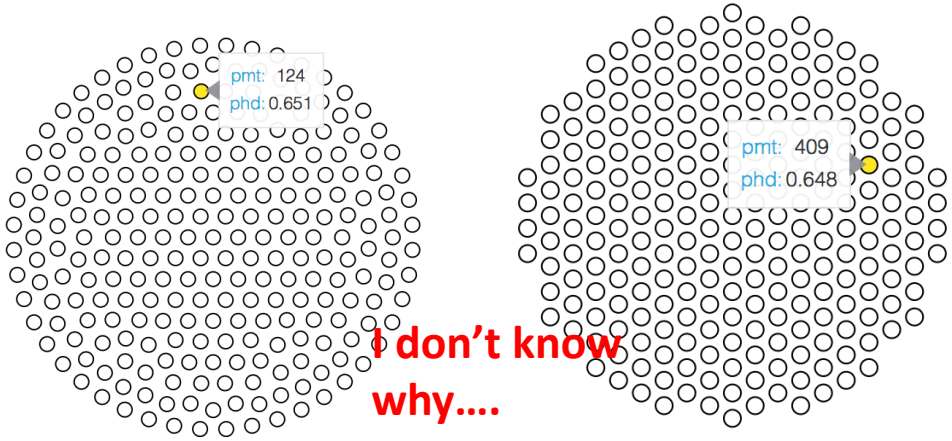


37

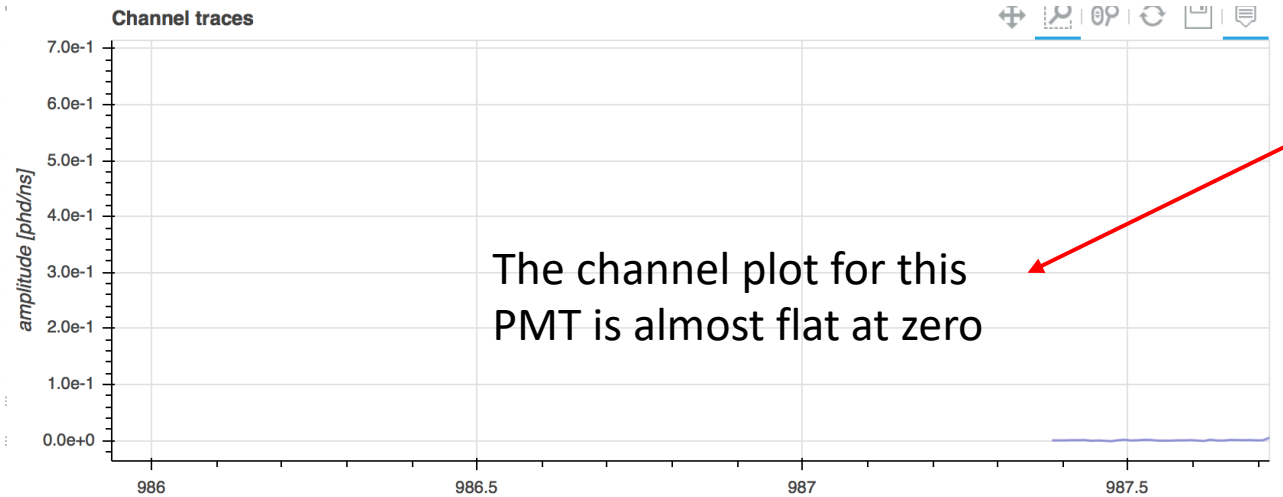




25



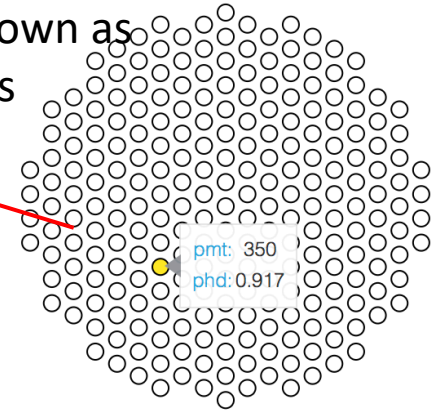
I don't know why….

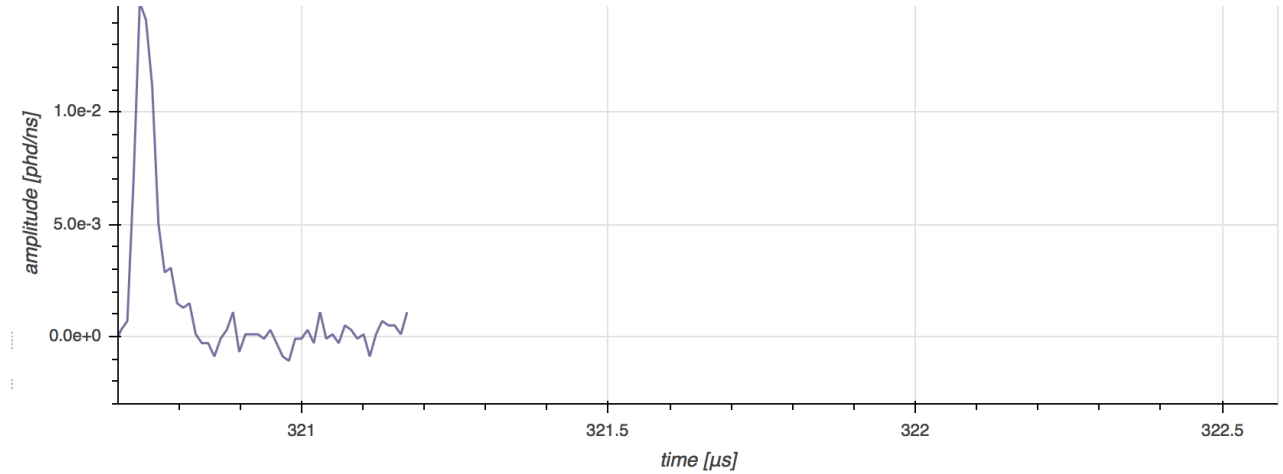


The channel plot for this PMT is almost flat at zero

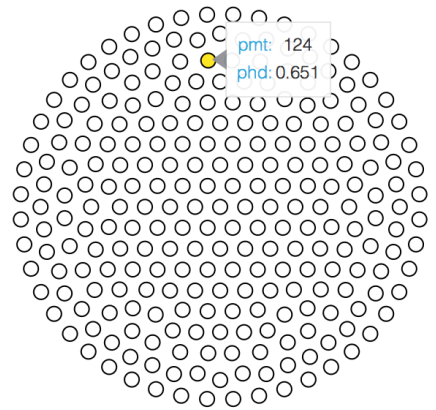
Even though the PMT 350 is shown as yellow and has 0.917phd

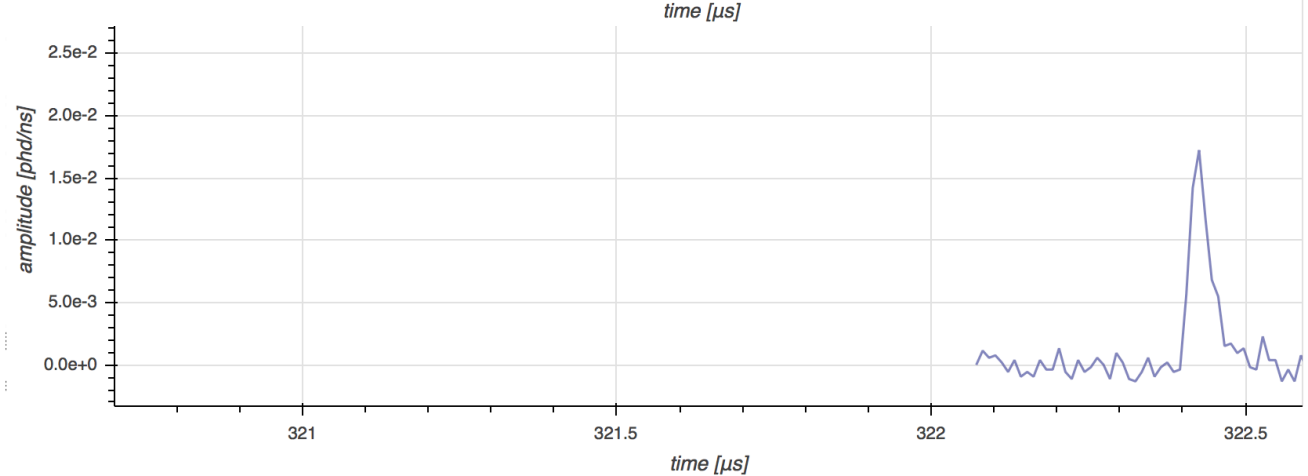
37 B



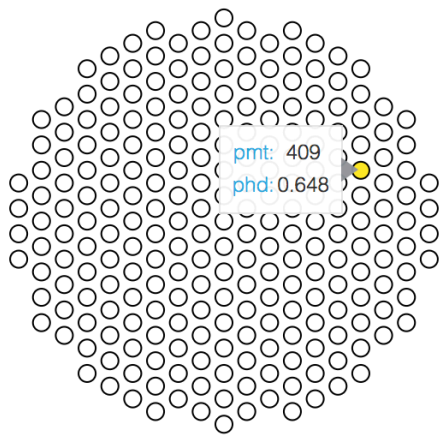


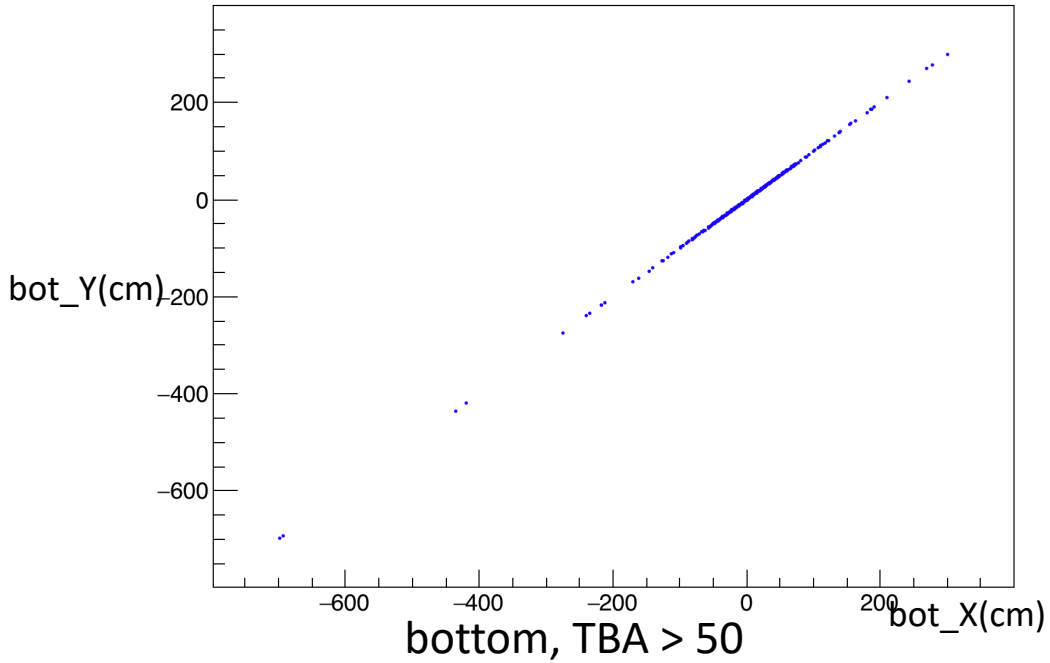
25 T





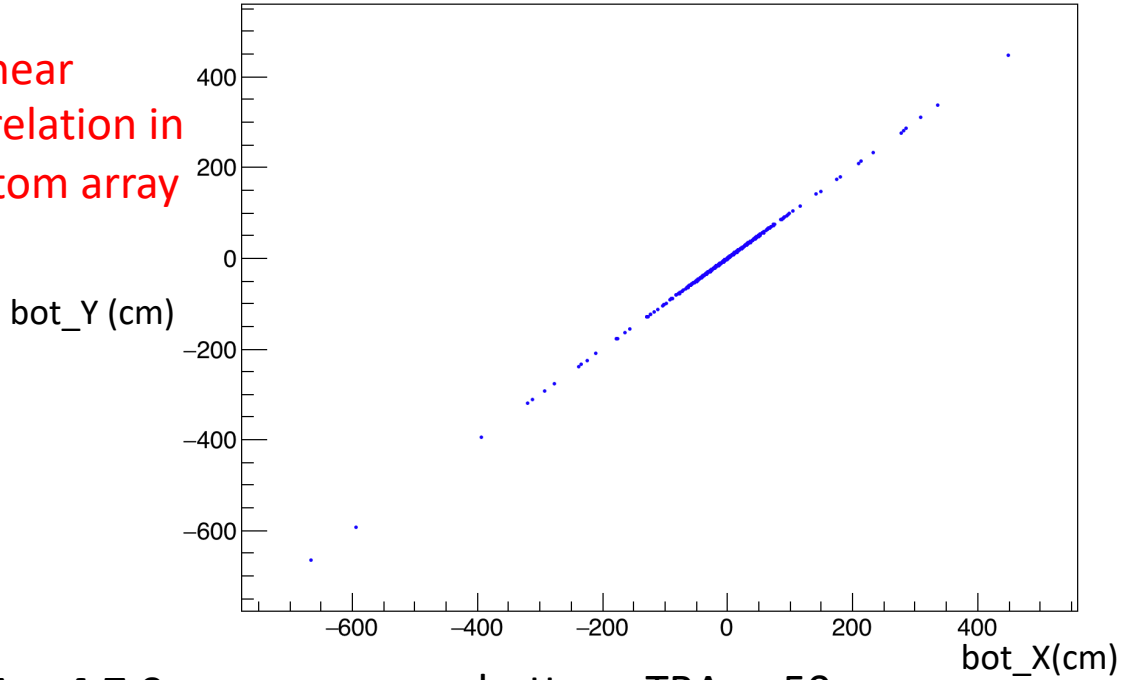
25 B





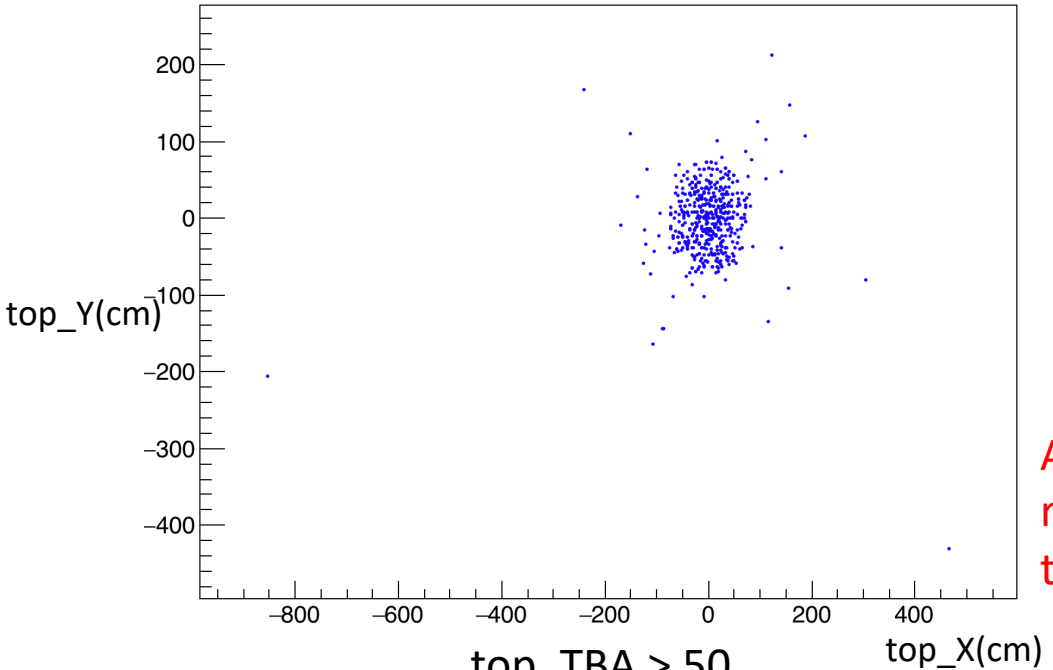
bottom, TBA > 50

A linear correlation in bottom array



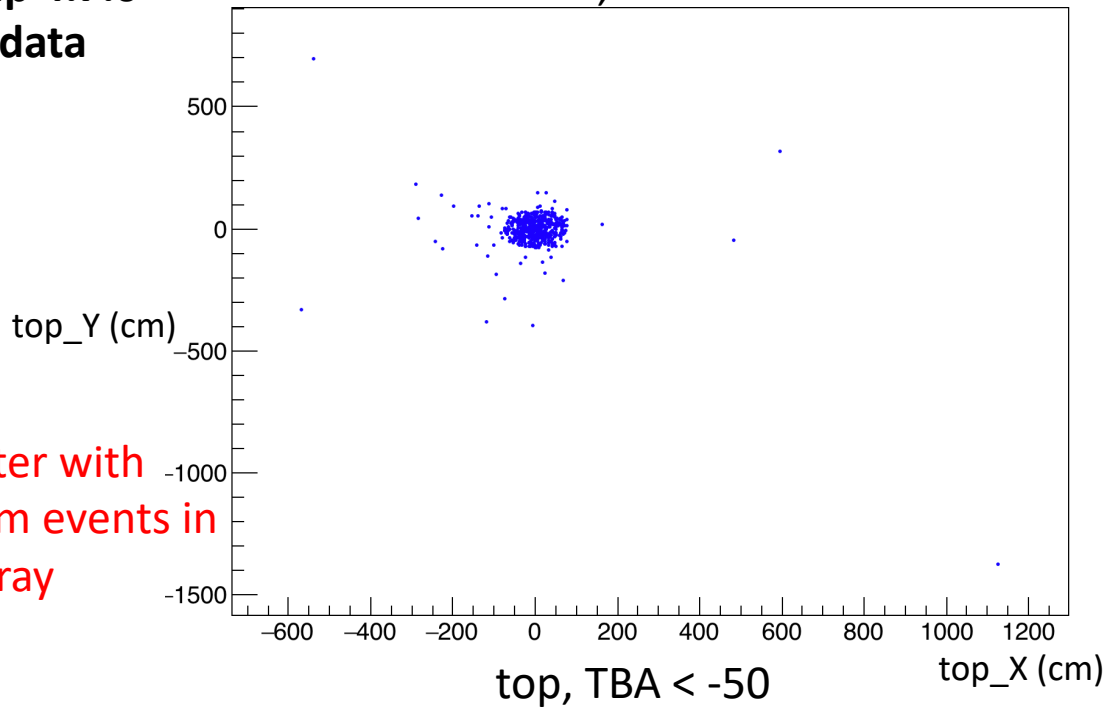
bottom, TBA < -50

LZap 4.7.0
8h data

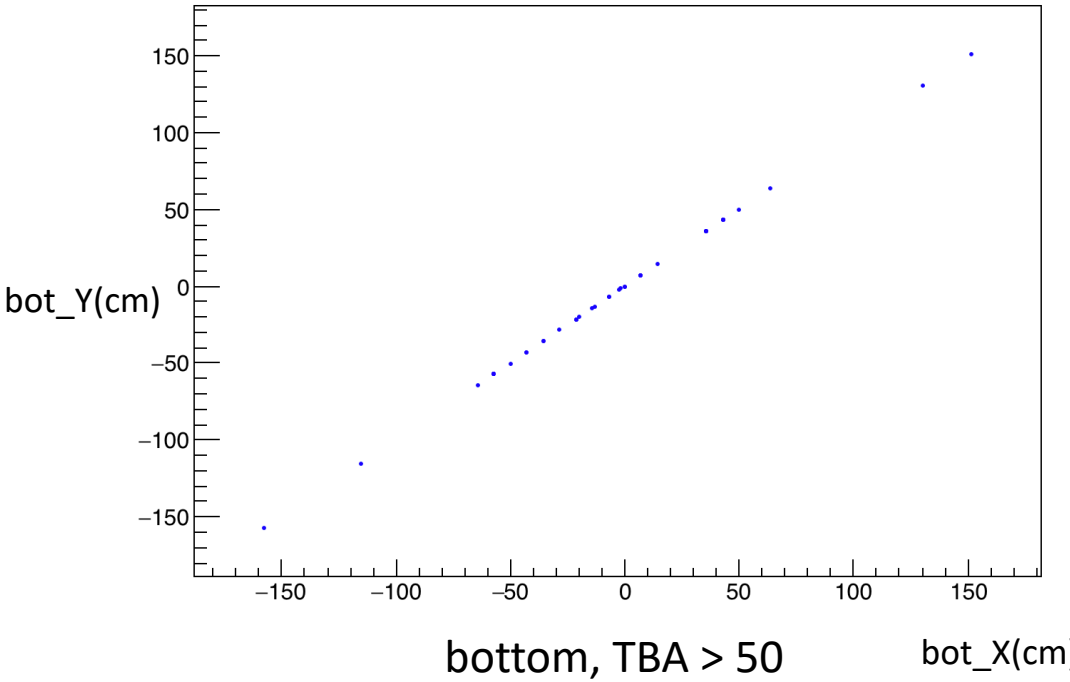


top, TBA > 50

A cluster with random events in top array

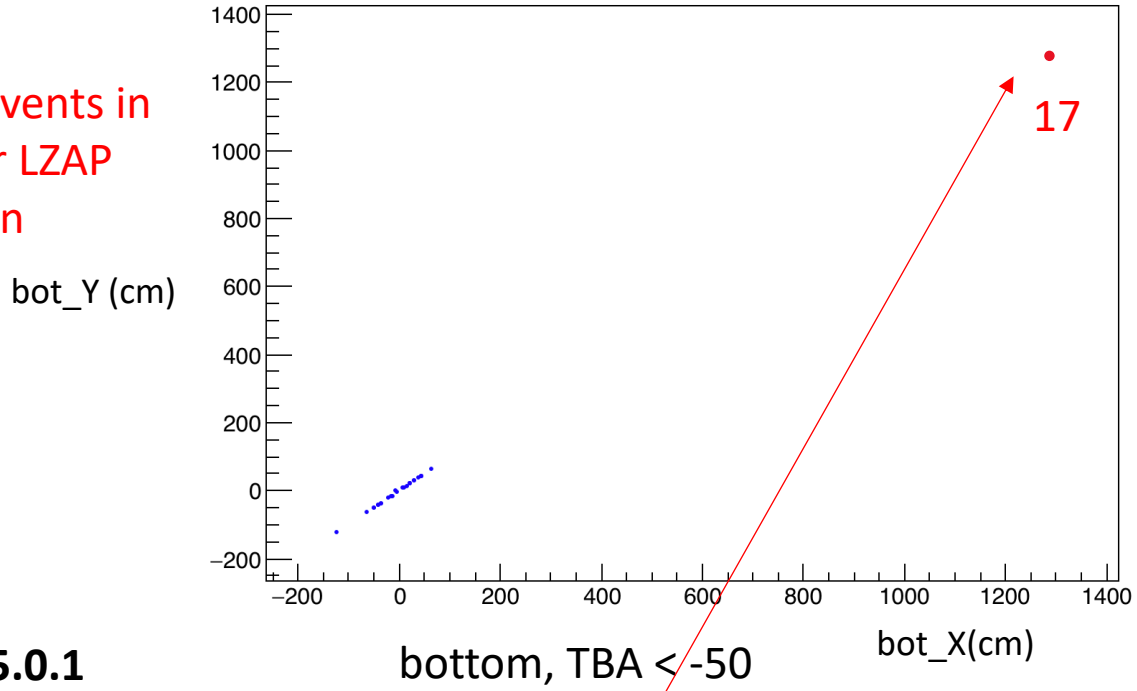


top, TBA < -50



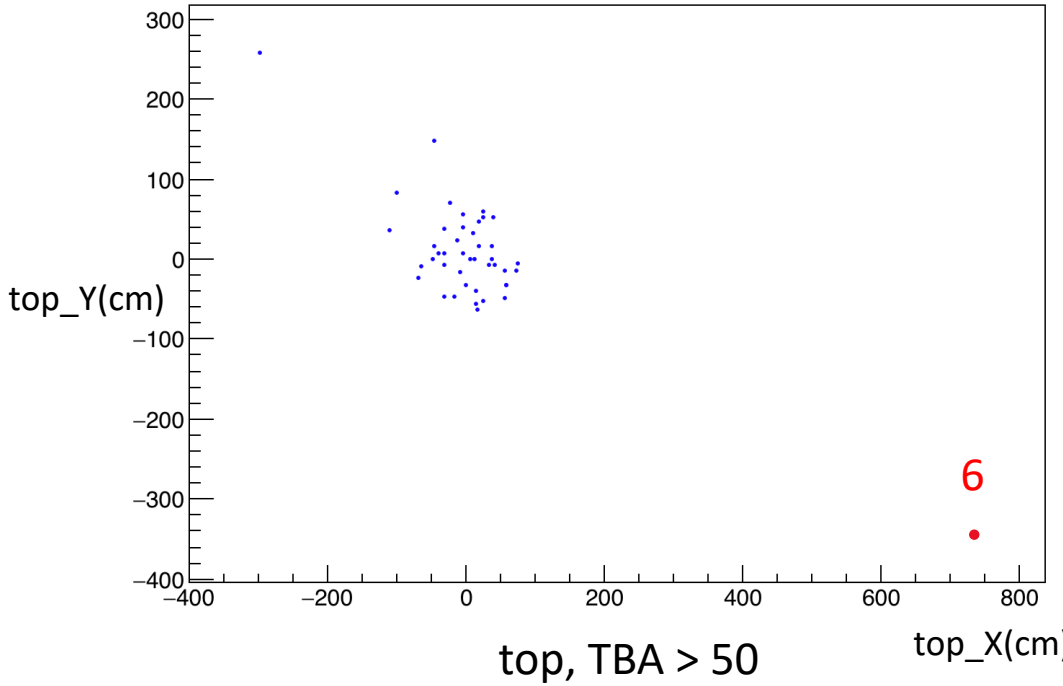
bottom, TBA > 50

Less events in newer LZAP version

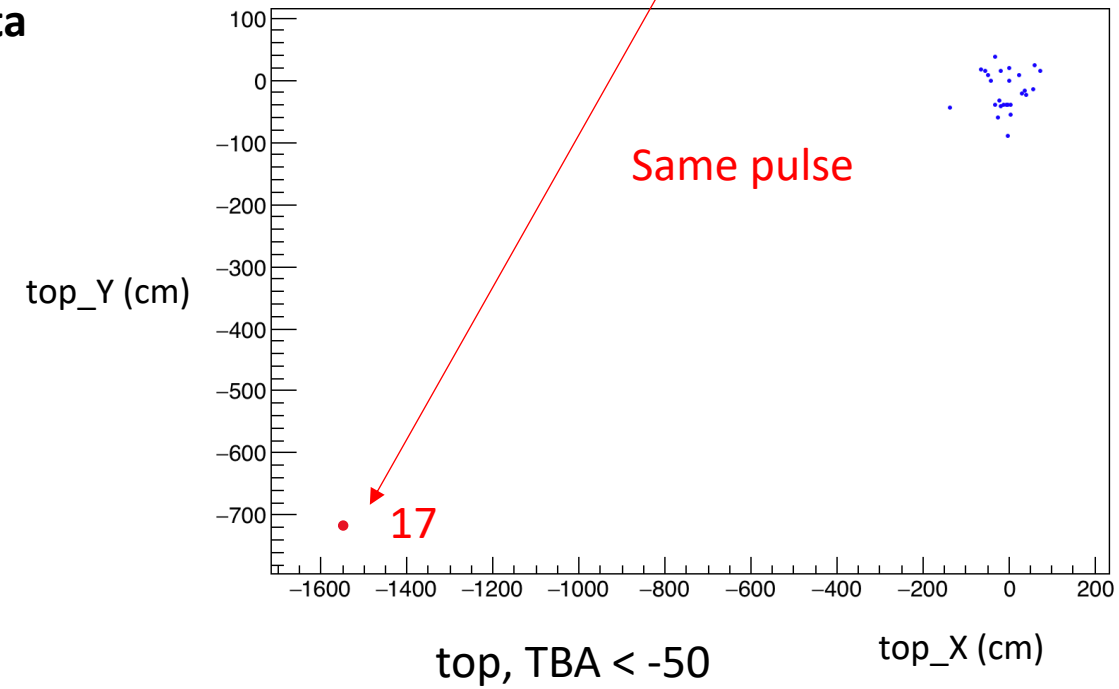


bottom, TBA < -50

LZap 5.0.1
8h data

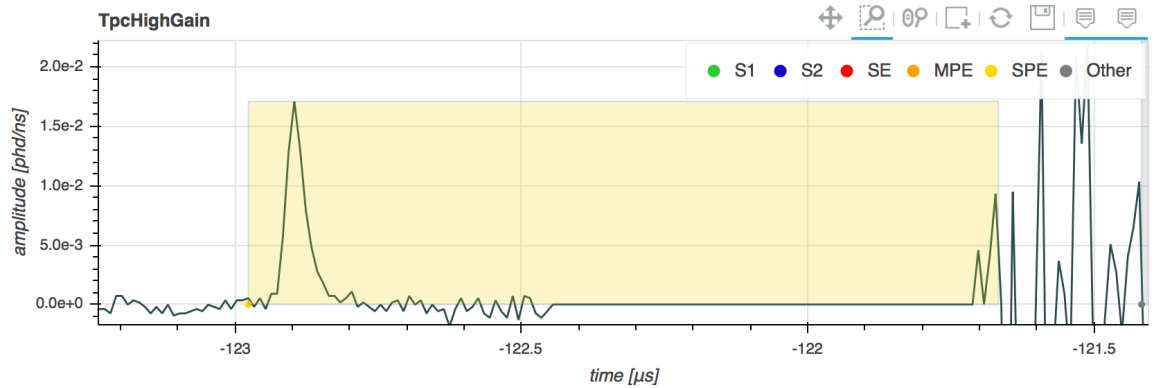


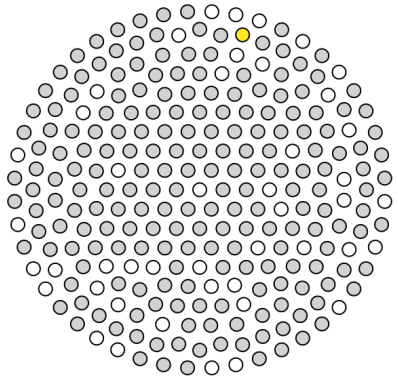
top, TBA > 50

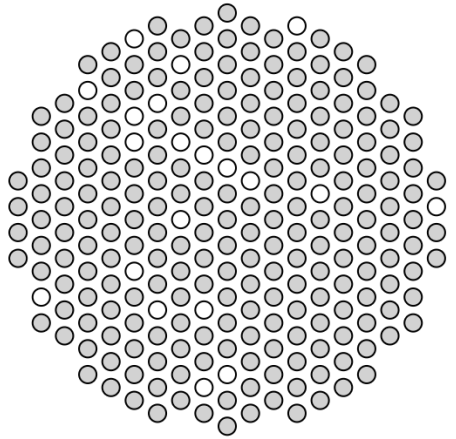


top, TBA < -50

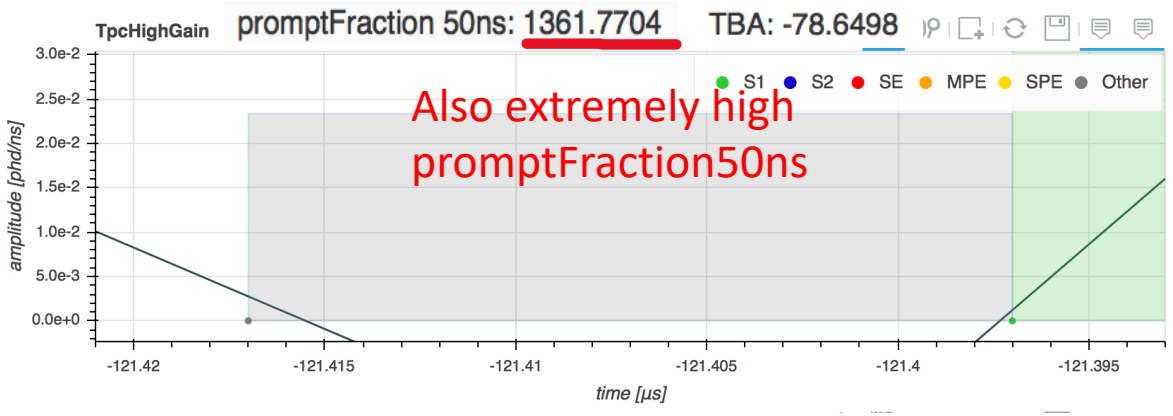
16



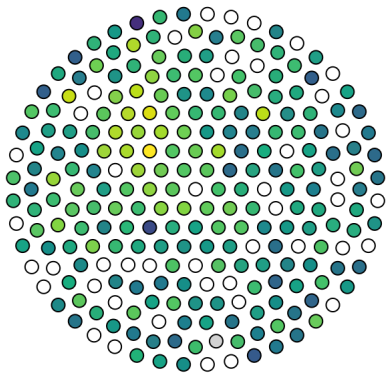


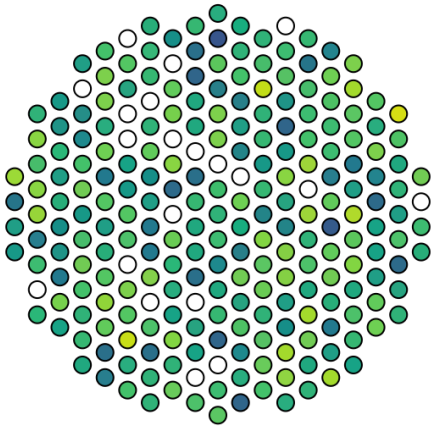


17

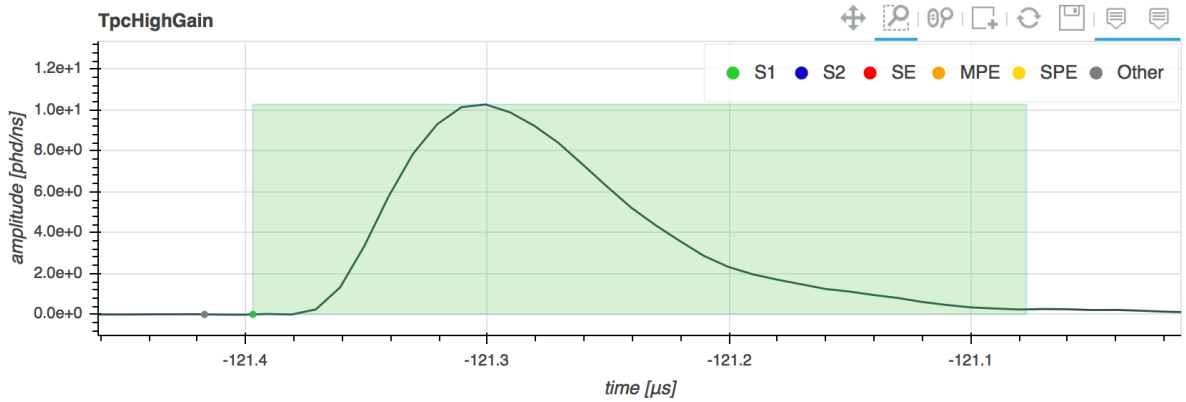


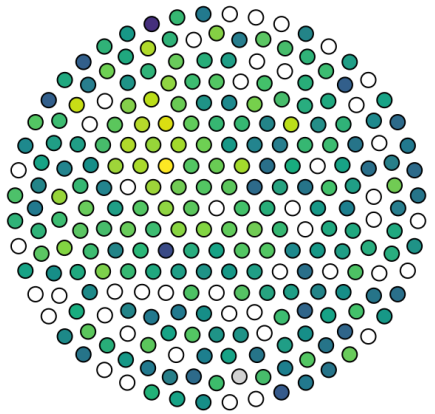
Also extremely high promptFraction50ns

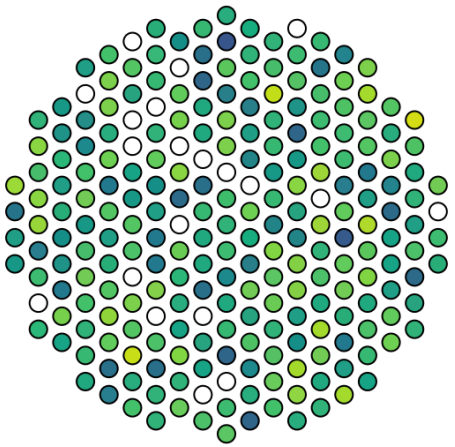


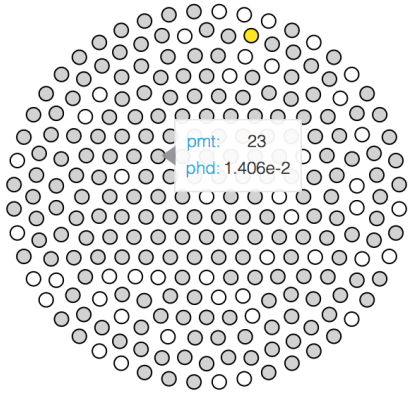


18

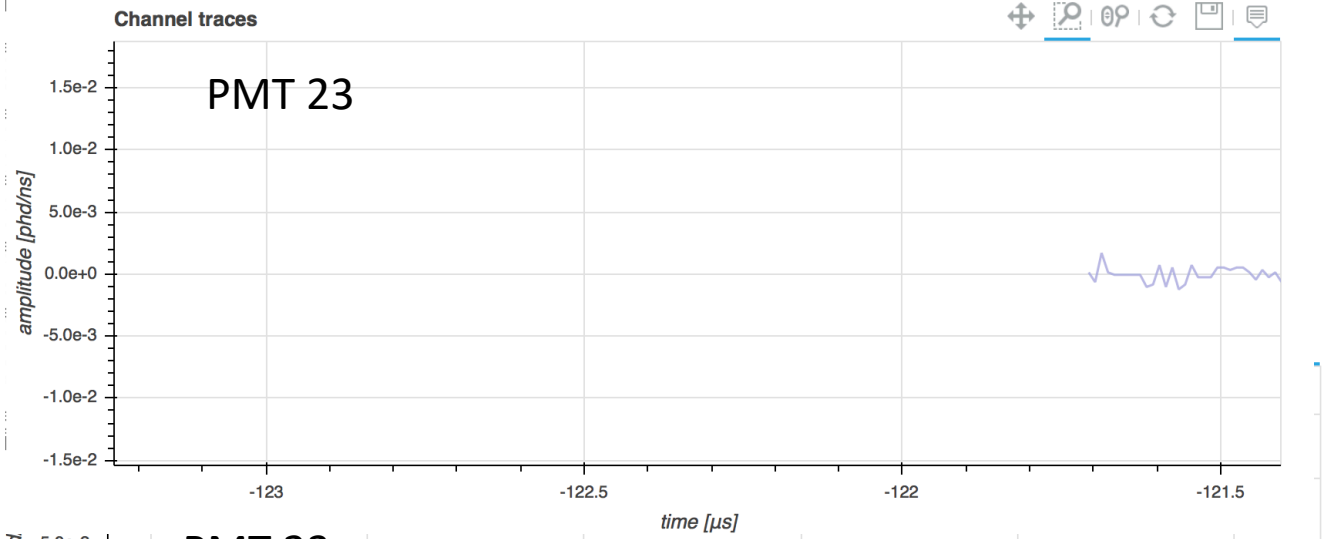






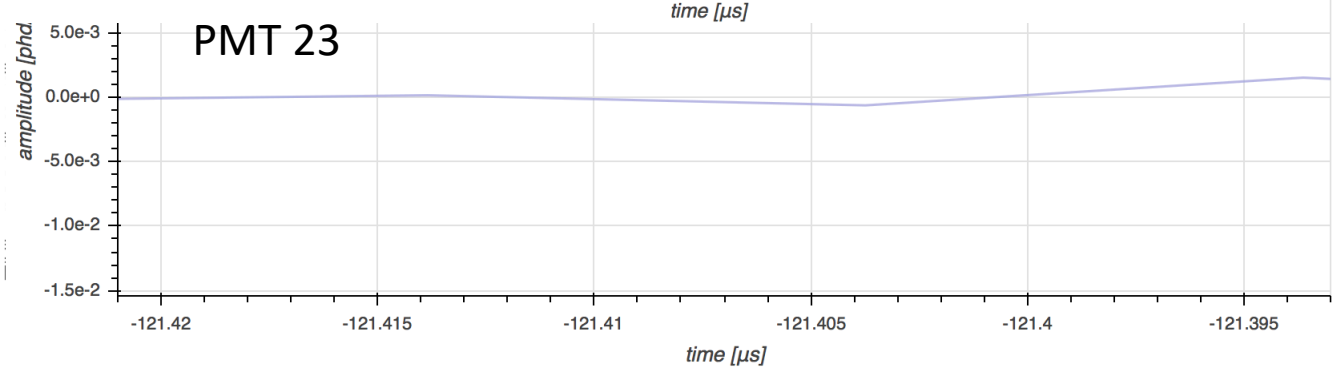


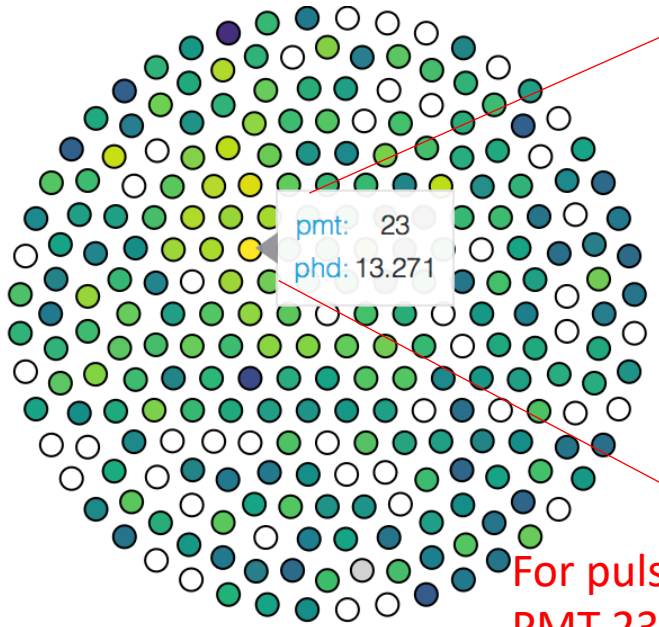
16



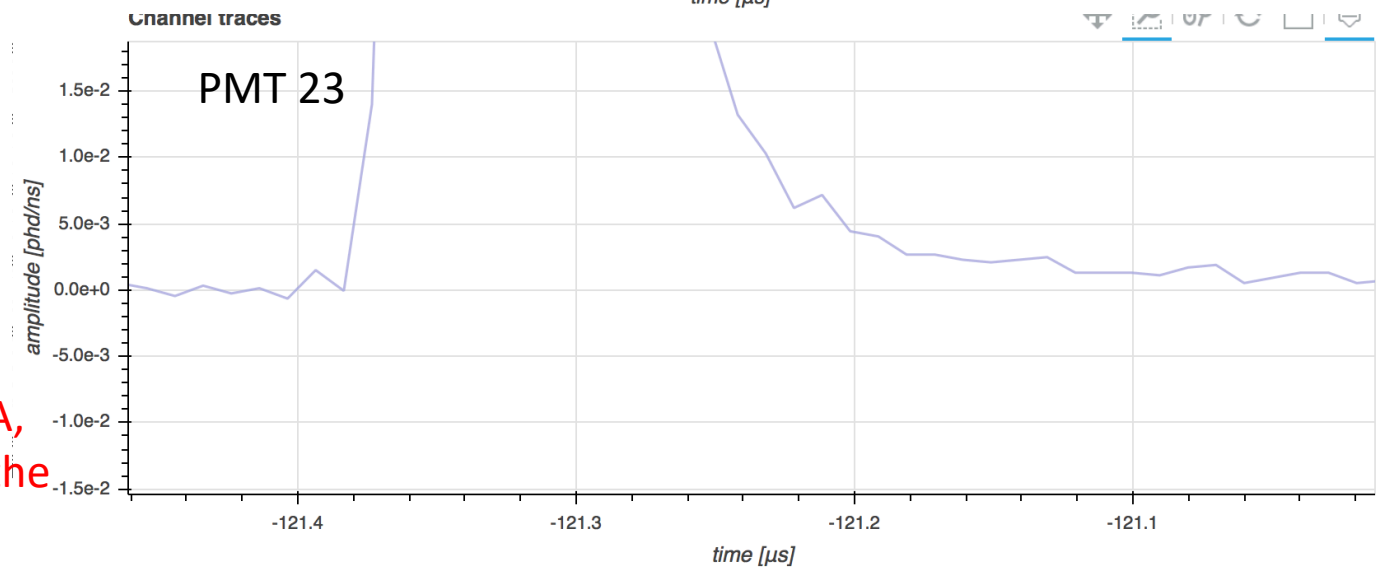
For pulse 17 (TBA = -78), PMT 23 shows 13.271 phd, but the channel plot is around zero

17



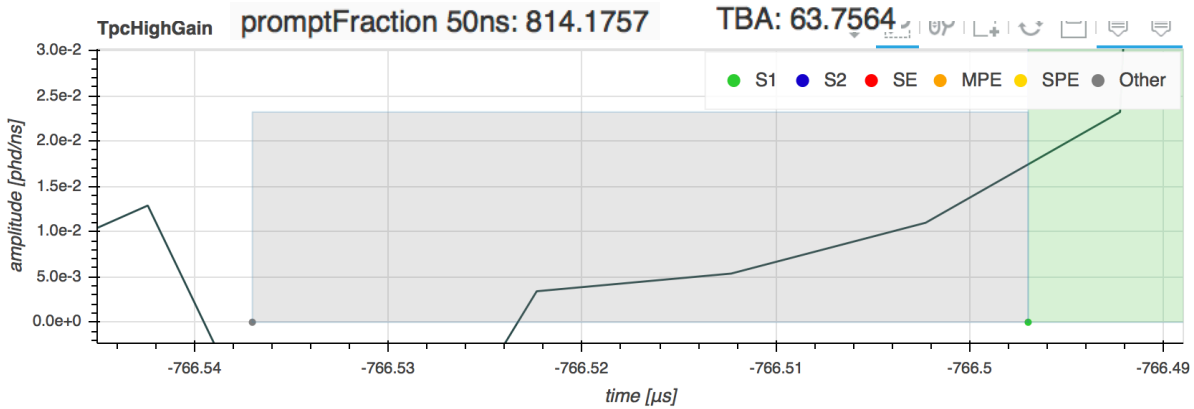


18

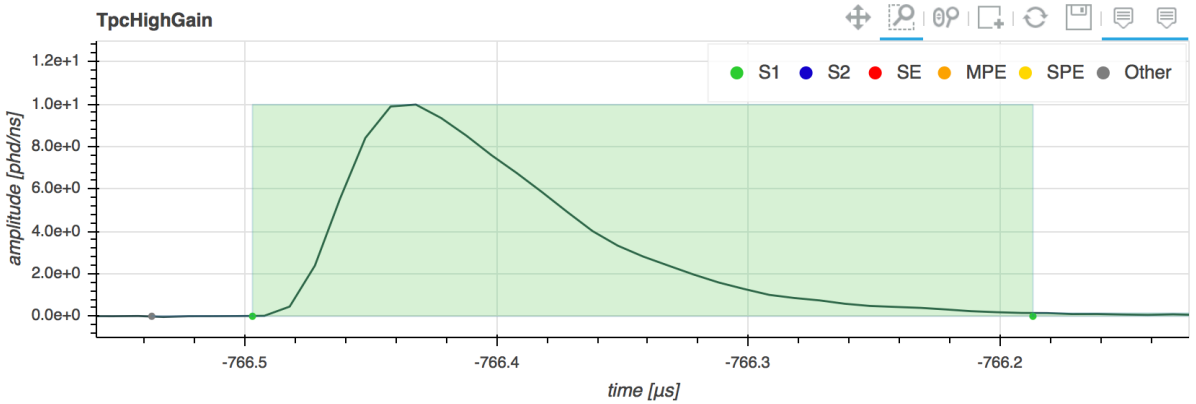


For pulse 18 with normal TBA, PMT 23 shows 13.271 phd, the channel plot looks plausible

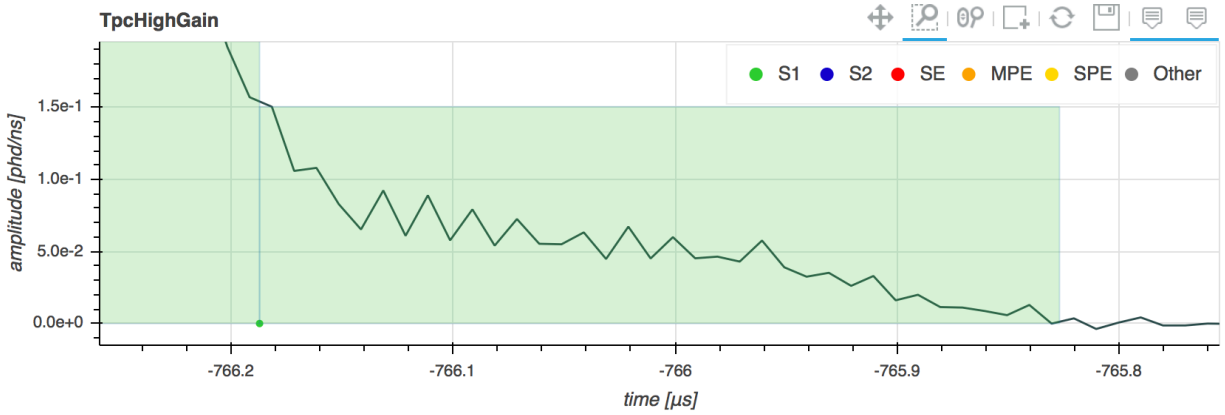
6



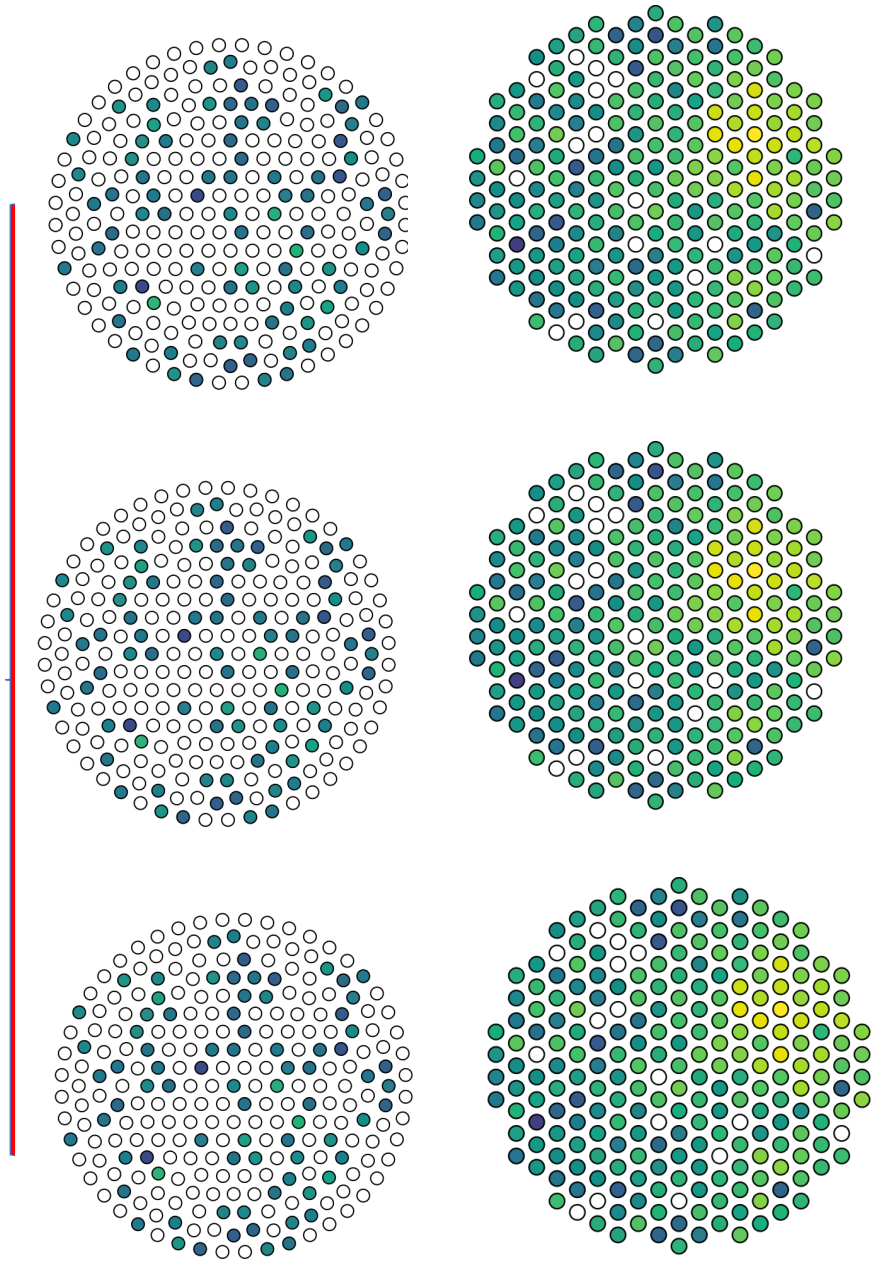
7

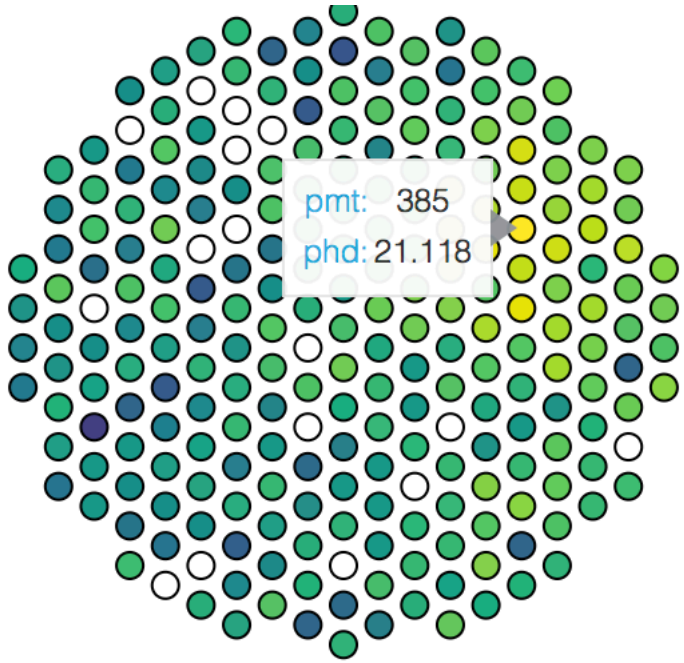


8

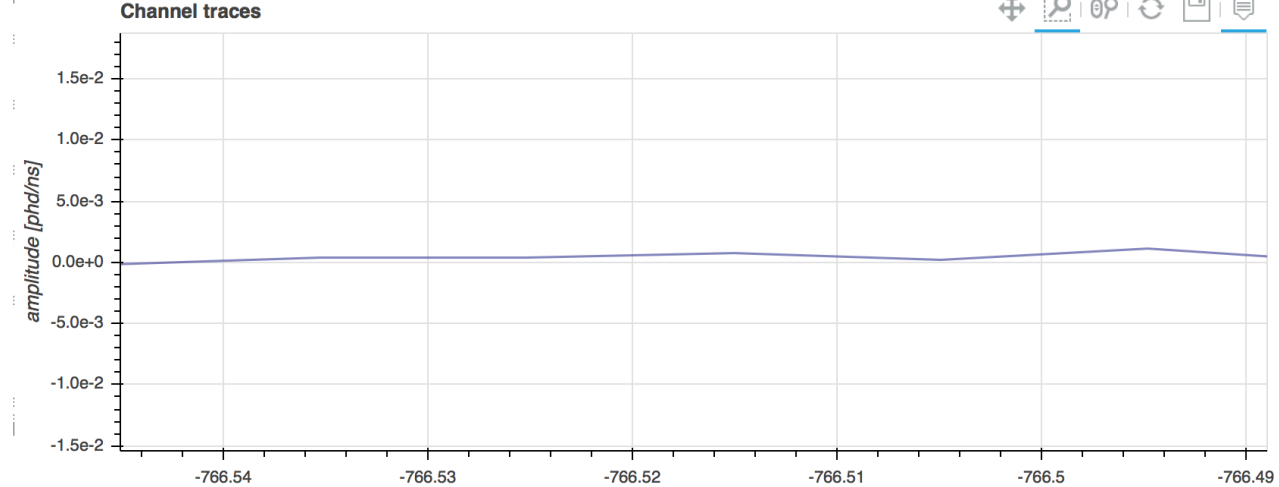


Same top and bottom array patterns, for different pulses

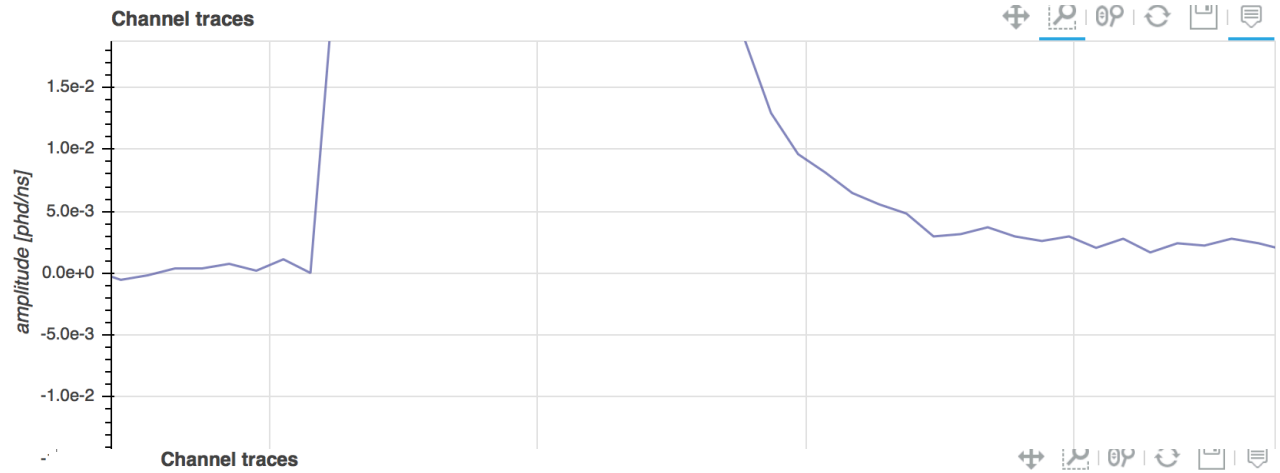



pmt: 385
phd: 21.118

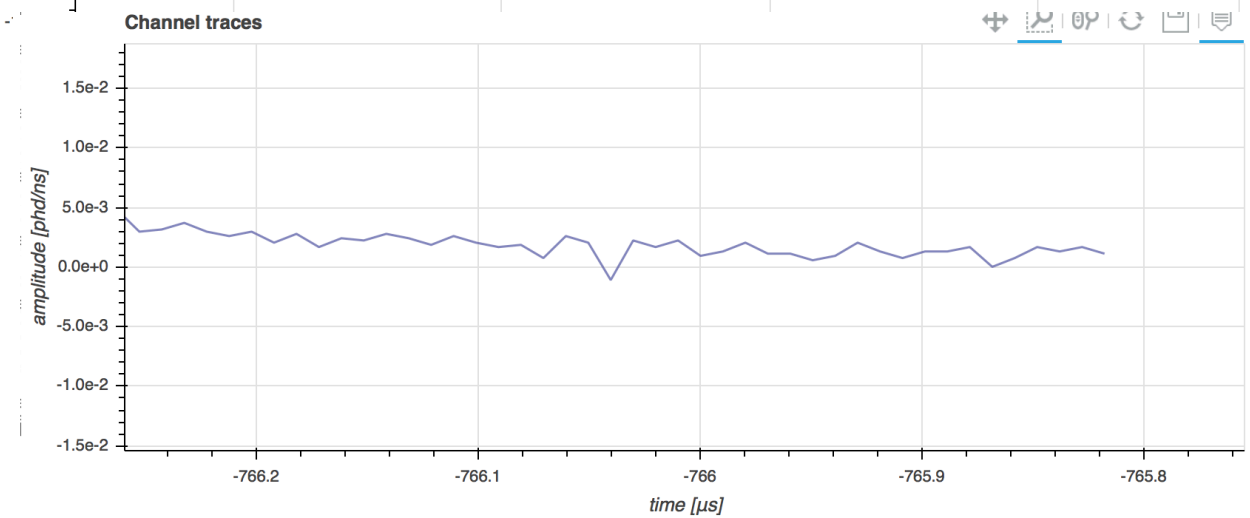
6


Channel traces
amplitude [phd/ns]
1.5e-2
1.0e-2
5.0e-3
0.0e+0
-5.0e-3
-1.0e-2
-1.5e-2
-766.54
-766.53
-766.52
-766.51
-766.5
-766.49

7


Channel traces
amplitude [phd/ns]
1.5e-2
1.0e-2
5.0e-3
0.0e+0
-5.0e-3
-1.0e-2

8


Channel traces
amplitude [phd/ns]
1.5e-2
1.0e-2
5.0e-3
0.0e+0
-5.0e-3
-1.0e-2
-1.5e-2
-766.2
-766.1
-766
-765.9
-765.8
time [μs]

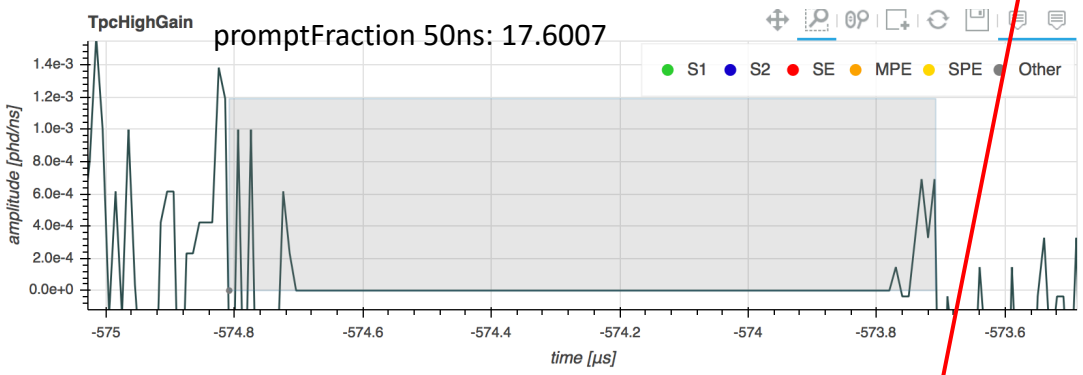
Extremely extreme TBA value

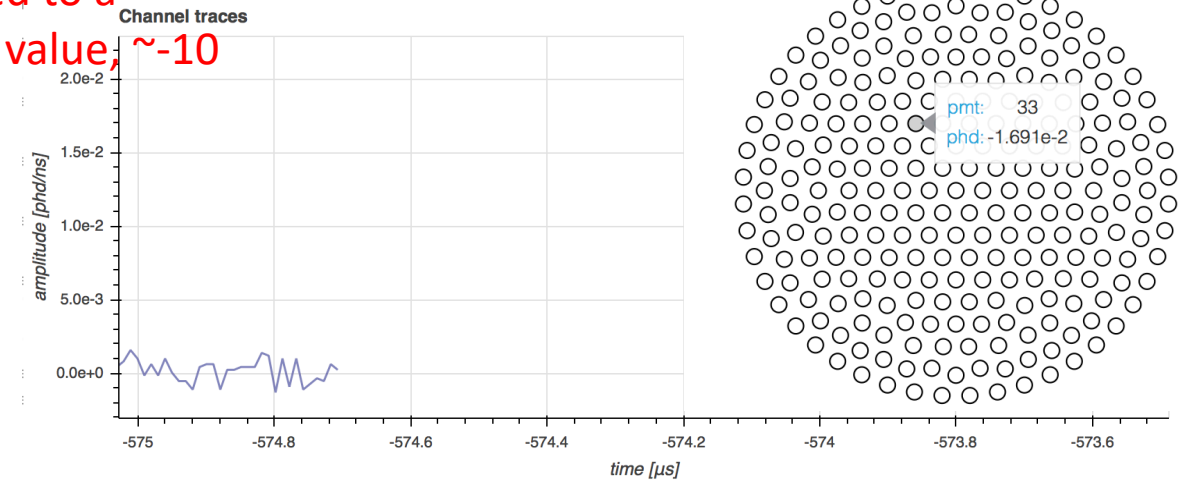
- TBA = 2130 (in LZAP 5.0.1)

Same pFraction50ns, but TBA changed to a reasonable value, ~-10

Process with Lzap 5.0.1

promptFraction 50ns: 17.6007

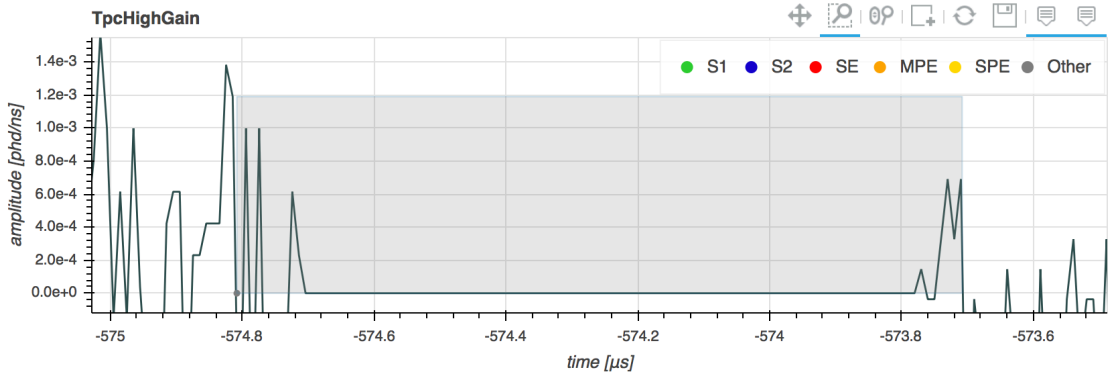


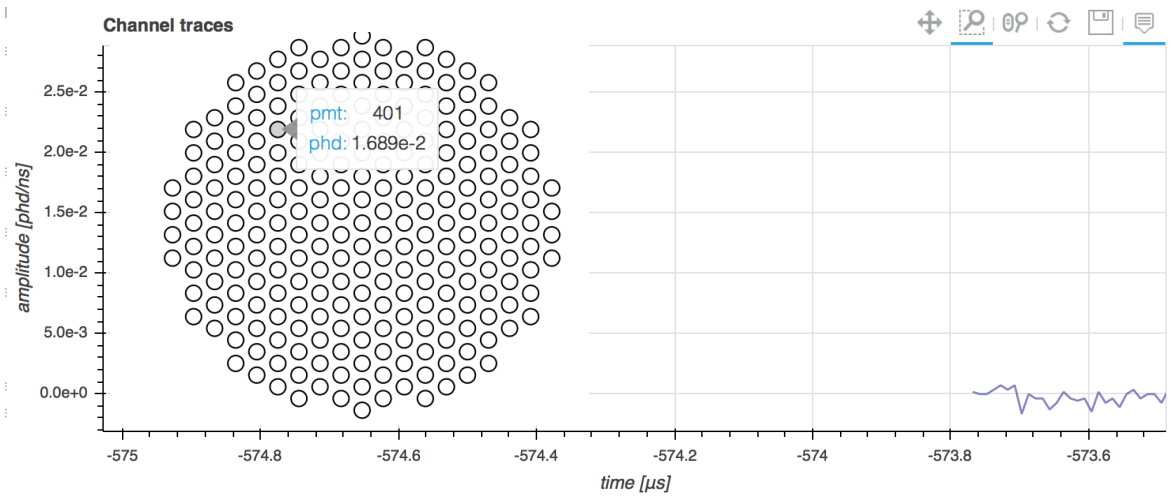


Process with Lzap 5.0.5

promptFraction 50ns: 17.6007

TBA: -10.8432





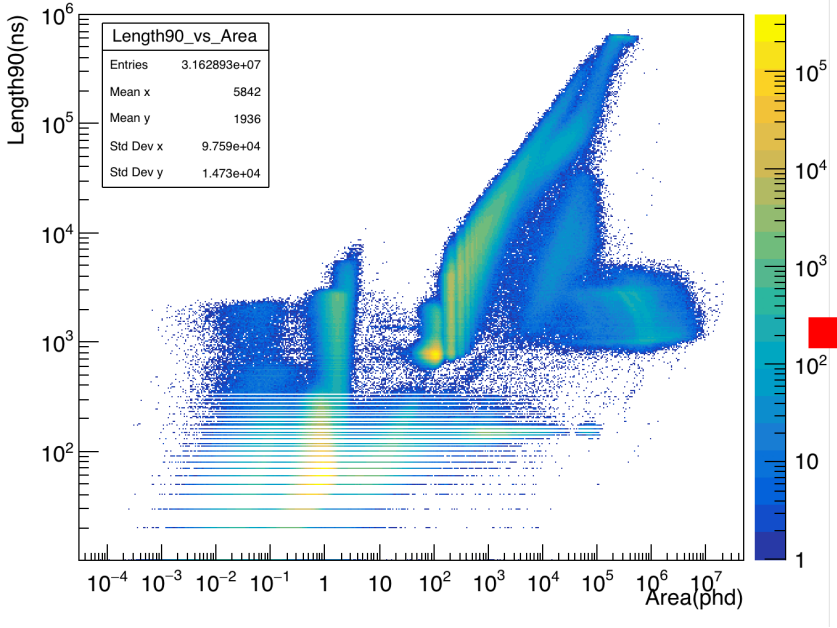
LZAP 5.0.5

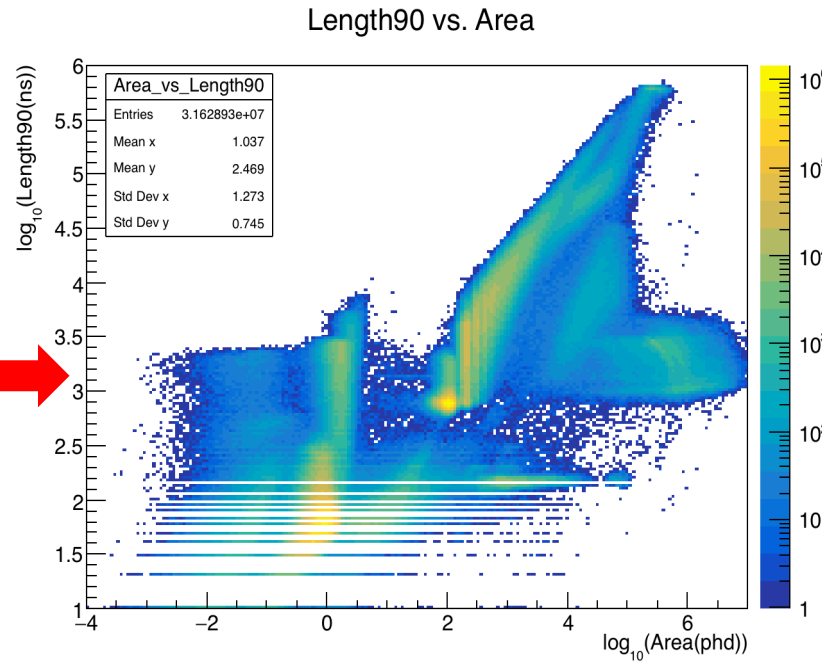
- Checked for the two with weird x, y positions:
  - 6: TBA: 63.75 → -0.2737
  - 17: TBA: -78 → 0.1623
  - Using more recent Lzap version decreases the # of events with extreme TBA
  - Still same problems with PMTs and pFraction50ns
- The newest: Lzap 5.2.x

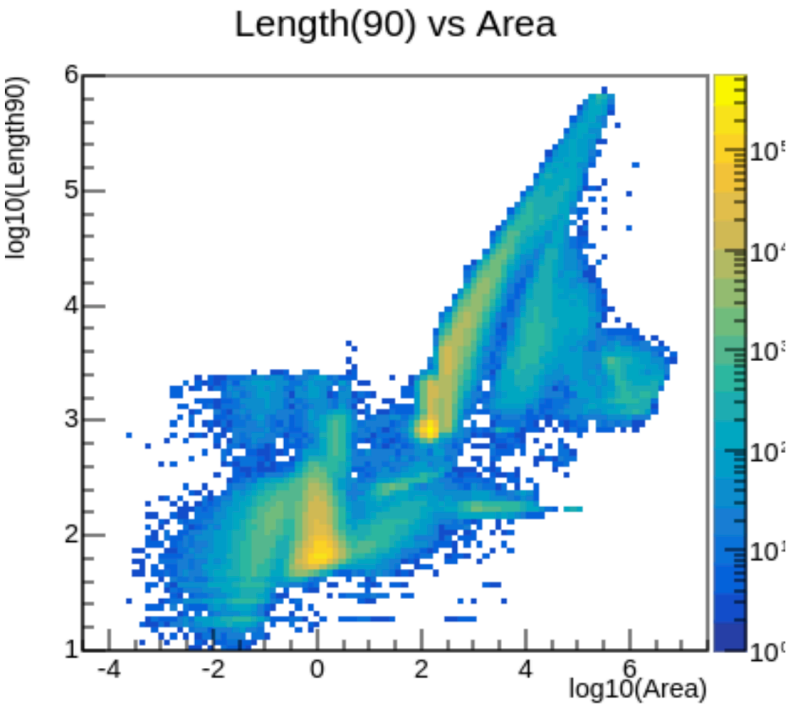
3rd March 2021

- Pulse Classification's Parameter Space:
  - Changed the scale for the PREM plot
  - Play with pFraction100
    - Sent Chico message on Slack
- Next module: Noise

Length90 vs Area





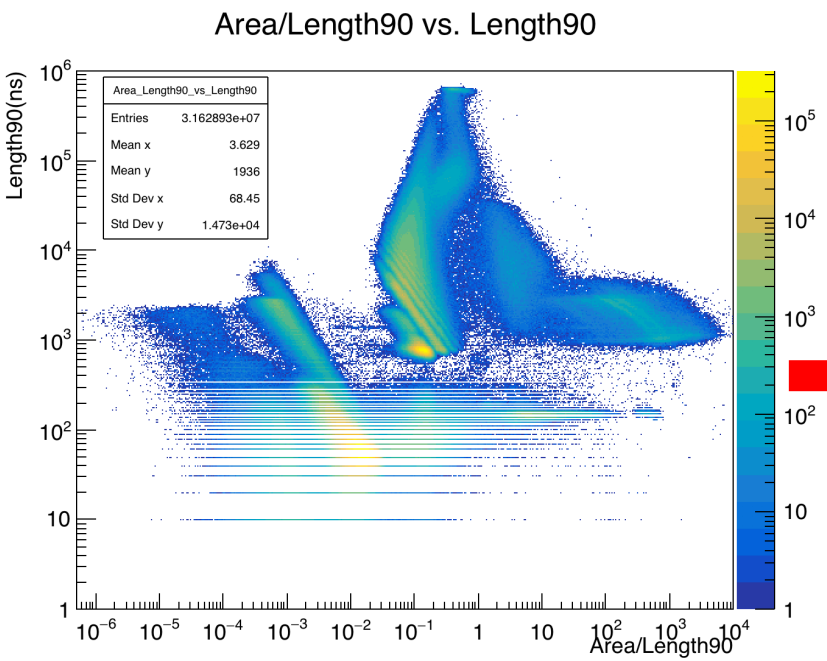


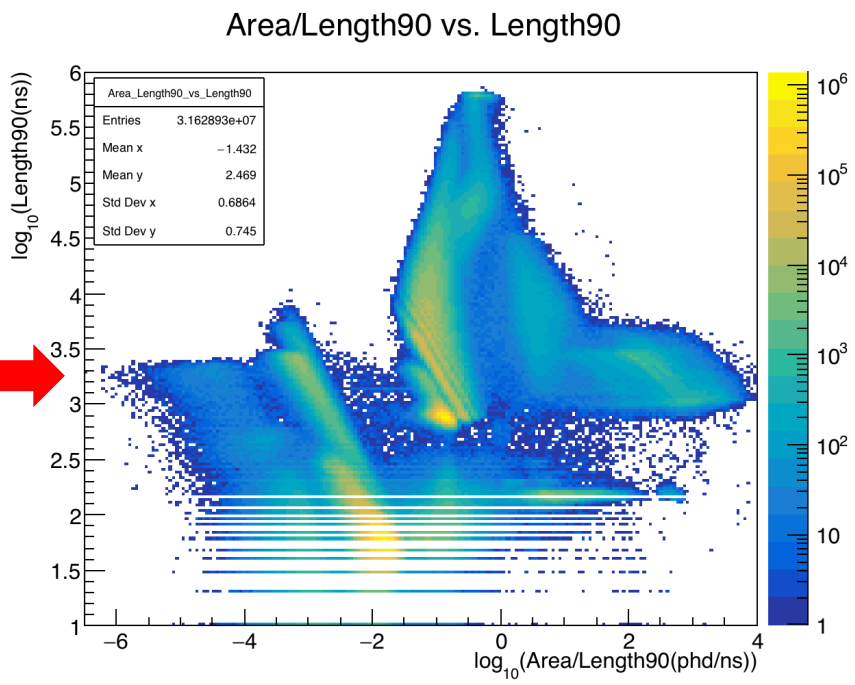
PREM

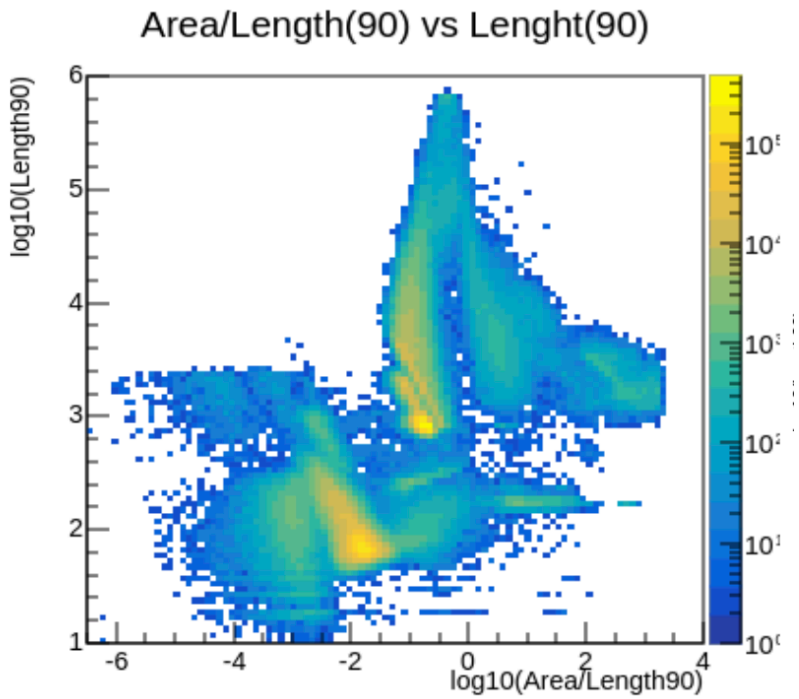
1. Change the log scale axis
2. Reduce the bin number
3. Will change the interval from 0.1 to 0.2 further reduce the stripe?

UPM

Area/Length90 vs Length90



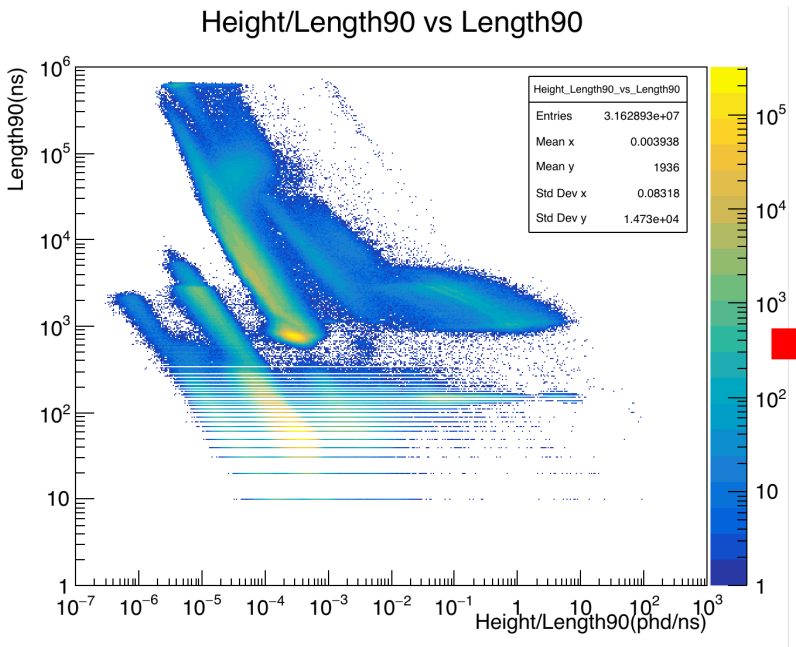


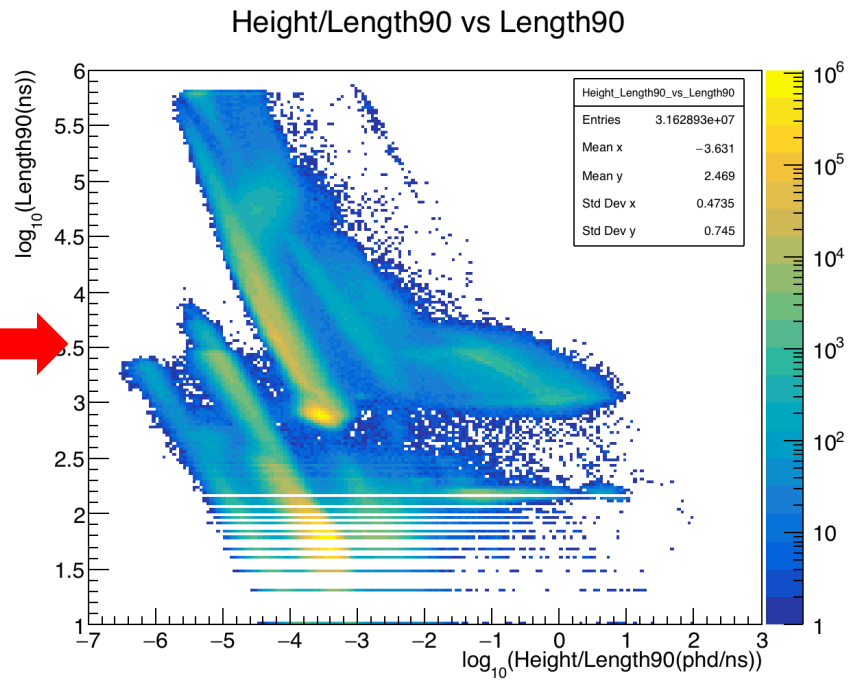


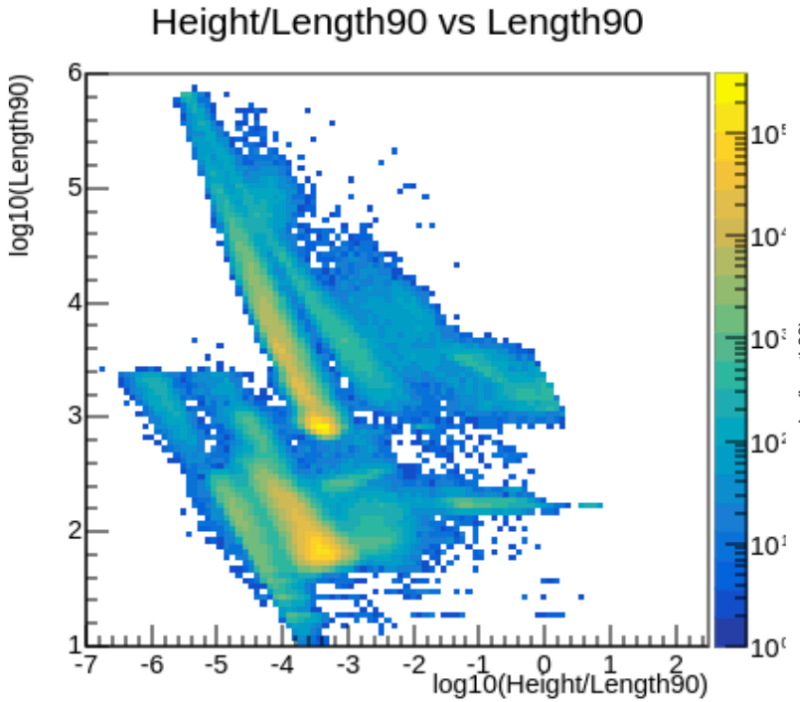
PREM

UPM

Area/Length90 vs Length90



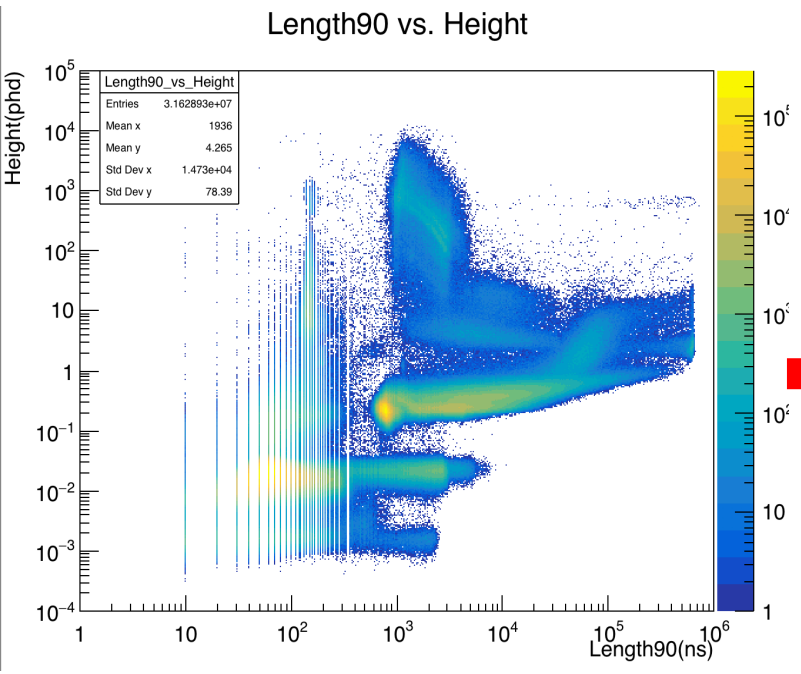


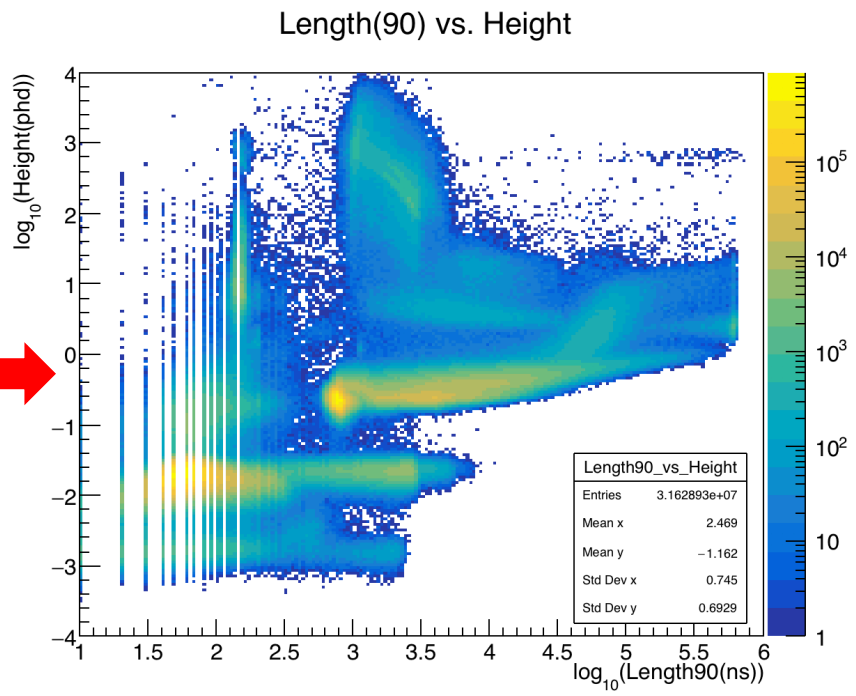


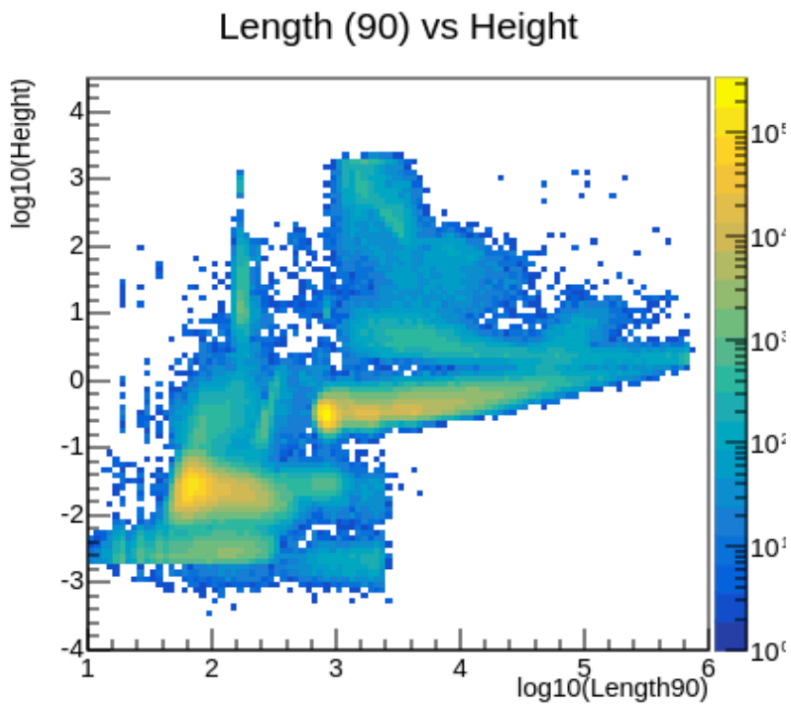
PREM

UPM

Length 90 vs Height



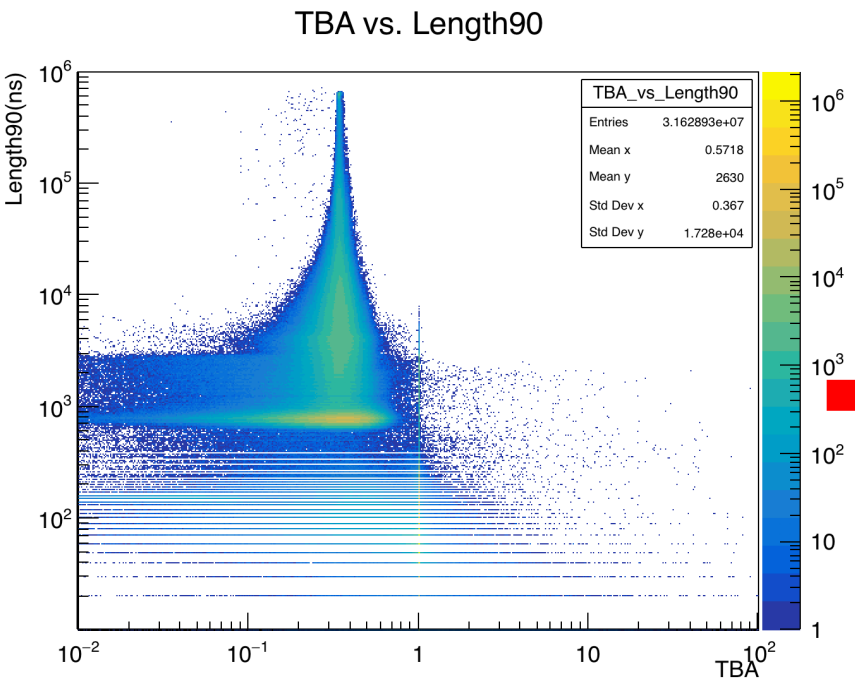


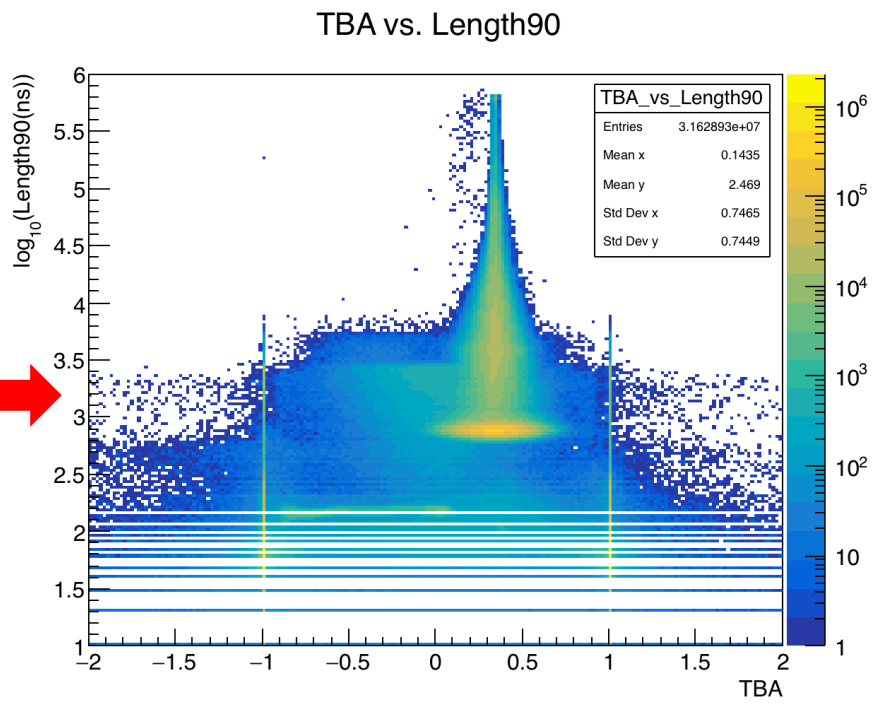


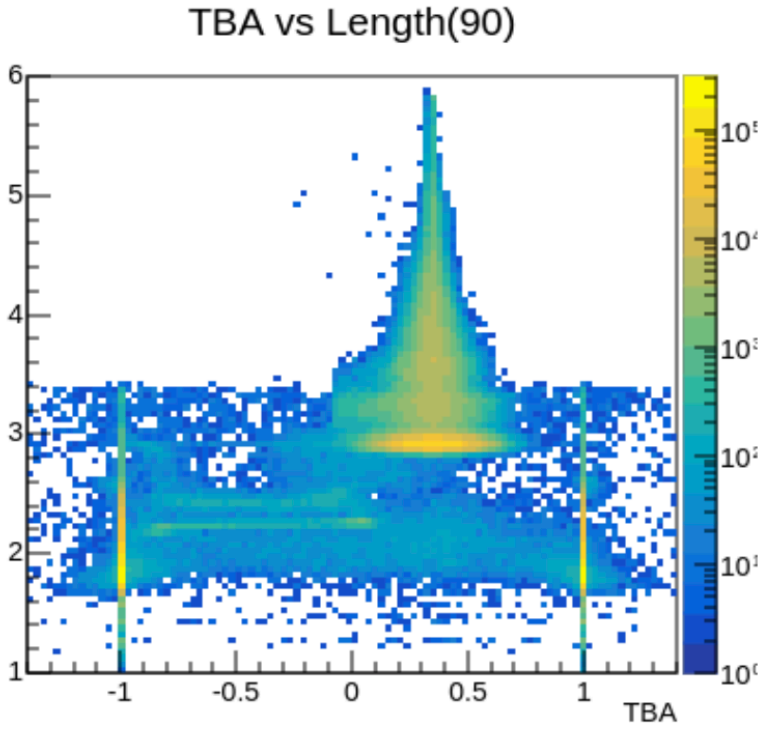
PREM

UPM

TBA vs Length90



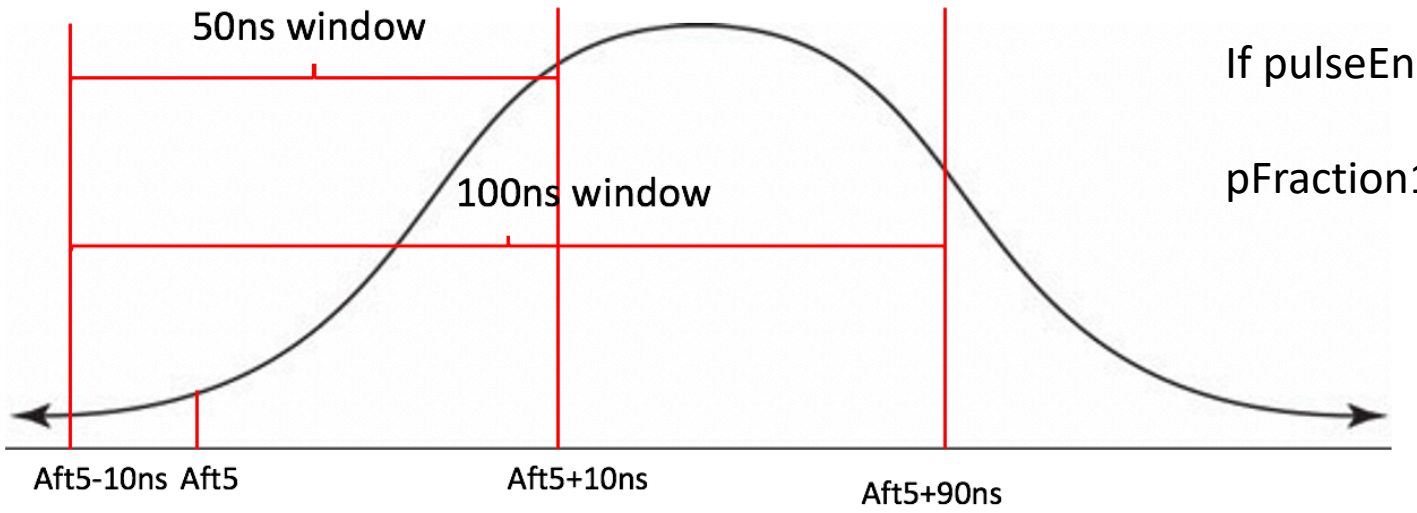




PREM

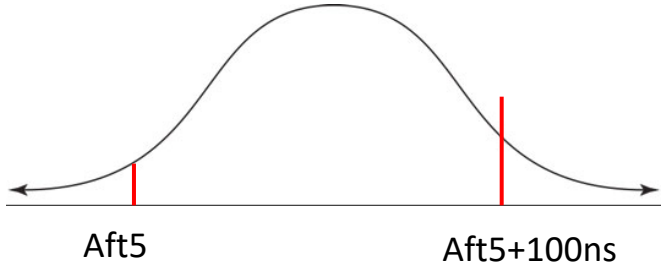
UPM

Guess on the pFraction100

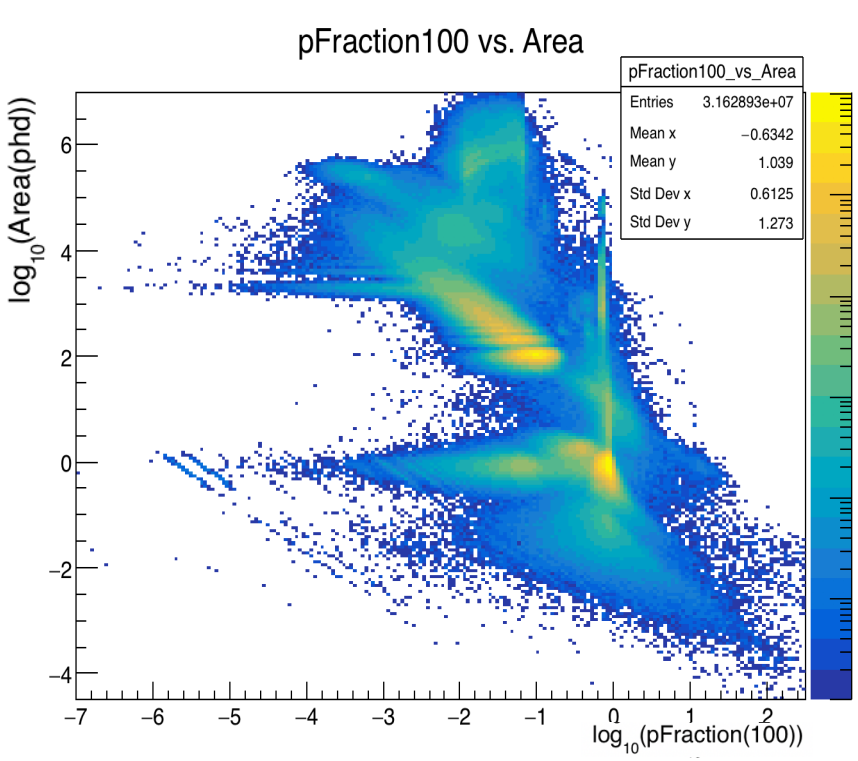


If pulseEndTime_ns = aft5 – 10ns:
get area_initial
If pulseEndTime_ns = aft5+90ns:
get area_final
pFraction100 = (area_final-area_initial)/total_area

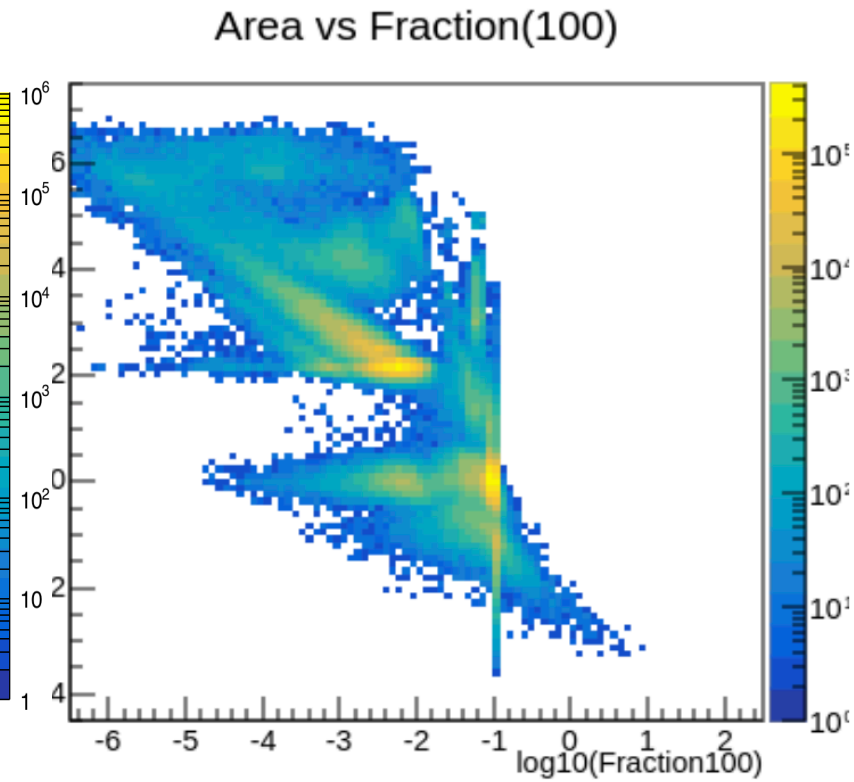
- pFraction100:
  - 1. `pulseArea100ns_phd` / `pulseArea_phd`
  - 2. `promptFraction50`



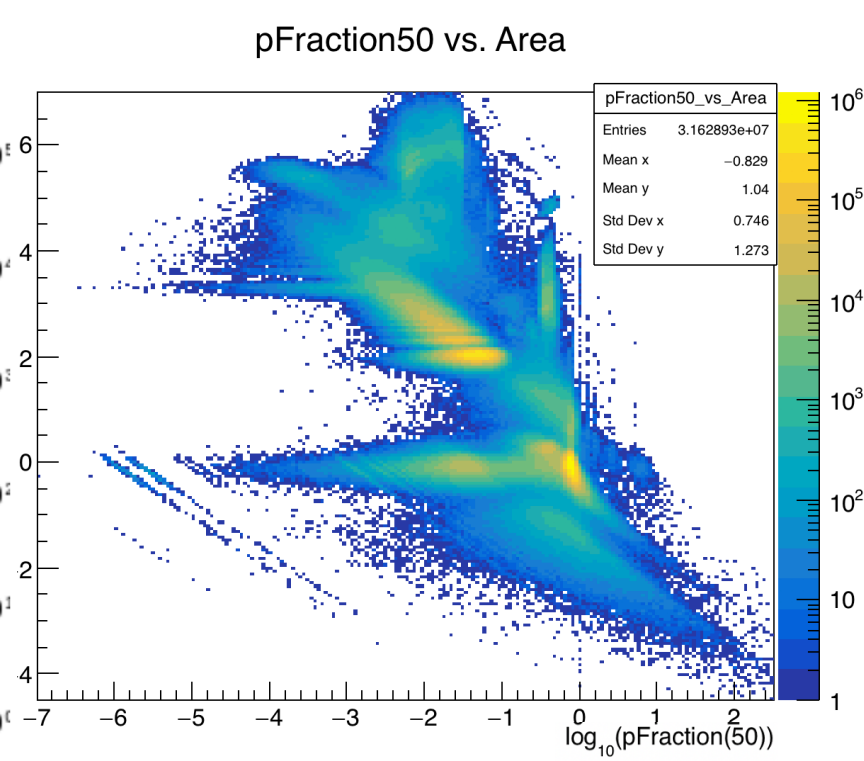
Area vs Fraction100



PREM



UPM



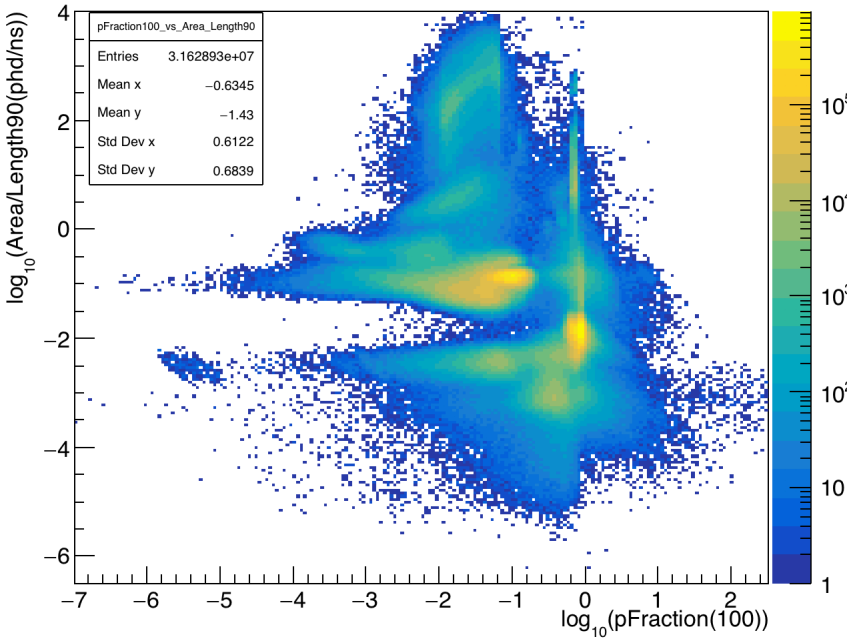
PREM

`pulseArea100ns_phd` / `pulseArea_phd`

`promptFraction50`

pFraction90 vs Area/Length90

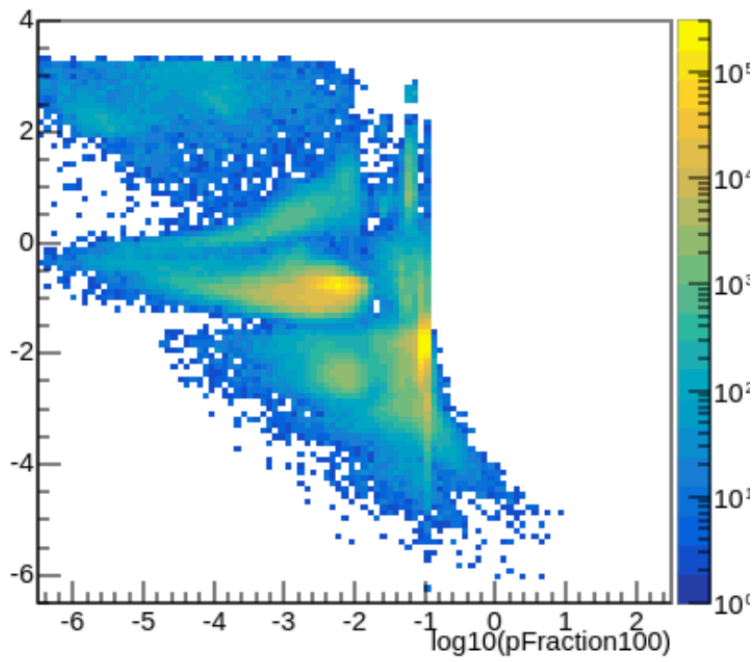
pFraction100 vs Area/Length90



PREM

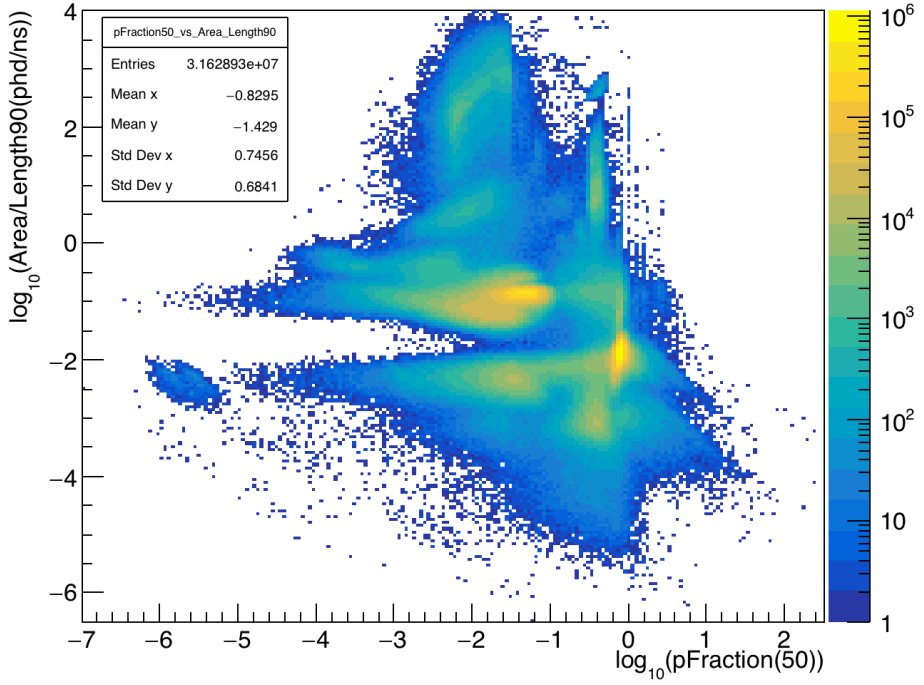
`pulseArea100ns_phd` / `pulseArea_phd`

pFraction(90) vs Area/Lenght(90)



UPM

pFraction50 vs. Area/Length90



PREM

`promptFraction50`

To do

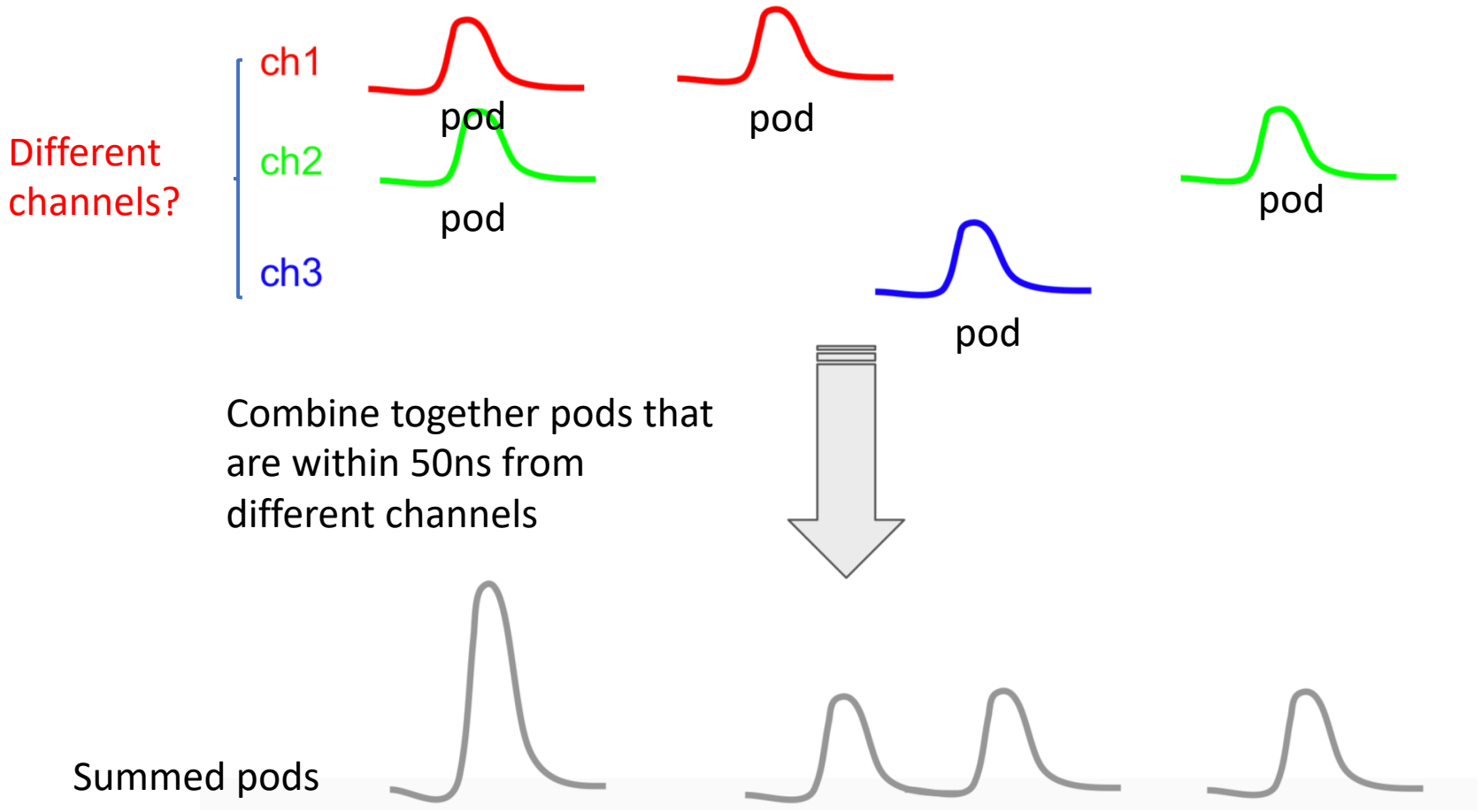
- Noise module, which category of RQ?

25th Feb. 2021

- **P**hysics **RE**adiness **M**onitor (**PREM**):
  - Uses the reduced quantities (RQs) to automatically generate plots from the data
  - Has shifters looking through the plots to look for the problem in the detector
  - **Input data:** fully processed data after LZAP ~after 8 hours
  - **My goal:**
    - Working on PREM_TPC module-> produce PREM plots and add them to PREM website:
      - **Pulse Classification's Parameter Space** (UPM module on Twiki); **input:** ~8h MDC3 data; all events pulse
        - Area vs Length90
        - Area vs pFraction100
        - Length90 vs Height
        - TBA vs Area
        - TBA vs Length90
        - Height/Length90 vs Area
        - Height/Length90 vs Length90
        - Area/Height vs Area
        - Area/Height vs Area/Length90
        - Area/Length90 vs Length90
        - pFraction90 vs Area/Length90
    - Understand the physics process behind the plot
    - Develop the proper algorithm for the plot: mean, std……

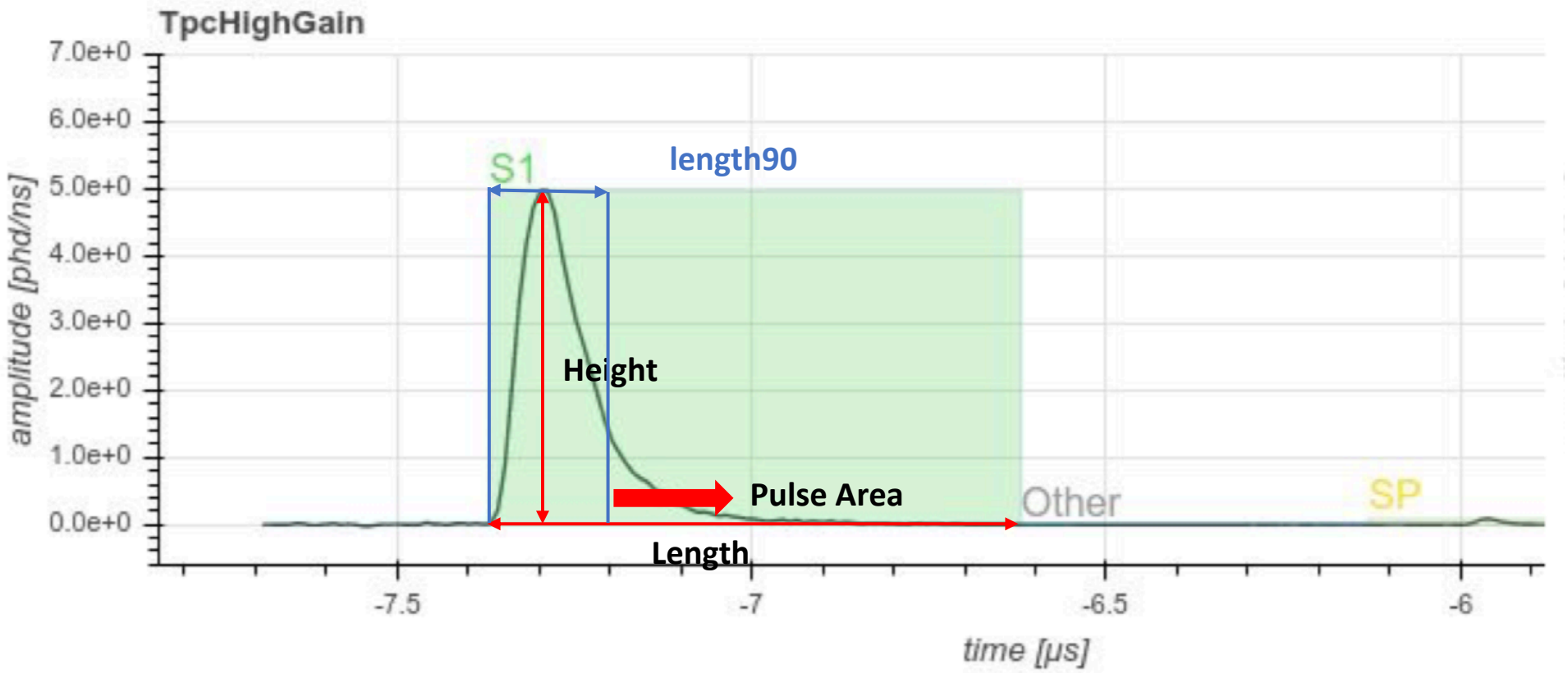
POD

http://teacher.pas.rochester.edu:8080/pub/Lz/MDC1KickOff20170720/20170721_LzCollabMtg_LZapOverview.pdf



http://teacher.pas.rochester.edu:8080/pub/Lz/AnalysisDocDB000035/Pulse_Classifier_HADES_Overview_20200706.pdf

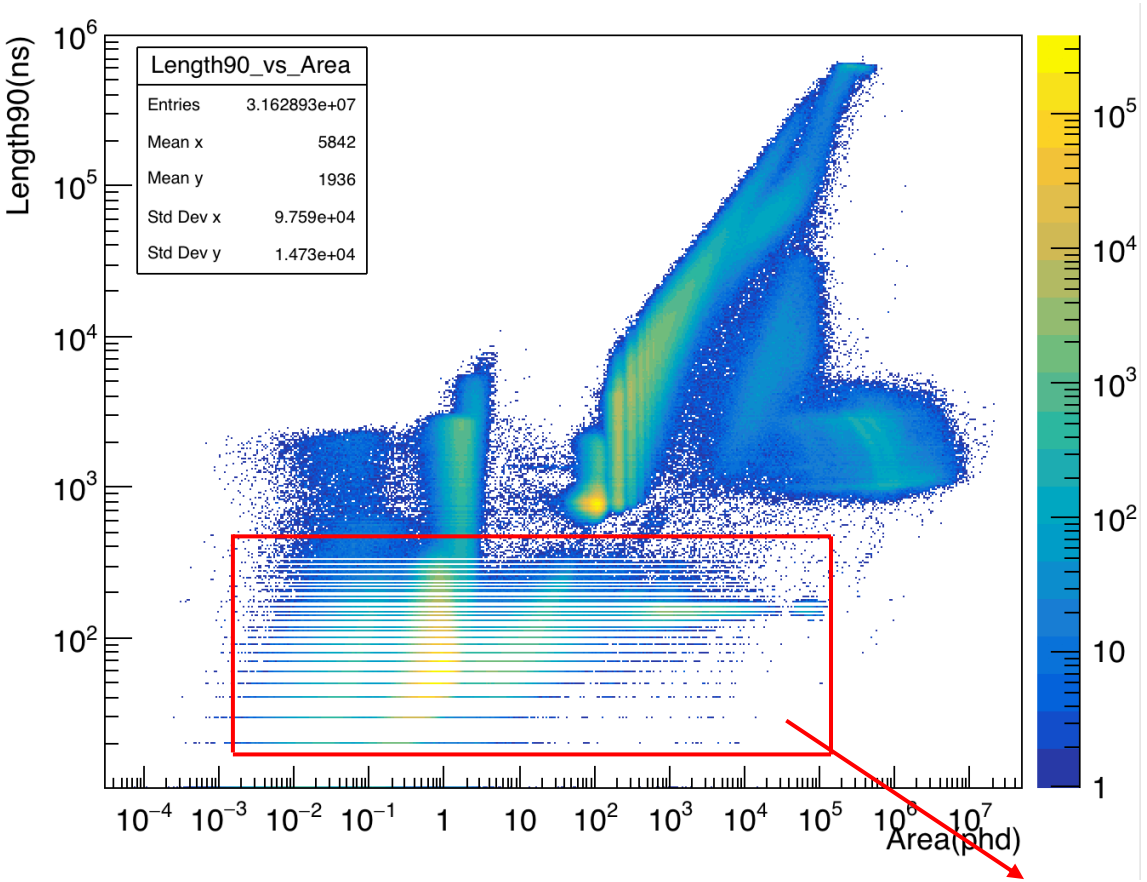
Pulse



Area vs Length90

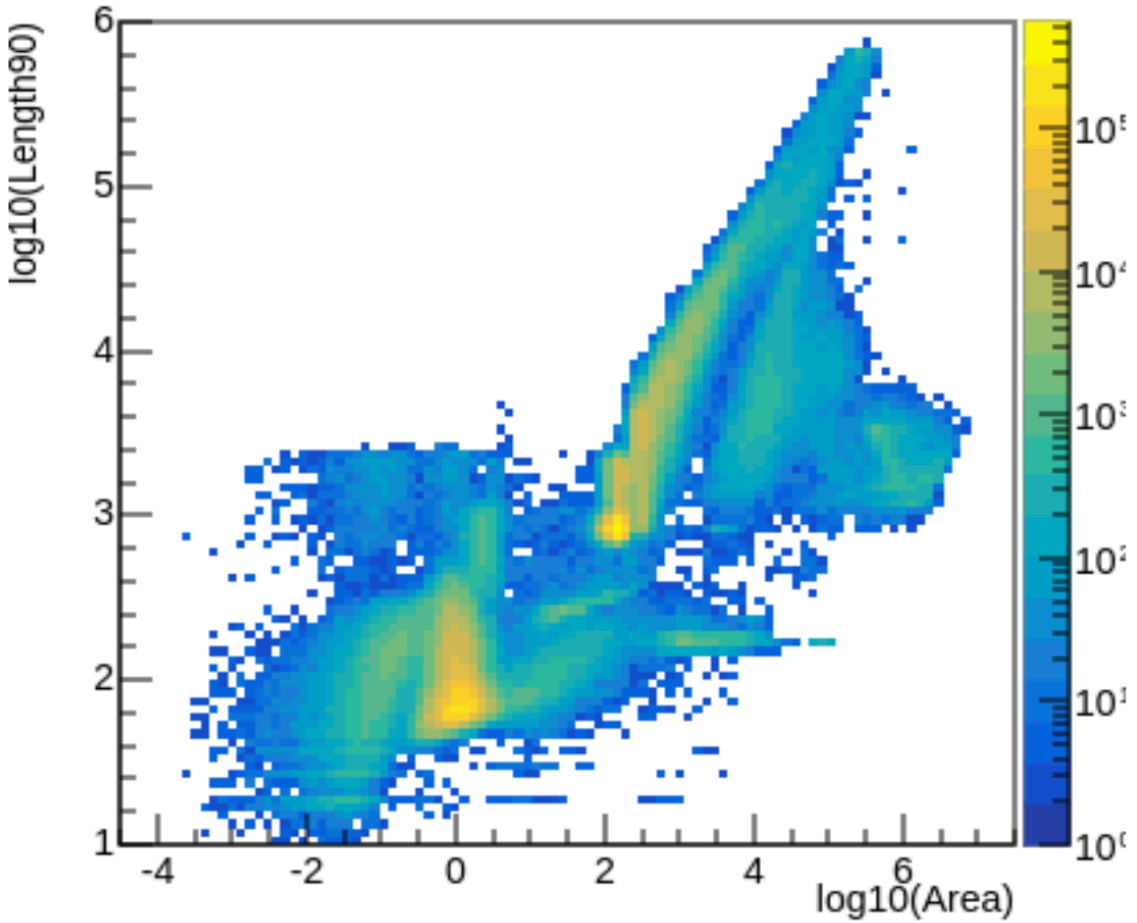
Length90: Time at which summed pod reaches 90% of total area

Area vs Length90



PREM

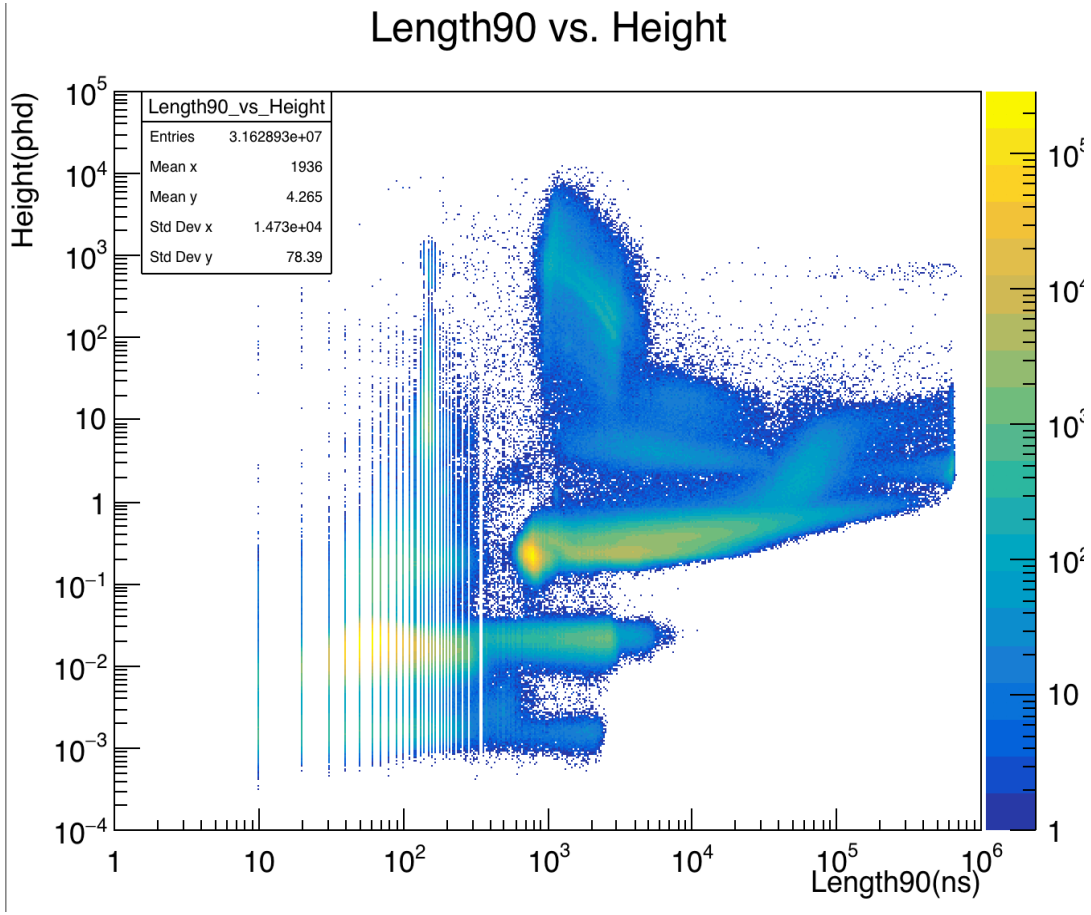
Length(90) vs Area



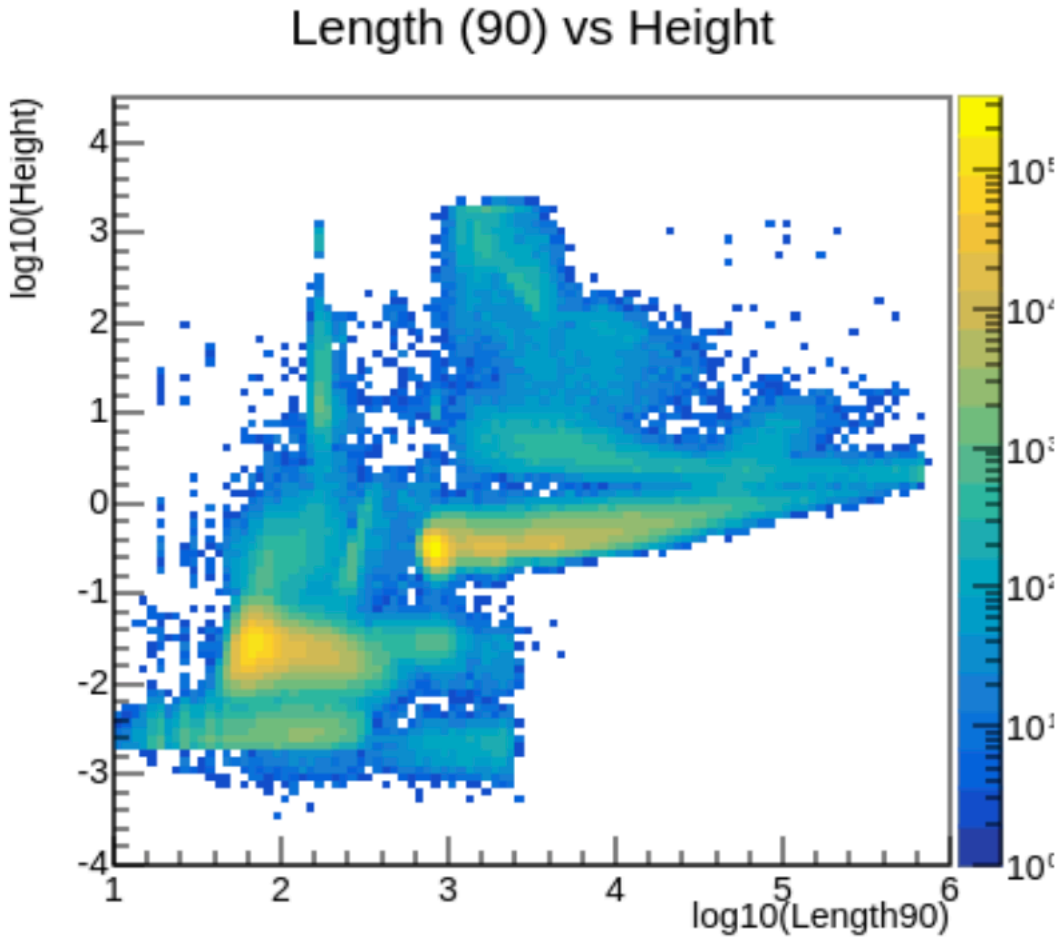
UPM

The smallest data sample interval = 10ns

Length 90 vs Height



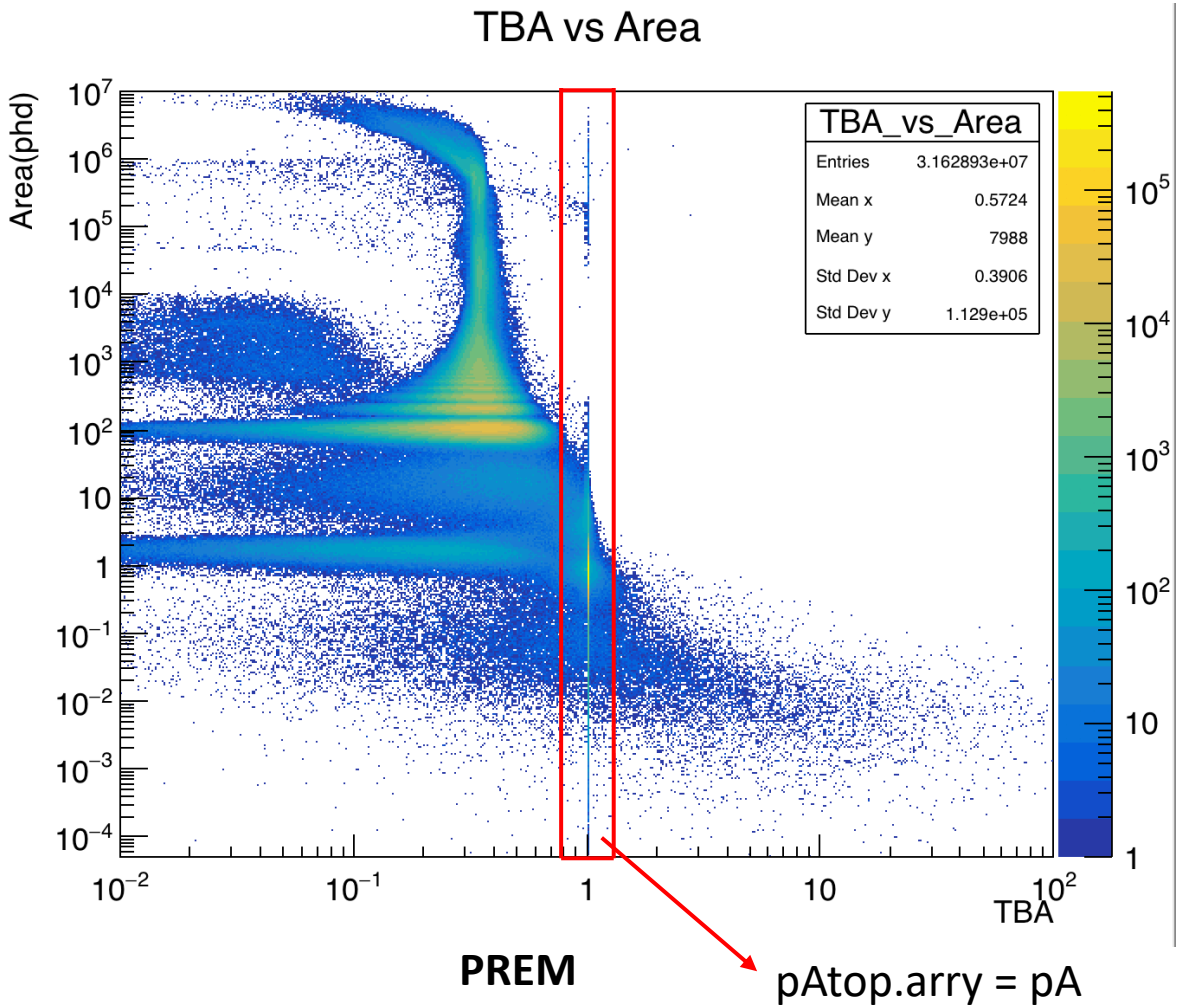
PREM



UPM

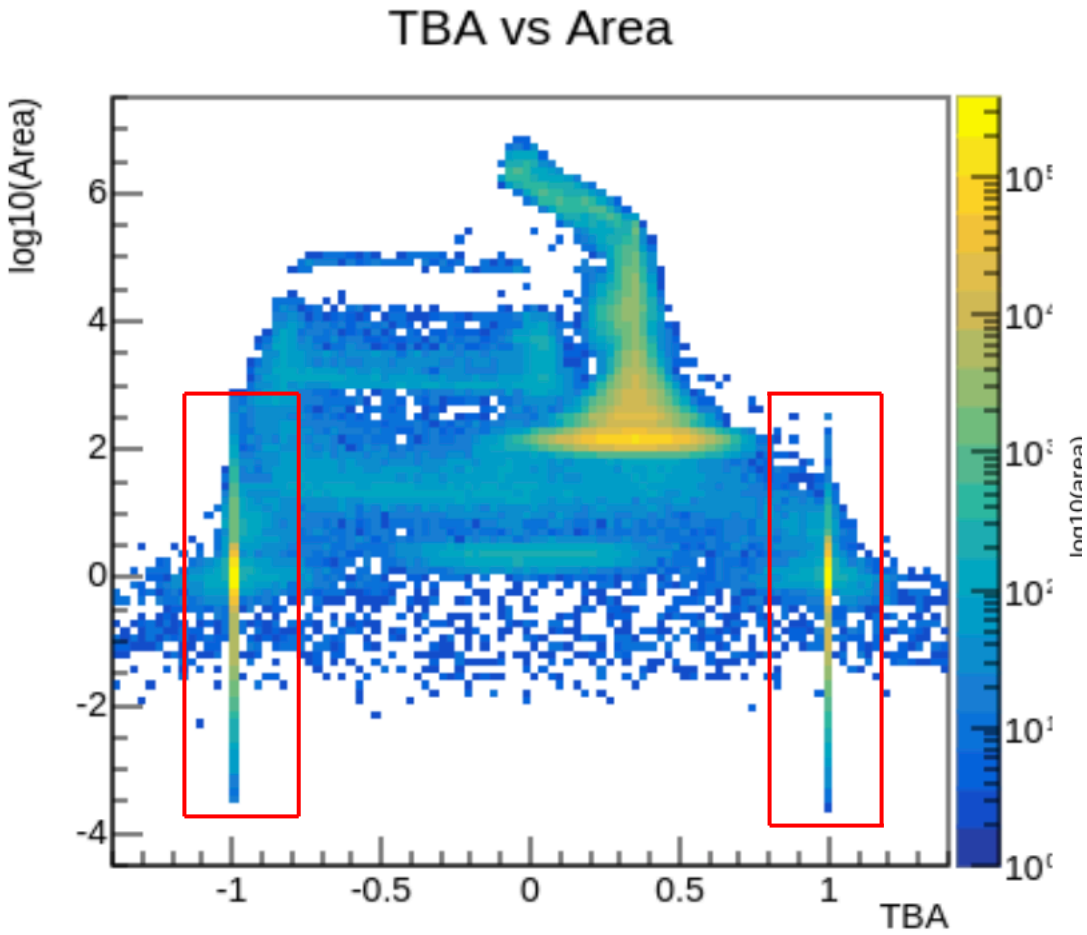
TBA vs Area

Top-bottom asymmetry (TBA) = (pAtop.array-pAbot.array)/pA



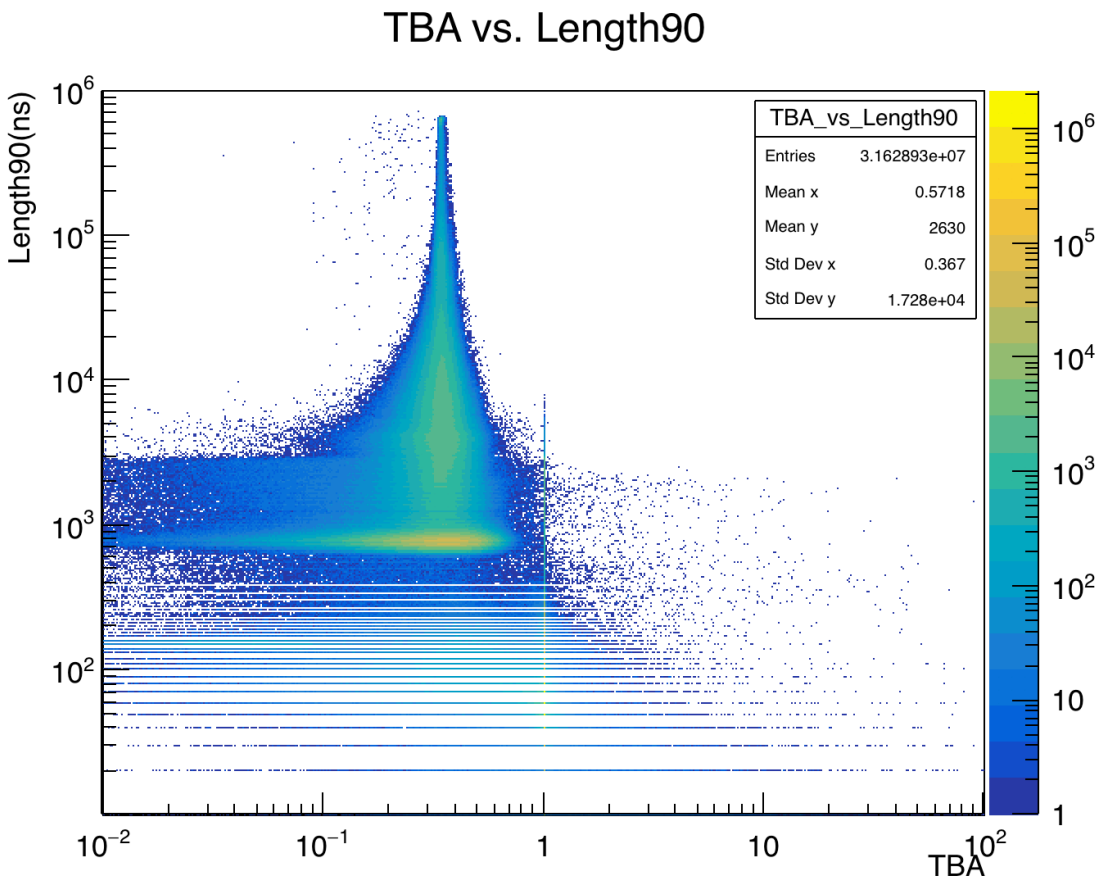
PREM

pAtop.arry = pA

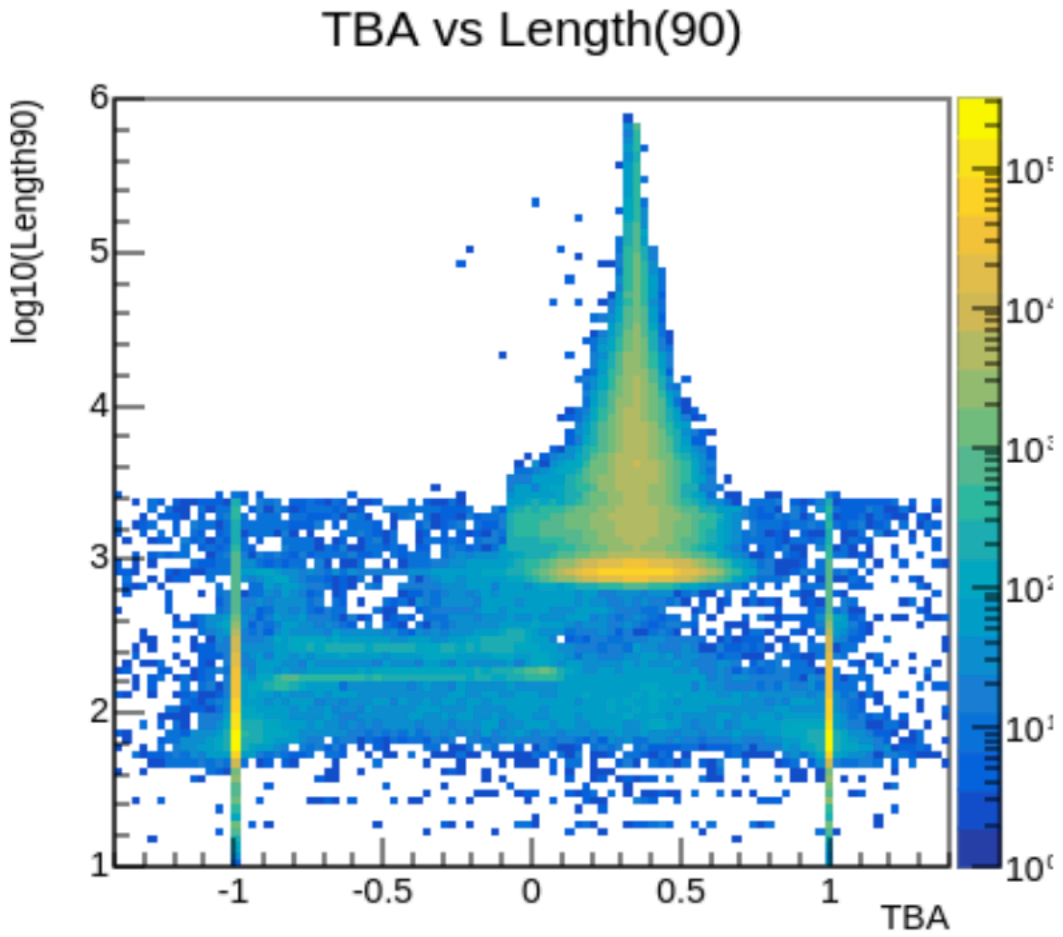


UPM

TBA vs Length90

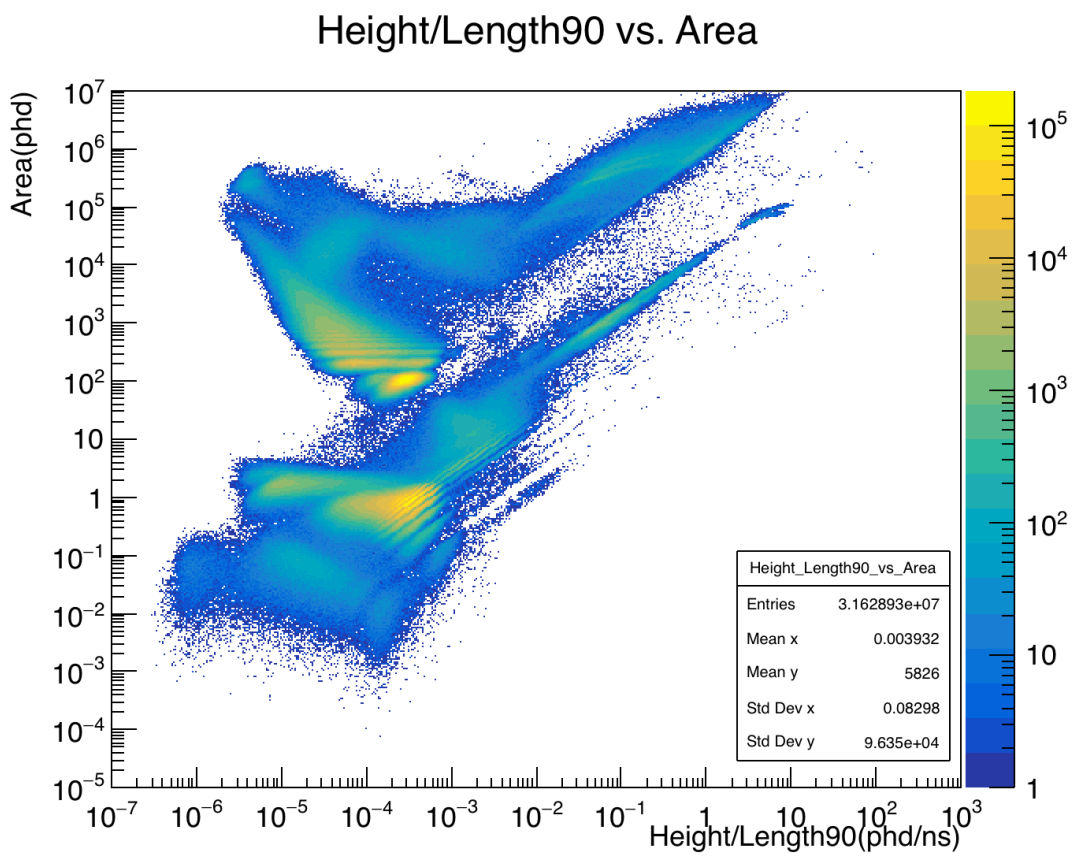


PREM

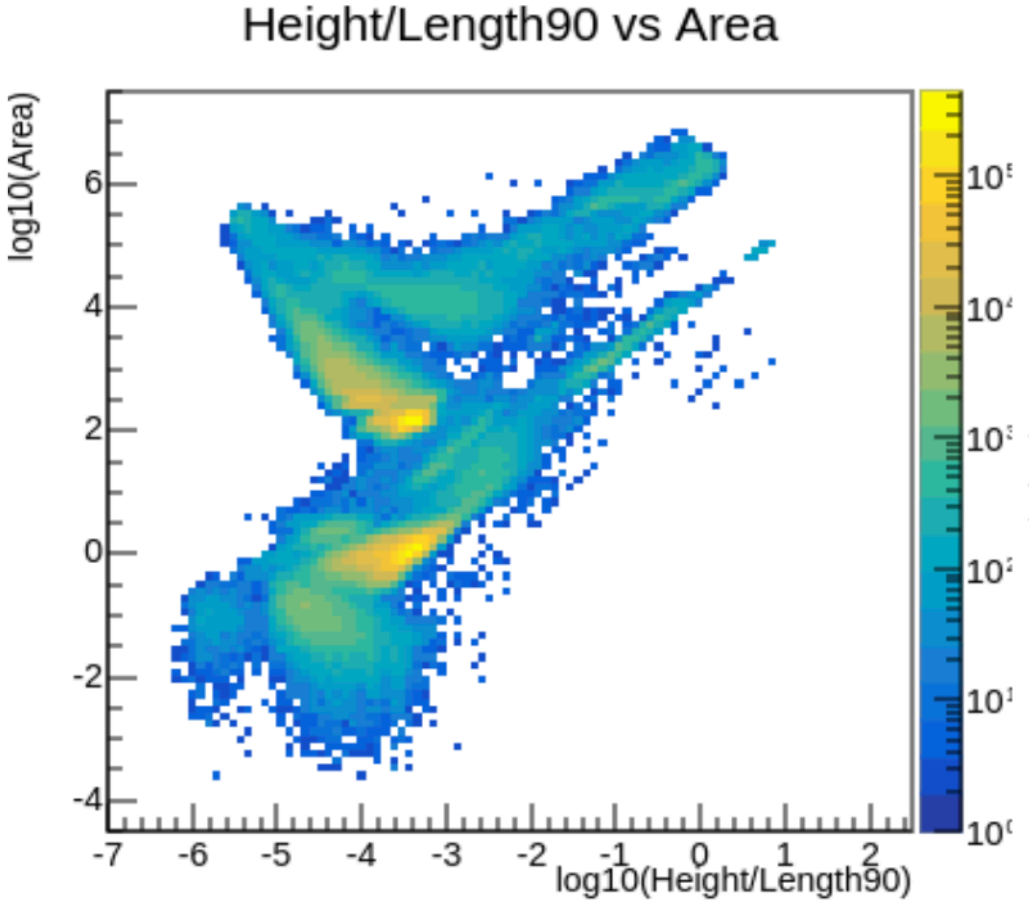


UPM

Height/Length90 vs Area

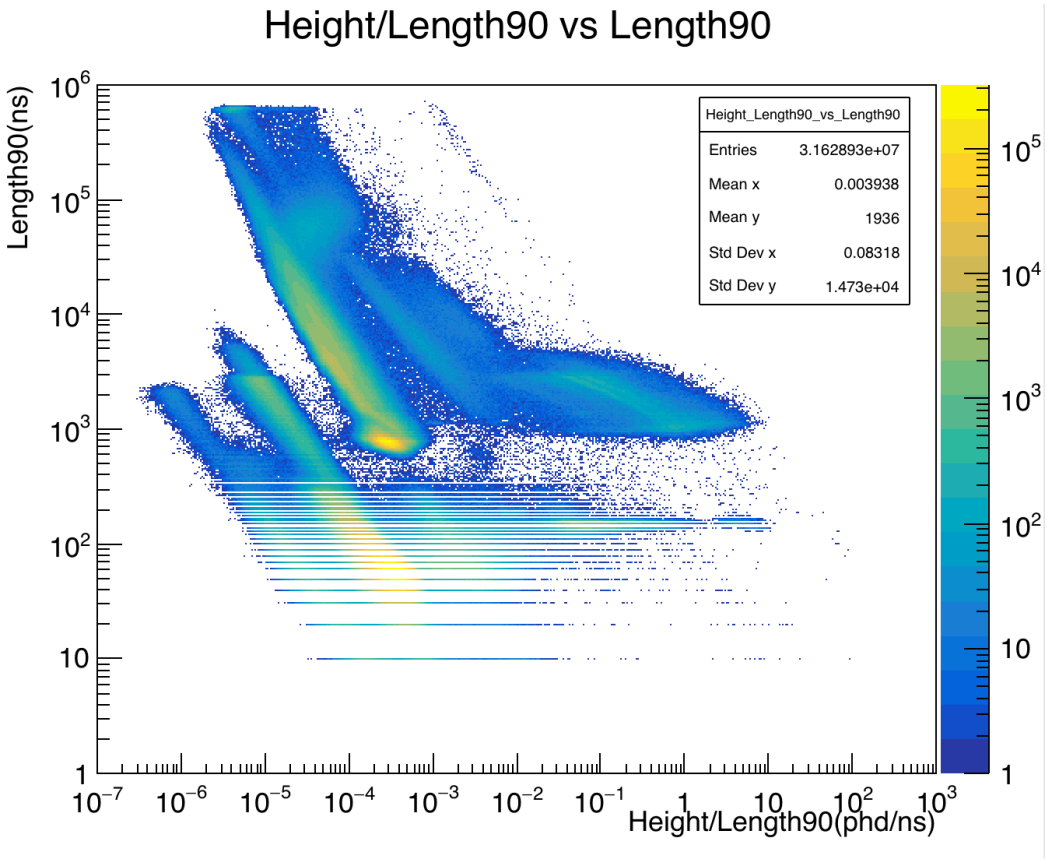


PREM

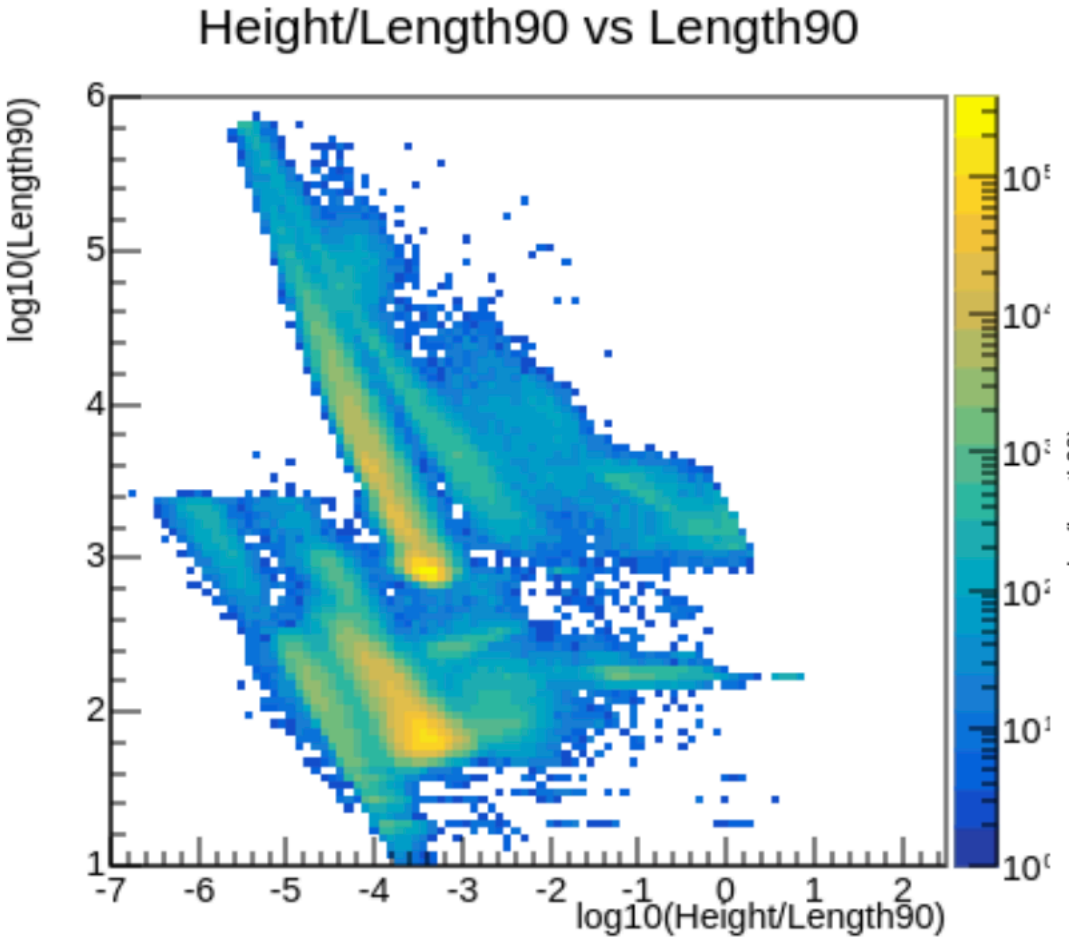


UPM

Height/Length90 vs Length90

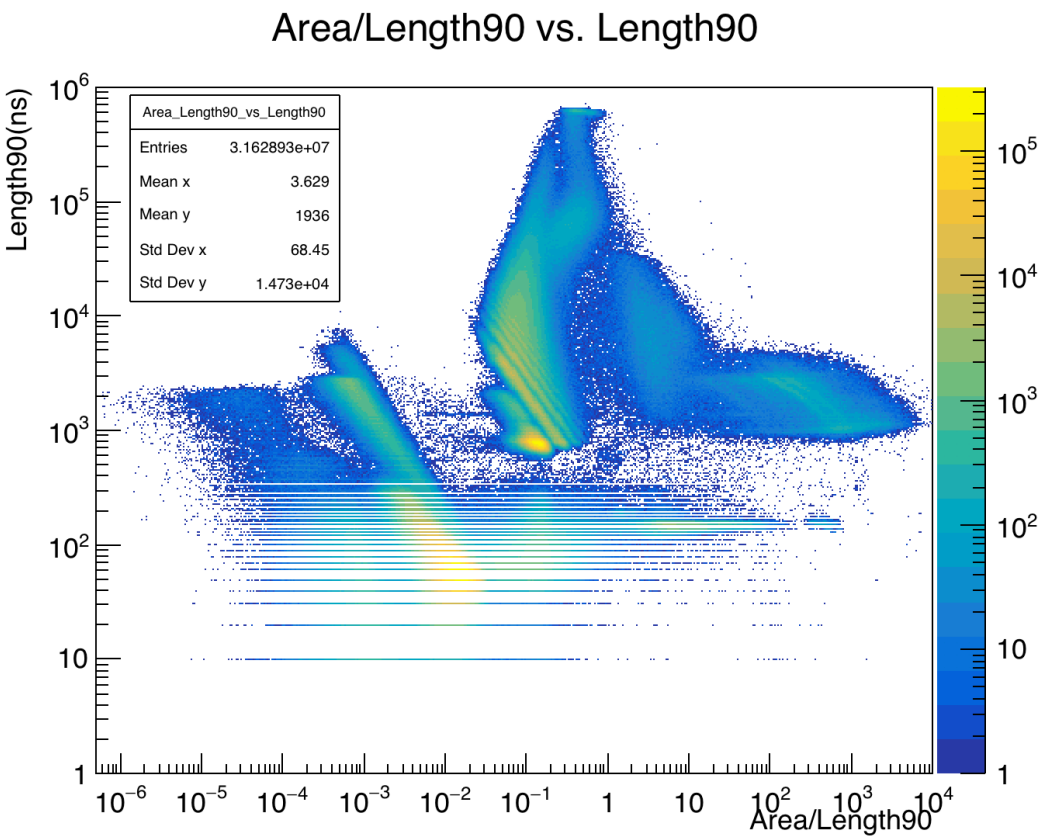


PREM

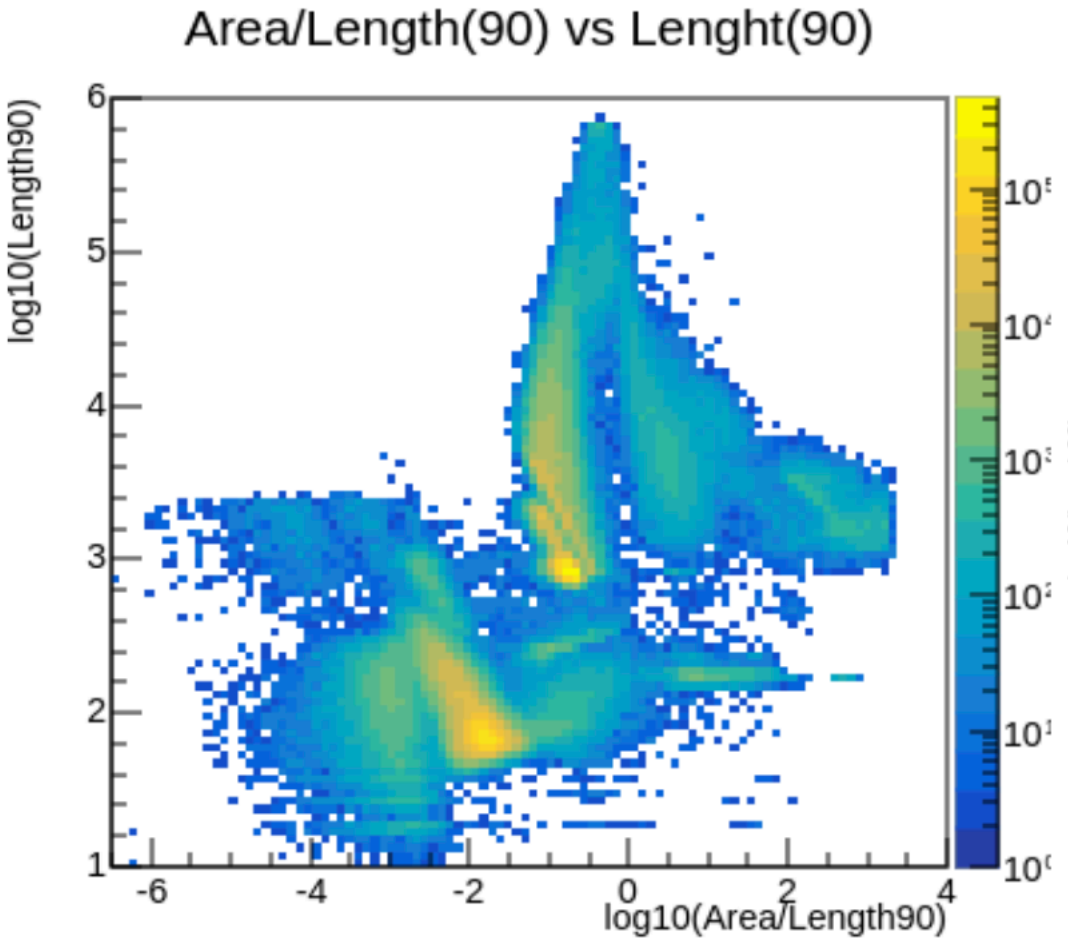


UPM

Area/Length90 vs Length90

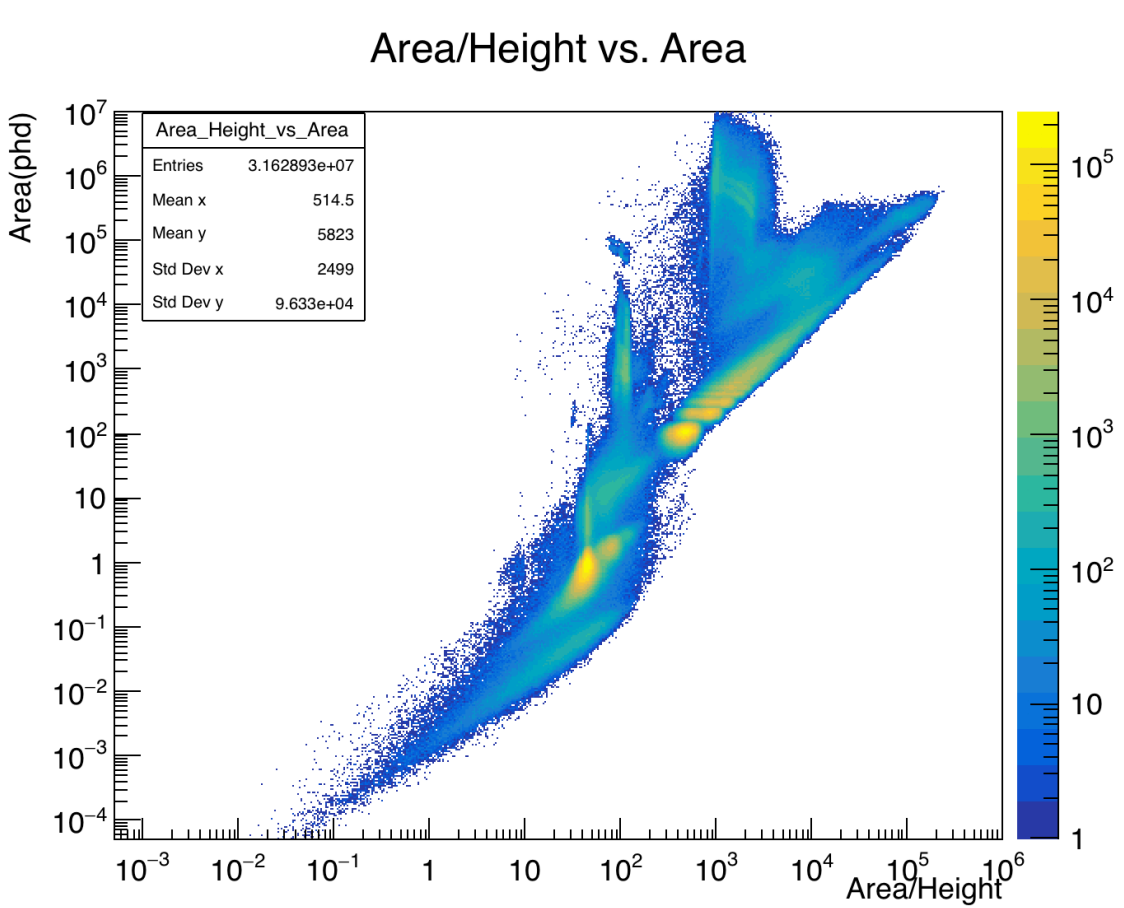


PREM

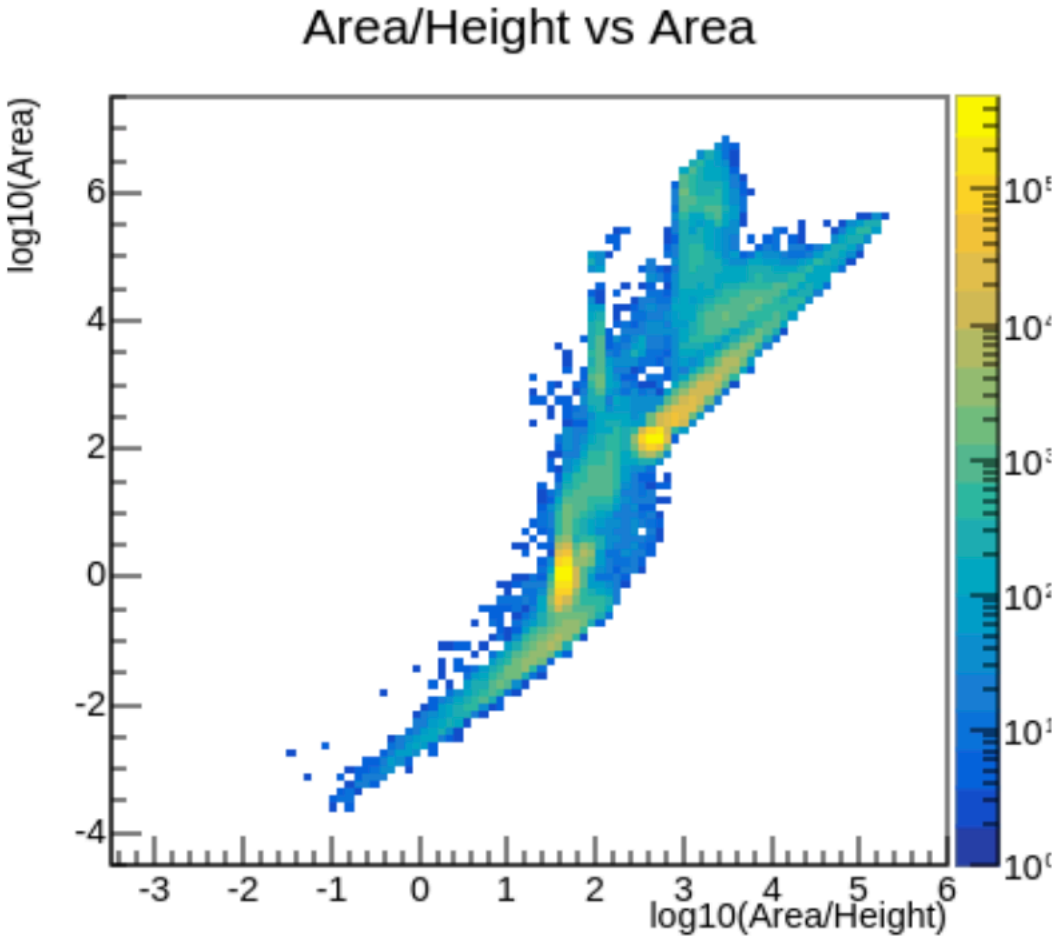


UPM

Area/Height vs Area

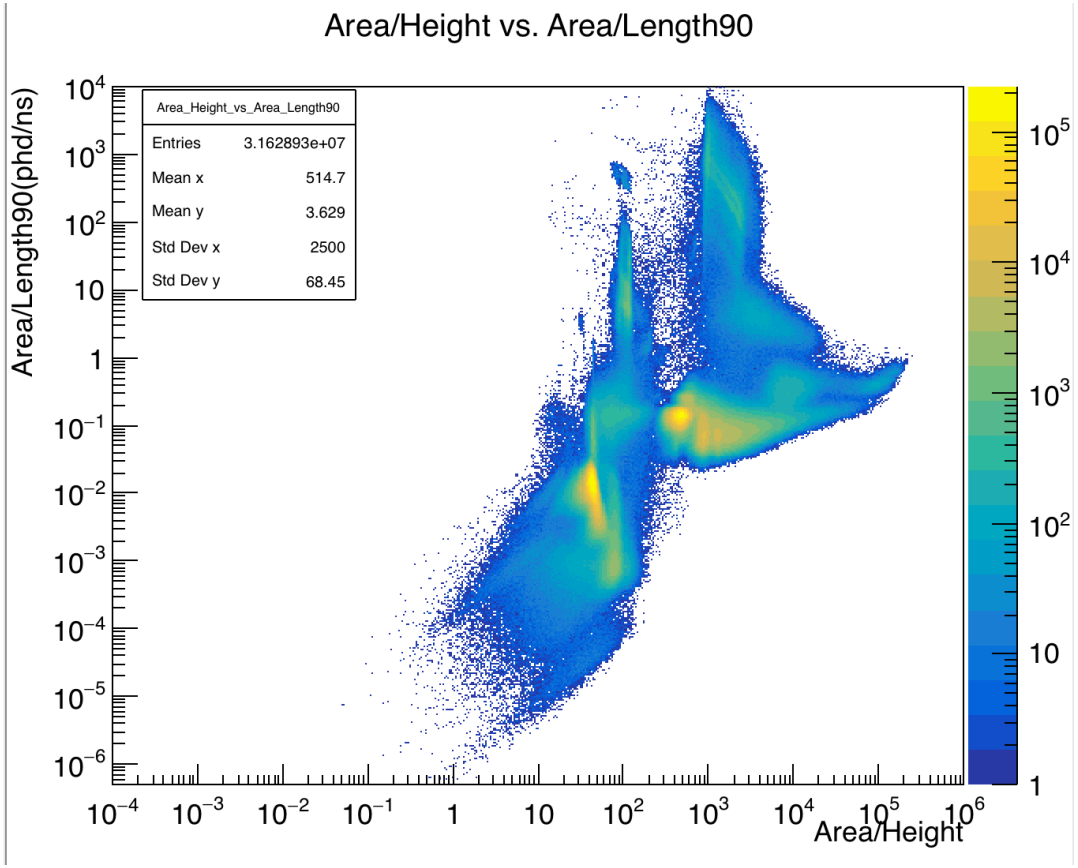


PREM

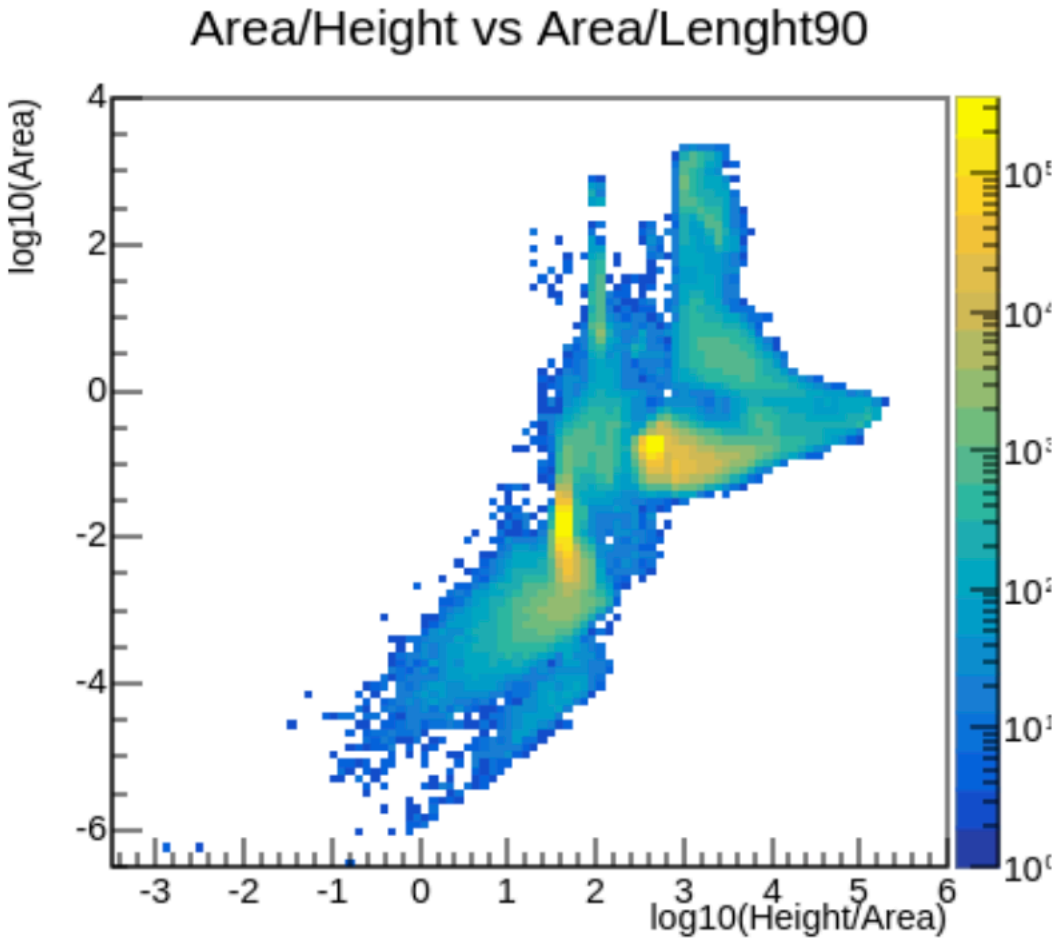


UPM

Area/Height vs Area/Length90



PREM



UPM

To do

- Clarify the RQ name of the variable pFraction100
- Think about the binning for Length90

18th Feb. 2021

- 1. **Account:**
  - LZ account: ☑
  - NERSC: ☑
- 2. **Code:**
  - Set up cori account
  - Installed Alpaca & PREM module
- 3. **To do:**
  - Add PREM module to Alpaca for running (environment not setting up properply?)
  - Look at the Twiki page to choose a part to work on

Cori setup

- 1. Set up NERSC account and two-factor authentication (OTP) on website
- 2. Log into Cori account on terminal: *ssh user_name@cori.nersc.gov,* with password+OTP
- 3. Create a folder at: */global/project/projectdirs/lz/users/your_username*
- 4. Set up shifter environment:
  - Write the .bashrc.ext file: https://luxzeplin.gitlab.io/docs/softwaredocs/computing/usdc/shifter.html#some-magic
  - source .bashrc.ext
  - shifterCOS7 bash
- 5. To use git command:
  - Generate a key on cori: https://docs.gitlab.com/ee/ssh/
  - Add it to GitLab: https://gitlab.com/-/profile/keys

10th Feb. 2021

- 1. **Account:**
  - LZ account: ☑
  - NERSC: in progress
- 2. **Code:**
  - Installed ALPACA & PREM modules
  - Walked through PREM modules with Rachel
- 3. **To do:**
  - Get the NERSC account
  - Run the code locally