First look at simulation Data: Simple RMS vs. clock speed and looking forward

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Q-Pix Simulation Software Meeting

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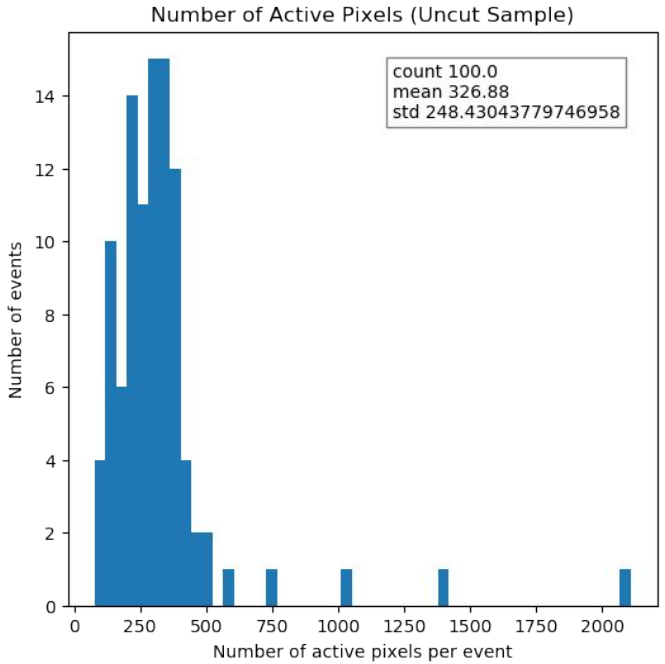
Overview

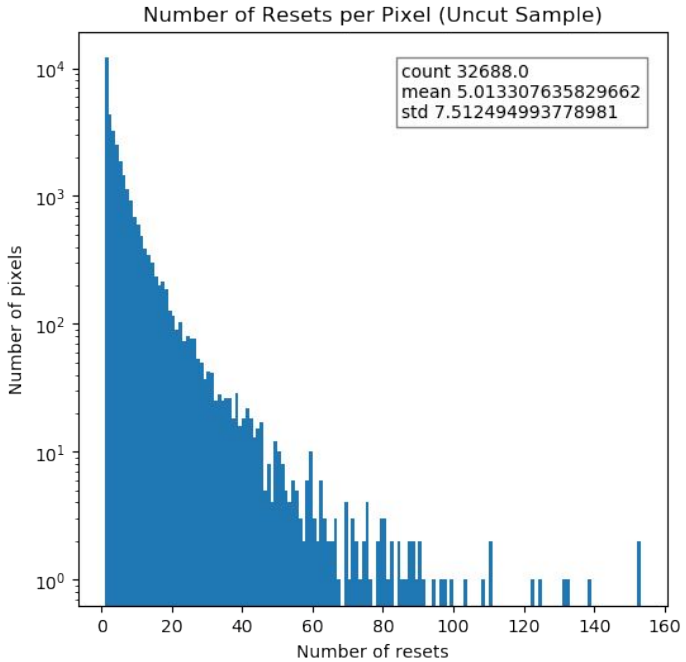
We have done two things:

1. Tried to really understand the simulation data
    a. A lot more detail than we were expecting. Data needs lots of cleanup from non-MIP events. Were hoping to get it fully understood and get the resolution out of a clean data set.
    b. Not done yet
2. Since the summer is ending, we pushed for a simple result on the resolution as a function of clock speed

Start by showing the data set, and how far we got

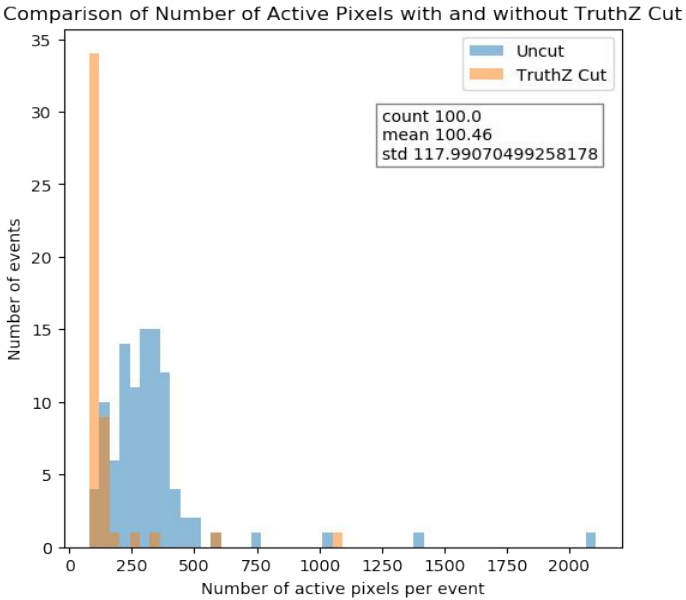
First look at the full Sample of 100 simulated Events

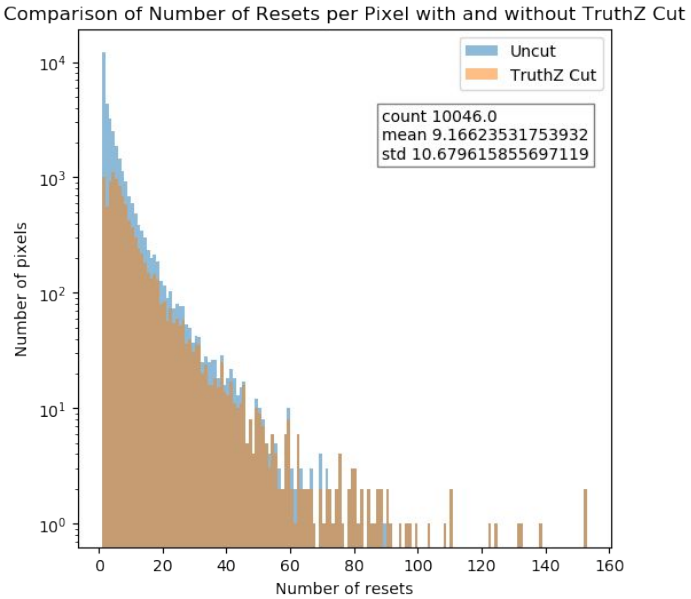




Only consider Pixels with Truth Z information

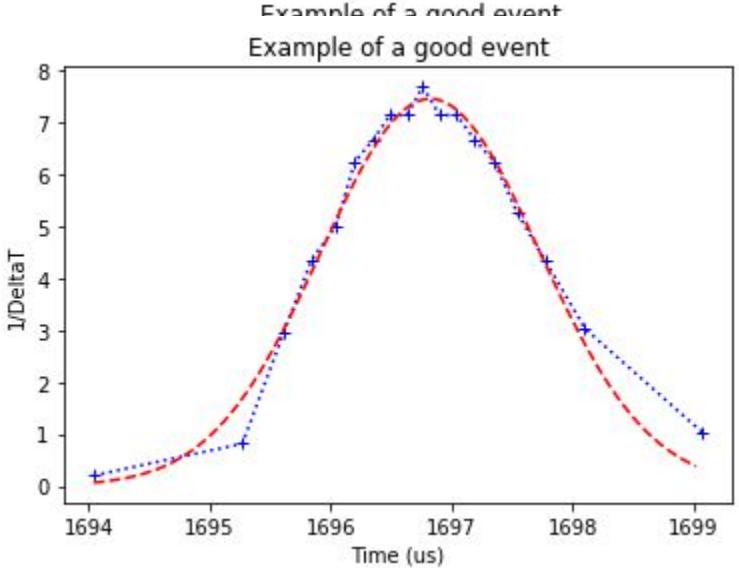
- Total Active Pixels = 32688
- Active Pixels with TruthZ info = 10046



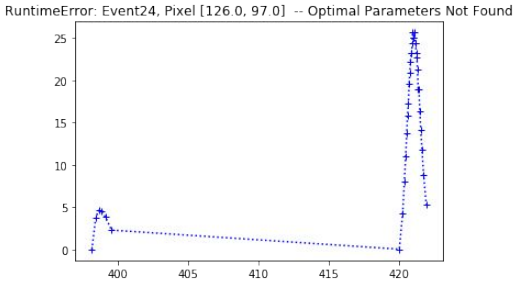


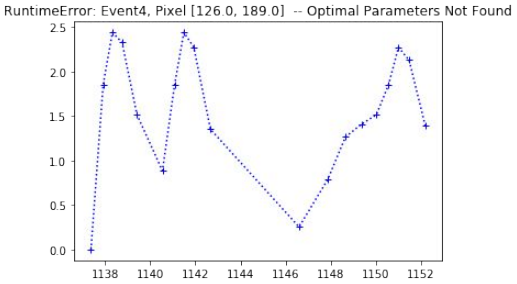
Examples of good events

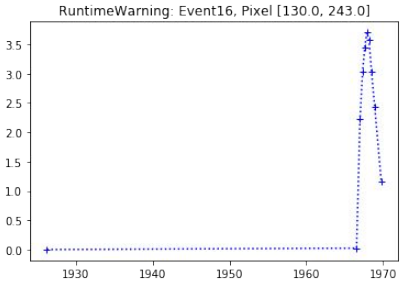
Fit looks good

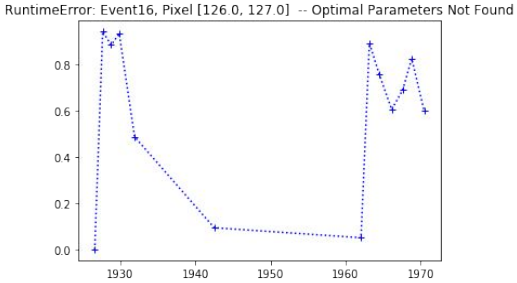


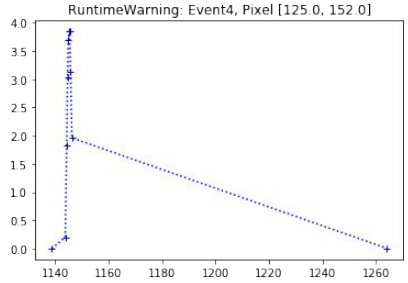
Some pixel distribution are not very Gaussian

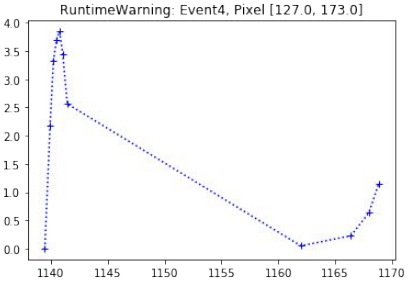












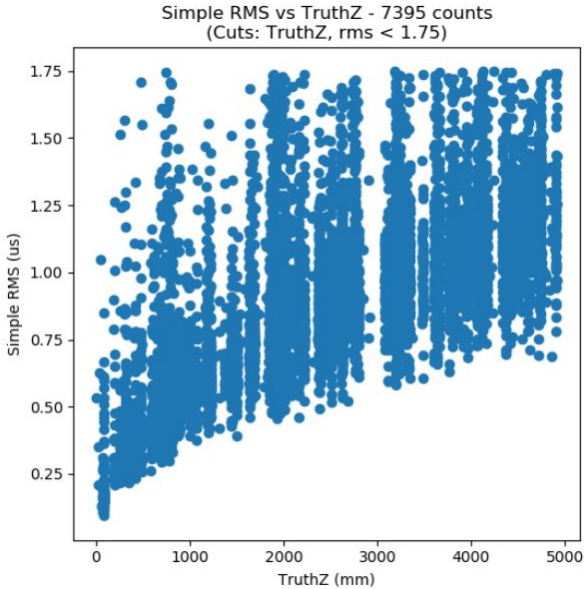
- Lots of tricks to get rid of these, but we aren't done yet
- Start with a simple analysis

Since we know the fitted RMS should be less than about 1.25, we start with simple cleanup cuts

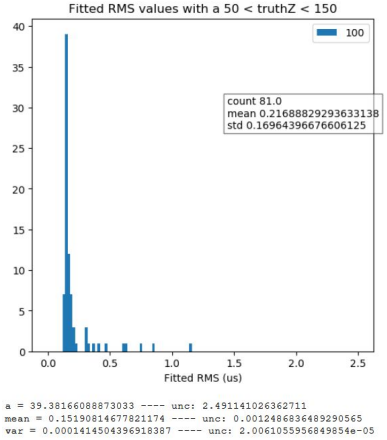
Calculate a “simple RMS” which is calculated by

$$\sqrt{\frac{\sum_i weight_i * (reset_i - \mu)^2}{\sum_i weight_i}}$$

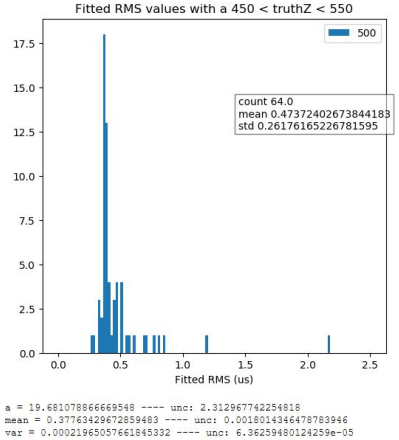
After cleanup, fit the pixel and then group by TruthZ to determine the RMS vs. TruthZ relationship



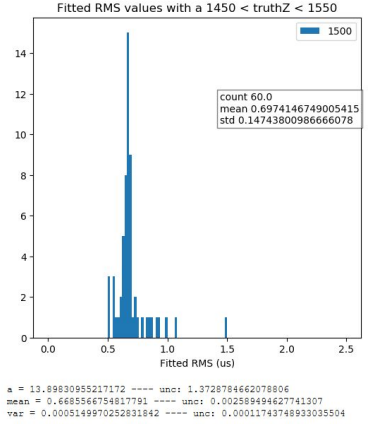
Fitted RMS for various truthZ bins



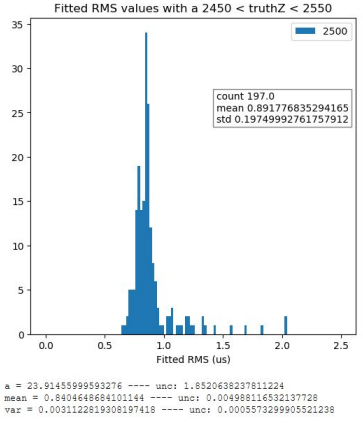
a = 39.38166088873033 ---- unc: 2.491141026362711
mean = 0.15190814677821174 ---- unc: 0.0012486836489290565
var = 0.0001414504396918387 ---- unc: 2.0061055956849854e-05



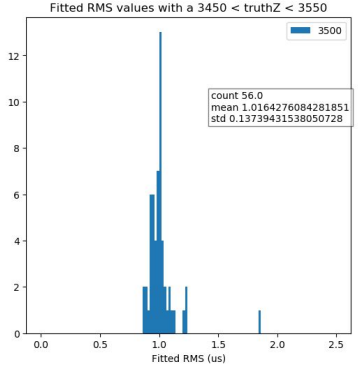
a = 19.681078866669548 ---- unc: 2.3129677422548 18
mean = 0.37763429672859483 ---- unc: 0.0018014346478783946
var = 0.0002196505766184533 2 ---- unc: 6.362594801242 59e-05



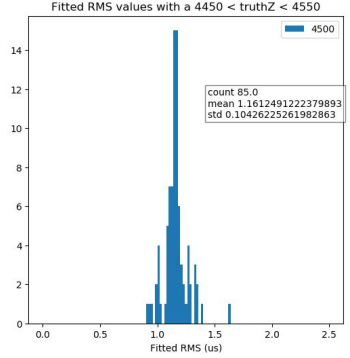
a = 13.89830955217172 ---- unc: 1.3728784662078806
mean = 0.6685566754817791 ---- unc: 0.0025894946277413 07
var = 0.0005149970252831842 ---- unc: 0.0001174374893303 5504



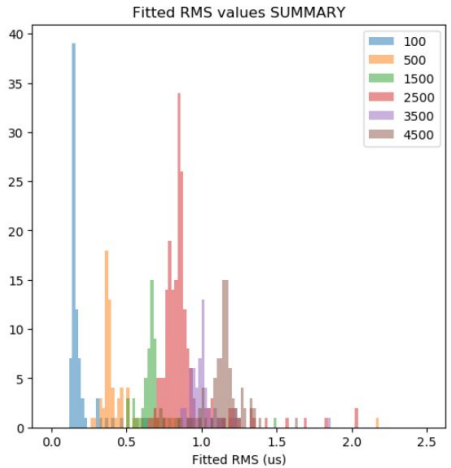
a = 23.914559995932 76 ---- unc: 1.8520638237811224
mean = 0.8404648684101144 ---- unc: 0.004988116532137728
var = 0.0031122819308197418 ---- unc: 0.0005573299905521238



a = 7.931398522958591 ---- unc: 1.2975028494313694
mean = 0.9892560747409047 ---- unc: 0.009434191541512997
var = 0.0024985639710413325 ---- unc: 0.0009486924514461984



[15, 1.16, 0.036187694704984]
a = 13.841651645039336 ---- unc: 1.559285640406849
mean = 1.154582743204998 ---- unc: 0.004507380526160999
var = 0.0012014857757684306 ---- unc: 0.0003132210782549163



Only cuts:

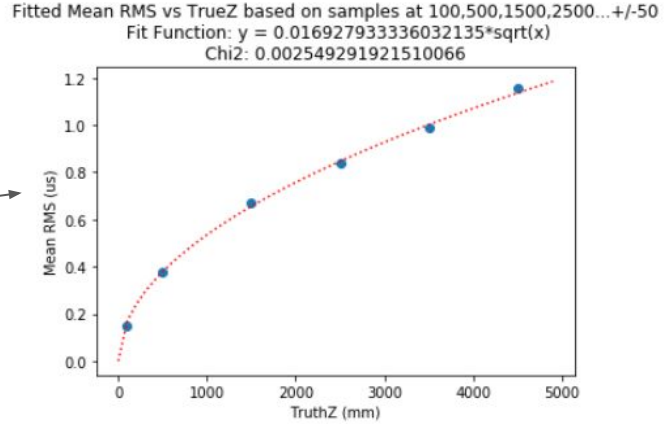
- Truth Z exists
- NReset>3
- Simple RMS<1.75
- Fit of resets gives returns a proper fit

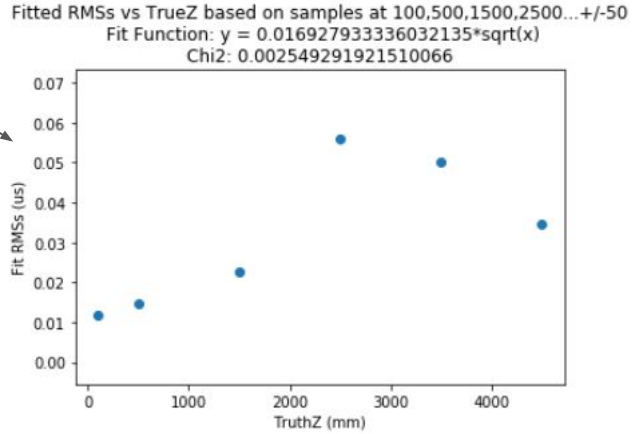
First results

Nice clear relationship as expected

Resolution as a function of Truth Z is basically flat

Can use this to determine clock speed recommendation



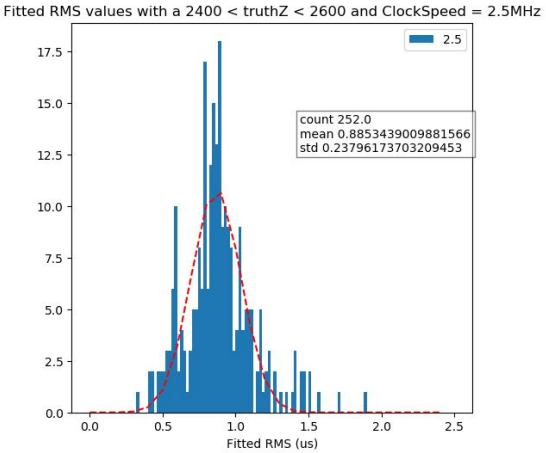


Ballpark uncertainty in Z at 2500 mm:

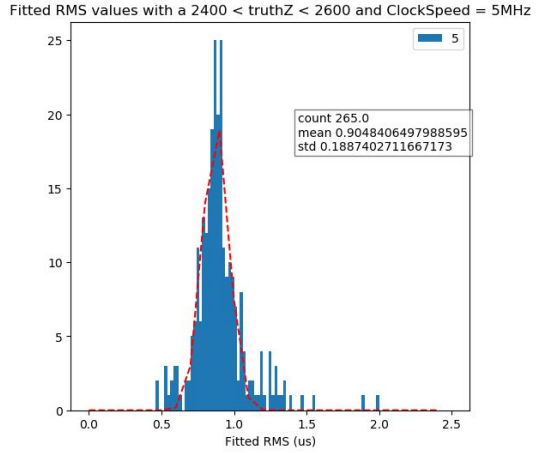
- We see an RMS of our measurement at about 0.04 on a mean of about 0.8. Call this about 5% measurement on RMS. Since Z prediction goes as RMS^2, we get about a 10% prediction of Z which is about 250 mm

Find resolution at a single Z

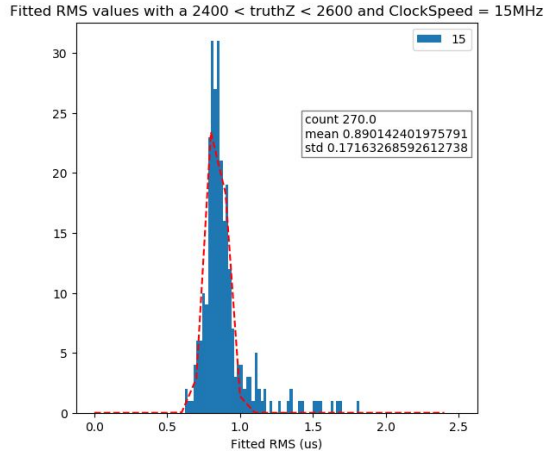
Expanded range from 2400 < TruthZ < 2600 (more statistics), and looked at distribution for different clock speeds. Gets wider as clock slows down




```
a = 10.84853814429051 ---- unc: 0.883593196008633
mean = 0.866163916032286 ---- unc: 0.01626708664762082
var = 0.029138870516594816 ---- unc: 0.005715736371260217
[21, 0.87, 0.2889173935497861 3]
<class 'function'> <class 'list'> <class 'list'> <class 'list'>
```



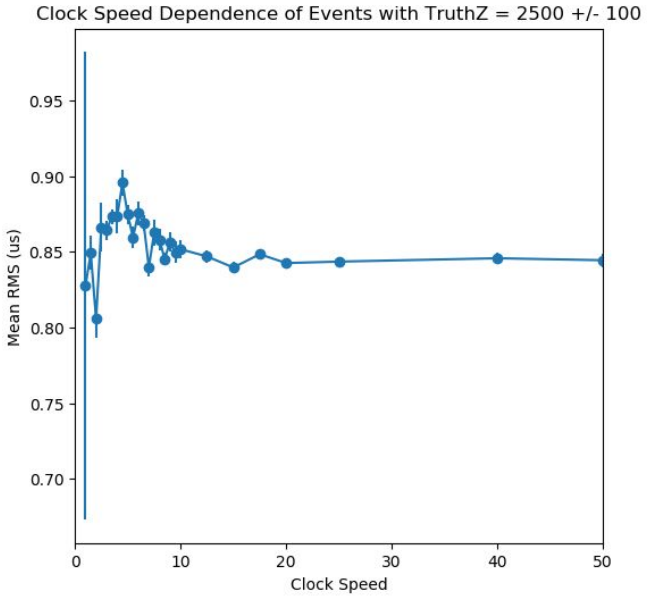

```
a = 19.687001389904722 ---- unc: 1.1566035734286602
mean = 0.8745658583021488 ---- unc: 0.006099599953414444 4
var = 0.008088987222698147 ---- unc: 0.0011045047107235602
[23, 0.87, 0.2344687735824125]
<class 'function'> <class 'list'> <class 'list'> <class 'list'>
```

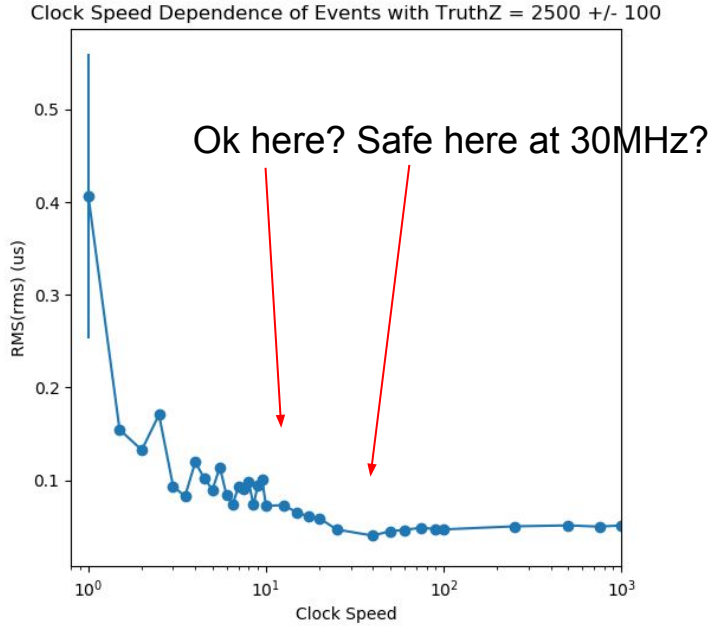



```
a = 28.125635646852785 ---- unc: 1.2973097036523538
mean = 0.8396019868769987 ---- unc: 0.003474430295849340 4
var = 0.004256006491470612 ---- unc: 0.000453367100877353 2
[32, 0.87, 0.1862101594209944 8]
<class 'function'> <class 'list'> <class 'list'> <class 'list'>
```

Results

Best fit Z_Estimated stays about the same (as expected), and resolution (width of the RMS distribution) gets worse for slower clock speeds. More statistics would smooth this out.

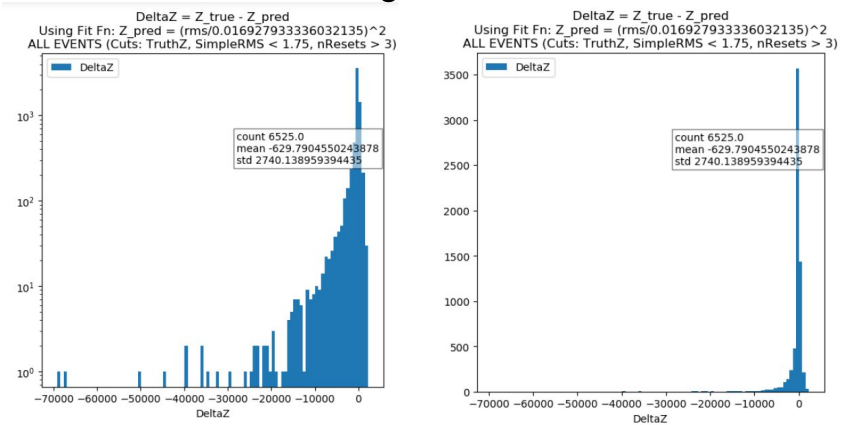




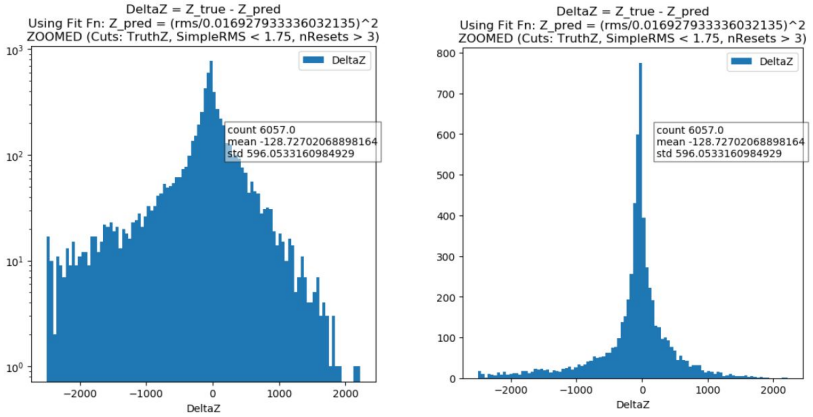
Looking Forward:

- *How well do we measure the Z value using the simple methods?* Take DeltaZ = true Z and estimate from RMS
- RMS gives about ~150mm which can be compared to 250mm
- Dominated by long tails of mis-measured events. Will take more study

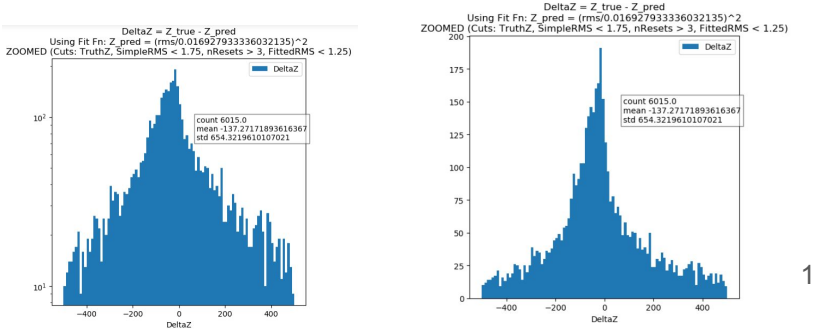
1: Full range of events



2: Zoomed to [-2500,2500]



3: Zoomed to [-500,500]



Conclusions? Next steps

- Looks like we can get an expected resolution of about ~200mm but that it should be Z dependent
  - Could do better with a cleaner sample
- 30MHz clock speed appears safe. Getting a better number will take more work
- Looks like Z-resolution and tails are dominated by mis-measured events. Cleaning up the sample is our next step