Re-examination of pd02b000

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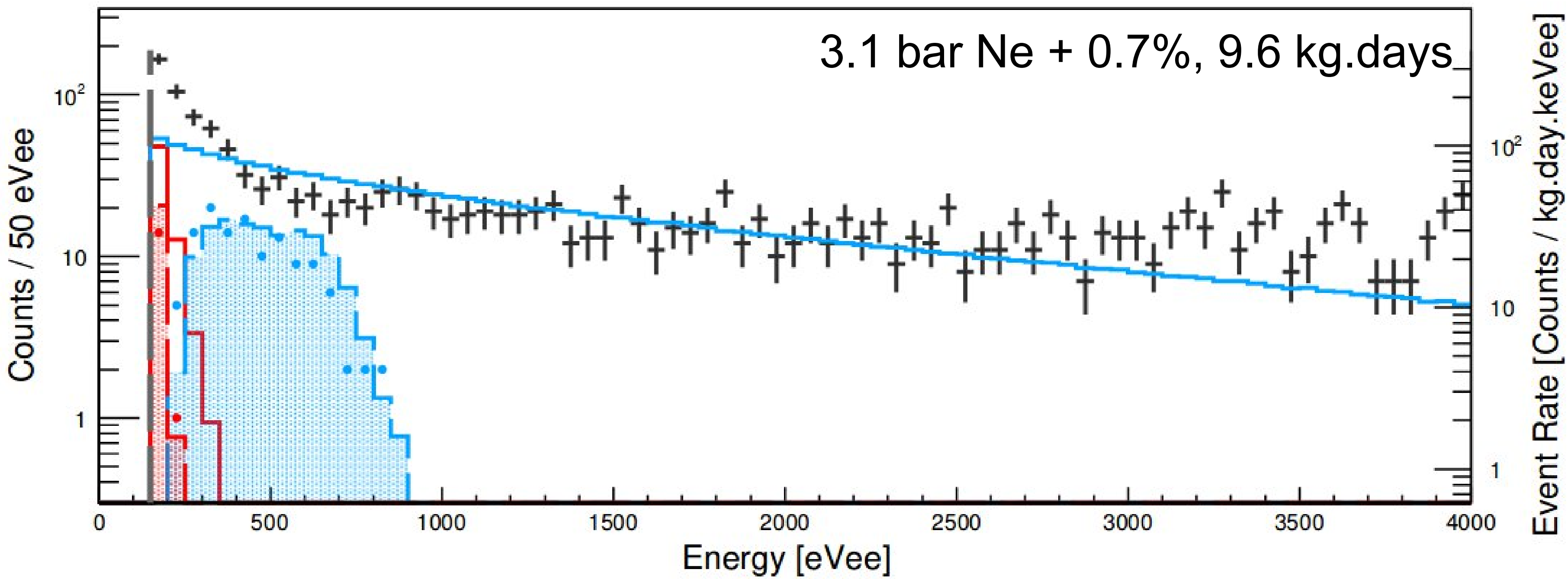
NEWS-G Collaboration Meeting
Grenoble, France

In our first published physics data set (2018), we had an un-explained low energy background above the expected flat background

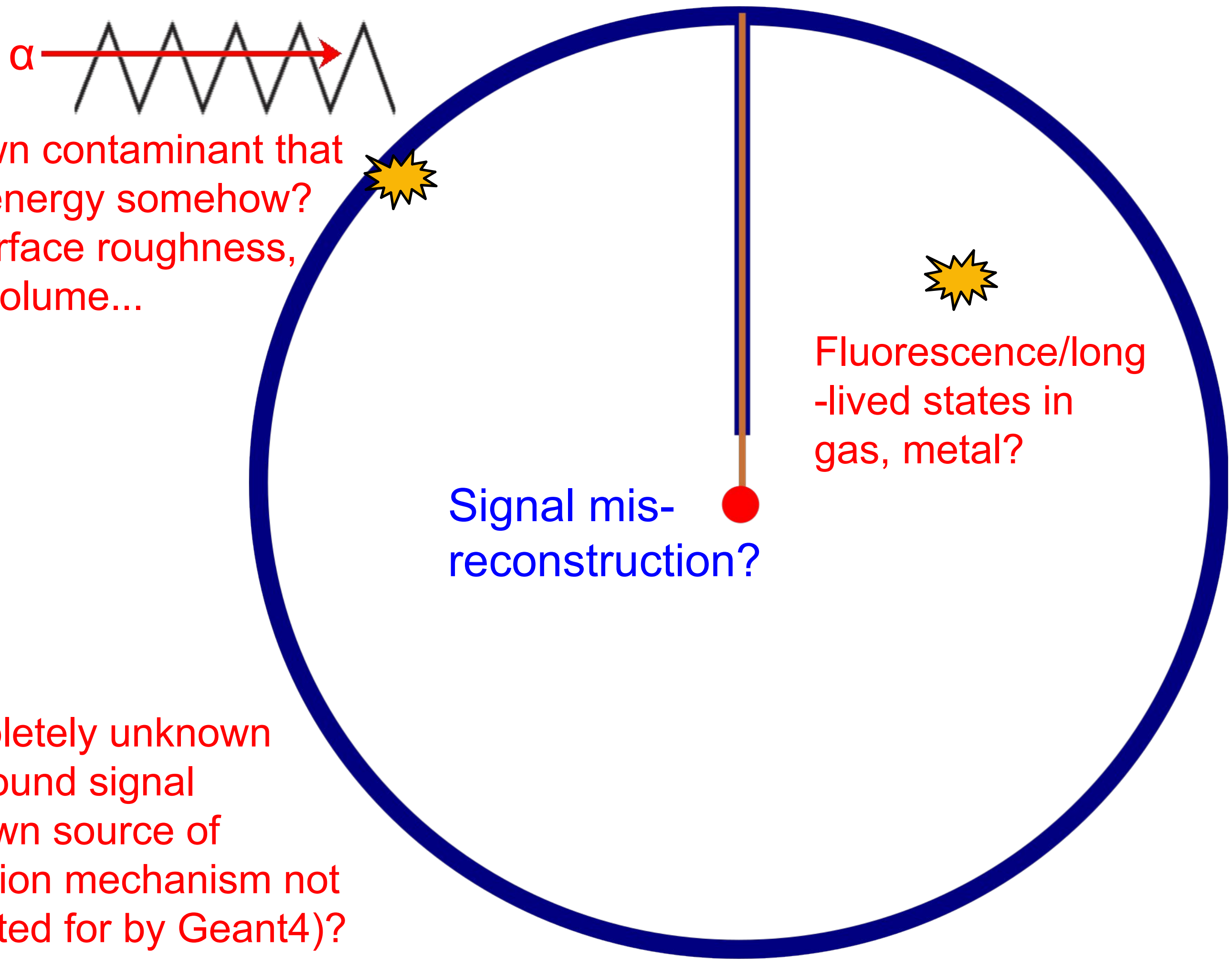
Is it possible we will see this again with Snoglobe?

The point of this study is not to improve our old results, but to try to understand this un-expected background so we know what to expect/if we can mitigate it



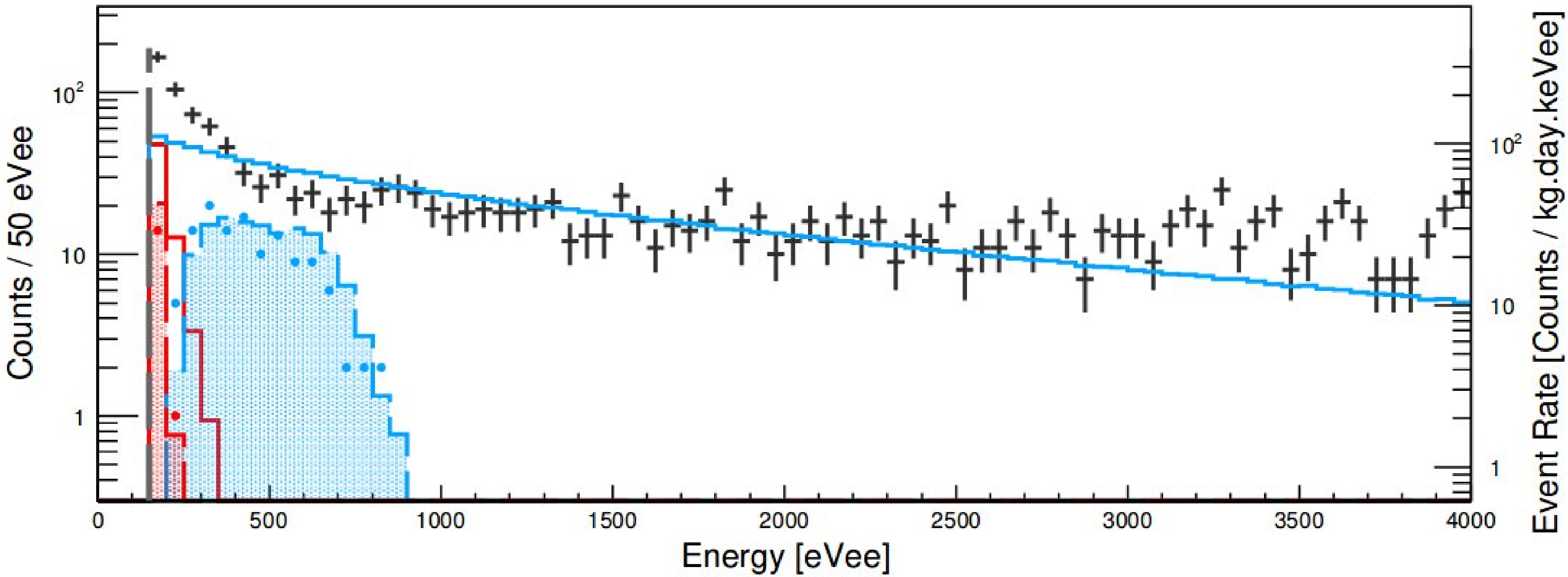
Q. Arnaud et al. (NEWS-G), Astropart. Phys. 97, 54 (2018)

What could be the cause? It could be physical or non-physical



If they are true physical events, can the source be mono-energetic?

Our energy response is roughly exponential at low energies but...



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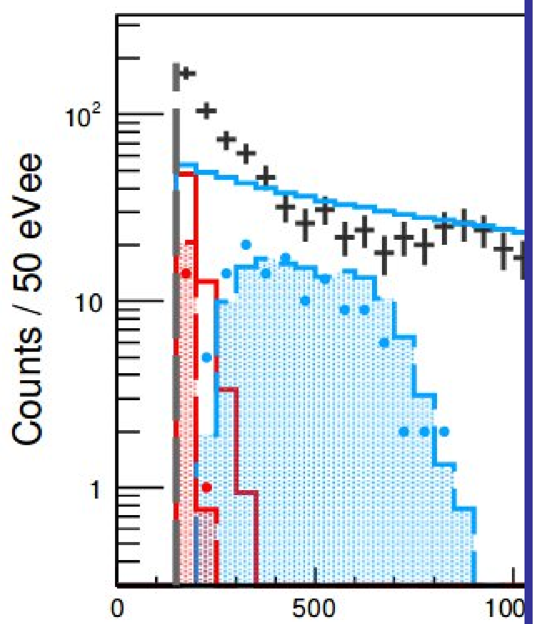
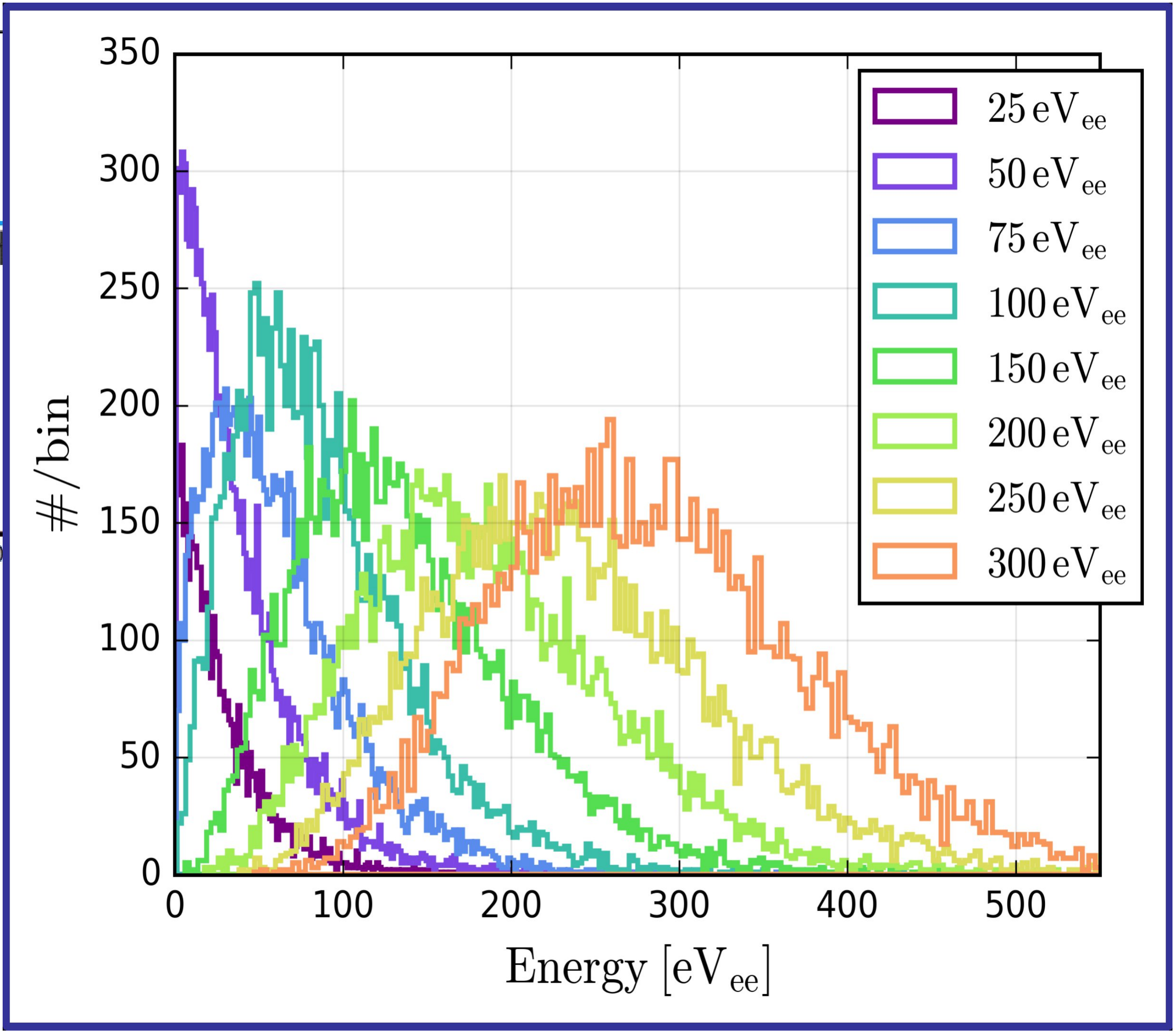
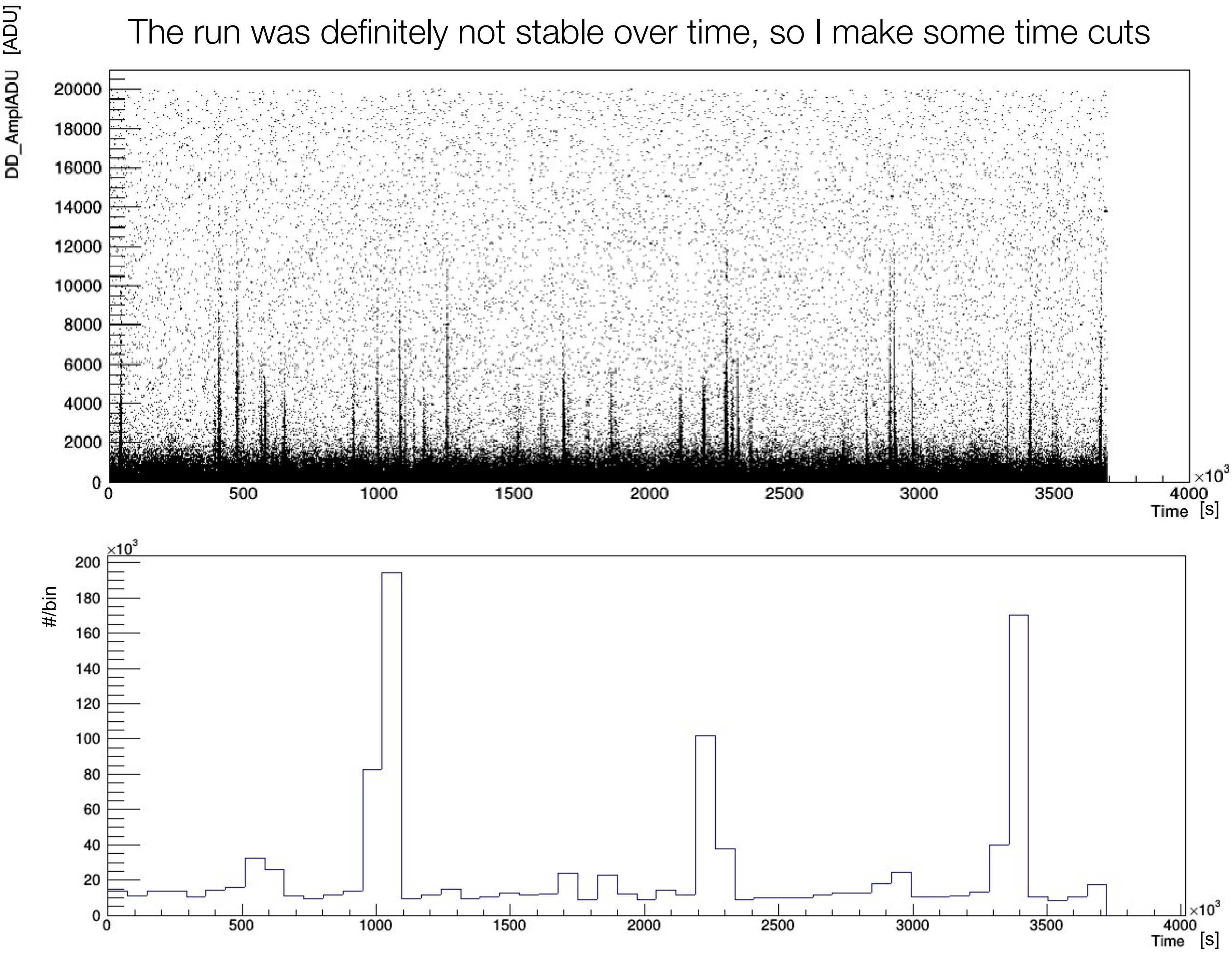




...No, at those energies mono-energetic sources have a clear peak

The run was definitely not stable over time, so I make some time cuts



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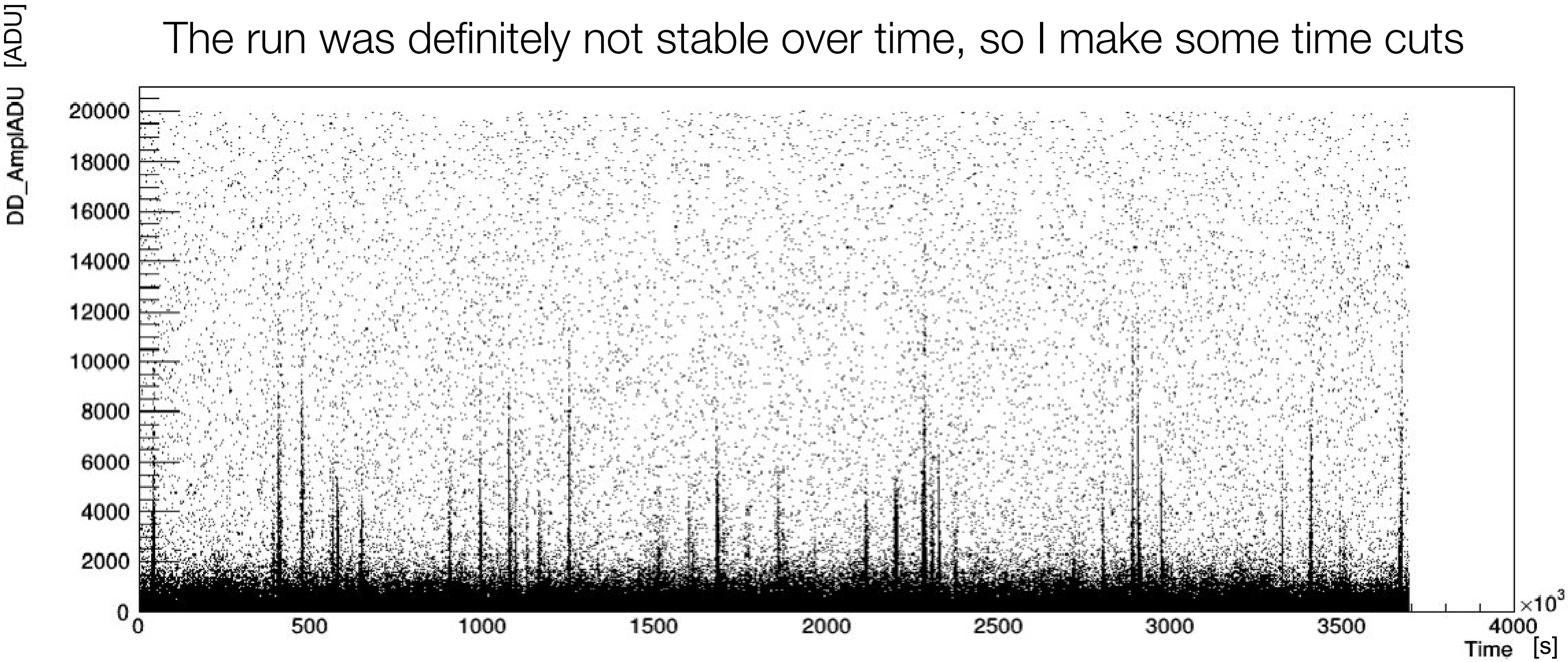
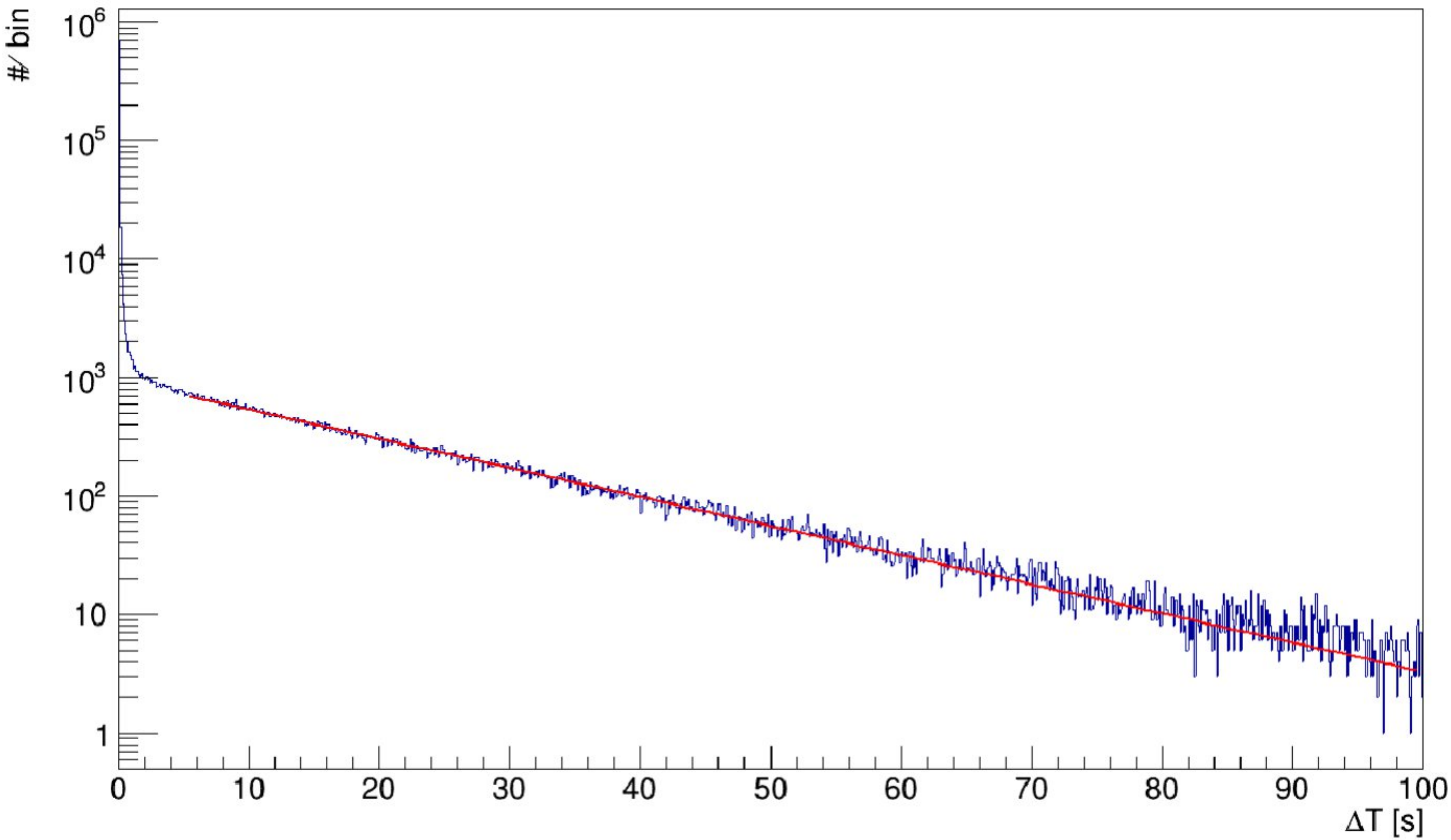


Time = "(0. < Time && Time < 550e3) || (590e3 < Time && Time < 640e3) || (670e3 < Time && Time < 980e3) || (1000e3 < Time && Time < 1060e3) || (1080e3 < Time && Time < 1680e3) || (1700e3 < Time && Time < 1830e3) || (1870e3 < Time && Time < 2180e3) || (2340e3 < Time && Time < 2850e3) || (2990e3 < Time && Time < 3320e3) || (3340e3 < Time && Time < 3400e3) || (3420e3 < Time && Time < 3650e3)";

Delta T looks normal at higher Delta T, but diverges from exponential behavior at about 2 seconds

Cutting at 4 seconds induces ~20% dead-time



Basic cuts

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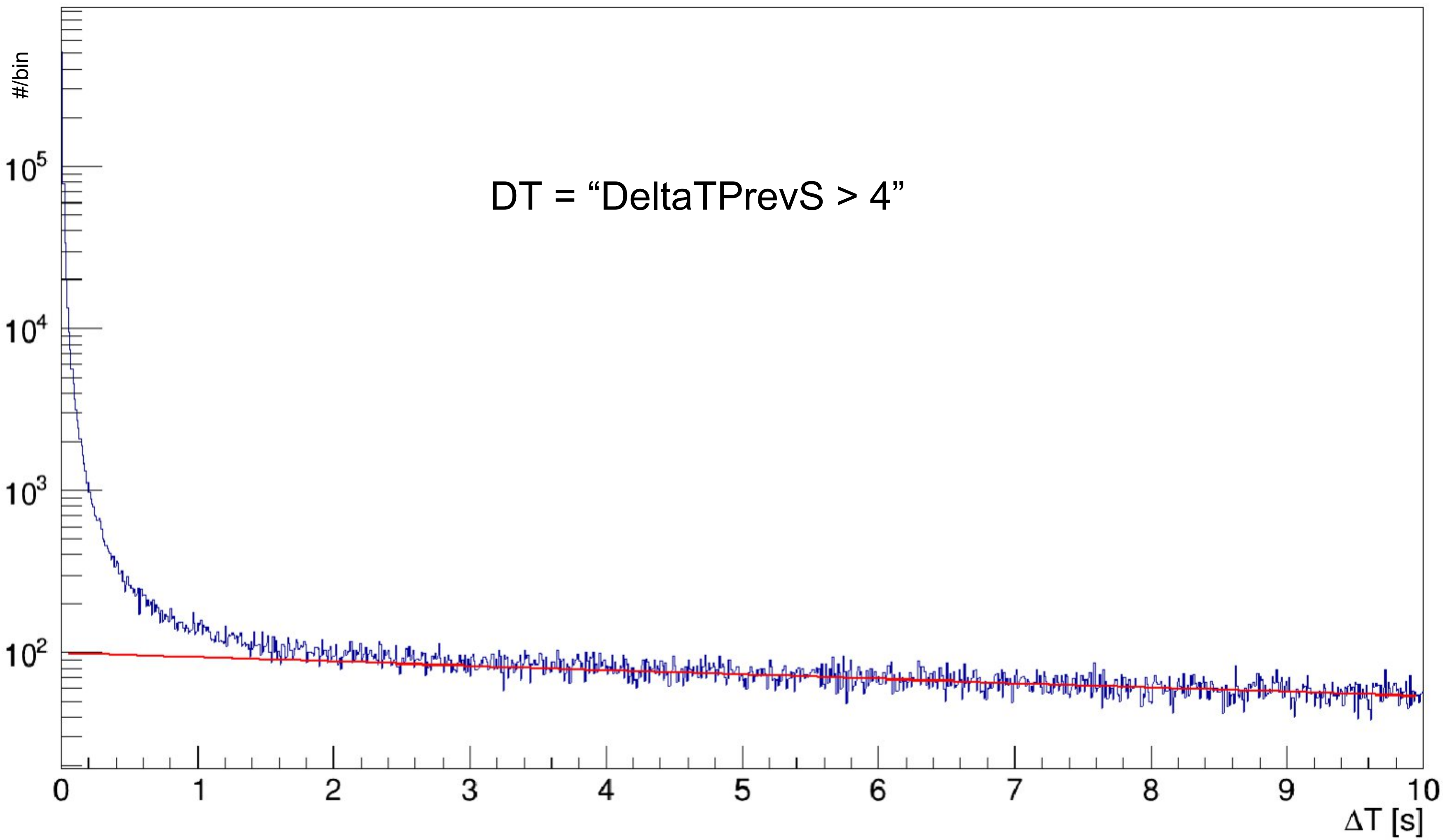
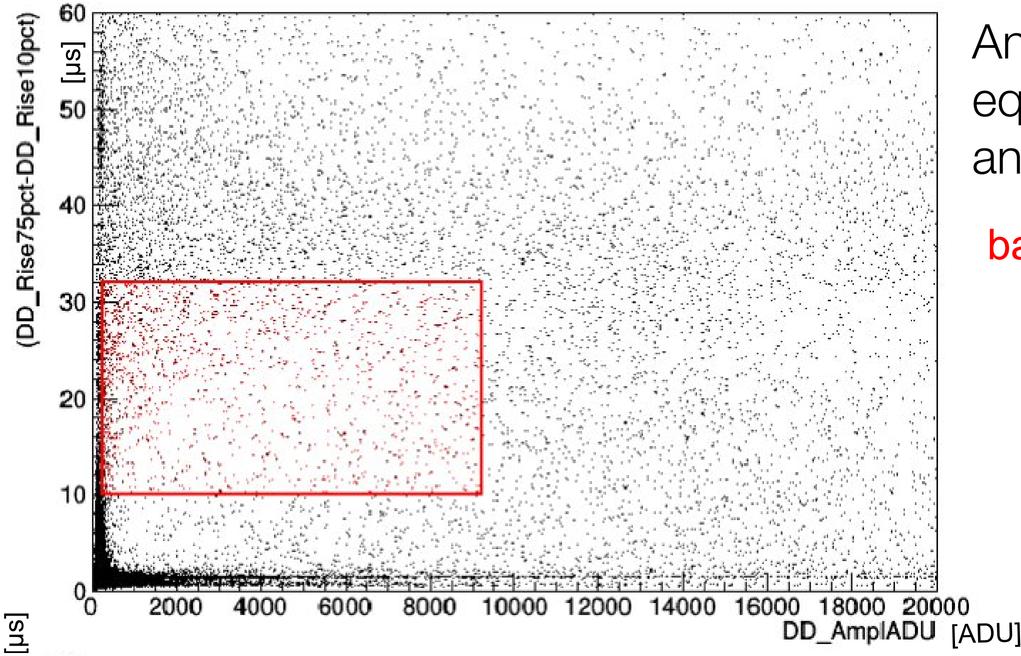
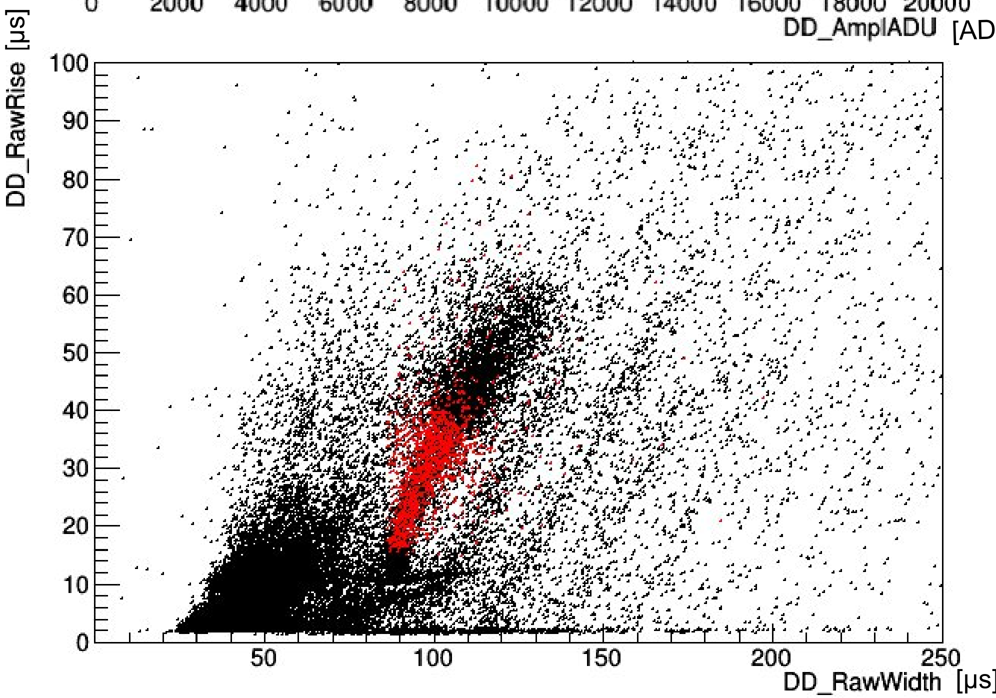




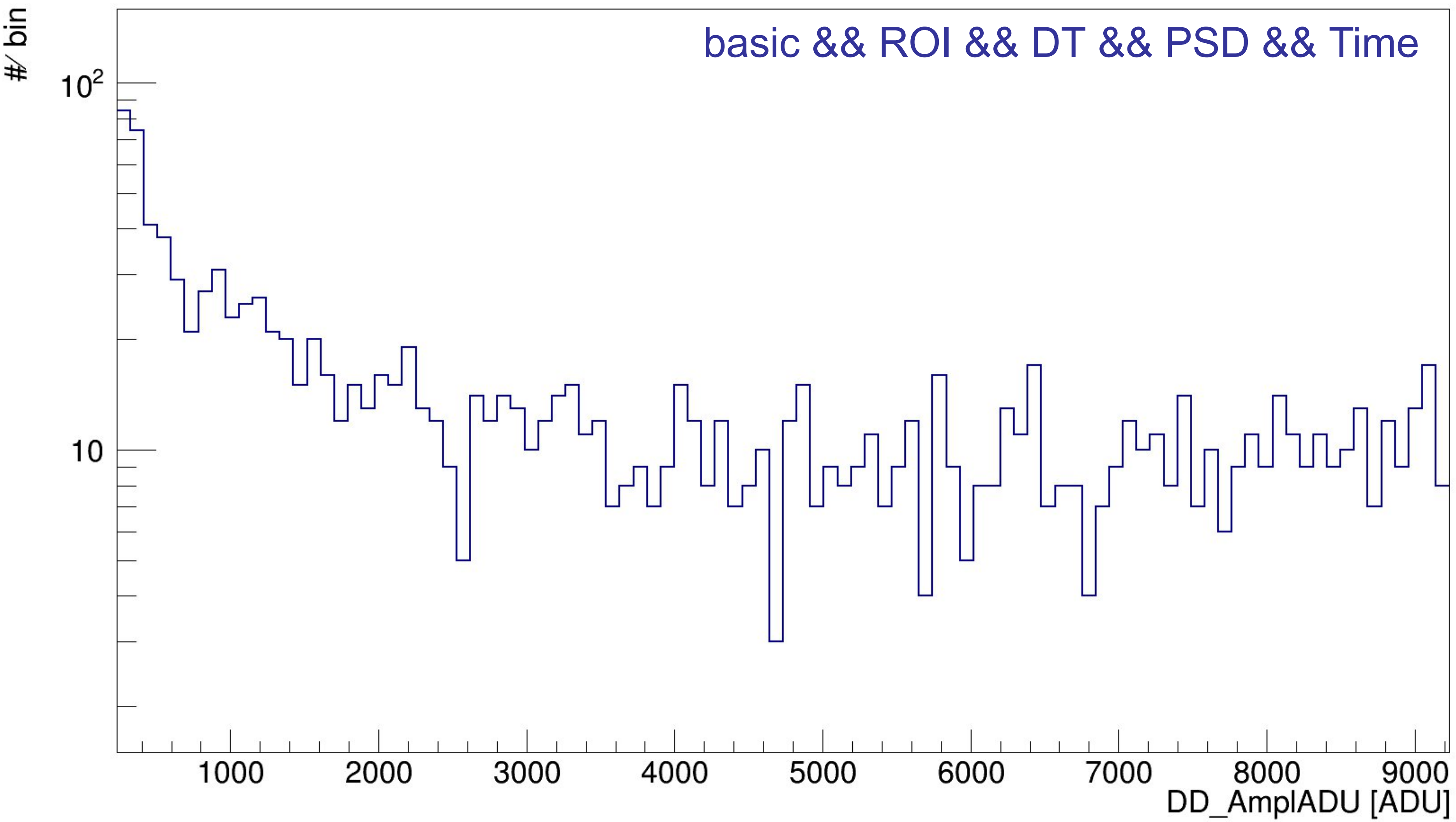
An amplitude/risetime ROI roughly equivalent to the original GG-method analysis

basic && TIme && DT && ROI



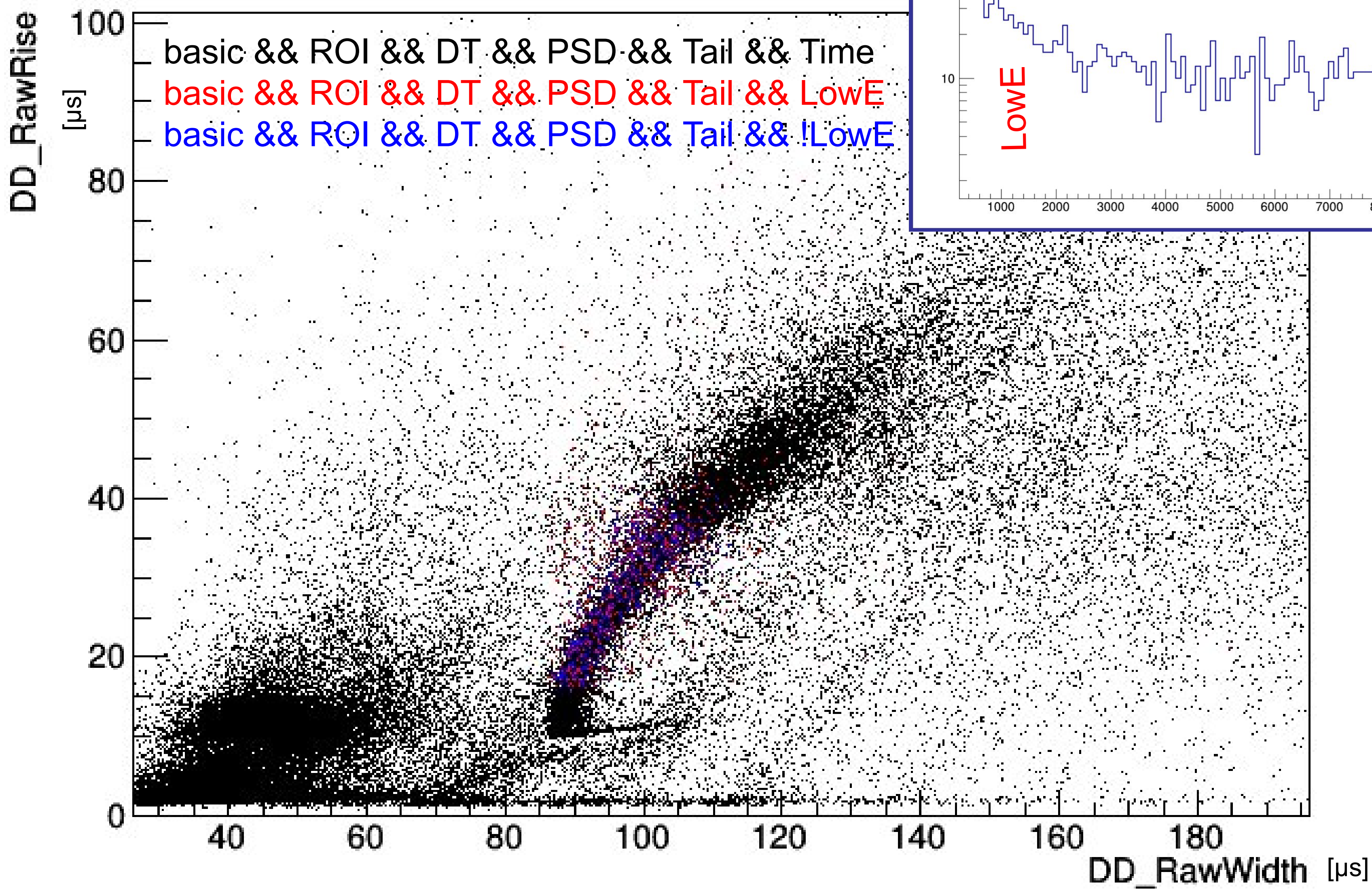
More agressive raw-rise/raw-width cuts

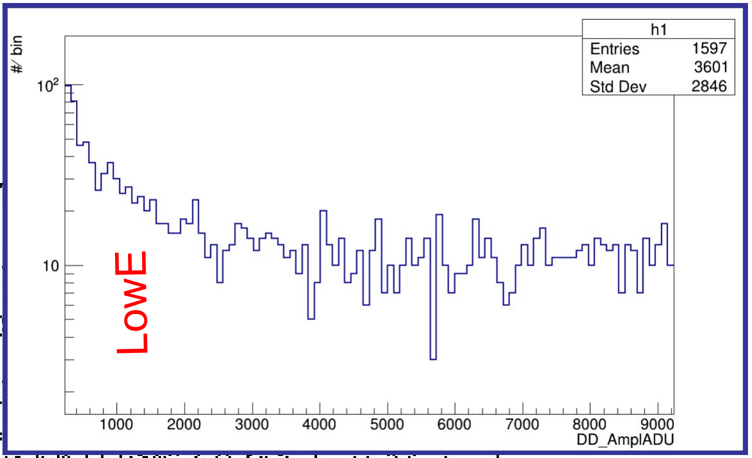
basic && TIme && DT && ROI && PSD


basic && ROI && DT && PSD && Time
#/ bin
10^2
10
1000
2000
3000
4000
5000
6000
7000
8000
9000
DD_AmplADU [ADU]

Is it noise and/or pulse-processing?

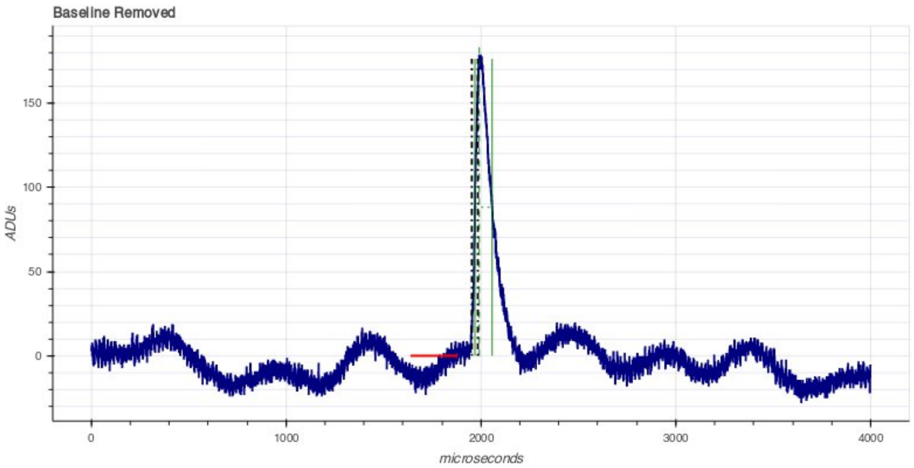
No obvious separation between low energy events and normal ROI events in our usual PSD space



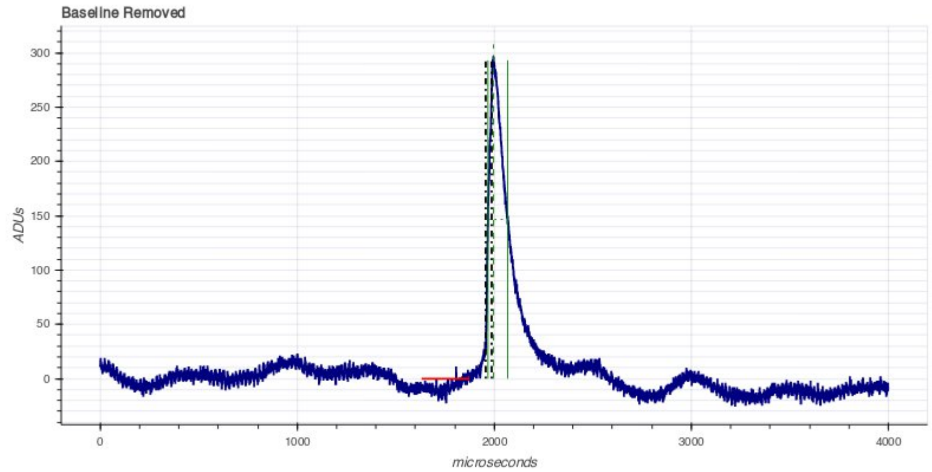


The mystery events mostly look normal

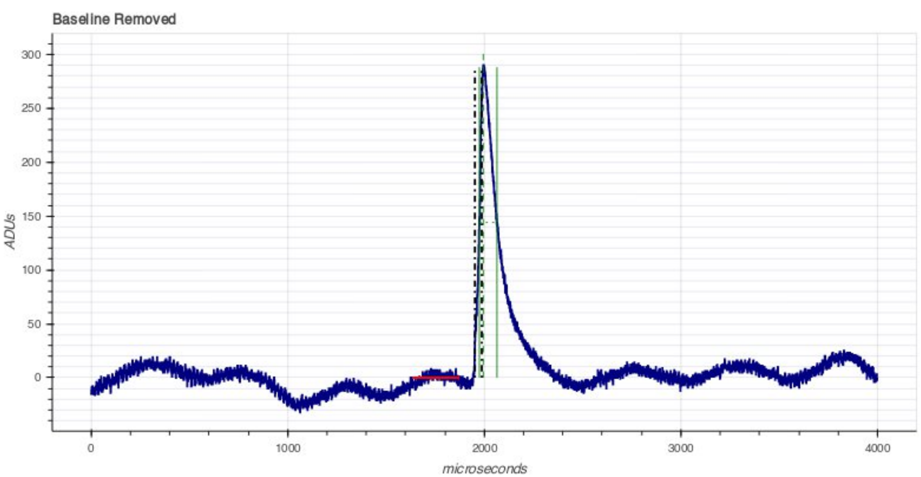
Event 1731



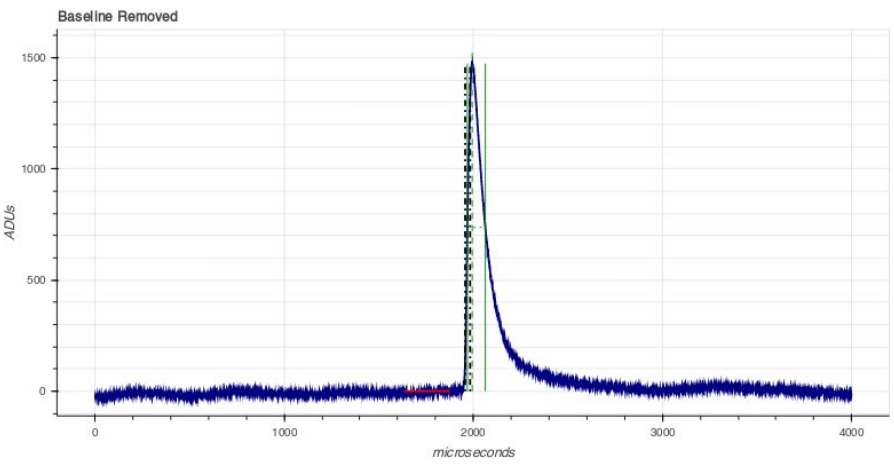
Event 10078



Event 21091



Event 2027



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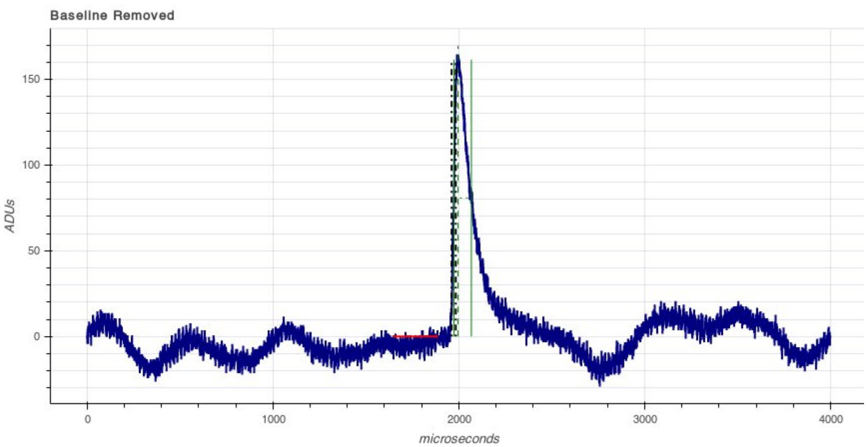
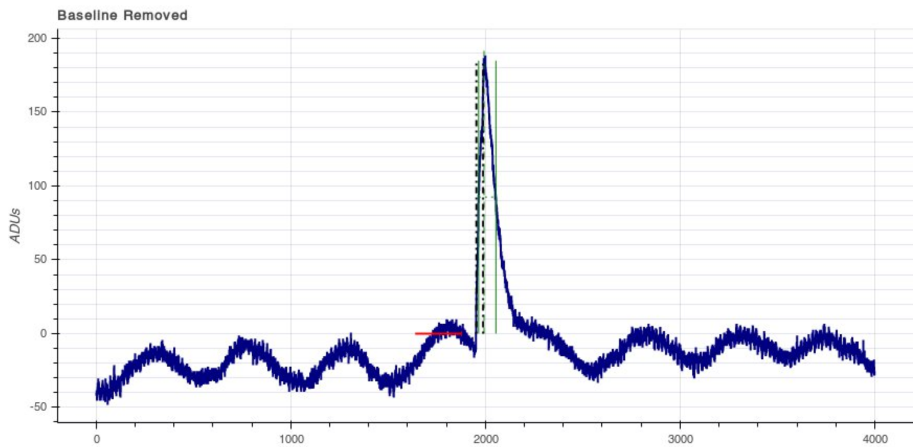
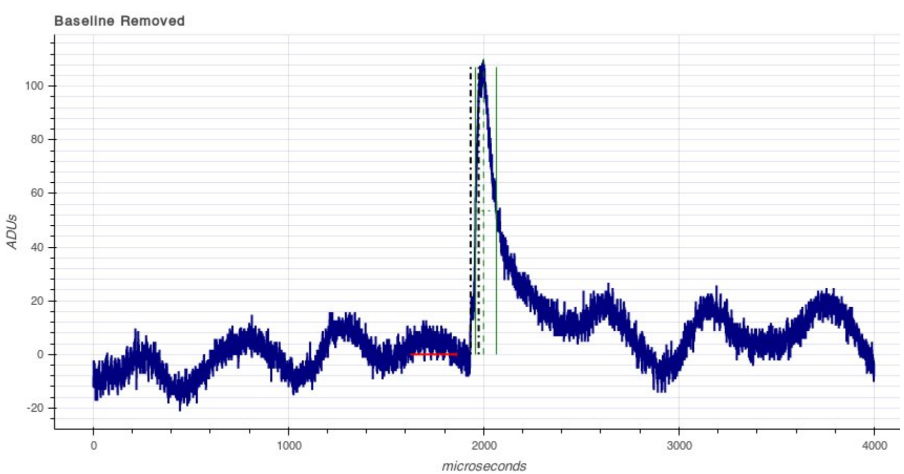
Event 8041



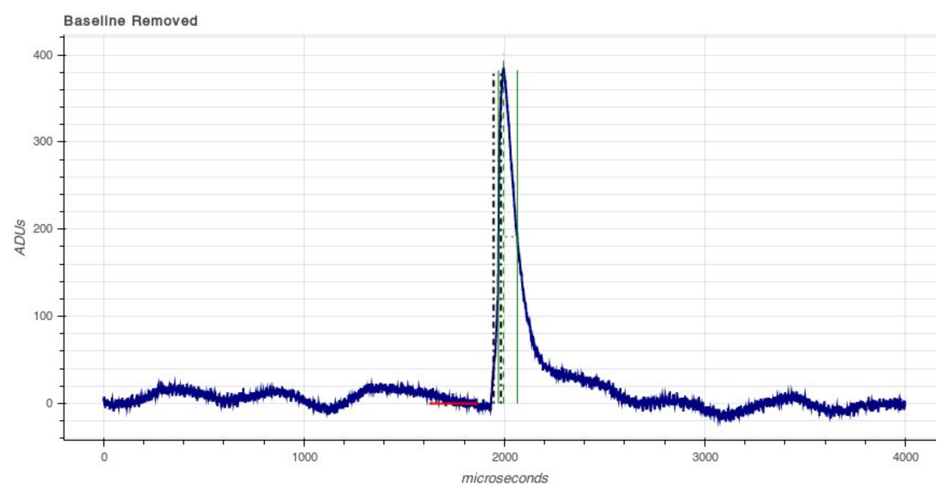
Event 230766



Event 246121



Event 737202



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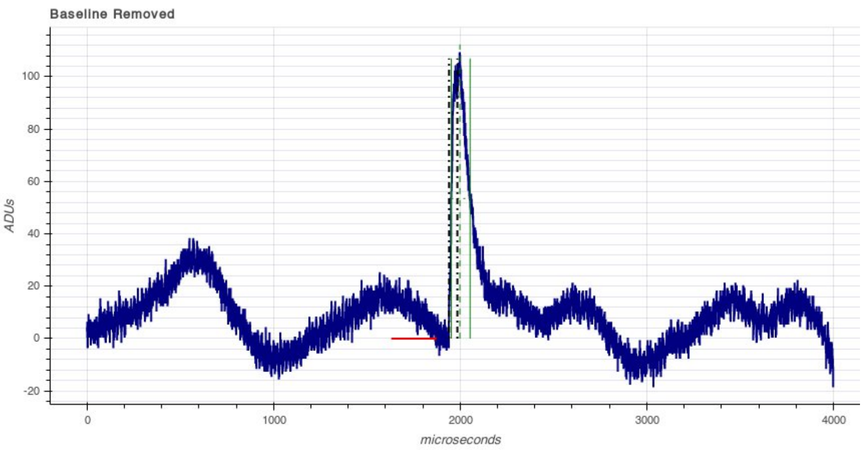
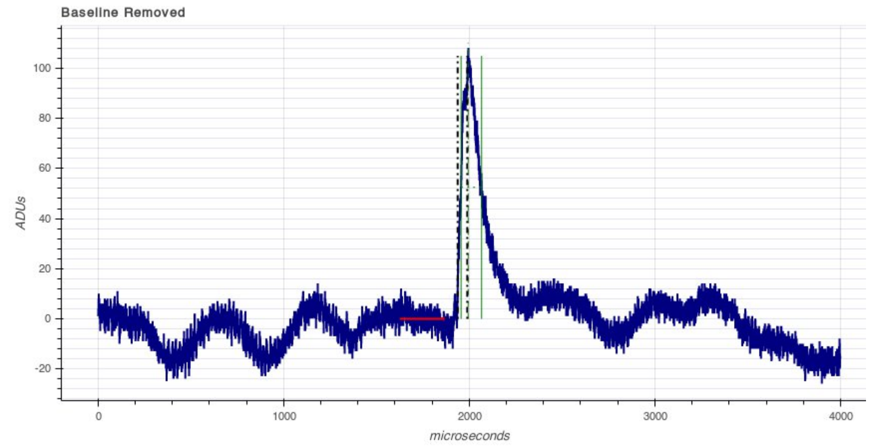
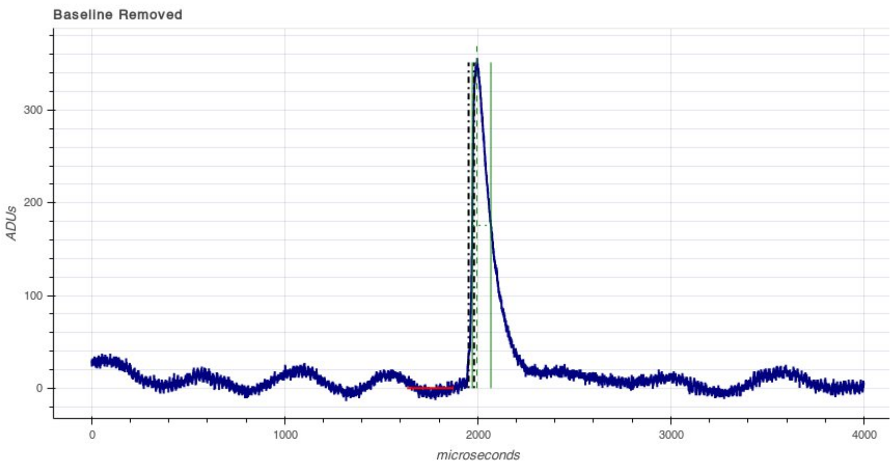
Event 799408



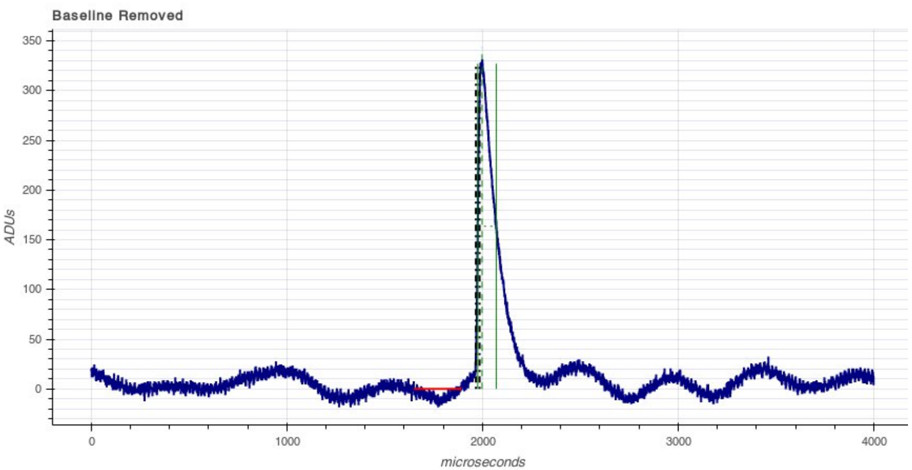
Event 875343



Event 1103262



Event 1146922



Is it noise and/or pulse-processing?

It doesn't seem so (proof by exhaustion):

» FFT of different pulse populations, comparison of power in different frequency bands
» Looked at the impact of the slope of the baseline at the pulse (thank you Paco)
» Looked at the hint of a correlation with DD_StopTime
» Made aggressive Raw-Width vs. Raw_Rise cuts
» They are uniform in time, not associated with large baseline noise
» Scanned for sub-populations in every DD2 variable
» ...

» In an act of desperation, I hand-scanned every event in the ROI and removed every pulse that was even remotely ugly:

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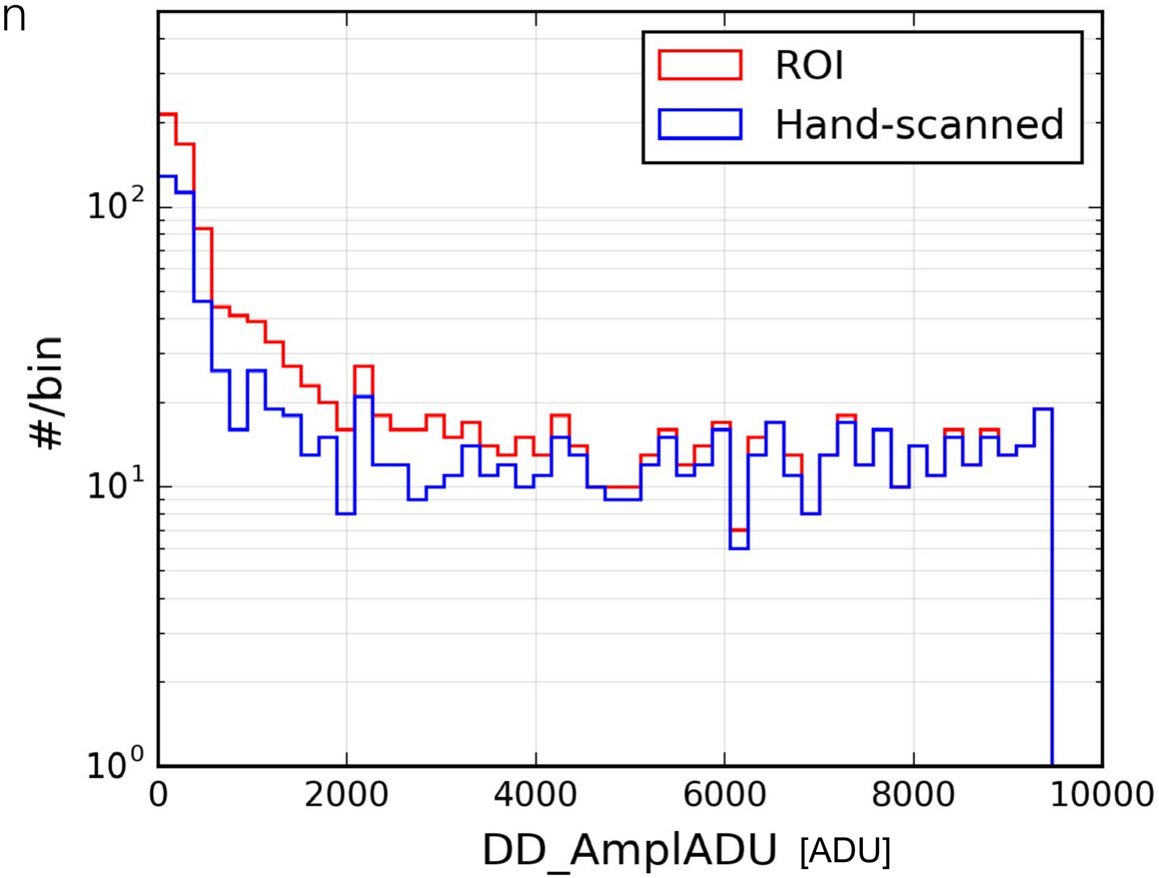
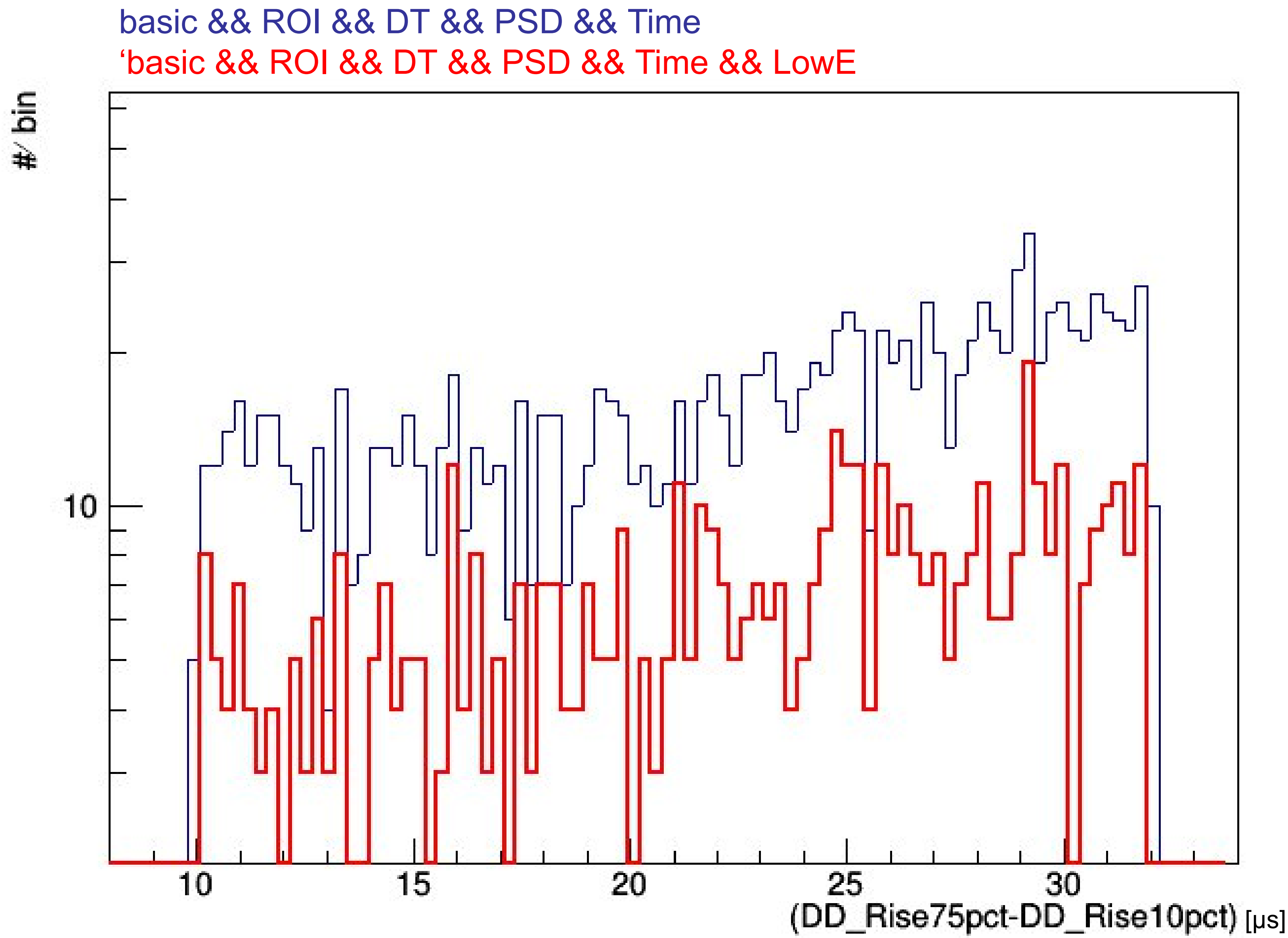
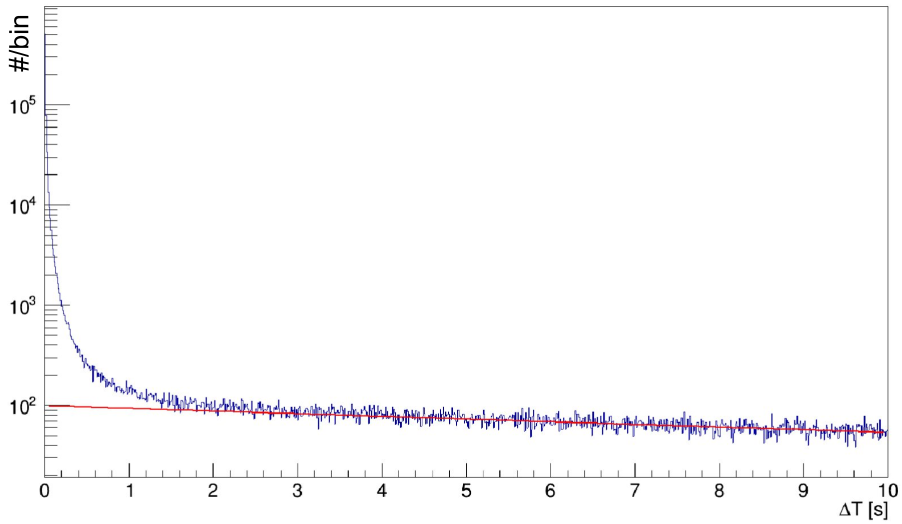


Is it a surface signal?

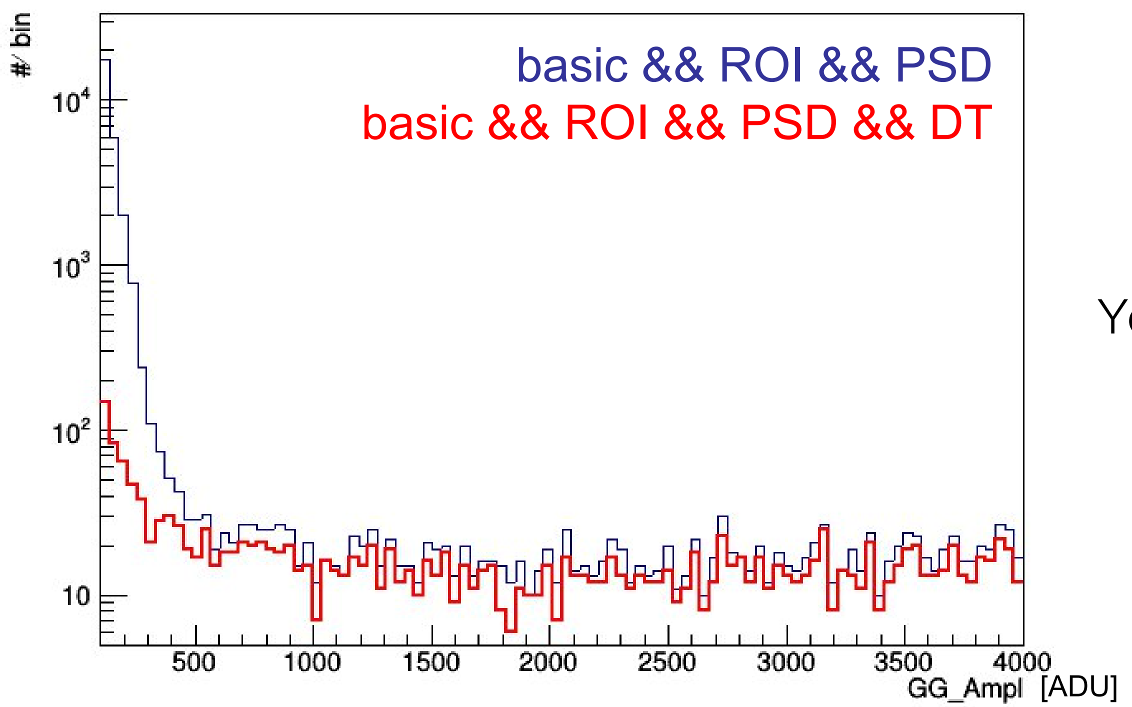
Same risetime distribution as the higher-energy events ⇨ it's not a surface signal



Δt is our most compelling hint of something weird



Any radio-active source (surface or other-wise) would still produce an exponential Δt spectrum

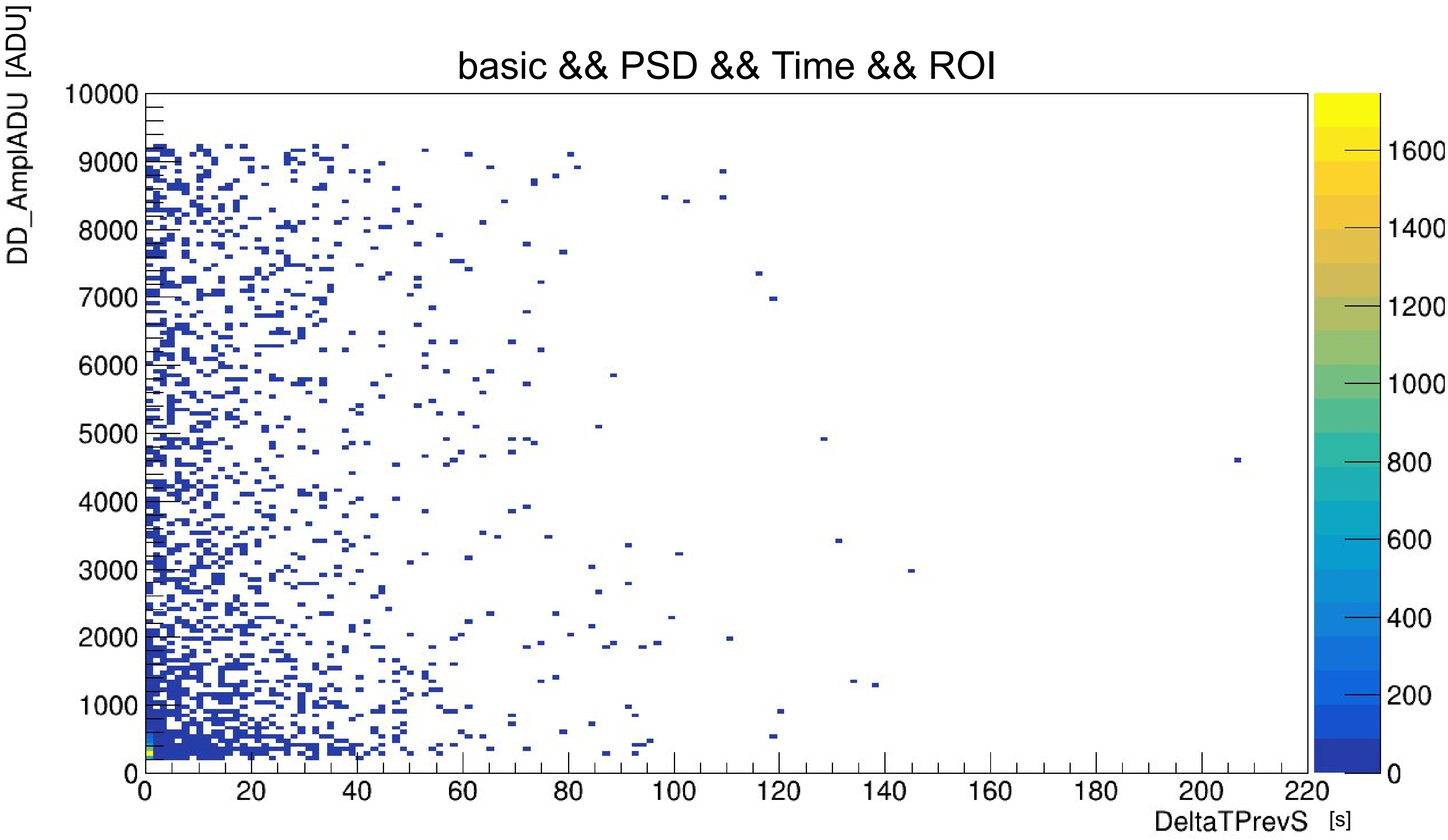


DeltaT cut is very significant!

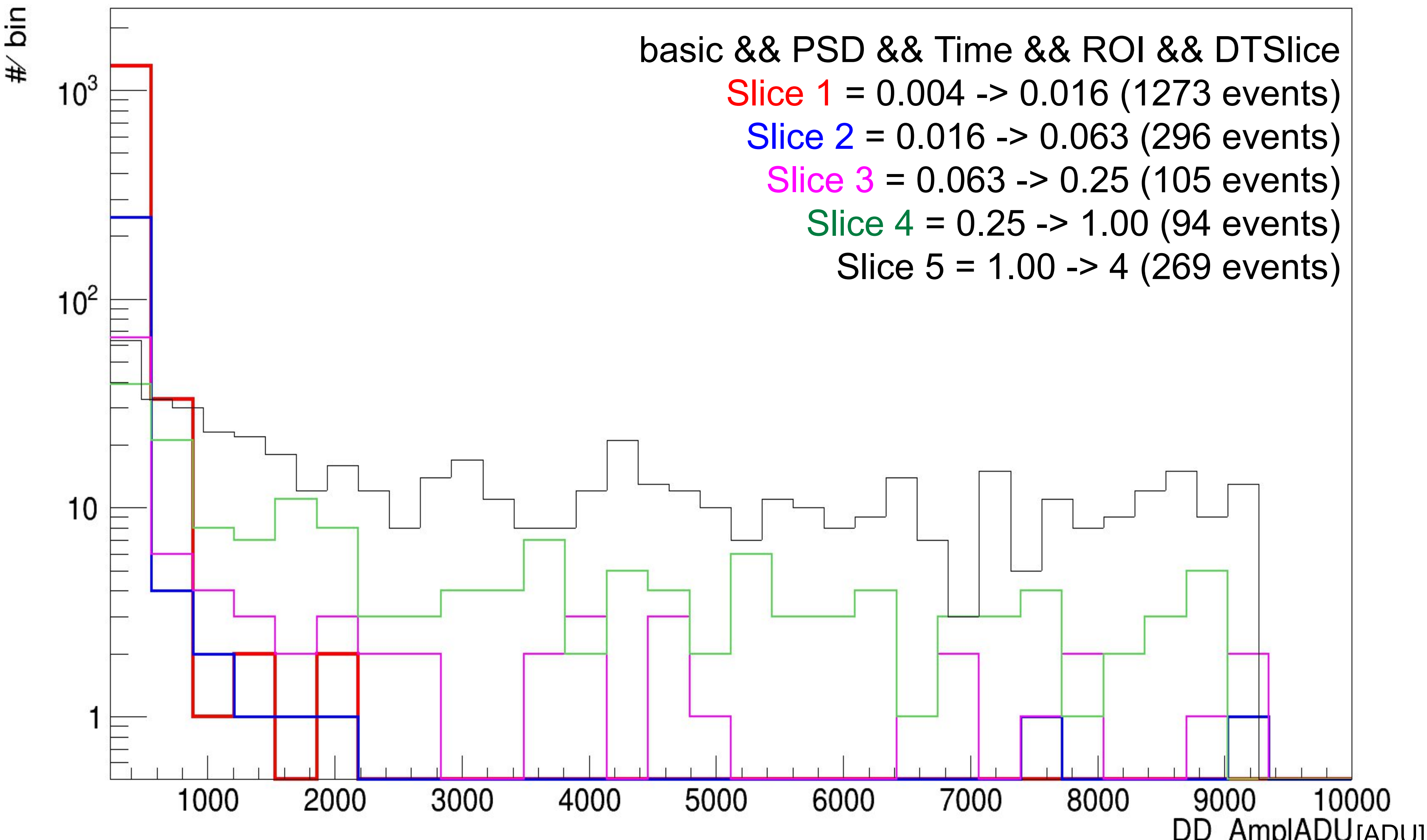
You can immediately see that the weird low-Δt events are disproportionately low energy

What are the low DeltaT events?

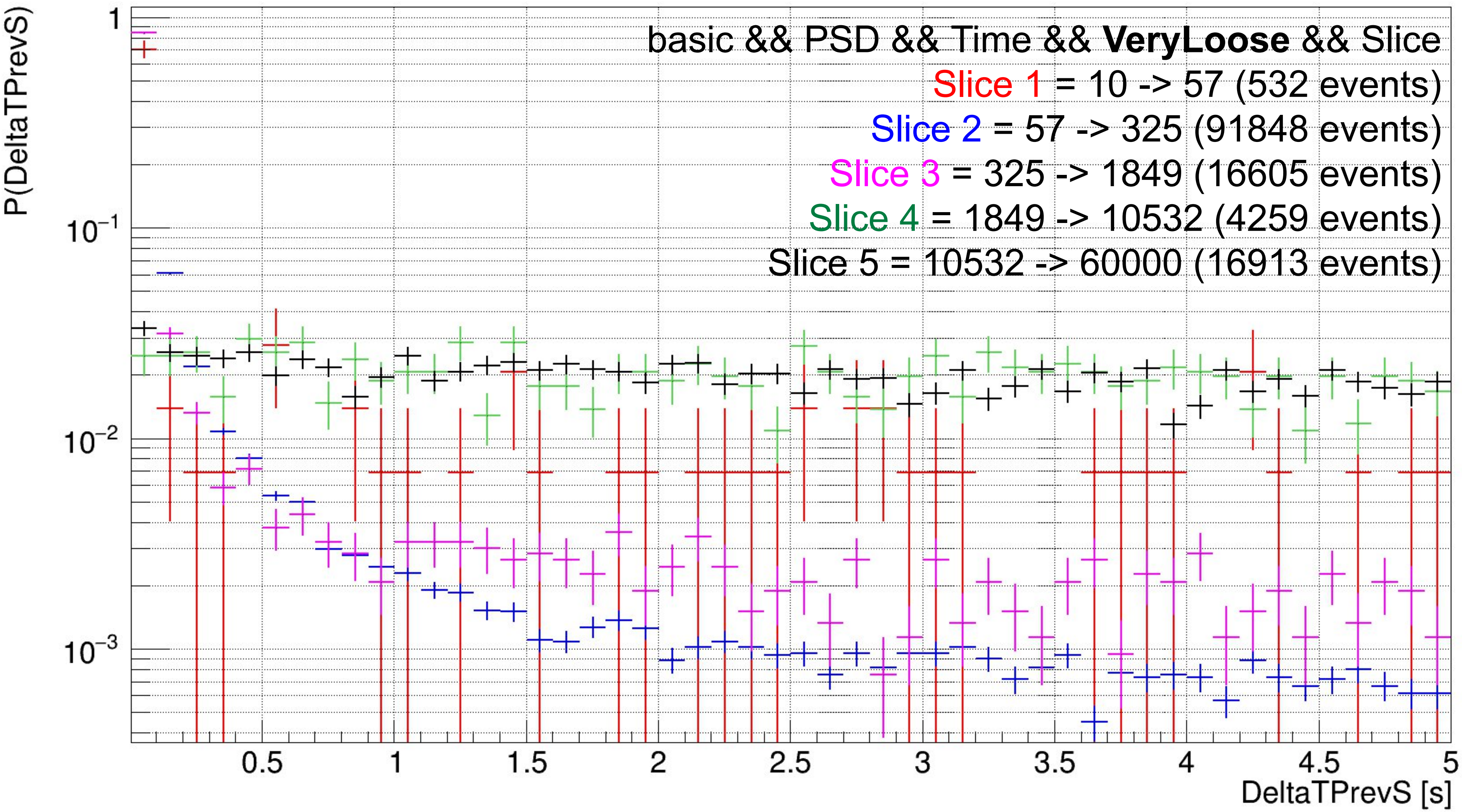
- There is no clear correlation between DeltaT and Amplitude



What if we look at amplitude for slices of DeltaT? Spectrum for 5 logarithmic slices:



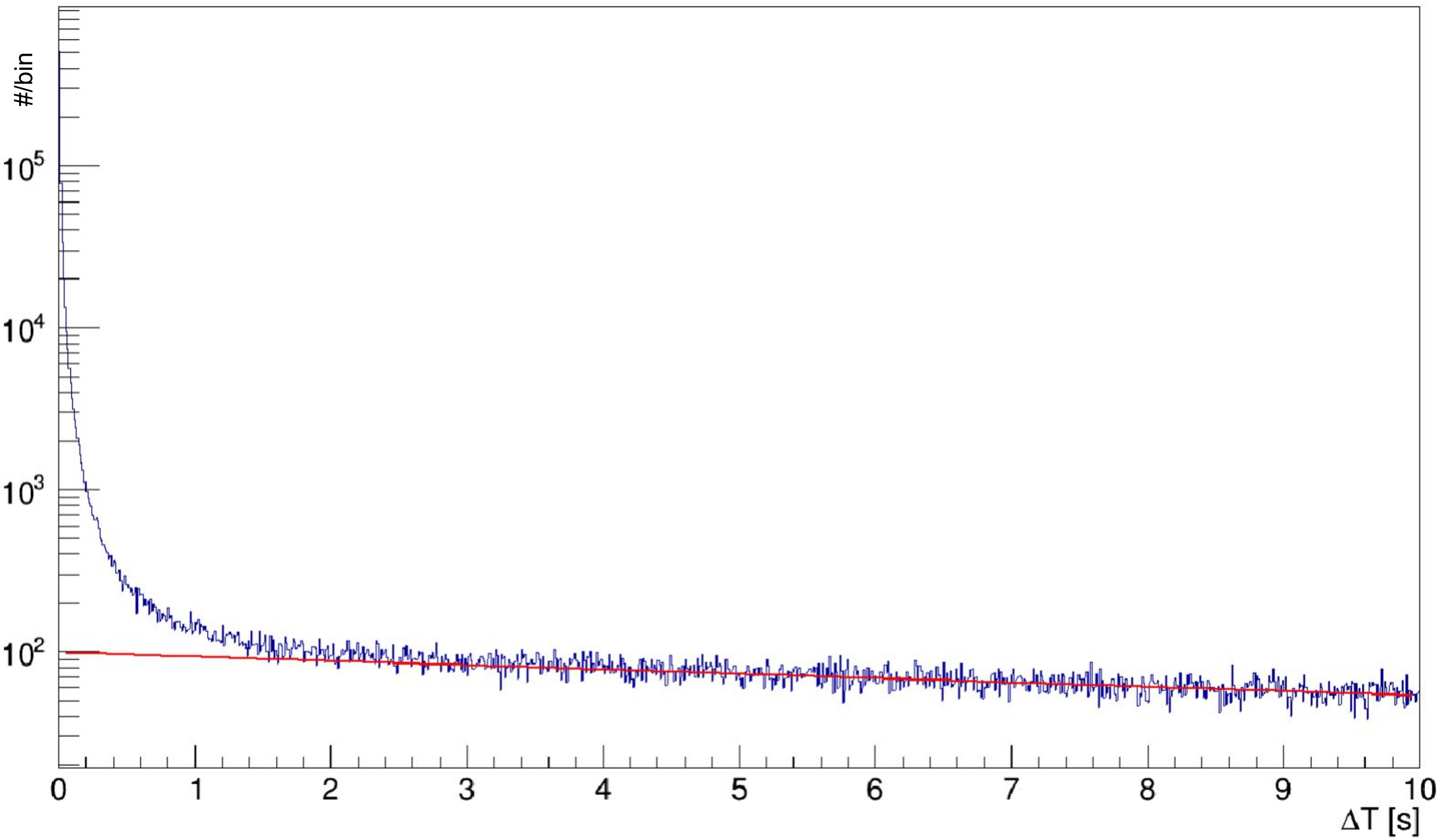
What if we do the opposite and look at DeltaT for slices of amplitude?



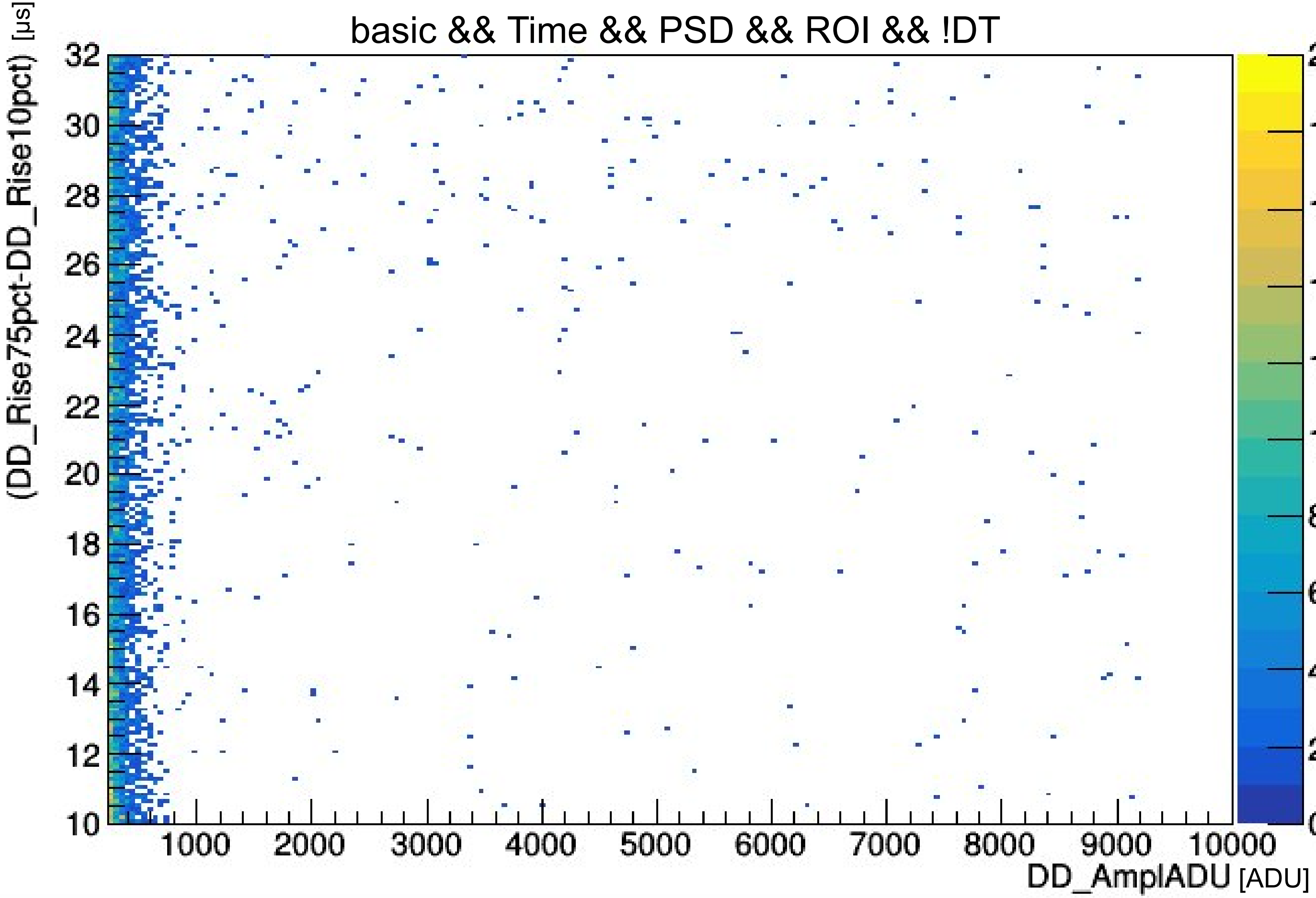
VeryLoose = "0. < (DD_Rise75pct-DD_Rise10pct) && (DD_Rise75pct-DD_Rise10pct) < 100 && 0. < DD_AmplADU && DD_AmplADU < 180e3"

Investigating the low-Δt events

So there is a non-trivial relationship between amplitude and Δt for this mysterious low-Δt population. But we cut at Δt = 4s, so does it matter?



1. Look at the Risetime vs. Amplitude spectrum of events that are in the ROI, but with low DeltaT



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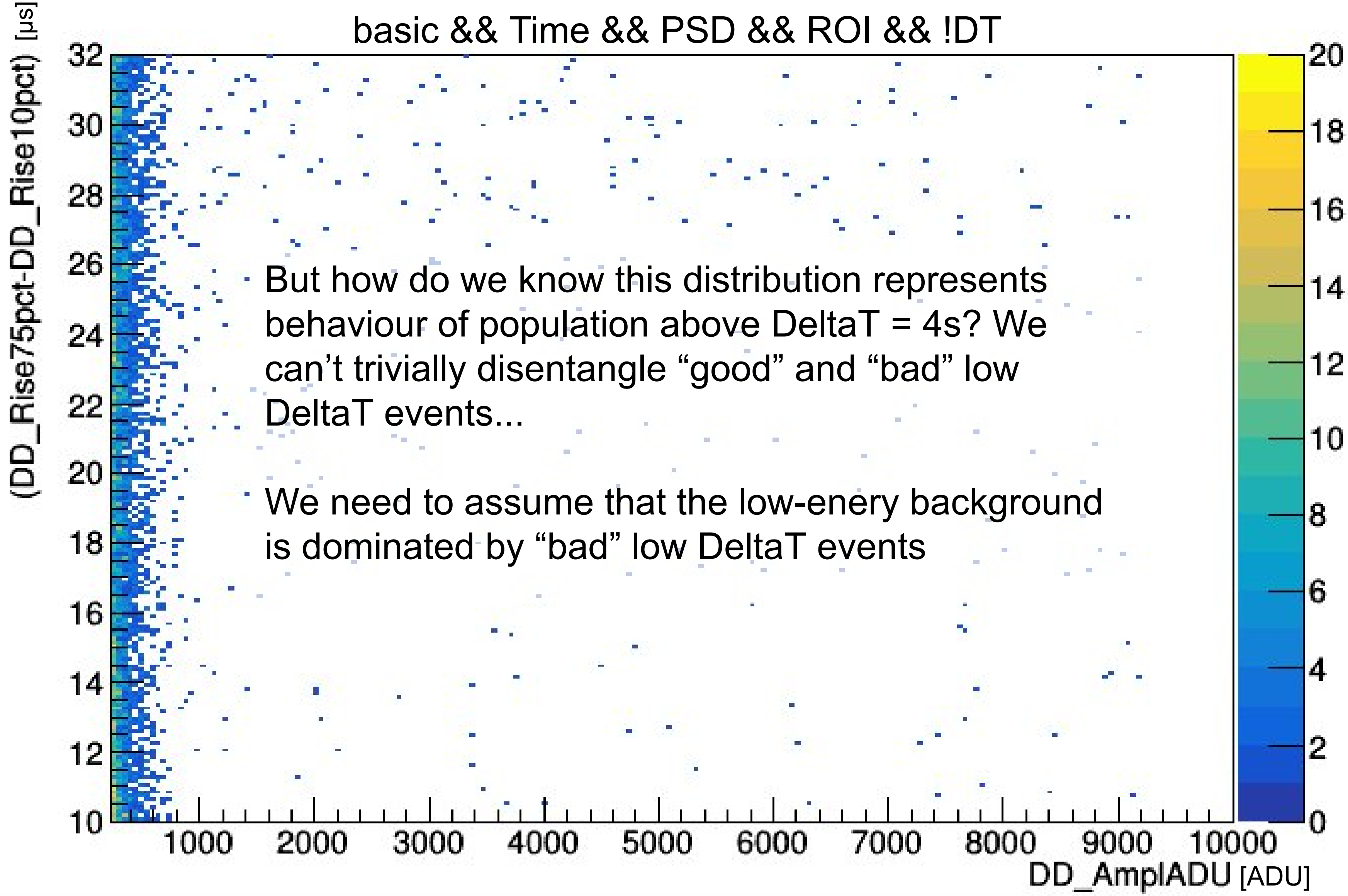
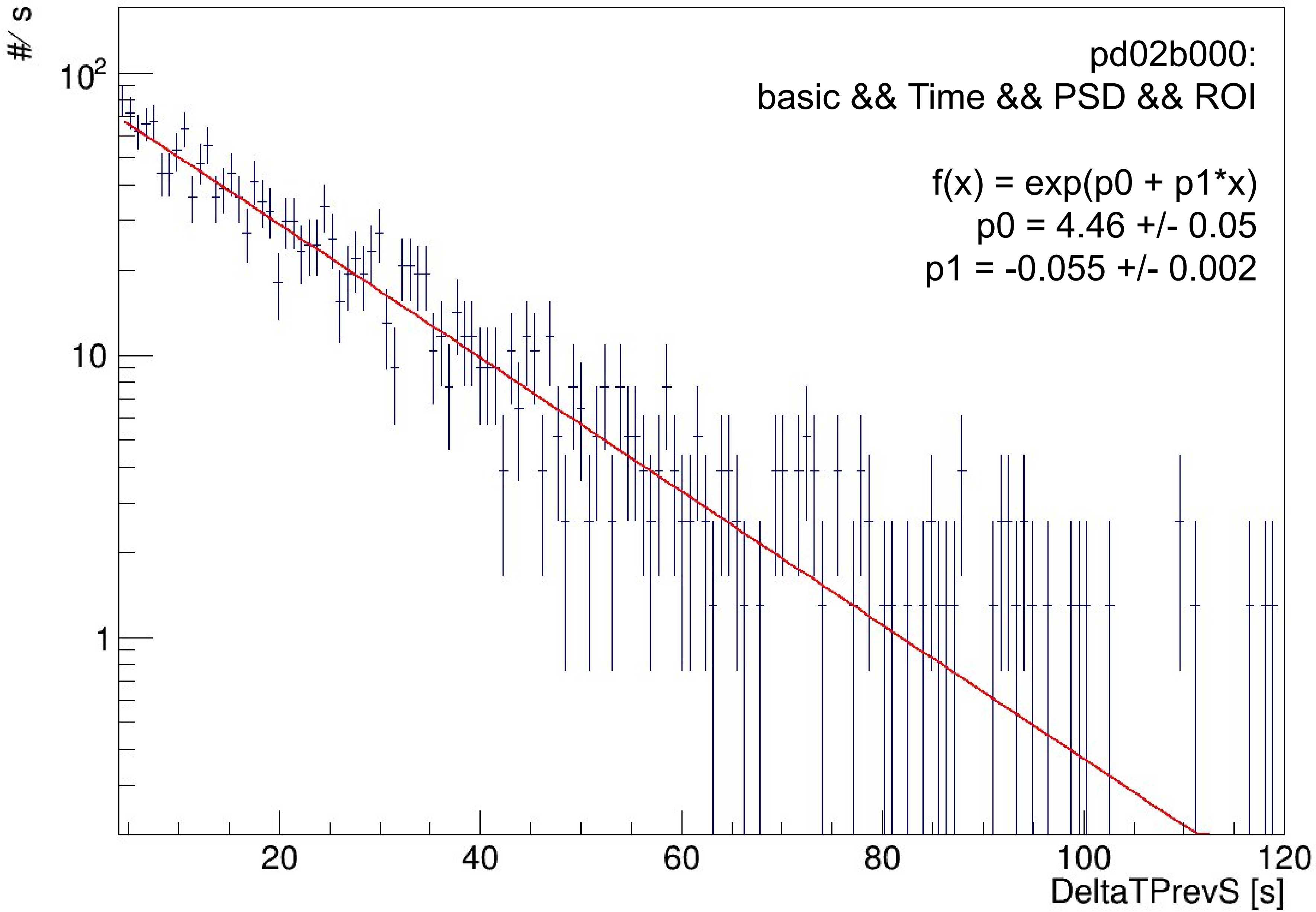
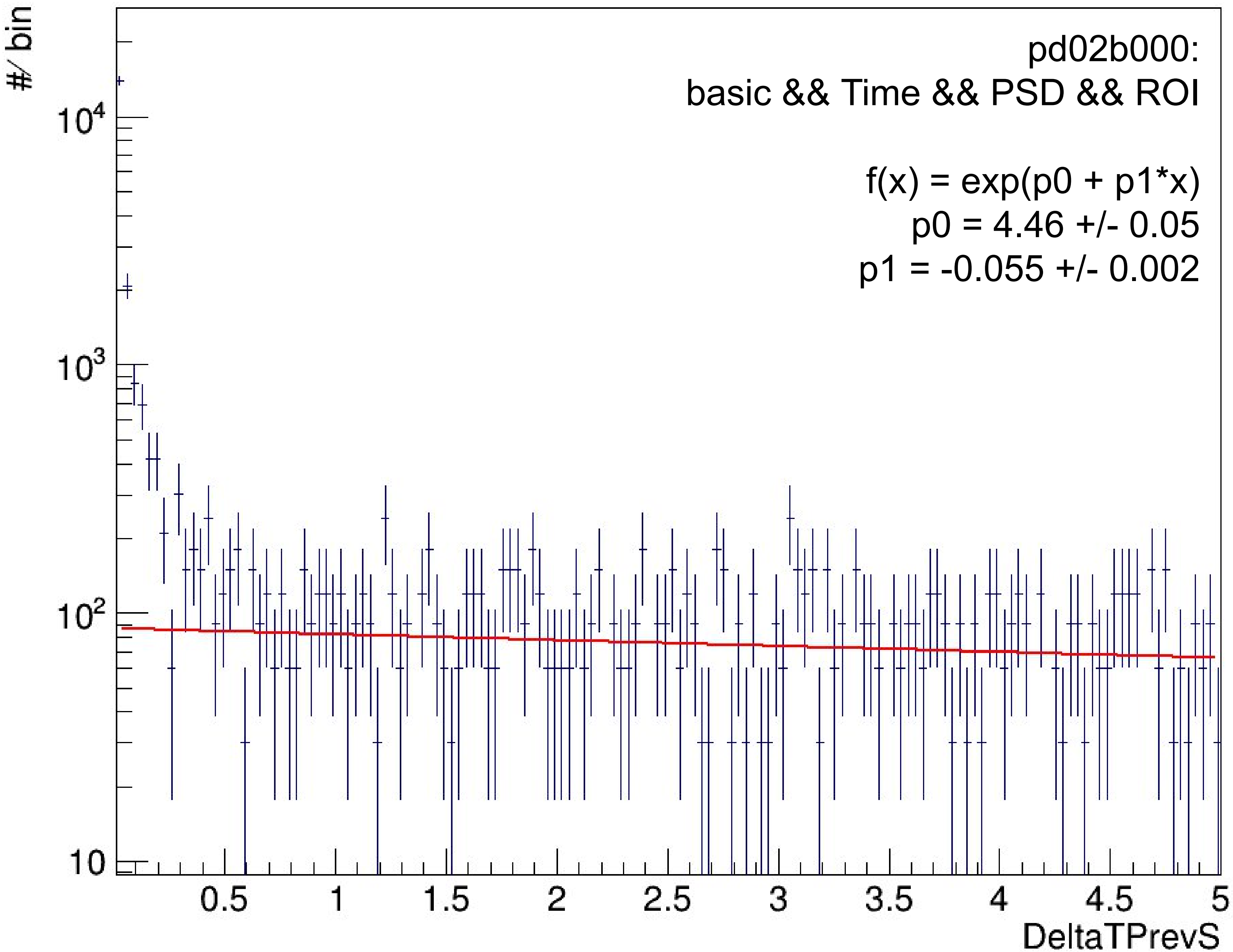


Δt cut leakage

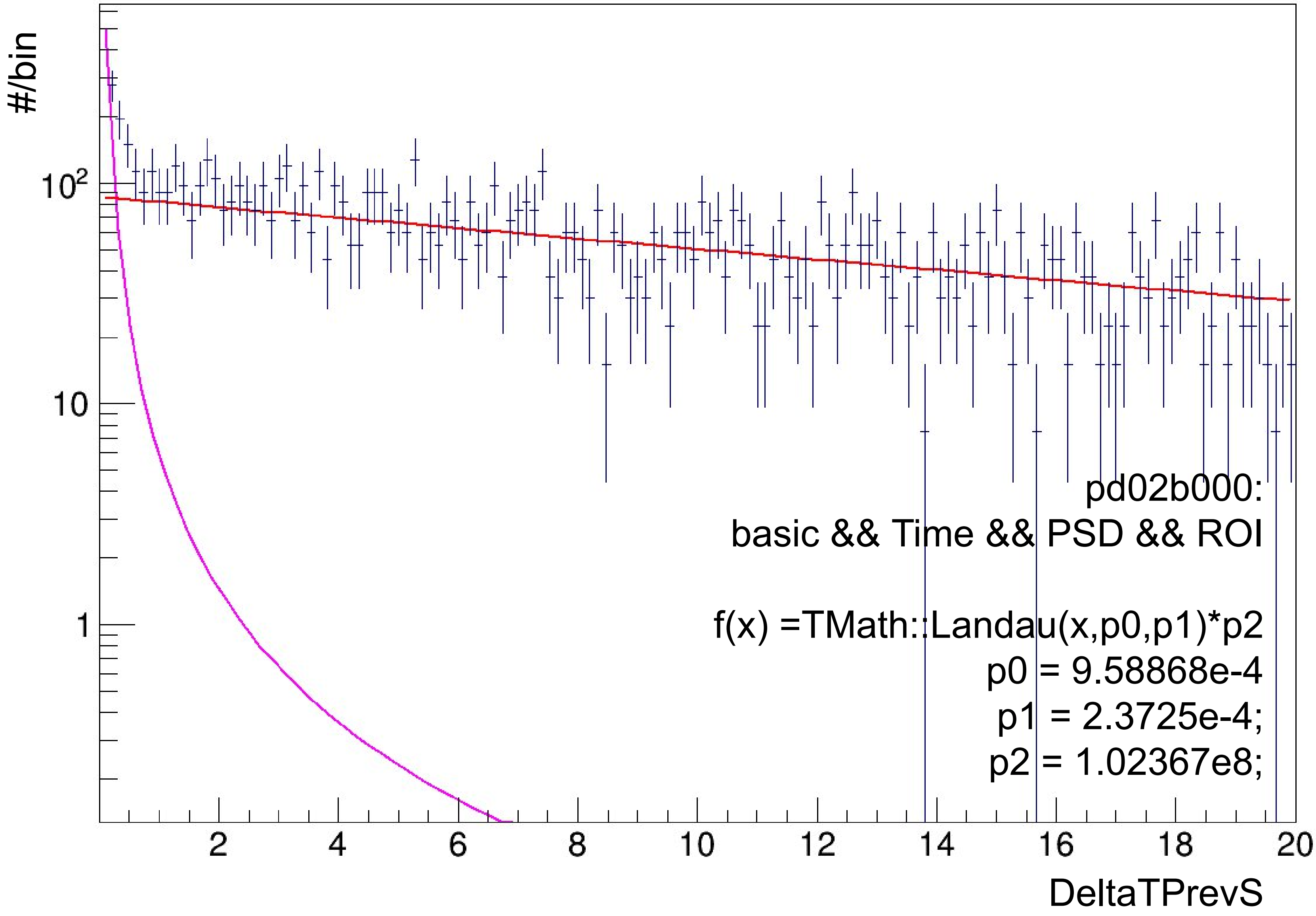
2. Fit the “normal part” of the DeltaT spectrum



3. Subtract this fit from the entire DeltaT spectrum

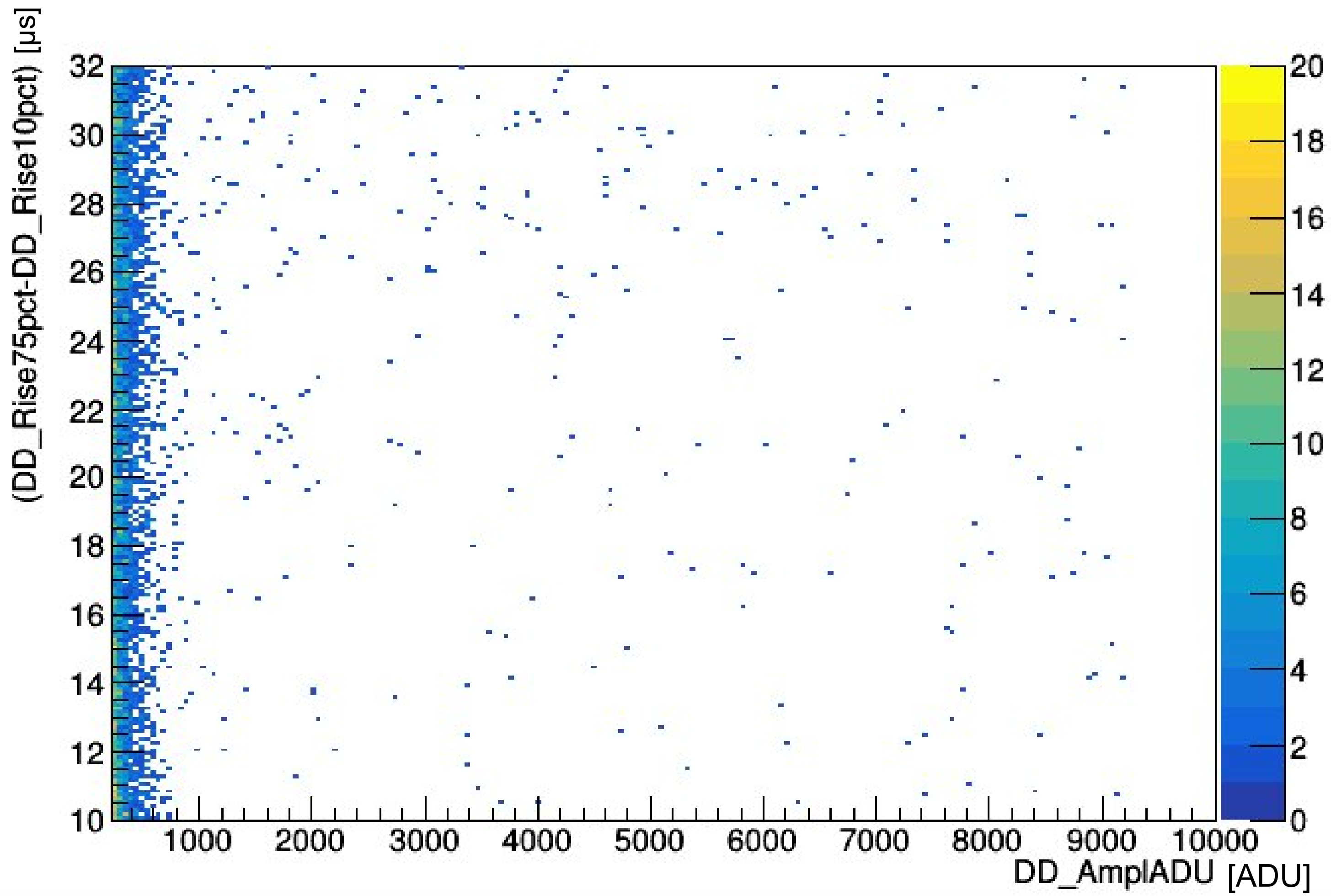


4. Fit what remains with something. It is not an exponential, but a Landau function was a reasonable fit

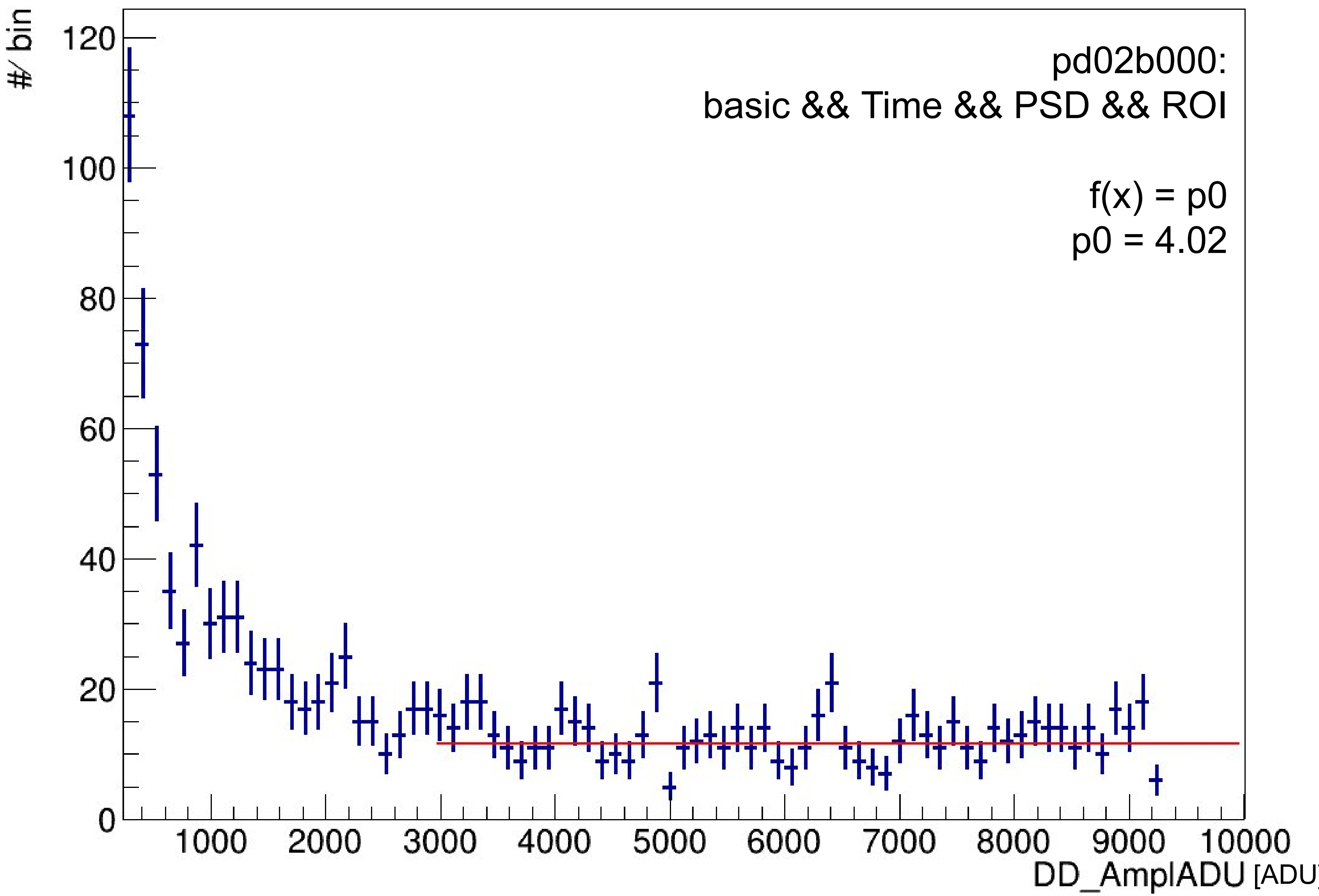


5. Integrate this fit function above the DeltaT cut (4 seconds) to estimate # of leaked events N = 617

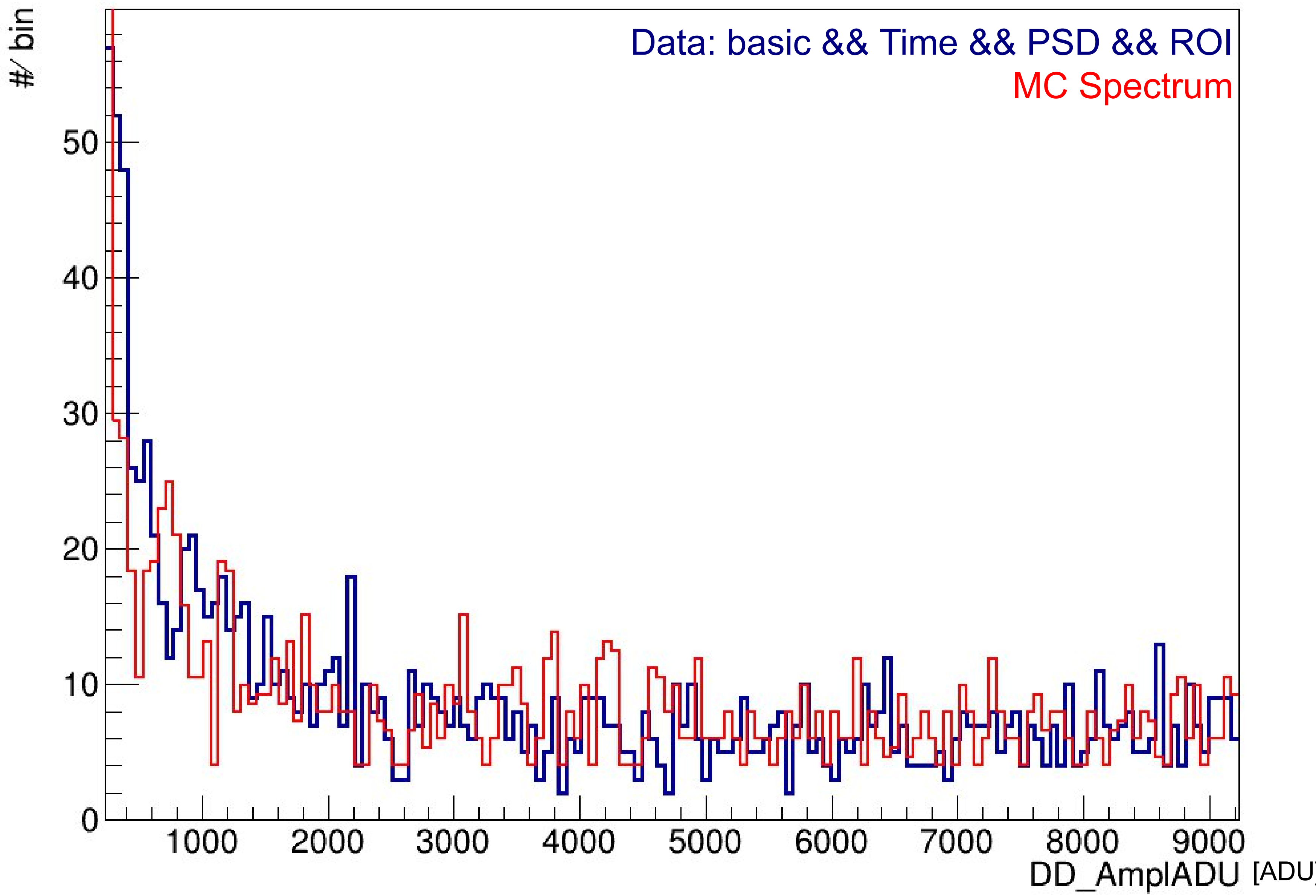
6. Draw N random events from the Risetime vs. Amplitude distribution of ROI events just below the DeltaT cut



7. Then fit the “normal part” of the ROI amplitude spectrum with a constant. Note that the number of excess events at low energy is N’ = 652



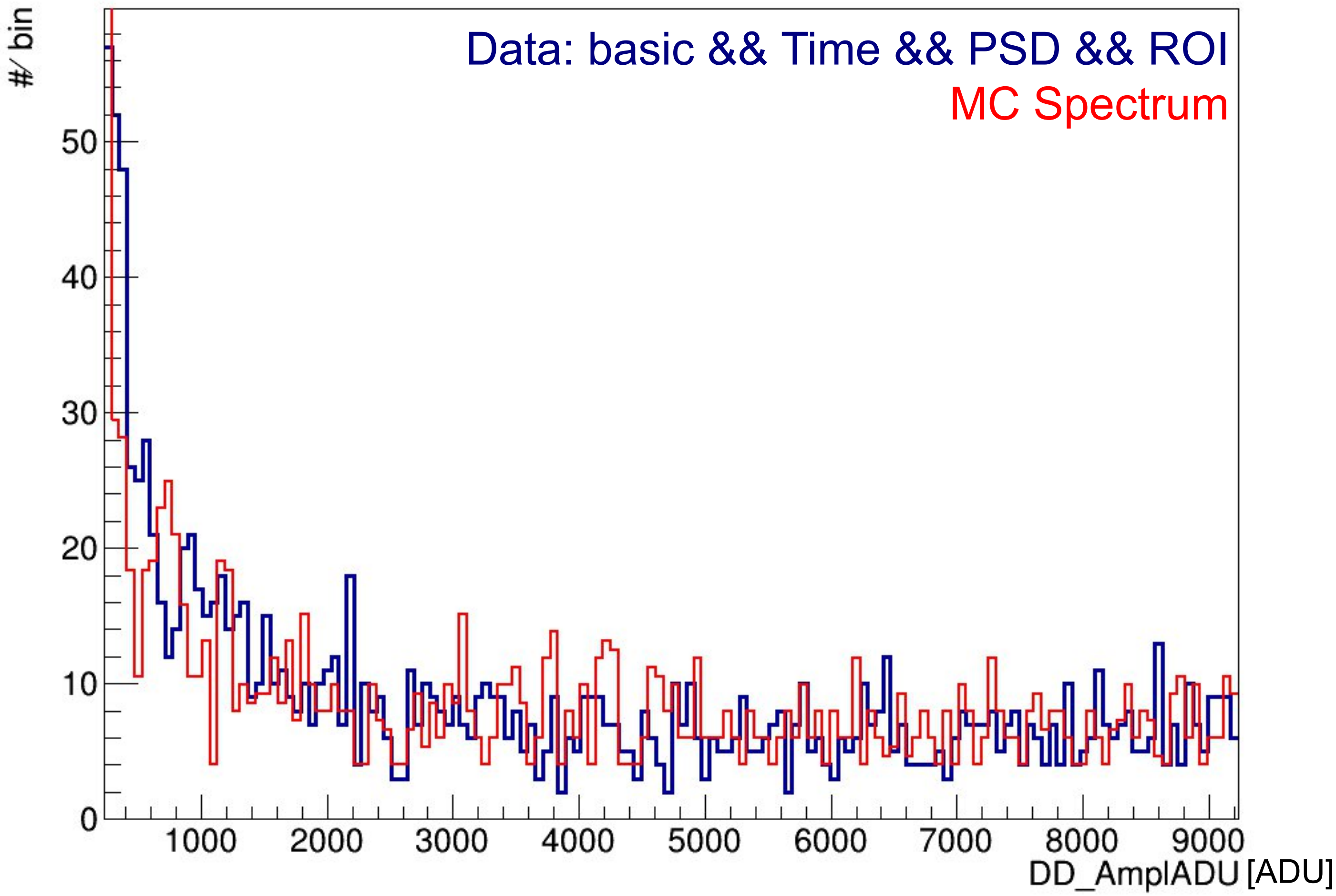
8. Then add the flat component to the constructed component:



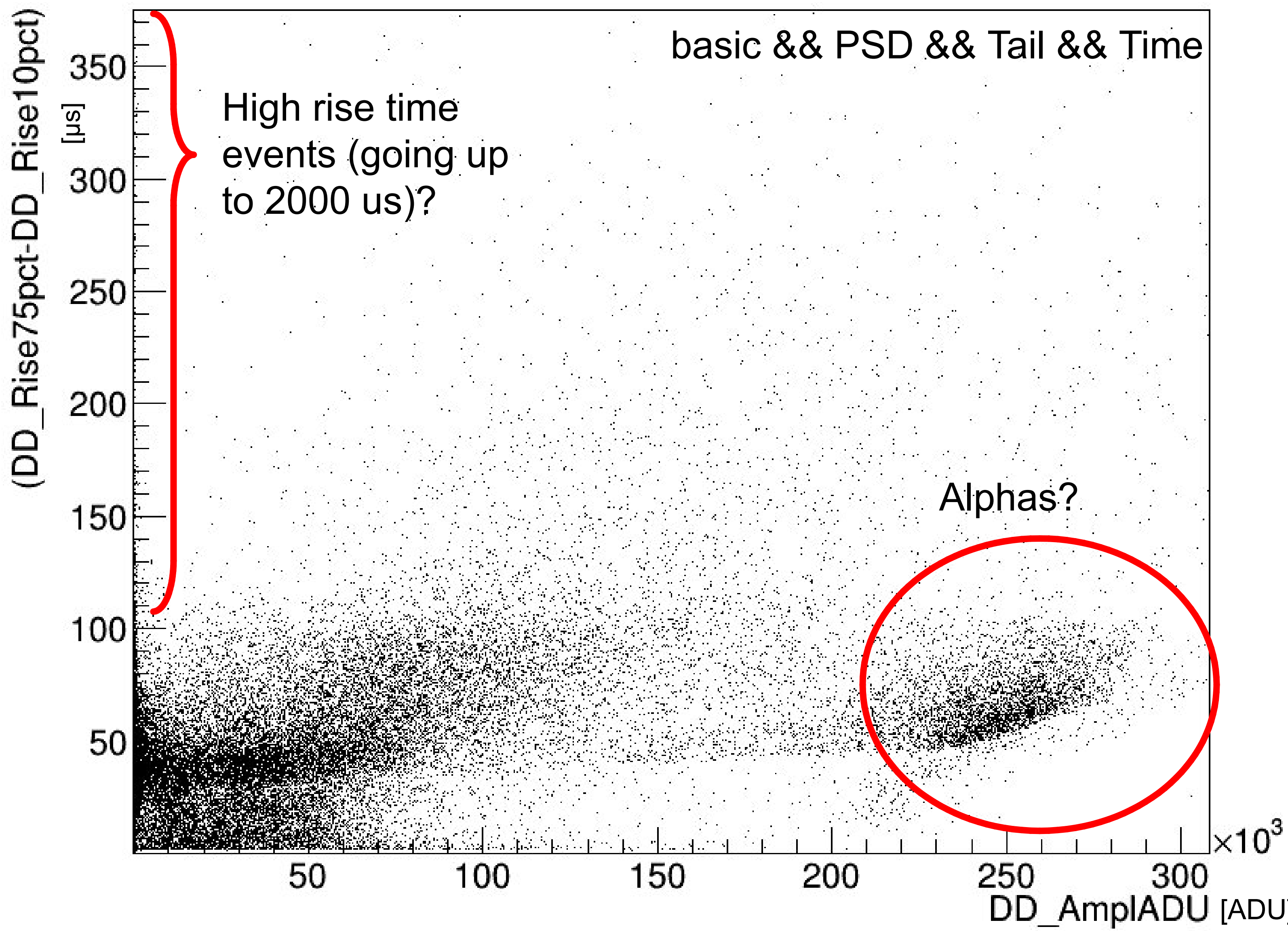
Δt cut leakage

This doesn't tell us anything about what the excess low-DeltaT events are, how to prevent them, if we'll see them again, etc.

But it does seem plausible that a leakage of these events (even above the very strong cut of 4 seconds) could account for the excess of low-energy events in the final data set

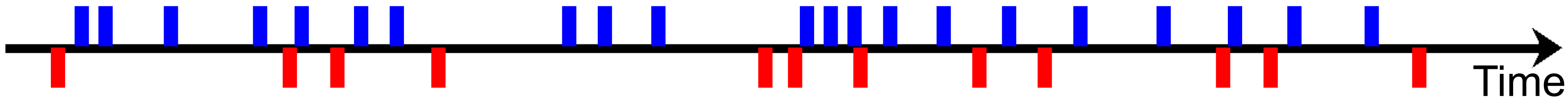


Is the mysterious background associated with a particular population?



Potential secondary events

Possible secondary events: must pass basic && Time && PSD && ROI && LowE



Possible progenitor events: must pass basic && Time && PSD && ?

Lot's of things you might want to look at:
The number/amplitude of secondary events compared to the progenitor amplitude
The Δt of the secondaries w.r.t. the progenitor
The rise-time distribution of progenitor/secondaries...

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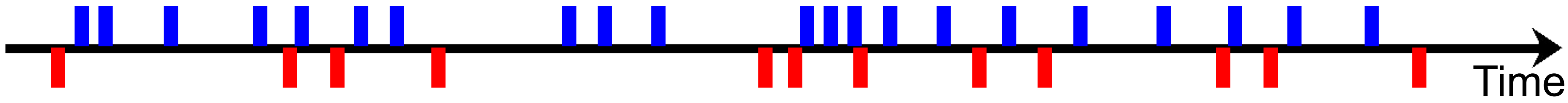

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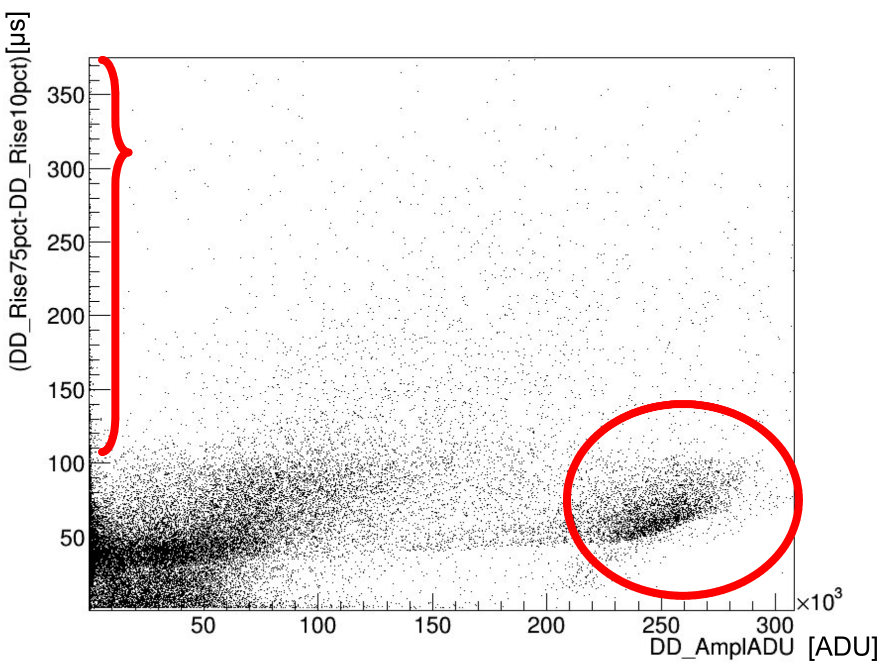
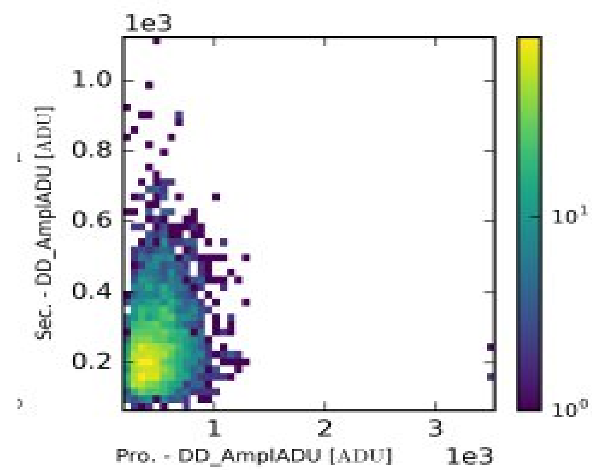
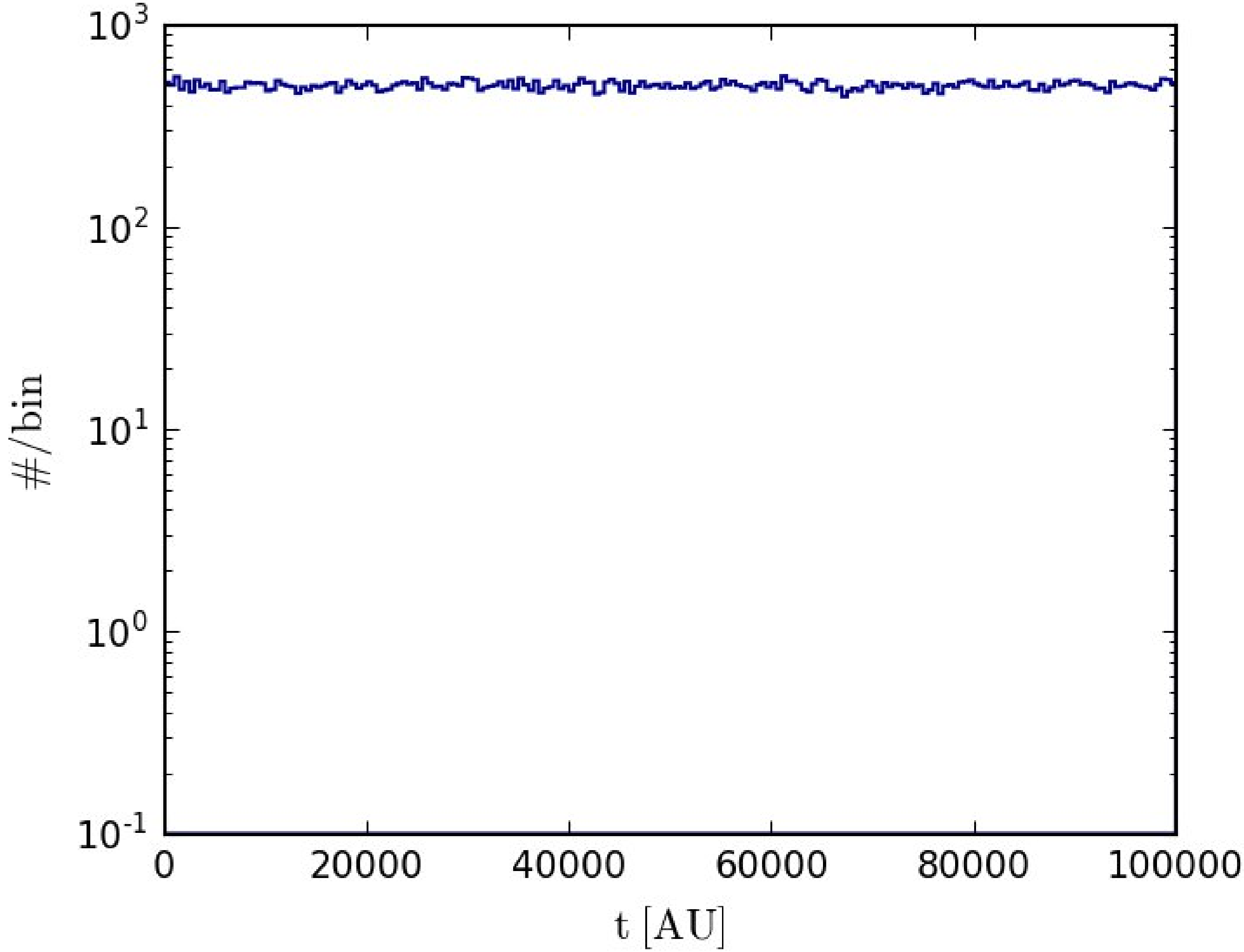


Work in progress, but some hints of correlation with high-risetime events:

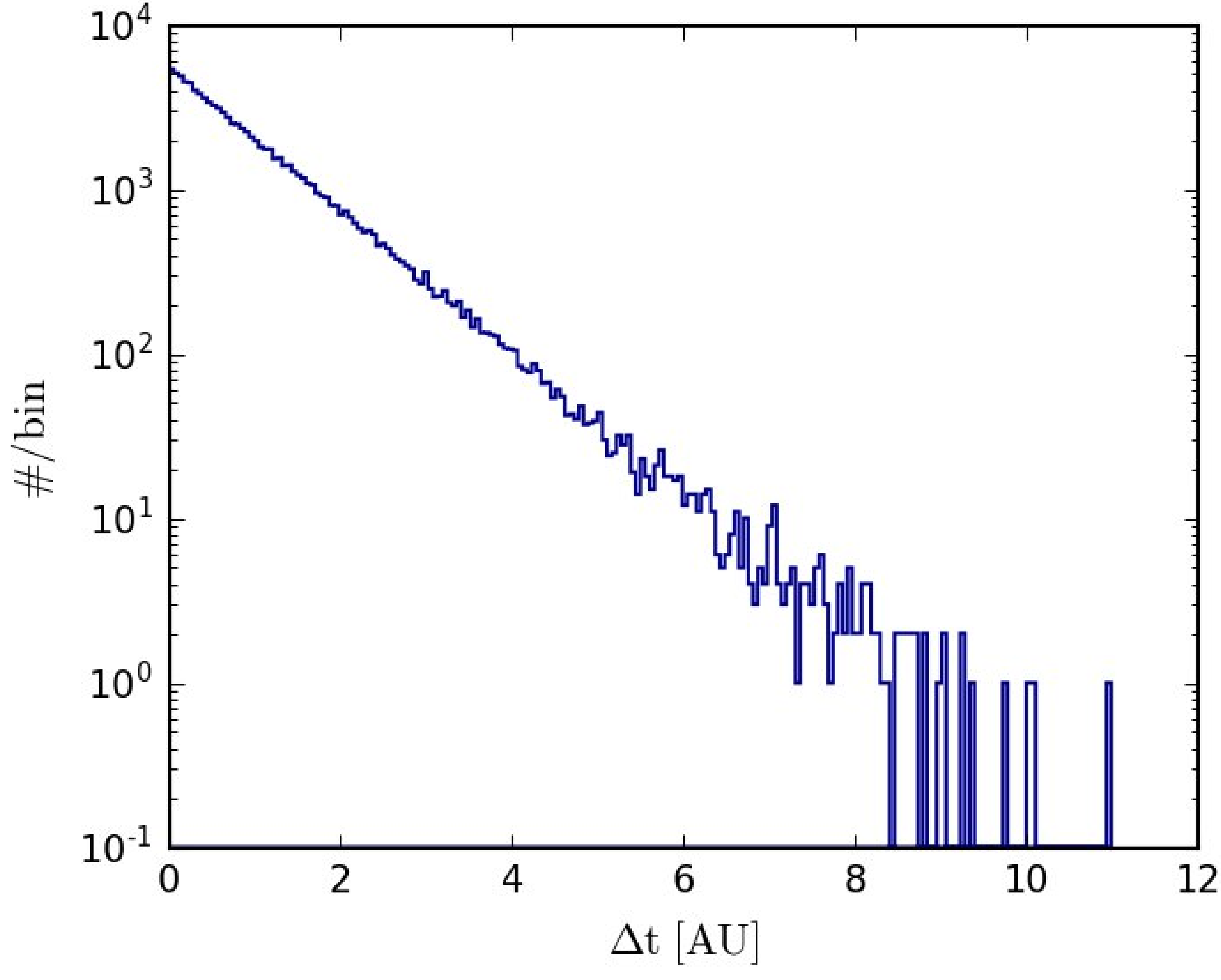


Not convinced about the implications of a “super-exponential” DeltaT plot?
Consider this toy MC...

Start with series of random “normal” events that are uniform in time...

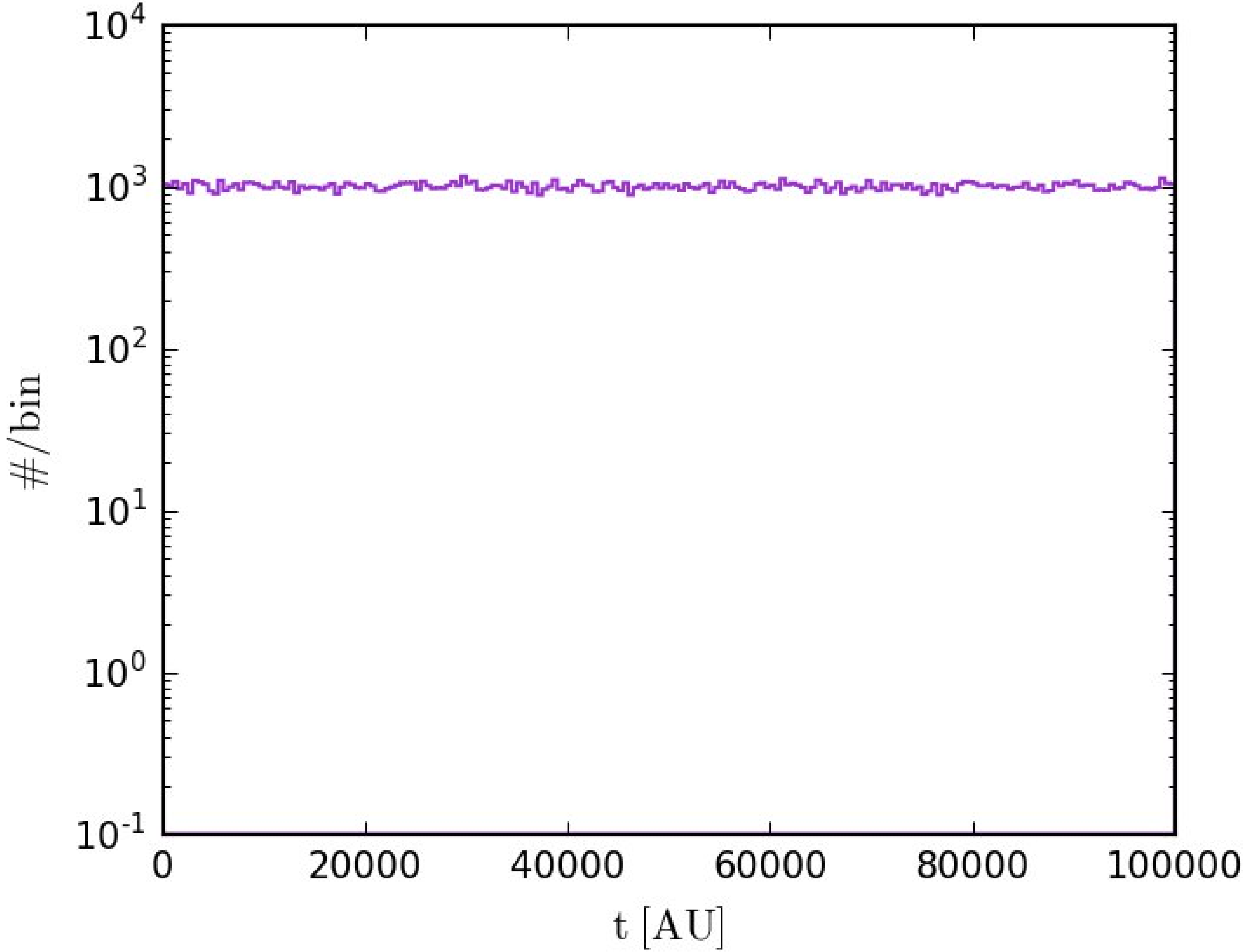


The DeltaT of these events looks exponential, as expected...



Then for each “normal” event, draw a Poissonian number of “secondary” events. For each secondary event draw an exponential event time relative to its “normal” event

They still look uniform in time but...



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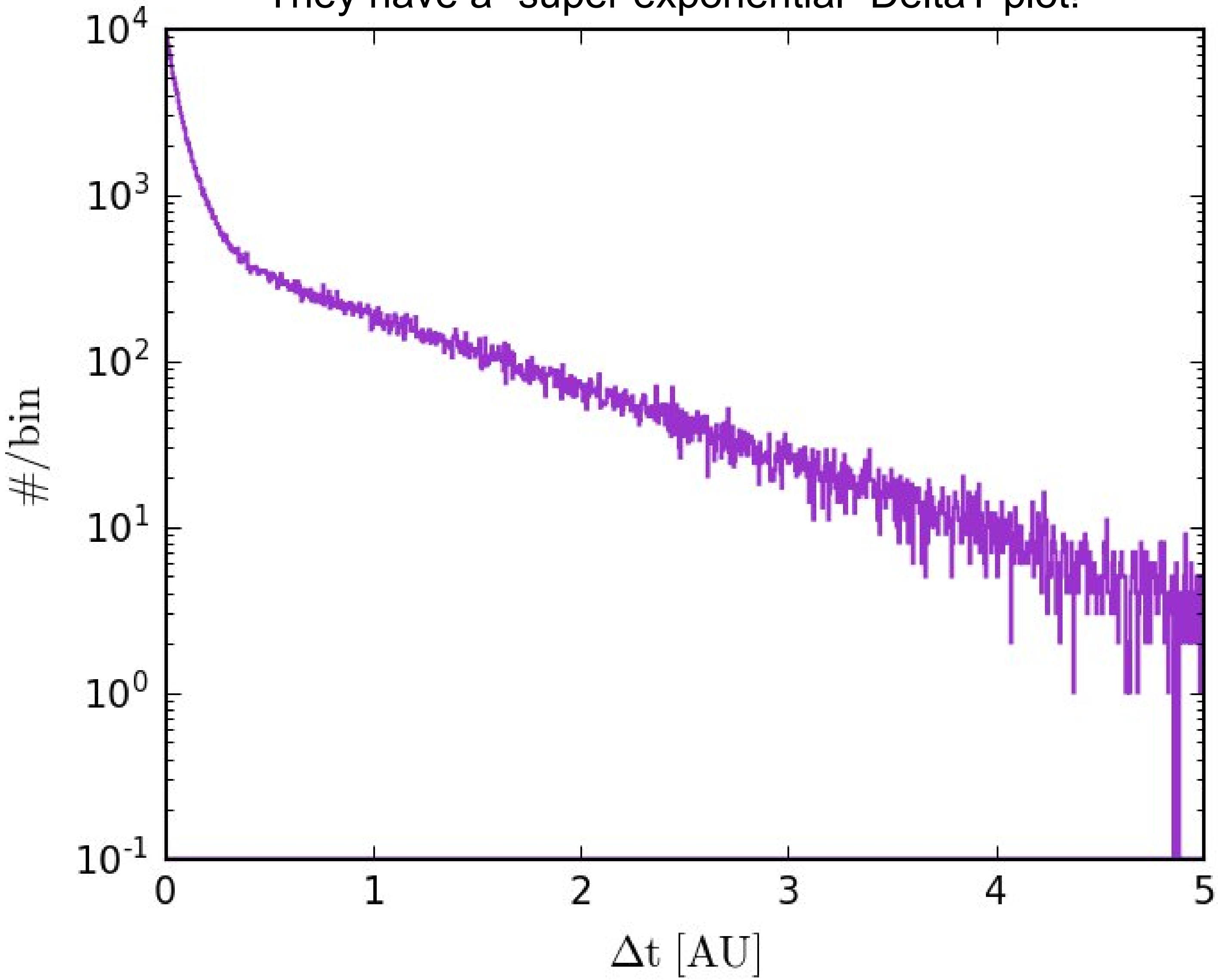
They have a “super exponential” DeltaT plot!



Python code to do this MC if you are bored on a plane:

```
import numpy as np
import matplotlib.pyplot as plt
#Data creation
A = np.random.uniform(low=0.,high=100000.,size=100000)
A = np.sort(A)
B = []
C = []
for i in range(len(A)):
   B.append(A[i])
   C.append(False)
   n = int(np.random.poisson(lam=0.5,size=1))
   for j in range(n):
      C.append(True)
      B.append(A[i]+np.random.exponential(scale=0.5,size=1))
B2 = np.ones_like(B)
for j in range(len(B)):
      B2[j] = B[j]
Dt_C = []
for i in range(len(B2)):
   if C[i] == True:
      Dt_C.append(B2[i]-B2[i-1])
Dt_C2 = np.ones_like(Dt_C)
for j in range(len(Dt_C)):
      Dt_C2[j] = Dt_C[j]
Dt_C2 = Dt_C2[:,0]
```

Python code to do this MC if you are bored on a plane:

```
#---Plots

plt.hist(A,200,log=True,histtype='stepfilled',facecolor='none',edgecolor='darkblue')
plt.xlabel('$\mathrm{t\;[AU]}$',fontsize=12)
plt.ylabel('$\mathrm{\#/bin}$',fontsize=12)
plt.show()
plt.hist(A[1:len(A)]-A[0:len(A)-1],200,log=True,histtype='stepfilled',facecolor='none',edgecolor='darkblue')
plt.xlabel('$\mathrm{\Delta t\;[AU]}$',fontsize=12)
plt.ylabel('$\mathrm{\#/bin}$',fontsize=12)
plt.show()
plt.hist(B2[1:len(B2)]-B2[0:len(B2)-1],2000,log=True,histtype='stepfilled',facecolor='none',edgecolor='darkorchid')
plt.xlim([0,5])
plt.xlabel('$\mathrm{\Delta t\;[AU]}$',fontsize=12)
plt.ylabel('$\mathrm{\#/bin}$',fontsize=12)
plt.show()
h,bins,patches=plt.hist(B2[1:len(B2)]-B2[0:len(B2)-1],2000,log=True,histtype='stepfilled',facecolor='none',edgecolor='darkorchid')
plt.hist(Dt_C2,bins,log=True,histtype='stepfilled',facecolor='none',edgecolor='forestgreen')
plt.xlim([0,5])
plt.xlabel('$\mathrm{\Delta t\;[AU]}$',fontsize=12)
plt.ylabel('$\mathrm{\#/bin}$',fontsize=12)
plt.show()
```

We still do not know what the low-energy background of SEDINE was but:

»It seems implausible that it is caused by signal processing issues or a strange class of noise events

»It seems implausible that it is a surface background, or from any single radio-active contaminant

»It does seem plausible that this phenomenon is associated with the mysterious low-Δt events - possibly some sort of after-pulsing?

»If we conclusively identify the progenitor population, a variable Δt cut would be a very effective solution

We will soon be in a position again to see if this low-energy background returns

Cut definitions for pd02b000_DD2_q03

basic = "0. < (DD_Rise75pct-DD_Rise10pct) && 0. < DD_Ampl && 0. < DD_RawRise && 0. < DD_RawWidth && DD_ThresholdStop == 0.5"

DT = "DeltaTPrevS > 4."

ROI = "10 < (DD_Rise75pct-DD_Rise10pct) && (DD_Rise75pct-DD_Rise10pct) < 32 && 231 < DD_AmplADU && DD_AmpADUl < 9234"

Loose = "100. < DD_AmplADU && DD_AmplADU < 20000. && 0. < (DD_Rise75pct-DD_Rise10pct) && (DD_Rise75pct-DD_Rise10pct) < 60.";

PSD = "9.8 < DD_RawRise && DD_RawRise < 200. && 86 < DD_RawWidth && DD_RawWidth < 200. && (94 < DD_RawWidth && DD_RawRise < 13)"

Time = "(0. < Time && Time < 550e3) || (590e3 < Time && Time < 640e3) || (670e3 < Time && Time < 980e3) || (1000e3 < Time && Time < 1060e3) || (1080e3 < Time && Time < 1680e3) || (1700e3 < Time && Time < 1830e3) || (1870e3 < Time && Time < 2180e3) || (2340e3 < Time && Time < 2850e3) || (2990e3 < Time && Time < 3320e3) || (3340e3 < Time && Time < 3400e3) || (3420e3 < Time && Time < 3650e3)";

PopDT = “DD_RealStopTime < 2000 || DD_RealStopTime > 2200"