

# SPS test beam analysis:

## Efficiency for SC, CMS-Si and pCVD detectors

SIC LAB WEEKLY

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# Efficiency calculation

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- Tracking cuts on the data, keep only well reconstructed events

$$\text{Efficiency} = \frac{1}{N_{bins}} \sum_{N_{bins}} \frac{\text{N hits in bin where (peak signal} > \text{threshold)}}{\text{N hits in bin}}$$

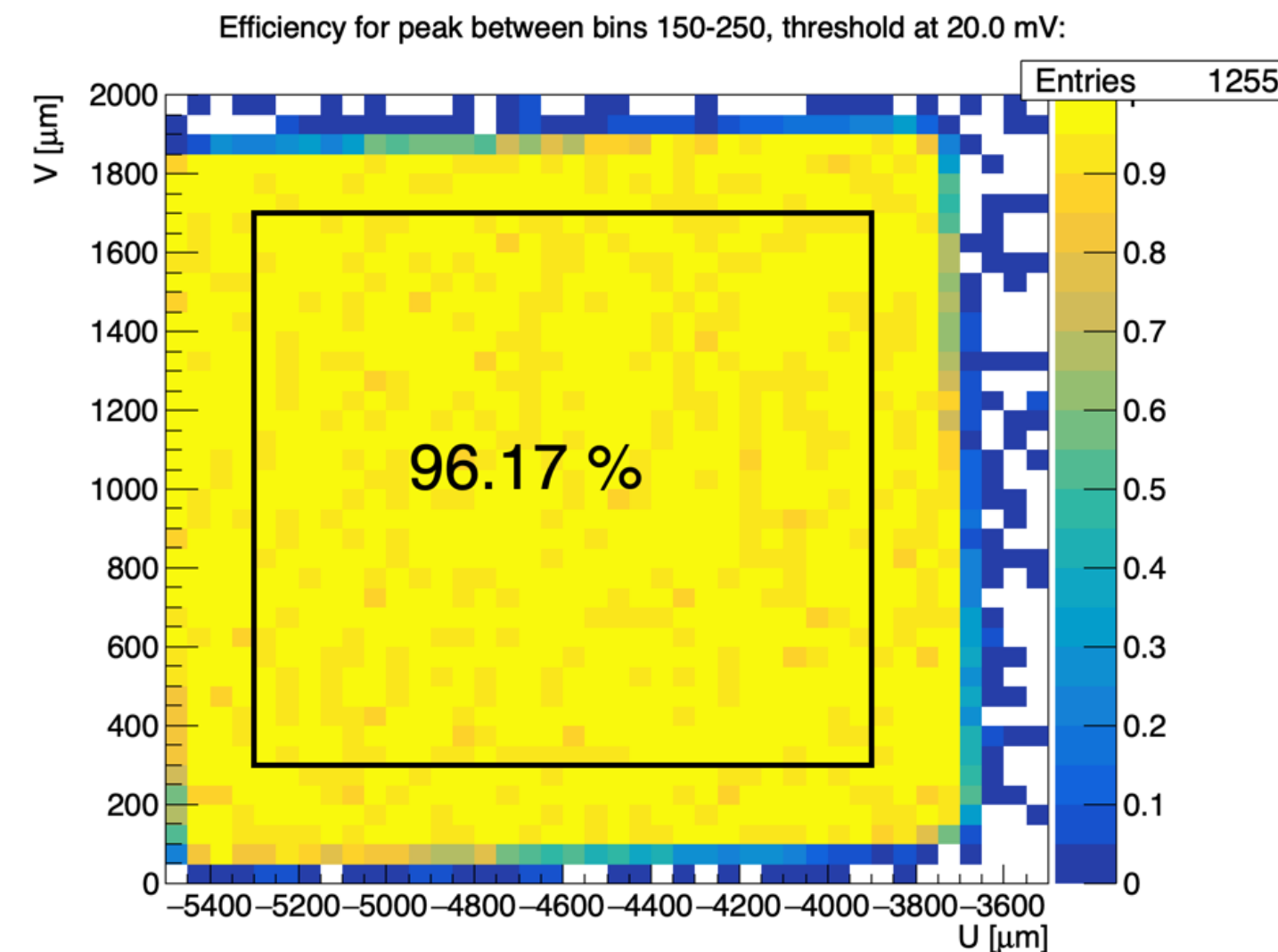
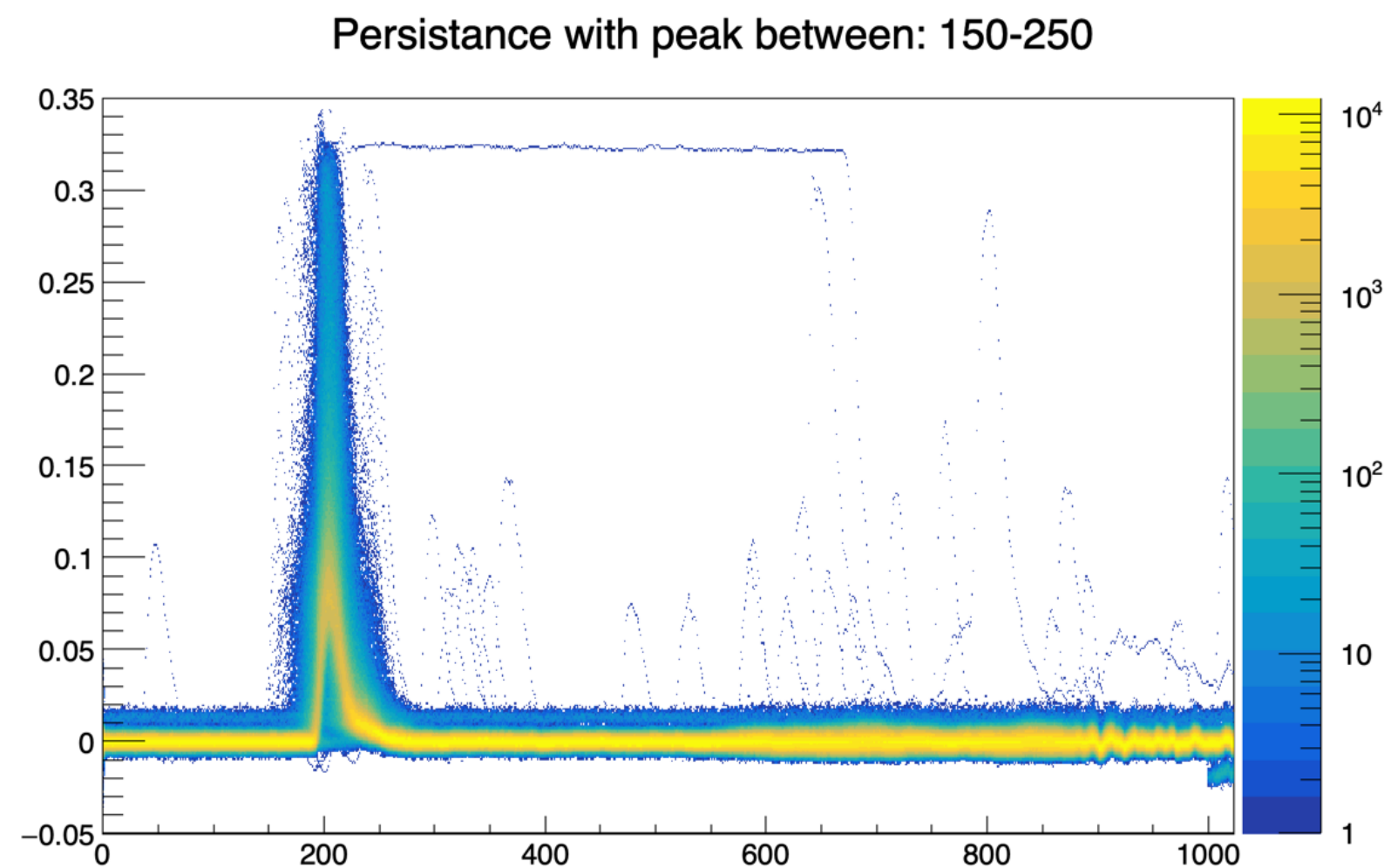
- Peak signal is determined in some time range based on the trigger

➡ Threshold = Desired analog signal value in mV, can be determined based on noise, HighT, LowT..

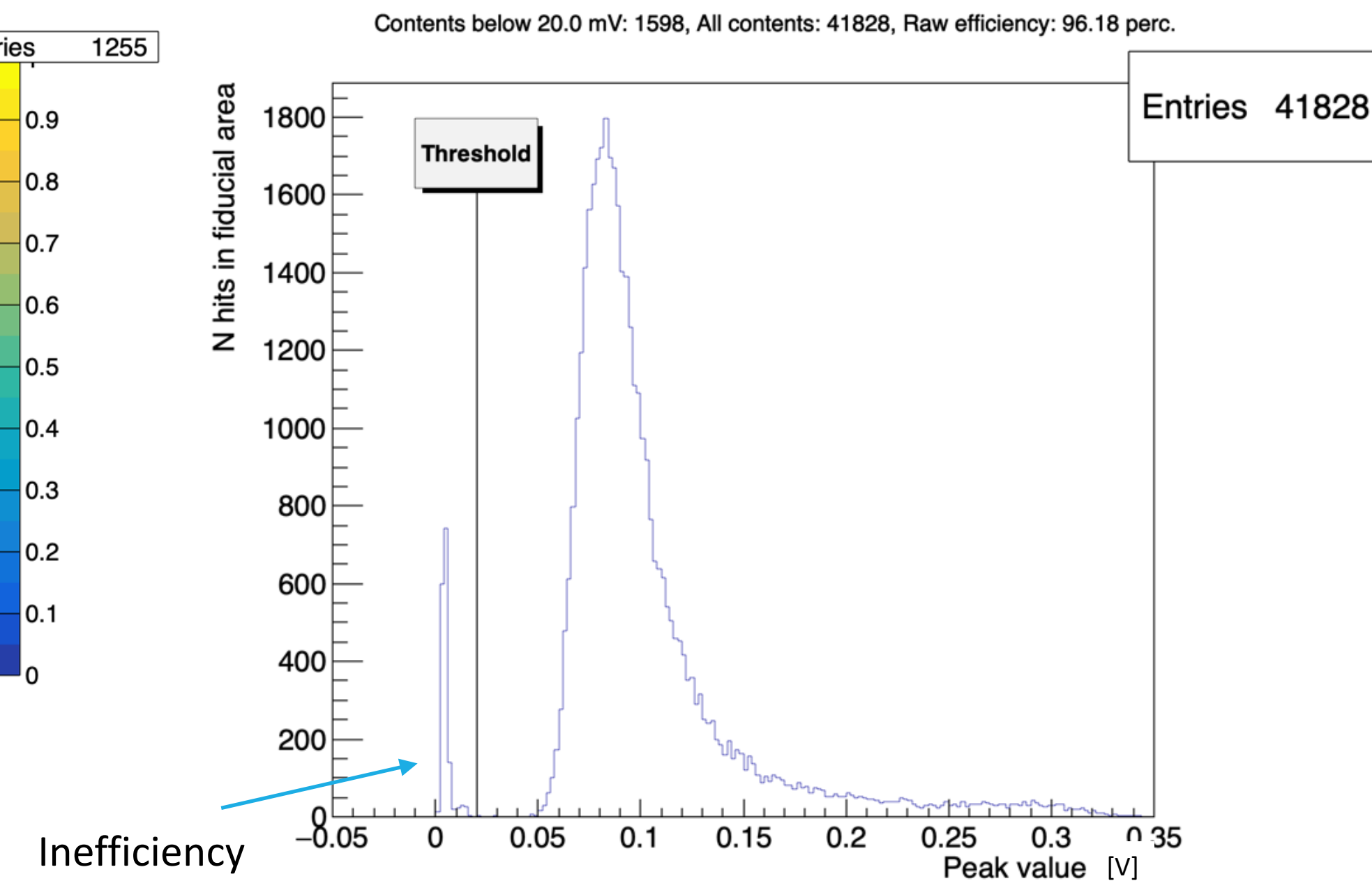
# CMS-Si analog efficiency

- Peak value is determined between DRS bins 150-250 (37.5 ns - 62.5 ns), where we expect the signals, most of them peak here
- Threshold for efficiency set at 20 mV, which equals around  $10\sigma$  ( $\sigma = 1.99$  mV)
- Example: run200073, -300 V, Fast-discharge enabled

Added waveforms of events that peak within the selected range

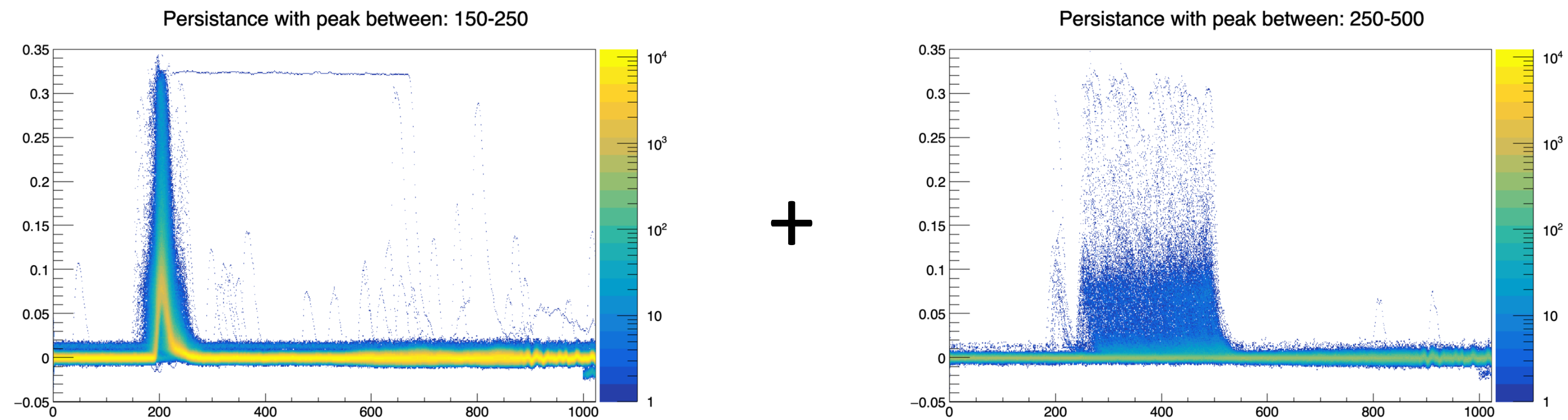


Distribution of signal peaks within the 150-250 DRS bin region



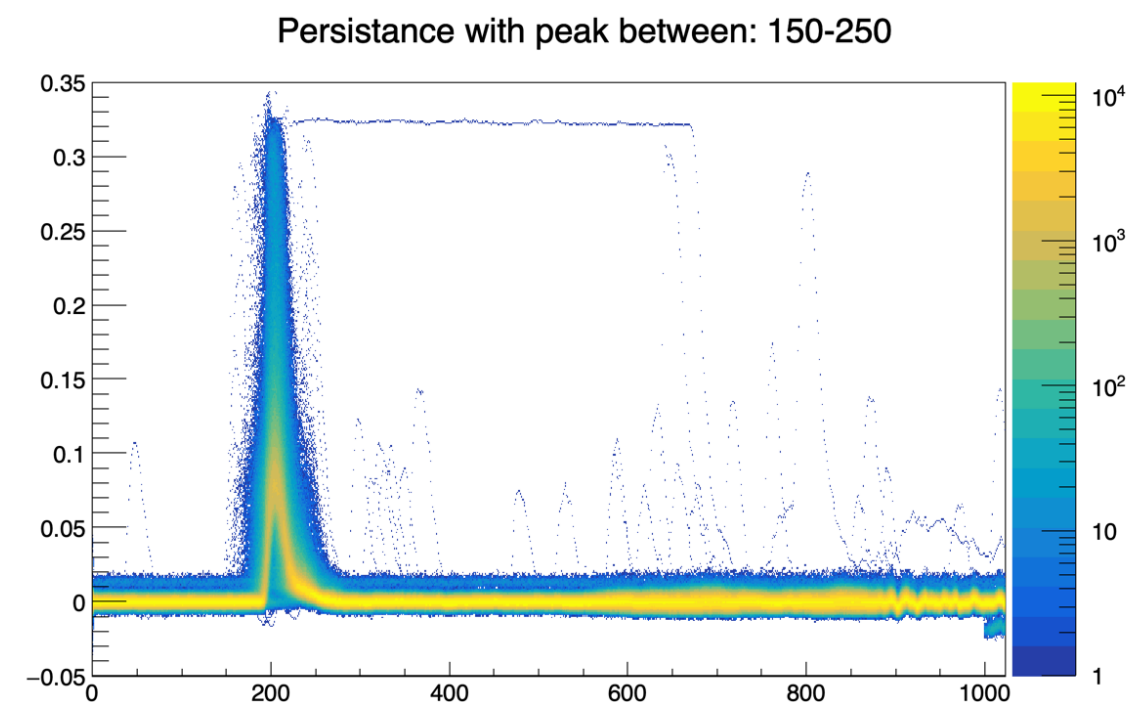
# CMS-Si analog efficiency

- What about unsynchronised waveforms and peaks, a relatively large number of waveforms have peaks between DRS bins 250-500 (62.5 ns - 115 ns).
- All test beam runs for various configurations have around 3% of such waveforms, which peaks between DRS bins 250-500.
- These unsynchronised waveforms should not be a consequence of Calypso unsynchronisation, but rather the telescope and trigger artefacts.

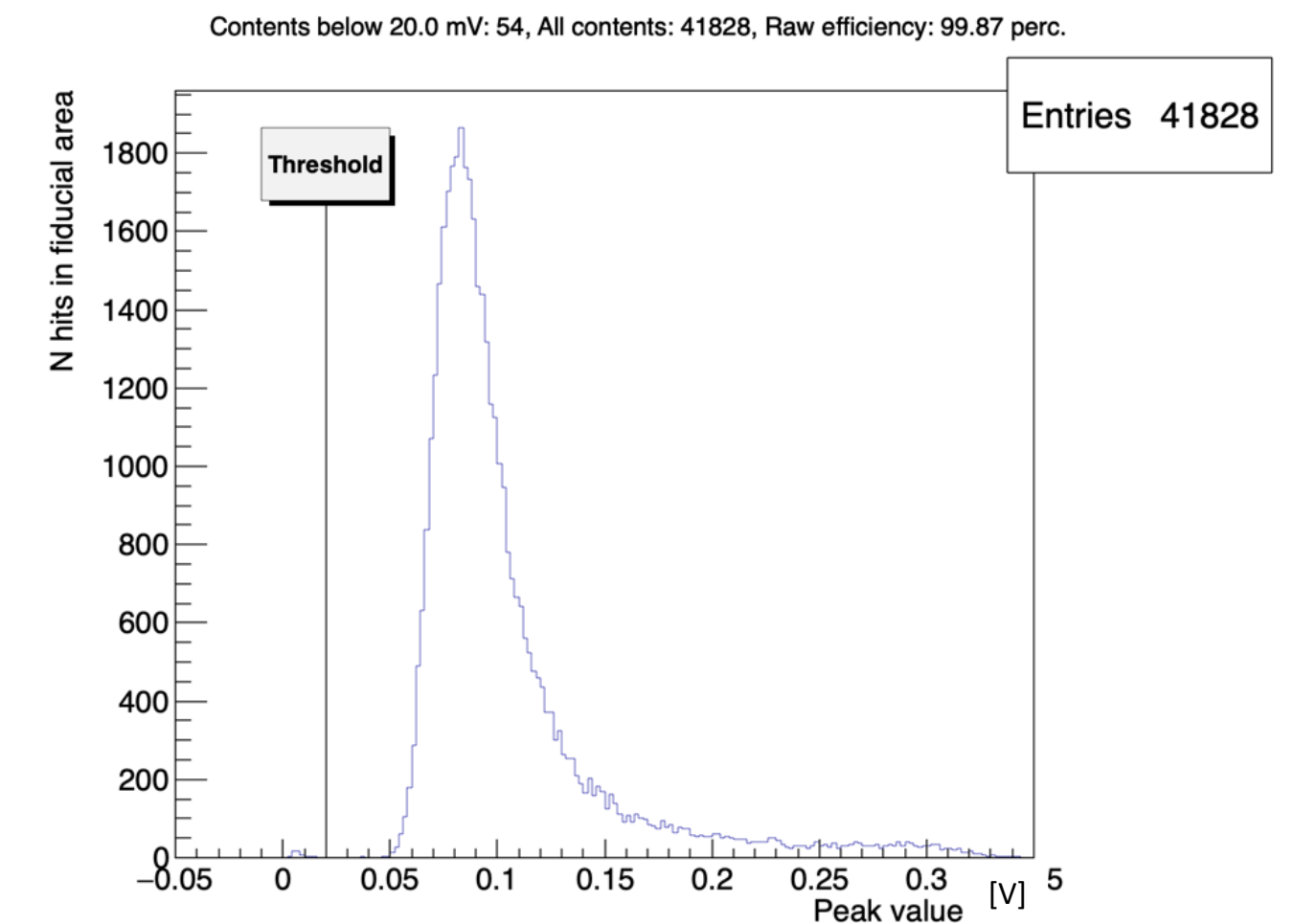
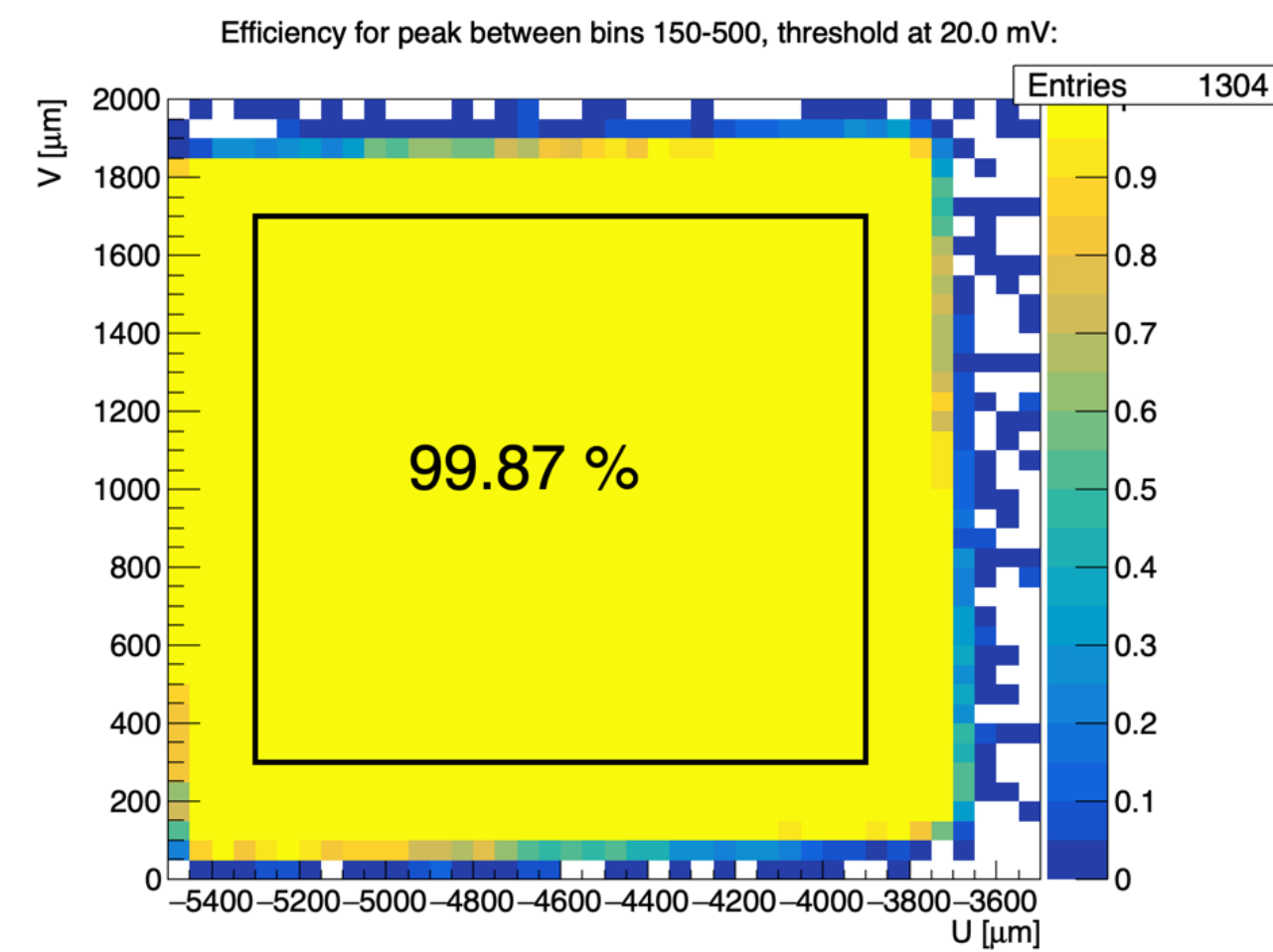
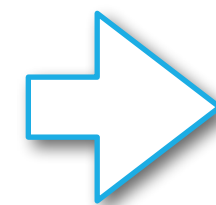
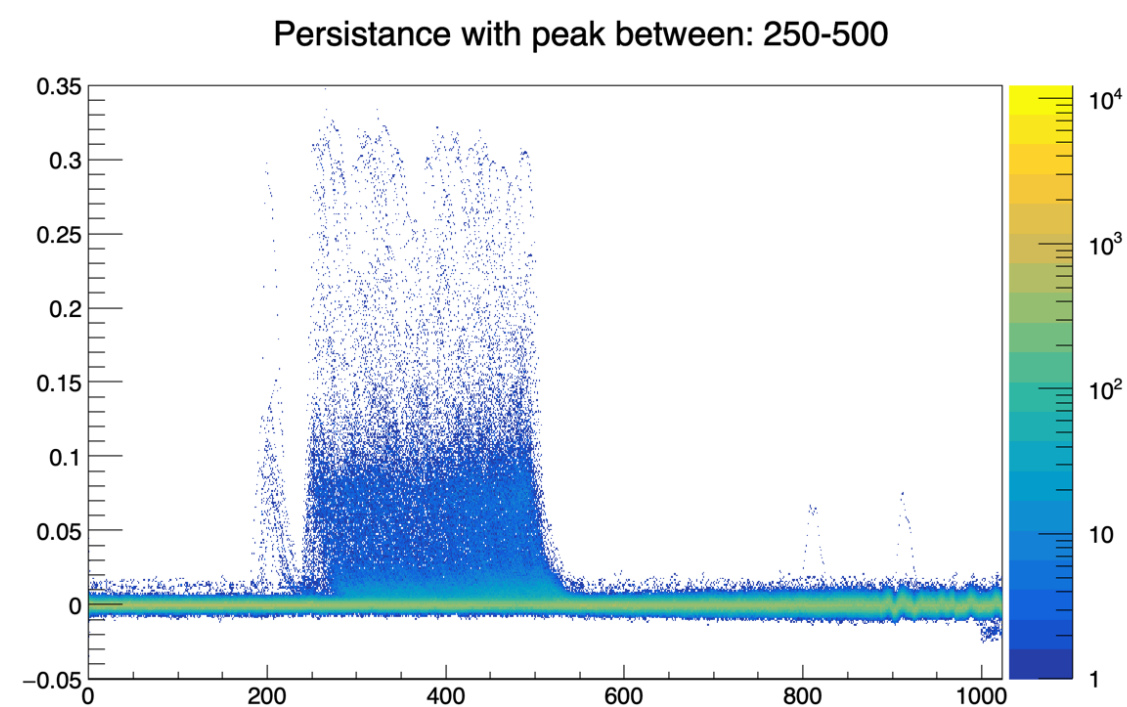


# CMS-Si analog efficiency

- Increase the range where we look for signal peak, now between DRS bins 150-500 (37.5 ns - 115 ns), to include “late” signals
- Threshold kept at 20 mV, which equals around  $10\sigma$
- Example: run200073, -300 V, Fast-discharge enabled
- Efficiency rises to 99.87% !



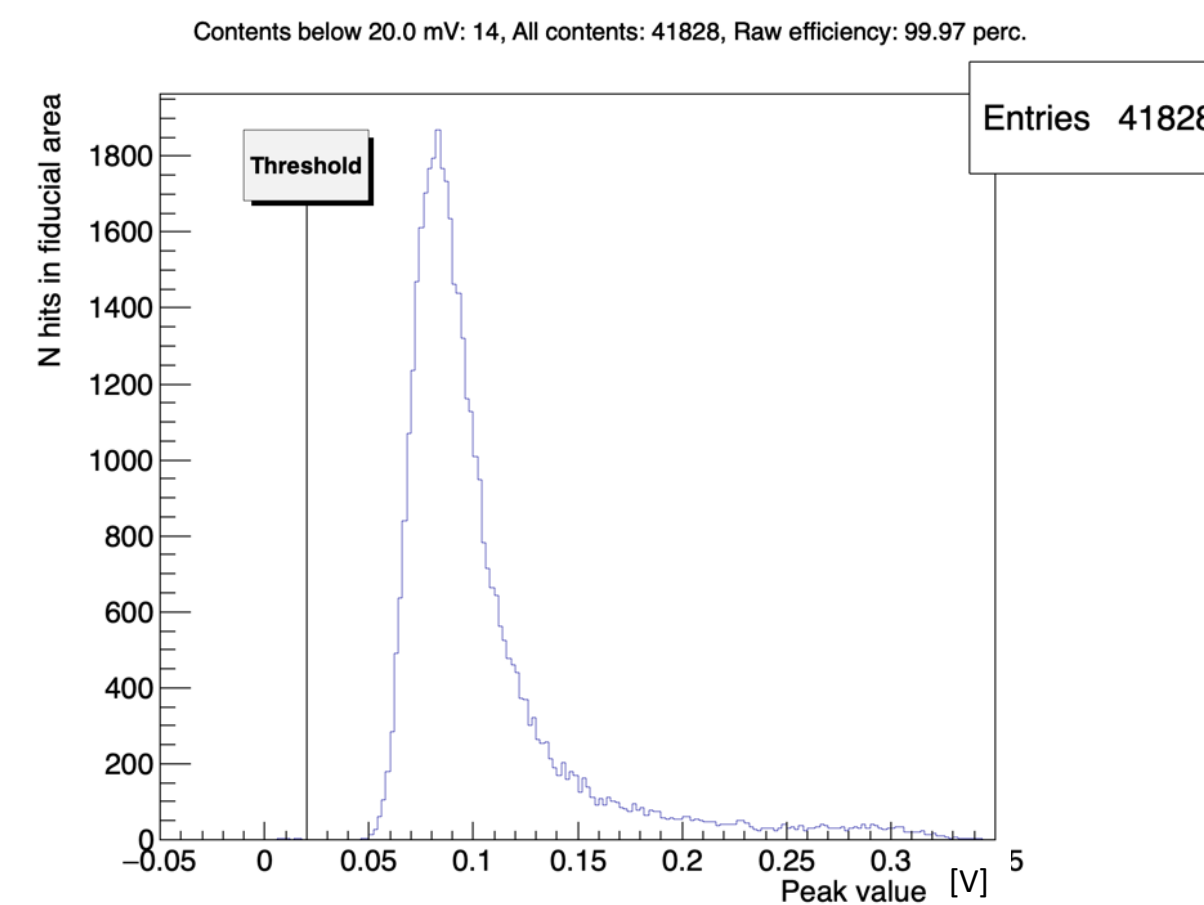
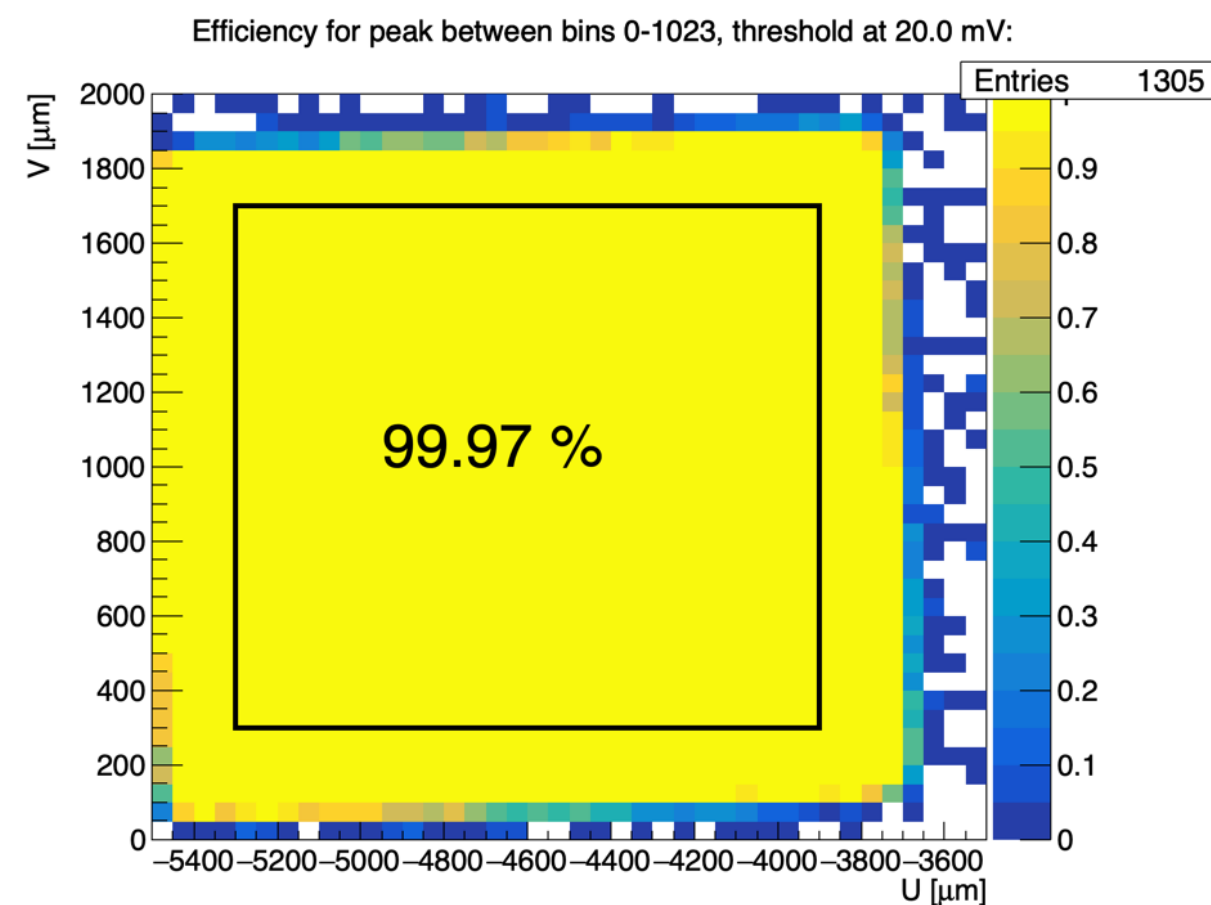
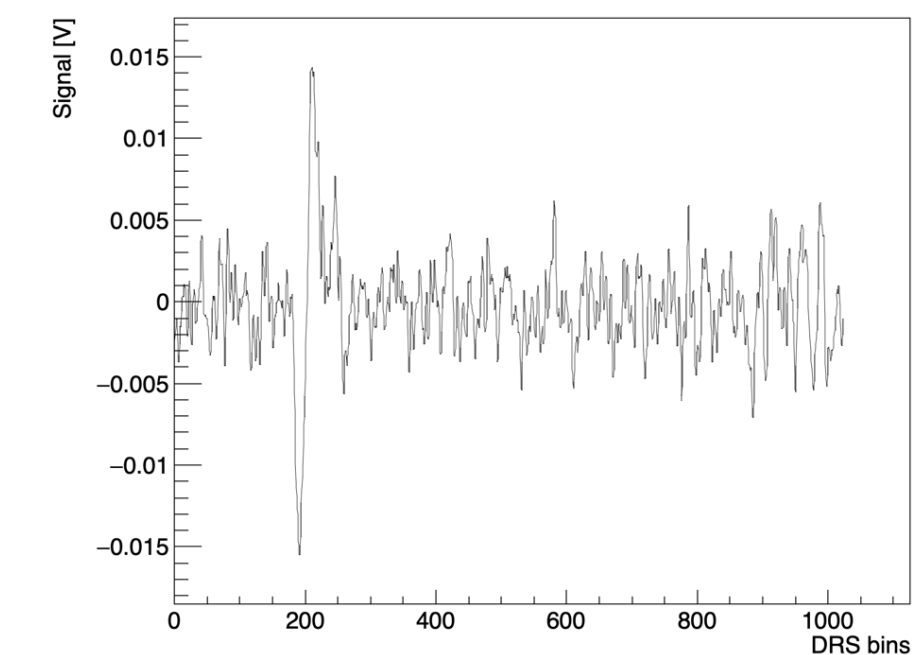
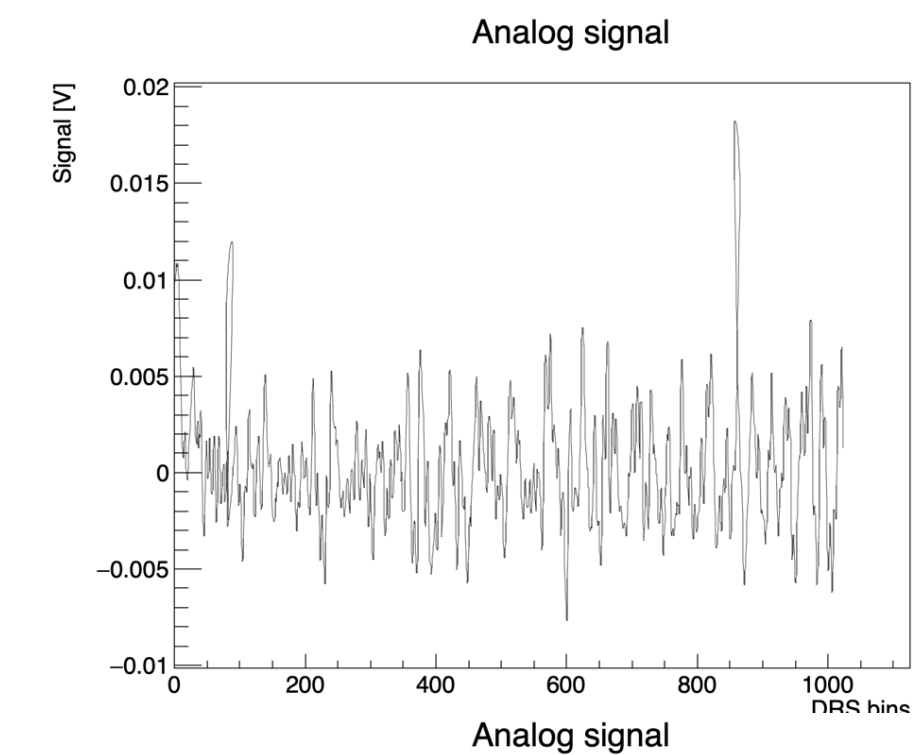
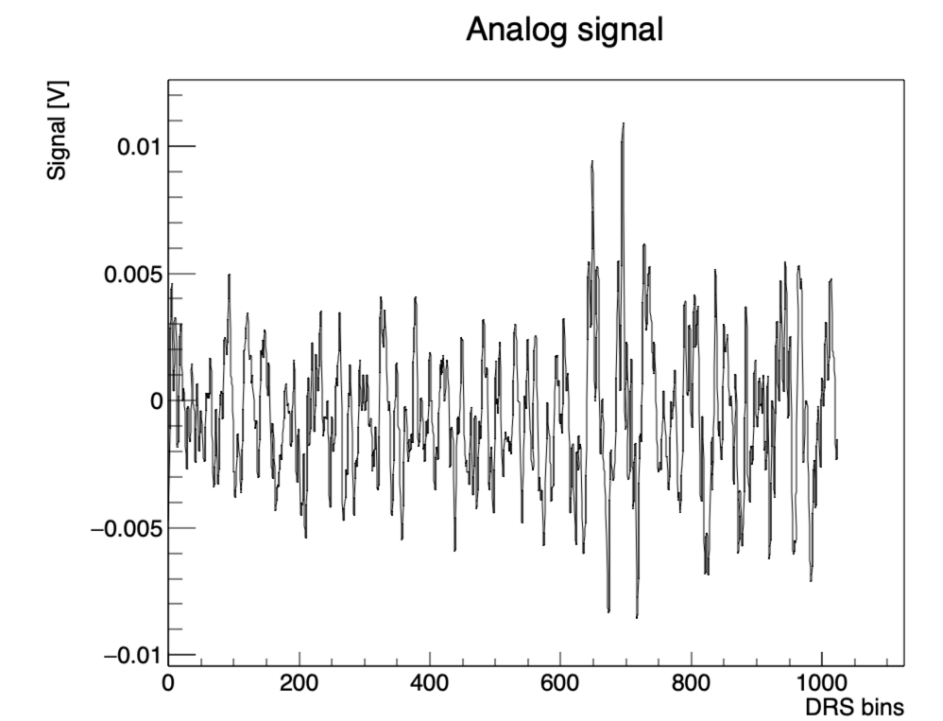
+



# CMS-Si analog efficiency

- Range where we determine the peak now increased to entire waveform, DRS bins 0-1023
- Threshold at 20 mV, which equals around  $10\sigma$
- Example: run200073, -300 V, Fast-discharge enabled
- Efficiency rises to 99.97%, only 14 events out of 41828 don't have a signal over threshold!

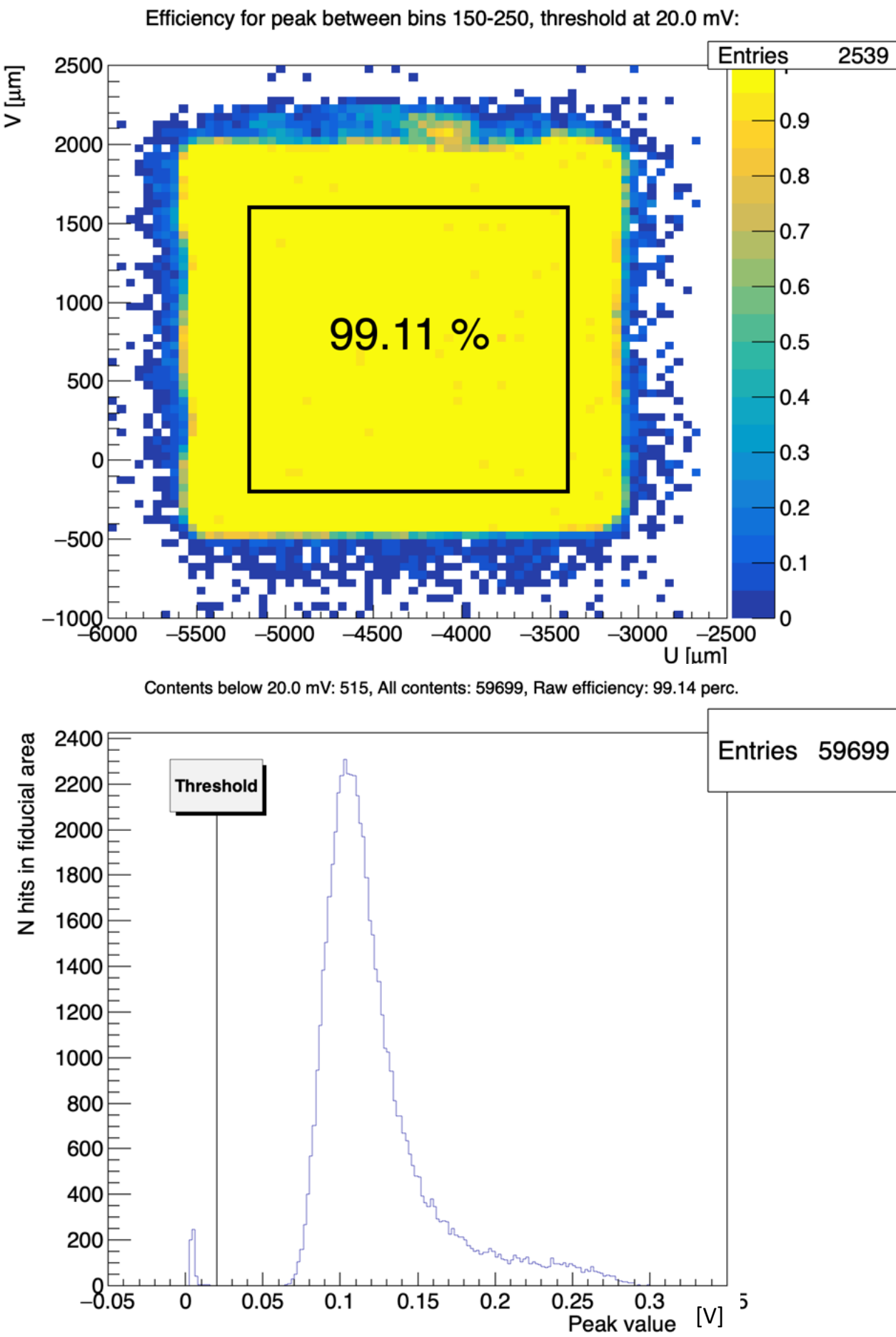
Examples of inefficient events:



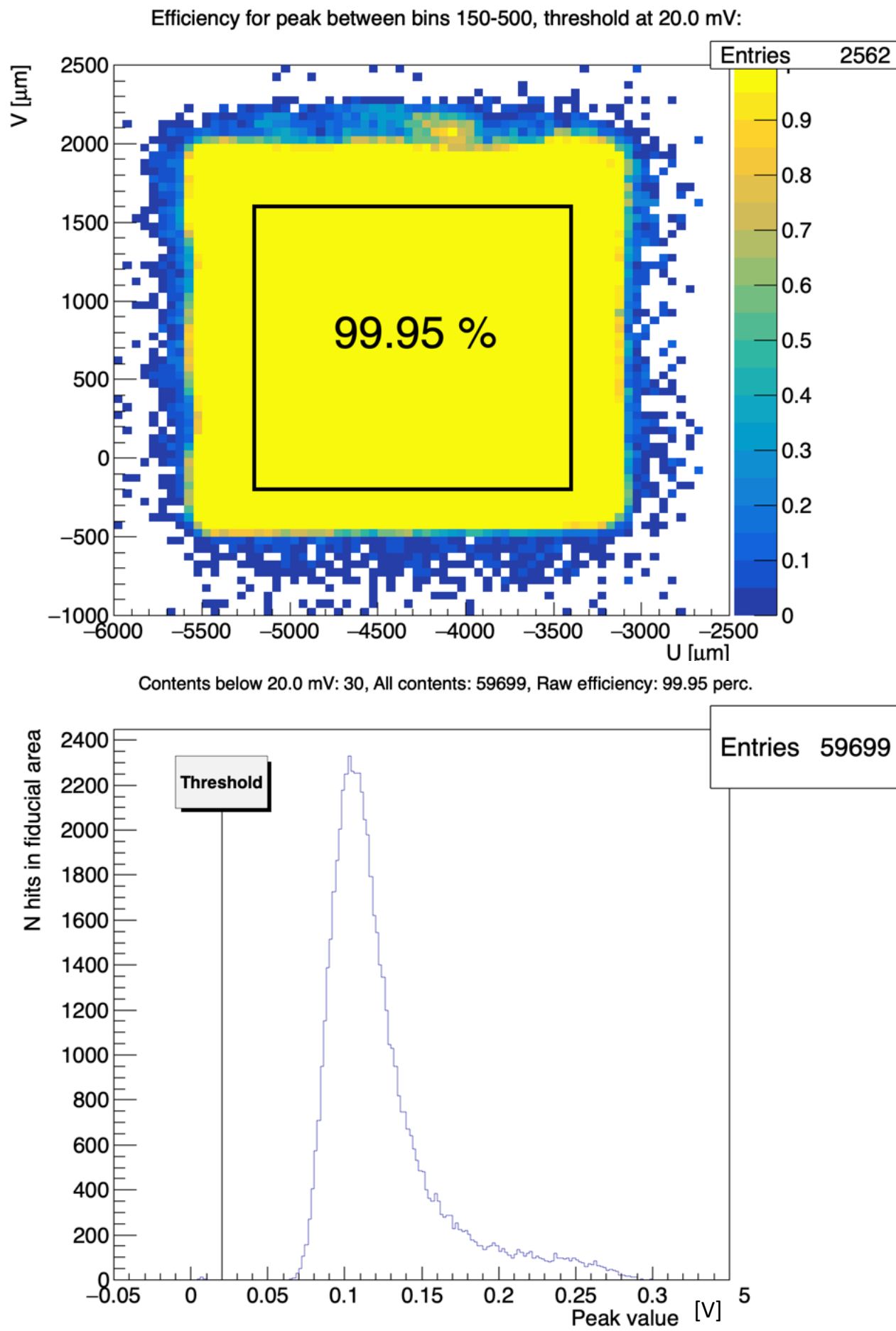
# SingleCrystal analog efficiency

- Run200021, -500 V, threshold = 20 mV (around  $10\sigma$ )

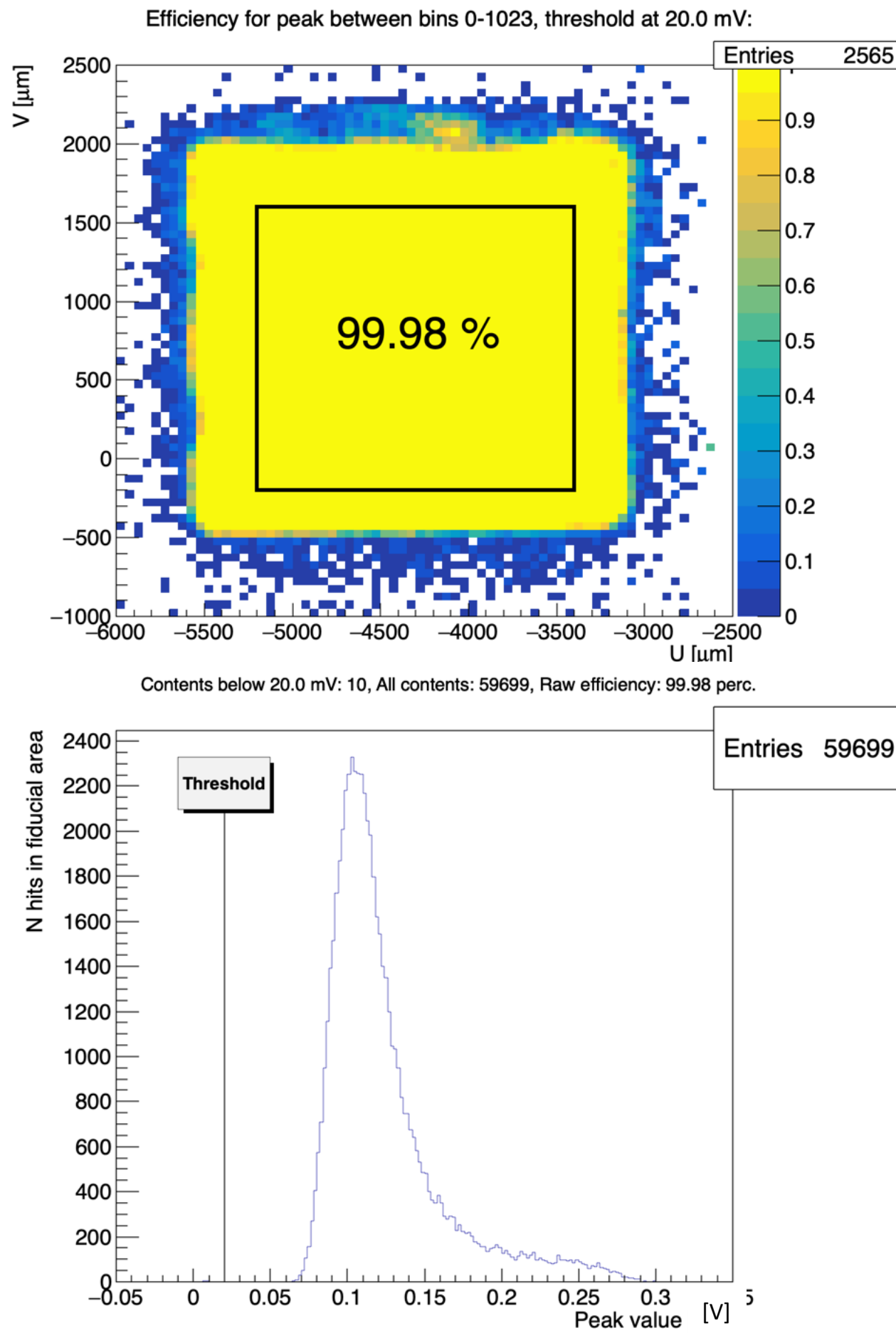
Only peaks between DRS bins 150-250:



Peaks between DRS bins 150-500:



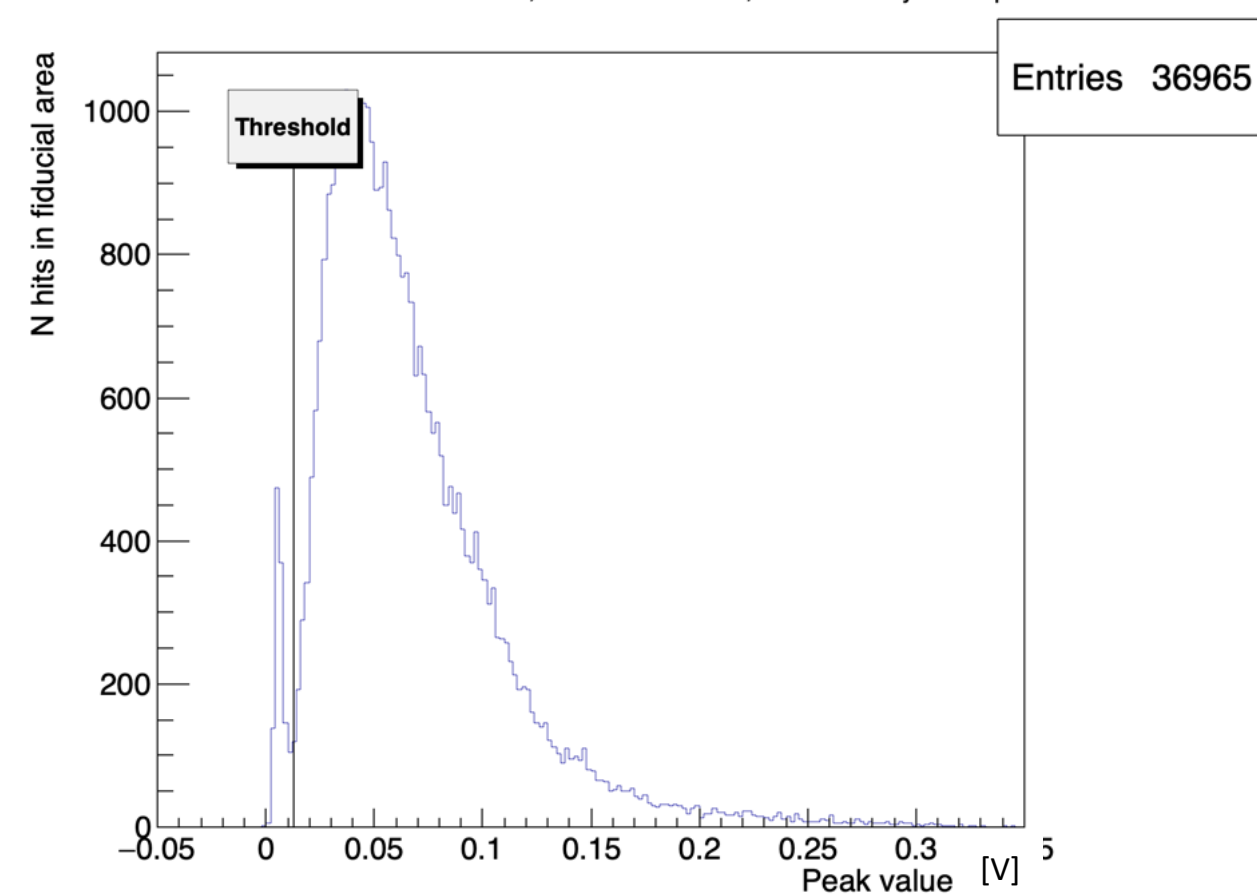
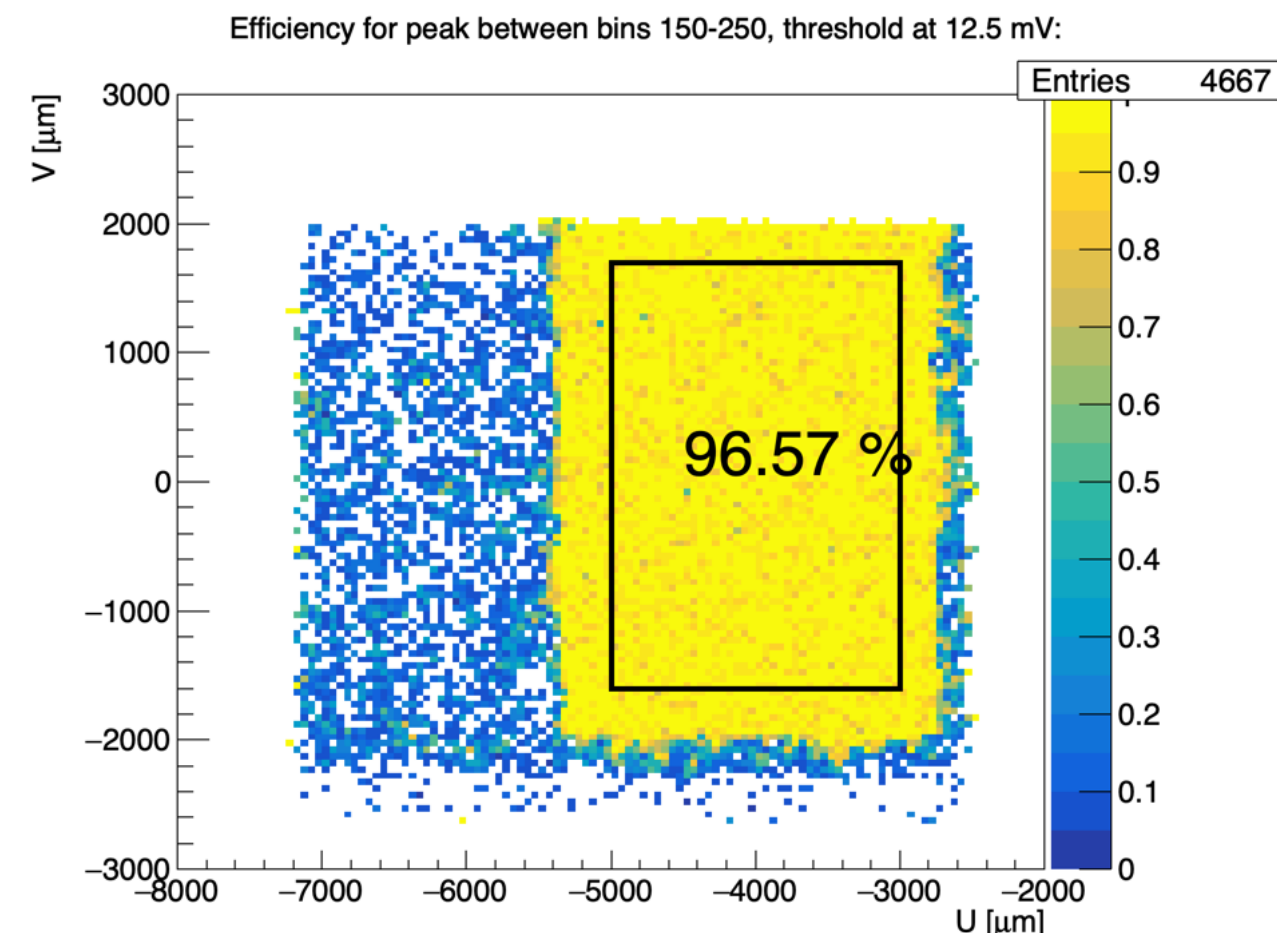
Peaks anywhere in the waveform



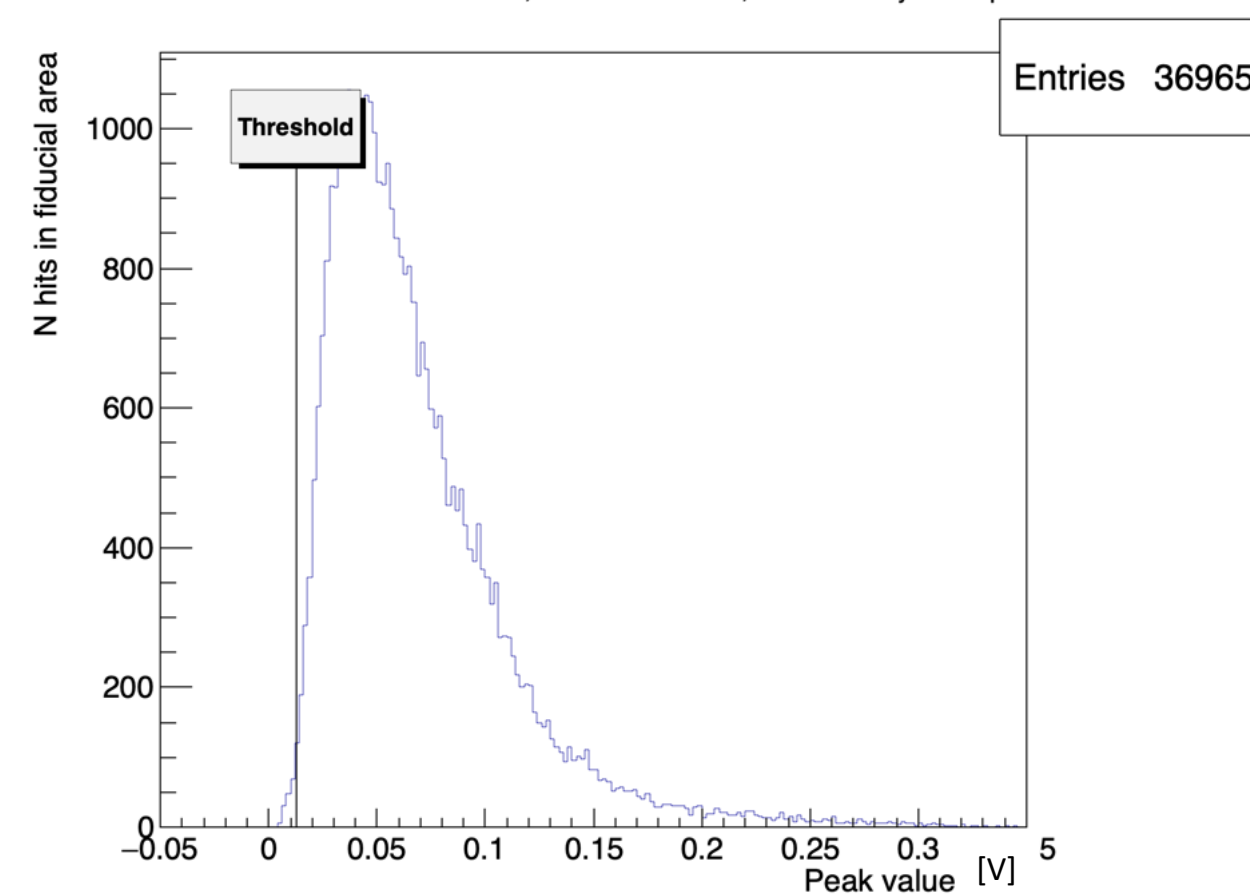
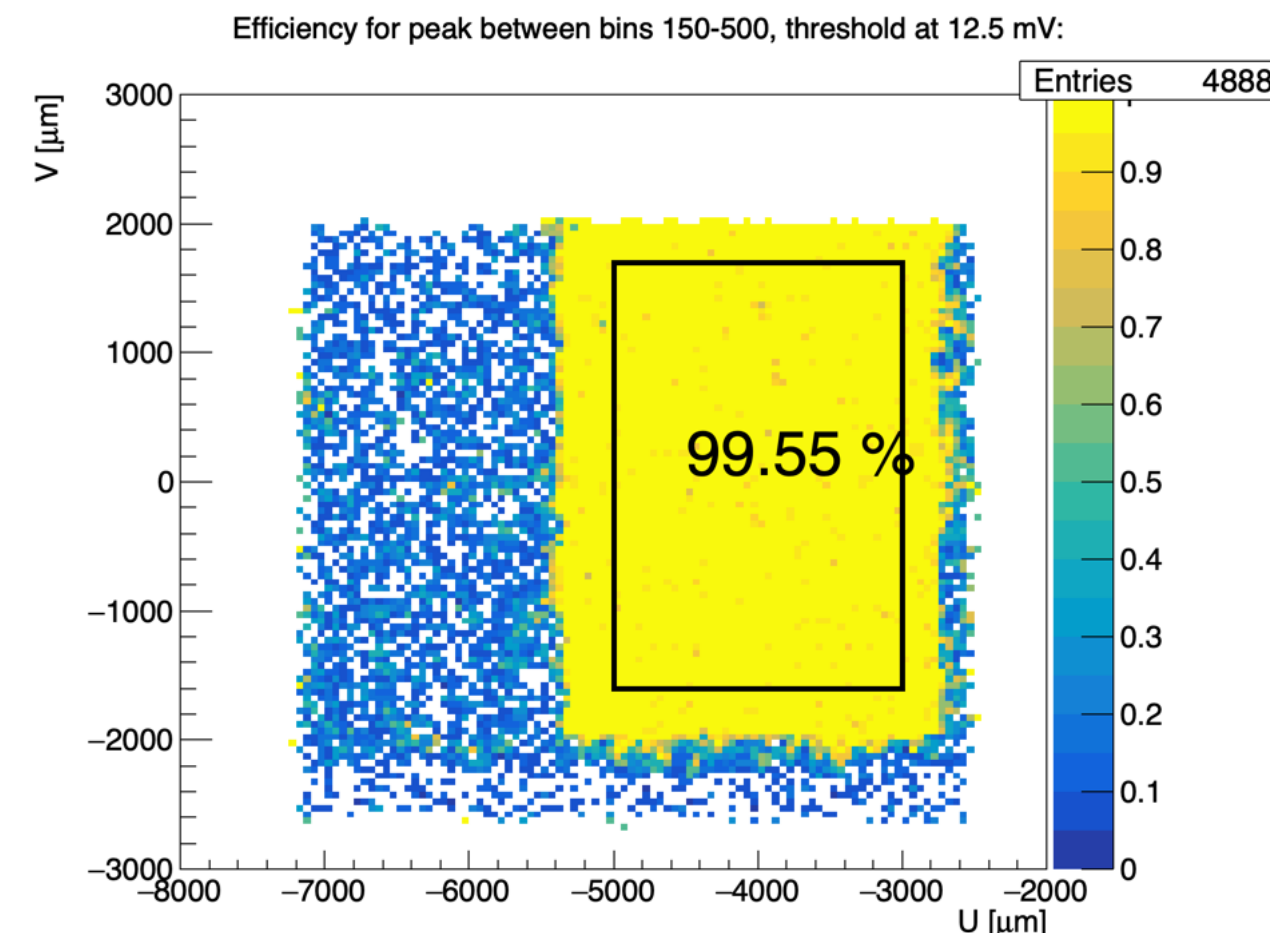
# pCVD diamond analog efficiency

- Run200099, -1000 V, **large pad**, threshold reduced to 12.5 mV (around  $5\sigma$ ) for easier separation

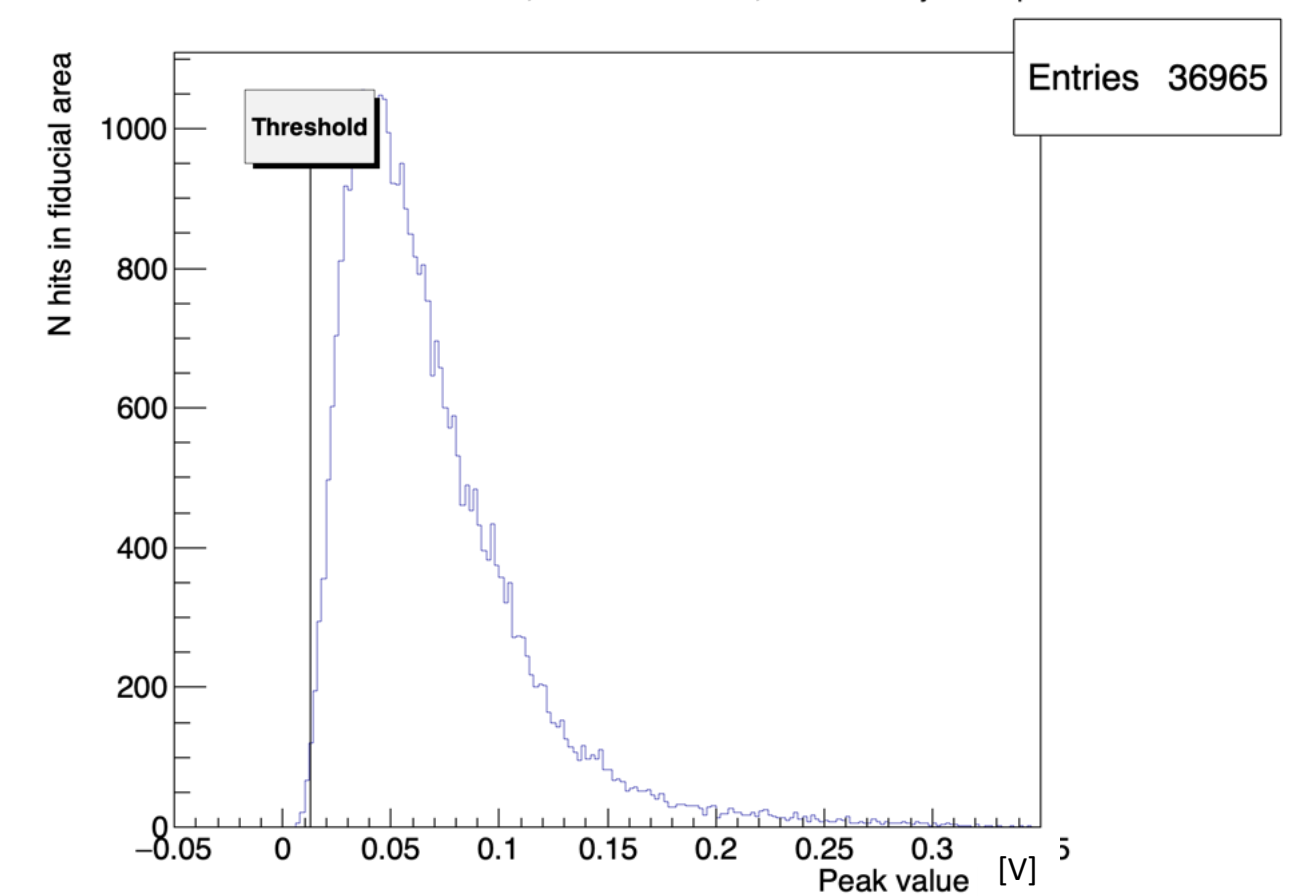
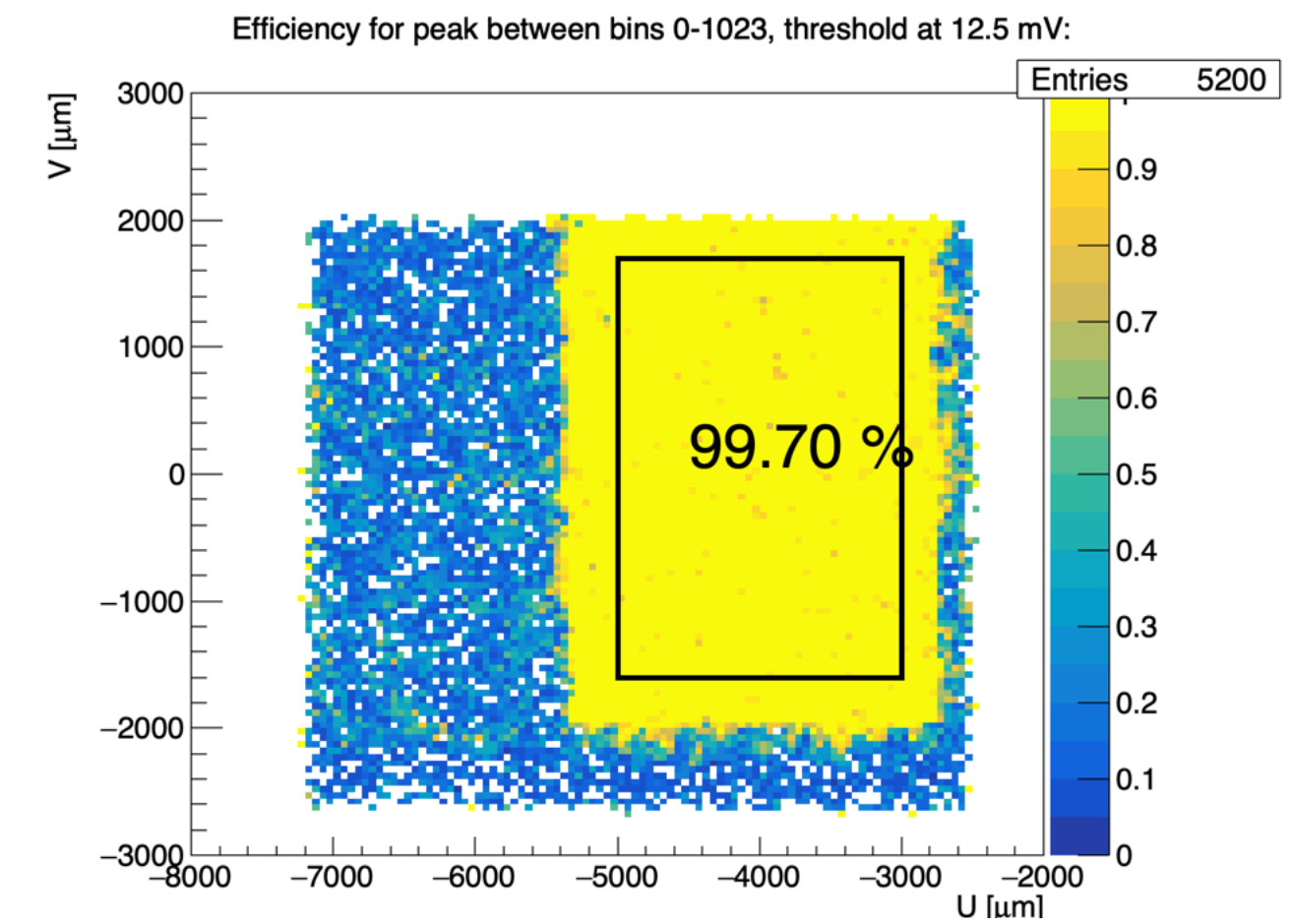
Only peaks between DRS bins 150-250:



Peaks between DRS bins 150-500:



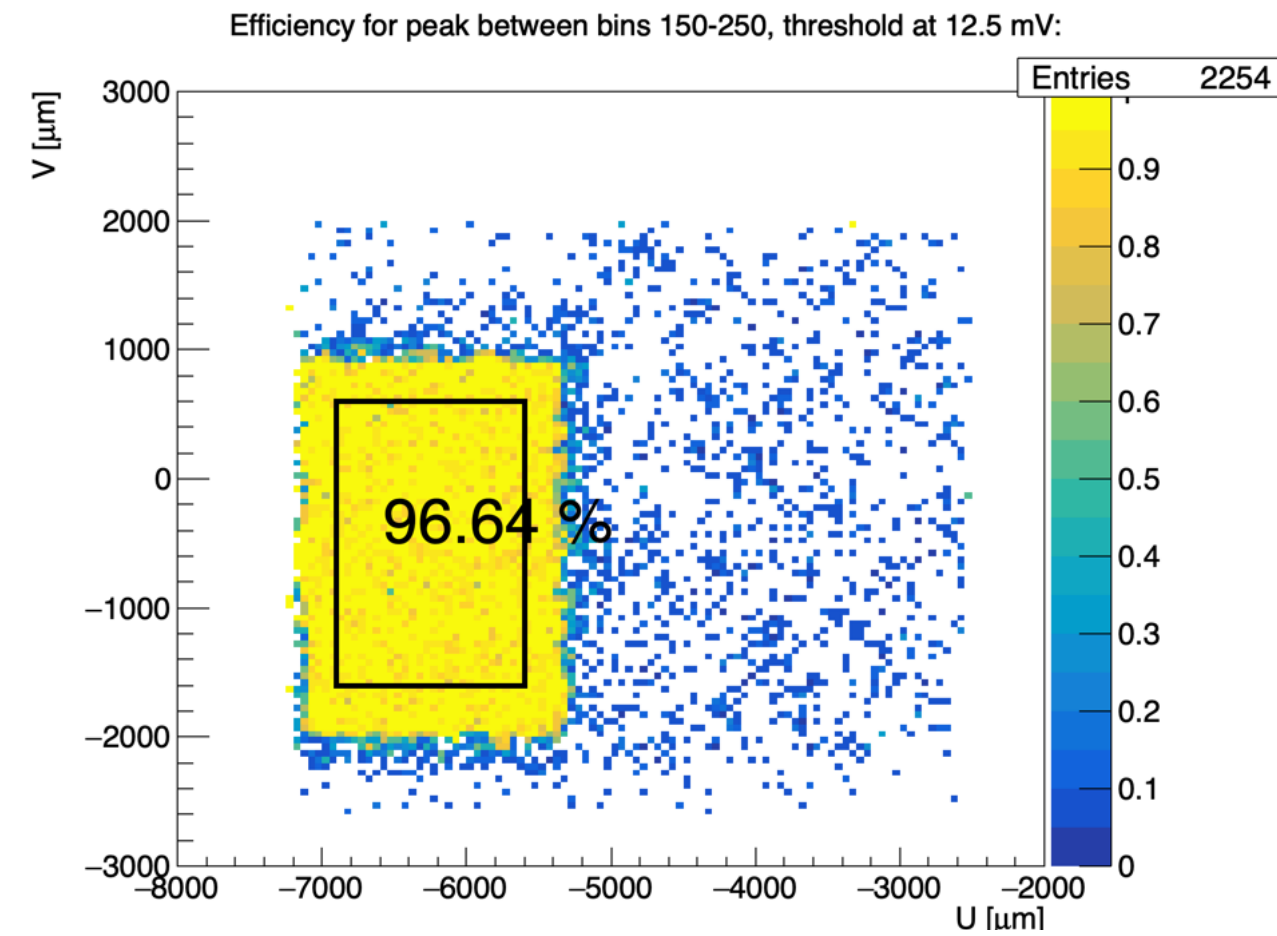
Peaks anywhere in the waveform



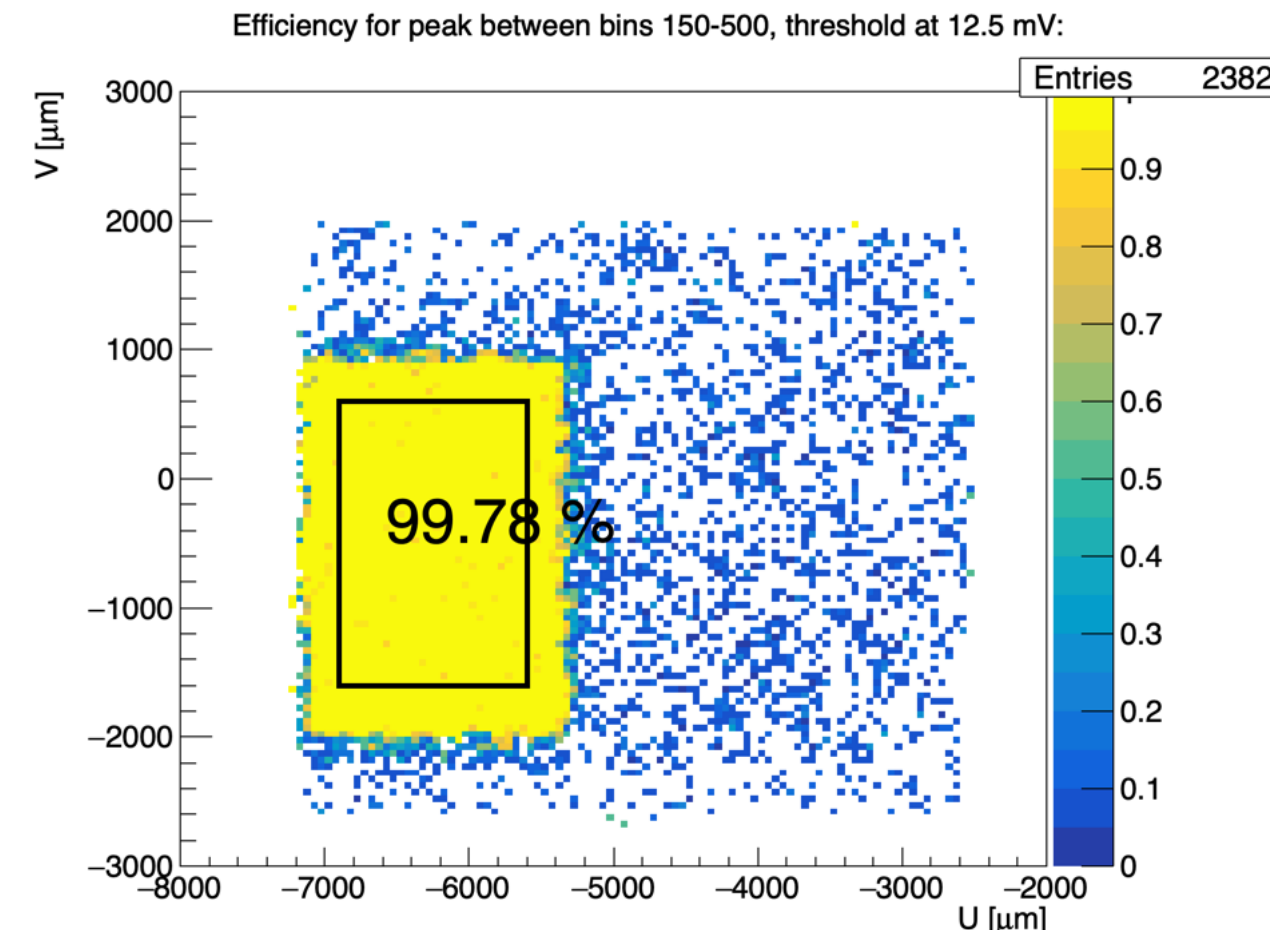
# pCVD diamond analog efficiency

- Run200099, -1000 V, **medium pad**, threshold reduced to 12.5 mV (around  $5\sigma$ ) for easier separation

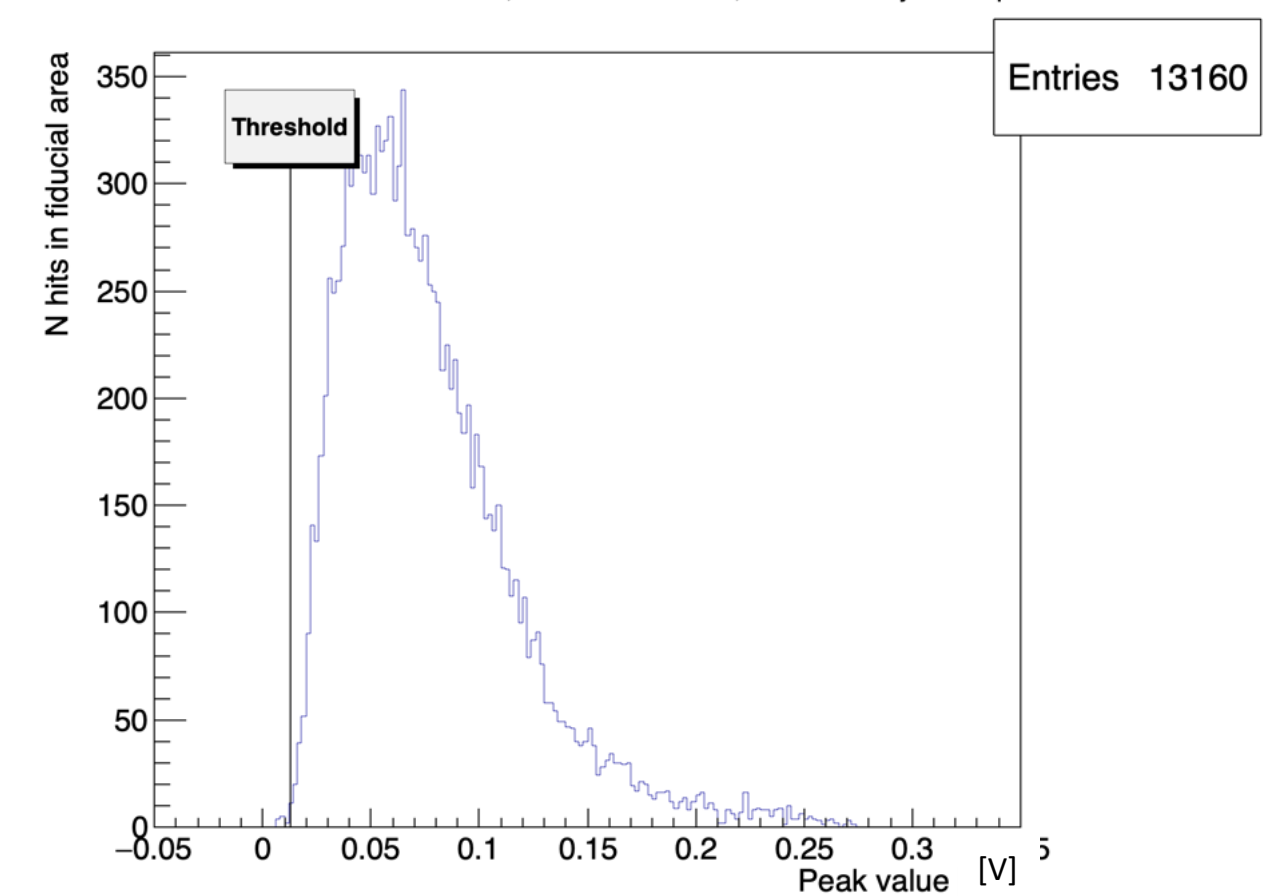
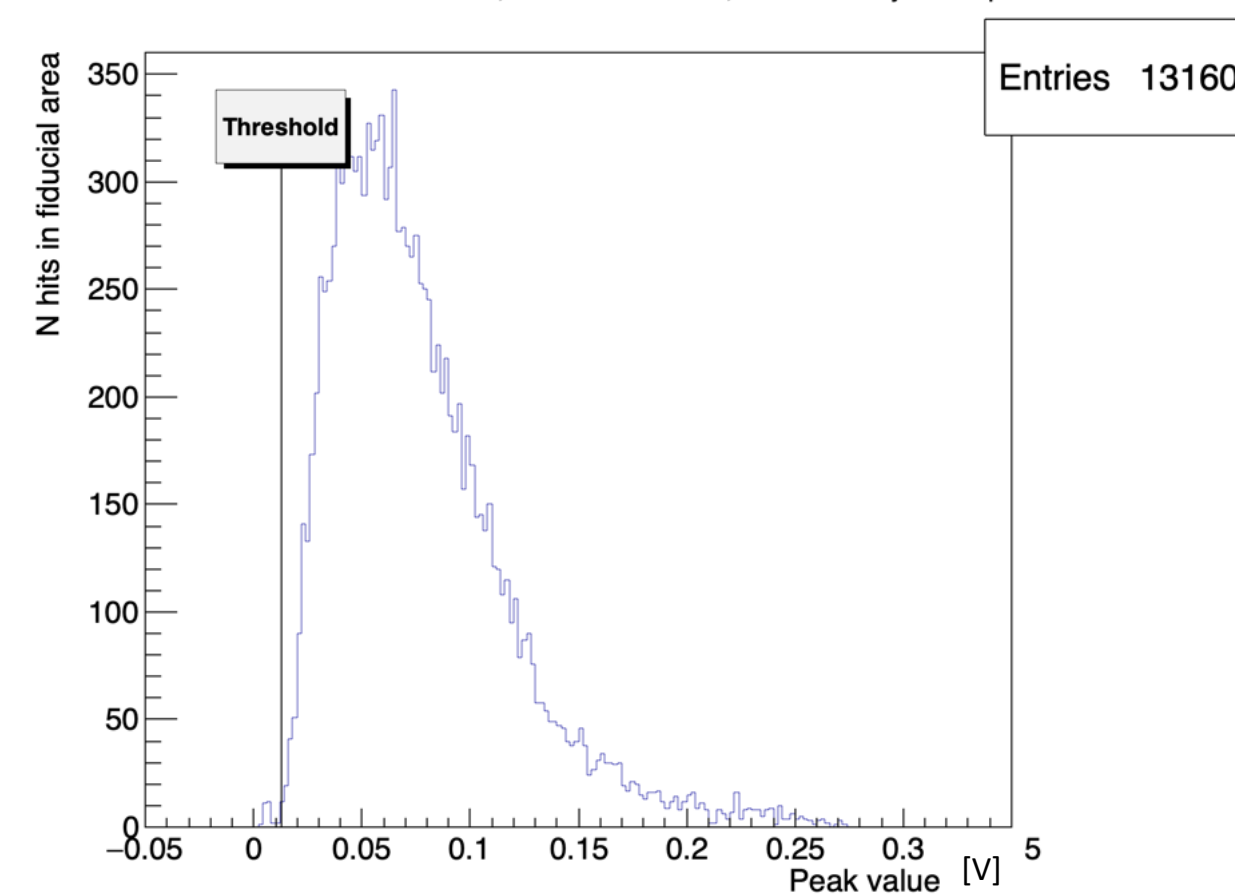
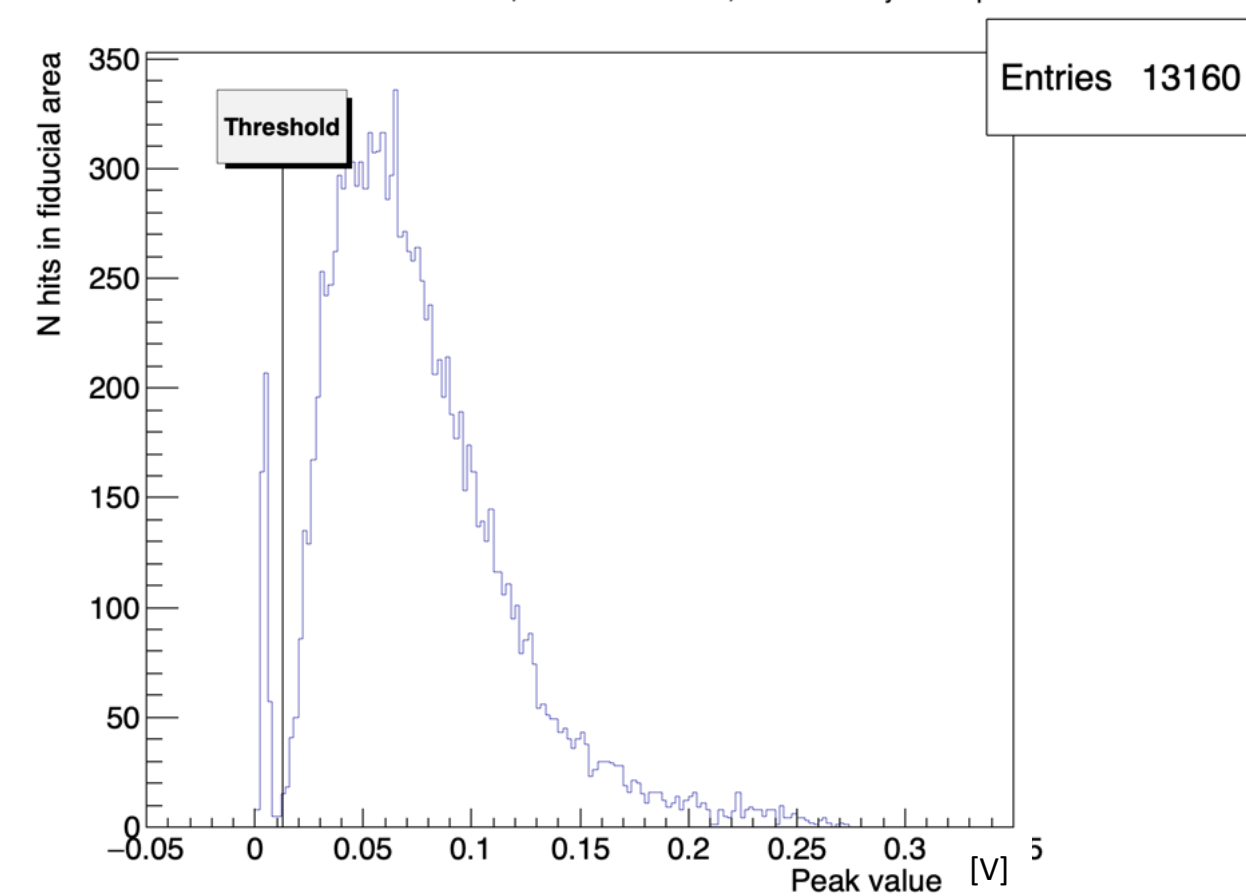
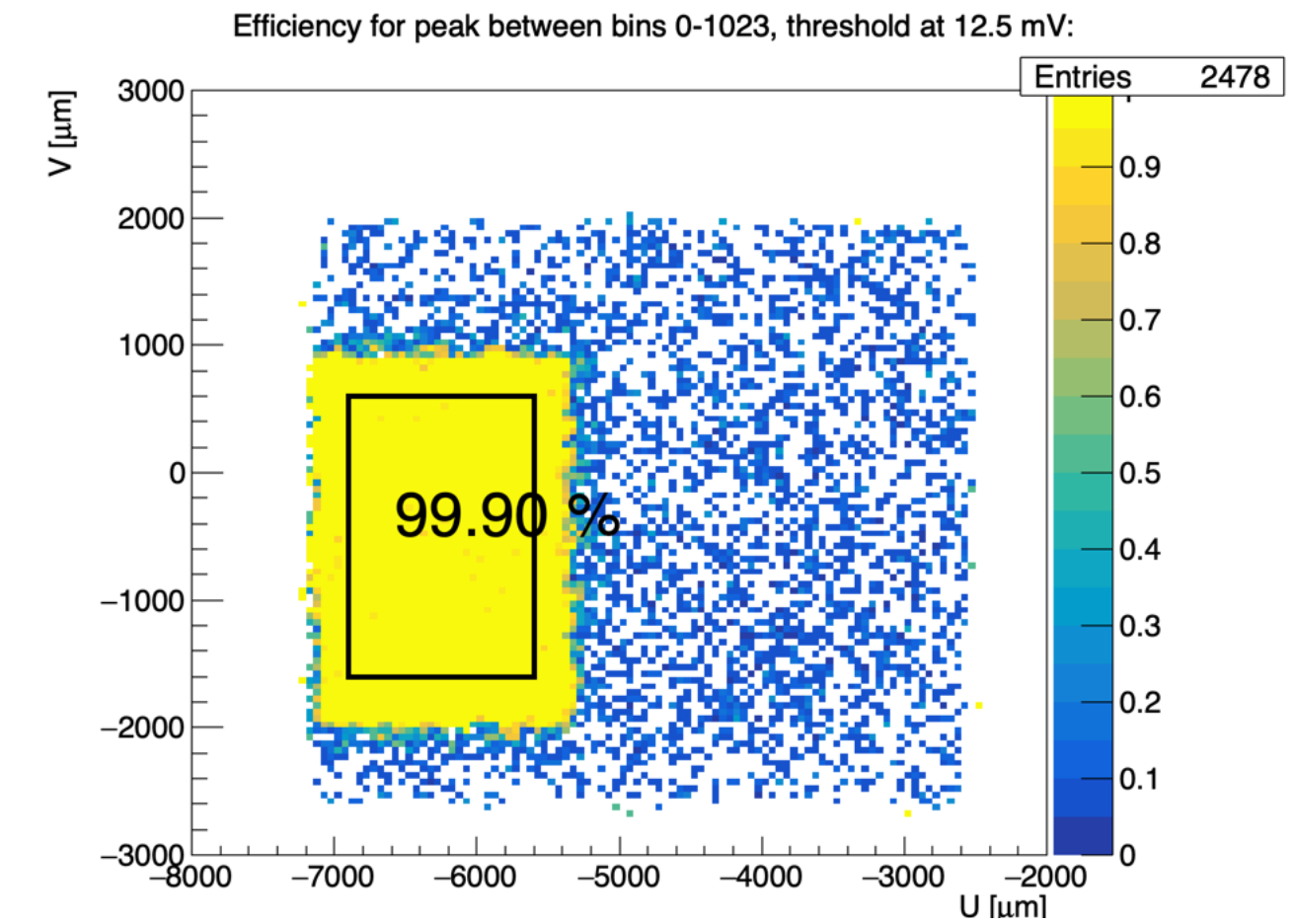
Only peaks between DRS bins 150-250:



Peaks between DRS bins 150-500:



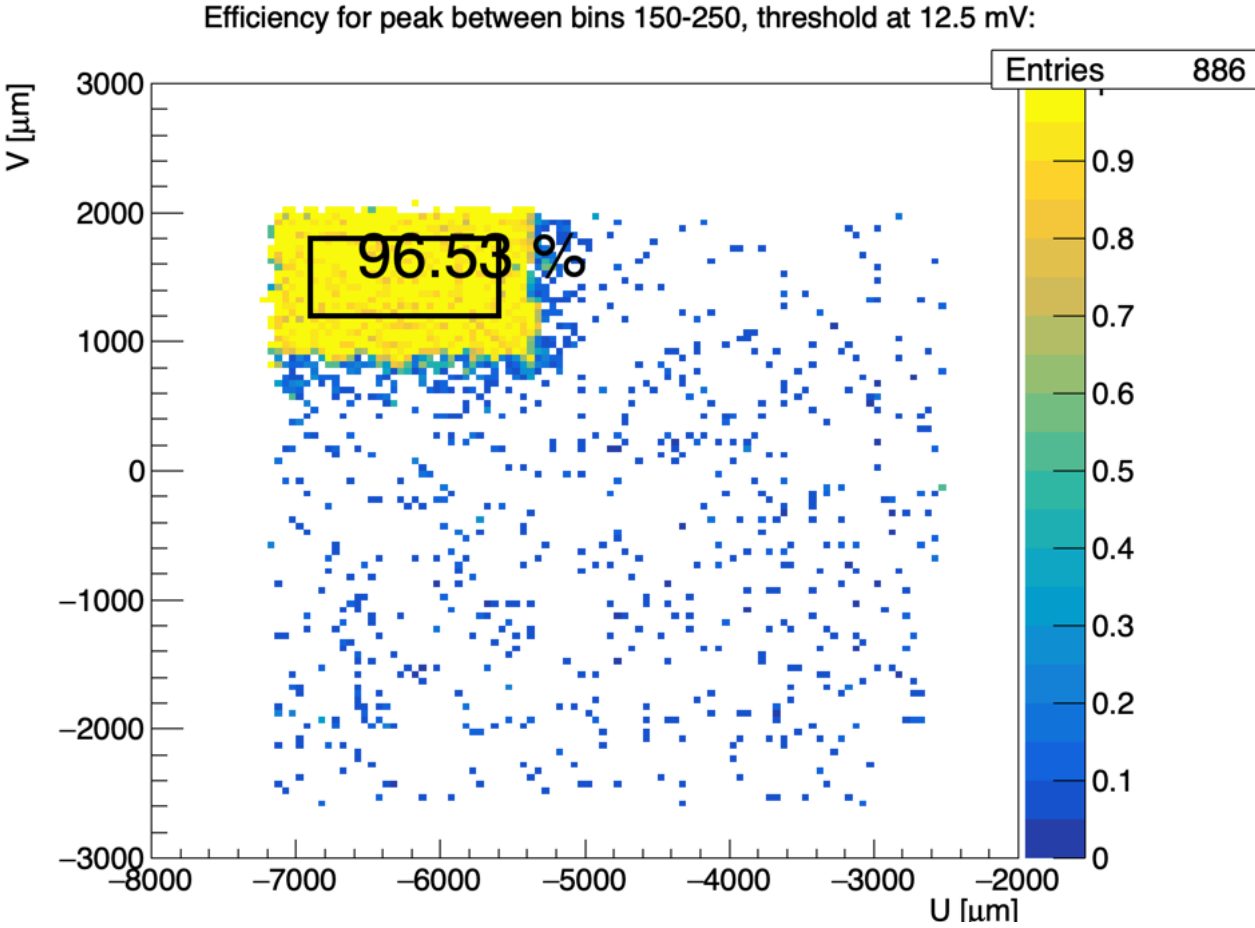
Peaks anywhere in the waveform



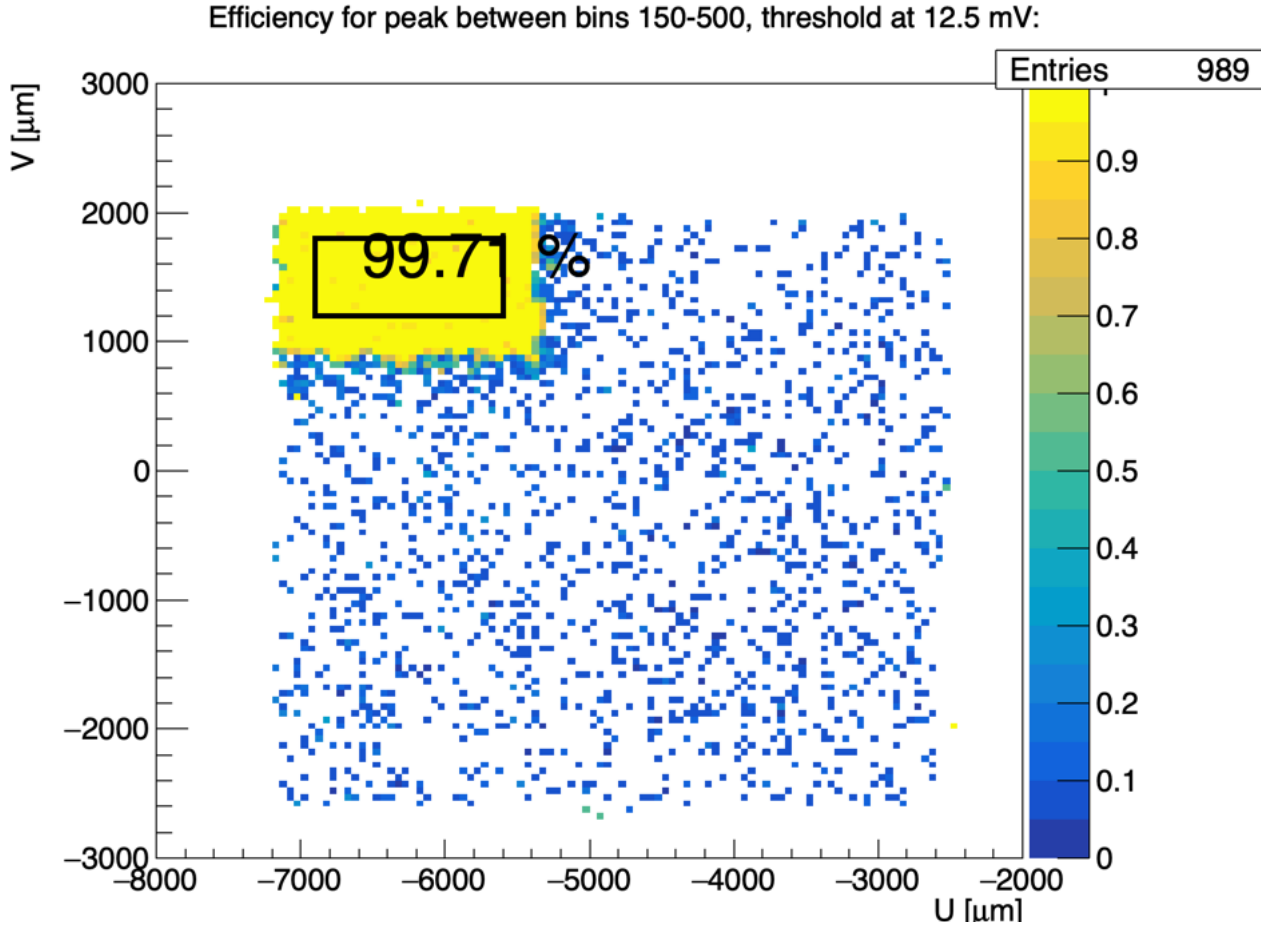
# pCVD diamond analog efficiency

- Run200099, -1000 V, **small pad**, threshold reduced to 12.5 mV (around  $5\sigma$ ) for easier separation

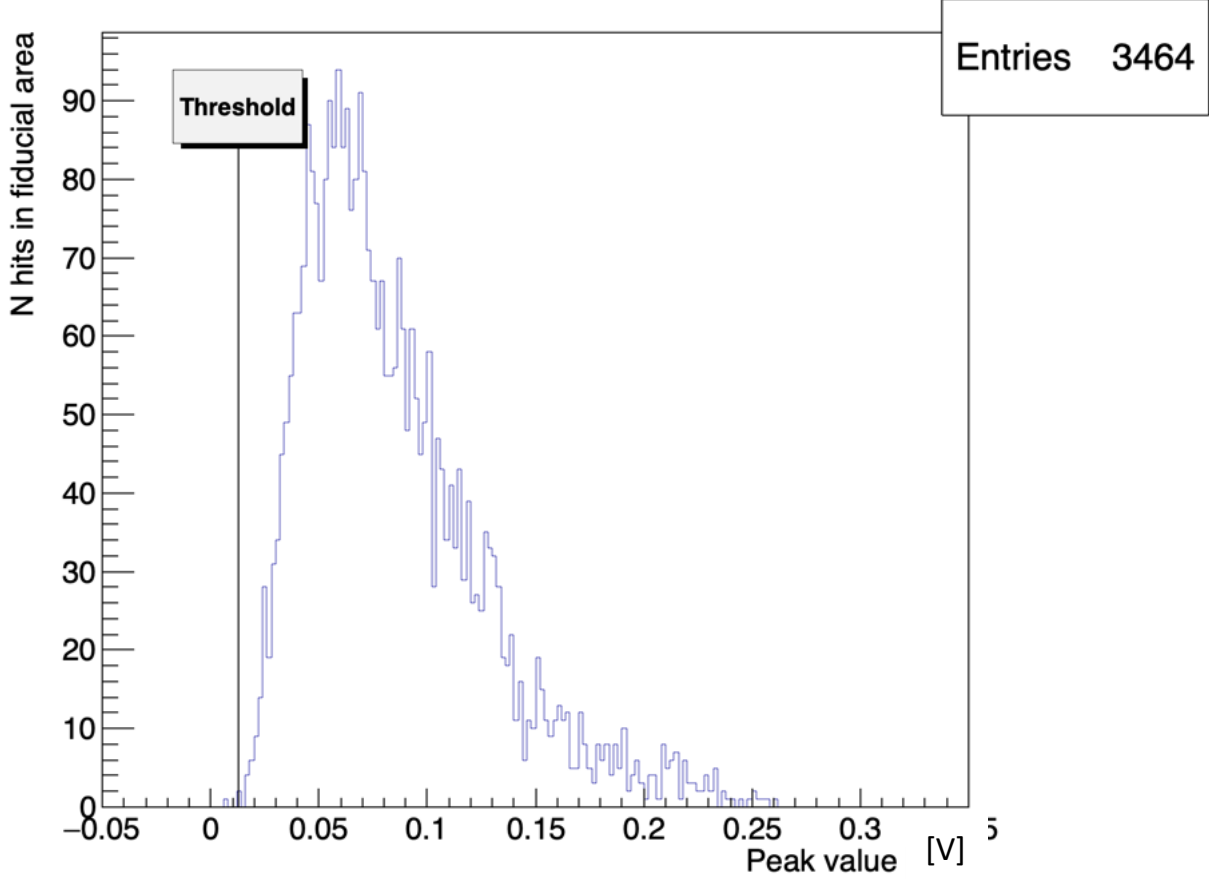
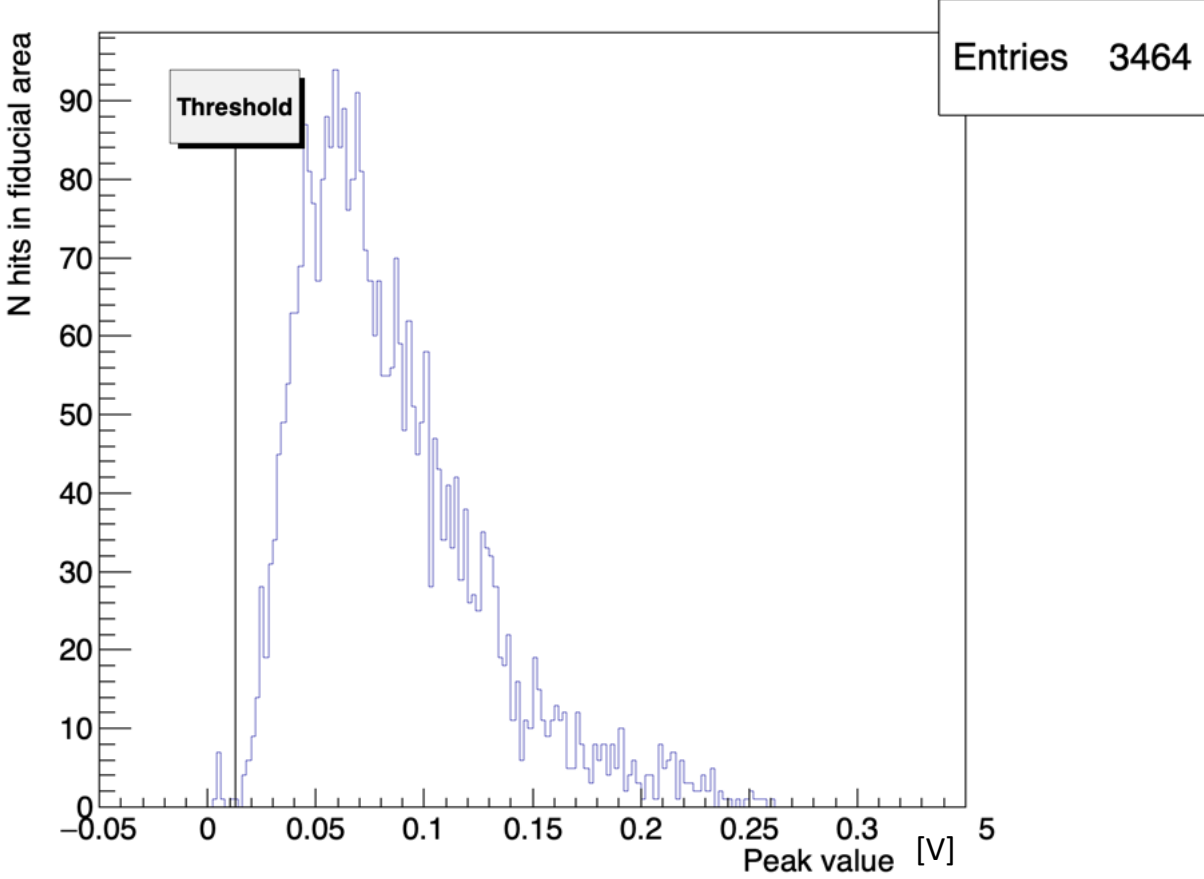
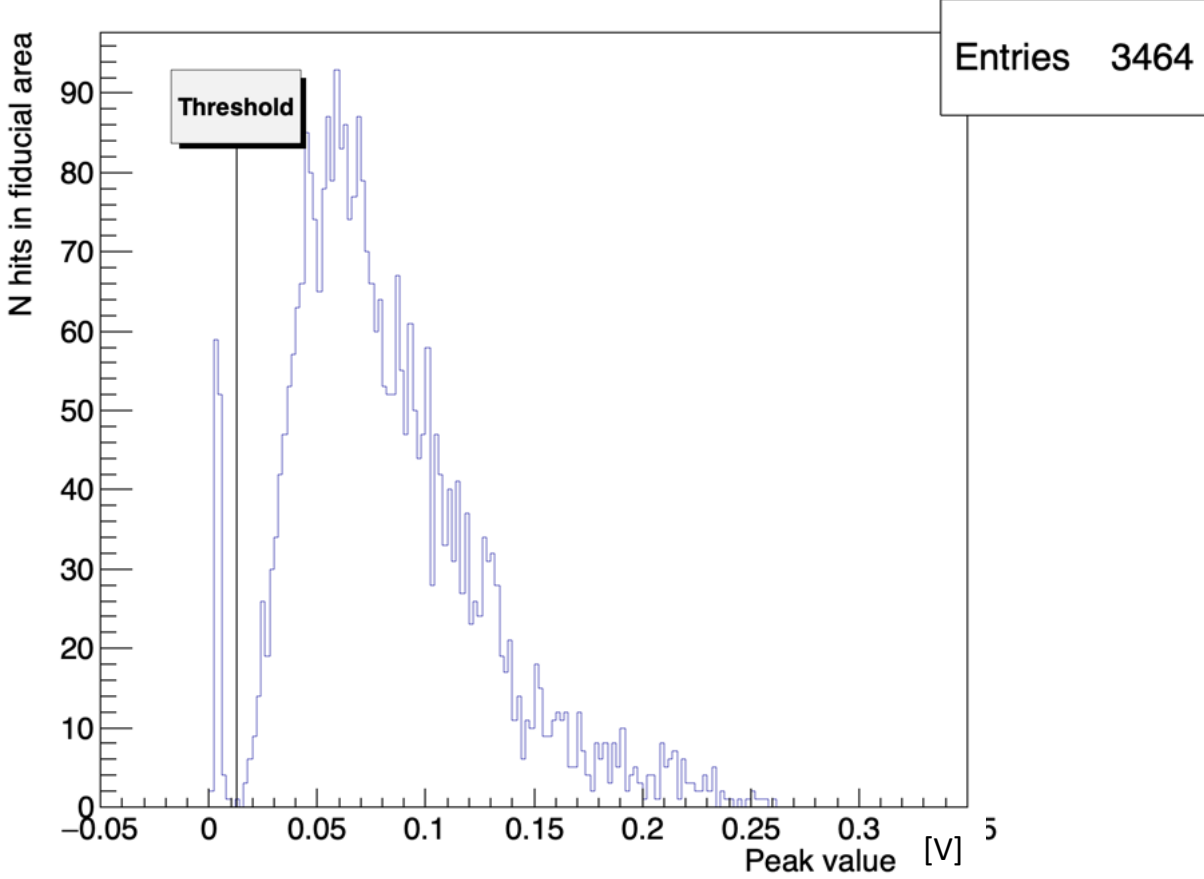
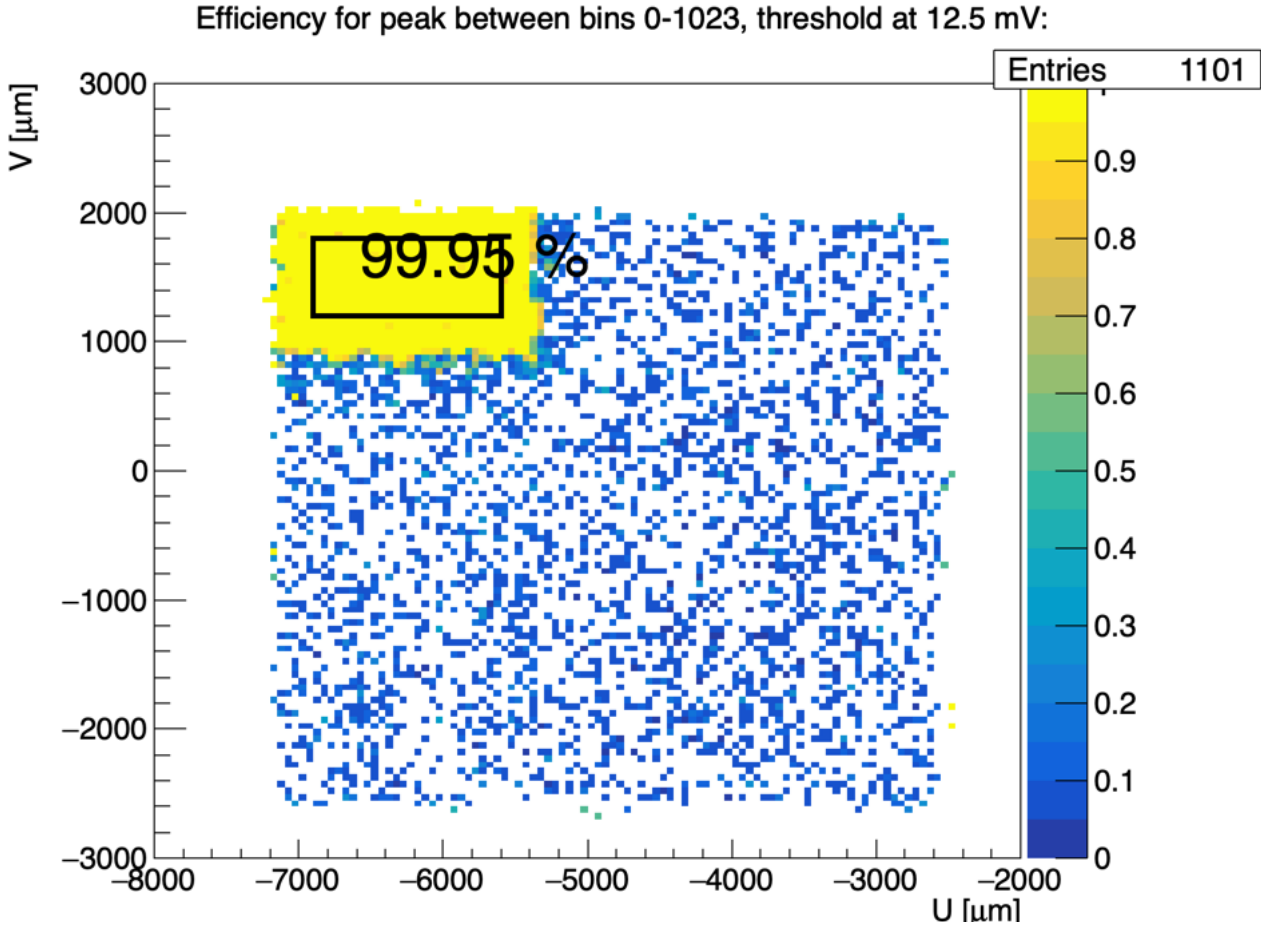
Only peaks between DRS bins 150-250:



Peaks between DRS bins 150-500:



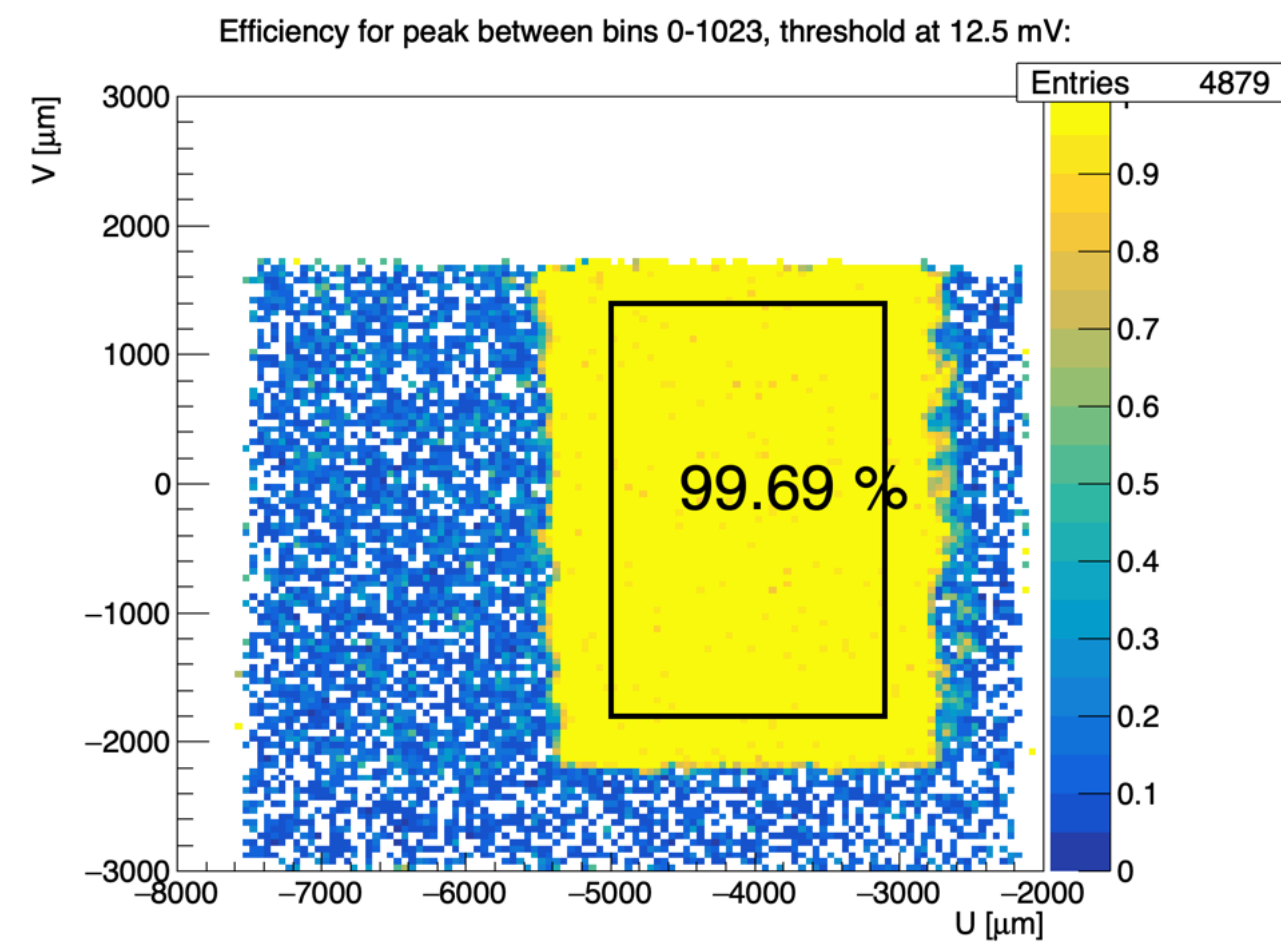
Peaks anywhere in the waveform



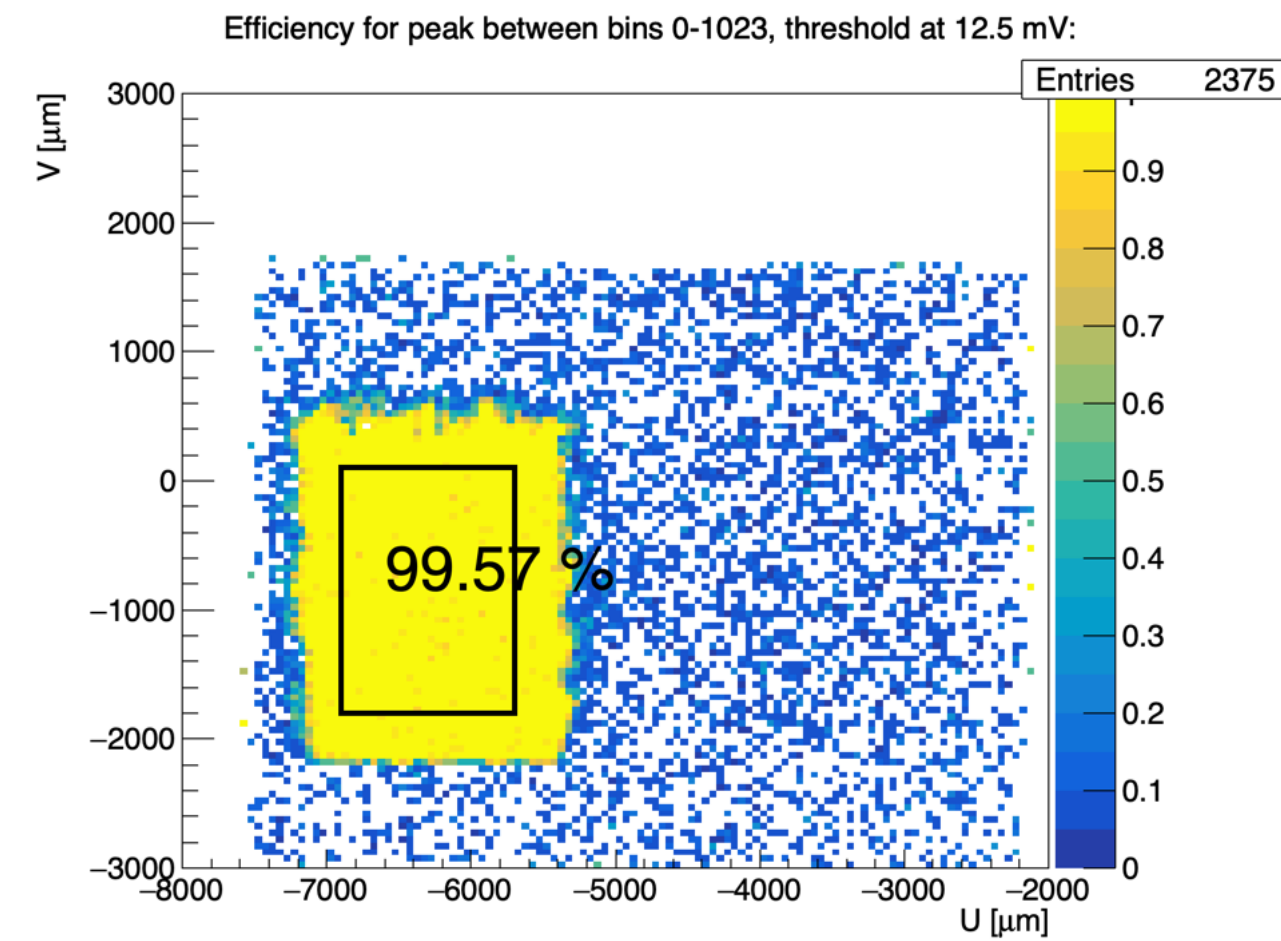
# pCVD diamond analog efficiency, rotated module

- Run200107, -1000 V, threshold reduced to 12.5 mV (around  $5\sigma$ ) for easier separation, all pads

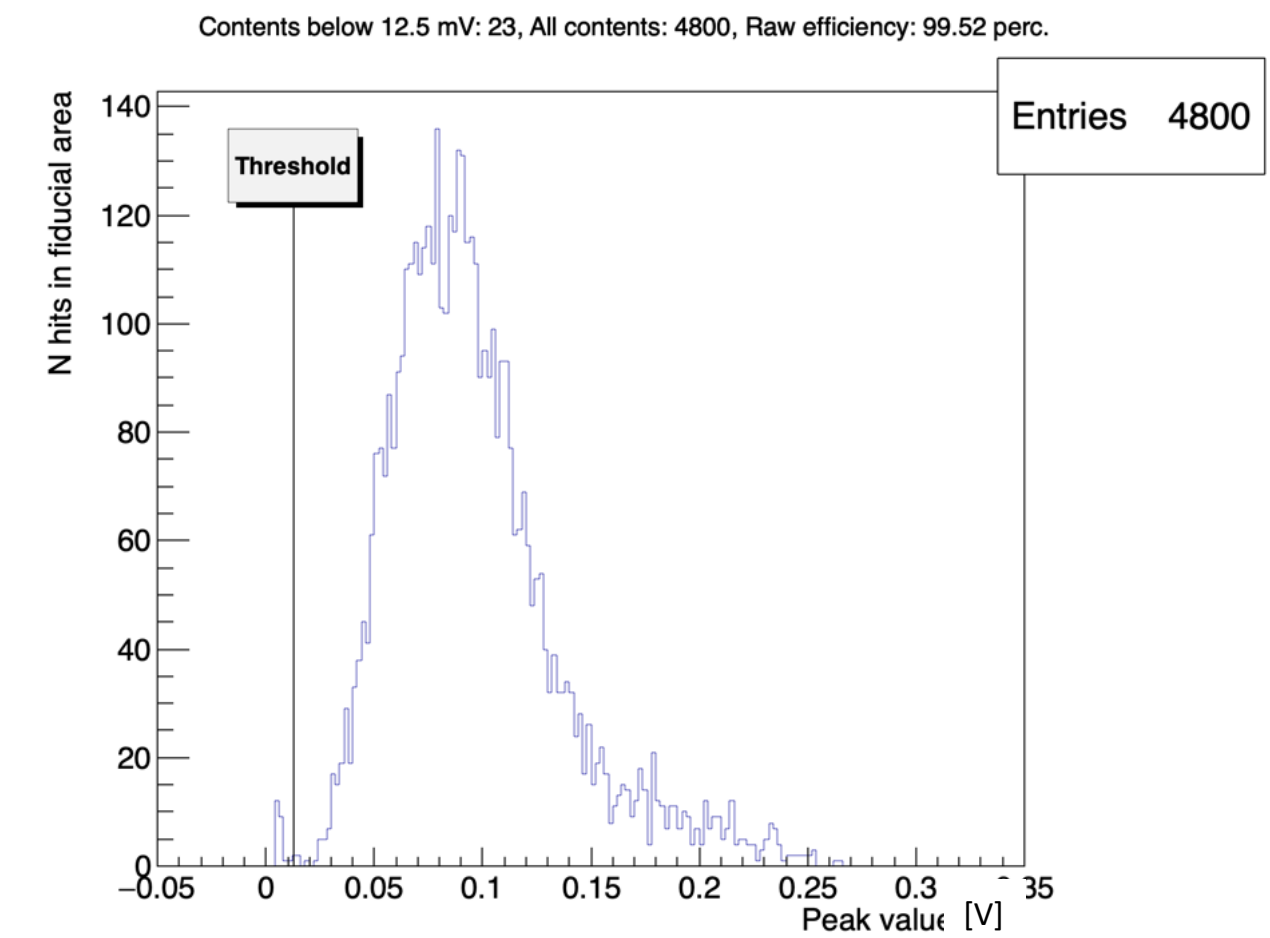
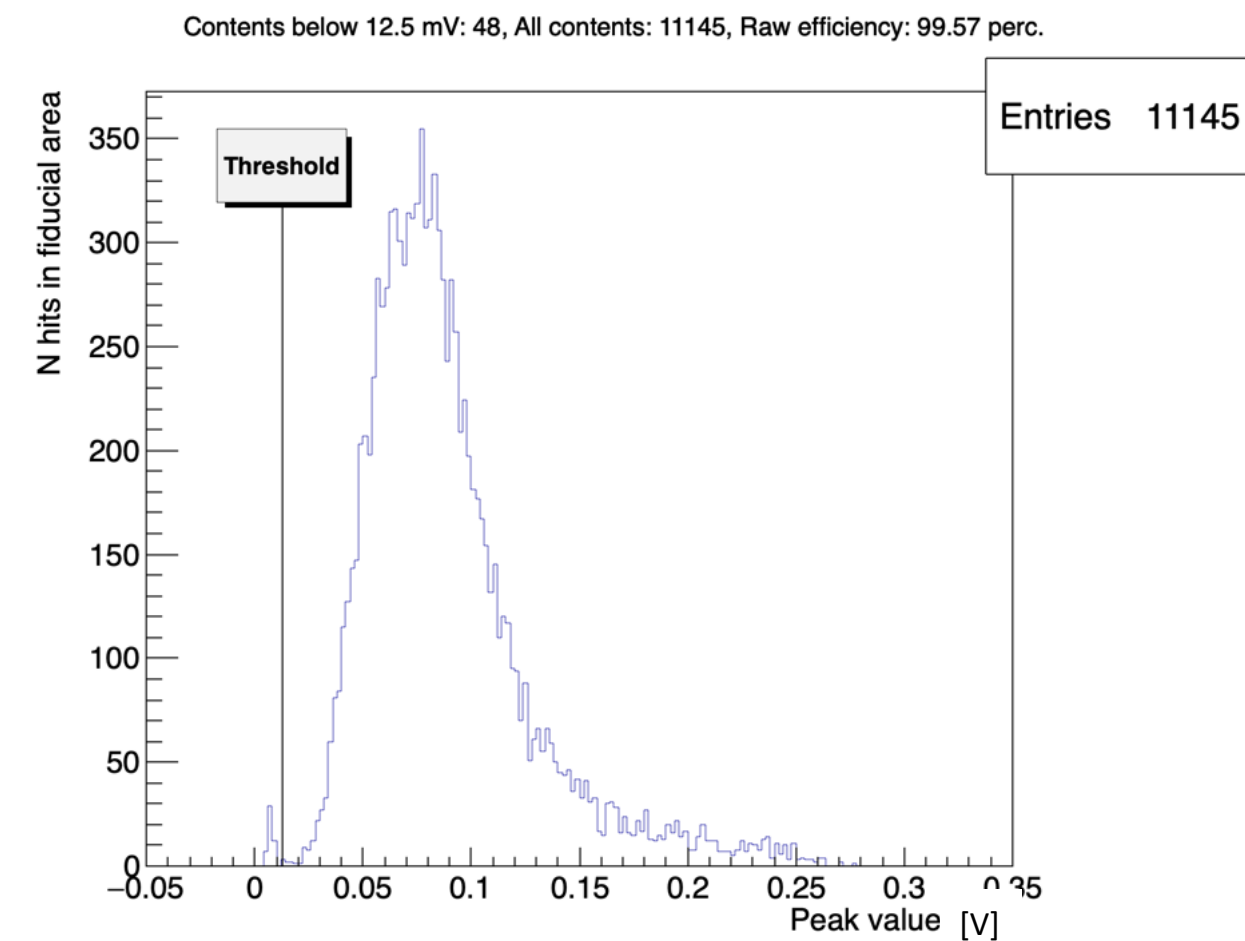
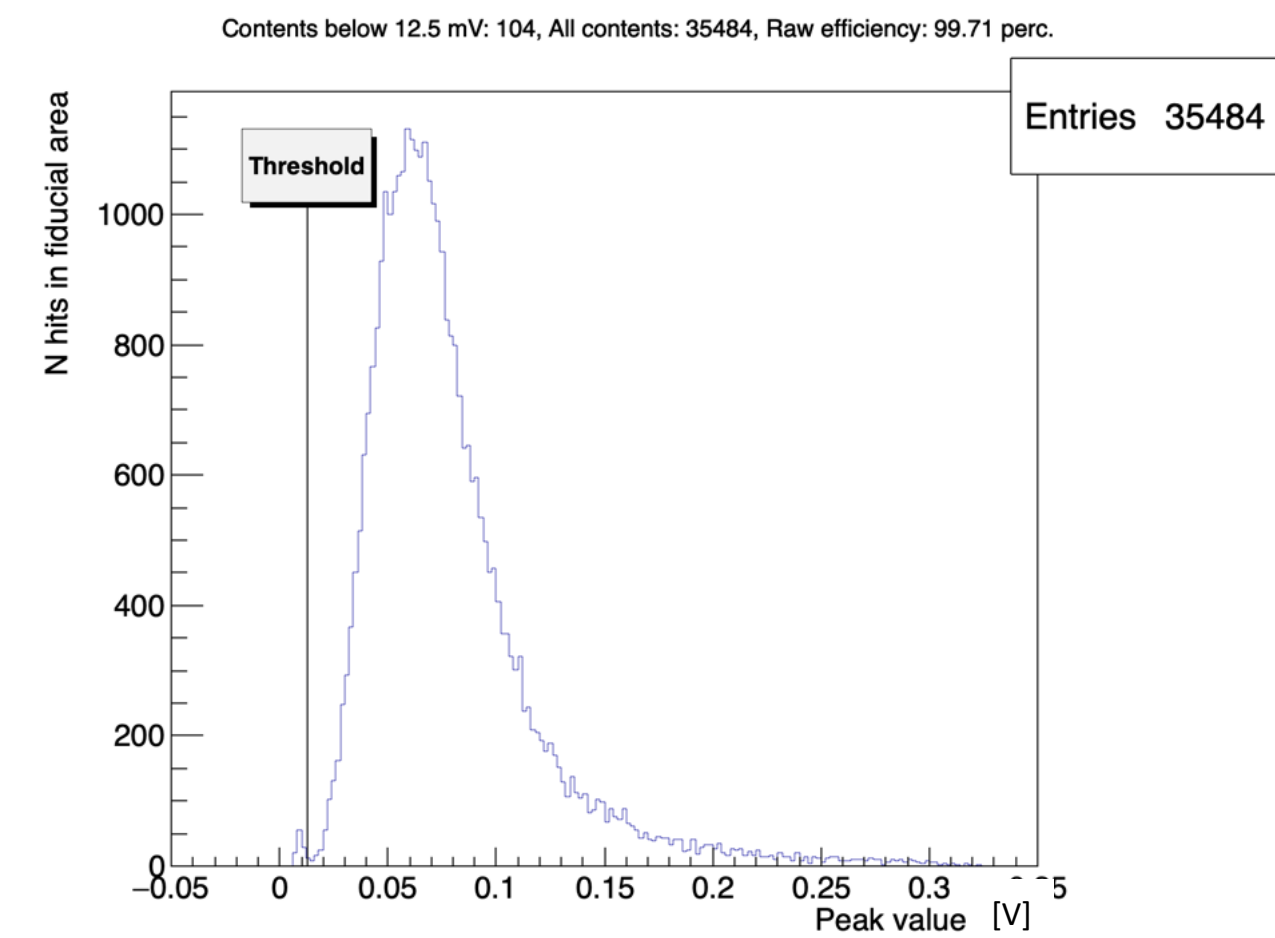
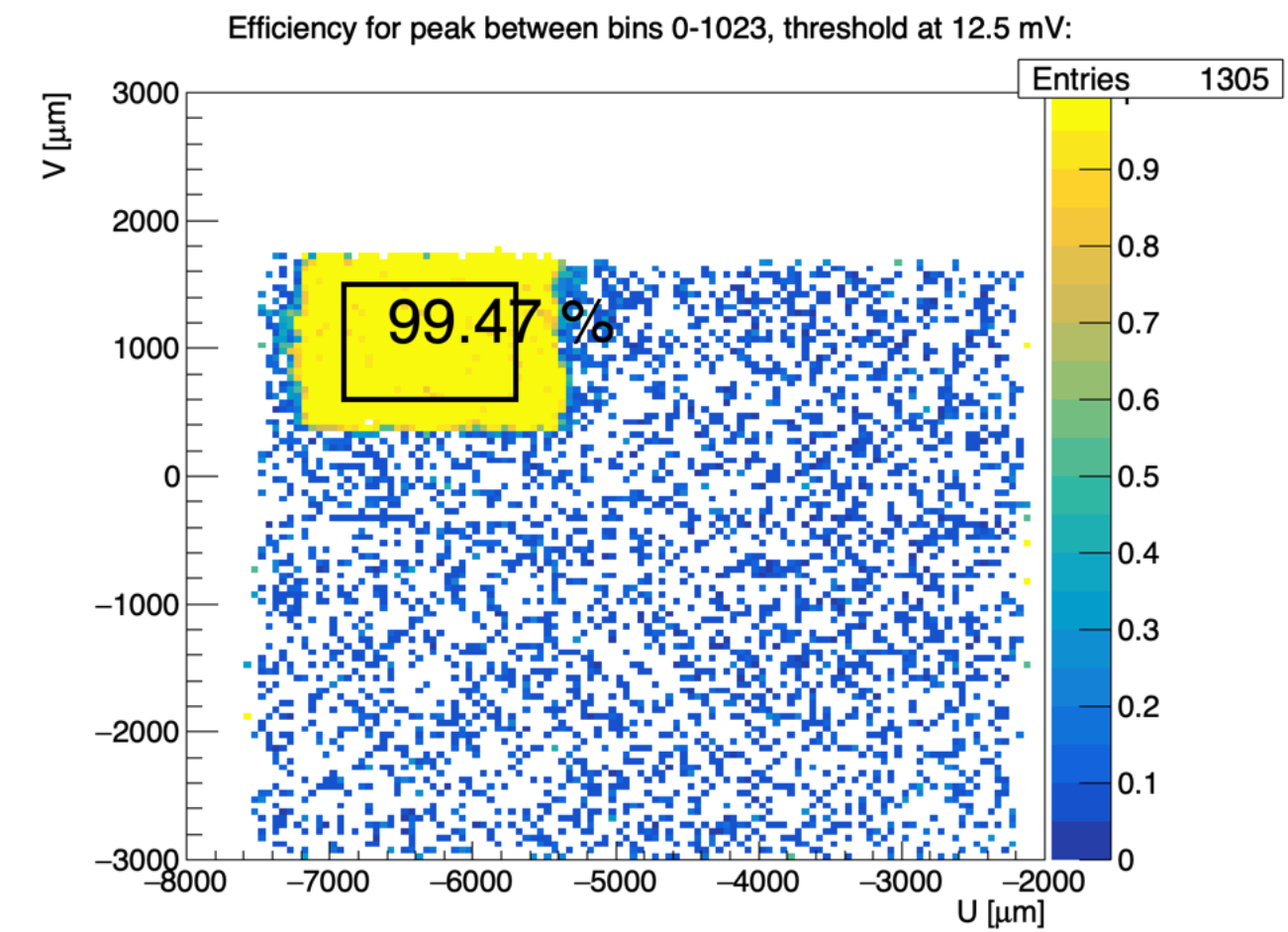
Large pad



Medium pad

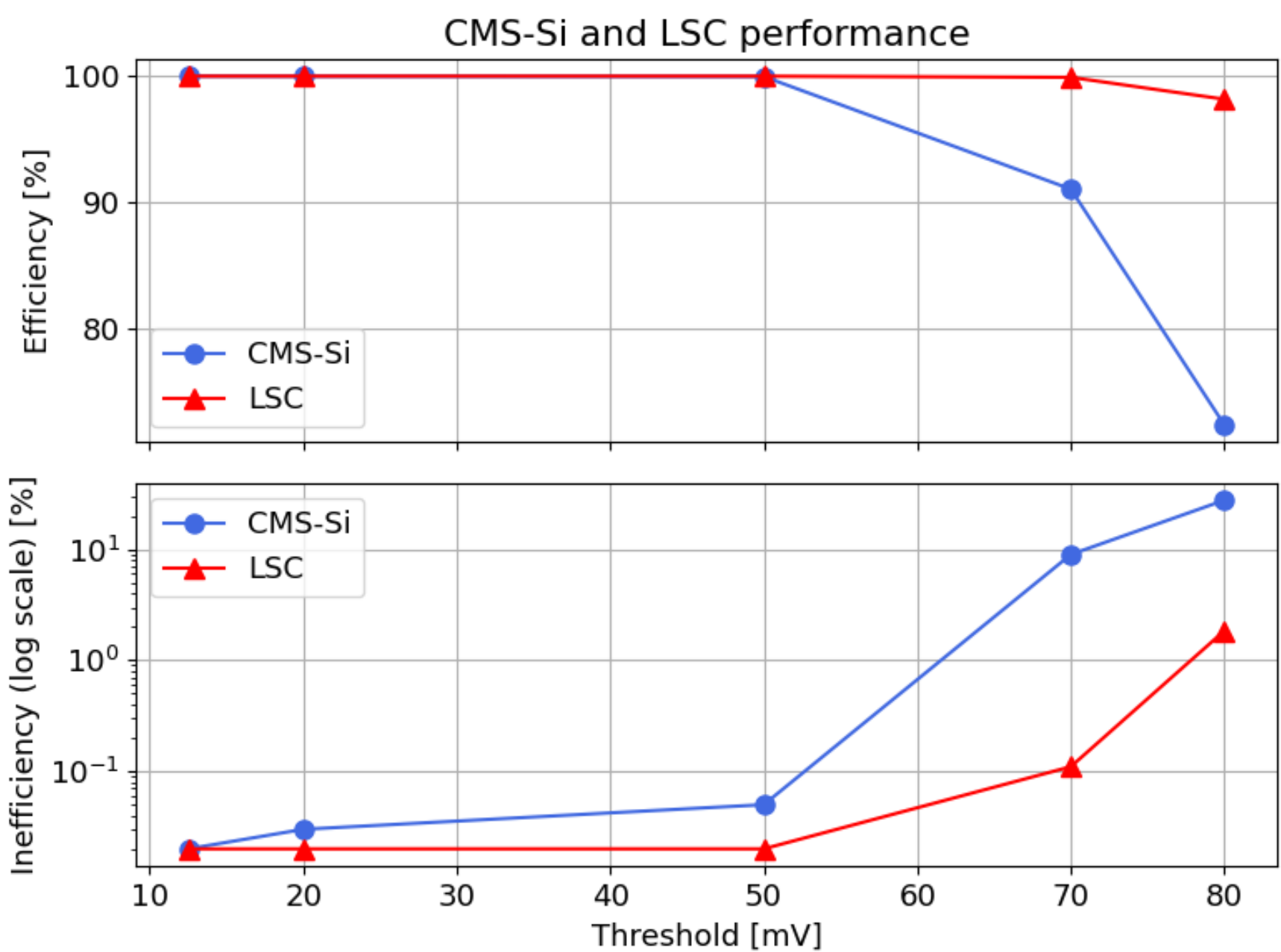


Small pad

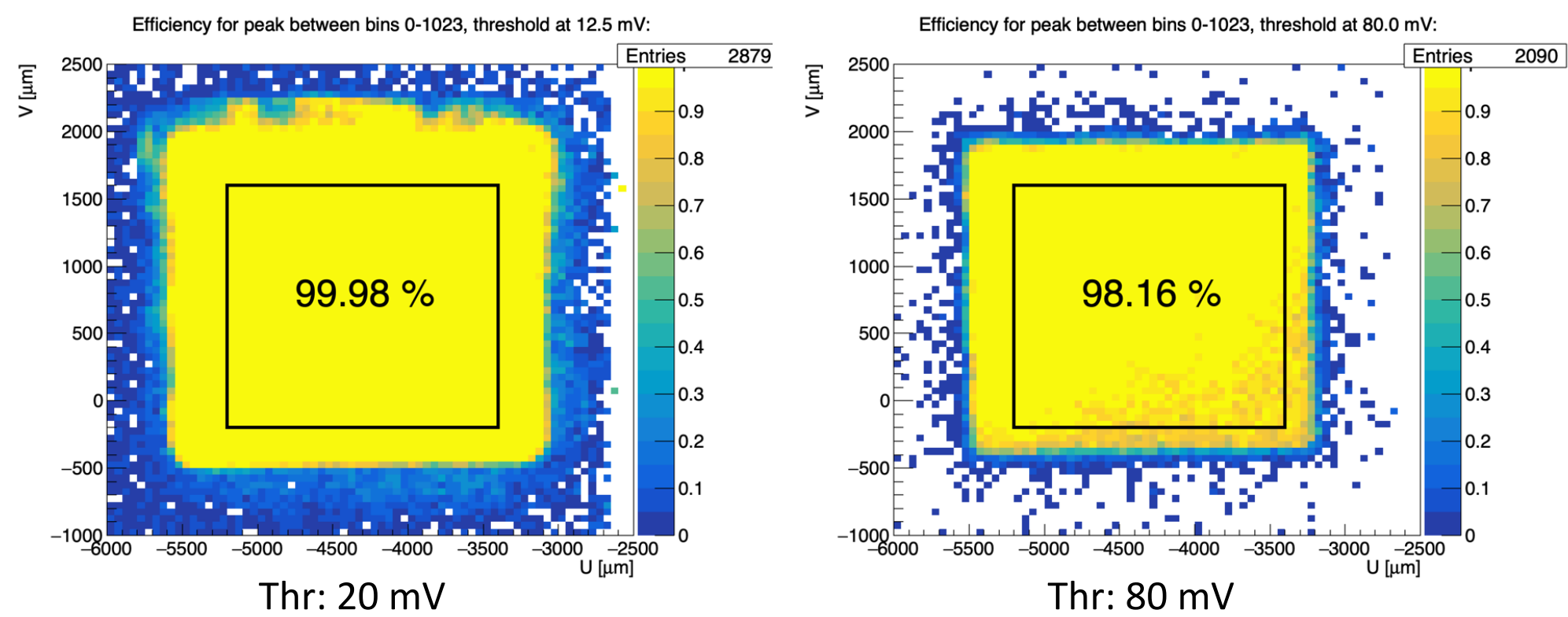


# Efficiency-threshold dependance: CMS-Si and LSC

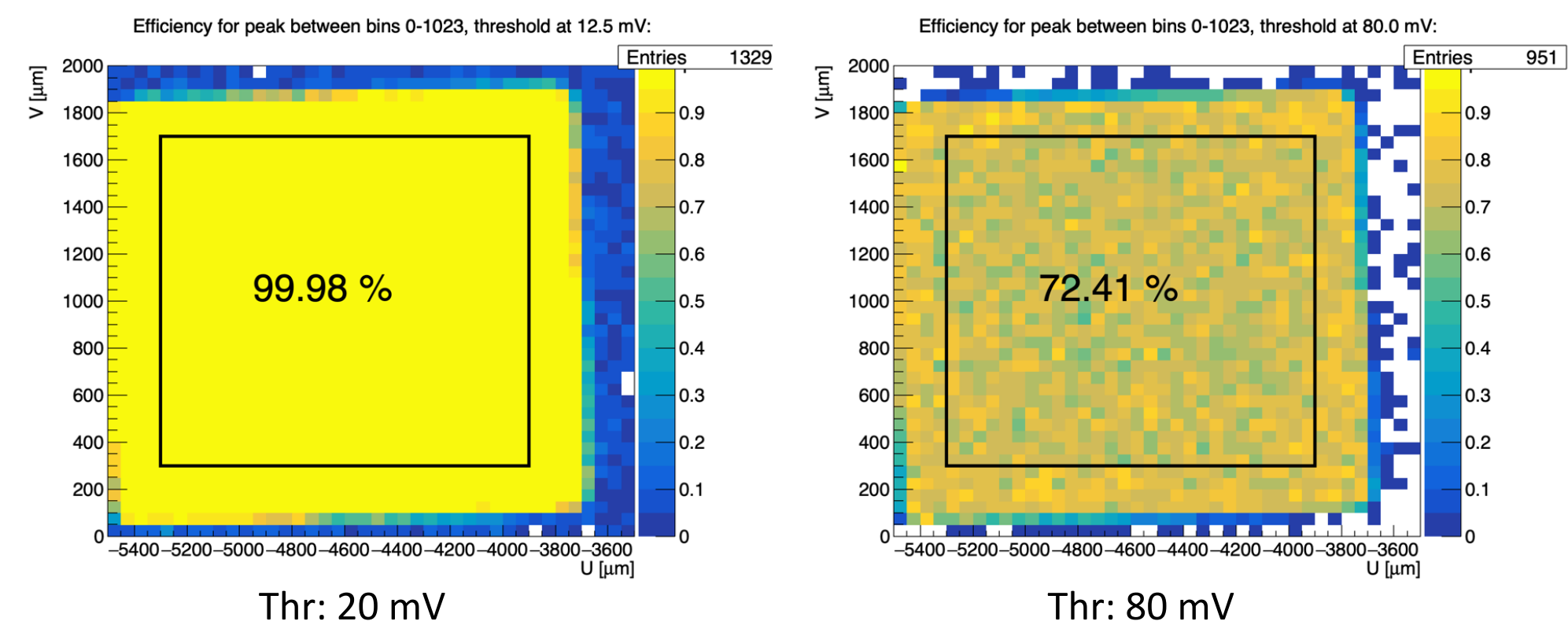
- Si and SC detectors have good S/N ratio and large expected signals -> efficiency will only drop at “high” threshold



LSC: high average signals, visible inefficiency pattern at higher threshold

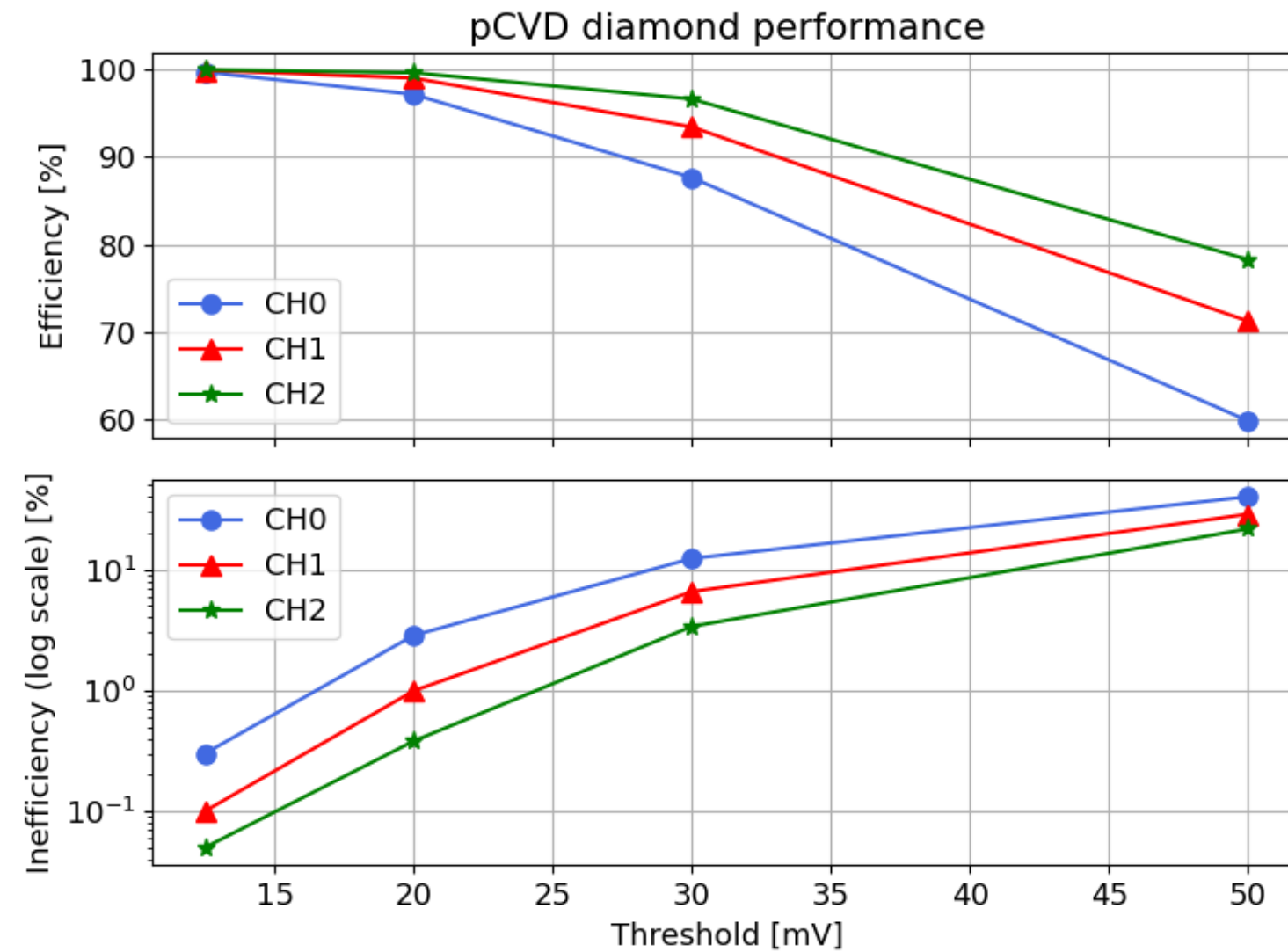


CMS-Si: uniform inefficiency at higher thresholds

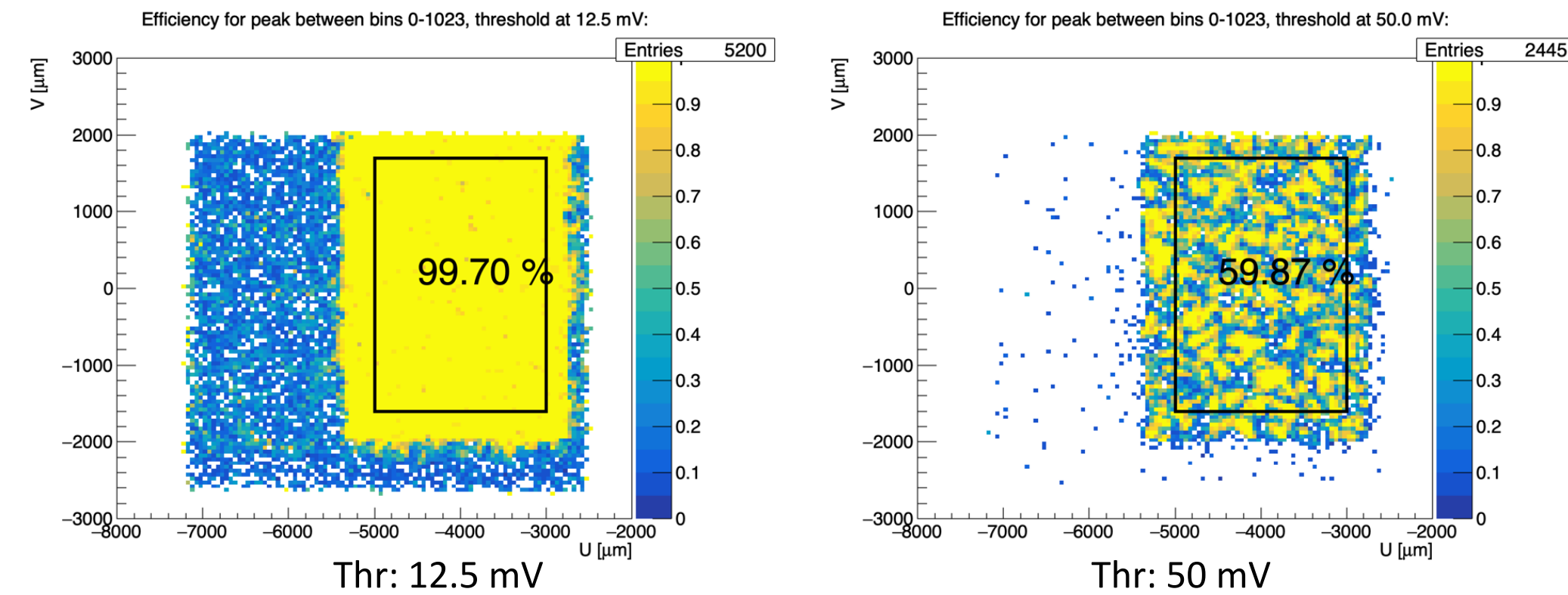


# Efficiency-threshold dependance: pCVD diamond

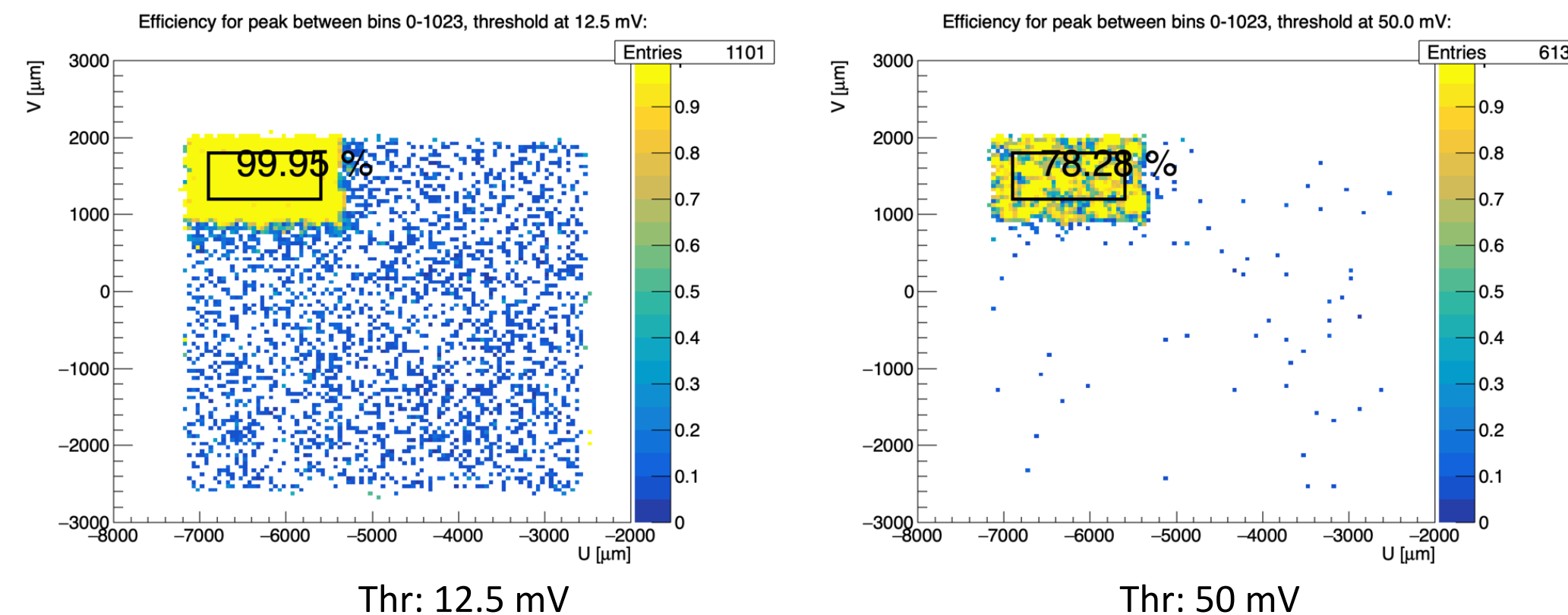
- pCVD diamond has the lowest expected signals, hard to discriminate between signal and noise
- Efficiency drops quickly as we increase threshold -> inefficiency areas appear in diamond pads



Largest pad: lowest average signals, efficiency drop is the quickest

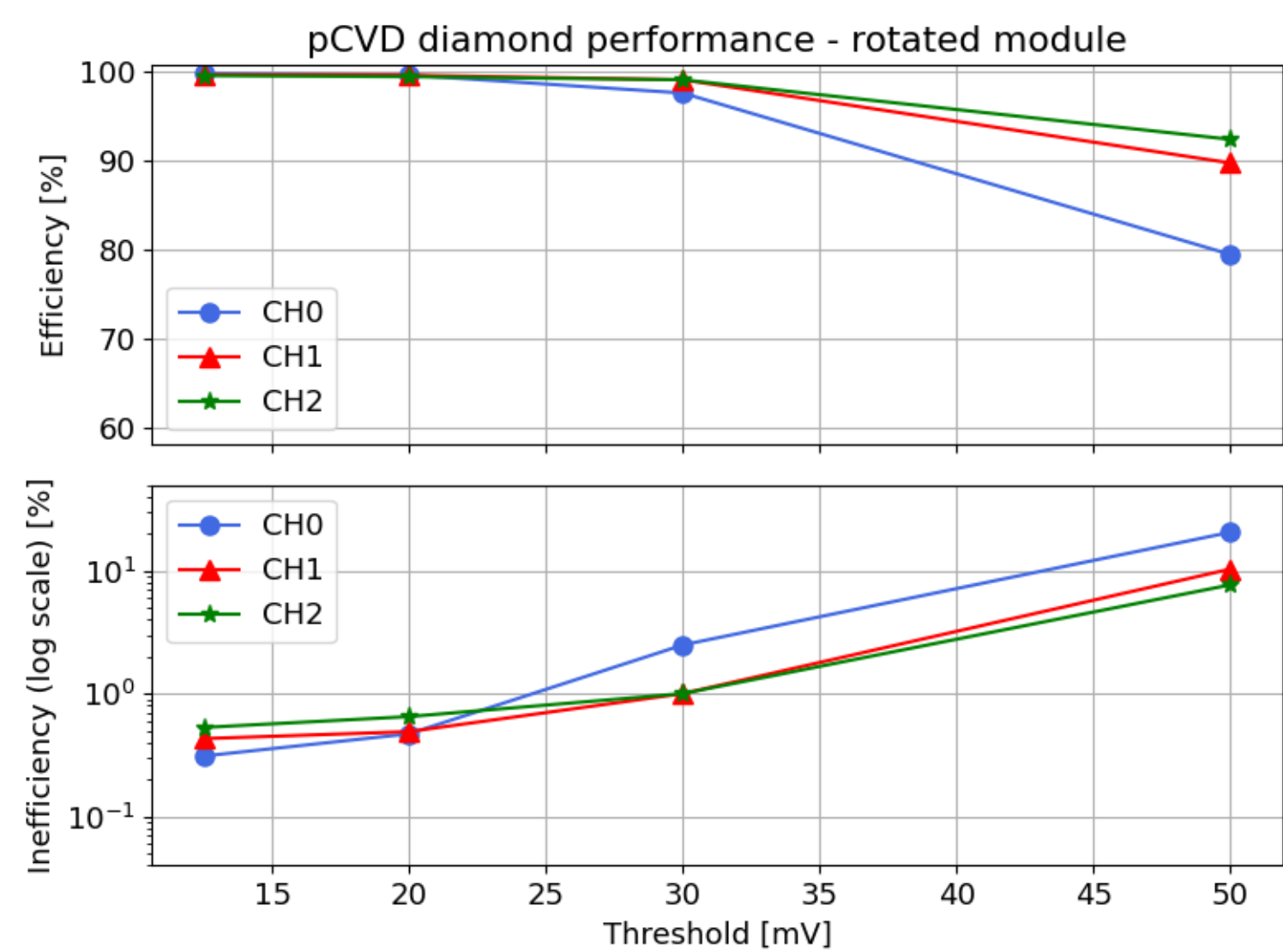


Small pad: largest average signal, efficiency drop is slower

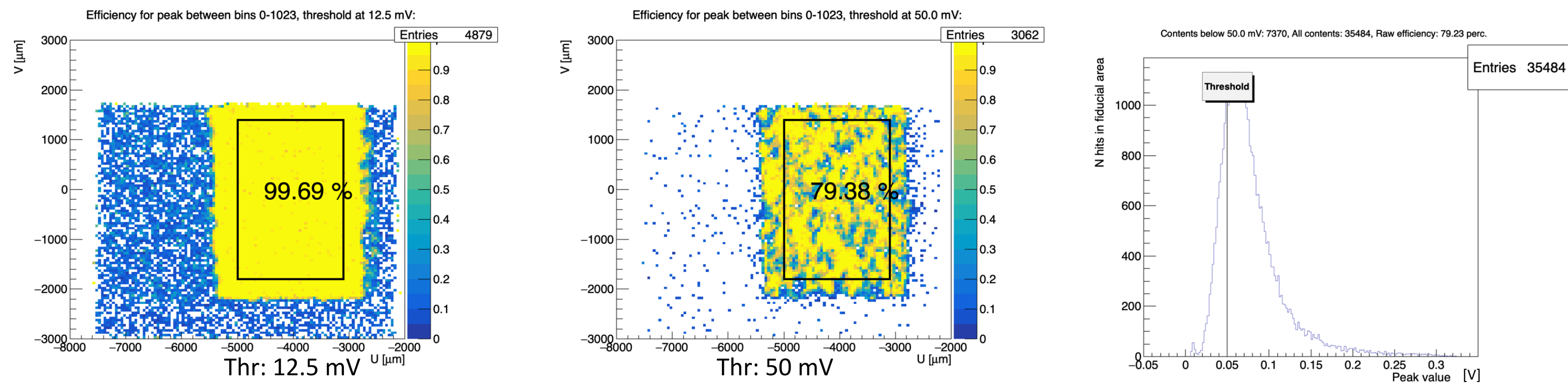


# Efficiency-threshold dependance: pCVD diamond, rotated module

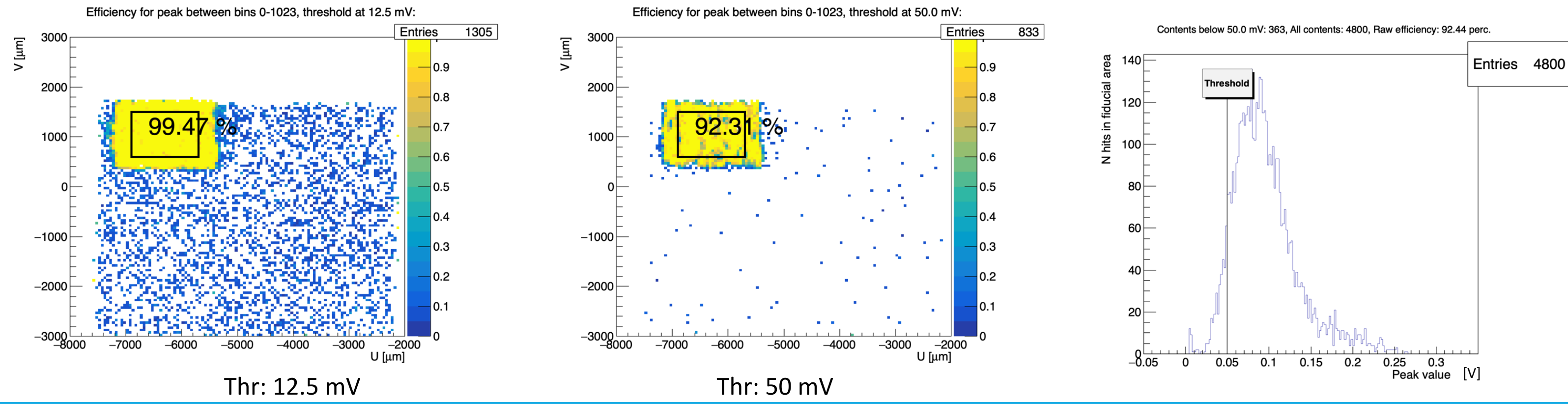
- Rotated module has higher average signals, noise remains the same as for “normal” pCVD
- Inefficiency areas appear, the same as for “normal” pCVD



Largest pad: lowest average signals, efficiency drop is the quickest



Small pad: largest average signal, efficiency drop is much slower

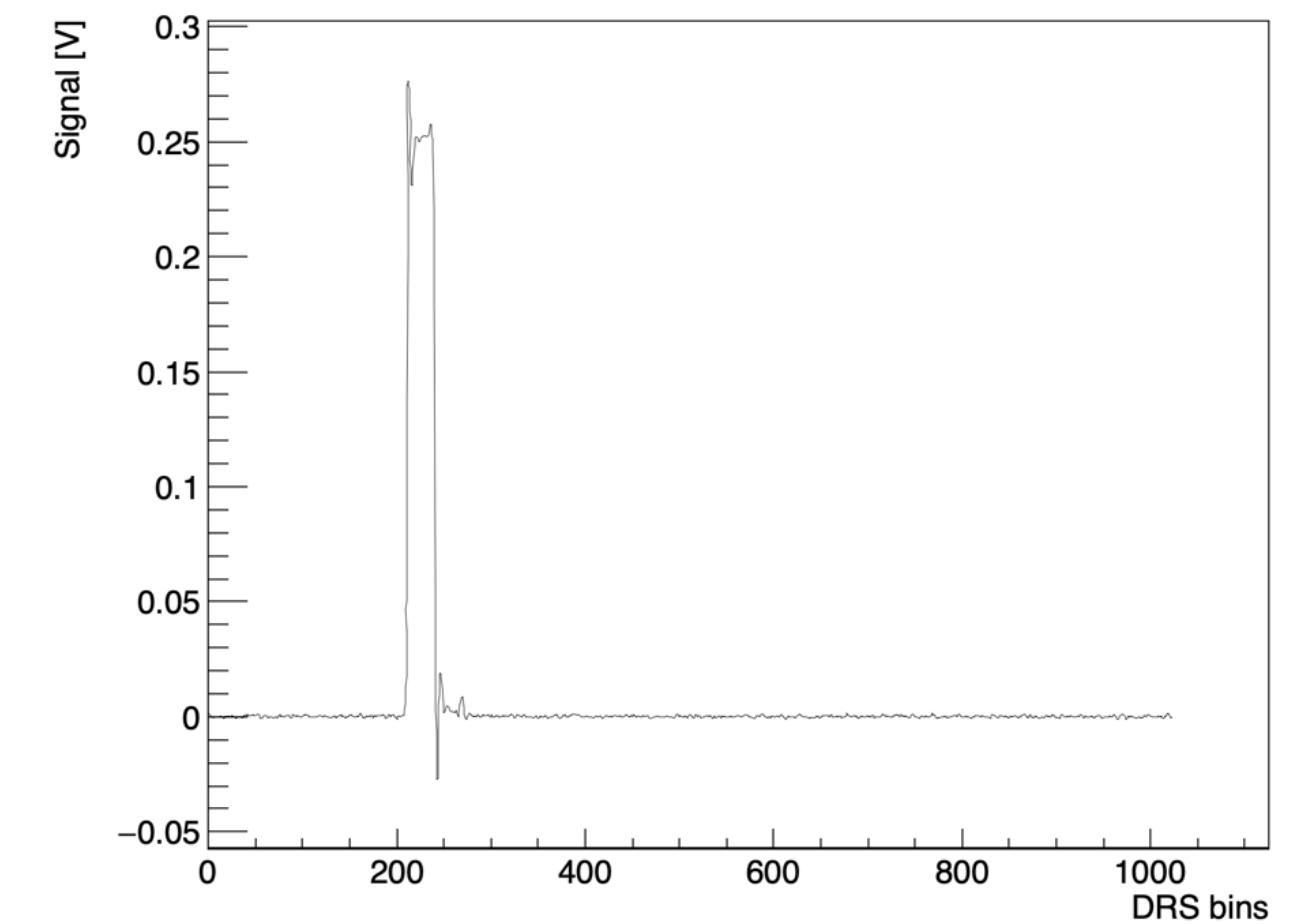


# pCVD diamond efficiency, digital signal, rotated module

- Overnight run 200113, only digital signals, currently only around 50k events used due to multiple desynchronisations -> low statistics
- Threshold for efficiency set at 120 mV, to discriminate between “hit” or “miss”
- DAC threshold in Calypso set to 0x30 -> this causes lower efficiency in the largest pad, where analog signals are the lowest

Example of a digital signal, average signal height is around 250 mV:

Digital signal



Digital signal “hit” and “miss” (peak) distribution for largest pad:

