ProtoDUNE TPC data:
Charge resolution with pulser data 2

ProtoDUNE sim/reco

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Introduction

Pulser data is useful for performance evaluation

- Same FE charge injected at regular intervals
- Amplifier and ADC same as for charge collected from TPC

Performance metrics

- Local charge resolution
  - E.g. RMS of measured charge for many pulses
    - For each channel and
    - For multiple charge injection levels ($\sim$ 1, 2, 3, … MIPs)
- Non-linearity in charge measurements
  - E.g. look at mean response for different charge injection levels
  - Complicated by non-linearity of pulser levels but may be able to use the fact that the same pulser signal is seen by all channels in an ASIC or FEMB
- Tails in charge measurements
  - E.g. how often pulse measurement is N-sigma from mean

Important for studying reco algorithms

- How are above metrics affected by pedestal evaluation, noise removal, ADC mitigation, undershoot correction, deconvolution, etc?

Calibration

Results here make use of calibrated data

- Calibration from pulser data presented here last month
- Calibration is linear: Q = gain × (ADC − pedestal)

Example pulses

- Plot on following page shows pulses at lowest pulser gain setting
  - I.e. pulse charge is around 21 ke (about 1 MIP)

Simple ROI algorithm

- Signals found with a (single-tick) threshold of 2.0 ke
- Retain 10 ticks before and 20 ticks after any tick above this threshold
  - Could be narrower for pulser signals but want to mimic TPC data
- ROI charge is the integral over this range
  - Presumably can do better with CE response function fit but we cannot use that with TPC data

Example signals from pulser
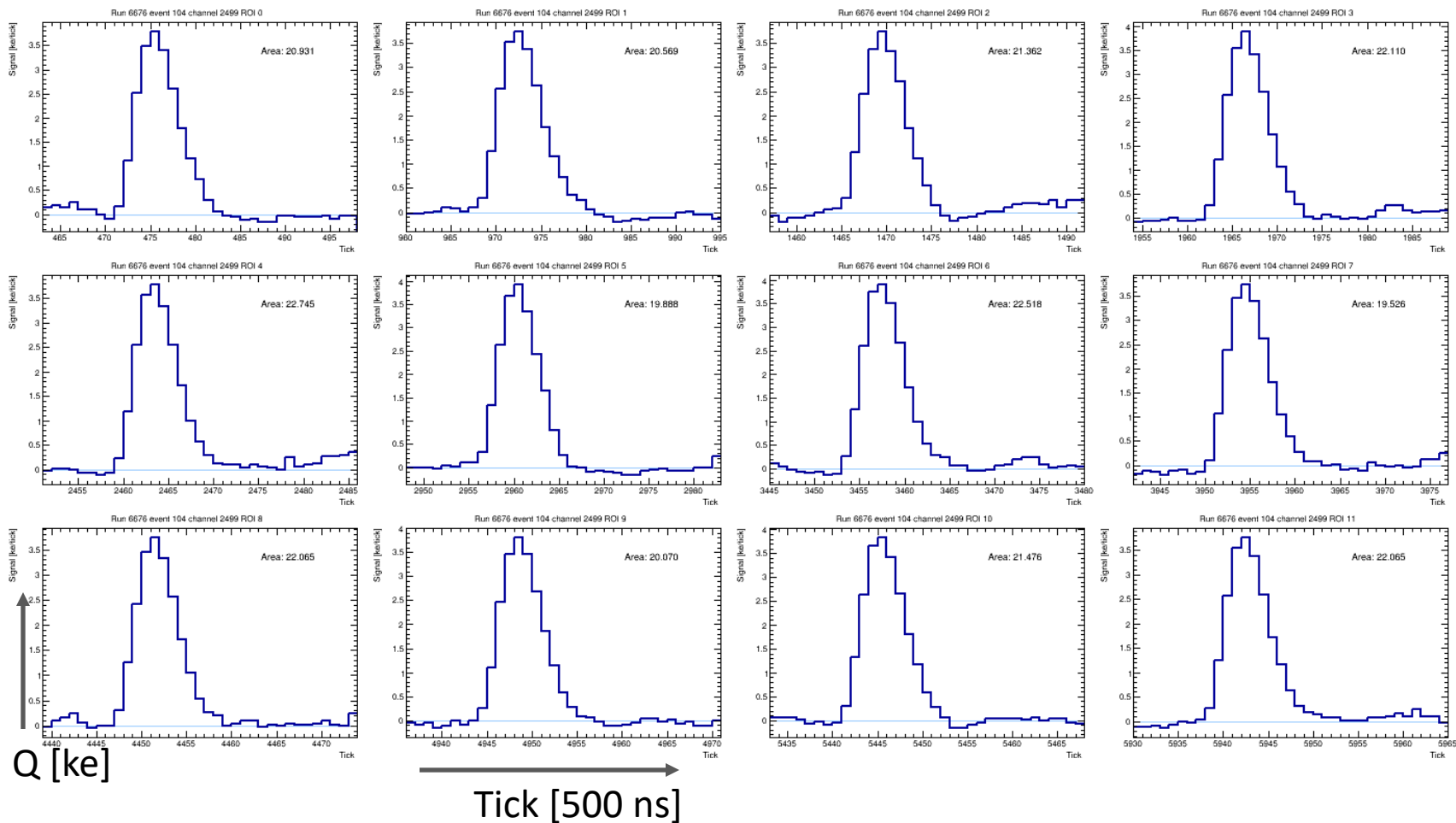
Calibrated pulses from run 6676. Pulser gain setting 1.

Study with HV off

Start with data taken with HV off

- Bias voltage is also off
- TPC signals are still seen but much less than with HV on
- Runs 6676 – 6691
  - Pulser settings 1-10
- Analysis
  - Process the first 50 events for each run (~600 pulses each channel)
    - Results shown with and without ADC mitigation
  - ROI area as described earlier
  - Histogram the area for each channel in each run
  - Evaluate the RMS for each histogram retaining entries within ±4×RMS
- New this week
  - Look at ROI with no signal
    - By shifting ROI by 150 ticks in the lowest gain pulser run
  - Begin to look at resolution with HV on

Results with HV off, ADC mitigation on

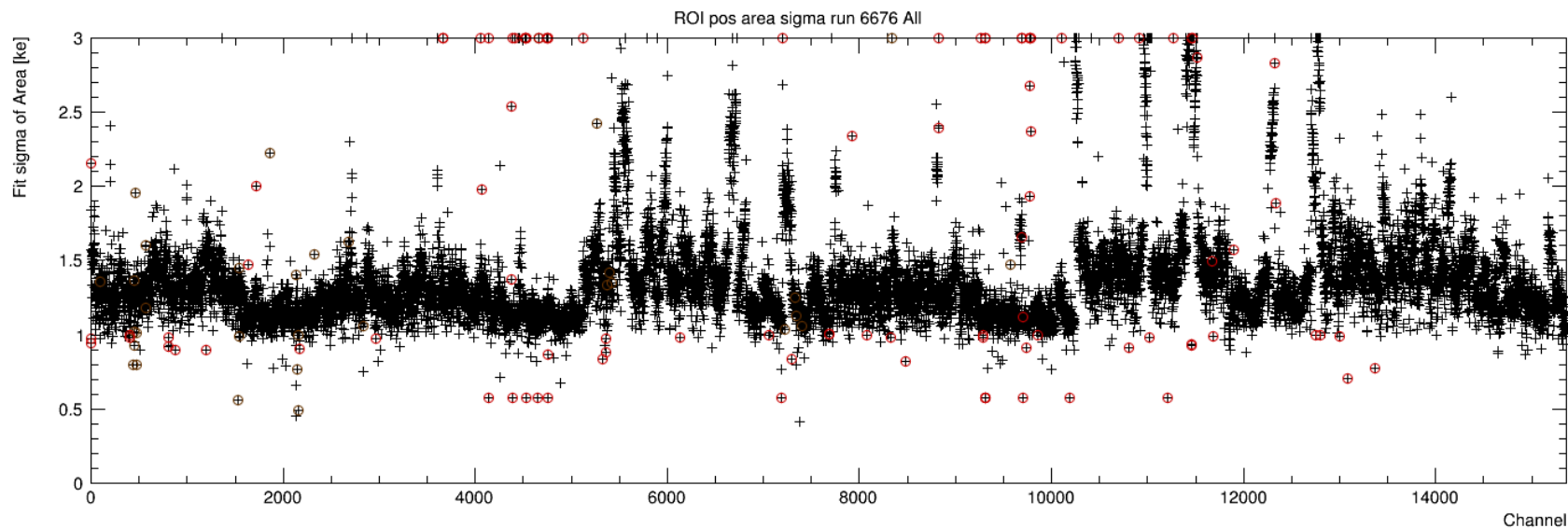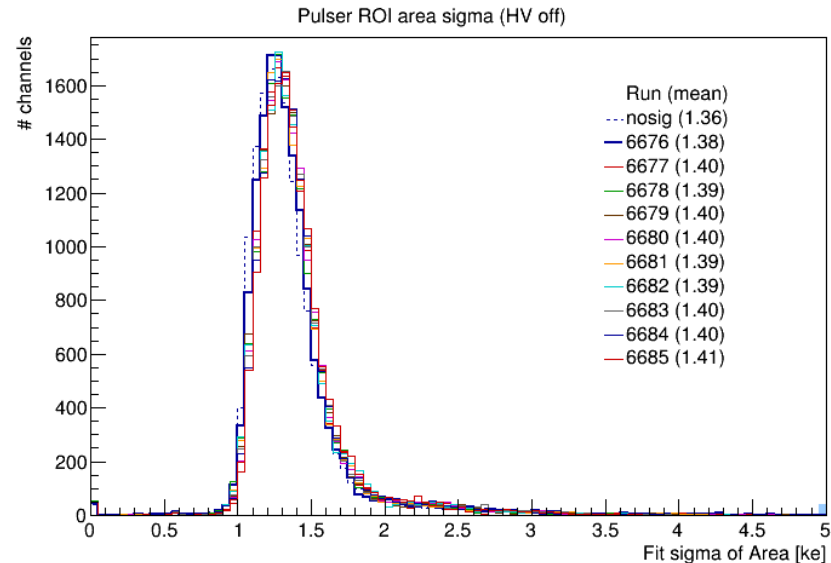## Results with ADC mitigation

- Same shown last week
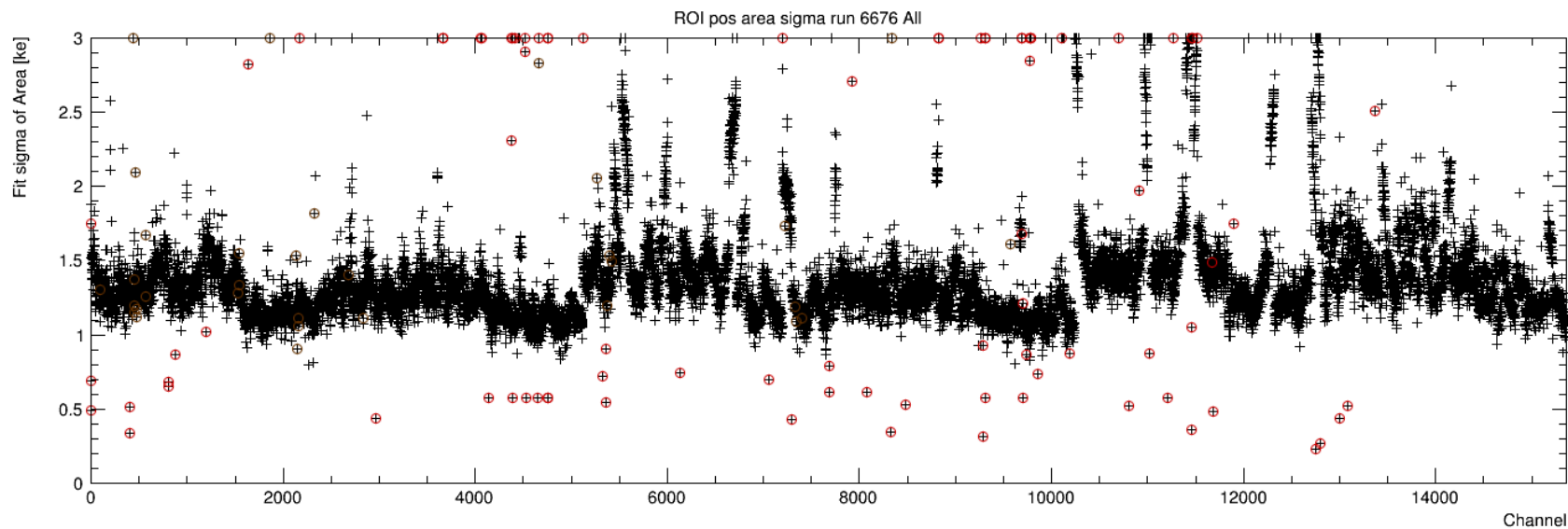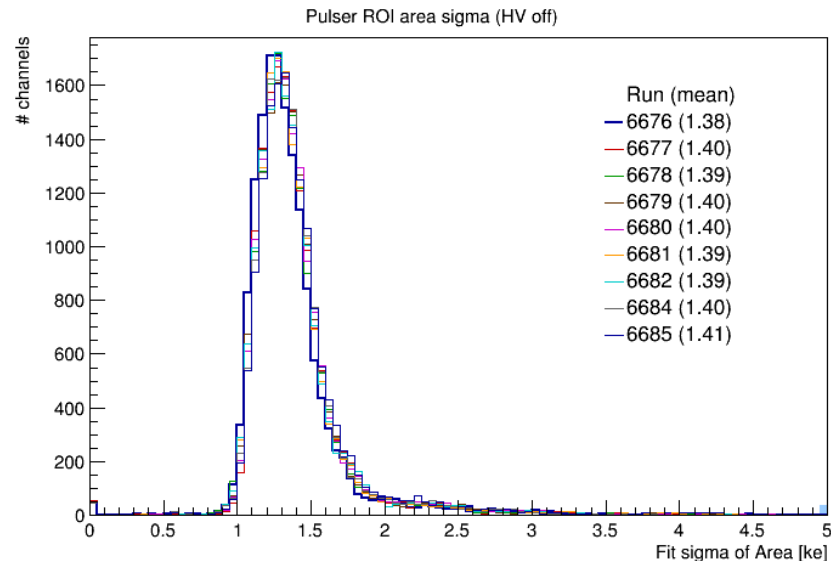
Adding sample away from pulser signal

Results for no peak

- Plot at right adds dist away from signal region

- ROI shifted down 150 ticks
  - Using A=1 run 6676

- Below shows mean sigma for each channel with this shift

Pulser ROI area sigma (HV off)

Run (mean)
- nosig (1.36)
- 6676 (1.38)
- 6677 (1.40)
- 6678 (1.39)
- 6679 (1.40)
- 6680 (1.40)
- 6681 (1.39)
- 6682 (1.39)
- 6683 (1.40)
- 6684 (1.40)
- 6685 (1.41)

ROI pos area sigma run 6676 All

Studying HV on

We would like to look at resolution with HV on

- Suspect the HV is adding noise

- BG from radioactive decay should be included

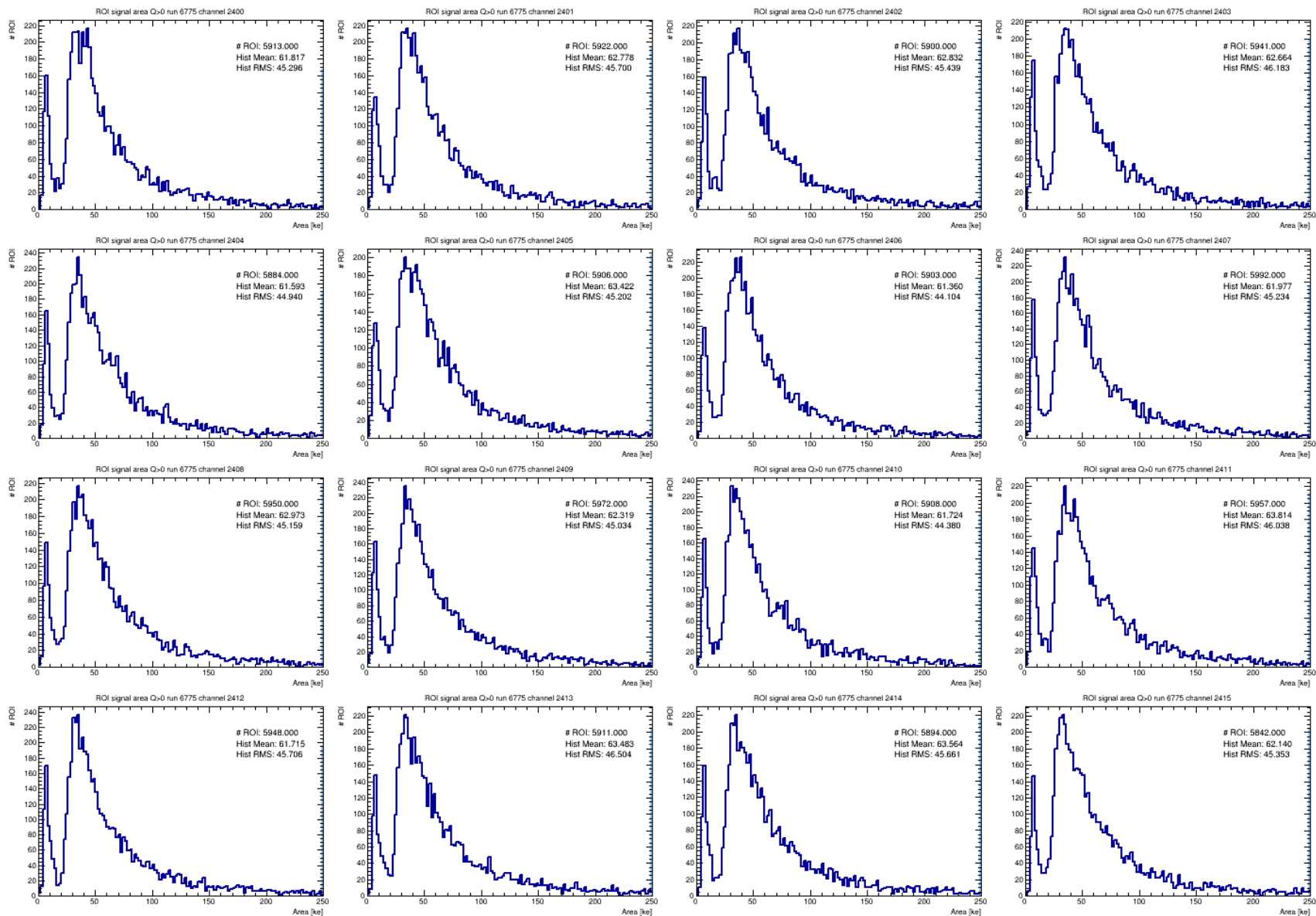- Cosmic contamination interesting for protoDUNE but will be much less for DUNE FD

Expect a lot of distortion from cosmic signals

- Pulser repeats every 497 ticks

- Mean time between cosmic ROIs is about 1500 tick

  - From study with single-bin threshold 0.7 ke

  - Most ROIs are above 1 "MIP"

- See plots on following two pages

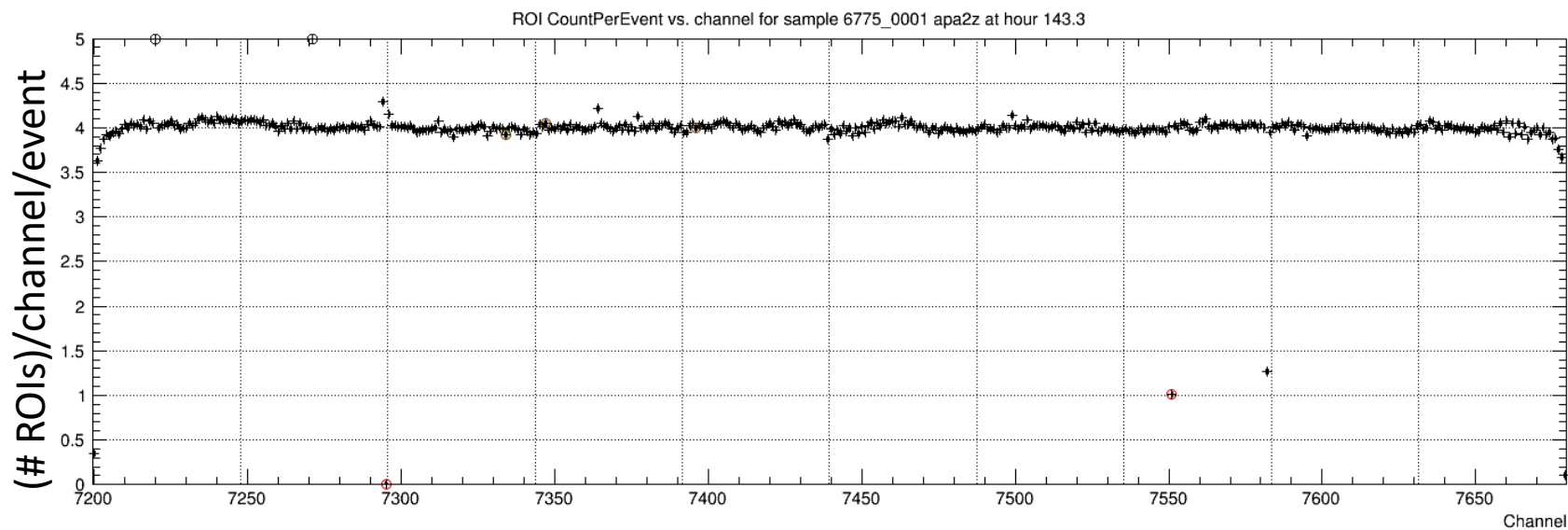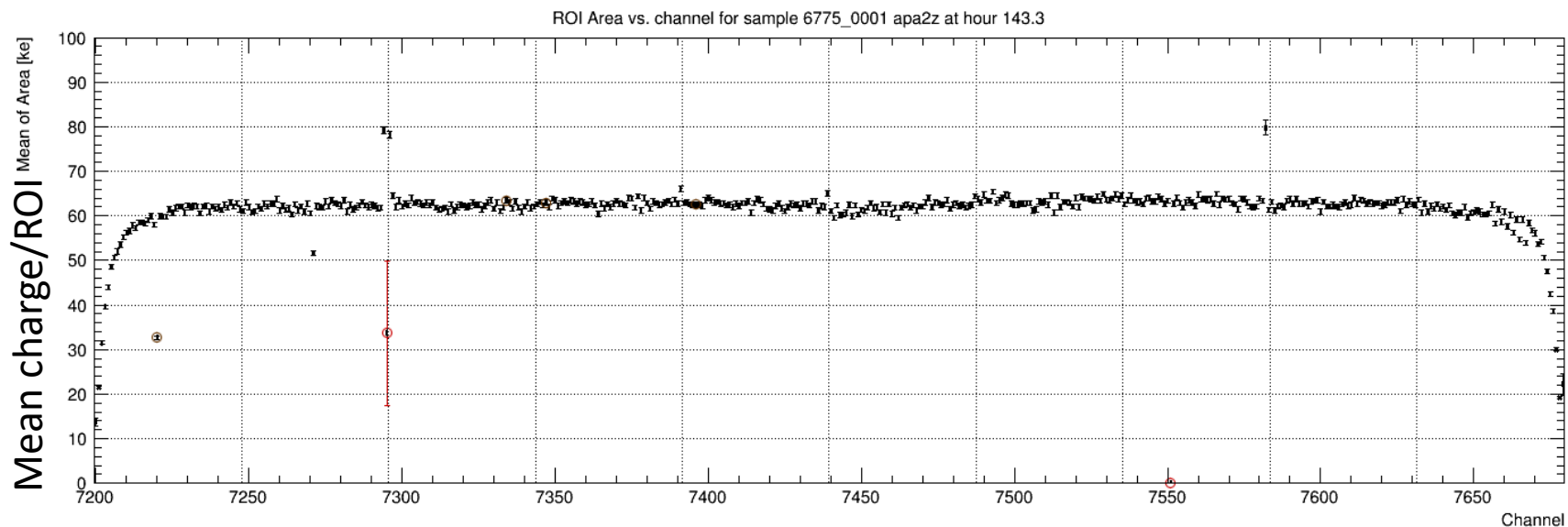- We look at core resolution so much of the cosmic signal is excluded

Start by applying HV off analysis to HV on data

# Example ROI spectra with HV on

Example ROI mean charge and multiplicity

ROI Area vs. channel for sample 6775_0001 apa2z at hour 143.3

ROI CountPerEvent vs. channel for sample 6775_0001 apa2z at hour 143.3

HV off results for A=3

Results with HV off

- Right is distribution of mean area sigmas for all channels
- Below is mean area sig for each channel

ROI pos area sigma run 6678 All

ROI pos area sigma run 6678 All
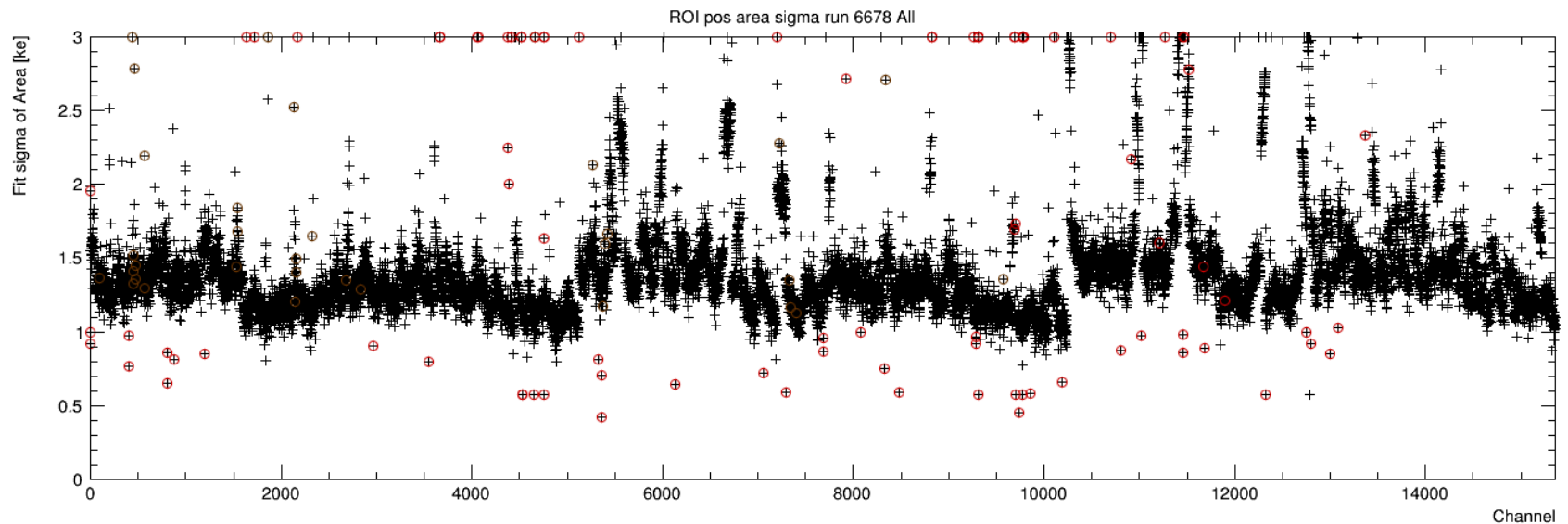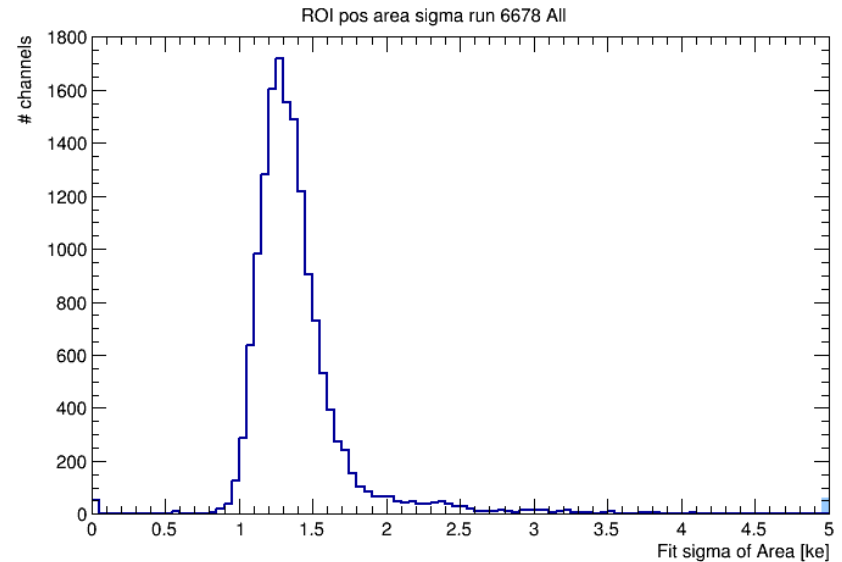
HV on results for A=3

Results for HV on

- As previous except for a run with HV on and so contamination from cosmics

ROI pos area sigma run 6096 All

ROI pos area sigma run 6096 All

Induction

TPC collection

Cryostat collection
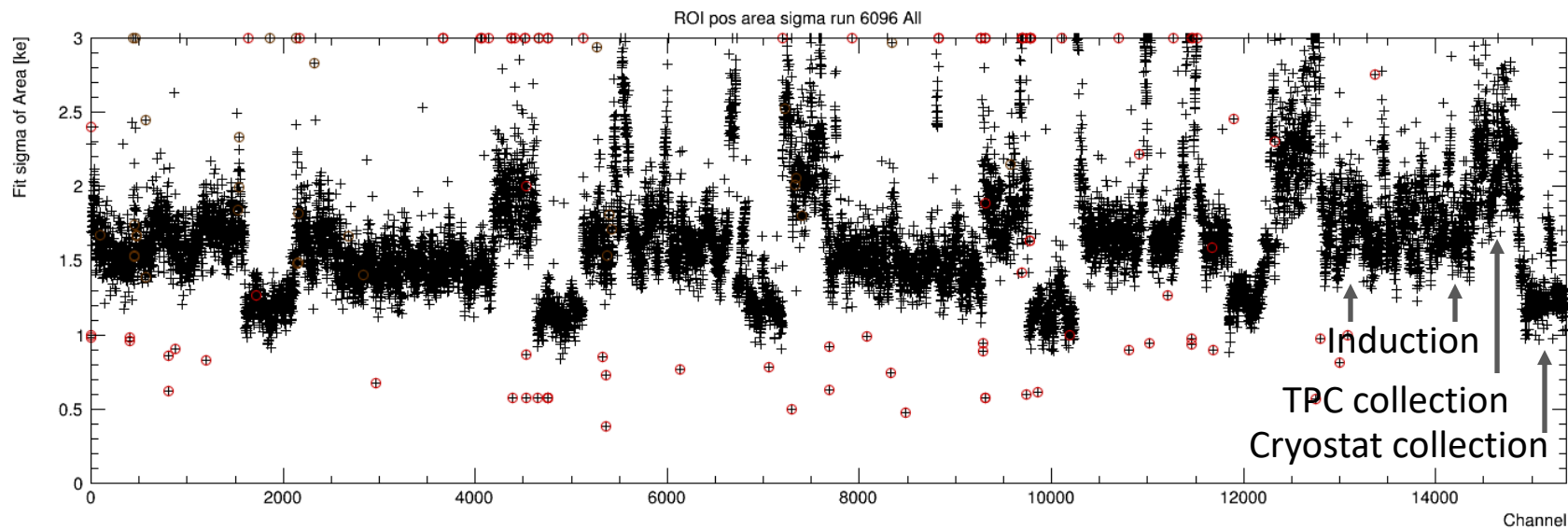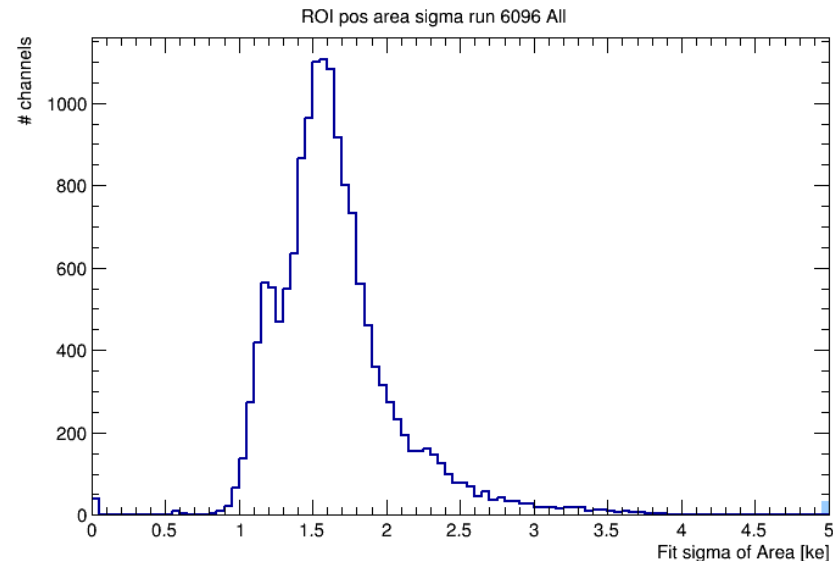
Resolution with HV on and timing

HV on has big effect on resolution

- See preceding plot
- But we are likely mixing cosmic signals with pulser signals
    - See following plots
    - Core cuts some but apparently not all BG

Pulser is regular ➡ use cut on timing to suppress cosmic BG

- Cut on tickmod == Tick%497
- But FEMB302 has fast clock
    - Uses clock on FEMB because connection to timing clock is broken
- Clock ratio was evaluated by eye to using event displays
    - R = 0.9995
- But this result for 6000 ticks is not good enough for the 50-500 sec of data used in the pulser analysis
- Timing ratio has been evaluated for a few pulser runs…

Timing ratios

Timing ratio evaluated with pulser data

- Look at peak of tickmod distribution in each event
- Plot this vs. timing clock
- Results are shown in table
- Ratio changes with time
  - Not important for reco
  - Important for pulser analysis
- Plots showing effect follow

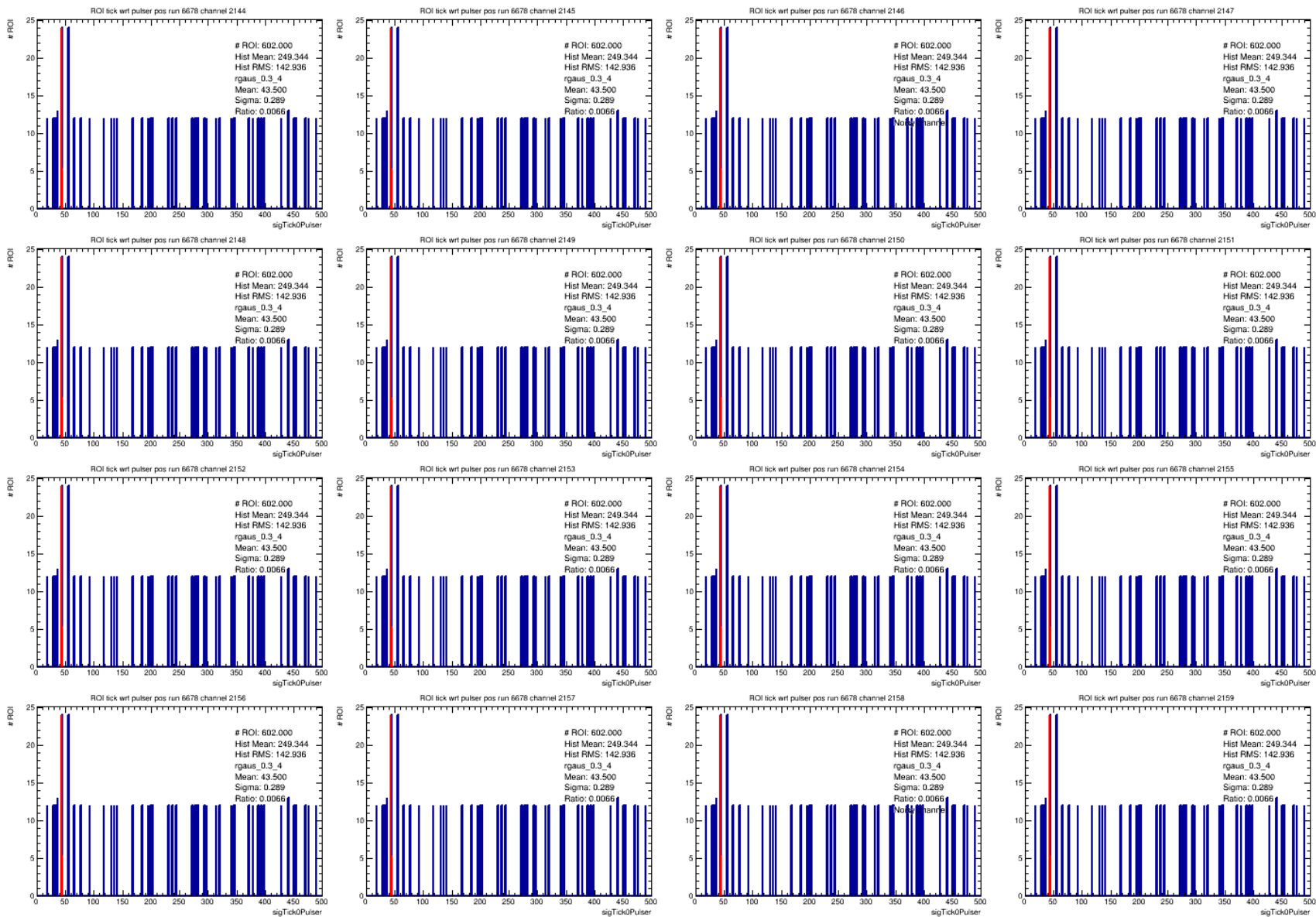| Run	Timing ratio
Event display	0.9995
5954	0.9992875
5531 (5526, 5540)	0.9992961
6036	0.9992927
6690	0.9992930

Next

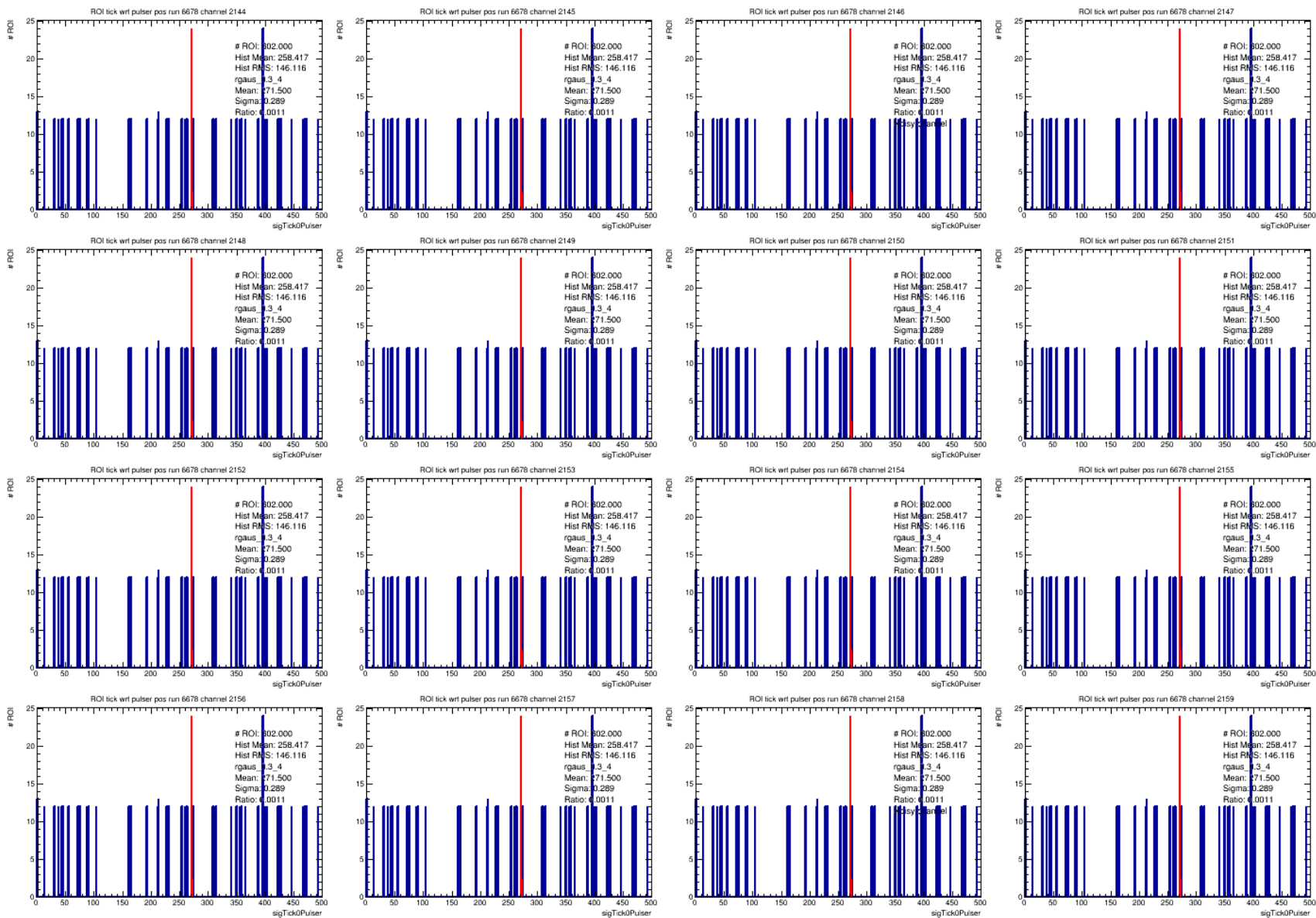- Resolution with tickmod cut coming soon…

FEMB 301 tickmods

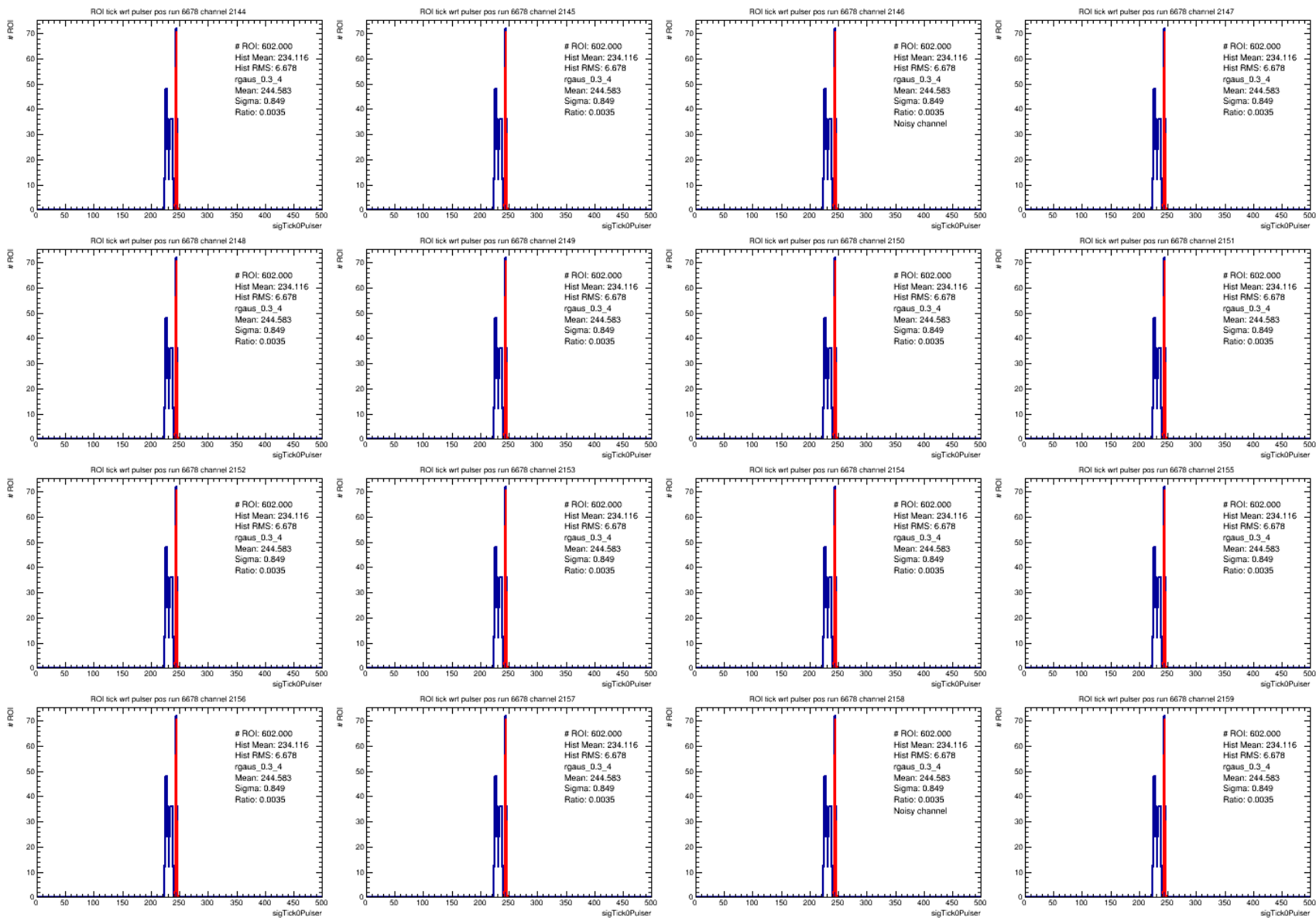# FEMB 302 tickmods with no timing correction

FEMB 302 tickmods TR = 0.9995

FEMB 302 tickmods TR = 0.9992930

FEMB 302 tickmods TR = 0.9992927