Overview

NPPS

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Introduction (to me)

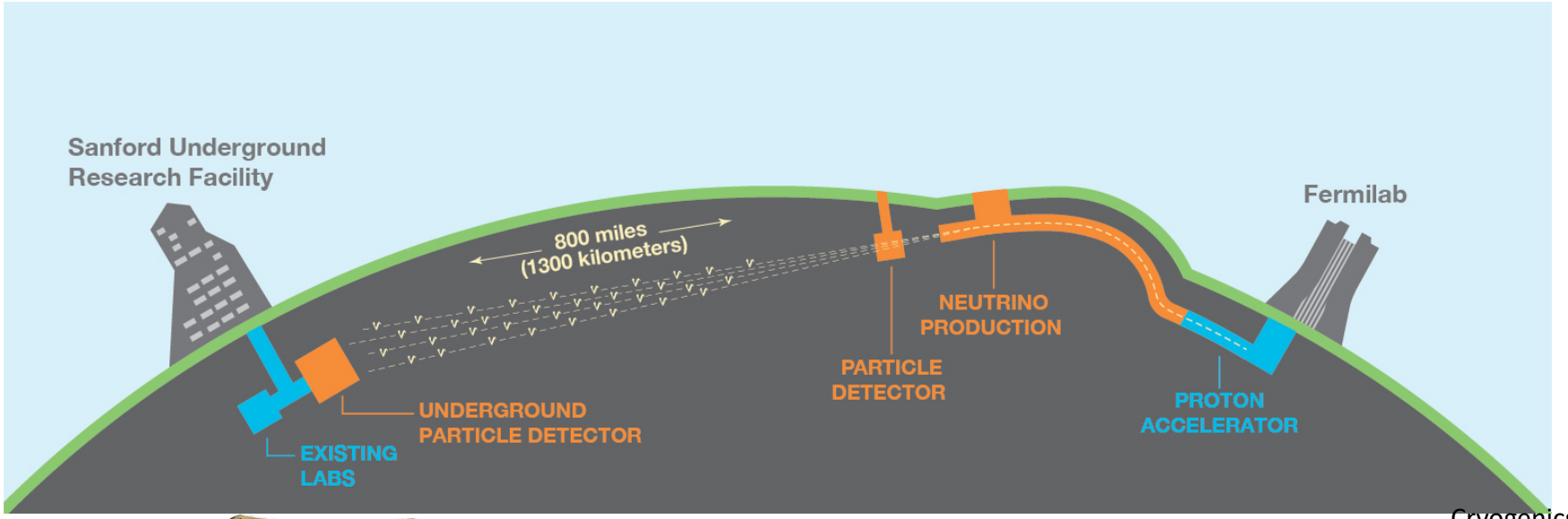
History

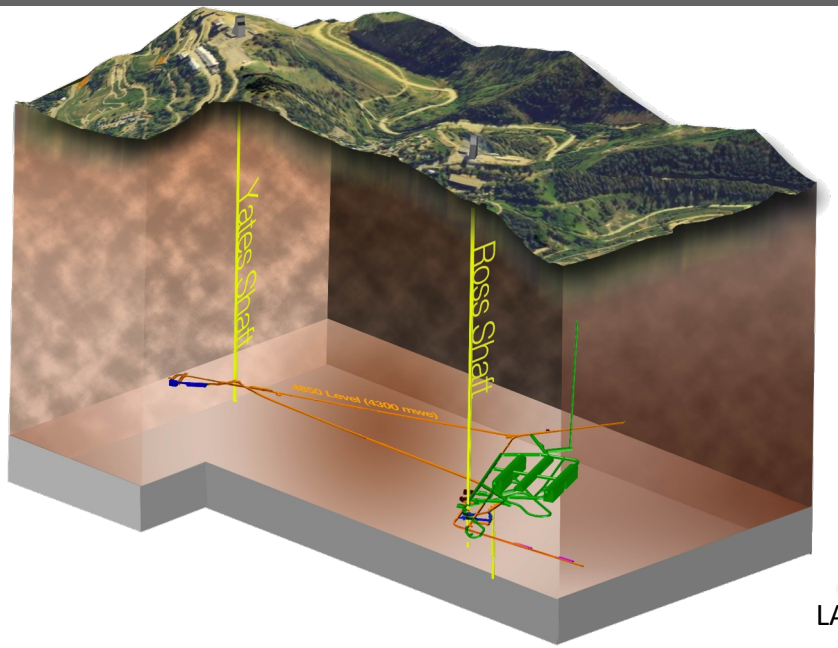
- D0: Track finding/reco, SW build infrastructure
- ATLAS: SW infrastructure, muon reconstruction, jet finding software, exotics searches: ($W' \longrightarrow l\nu$, $X \longrightarrow (jj)(jj)$)

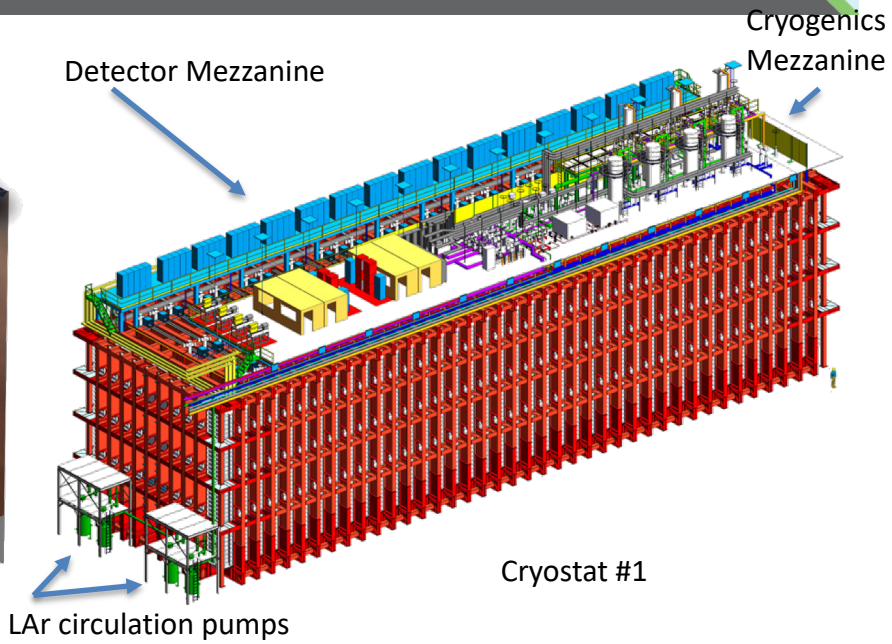
Current: DUNE

- SW infrastructure
  - Algorithm encapsulation and frameworks
  - Offline (and beyond) SW packaging
  - Weekly release builds
- LAr TPC signal reconstruction
  - Sticky code mitigation
  - Noise removal
  - Performance metrics
  - Monitoring and event display

DUNE overview







Algorithm encapsulation

Where to put the code?

- Tradition: art framework calls *modules* that pull input from event data store and write output back
- Many lines of code and so difficult to understand, maintain and configure (run time specification of parameters)
- New ideas ➔ add more code and configuration
- Module interface is art specific and very difficult to use or test outside the art framework
- In practice many copies of code: new collaboration or detector within a collaboration started by copying earlier modules

Better approach

- Divide and conquer with *tools*
- Divide module code into steps implemented in tools that can be swapped around

Tools

Art tool

- C++ class with dynamic lookup and fcl configuration
  - Fcl is fairly simple configuration language (param: value)
- Typically inherit from interface so client has no compile or link time dependency on the tool class
- Minimal intrusion/dependency on framework
  - Class needs on-line macro to declare name for dynamic lookup
  - And ctor with FCL as argument
    - Easy to imagine adding another ctor for a new configuration language
  - No inheritance from generic tool base class (type safety issue)
  - Easy to use outside the art framework (standalone exe, Root script, …)

Tool manager (DUNE extension)

- Map tool configurations to names
  - Configuration = tool class name plus values for parameters
- Referencing tools by name instead of full configuration simplifies the configuration of their clients
- And allows multiple clients to share (or not) a tool instance

Dataprep

Primary example of tool use is DUNE data preparation

- Input is (decoded) raw data
  - Array of ADC samples for many channels
  - ProtoDUNE is typically 6k samples for 15k channels
- Output is processed ROI waveforms
  - E.g. arrays of ~100 float samples
- Processing done in a series of steps that act on the samples
  - Identifying and mitigating problems
  - Removing noise
  - Deconvoluting with response function
  - Finding ROIs
- Each step is a tool instance with interface that takes one or a collection of channels
  - Multiple channels are useful for removing correlated noise

Example configuration of the dataprep service

```
services.RawDigitPrepService: {
   AdcChannelToolNames: [
     "digitReader",
     "pd_adcPedestalFit",
     "adcSampleCalibration",
     "pdsp_sticky_codes_ped",
     "pdsp_adcMitigate",
     "adcTailRemovalKe",
     "pdsp_noiseRemovalKe",
     "pedmetSignalFinderKe”]
   DoWires: ”true"
   LogLevel: 3
   service_provider: "ToolBasedRawDigitPrepService"
 }
```

Processing tool names.

Display and monitoring tools can be inserted between steps to see progress in cleaning signal

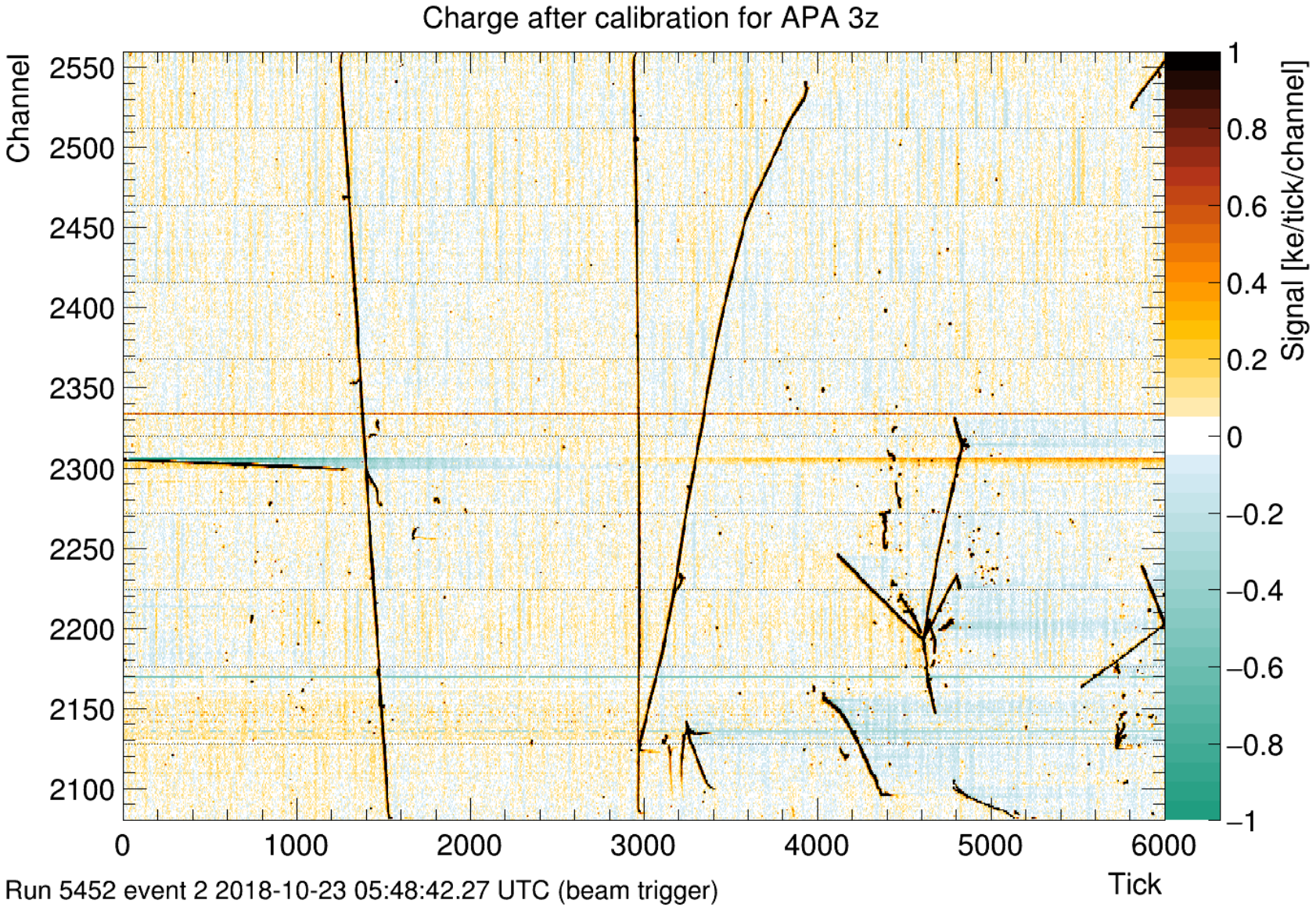
Class name.
Top level of dataprep is implemented as *service*.
Could/should be a tool?

Example tool configuration

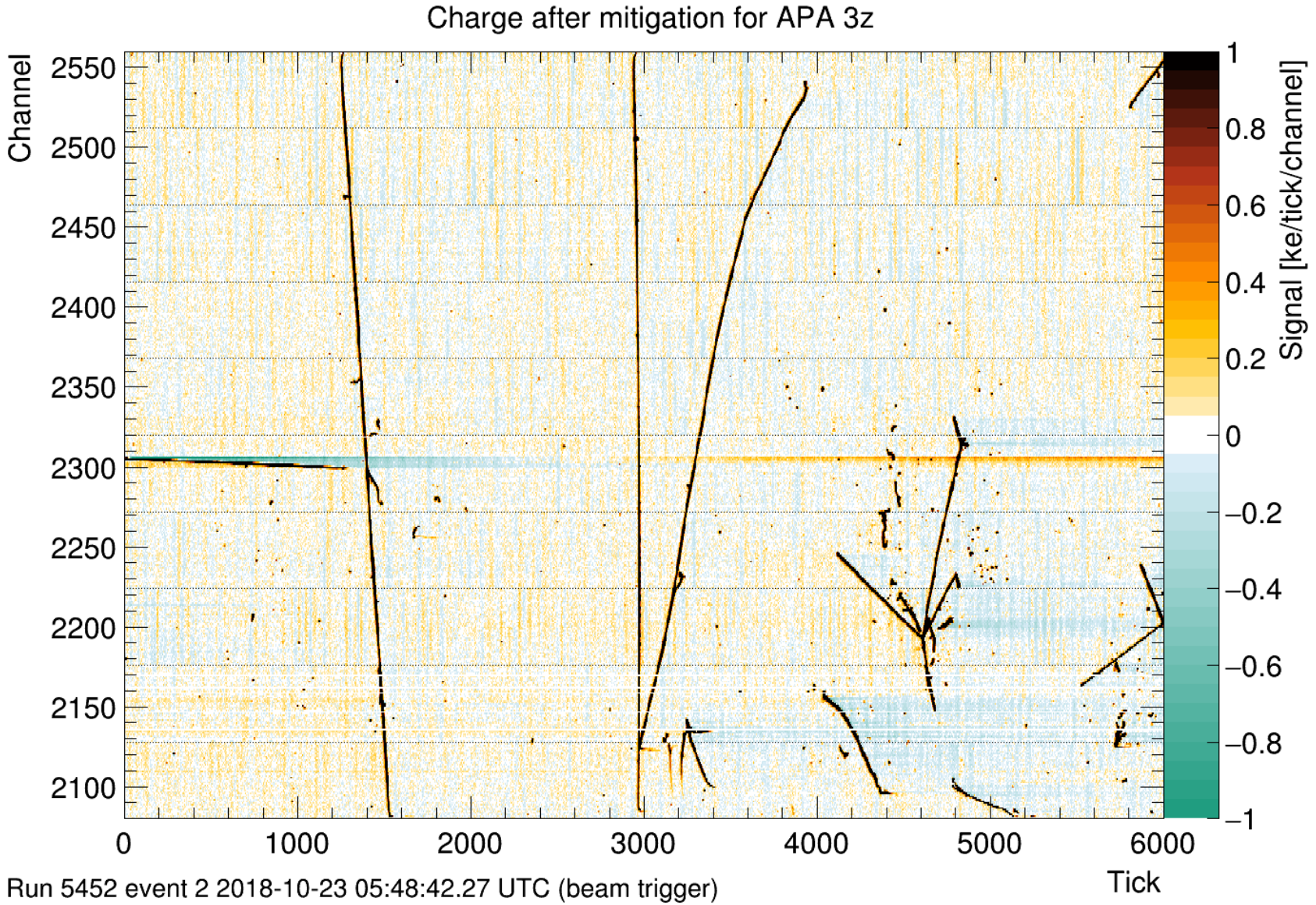
```
tools.pedmetSignalFinderKe: {
   BinsAfter: 20
   BinsBefore: 10
   FlagNegative: "true"
   FlagPositive: "true"
   LogLevel: 1
   MaxLoop: 20
   SigFracMax: 0.8
   ThresholdMin: 0.5
   ThresholdRatio: 5
   ThresholdRatioTol: 0.1
   tool_type: "AdcNoiseSignalFinder"
 }
```

Class name

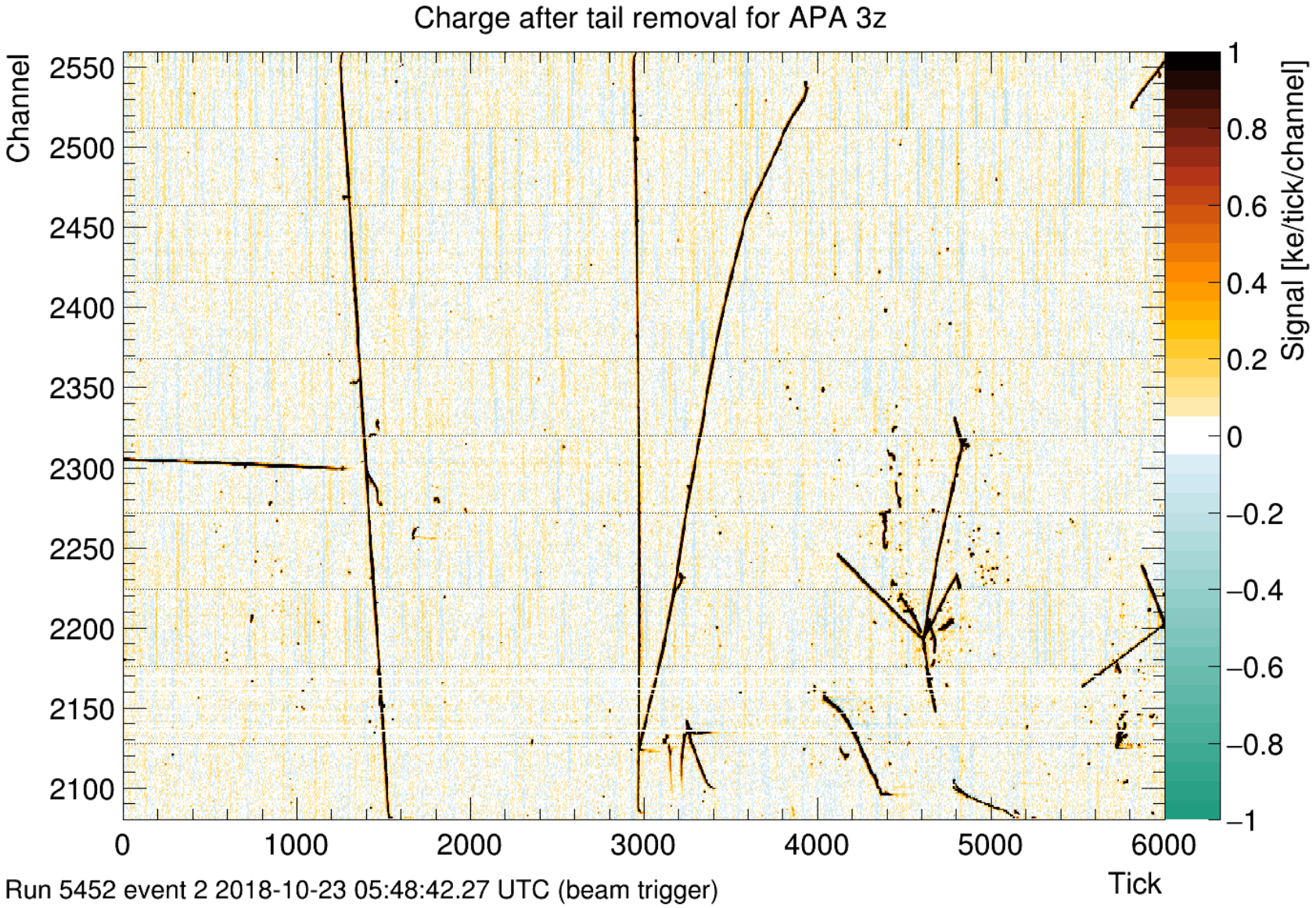
Example data: calibrated raw - pedestal



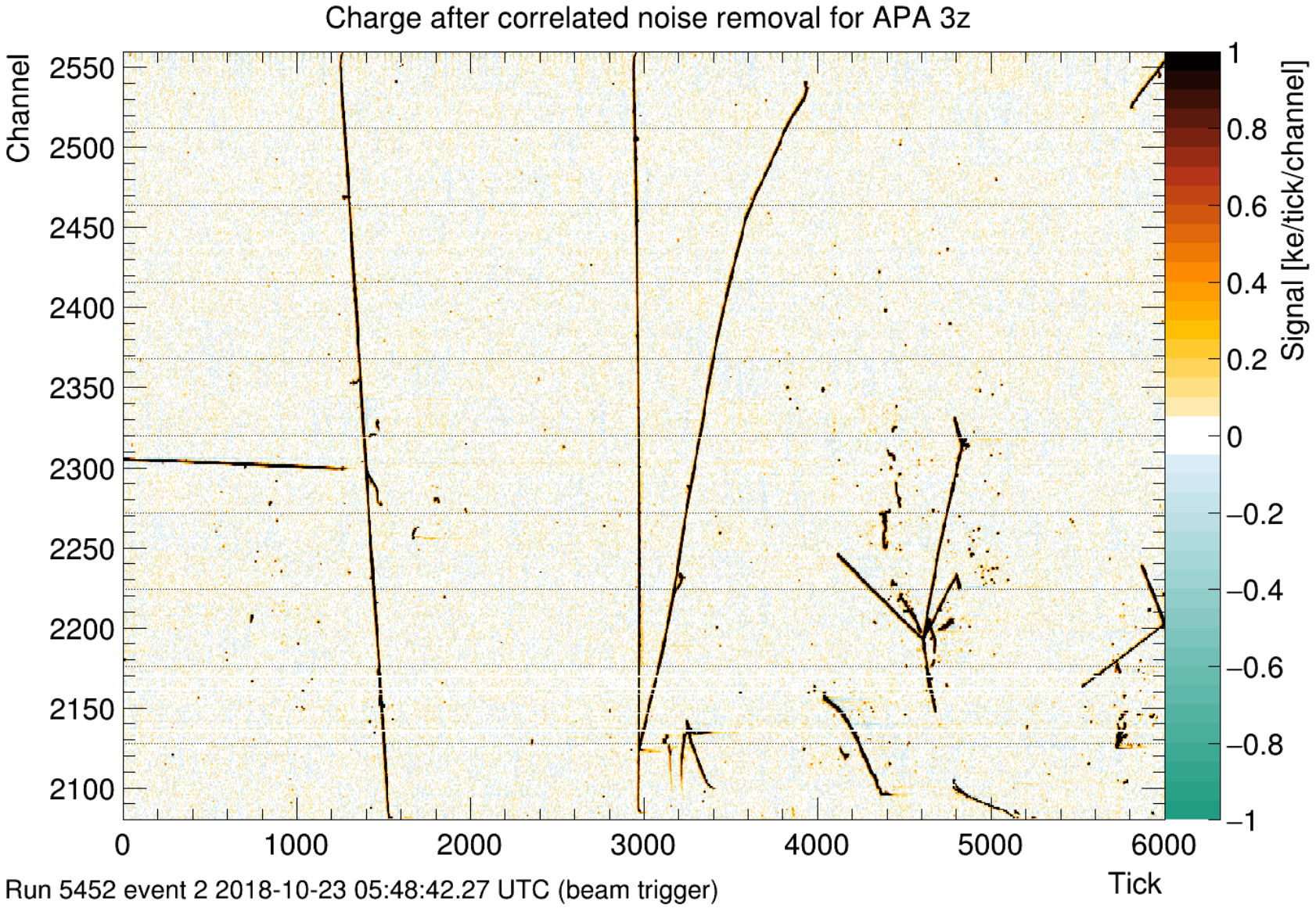
Plus sticky code mitigation, bad channel removal



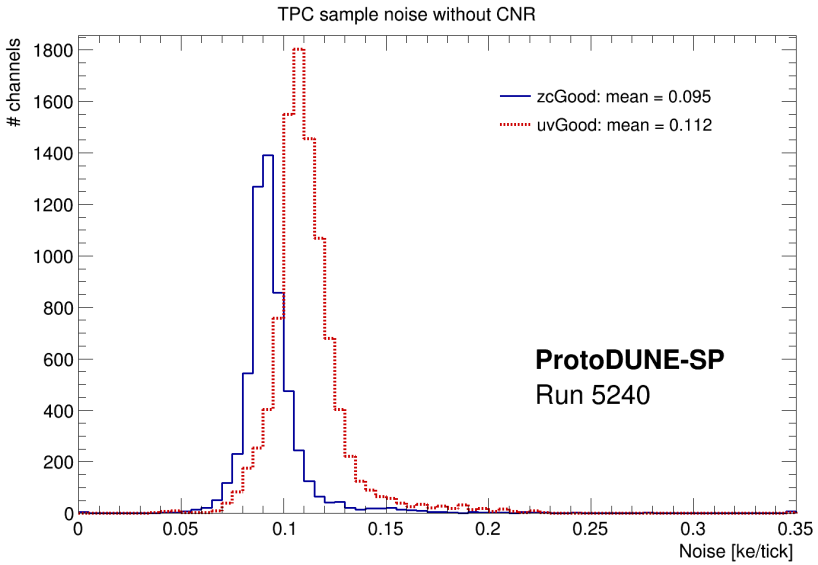
Plus tail removal (tails from AC coupling)

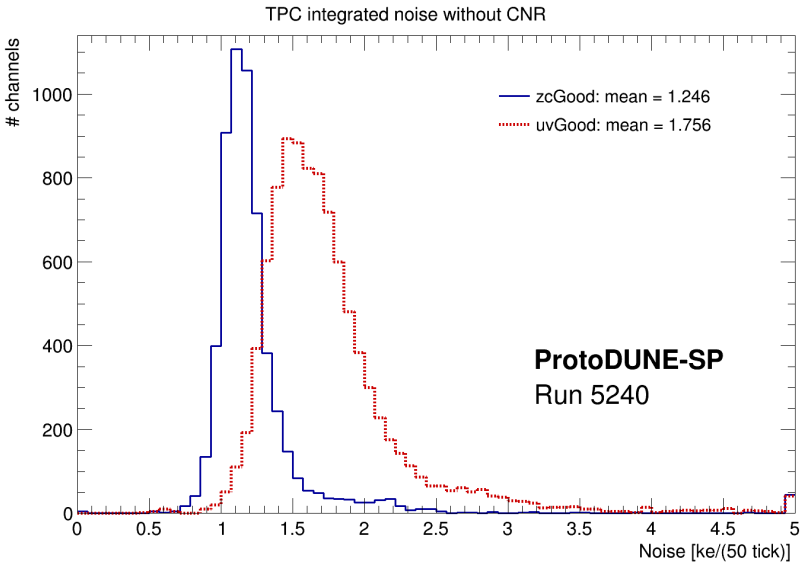


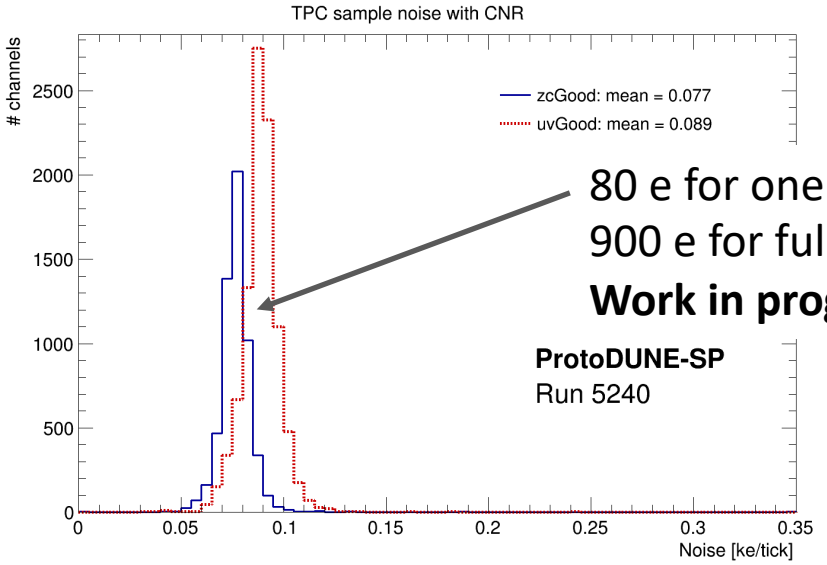
Pus channel-correlated noise removal

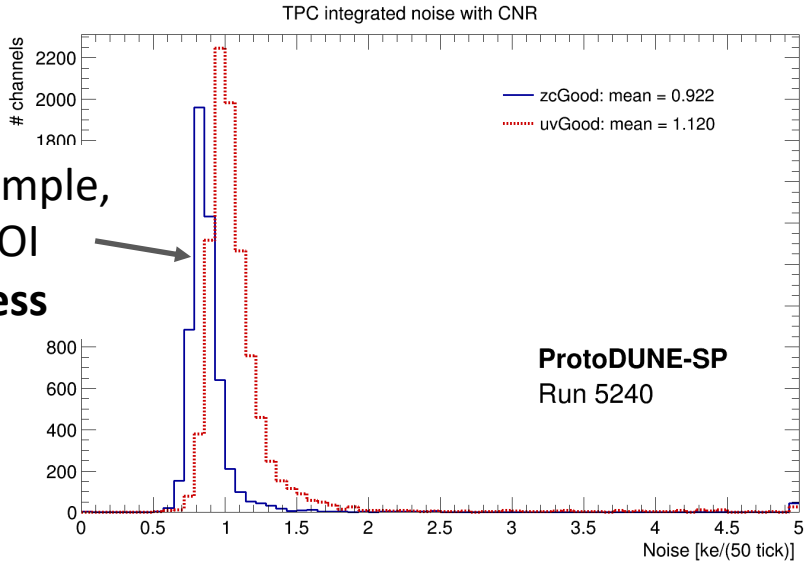


Example from resolution study



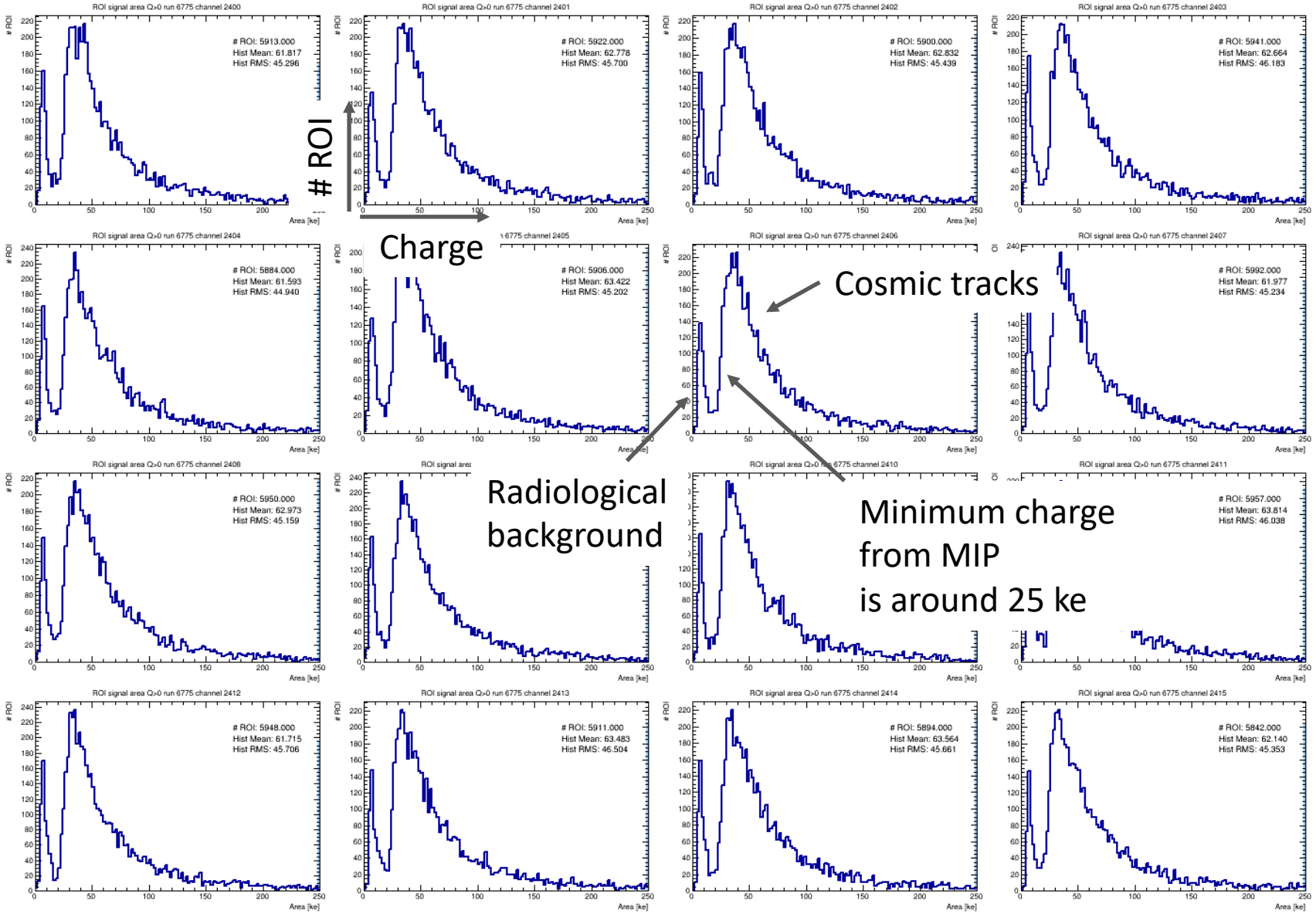




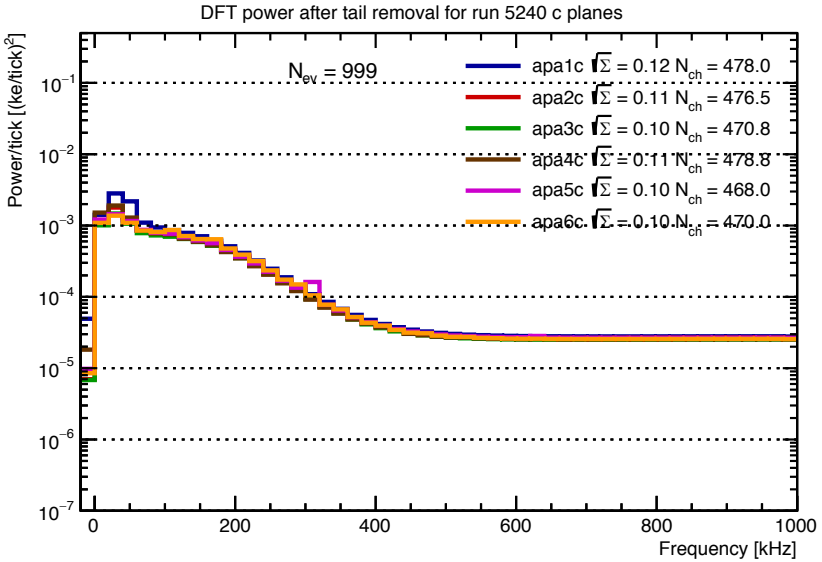


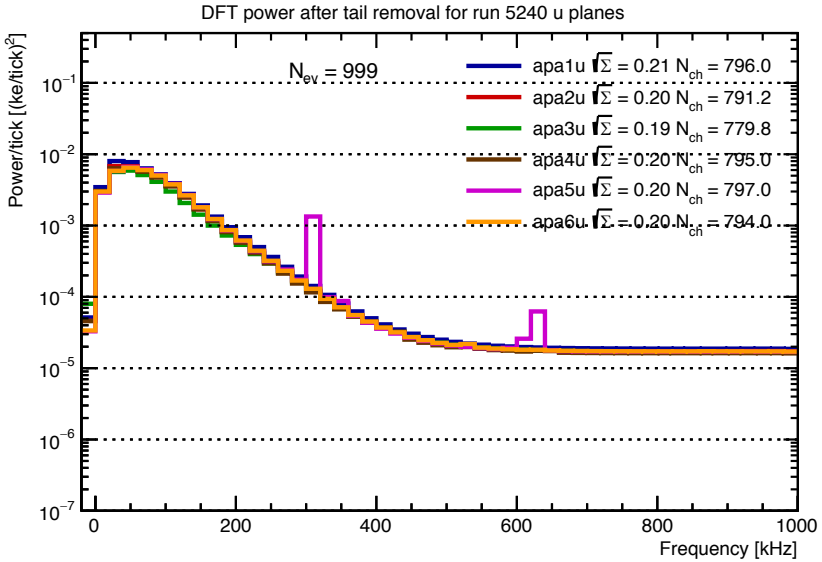
80 e for one sample,
900 e for full ROI
Work in progress

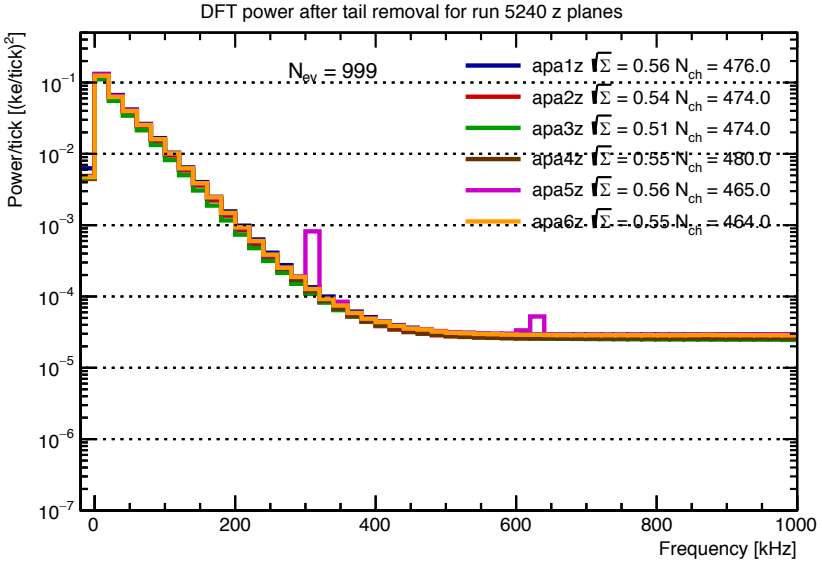
ROI collected charge (calibrated)

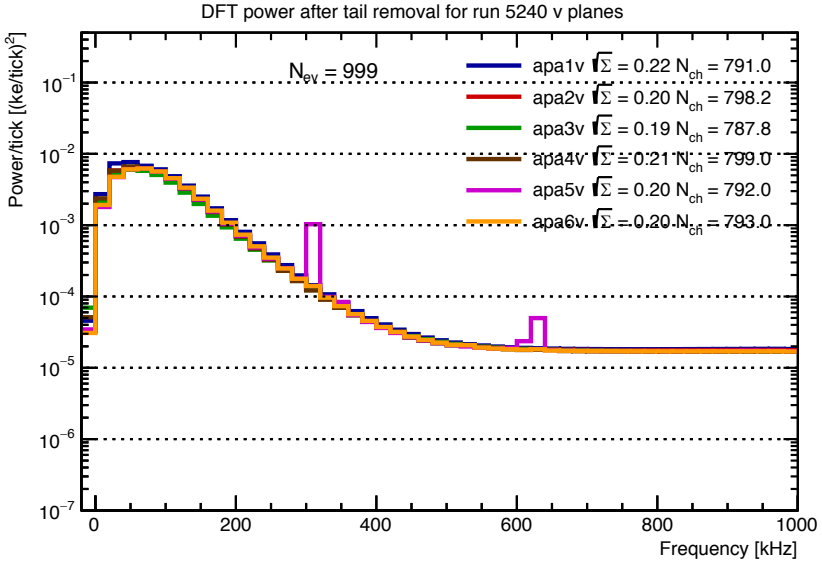


DFT for run 5240

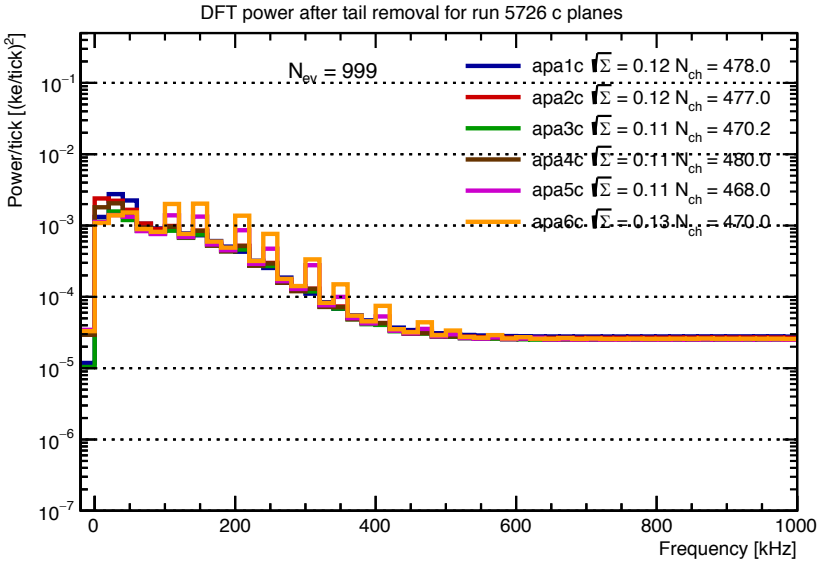


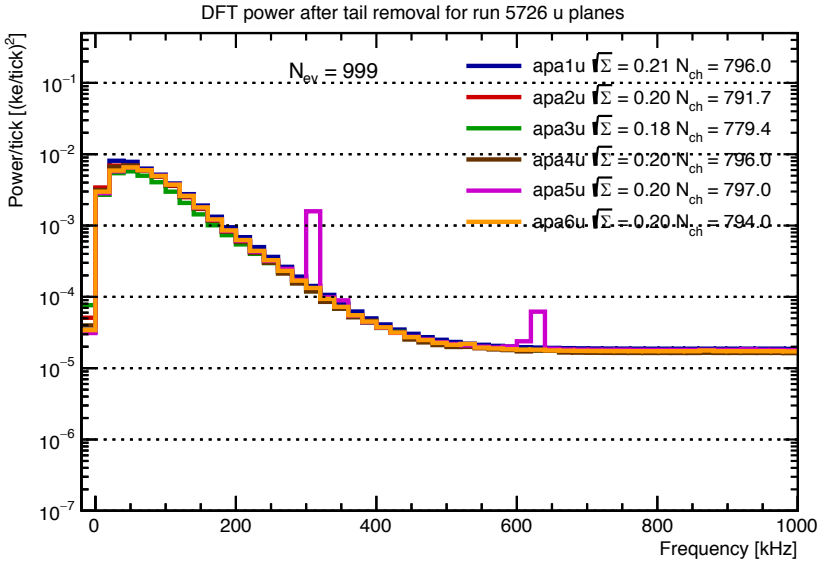


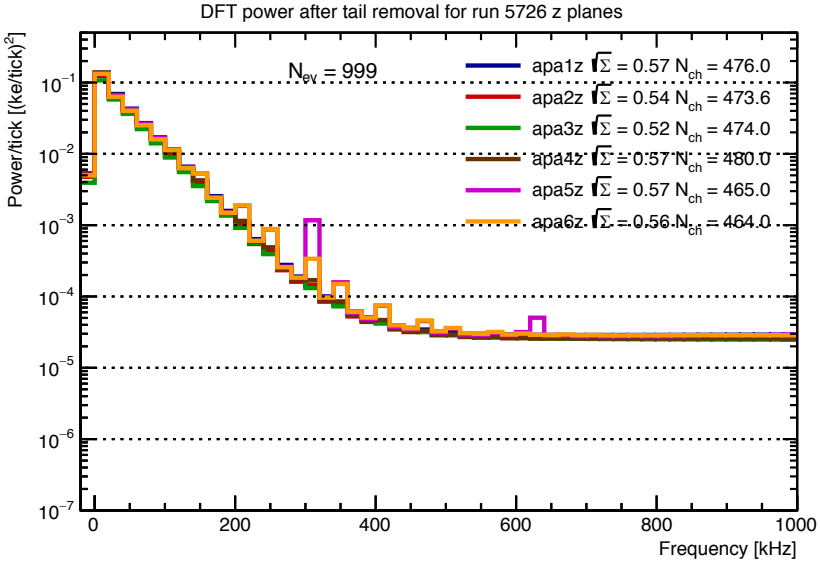


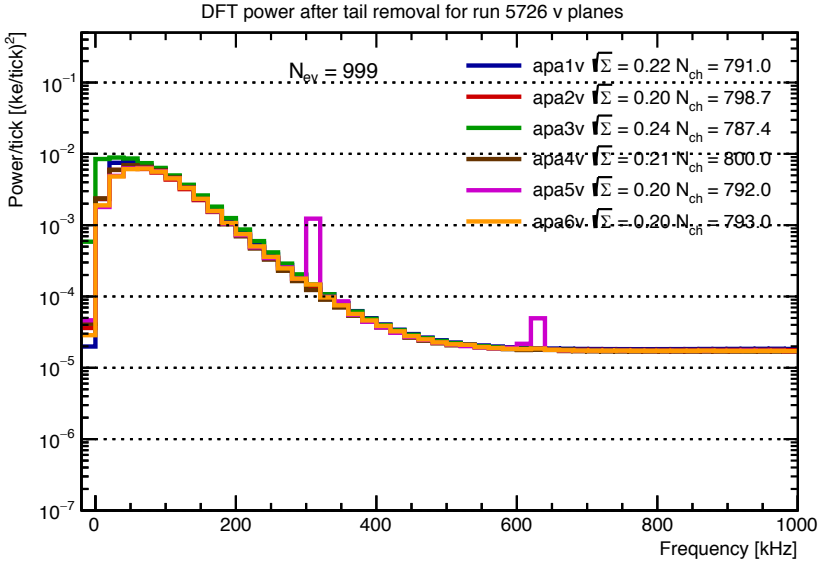


DFT for run 5726









Packaging

At present, most DUNE SW in one package

- Offline sim, reco, analysis
- Discussion underway to split this up
- Avoid very long time for developers to compile their contributions
- I will likely contribute significantly here

New dataprep module

TPC decoder

- Decoding TPC data uses much memory
- Copy large block of data from Root to event store to transient representation used in data processing
- Already have option to process one APA at a time in dataprep
  - ProtoDUNE has 6 APAs
  - DUNE will have many more
- New tool-based decoder tool (instead of module) provides the option to also decode one APA at a time
  - And not put data in event store
- Dataprep being modified (by me) to use this tool in this way

Tracking

Torre pointed out new tracking package ACTS

- I looked at one paper and the approach looks good
- I.e. very similar design to what we implanted for D0 run II
- DUNE already has couple solutions here
- But something I may look at later…

The event

Traditional HEP data processing based on events

- Each event processed independently
- Art framework assumes this
- DUNE plane for event is typically full detector for 6k or 10k time samples (3-5 ms)
  - Call this big event
- Can also trigger on and record data around ROIs
  - Small events

But model is breaking down

- Supernova will emit neutrinos over 10s of seconds
- If events are big, we will want to split them to separate overlapping signals and merge if track crossed from one to the next
- Small events will have to be merged

Don’t let offline processing model restrict DAQ

- Want maximum exposure time

Comments/conclusions

I am keeping busy with DUNE

- Software/computing design
- Understanding TPC data and helping to develop tools for signal processing