



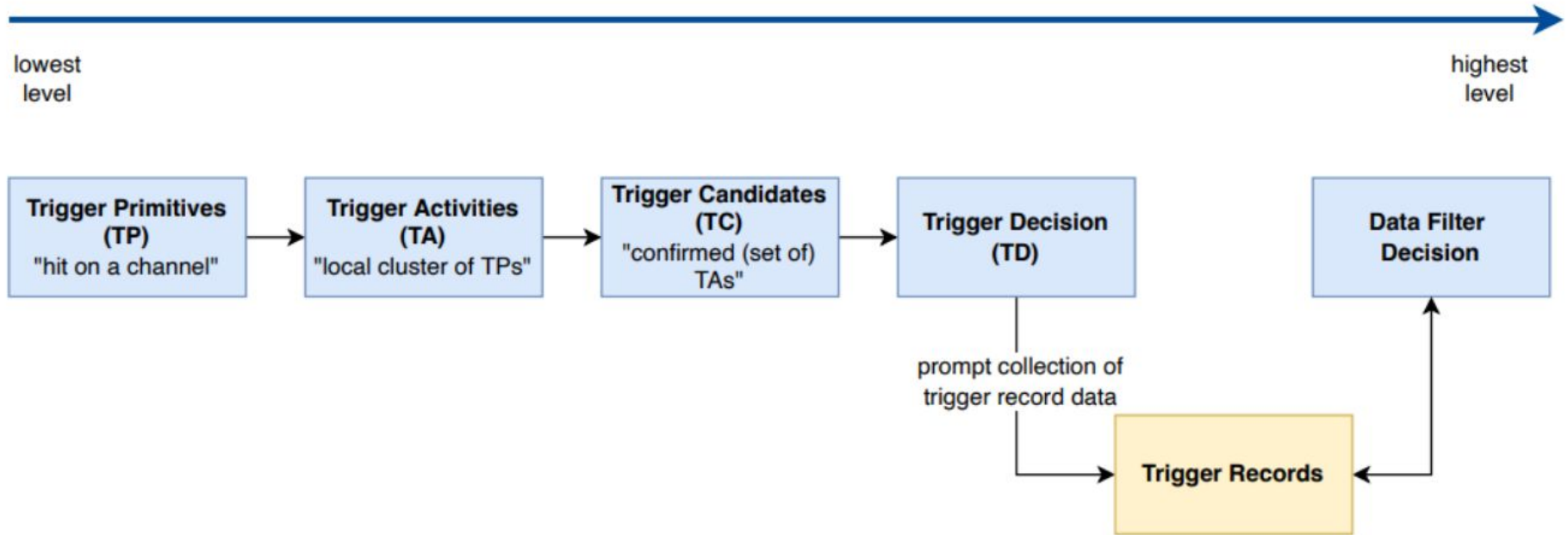
# LAr-trigger Simulation and Analysis

*Simranjit S Chhibra (QMUL), James Shen (UPenn)*

FD Sim/Reco Meeting, 18 November 2024

- **Aim:** reproduction of online DUNE-DAQ trigger chain in place for TPC simulation, and analysis
- **Simulation:** apply existing trigger algorithms (ADCSimpleWindow, ChannelAdjacency, etc) to simulation
  - Performance studies, comparisons to data (→ improved simulation)
- **Analysis:** make trigger objects (TPs, TAs, and TCs) available for offline analysis
  - TP-stream data analysis, trigger validation studies, etc
- **Development and testing of new algorithms**
- *Last presentation:* [by Wes's at the DUNE Collaboration Meeting](#)

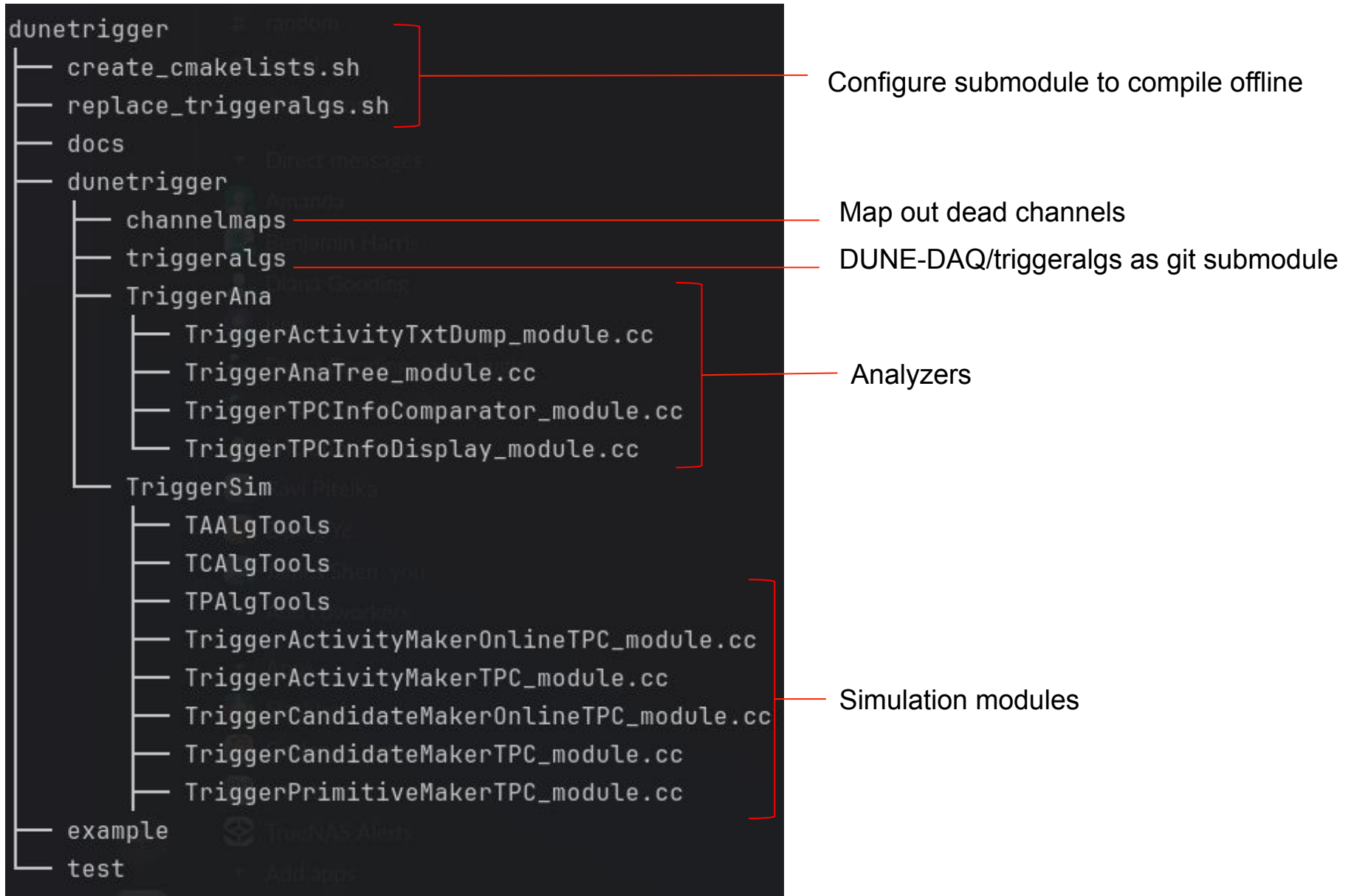
# Trigger Overview



# Technicalities

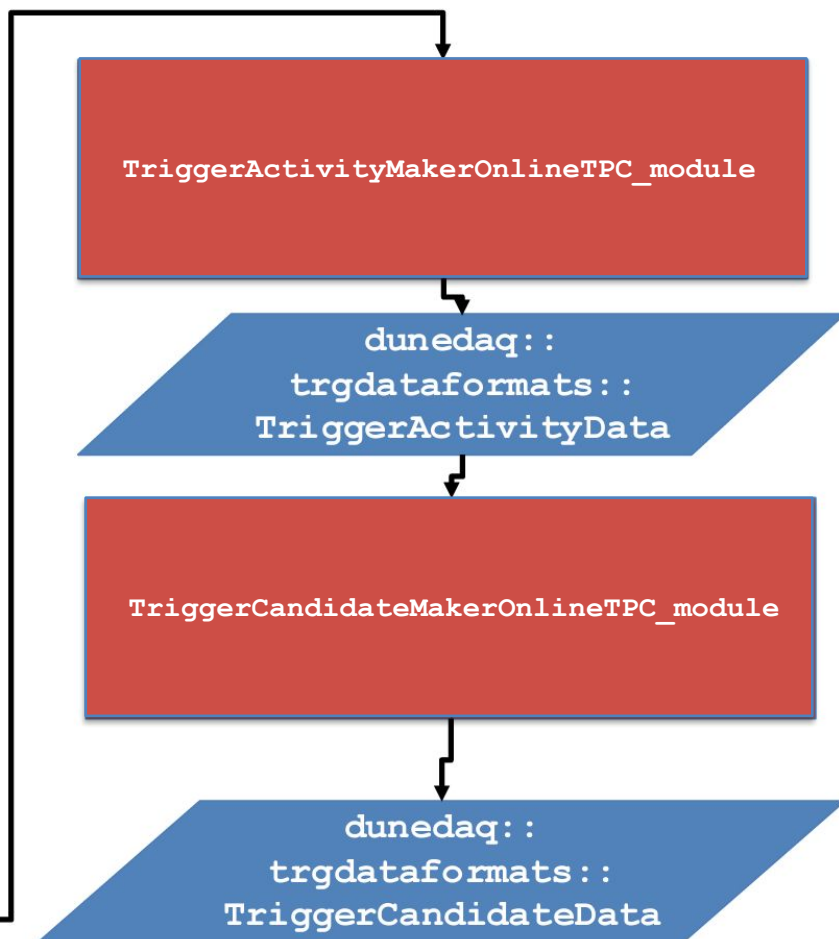
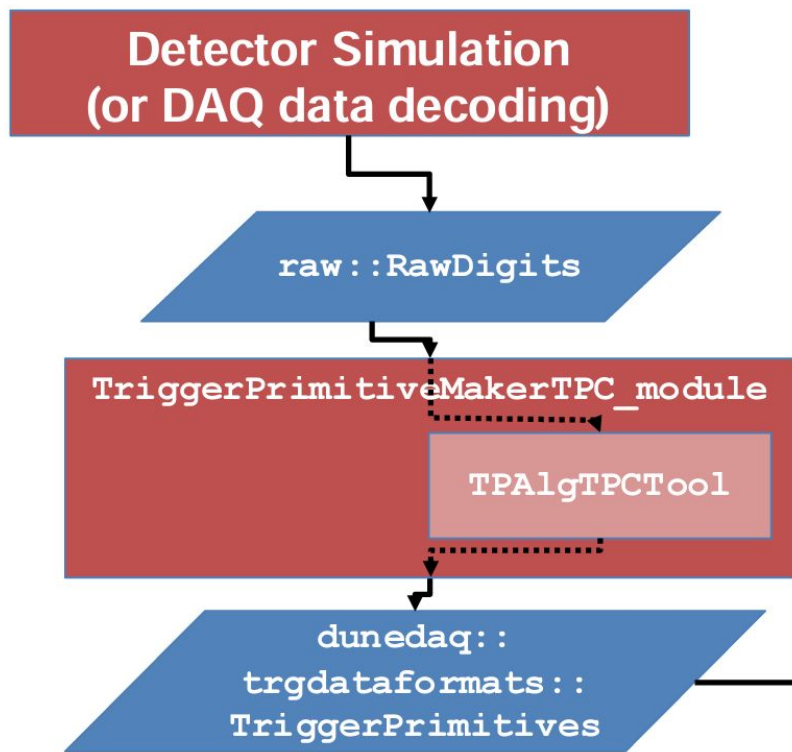
- **Base code:** [github.com/wesketchum/dunetrigger.git](https://github.com/wesketchum/dunetrigger.git)
  - *H. Amar, S. Chhibra, D. Drobner, W. Ketchum, A. Oranday, M. Rigan, J. Shen, ...*
- **New development:** branch [schhibra/daq\\_triggeralgs](#)
  - S. Chhibra and J. Shen
- **TP Maker:** SimpleThreshold algorithm implemented
- **TA and TC makers** (following D. Drobner's [footprints](#)):
  - **Online:** <https://github.com/DUNE-DAQ/triggeralgs>
  - **Offline:** <https://github.com/wesketchum/dunetrigger>
  - The `online` is made a git submodule of `offline`
    - `CMakeLists.txt` and `#include` paths changed for `online` (bash scripts)
    - Code developed for running the TA(C)Makers (utilising `AbstractFactory`)
- **ProtoDUNE-II HD raw data file** (used for today's validation studies):  
`np04hd_raw_run028508_0000_dataflow0_datawriter_0_20240730T160245.hdf5`
  - Decoded using `example/run_pdhd_tpc_decoder.fcl`

# Code structure



# Updated Simulation/algorithm flow in LArSoft for TPC

*H. Amar, S. Chhibra, D. Drobner, W. Ketchum, A. Oranday, M. Rigan, J. Shen, ...*



Also construct contained collections and associations as required

# Code setup and running

- [https://github.com/wesketchum/dunetrigger/blob/schhibra/daq\\_triggeralgs/docs/README.md](https://github.com/wesketchum/dunetrigger/blob/schhibra/daq_triggeralgs/docs/README.md)
- Setting up a development environment
- Cloning `dunetrigger` and submodule `triggeralgs@production/v4`
- Making required changes for `triggeralgs` and code compiling
- Decoding raw data files from ProtoDUNE-II HD
- Running the LAr-trigger emulation on ProtoDUNE-II HD data
- Running comparisons of online and offline trigger data
- Running the LAr-trigger emulation on simulation data
- Running analysis of trigger data from simulation

• example/run\_tpalg\_taalg\_tcalg\_online\_**ADCSimpleWindow**.fcl

**tpmakerTPC:**

```
{
  module_type: TriggerPrimitiveMakerTPC
  rawdigit_tag: "tpcrawdecoder:daq"
  tpalg: {
    tool_type: TPAIgtPCSimpleThreshold
    threshold_tpg_plane0: -1 #(plane not used for TP generation)
    threshold_tpg_plane1: -1 #(plane not used for TP generation)
    threshold_tpg_plane2: 60
    verbosity: 0
  }
}
```

**tamakerTPC:**

```
{
  module_type: TriggerActivityMakerOnlineTPC
  tp_tag: "tpmakerTPC"
  algorithm: "TriggerActivityMakerADCSimpleWindowPlugin"
  algconfig_plane0: @local::algconfig_ta
  algconfig_plane1: @local::algconfig_ta
  algconfig_plane2: @local::algconfig_ta
  algconfig_plane3: @local::algconfig_ta
  verbosity: 1
}
```

**tcmakerTPC:**

```
{
  module_type: TriggerCandidateMakerOnlineTPC
  ta_tag: "tamakerTPC"
  algorithm: "TriggerCandidateMakerADCSimpleWindowPlugin"
  algconfig: @local::algconfig_tc
  verbosity: 1
}
```

```
algconfig_ta:
{
  window_length: 60000
  adc_threshold: 20000000
}

algconfig_tc: {}
```



# Eventdump

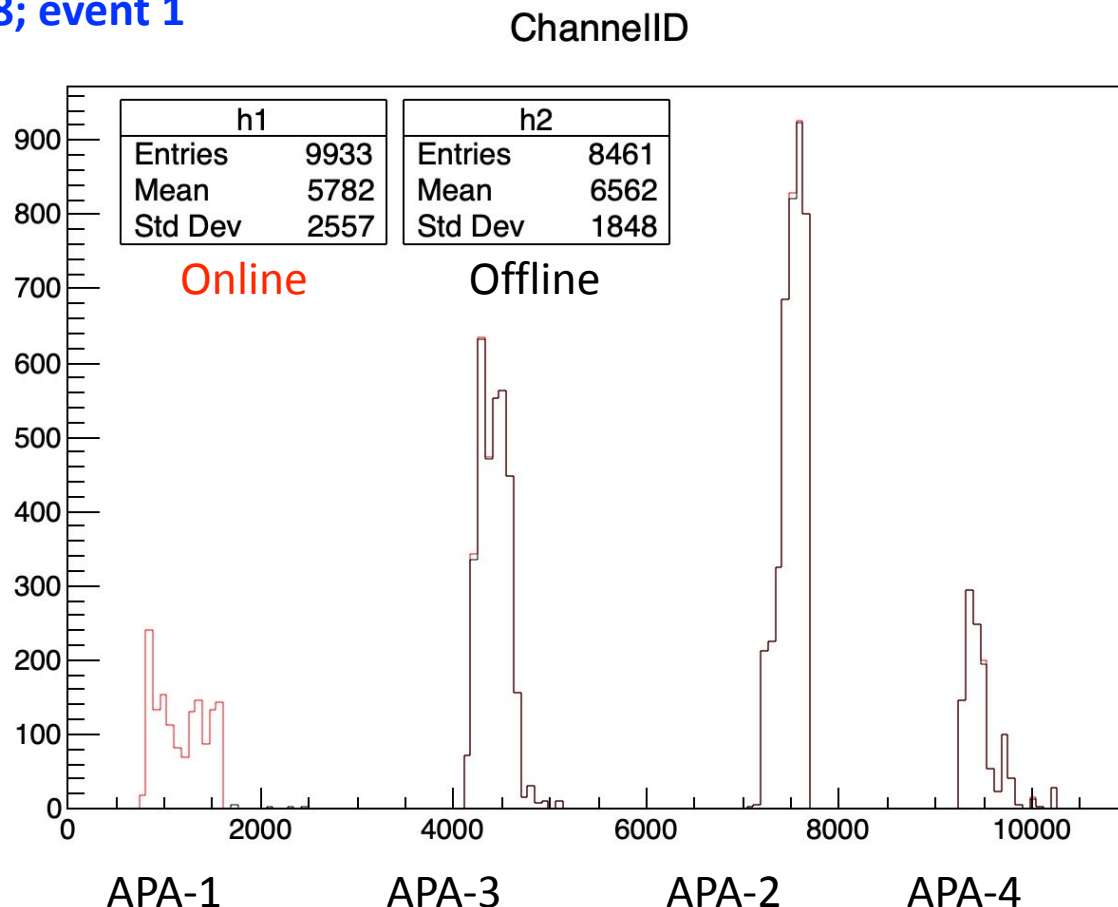
- Online: 9933 TPs; 1 TA, made of 3276 TPs
- Offline: 8461 TPs; 1TA, made of 3276 TPs

```
PROCESS NAME..... | MODULE LABEL.. | PRODUCT INSTANCE NAME | DATA PRODUCT TYPE..... | .SIZE
runpdhdtpcdecodermodule | daq..... | trigger..... | raw::RDTimeStamp..... | ....-
runpdhdtpcdecodermodule | trigrawdecoder | daq..... | art::Assns<dunedaq::trgdataformats::TriggerCandidateData,dunedaq::trgdataformats::TriggerActivityData,void> | ....1
runpdhdtpcdecodermodule | daq..... | ..... | raw::DUNEHDF5FileInfo2..... | ....-
runpdhdtpcdecodermodule | trigrawdecoder | daqinTCs..... | std::vector<dunedaq::trgdataformats::TriggerActivityData>..... | ....1
runpdhdtpcdecodermodule | trigrawdecoder | daq..... | std::vector<dunedaq::trgdataformats::TriggerActivityData>..... | ....1
runpdhdtpcdecodermodule | tpcrawdecoder. | daq..... | std::vector<raw::RawDigit>..... | 10240
runpdhdtpcdecodermodule | trigrawdecoder | daq..... | std::vector<dunedaq::trgdataformats::TriggerPrimitive>..... | .9933
runpdhdtpcdecodermodule | TriggerResults | ..... | art::TriggerResults..... | ....1
runpdhdtpcdecodermodule | trigrawdecoder | daq..... | std::vector<dunedaq::trgdataformats::TriggerCandidateData>..... | ....1
runpdhdtpcdecodermodule | tpcrawdecoder. | daq..... | std::vector<raw::RDTimeStamp>..... | 10240
runpdhdtpcdecodermodule | trigrawdecoder | daq..... | art::Assns<dunedaq::trgdataformats::TriggerActivityData,dunedaq::trgdataformats::TriggerPrimitive,void>.... | .3276
runpdhdtpcdecodermodule | tpcrawdecoder. | daq..... | std::vector<raw::RDStatus>..... | 10240
runpdhdtpcdecodermodule | trigrawdecoder | daqinTAs..... | std::vector<dunedaq::trgdataformats::TriggerPrimitive>..... | .3276
runpdhdtpcdecodermodule | tpcrawdecoder. | daq..... | art::Assns<raw::RawDigit,raw::RDTimeStamp,void>..... | 10240
RunTP..... | tcmakerTPC.... | ..... | std::vector<dunedaq::trgdataformats::TriggerCandidateData>..... | ....1
RunTP..... | tpmakerTPC.... | ..... | std::vector<dunedaq::trgdataformats::TriggerPrimitive>..... | .8461
RunTP..... | tamakerTPC.... | ..... | art::Assns<dunedaq::trgdataformats::TriggerActivityData,dunedaq::trgdataformats::TriggerPrimitive,void>.... | .3276
RunTP..... | tamakerTPC.... | ..... | std::vector<dunedaq::trgdataformats::TriggerActivityData>..... | ....1
RunTP..... | TriggerResults | ..... | art::TriggerResults..... | ....1
```

# Offline vs online performance: TP channel ID

- `example/run_triggerTPCInfoComparator.fcl`

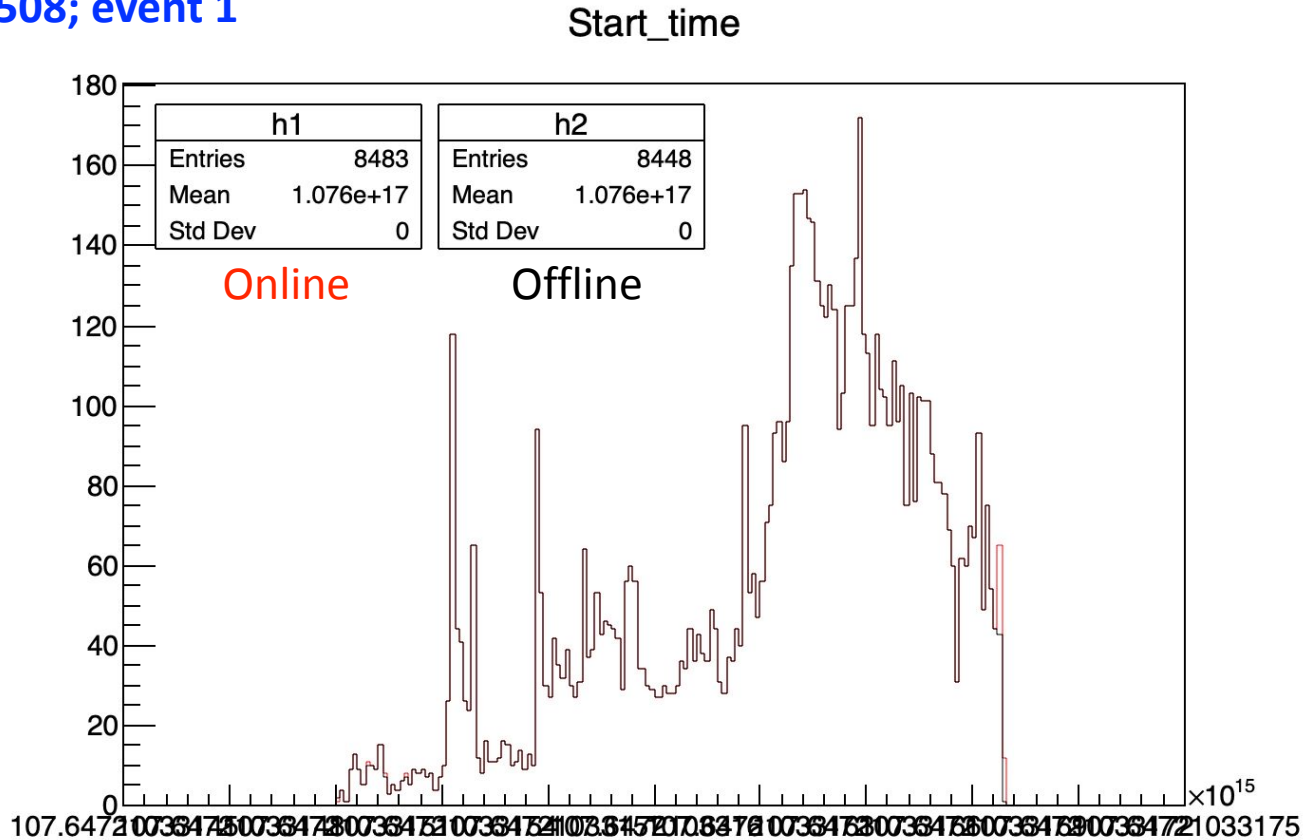
run028508; event 1



- **APA 2, 3 and 4 only:** 8448 TPs offline; **8483 TPs online**
- *All offline TPs match to online TPs*

# Offline vs online performance: TP start time

run028508; event 1



- **APA 2, 3 and 4 only:** 8448 TPs offline; **8483 TPs online**
- *All offline TPs match to online TPs*

# Offline vs online performance: TPs in a TA

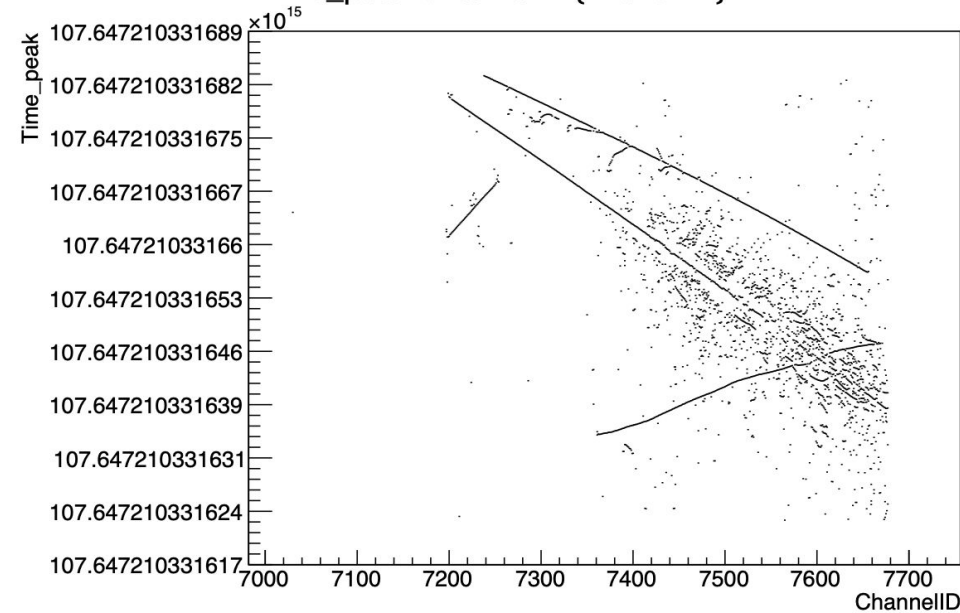
run028508; event 1; TA 1

- Online: 3276 TPs
- Offline: 3276 TPs

- **ADCSimpleWindow algorithm**

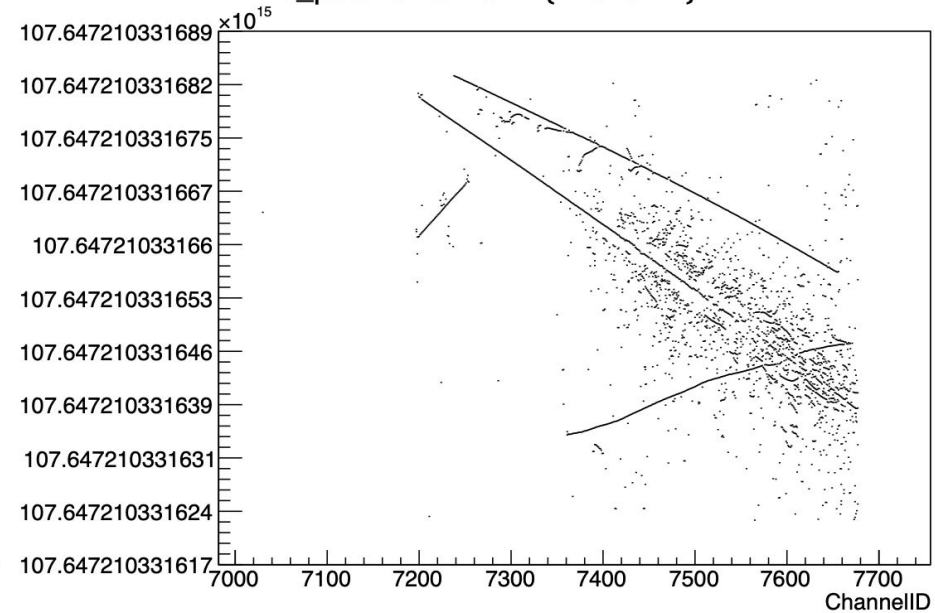
Offline

Time\_peak:ChannelID {Event==1}



Online

Time\_peak:ChannelID {Event==1}

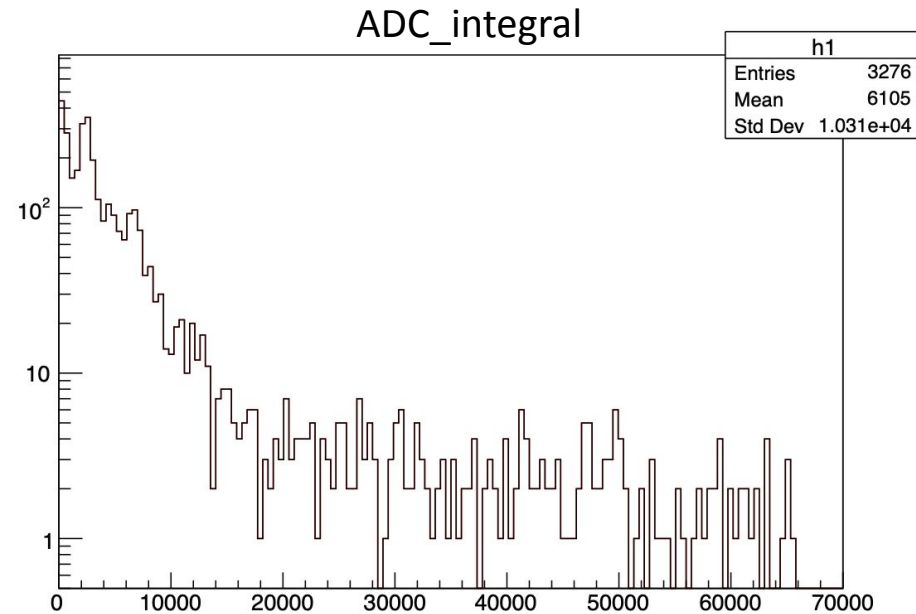
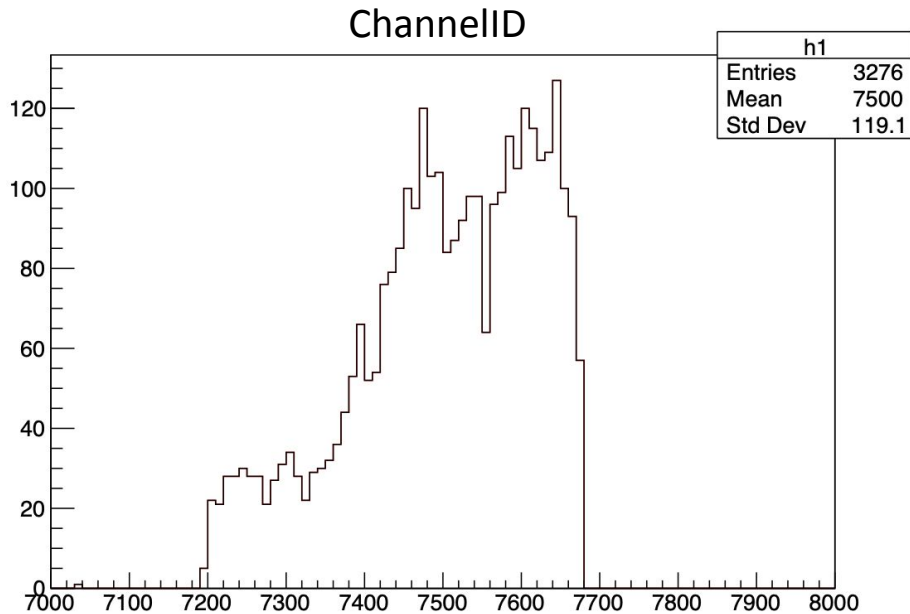


# Offline vs online performance: TPs in a TA

run028508; event 1; TA 1

- Online: 3276 TPs
- Offline: 3276 TPs

- ***ADCSimpleWindow algorithm***

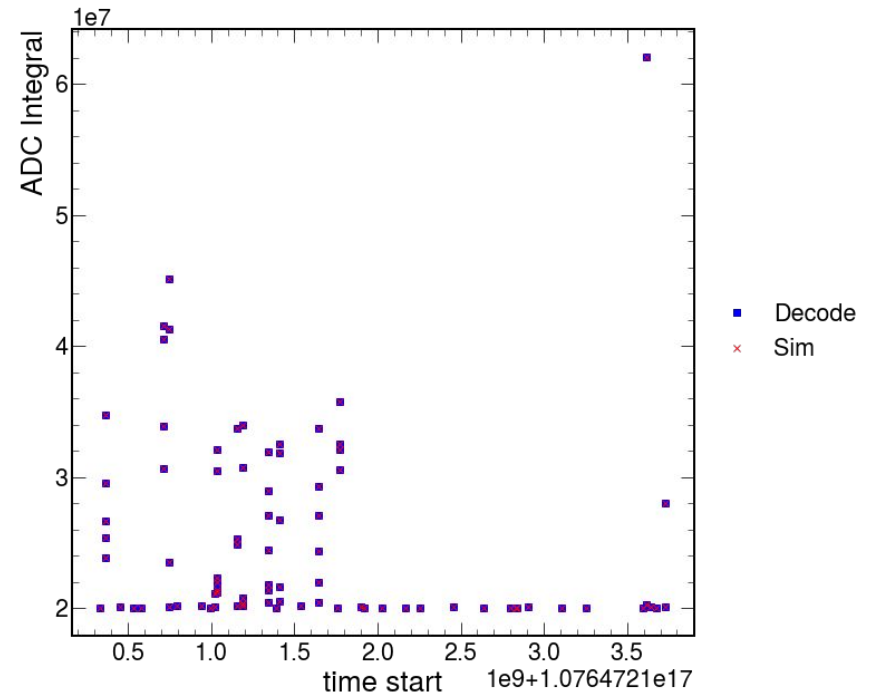
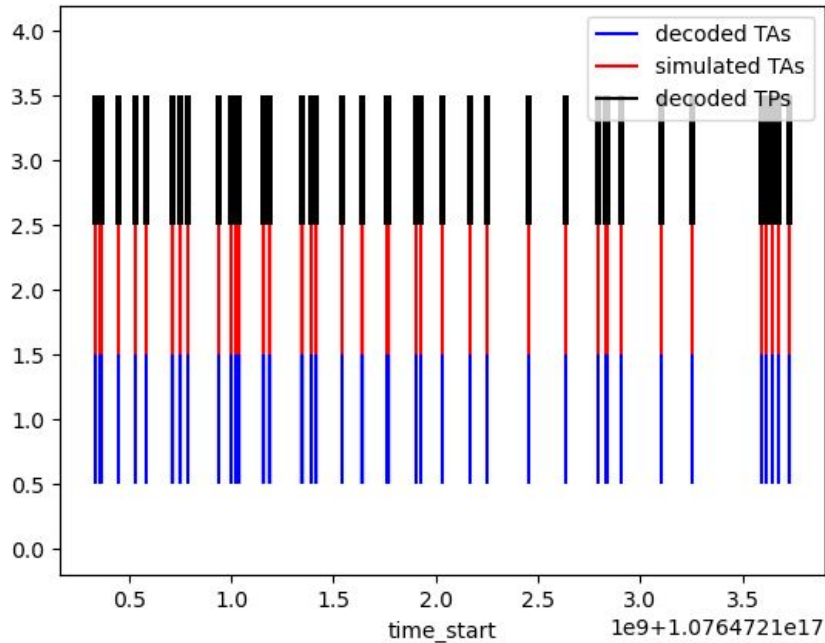


# Offline vs online performance: total TAs

run028508; ALL events

- Online: 82 TAs
- Offline: 82 TAs

- ***ADCSimpleWindow algorithm***



• example/run\_tpalg\_taalg\_tcalg\_online\_ChannelAdjacency.fcl

#### tpmakerTPC:

```
{
  module_type: TriggerPrimitiveMakerTPC
  rawdigit_tag: "tpcrawdecoder:daq"
  tpalg: {
    tool_type: "TPAlgTPCSimpleThreshold"
    threshold_tpg_plane0: -1 #(plane not used for TP generation)
    threshold_tpg_plane1: -1 #(plane not used for TP generation)
    threshold_tpg_plane2: 60
    verbosity: 0
  }
  verbosity: 1
}
```

#### tamakerTPC:

```
{
  module_type: TriggerActivityMakerOnlineTPC
  tp_tag: "tpmakerTPC"
  algorithm: "TriggerActivityMakerChannelAdjacencyPlugin"
  algconfig_plane0: @local::algconfig_ta
  algconfig_plane1: @local::algconfig_ta
  algconfig_plane2: @local::algconfig_ta
  algconfig_plane3: @local::algconfig_ta
  verbosity: 1
}
```

#### tcmakerTPC:

```
{
  module_type: TriggerCandidateMakerOnlineTPC
  ta_tag: "tamakerTPC"
  algorithm: "TriggerCandidateMakerChannelAdjacencyPlugin"
  algconfig: @local::algconfig_tc
  verbosity: 1
}
```

```
algconfig_ta:
{
  window_length: 60000
  adjacency_threshold: 480
  adj_tolerance: 5
  prescale: 1
  print_tp_info: false
}

algconfig_tc:
{
  adc_threshold: 10000000
  n_channels_threshold: 210
  trigger_on_adc: true
  trigger_on_n_channels: false
}
```

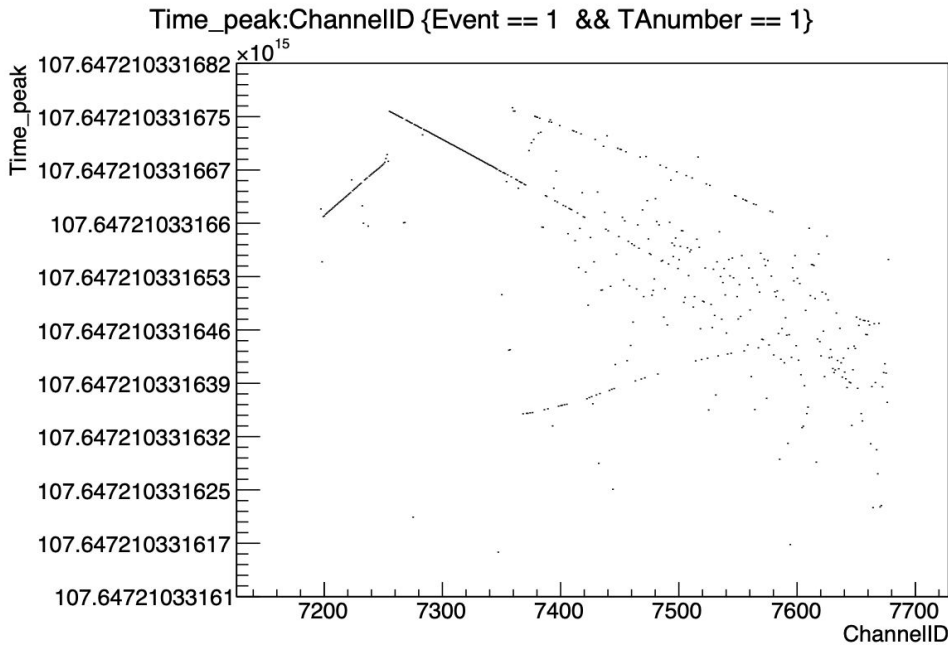
# Offline vs online performance: TPs in a TA

run028508; event 1; TA 1

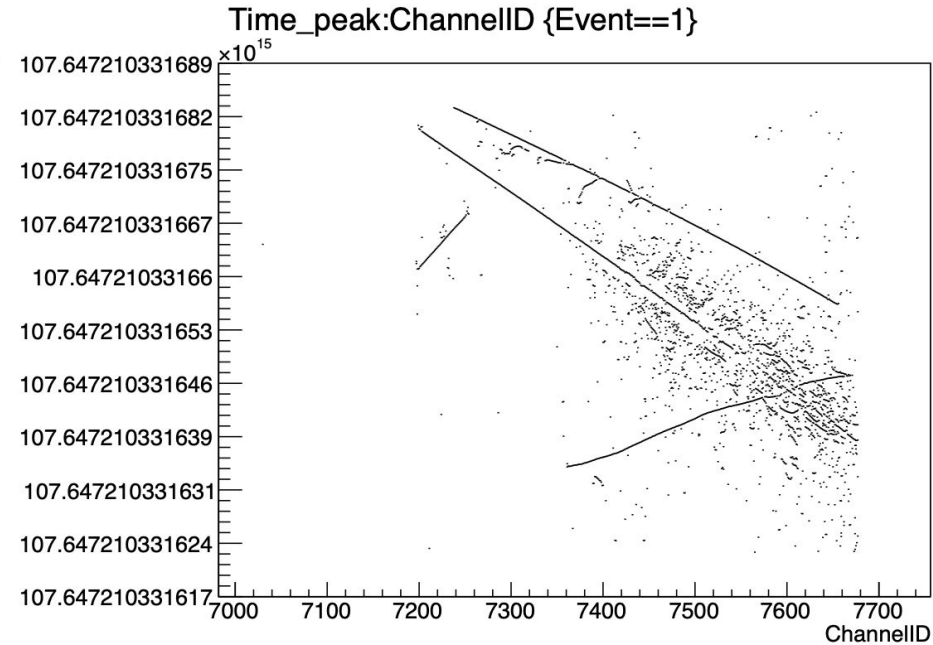
- Online: 3276 TPs
- Offline: 481 TPs

- **ChannelAdjacency algorithm**
- **ADCSimpleWindow algorithm**

Offline



Online



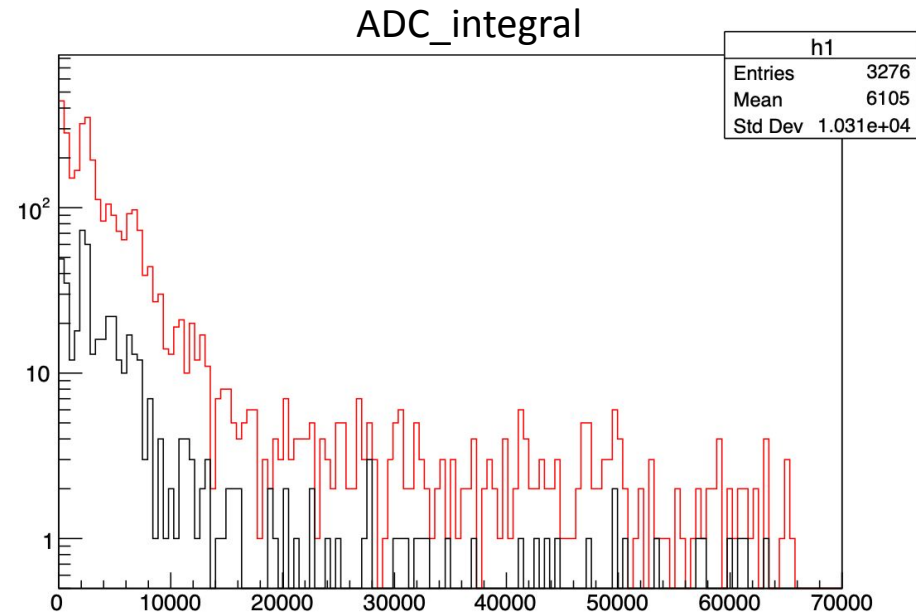
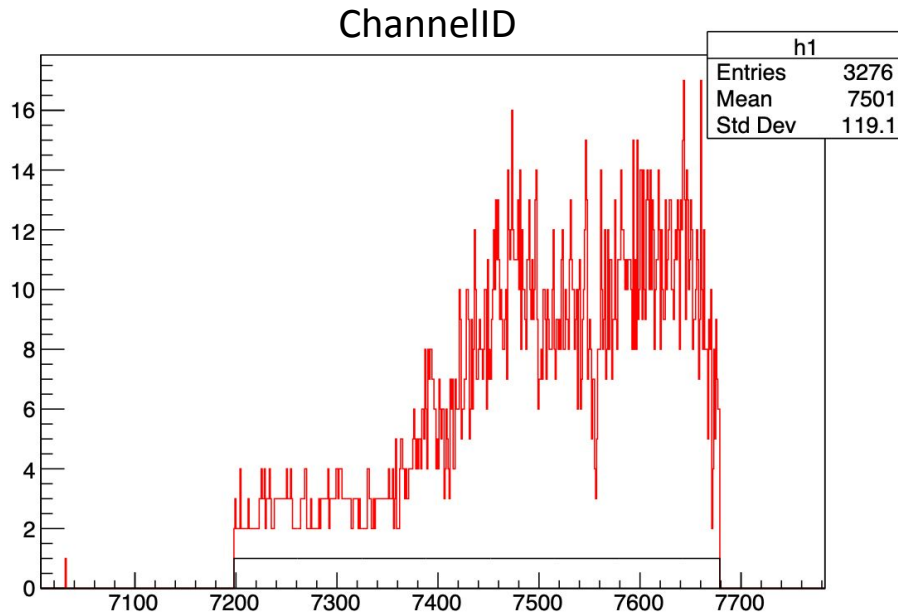


# Offline vs online performance: TPs in a TA

run028508; event 1; TA 1

- Online: 3276 TPs
- Offline: 481 TPs

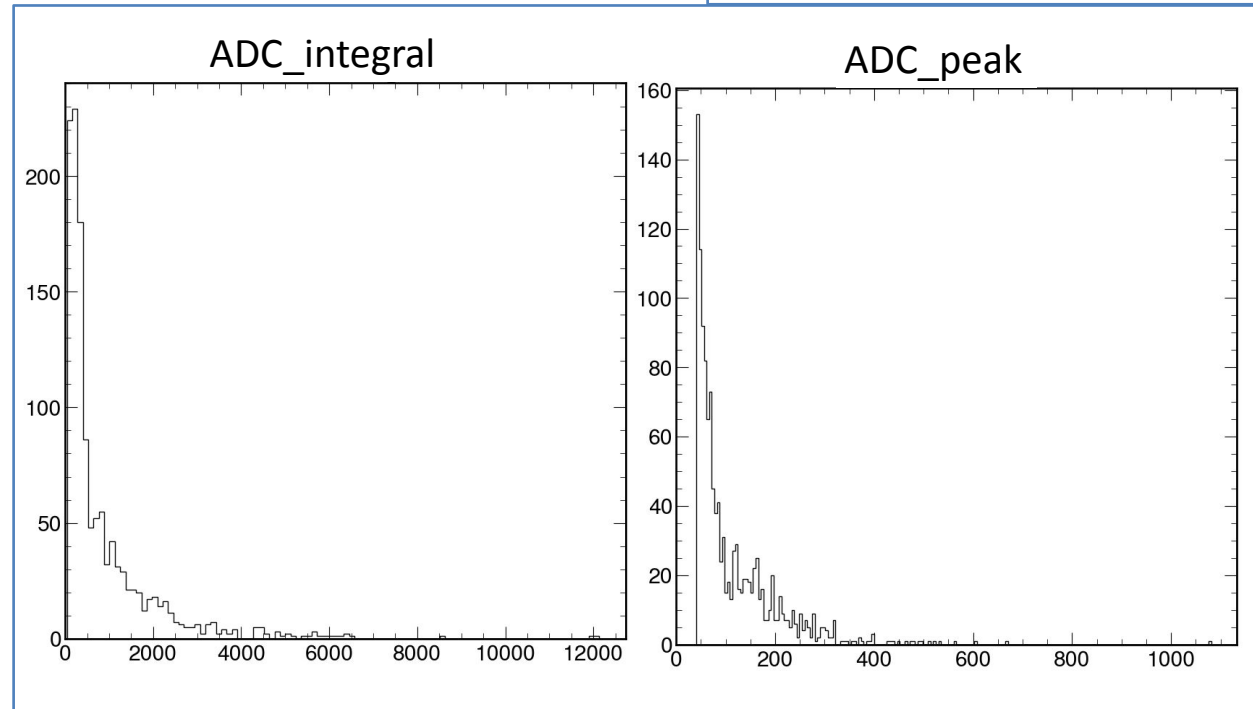
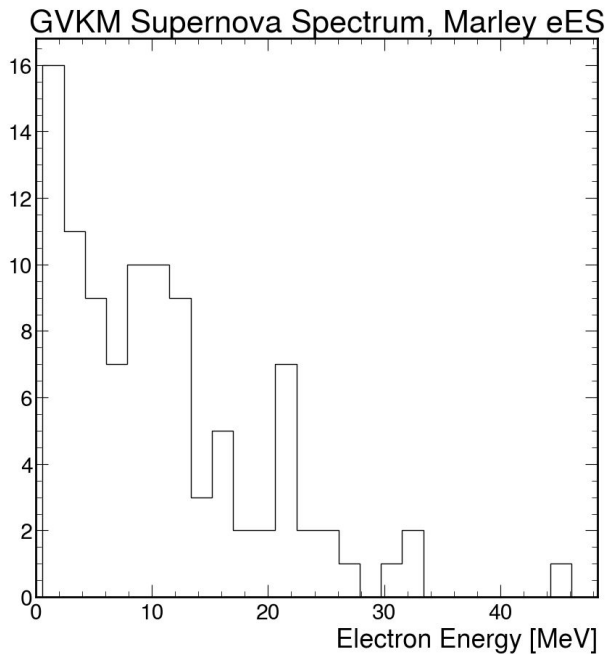
- **ChannelAdjacency algorithm**
- **ADCSimpleWindow algorithm**



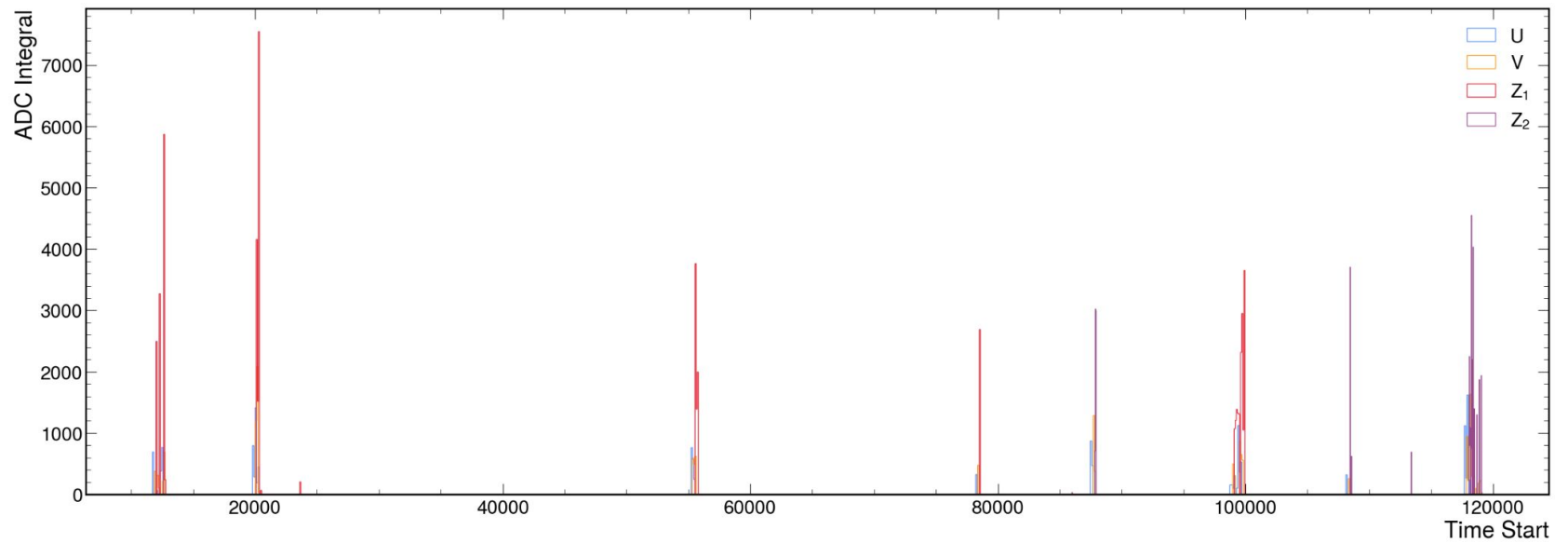
# Simulation: TP generation

- Supernova pointing simulation (100 events)
  - Using LArSoft + DUNE-SW v10.00.04d00
  - Using the latest fcls (with detector noise, no radiologicals):
    - `prodmarley_nue_es_gvkm_dune10kt_1x2x6.fcl`
    - `supernova_g4_dune10kt_1x2x6.fcl`
    - `Detsim_dune10kt_1x2x6_notpcsigproc.fcl`

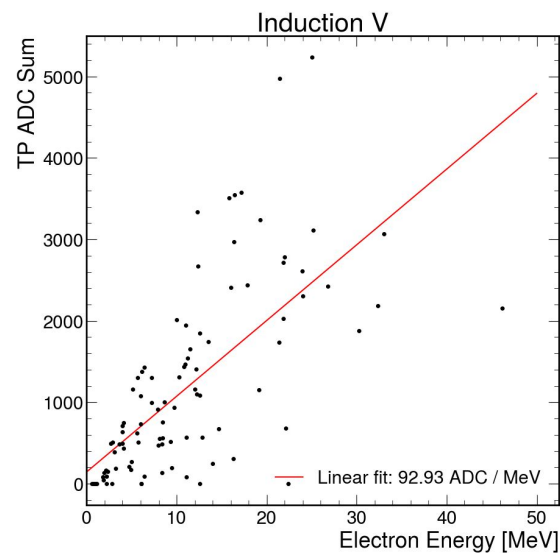
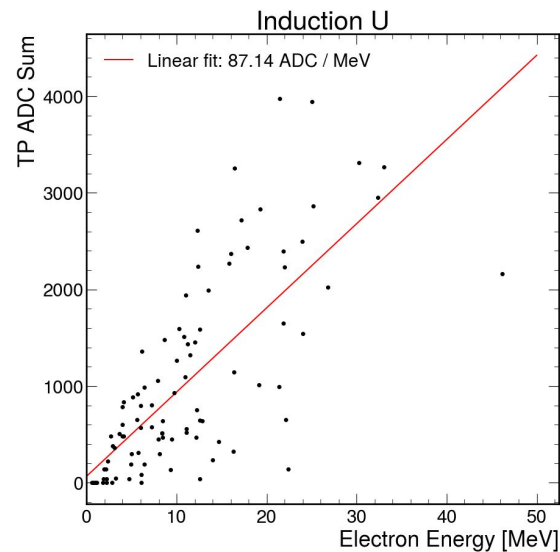
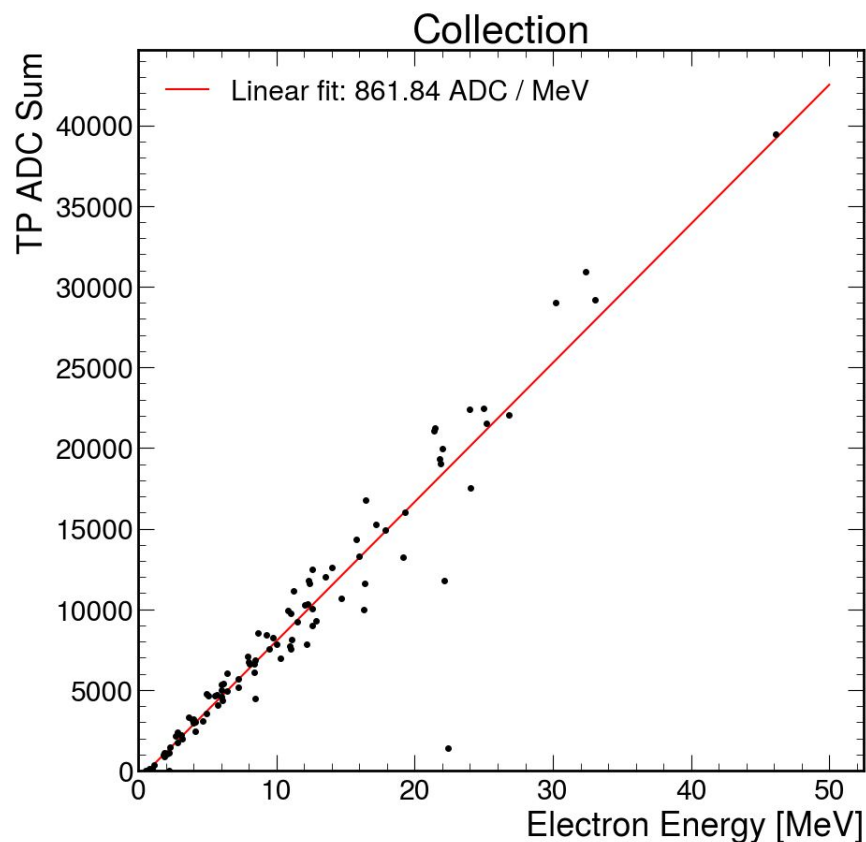
threshold\_tpg\_plane{0,1,2}: 40



# Simulation: TP coincidence



# Simulation: TP sum(adc\_integral) vs Ee per event



# Summary

- **Initial development of LAr-trigger is done!**

- Decoding tools, enabling offline analysis using trigger records and TP-stream files
- Reproduction of TPs (SimpleThreshold algorithm), and TA(C)s (sharing the online code!)
  - Validated using ProtoDUNE-II HD data
  - Initial simulation-based analysis results shown using Supernova pointing events

To-do:

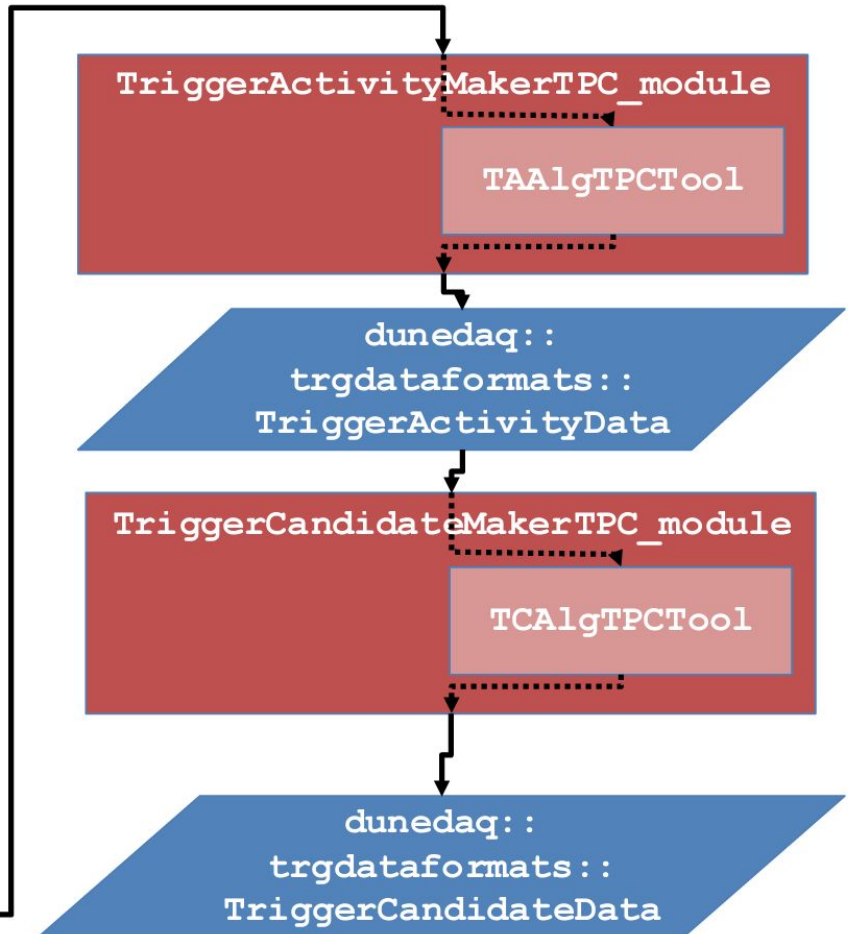
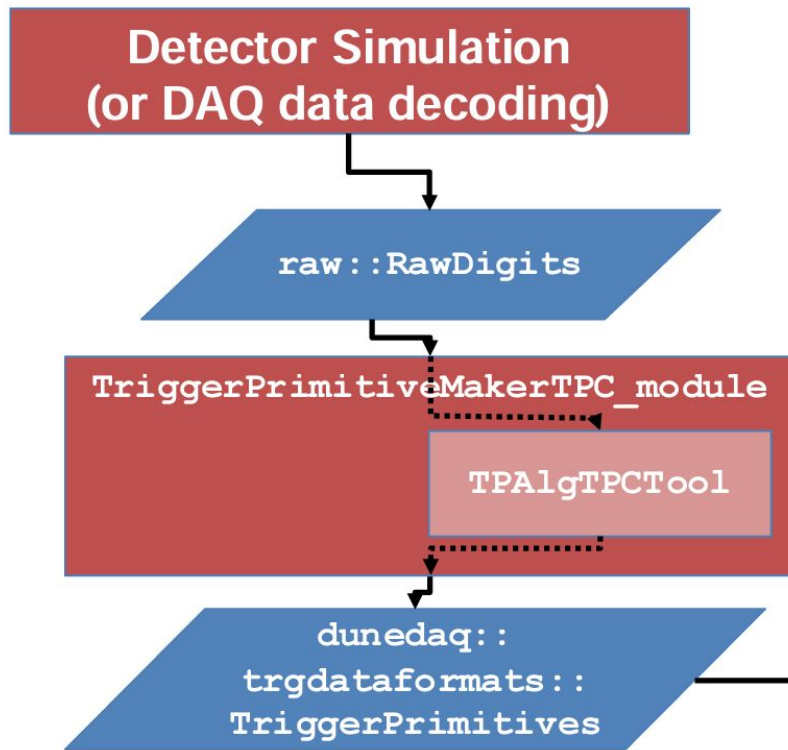
- (Absolute)RunningSum TPG algorithms implementation (needed for induction planes)
- Pending PR#16 targeting LArSoft v10 (geometry service replaced with the WireReadout class to perform channel mapping)
- Some code integrity clean up (remove old code, structure fcl files...)
- Preliminary physics-goal studies (SN burst trigger efficiency, low energy beam particle triggering, solar, etc.)

- **We plan to make dunetrigger a part of official dunesw and production**

# Backup

# Simulation/algorithm flow in LArSoft for TPC

H. Amar, S. Chhibra, D. Drobner, W. Ketchum, A. Oranday, M. Rigan, J. Shen, ...



Also construct contained collections and associations as required

# Offline vs online performance: TPs in a TA

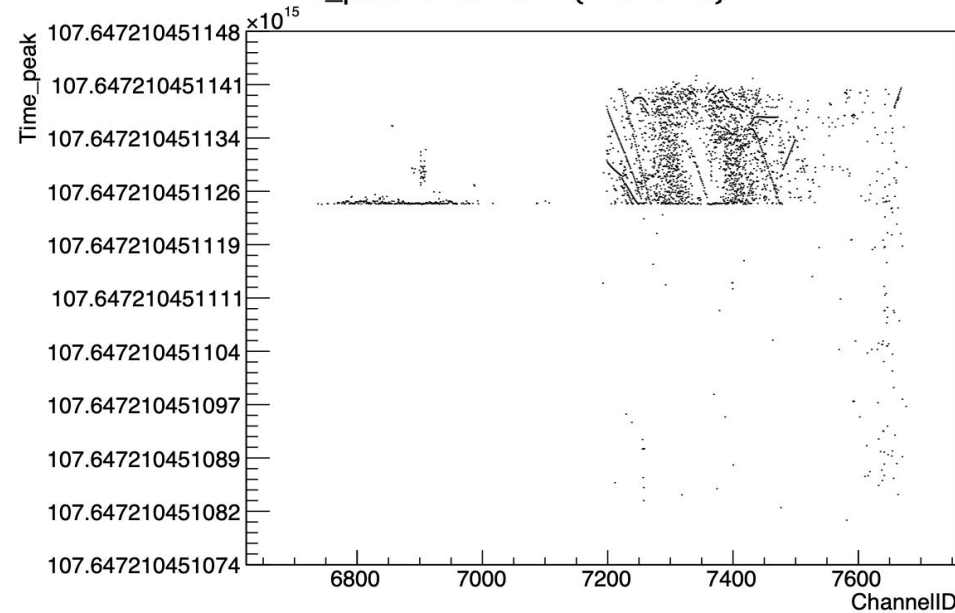
run028508; event 3; TA 1

- Online: 2706 TPs
- Offline: 2730 TPs

- **ADCSimpleWindow algorithm**

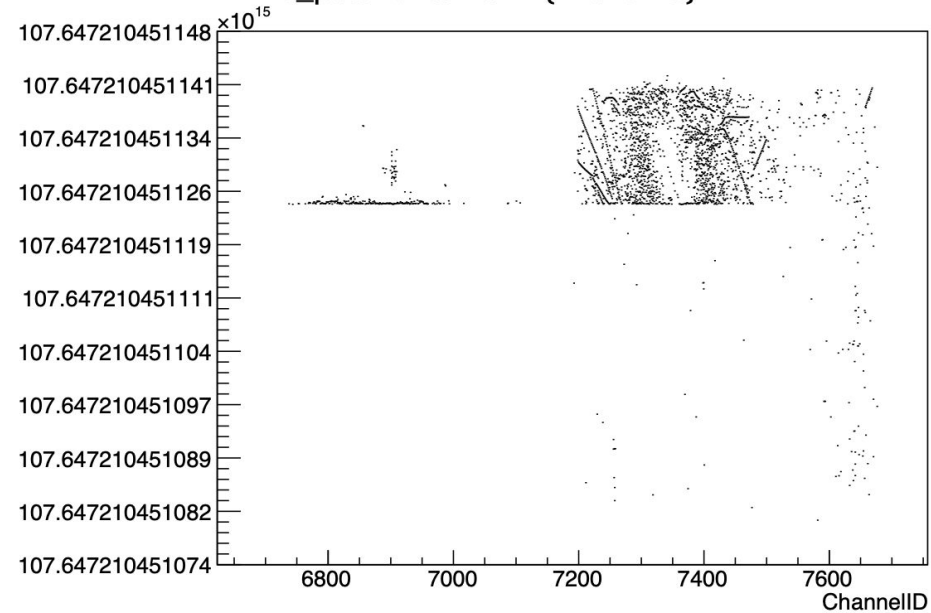
Offline

Time\_peak:ChannelID {Event==3}



Online

Time\_peak:ChannelID {Event==3}



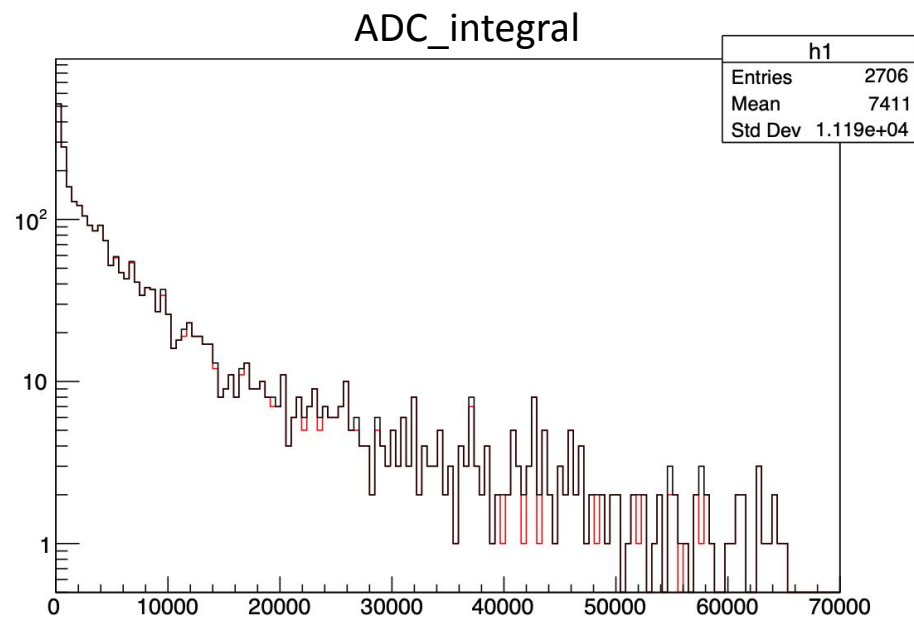
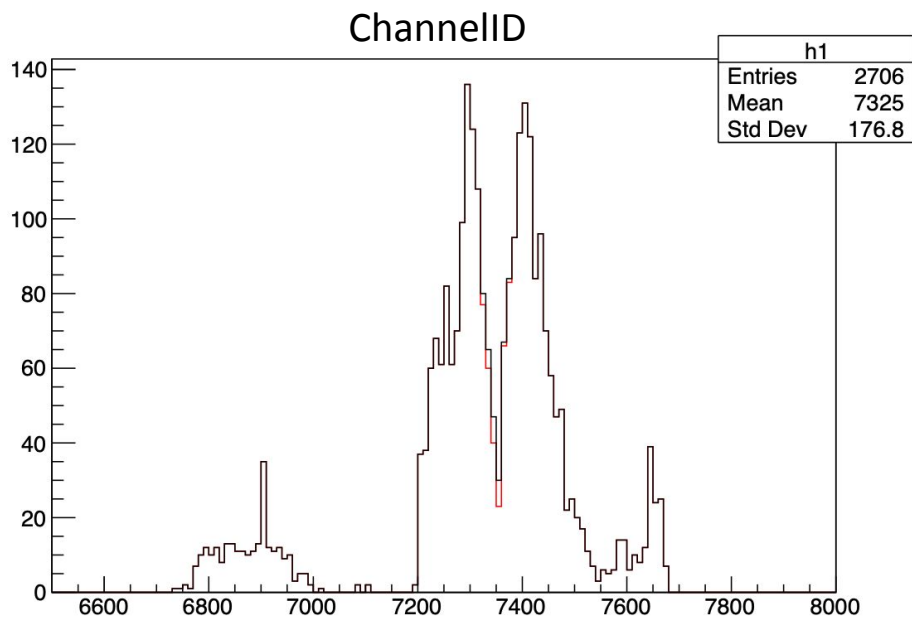


# Offline vs online performance: TPs in a TA

run028508; event 3; TA 1

- Online: 2706 TPs
- Offline: 2730 TPs

## • *ADCSimpleWindow* algorithm



# Simulation: TP coincidence

