

# Cosmic runs w/CRT trigger: Data taking and opportunities for fresh real data analysis

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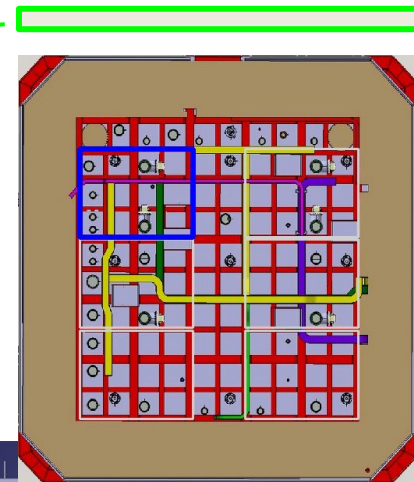
DUNE Collaboration Call  
December 2019

# Cosmic ray taggers in ProtoDUNE-SP

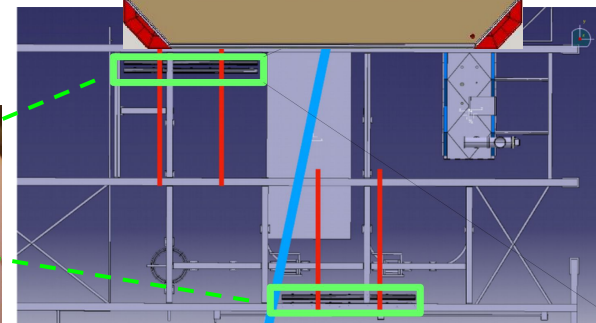
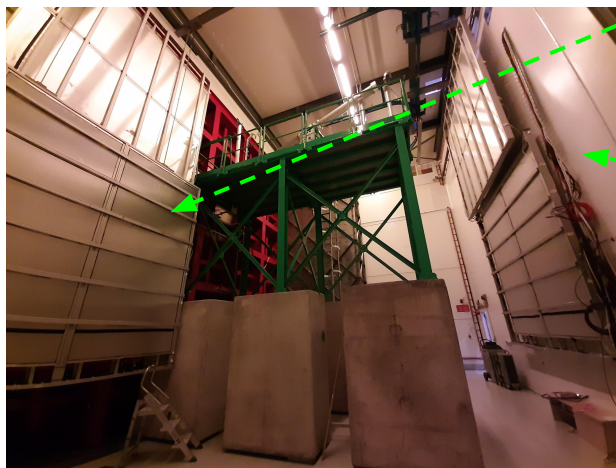
- Trigger TPC with ongoing muons (cosmics, beam halo)
  - Space charge and TPC performance
  - PDS attenuation studies
  - T0 tagging for Michel studies
- ~6.8m x 6.8m upstream and downstream panels
  - 2 layers of parallel scintillator strips
  - Upstream panels staggered
- CRT actively used during the beam runs
- **Re-activated recently for the cosmic runs**
  - **Characterize detector response after 1 year of operation**



Downstream CRT



Beam left upstream CRT

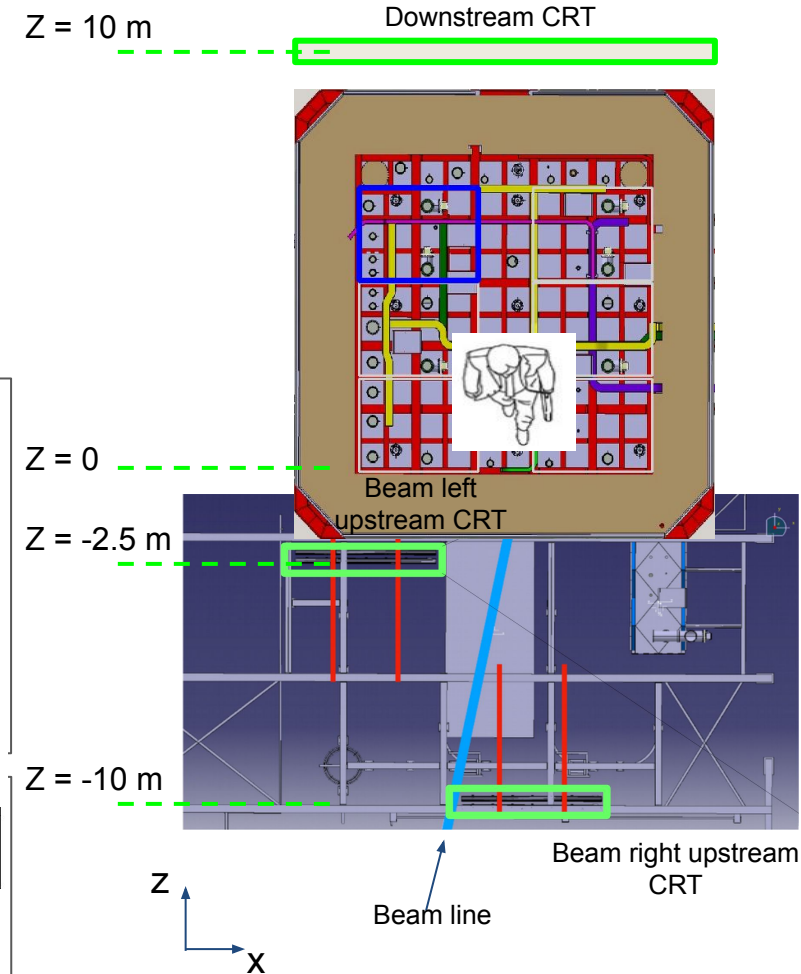
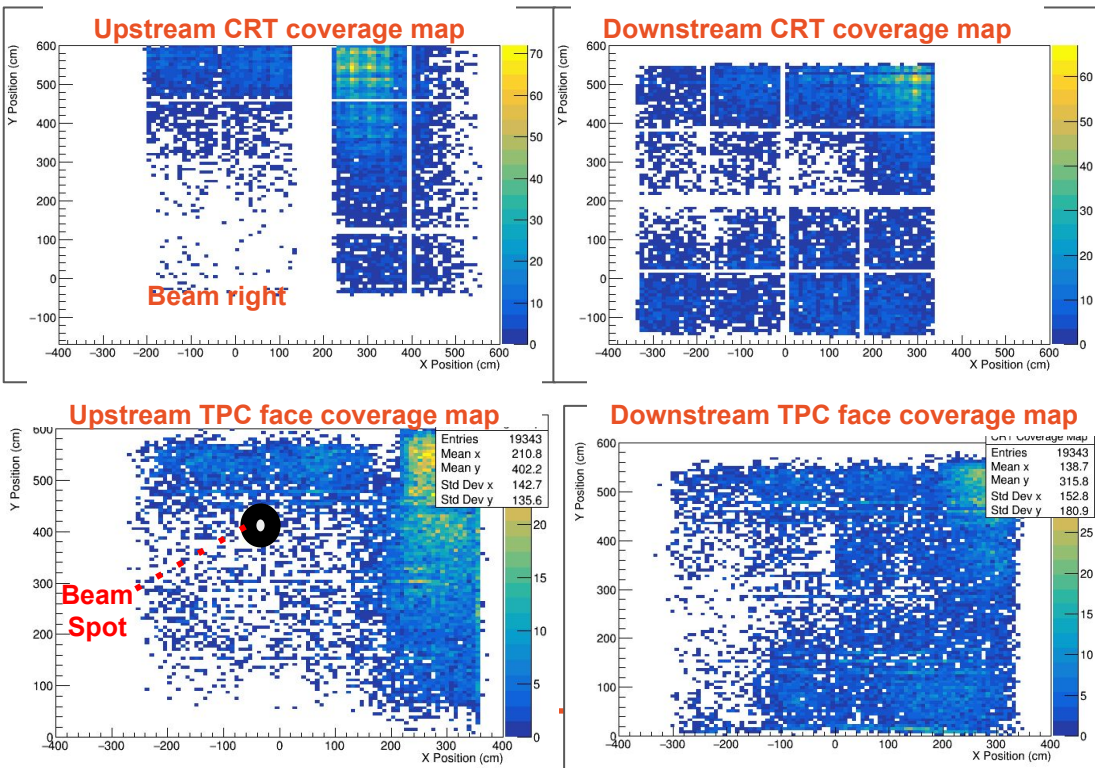


Beam right upstream CRT

Beam line

# CRT during the beam run

- CTB would send a specific trigger to the CRT if any US and DS CRT modules were triggered in a 60 ns window
  - 20k TPC-CRT matched tracks during beam
  - However, the BR US CRT modules are 20 m away from the DS CRT modules ( $20 \text{ m}/c=67 \text{ ns}$ ), so we were dropping those triggers and losing the ability to match to TPC tracks in that region



# Reactivation of the CRT and improving its performance

- CRT controls have been fully implemented to the slow controls
- CRT readout code was improved
  - Cope with different trigger inhibiting scenarios
    - Allowed stable and long CRT runs
  - Reduced missing event rate
  - Delayed US beam left CRT to allow better beam right coverage



Thanks to CRT, trigger and DAQ groups!!



# Data taking campaign and run plan

- Three weeks (Nov 18 - Dec 6) of dedicated data taking with CRT triggers:
- Run Plan:
  - Cover as much as possible the beam right side for CRT studies on tracking and space charge effect (Week 1 and 3)
  - Run varying the Electric field for better understandings of the electron lifetime (Week 3)
  - Trigger on location-specific CRT hits for attenuation studies for PDS. (Week 2)
  - Calibration runs for PDS and TPC ADCs. (Week 2)

| <i>Shift Calendar</i>                    |                                     |         |           |          |          |          |          |
|--|-------------------------------------|---------|-----------|----------|----------|----------|----------|
| <i>Week of Nov 18th - Nov 24th</i>       |                                     |         |           |          |          |          |          |
|  | Monday (Nov 18)                     | Tuesday | Wednesday | Thursday | Friday   | Saturday | Sunday   |
| 9am-4pm<br>(at EHN1 control room)        | Serhan                              | Camillo | Camillo   | Camillo  | Serhan   | Camillo  | No Shift |
| 4pm-8pm at EHN1 +<br>8pm-midnight remote | Camillo                             | Dante   | Maura     | Dante    | Camillo  | No Shift | No Shift |
| <i>Week of Nov 25th - Dec 1st</i>        |                                     |         |           |          |          |          |          |
|  | Monday (Nov 25)                     | Tuesday | Wednesday | Thursday | Friday   | Saturday | Sunday   |
| 9am-4pm<br>(at EHN1 control room)        | Niccolo                             | Maura   | Paola     | Paola    | No Shift | No Shift | No Shift |
| 4pm-8pm at EHN1 +<br>8pm-midnight remote | Paola (might be<br>15 minutes late) | Niccolo | Maura     | Niccolo  | No Shift | No Shift | No Shift |
| <i>Week of Dec 2nd - Dec 6th</i>         |                                     |         |           |          |          |          |          |
|  | Monday (Dec 02)                     | Tuesday | Wednesday | Thursday | Friday   | Saturday | Sunday   |
| 9am-4pm<br>(at EHN1 control room)        | Serhan                              | Maura   | Maura     | Maura    | Kyle     | No Shift | No Shift |
| 4pm-8pm at EHN1 +<br>8pm-midnight remote | Zahra                               | Kyle    | Kyle      | Kyle     | Zahra    | No Shift | No Shift |

**Collaborators from US, Brasil, Italy and CERN has contributed to the data taking!**  
**Thanks to all shifters and detector experts!!!**

# DAQ support during the data taking

- Accent on support with extended on-call hours and active monitoring on the data taking quality

| DAQ on-call shifter during the CRT runs |       |                          |                     |
|---|-------|--------------------------|---------------------|
| 18/11                                   | 22/11 | Alessandro Thea (161800) | Pierre Lasorak (PP) |
| 23/11                                   | 24/11 |                          |                     |
| 25/11                                   | 29/11 | Karol (UD - 165828)      | Bonnie King (FAC)   |
| 30/11                                   | 1/12  | Giovanna LM (162076)     |                     |
| 2/12                                    | 6/12  | Aran Borkum (DS)         | Pengfei Ding (DF)   |

- The three data taking weeks were “plagued” by the cooling failures and power cuts
  - Cooling failure on Nov 11th afternoon → all DAQ off
  - Major intervention on water circuit from Nov 14th - 17th → all DAQ off
  - Power cut on Nov 27th afternoon
    - Main DAQ recovered within 5 hours, but problems with storage volumes → DAQ work passed from CERN to FNAL experts, allowing to completely recover the DAQ on 28th
  - Cooling failure on the last day of the run in the morning
    - Luckily managed to avoid shutting off the whole DAQ

} Shortening the preparation time for runs

# Collected data

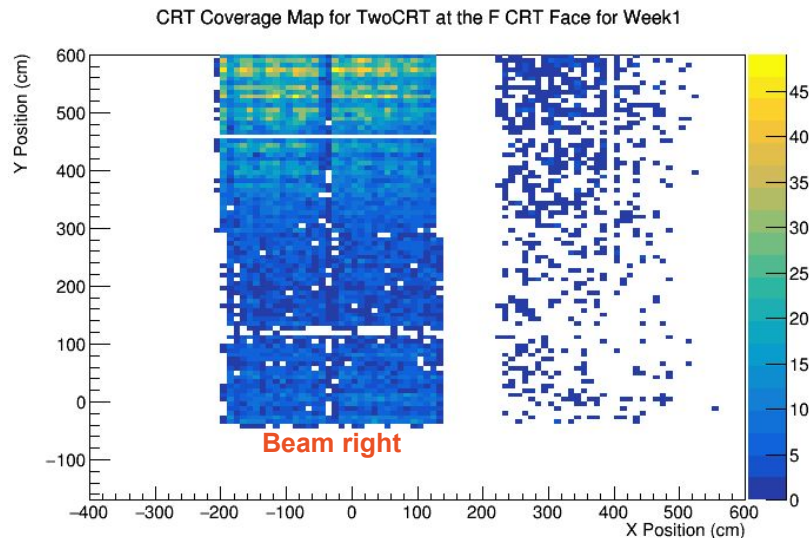
- Collected more than 100h of cosmic data with 15Hz CRT trigger
  - Large amount of data: just an example for the scale, ~3h of run is ~7.5 TB
- The data from the week-1 has been reconstructed:
  - 1million events, 26k CRT matched tracks
- “After Beam Run” runlist has been updated with the good cosmic and HV scan runs
  - <https://docs.google.com/spreadsheets/d/1gPqQbPFoOZjDLPfPVHBfCrZz9q0IQoqWUUhFnKVx6aQ/edit#gid=0>
- PDS and CE calibrations runs
  - <https://docs.google.com/spreadsheets/d/1CXmx5378kdNpW9ziBvR6zpb5XyrlNdbt0UySh6rvcV4/edit#gid=2023561964>
- Thanks to DUNE computing group for their support to handle and process the data smoothly

**Large amount of fresh cosmic data is available and waiting to be analyzed!!**

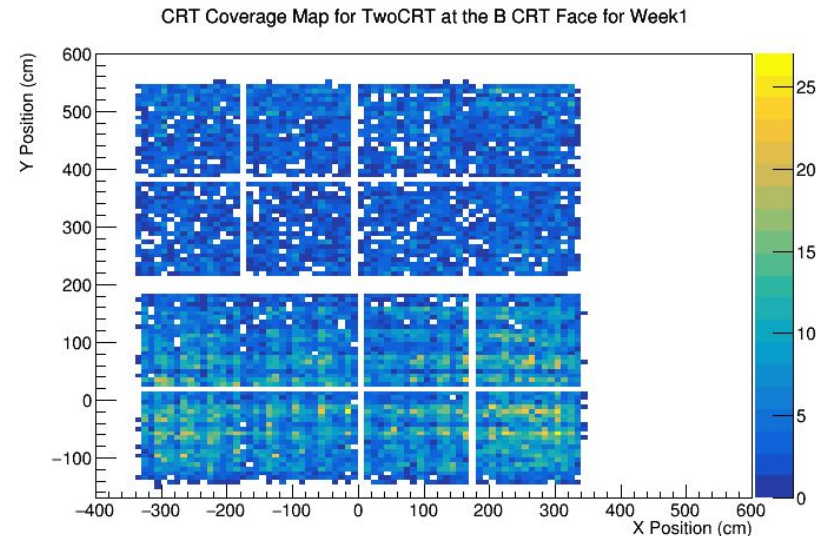
# CRT Coverage of Week 1 Matched Tracks

R. Diurba

- Bumped the CTB trigger for CRT to 100 ns and added a delay on US BL CRT triggers of 40 ns.
- We might do too good of a job for Week 1 data, so Week 3 data only has a 20 ns delay for US BL CRT triggers.



Upstream CRT



Downstream CRT

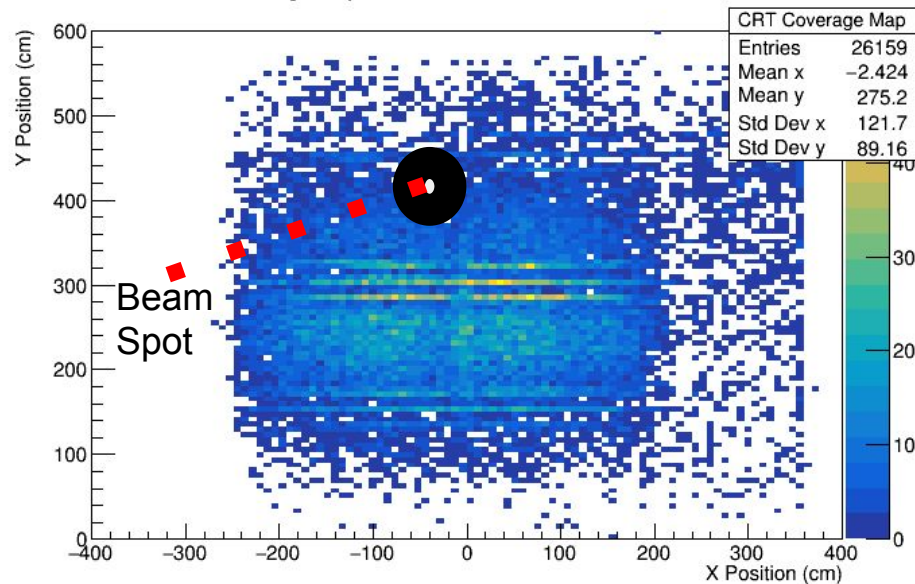


# Coverage map on TPC faces with Week 1 Matched Tracks

R. Diurba

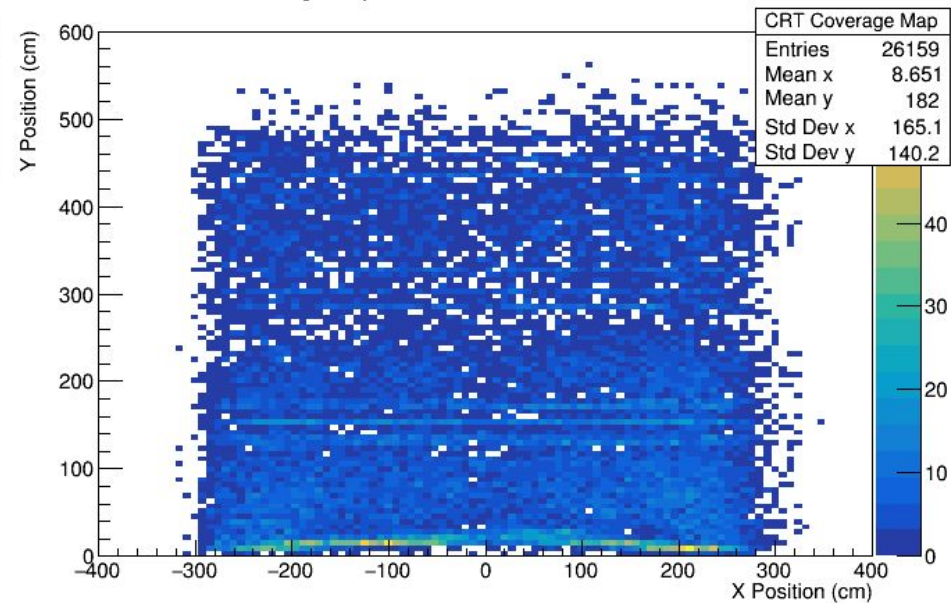
- Get much better coverage of where the beam actually enters the detector

CRT Coverage Map for TwoCRT at the F TPC Face for Week1



Upstream TPC face

CRT Coverage Map for TwoCRT at the B TPC Face for Week1

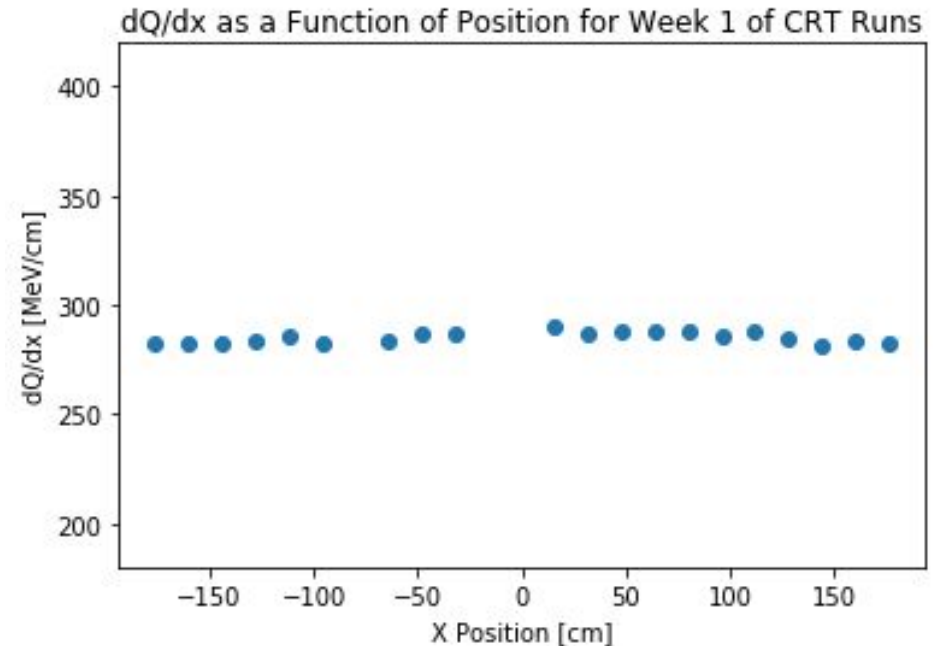


Downstream TPC face

# Preliminary $dQ/dx$ from Week 1 Runs

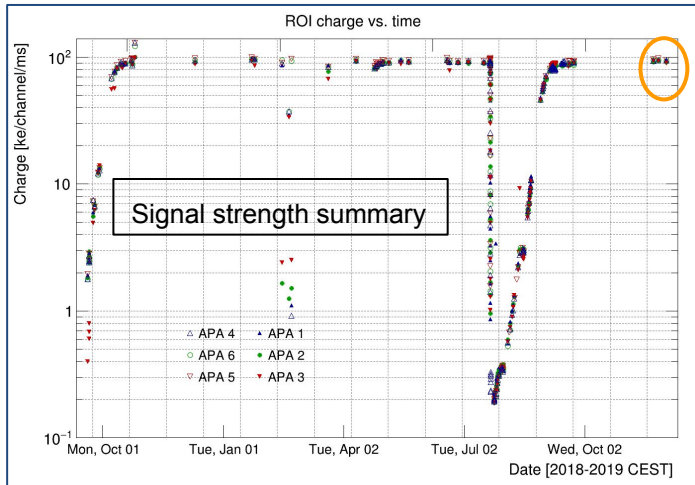
R. Diurba

- Run 10374 (3.7k tracks)
- T0-tag using CRT matched tracks
- Calibrate  $dQ/dx$  using E-field map
- $dQ/dx$  stable, suggests high purity



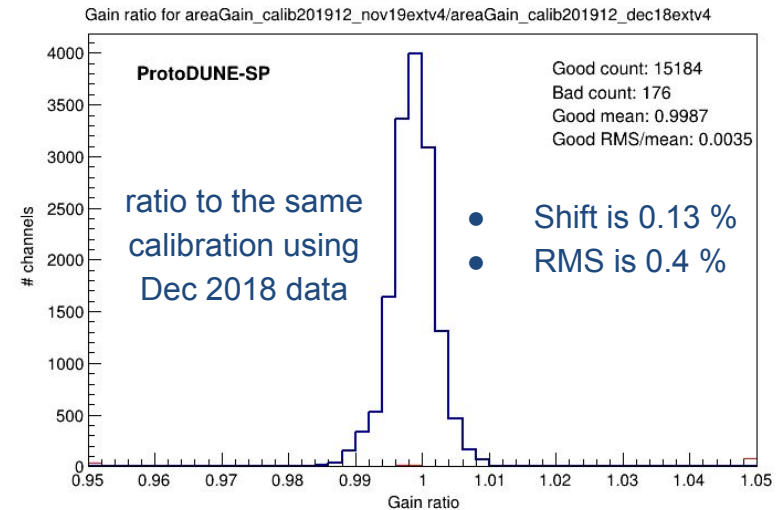
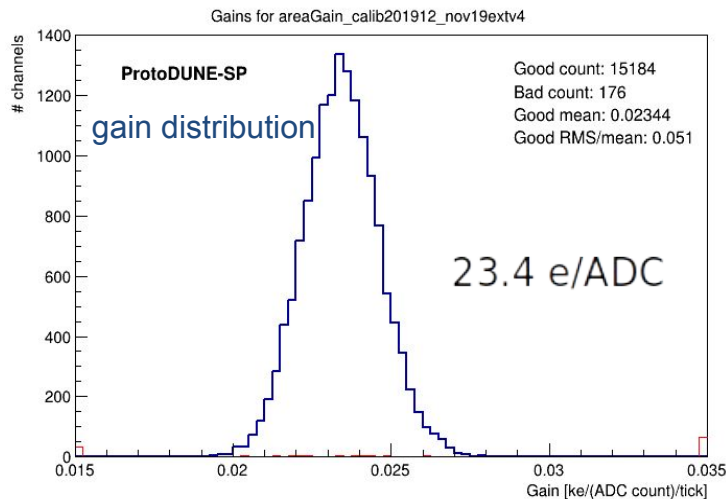
# Signal strength, new calibration and bad channels

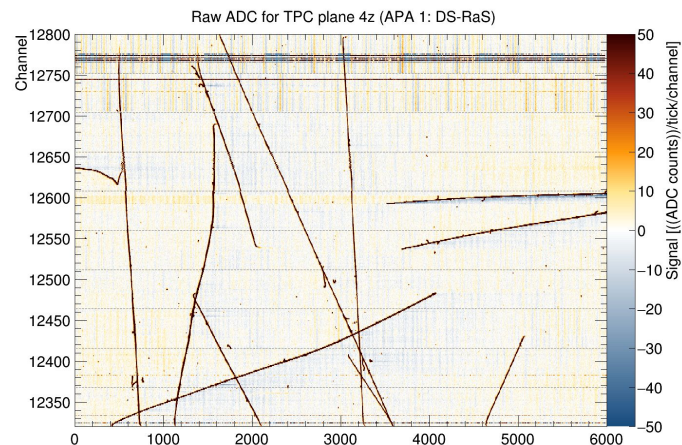
D. Adams



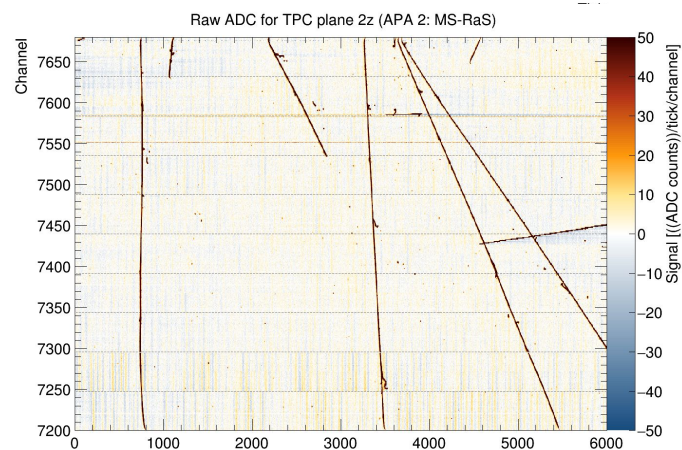
- Bad channels: found 6 new channels. 5 disconnected, 1 very noise

## • New calibration with November 2019 data





APA-1

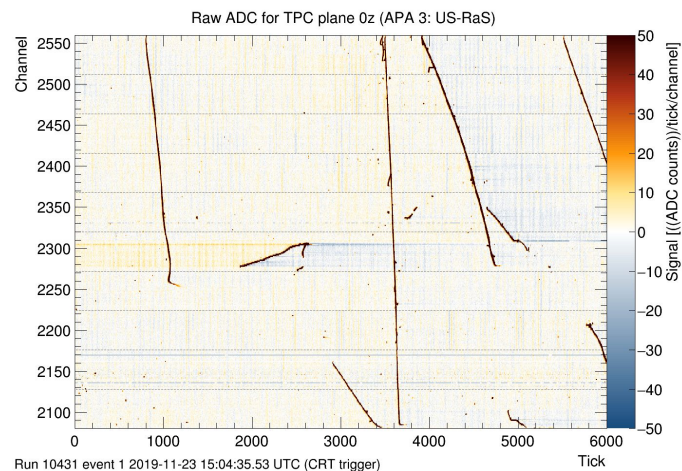


APA-2

## Through going tracks

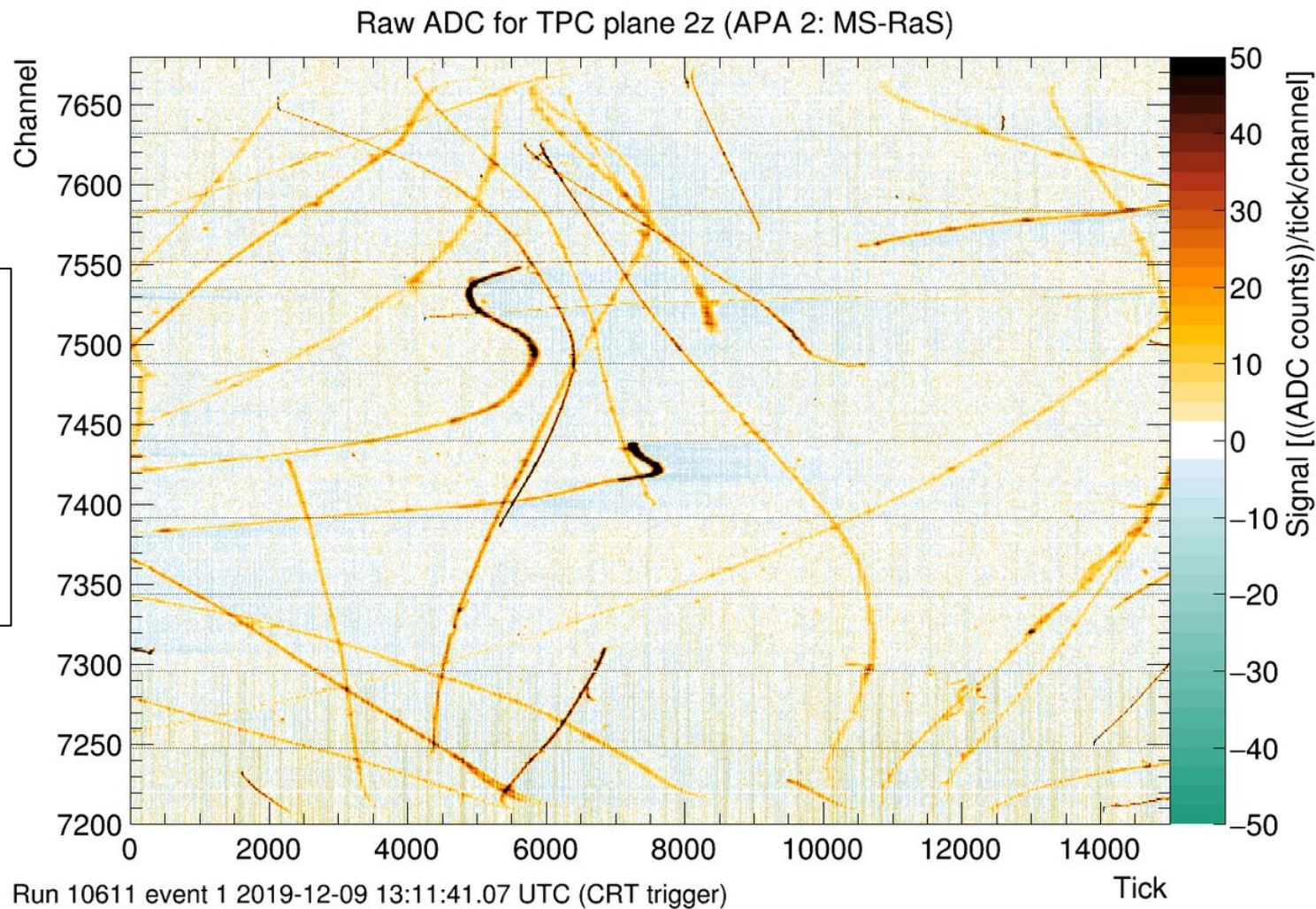
Run-10431:

- CRT triggered run
- 500V/cm
- 3ms readout



APA-3



**HV scan runs**

Run-10611:

- **100V/cm field**
- APA-2, collection plane
- 7.5ms readout window



# Conclusions

- Reactivated CRT, improved its performance and stability
- Using CRT triggers, collected large amount of cosmic data
- Quick response from collaborators and continues support from the working groups, lead us to have a successful data taking
- The preliminary analysis of the data has proved how useful this data is
- No degradation on the detector performance and components observed. On the contrary, ProtoDUNE-SP is working very good, even having better performance (HV, S/N, lifetime, ..)
- Large amount of data is waiting to be analyzed!!