Integration of CRP2+ CB tests in dunesw framework
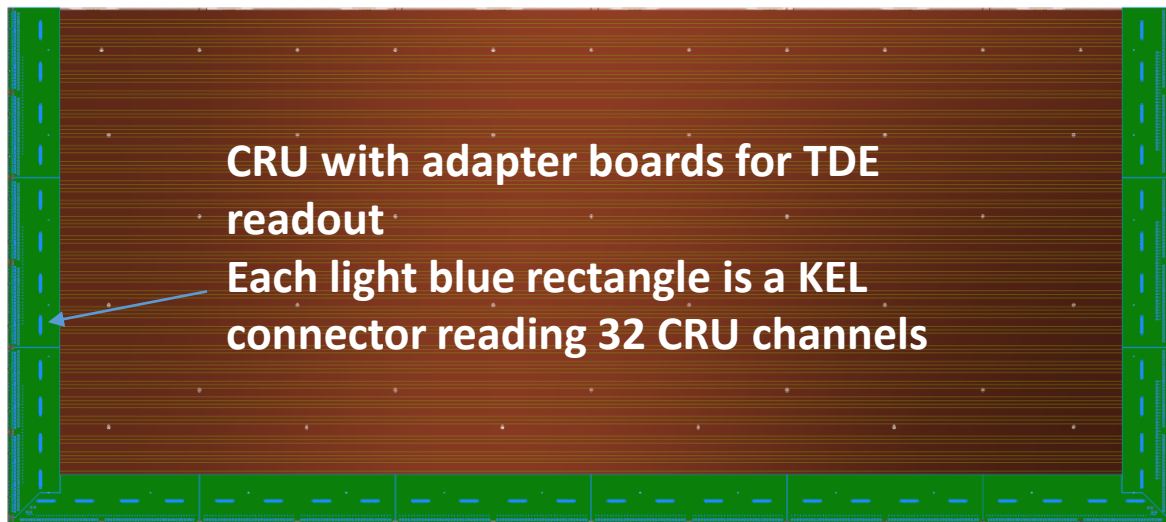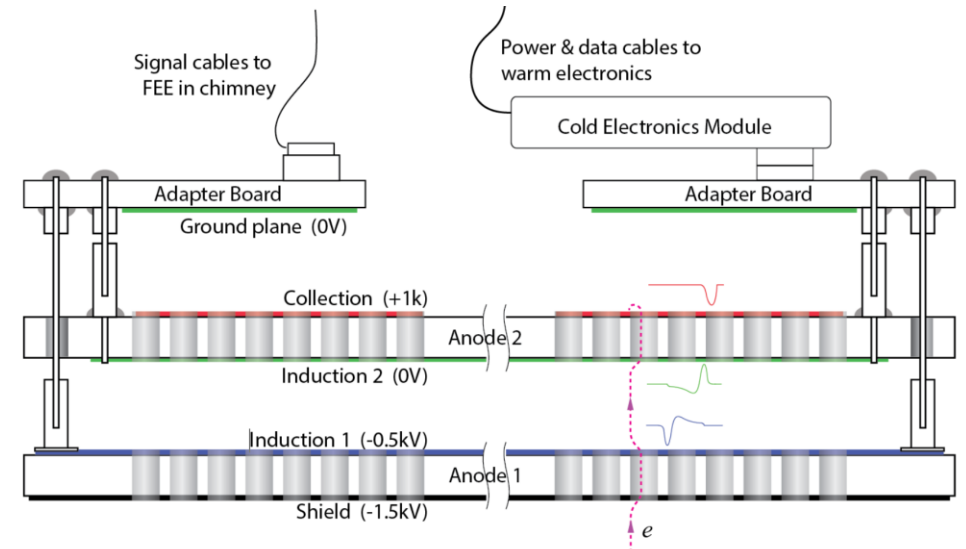
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VD Analysis Discussion
September 09 / 2022

Nomenclature recap

- A VD Charge Readout Plane (CRP) is made of two Charge Readout Units (CRUs):

  - CRU dimensions is given by the PCBs glued and silver-printed that provide shield / induction 1 / induction 2 and collection layers ➔ two assembled PCBs per CRU

  - The strip signal lines are brought up to the readout electronics via Adapter Boards mounted along the outer periphery of CRP

CRU with adapter boards for TDE readout
Each light blue rectangle is a KEL connector reading 32 CRU channels

CRU with adapter boards for BDE readout with CE boxes each reading 128 ch
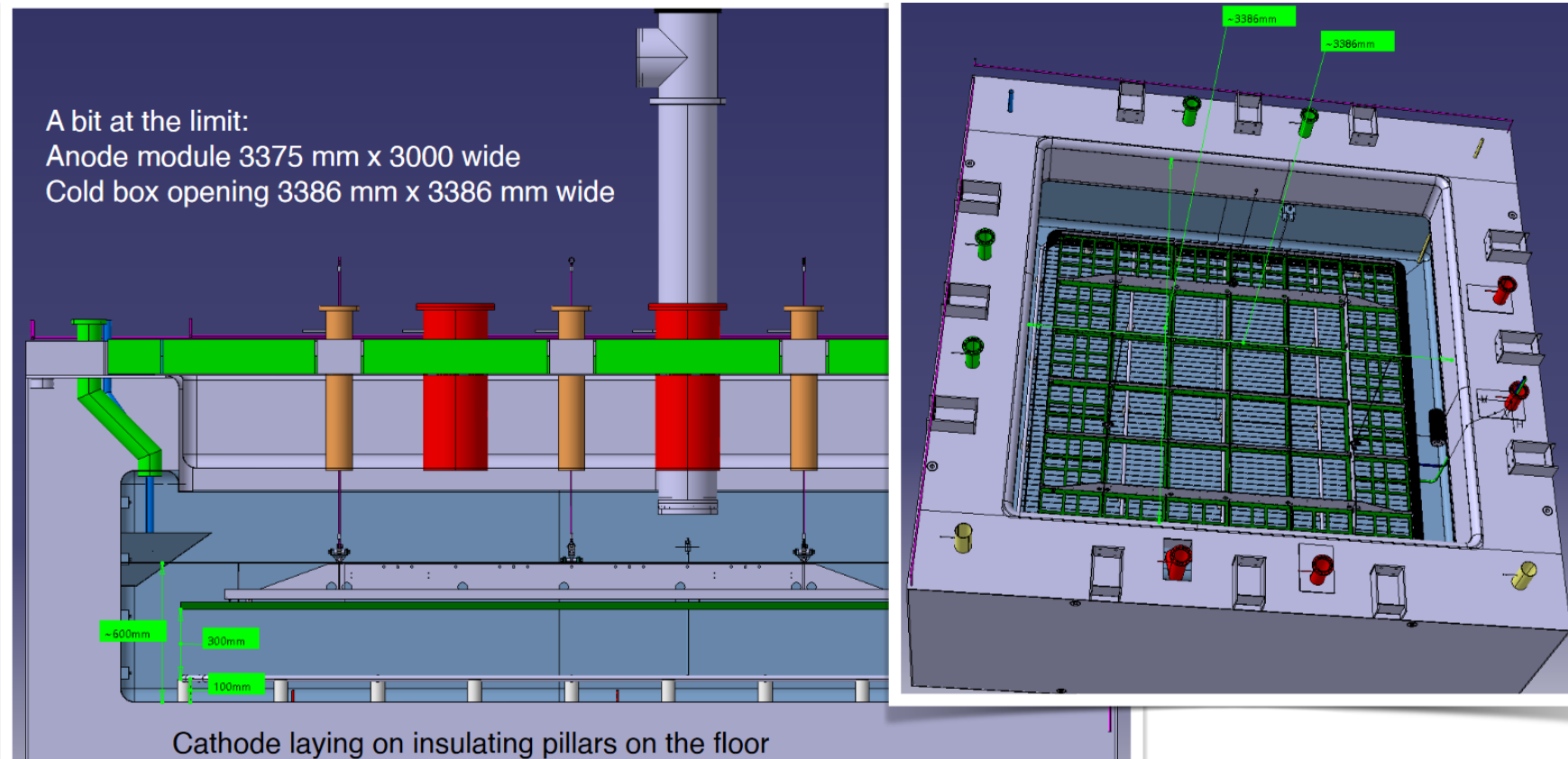
Nomenclature recap

VD CRP numbering scheme recap:

- CRP1:
  - 48deg / 0deg / 90 deg Ind1/Ind2/Col (angle wrt z axis)
  - Two types of readout electronics each reading one CRU (TDE reading CRP channels 0 – 1599 and BDE reading 1600 – 3199)
  - Tested in CB at CERN in Oct – Dec, 2021 and retested in Spring 2022
  - This CRP anode design is no longer considered for DUNE FD2

- CRP2, CRP3, CRP4, CRP5:
  - So called "**60D**" anode design now adopted for DUNE FD2: +/-30 deg Ind1/Ind2 and 90 deg Col
  - Optimized number of channels per CRP: 3072
  - Unique readout system per CRP: TDE for CRP2/3 and BDE for CRP4/5
  - The four CRPs will go into NP02 cryostat as part of the ProtoDUNE VD Module – 0 detector
  - Prior to this go through CB tests (CRP2 tested last Summer)

Integration CRP2+ geometry for CB tests

- Basically new dunesw prototype project:
    - Geometry description
    - Channel numbering scheme
    - Offline "channel-to-wire" map
    - FCL configs

- Many configurations can be recycled for different CB CRP2+ tests
    - GDML files should be fine and associated configs
    - Channel numbering scheme
    - Good part of dataprep configs for DQM and preprocessing

- Some parts are of course are unique:
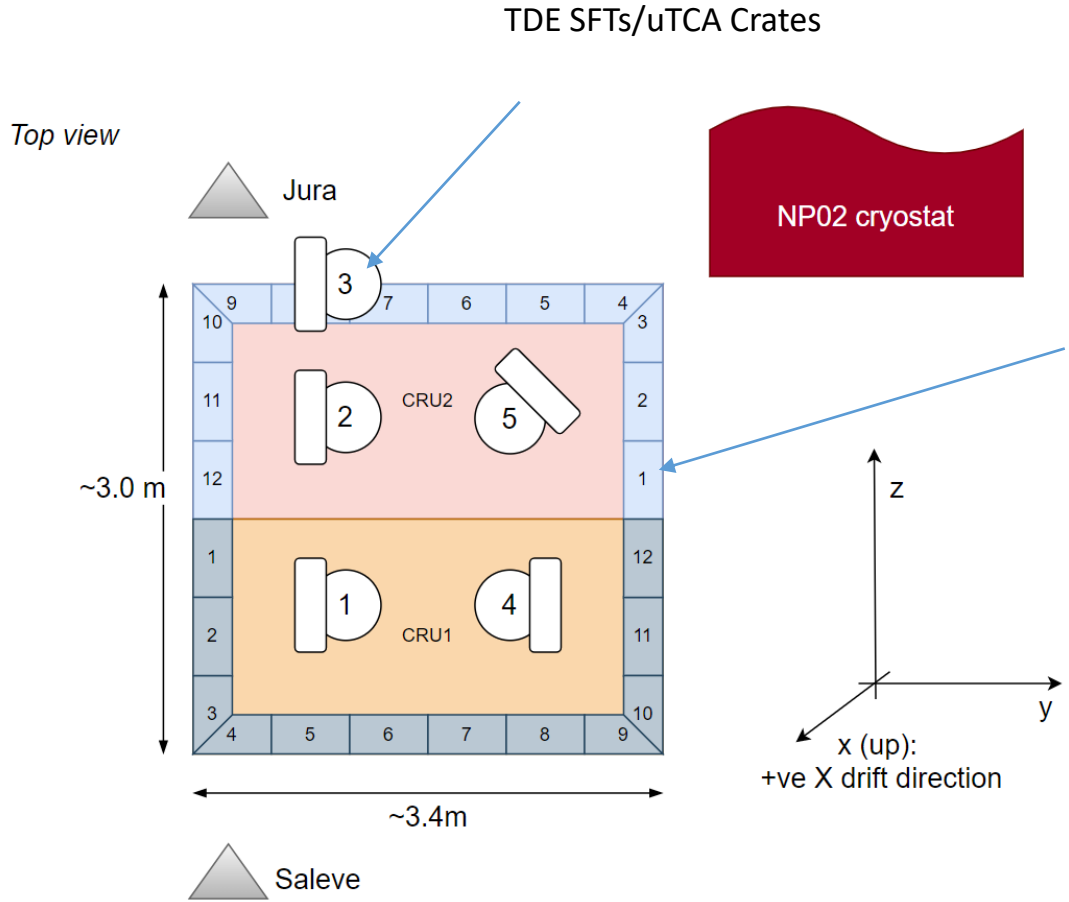   - Lists of bad channels
    - ...

"Coldbox" cryostat for CRP tests at CERN
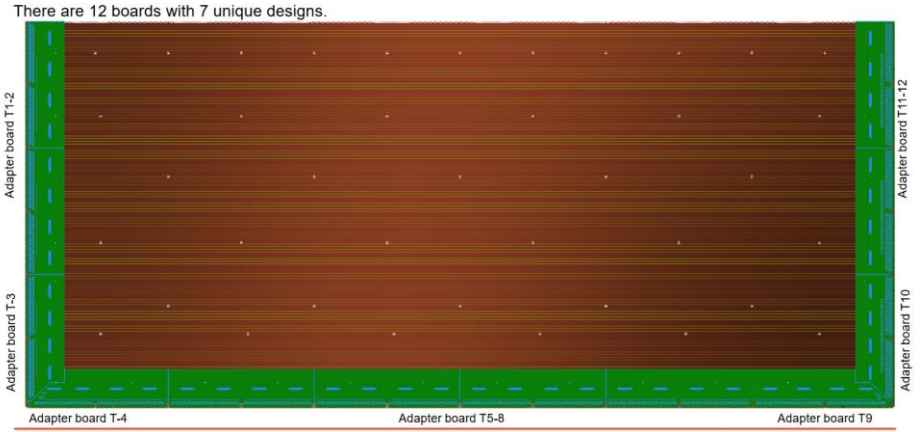

A bit at the limit:
Anode module 3375 mm x 3000 wide
Cold box opening 3386 mm x 3386 mm wide

Cathode laying on insulating pillars on the floor

Drift 23 cm
The inner membrane of approximate internal dimensions:
1m (high) by 3.9m × 3.9m,

CRP2 in CB: sketch of layout and axes convention

Top view

TDE SFTs/uTCA Crates

Jura

NP02 cryostat

Adapter boards: each number is the one from design

~3.0 m

~3.4m

Saleve

z

y

x (up):
+ve X drift direction

Arrangement of the TDE Adapter Boards
There are 12 boards with 7 unique designs.

Adapter board T1-2

Adapter board T-3

Adapter board T-4

Adapter board T5-8

Adapter board T9

Adapter board T10

Adapter board T11-12

Brookhaven National Laboratory   DUNE

Production of GDML files for CRP2+

- The method to generate "wires" for larsoft geometry was remade

- Now the problem of generating the wire pattern is parameterized in terms of:
  - Number of channels in a given plane per CRU
  - Active area of CRU which defines the bounding plane for the wire pattern

- Once CRU wire patterns are produced they are split in two halves to fill the two vol TPC modules needed for each CRU

Graphical illustration

CRU Ind 1 Bot view
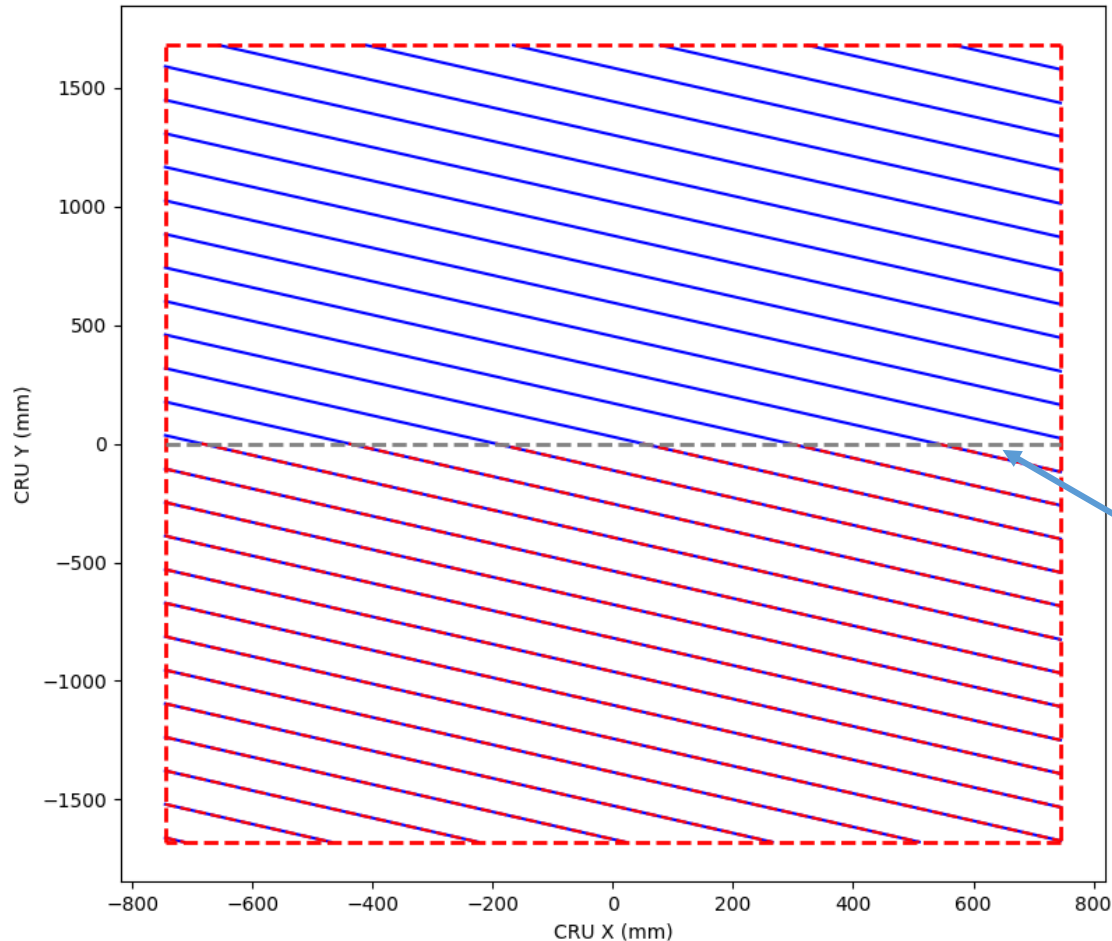
- Red bounds are given by CRU active area
- Blue lines represent the generated wire for this CRU drawing every nth one for clarity and showing only one of the induction views

- Dashed red are "wires" that will populate the readout planes in a given volTPC geo object (so half of CRU)

- By construction all volTPC wires will align on the boundary where they were split ➔ This is needed for eventual mapping of the pairs to a single readout channel

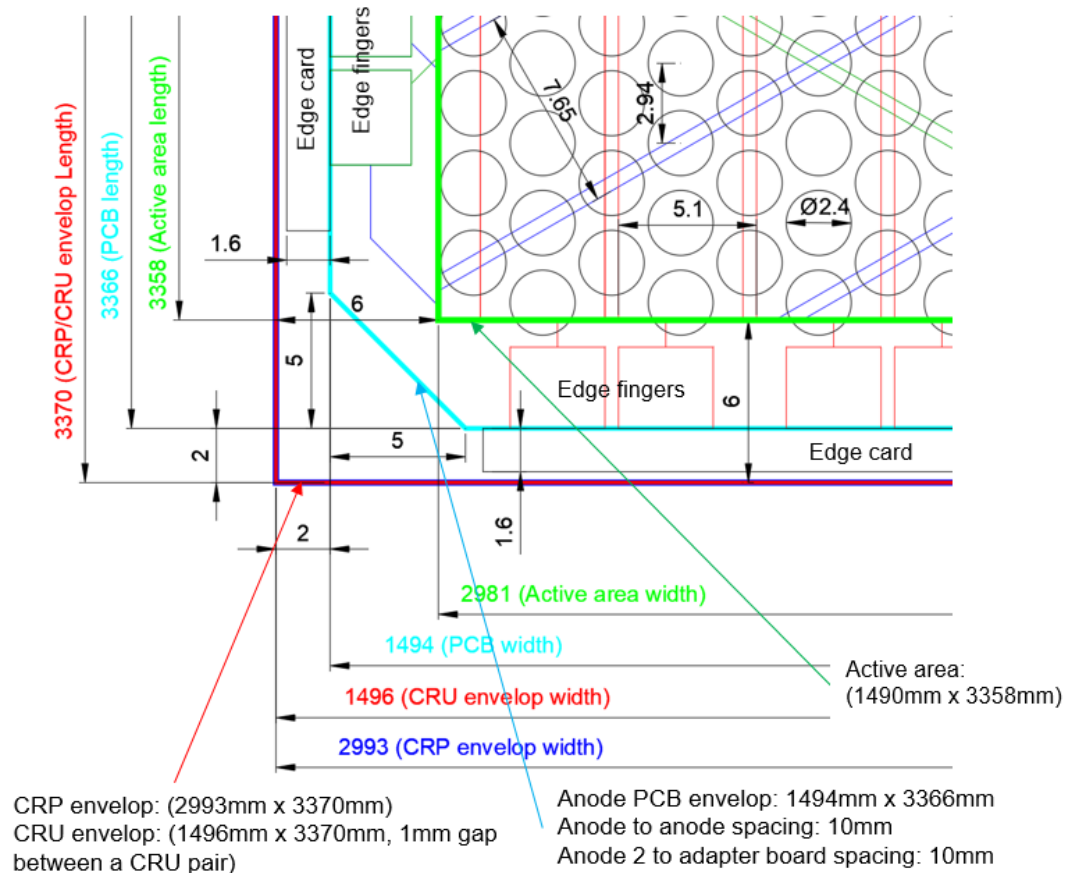# Adding 2ⁿᵈ CRU to form CRP

The wire coordinates for the 2ⁿᵈ CRU are computed from 1ˢᵗ CRU by making a 180 deg rotation
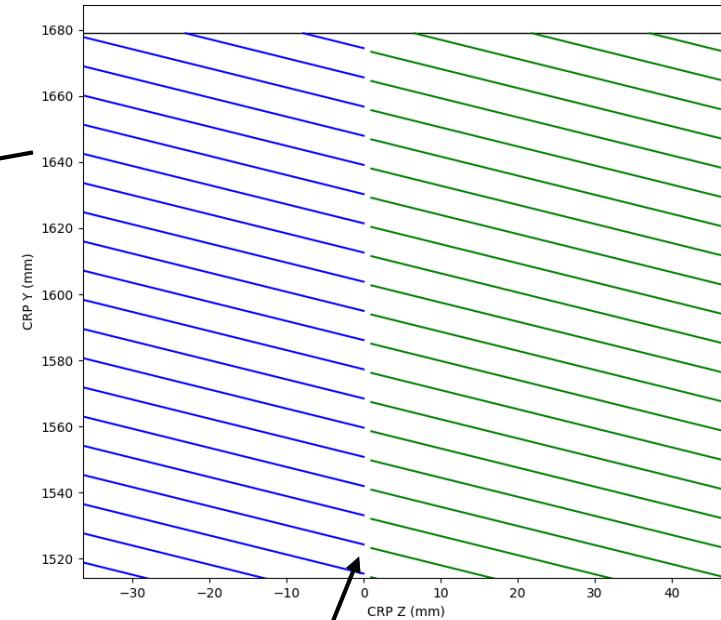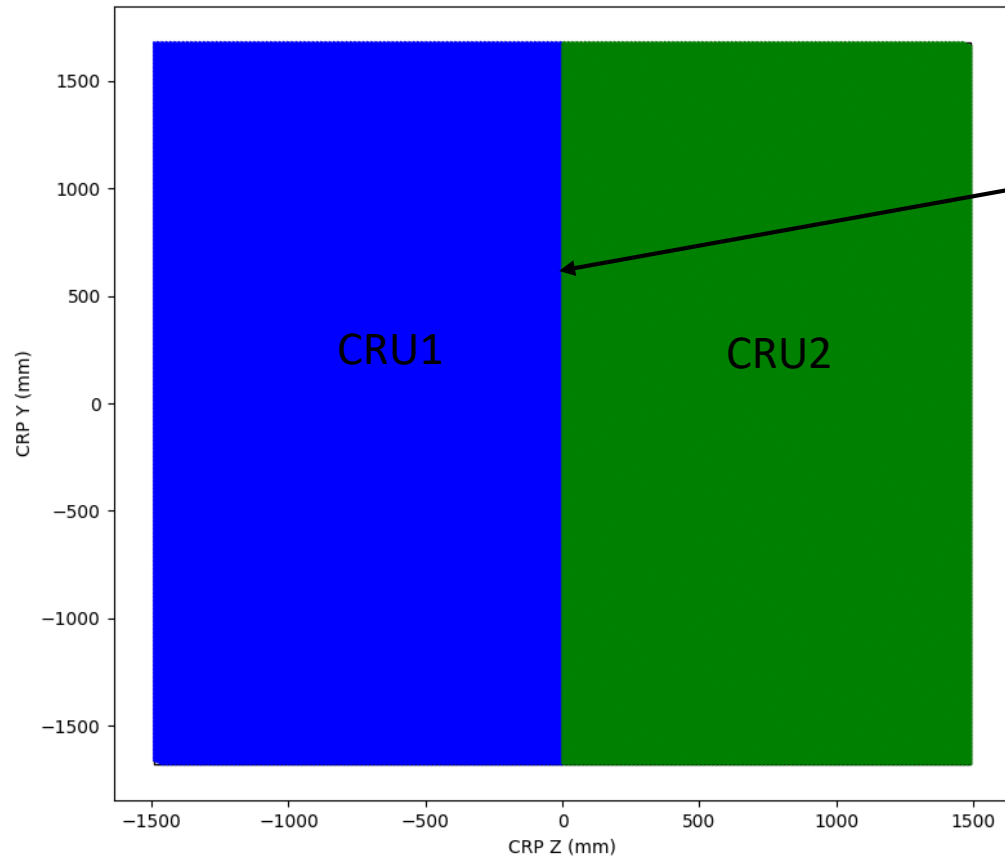
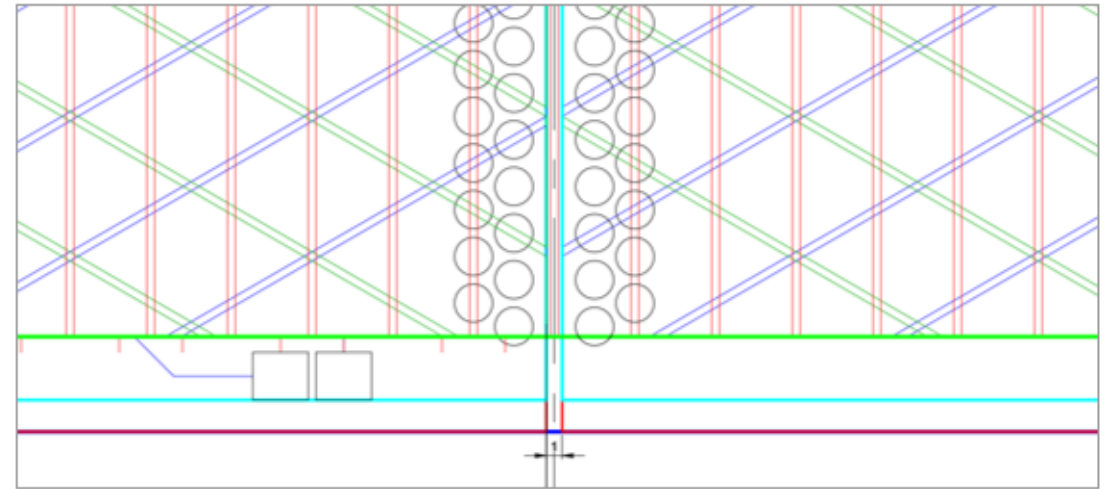The inner space between two CRUs is set to 1mm

Active plane dimensions

CRU active are from design:
1490 mm x 3358 mm

CRP border size including edge cards: 6 mm

The left and right CRUs on a CRP are identical (180° rotation). Across the CRU gap (1mm) within a CRP, the induction strips are aligned, and the collection strip pitch is maintained.

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Geo model

Generator script

```
generate_dunevdcb2_v1_refactored.pl
dunevdcb2_v1_refactored.gdml
dunevdcb2_v1_refactored_nowires.gdml
```

GDMLs

```
--- Generating Geometry ---
$script is generate_dunevdcb2_v1_refactored.pl
$base is dunevdcb2_v1_refactored
Some of the principal parameters for this TPC geometry (unit cm unless noted otherwise)
 Wire pitch in U, Y, Z : 0.765, 0.765, 0.51
 CRP volume            : 23 x 337 x 299.3
 Argon volume          : (100, 389, 391.3)
 Argon buffer          : (16.94, 26, 46)
 Detector enclosure : 400.24 x 789.24 x 791.54
 TPC Origin            : (71.56, 0, 149.65)
 Field Cage            : off
 Cathode               : off
 Wires                 : 1
 CRP vol dimensions       : 23.06 x 337 x 299.3
 TPC vol dimensions       : 23.06 x 168.5 x 149.65
--- done
```

CRP envelope

DUNE geometry helper service

geometry_dune.fcl

```
# === Vertical drift cold box geometries
dunevdcb_geo: @local::dune10kt_geo
dunevdcb_geo.Name: "dunevdcb1"
dunevdcb_geo.GDML: "dunevdcb1_refactored.gdml"
dunevdcb_geo.ROOT: "dunevdcb1_refactored.gdml"

dunevdcb2_geo: @local::dunevdcb_geo
dunevdcb2_geo.Name: "dunevdcb2"
dunevdcb2_geo.GDML: "dunevdcb2_v1_refactored.gdml"
dunevdcb2_geo.ROOT: "dunevdcb2_v1_refactored.gdml"
# ===
```

CRP2 CB geo

Geometry currently on feature branch only

```
git diff --stat --color feature/vgalymov_vdcb_crp2_geo remotes/origin/develop
 dunecore/Geometry/CheckDPhaseGeometry_module.cc            |    35 +-
 dunecore/Geometry/ColdBox2ChannelMapAlg.cxx                |   735 ---
 dunecore/Geometry/ColdBox2ChannelMapAlg.h                  |   629 --
 dunecore/Geometry/DUNEGeometryHelper_service.cc            |     7 +-
 dunecore/Geometry/gdml/dunevdcb2_v1_refactored.gdml        | 38707 ----------
 dunecore/Geometry/gdml/dunevdcb2_v1_refactored_nowires.gdml |  743 ---
 dunecore/Geometry/gdml/generate_dunevdcb2_v1_refactored.pl |  1580 -----
 dunecore/Geometry/geometry_dune.fcl                        |     7 -
 8 files changed, 7 insertions(+), 42436 deletions(-)
```

Need to complete a channel map algorithm that puts two wires "together" for U/V views to form one readout channel following the offline map scheme
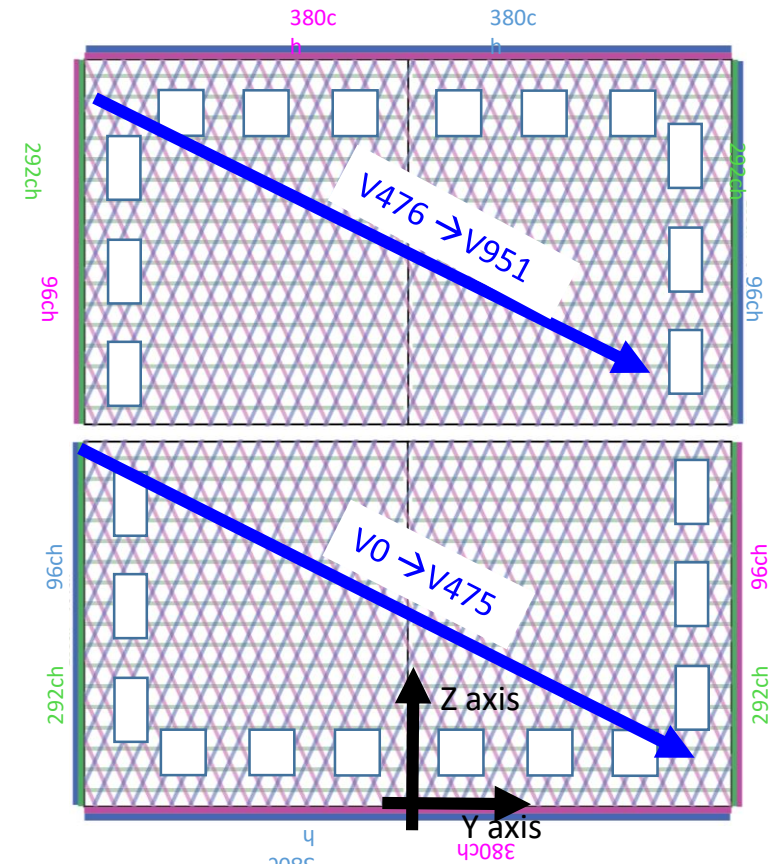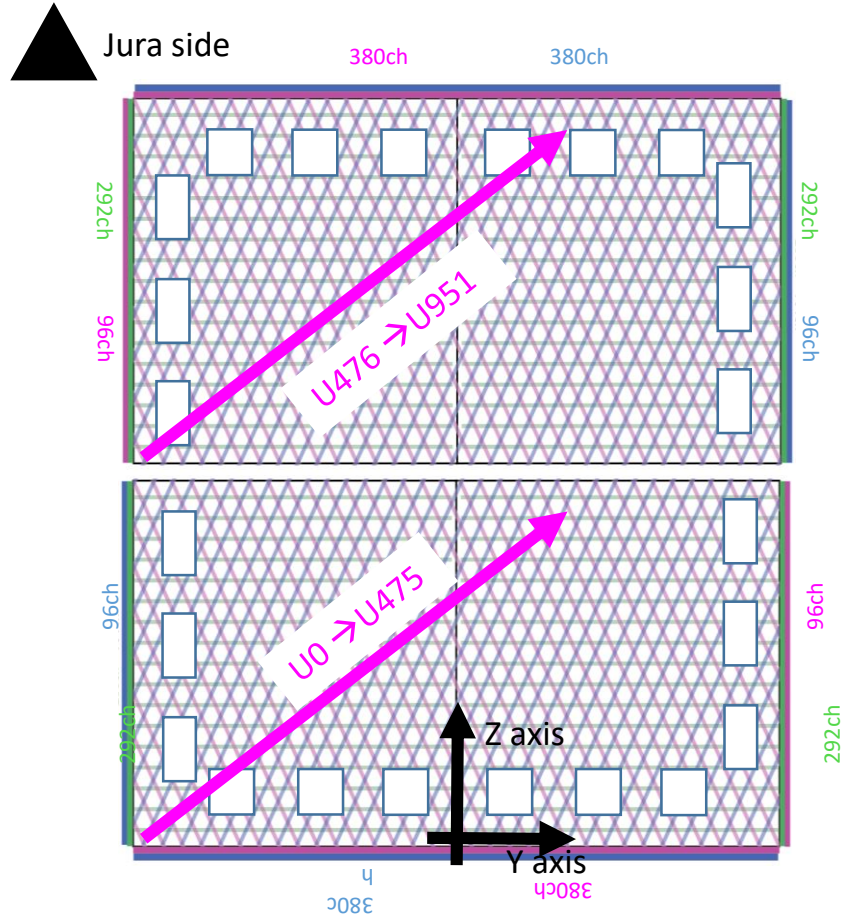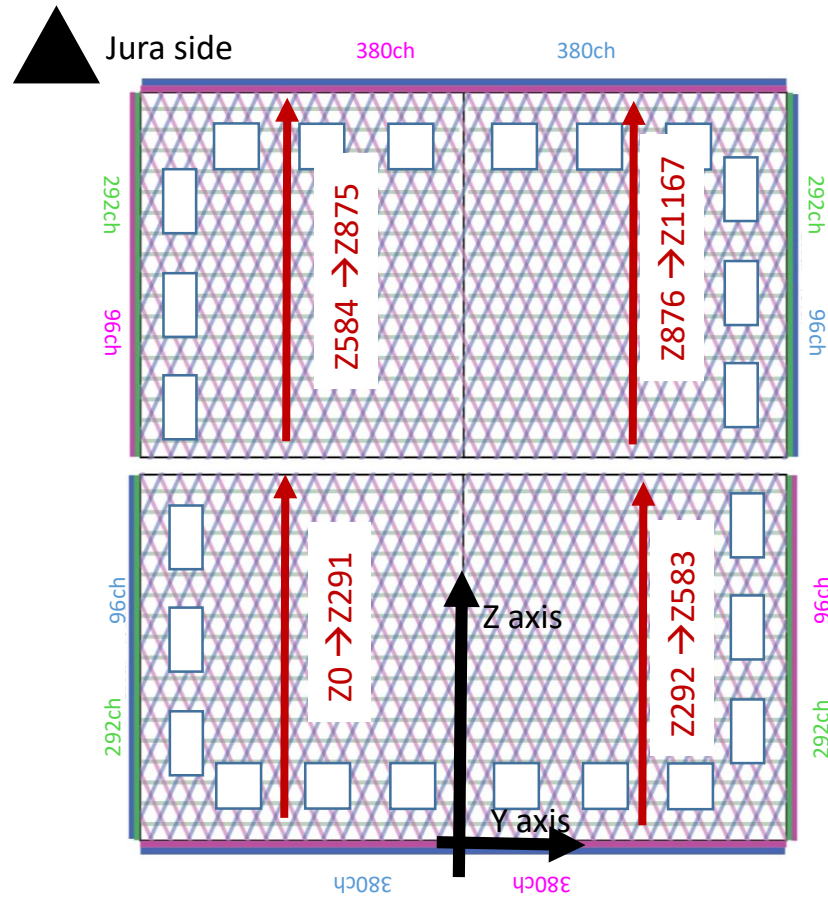
Offline readout plane channel ranges
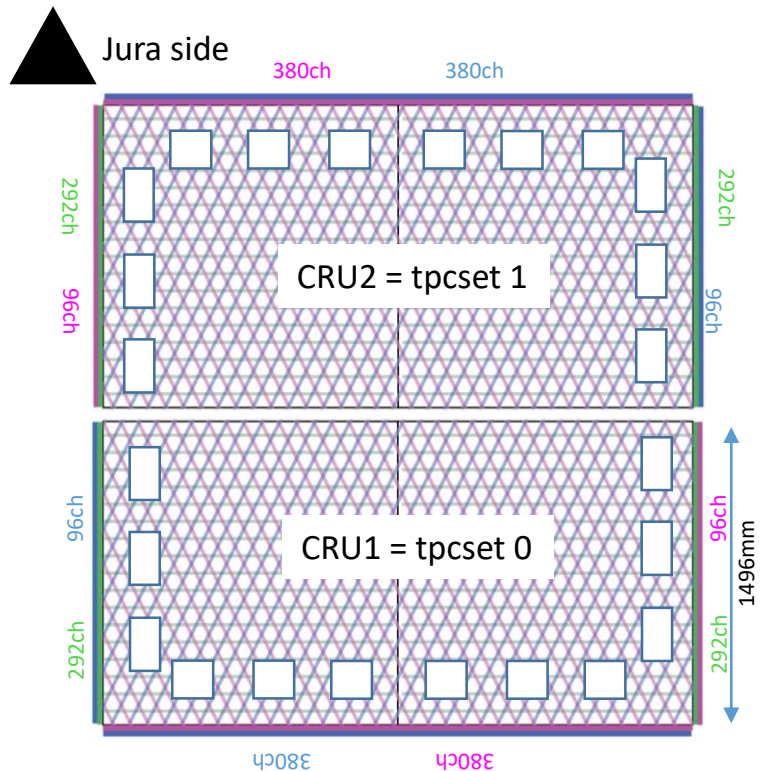
- Each CRU:
  - 476 Ind1 / 476 Ind2 / 584 Col

- Each readout plane (ROP) is mapped to a continuous block of channels:

ROP	Plane	Type	raw::ChannelID_t
0 (CRU 0 + 1)	0	Ind1	0 – 951
1 (CRU 0 + 1)	1	Ind2	952 – 1903
2 (CRU 0 + 1)	2	Col	1904 - 3071

Channel numbering: induction 1 & 2

Channel numbering: collection

Count per CRU in Z along Y neg and then Ypos half and 2nd CRU

Readout channel map for CRP2 TDE

- Implemented channel map for TDE CRP2 readout based on the cabling scheme and adapter board design ([dunedocdb 25847](#))

- Pushed into *duneprototypes* develop branch

- The channel map service: [VDColdboxTDEChannelMapService](#)
  - MapName : "vdcb2crp" for new CRP2 (preferably 3 as well)
  - MapName : "vdcb1crp" for old CRP1

- Example decoder + basic dataprep (under preparation) fcl:
  [vdcoldbox_raw_dataprep_crp2.fcl](#)

Raw ADC dataprep DQM display
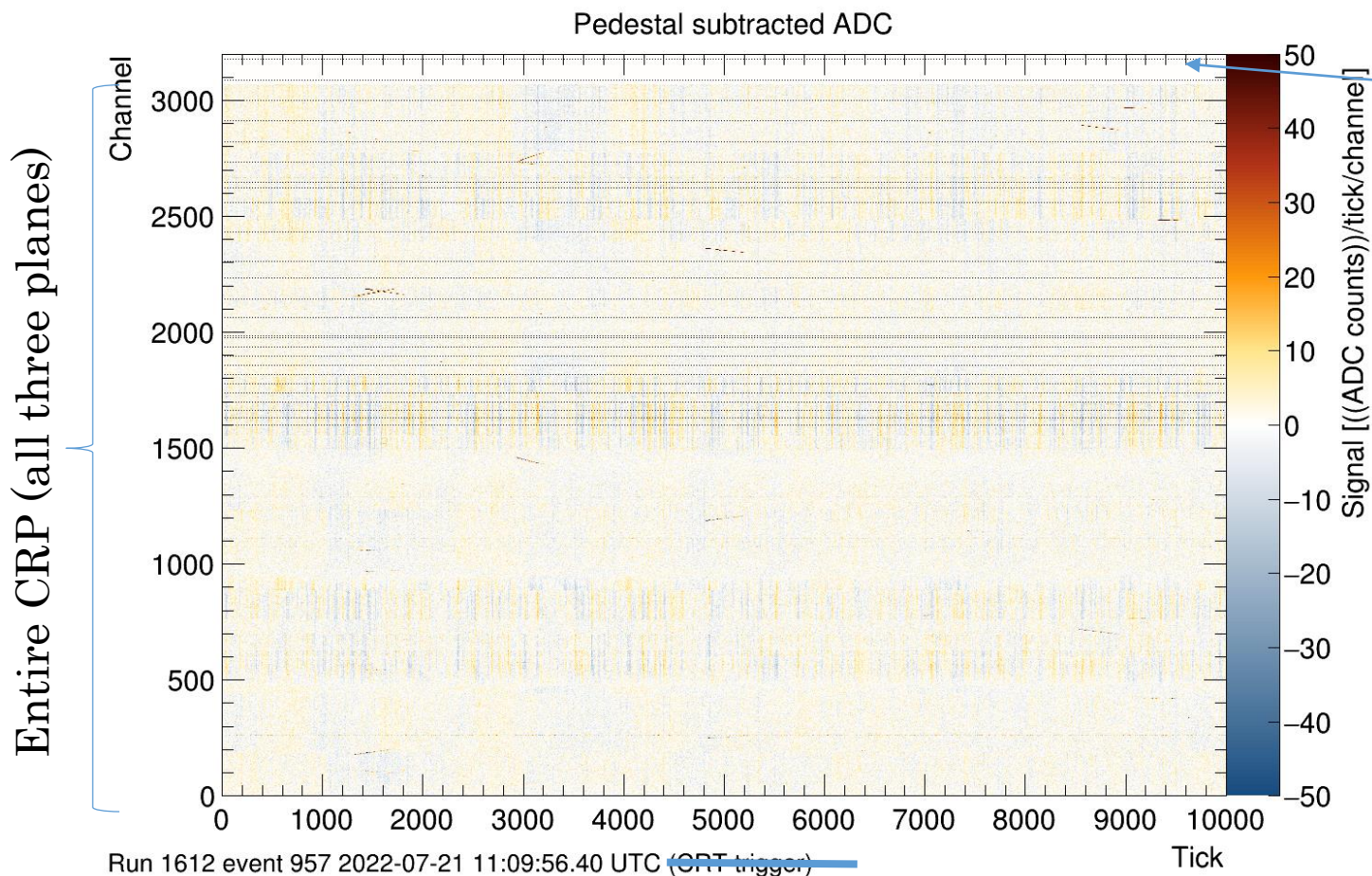
Old channel range from CRP1 (3200 channels), so the last 128 ch are 0

Also channel ranges for ch 1600+ are from CRP1 FEMBs

But the mapping looks to be correct

One of the July CRP2 runs (random trigger)

Raw RMS dataprep DQM plot

Again the solid vertical lines designated view boundaries from CRP1 which are no longer correct for CRP2
Same for the dashed lines, which used to represent boundaries for the adapter boards on CRP1

ADC-pedestal RMS for run 1612 event 957 CRU
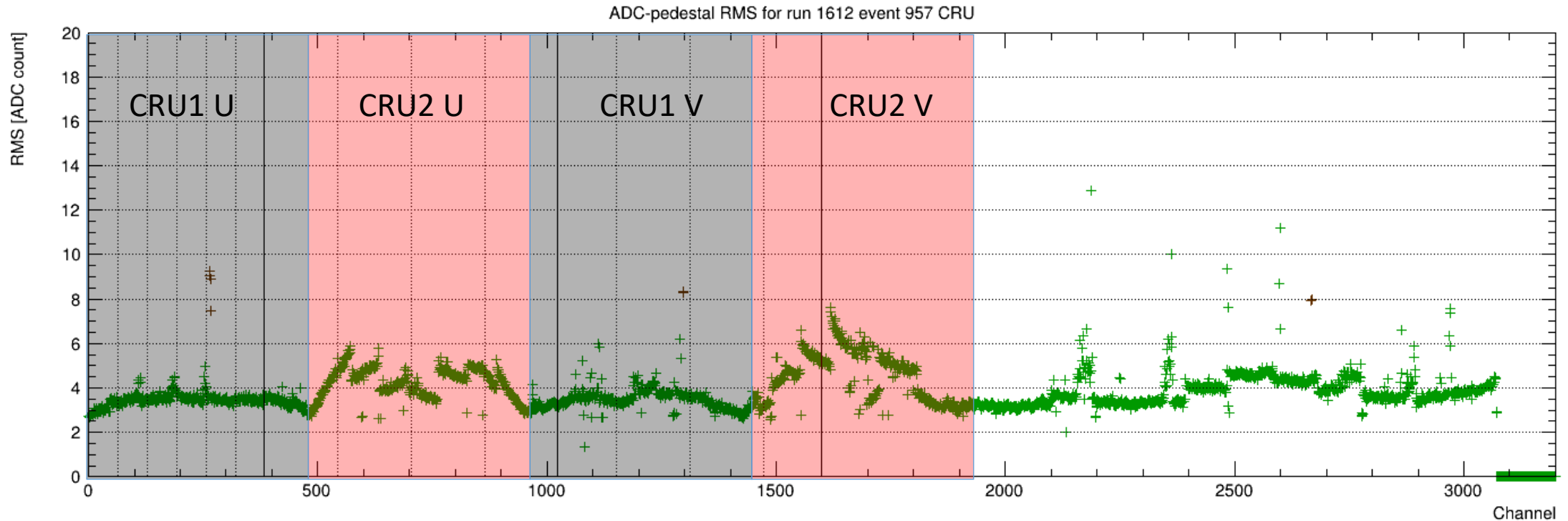
CRU2 sees more coherent noise
as can be seen from evd plot

Naming conventions

- For CRP2+ since this will go to protudune vd module 0, propose to:

  - Use pdunecrpcb as base name for tools / configs applicable to all module – 0 CRPs in coldbox tests

  - Use pdunecrpXcb, with X = 2,3,4,5 for configs specific for a given CRP
    - So should rename **vdcoldbox_raw_dataprep_crp2.fcl** to **vdcoldbox_raw_dataprep_pdunecrp2cb.fcl**
    - Similarly **channelstatus_vdcrp2.fcl** should **channelstatus_pdunecrp2cb.fcl**