

# Reconstructing 3D trajectories in DUNE

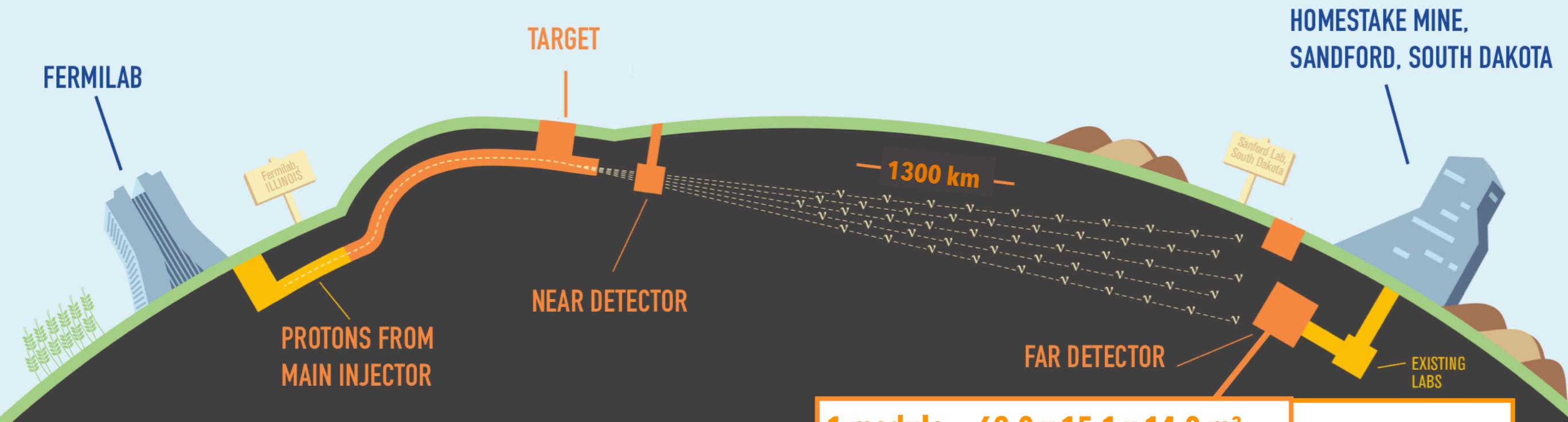
Etienne Chardonnet on the behalf of the DUNE collaboration

Laboratory APC, Paris



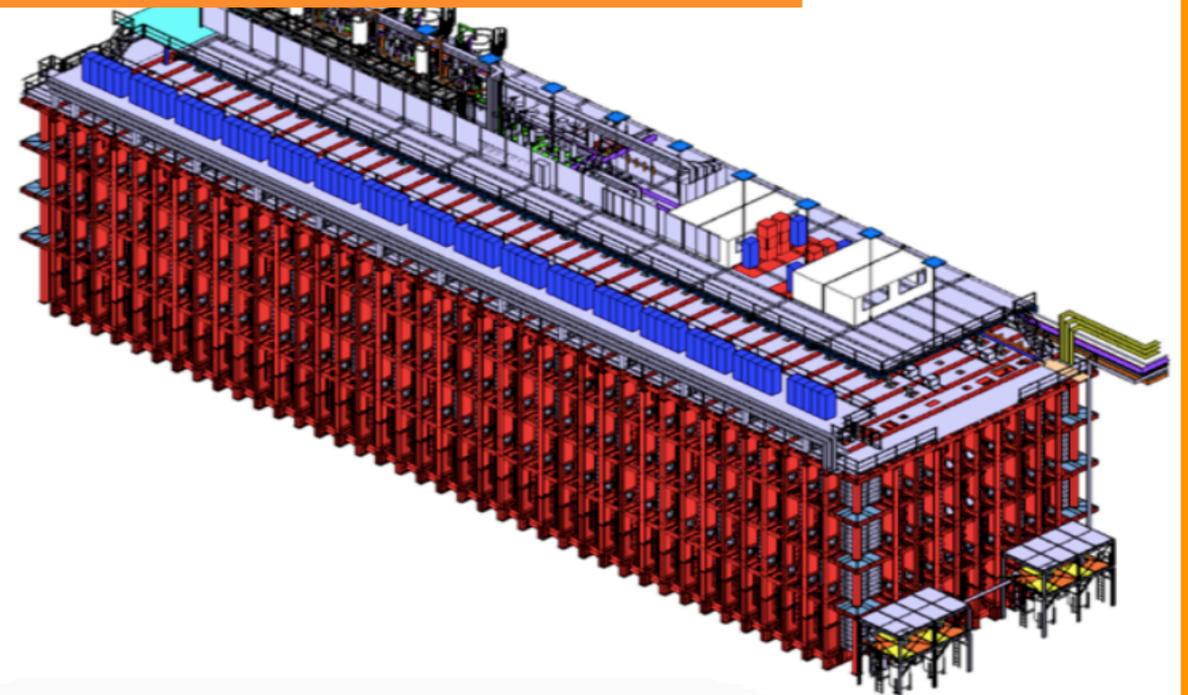


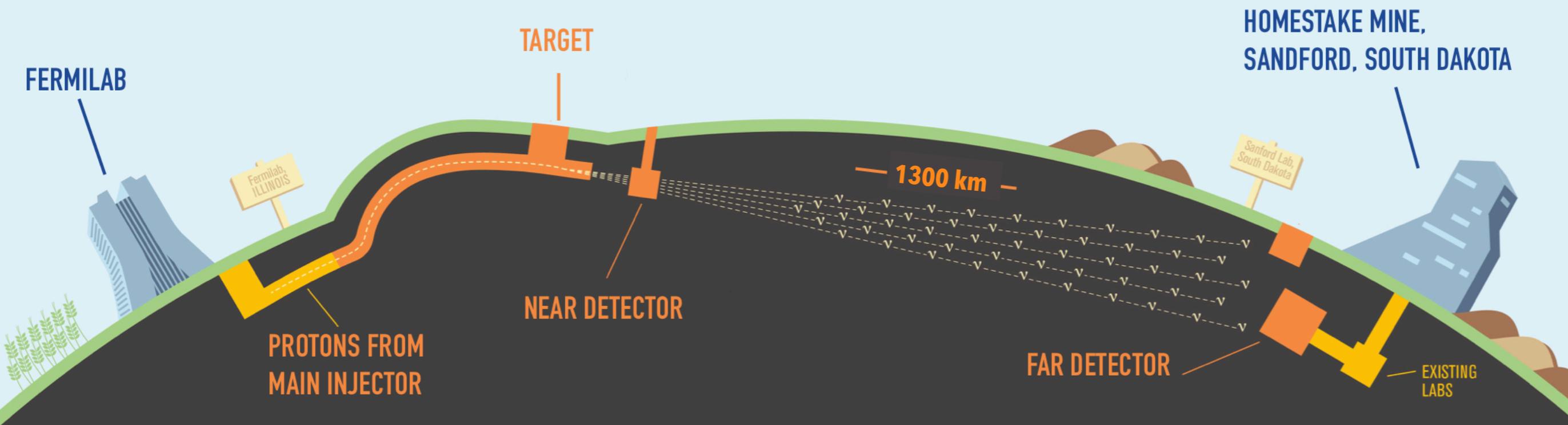
# SETUP



- Very Long Baseline experiment (~ 1300km)
- Beam of mainly  $\nu_{\mu}$  or anti- $\nu_{\mu}$ , [0.5 – 8] GeV
- Far Detector: 4 cryostats with 17kt LAr each
- Technology needs large scale validation

1 module = 62.0 x 15.1 x 14.0 m<sup>3</sup>





Accelerator Neutrino: oscillation  $\nu_{\mu} \longrightarrow \nu_e$  ( $\nu_e$  appearance)

and  $\nu_{\mu} \longrightarrow \nu_{\mu}$  ( $\nu_{\mu}$  disappearance) interesting to:

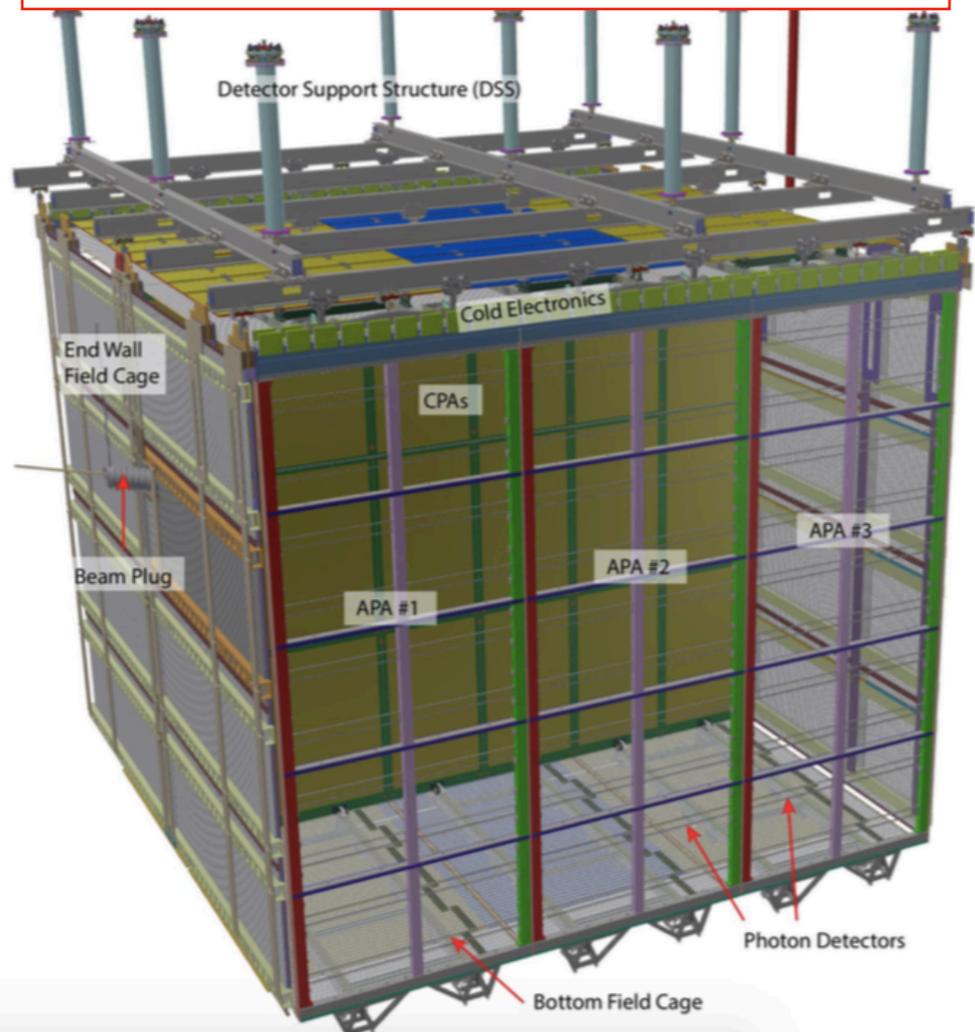
- Discovery of CP violation for leptons
- Mass Hierarchy
- Precision measurements on oscillation parameters

Neutrinos from natural sources:

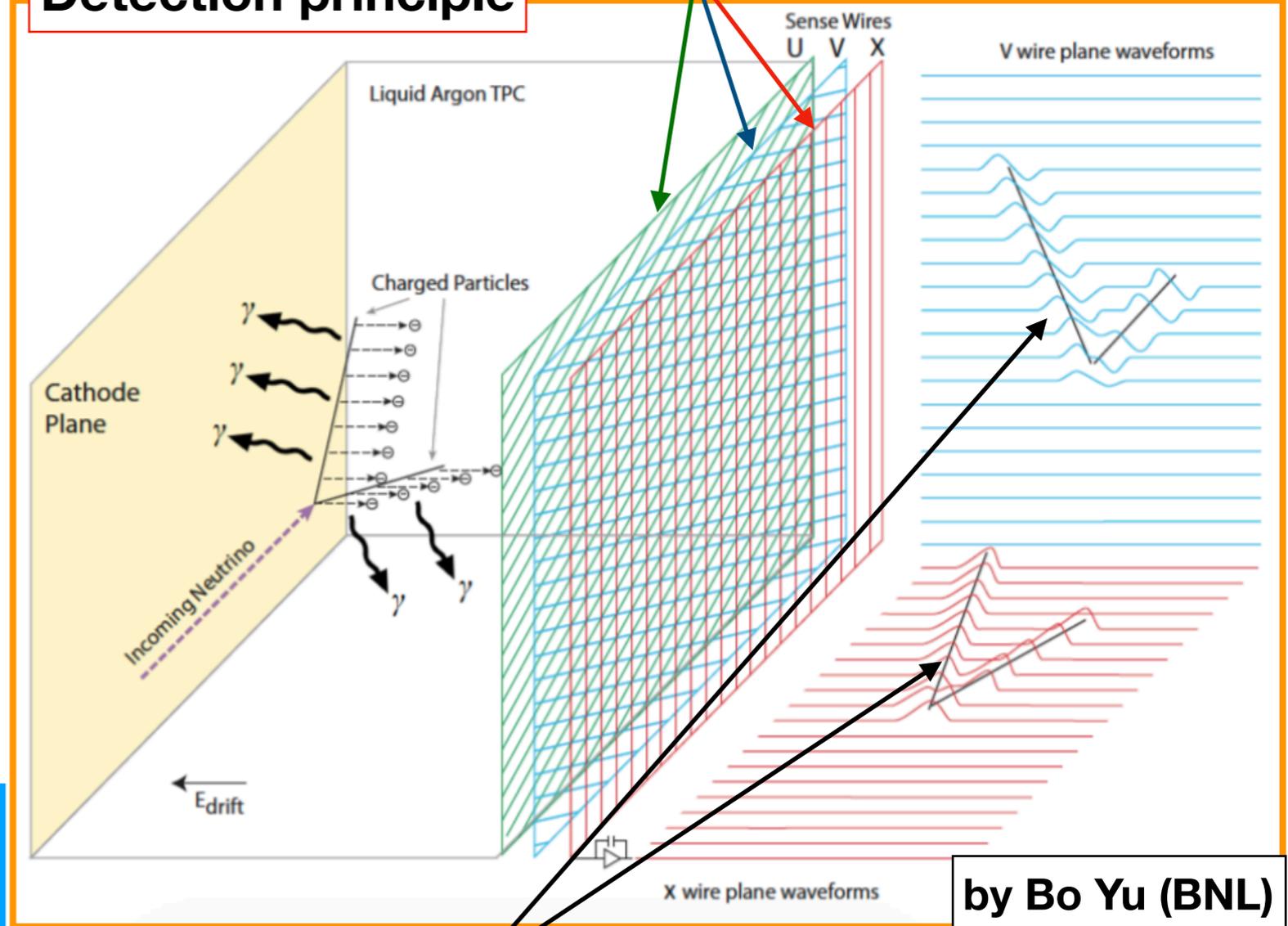
- Capability to detect and study neutrino from the supernovae core collapse
- Study of the atmospheric neutrino flux

# DUNE's Liquid Argon TPC

6x6x6m<sup>3</sup> ProtoDUNE scheme



Detection principle



Readout planes (views)

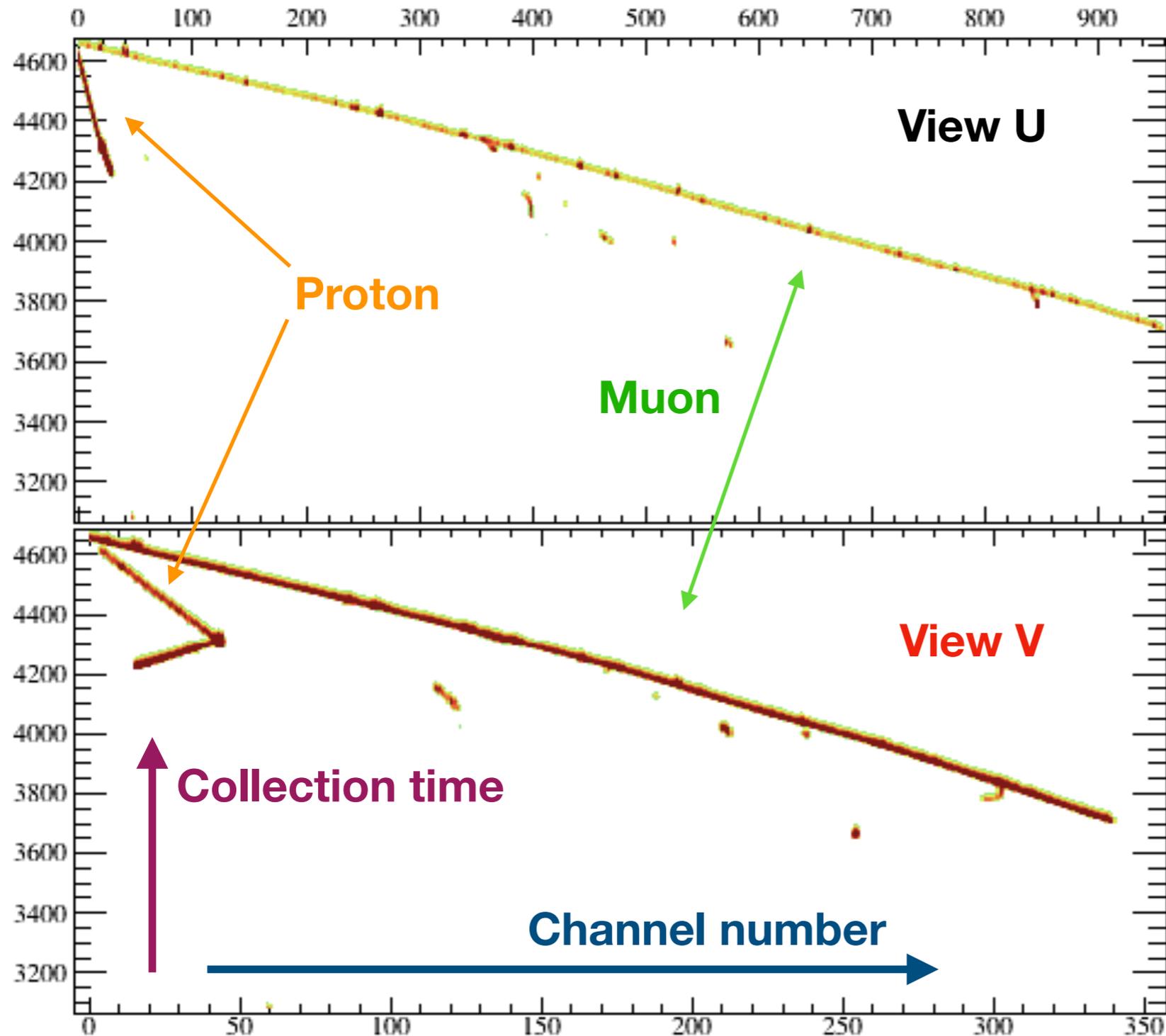
Signal pulses

Prototype of the FD built @CERN  
Demonstrate the capability of each area of the design (stability, reconstruction performances, etc)

More on readout planes on next slide...

# DUNE views

Example of two views for a  $\nu_\mu$ -CC event



Each view is a 2D projection of the event with:

Collection time (drift direction)

x

View-specific channel number

3D trajectories are reconstructed by matching the views together

# 3D reconstruction in DUNE

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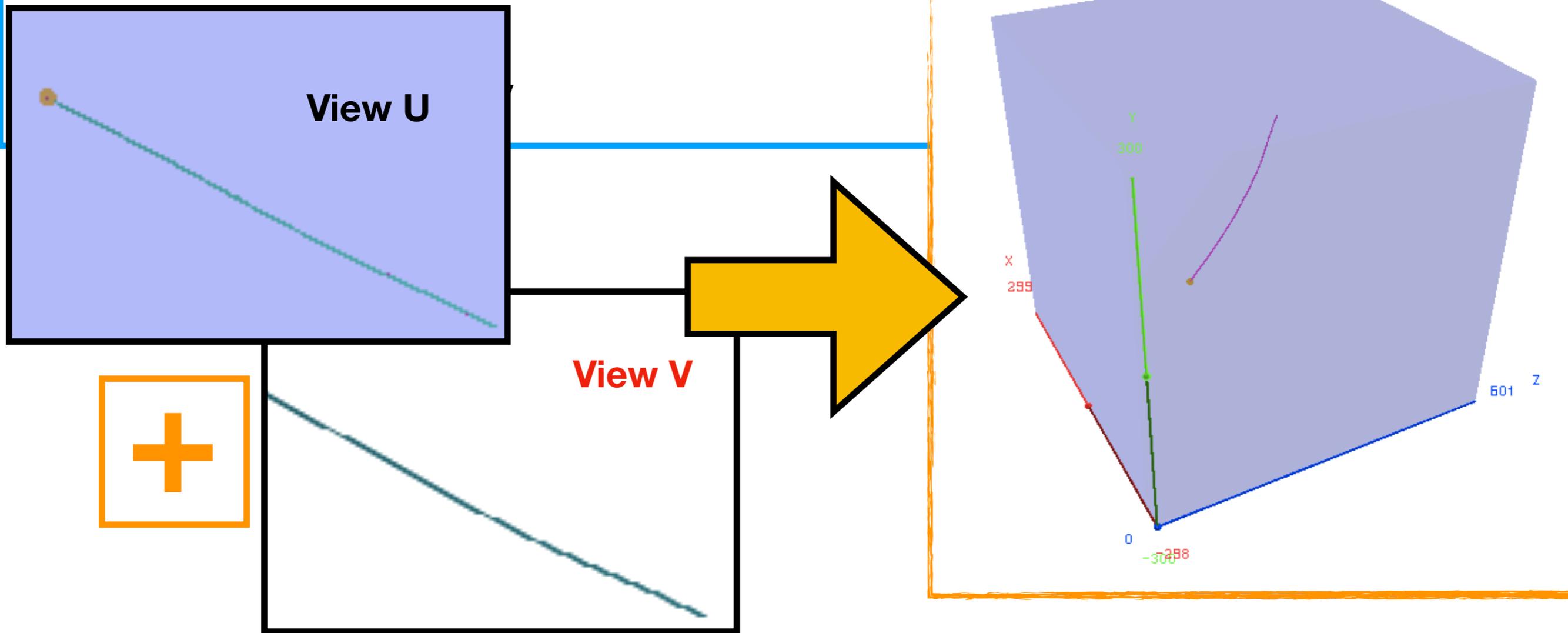
## Standard event reconstruction:

- Clustering hits
- Matching clusters from different views (3D track/shower creation)
- Vertexing
- Particle hierarchy

# 3D reconstruction in DUNE

## Standard event reconstruction:

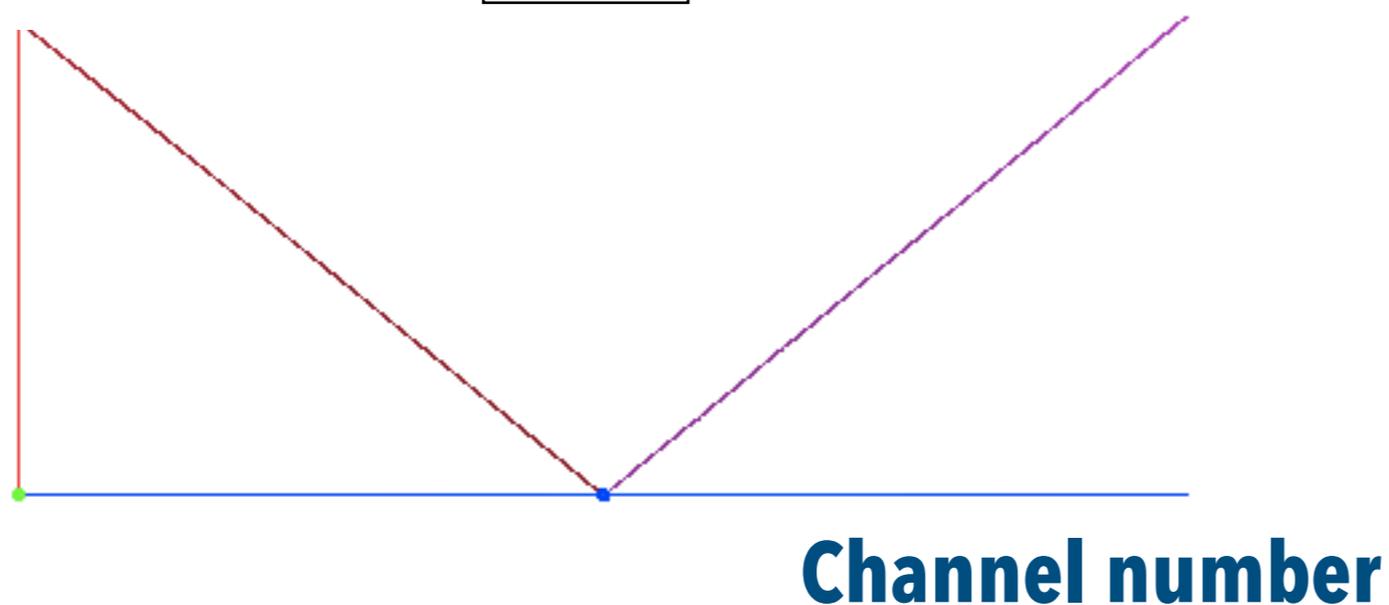
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# View-matching with calorimetric information

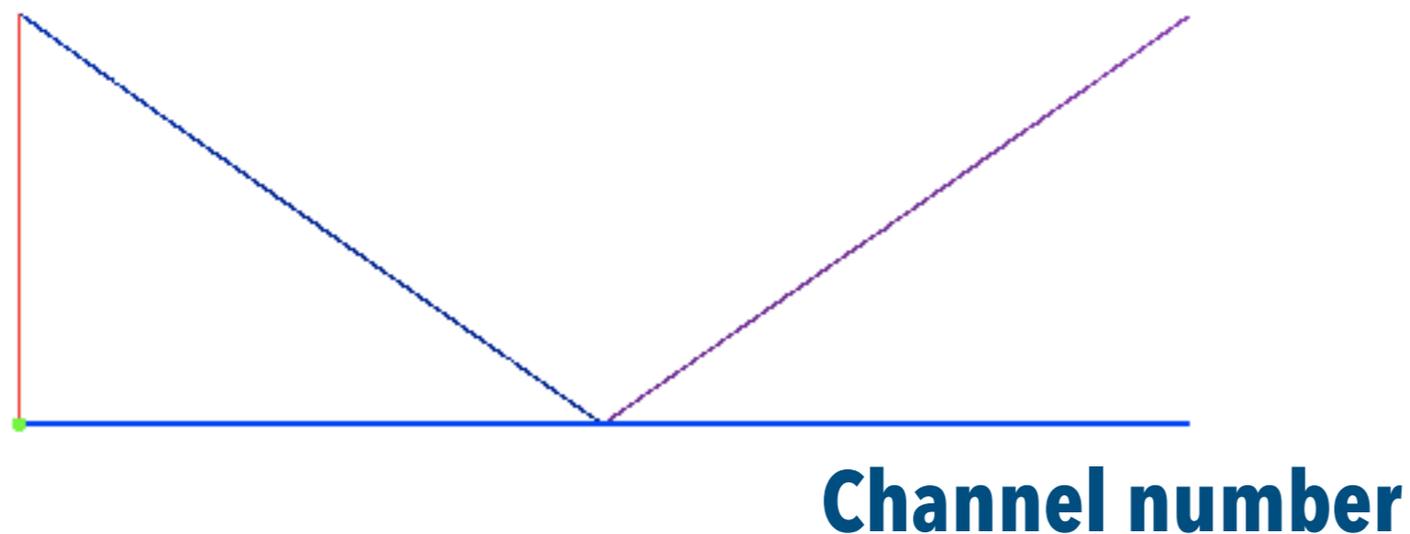
Collection time

View U



Collection time

View V



10k simulated muon pairs

- Perfectly symmetrical muons (wrt to Collection time)

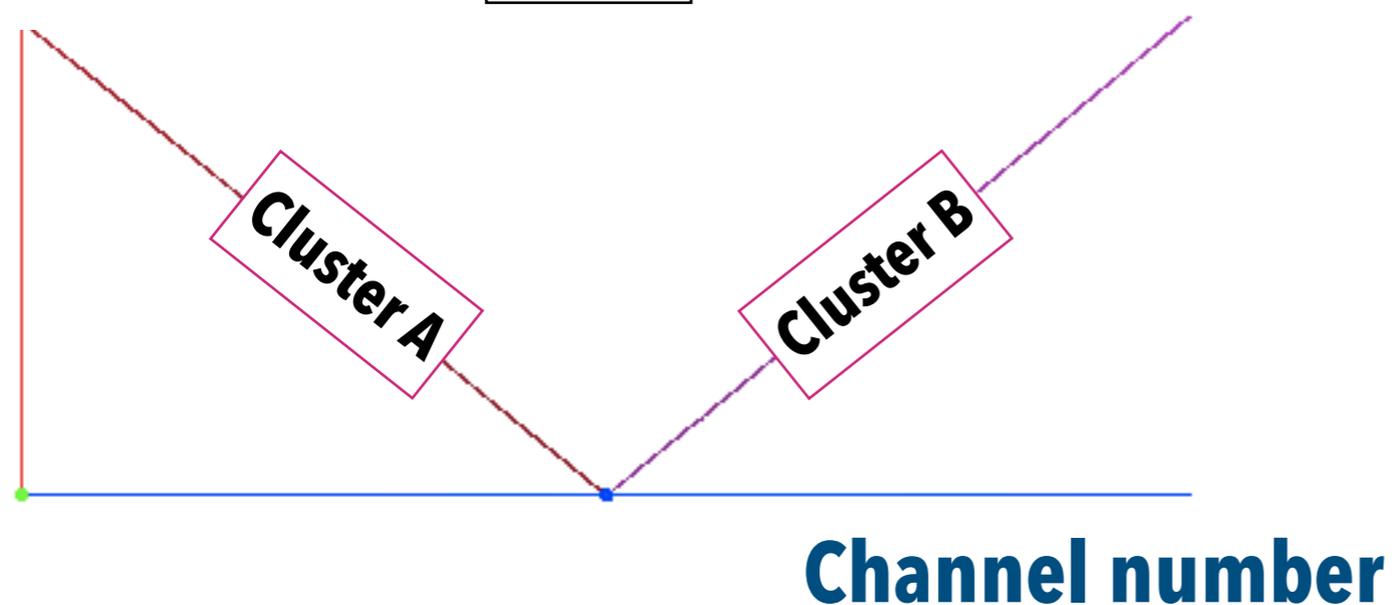
➡ Indistinguishable using only their time of collection

➡ Calorimetry comes in play!

# View-matching with calorimetric information

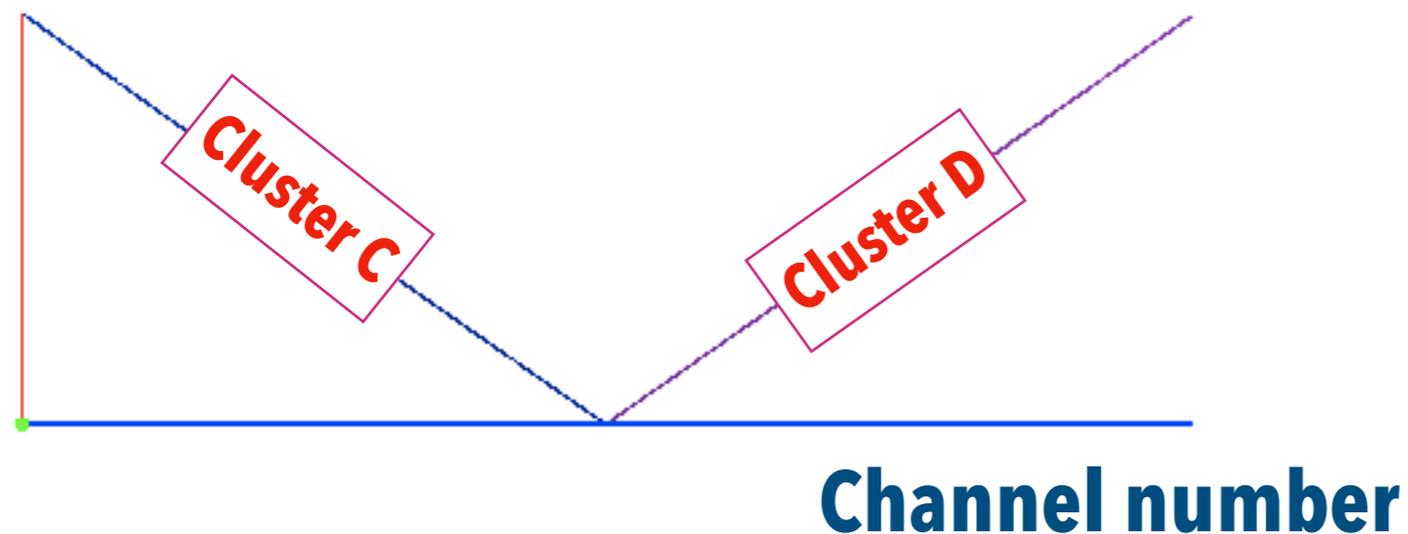
Collection time

View U



Collection time

View V

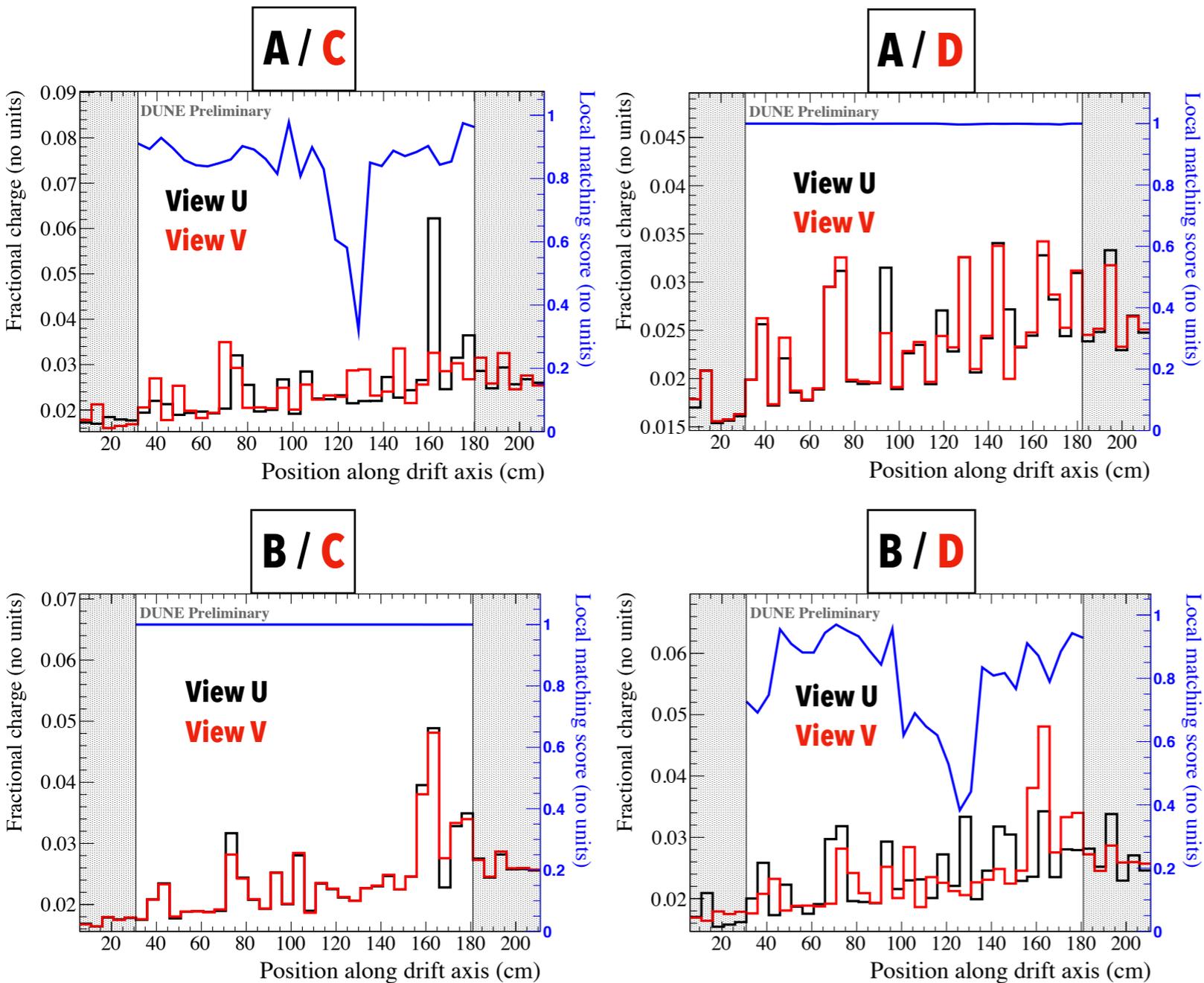


Algo tests which clusters should go together.

➔ 4 comparisons

Compare the fractional charge profiles

# View-matching with calorimetric information

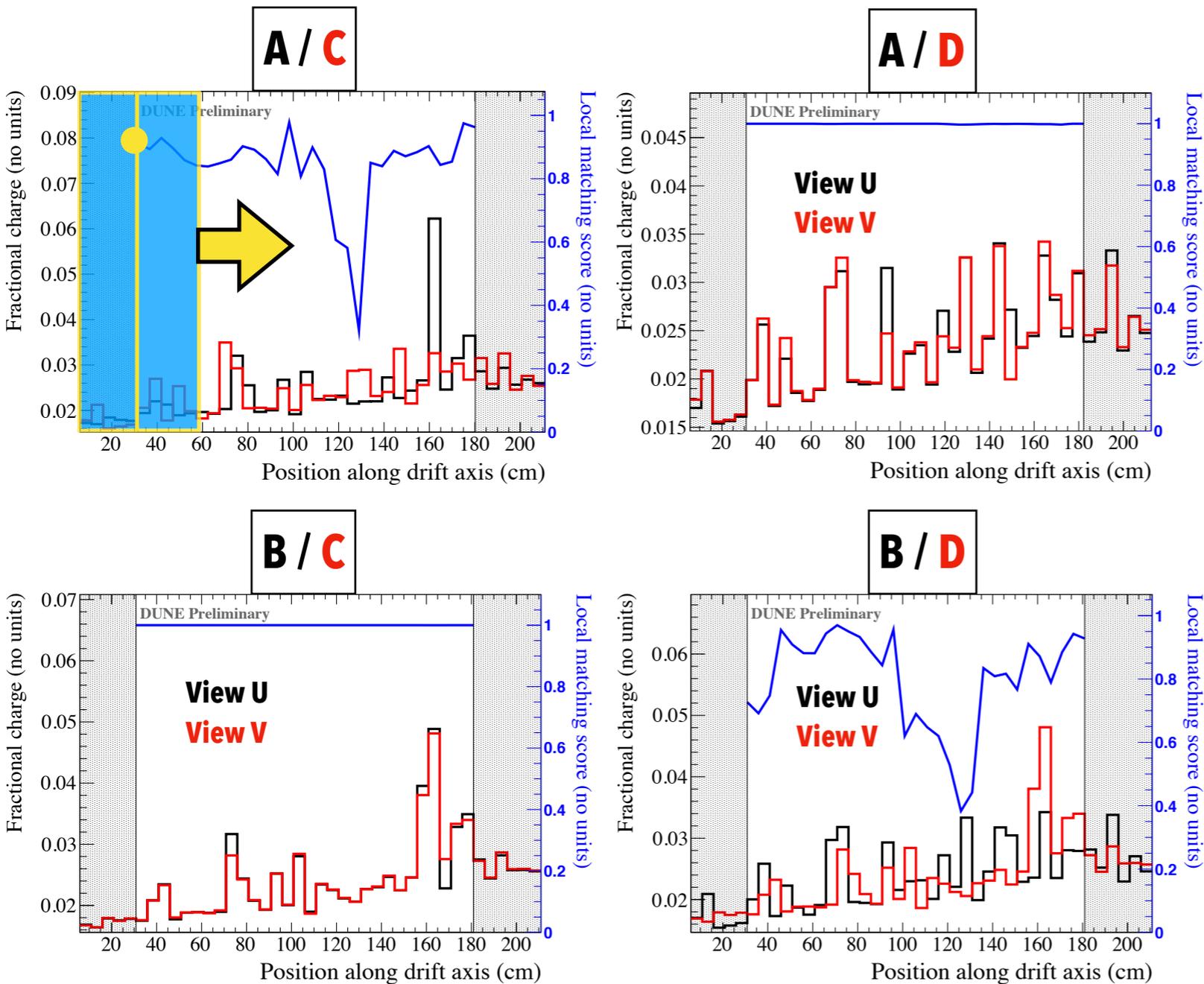


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# View-matching with calorimetric information



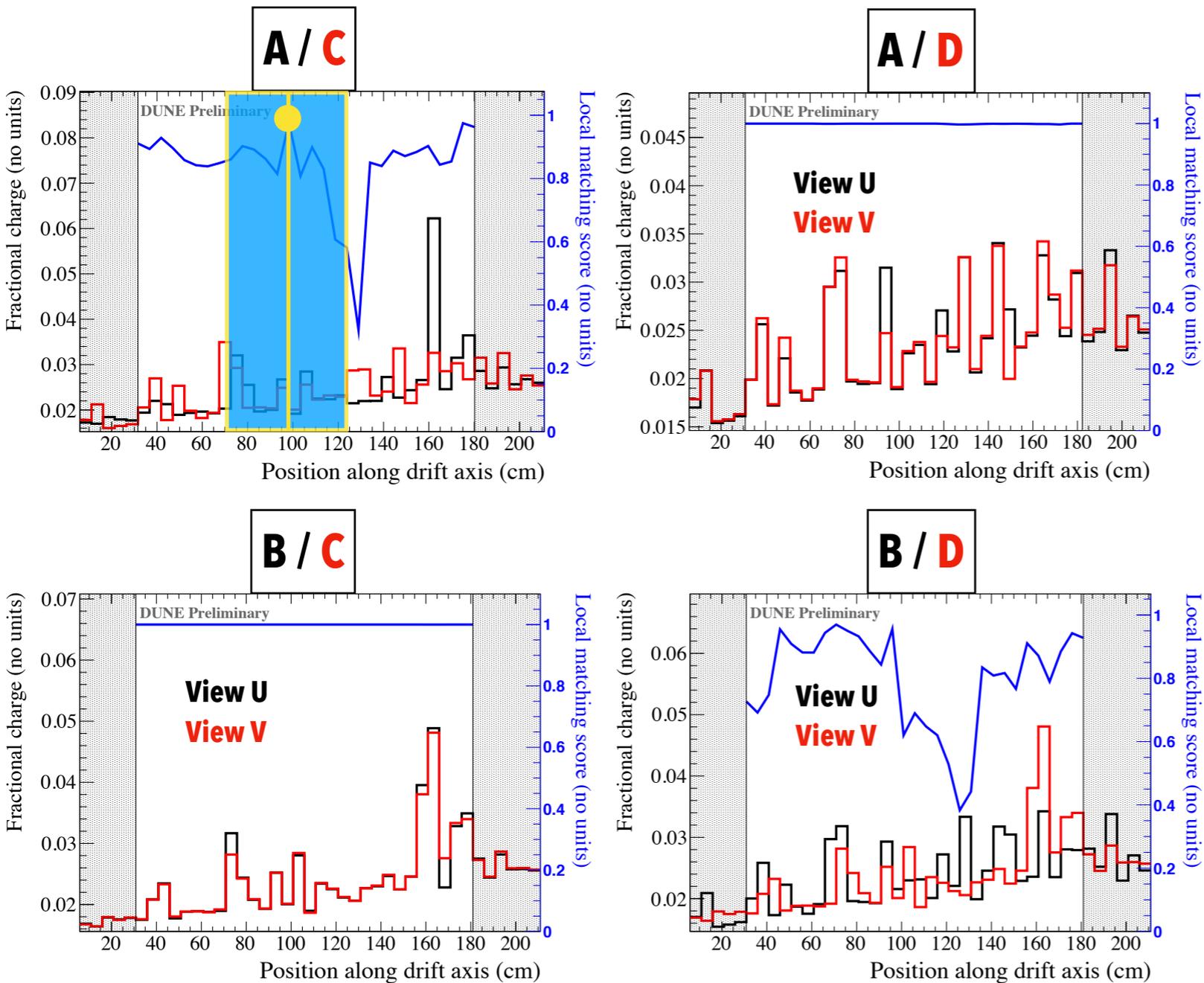
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Compare the fractional charge profiles

- Local correlations calculated for every 11 bin wide subsamples of the profiles
- Results are associated to the center of each subsample

# View-matching with calorimetric information



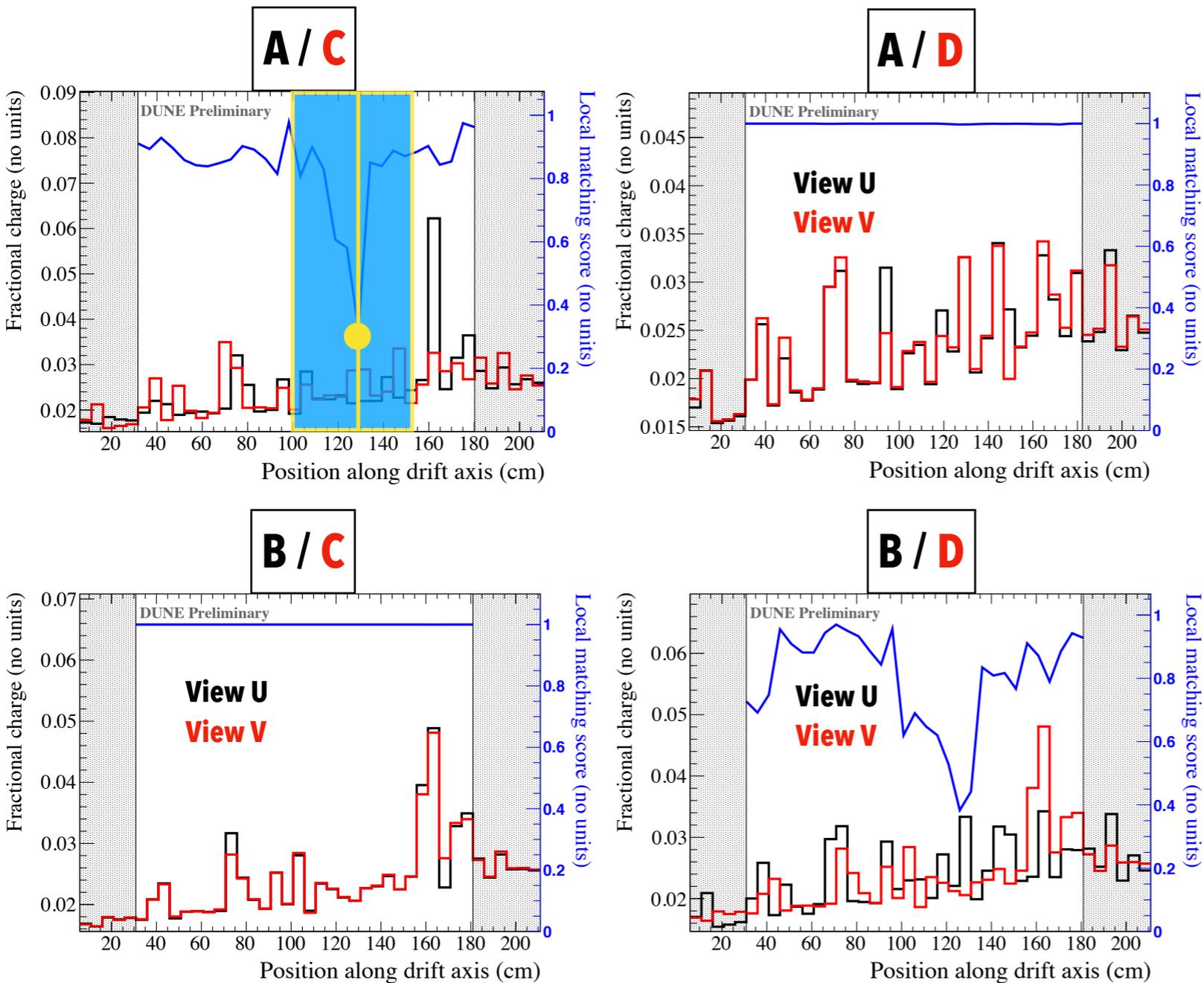
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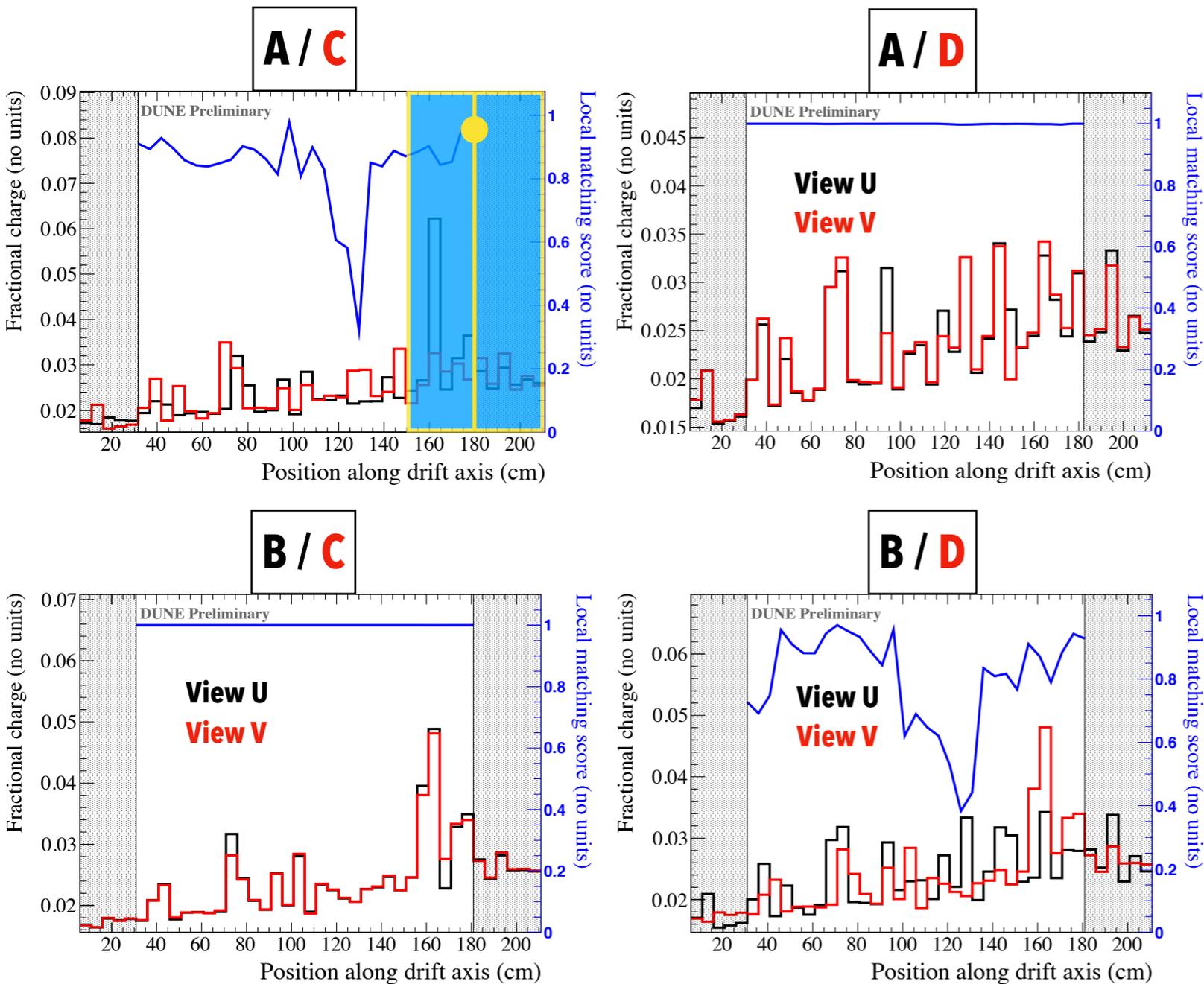
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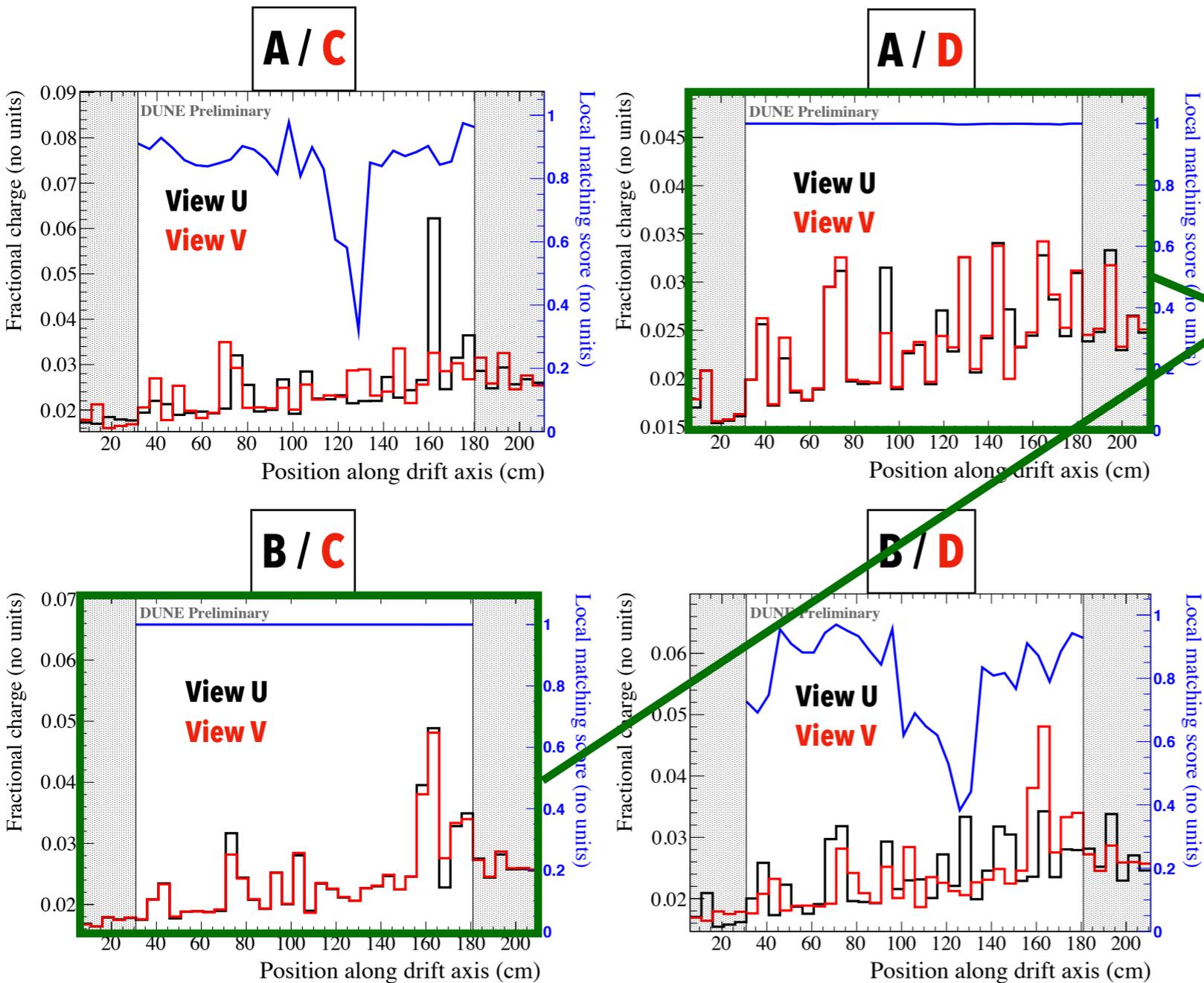
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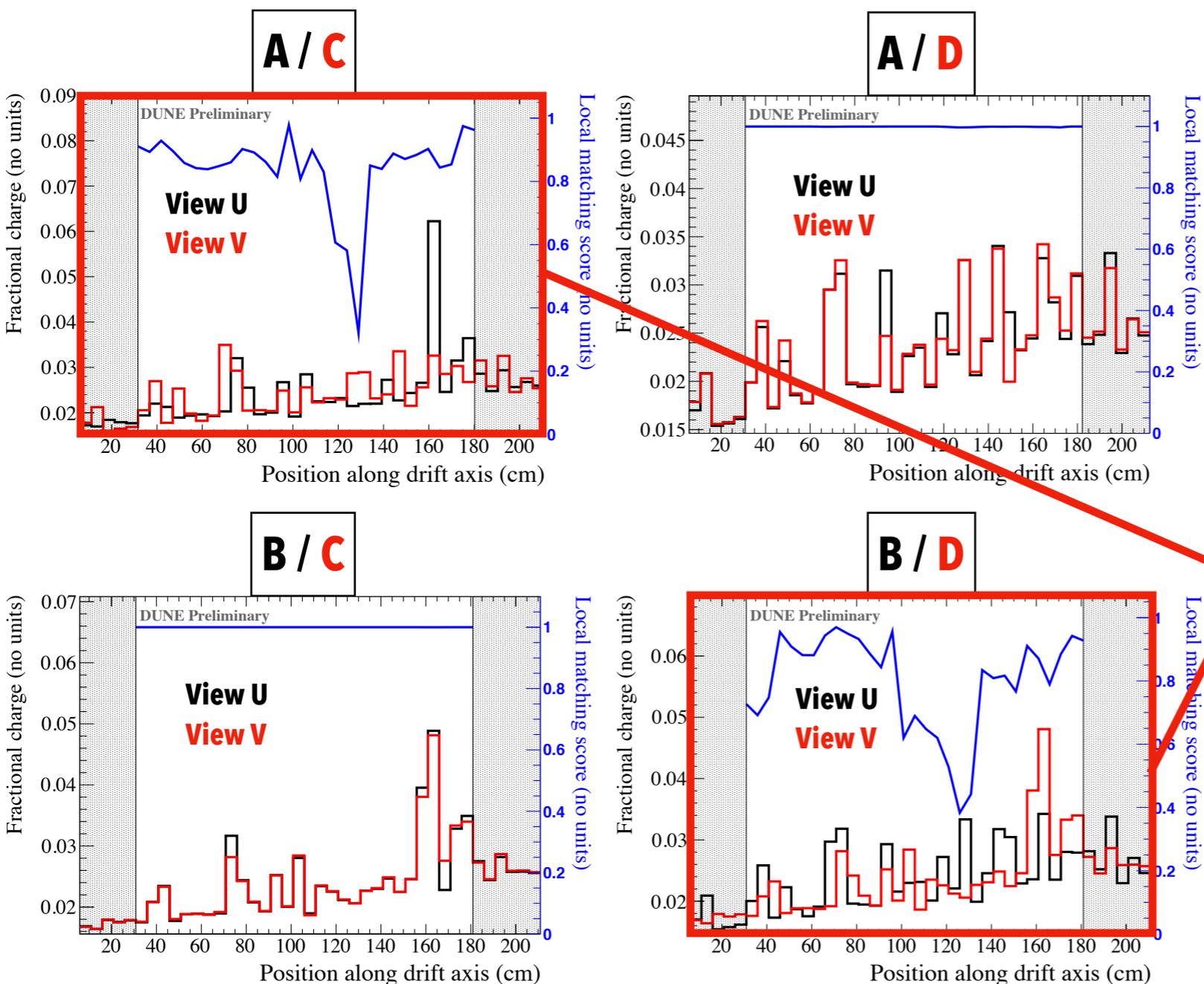


**Blue curves are made of all the local correlations:**

**● If correlated, score is very close to 1**

**● If uncorrelated, score can be anything between 0 and 1 (uniformly)**

# View-matching with calorimetric information

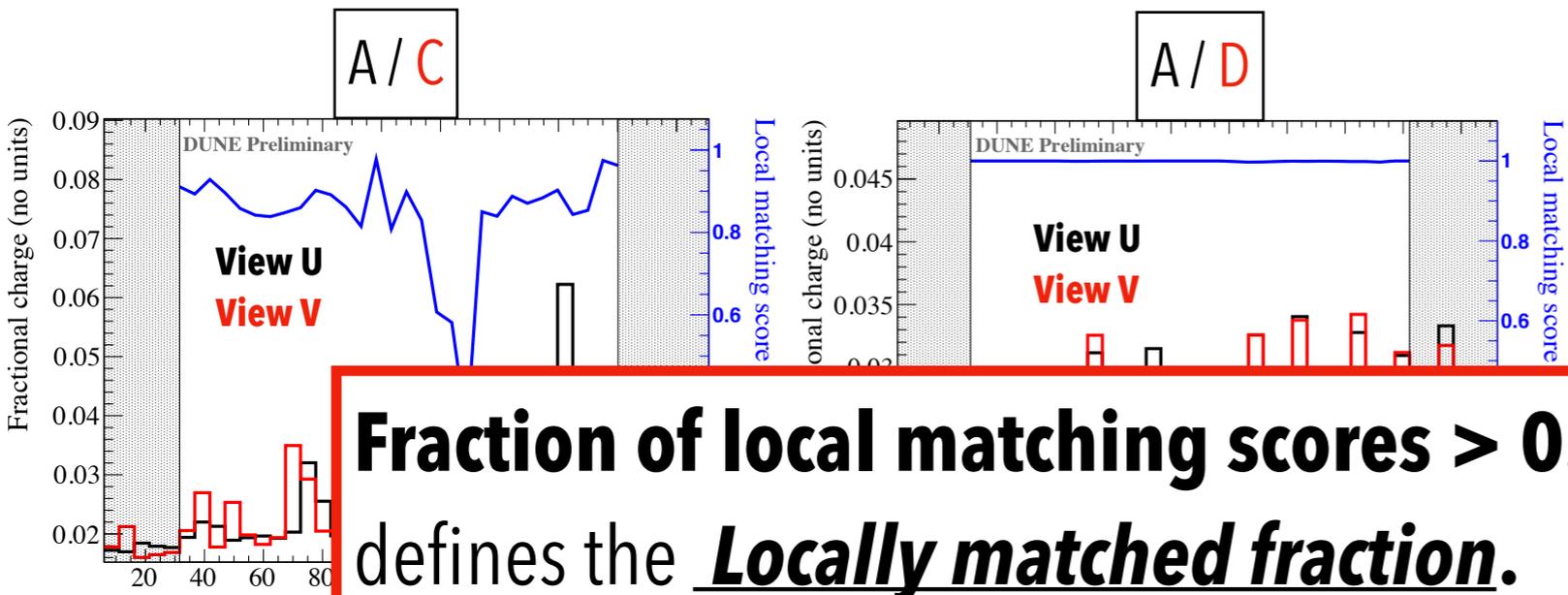


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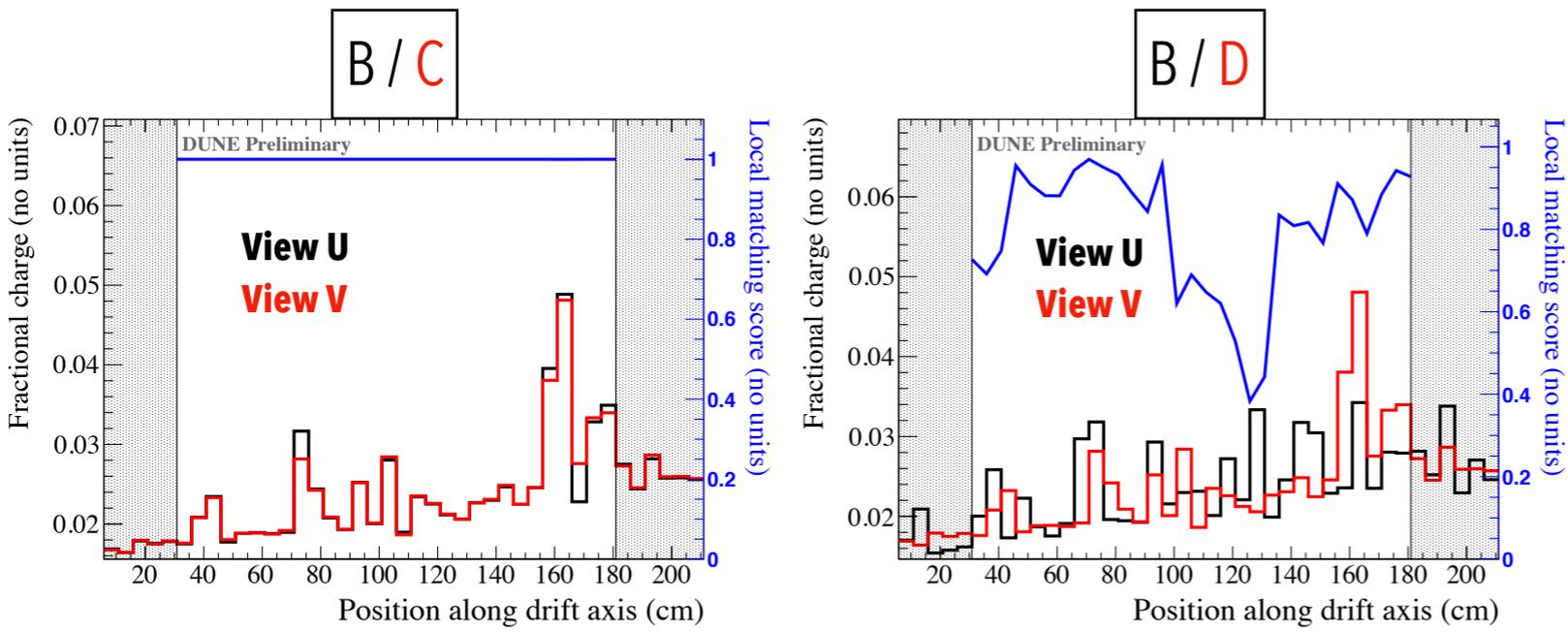
# View-matching with calorimetric information



**Fraction of local matching scores  $> 0.99$  defines the *Locally matched fraction*.**

Blue curves are made of all the local correlations:  
related, score is very close

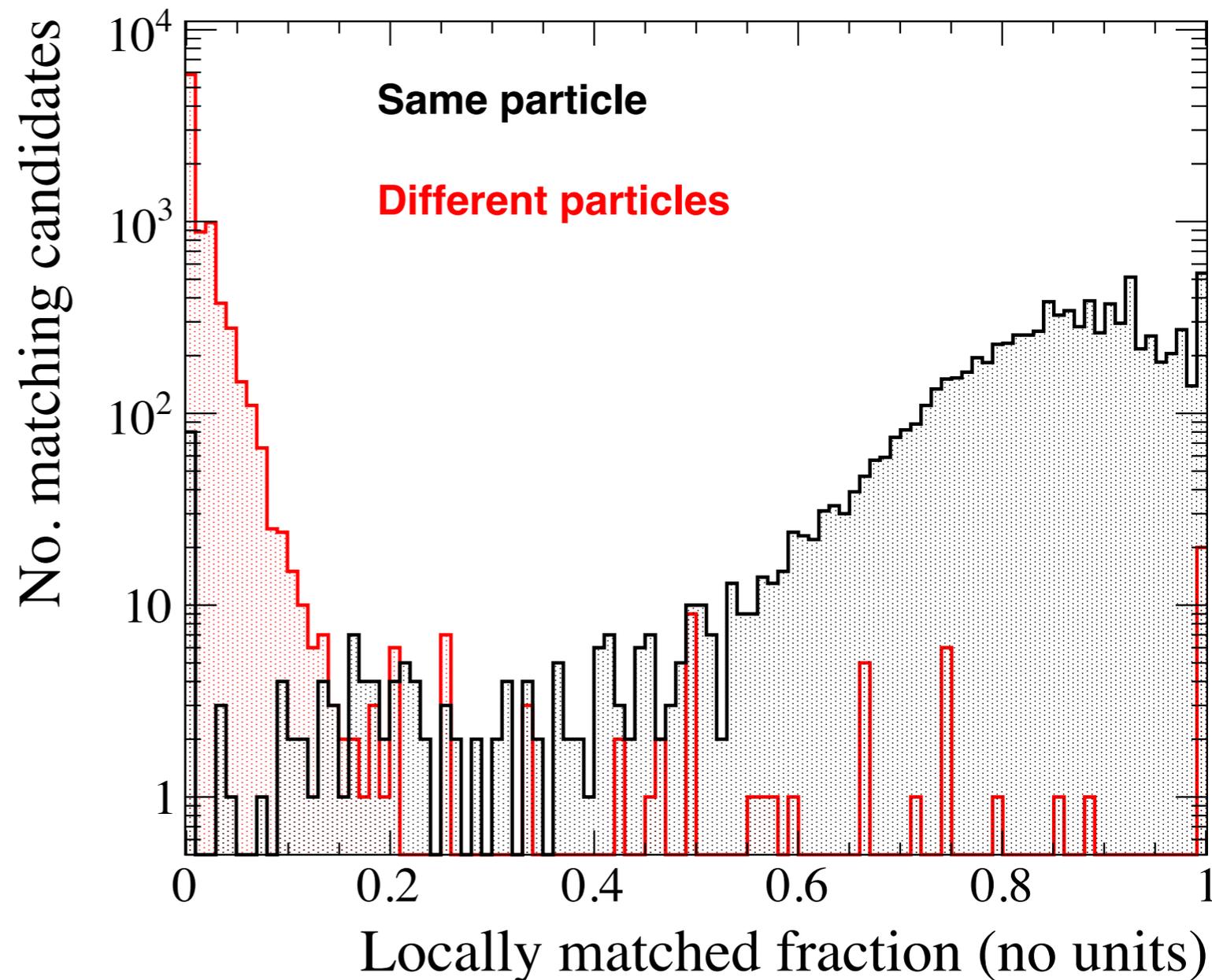
- If uncorrelated, score can be anything between 0 and 1 (uniformly)



# View-matching with calorimetric information

Here is a performance plot showing the **distributions of Locally matched fraction** when comparing clusters from the **Same particle (in black)** and **Different particles (in red)**.

**View-matching is done when Locally matched fraction  $> 0.5$**



# On-going/next steps

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The exact same idea is under study for showers and has already shown improvements in the reconstruction performances.

Tools using the calorimetric information are currently being developed targeting two specific situations :

- Two particles reconstructed as one
- One particle reconstructed as two (or more)

Goal is to incorporate calorimetric matching algorithm as part of the 3-view event reconstruction chain.

**BACK UP**

# 3D reconstruction in DUNE

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## Standard event reconstruction:

- Clustering hits
- Matching clusters from different views (3D track/shower creation)
- Vertexing
- Particle hierarchy

## Deep learning approach (on-going development):

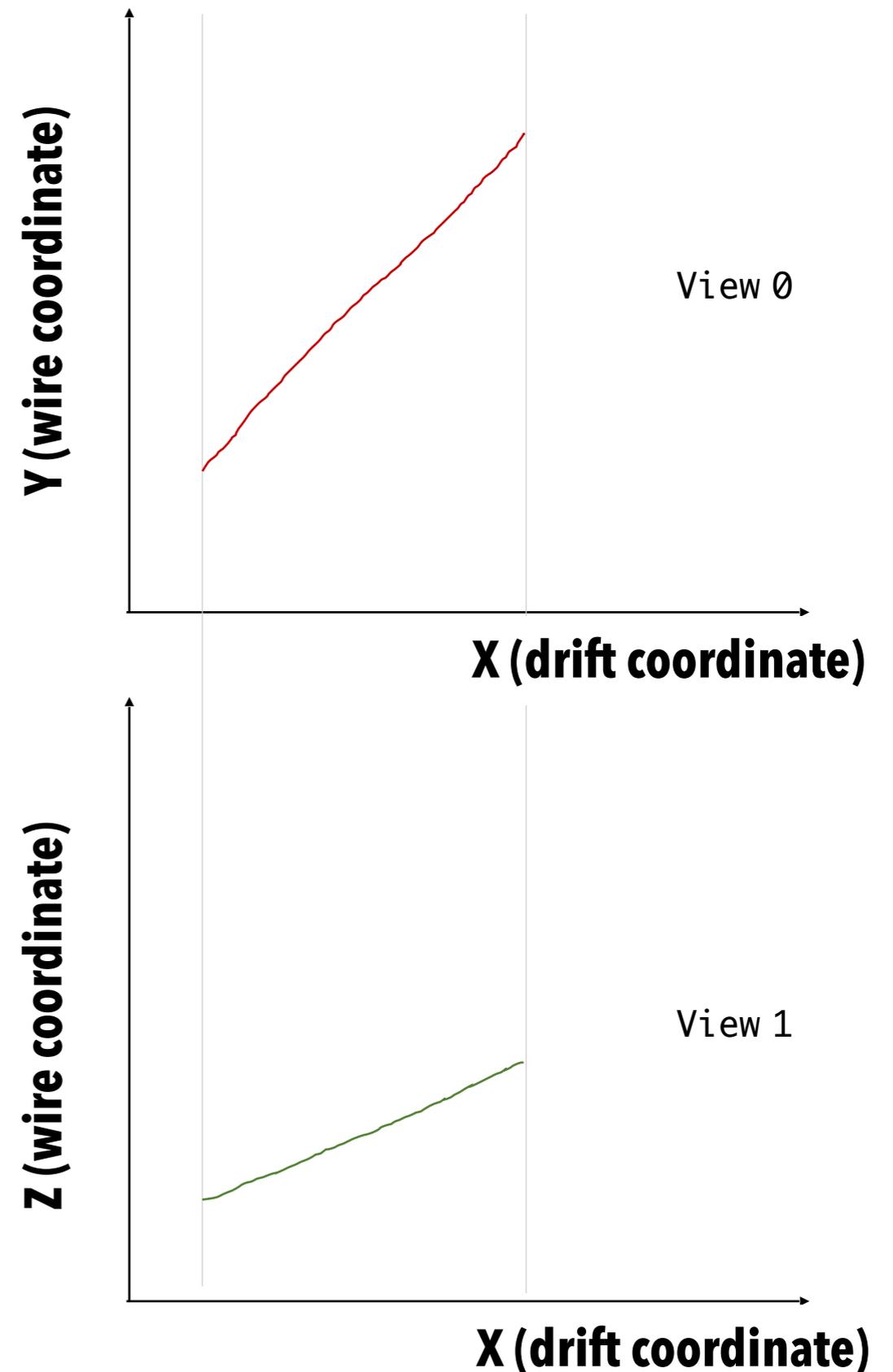
- 3D pixel map from hits of all views
- Direction of the neutrino
- Vertexing

# **Tools for calorimetric matching**

# Tools for ProtoDUNE-DP cosmic reconstruction

- **Clear tracks tool**

Performs **matching**  
**in non-ambiguous**  
**cases** (Only two clusters  
overlapping in a given X  
region)

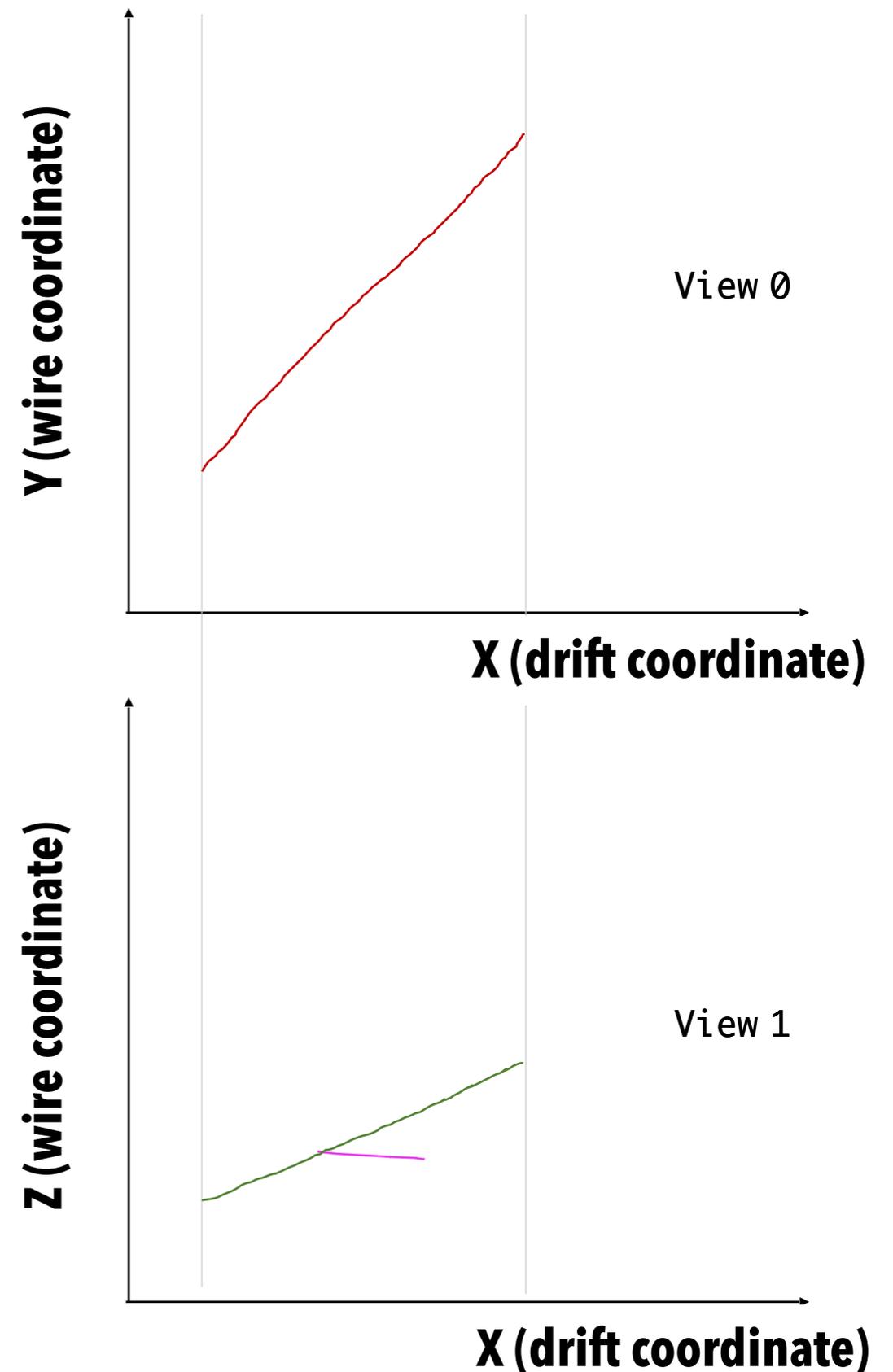


# Tools for ProtoDUNE-DP cosmic reconstruction

- **Long tracks tool**

Performs **matching in cases of obvious ambiguities**

(one long candidate with larger number of matched points than others)



# Tools for ProtoDUNE-DP cosmic reconstruction

- **Simple tracks tool**

**Ranks all remaining candidate matches**, and picks best one according to the following conditions:

- **Locally matched fraction**

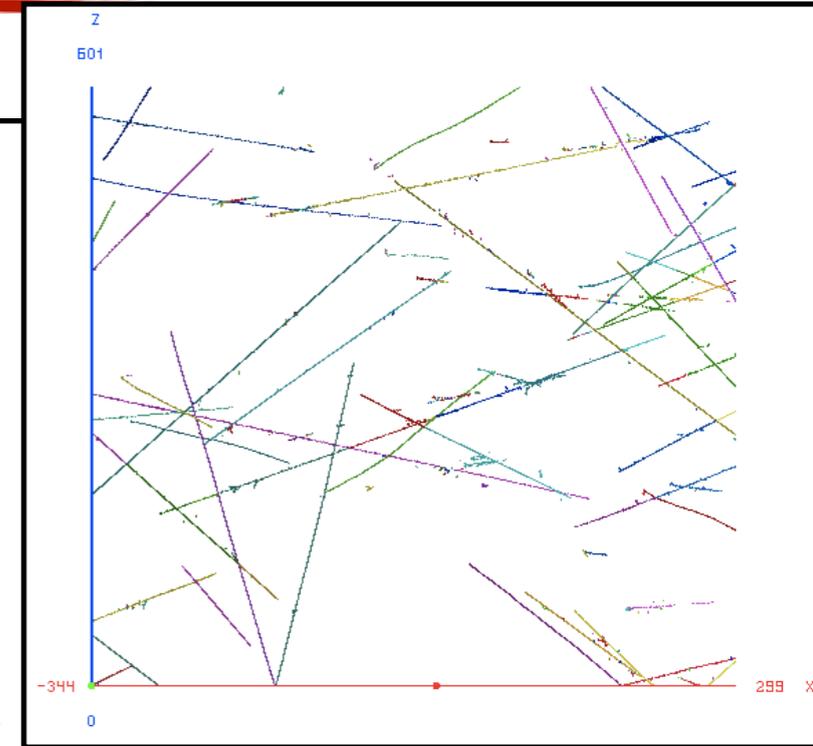
(the fraction of local matching scores above a threshold)

- **Matching score**

(calculated as the local matching score, over whole overlap region)

- **Number of matched points**

(the number of local matching scores above a threshold)

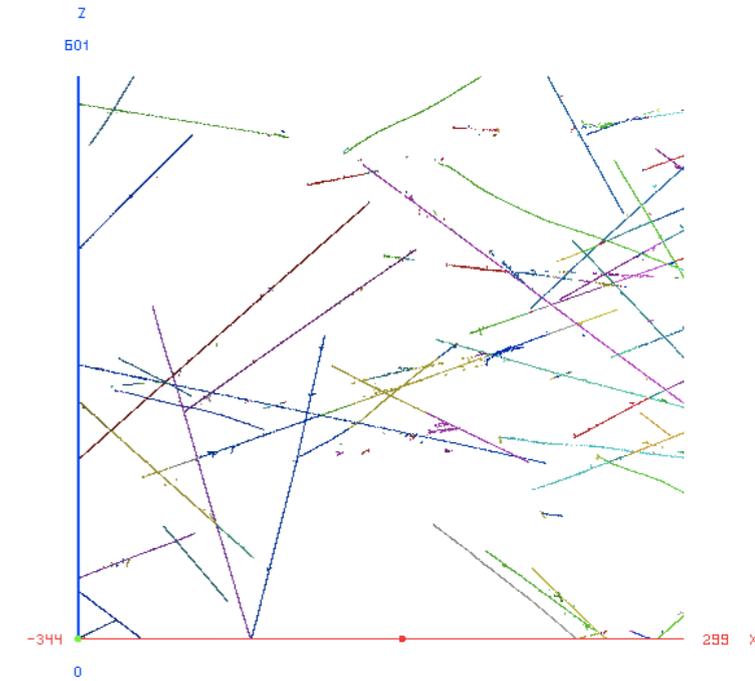


# **Some numbers**

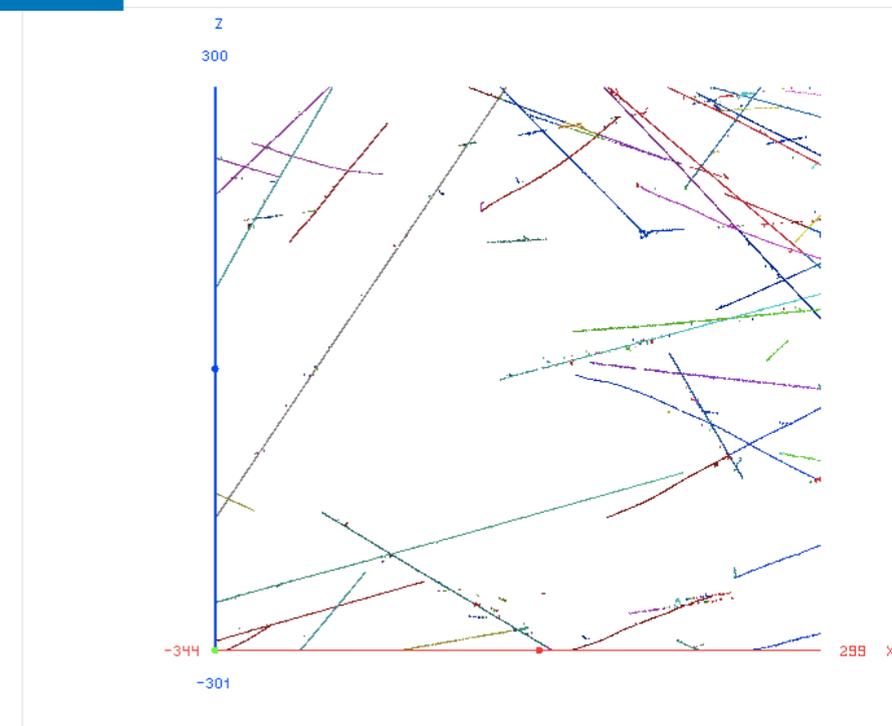
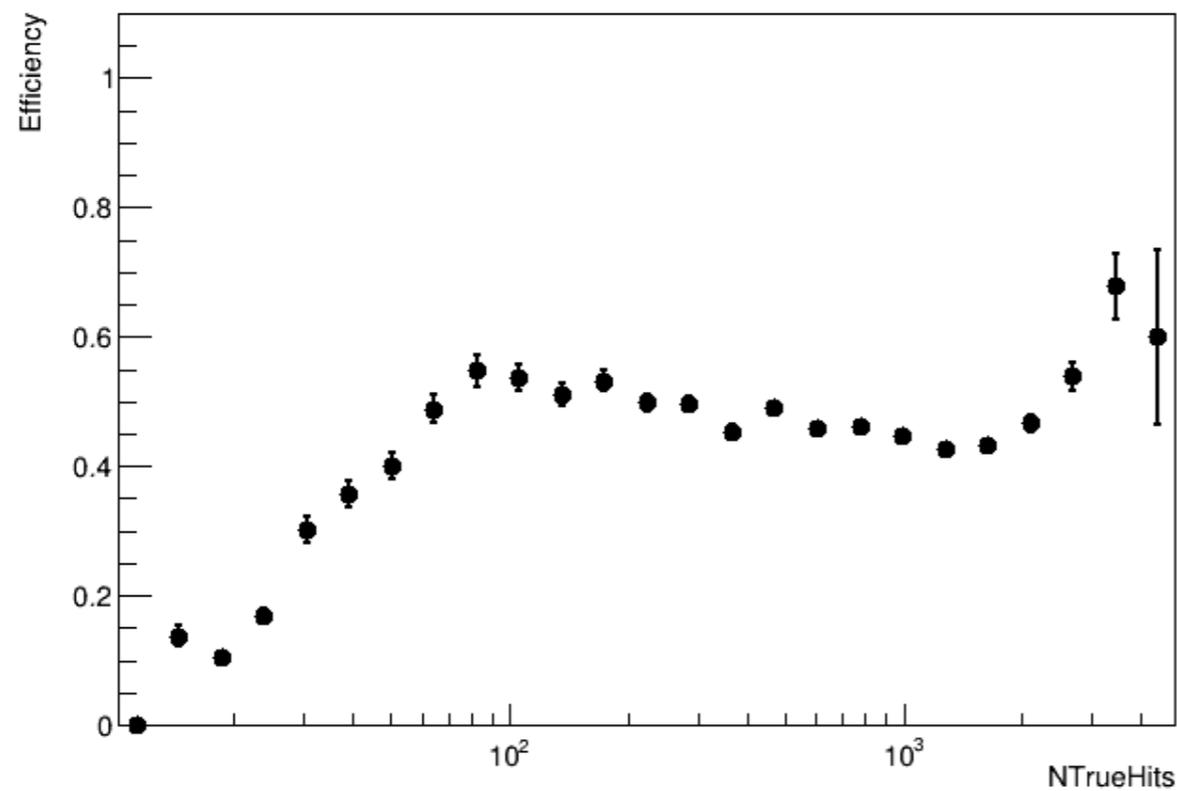
# Performances

● Pandora starting point

46%



Efficiency vs NTrueHits

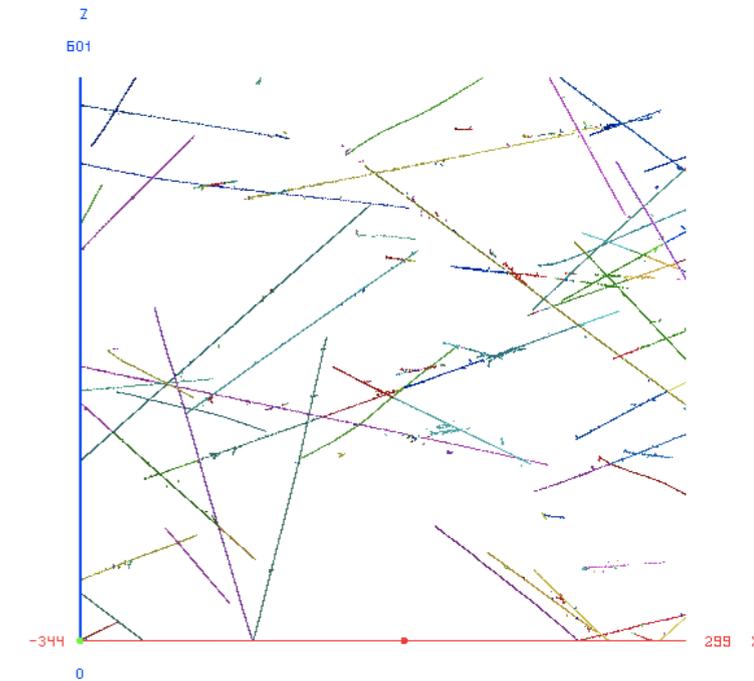


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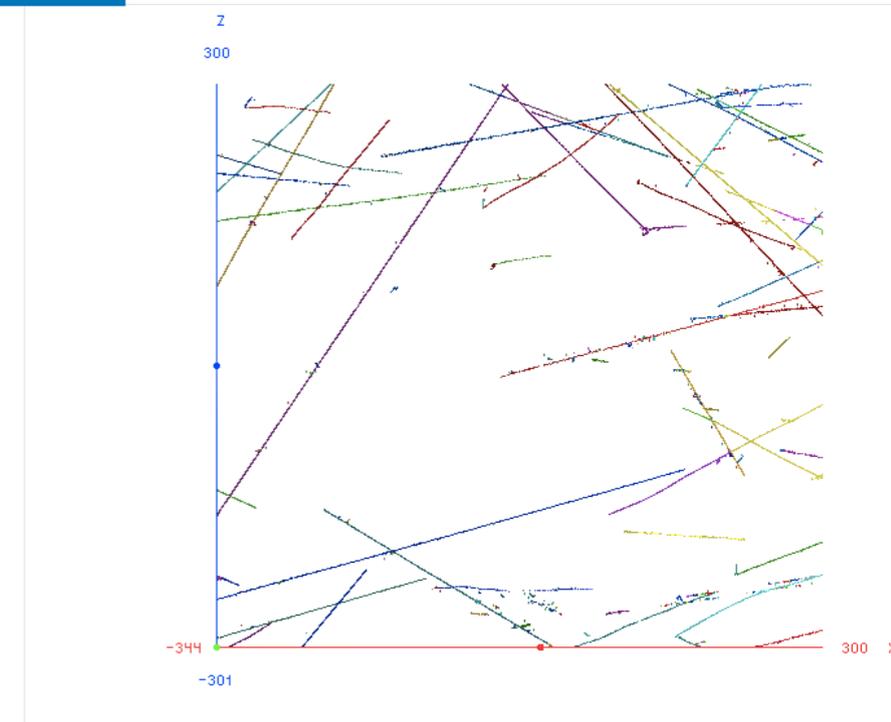
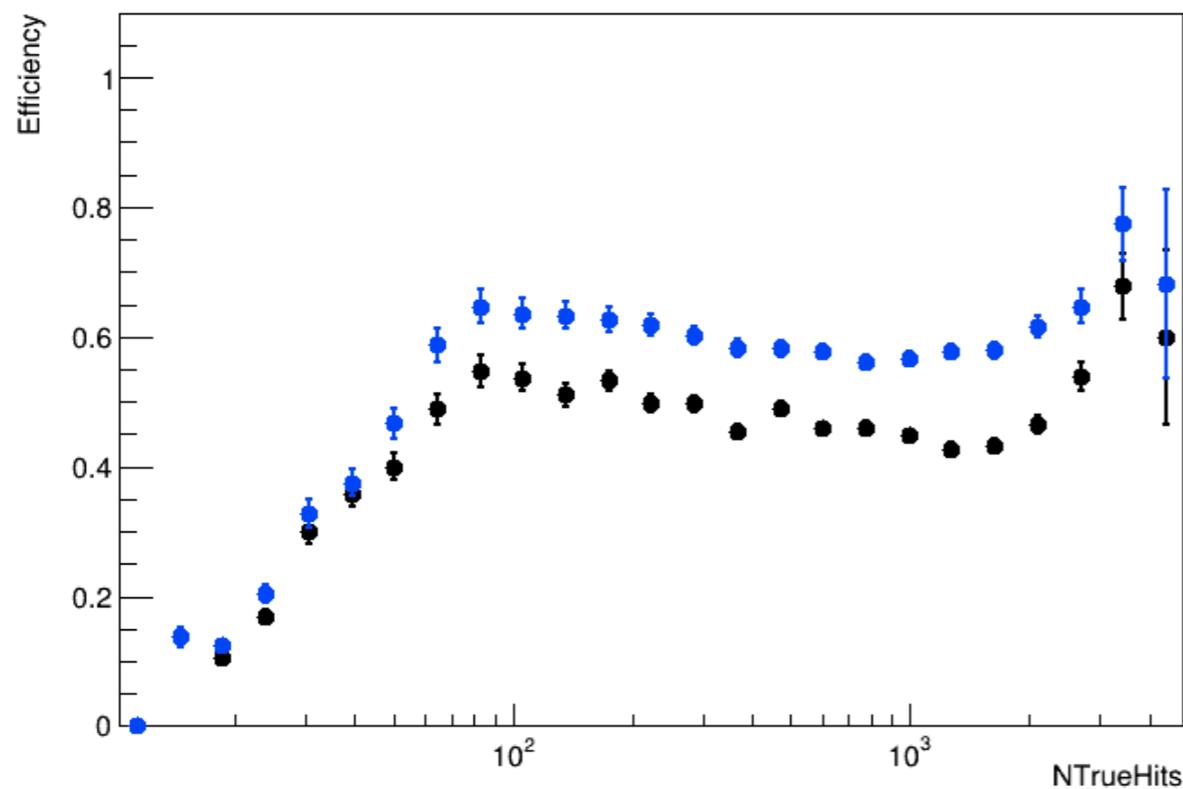
- Pandora starting point
- **Adding HitWidth + Two-view matching (only ClearTrack tool)**

46%

**57%**



Efficiency vs NTrueHits



# Performances

- Pandora starting point 46%
- Adding HitWidth + Two-view matching (only ClearTrack tool) 57%
- **Adding LongTrack and SimpleTrack tools 76%**

