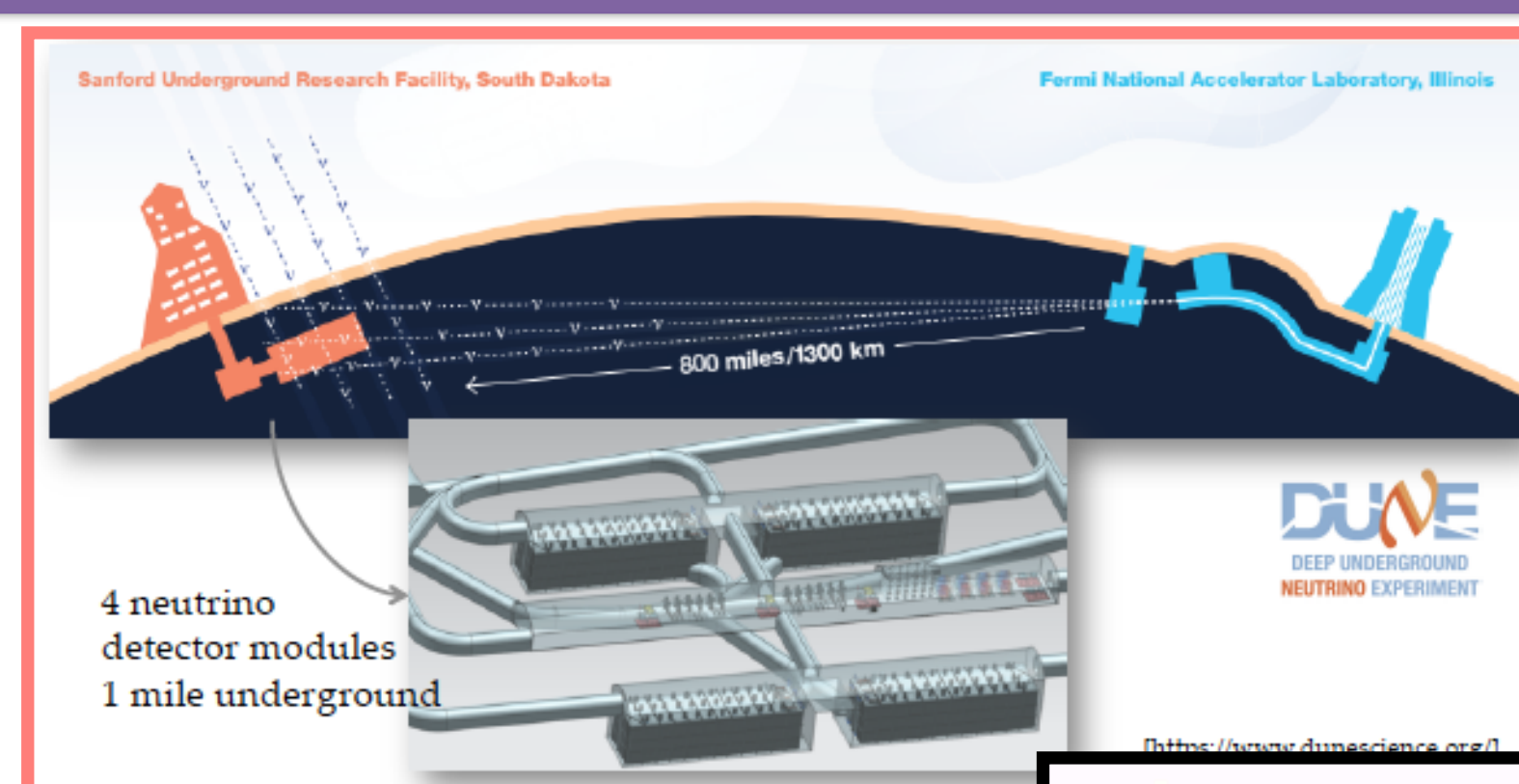


Real-time Data Processing for high-rate 3D Particle Imaging

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on behalf of MicroBooNE, SBND, and DUNE collaborations

Data Processing Requirement for 3D Imaging Detectors

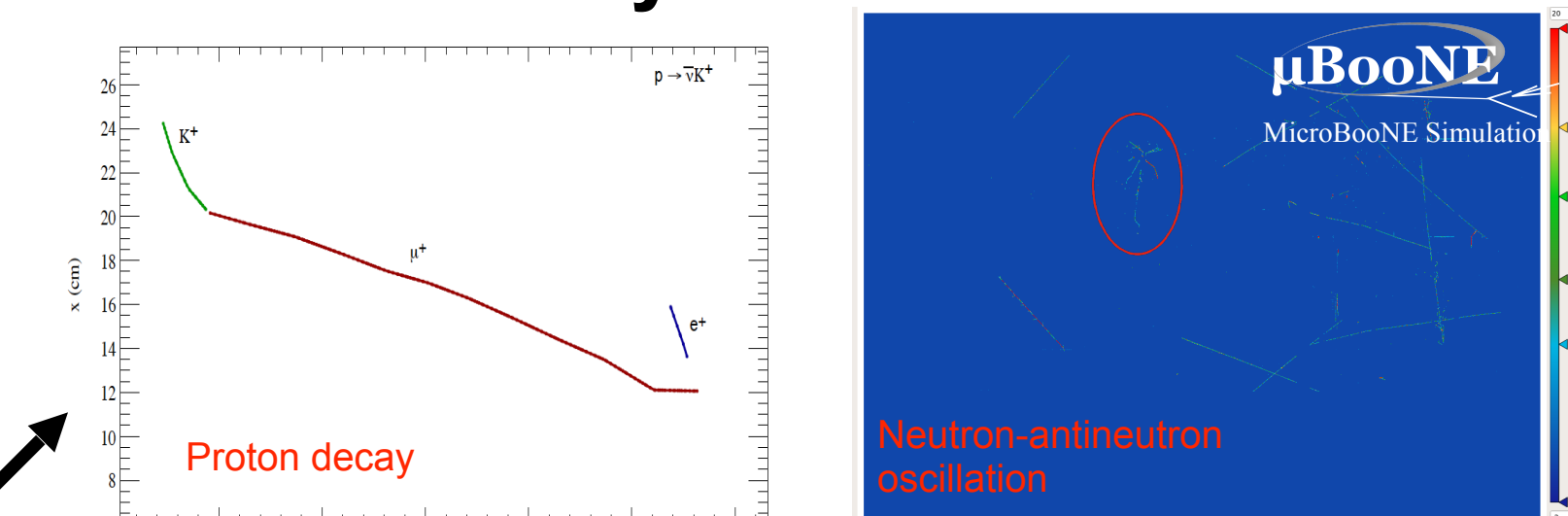
Deep Underground Neutrino Experiment (DUNE): World's largest neutrino detector, under construction
Gigantic **liquid argon time projection chamber (LArTPC)** far detector with millions of readout channels.



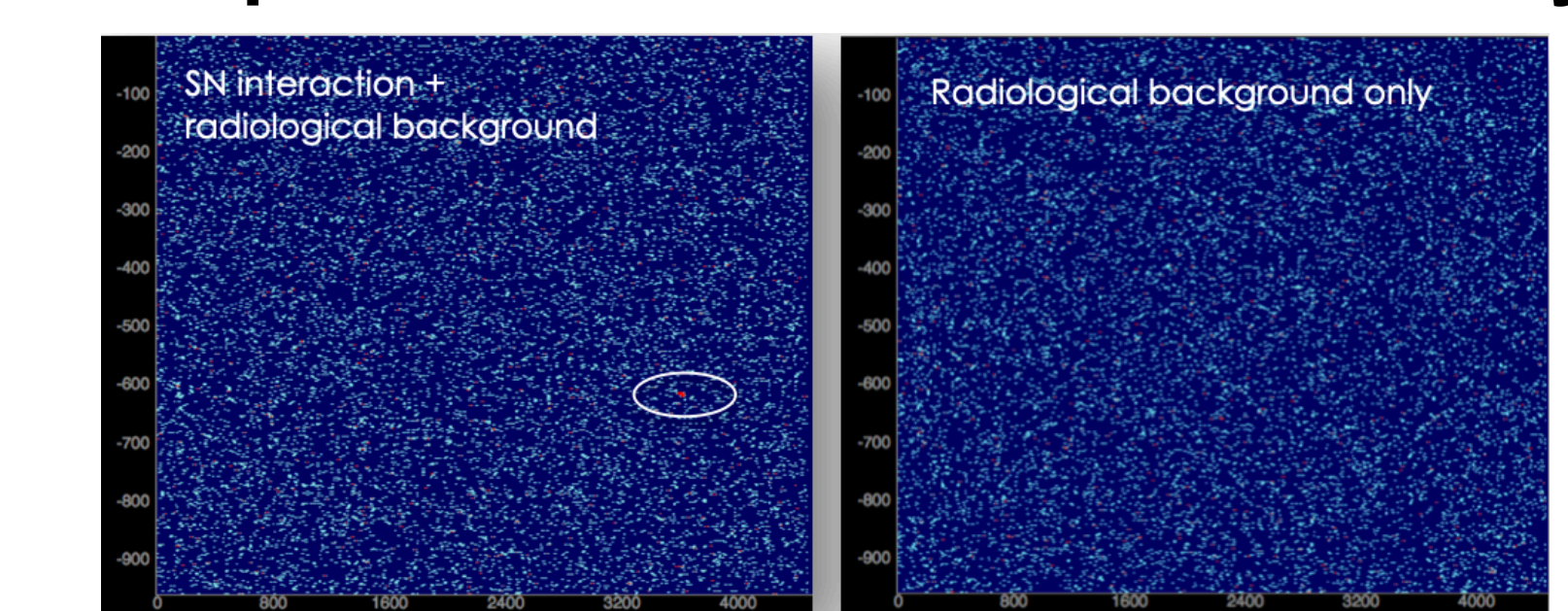
Signals from Neutrino events :
Use beam timing information

Signals from new interactions
(Physics beyond Standard Model)
unpredictable signals
rare and faint signals

baryon number violation processes:
<1 interaction/year



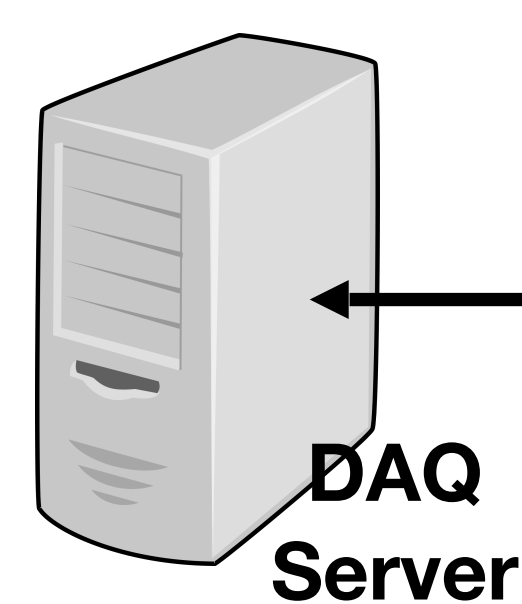
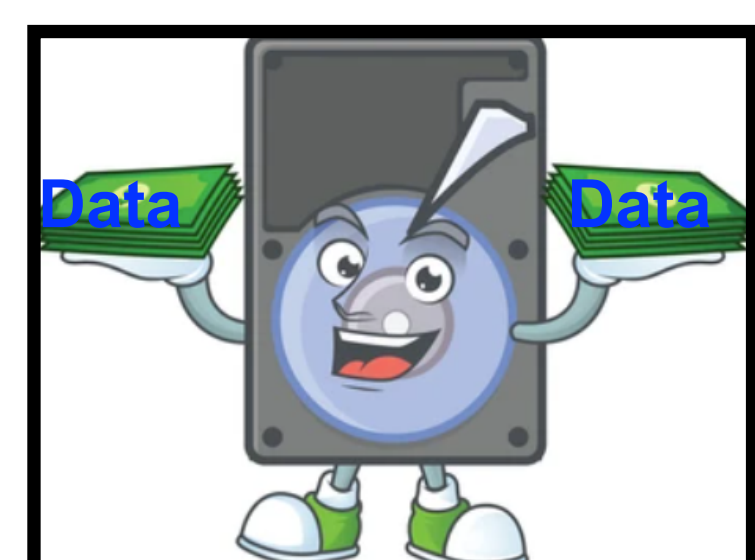
very low energetic neutrinos from
supernova bursts : once in a century



Three different 2D
projected views of
3D interaction
volume

Charge collected by wires & light collected by light collection system produces 3D images of particle interactions

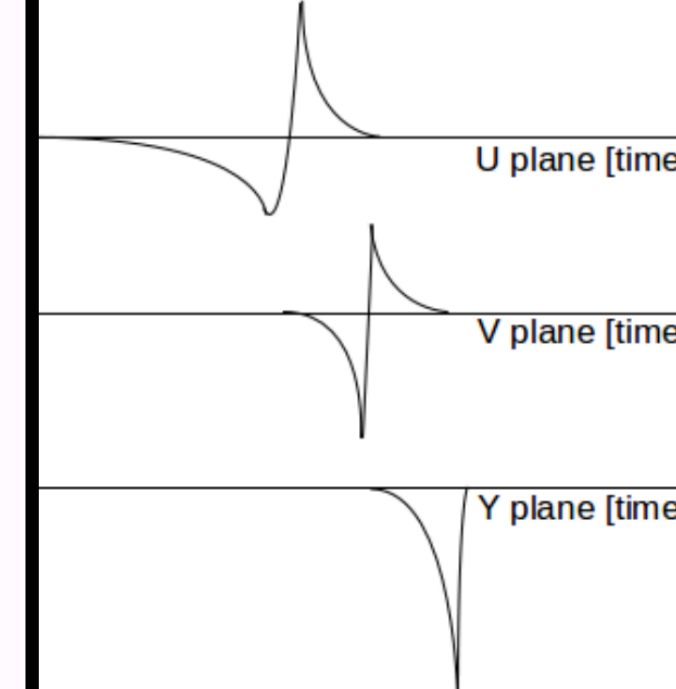
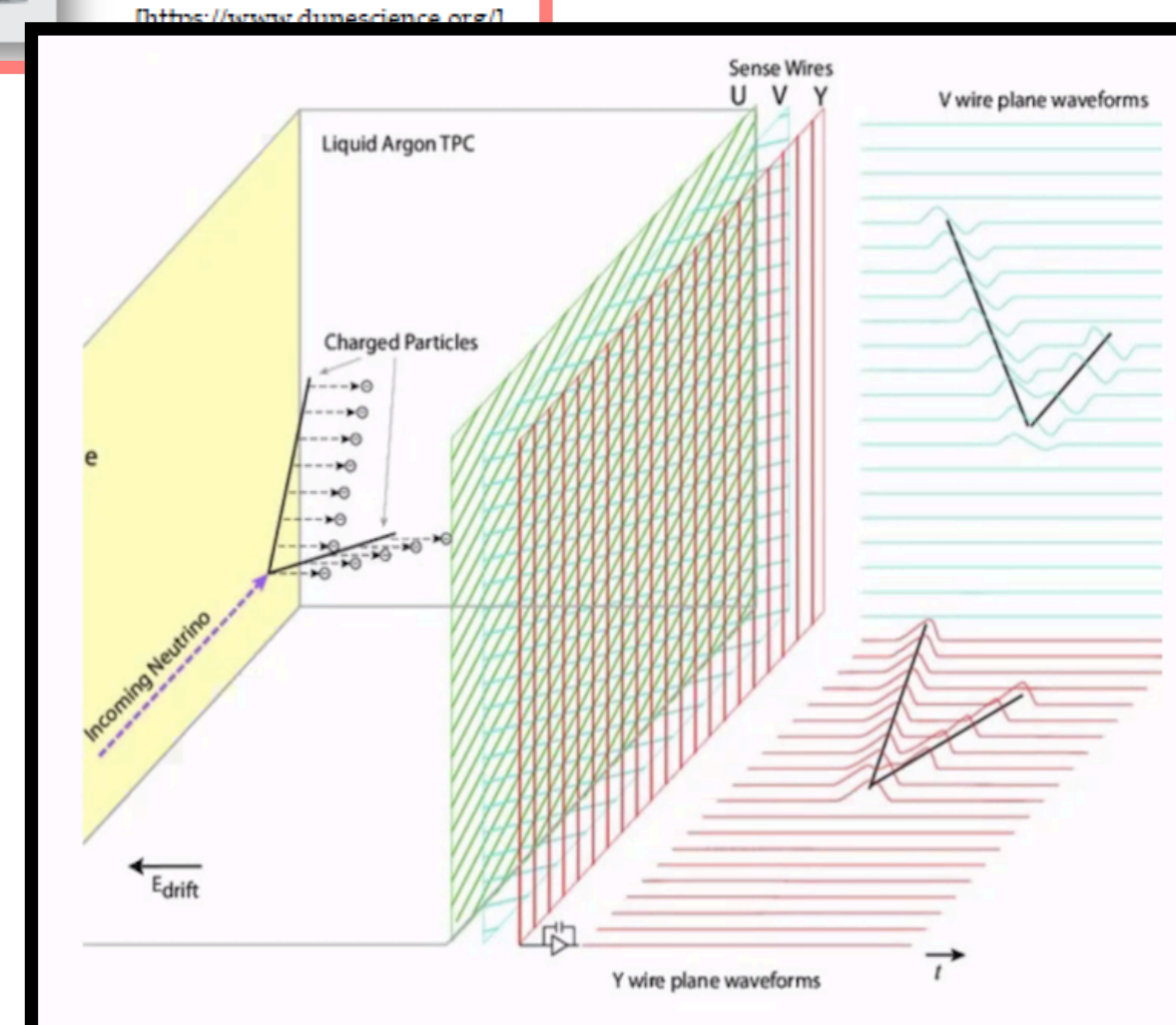
Disk requirements:
30 PB/year



100% live time, continuous
data for a decade (5 TB/s)

Data reduction

Require intelligent data-selection techniques to preserve rare signals & to meet disk requirements.



Data Selection Strategy

Real-time data selection strategy:
Goal is to have quick decision (1-2 s)

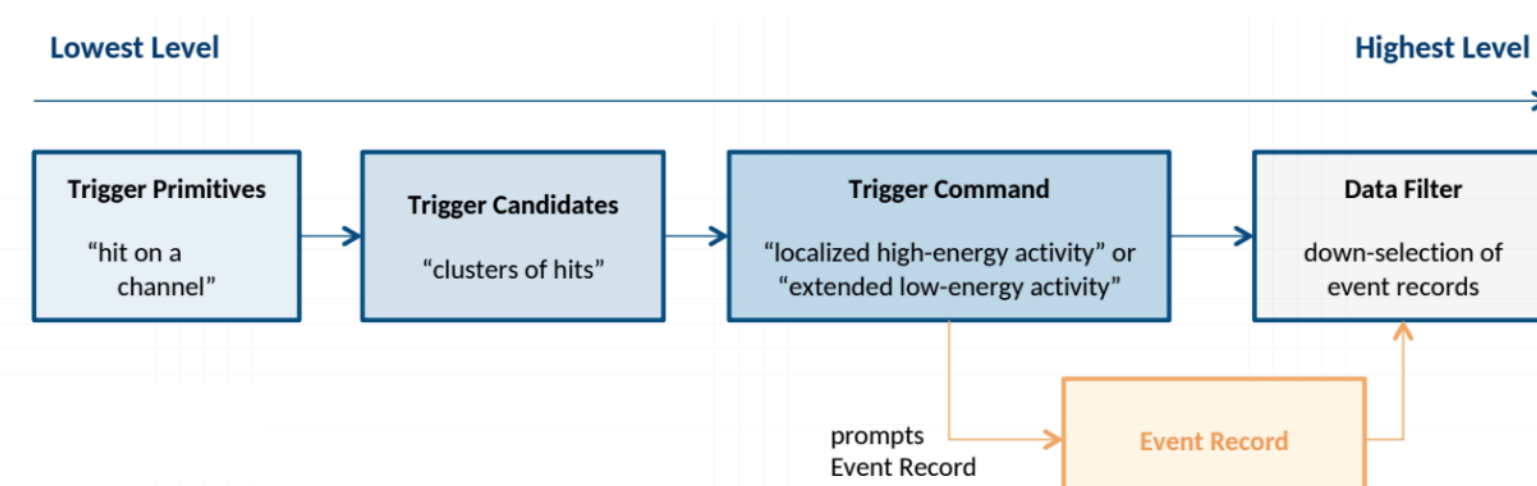
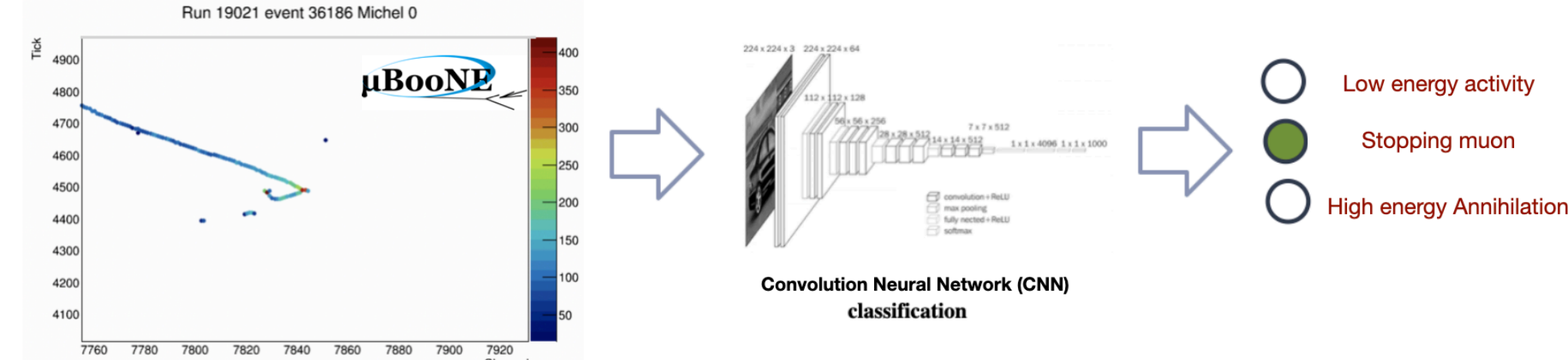


Figure 2. DUNE Trigger Strategy (1).

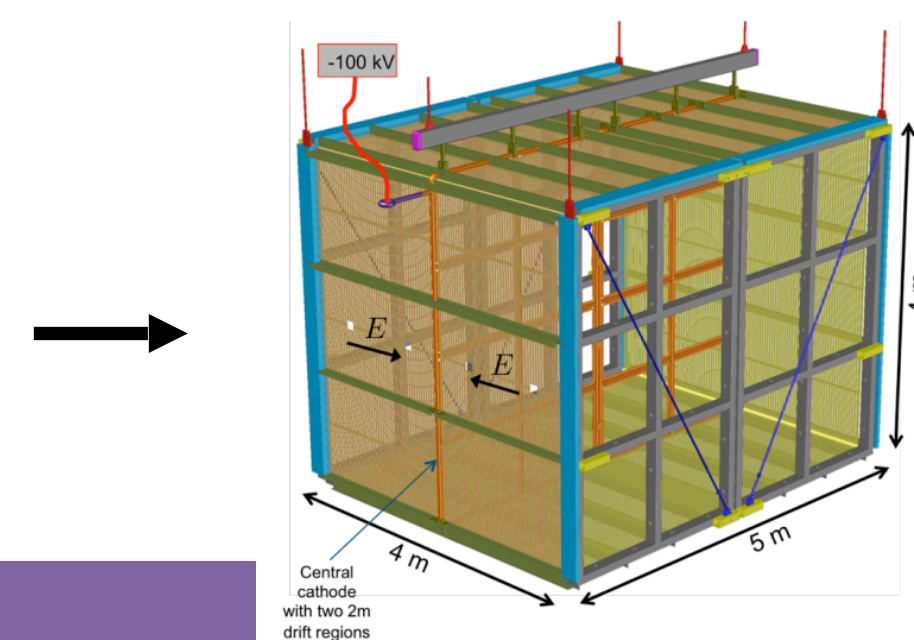
Demonstration is taking place in ProtoDUNE, CERN

Future Prospects

Utilize machine learning tools

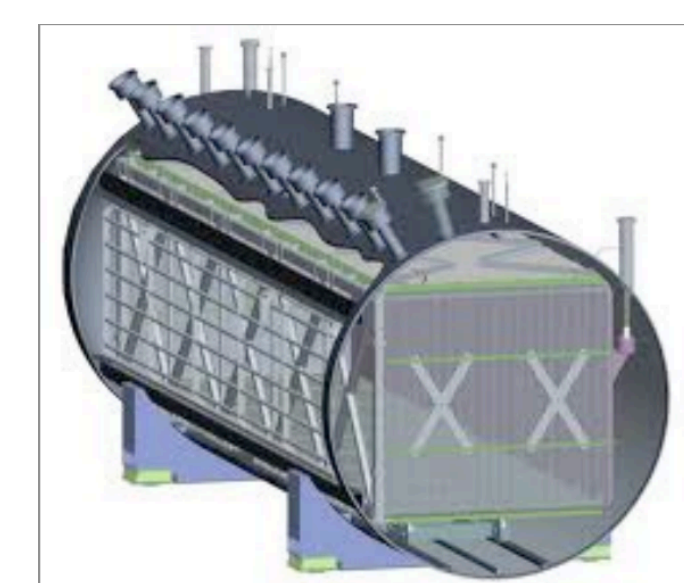


Demonstrate real-time data selection strategies in Short-Baseline Neutrino Detector (SBND) as readout scheme is similar to MicroBooNE.



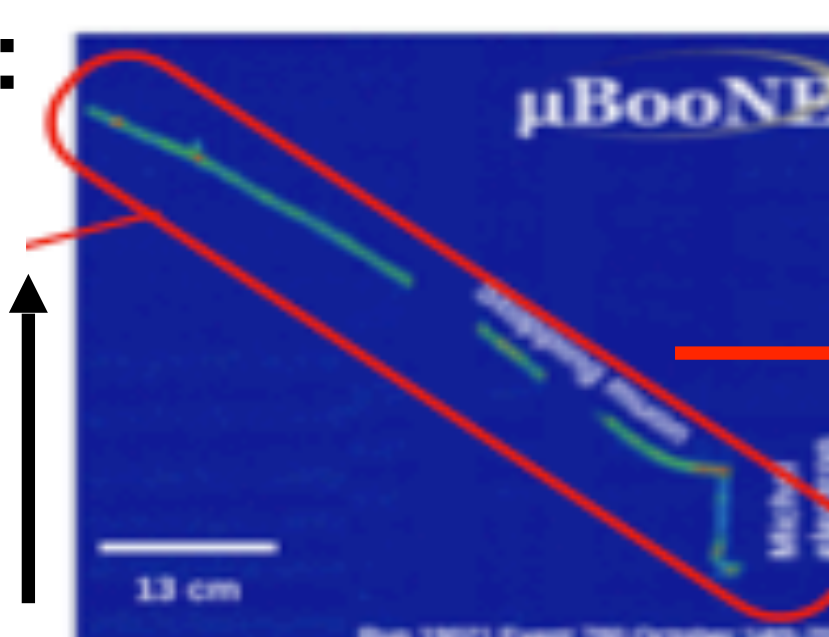
Demonstration with current MicroBooNE Experiment

MicroBoosterNeutrino (MicroBooNE):
LArTPC detector, x500 smaller than DUNE.



3D interaction volume
produces stereoscopic
images

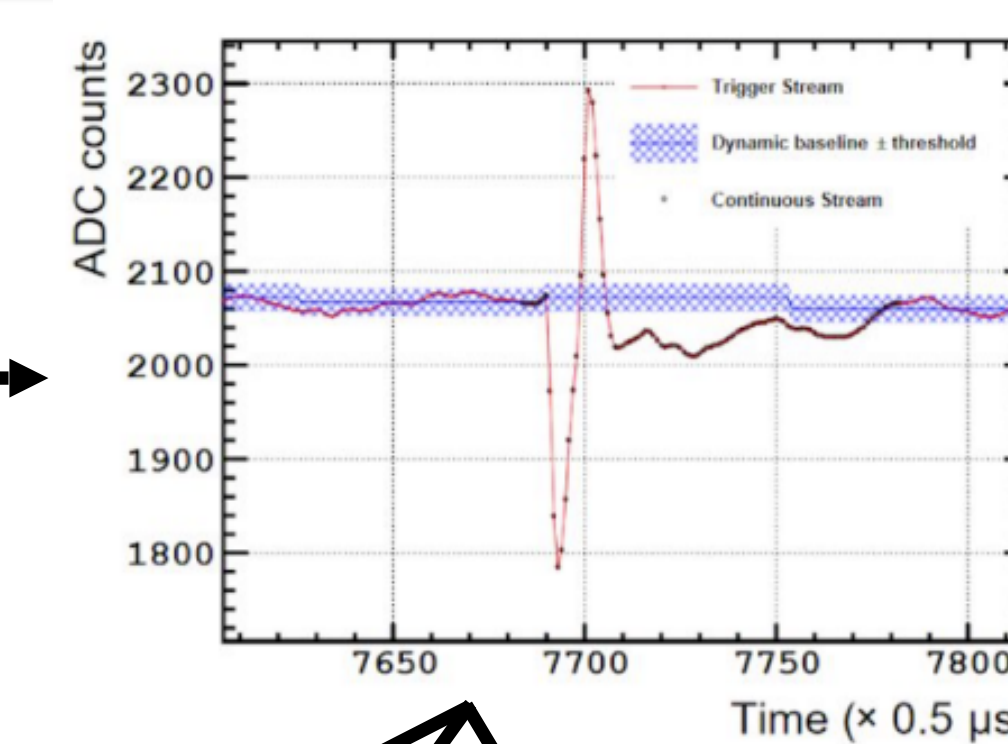
time



"hit" per
channel

channel

Figure 3. An example of generating Regions of Interest (ROIs).



Rate of rare signals in MicroBooNE is very low.
Targeting **stopping muon event topology** making use of **topological** and **calorimetric** information.

Being implemented in DUNE.

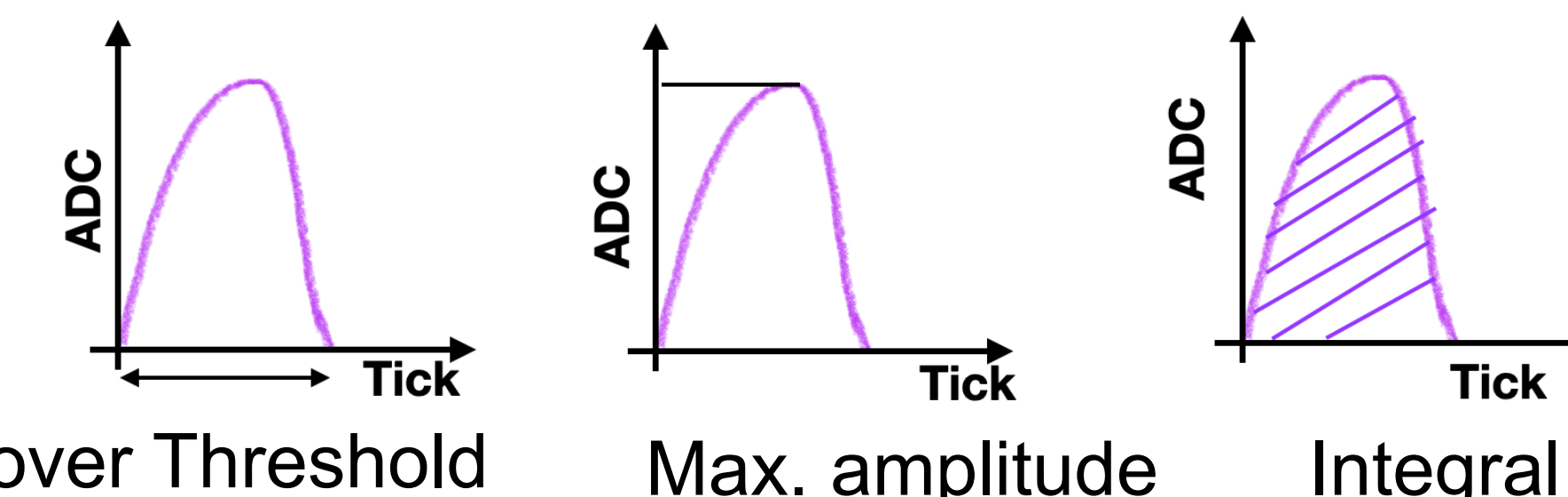


Figure 4. Cartoon display showing how the ROIs are summarized to generate trigger primitives.

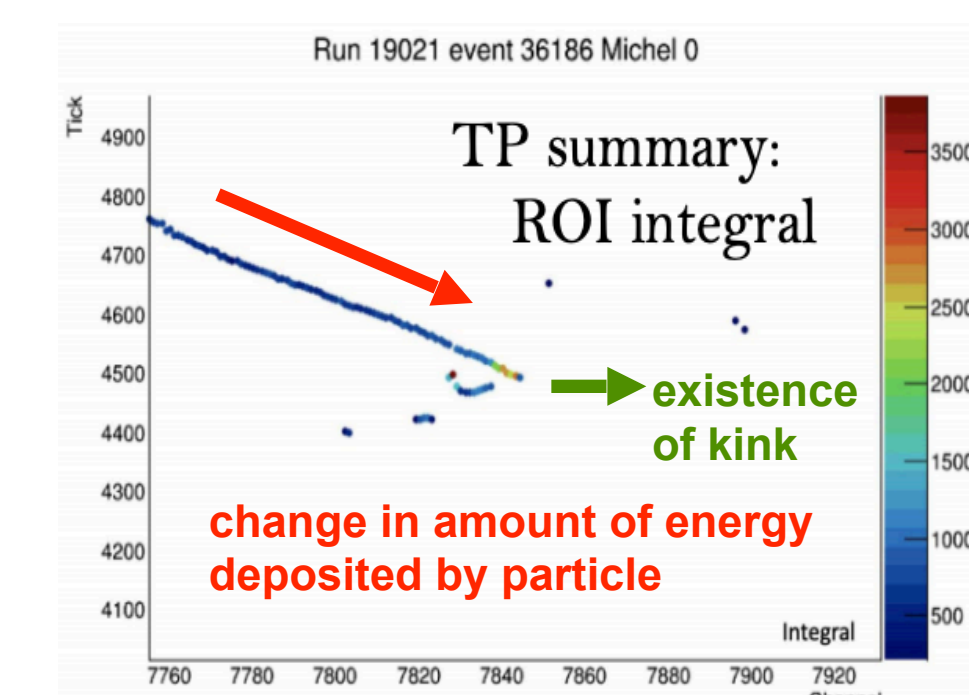


Figure 5: Stopping muon event topology in MicroBooNE (2)

Acknowledgements

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References

1. B. Abi et al. 2020 The DUNE far detector single-phase technology *JINST* **15** T08010.
2. P. Abratenko et al. 2021 The continuous readout stream of the MicroBooNE liquid argon time projection chamber for detection of supernova burst neutrinos *JINST* **16** P02008.

Conclusions

One of the first demonstrations with a real LArTPC for real-time data selection. Important proof-of-principle for upcoming SBND and future DUNE experiment.