INTENSE – ESR Meeting

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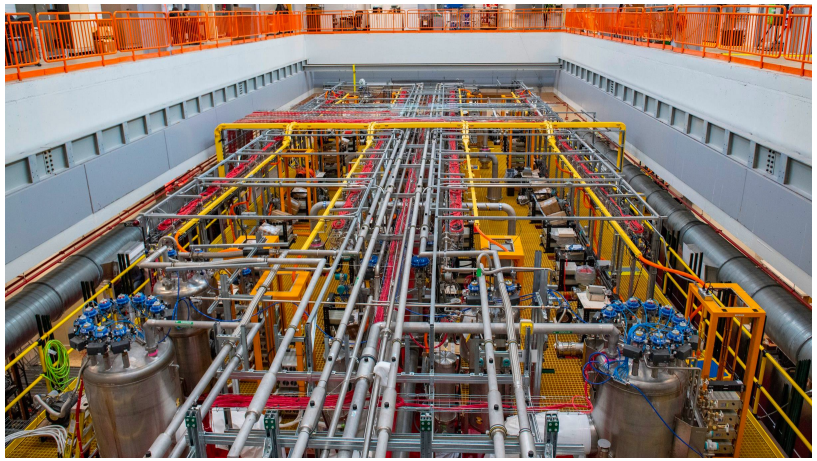
September 2022

SUPERVISOR: PROF. DANIELE GIBIN

800 1222·2022 ANNI
Università degli Studi di Padova
Dipartimento di Fisica e Astronomia Galileo Galilei
European Commission
Intense
H2020 MSCA ITN G.A. 858199

A little bit about myself…

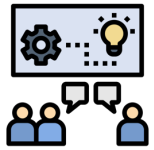
- I joined the ICARUS Neutrino Group based in Padova on January 2021
- Up to now my work has been mainly dedicated to the calibration of the ICARUS detector during its commissioning phase at FNAL



- ICARUS is a LArTPC and the far detector of the Short Baseline neutrino program
- Aims to definitive clarify the sterile neutrino puzzle

Courses

- Multimessenger Astroparticle Physics by A. De Angelis "*Neutrinos as Multimessenger particles*" March 2021
- Neutrino Physics by R. Brugnera, M. Lattanzi and S. Dusini "*Where are we with sterile neutrinos?*" June 2021
- Statistical Data Analysis by T. Dorigo, D. Bastieri and L. Stanco *"Statistical status on sterile neutrinos" July 2021*
- Standard Model & Flavour Physics by G. Simi and M. Tosi *"Test of lepton universality in beauty-quark decays" September 2021*
- *EU funding: opportunities for Research and Innovation and proposal writing by M. Schisani June 2022*



Workshops

- XIX International Workshop on Neutrino Telescopes held online during 18-26th February 2021, organized by INFN Padova
- Calibration Workshop: Ntuples Tutorial held remotely on 27th Sept–1st Oct 2021, organized by SBN Collaboration
- International Workshop on Cosmic-Ray Muography held in Ghent, Belgium during 24-26th November 2021, organized by Ghent University as part of the European Project INTENSE-Rise
- Workshop "Summer Students at Fermilab and other US Laboratories", held in Pisa during 18-21st July 2022, as part of the INTENSE training

Actively involved in the ICARUS Analysis working groups where I periodically report the status of my progress

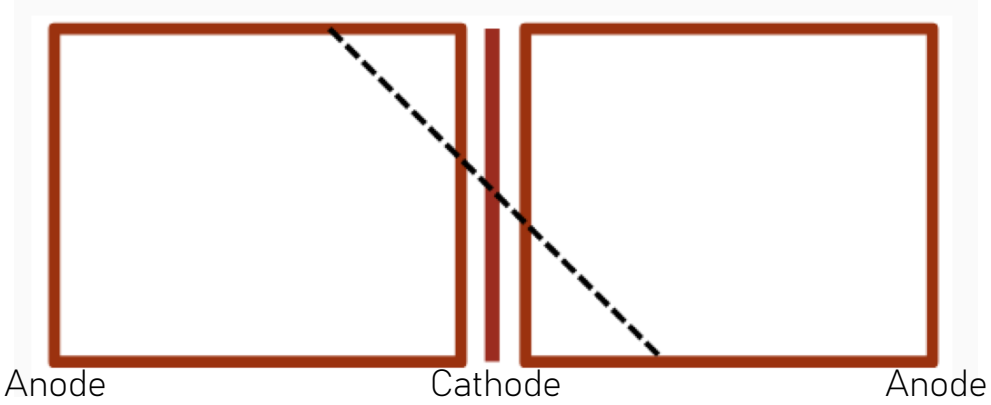
Trainings

- *Neutrino Summer Lecture Series held online during June/July 2021 and organized by Fermilab*
- *Fermilab 2021 Summer Student School at INFN Laboratori Nazionali di Frascati, online attendance during 2-4th August 2021*
- *FNAL C++ Software School held remotely during August/September 2021*
- *INFN School Of Underground Physics: Theory & Experiment, at LNGS, Gran Sasso during 20-24th June 2022*
- *Tri-Institute Summer School on Elementary Particles, at TRIUMF, Vancouver during 4-15th July 2022*

- *Research stay at Fermilab, at Batavia, USA from 18-31th July 2022*
- *108° Congresso Nazionale SIF in Milano during 12-16th September, giving a talk: "Short-Baseline neutrino oscillation searches with the ICARUS detector"*

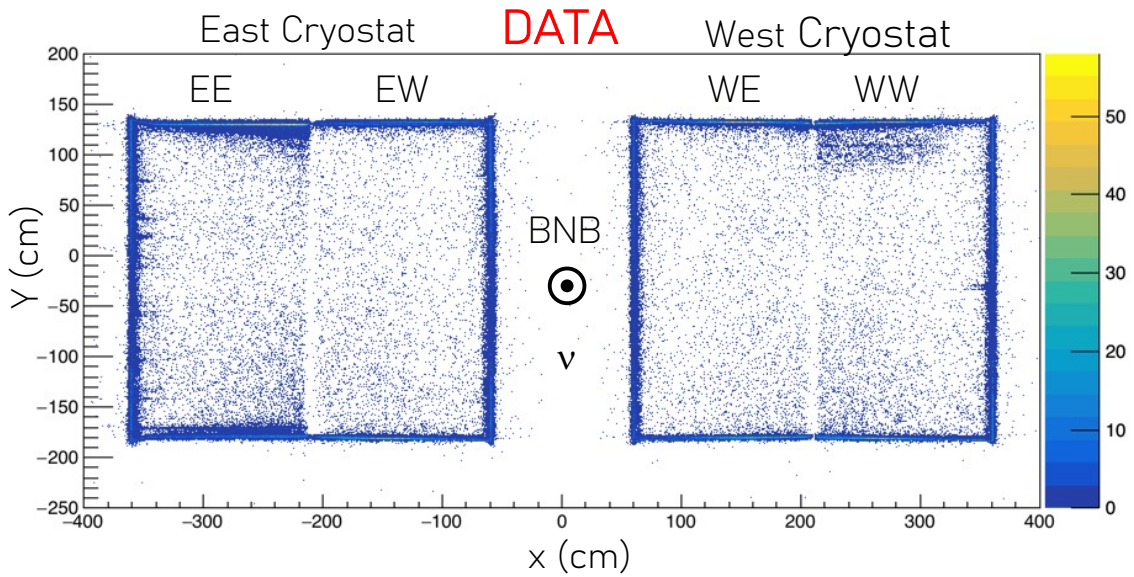
Study on containment conditions

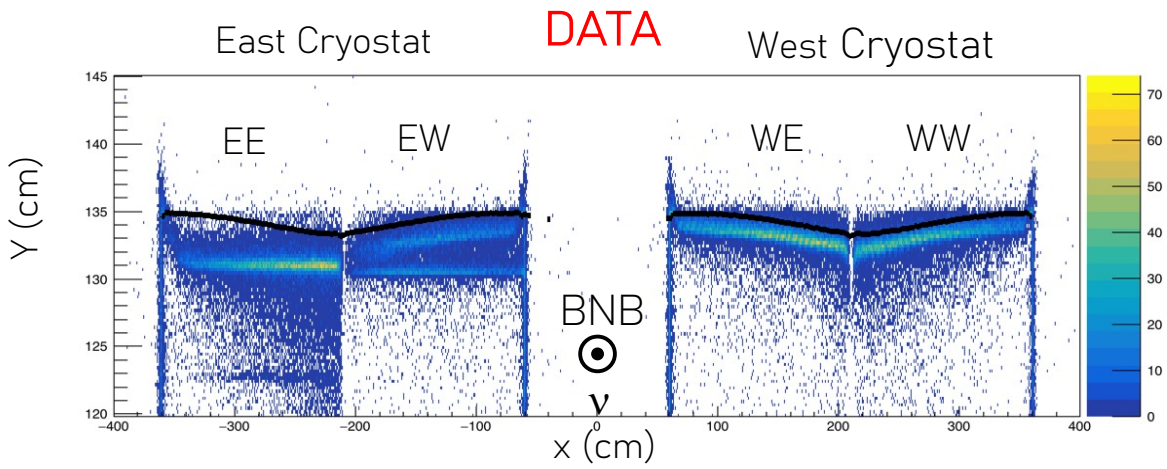
- Our main goal is to optimize the detector response in order to perform a high-quality analysis for neutrino events
- We are interested in $\nu_\mu CC$ contained events, which guarantees us that all calorimetric variables can be fully reconstructed
- Containment conditions are very effective in rejecting backgrounds events associated to charged cosmic rays
- Necessity to quantify the capability to correctly identify contained events
- We studied a sample of straight cosmic muons crossing the cathode, for which the absolute position inside the detector is determined with few mm precision



Study on containment conditions

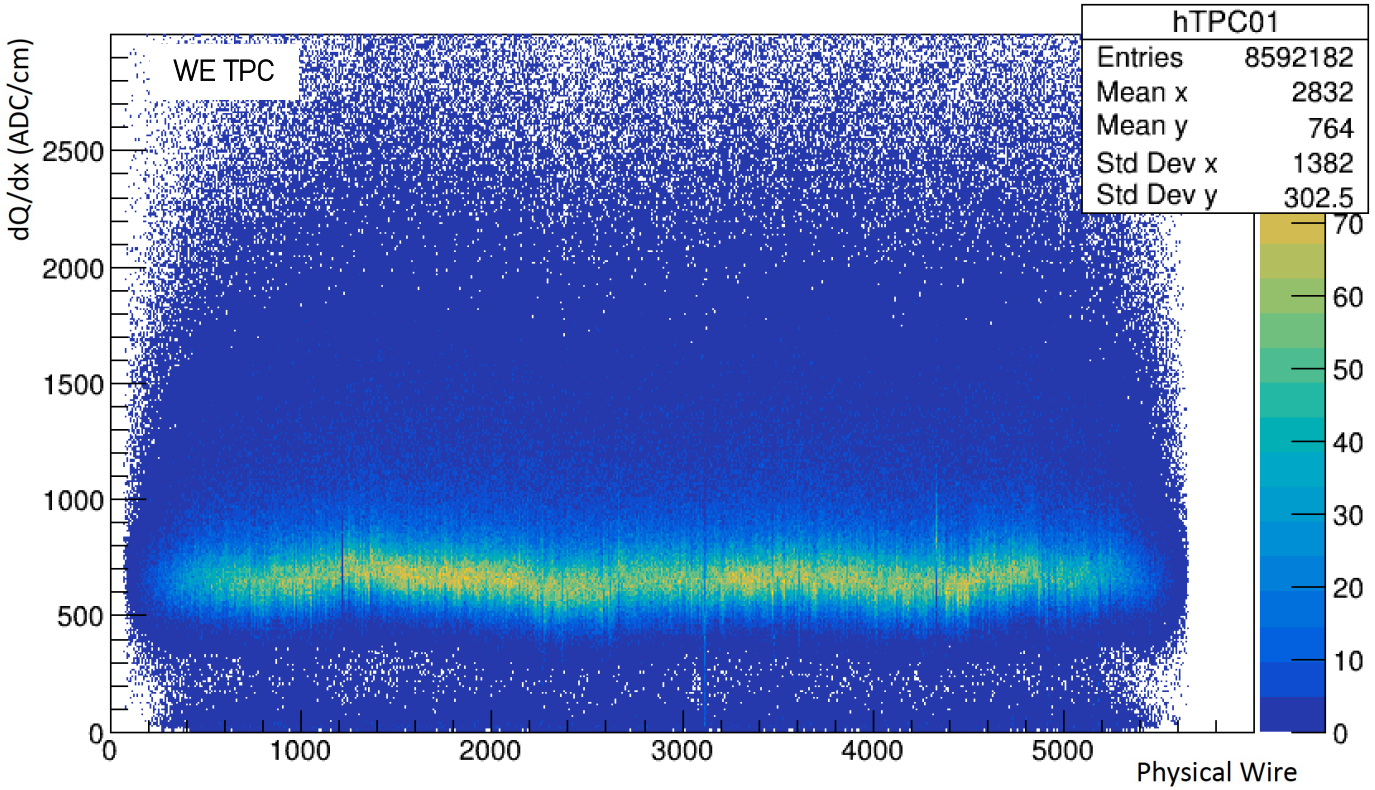
- Despite removing all tracks tagged as stopping particles, we found many of them starting or ending in the middle of the detector
- 5-10% of the points are reconstructed more than 5cm away from the borders, depending on the TPC
- We realised that due to Space Charge Effects (SCE) and possible reconstruction effects we were wrongly modeling the borders of the detector
- Small anomaly was observed in one of the TPC which could be explained with a known problem in the polarization field
- Anomalous track reconstruction does not have a strightforward explanation, hence a dedicated study is ongoing to adress and mitigate the reconstruction failures



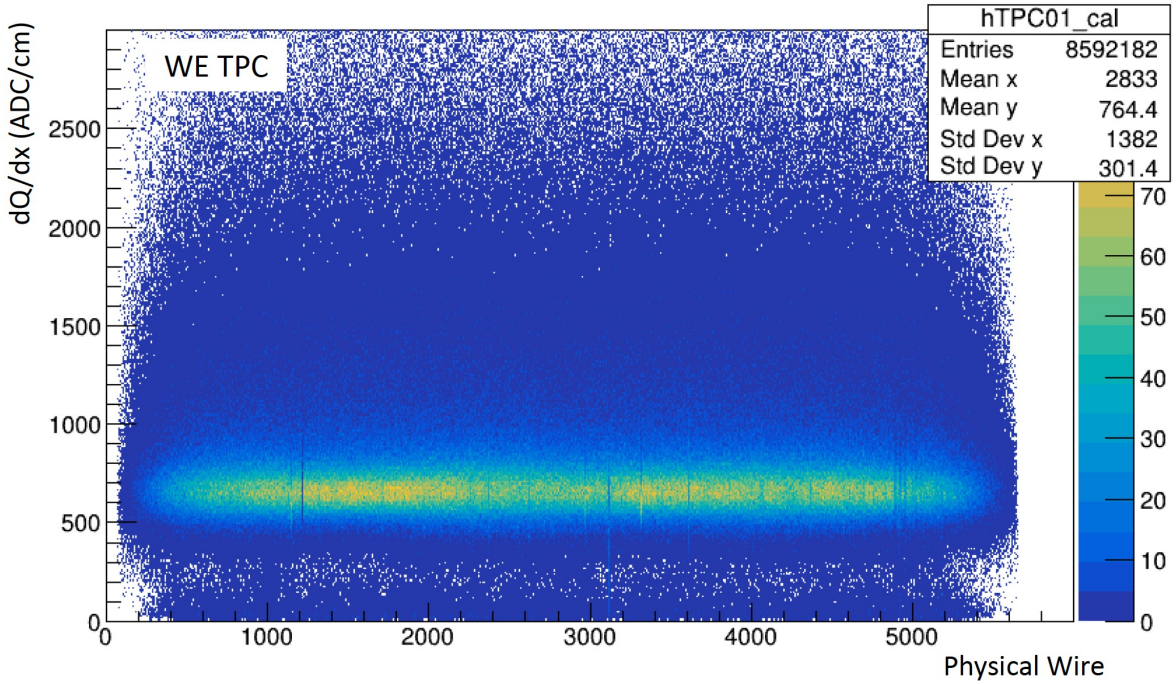


Equalization of the TPC wire response

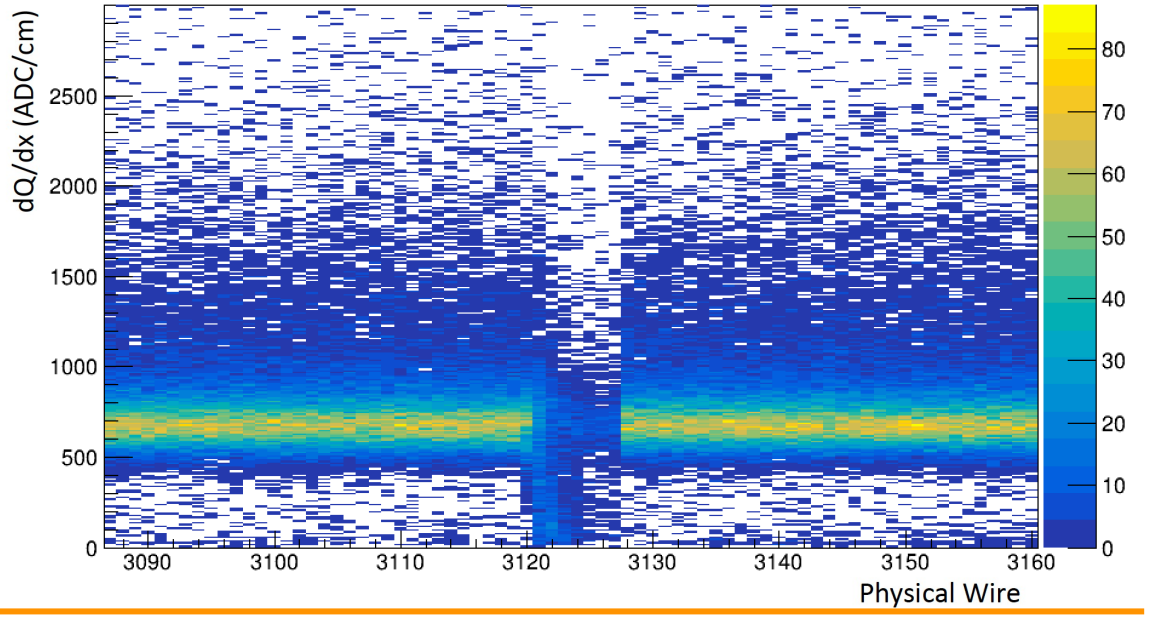
- Measurement of deposited energy along the track is mandatory for particle identification
- The basic idea is to equalize the distribution of the deposited charge along the track (dQ/dx) for each wire to a common value ⇒ equivalent responses of front-end electronics
- To account for signal attenuation due to the electronegative impurities we need to correct dQ/dx as a function of the electron lifetime



Equalization of the TPC wire response



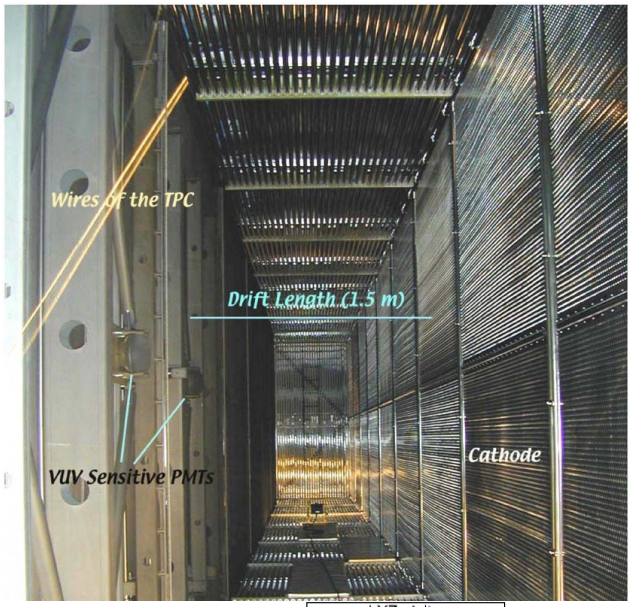
- The distribution of collected wire signals produced by cosmic muons was fitted with a Landau convoluted with a Gaussian
- The fitted most probable value of the distribution was used to compute the calibration factor



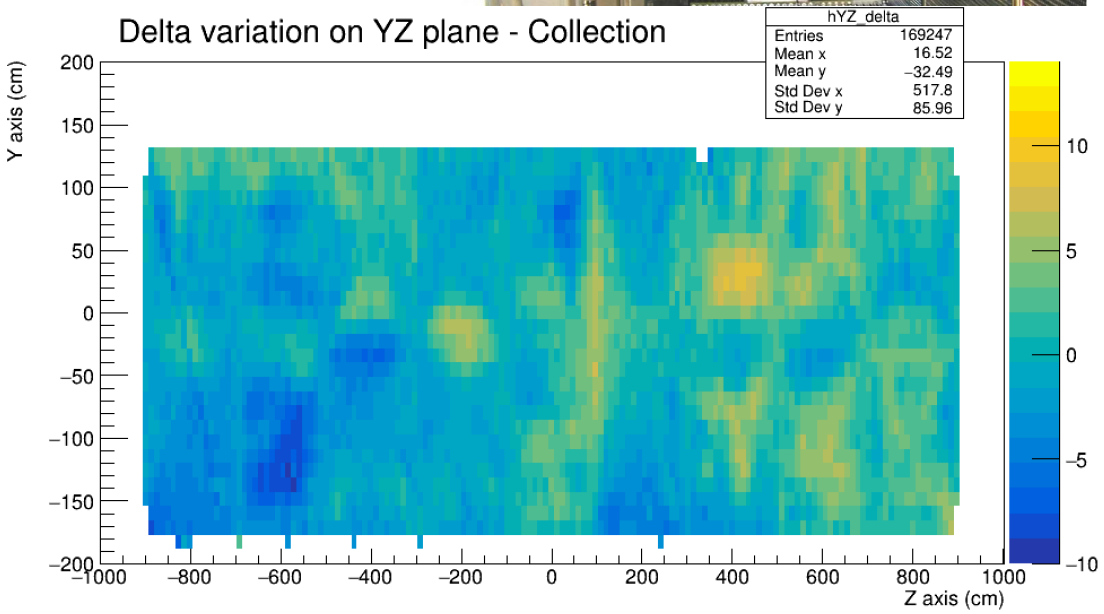
- The dispersion of the MPV distribution for all the wires drastically reduces from $\sim 4\%$ before calibration to $< 1\%$ after the calibration
- We were also able to use the method to spot malfunctioning channels, that will be considered for further analysis

Cathode planarity studies

- For an accurate neutrino analysis we need precise determination of the absolute position of the track along the drift coordinate
- Measurement of the absolute time t_0 at which the particle is crossing the detector
- Local deviations from planarity in the central cathode could affect the uniformity of the electric field causing poorly reconstructed drift time

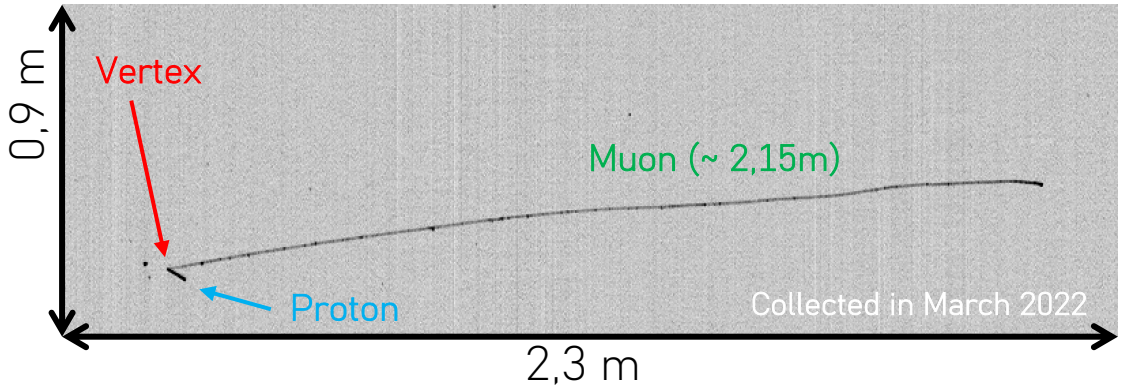


- We tested the cathode planarity by exploiting cathode crossing cosmic muons
- Observed variations corresponding to an absolute cathode displacement of up to $\sim 2\ cm$
- We found some geometrical considerations of the detector which were not yet implemented in MC



Reconstruction of neutrino events

- Thanks to a scanning effort we have a significant sample of visually scanned neutrino events
- We are testing the performance of the pattern recognition algorithm
- The goal is to spot possible flaws inside the reconstruction chain
- Focus on bad reconstruction muon tracks in $\nu_\mu\, CC$ events from the BNB beam
- Study of split tracks looking for discrepancies between the scanned and reconstructed track length



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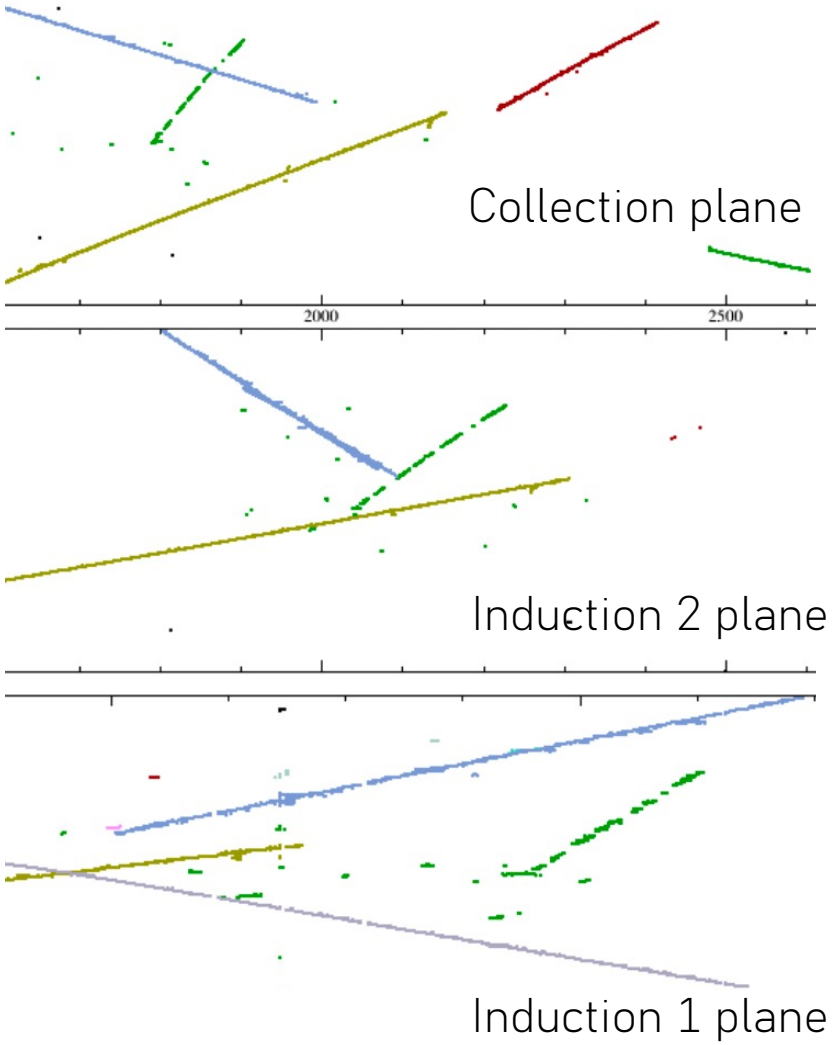
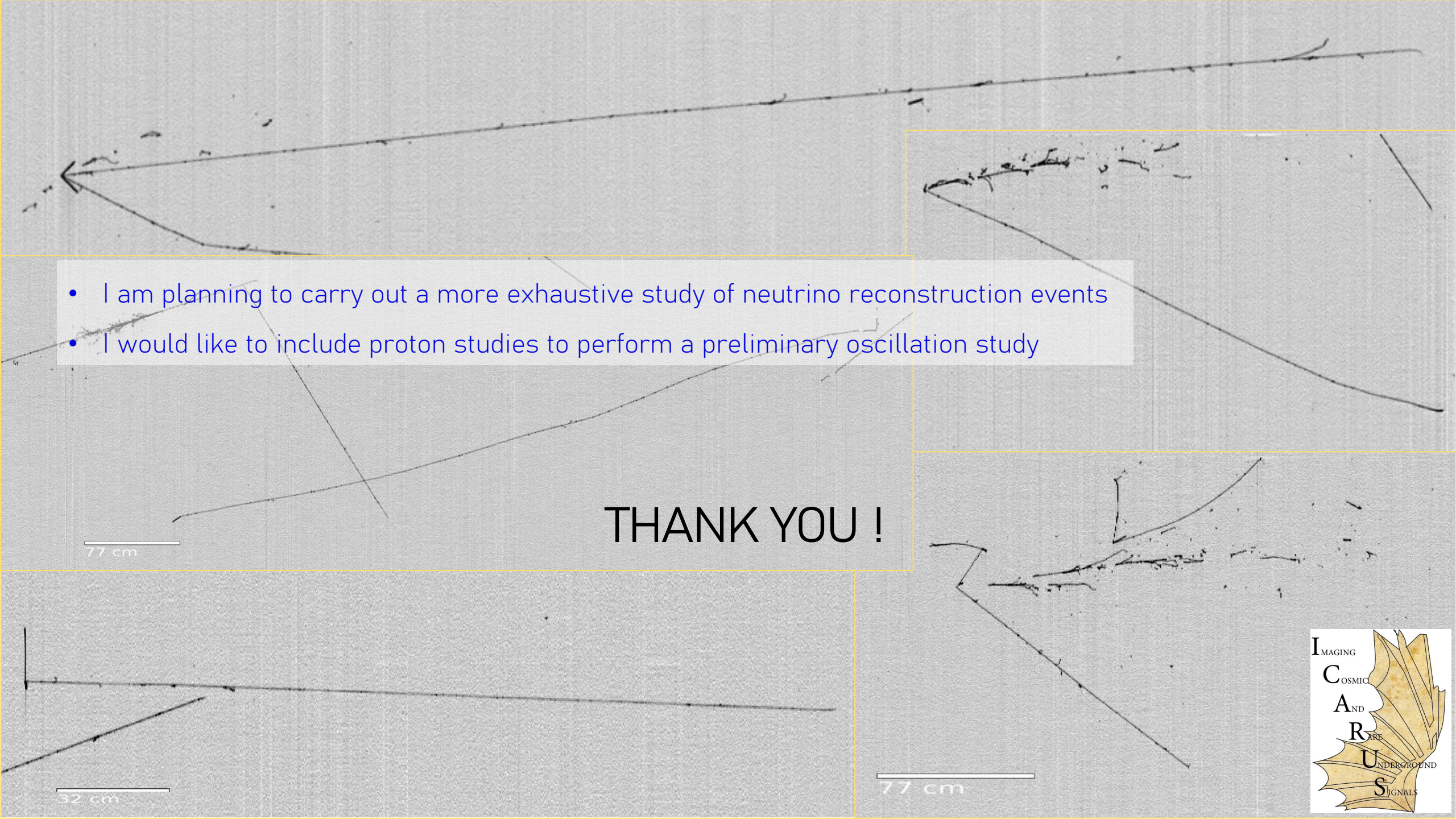




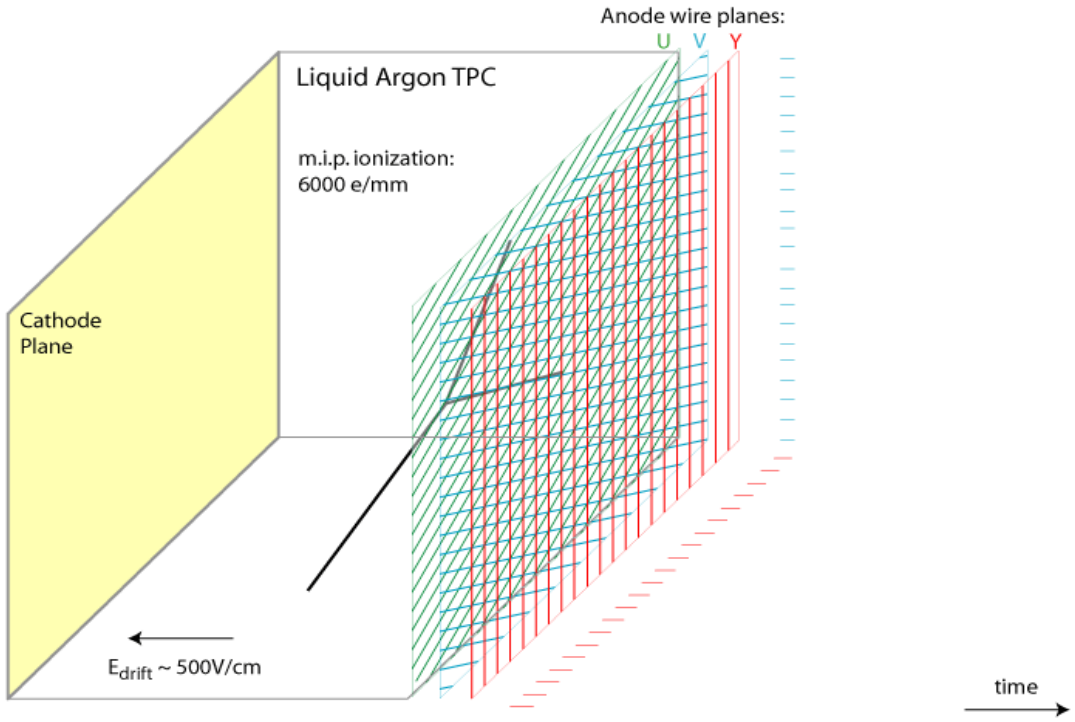
- I am planning to carry out a more exhaustive study of neutrino reconstruction events
- I would like to include proton studies to perform a preliminary oscillation study

THANK YOU !

ICARUS — Imaging Cosmic And Rare Underground Signals

BACKUP SLIDES

LAr TPC Working Principle



- When a neutrino interacts with liquid argon it produces charged particles that deposit their energy, creating ionization electrons and scintillation light

- The scintillation light propagates inside the detector until it is collected by the PMTs behind the wires. We use this light to recognize when an interaction has occurred

- The ionization electrons are collected in the wire planes, thanks to the electric field. We combine the collected signals to obtain a complete 3D reconstruction of the event