# A New Era in Neutrino Physics
# The SND@LHC Experiment

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LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia
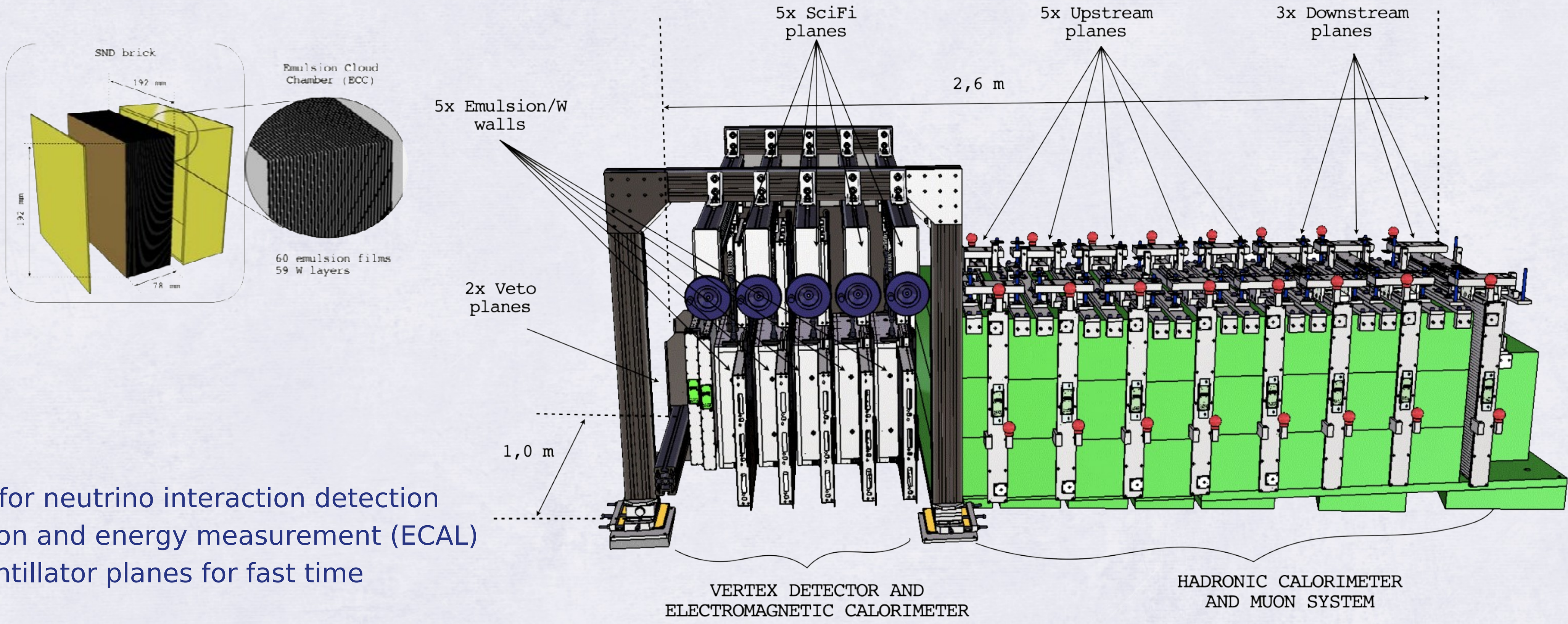
Scattering and Neutrino Detector
at the LHC

**SND@LHC is the newest experiment installed at CERN, aimed at probing neutrinos of all flavours produced in the ATLAS IP.**

## Goals:
- Heavy flavour production in pp collisions
- Lepton flavour universality
- Feebly interacting particles

## Location:
- Tunnel TI18, 480 m from the ATLAS IP
- Slightly off axis, probe neutrinos produced mostly from charm decays
- Pseudorapidity range $7.2 < \eta < 8.6$

## Design:
- VETO PLANES: tag penetrating muons
- TARGET REGION (830Kg):
  - Emulsion cloud chamber ECC (emulsion+tungsten) for neutrino interaction detection
  - Scintillating fiber tracker (SciFi) for timing information and energy measurement (ECAL)
- MUON SYSTEM: iron walls interleaved with plastic scintillator planes for fast time resolution and energy measurement (HCAL)
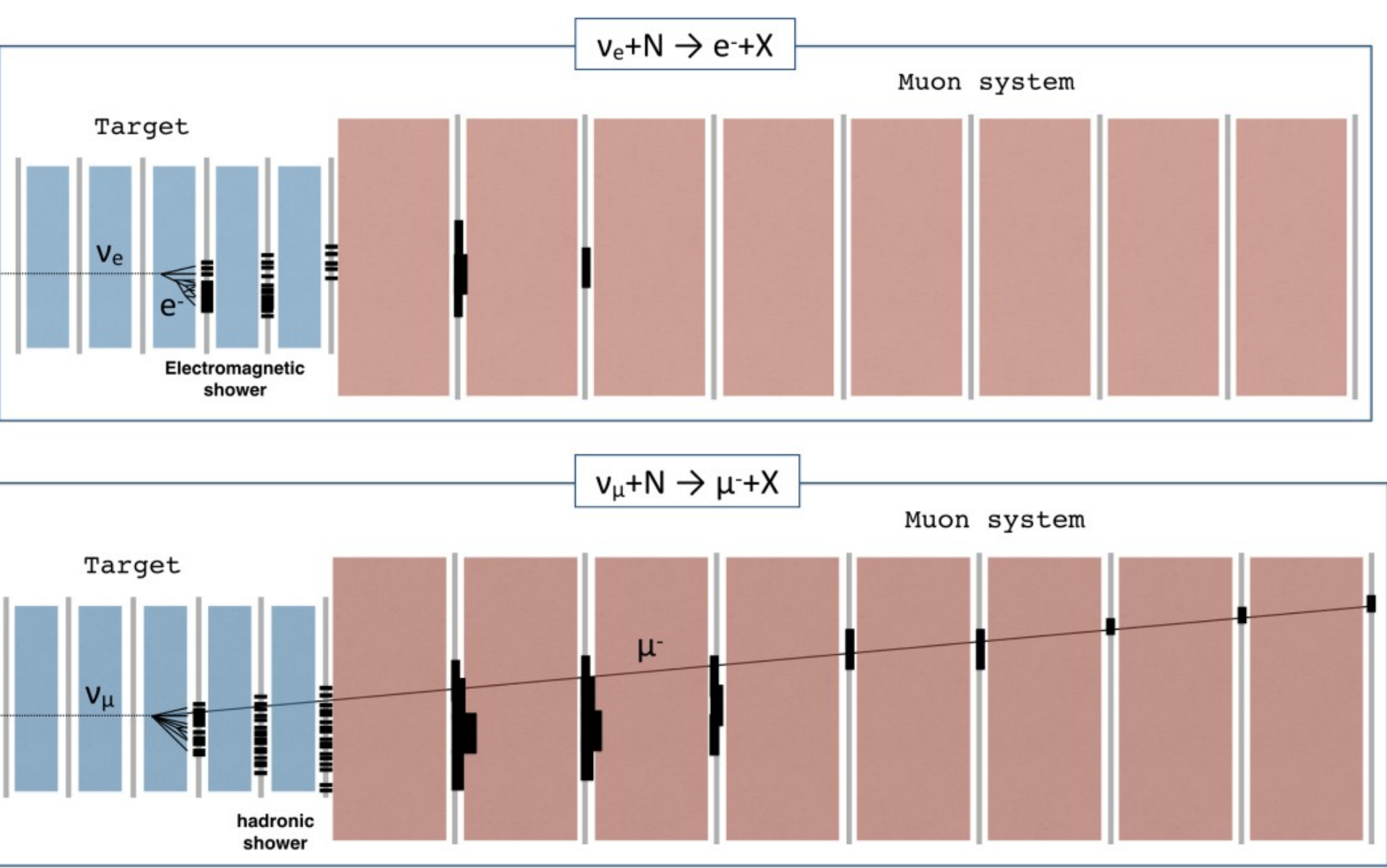


SND brick

Emulsion Cloud Chamber (ECC)

60 emulsion films
59 W layers

5x SciFi planes
5x Upstream planes
3x Downstream planes
2,6 m
5x Emulsion/W walls
2x Veto planes
1,0 m

VERTEX DETECTOR AND ELECTROMAGNETIC CALORIMETER

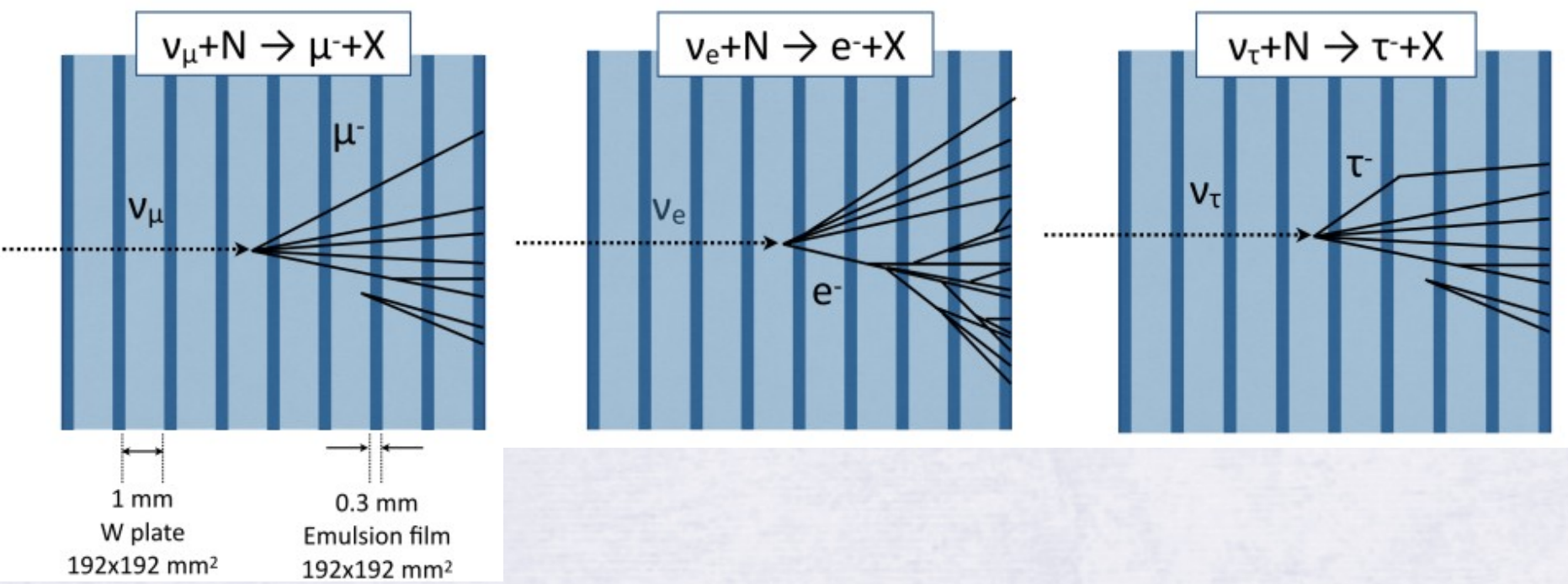HADRONIC CALORIMETER AND MUON SYSTEM

# DETECTOR INSIGHTS

## DETECTING NEUTRINOS

Relying on emulsions means that until these are removed, revealed, scanned and analyzed, the only data available pertains to the eletronic trackers.

Charged Current events from electron and muon neutrinos have very specific signals that can be seen with electronic detectors alone



$\nu_e + N \rightarrow e^- + X$

Target — Muon system
Electromagnetic shower

$\nu_\mu + N \rightarrow \mu^- + X$

Target — Muon system
hadronic shower

Once emulsion data is available, more detailed topologies can be seen, like tau neutrinos:



$\nu_\mu + N \rightarrow \mu^- + X$
$\nu_e + N \rightarrow e^- + X$
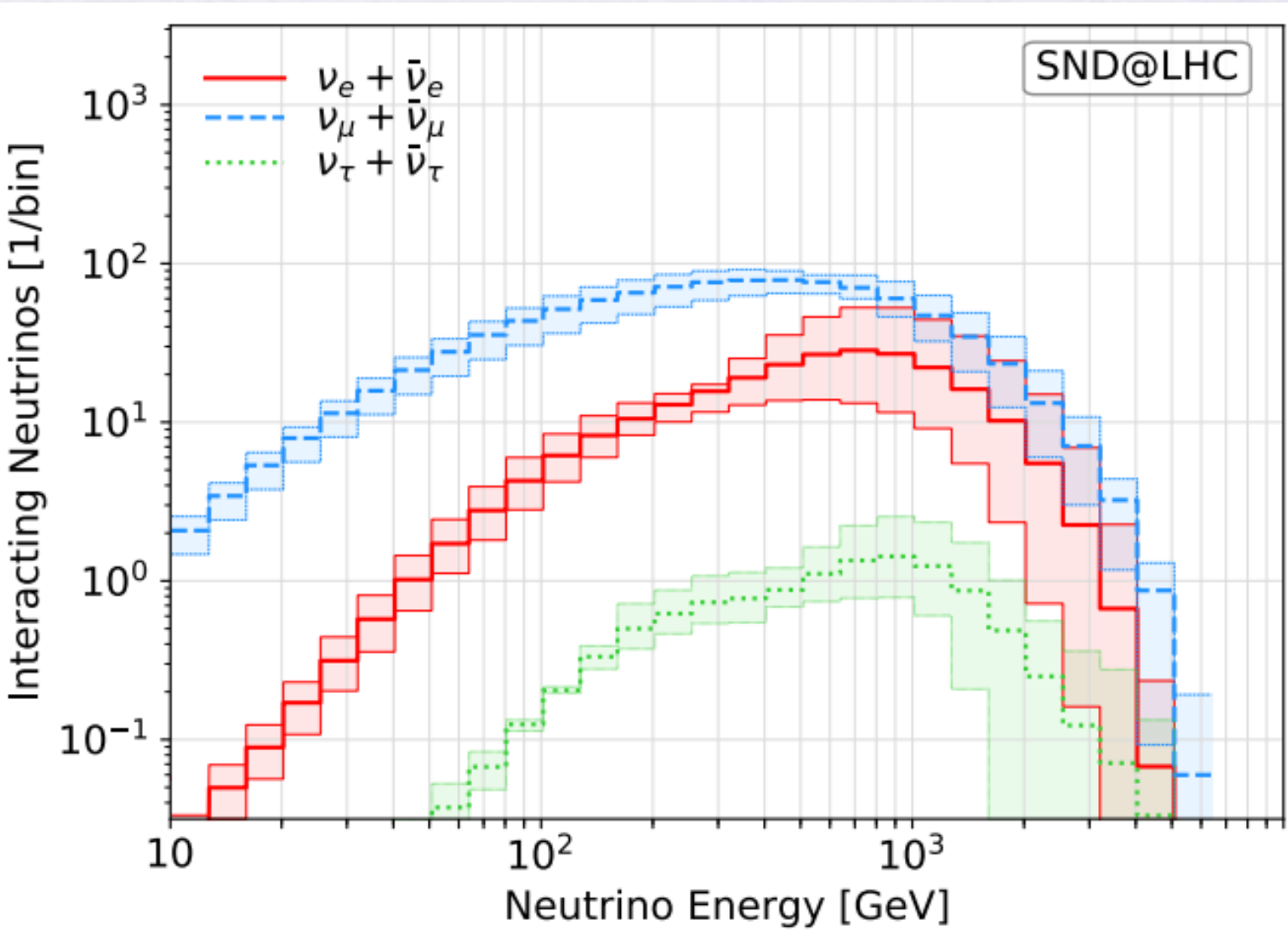$\nu_\tau + N \rightarrow \tau^- + X$

1 mm W plate 192x192 mm²
0.3 mm Emulsion film 192x192 mm²

Additionally, exotic interaction with topologies similar to Neutral Current neutrino interactions can be seen:



$\chi + e^- \rightarrow \chi + e^-$
$\chi + p \rightarrow \chi + p$
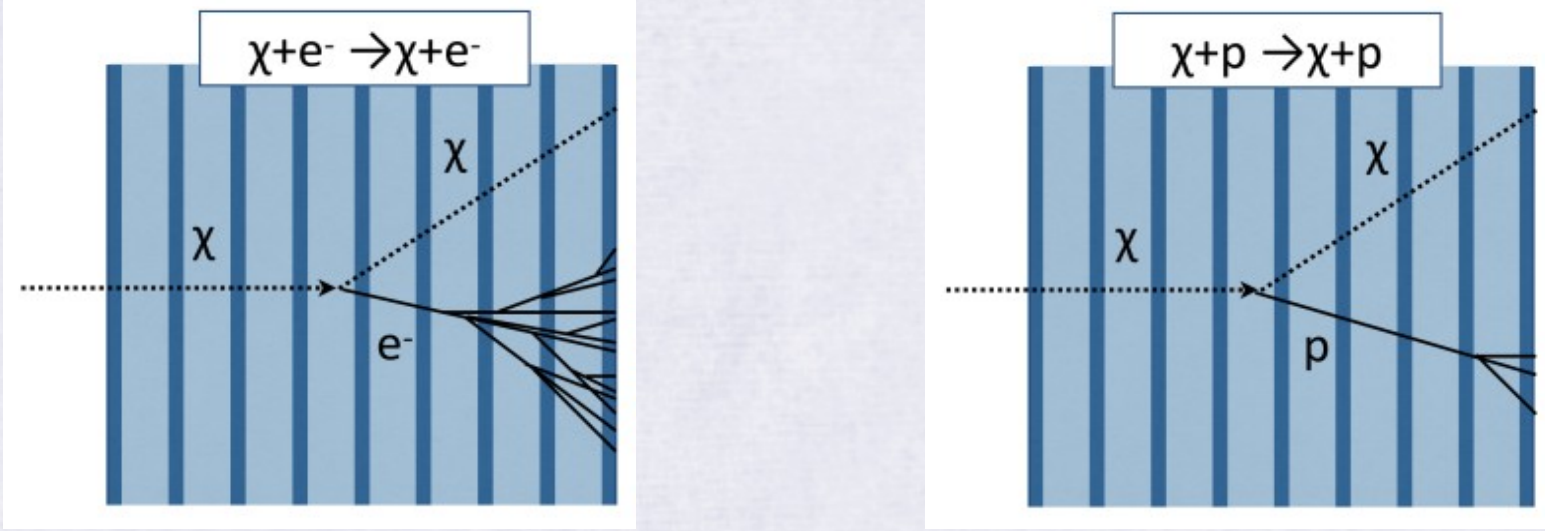
## NEUTRINO INTERACTIONS

The detector is designed to study all neutrino flavours



SND@LHC
$\nu_e + \bar{\nu}_e$
$\nu_\mu + \bar{\nu}_\mu$
$\nu_\tau + \bar{\nu}_\tau$
Interacting Neutrinos [1/bin]
Neutrino Energy [GeV]

Estimates for 150 fb⁻¹ (280 fb⁻¹ expected in Run 3)

### MAIN PHYSICS GOALS

- Neutrino energies from 100 GeV $\leq E\nu \leq$ 3 TeV
- Charmed hadron production in pp collisions from electron neutrino flux
- Lepton Flavour Universality test through neutrino CC Interactions
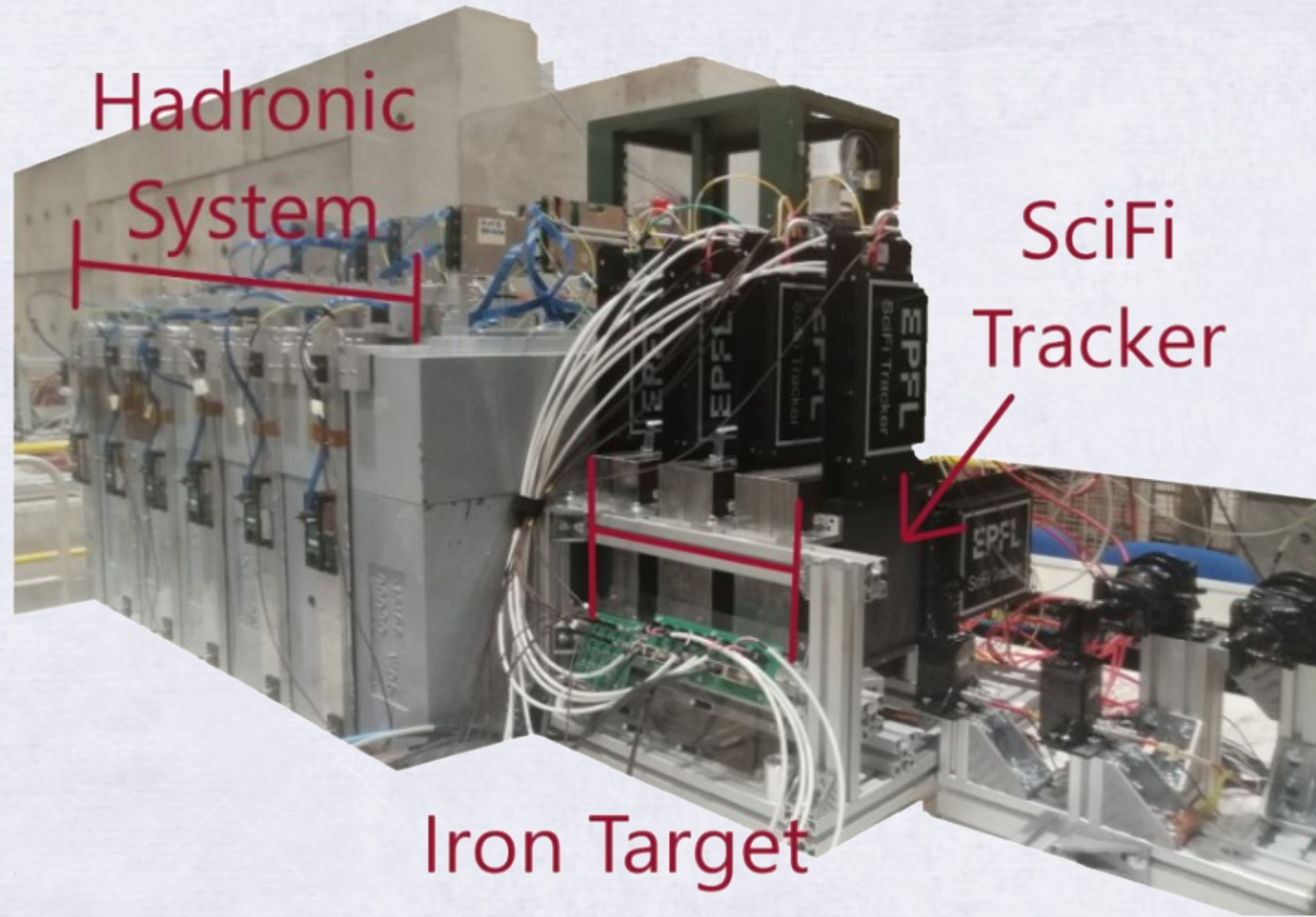- Measurement of NC/CC ratio and probing of Light Dark Matter

### NEUTRINO CROSS-SECTION PARADIGM



$\sigma^{CC}_\nu / E_\nu$ [$10^{-38}$ cm² GeV⁻¹ nucleon⁻¹]
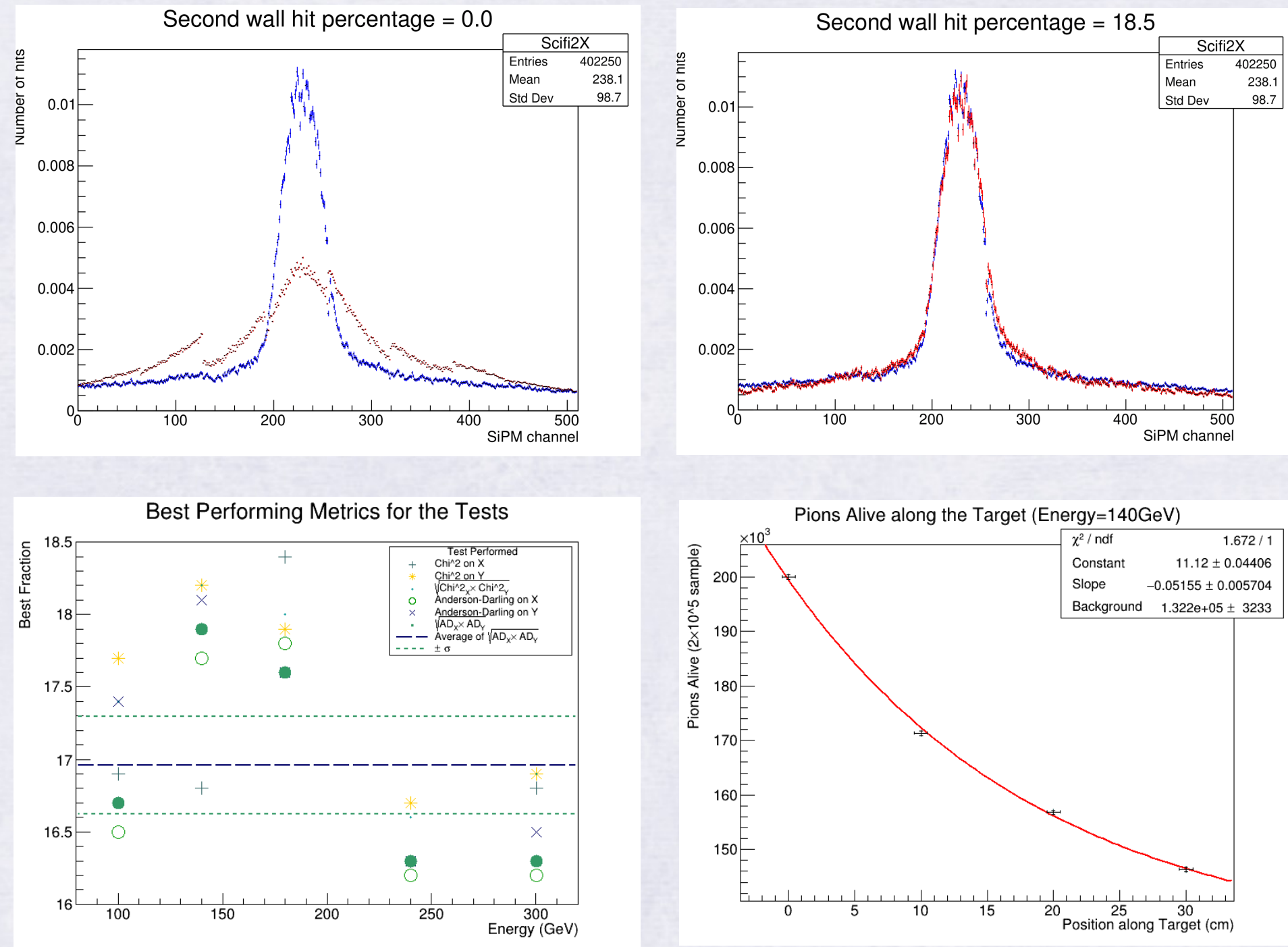Neutrino energy $E_\nu$ [GeV]
SND@LHC
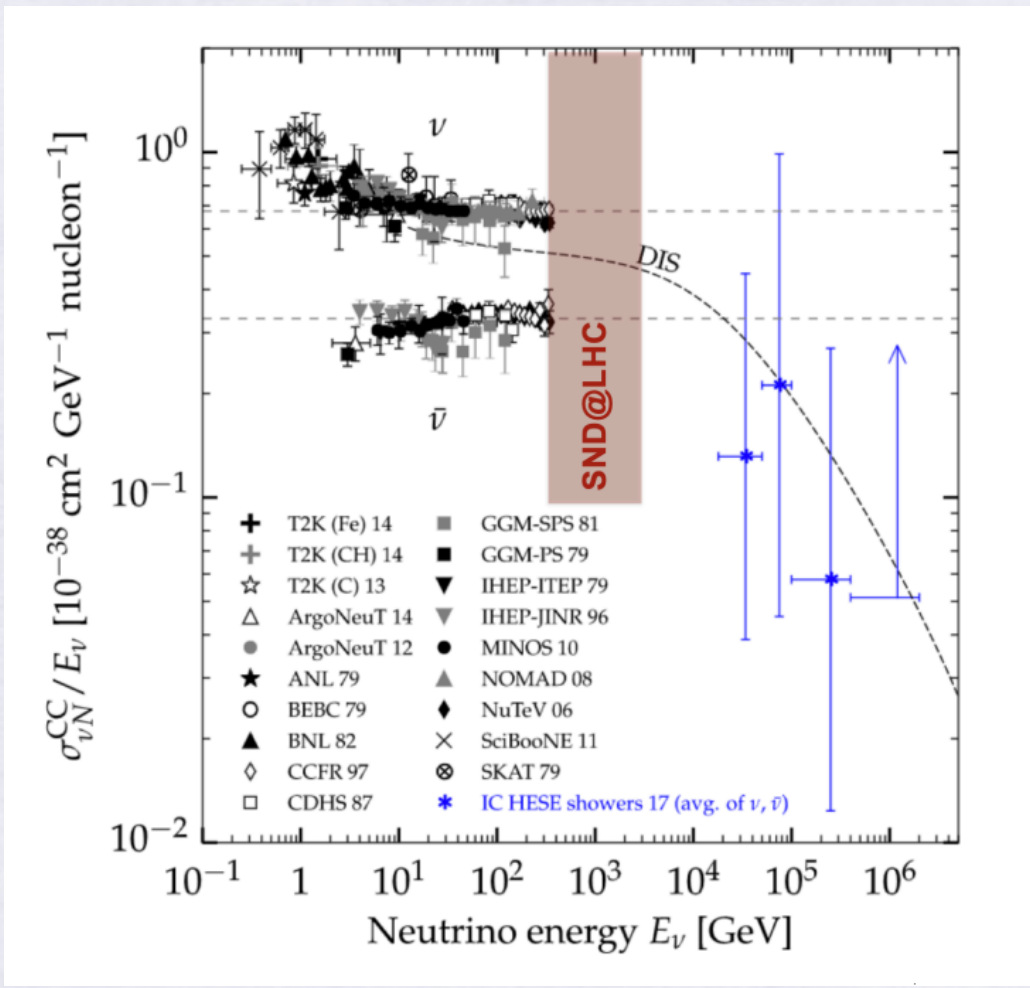
## 2023 Test Beam

### Objective:

Build functional **Detector Replica**
Study detector response under controled environment
Calibrate the detector
Extrapolate to the LHC data



Hadronic System
SciFi Tracker
Iron Target

### Calibration – Shower Tagging:

- Crucial to correctly interpret Hadronic System data
- Determine interaction brick by comparing beam profiles between SciFi Trackers
- Define selection criterion and obtain optimal value
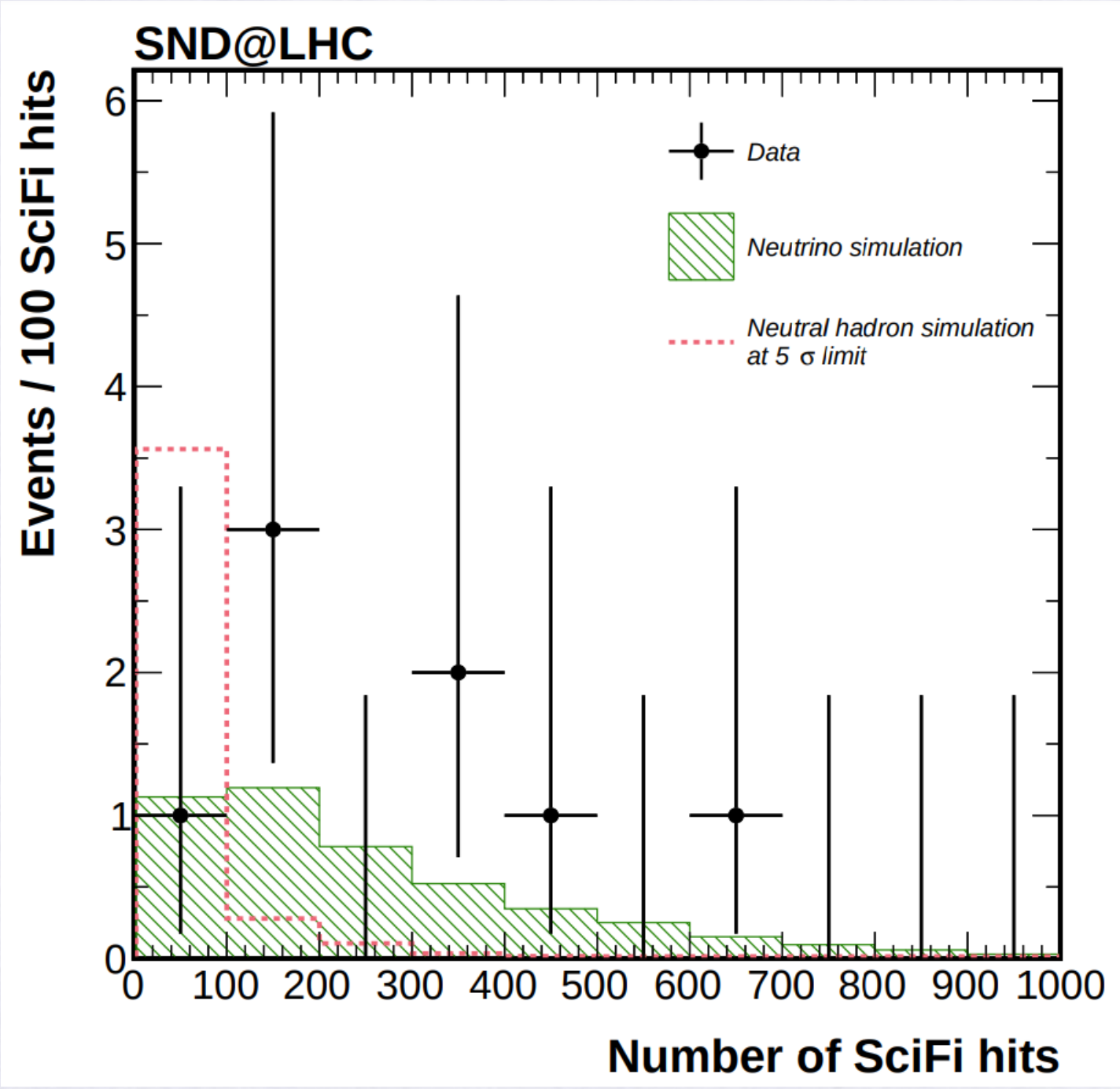- Once defined, start applying in following analyses



Second wall hit percentage = 0.0
Second wall hit percentage = 18.5
Best Performing Metrics for the Tests
Pions Alive along the Target (Energy=140GeV)

# SND@LHC TODAY

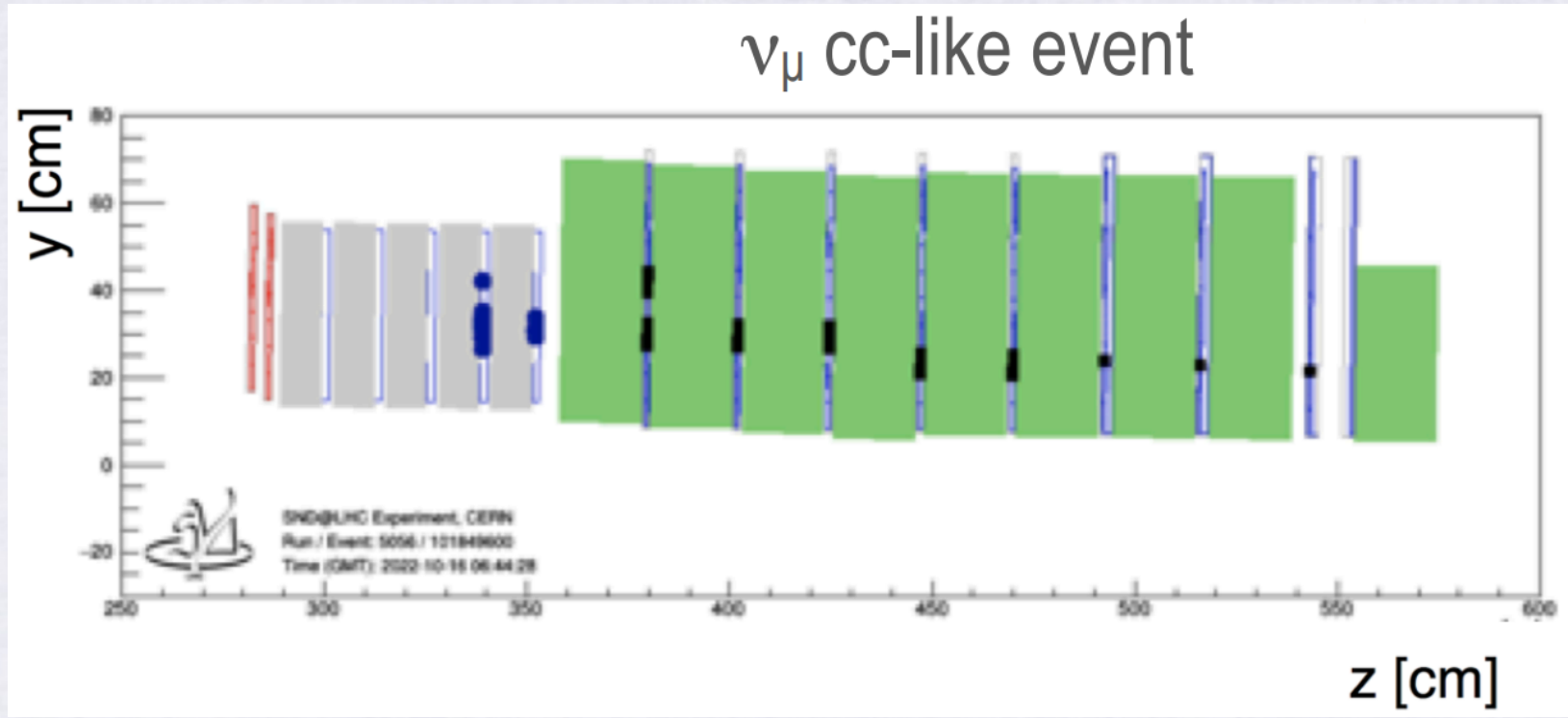The detector has been installed in TI18 since November 2021 and is currently observing neutrinos.



Current installation of the experiment at TI18, with the Cold Box/Neutron Shield surrounding the Veto System and Emulsion Targets



SND@LHC
Events / 100 SciFi hits
Number of SciFi hits
Data
Neutrino simulation
Neutral hadron simulation at 5 σ limit

Collider produced muon neutrinos observed during 2022
Analysis is currently being updated to include 2023 data

$\nu_\mu$ CC-like event observed at the SND@LHC detector



$\nu_\mu$ cc-like event
y [cm]
z [cm]

### Acknowledgements

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