

A new era of neutrino physics at colliders: the **SND@LHC** experiment



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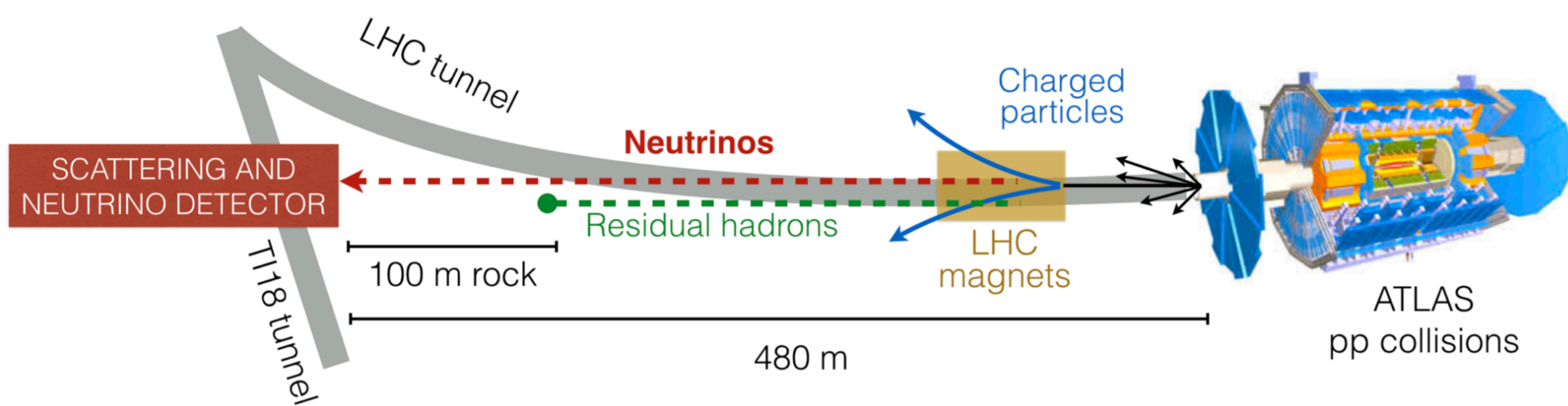


1 - Scattering and Neutrino Detector

The **SND@LHC** is a **neutrino experiment** approved by CERN on March, 2021.

Installed and commissioned in **less than 1 year**, it is now **taking data** during the LHC **Run3**.

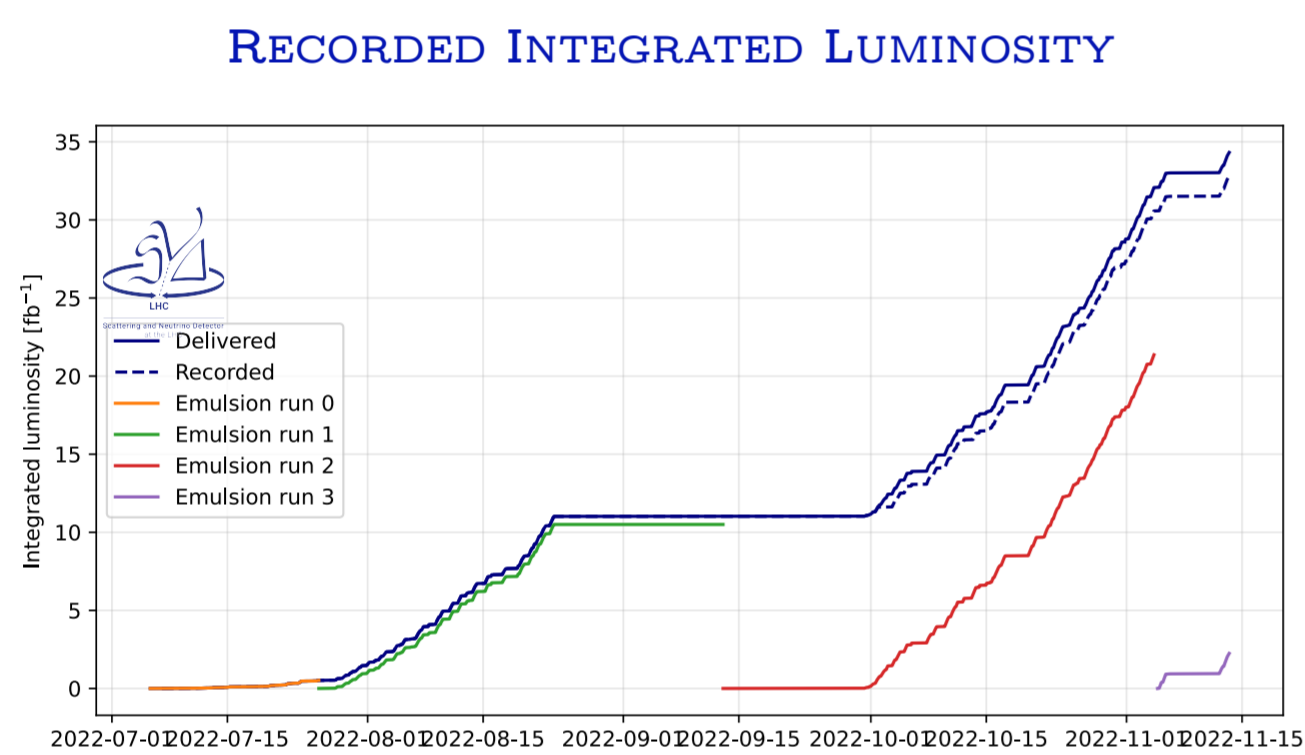
The experiment is located in the TI18 tunnel, ca. **480 m** away from the **ATLAS** collision point.



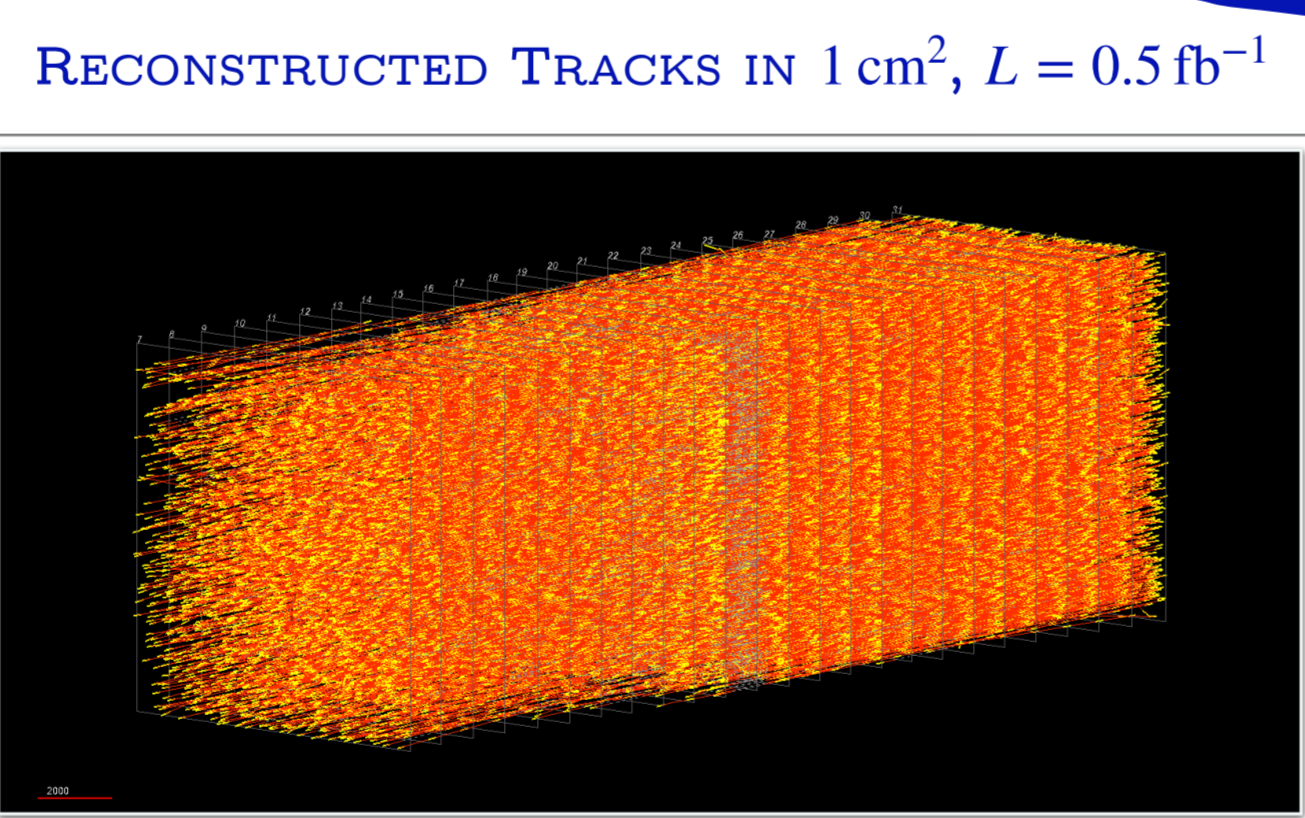
Neutrinos and **exotic particles** produced in ATLAS collisions travel undisturbed to SND@LHC, where they are later detected.

In SND@LHC **angular acceptance** $7.2 < \eta < 8.4$ neutrinos come mostly from **charm decays**.

5 - First data and early measurements



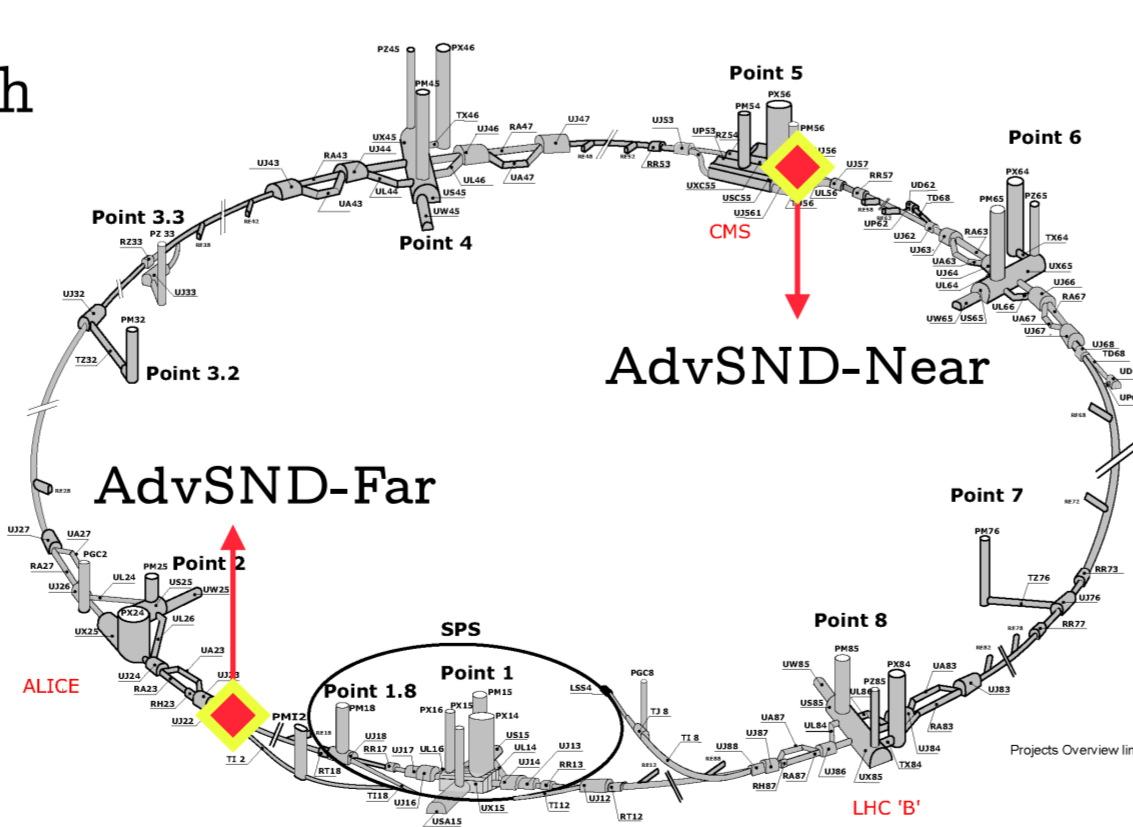
- Electronic detectors** measurements:
 - Passing muons and muon-induced **background rates** in TI18
 - First observation of **neutrino interactions** at a collider experiment
- Nuclear emulsions** analysis:
 - 0.5 fb^{-1} of data collected in the period April-July 2022 is now **being analysed**
 - Evaluate the background and define **emulsion replacement** strategy



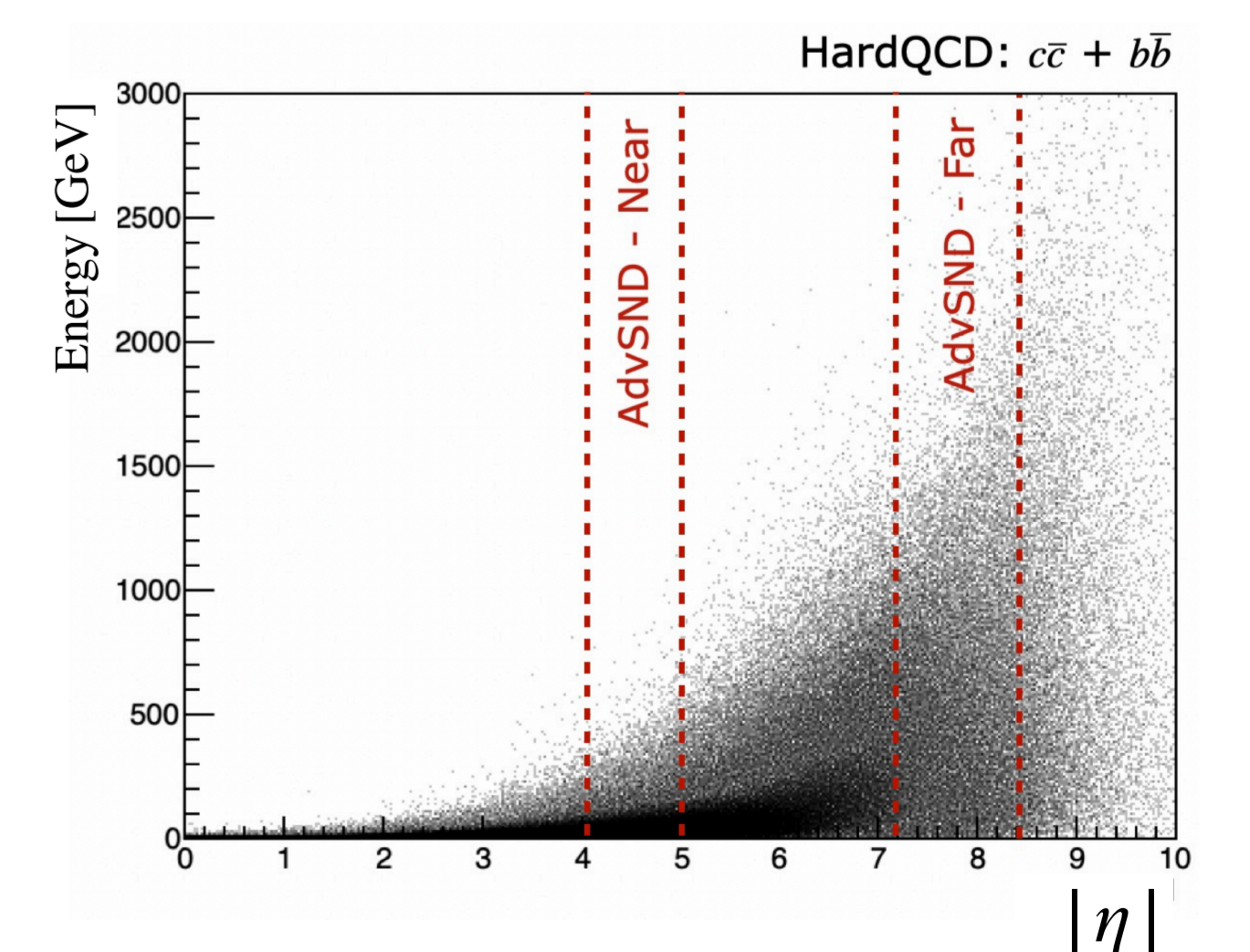
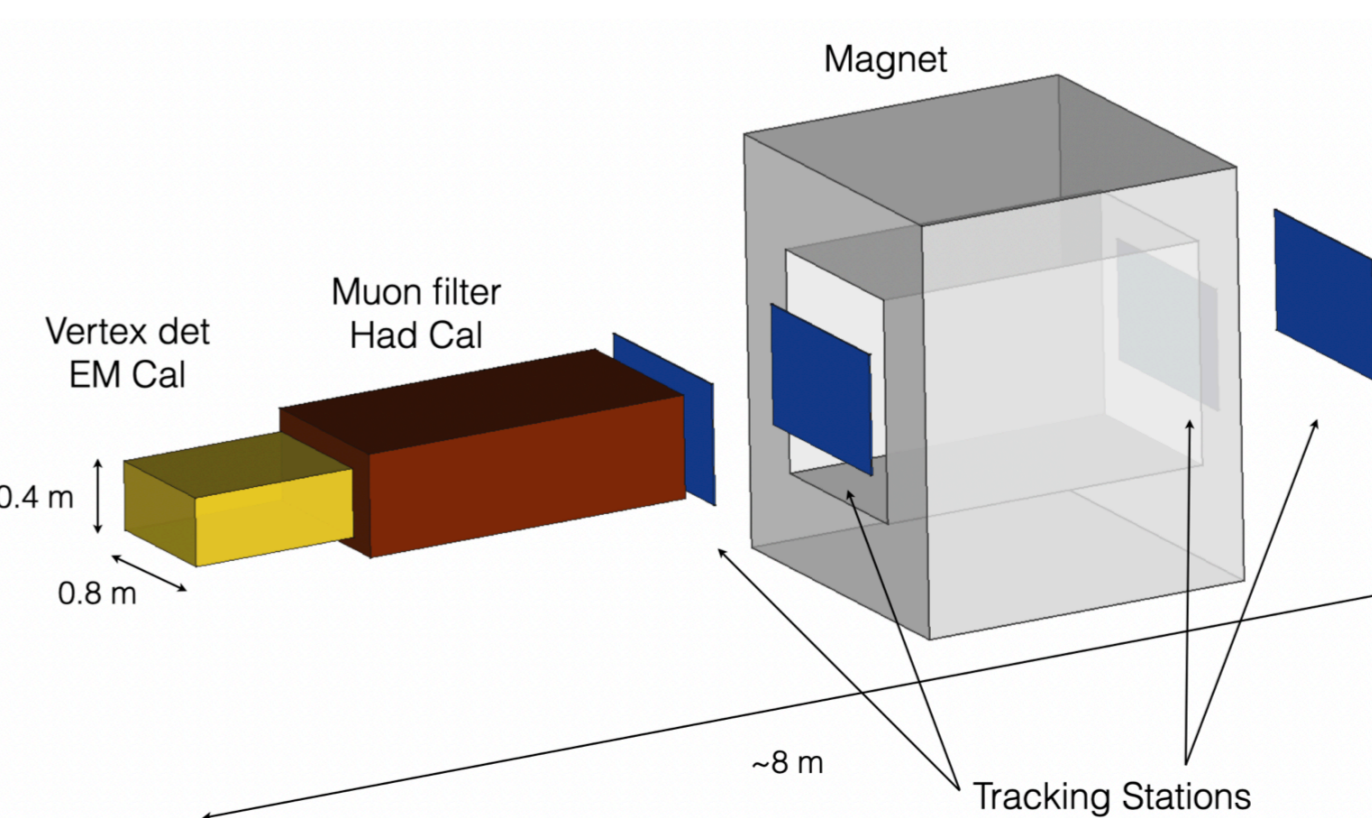
6 - Beyond Run3: Advanced SND

Advanced SND is an **upgraded** prototype of SND@LHC in view of **Run4** data-taking

- Extended physics case** and wider angular coverage with **two detectors**
 - AdvSND-Near ($4 < \eta < 5$)
 - AdvSND-Far ($7.2 < \eta < 8.4$)
- Improved detector** layout and **new technologies**
 - Silicon pixel vertex detector
 - Muon **magnetic spectrometer** for momentum and charge measurement



ADVANCED SND LAYOUT



2 - Detector concept

GOAL identifying all the neutrino flavours \Rightarrow **SOLUTION** hybrid detector

1. Neutrino Target and vertex detector

▶ **Emulsion Cloud Chamber (ECC)** using tungsten as passive material.

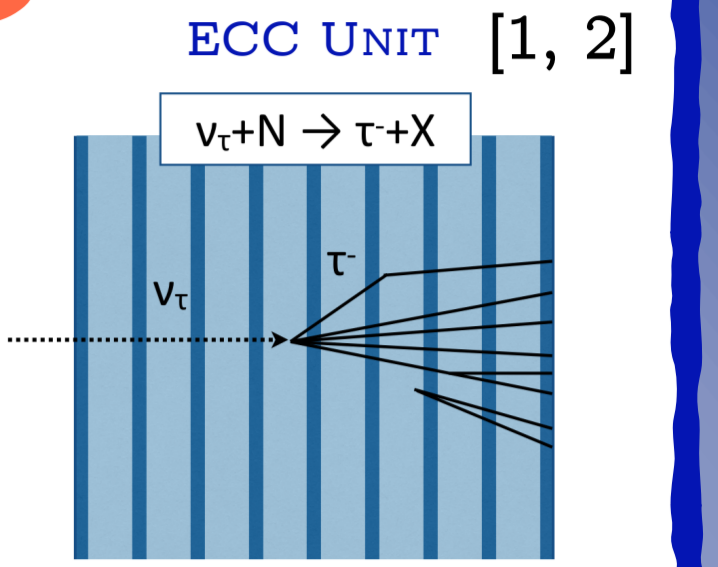
2. ECAL

▶ Scintillating Fiber tracker (**SciFi**). **Time stamp** and electromagnetic showers energy measurement

3. HCAL + Muon identification system

▶ iron walls + **scintillators**

▶ Veto and Downstream to tag penetrating muons

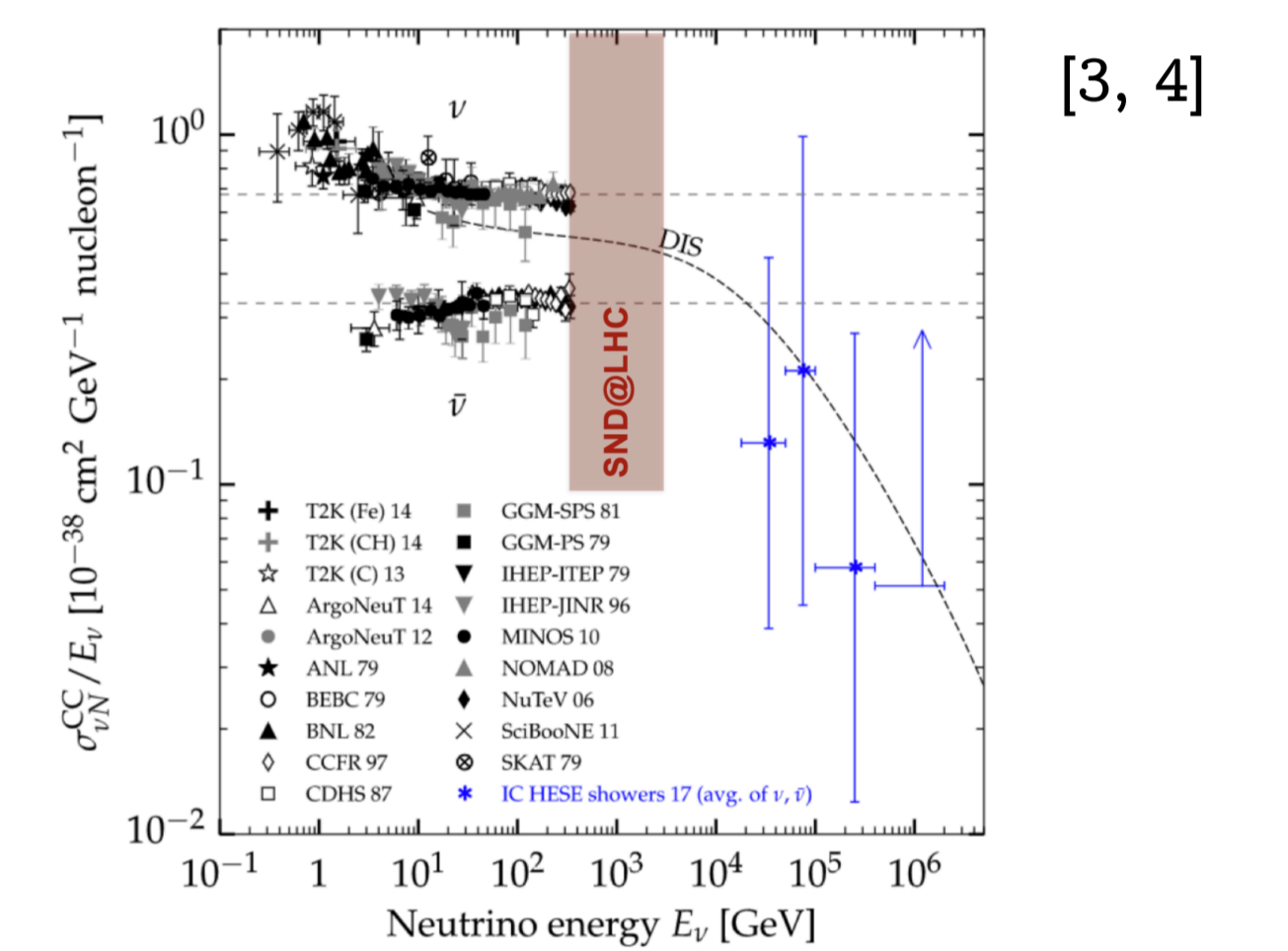


3 - Physics program

EXPECTED NEUTRINO INTERACTIONS (RUN3: 290 fb^{-1})

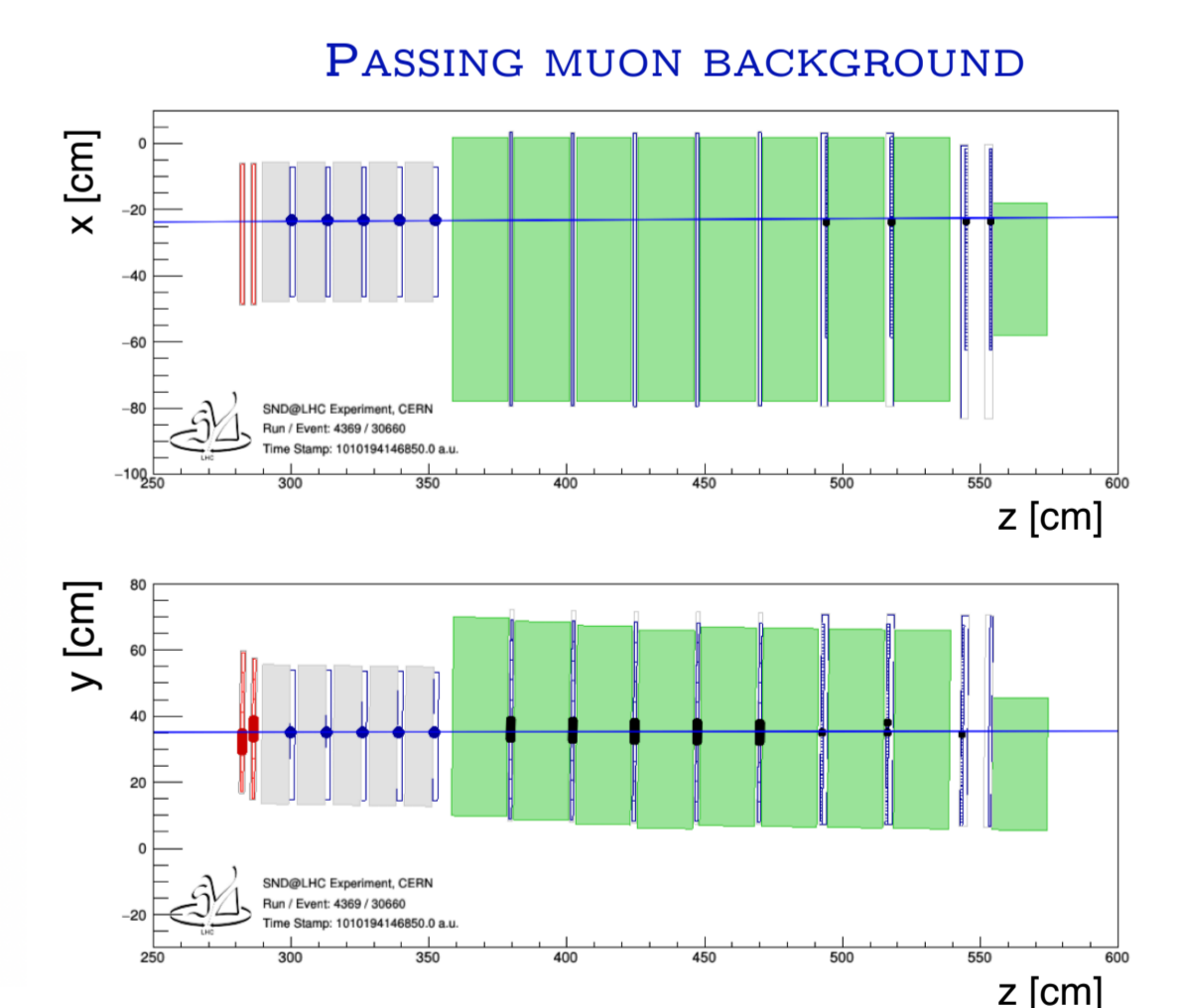
	(E) [GeV]	tot. NC	tot. CC
$\nu_e + \bar{\nu}_e$	265	146	450
$\nu_\mu + \bar{\nu}_\mu$	122.5	467	1447
$\nu_\tau + \bar{\nu}_\tau$	390	13	34

- Measurement of the $pp \rightarrow \nu_e + X$ cross-section
- ν_e flux used as a probe of **charm quark production**
- QCD**: constrain the gluon PDF with data at small x
- Lepton flavour universality** test with ν_e/ν_τ and ν_e/ν_μ

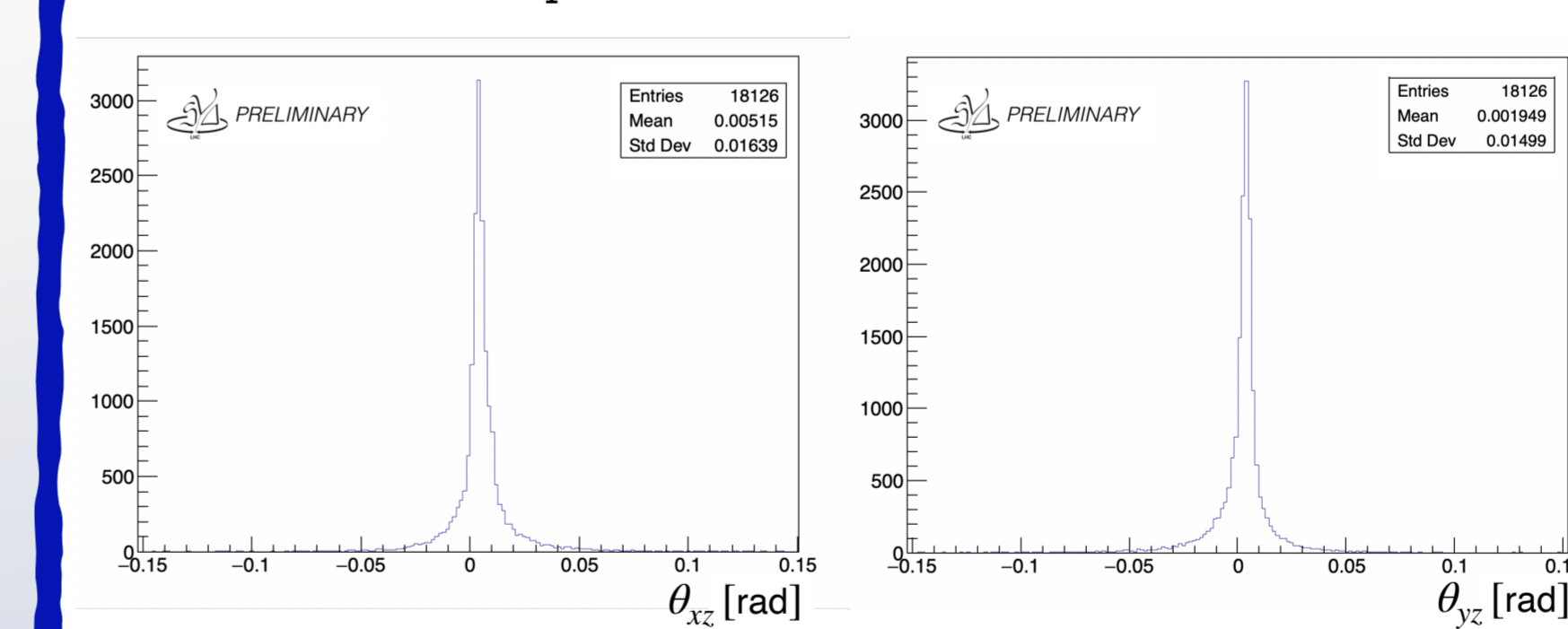


4 - Backgrounds

- Passing muons** from the ATLAS interaction point. Predicted **muon flux** of $\sim 350 \text{ Hz}$ in acceptance.
- Muon-induced**: neutral particles (n, K) generated from **Deep Inelastic Scattering** of muons in the rock surrounding the detector with a signal-like topology.



RECONSTRUCTED TRACK SLOPES compatible with muons from ATLAS



References and resources:

- OPERA Collaboration, Discovery of τ neutrino appearance in the CNGS neutrino beam with the opera experiment, Phys. Rev. Lett. 115, 121802, September 2015
- OPERA Collaboration, Final Results of the OPERA Experiment on ν_τ appearance in the CNGS Neutrino Beam, Phys. Rev. Lett. 120, 211801, April 2018
- M. Bustamante et al., Extracting the Energy-Dependent Neutrino-Nucleon Cross Section above 10 TeV Using IceCube Showers, Phys. Rev. Lett. 122, 041101, January 2019
- SND@LHC - Scattering and Neutrino Detector at the LHC, Technical Proposal, LHCC-P-016, February 2021

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