The Scattering and Neutrino Detector at the LHC (SND@LHC) is a stand-alone experiment to probe neutrino production at the LHC in the forward direction.

Approved by the CERN Research Board on March 17, 2021.

Comprises 24 institutes from 13 countries.
Location: TI18

- TI18 is a former service tunnel connecting SPS to LEP
- Symmetric to TI12, where FASER is located
- 480 m from ATLAS interaction point
- Well shielded with ~ 100 m of rock
Detector Layout

- Off-axis location
  → Allow to probe region of $7.2 < \eta < 8.6$
- Veto system, target tracker (emu+scifi), muon system
- Target material: tungsten
- Passive muon material: Iron
- Target region placed in a cold box
- Detector placed on a slope
Physics program during Run 3

- Measurement of the $pp \rightarrow \nu + X$ cross-section for all neutrino flavors in the range $7.2 < \eta < 8.6$
- Study charm production using $\nu_e$ as a probe
- Lepton universality tests: $\nu_\tau/\nu_e$ and $\nu_\mu/\nu_e$
- Measurement of the NC/CC ratio
- Direct search for feebly interacting particles
Event reconstruction

First phase: electronic detectors
- Identify $\nu$ candidates
- Identify final state muons
- Reconstruction of EM showers (SciFi)
- Measure $\nu$ energy (Muon+SciFi)

Second phase: nuclear emulsions
- Identify EM showers
- $\nu$ vertex reconstruction
- Match with electronic detectors (timestamp)
The Veto Detector

- Veto located in front of Emulsion/Scifi target tracker
- Used to veto incoming charged particles
- Comprises 2 planes of 7 stacked scintillating bars r/o by 8 SiPMs per bar end
- DAQ with custom PCB + TOFPET
The Emulsion Target

- Target region of Emulsion cloud chambers (Emulsion + Tungsten) for neutrino interaction detection
- Comprises 5 emulsion wall
- Target mass: 830 kg
- Covers a surface of $390 \times 390 \text{ mm}^2$
The SciFi Tracker

- SciFi tracker embedded in the target
- 5 planes Scintillating fibres
- Used to provide timestamp to emulsion tracks
- Provides identification of EM showers (ECAL)
- Provides energy of $\nu$ together with Muon system (HCAL)
- DAQ based on TOFPET
The Muon System

- Located behind the target region
- Scintillating planes interleaved with iron as passive material
- Used to identify muons (most penetrating) and together with SciFi acts as a HCAL
- Upstream Muon: 5 planes of 10 stacked scintillating bars r/o by 8 SiPMs per bar end
- Downstream Muon: 3 double planes (horizontal and vertical) of this scintillating bars r/o by single SiPMs per bar end for horz. and only from top for vert.
  → additional 4th vert. layer to increase efficiency
- DAQ with custom PCB + TOFPET
Detector assembly
Muon system energy calibration

- Together with the SciFi, the muon system will be used as a hadronic calorimeter for energy reconstruction of the muon
- Energy calibration needed to tune MC
- Two testbeams at the CERN SPS H8 beamline in Sept 1-5 and Oct. 1-6
- Collected data with:
  - 140, 180, 240, 300 GeV $\pi$
  - Beam muons, cosmics
Commissioning

- Commissioning ongoing in the H6 beamline of SPS (parasitic muons)
- Integration of Veto, Muon, Scifi
- Check mechanical structure
- Installation dry run (with spacial constraints)
Installation Schedule

- Installation of electronic detectors and mechanics from Nov-Dec 2021
- First emulsion wall installed in Feb 2022, 5 planes installed in June 2022
SND@LHC is one of two neutrino detectors at the LHC

Unique physics program covering Run 3 of the LHC to study all 3 neutrino flavors

Comprises a veto system, target tracker (emu+SciFi) and a downstream muon ID system

Approved in March 2021

Construction mostly complete

Installation beginning Nov. 2021
### Uncertainties

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Uncertainty</th>
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<tbody>
<tr>
<td>$pp \rightarrow \nu_e X$ cross-section</td>
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<tr>
<td>Charmed hadron yield</td>
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<tr>
<td>$\nu_e/\nu_\tau$ ratio for LFU test</td>
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<tr>
<td>$\nu_e/\nu_\mu$ ratio for LFU test</td>
<td>10%</td>
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<tr>
<td>NC/CC ratio</td>
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