The SND@LHC data acquisition system

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EPFL

Outline

- The SND@LHC detector
- Detector preparation
- Data Acquisition (DAQ) system

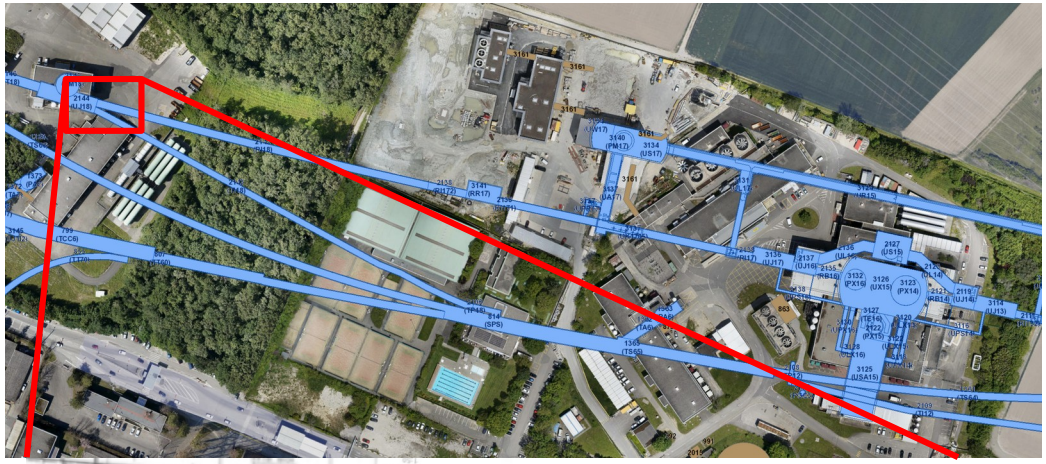
SND@LHC

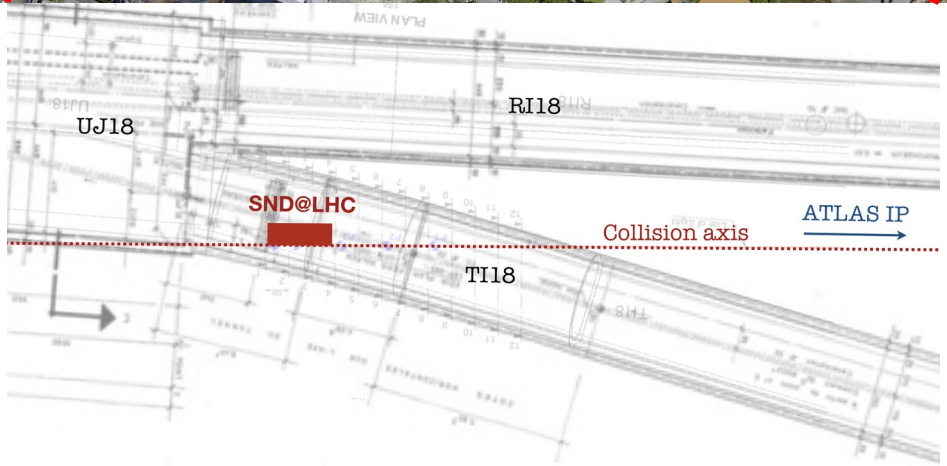
- Scattering and Neutrino Detector at the LHC
  - 24 institutes in 13 countries
  - In Switzerland: EPFL and UZH
- Compact experiment, optimised for detecting the 3 neutrino flavours
- Experiment approved by the research board in March 2021
- Assembly and preparatory works currently ongoing

- Physics programme
  - Measurement of the $pp \longrightarrow \nu_e X$ cross-section
  - Heavy flavour production in pp collisions
  - Lepton flavour universality in neutrino interactions
  - Measurement of the NC/CC ratio
  - Search for non-SM feebly-interacting particles

Location

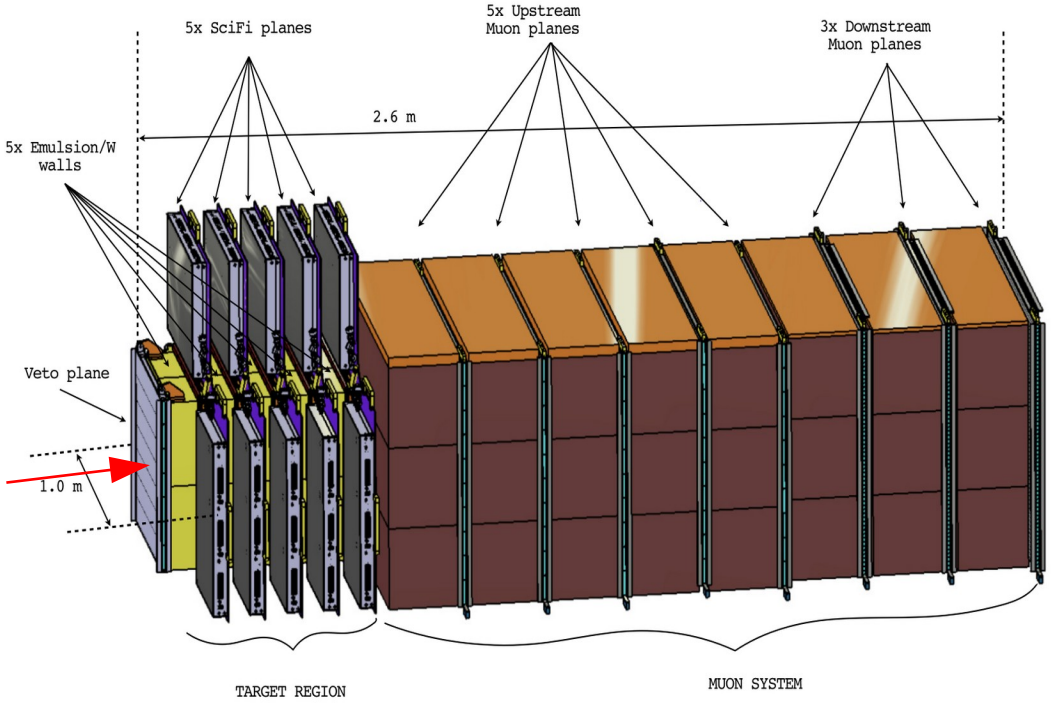
- TI18 tunnel
  - Former service tunnel connecting SPS to LEP
  - Symmetric to TI12, where FASER is located
- ~480 m from ATLAS interaction point
  - Shielded with ~100 m of rock
- Angular acceptance: $7.2 < \eta < 8.6$
  - Offset wrt collision axis





SND@LHC

- Veto
  - Scintillators: tag incoming muons
- Target region
  - Emulsion cloud chambers (830 kg): neutrino interaction detection
  - Scintillating fibres tracker: timestamp, position and energy measurement
- Muon system
  - Iron walls and scintillators: energy measurement and muon detection

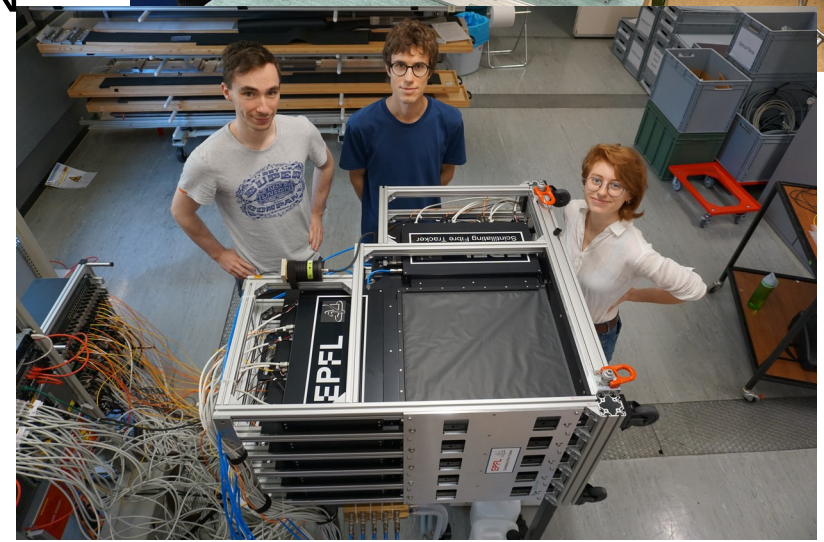


Tunnel preparation

- Ongoing preparatory works
- Services installation
- Cryostat protection

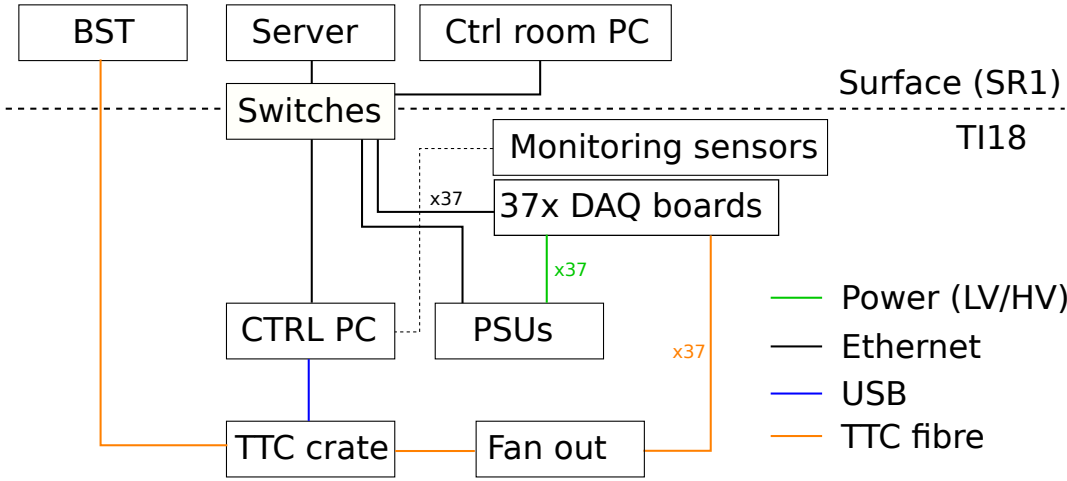
Detector assembly

- Assembly and testing currently ongoing
  - SciFi tracker and DAQ at EPFL
  - Veto and muon system at CERN
- Full detector commissioning at CERN starting this month
- Installation in the tunnel in November



The DAQ system

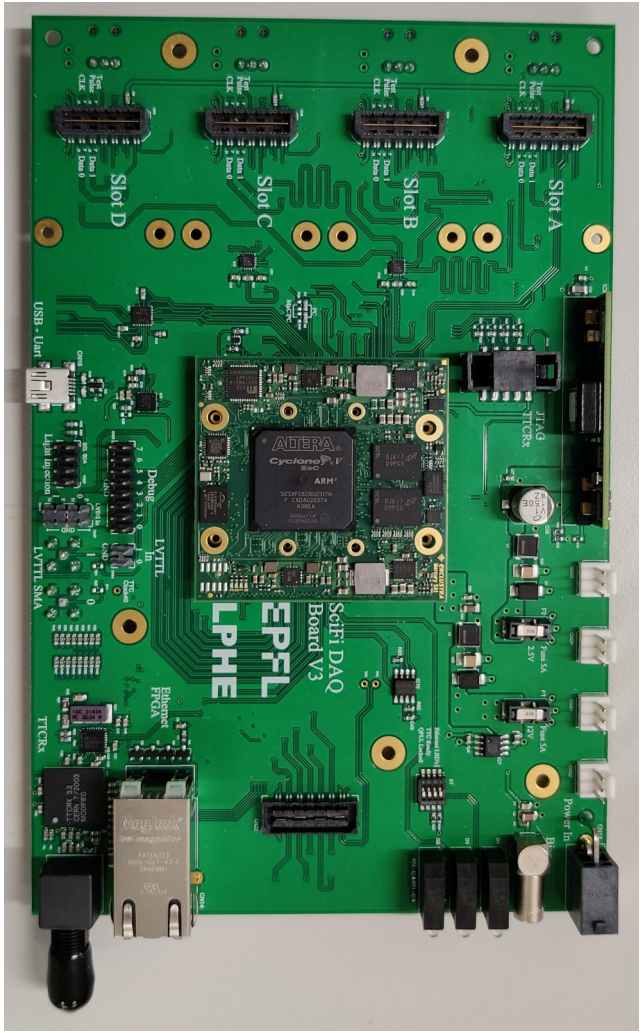
- Veto, SciFi tracker, muon system read-out with common DAQ board
  - 37 boards used
  - Synchronous to LHC clock
  - Data transmitted to server on the surface
- TTC system receives LHC clock from BST and distributes it to DAQ boards



TTC: Timing, Trigger and Control
BST: Beam Synchronous Timing

The DAQ boards

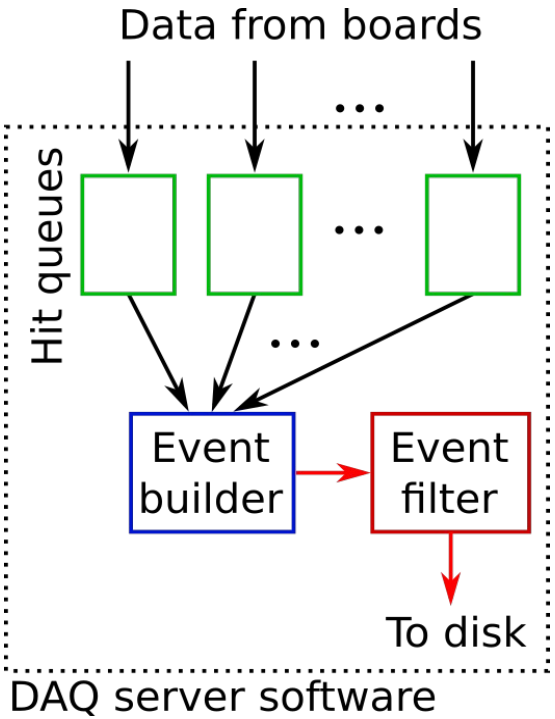
- Same DAQ board for all subsystems
- Developed at EPFL, based on Cyclone V processor+FPGA
  - Clock from TTC system, using TTCrx chip
  - Data transmitted over Ethernet to the server
- 4 front-end board slots
  - 512 channels in total



The front-end boards

- Each board contains 2 TOFPET2 chips
  - Analogue front-end and ADCs
  - Data fully digitized
  - 128 channels in total
- Allows for low signal thresholds (1.5 pe)
  - 3-threshold system for best time and amplitude resolution and dark noise reduction
- Good timing (40 ps resolution) and amplitude measurement with charge integration or time-over-threshold

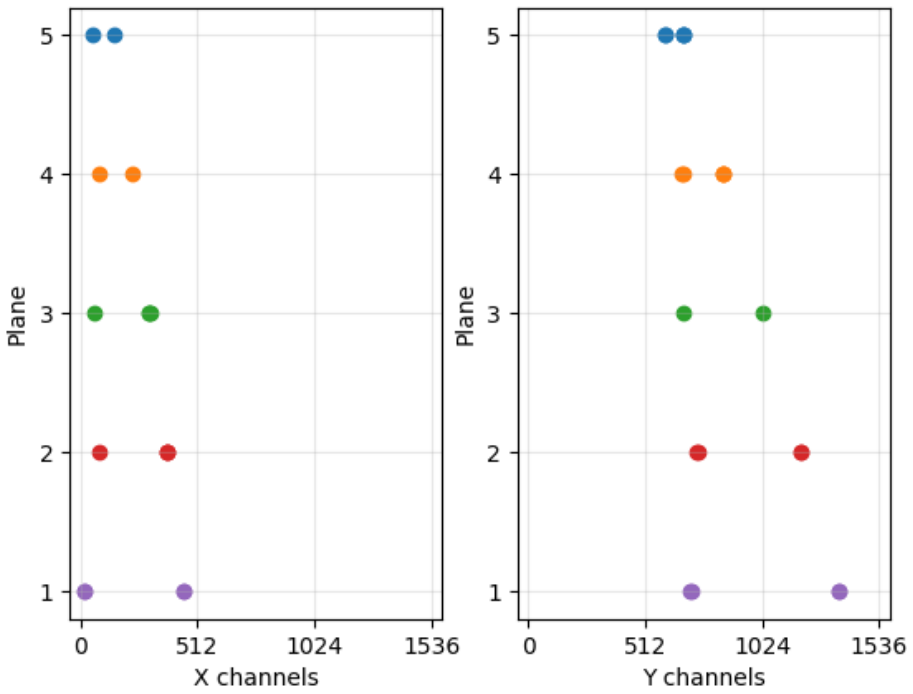
The DAQ system



- Triggerless system
  - All data above threshold is sent to the server
- Event building
  - Hits from all boards are build into events based on timestamp
- Online noise suppression
  - Events required to have signal from a minimum number of boards
- Valid events saved to disk

First data

- First test of DAQ system performed on SciFi tracker
- Detector oriented to take cosmic rays data
- First runs
  - Determine event building capabilities (max hit rate ~ 200 kHz)
  - Find best thresholds and parameters



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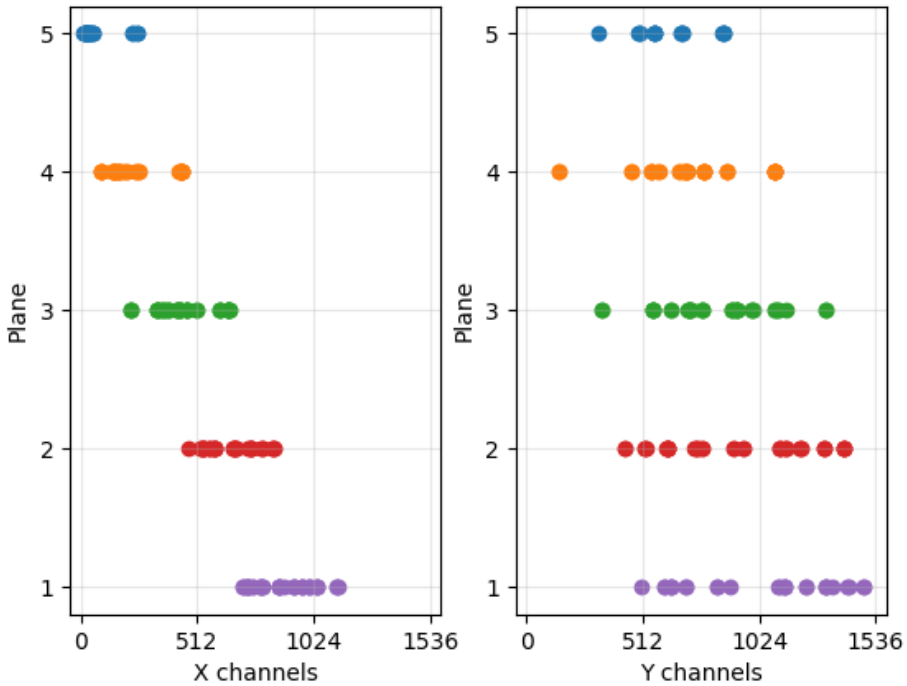

Conclusions

- SND@LHC is a compact detector optimized for the 3 neutrino flavours
- Its construction is underway, expected installation at the end of the year
- DAQ system based on custom DAQ board and front-end
  - Triggerless readout
  - Online event building and noise suppression
- System performance is being evaluated

Backup

Performance assessment

- Efficiency measurement
  - With tracks reconstruction
- Channels time alignment
  - Using light injection system
- Time/energy resolution evaluation
- Will be performed in the coming weeks