FASER Experiment - General Overview

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CHIPP Winter School, Adelboden, 20^{th} January, 2022

Introduction

Why building a new detector?

- LHC searches focus on high p_T regions $\longrightarrow$ heavy, strongly interacting particles
- For light and weakly interacting particles, this may be completely misguided
- Searches for new weakly interacting light particles, coupling to SM in forward region
  - Produced in decays of light mesons (e.g. π, K), abundantly present in pp collisions, primarily in large pseudorapidity

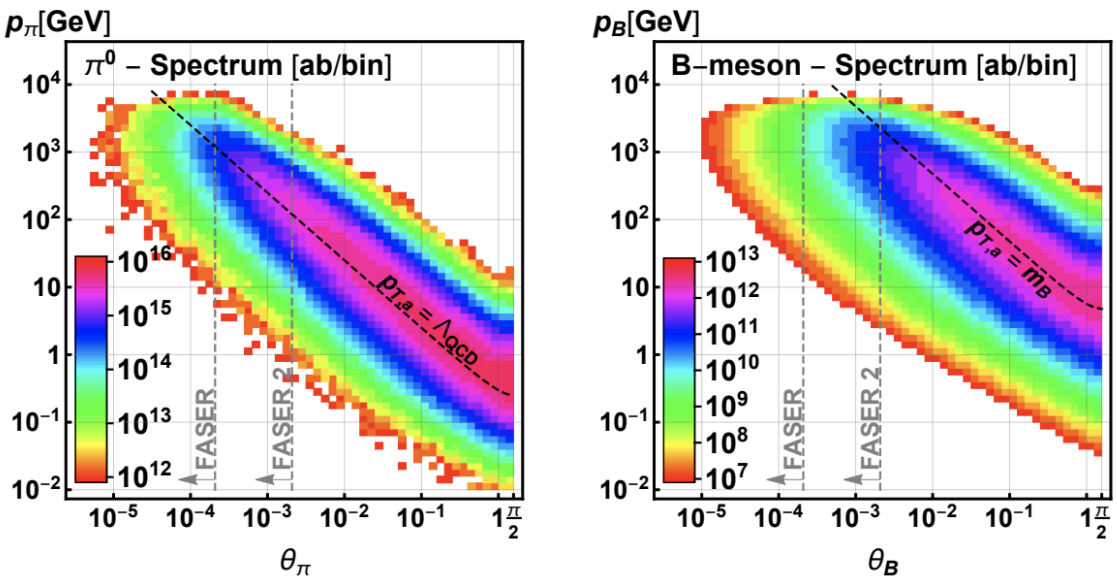


Figure: Production rates of light hadrons in pp collisions in LHC as a function of θ and p.

FASER experiment

Requirements and specifics of the detector

- Tight timeline between the experiment approval and installation, limited budget and environment of the LHC tunnel:
  - detector that can be constructed and installed quickly and cheaply
  - tried to re-use existing detector components where possible
  - tried to minimize services to simplify the installation and operations
  - aimed for the simple and robust detector (difficult access)
- A lot of challenges specific for the LHC experiments not present:
  - trigger rate $\mathcal{O}(500\,\mathrm{Hz})$ — mostly single muon events
  - low radiation
  - low occupancy
  - small event size

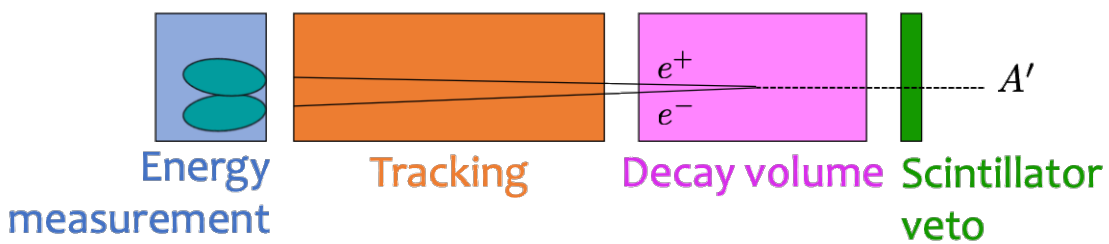
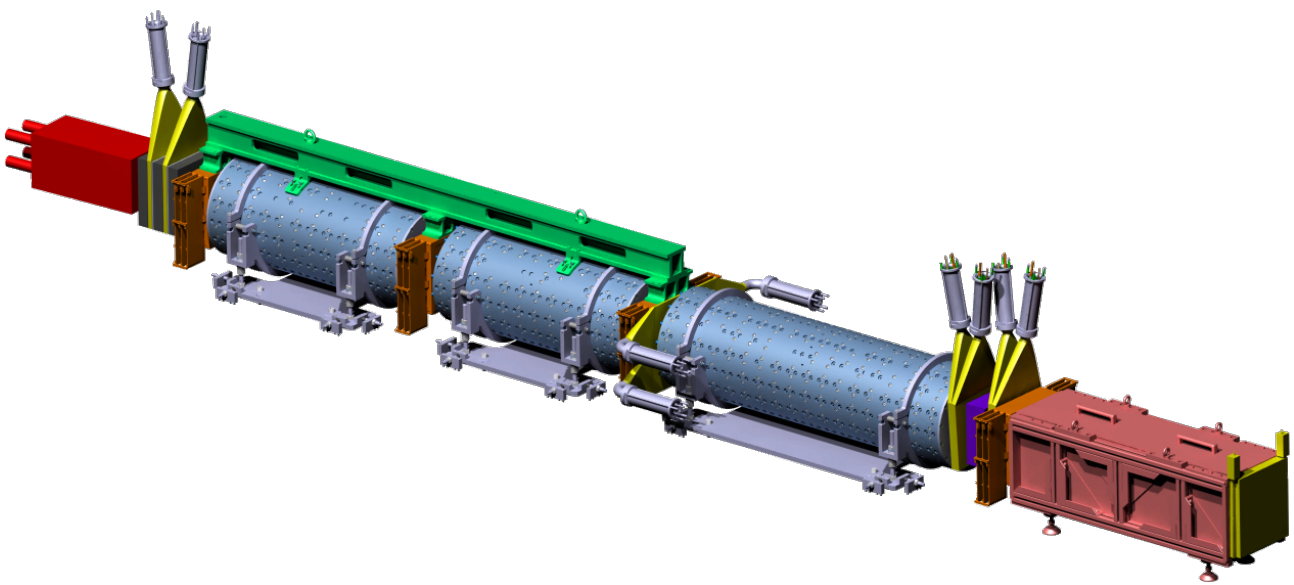


Figure: The main detector subsystems.

Detector design

FASER

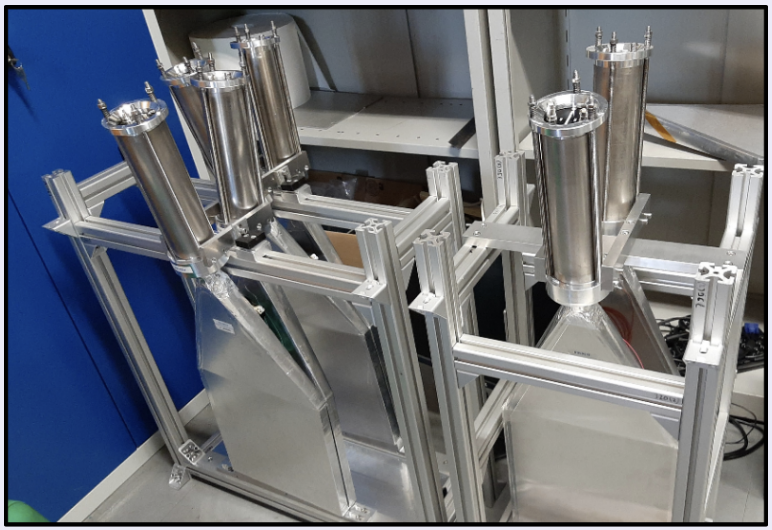
- Consists of several key components
  - scintillators
  - FASERν
  - tracker
  - permanent magnets (0.55 T, 1.5 m long decay volume)
  - calorimeter
  - TDAQ

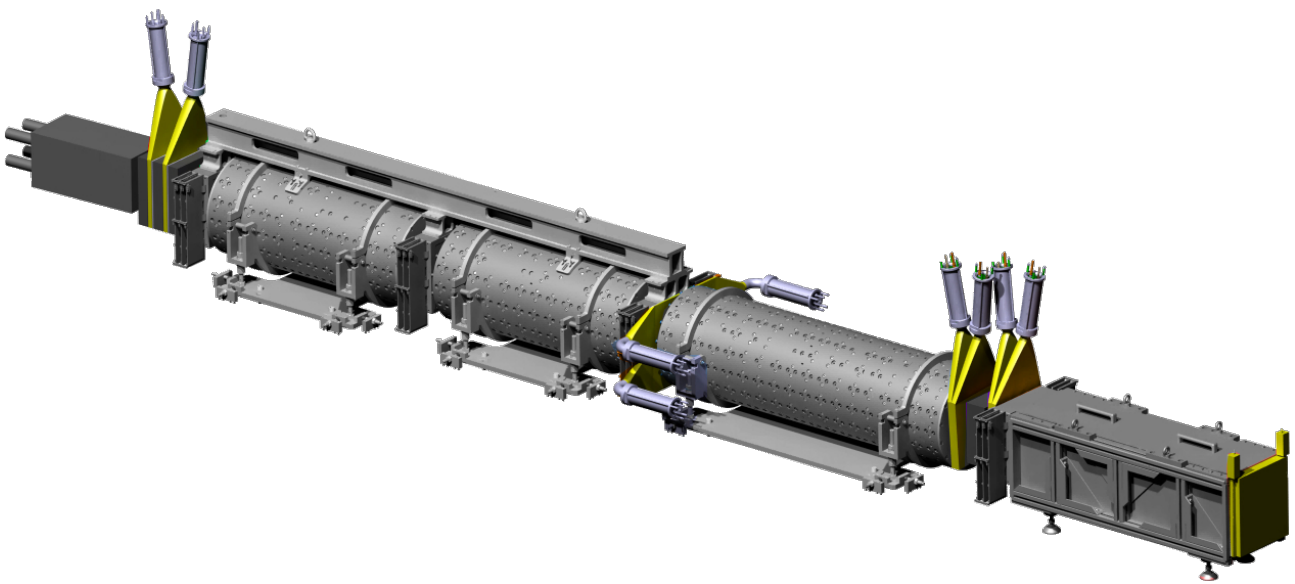


Detector design

Scintillators

- Four scintillator stations
  - triggering
  - veto
  - timing of the event $\mathcal{O}(1)$ ns
  - preshower for the calorimeter

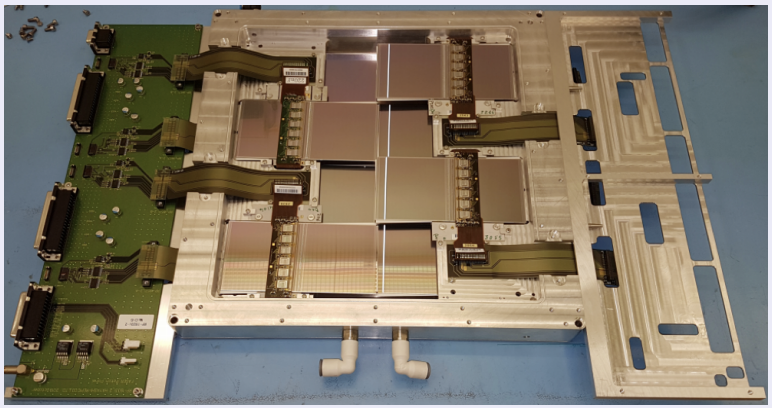


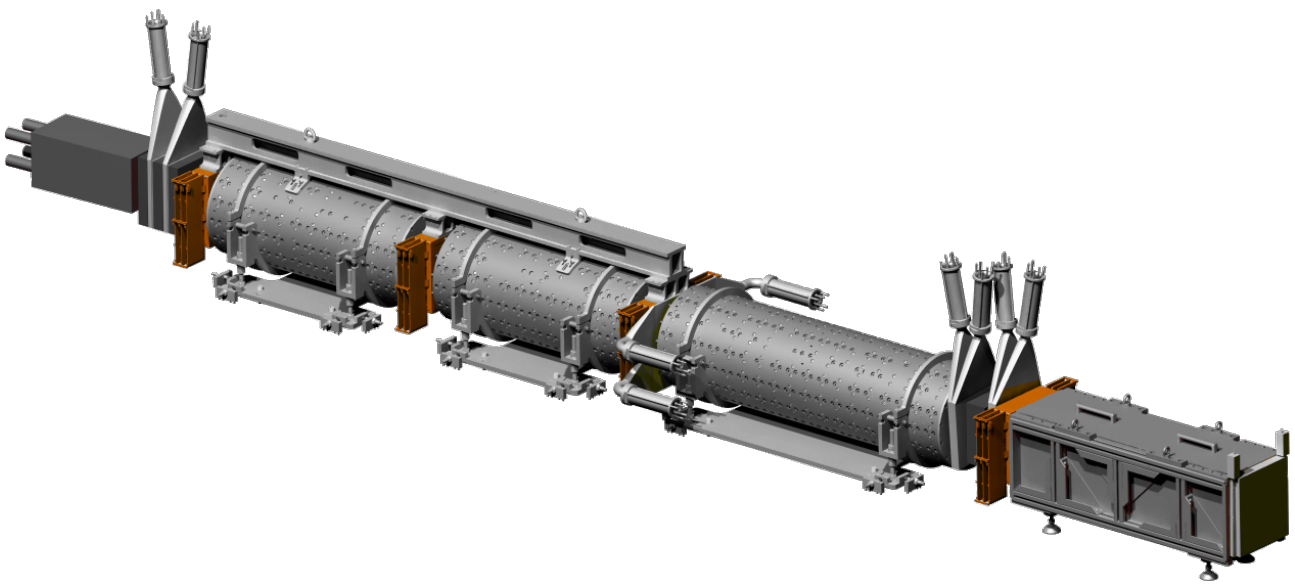


Detector design

Tracker

- Consists of three tracking stations + interface tracker
  - Each station has three layers
  - Each layer has 8 silicon strip double-sided modules (originally for ATLAS)
- strip pitch 80 μm with 40 mrad stereo angle

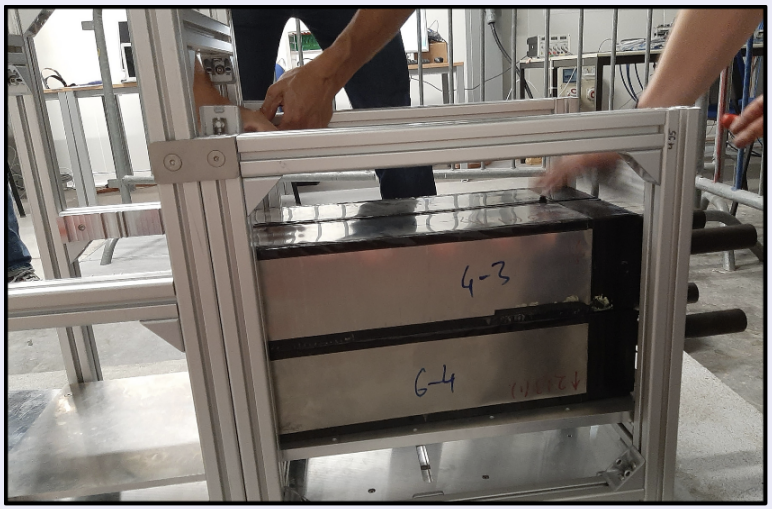


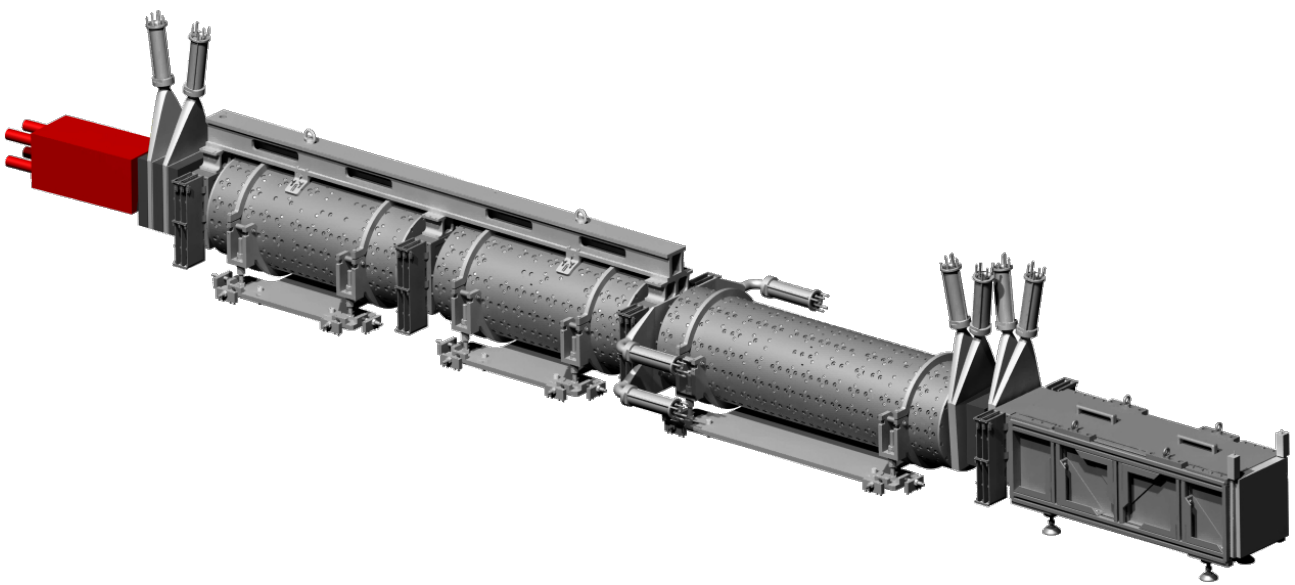


Detector design

Calorimeter

- Uses four spare LHCb outer ECAL modules.
- Electromagnetic calorimeter designed to stop highly energetic photons and electrons, identify them and measure their energies
- Energy resolution ∼1% for TeV deposits

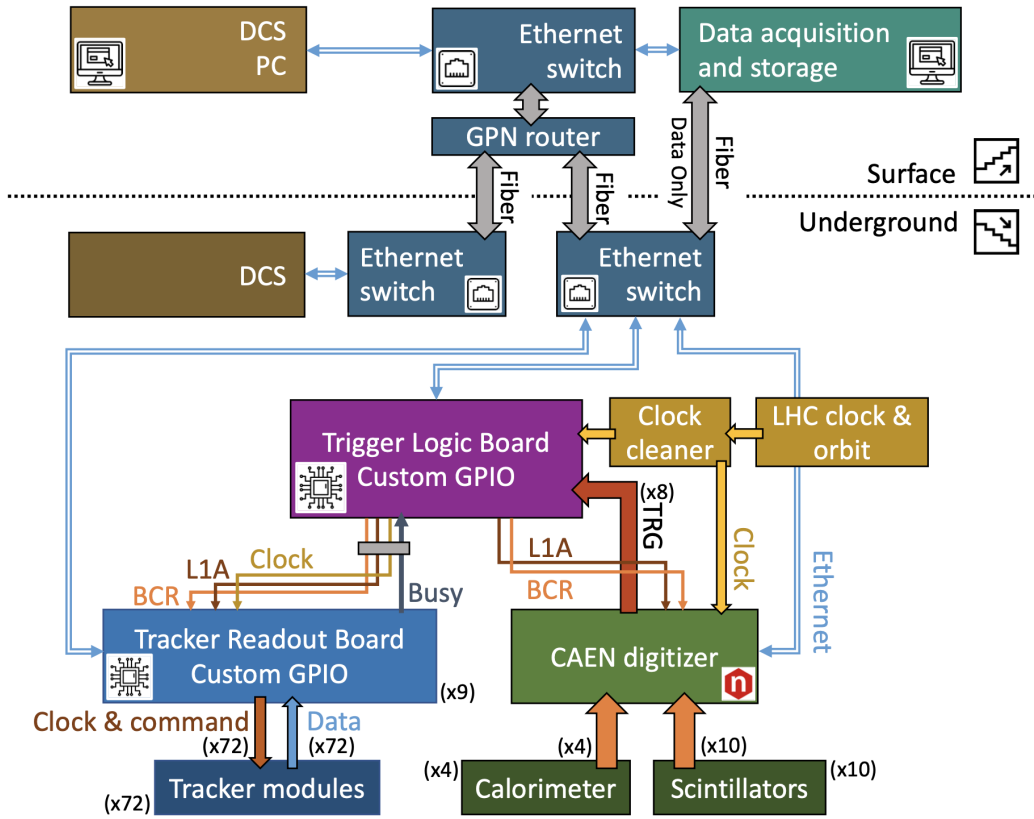




Detector design

TDAQ

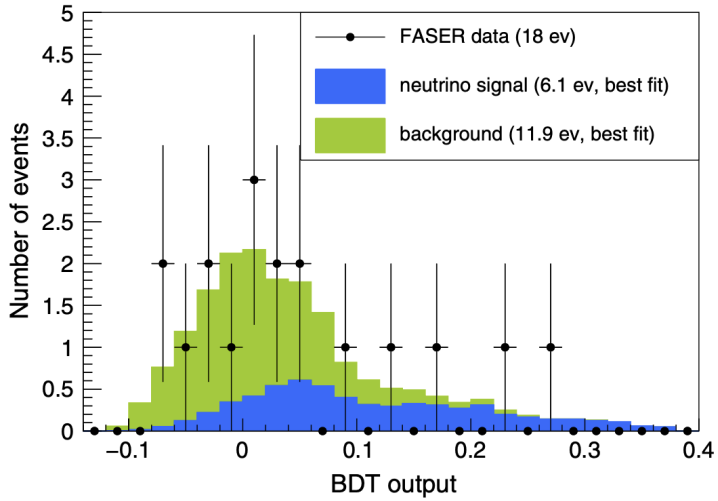
- Scintillators and calorimeter used for triggering
- Expected trigger rate of 500-1000 Hz
  - dominated by muons from the ATLAS IP
  - ∼5 Hz of energetic signatures deposited in calorimeter
- TDAQ electronics placed in TI12

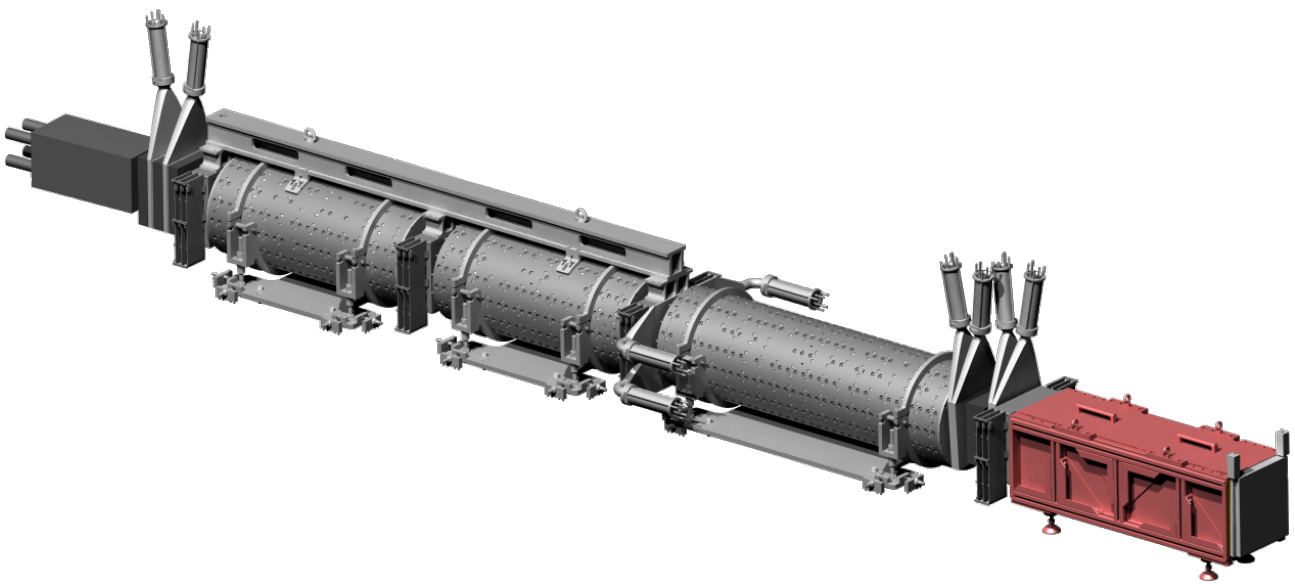


Detector design

FASERν

- FASER subdetector aiming for the first-ever detection of collider neutrinos
- Emulsion detector – 770 emulsions interleaved with 1-mm-thick tungsten plates (total target mass of 1.1 tonnes)
- A small FASERν pilot detector, installed into the LHC tunnel for 1 month in 2018 LHC running, detected several ν candidate events (PhysRevD.104.L091101)





FASER installed in the tunnel TI12

Outlook

- Waiting for the first beams in Run 3 and the first data
  - discovery potential or putting constrains on current theories
  - the first collider-originated neutrino measurements
- Preparing upgrade for FASER preshower detector do be able to distinguish two-photon events
- Studies started for a bigger FASER2 detector, as part of the proposed Forward Physics Facility (FPF) arxiv:2109.10905

Thank you for your attention