Design and commissioning of the FASER trigger and data acquisition system

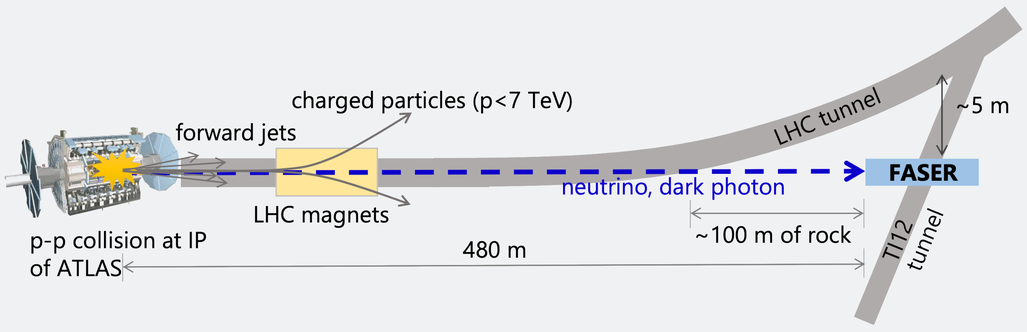
Ondřej Theiner on behalf of FASER collaboration

EPS-HEP Conference 2021, virtual edition, 26th-30th July 2021

UNIVERSITÉ DE GENÈVE

Introduction

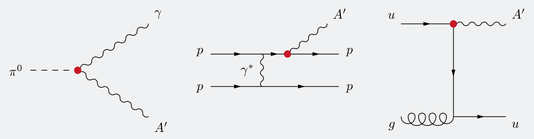
- FASER is a small **new experiment** looking for decays of **exotic weakly-interacting particles** and **TeV energy neutrinos**, produced in pp collisions at ATLAS in the very forward region, **out of the ATLAS** detector **acceptance**
- it is placed 480 m downstream of the ATLAS interaction point (IP) in unused service tunnel TI12



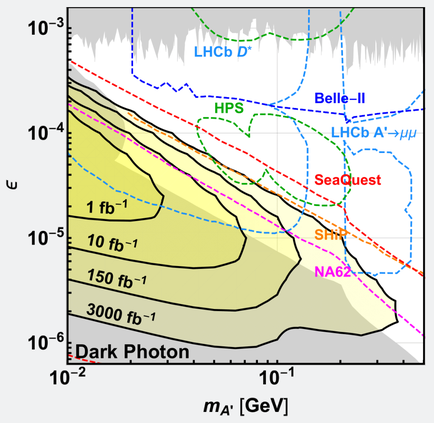
FASER location inside TI12 with respect to the ATLAS IP.

Physics motivation

- **large number of light particles** is produced in pp collisions with **very low** p_T
  - possible exotic light particles weakly coupled to SM
- large boost factors $\rightarrow$ probability of long–lived particles (LLPs) decaying in FASER
  - dark vectors, dark scalars, heavy neutral leptons, axion-like particles (ALPs), ...



Some production modes of dark photon.



FASER's reach for dark photons. ϵ is the coupling parameter of dark photon to SM. Gray–shaded regions are excluded by current bounds.

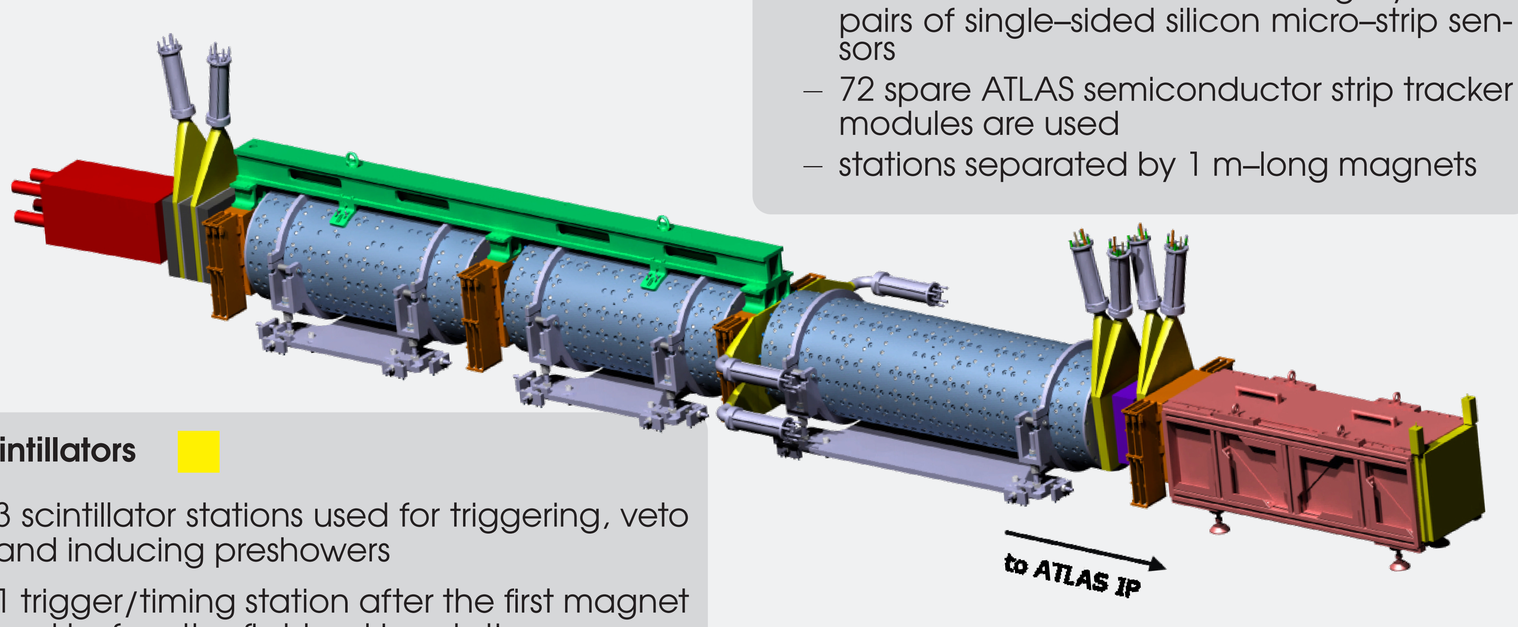
Detector design

Calorimeter

- electromagnetic calorimeter designed to stop highly energetic photons and electrons, identify them and measure their energies
- uses four spare LHCb outer ECAL modules

Tracker

- 3 tracking stations used to detect two oppositely charged tracks originating from common vertex + 1 interface tracking station connecting FASERν and main FASER detector
  - each station consists of 3 tracking layers of 8 pairs of single–sided silicon micro–strip sensors
  - 72 spare ATLAS semiconductor strip tracker modules are used
  - stations separated by 1 m–long magnets



Scintillators

- 3 scintillator stations used for triggering, veto and inducing preshowers
- 1 trigger/timing station after the first magnet and before the first tracking station
- 1 scintillator before FASERν

FASERν

- FASER sub–detector – designed to detect **collider neutrinos** for the first time
- composed of a repeated structure of emulsion films interleaved with 1-mm-thick tungsten plates (1000 emulsion in total)

Magnets

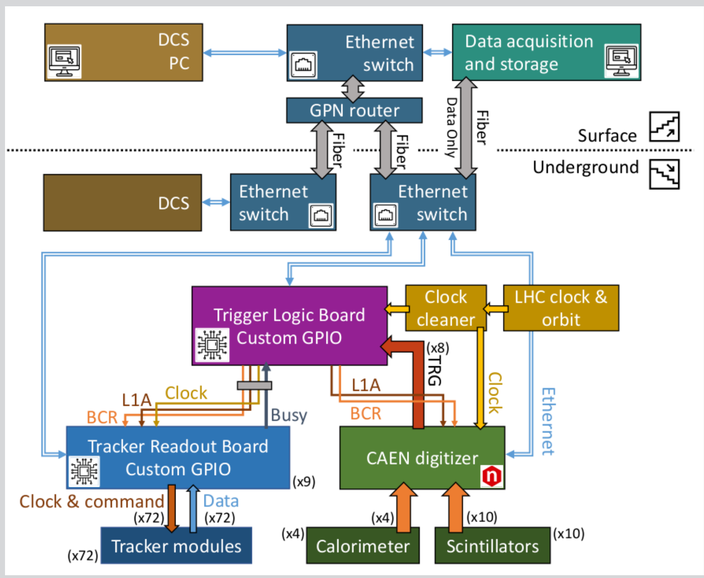
- one 1.5 m–long (decay volume)
- two 1 m–long permanent magnets (spectrometer)
- 0.55 T to distinguish pairs of oppositely charged, high–energy SM particles, originating from decays of new physics particles

TDAQ

- scintillators and calorimeter used for triggering
- expected trigger rate of 500-1000 Hz
  - dominated by muons from the ATLAS IP
  - $\sim$5 Hz of energetic signatures deposited in calorimeter

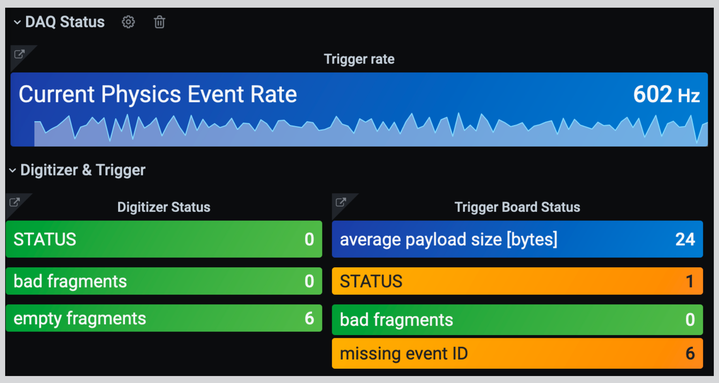
Data flow

- digitizer board generates trigger signals after receiving above-threshold detector signal from scintillators and/or calorimeter
- trigger signal processed by trigger logic board (TLB) - central triggering board of the experiment
- TLB provides global accept signal to detector boards to read out the data from detector
- data are assembled and saved to the storage



Monitoring

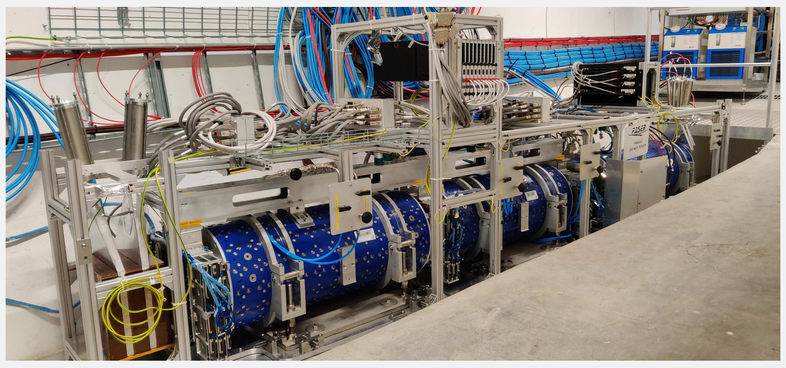
- FASER will not have any control room $\rightarrow$ need of robust run control and monitoring system
- monitoring is mostly based on Grafana – database used for time series plotting



Part of Grafana monitoring dashboard.

Commissioning

- commissioning split into three parts
  - testing individual components at UniGe and CERN
  - on-surface commissioning of complete detector setup at CERN in a dedicated hall
  - commissioning of assembled detector in TI12 tunnel
- all testing steps used generator pulses or cosmic muons



FASER inside the tunnel TI12.

Testing individual components

- development of TDAQ system, testing of scintillators, calorimeter modules and tracker stations

On-surface commissioning

- commissioning of various detector pieces and also testing mechanical assembly of the whole experiment

Commissioning in the tunnel

- detector in the full setup
- mainly focused on testing of reliability and robustness of the system
  - extensive testing with help of shifters who were checking monitored variables 24/7 during several weeks
  - further test are currently ongoing
- using cosmic muons for triggering

HEISING-SIMONS FOUNDATION
SIMONS FOUNDATION
FNSNF FONDS NATIONAL SUISSE DE LA RECHERCHE SCIENTIFIQUE

https://faser.web.cern.ch/