The FASER experiment @ the LHC

https://faser.web.cern.ch

Andrea Coccaro on behalf of the FASER collaboration
Lomonosov Conference - https://lomcon.ru/
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Physics prospects

Experiments at the LHC focus on heavy, strongly interacting particles by looking at the transverse plane. In absence of signals of new physics at the TeV scale, the initial paradigm broadened

- Using existing experiments / with new triggers, or new reconstruction techniques, with displaced objects, with analysis with trigger-level quantities, etc.
- Proposing new experiments / to complement the coverage of existing experiments, mainly towards longer lifetimes and lower masses

FASER aims at searching for light and weakly-interacting particles

- By looking at the very-forward region at a distance where known background is highly suppressed
- With a dedicated, low-budget detector placed in the TI12 side tunnel at the LHC
- Supported by the Simons and Heising-Simons foundations

The idea behind FASER

New physics at the LHC focus at high p_T

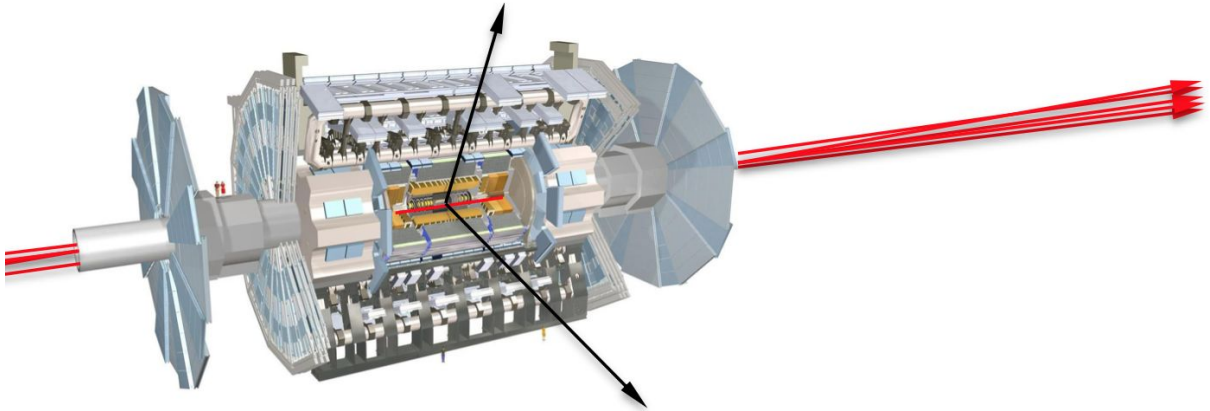
$$\sigma_{NP} \sim \text{pb/fb} \Rightarrow N_{NP} \sim 1.5 \cdot 10^2/10^5 \text{ with } \mathcal{L}=150/\text{fb}$$

If new physics is light and weakly-interacting

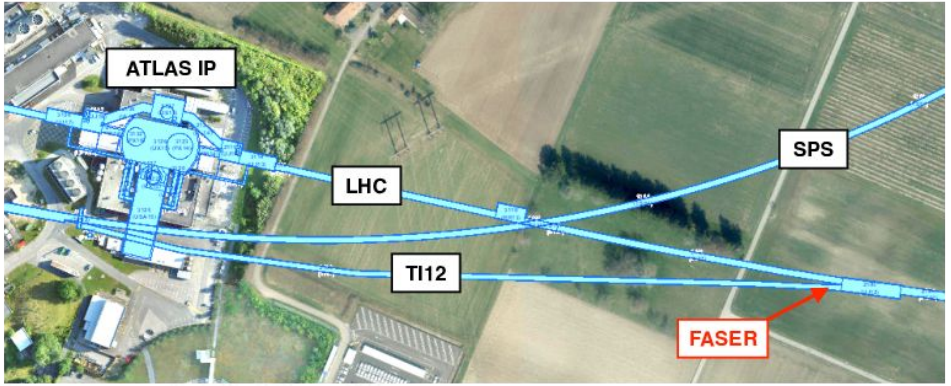
$$\sigma_{\text{Inelastic}} \sim 75\ \text{mb} \Rightarrow N_{\text{Inelastic}} \sim 10^{16} \text{ with } \mathcal{L}=150/\text{fb}$$

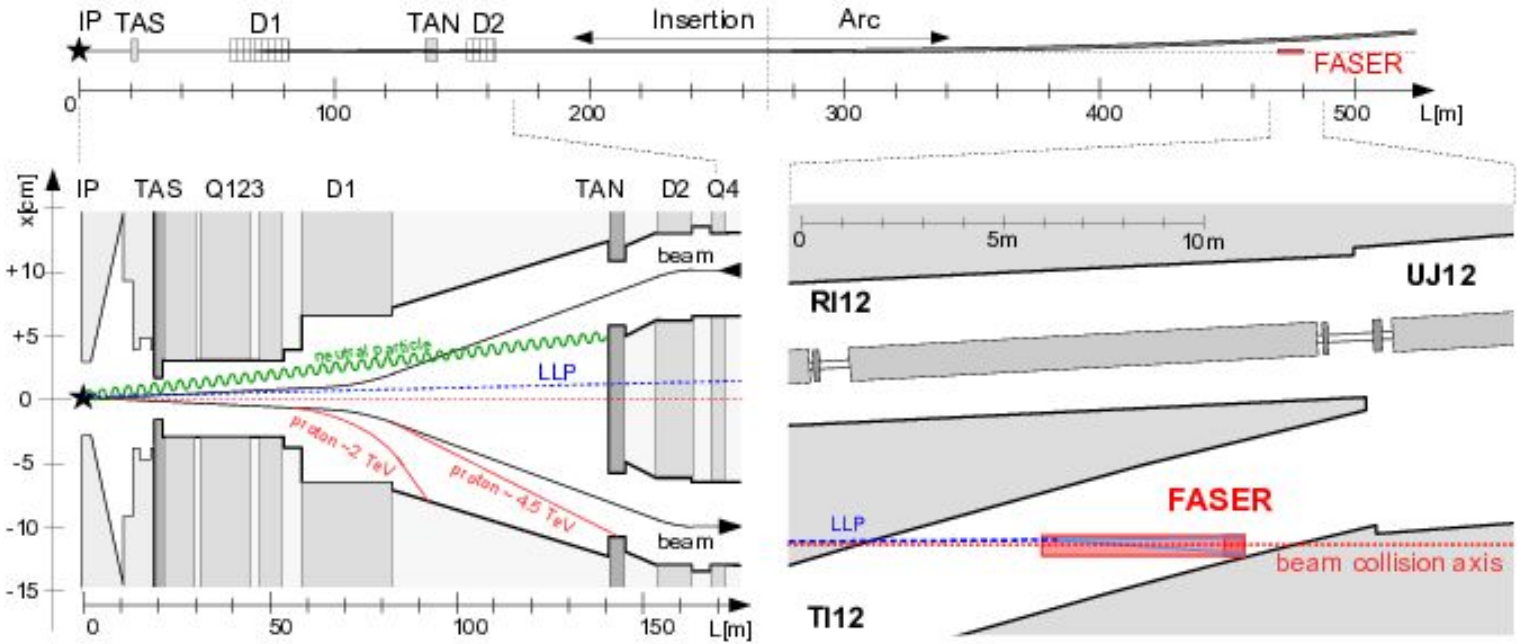
That implies extraordinary rates for low-mass SM particles in the very-forward region

$N(\pi^0) \sim 10^{17} \Rightarrow$ ~1% within the FASER acceptance (and decay products also highly collimated)



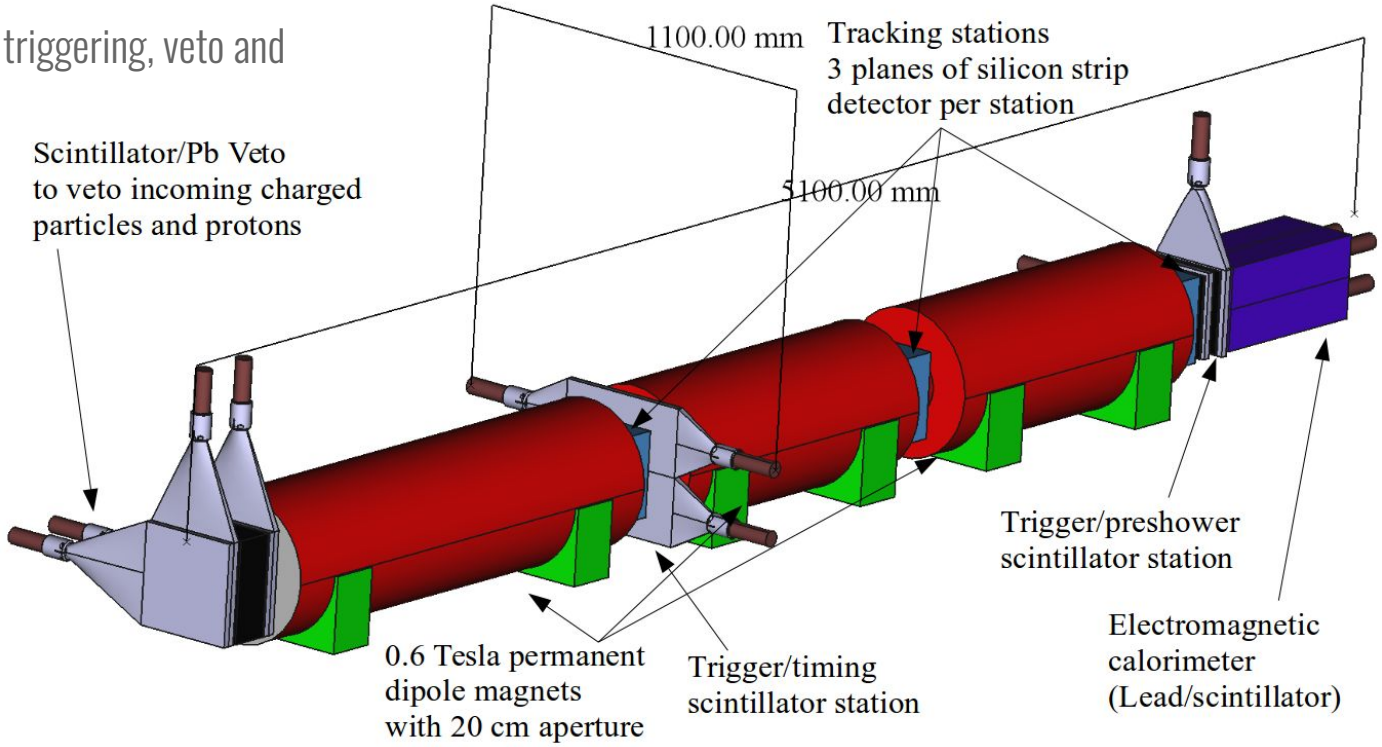
FASER location



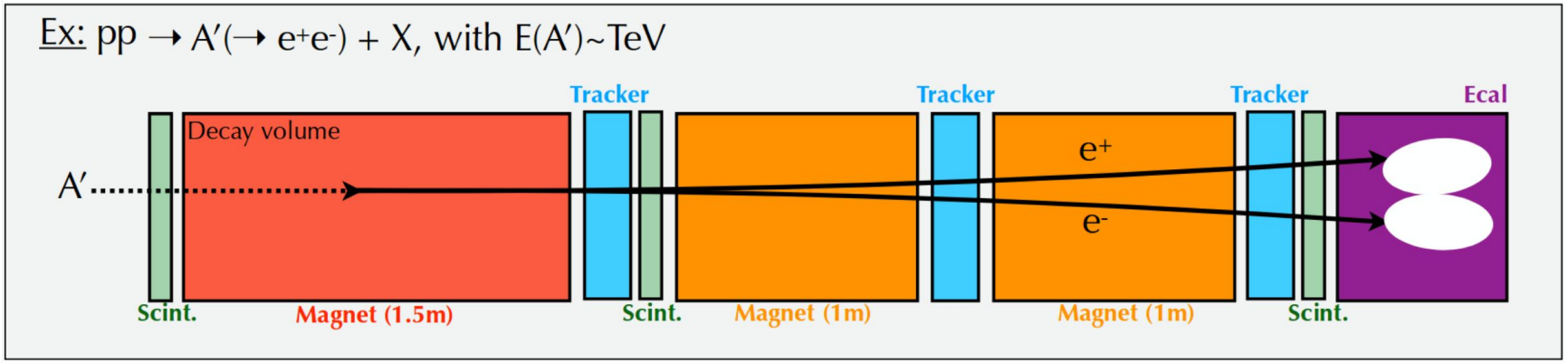


Detector Layout

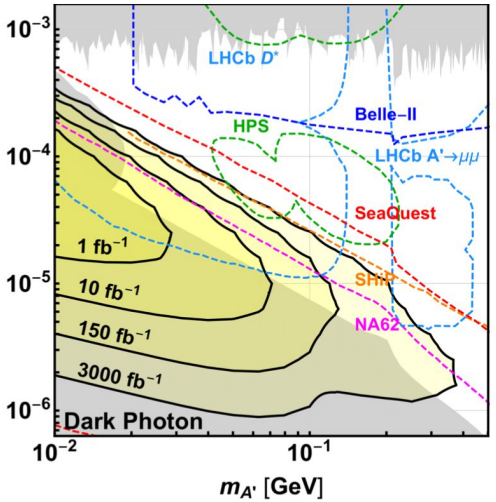
- 1.5-meter magnetized decay volume
- 2-meter spectrometer with three tracking stations
- electromagnetic calorimeter
- three scintillator stations for triggering, veto and precise timing
- 20cm aperture (η>9.1)



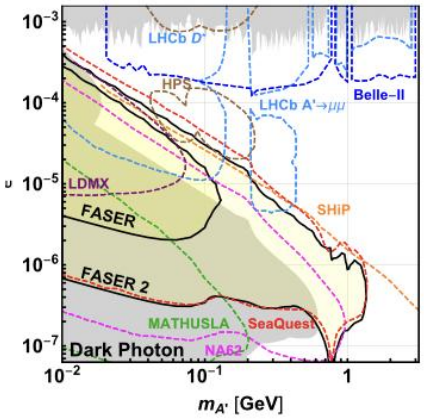
Sensitivity to dark photons

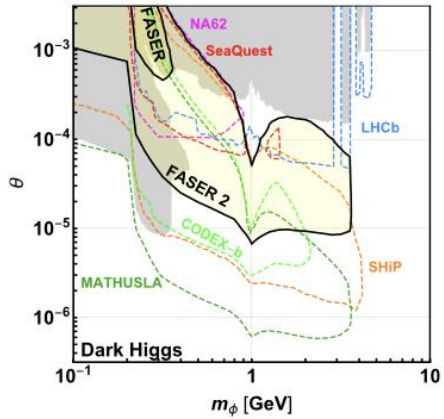


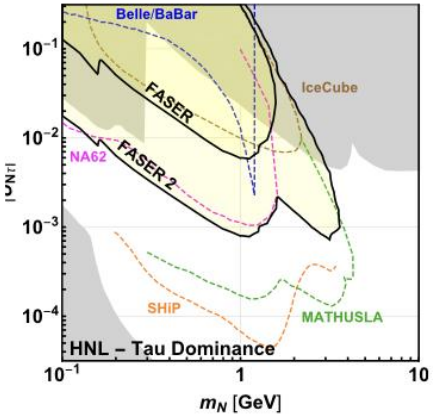
- two high-energetic, oppositely-charged tracks originating from common vertex in the decay volume and pointing back to the IP
- no signal in the scintillator station
- energy deposit in the calorimeter

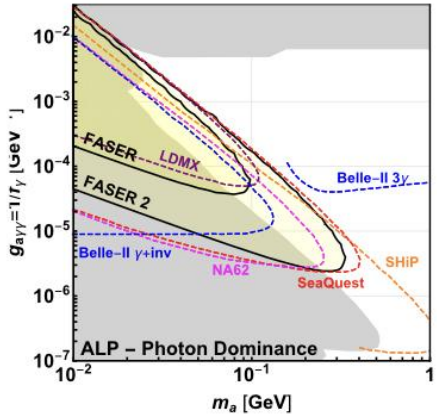


Discovery potential









FASER (fully funded)

- L=1.5m, R=10cm, $\mathscr{L}$=150/fb

FASER2 (projection for HL-LHC)

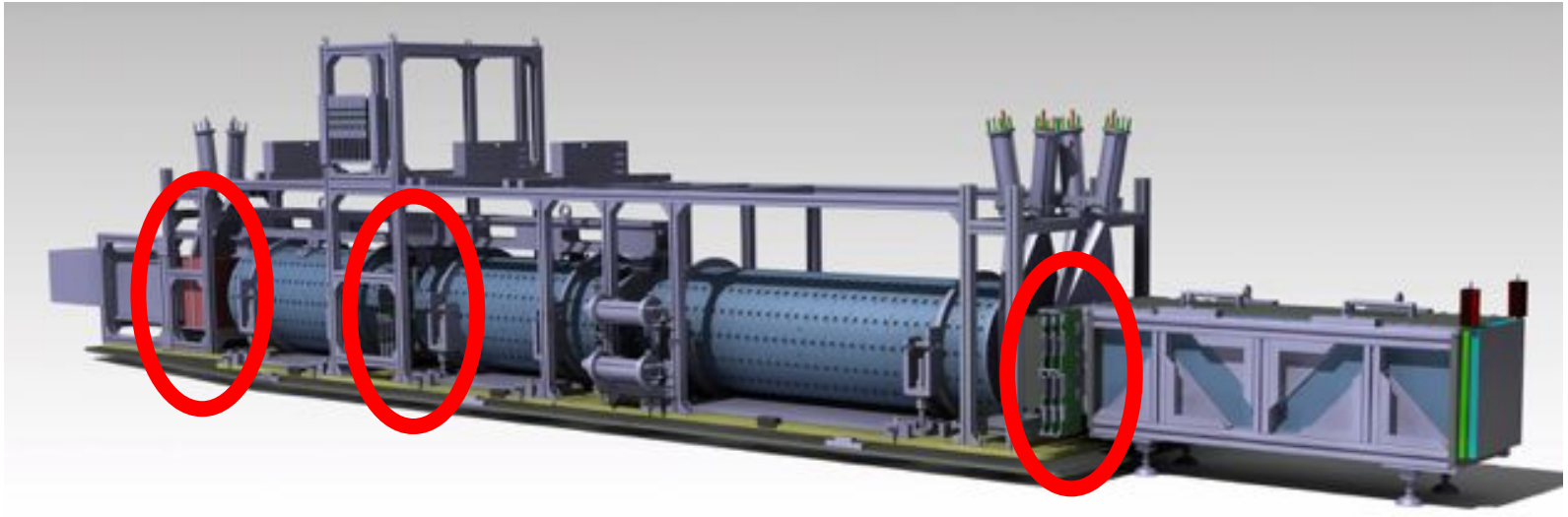
- L=5m, R=1m, $\mathscr{L}$=3/ab

More details on the FASER physics in [Phys. Rev. D 99, 095011]

Tracker

Using spare silicon strip modules (SCT) from ATLAS

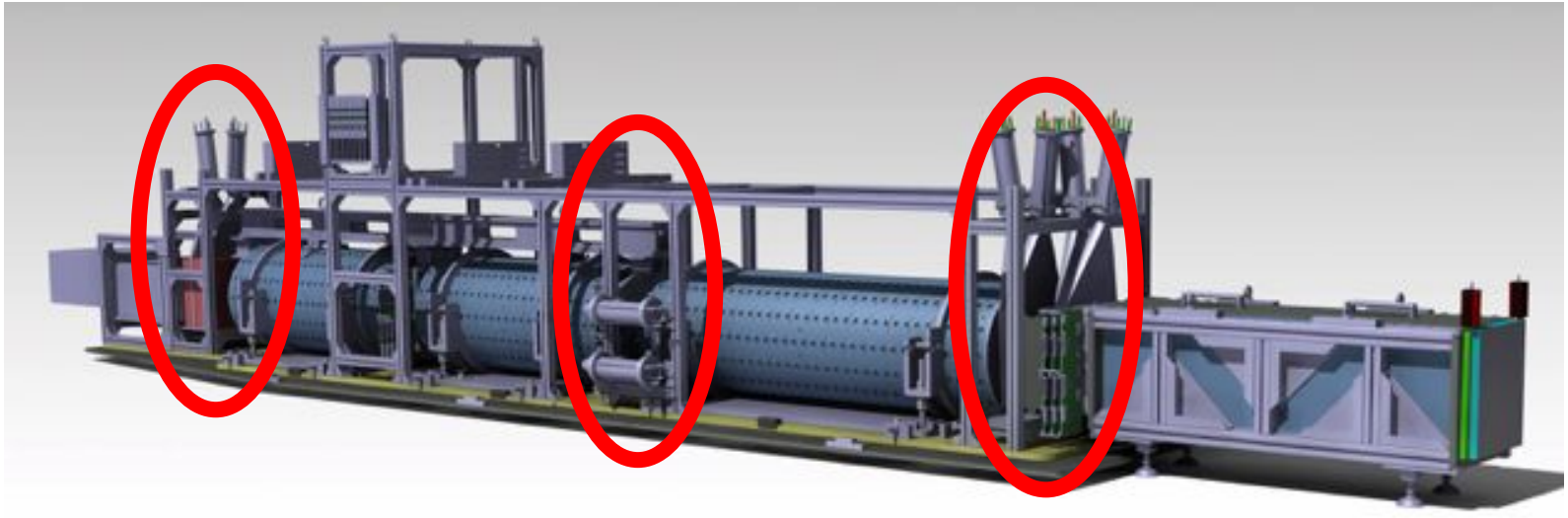
- 72 modules with O(10^5) channels arranged in 3 stations with each 3 layers of 8 modules
- 25um resolution and <0.1% defects with extensive testing on surface and cosmic ray runs



Scintillators

Trigger capabilities in 3 scintillator stations

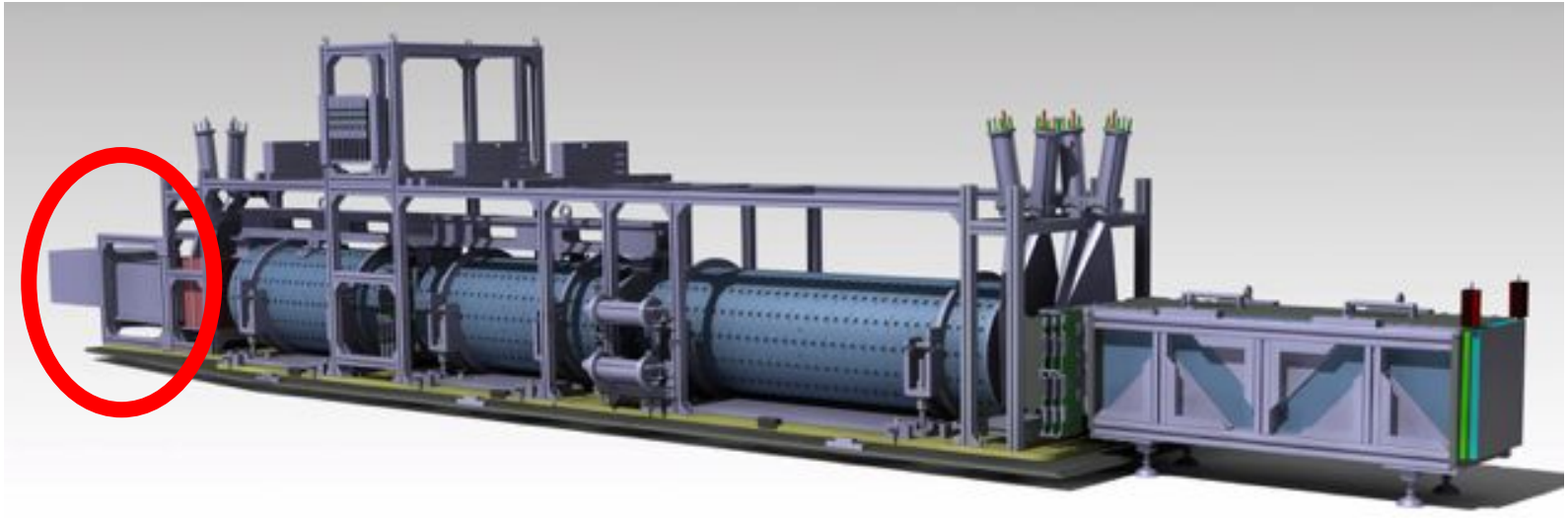
- For vetoing charged particles
- Efficiency measured in cosmic data to be >99.9% for a single layer



Calorimeter

Using spare modules from LHCb outer calorimeter

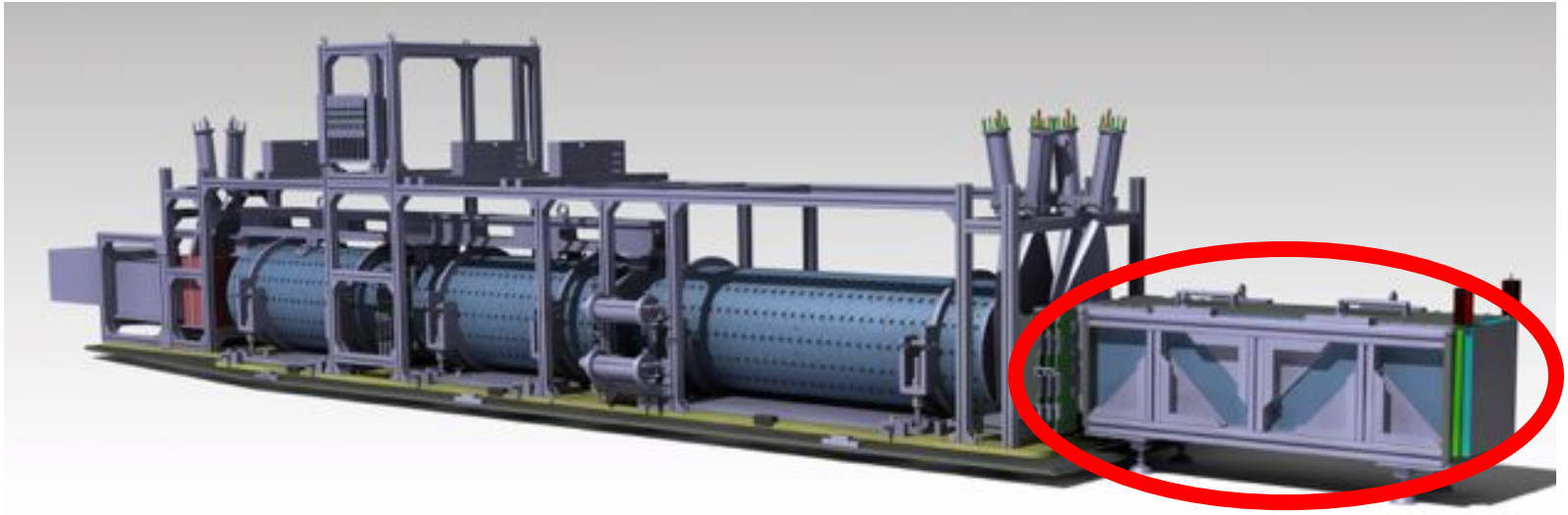
- Readout using PMTs with custom voltage divider base
- 66 layers of lead and scintillators corresponding to 25 radiation lengths
- 1% energy resolution at 1 TeV



FASERnu

Neutrino program with dedicated emulsion-based detector

- Study of neutrino production, propagation and interaction at the TeV scale
- First neutrino interaction candidate events at the LHC with pilot run in arXiv 2105.06197
- Dedicated talk by Tomohiro Inada at tomorrow's neutrino session

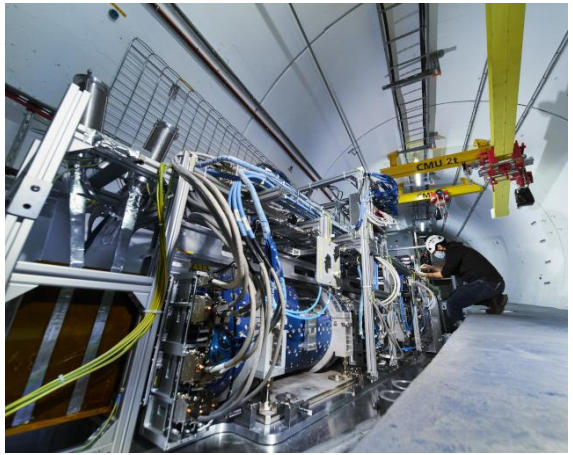


FASER evolution in photos

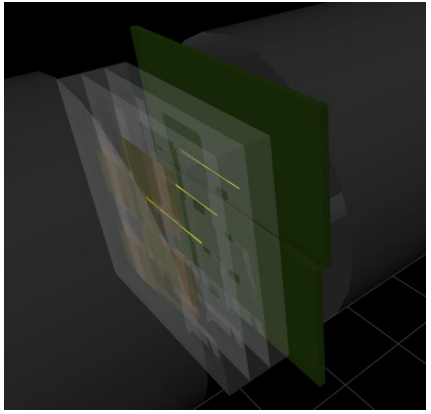
FASER schedule

Detector fully and successfully installed into TI12 tunnel in March 2021

- Cosmic ray data since then plus test-beam data in August 2021
- Extensive studies of taken data is ongoing
- On track for physics runs in LHC Run-3

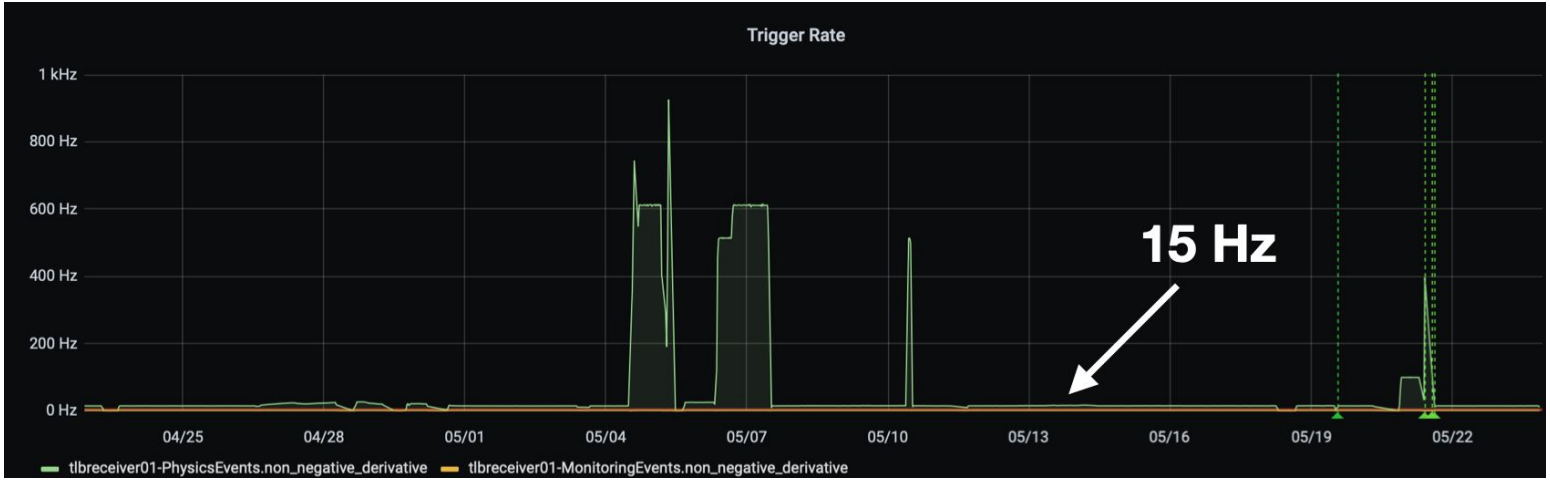


FASER commissioning



Detector running almost continuously since the start of cosmic data taking

- Monitoring, prompt reconstruction being exercised
- 10-15 Hz trigger rate requiring 2-scintillator coincidence
- Per-station tracks triggered by nearby scintillator and reconstructed with a rate of 1/minute
- Detector simulation, reconstruction being developed



Summary

FASER is a new experiment at the LHC

- Designed for detecting light and weakly-interacting particles
- Complemented by a dedicated detector for neutrino physics

FASER is installed in the TI12 LHC tunnel

- Large amount of cosmic and test-beam data being analysed
- Commissioning thus far proceeding smoothly
- Ongoing work on reconstruction, calibration, dataflow
- First neutrino interaction candidate observed and related paper submitted for publication

FASER is looking forward to first LHC Run-3 collisions in 2022!

The Collaboration

78 collaborators, 21 institutions, 9 countries