PROCEEDINGS OF SCIENCE

FASER: Forward Search Experiment at the LHC

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The FASER experiment is a new small and inexpensive experiment that is being placed 480 meters downstream of the ATLAS experiment at the CERN LHC. The experiment will shed light on currently unexplored phenomena, having the potential to make a revolutionary discovery. FASER is designed to capture decays of exotic particles, produced in the very forward region, out of the ATLAS detector acceptance. This talk will present the physics prospects, the detector design, and the construction progress of FASER. The experiment has been successfully installed and will take data during the LHC Run-3.

**** The European Physical Society Conference on High Energy Physics (EPS-HEP2021), ****
**** 26-30 July 2021 ****
**** Online conference, jointly organized by Universität Hamburg and the research center DESY ****

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PoS(EPS-HEP2021)705

1. Physics Prospects

Most LHC experiments such as CMS and ALTAS focus on heavy, strongly interacting particles, however, no detector could be used to study light and long-lived particles. The Forward Search Experiment(FASER) is a new and inexpensive experiment designed to search for new physics at the LHC. For example, dark photons and axion-like particles produced in proton-proton collisions at the ALTAS interacting point. Following proton-proton interaction, a lot of particles are produced. The charged particles are deflected by LHC magnets. The neutral hadrons are absorbed by the LHC infrastructure (TAS/TAN) or 100 meters of rock between the interacting point and the FASER detector. The long-lived particles will pass though the LHC infrastructure and rock without interacting.

Figure 1 is the future sensitivities for searching dark photon of the FASER experiment and other experiments. The gray-shaded regions are excluded by current experiments.

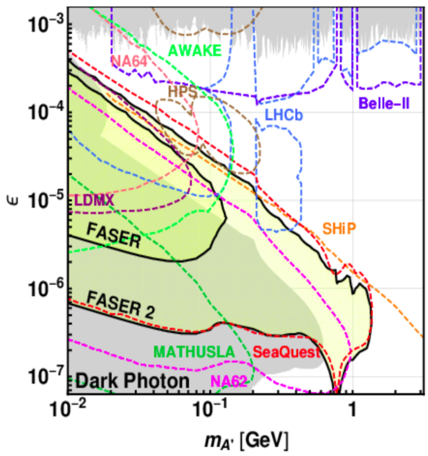

Figure 1: Plot of sensitivity.

The location of the FASER detector is TI12 side tunnel as shown in Fig.2. After being created in ALTAS IP, the long-lived particles will travel along the beam collision axis line of sight for 480 m, and some of them will decay into visible Standard Model particles in the decay volume. To separate the charged particle pairs and measure their momentum, we require magnetic field and high resolution tracker as shown in Fig.3.

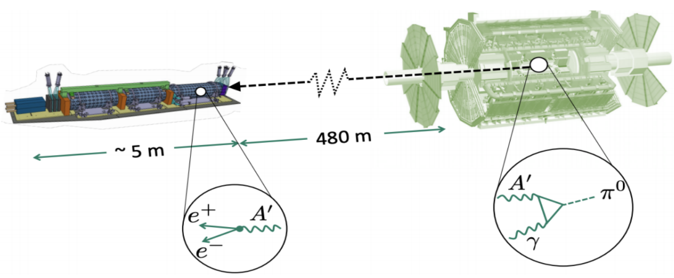

Figure 2: Location of the FASER detector.

2. The FASER Detector

The FASER detector composes of scintillators, a decay volume, a spectrometer, tracker stations and an electromagnetic calorimeter. The radius of the FASER detector is 0.1 m and the length of the FASER main detector is 5 m. Besides the FASER main detector, there is a subdetector called FASERν. The FASERν experiment is going to study high energy neutrino beam at the LHC.

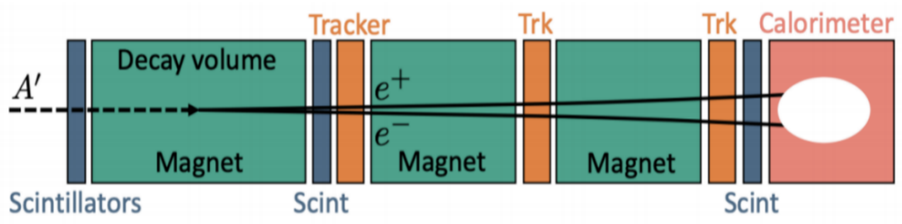

Figure 3: Scratch of the FASER Main detector

3 tracker stations are installed on the FASER main detector to track the charged particles produced by the targeting particles decay. The first tracker station is installed after the decay volume which is followed by a scintillator station. Three tracker stations are separated by two 1-meter-long magnets. Each tracker station consists of 3 tacker planes. 8 semiconductor strip tracker (SCT) modules are installed in 1 tracker plane as shown in Fig.4. The SCT modules are spares from the ALTAS experiment.

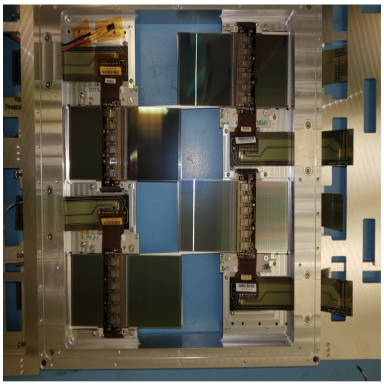

Figure 4: Tracker plane of the FASER main detector

The FASER experiment uses 0.55T permanent dipole magnets to separate the charged particles produced by long-lived particles decay. The length of magnet for the decay volume is 1.5m. Other two 1-meter-long magnets are for the spectrometer. All the magnets have passed the commissioning test and installed in the detector. Fig.5 is the picture of the magnets.

4 scintillator stations are installed to vote the charged particles entering the decay volume. The first two stations are veto stations used to suppress charged particles produced externally. The trigger and preshower station located in front of the calorimeter to reduce the non-physics events.

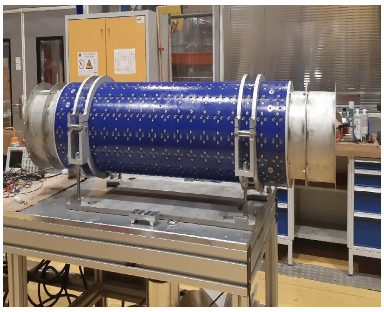

Figure 5: Megnet of the FASER main detector

The scintillator efficiency has been measured with cosmic ray to be higher than 99.99%.

The electromagnetic calorimeter is designed to stop the decay products and measure their energy. The calorimeters modules are spares from the LHCb experiment as shown in Fig.6.

Figure 6: Calorimeter of the FASER main detector

The FASER experiment is sensitive to unexplored phase space for a range of hidden sector physics. The FASER2 experiment is a possible future upgrade after LHC Run-3. The radius of the FASER2 detector will be 1 meter and the length will be 5 meters. FASER2 will provide more opportunity to probe more benchmarks, such as new particles produced in heavy meson decay. The calibration and installation of the FASER detector has been finished. Now the detector is installed in the TI12 tunnel as shown in Fig.7. Data taking will start at LHC Run-3 in 2022.

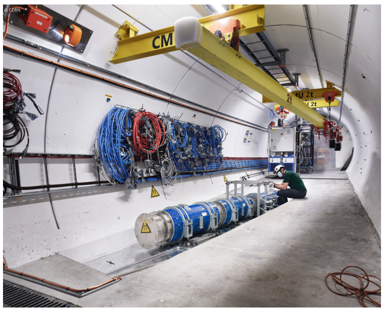

Figure 7: Calorimeter of the FASER main detector

References

[1] FASER Collaboration, A. Ariga *et al.*, [arXiv:1812.09139 [physics.ins-det]].

[2] FASER public webpage, https://faser.web.cern.ch.

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