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COLLIDER PHYSICS

The FASER Experiment at the LHC

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Abstract—FASER is a small experiment designed to search for light and weakly-coupled particles during Run-3 of the LHC. Such particles, predicted in many extensions of the Standard Model, may be copiously produced along the beam collision axis and travel a significant path before decaying to detectable particles. FASER, conveniently located 480 m downstream of the interaction point of the ATLAS experiment, is designed to look for such signatures. The FASER location, its detector layout, and commissioning towards data-taking in 2022 are reviewed.

Keywords: collider physics, FASER, weakly-coupled particles

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1. INTRODUCTION

FASER (ForwArd Search ExpeRiment) is a new and small experiment dedicated to searching for light and weakly-interacting particles which may be produced in proton–proton collisions at the LHC. Such new particles may travel macroscopic distances without interacting and may decay into visible particles in FASER, which is placed 480 m downstream of the ATLAS interaction point (IP1). The FASER experiment [1, 2] was approved by the CERN Research Board in March 2019 and the full detector was installed in its final location in Spring 2021. It is currently being commissioned towards data taking during LHC operation in Run-3, starting in 2022.

2. SIGNATURE AND LOCATION

The typical signal being looked at is $pp \to LLP + X$ where LLP is a new light and long-lived particle which travels enough distance to reach the FASER decay volume and then decays to e^+e^-, $\mu^+\mu^-$, $\pi^+\pi^-$ or $\gamma + \gamma$. The LLP decay products are expected to have energies in the TeV regime; hence, the target signature is two oppositely high-momentum charged tracks or photons emerging from a common vertex and with a combined momentum pointing back to the IP1 [3].

FASER is located in the TI12 service tunnel, which provides an ideal location being on the line-of-sight with the collision axis and being shielded by $\sim$100 m of concrete and rock. The expected backgrounds were evaluated using FLUKA simulations and in situ measurements and are mainly composed by muons originating from the IP1. Other backgrounds such as off-orbit protons hitting the beam pipe and beam-gas interactions are expected to be negligible. Due to low radiation levels in TI12, the detector components do not require radiation-hard electronics.

3. DETECTOR LAYOUT

The FASER detector is a 5.5 m long spectrometer with a 20 cm aperture and a decay volume length of 1.5 m. The experimental apparatus consists of tracking stations [8], scintillator stations and a calorimeter and is depicted in Fig. 1a. It is complemented by an additional detector that constitute the FASERν experiment [5, 6], which aims at measuring neutrino cross-sections originating in collisions at the LHC [7]. The detector volume is dominated by three dipole permanent magnets with fixed 0.55 T magnetic field. The first magnet has a length of 1.5 m and surrounds the decay volume, while the other two magnets are 1 m long and, together with the tracking stations, are the FASER spectrometer.

The tracking detector is composed of four stations, which three layers per station. Each layer is composed of 8 double-sided silicon strip modules. A mechanical structure connects three stations with the two magnets guaranteeing the relative alignment of

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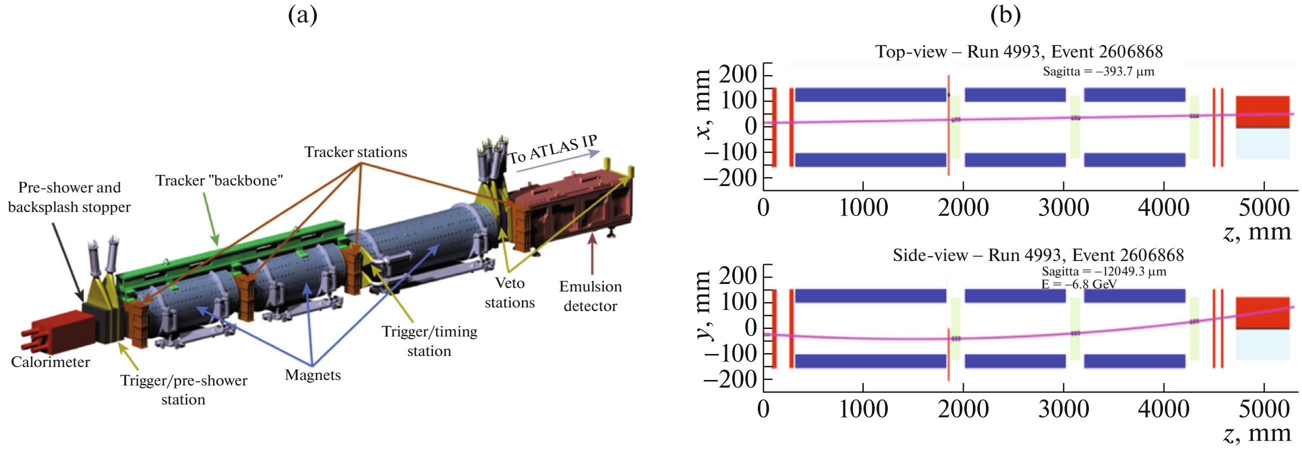

Fig. 1. (a) Sketch of the FASER detector with the various subsystems highlighted in different colours. (b) Display of a registered commissioning event with a muon passing through all the detector components from the LHC pilot run.

the spectrometer components while the fourth stations is in between the FASER and FASERν detectors.

The trigger signal is being provided by four scintillator stations. The first two stations are located in from of FASERν and in front of the first magnet. These stations detect minimum ionizing particles with the purpose of discarding muon-induced background. The third station is located on the end of the first magnet and is used to detect the presence of charged particles and to provide a measurement of their arrival time with respect to the interaction in IP1 to a precision of less than 1 ns. The fourth station is located in front of the calorimeter to create a simple pre-shower detector to help identify a physics signal of energetic photons. A calorimeter with a total of 25 radiation lengths for detecting electrons and photons is at the end of the FASER detector, with respect to a particle entering from IP1. The whole detector is equipped with a dedicated trigger and data acquisition system designed to retain the events of interest for calibration and physics analyses [9].

4. DETECTOR COMMISSIONING

The first commissioning phase consisted of testing the individual components independently. Subsequently, an extensive on-surface commissioning was carried out in a dedicated area in the CERN EHN1 experimental hall in 2020, followed by a test-beam in 2021. The last stage of the commissioning was performed directly in the final location in TI12 using the full detector setup and focusing on the reliability and robustness of the whole detector and the data acquisition and reconstruction systems.

Events with muons from cosmic and from the LHC pilot run were successfully registered and reconstructed proving the readiness of the FASER experiment to LHC operations in Run-3, starting in 2022. An example of such an event with a muon traversing all the detector components is depicted in Fig. 1b.

CONFLICT OF INTEREST

The author declares that he has no conflicts of interest.

REFERENCES

1. FASER Collab., “Letter of intent for FASER: ForwArd Search ExpeRiment at the LHC,” arXiv: 1811.10243 [physics.ins-det].
2. FASER Collab., “Technical proposal for FASER: ForwArd Search ExpeRiment at the LHC,” arXiv: 1812.09139 [physics.ins-det].
3. J. L. Feng, I. Galon, F. Kling, and S. Trojanowski, “ForwArd Search ExpeRiment at the LHC,” Phys. Rev. D **97**, 035001 (2018); arXiv: 1708.09389 [hep-ph].
4. FASER Collab., “FASER’s physics reach for long-lived particles,” Phys. Rev. D **99**, 095011 (2019); arXiv: 1811.12522 [hep-ph].
5. FASER Collab., “Detecting and studying high-energy collider neutrinos with FASER at the LHC,” Eur. Phys. J. C **80**, 61 (2020); arXiv: 1908.02310 [hep-ex].
6. FASER Collab., “Technical proposal: FASERnu,” arXiv: 2001.03073 [physics.ins-det].
7. FASER Collab., “First neutrino interaction candidates at the LHC,” Phys. Rev. D **104**, L091101 (2021); arXiv: 2105.06197 [hep-ex].
8. FASER Collab., “The tracking detector of the FASER experiment,” arXiv: 2112.01116 [physics.ins-det].
9. FASER Collab., “The trigger and data acquisition system of the FASER experiment,” J. Instrum. **16**, P12028 (2021); arXiv: 2110.15186 [physics.ins-det].