Forward calorimeter upgrade project in ALICE†

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A new forward high-resolution calorimeter, called FoCal (Forward Calorimeter) is being planned as one of the upgrade projects for the ALICE experiment at CERN. FoCal will be installed during LS3 (2026–2028) for physics data taking in LHC Run-4 (2029–2032). The letter of Intent for FoCal[1] has been submitted to the LHCC, and the FoCal project has been endorsed for the final R&D process for the Technical Design Report (TDR).

FoCal is a highly granular silicon-tungsten electromagnetic calorimeter combined with a conventional sampling hadronic calorimeter covering pseudorapidities of $3.2 < \eta < 5.8$. It provides to the LHC the unique capabilities to probe small-x gluon distributions via prompt photon production. FoCal significantly enhances the scope of existing ALICE physics programs by providing measurements of inclusive production cross-sections and correlations of neutral mesons, prompt photons, and jets at high rapidities, to explore the unknown dynamics of quarks and gluons inside a nucleus at small momentum fraction, $x = 10^{-6}$ for the first time. It is also expected to elucidate the existence of the color glass condensate (CGC),[2,3] which describes the dynamics of very densely populated gluon states at very small momentum fractions x in the nucleus and is expected to be important for the early stage formation of quark-gluon plasma in heavy-ion collisions.

FoCal will be located outside the ALICE solenoid magnet, at a distance of 7 m from the ALICE interaction point. The FoCal electromagnetic calorimeter (FoCal-E) is a compact silicon-tungsten sampling electromagnetic calorimeter with longitudinal segmentation. The current design comprises 18 layers of tungsten and silicon pads (FoCal-E PAD) with a granularity of 1 cm^2 and two layers of tungsten and silicon pixels (FoCal-E PIXEL) with a high granularity (30×30 μm^2). The pad layers provide measurements of the shower energy and profile, while the pixel layers enable two-photon separation down to a few mm, to discriminate between isolated photons and merged showers of decay photon pairs from neutral pions. The total silicon sensor area for FoCal-E is approximately 12 m^2 with approximately 150 thousand individual pad channels and approximately 8 thouasnd pixel sensors.

The FoCal hadron calorimeter (FoCal-H) is a Cu-scintillating fiber spaghetti calorimeter with a high granularity of approximately 2×2 cm^2, which provides good hadronic energy resolution and compensation. FoCal-H contributes to the measurement of photon isolation energy, to improve the selection of prompt photons, and to jet measurements.

In 2022, prototypes of three FoCal subsystems, namely FoCal-E PAD, PIXEL, and FoCal-H, were built and tested at the PS and SPS beam lines (Fig. 1). We (Tsukuba/RIKEN/Grenoble LPSC groups) constructed 18 layers of FoCal-E PAD prototype based on p-type silicon sensors with 320 μm thickness, 8×9 pad segmentation with 1 cm^2 pad size, and tungsten plates. HGCROC[4] readout ASICs were used for the PAD detector and successfully read out thorough data aggregation, a common readout unit (CRU), and a first level processor (FLP) together with other subsystems for the first time. The test beam data analysis is ongoing.[5] We also performed an irradiation test with neutrons by using the RIKEN accelerator-driven compact neutron source (RANS). We irradiated monitor silicon sensors (p-substrate and n-substrate) and measured IV characteristics. The total neutron dose at RANS at this time reached up to 10^{14} NEQ (1 MeV neutron equivalent fluence). The performance evaluation of irradiated sensors is also ongoing. Based on test results, TDR will be prepared for the final review of the detector construction and integration into ALICE in 2023.

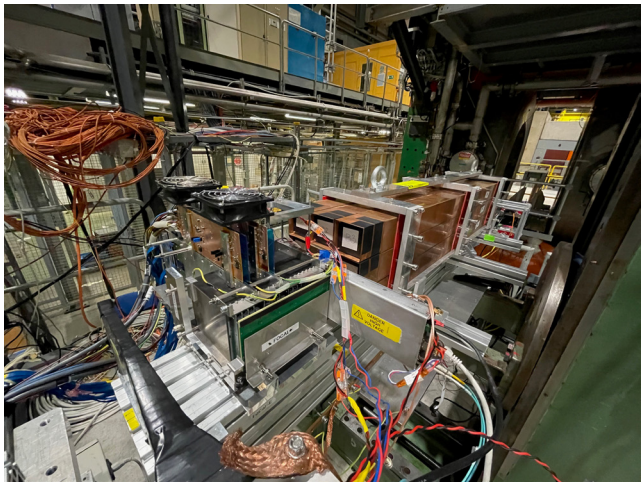

Fig. 1. FoCal prototype at CERN SPS test beam line in the experimental hall H2 (Nov., 2022).

References
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† Condensed from the article in EP Newsletter, CERN, March 14, 2022

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