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## Development of the upgraded LHCf calorimeter with Gd<sub>2</sub>SiO<sub>5</sub> (GSO) scintillators.

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The Large Hadron Collider forward (LHCf) experiment is designed to measure the hadronic production cross sections of neutral particles emitted in the very forward angles in p-p collision at the LHC.

LHCf has reported energy spectra of forward photons and neutral pions at  $\sqrt{s} = 900$  GeV and 7 TeV proton-proton collisions measured at LHC.

Forward spectra can be helpful in verifying cosmic ray interaction models.

The next operation in 2015 is expected under much higher radiation dose. Therefore, we are upgrading the detectors, especially their scintillators, to be radiation harder one.

Plastic scintillator layers and Scintillating Fiber (SciFi) tracker are replaced with GSO layers and fine GSO hodoscope respectively.

Basic properties of new sensors of the upgraded detector are measured by 400 MeV/n carbon beams at the Heavy Ion Medical Accelerator in Chiba (HIMAC) in June, 2012.

Energy resolution and position resolution of the upgraded detector are evaluated by using electron beams of 50-250 GeV at Super Proton Synchrotron (SPS) in summer, 2012.

The results are understood by Monte Carlo simulations and are good enough for the requirements of the LHCf experiment.

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