The Zero Degree Calorimeter (ZDC) at the LHC is a far-forward hadronic calorimeter used to measure spectator neutrons from heavy-ion collisions at the LHC. In addition to spectator neutrons, an electromagnetic module (EM) within the ZDC may be used to measure far-forward neutral particles like photons and neutral pions. The Joint Zero-degree Calorimeter Project (JZCaP) is a collaboration between ATLAS and CMS groups working on R&D towards an upgraded ZDC for the High-Luminosity (HL) LHC, usually referred to as the HL-ZDC. As a part of this upgrade, the EM module is being redesigned to increase the discrimination power between forward photons and spectator neutrons.

**HL-ZDC design**

The tungsten plates act as the absorber, creating a particle shower, which in turn creates Cherenkov photons in the fused silica rods that guide the photons upwards towards the PMTs.

EM module: 4X3 segmentation, defined by the light-guides and the corresponding PMTs. The beam test prototype had 3X3 segmentation.

**Transmission improvement - polishing**

To maximize light transmission from the rods to the light-guide, we polish the corresponding face of the rods. To accomplish this step, a custom polishing setup was constructed.

Transmission measurement setup:

Polishing significantly improves the light transmission over a broad wavelength range.

**EM Photon-Neutron discrimination**

We can exploit shower shape differences to discriminate between photons and neutrons. Dedicated studies were carried out simulating the detector response in Geant4:

\[ L_F = \frac{N_{\gamma}^{Ch} - N_{\gamma}^{Ch}}{N_{\gamma}^{Ch} + N_{\gamma}^{Ch}} \]

\[ SQ_{\gamma,n} = \sum_{i \in \text{segments}} \left( L_F - \frac{N_i}{N_i} \right) \]

If: \( SQ_{\gamma} < SQ_{\gamma,n} \rightarrow \) photon
\( SQ_{\gamma} > SQ_{\gamma,n} \rightarrow \) neutron

**Test beam EM analysis**

The test beam took place in CERN SPS H2&H4 beam lines, using different energy \( e^- \) beams & \( p \) beam.

Reconstruction of the center of mass in the x-z plane using the EM signals. A clear correlation between the x position of the beam and the center of mass is observed.