

אוניברסיטת בן-גוריון בנגב  
جامعة بن غوريون في النقب  
Ben-Gurion University of the Negev



# The Electromagnetic Module for an LHC Run-4 Zero Degree Calorimeter

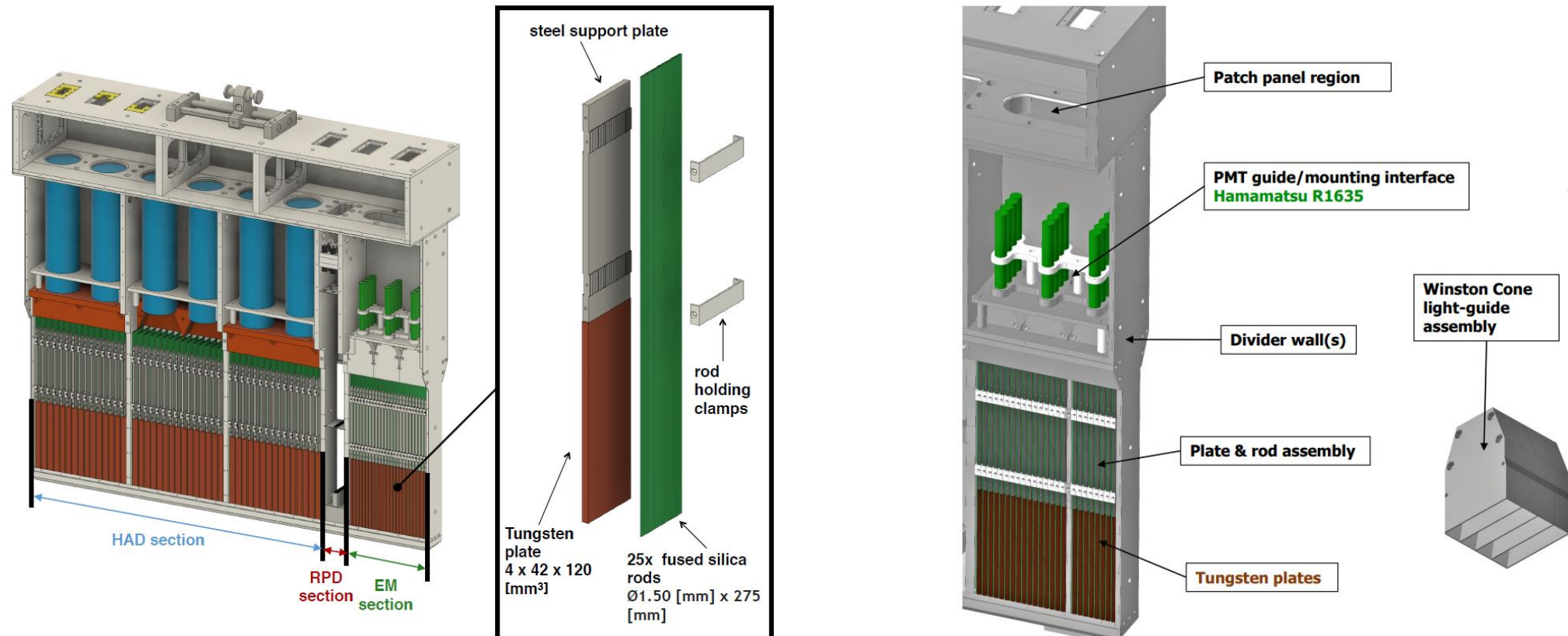
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The Zero Degree Calorimeter (ZDC) at the LHC is a far-forward hadronic calorimeter used to measure spectator neutrons from heavy-ion collisions at the LHC. In addition to spectator neutrons, an electromagnetic module (EM) within the ZDC may be used 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.



# 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:

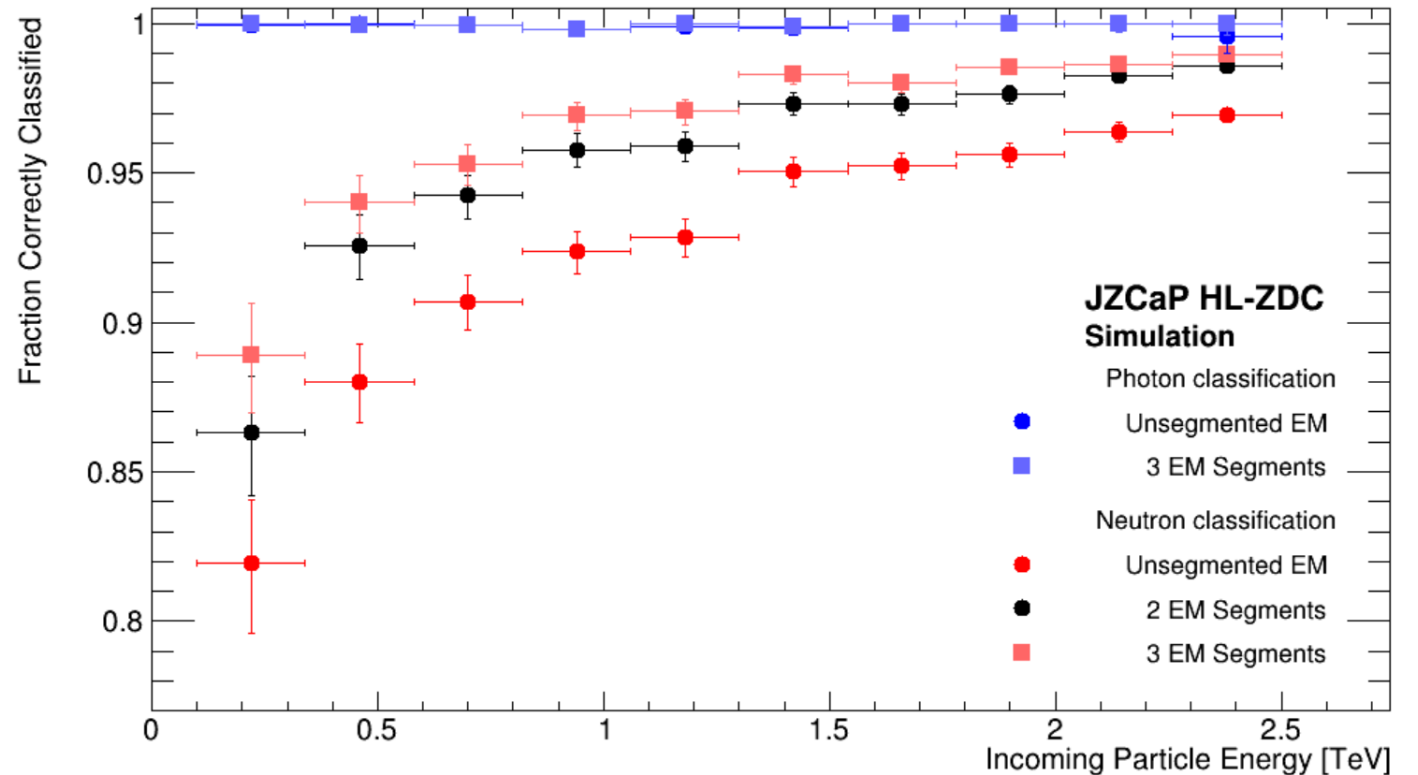
$$LF_i = \frac{N_i^{\text{Ch}}}{\sum_{j>i} N_j^{\text{Ch}}}, \quad N_i^{\text{Ch}} - \text{detector response in segment } i$$

$$SQ^{\gamma,n} = \sum_i^{\text{segments}} (LF_i - \langle LF \rangle_i^{\gamma,n})^2$$

If:  $SQ^\gamma < SQ^n \rightarrow$  photon

$SQ^\gamma > SQ^n \rightarrow$  neutron

The highest level of photon-neutron discrimination is observed for 3 longitudinal segments.

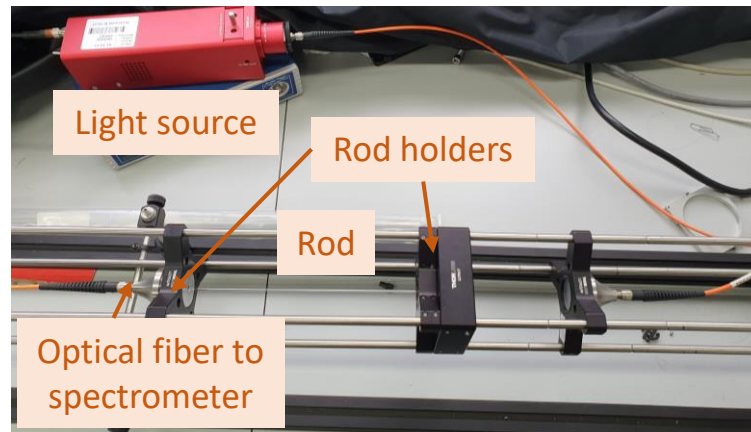
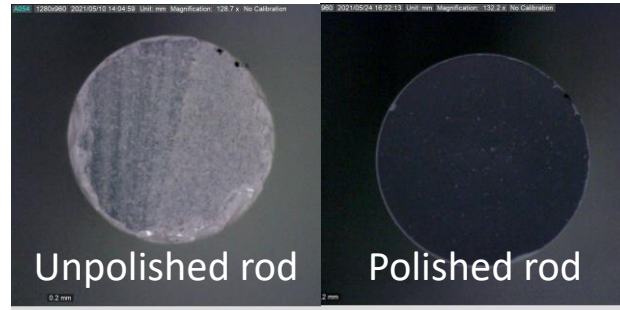


# Transmission improvement - polishing

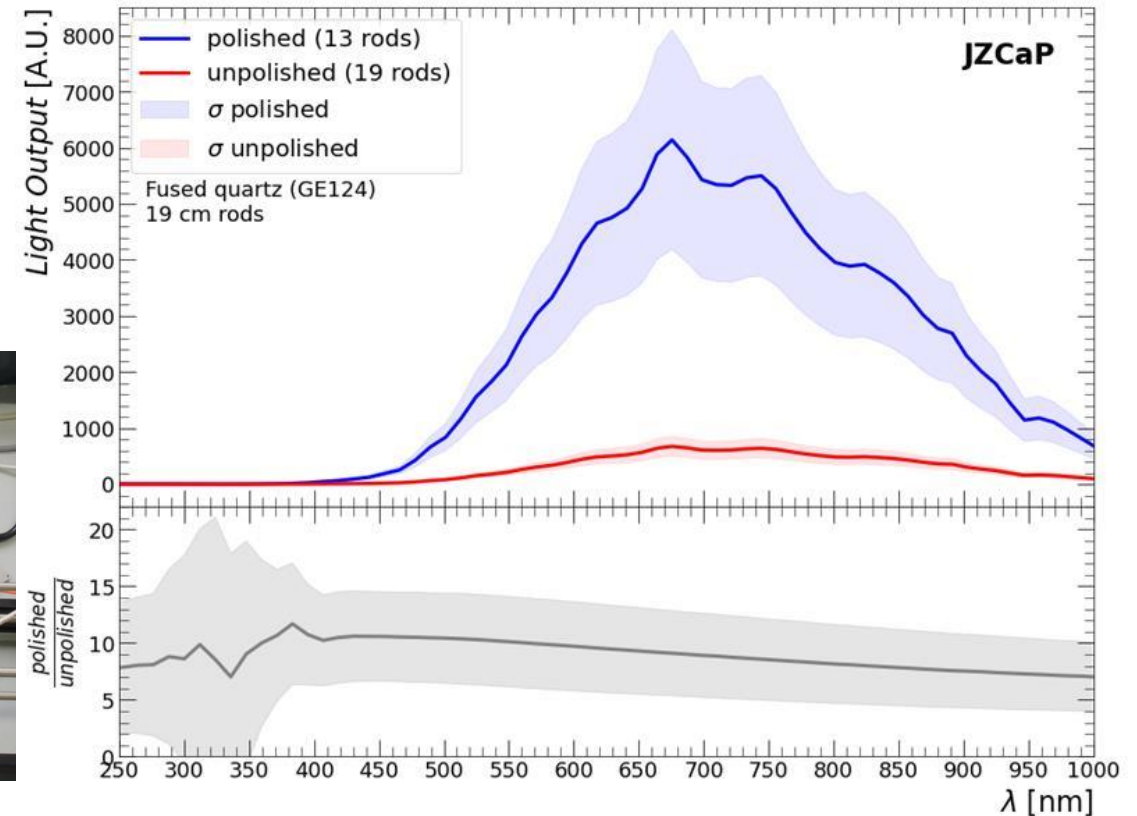
To maximize light transmission from the rods to the light-guide, we polish the corresponding face of the rods. To accomplish this step, a custom polishing setup was constructed.



Polishing setup



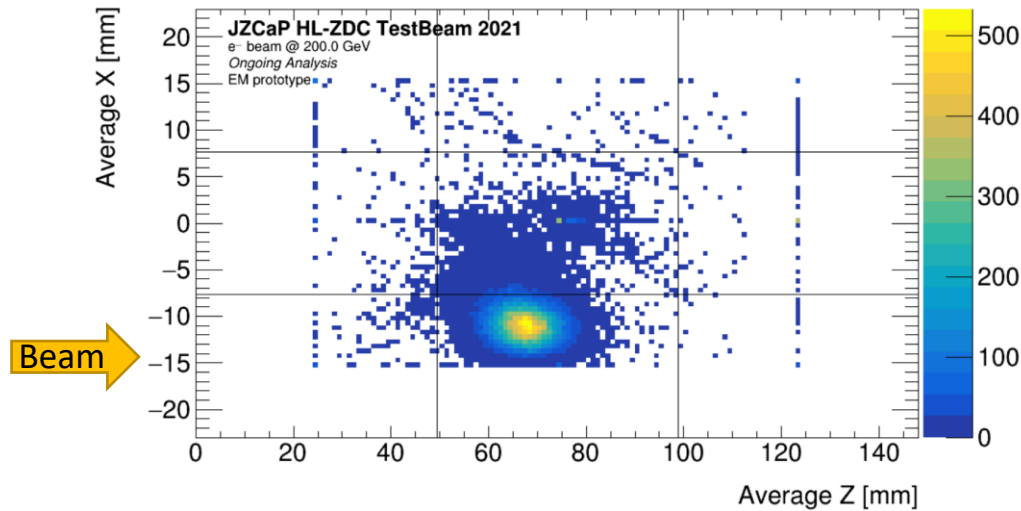
Transmission measurement setup



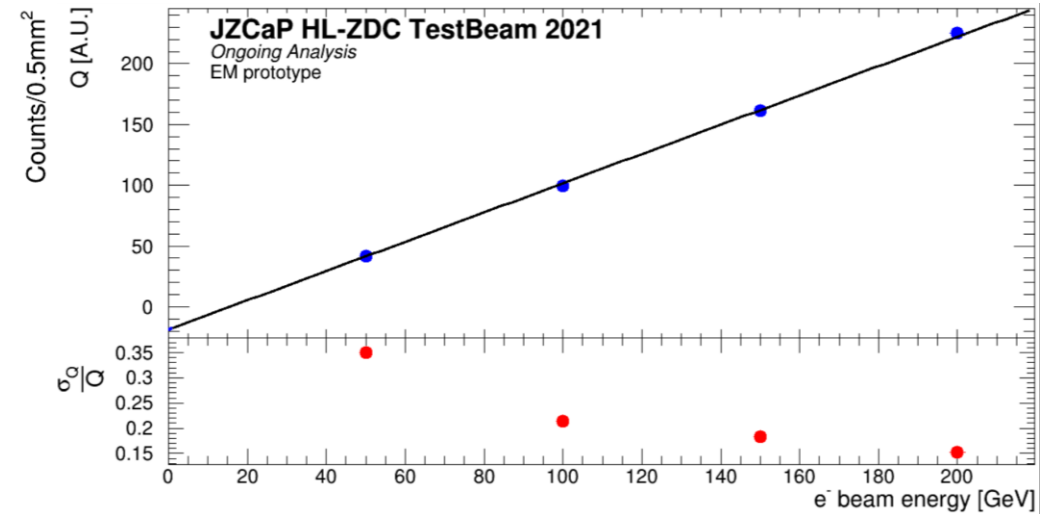
Polishing significantly improves the light transmission over a broad wavelength range.

# 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.



Linear response in energy