

Development of 3D-Printed Tungsten Absorbers for the LHCb ECAL Upgrades

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During the third long shutdown of the LHC (LS3), the LHCb experiment will strengthen and upgrade the central area of the electromagnetic calorimeter (ECAL). In the most central area of the ECAL, a new sampling structure and new calorimeter modules will be used to address the performance degradation of the calorimeter in an extremely high radiation environment. The feature of this new sampling structure is, the scintillating fibers insert into an absorber with a large number of small holes (SpaCal). A key challenge in this upgrade is the production of absorbers featuring small, high-precision holes into which scintillating fibers must be inserted without damage. Pure tungsten was selected as the absorber material due to its high atomic number and superior radiation absorption properties. However, its inherent brittleness and difficulty to machine make traditional methods like die-casting unsuitable for producing the required complex geometries. To overcome this, we employed Selective Laser Melting (SLM), an additive manufacturing technique. The fabrication process encompassed SLM 3D printing followed by post-processing steps—including chemical polishing, sandblasting, and wire-cutting, etc. Through systematic optimization of parameters such as laser spot compensation, calibration factors, fan frequency, and so on, we have successfully produced both reduced-size (approx. $40 \times 40 \times 50$ mm³) and full-module-size (approx. $121 \times 121 \times 50$ mm³) tungsten absorbers. A rigorous quality assurance procedure was implemented, evaluating dimensional accuracy, surface roughness, flatness, and perpendicularity to ensure compliance with specifications. These components were used to assemble a functional SpaCal-W prototype. This successful development not only paves the way for the final production and integration of the new absorbers for the LS3 upgrade but also demonstrates the profound potential of metal 3D printing for fabricating complex radiation-hardened components in future high-energy physics experiments.

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