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Design and Validation of a 1:1 Scale Cryogenic Payload with Sapphire-Based Suspension at ARCLaboratory

At the ARC laboratory in Rome, a 1:1 scale cryogenic payload prototype is being developed to study conductive cooling methods. Sapphire has been chosen for the optics and suspension systems due to its excellent mechanical and thermal properties. In particular, at low temperatures (10-20 K), sapphire exhibits high thermal conductivity, which enables efficient heat extraction during cooling and experiments. The prototype can also be equipped with crystalline silicon suspension.

The payload structure consists of three main components: the platform, the marionette, and a dummy mirror. The marionette and the mirror are arranged in cascade on the platform, parallel to the actuation cage that surrounds the double pendulum. The marionette is suspended from the platform via a sapphire rod using a mechanical locking system with half-cone elements, while the mirror body is connected to the marionette through sapphire flats and suitable ears. Additionally, an HCB-bonded suspension employing sapphire ribbons is being developed.

Two test campaigns are currently underway, using a tabletop universal testing machine to validate the suspension systems. The first campaign aims to assess the strength of the half-cone system, while the second tests the HCB bonding through a three-point bending test, which leads to the anchoring of the sapphire ribbons. The production of these specific sapphire components and the associated costs in the R&D phase represent the main challenges of the experiment; thus, the ongoing tests are crucial. The complete suspension system will be tested next.

Primary authors: CRUCIANI, Angelo (INFN ROMA1); KALEMI, Benedetta (INFN); PASCIUTO, Daniele (INFN Roma1); MAJORANA, Ettore; BENEDETTI, Eugenio (INFN Roma1); Prof. RICCI, Fulvio (University of Rome Sapienza); NATICCHIONI, Luca; ORSINI, Marco (University of Sapienza, INFN Roma1); RICCI, Marco; PUPPO, Paola; Prof. RAPAGNANI, Piero (La Sapienza University & INFN Sezione di Roma); PIRRO, Stefano (Laboratori NAzionali del Gran Sasso); HOANG, Van Long (INFN-Roma1)

Presenters: KALEMI, Benedetta (INFN); MAJORANA, Ettore; BENEDETTI, Eugenio (INFN Roma1); ORSINI, Marco (University of Sapienza, INFN Roma1); RICCI, Marco; HOANG, Van Long (INFN-Roma1)

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