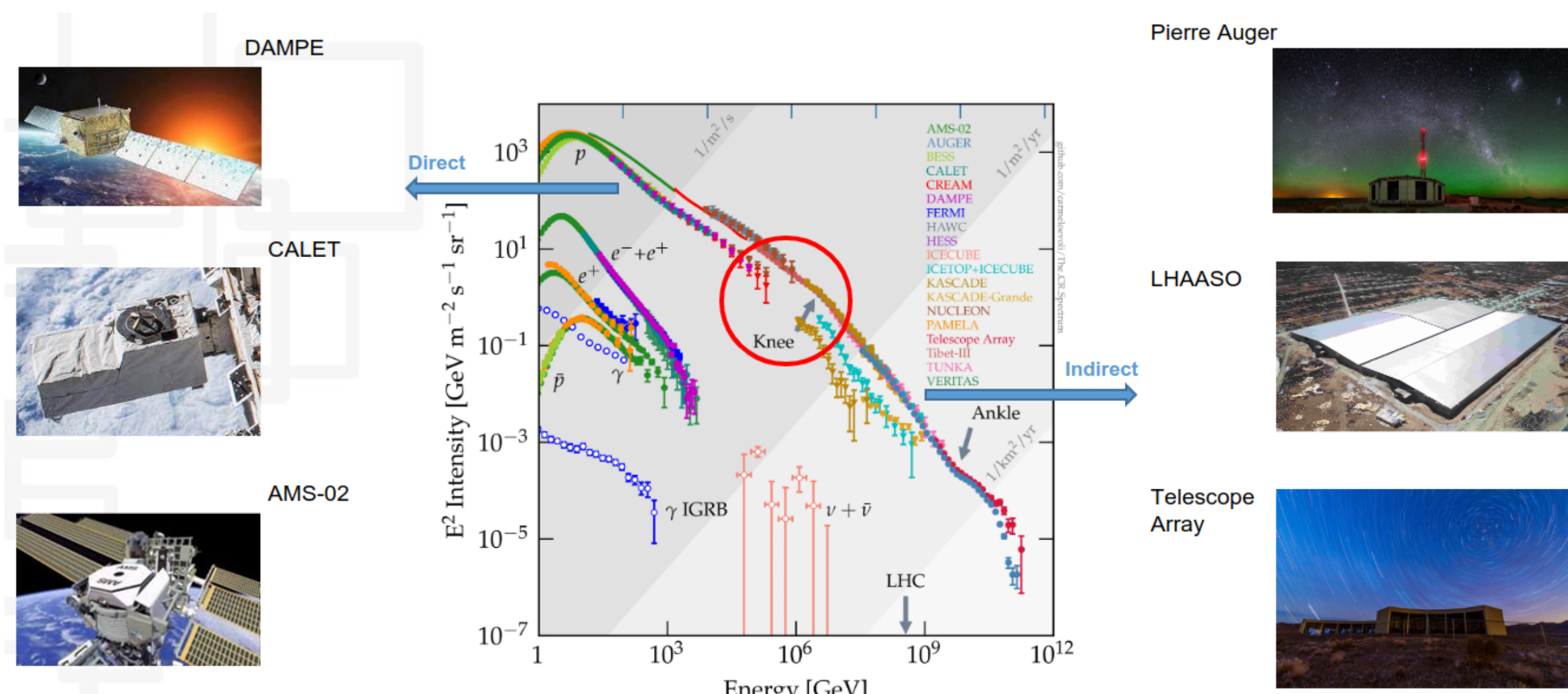


### The experiment

The **High Energy cosmic-Radiation Detection (HERD)** facility is a future space based cosmic ray detector, to be installed aboard the Chinese Space Station at the end of 2027. Thanks to its novel design, HERD is expected to achieve frontier goals in particle detection from space. Its scientific objectives are:

- Direct measurement of Cosmic Ray energy spectrum up to the *knee* region (PeV scale)
- Electron + positron spectrum up to  $\sim 10$  TeV
- Gamma-ray monitor for transients and sky survey up to 100 TeV
- Indirect dark matter searches



The core idea for the novel design of the HERD detector is a **3-D approach**, using 5 sensitive faces to measure cosmic rays incoming from all sides. This allows for a large acceptance without the price of a dramatic increase of the instrument size and weight.

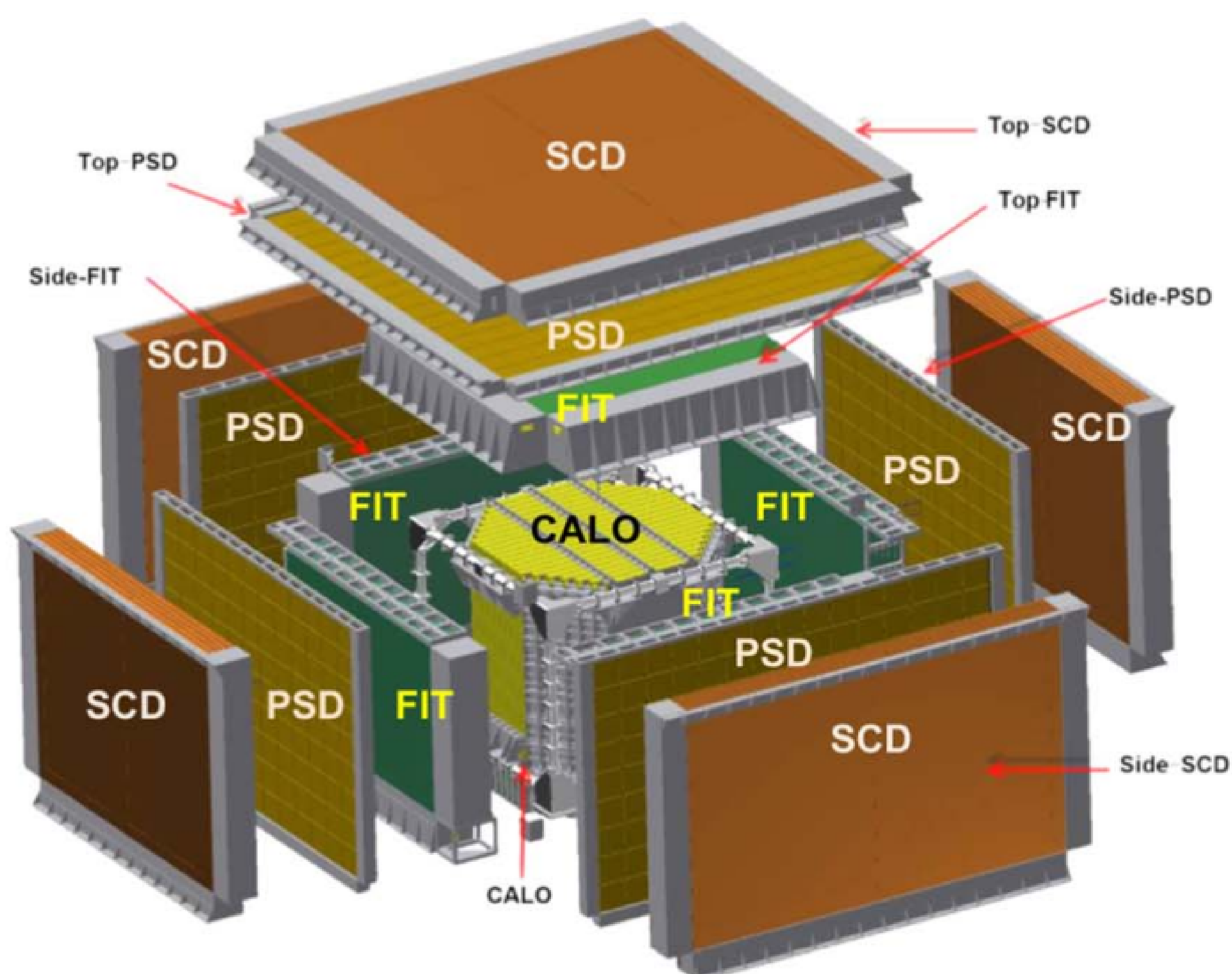


Figure: Exploded HERD layout with its sub-detectors.

Item	Value
$\gamma/e$ energy resolution	$< 1\%$
$\gamma/e$ angular resolution	$< 0.1^\circ$
$e - p$ discrimination	$> 10^6$
Geom. acc.	$3 \text{ m}^2 \text{ sr}$

Table: Expected HERD performance.

The HERD sub-detectors, starting from the outermost layer, are:

- **Silicon Charge Detector (SCD)** to measure the absolute value of the electric charge of incoming particles
- **Plastic Scintillator Detector (PSD)** for photon identification in anti-coincidence and additional charge measurement
- **Fiber Tracker (FIT)** made of scintillating fibre mats, serves as the tracking system
- **CALO**, a deep electromagnetic calorimeter to measure the energy of impinging cosmic rays and discriminate between hadrons and leptons
- A **Transition Radiation Detector (TRD)** will be placed on one side of the instrument to facilitate the cross-calibration with the CALO at TeV energies

The GSSI group is currently taking part in the **construction of a prototype of a full-scale single side of HERD with an ASI (Agenzia Spaziale Italiana) contract**, in preparation for the HERD launch foreseen in 2027.

### Activities at GSSI

The GSSI group is mainly involved in the **R&D of the PSD** sub-detector. The PSD is made of layers of scintillating bars or tiles, coupled with Silicon Photomultipliers (SiPMs). The development of the detector design is carried out through two channels: software simulation and laboratory testing and prototyping.

- **Simulations** are performed to find the optimal configuration of the PSD given the technological constraints of the payload. As an example, GEANT4 simulations have been used to estimate the PSD hermeticity and to better understand how the light propagates inside the scintillator and how much of it is collected by the SiPMs.
- The GSSI team also takes part in the development of the full-detector simulation and analysis framework, which is needed to perfect the overall design and to facilitate the data analysis part.

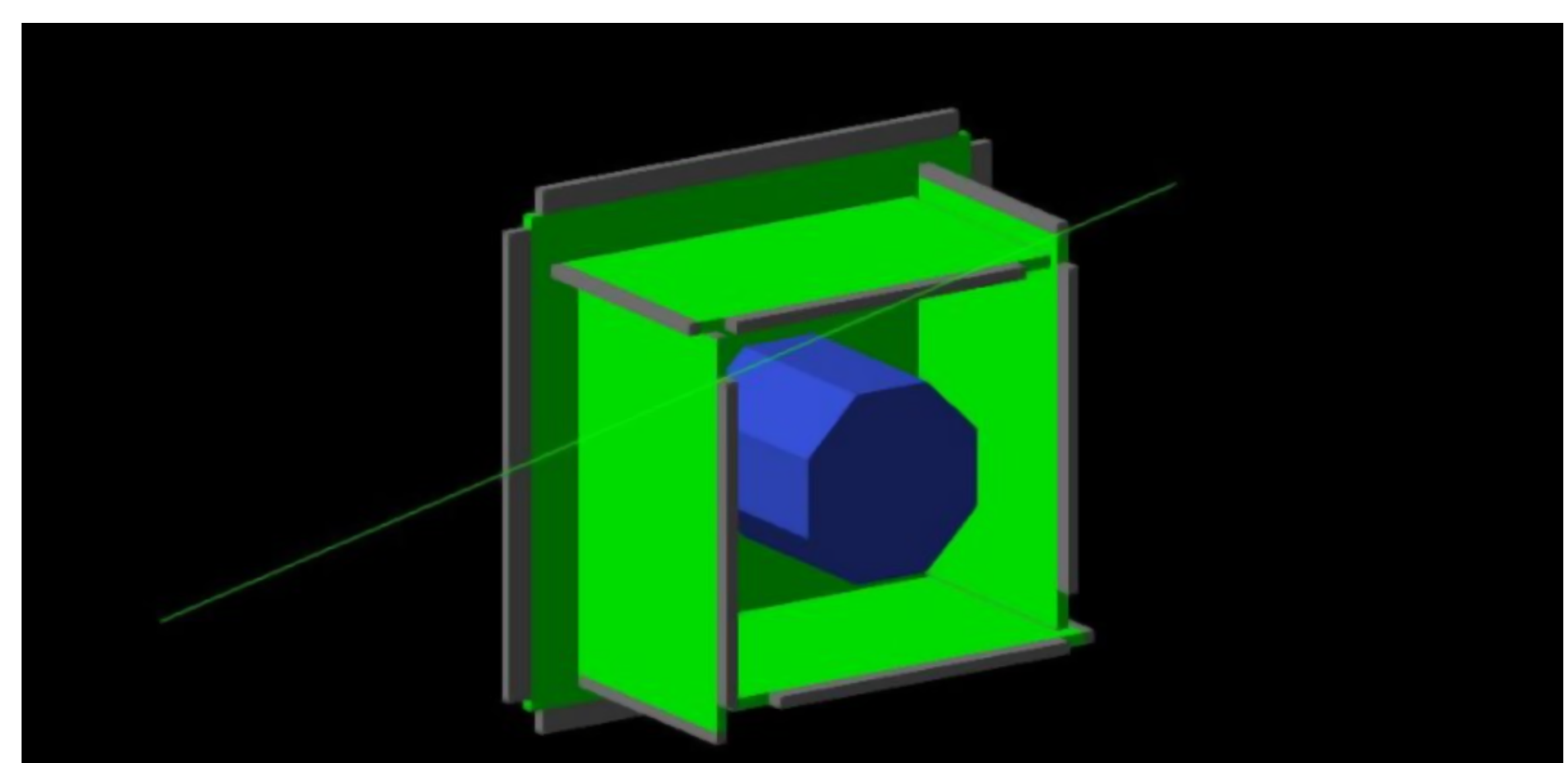


Figure: GEANT4 simulation of full-scale PSD and CALO detectors to test the hermeticity.

- The **hardware** activities are carried out mostly at the INFN - LNGS laboratories in Assergi, and several tests have been conducted during the past years at CERN (Geneva, CH), CNAO (Pavia), and Bari INFN laboratories. In particular, activities such as the testing of single components are carried out at LNGS, while operations such as prototype assembling take place in Bari.

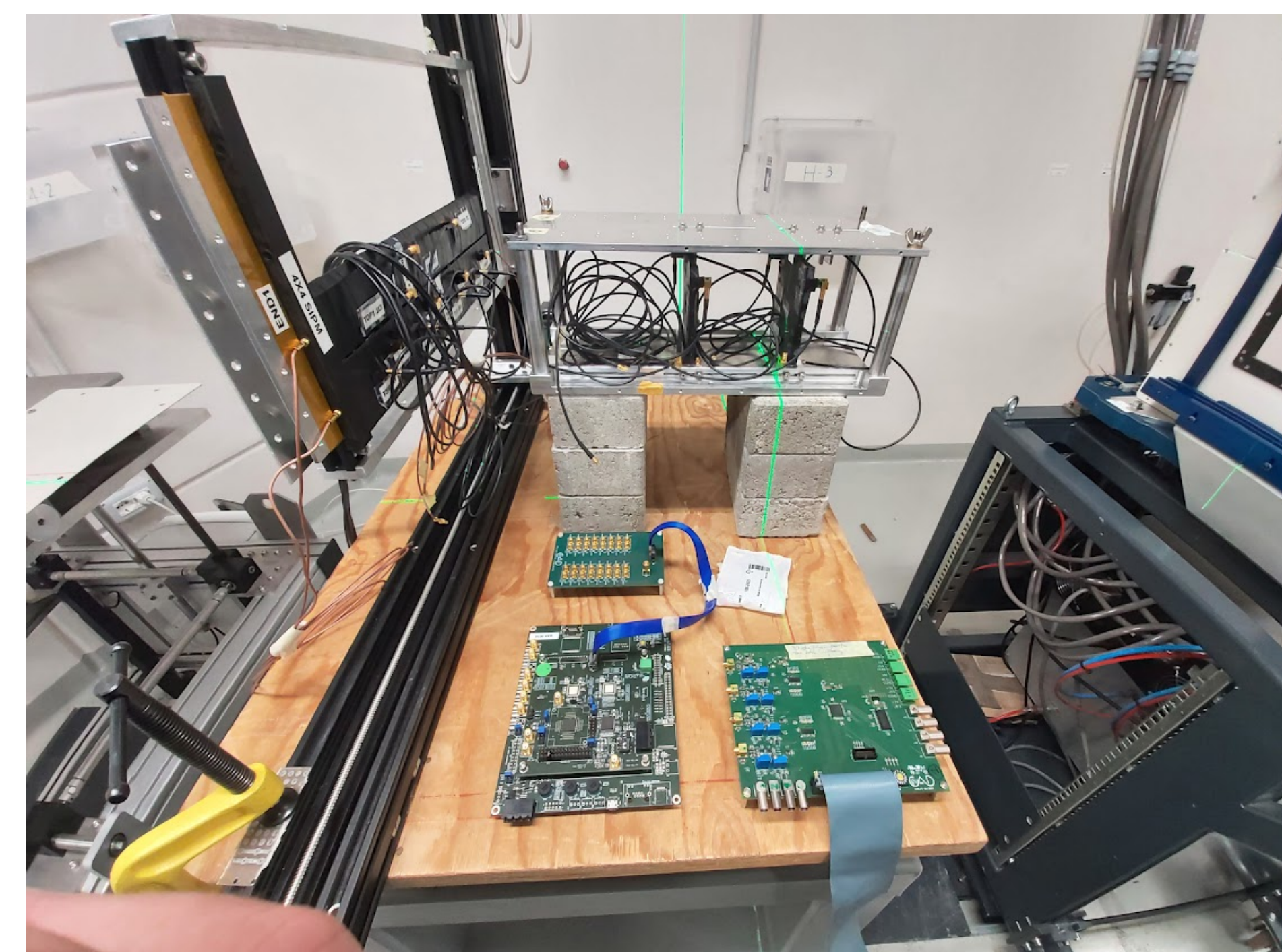


Figure: PSD prototype set-up during CNAO beam test.

- Several test campaigns were made at CERN and CNAO, with more yet to come in the following years. These data taking tests usually include a pre-campaign phase with training in data acquisition, data-taking shifts, and post-campaign data analysis.



Figure: Detectors set-up along the CERN SPS beamline during the November 2022 beam test.