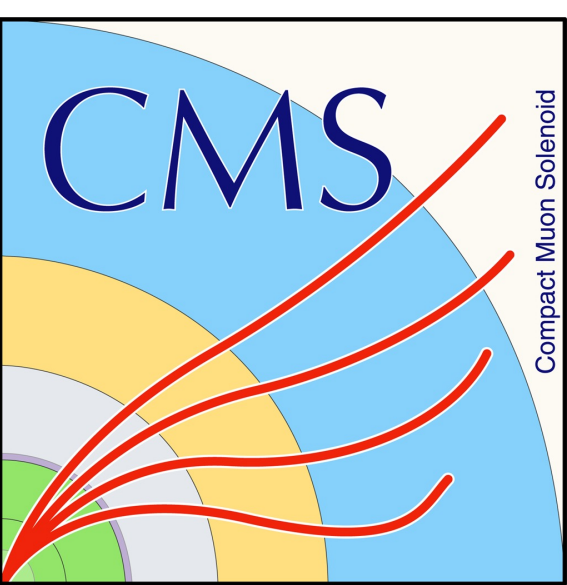




TetraBall: a Single-Moderator Neutron Spectrometer for CMS BRIL at HL-LHC

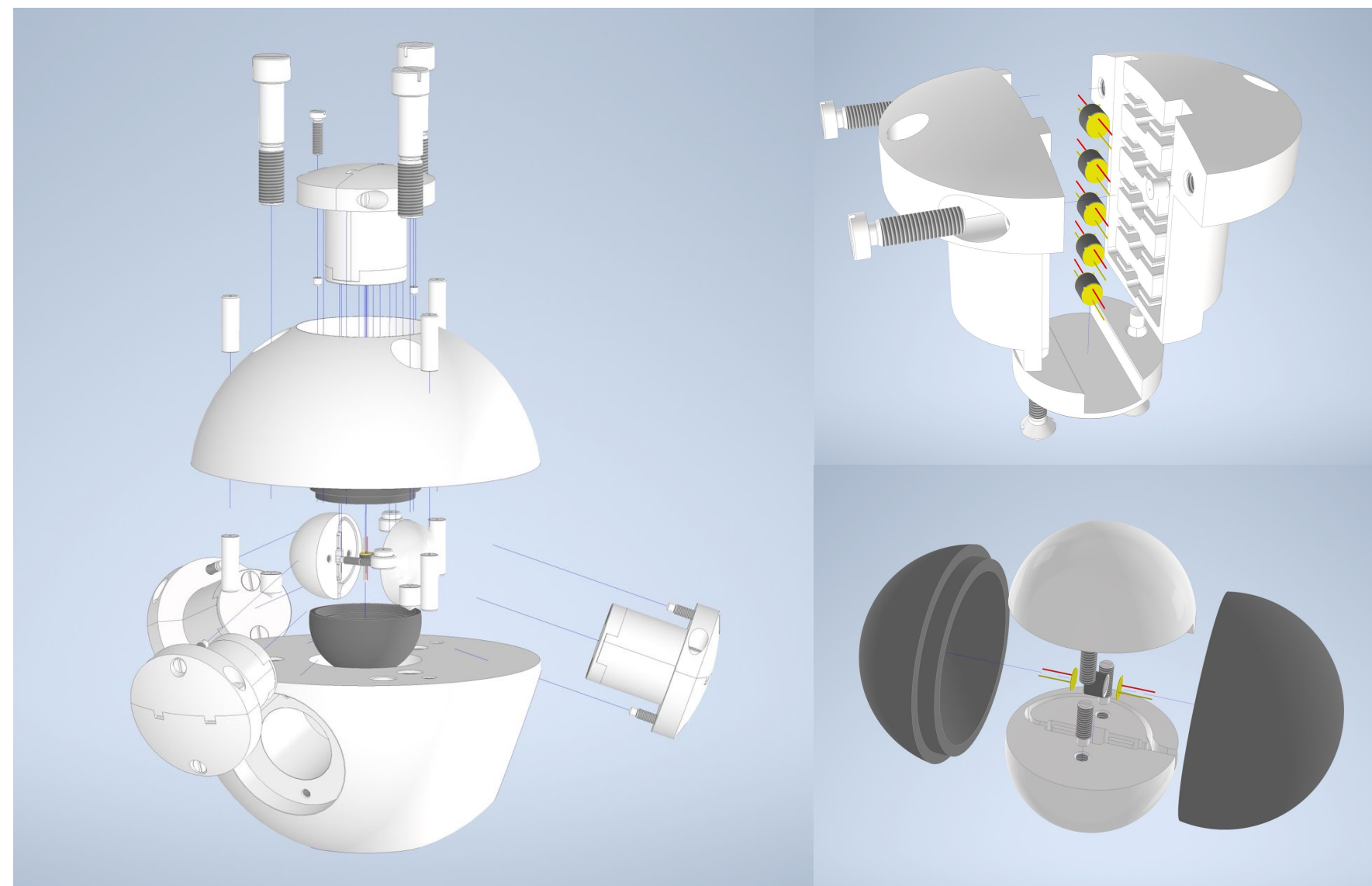


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R. Bedogni^[c], A. I. Castro Campoy^[c], L. Russo^[c], T. Napolitano^[c], J. M. Gomez-Ros^[d],
S. Mallows^[e], A. Lokhovitskiy^[e,f], A. L. Svardstrom^[e,g]
on behalf of the TetraBall and CMS BRIL Teams

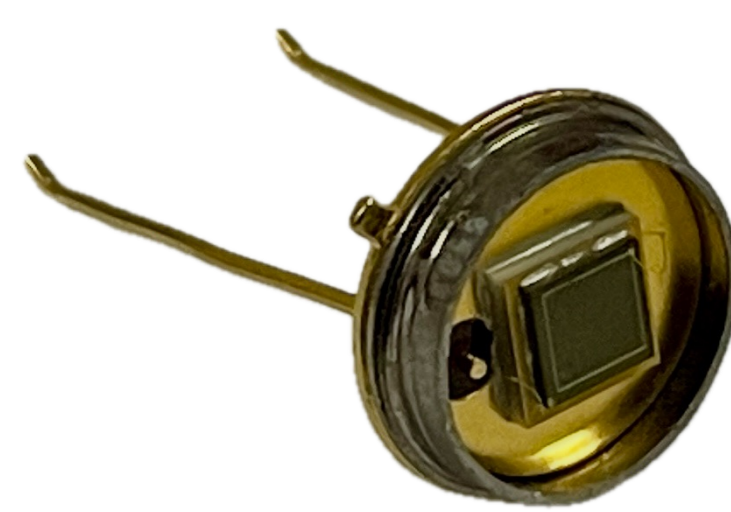
Developed by INFN for the **CMS BRIL Phase-2 Upgrade**:

- To **benchmark CMS FLUKA** MC simulations
 - Evaluation of the CMS radiation environment
 - Input to future maintenance/upgrades
- To measure a **wide energy range neutron spectrum** (meV to GeV) in a **mixed field** (gamma, charged hadrons)
- To withstand a **hostile environment**: magnetic field, high radiation levels, inaccessibility of the CMS cavern

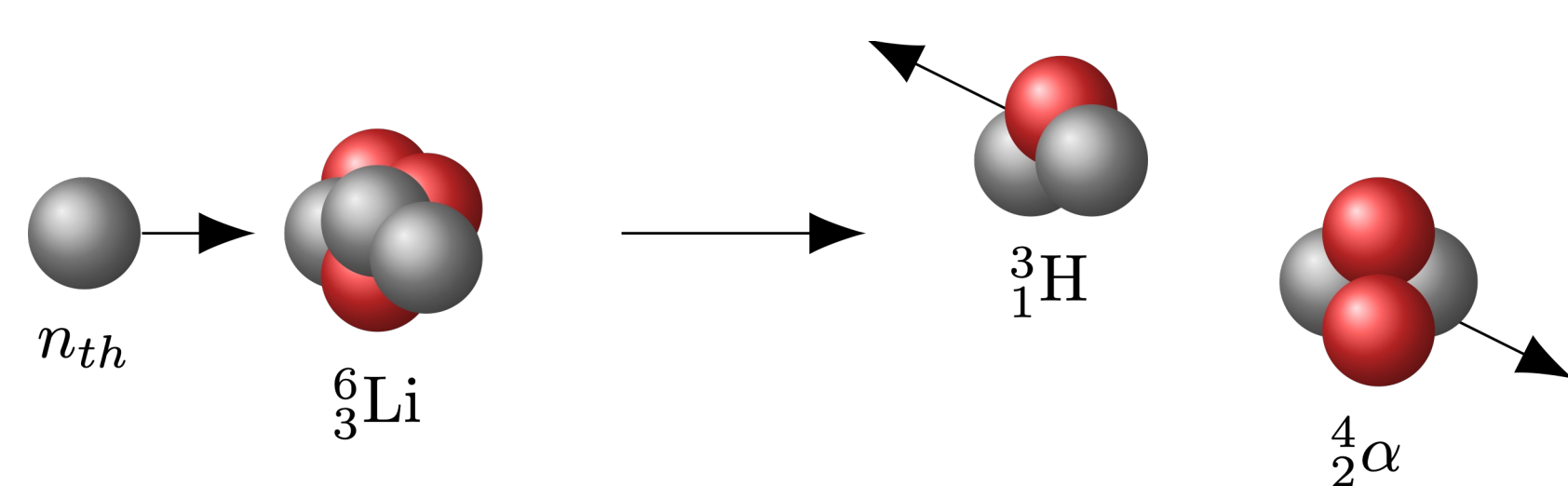
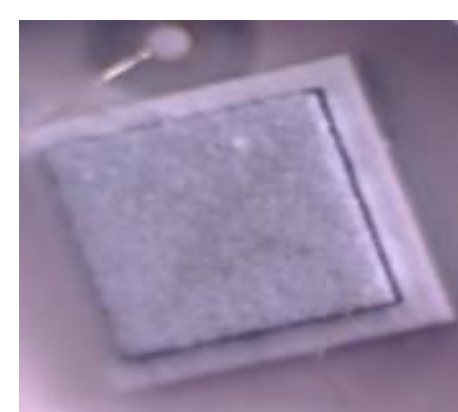
TetraBall exploded view



TetraBall SiC diode

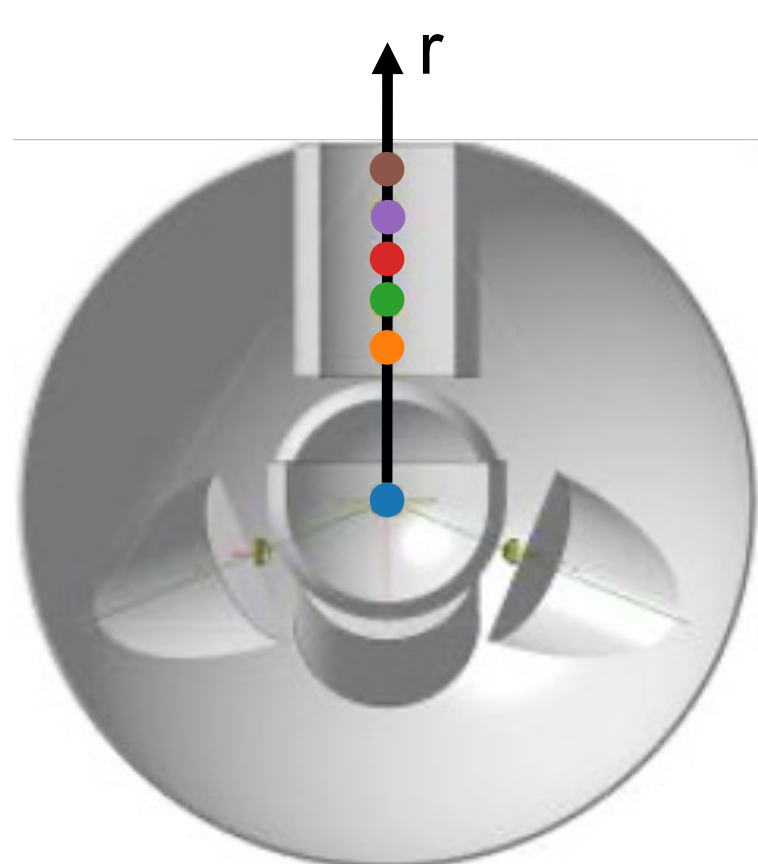


⁶LiF deposit

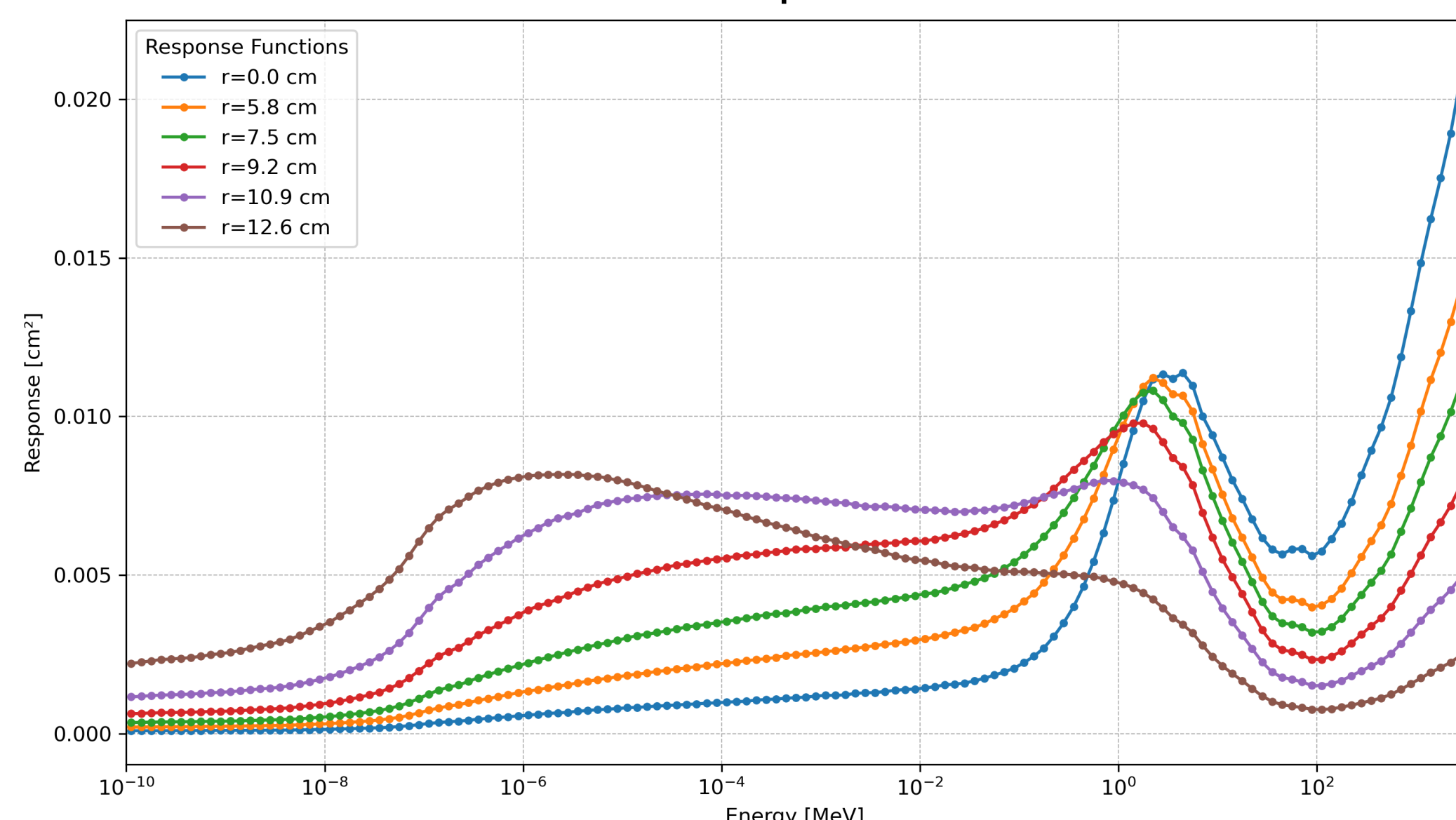


TetraBall main features:

- HDPE single** spherical moderator
- 42 SiC diodes** in a **tetrahedral** geometry ($\rightarrow$ **isotropic response**), arranged in **21 pairs** (differential reading)
 - commercially** available
 - n conversion via **⁶LiF layer**
 - tested for rad tolerance (TRIGA @ LENA, Pavia)
- Pb inner shell** for high-energy n detection (n,xn)
- Compactness** to be easily moved in the CMS cavern
- Resolving power $\leftarrow$ **response matrix** (MCNP simulation, validation with reference neutron fields)
- Neutron spectrum extraction** through unfolding methods



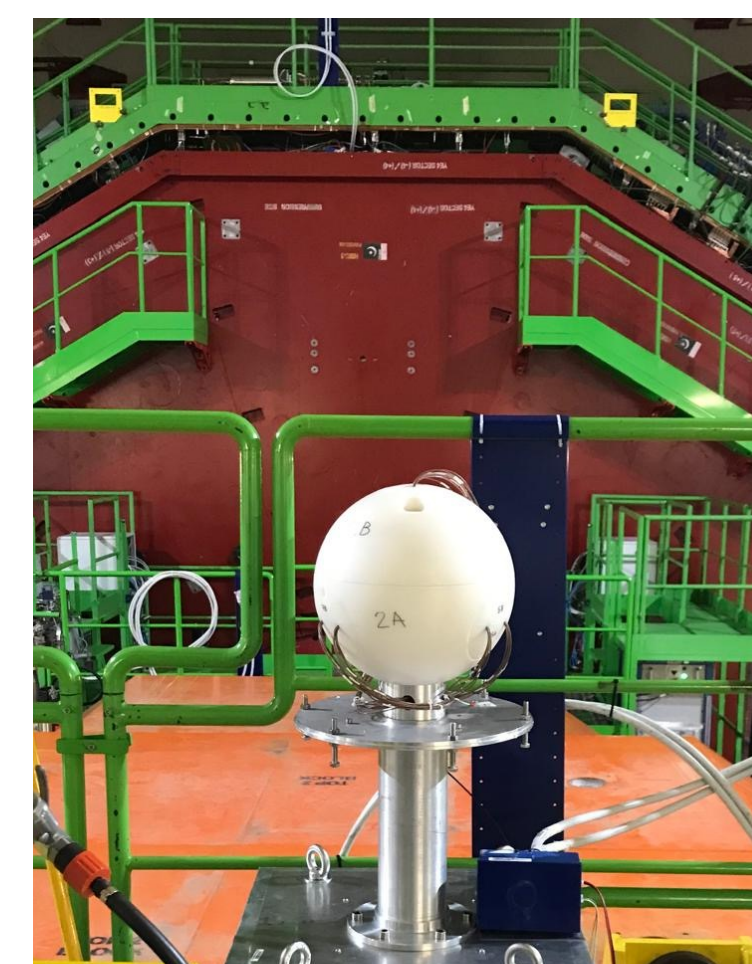
TetraBall Response Matrix



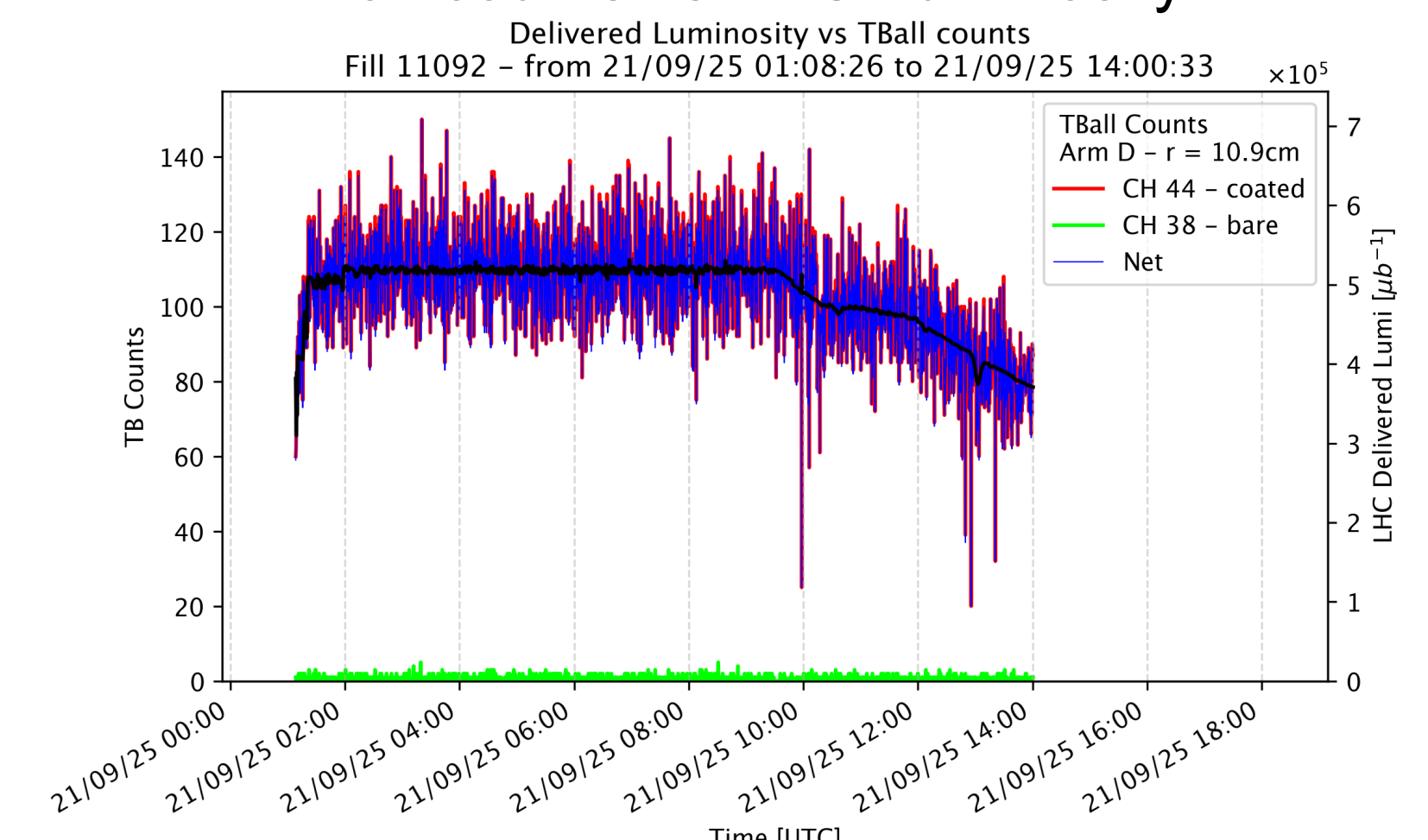
The project so far:

- Development (2024-2025)
- First prototype installed (Jun 2025)
- Continuous data-taking (Aug-Oct 2025, Mar-May 2026):
 - TBall counts vs LHC luminosity **proportionality**
 - System **stability** monitored over time
 - Extraction of **Alevra plots** necessary for **unfolding**
- Unfolding of **first spectra**:
 - using **CMS FLUKA v.5.6.0.4** as a-priori information
 - comparing between **FRUIT6** and **GRAVEL**-based unfolding tools

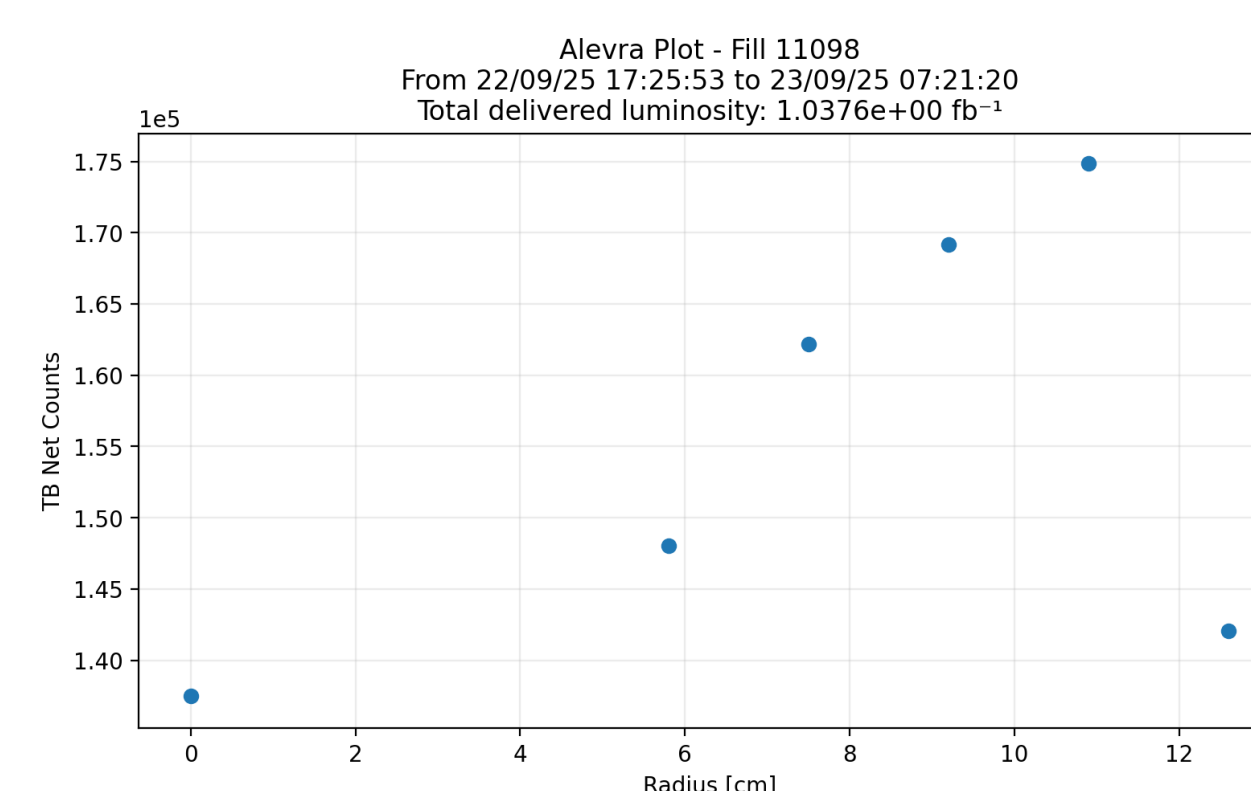
TBall in the CMS cavern



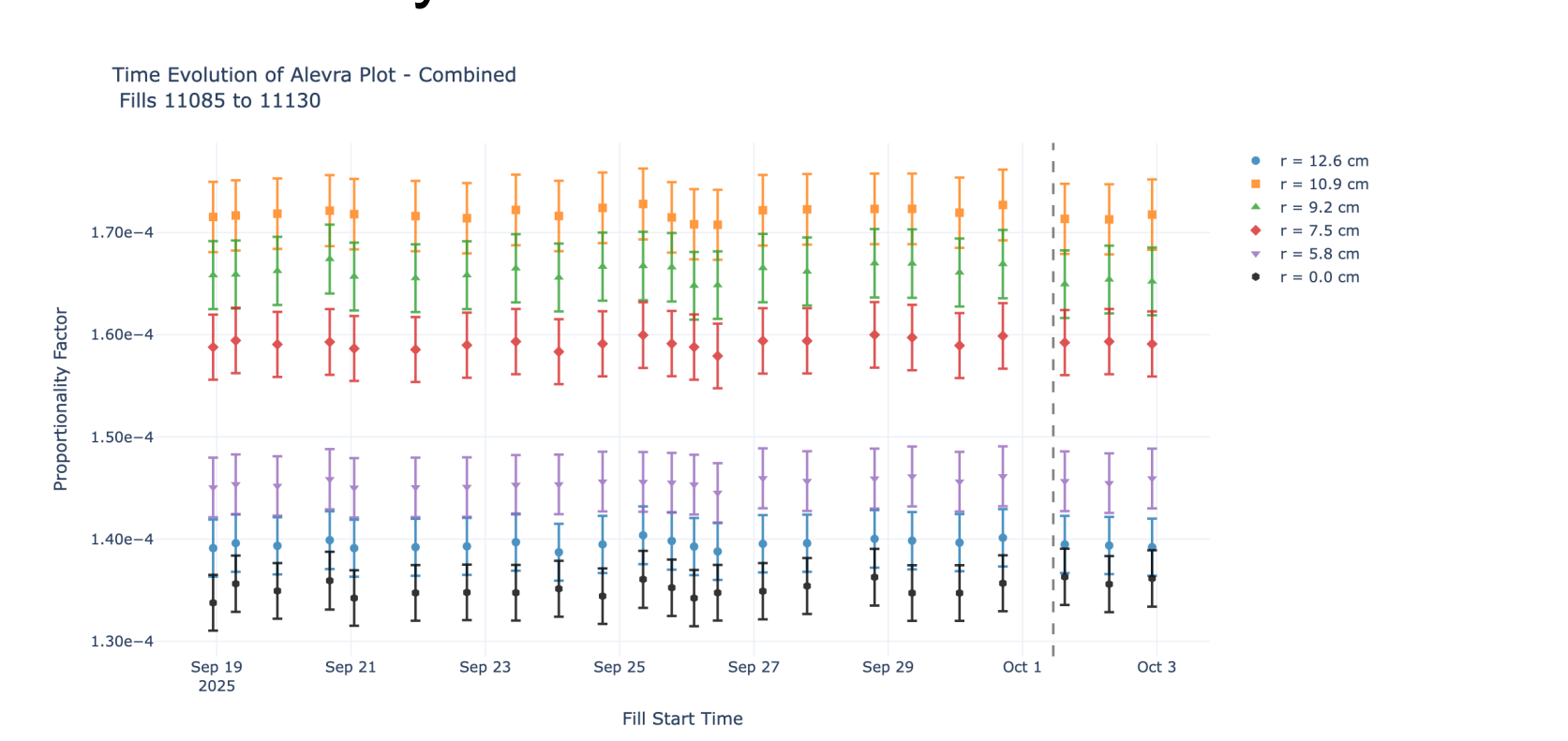
TBall counts vs LHC Luminosity



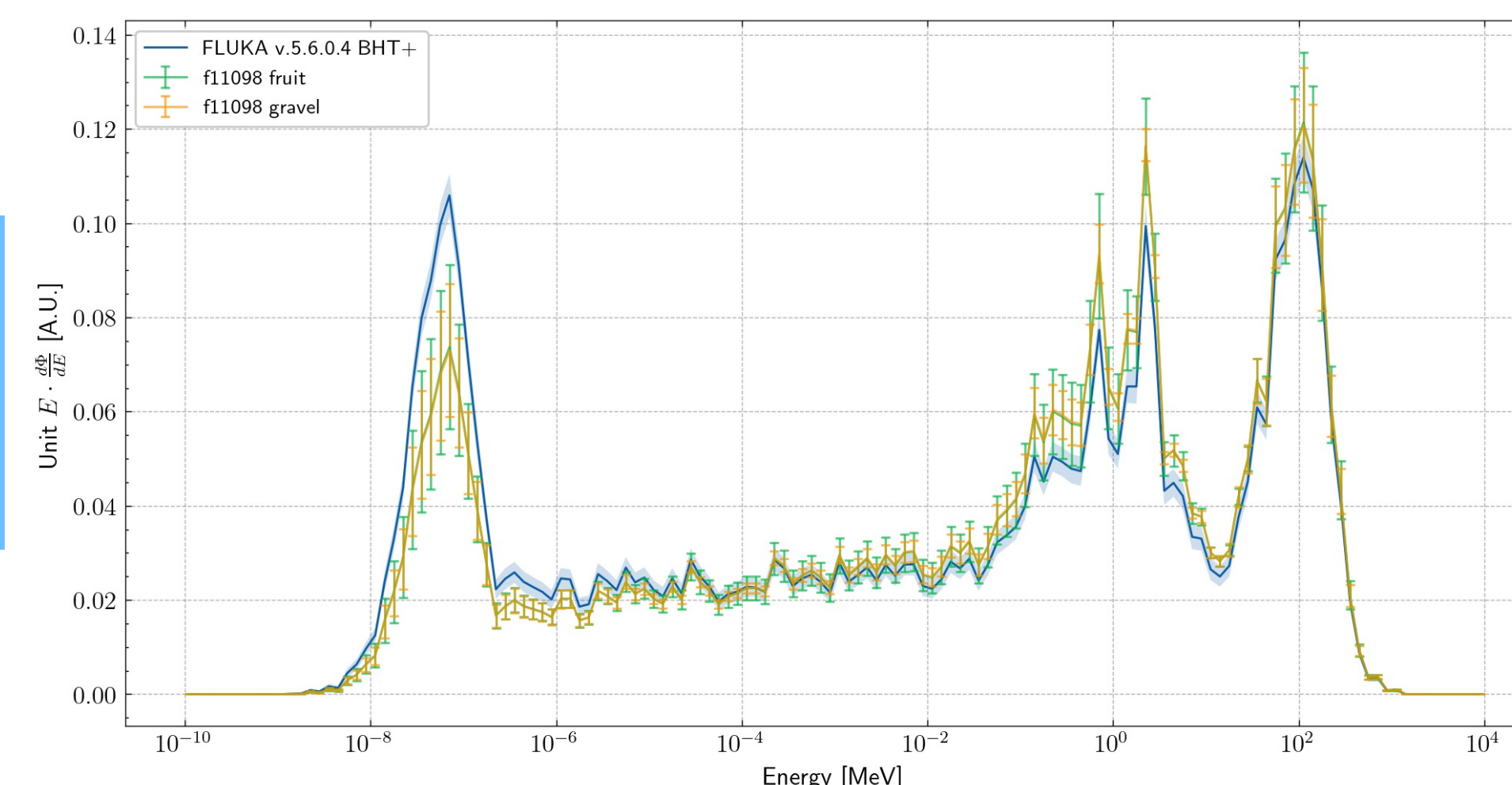
TBall Alevra Plot



Stability of TBall data over time

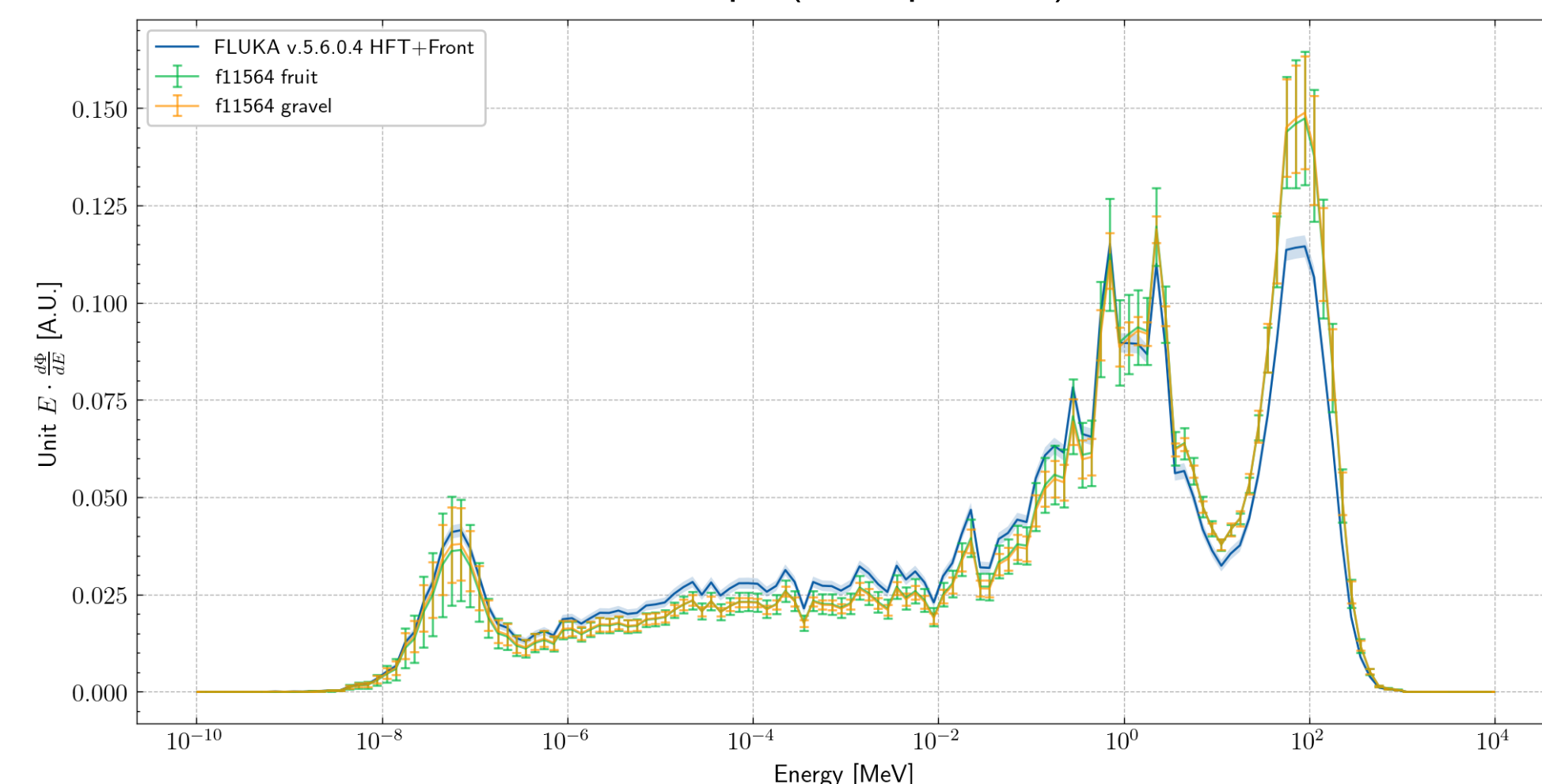


CMS BHTop+ (2025 position)



FLUKA-simulated vs. TBall unfolded equi-lethargic neutron spectra ($E * \frac{d\phi}{dE}$) for 2025 and 2026 data

CMS HFTop+ (2026 position)



Future work:

- Integration of the TetraBall DAQ chain into **CMS DCS** and **BRIL DAQ framework**
- Production of 4 new TetraBall systems** during LS3, to populate up to **24 positions** in the CMS experimental cavern

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