16th Pisa Meeting on Advanced Detectors - La Biodola, Isola d'Elba (Italy), 26th May – 1st June 2024

The LaBr3-based detection setup for the **FAMU** experiment at RIKEN-RAL

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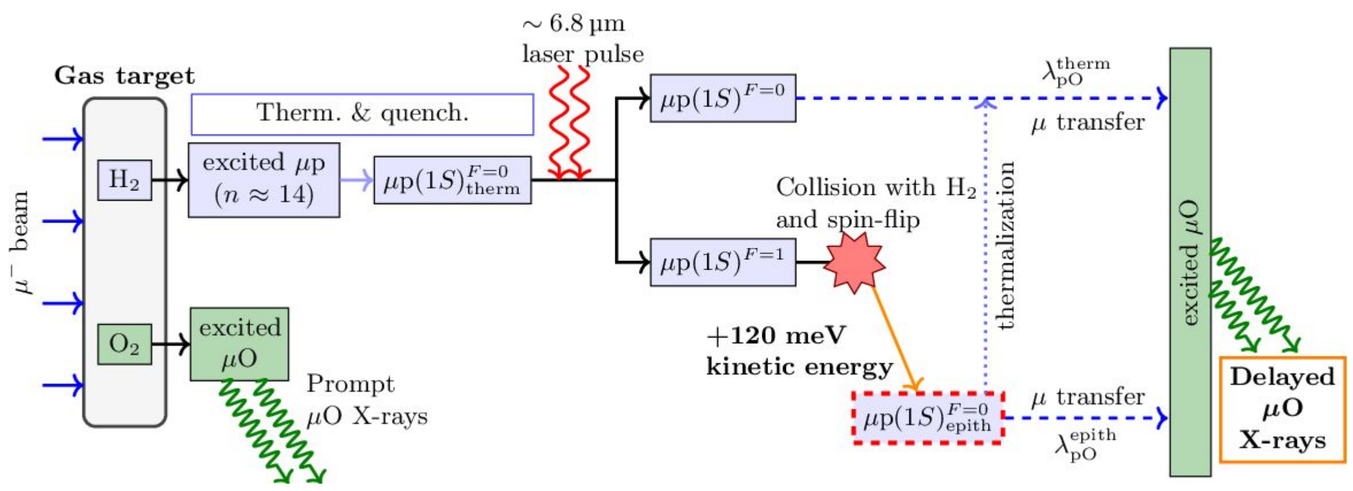
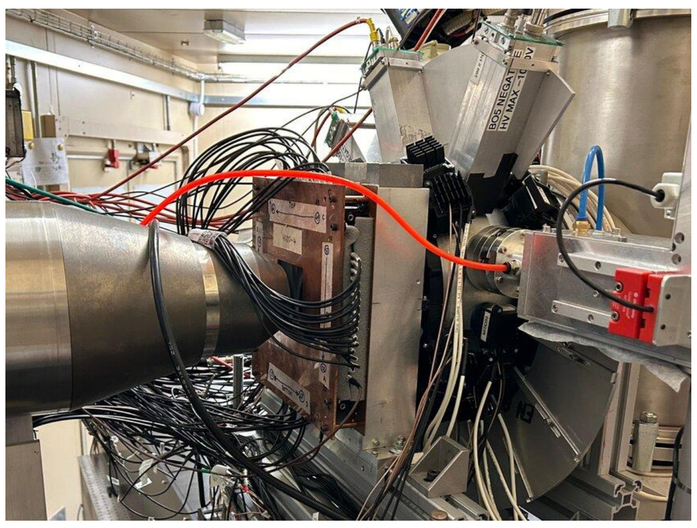
on behalf of the FAMU Collaboration.

FAMU is a Nuclear Physics experiment for an indirect determination of the proton Zemach radius by measuring the hyperfine splitting in muonic hydrogen.
Past runs: two runs in 2023 (October-December) = tot. **14 points** at different wavelengths;
Future runs: two in 2024 (July-October), one in 2025 (February).

Method

1. Muonic hydrogen formation (RIKEN-RAL Port1 negative muon beam, ISIS, United Kingdom)
2. Spin flip excitation (FAMU laser system)
3. Detection of the observable (muonic oxygen X-rays due to enhanced muon transfer probability)





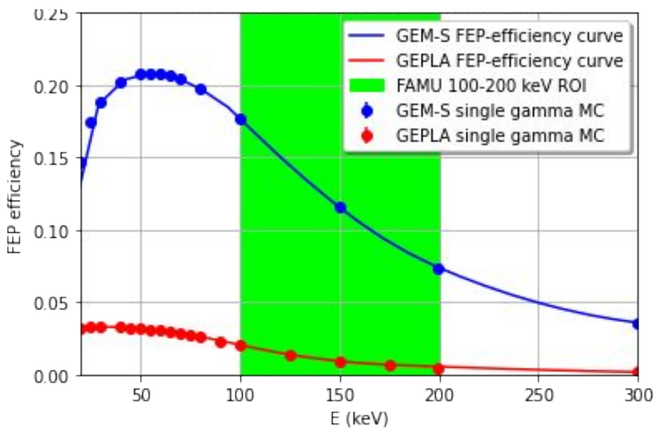
Germanium detector

Detector used as a reference for **inter-calibration** and to verify the gaseous target conditions.

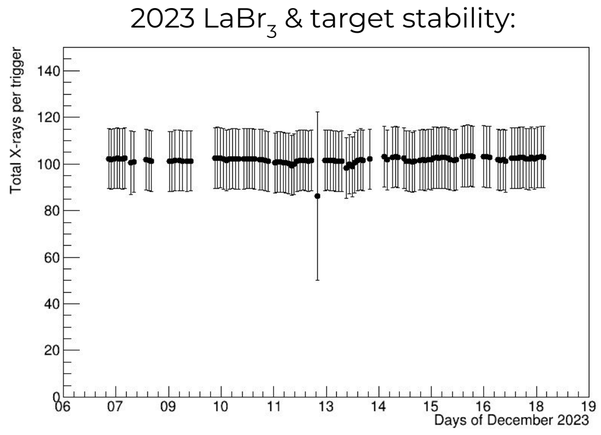
Energy resolution @ 141 keV: (1.26 ± 0.17) %

Two detectors were available from previous FAMU runs (2014-2018): a planar and a coaxial. The latter has been installed to maximise efficiency.

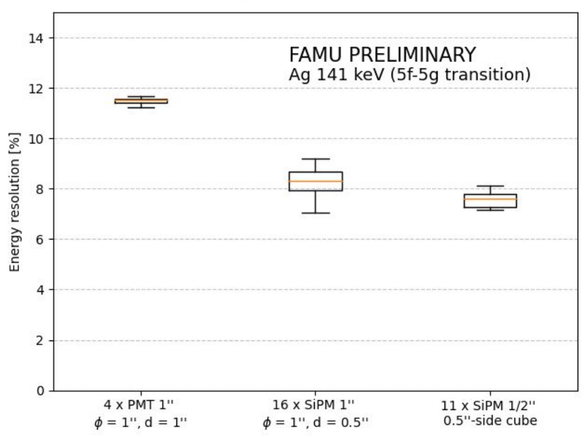
Coaxial (GEM-S) vs Planar (GEPLA) simulated efficiency curves:

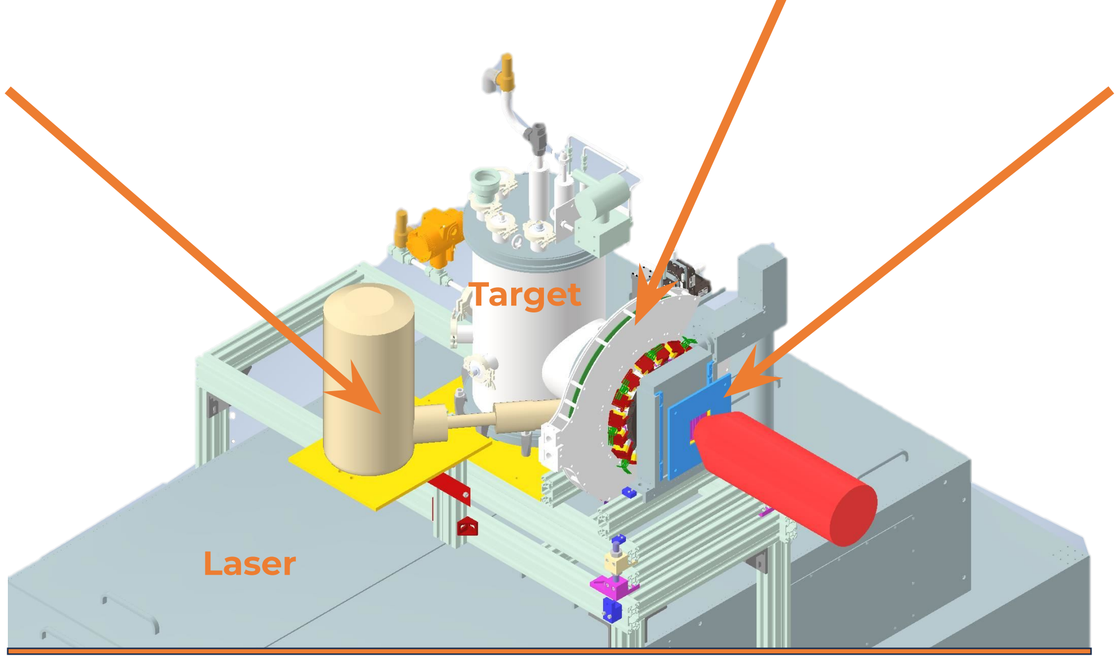


2023 $LaBr_3$ & target stability:

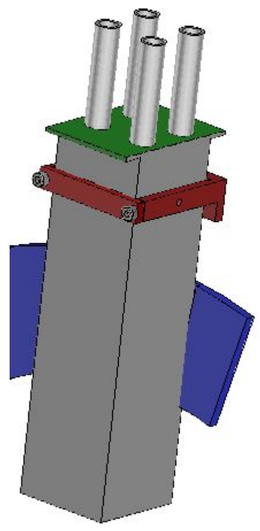


2023 $LaBr_3$ energy resolutions

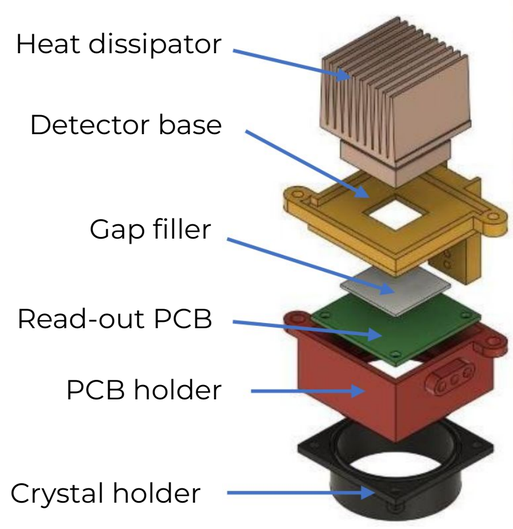




Courtesy of M. Bonesini



1''-PMT detector



1''-SiPM detector

$LaBr_3$ detectors

2023 setup: Cylindrical 1''-diameter $LaBr_3$:Ce crystals read-out by SiPM arrays (16x) and PMTs (6x)
+ ½''-cube $LaBr_3$:Ce crystals read-out by SiPM (12x).

2024 $LaBr_3$ detector upgrade: Cylindrical 1''-diameter $LaBr_3$:Ce crystals read-out by SiPM arrays (24x) and PMTs (6x),
i.e. all ½'' detectors substituted by new 1''-SiPM detectors.

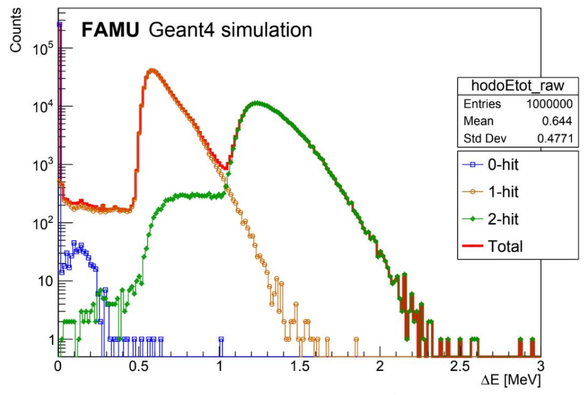
Fast detectors → risetime between 12 ns [PMT] and 30 ns [1''-SiPM], falltime between 100 ns [PMT] and 150 ns [1''-SiPM] , for increased timing capabilities, necessary to identify delayed X-rays, efforts in the development of fast read-out for the 1''

Energy resolved detectors → optimisation of read-out circuits to optimise energy resolution, important to identify muonic hydrogen X-rays among other delayed emissions.

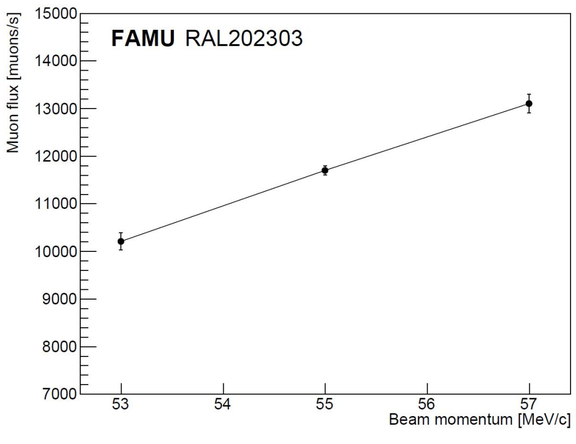
Beam monitor

32+32 squared 1 mm-pitch scintillating fibres read by SiPMs, spaced by 1 mm.

Simulated response function to 55 MeV/c μ^-:



Estimated muon flux:



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