

From Germany to France: Towards Neutrino Detection with the NUCLEUS Experiment

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NUCLEUS goal:

Coherent-Elastic Neutrino-Nucleus scattering (CEvNS) detection with reactor anti-neutrinos [1,2]

CEvNS cross-section $\sigma_{\text{CEvNS}} = \frac{G_F^2}{4\pi} Q_W^2 E_\nu^2 F^2(q^2)$

Fermi const G_F Electro-weak charge Q_W Form factor $F \approx 1$ Neutrino energy E_ν Neutron number N

$[Z(1 - 4\sin^2\theta_W) - N]^2$

Signal: sub-keV nuclear recoil energy

Method: cryogenic CaWO_4 crystal calorimeters with ~ 10 eV-scale thresholds operated at 10 mK

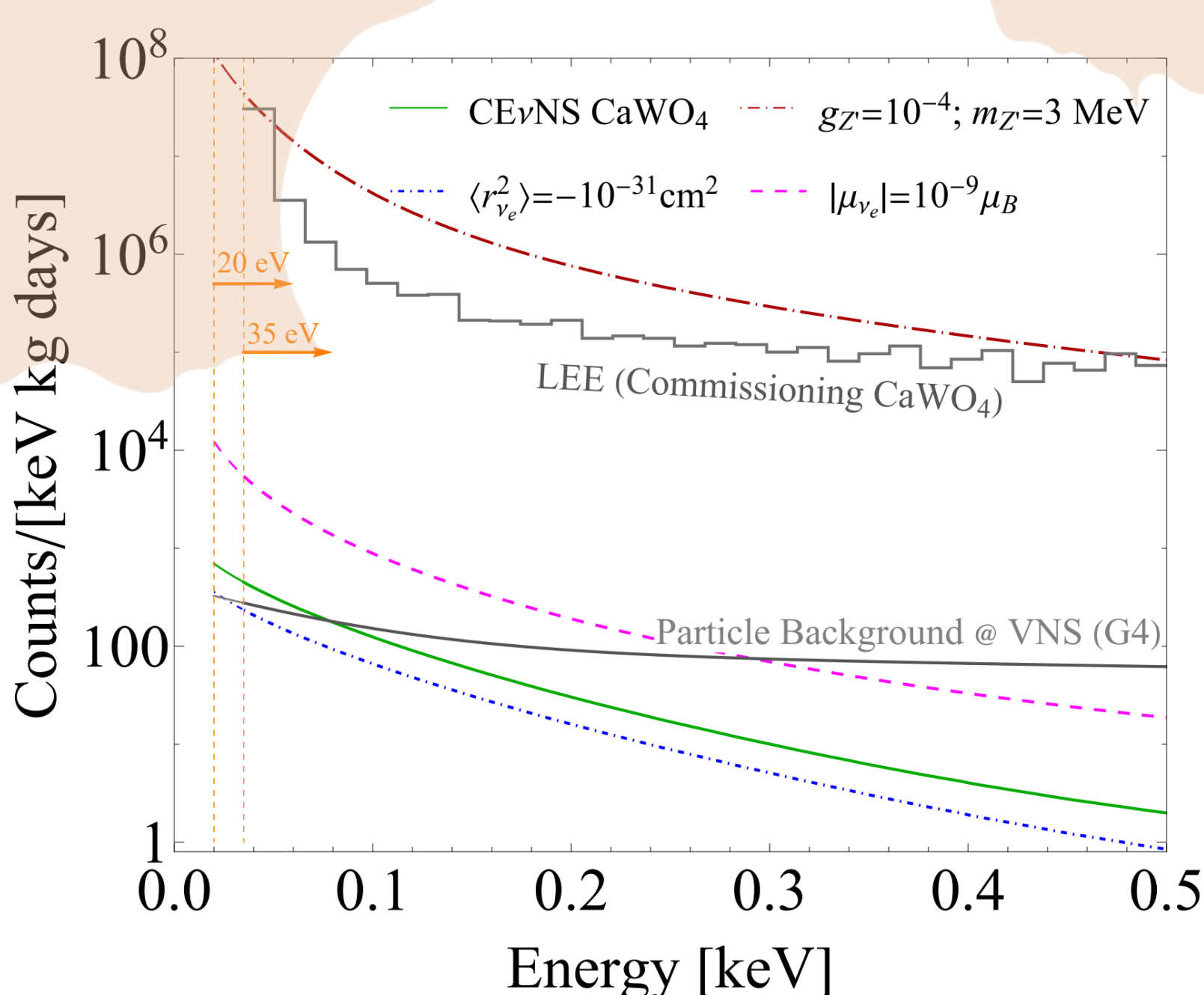
Experimental Site:
Chooz Nuclear Power Plant in France

Chooz

NUCLEUS is in a basement room between two 4.25 GW_{th} reactor cores (72 m and 102 m):
 $\phi_\nu = 1.7 \times 10^{12}$ $\nu/\text{cm}^2/\text{s}$ accounting for duty cycle [4]



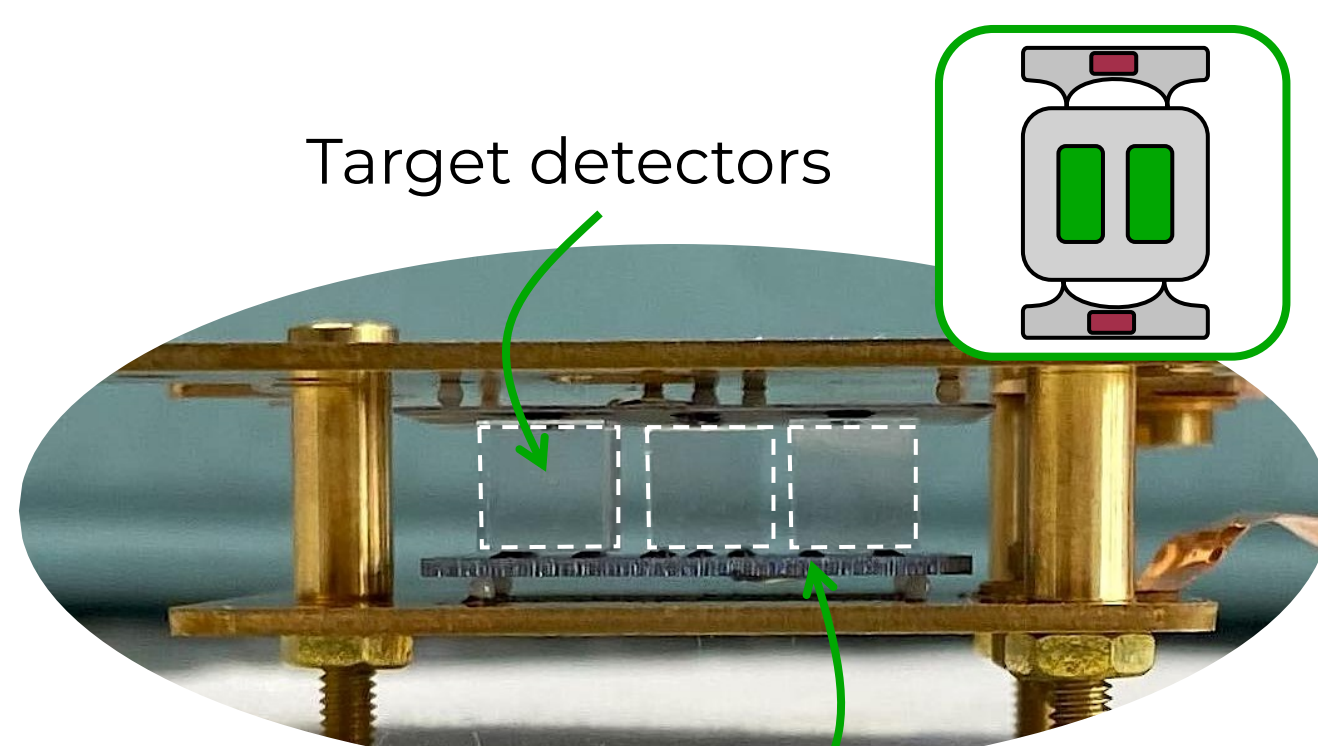
Full cryogenic system is cooling the detector down in Chooz now!



Sensitivity to [8]:

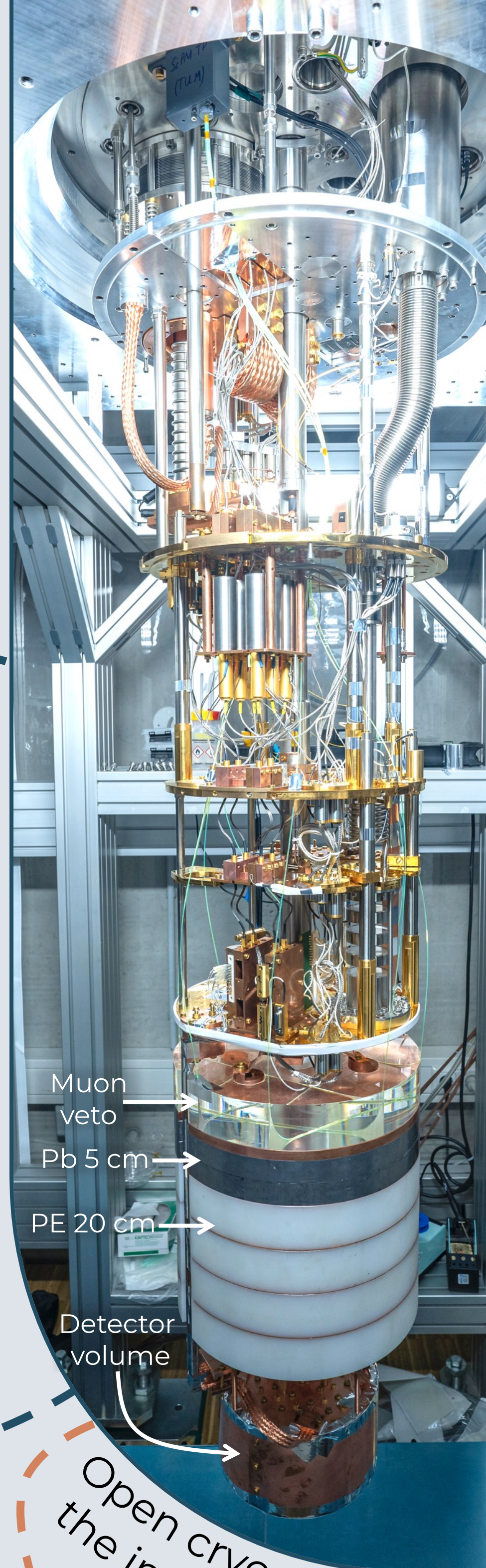
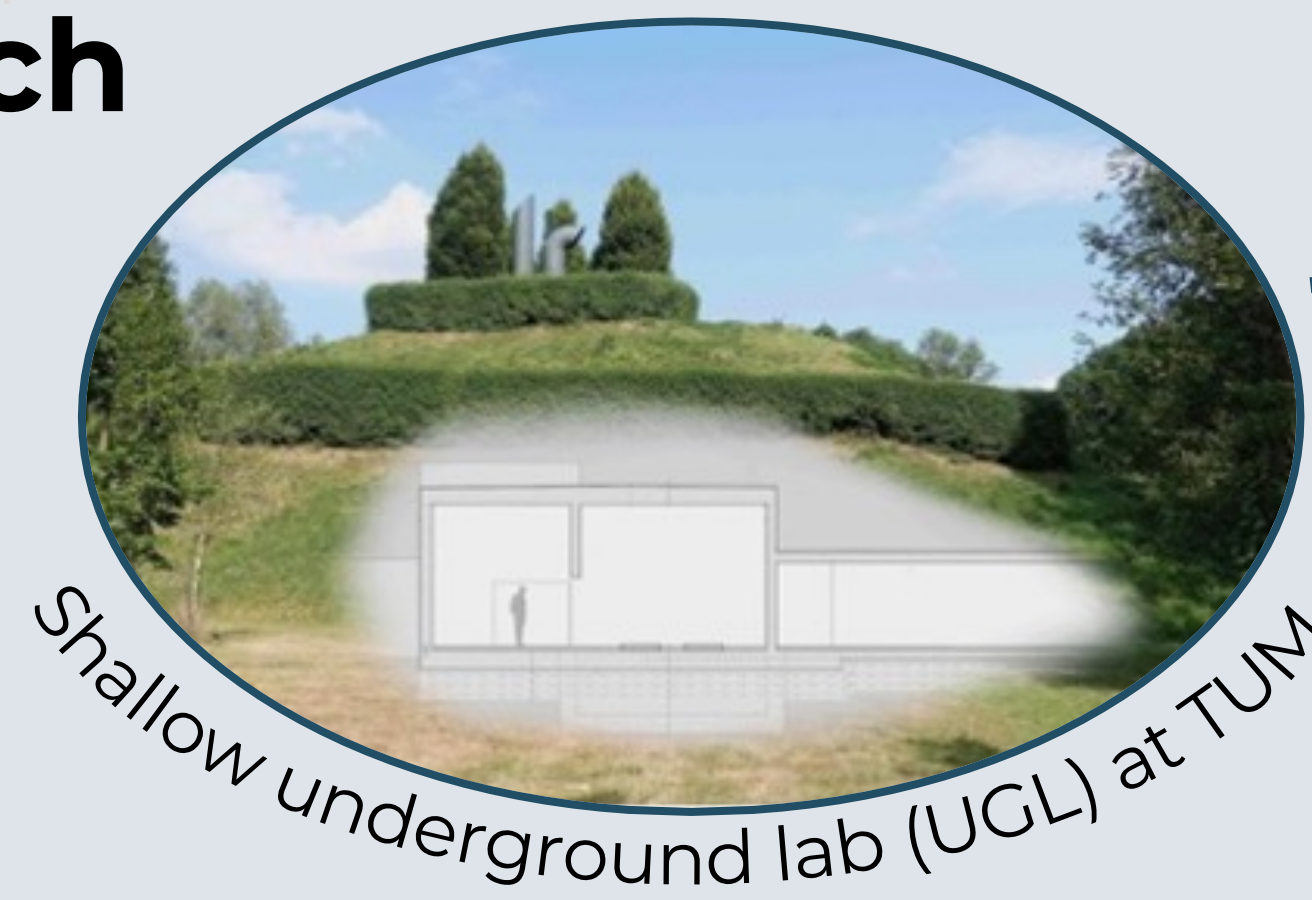
→ SM CEvNS
→ neutrino magnetic moment

→ modified neutrino charge radius
→ new light universal mediator



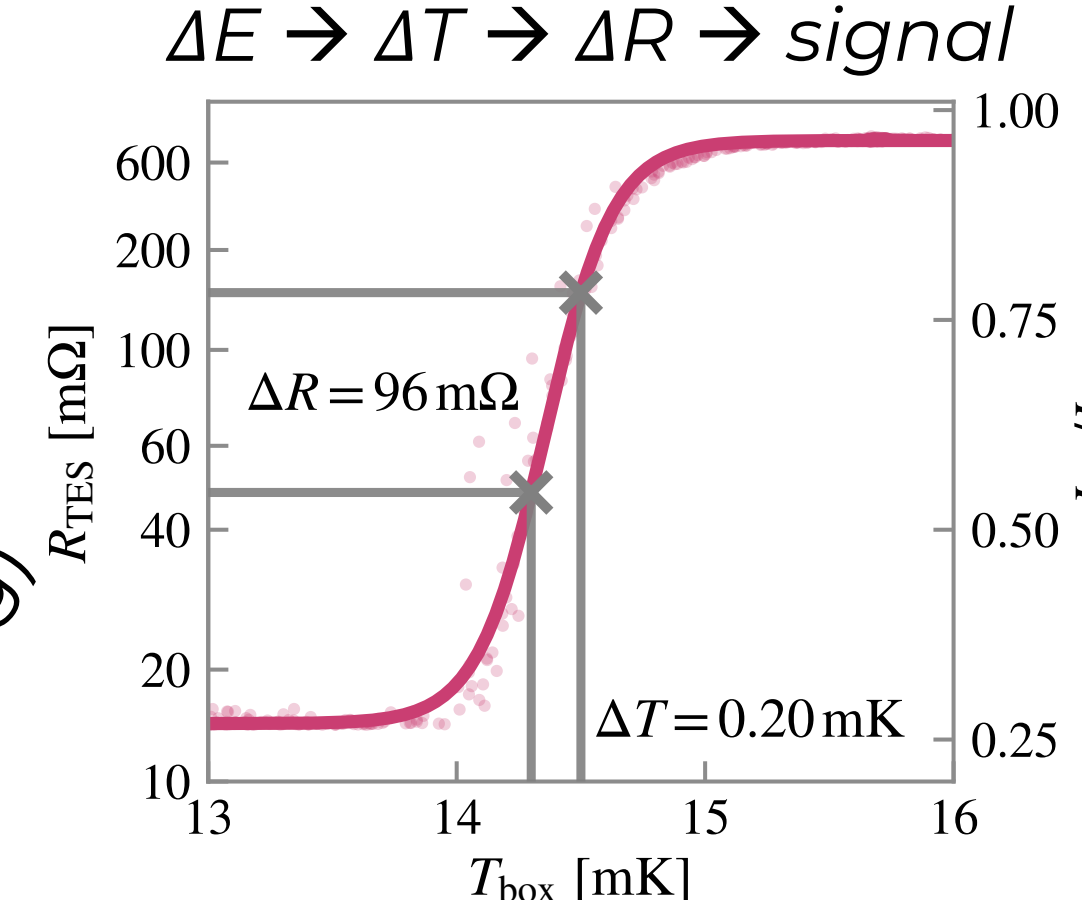
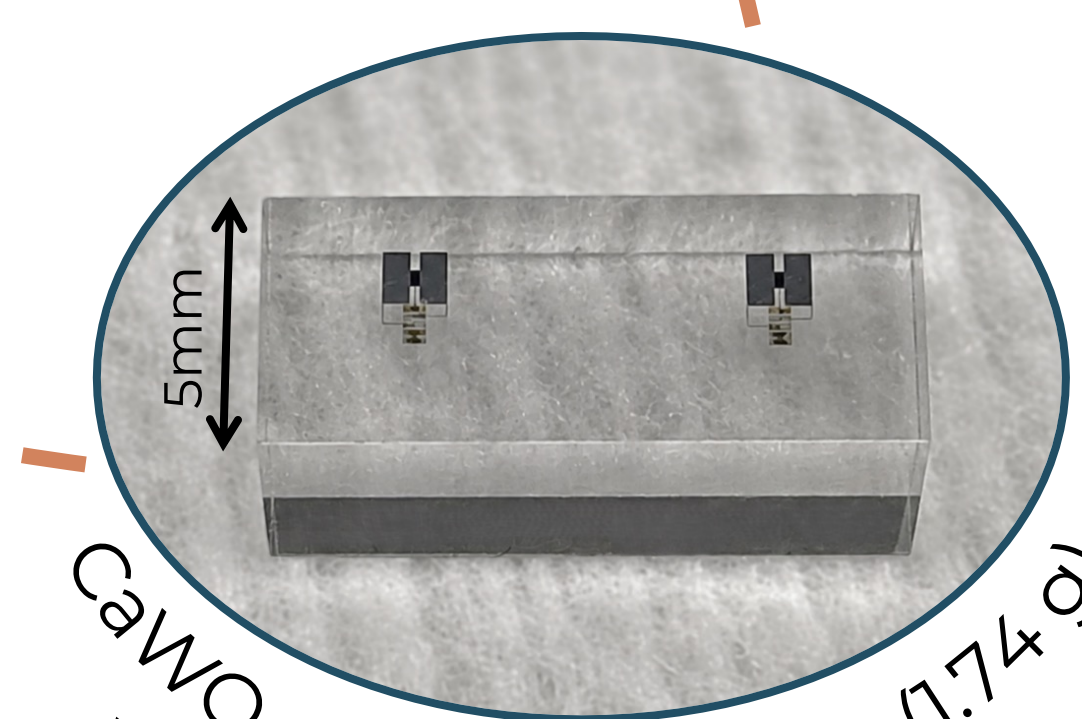
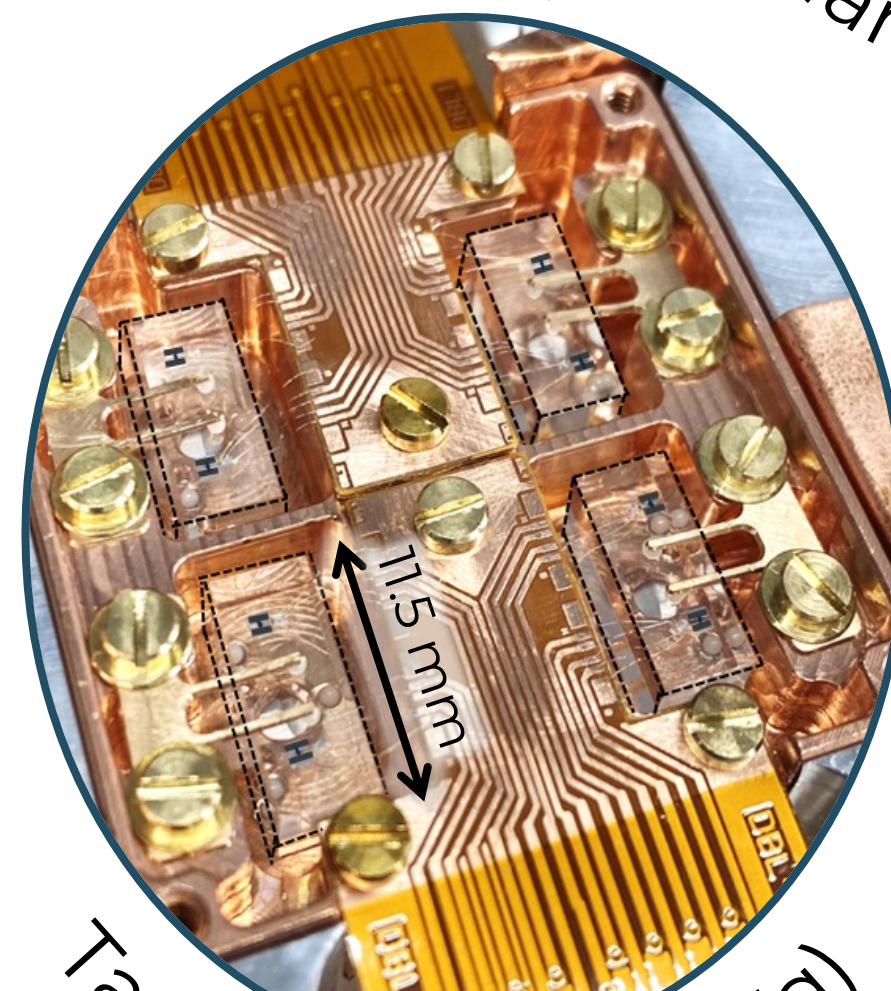
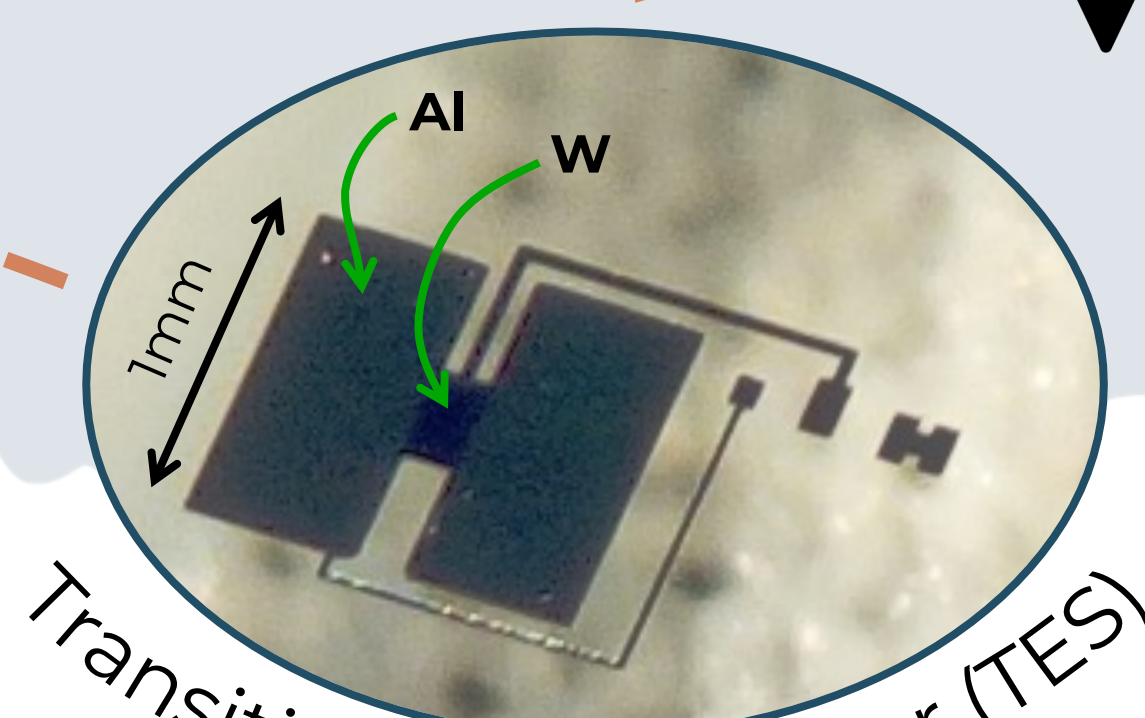
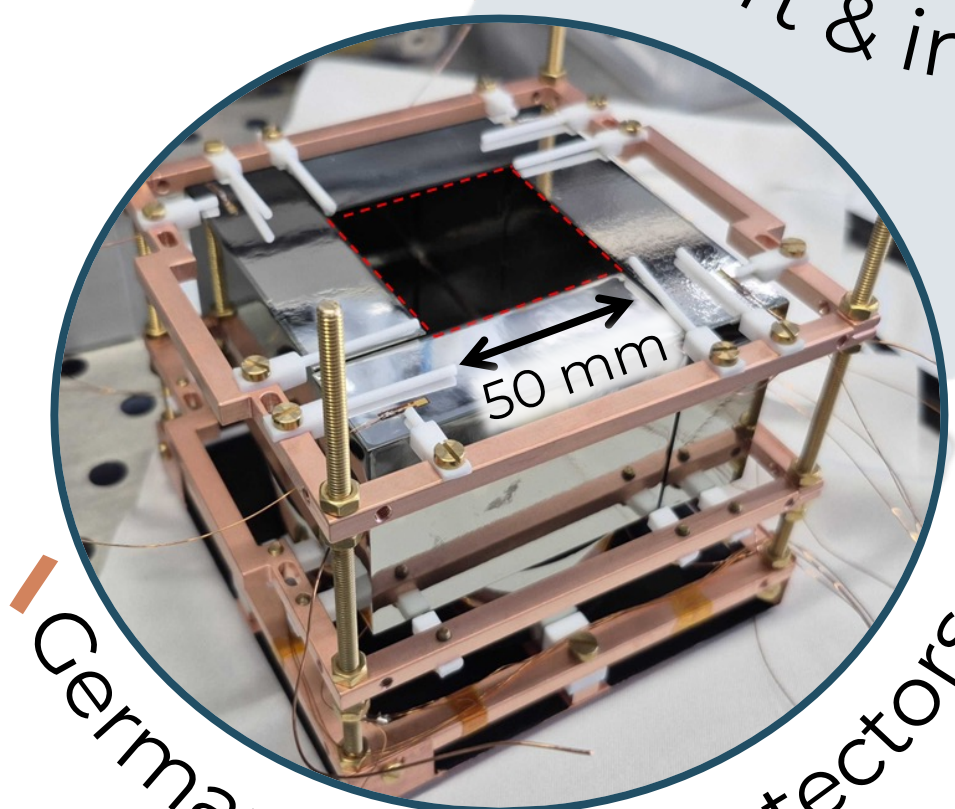
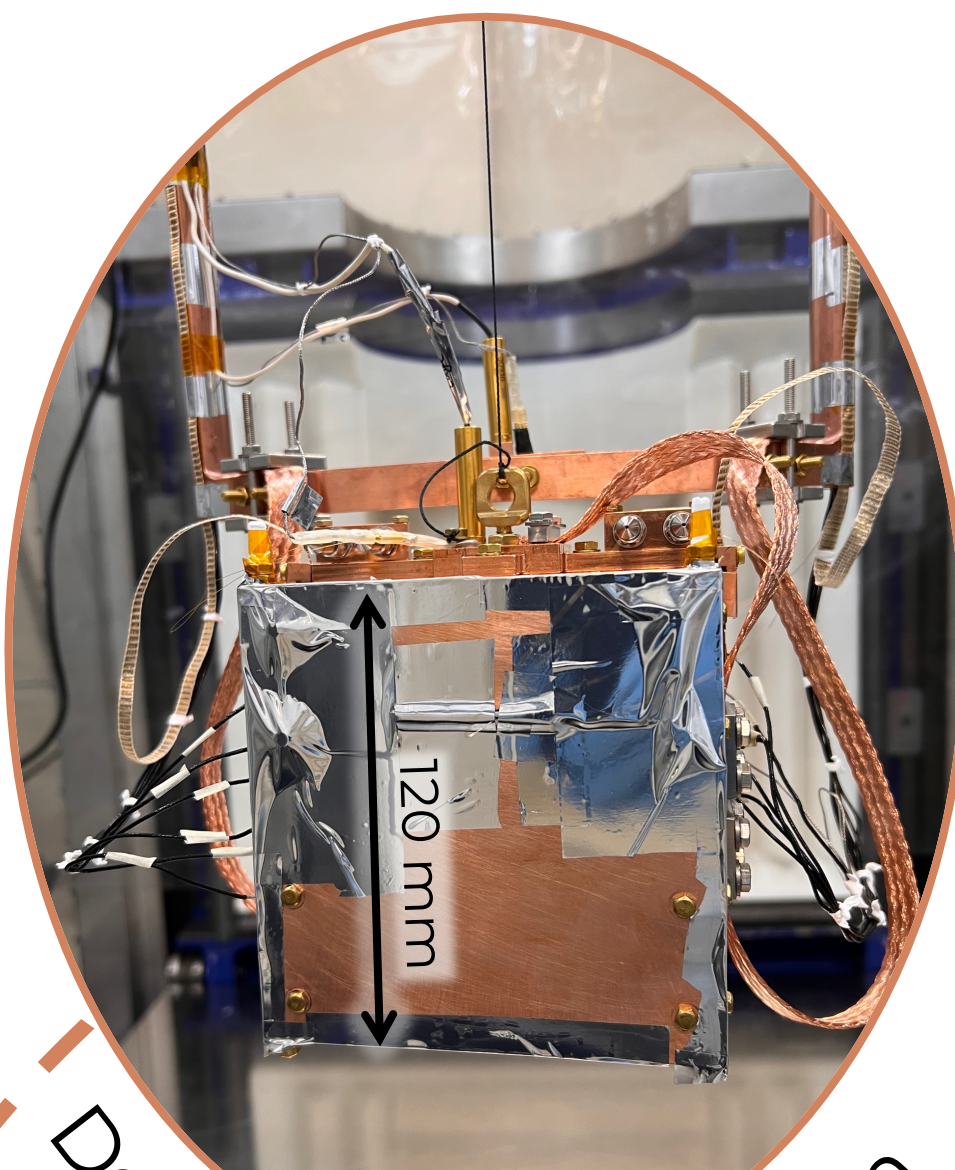
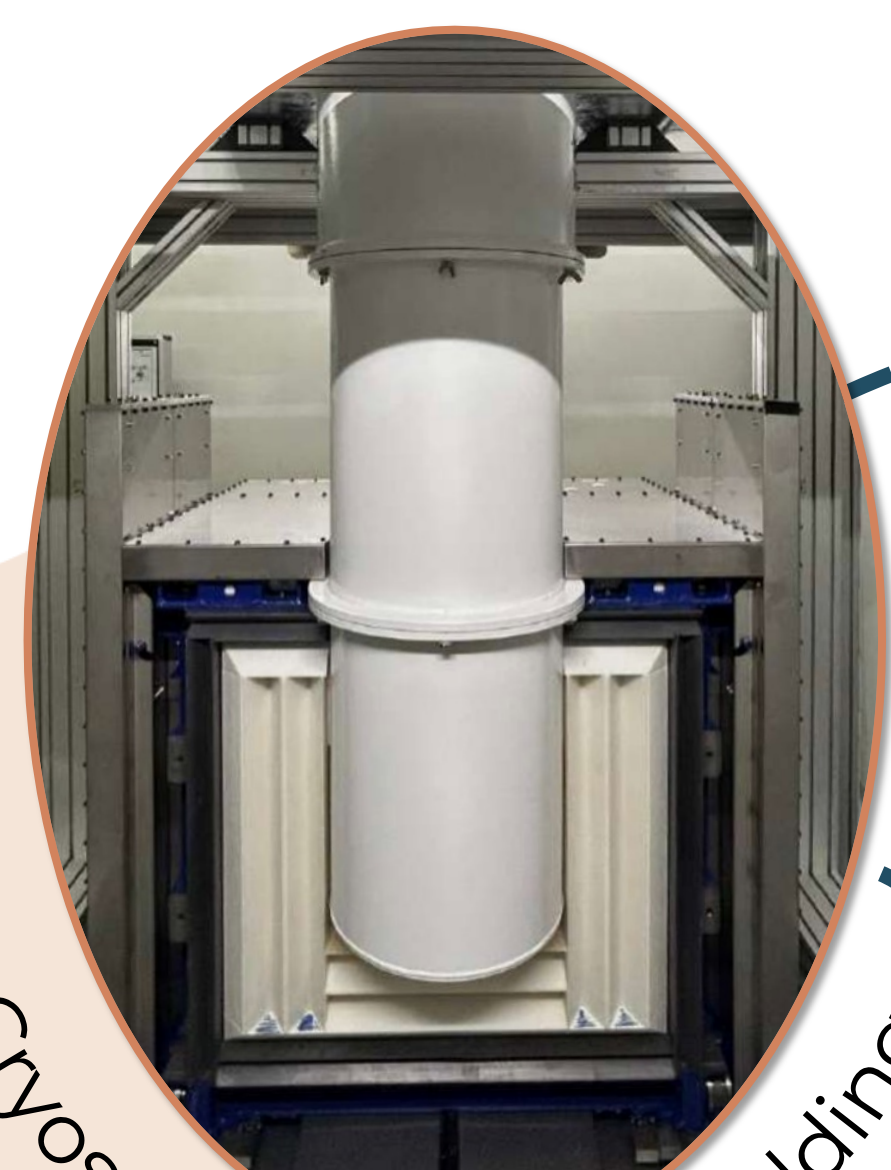
Si veto wafers instrumented with TES supporting the crystals

Full NUCLEUS setup operated stably at UGL (TUM) for two months in 2024 [3]
→ Ready for the move to Chooz

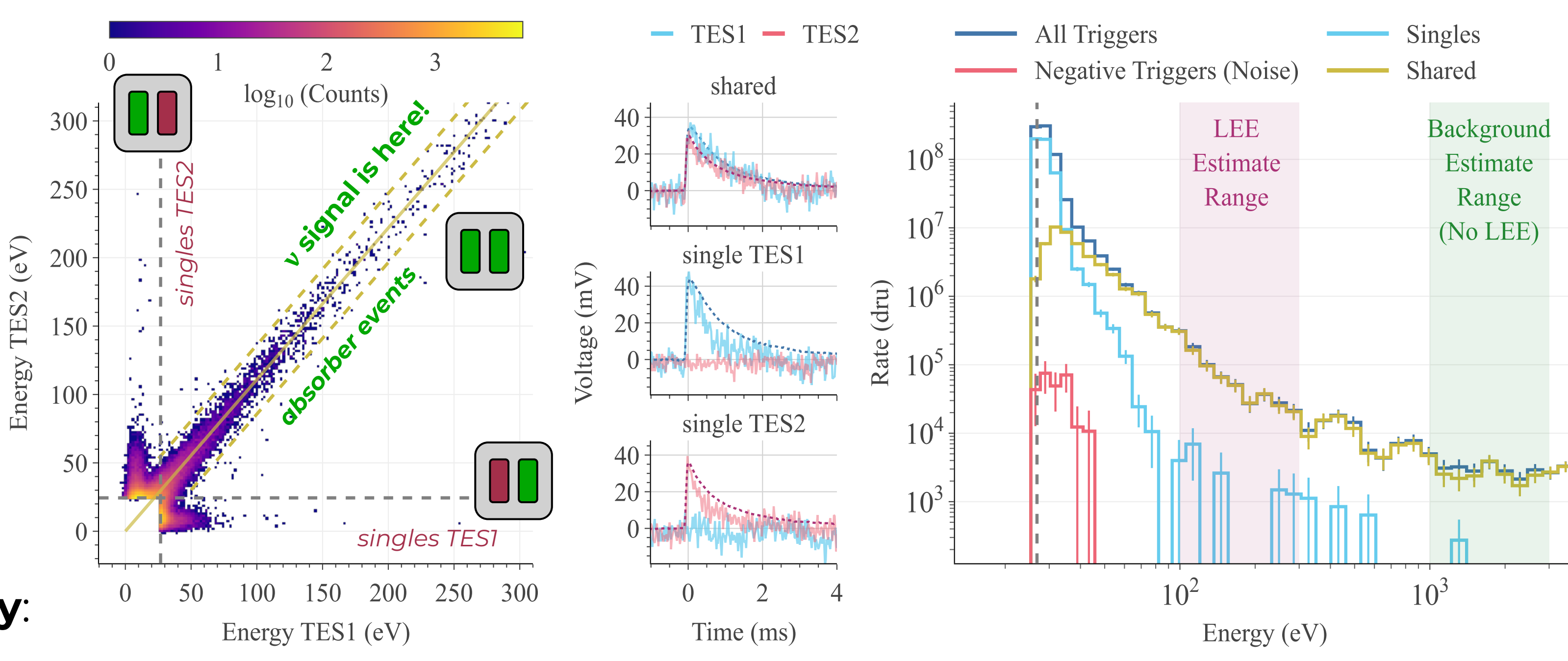


Open cryostat with the inner shielding and detectors [3]

Munich



Main challenge: backgrounds of unknown origins in the ROI steeply rising towards low energies = Low Energy Excess (LEE) [7]



LEE study at TUM with an Al_2O_3 double-TES detector [7]:
→ LEE rate does **not** correlate with particle background
→ LEE rate decays with time since cooldown with a consistent power-law exponent $k=0.59 \pm 0.06$ across the measurements

REFERENCES:

- [1] Phys. Rev. D 96, 022009 (2017)
[2] Eur. Phys. J. C 79, 1018 (2019)
[3] Phys. Rev. D 112, 072013 (2025)
[4] Eur. Phys. J. C 86, 29 (2026)
[5] arXiv:2603.28276 (2026)
[6] JINST 20 P05022 (2025)
[7] arXiv:2603.07687 (2026)
[8] arXiv:2603.24450 (2026)

