Investigations with micro-structured units at the KATRIN experiment

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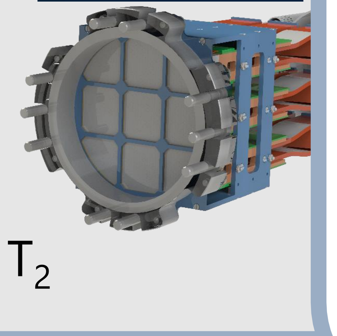
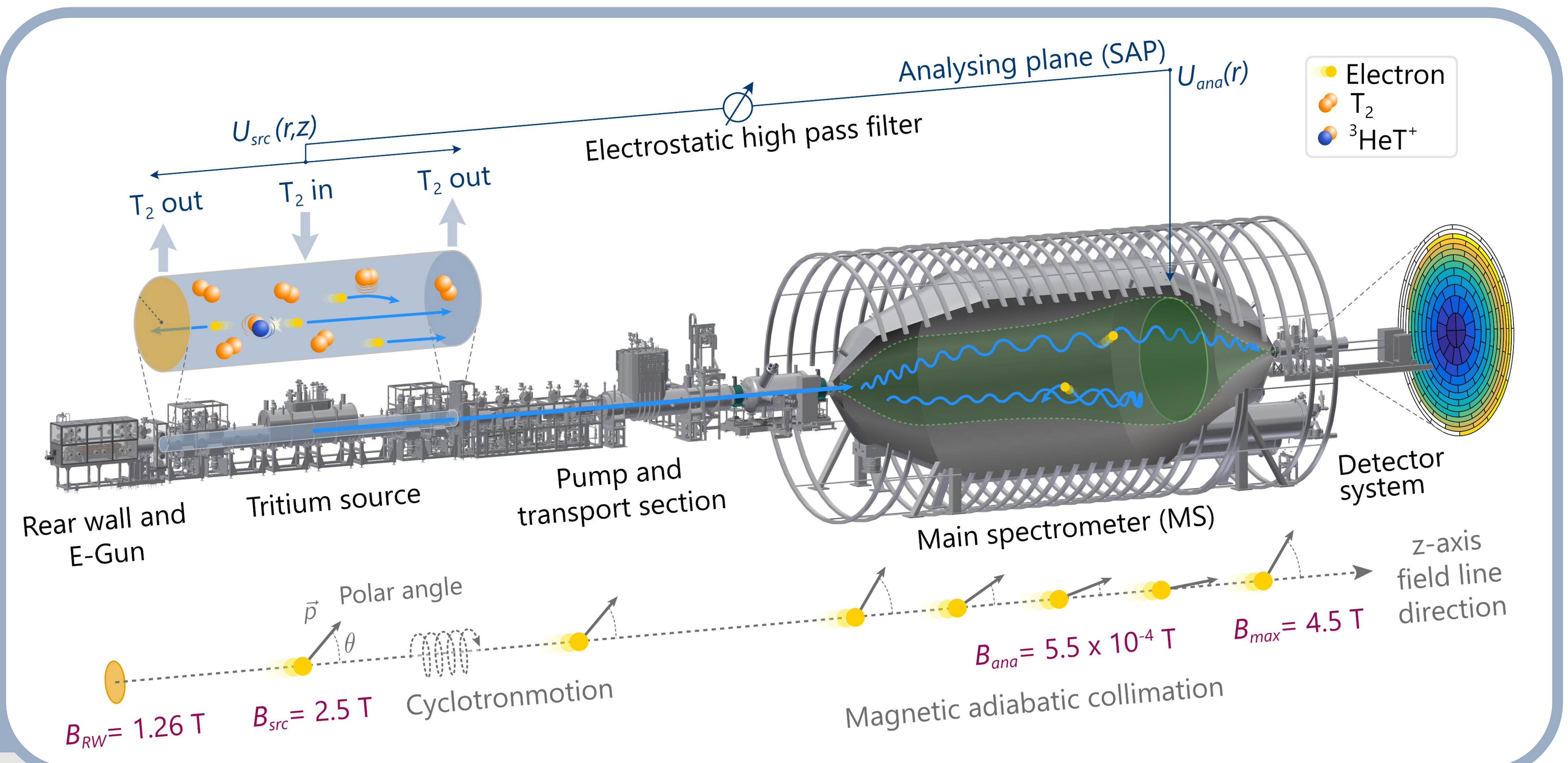
Measuring neutrino masses with KATRIN

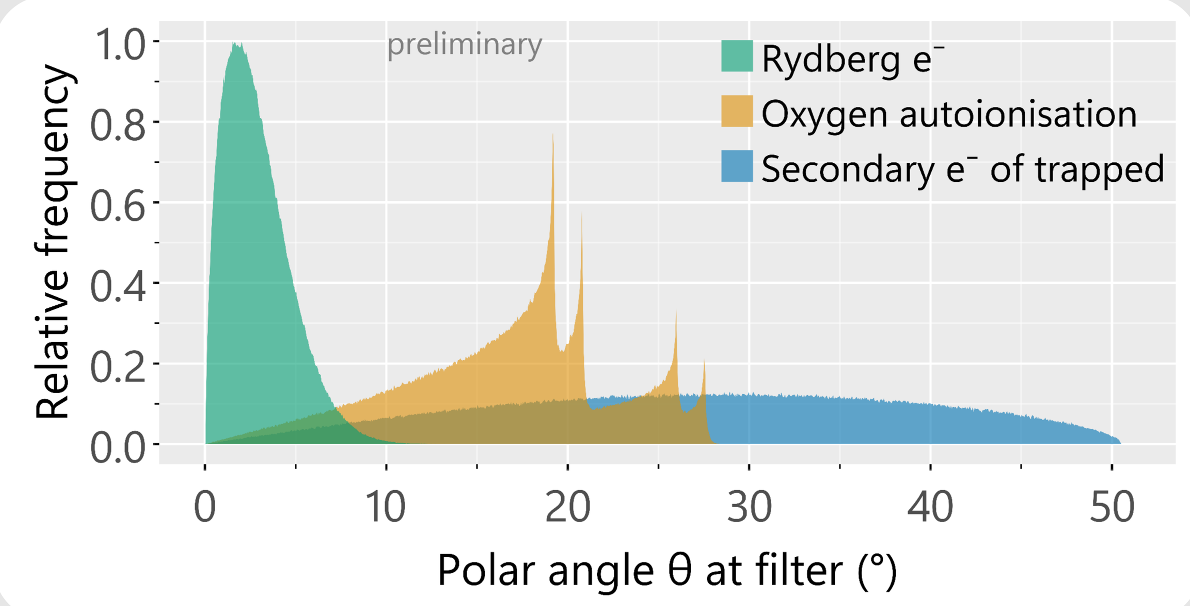
- Spetroscopic investigation of tritium beta decay
- MAC-E filter principle ←→ Adiabatic motion
- Stepwise integral measurement of electrons
- Effective neutrino mass affects spectral shape at E_0
- Final sensitivity: $m_\nu < 0.3$ eV/c^2

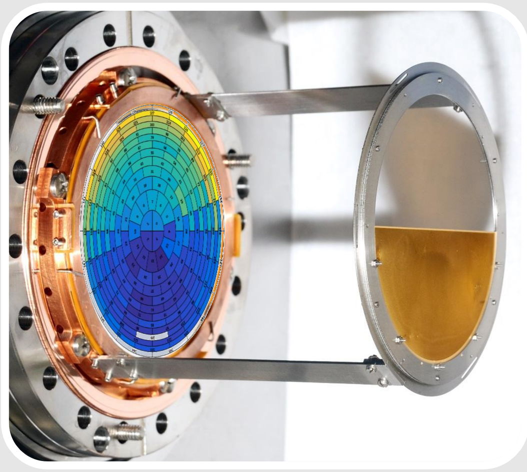
Future upgrade: TRISTAN Detector → Siegmann #16

- Silicon drift detector with good energy resolution: ≈300 eV @ 20 keV
- Handles high rates (>10^5 cps/pixel)
- Differential measurement of β-spectrum
- Designed for sterile neutrino search with T_2









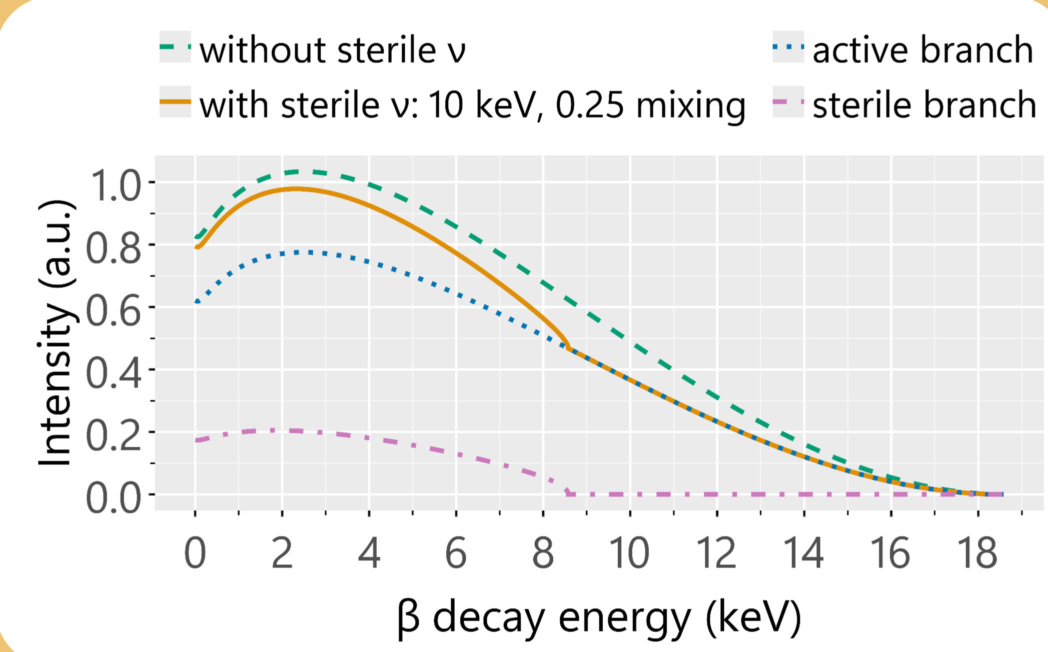
Rydberg background model investigation

- Final sensitivity limited by background rate O(0.2 cps)
- The background is created by the ionisation O(meV) of sputtered excited atoms, which are induced by radioactive decays of ^{210}Pb
- Probing this hypothesis by a transverse energy filter at 2.5 T field
  - The low energy corresponds to small polar angles at the filter
  - Micro-structured golden filter with hexagon channels O(100µm)
  - Observation not consistent with Rydberg model → extension

Systematics at sterile neutrino search with the TRISTAN detector upgrade

Completely different operation mode

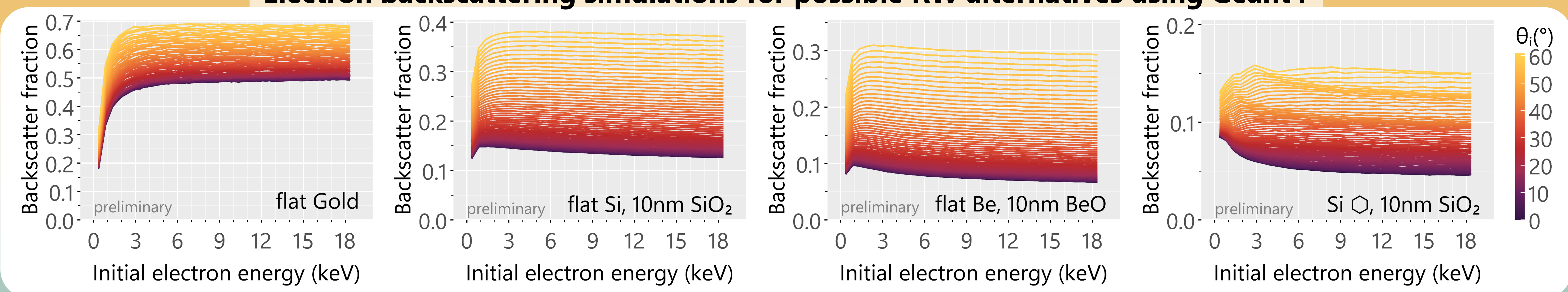
- Low retarding potential O(1 keV)
- Lower source acitivity O(0.1 – 1%)
- Higher main spectrometer magnetic field for better transmission of electrons of varying energy
- More detector pixels 148 → 1494 (1st stage)
  → Other systematics → Onillon #260



Rear wall as major bottleneck of current setup

- Rear end of experiment: golden disc
  → High backscattering probability (BSP)
- From simulations: >50% of detected electrons have scattered and lost energy
  → Exchanging the Rear wall (RW) is mandatory
- Simulations to find a new RW solution with optimisation of the BSP and systematic reduction

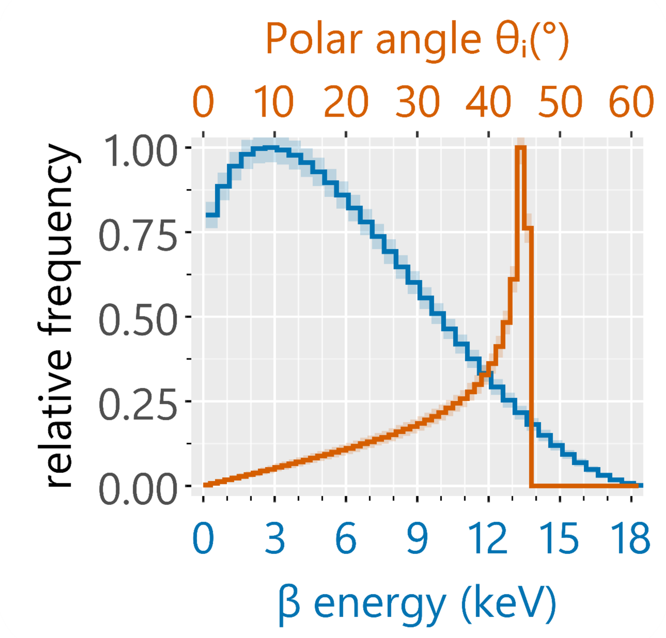
Electron backscattering simulations for possible RW alternatives using Geant4

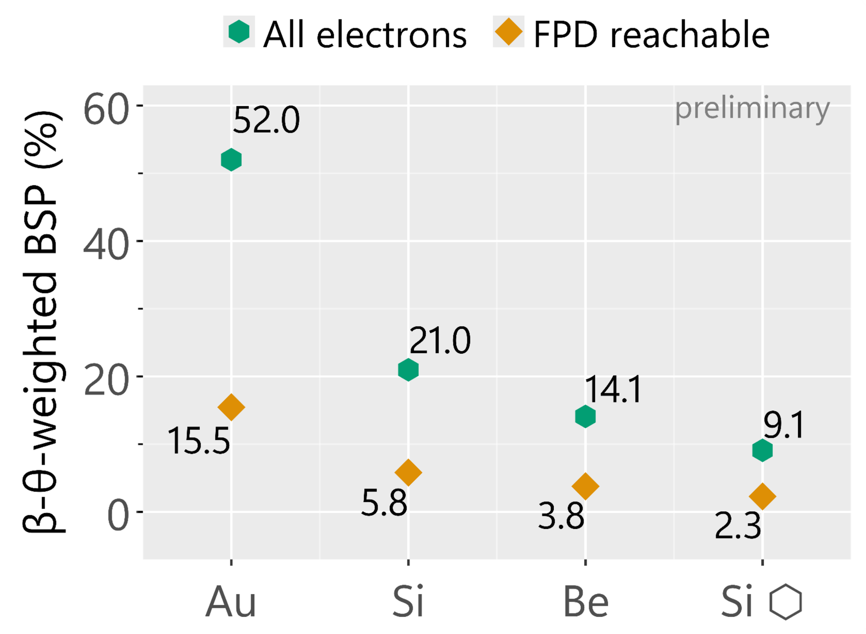


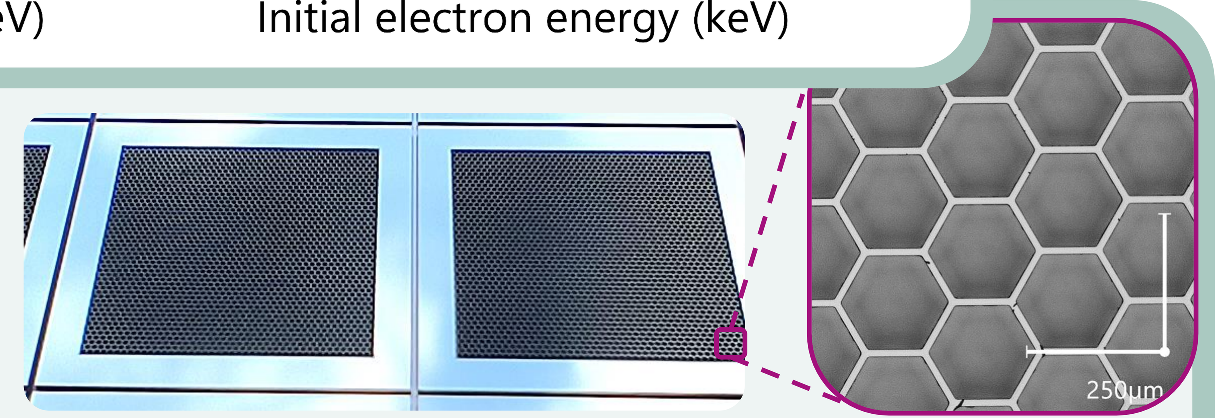
Comparison of different RW scenarios

- Isotropic β-spectrum with N = 1 million e⁻
  - ΔE = 500 eV and Δθ = 1°
  - B_{RW} = 1.26 T (standard)
- Flat and micro-structured surfaces of different materials w/ & w/o special oxide layers
- Weighted BSP according β-decay energy and polar angle distribution at RW (2.5 T → 1.26 T)

- Silicon micro-structure is most auspicious
- Larger surface area for tritium accumulation







Upcoming hardware investigations

- Four Si micro-structured samples produced
  - Varying hexagonal channel diameter
- Tritium loading tests on Si, Be and Si ⬡
- Verification of Geant4 simulations with electron backscattering measurements in Milano-Biccoca → Nava #523

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