Magnetic electron spectrometer for characterising anti-neutrino anomaly

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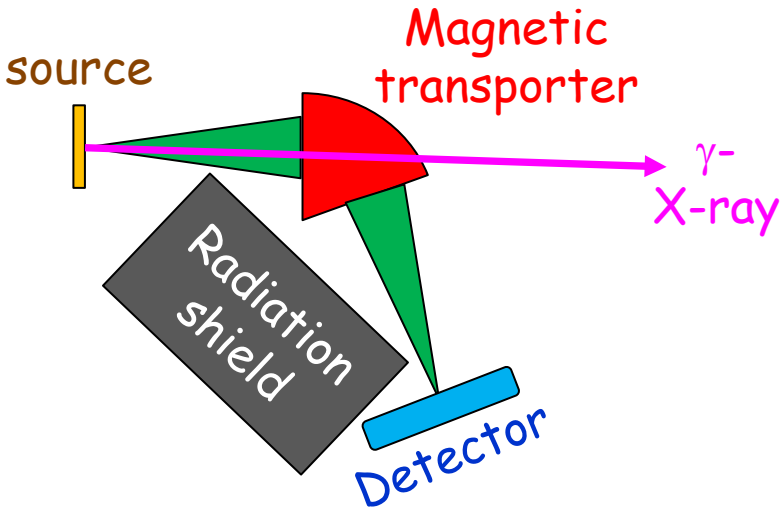
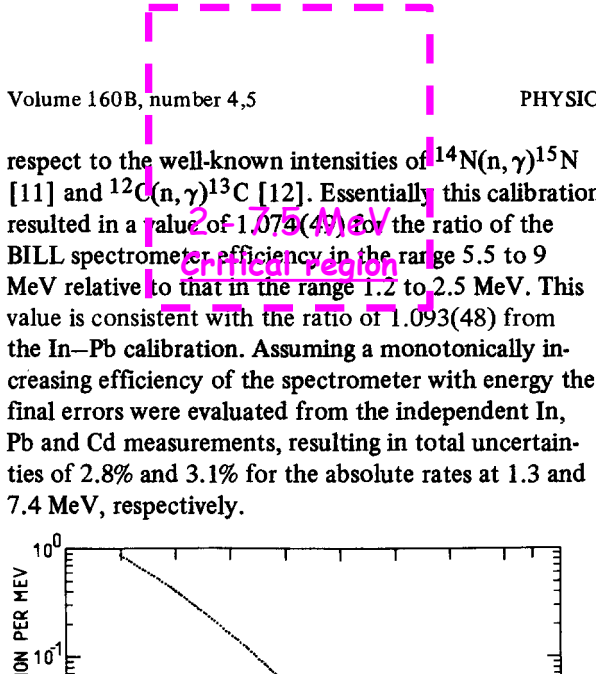
AIMS

- Measure continuous β-spectra up to 10 MeV
- Supress γ- and X-rays, room and neutron beam backgrounds
- Better than 25 keV (0.025 MeV) energy resolution; resolve discrete energy conversion electrons and β-rays
- High efficiency to determine β-spectrum with better than 1% accuracy up to 8 MeV – critical to observe and characterise oscillations

Ideal tool:



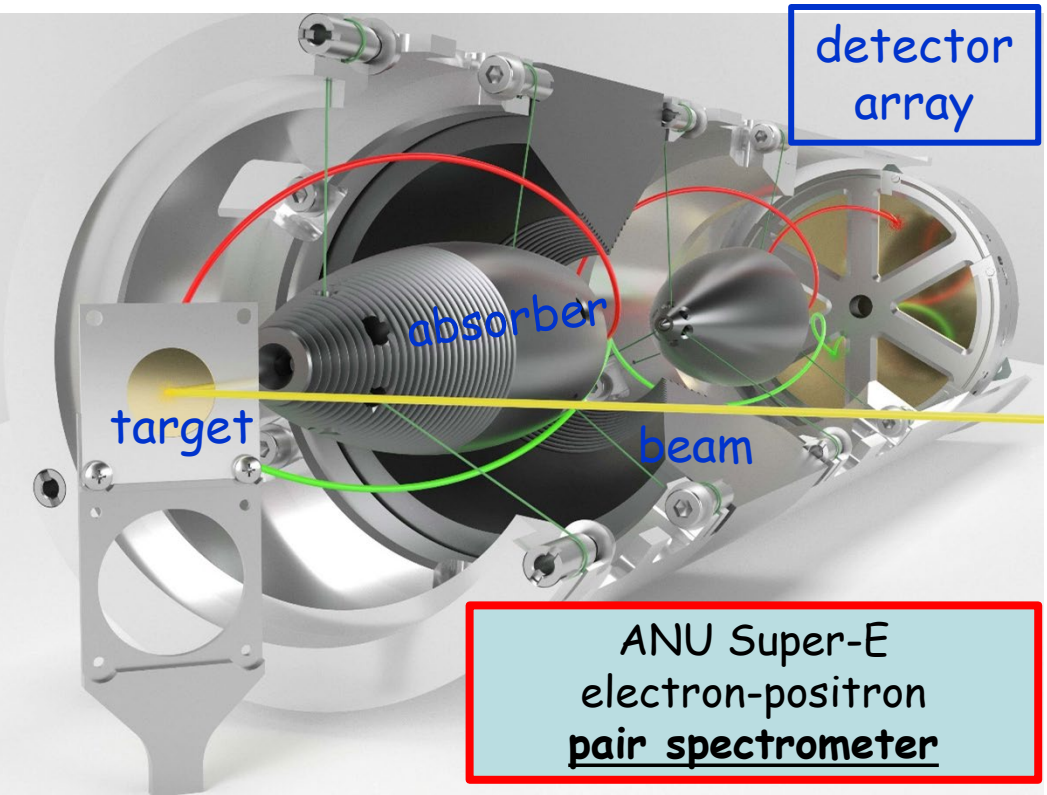
β-spectrum of ^{235}U fission products



K. Schreckenbach et al., Phys. Lett. B 160 (1985) 325

Super-E

- Super-E: 2.1 tesla solenoid to transport up to 15 MeV β-rays
- Operational since 1991
- 2 loops absorber system: complete suppression of γ- and X-rays
- Si(Li) array in sum-coincidences: FWHM < 10 keV energy resolution at 7.65 MeV
- Well defined electron transport: high accuracy in intensity measurements



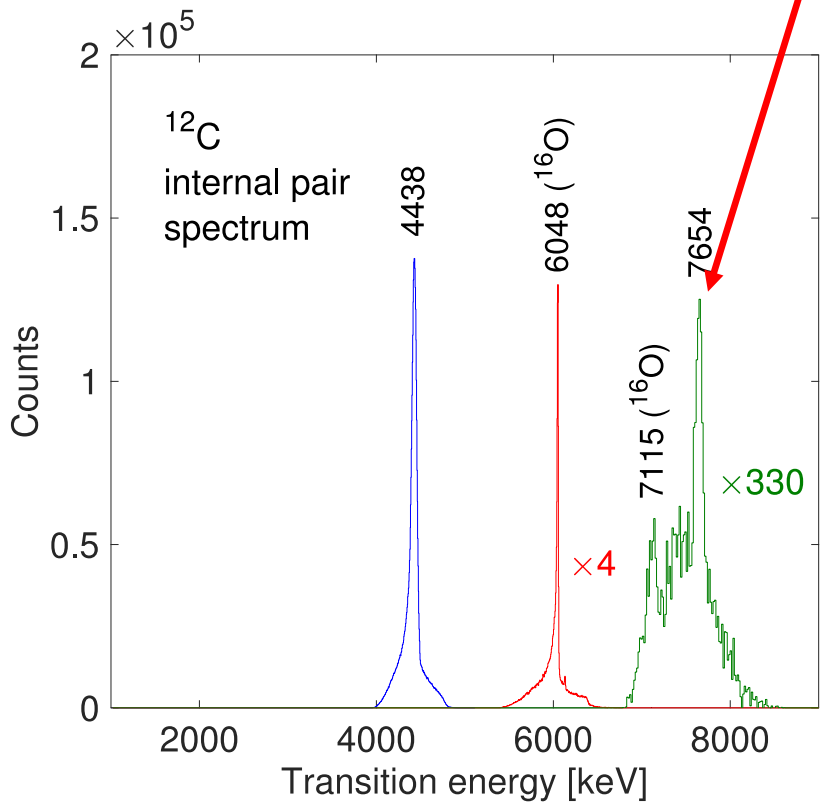
Recent highlights

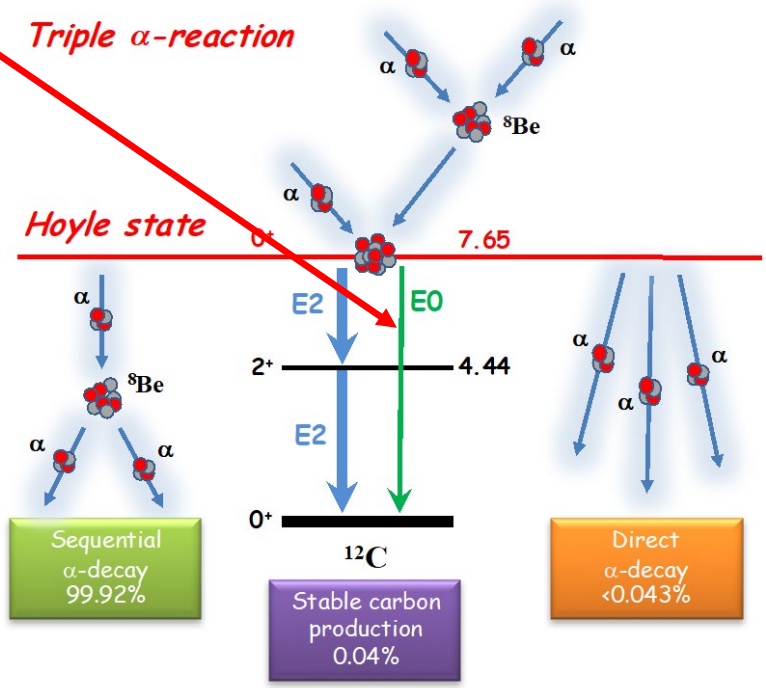
- **Carbon production in the universe**
  PRL 125 (2020) 182701
  PRC 102 (2020) 024320
- Searching for E0 in ^{24}Mg, ^{40}Ca, ^{50,52}Cr, ^{54,56}Fe, ^{58,60,62}Ni
  PLB 779 (2018) 396
  PRC 99 (2019) 024306
  EPJ Web of Conf. 232 (2020) 04004

Super-E - searching for weak decays

Carbon production in the universe:
34% increase in 3α reaction rate
PRL 125 (2020) 182701
PRC 102 (2020) 024320

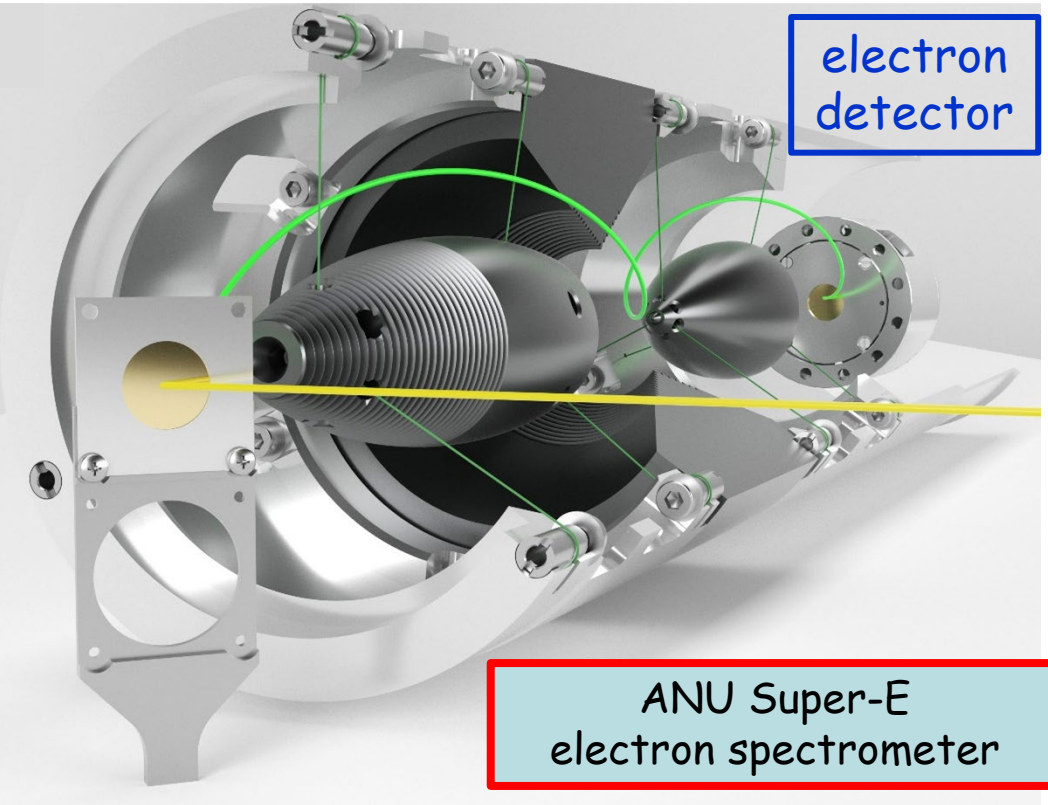
7654 E0: $\Gamma_\pi(E0)/\Gamma = 8.2(5)\ 10^{-6}$

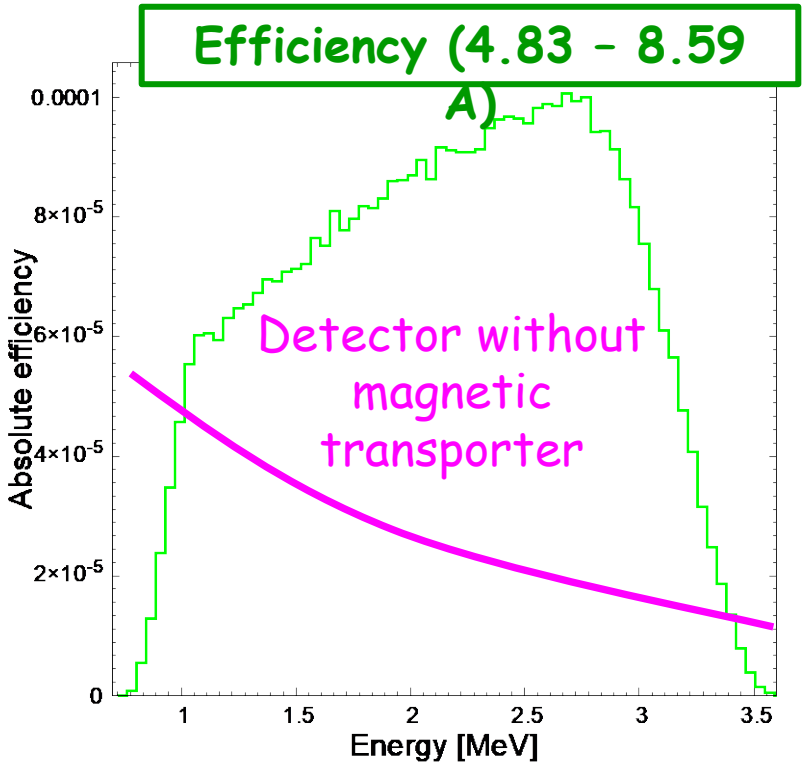




From Super-E to Super-E2

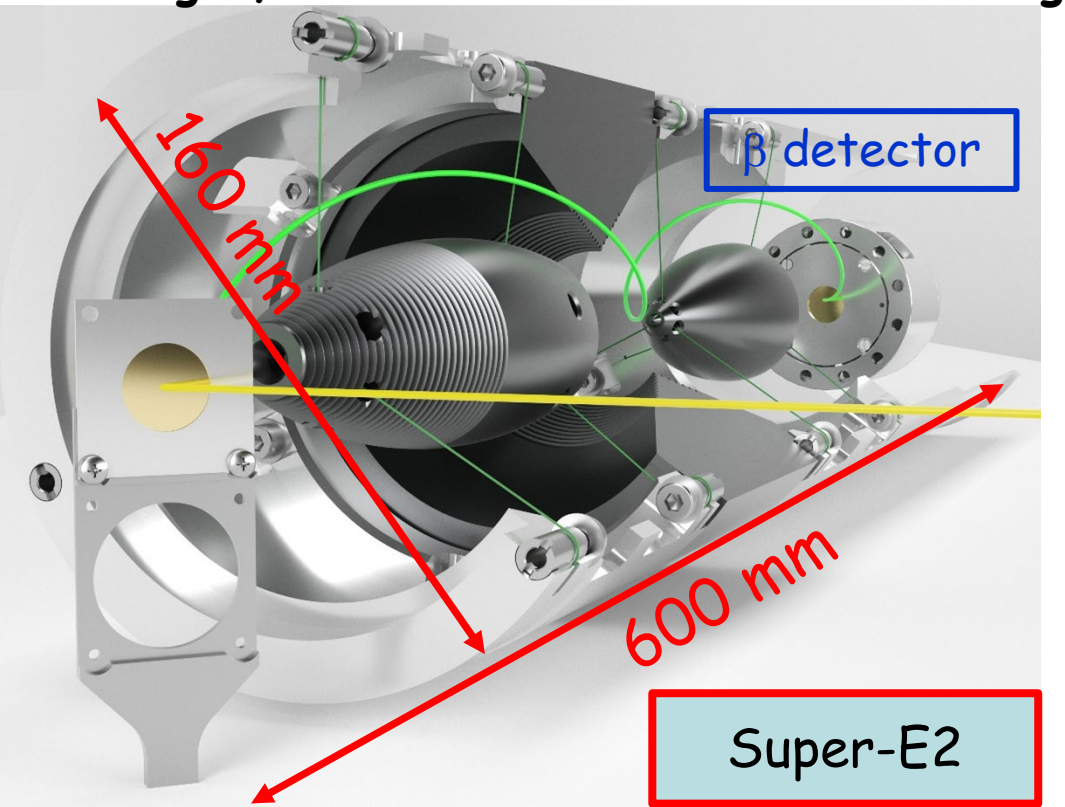
- Singles electron measurements: Si(Li) detector, FWHM= 2.5 keV at 1.6 MeV
- Well defined electron transport: high accuracy in intensity measurements





Super-E2 for integral electron measurements

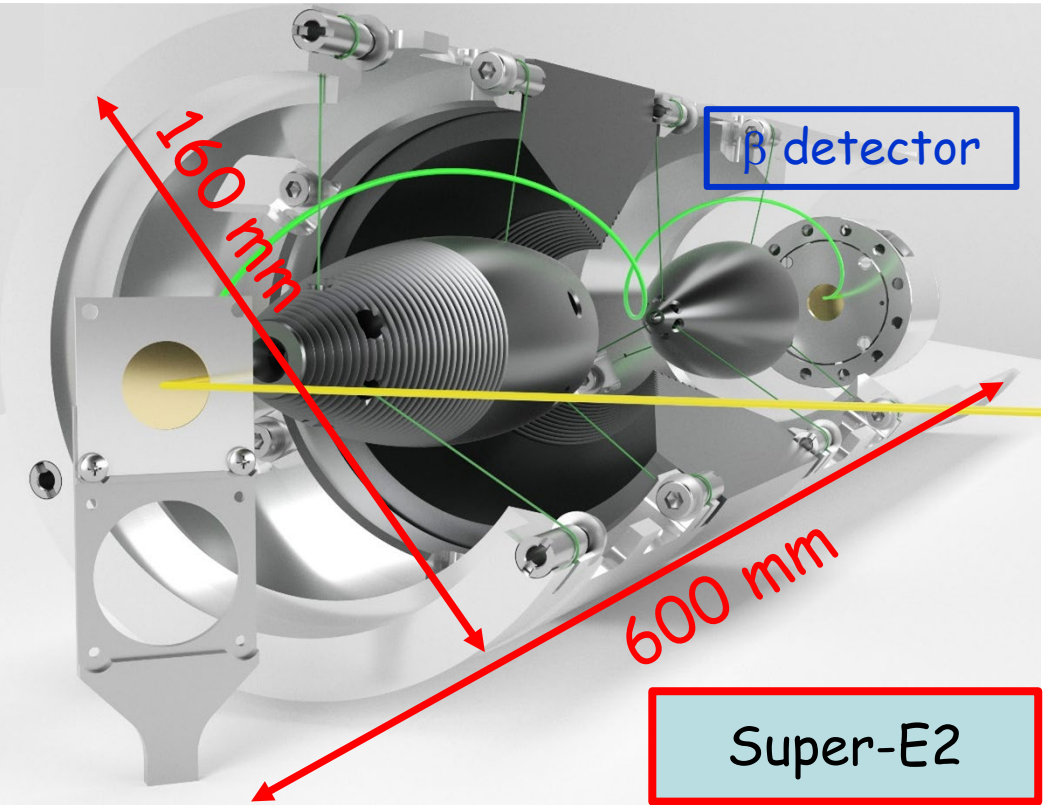
- 1 tesla solenoid; ~160 mm bore; ~600 mm length
- 2 loops lens; 32 cm of HeavyMet shield; 3% solid angle; ILL Grenoble: 3×10^{-4}%
- Compatible with 39 mm diameter neutron beam from HFIR
- hpGe detector: FWHM < 15 keV; DE-E hpGe telescope
- Target, solenoid bore and detector in high vacuum



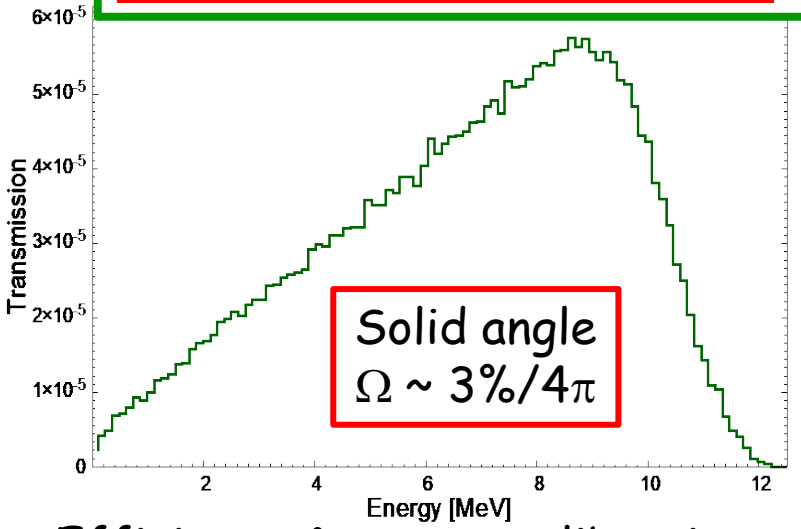
Neutron beam
Not affected by
magnetic field

Super-E2 for integral electron measurements

- Efficiency: smooth function of β-energy
- Swept magnetic field to cover broader energy range
- Compact, easy to operate, versatile instrument



0 – 10 MeV
0 – 0.7 tesla
Ramp up /down ~30 m
2nd solenoid for normalisation



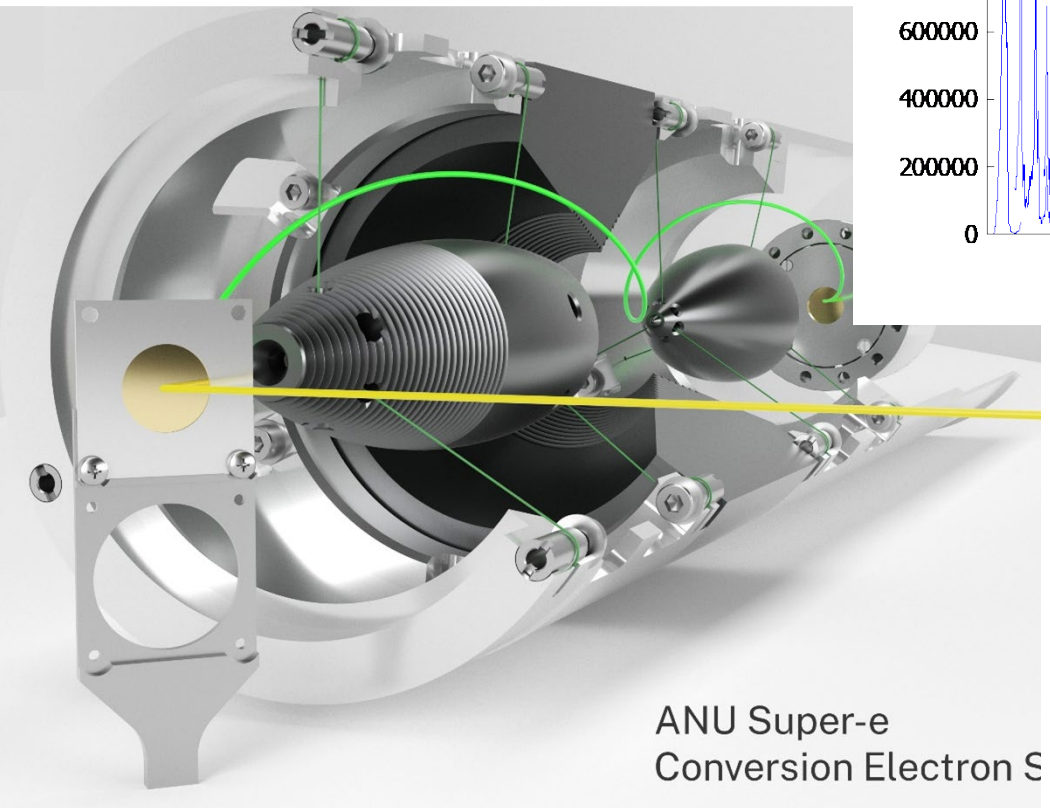
Efficiency & energy calibration:

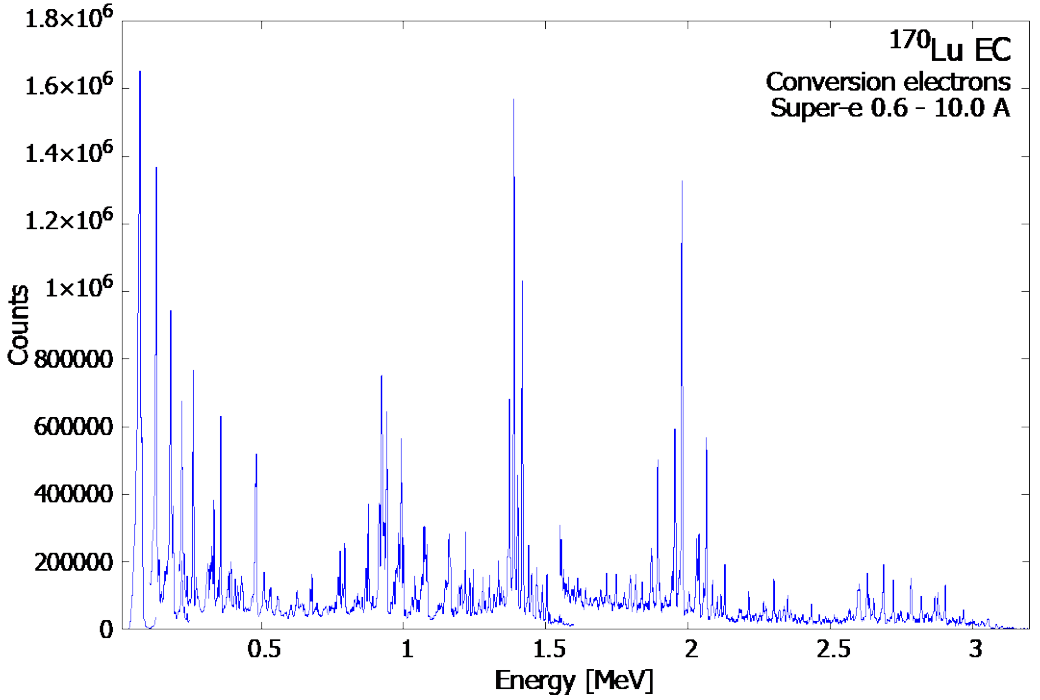
^{207}Bi EC (up to 1.7 MeV)
^{170}Lu EC (up to 3.3 MeV)
^{197}Au(n,e) E1 lines up to 6.5 MeV
^{115}In(n,g), Q_β=3.3 MeV
^{11}B+n ^{12}B Q_β=13.3 MeV

Capital cost: USD 1 M

Thanks

ANU Super-e





170Lu EC
Over 200 CE lines
FWHM=2.5 - 3.6 keV
0.6-10.0 A