The **ISOLDE** Decay Station: current status and perspectives

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On behalf of the ISOLDE Decay Station Collaboration

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23rd of September 2025

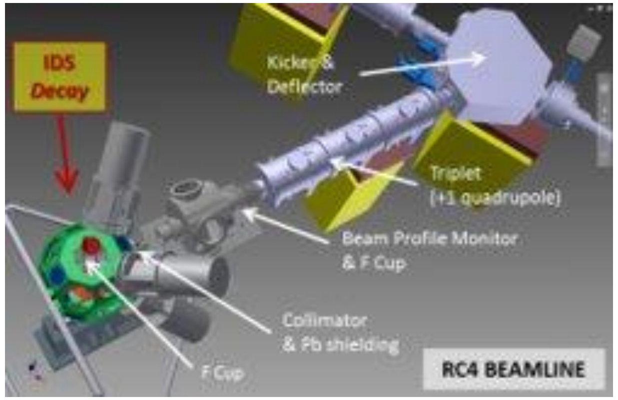
The ISOLDE Decay Station (IDS)

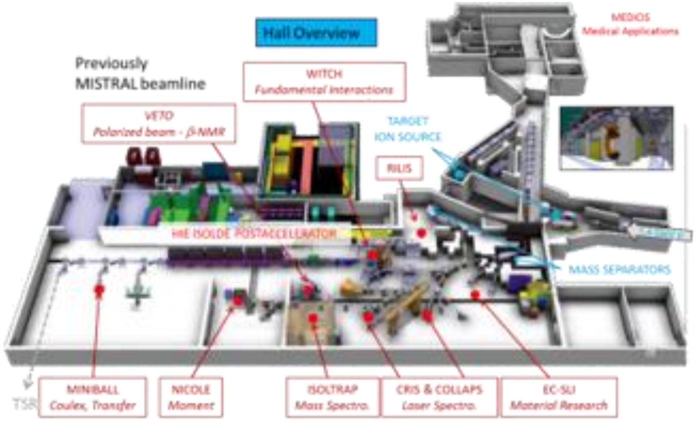
http://isolde-ids.web.cern.ch/

Physics Program

- Nuclear Structure (80%)
- Nuclear Astrophysics (10%)
- Nuclear Industry and Medicine (5%)
- Solid State Physics (5%)

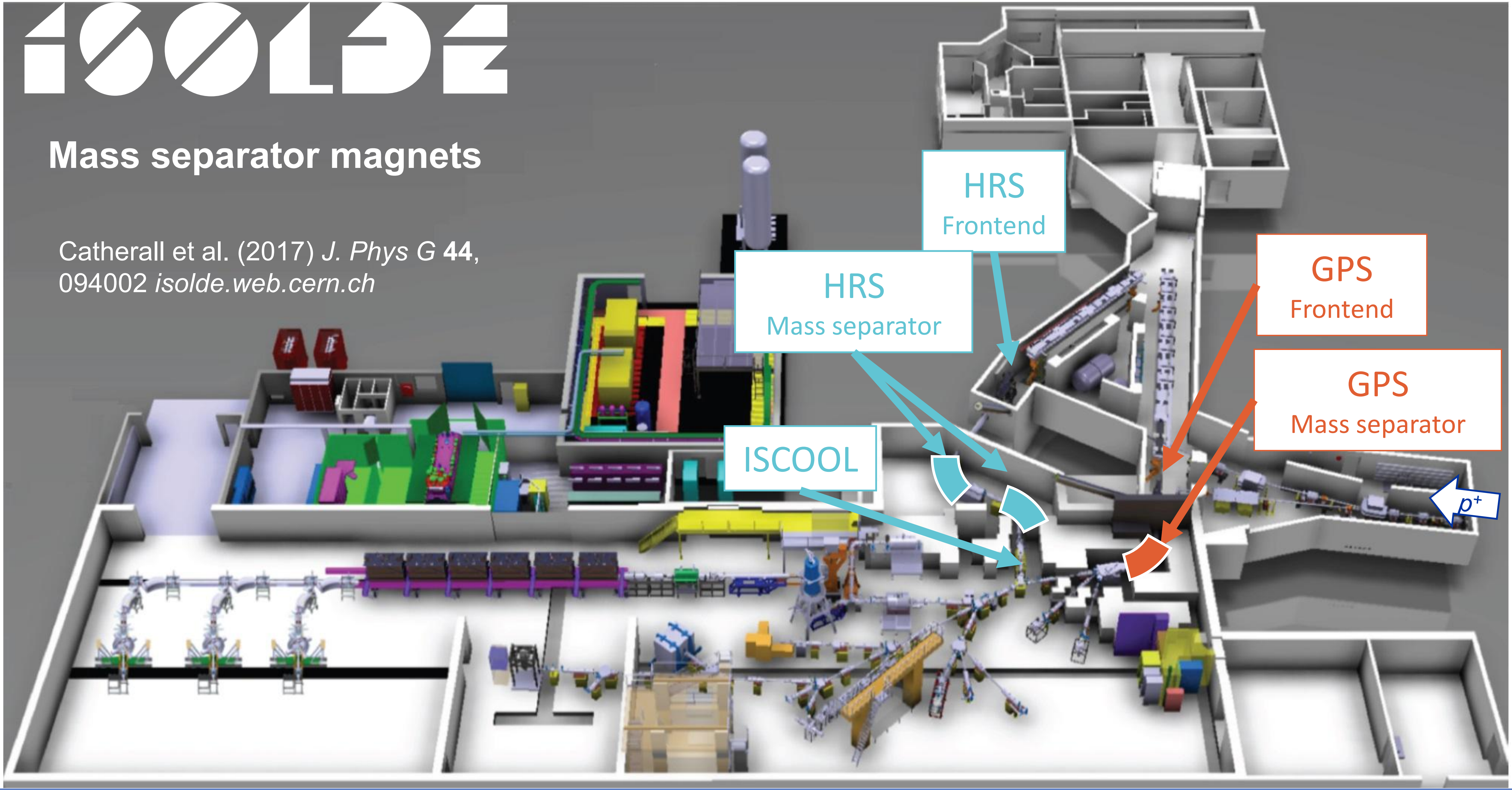
Permanent Setup at low-energy branch of ISOLDE facility at CERN

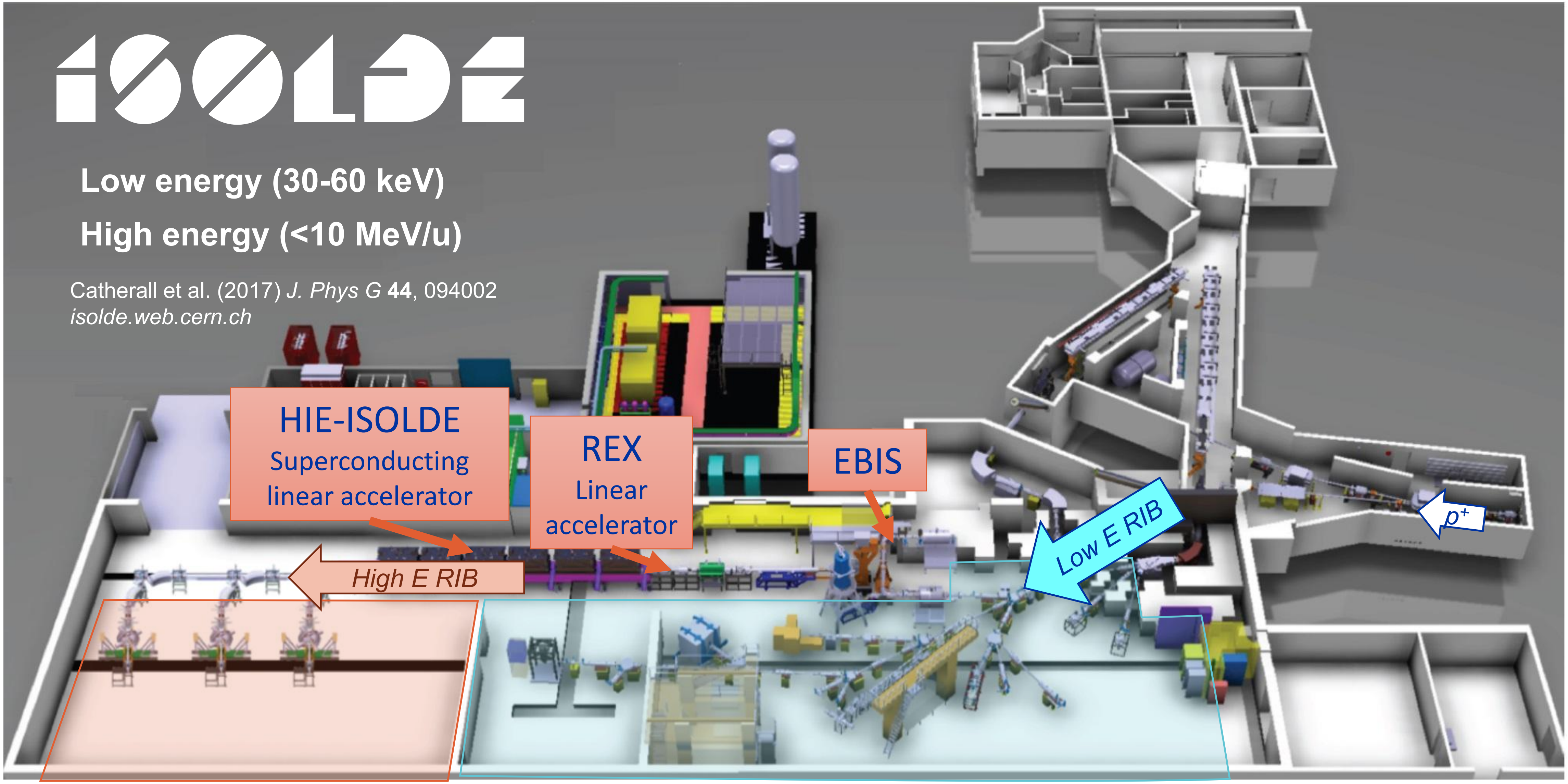




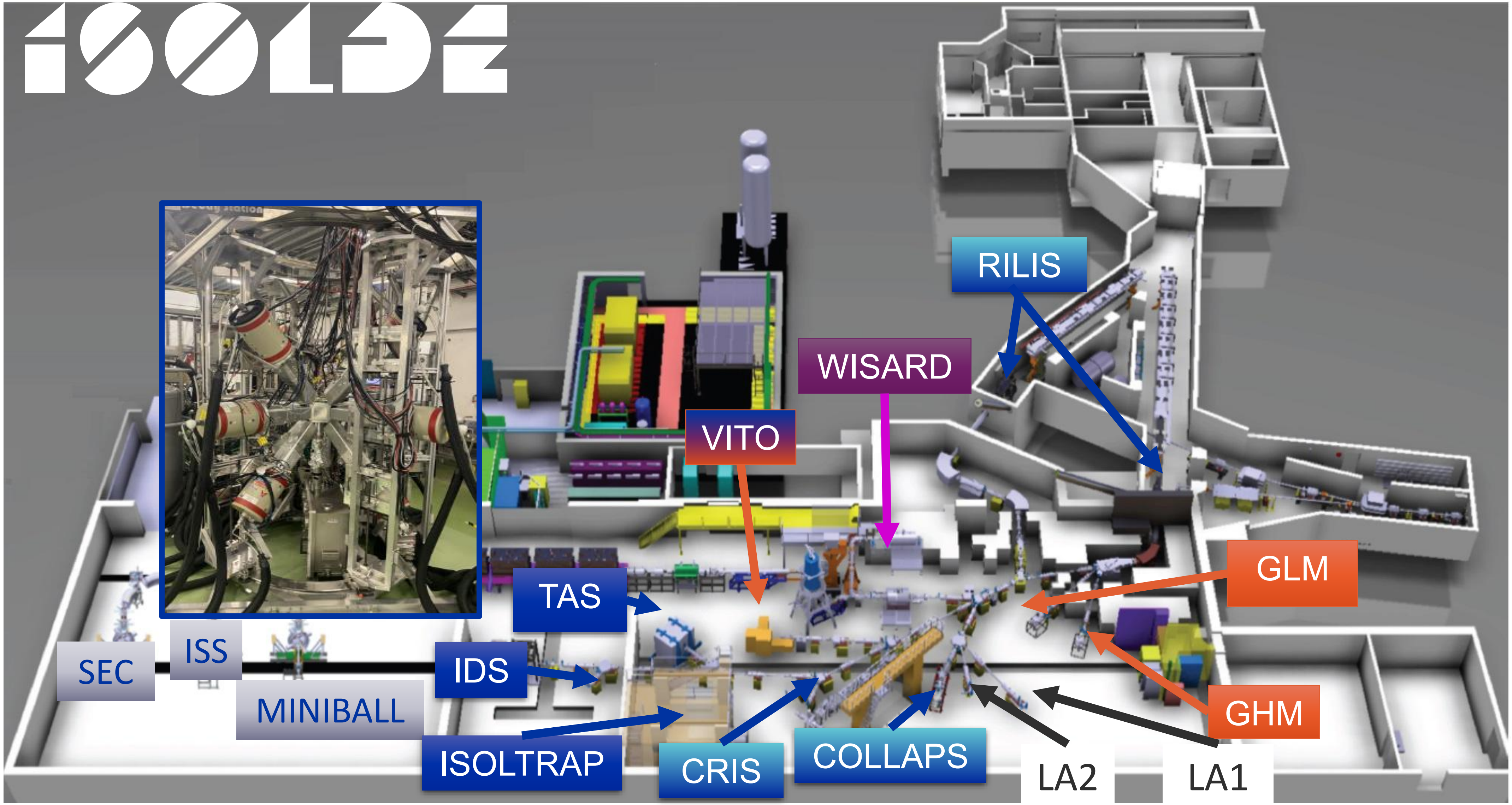
Mass separator magnets

Catherall et al. (2017) *J. Phys G* **44**, 094002 *isolde.web.cern.ch*




ISOLDE
Low energy (30-60 keV)
High energy (<10 MeV/u)
Catherall et al. (2017) *J. Phys G* **44**, 094002
isolde.web.cern.ch
HIE-ISOLDE
Superconducting linear accelerator
REX
Linear accelerator
EBIS
High E RIB
Low E RIB
p^+

ISOLDE Experiments

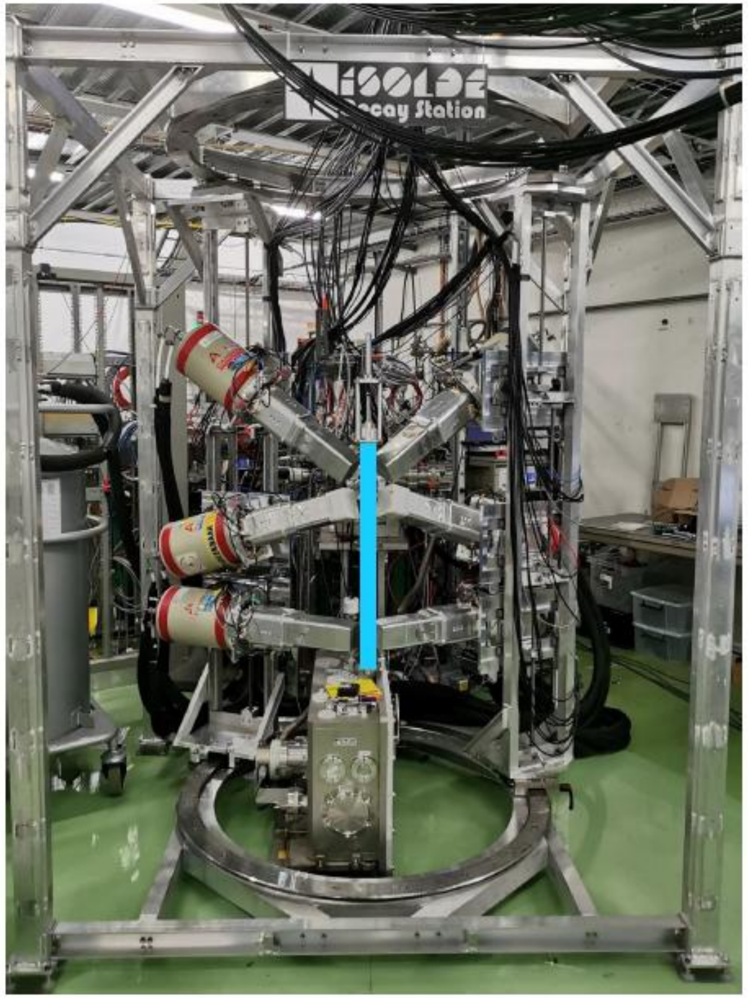


Core IDS Setup

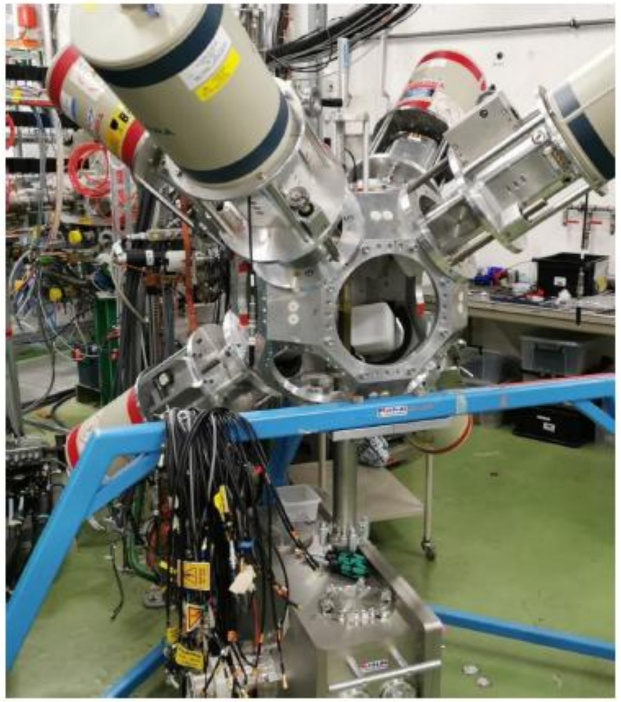
15 HPGE clover detectors (+6 Aug. 2024)
- 4 crystals / clover
- 20% relative eff. / crystal
- 2 thin-carbon window detectors for low-E (~10 keV)

Flexible + dynamic support structure (2023)
- Minimise material around implantation position
- Detectors mounted on vertical gantries, 3 clovers per gantry, gantries mounted on circular rails
- Can move detectors radially + vertically, tilt vertically, rotate on axes

Digital XIA pixie-16 acquisition system
- 16 channels per module
- 12-16 bit ADC
- 100, 250 and 500 MHz modules
- 208 channels/crate



Old, pre-2023 system



Movable tape system
- Reel-to-reel aluminised mylar tape (~2.5 km)
- Fully automated system
- Integrated with ISOLDE beam logic, RILIS laser system, and our DAQ

Core IDS Setup

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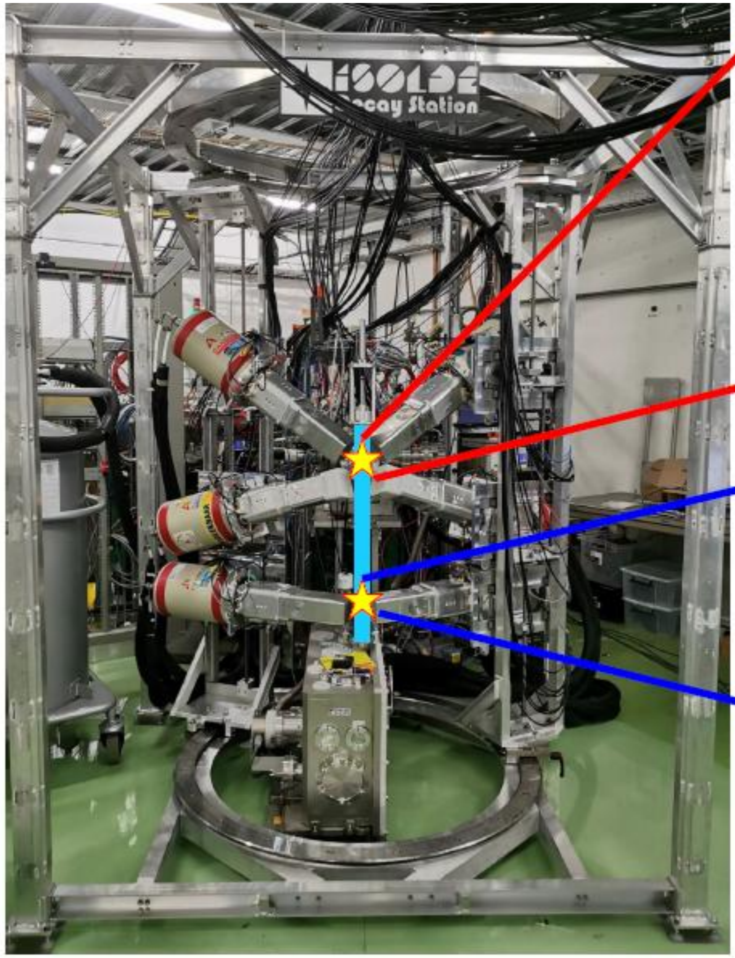
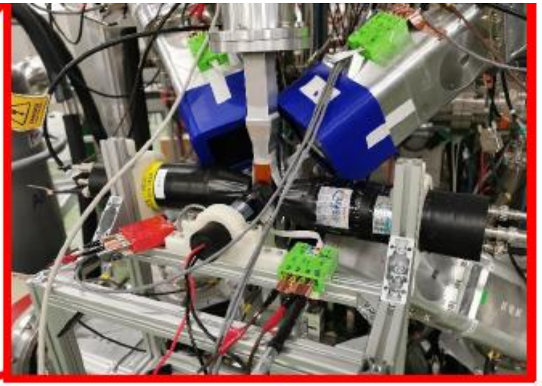
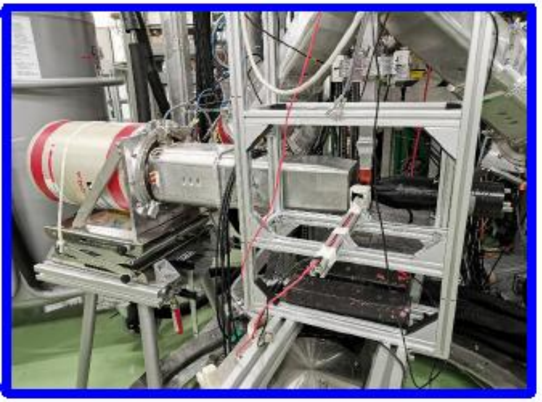
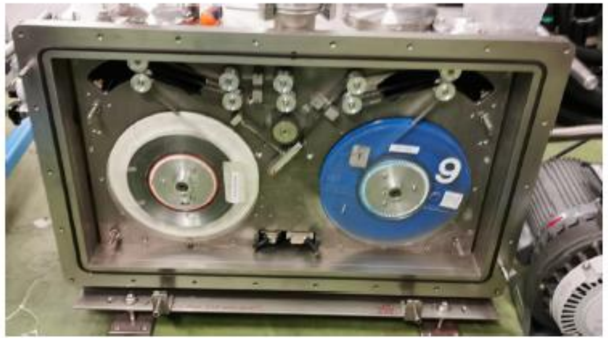






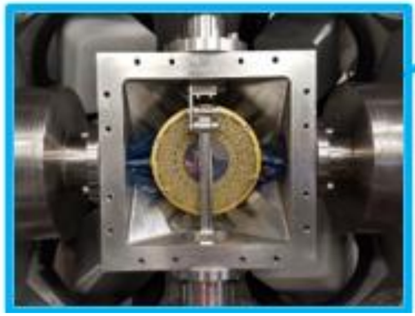


Movable tape system
- Reel-to-reel aluminsed mylar tape (~2.5 km)
- Fully automated system
- Integrated with ISOLDE beam logic, RILIS laser system, and our DAQ
- Primary “implantation” position
  For main aims of experiments
- Secondary “decay” position
  Free “bonus” experiment, long-lived activity

Ancillary systems

High β-γ efficiency

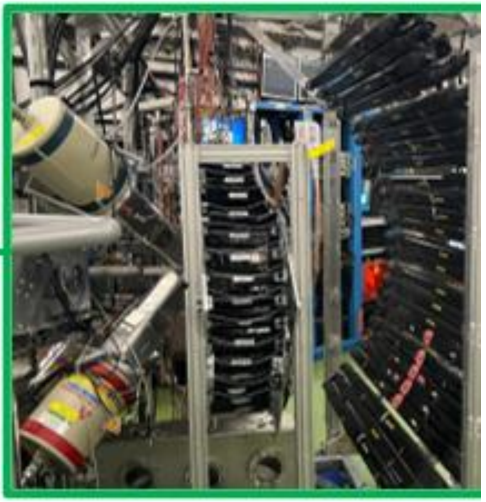
Fast-timing



Conversion electrons

ISOLDE Decay Station

Charged-particle Spectroscopy



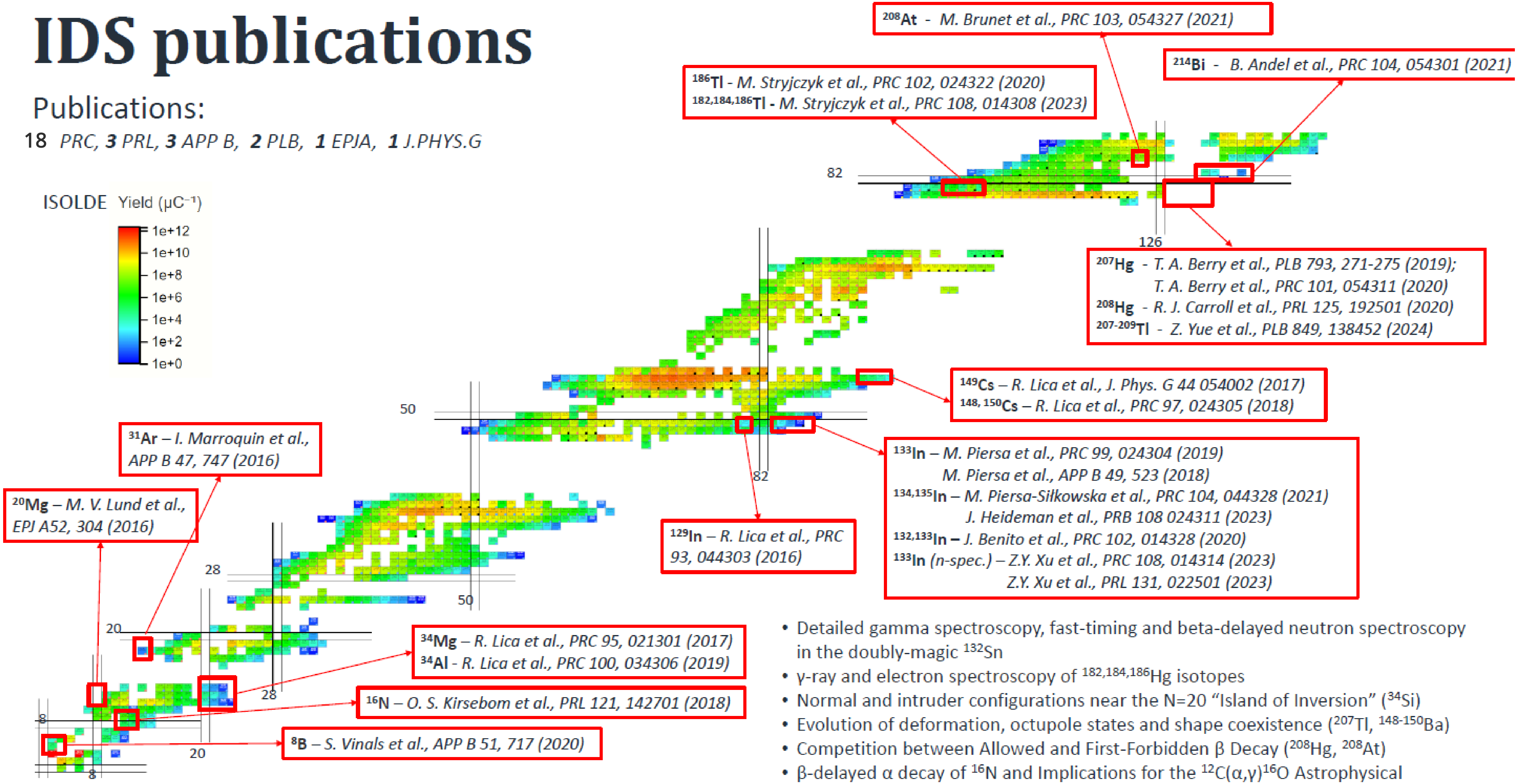
Neutron Spectroscopy

Plastic scints. (β tagging)

IDS publications

Publications:

18 *PRC*, **3** *PRL*, **3** *APP B*, **2** *PLB*, **1** *EPJA*, **1** *J.PHYS.G*



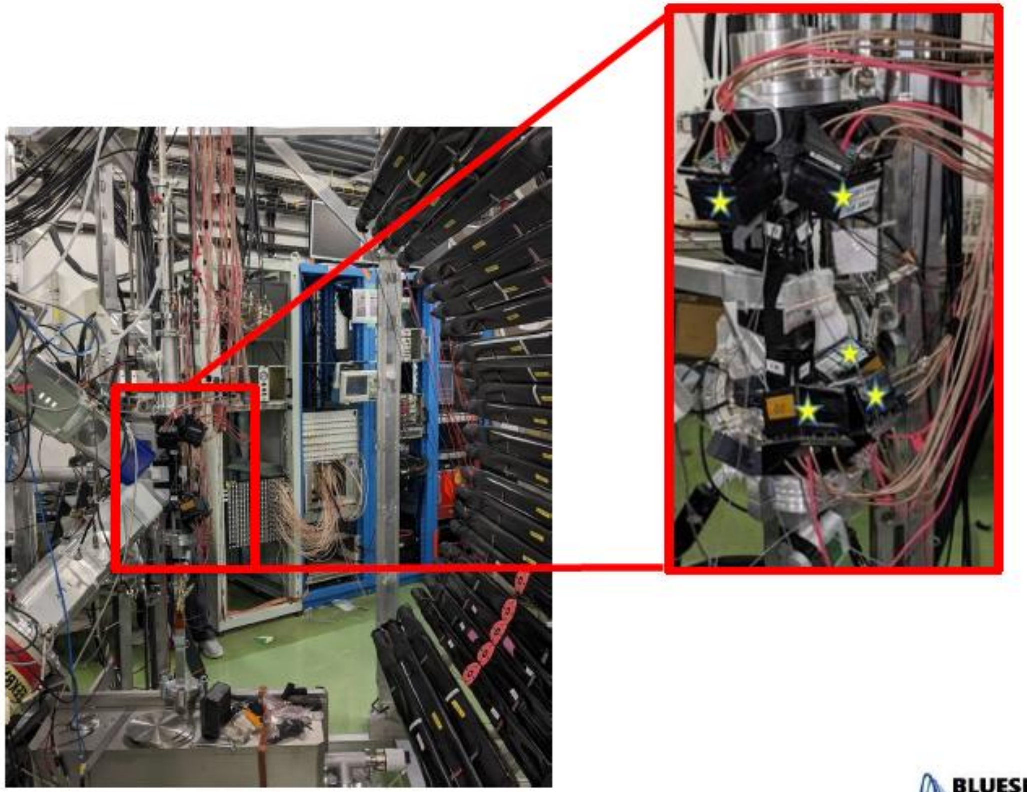
- Detailed gamma spectroscopy, fast-timing and beta-delayed neutron spectroscopy in the doubly-magic ^{132}Sn
- γ-ray and electron spectroscopy of ^{182,184,186}Hg isotopes
- Normal and intruder configurations near the N=20 "Island of Inversion" (^{34}Si)
- Evolution of deformation, octupole states and shape coexistence (^{207}Tl, $^{148-150}$Ba)
- Competition between Allowed and First-Forbidden β Decay (^{208}Hg, ^{208}At)
- β-delayed α decay of ^{16}N and Implications for the ^{12}C(α,γ)^{16}O Astrophysical Reaction Rate

Chart source: https://isoyields2.web.cern.ch/IsoldeYieldChart.aspx

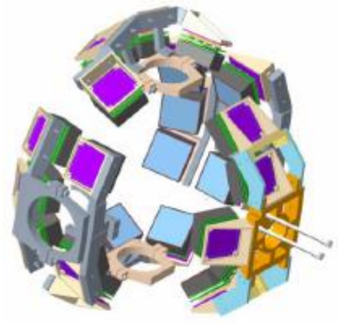
IS662/705: β-delayed neutron of ^{134,135}In

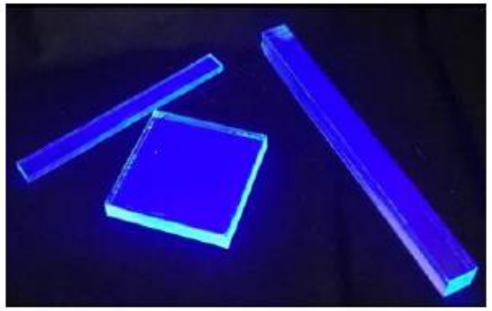
Spokespersons: R. Grzywacz, A. Korgul, M. Madurga, L. Fraile, **PhDs Peter Dyszel & Jacob Gouge**

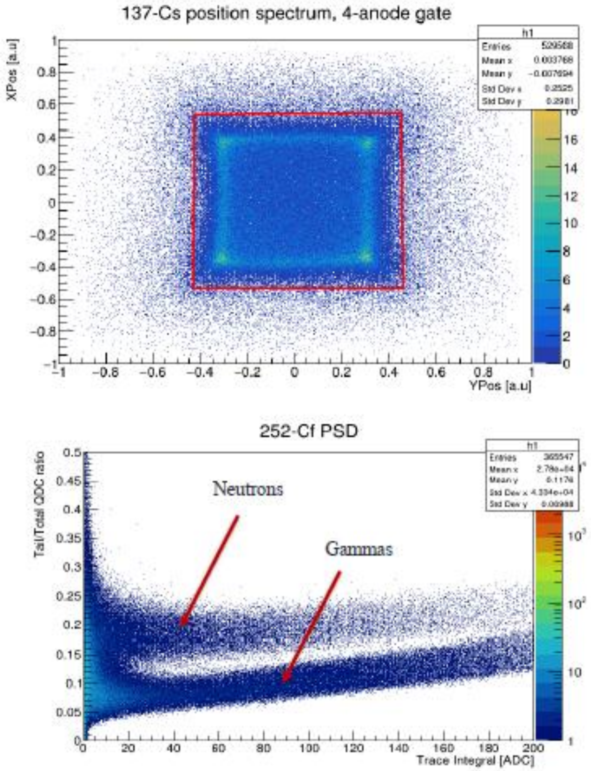
- May 2024 searched for rare 2n decays from ^{134}In (Q_β=14.7 MeV, S_n=3.6 MeV, S_{2n}=6.03 MeV)
- **Working OGS "nest"** for low-E neutrons



Very bright 50x50x6 mm^3
$\sim$80% eff. for 50 keV neutrons,
excellent PSD for γ vs. neutron







BLUESHIFT OPTICS

Courtesy of P. Dyszel, R. Grzywacz (U. Tenn. Knox.)

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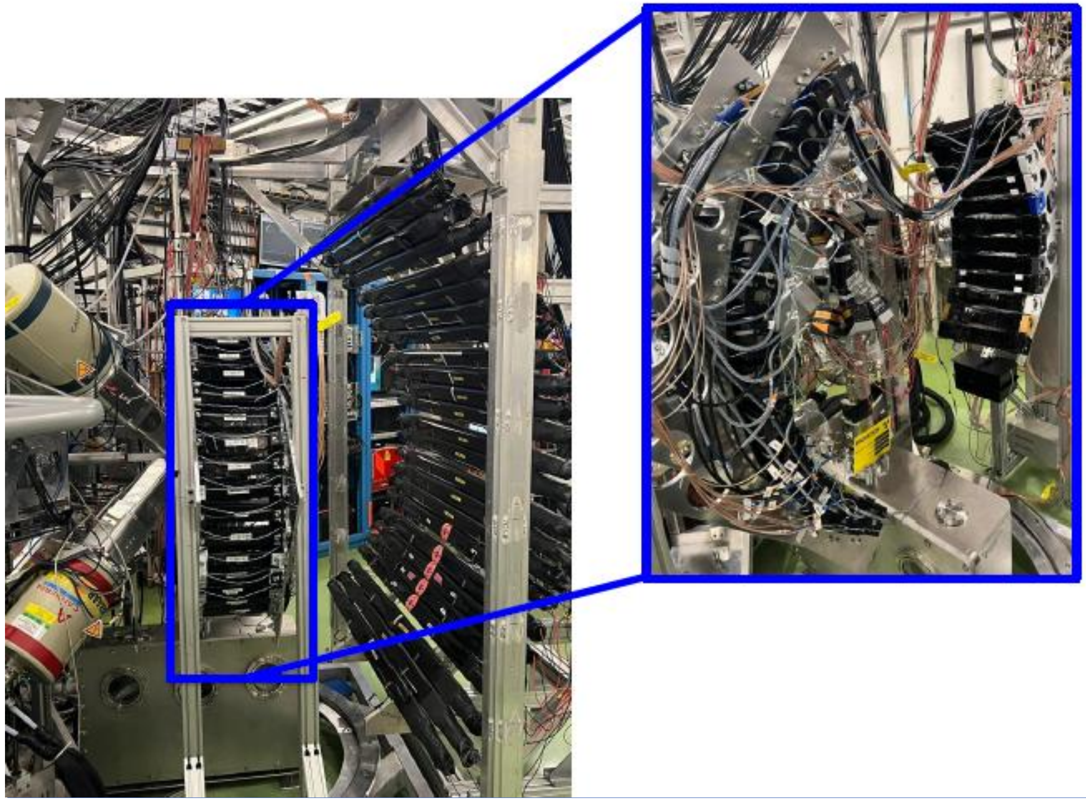
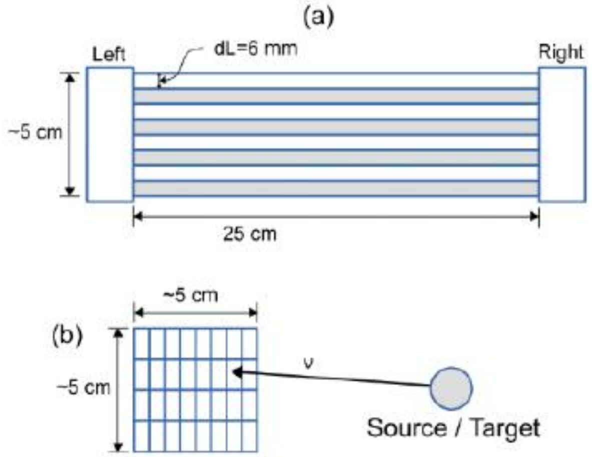
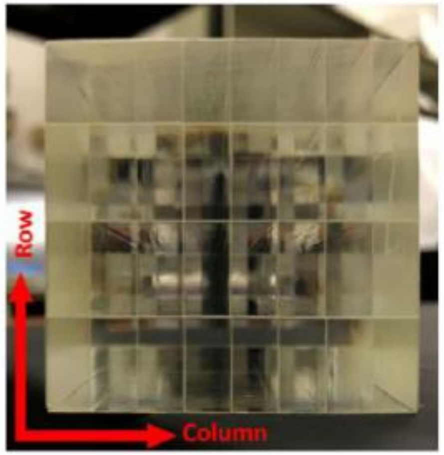
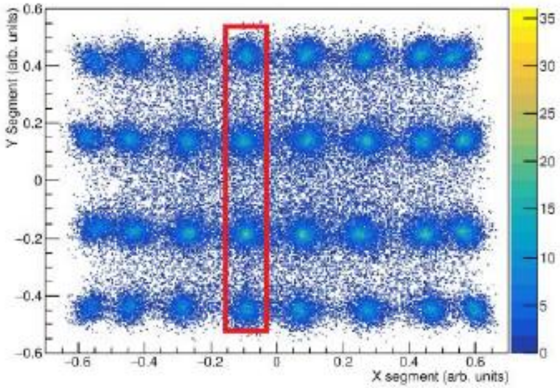
- **Working OGS "nest"** for low-E neutrons
- **New "NEXT" array** – 27 modules of Neutron dEtector with multi-neutron (Xn) Tracking
  - 4x8 segmentation with position sensitive PMT (~1 mm)
  - PSD possible (EJ-276 or EJ-299)
  - New pixie-32 DAQ built by xia for this specific experiment





$$\left(\frac{\Delta E}{E}\right)^2 = \left(\frac{2\Delta T}{T}\right)^2 + \left(\frac{2\Delta L}{L}\right)^2$$



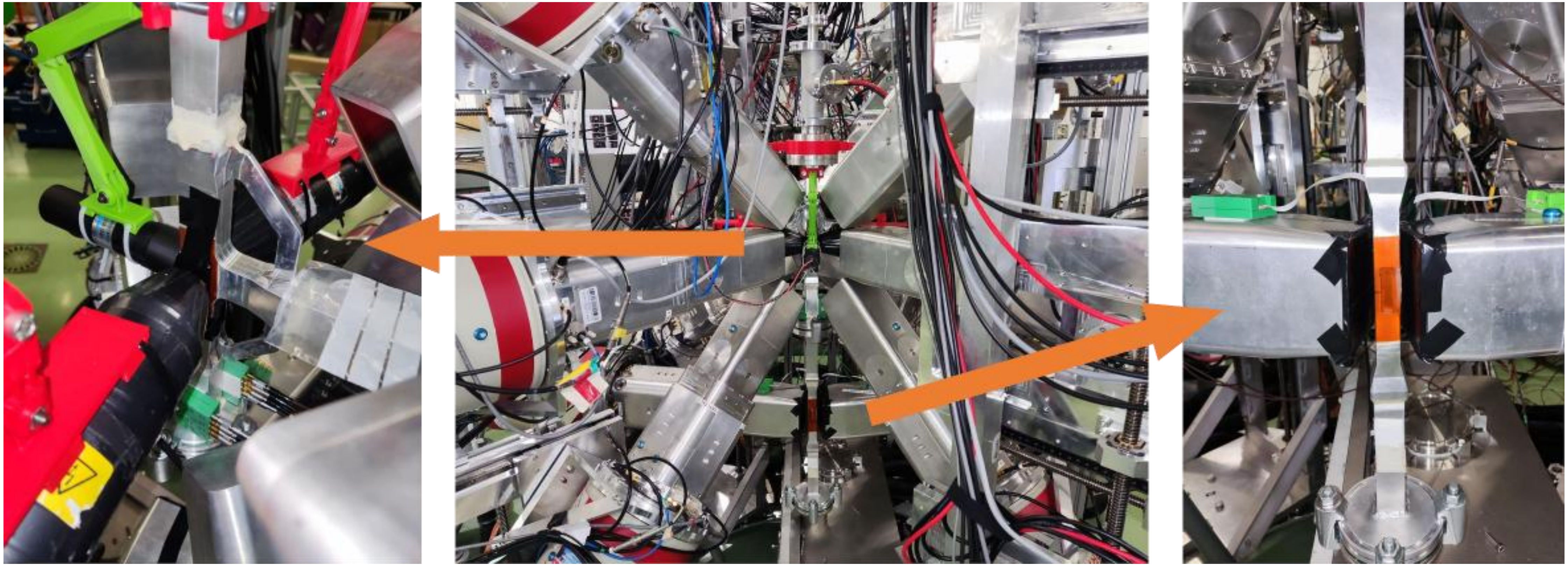


Courtesy of P. Dyszel, R. Grzywacz (U. Tenn. Knox.)

IS771: Shell evolution in Ge isotopes via fast-timing

Spokepesons: A. Illana, J. Benito, LM. Fraile, PhD Pablo González-Tarrío

- March 2025, shell evolution on the Ge isotopes with N<=50
- Fast Timing Setup, 12 Clovers, g-g angular correlations, Implantation and Decay, 5 beta-detctors

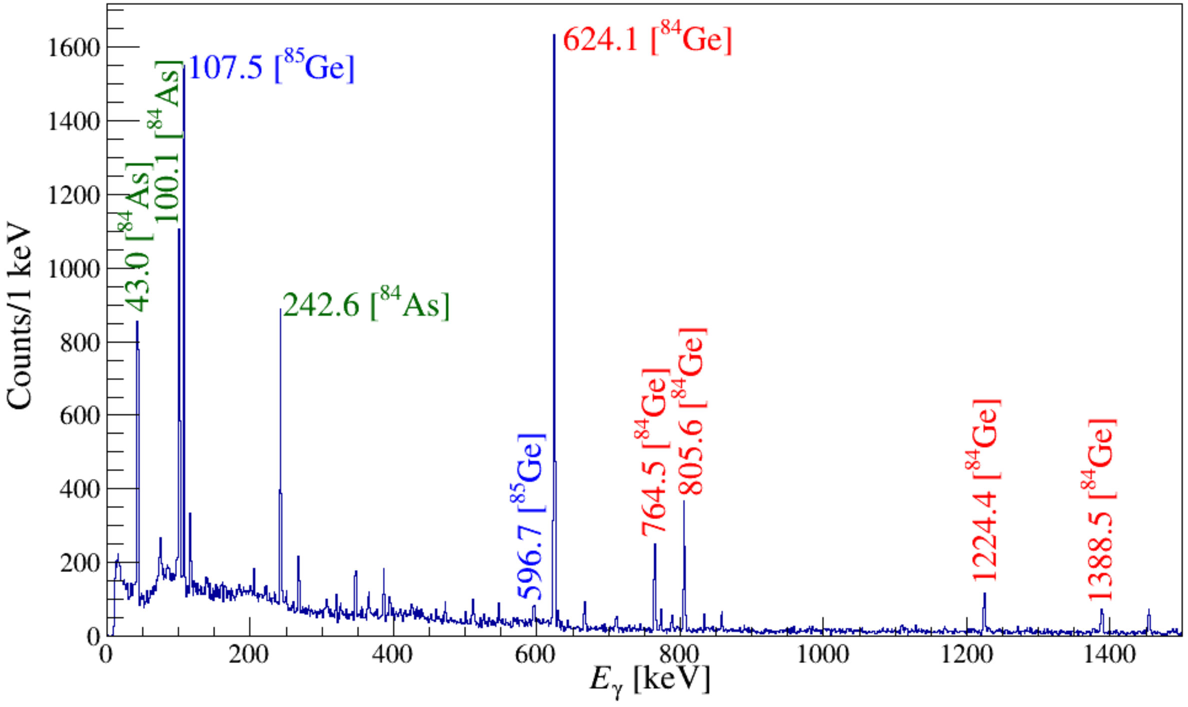


IS771: Shell evolution in Ge isotopes via fast-timing

Very neutron-rich nucleus:

- Beta-delayed neutron emitter.
- Approaching the astrophysical rapid neutron capture process.
- Proton $0f_{5/2}$ and $1p_{3/2}$ orbitals possibly inverted, interesting for nuclear structure s

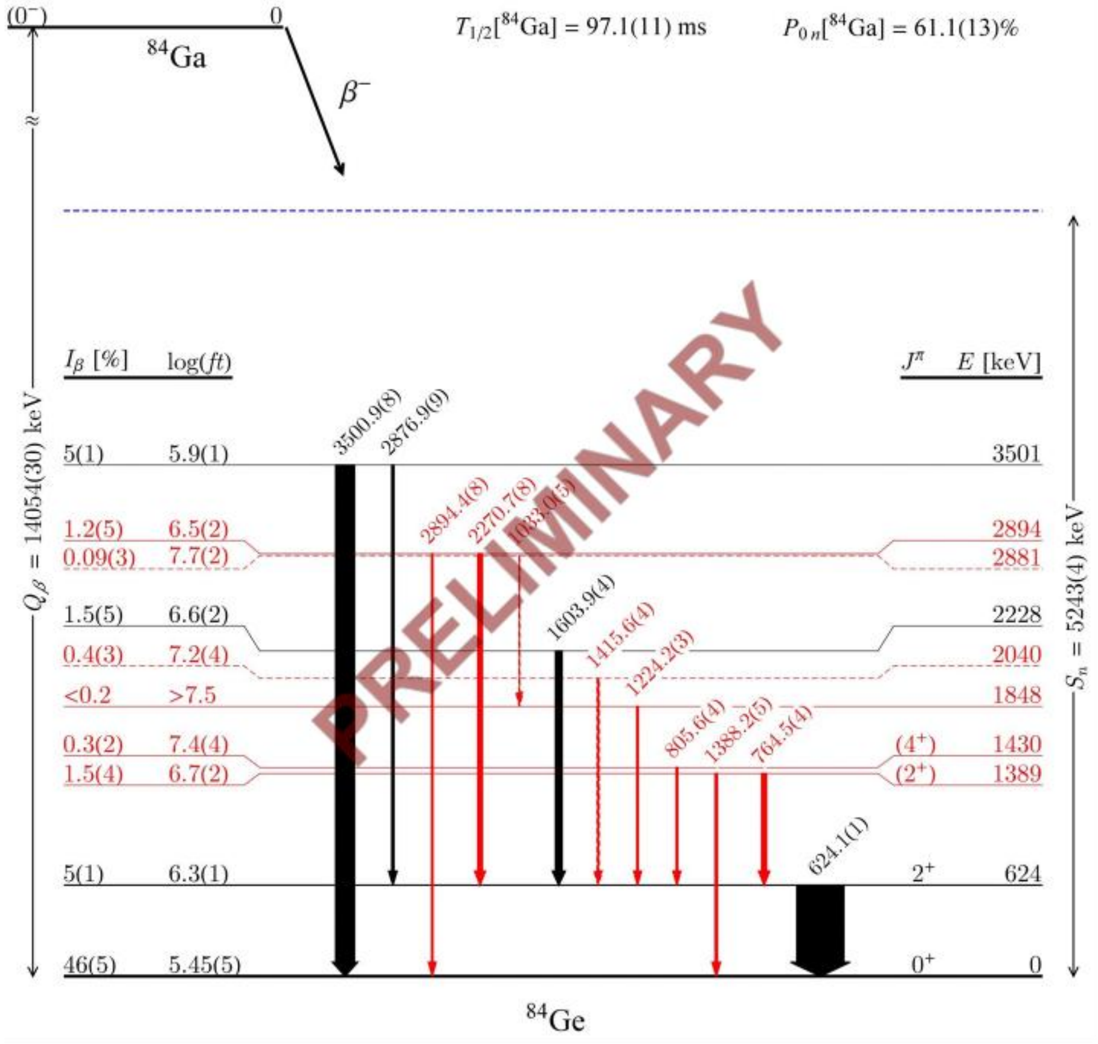
Data from test in 2023
Only a few minutes of data using a compact setup with 6 HPGe clovers and fast-timing detectors

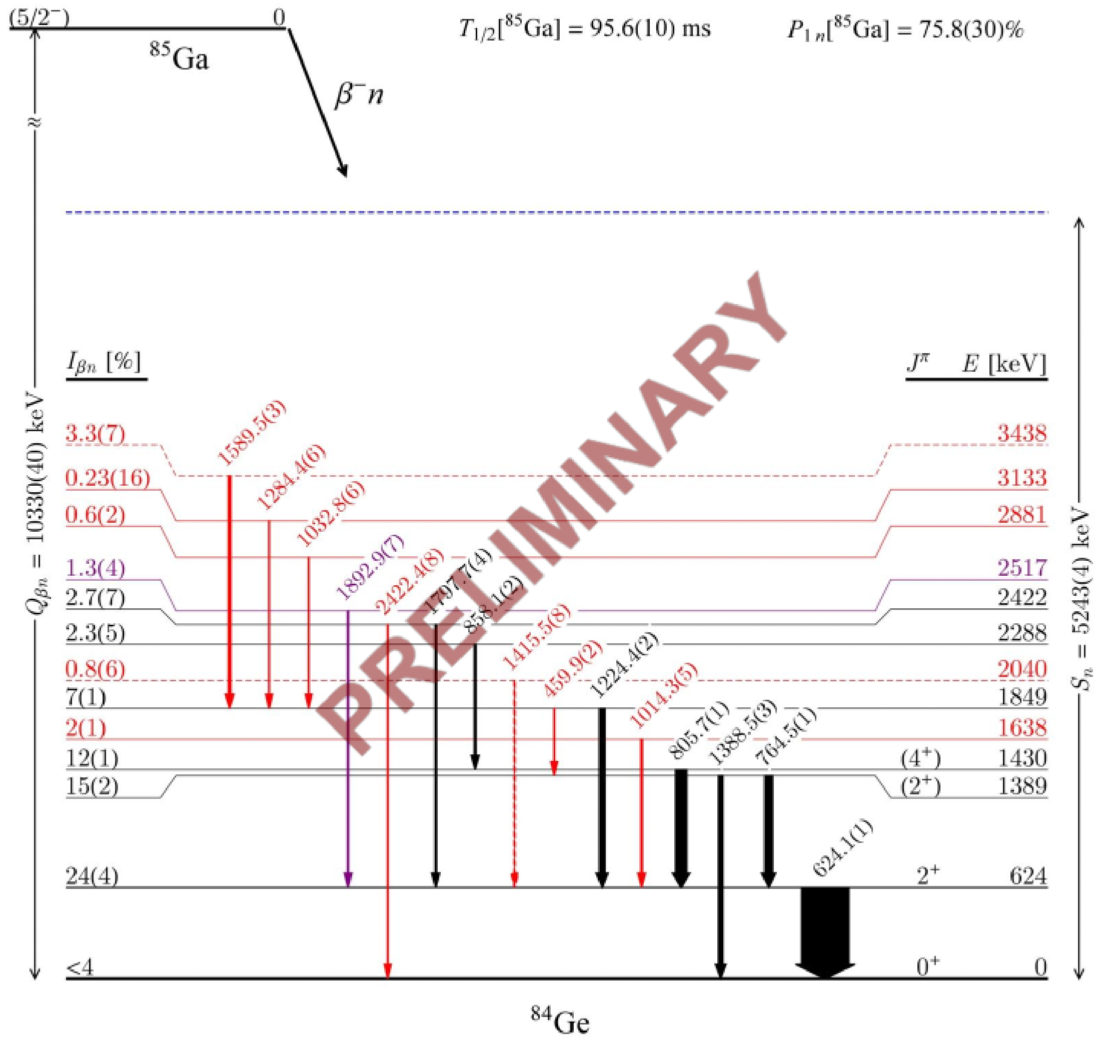


IS771: Shell evolution in Ge isotopes via fast-timing

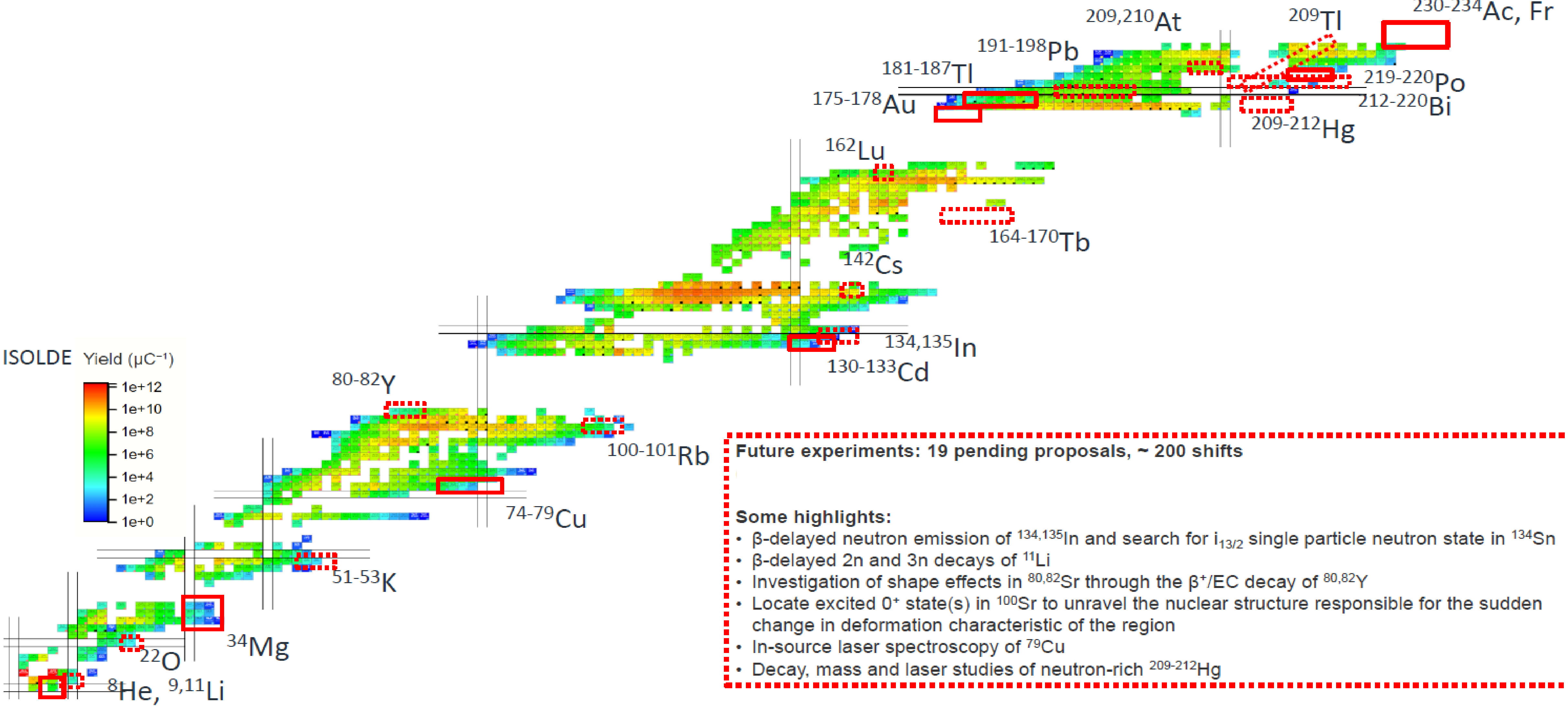
Beta and beta-n decays

P. González-Tarrío et al.





Recent and future experiments at IDS



Future experiments: 19 pending proposals, ~ 200 shifts

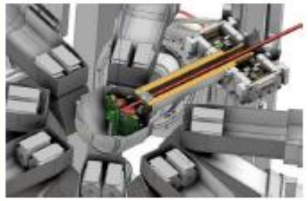
Some highlights:

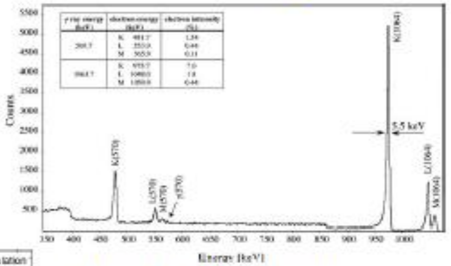
- β-delayed neutron emission of ^{134,135}In and search for $i_{13/2}$ single particle neutron state in ^{134}Sn
- β-delayed 2n and 3n decays of ^{11}Li
- Investigation of shape effects in ^{80,82}Sr through the β$^+$/EC decay of ^{80,82}Y
- Locate excited 0$^+$ state(s) in ^{100}Sr to unravel the nuclear structure responsible for the sudden change in deformation characteristic of the region
- In-source laser spectroscopy of ^{79}Cu
- Decay, mass and laser studies of neutron-rich $^{209-212}$Hg

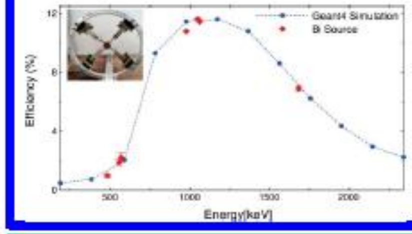
Chart source: https://isoyields2.web.cern.ch/IsoldeYieldChart.aspx

Future Plans: IDS++

New conversion e- setup



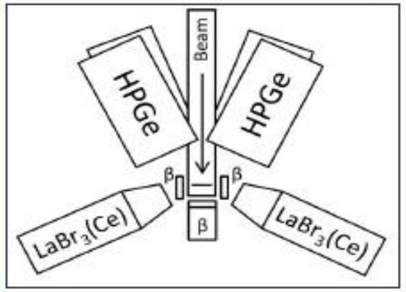


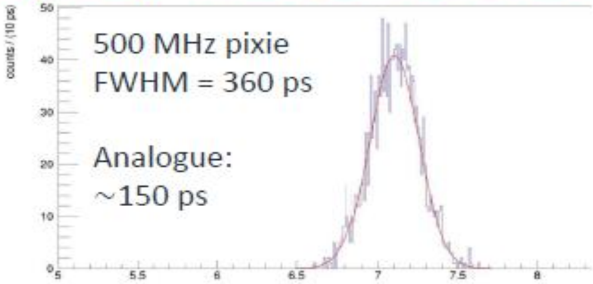


New SPEDE chamber

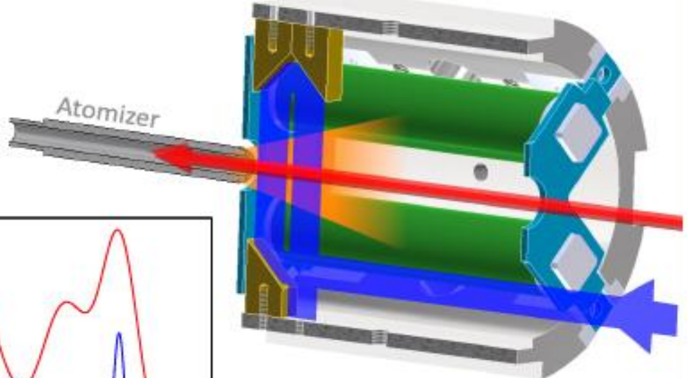
SLICES (LN2 cooled)
[Marchini *et al.*, NIM A **1020**, 165860 (2021)]

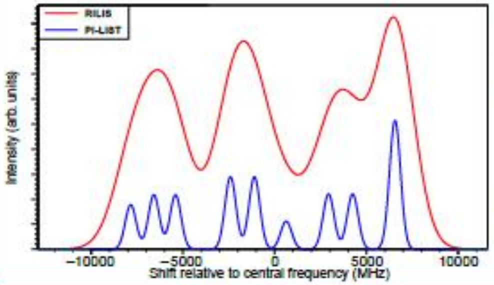
Fully digital fast-timing setup – increase #detectors





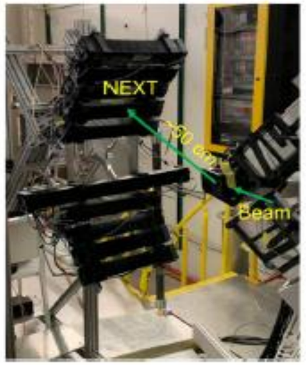
Collaborate with ion-source and laser teams

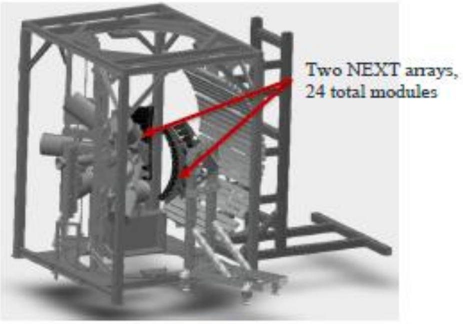


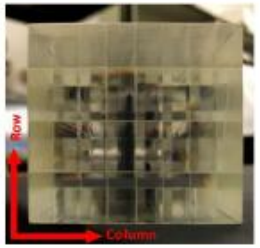


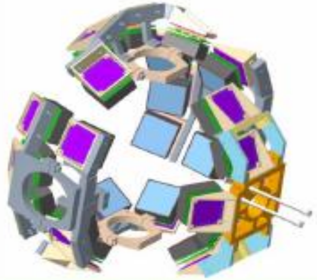
R. Heinke *et al.*, *Hyperfine Interactions* **238**, 6 (2017)

Full neutron setup: INDiE + NEXT + OGS









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Summary and Conclusions

- **Clear and growing demand from community**
  - July 2023: 10 approved beamtimes with 100 shifts
  - Feb. 2024: 19 approved beamtimes with 200 shifts
  - Sep. 2025: 25 approved beamtimes with 314 shifts

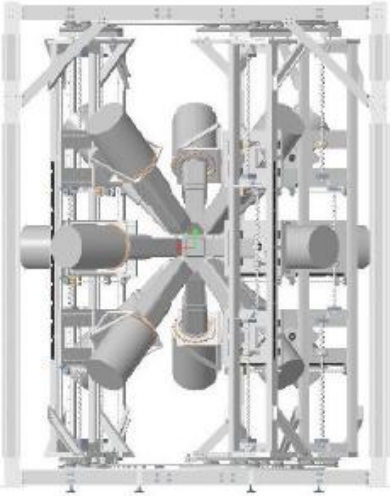
- **Flexible approach has been great success for us**
  - Dedicated systems, how best to implement + combine
  - Coupling to and working with other teams to perform comprehensive studies (RILIS, ISOLTRAP)

- **Increasing sensitivity and new methods key for future**
  - Improved $\gamma - \gamma$ efficiency, angular correlations
  - New setups → new physics motivations
  - Improved background suppression with higher multiplicities

- **CERN LS3 period…**
  - Several upgrades planned – more ideas always welcome
  - IDS on tour – PSI for muX? KISS@RIKEN?
  - Long "winter" physics – high stats measurements



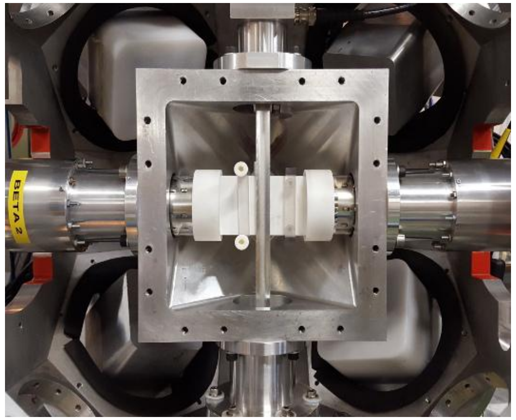


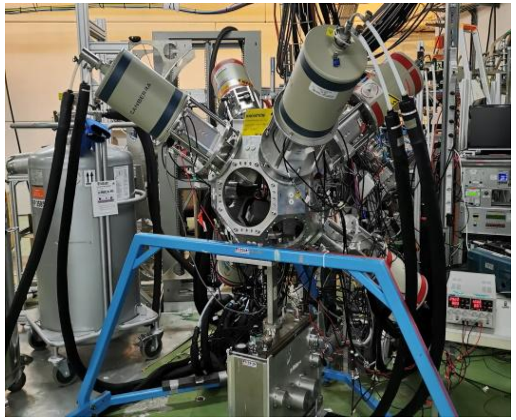
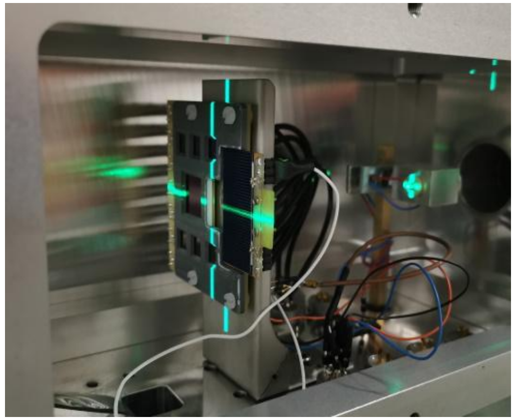


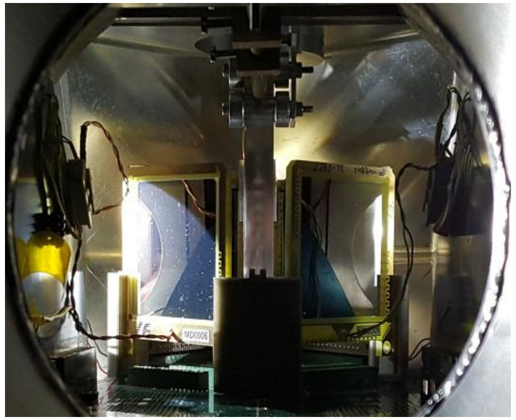
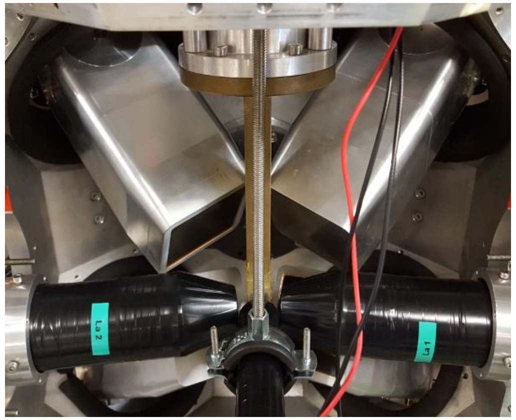
Thank you!

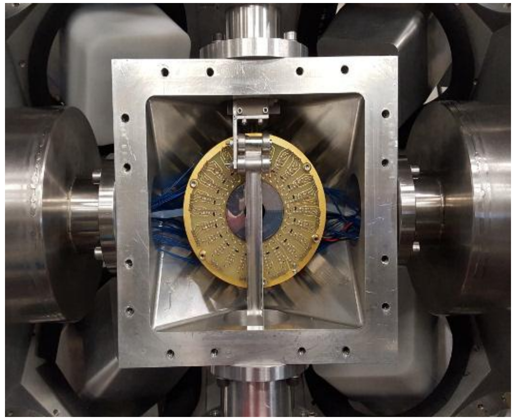
Special thanks to James Cubis for material!

The ISOLDE Decay Station (IDS)






Isolde Decay Station IDS

12 HPGe clovers detectors (as of Sep. 2024)

- 4 crystals / clover
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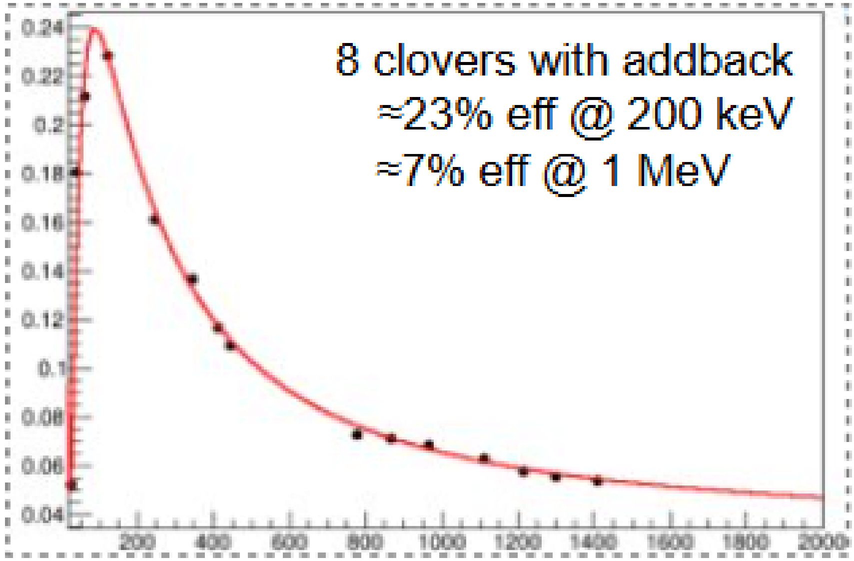
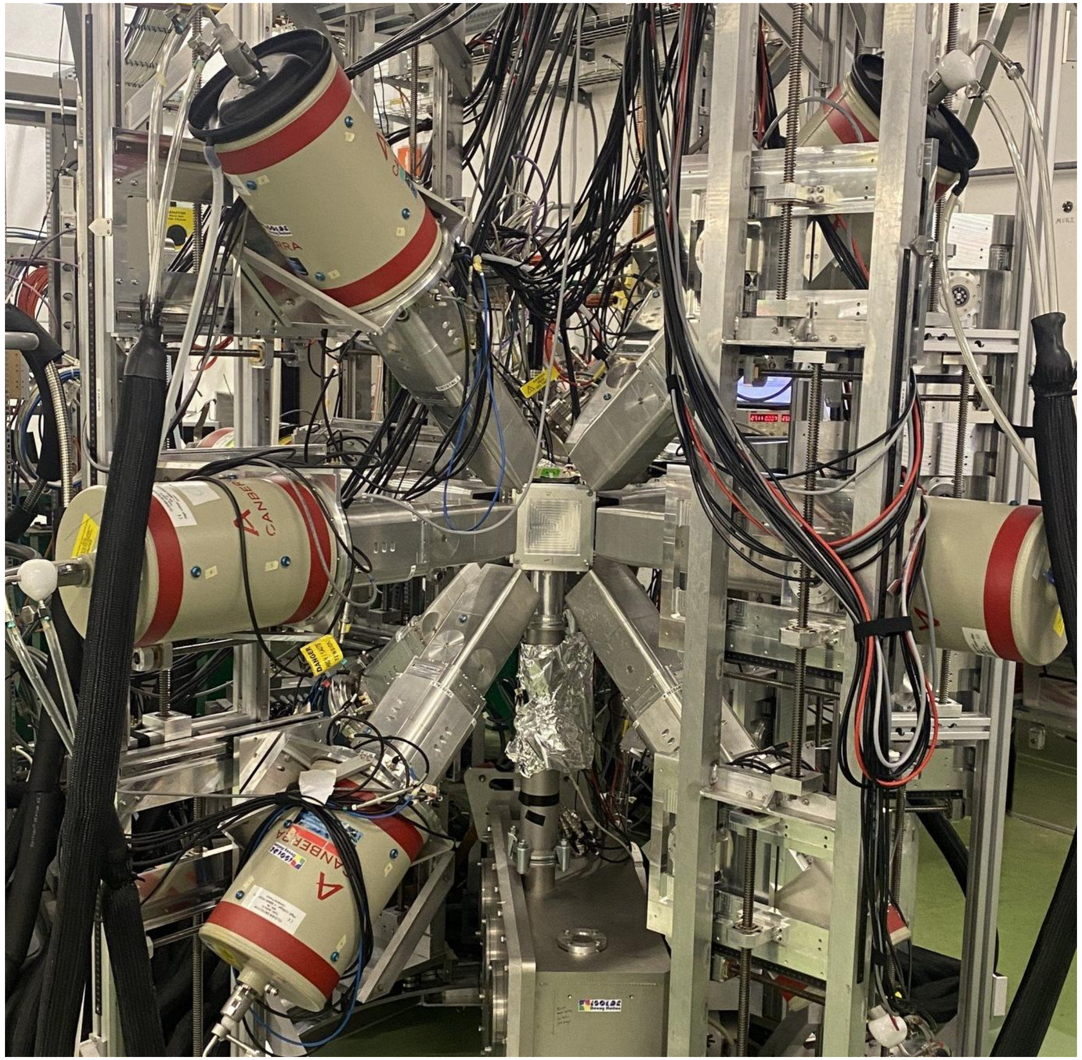




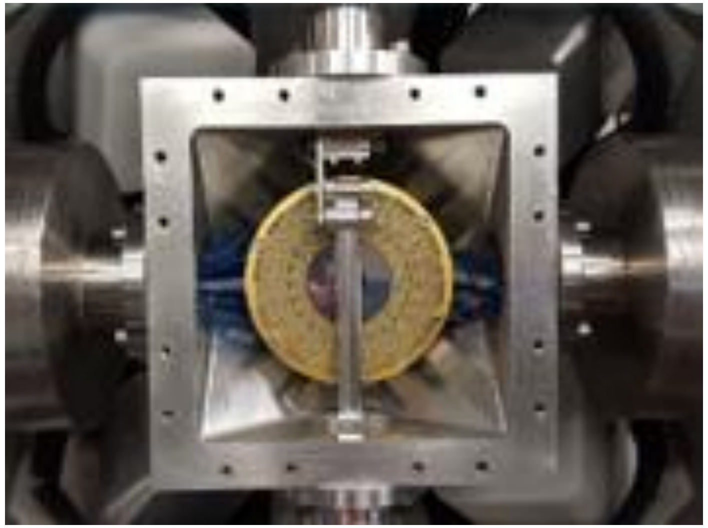
HPGe Detectors: High-resolution γ-ray detection
⟶ Level energies (parity doublets)
⟶ Transition intensities, branching ratios,
⟶ Spin and parity: γ–γ angular correlations

Slide courtesy of James Cubis

Physics Observables Ancillary systems

$LaBr_3$(Ce) Fast-Timing Arrays
⟶ Lifetime measurements (ps–ns range)
⟶ Model independent
⟶ Transition probabilities B(E1), B(E3), etc
⟶ Quadrupole, Octupole deformation

Lifetime measurements of $^{214,216,218}Po$
R.Lica et al., PRL 134 052502, 2025



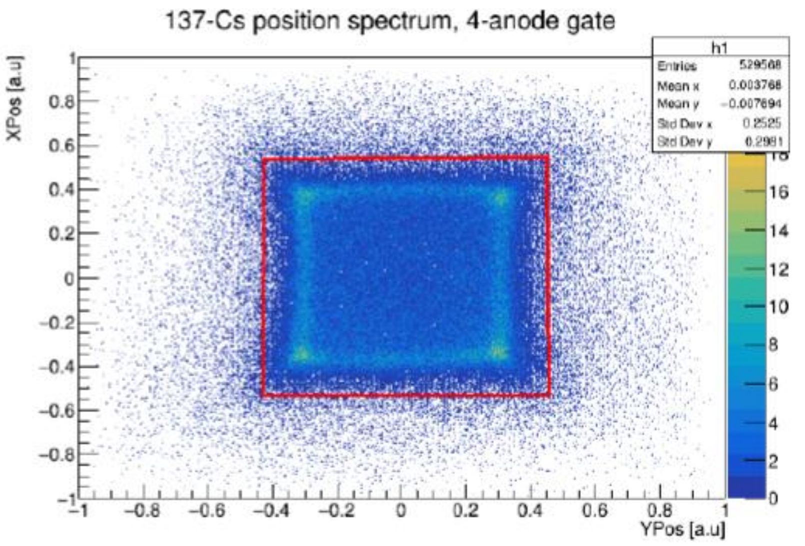
Conversion Electron Spectrometers
⟶ E0 transitions
⟶ Multipolarity and mixing ratio determination
⟶ Highly converted γ-rays.Small splitting

ISOLDE Decay Station

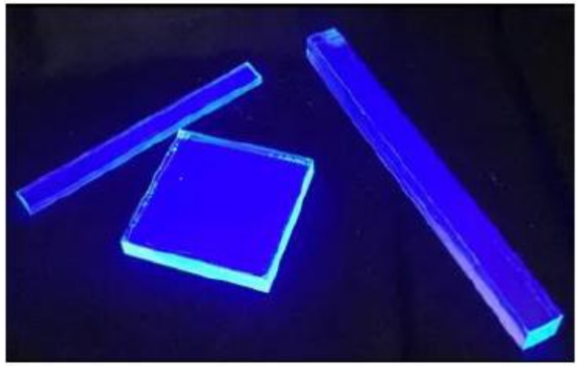
Images courtesy of James Cubis

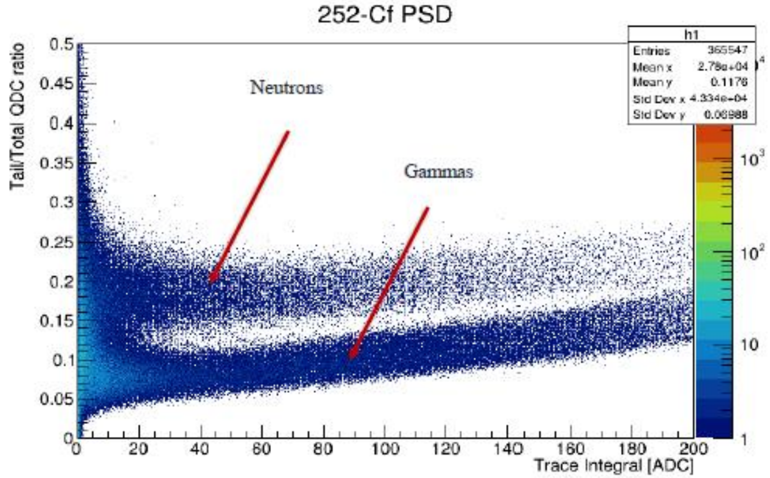
What is OGS

- Compact (approx. 50x50x6 cm^3) OGS (organic glass scintillator) developed for detection and measurement of low energy neutrons.
- Very bright with excellent PSD and efficiency (~0.8 for 50 keV neutrons)
- Coupled to Hamamatsu H12700 PMT
- Anger-logic readout ➔ Position readout
- Demonstrate neutron – γ discrimination



BLUESHIFT OPTICS





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