Beta-decay spectroscopy at the ISOLDE Decay station (2014-2015)

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ISOLDE Decay Station

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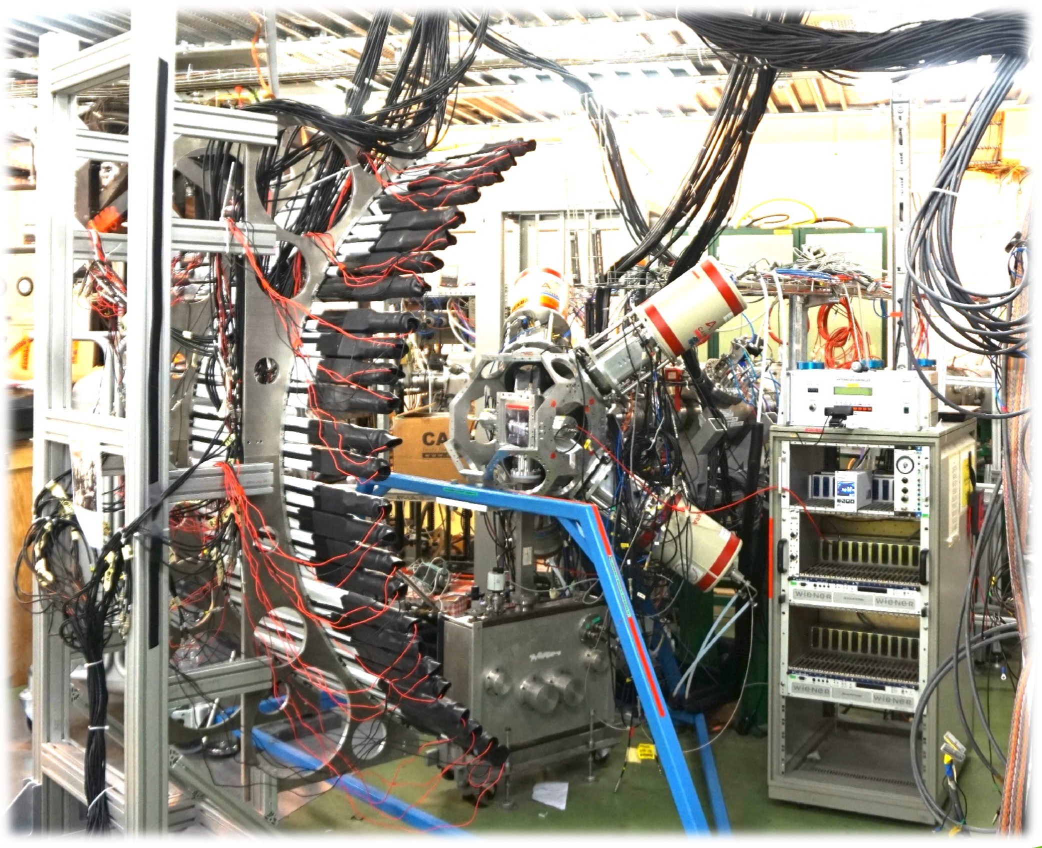
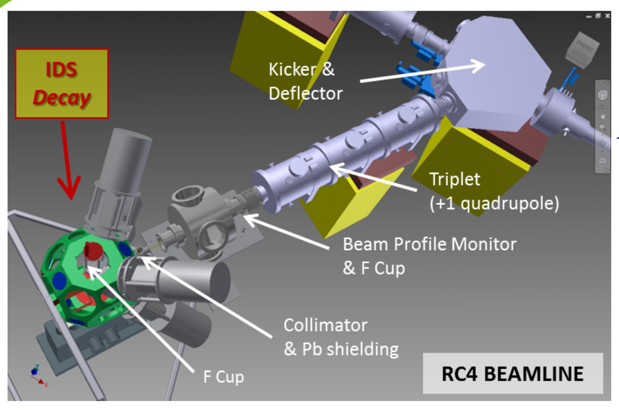
IDS at ISOLDE

- The **Isolde Decay Station (IDS)** project aims at providing a permanent, yet flexible, experimental set-up for decay studies using the radioactive ion beams (RIB) from ISOLDE, CERN since 2014.
- The detection system of IDS is very versatile, with a core of four germanium clusters (HPGe) used for gamma detection. Four different setups can be provided depending on the case under study and physics aim:
  - **high efficiency beta-gamma spectroscopy**
  - **neutron time-of-flight spectroscopy**
  - **charged particles spectroscopy using Si detectors**
  - **beta-decay fast-timing studies using LaBr3(Ce) detectors.**
- The low background and high sensitivity of the setup allow measurements to be performed on short-lived isotopes with half-lives less than 50 ms and yields down to a few ions/sec.



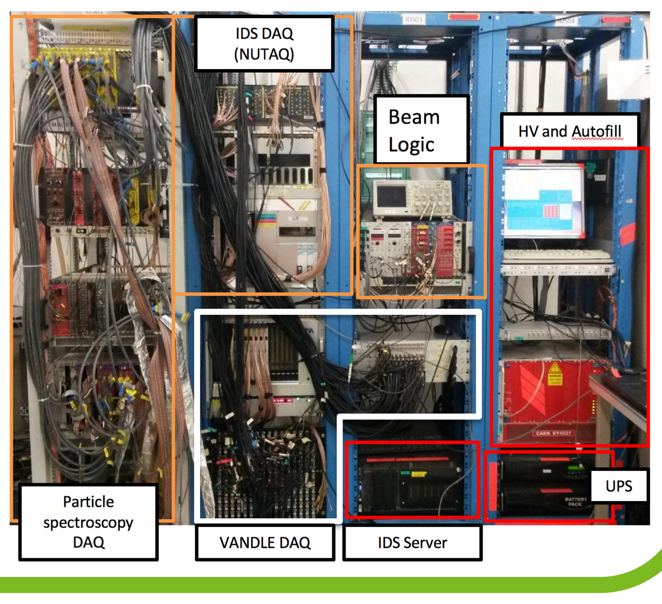
IDS Beamline



- The **RC4** beamline of ISOLDE was designed in 2013 to accommodate the new IDS permanent setup withing the existing infrastructure.

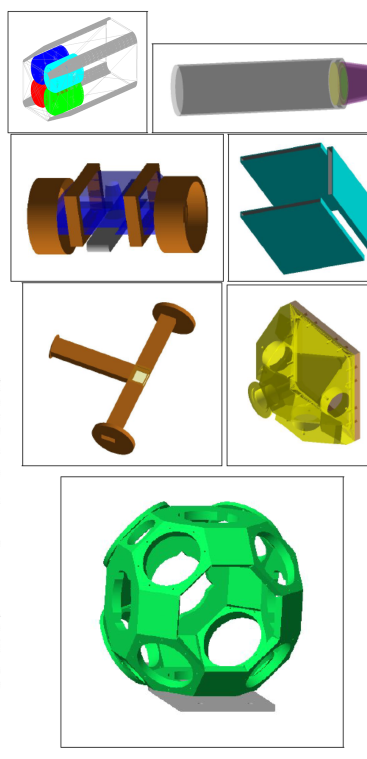
Data acquisition (DAQ)

- The **DAQ** of IDS is very complex, consisting of both digital and analog systems.
- **100 MHz NUTAQ Lyrtech [1]** digitizers represent the main DAQ of IDS which is used in parallel with other systems dedicated for particle or neutron spectroscopy.

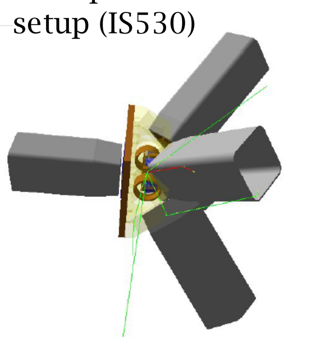


GEANT4 simulations of the IDS setup

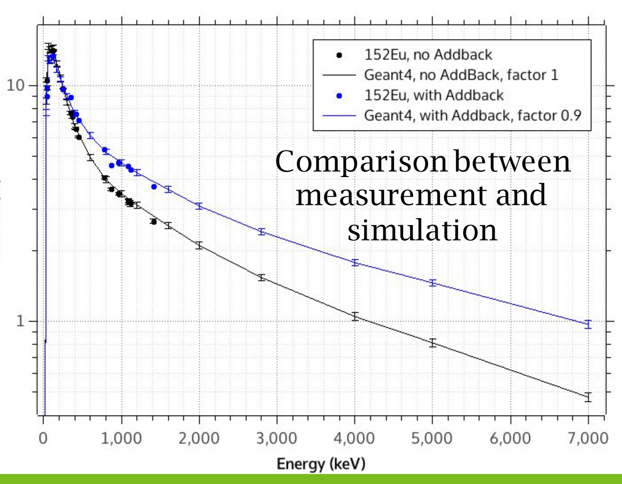
- A dedicated code using GEANT4 was developed in order to characterize the detectors of IDS.
- The geometries were imported from CAD models.
- A very good agreement (95%) was achieved for the HPGe Clovers in determining their absolute detection efficiency.



Graphical representation of an actual experimental setup (IS530)

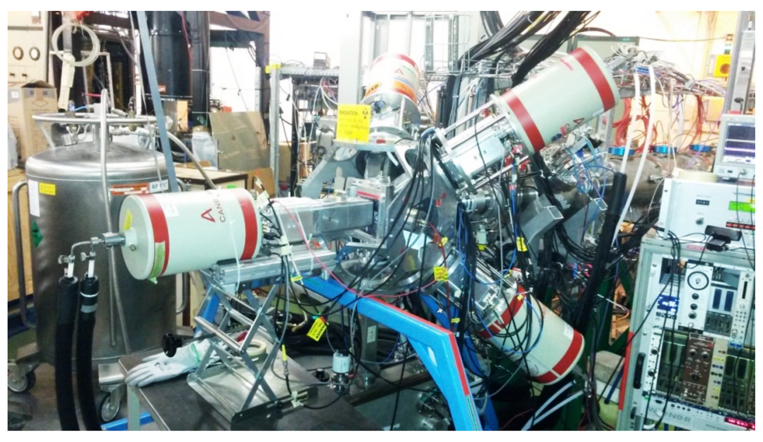


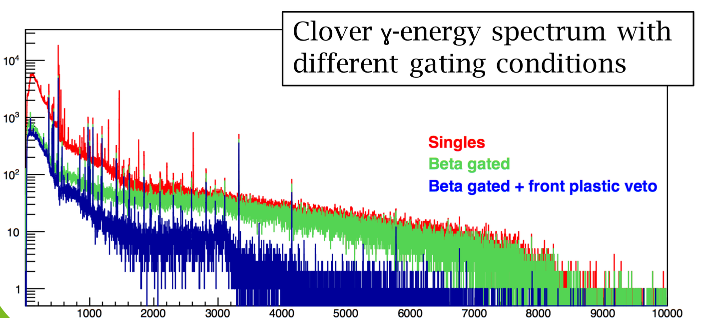
Comparison between measurement and simulation



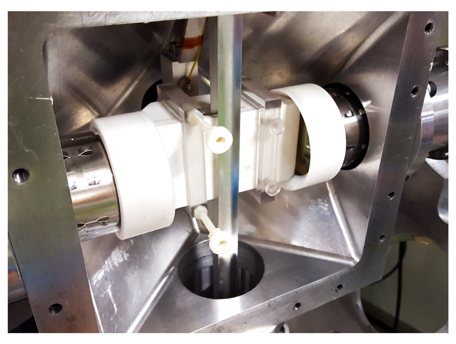
High Efficiency β-γ spectroscopy

- 5 HPGe Clover detectors are used together with a high efficiency (~95%) plastic scintillator as β particle detector.
- The radioactive ions are implanted on a moving tape in order to remove the activity.
- Experiments: IS588 ($^{207-208}$Hg), IS530 (^{34}Mg)





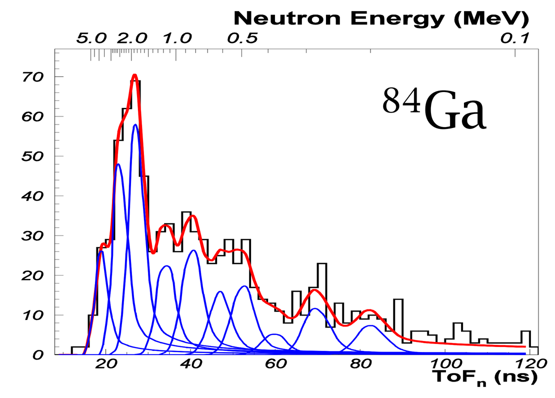
Clover γ-energy spectrum with different gating conditions

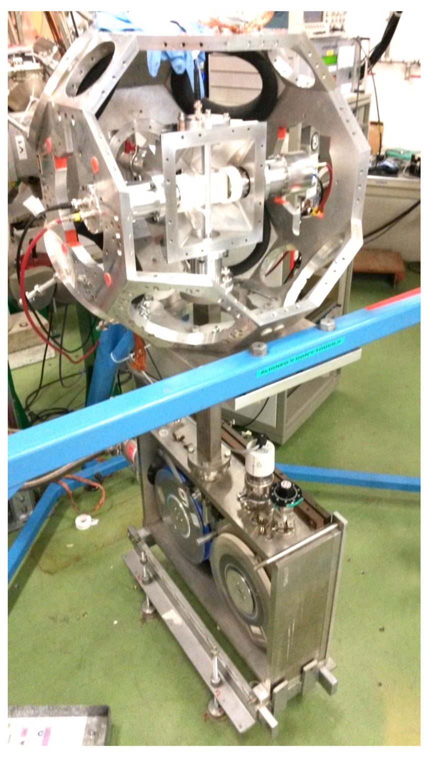


High efficiency β detector surrounding the implantation point on the moving tape

Neutron TOF spectroscopy using VANDLE

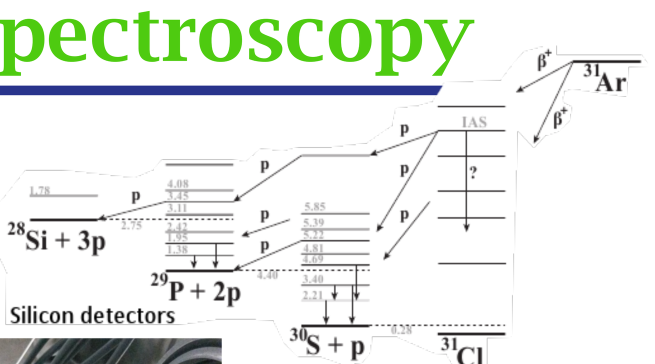
- VANDLE (Versatile Array for Neutron Detection at Low Energies), developed at UTK (USA) [2], consisting of scintillator bars read with two photomultipliers at both ends, recorded neutron signals in coincidence with β particles.
- Experiments:
- IS599 ($^{51-53}$K), IS600 ($^{130-132}$Cd)



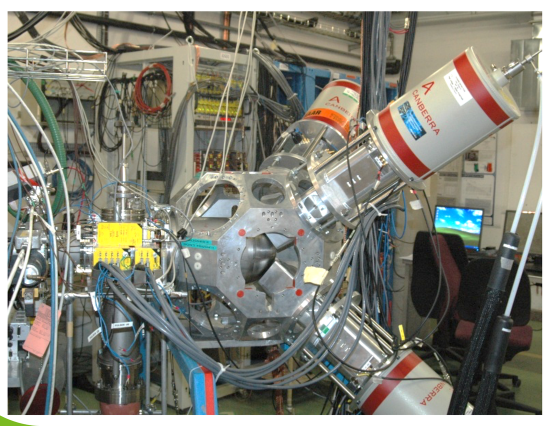


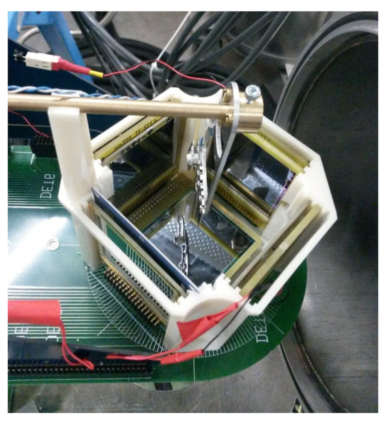
Charged particle spectroscopy

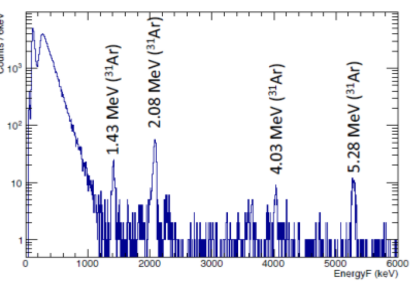
- Particle detectors (Si pads and DSSSD) are used together with HPGe clovers
- Experiments: IS476 (^{31}Ar), IS545($^{112-118}$Ba), IS507 (^{20}Mg), IS605 (^{16}N)



Silicon detectors



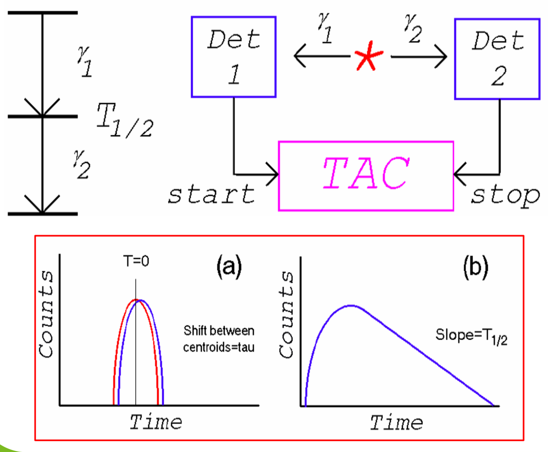


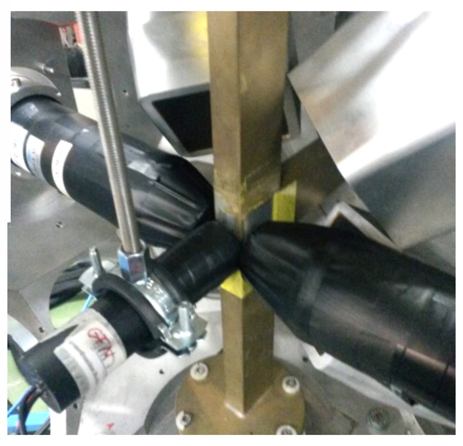


Proton energy spectrum

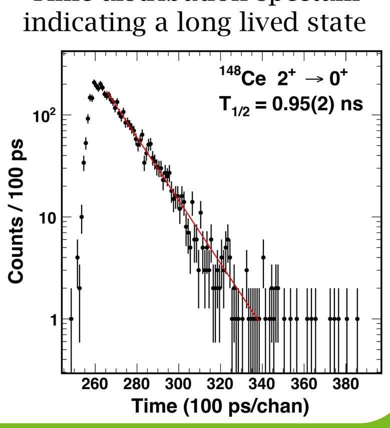
β-decay fast-timing studies

- $LaBr_3$(Ce), fast plastic scintillators and HPGe clover detectors are used for life-time measurements using the $\beta\gamma\gamma_{(t)}$ fast-timing technique [3].
- The ranges available for measurement are 10 ps - 100 ns
- Experiments: IS579 ($^{148-152}$Ba), IS590 (^{68}Mn)

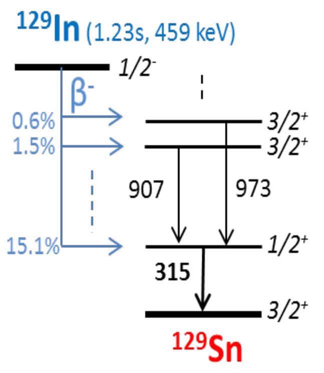




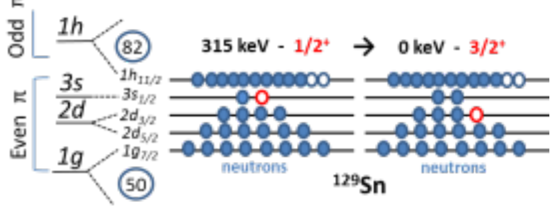
Time distribution spectrum indicating a long lived state



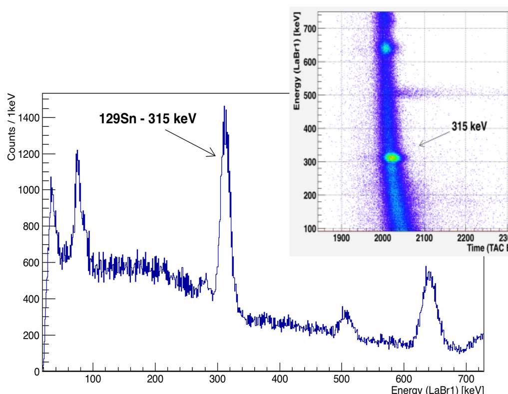
First physics case: Fast-timing study of ^{129}Sn [4]

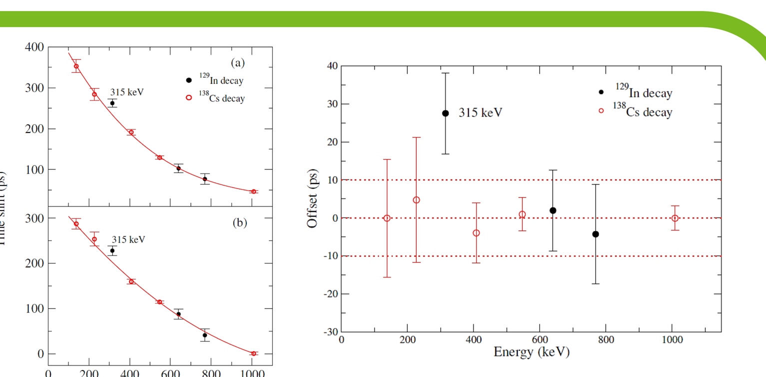


- A state in ^{129}Sn was predicted to have a $T_{1/2} \sim 4$ ns and was accessible to study at IDS via the β decay of ^{129}In.
- The $3s_{1/2} \rightarrow 2d_{3/2}$ transition represents a good test case for M1 effective operators near shell closures.



- Preliminary analysis showed a shortlived state, $T_{1/2} < 40$ ps





- After calibrations and time-walk corrections, the half-life value was extracted using the centroid shift technique, $T_{1/2} = 19(10)$ ps

References

[1] www.nutaq.com
[2] S. V. Paulauskas et al., NIM **A737** (2014) 22-28
[3] H. Mach et al., NIM **A280** (1989) 49
[4] R. Lica et al., Phys Rev C **93**, 044303 (2016)

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