WP5: EXPLORING THE LIMITS OF NUCLEAR EXISTENCE

LISA General Training 1

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Objectives of WP5

- Optimize actinide sample preparation and characterization techniques for the LISA network
- Perform laser spectroscopy using highly sensitive techniques on isotopes of both actinide and trans actinide elements with the goal of probing fundamental atomic and nuclear properties and to benchmark state of the art atomic and nuclear theoretical calculations
- Characterize and optimize the novel in gas jet spectroscopy technique for final implementation at GANIL S3.

Optimised actinide target preparation and characterisation

Method 1: Electrodeposition [1]

- Deposition yields < 90 %
- Well established
- Need for baking procedure
- Compound dissolved in reducing agent → Attracted to cathode → Binds to backing electrochemically

Method 2: Novel Drop-on-Demand (DoD) printing [2]

- Deposition yields ≥ 97 %
- Substrate on xy translation stage
- Not electrochemically bound → less stable in beam
- Salt dissolved → Solution inkjet printed on backing → Solvent evaporates leaving salt on backing

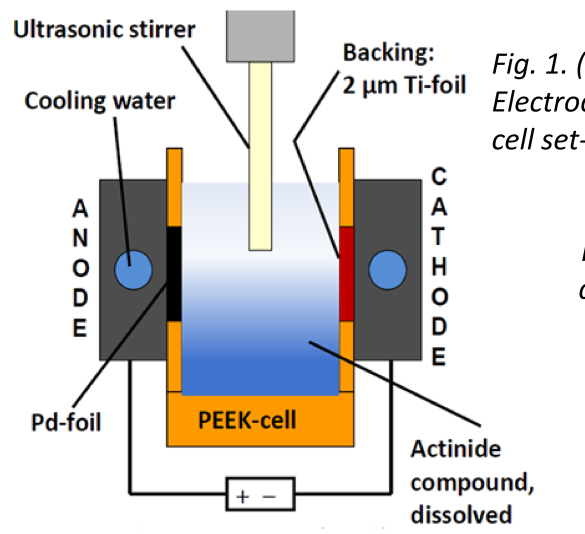


Fig. 1. (Left) Electrodeposition cell set-up [3]

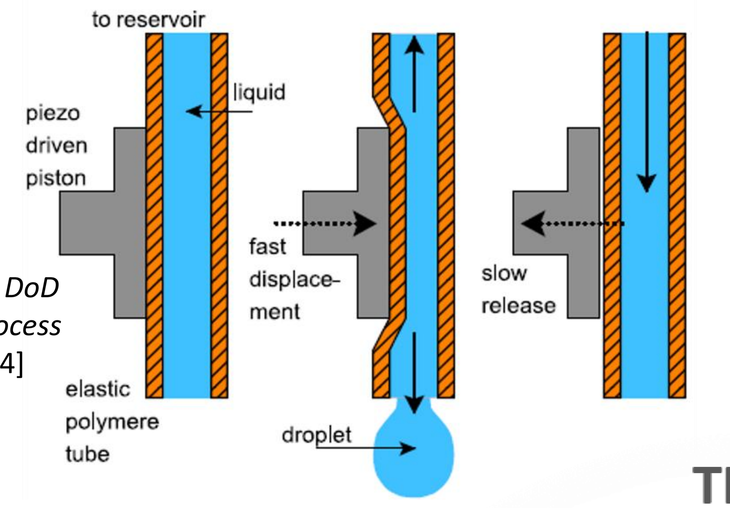


Fig. 2. (Right) DoD dispensing process schematic [4]

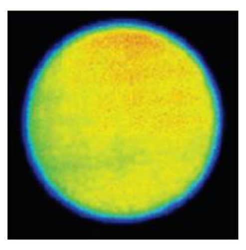


Fig. 3. Electrodeposited ^{242}Pu target radiographic image [5]

Target characterisation techniques:

- Chemical composition: XRF, XPS
- Layer growth mechanisms: SEM, AFM
- Layer homogeneity: α-spectroscopy, radiographic imaging
- Deposition yields: α- or γ- spectroscopy, NAA

In-gas-jet resonance ionization spectroscopy

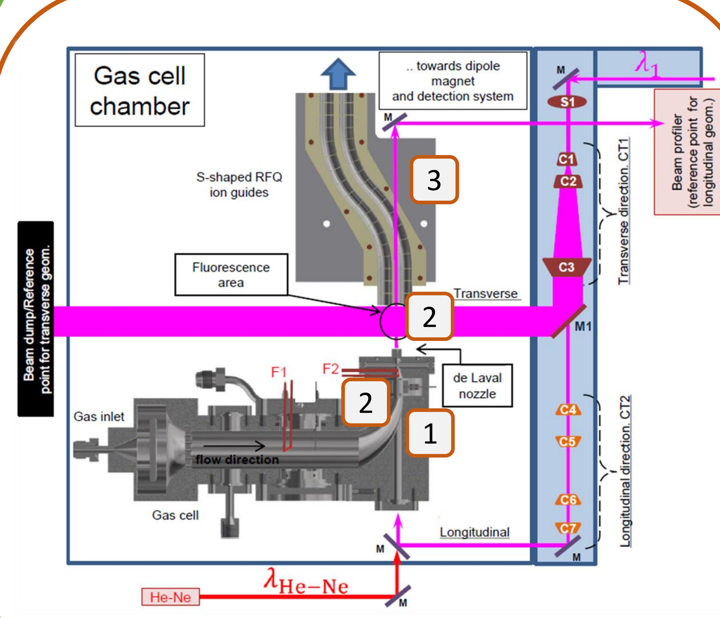


Fig. 6. Layout of gas-cell chamber for PLIF [6]

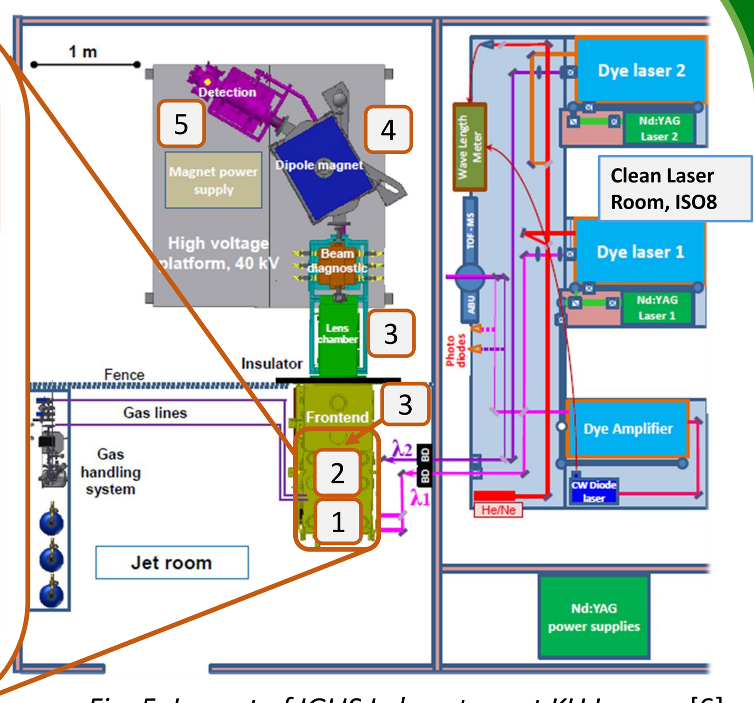
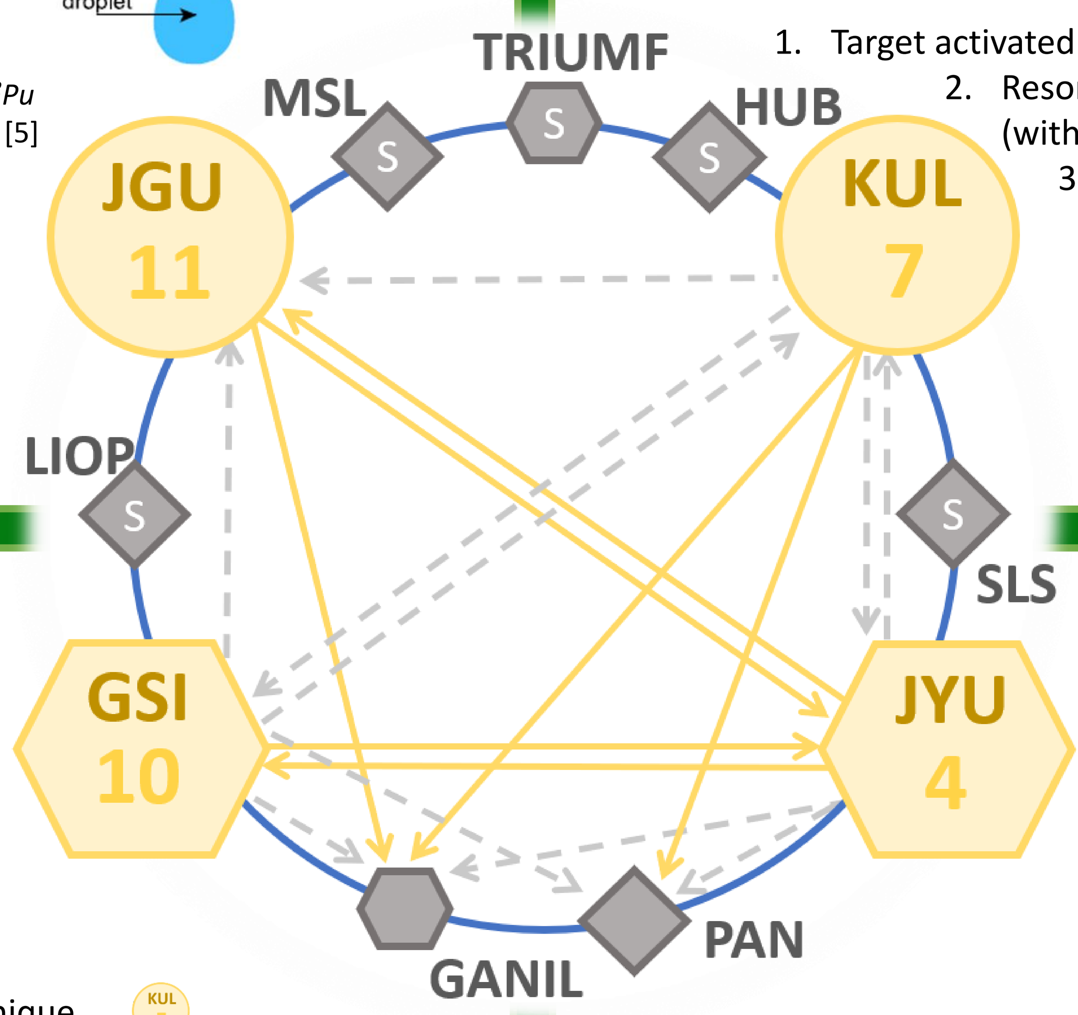


Fig. 5. Layout of IGLIS Laboratory at KU Leuven [6]

1. Target activated by ablation laser, products carried with gas-jet of neutral gas
2. Resonance ionization takes place at intersection of lasers and gas-jet (with product)
3. Laser produced ions are confined and transported through RF Ion guides towards dipole magnet
4. Dipole magnet separates isotopes according to mass to charge ratio
5. Isotopically pure beams measured at detection station



Studying the heaviest actinides

- Limited / no information on atomic & nuclear properties
- Challenging, accelerator-based production
- Search for first atomic states to determine ionization potential, nuclear spin, charge radius, shape…
- Method for level search: Radiation Detected-RIS
- High resolution spectroscopy of HF structure: in gas-jet technique

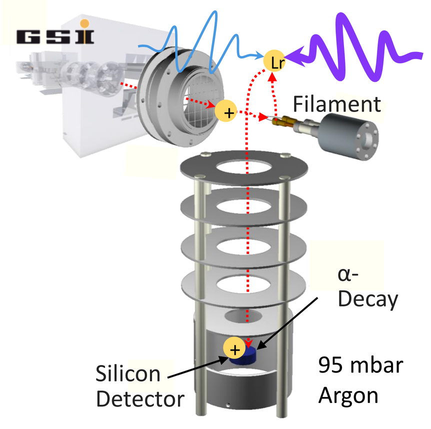


Fig. X. Scheme of the RADRIS technique [x]

Nobelium

- First states only recently determined via RADRIS
- Multiple Rydberg states identified

Lawrencium

- Atomic structure only known from theory
- Low IP: challenging filament desorption optimum material identified (MS21))

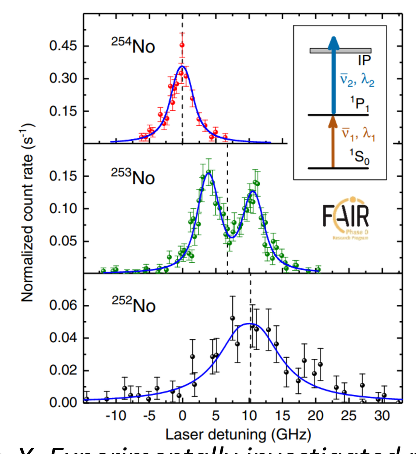


Fig. X. Experimentally investigated resonances of the $1P_1$ level of different No isotopes [X]

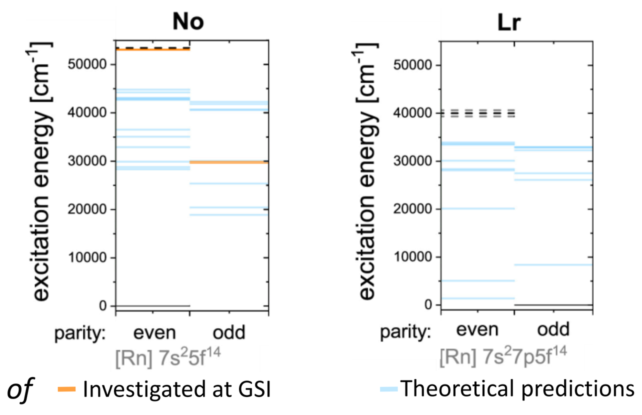


Fig. X. Atomic energy levels of No and Lr [X]

Investigation of fundamental Actinides properties at IGISOL

In-gas-cell laser ionization [A1]

- Gas phase chemistry
- Investigation of ionization schemes with grating Ti:Sa laser

Production techniques:

- **Online**
  - -Fusion evaporation reaction
- **Offline**
  - -In-gas-cell Alpha-recoil source
  - -Heated Actinides filaments

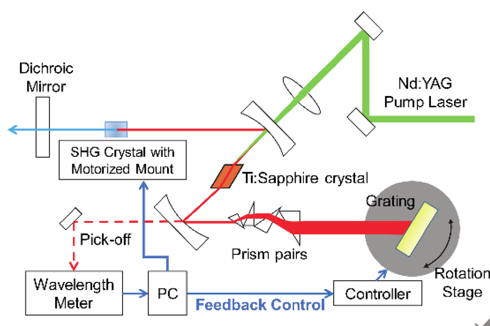


Fig. xx Grating-based Ti:Sa laser [A2]

Decay Spectroscopy

- Decay modes
- Lifetimes
- Production yields

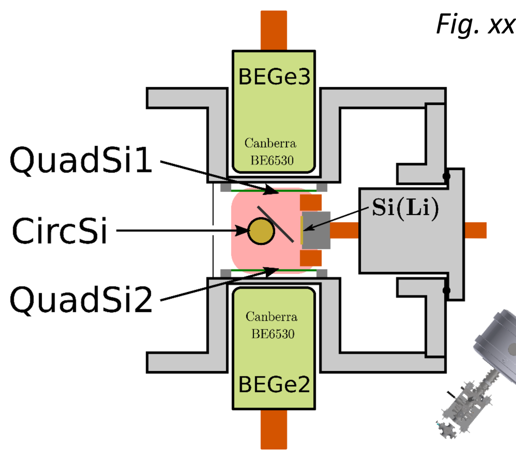


Fig. xx Decay spectroscopy station

High resolution collinear laser Spectroscopy

- Hyperfine structure
  - -nuclear spins
  - -electromagnetic moments
  - -mean-square charge radii
- Octupole deformation in neutron-deficient Th and U

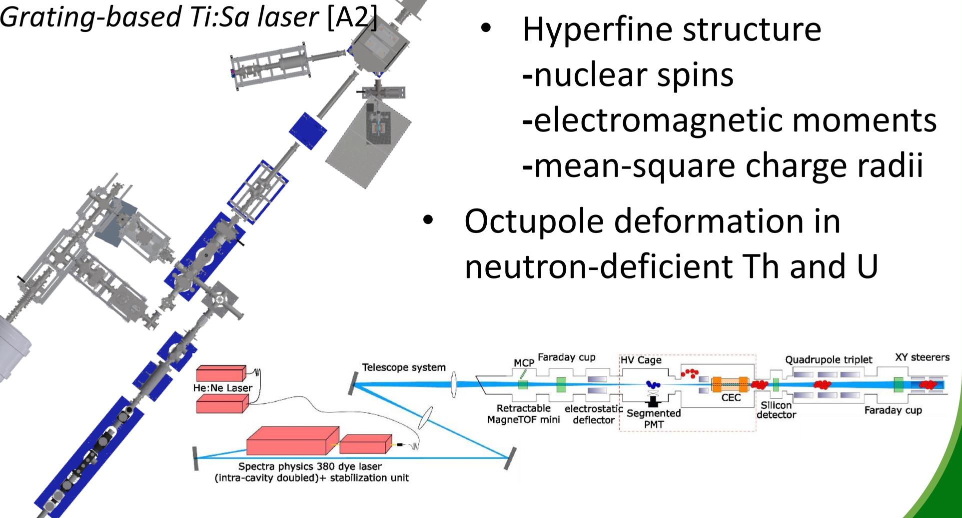


Fig. xx Collinear beamline at IGISOL [A3]

ESR number & host | Research facility | Academic institution | Industrial partner | Travel to secondment | Travel to short stay | S Host all ESRs short stay

References

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LASER IONISATION AND SPECTROSCOPY OF ACTINIDES