WP5: EXPLORING THE LIMITS OF NUCLEAR EXISTENCE

LISA General Training 1

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Objectives of WP5

- Optimize actinide target preparation and characterization techniques for the LISA network
- Characterize and optimize the novel in gas jet spectroscopy technique for final implementation at GANIL S3
- Perform laser spectroscopy using highly sensitive techniques on both actinide and transactinide isotopes to probe atomic and nuclear properties and to benchmark state of the art atomic and nuclear theoretical calculations

Optimized actinide target preparation and characterization

Method 1: Electrodeposition

- Deposition yields < 90 % [1]
- Well established
- Salt dissolved in an alcohol → Attracted to cathode → Binds to backing electrochemically

Method 2: Drop-on-Demand (DoD) printing

- Deposition yields ≥ 97 % [2]
- 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

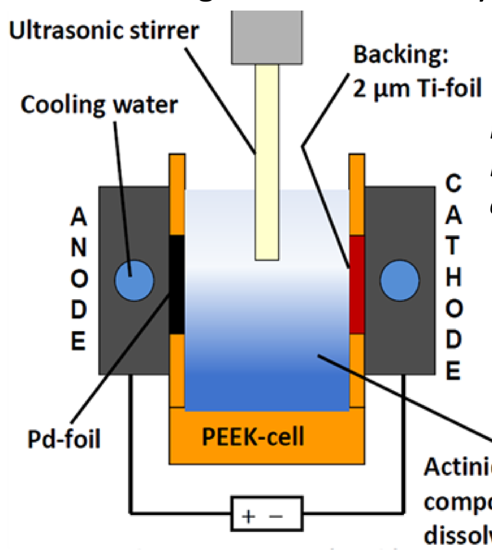


Fig. 1. (Left) Electrodeposition cell set-up [3]

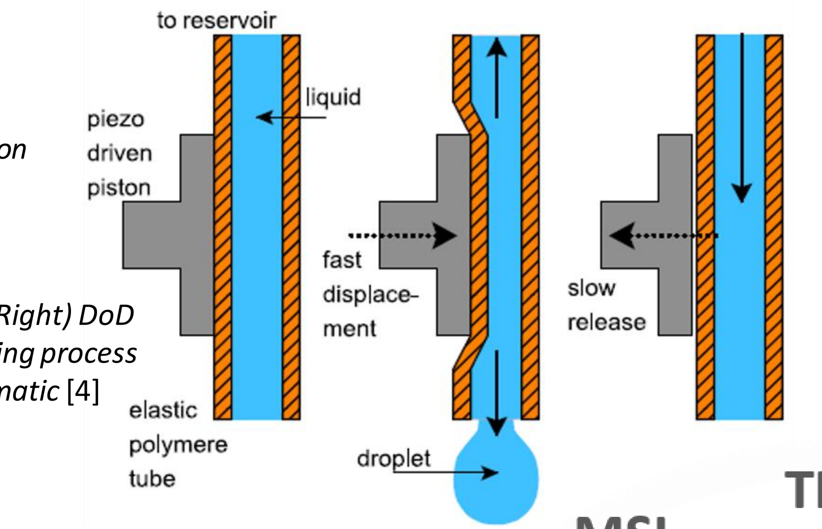


Fig. 2. (Right) DoD dispensing process schematic [4]

Target characterization techniques:

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

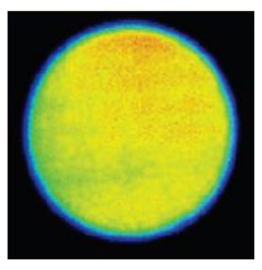


Fig. 3. Electrodeposited ^{242}Pu target radiographic image [5]

In-gas-jet resonance ionization spectroscopy

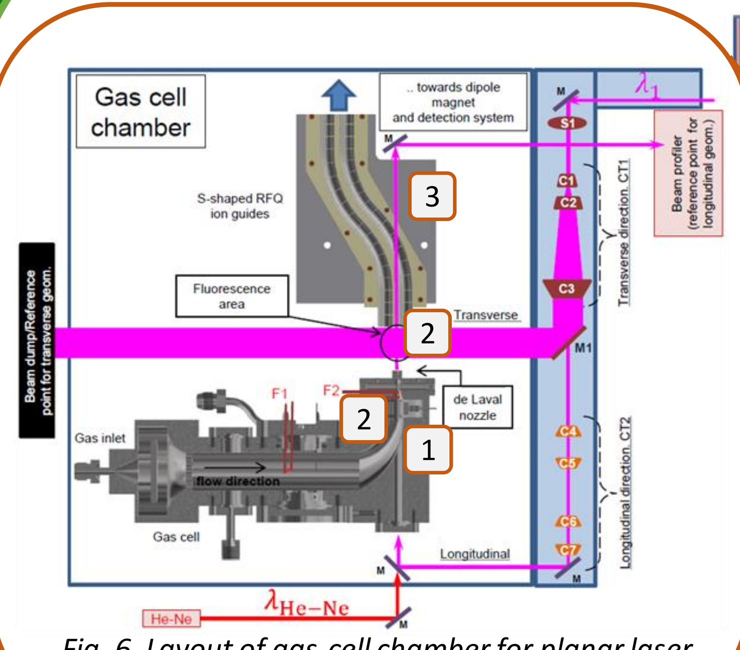


Fig. 6. Layout of gas-cell chamber for planar laser-induced fluorescence measurements [6]

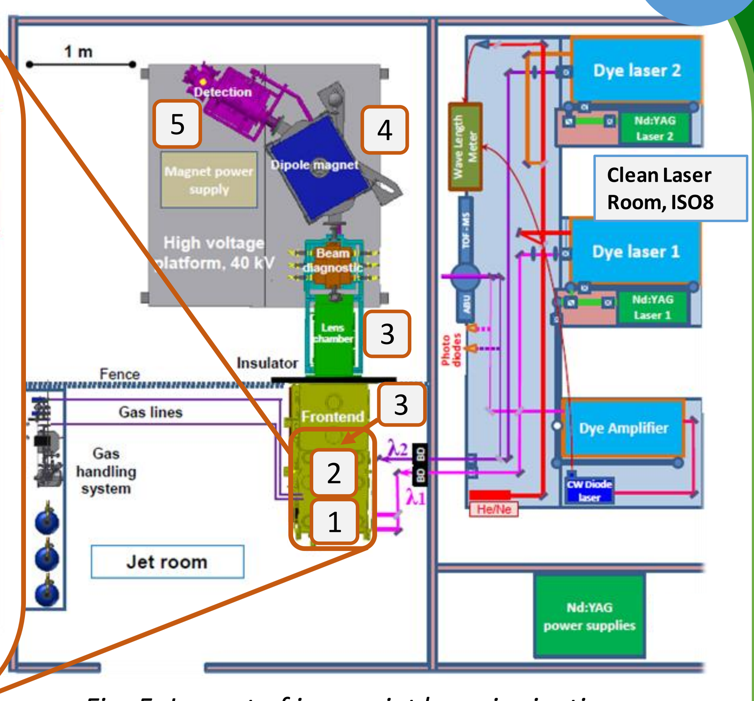
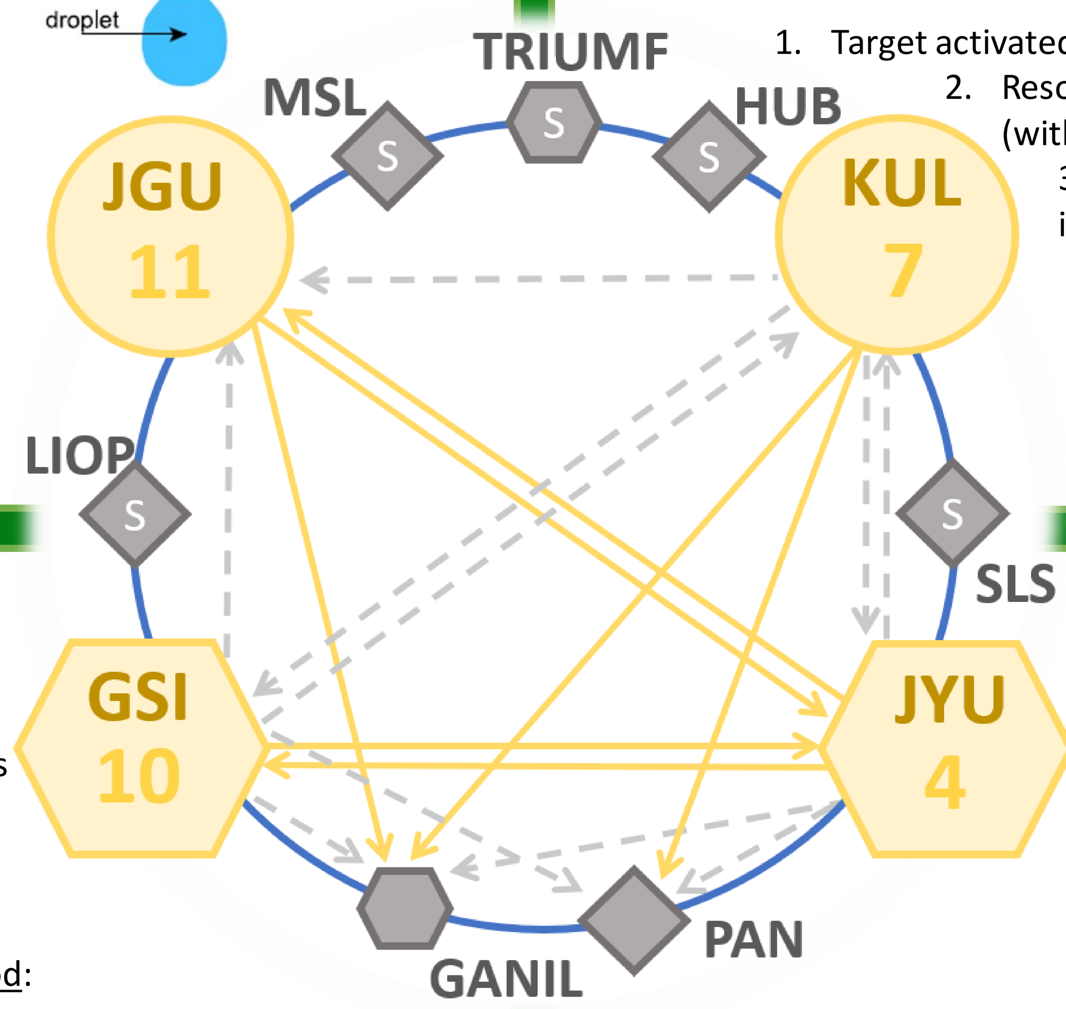


Fig. 5. Layout of in-gas-jet laser ionization spectroscopy laboratory at KU Leuven [6]

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 at GSI

Determine nuclear properties from first laser spectroscopy in the heaviest actinides produced by heavy ion fusion reactions

- Only limited / no information on atomic & nuclear properties
- Challenging, accelerator-based production, low yields, short lifetimes

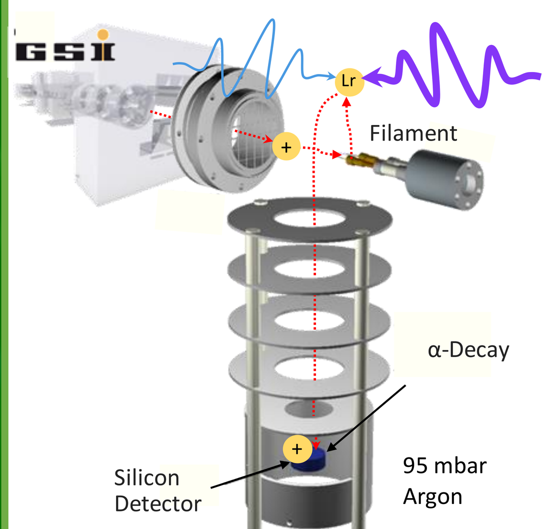


Fig. 13 Scheme of the RADRIS technique [10]

Radiation Detected-RIS Method:

- Neutralization on filament
- Resonance ionization in gas cell
- Selective, efficient detection via α-decay

For high resolution spectroscopy of hyperfine structure: in-gas-jet technique

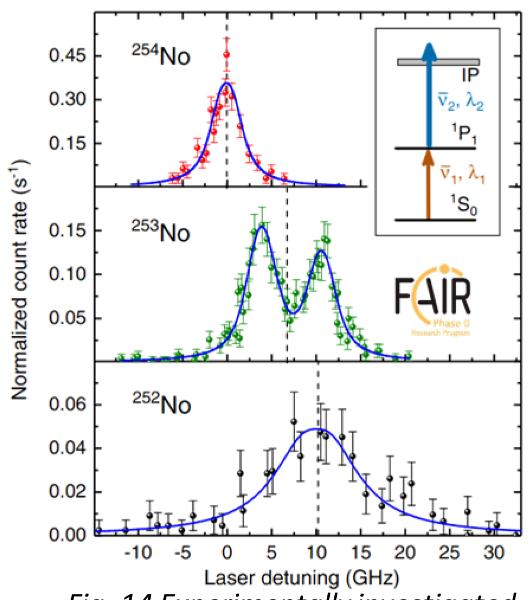


Fig. 14 Experimentally investigated resonances of the $1P_1$ level of different No isotopes [11]

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))

Investigation of fundamental Actinides properties at IGISOL

In-gas-cell laser ionization [7]

- 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

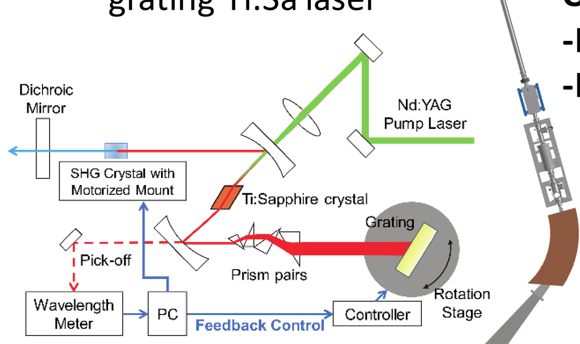


Fig. 10 Grating-based Ti:Sa laser [8]

Decay Spectroscopy

- Decay modes
- Lifetimes
- Production yields

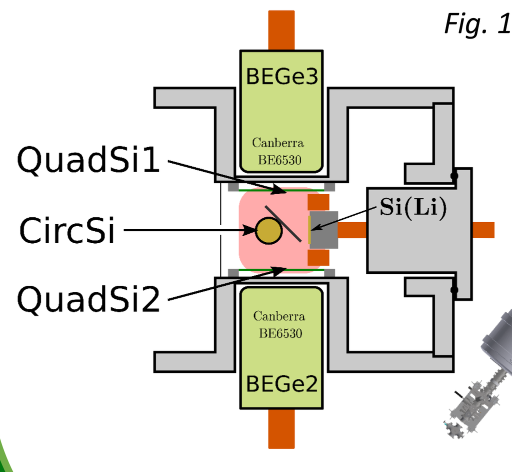


Fig. 11 Decay spectroscopy station

High resolution collinear laser Spectroscopy

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

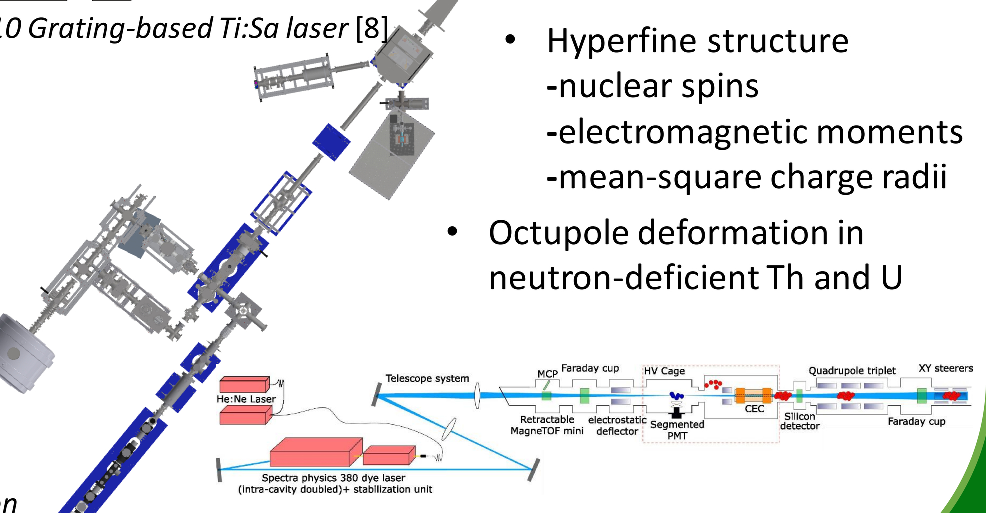


Fig. 12 Collinear beamline at IGISOL [9]

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

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LASER IONISATION AND SPECTROSCOPY OF ACTINIDES

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