

A New Laser Ablation Ion Source for ISOLTRAP

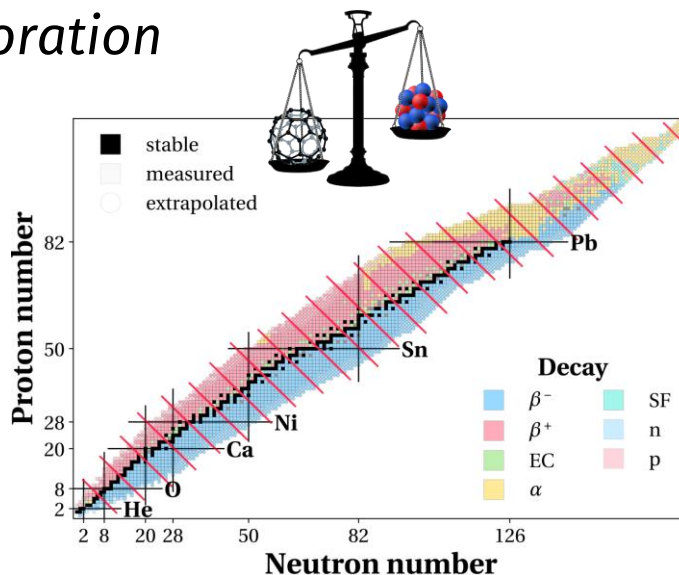
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For the ISOLTRAP Collaboration

Motivation and Applications

- Systematic studies of uncertainties of
 - Multi-Reflection Time-of-Flight Mass Spectrometer (MR-ToF MS)
 - Phase-Imaging Ion-Cyclotron-Resonance (PI-ICR) technique
- Source of various reference masses
- Ablation of long-lived radioactive ions



ISOLDE 30 kV
ion beam

RFQ

MR-ToF MS

MCP for ToF
detection

Precision
Penning trap

Preparation
Penning trap

EMP

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- How it works
- Design considerations
- History of LAS at ISOLTRAP
- SIMION simulations
- Daily struggle in the lab



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Abstract / Motivation

- The ISOLTRAP mass spectrometer at ISOLDE/CERN comprises various ion traps for precision mass spectrometry on short-lived radioactive isotopes [1].
- The **Laser Ablation Ion Source (LAS)** has a long history at ISOLTRAP, was used for studying the Time-of-Flight Ion Cyclotron Resonance technique (ToF-ICR) [2].
- Remodeling of ISOLTRAP's vertical beamline and the implementation of a Multi-Reflection Time-of-Flight Mass Spectrometer / Mass Separator (MR-ToF MS) [3] required a **relocation and redesign of the LAS**.
- Multiple applications:
 - **Systematic studies of uncertainties** associated with different measurement techniques to increase the highest reachable precision and resolving power
 - **Source of various reference masses** for mass measurement campaigns
 - **Ablation of long-lived radioactive ions**

ISOLTRAP Mass Spectrometer

The ISOLTRAP mass spectrometer consists of the following ion traps:

- Radio-Frequency Quadrupole cooler/buncher (RFQ)** for beam preparation
- Preparation Penning Trap** for beam preparation and purification
- Precision Penning Trap** for precision mass measurements using ToF-ICR and the recently implemented Phase-Imaging Ion-Cyclotron-Resonance (PI-ICR) techniques [4,5]

Evolution of Laser Ablation Ion Sources at ISOLTRAP

1980s Version

- Located on a 60 VDC high-voltage platform in front of RFQ
- Strong space constraints: W, laser and vacuum system on a footprint of 1 m²
- 1D linear motion for target positioning

2010s Version

- Carbon target on rotatable feedthrough
- Located in-between MR-ToF MS and Penning traps
- Suffered from count rate **stability problems** resulting in poor beam cooling in Preparation Penning Trap

2020s Version

- Stationary carbon target
- In-line with both Penning traps
- Systematic studies of ToF-ICR technique [2]
- Had to be removed for beam line upgrades

Laser Ablation on Targets

The case for carbon clusters

- Absolute mass measurements**: mass unit u based on ¹²C
- Plenty of ref. masses where reference is only 6u
- Determination of mass differences and negative ions
- Also: possibility for fragmentation and dissociation

Fragmentation and dissociation

- Laser irradiation leads to desorption, fragmentation and ionization of C_n clusters
- Figure on the right: ToF image of laser ablated cluster from fullerene target

SIMION Simulations

Overall beam energy **cannot exceed 50 eV** relative to buncher potential to be trapped

- Extraction electrodes designed in **Pierce geometry** for optimized beam extraction in LAS part [6]
- Initial ion distribution as Maxwellian superimposed with thermal shockwave distr.
- Simplex optimizer [9] for optimizing beam transport for both LAS and surface ion source
- A total of 30 individual voltages in whole section (16 optimized, 12 starters)

References

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