A New Laser Ablation Ion Source for ISOLTRAP

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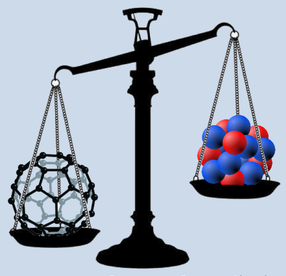
Abstract / Motivation

- 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**

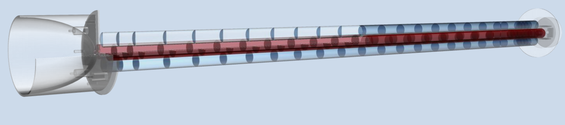


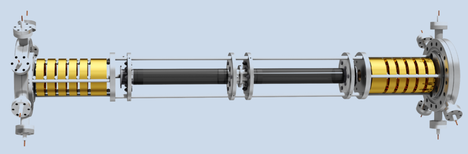
cluster as mass reference for radio-isotopes

ISOLTRAP Mass Spectrometer

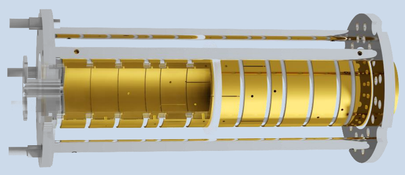
The ISOLTRAP mass spectrometer consists of several ion traps

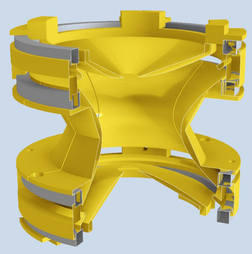
- **Radio-Frequency Quadrupole cooler/buncher** (RFQ) for beam preparation



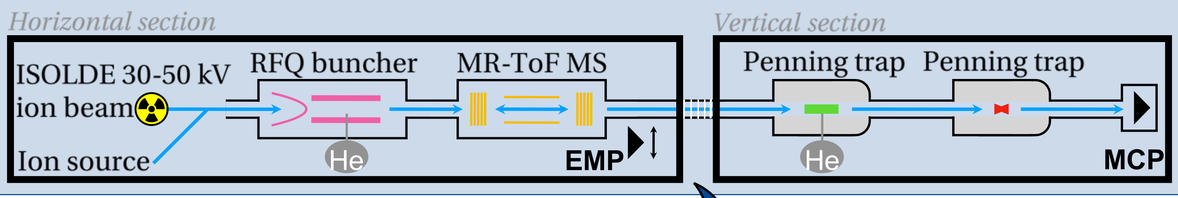


- **MR-ToF MS Trap** for mass separation and mass measurements
- **Preparation Penning Trap** for beam preparation and purification

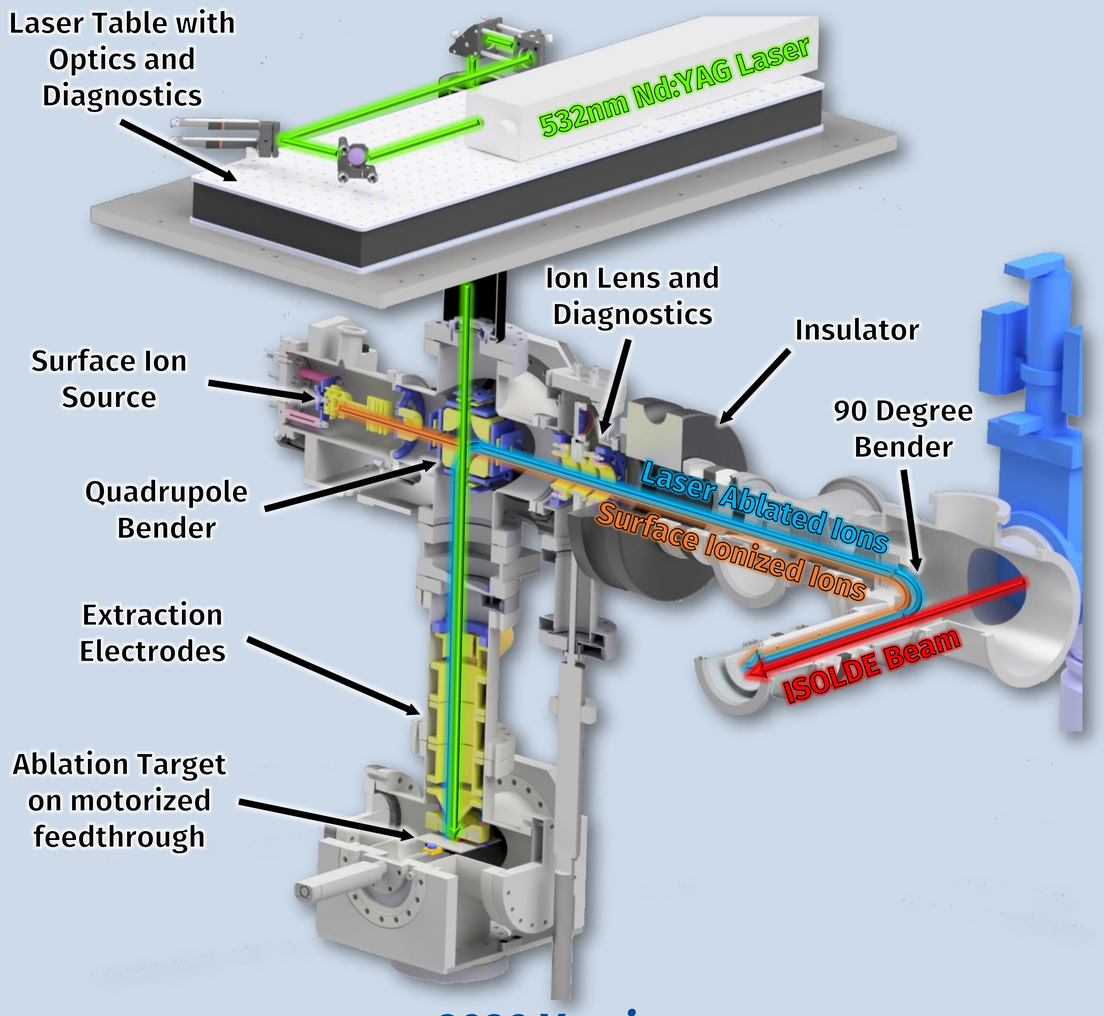


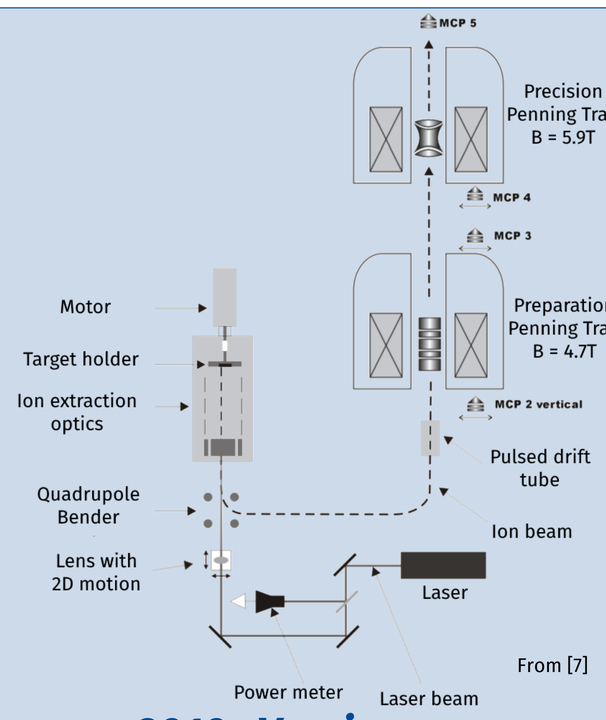


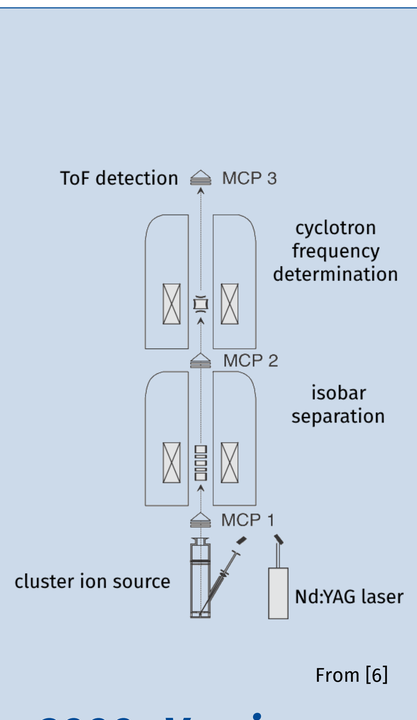
- **Precision Penning Trap** for precision mass measurements using ToF-ICR and the recently implemented Phase-Imaging Ion-Cyclotron-Resonance (PI-ICR) techniques [4,5]



Evolution of Laser Ablation Ion Sources at ISOLTRAP







2020 Version

- Located on a **60 kVDC high-voltage-platform** in front of RFQ
- Strong **space constraints**: HV, laser and vacuum system on a footprint of < 1 m^2
- 1D **linear motion for target** positioning
- Both LAS and **surface ion source** mounted simultaneously
- New **laser**: Litron LG250 (10ns pulse length, 10 Hz rep. rate)
- Neg. and pos. ions now available for all traps and w/ initial energy of ISOLDE ions

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

2000s 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

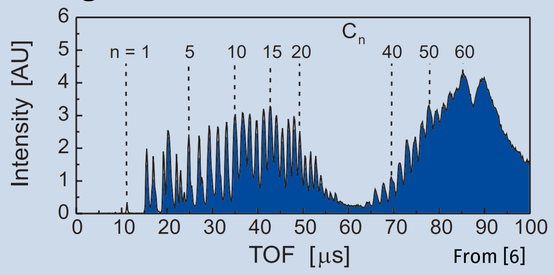
Laser Ablation of Carbon Targets

The case for carbon clusters

- **Absolute mass measurements** (def. of atomic mass unit u based on ^{12}C)
- Plenty of ref. masses where max. mass difference is only 6u
- Determination of mass-dependent upper limit of precision
- Also: possibility for studying cluster physics andnegative ions

Fragmentation and desorption of C_{60} fullerenes

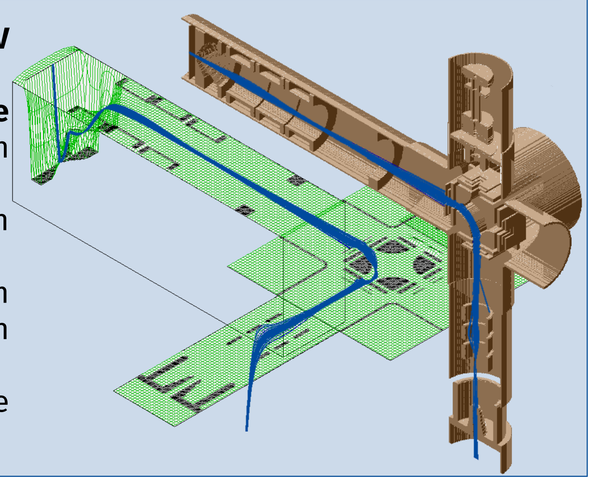
- Laser irradiation of C_{60} targets leads to desorption, fragmentation, and photo-ionization of C_n-cluster
- Figure on the right: ToF spectrum of laser ablated cluster from fullerene target



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 [8]
- Initial ion distribution as Maxwellian superposed 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 (18 optimized, 12 steerers)



References

[1] M. Mukherjee et al., *ISOLTRAP: An on-Line Penning Trap for Mass Spectrometry on Short-Lived Nuclides*, Eur. Phys. J. A **35**, 1 (2008)
[2] A. Kellerbauer et al., *From Direct to Absolute Mass Measurements: A Study of the Accuracy of ISOLTRAP*, Eur. Phys. J. D **22**, 53 (2003).
[3] R. N. Wolf et al., ISOLTRAP's Multi-Reflection Time-of-Flight Mass Separator/Spectrometer, Int. J. Mass Spectrom. 349–350, **123** (2013)
[4] E. Eliseev et al., *Phase-Imaging Ion-Cyclotron-Resonance Measurements for Short Lived Nuclides*, Phys. Rev. Lett. **110, 082501** (2013).
[5] V. Manea et al., *First Glimpse of the N = 82 Shell Closure below Z = 50 from Masses of Neutron-Rich Cadmium Isotopes and Isomers*, Phys. Rev. Lett. **124**, 092502 (2020).
[6] K. Blaum et al., Carbon Clusters for absolute mass measurements at ISOLTRAP, Eur. Phys. J. A **15**, 245-248 (2002)
[7] V. Manea et al., *Current status of the ISOLTRAP Laser Ion Source*, Internal Communication (2012).
[8] J. Lommen, *Design and Implementation of a Pierce Geometry to the Cluster Ion Source as ISOLTRAP*, CERN-THESIS-2011-310 (2011)
[9] L. Nies, *Progress towards WISArD: Beam line simulations and detector studies for the Weak Interaction Studies with 32Ar Decay (WISArD) experiment*, CERN-STUDENTS-Note-2018-155 (2018)

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