A Status Report on: Precision Measurements of Very Short-Lived Nuclei Using an Advanced Trapping System for Highly-Charged Ions

Klaus Blaum: MPI-K, Heidelberg

for the MATS Collaboration
<table>
<thead>
<tr>
<th>Type of reaction</th>
<th>ISOL-TRAP</th>
<th>CPT</th>
<th>SHIP-TRAP</th>
<th>JYFL-TRAP</th>
<th>LEBIT</th>
<th>MAFF-TRAP</th>
<th>TITAN TRAP</th>
<th>TRIGA-TRAP</th>
<th>HI-TRAP</th>
<th>MATS/FAIR</th>
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</table>

There is a high degree of complementarity!

FAIR-beams will provide unique opportunities!
A Brief History of Mass Spectrometry

Mass Uncertainty $\delta m/m$

- 1930
- 1940
- 1950
- 1960
- 1970
- 1980
- 1990
- 2000
- 2010

$38^{\text{Ca}} \left( T_{1/2} = 440\text{ms} \right) 28^{\text{Si}}$

- PTMS
- Reaction Q
- SMILETRAP, MIT-TRAP (now at FSU), Seattle-TRAP, HD-TRAP
- Dehmelt, Gräff, van Dyck, Werth, Kluge
- CPT, ISOLTRAP, JYFLTRAP, LEBIT, SHIPTRAP

Masses must be measured with a clock!
The lightest masses: (SMILETRAP, TITAN)

The shortest lived nuclide: (TITAN)

The lowest production rate: (SHIPTRAP)

The heaviest masses: (SHIPTRAP)

The discovery of a new isotope: 
$^{229}$Rn: mass, spin, half-live unknown (ISOLTRAP)

The highest precision: (JYFLTRAP, LEBIT)
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Mass Spectrometry Facilities at FAIR

New Experimental Storage Ring

HITRAP Penning traps

MATS Penning traps
Experiments with Slowed and Stopped Beams

- Laser spectroscopy (LASPEC)
- Precision mass measurements (MATS)
- In-flight spectroscopy (HISPEC)
- Gas stopping cell
- Decay spectroscopy (DESPEC)
- Energy buncher / spectrometer
MATS – Setup:

- Setup:
  - LaSpec
  - RFQ
  - mass separation

- Ions from Super-FRS

- 10 m

- Annex building 6b
  - Second floor

- MATS lab
  - Laser lab
  - 55 m²

- LaSpec lab
  - 210 m²

- Ions
  - Atoms
  - Gas catcher / inverse cyclotron

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MATS – Experiments with Exotic Nuclei

Detectors:
- FT-ICR
- TOF-ICR
- Si(Li) electron

Precision trap:
mass measurements

Cooler trap:
beam preparation & spectroscopy

Magn. deflector:
q/m separation

EBIT:
charge breeding

\[ f_c = \frac{1}{2\pi m} q B \]
Design parameters:

- Overall efficiency: 1-5%
- Maximum resolving power: $10^8$
- Accessable half-life: 10 ms
- Relative mass uncertainty: $10^{-9}$

Organisation and responsibilities:

- Mainz, Greifswald, GSI, MSU, Stockholm: Penning trap system
- Orsay, Jyväskylä, Gießen, Huelva: RFQ cooler and buncher
- Heidelberg, Livermore, Stockholm: EBIT
- Greifswald, Mainz, PNPI: Detection system and electronics
- PNPI, Munich, Jyväskylä, Huelva: Trap assisted spectroscopy
The Test Facility TRIGA-SPEC

TRIGA Mainz

In collaboration with:
K. Eberhardt
G. Hampel
W. Nörtershäuser
N. Trautmann

Klaus Blaum : Status of MATS @ FAIR
The TRIGA–Trap Setup

TRIGA-TRAP setup at beam port B of the TRIGA reactor

Center frequency:

\(746541.43059 \pm 1.40931\) Hz

\(808707.3769 \pm 0.1182\) Hz

\(^{133}\text{Cs}^+\)

5314 ions
### The CARIBU-Project vs. TRIGA-SPEC

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Half-Life / s</th>
<th>Low-Energy Beam Yield / (1/s)</th>
<th>Acc. Beam Yield / (1/s)</th>
<th>TRIGA Yield / (1/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zr-104</td>
<td>1,2</td>
<td>6,00E+05</td>
<td>2,10E+04</td>
<td>1,03E+05</td>
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<td>Ba-143</td>
<td>14,3</td>
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<td>4,30E+05</td>
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<td>0,5</td>
<td>3,30E+03</td>
<td>1,20E+02</td>
<td>2,73E+03</td>
</tr>
</tbody>
</table>

**TRIGA yields:** cumulated yields for a 300µg Cf-249 target and a thermal neutron flux of 1,8E11 n / (cm² s)

**CARIBU-yields:** 1 Ci Cf-252 fission source
Latest MATS-News

- Setup of a Penning trap prototype system at the nuclear research reactor TRIGA Mainz
- New MR-TOF-MS developments (Gießen)
- Finland: start to finance FAIR-projects
- TDR – submission date 2008/2009
- Readiness to move the equipment to the building in 2012/2013
- Readiness for beam in 2013/2014
- IMoU ready and signed
MATS Collaboration

Belgium
Universite Bruxelles
Canada
TRIUMF
France
Paris, CNRS
Finland
Jyväskylä
Germany
EMAU, FAU, JoGu, GSI, MPIK, JLU, LMU
India
Kolkata
Russia
PNPI, PSU
Spain
Huelva
Sweden
Stockholm
USA
LLNL, MSU

10 countries
17 instituts
73 members

Spokesperson:
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Co-spokespersons:
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José Crespo, MPI-K
Project manager:
Frank Herfurth, GSI