Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

The Ion Guide - Laser Ion Source (IG-LIS) (Formerly RFQ-LIS)

Ion source for isobar-suppressed rare isotope beams

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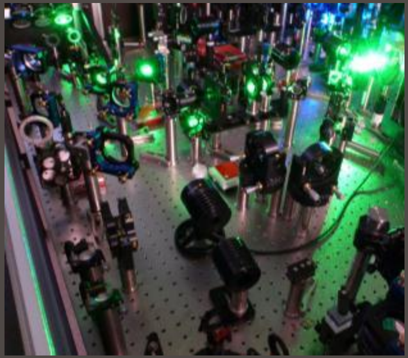
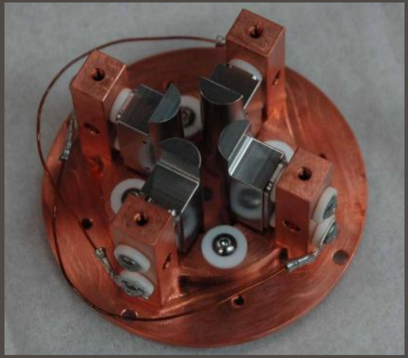
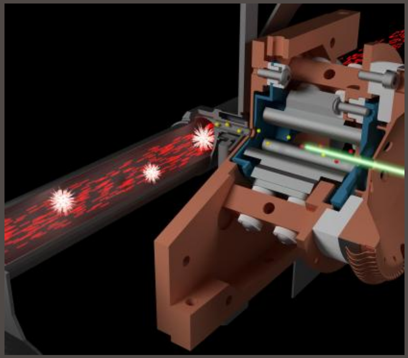
Presentation for ISAC OPS – Feb 6, 2014







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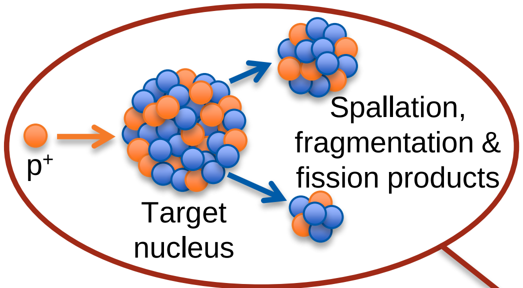
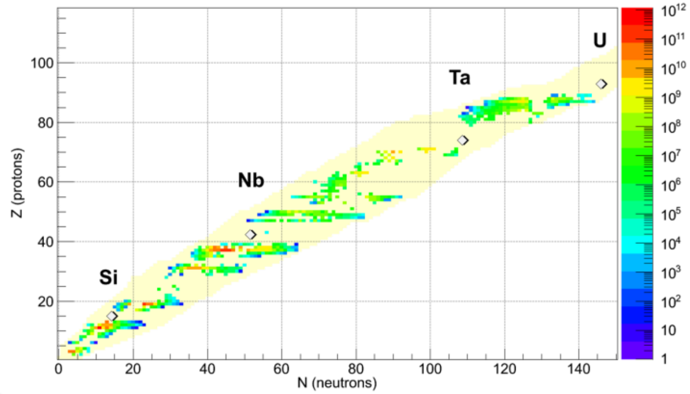
ISAC RIB production



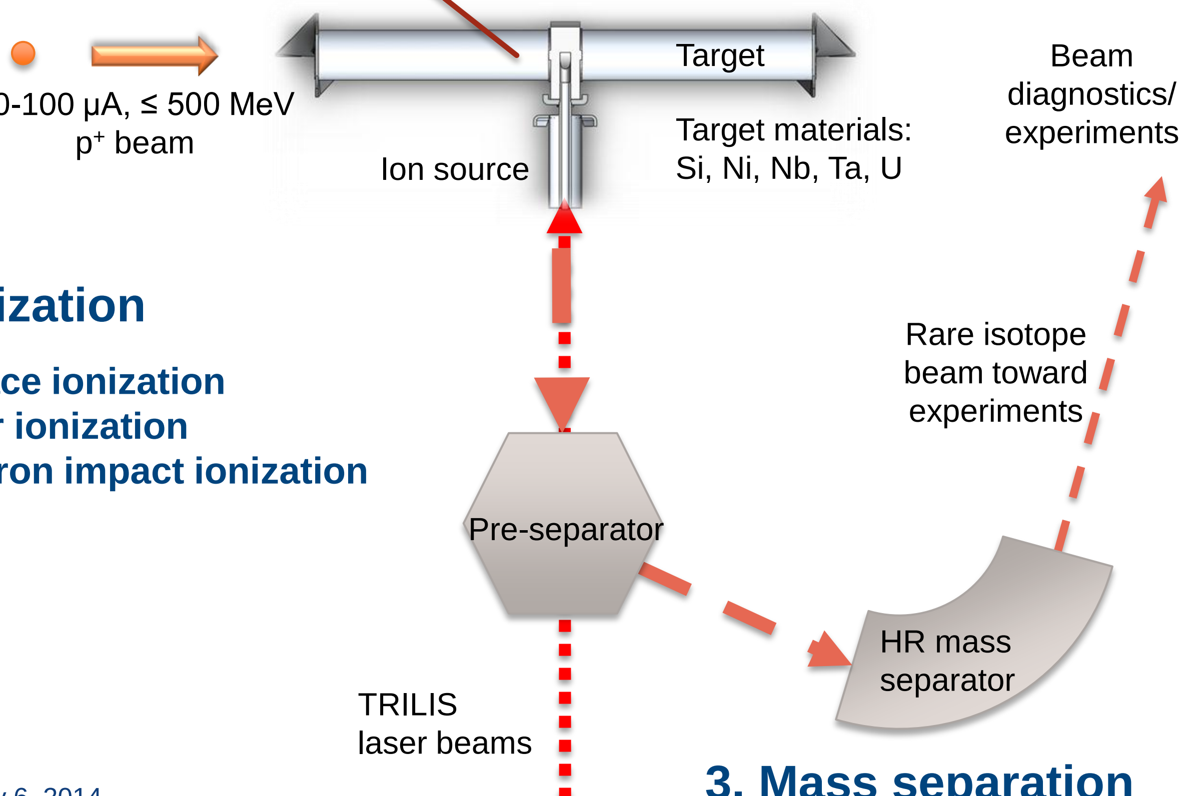
1. Isotope production



Delivered RIB

All nuclides that are

- **Produced**
- **Released from target**
- **Ionized**
- **Not filtered by magnets**



2. Ionization

- **Surface ionization**
- **Laser ionization**
- **Electron impact ionization**

How to increase RIB purity?

- **Production not very selective**
- **Magnet res. competes against beam intensity**
- ➢ **Ionization main element for selectivity increase**

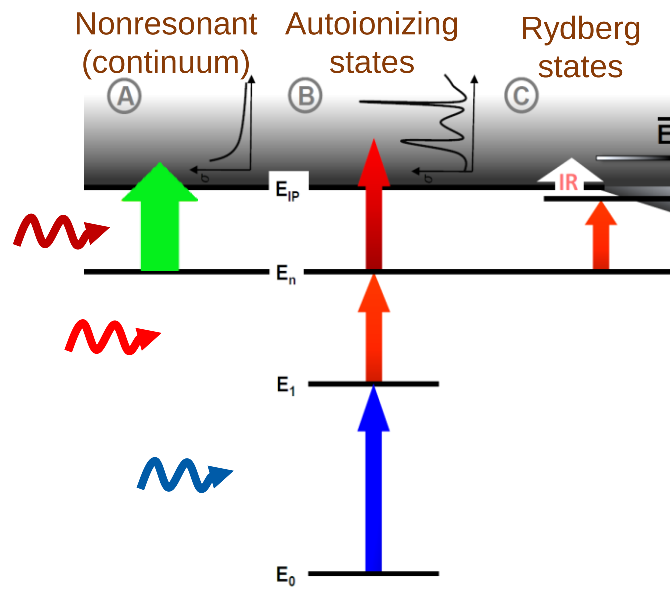
3. Mass separation

The RILIS advantage

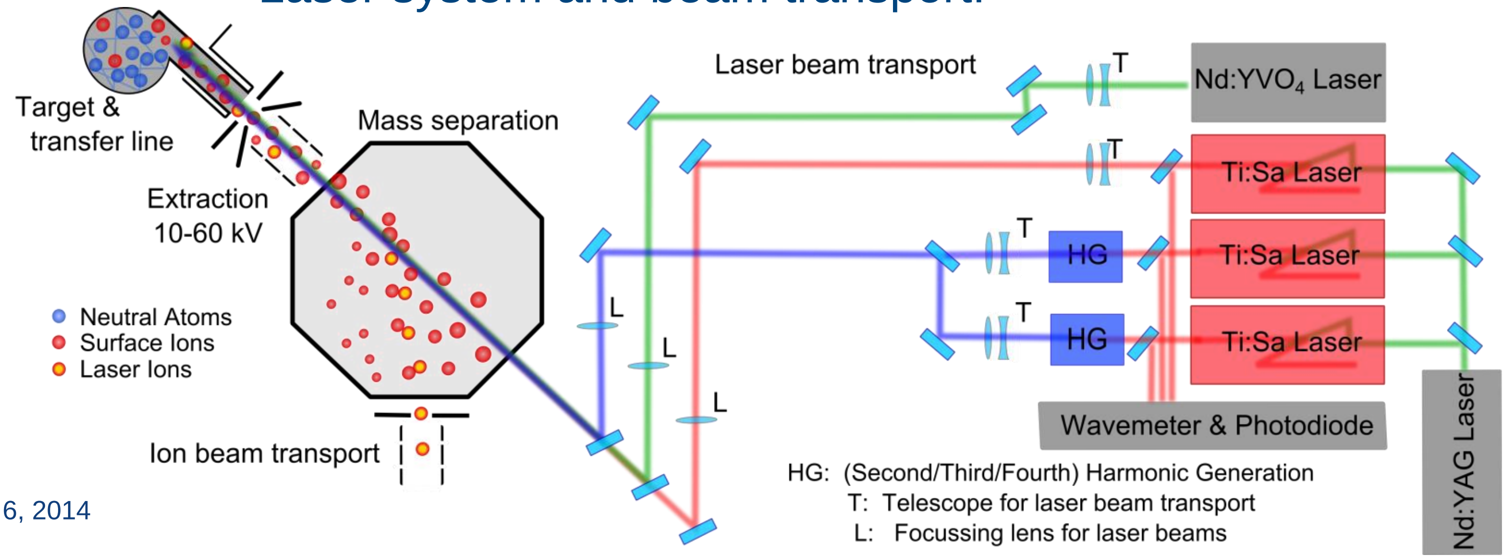
TRILIS: TRIUMF's Resonance Ionization Laser Ion Source

- Each element has its unique atomic shell structure
- Multi-step resonant excitation of an electron
  - ➢ Element-selective ionization

➢ RILIS greatly enhances the yields of all isotopes of a certain element



Laser system and beam transport:



Monoisotopic beams?

- Non-selective production of nuclides

➕

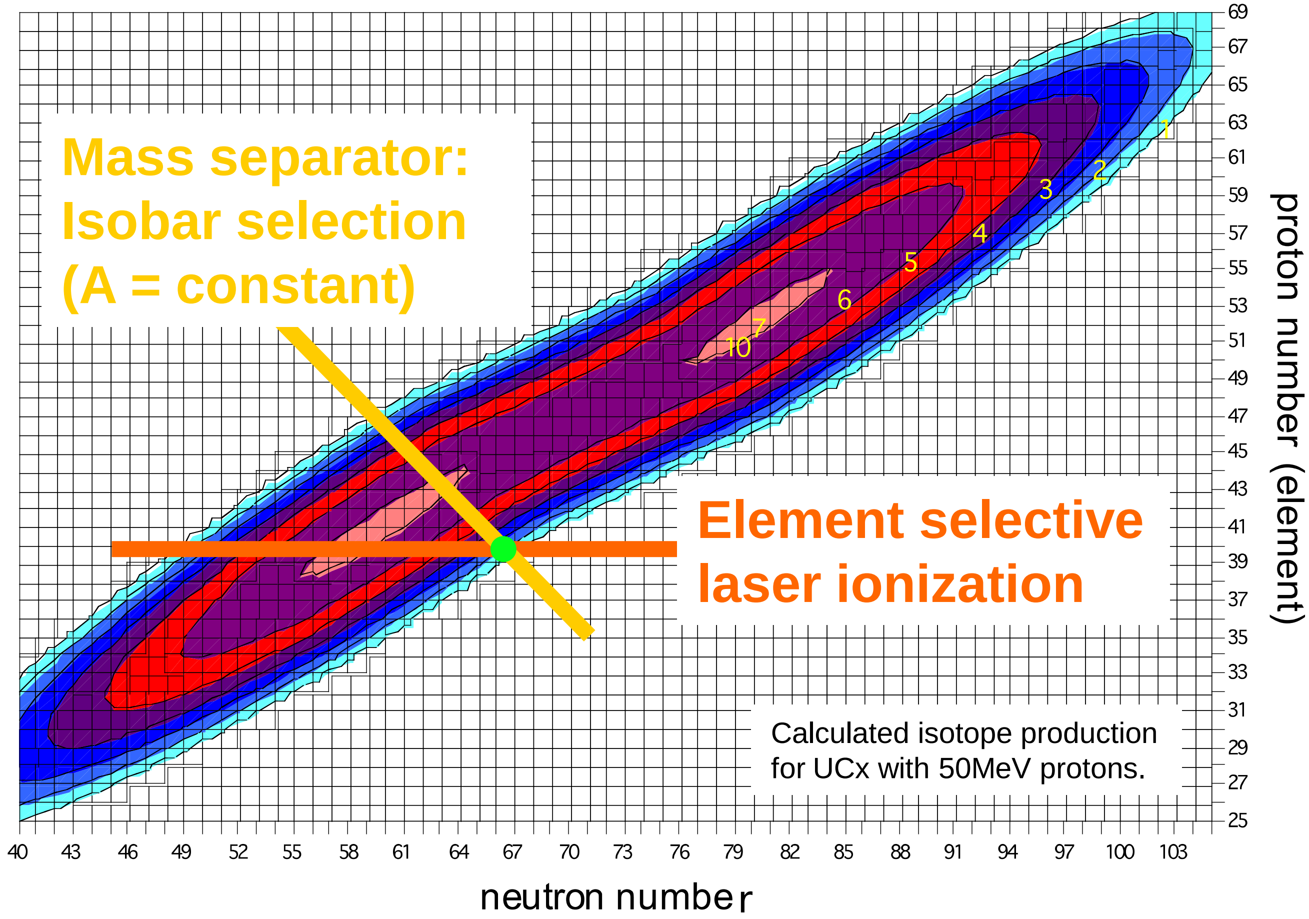
- Laser ionization of chosen element

➕

- Mass selection by separator magnets

=

Isotope selectivity

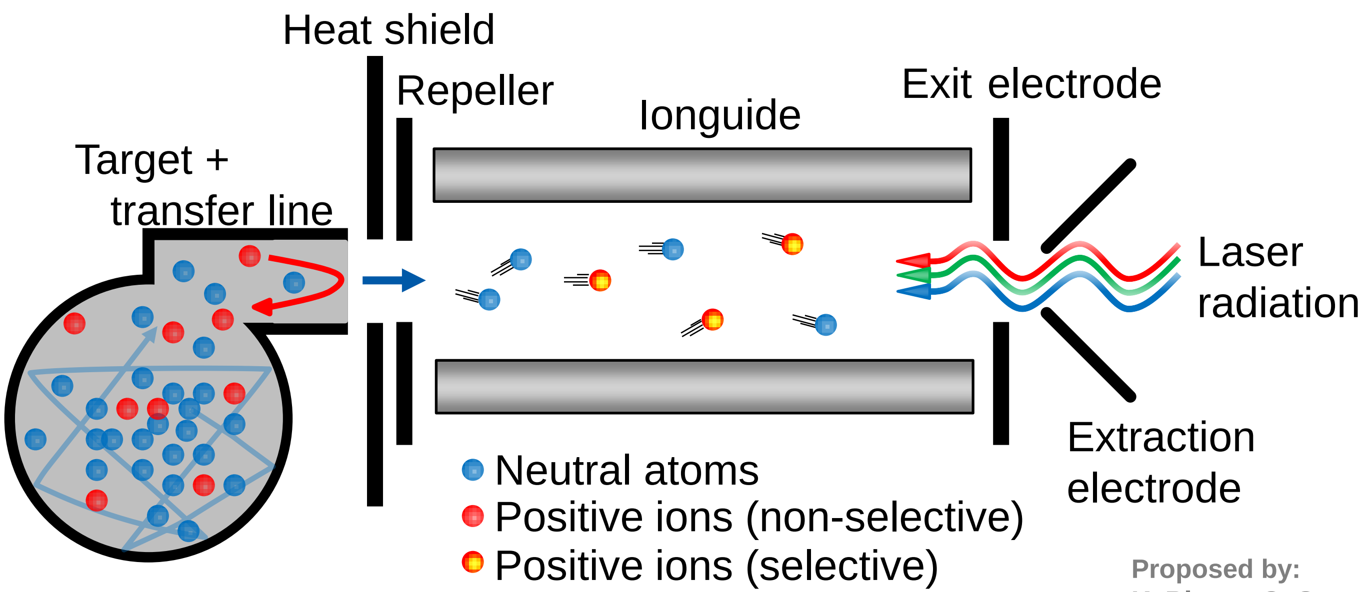


Problem:

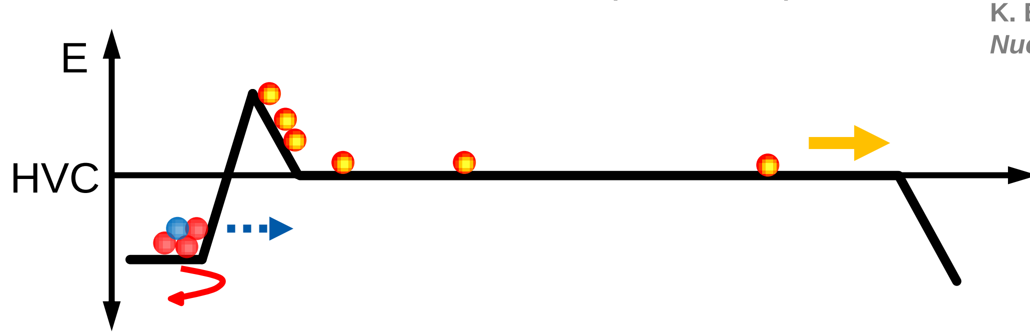
- Surface ionization from hot target usually creates isobaric contamination
- Contamination rate can exceed rate of desired isotope by orders of magnitude

Concept IG-LIS

- Suppress surface ions with electro static potential barrier
- Extract ions created by laser ionization in cold environment behind the barrier
- Ion guide to confine the diverging laser ions and guide them toward the extraction

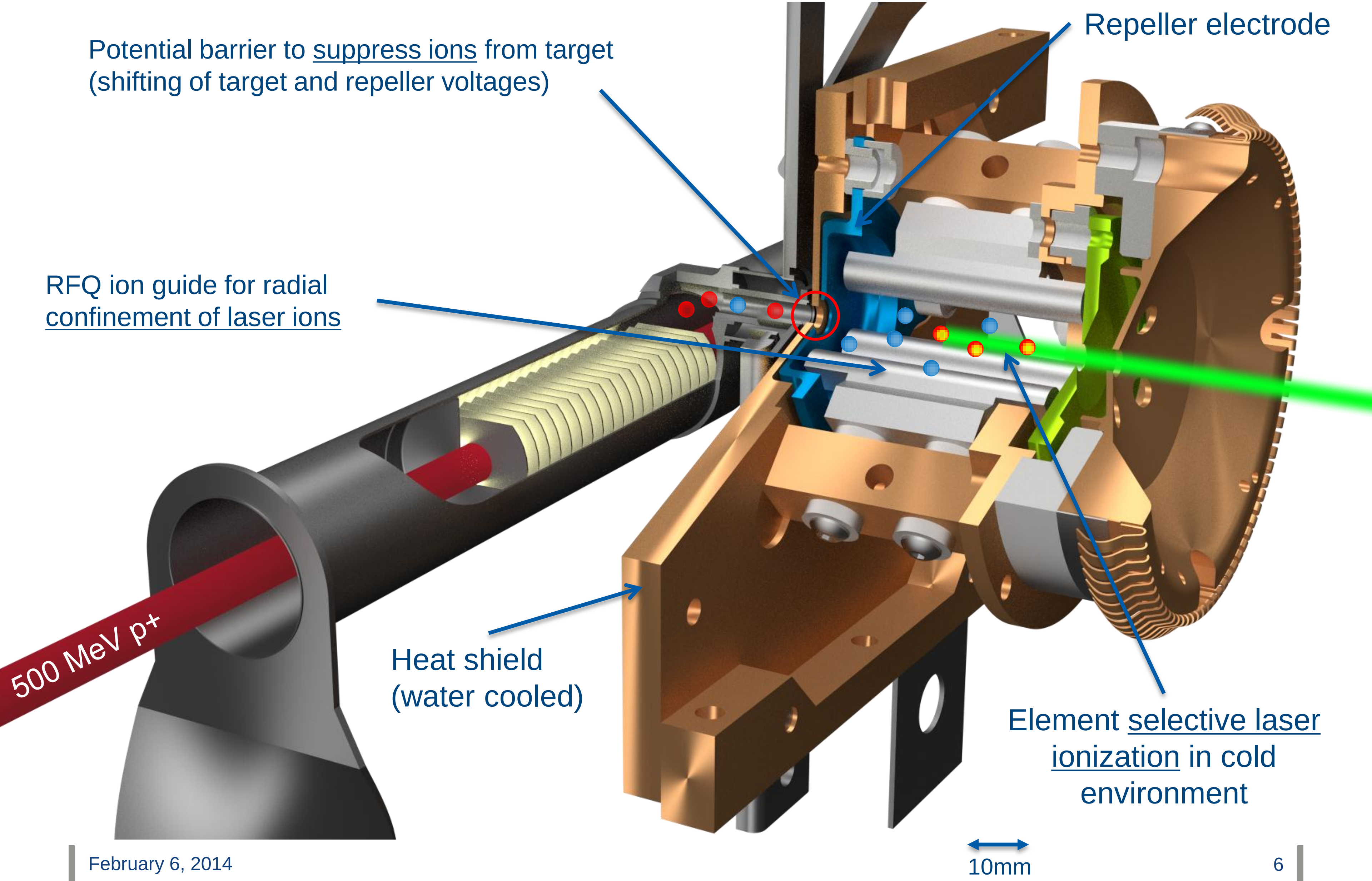


Proposed by:
K. Blaum, C. Geppert and H.-J. Kluge et al., *Nucl. Instr. Meth. Phys. Res.* B, 204, 2003

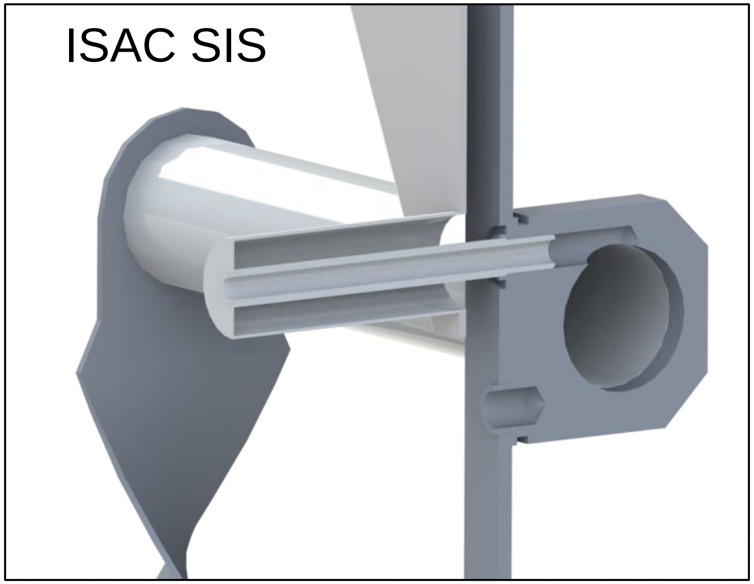


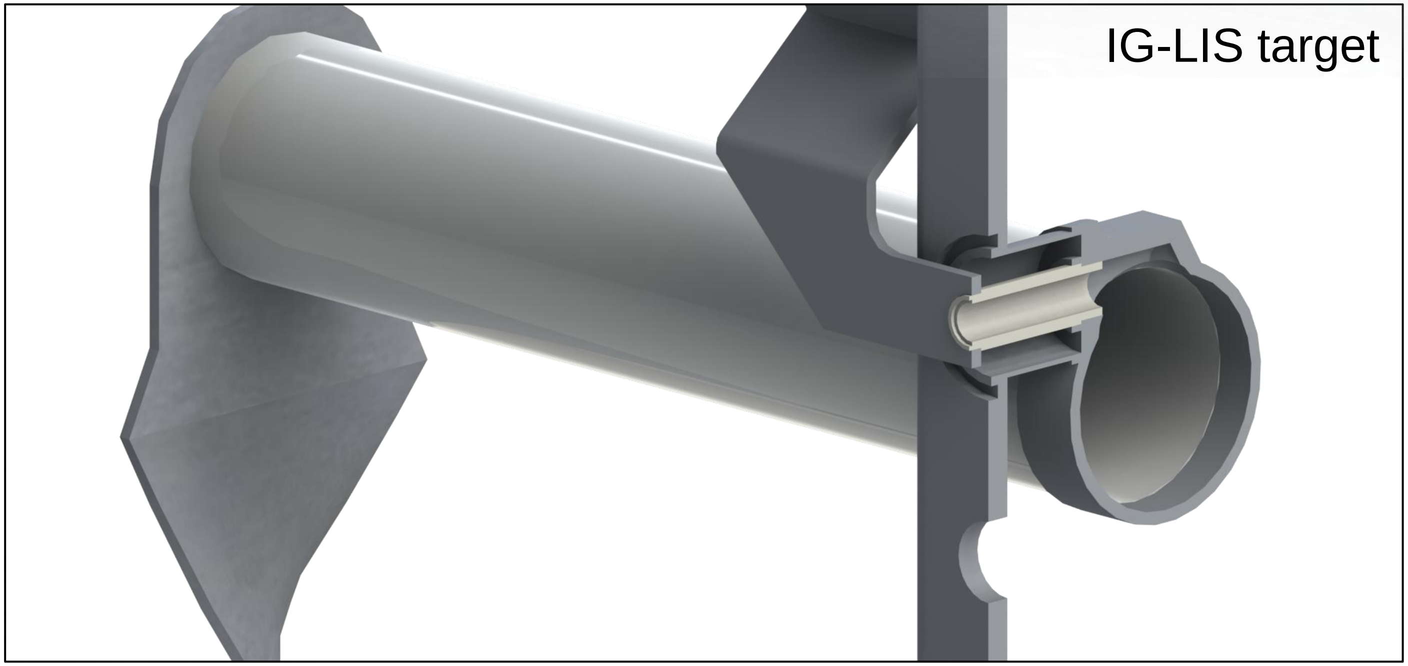
➢ Drawback: Decrease of ionization efficiency/ beam intensity

Technical realization: IG-LIS @ ISAC

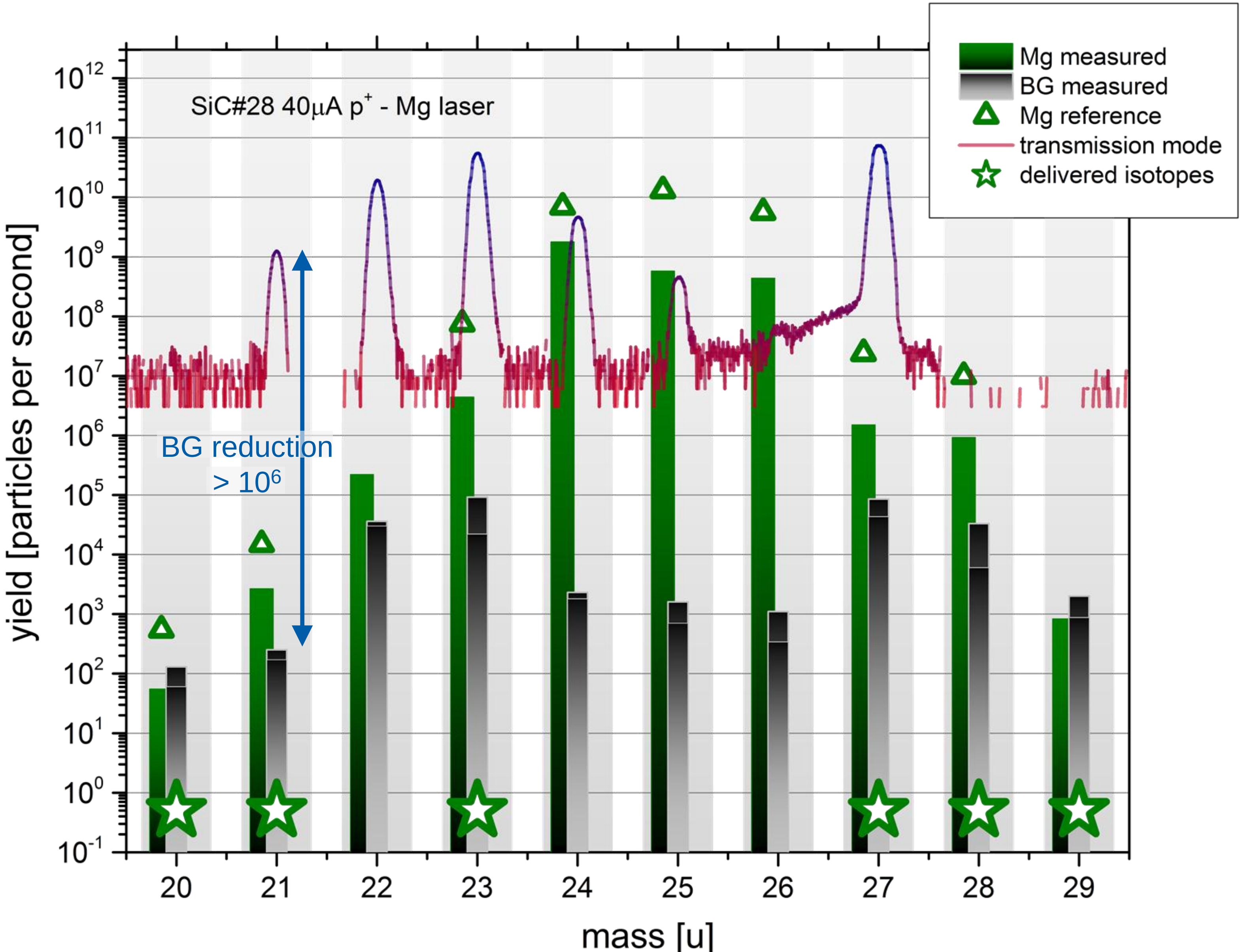


Modified target for IG-LIS operation





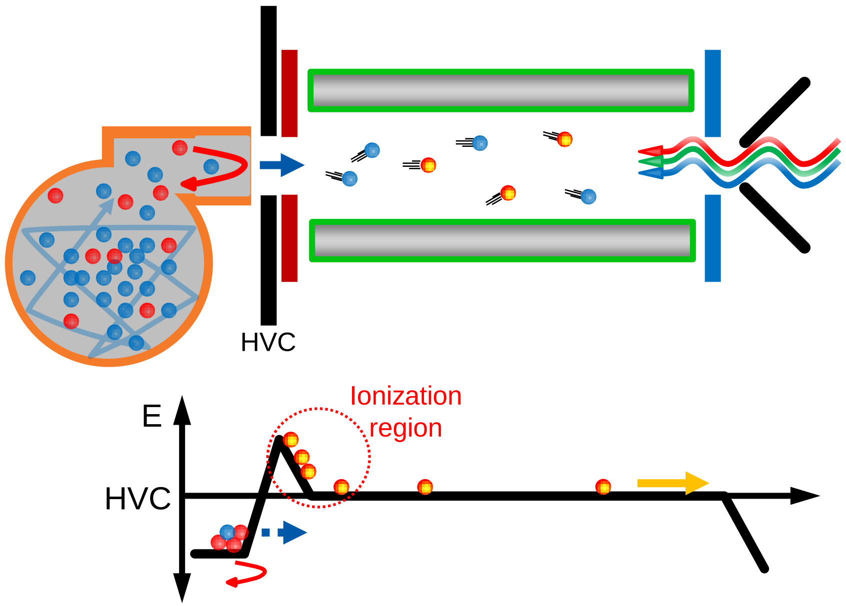
First on-line application (May 2013)



Reference: Yield DB SiC#19-LP-SIS

Operation: Ion source modes

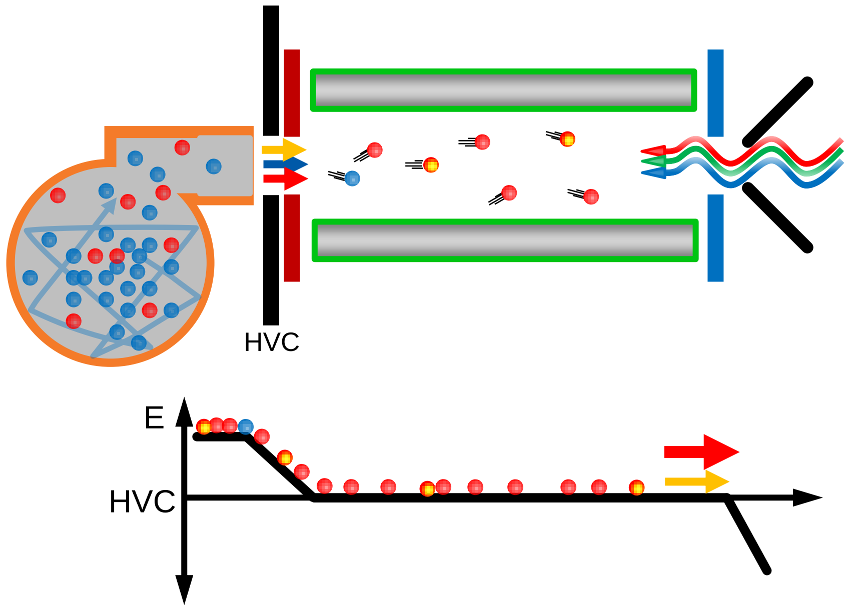
High selectivity mode (HS)



TGTBIAS	< 0V (typ. -5V to -10V)
REPL	> 0V (typ. 5V to 10V)
IONG:OFFS	< REPL (typ. 0V to 3V)
IONG:AMPL	15-70V (dep. on f_{WFG}, M_{ion})
EXIT	≤ IONG:OFFS (typ. 0V)

- High purity beams (mainly laser ions)
- Generally lower beam intensities

High transmission mode (HT)

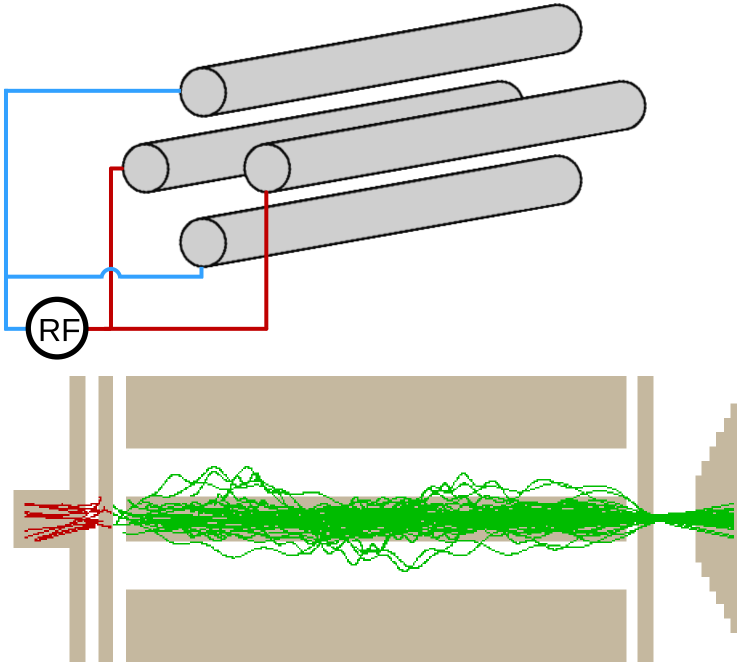


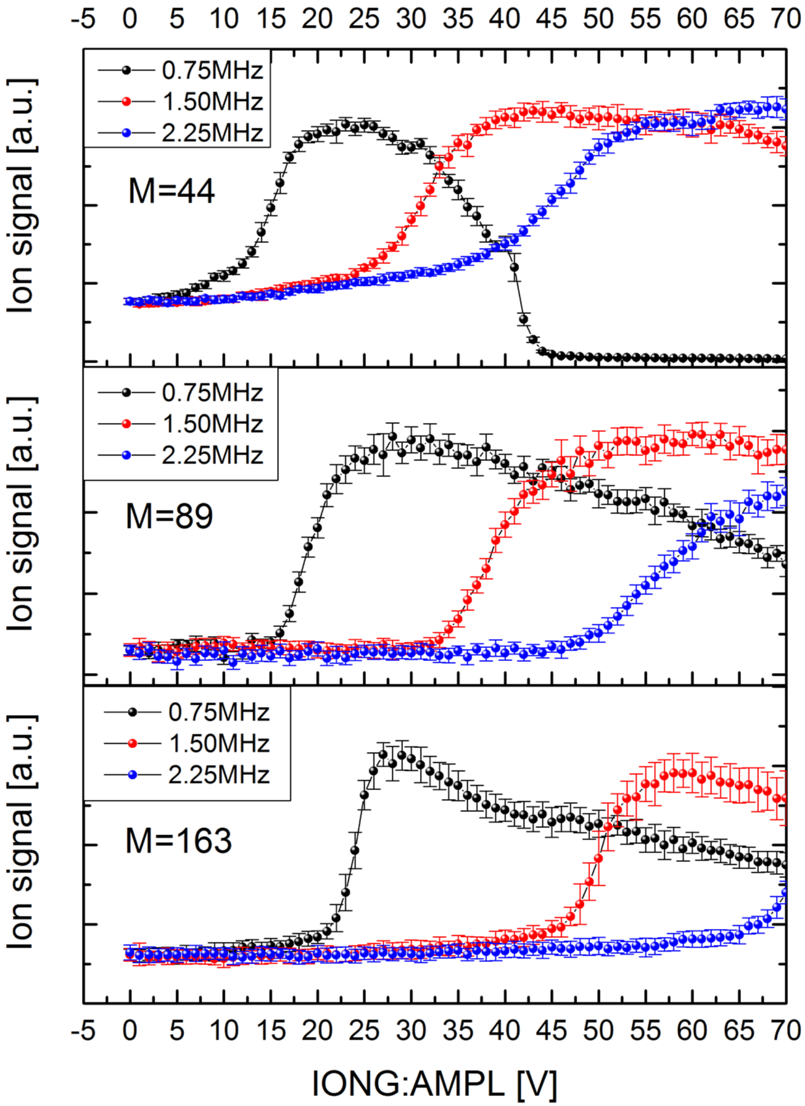
TGTBIAS	> 0V (typ. 2V to 10V)
REPL	< TGTBIAS (typ. 0V)
IONG:OFFS	≤ REPL
IONG:AMPL	15-70V (dep. on f_{WFG}, M_{ion})
EXIT	≤ IONG:OFFS

- Higher intensity beams
- Surface ions are also extracted

Operation: The ion guide

- Square wave (SW) driven RF quadrupole
- Fast switching of electric field allows overall focusing of ions
- Stability of ion trajectories depends on
  - Ion mass
  - SW amplitude (IONG:AMPL)
  - SW frequency (WFG0, typ. ~1MHz)





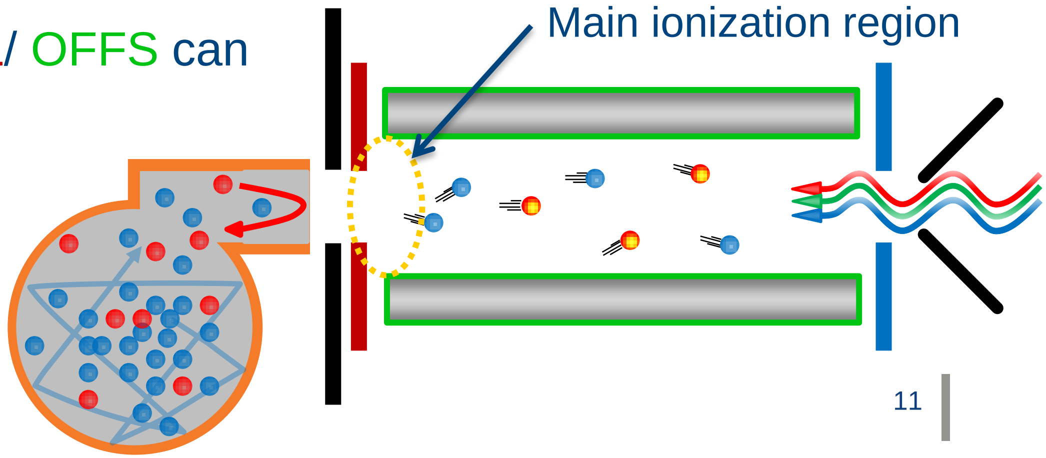
Operation: Suppression

- Source parameters:
  - TGTBIAS, REPL, IONG:OFFS
- REPL & OFFS voltages define the potential in the ionization region
  - Laser ion energy (in HS mode)
- TGTBIAS directly defines energy of ions extracted from the target (HT mode)
- Mass separator very sensitive to energy changes
  - Usually needs adjustment after changes
  - Tuning of source parameters on signal not necessarily ideal
  - CEM upstream of the mass separator could make this task easier

Extreme caution when tuning source parameters.

Rising TGTBIAS and/or lowering REPL/ OFFS can cause break through of surface ions

- Drastic signal increase (CEM!)
- Possible breach of safety report

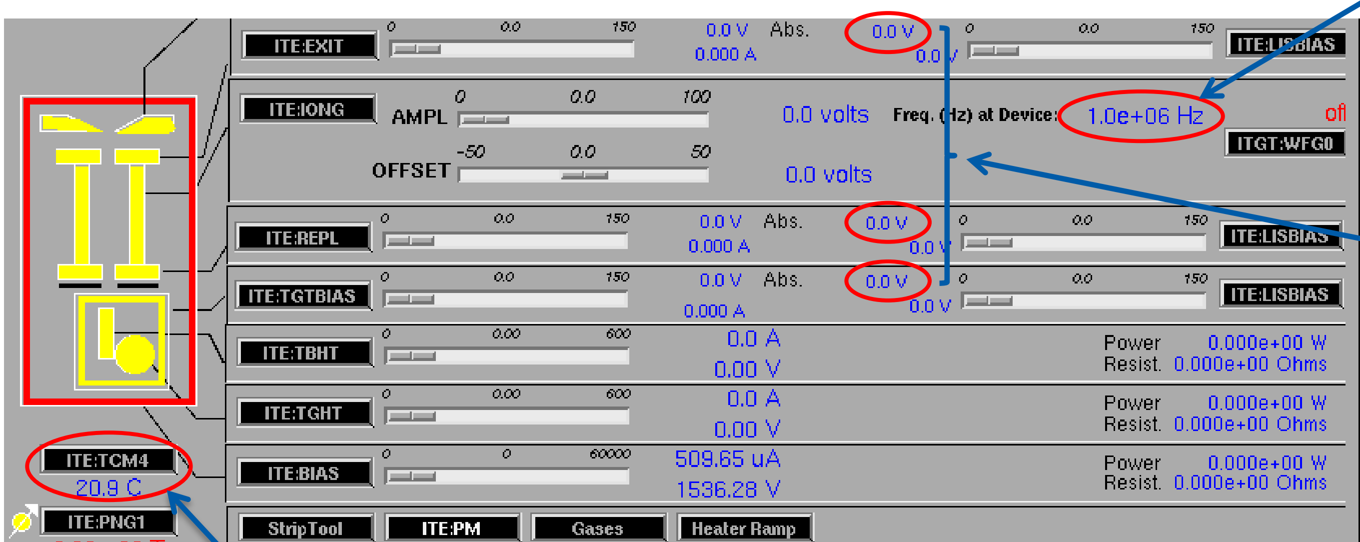


Operation: Controls

Attention:

- TGTBIAS, REPL and EXIT PSs are neg. biased by LISBIAS PS
  - V_{TGT} = TGTBIAS - LISBIAS
  - V_{REPL} = REPL - LISBIAS
  - V_{EXIT} = EXIT - LISBIAS
- Ion guide frequency = WFG0 frequency / 2

Actual frequency at ion guide (WFG0 will show 2.0e+06 Hz)



Actual voltages:
EXIT
REPL
TGTBIAS

Temperature of ion guide square wave driver electronics (!< 75ºC – proportional to IONG amplitude & frequency)

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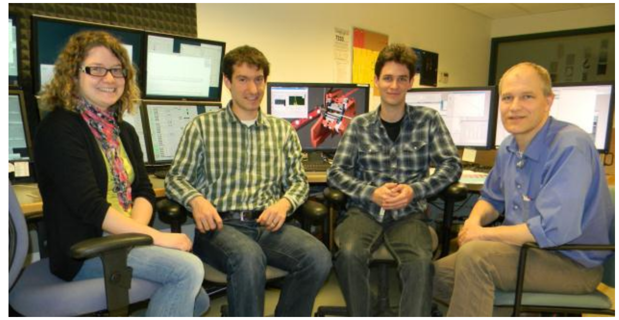
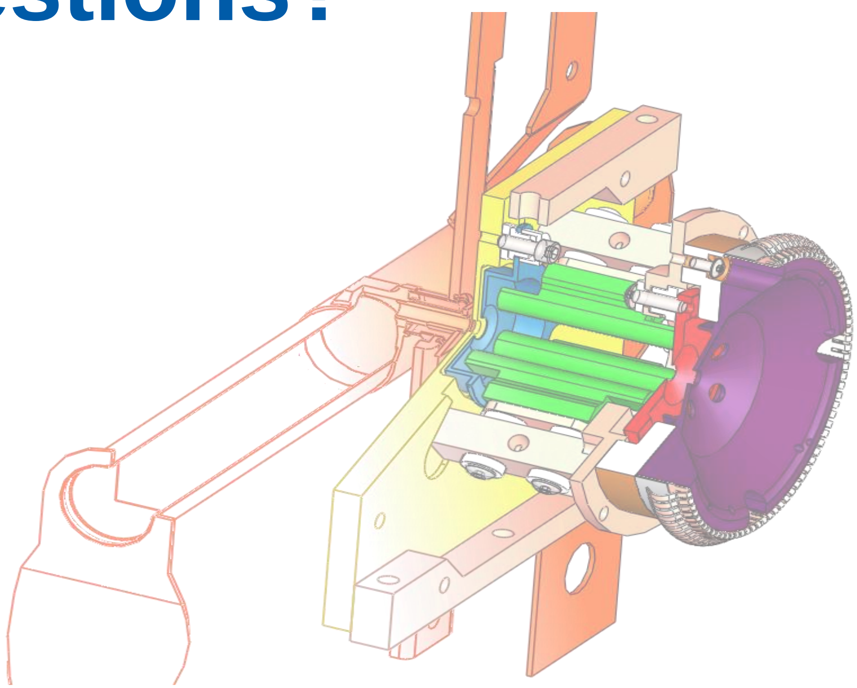
Thank You!



Questions?



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