

Nuclear Excitation via Electron Capture with TITAN

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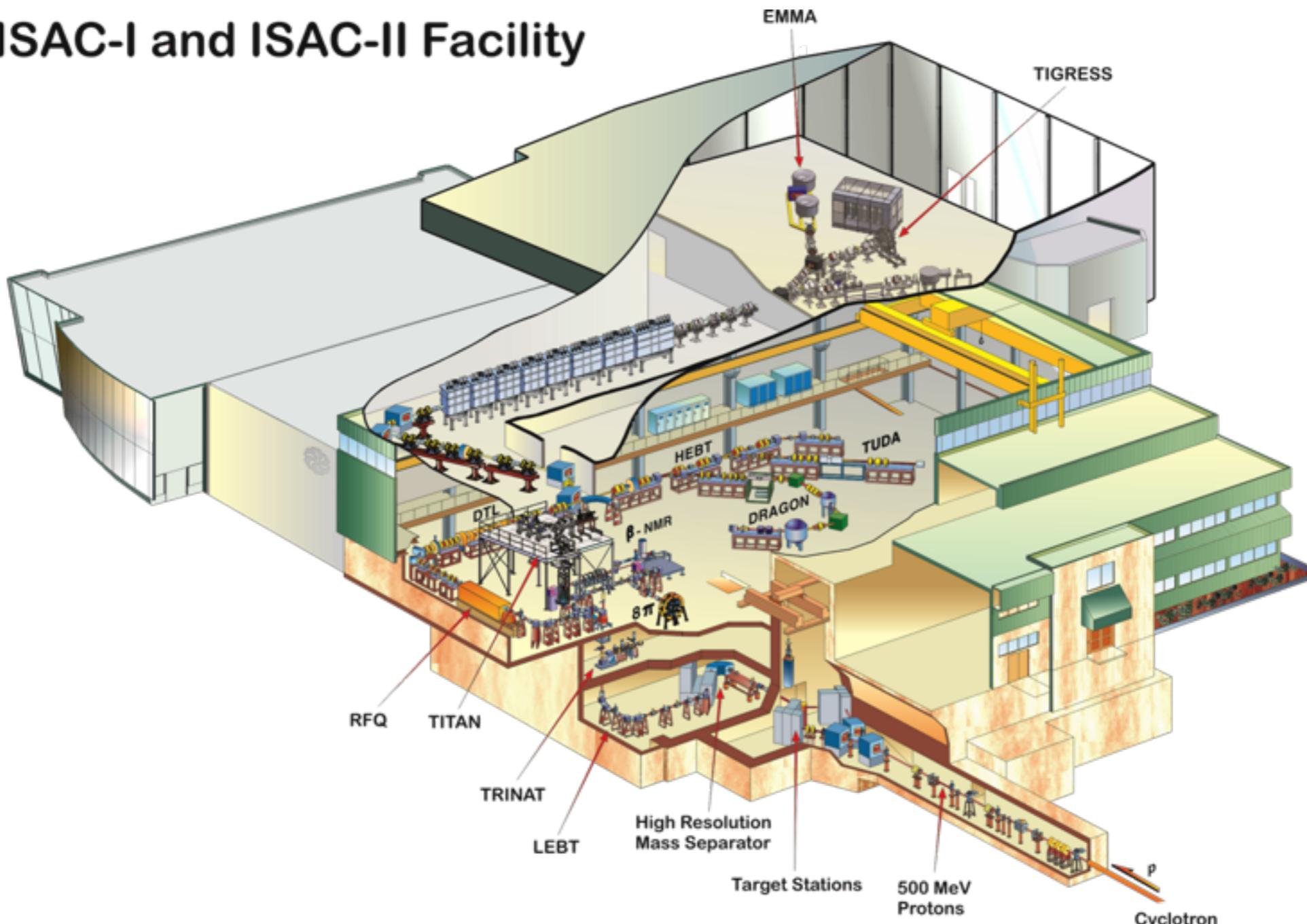
NEEC

- “In the resonant process of NEEC, a free electron is captured into a highly charged ion with the simultaneous excitation of the nucleus” [1]
- Atomic electron is captured into a vacancy of a highly charged ion causing energy to be transferred to the nucleus
- NEEC requires that the K.E. of the captured free electron plus its binding energy must equal the difference between the two nuclear states [2]. This is a resonant process.
- NEEC was recently reported for the first time in 2018 via in beam measurement at Argonne National Laboratory in ^{93}Mo [2]
- By considering unstable nuclei for NEEC, the number of suitable cases increased dramatically.

1. A. Palfy et al., Phys. Rev. Lett. **99**, 172502 (2007)
2. C. J. Chiara et al., Nature **554**, 216-218 (2018)

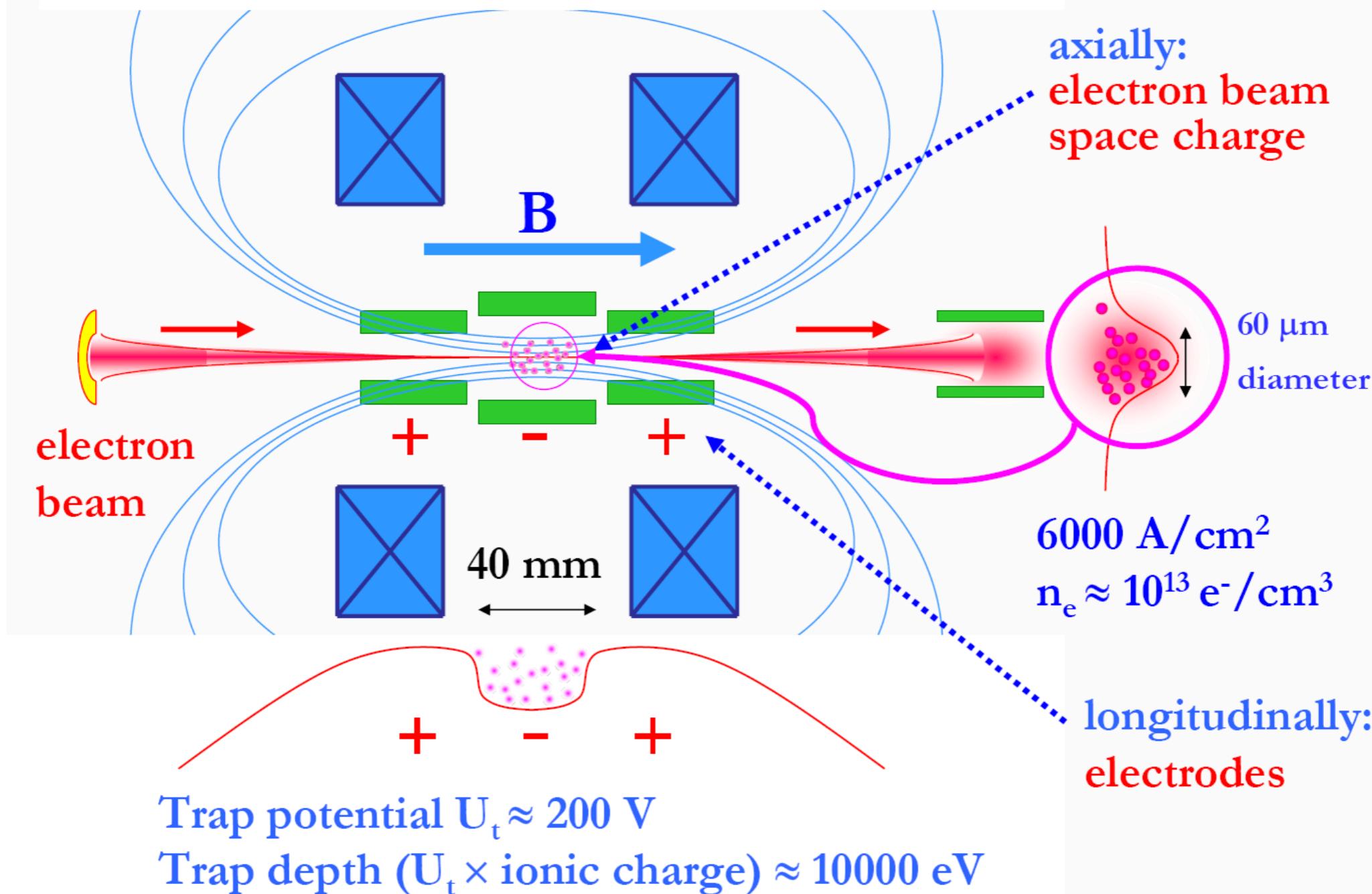
TRIUMF - ISAC beam

ISAC-I and ISAC-II Facility

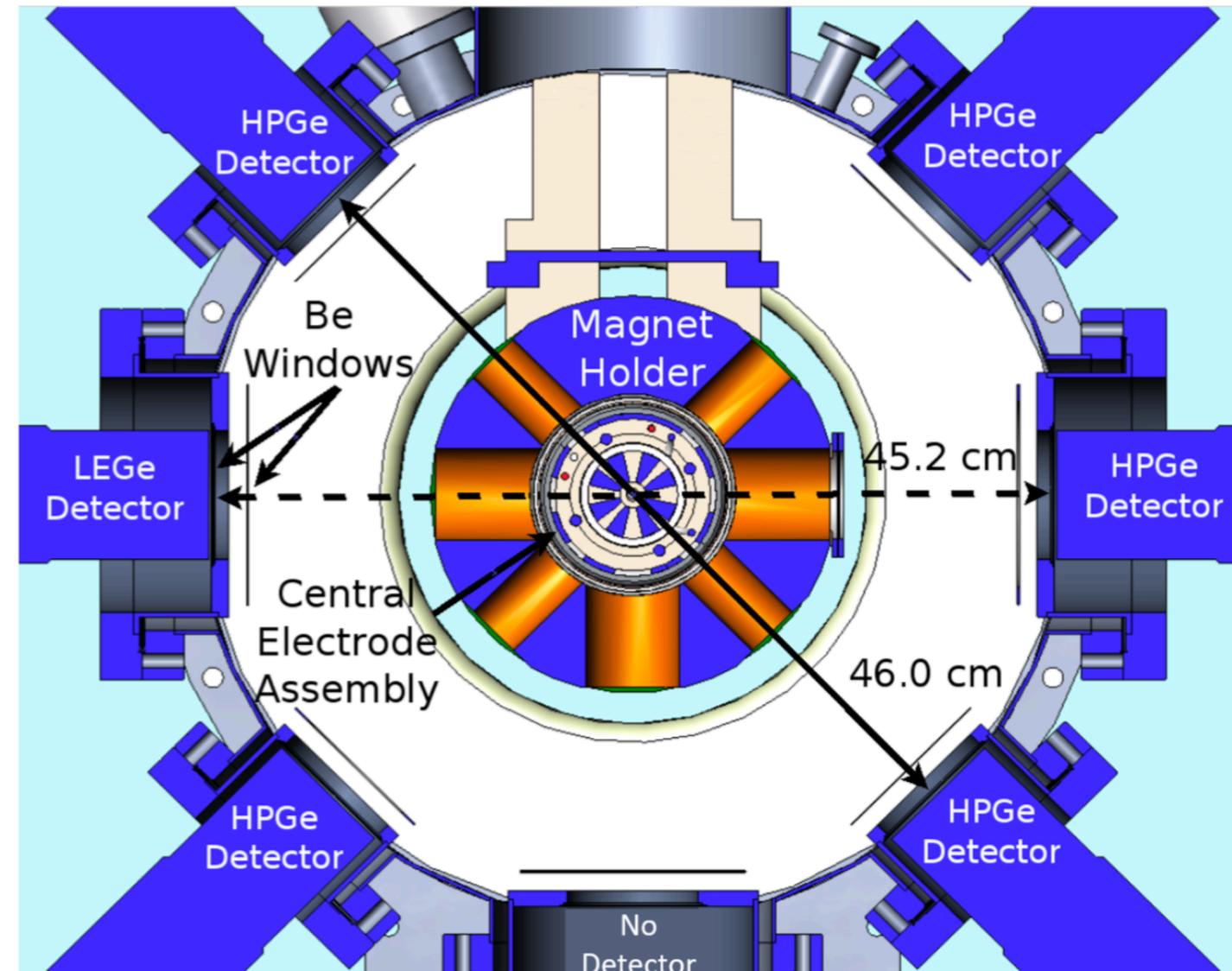
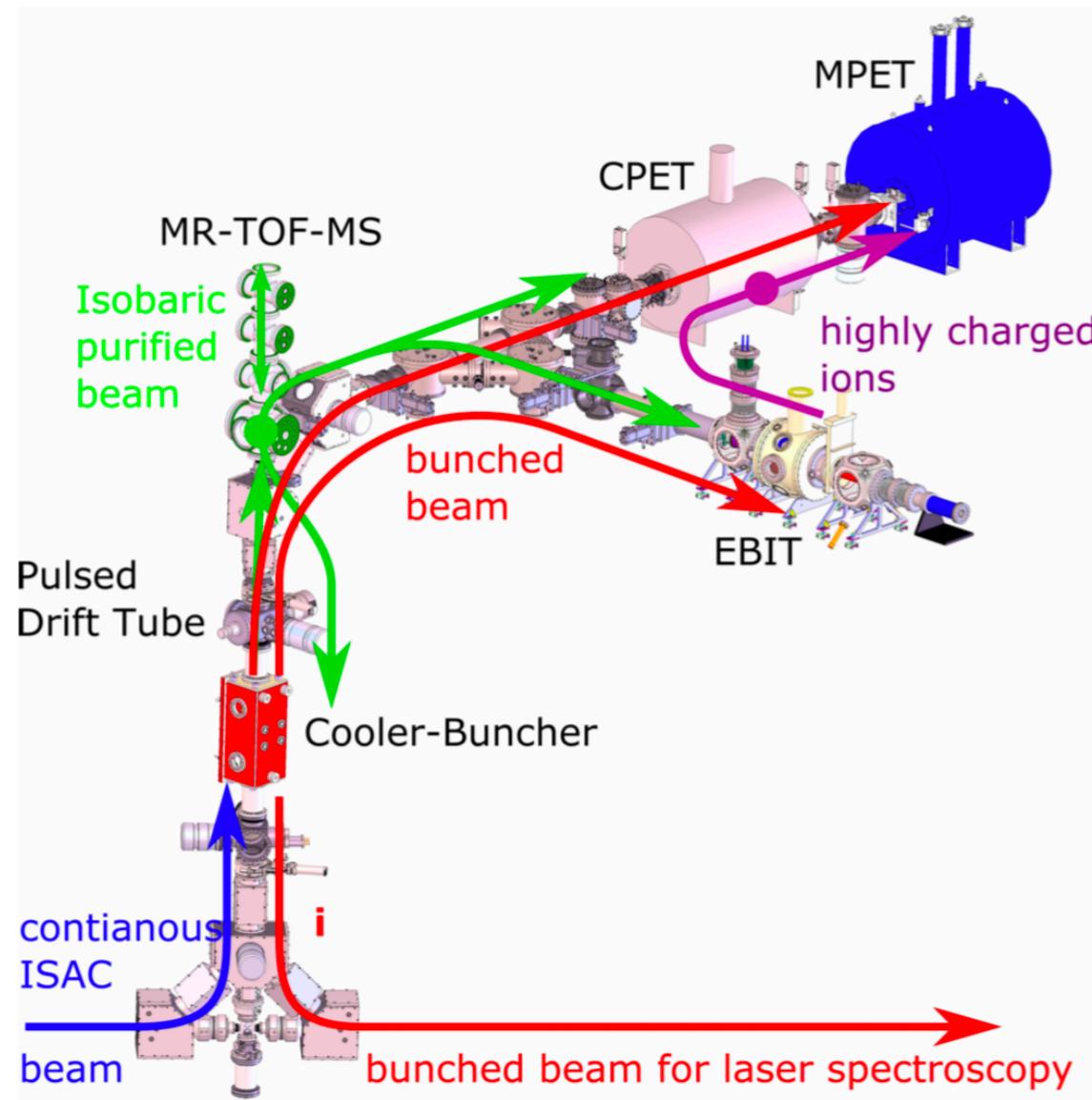


EBIT - Electron Beam Ion Trap

The trap: the electrons attract ions and ionize them more and more



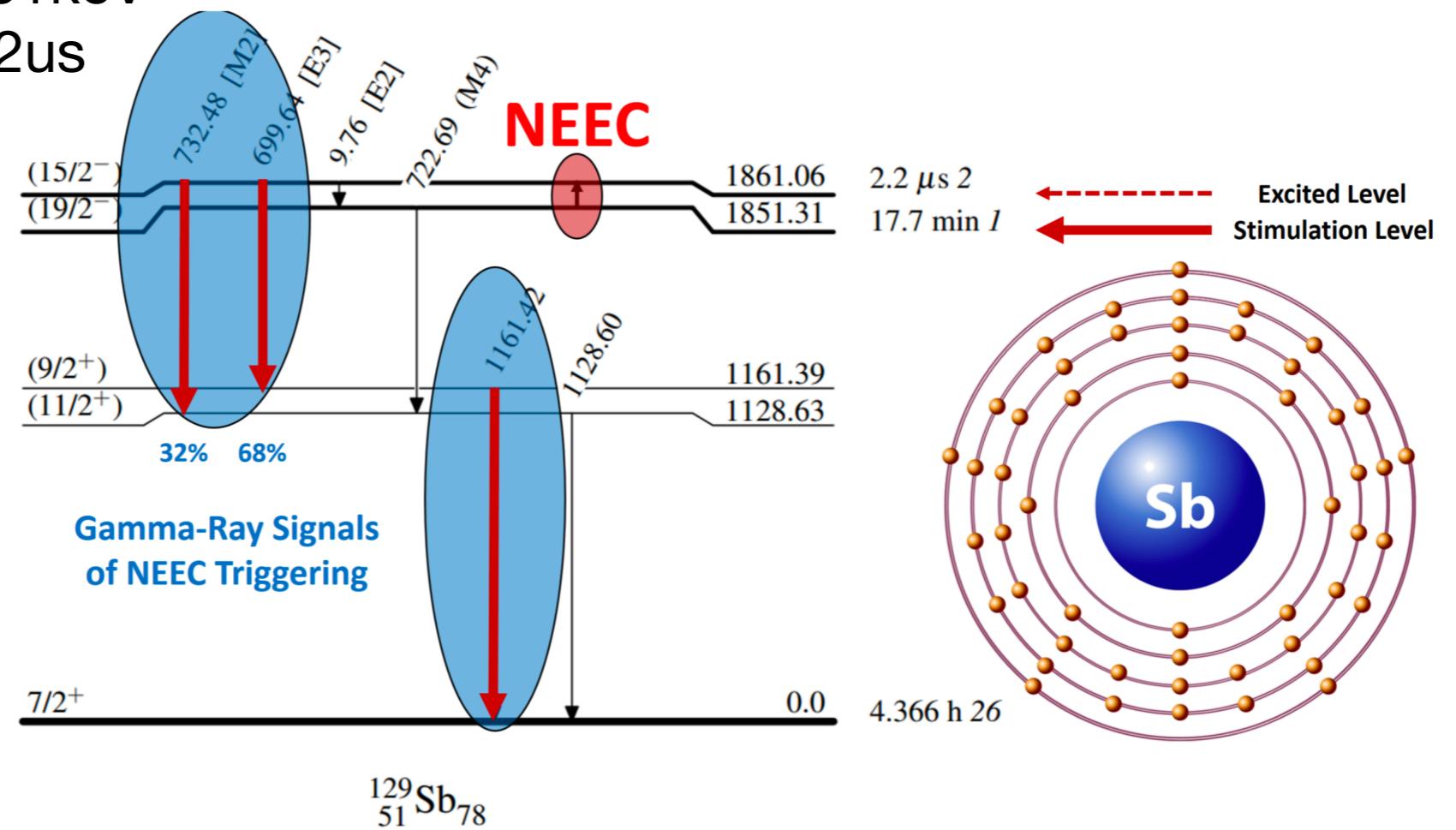
TITAN - EBIT (Electron-Beam Ion Trap)



- TITAN - TRIUMF's Ion Trap for Atomic and Nuclear Science
- 7 access ports to house 5 HPGe's & 1 ULE-HPGe detector
- Geometric acceptance is ~ 2% of 4π

NEEC of ^{129}Sb

- Candidate : ^{129}Sb (Antimony)
- NEEC : $1851.31\text{keV} \rightarrow 1861.06\text{keV}$
- Gamma's : 699keV & 1161keV
- Half-life : $\sim 17.7\text{min} \rightarrow 2.2\mu\text{s}$
- Energy diff : 9.7keV



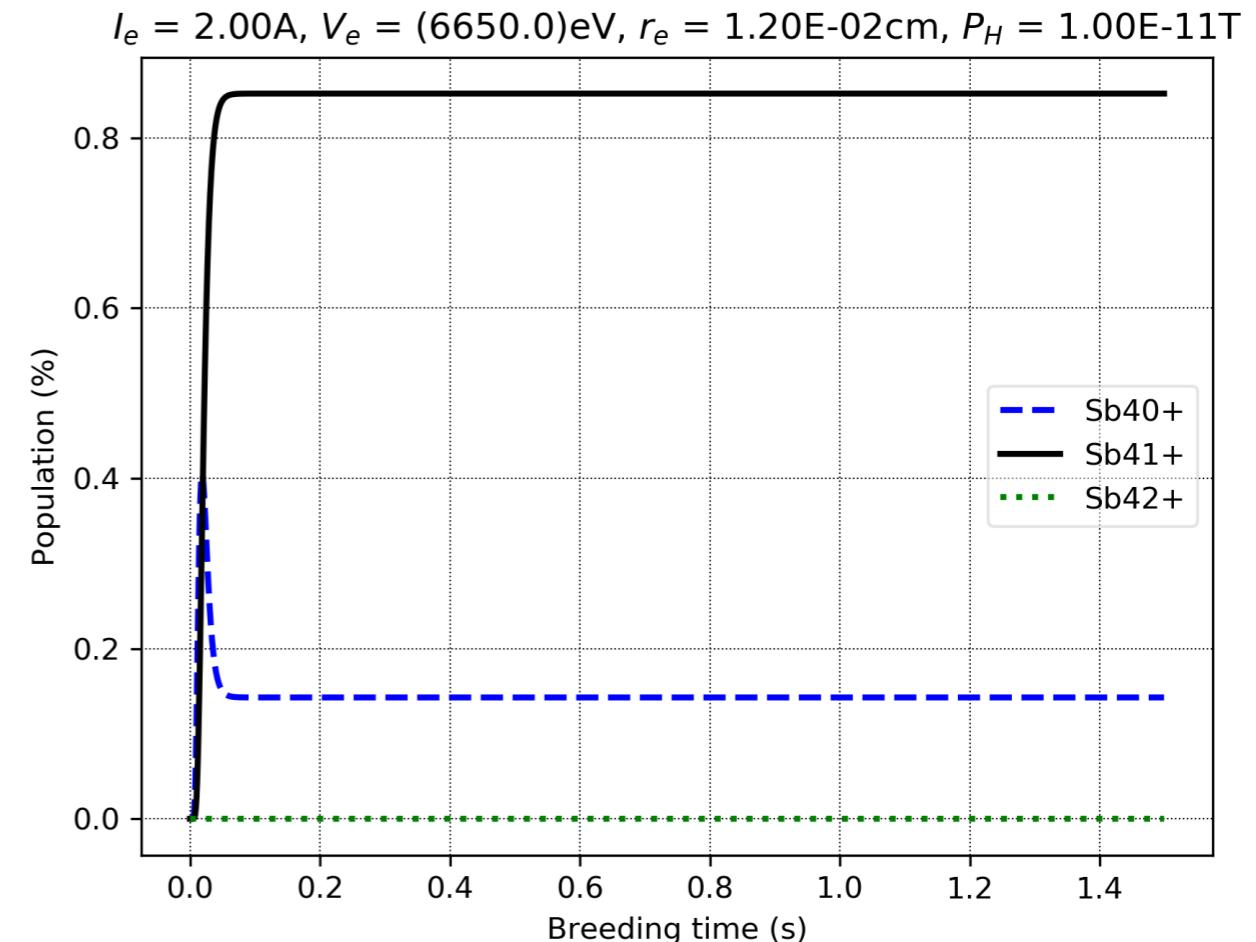
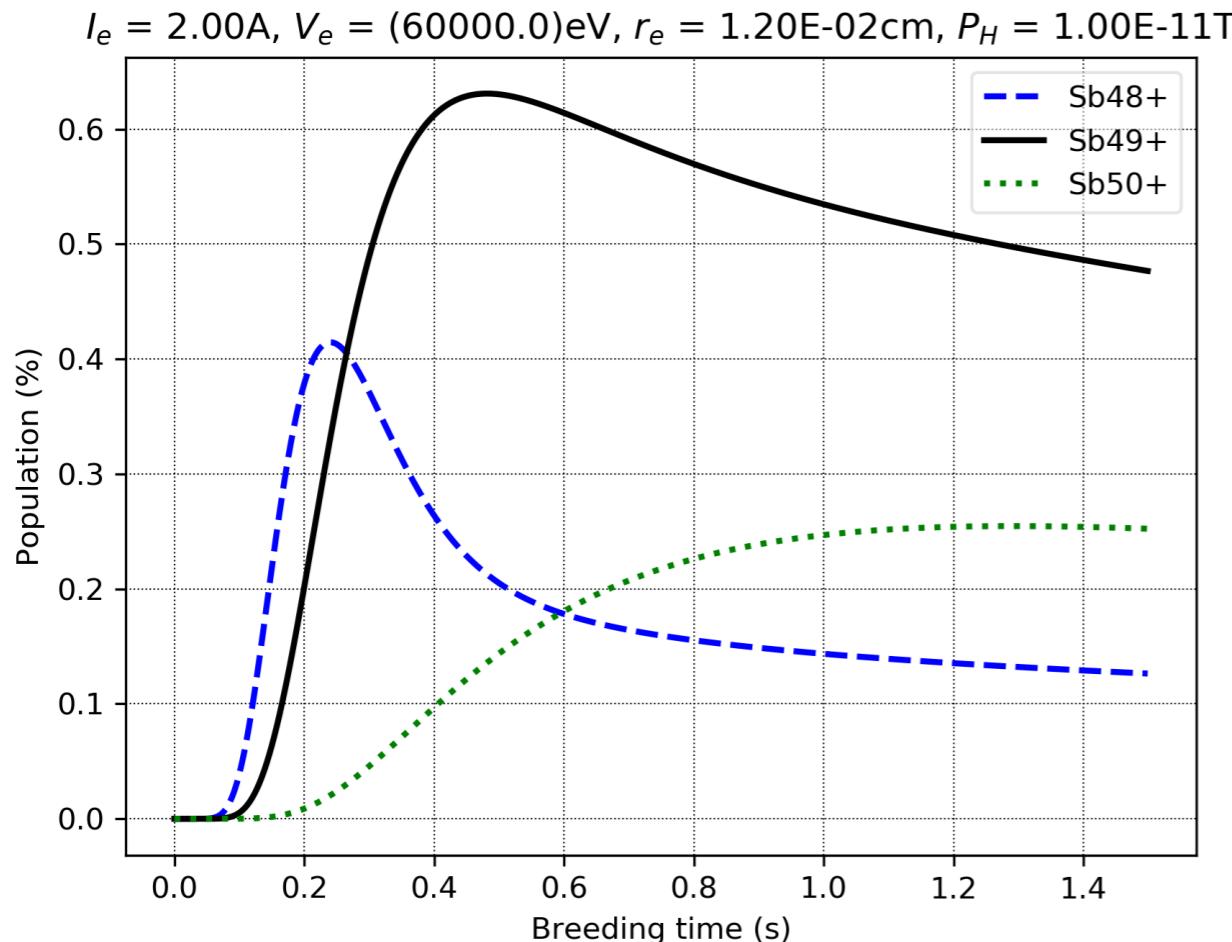
He-like case : L-shell atomic vacancy - Recombination x-section : $1.6 \times 10^{-3} b \cdot eV$

Ne-like case : M-shell atomic vacancy - Recombination x-section : $3.0 \times 10^{-5} b \cdot eV$

- A. Palfy, Private Communication (2018)
- K G. Leach et al., TRIUMF EEC Lett. of Intent 1865 (2019)

Charge Breeding Simulations

Antimony - 129Sb



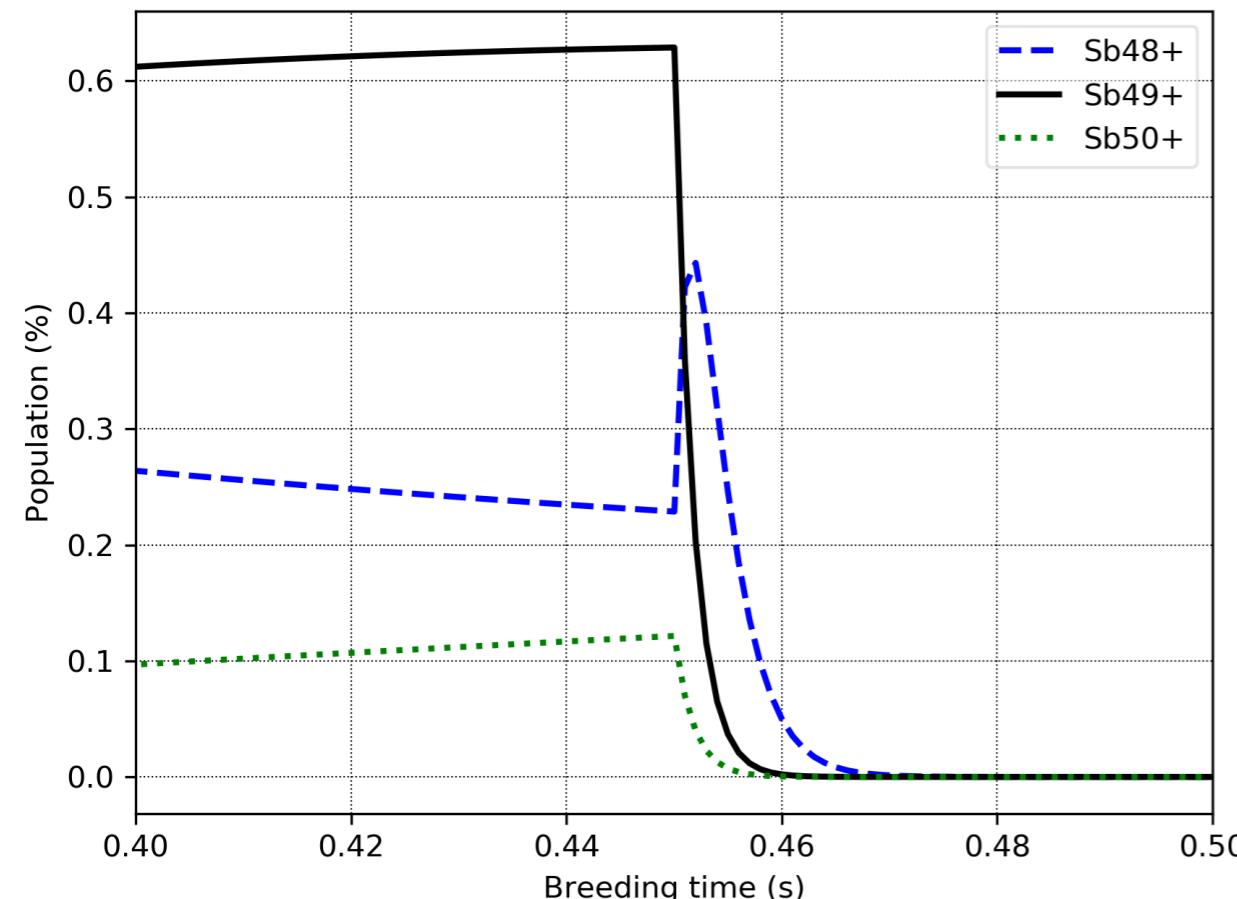
Charge breeding for the He-like (left) and Ne-like (right) cases

<https://github.com/mineselectroweakgroup/ebitsim>

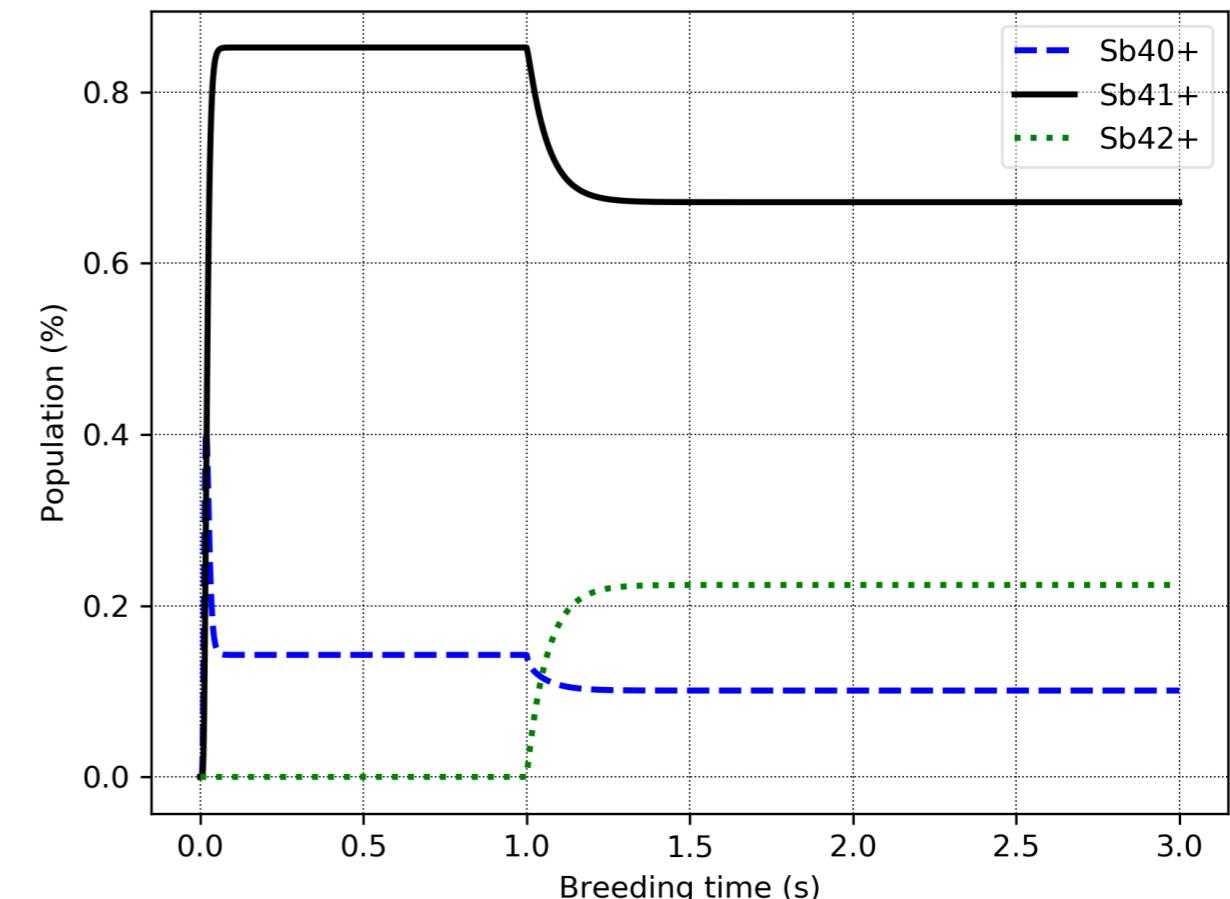
Simulation of charge breeding w/ ebeam ramping

Antimony - 129Sb

$I_e = 2.00A, V_e = (60000.0 \rightarrow 1000.0)eV, r_e = 1.20E-02cm, P_H = 1.00E-11T$



$I_e = 2.00A, V_e = (6650.0 \rightarrow 6800.0)eV, r_e = 1.20E-02cm, P_H = 1.00E-11T$



He-like (left) - Ne-like (right)

Conclusions

- In the TITAN EBIT we have been able to perform decay measurements of highly charged ions
- This setup is ideally suited to perform controlled measurements of the NEEC process on a wide variety of stable and unstable cases
- New HPGe's must be installed on TITAN
 - In addition to the ULE-HPGe already installed 5 HPGe's will be installed in order to achieve our desired 2% of 4pi
- New Multi-Channel Analyzer (MCA) must be installed
 - A new 16 channel MCA will be installed to facilitate data acquisition from the 5 HPGe's
- Upgrades to the electron beam to reach higher currents
 - With the new electron gun currents of 2Amps should be achievable
- Need to determine the best way to quickly ramp the electron beam between energy levels
- Run the experiment and take data!!

Acknowledgements

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TITAN collaboration



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