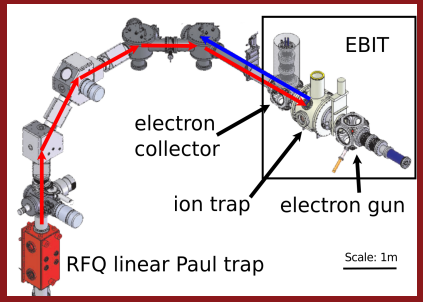
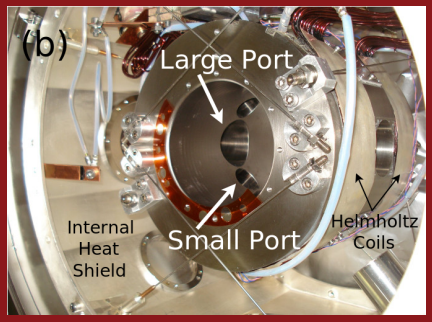
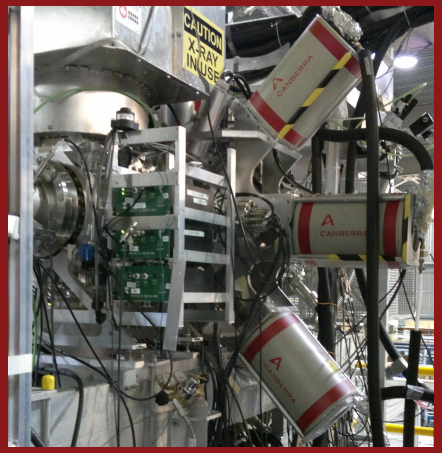
TRIUMF

Canada's National Laboratory for Particle and Nuclear Physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

Low-Background In-Trap Decay Spectroscopy with TITAN at TRIUMF

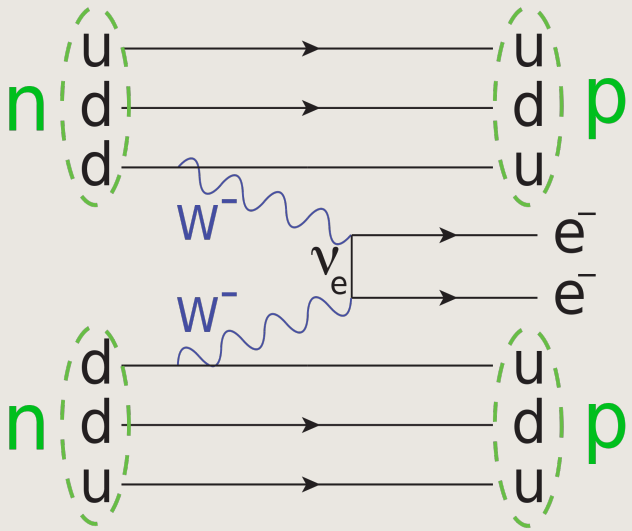


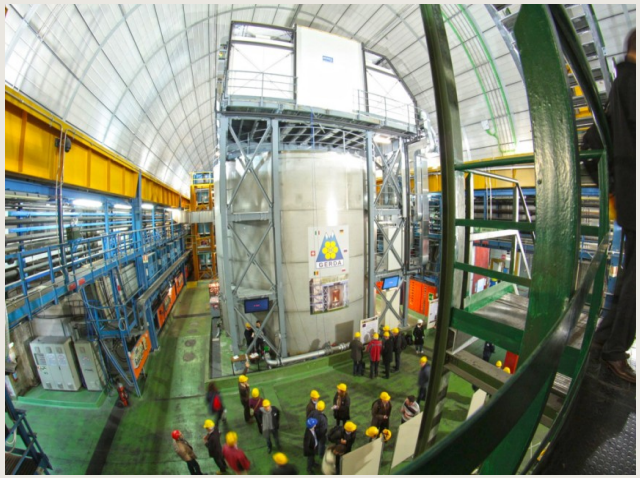




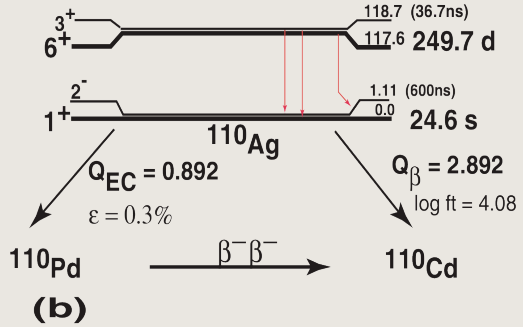
Kyle G. Leach | TITAN | **TRIUMF, SFU**

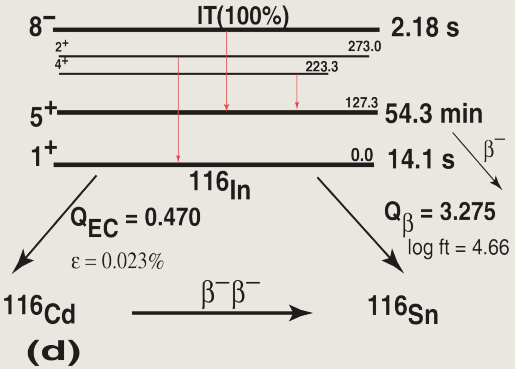
Neutrinoless ββ Decay





GERDA

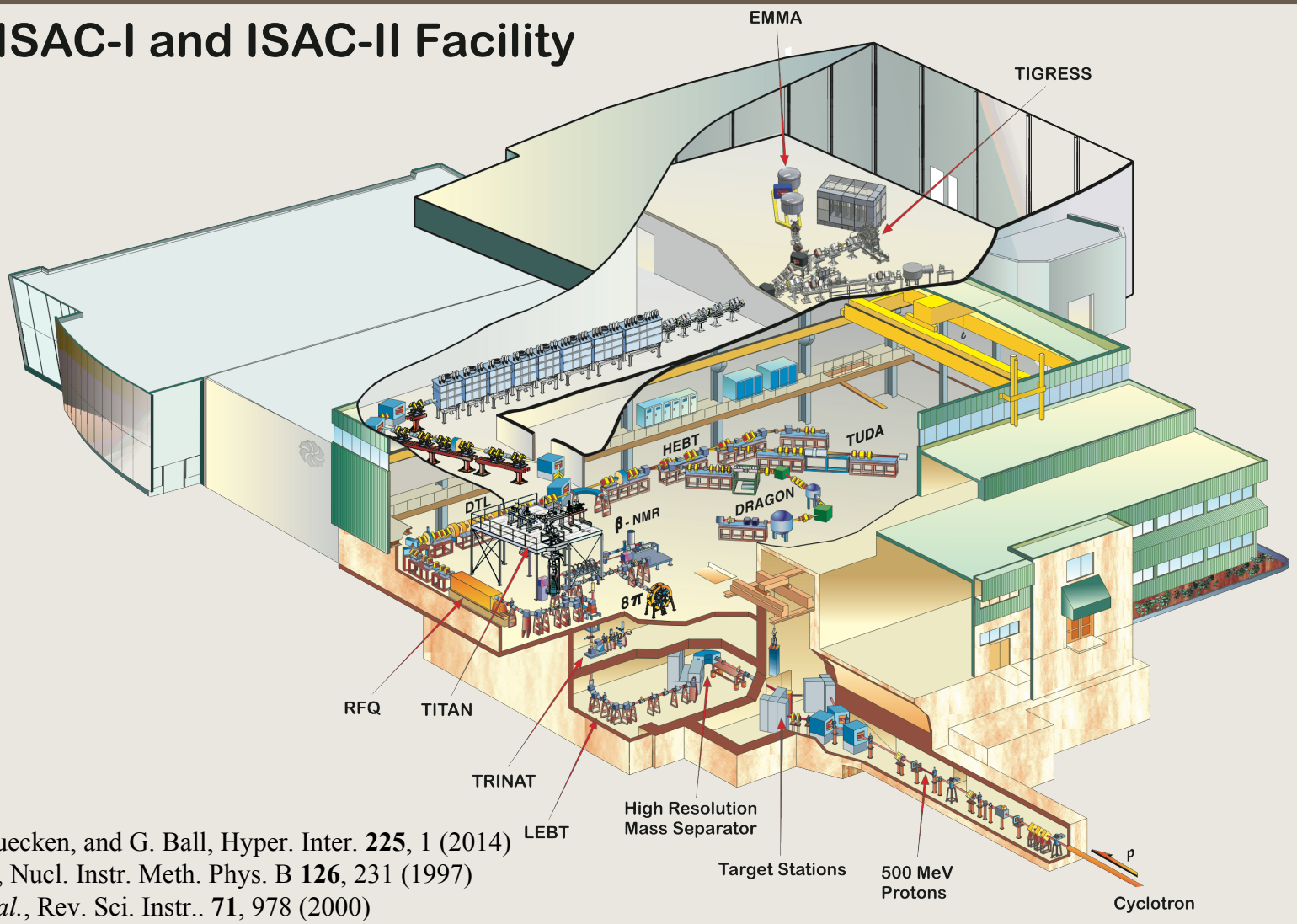




$$\left(T^{0\nu}_{1/2}\right)^{-1} = G^{0\nu}\left(Q_{\beta\beta}, Z\right)\left(M_{0\nu}\right)^2 m^2_{\beta\beta}$$

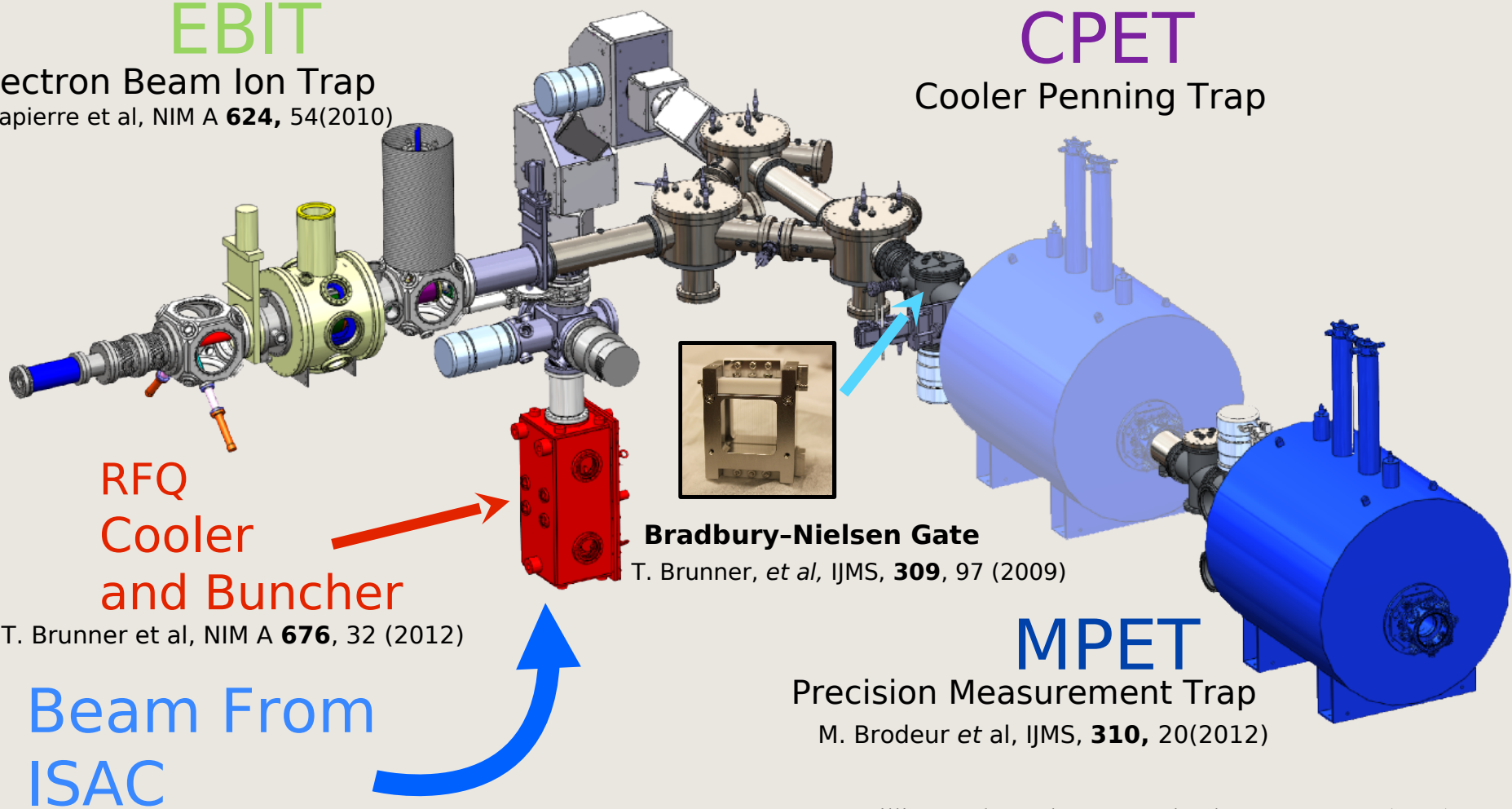
D. Frekers, J. Dilling, and I. Tanihata, Can. J. Phys. **85**, 57 (2007)

The TRIUMF-ISAC Facility



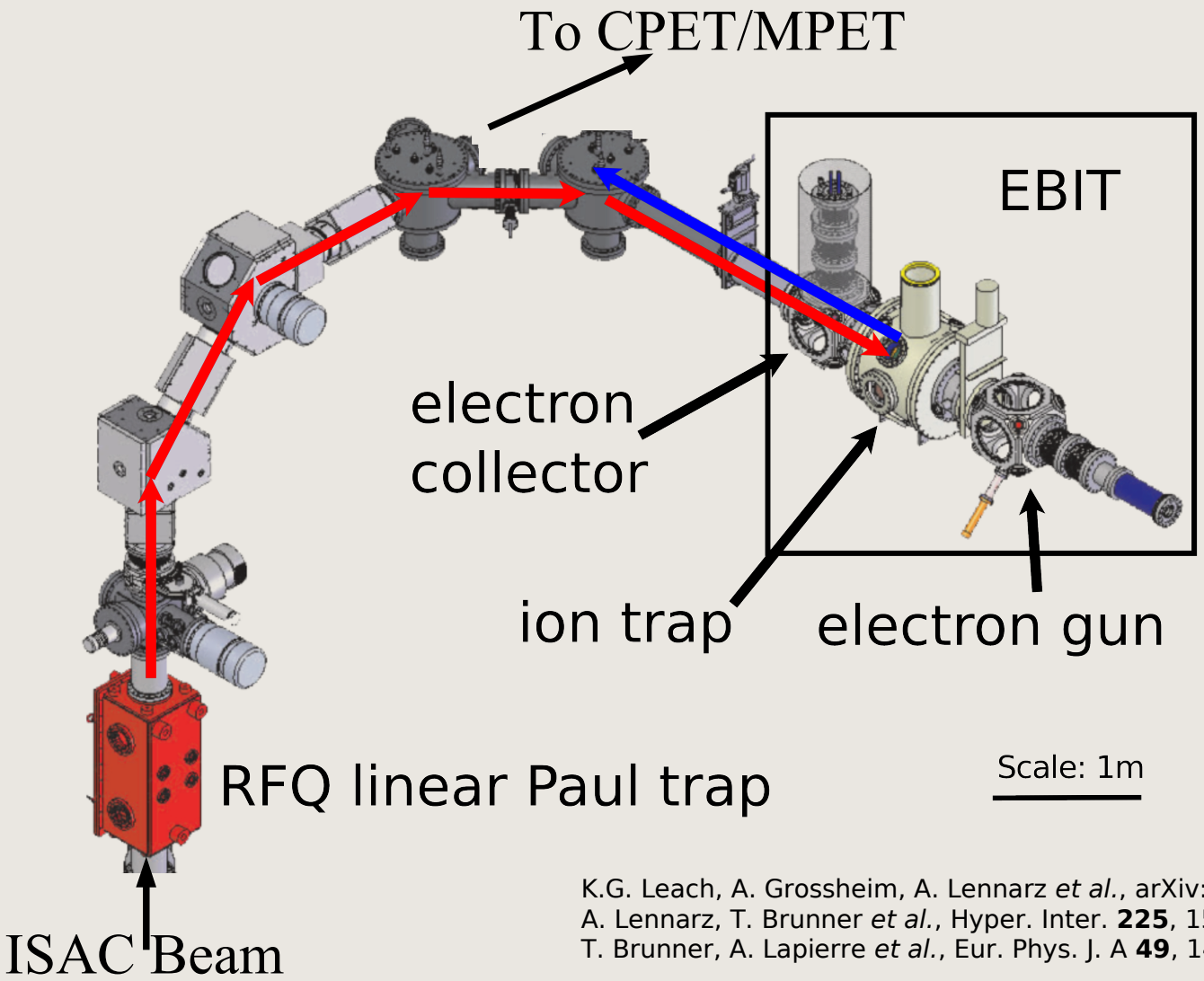
J. Dilling, R. Kruecken, and G. Ball, Hyper. Inter. **225**, 1 (2014)
P. Bricault *et al.*, Nucl. Instr. Meth. Phys. B **126**, 231 (1997)
M. Dombsky *et al.*, Rev. Sci. Instr.. **71**, 978 (2000)

TRIUMF's Ion Trap for Atomic and Nuclear Science (TITAN)



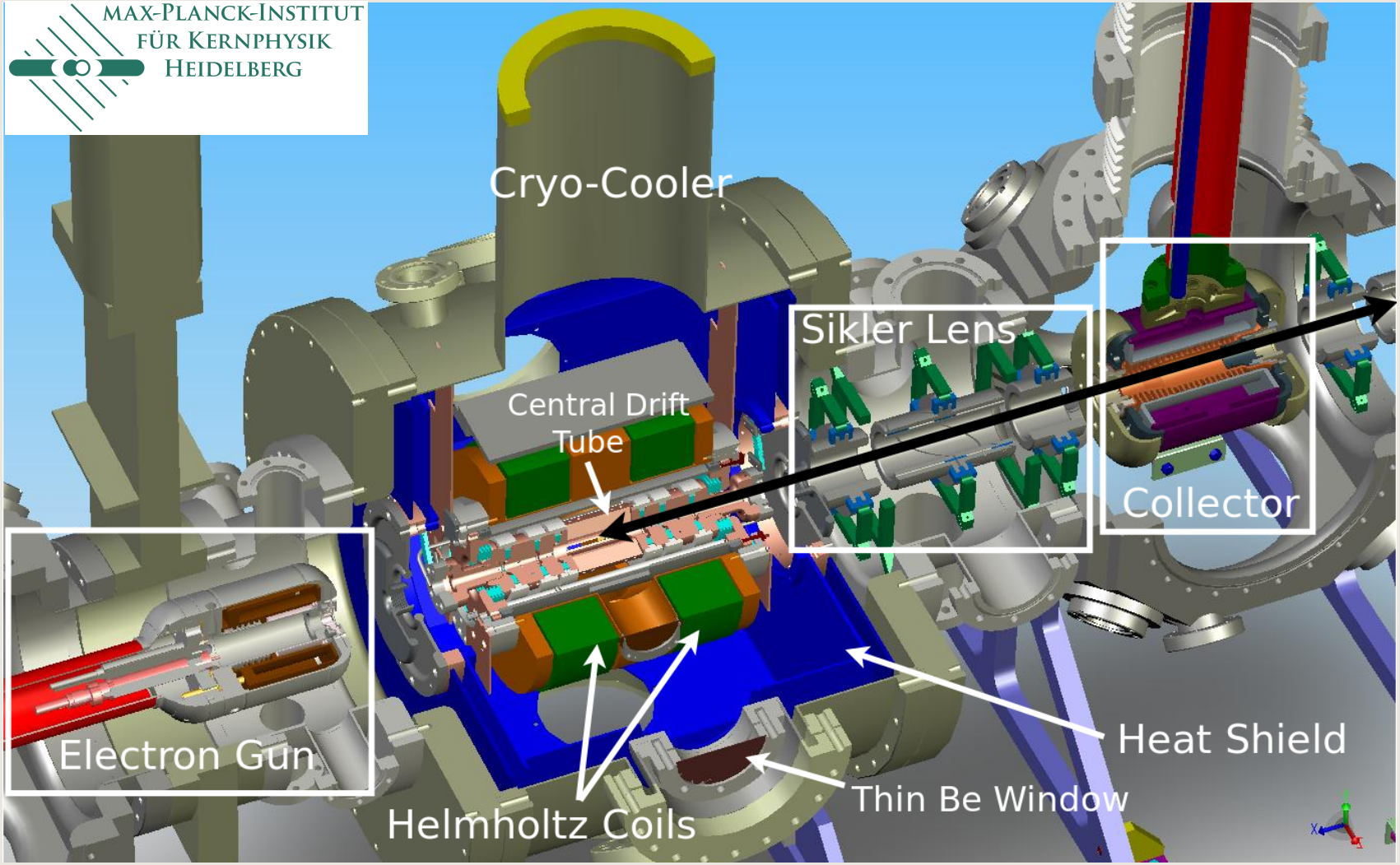
J. Dilling *et al.*, Nucl. Instr. Meth. Phys. B **204**, 492 (2003)
J. Dilling *et al.*, Int. Journ. Mass Spec. **251**, 198 (2006)

Decay Spectroscopy with TITAN

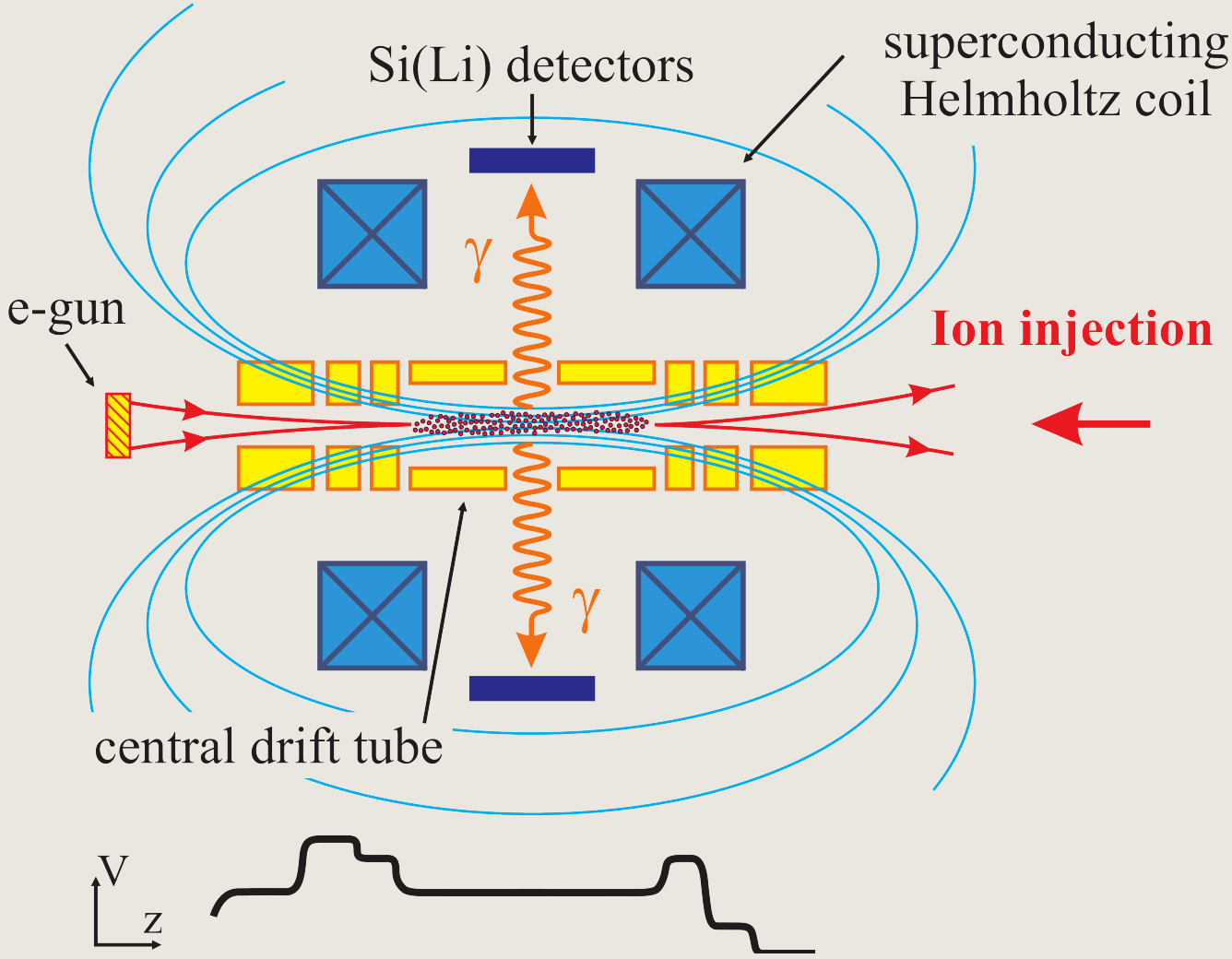


K.G. Leach, A. Grossheim, A. Lennarz *et al.*, arXiv:1405.7209 (2014)
A. Lennarz, T. Brunner *et al.*, Hyper. Inter. **225**, 157 (2014)
T. Brunner, A. Lapierre *et al.*, Eur. Phys. J. A **49**, 142 (2013)

Decay Spectroscopy with TITAN

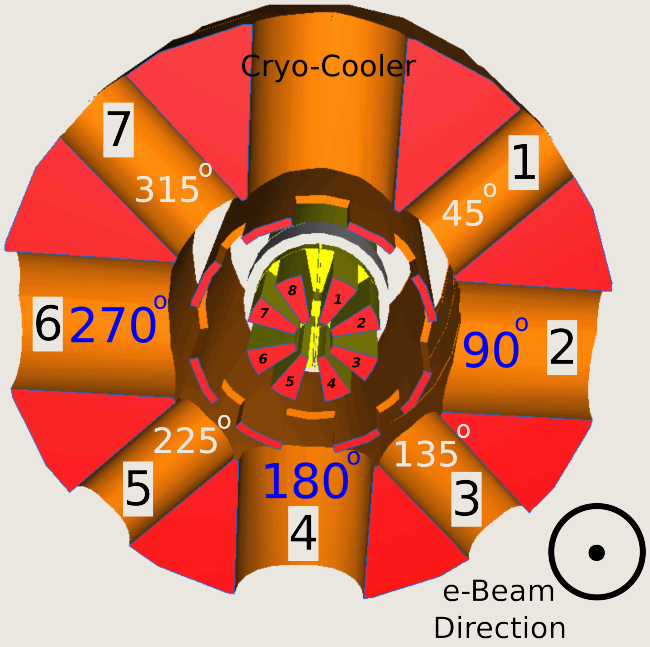


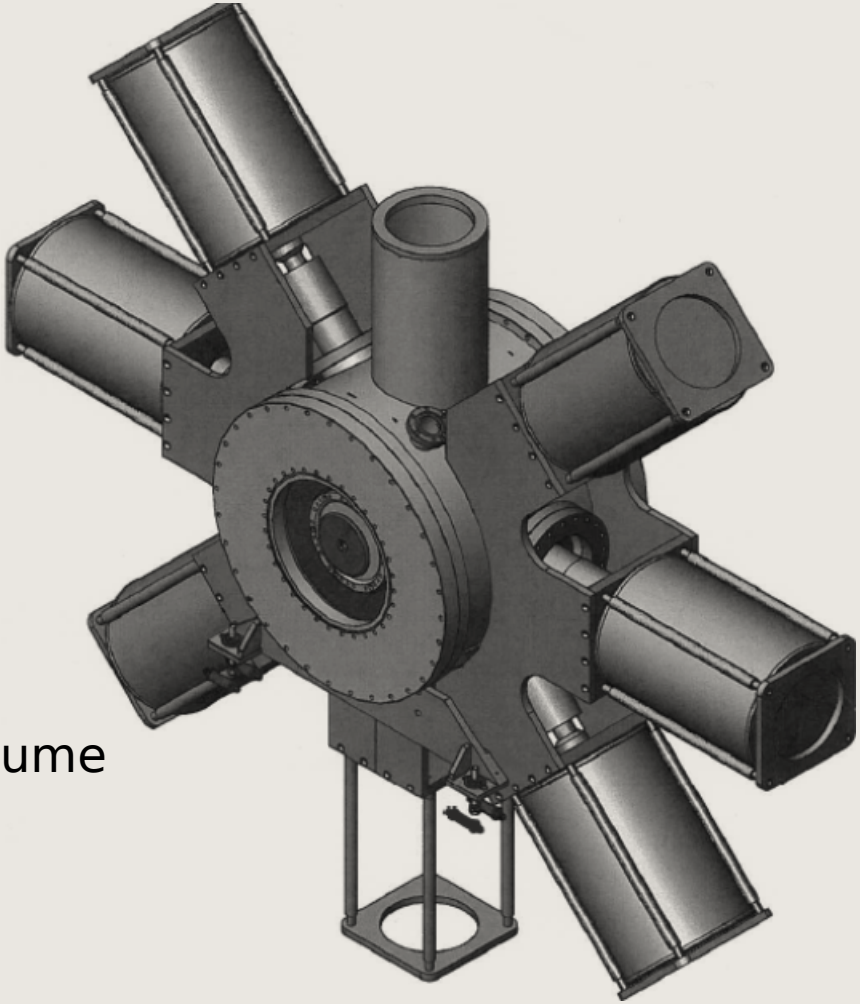
Ion-Bunch Confinement



K.G. Leach, A. Grossheim, A. Lennarz, *et al.*, arXiv:1405.7209 (2014)

Decay Spectroscopy on Trapped Radioactive Ions

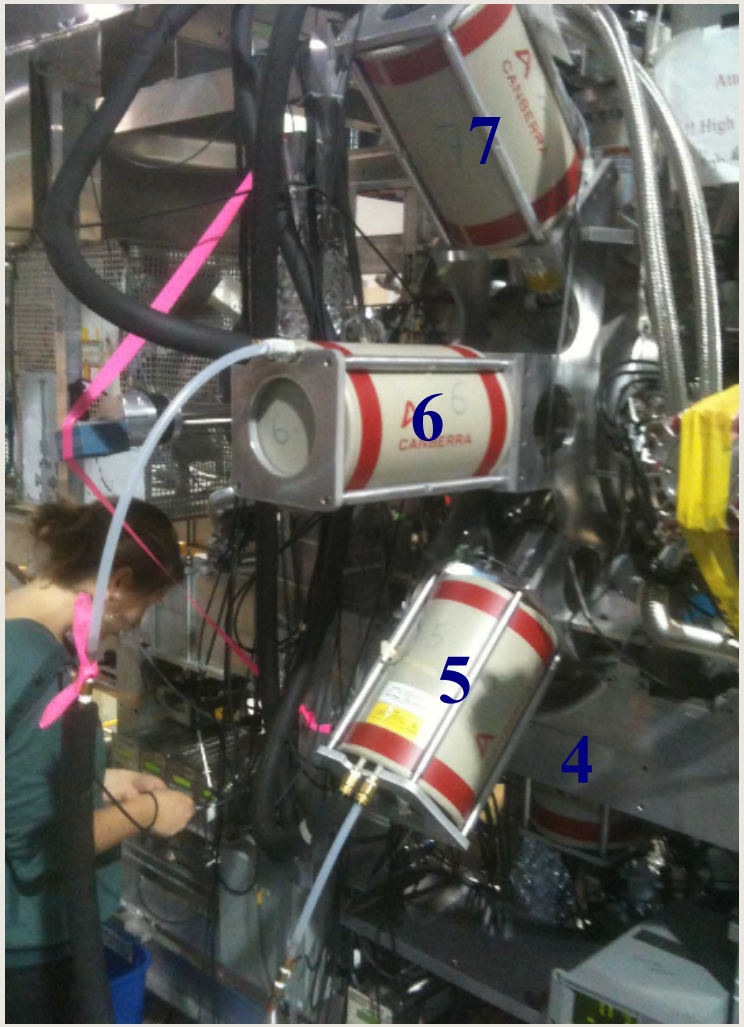


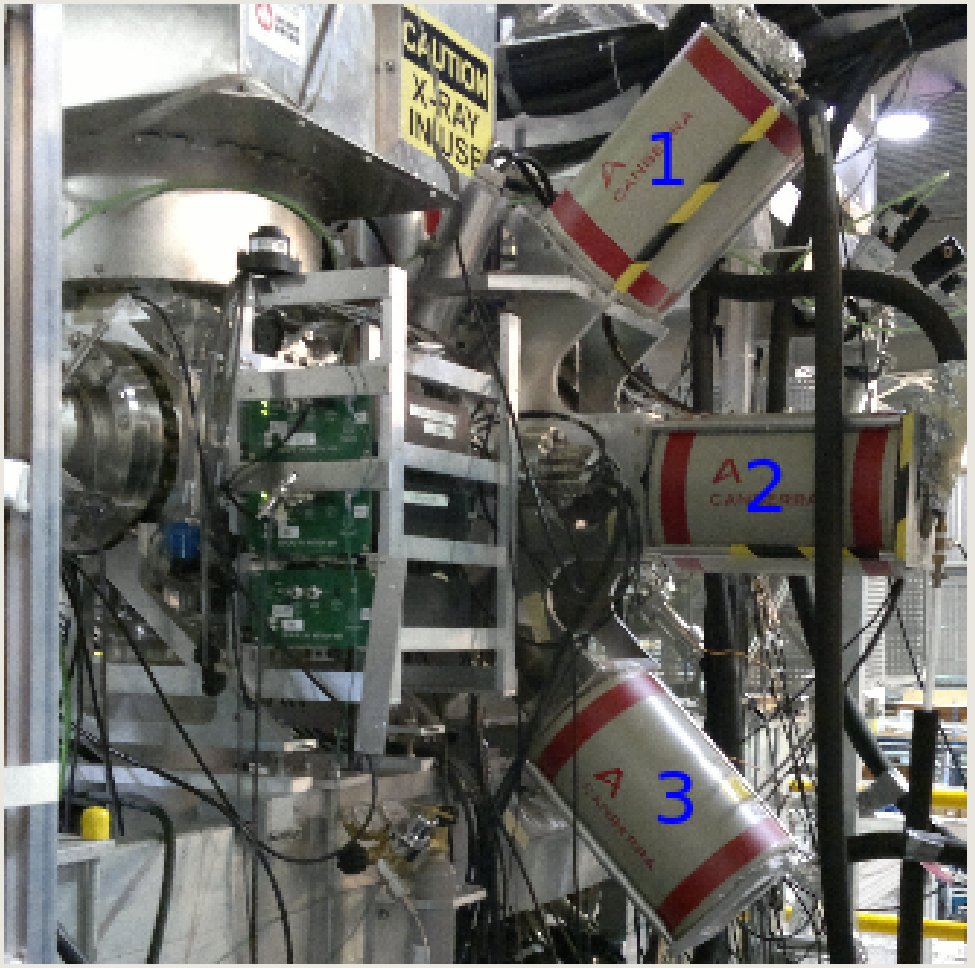


- Up to 6 T field with a 7 cm trapping volume
- Up to 500 mA e-beam
- 7, 5 mm thick Si(Li) detectors
- 1 LeGe detector for monitoring

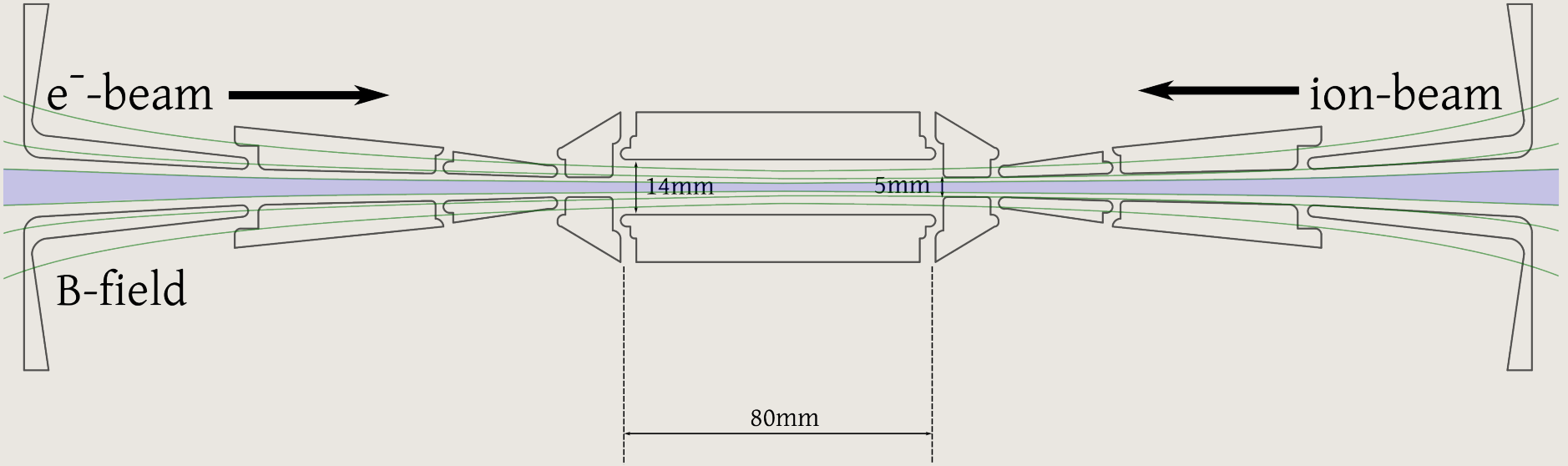
K.G. Leach, A. Grossheim, A. Lennarz, *et al.*, arXiv:1405.7209 (2014)

Decay Spectroscopy on Trapped Radioactive Ions



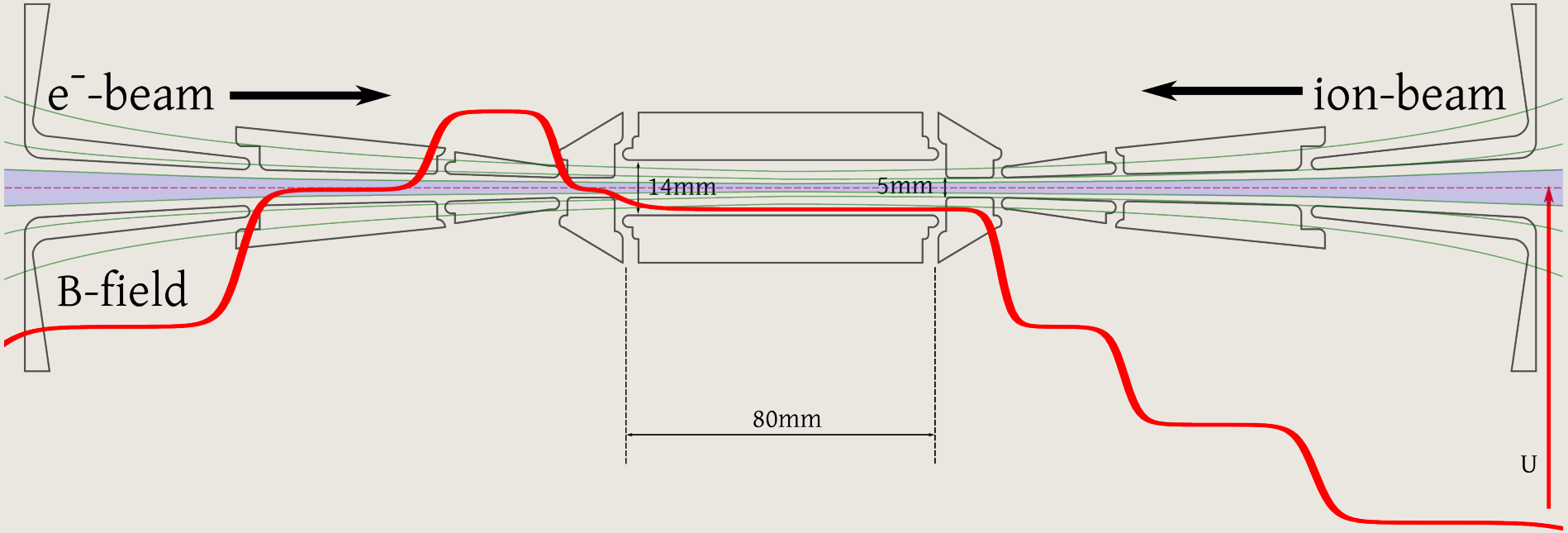


EBIT Ion-bunch Injection



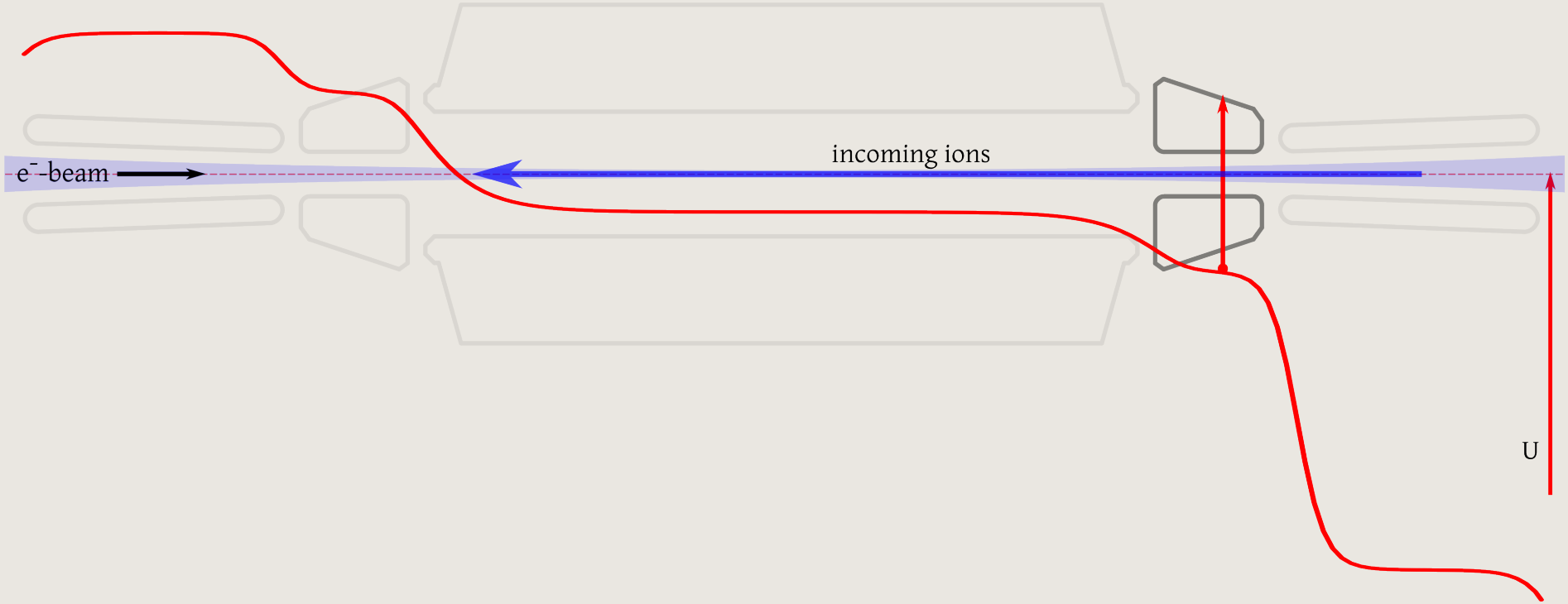
Courtesy R. Klawitter

EBIT Ion-bunch Injection



Courtesy R. Klawitter

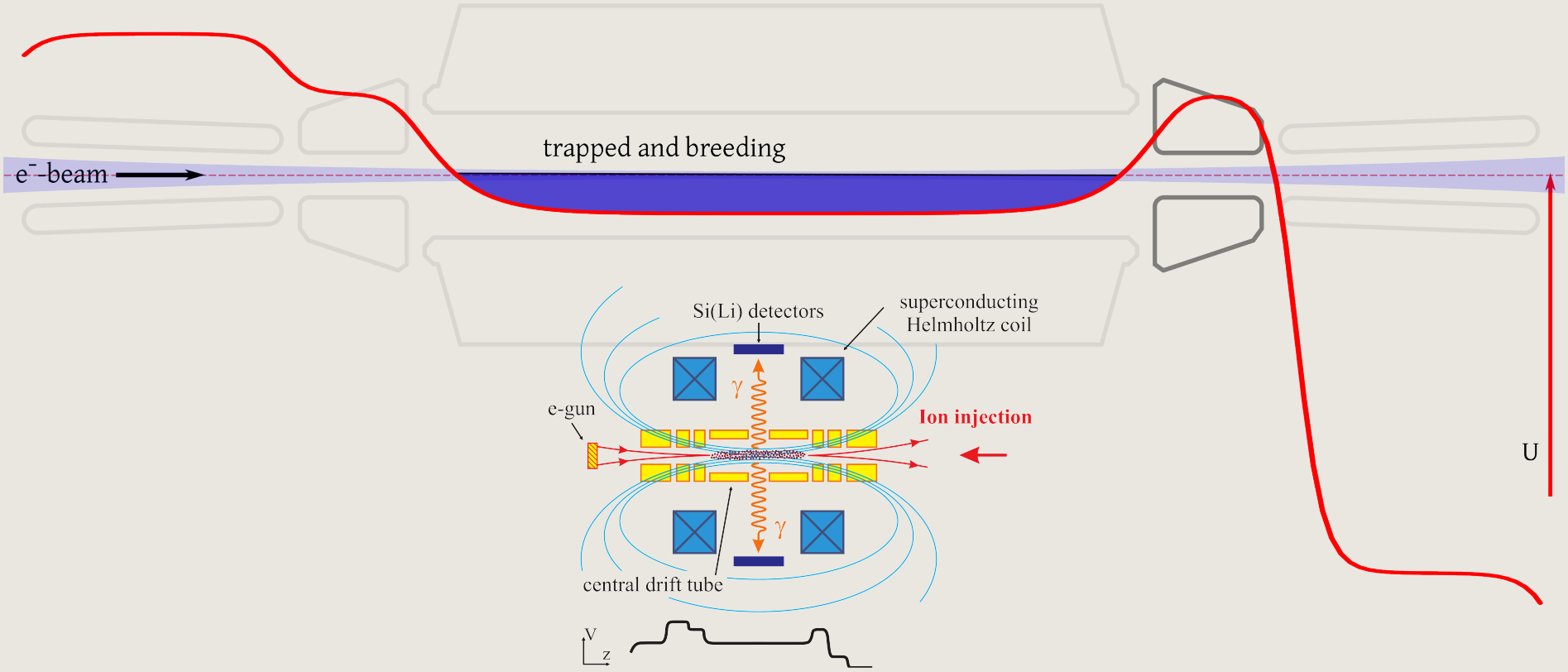
EBIT Ion-bunch Injection



Inner-most collector side electrode potential is lowered for injection

Courtesy R. Klawitter

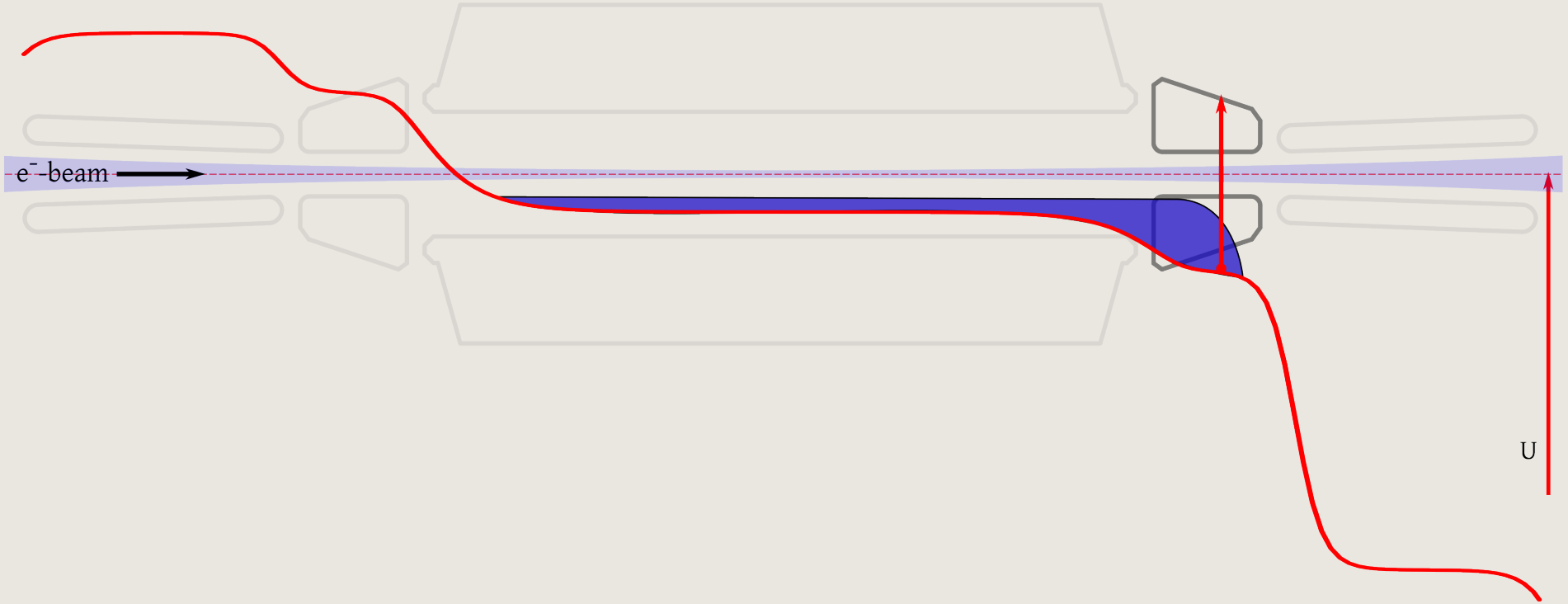
EBIT Ion-bunch Injection



Inner-most collector side electrode potential is raised for axial confinement of the ion bunch

Courtesy R. Klawitter

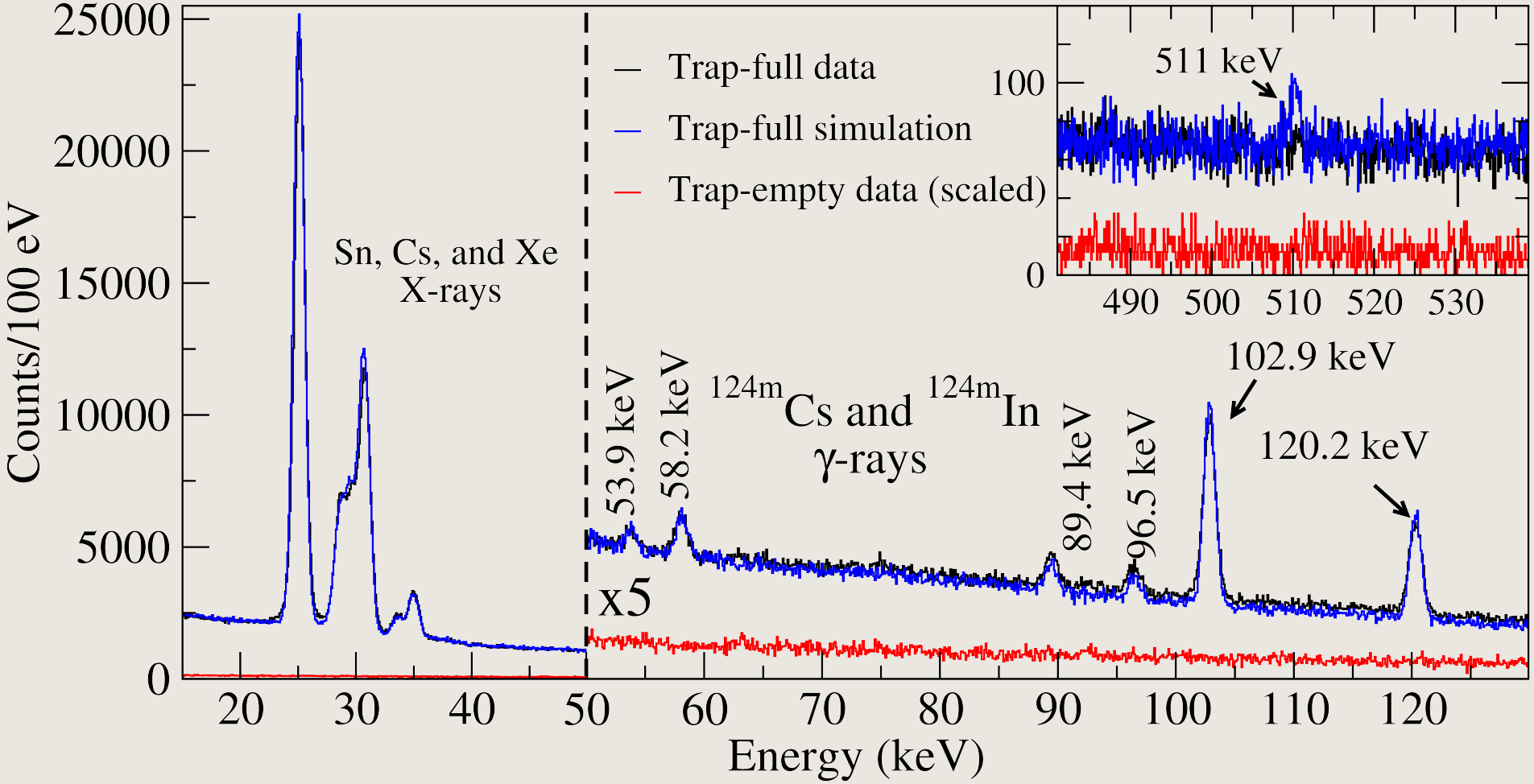
EBIT Ion-bunch Injection



Inner-most collector side electrode potential is lowered again, and bunch is removed from the trap

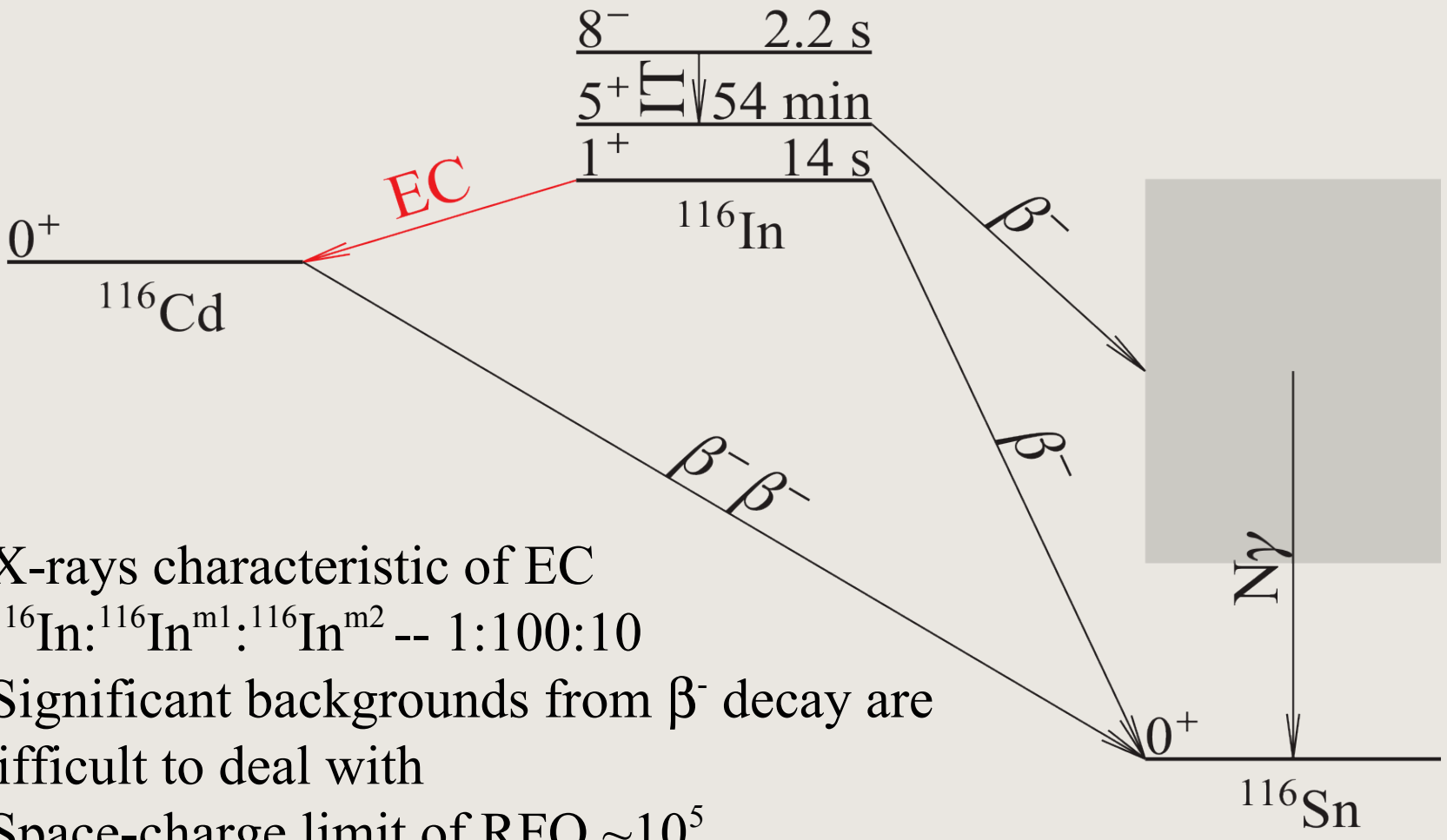
Courtesy R. Klawitter

A=124 On-Line Commissioning



A. Lennarz, A. Grossheim, K.G. Leach *et al.*, PRL *submitted* (2014)

^{116}In On-Line Commissioning



- X-rays characteristic of EC
- ^{116}In:^{116}In^{m1}:^{116}In^{m2} -- 1:100:10
- Significant backgrounds from β^- decay are difficult to deal with
- Space-charge limit of RFQ ~10^5

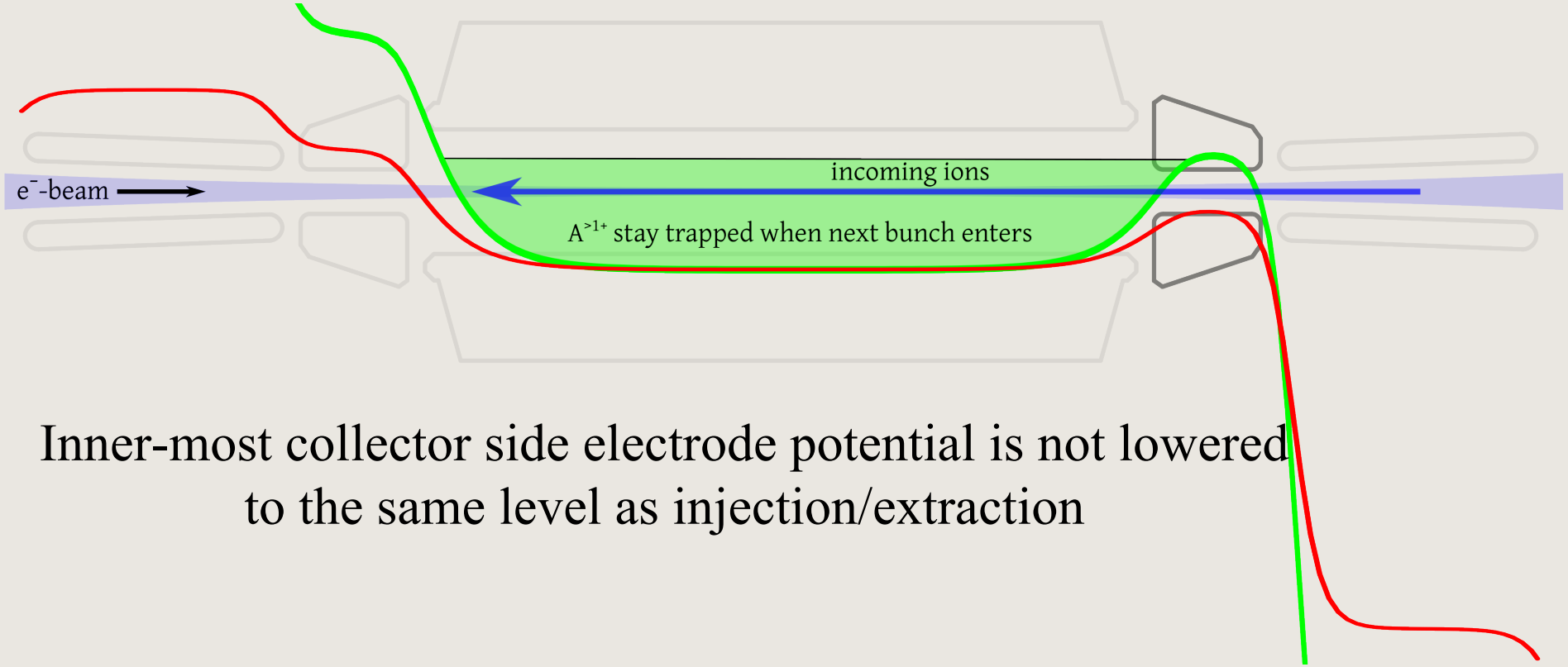
C. Wrede *et al.*, Phys. Rev. C **87**, 031303(R) (2013)

Multiple Ion-bunch Stacking

Ions are trapped, and in charge-state $q>2+$

Courtesy R. Klawitter

Multiple Ion-bunch Stacking

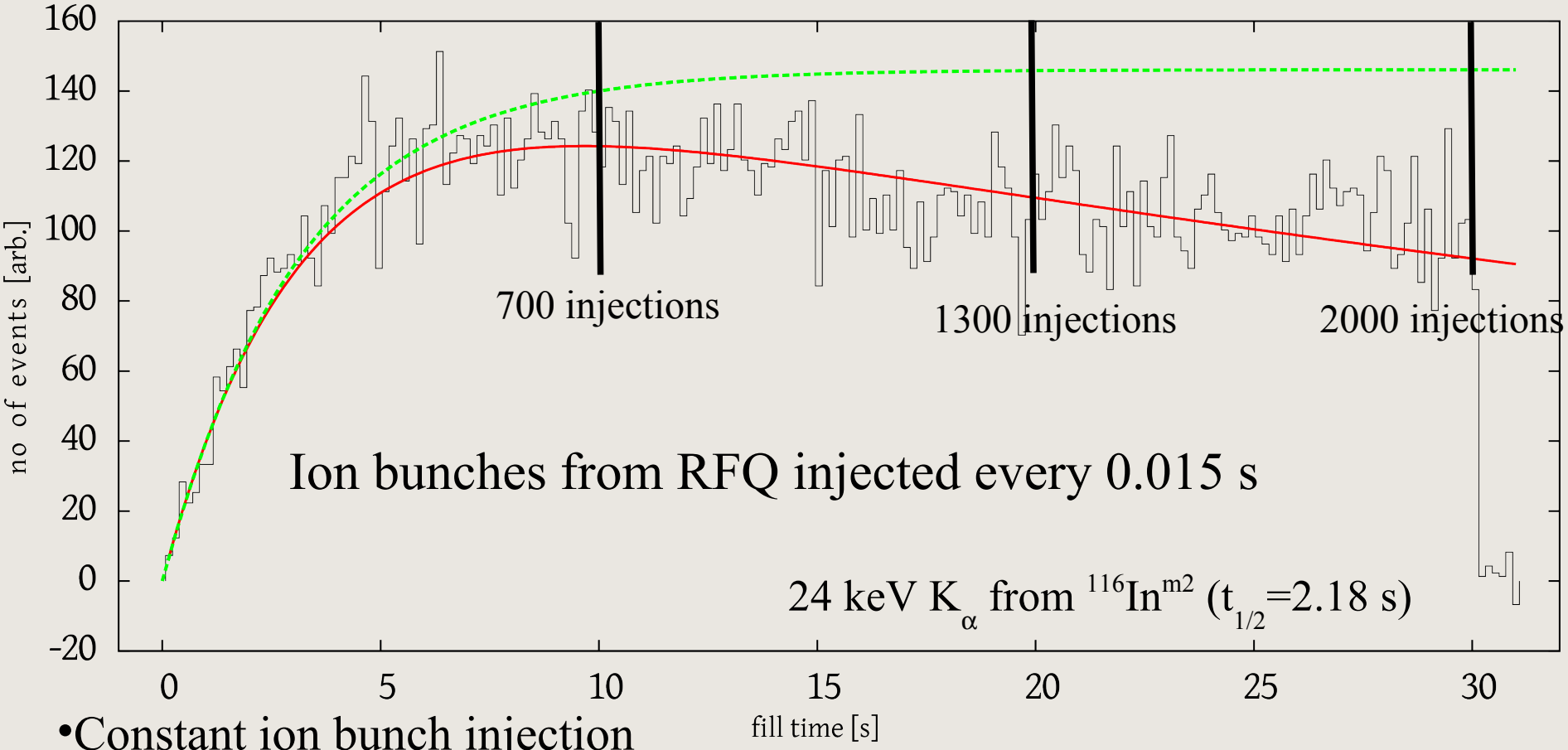


Inner-most collector side electrode potential is not lowered to the same level as injection/extraction

Subsequent ion bunches are rapidly injected, where they are quickly Charge-bred, and remain trapped

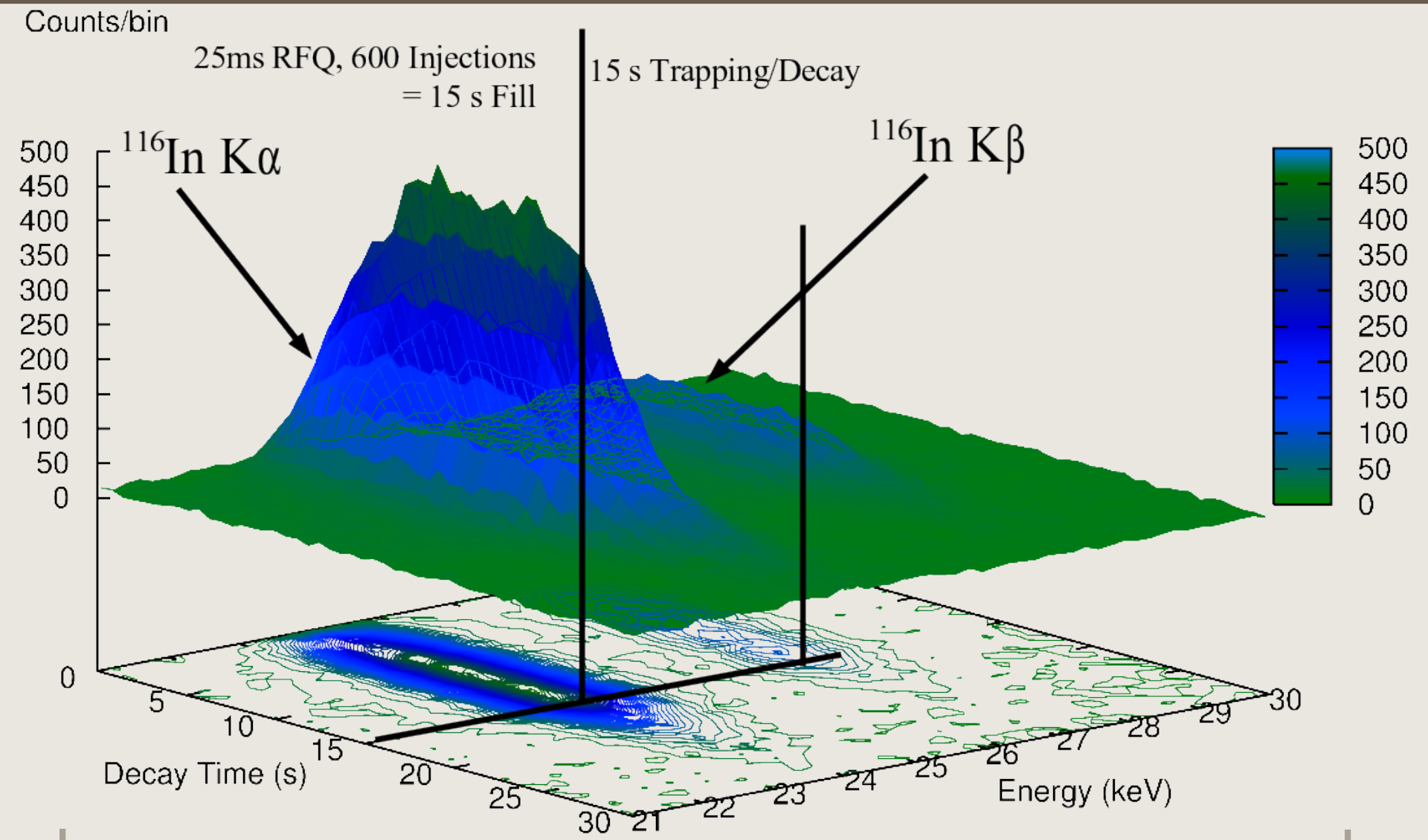
Courtesy R. Klawitter

Multiple Ion-bunch Stacking

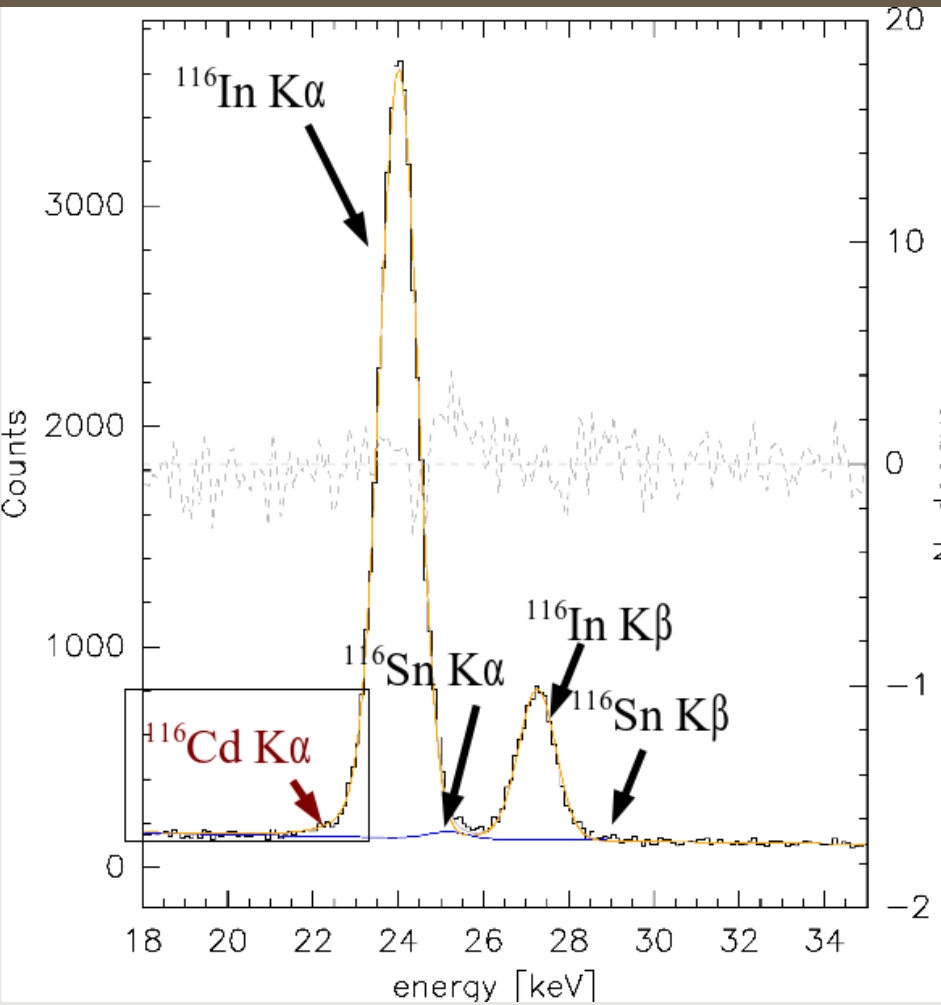


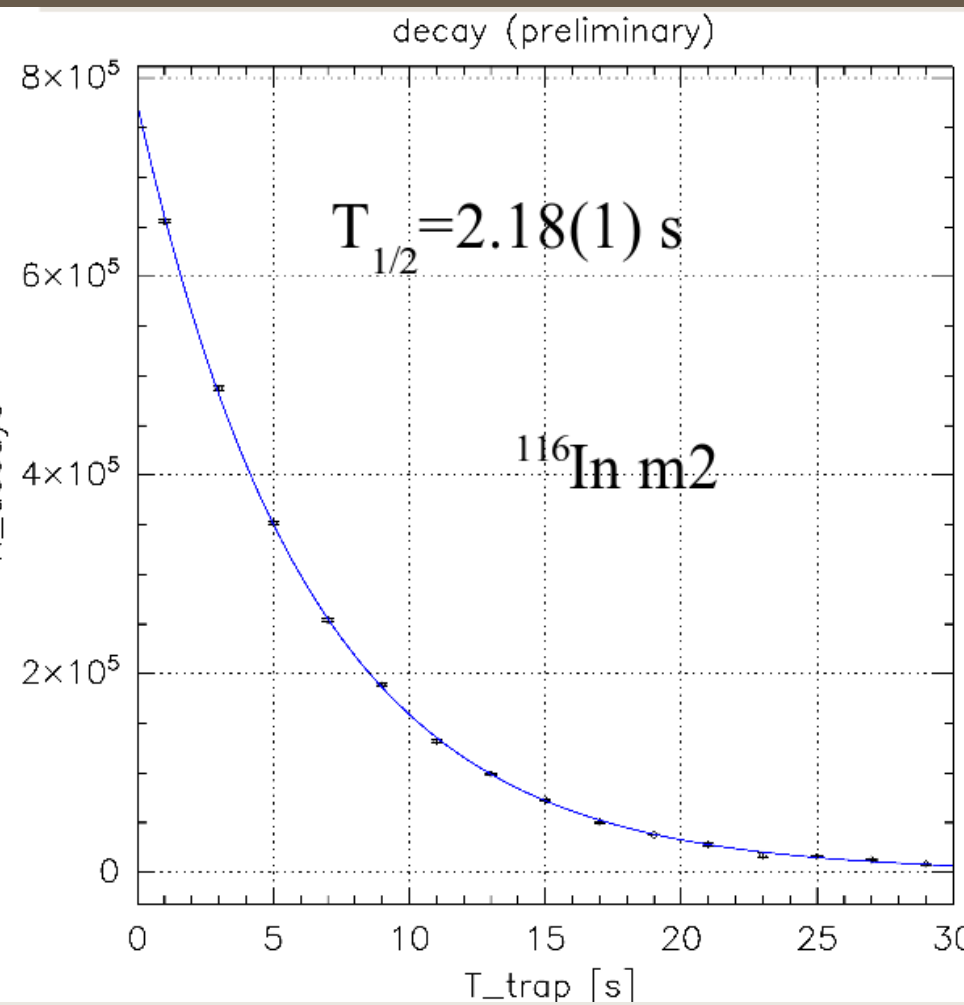
- Constant ion bunch injection
- Max after 700 bunches (~10^6-10^7 ions, for RFQ space charge of <10^5)
- e-beam: 100 mA, 1.7 keV - space charge limit is about $10^9 e$

^{116}In Decay Spectroscopy



^{116}In Decay Spectroscopy





Conclusions

- An ion-trap decay spectroscopy tool has been constructed and comissioned with TITAN at TRIUMF

- Consists of:
  - Up to 6 T open-access ion trap
  - 500 mA *e*-gun
  - Seven 5mm thick planar Si(Li) detectors

- Have achieved trapping times of minutes with no ion losses

- Demonstrated multiple-injection technique (^{116}In decay)

- Plan to perform first physics measurement on ^{110}Ag this fall

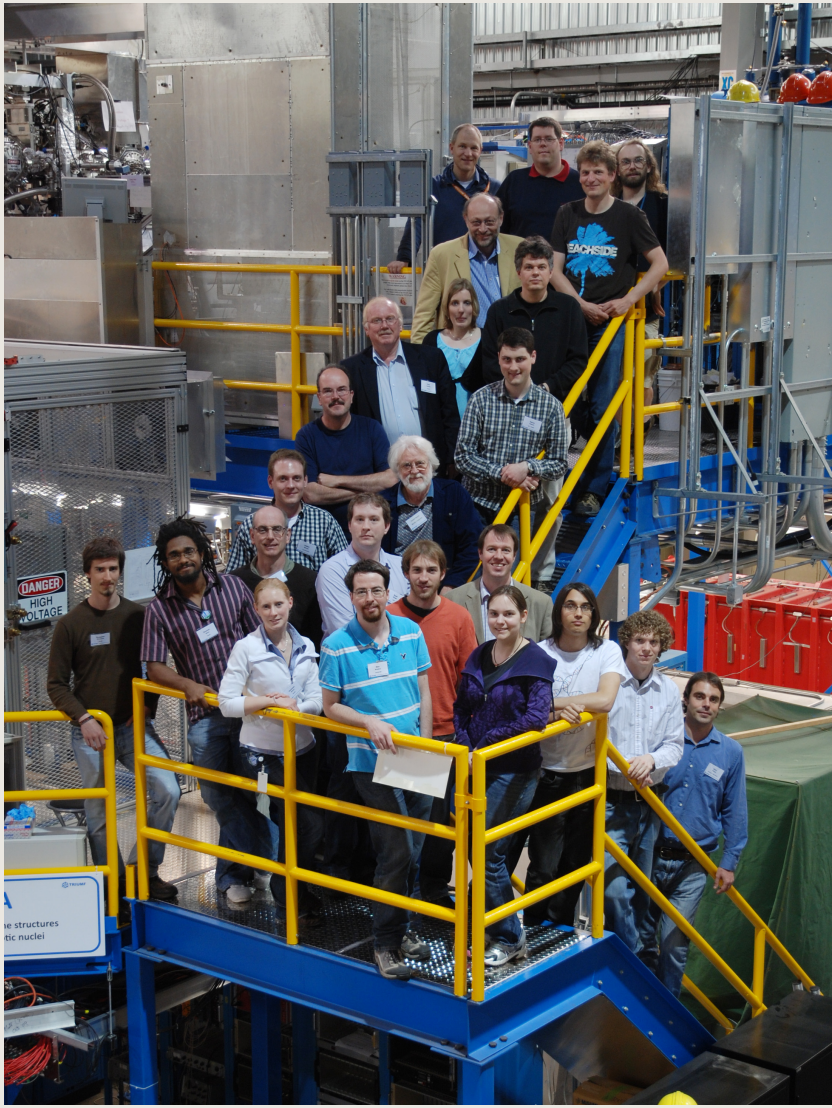
TRIUMF

Canada's National Laboratory for Particle and Nuclear Physics
Laboratoire national canadien pour la recherche en physique nucléaire
et en physique des particules

Thank You!

Merci!

Harvard
Notre Dame
U. of Manitoba
McGill U.
Muenster U.,
Max Plank Inst. für Kernphysik
GANIL
CNRS/Orsay
Yale
Giessen
Stanford U.
Uni Mainz
U. of Windsor
TU Dresden
TRIUMF
UBC
SFU
TU Munich
St Mary's



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