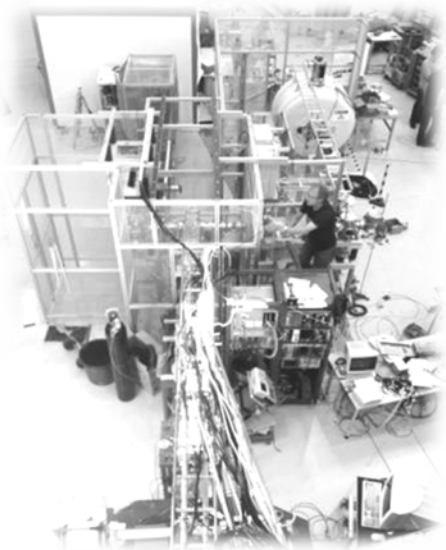
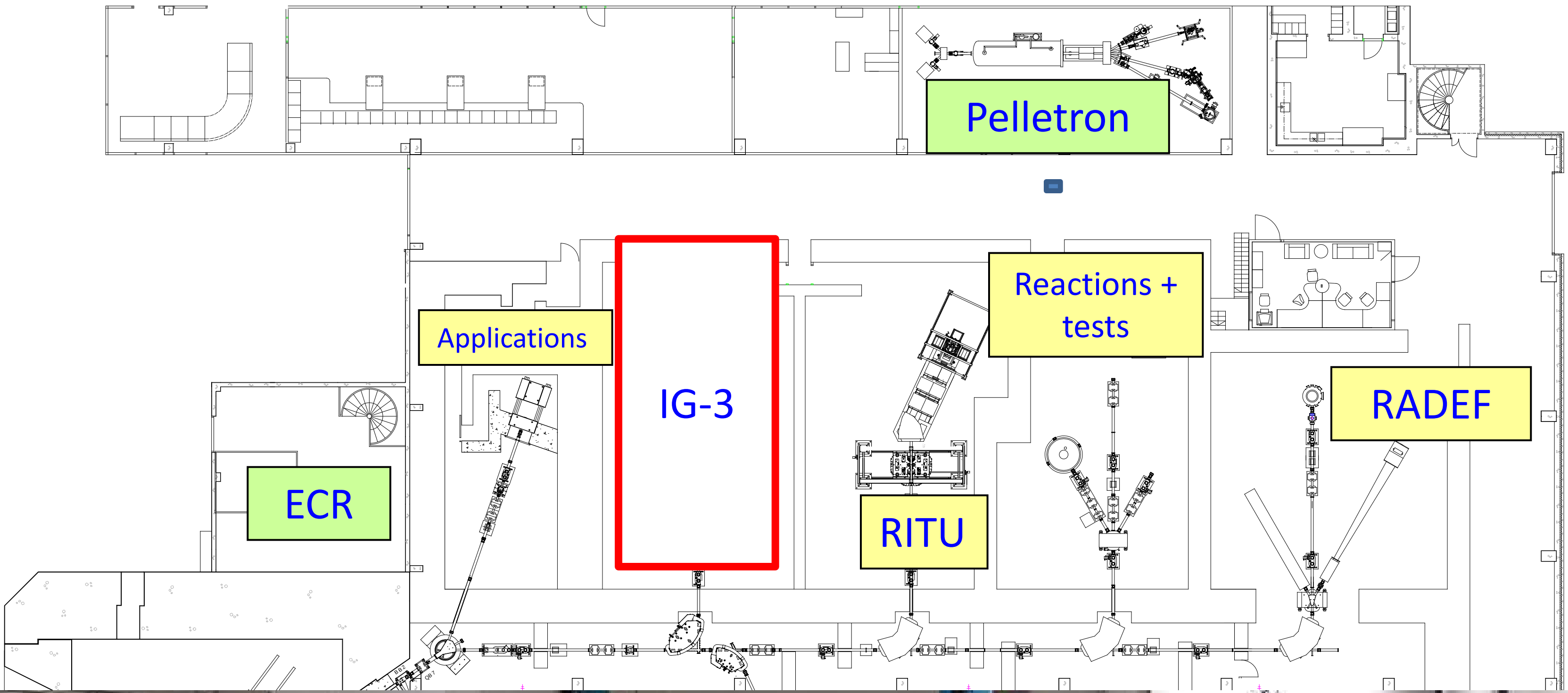
Commissioning of the new IGISOL-4 facility

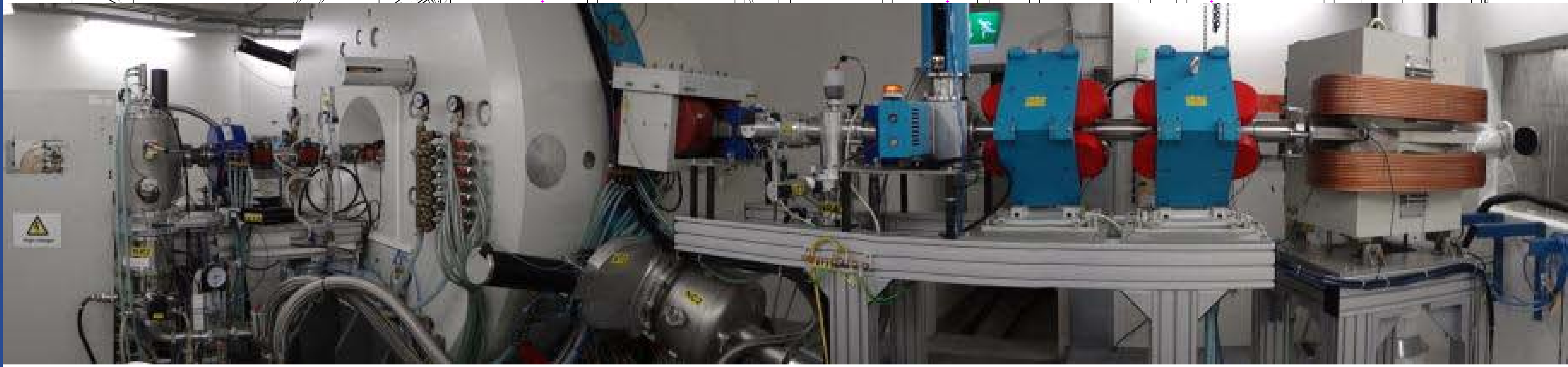


Iain Moore

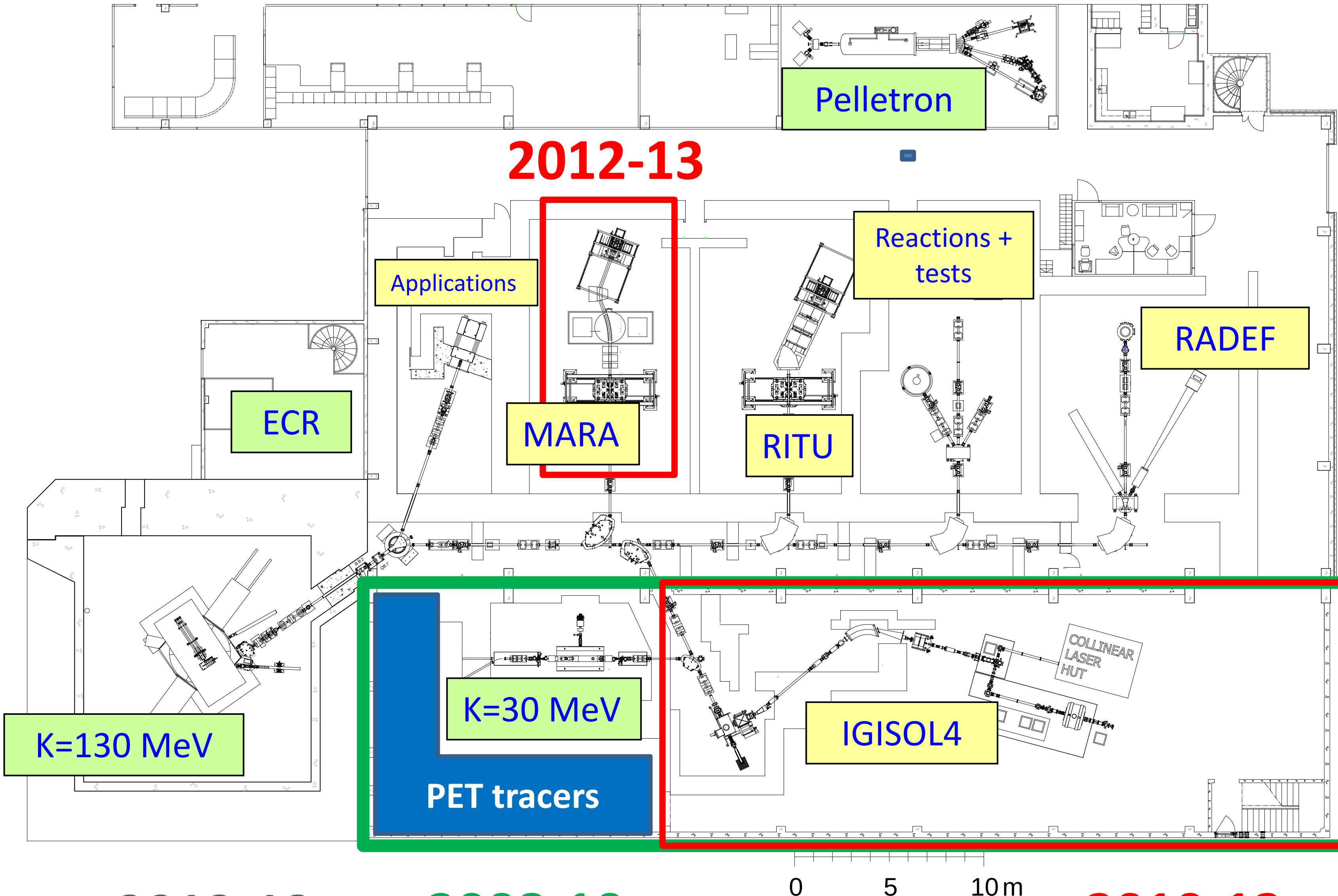
JYFL, Finland

JYFL Accelerator Lab: prior to upgrade (EMIS XV)





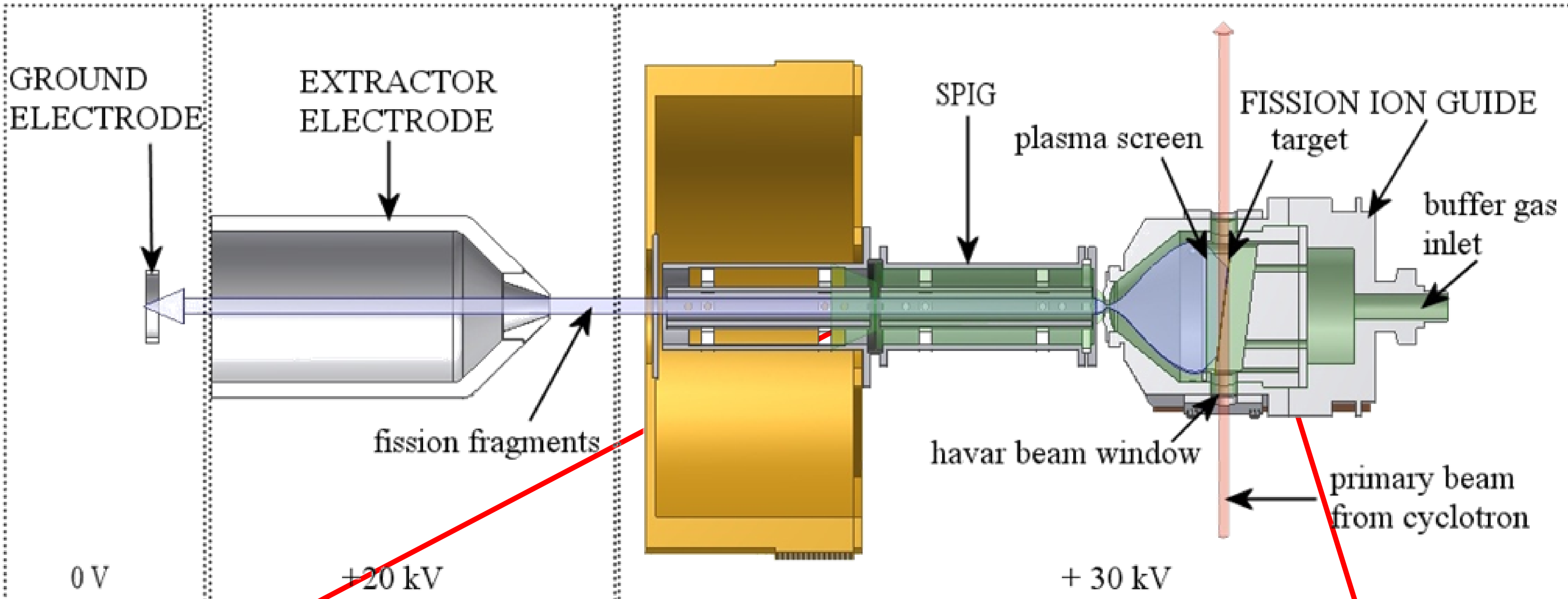
Present status (EMIS XVI) and immediate future

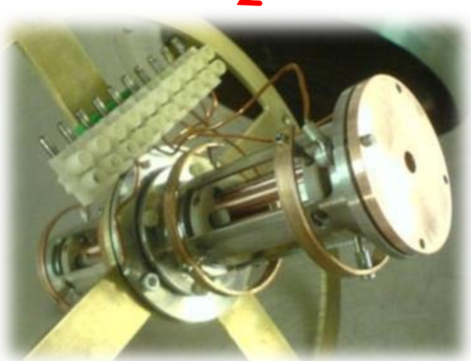


2012-13 2008-10 2010-12

Principal operating features of the ion guide technique

(0), +1, (+2) charge states



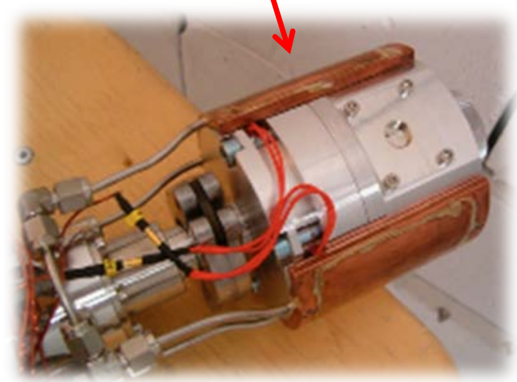


Advantages:

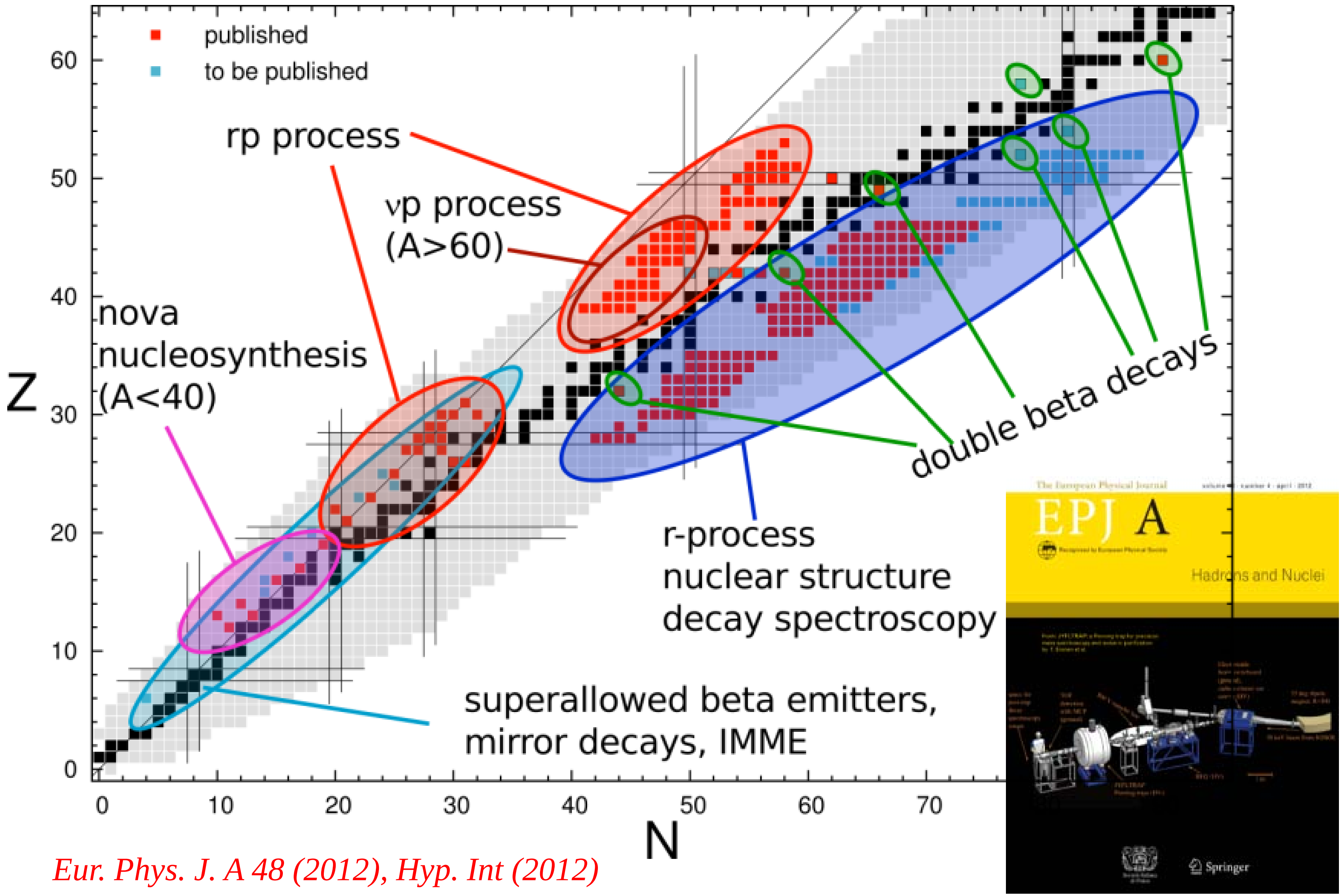
- ✓ Fast extraction
- ✓ Universal

Drawbacks:

- ➢ Relatively low efficiency
- ➢ Poor selectivity

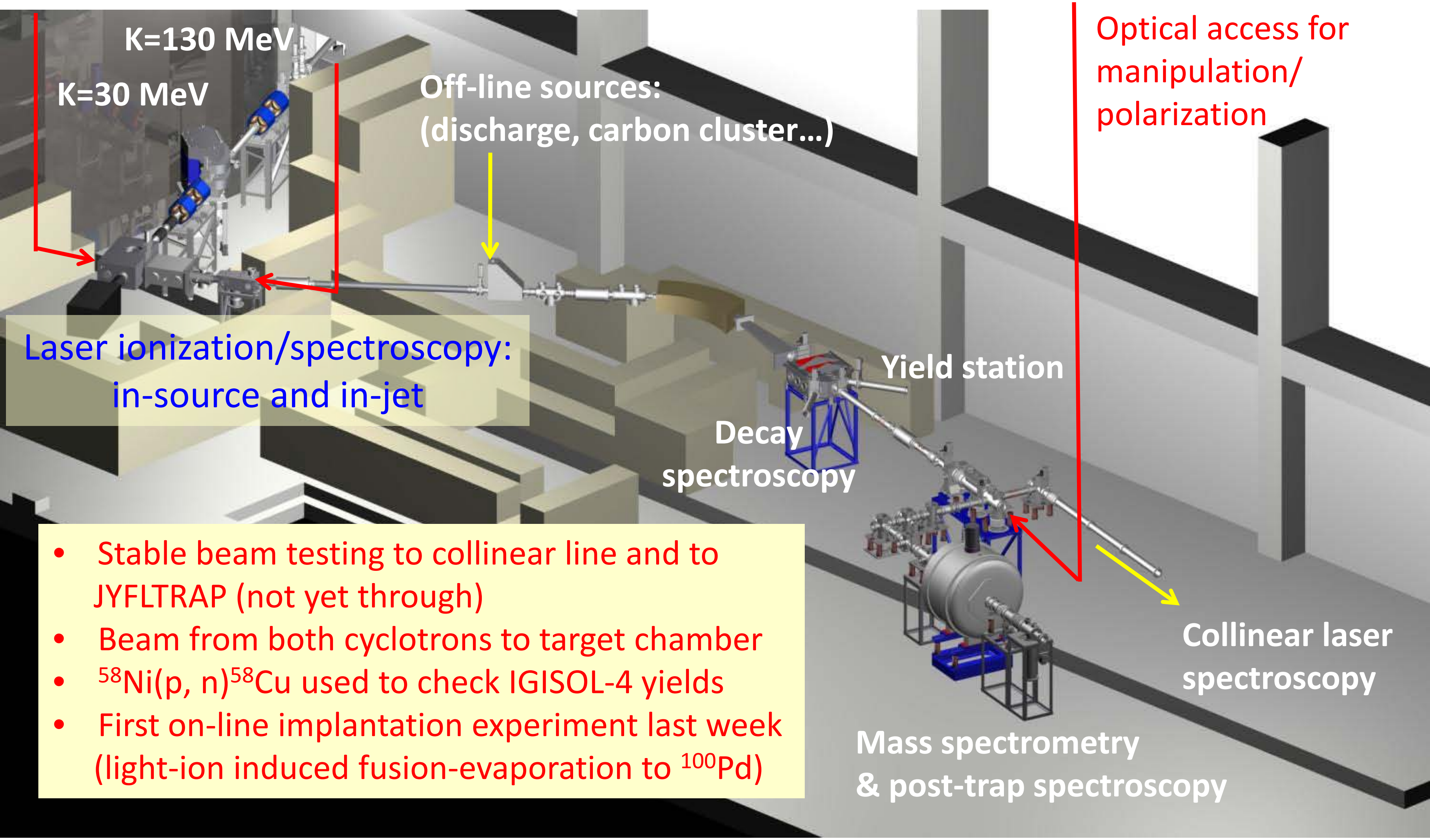


Rare isotope beam science at IGISOL



Eur. Phys. J. A 48 (2012), Hyp. Int (2012)

IGISOL-4: a new facility 2012



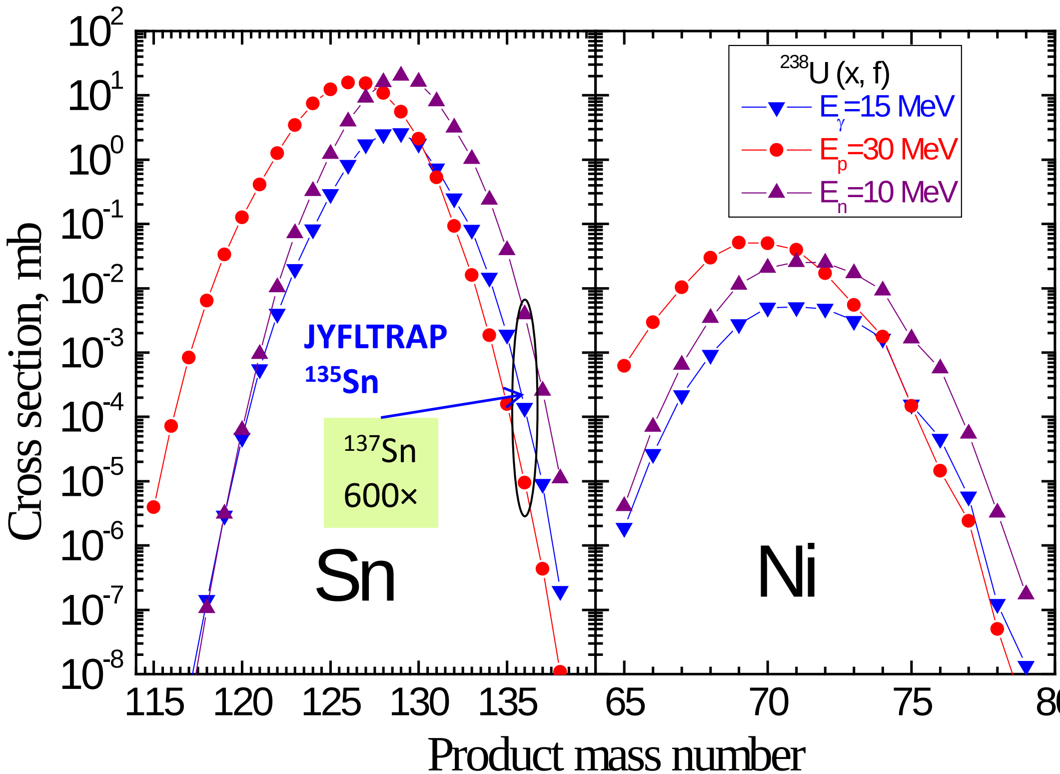
- Stable beam testing to collinear line and to JYFLTRAP (not yet through)
- Beam from both cyclotrons to target chamber
- $^{58}Ni(p, n)^{58}Cu$ used to check IGISOL-4 yields
- First on-line implantation experiment last week (light-ion induced fusion-evaporation to ^{100}Pd)

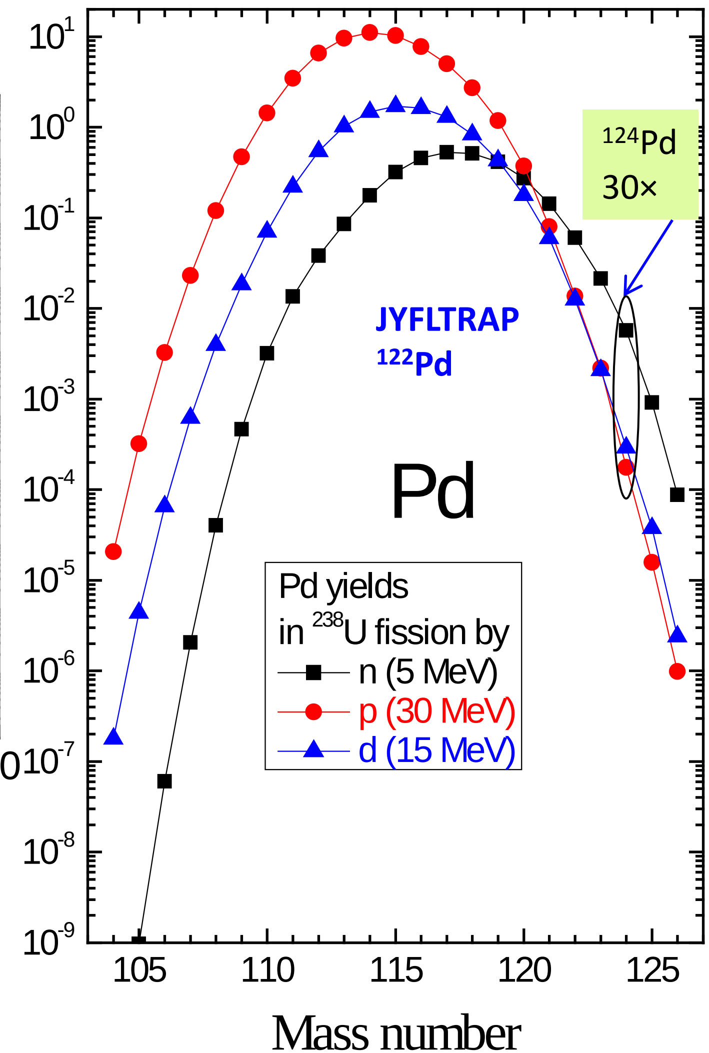
https://www.jyu.fi/fysiikka/en/research/accelerator/igisol

Towards more exotic n-rich nuclei

Independent isotope production cross sections for fission of ^{238}U

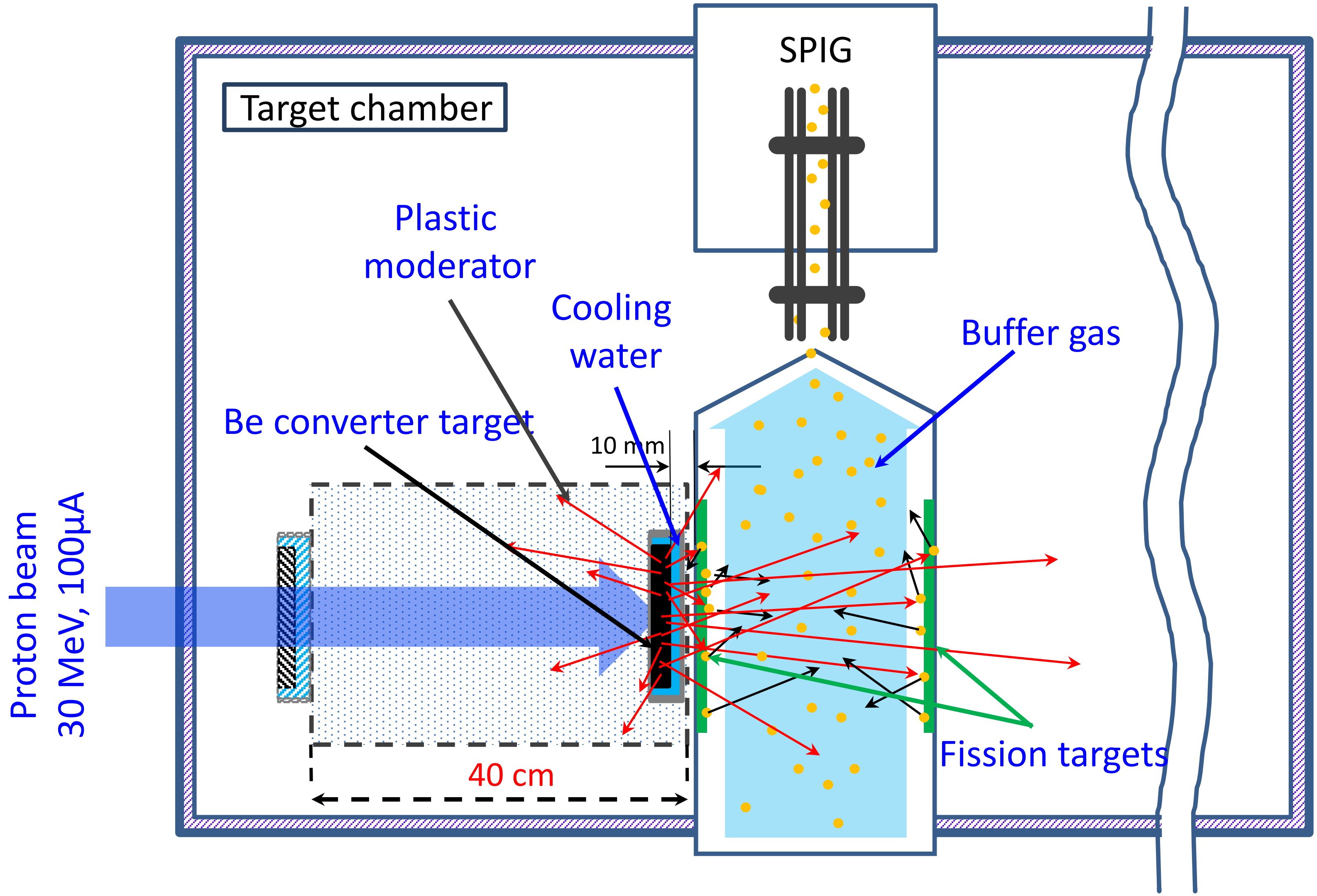
Calculations by V. Rubchenya (JYFL)





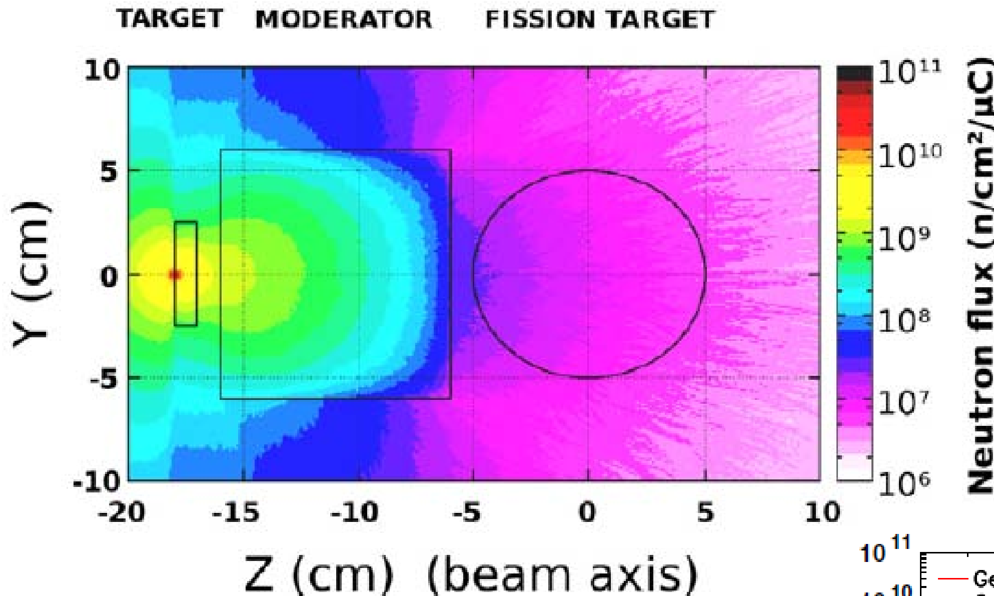
Yields of neutron-rich isotope for neutron entrance channel substantially higher than other channels

Neutron converter, fission target + moderator



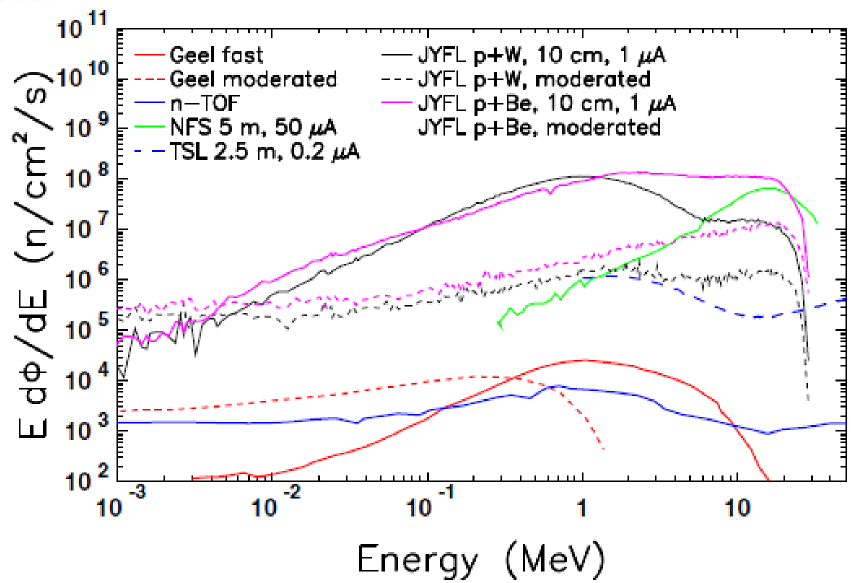
Courtesy of D. Gorelov

FLUKA simulations – Uppsala University



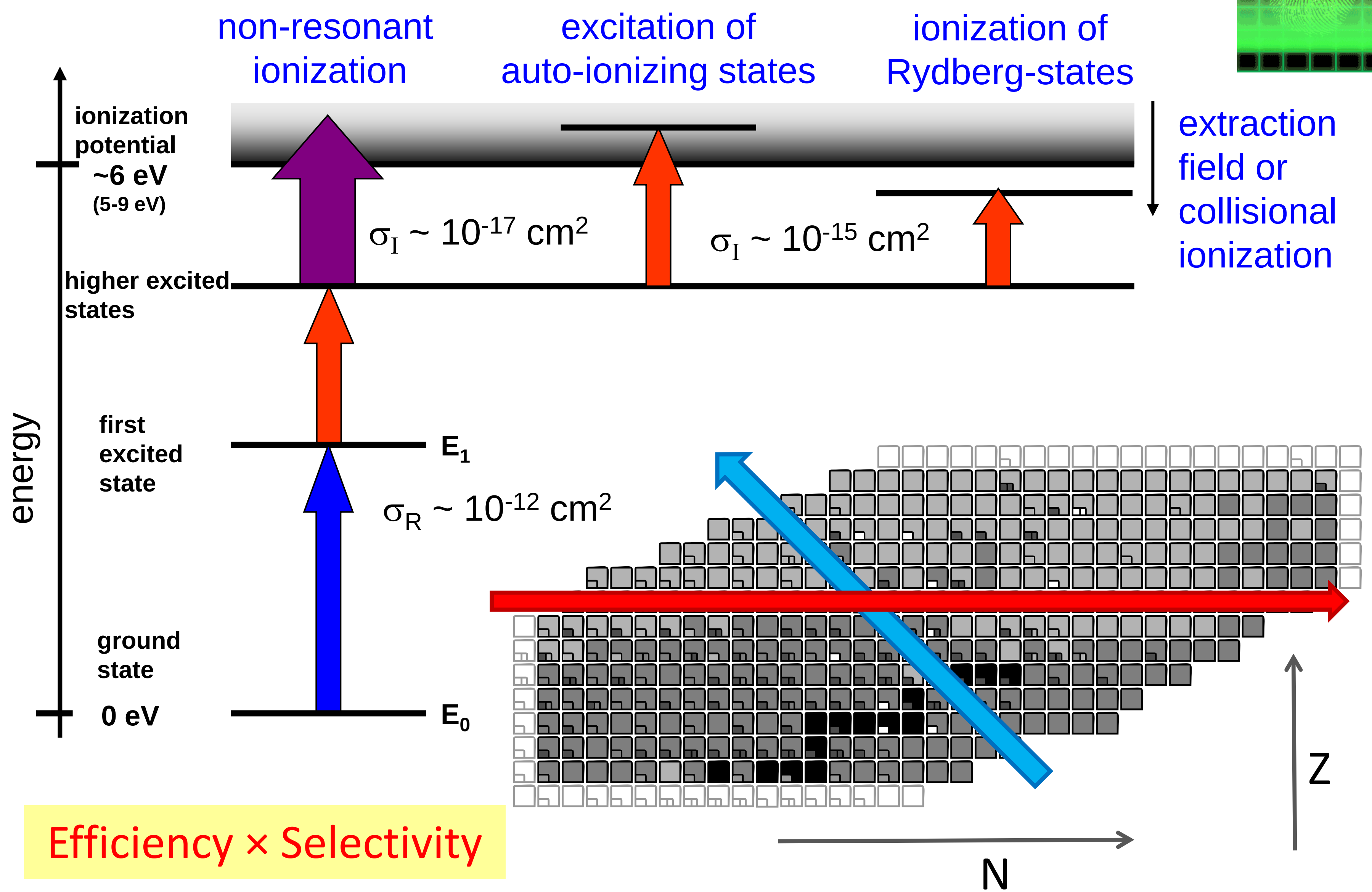
- 30 MeV p on W target
- 10 cm-thick CH_2 moderator
- Fission target, cylindrical foil, 10 cm φ, 10 cm width

- Fast and thermal neutron spectra
- 30 MeV protons on W or Be
- 100μA protons yield 10^{12} fast neutrons/sr/s
- Calibration measurement at TSL 2012; energy, angular spread



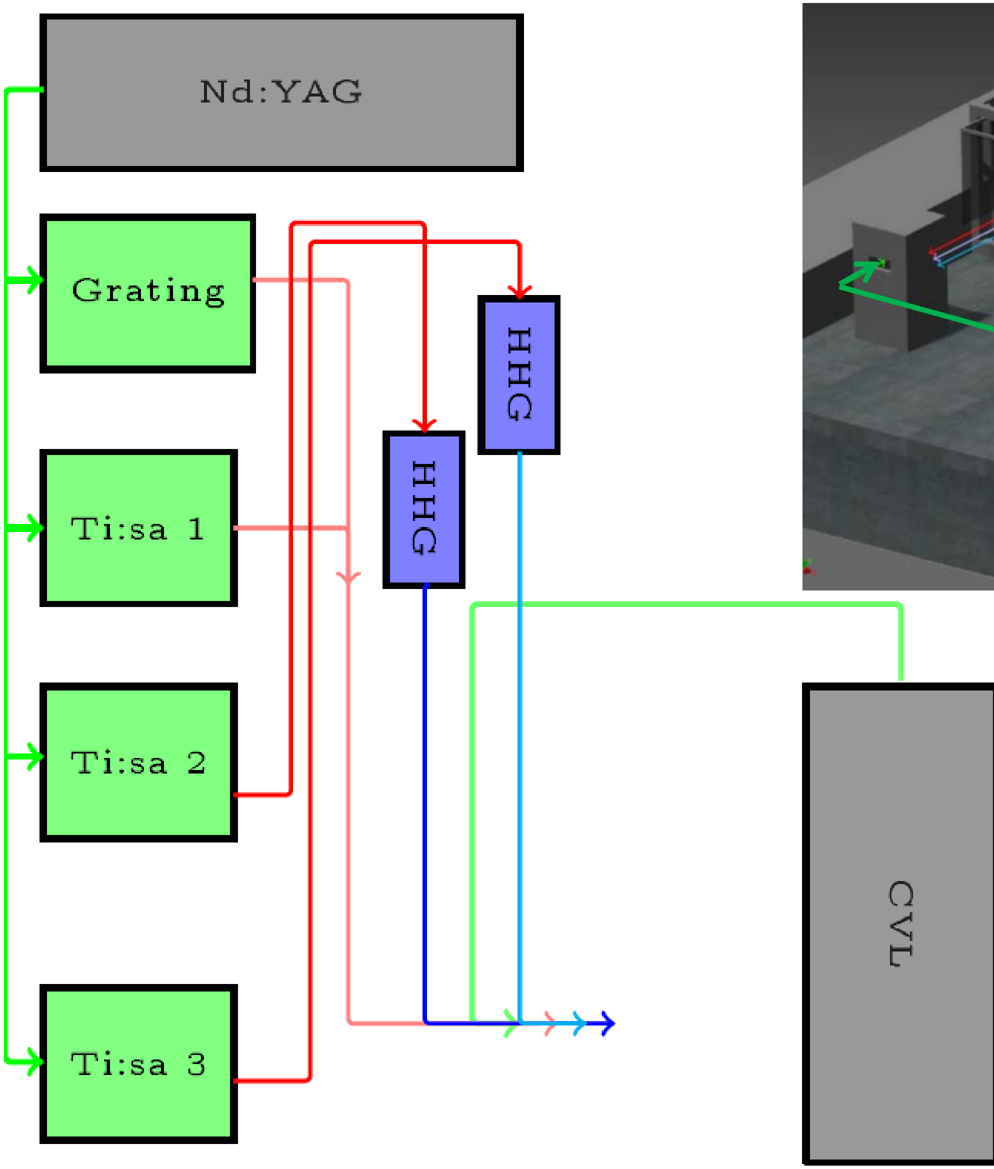
M. Lantz, D. Gorelov et al., Phys. Scr. T150 (2012) 014020

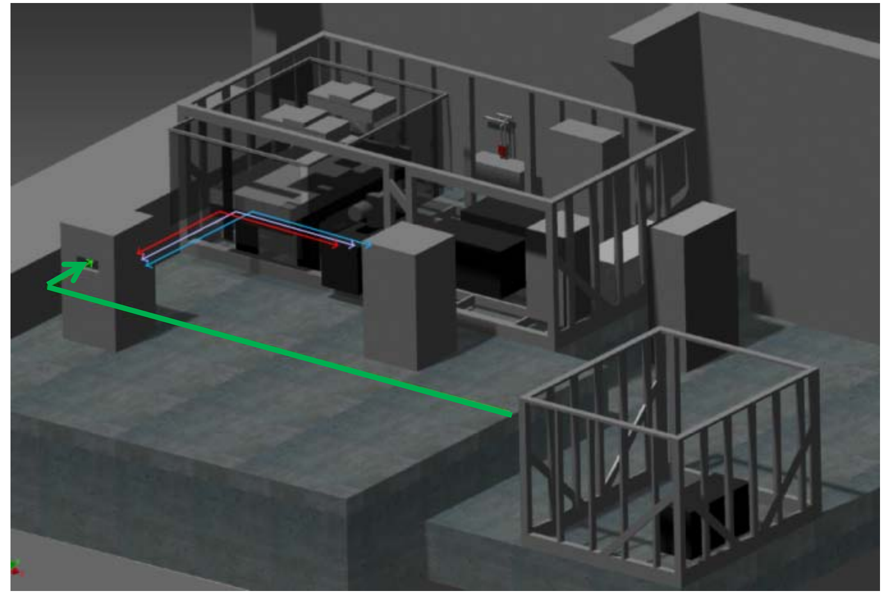
Addressing selectivity with laser ionization



Efficiency × Selectivity

JYFL: a high-repetition rate solid-state laser ion source





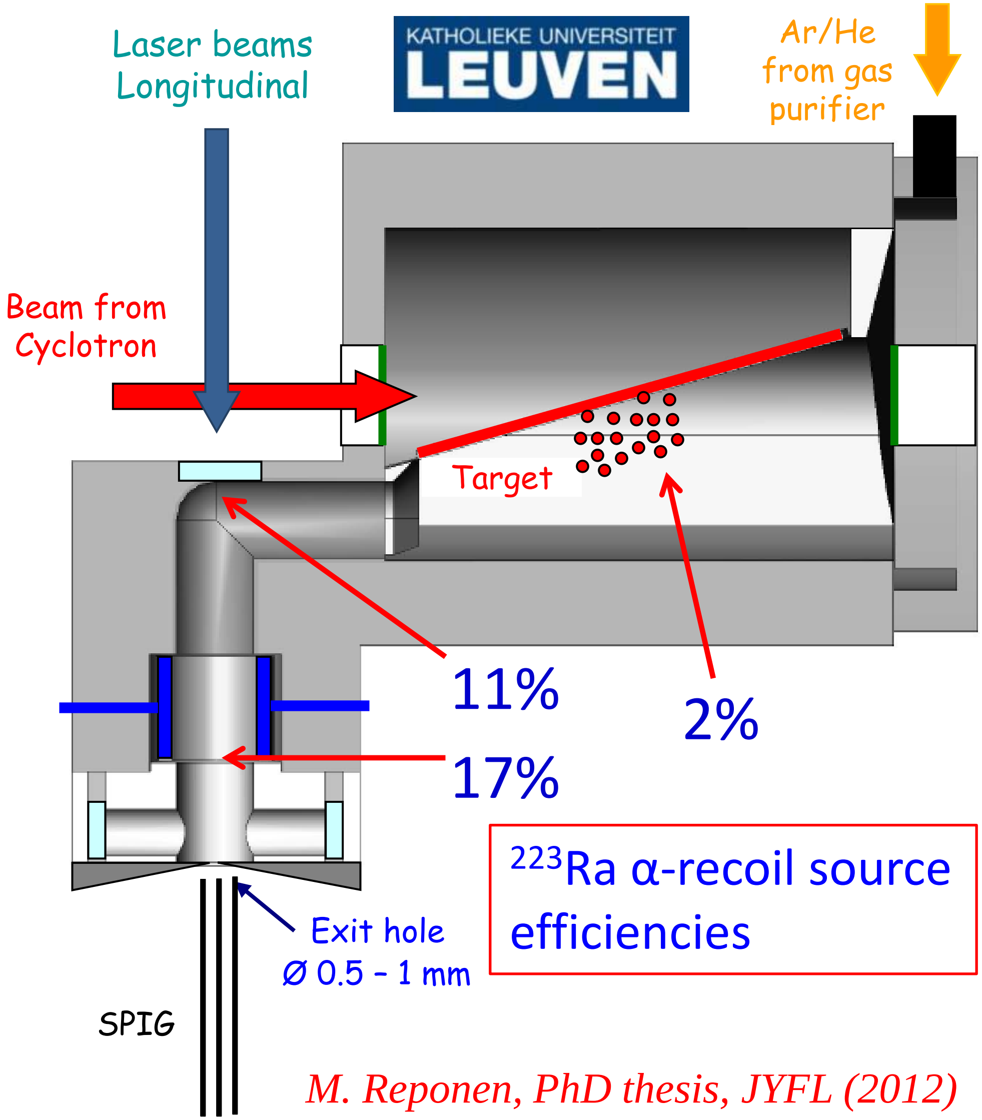
- repetition rate: ~10 kHz
- tuning range:

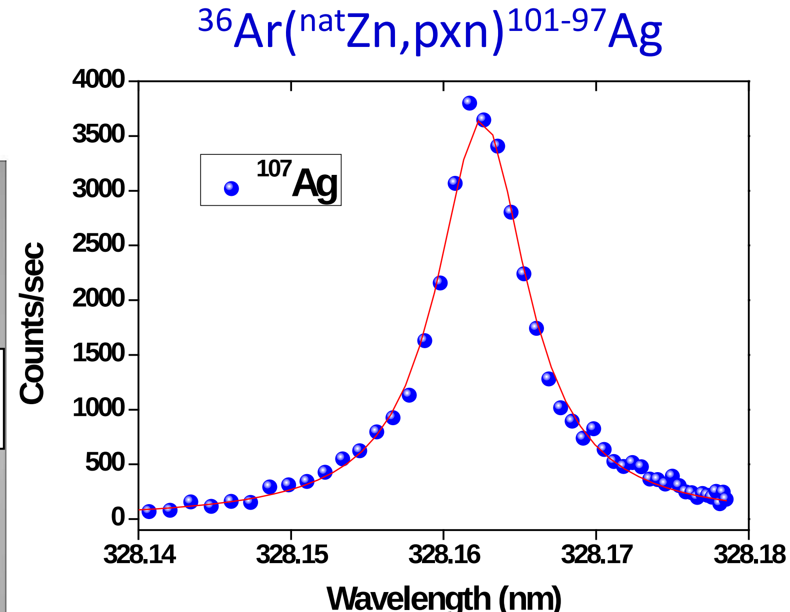
fundamental	700 - 1000 nm
frequency doubled	350 - 490 nm
frequency tripled	233 – 327 nm
frequency quadrupled	200 - 240 nm

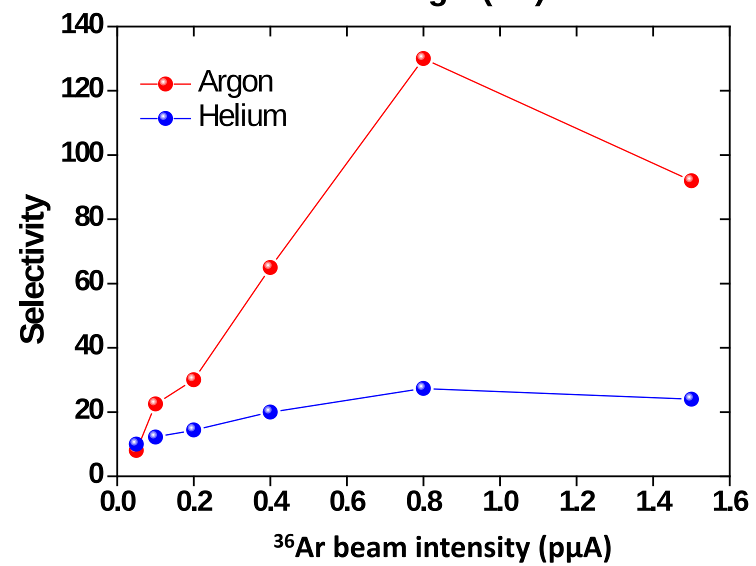
- laser linewidth: ~ 3-5 GHz

See poster #89, M. Reponen

Dual-chamber gas cell commissioning (2012)



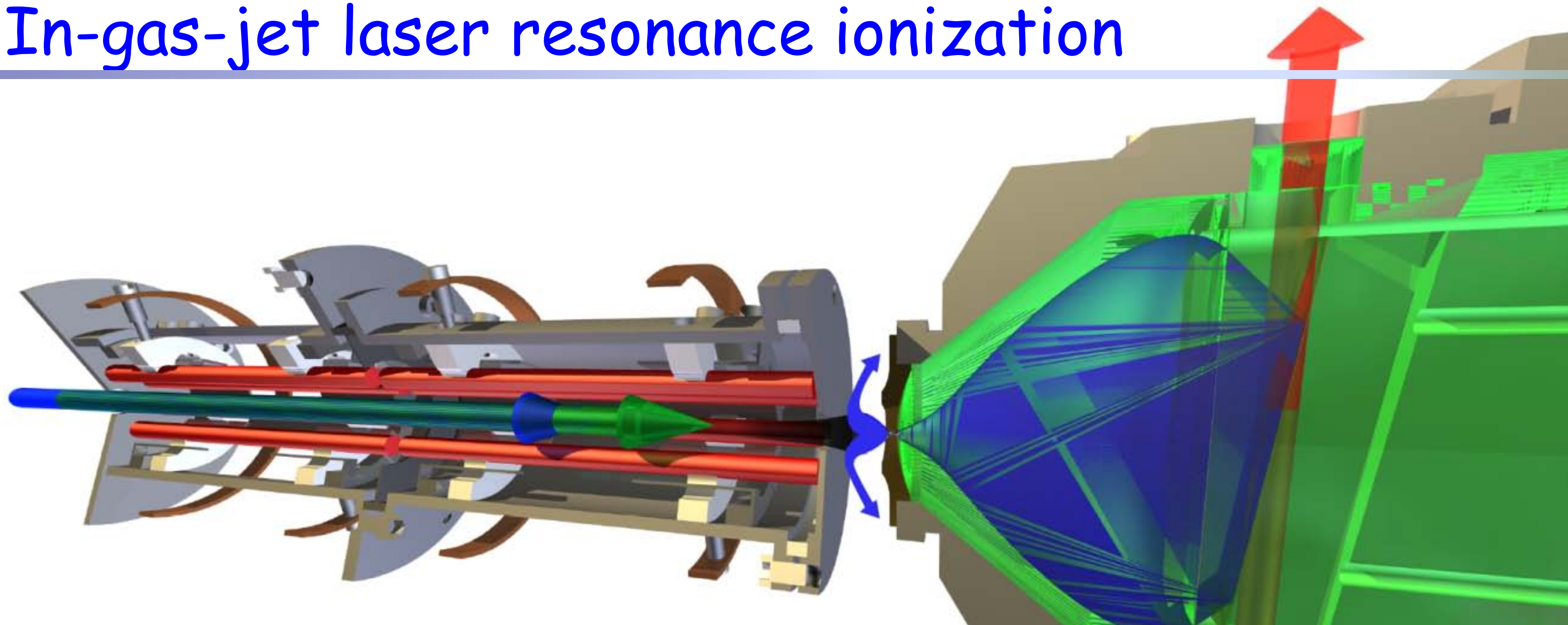




M. Reponen, PhD thesis, JYFL (2012)

Yu. Kudryavtsev et al., NIM B 267 (2009) 2908

In-gas-jet laser resonance ionization



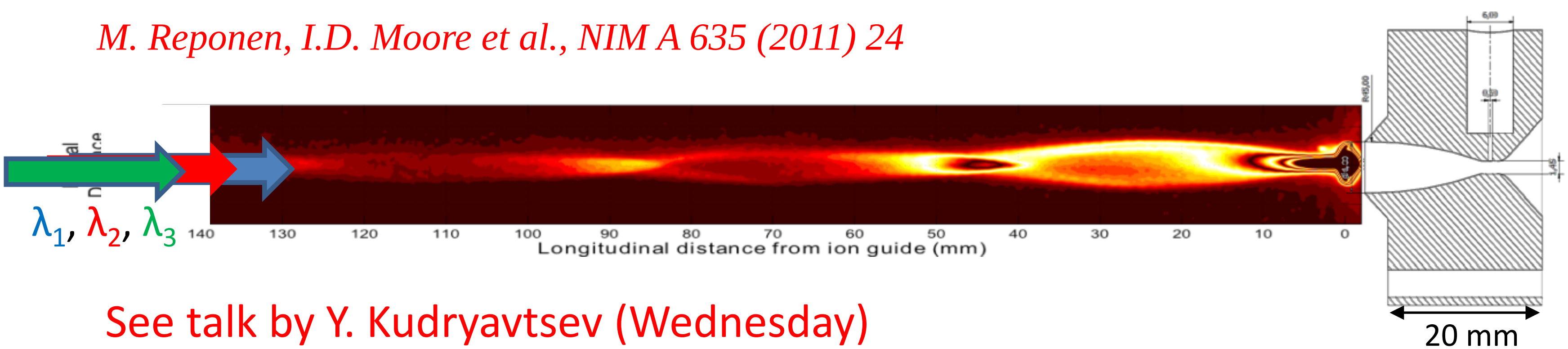
- Time overlap (high repetition rates)

  R. Ferrer-García, V. Sonnenschein et al., NIM B 291 (2012) 29

- Spatial overlap (nozzle design)

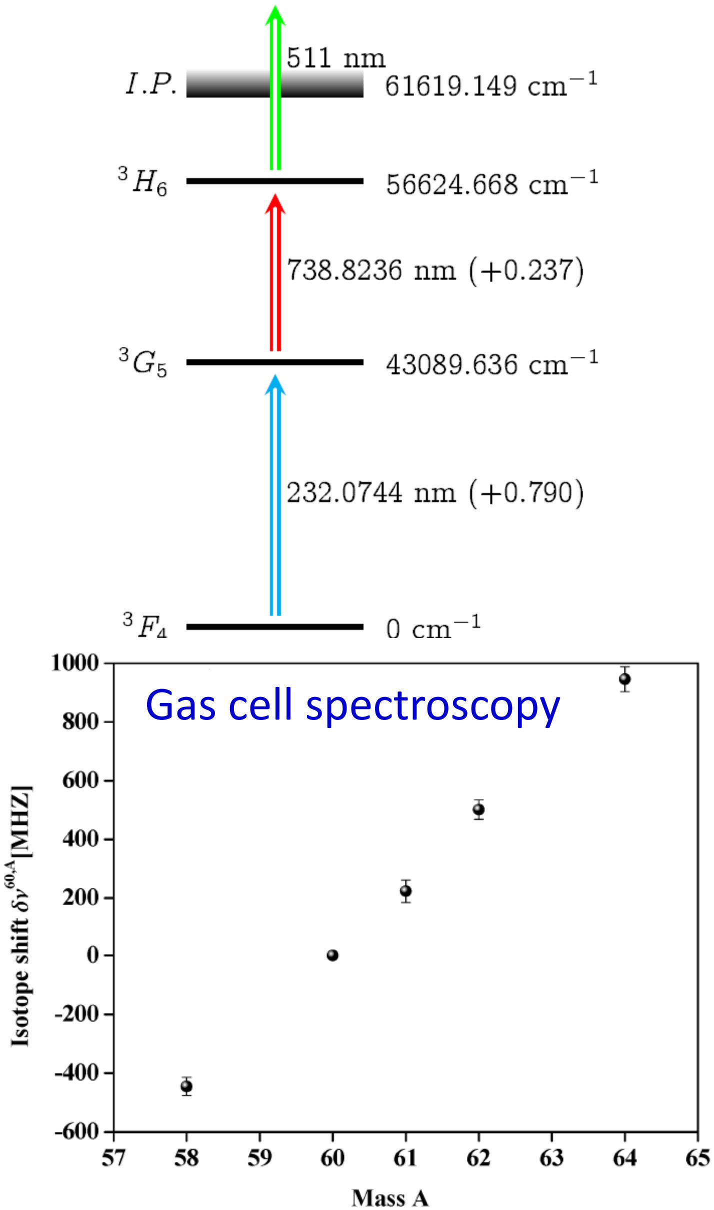
  Yu. Kudryavstev et al., accepted in NIMB (2012)

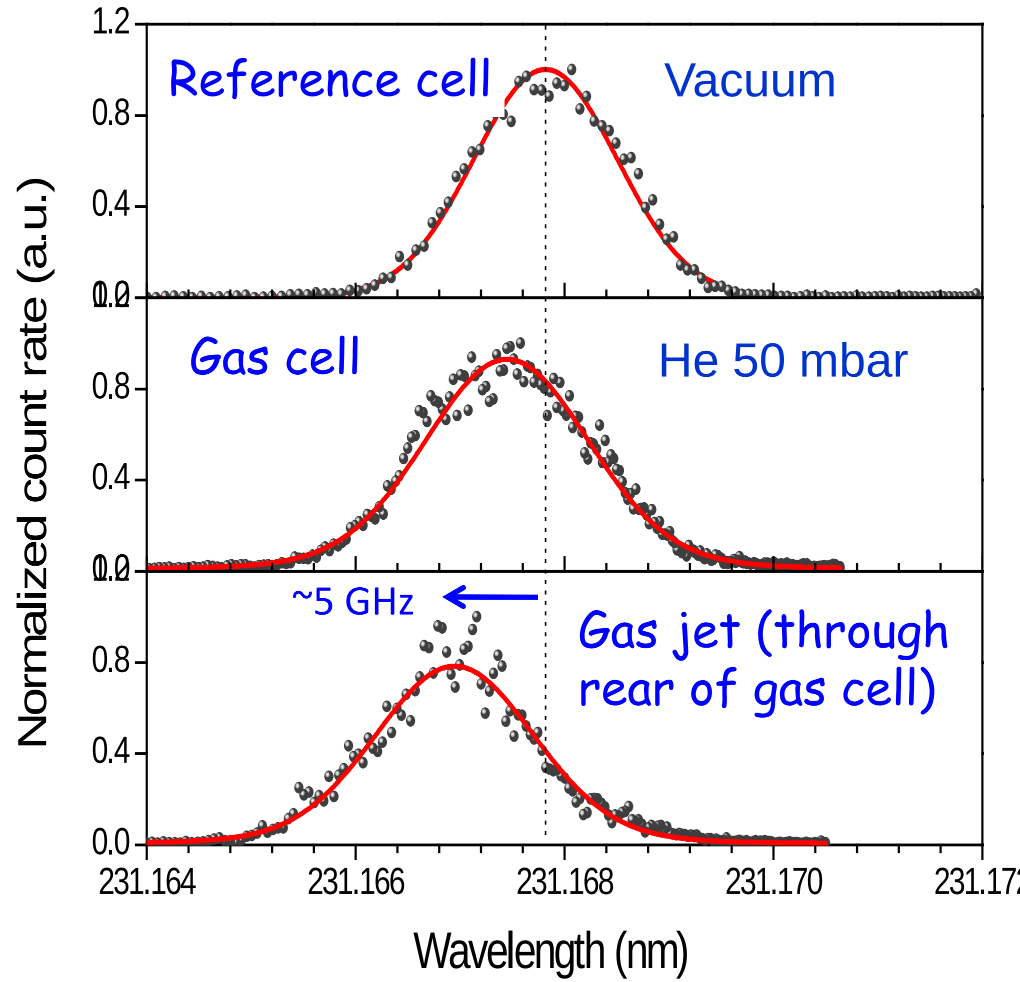
  M. Reponen, I.D. Moore et al., NIM A 635 (2011) 24



See talk by Y. Kudryavtsev (Wednesday)

Laser spectroscopy of Ni: gas cell vs. gas jet

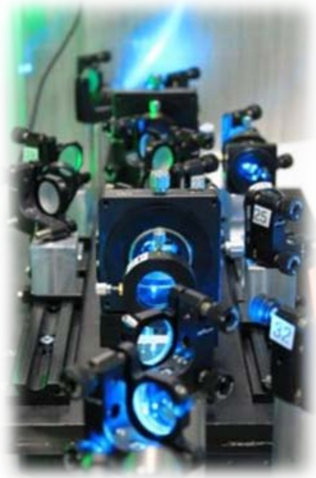


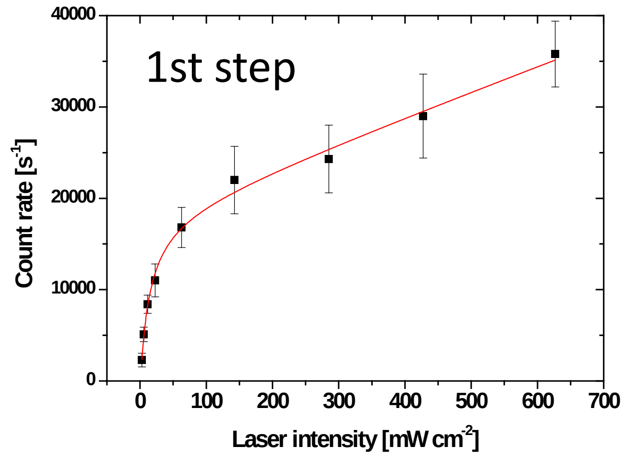


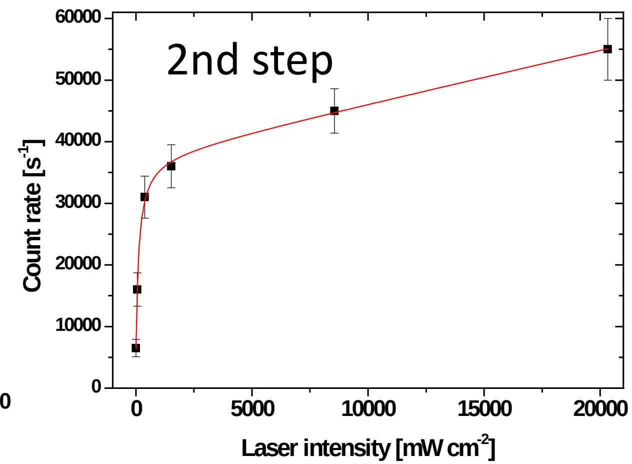
- 5 GHz Doppler shift corresponds to ~1130 m/s jet velocity

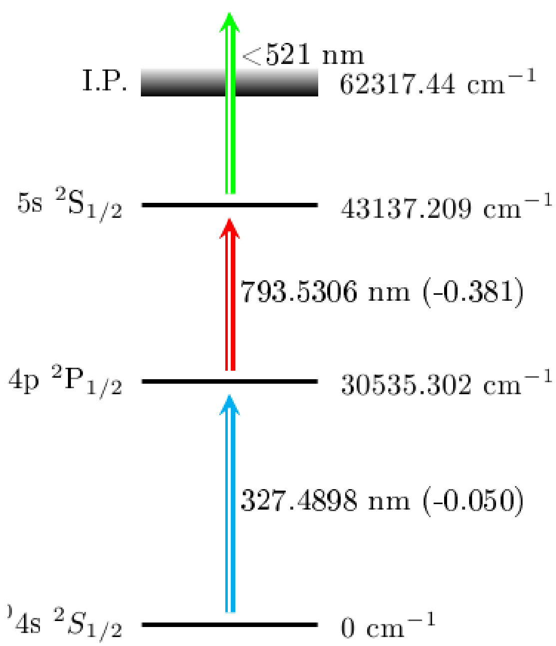
M. Reponen, I.D. Moore et al., EPJ A 48 (2012) 45

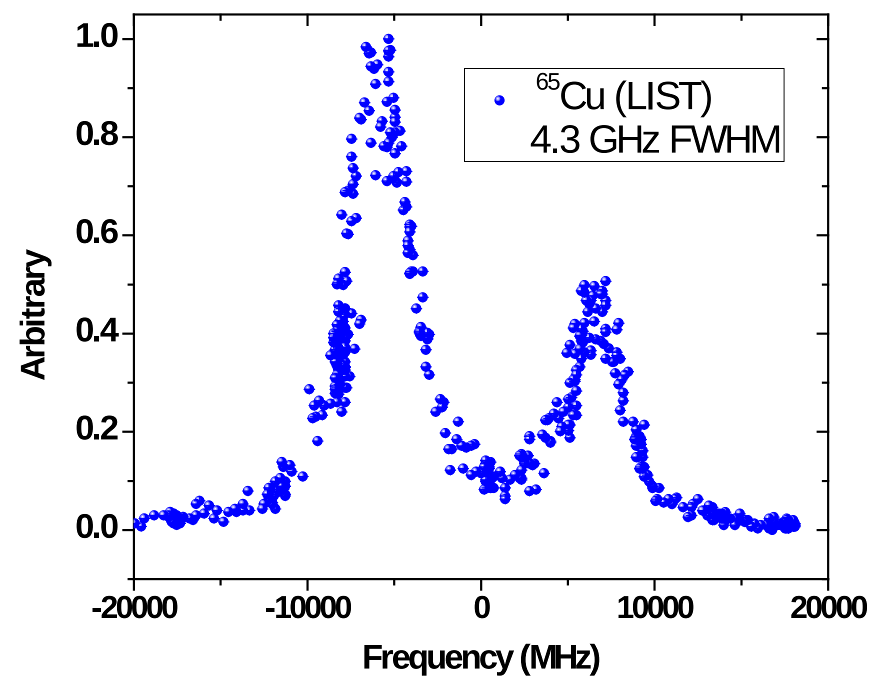
First gas jet ions in LIST geometry (^{65}Cu, Nov. 2012)











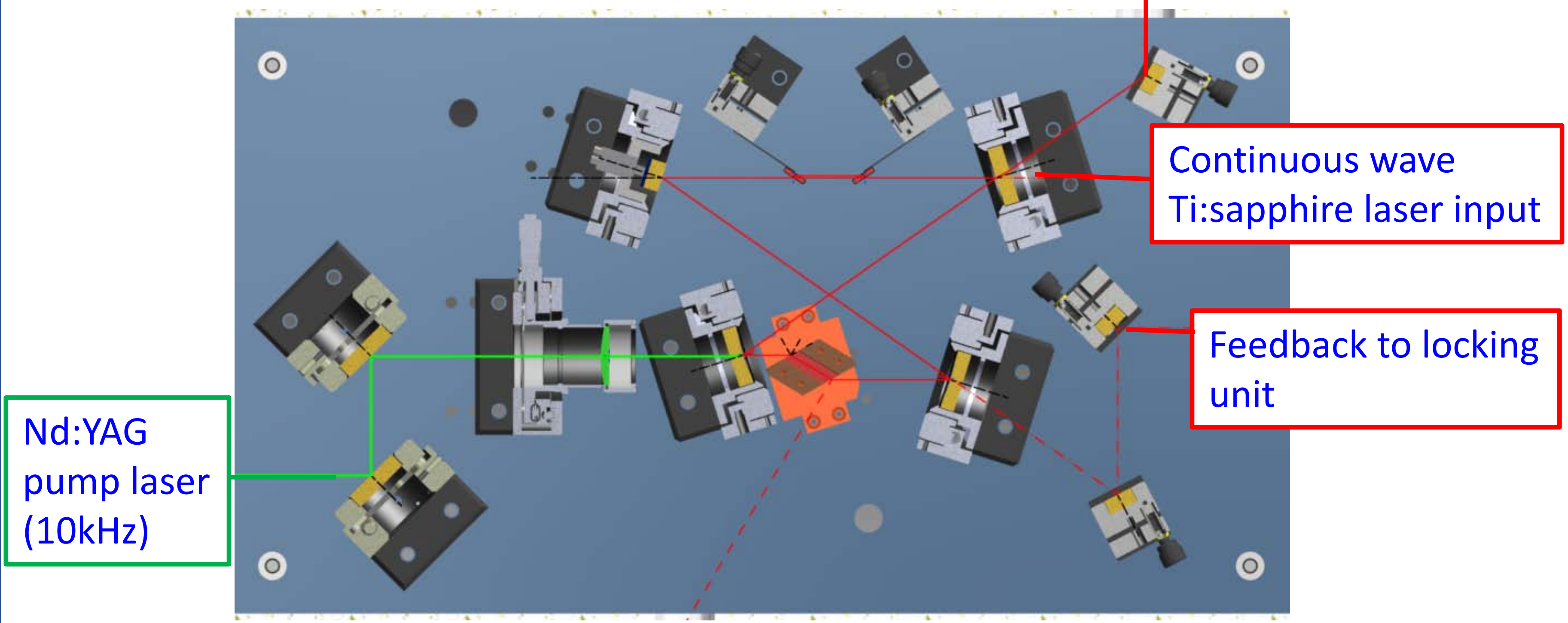
A stepwise reduction in laser linewidth

- Double-etalon combination in Ti:sapphire resonator (2012)

  Linewidth reduced to <1 GHz; See poster #131, S. Rothe

- Injection-locking of a pulsed Ti:sapphire (2013)

  Goal ~10 MHz; See poster #75, C. Sakamoto



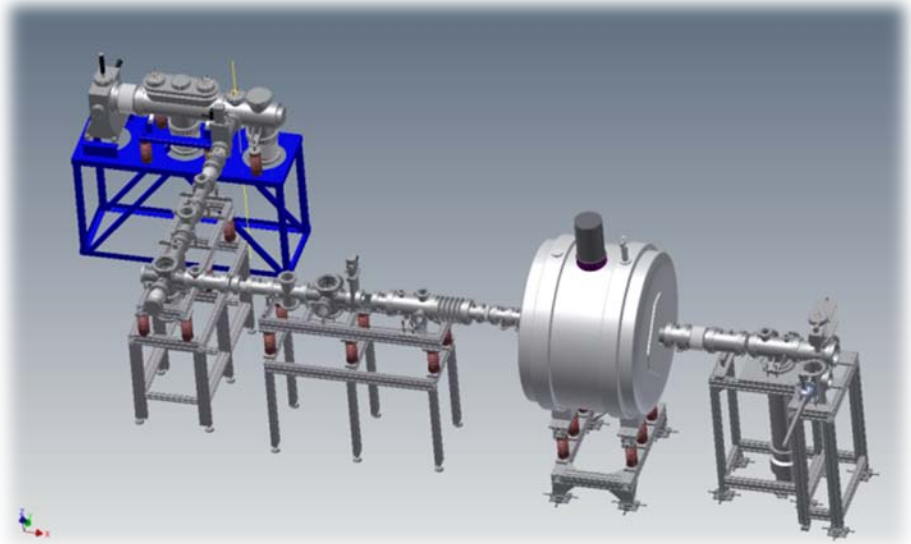
T. Kessler et al., Laser Phys. 18 (2008) 842

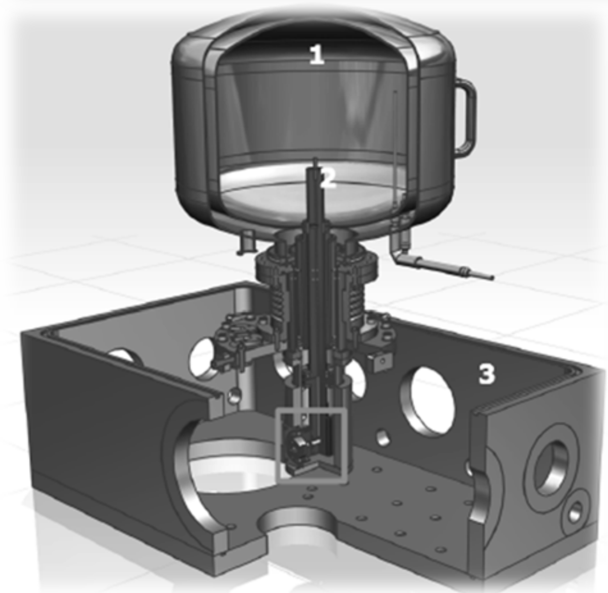
Future (after EMIS XVI)

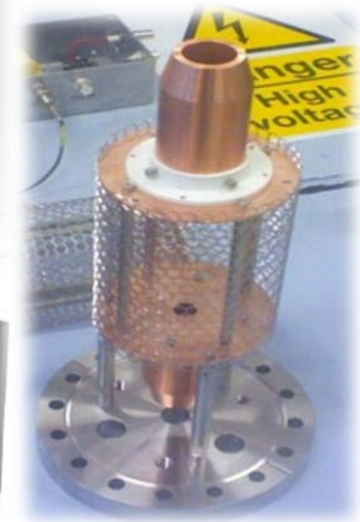
- Ion resonance ionization (in RFQ)
- MR-TOF-MS
- In-trap/post-trap spectroscopy (V. Kolhinen JYFLTRAP talk)
- Cone trap (Manchester)
- RF hot cavity (towards ^{94}Ag)
- Cryogenic ion guide
- ^{252}Cf source for laser ionization studies in ion guide QMS setup
- EBIT?

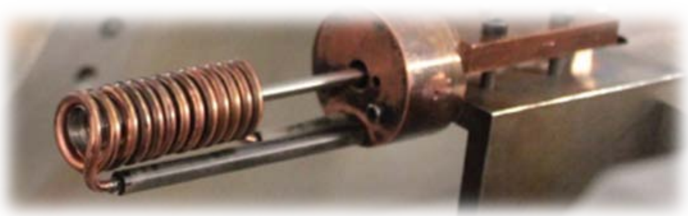
More beam time for longer and more complex experiments…

~200 days of proposals to go!









Thank you

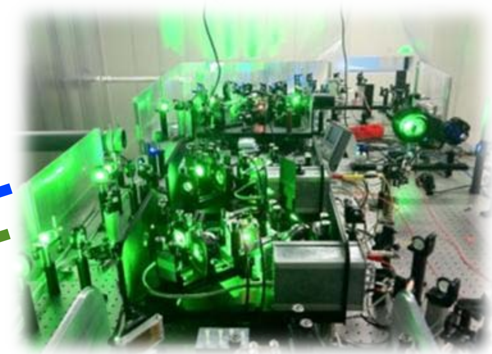
https://www.jyu.fi/fysiikka/en/research/accelerator/igisol

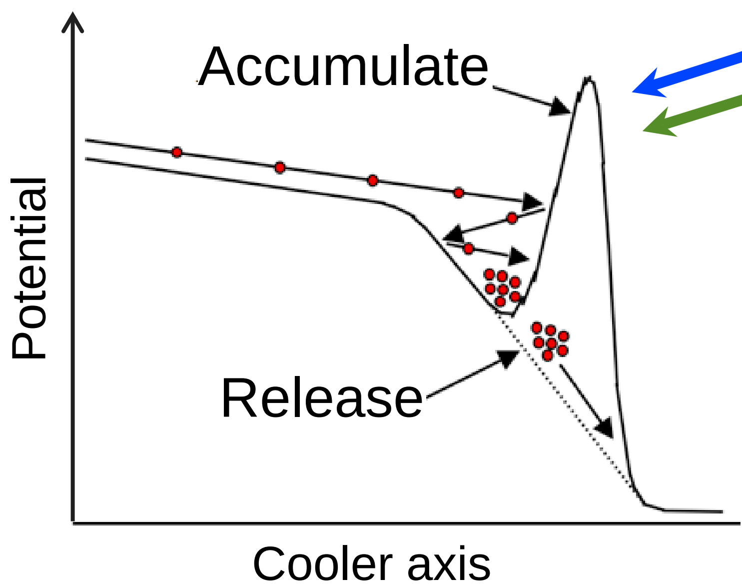
Other developments: ultra-pure beams from an rf cooler

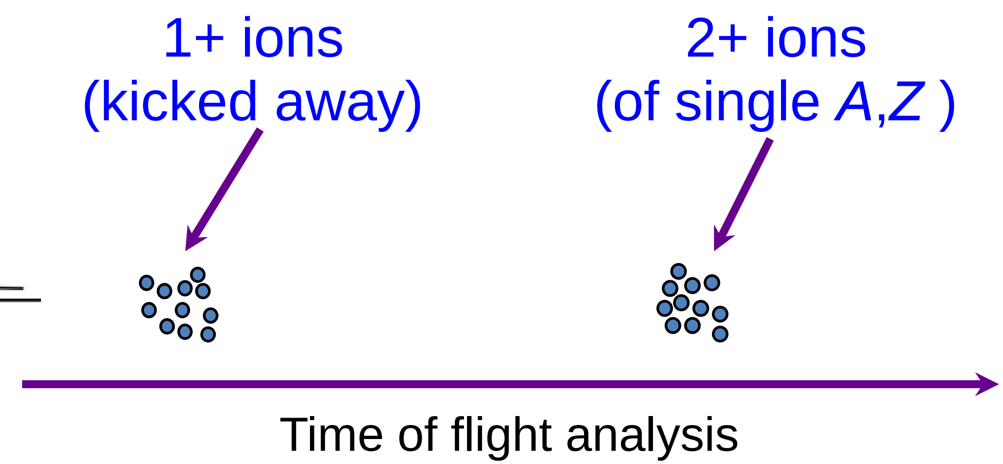
Proposal: B. Cheal

The University of Manchester

Lasers (resonantly ionize 1+ ⟶ 2+)



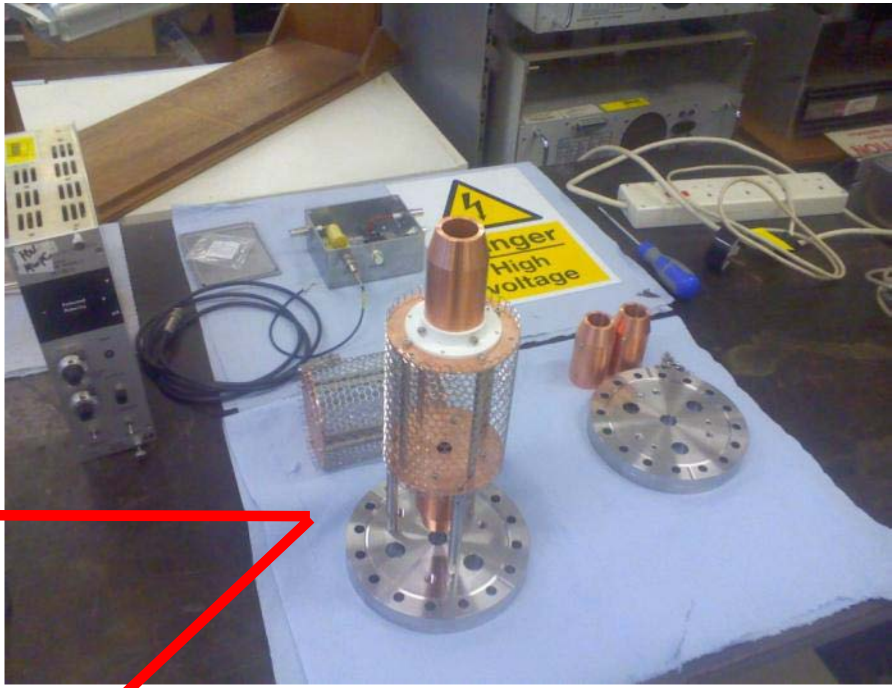


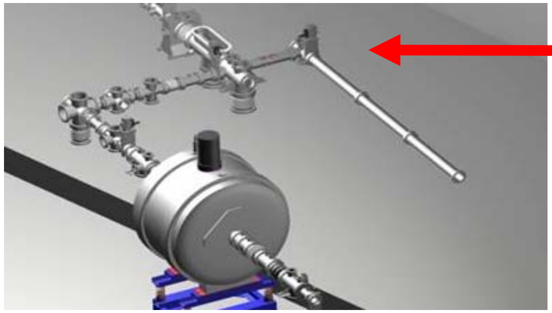


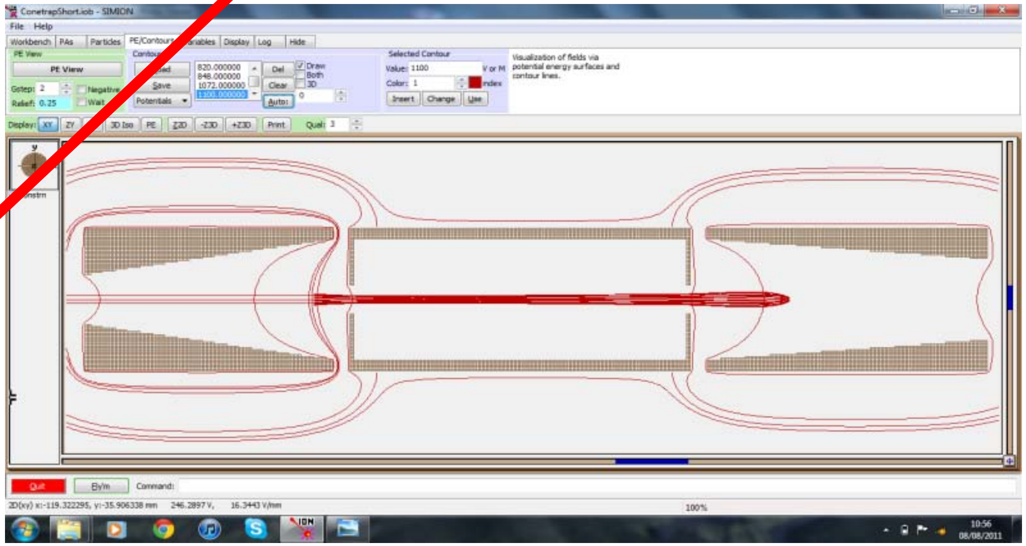
- Pure beam of single *A* **and** *Z*
- No contaminant will have *m/q* selected by magnet **and** *m/(2q)* selected by TOF (or other device)

Cone trap

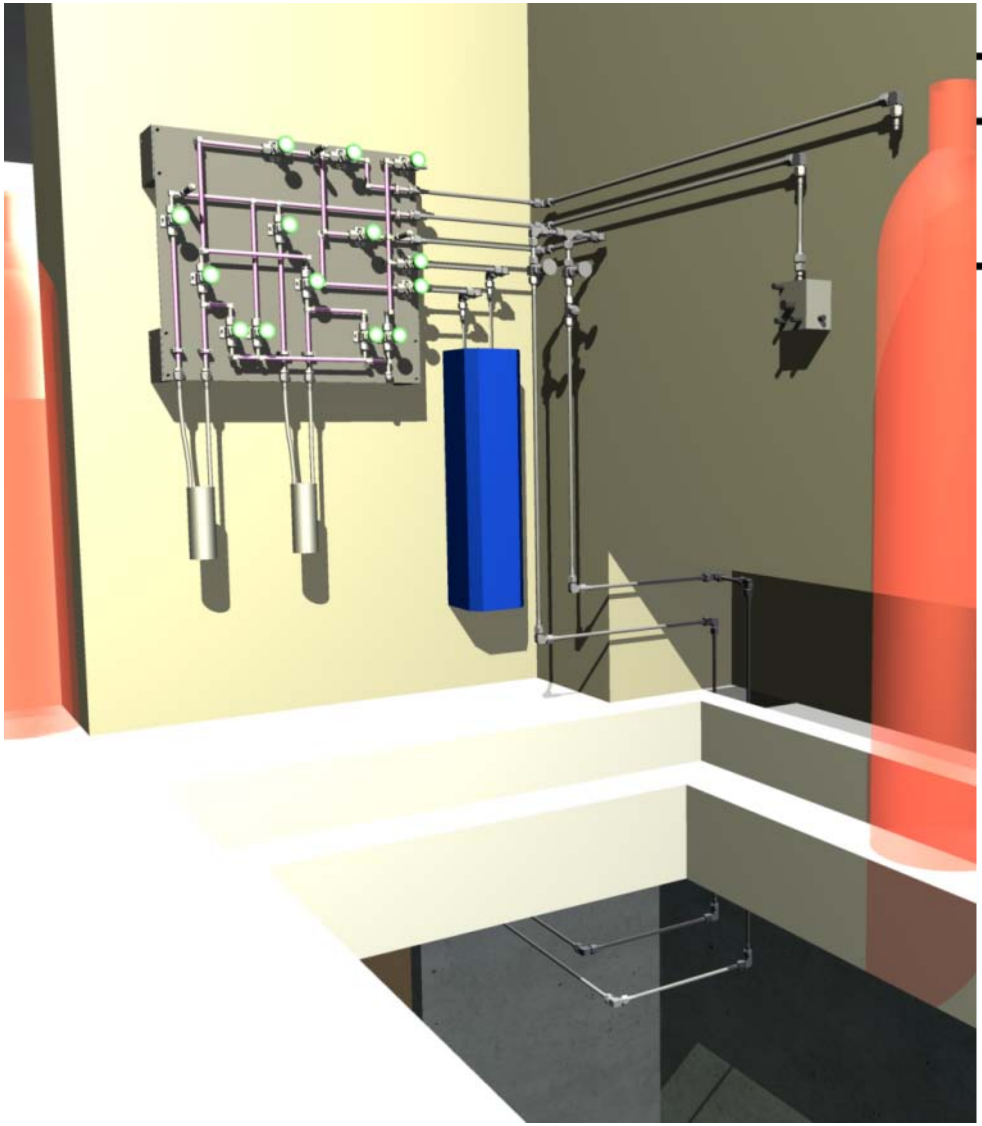
- ➔ UHV pumping (>1eV)
- ➔ RIS (purification)

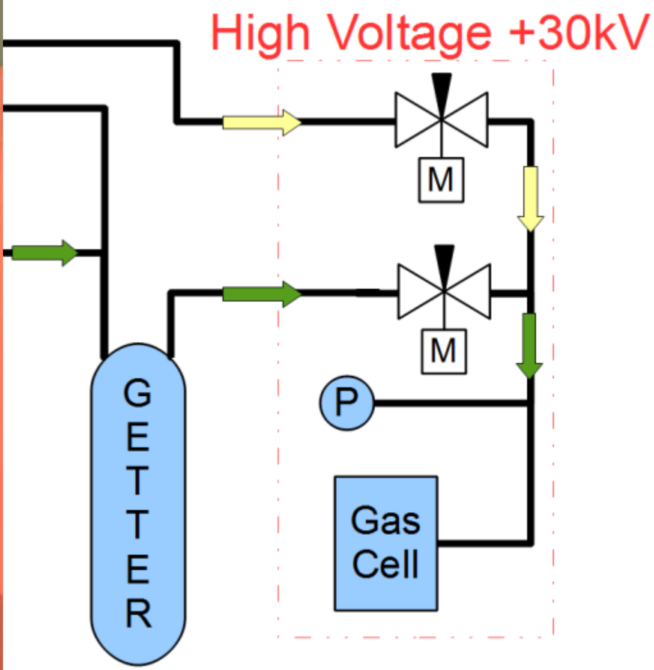






New buffer gas feeding system





- Goal: Sub-ppb level impurities
- Purification of recycled grade 4.6 helium
  - 13X-Zeolite cold traps for H_2O
  - MonoGetter for N_2 and O_2
- All lines bakeable

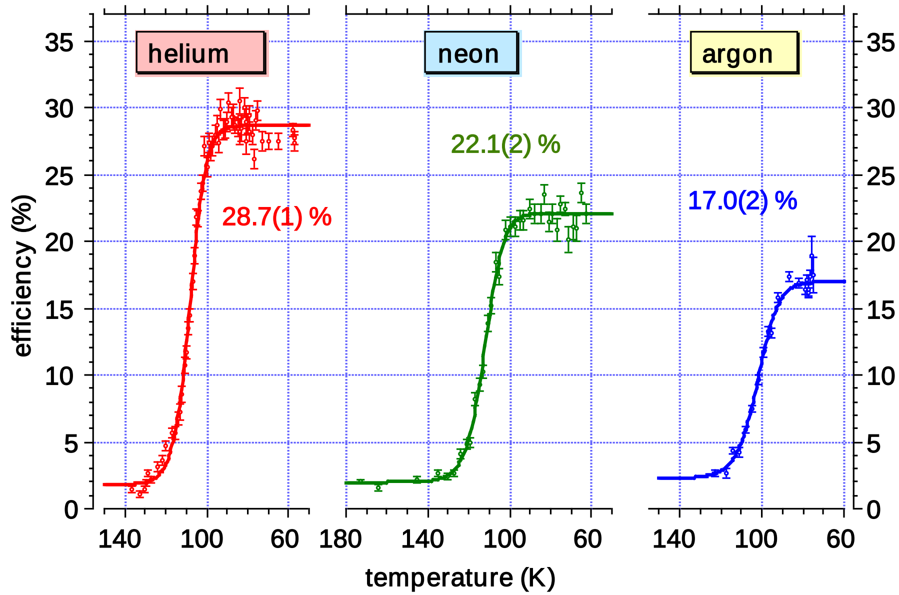
Courtesy of I. Pohjalainen

Cryogenic techniques at IGISOL

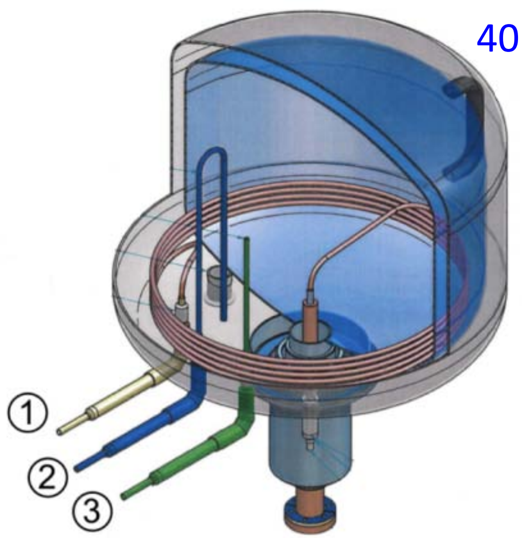
The motivation:

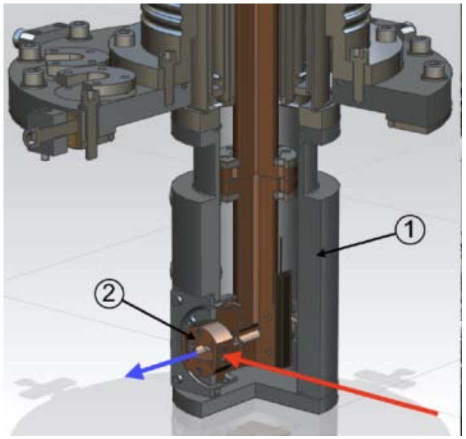
- Verify any obstacles to the use of high-density cryogenic He gas for RIB production
- Suppression of impurities thus improving the extraction efficiency

P. Dendooven et al., NIM A 558 (2006) 580



40 litre LN_2 bath

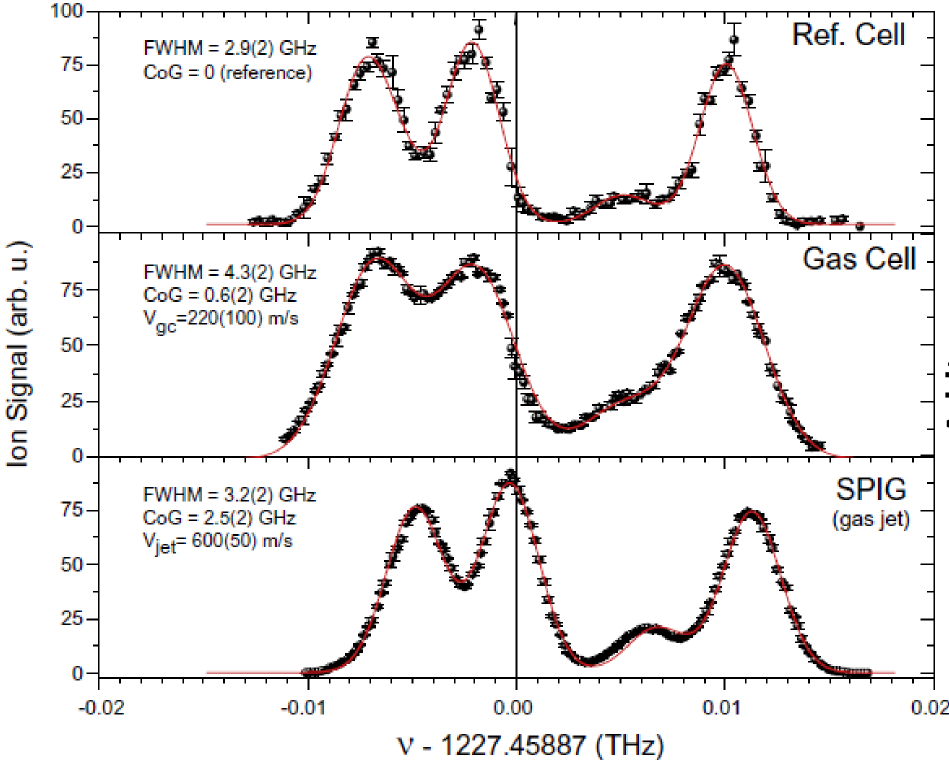


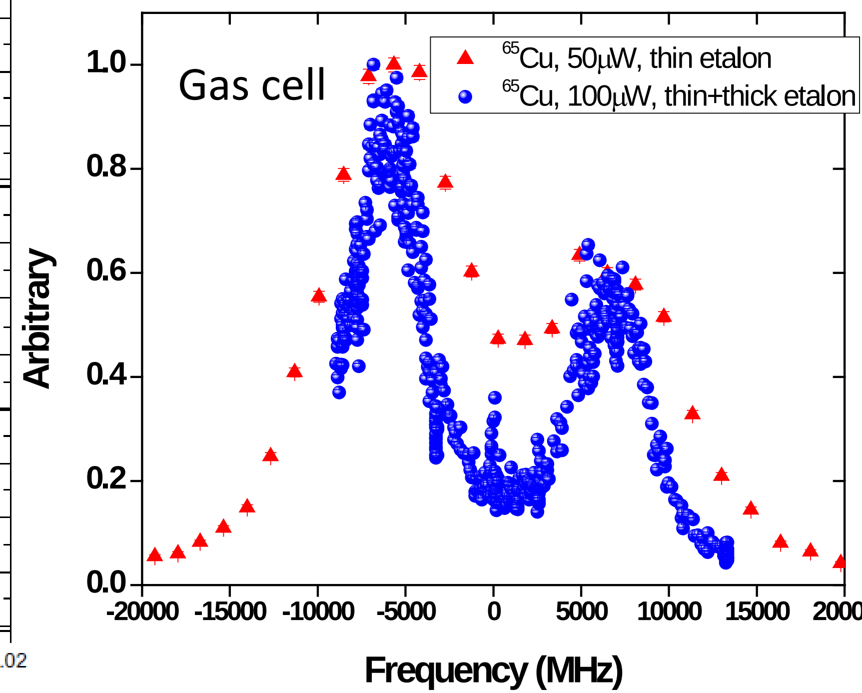


Cold finger and gas feeding line to light-ion ion guide

Stepwise reduction in laser linewidth I

Double-etalon combination in Ti:sapphire resonator

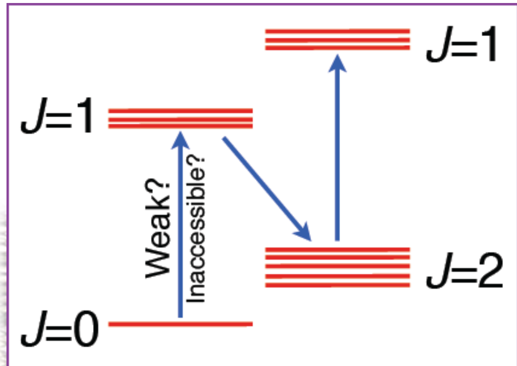




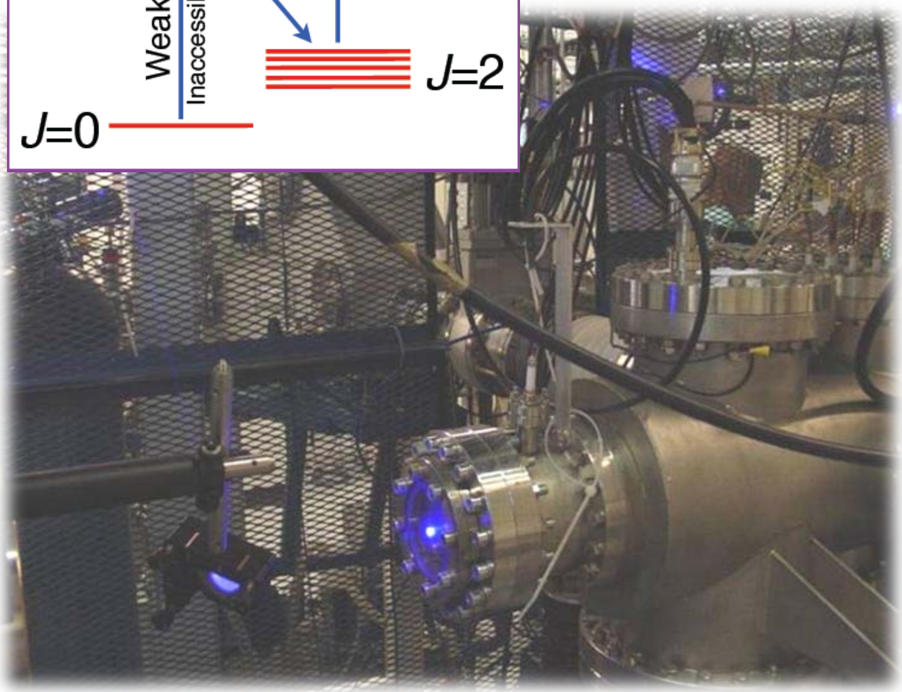
- 244 nm THG: 15 GHz to <3 GHz
- 327 nm THG: 5 GHz to 2 GHz

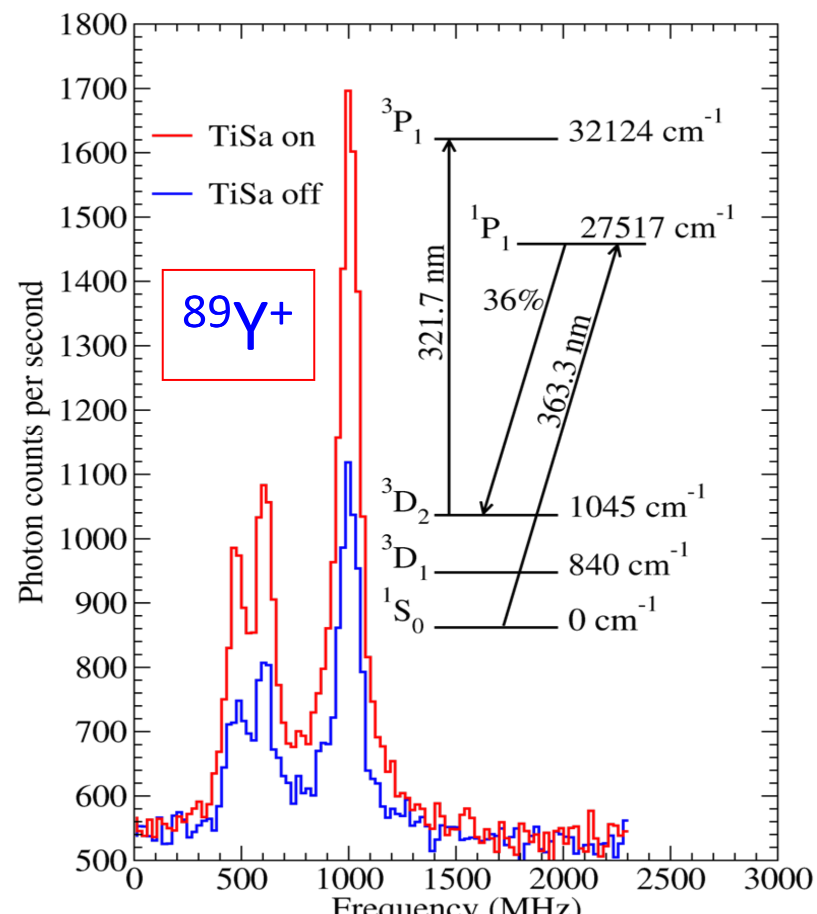
R. Ferrar, V. Sonnenschein et al., NIM B 291 (2012) 29

Optical manipulation of atomic states



- J=0 → J=1 gives μ, Q, $\delta\langle r^2\rangle$ but not I
- Access to more accessible/efficient transitions
- New elements to study (eg. transition metals)





F.C. Charwood et al., Phys. Lett. B ***674*** *(2009) 23*
B. Cheal et al., Phys. Rev. Lett. ***102*** *(2009) 222501*

Future extension: polarization of beams