Laser spectroscopy of nobelium

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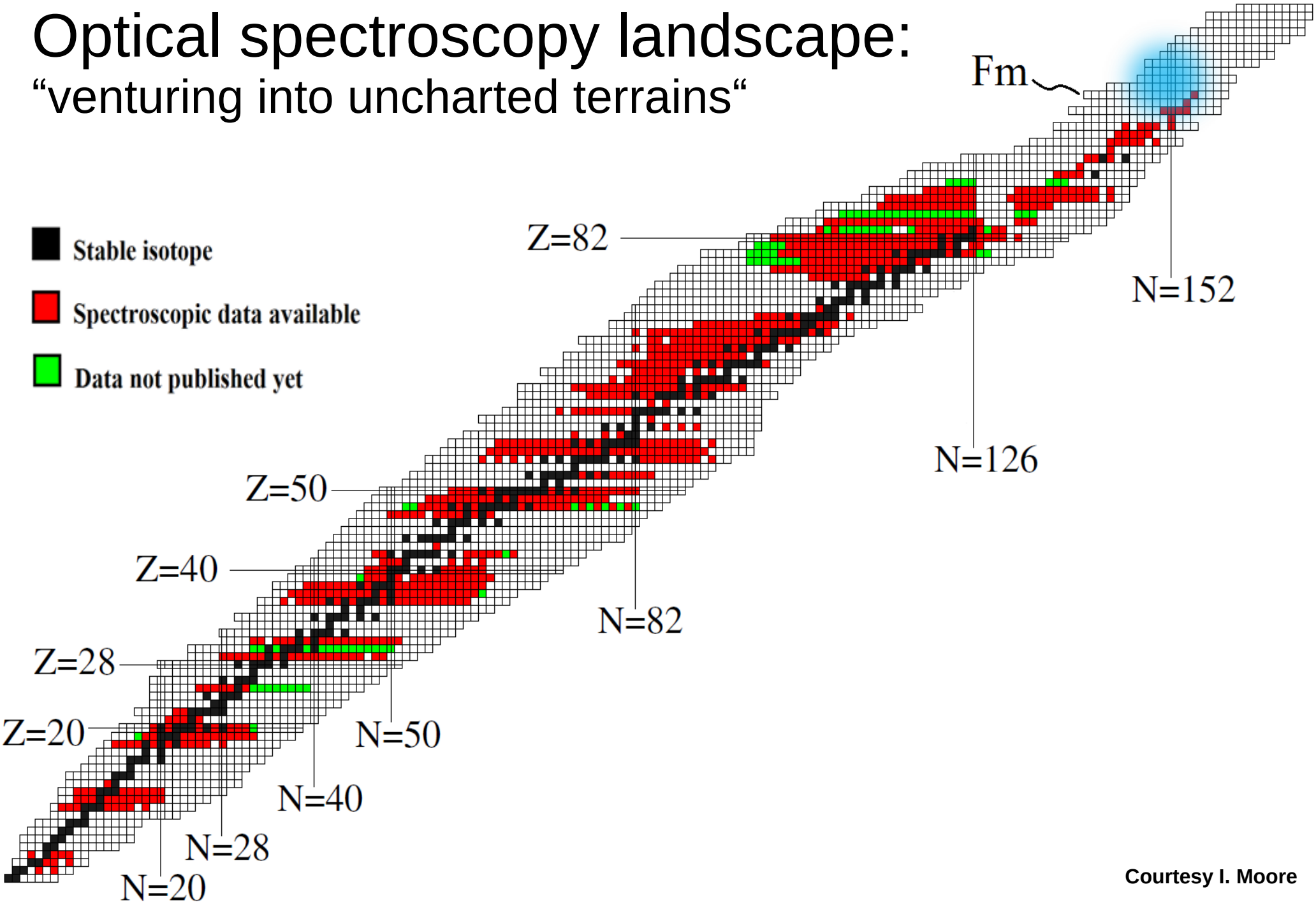
Outline

- Motivation
- Experimental method
- Results
- Conclusions
- Future prospects

Optical spectroscopy landscape:

“venturing into uncharted terrains“



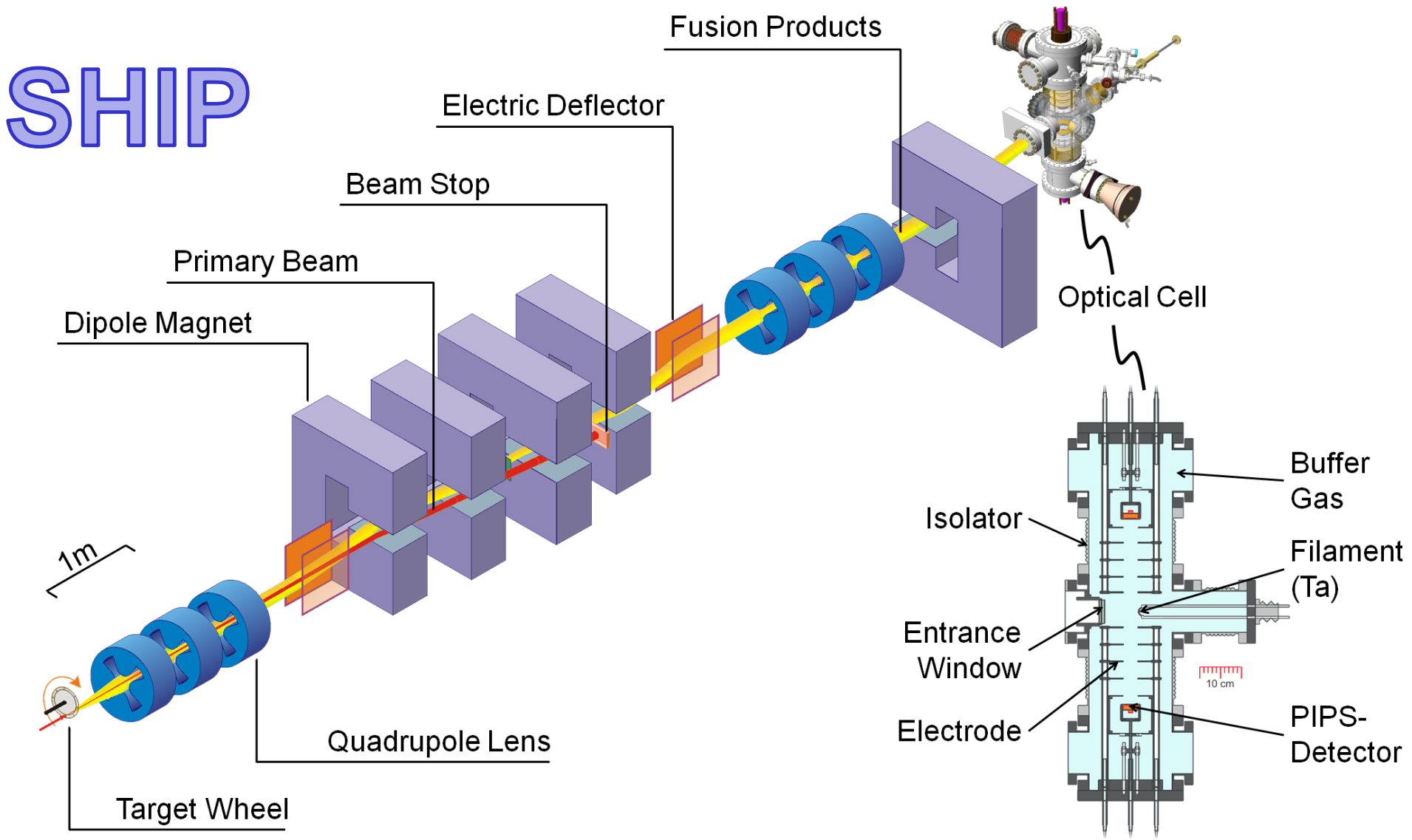
Courtesy I. Moore

Nobelium isotopes

- Element of interest: No (Z=102)
  - GS: [Rn]$5f^{14}7s^2\ {}^1S_0$
  - Relatively high production cross sections

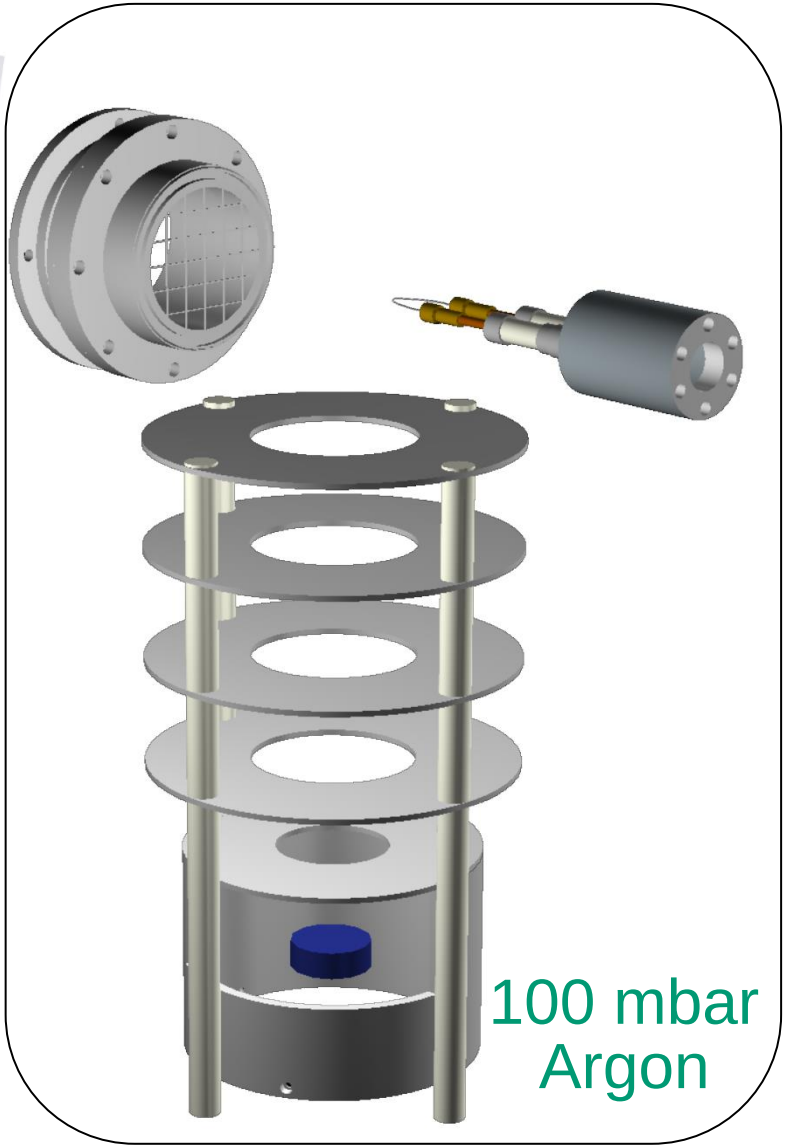
Isotope	I^P	$T_{1/2}$ (s)	Nuclear reaction	Production rate @ 1μA_P (1/s)	α- energy (MeV)
^{252}No	0	2.1	^{206}Pb(^{48}Ca,2n)^{252}No	4	8.42
^{253}No	$(9/2^-)$	102	^{207}Pb(^{48}Ca,2n)^{253}No	11	8.01
^{254}No	0	55	^{208}Pb(^{48}Ca,2n)^{254}No	17	8.10
^{255}No	$(1/2^+)$	186	^{208}Pb(^{48}Ca,1n)^{255}No	2	8.12

Experimental Setup

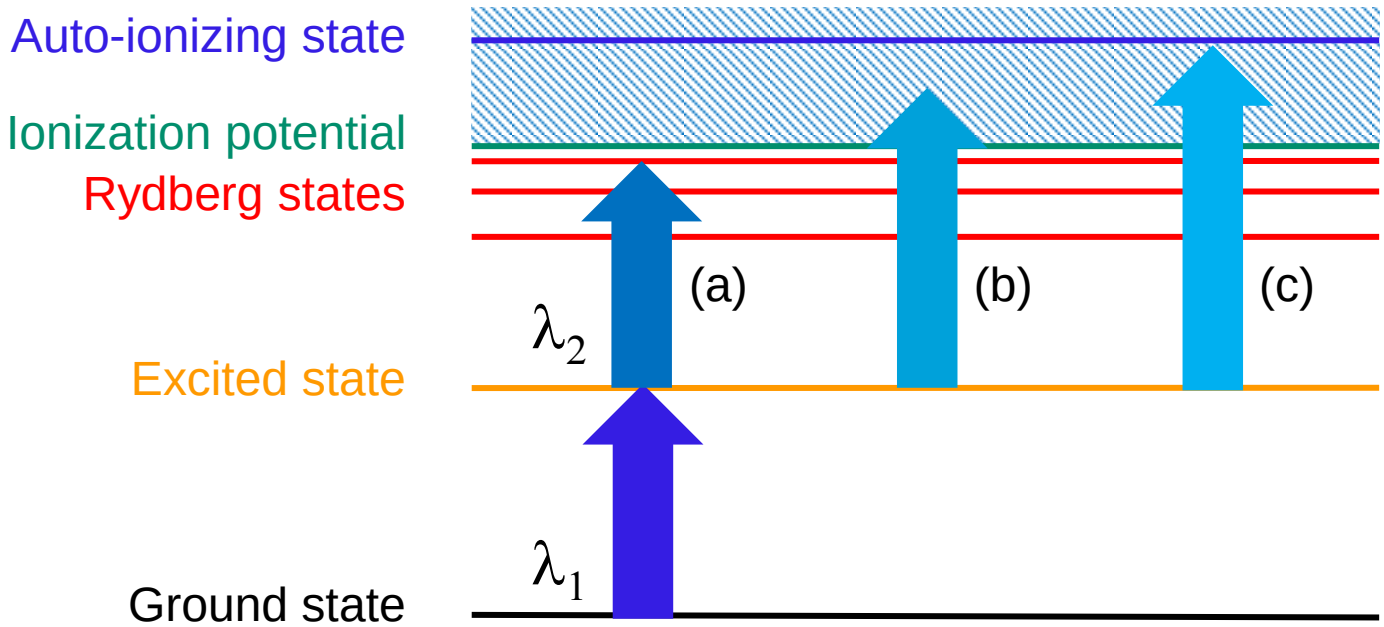


Radiation Detected Resonance Ionization Spectroscopy (RADRIS)

SHIP

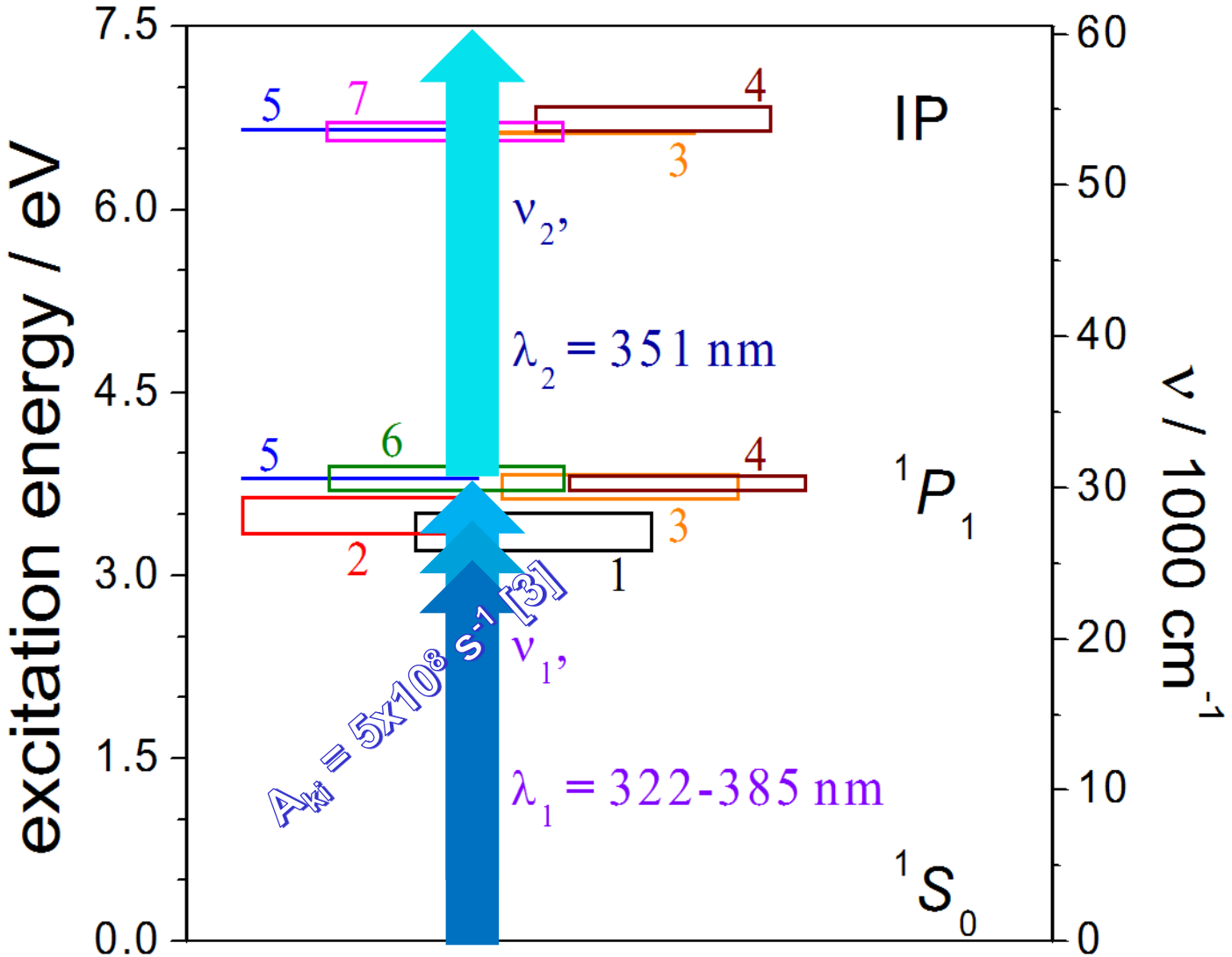


Laser spectroscopy: “2–Step Resonance Ionization”



- (b) about 2 orders of magnitude less efficient compared with (a) and (c)

Excitation scheme & predictions



1 (MCDF): S.Fritzsche, Eur. Phys. J. D 33 (2005) 15

2 (MCDF): S.Fritzsche, Eur. Phys. J. D 33 (2005) 15

3 (IHFSCC): A.Borschevsky et al., Phys. Rev. A 75 (2007) 042514

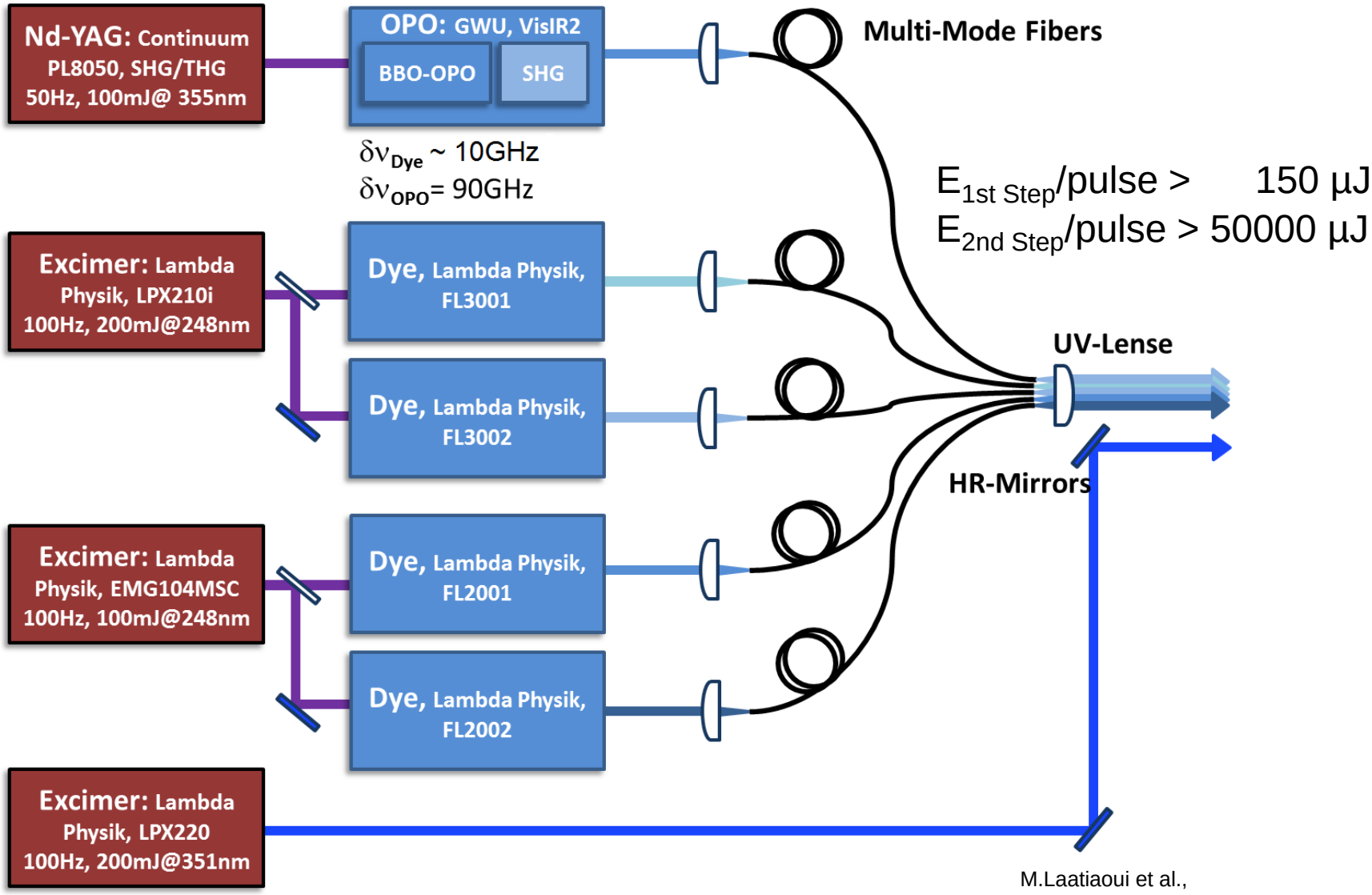
4 (RCC): V.A.Dzuba et al., Phys. Rev. A 90 (2014) 012504

5 (MCDF): Y.Liu et al., Phys. Rev. A 76 (2007) 062503

6 (MCDF): P.Indelicato et al., Eur. Phys. J. D 45 (2007) 155

7 (extrapolation): J.Sugar, J. Chem. Phys. 60 (1974) 4103

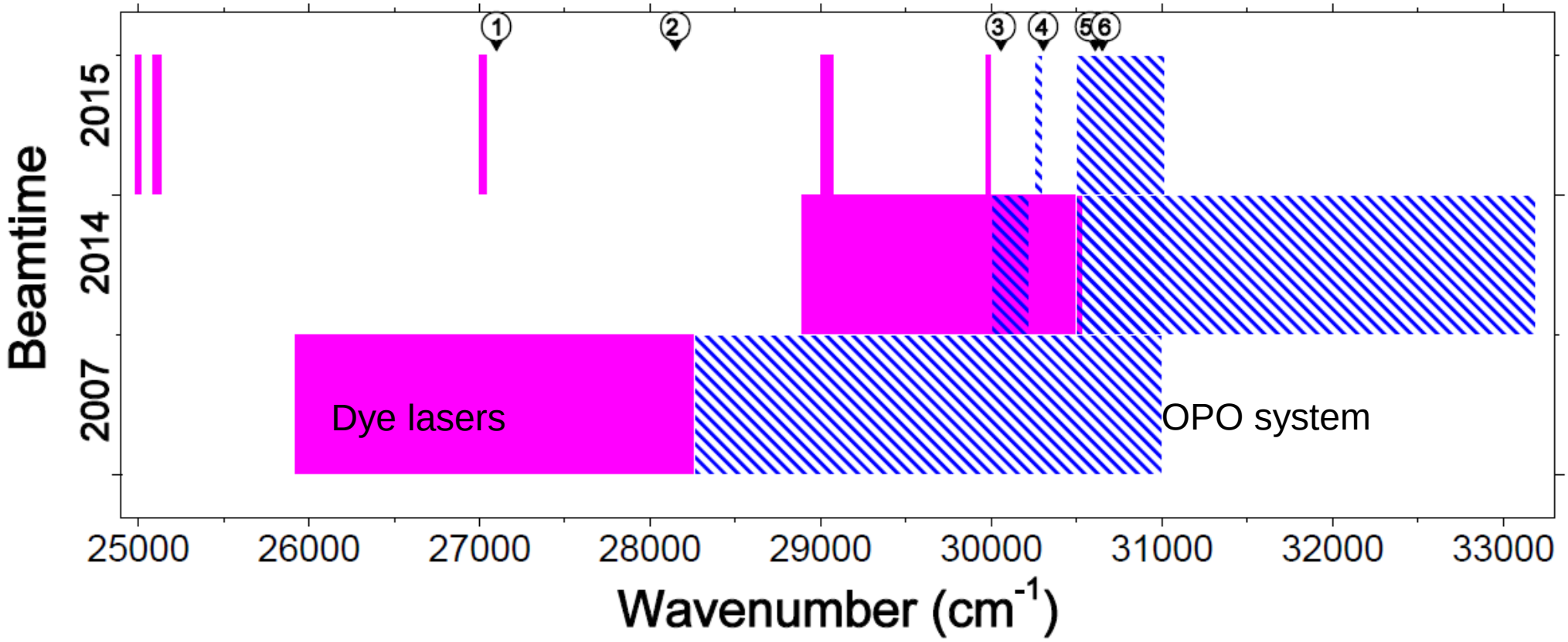
Laser systems



M.Laatiaoui et al.,
Hyperfine Interact. **227** (2014) 69

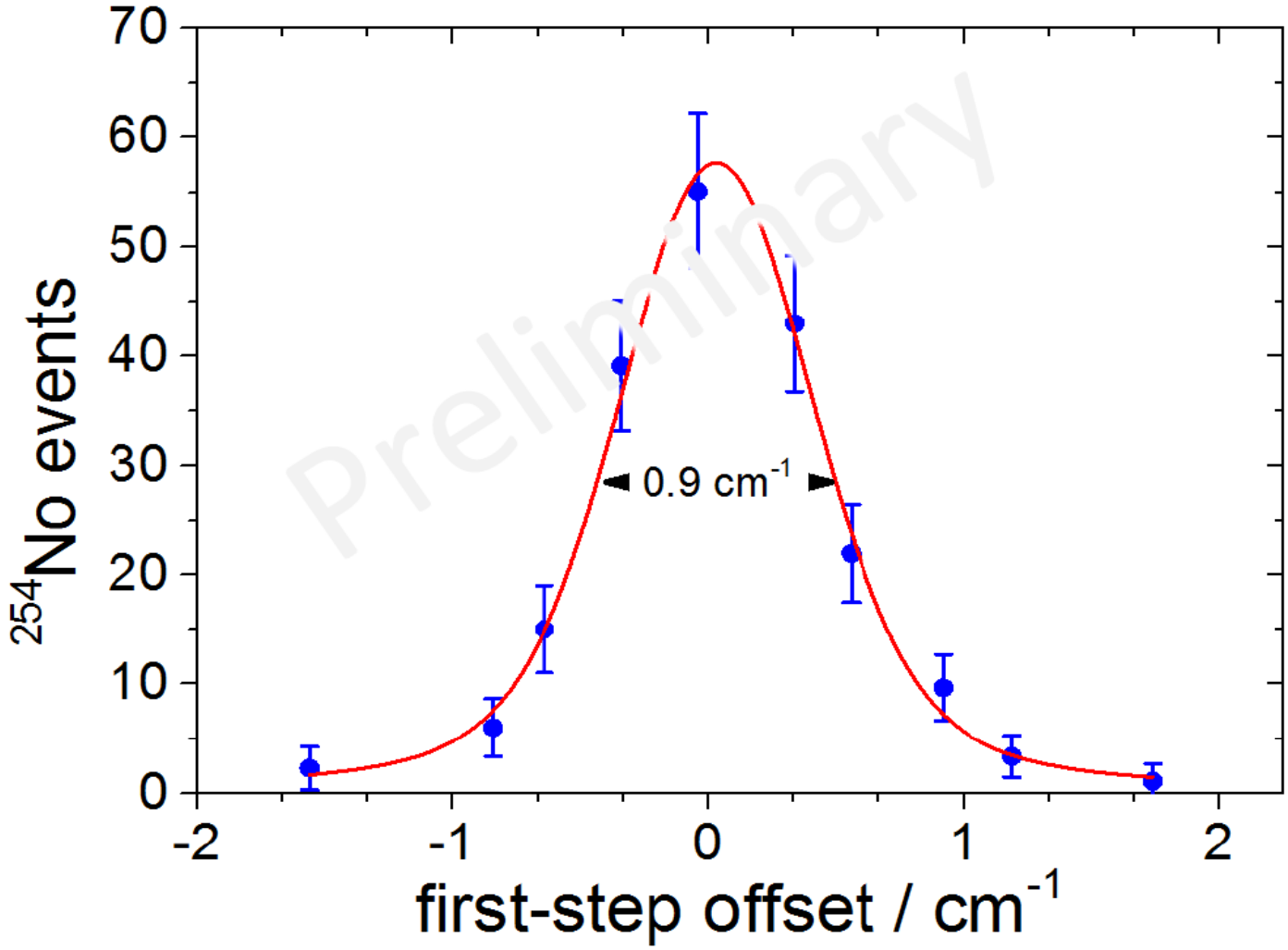
Level search in ^{254}No

Year	2007	2014
Scan range (cm^{-1})	25920 – 31001	28887 – 33191
Net scan time (h)	39	67



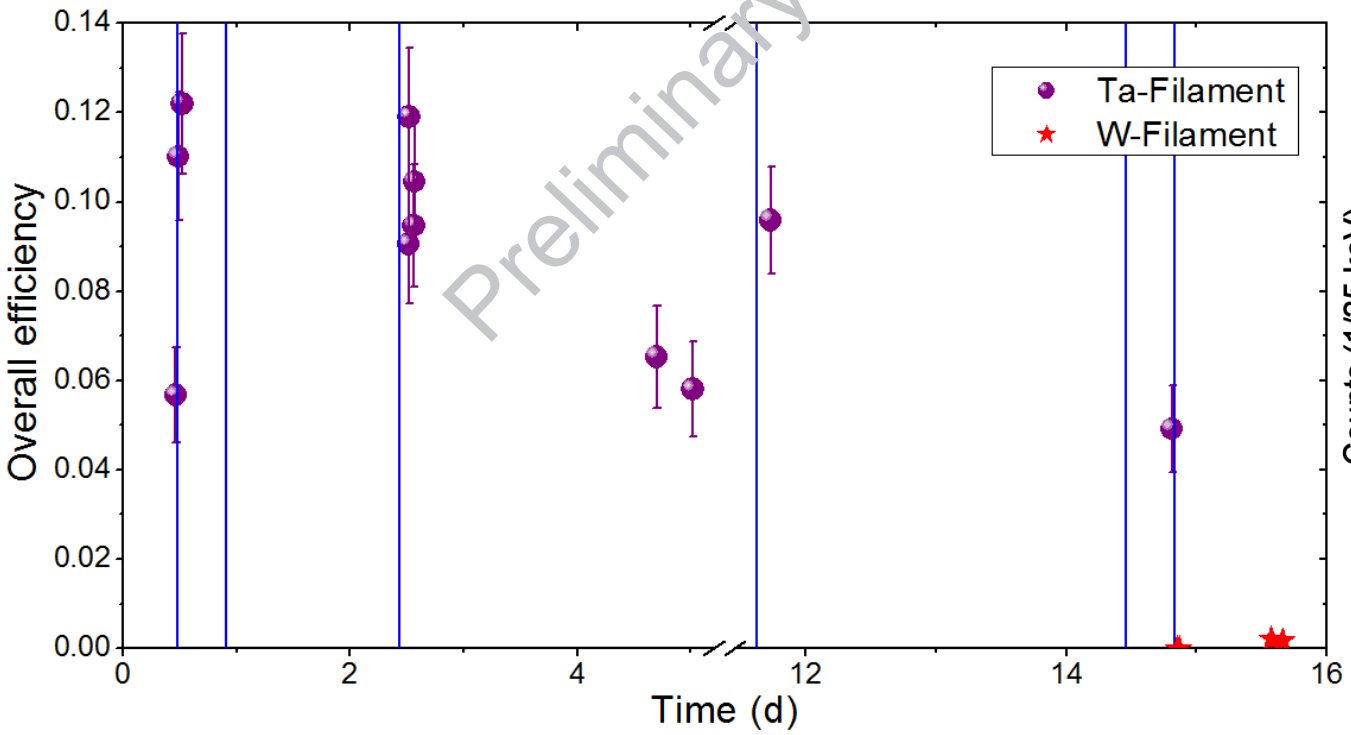
1: MCDF (2005), 2: MCDF (2005), 3: IHFSCC (2007), 4: RCC (2014), 5: MCDF (2007), 6: MCDF (2007)

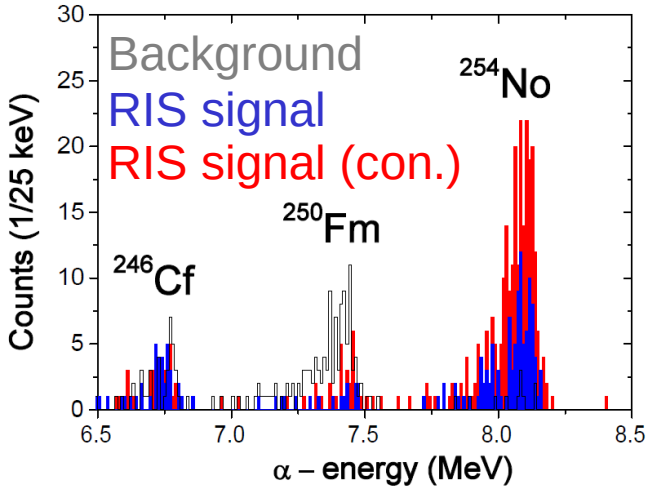
Finally, we got it!



The overall efficiency

- Selectivity of about 25 has been reached for No-254.
- Reproducible overall efficiency of about 6.4(10) % for No-254 using Ta-filaments.
- For a rel. short time, efficiency enhancement after filament conditioning
- 0 % efficiency obtained for W-filaments.





Conclusions

- Laser spectroscopy of elements beyond fermium is possible!

- The detected resonance corresponds to the strongest ground-state transition in the nobelium (Z=102) atom, the $^{1}S_{0} \rightarrow {}^{1}P_{1}$ – transition.

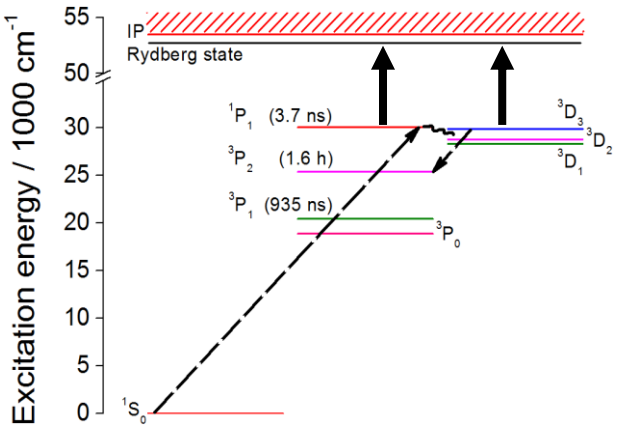
- An overall efficiency of about 6.4% was achieved for the isotope ^{254}No.

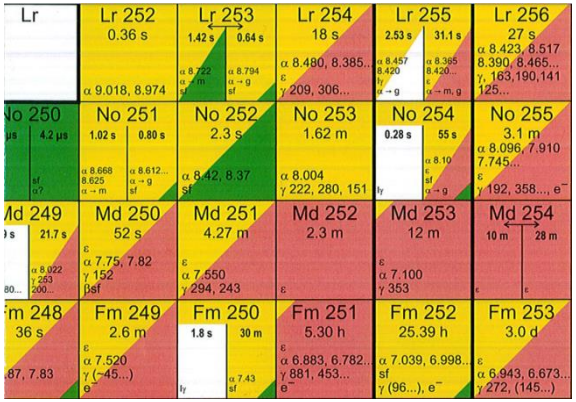
- Few Rydberg states near the IP were observed.
Limits for the IP were extracted.

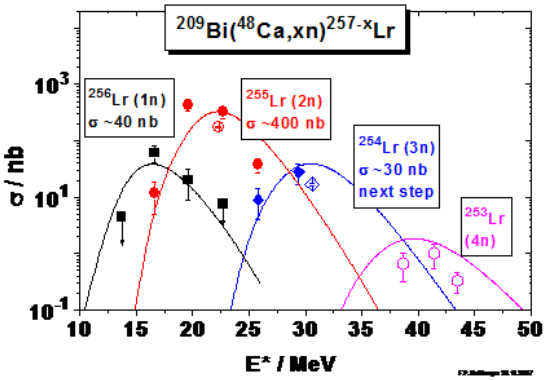
- Hyperfine structure and isotope shift measurements were successfully performed for the isotopes ^{253}No and $^{252\text{-}254}$No, respectively (data analysis in progress).

Future prospects

- More Rydberg studies in nobelium
- Laser spectroscopy of the element lawrencium (Z=103)
  - Studying desorption and surface ionization mechanisms ...
  - First level search around 497nm (excited state: $7s^2 8s\ ^2S_{1/2}$)
- (Optional: Laser spectroscopy of ^{255}No (produced via EC of ^{255}Lr)
- 18 days approved for this year‘s beamtime







Thank you for your attention!

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