First observation of an atomic level in the element nobelium

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Outline

- Motivation
- Experimental method
- Level search in ^{254}No
- Conclusions & future prospects

Motivation: atomic physics

- Study of relativistic- and QED effects and how they influence the electronic structure of the heaviest elements by means of laser spectroscopy

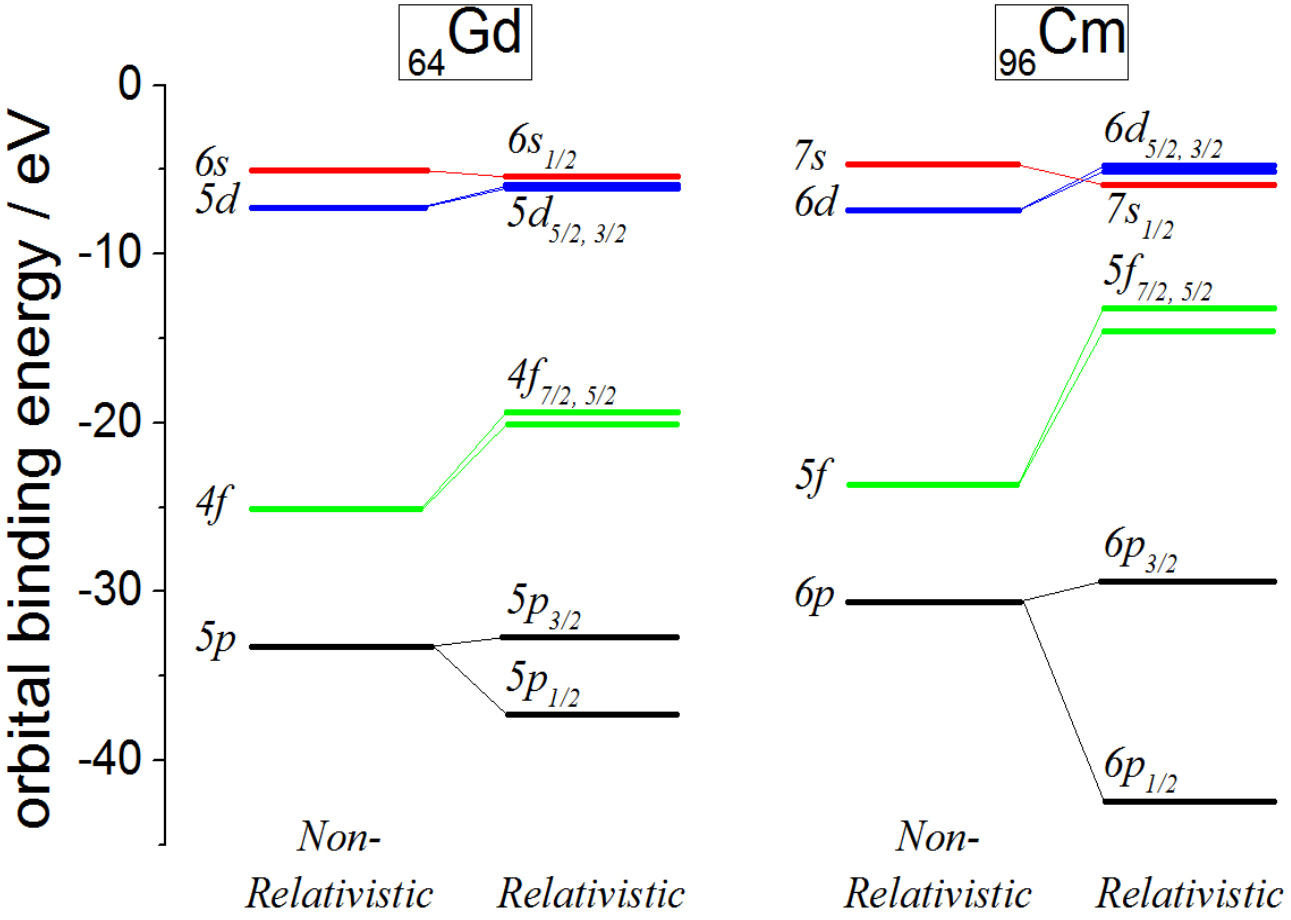
➔ $\frac{Ze^2}{r^2} = mr\omega^2$

$with \quad l = mvr = n\hbar$

$\Rightarrow v = \frac{Ze^2}{n\hbar}$

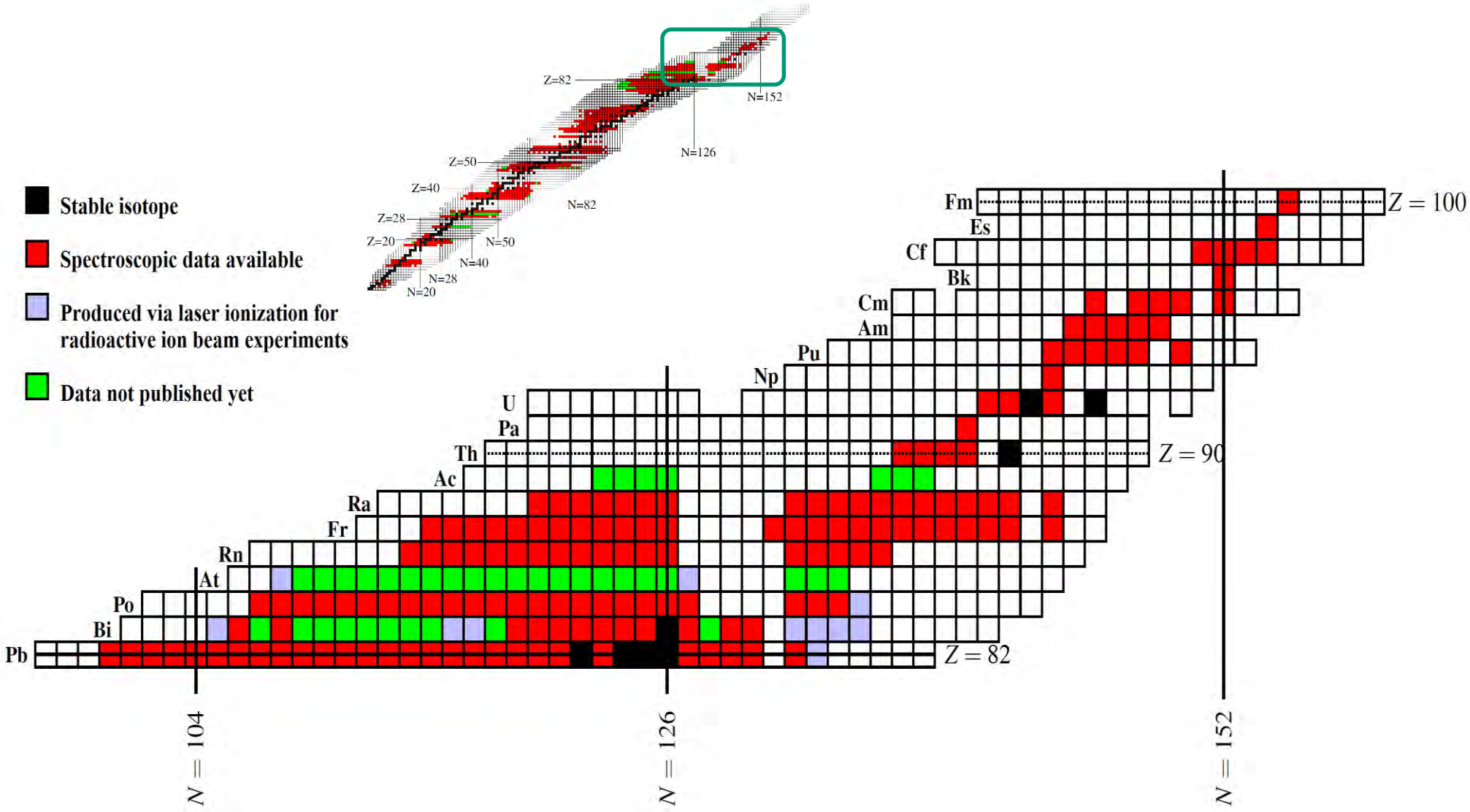
➔ For H-like gadolinium (Gd)
v/c = 0.47

➔ For H-like curium (Cm)
v/c = 0.70



J.P. Desclaux, At. Data Nucl. Data Tables **12**, 311 (1973)

Motivation: overview on optical spectroscopy



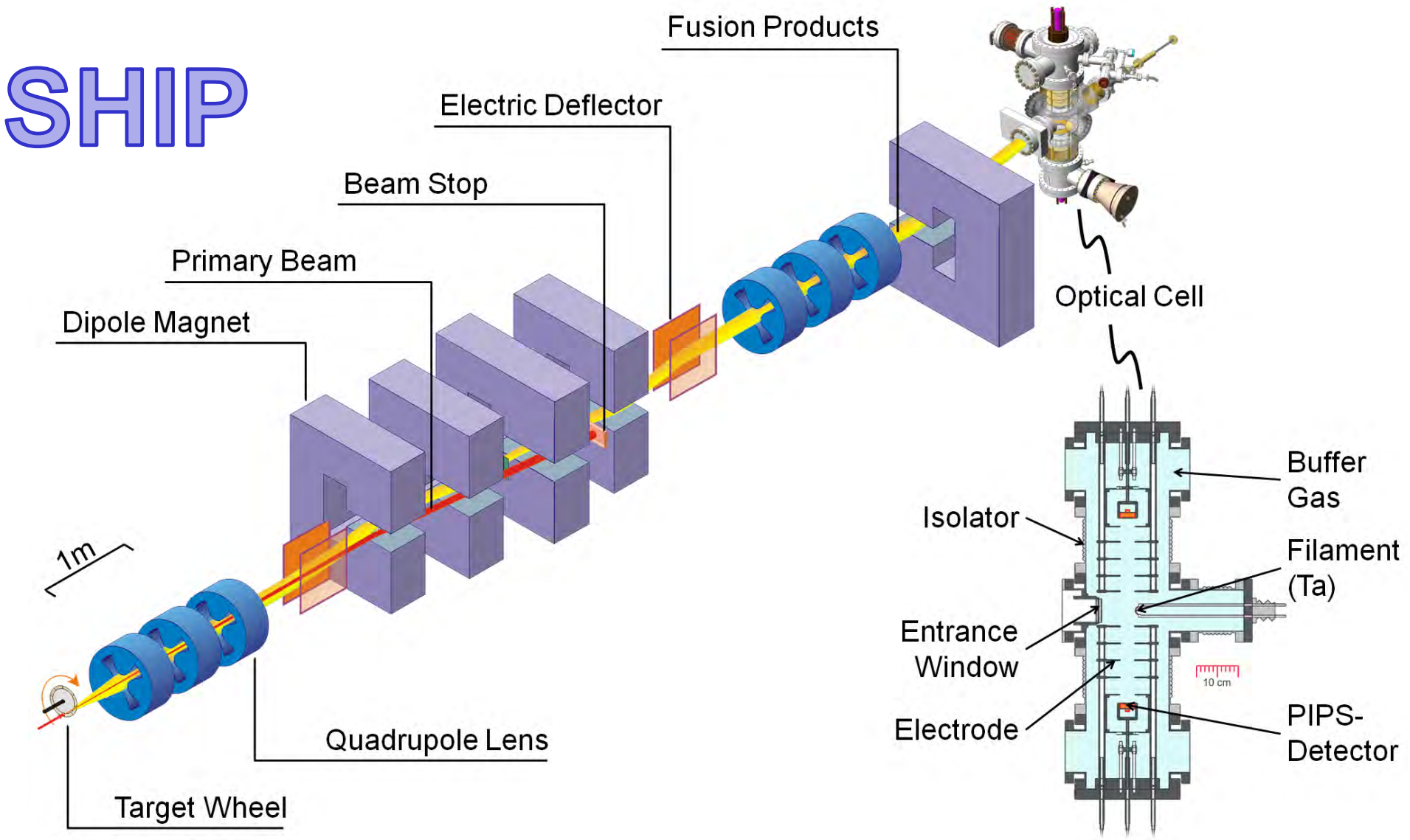
Courtesy I.Moore

Nobelium isotopes

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

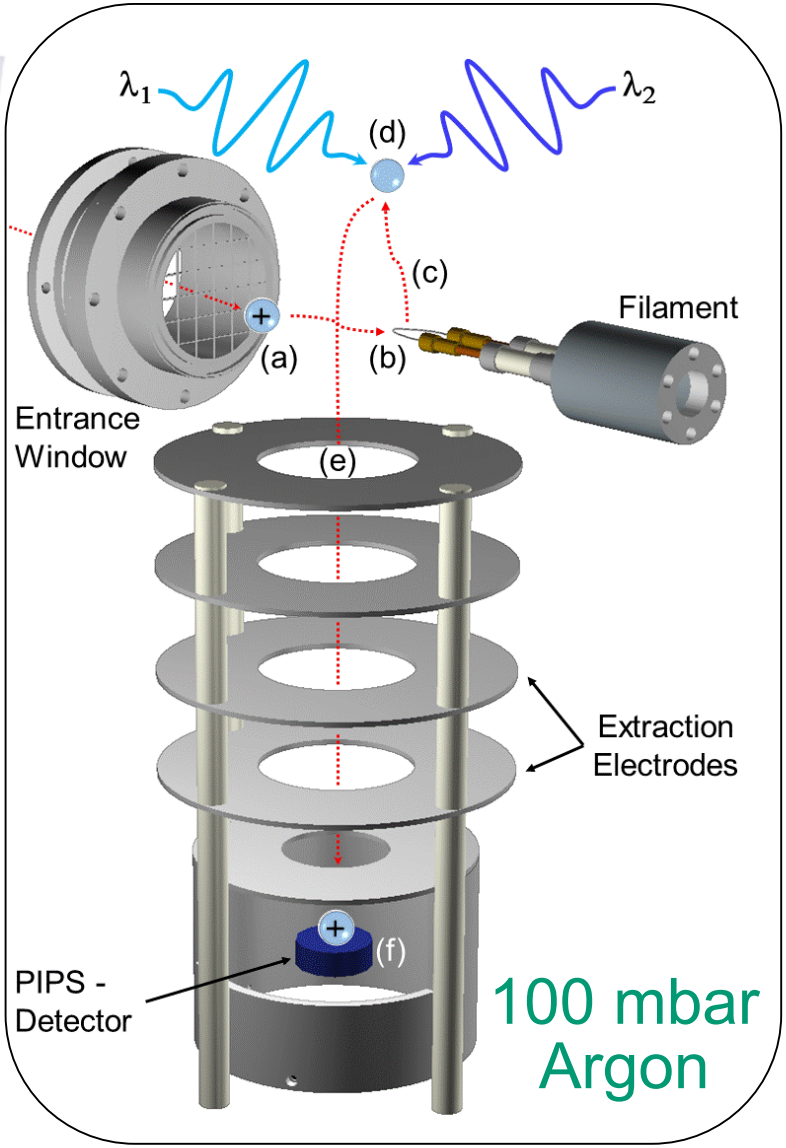
Isotope	I^P	$T_{1/2}$ (s)	Nuclear reaction	Production rate @ 1μA_P (1/s)	α- energy (MeV)	α-branching (%)
^{252}No	0	2.1	^{206}Pb(^{48}Ca,2n)^{252}No	4	8.42	73.1
^{253}No	$(9/2^-)$	102	^{207}Pb(^{48}Ca,2n)^{253}No	11	8.01	80
^{254}No	0	55	^{208}Pb(^{48}Ca,2n)^{254}No	17	8.10	90
^{255}No	$(1/2^+)$	186	^{208}Pb(^{48}Ca,1n)^{255}No	2	8.12	61.4

Radiation Detected Resonance Ionization Spectroscopy (RADRIS)

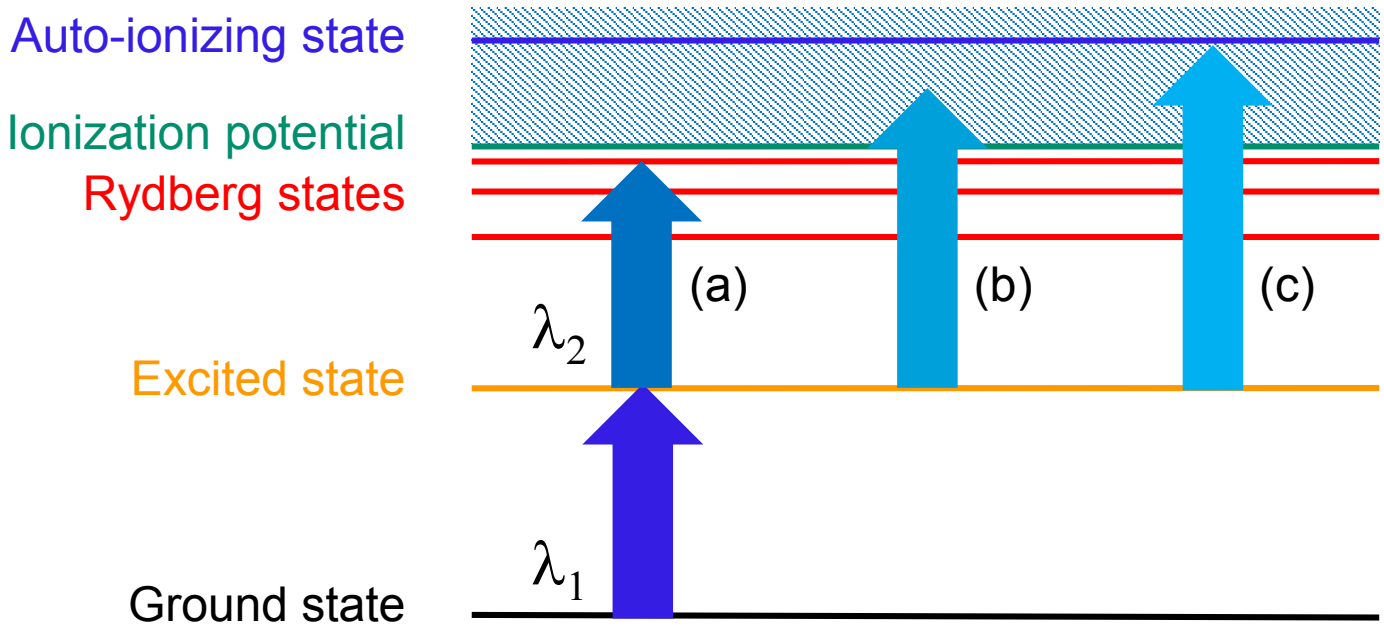


Radiation Detected Resonance Ionization Spectroscopy (RADRIS)

SHIP

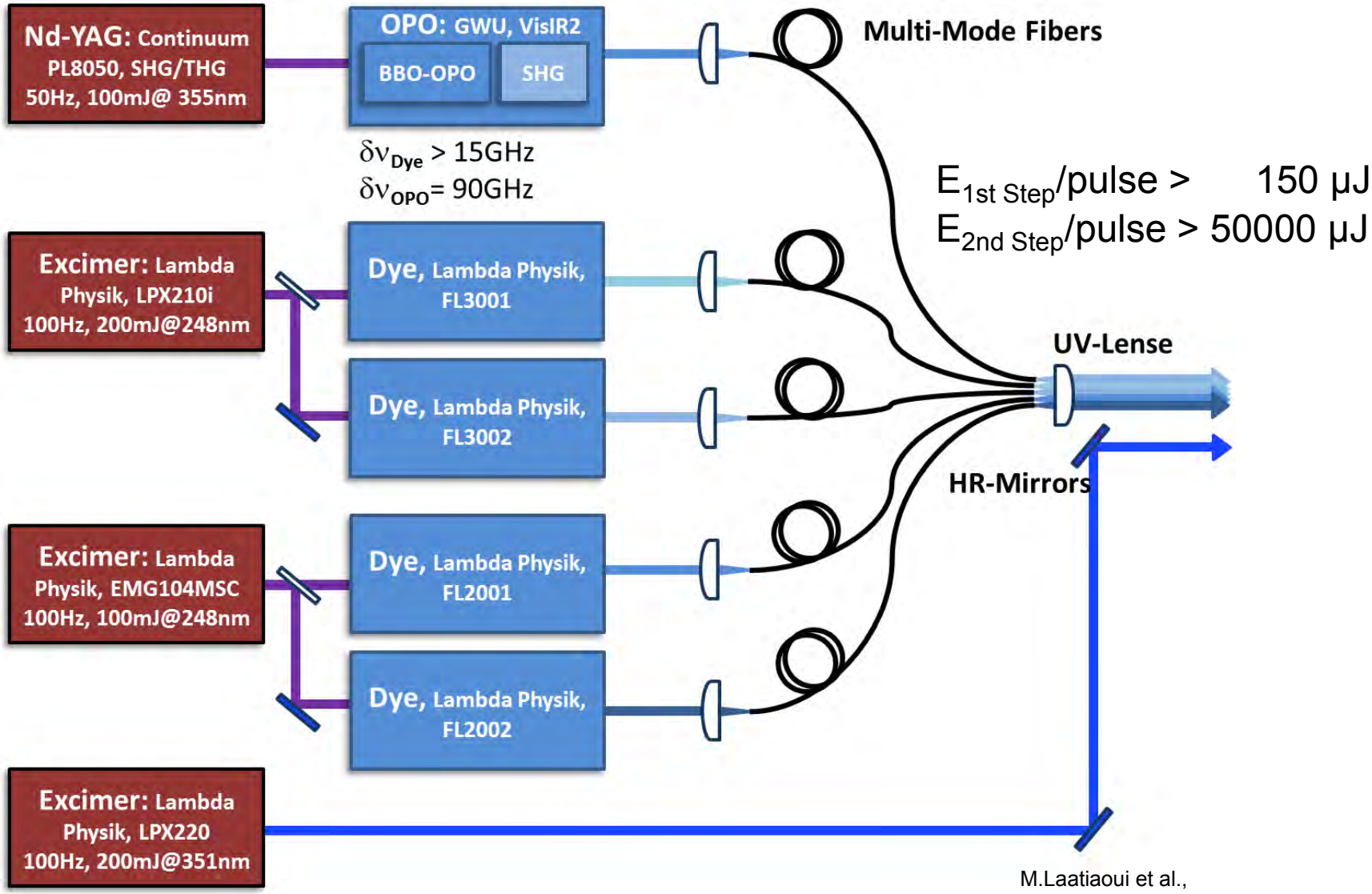


Laser spectroscopy: “2–Step Resonance Ionization”

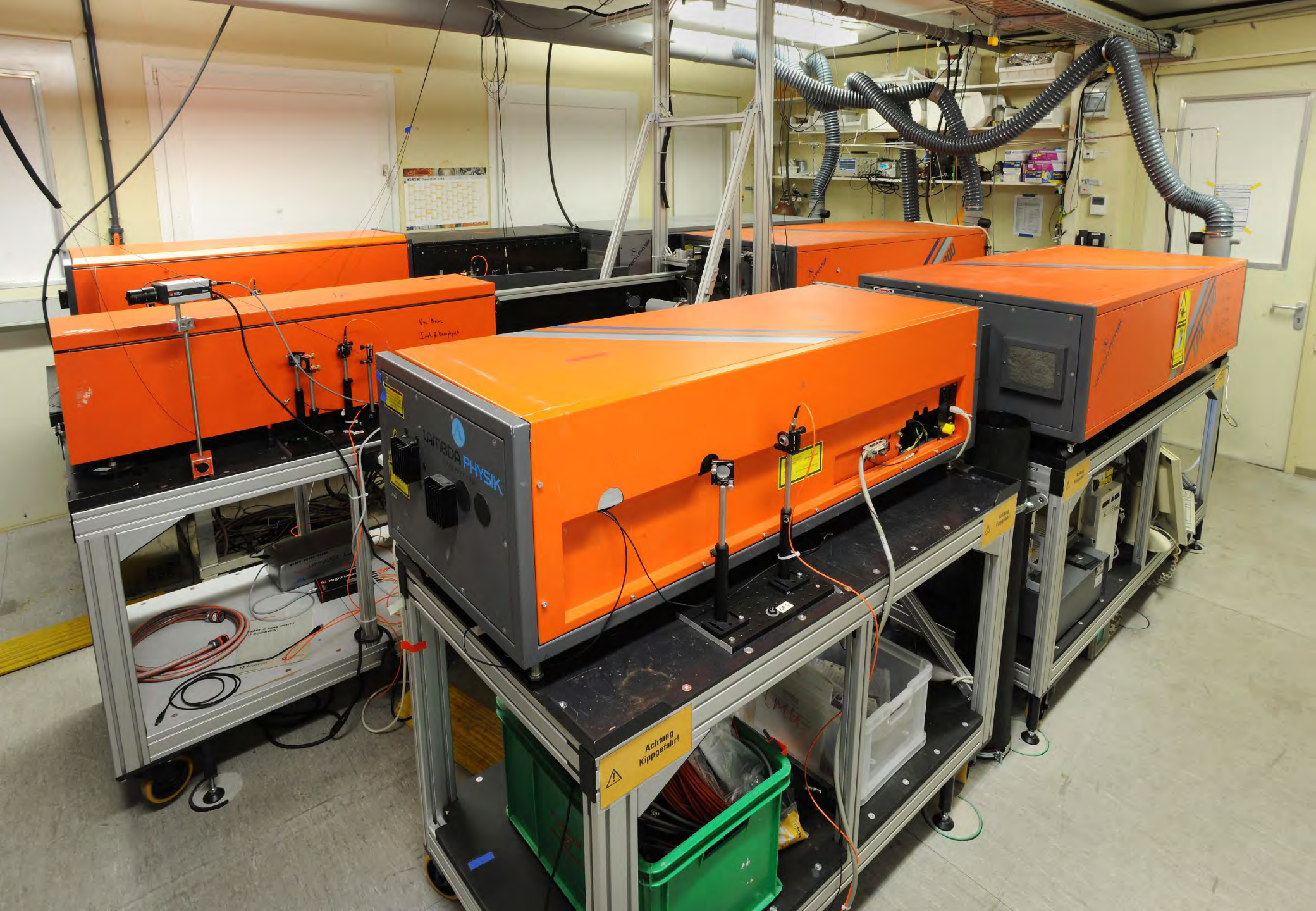


- 2 orders of magnitude less efficient excitation for scenario (b) compared with (a) and (c)

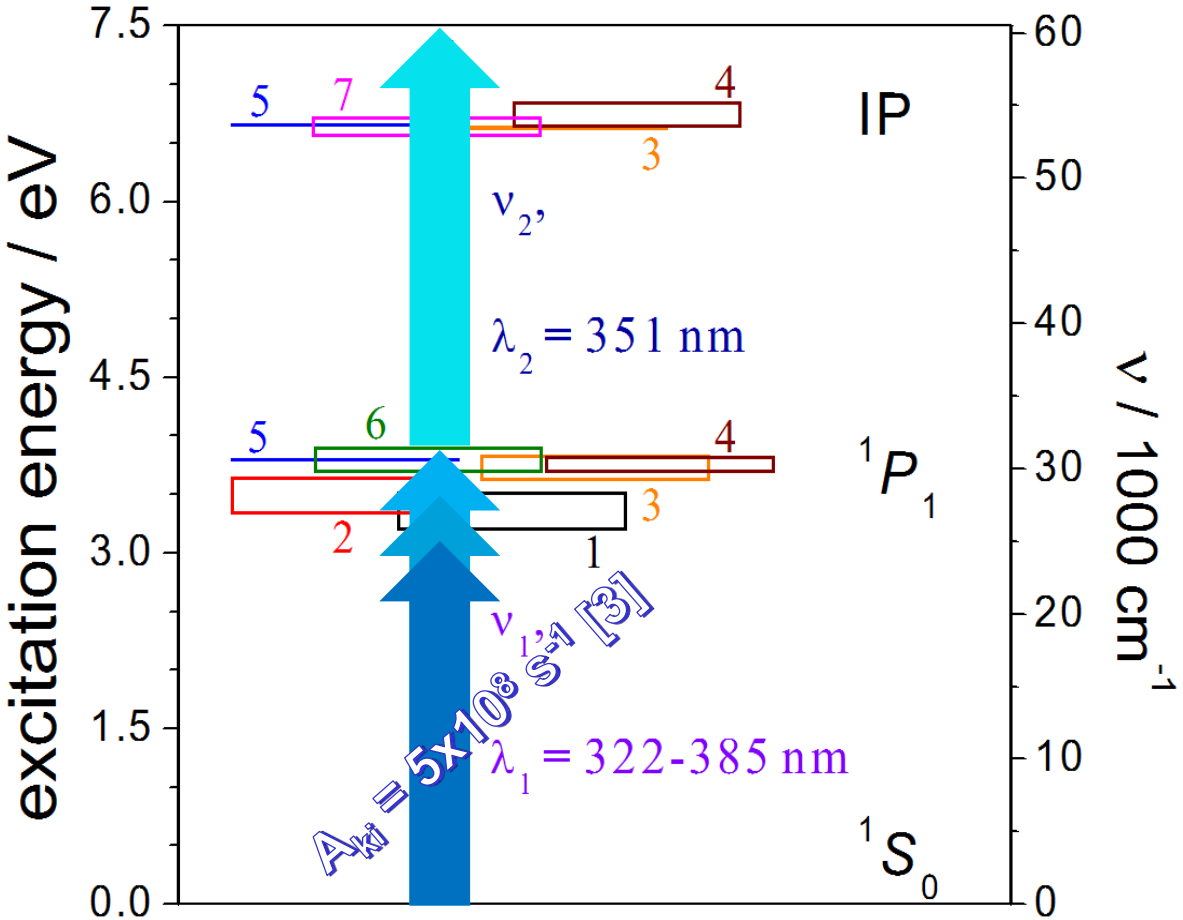
Laser systems



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


LAMBDA PHYSIK
Achtung
Kippgefahr!

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

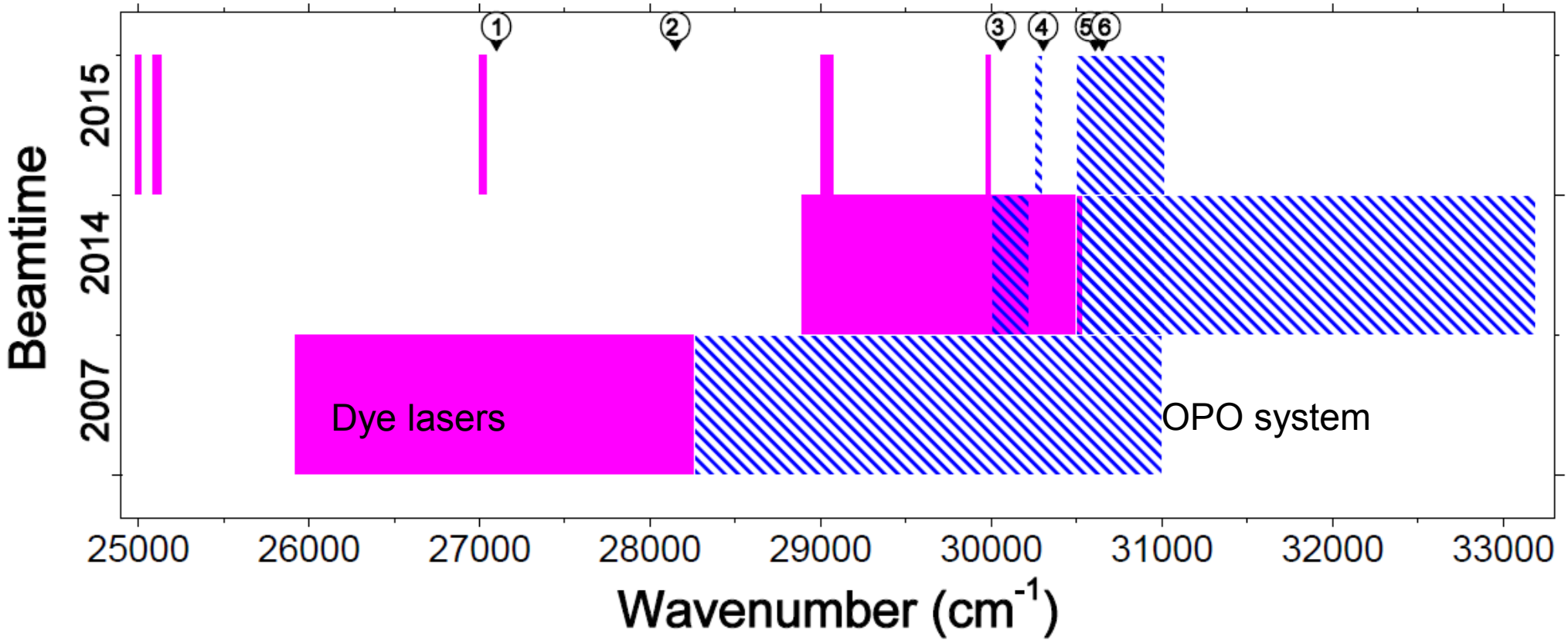
5 (MCDF): Y.Liu et al., Phys. Rev. A 76 (2007) 062503

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

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

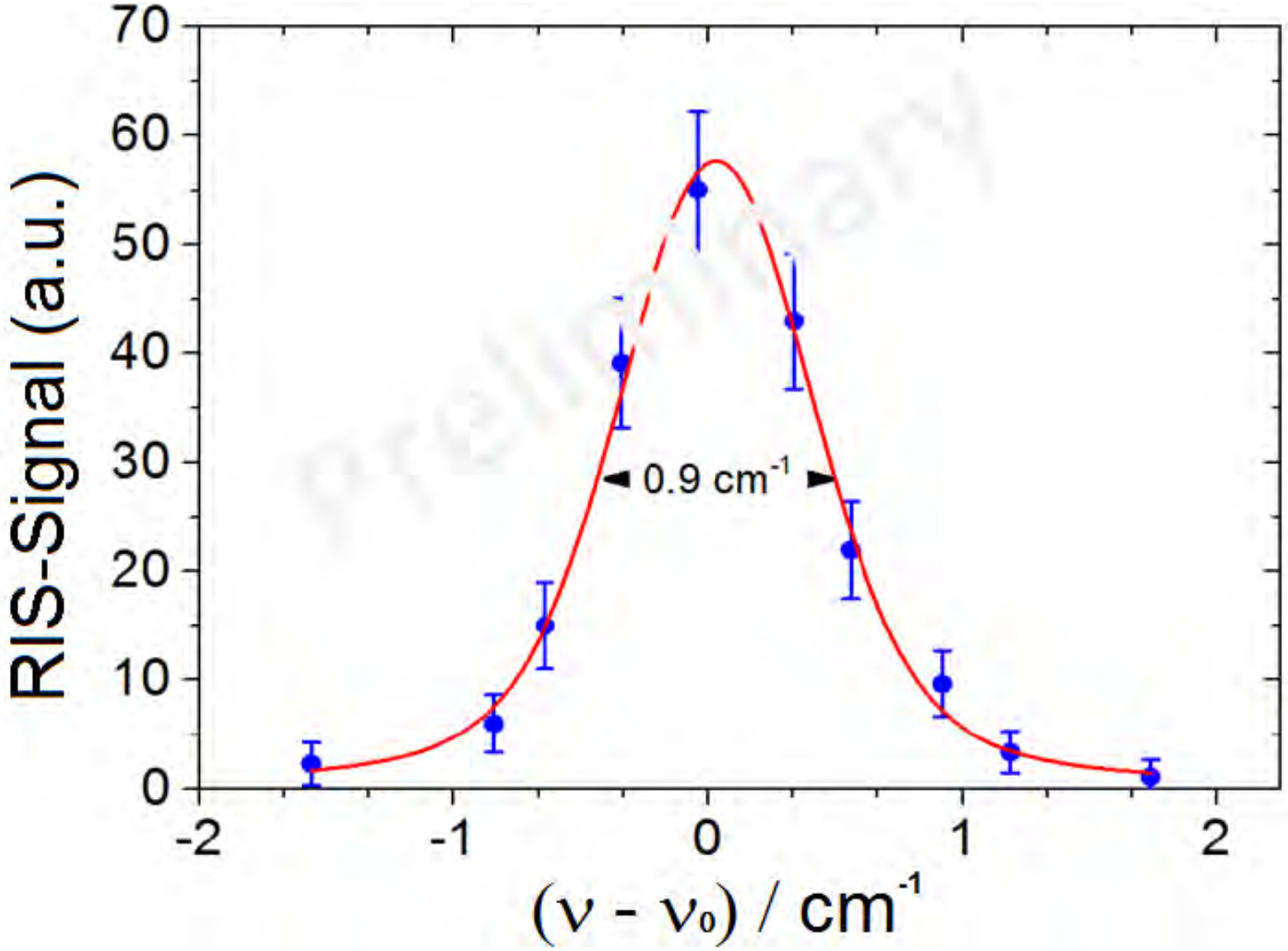
Level search in ^{254}No

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)

3rd run, 2015: "FINALLY, WE GOT IT!"



Conclusions and future prospects

- 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 $^1S_0 \rightarrow {}^1P_1$ – transition.

- An overall efficiency of about 10% was achieved for the isotope ^{254}No.

- Several Rydberg states near the IP were observed (data analysis in progress).

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

- Next step: laser spectroscopy of the element lawrencium (Z=103)…

Thank you for your attention!

RADRIS Collaboration:

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