Laser Spectroscopy of the Heaviest Elements at GSI

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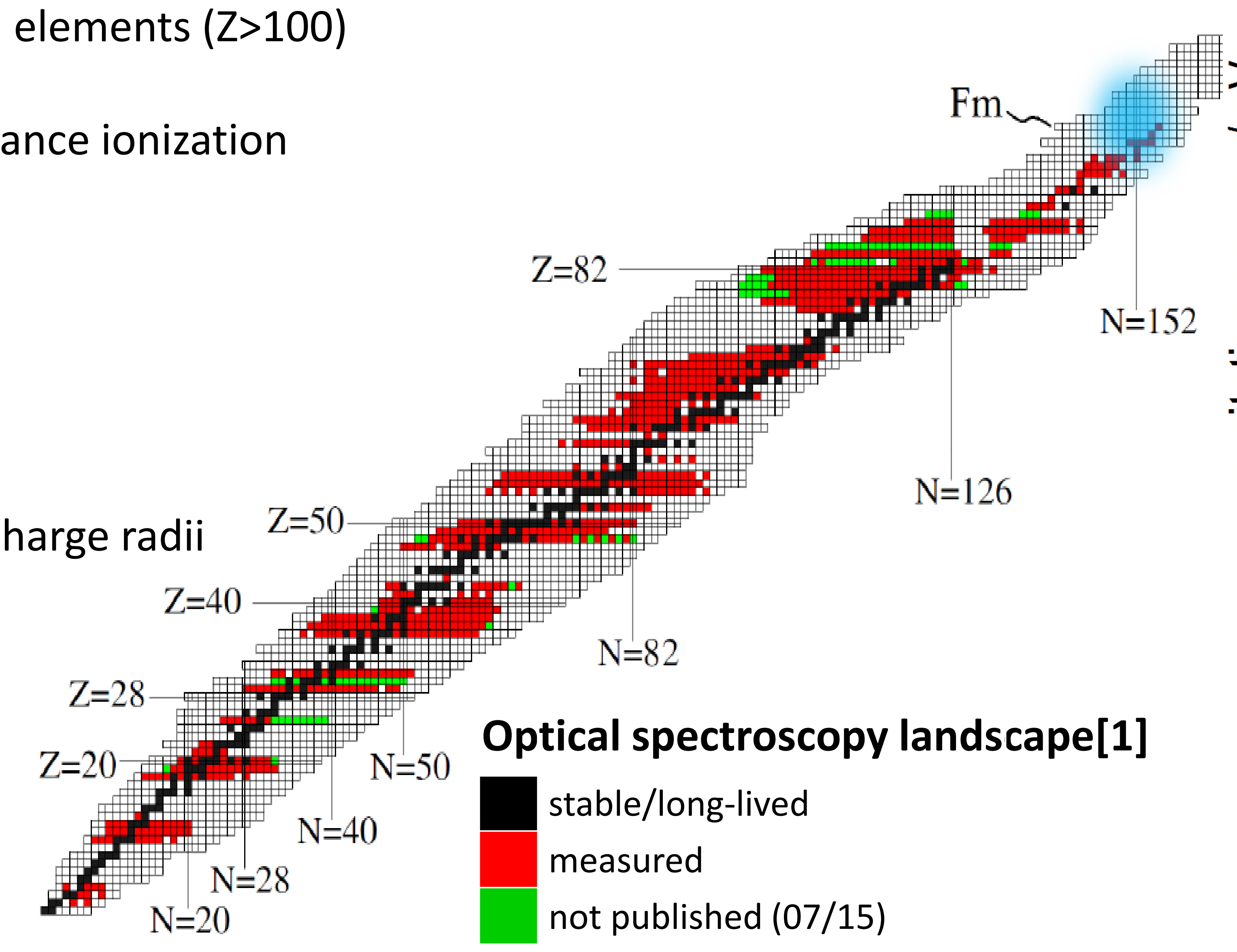
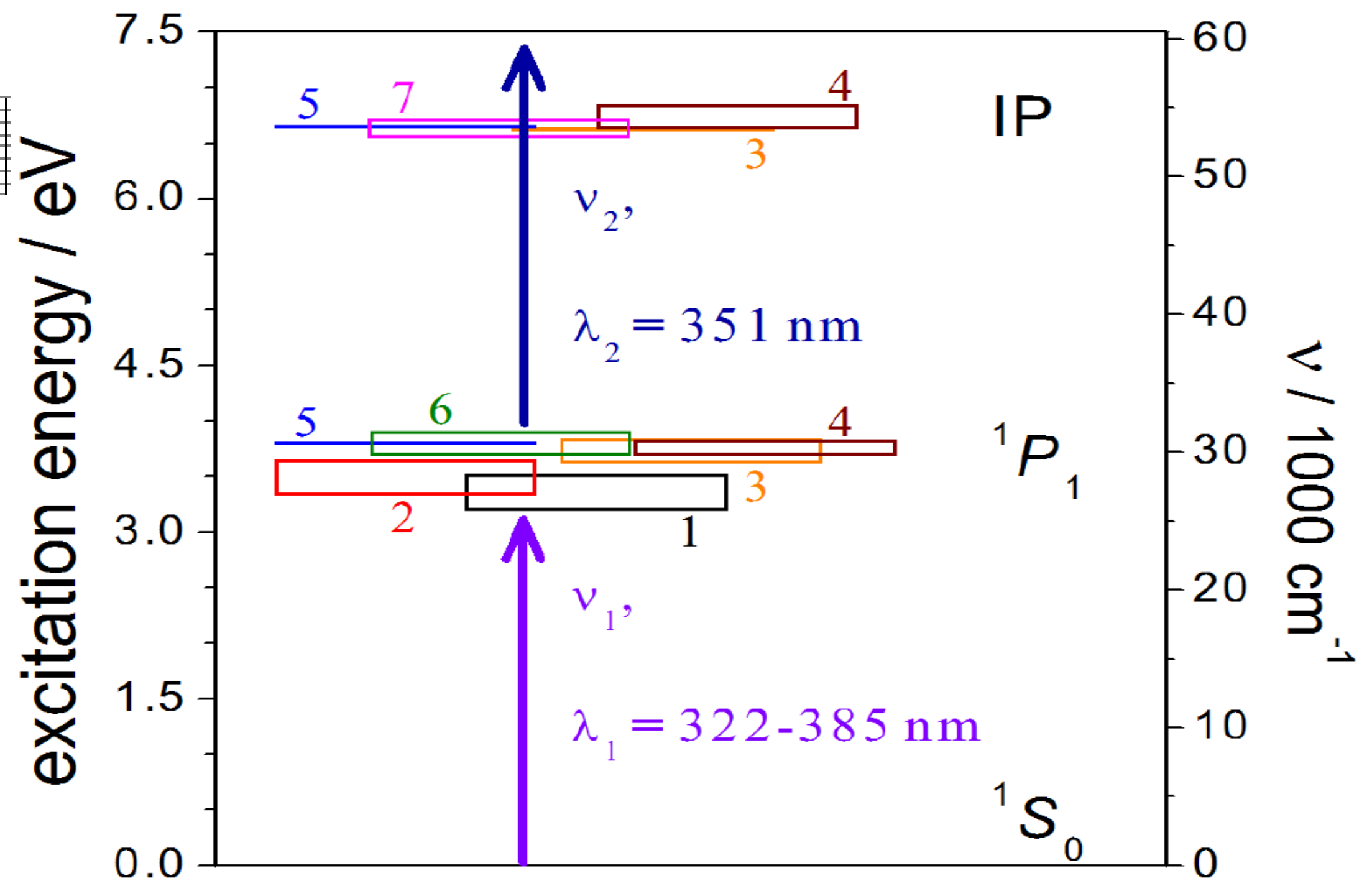
Introduction and motivation

- Explore the atomic structure of transfermium elements (Z>100)
- Search for atomic transitions via 2-step resonance ionization
  - Study of relativistic effects
- Investigation of hyperfine structure
  - Extract nuclear spin and moments
- Study of isotope shifts
  - Extract the changes in mean square charge radii
- Nuclide of interest : ^{254}No (Z=102)
  - Production : ^{208}Pb(^{48}Ca,2n)^{254}No
- Why nobelium?
  - Ground state : [Rn] 5f^{14}7s² $^1S_0$
  - Production cross-section : 2 µb



Optical spectroscopy landscape[1]

■	stable/long-lived
🟥	measured
🟩	not published (07/15)



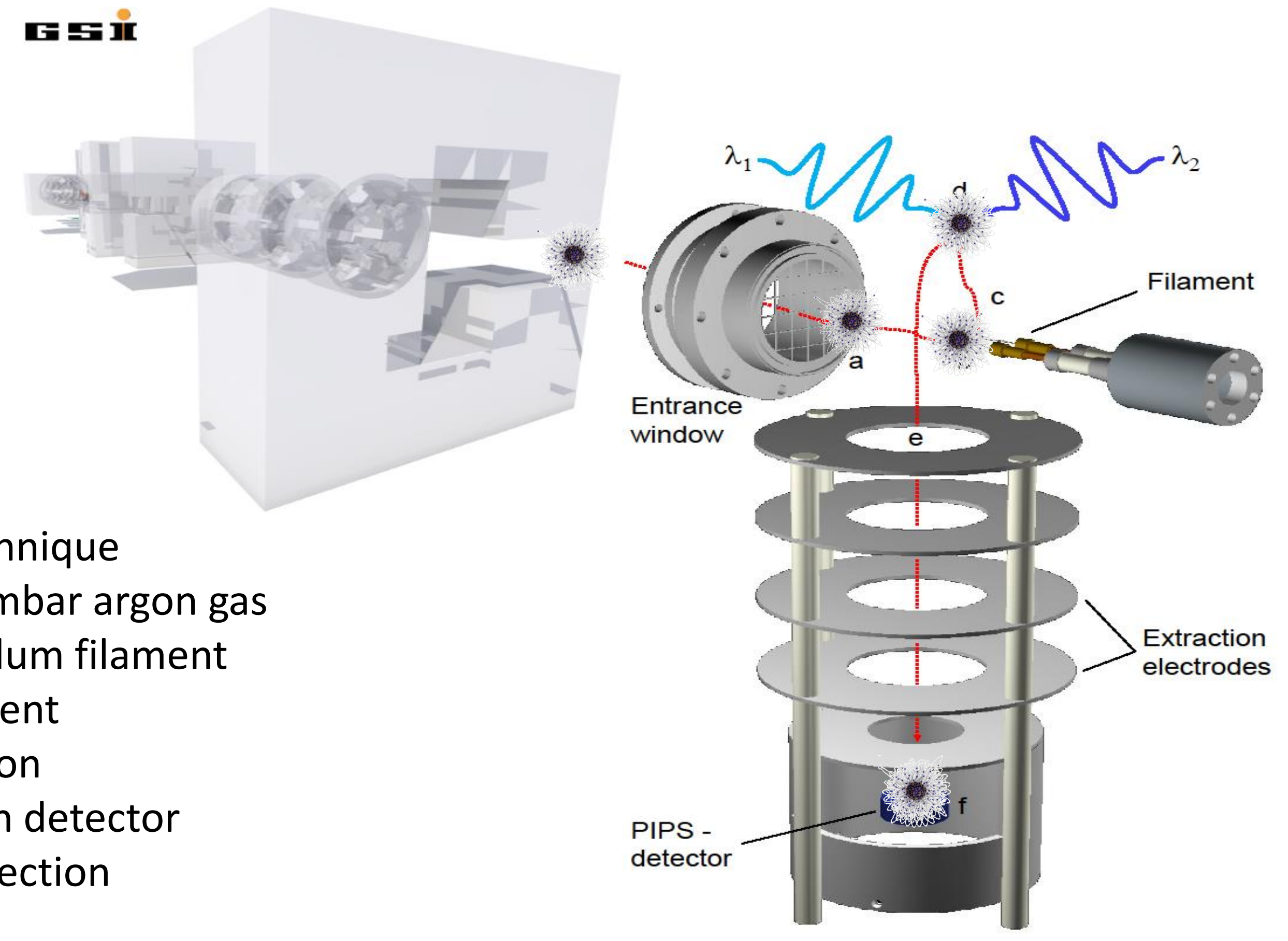
Theoretical calculations for nobelium

1,2 : S. Fritzsche, Eur. Phys. J. D 33 (2005) 15
3 : A. Borschevsky et al., Phys. Rev. A 75 (2007) 04514
4 : V. A. Zuaba et al., Phys. Rev. A 90 (2014) 012504
5 : Y. Liu et al., Phys. Rev. A 76 (2007) 062503
6 : P. Indelicato et al., Eur. Phys. J. D 45 (2007) 155
7 : J. Sugar, J. Chem. Phys. 60 (1974) 4103

Experimental setup

Radiation Detected Resonance Ionization Spectroscopy (RADRIS)[2]

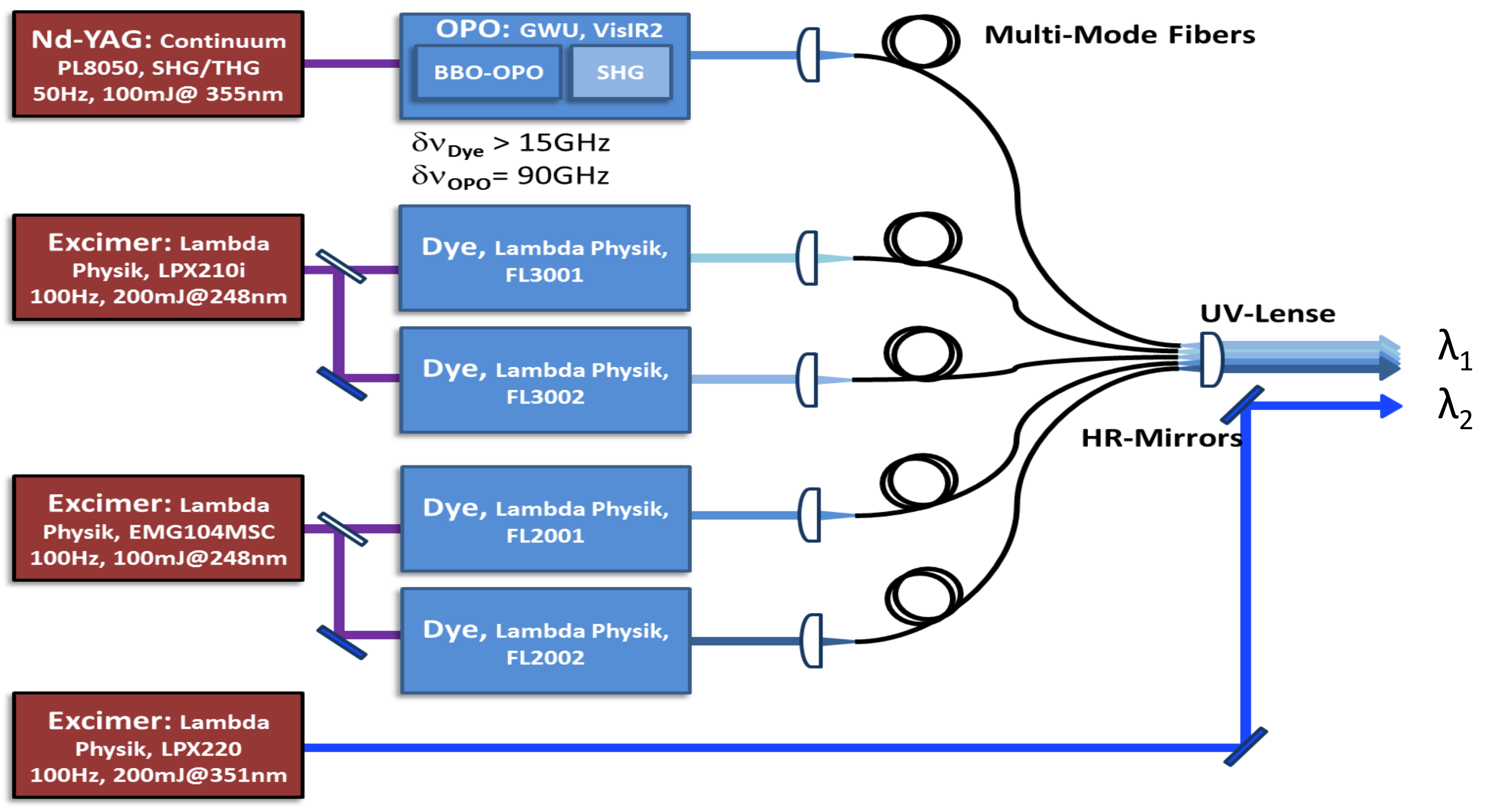
- Gas filled stopping cell behind the velocity filter **SHIP @ GSI**



Principle of the RADRIS technique
(a) Thermalization in 100 mbar argon gas
(b) Accumulation on tantalum filament
(c) Evaporation from filament
(d) Two step photoionization
(e) Accumulation on silicon detector
(f) Charateristic decay detection

Laser systems

- One tunable frequency-doubled OPO and 4 dye lasers for λ_1
- One excimer laser @ 351 nm for second non-resonant step λ_2

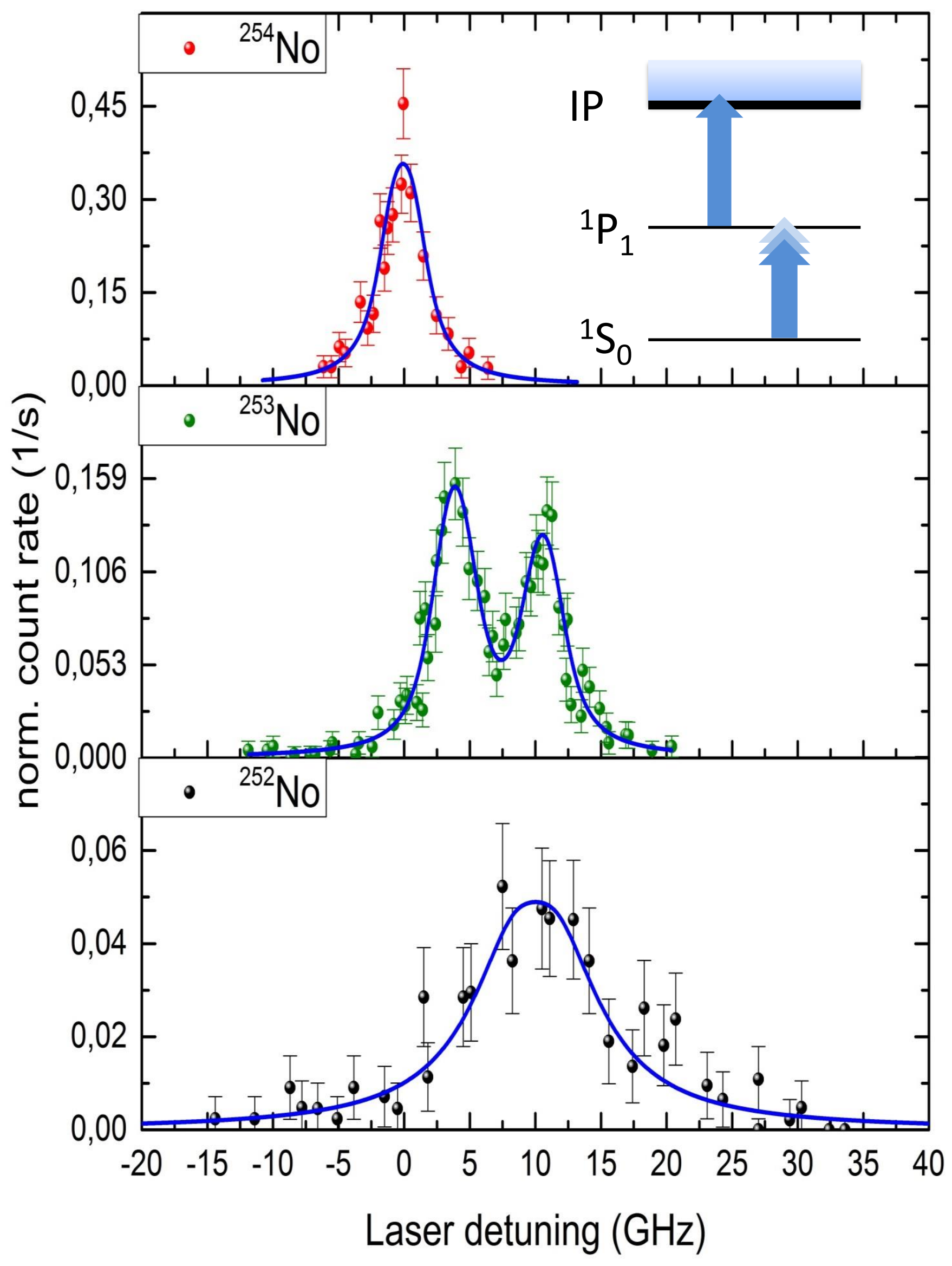


Results & outlook

Measurements on nobelium [3]:

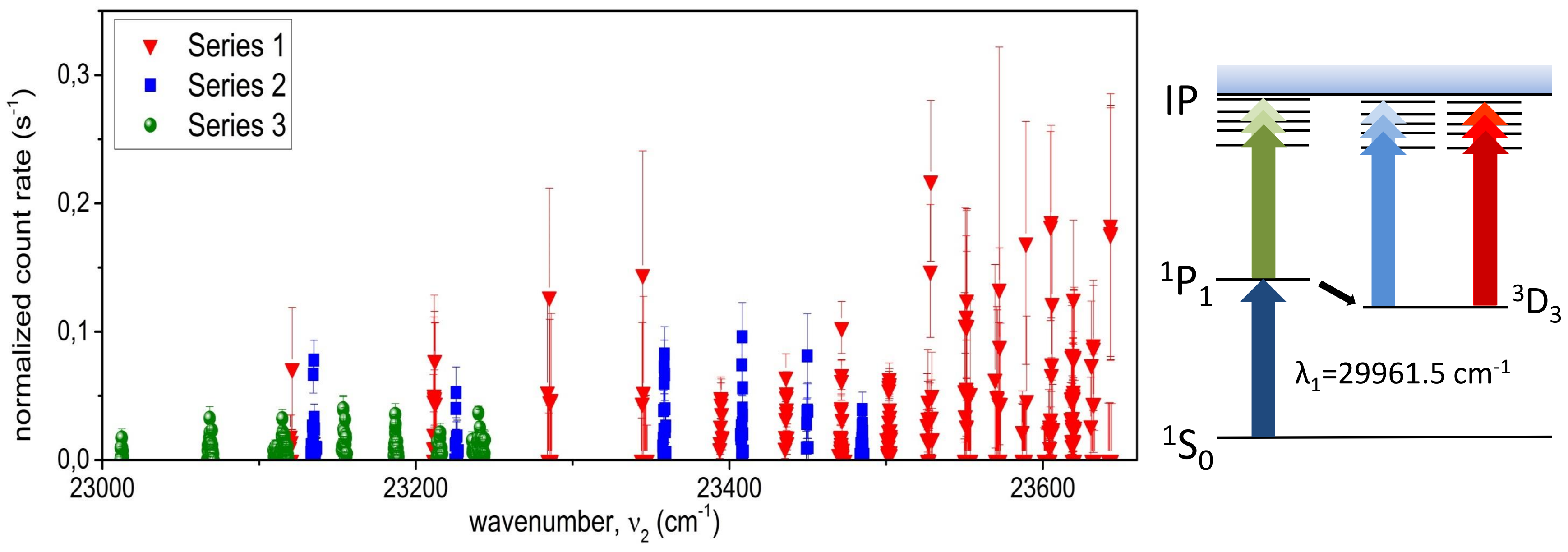
- $^1P_1$ state at 29961.46(4) cm^{-1}
- Overall efficiency for ^{254}No : (6.4 ± 1)%
- Isotopic shift for $^{252-254}$No measured
- Hyperfine structure for ^{253}No measured
- A= 734(46) MHz; B= 2815(686) MHz

	$\mu(\mu_N)$	Q_s (b)
Laser Spectroscopy	-0.527 ± 0.034	5.79 ± 1.42
Nucl. spectroscopy [4]	- 0.593	7.145



First ionization potential (IP) on nobelium:

- Several high-lying Rydberg states observed in ^{254}No.
- IP extracted from the Rydberg convergence to be 6.6261(1) eV.



Future measurements

- Extend the isotope chain of No, *e.g.* ^{251}No, ^{255}No
- Laser spectroscopy of lawrencium (Lr, *Z* = 103) and beyond

Work supported by BMBF, HIM and ENSAR

[1] Campbell et. Al. Nucl.Phys. **86** (2016) 127, [2] F. Lautenschläger et al. Nucl. Instrum. Methods B **383** (2016) 115, [3] M. Laatiaoui et al., Nature **538** (2016) 495, [4] R.D. Herzberg *et al., Eur. Phys. J. A* ***42**, (2009) 333*

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