

# Developments towards Doppler-free in-source laser spectroscopy at ISOLDE RILIS

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# Summary

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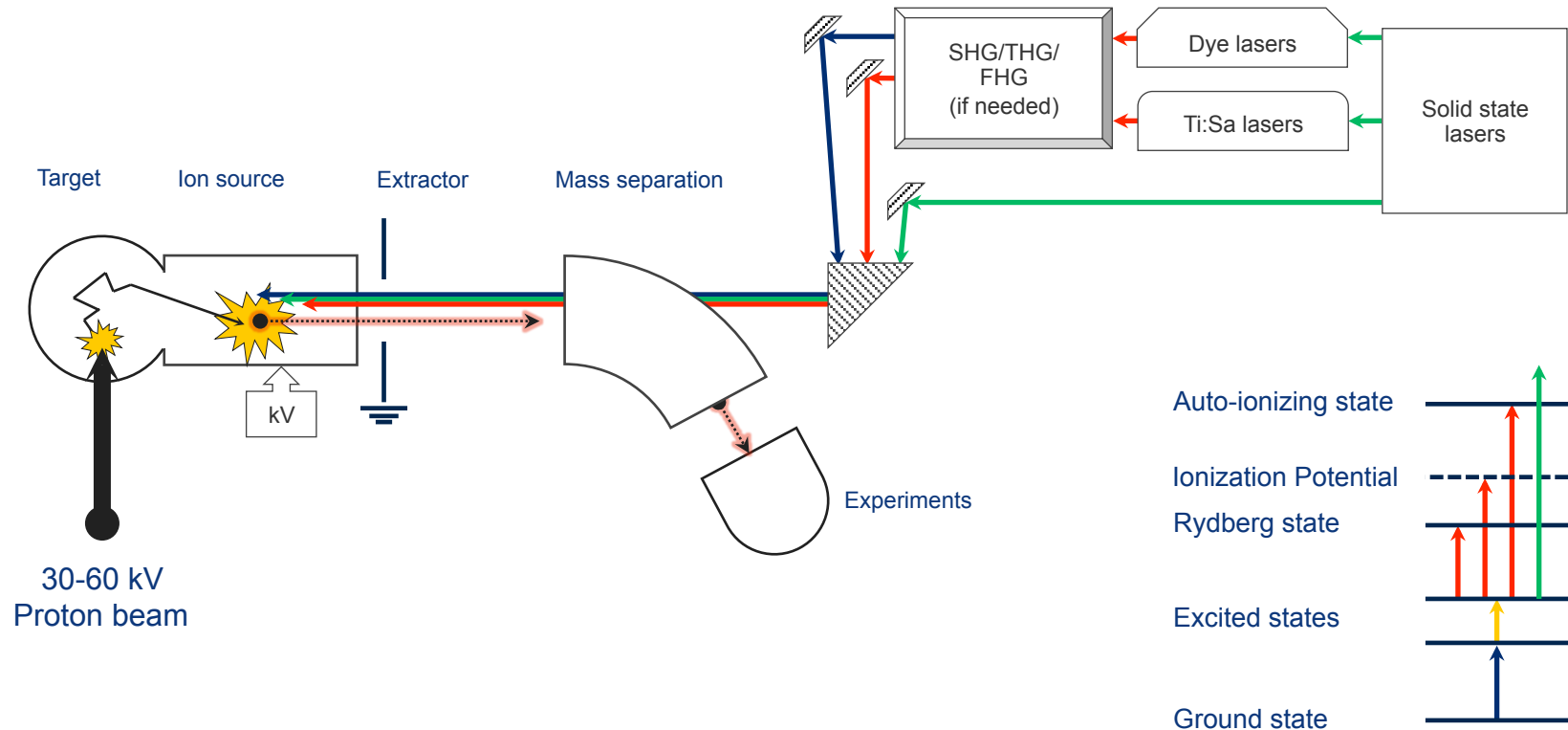
- I. RILIS : Resonance Ionization Laser Ion Source
- II. Motivations and requirements for In-source Doppler-free laser spectroscopy
- III. Possible experimental layout

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# RILIS : Resonance Ionization Laser Ion Source [1]



# RILIS : Resonance Ionization Laser Ion Source [1]

- Multi-step resonance photo-absorption

- Unique combination of frequency-tuneable Dye-Ti:Sa system, enabling a wavelength range from 210 to 950 nm
- 10-30 ns pulses at 10 kHz repetition rate (Sufficient photon flux  $\rightarrow$  0.1-40 W).
- Broadband laser system with laser-linewidth of 10-20 GHz and narrowband laser system of 1 GHz laser linewidth.
- Enables element selectivity; isomer selectivity in some cases

- Use of a hot cavity

- Ensure atom confinement between the laser pulses and fast effusion of reaction products
- Leads to a Doppler broadening of the atomic lines, constraining the RILIS system to a bandwidth of few GHz

[1] B. Marsh. Resonance ionization laser ion sources for on-line isotope separators (invited). Review of Scientific Instruments, 85(2), 2014.

# Summary

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## I. Principles of RILIS

## II. Motivations and requirements for In-source Doppler-free laser spectroscopy

## III. Possible experimental layout

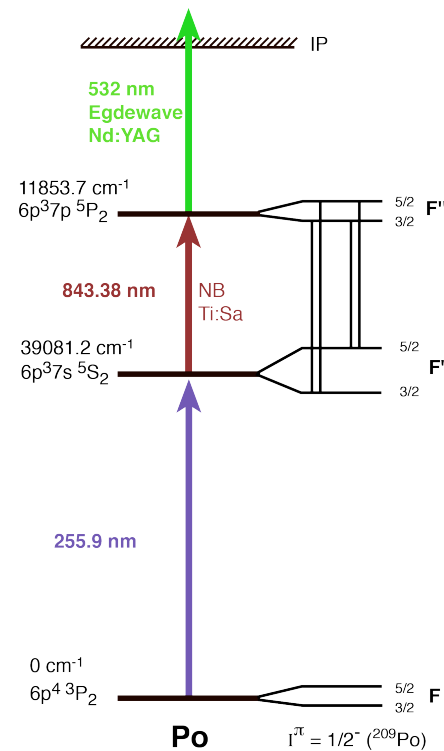
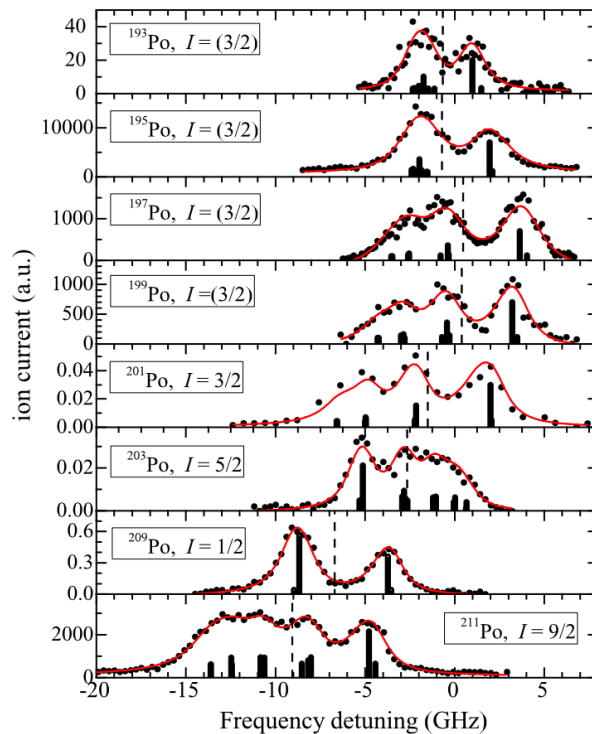
# Motivations

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- Principles of in-source resonance ionization spectroscopy
  - Observation of photo-ions instead of fluorescence photons → more suitable for the study of exotic isotopes with low production rates
  - One of the transition of the ionization scheme is chosen for laser scanning, using a narrow band laser (Spectral resolution limited only by Doppler broadening)

# Motivations

- Principles of in-source resonance ionization spectroscopy : Example spectra [2]



[2] M.D. Seliverstov, et al. Charge radii of odd-A  $^{191-211}\text{Po}$  isotopes. Physics Letters B 719 (2013) 362–366

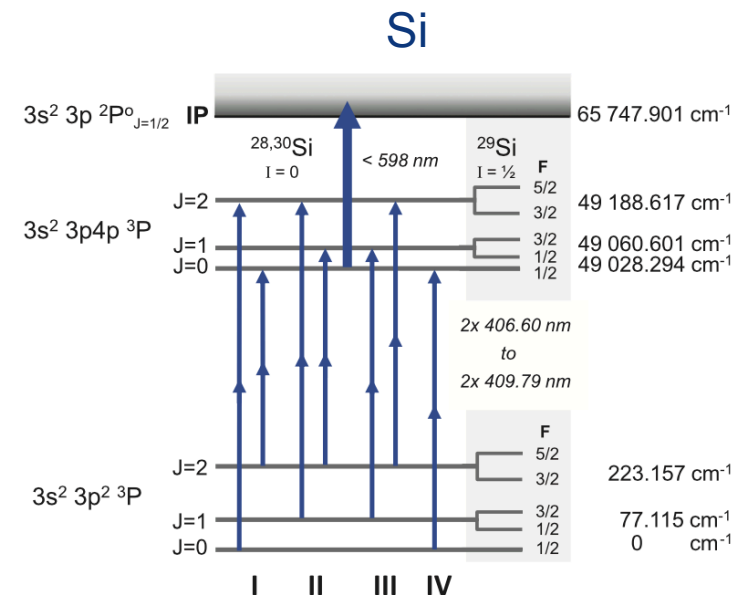
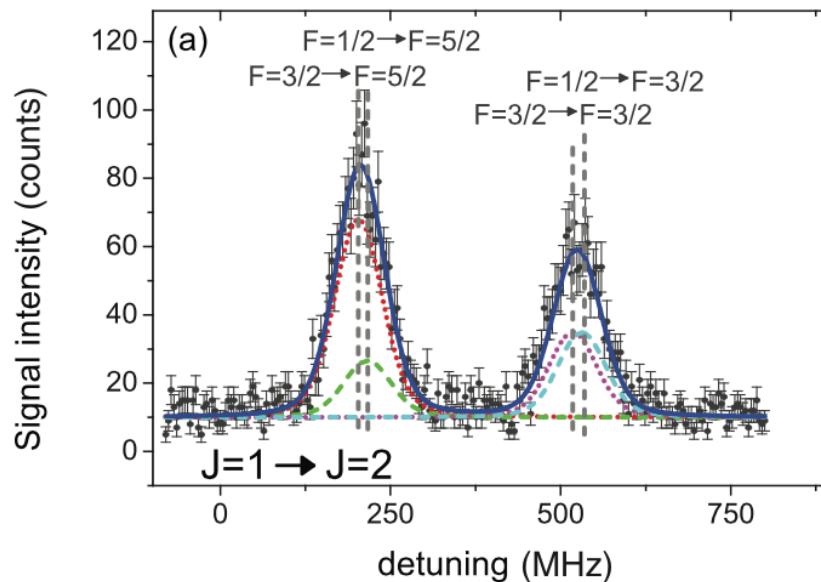


# Motivations

- Comparison with two photon spectroscopy [3]

$$\omega \left(1 + \frac{v}{c}\right) + \omega \left(1 - \frac{v}{c}\right) = 2\omega. \quad \rightarrow \text{equal and opposite Doppler shift for each beam}$$

Transition from  $3s^2 3p^2 \ ^3P_1 \rightarrow 3s^2 3p 4p \ ^3P_2$  in  $^{29}\text{Si}$



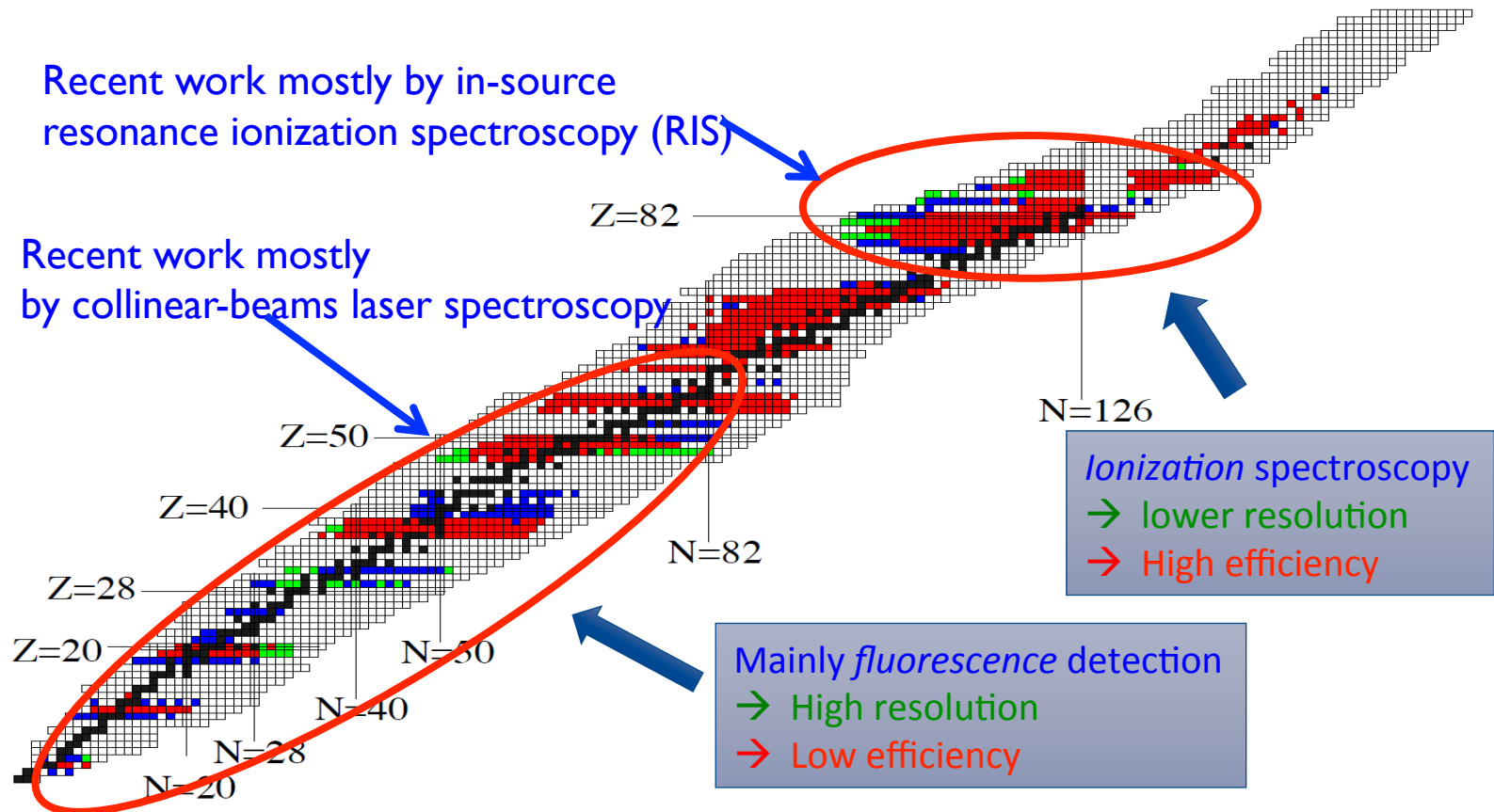
[2] K. Wendt, et al. Hyperfine structure and isotope shift in the  $3s^2 3p^2 \ ^3P_{0,1,2} \rightarrow 3s^2 3p 4p \ ^3P_{0,1,2}$  transitions in silicon by Doppler-free in-source two-photon resonance-ionization spectroscopy. Phys. Rev. A, 88:052510, Nov 2013.

# Motivations

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- Could provide on-line, high-resolution experiments with spectral resolution down to several MHz
  - Isotope selectivity
  - High resolution measurements of hyperfine structure and isotope shift
  - Isomer separation
  - Give access to light elements for in-source spectroscopy

# Motivations



**Updated plot provided by Bradley Cheal from 2010 review** (B. Cheal & K.T. Flanagan J. Phys. G 37 (2010) 113101)

# Requirements

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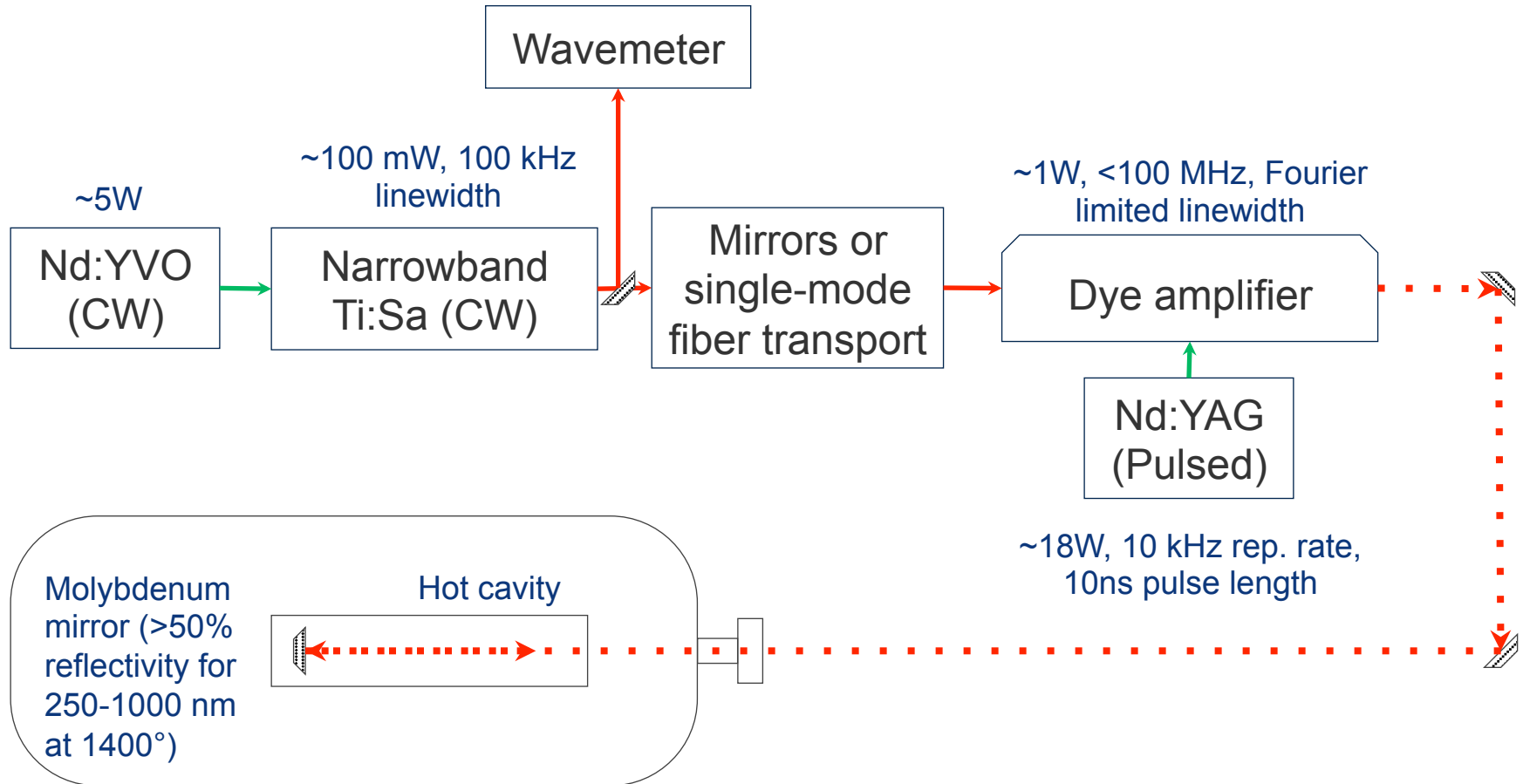
- Simultaneous colinear and anti-colinear laser-atom interaction
- Narrow linewidth, high power, tuneable laser system
- Compatibility with RILIS laser system requires pulsed operation (30 ns, 10kHz rep rate)

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# Possible experimental layout



# Conclusions and forthcoming work

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- Doppler-free two photon spectroscopy is a promising technique for high resolution spectroscopy inside hot cavity ion sources
- An optimal laser setup is currently under development, the narrowband Ti:Sa is lasing at 80 mW (at 760 nm) and needs to be optimized.
- An element with convenient two photon transition will be chosen to test the technique and the setup



Thank you !