

RILIS operation in 2022

Katerina Chrysalidis
On behalf of
RILIS



RILIS - runs

Run summary



30/11/2022



LISA – Laser Ionization and Spectroscopy of Actinides.
This Marie Skłodowska-Curie Action (MSCA) Innovative Training Networks (ITN) receives funding from the European Union's H2020 Framework Programme under grant agreement no. 861198



Run summary

GPS schedule 2022																																																																																																																								
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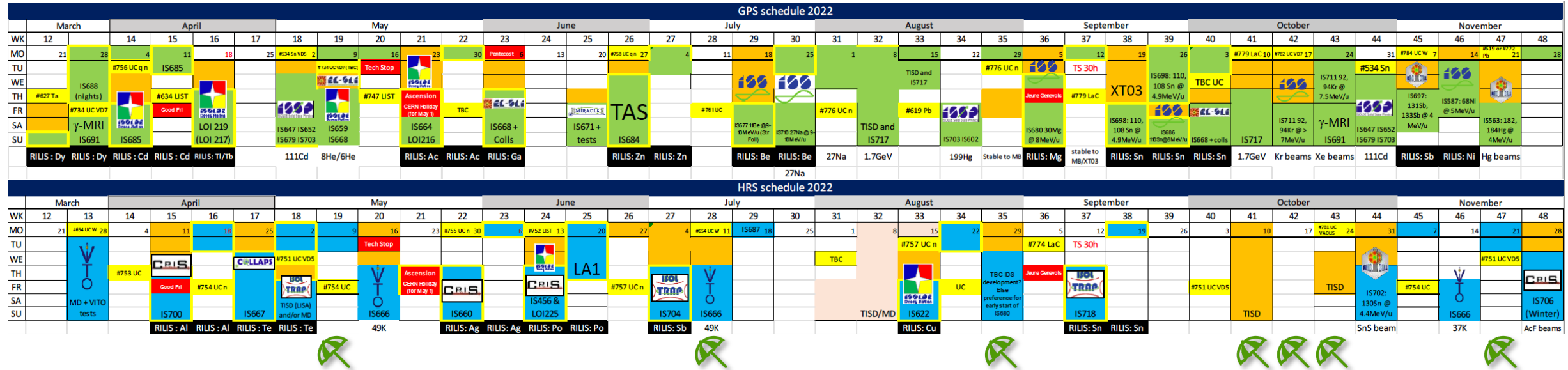
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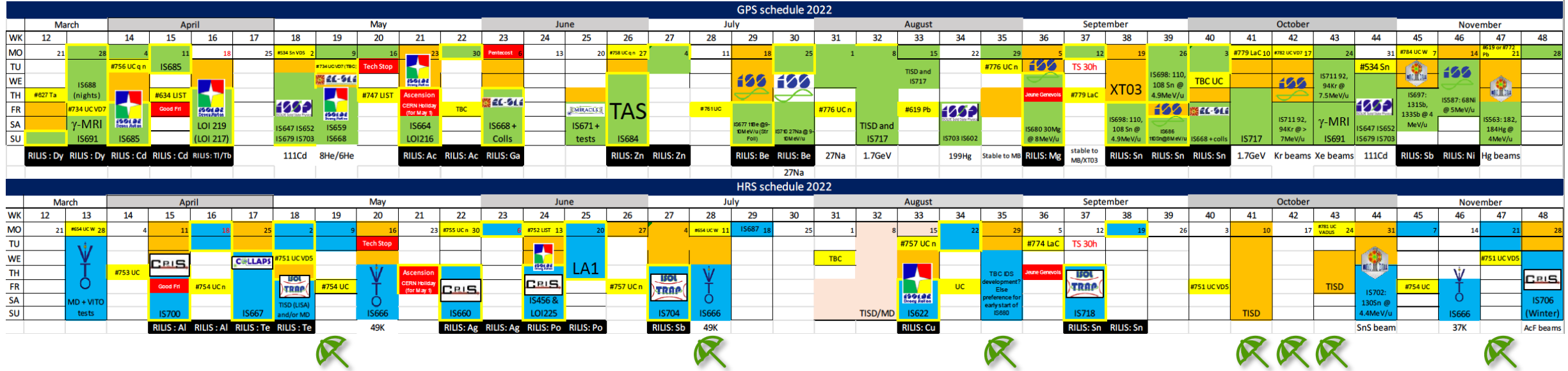
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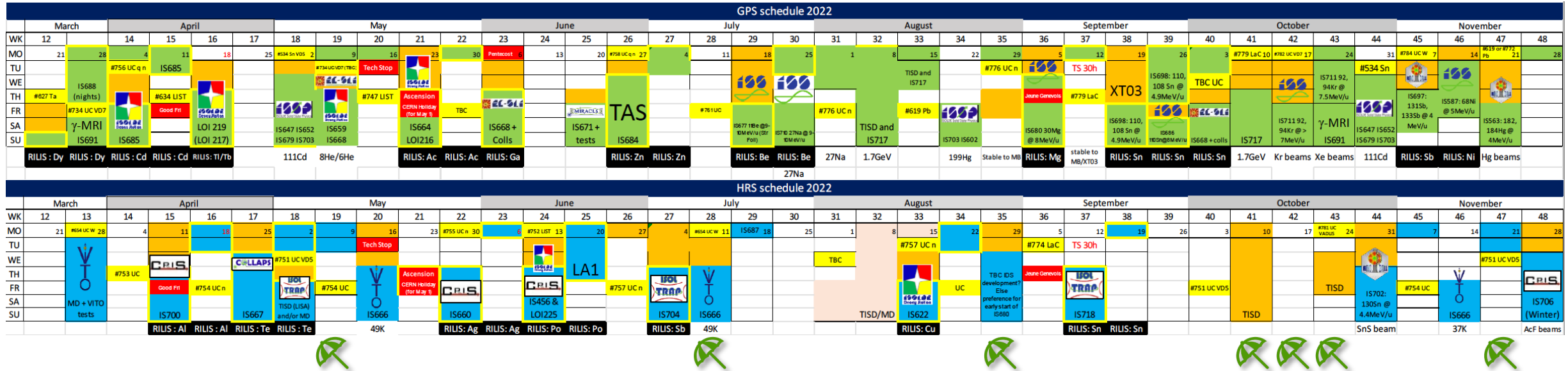


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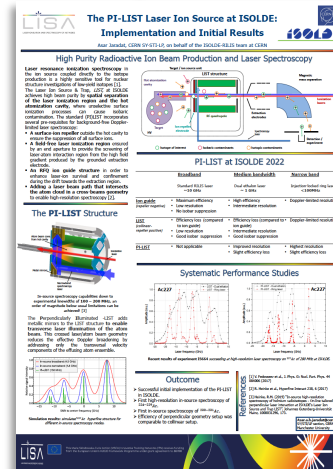
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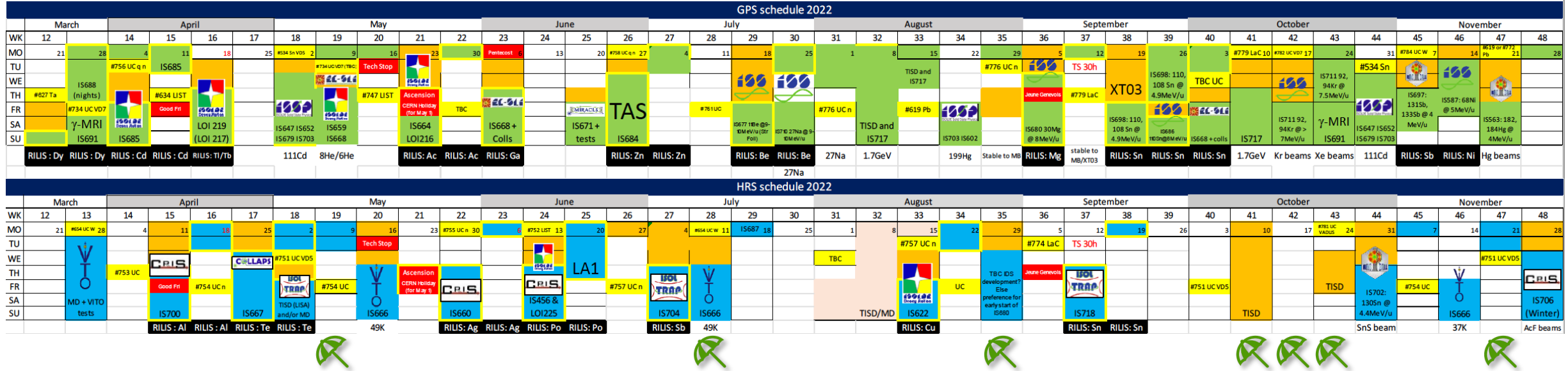


ISOLDE's new high-resolution laser ion source PI-LIST

Nuclear structure investigation and isomer-pure beams

Reinhard Heinke ^{SY-STI-LP, CERN}
 for the PI-LIST collaboration

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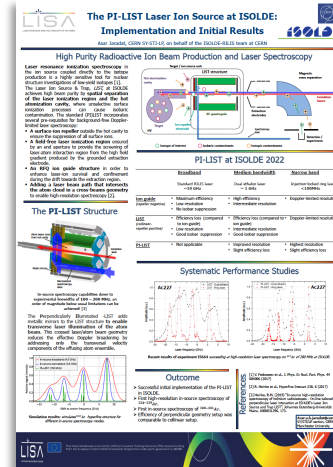
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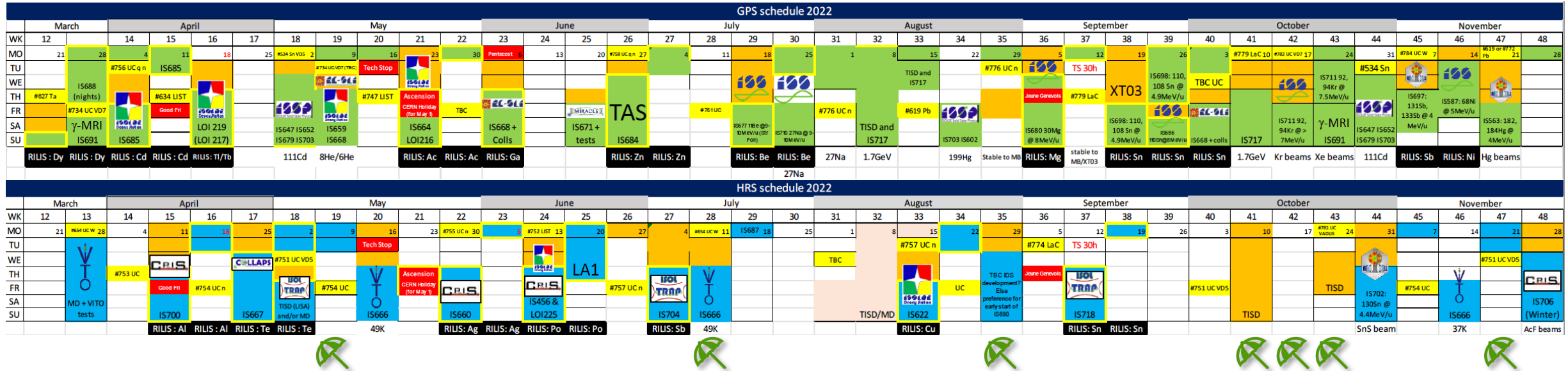


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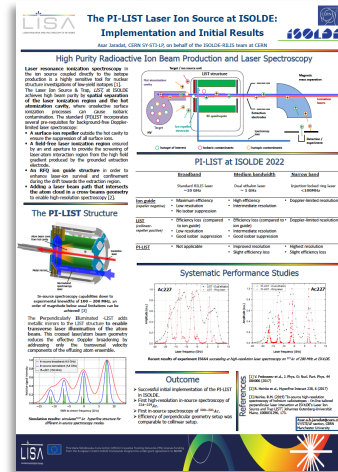
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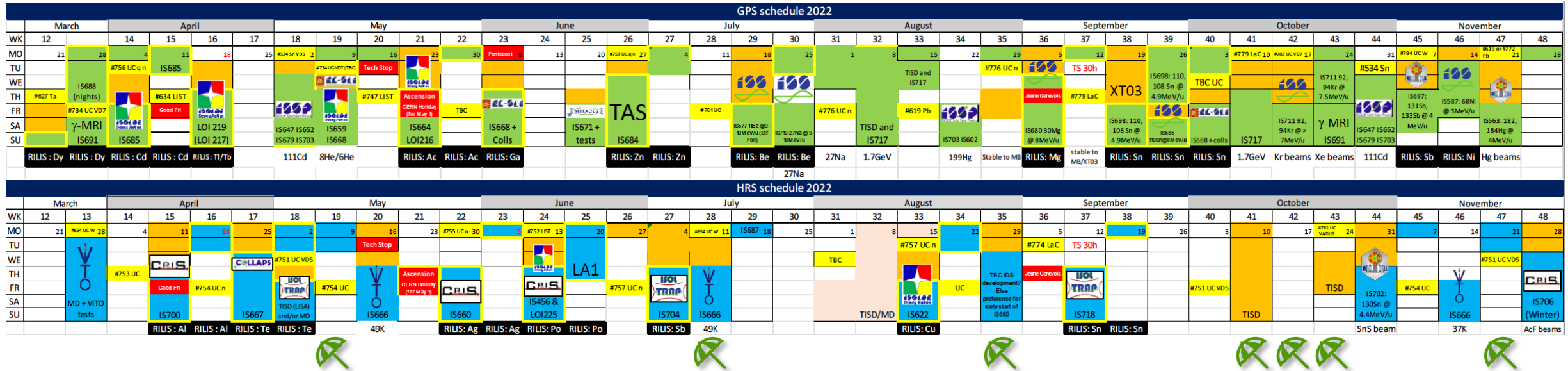


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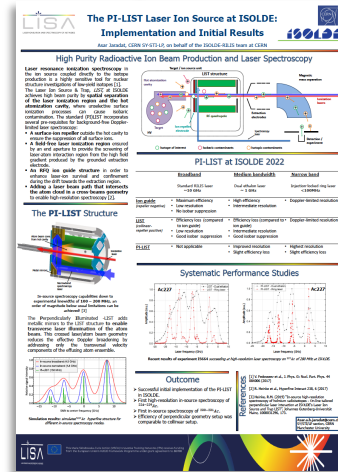
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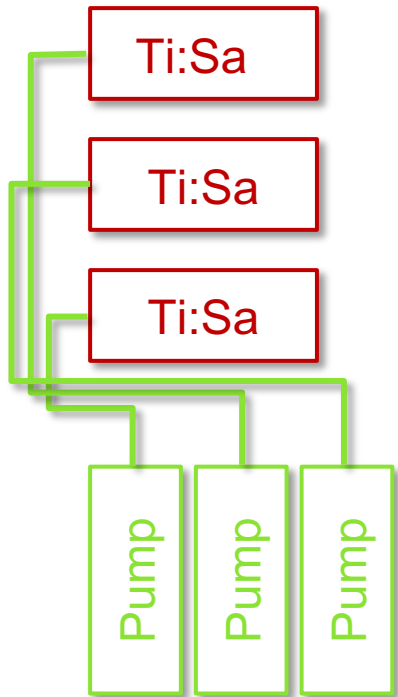


The Line-up - Lasers

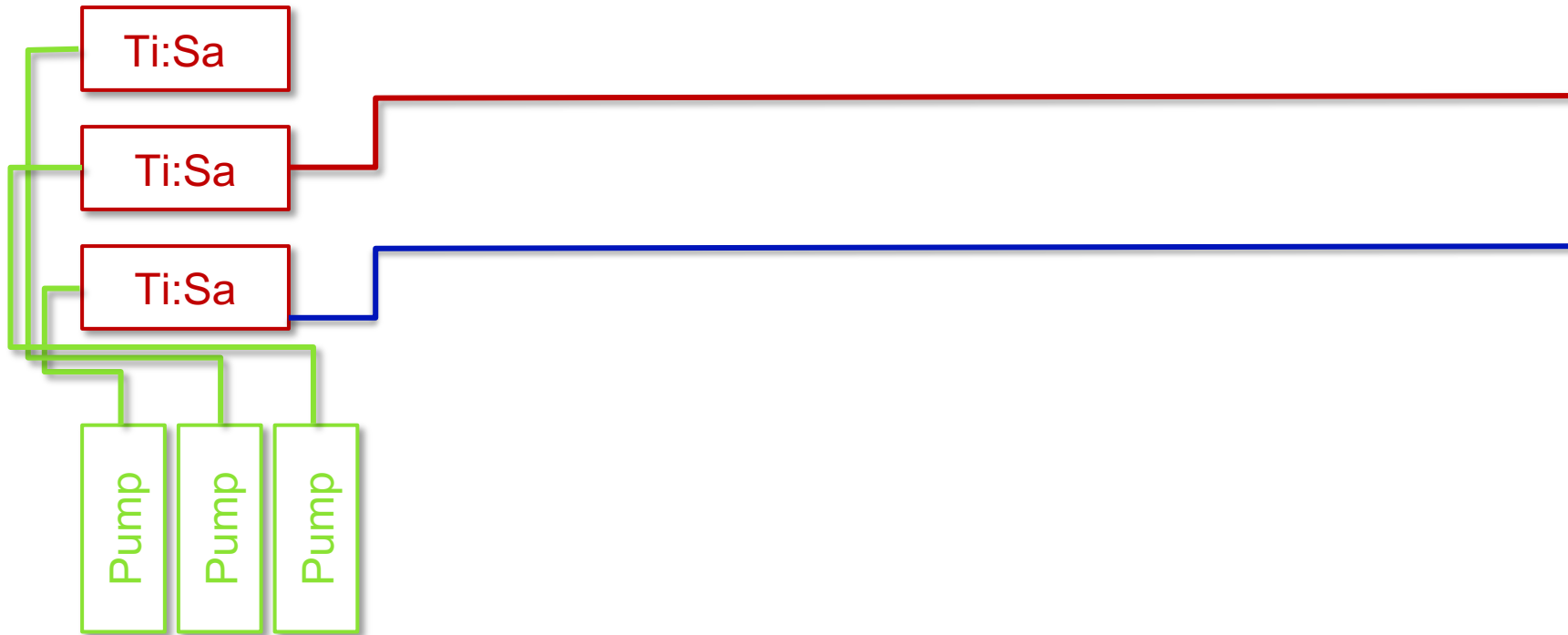
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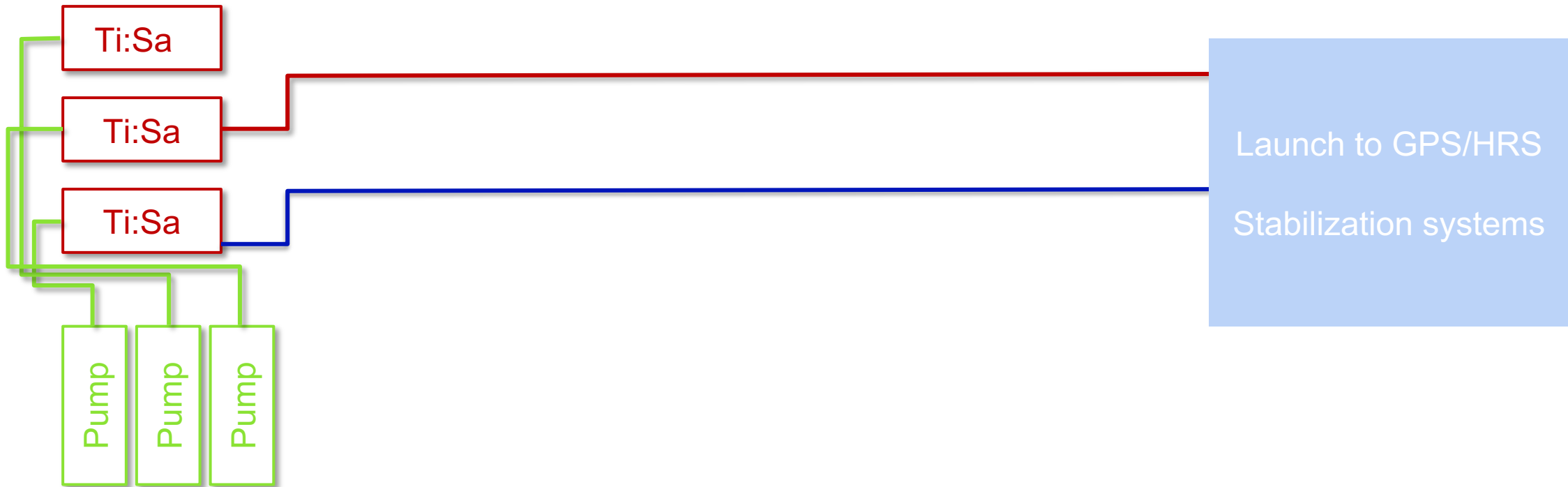
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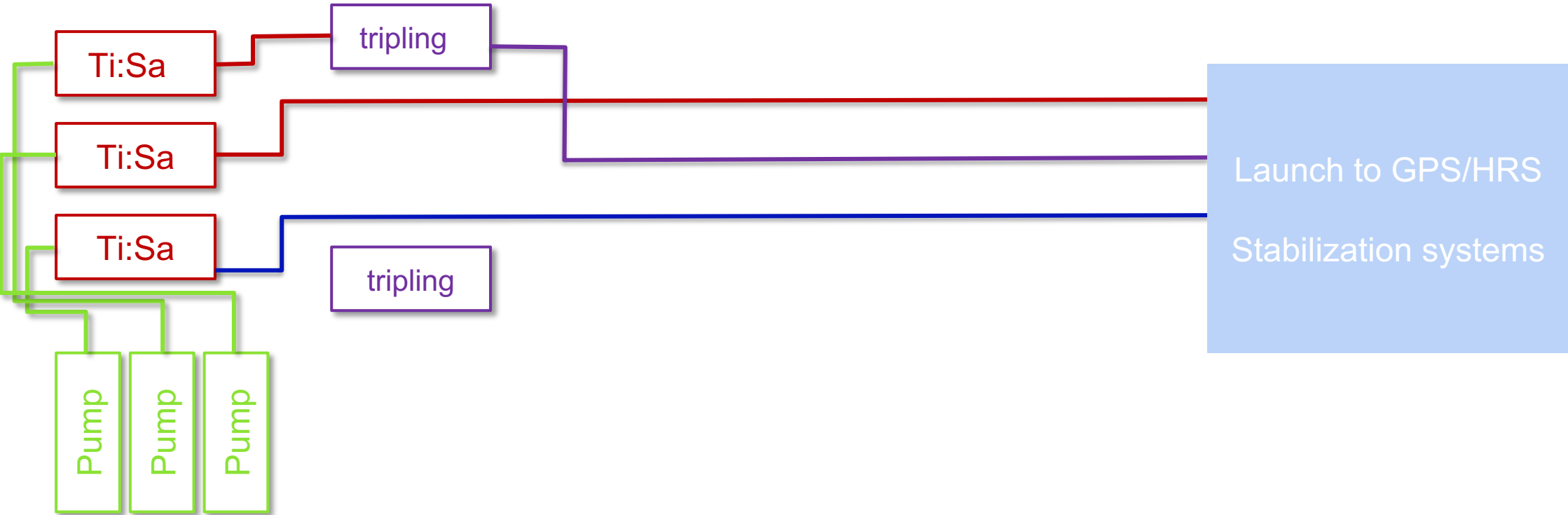
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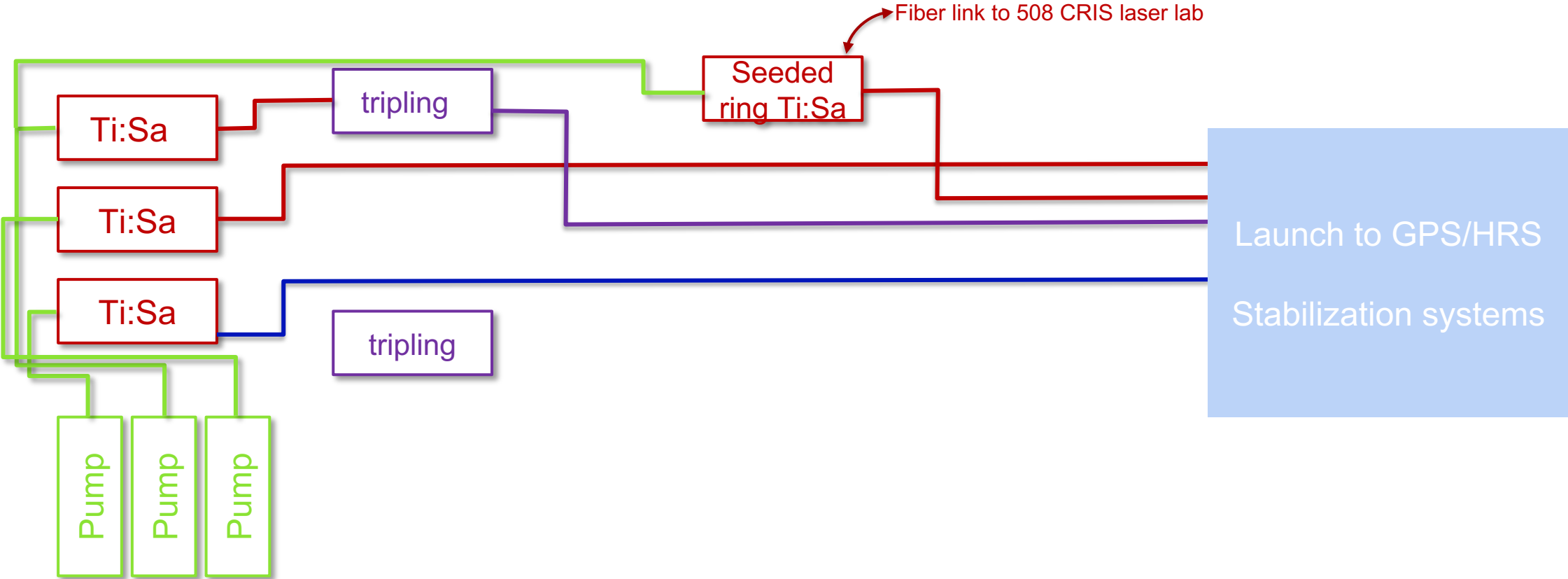
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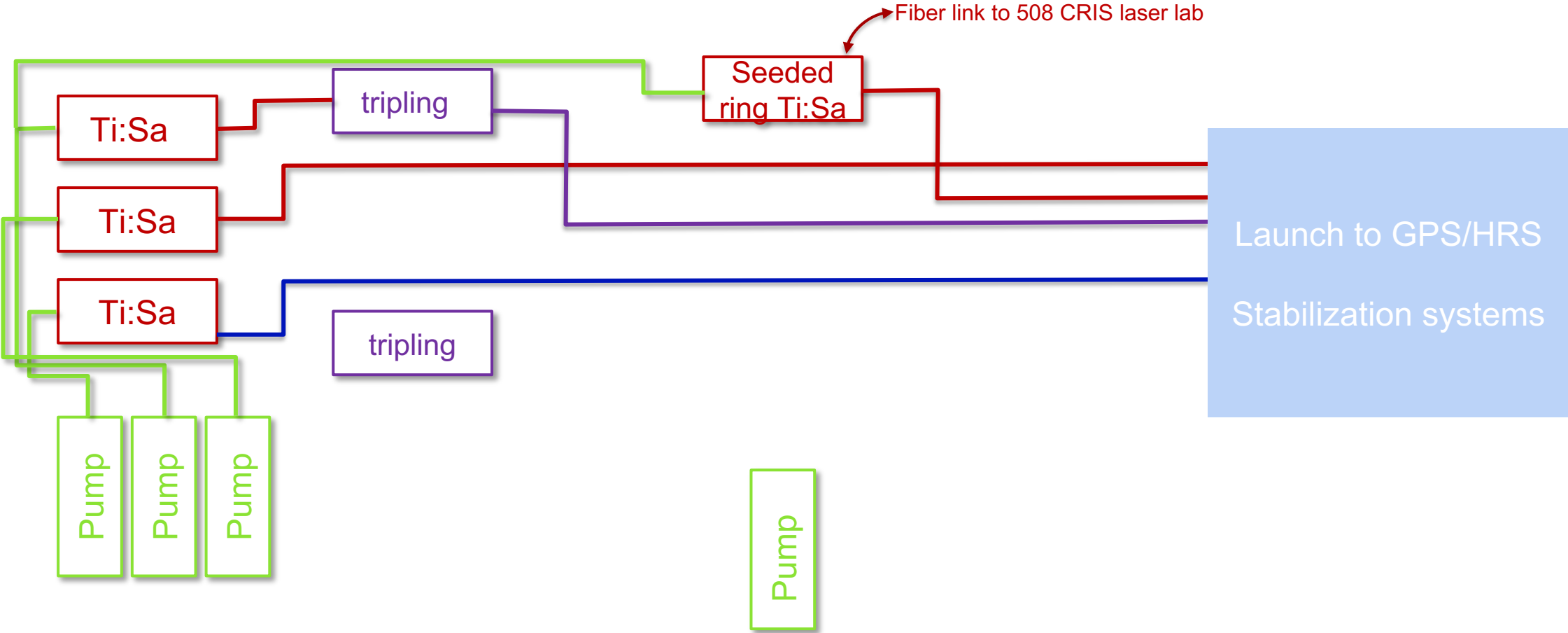
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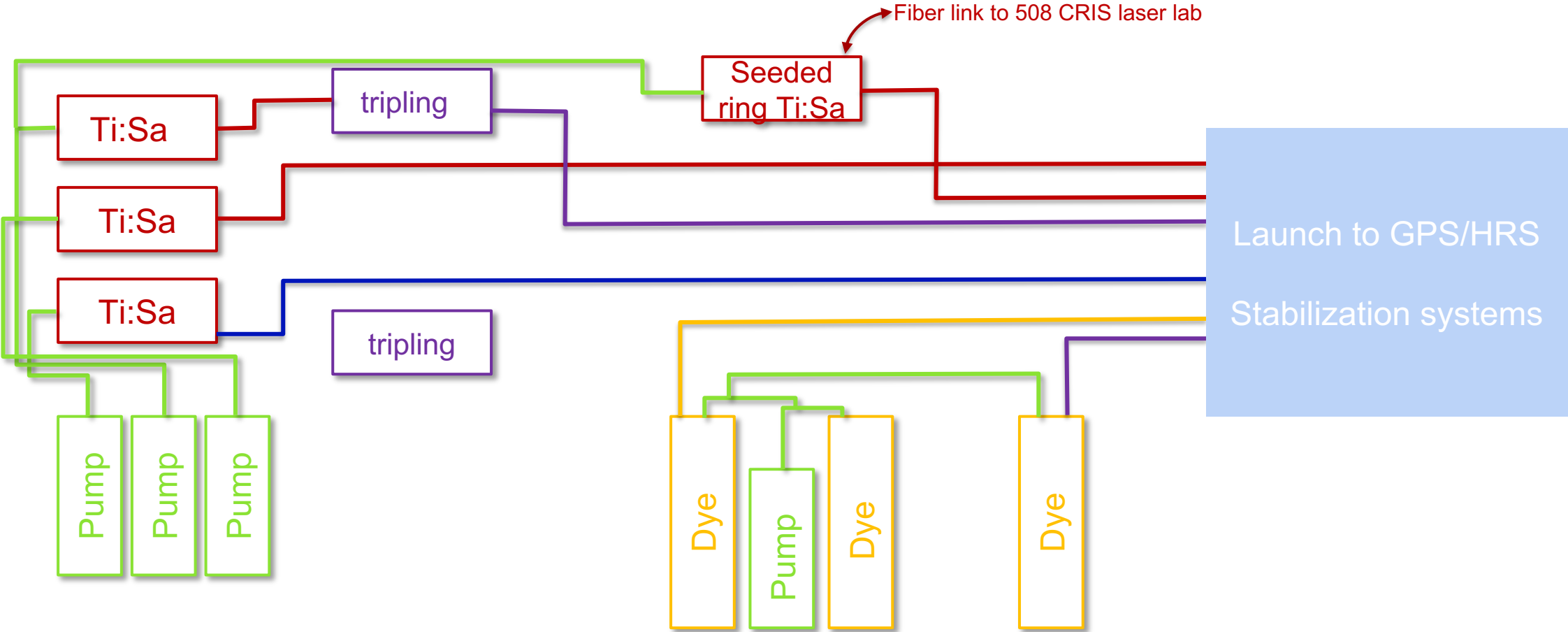
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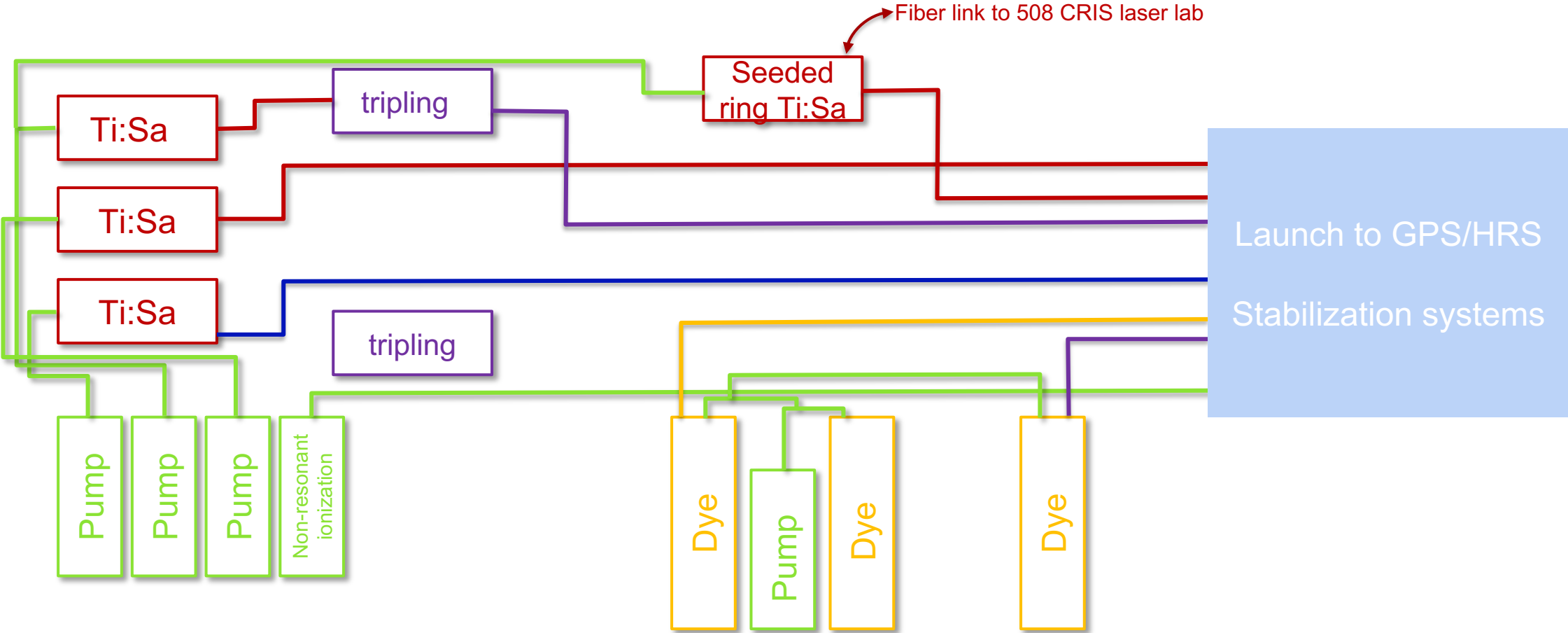
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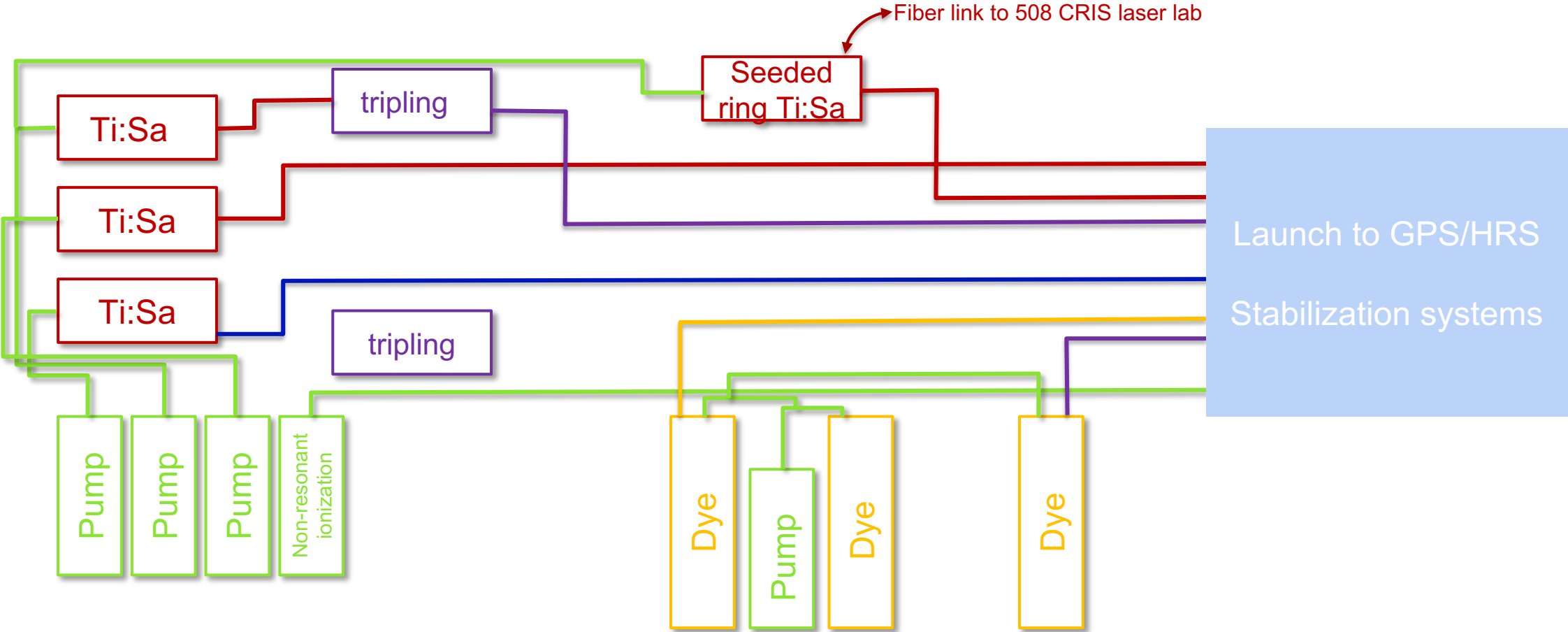


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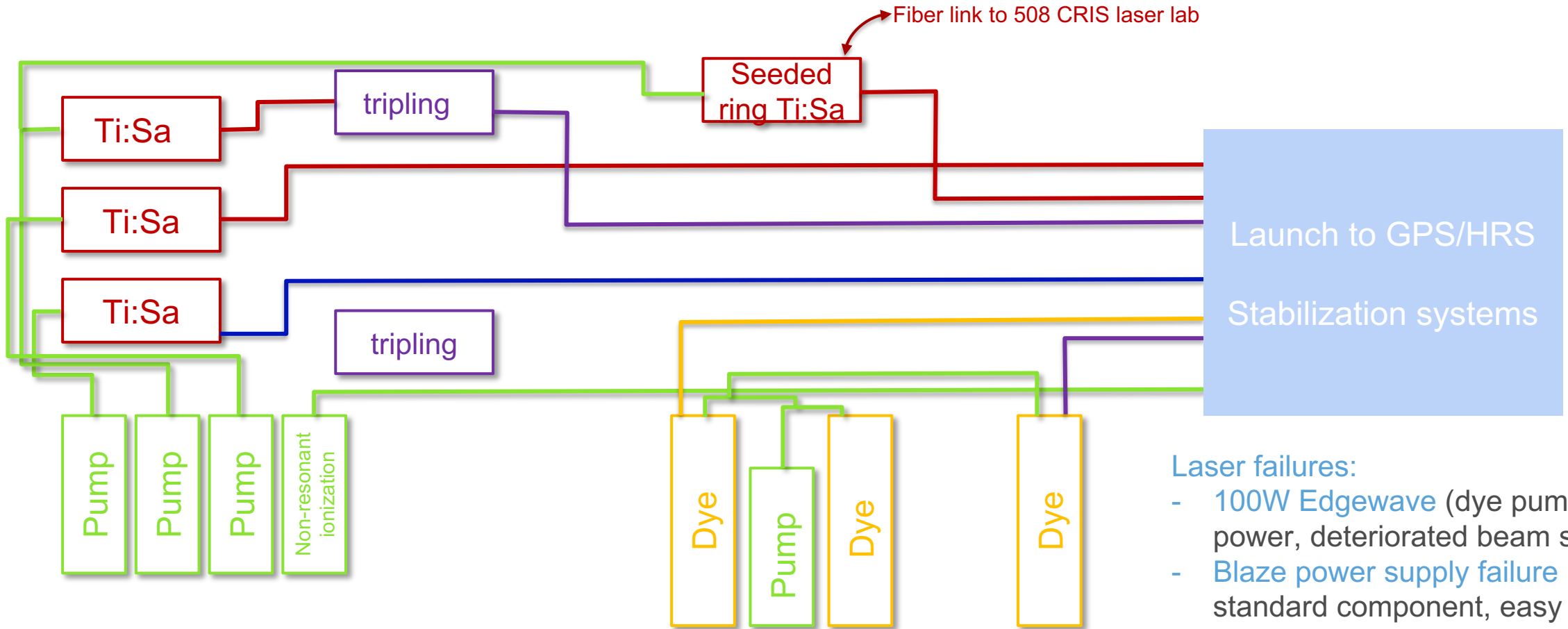
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6 tunable lasers, 1 NB seeded laser, 5 Nd:YAG/YVO₄ lasers



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Laser failures:

- 100W Edgewave (dye pump) lost power, deteriorated beam shape
 - Blaze power supply failure → standard component, easy to replace
- **NO downtime** due to laser failures!

The Line-up – Team members



Bruce Marsh
Section leader SY-STI-LP
Since 2022,
Replacing Valentin



Eduardo Granados
Staff
Raman laser dev



Reinhard Heinke
Fellow



Asar Jaradat
LISA-ITN ESR



Ralitsa Mancheva
Doct student



Valentin Fedosseev
Honorary Staff member
since May 2022

Ralf Rossel
Staff since May 2022



Cyril Bernerd
KU Leuven post-doc



Daniel Echarri
Doct student
Left July 2022



Katerina Chrysalidis
Staff since May 2022
RILIS team leader,
Replacing Bruce

Isabel Hendriks
Tech student

Finished this year

Georgios Stoikos
Tech student
Left Oct 2022



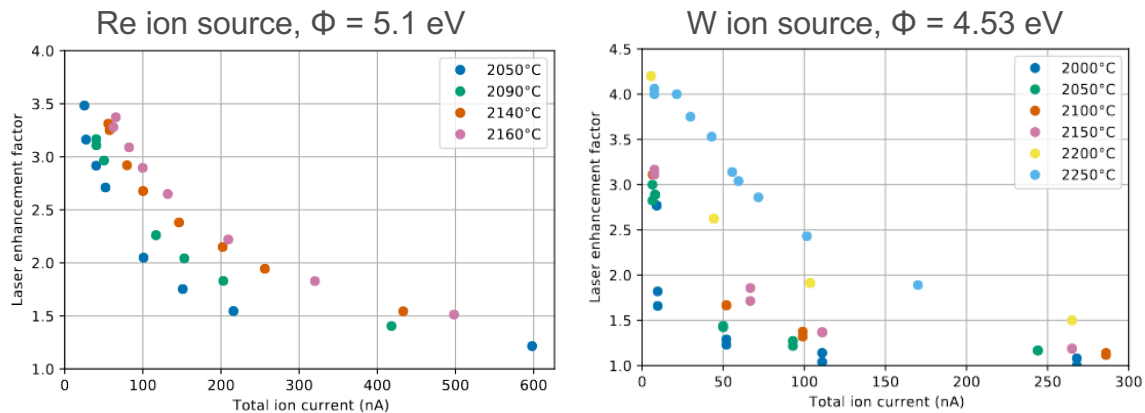
Development work

High ion throughput source

- Investigations of laser ion survival at high ion loads
- Symptoms: at (high) total ion current laser ion extraction efficiency reduces!
- Main interest: MEDICIS → short collection times with high ion currents
- Establishment of procedure for determining limits
- Laser enhancement tests with Sm and K contamination
- Visible effects in enhancement factor & time structure

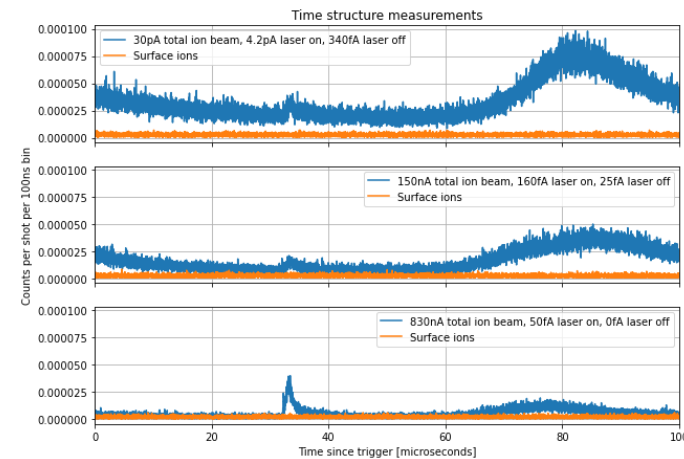
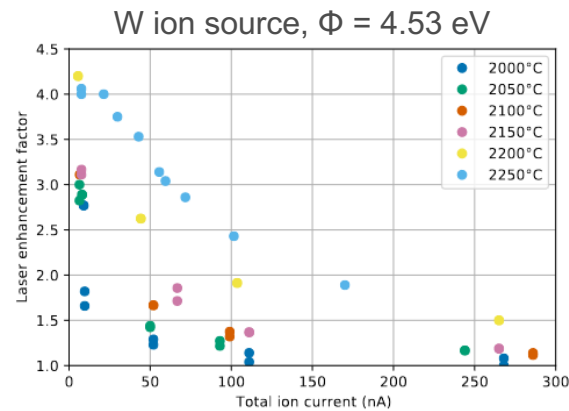
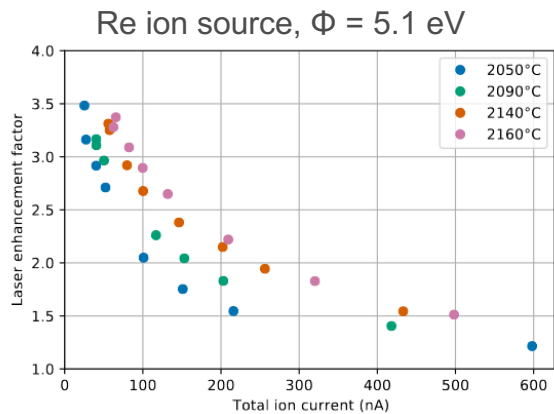
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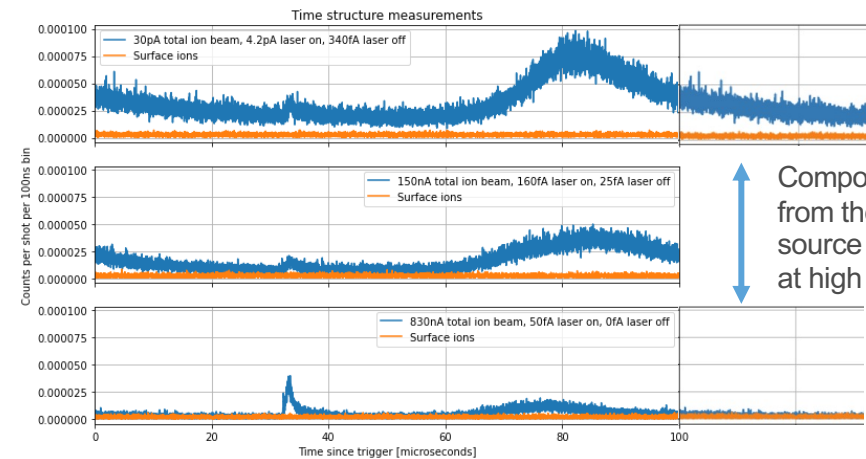
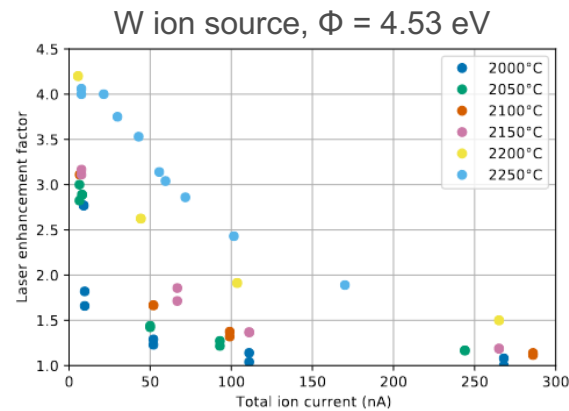
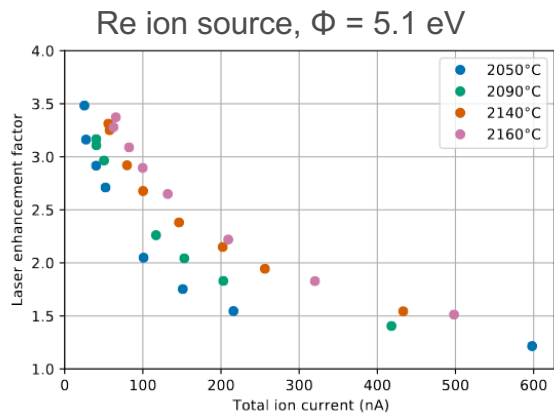
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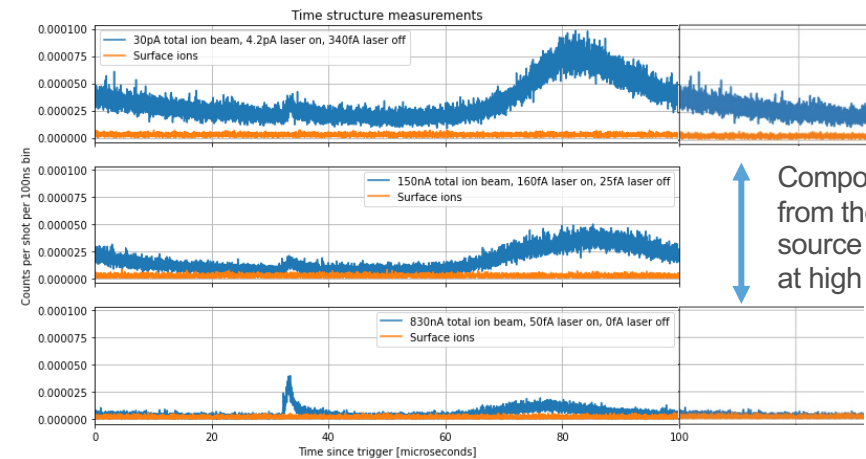
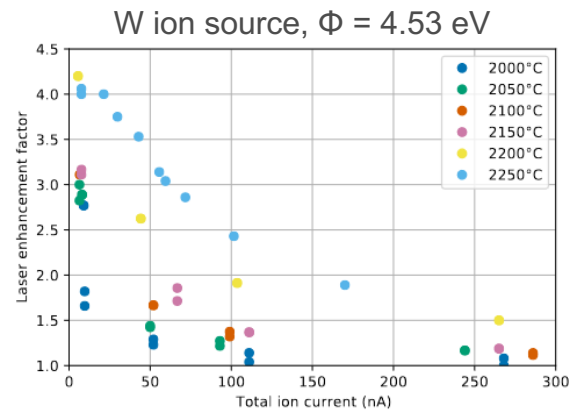
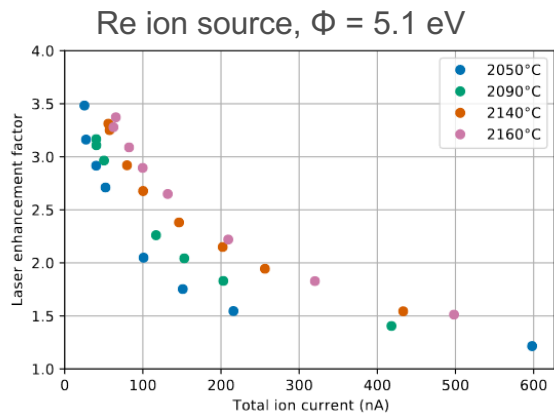
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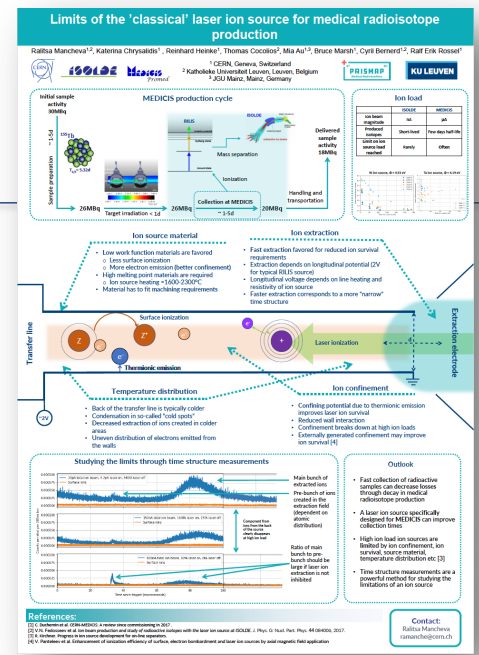
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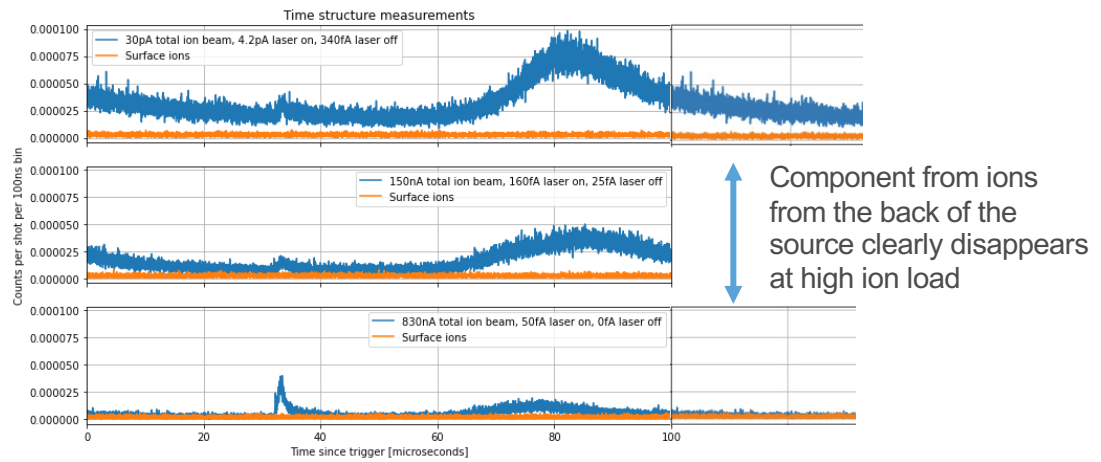
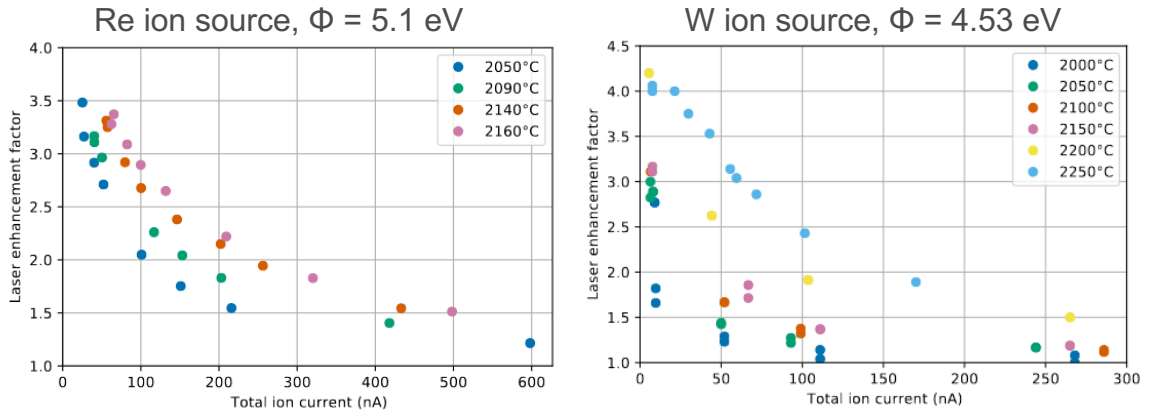
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See poster by R. Mancheva



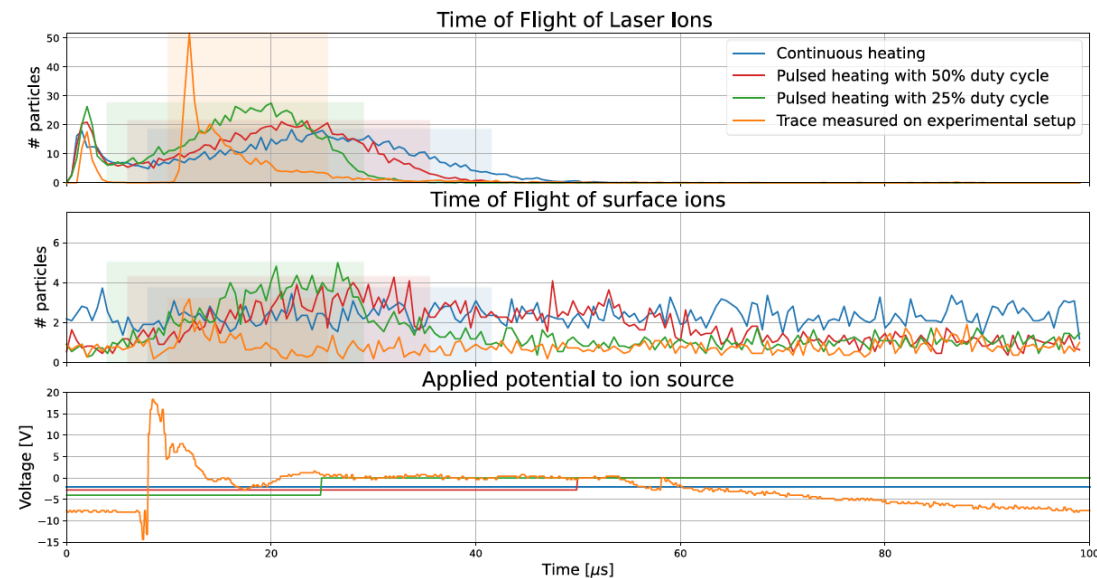
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Pulsed heating

- “Small project” funding secured by R. Heinke, collaboration with SY-ABT-PPE
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- DC heating of ion source leads to potential drop along the source → guiding ions towards extraction field
- Introduce duty cycle to heating → same average power but pulsed

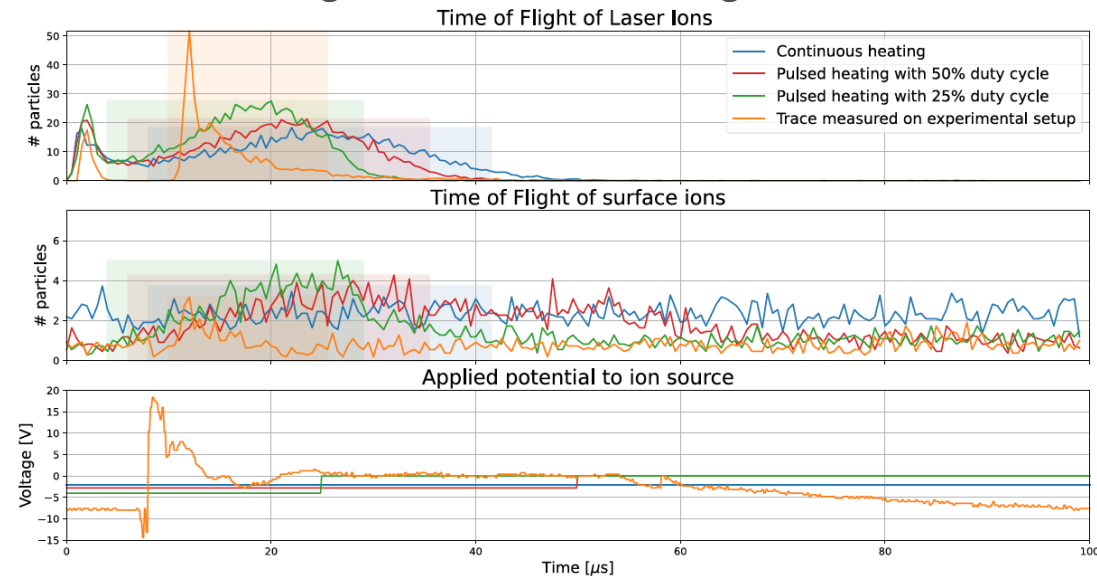
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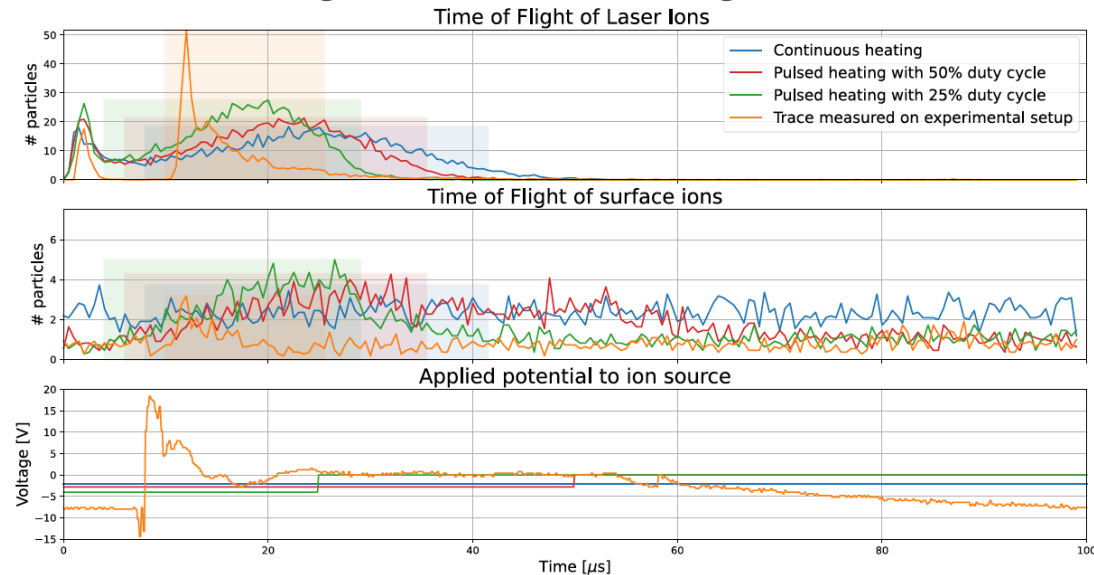
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Enhancing ISOLDE beam purity by ion bunch width compression via fast modulated heating of the RILIS ion source
 I. E. Hendriks^{1,2}, R. Heineke³, B. Marth³, C. Borelli⁴, G. Grassano⁵, K. Chrysalidis⁶, R. Basso⁷, J. Rupp⁸, T. Krüger⁹, V. Seng¹⁰, L. S. DuBois¹¹, S. Roth¹², M. Barner¹³, R. J. M. van der Vliet¹⁴, T. Stadbauer¹⁵, T. Kalin¹⁶

¹ CERN, ² Lund University, ³ TU Darmstadt, ⁴ TU Braunschweig, ⁵ TU Wien, ⁶ University of Jyväskylä, ⁷ University of Jyväskylä, ⁸ University of Jyväskylä, ⁹ University of Jyväskylä, ¹⁰ University of Jyväskylä, ¹¹ University of Jyväskylä, ¹² University of Jyväskylä, ¹³ University of Jyväskylä, ¹⁴ University of Jyväskylä, ¹⁵ University of Jyväskylä, ¹⁶ University of Jyväskylä

Radioactive Ion Beam Production with RILIS

ISOLDE produces radioactive ion beams by creating a target of heavy nuclei with protons. To create a beam, the isotopes are ionized and extracted out of the ion source using a high voltage extraction electrode. They are then directed through a mass separator to select a single mass (Fig. 1) [1].

At ISOLDE, the most commonly used ion source is the Resonance Ionization Laser Ionization Source (RILIS). Here, beams are tuned to match unique electronic shell transitions of a single element (Fig. 2). The beams will ionize the selected element while leaving other elements unaffected. By selecting a single mass with the mass separator and a single element with the laser, the desired isotope is singled out (Fig. 3). This method is very commonly used as it is a highly element selective and creates very pure beams [2].

Surface ionization is the main source of contamination. This happens when a neutral particle gives an electron to the hot ion source surface and becomes positively charged. Surface ions with the same mass as the desired isotope (isobaric contaminants) will still end up in the beam. This poster presents an ion source heating scheme aimed at manipulating the ion bunch time structure to apply effective beam purification gating techniques.

Time Structure Manipulation

The ion source is a hollow tube that is heated to 2000 °C through resistance heating with a current of 300 A. This current creates a linearly increasing potential along the ion source. The RILIS laser system operates pulsed at a 30 kHz rate. As a consequence, the ions come out in bunches, as shown in the step to the right.

The graph on the right shows the resulting time structure of the ions when they arrive. The ion bunches are not perfectly continuous while the laser ions arrive in bunches. The principle of pulsed heating is to pulse the heating current synchronized to the laser pulses, a higher potential gradient during on-time is achieved, thus extracting the ions in a more compressed bunch. Subsequent ion bunches can be applied more efficiently.

Simulation Results

The pulsed heating scheme was simulated using SIMU [4]. The simulation configuration is shown to the right.

- The ions are bunched as expected.
- The measured trace shows a more pronounced peak when the laser is on.
- The bunching of the contamination is more severe than expected.
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Experimental Results

The circuit below has been used as a first simple approach to test the performance of pulsed heating. The measured traces of the voltage and the current are shown to the right.

The heating curves should overlap. The offset is most likely due to measurement inaccuracies. The pulsed heating scheme gives a higher peak voltage at the same temperature.

Outlook

- The simple circuit was simulated using LTSPICE [5]. The result is shown in the plot below. From this plot we can conclude that this setup is limited to a triangular pulse shape.
- The circuit below shows a more advanced approach that can create different shapes of pulses [6]. The plot below shows a square pulse shape which obtained with Diodes using the parameters shown in the circuit.

Contact and References

Charge Detector

Low voltage power supply

Advanced Approach

Simple Approach

References: [1] I. E. Hendriks et al., Phys. Rev. Lett. 121, 044801 (2018). [2] R. Heineke et al., Phys. Rev. Lett. 121, 044801 (2018). [3] I. E. Hendriks et al., Phys. Rev. Lett. 121, 044801 (2018). [4] I. E. Hendriks et al., Phys. Rev. Lett. 121, 044801 (2018). [5] I. E. Hendriks et al., Phys. Rev. Lett. 121, 044801 (2018). [6] I. E. Hendriks et al., Phys. Rev. Lett. 121, 044801 (2018).

See poster by I. Hendriks

Single mode Raman laser – first use at OL2

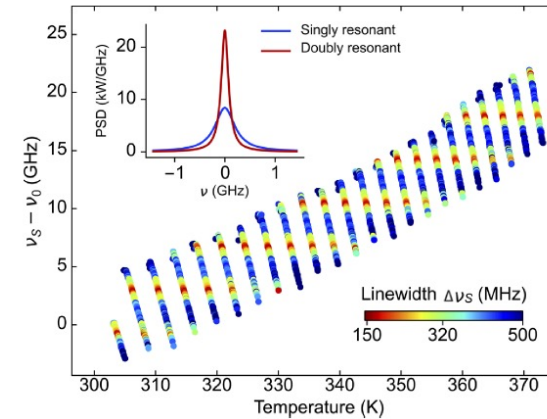
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- Can be used for shifting wavelength up
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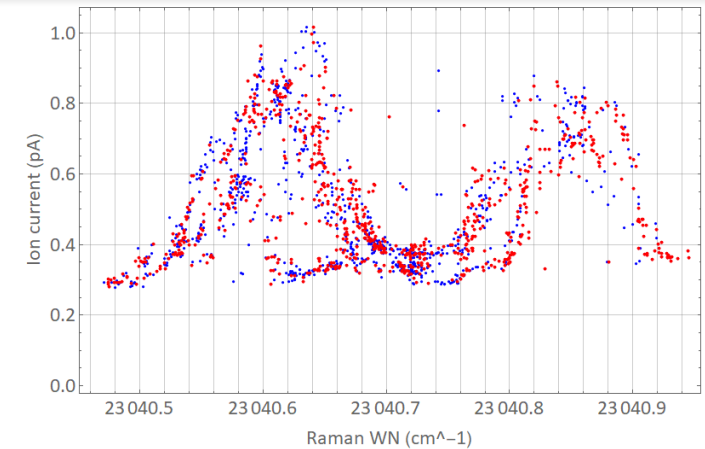
Eduardo Granados and Georgios Stoikos, *Opt. Lett.* 47, 3976-3979 (2022); <https://doi.org/10.1364/OL.464816>

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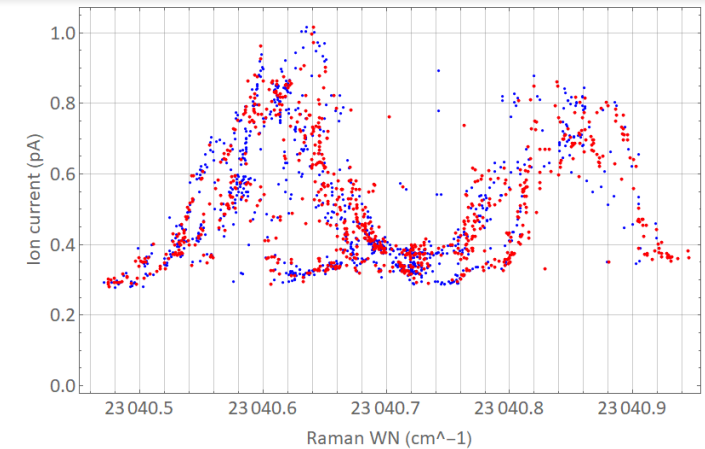
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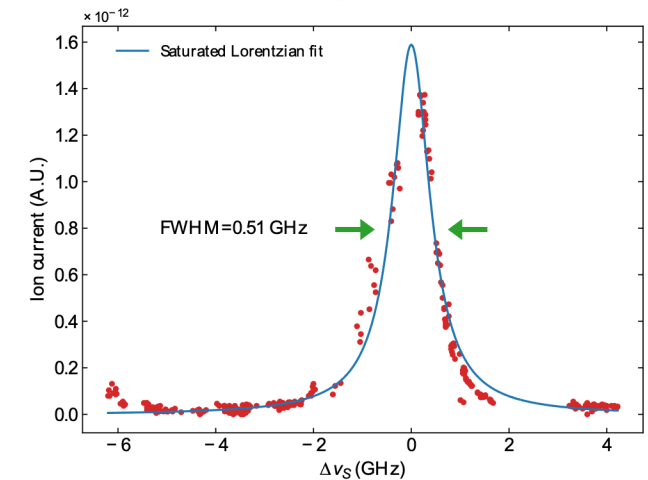
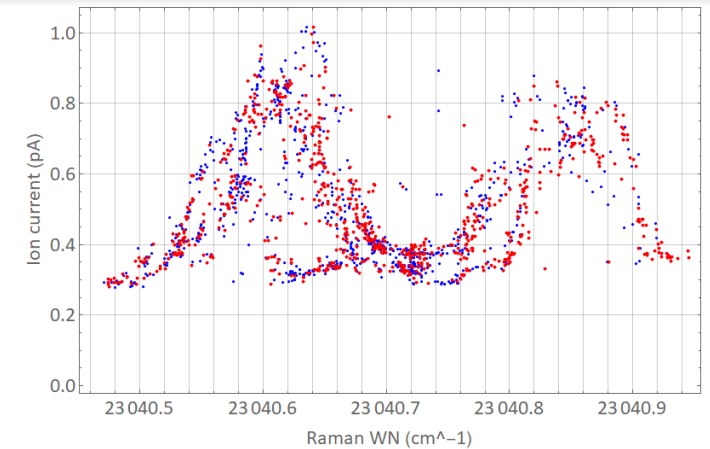
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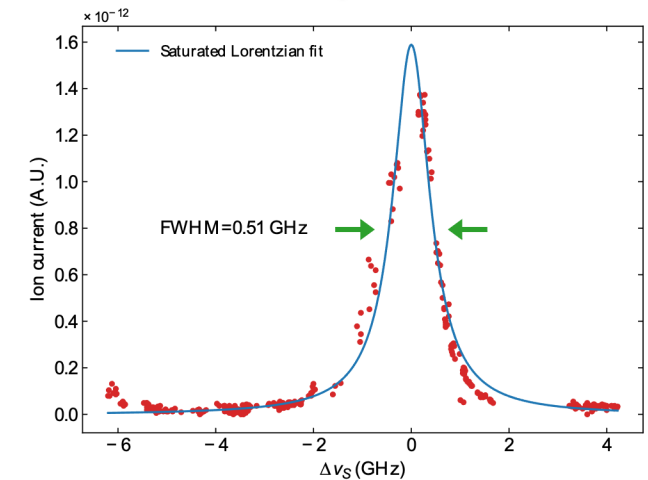
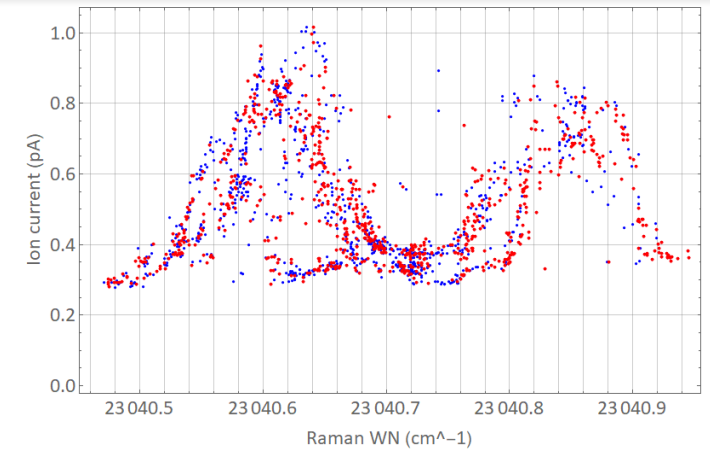
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Plot provided by G. Stoikos

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Monolithic diamond resonators for high-resolution spectroscopy
G. Stoikos, H. Reinhard, D. T. Echarrri, K. Chrysalidis, B. Marsh, V. Fedosseev and E. Granados

Introduction
It has been demonstrated that a single Longitudinal Mode (SLM) Raman laser in a monolithic diamond resonator can produce narrow-linewidth Stokes output.

High-resolution spectroscopy
To demonstrate the resonator's capabilities for HR spectroscopy, we used it in a Resonant Ionisation Spectroscopy (RIS) experiment. RIS is an element selective for isotope ionization which is the working principle for RILIS at CERN.

Experiment
The experiment took place in the Offline-2 facility at CERN which is testing facility equipped with a mass separator, PI-LIST and an optical table for RIS experiments.

Results
The Stokes output as a function of temperature along with the resulting ion current can be seen below.

See poster by G. Stoikos/ E. Granados

Light generation for Ag at CRIS

- Collaborative effort with CRIS to generate light at 328nm
- Option 1: frequency mixing of 532nm SM with seeded ring Ti:Sa laser
 - Construction of frequency mixing unit at RILIS

Photos/data by M. Urquiza



30/11/2022



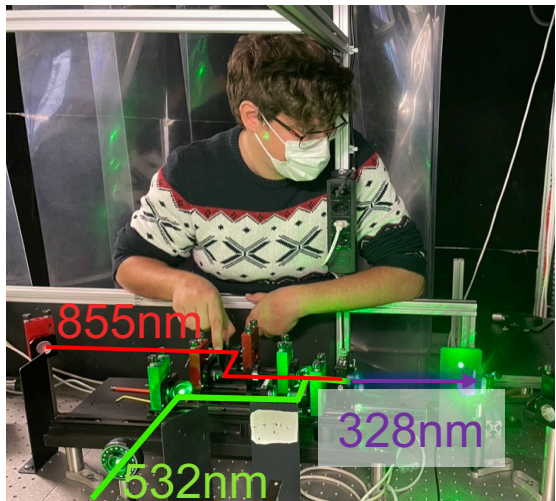
LISA – Laser Ionization and Spectroscopy of Actinides.

This Marie Skłodowska-Curie Action (MSCA) Innovative Training Networks (ITN) receives funding from the European Union's H2020 Framework Programme under grant agreement no. 861198



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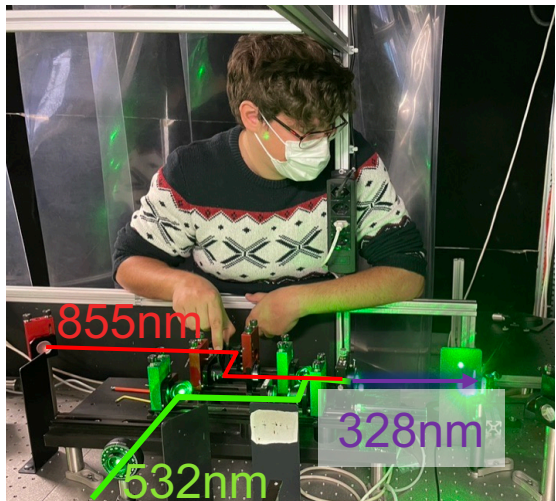
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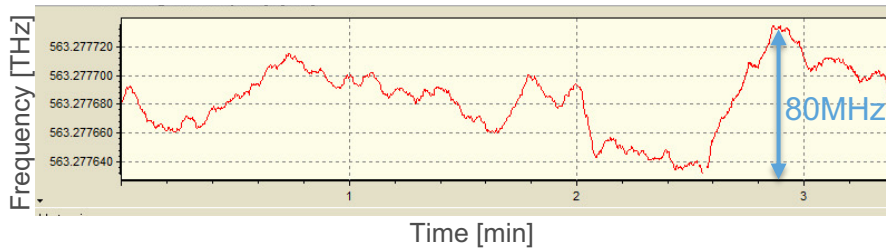
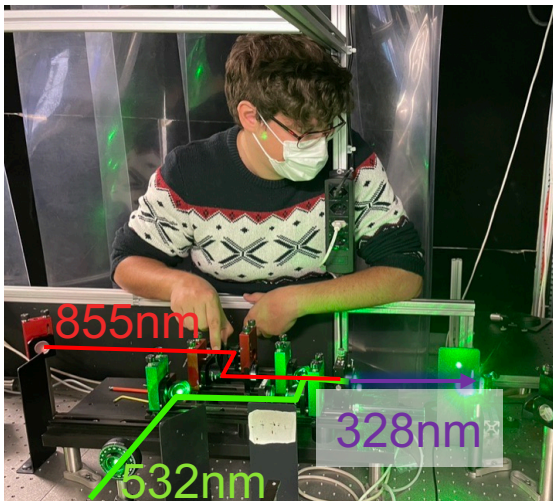
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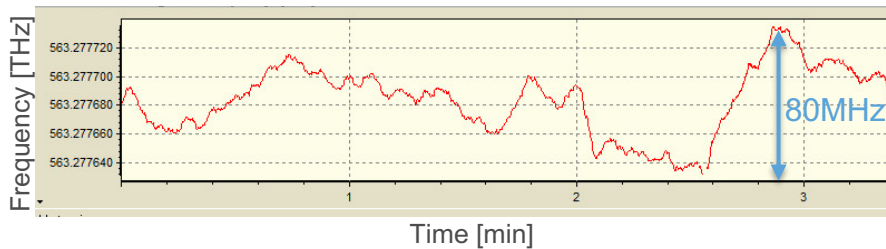
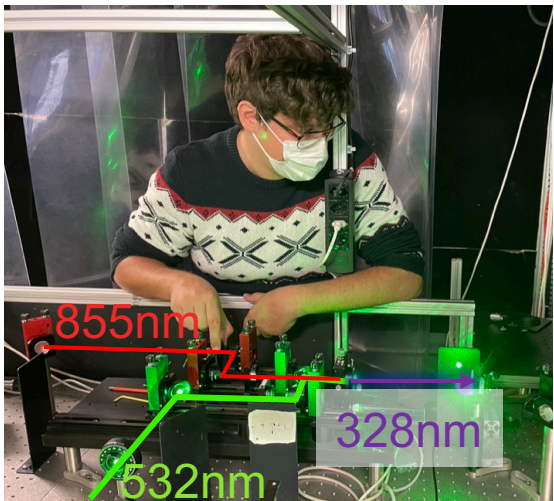
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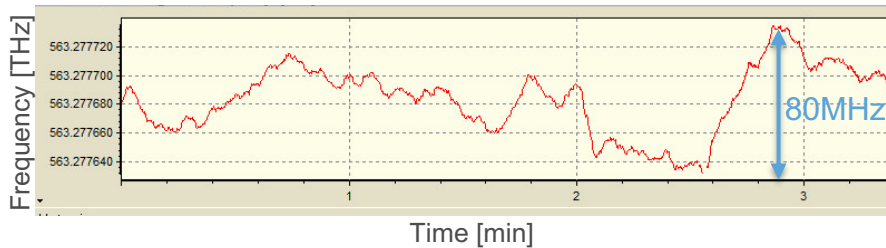
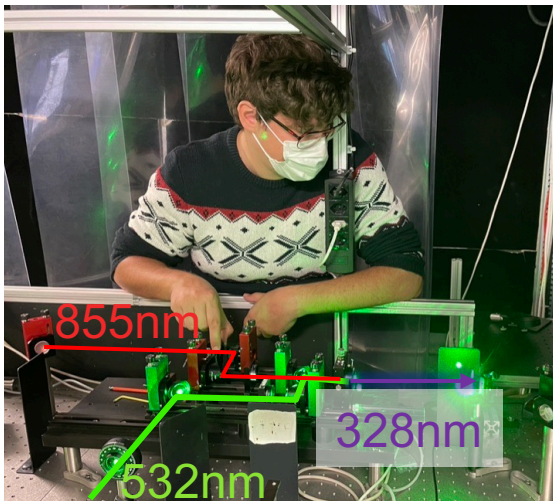


→ Frequency fluctuations of the green too large, no counter drift possible

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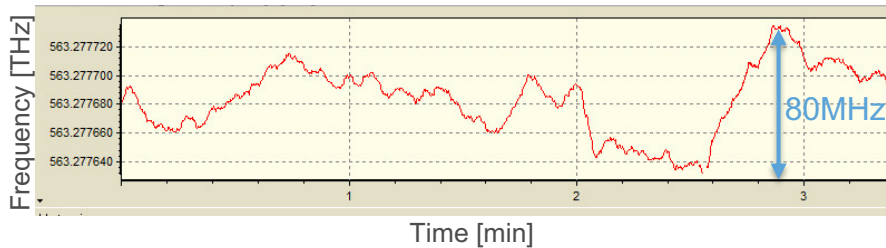
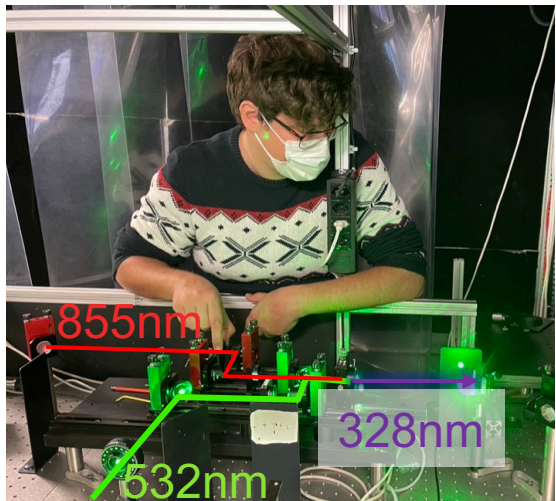


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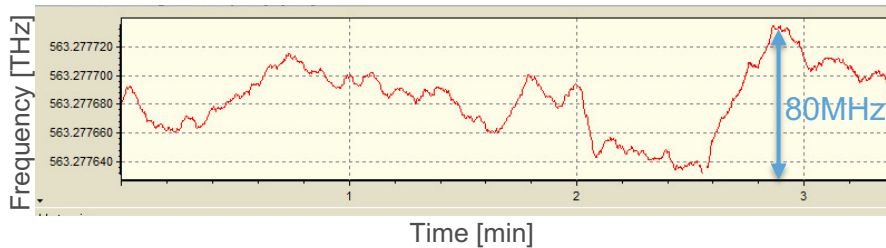
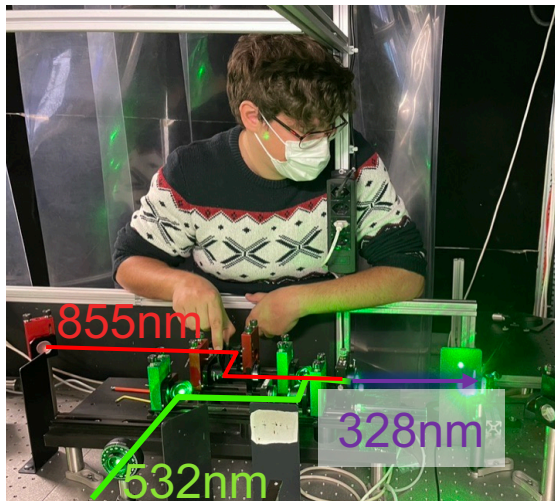


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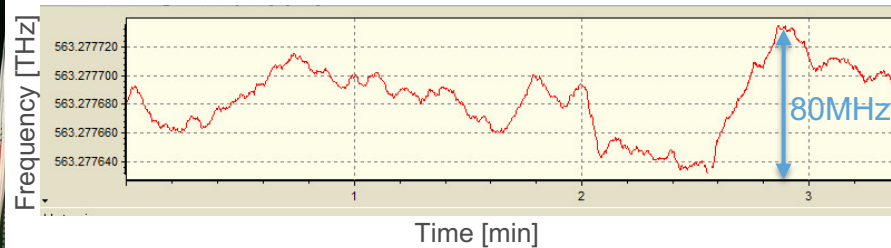
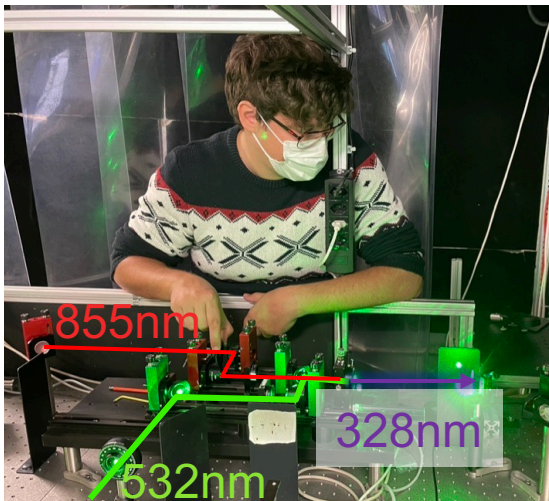
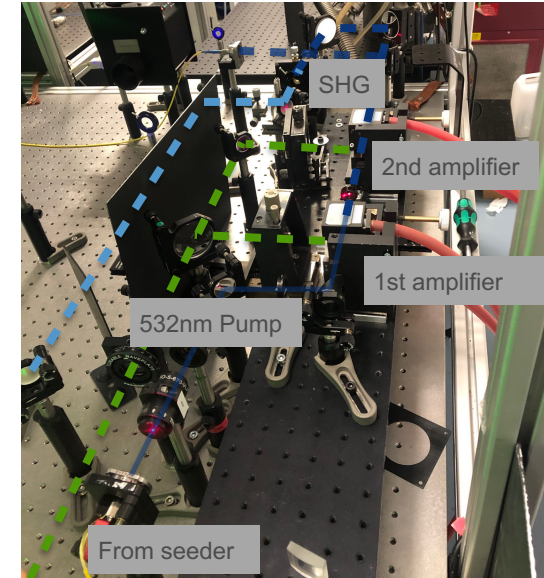


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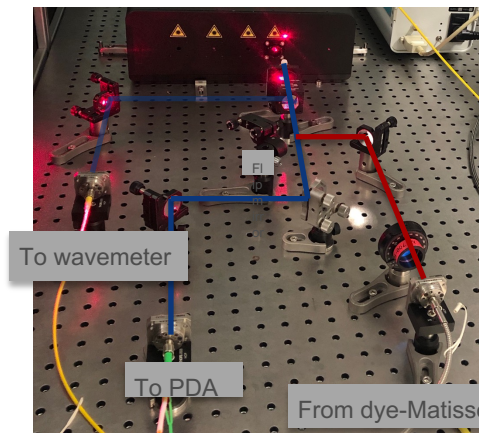
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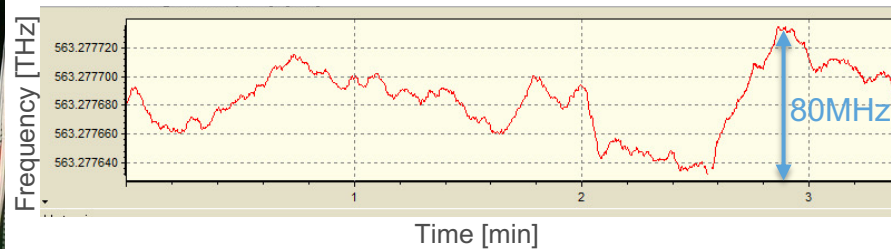
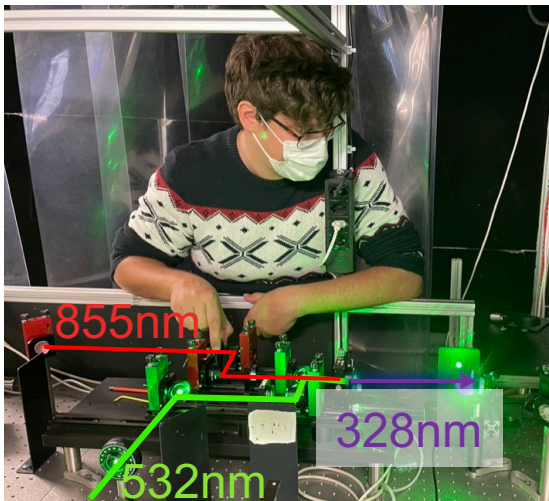
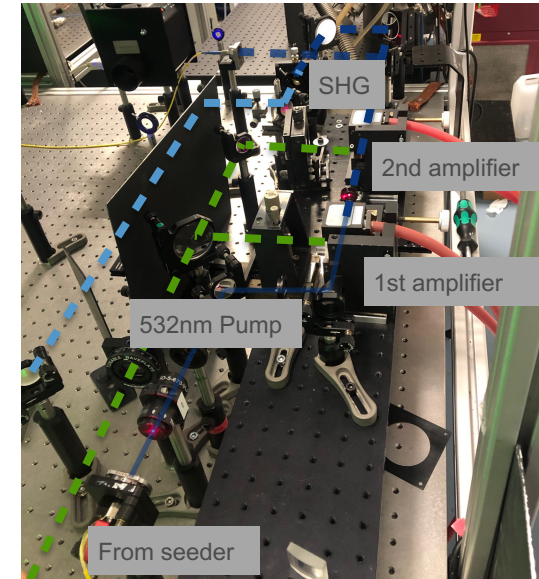
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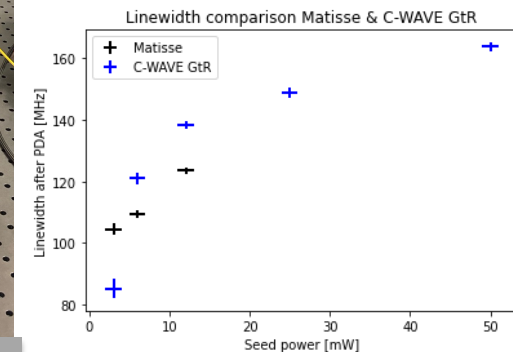
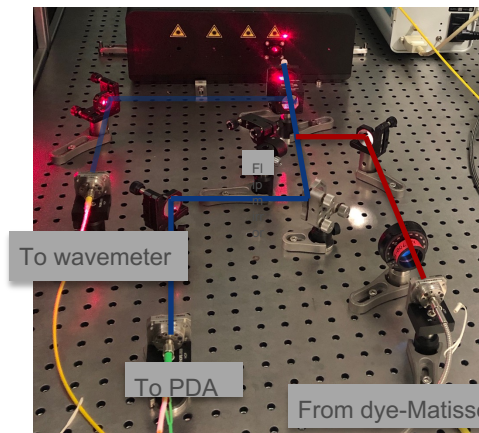
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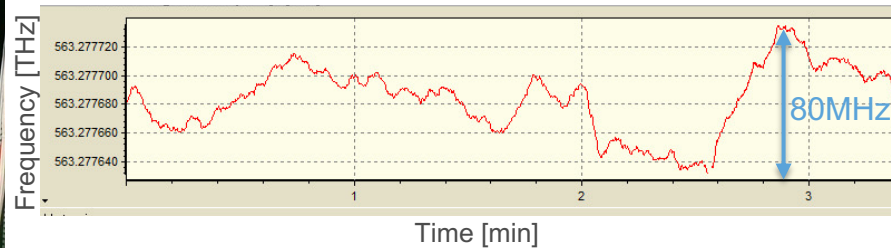
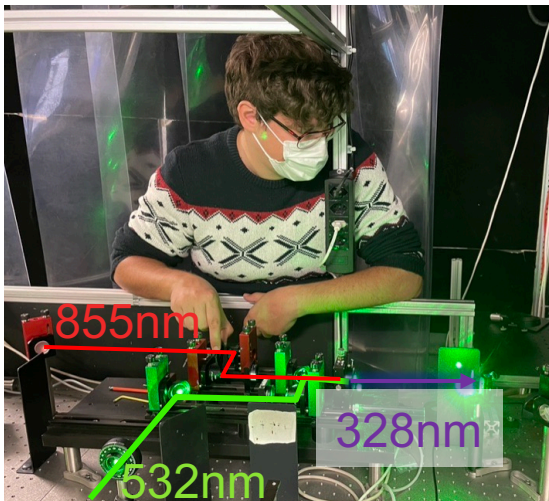
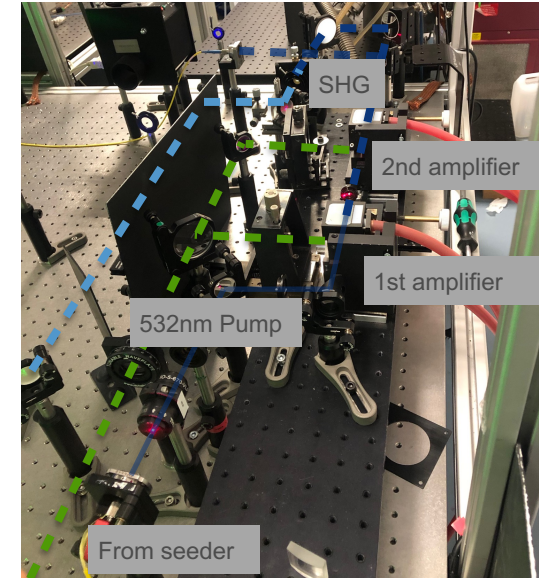
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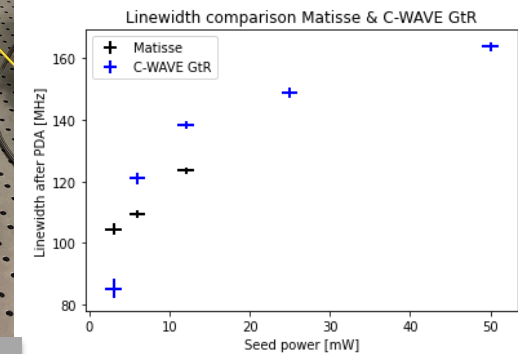
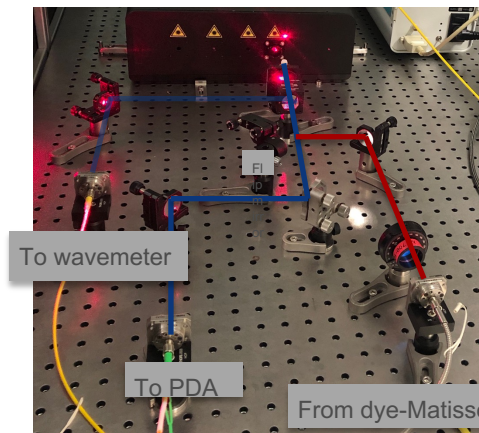
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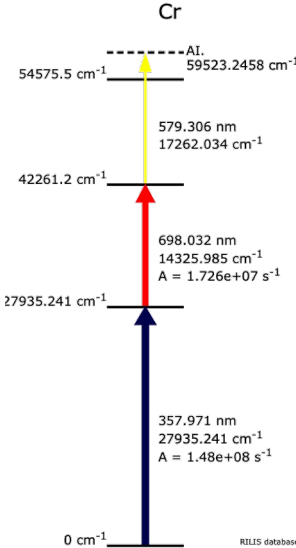
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Cr laser scheme development

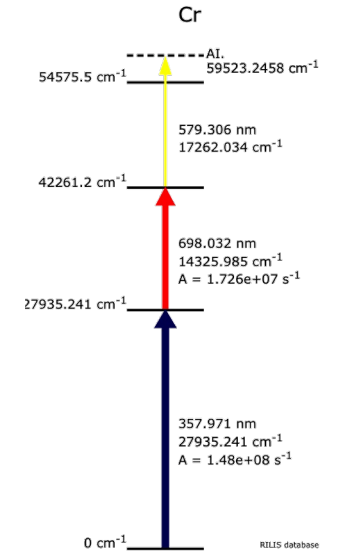
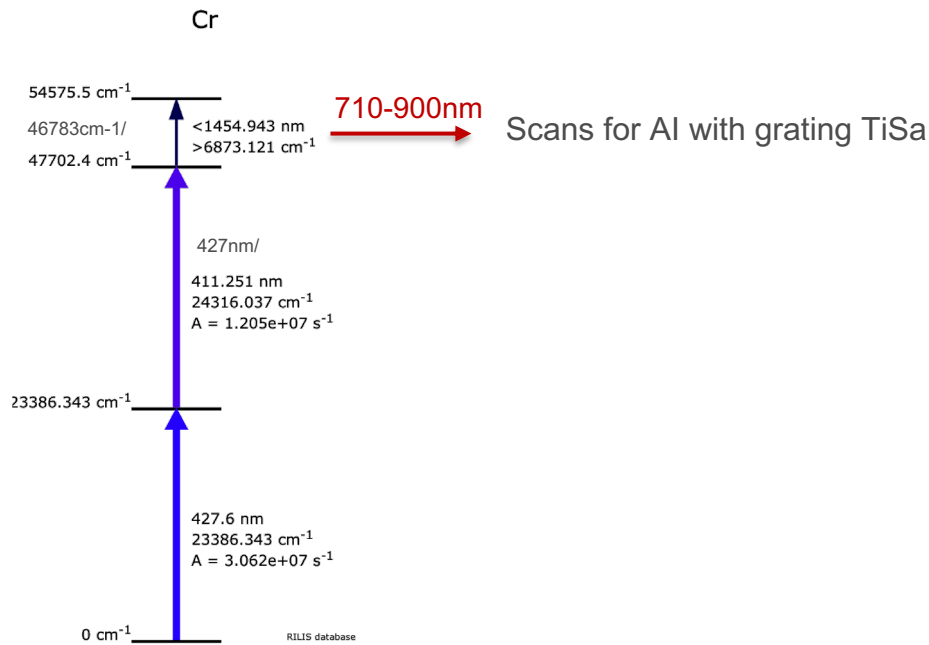
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T. Day Goodacre, <https://doi.org/10.1016/j.sab.2017.01.001>

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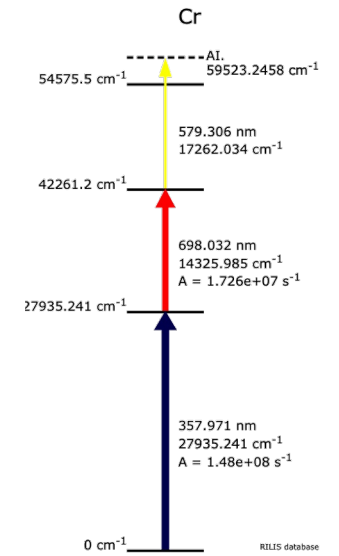
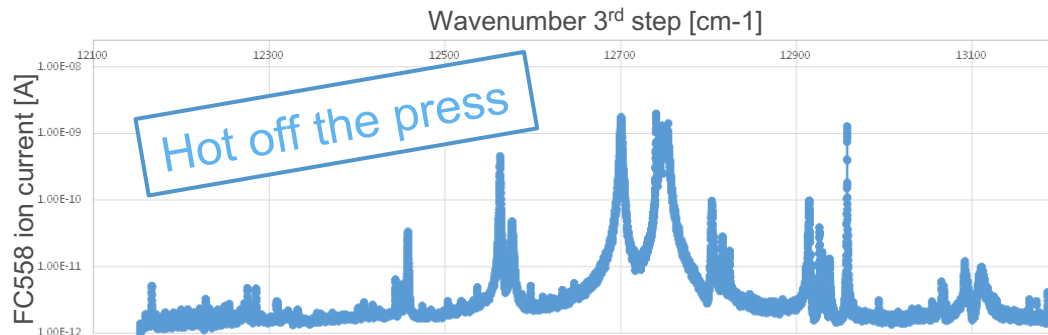
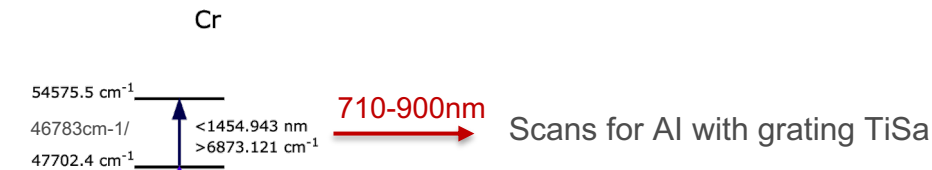
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- Develop new scheme based on TiSa laser transitions
- Currently on-going, last development of this year



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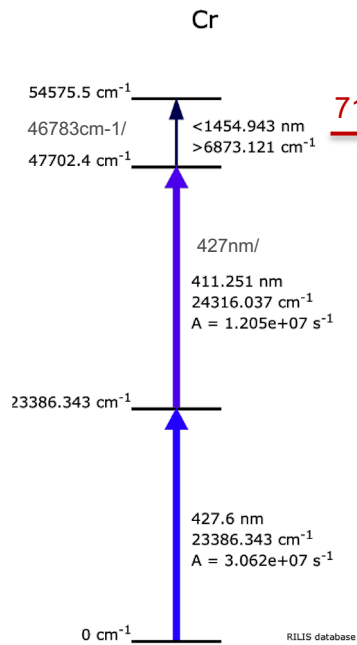
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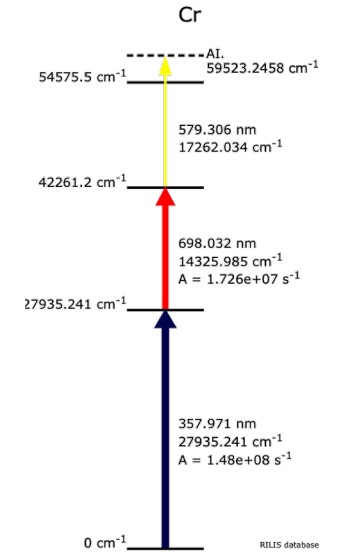
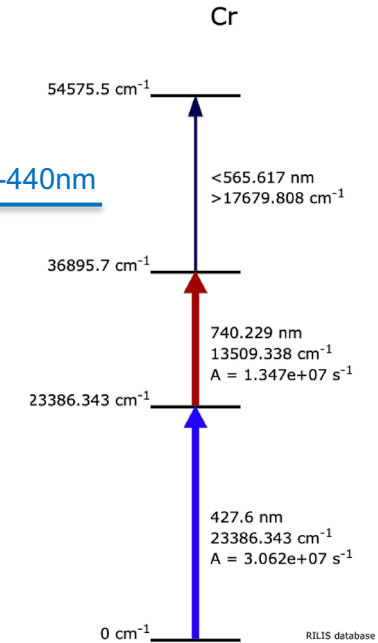
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Scans for Al with grating TiSa

Use oven for phase-matching of intra cavity doubling the grating TiSa for increased scan-range

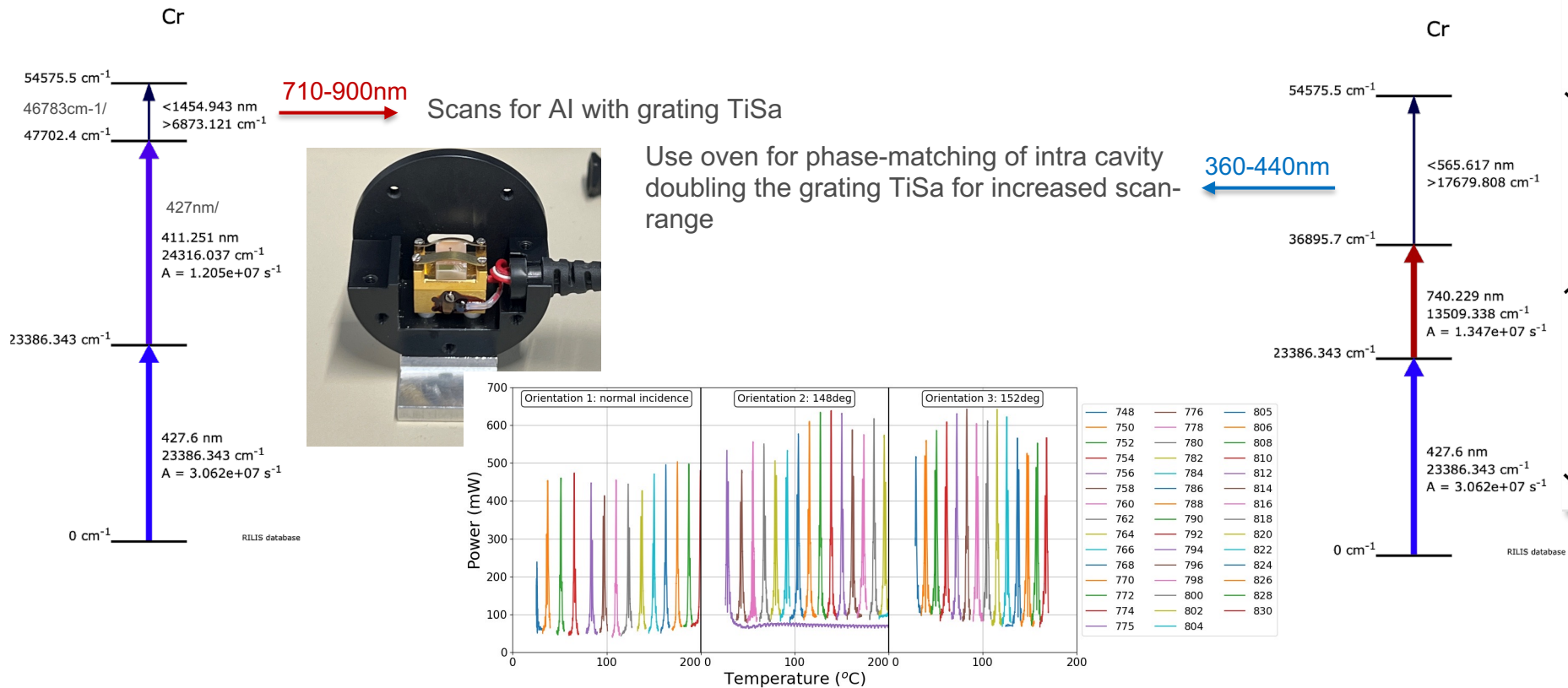
360-440nm



T. Day Goodacre, <https://doi.org/10.1016/j.sab.2017.01.001>

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Operation and new development at the MELISSA laser lab in MEDICIS
C. Bernerd, J. Suolinna, R. Mancheva, R. Heinke, J. Johnson, K. Chrysalidis, B. Marsh, T. E. Cocolios, R. Rossel, L. Lambert, T. Stora.

MEDICAL Isotope Collected from ISOLDE [1]

Resonance Ionization Laser Ion Source [2]

MEDICIS laser laboratory : MELISSA [3]

Laser development

1. Crystal oven for stability and blue-range scalability
2. Nonlinear processes : Sum and Difference Frequency Generation

Full solid-state laser laboratory covering every isotope laser ionization scheme
Feasibility for intra-cavity SFG and DFG for better beam-shape and power

Long-term power stability of laser infrastructure
Large blue-range versatility for fast switching or scheme development

Insert phone

[1] R. M. dos Santos Augusto et al. CERN-MEDICIS (Medical Isotopes Collected from ISOLDE): A New Facility. Appl. Sci. 2014, 4, 265-281
[2] Marsh, S.A. Resonance ionization laser ion sources for on-line isotope separation. J. Phys.: At. Mol. Opt. Phys. 2014, 48(8), 083001
[3] M. M. Gadea et al. MELISSA: Laser ion source setup at CERN-MEDICIS facility. J. Phys.: At. Mol. Opt. Phys. 2016, 50(1), 014001

See poster by C. Bernerd

Contact us

- KU Leuven Post-Doc position to work on MELISSA
→ <https://www.kuleuven.be/personeel/jobsite/jobs/60171404>
- PhD Student projects on
 - Laser development for resonance laser ionization
 - Laser Ion source developments
 - High resolution laser spectroscopy of Lanthanides



Thank you for
your attention!

