RILIS operation and developments 2025

Anjali Ajayakumar

On behalf of RILIS team

Content

- Introduction to RILIS
- Operation in 2025
- Developments
- In-source spectroscopy
- Outlook

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- **Introduction to RILIS**
- Operation in 2025
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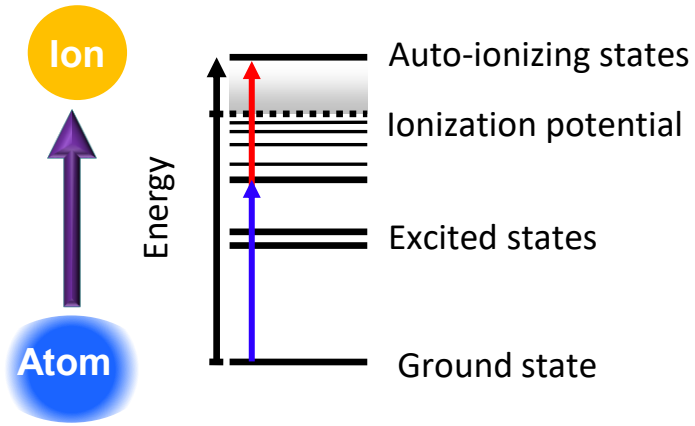
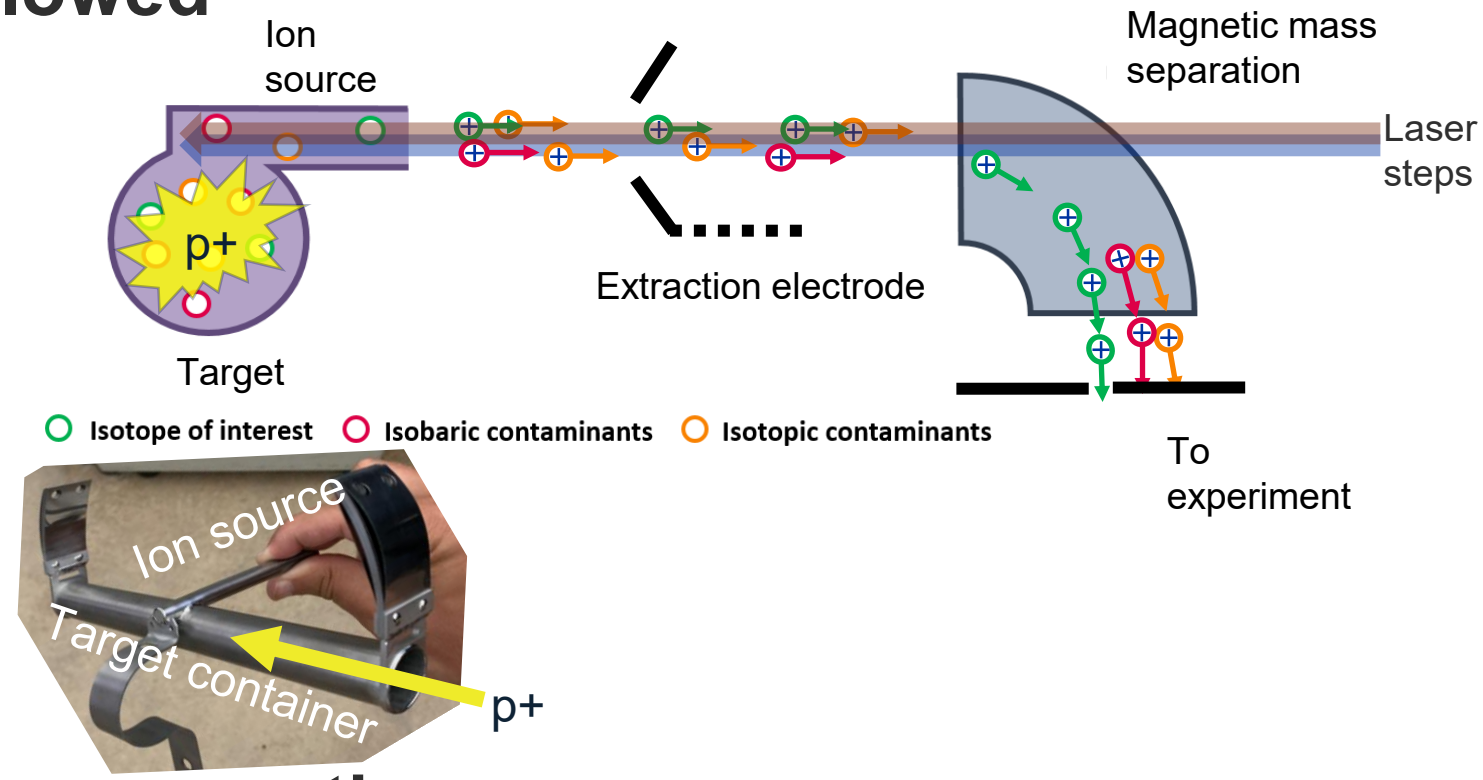
RILIS: Resonance Ionization Laser Ion Source

- **Step wise excitation followed by ionization**





- **Ion extraction and mass separation**
- **Pulsed solid state and dye lasers with frequency mixing**

RILIS: Resonance Ionization Laser Ion Source

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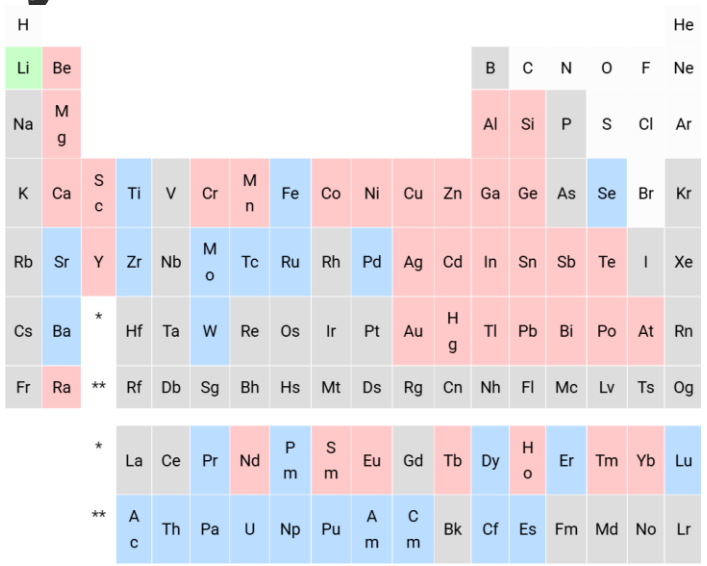
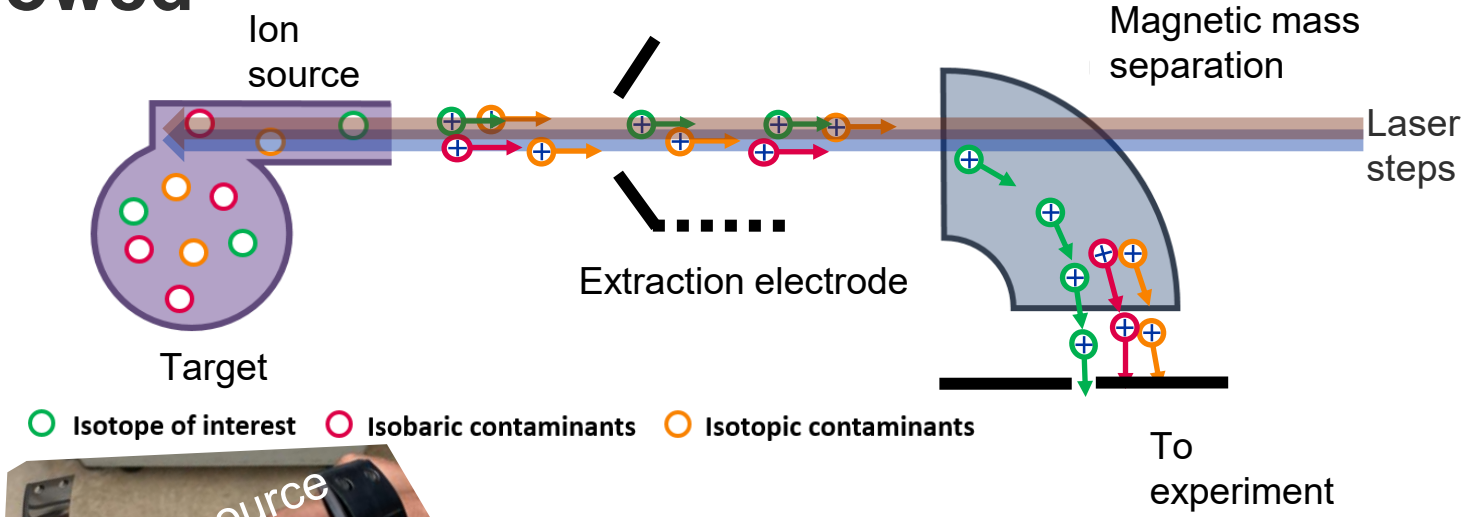
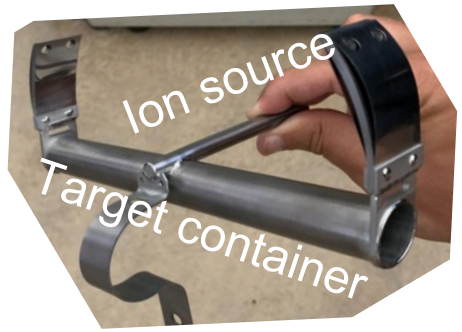


https://rims-code.github.io/





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RILIS: Resonant Ionization Laser Ion Source

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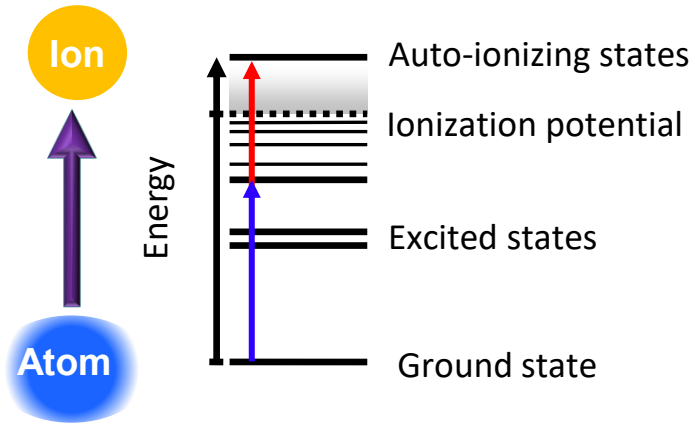
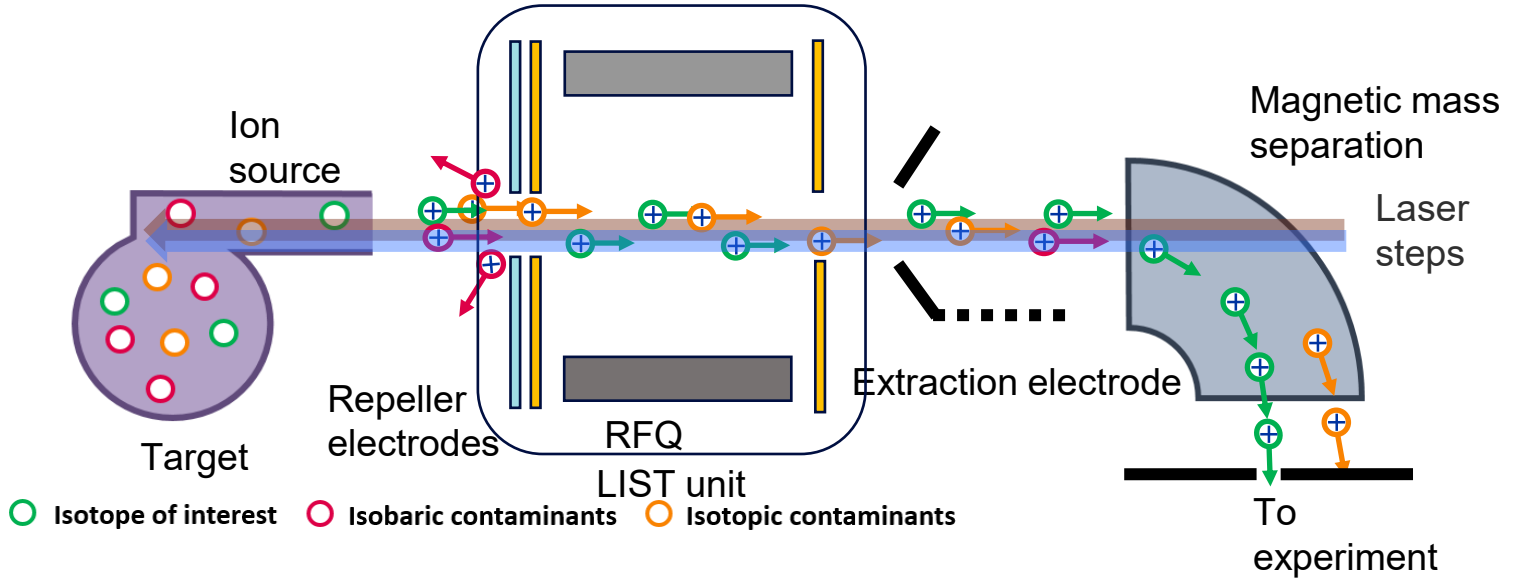


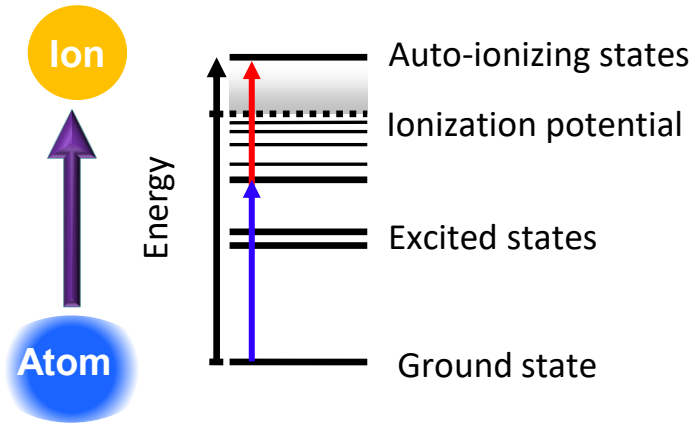


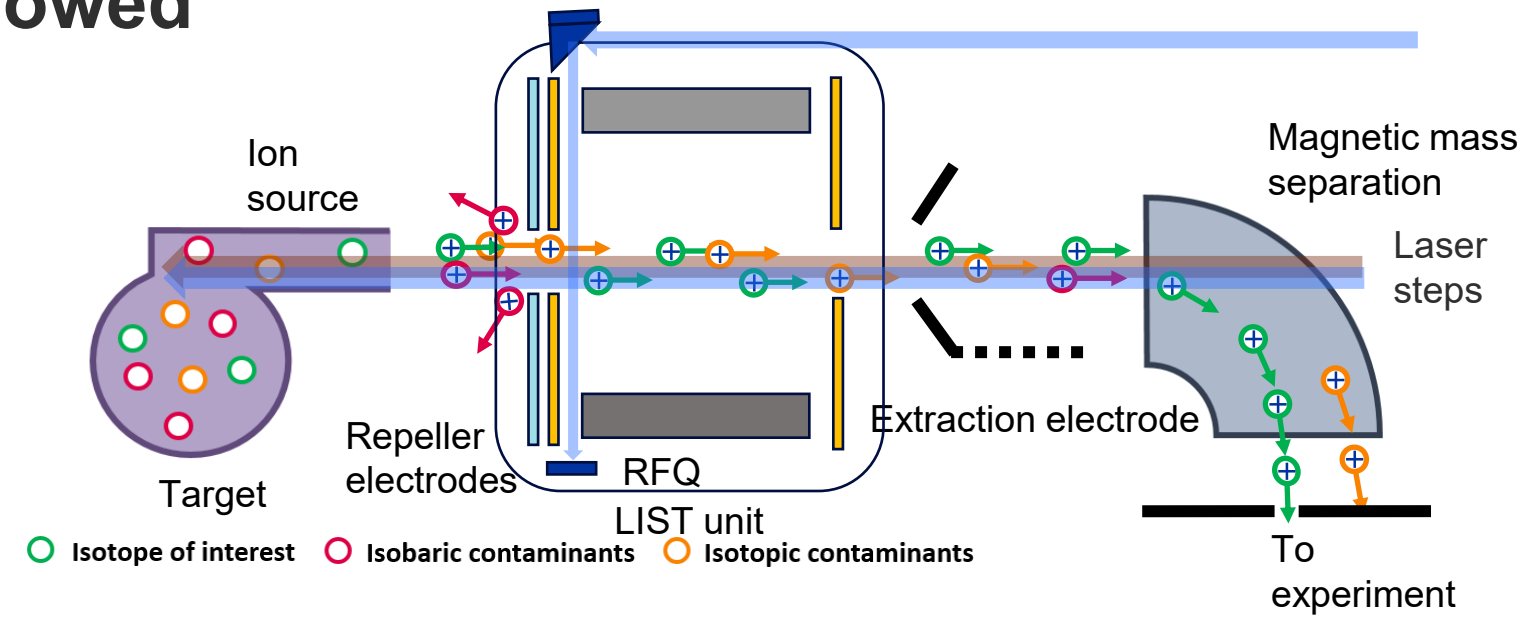
A Jaradat talk on LIST

- **LIST Ion source : additional contaminant suppression**

RILIS: Resonant Ionization Laser Ion Source

- **Step wise excitation followed by ionization**





A Jaradat talk on LIST

- **LIST Ion source : additional contaminant suppression**
- **Perpendicularly Illuminated-LIST with narrowband laser: High resolution spectroscopy**

RILIS Team

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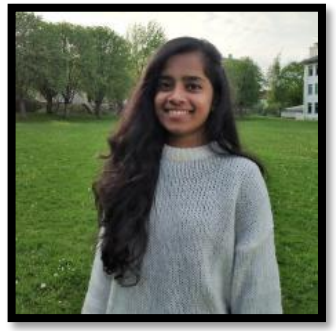

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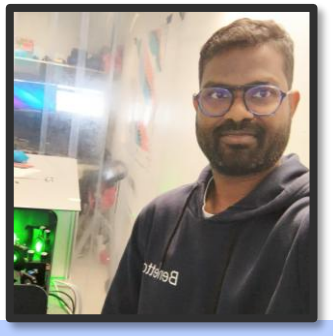

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SY-STI-LP

Content

- Introduction to RILIS
- **RILIS operation in 2025**
- Developments
- In-source spectroscopy
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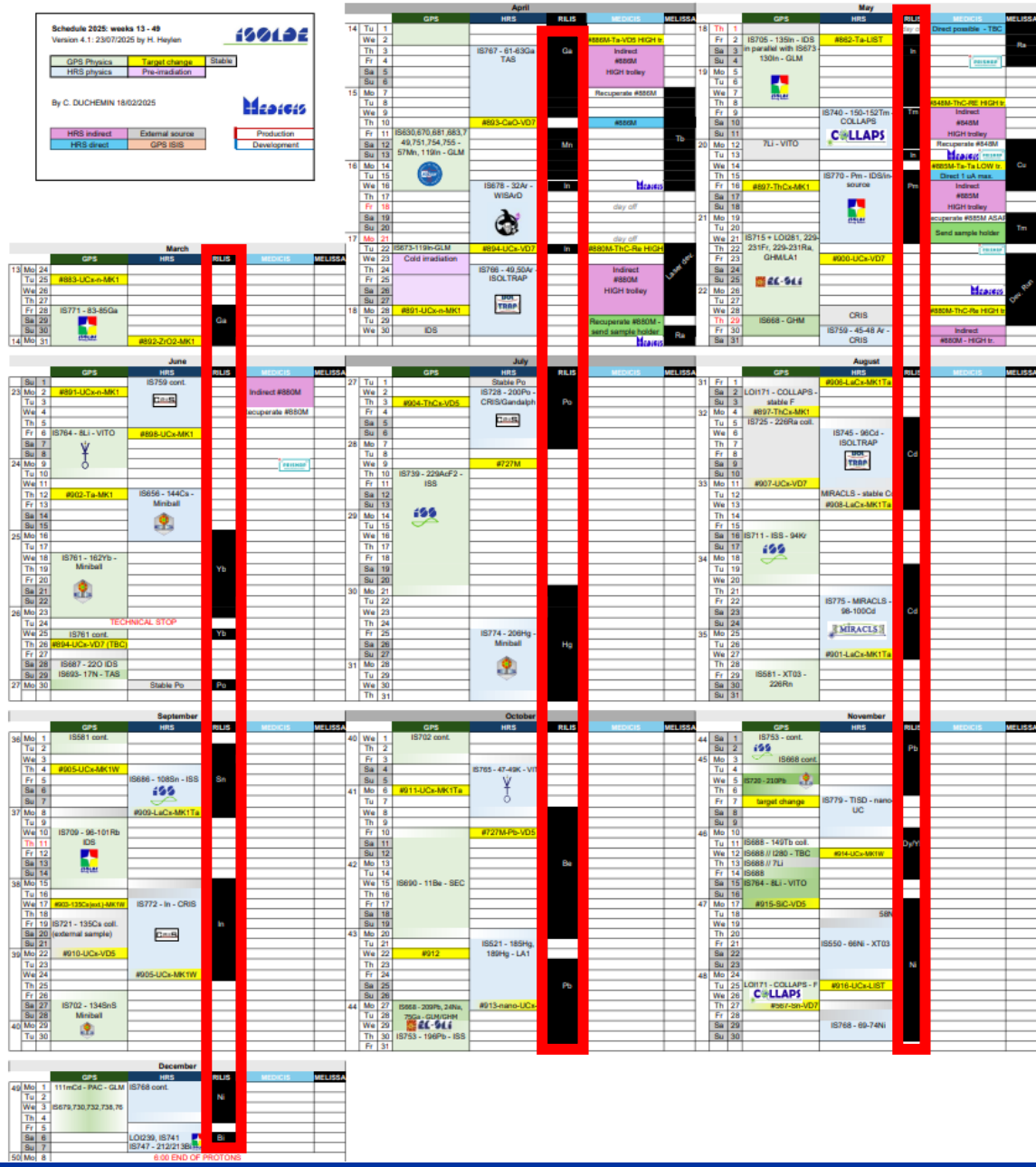
RILIS operation 2025

- **15 Elements: Ga, Mn, In, Tm, Pm, Yb, Po, Hg, Cd, Sn, Be, Pb, Dy, Ni, Bi**

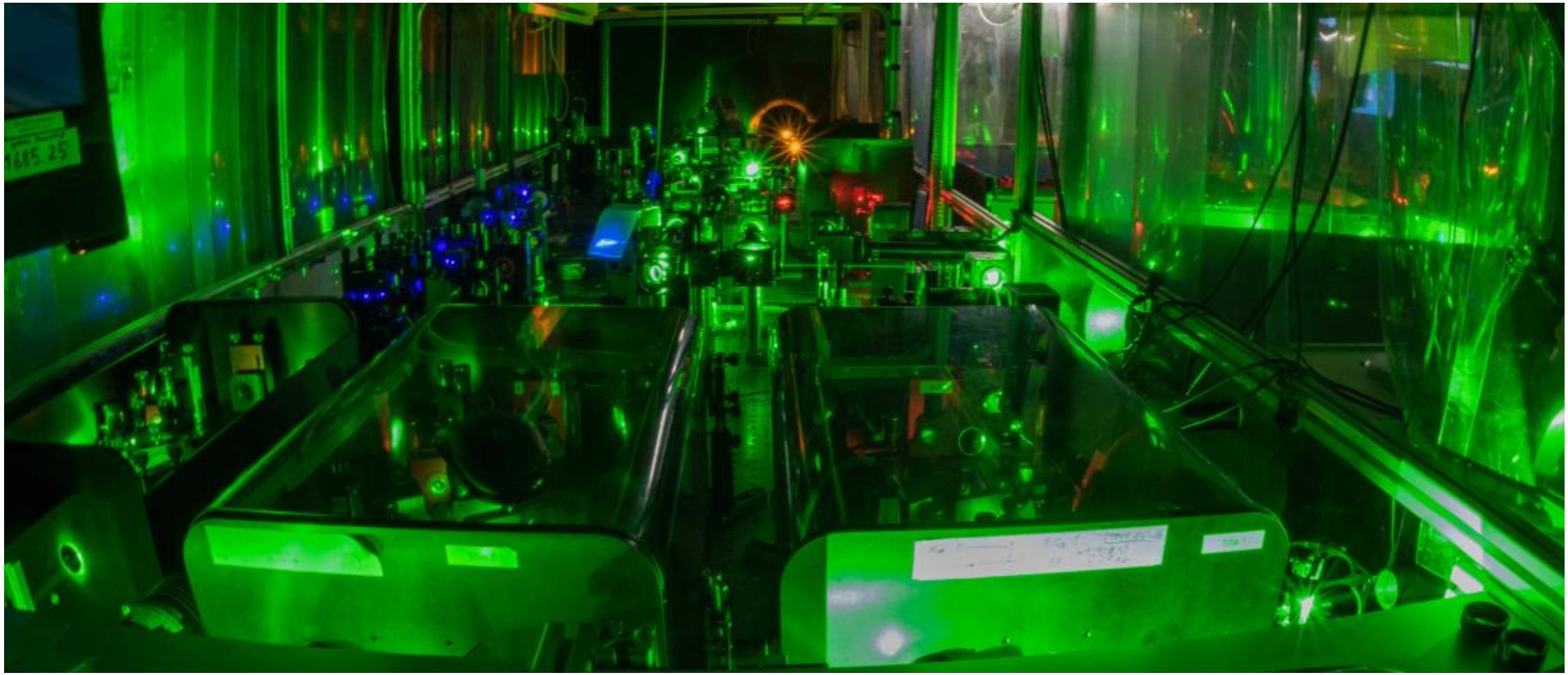
  -RIB delivery and in-source spectroscopy

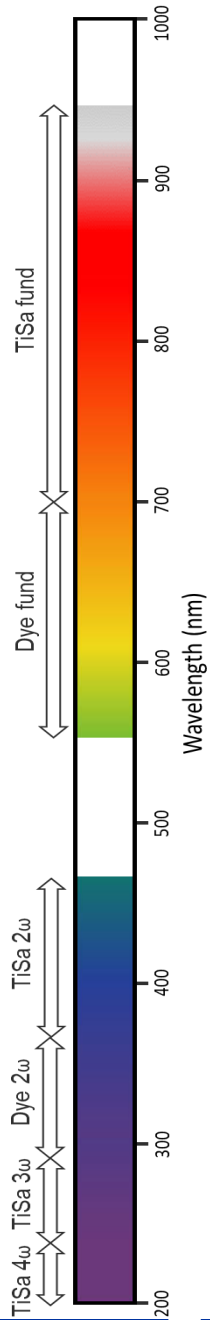
- **4 (2PI-)LIST runs: Tm, Pm, Ni and Bi**
- **Picquet on call service from 2025**

  -full availability of operators including weekends



RILIS layout





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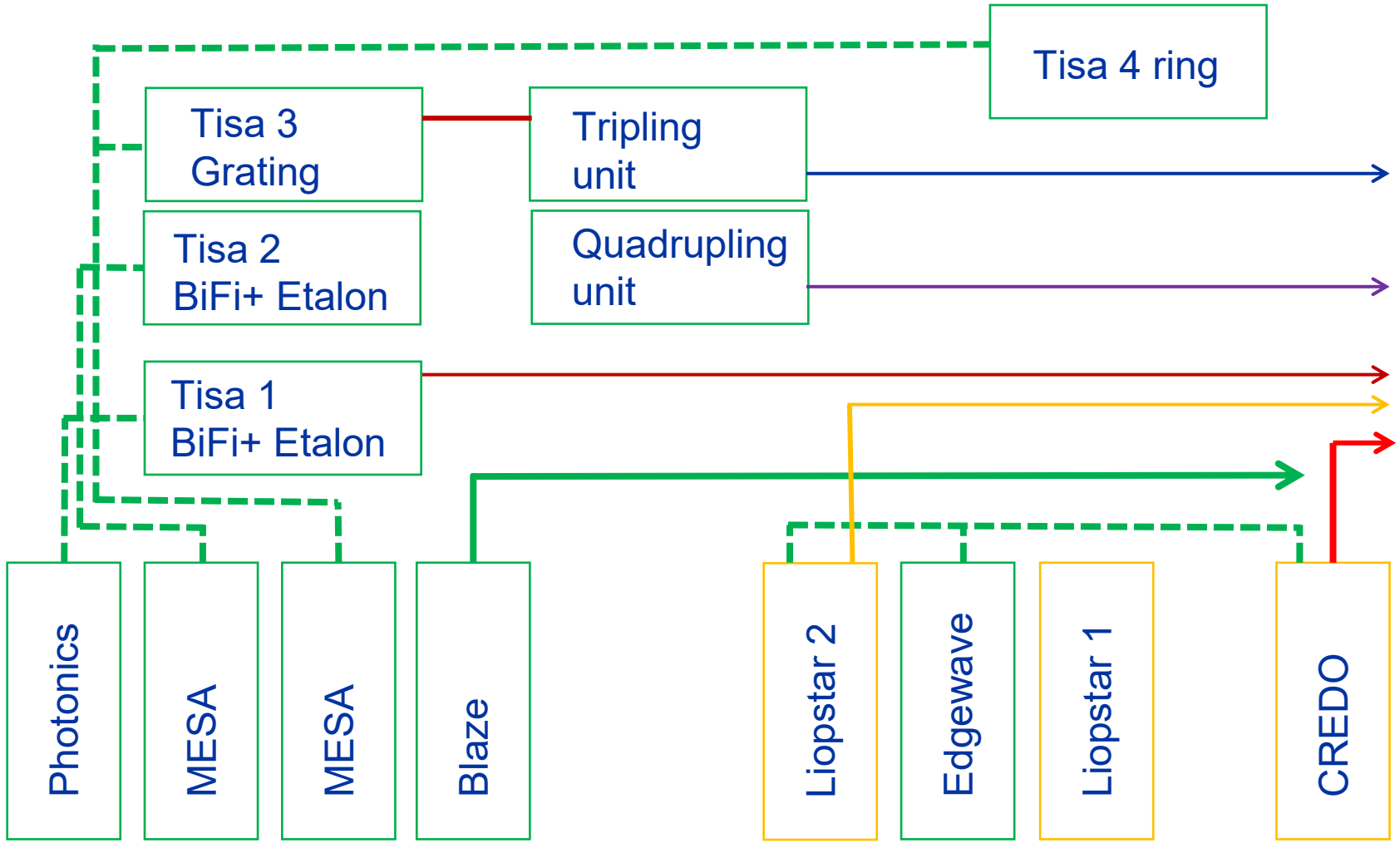

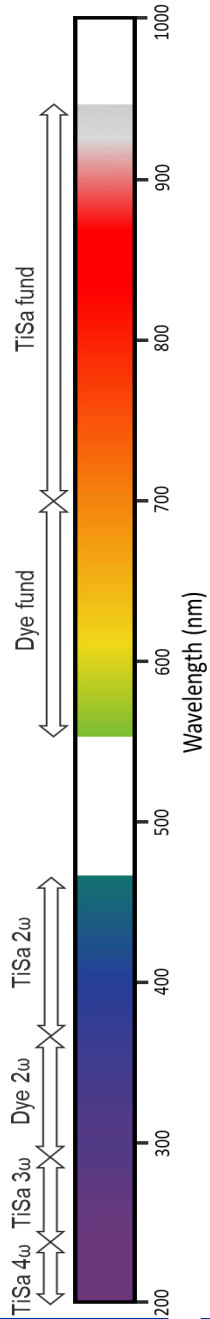

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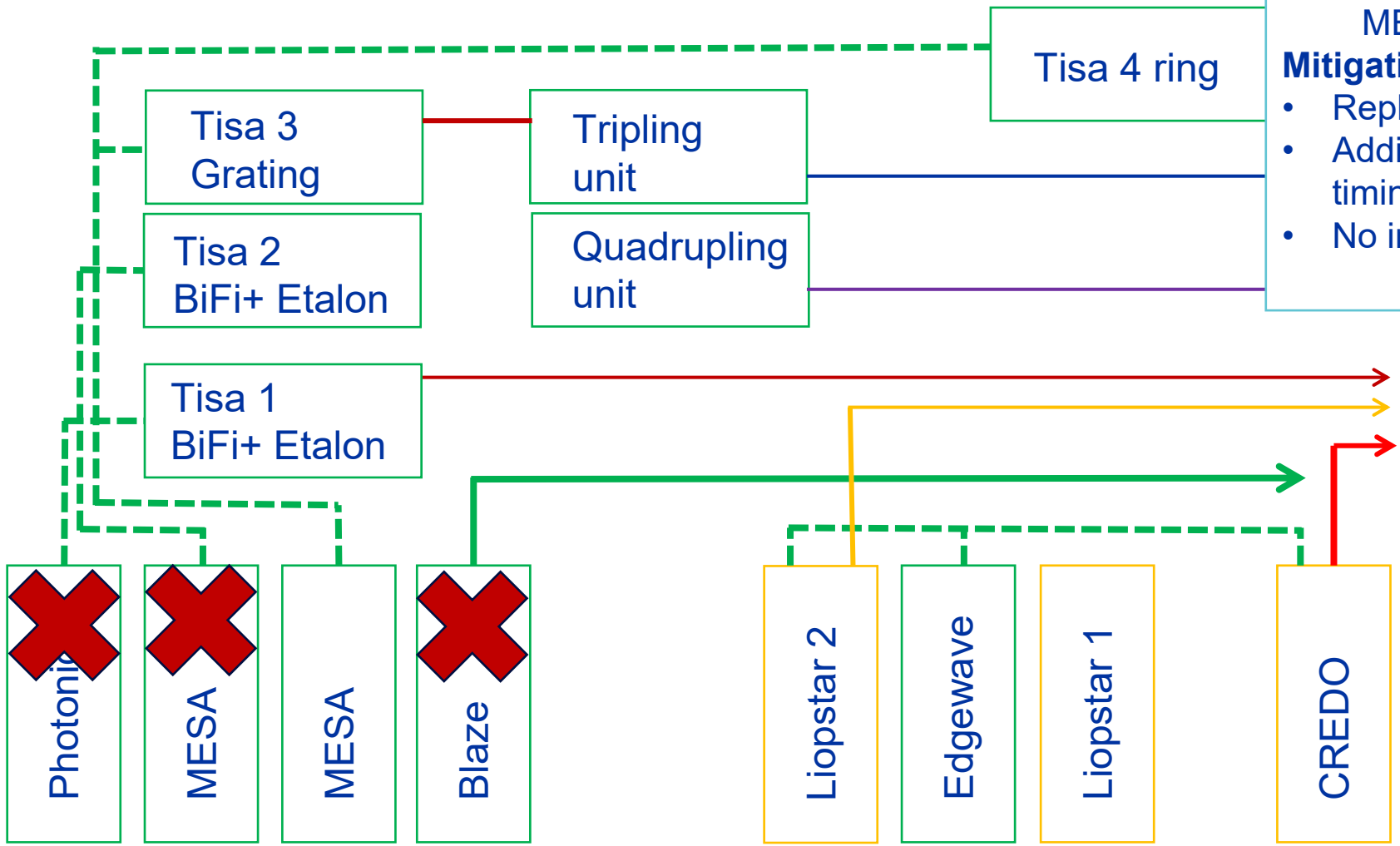


Failures:

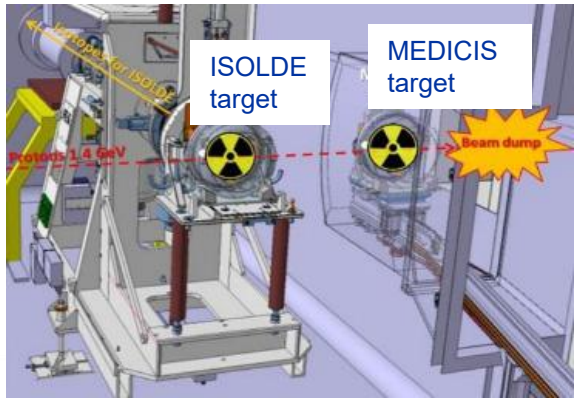
- Pump laser failures
  -Blaze (non resonant step), MESA, Photonics

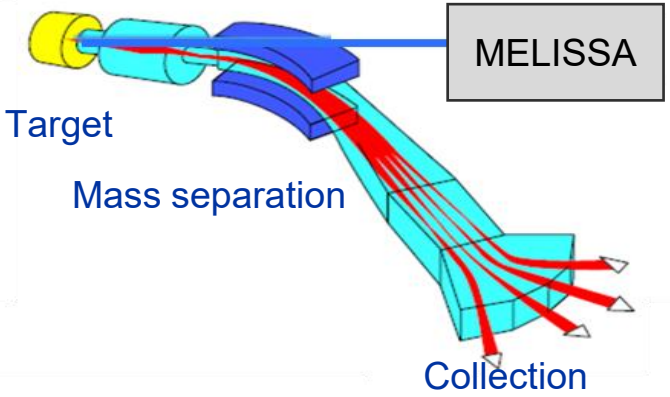
Mitigation:

- Replacement of Blaze with EW
- Addition delay line for EW pulse timing overlap
- No impact on physics

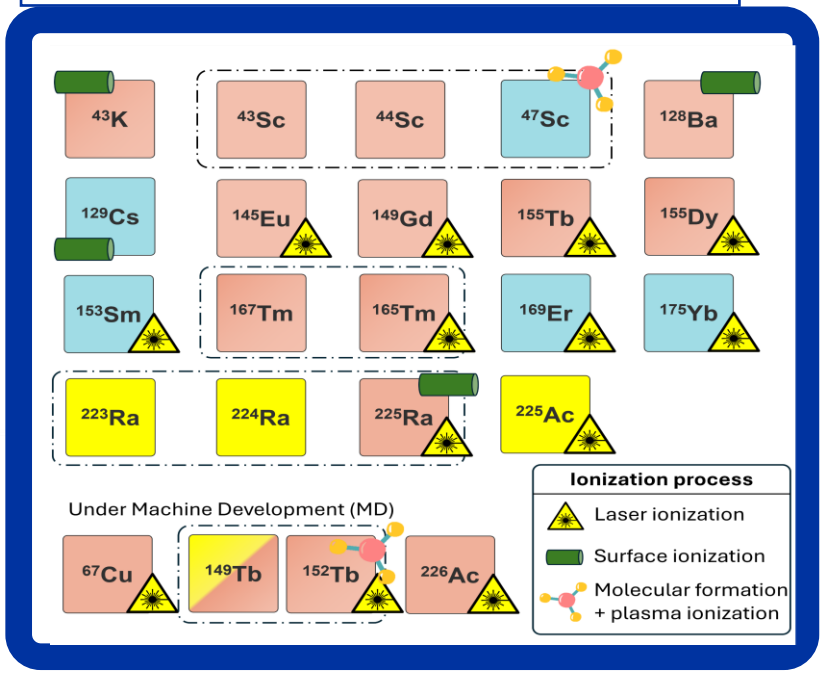
CERN-MEDICIS – MELISSA laser laboratory

- MEDICIS-dedicated laser laboratory **(MELISSA)** for ionization
- MELISSA operation supported by the ISOLDE-RILIS team (SY-STI-LP)
- Strong support from KU Leuven (PJAS & PhD Students) and RILIS, since commissioning

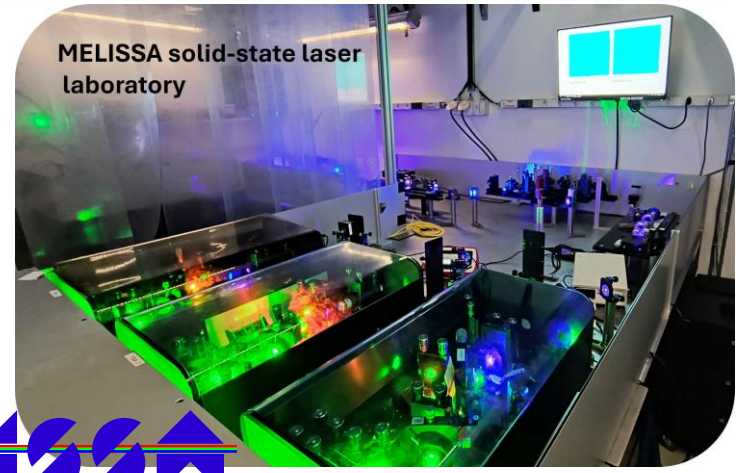




The MEDICIS portfolio

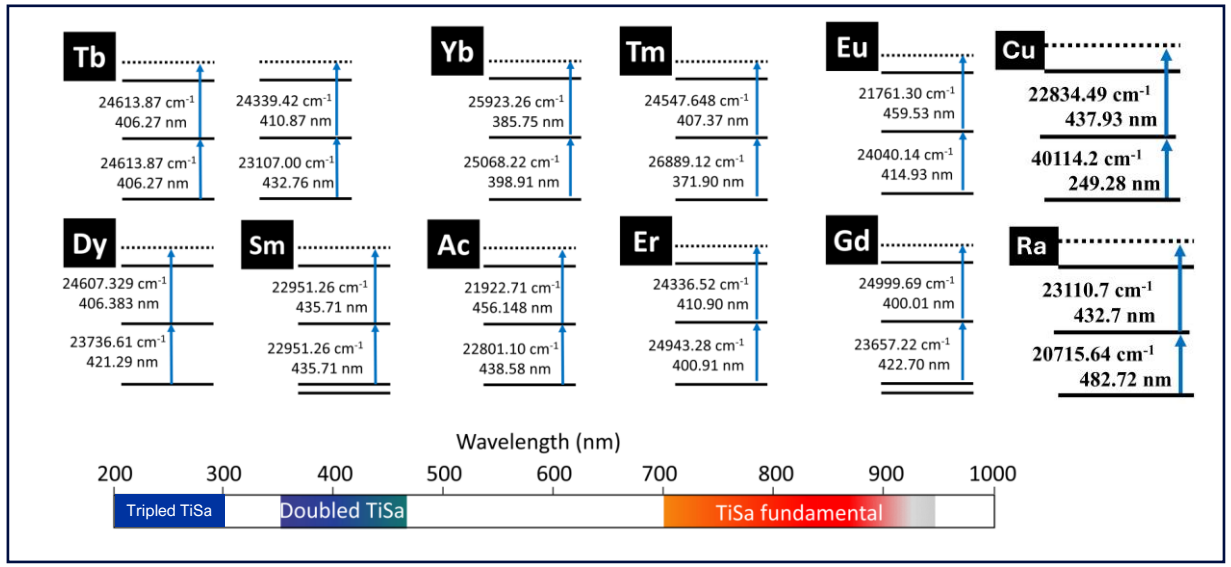


Edgars Manis' talk



https://www.prismap.eu

MELISSA in 2025



Developments 2025:

- Scheme development for Eu (Thesis R. Mancheva)
- Broadband Raman laser development ongoing (C. Bernerd)
- New BiFi installed TiSa successfully used for Ra collection

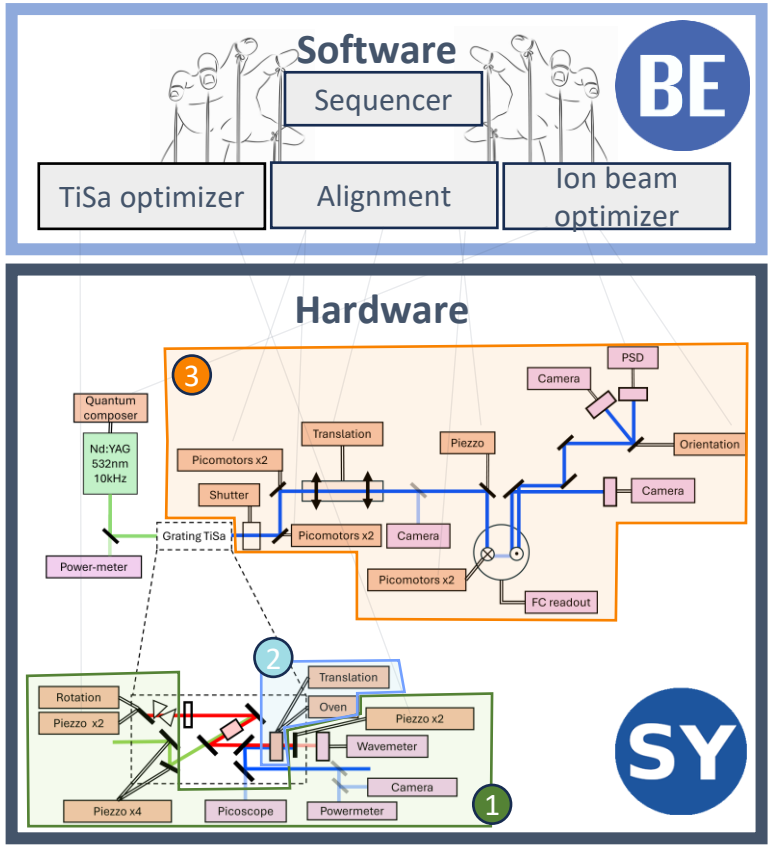
TALISMAN Project: aiming for 'operator free' MELISSA runs

- Knowledge transfer funded project to start Jan 2026
- Laser automation for doubled Tisa range

1 Self alignment | 2 Doubling | 3 Laser beam path alignment

MELISSA Infrastructure:

- ✓ Pump lasers (10ns, 18W, 10kHz)
- ✓ Ti-Sa laser cavities – z-cavity, Grating cavity
- ✓ Intracavity doubling with Ti-Sa: Blue wavelengths
- ✓ External tripling unit: UV wavelengths
- ✓ Laser stabilization system



-I- Laser scheme determination

-II- Laser Preparation

-III- Beam Path

-IV- Ion Beam Optimization

-V- Monitoring

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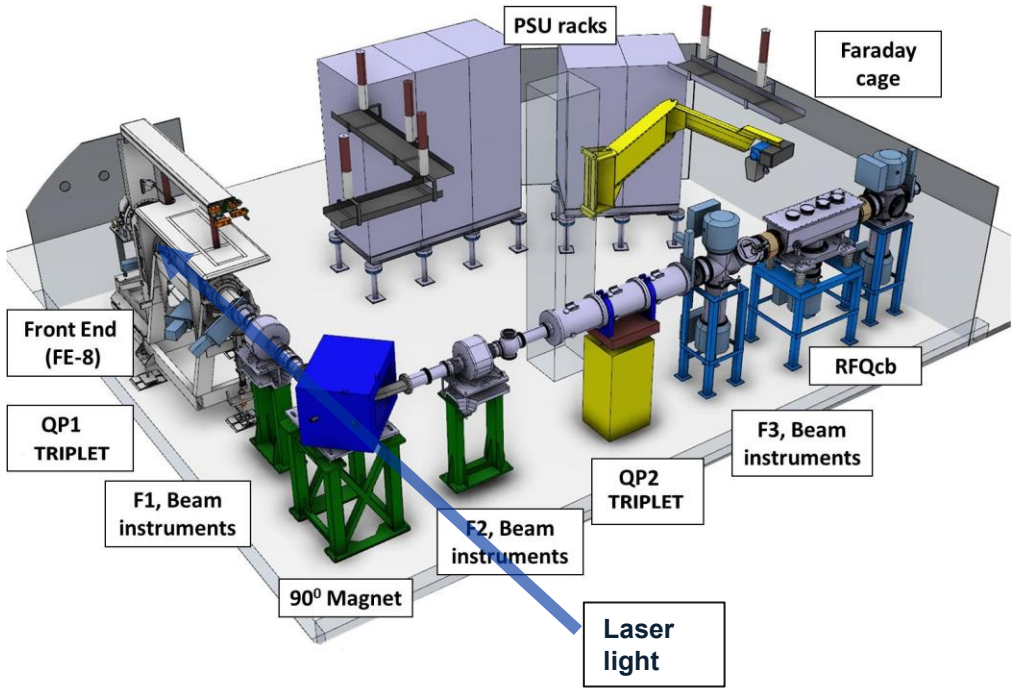
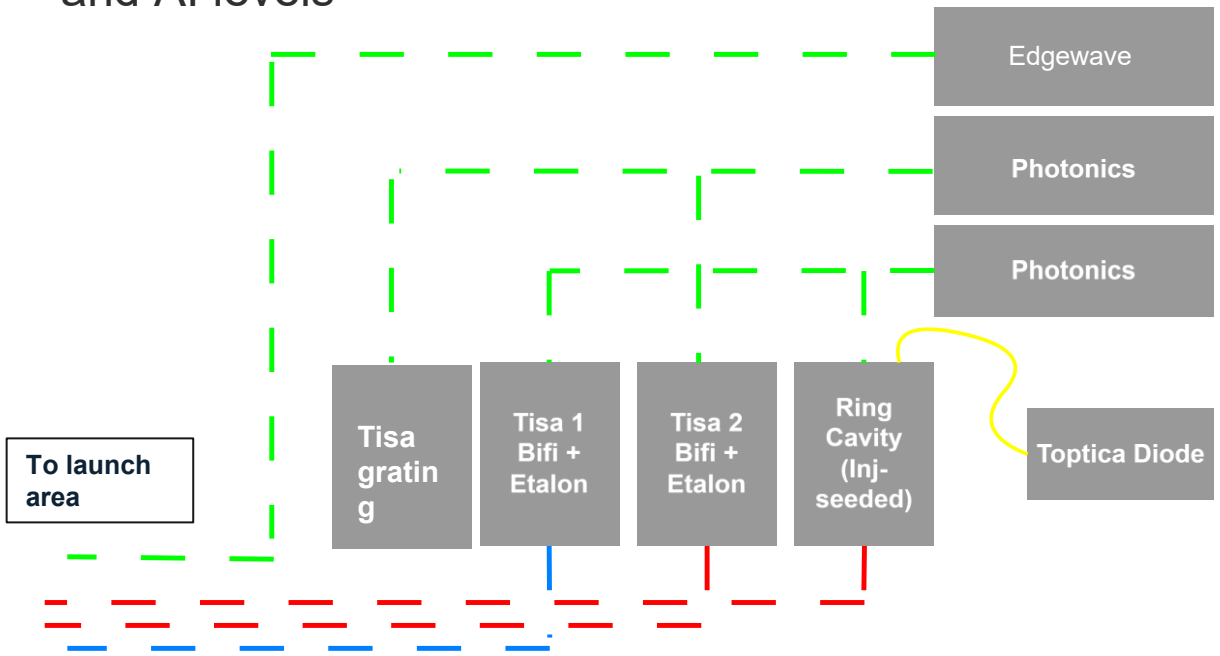
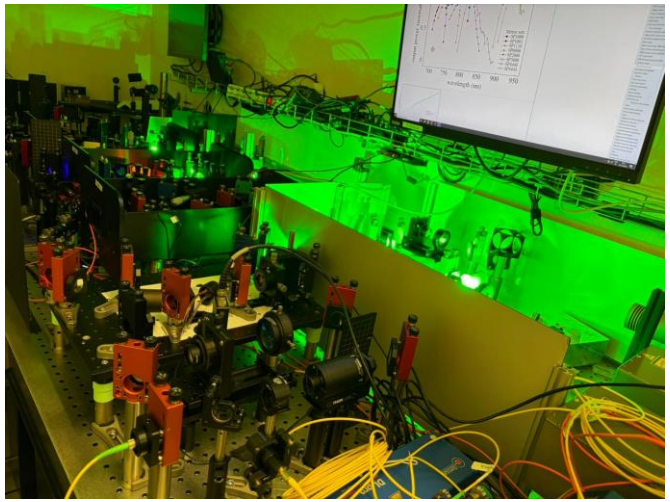
Offline laboratory

High resolution scans at YOL2

- New Seed laser setup and labview remote control setup for continuous wavelength tuning and scanning
- Additional laser setups at YOL2 for LIST/PI-LIST tests
- Test Ni scheme offline: Tests new Ni scheme, Rydberg and AI levels

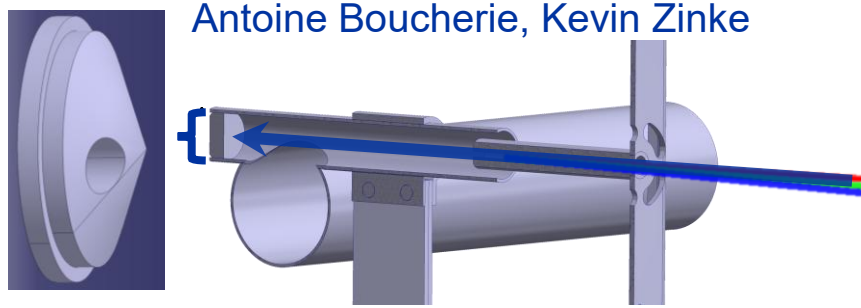






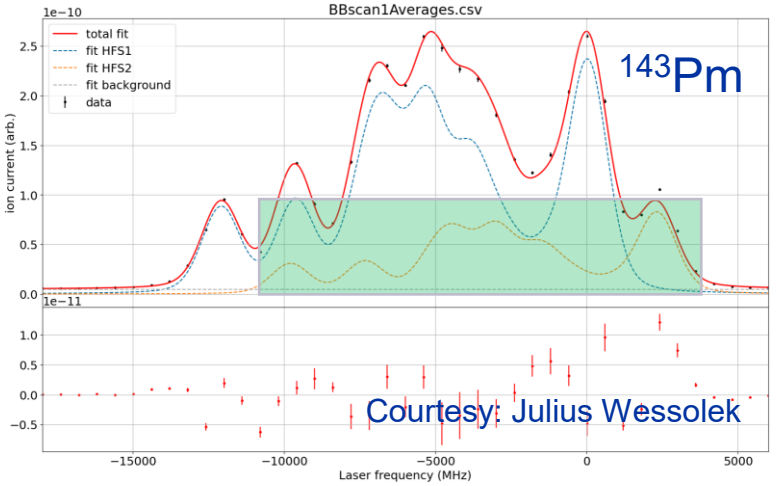
Offline laboratory

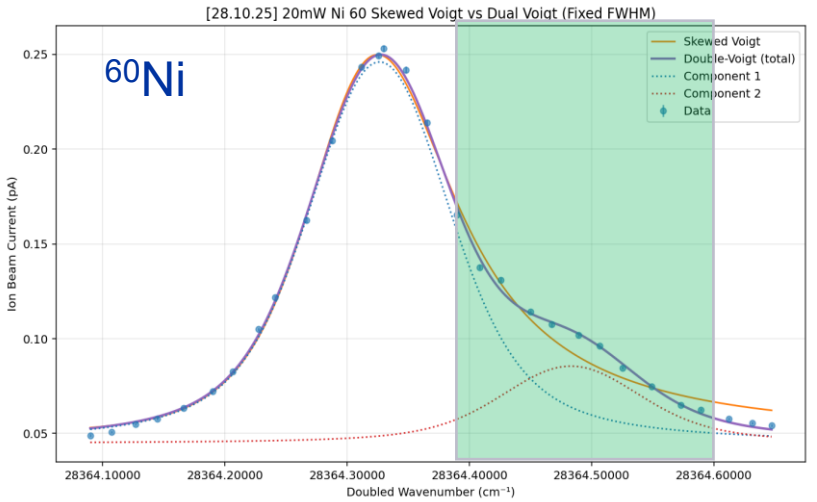
Antoine Boucherie, Kevin Zinke

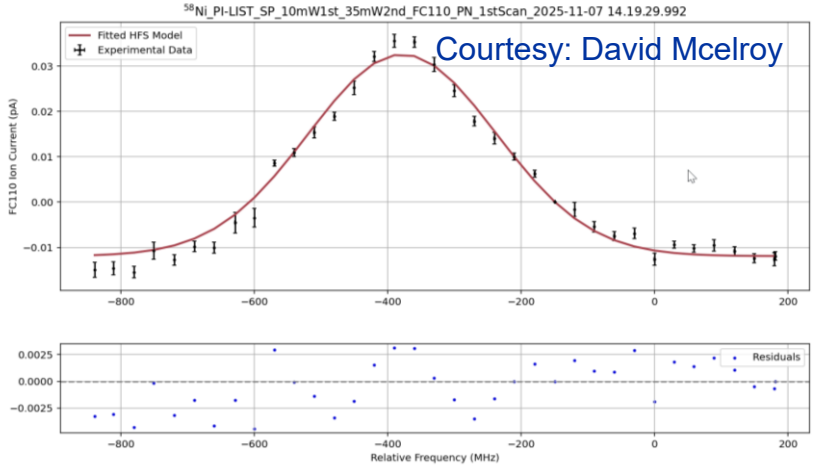


High resolution scans at YOL2

- New Seed laser setup and labview remote control setup for continuous wavelength tuning and scanning Spectral resolution achieved for mass 58: 550 MHz FWHM
- Test Ni scheme offline: Tests new Ni scheme, Rydberg and AI levels
- Test new LIST ion source conical plugs to reduce Doppler shifted peak from back reflection (SY-STI-RBS)
- Mirror reflectivity tests for improving ionization efficiency in PI-LIST mode



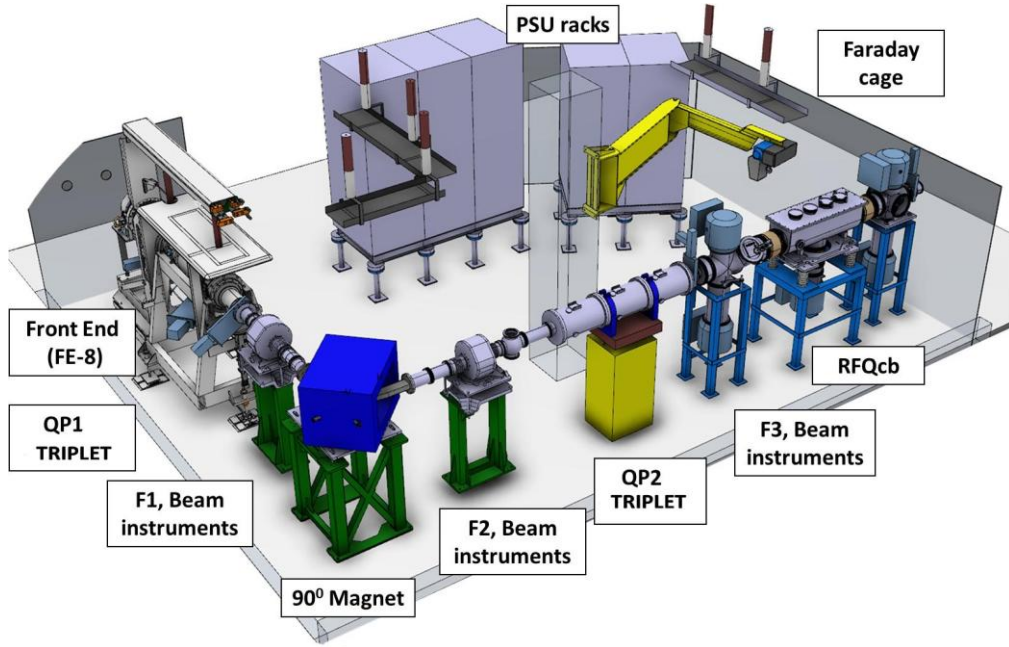


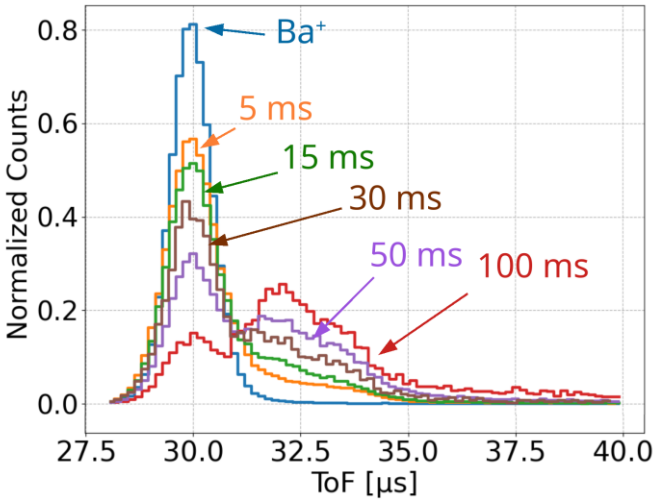


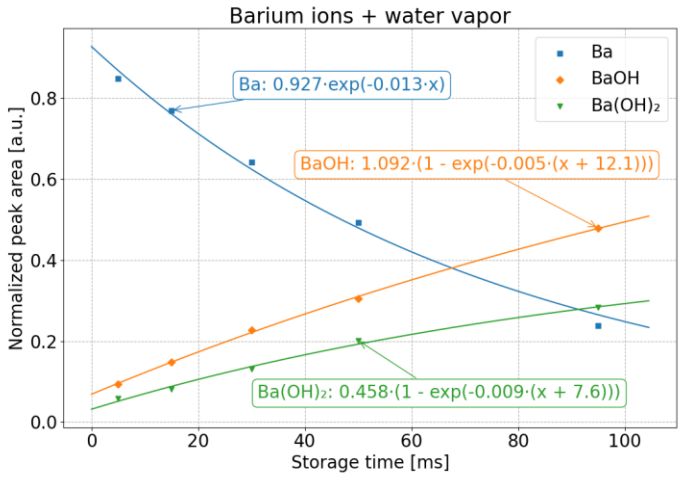
Offline laboratory

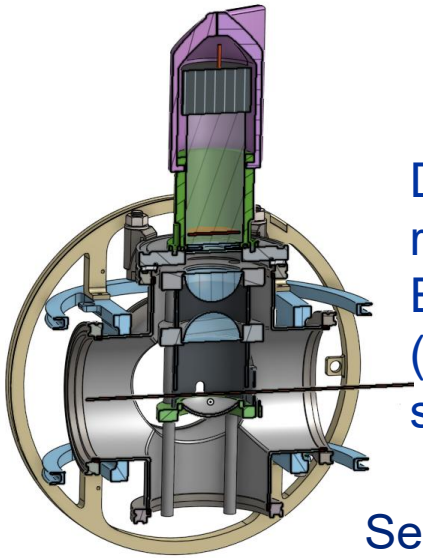
Prospects for laser spectroscopy of molecules at YOL2

- Polyatomic molecules can now be formed in-trap via controlled gas injection ! See poster of Alexander Schmidt
- Light collection region under construction
- Optics for laser light injection installed
- Optics for light collection simulated and installed
- Revival of M-squared CW Tisa(support from KU leuven, Uni Manchester and Hubner Photonics)





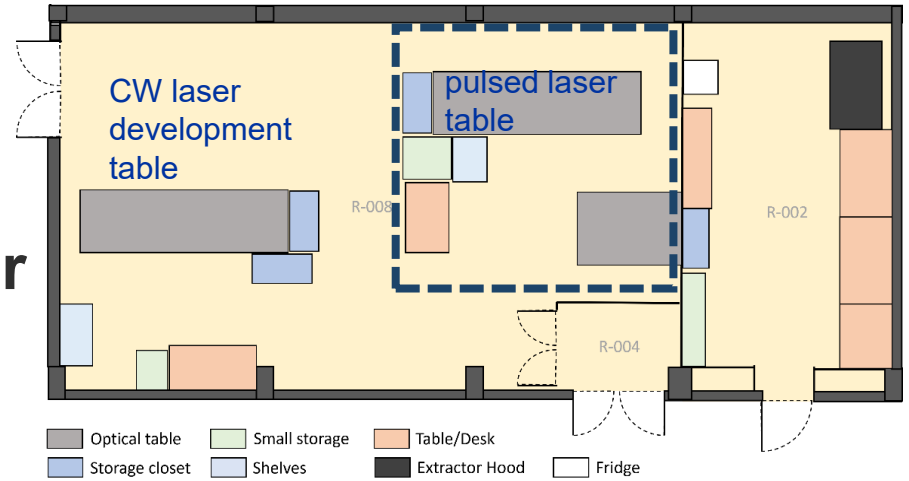




Downstream optical detection region
Enables cross-beam and (anti)collinear laser spectroscopy

See poster of Justus Berbalk

LARIS laboratory

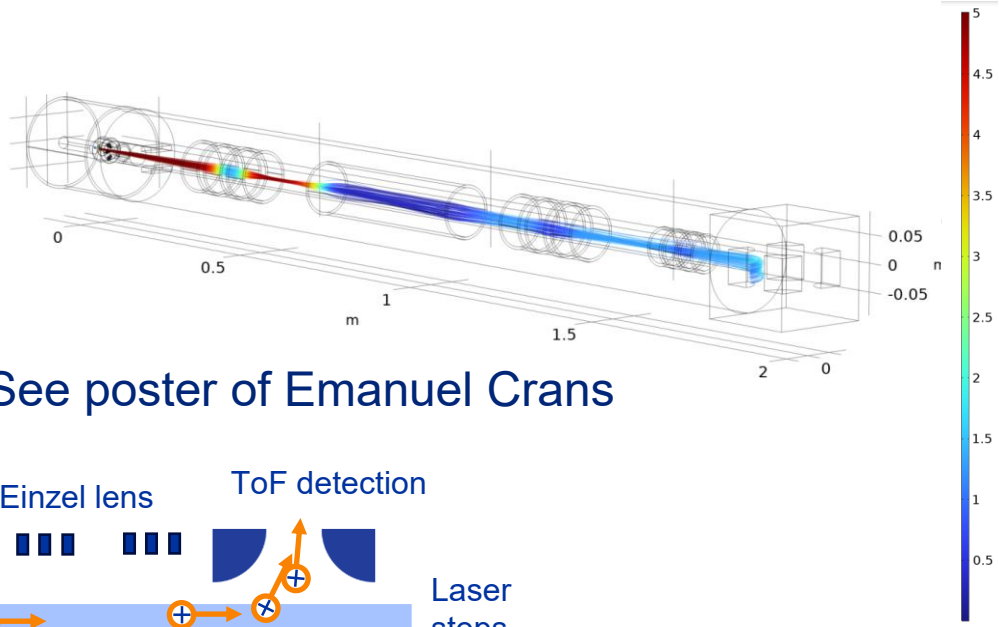


Investigate efficient laser ionization pathways for RILIS experiments

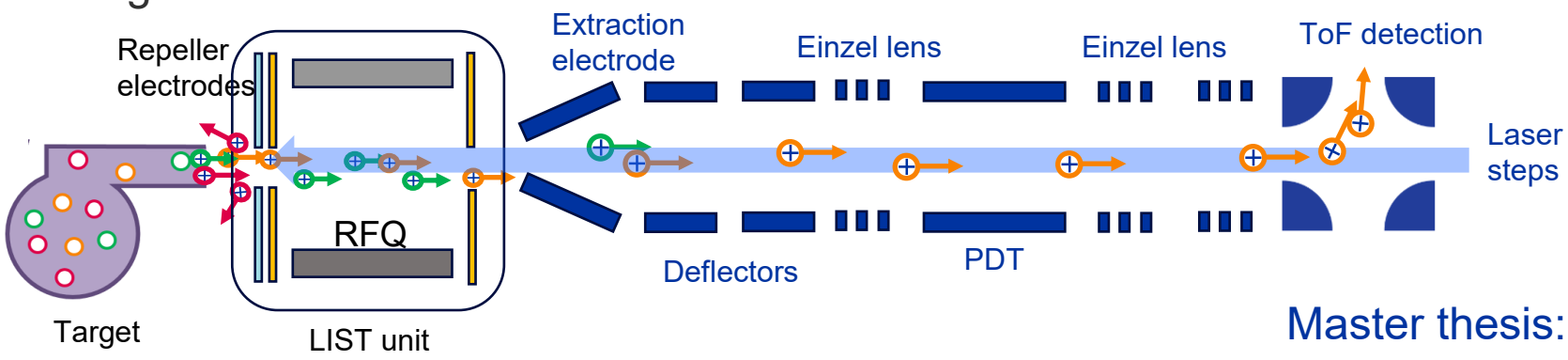
- Space for laser developments

New offline beam setup for dedicated LIST characterization and tests

- Will lift tight timelines for offline 2 tests, more room for LIST developments and upgrades.
- Simulation of beam optics (COMSOL) in progress
- Future steps: time dependent beam trajectory studies, CAD design



See poster of Emanuel Crans

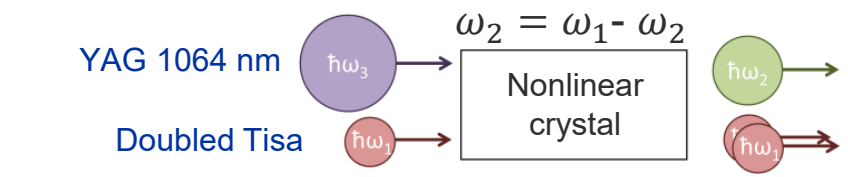


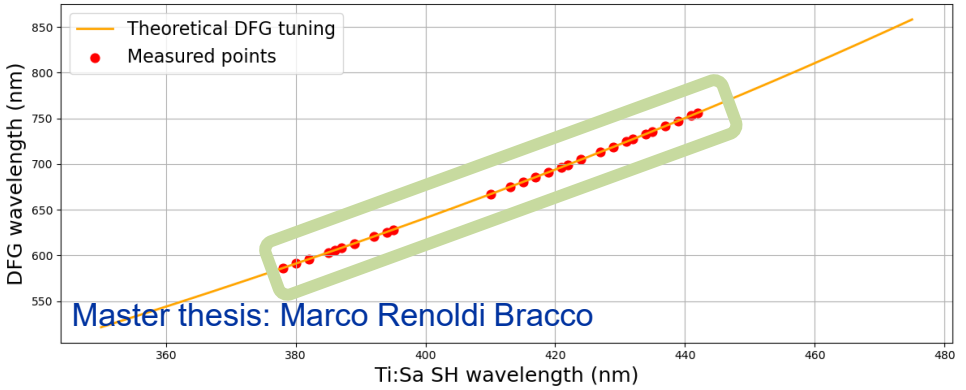
Master thesis: Emanuel Crans

Laser developments

Frequency mixing

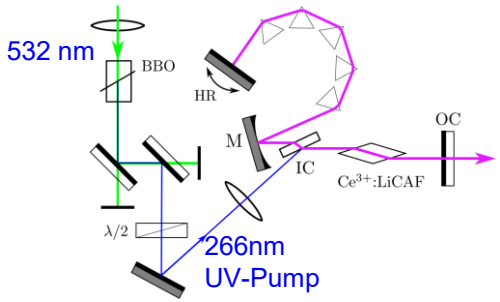
- DFG studies to replace dye laser wavelength ranges
- Tunability achieved
- Requires further studies for improved power

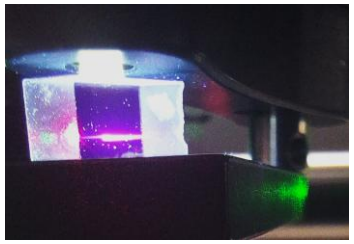




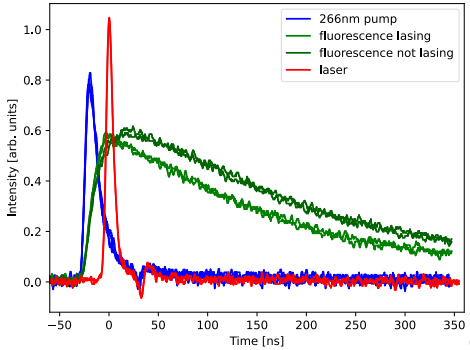
UV pumped Ce^{3+}:LiCAF laser

- Emission: 280-315 nm
- First prototype: 6 nm tuning range
- 8-13 ns pulse length





PhD: Hendrik Buker



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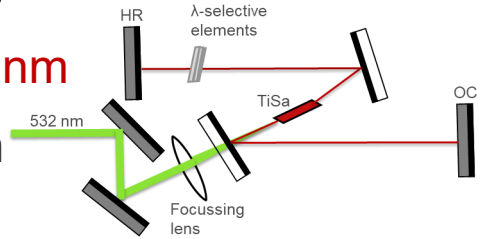

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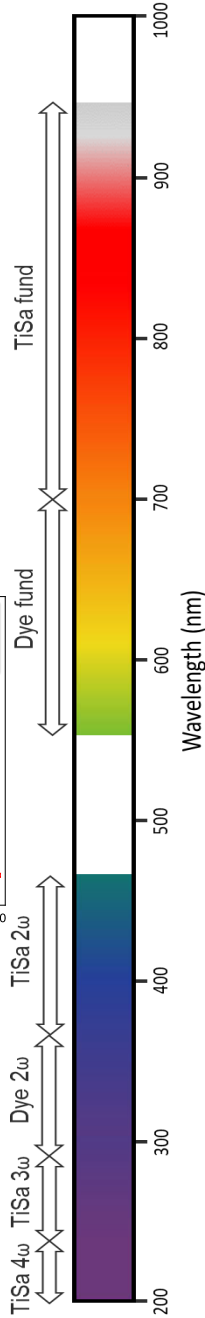
C. Bernerd et. al. Optics Letters Vol. 50, Issue 21, pp. 6831-6834 (2025)



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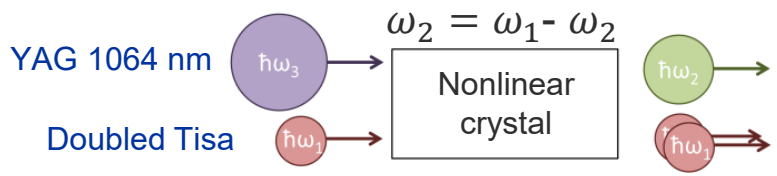

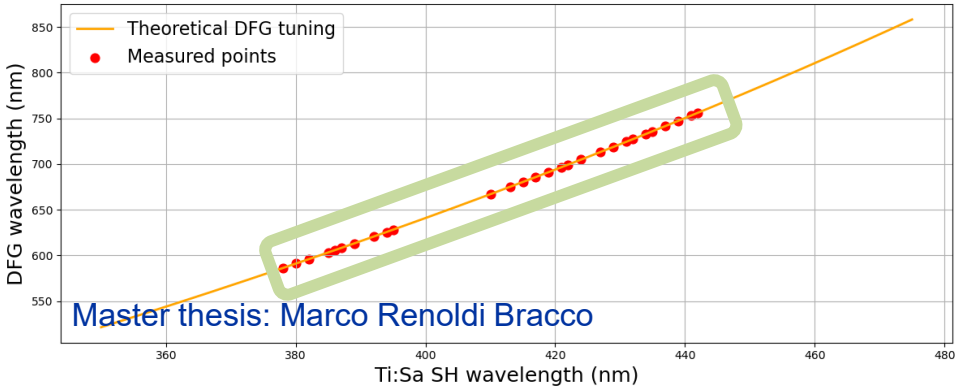

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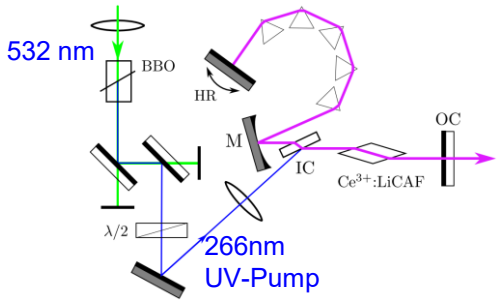

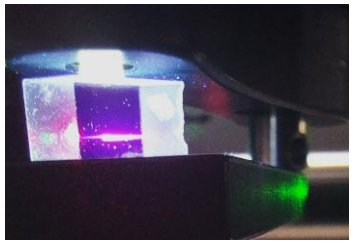

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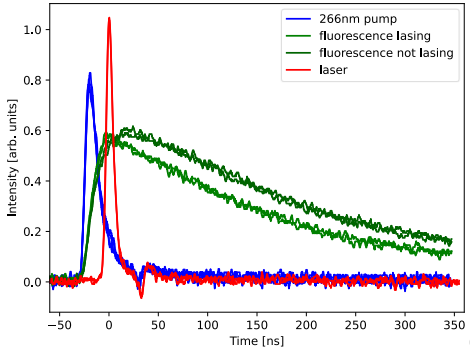

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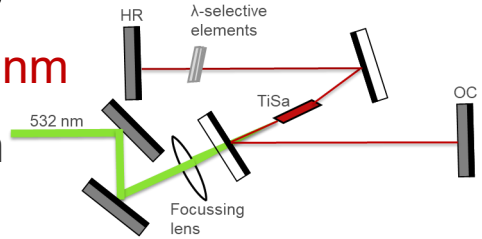

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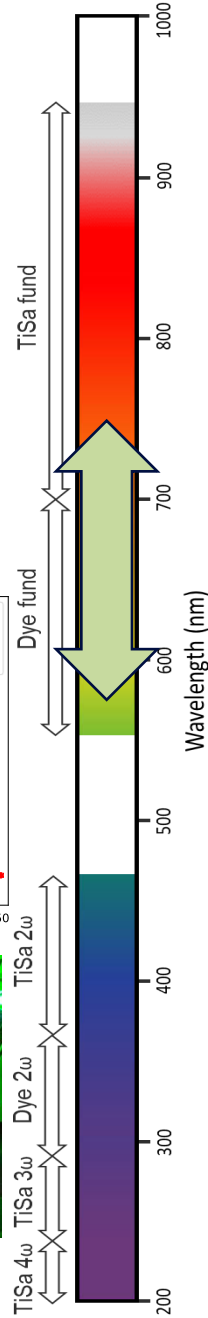

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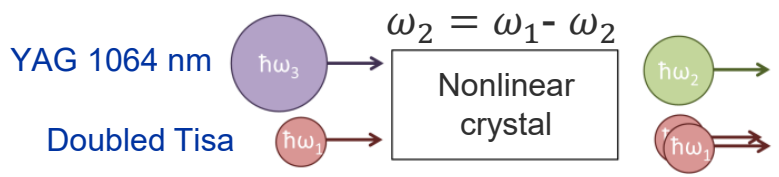

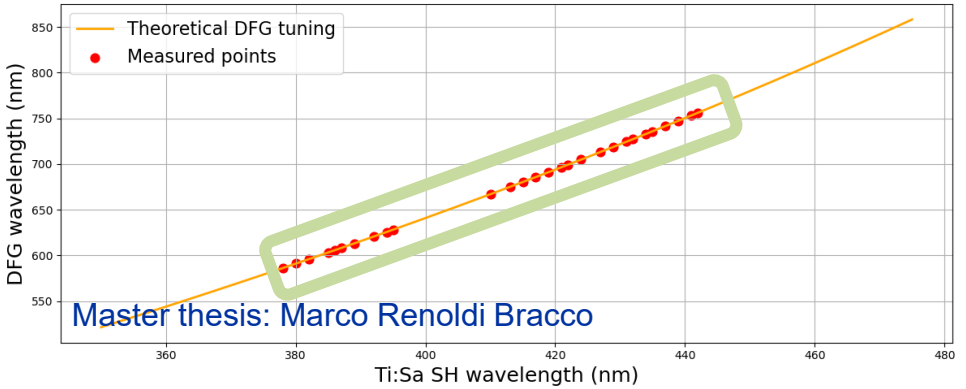

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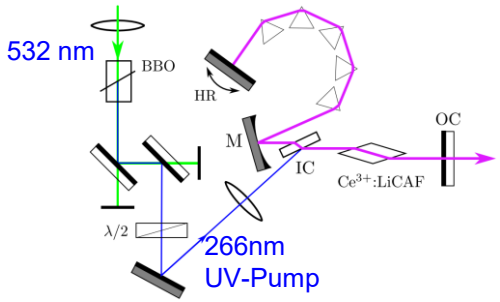

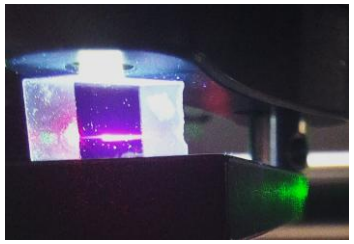

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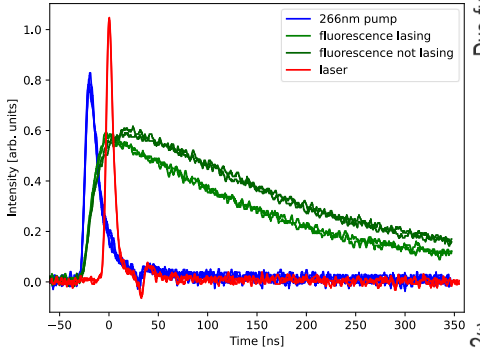

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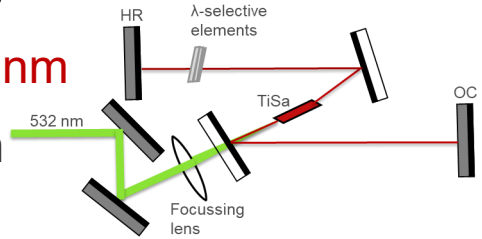

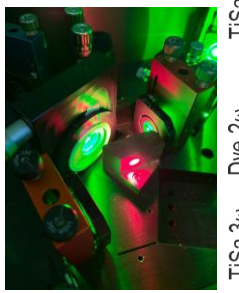

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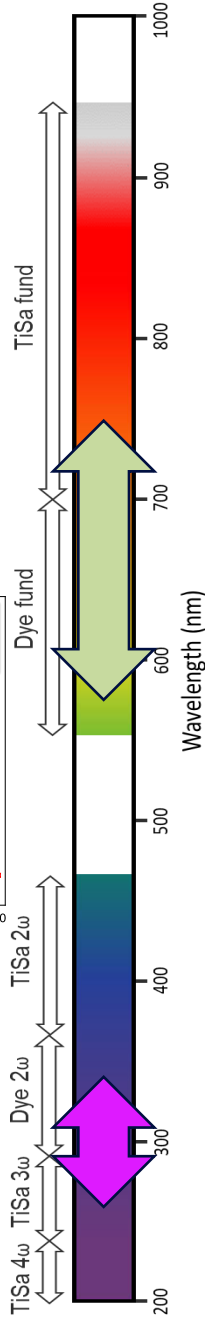

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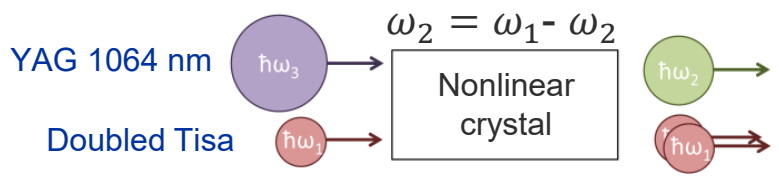

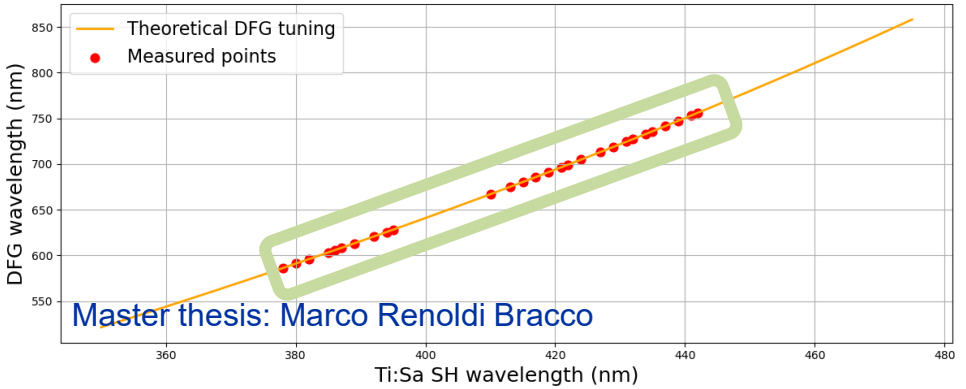

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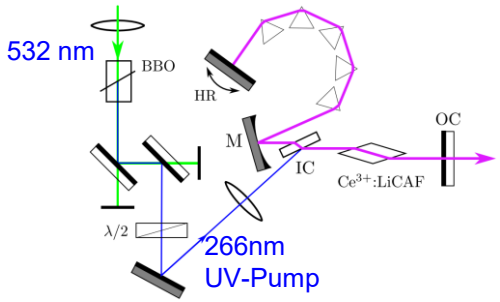

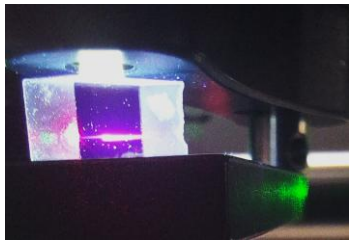

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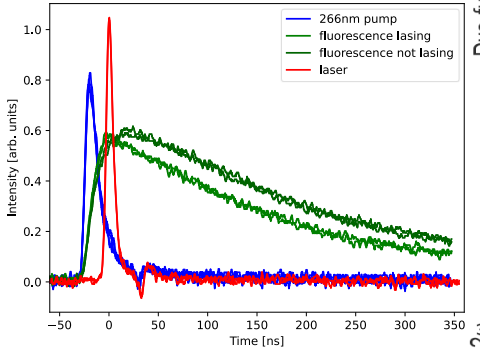

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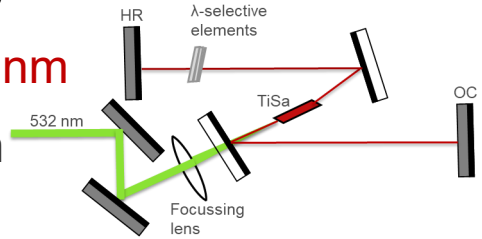

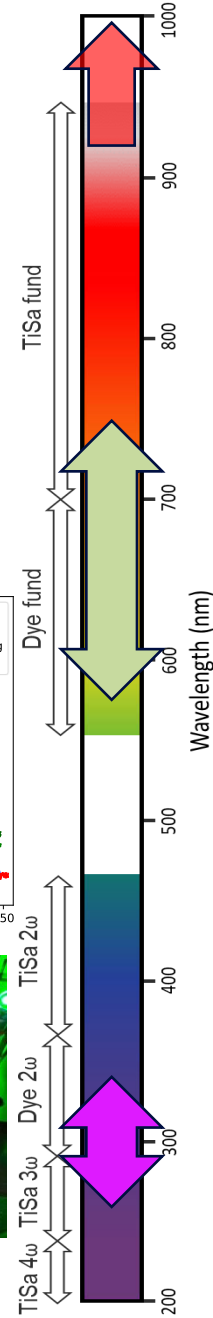

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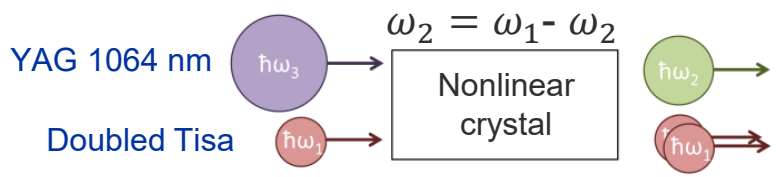

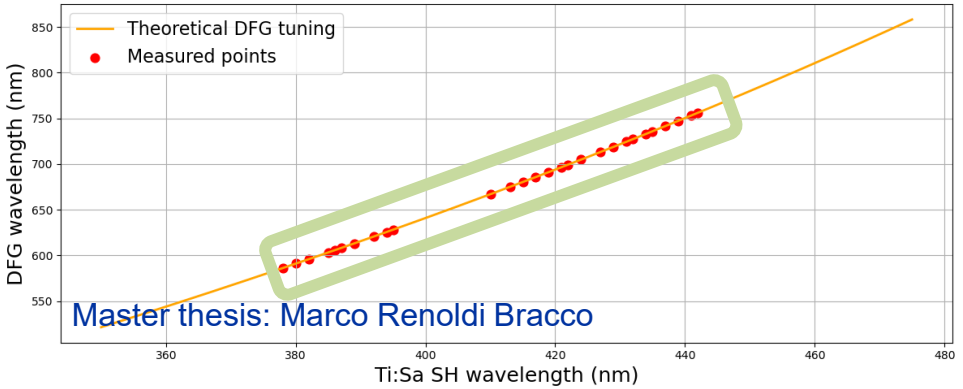

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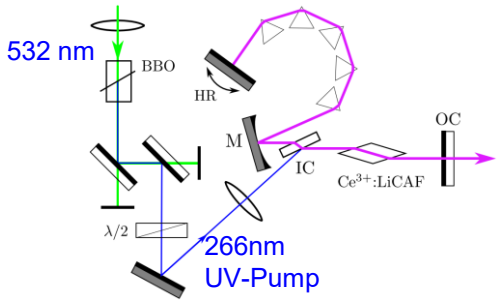

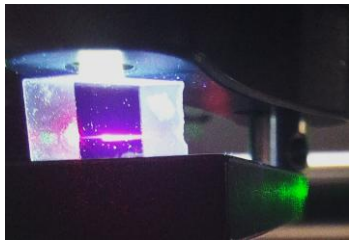

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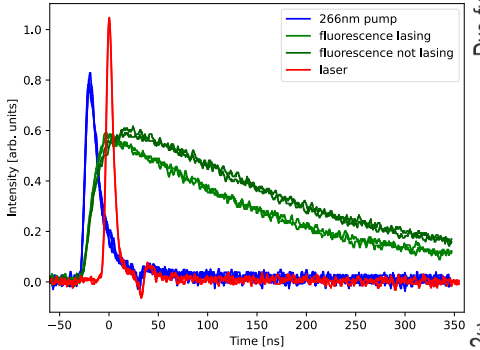

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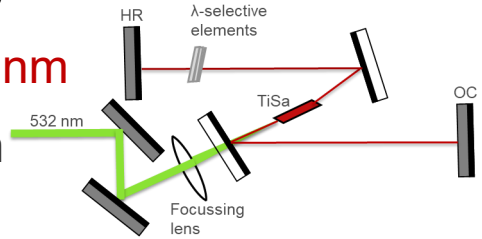

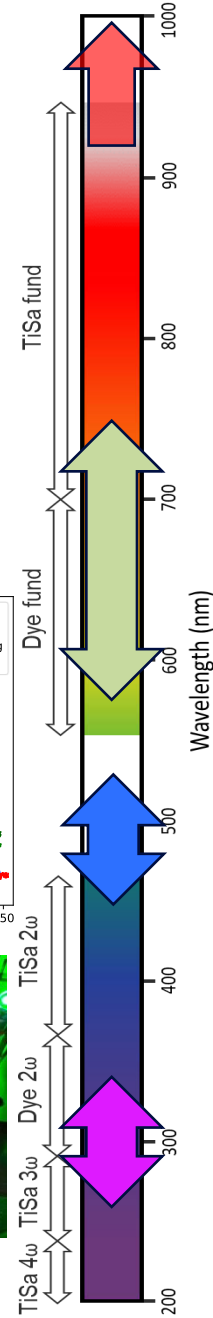

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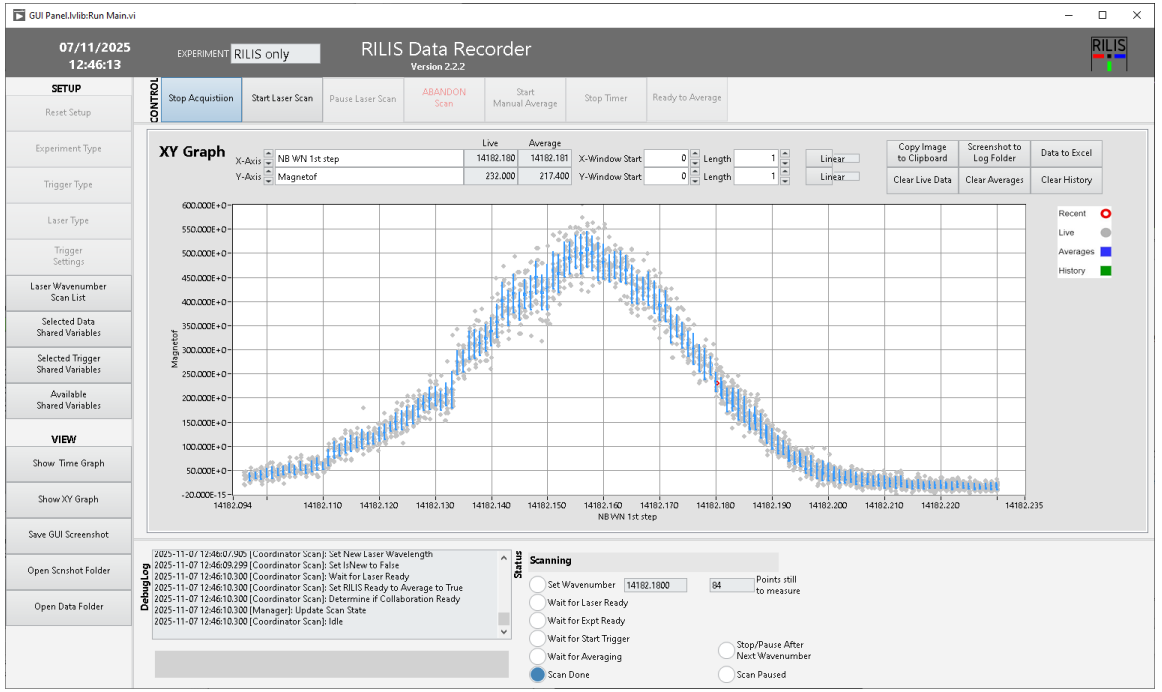
RILIS Data recorder

- Ongoing effort to make RILIS variables accessible through CMW
- ANGARA & BE/CEM: consolidation/improve flexibility of RILIS software programmes
- Tested offline and used successfully for 2025 Pm and Ni online campaigns



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- Developments
- **In-source spectroscopy**
- Outlook

Pm run 2025

- Online-in source laser spectroscopy campaign PI LIST resolution : 450 MHz achieved
- LIST-Ta-MK1 target used
- $^{135\text{-}149}$Pm measured during the run
- Previous measurements: $^{143\text{-}147}$Pm
- Extraction of moments and mean square charge radii

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Proposal to the ISOLDE and Neutron Time-of-Flight Committee

First online laser spectroscopy study of promethium isotopes

October 2, 2024

A. N. Andreyev[1], O. Ahmad[2], A. Ajayakumar[3], B. Andel[4], S. Antalic[4], M. Au[3], J. Benito[5], C. Bernerd[3], K. Blaum[6], K. Chrysalidis[3], T. E. Cocolios[2], J. G. Cubiss[1,7], T. Day Goodacre[8], S. Goriely[9], C. Fajardo[2], V. N. Fedosseev[3], K. Flanagan[8], L. M. Fraile[5], L. P. Gaffney[10], P. F. Giesel[11], R. Heinke[8], S. Hilaire[12], A. Illana[5], U. Köster[13], D. Lange[6], R. Lica[14], D. Lunney[15], K. M. Lynch[8], D. McElroy[8], A. McFarlane[1], A. McGlone[8], C. Mihai[14], J. Mišt[4], L. Nies[3], C. Page[1], S. Péru[12], J. R. Reilly[3], R. E. Rossel[3], S. Rothe[3], Ch. Schweiger[6], L. Schweikhard[11], D. Studer[16], J. Warbinek[3], J. W. Wessolek[3,8], J. Wilson[1], J. L. Wood[17], Z. Yue[1,3] + IDS Collaboration

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Letter of Intent to the ISOLDE and Neutron Time-of-Flight Committee

Yield measurements for lanthanide elements with Ta-foil target and a LIST ion source

September 27, 2022

Katerina Chrysalidis[1], Reinhard Heinke[1], Mia Au[1,2], Cyril Bernerd[1,3], Asar A H Jaradat[1,4], Ulli Köster[5], Ralitsa Mancheva[1,3], Bruce Marsh[1], Edgar Reis[1], Maximilian Schütt[1], Sebastian Rothe[1], Simon Stegemann[1], Julius Wessolek[1,4]

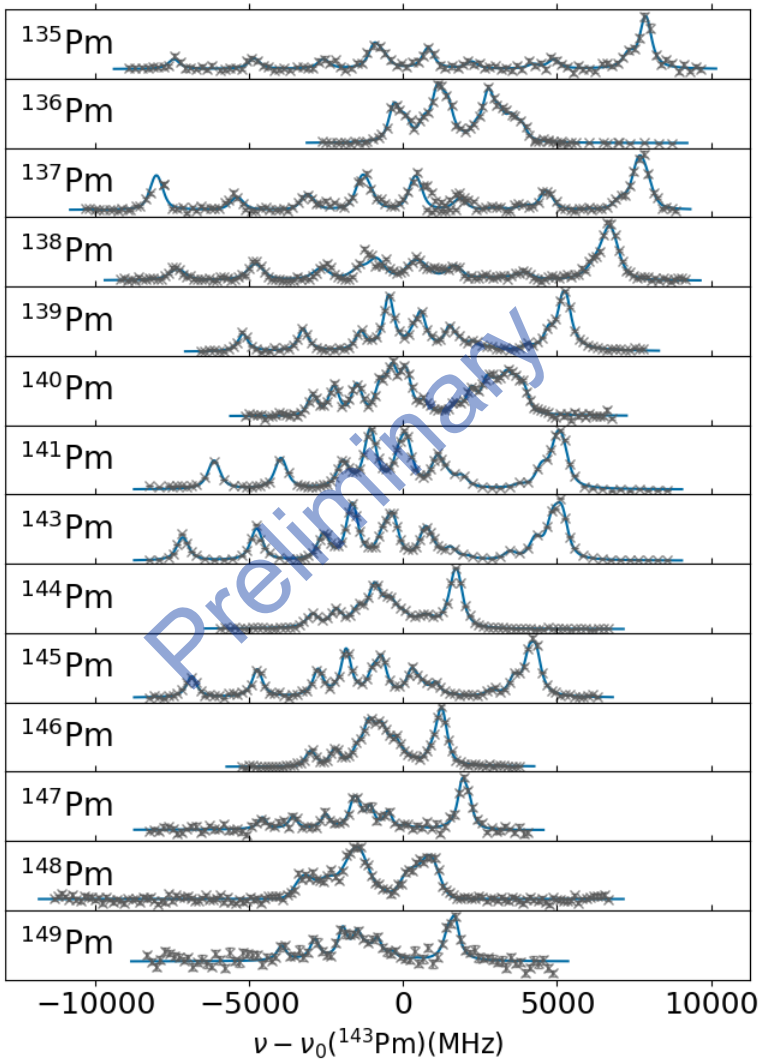
Eur. Phys. J. A (2020) 56:69
https://doi.org/10.1140/epja/s10050-020-00061-8

THE EUROPEAN PHYSICAL JOURNAL A

Regular Article - Experimental Physics

High-resolution laser resonance ionization spectroscopy of $^{143-147}$Pm

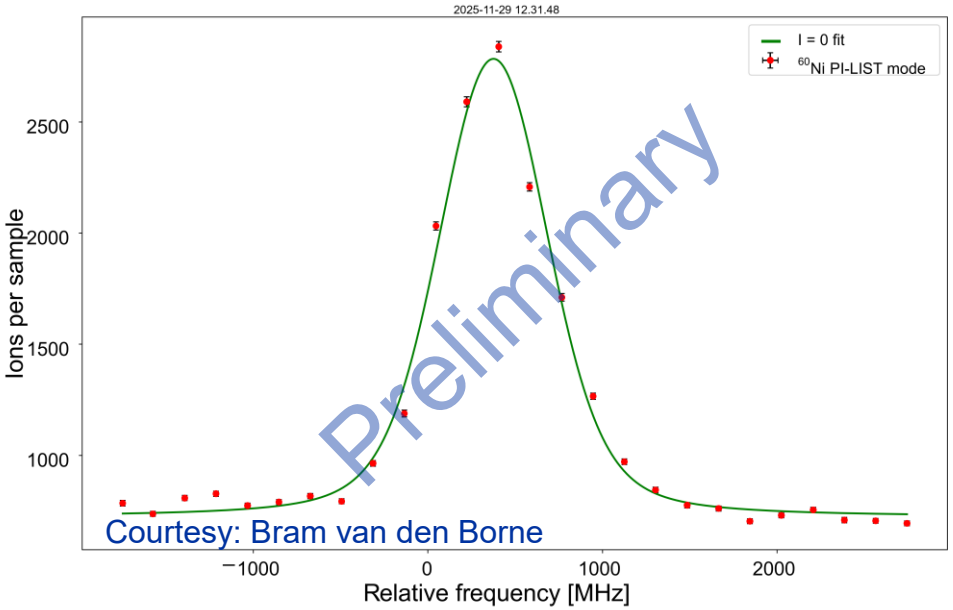
Dominik Studer[1,a], Jiri Ulrich[2], Saverio Braccini[3], Tommaso Stefano Carzaniga[3], Rugard Dressler[2], Klaus Eberhardt[4], Reinhard Heinke[1], Ulli Köster[5], Sebastian Raeder[6,7], Klaus Wendt[1]



Analysis ongoing by Julius Wessolek

Ni run 2025

- First online campaign of PI-LIST in medium mass region
- UCx-W-MK1 target used
- Online-in source laser spectroscopy campaign PI-LIST resolution : **500 MHz achieved**
- ^{69,71}Ni measured with ISOLTRAP/IDS in broadband ion guide mode
- ^{60}Ni used as reference



Analysis to be made, Jordan Ray Reilly and David McElroy

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Laser spectroscopy of neutron-rich Ni with PI-LIST

October 2, 2024

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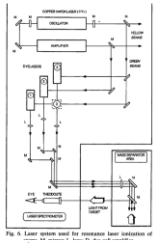
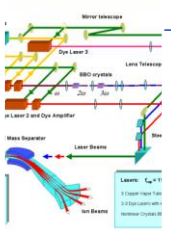
- **Outlook**

Outlook



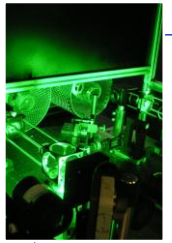
1988: Proposal for laser ion source to ISOLDE committee submitted

1990: RILIS tested online at ISOLDE-3/ SC

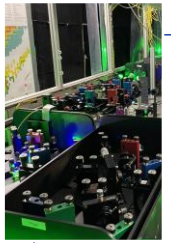


1994: RILIS available at ISOLDE for RIB production

2001: First in-source spectroscopy experiment at ISOLDE

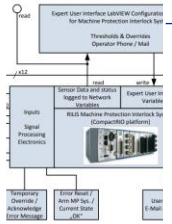


2010: RILIS replaces CVP lasers with DPSS reducing maintenance downtime

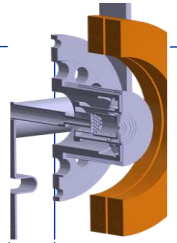


2011: RILIS adds Ti:Sa lasers to increase spectral range

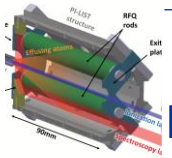
2013 (LS1): Second extension of RILIS laser cabin



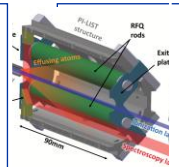
2014: Switch to on-call operation due to implementation of the RILIS machine protection system



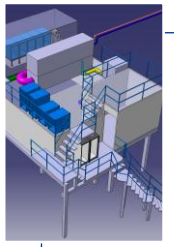
2015: First online use of VADLIS



2021: First online use of PI-LIST unlocks new possibilities for RILIS



2025: Improved efforts for high resolution laser spectroscopy with PI-LIST



2026: RILIS consolidation for extended and improved operation

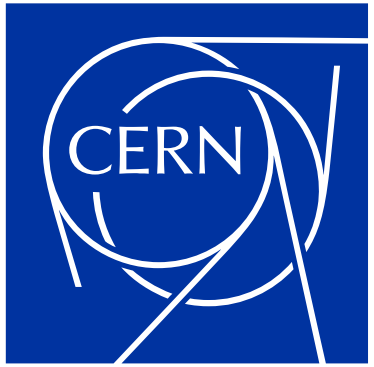
Thankyou

Sebastian Rothe
Katerina Chrysalidis
Lukas Nies
Reinhard Heinke
Cyril Bernerd
Jordan Ray Reilly
Anjali Ajayakumar

Mia Au
Alexander Schmidt
Chavdar Dutsov
Manikanta Elle
Ralitsa Ivaylova Mancheva
Line Le
Ralf Eric Rossel

David McElroy
Asar A H Jaradat
Hendrik Buker
Julius Wessolek
Justus Berbalk
Valentin Fedosseev
Eduardo Granados

Simon Stegemann
Bernard Crepieux
Antoine Boucherie
Kevin Zinke



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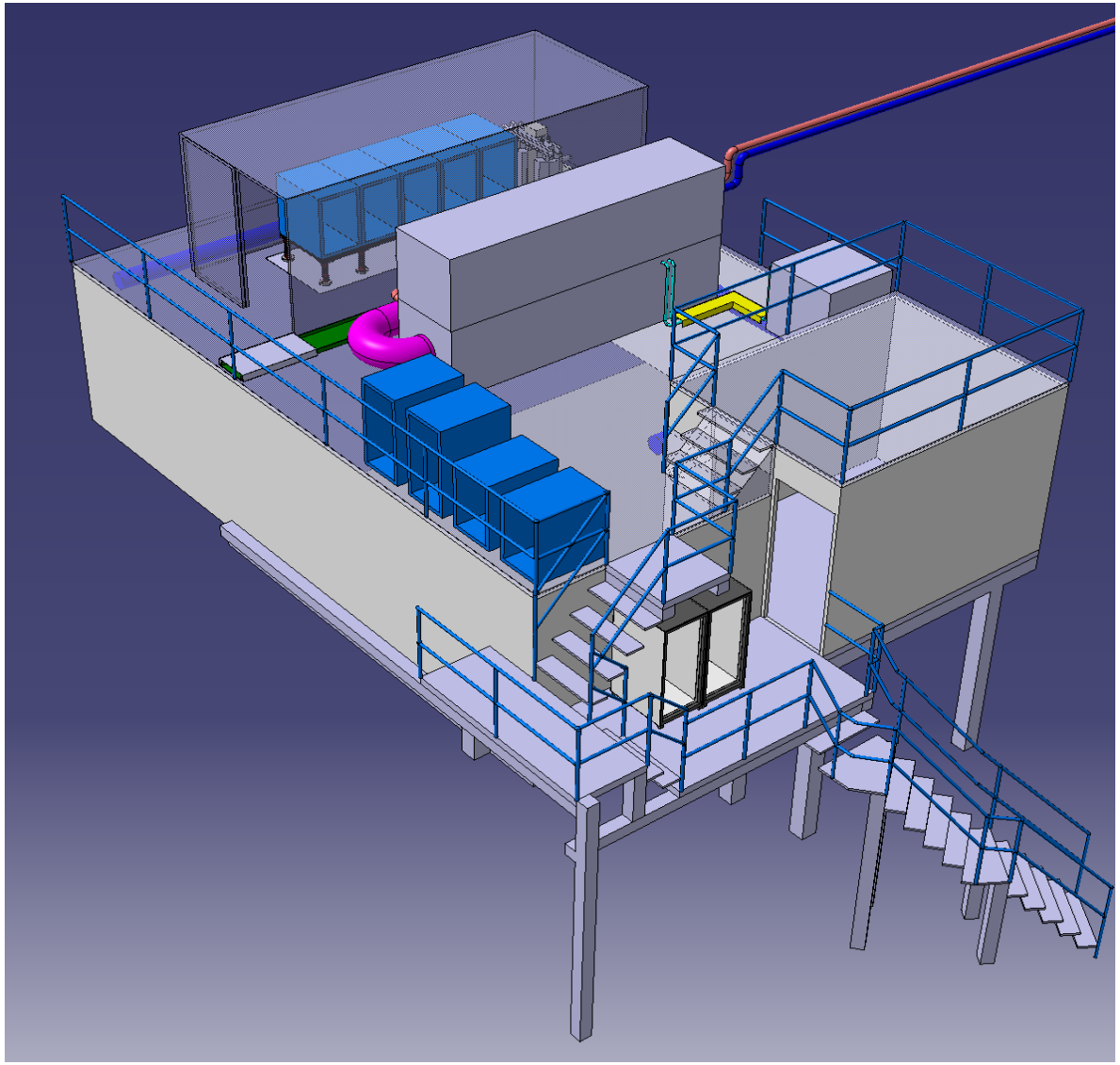
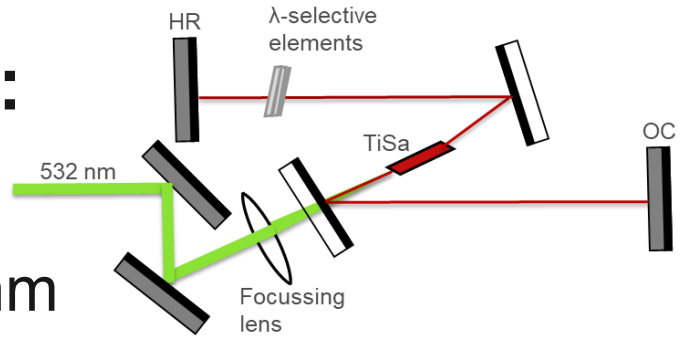
RILIS laboratory consolidation

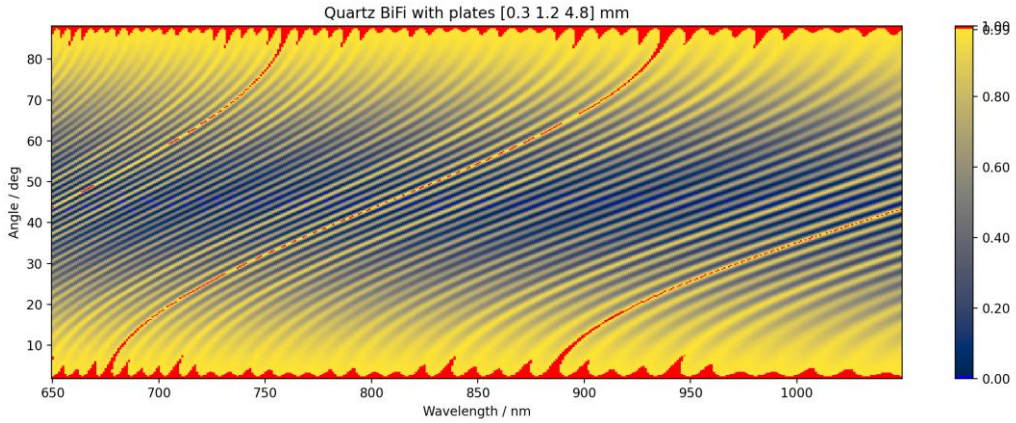


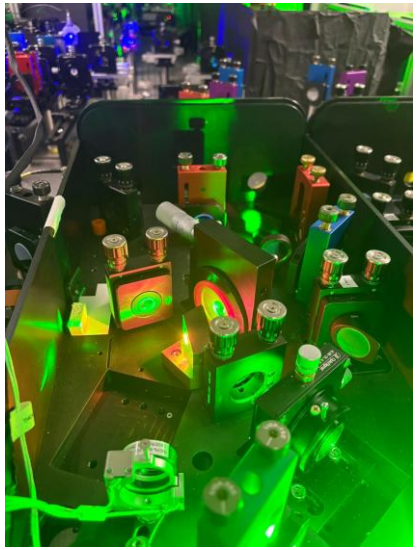
Sirah bifi for Tisa:

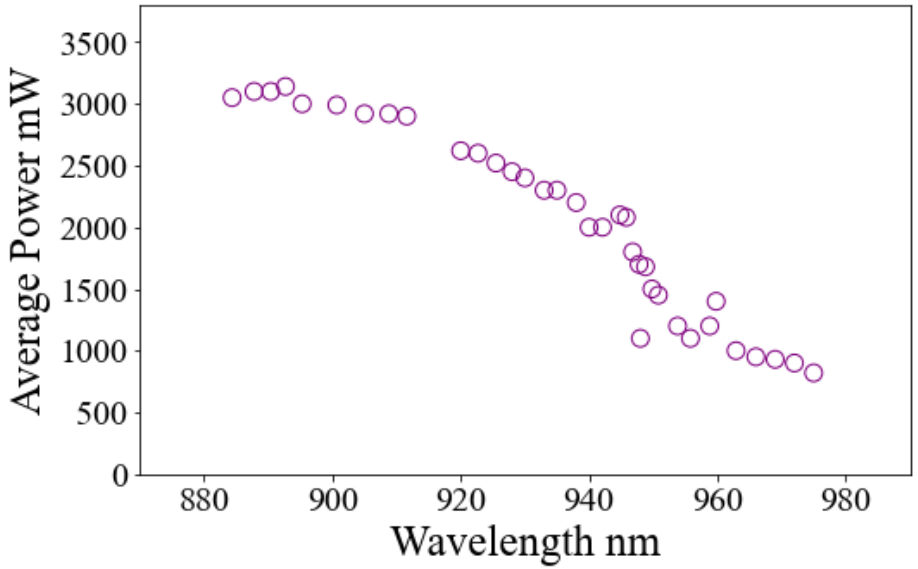
open cavity <980 nm

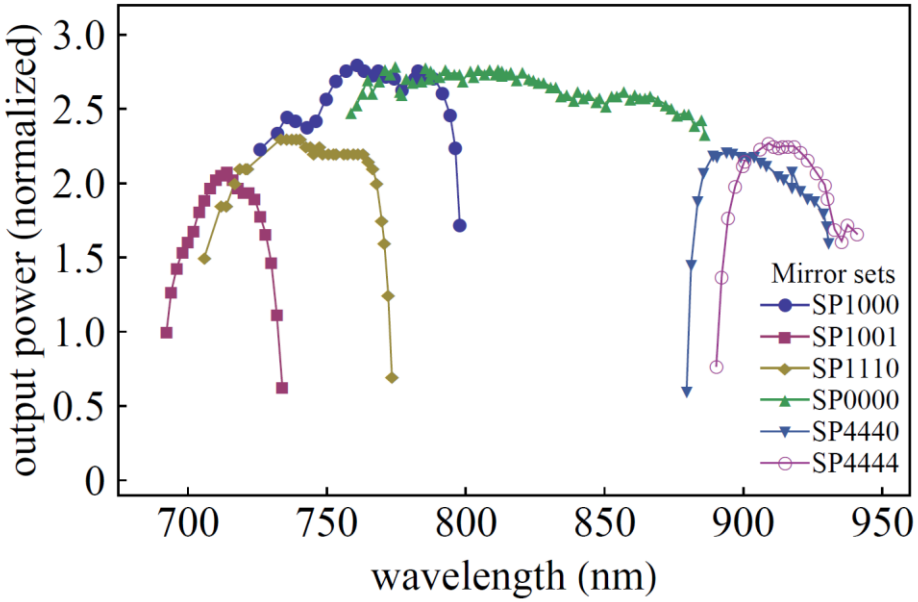
closed cavity <1000 nm





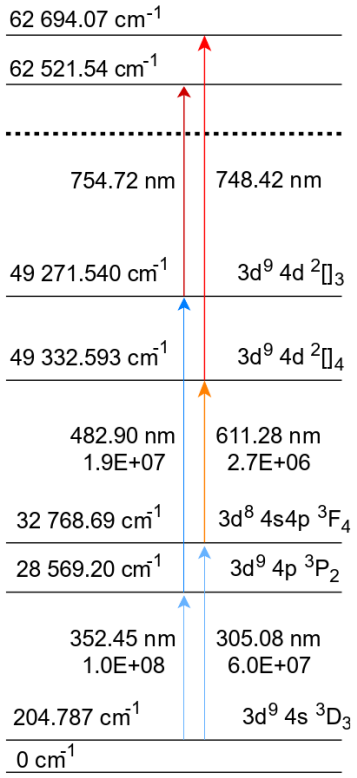






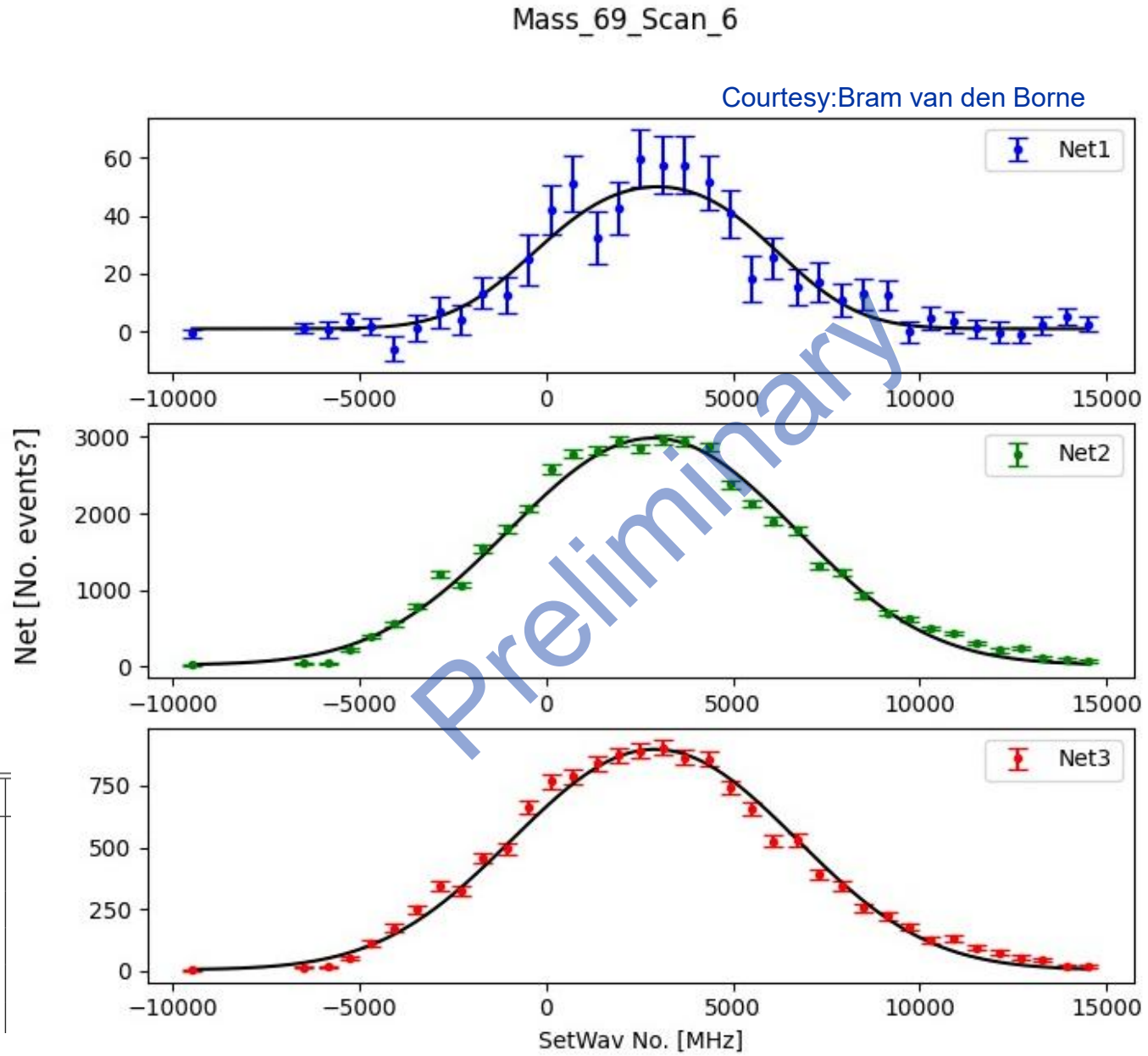
Ni online run

BB scan ion guide with IDS ~ 7 GHz
3rd step: Rydberg level

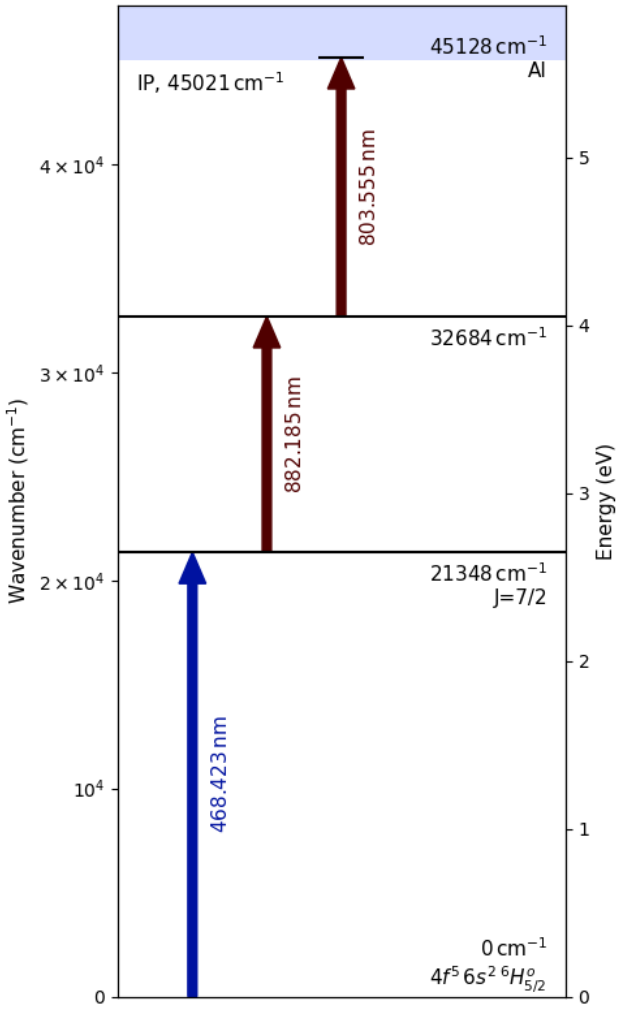


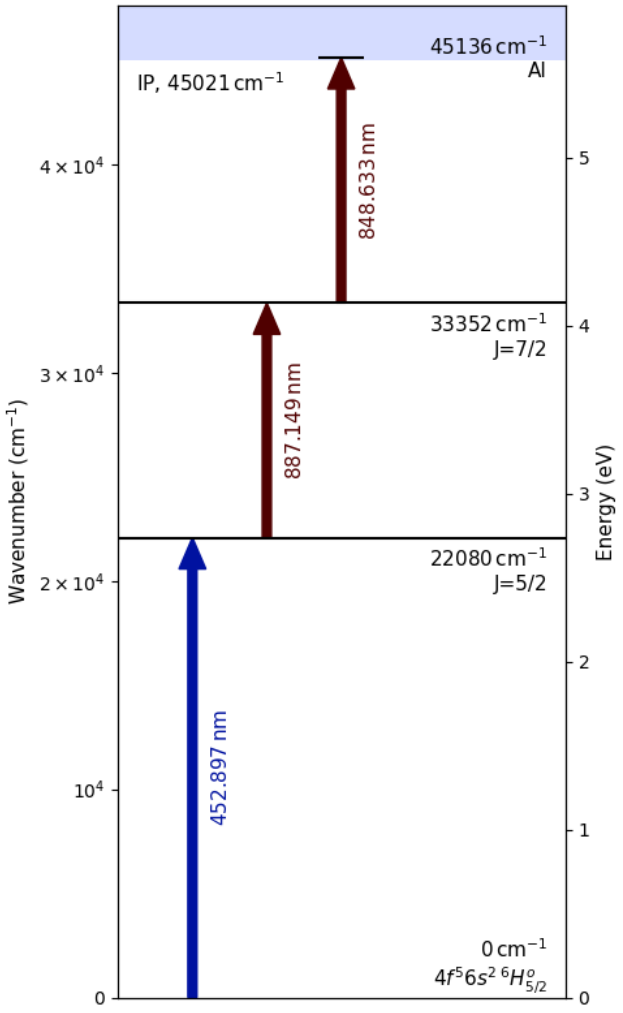
Isotope	I^π	$T_{1/2}$
^{66}Ni	0^+	54.6 hr
^{69}Ni	$(9/2^+)$	11.4 s
^{69m}Ni	$(1/2^-)$	3.5 s
^{70}Ni	0^+	6.0 s
^{71}Ni	$(9/2^+)$	2.6 s
^{71m}Ni	$(1/2^-)$	2.3 s

Courtesy:Bram van den Borne



Pm online run





A	$T_{1/2}$
132	6.9 s
133, 134	$\geq$ 5 s
135	49 s
136	107 s
137	2.4 mins
138	3.3 mins
139	4.1 mins
140	9.2 s
141	20.9 mins
142	40.5 s
144	363 days
148	5.4 days
149	53 hrs
150	2.7 hrs
151	28.4 hrs
152	4.1 mins
153	5.3 mins