RILIS @ CRIS Collab

Jan 2025

J. R. Reilly, A. Ajayakumar, M. Au, J. Berbalk, C. Bernerd, H. Büker, K. Chrysalidis, M. Elle, V. Fedosseev, L. T. Glöggler , M. V. U. Gonzalez, R. Heinke, A. A. H. Jaradat, R. Mancheva, R. Rossel, S. Rothe, A. Schmidt, J. Wessolek

Overview

- The RILIS Team
- RILIS in 2024 (Tm, Lu, Hg)
- Developmental labs: YOL2, LARIS
- Online: RILIS
- What’s coming up

The RILIS Team

Staff

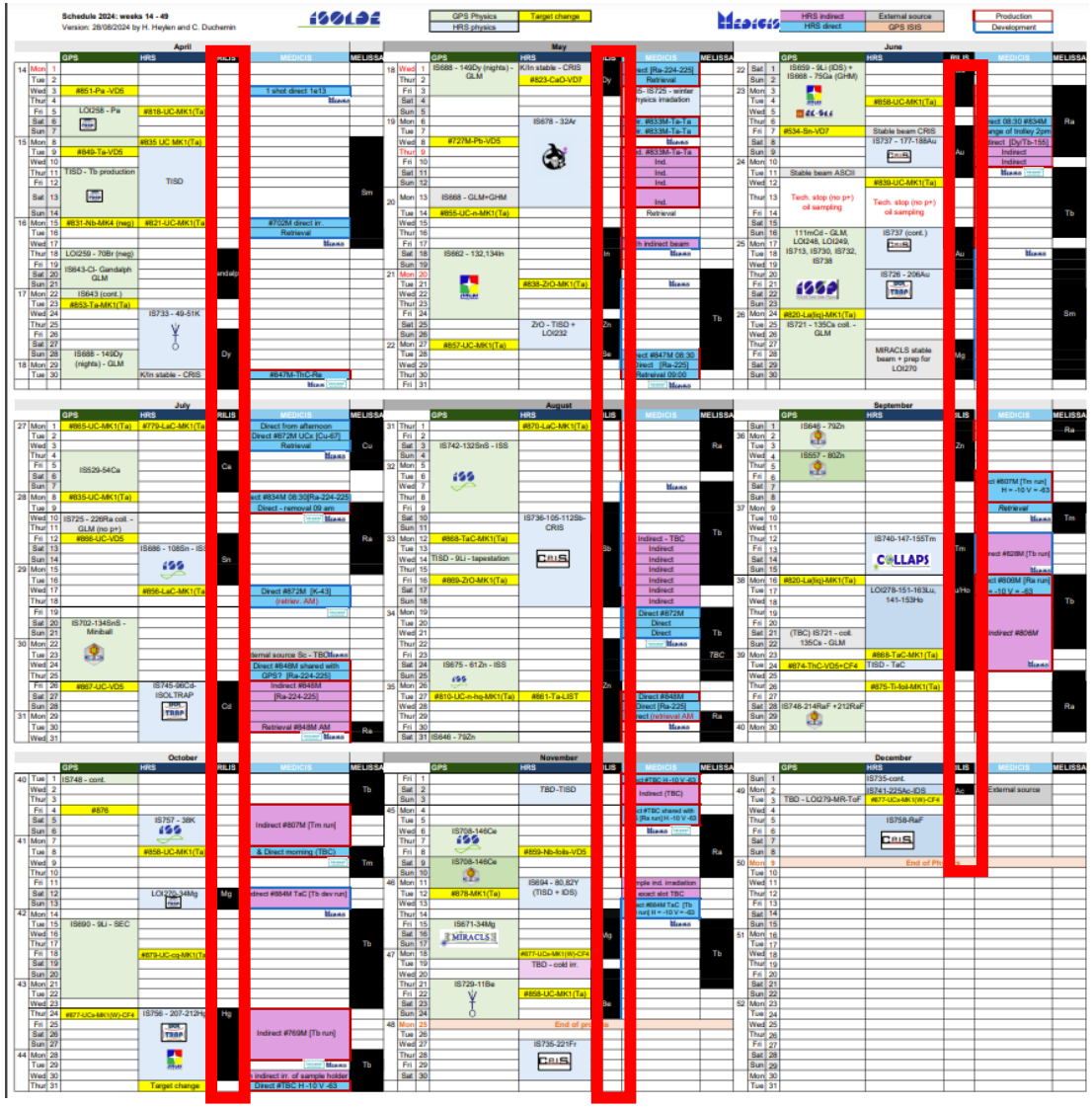
Fellows

PIJAS

PhD Students

Legacy Member

Resonance Ionization Laser Ion Source



RILIS Online Period

- **22** experiments requiring laser ionized species
- **60%** of campaigns throughout the running period and winter physics
- Cl, Dy, In, Zn, Se, Ga, Au, Mg, Ca, Sn, Cd, Sb, Tm, Lu, Ho, Hg, Sr, Al, Be, Ac
- **1 x 3:00 am Chiller substitution**
- 1 x LIST/PI-LIST campaign (**Tm/Lu**)
- 1 x 12-hour LIST target construction and change
- 1 x In-source spectroscopy campaign (**Hg**)
- Many collaborative efforts with **TISD/ISOLTRAP/IDS**

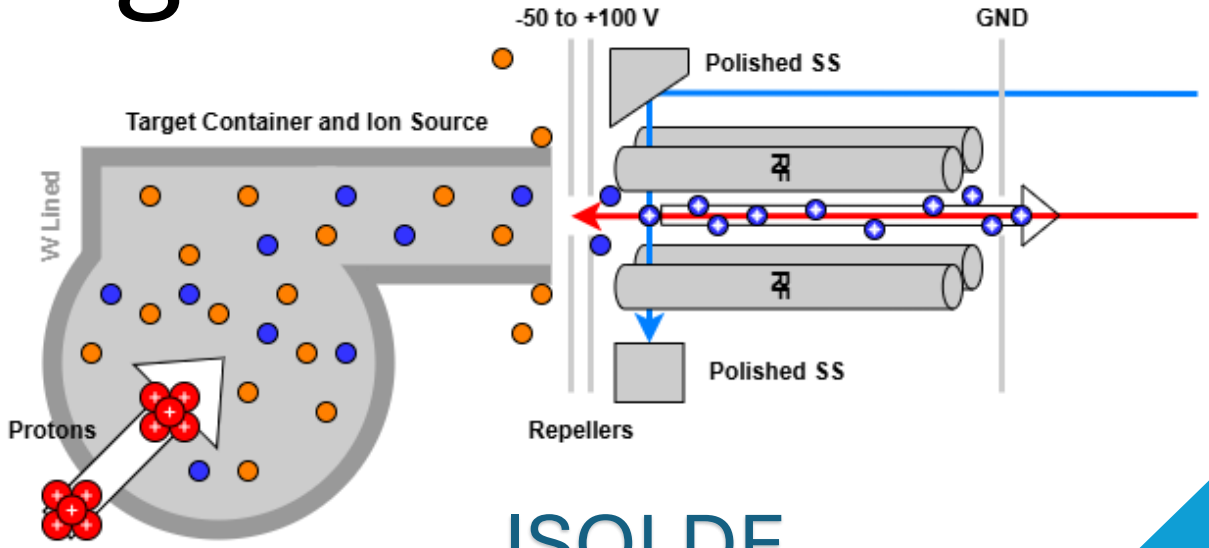
Perpendicular Illumination Laser Ion Source and Trap

J. R. Reilly

RILIS @ CRIS Collab

PI-LIST: Ever growing demand!

- Extension to the standard Ion source
- Perpendicular illumination in the LIST interaction region
- Repellers to suppress surface ionization (x10^6)
- RILIS → LIST: **100 Loss factor**
- RILIS → PI-LIST (opt): **2000 Loss factor**
- Each PI-LIST target requires thorough troubleshooting



Offline 2

- ✓ **Construction of the LIST container**
- ✓ **Coupling to ISOLDE target container**
- ✓ **Vacuum Tests**
- ✓ **Temperature calibration + Mechanical durability**
- ✓ **Electronics and RF set up**
- ✓ **Surface ion extraction and RF guiding**
- ✓ **Laser access and laser ion extraction**
- ✓ **Surface ion suppression: Ion guide mode vs LIST mode**
- ✓ **PI-LIST configuration access**

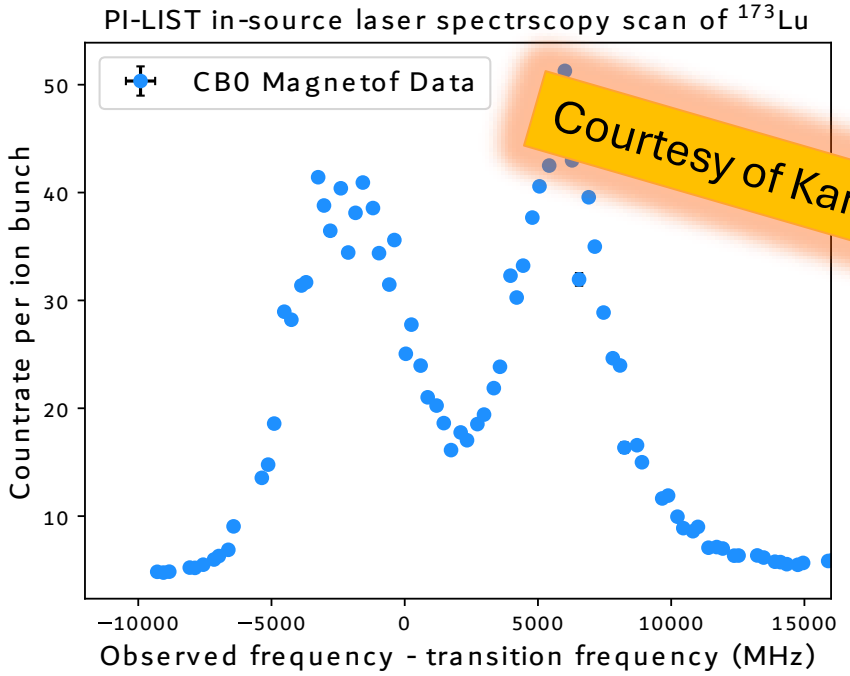
Transport

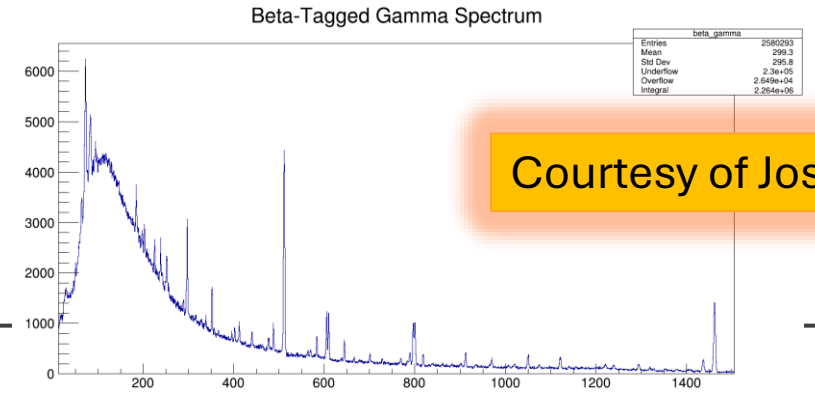
ISOLDE

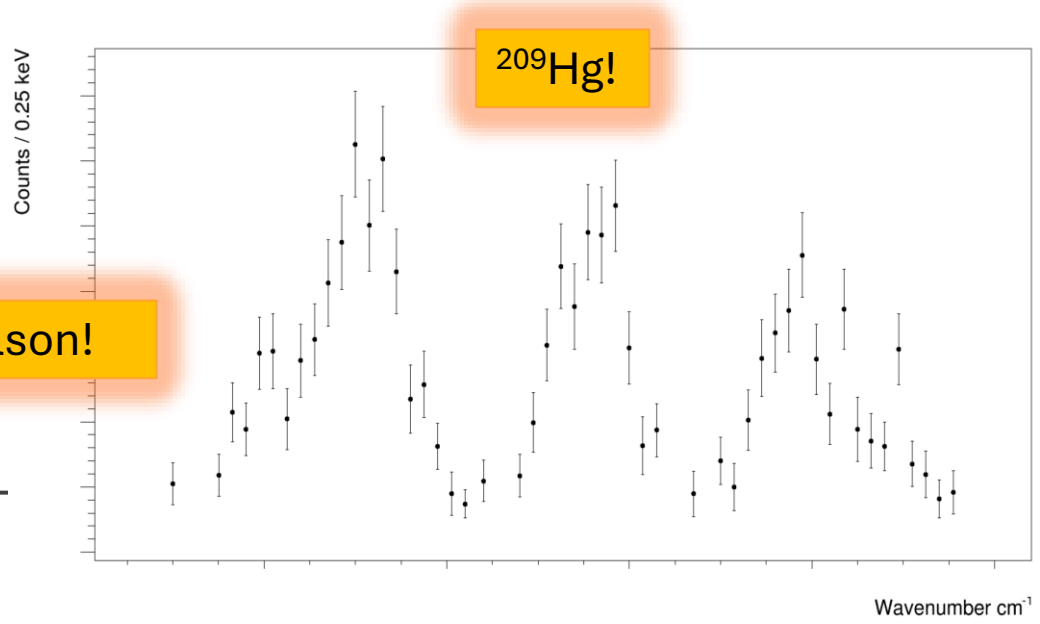
- ✓ **Electronics and RF set up**
- ✓ **Surface ion extraction and RF guiding**
- ✓ **Laser access and laser ion extraction**
- ✓ **Surface ion suppression: Ion guide mode vs LIST mode**
- ✓ **PI-LIST configuration access**

RILIS Results 2024

- PI-LIST & In-source Campaigns on Lu, Tm and Hg
- RILIS + IDS + ISOLTRAP
- Tm: COLLAPS run towards shell closure (Sept 2024)
- Lu: Scheme development and yield checks (Sep 2024)
- Hg: New laser spec and decay spec on neutron-rich side (Oct 2024)







Offline 2

Upgrading the YOL2 Laser Lab!

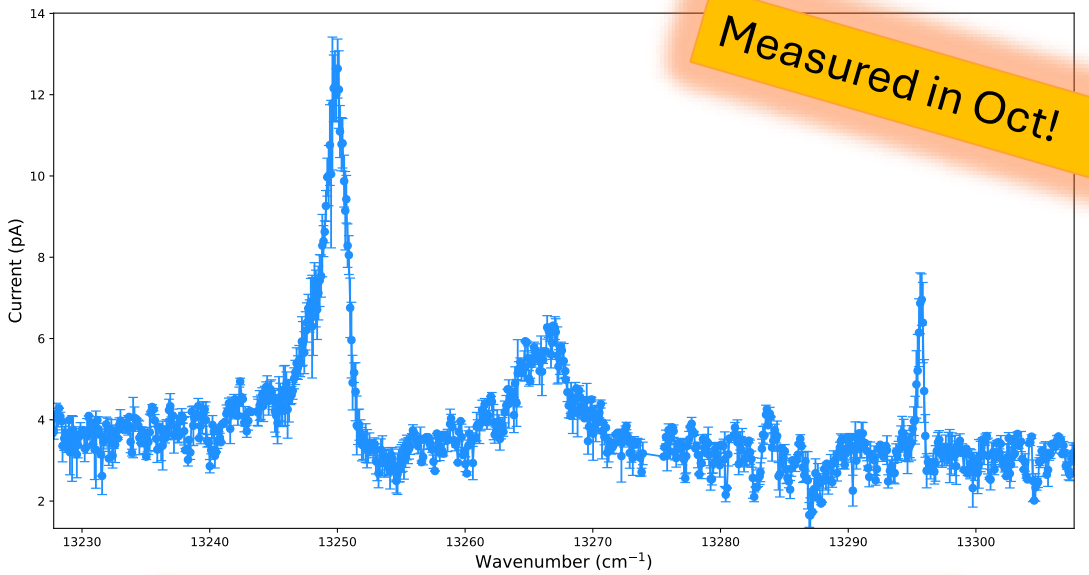
Oct 2024: Ni Scheme development – New AIs found with spectroscopy transition

December 2024: Accepted proposal to study Ni online with PI-LIST – investigate resolution limit in medium mass region offline

Providing more laser capabilities in YOL2 for Ni development as well as future endeavors:

- 4 x TiSa cavities (2 x BiFi + etalon, 1 x Grating, 1 x injection-seeded)
- 2 x Pump lasers
- 1 x Non-res 1064/532/355
- 2 x Diode lasers

To meet the demands in YOL2, we had to borrow Grating from MEDICIS – temporary solution



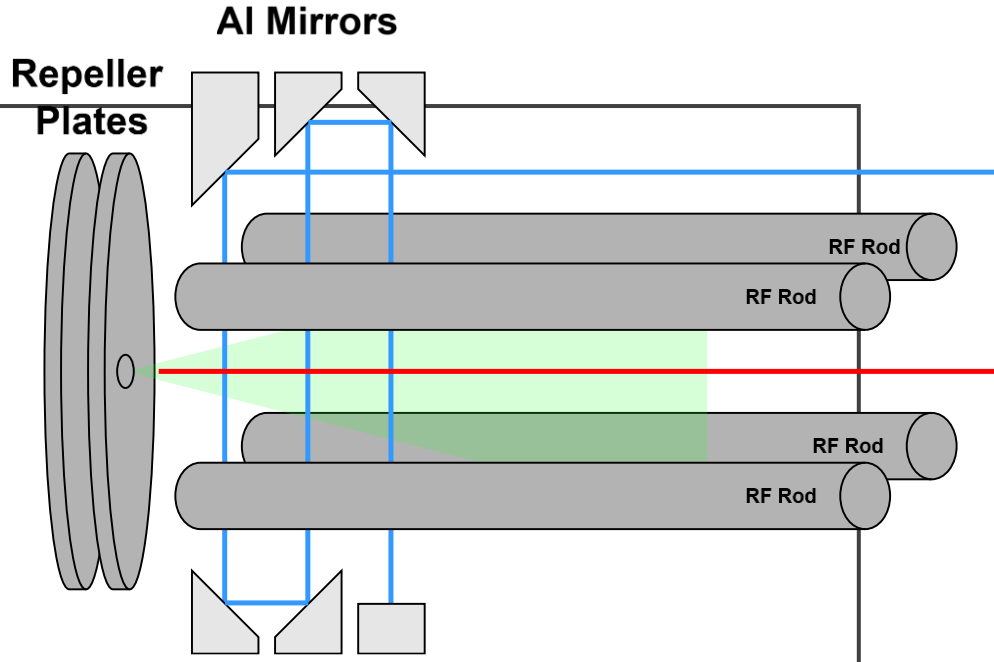
New autoionizing states found in Ni!

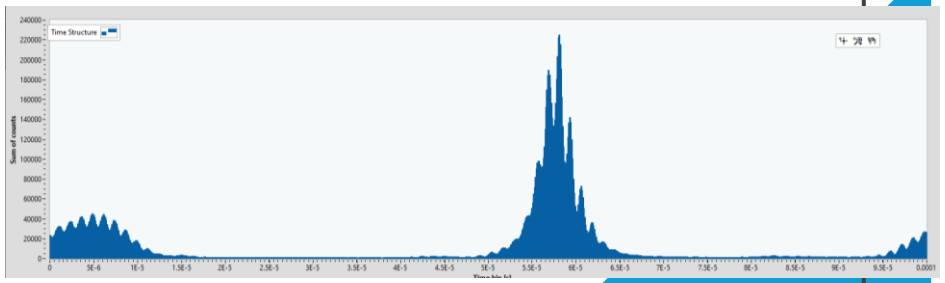
Offline 2

Not only lasers!

Also investigating PI-LIST developments:

- RF + laser pulse synchronisation (**Summer 2024**)
- Single pass vs Triple pass (**Feb 2025**)
- Voltage offset: deployed online for Tm (**Autumn 2024)**
- H-bridge current switching (**Spring/Summer 2025**)
- New Transducer box (**Manchester collaboration**)





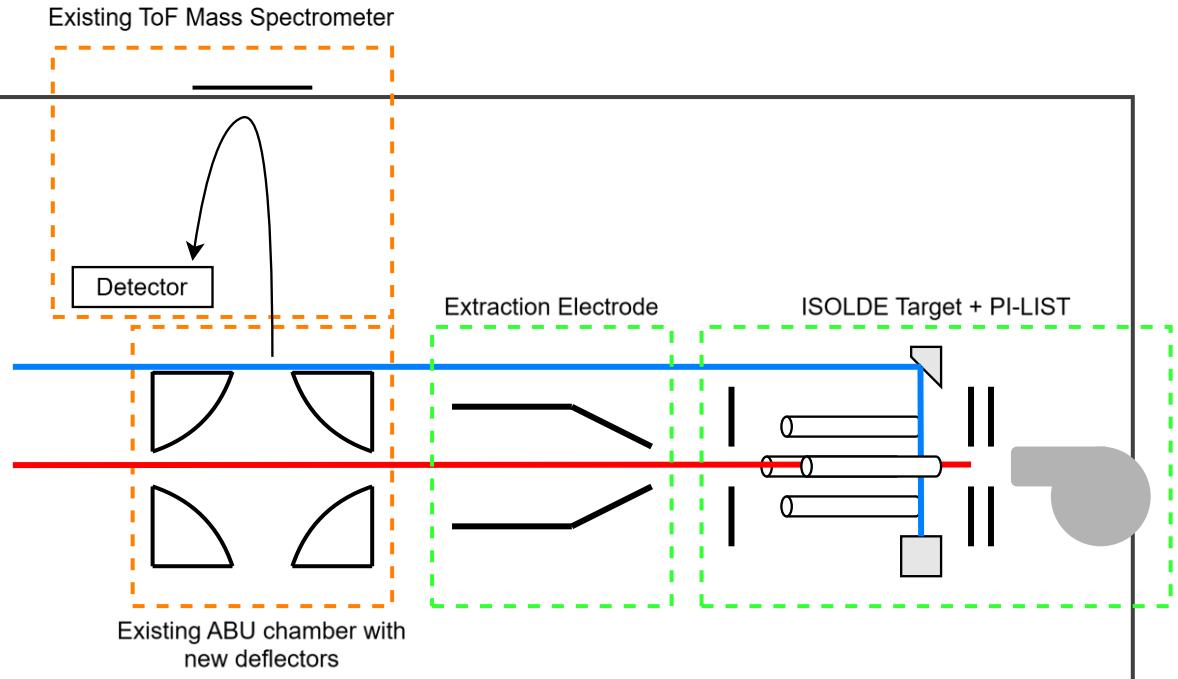
Also aim to duplicate electronics this year to have a permanent ISOLDE and YOL2 set-up

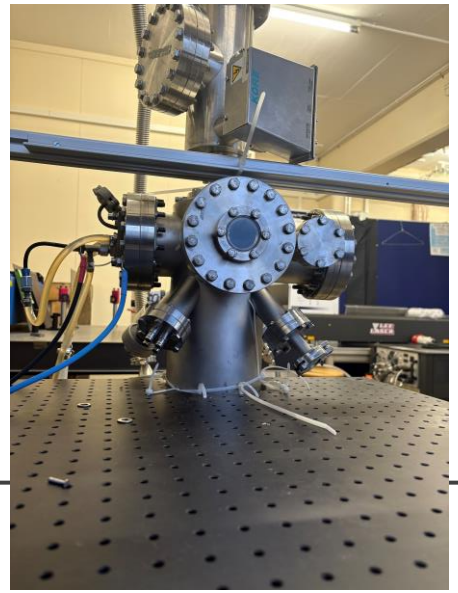
LARIS

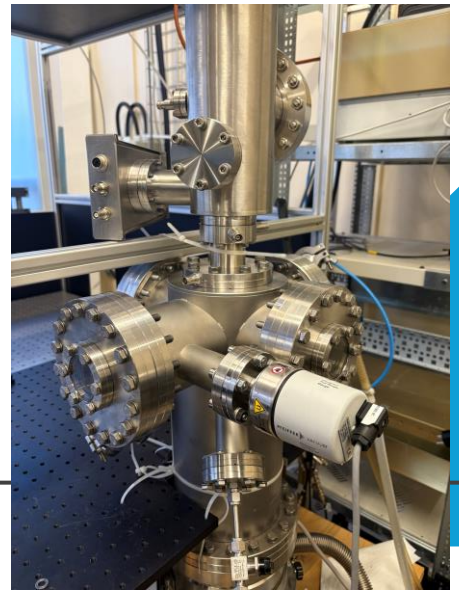
Returning ABU to its former glory!

Plans to add an extension to **existing** and **new** design:

- deflectors/bending plates added to existing chamber
- Retractable extraction electrode
- ISOLDE target coupling capabilities
- Anti-collinear access
- Decrease demand on Offline 2
- Not only LIST but other ISOLDE targets!



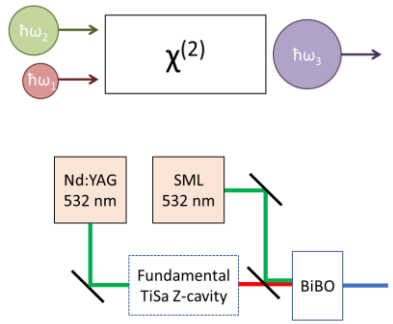
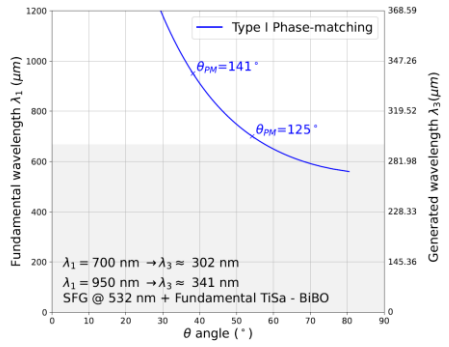
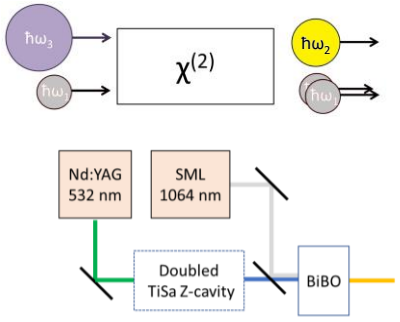
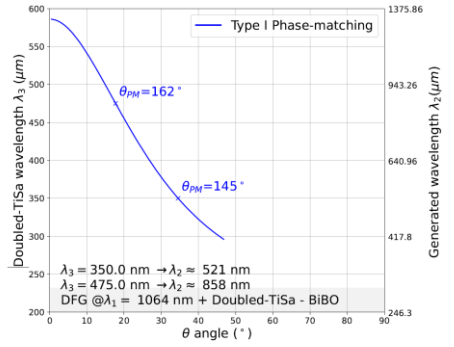




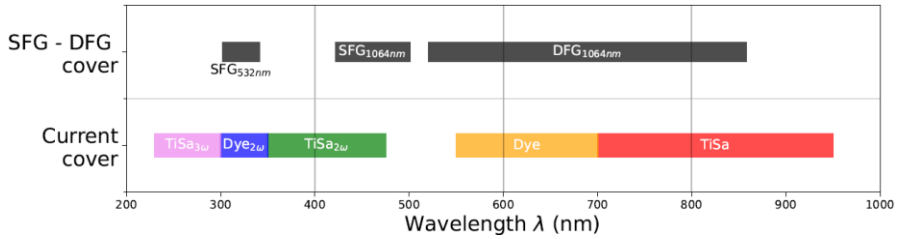
Slide provided by Cyril!

LARIS

Frequency mixing: Covering Dye laser wavelengths with solid-state systems & non-linear optics

Process	Schematics	Phase-matching BiBO
Sum frequency generation **SFG**		
Difference frequency generation **DFG**		

Potential coverage :



⇒ SFG tested at RILIS and CRIS in 2023 Ag (532nm SM not stabilized)

⇒ Proof of principle with broadband 1064nm MIRUS laser from Mainz in LARIS in 2025

⇒ Test for intra-cavity frequency mixing

⇒ If successful : stabilized 1064nm SML → call for tender

Slide provided by Cyril!

RILIS DAQ: Spectroscopy

⇒ General upgrade of the RILIS Labview software environnent (contract with ANGARA)

⇒ Upgrade of the RILIS DAQ software for in-source spectroscopy:

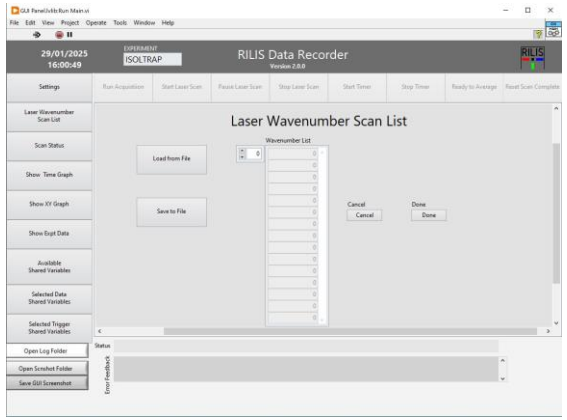
⇒ Work in progress by ANGARA

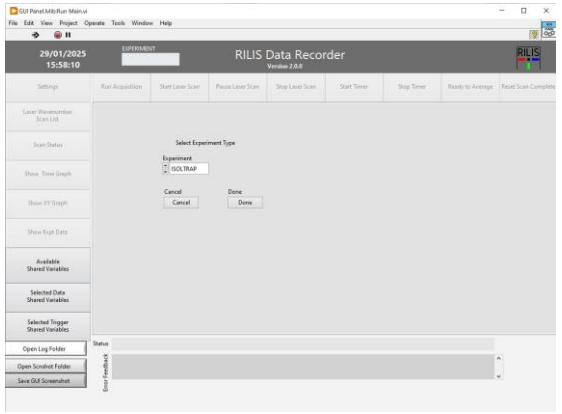
⇒ Testing and debugging in February-March – To be ready for use in April

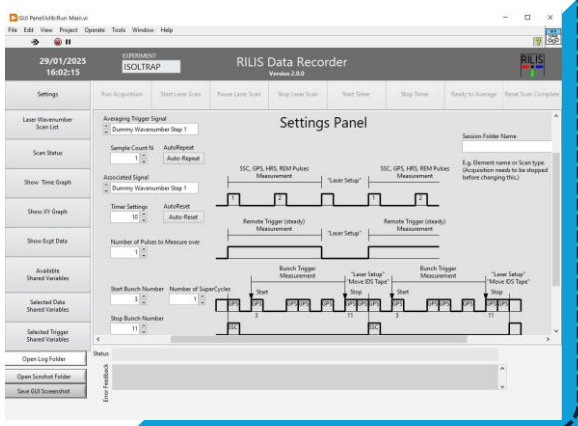
⇒ Possibility to add new trigger configuration (time, proton bunch, supercycle…). Any suggestions ?

Old version

New version





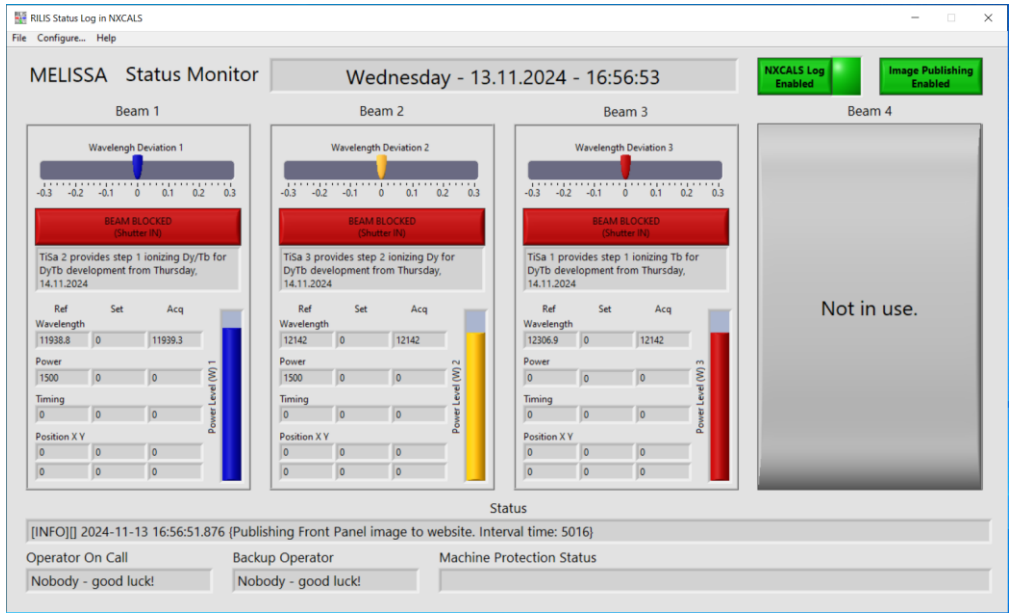


Slide provided by Cyril!

RILIS DAQ: Operation

⇒ New monitoring capabilities for RILIS
⇒ Monitoring of (<u>when possible</u>):
- Position XY
- Intensity (ref)
- Wavelength
- Timing

⇒ Values pushed through CERN middleware and accessible in Timber



timber.cern.ch

What's coming up?

Ever-growing demand for (PI)-LIST!

- **2** Confirmed PI-LIST campaigns: Ni + Pm
- **1** tbc PI-LIST campaign: Lu
- **1** In-source LIST campaign: Bi/Cu
- **1** LIST target Campaign: Tm (COLLAPS)

4 x LIST for Online + 1 Development

Not just the typical LIST targets:

- **1** W-lined for Ni
- **1** Neutron-converter for Bi/Cu

In-source laser spectroscopy of neutron-deficient lutetium isotopes

January 8, 2025

K.M. Lynch[1], T.E. Cocolios[2], R. Heinke[1,4], A. Ajayakumar[4], M. Au[4], M. Bender[5] C. Bernerd[4], S. Casci[2,6], B. Cheal[3], K. Chrysalidis[4], J. Cubiss[7], M. Elle[2,4], R. Ferrer[2], S. Geldhof[9], Harshithbabu[2], M. Heines[2], A.A.H. Jaradat[1,4], D.T. McElroy[1], S. Mohammed[2], W.W.M.M. Phyo[2], J. Reilly[1,4], M. Reponen[10], L.V. Rodríguez[11,12], A. de Roubin[8], W. Ryssens[13,14] J. Shaw[2], J. Warbinek[11], J. Wessolek[1,4]

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

Laser spectroscopy of neutron-rich Ni with PI-LIST

October 2, 2024

J. R. Reilly[1], M. Athanasakis-Kaklamanakis[2], M. Araszkiewicz[3], K. Chrysalidis[1], A. Ajayakumar[1], A. N. Andreyev[4], M. Au[1], C. Bernerd[1], J. G. Cubiss[4,5], L. M. Fraile[6], M. J. G. Borge[7], P. Garczyński[3], G. Georgiev[8], P. F. Giesel[9], R. de Groote[10], R. Grzywacz[11], R. Heinke[12,1], M. Karny[3], Á. Koszorús[10], R. Kuczma[3], L. Lalanne[13], D. Lange[14], K. M. Lynch[12], D. McElroy[12], M. Młynarczyk[3], L. Nies[1], F. Nowacki[13], B. Olaizola[7], S. Rothe[1], C. Schweiger[14], A. I. Sison[6], K. Solak[3], K. Stoychev[15], R. Taniuchi[4], B. van den Borne[10], P. Wakuluk[3], J. Warbinek[16], J. Wessolek[1,12], J. Wilson[4], S. Zajda[3]

What's coming up?

A busy year for PI-LIST, with challenging laser Schemes!

Our plans to provide the high-res light:

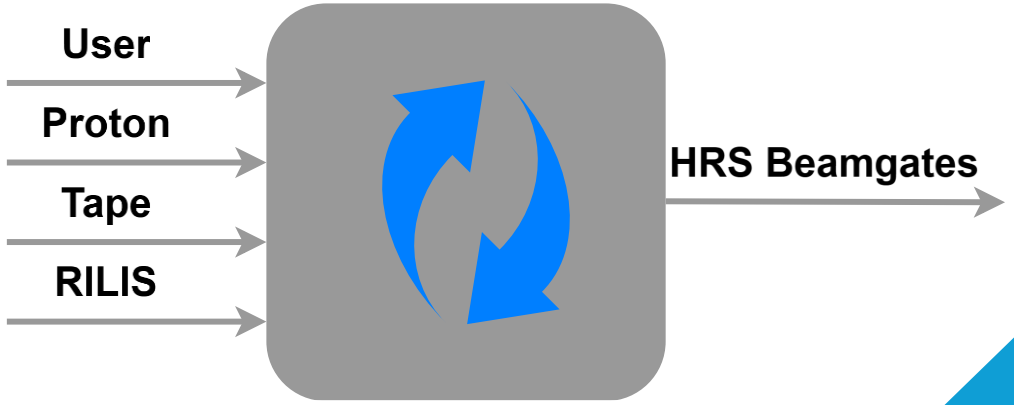
- Currently high-res seed light is provided by the **CRIS Matisse**
- This year, we have purchase **Toptica diode laser (DLPRO)** + trying to revive **TUI Optics diode laser**
- Diode lasers moved between RILIS/YOL2/LARIS – wear and tear on equipment
- Purchasing + swapping diodes for 2025
- Growing demand for high-res PI-LIST and busy schedule for CRIS puts a strain on Matisse + Locals

New Matisse to be housed in CRIS laser lab?

2025
Ar: 763.5 nm
In: 738 nm
Pm: 905 nm
Ni: 704 nm
Lu: 897 nm
Missing any??

10 kHz Fast Beamgates

- Recent implementation of the cRIO
- Mixing input TTL signals
- **RILIS T0**, **USER** or **Tape** triggered beamgate
- All inputs mixed for a single output
- Recent upgrades allow **proton triggered** + **proton counting triggered** beamgate
- Implementation on GPS this year!



New online Database for Laser Ionisation schemes

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

Or use the QR code!

Conclusion

- Busy year with **60%** of ion beams at ISOLDE requiring RILIS
- Exchange of lasers and many late nights
- Ongoing developments for PI-LIST
- 10 kHz beamgates for ion beam improvements
- **New TiSa only Ni scheme**
- Experimental runs on **Lu**, **Tm** and **Hg** in 2024

Thank you!

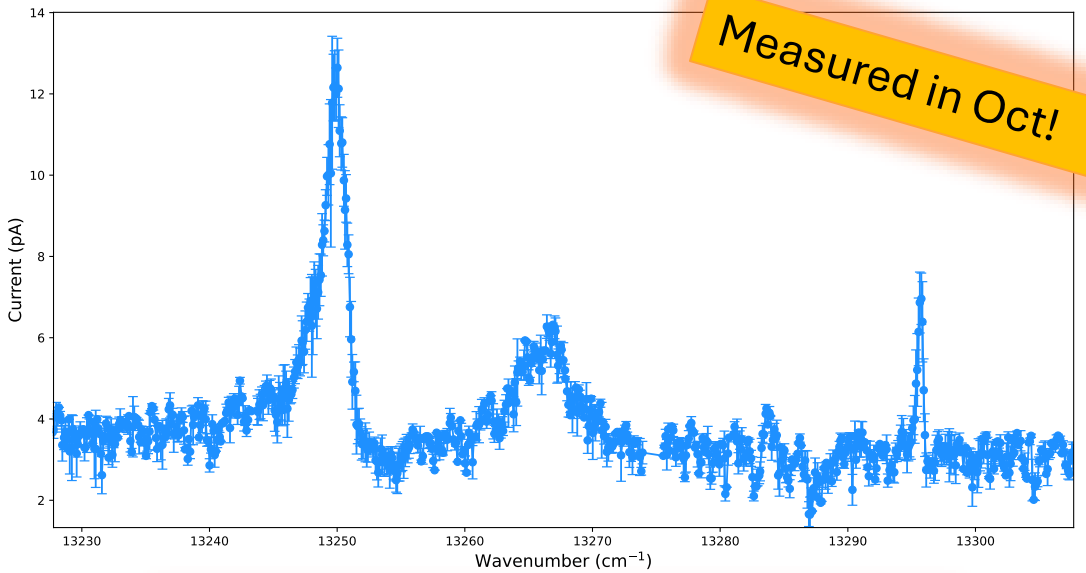
Future Outlooks

- New accepted proposals on **Ni** and **Pm**
- **4 LIST** Campaigns
- Implementing high-res in YOL2
- Construction of new ABU in LARIS
- **New High-res laser in CRIS laser lab**
- **New RILIS DAQ**

Back up Slides

Ni Scheme Development

- 3 New autoionizing states in Ni observed
- This scheme utilizes the laser spectroscopy transition used in literature
- Motivated the submission of INTC proposal to study Ni using PI-LIST!
- Scheme **at least** as efficient as production



New autoionizing states found in Ni!

Thank you!

Questions?

Conclusion

- Busy year with **60%** of ions beam at ISOLDE requiring RILIS
- Exchange of lasers and many late nights
- Ongoing developments for PI-LIST
- In-trap decay & 10 kHz beamgates for ion beam improvements
- First online deployment of intracavity triple TiSa
- **New TiSa only Ni scheme**
- Experimental runs on **Lu**, **Tm** and **Hg**

Future Outlooks

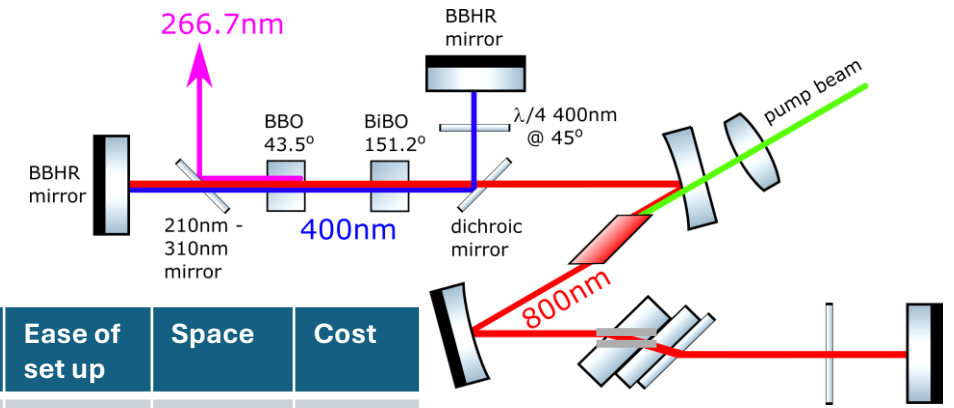
- Submitted proposals on **Ni & Pm**
- Further upgrades to offline2 laser laboratory for high-resolution
- Construction of new ABU in LARIS
- Raman laser development

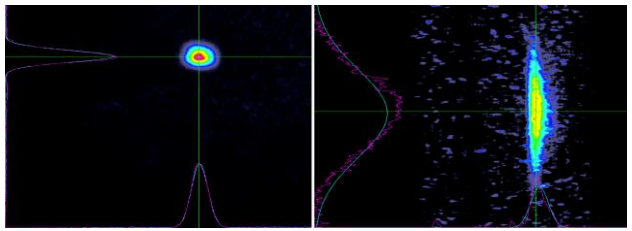
Courtesy of Julius

First online deployment of intra-cavity tripling

65 mW of 304 nm laser light for the production of **indium** beams

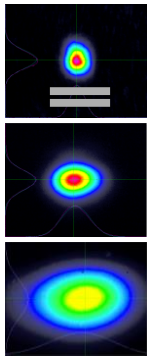
- **Stable operation for 7 days** without intervention
- Compared to Dye lasers which need constant monitoring





Intracavity THG *Single-Pass THG*

	Beam Profile	Output Power	Stability	Ease of set up	Space	Cost
Intra	+ +	=	=	+	+	+
External	- -	=	=	-	-	-

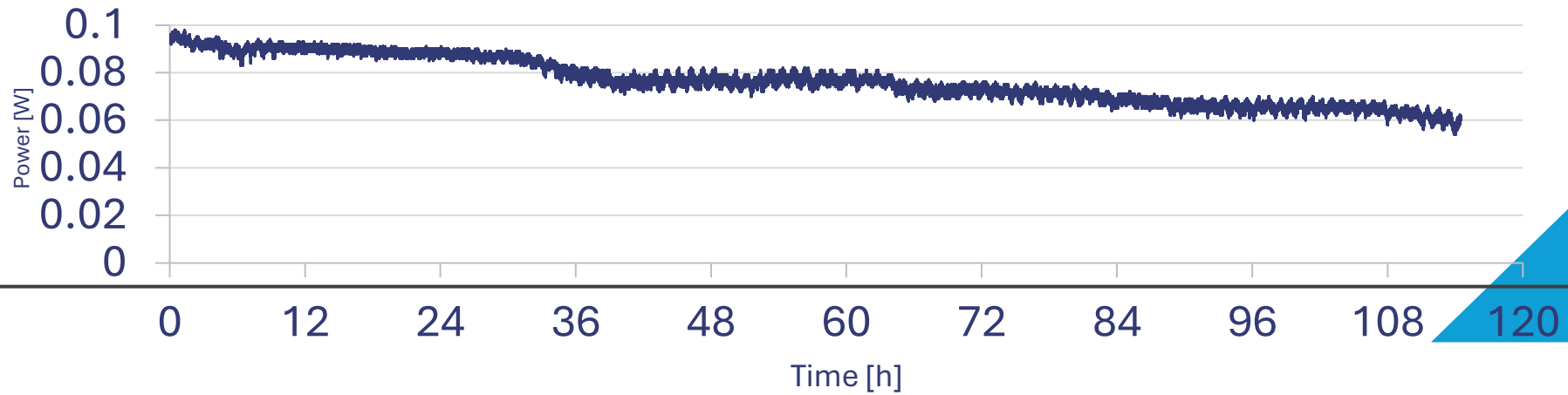


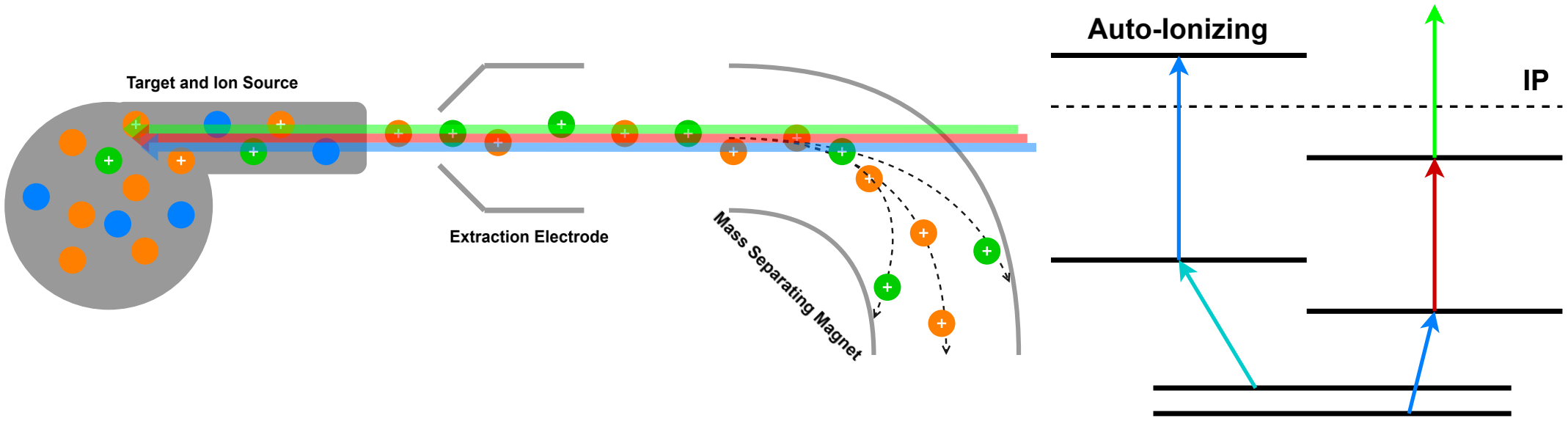
25 cm

100 cm

250 cm

Long-term stability test for Au 2nd step @ 306nm and 10kHz has shown a slow decrease of power but easily recovered:





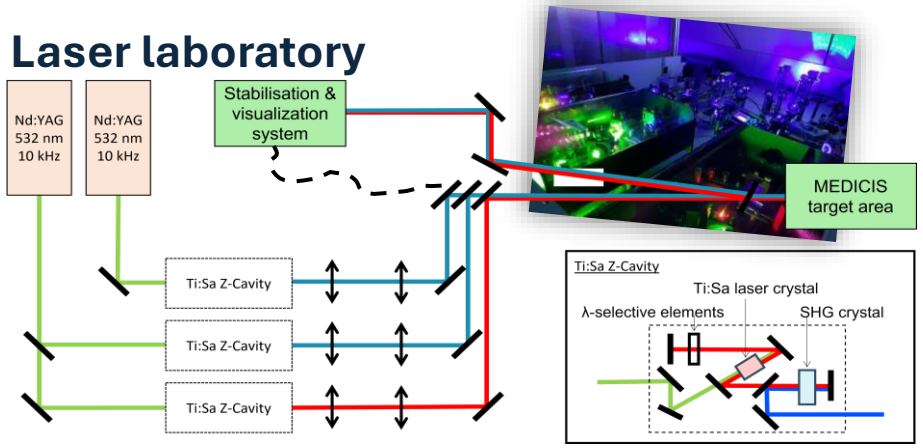
Resonance Ionization Laser Ion Source

- RILIS uses a variety of 10 kHz lasers
- Unique atomic transitions to step-wise excite and ionize the element of interest
- Coupled with mass selectivity for high resolving power

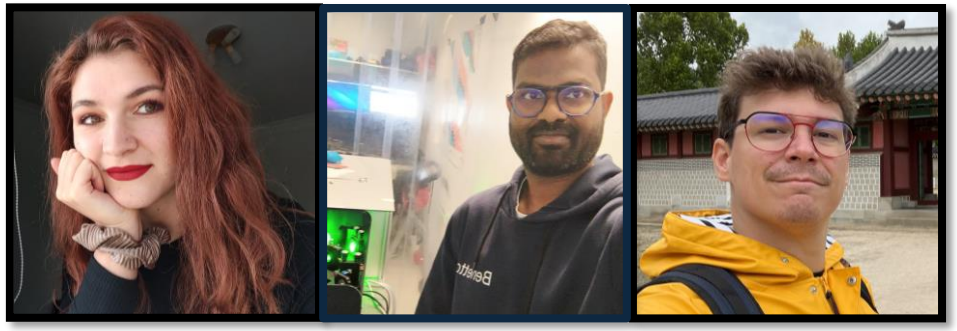
Courtesy of Cyril

MELISSA in 2024

Laser laboratory

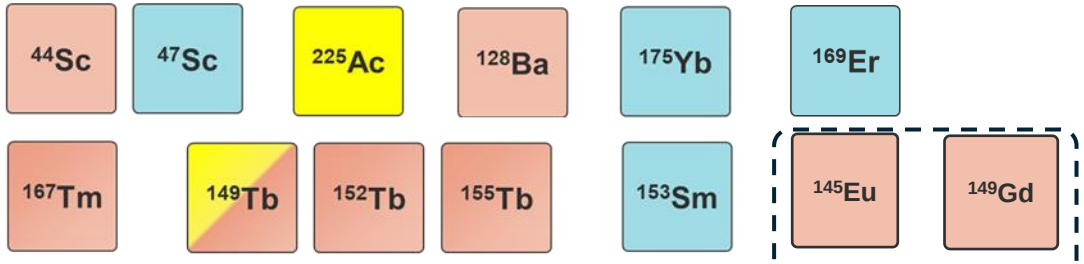


Operators 2024 New 2024



KU LEUVEN

Portfolio



Development 2024

⇒ 2 new collections at MEDICIS in 2024: ^{145}Eu and ^{149}Gd

⇒ Validation of Eu laser scheme developed in RILIS (B. van Dingenen KU Leuven)

⇒ Raman laser : Final z-fold design

Operation 2024

Month	May				June				July					August				September				October					November				D
Week nº	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
Element		Tb Dy	Tb Dy	Tb Dy		Tb Dy	Sm		Cu	Tb Dy				Tm	Tm	Tb			Tm	Tb Dy			Gd Eu	Tb Dy	Tb Dy	Tb Dy		Tb Dy	Tb Dy	Sc	Sc

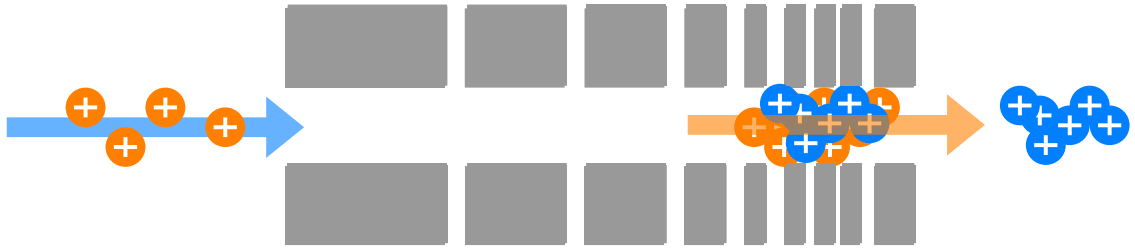
In-trap Decay

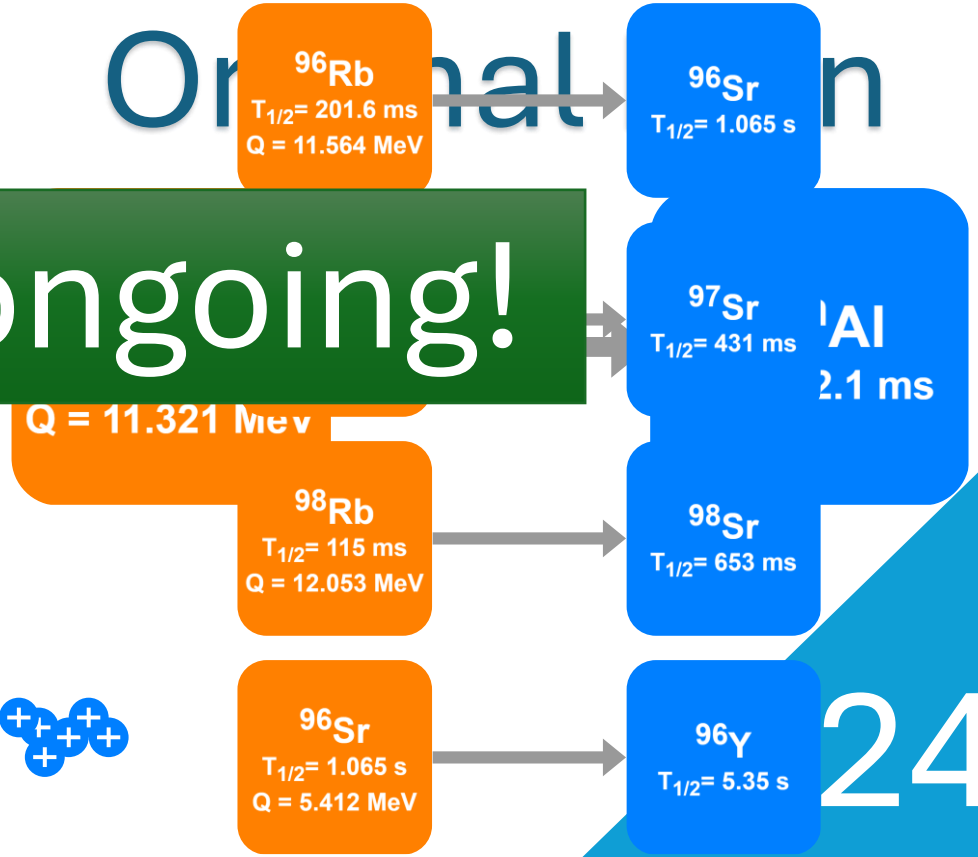
- LOI to investigate in-trap decay using ISCOOL RFQ
- Provide non-produced and challenging to extract elements
- Improve ion conf… **He gas pressure… depth**
- Thanks to efforts of… TISD/RILIS/ISOLTRAP!
- Laser ionized Sr tested!

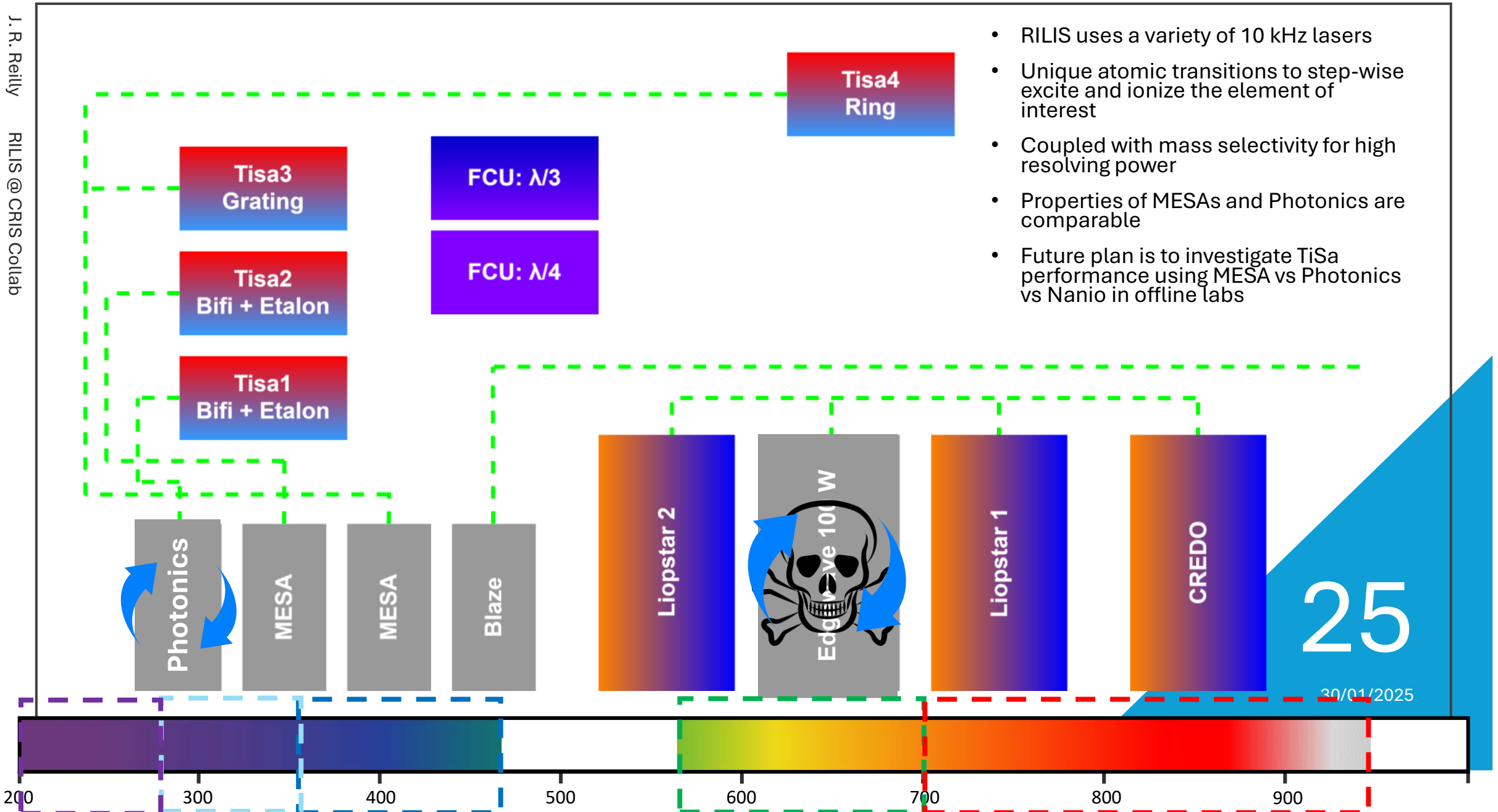
Revised Plan

Or…nal…n

Analysis ongoing!







- RILIS uses a variety of 10 kHz lasers
- Unique atomic transitions to step-wise excite and ionize the element of interest
- Coupled with mass selectivity for high resolving power
- Properties of MESAs and Photonics are comparable
- Future plan is to investigate TiSa performance using MESA vs Photonics vs Nanio in offline labs