Implementation of titanium:sapphire lasers at ISOLDE RILIS

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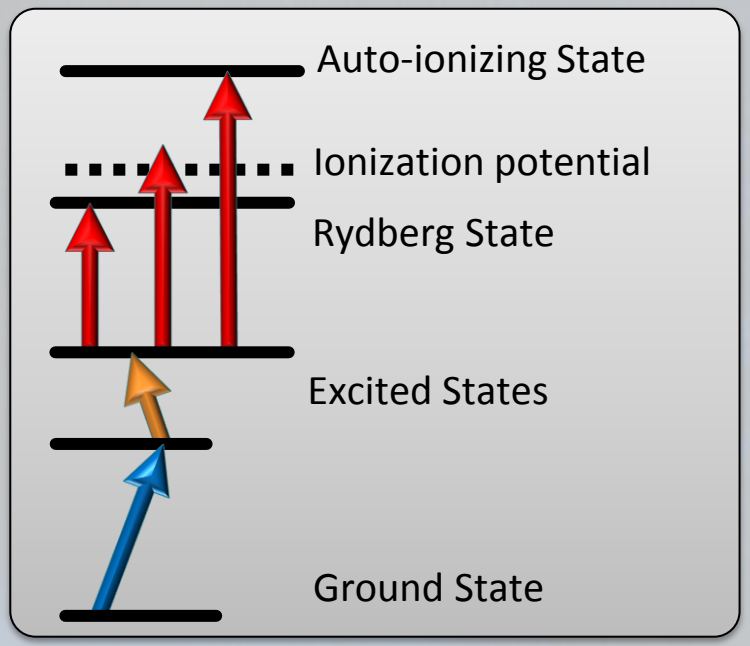
ISOLDE Workshop 2011

Outline

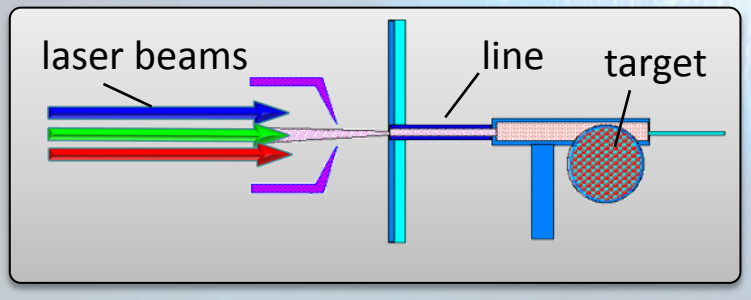
- The RILIS principle
- The new solid-state laser system
- RILIS operation 2011
- In-source laser spectroscopy of Astatine

The Resonance Ionization Laser Ion Source (RILIS)

Laser ionization scheme



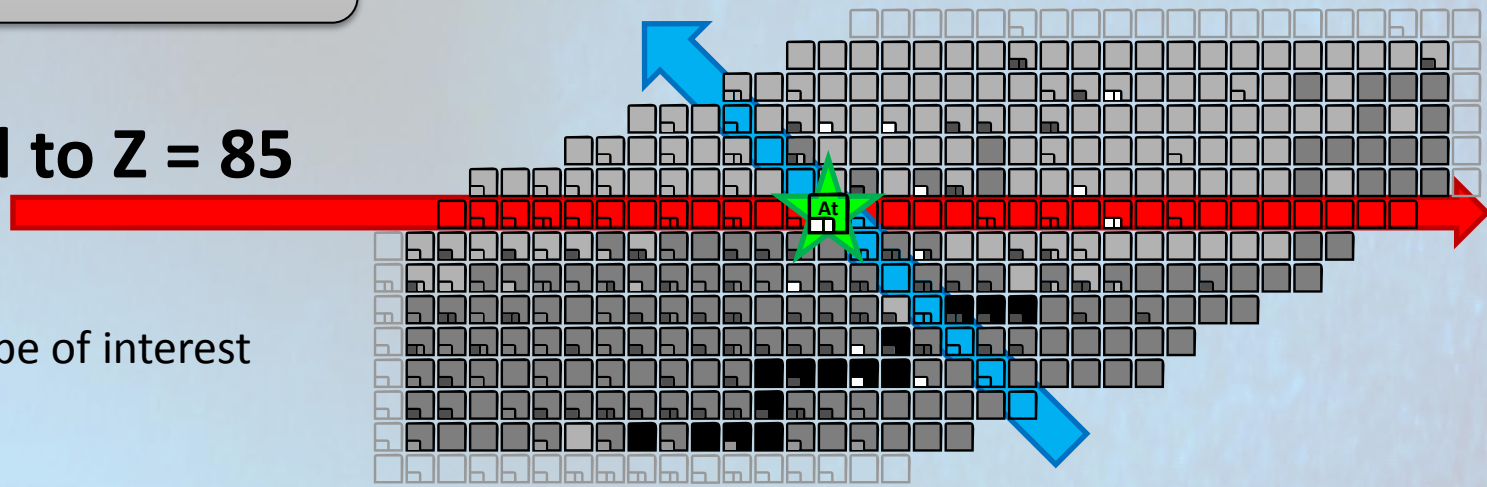
Laser Ion Source

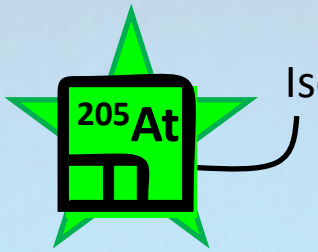


- Simple setup at target site: same as surface ion source
- RILIS lasers excite and ionize atoms

Z selective

Laser tuned to Z = 85



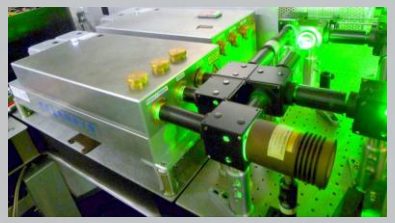


Isotope of interest

Magnet set to A = 205

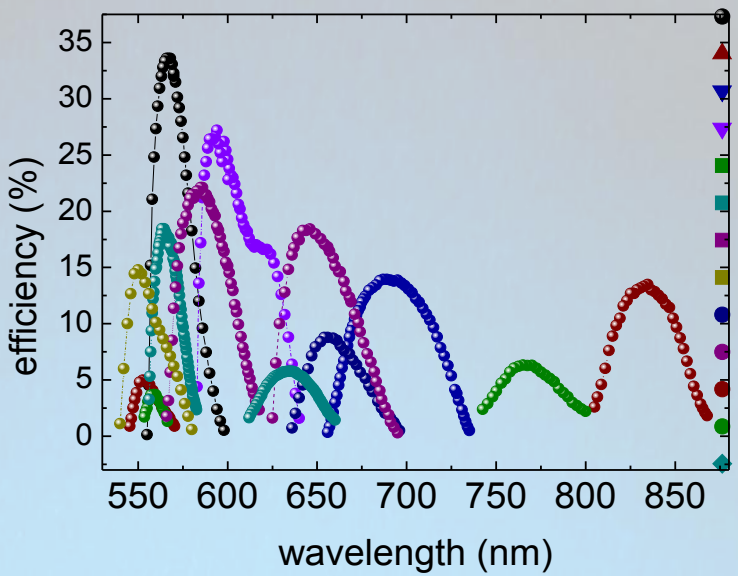
The RILIS dye lasers

Pump laser: Nd:YAG (532 nm)
Repetition rate: 10 kHz, Pulse duration: 9 ns
Power: 100 W

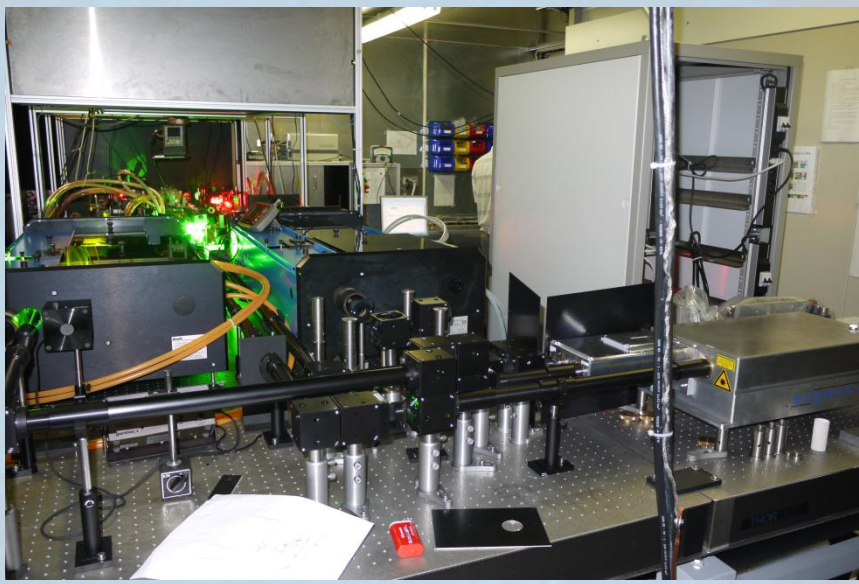


dye lasers:
2 x broadband (6 GHz)
1 x narrow band (1 GHz)

After CVL removal 2010

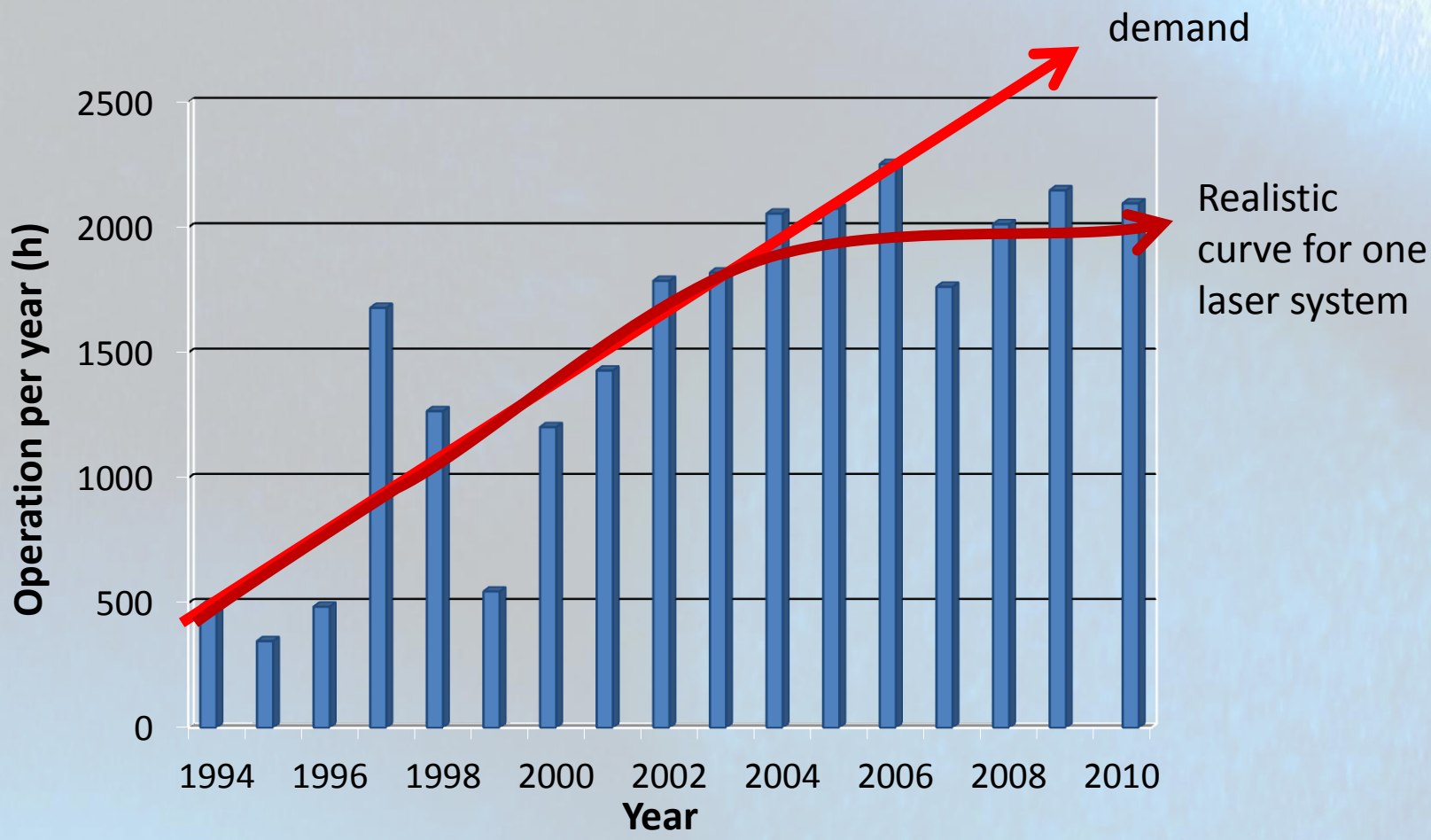


> 10 different dyes used

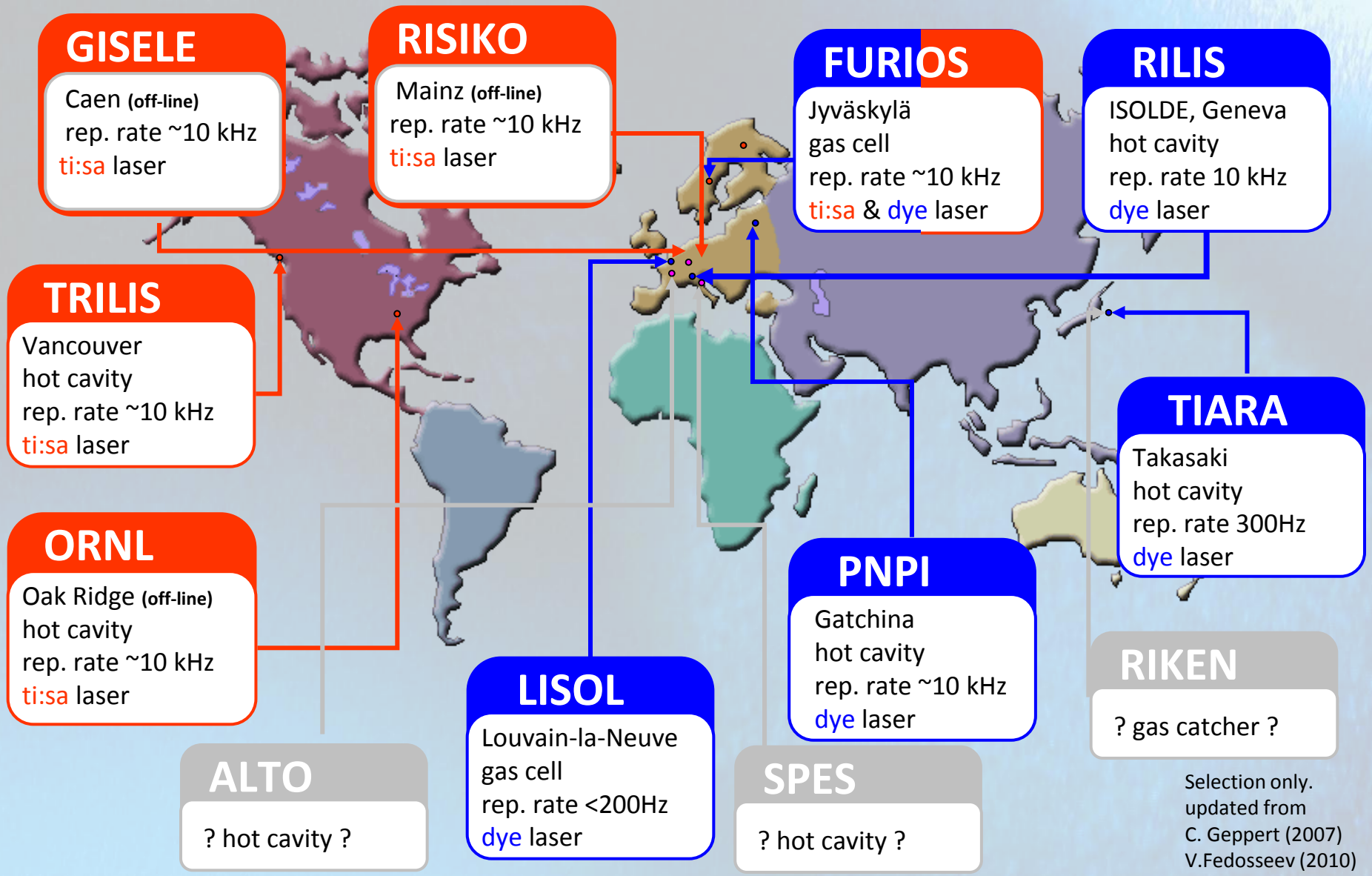


Laser table Jan. 2011

RILIS operation 1994 to 2010



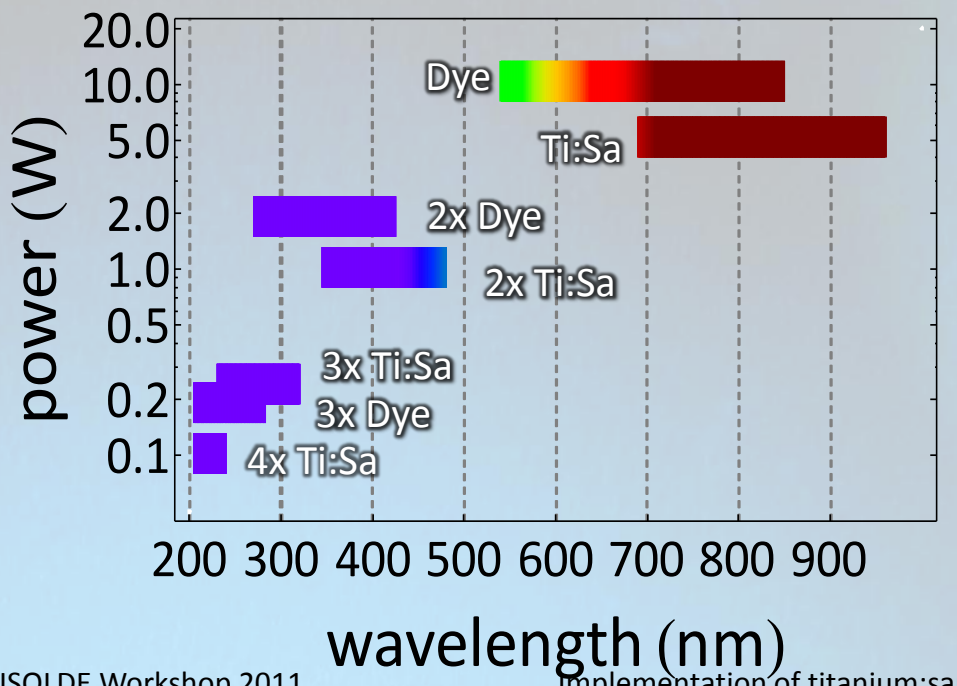
Laser ion sources World-Wide

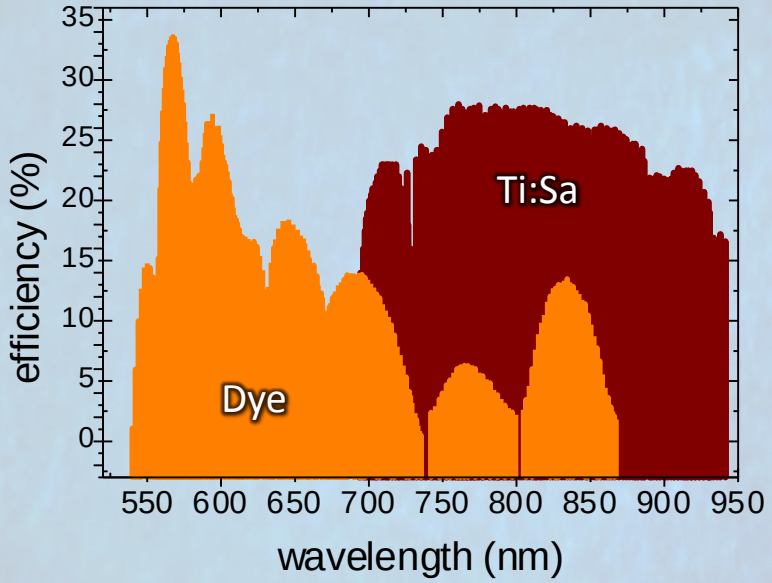


Selection only.
updated from
C. Geppert (2007)
V.Fedosseev (2010)

Comparison dye vs. Ti:Sa system

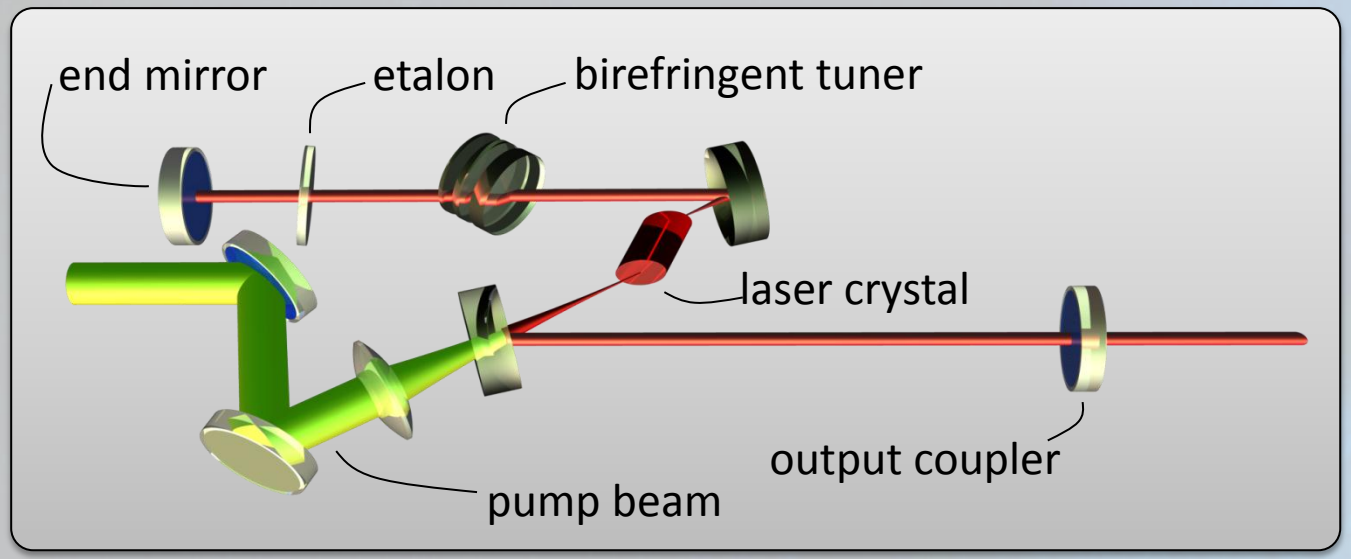
	Dye	Ti:Sa
Active Medium	> 10 different dyes	=1 Ti:sapphire crystal
condition of aggregation	liquid (org. solvents)	solid-state
Tuning range	540 – 850 nm	680 – 980 nm
Power	< 12 W	< 5 W
Pulse duration	~8 ns	~50 ns
Synchronization	optical delay lines	q-switch, pump power
# of schemes developed	47	37
Maintenance	renew dye solutions	~ none





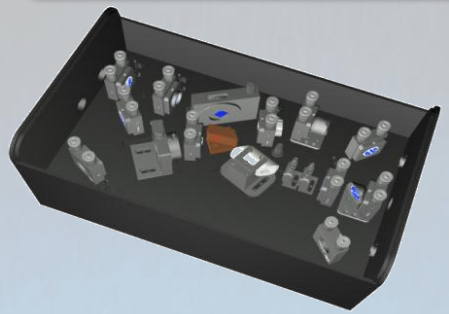
Ti:Sa system is complementary

The Ti:Sa laser



Lasing medium:

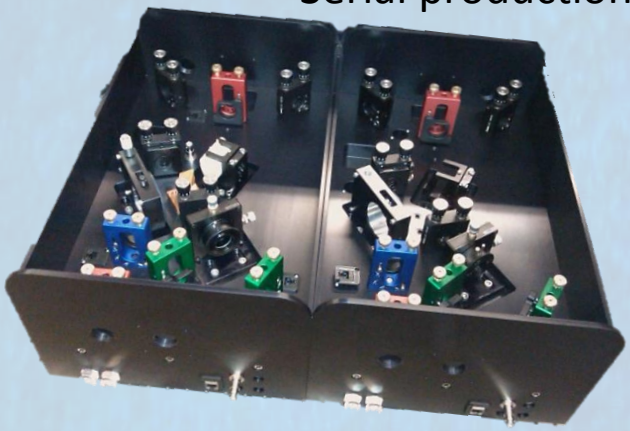
- solid-state Ti doped sapphire ($Ti:Al_2O_3$)
- Hardness 9

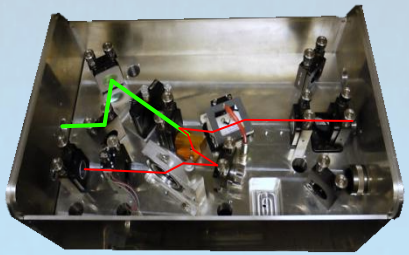


3d model

- Mainz-Type
- Design optimized for on-line operations

Serial production





Prototype

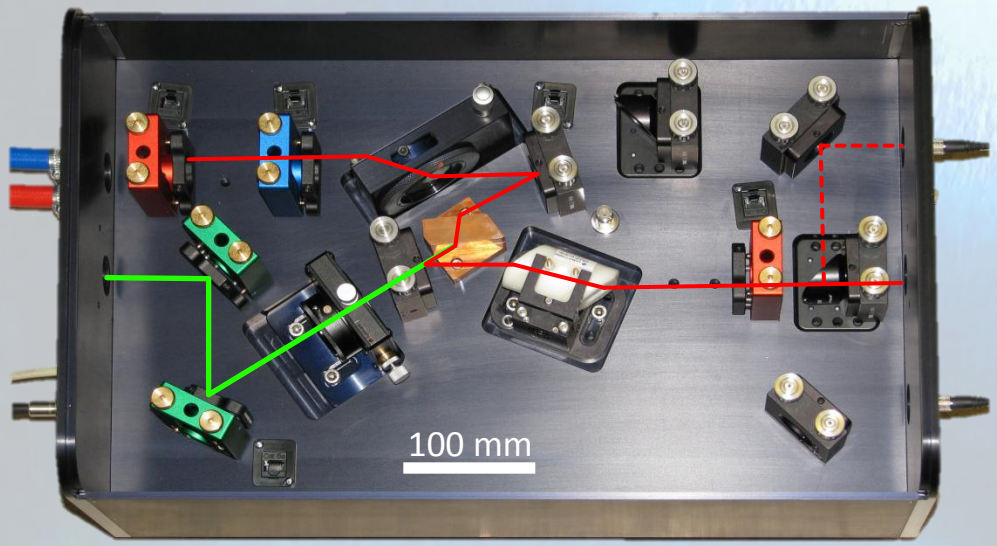
- Machined at Mainz University workshop

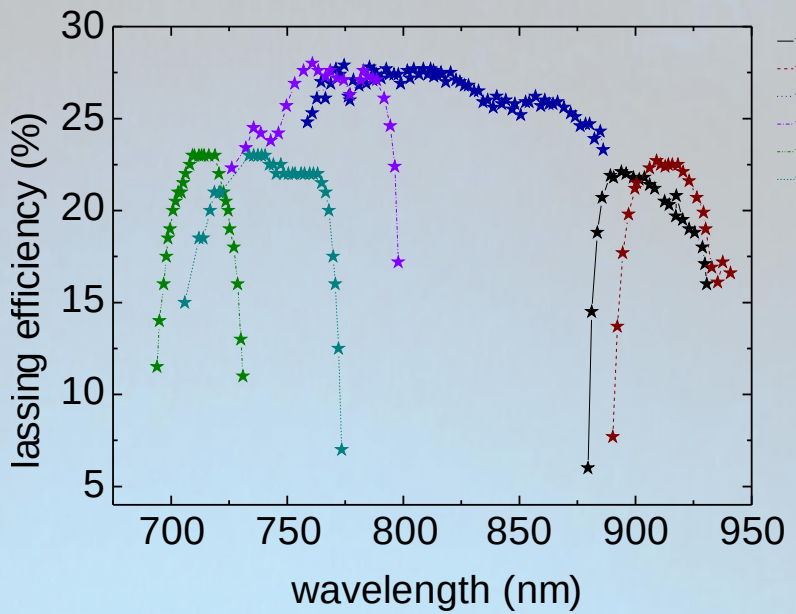
Serial production

- 3 Ti:Sa modules available

The RILIS Ti:Sa lasers

Pump laser: Nd:YAG (532 nm)
Repetition rate: 10 kHz
Pulse length: 180 ns
Power: 60 W





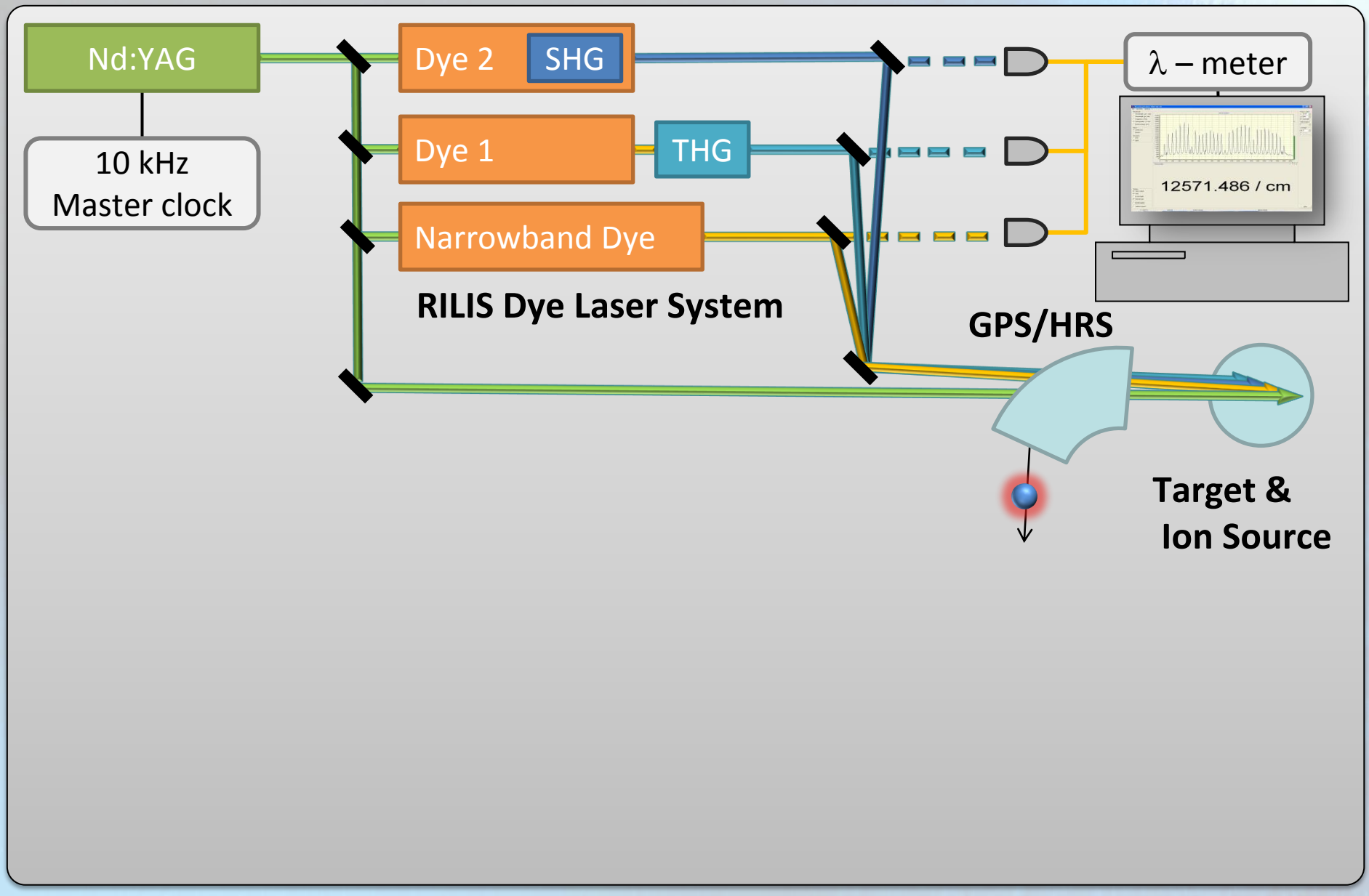
Ti:Sa lasers:
Line width: 5 GHz
Pulse length: 30-50 ns

Wavelength tuning range:

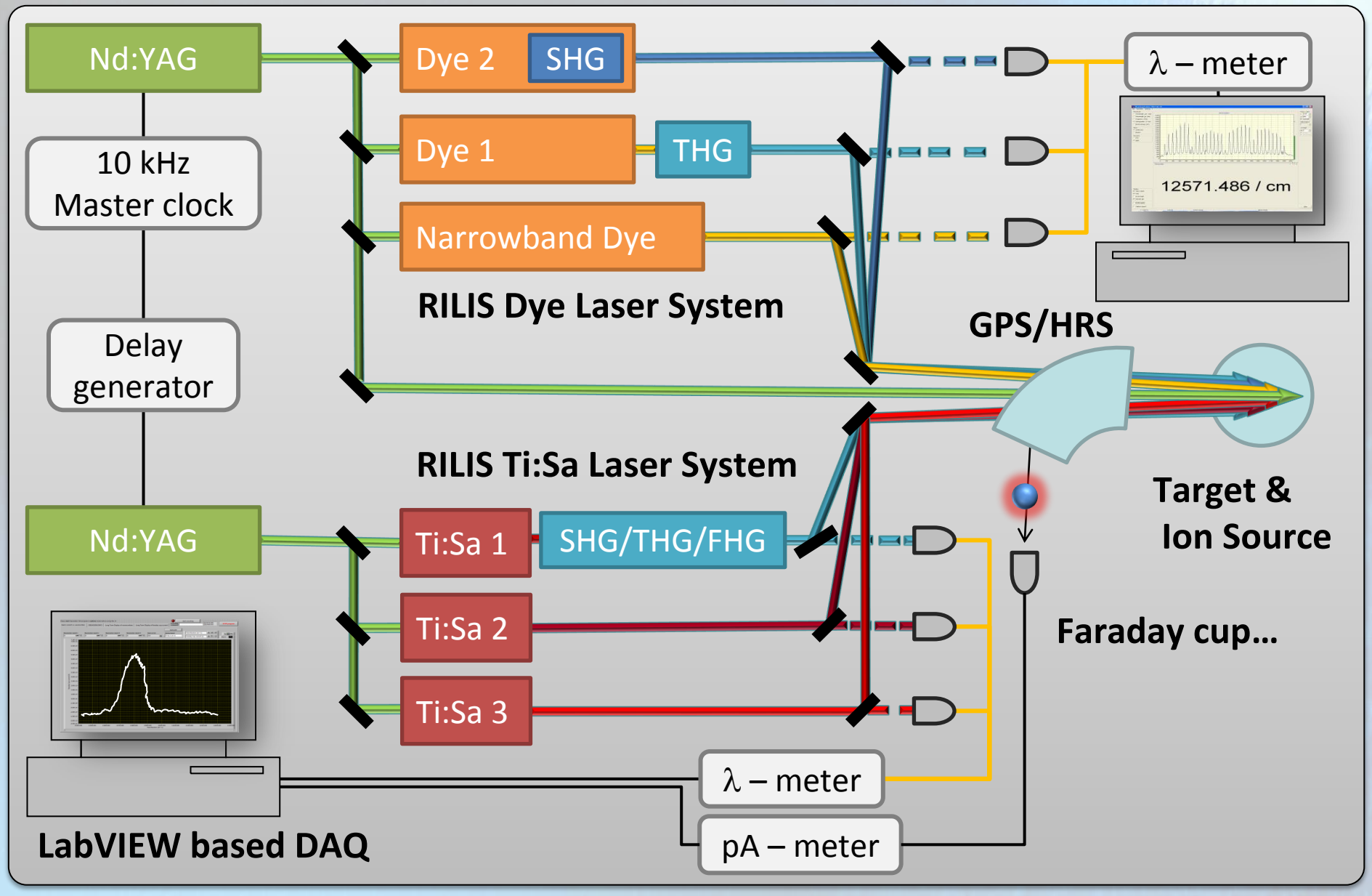
- Fundamental (ω) **690 - 940** nm (5 W)
- 2nd harmonic (2ω) **345 - 470** nm (1 W)
- 3rd harmonic (3ω) **230 - 310** nm (150 mW)
- 4th harmonic (2w) **205-235** nm (50 mW)

6 resonator mirrorsets cover the Ti:Sa range

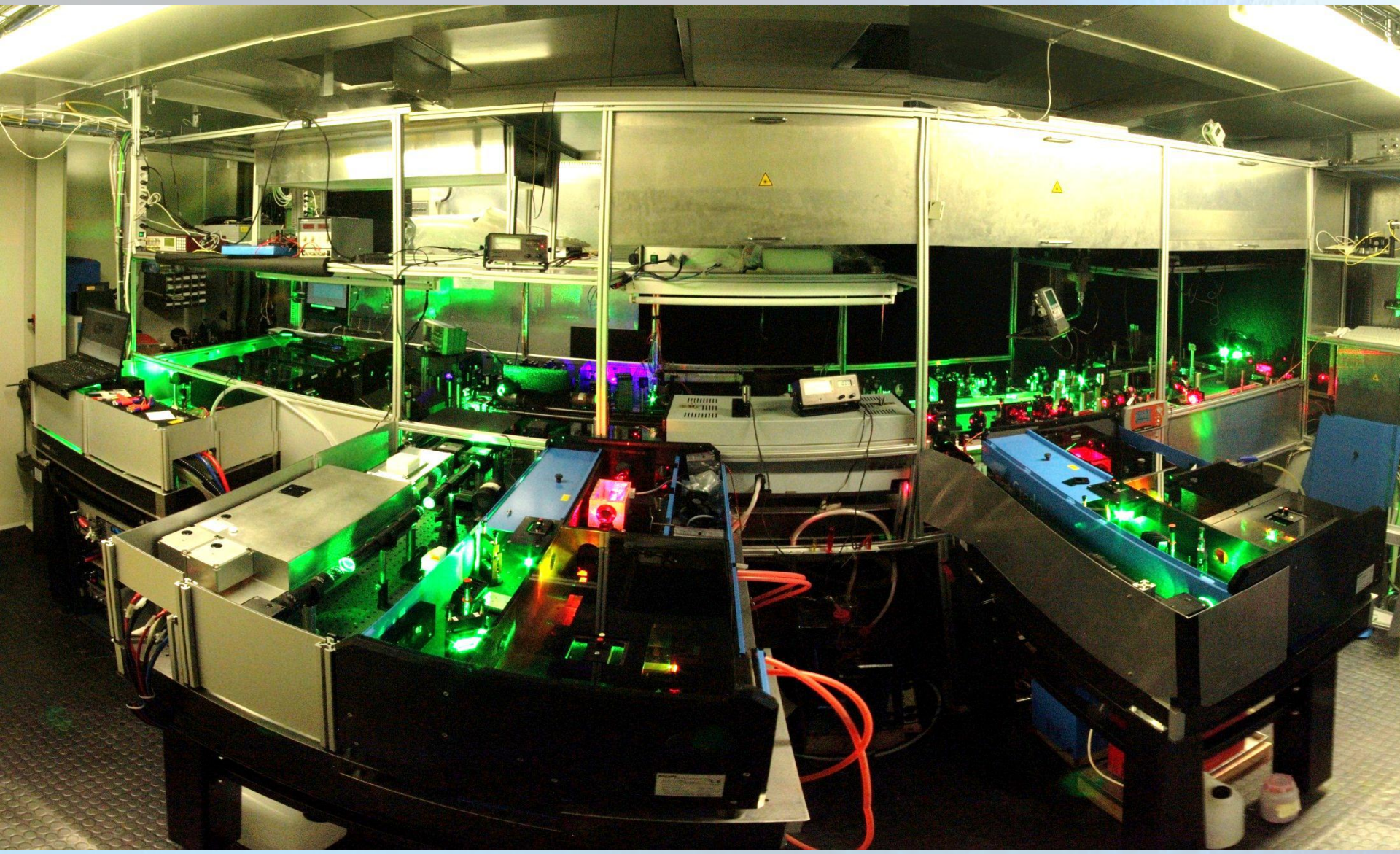
Dye RILIS


Nd:YAG
10 kHz
Master clock
Dye 2
SHG
Dye 1
THG
Narrowband Dye
RILIS Dye Laser System
λ – meter
12571.486 / cm
GPS/HRS
Target &
Ion Source

Ti:Sa & Dye RILIS

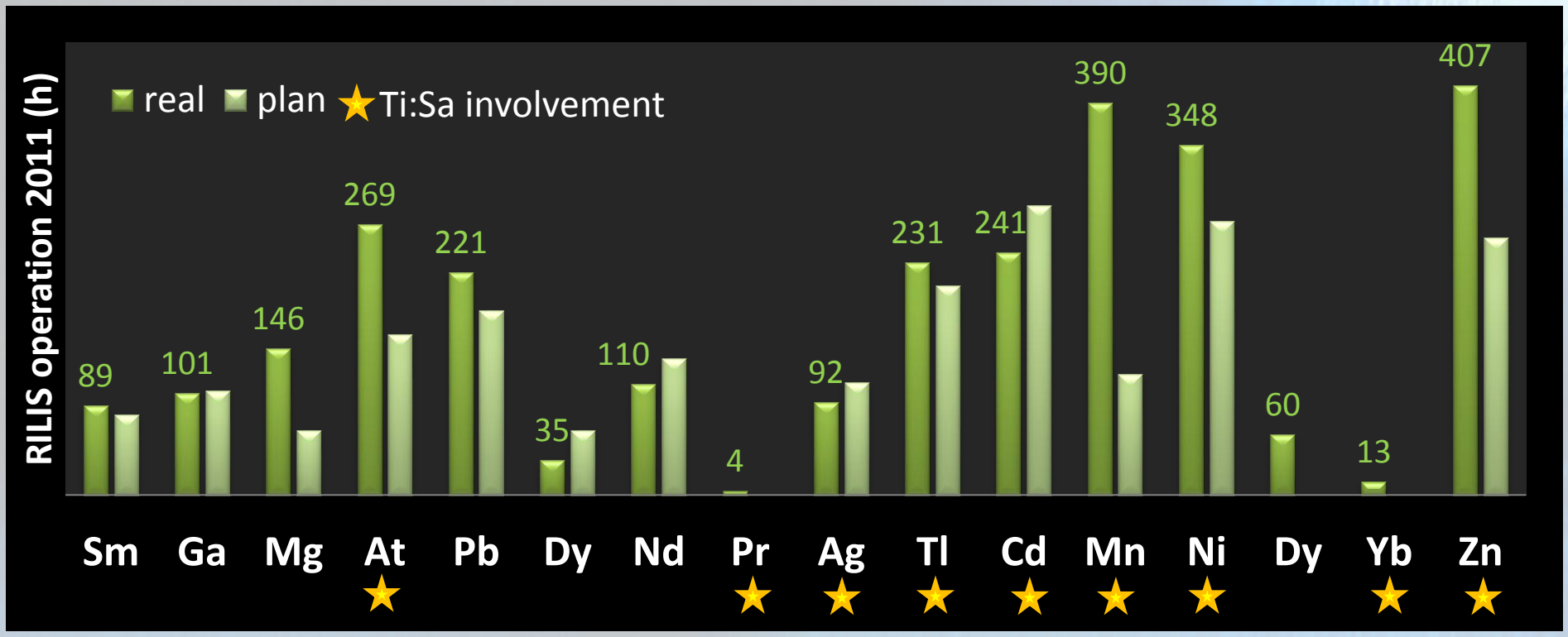


RILIS in operation



RILIS in operation

RILIS operation 2011



Ion beams of 16 elements were produced since beginning of the running period:

- **2573 h for on-line experiments**
- Ti:Sa system used already with 9 elements
- Some additional tests only feasible because of the ‘spare’ laser system

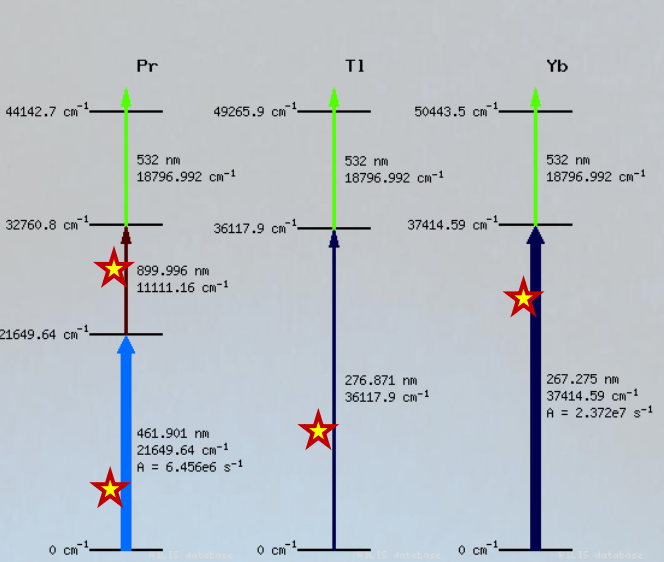
New modes of operation – The Dual RILIS

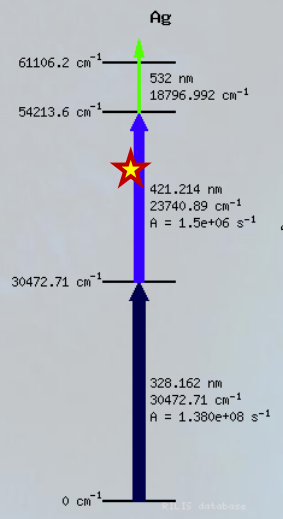
Condition for dual operation: **Temporal synchronization** of the two laser systems

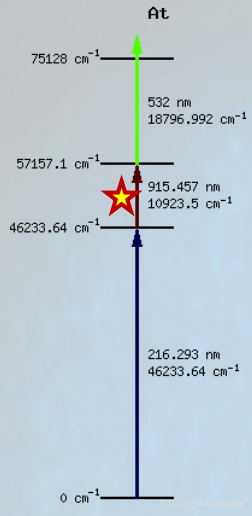
Ti:Sa only mode
100 W Nd:YAG laser available for non-resonant ionization

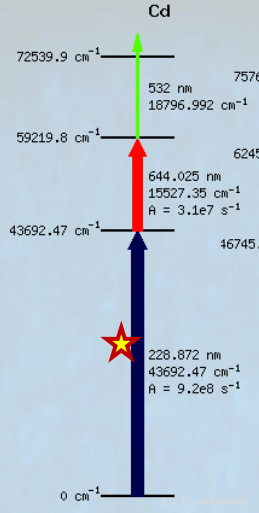
Mixed mode
Combination of dye and Ti:Sa

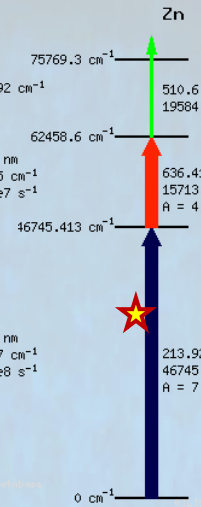
Backup mode
dye and Ti:Sa are exchangeable

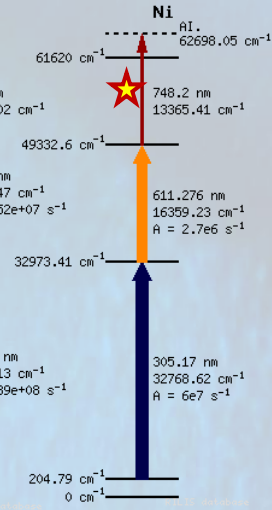










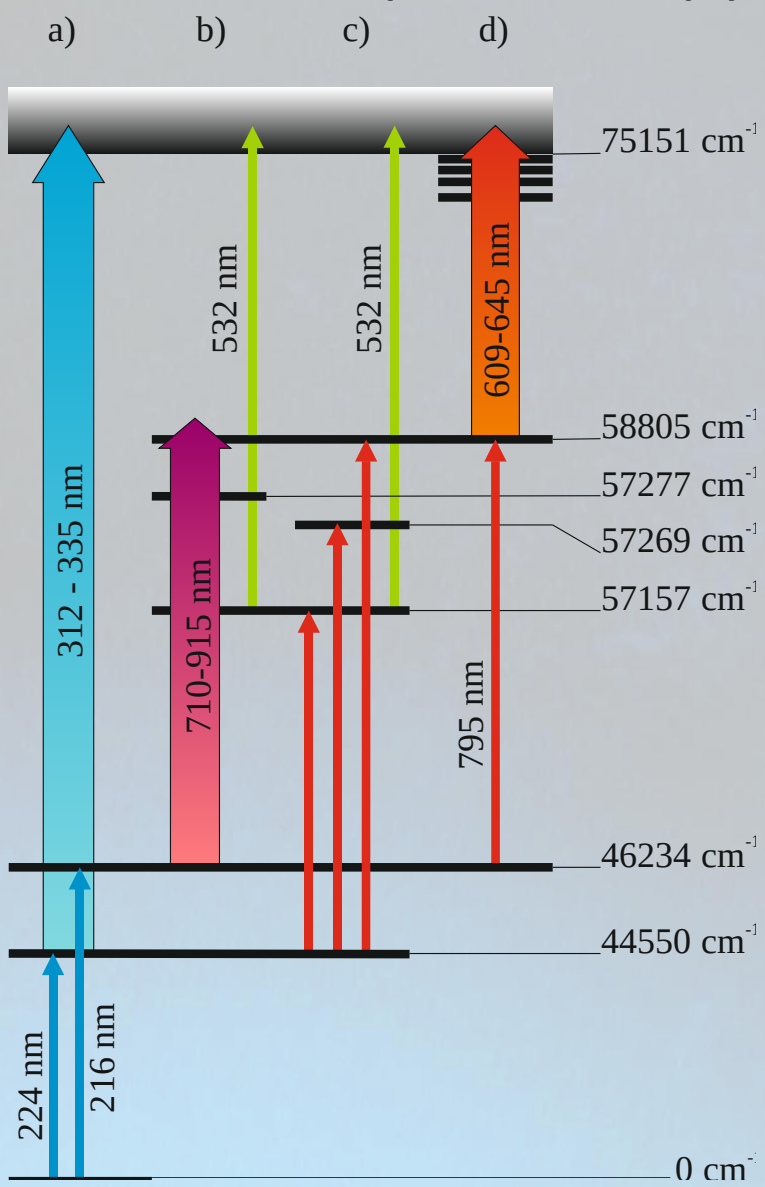


Highest efficiencies

New RILIS elements

Reduction in down time

At in-source spectroscopy

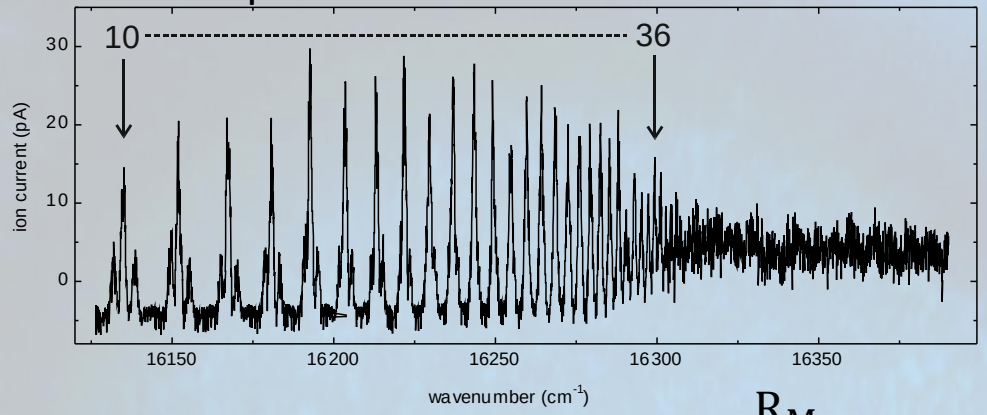


a) Photoionization threshold : 75129(95) cm^{-1}

b) Scan for 2nd step transitions (at TRIUMF)

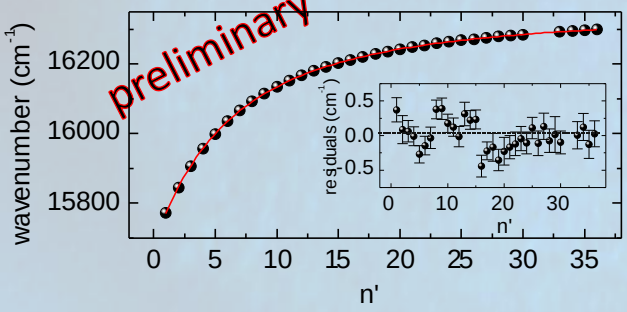
c) Verification of levels, yield measurements

d) Scan of ionizing laser: converging Rydberg levels allow precise determination of the IP



Rydberg-Ritz formula

$$E_n = E_{IP} - \frac{R_M}{\left(n - A + \frac{B}{(n-A)^2}\right)^2}$$



E_{IP}(At) = 75151(1) cm^{-1} preliminary

Phys. Rev. Letter in preparation

Summary

- A complementary second laser system of Ti:Sa lasers was installed at RILIS
- RILIS operated smoothly >2500 h in 2011
- Dual RILIS (Combined dye and Ti:sapphire laser system) is in regular operation
- In-source laser spectroscopy of Astatine led to development of an efficient ionization scheme and first and precise determination of the ionization potential

Outlook / Comments

- RILIS scheme development could become partly opportunistic (e.g. astatine)
- Machine protection, monitoring and remote control progressing
- For Ti:Sa-only schemes RILIS could operate in *on-call* mode very soon
- RILIS scheme database (cern.ch/riliselements) in beta phase

Acknowledgements

RILIS - Team

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