ISOLDE RILIS: upgrade and development report

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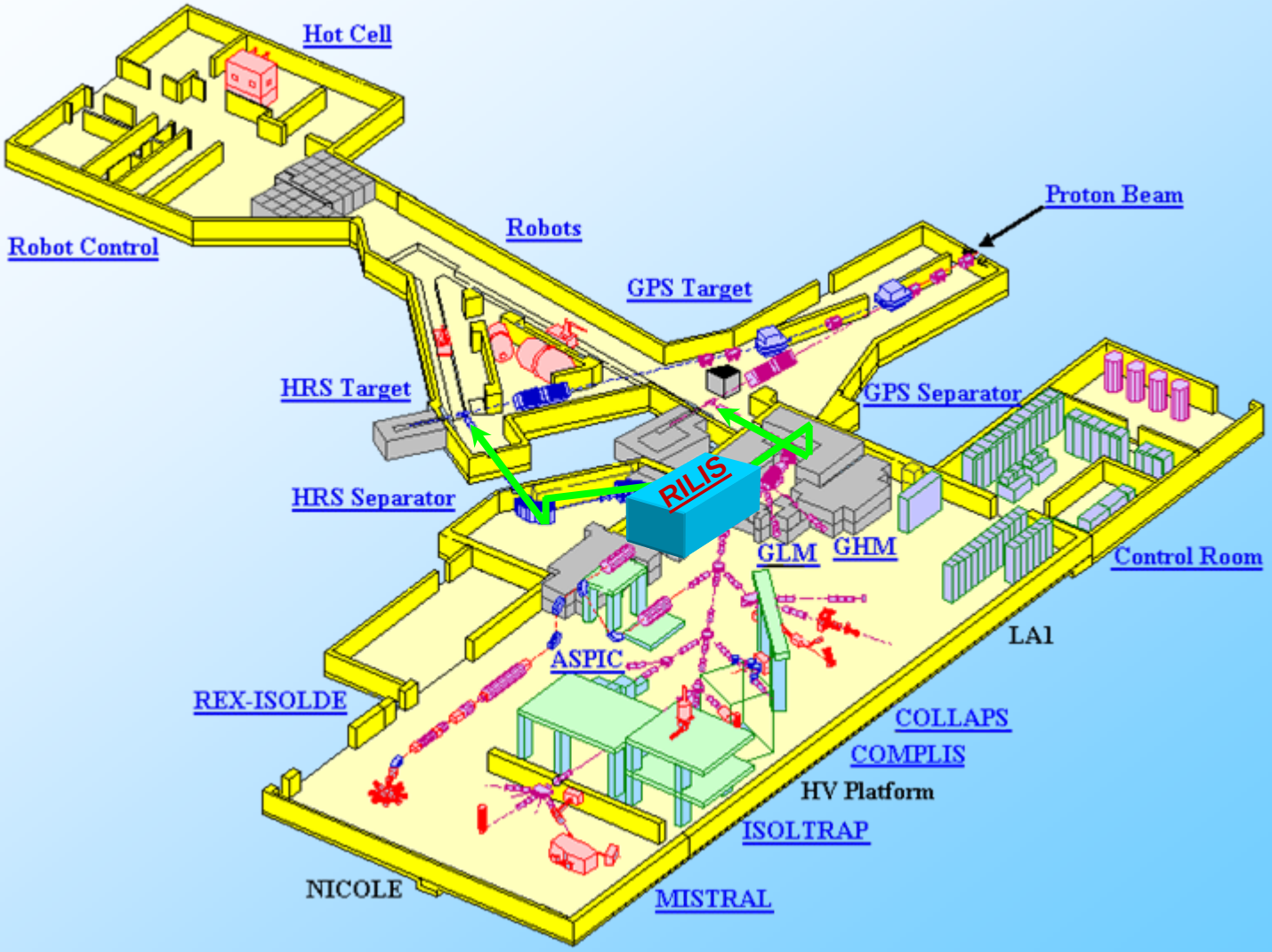
RILIS at ISOLDE Facility



RILIS ion beams

Ion beams of 29 elements are produced at RILIS

elements available at ISOLDE LIS

ionization scheme tested

ionization scheme untested

1 H																2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Ha	106 Sg	107 Ns	108 Hs	109 Mt	110	111	112						

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

- RILIS web page: http://isolde-project-rilis.web.cern.ch/isolde-project-rilis/intro/principle.html

Upgrade of RILIS laser system

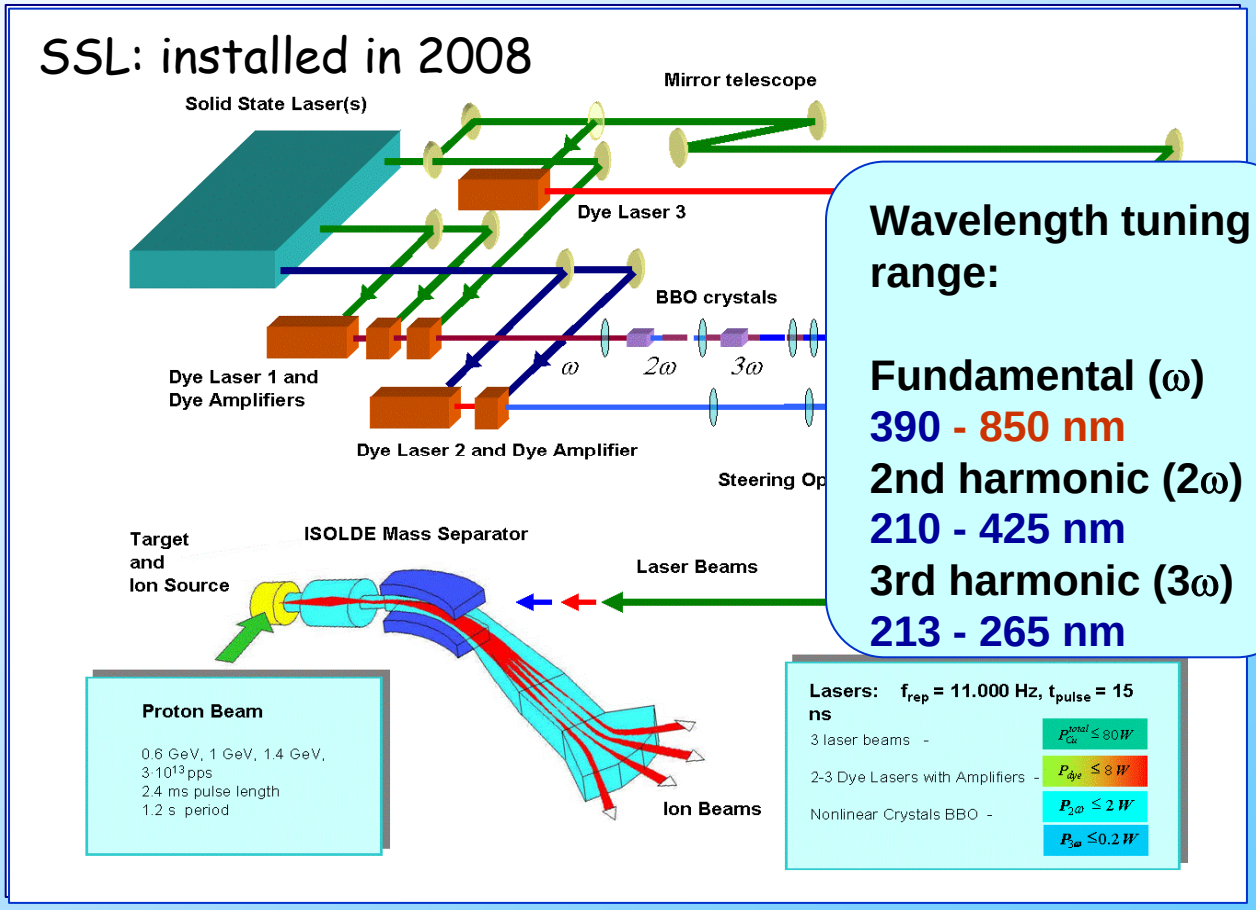
Replacement of CVL by SSL

Advantages:

- Better beam quality
- Stability of operation
- Spectral coverage UV-NIR without gaps

Complications:

- New ionization schemes are needed (Mn, Au)
- Service by manufacturer only



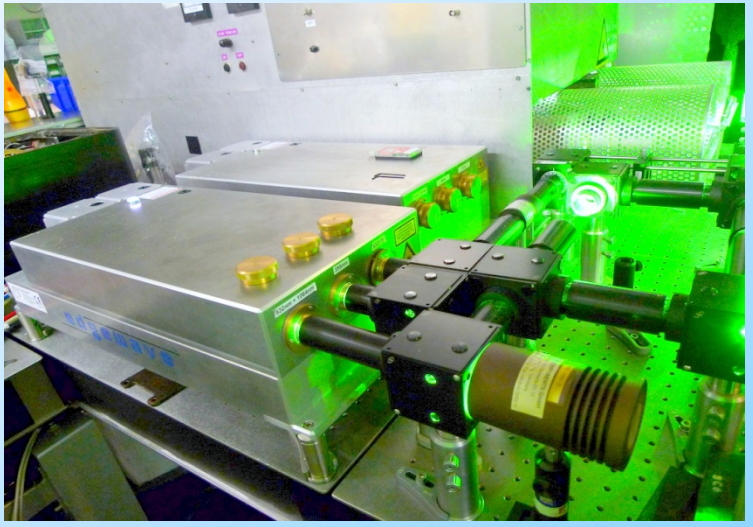
Wavelength tuning range:

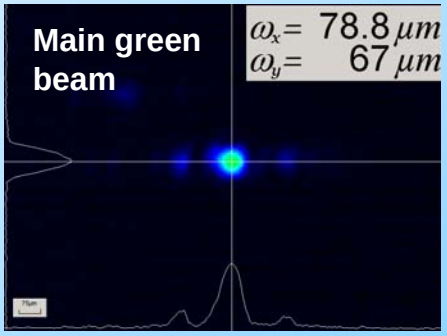
Fundamental (ω)
390 - 850 nm
2nd harmonic (2ω)
210 - 425 nm
3rd harmonic (3ω)
213 - 265 nm

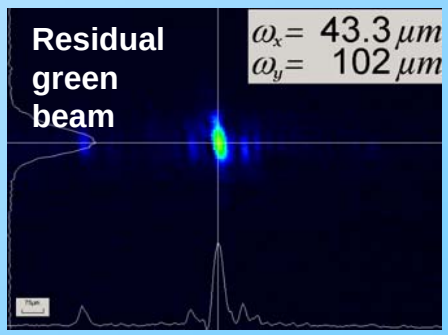
New Nd:YAG lasers at ISOLDE RILIS

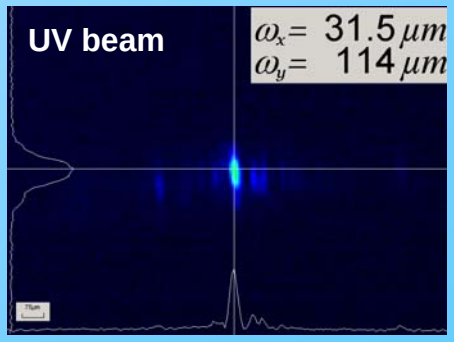
Copper Vapor Lasers are replaced by Diode Pumped Solid State Nd:YAG Lasers

- Two lasers are available:
- one in use, second as a backup









Laser generates 3 beams at 10 kHz:

- Main green beam – 532nm, 70-80 W, 8 ns
- Residual green beam – 532 nm, 12-28 W, 9 ns
- UV beam - 355 nm, 18-20 W, 11 ns

SSL implementation in RILIS room

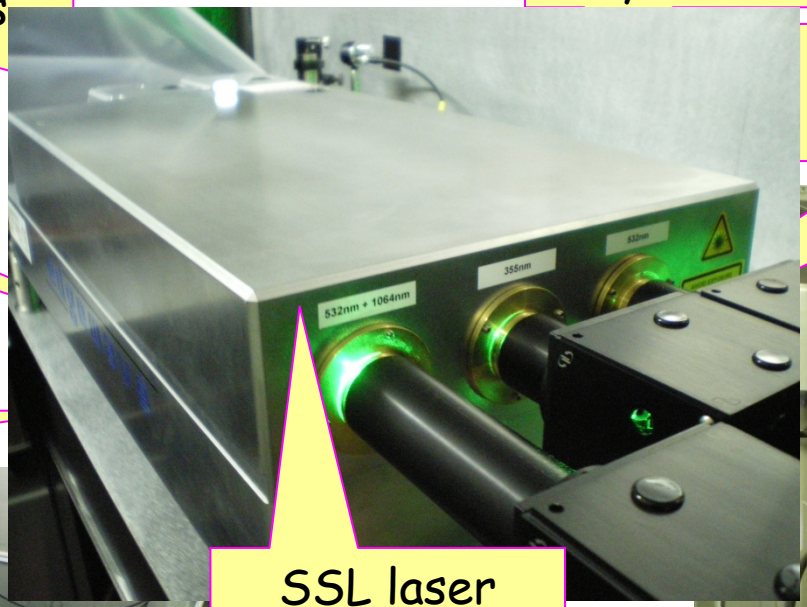
CVL amplifiers

Dye lasers

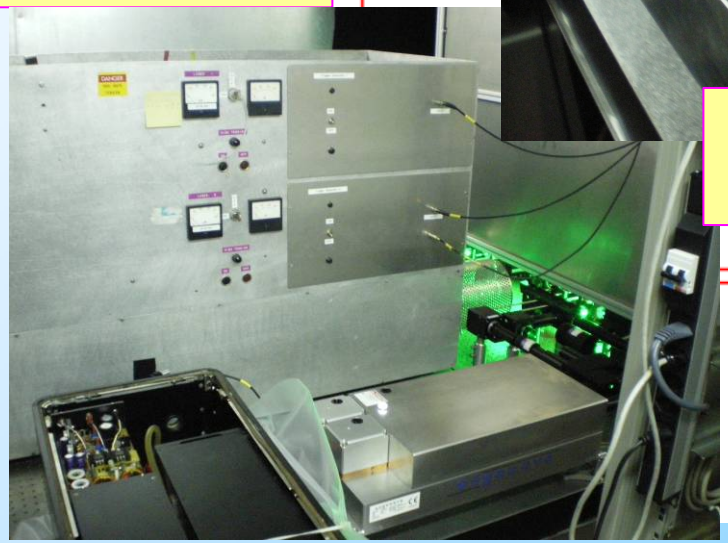
CVL oscillator

SSL power supply and chiller

CVL power supply



SSL laser systems



SSL use: enhancements and current limitations

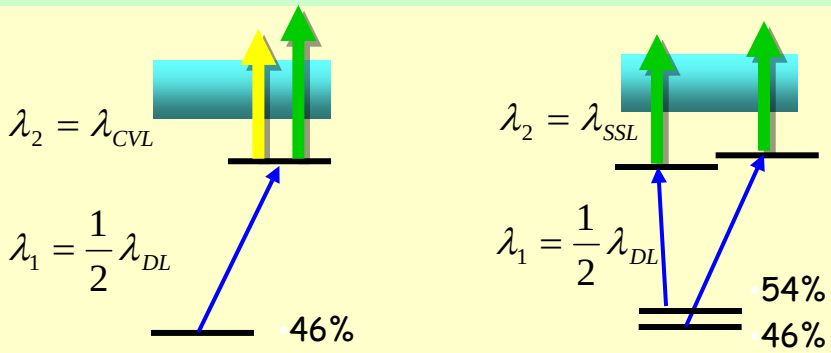
elements available at ISOLDE LIS

ionization scheme tested

1 H																	2 He
3 Li	4 Be																10 Ne
11 Na	12 Mg																18 Ar
19 K	20 Ca	21 Sc															36 Kr
37 Rb	38 Sr	39 Y															54 Xe
55 Cs	56 Ba	57 La															86 Rn
87 Fr	88 Ra	89 Ac															
		58 Ce															
		90 Th															

- Good example: **Gallium**
- (used in 2008 and *2009* for COLLAPS)

- Two dye lasers were applied at 1st step of excitation - >2x improvement
- More power could be delivered to HRS target at the 2nd step of excitation



- + More gre
- Most sche
- Some scher
-
-

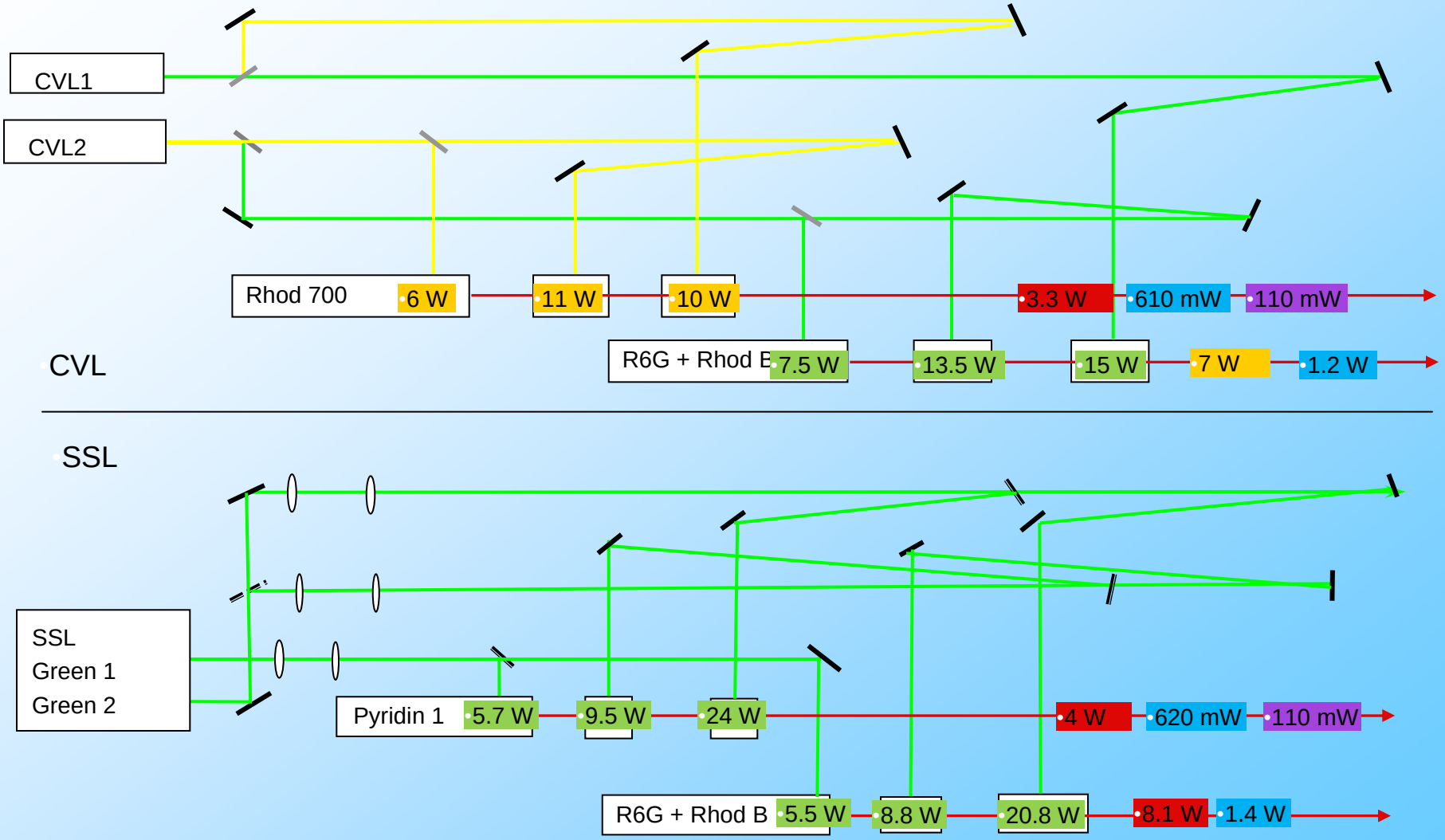
11 or 578 nm

wer

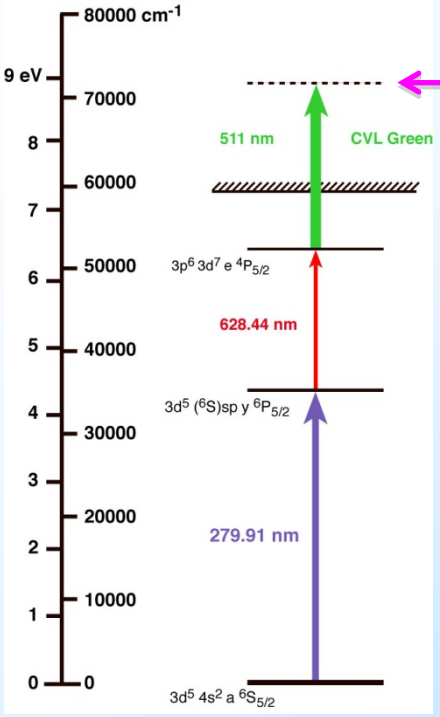
(Mn)

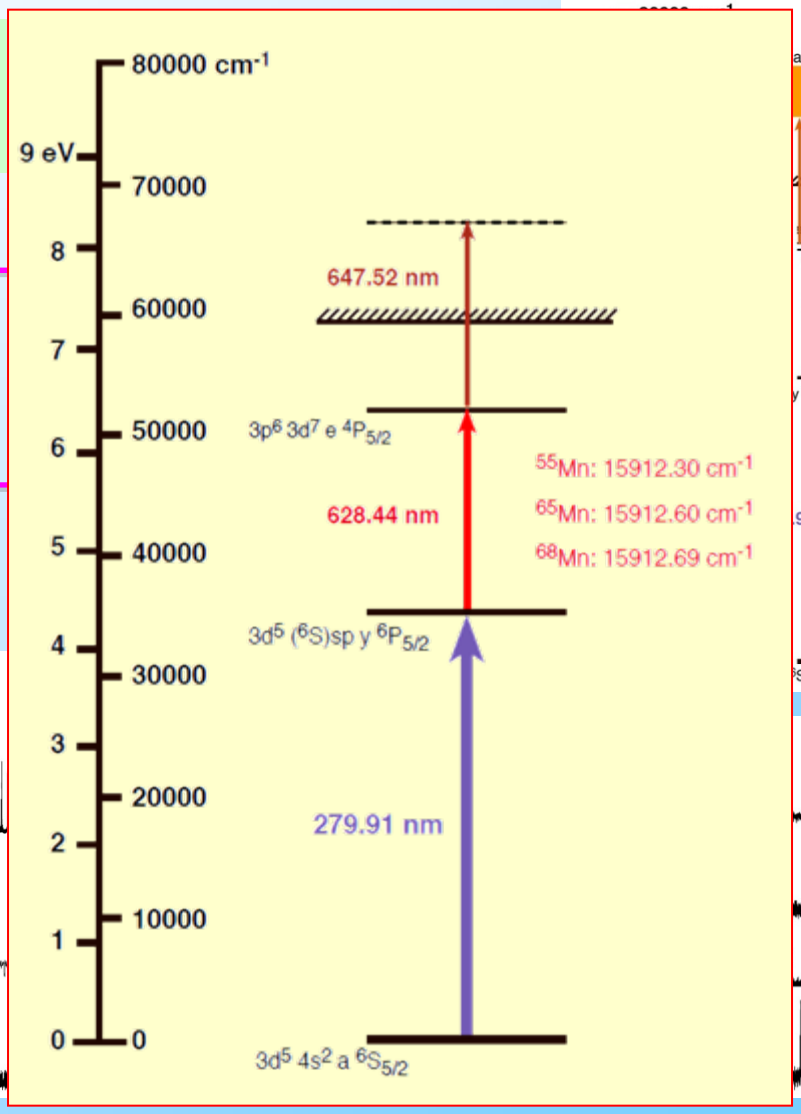
- Need for a < 540 nm fundamental wavelength.

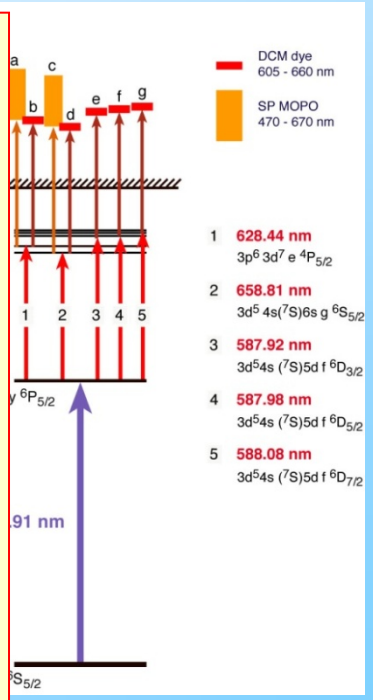
New beam set-up for Be ionization

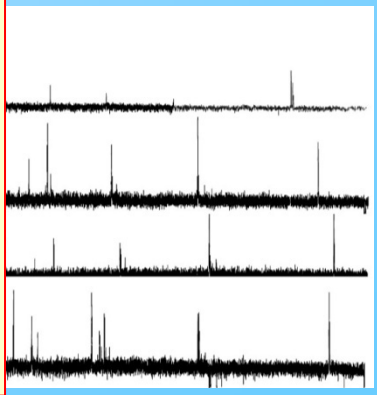


A new RILIS scheme for manganese - LARIS result









Outcome of RIS study of Mn at LARIS:

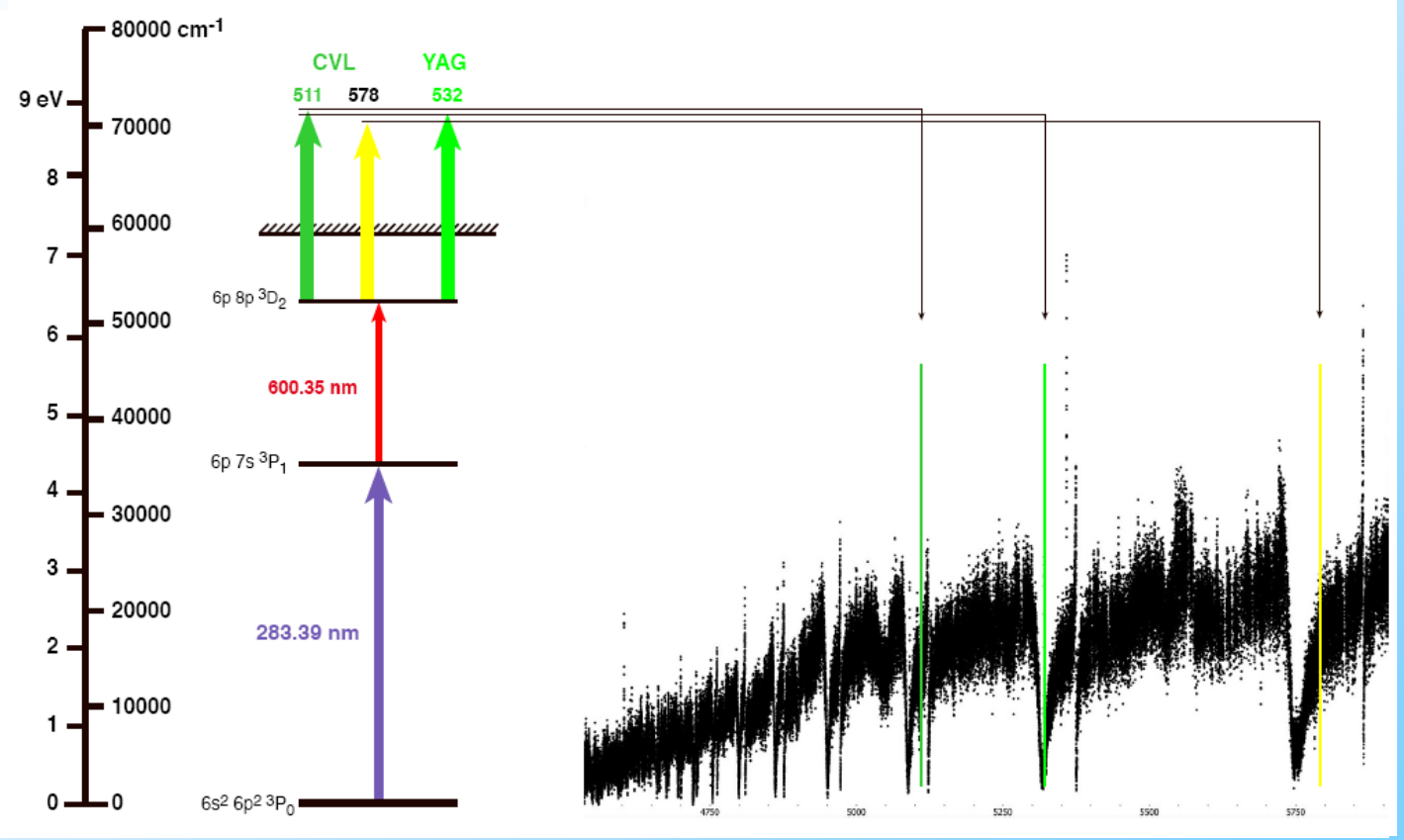
Many new auto-ionizing states found

Various promising Nd:YAG based schemes tested

New scheme applied at RILIS
Efficiency > 8 %

LARIS result – Pb scheme test

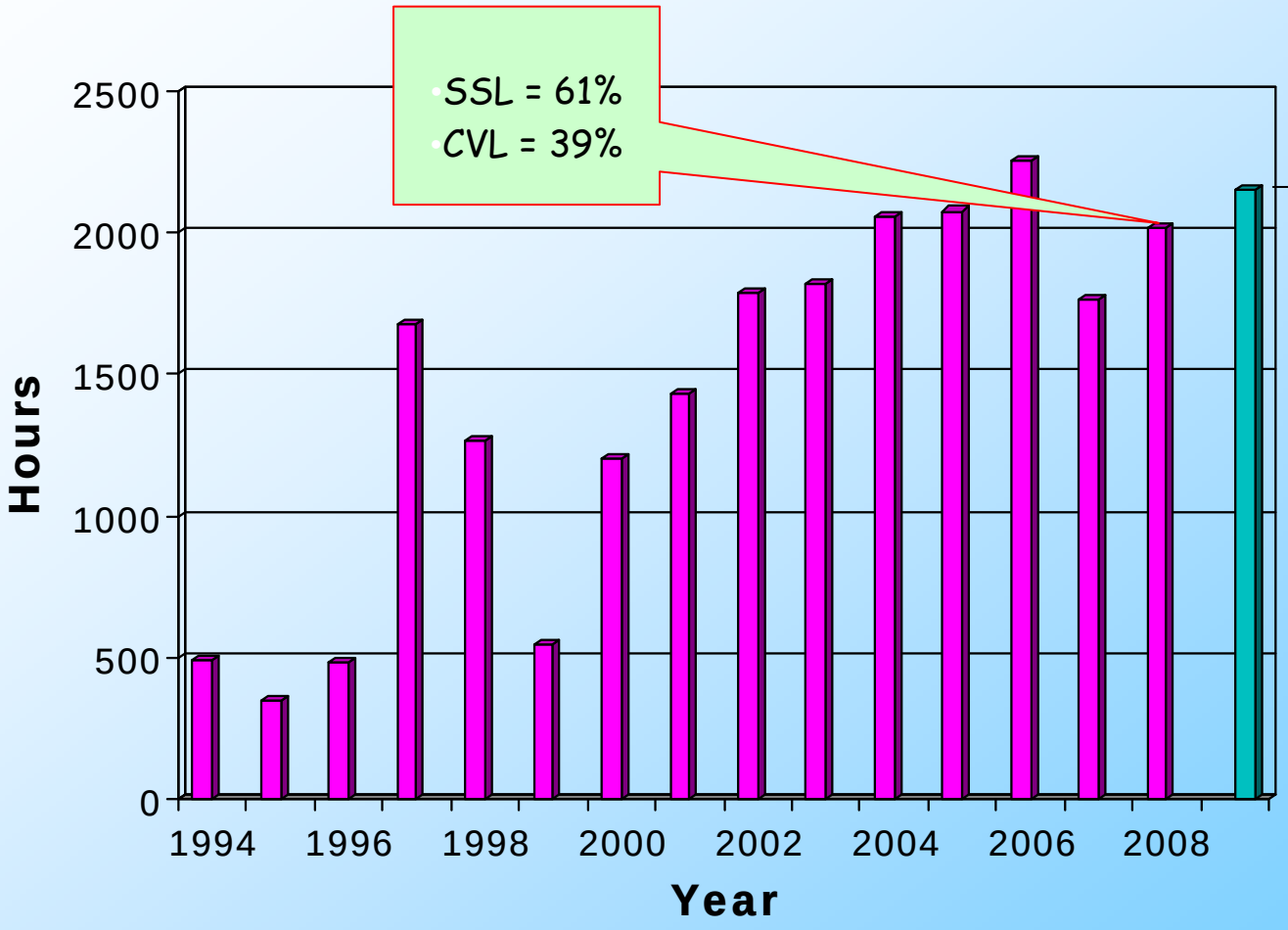
- Check performance of 532 nm final step compared to CVL beams



- For the current RILIS scheme, the 532 nm YAG wavelength falls in the trough of a Rydberg/continuum interference (Fano) profile.
- The 511 nm and 578 nm CVL wavelengths are more efficient.

- An alternative RILIS second step gives access to a flat continuum region with the 532 nm YAG beam.

RILIS operation in 1994-2009



Laser ON time in 2009:

- 2148 h - total
- 1992 h - on-line

In 2009 Nd:YAG lasers have been used for ALL 14 RILIS runs

Be, Ga, Ag, Nd, Po, Mn, Mg,
Po, Sn, Mg, Mn, Be, Zn, Ni

Comparison of isotope yields

Element	Isotope	Measured with CVL	Measured with Nd:YAG	Ratio YAG/CVL
Be	7	1.40E+10	4.00E+10	2.9
	11	7.00E+06	2.00E+07	2.9
Mg	29	1.60E+06	5.00E+06	3.1
	32	3.00E+04	1.80E+05	6.0
Ni	65	7.00E+07	4.90E+07	0.7
	66	1.00E+08	7.08E+07	0.7
Cu	69	1.80E+08	3.50E+07	0.2
	75	1.50E+05	4.80E+04	0.3
Zn	77	8.00E+05	2.50E+05	0.3
	80	3.00E+04	1.00E+04	0.3
Ga	73	2.80E+08	2.00E+09	7.1
	83	4.50E+03	6.50E+04	14.4
Mn	61	3.50E+06	4.30E+06	1.2
	63	1.00E+05	9.00E+04	0.9
Pb	188	1.70E+06	1.30E+06	0.8
	192	4.00E+07	4.00E+07	1.0
Po	202	1.70E+07	8.00E+07	4.7

Extracted from ISOLDE e-logbooks

Closer to hardware limits

- Damage of non-linear crystals:

Third harmonics BBO damaged by UV

- 213 nm, λ1 for Zn,
- 70 mW

- Degradation of laser dyes:

Lifetime of Styryl 9 < 8 hours

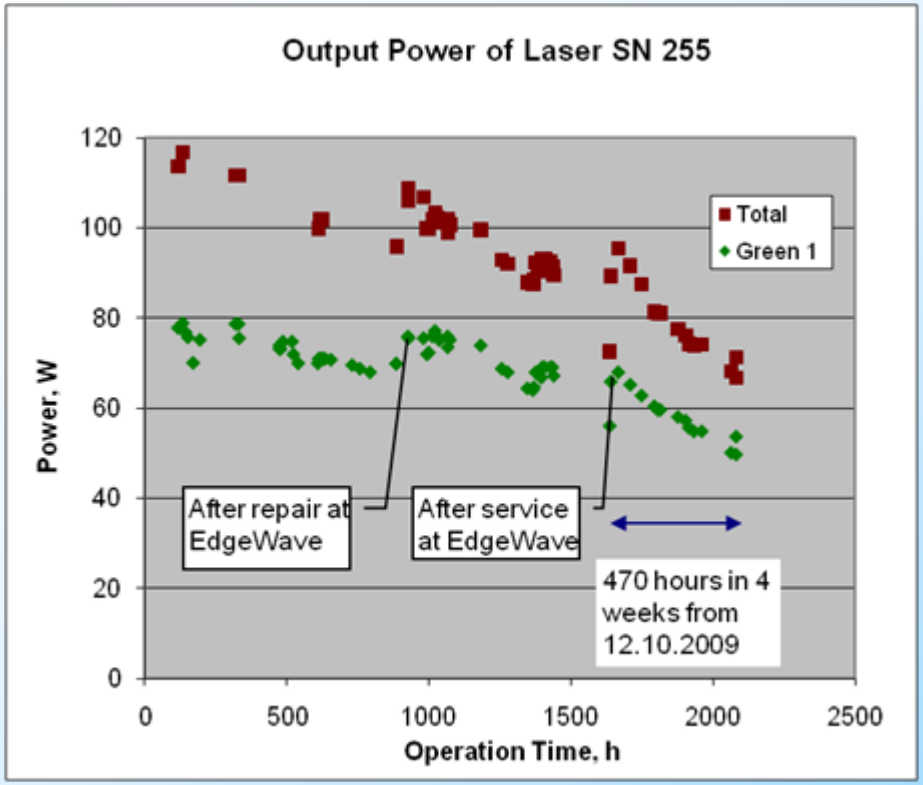
- 823 nm, λ3 for Sn,
- 5 W from 22W pump

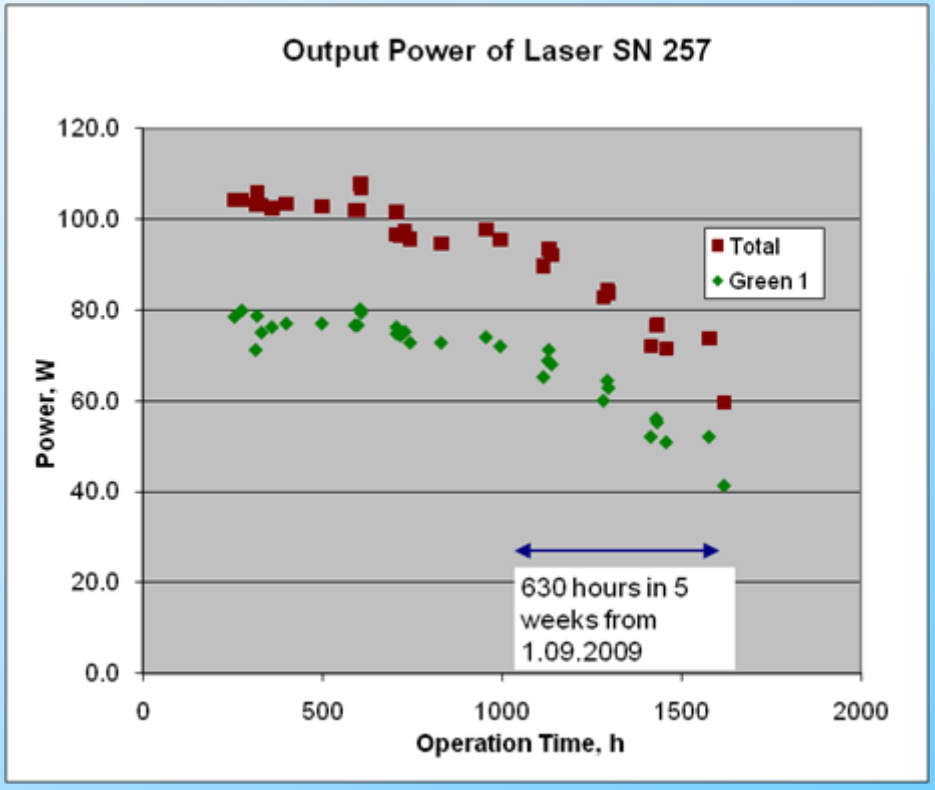
Bigger quantities of dye solutions are needed for RILIS runs with new pump lasers

Dye laser power had to be reduced to avoid crystal damage

Long-term laser power drift

In September – November lasers were running > 70% of time





The reason of power reduction is under investigation:

- Cooling efficiency dropped ?
- Optics contamination or damage ?
- Ageing of pumping diodes ?

RILIS after CVL-YAG transition

- More laser power -> higher ionization efficiency
- High stability of SSL power -> ion current stability much better
- Time from cold start of SSL to nominal operation ~ 30 min.
- No electromagnetic noise to experimental hall from RILIS
- New ionization scheme of Mn is developed
- CVLs can be removed from laser cabin

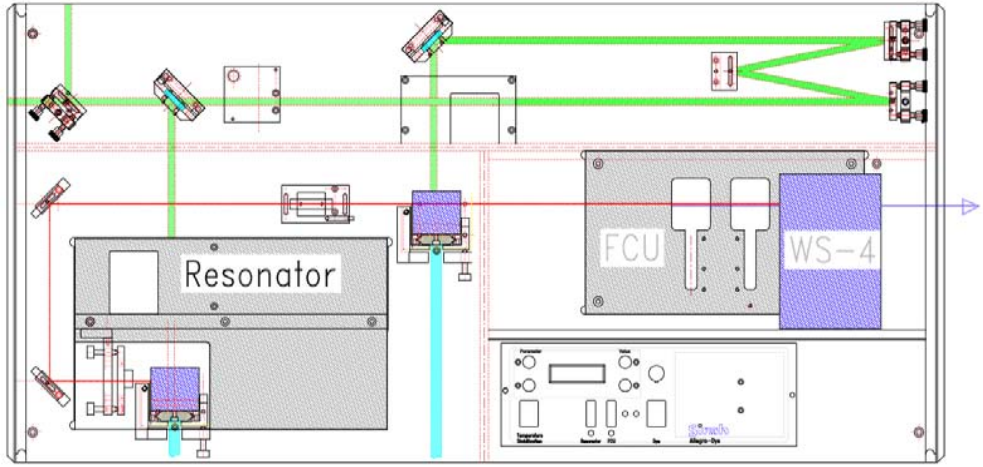
  - SSL alignment and repair is possible only at EdgeWave
  - UV power is limited by the optical resistance of harmonics crystals
  - Efficiency of dye lasers is reduced due to shorter pump pulse
  - Lifetime of dyes is reduced
  - Operation of dye lasers and harmonics generators still requires continuous supervision by laser specialists

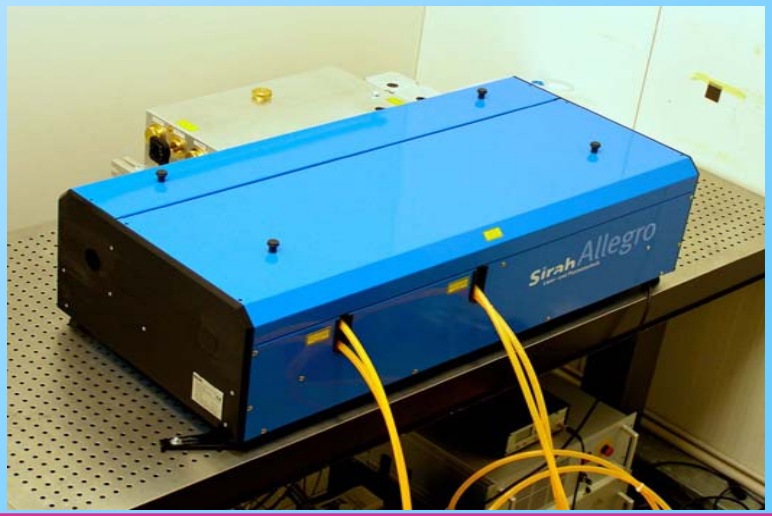
Next steps

- **Dye Laser Upgrade**
- **One narrow (1 GHz) and two broadband (15 GHz) lasers are ordered**

- Improve beam quality, especially for UV beams
- Increase harmonic generation efficiency
- Improve UV pumping performance

Allegro (made by Sirah GmbH) dye laser with amplifier and frequency doubling unit pumped by EdgeWave laser running at 10kHz





Next steps

- **Nd:YAG pumped Ti:Sa system**
- **An additional independent fully solid state RILIS laser system**

- Reduction of the reliance on laser dyes.
- Better coverage of the IR and blue spectral ranges
- Dual RILIS system could enable simultaneous RILIS setup and operation.

- **Pump laser:** **2 X commercial PI Nd:YAG, 532 nm, 60 W at 10 kHz**
- **Tunable lasers:** **3 single sided UMz Ti:Sapphire lasers**
- **- frequency doubling, tripling and quadrupling**
- **- computerized temporal and spectral control, 3 GHz, 30 ns**
- **- specs: 3 - 5 W @ 690-980 nm, 1 W @ 350-470, 150 mW @ 200 – 315 nm**

Construction and purchasing of elements is started
(Sebastian Rothe, PhD student in Mainz Uni and CERN)

Space presently occupied by CVLs will be available for Ti:Sa system

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