RILIS upgrade and LARIS scientific priorities

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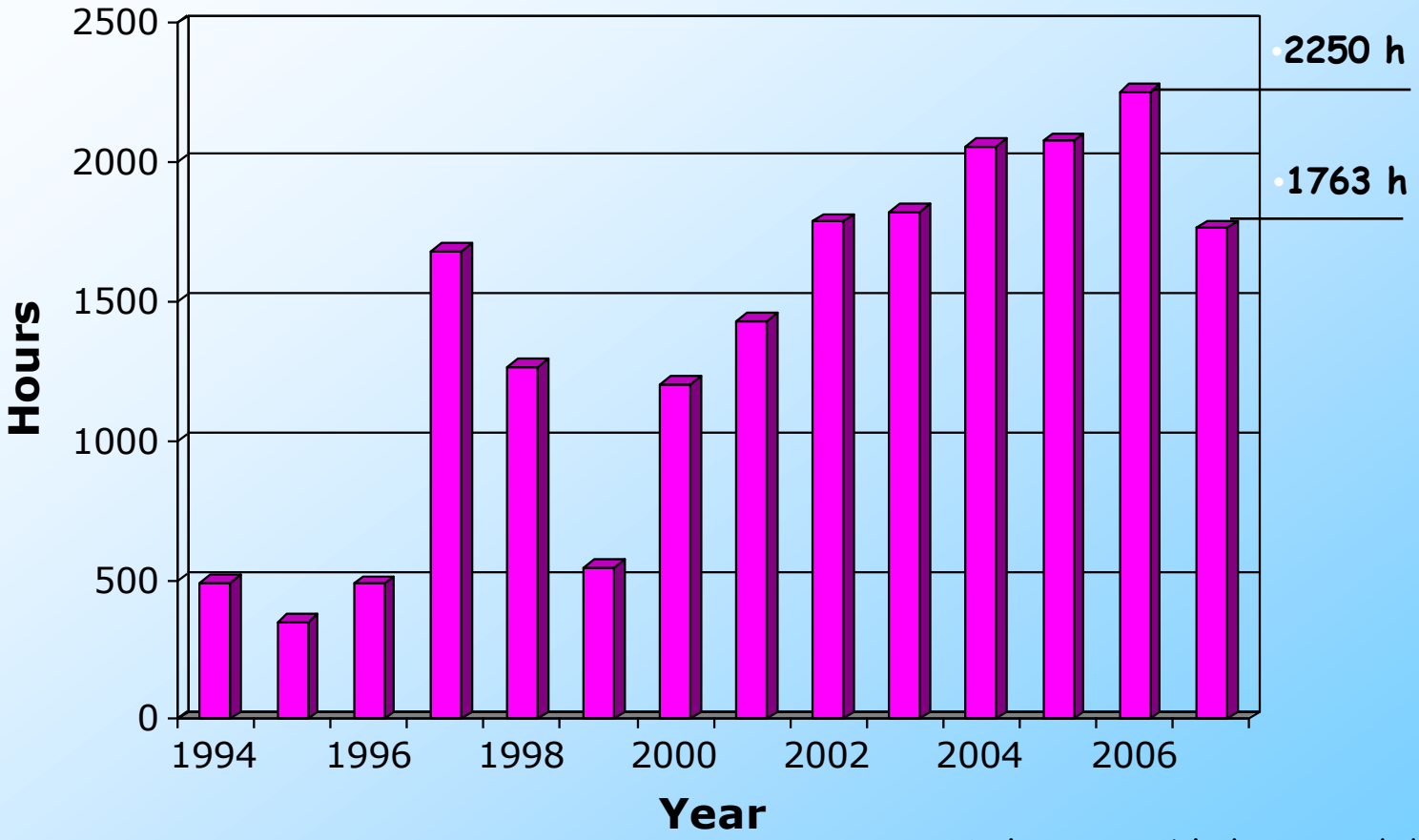
Report to the Standing Group for the Upgrade of ISOLDE

13/11/2007

RILIS operation in 1994-2007



Reduction of planned RILIS operation time for 2007 down to 1500 hours has been was recommended in the conclusions of the 2007 ATC/ABOC days.

No laser trouble happened during scheduled operation, all required service and repair work was performed between runs

Upgrade of RILIS laser system

Stage 1: New pump lasers

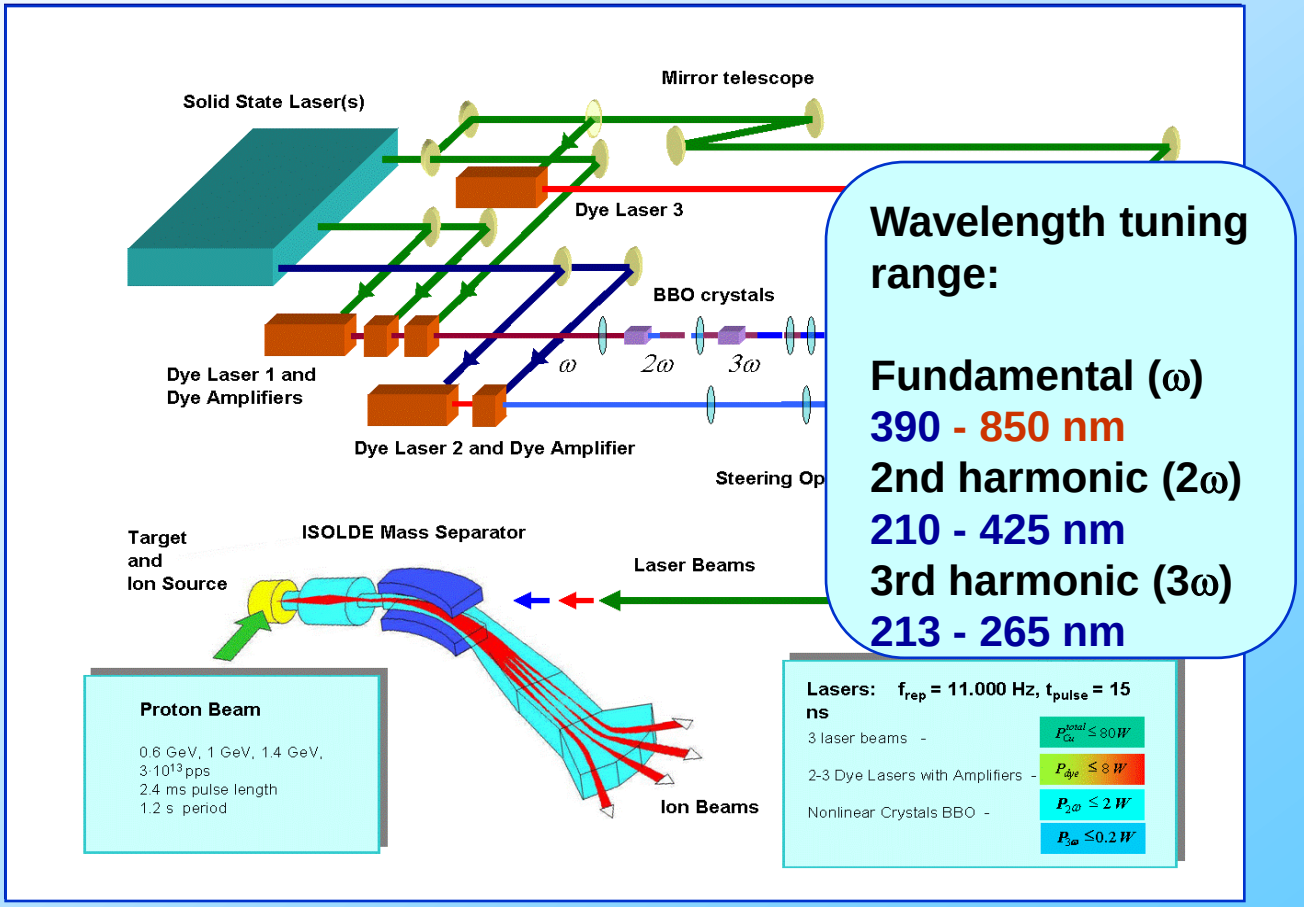
Replacement of CVL by SSL

Advantages:

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

Questions:

- New ionization schemes
- Reliability
- Service



Wavelength tuning range:

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

Installation in shutdown 2007-2008

Requirements to RILIS Solid State Lasers

	Beam A - 532 nm High quality beam for ionization	**Beam B – 532 nm** Medium quality beam for dye laser pumping	**Beam C – 355 nm** Medium quality beam for dye laser pumping
Pulse repetition rate	8-15 kHz	8-15 kHz	8-15 kHz
Pulse duration	10-30 ns	10-20 ns	10-20 ns
Output pulse timing jitter	< 3 ns	< 3 ns	< 3 ns
Average power	40 W	30-40 W	15-20 W
Power stability	+/- 5% over 24 hours	+/- 5% over 24 hours	+/- 5% over 24 hours
Beam divergence or M^2	< 0.1 mrad after expanding to 20 mm diameter	M^2 = 5-20	M^2 = 15-20
Beam pointing stability	< 0.02 mrad after expanding to 20 mm diameter		

Laser market survey

- Replacement of CVL system

Enquiries and contacts in 2003 – 2006:

1. **Coherent Inc.**
   USA
2. **Lambda Physik AG**
   Germany
3. **Spectra-Physics LAS GmbH**
   Germany
4. **Lightwave Electronics**
   USA
5. **Quantronix Corporation**
   USA
6. **Positive Light, Inc**
   USA
7. **Spectron Laser GmbH**
   Germany
8. **Groupe QUANTEL**
   France
9. **LEE LASER, Inc**
   USA
10. **THALES LASER S.A.**
    France
11. **Photonics Industries International**
    USA
12. **Powerlase Limited**
    UK
13. **EdgeWave GmbH**
    Germany
14. **General Atomics Photonics**
    USA

+ Contacts with other companies at Laser exhibitions at Munich (2003, 2005) and CLEO Conference

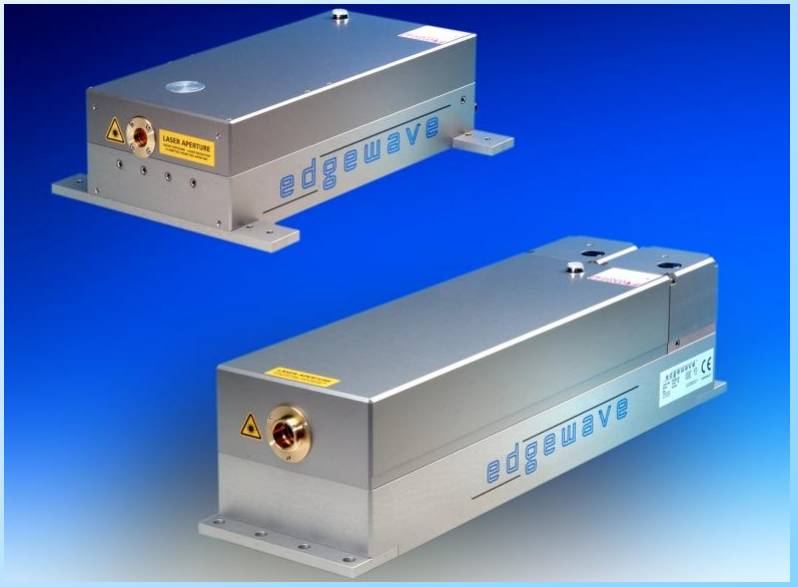
Lasers of EdgeWave GmbH, Germany

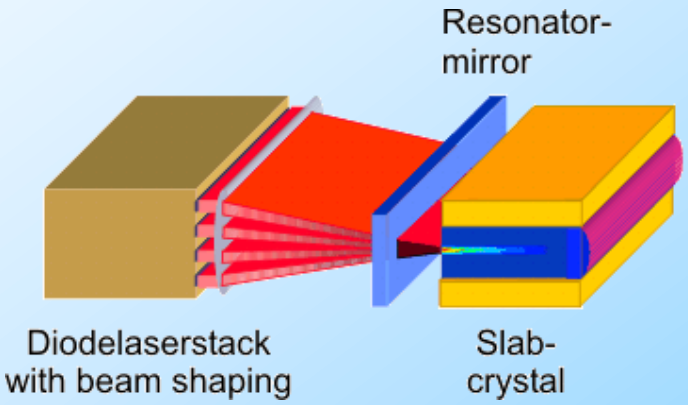
DIODE Pumped Nd:YAG, Nd:YLF and Nd:YVO_4 lasers

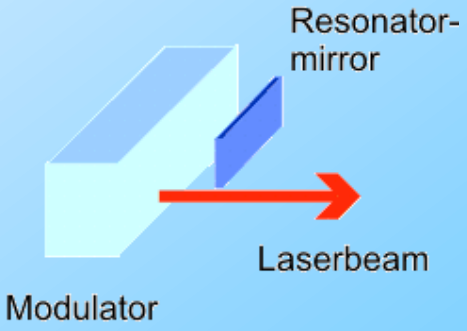
3 lasers:
2 x Green + 1 x UV

- **Short cavity : naturally shorter pulses**
- **Specifications more or less satisfied in previously supplied lasers**
- **Separate laser system**

- **Small, relatively new company**
- **Long term availability of parts/service?**



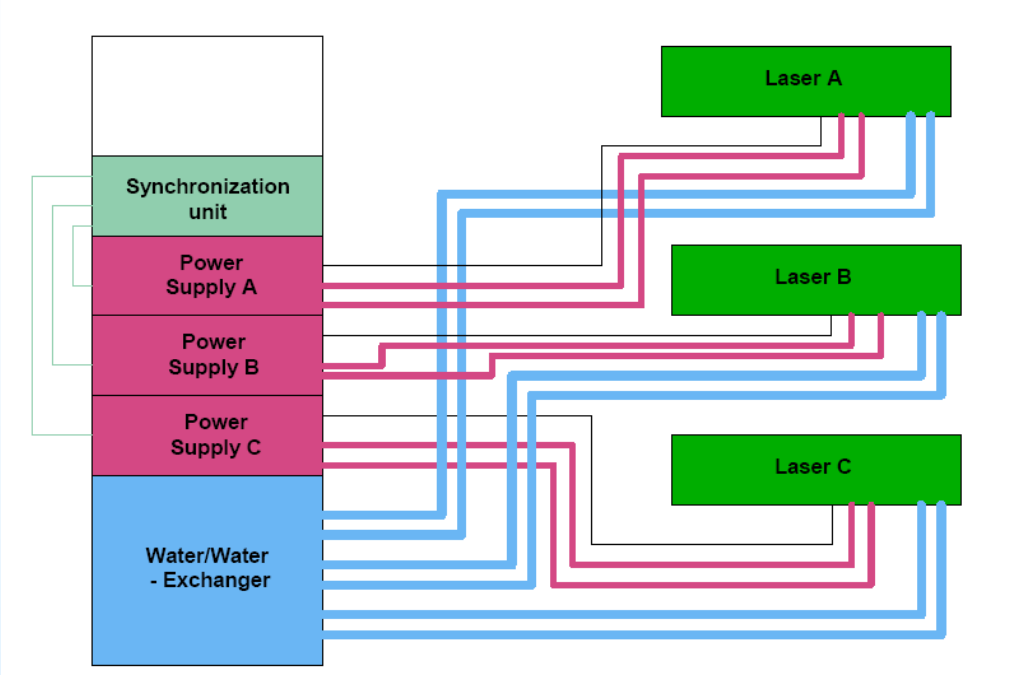




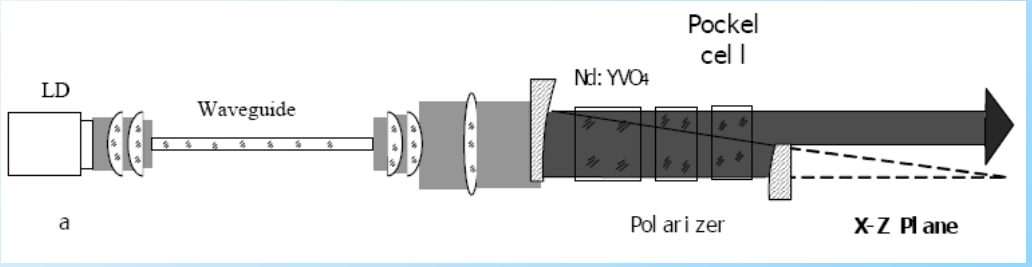
Nd:YLF, pulse length 10 ns at 10kHz, output average power 40W, M^2 = 1,7

Nd:YLF, pulse length 12 ns at 10kHz, output average power 20W, M^2 = 4,

SSL design proposal 1



	Beam A 532 nm	Beam B 532 nm	Beam C 355 nm
Pulse duration	9 ns	9 ns	10 ns
Jitter	< 3 ns	< 3 ns	< 3 ns
Average power	40 W at 10 kHz	40 W at 10 kHz	20 W at 10 kHz
Beam diameter	10 mm	10 mm	5 mm
Beam divergence	<0.2 mrad	0.2 mrad	0.3 mrad
Beam pointing stability	<0.04 mrad	<0.04 mrad	<0.06 mrad

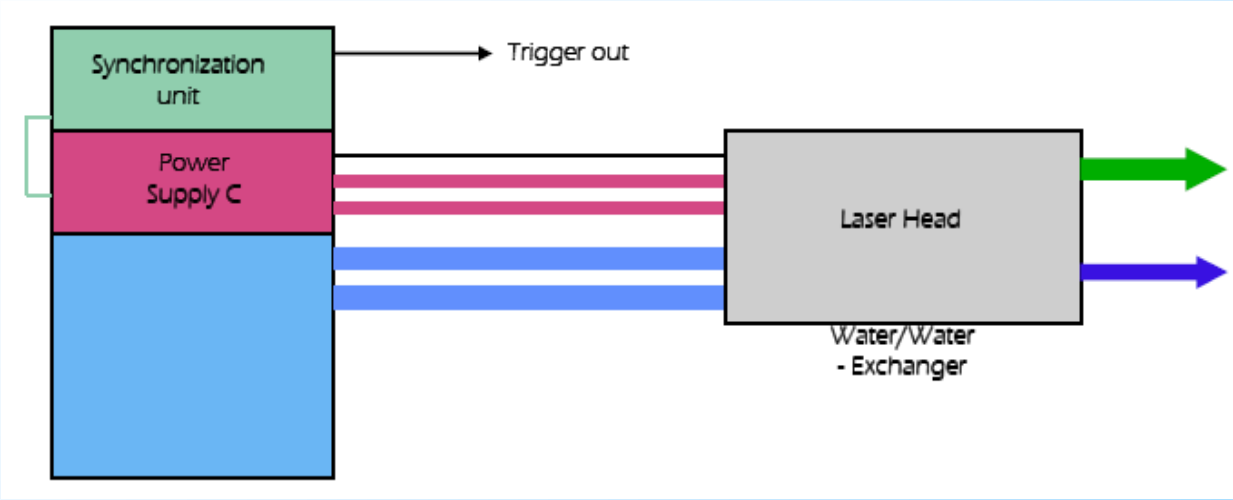


Scheme of the oscillators

- EdgeWave will build up a spare laser, incl. one laser head, one power supply and the software.
- If failure happens, EdgeWave will send the spare laser immediately to CERN.

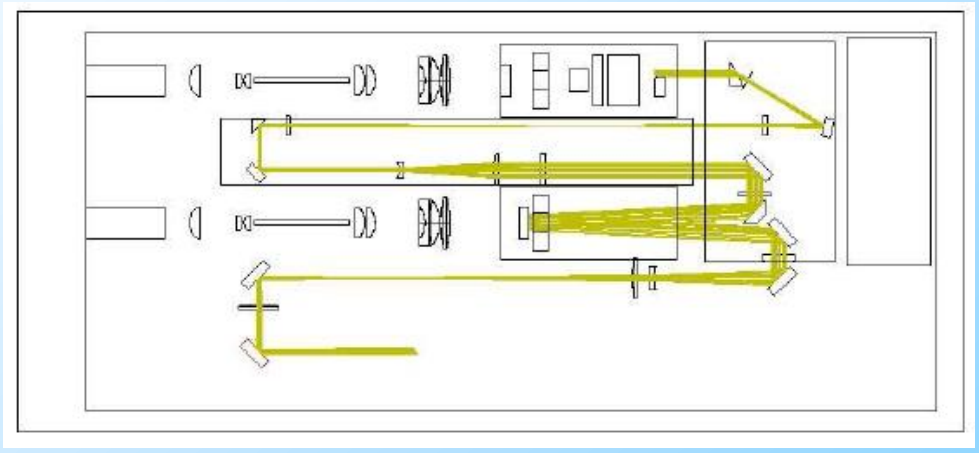
SSL design proposal 2

Suggested on 31.10.2007 following difficulty to fulfill the requirement of jitter < 3 ns



Beam A+B
80W @ 532nm

Beam C
20W @ 3nm

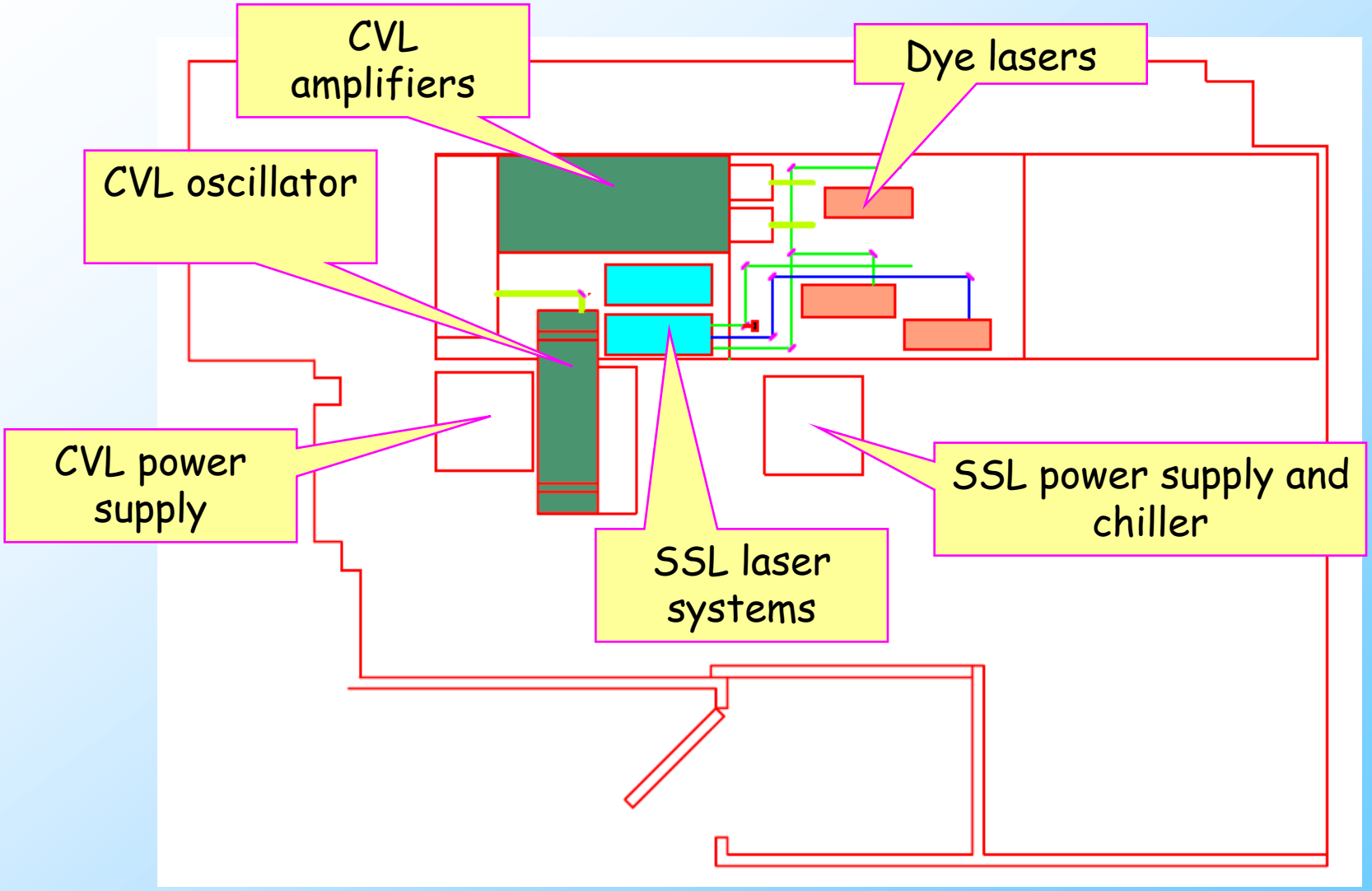


Scheme of the Nd:YAG oscillator - amplifier

- EdgeWave will build up two laser heads and power supplies.
- Both laser systems will be shipped to CERN.

Warranty period = 2 years
+ 2 years of warranty extension included

SSL implementation in RILIS room



RILIS hardware

- CVL lasers
  - Built >15 years ago, to be replaced by Nd:YAG lasers
  - In operation during 2008
- Nd:YAG lasers
  - New, to be installed in 2008
  - Operation starting from 2008
- Dye lasers and dye amplifiers
  - Built >15 years ago
  - Upgrade planned for 2008-2009
- Non-linear optics elements
  - Consumable crystals
  - Could be included in new dye lasers (2009)
- Laser beam transport optics
  - Quartz prisms – losses > 40%
  - Minor improvements are possible
- Control tools
  - Currently only local control for most of parameters
  - Remote control is under development

Road map of RILIS upgrade

2008

- **Installation of solid state lasers for dye laser pumping. Keeping CVL lasers at RILIS as backup until reliable SSL performance is reached.**
- **Market survey for high pulse rate dye lasers. Purchasing of new dye lasers.**
- **Providing conditions for remote control of key RILIS parameters**

2009

- **Including RILIS operation in the ISOLDE separator courses**
- **Switching RILIS running from “shift” to “on-call” operation mode**

2010

- **Installation of Ti:Saphire lasers in addition to dye lasers**
- **Availability of RILIS for parallel running at GPS and HRS**

LARIS lab -
LAaser Resonance Ionization Spectroscopy lab

Primary objectives:

- **Investigate new ionization schemes (free from ISOLDE scheduling)**
- **Improve upon current schemes that rely on non-resonant ionization**
  - search for auto-ionizing states
- **Prepare for RILIS transition to Solid State Laser system**
  - different wavelength range (532 nm and 355 nm pumped dye lasers)

Secondary objectives:

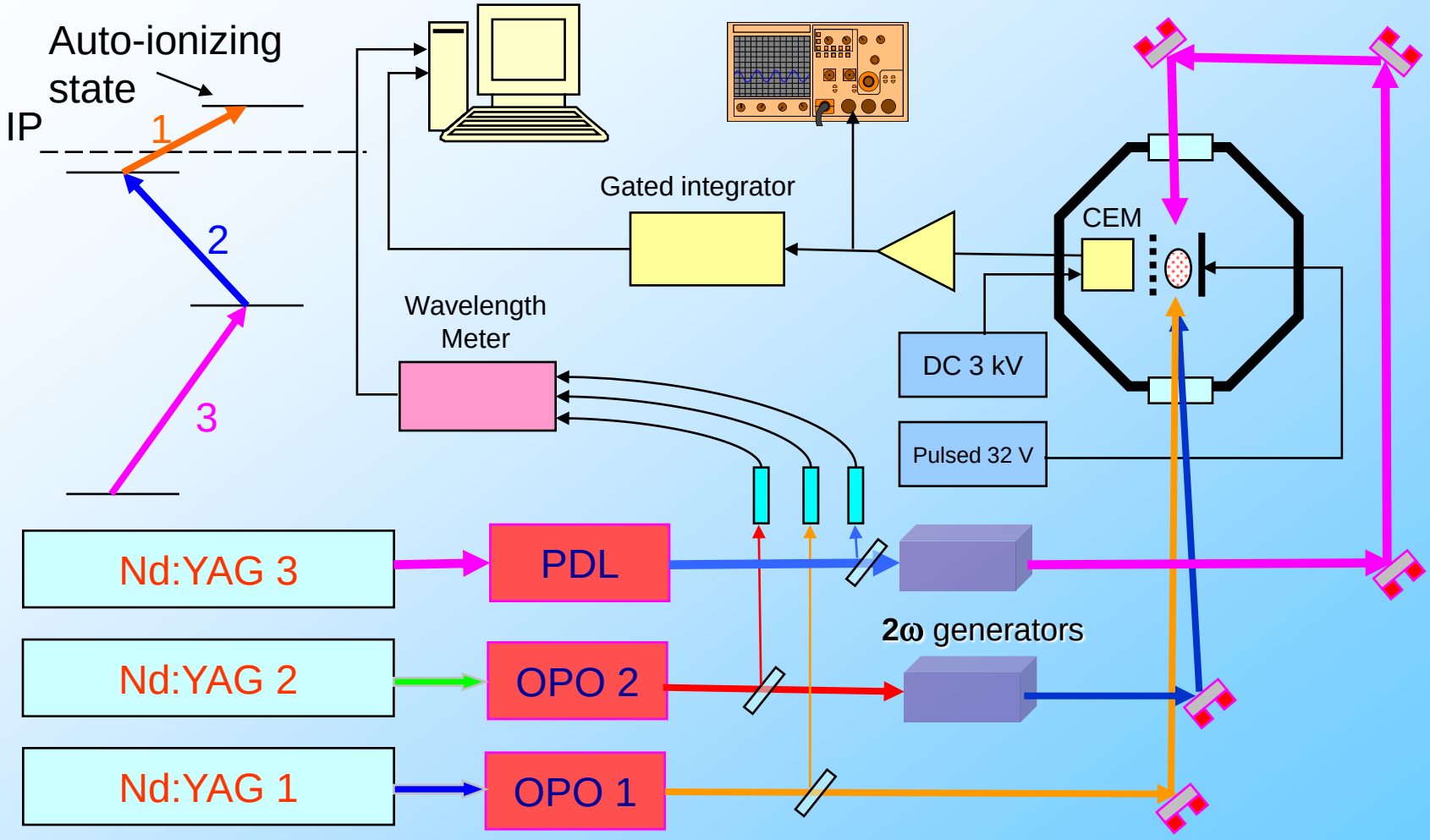
- **Investigate RILIS selectivity improvements**
  - HFS measurements (isomer selectivity)
  - Hot cavity optimization / material testing

Tertiary objectives:

- Questions related to fundamental atomic spectroscopy, e.g. accurate determination of atomic ionization potentials.

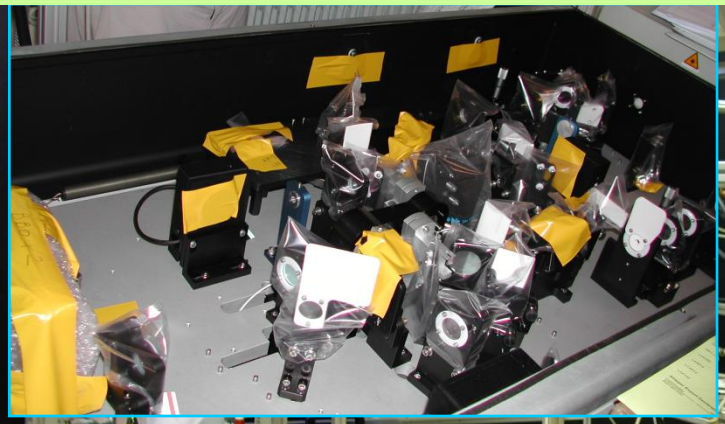
CERN/KTH collaboration

LARIS laser photoinization spectrometer

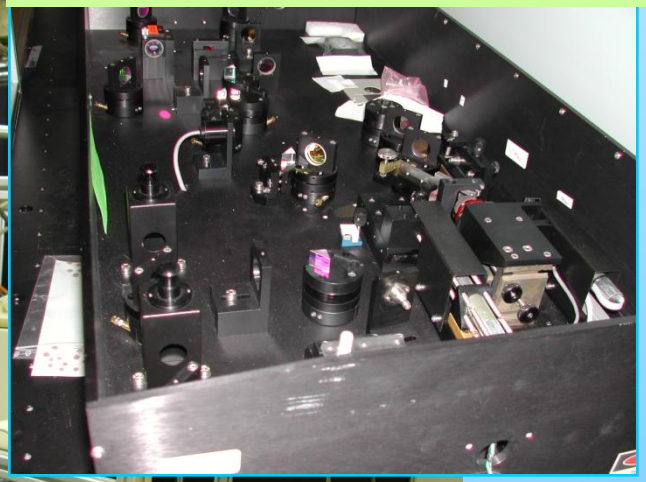


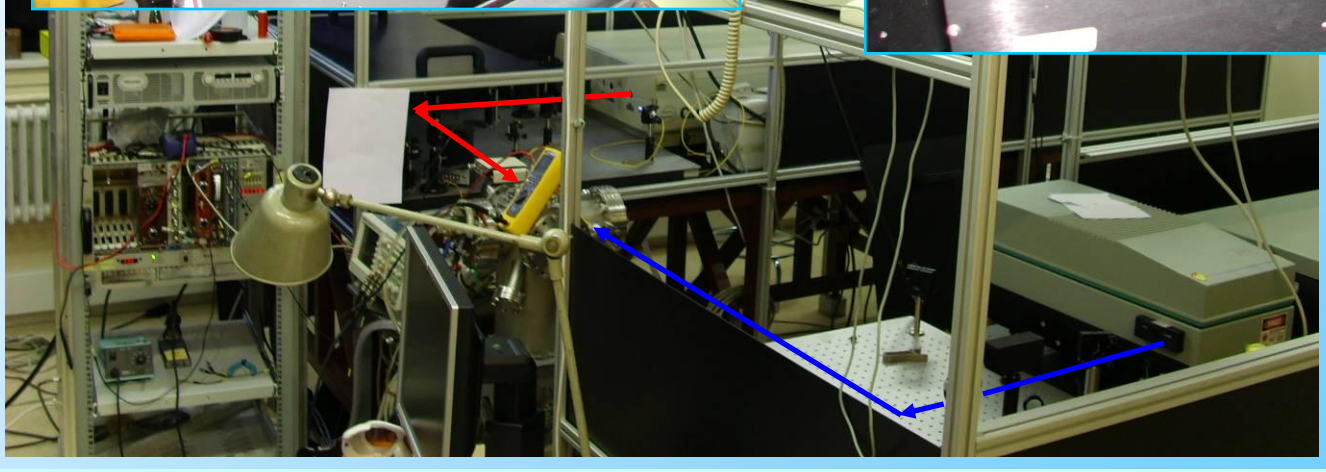
LARIS lasers

Spectra Physics Quanta-Ray PRO 230-10 + MOPO HF
Tuning range: 450 -690 nm (signal), 730 -1680 nm (idler),
2nd harmonics: 225 – 345 nm, 365 – 450 nm



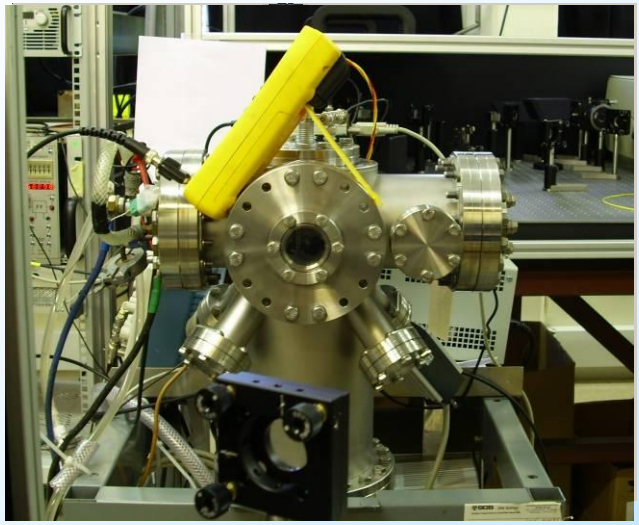
Continuum PowerLite 7010 + OPO Mirage
Tuning range: 720 - 920 nm (fund.),
2nd harmonics: 360 - 460 nm





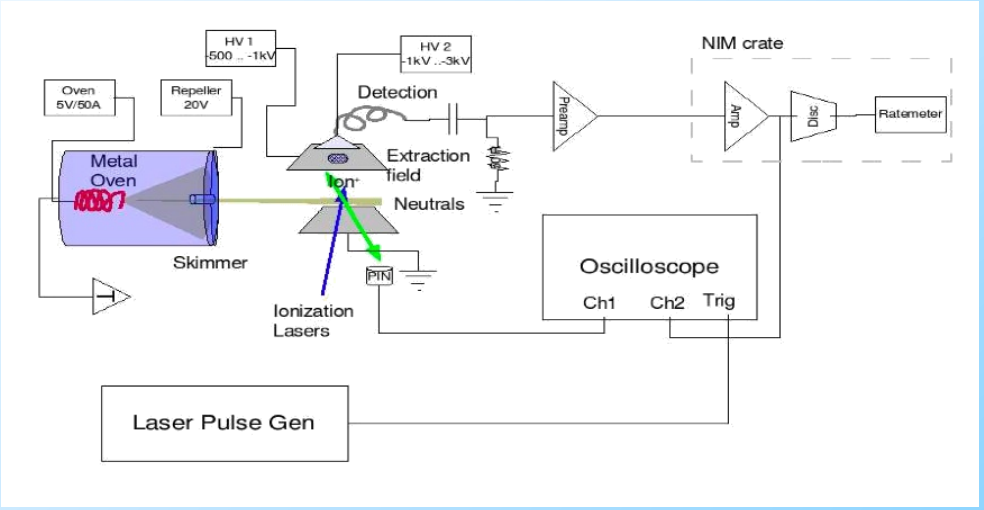
Lumonics Hyperdye dye laser pumped by Quantel Nd:YAG laser to be installed

Simple atomic beam setup



Current ABU system with oven:

- Measure relative efficiencies of ionization schemes
- Systematic study of auto-ionizing states
- New ionization schemes for currently unavailable elements
- Replace schemes that require CVL pumping at 511 nm



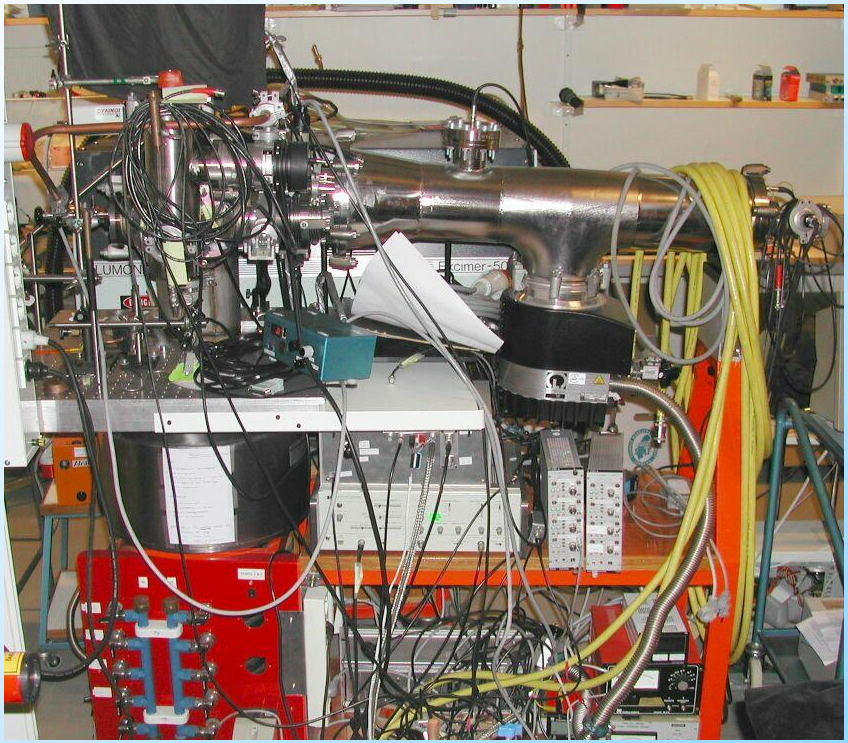
Later:
Upgrade to a more RILIS specific ABU (replica of ISOLDE target-ion source unit)

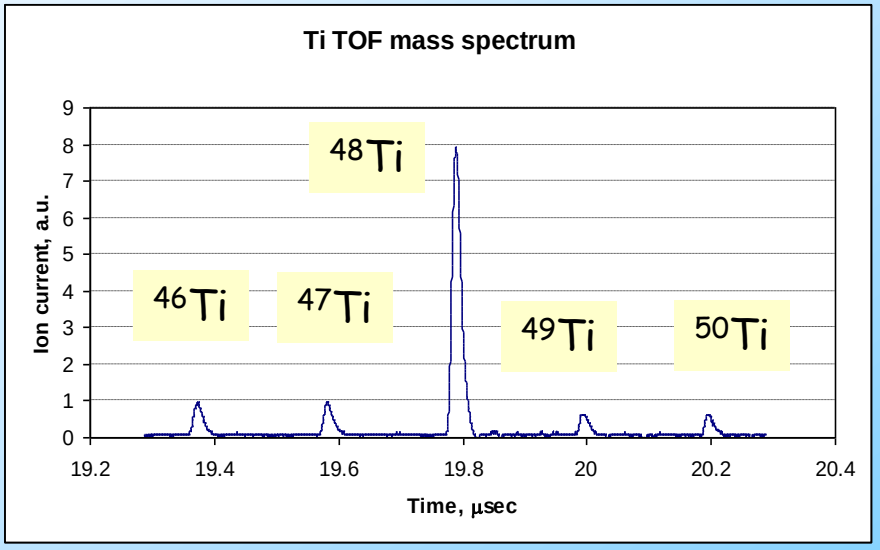
- Higher temperature
- Test cavity materials
- New ideas for better selectivity

RIMS spectroscopy

To acquire higher resolution laser spectra for specific isotopes

- Measure isotope shifts for stable isotopes
- Measure HFS for different atomic transitions in various ionization schemes
- Feasibility study for ***isomer separation***

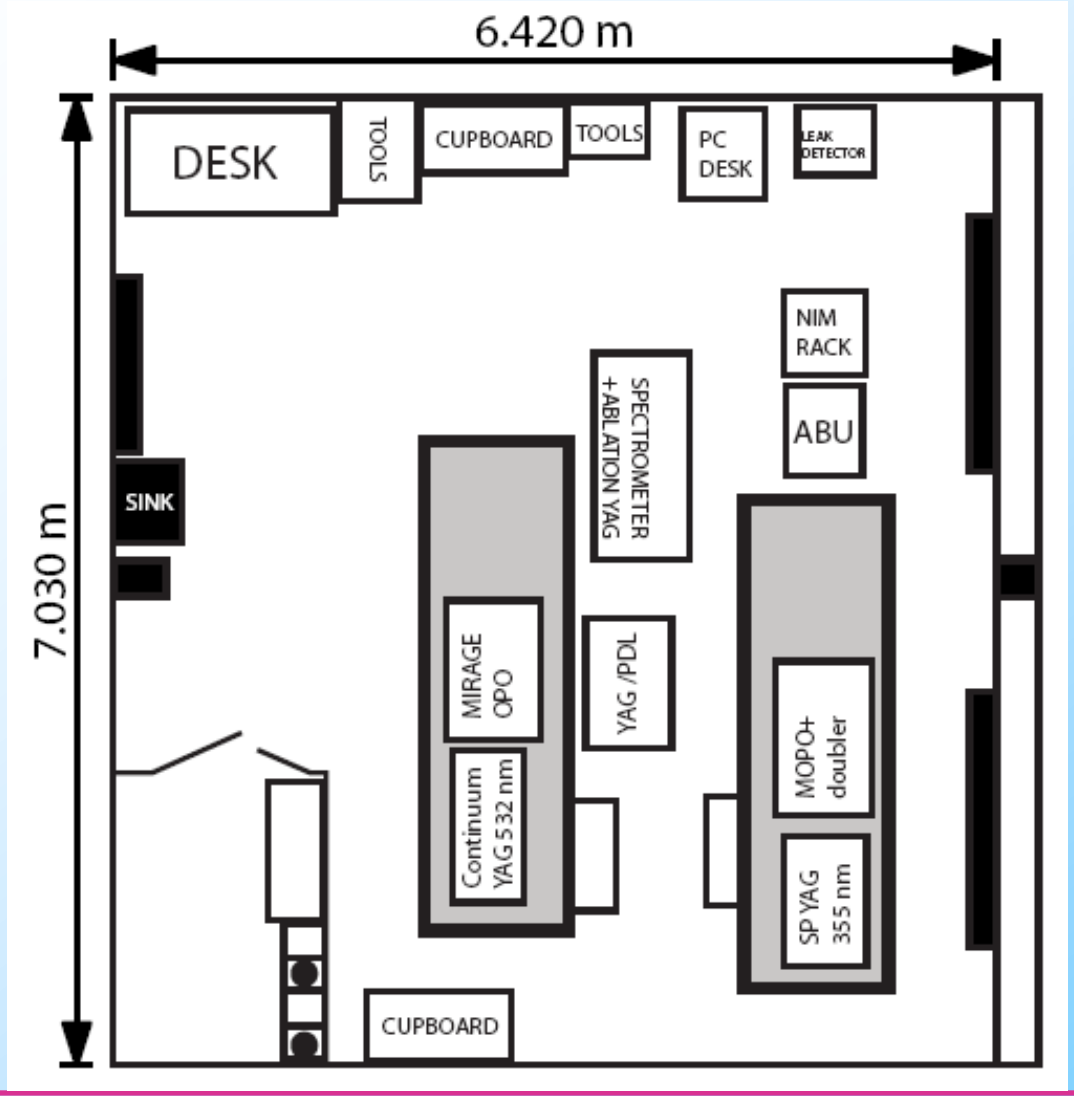




Titanium atoms were:

- Ablated out of rod by Nd:YAG laser
- Transported by Ar gas
- Ionized by MOPO beam (294.2 nm)
- Mass-separated in TOF mass-spectrometer
- Detected with MCP

LARIS lab



- Building 252-R-004
- 45 m²

- For tests with ISOLDE target-ion source units an extension is envisaged:
- The neighboring room of 22 m² could be available after LHC completion

LARIS hardware

- Nd:YAG lasers — Built >5 years ago, in operation after service
- Optical parametric oscillators (OPO) — Built >5 years ago, in operation after service
- Dye laser — Built >10 years ago, ready for use
- Frequency doublers — One is new , another in operation after service
- Laser beam transport optics — New, assembling is going on
- Control tools — New commercial instruments
- Atomic beam unit — Assembled and tested with low temperature oven
- Time-of flight mass spectrometer — Built >5 years ago, in operation after service
- Ablation laser — New, purchased in 2007
- Data acquisition system — Under construction, based on commercial elements

Budget plan

	2006 Spent	2007 Spent + Committed	2008 – 2009 To be spent	Total
RILIS Upgrade	0	705	845	1550
LARIS lab	224	170	306	700
Subsistence and travel	76	67	7	150

Grand Total = 2400 kCHF

Thanks to:
Knut and Alice Wallenberg Foundation

CERN – KTH Collaboration

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