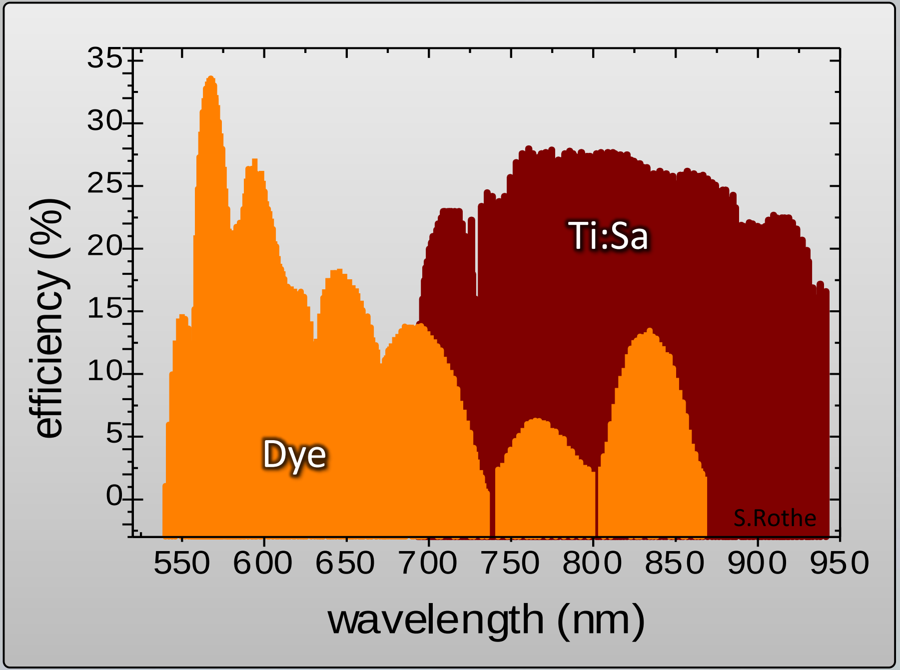
A development platform for Ti:Sa lasers

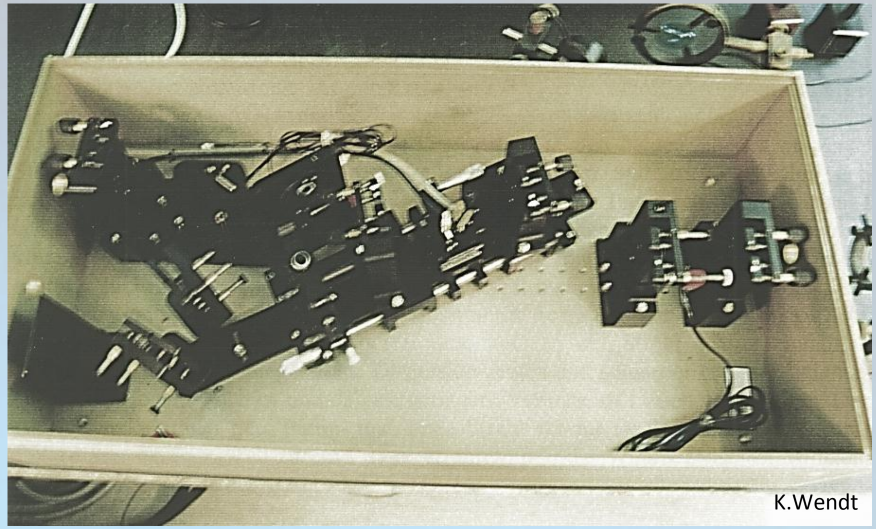
S. Rothe, EN-STI/LP

Contents

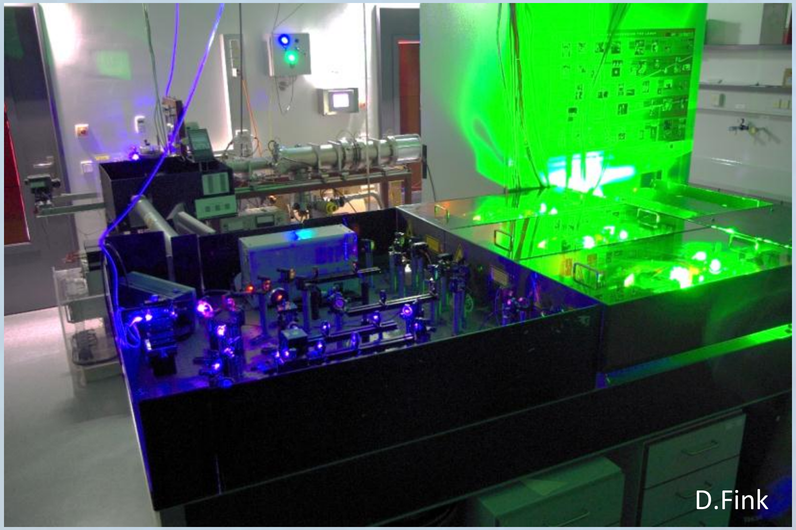
Motivation for the Mainz Ti:Sa laser system



- A reliable laser system was required to put ultra trace detection of plutonium isotopes to a routine operation (RIMS)
- Ti:Sa is widely tunable in the IR
- Maintenance ~0 (no dye changes)
- Good reliability expected due to solid state Nd:YAG pump laser
- 1997 Prototype was put in operation
- Replaced the CVL pumped dye laser system

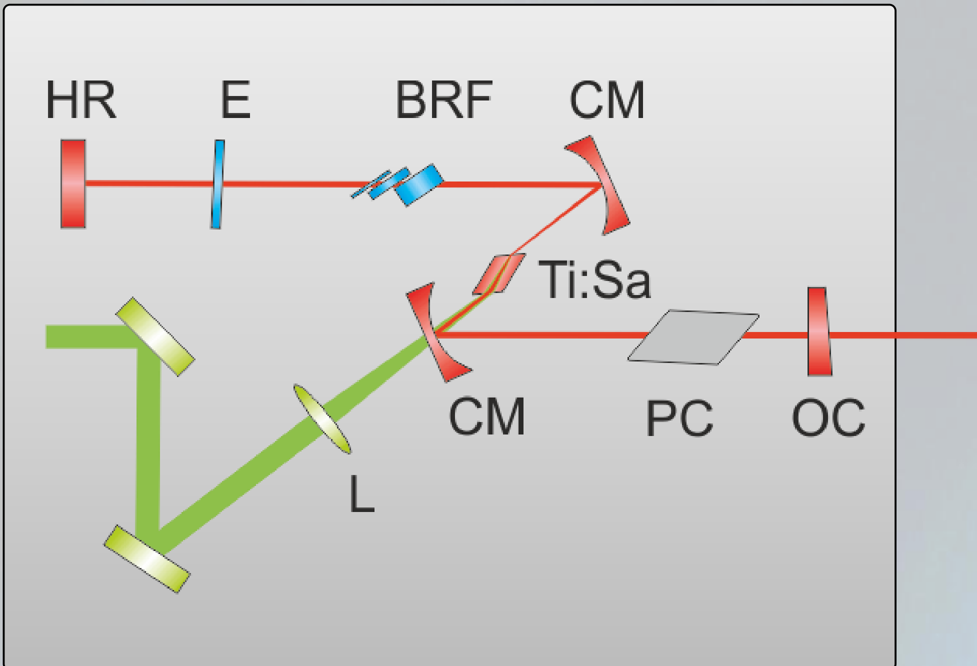


Mz-Ti:Sa Prototype, 1997



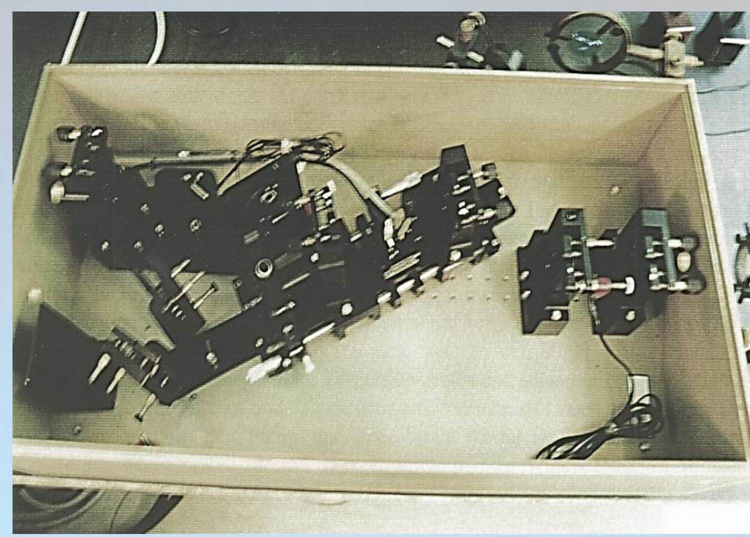
Still operating

Layout of the Mainz Prototype Ti:Sa

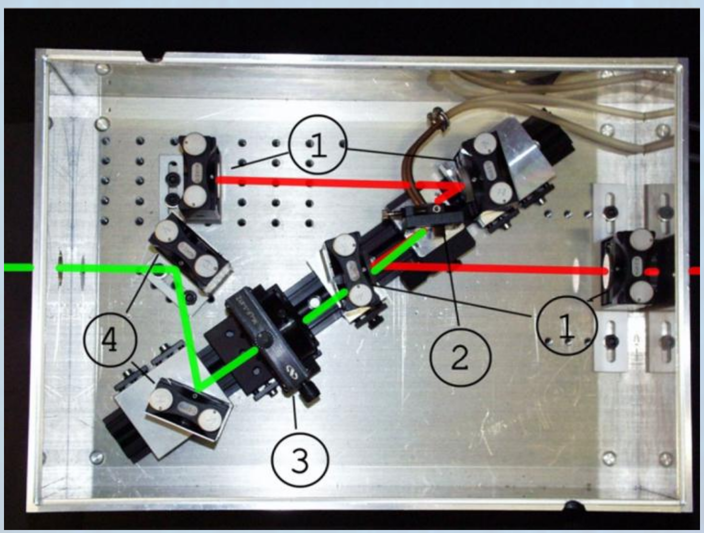


- Z shaped resonator
- Frequency selection with birefringent tuner and etalon
- Synchronization with Pockels cell
- Pumped with a flash lamp pumped Nd:YAG (Clarc ORC-1000) at 7kHz

- Suitable as Laser Ion Source (LIS)
- Tests at TRIUMF (2002) , ORNL (2004), CERN (2004)

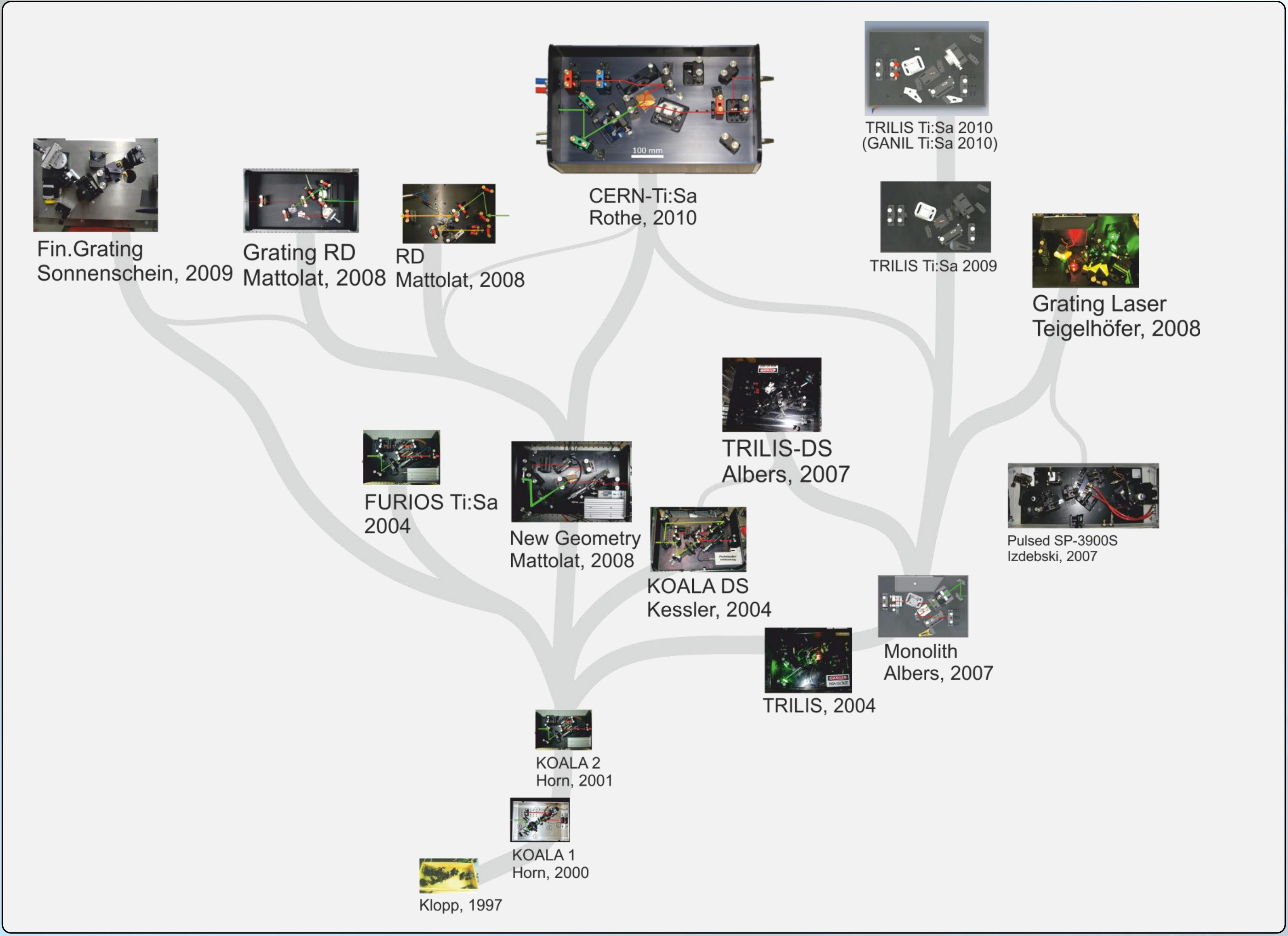


UMz-Ti:Sa Prototype, 1997

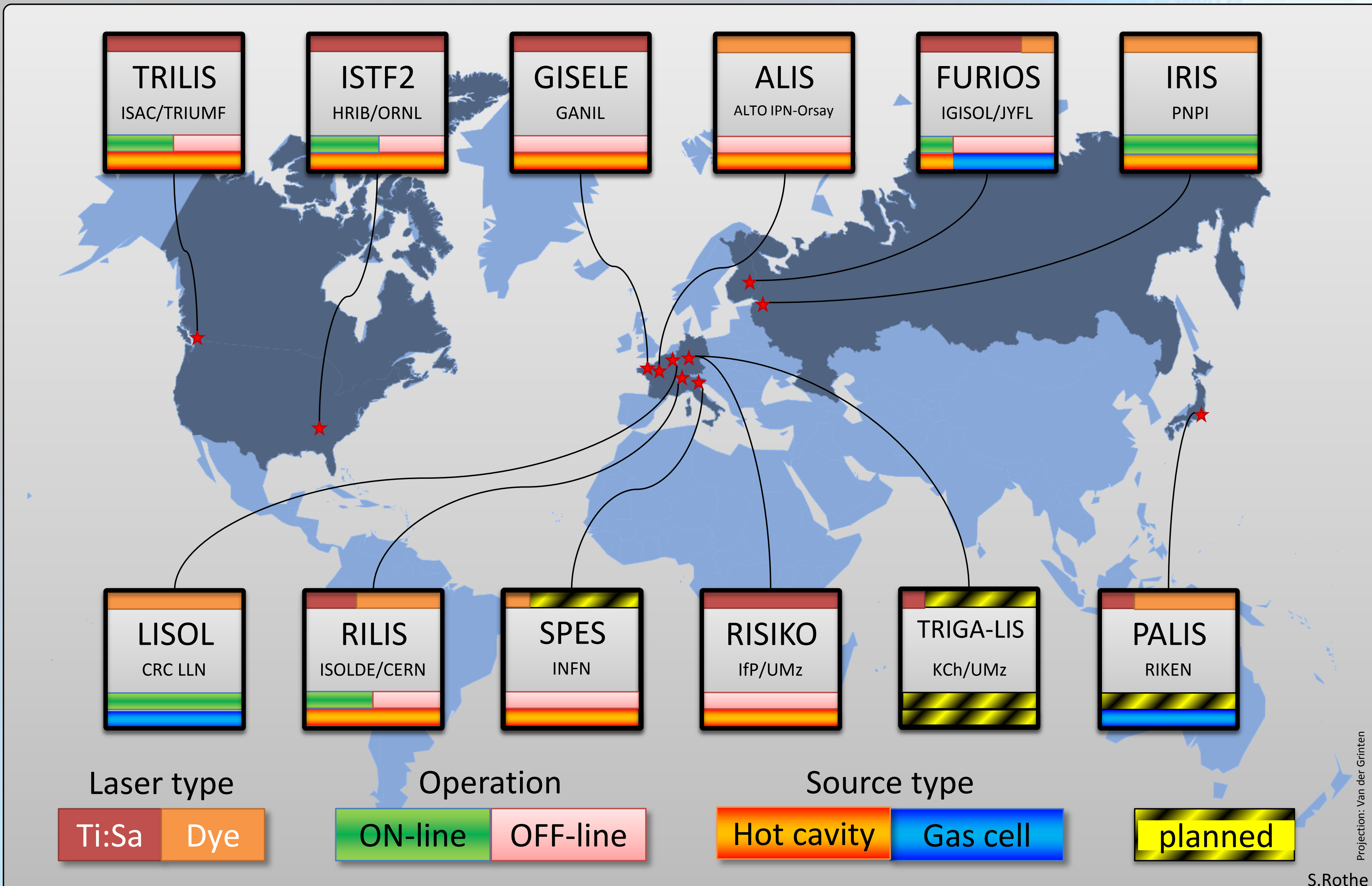


KOALA 1, R. Horn 2001

The Mainz-Ti:Sa and its offspring



Laser ion source activities world-wide



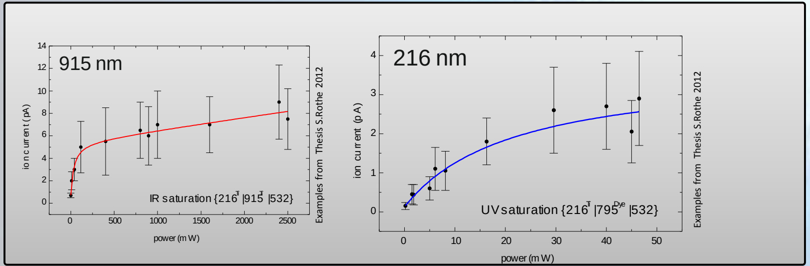
Skills always in demand

1. Output Power

   Efficient higher harmonics generation

   Saturate transitions

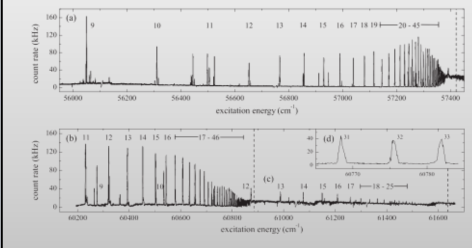
   Talk by Volker



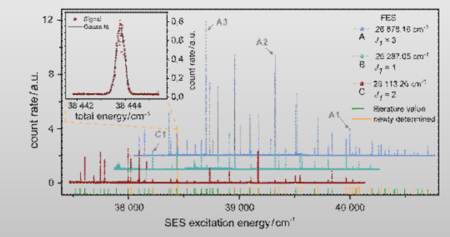
2. Wide tuning capabilities

   Spectroscopy for
   - Ionization potentials (IP)
   - Scheme development

   Talks by Volker, Tom



Ch. Mattolat *et al., Phys. Rev. A* **81**, 052513 (2010).

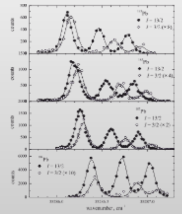


S. Raeder *et al., J. Phys. B* **44**, 165005 (2011).

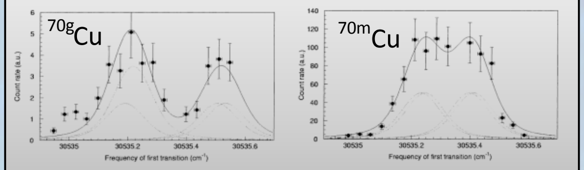
3. Reduction of line width

   - In source laser spectroscopy
   - Isomer separation

   Talks by Tobias, Volker



M.D. Seliverstov *et al. The European Physical Journal A* **41**, 315–321 (2009).

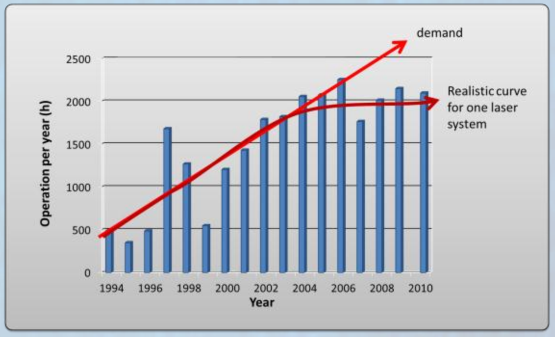


U. Köster *et al., Hyperf. Interact*. **127**, 417 (2000).

4. Reliability
   - RILIS is most wanted (3000 h p.a.)

   Talk by Bruce

5. Usability
   - Set-up time
   - Ease of use

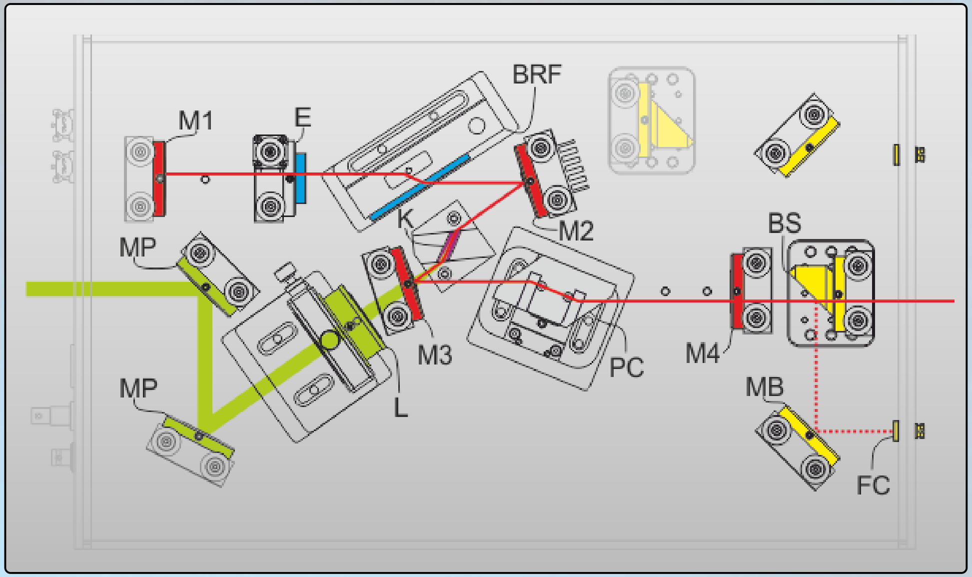


Evolved design features

- Commercial Pockels cell driver
- Commercial optomechanics (if available)
- Monolithic base plate
  - Reduction of degrees of freedom
  - Fixed distances and angles
- Feed-troughs for water, motors, HV
- Fiber coupling for alignment and sampling




Example: Layout of the CERN-Ti:Sa

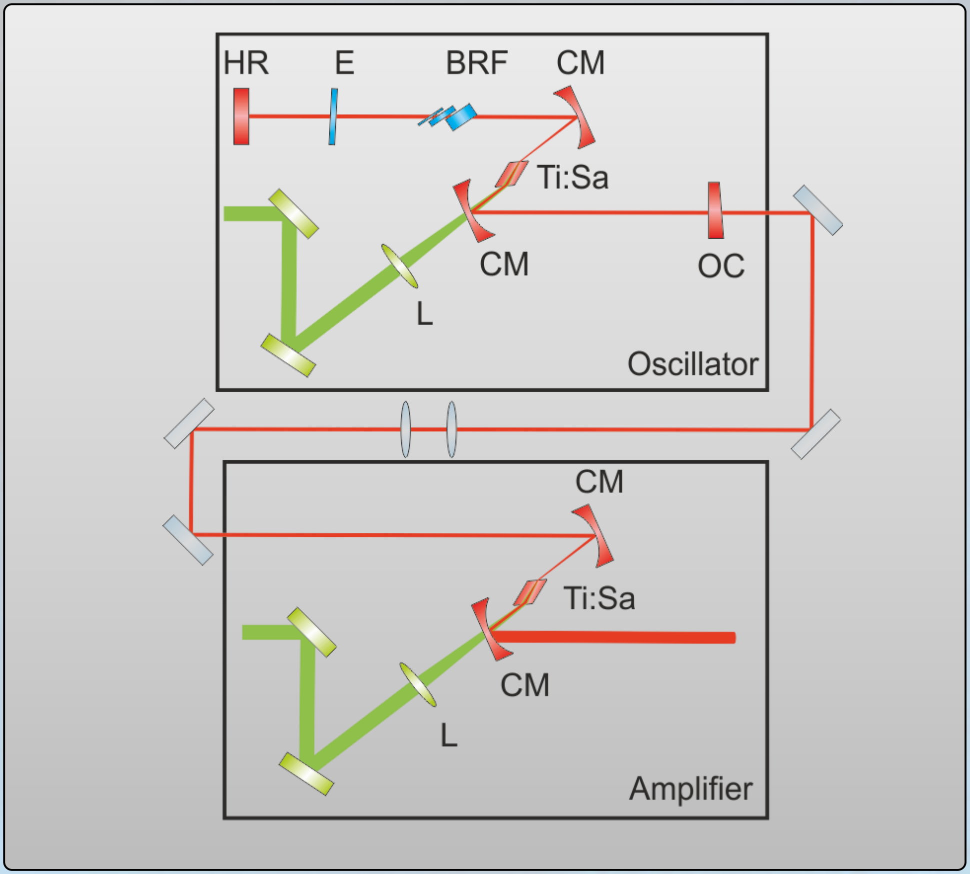


Nice for on-line operation

Not really suitable for development

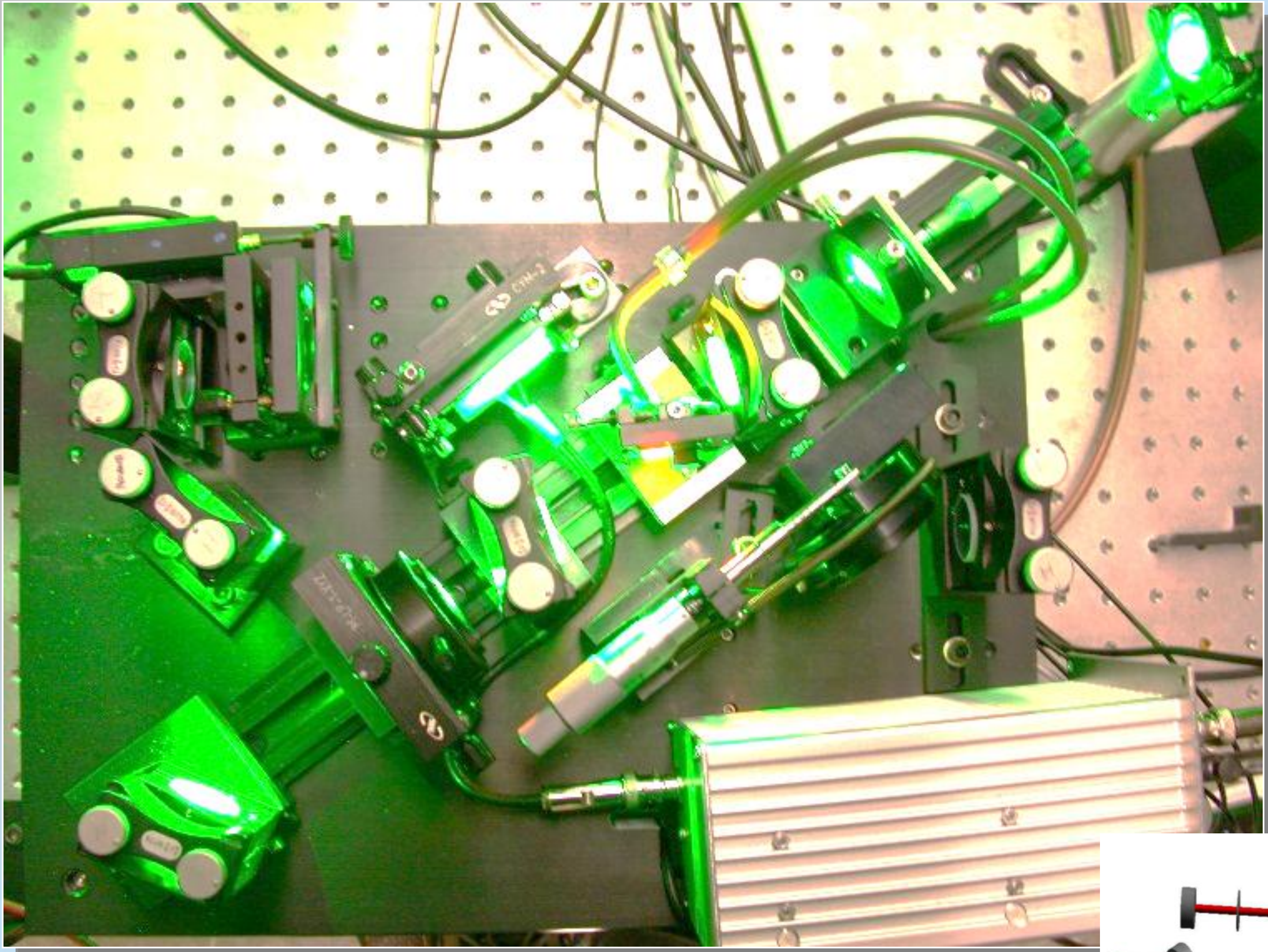
Development workarounds: Single-pass amplification

Coupling of two Ti:Sa lasers

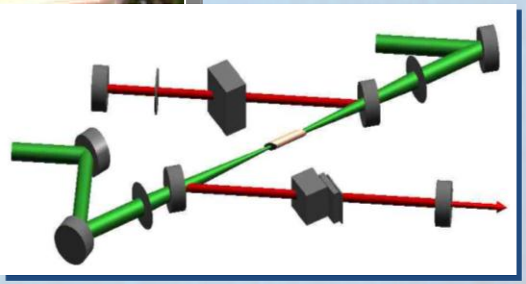


T. Kessler: factor 1.8
S. Rothe: factor 2.2

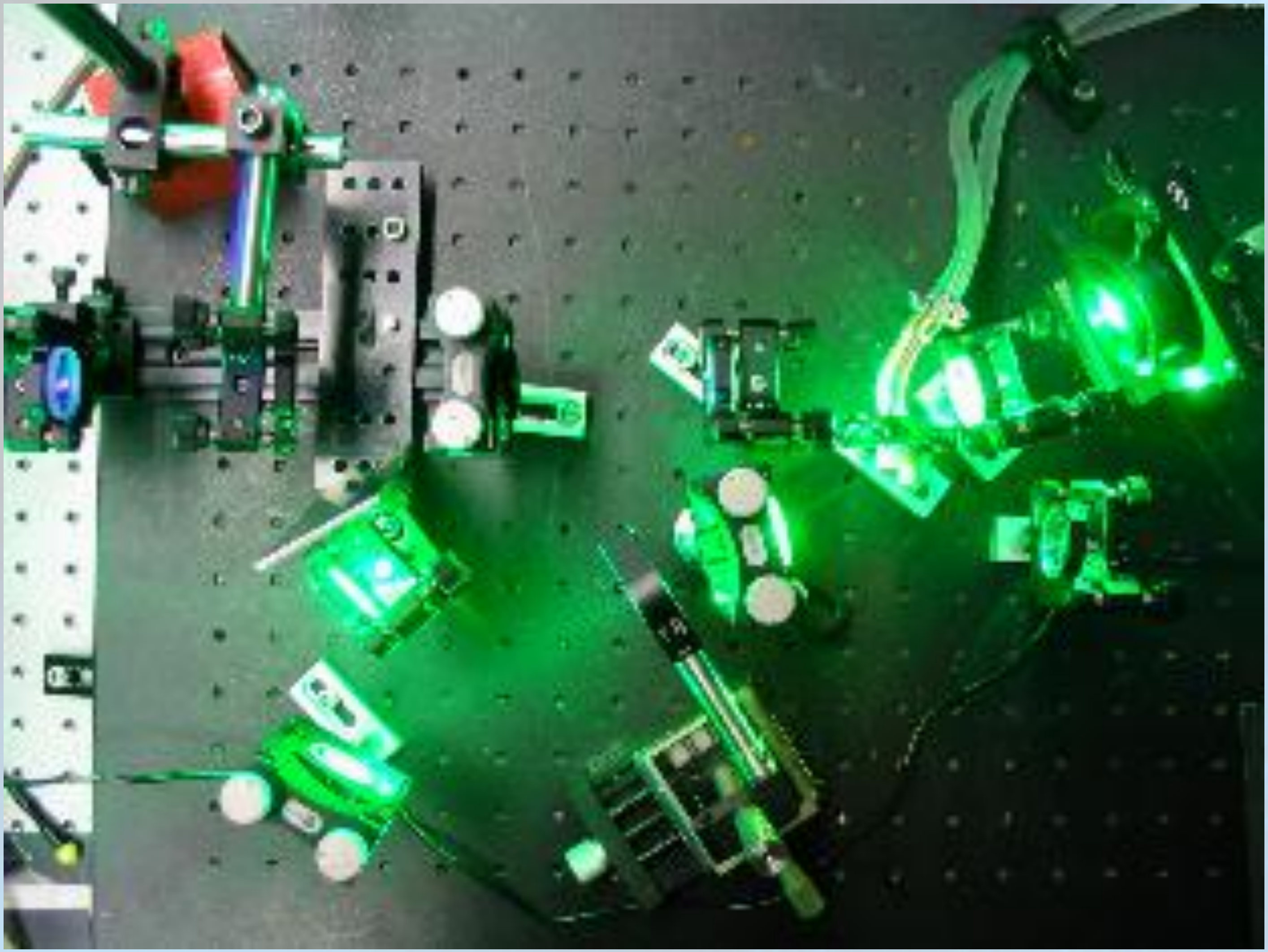
Development workarounds: The first DS-Ti:Sa



KOALA DS
T. Kessler, DPG (2005)



Early development platform

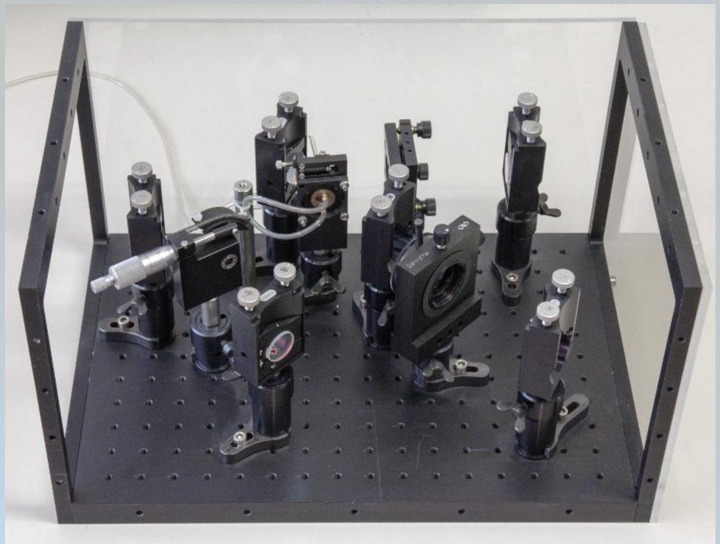


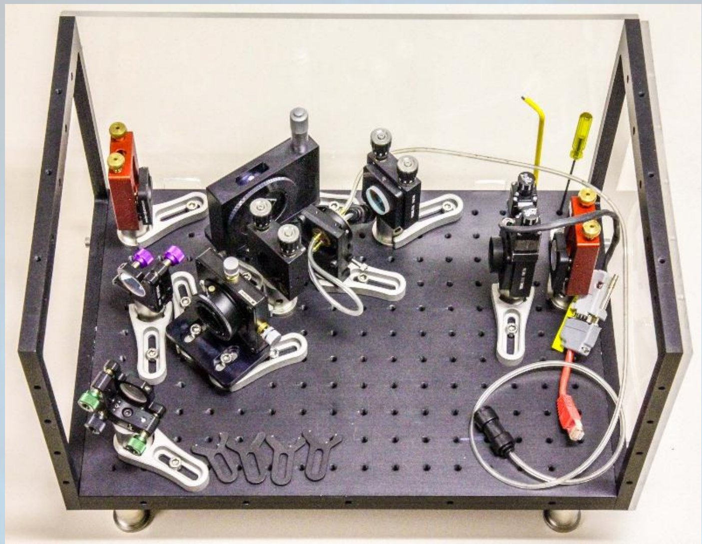
Intra-cavity SHG, T.Kessler (DPG 2004)

A dedicated development platform for RILIS

- Development Kit character
- Mostly commercial parts
- Use of printed (or CNC cut) layouts

The breadboard Ti:Sa (BB-Ti:Sa)





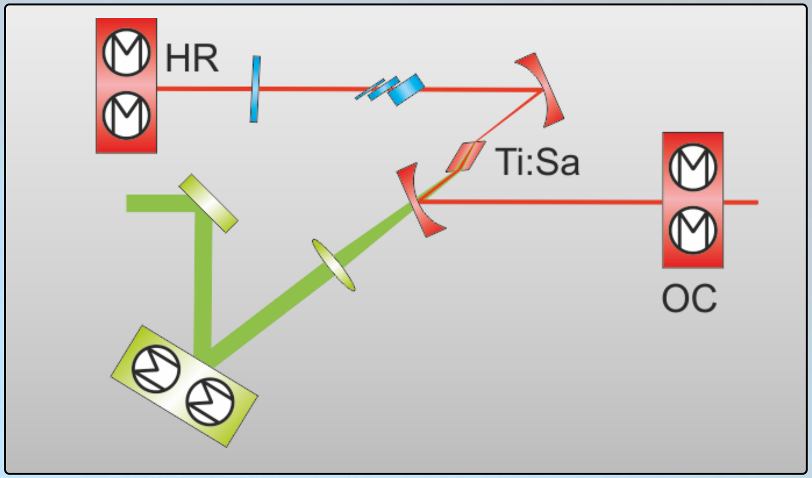
Original “found” in AD (J.Walz group)
BB version/copy of the KOALA 1

New optomechanics
Fixed beam height
Layout = CERN Ti:Sa

More automatization

- Wavelength stabilization (R.E. Rossel, BSc.Thesis 2011)
- Automatic dual etalon scan (RILIS)
- SHG tracking (TRILIS)

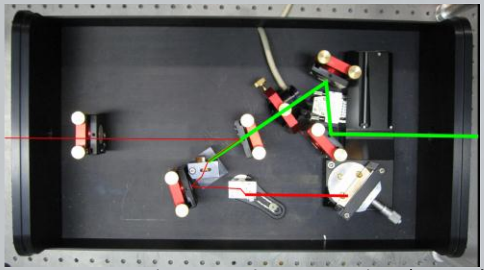
? • Automated cavity optimization



- Additional parameters can be optimized (CM distance, Pump telescope)
- Wavelength tuning curves
- Reliable results for testing new cavity layouts

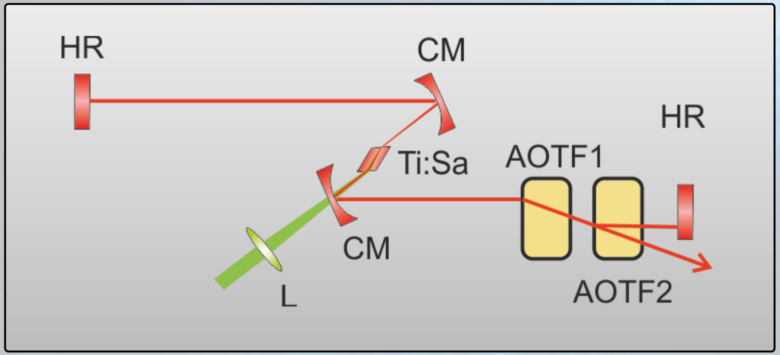
Investigation of wavelength tuning concepts

- Lyot filter & etalon
- Z-Grating-Ti:Sa



Thesis, Ch. Mattolat (2010)

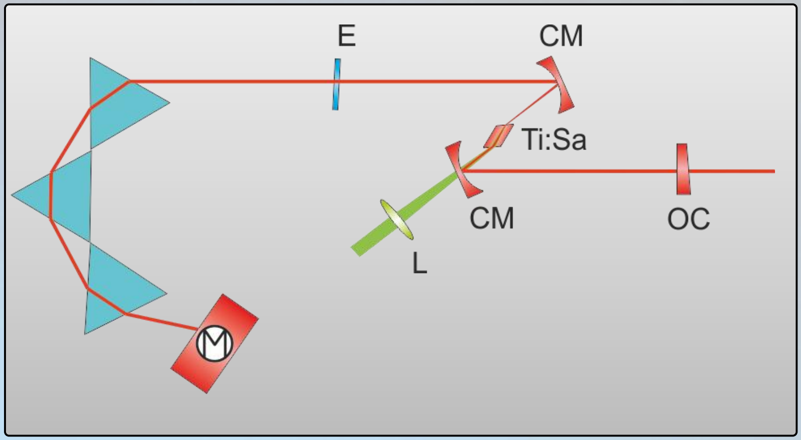
- Acousto-optical tuning filter



Y. Wang et al., Optics Letters, **7**, 27, (2002)

No moving parts

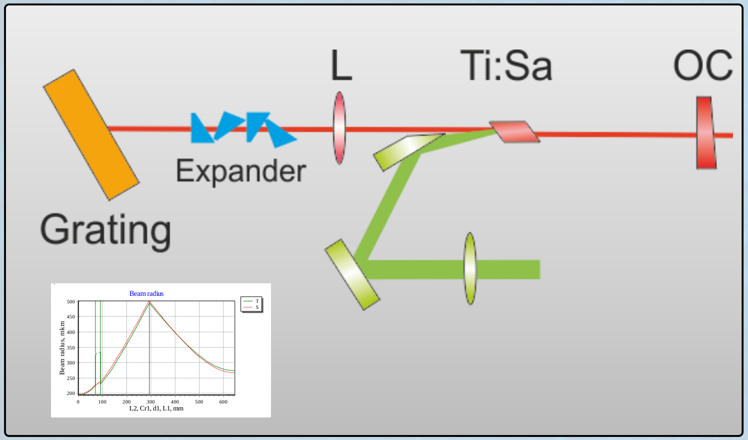
- Prism Ti:Sa



B.Jungbluth, Thesis *RWTH Aachen*, (2010)

Higher output power ?

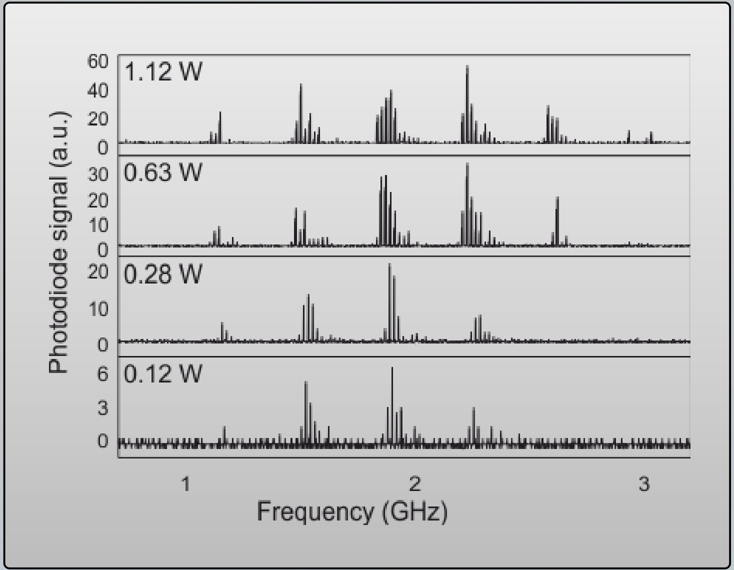
- Linear grating Ti:Sa



Off-axis pump scheme
suitable for low M^2 pump

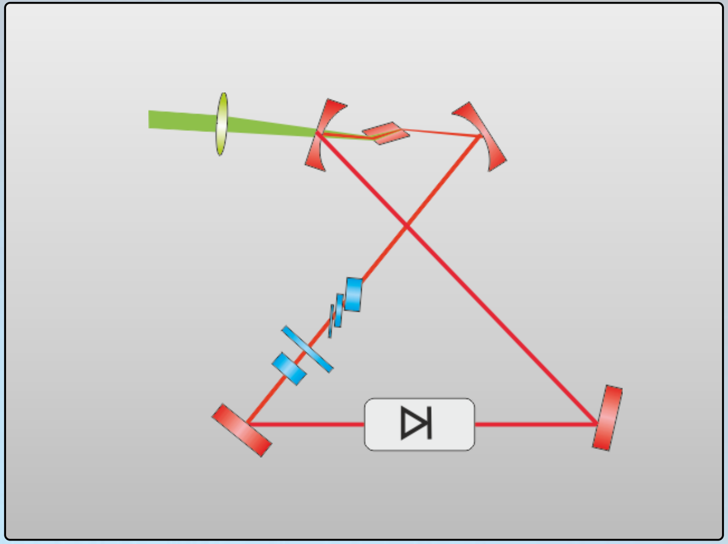
NB-Ti:Sa Reduction of linewidth

✓ • Double etalon in Z-cavity   Talk by V. Sonnenschein, T.Kron



Reduction of pump power reduces gain
-> Less resonator modes

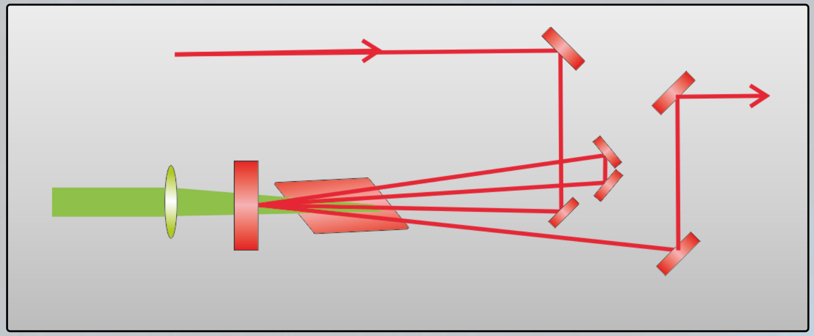
? • Double etalon in bow tie cavity



Avoid spatial hole burning
Operate Ti:Sa at threshold ?

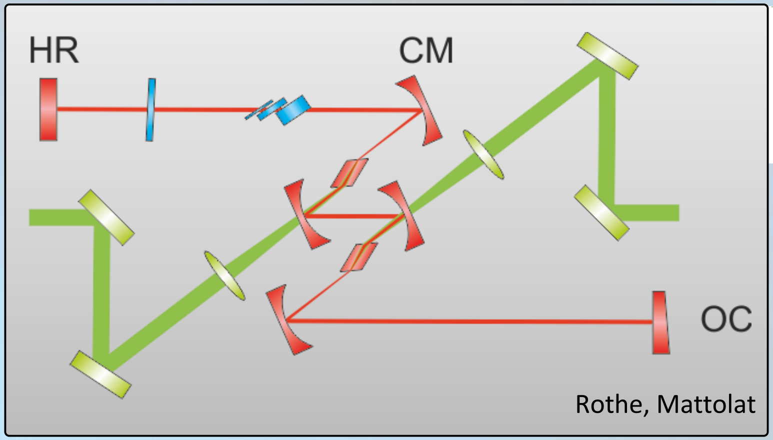
Increasing the output power

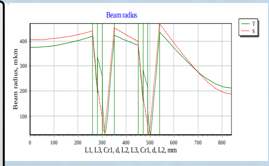
- ✓ Double-sided pumping
- ✓ Single Pass amplification
- ? Multi-Pass amplification



Inspired by B.Marsh (inspired by Continuum Mirage OPO)

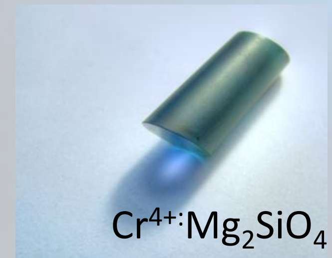
- ? Double crystal cavity (DCT)

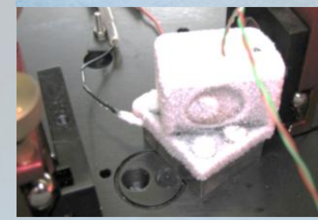


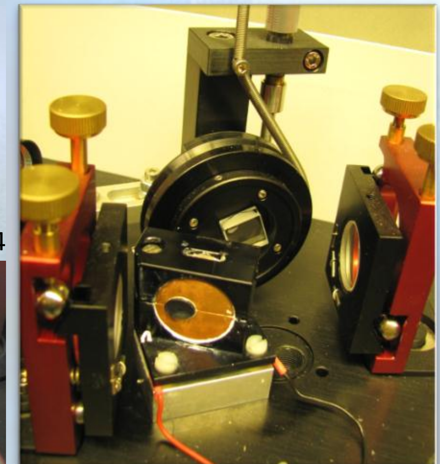


Extension of tuning range

- ✓ Cr:Forsterite medium
  - Tested in Z-Ti:Sa cavity
  - Tuning range: 1220….1275 nm, 1.7 W
  - Requires Peltier cooling
  - ? Intracavity SHG

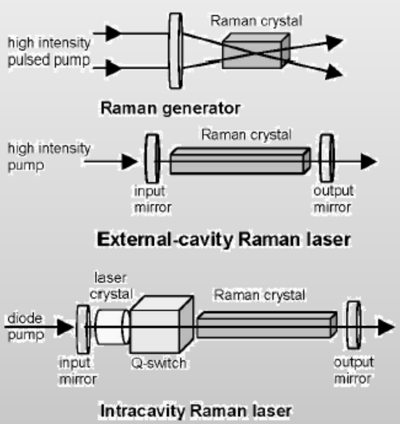




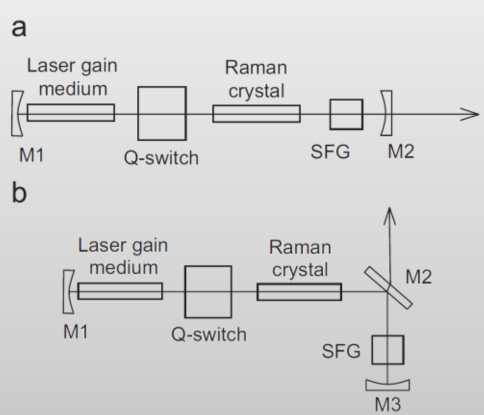


S.Rothe, Dipl.Thesis (2009)

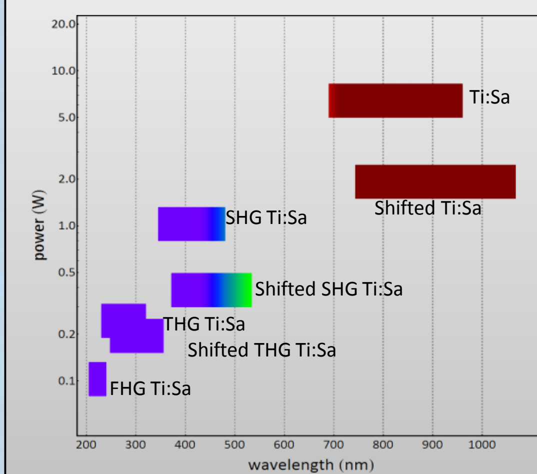
- ? Raman shifter
- ? Raman Laser (combination with IC-SHG Ti:Sa or SHG of dye laser)
- ? Intra cavity Raman laser (temperature tuning possible)



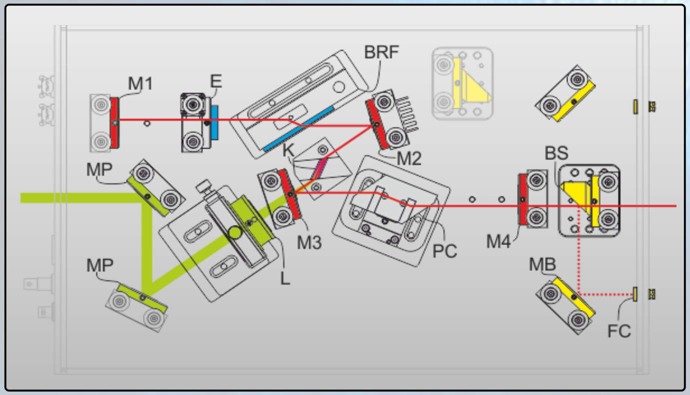
IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS, VOL. 13, NO. 3, MAY/JUNE 2007



Pask, H. M *et al.*, *Progress in Quantum Electronics* **32**, 121–158 (2008).



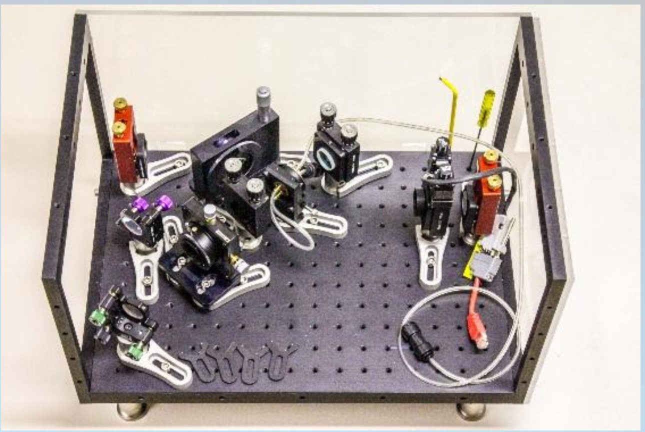
Summary

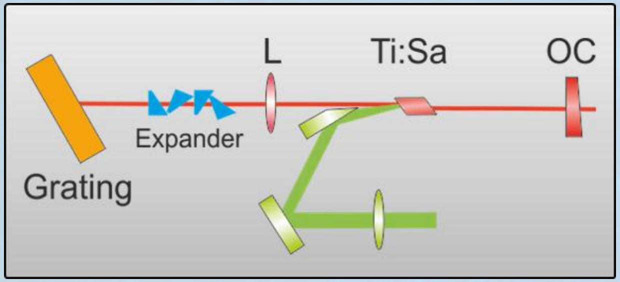


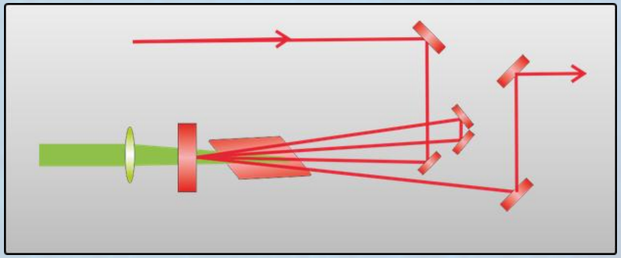
evolution

v.s.

(R)evolution ?







Thank you