



Installation, Commissioning and Operation of the Master Laser Oscillator at FLASH

Patrick Geßler DESY

II Timing & Synchronization Workshop, ICTP, Trieste 09.03.2009

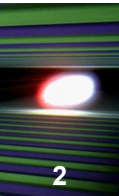


V. Arsov, B. Bayer, M. K. Bock, M. Felber, K. Hacker, F. Loehl, B. Lorbeer, F. Ludwig,
K-H. Matthiesen, H. Schlarb, B. Schmidt, A. Winter, J. Zemella
(Deutsches Elektronen-Synchrotron)



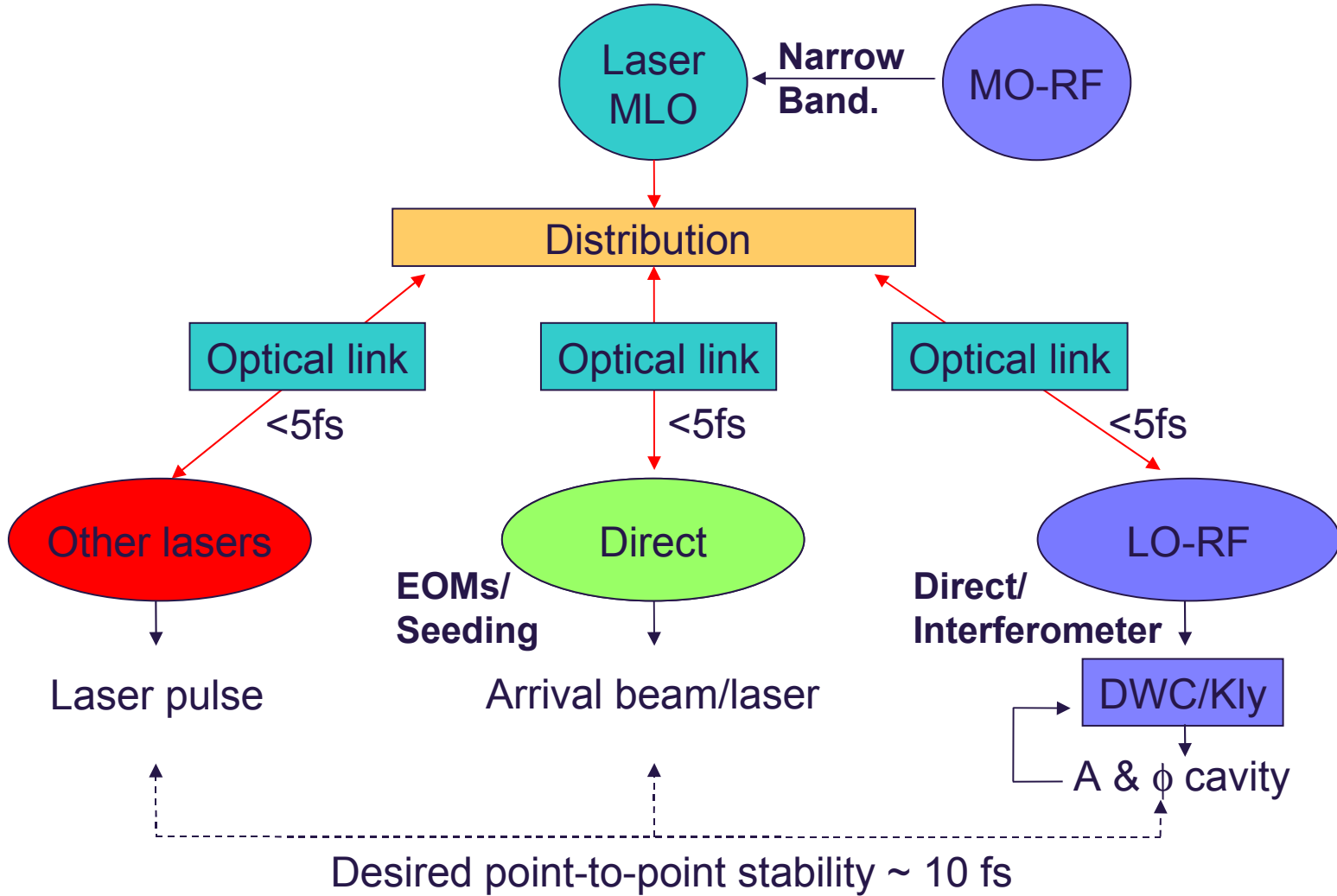
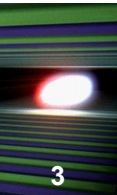
S. Schulz, L. Wissmann
(Universität Hamburg)



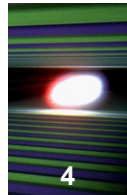


- Overview of the Synchronization System at FLASH
- Requirements for the Master Laser Oscillator (MLO)
- 3 Generations of MLOs
- RF Lock to Master Oscillator
- Measurements
- Pitfalls
- Conclusion

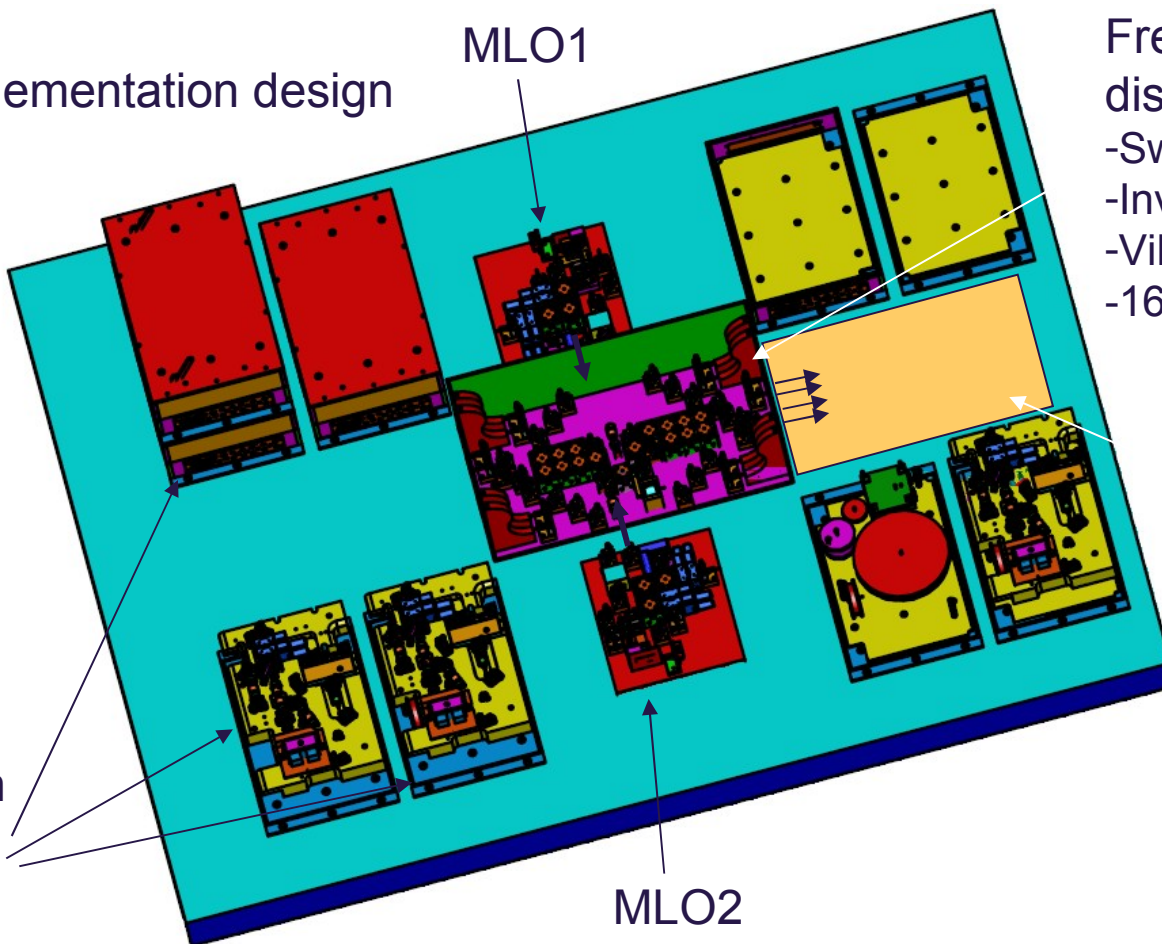
Overview of the Synchronization System



Overview of the Synchronization System



Final implementation design



Free space opt. distribution

- Switching unit
- Invar base plate
- Vibration isolated
- 16 outputs

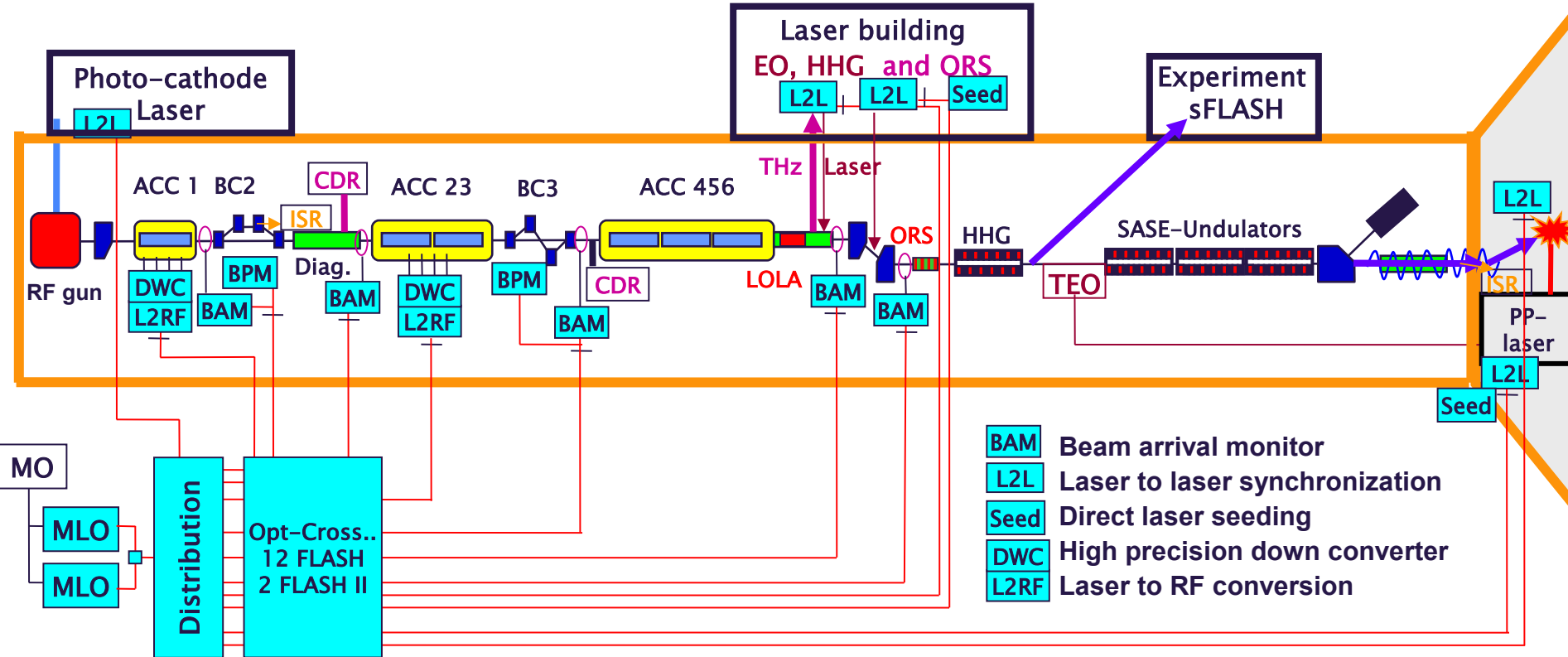
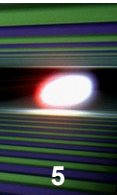
Distr. With EDFA for each link

- Special passive thermal stabilization
- One output for MLO lock based on Sagnac loop at 1.3GHz

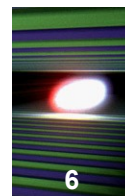
Fiber link stabilization units (max 14)

B. Beyer

Overview of the Synchronization System

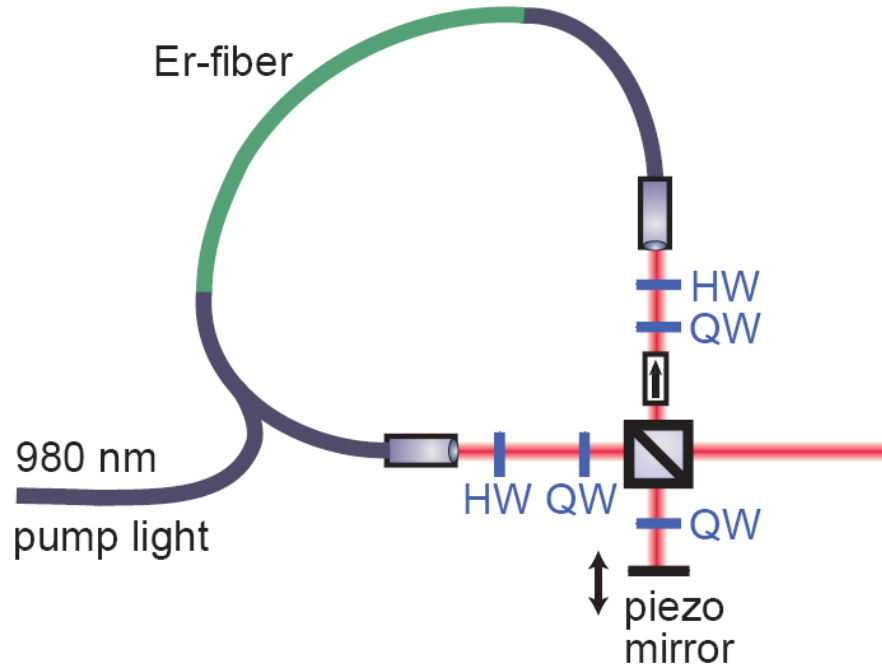
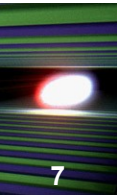


- Backbone: beam based stabilization of arrival time
- Conjunction with high precision synchronization of lasers
- Synchronization of all timing critical devices (~ 14 incl. FLASHII)
- Point-to-point synchronization ~ 10 fs rms (e- < 30 fs rms)
- Permanent operation and long term stability /availability investigation

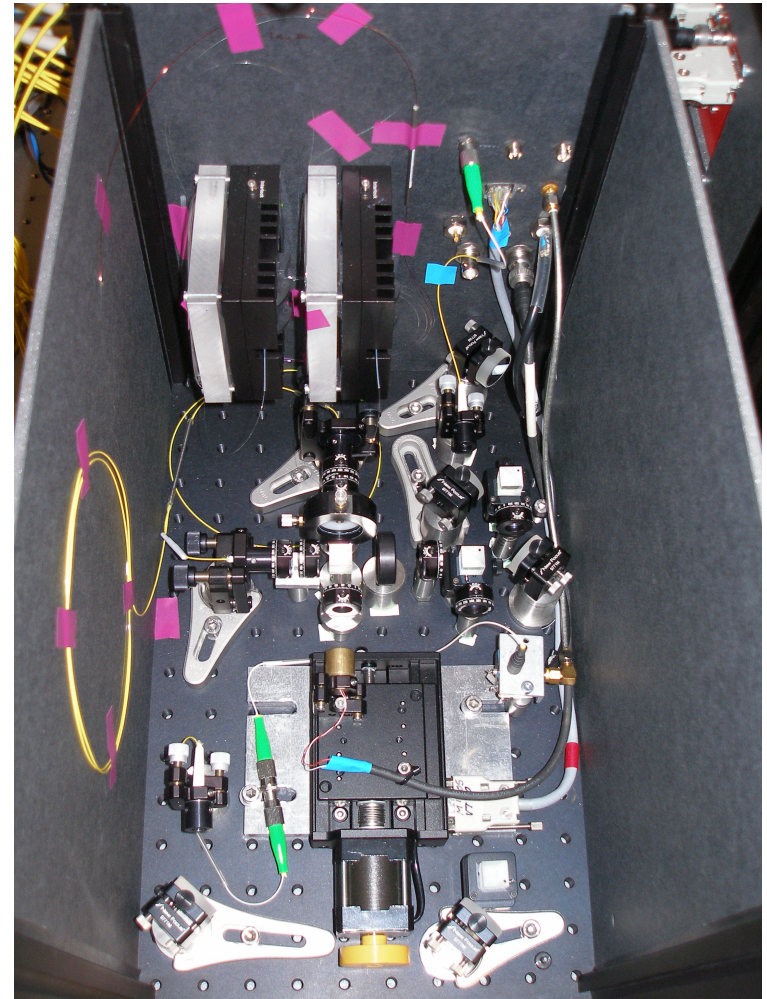


- Mode-Locked Erbium Doped Fiber Laser
- Pulse Duration $<100\text{fs}$ (FWHM)
- Repetition Rate 216.66MHz
- Output Power $>120\text{mW}$
- Integrated Timing Jitter $<10\text{fs}$ [10Hz – 40MHz]
- Amplitude Noise $<2 \times 10^{-4}$ [10Hz – 1MHz]
- Reliability / Redundancy

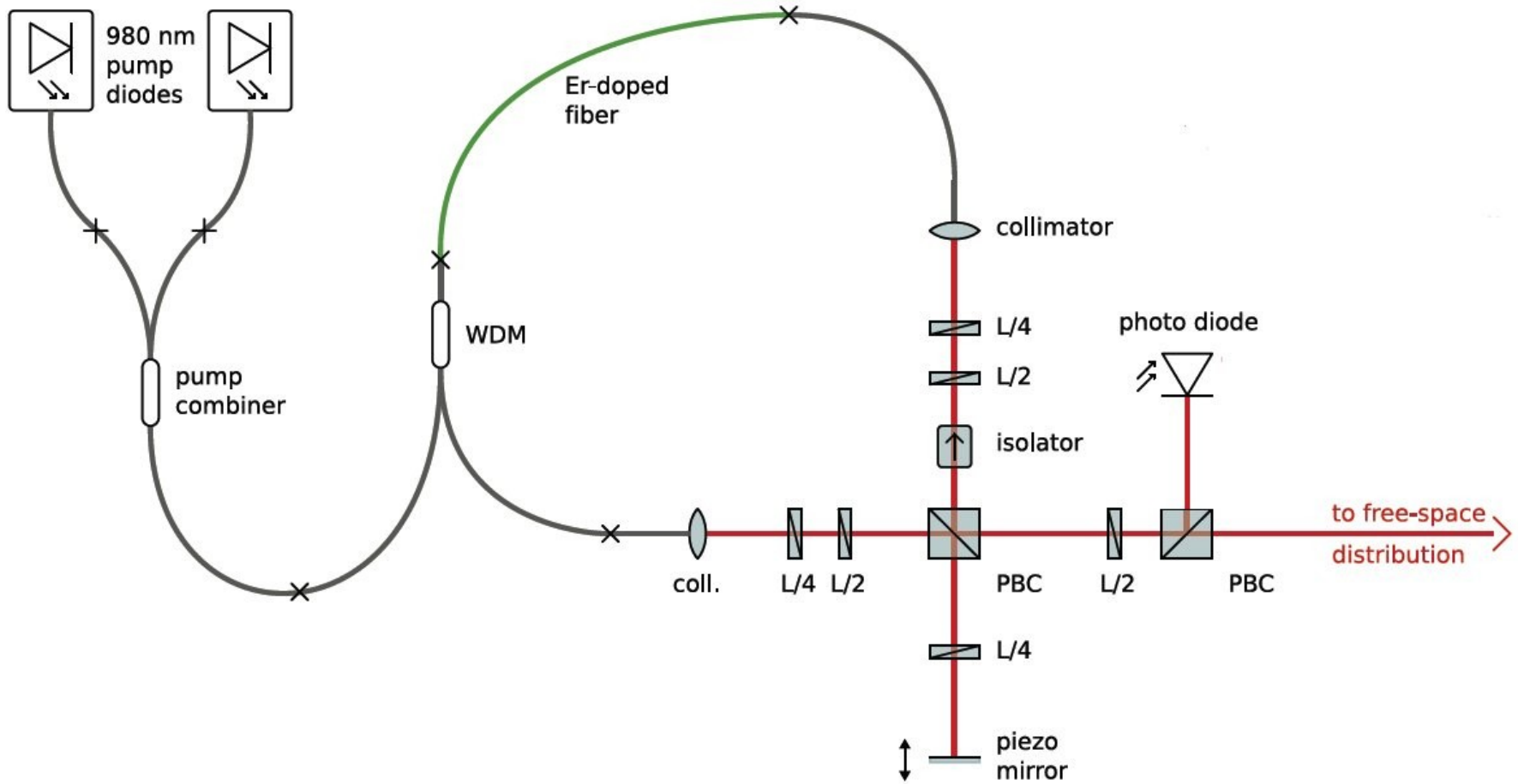
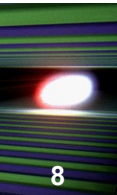
1st Generation MLO (Breadboard Version)



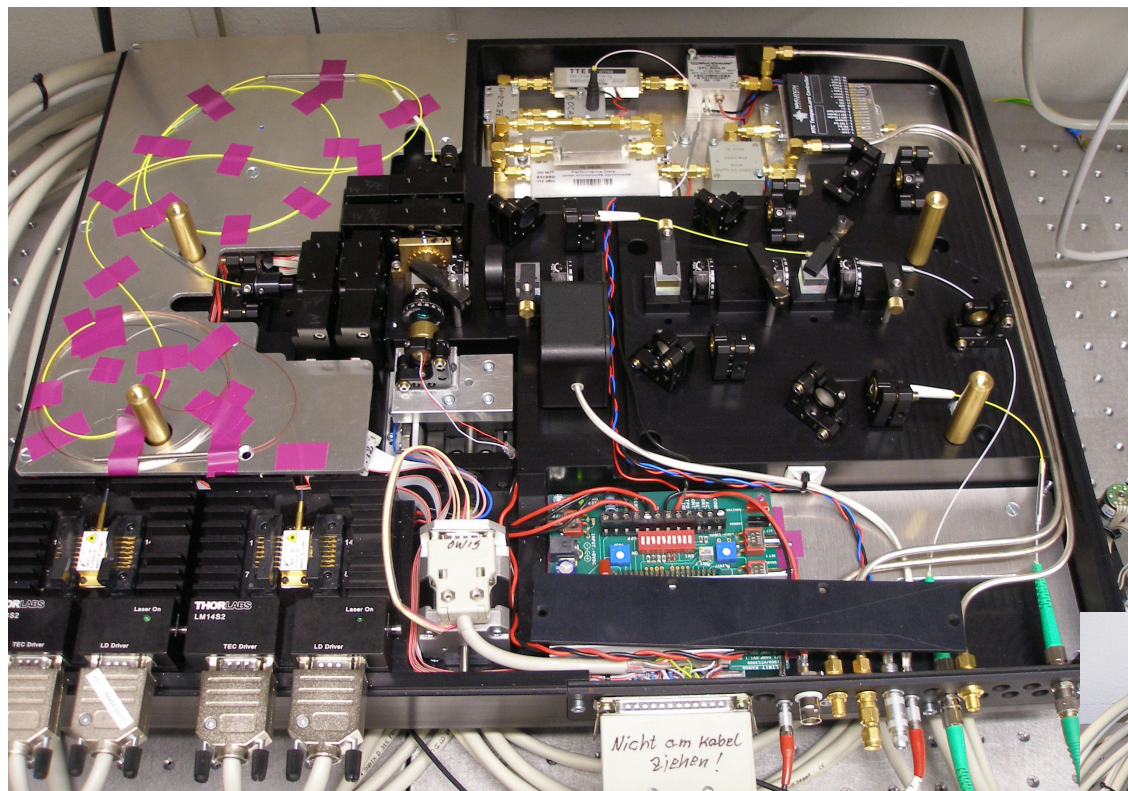
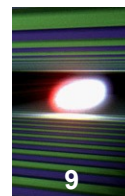
Original design:
J. Chen et. al., Opt. Lett. **32**,
1566-1568 (2007)



F. Löhle



F. Löhle

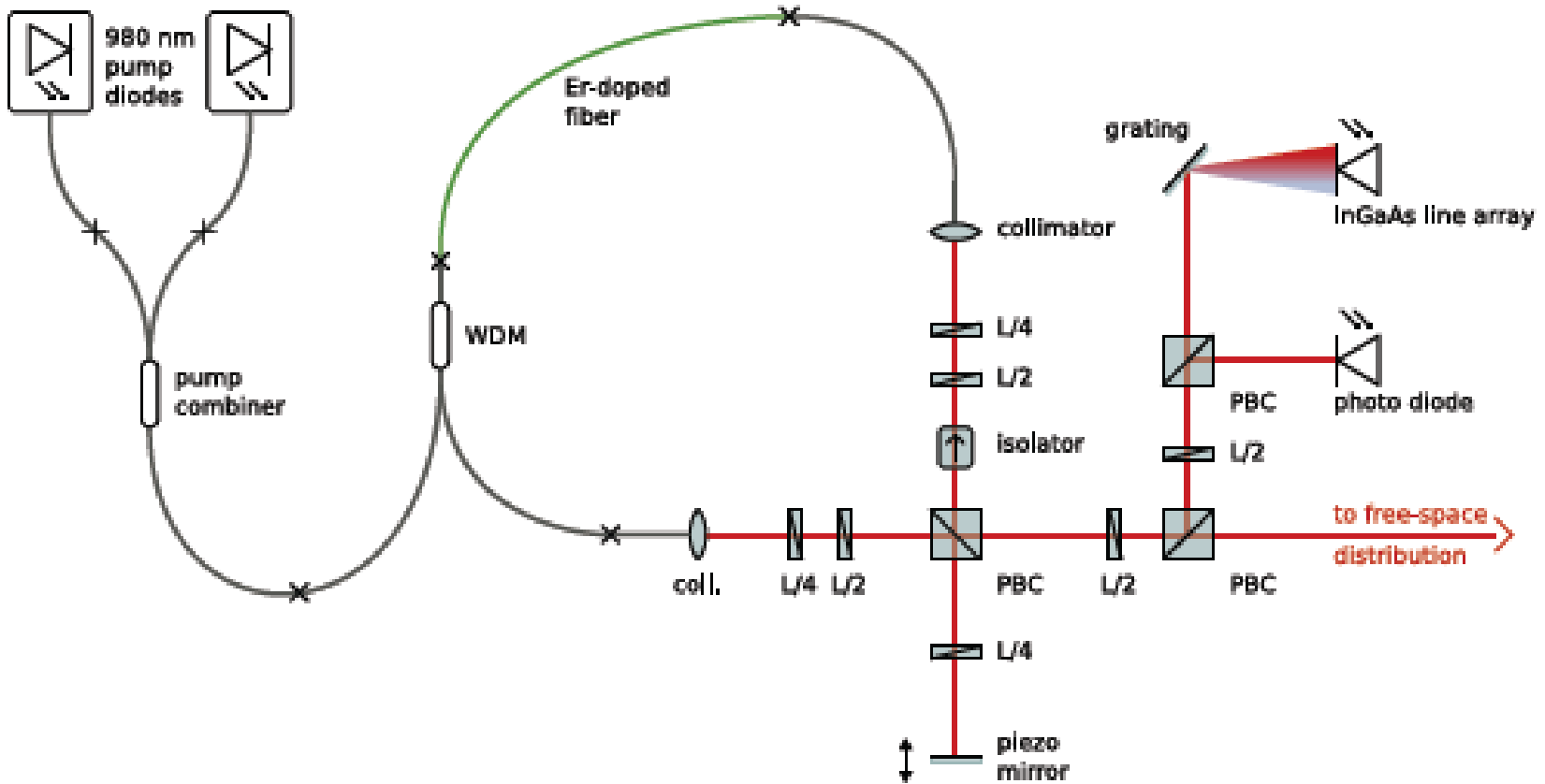
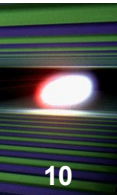


- Temp. Stabilization
 - Controller included
 - Variable Set point
- Stable Ground Plate
- Distribution included
- RF Electronic included
- Motorized Wave Plates

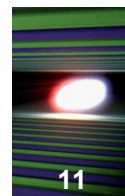


F. Löhli

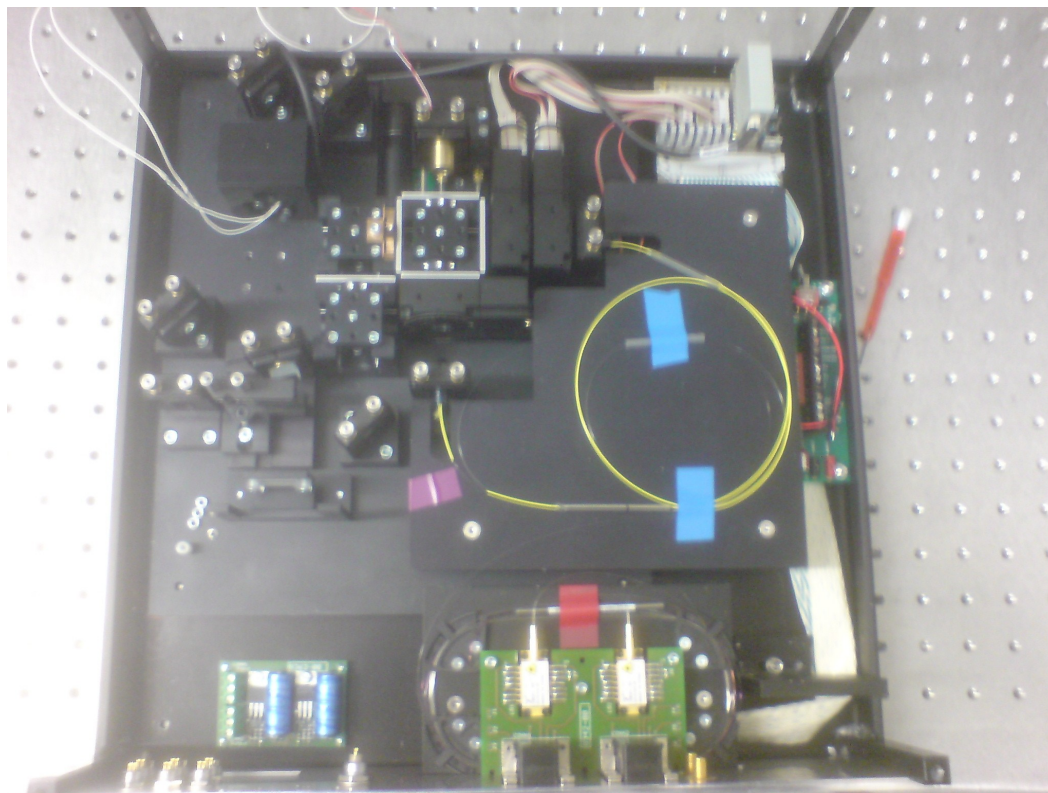
3rd Generation MLO



A. Winter



- Compact
- Modular Parts
- Lower Costs
- Online Spectrometer

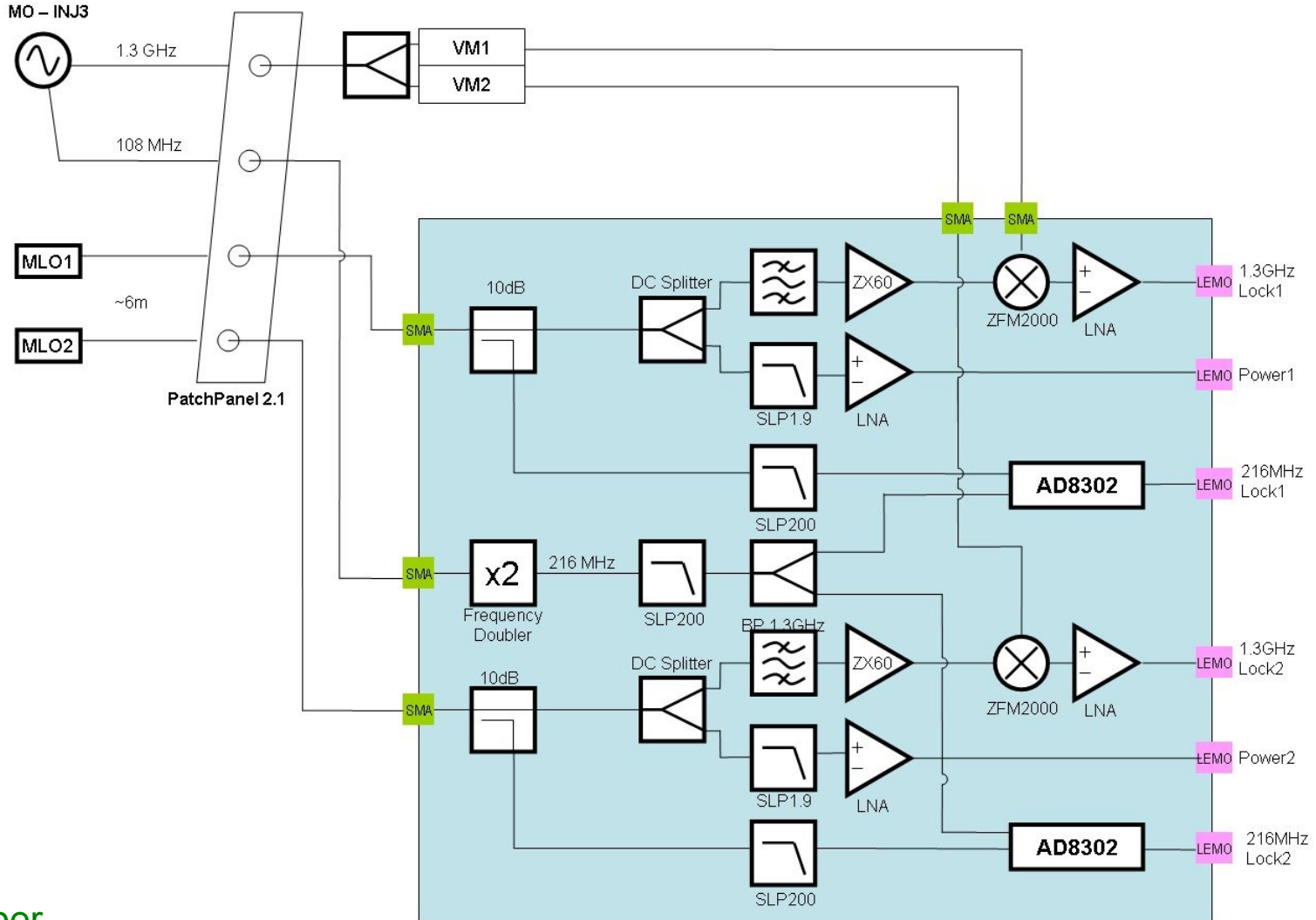
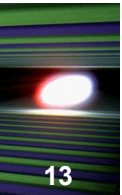


A. Winter

MLO Included Features Overview

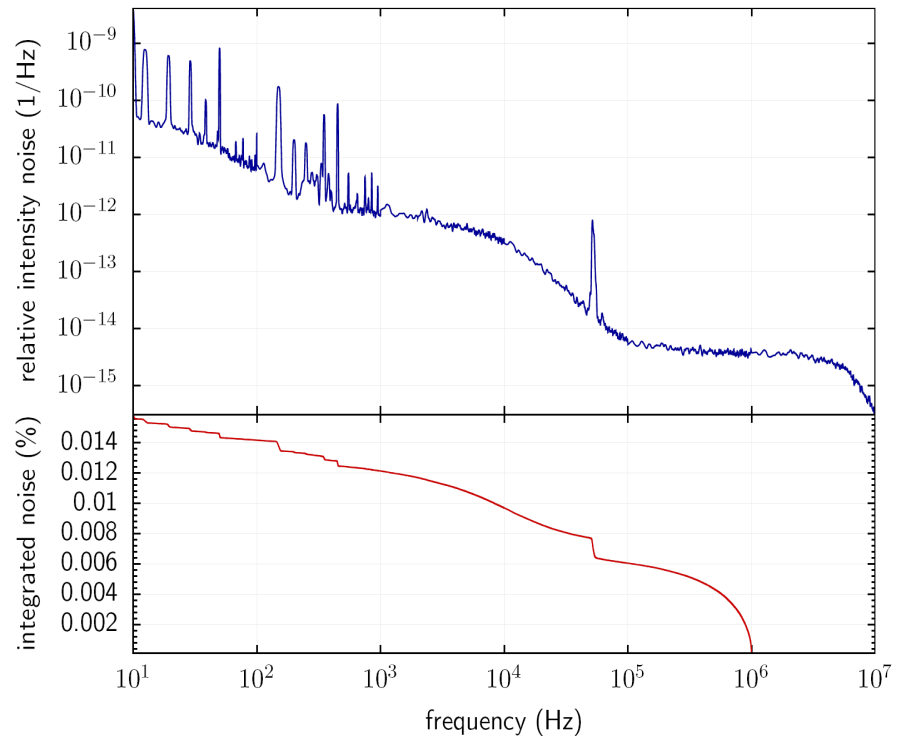
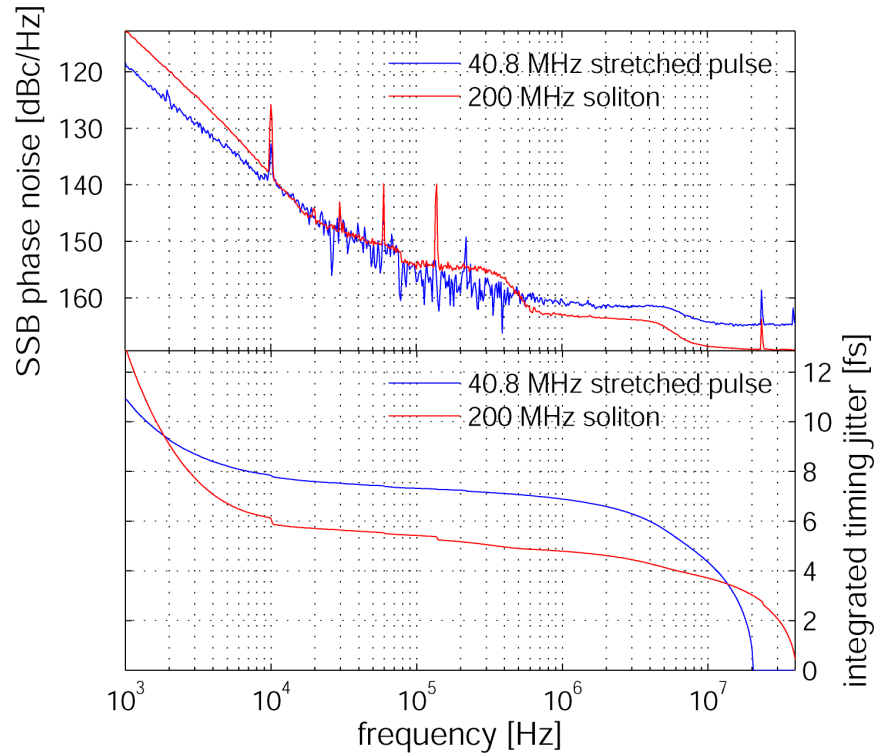
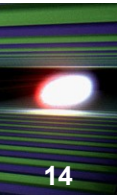
	1st Generation	2nd Generation	3rd Generation
Piezo	✓	✓	✓
Motorized Translation Stage	✓	✓	✓
Optical Monitor Output	✓	✓	✓
Electrical Monitor Output		✓	✓
Temperature Stabilization		✓	✓
Motorized Wave Plates		✓	✓
Modular Parts	✓		✓
RF Lock Electronic		✓	
Online Spectrometer			✓

RF Lock to Master Oscillator



M. Felber

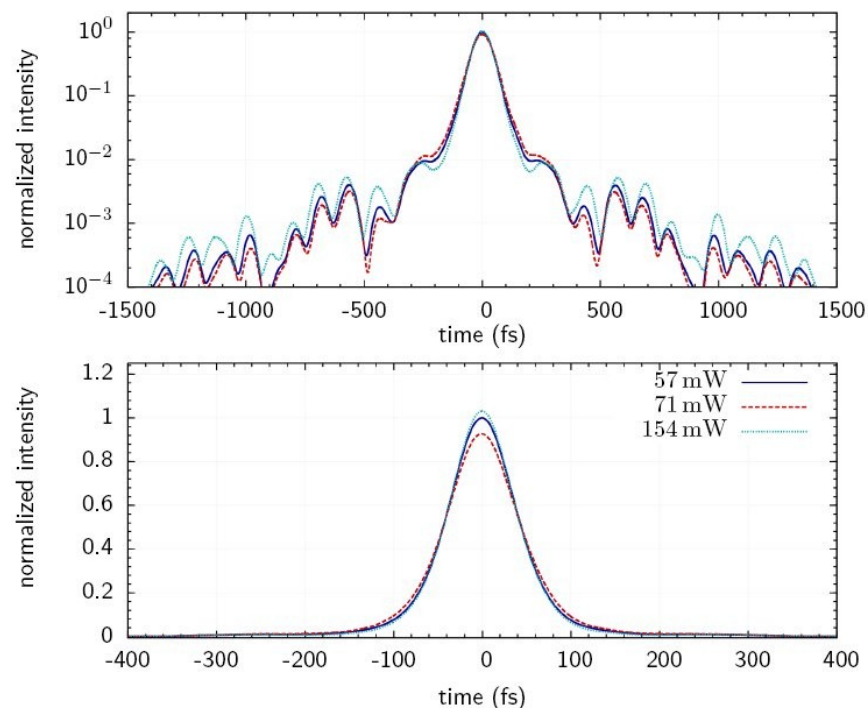
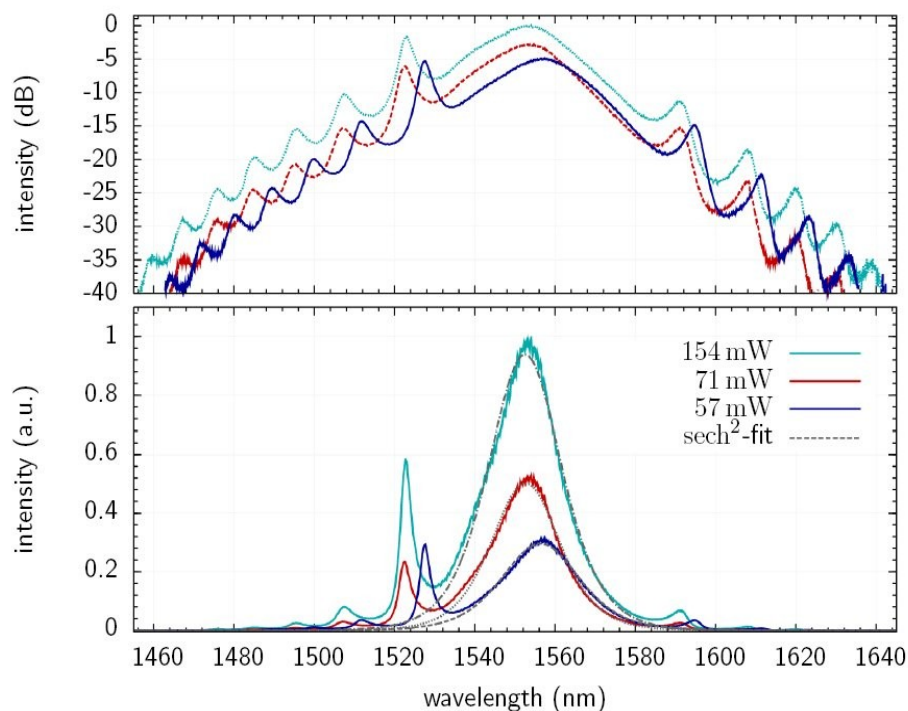
Measurements – Noise and Jitter



Integrated timing jitter:
< 6 fs [10kHz – 40 MHz]

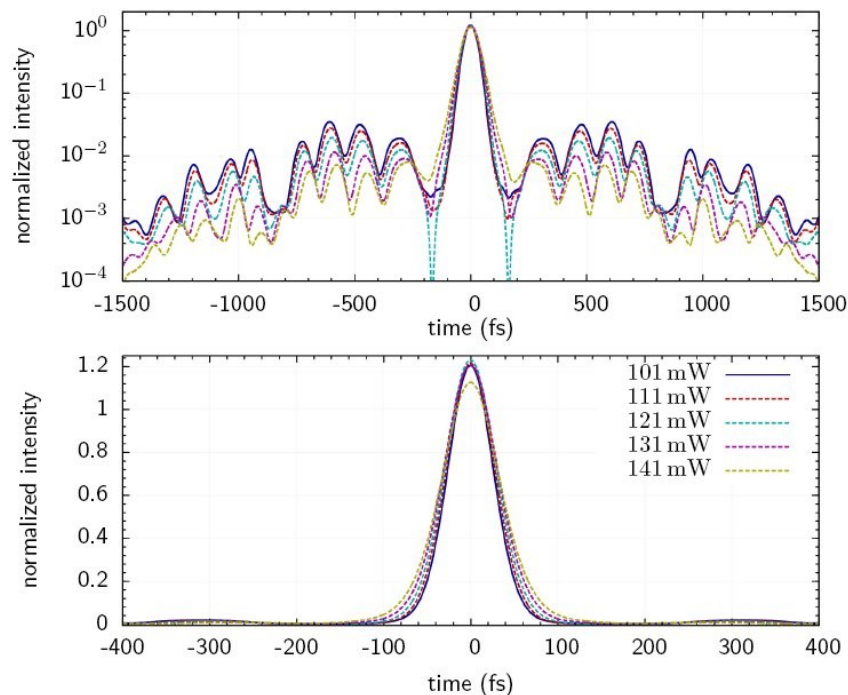
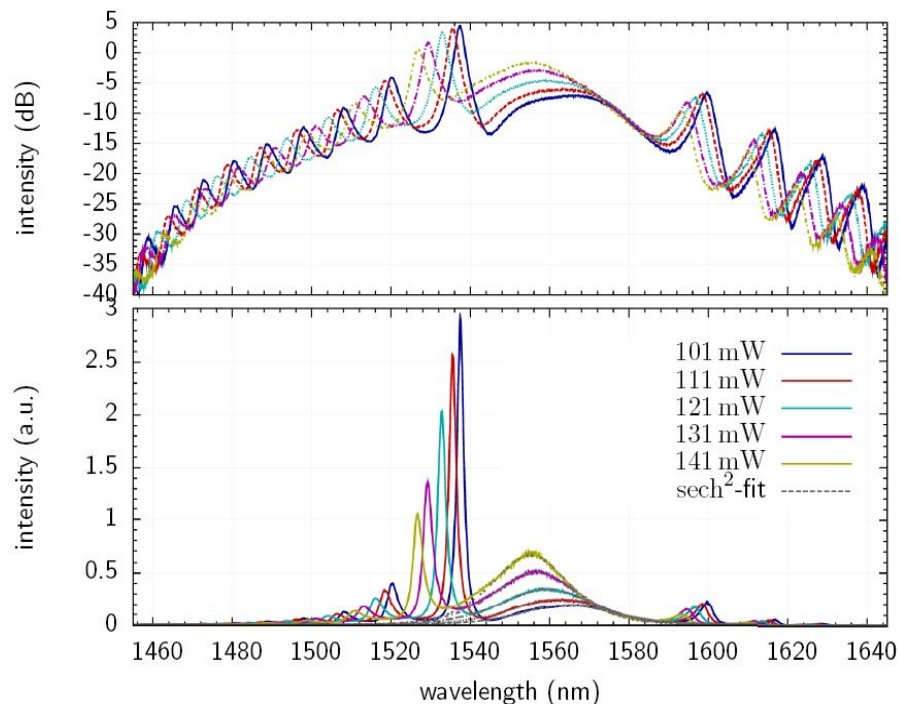
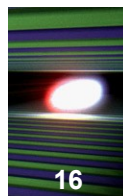
relative intensity noise:
0.016 % [10 Hz – 1MHz]

F. Löhle



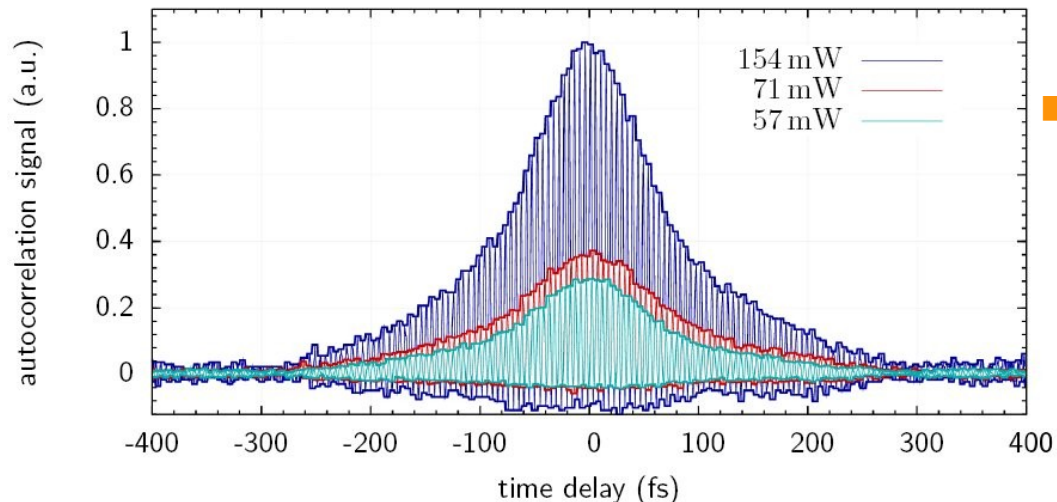
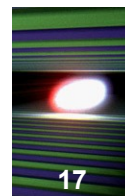
- For different Pump Laser Power Level
- Wave Plates optimized for maximum Output Power
- Similar Spectra / Shapes are Achievable

F. Löh



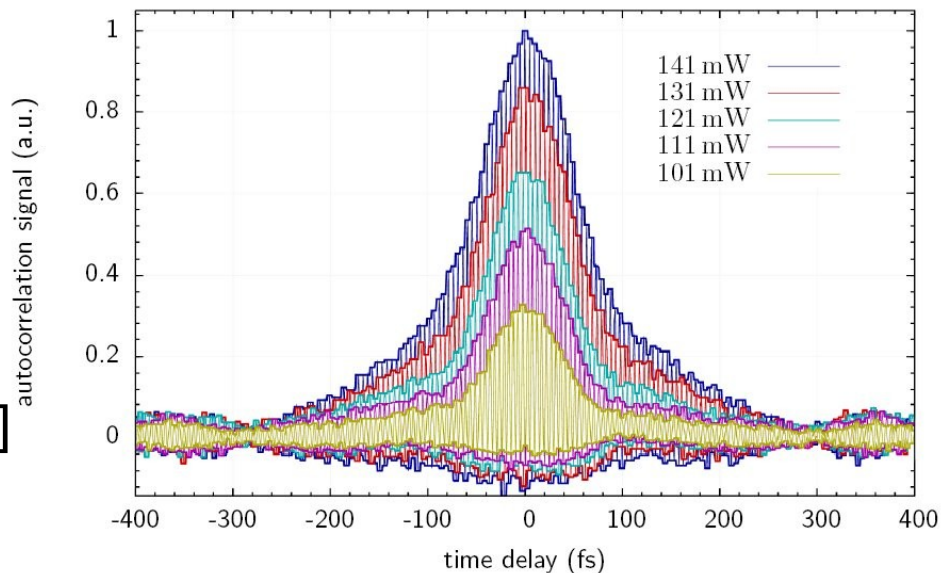
- For different Wave Plate Settings
- Constant Pump Laser Power of around 890mW

F. Löh



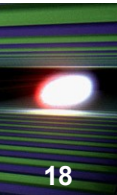
■ Different Output Power

- Different Wave Plate Settings
- Constant Pump Laser Power
- Pulse Width: 60 – 90 fs [FWHM] (depending on Configuration)

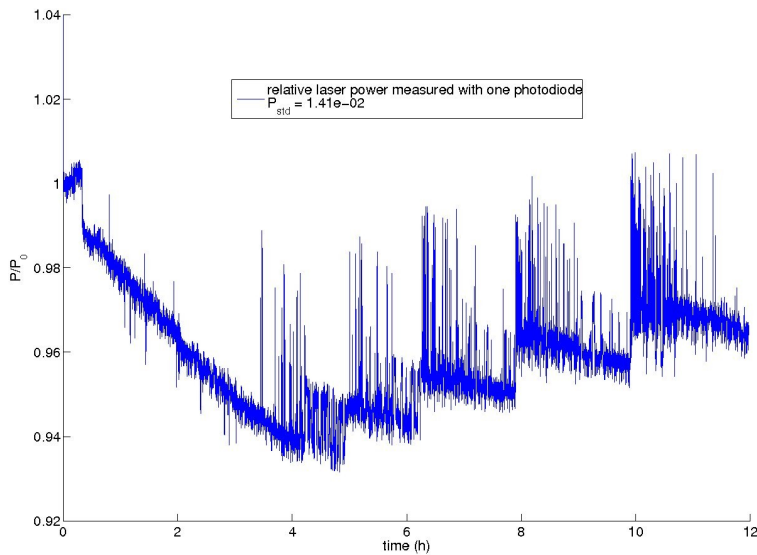


F. Löhle

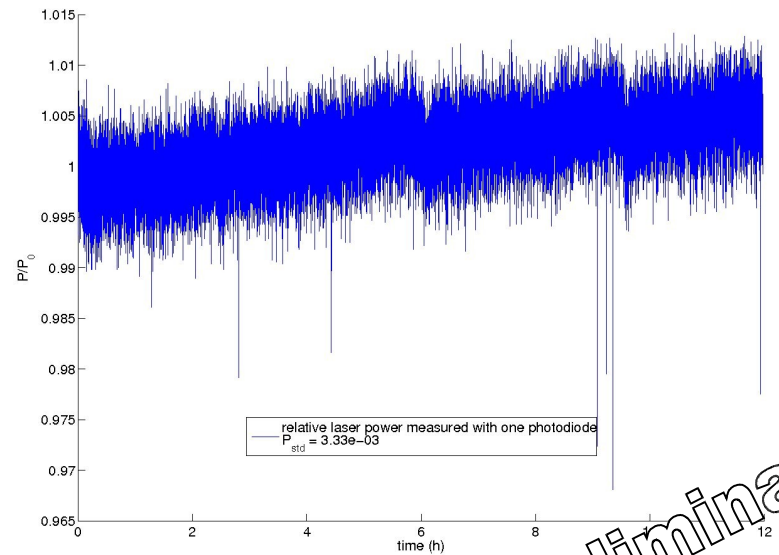
Measurements – Amplitude Stabilization



Without Feedback

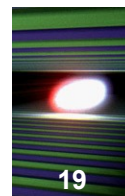


With Feedback

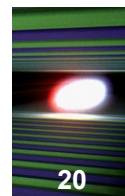


Preliminary

J. Zemella



- Piezo bends due to weight / torque → Alignment
- Make every Parts removable from the top
- Have enough degrees of Freedom
- Make the Ground Plate thick / stable enough
- A Modular Design could cause alignment problems
- Put the Shutter not before the RF Lock Monitor Port



- The MLO has a strong influence on the complete system
- Wave plate and pump power settings influence the optical spectrum
- A high precision diagnostic is needed to investigate the impacts
- In contrast to stretched pulse lasers, to achieve mode-locking wave plate settings have to be changed
- Different wave plate settings for minimum phase noise and maximum output power
- Questionable whether two identical MLOs could be set up such that switching has no impact

Thanks for your attention