

# The MBI Laser System

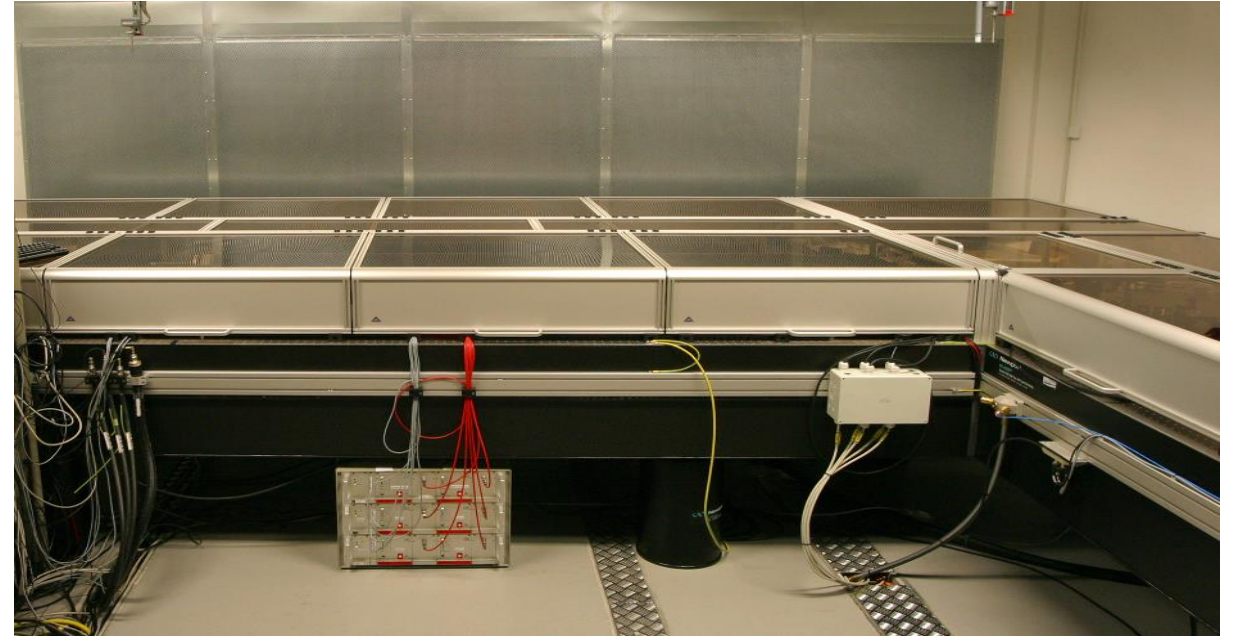
Teaching for the PITZ shift crew

Matthias Gross

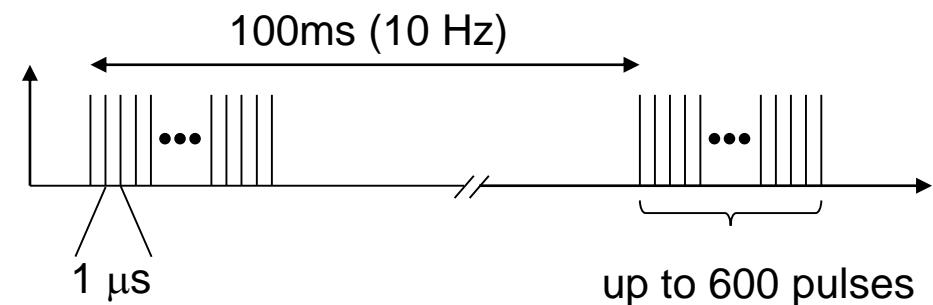
# Solid State Photocathode Laser at PITZ

Built and maintained by Max Born Institute

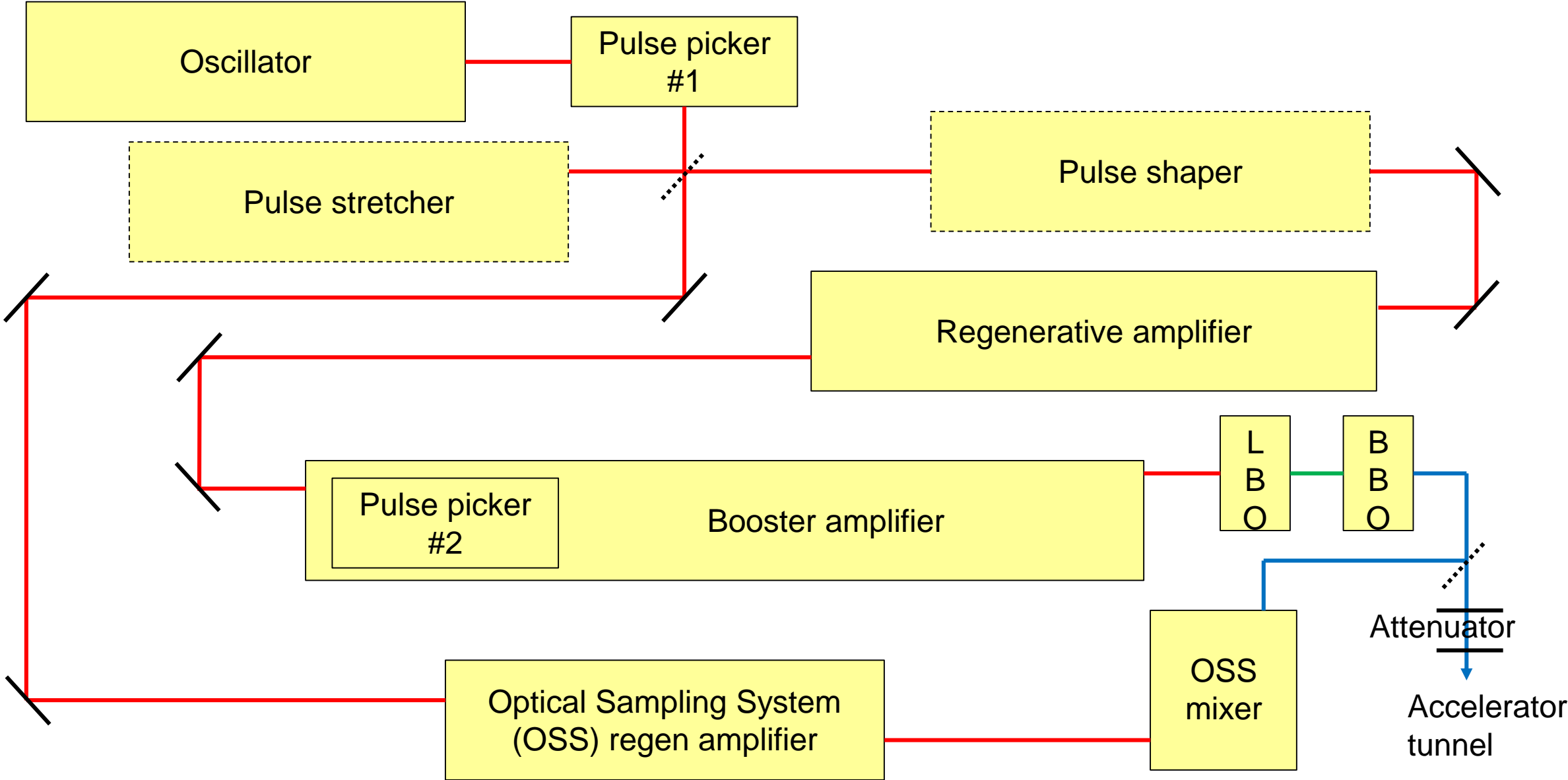
- Basic principle
  - Solid state: Yb:KGW oscillator, Yb:YAG amplifier, 2x frequency doubling
- Basic parameters
  - Wavelengths: 1030/515/257 nm
  - Pulse length:  $\approx 2 \dots 25$  ps
  - Pulse energy:  $< 5 \mu\text{J}$  in the UV
  - Repetition rate: 10 Hz (1 MHz in burst)
- Manufacturer
  - Max Born Institute, Berlin (custom product)
- Application
  - Photocathode laser



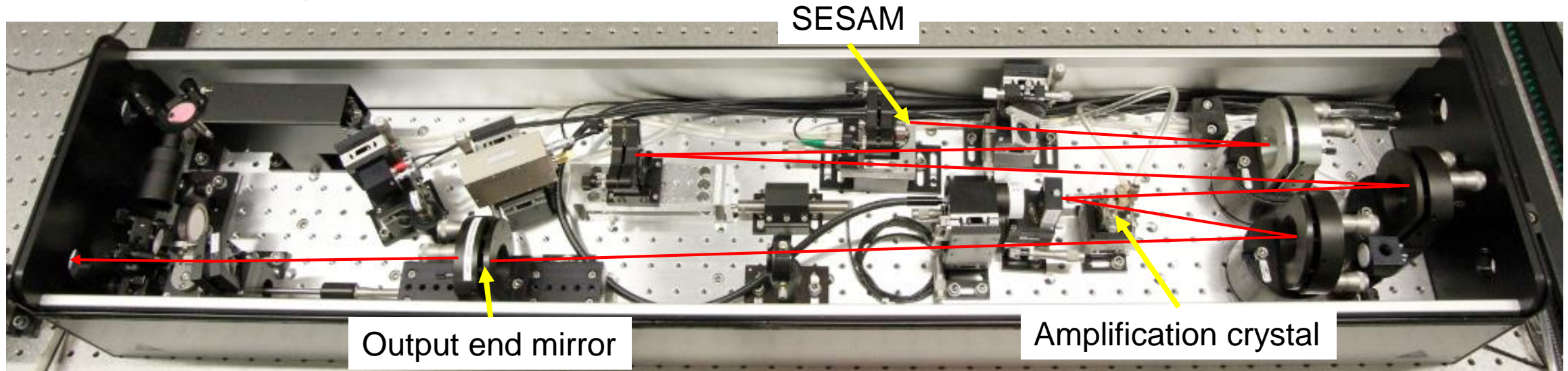
Laser pulse timing structure:



# Max Born Institute Laser - Setup

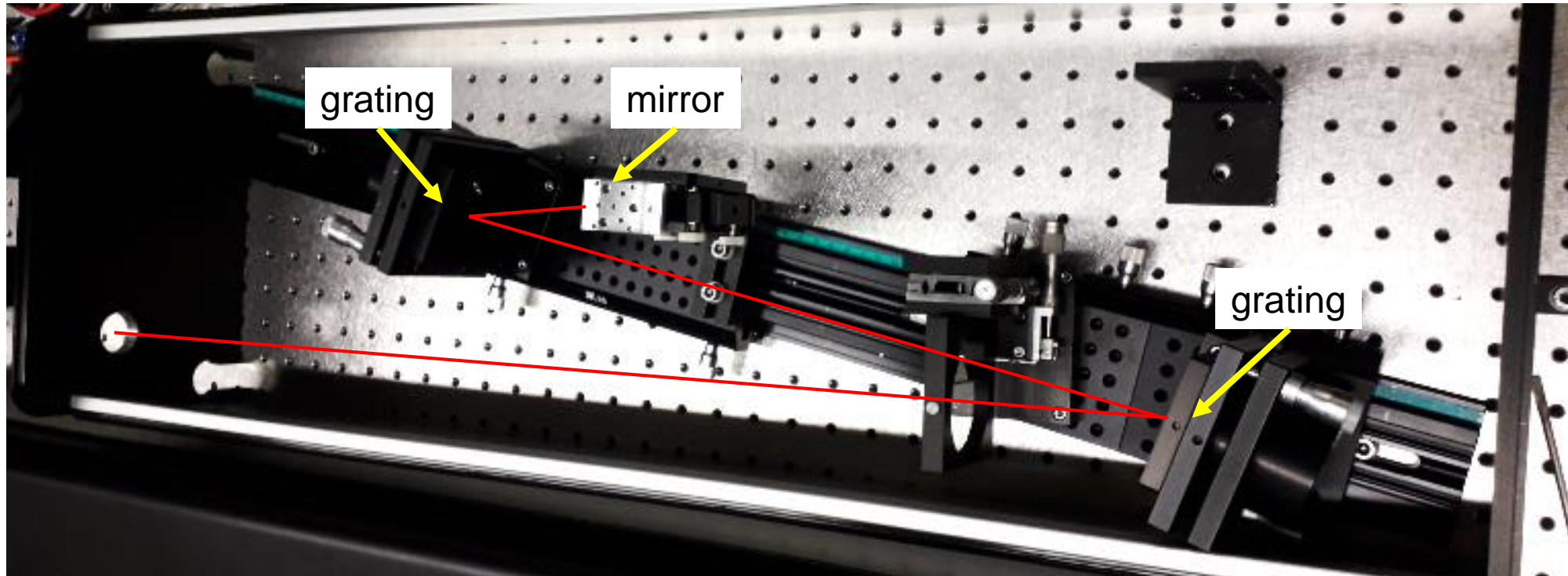


# MBI Laser - Oscillator



- Short ( $\approx 1$  ps) pulse generation with passive mode locking with SESAM (**S**emiconductor **S**aturable **A**bsorber **M**irror)
- Repetition frequency  $f_{osc}$  (54 MHz) is given by resonator length:  $f_{osc} = c/2L$  with  $L = 2.78$  m
- Pulse length inverse proportional to gain bandwidth:  $\tau_p \approx 1/\Delta\nu$
- Synchronized to PITZ master oscillator at 54 MHz and 1.3 GHz
- Output power: 100 mW (pulse energy: 2 nJ)
- Yb:KGW amplifier crystal  $\rightarrow$  center wavelength 1032nm

# MBI Laser - Pulse Stretcher

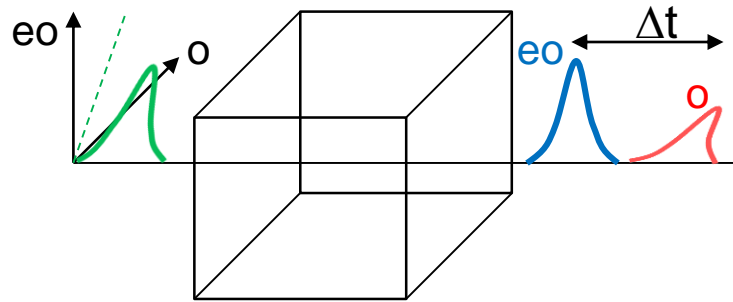


- Contains two reflective gratings; pulse stretching can be adjusted by changing the distance between the gratings.
- Output pulse has Gaussian profile and has energy chirp (same principle as in OPCPA).
- Current range of available FWHM pulse length:  $\sim 4$  ps to  $\sim 7$  ps.

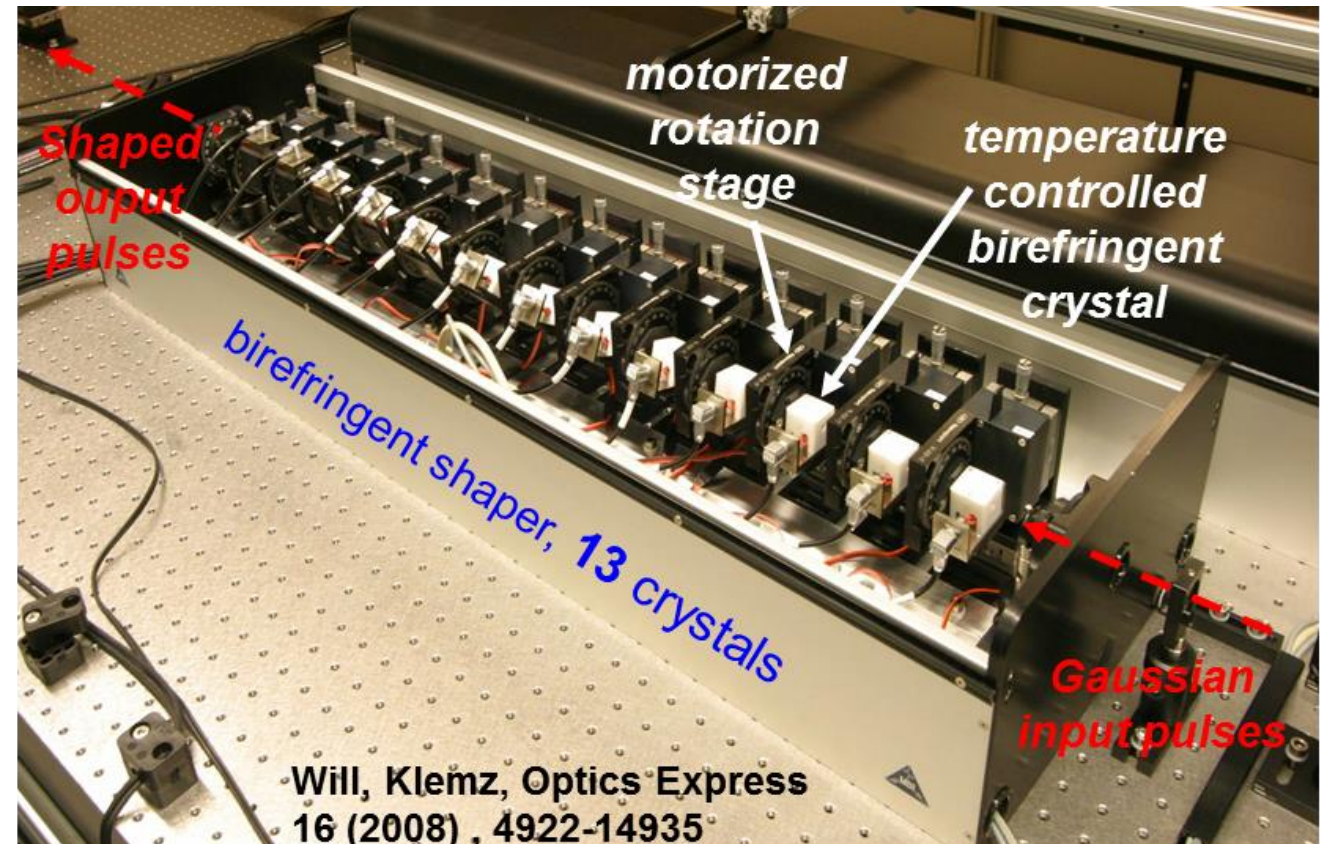
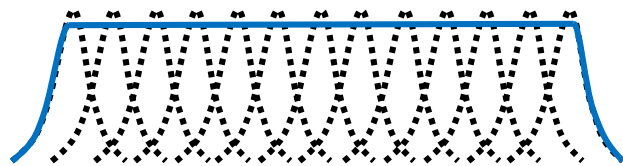
# MBI Laser - Pulse Shaper

- Contains 13 birefringent  $\text{YVO}_4$  crystals. Pulses are split according to polarization. Delay is given by crystal thickness; relative amplitude can be varied freely by adjusting relative angle between crystals

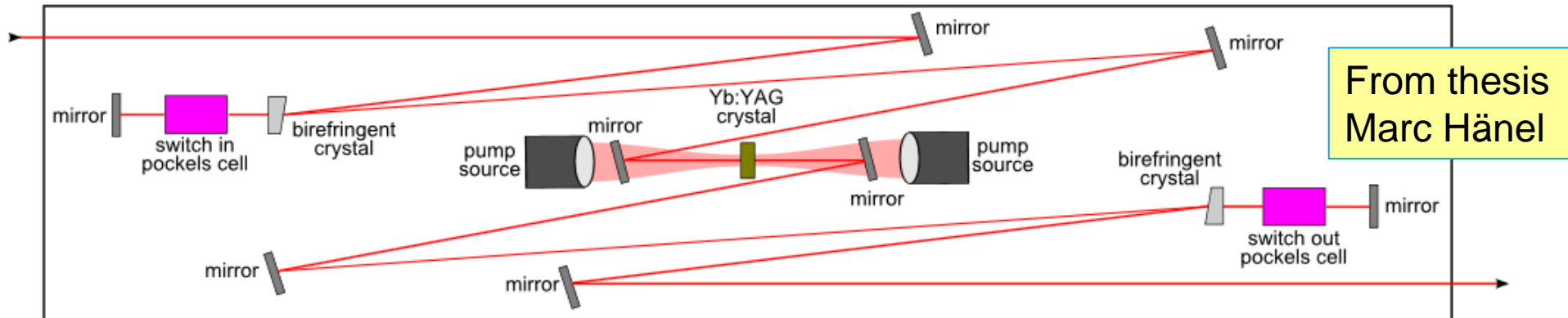
- Basic process



- Free pulse shaping, e.g. flat top

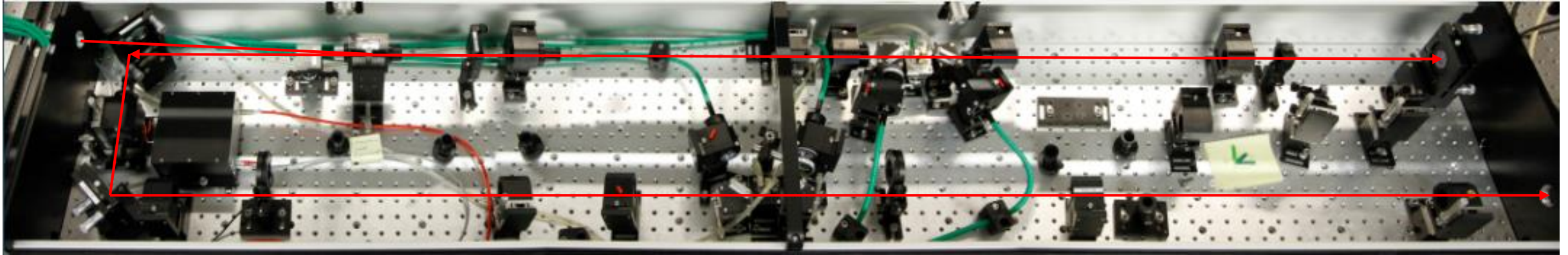


# MBI Laser – Regenerative Amplifier



- 15 round trips → pulse energy gain up to  $\approx 100,000$
- Yb:YAG amplifier crystal → new center wavelength: 1030 nm
- Option: stretch pulse length from 2 ps up to  $\approx 12$  ps
  - Use Lyot filter(s) together with polarizer
  - Polarization rotation dispersion → reduce bandwidth → increase pulse length (pulse is bandwidth limited)

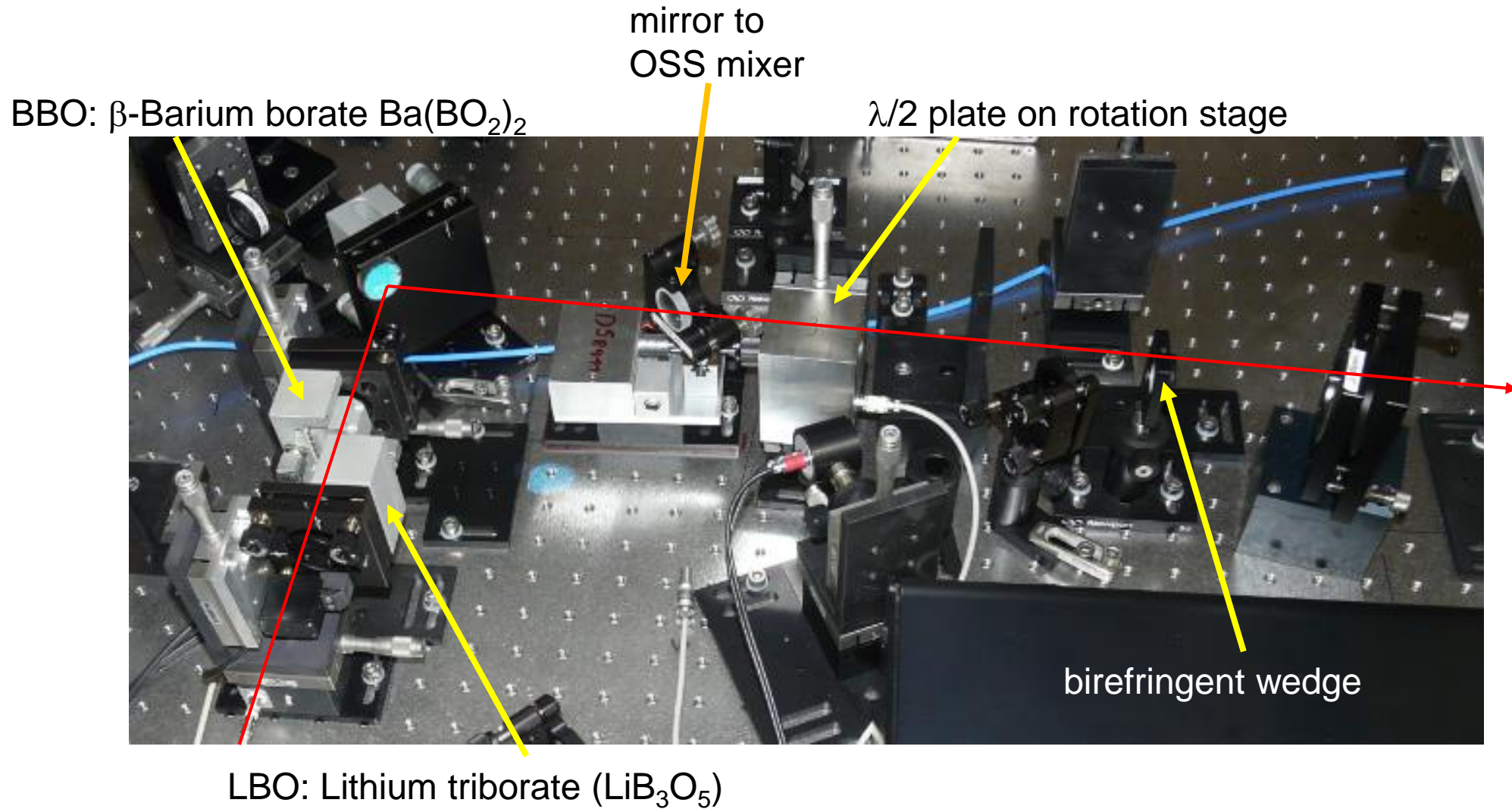
# MBI Laser – Booster Amplifier with Pulse Picker



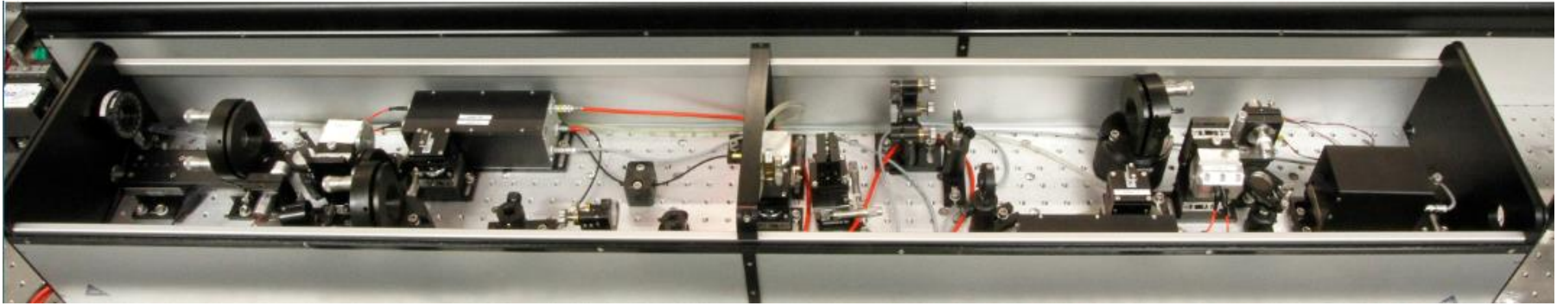
- Double pass amplifier
  - $\approx 4x$  amplification
  - Pulse guiding with  $\lambda/2$  waveplate / Faraday rotator / birefringent wedge
- Pulse picker: Pockels cell
  - Definition of laser pulse train length
- Booster amplifier
  - $\approx 2x$  amplification



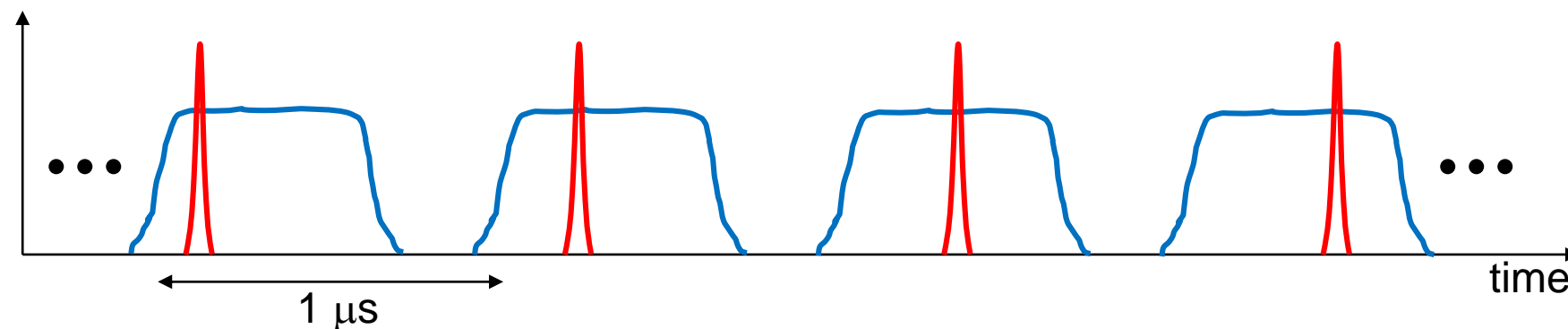
# MBI Laser – IR to UV Conversion + Attenuator



# MBI Laser – Optical Sampling System (OSS)

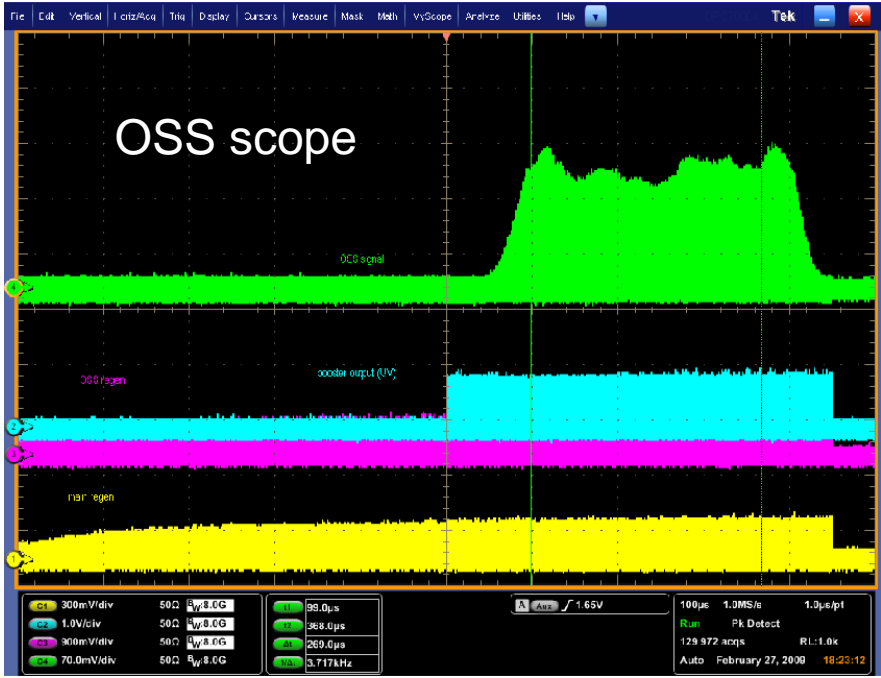


- Regenerative amplifier – same functionality as in the main laser path
- Specialty: one end mirror is oscillating ‘flying mirror’, mounted on voice coil → time scan



# MBI Laser – OSS Mixer

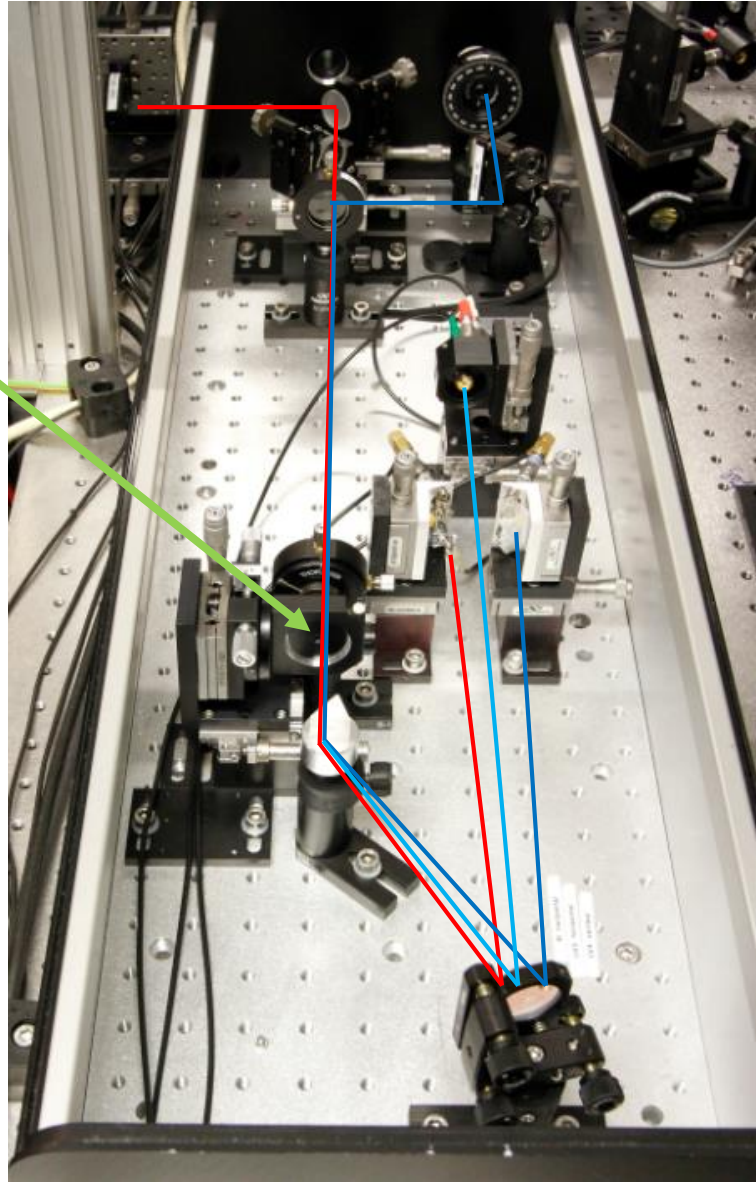
- Spatial overlap of IR and UV pulses with dichroic mirror
- Frequency conversion in BBO crystal: difference frequency generation (DFG)
- Spatial separation with prism
- Detection with 3 fast photo diodes



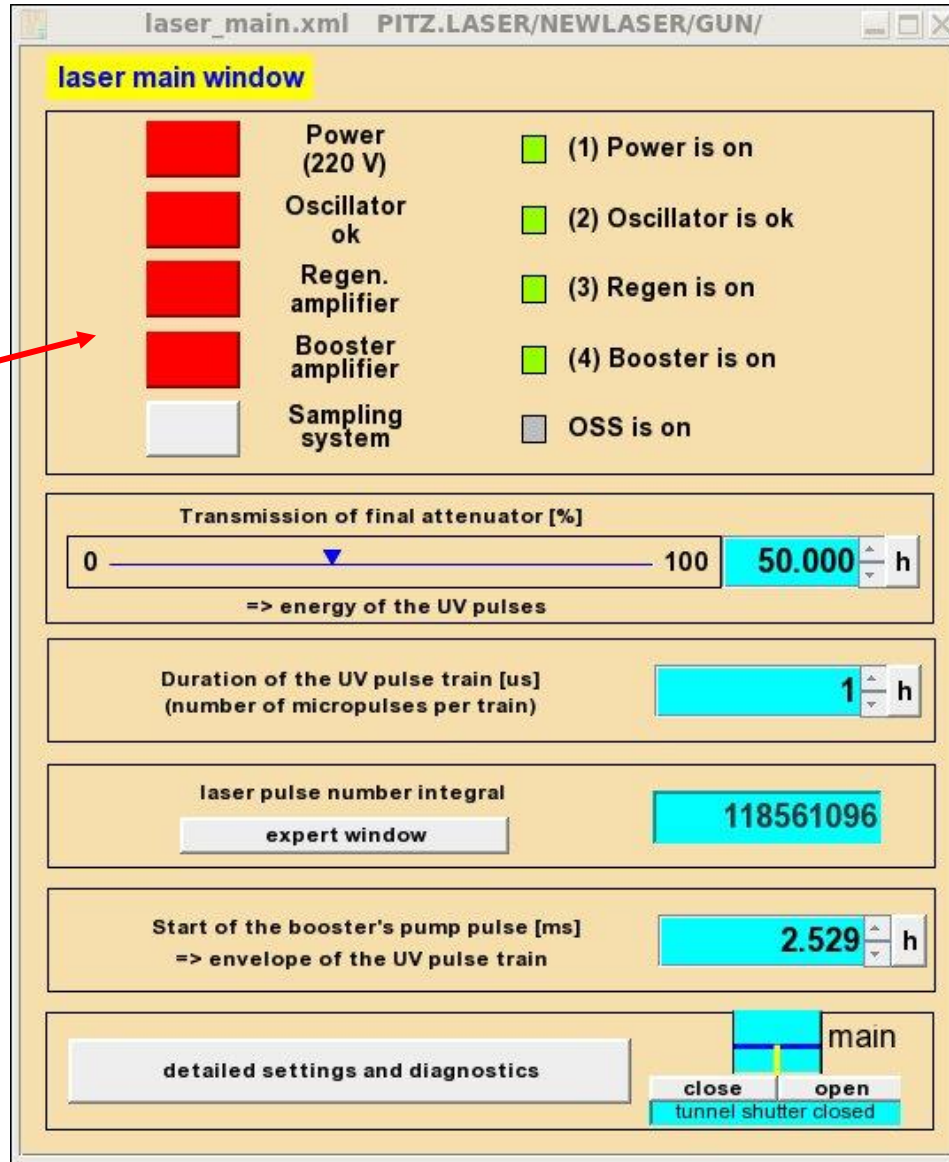
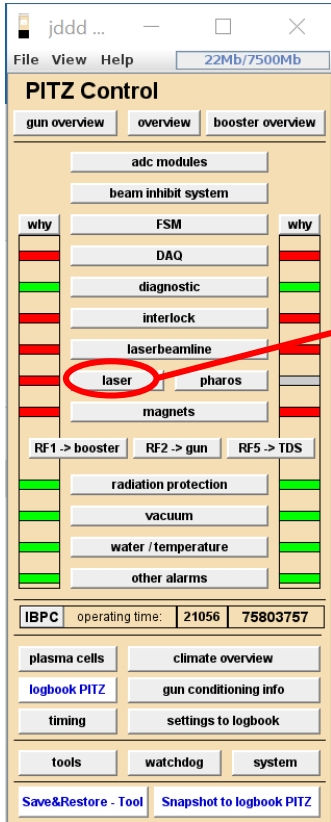
DFG

UV

IR



# MBI Laser GUI



Switching laser on/off  
 Red: active buttons  
 Green: status buttons

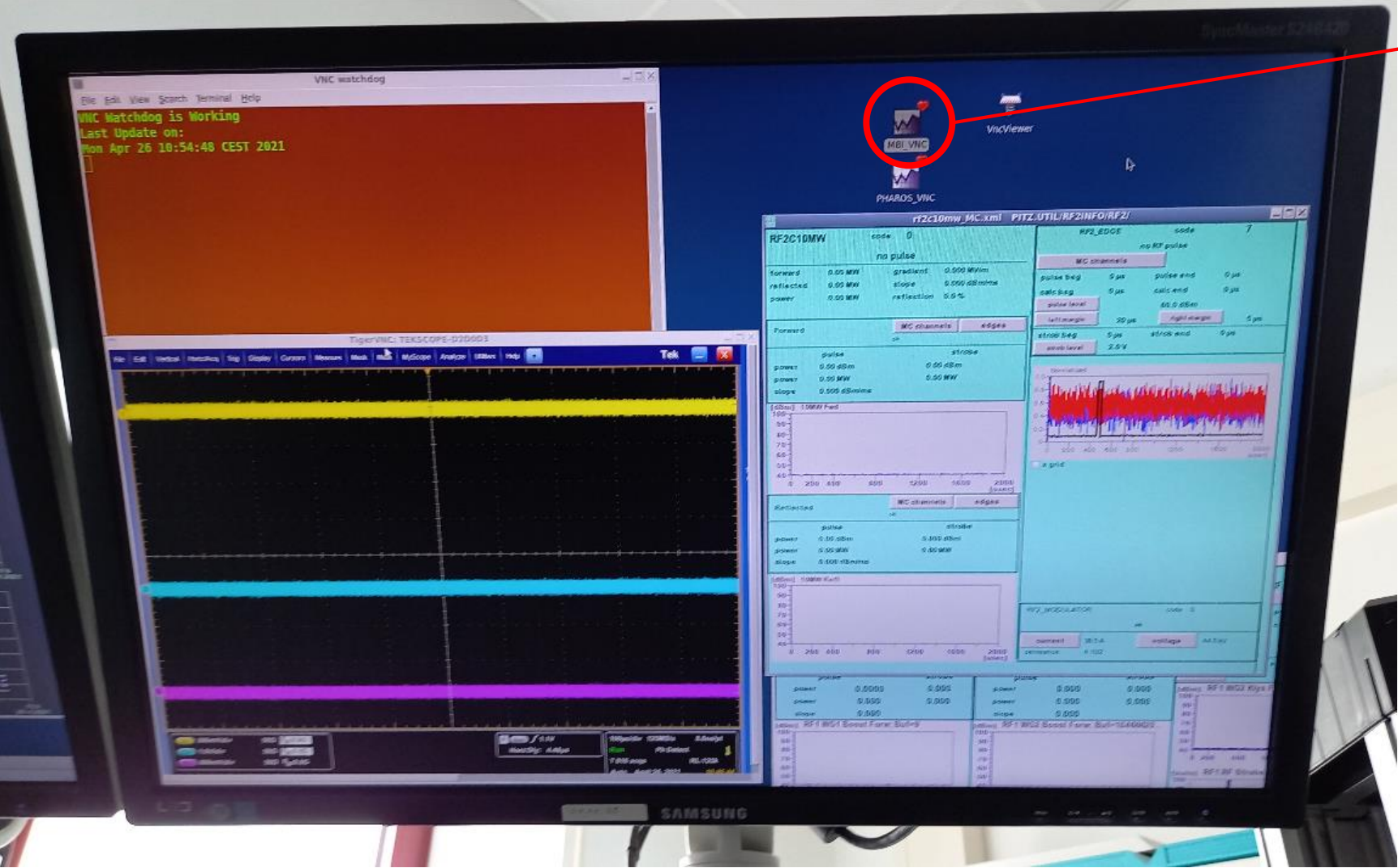
Laser transmission  $0\% \leq LT \leq 100\%$   
 Nearly linear (depends on calibration)  
 There is optical energy at 0% (leakage)

Typical max. # of pulses: 100 (if needed up to 600)

Expert adjustments, not needed for shift crew  
 except tunnel shutter

# Status screen in control room

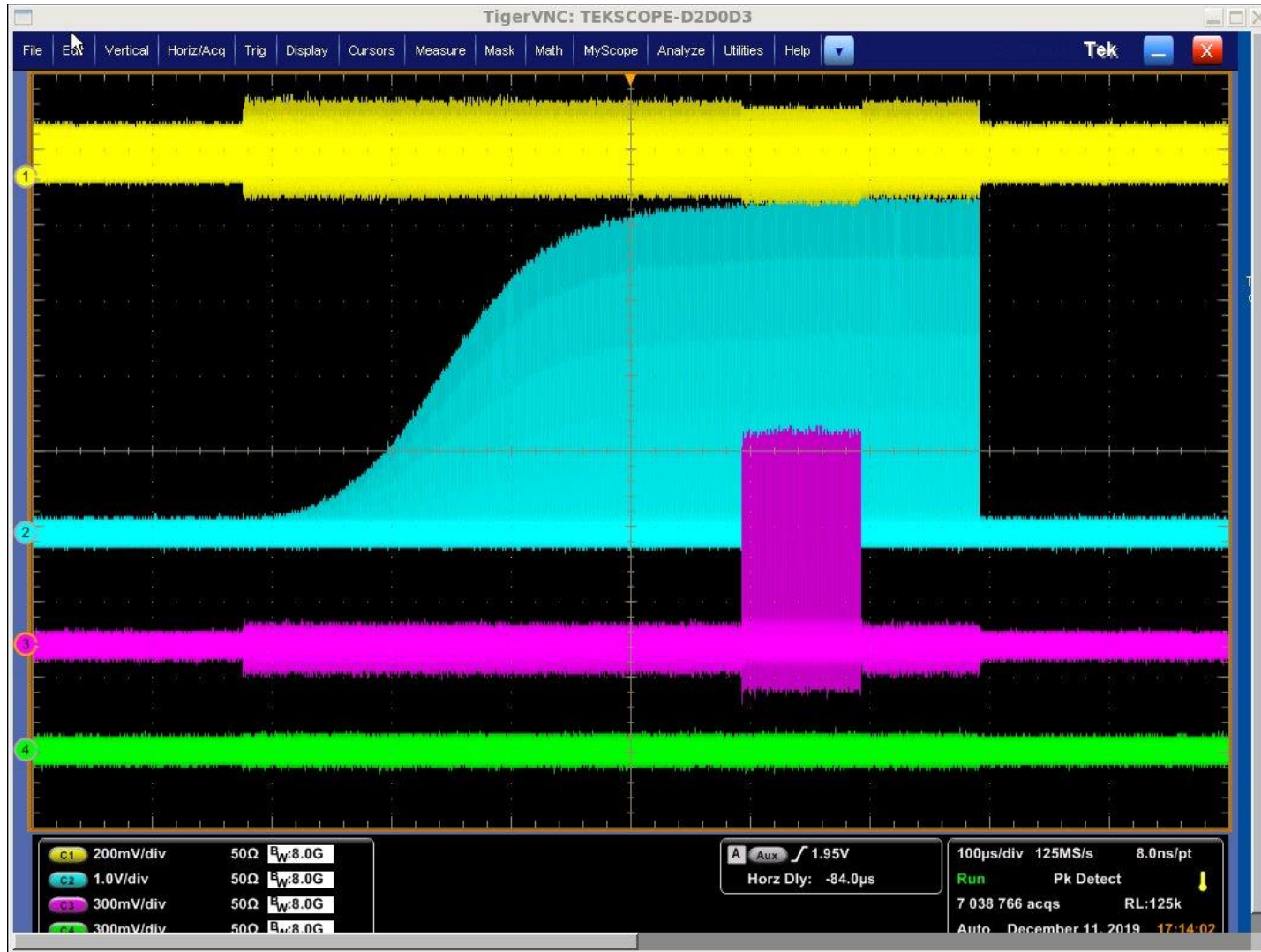
Typically on upper right screen



**MBL\_VNC**

- VNC connection to laser scope
- Only on this computer: watchdog to automatically restore connection since it is lost regularly

# Typical Laser Scope Picture



Oscillator

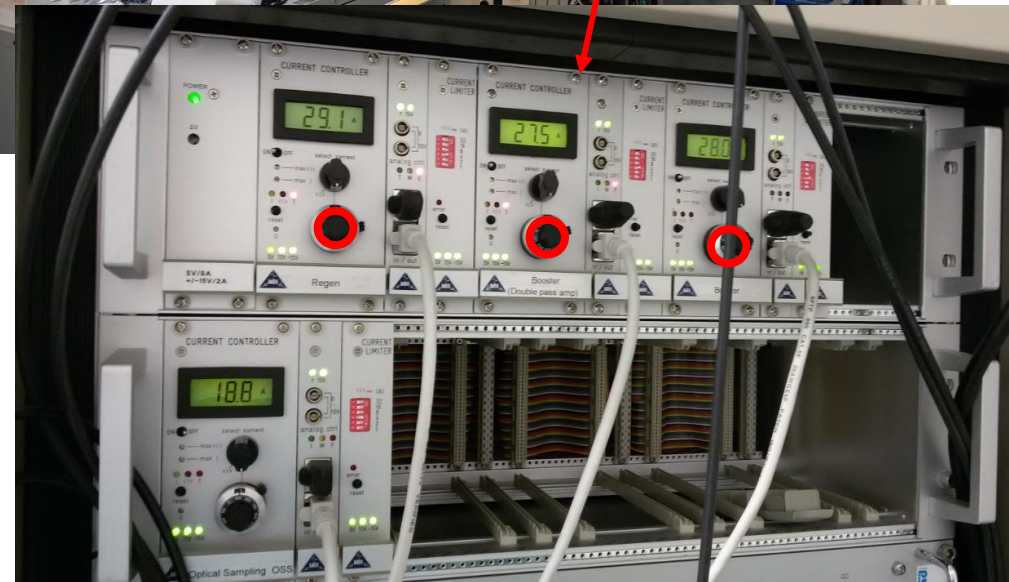
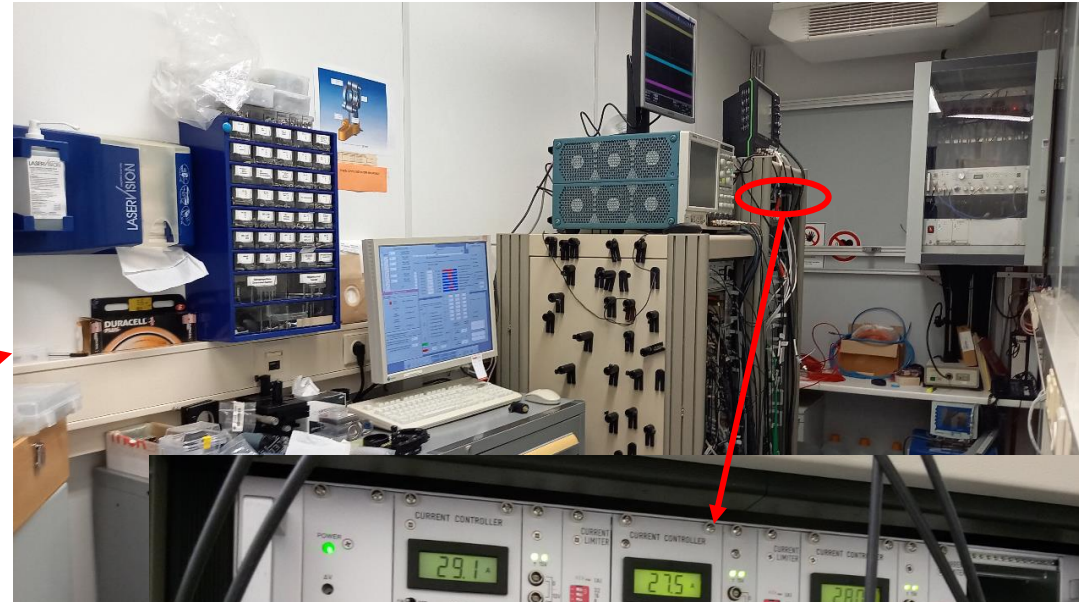
Regenerative amplifier

UV output

OSS

# Pump diode current control

Amplifier crystals are pumped with cw laser diodes via optical fiber



Do not change without advice from laser experts!

# Contact Laser on-call, if...

...or other severe problems

The screenshot shows the 'laser\_main.xml' window with the following controls:

- Power (220 V):**  (1) Power is on
- Oscillator ok:**  (2) Oscillator is ok
- Regen. amplifier:**  (3) Regen is on
- Booster amplifier:**  (4) Booster is on
- Sampling system:**  OSS is on

Transmission of final attenuator [%]: 0 to 100 slider, labeled => energy of the UV pulses.

Duration of the UV pulse train [us] (number of micropulses per train): [Slider]

laser pulse number integral: 33

Start of the booster's pump pulse [ms] => envelope of the UV pulse train: [Slider]

Buttons: expert window, detailed settings and diagnostics, close, tunnel s...

The screenshot shows the 'AVIR: Video 1 lens' software interface with a 2D image of a laser spot and a 3D plot. The 2D image has a red spot on a blue background. The 3D plot shows a blue sphere with a red spot. The interface includes a toolbar with options like xScale, yScale, and Normalization.

The screenshot shows the 'TekScope-D2D03' oscilloscope interface. The main display shows a yellow waveform at the top and a cyan waveform below it. The interface includes a menu bar (File, Edit, Vertical, Horiz/Acq, Trig, Display, Cursors, Measure, Mask, Math, MyScope, Analyze, Utilities, Help) and a status bar at the bottom with settings like 187µs, 290µs, 103µs, 550mV, 100µs/div, 125MS/s, 8.0ns/pt, 81 626 acqs, and RL:125k.