The MBI Laser System

Teaching for the PITZ shift crew

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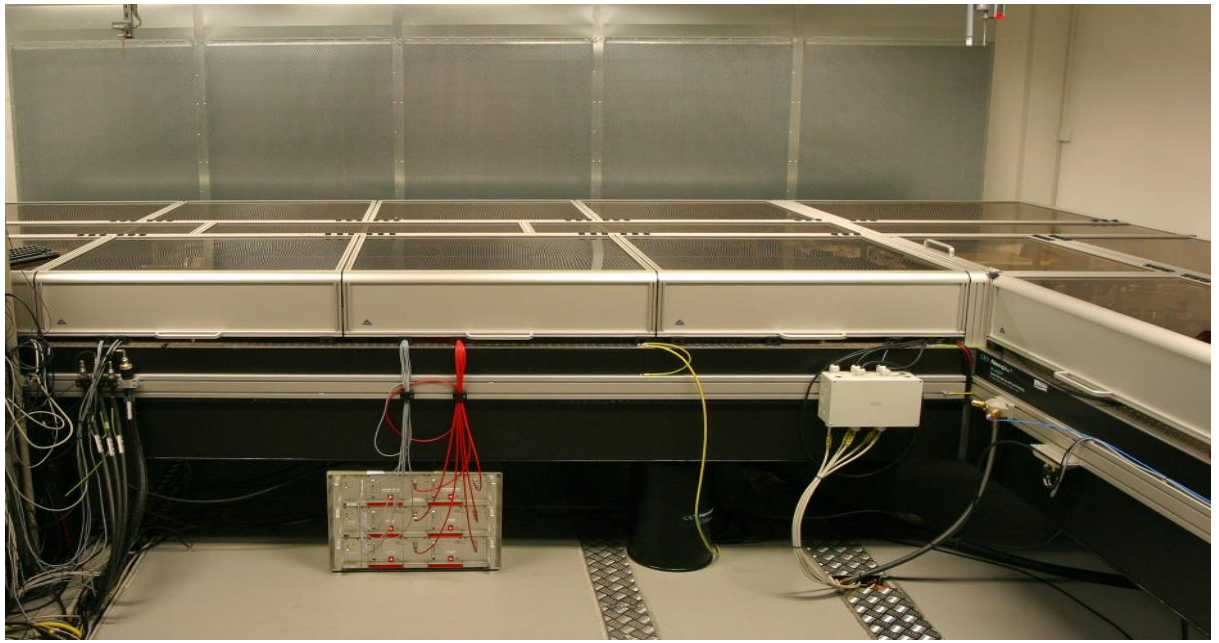
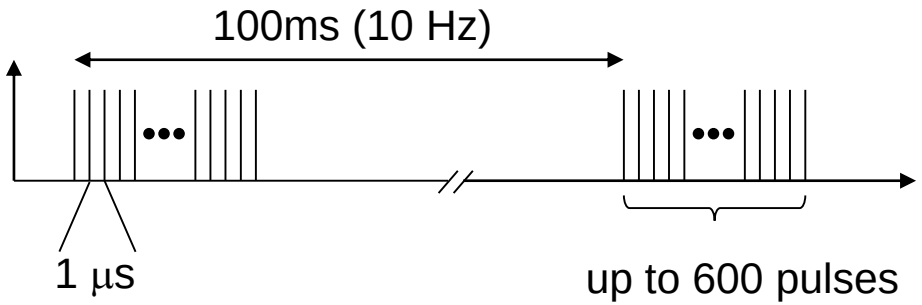
Solid State Photocathode Laser at PITZ

Built and maintained by Max Born Institute

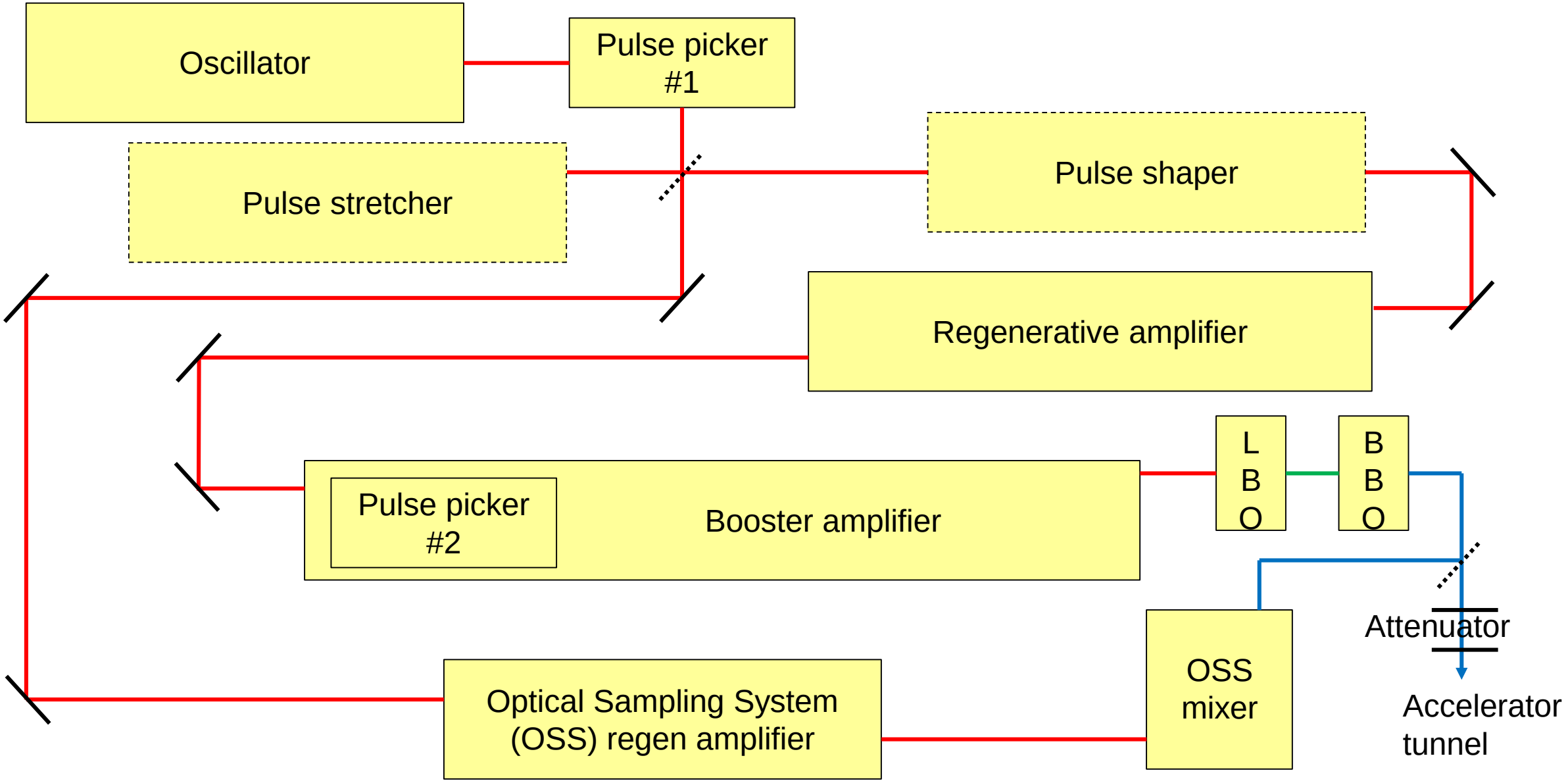
- Basic principle
  - Solid state: Yb:KGW oscillator, Yb:YAG amplifier, 2x frequency doubling
- Basic parameters
  - Wavelengths: 1030/515/257 nm
  - Pulse length: ≈2…25 ps
  - Pulse energy: <5 µJ in the UV
  - Repetition rate: 10 Hz (1 MHz in burst)
- Manufacturer
  - Max Born Institute, Berlin (custom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



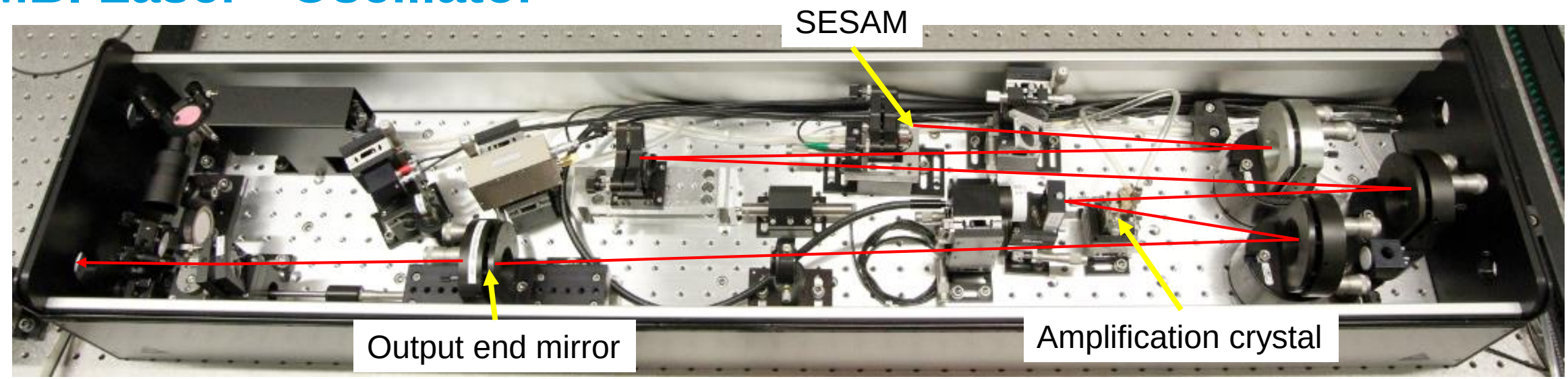
Laser pulse timing structure:



Max Born Institute Laser - Setup

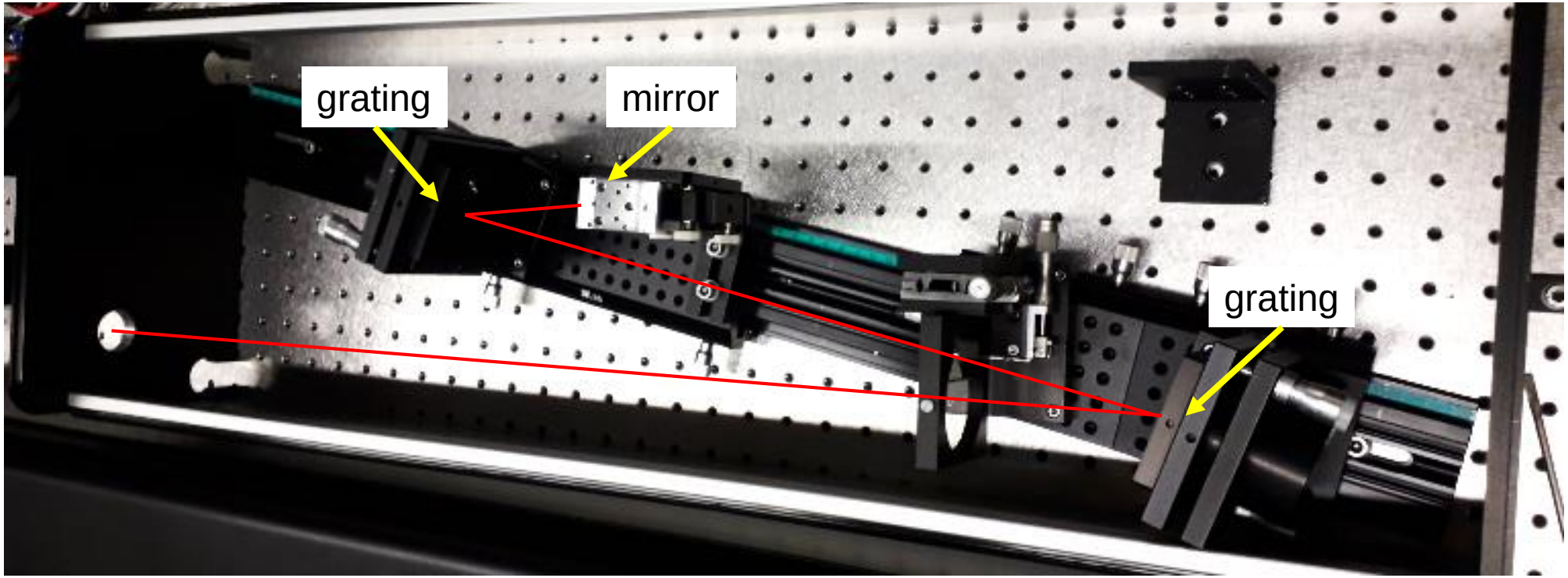


MBI Laser - Oscillator



- Short (≈1 ps) pulse generation with passive mode locking with SESAM (**SE**miconductor **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 → center wavelength 1032nm

MBI Laser - Pulse Stretcher

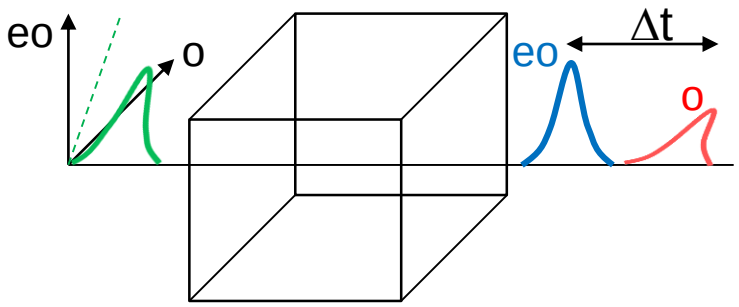


- Contains two reflective gratings; pulse stretching can be adjusted by changing the distance between the gratings.
- Output pulse has Gaussian profile and has energy chirp (same principle as in OPCPA).
- Current range of available FWHM pulse length: ~4 ps to ~7 ps.

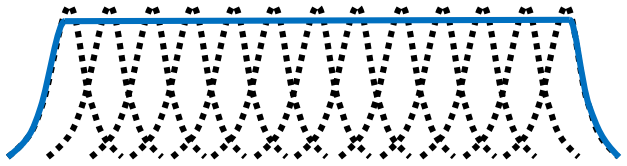
MBI Laser - Pulse Shaper

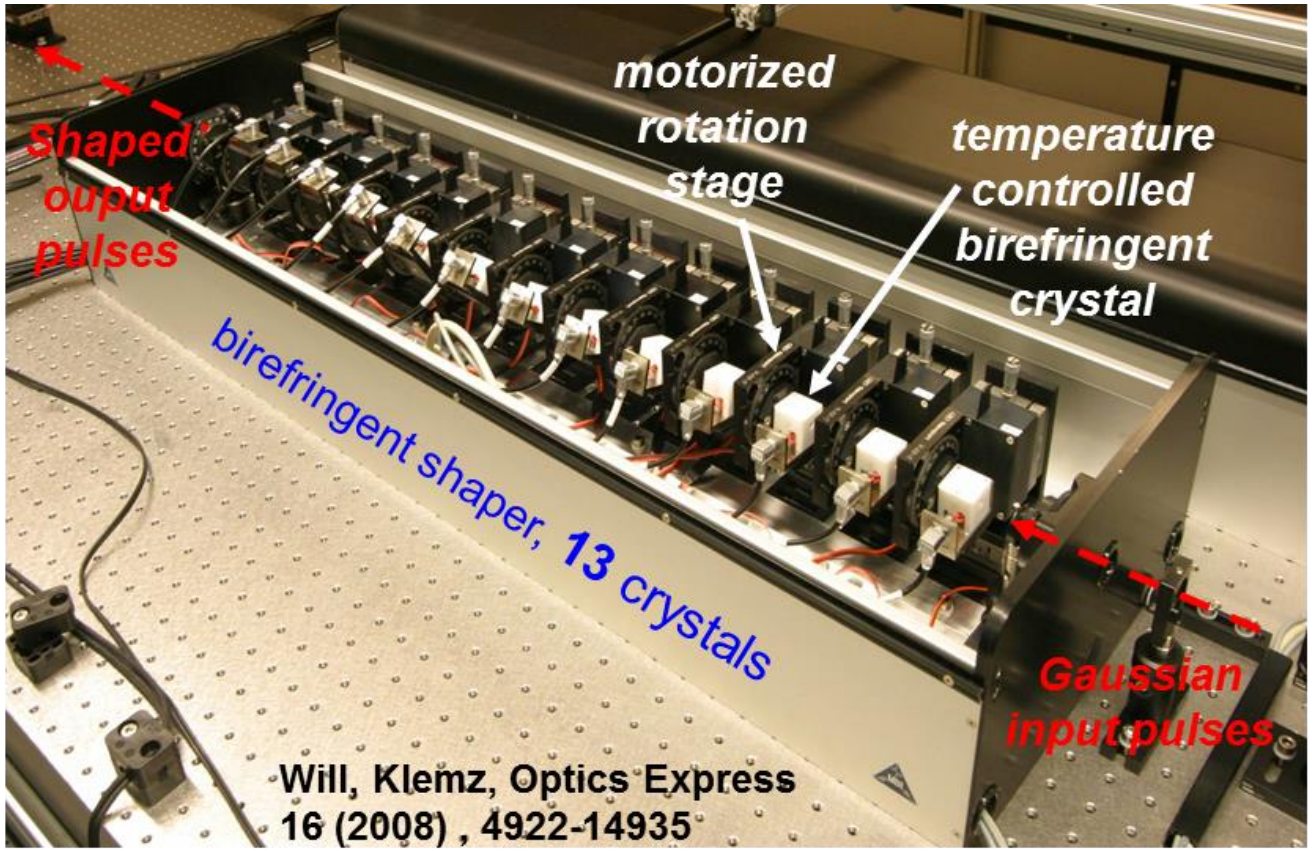
- Contains 13 birefringent YVO_4 crystals. Pulses are split according to polarization. Delay is given by crystal thickness; relative amplitude can be varied freely by adjusting relative angle between crystals

  - Basic process

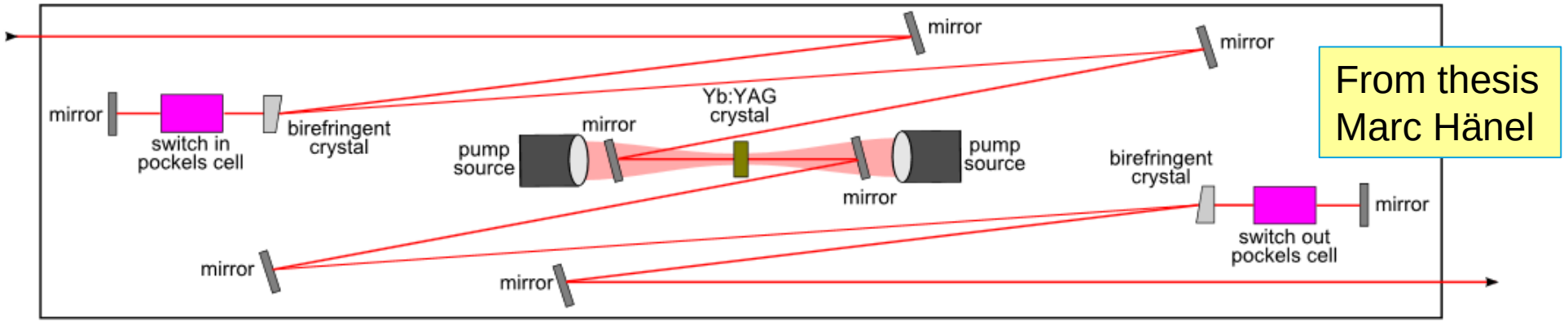


  - Free pulse shaping, e.g. flat top





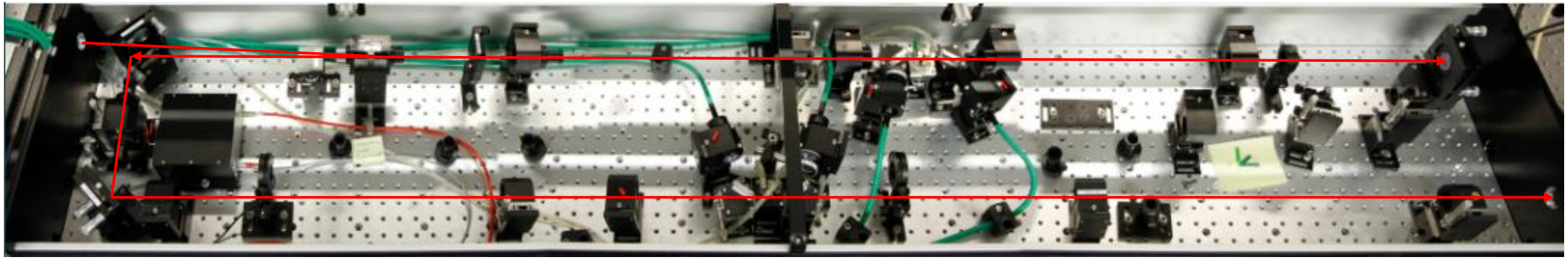
MBI Laser – Regenerative Amplifier



From thesis
Marc Hänel

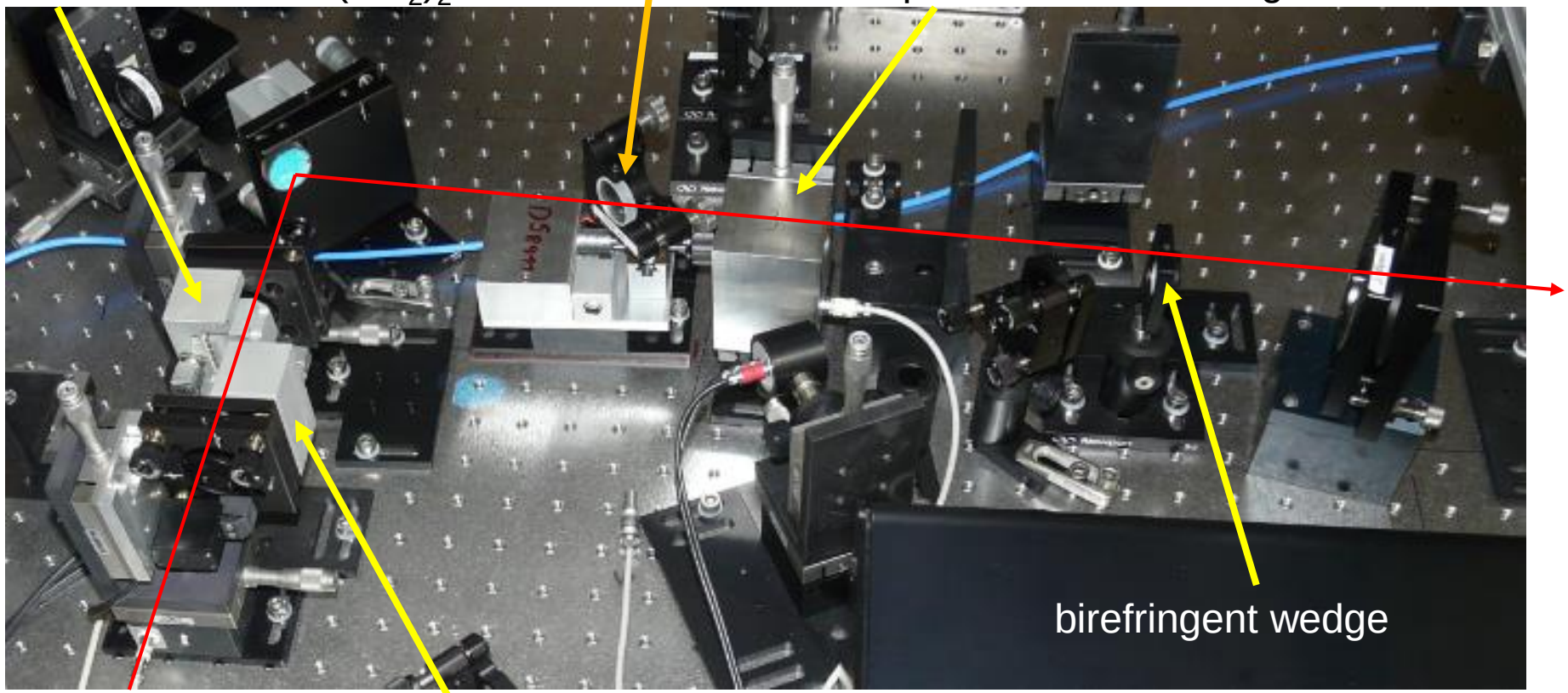
- 15 round trips → pulse energy gain up to ≈100,000
- Yb:YAG amplifier crystal → new center wavelength: 1030 nm
- Option: stretch pulse length from 2 ps up to ≈12 ps
  - Use Lyot filter(s) together with polarizer
  - Polarization rotation dispersion → reduce bandwidth → increase pulse length (pulse is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

MBI Laser – Booster Amplifier with Pulse Picker



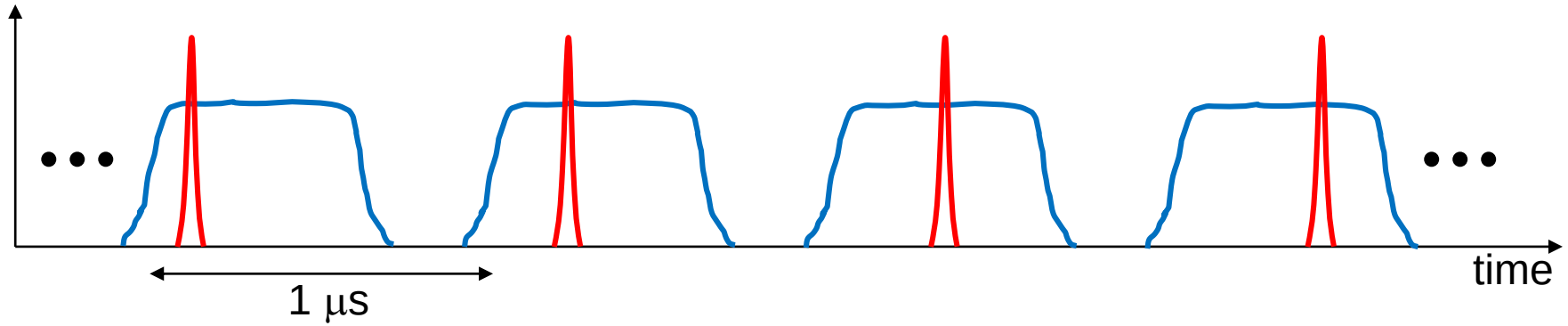
- Double pass amplifier
  - ≈4x amplification
  - Pulse guiding with λ/2 waveplate / Faraday rotator / birefringent wedge
- Pulse picker: Pockels cell
  - Definition of laser pulse train length
- Booster amplifier
  - ≈2x amplification

MBI Laser – IR to UV Conversion + Attenuator



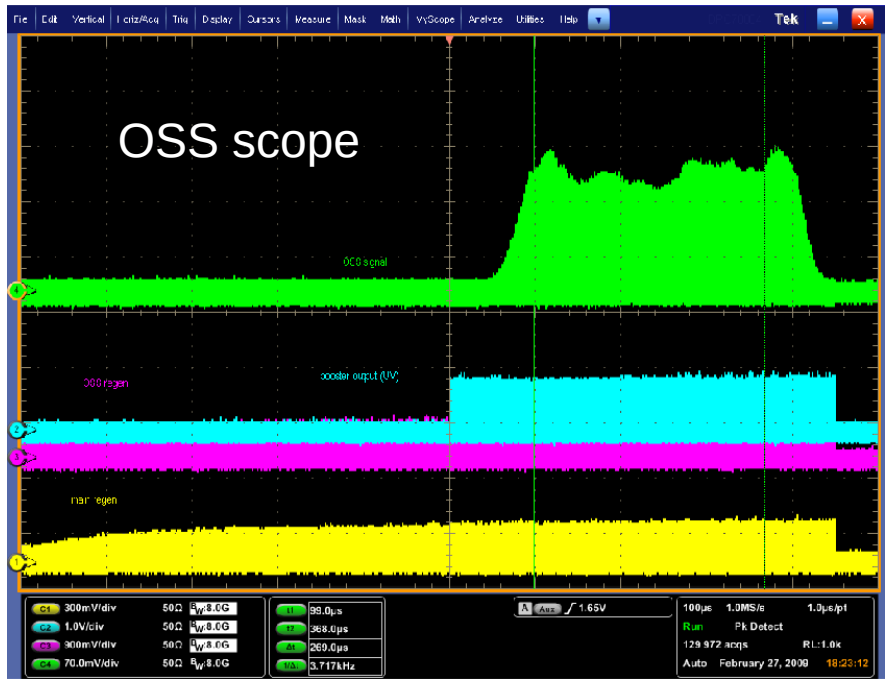
MBI Laser – Optical Sampling System (OSS)

- 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

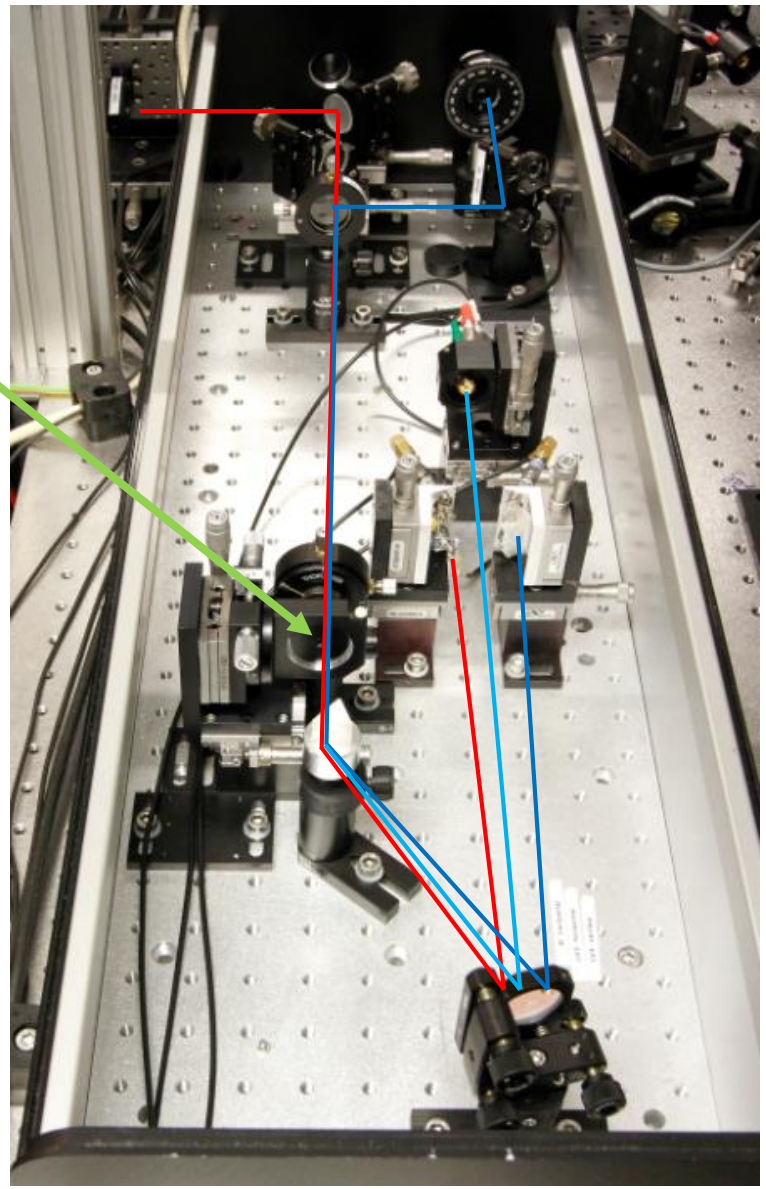
- Spatial overlap of IR and UV pulses with dichroic mirror
- Frequency conversion in BBO crystal: difference frequency generation (DFG)
- Spatial separation with prism
- Detection with 3 fast photo diodes



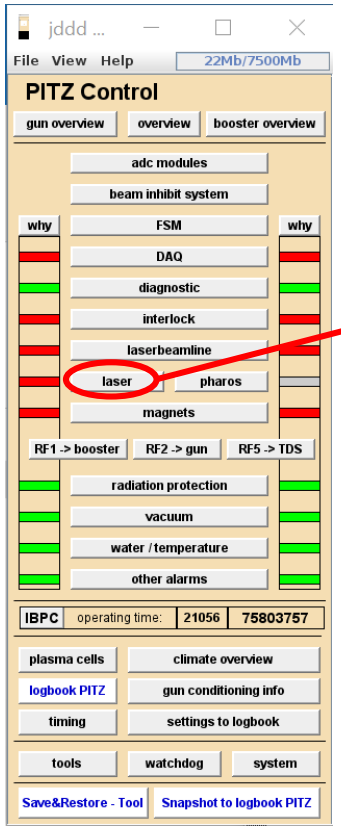
DFG

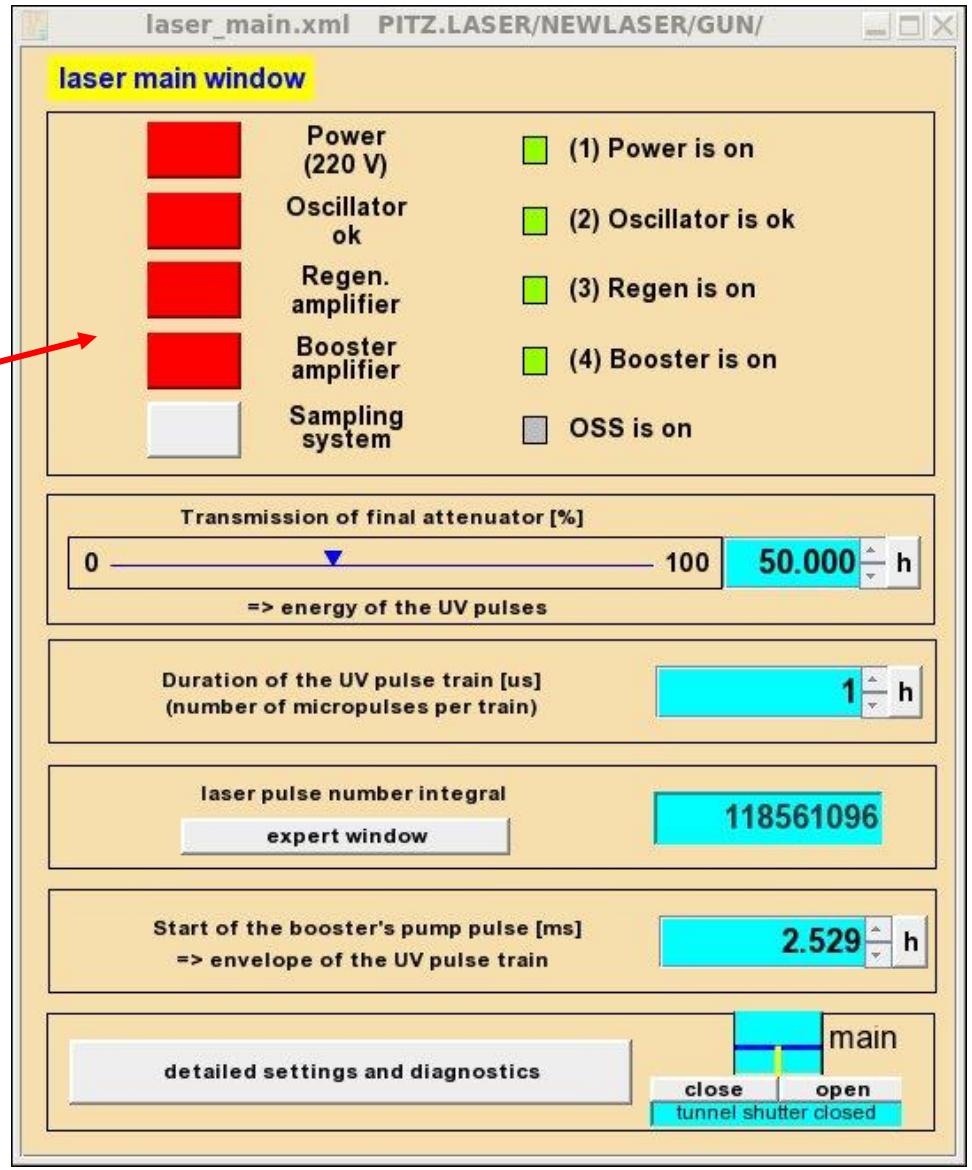
UV

IR



MBI Laser GUI





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

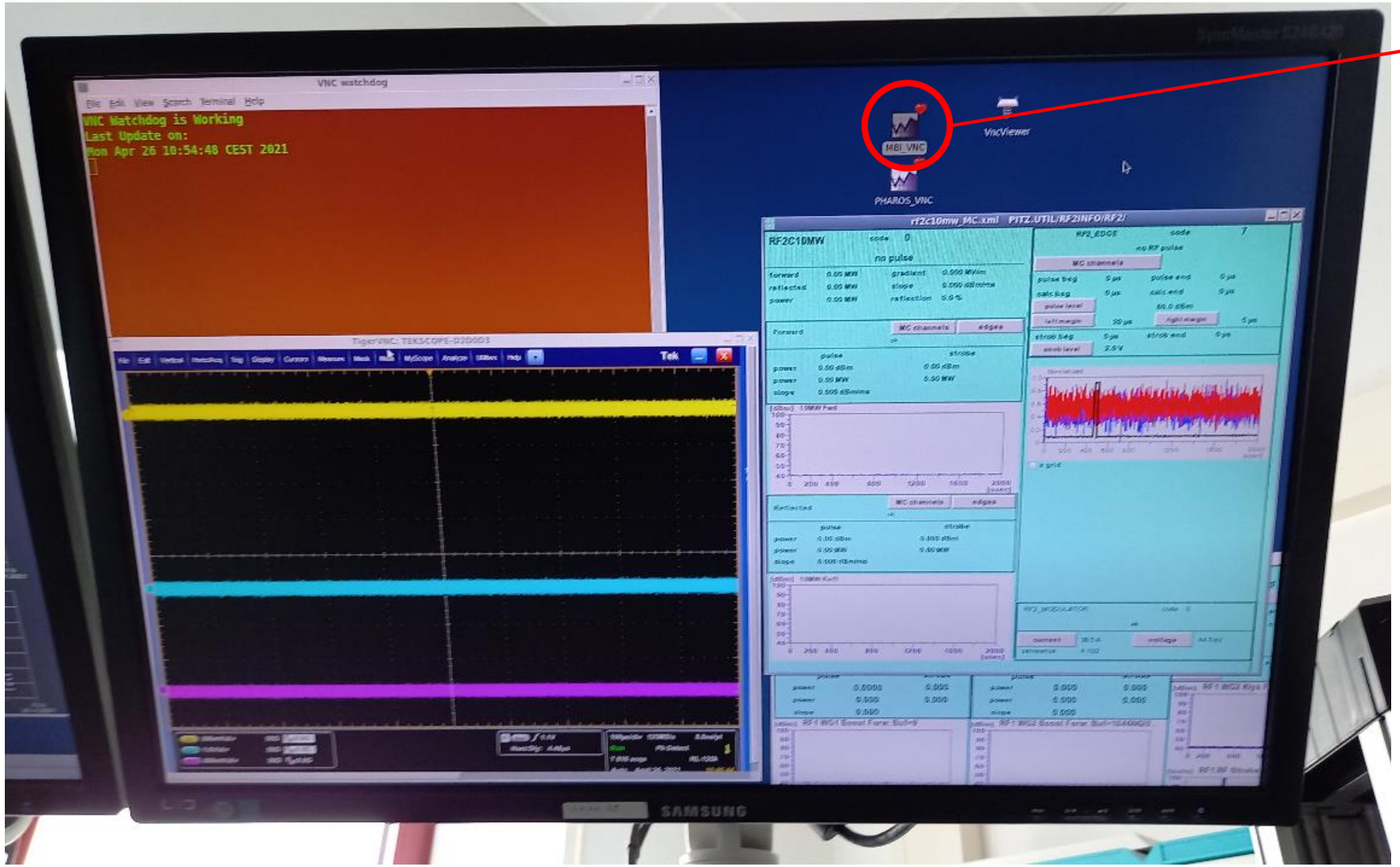
Laser transmission $0\% \leq LT \leq 100\%$
- Nearly linear (depends on calibration)
- There is optical energy at 0% (leakage)

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

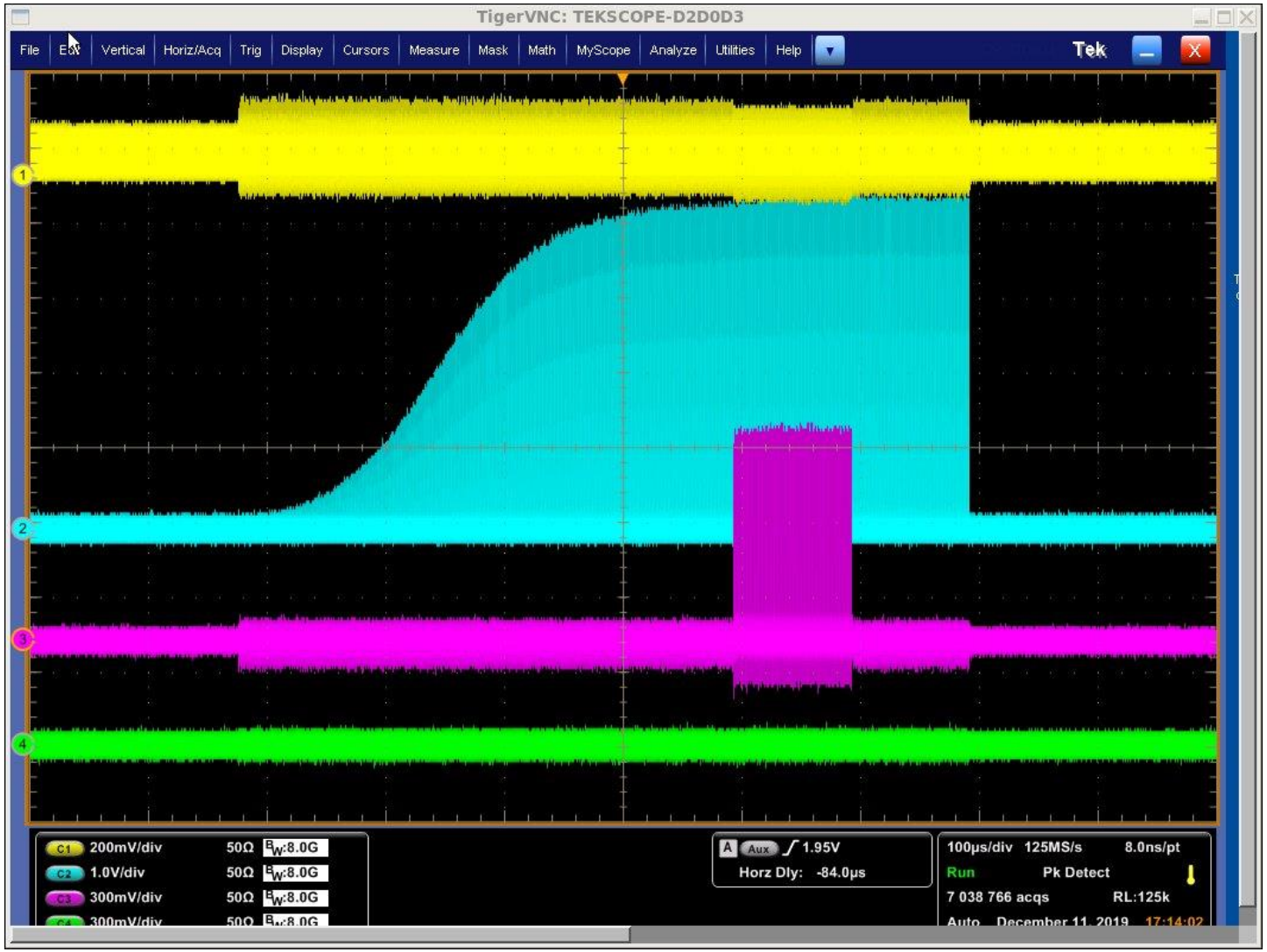
Typically on upper right screen



MBI_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

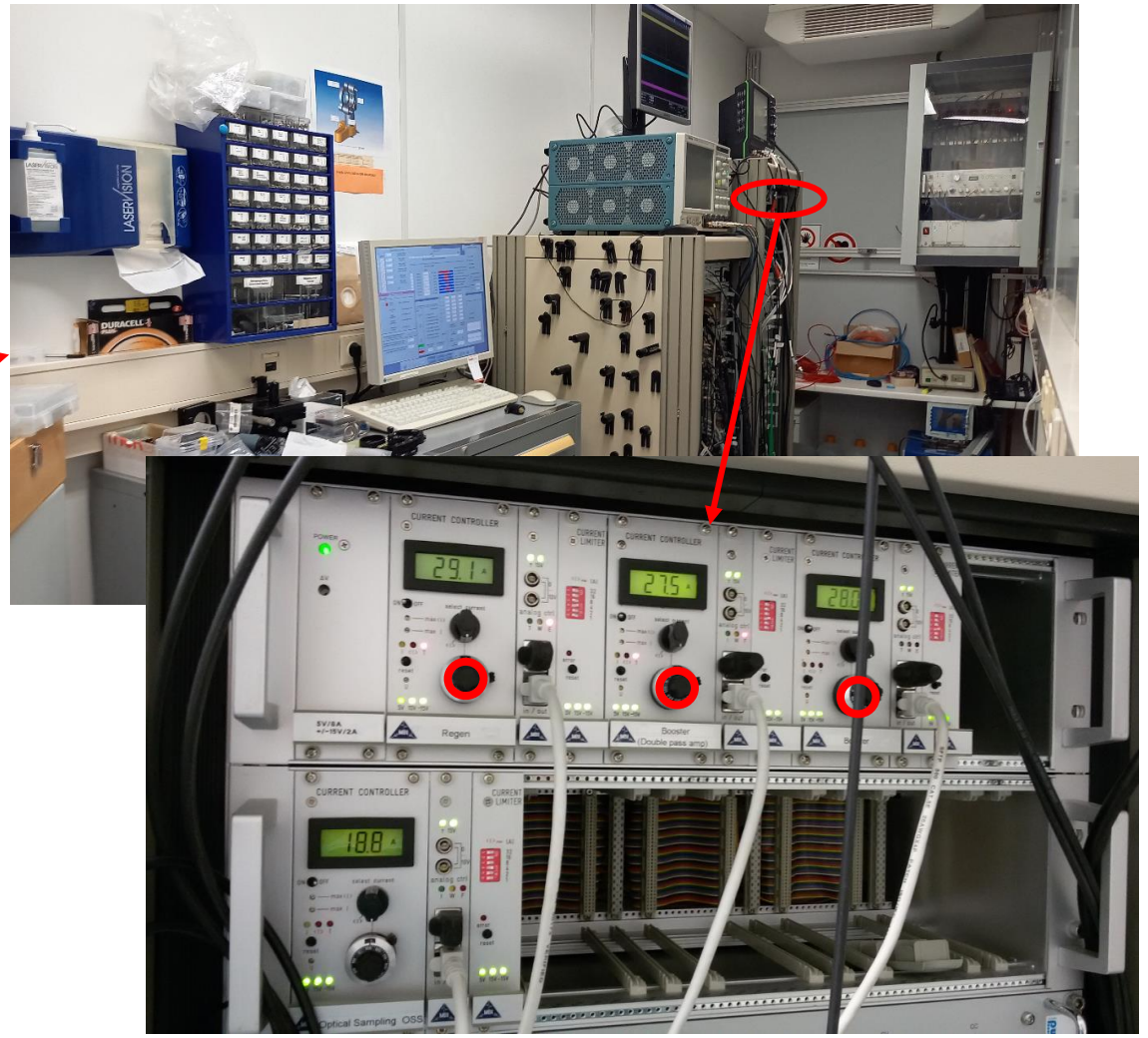
Regenerative amplifier

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