Amplification of Ultrashort Pulses at 80 MHz for In Vivo Two-Photon Microscopy Enhancement

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Motivation:

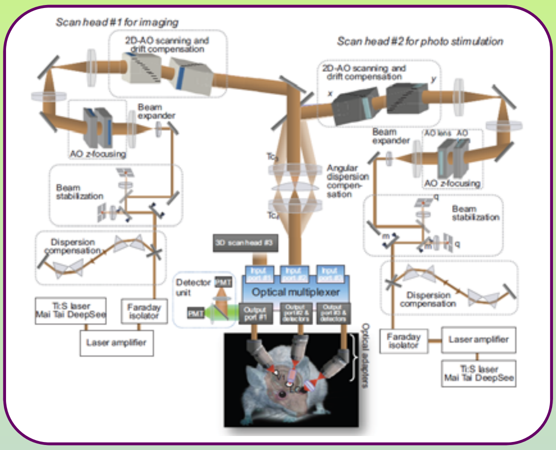
There is a significant demand on high repetition frequency laser amplifiers, it can be used for high photon yield experiments. Especially, in e.g. in vivo random access 3D two-photon microscopy of brain cells, it is desirable to scan the largest possible volume for neuronal activity. Higher pulse intensities can achieve deeper penetration in brain tissues; ultimately help to get a better understanding of brain computations.

Aims:

Develop a laser that provides at least 5 fold higher average power pulses than the state-of-the-art technology, transform limited pulses with 100 fs pulse duration, spectral tuning in the range of 720-950 nm and finally a repetition frequency of 80 MHz.

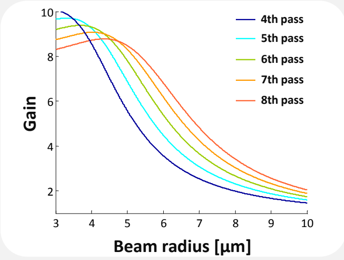
Possible experimental realizations

- CW laser pumped Ti:Sapphire
- Pulsed laser pumped Ti:Sapphire
- Pulsed laser pumped OPA



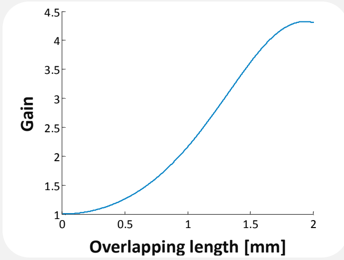
a. Pulsed laser pumped Ti:Sapphire model

- Frantz-Nodvik equations
- Multipass configuration
- 60 W Pump power is required
- Optimal medium parameters: 6 mm long with 4 1/cm, or 4 mm long with 5 1/cm absorption coefficient
- No need for stretcher/compressor



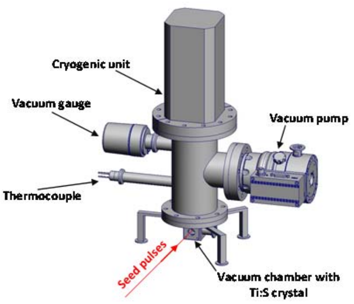
b. Pulsed laser pumped OPA model

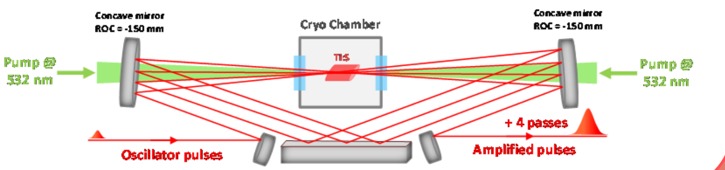
- Numerical model for spectral gain calculation
- Double stage configuration
- Need for pulse stretcher and compressor: 6 ps signal, 20 ps pump pulse time duration



a. Ti:Sapphire Design

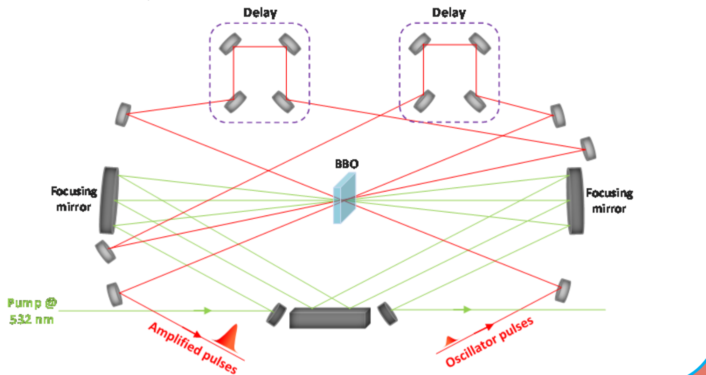
- 8-pass configuration: triangle resonator, confocal geometry
- Pump through focusing mirrors
- Broadband coating on focusing, Ag coating on rect. mirror providing spectral tunability
- Very tight focusing
- AR 700-900 nm coating on vacuum windows to minimize seed energy losses





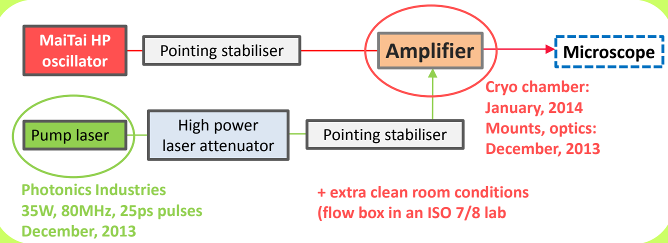
b. OPCPA Design

- 3-pass configuration
- Noncollinear geometry
- Most promising nonlinear medium: BBO crystal
- No need for cooling
- Detailed ray-tracing simulation for Astigmatism compensation
- Pointing-stabilizer needed



Readiness level

- A 35 W avg. power, state-of-the-art 80 MHz repetition rate pump laser is purchased from Photonics Industries, however still needs some revision.
- High average power oscillator is under purchasing.
- Cryogenic cooling system and vacuum chamber is ready.
- Clean-room laboratory space with flow-box system allocated.
- High power laser attenuator is developed and assembled.
- Pointing stabilization system acquired.
- Vast majority of crystals, optics and optomechanics have been purchased.



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