RECENT LASER DEVELOPMENTS AT THE IGISOL FACILITY

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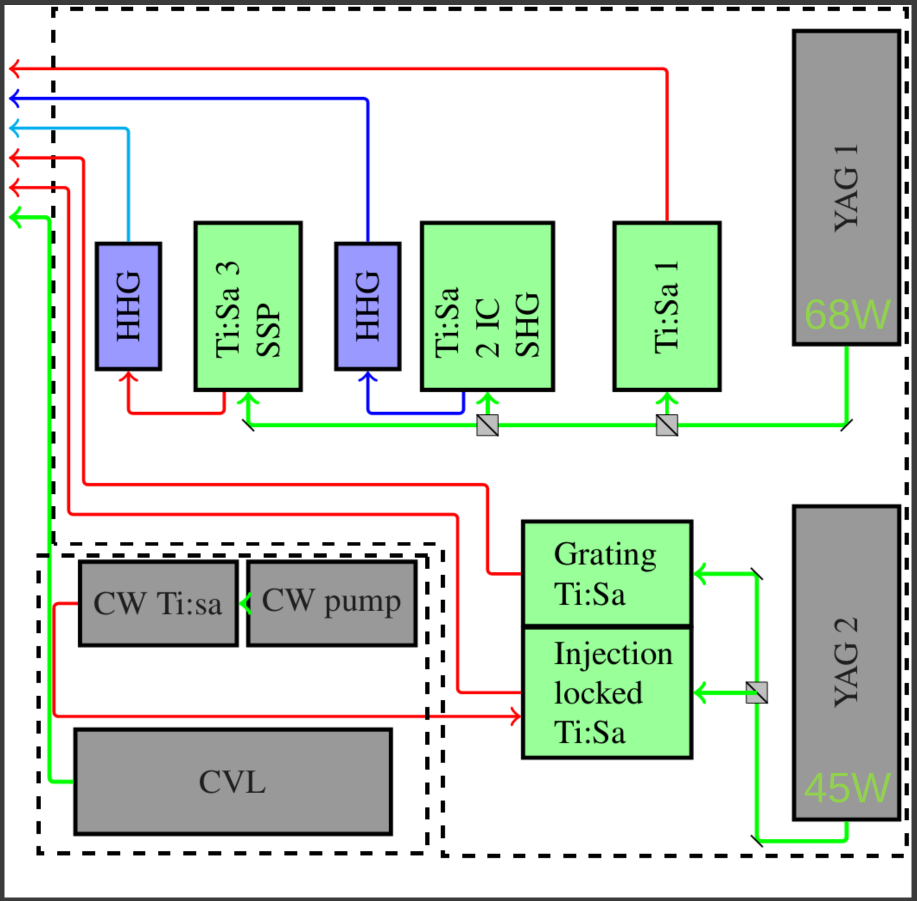
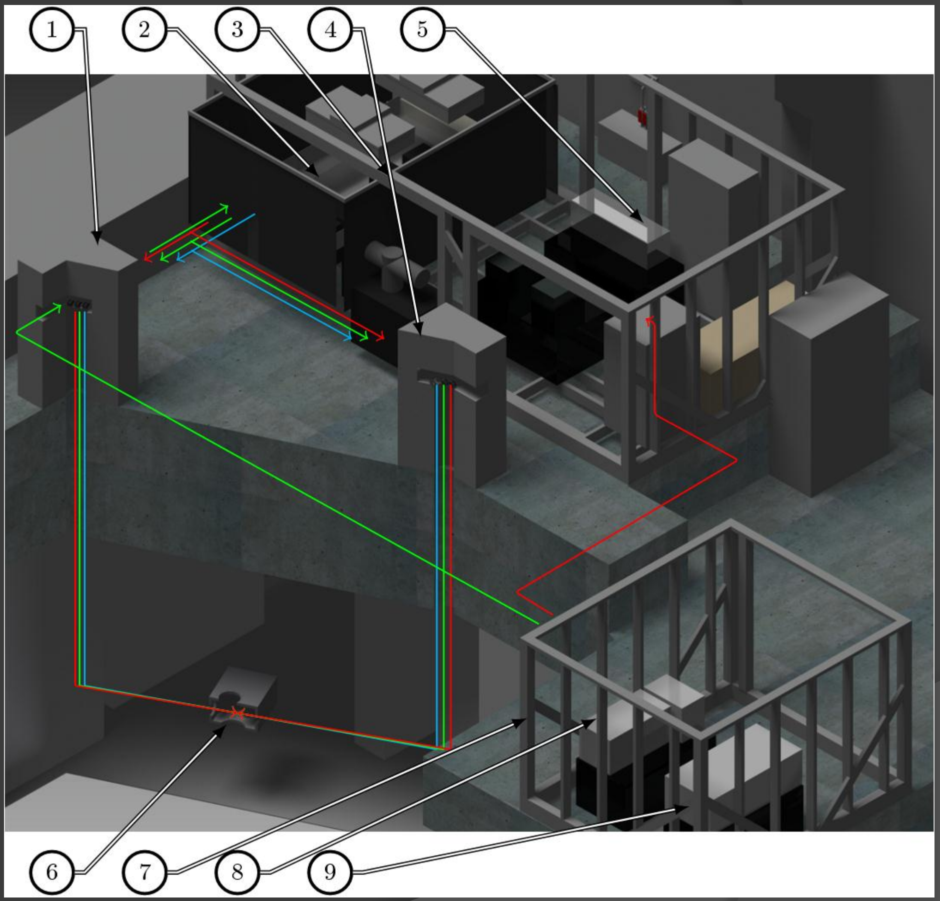
Outline

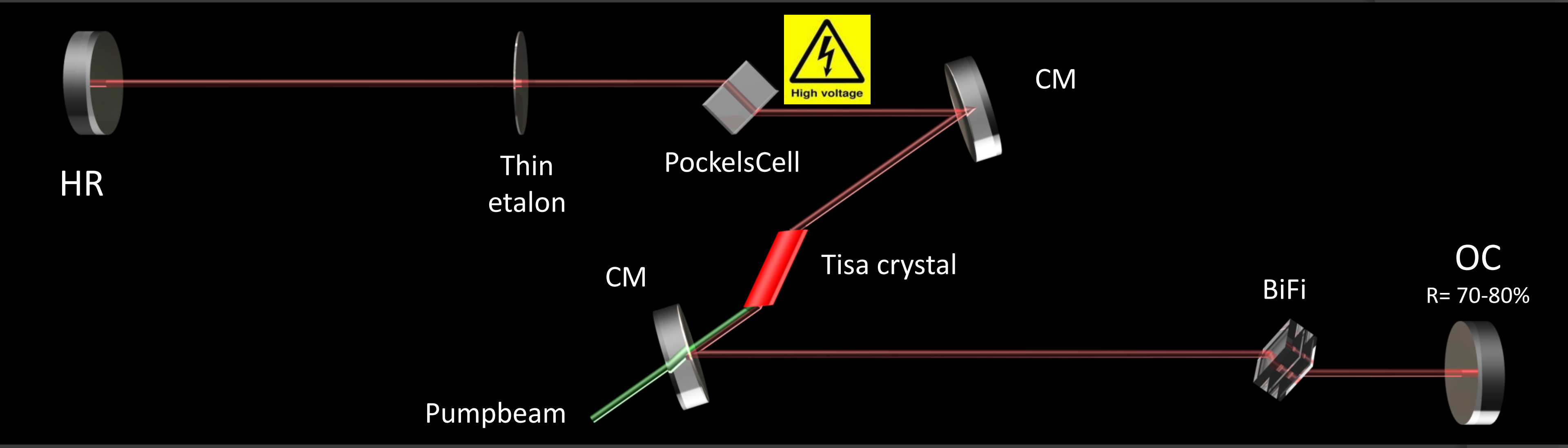
- Laser Layout at IGISOL
- Basic Ti:sa laser features
- Narrow band Ti:sa performance
- intracavity SHG + quadrupling efficiency
- Difference frequency mixing
- high power fiber coupling
- Conclusion, Status, Outlook

Laser system Layout at IGISOL 4



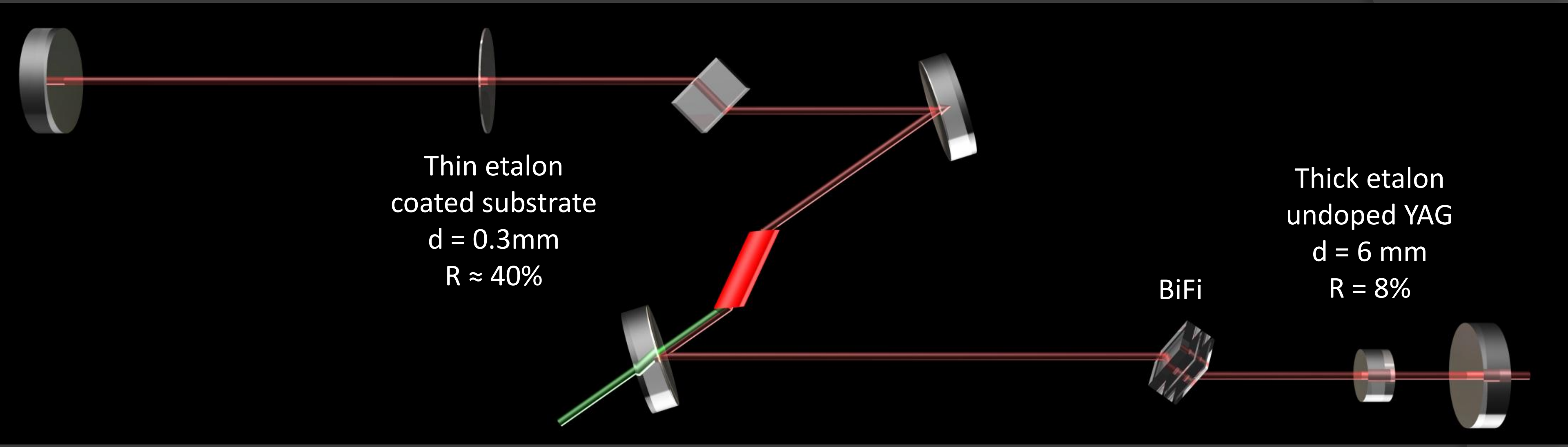


Basic Ti:sapphire cavity



wavelength range	700-1000nm (350-500nm, 240-330nm, 205-250nm)
linewidth	>5 GHz
pulse duration	40 ns
Power output	3-5W
Repetition rate	10 kHz
SHG Power	250-800 mW
THG Power	50-150 mW
FHG Power	20-60 mW

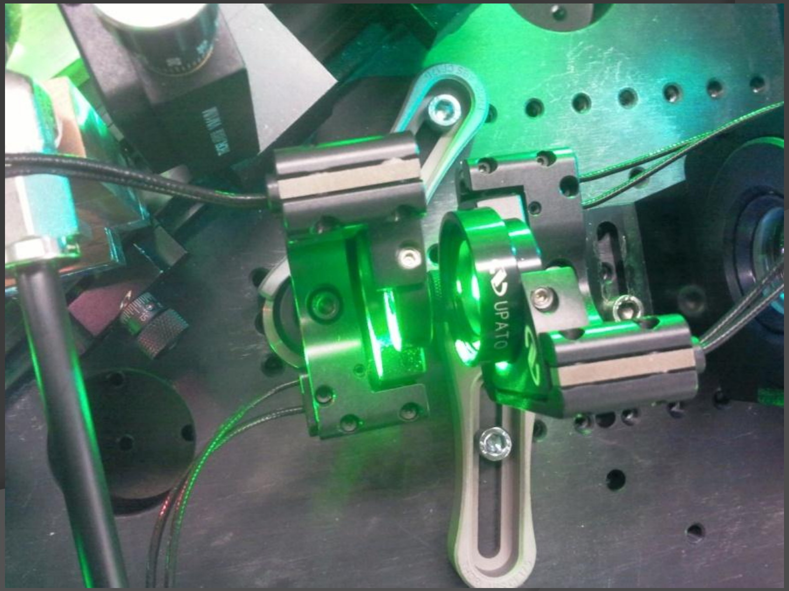
NarrowBand Ti:sapphire



- Movement of etalons needs synchronization
- space constraints require compact mounting

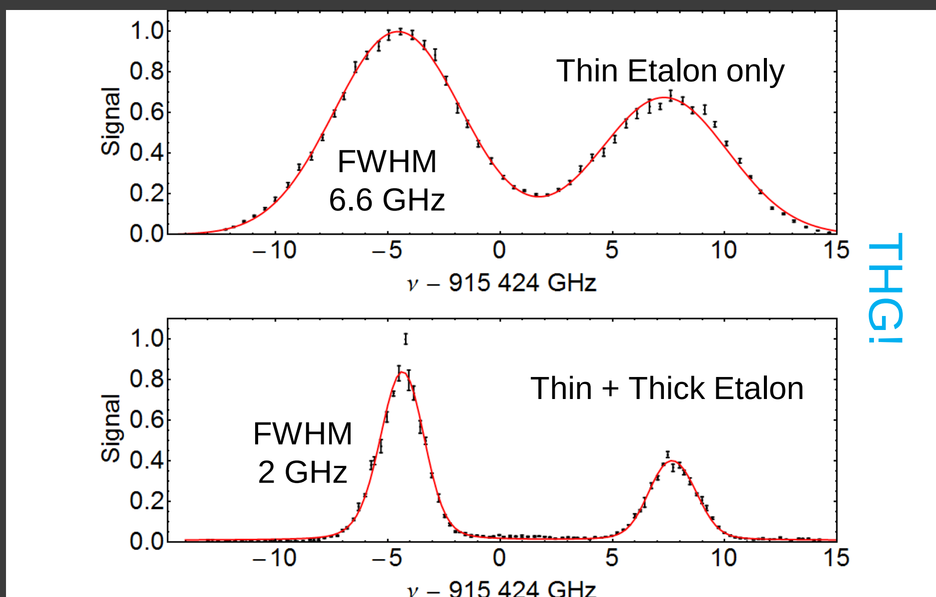
used motorset:

Agilis AG-M100L, piezo driven,
control with labview



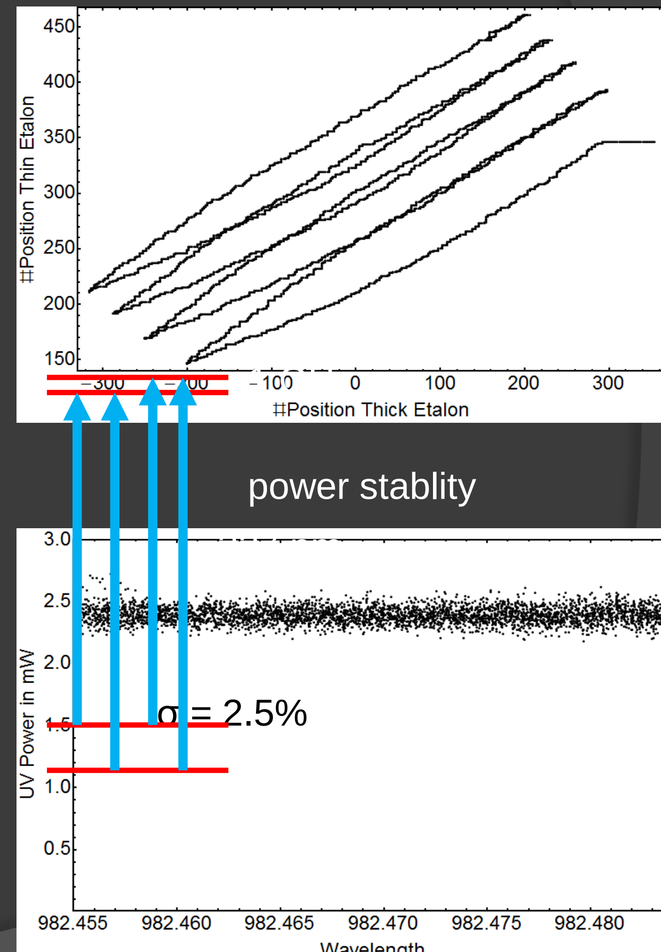
NarrowBand Ti:sapphire

- Linewidth of < 1GHz achieved
- synchronization based on power stabilization



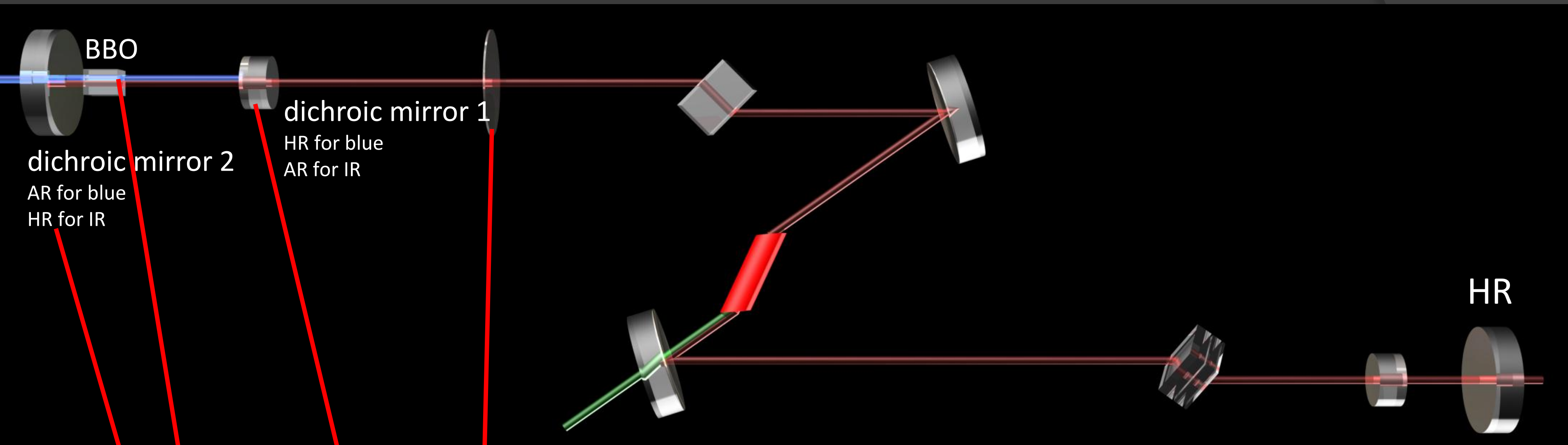
THG!

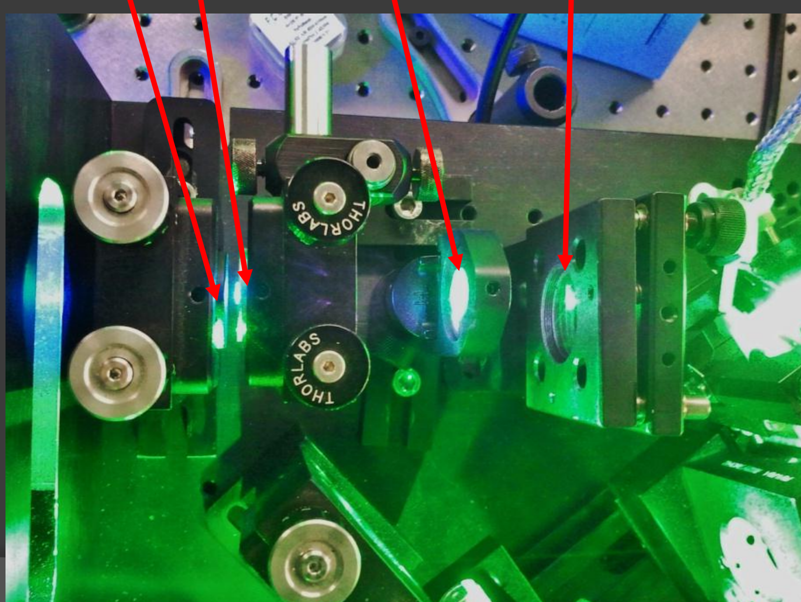
Motor movement



For more details - see talk by T. Kron

Intracavity SHG

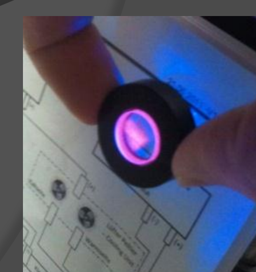




blue output power (typical @ 21W pump)	
only BBO inserted	400 mW
OC replaced with HR	1000 mW
dichroic mirror 1 inserted	1700 mW
HR Replaced with dichroic 2	>2000 mW

best case performance	
@ 820/410 nm	3700 mW

Performance @ 1000/500 nm	
(no dichroic, with dual Etalon)	1300 mW
external doubling	*400 mW*



Intracavity SHG – considerations

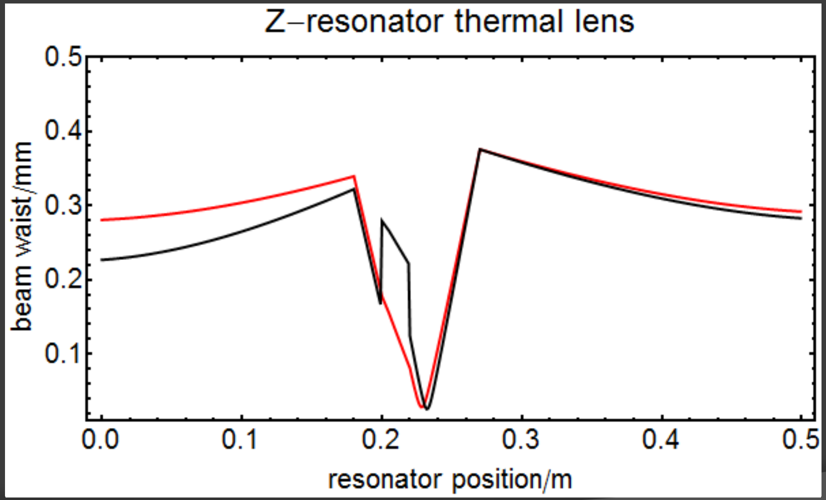
AR coatings of crystal and dichroic filters

- lower loss in cavity → better conversion: $n = (1-(1-\text{Loss}))^{-1}$
- reflections can cause Etalon effects → Mode jumps

HR cavity

- higher IR intensity → damage thresholds
- lower lasing threshold → wavelength range
- no/little IR output → cavity optimization?

Crystal Position

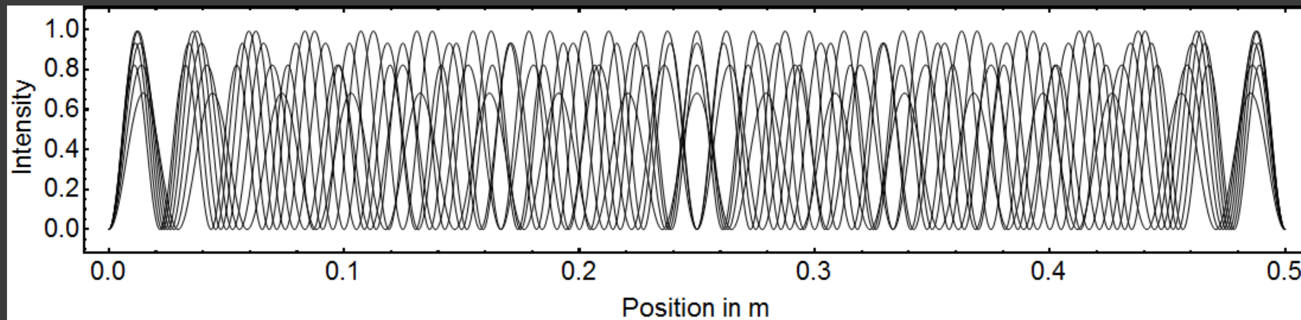


conversion efficiency :

$I_{blue} \sim Ic_{IR}^2 \sim 1/w^4$

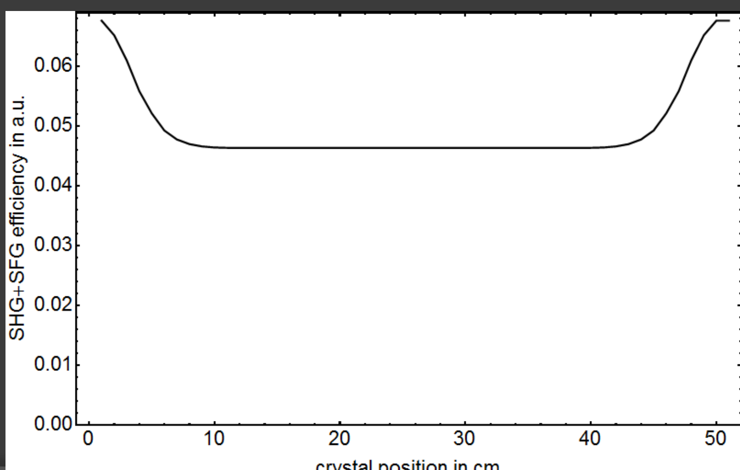
Intracavity SHG – considerations

Standing waves in Z-Cavity, multiple modes with frequency $f_0 \pm i * \mathrm{FSR}$



$$I_{blue} \sim \sum_{\substack{i,j=-N \\ i\neq j}}^{N} d_{eff}\, I\,(k_i)\; I\,(k_j) + \sum_{i=-N}^{N} d_{eff}\, I\,(k_i)^2$$

SFG SHG



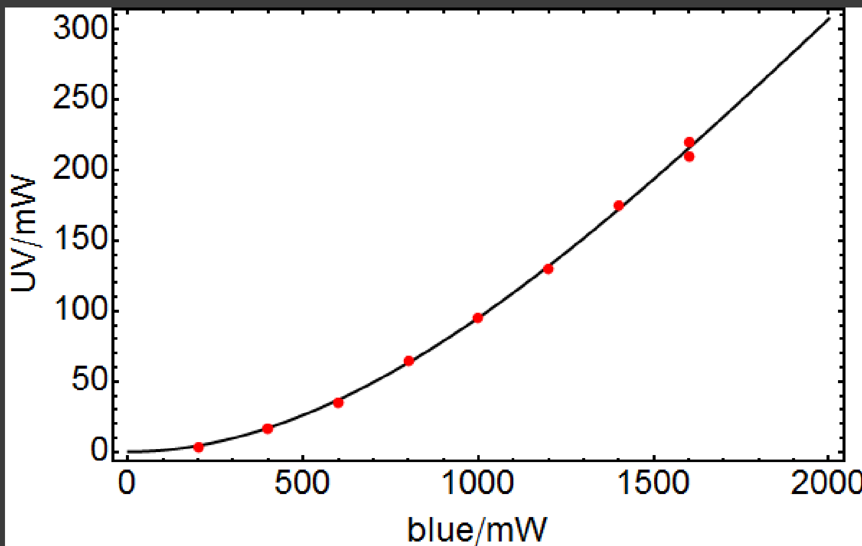
roughly 25% better conversion efficiency near end-mirrors – measurable?

C. Czeranowsky et al. Stabilization of intracavity frequency doubled lasers with Type I phase matching Optics Letters 28, No. 21, 2003

Power stability?

Intracavity SHG – quadrupling efficiency

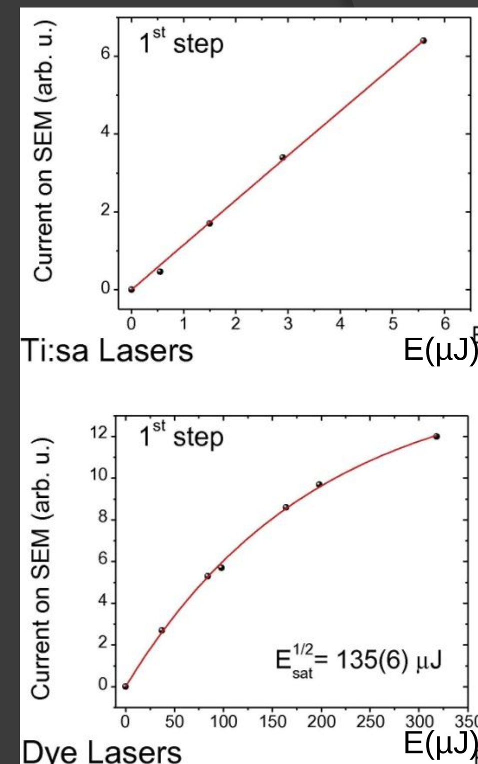
904/452/226nm



near quadratic dependence as expected

extrapolation to 3W blue:
500+ mW UV

Saturation of Cu 244nm
1st step transition



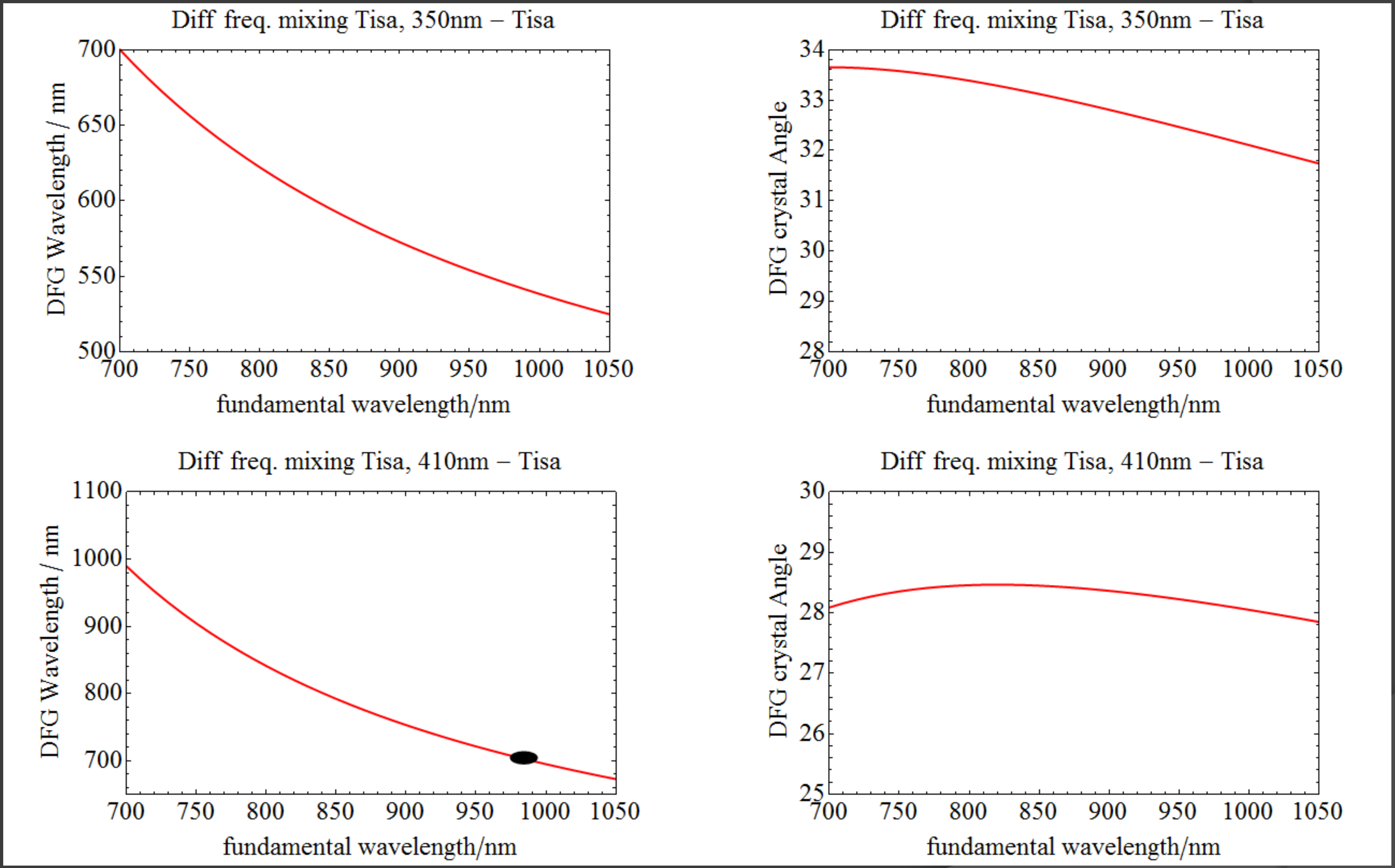
Ferrer et al. NIM B, Volume 291, p. 29-37.

	IR@976 nm	blue@488 nm	UV@244 nm
external	3.2 W	400 mW	35 mW
intracavity	-	1300/1800* mW	180/300* mW

What to do with so much power?

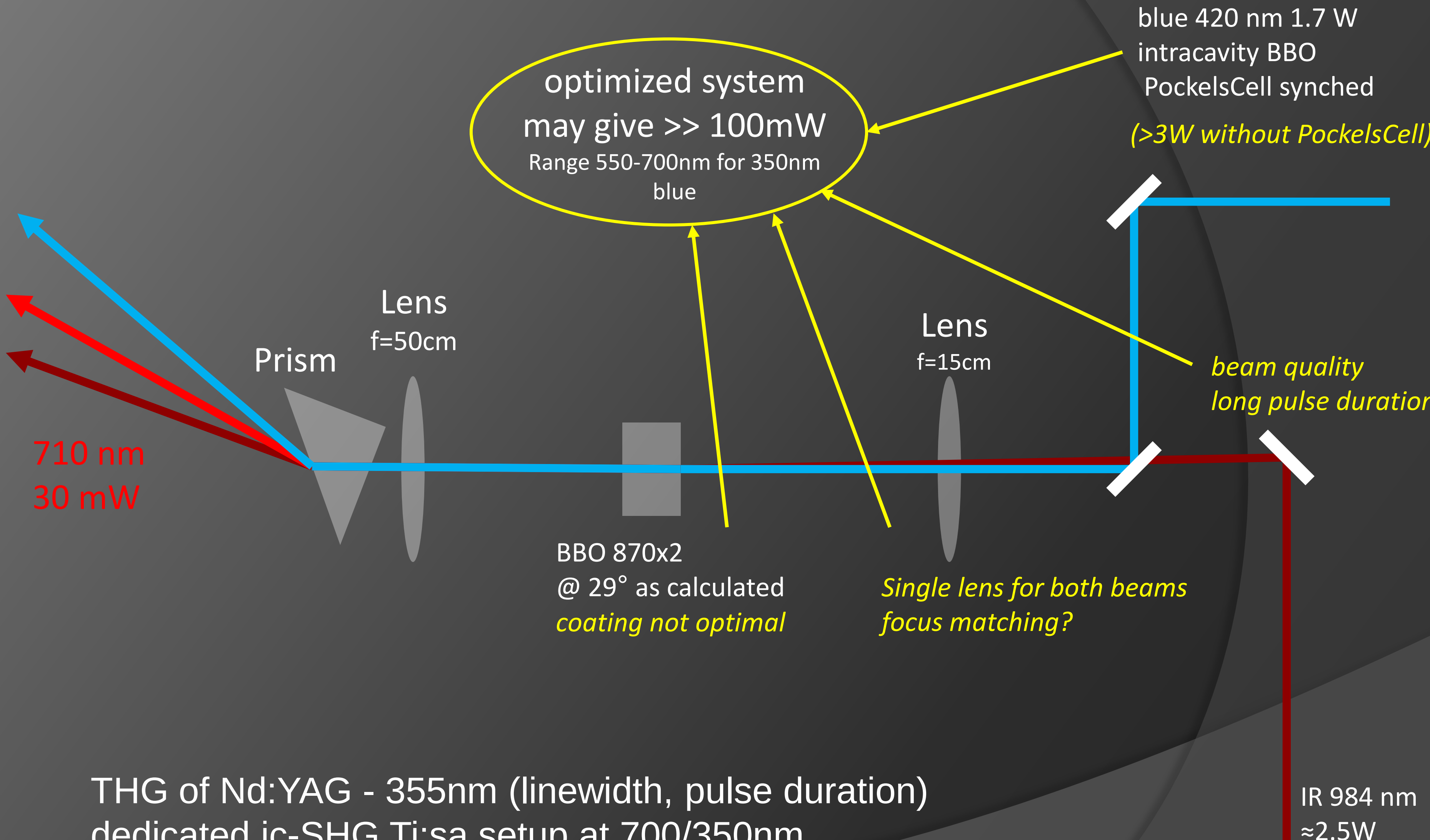
- abuse it for evil schemes
- weak transitions / large volumes
- two photon transitions → new RIS elements
- new wavelengths with frequency mixing

Difference frequency generation



DFG angle is close to doubling angles: 700nm->350nm = 33.6°

DIFFERENCE FREQUENCY GENERATION



THG of Nd:YAG - 355nm (linewidth, pulse duration)
dedicated ic-SHG Ti:sa setup at 700/350nm
ic SHG+DFG?


YAG rest light
Blue
DFG
Red
984 nm IR
invisible by eye
and camera,
but mobile
phone works

High power fiber coupling

Advantages

easy transport to offline ion source
- less mirrors/mirrorstands
- less protective lasertubing
- faster alignment
- use for laser ablation source?

long distance transport to opt. pumping
- no beam steering/shaking
- no expensive „beamlok“ sytem necessary

Limitations

- absorption of UV below 350nm
- beam quality reduction $M^2=1 \rightarrow M^2 > 50$?

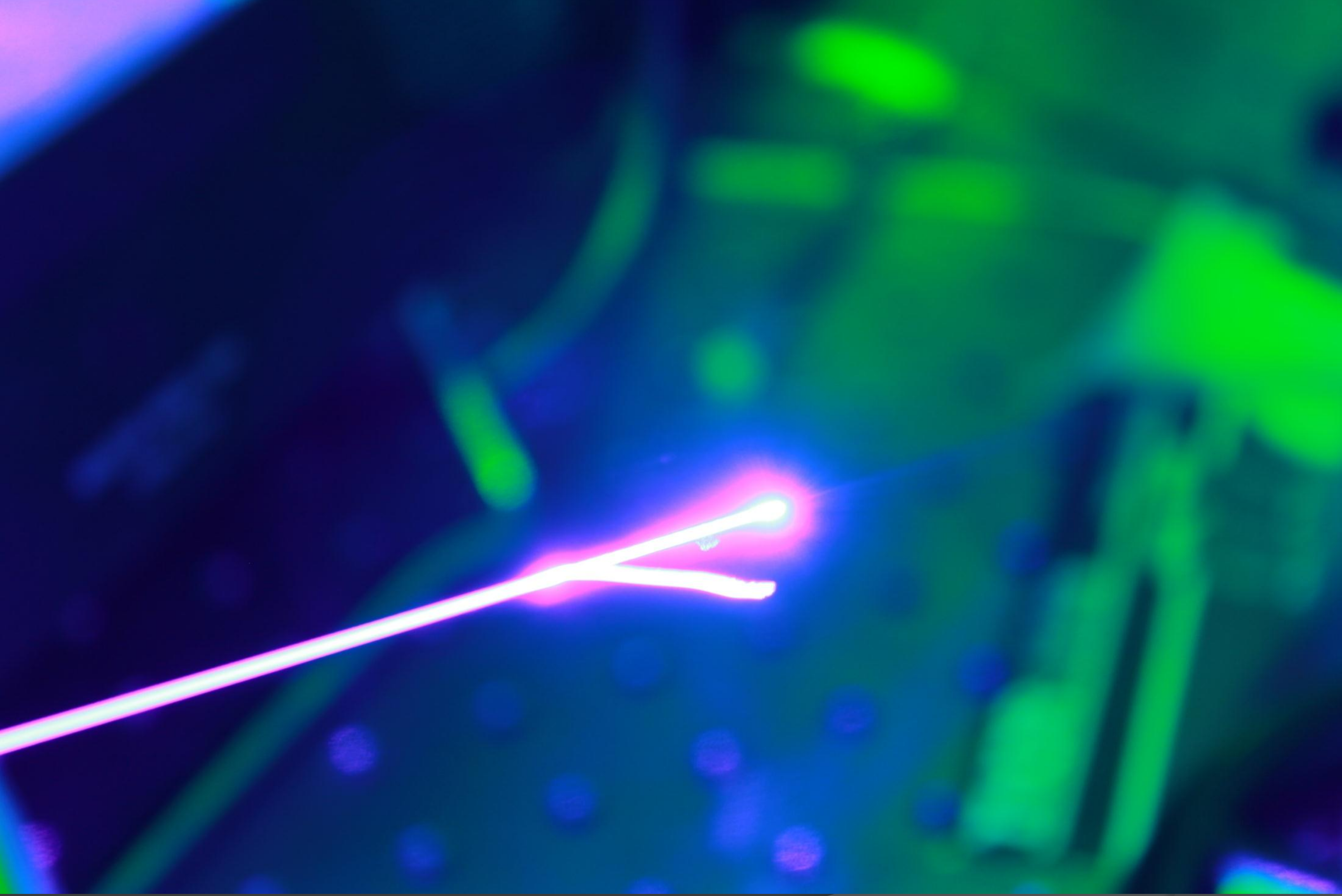
How to

Source of fiber-dmg often connector
- heating/damage through coupling losses and backreflections

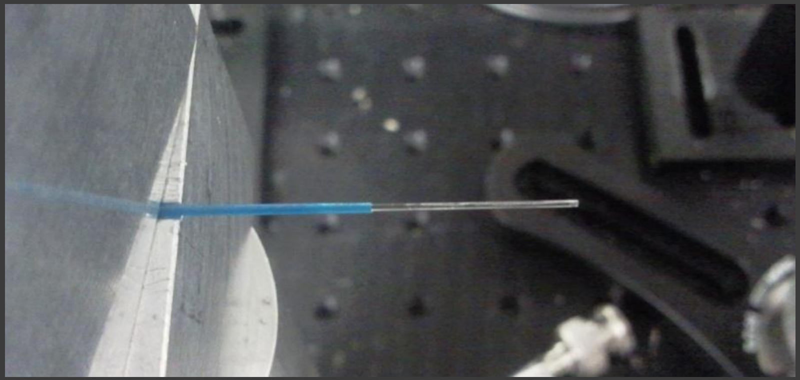
Avoid damage by
- bare fiber (no coating/connector/tubing)
- or special high-power connectors

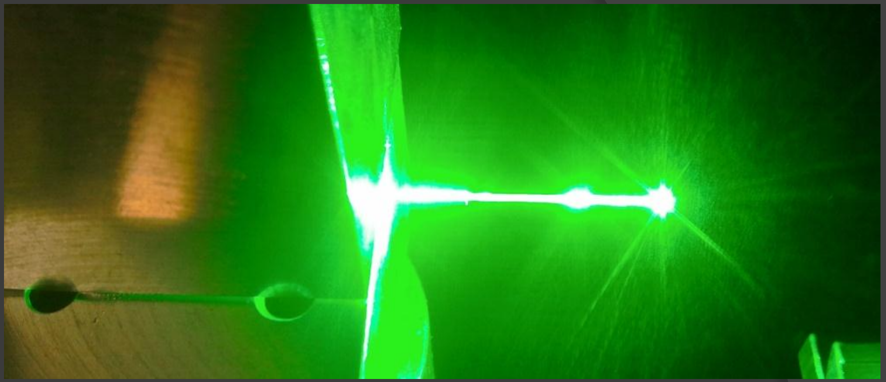
fiber specs (thorlabs)

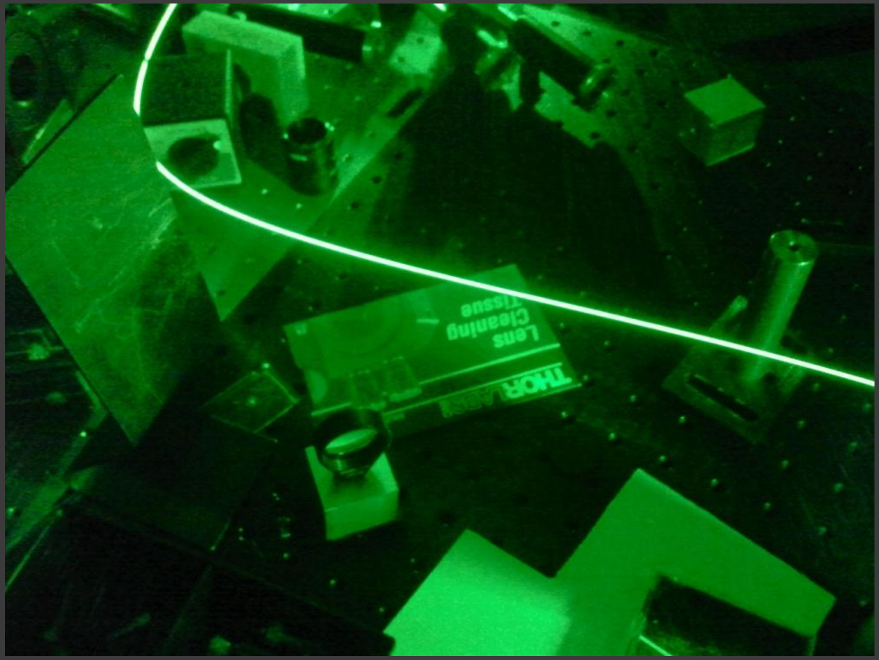
	Core Diameter	Max Power Capability (Pulsed)*	Max Power Capability (CW)
FG200UC	200 µm	1.0 MW	0.2 kW
FG365UE	365 µm	3.4 MW	0.7 kW

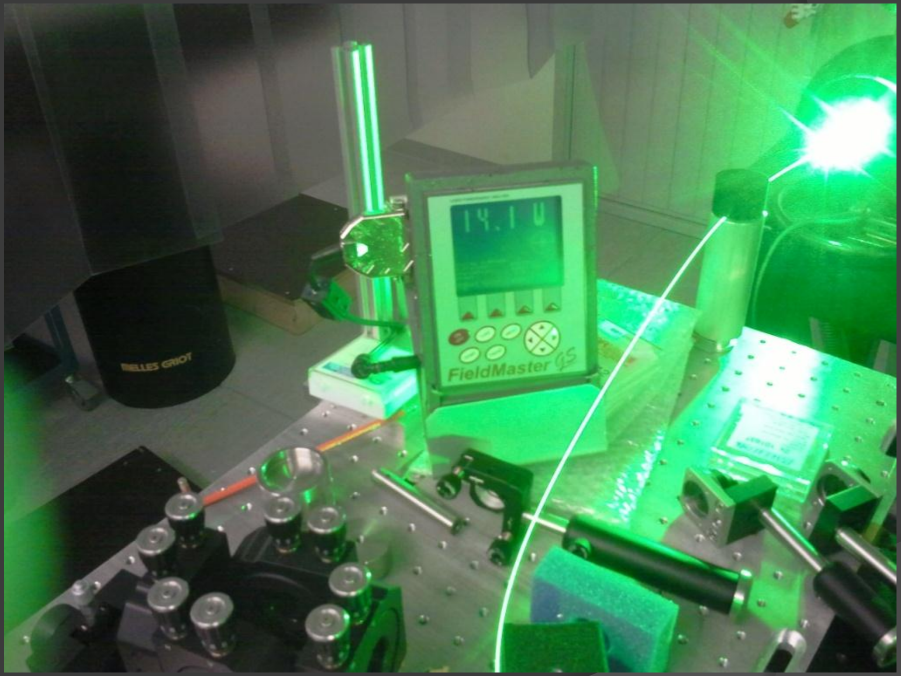


80% transmission efficiency for 1.8W of blue









~75% transmission efficiency for 40W of green from YAG pump laser

Status & Outlook