Pilot experiment of PALS petawatt upgrade using hybrid iodine laser SOFIA

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Outline

1. Petawatt amplification by OPCPA
2. PALS petawatt project (λ=800 nm)
3. Hybrid laser SOFIA (λ= 1315 nm)
4. Pilot experiment at 30TW
5. Summary

http://www.fzu.cz/departments/nonlinoptics/

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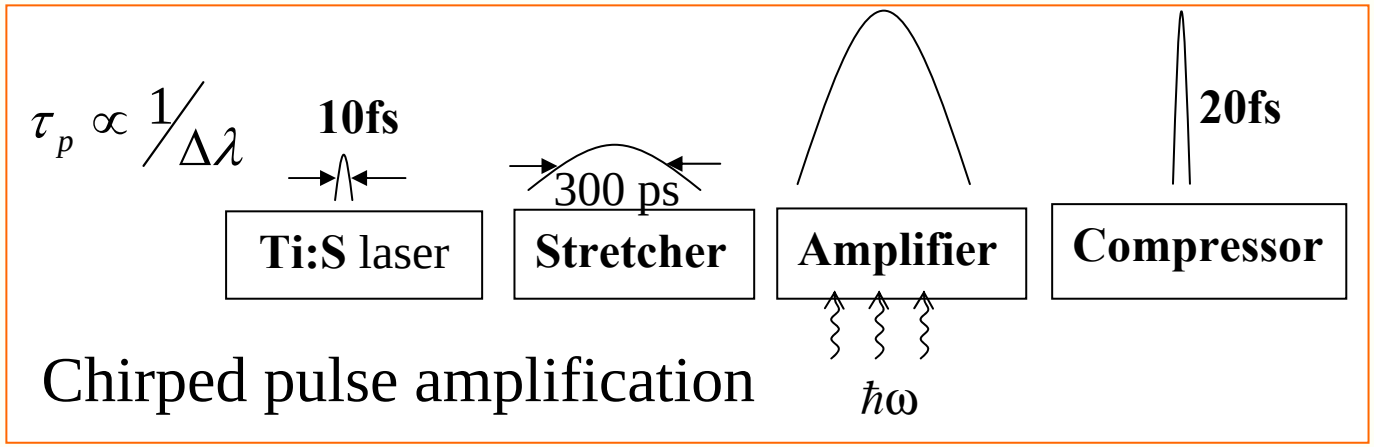
Femtosecond pulse amplification



Gain linewidth of amplifier

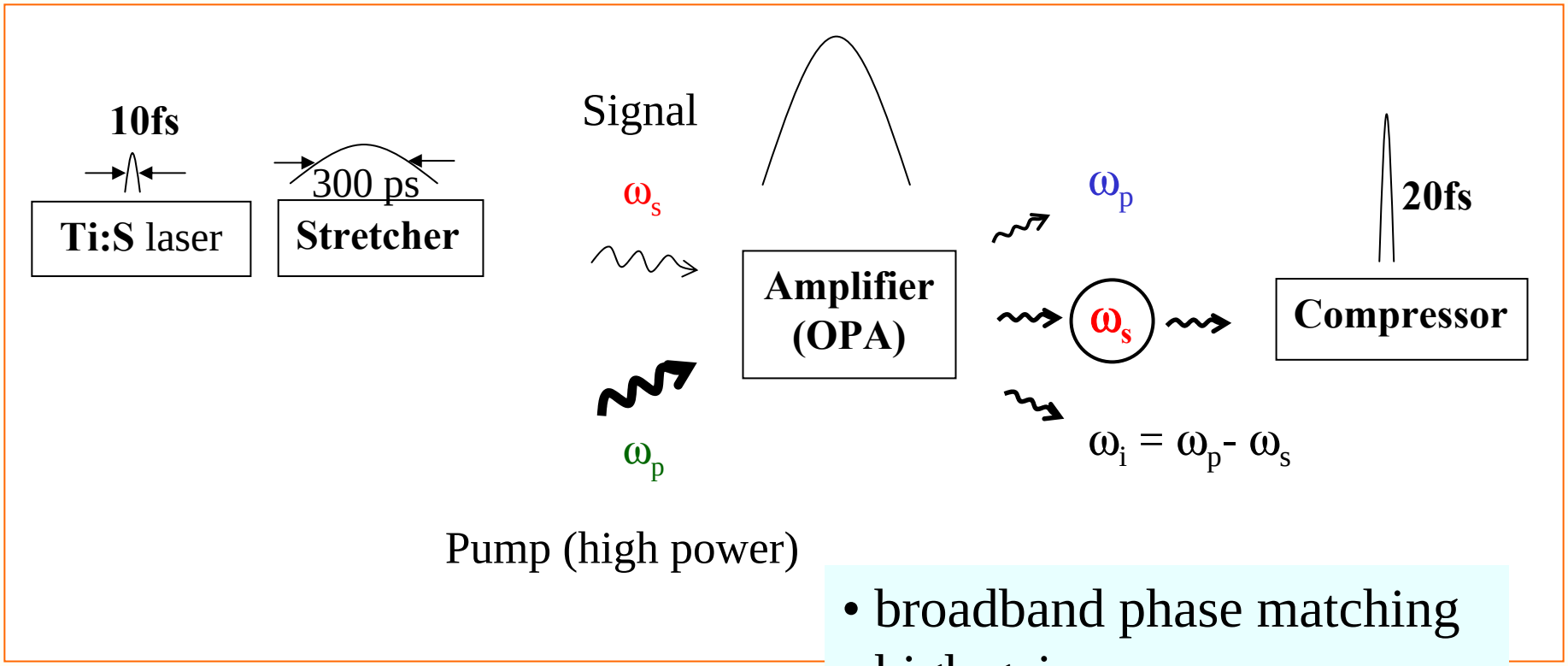
1. **Stimulated emission (CPA)**

- Ti:sapphire 100 nm
- Nd:laser, Yb: laser 10 nm
- iodine 0.02 nm $\rightarrow$ $\tau \sim$ **100 ps** ☹ NOT for PALS

2. **Optical parametric amplification (OPCPA)**

- nonlinear crystals 200 nm ☺ PROMISSING for PALS (**3ω**)

Femtosecond pulse amplification by OPCPA

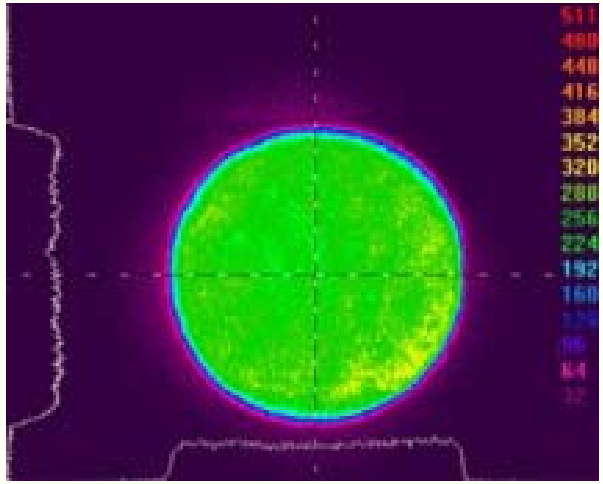


- broadband phase matching
- high gain
- high pulse contrast
- low dispersion
- small thermal load
- small beam distortion
- synchronization of pulses

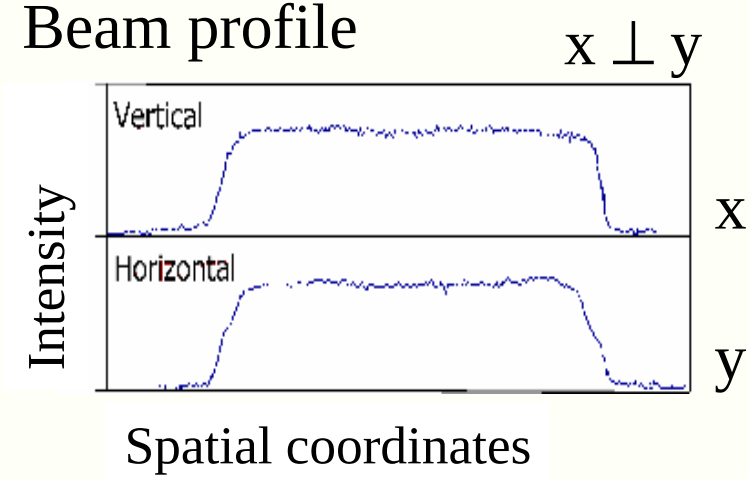
Terawatt gaseous iodine laser PALS

Single beam

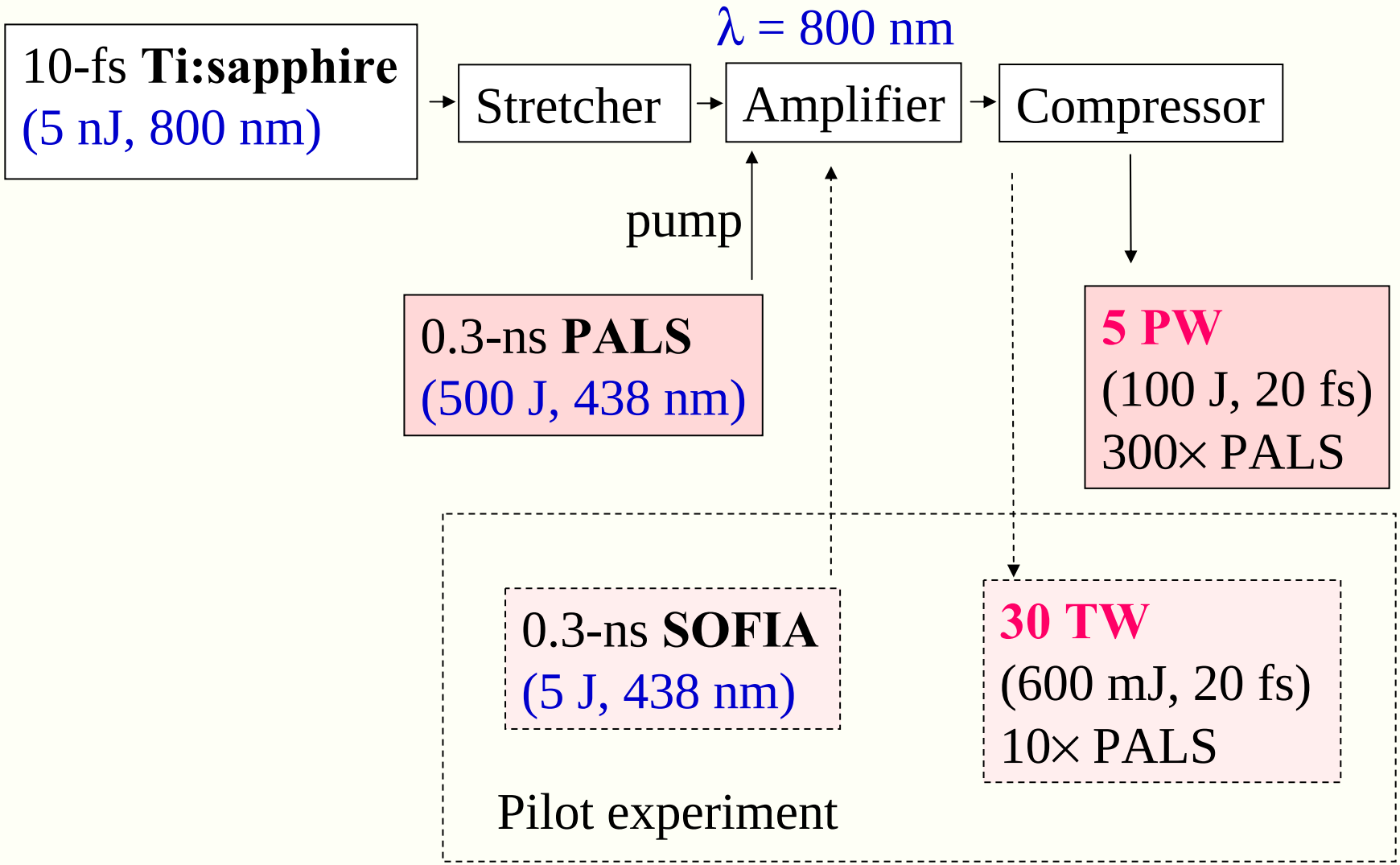
Wavelengths	1315 nm
Energy	1 kJ
Pulsewidth	300 ps
Power	3 TW
Beam diameter	30 cm
Repetition	1 pulse per 25 min



Beam profile

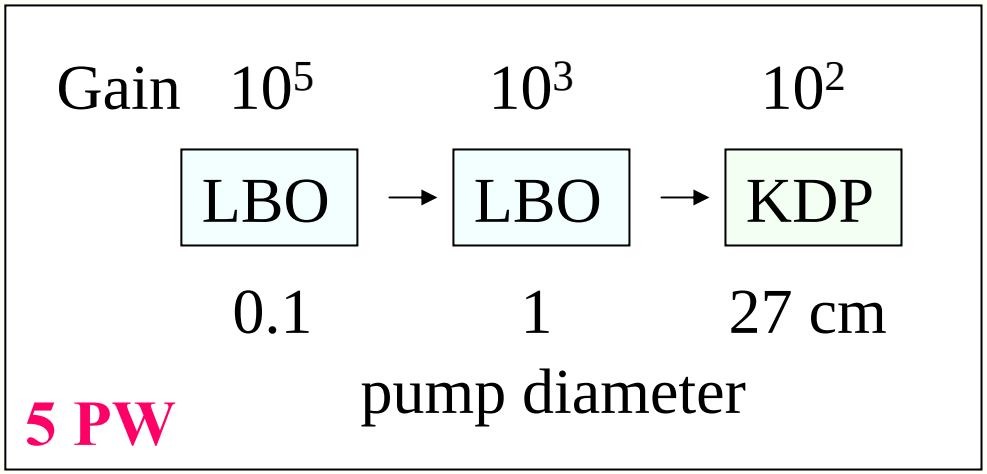


Petawatt proposal started with new laser SOFIA

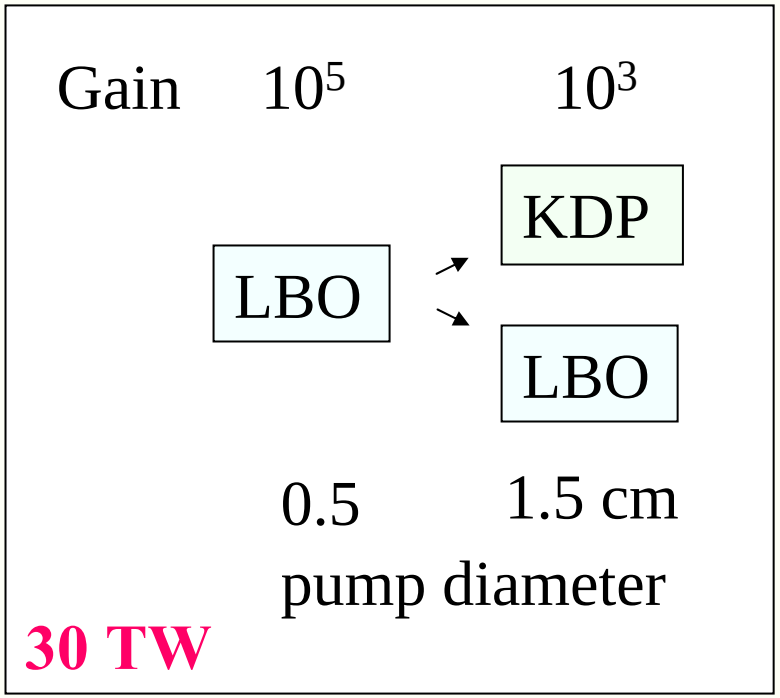


OPCPA amplifiers

PALS (pump 500J)



SOFIA (pump 5J)



Expected conversion > 20%

Application of ultra-high energy density pulses

- nonlinear relativistic optics
- high-energy particles and photons
- laser accelerator
- laboratory astrophysics
- thermonuclear fusion
- radiotherapy
- nuclear reactions

Laboratory of SOFIA

2001 - beginning

2002 - lab reconstruction, TiS laser, SOFIA setup,

2003 - hybrid laser, setup of stretcher, amplifier and compressor

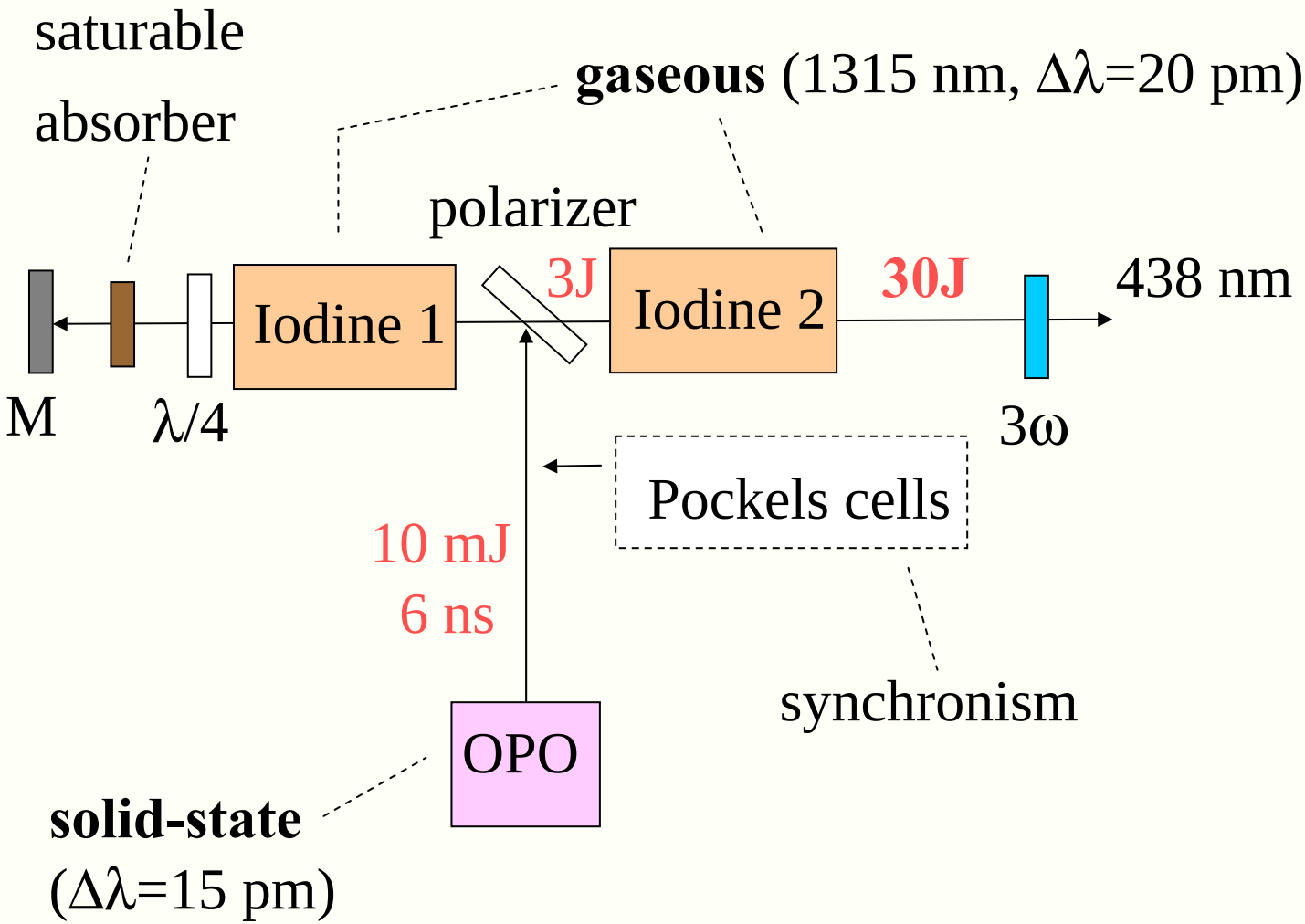
2004 - 30TW

2006 - user laboratory

PALS upgrades

- petawatt
- fiber oscillator
- adaptive optics

Hybrid laser SOFIA



Solid-state **O**scillator **F**ollowed by **I**odine **A**mplifiers (**SOFIA**)

Oscillator of SOFIA

wavelength	1315 nm (idler)
linewidth	15 pm
energy	10 mJ
power fluctuations	10%
repetition	10 Hz
wavelength matching	absorbing iodine cell

Iodine amplifiers of SOFIA

Amplifying medium

$C_3F_7I + SF_6 + He$

gain length 1-2 m

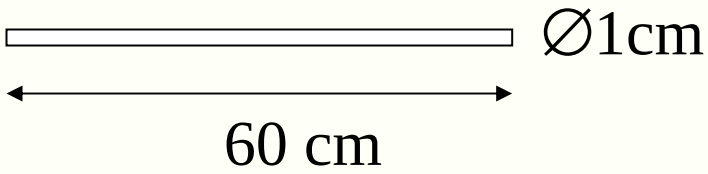
Free running 1315 nm

iodine1 16J

iodine2 50J

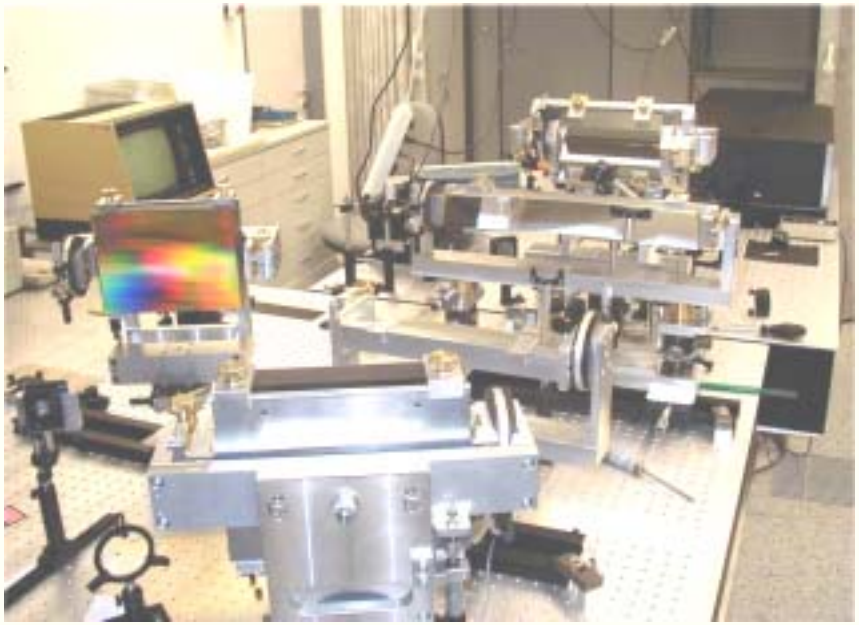
Xe flashlamps

power supply	2-4 kJ, 5kV
pulse	270 µs
lifetime	5000 shots
optical efficiency	5%



Pulse energy	30 J (← 10 mJ)
pulsewidth	2 ns
repetition	1 pulse per 5 min

Beginning of the petawatt technique at SOFIA



stretcher and compressor

amplifiers of SOFIA

Summary and future

- OPCPA petawatt proposal for PALS
- Hybrid laser SOFIA
  - solid-state OPO (10 Hz)
  - gaseous iodine amplifiers (1315.24±0.02 nm, 1pulse/5 min)
- 30 J pulse
- Next steps

→

- Synchronism with Ti:sapphire oscillator (80 MHz)
- Beam clean up
- 3ω conversion
- 30 TW femtosecond pulse by OPCPA
- user laboratory