Status of 1kJ Petawatt Laser System for SG-II Upgrade Program

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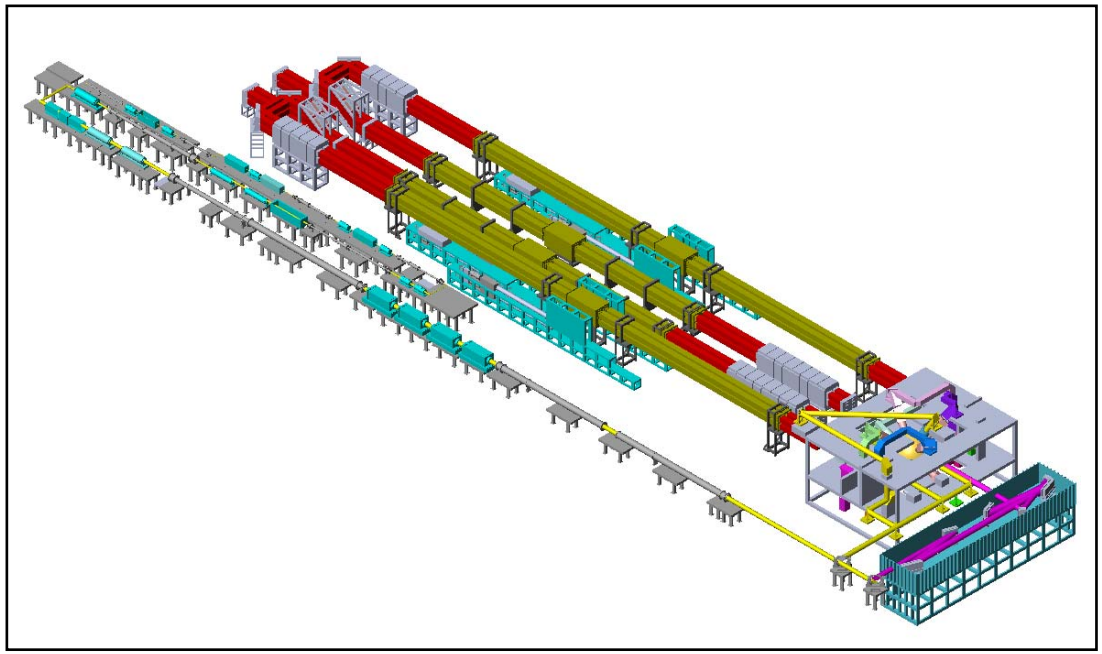

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3rd International Conference on Ultrahigh Intensity Lasers
Shanghai-Tongli China
27 – 31 October 2008

SG-II upgrade program motivated by the research on high energy density physics

- There are two primary missions in SG-II upgrade (SGII-U) program.
  - to setup one Nd:glass laser system with eight beams
  - to upgrade the existing ninth beam of SG-II with PW output
- SG-II-U program has been carried out since October 2007.
- SG-II-U laser system is under construction and will be completed in 2010.

SG-II-U laser system arranged in NLHPLP laser building

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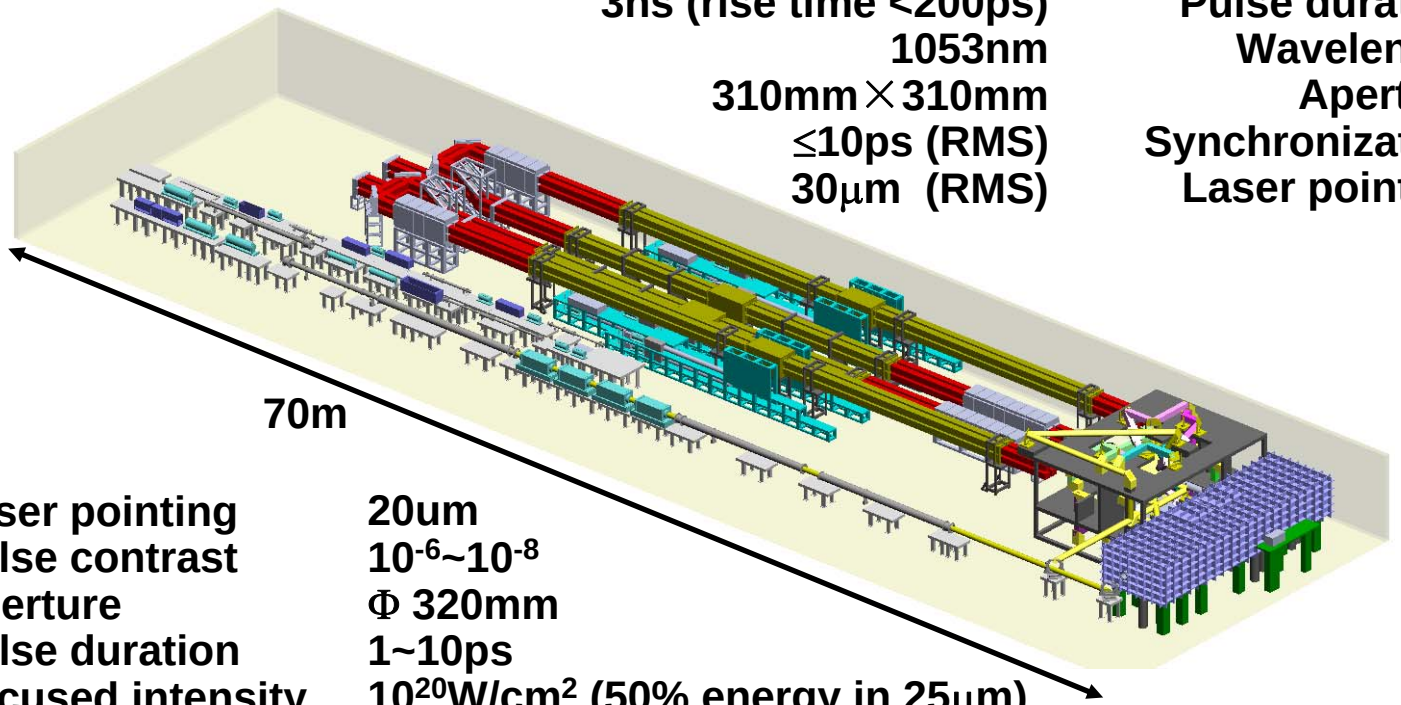
Energy	40kJ/8 beams
Pulse duration	3ns (rise time <200ps)
Wavelength	1053nm
Aperture	310mm×310mm
Synchronization	≤10ps (RMS)
Laser pointing	30μm (RMS)



Laser pointing	20um
Pulse contrast	10^{-6}~10^{-8}
Aperture	Φ 320mm
Pulse duration	1~10ps
Focused intensity	10^{20}W/cm^2 (50% energy in 25μm)
Wavelength	1053nm
Energy	1.7kJ (chirped pulse) /1kJ (compressed pulse)

The ninth beam was completed and coupled with SG-II in March 2005 as a probing beam of physical experiments

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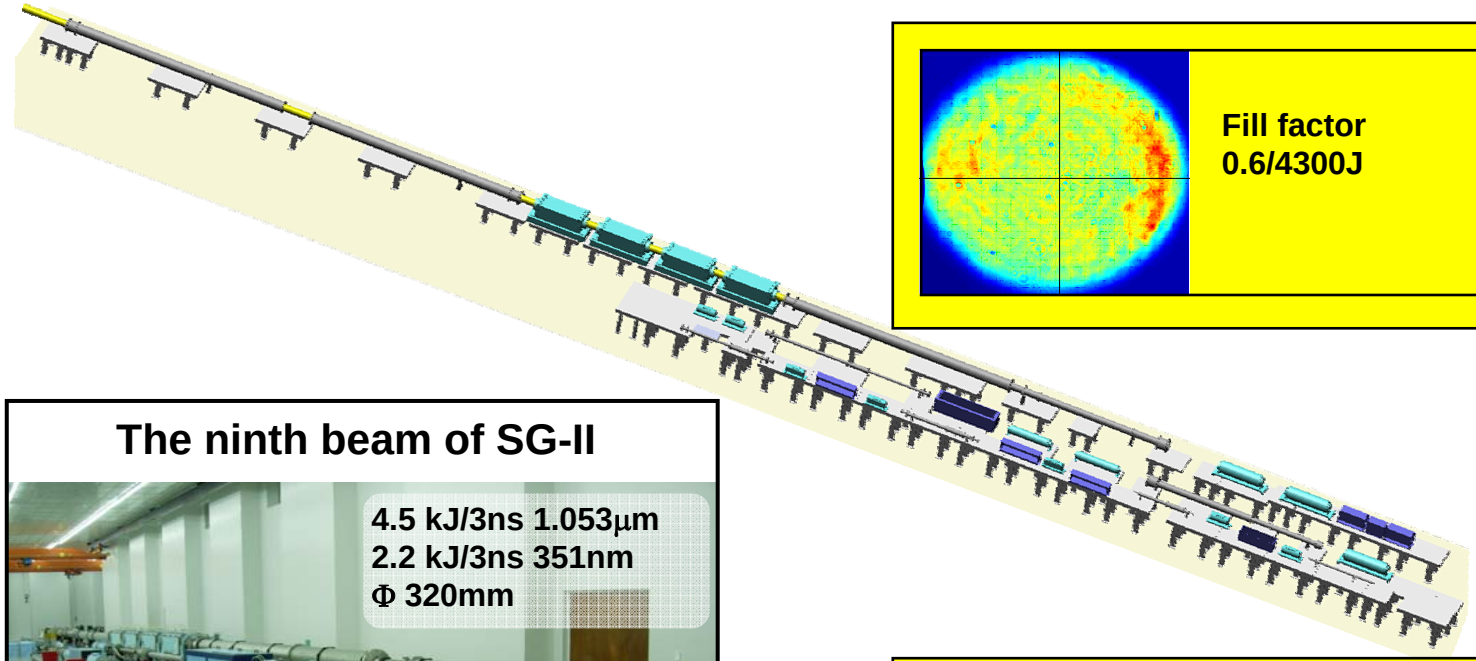
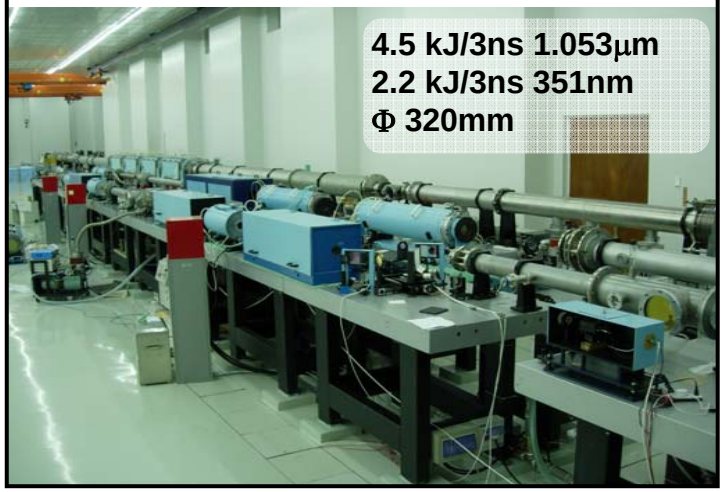
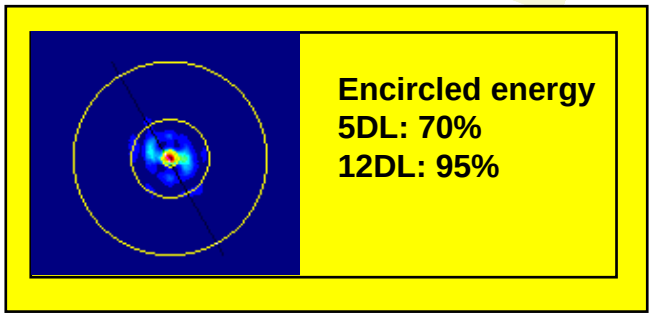


The ninth beam of SG-II





Utilizing the existing ninth beam of SG-II 1kJ PW laser is being developed in SG-II-U program

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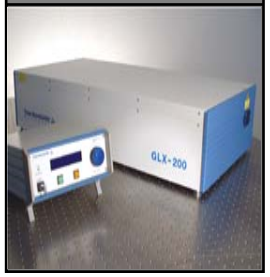
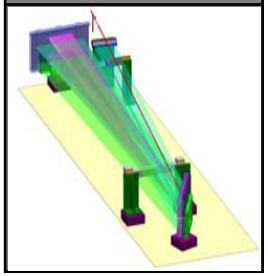
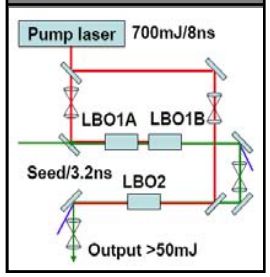
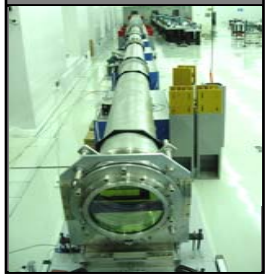
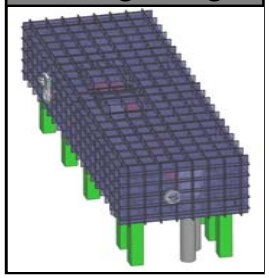
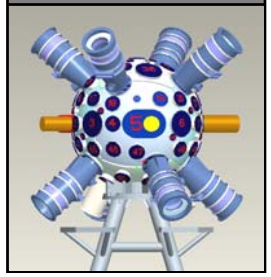
GLX-200	Offner triplet	Two-stage	The ninth beam	Single-path four-grating	Target chamber
					

Oscillator	Stretcher	OPCPA	Amplifier	Compressor	A.O system
Pulse duration 230fs Bandwidth 6.5nm Wavelength 1053nm Power 285mW Repetition 70MHz	Chirp ratio 3.2ns/6.5nm Spectral transmission 17nm Grating size 400×200mm Groove density 1740g/mm	Energy 50mJ Pulse contrast 10^{-8}(Prep) stability 3%(RMS)	Pulse duration 3ns Energy 1.7kJ ΣB 1.7 Bandwidth 3.4nm Aperture 320mm	Chirp ratio 3ns/6.5nm Spectral transmission 6.8nm Grating size 1200×350mm 430×350mm Groove density 1740g/mm Threshold 1.2J/cm^2	Target Chamber Chamber size 2400mm Focal length 800mm

The amplifier chain of the ninth beam has the capability to meet the output energy requirement of the PW laser

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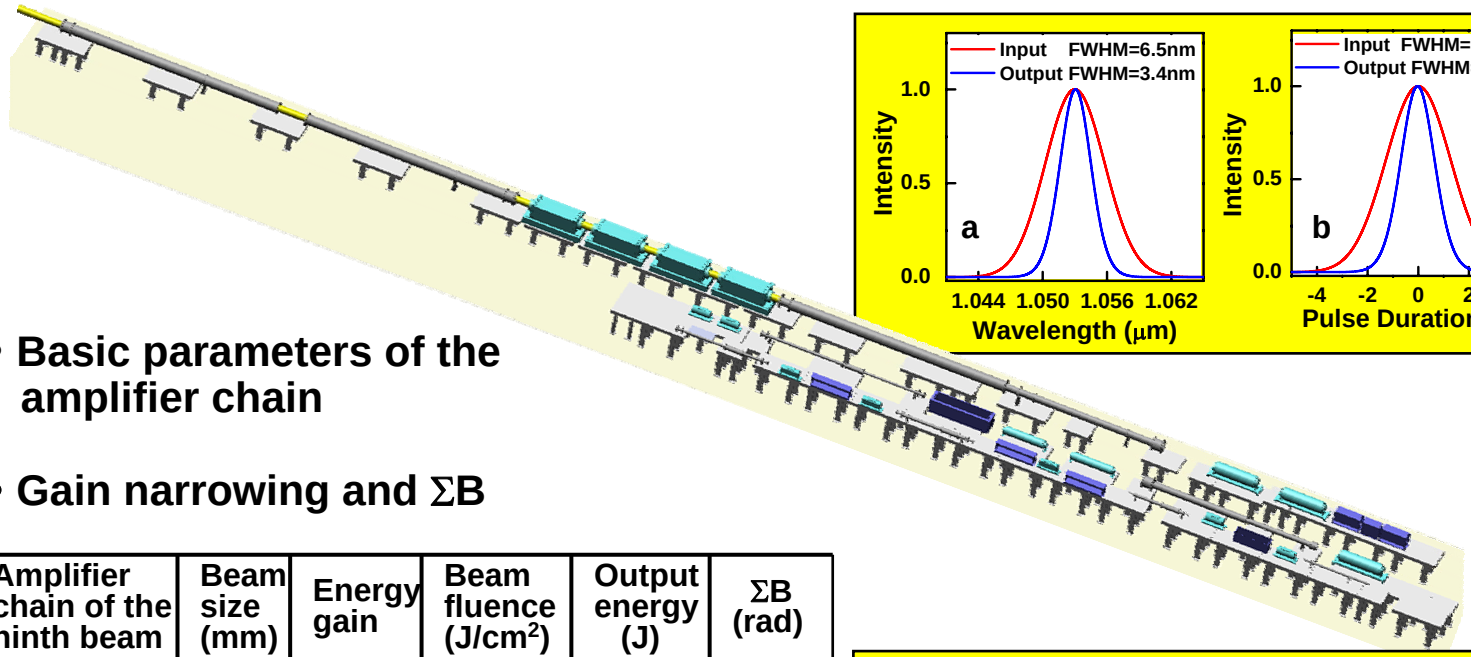
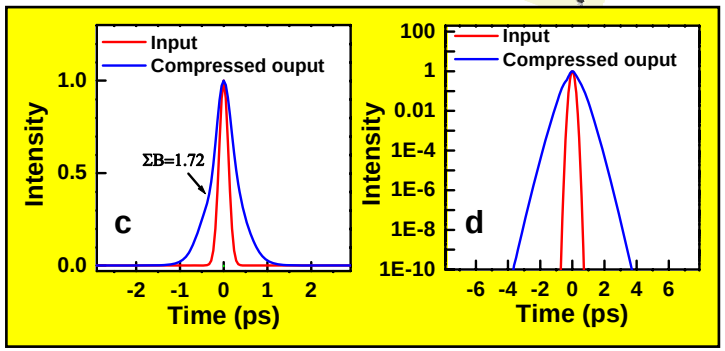


- Basic parameters of the amplifier chain
- Gain narrowing and ΣB

Amplifier chain of the ninth beam	Beam size (mm)	Energy gain	Beam fluence (J/cm^2)	Output energy (J)	ΣB (rad)
two Φ40 rod amps	30	195	1.33	9.40	0.117
two Φ70 rod amps	60	5.9	1.76	49.9	0.37
two Φ100 disk amps	90	6.4	4.54	289	0.99
three Φ200 disk amps	190	3.2	2.49	708	1.36
four Φ350 disk amps	320	3.1	2.11	1700	1.72



Technology issues to be developed for PW laser

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- When the intensity of the prepulse is as low as 10^{-8} of the main laser pulse or less, it will generate the preplasmas on a target surface and finally makes the fast ignition mechanism complicated and unclear.
  - one OPCPA system with two stages will be employed as a noise cleaner in the front end of the PW with prepulse ratio of 1×10^{-8}.
- The dynamic correction of wavefront errors that arise from propagation through the optical chain of the laser system is necessary.
  - an adaptive optic that has been developed for Shen Guang-III (SG-III) prototype will be transplanted to PW laser.
- For PW laser system with high energy output, the bottleneck is the limitation of the damage threshold of the final grating in the pulse compressor.
  - to manufacture multilayer dielectric (MLD) coating diffraction gratings.
  - to develop grating tiling.

Two-stage OPCPA pumped by Nd:YAG laser with super-Gaussian temporal and spatial profile

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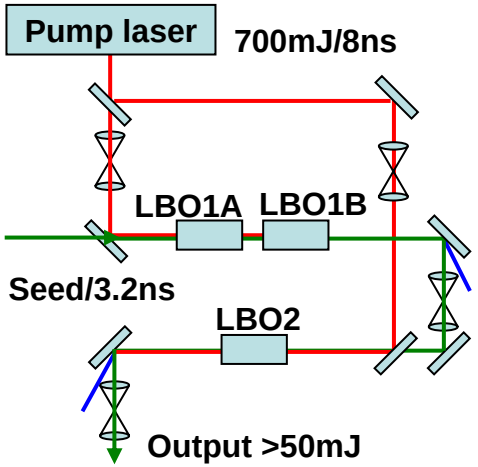
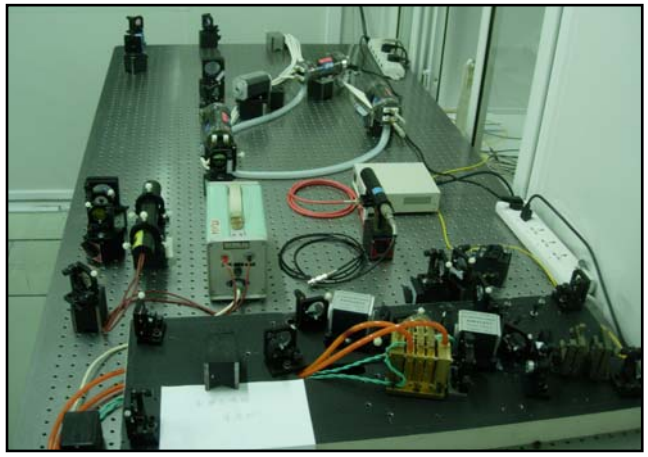
- Two stages
  - preamplifier two 5×5×30mm^3 LBO crystals cut at 11.8°
  - power amplifier one 7×7×15mm^3 LBO crystal



- Nd:YAG pump laser
  - energy 700mJ/532nm
  - pulse duration 8ns(FWHM)
  - super-Gaussian temporal and spatial profile
  - energy stability <2%(RMS)
  - pointing stability <50urad
  - beam divergence <0.6mrad
  - synchronization <15ps



Development of MLD diffraction gratings

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Holographic exposure system

RF ion beam etcher

200mm×400mm MLD grating

Coating chamber

Current achievements of the MLD diffraction grating

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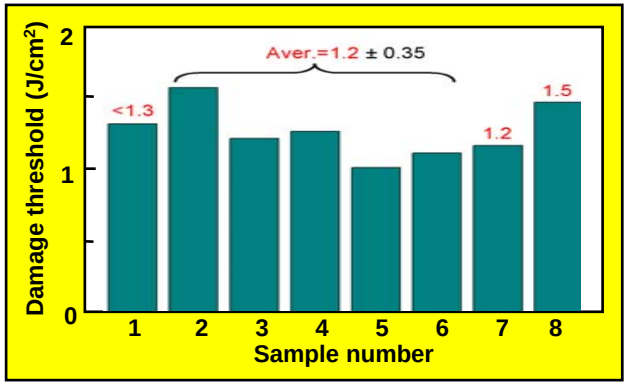
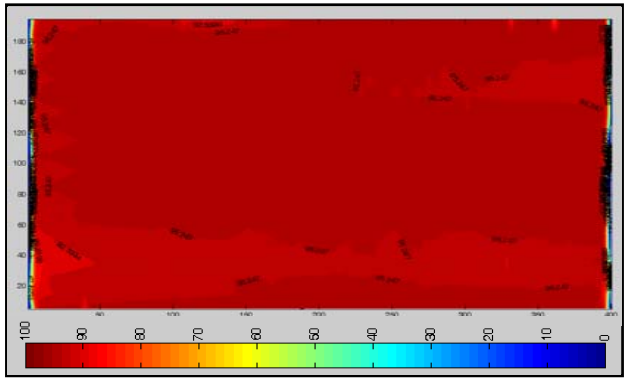
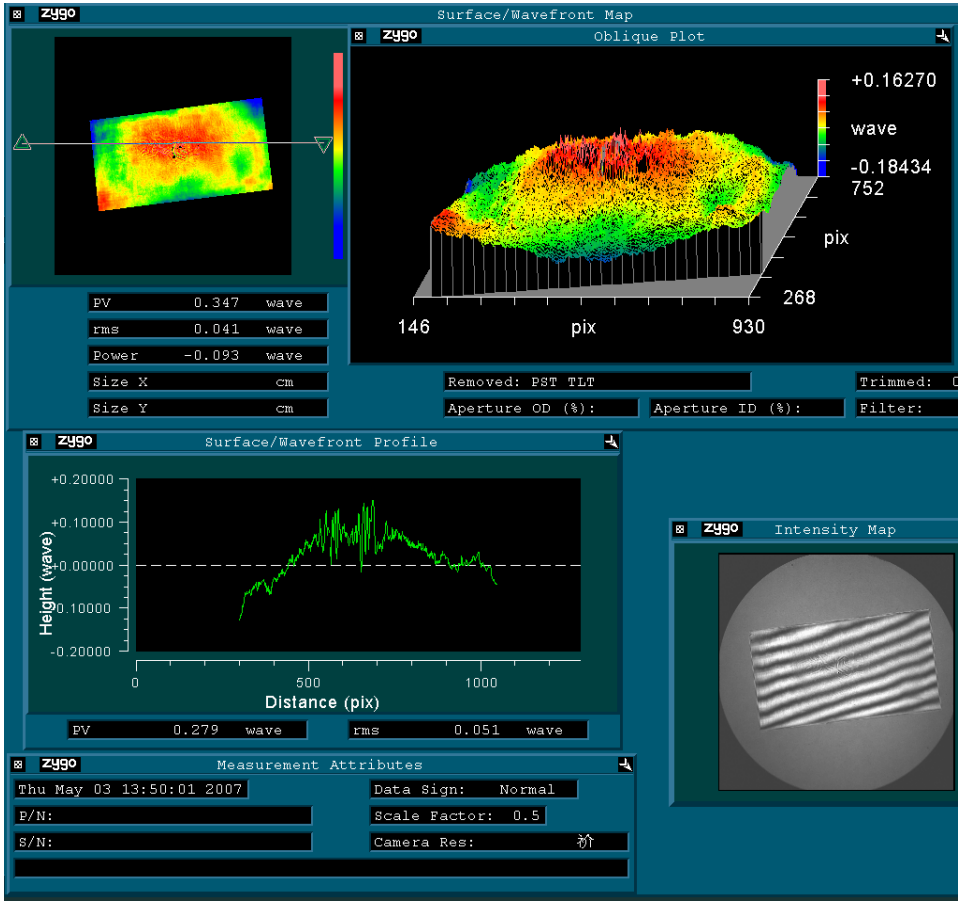
- Damage threshold on grating surface 1.2J/cm^2 for 1ps

- Holographic wavefront error 0.35λ
- Diffraction efficiency ~96%







Research on large scale grating tiling

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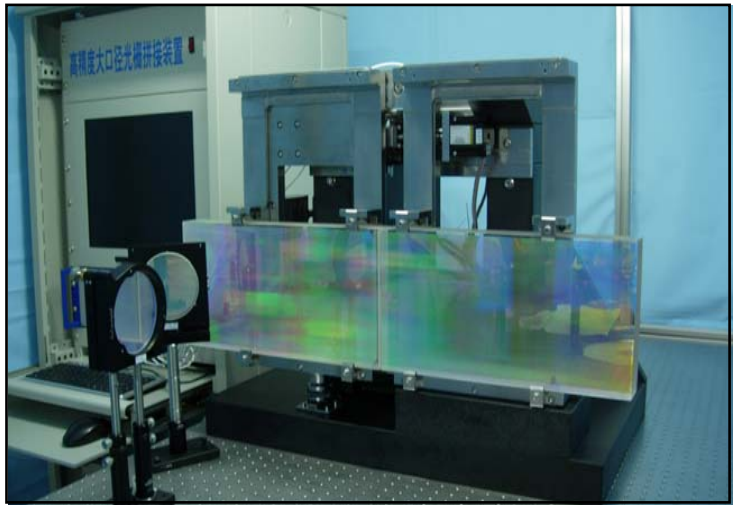
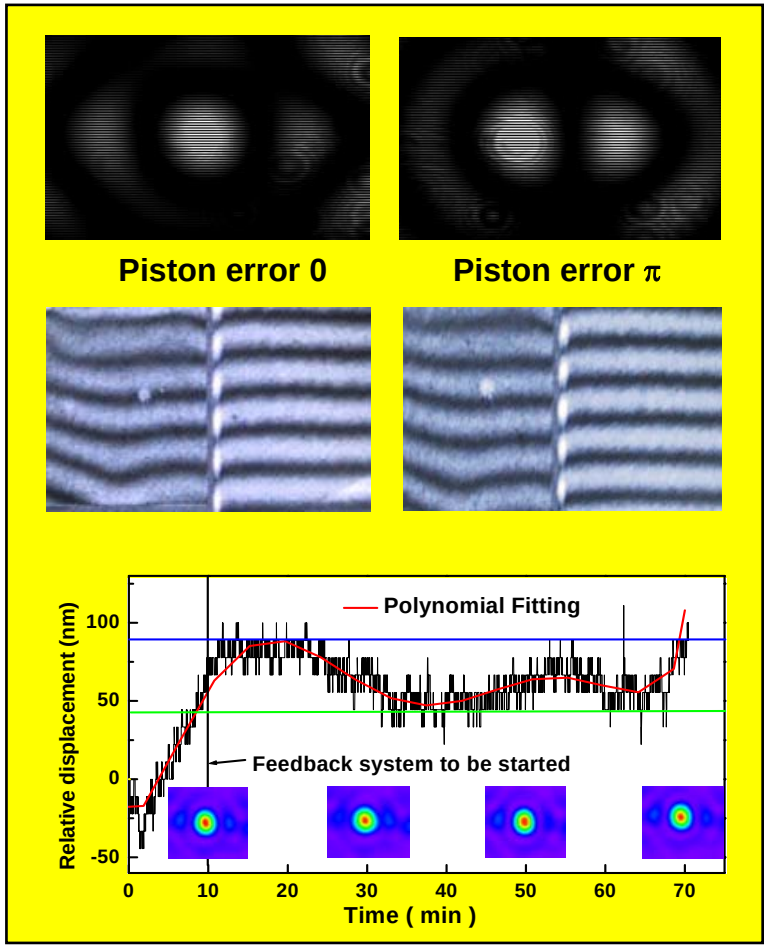
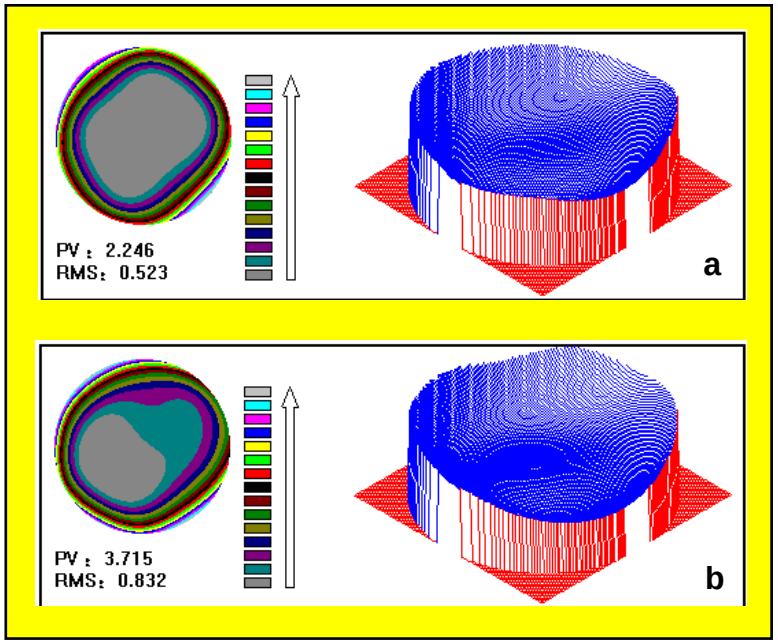


- Alignment method
  - far-field pattern
  - interferometry
- Feedback system



Based on the beam quality of the ninth beam a deformable mirror has been manufactured

- Wavefront measurement of the ninth beam
  - the static aberrations
  - the distortions caused by the thermal gradients during the course of firing laser shots



- Clear aperture Φ 340mm
- 55 actuators
- Damage threshold 8.8J/cm^2