Progress on Developing the Petawatt Laser Facility XG-III

Qihua Zhu

(朱启华）

Research Center of Laser Fusion, CAEP

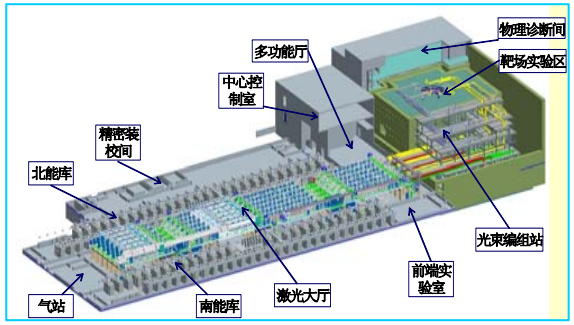
P.O.Box 919-988, Mianyang, China, 621900. Fax: 86-0816-2491410, Email:qihzh@163.com

High Power Solid-state Laser Facility R&D Plan at LRC

NANOSECOND

ULTRASHORT

SG-III
2012



XG-PW
2009

TIL
2007

150Jps
2006

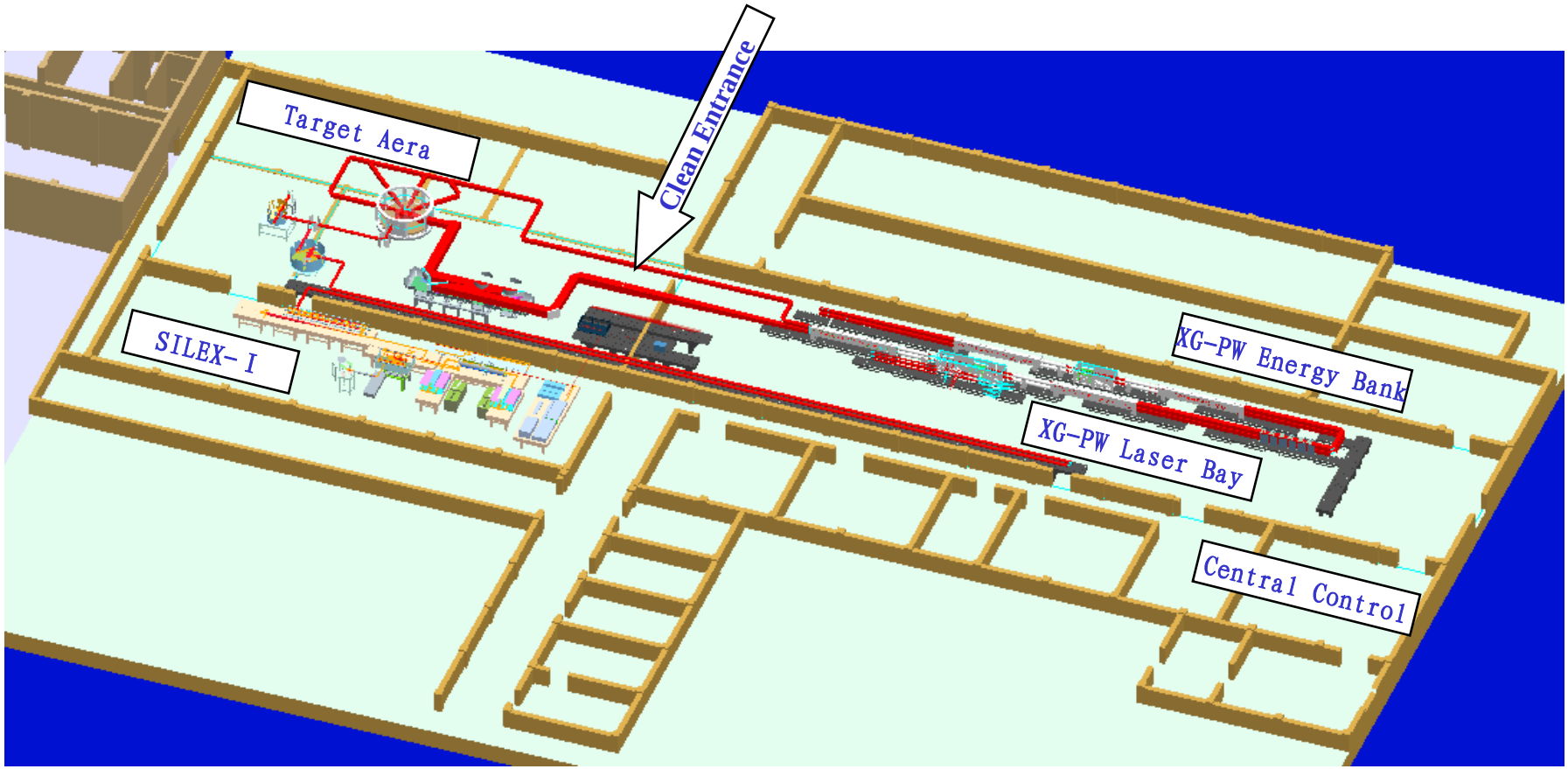
XG-Ⅱ
1985,93

SILEX-Ⅰ
2004

The Main Specifications of XG-III

- **The Three Beams of The PW Laser Facility Synchronized with Each Other without Jitter Time.**
  - The Ti:sapphire femto-second laser:
    - **Energy: 15J**
    - **Power: 500TW**
    - **Pulse Width: 30fs**
    - **Wavelength: 800nm**
  - The Nd^{3+}:glass pico-second laser:
    - **Energy: 1kJ**
    - **Power: >1PW**
    - **Pulse Width: 0.5-10ps**
    - **Wavelength: 1053nm**
  - The Nd^{3+}:glass nano-second laser:
    - **Energy: 1000J**
    - **Pulse Width: 1ns**
    - **Wavelength: 1053nm**

The Optical Layout of XG-III Laser Facility



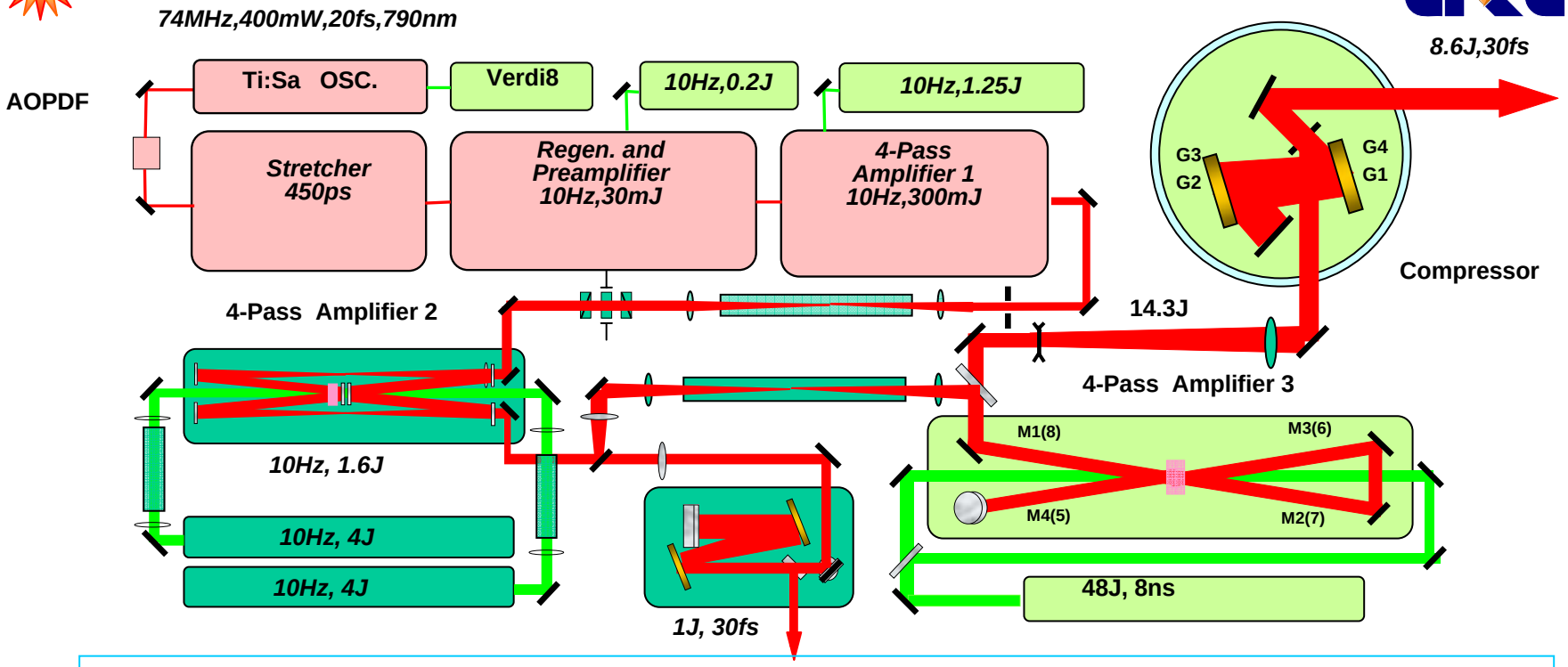
The Ti:Sapphire Femtosecond Laser SILEX-I

Super Intense Laser for Experiments on the Extremes.

- **Centre wavelength: 800nm;**
- **Pulse width (FWHM): 29.7fs;**
- **Output energy: 9.9J;**
- **Output power: 330TW;**
- **Focus spot (FWHM): 5.7 μ m (F/2.2);**
- **Power density at focus: $>10^{20}W/cm^2$.**
- **S/N: 10^7;**

- **It's an existing system established in 2004.**
- **This system has been routinely operated for intense-field experiments with good stability for more than 4 years.**
- **Revises have being taken to improve its performance in these years.**
- **It will be upgraded to 500TW, and become the femtosecond beamline of the new facility XG-Ⅲ in 2009.**

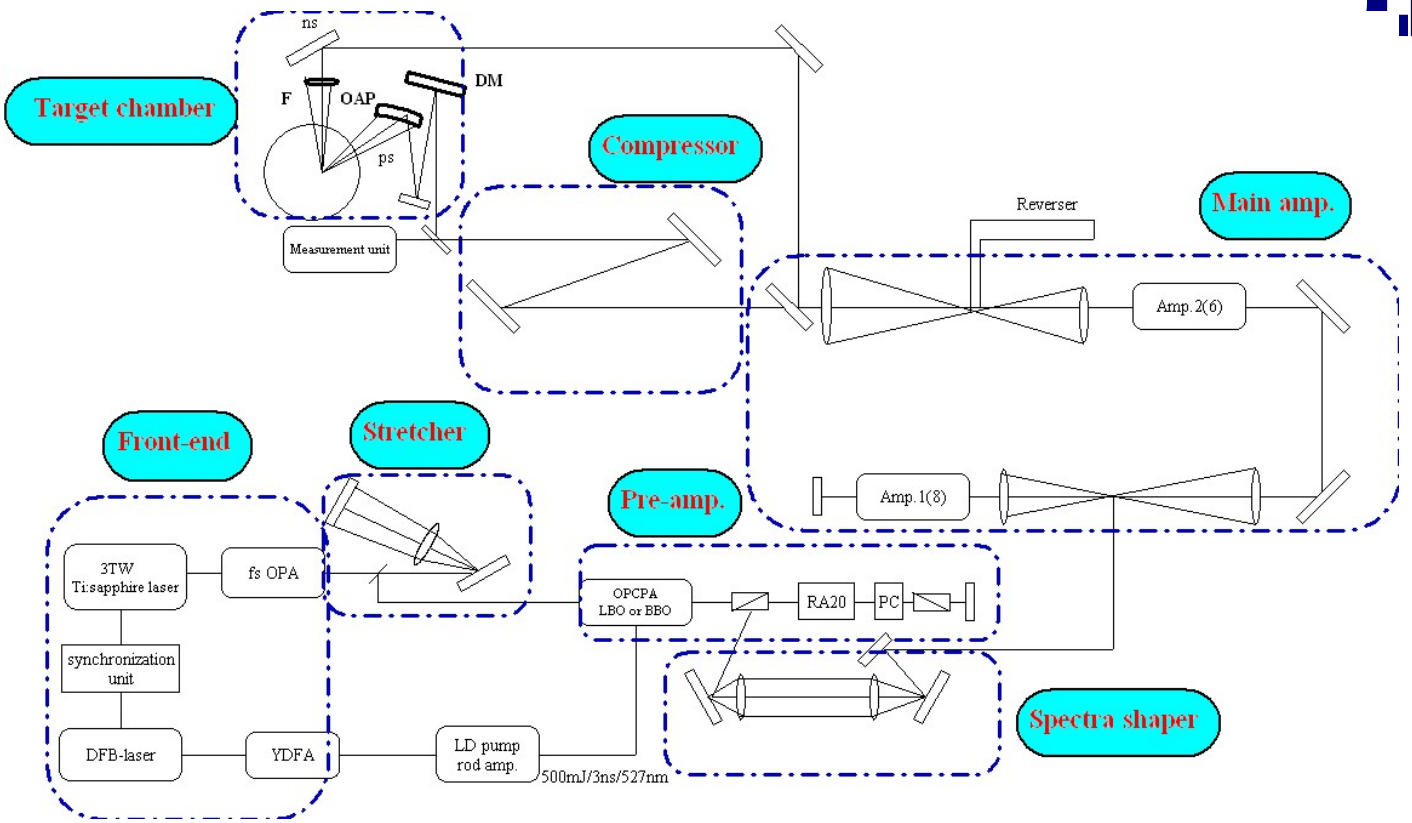
Optical layout of SILEX-I



Measures for upgrading SILEX-Ⅰ to 500TW output power:

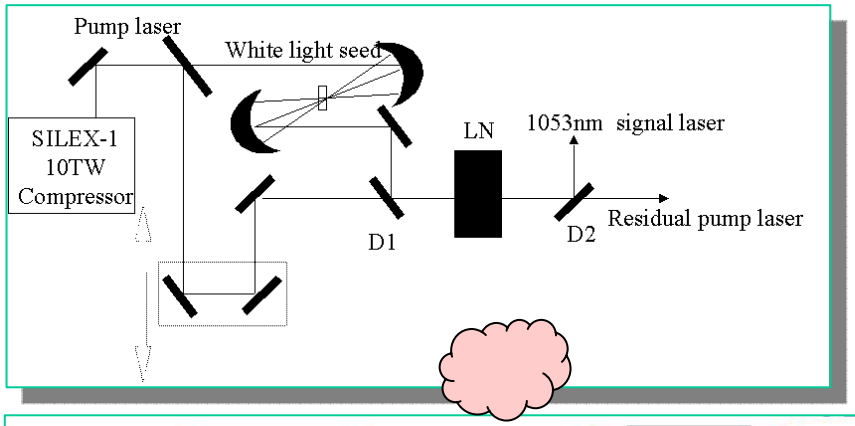
- **Improve the near field quality of the pumping soures;**
- **Liquid cladding to suppress ASE of the main amplifier;**
- **Add adaptive optics system to increase the energy concentration of focus;**
- **Use XPW to increase S/N ratio.**

Layout of the Nd^{3+}:glass Lasers



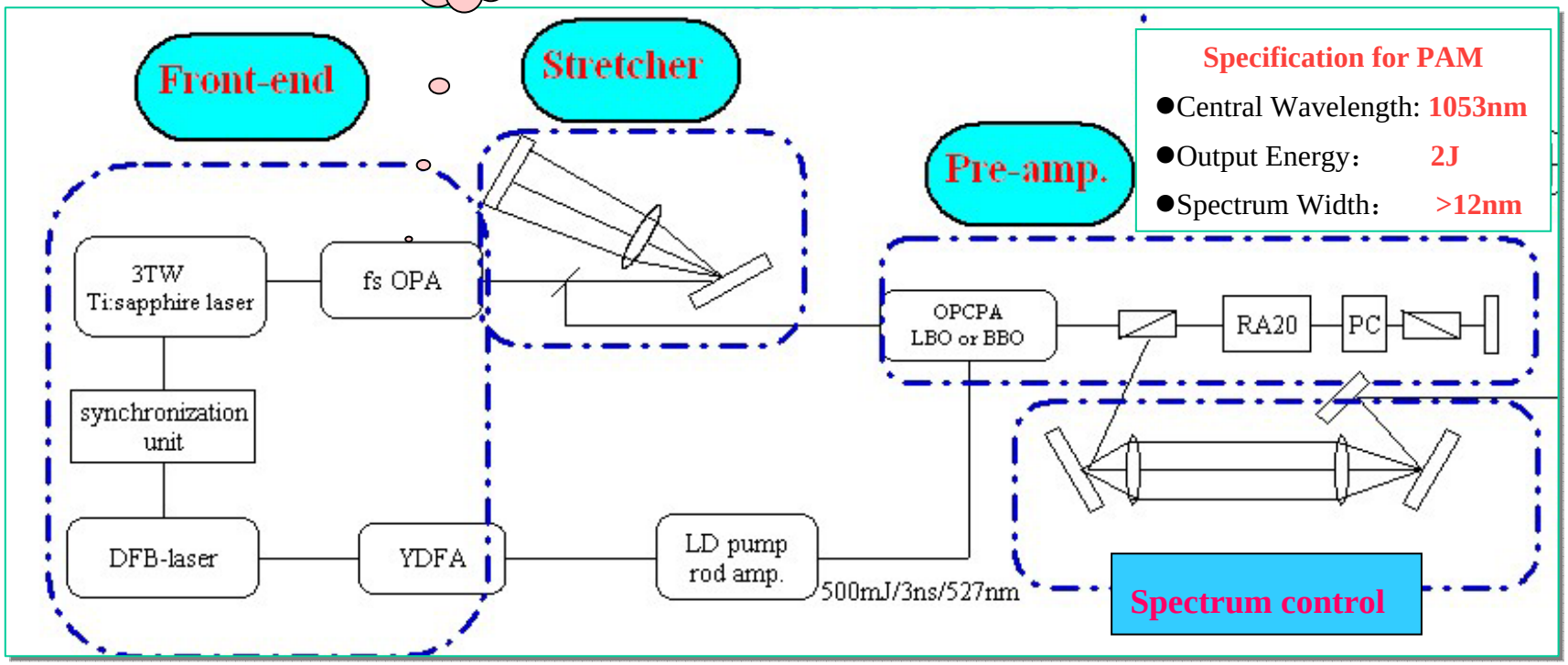
- **Multi seeds with different wavelength and pulse duration synchronized without jitter time;**
- **Femtosecond pumping OPA seeded by SWL to achieve high S/N;**
- **Controlling and monitoring for tiled gratings, to assure PWs laser possible;**
- **Gain narrowing suppressed by active spectrum control technique enabling higher energy and shorter compressed pulse width.**

The Front-end and Preamplifiers



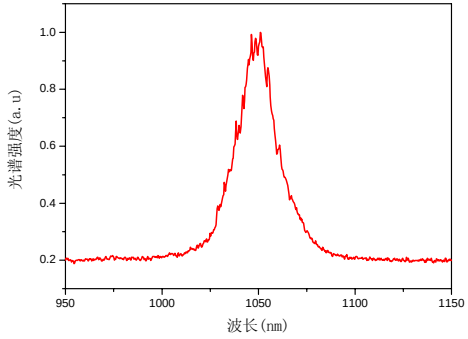
Femto-second pumping OPA seeded by supper-continuum white light can:

- **Synchronize the three beams without jitter time;**
- **Improve the S/N ratio;**
- **Improve the beam quality of the 1054nm seeds for Nd^{3+}:glass beamlines.**

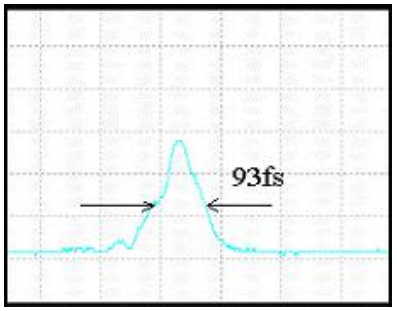


The Front-end

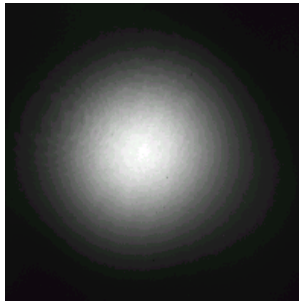
- **Wavelength :** **1053nm**
- **Energy:** **5mJ**
- **Pulse width:** **93fs**
- **Spectrum width:** **25nm**
- **Beam quality:** **1.5DL**



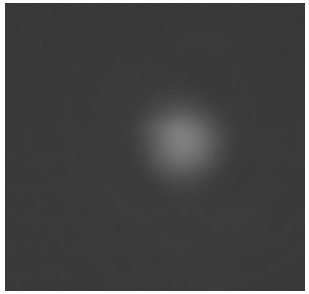
Spectrum



Pulse width

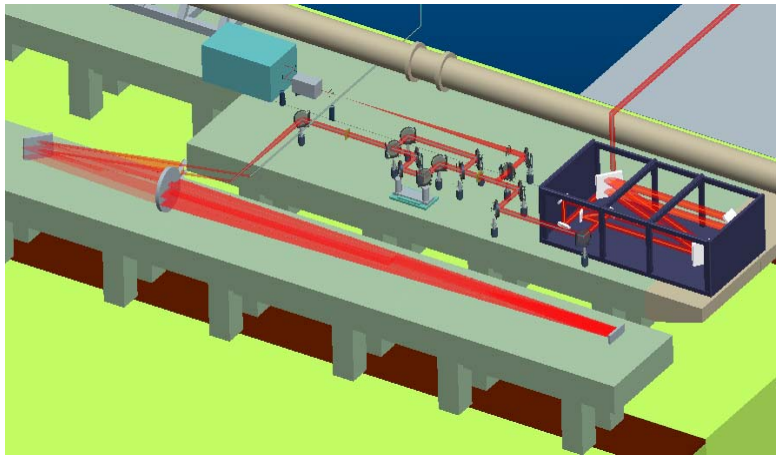


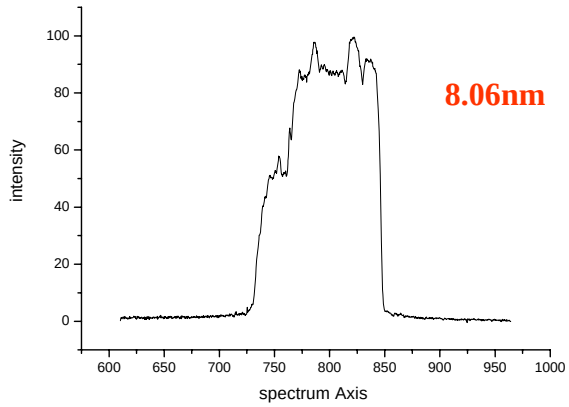
Near field



Far field
1.5XDL

Stretcher





spectrum

Pulse width

Preliminary Experiments of Spectrum Control

- **An AOPDF device used in 1053nm was developed and preliminary experiments showed that the spectrum of the chirped pulse could be actively controlled.**

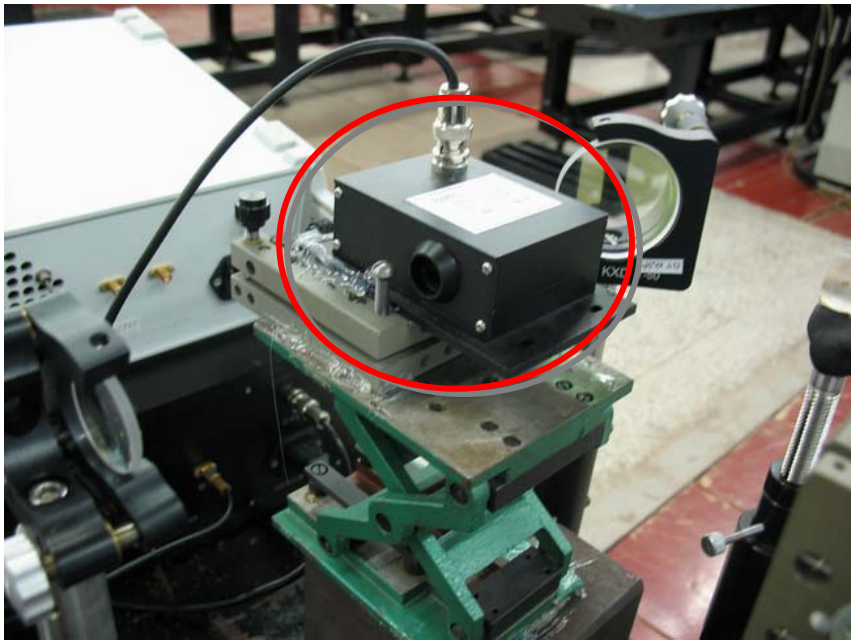
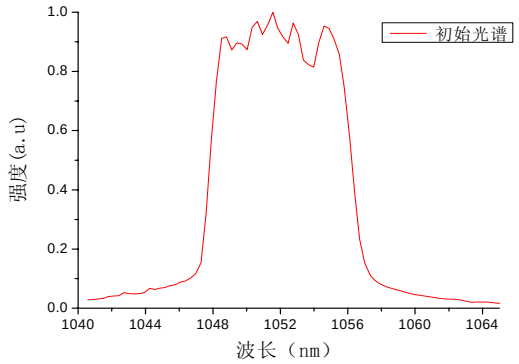
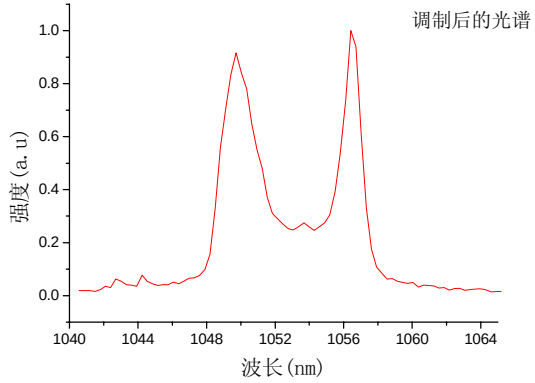


Photo of the AOPDF



The spectrum of the input seeds

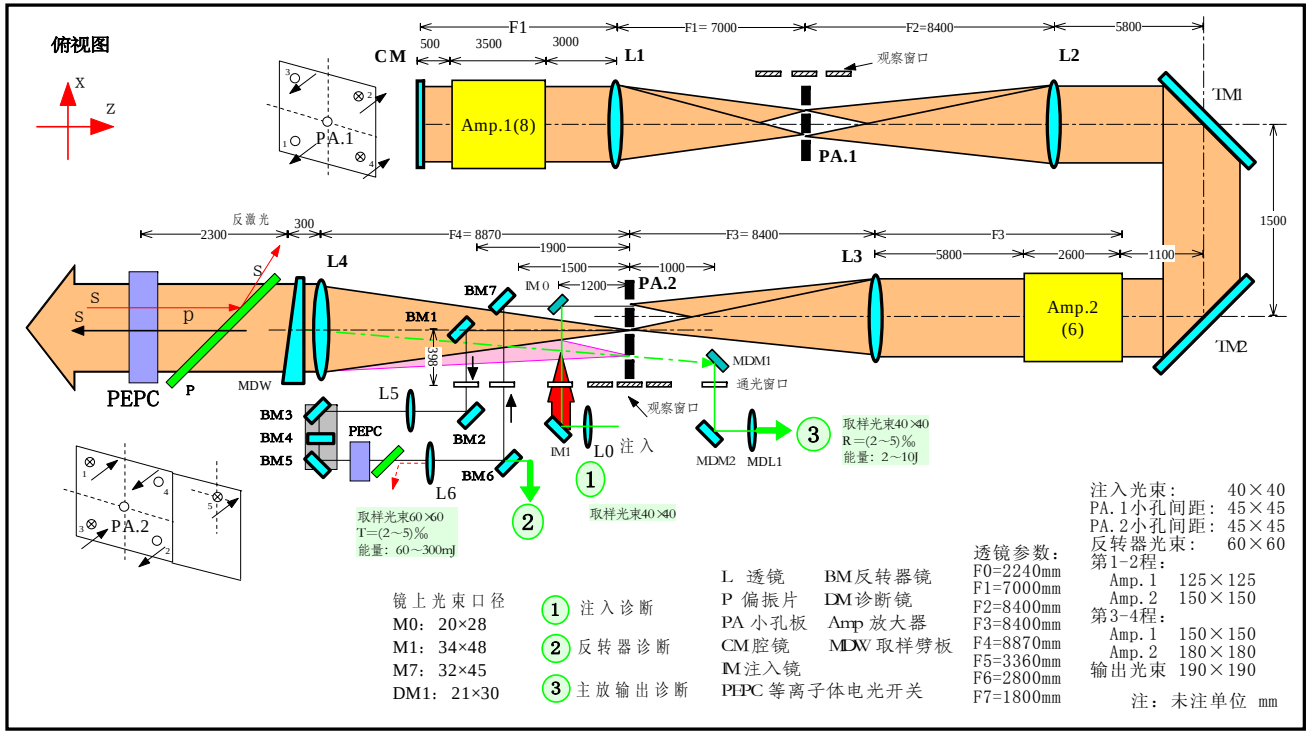


The spectrum after the AOPDF

Preamplifiers

OPCPA and its pumping soures

The Main Amplification Stage



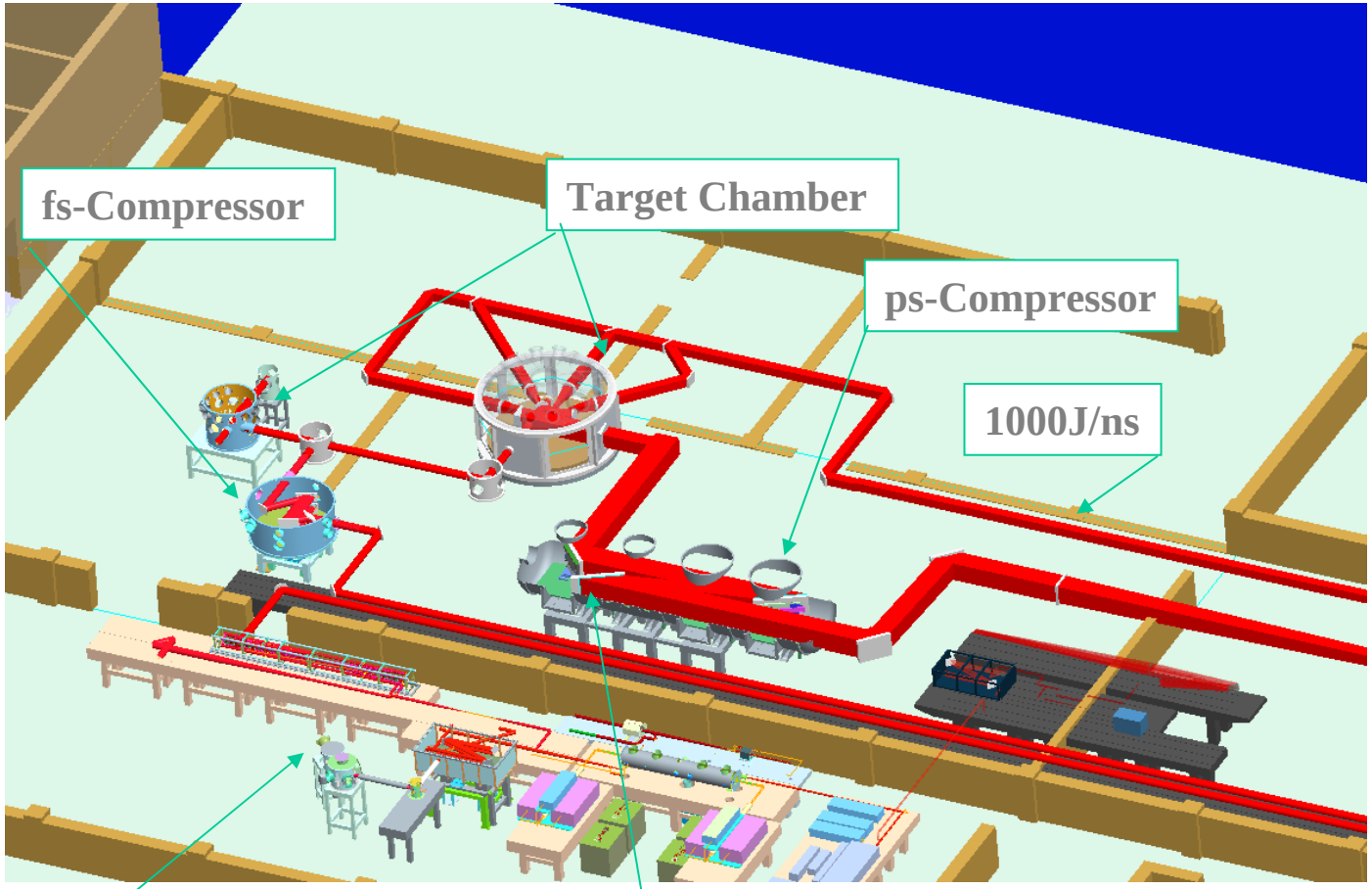
- **8+6 multi-segment amplifiers, image relay and all 4-pass amplification configuration;**
- **Different beam size in 1-2 pass and 3-4 pass and beam rotation by reverser for 90°, decrease the beam wave front aberrations especially pumping-induced thermo distortion of disk amplifier and astigmatism errors.**
- **U-turn beam reverser with small PEPC (80mm×80mm).**

Designed Specifications for Main Amp. Stage

- **Numbers of Aperture：　2Apertures（2×1Array）；**
- **Central Wavelength：　1053nm；**
- **Output Energy：　1.3kJ/beam；**
- **Output Spectrum Width：8nm；**
- **Output Pulse Duration：　2ns；**
- **Beam Aperture：　190mm×190mm；**
- **Near Field：　Supper Gausion，Modulation< 1.5:1.**

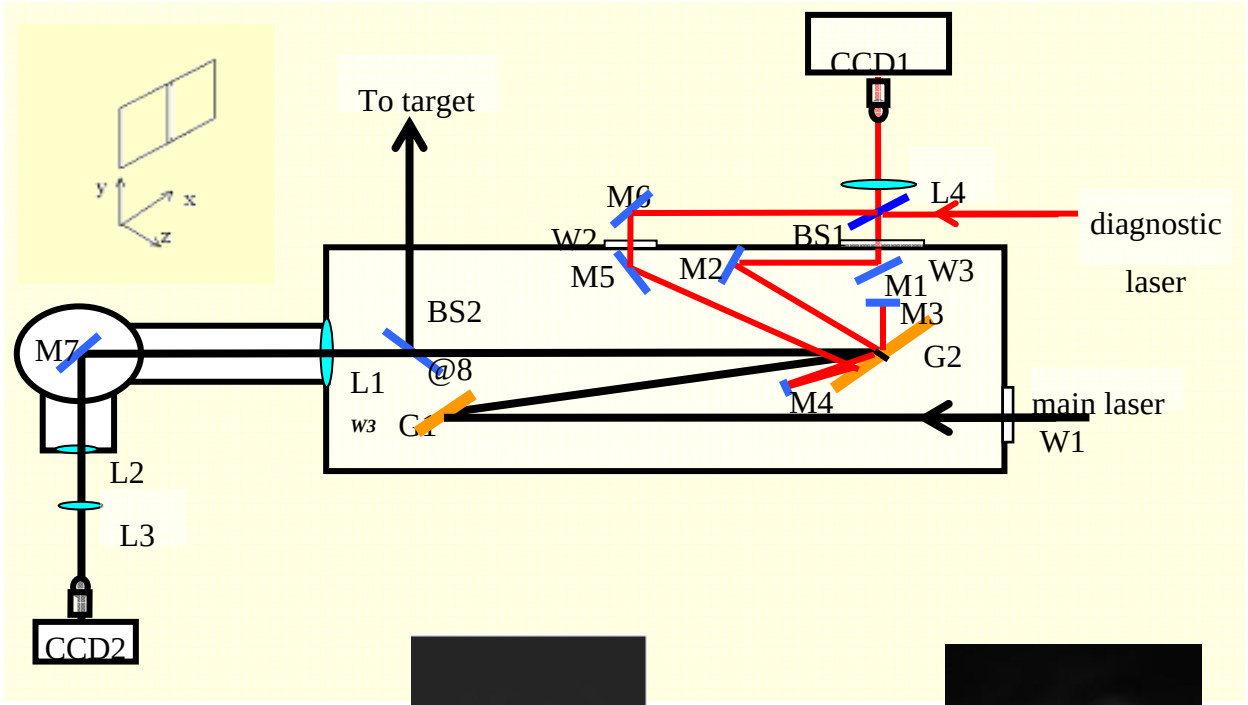
Photo of the Main Amp. Stage

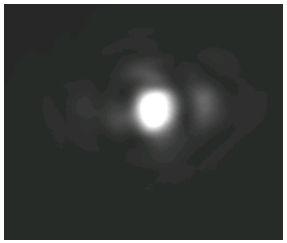
Target Area


fs-Compressor
Target Chamber
ps-Compressor
1000J/ns
SILEX- Ⅰ
Tiled MLD Gratings

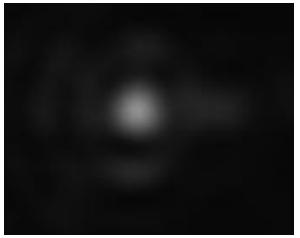
Gratings Tiling

- **Matched wavelength and incident angle for the diagnostic beam to monitor coherent grating tiling online;**
- **The tiled gratings last stable for 20 minutes, which is enough for use by controling online.**





Far field of the main laser



Far field of the diagnostic laser

Far field of the main laser

Far field of the diagnostic laser

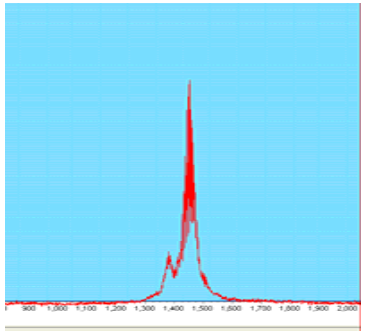
Results on the 150J picosecond laser system

Compressor

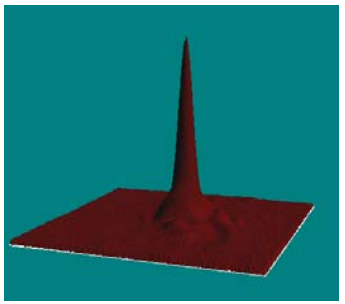
Tiled MLD gratings(420mm*210mm)

Main Specifications:

- **Energy:** 150J;
- **Pulse width:** <1ps;
- **Beam quality:** 1.3XDL;
- **S/N:** ~10^9;
- **Spectrum width:** 5.5nm.

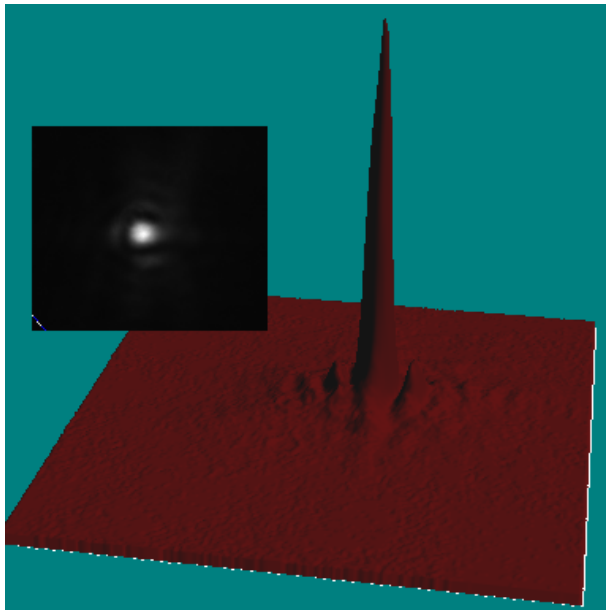


710fs

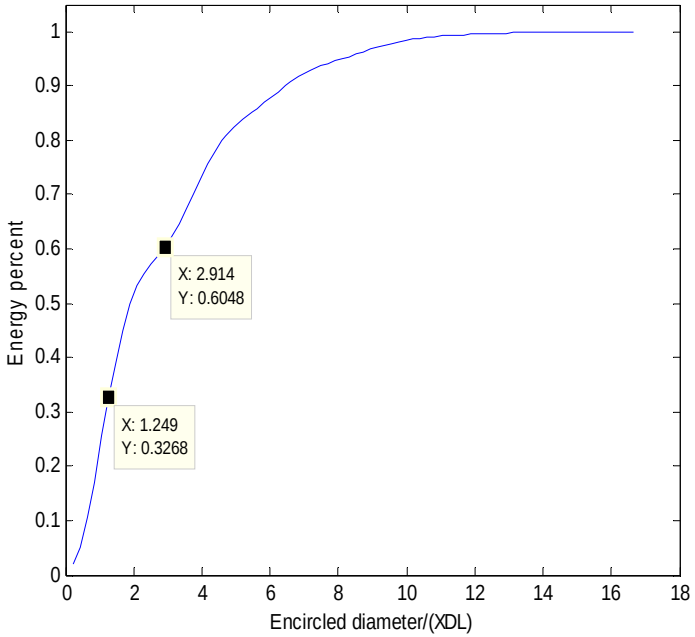


1.31XDL (FWHM)

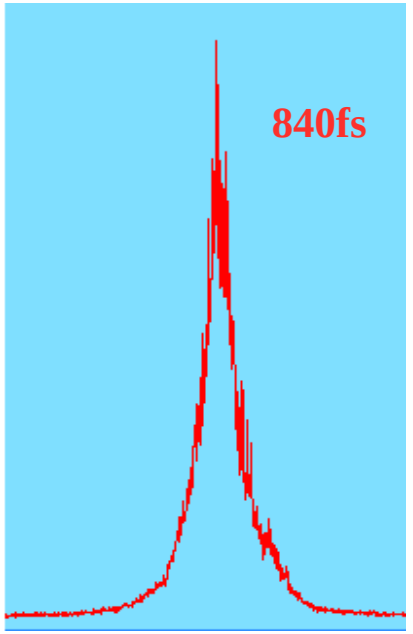
Preliminary Results of XG-PW



Far Field



Energy Concentration



Pulse Width

Conlusion

- **The Petawatt laser facility XG-Ⅲwith three beams for fast ignition research and strong-field physics applications has been designed and is being constructed.**
- **The output power of the Ti:sapphire femto-second laser beam line has reached to 330 TW and will upgraded to 500TW in 2009.**
- **The other two Nd^{3+}:glass laser beam lines which output energy are larger than 1kJ and pulse width are about 1ps and 1ns respectively ,are now being constructed.**
- **By using the technology of femtosecond pumping OPA seeded by SWL, the three beams are synchronized with each other without jitter time .Seeds from femtosecond laser pumping OPA will greatly improve the signal to noise ratio of the PW Nd^{3+}:glass laser.**
- **Tiled MLD gratings are used for the compressor of the PW beam. They have been used stably in a 150J Nd^{3+}:glass picosecond laser system.**
- **Active spectrum control will be used to compensate gain narrowing.**

Thanks for attention!