Recent Progress of SG-Ⅲ Laser Facility and its Prototype

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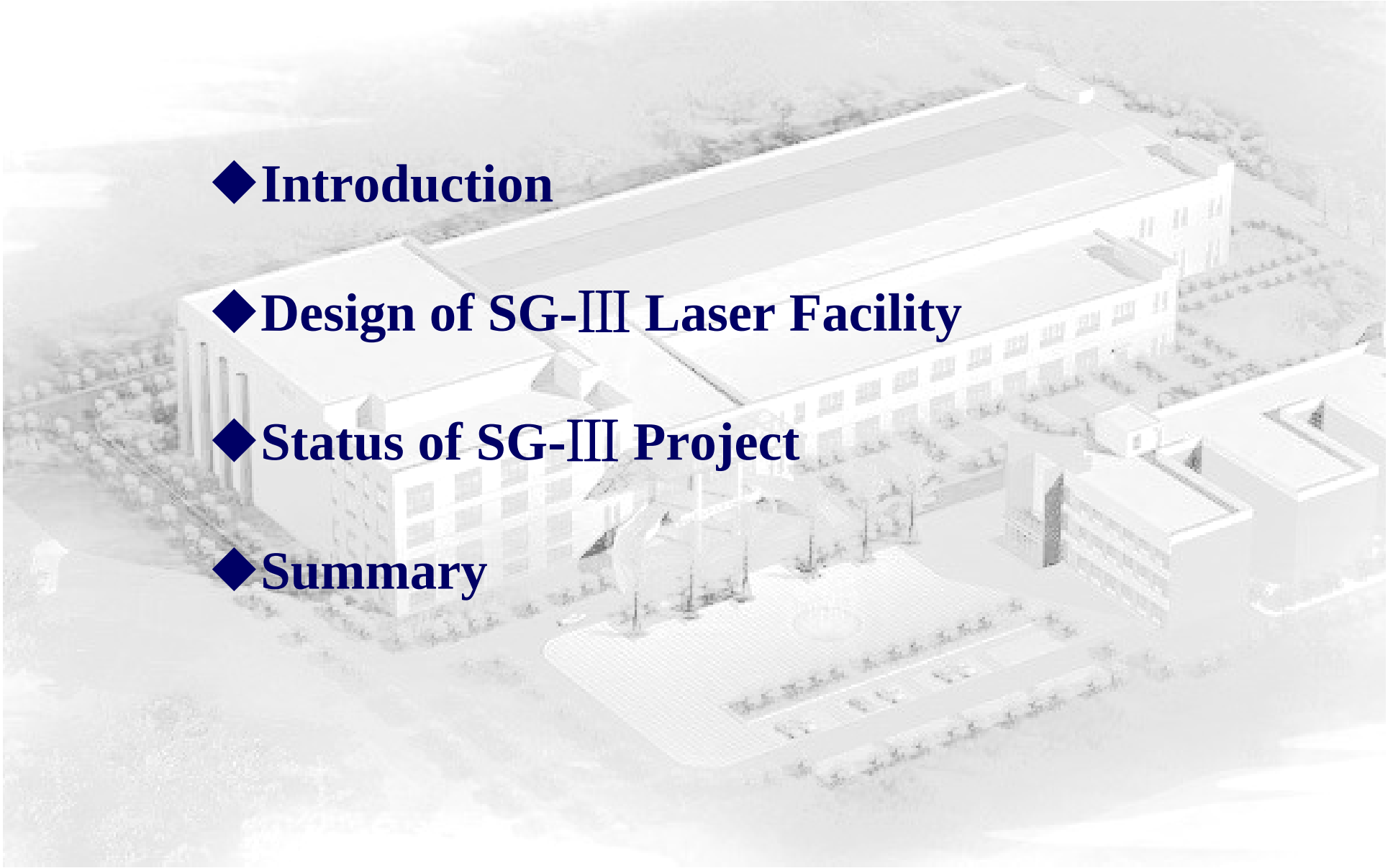
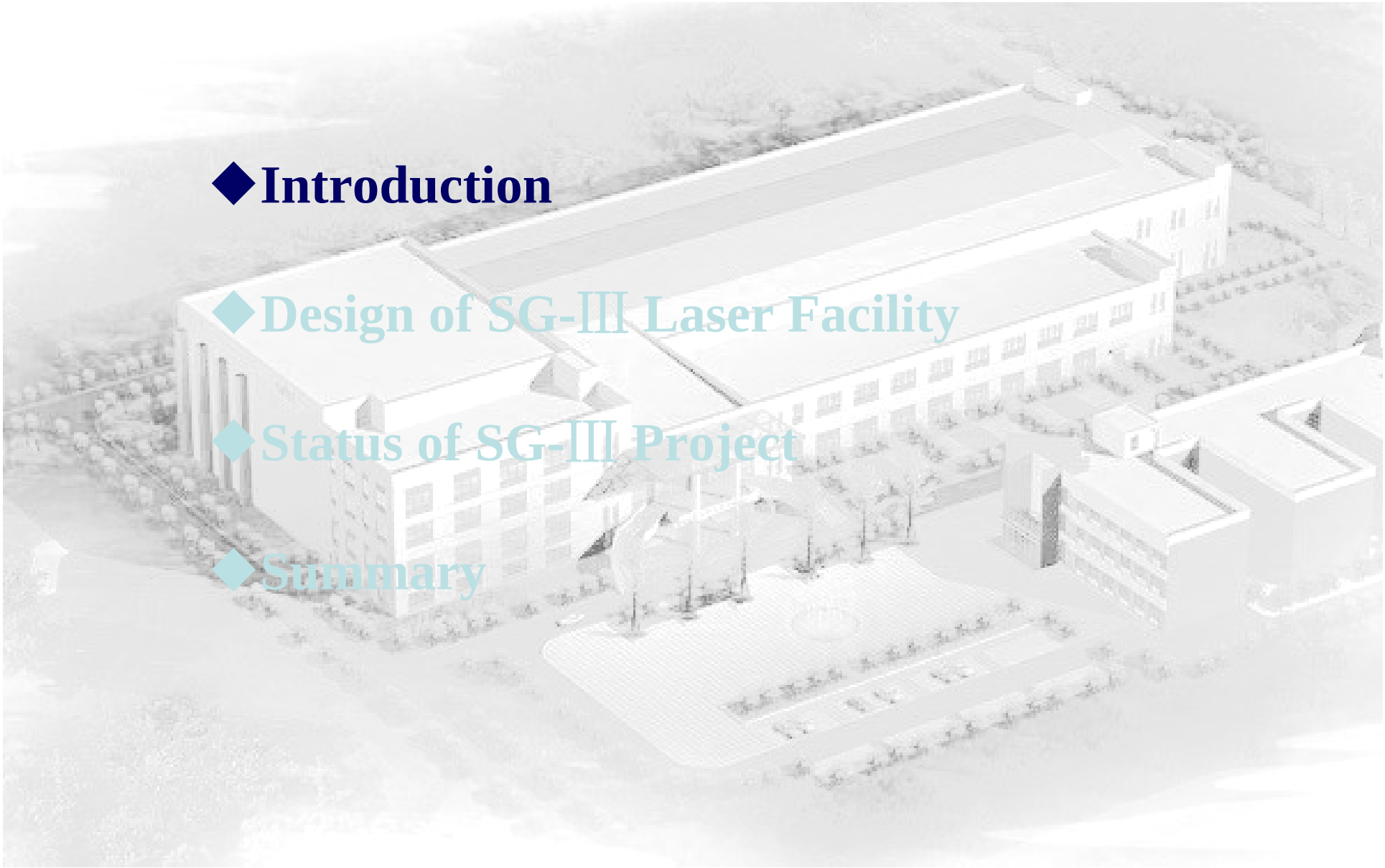
Outline



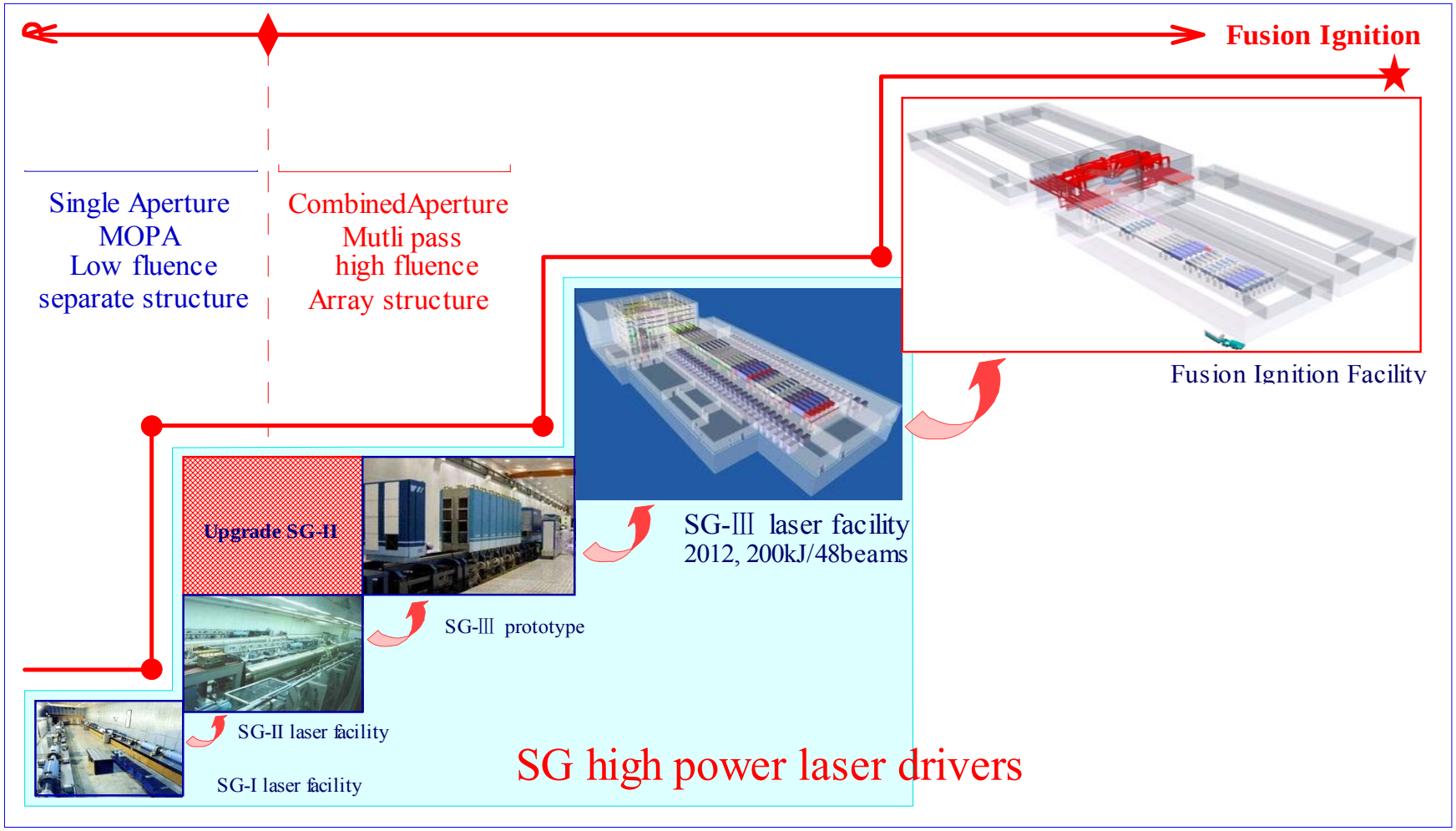
- Introduction
- Design of SG-Ⅲ Laser Facility
- Status of SG-Ⅲ Project
- Summary

Outline



- ◆Introduction
- ◆Design of SG-Ⅲ Laser Facility
- ◆Status of SG-Ⅲ Project
- ◆Summary

Introduction – Plan of developing ICF drivers in China



Introduction – Prototype of SG-III

Function 1: The main test bed to validate the key technology applied in SG-III.

Function2 :Provide shots for physical experiments

Specifications:

(1).Beam number: 8 (4×2)

(2).Beam aperture: 290mm×290mm

(3).Wavlength: 0.351μm

(4).Energy: 1.2kJ/1ns/0.35μm/beam

1.8kJ/3ns/0.35μm/beam

(5).Temporalshape: 1.0ns～3.0ns

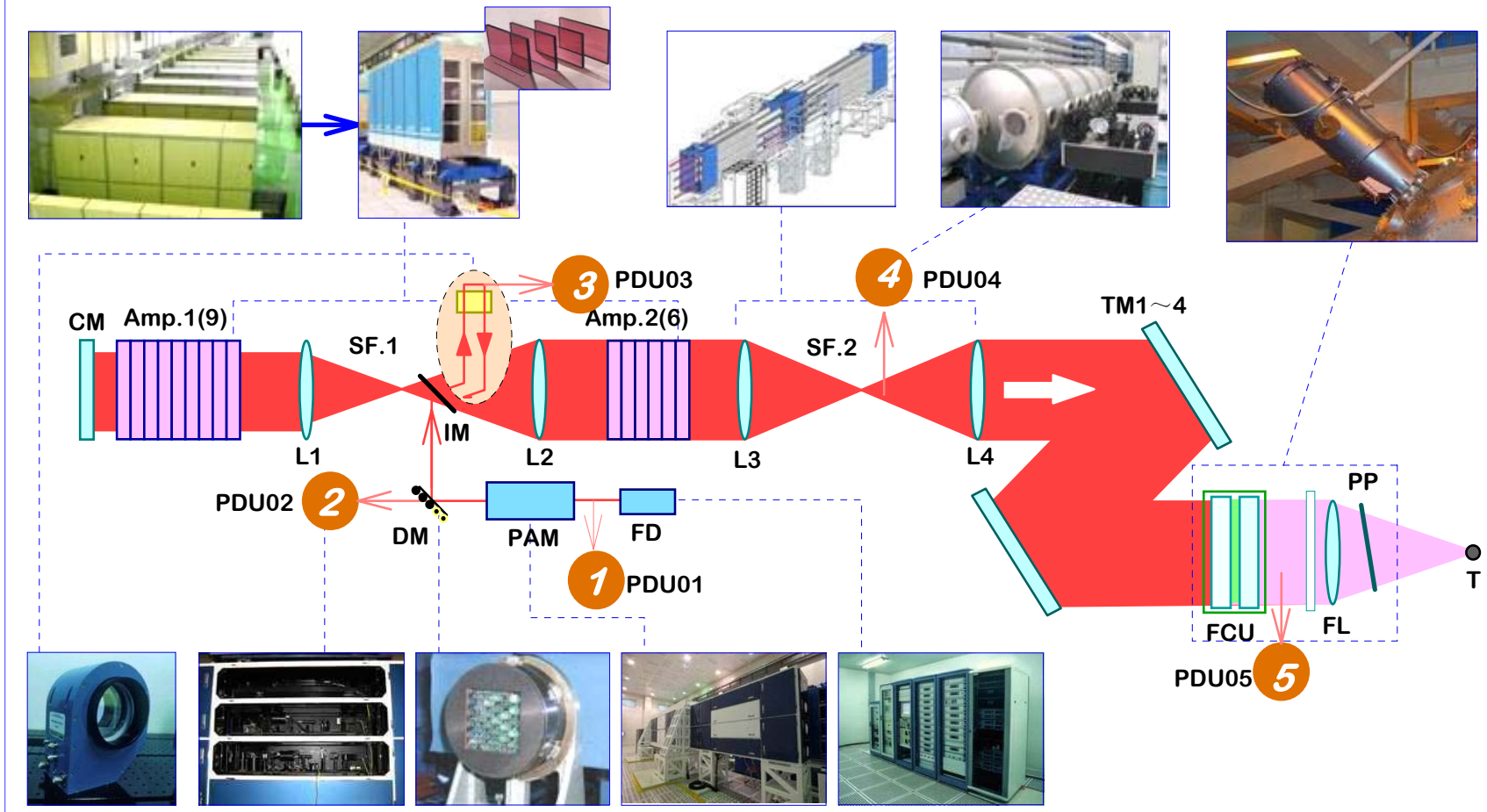
(6).Beam divergence : 70μrad (95%energy enclosed)

(7).Pointing: 30μm(RMS, f=2.2m)

(9).Energy spread: 10%(RMS)

Introduction – Key units in Prototype of SG-Ⅲ

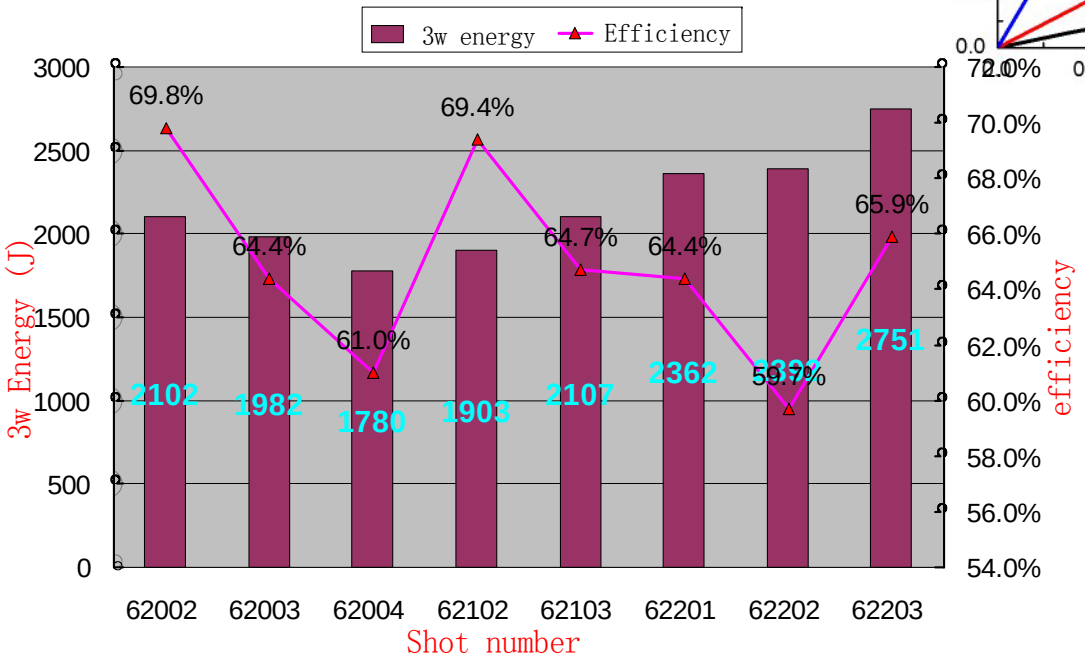
Energy bank Disk amplifier Spatial filter Final optical assembly

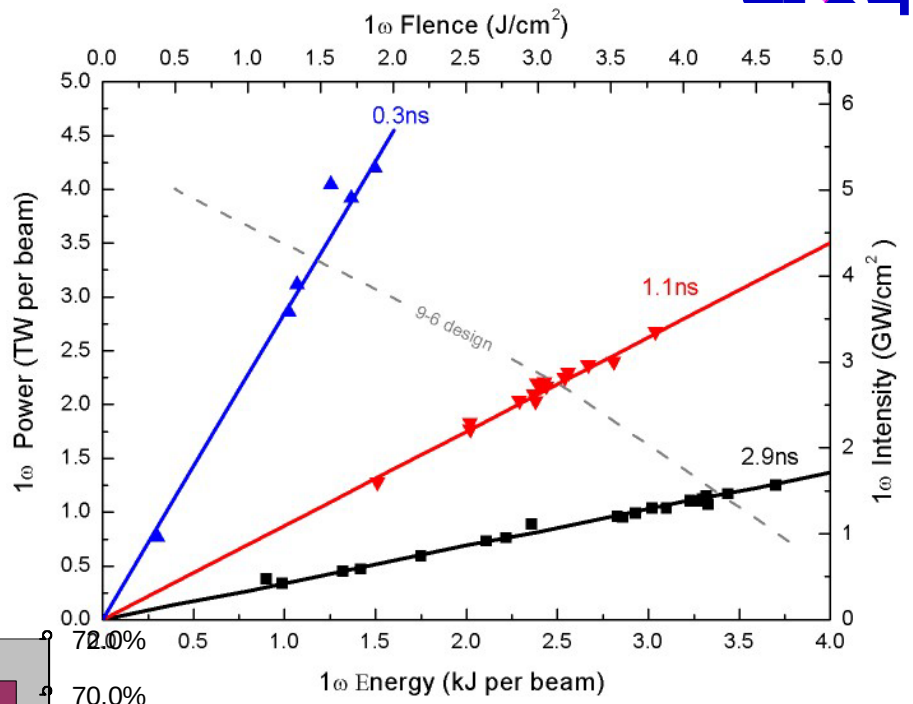


PEPC Deformable mirror Preamplifier Front End

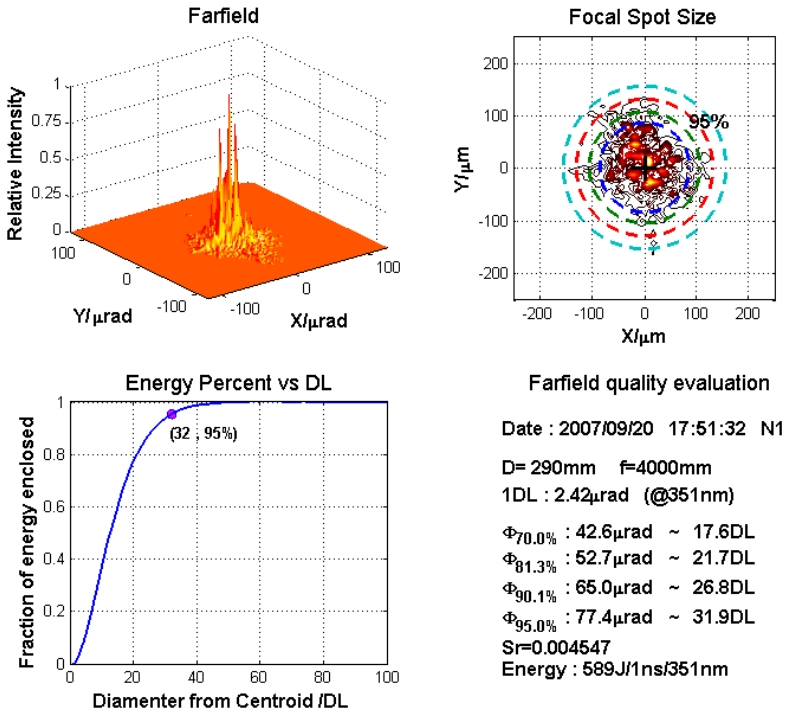
Introduction – Performance of Prototype of SG-Ⅲ

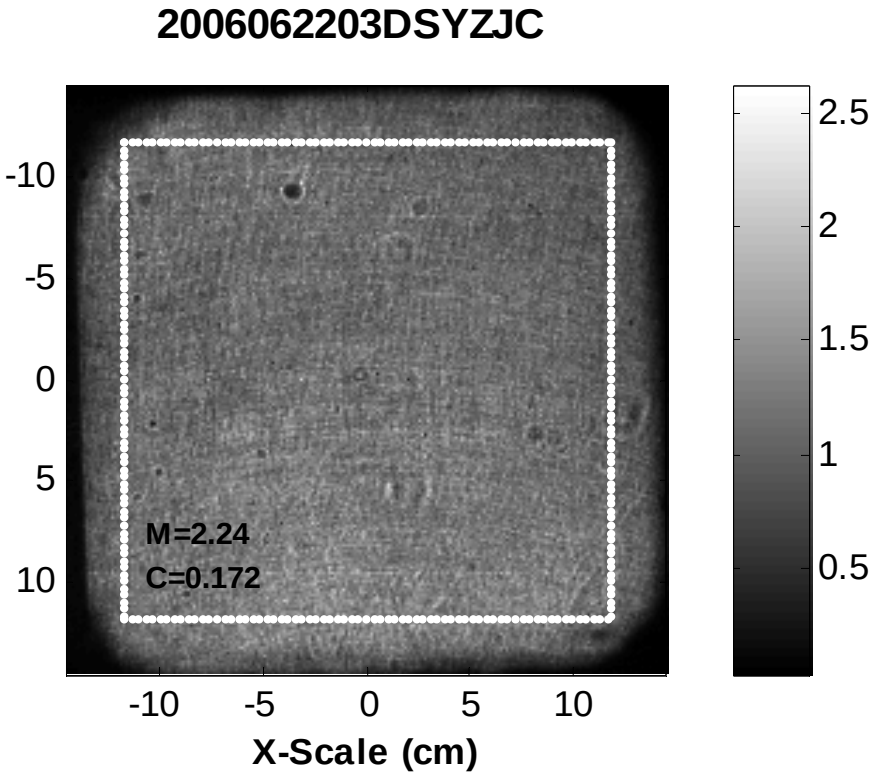
Energy





Beam quality: Far field and near field of 3ω

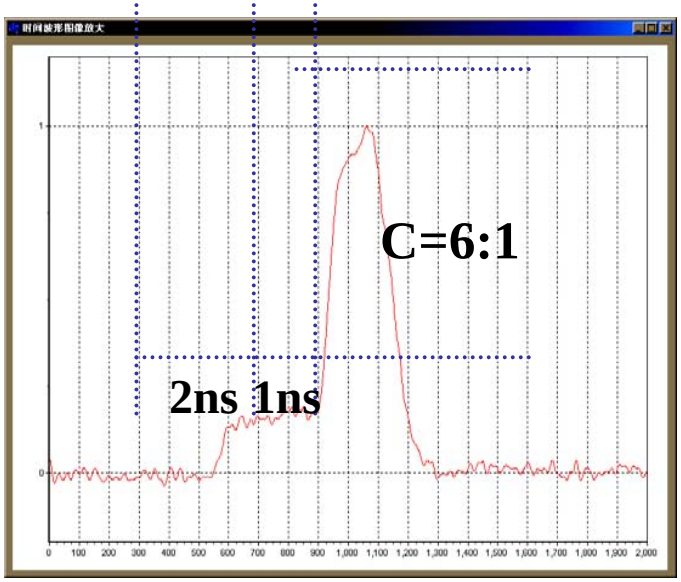




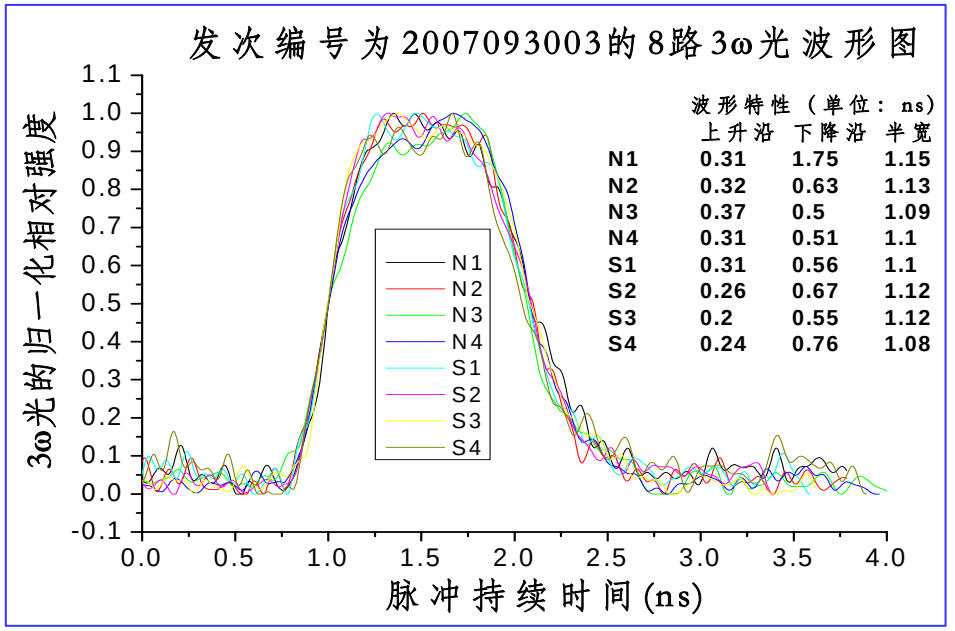
About 30DL (95%energy enclosed)

Modulation of near field is about 2.2

Temporal shape



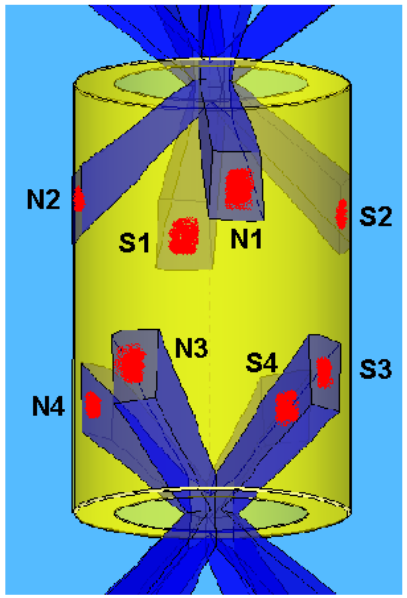
Shaped pulse

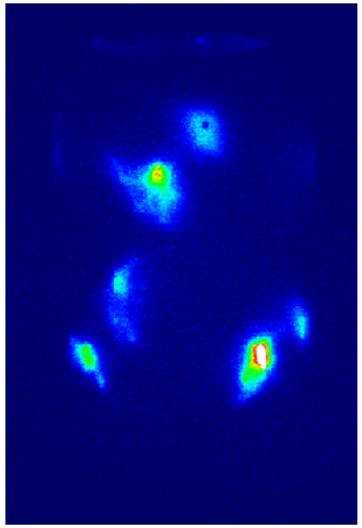


Pulse width :1.1ns, Average energy:939J

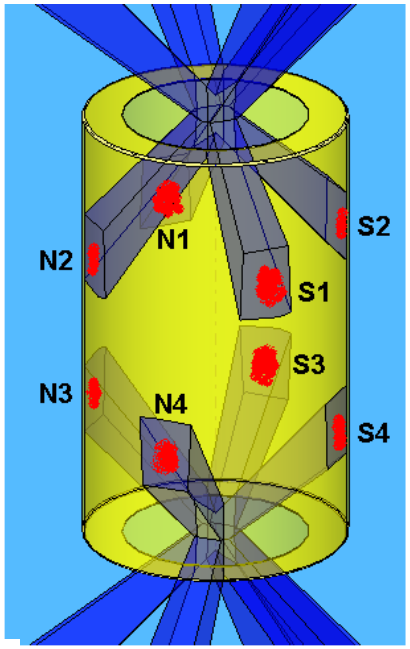
Pointing

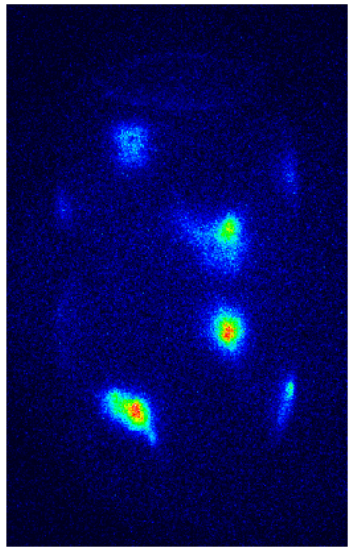
Experiment shows the pointing accuracy can reach 25um(RMS,f=2.2m)





Pointing image in degree 1

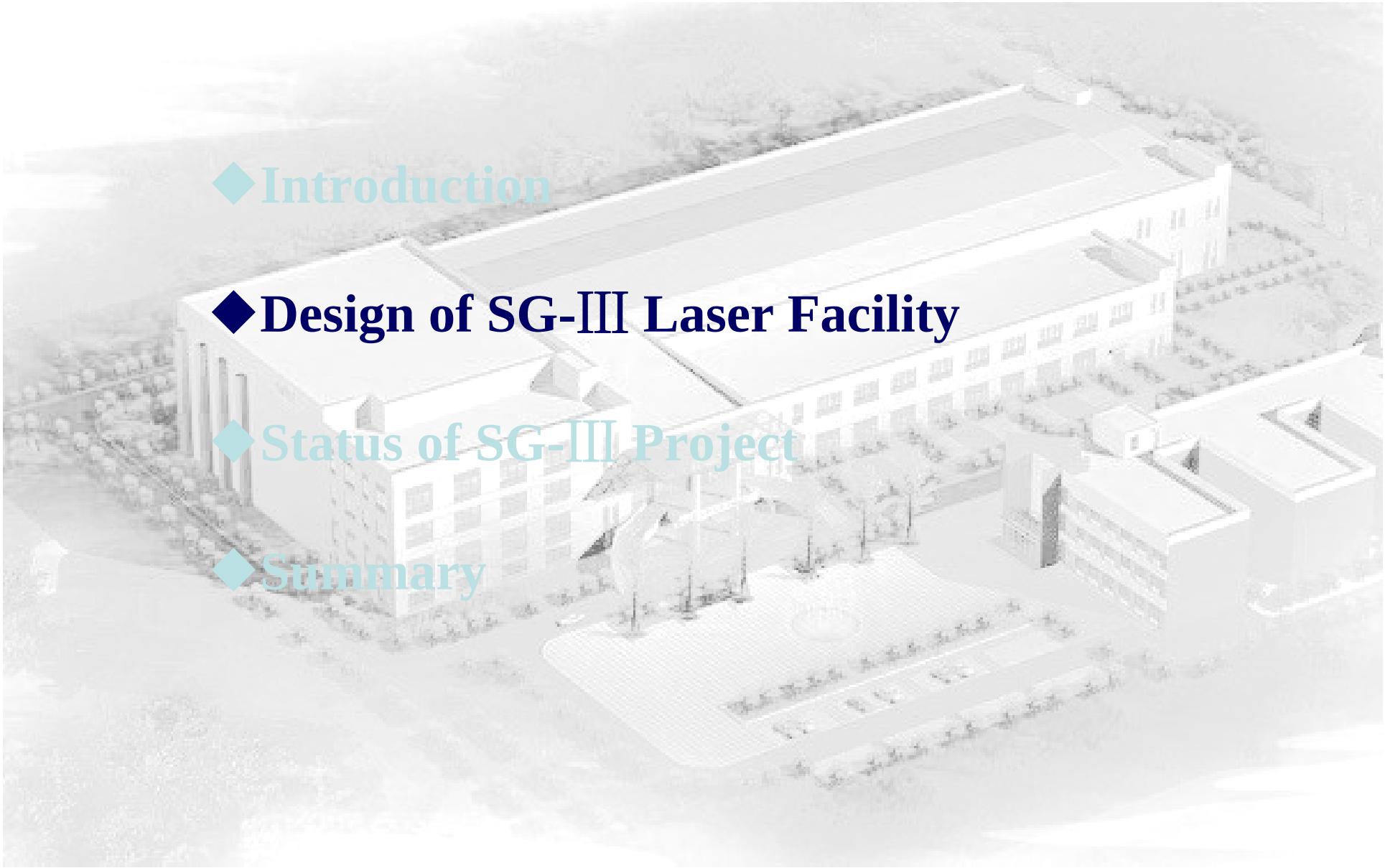




Pointing image in degree 2

Distribution of the 8 focal spots in the LEH captured by X-ray pinhole camera.
（100J/0.25ns/beam）

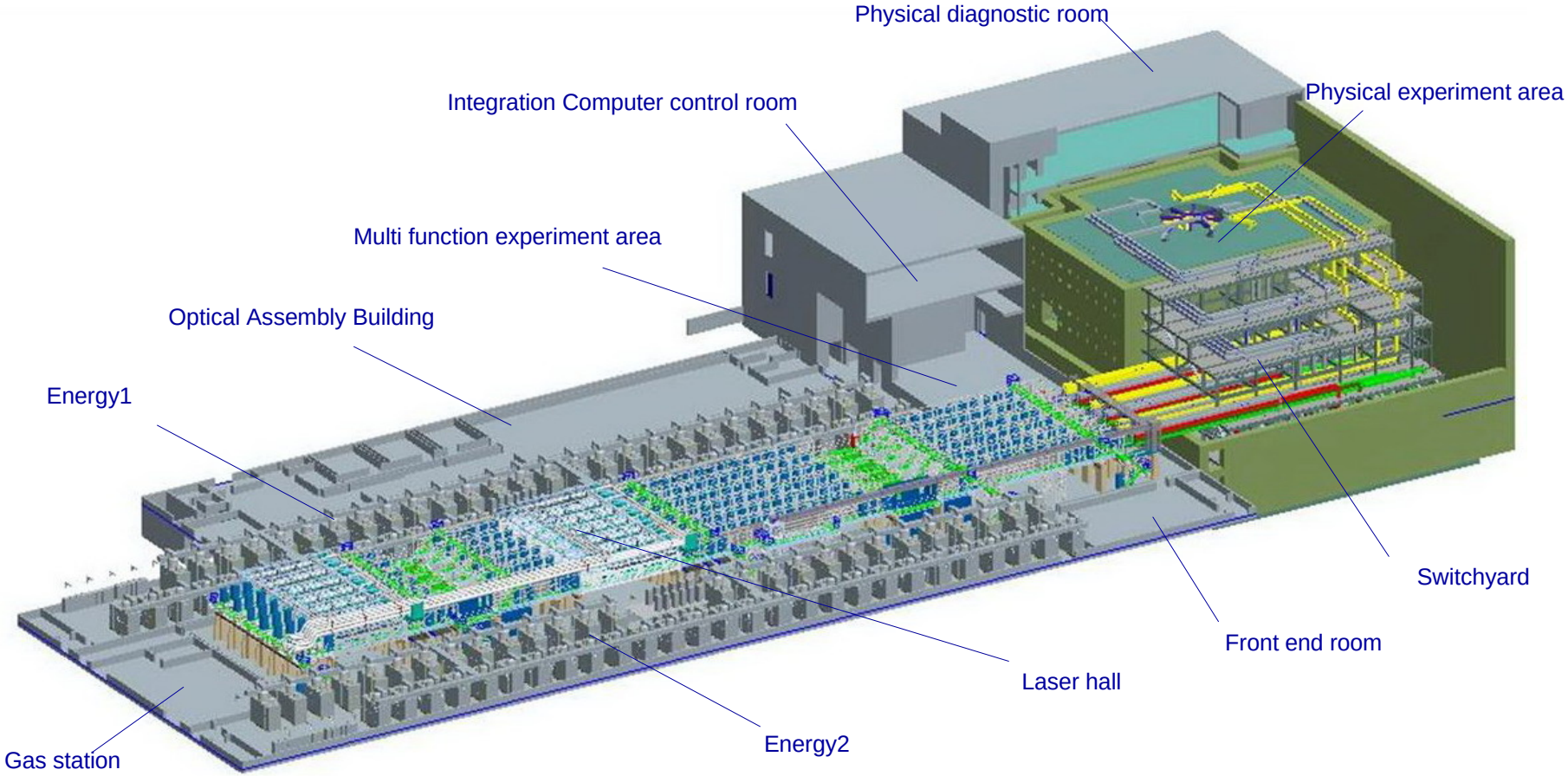
Outline



- Introduction
- **Design of SG-Ⅲ Laser Facility**
- Status of SG-Ⅲ Project
- Summary

Design of SG-Ⅲ Laser Facility – Overview

Research Center of Laser Fusion CAEP

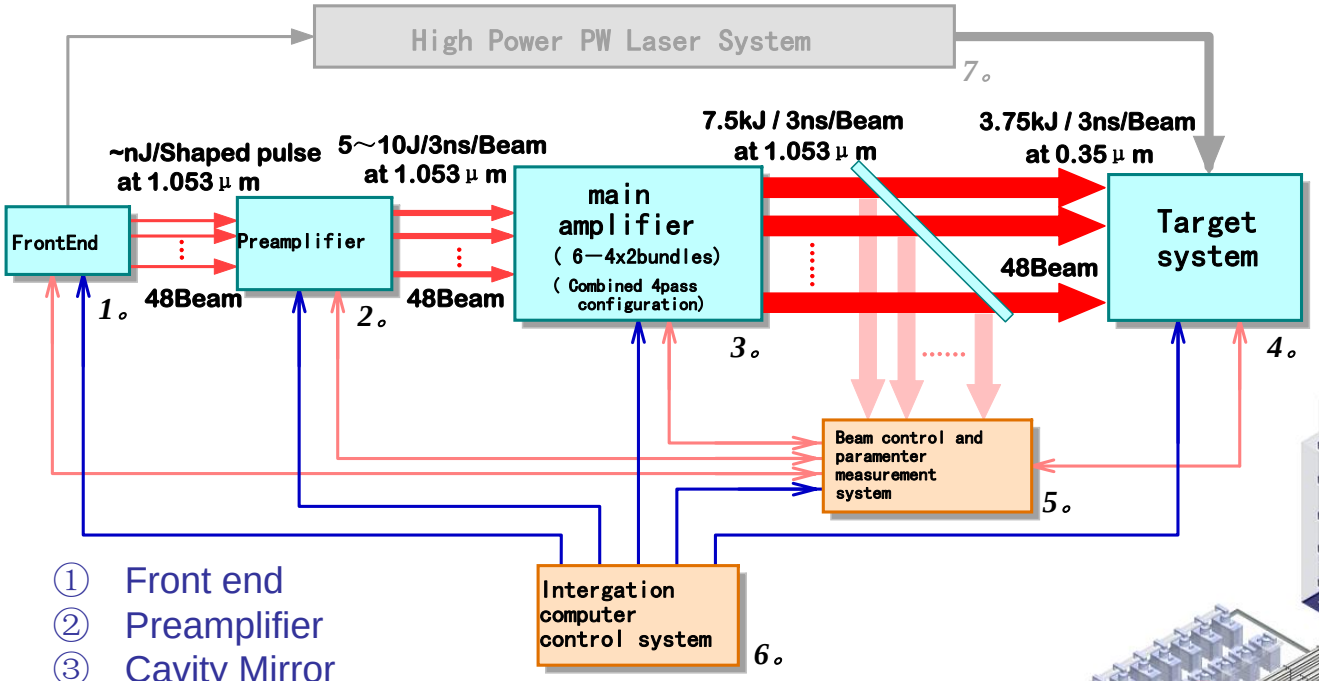


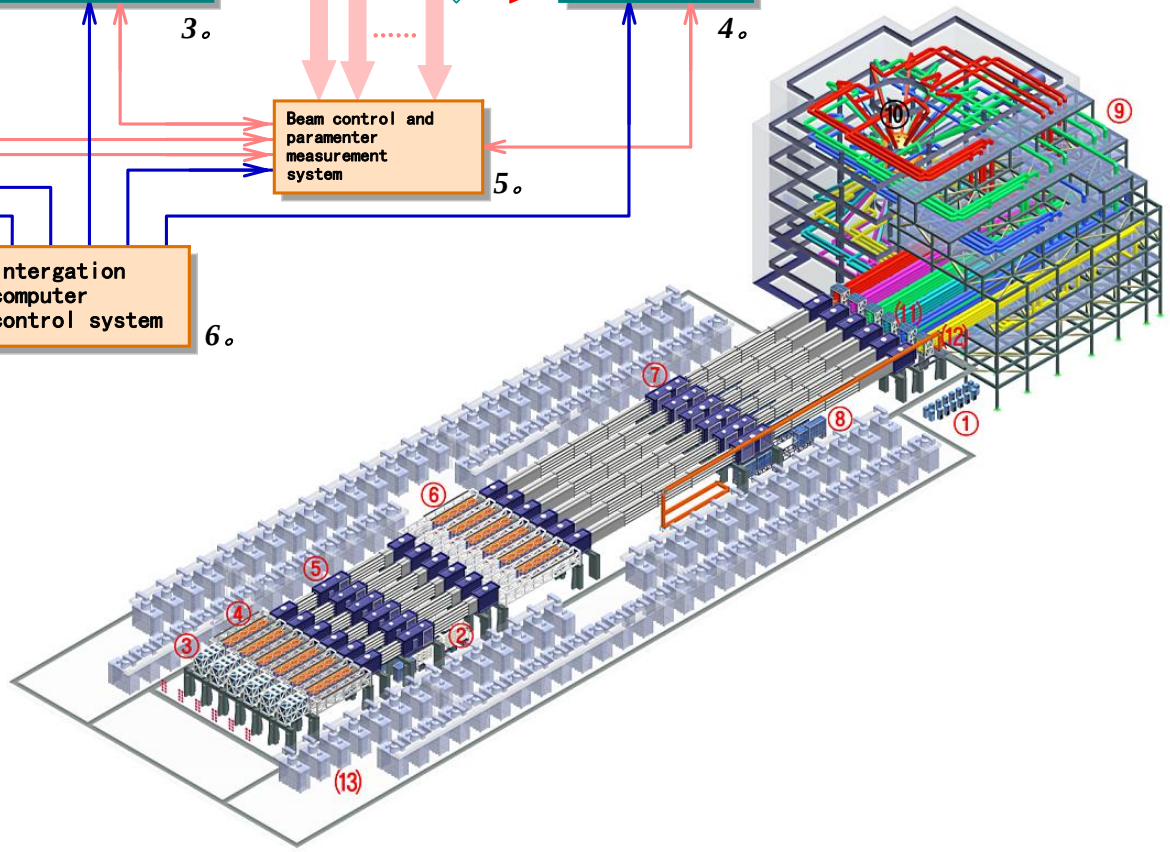
Three function area: 1. Laser hall, 2. Optical Assembly Building,3.Target area

Area size: 172.8m×76m

Design of SG-Ⅲ Laser Facility – Overview

Research Center of Laser Fusion CAEP



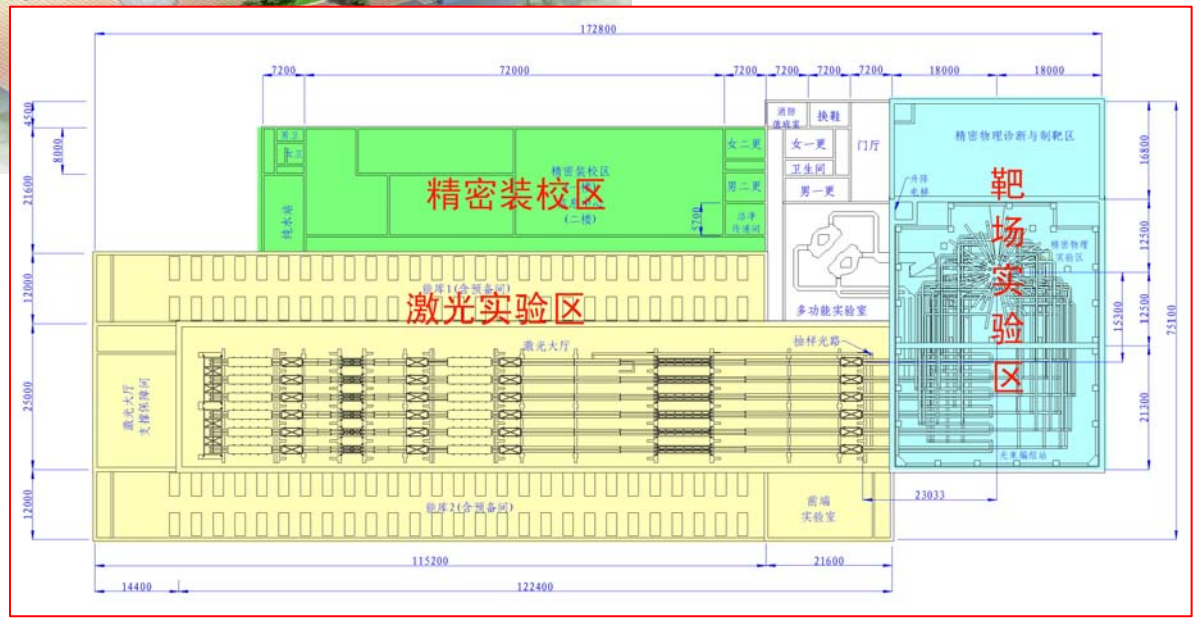


① Front end
② Preamplifier
③ Cavity Mirror
④ Main Amplifier
⑤ Cavity Spatial filter
⑥ Booster Amplifier
⑦ Transport Spatial Filter
⑧ Beam Reverser
⑨ Switchyard
⑩ Target Chamber
11 Sampling Wedge
12 Sampling shift module
13 Energy Bank

Design of SG-Ⅲ Laser Facility --- Laboratory

Lab area：176m×76m

SG lab. is divided into three parts: laser system area, target experiment area and cleaning assembling area.



Design of SG-Ⅲ Laser Facility – Specifications

- ✓Beams number: 48 (4×2-6)
- ✓Beam Size: 360mm×360mm
- ✓Wavelength: 351nm
- ✓Energy: 180KJ @3ns flat top pulse
- ✓Temporal shape: arbitrary shape
- ✓Beam quality: 10DL enclosed 95%Energy
- ✓Beam spectrum: 0.1nm～1.2nm
- ✓Power Balance: 10% RMS (foot)
- ✓Pointing: 30um RMS (f=4,000mm)

SG-Ⅲ Laser Facility ----System distribution

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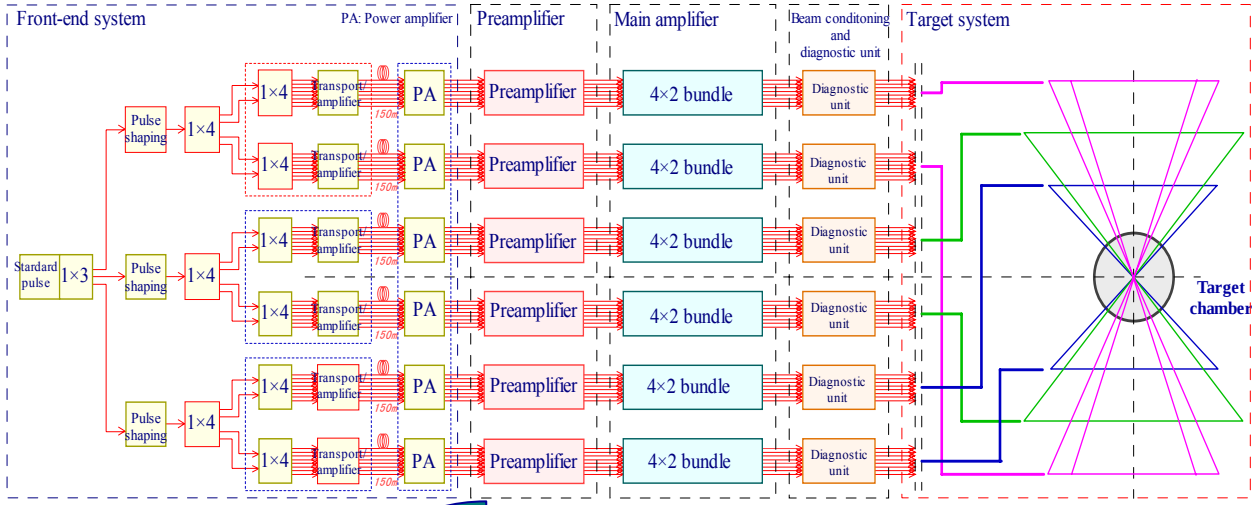
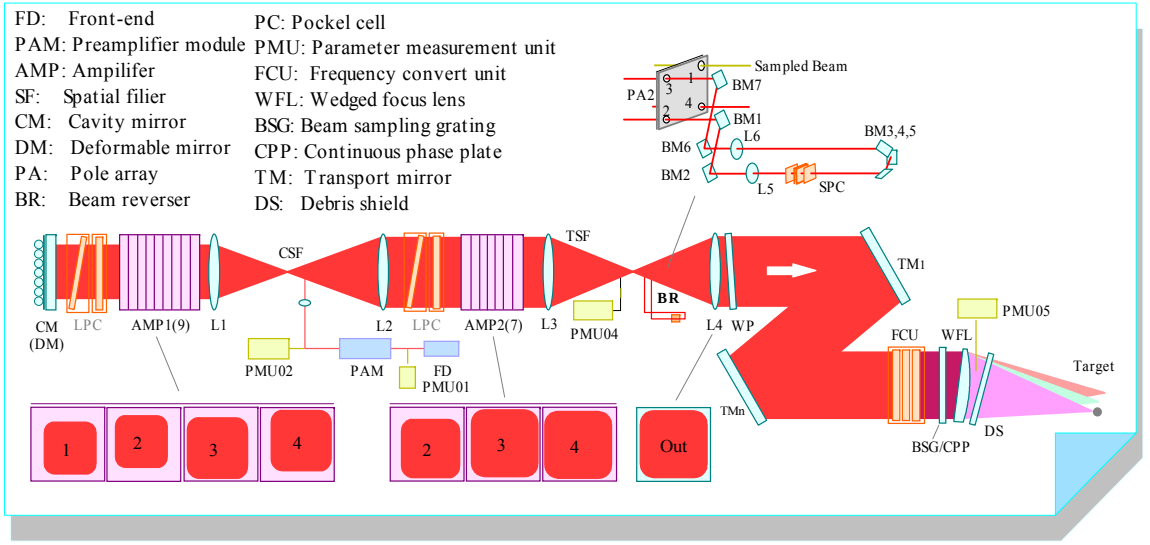


Characters:

【basic rule】"Pulse with same character in one cone and adjustable among different cone"

【Method】 "One bundle corresponding to one cone on target chamber"

FD: Front-end
PAM: Preamplifier module
AMP: Ampilifer
SF: Spatial filier
CM: Cavity mirror
DM: Deformable mirror
PA: Pole array
BR: Beam reverser
PC: Pockel cell
PMU: Parameter measurement unit
FCU: Frequency convert unit
WFL: Wedged focus lens
BSG: Beam sampling grating
CPP: Continuous phase plate
TM: Transport mirror
DS: Debris shield



Schematic of one of the 48 beamlines in the SG-Ⅲ facility

SG-III Laser Facility ----Fluence distribution

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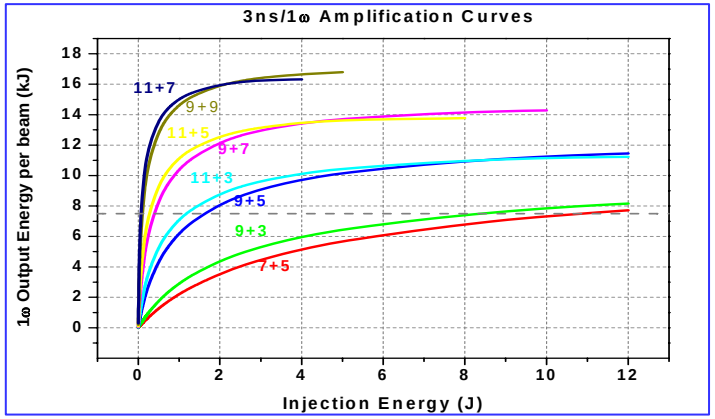
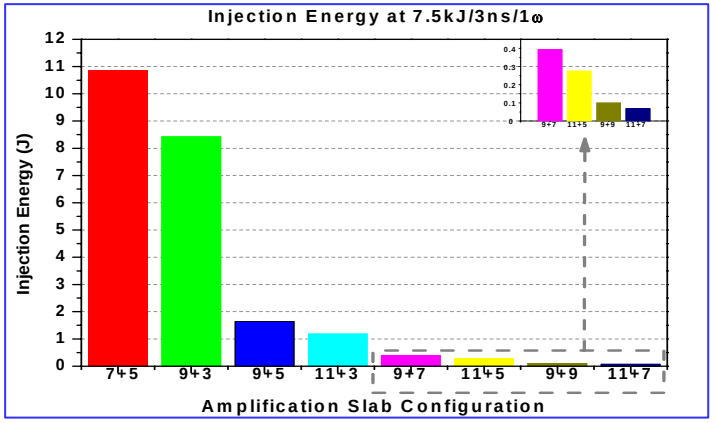
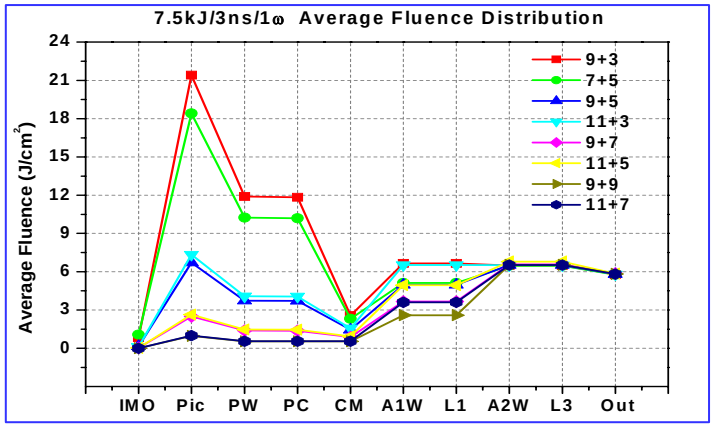
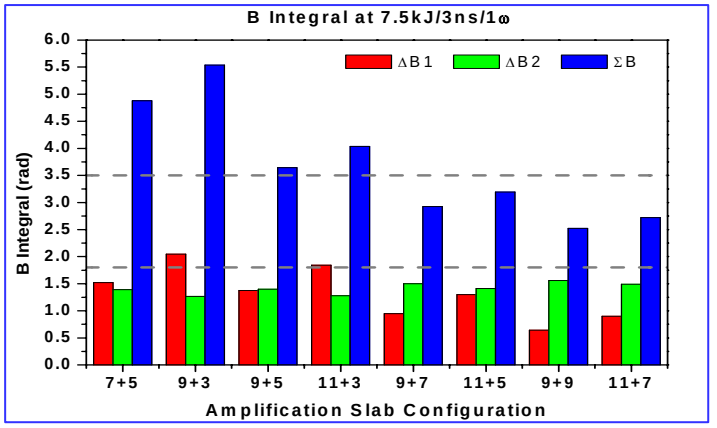


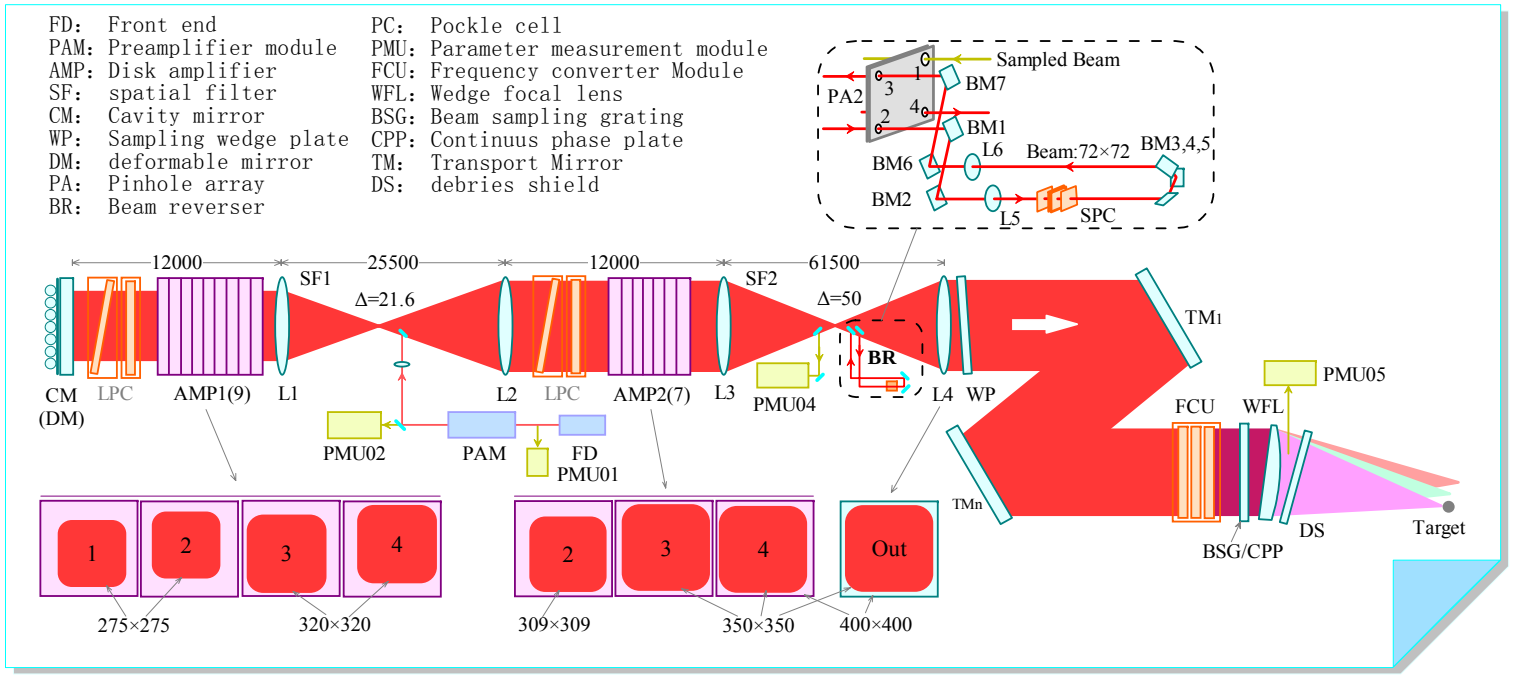






SG-III laser facility optimization design and disks distribution.

Design of SG-Ⅲ Laser Facility – Optical layout



- **The multi-pass architecture that is common to all of the 48 beamlines of SG-Ⅲ.**
- **Pulse is Injected from CSF and the beam reverser is located in TSF. There are four passes through the main amplifier and three passes through the power amplifier.**
- **Deformable mirror with large aperture located in CM to compensate the wavefront distortion.**

Design of SG-Ⅲ Laser Facility –Main amplifier

Specifications	SG-III	NIF	LMJ	备注
Total disk	16	18	18	
Diskconfiguration	9+7	11+7	9+9	
Equivalent disk	57	58	72	
Total gain length of disk	273cm	277cm	344cm	Disk thickness: 4cm
Length of main amplifier	~112m	~ 123	~ 101m	From to CM L4
Injecting method	CSF farfield injecting	TSF farfield injecting	TSF farfield injecting	
Injecting energy	<1J	~several hundred mj	~several hundred mj	
Beam aperture in main amplifier	275mm,320mm	360mm	360mm	
Beam aperture in booster amplifier	309mm,350mm	360mm	360mm	
Filling factor in booster amplifier	76%	81%	81%	
Beam aperture in reverser	72mm	–	?	
Vignetting allowance*	50mm	35mm	?	
Fluence on Pickoff mirror	~4J/cm^2	–	?	

Design of SG-III Laser Facility – Optical layout of main amplifier

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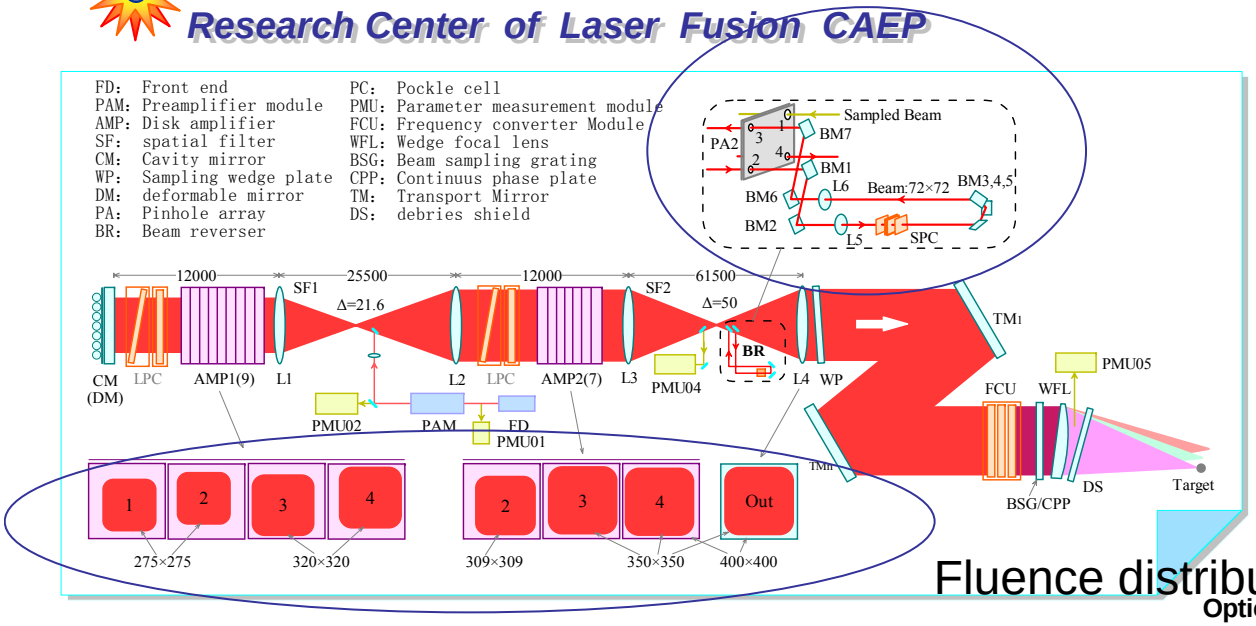
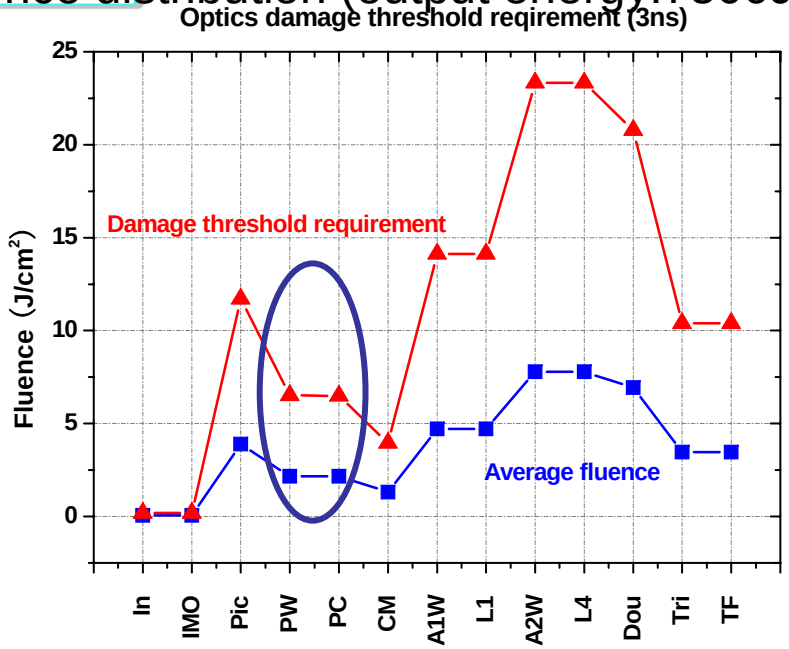


U-turn beam reverser with small PEPC (80mm×80mm)

Fluence distribution (output energy:7500J/1ω)

- Different beam size in 1-2 pass and 3-4 pass to mitigate effect on beam quality from the static wavefront distortion of the edge of laser glass.
- Image relay design
- Low fluence on Pick-off mirror to ensure the system work stably.



Design of SG-Ⅲ Laser Facility – Optical Layout of Reverser

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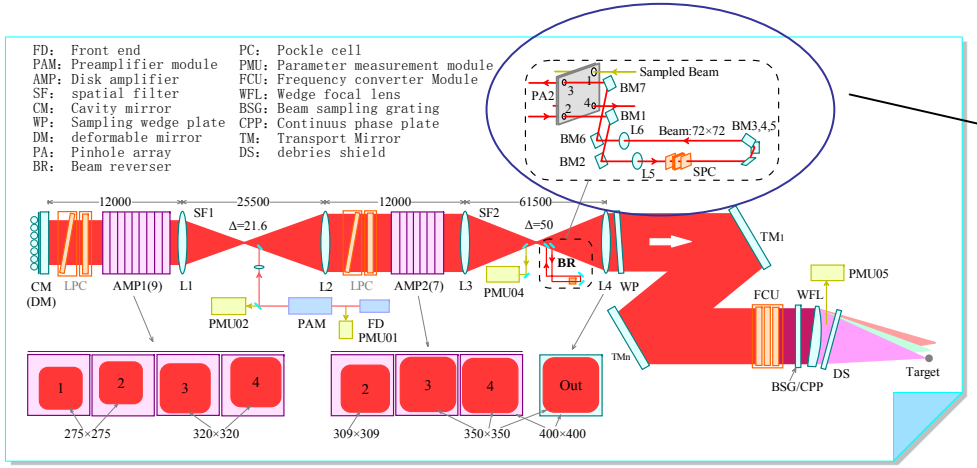
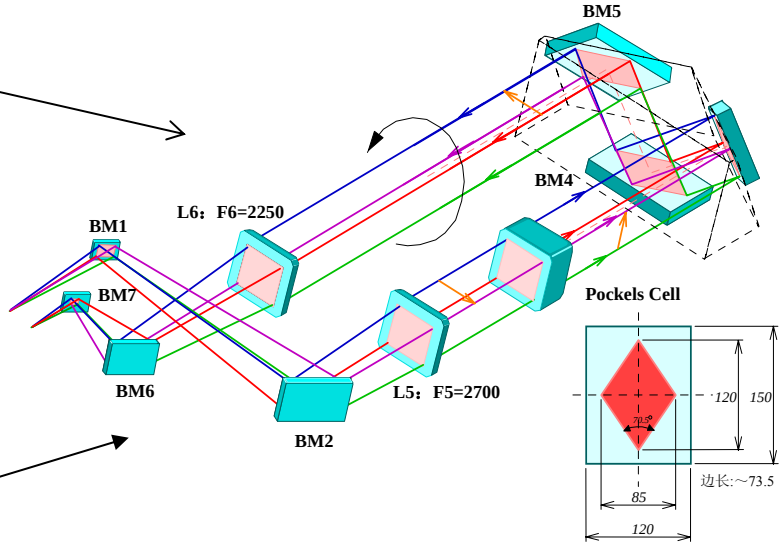


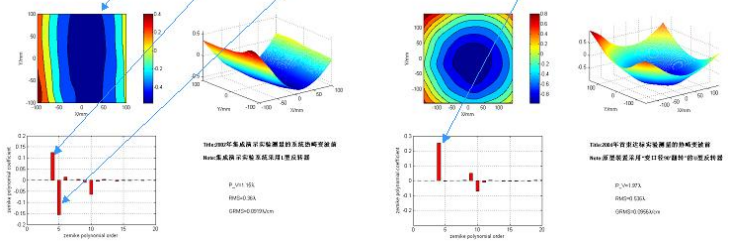


Rotate the beam in beam reverser before 3-pass the main amplifier, the stigmatism caused by thermal distortion of laser glass can converted to defocus. Therefore beam quality can be improved.

$$p(r,\theta) = r^2\cos^2\theta = \frac{1}{2}r^2 + \frac{1}{2}r^2\cos 2\theta$$

$$p(r,\theta+\frac{\pi}{2}) = r^2\cos^2(\theta+\frac{\pi}{2}) = \frac{1}{2}r^2 - \frac{1}{2}r^2\cos 2\theta$$

r^2



Design of SG-Ⅲ Laser Facility – Optical layout of FOA

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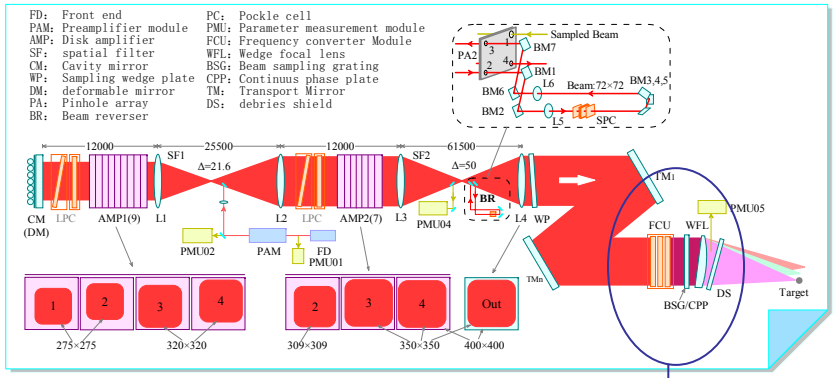
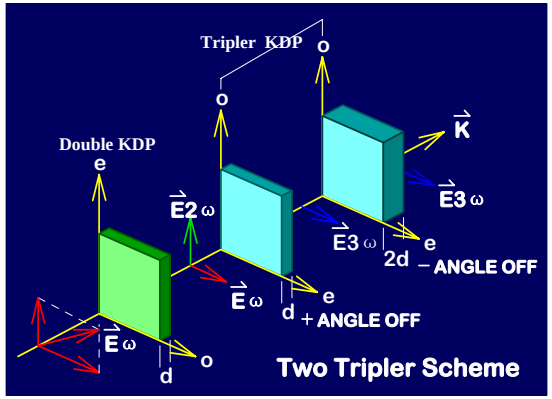
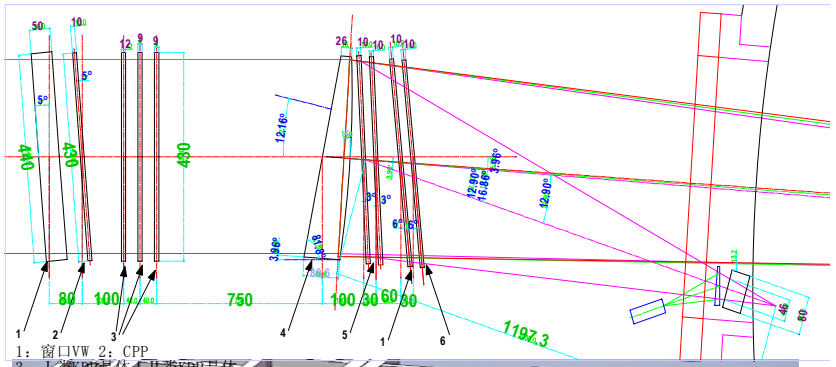
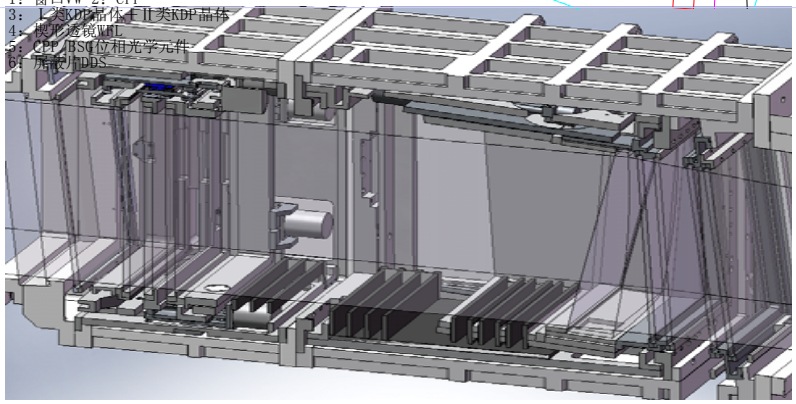




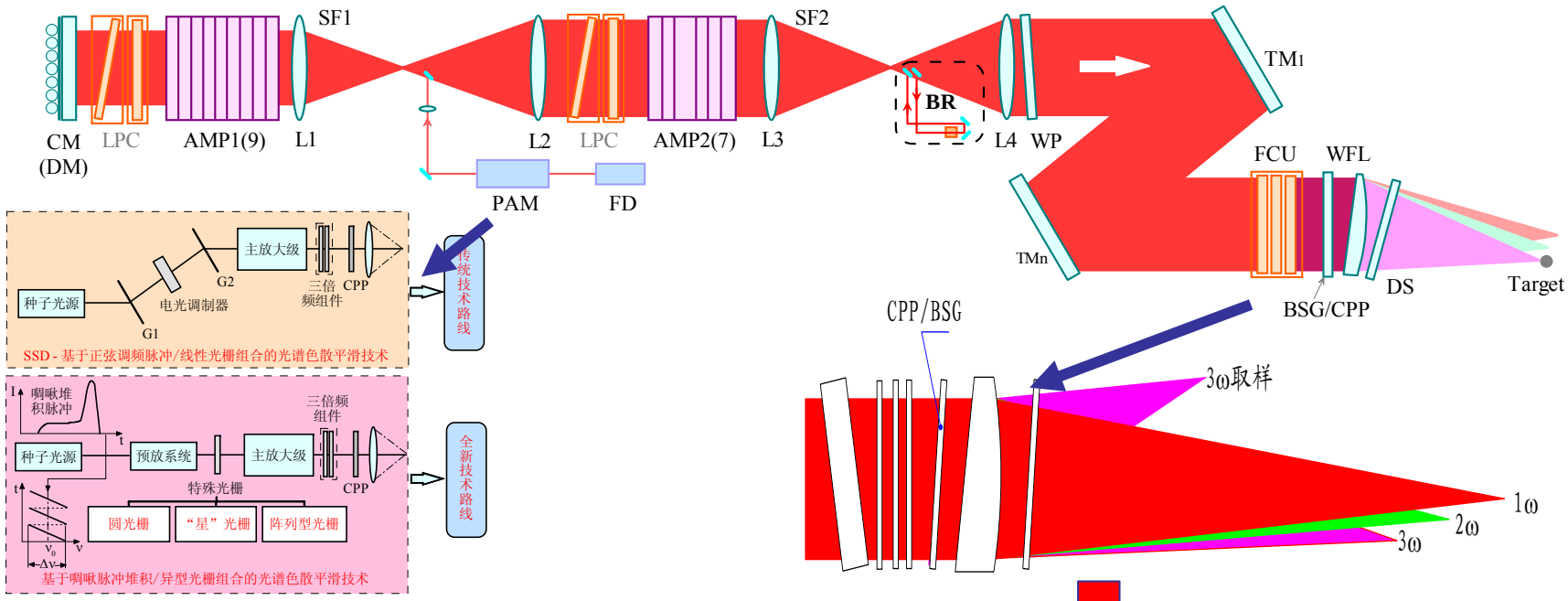


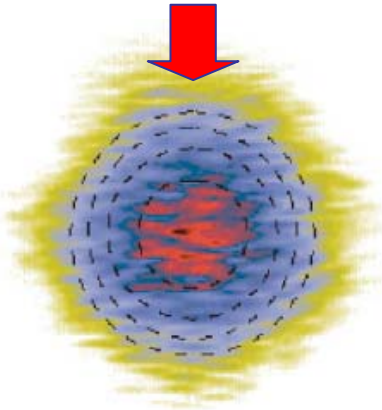


- Type I+Type II+Type II design for Frequency converter to match 1.2nm band width of pulse
- Two kind of diffractive element (BSG,CPP) is designed.
- BSG: to sample 3w beam for Energy and temporal shape measurement
- CPP: to shape the intensity distribution of focal spot.

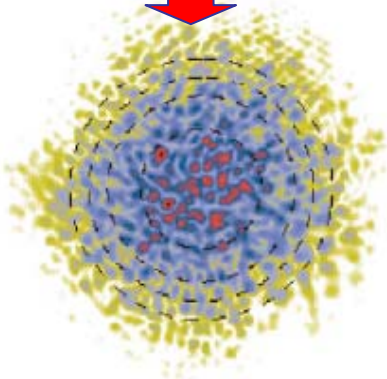
Design of SG-Ⅲ Laser Facility – Optical layout of beam smoothing

Beam smoothing





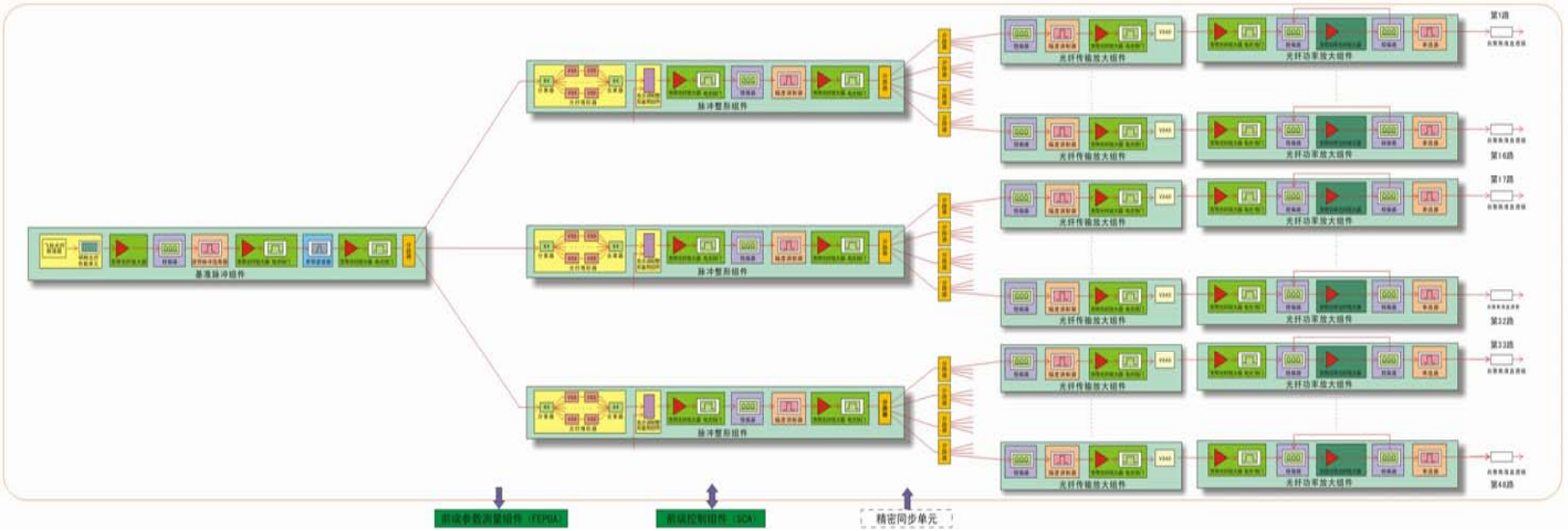
SSD: to eliminate intensity modulation of focal spot (wavelength from 10um to 100um)



CPP: to control the shape of focal spot

- ✓ Pulse rise time: <100ps
- ✓ Pulse width: 1.0ns～6.0ns
- ✓ arbitrary shaped
- ✓ Pulse contrast: 80:1
- ✓ Spectral width: ～1.2nm
- ✓ Pulse SRN: >45dB
- ✓ Pulse energy: 10.0μJ/1Hz/beam
- ✓ Energy spread: <2.0%(RMS)
- ✓ Synchronization：≤2.0ps(RMS)

- ➢ Three kind of pulse(fs/ps/ns) can be generated without time jitter.
- ➢ Realize pulse shaping and long /short pulse synchronizing without time jitter based on optical method
- ➢ All fiber system.



Design of SG-Ⅲ Laser Facility –Preamplifier

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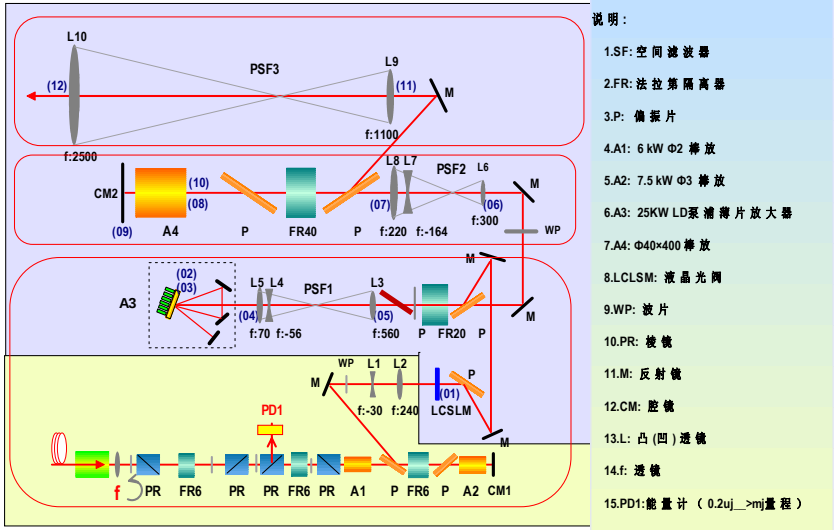
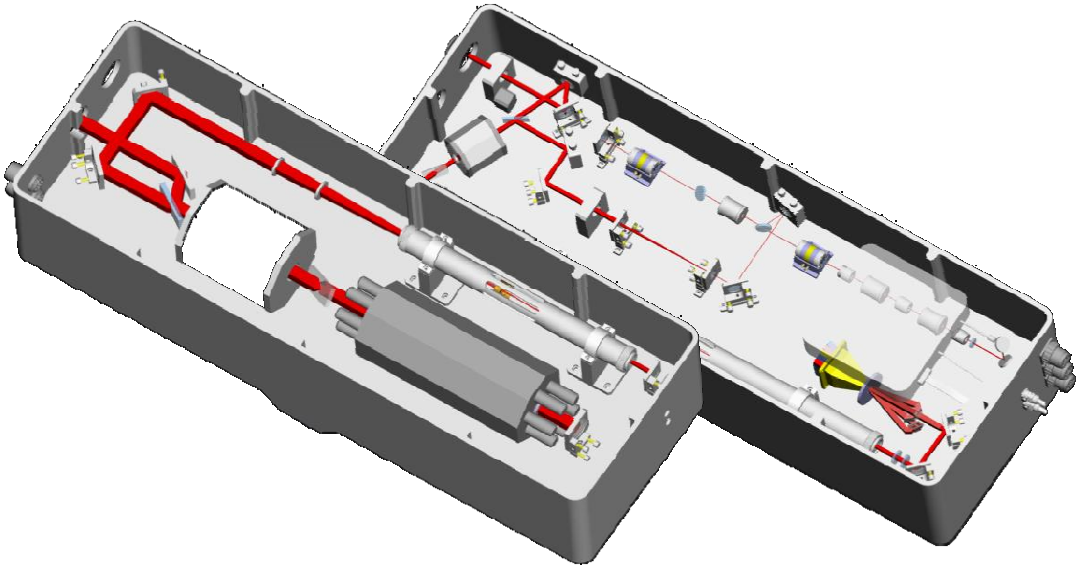
- ✓ Energy： 5J/3ns/beam/20min,100mJ/beam/1Hz
- ✓ Pulse width： 1.0ns～10.0ns
- ✓ Beam spatial distribution ： super gauss
- ✓ Modulation： ≤1.4:1
- ✓ Beam divergence ： ≤150μrad
- ✓ Energy stability： ≤4.0%(RMS)
- ✓ Spectral width： 1.2nm
- ✓ Beam drift： ≤10μrad(RMS)（4 hours）



- ➢ Liquid crystal is used to shape the output spatial distribution of beam and compensate the gain non-uniformity of disk amplifier
- ➢ Whole image relay design

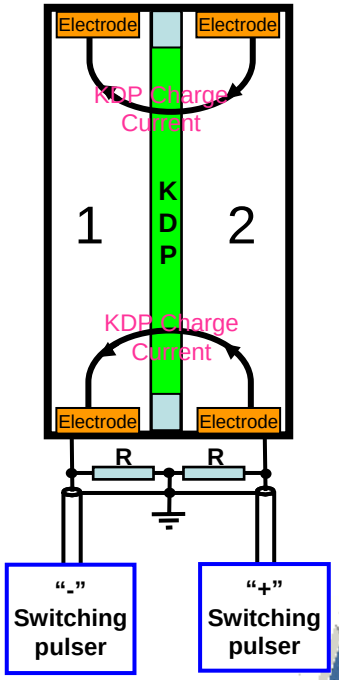


Design of SG-Ⅲ Laser Facility – Disk Amplifier

- ✓ Clear aperture： 400×400mm2
- ✓ Storage density： ρst~0.24J/cm3
- ✓ g： 5.0%cm-1(thickness:40mm)
- ✓ gain uniformity ： βpeak /βave≈1.08:1
- ✓ Storage efficiency： ηst大于3.0%
- ✓ Static wavefront distortion: < λ/3/disk (λ＝632nm)
- ✓ Shot interval： <4 hours

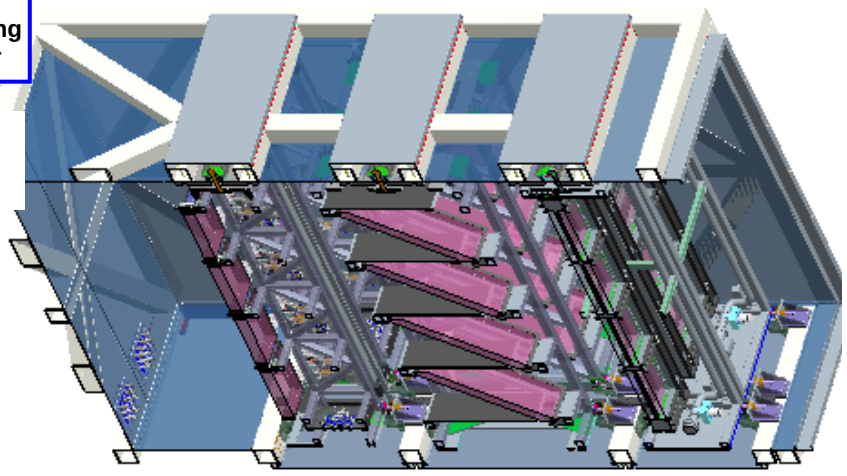
- ➢ Water cooling design is considered.
- ➢ Performance of disk amplifier is undergoing validated, especially the gain non-uniformity and thermal distortion

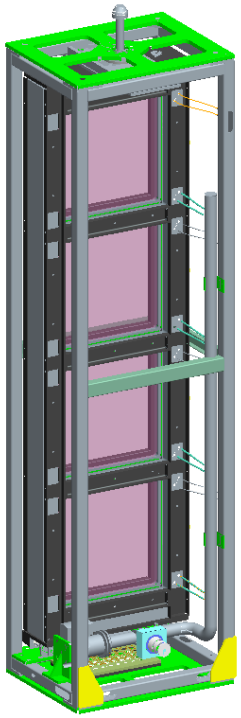
Design of SG-Ⅲ Laser Facility – PEPC of large aperture

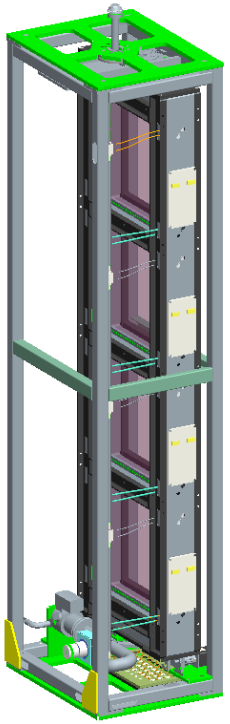


- ✓Clear aperture: 400mm×400mm
- ✓Wavelength: 1.053 μm
- ✓Static transmission: ≥88%
- ✓Isolation ratio: ≥200:1
- ✓Switch efficiency: ≥99%
- ✓Switch rise time: ≤200ns
- ✓Switch time window: 600ns

Single pulse drive mode.

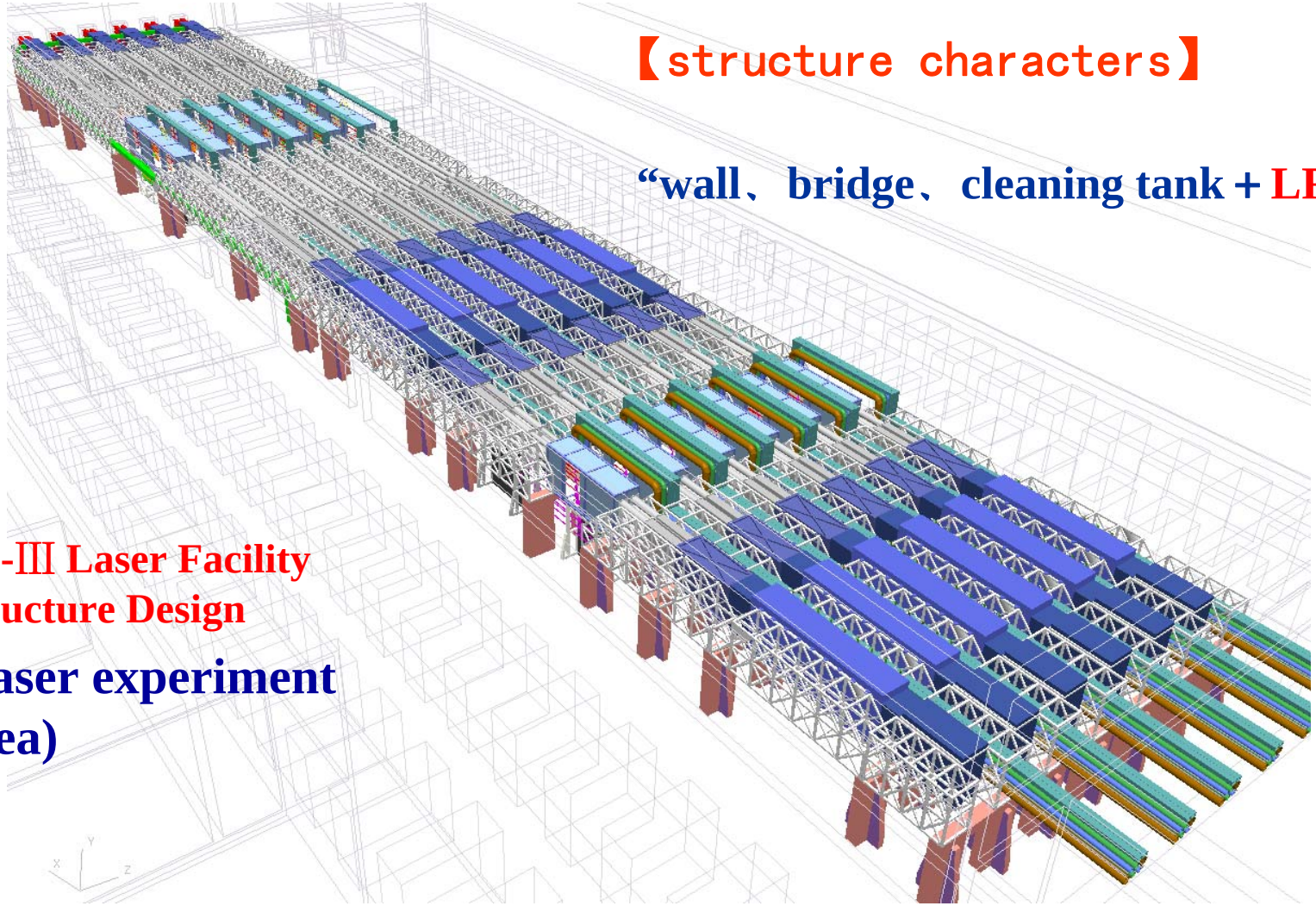






【structure characters】

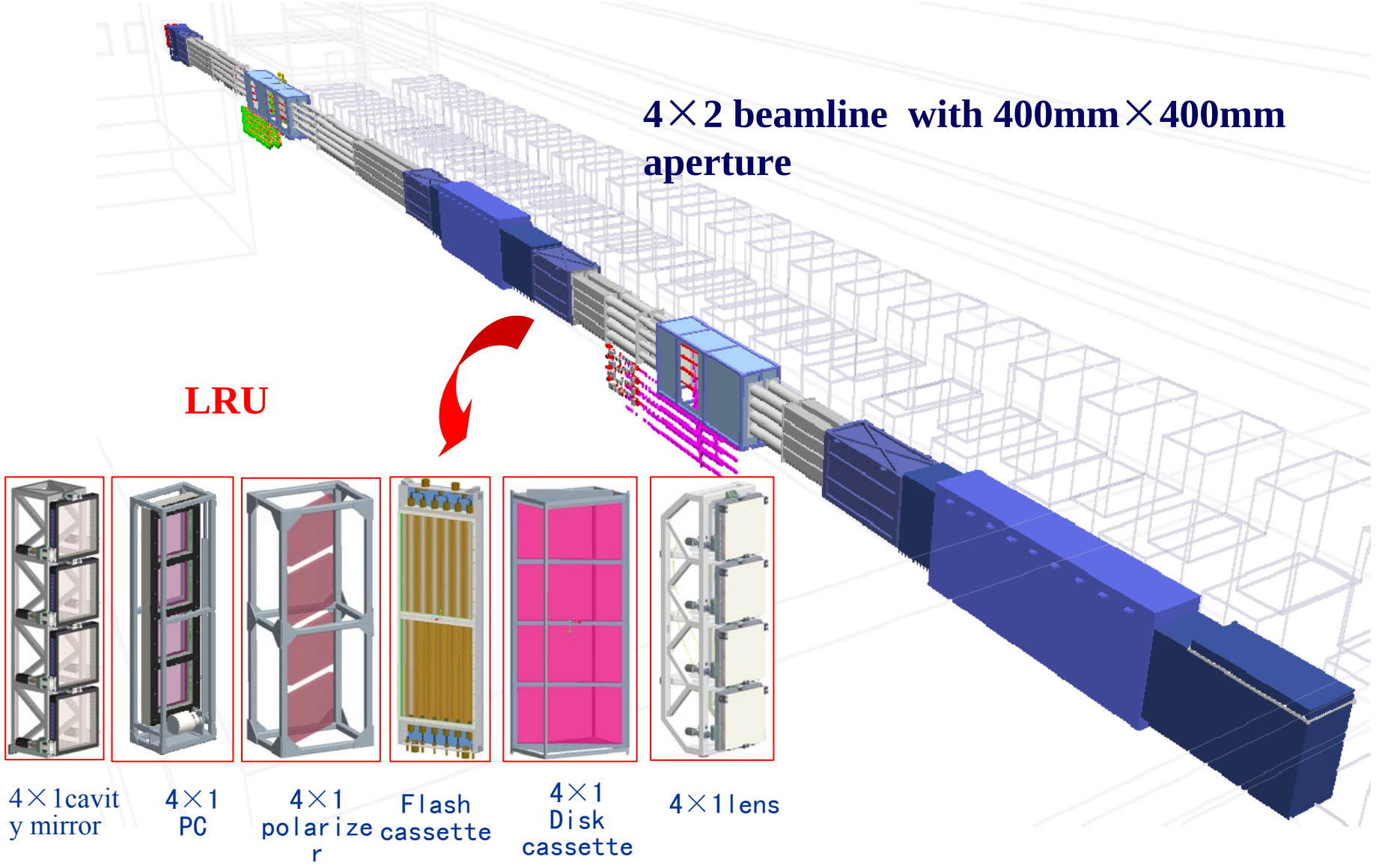
“wall、bridge、cleaning tank＋LRU”



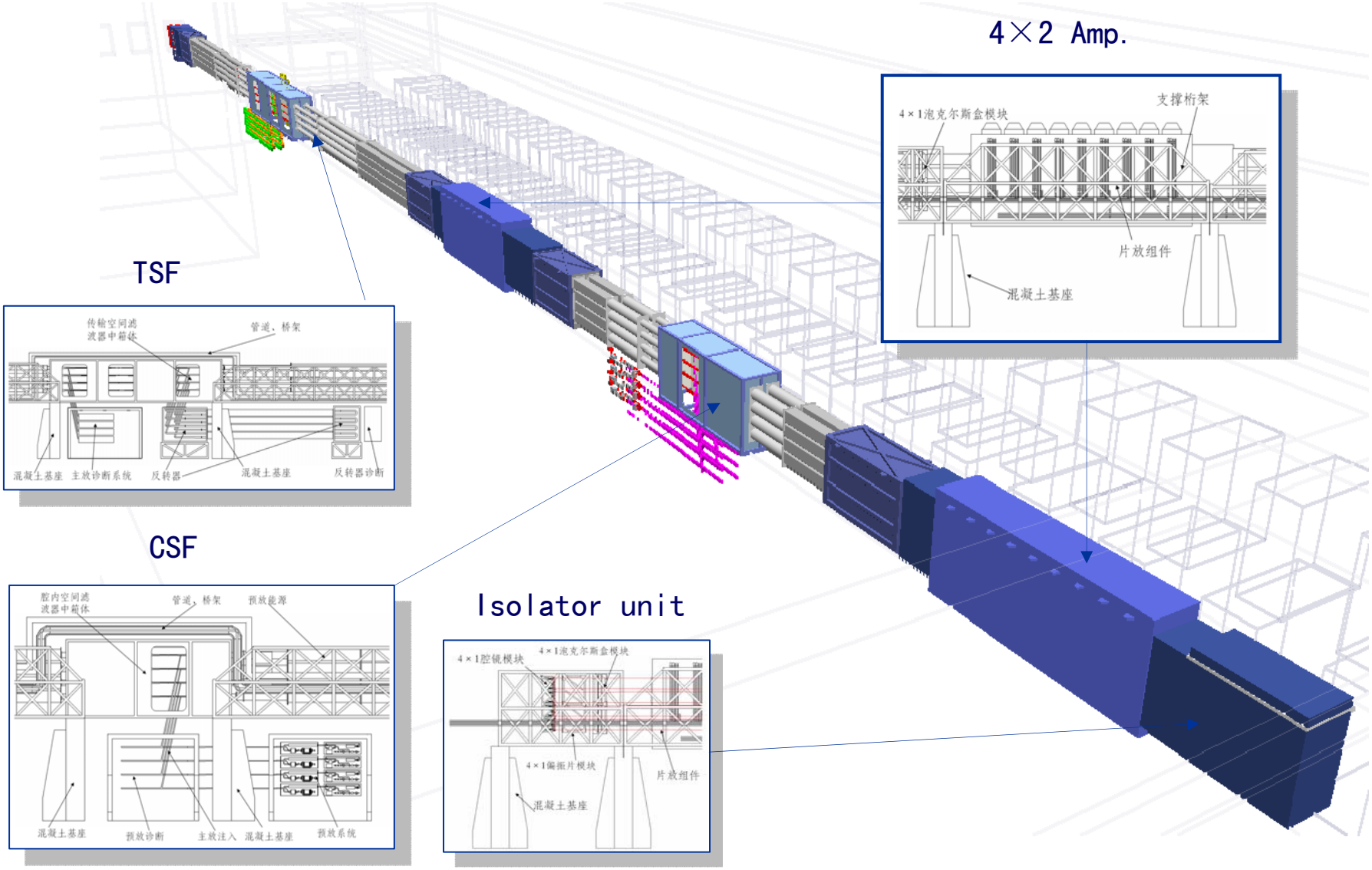
SG-Ⅲ Laser Facility Structure Design

(laser experiment area)

Design of SG-Ⅲ Laser Facility ----- Structure of beamline

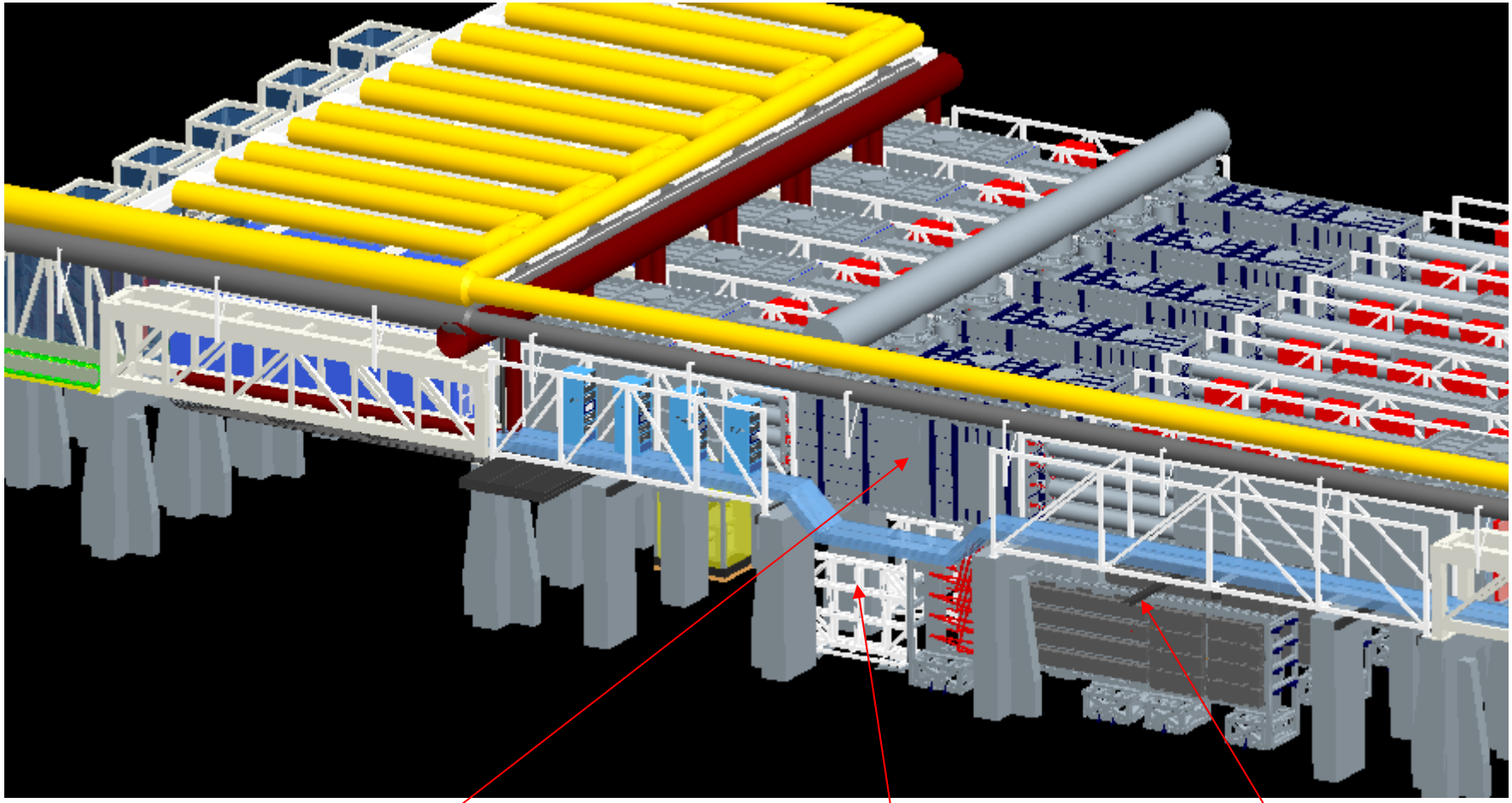


Design of SG-Ⅲ Laser Facility -----Structure of beamline

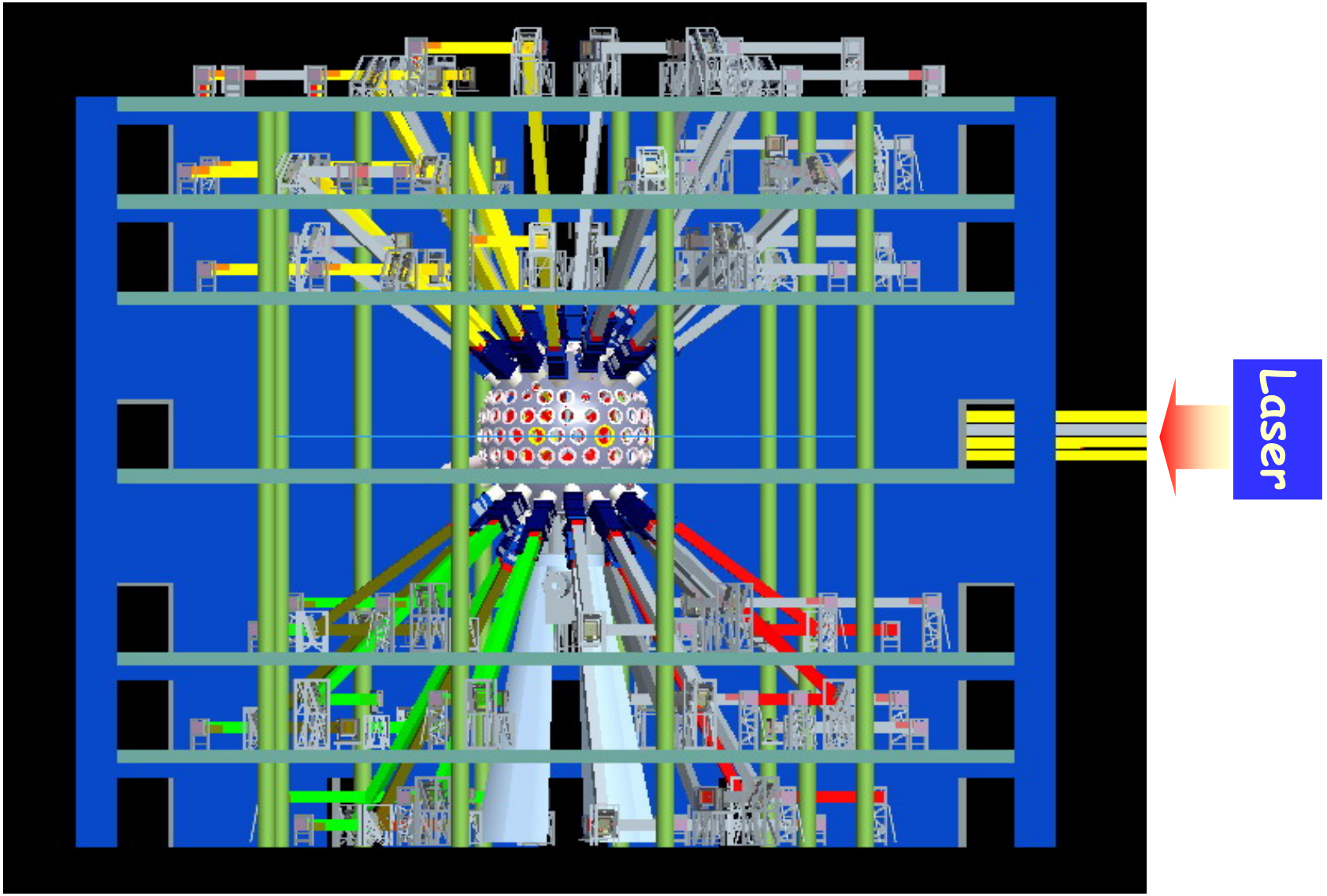


Design of SG-Ⅲ Laser Facility ---- Structure of laser area

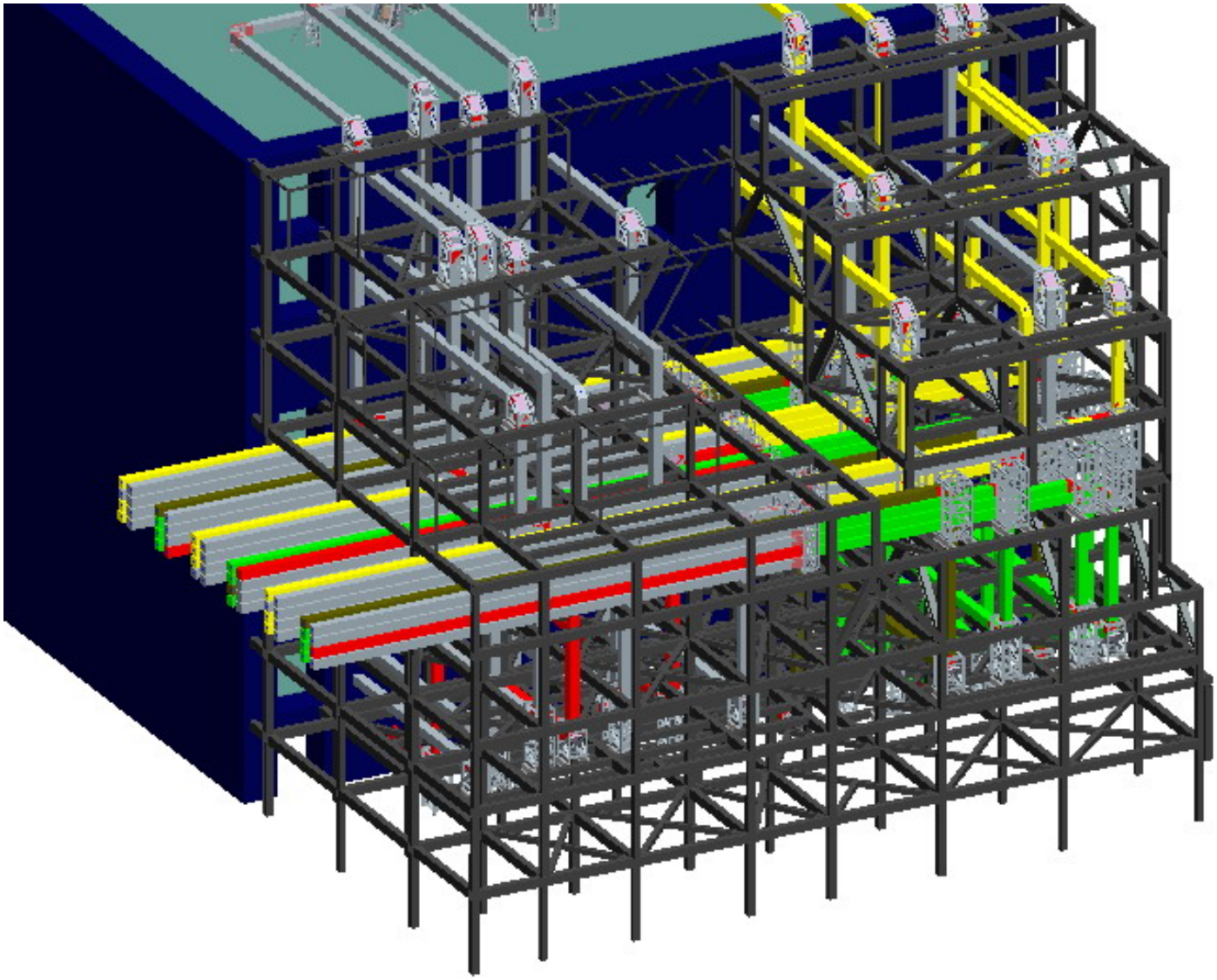
Research Center of Laser Fusion CAEP



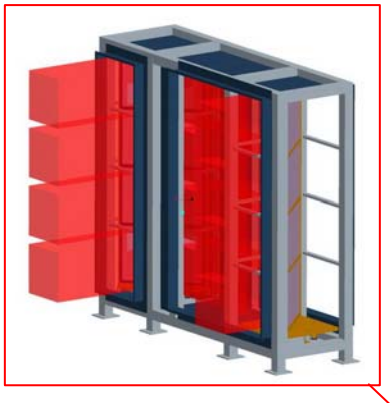
Design of SG-III Laser Facility ---- Structure of target area



Design of SG-Ⅲ Laser Facility ---- Structure of switchyard

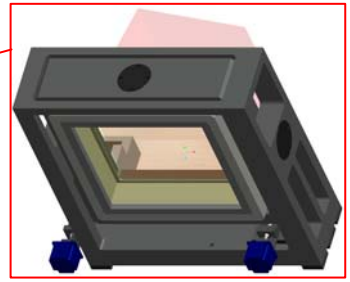


Design of SG-Ⅲ Laser Facility ---- Structure of switchyard

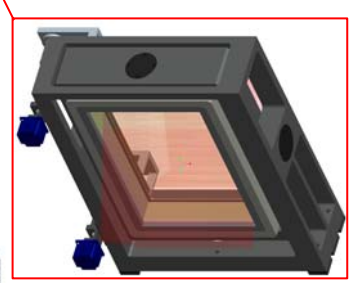


Array reflect mirror

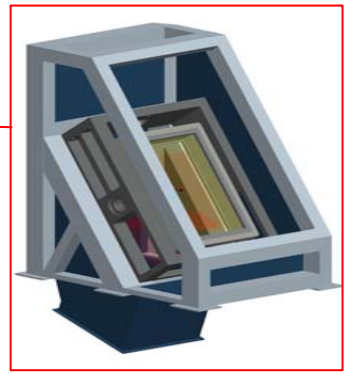
Reflect mirror Ⅲ

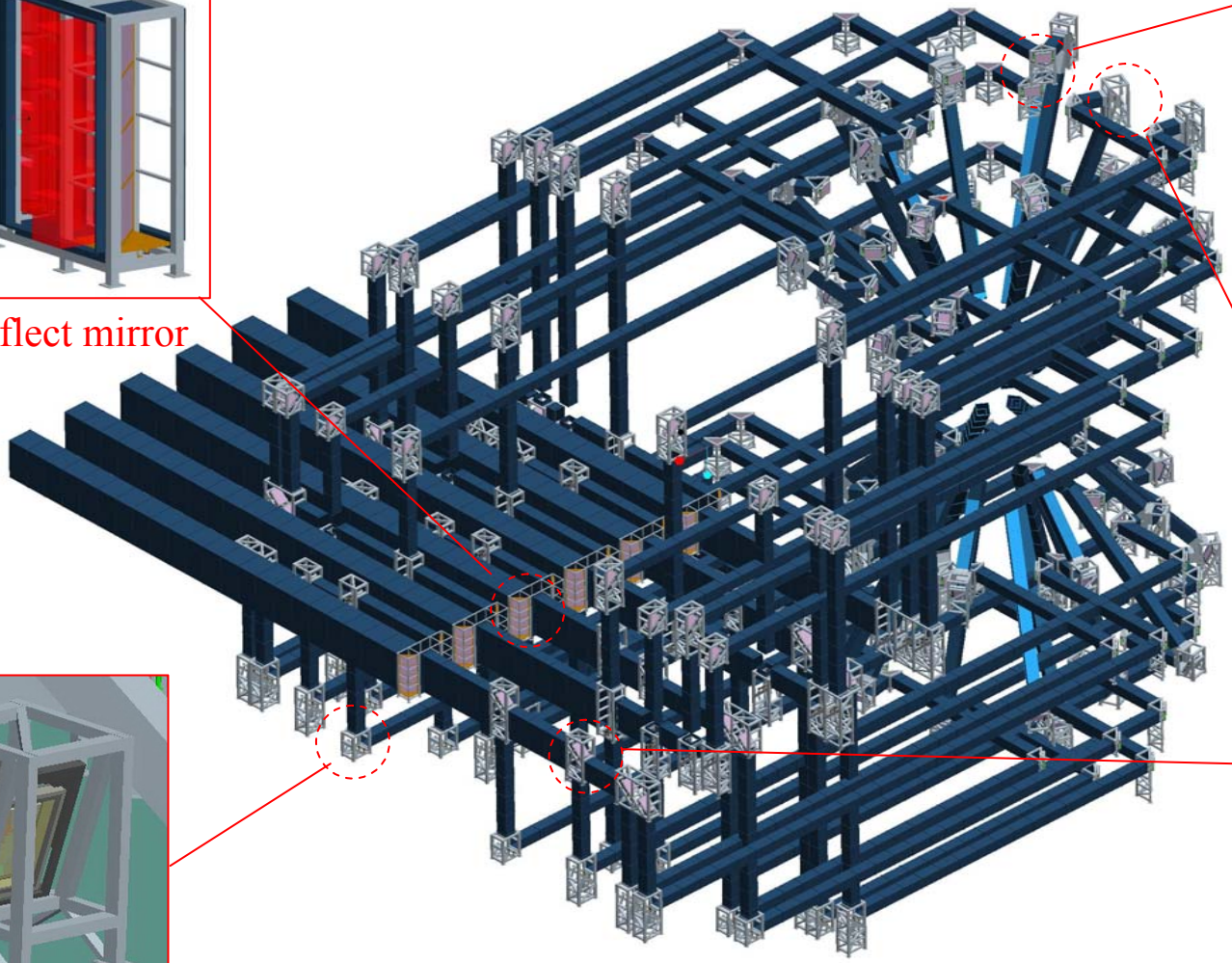


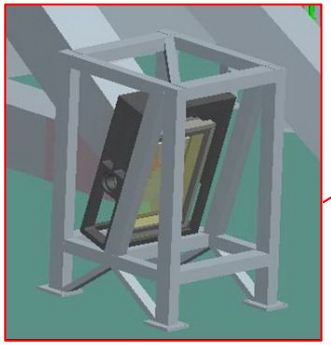
Reflect mirror Ⅱ



Reflect mirror Ⅰ

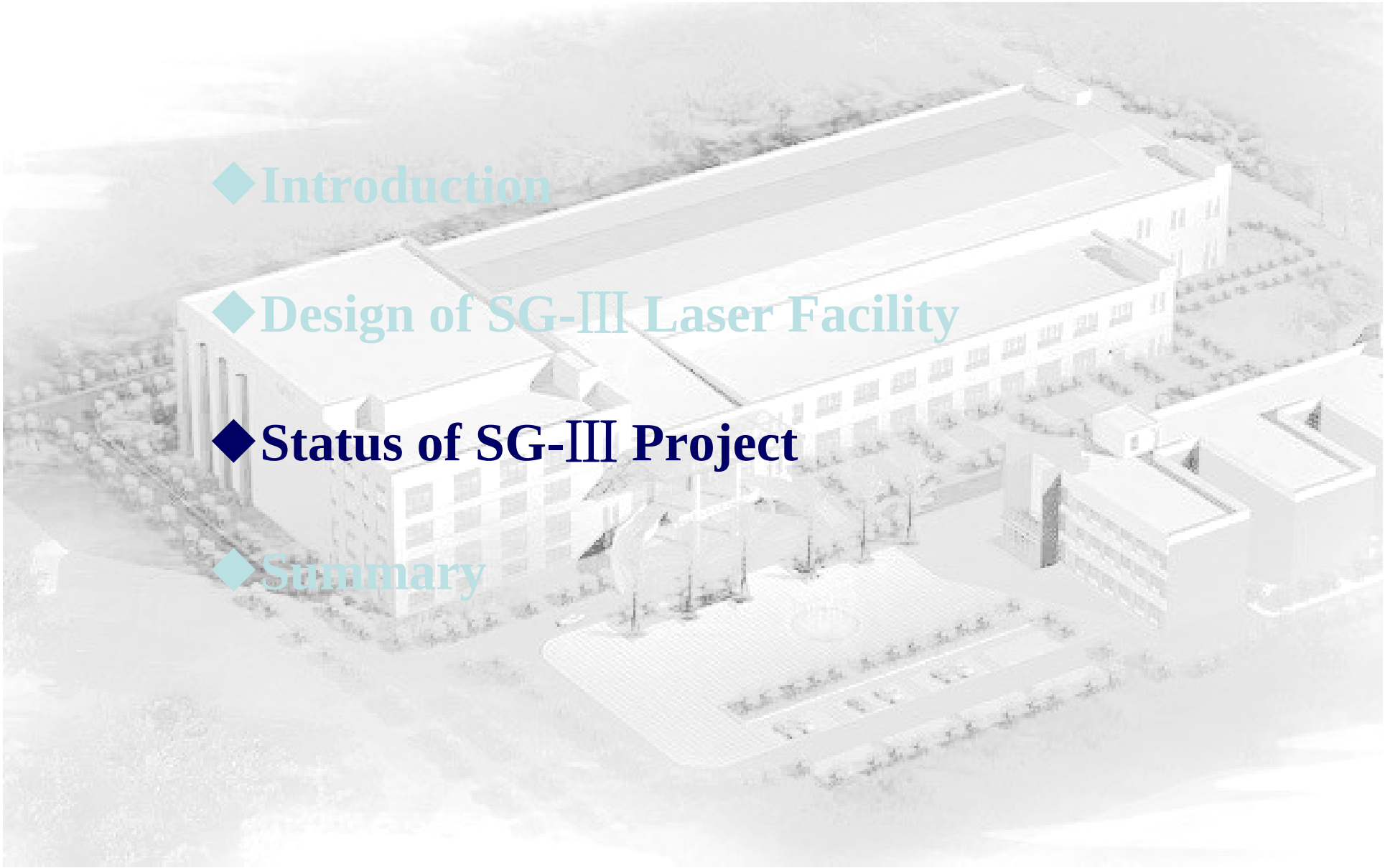






300 reflect mirrors

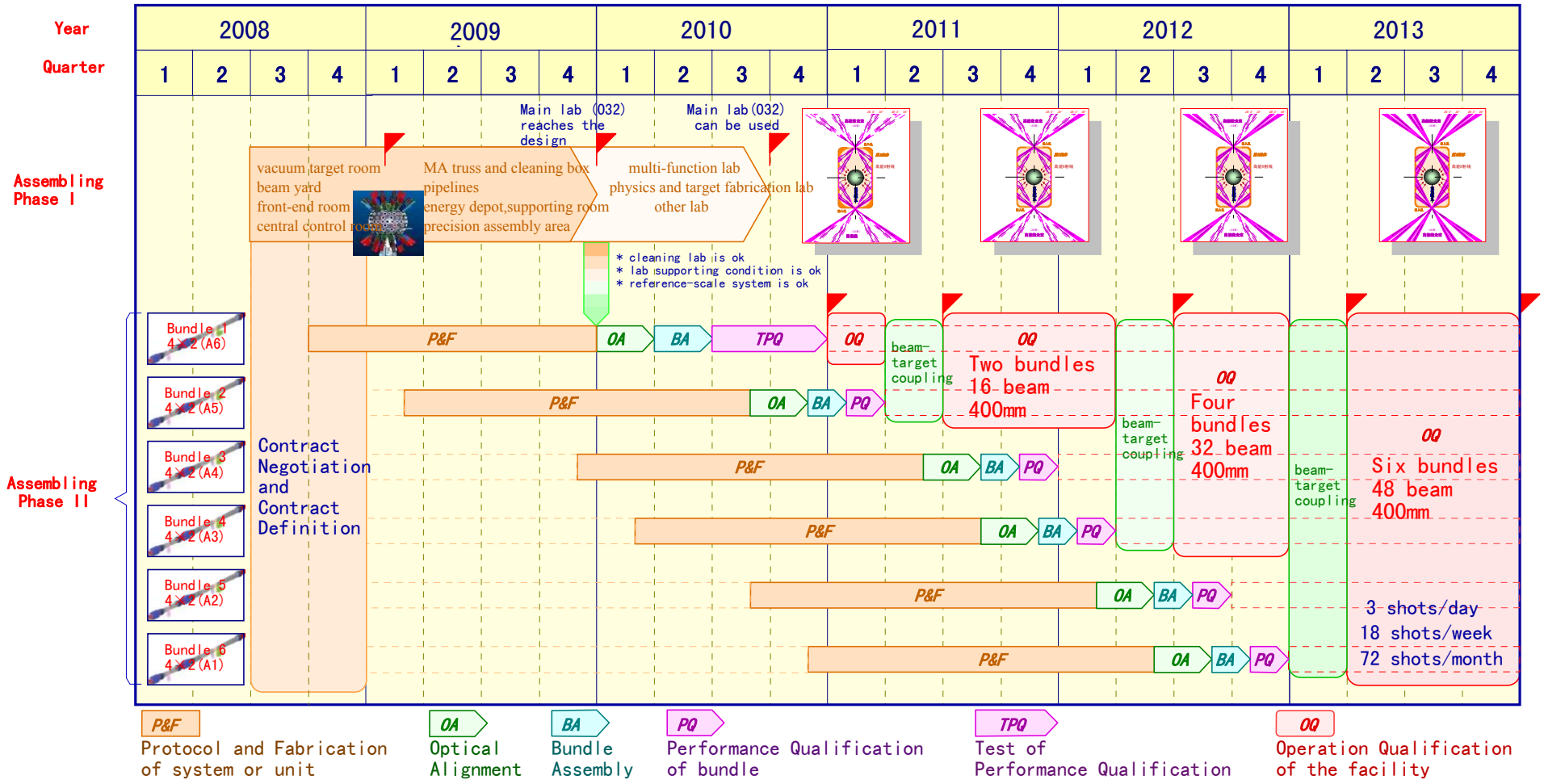
Outline



- Introduction
- Design of SG-Ⅲ Laser Facility
- **Status of SG-Ⅲ Project**
- Summary

Status of SG-III Project –Schedule

Research Center of Laser Fusion CAEP



Status of SG-III Project – Laser house

Research Center of Laser Fusion CAEP

Laser hall

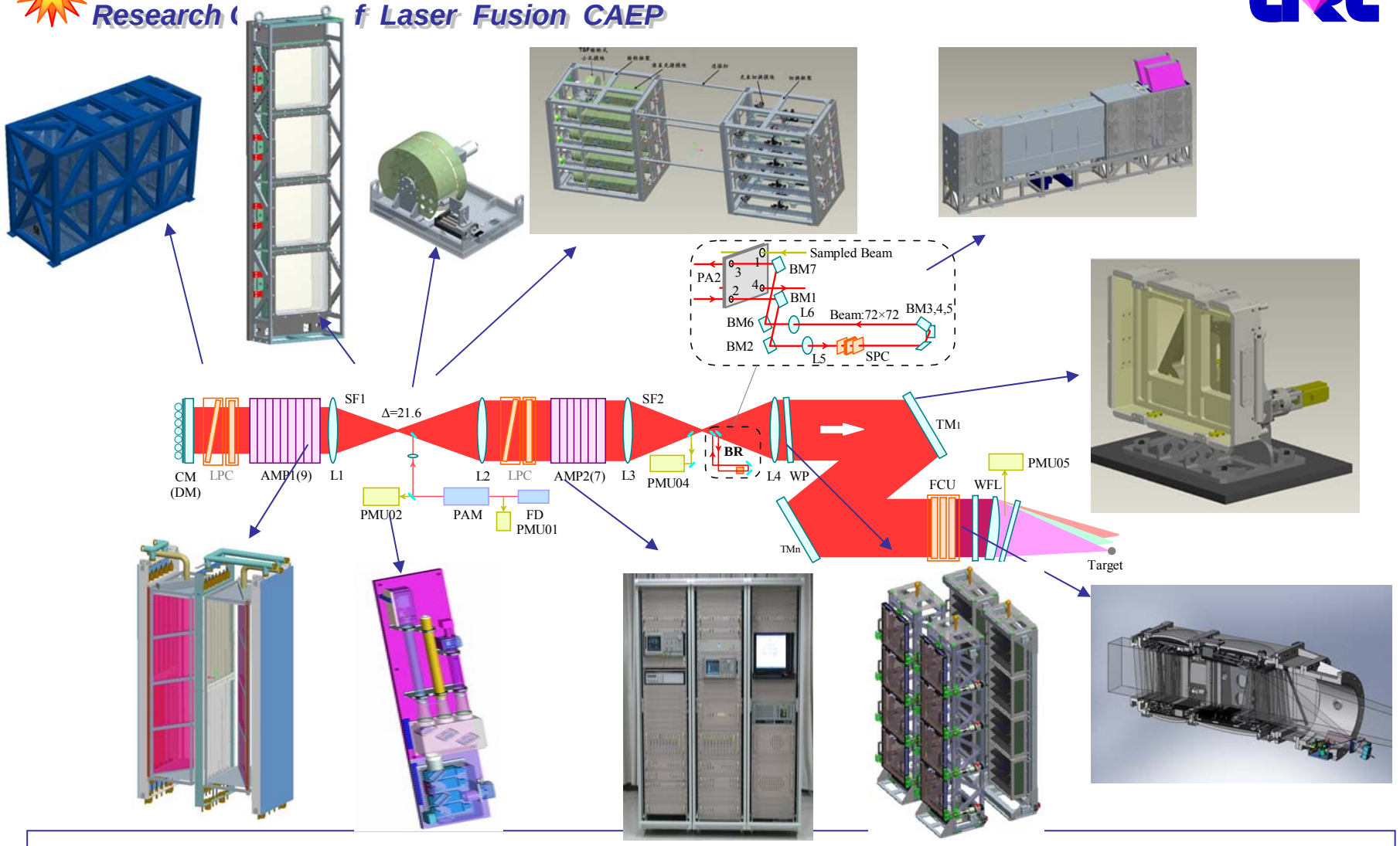
Shear wall in laser hall

Target area

The laser house are being constructed and will be completed in the end of June,2009

Status of SG-III Project – Engineering design

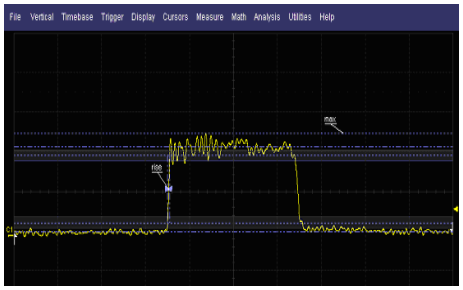
Research Center of Laser Fusion CAEP



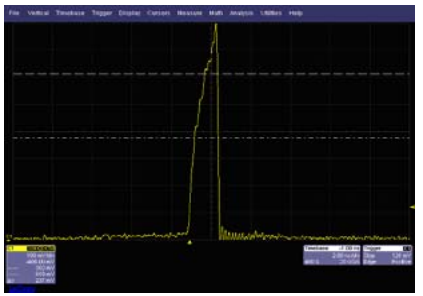
The detailed engineering design has been finished before may,2008, the main manufacturer for key unit and vendor for optics material have been selected.

Status of SG-III Project – Performance test of key unit and module

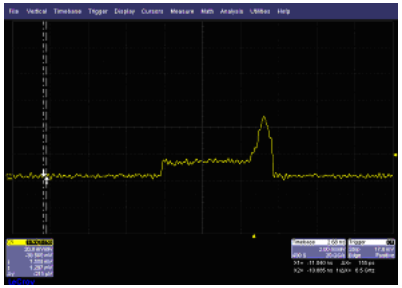
Front end

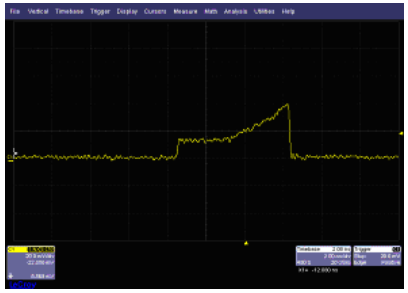


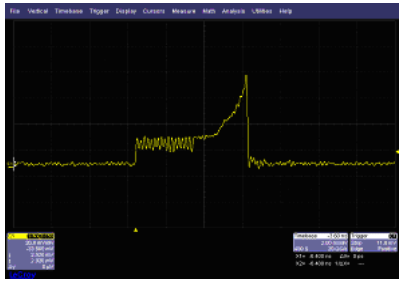
Rise time less than 100ps



Contrast 1:80







Different kind of shaped pulse

Main units in Front end were validated and can meet the requirement of design.

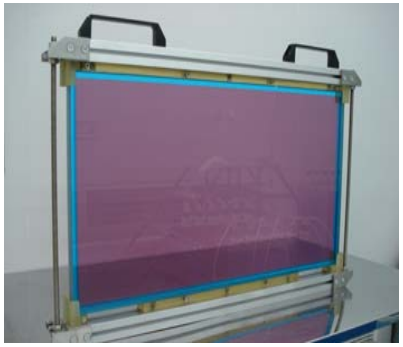
Status of SG-III Project – Performance test of key unit and module

The installation of 4×2×3 disk amplifier In July,2008,

Overview of the 4×2×3 disk amplifier performance testbed

Disk Amplifier

Flash lamp module

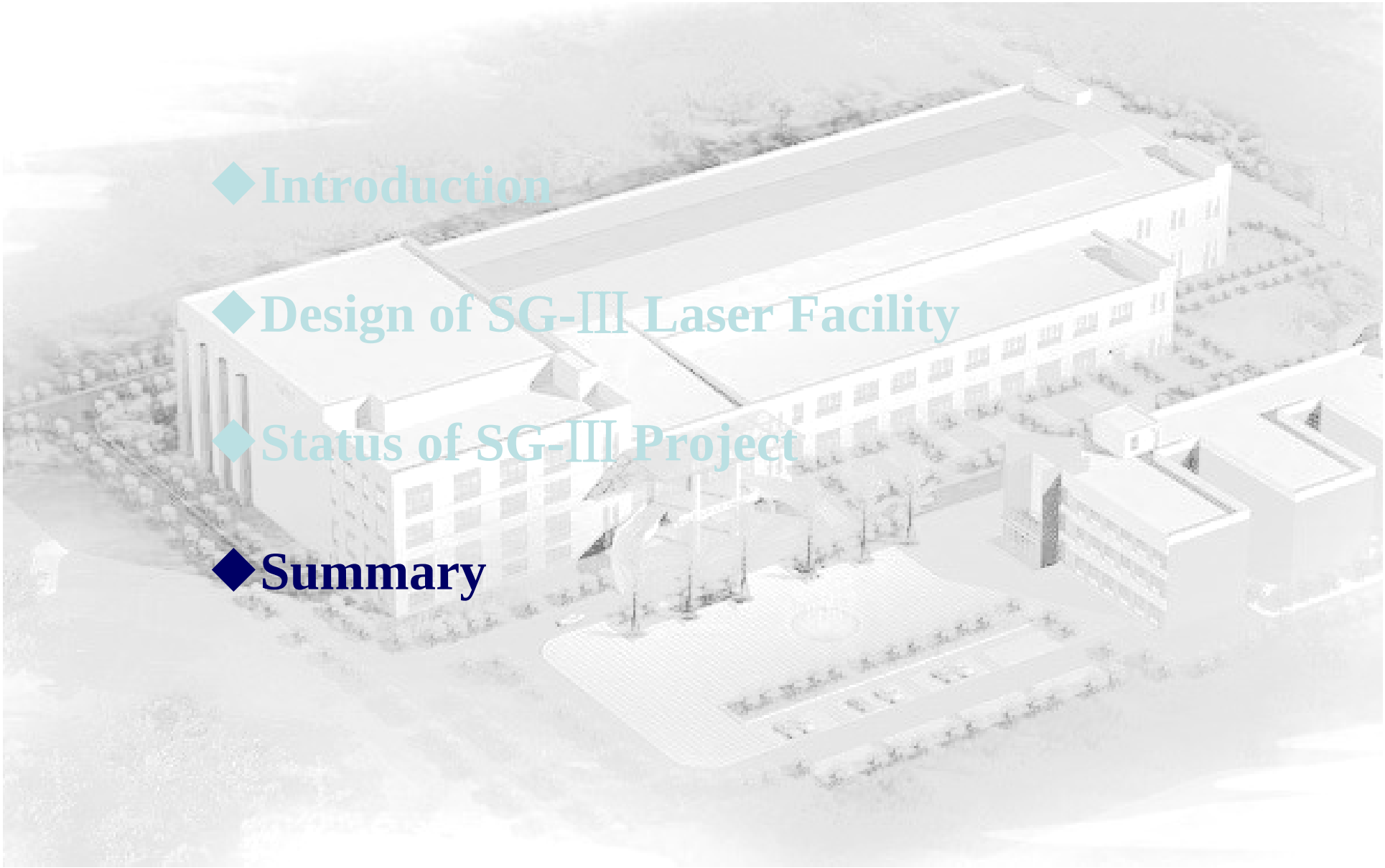


Nd glass

Energy bank

Installation of 4×2×3 Disk Amplifier Module was completed, and erformance experiment including gain measurement are started.

Outline



- Introduction
- Design of SG-Ⅲ Laser Facility
- Status of SG-Ⅲ Project
- **Summary**

Summary

1. Experiment results demonstrated the main specifications of the TIL ,the prototype of SG-Ⅲ, have been reached, the first round of physics experiment shows that TIL has the capability to provide shots for experiment.

2. The detailed design of SG-Ⅲ has been finished and the fabrication plan has been started.

3. Experiment to validate performance of key unit such as amplifier， front end, pre-amplifier are being carried out.

Thanks for attention!