X-ray and Proton Generation at the 40TW-Level with Z-Petawatt

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Facility Overview
(“Buildings 983/986”)

Short Pulse Upgrade
Front end:
OPCPA
(2+2+1 BBO)

40mJ
\( \lambda = 1054 \text{nm} \)
\( \delta \lambda = 8 \text{nm} \)
\( t_{\text{stretch}} = 2.4 \text{ns} \)
rep=10Hz
Z-Petawatt
Front End

Rod Amps:

16mm 2x-path
25mm 2x-path

5J

20 min rep.
Main Amps:
10x ZBL-slabs
10-100J
(sub-aperture)
150 min rep.
Laser Performance

10 Hz OPCPA signal on target

FWHM x: 6.3 µm
FWHM y: 6.4 µm

Radius of disc which includes...
65.7% of total energy: 4.71 µm
81.1% of total energy: 7.55 µm
90.8% of total energy: 10.86 µm

Strehl ratio: 0.58

Amplified energy: typ. 25 J, max. 33 J
Full pulse width: < 3 ps (BW limit ~450fs)
ASE prepulse better $10^{-6}$ @ < 1ns

Focus shape is approximately maintained for rod-shots.
Full system shot foci have not been measured yet.
Target Chamber

steering mirrors

OA-parabola

Image plate

diagnostic / detector stage

cu-foil

target holder

K$_{\alpha}$-imager

2$\omega$ probe / alignment beam
Target Diagnostic
(in collaboration with UCSD: Farhat Beg / Jim King)

• Diagnostic: Spherically curved crystal; $K_{\alpha}$ X-ray imager
• Target: 25 µm Cu foil
• Detector: Fujifilm BAS-SR image plate
• Laser energy: 20 J
• Spot diameter: FWHM~60 µm
• Magnification: 7.1x

• Diagnostic: Shadowgraphy image / probe beam
• Target: 25 µm Cu foil
• Detector: Roper internally cooled CCD
• Exposure time: ~300 fs
• Magnification: ~9
X-ray Spectra

$K_a$- Spectroscopy

Shot # B6022404

Shot # B6083003 (Cu)

Shot # B6091101 (Ge / 10keV)
Proton Radiography

First Results

SHOT # B6090104:
Layer #18: \( E_{\text{proton}} \sim 20 \text{ MeV} \)

Stack: 8x GAFchromic HD-type
+ 12x GAFchromic MD-type

Laser energy: 24.5 J
Target: 8 µm Cu

SHOT # B6092003
Proton Spectra

First Results
Proton Spectra
First Results

Shot #B5091304

The graph shows the proton spectra for a specific shot, with the proton energy on the x-axis and photon yield in relative units on the y-axis. The data peak around a proton energy of 2 NeV and decreases as the energy increases.
Proton Radiography

Scattering vs. Energy Loss

RCF sensitivity range

intensity vs. energy

energy loss target

100µm W wire (6mm distance)

100µm W foil (contact)

scatter target

SHOT # B6090701 (5th layer)
Z-Petawatt

Outlook

Main Beam:
- \( E: \) 400 – 1000 J
- \( t: \) 500 fs
- \( \lambda: \) 1054 nm
- \( I_\lambda^2: \) \( 10^{21} \) W/cm²

800 nm Probe:
- 3 J @ 30 fs

Commissioning
For ZR: Summer 2007
Stand alone: TBD