SAND2007-575

Overview of the Z-Backlighter Facility at Sandia National Laboratories

Osaka, September 6, 2007

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Z Backlighter

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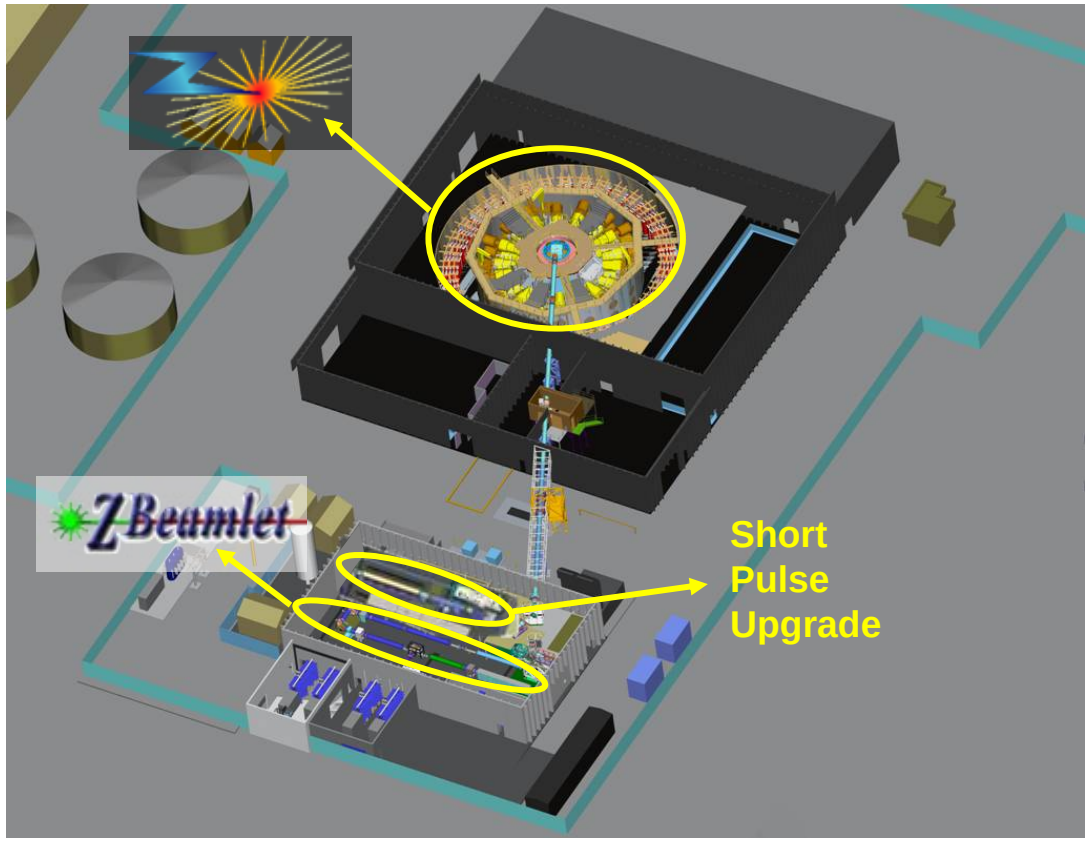
Facility Overview
("Buildings 983/986")



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Z-Machine

- Sandia's Z-machine uses large electrical impulses (currents of 20 MA and stored energies of 11 MJ) to implode wire arrays.

- The resulting plasmas provide high energy density physics (HEDP) conditions capable of producing up to 280 TW of x-rays (for 1.8 MJ total energy).

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Available Laser Systems

- λ=527nm
- τ=0.3-8ns (2ns common)
- ϕ~75μm spotsize
- E<2kJ
- I<10^{17} W/cm^2
- ~3 hr/shot
- 2 pulse MFB

- λ=1054nm
- τ=500fs min
- ϕ~30μm spotsize
- E<60J (<500J pending)
- I>10^{19} W/cm^2
- ~3 hr/shot
- Sub-ps probe @ 527nm, <20mJ

- λ=1064nm (532nm option)
- τ=150ps
- ϕ~5μm spotsize
- E<10J
- I<10^{17} W/cm^2
- ~20 min/shot
- Pending: 8-10ns operations at >100J @1ω

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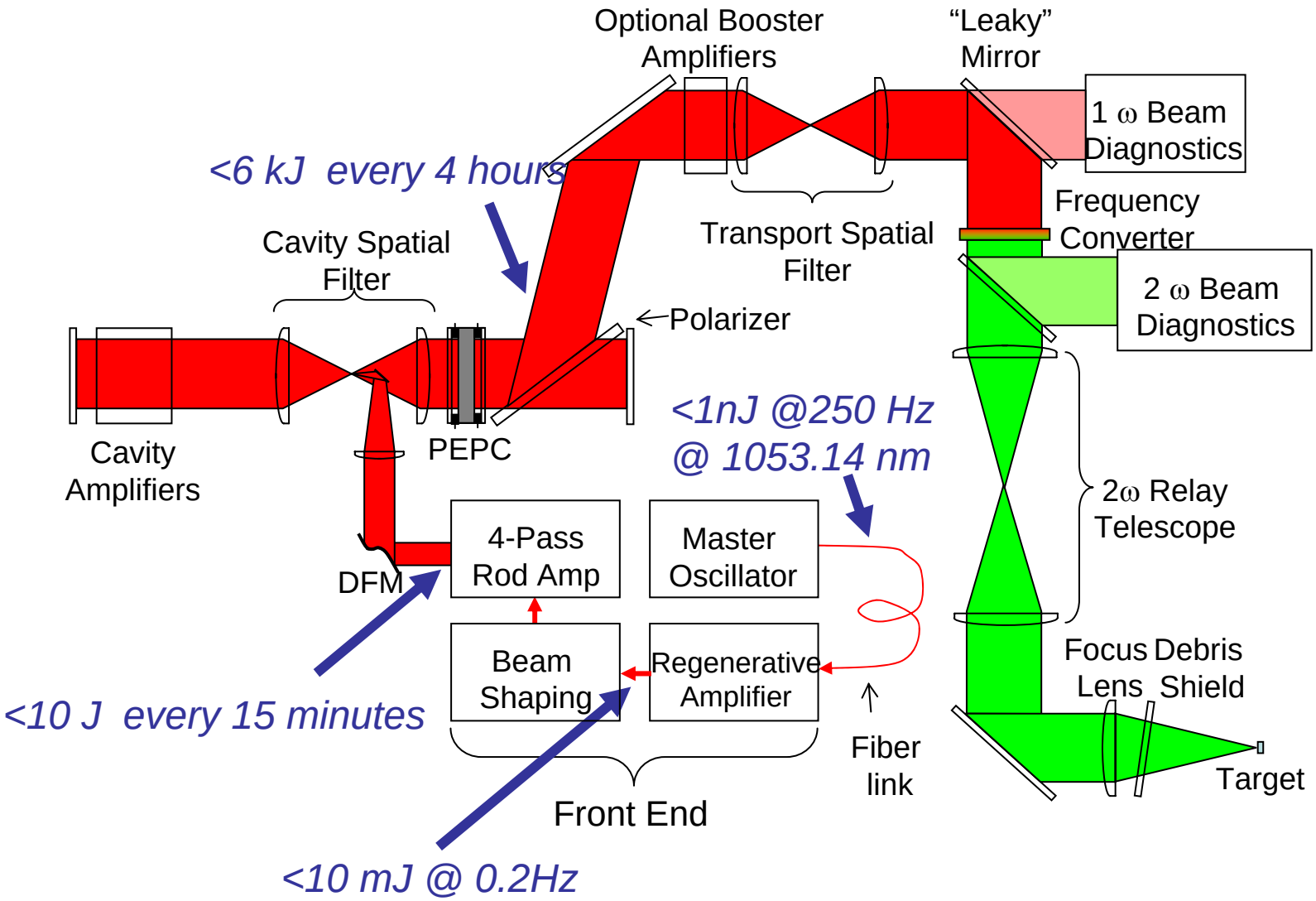
Z-Beamlet Architecture



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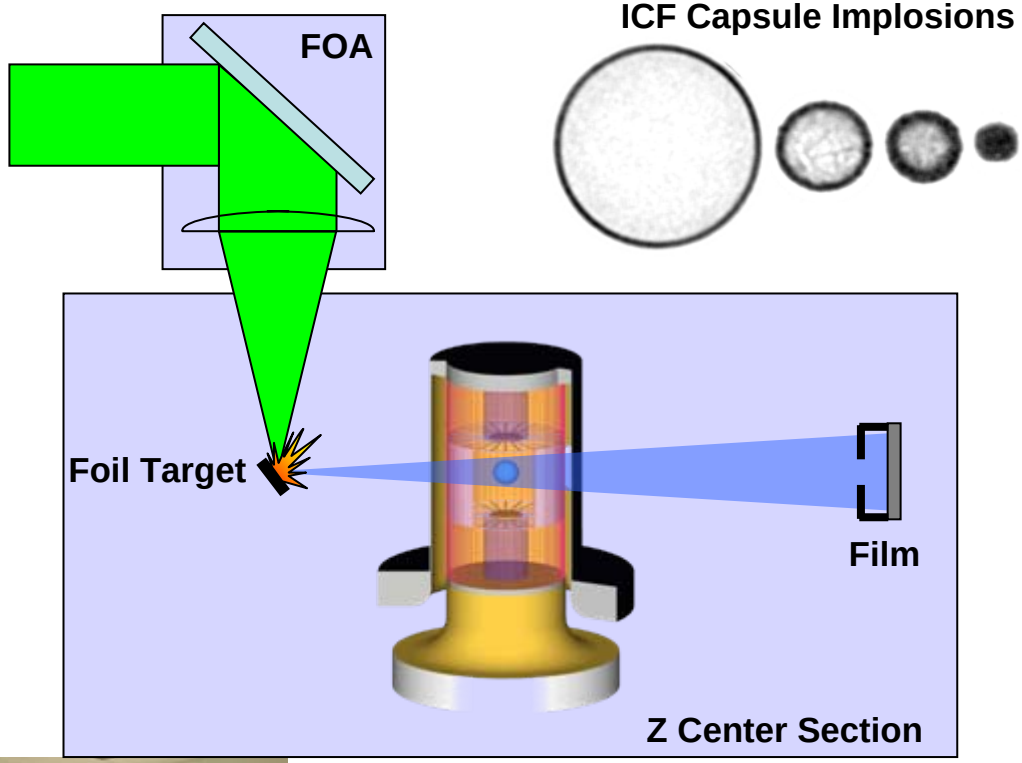
Z-Beamlet



ICF Capsule Implosions

- 5kJ @ 1053nm
- 2.5kJ @ 527nm
- 4 shots per day
- 0.3-2ns pulse length
- 1-9 keV radiography

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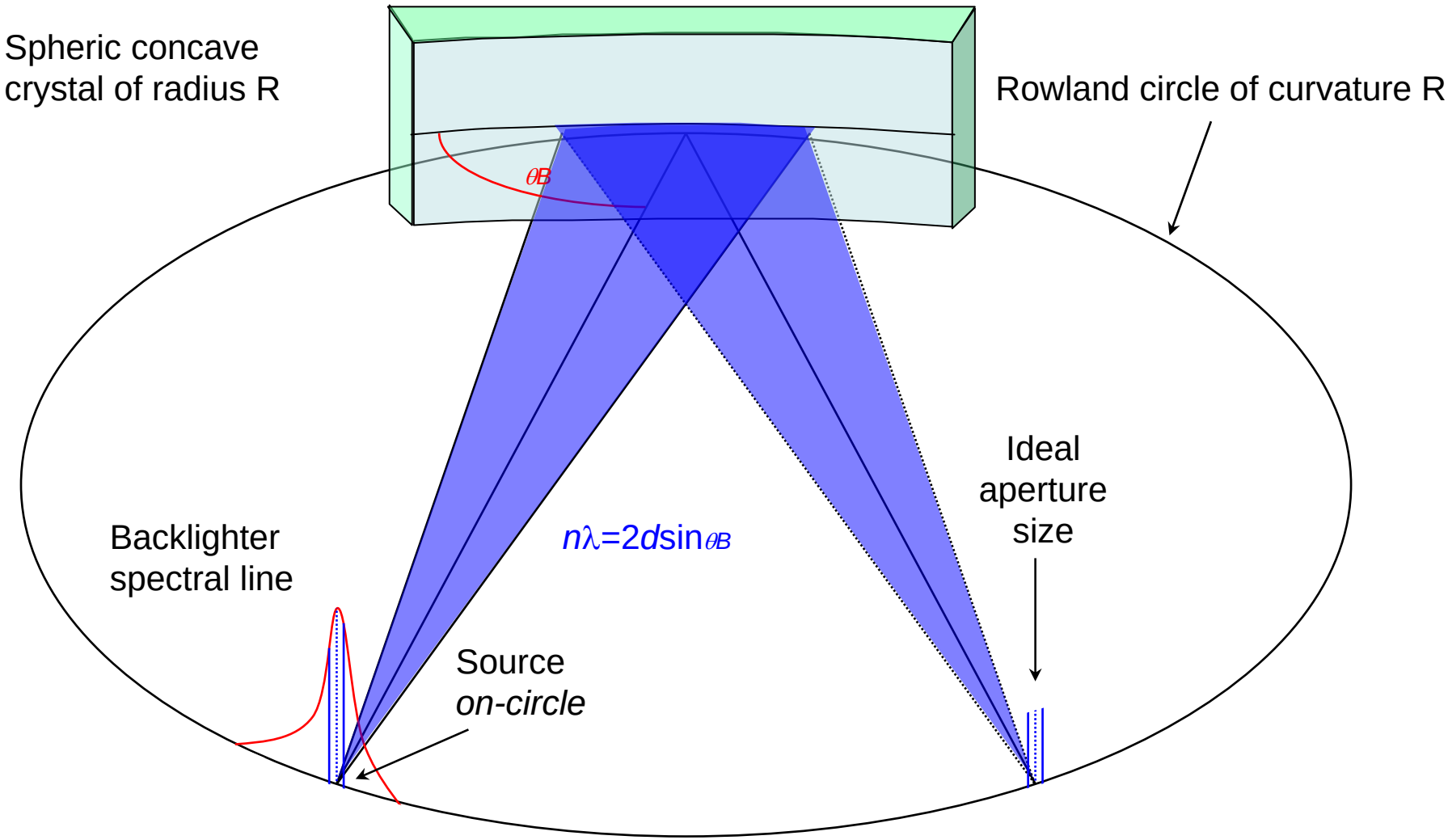
Bent Crystal Imaging



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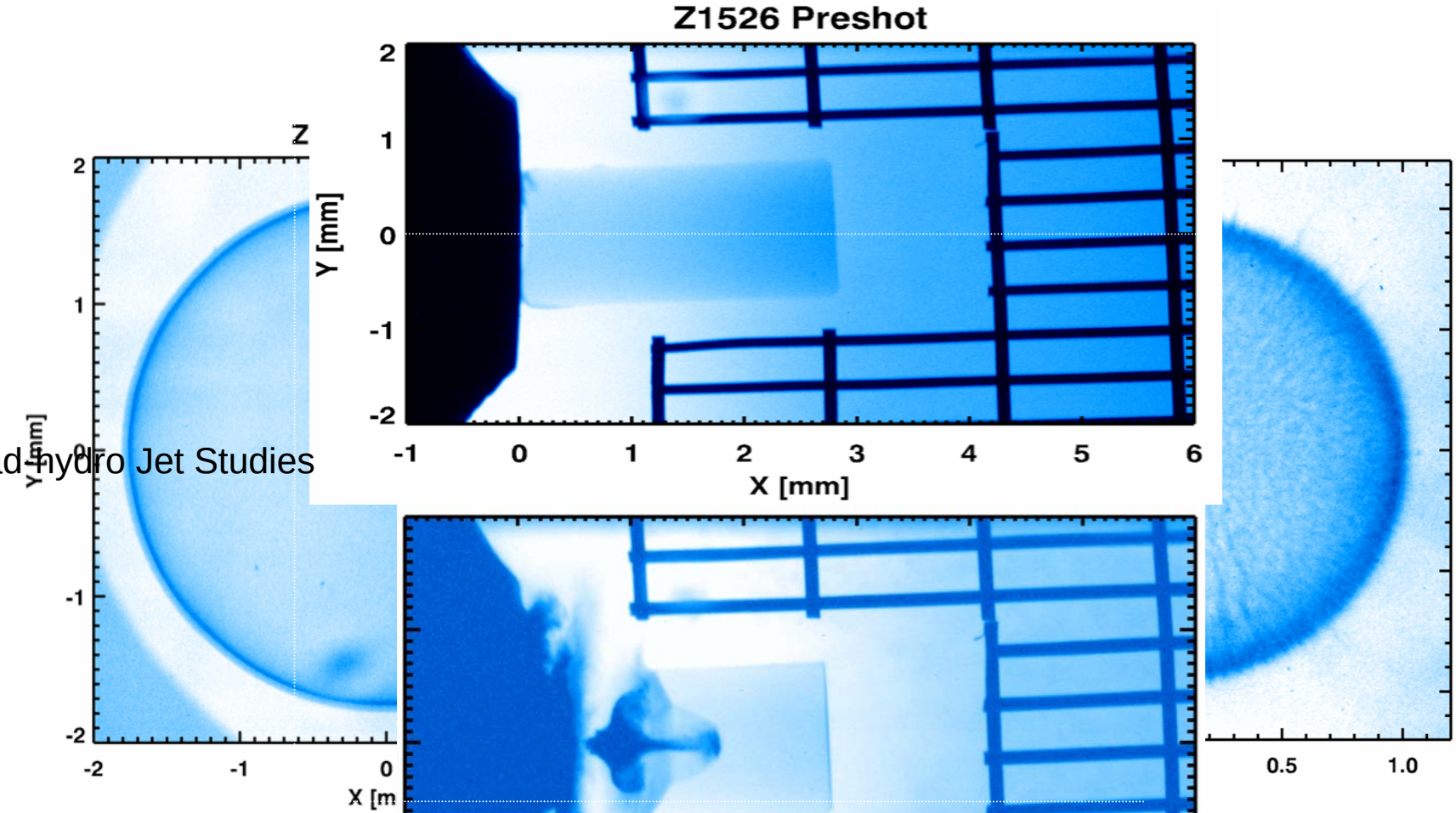
Radiography Improvements

- Application of bent crystal x-ray imaging has improved the field of view and resolution dramatically!



Rad-hydro Jet Studies

ICF Implosion Studies

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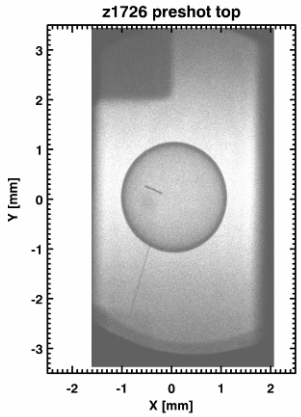
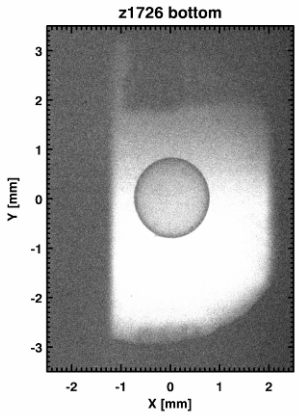
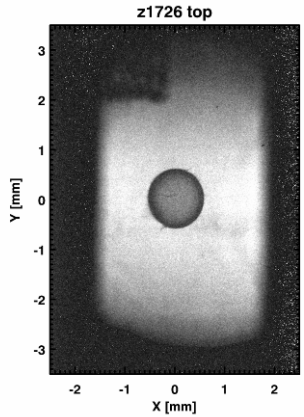
Two Frame Backlighting

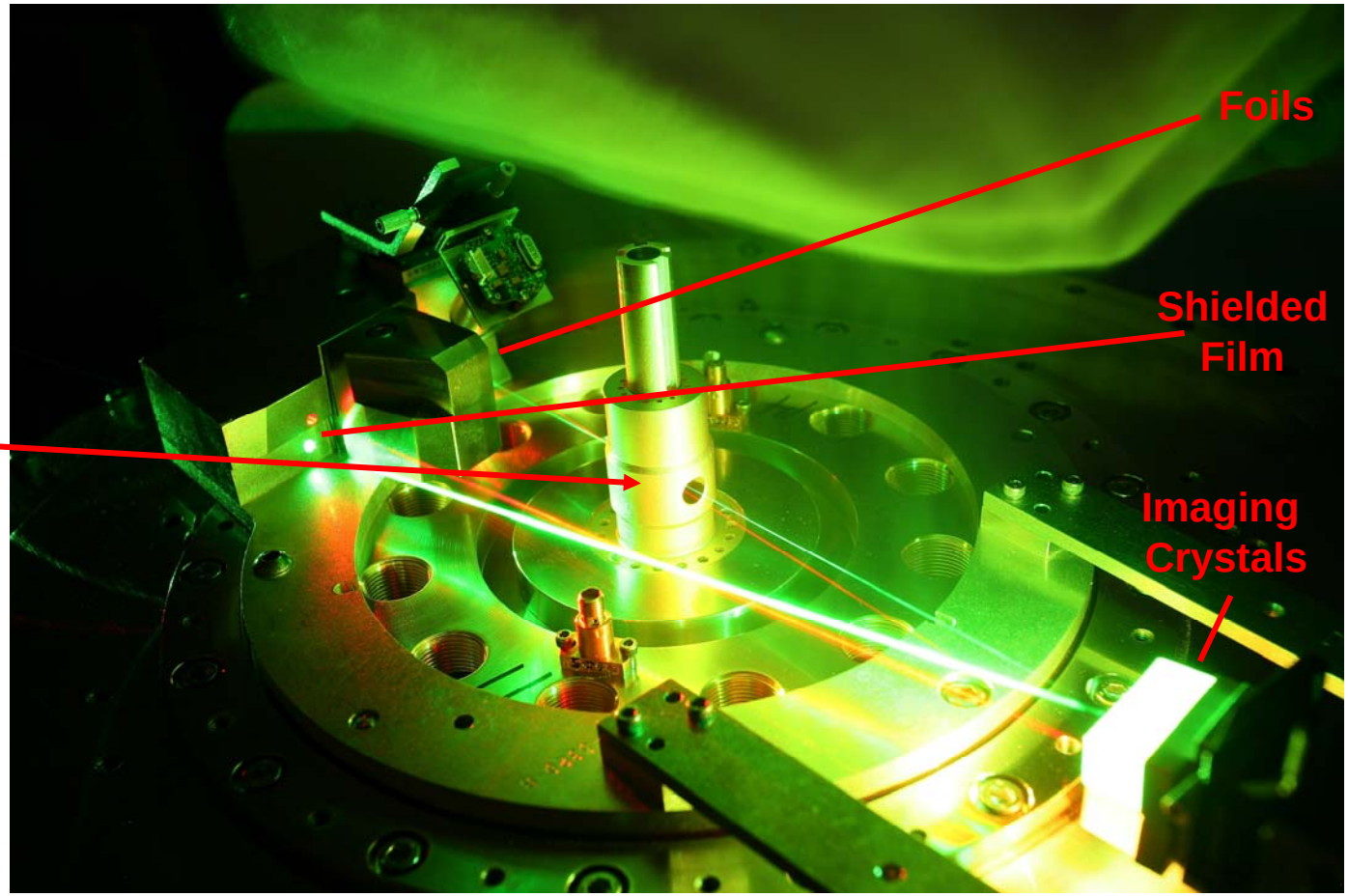




Δt=8ns



- Modifications to ZBL allow two separate pulses to go through the system at slightly different angles which allows for two radiographs on the same Z shot.



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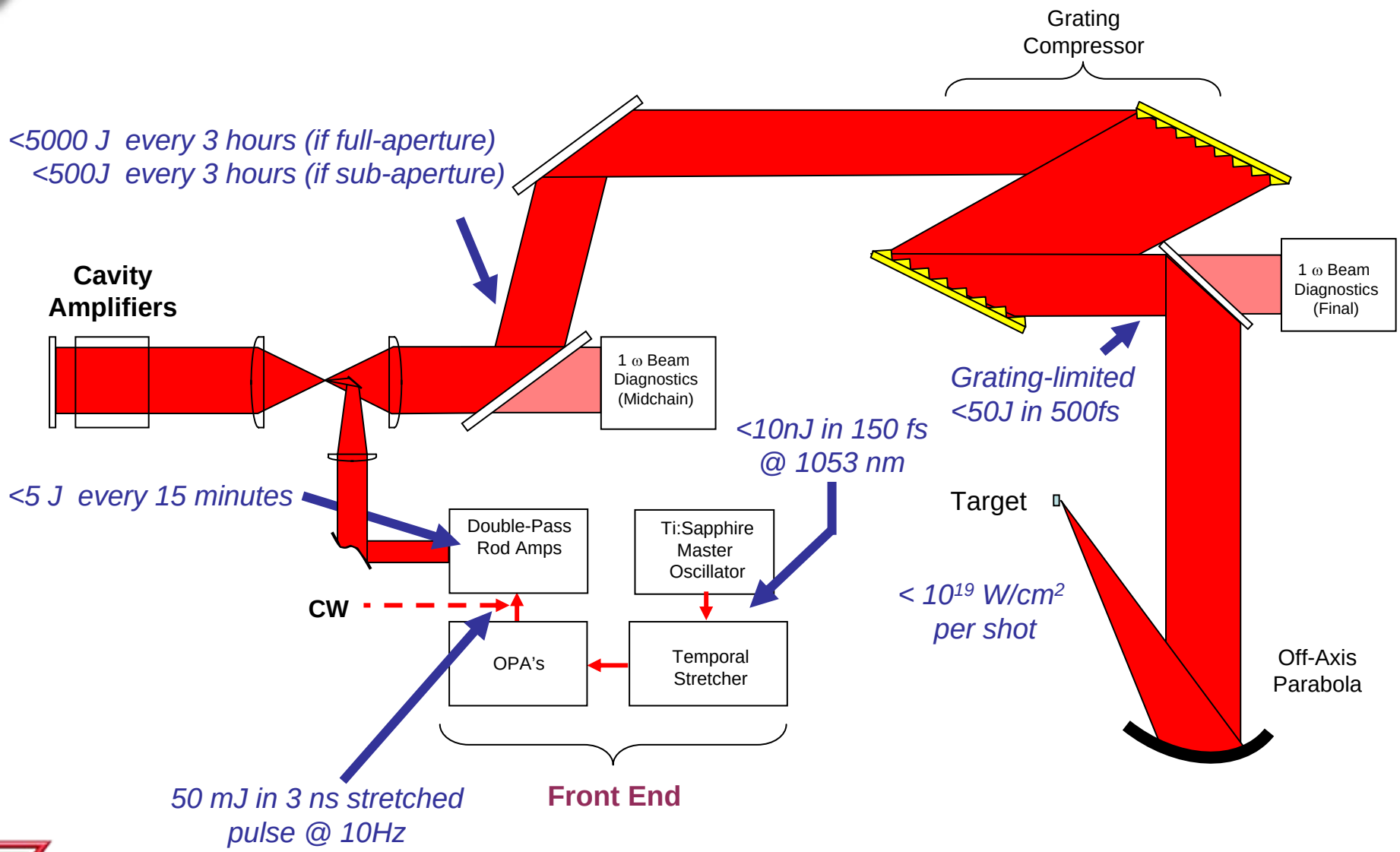
The 100TW/Petawatt System



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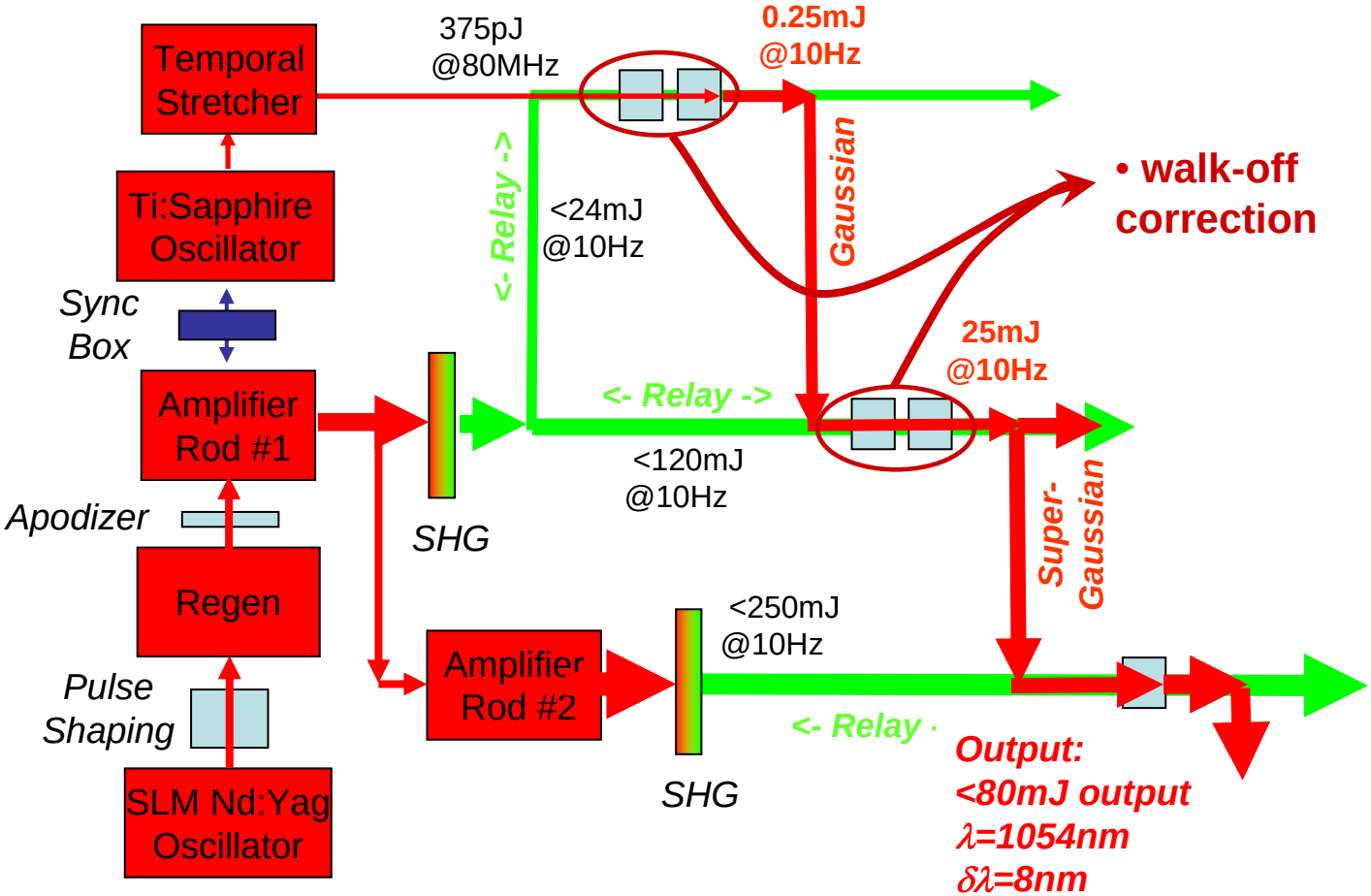
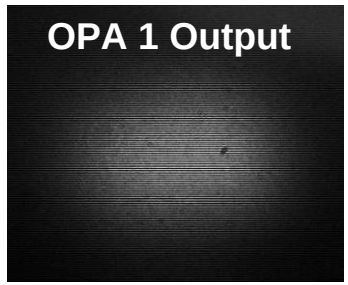
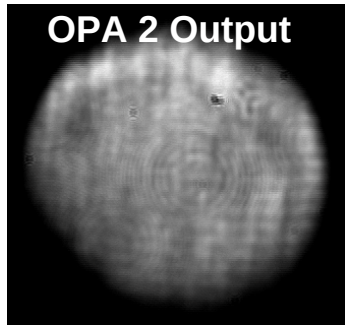
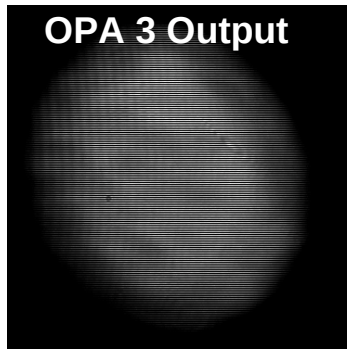
The OPCPA Front End









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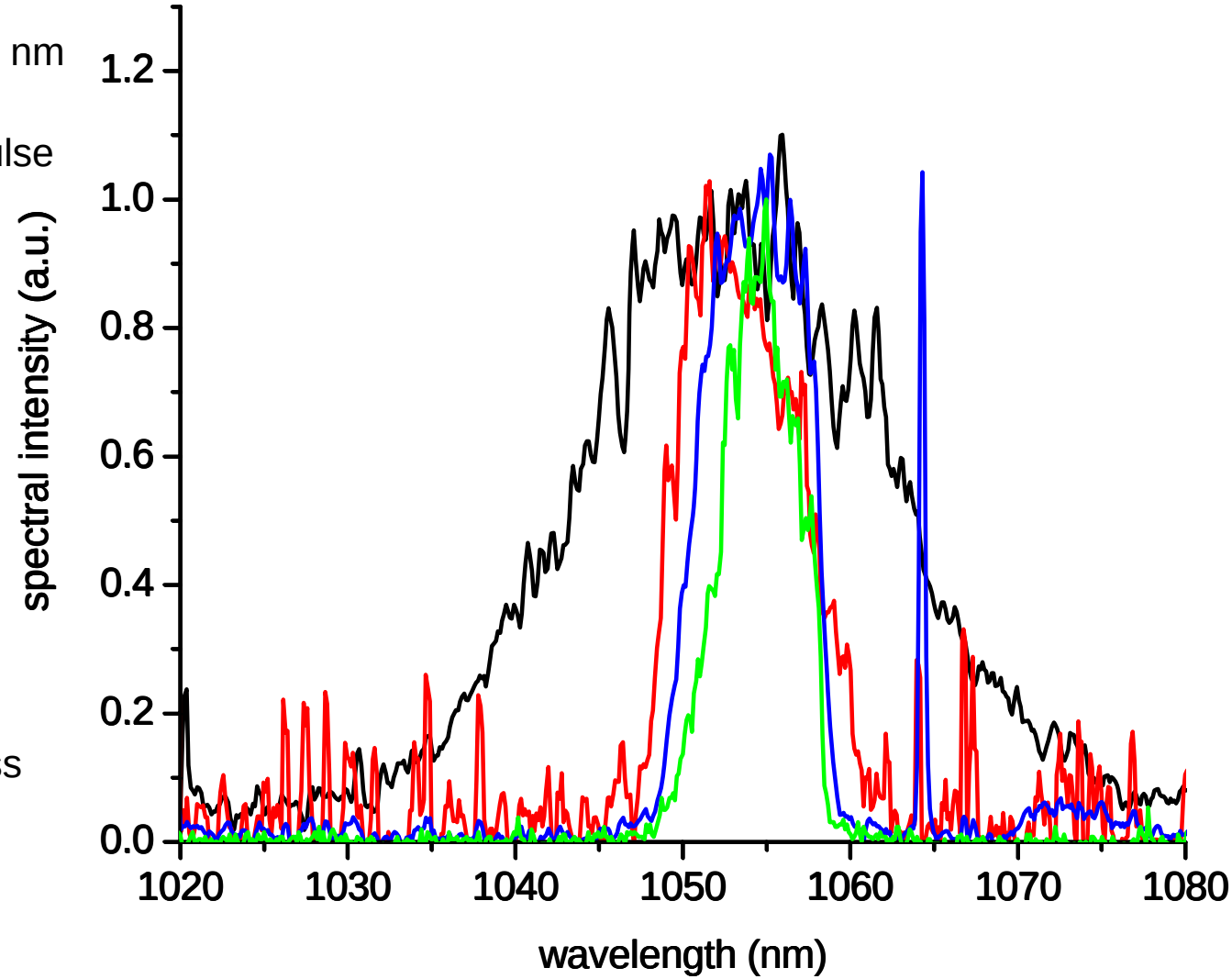
The OPCPA Front End

- Oscillator output $\Delta\lambda \approx 20$ nm
- Clipped spectrum after pulse stretching $\Delta\lambda \approx 11$ nm
- Spectrum at OPA 3 $\Delta\lambda \approx 8$nm
- 3 TW shot spectrum $\Delta\lambda \approx 5.5$ nm

$\Rightarrow$This spectral bandwidth can support pulses of less than 400 fs.



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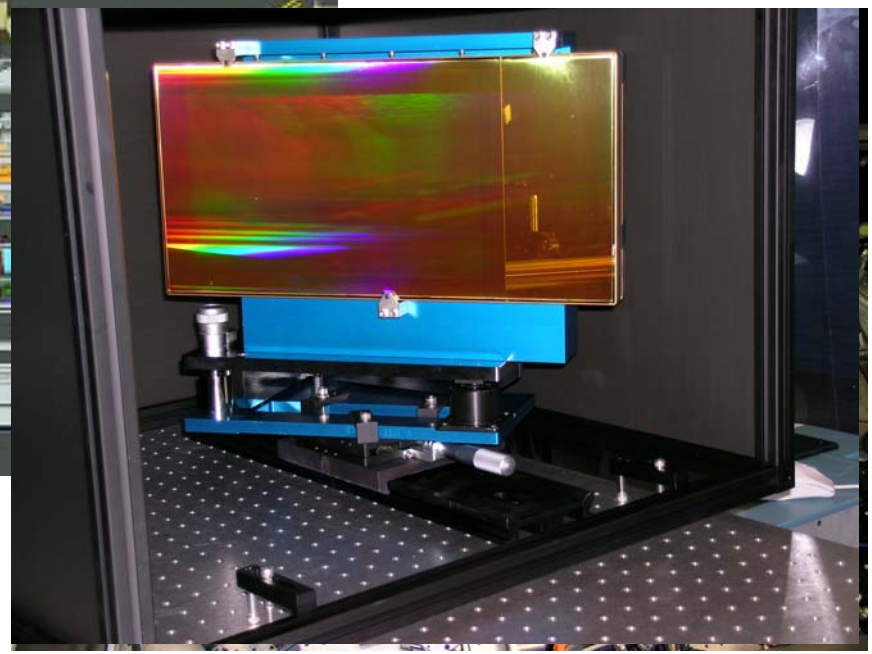
The 100TW/Petawatt System

OPCPA Front End

Front-end Compressor

OPCPA Power Amp



Energy: < 500 mJ

Pulsewidth: 30 fs

Bandwidth: 50 nm

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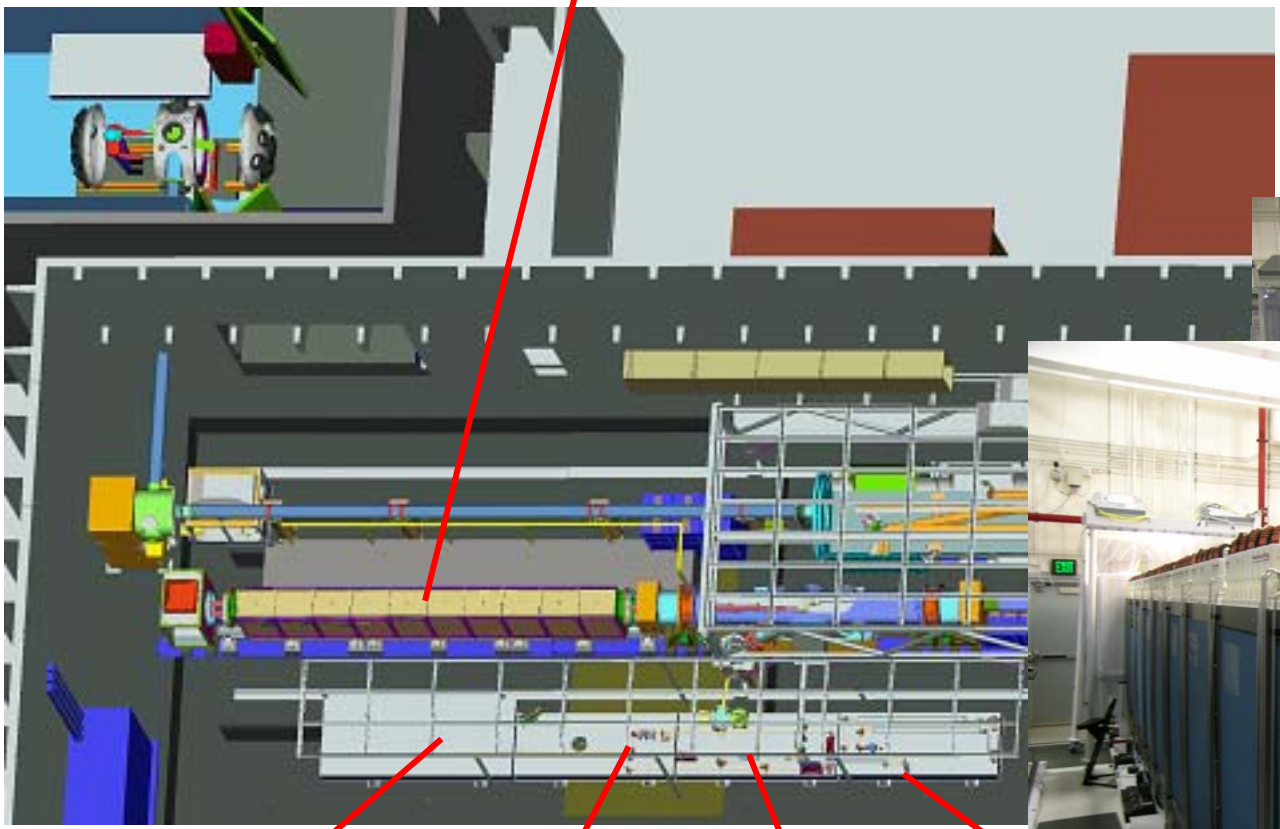
The 100TW/Petawatt System

Double-pass Amplifier



Energy: < 600 mJ

Pulsewidth: 1.2 ns

OPCPA Front End

Front-end Compressor

OPCPA Power Amp

Front-end

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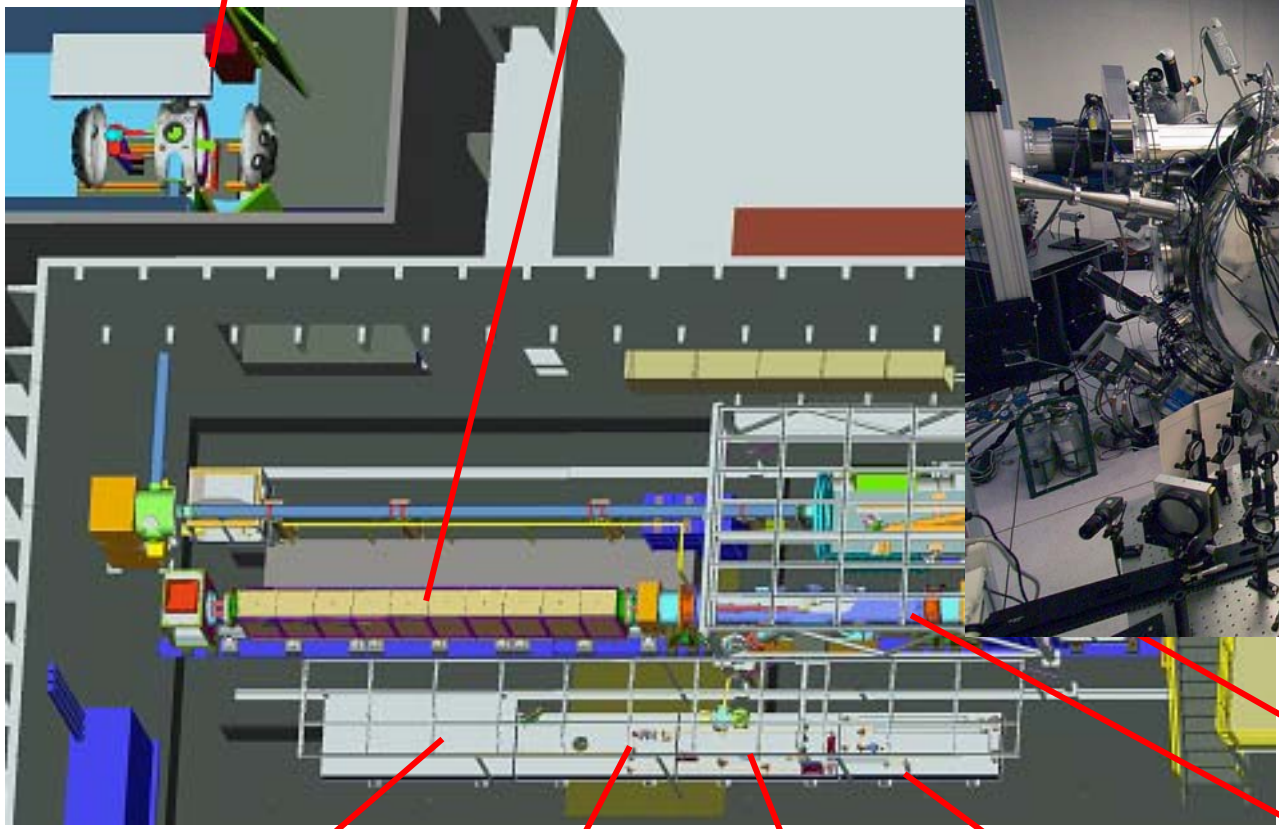

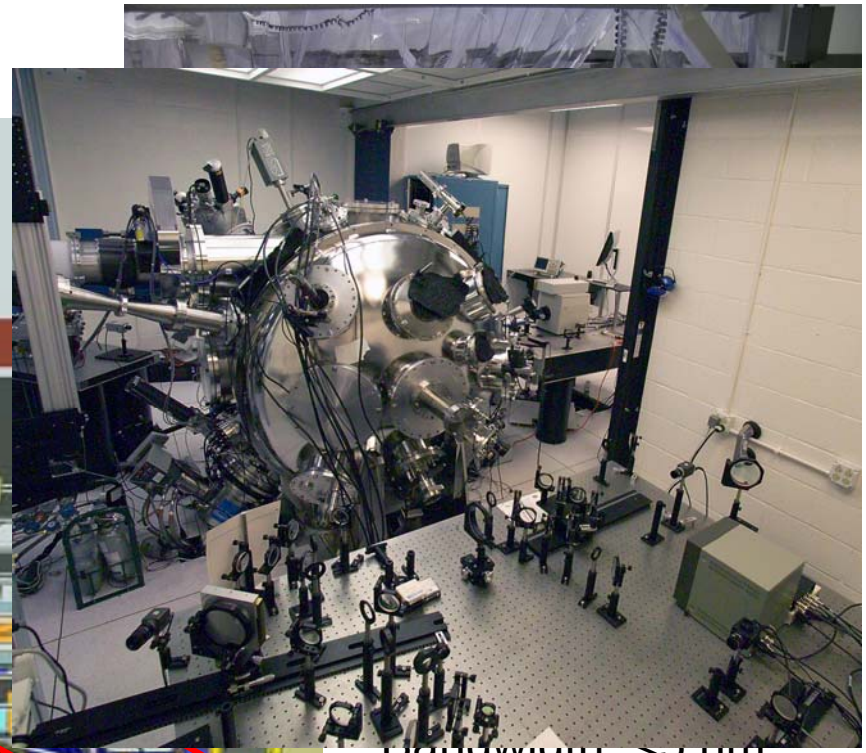

Bandwidth: <3 nm

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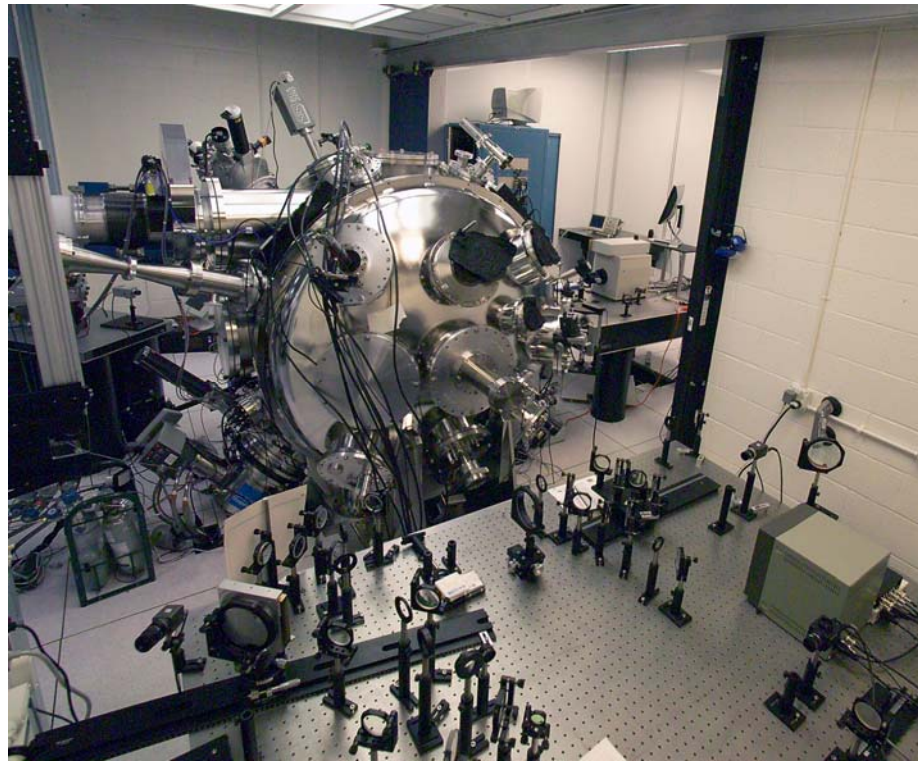
100TW Target Area

Lasers:

- Typical: 1054 nm, 50 J, < 1 ps, ~ 10^{19} W/cm^2 laser intensity pointing stability < 50 μm
- Optical probe beam at 1054/527 nm, 30/10 mJ, τ < 500 fs, ps to multi ns delay possible



Diagnostics:

- Kα imager, X-ray pin-hole cameras
- multiple X-ray and optical streak cameras, 200 fs resolution at 1:40 dynamic range, 5 ps at 1:1000
- various X-ray and optical spectrometers
- single photon counting CCD's
- 12 GHz digital scopes
- Thompson parabola
- HV supplies up to 20 kV
- IP and CR39 detectors
- EMI shielded instrumentation cabinets up to 120 dB

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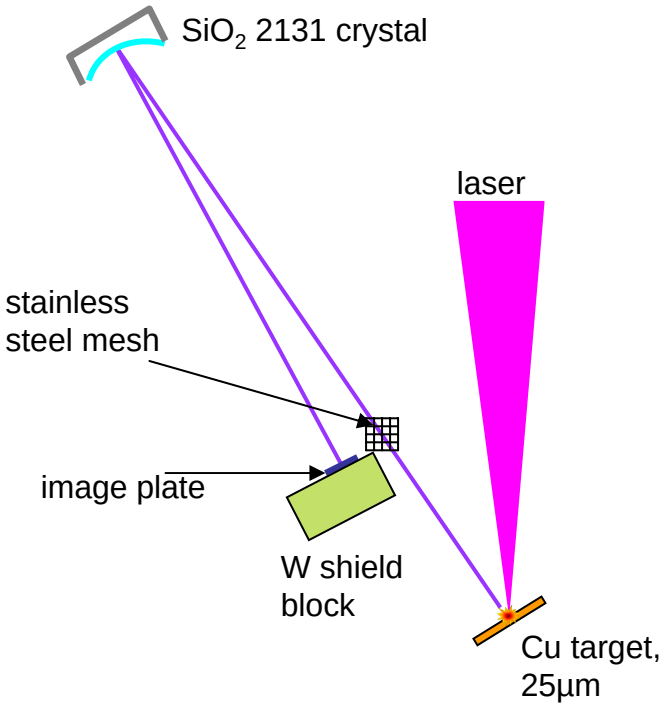
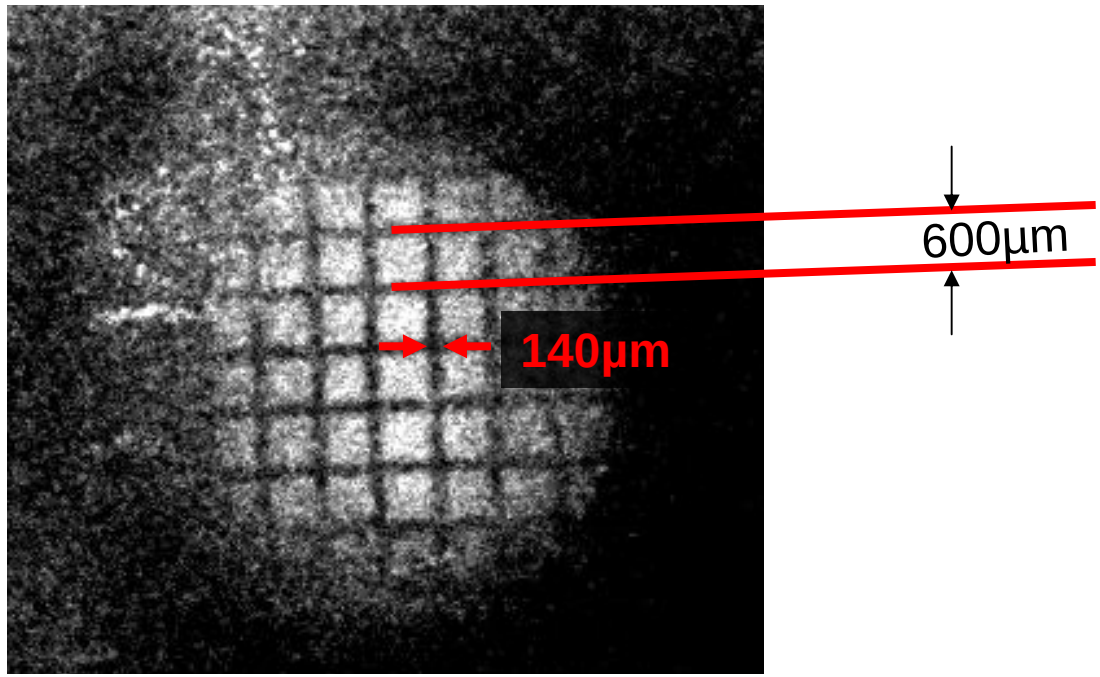
Cu Kα Radiography

1:1 Imaging at 8 keV





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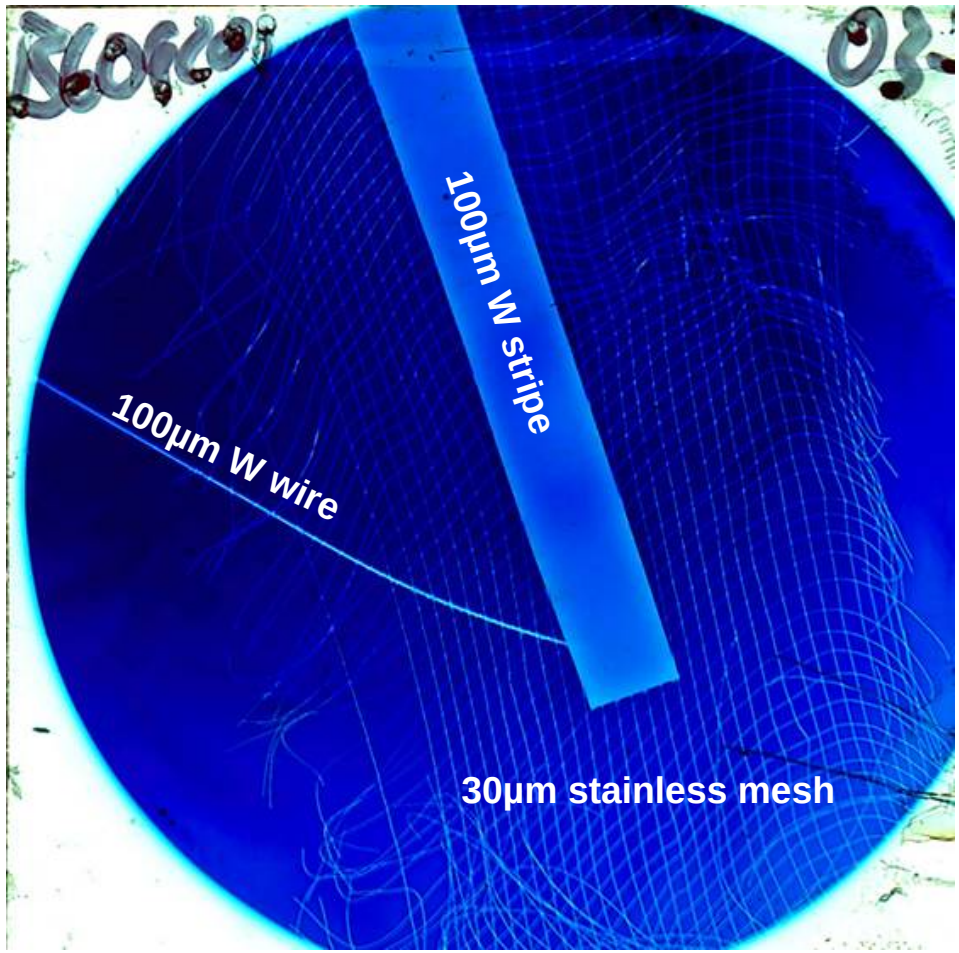
Proton Radiography

First Results



SHOT # B6092003
8 μm Cu target
Laser energy 31.5 J
Proton energy > 7MeV

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MLD Upgrades

Supported bandwidth: *>4 nm*

Pulsewidth: *~400 fs*

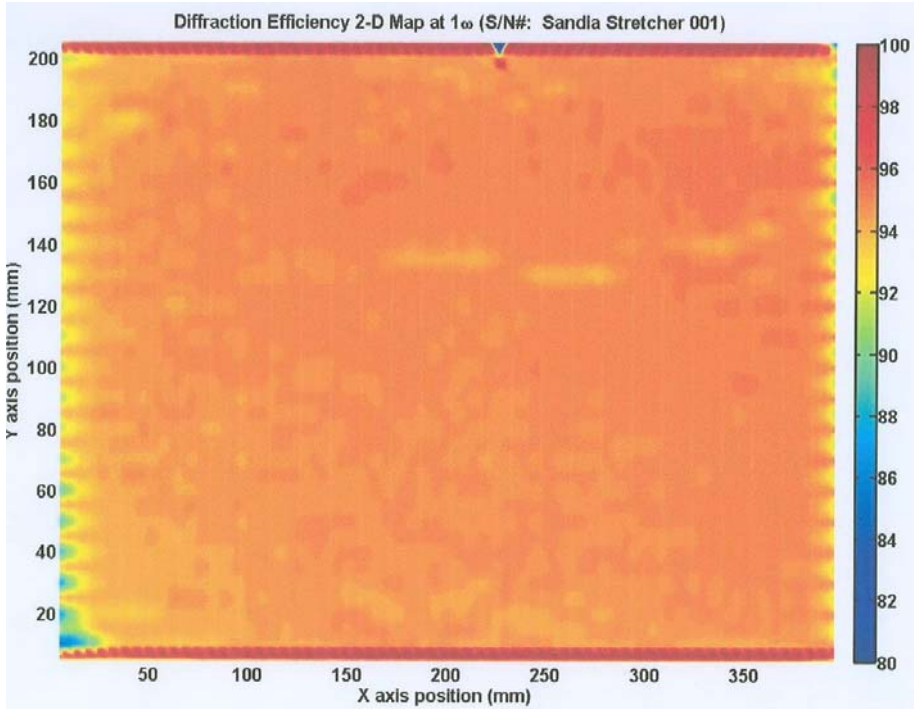
Beam Size: *ϕ = 14.5 cm*
(to allow 10 nm through JY compressor)

Beam Area: *165 cm^2*
(in a right hand cross-section)

238 cm^2
(projected onto grating)

Laser Energy : ~ 45 J (if gold at 0.2 J/cm^2)
~ 95 J (if gold at 0.4 J/cm^2)
~ 235 J (if MLD at 1.0 J/cm^2)

Maximum Peak Power: *~ 110 TW (gold at 0.2 J/cm^2)*
~ 235 TW (gold at 0.4 J/cm^2)
~ 595 TW (MLD at 1.0 J/cm^2)



1740 l/mm stretcher grating
from PGL with a wavefront of:

0.06 waves PV
0.007 waves RMS
measured at Littrow angle

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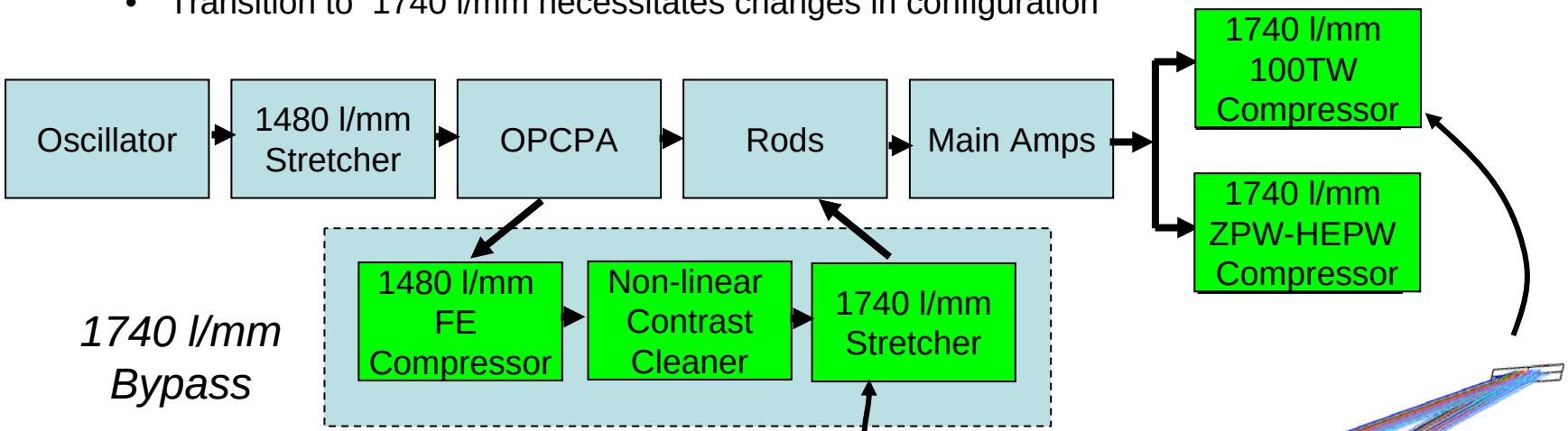
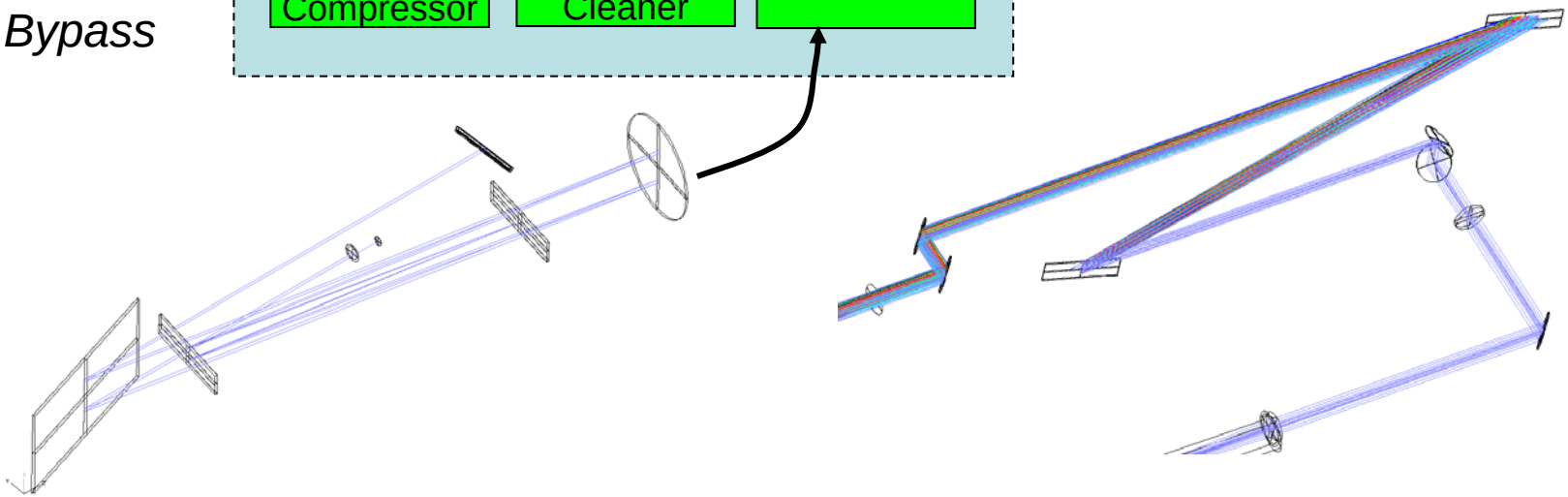
Future Modifications for 100TW

- MLD upgrade:
  - Pending ZPW completion and MLD delivery
  - Transition to 1740 l/mm necessitates changes in configuration





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The Petawatt Back-End

- Vacuum Compressor Vessel was delivered August 2006
- Three sections form vessel
  - Size: 13.56 × 4.36 × 4.36 m^3
  - Weight: 32.3 Tons
- Initial compression will use LLNL Nova gold gratings to operate in the 500J/500fs regime.
- Future upgrade to MLD will be necessary for HEPW operation.

Petawatt implementation will transport and expand the beam 3x to a 43cm diameter.

- 4600 m^3/h roughing + 3 ISO-K 500 Cryos allow: 1x10-5 Torr in 3 hours or 2x10-7 Torr in 15 hours

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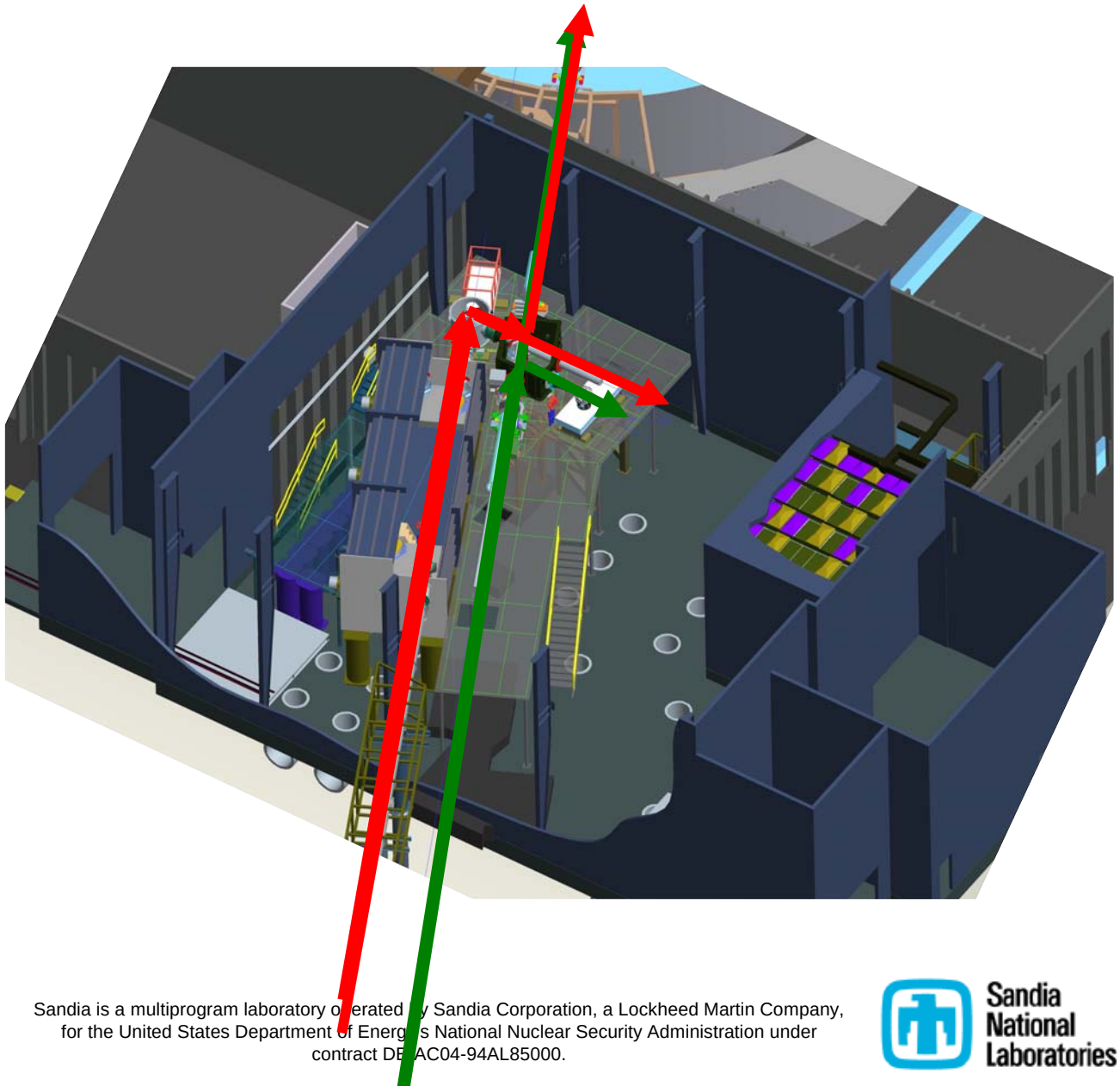
The Path Forward

- **Experimental Capabilities:**
  - **ZBL only**
  - **Z-PW only**
  - **ZBL and Z-PW**



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