SAND2008-0953C

The initial commissioning of Z-Petawatt

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Z Backlighter

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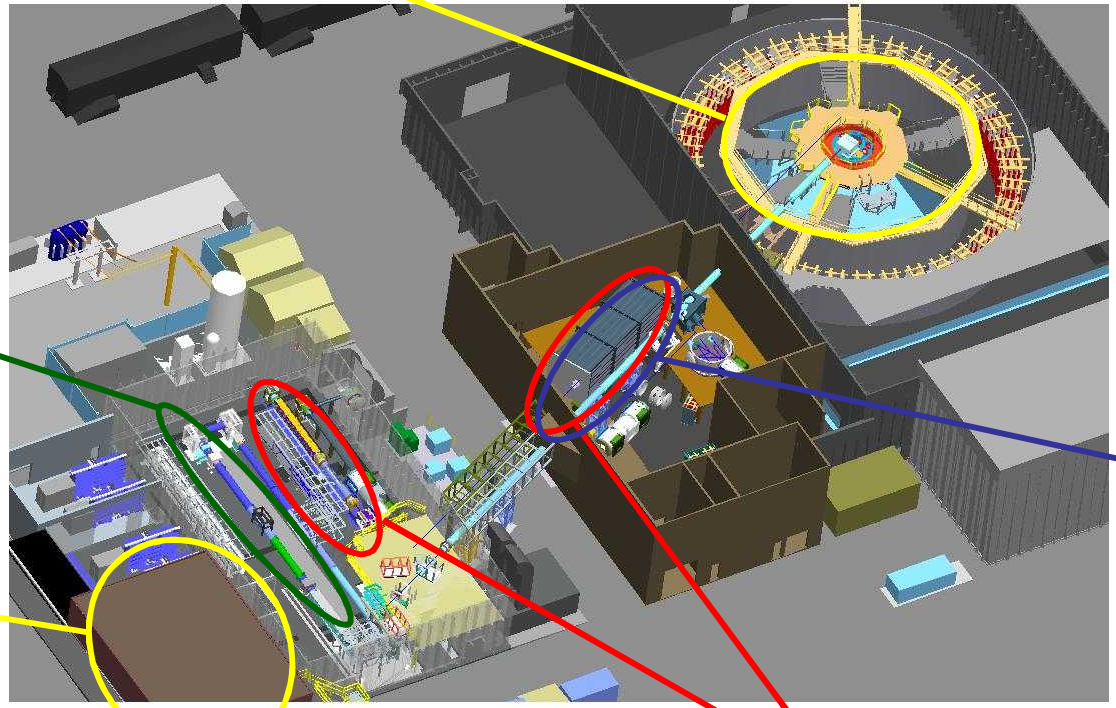
Facility Overview
("Buildings 983/986")



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Large Scale Coating Chamber

- Backlighting operations require a continuous supply of AR coated debris shields.
- To this end, we installed a 90” e-beam deposition coating chamber.
- Single-run capability: 3 at 94 cm optics
  1 at 1.5 m option
- Ion-assisted deposition (IAD) optional

- Recent coating efforts have focused on Z-Petawatt needs, including 94 cm truncated HR mirrors.

FY07 Optics	*30 cm*	*60 cm*	*94 cm*
Z-Beamlet	42 AR	4AR	
Z-Petawatt	6AR & 4HR	3AR	3HR

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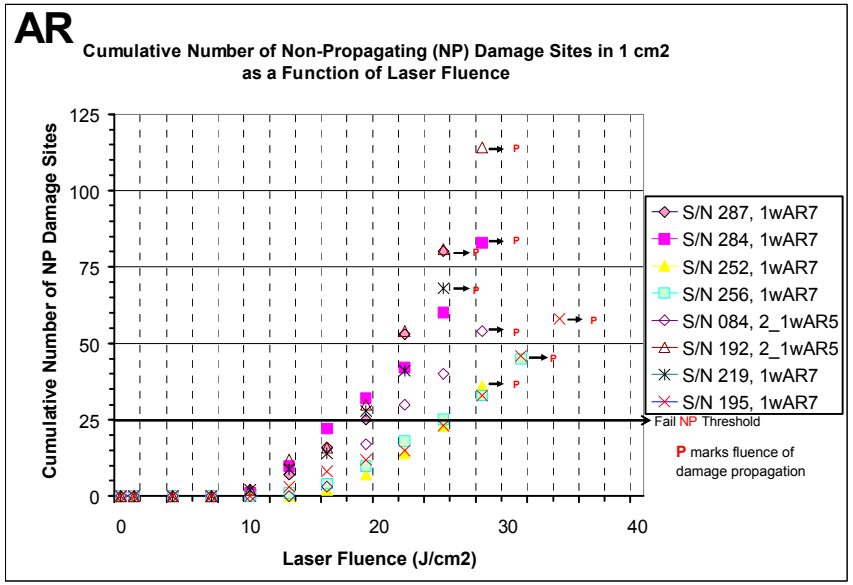

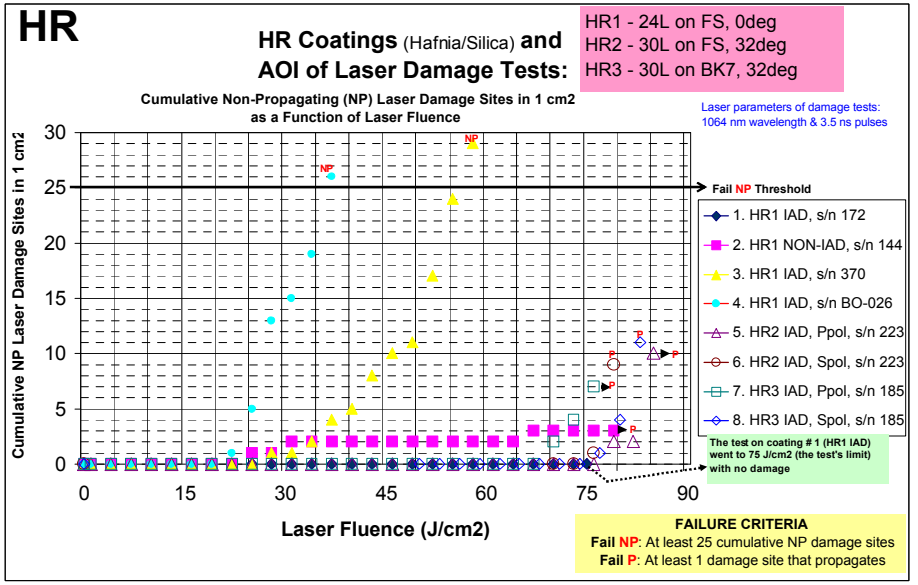

- Independent damage testing (SPICA) has shown good test results. Using a definition of 25 cumulated damage sites (non-propagating) gives thresholds:
  - In the range of 17-25 J/cm^2 for AR coatings
  - In the range of 75-85 J/cm^2 for HR coatings
- Successful application to both air and vacuum use environments.

* 1064nm, 3.5ns pulse, 1.06mm spot scanned to fill 1cm^2 with 2300 shots for each of 13 levels from 1-37 J/cm^2, NP sites are of size 15µm

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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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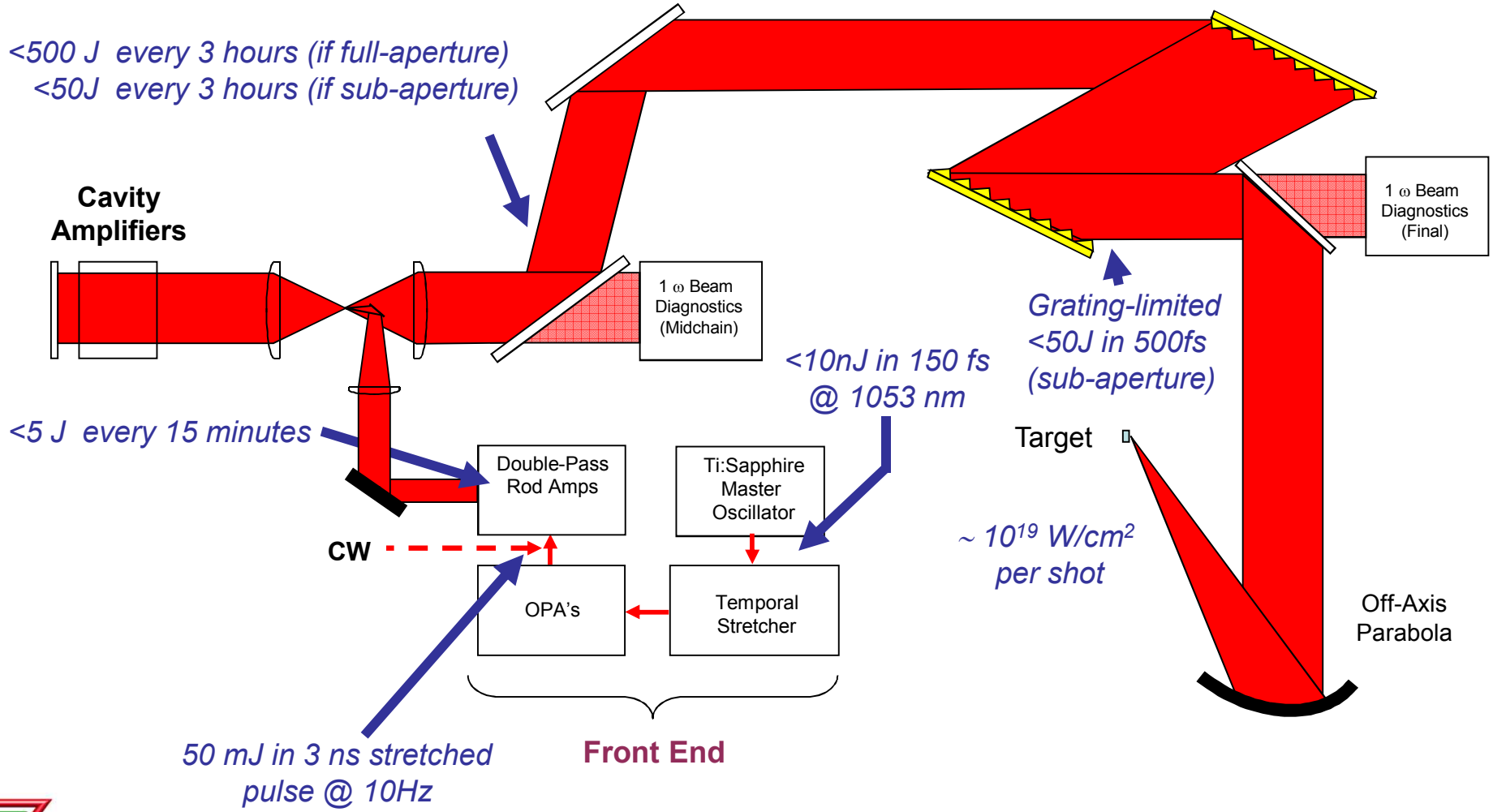
The 100TW/Petawatt System



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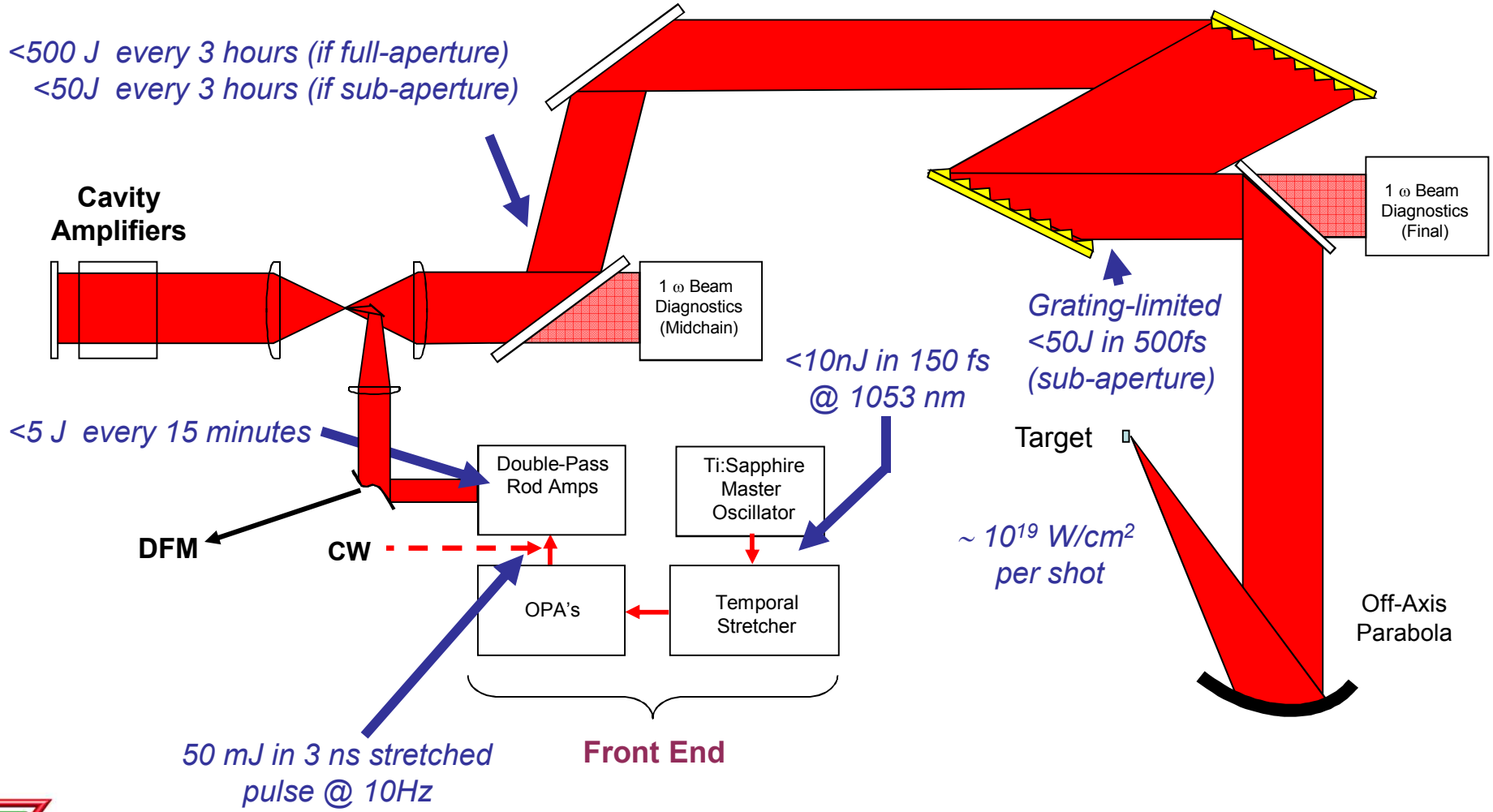

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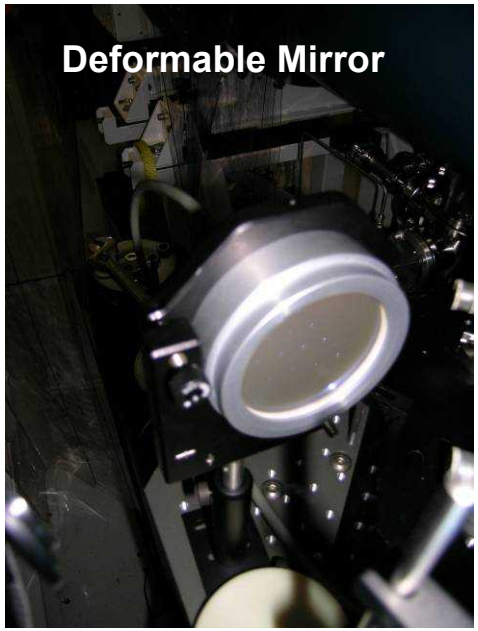
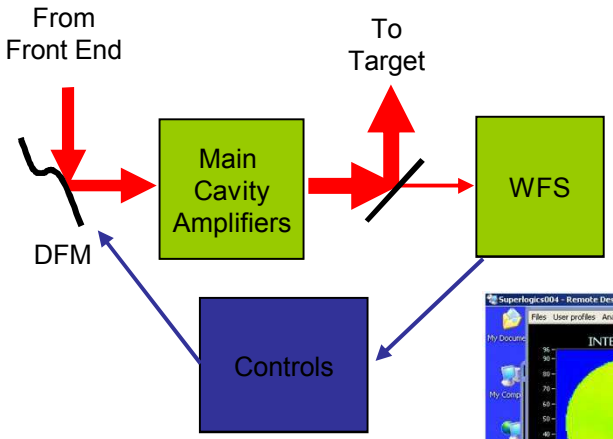
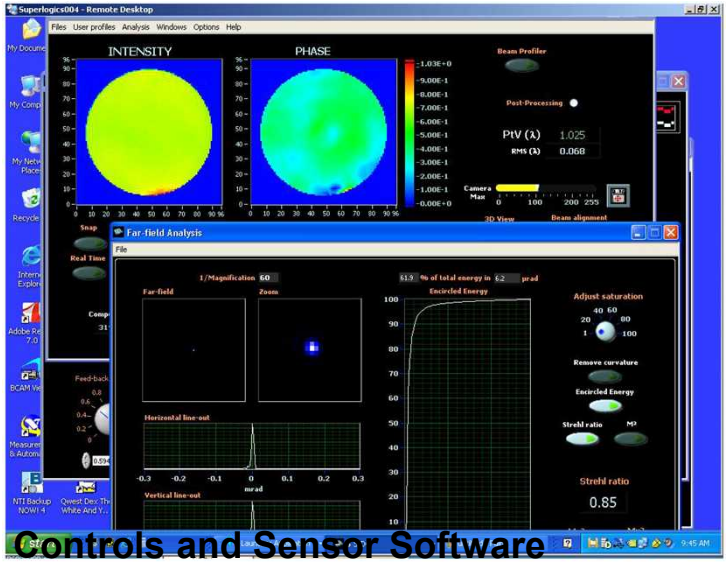
Adaptive Optics

- For higher order corrections, a commercial Phasics adaptive optics system has been installed in August 2007.





• This screen shot shows a compensated full system shot:
  PV: 1.03 waves
  RMS: 0.07 waves
  Strehl ratio: 0.85.



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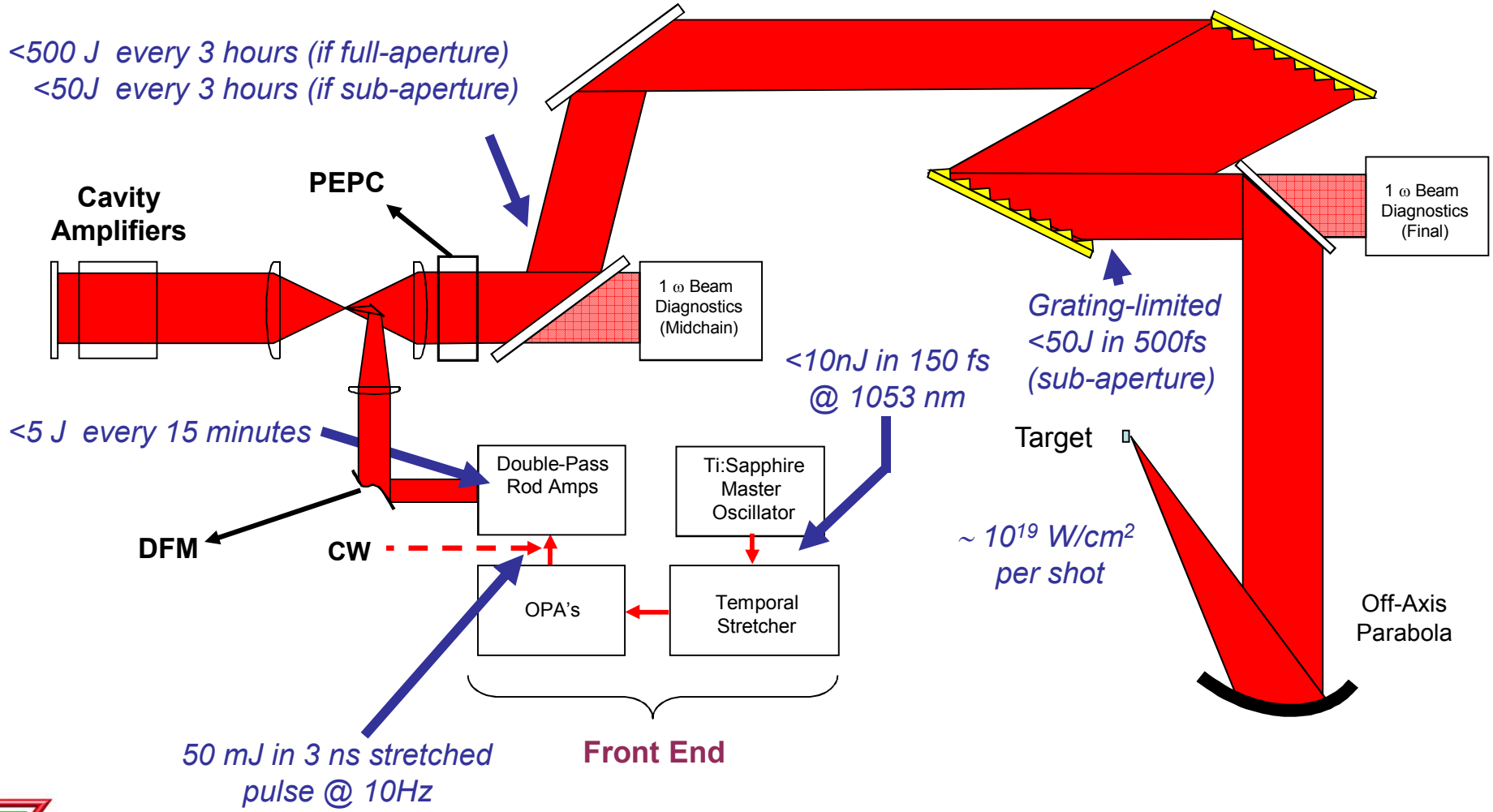

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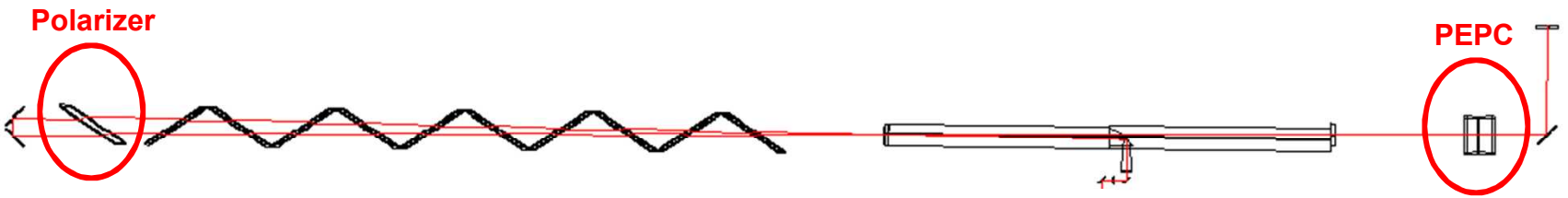
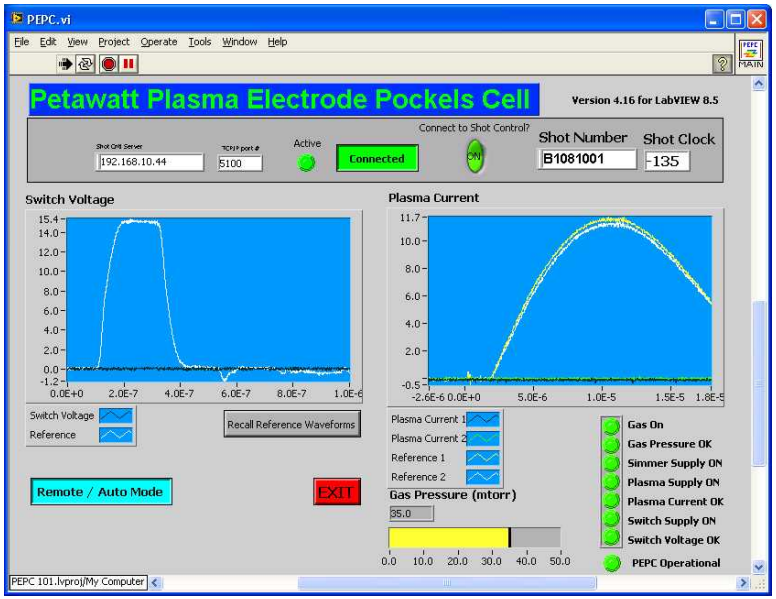
PEPC for Backreflection Isolation

- Initial tests on 100 TW system showed that target back reflection would cause laser damage at 1 PW level.

=> Installation of plasma electrode Pockels cell for isolation





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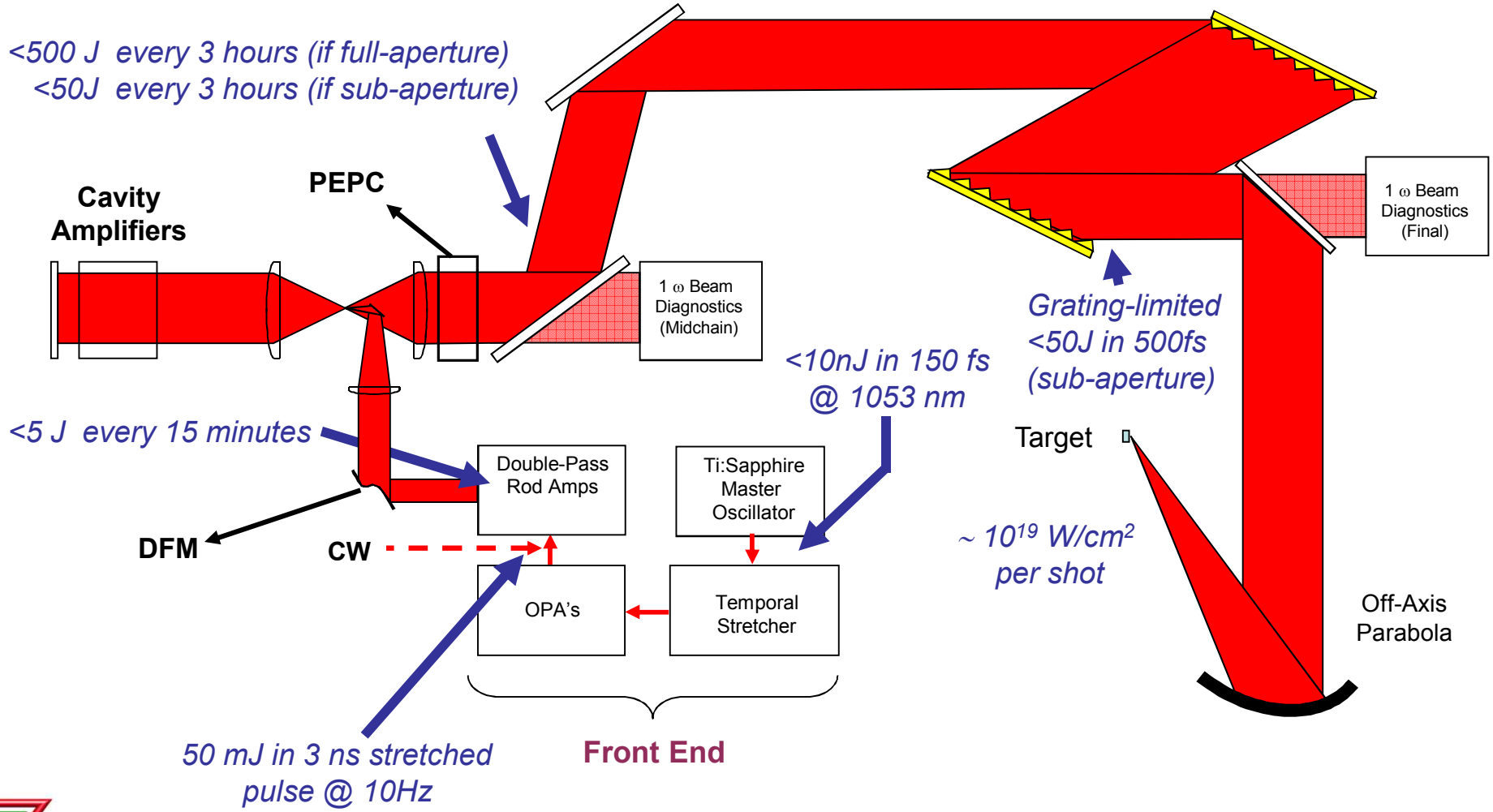

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Diverter and Periscope

• Optics and hardware installed and aligned.

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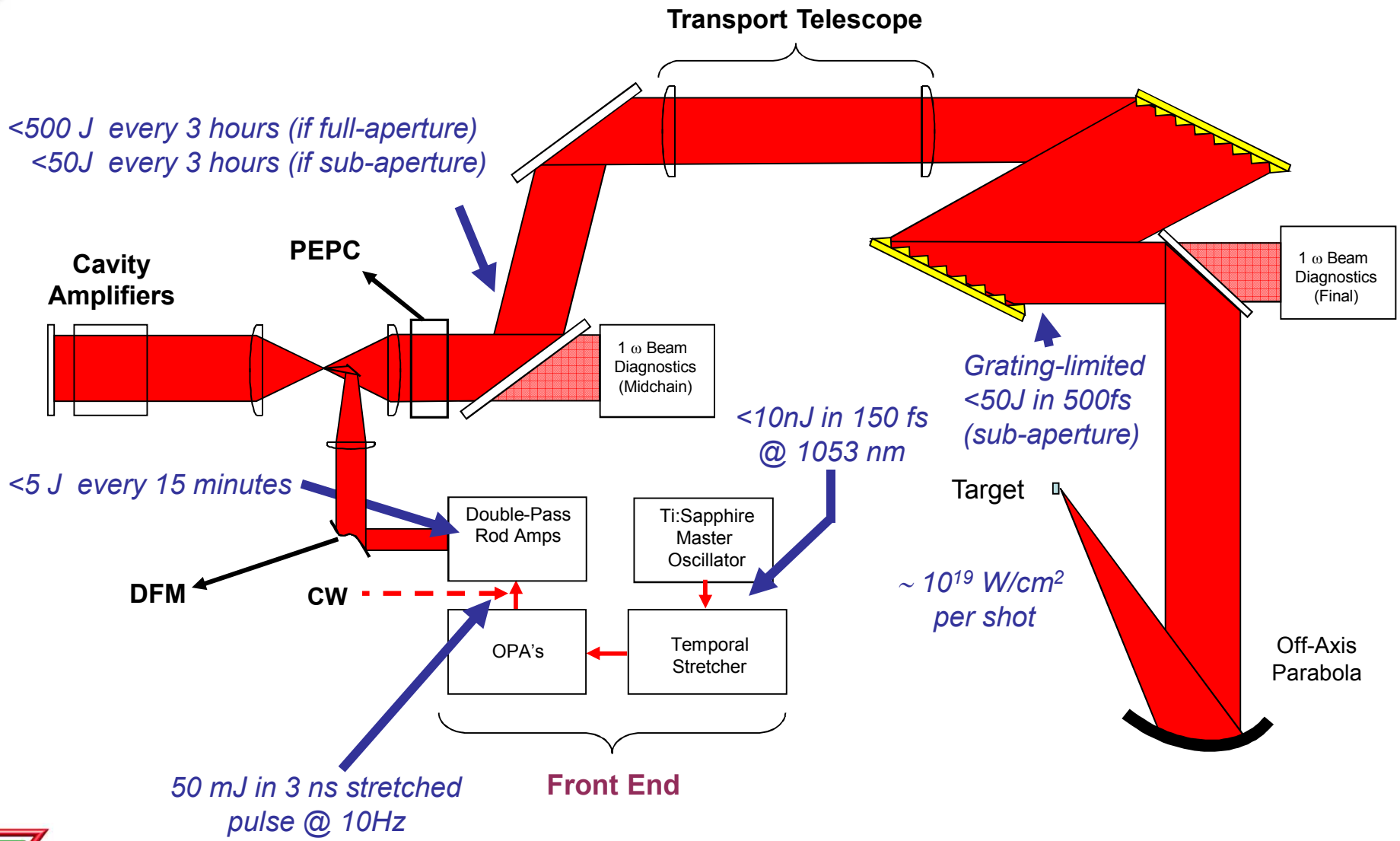

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Transport Telescope

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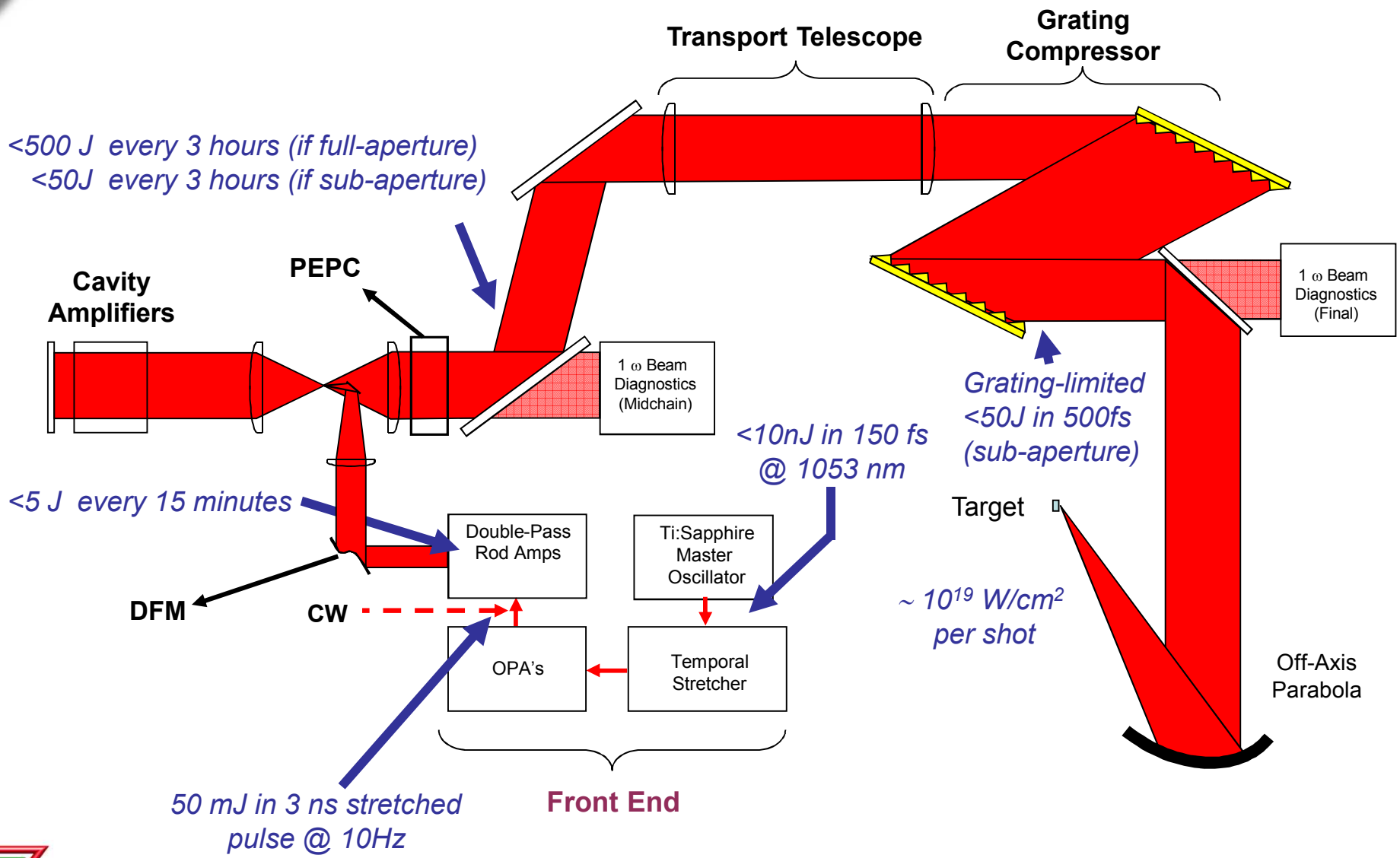

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Petawatt Compressor Vessel

Three sections form vessel:
each 4.4 x 4.4 x 4.4 m^3
- 2 Tier design
- weight: 43 tons
- 4600m^3/h roughing + 3 ISO 500

Cryos allow:
$1x10^{-5}$ Torr in 3 hours or
$2x10^{-7}$ Torr in 15 hours

Uncompressed energy: 420 J

Initial temporal compression: < 2ps
Compressed energy: 125 J

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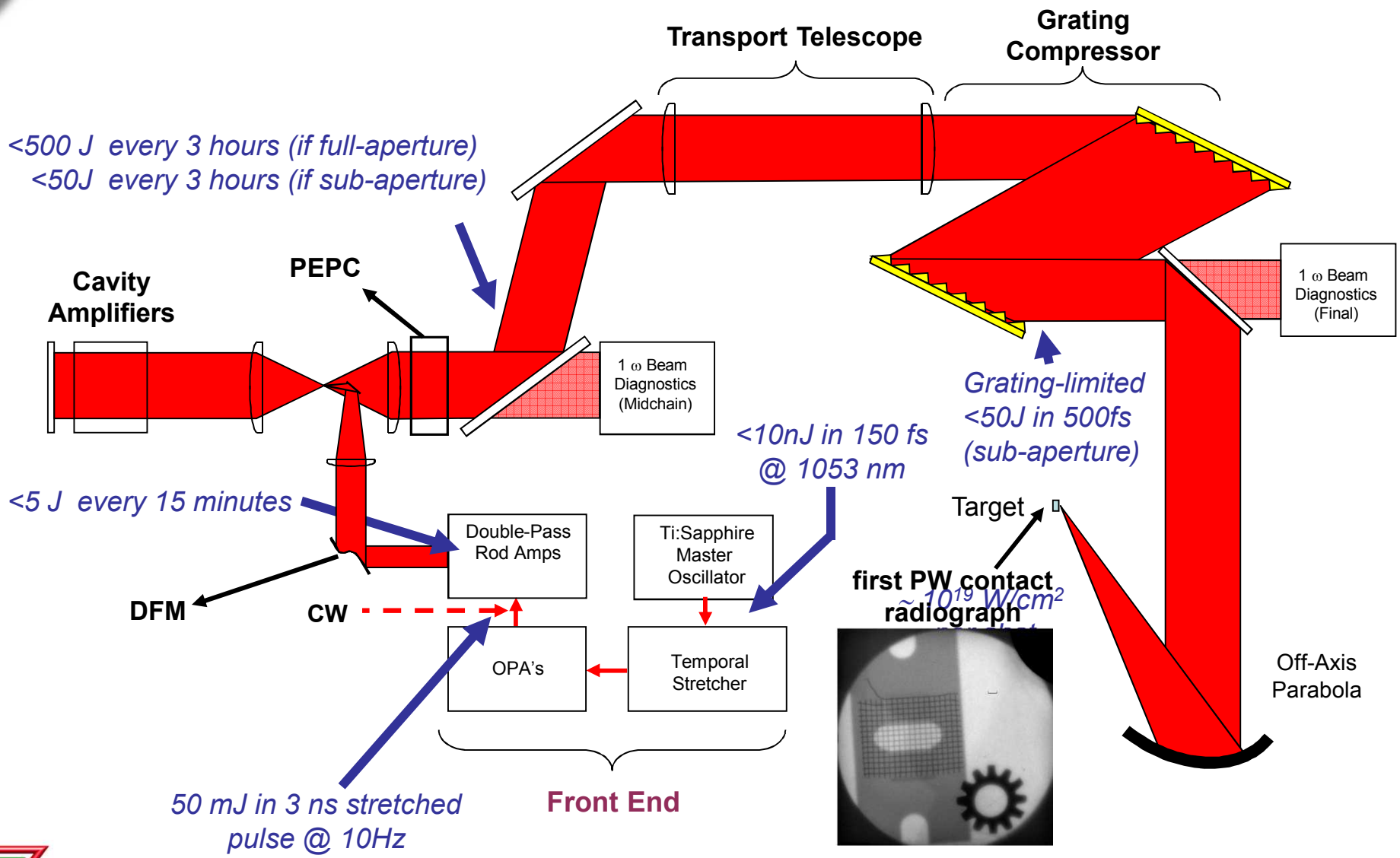

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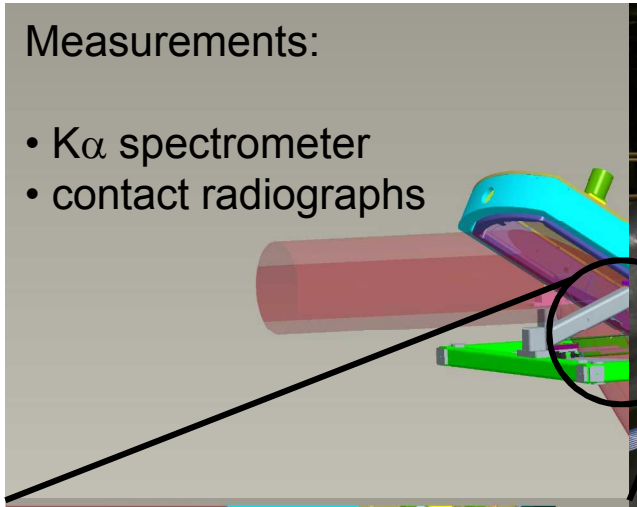
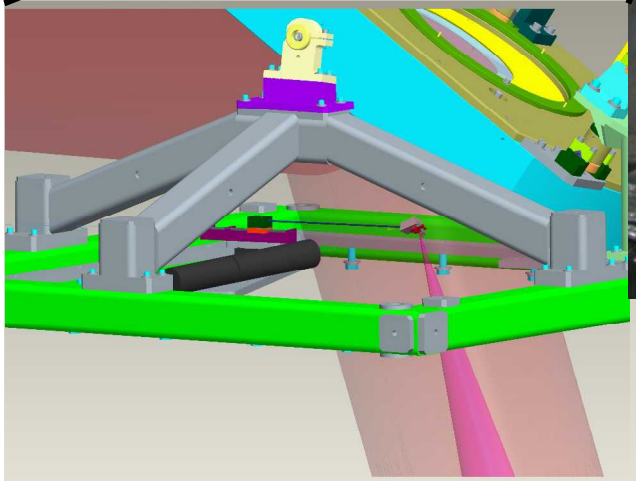
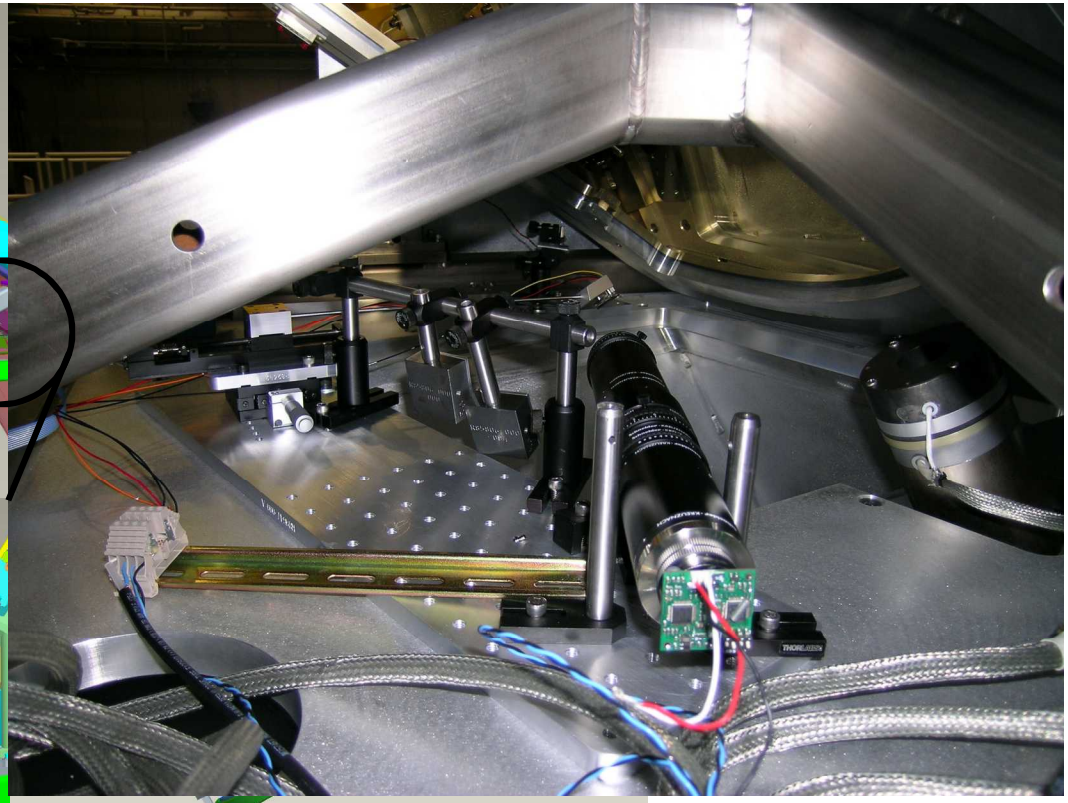
Commissioning Shot Setup

Measurements:

- Kα spectrometer
- contact radiographs







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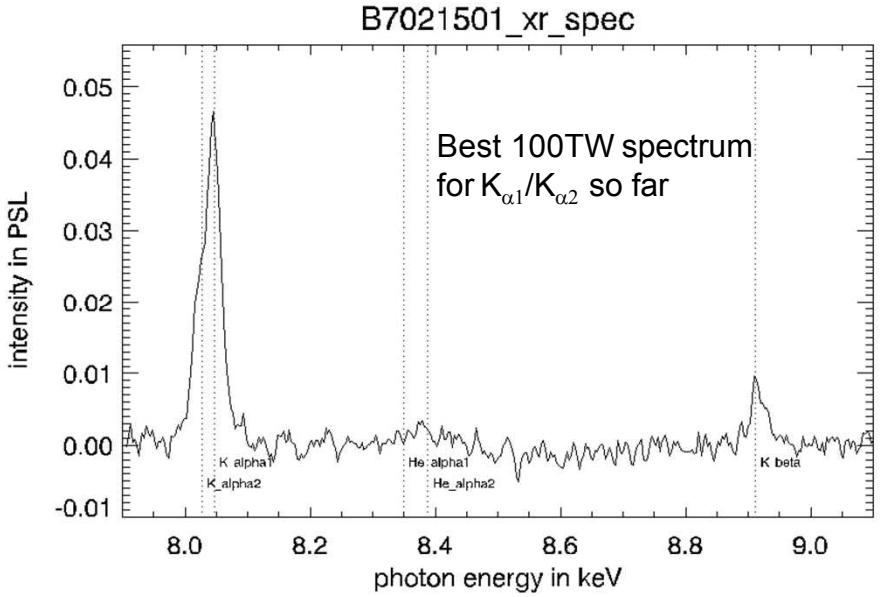
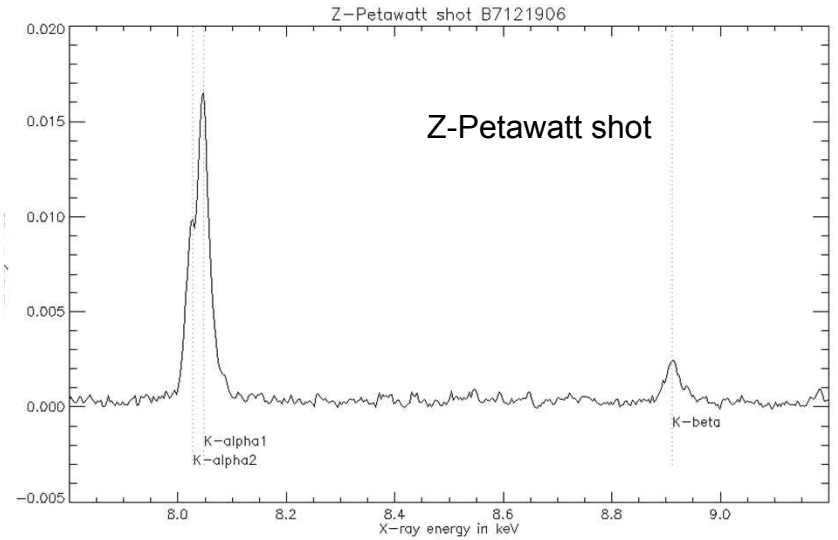
1st Z-Petawatt Shot (Spectrum)





- Intensities don't scale (different scanning parameters).
- Signal-to-noise ratio for the Z-Petawatt shot is the best we have ever achieved for K_α measurements.
- Very nice resolution/separation of $K_{\alpha1}/K_{\alpha2}$ doublet.

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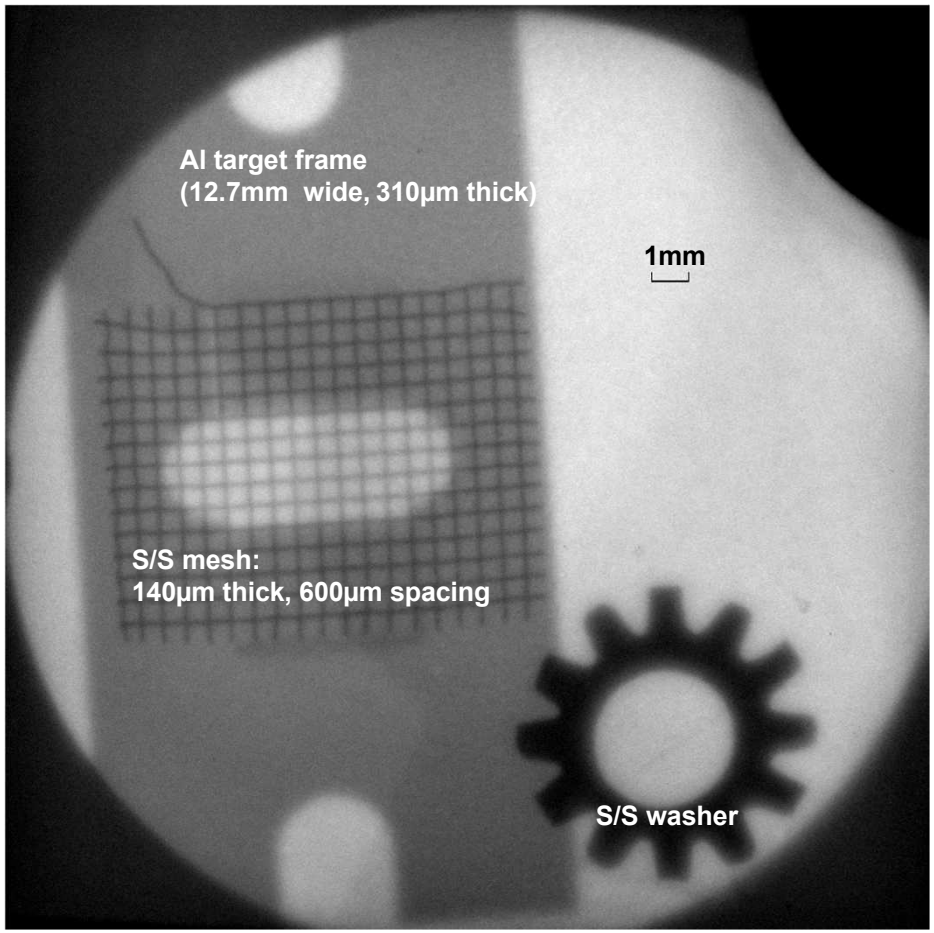
1st Z-Petawatt Shot (Radiograph)



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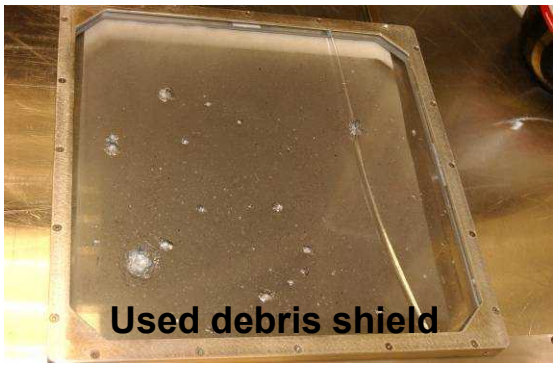
PW FOA Debris

• Debris is generated from laser target interactions (minor) and z-pinch (major) sources.
  • Vapor debris <25km/s
  • Particulate debris <1km/s

• Terawatt/nanosecond scale backlighting deals debris via debris shields (30X30X1cm^3)


Used debris shield

• Petawatt/picosecond scale backlighting must deal with debris differently due to B-integral effects:
  • Thin (2.7 μm) polymer film shields (passive)
  • Intelligent optics enclosure design
  • Fast debris shutters (active)

Target s
• Forces c
optics to r
• Possibly
large debr

bris

n

bris

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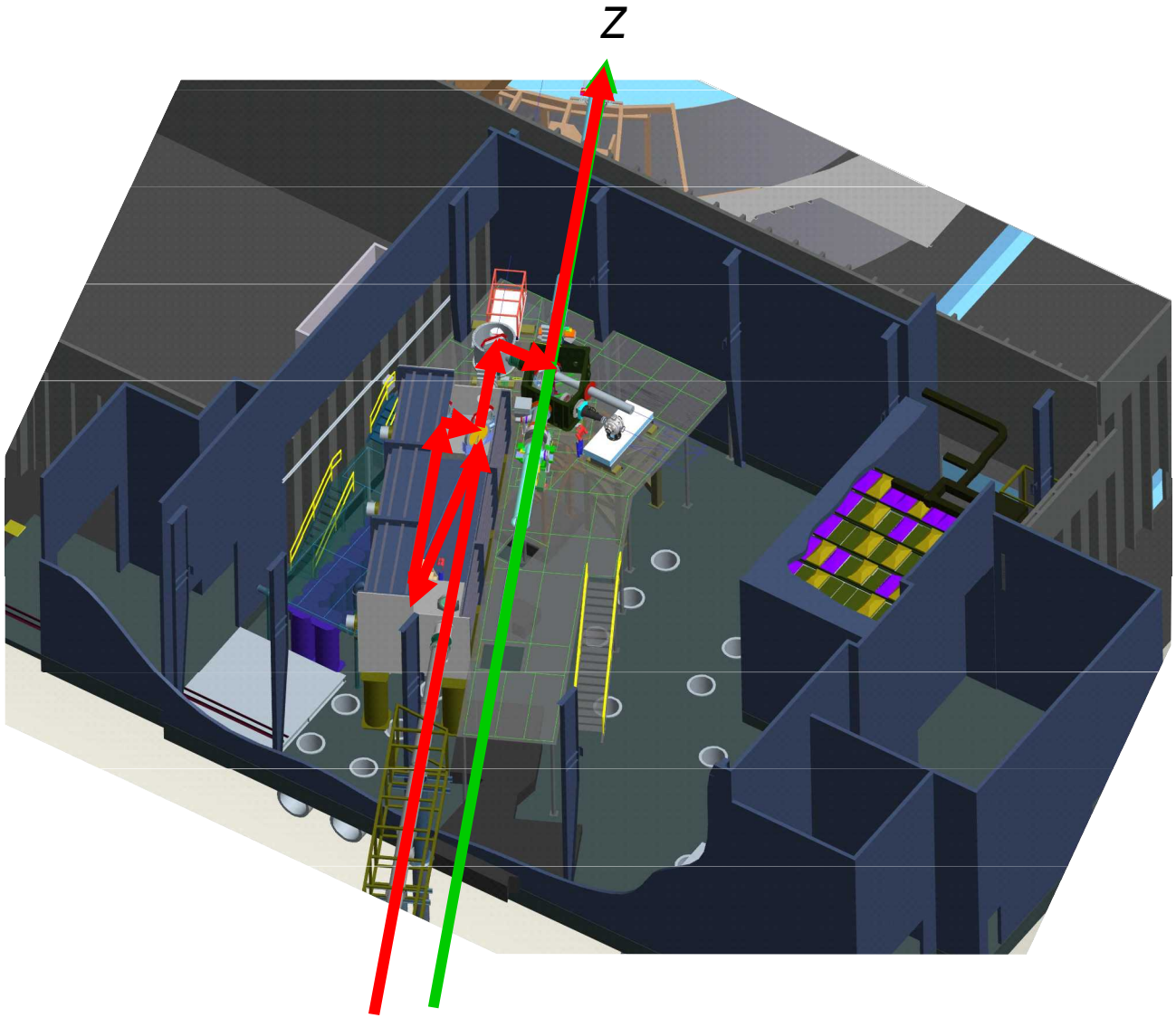
Experimental Capabilities with Z

- **ZBL only**
- **Z-PW only**
- **ZBL and Z-PW**



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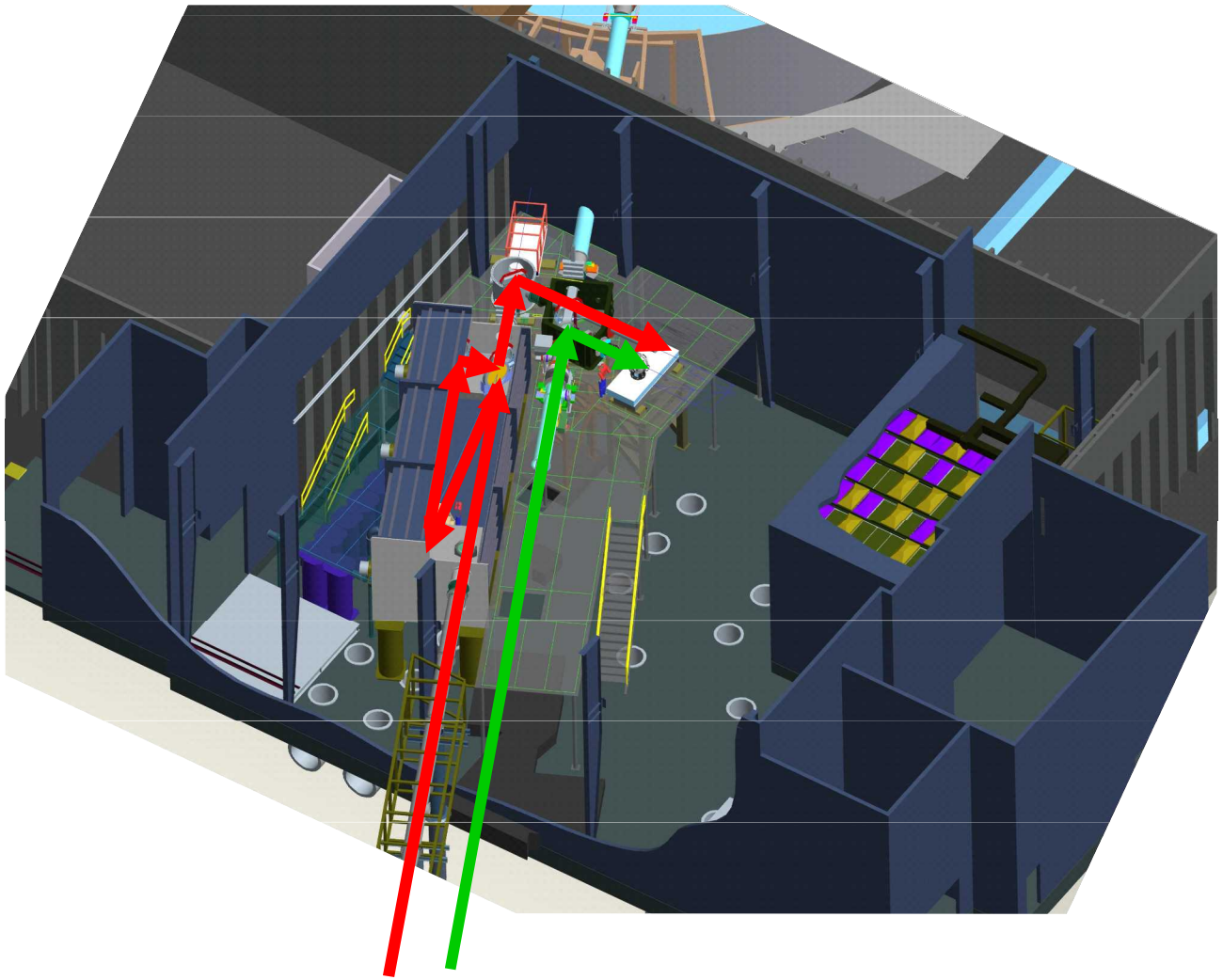
Stand-alone Experimental Capabilities

- **ZBL only**
- **Z-PW only**
- **ZBL and Z-PW**



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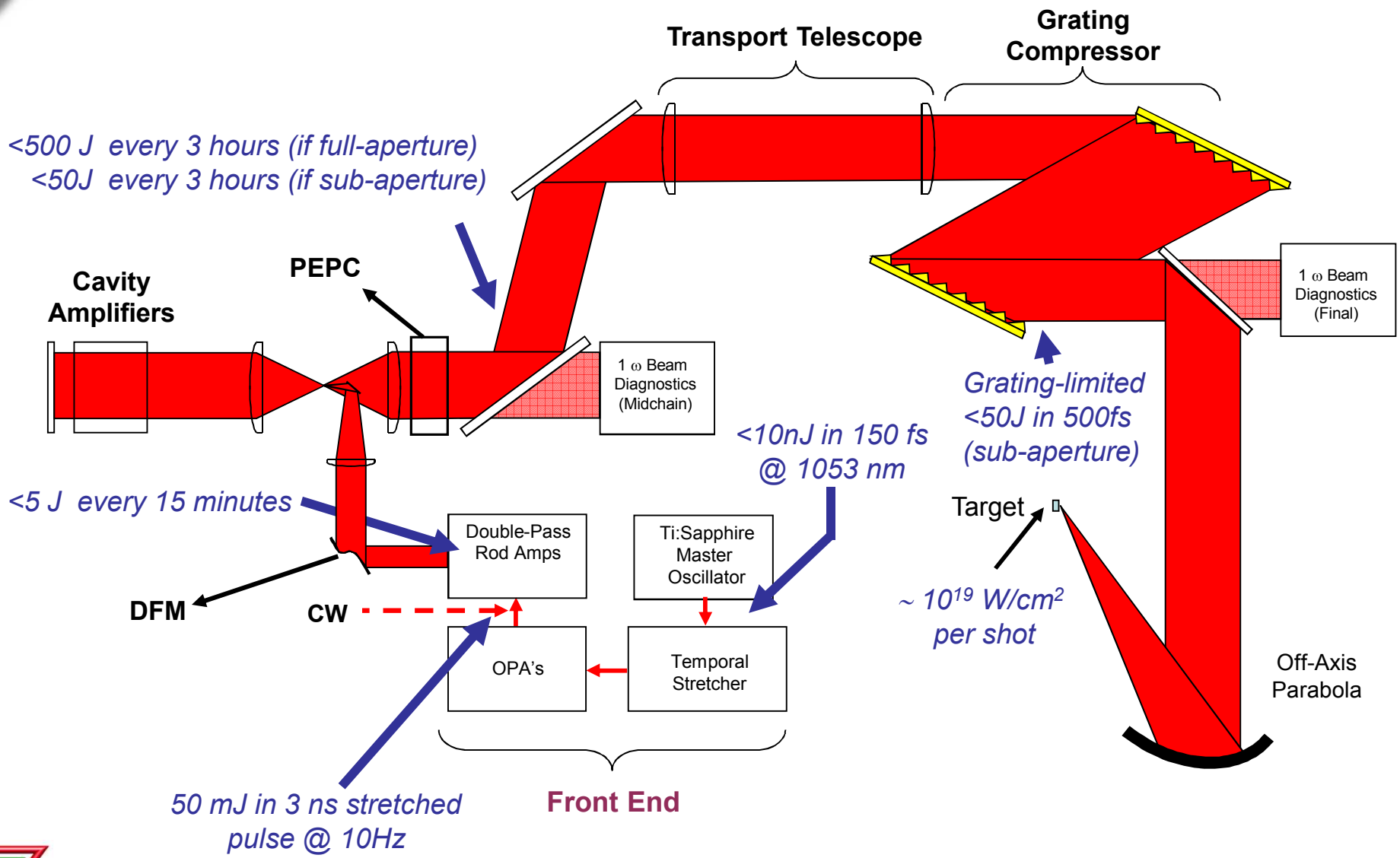
The 100TW/Petawatt System



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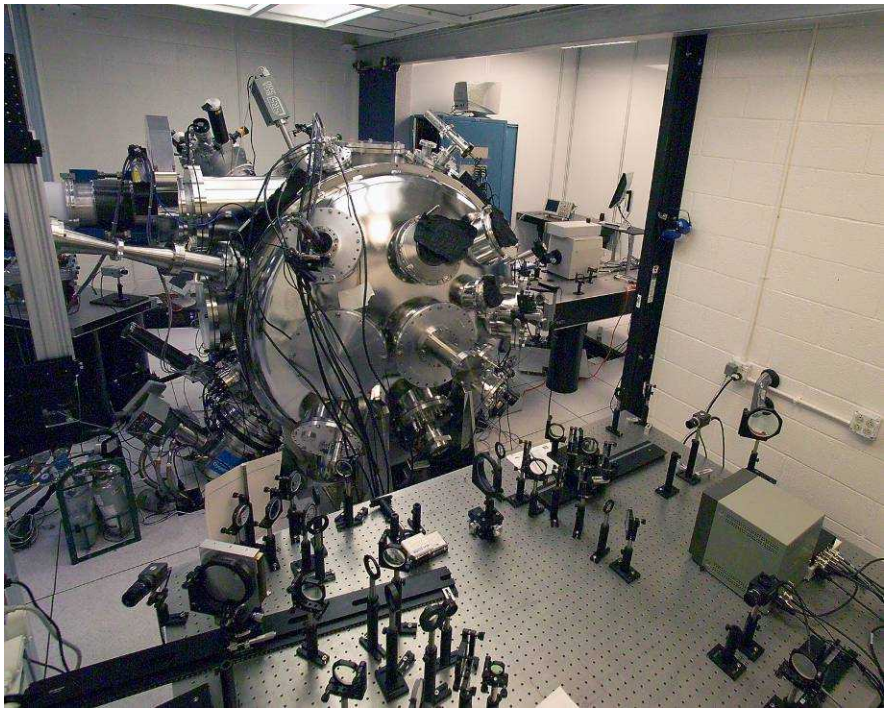
100TW Target Area

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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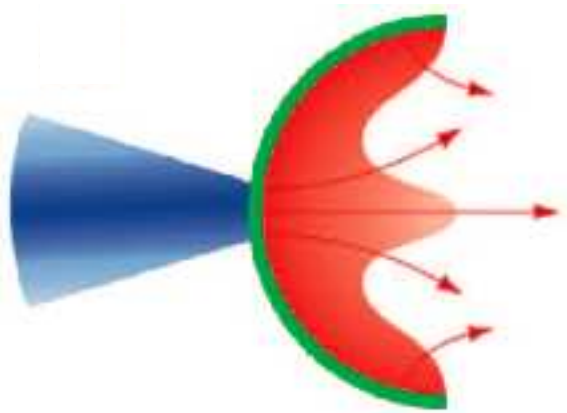
Proton Focusing

Applications:

- Use proton beam on secondary target to increase x-ray yields for backlighting
- Possible candidate for FI applications
- Focused proton beam as an initial stage for particle acceleration

Experiments:

- Ballistic focusing in which focusing is achieved through target geometry (e.g. Gaussian)
- External magnetic fields in which protons are focused through quadrupoles



Collaboration with: Marius Schollmeier, Jörg Schütrumpf, Markus Roth (TUD), Kirk Flippo, Manual Hegelich, Sandrine Gaillard (LANL), Stefan Becker, Florian Grüner, Dieter Habs (MPQ/LMU)

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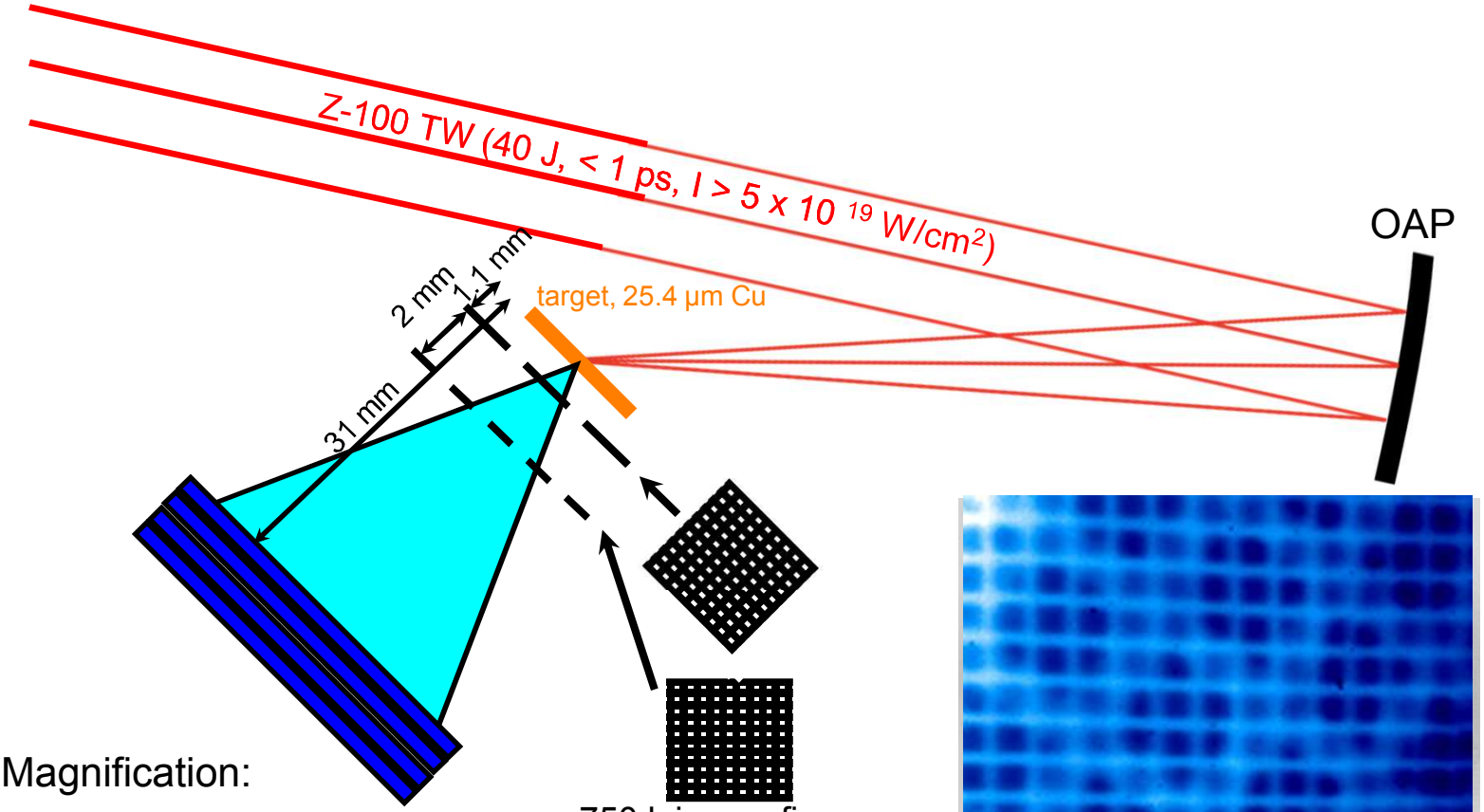
Ballistic Proton Focusing Diagnostic



Magnification:

12x for small pattern
45x for large pattern

750 lpi superfine mesh:

wire distance: 33.9 μm
wire thickness: 8.6 μm

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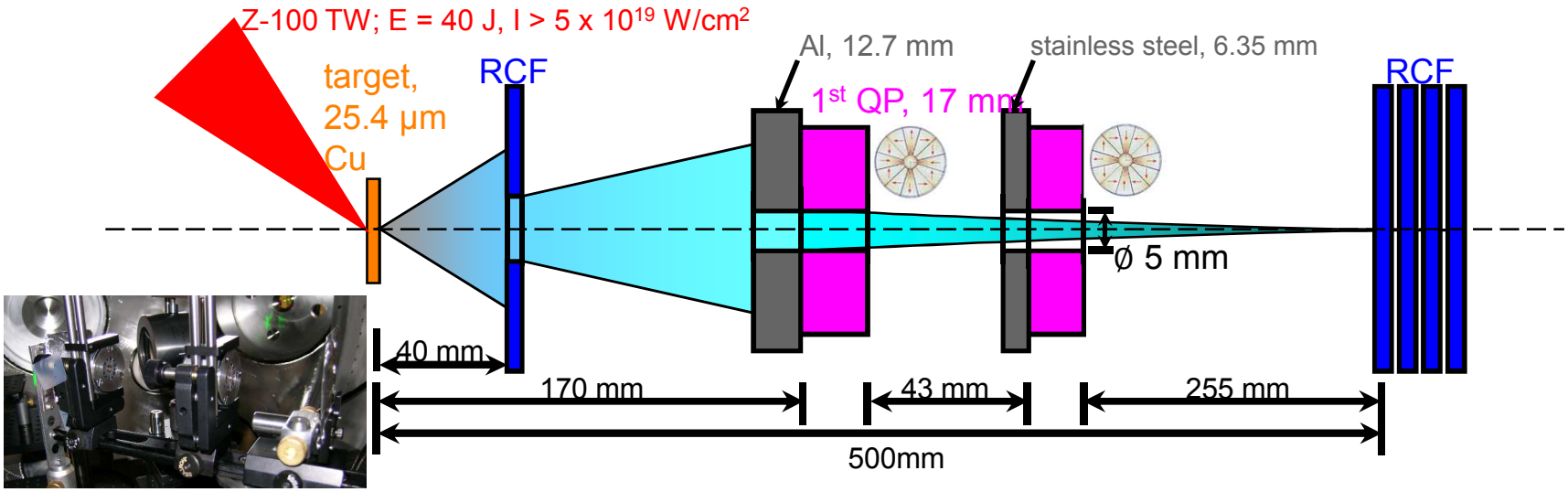
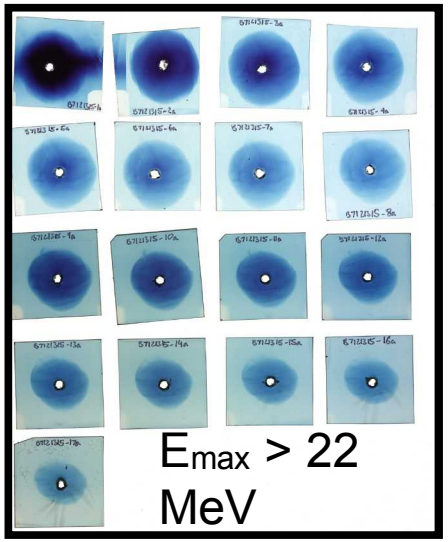
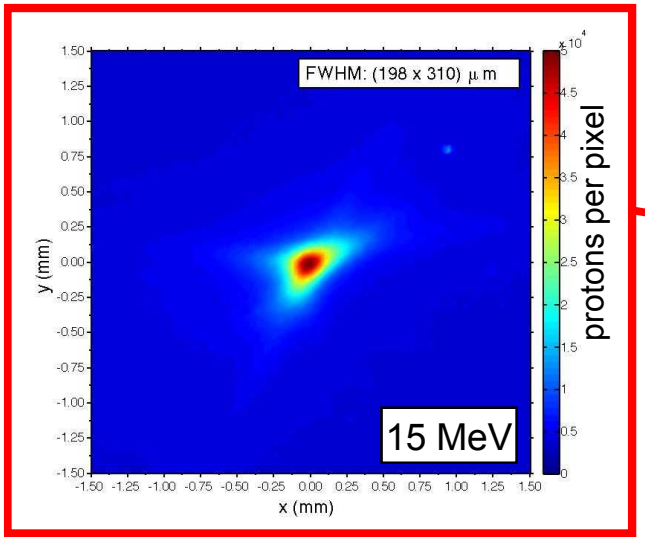
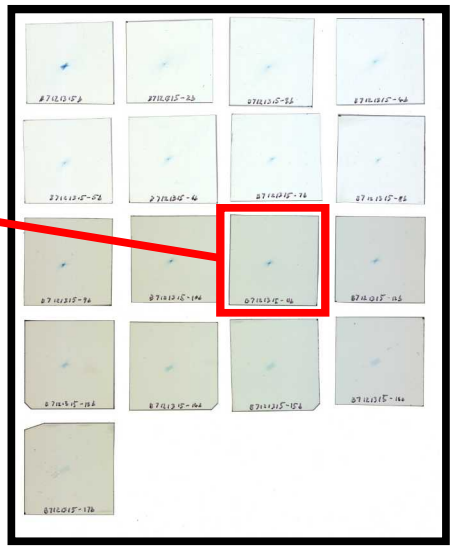
Quadrupole Focusing Experiments









Conclusion/Future Upgrades

- Every component of the PW system has been exercised and the commissioning shot last year demonstrated integrated system functionality.
- New PW FOA needs to be assembled and installed for ZPW on Z.
- Several subsystems need to be optimized, e.g.: PEPC, DFM, laser diagnostics
- Dichroic mirror will enable ZBL/ZPW on same shot; focusing needs to be addressed
- PW target chamber in Target Bay will allow ZBL/ZPW experiments (planned FY08/09)
- Upgrade to MLD gratings (1.2 m x 0.4 m) will safely allow: 4.2 kJ @ 10 ps
  94 cm x 40 cm gratings already demonstrated at Osaka, 60 cm x 20 cm for testing in house 1.4 kJ @ 600 fs
- Main cavity redesign to full aperture 4-pass configuration will allow to extract up to 5 kJ long pulse; cavity lenses and transport telescope lenses are on order

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