Orion – Overview and Progress Update

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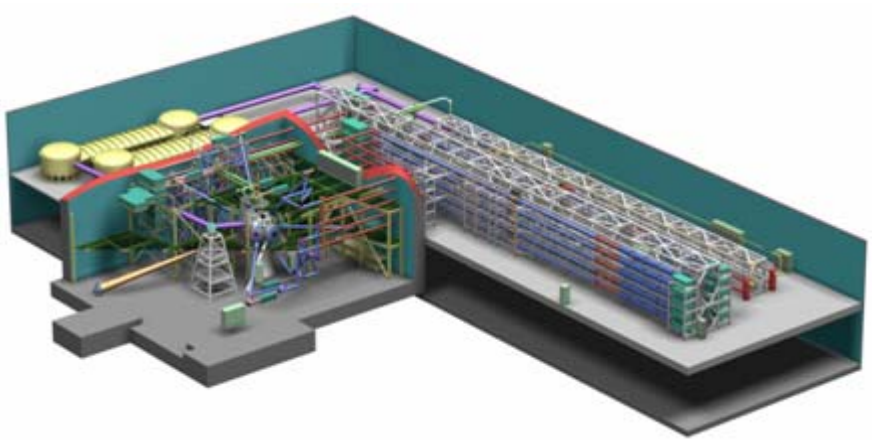
Introduction

Orion is designed as an entirely new laser facility for AWE for studying high energy density physics.

Orion combines ten laser beams operating in the nanosecond regime with two operating below 1 picosecond.



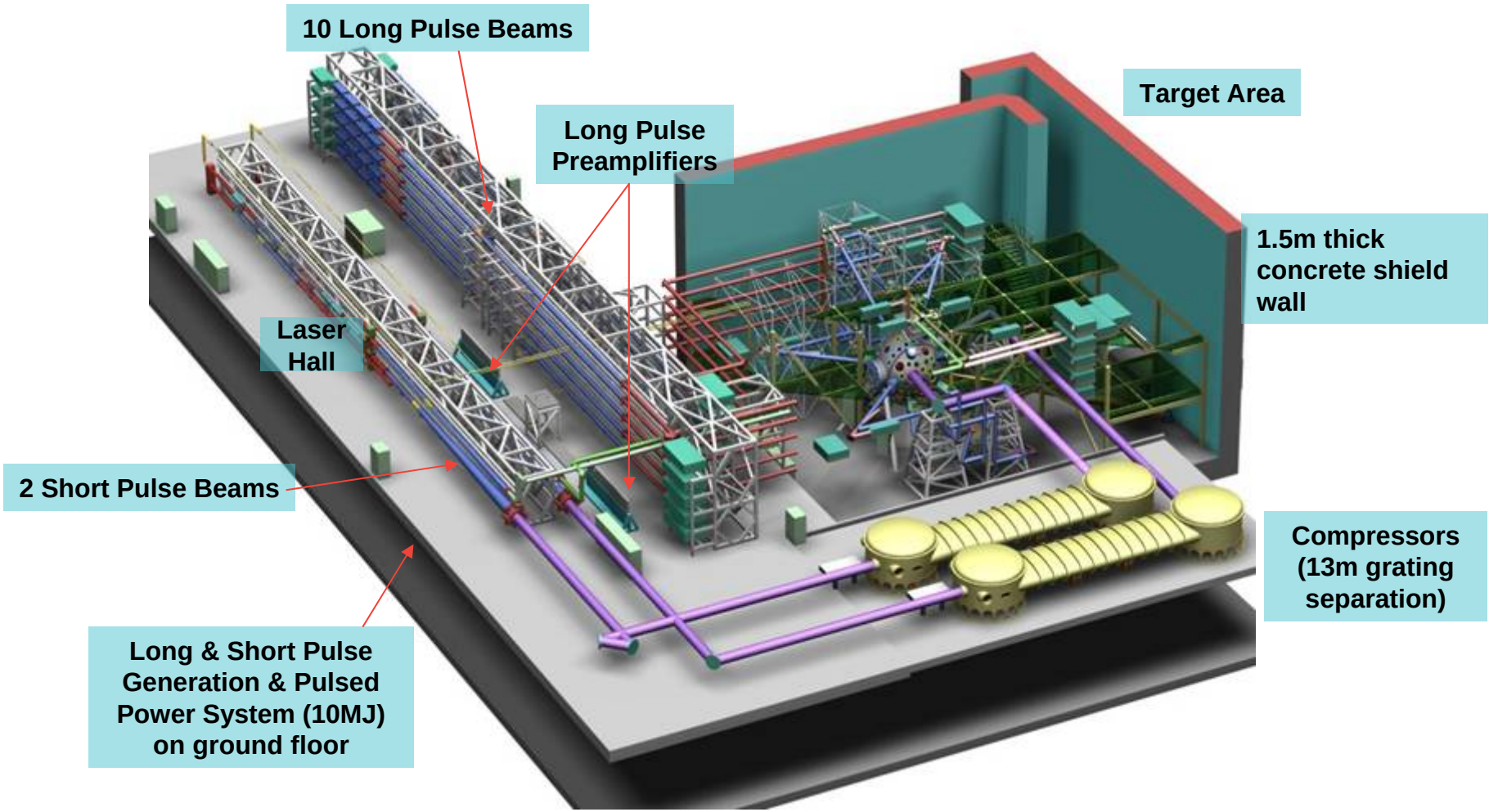
LP performance:
500J per beam @ 351nm in 1ns pulse
90% of energy in 100um spot

SP performance:
500J per beam @ 1054nm in 0.5ps pulse
Near-diffraction limited f/3 focussing
$>10^{21}Wcm^{-2}$ per beam

Technical Strategy

- Orion's 10 long pulse (ns) beams can be used for compression
- 2 short pulse (ps) beams can be used for heating and/or backlighting
- The 2 short pulse beams can also be converted to provide additional ns-duration pulses
- Based on existing LP & SP beamline architectures, Orion will deliver novel scientific opportunities
- The Orion contract includes a substantial inventory of target diagnostics to ensure that the facility is scientifically productive at start-up

Layout

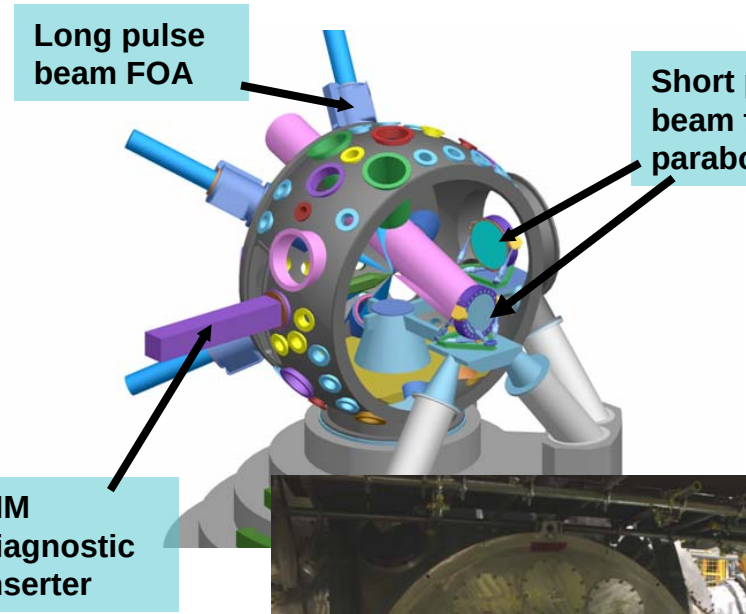

10 Long Pulse Beams
Target Area
Long Pulse Preamplifiers
1.5m thick concrete shield wall
Laser Hall
2 Short Pulse Beams
Compressors (13m grating separation)
Long & Short Pulse Generation & Pulsed Power System (10MJ) on ground floor

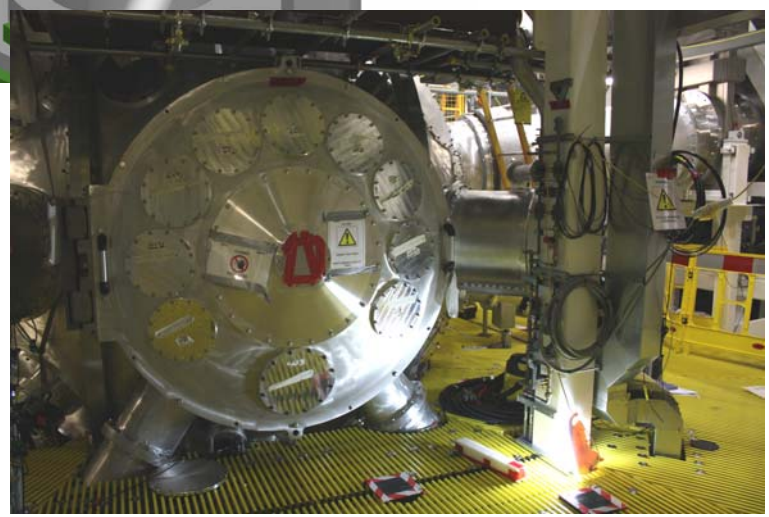
Laser Hall

Compressor hall

Target Hall

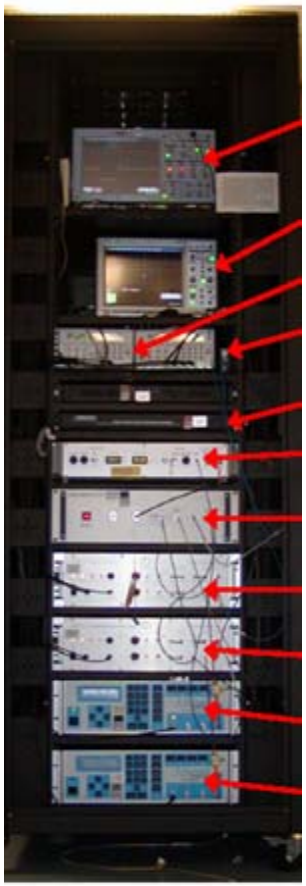
Orion Target Chamber



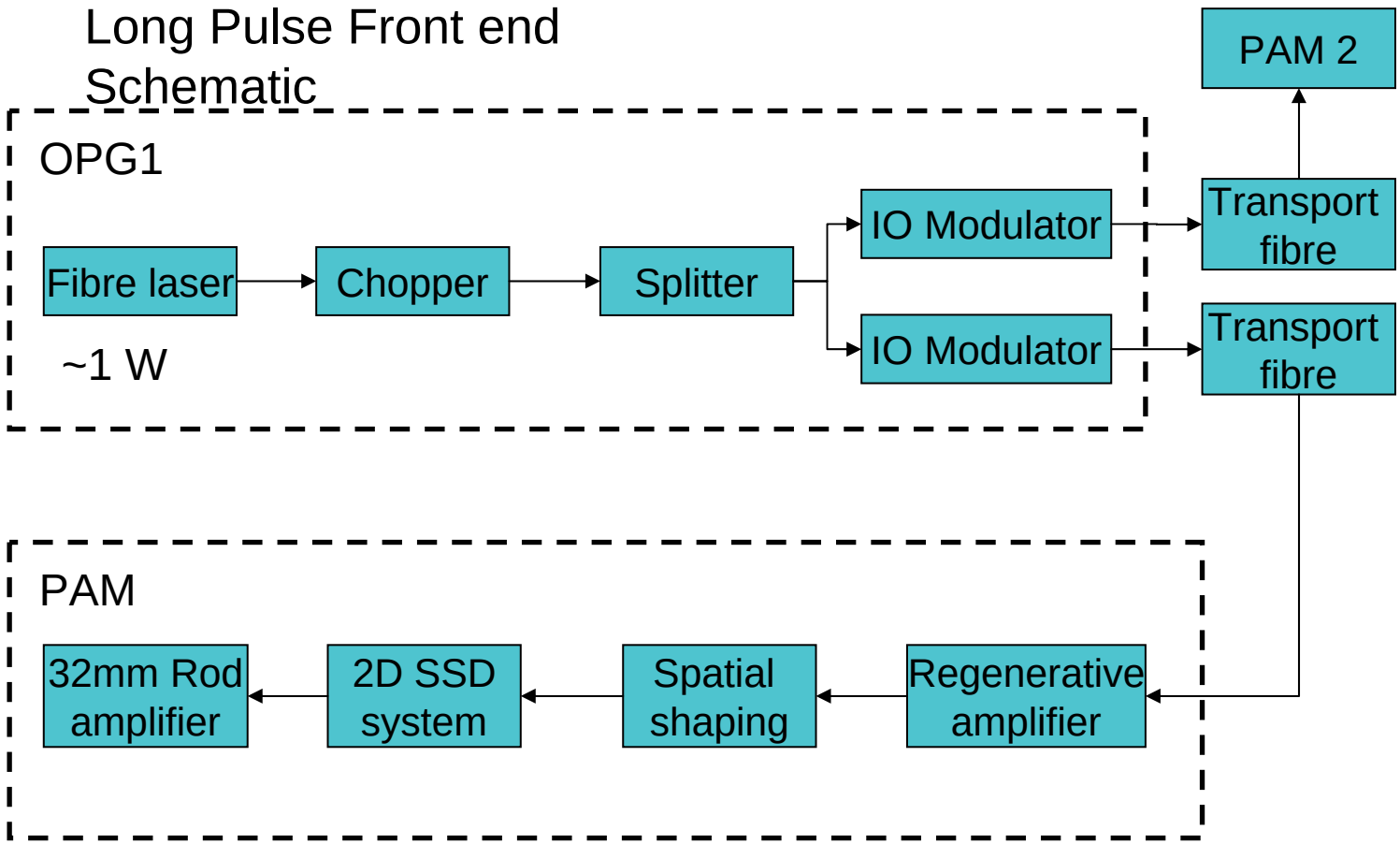


Long pulse beams

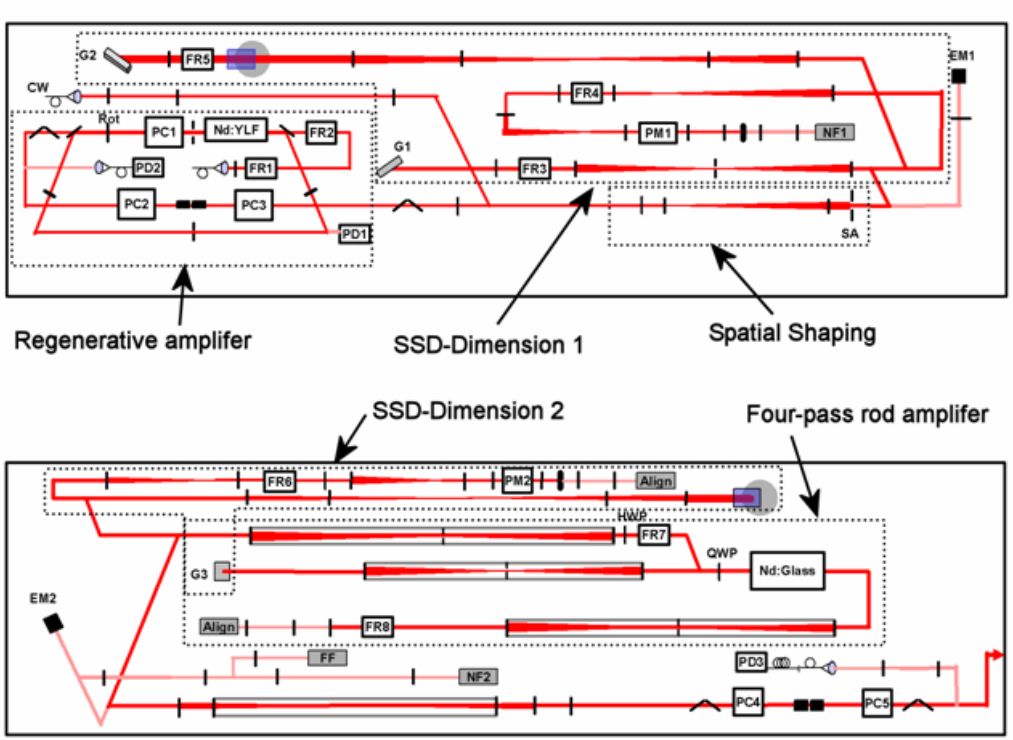
OPG1 and PAMs generate 100ps-5ns, 0.5J laser pulses



Long Pulse Front end Schematic

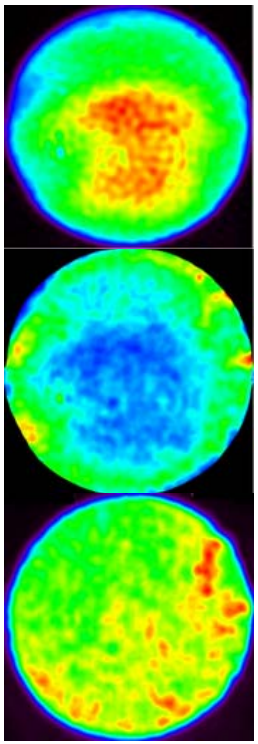


PAM overview



PAM performance

Rod amp
spatial profiles

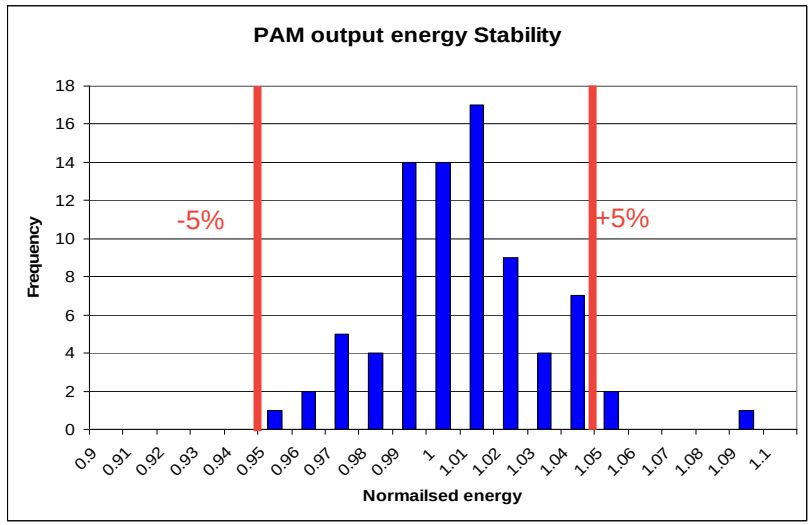


Input

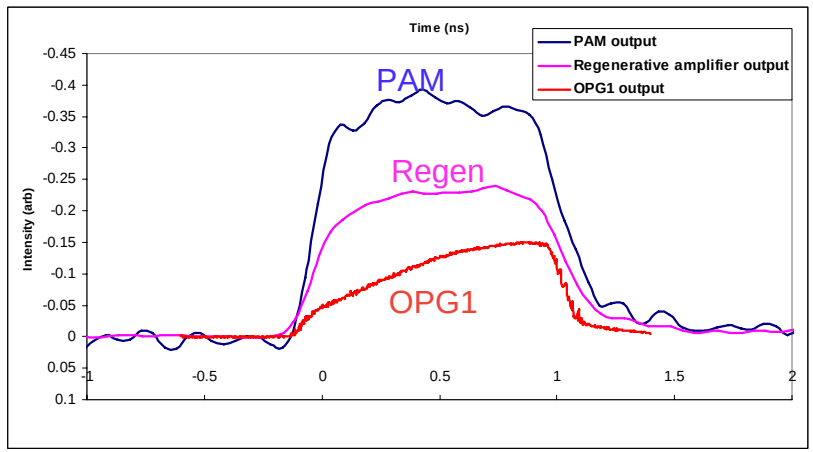
Gain
profile

Output

Energy
stability

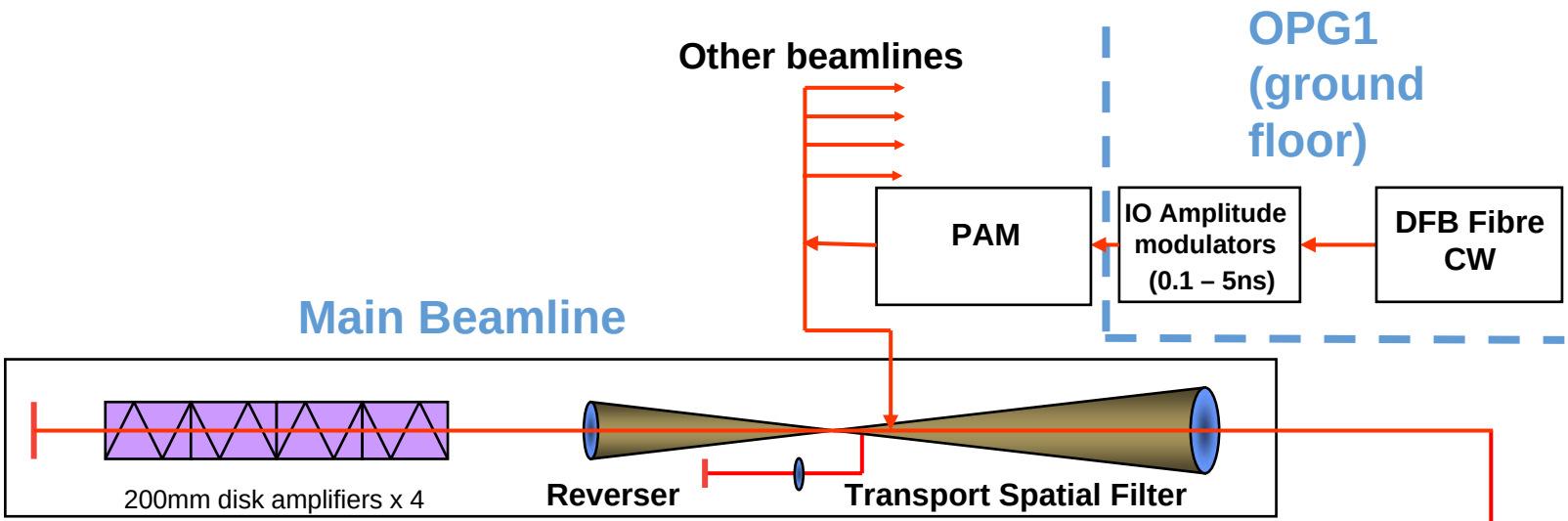


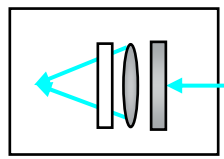
Temporal
profiles



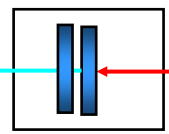
Long Pulse Beamlines

The 10 long pulse beamlines will be based on the HELEN multi-pass beamline.





f/4 Final Focus Optics



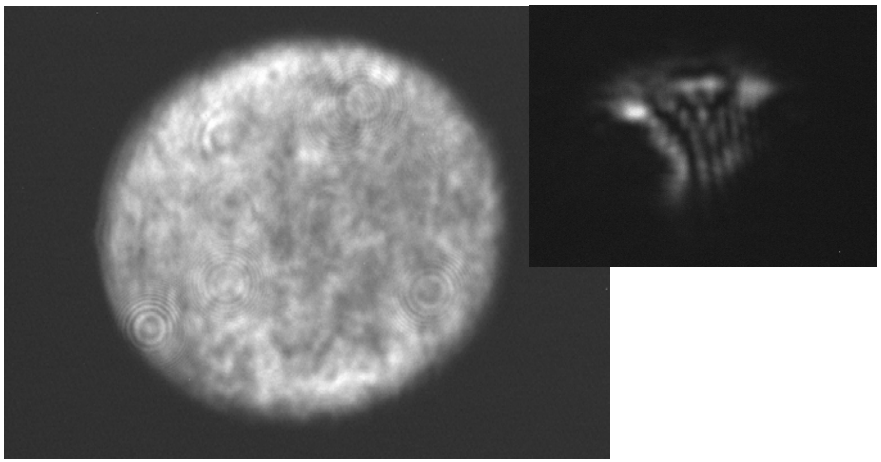
Harmonic conversion crystals

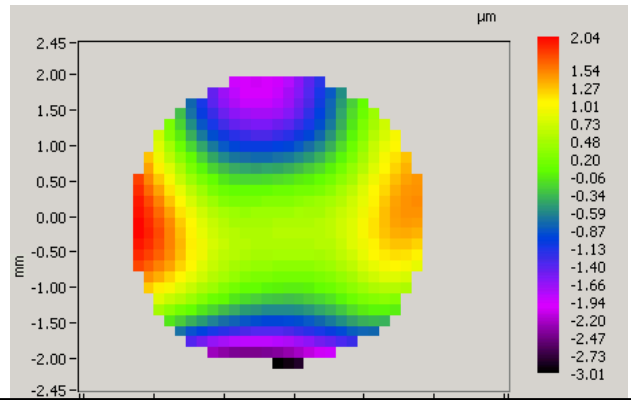
2 cones of 5 beams, 50° half-angle at chamber, 300mm dia

500J per beam @ 351nm in 1ns pulse

90% of energy in 100μm spot

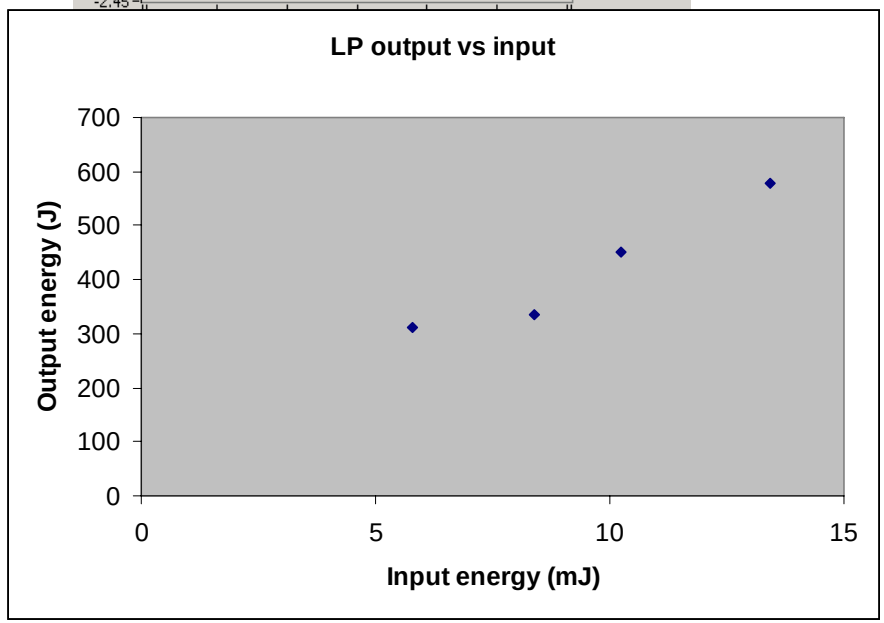
LP Beamline Characterisation





- Far-field / wavefront taken after 5 shots
- ~5 waves P-V astigmatism
- Increases with no. of shots
- Aim to correct for “middle shot” using static wavefront corrector

- 600 J demonstrated to date with 1ns square pulse
- Performance spec is 800J at 1w

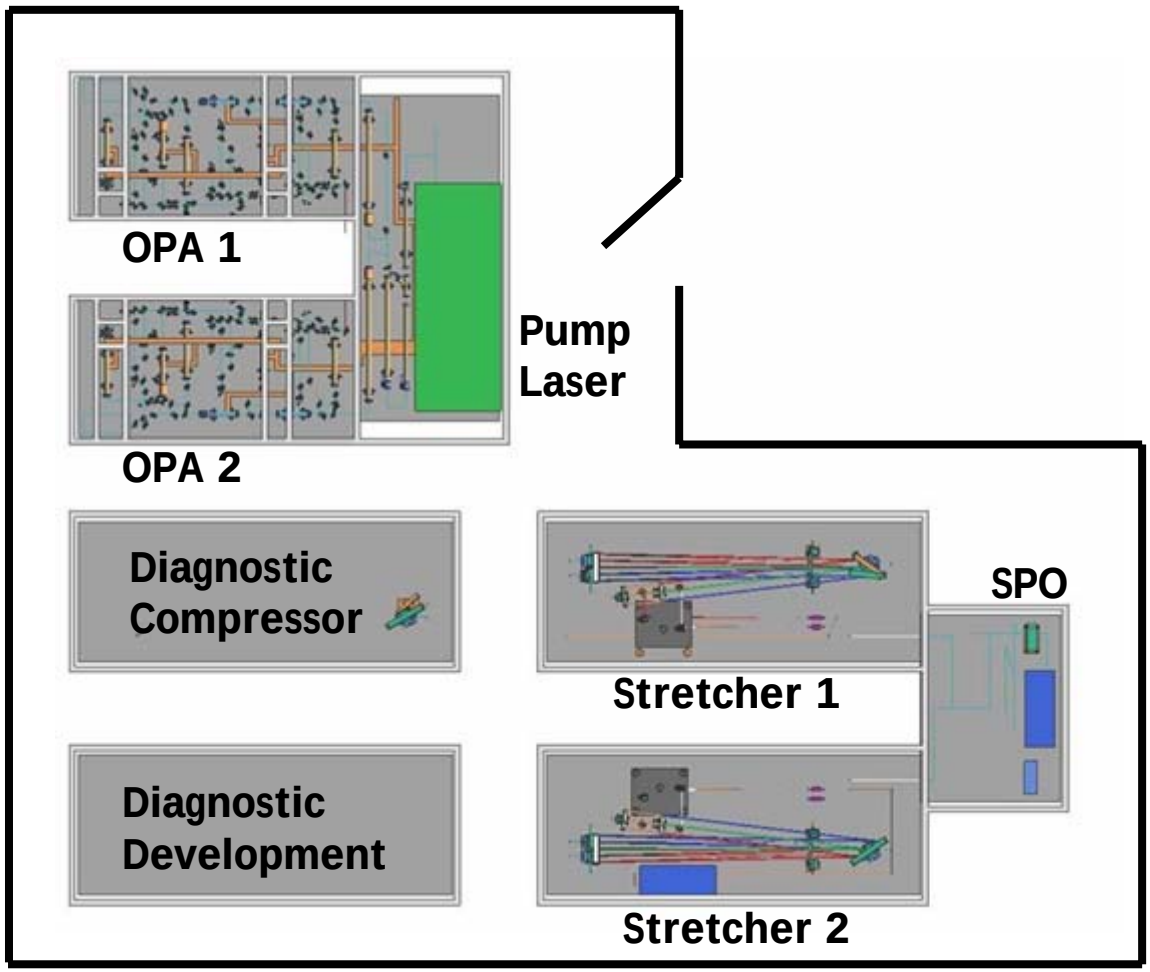


Short pulse beams

Orion Short Pulse Beams Performance

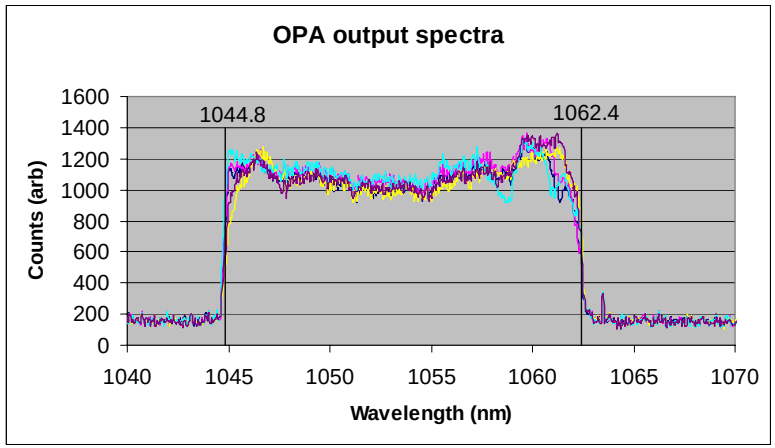
- **Output Beam Size:** 600mm diameter
- **Configuration:** At target chamber: one beam along the axis of one long pulse cone and the other orthogonal in the horizontal plane.
- **Output Energy:** 500J at 1053nm in 0.5ps pulse.
- **Pulse duration:** 0.5 - 20ps
- **Contrast ratio:** 10^{6}:1 at +/-1ns
- **Intensity on target:** 10^{21} Wcm^{-2} using f/3 focus parabola

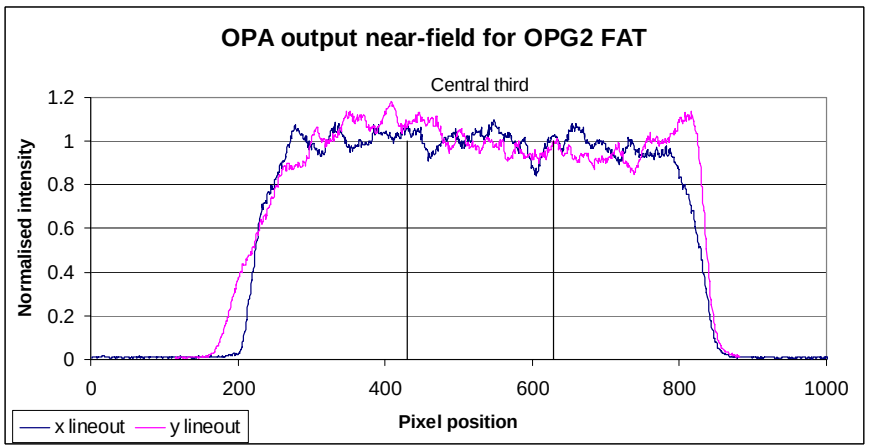
OPG2 – Short pulse front end

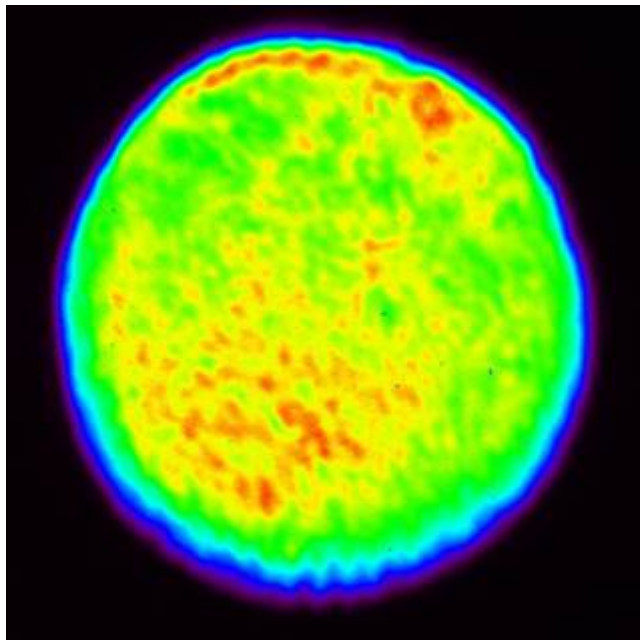


- SPO, Stretcher 1, Stretcher 2 successfully installed, tested and commissioned Jan 09
- Rest of OPG2 currently being commissioned
- OPA output nominal ~150mJ, 17nm bandwidth demonstrated
- Details in separate ICUIL presentation.

OPCPA - Design Proving Results



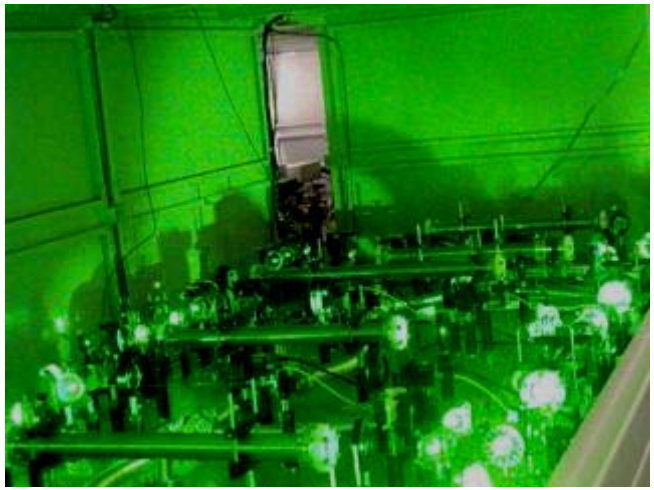


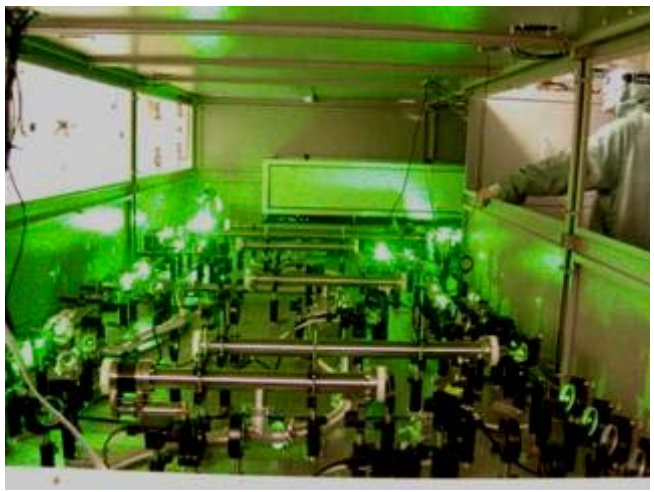


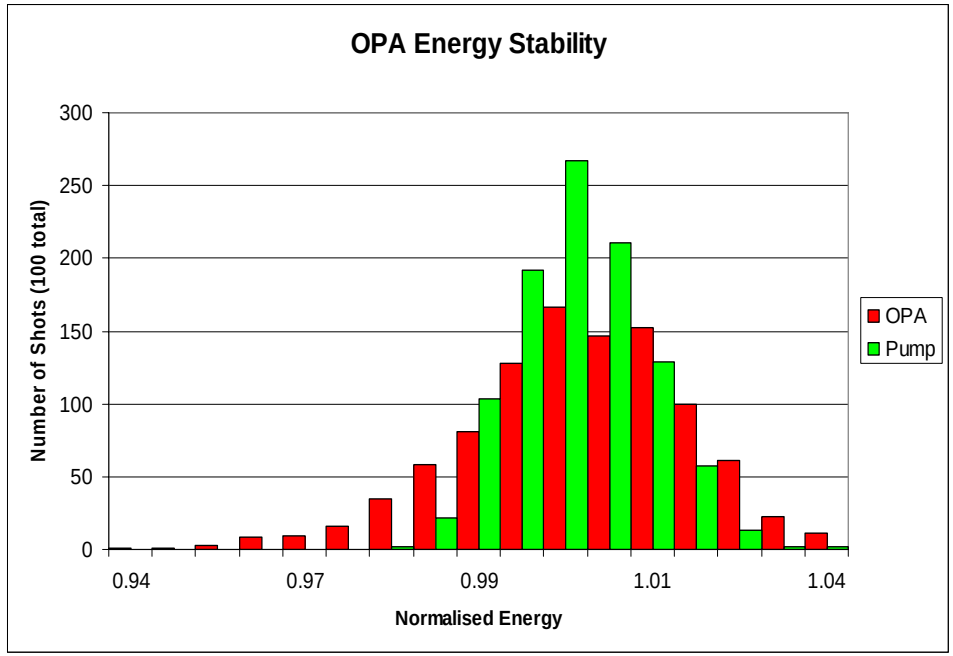
Top-hat spatial profile

Output spectrum “flat” with >17nm bandwidth – equivalent temporal profile

OPCPA – Design Proving Results



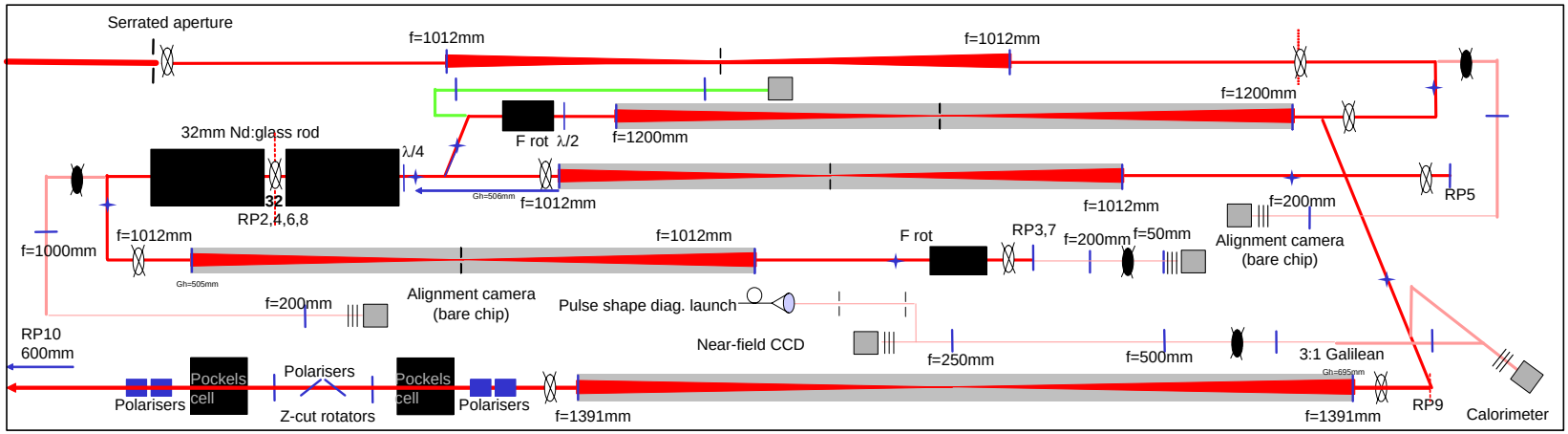




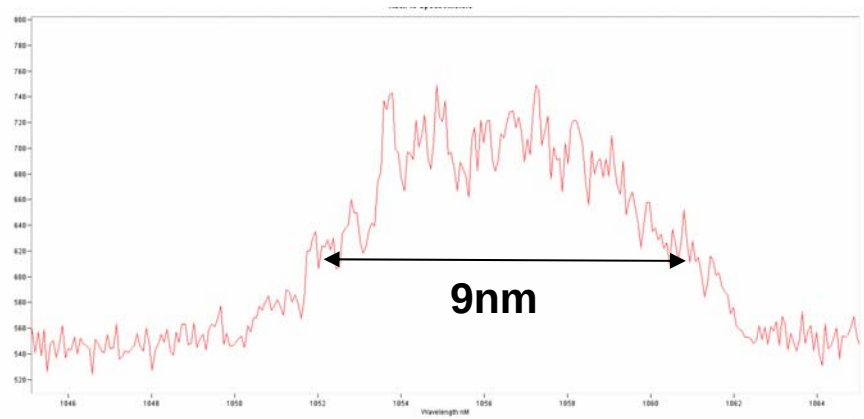
Nominal output energy ~150mJ

Energy Stability <1.5% RMS (better with Orion timing system?)

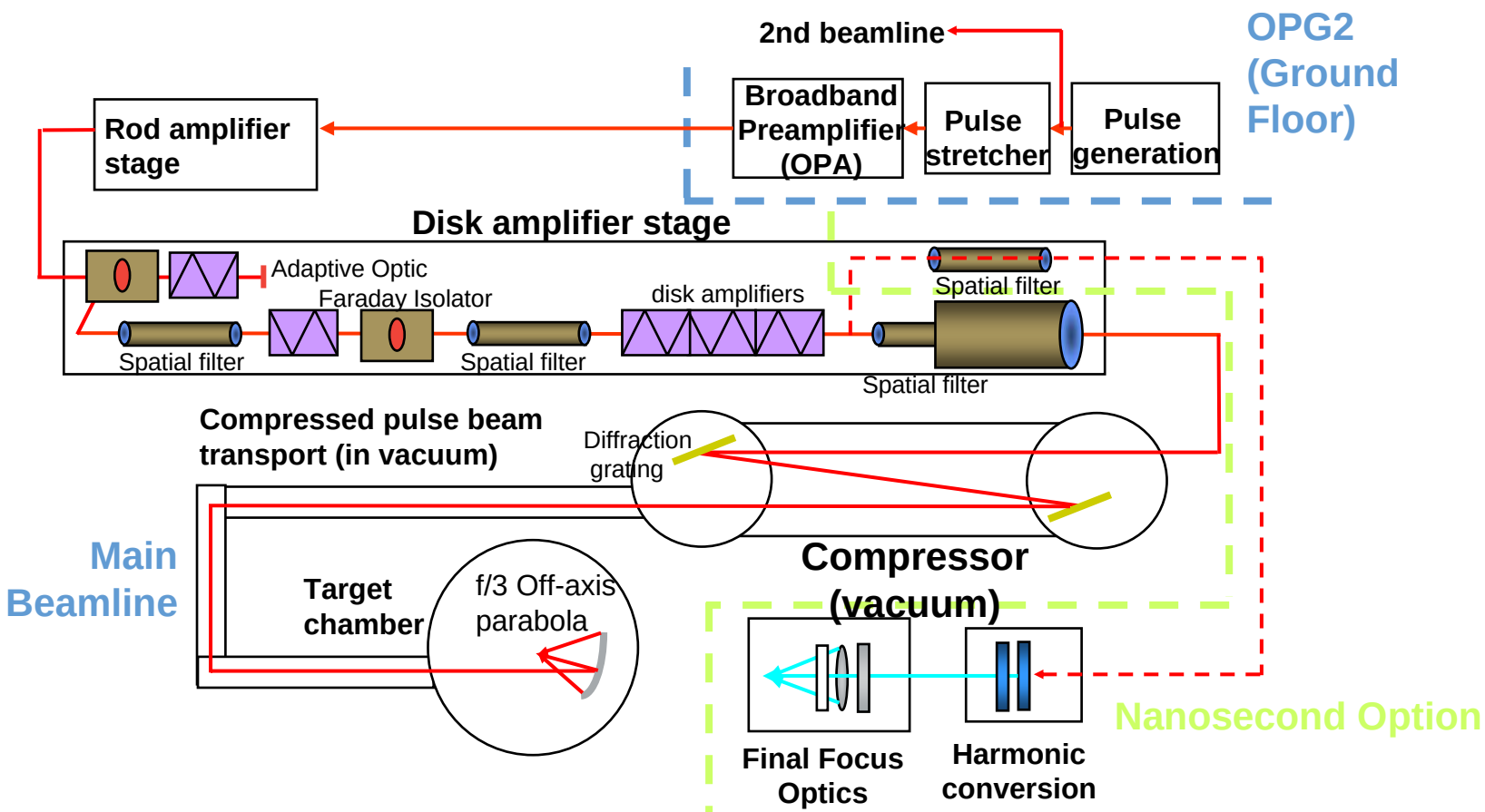
SPRA overview



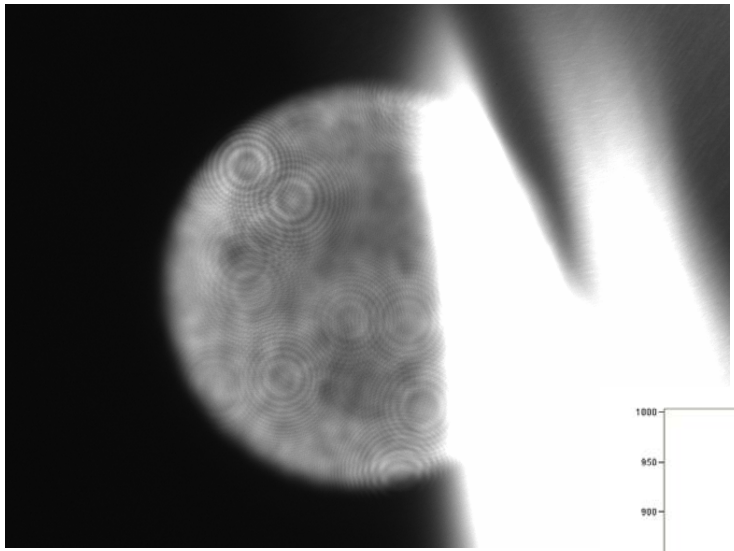
- **Four-passed double rod amp system**
- **2 off 32mm rod amps**
- **1 phosphate, 1 silicate**
- **Operating spec:**
  - **1.5J**
  - **16mm beam diameter**
  - **9nm FWHM bandwidth**
  - **1058nm peak wavelength**

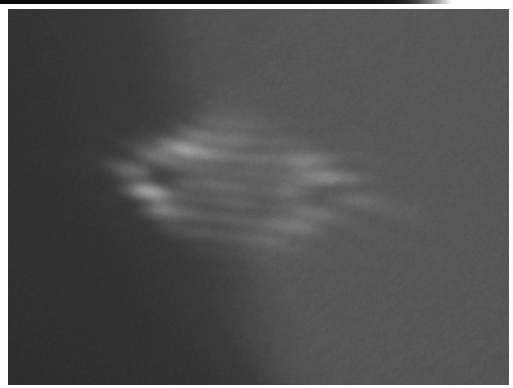


Short Pulse (PW) Beamlines

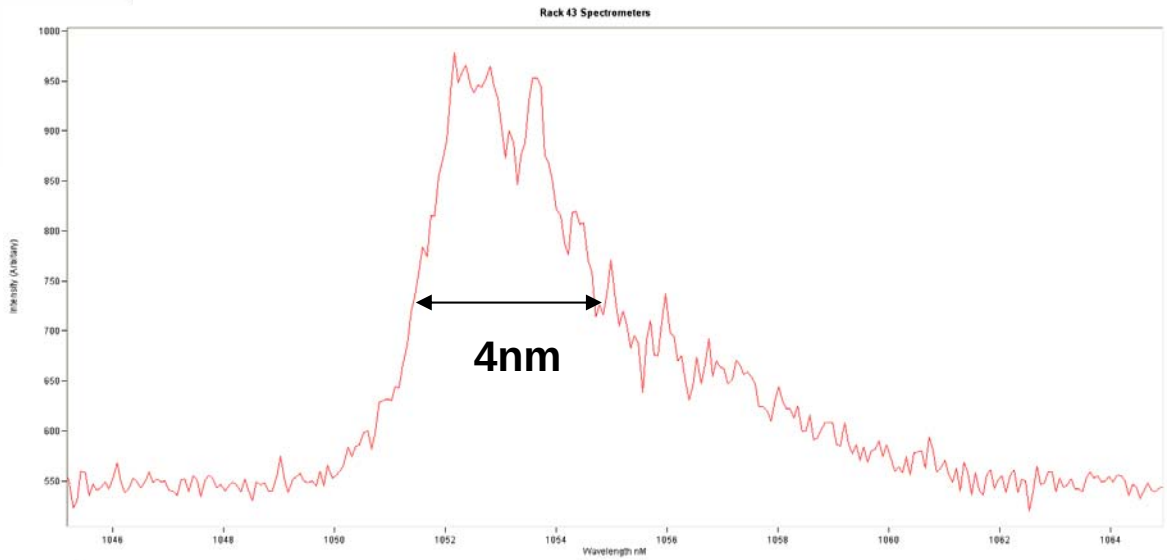


SP Beamline Characterisation





- Very preliminary data!
- No spatial filter prior to diagnostic station
  - More baffling required!
- More silicate gain available to increase bandwidth



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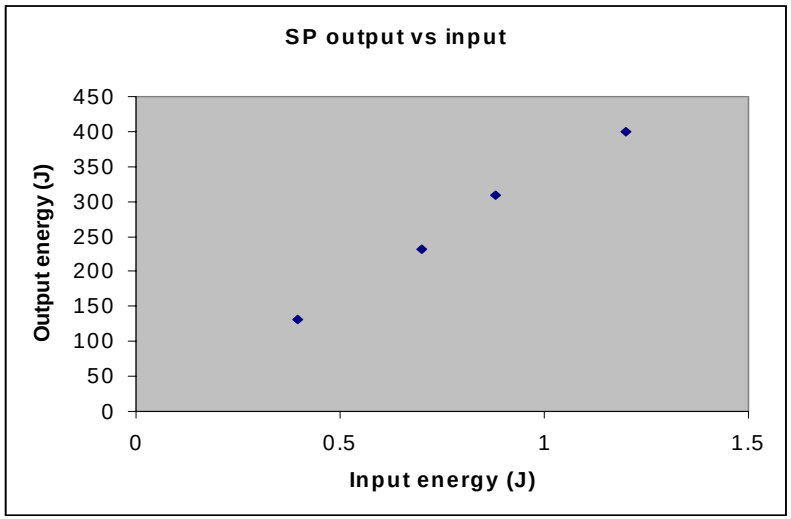
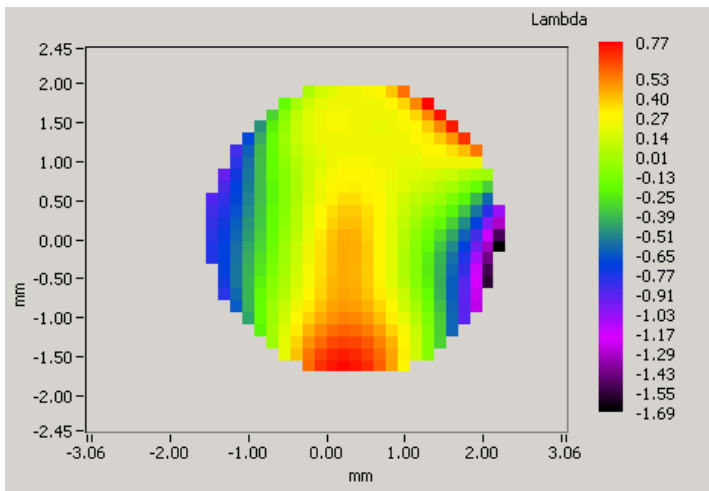


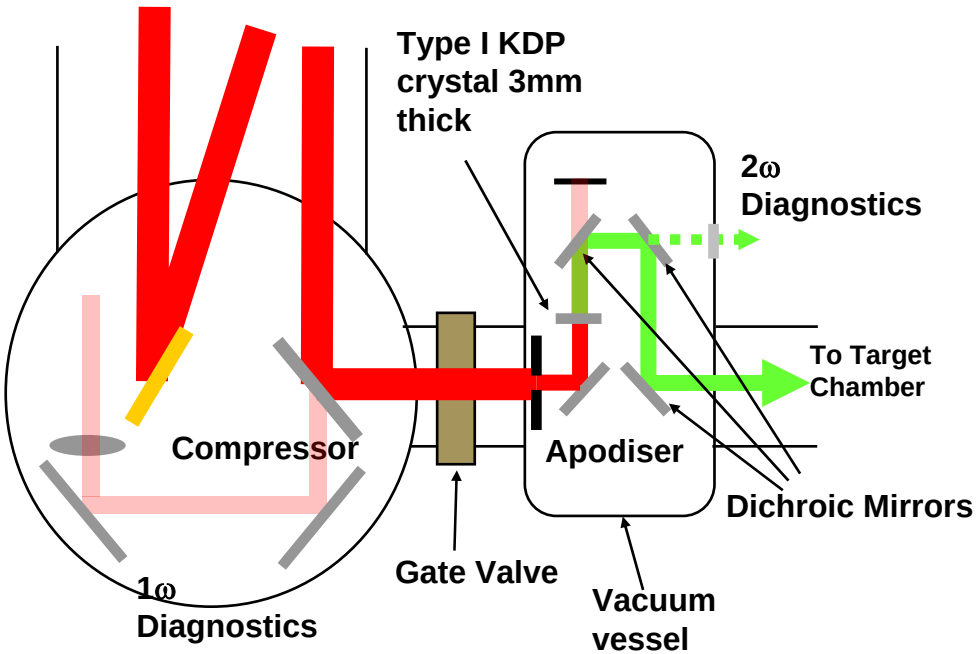
- 400 J demonstrated to date
- 700 J required to yield spec of >500J on target

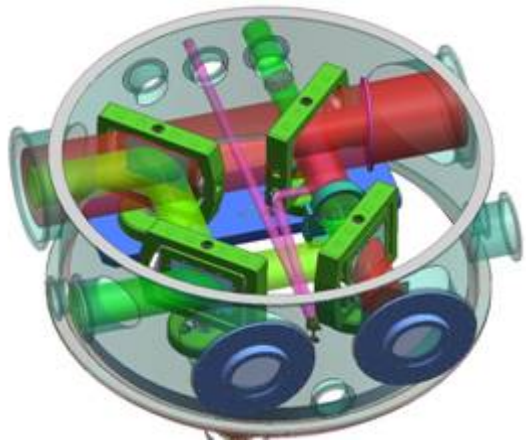


- Aberration of 2.5 waves P-V, mostly astigmatism
- Deformable mirror specified to easily correct this wavefront

PW Issues – Pulse Contrast

- Some experiments will require the best possible contrast for the PW beams rather than maximum intensity. Non-linear nature of conversion to 2nd harmonic provides enhancement in contrast of several orders of magnitude.
- The option for one SP conversion to the second harmonic at reduced aperture (300mm) will be provided in a vessel immediately following the compressor.
- Dichroic mirrors leak away residual 1w energy.
- 2w campaigns with HELEN 100TW CPA beam informed Orion design





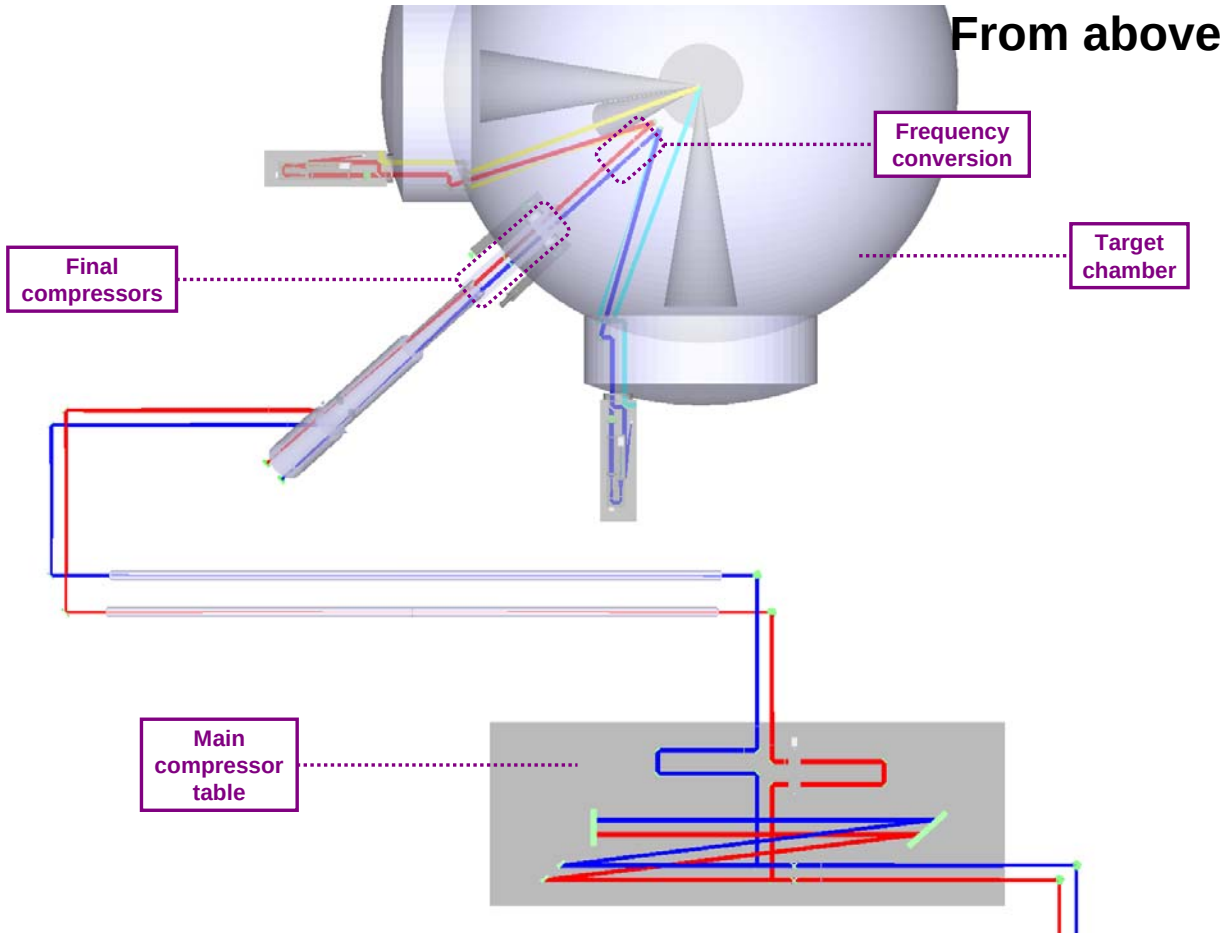
SP optical probe beam

~1J picked off midway through laser chain.

Beam reduced to 35mm and relayed into target hall.

Dual stage compression:

- **Main compressor reduces pulse length to 110ps.**
- **Lens-based relaying through final compressor**
- **Pulse length reduced to ~350fs**
- **Frequency quadrupled**
- **Mirror based relaying to chamber centre**
- **~70mJ delivered to target**



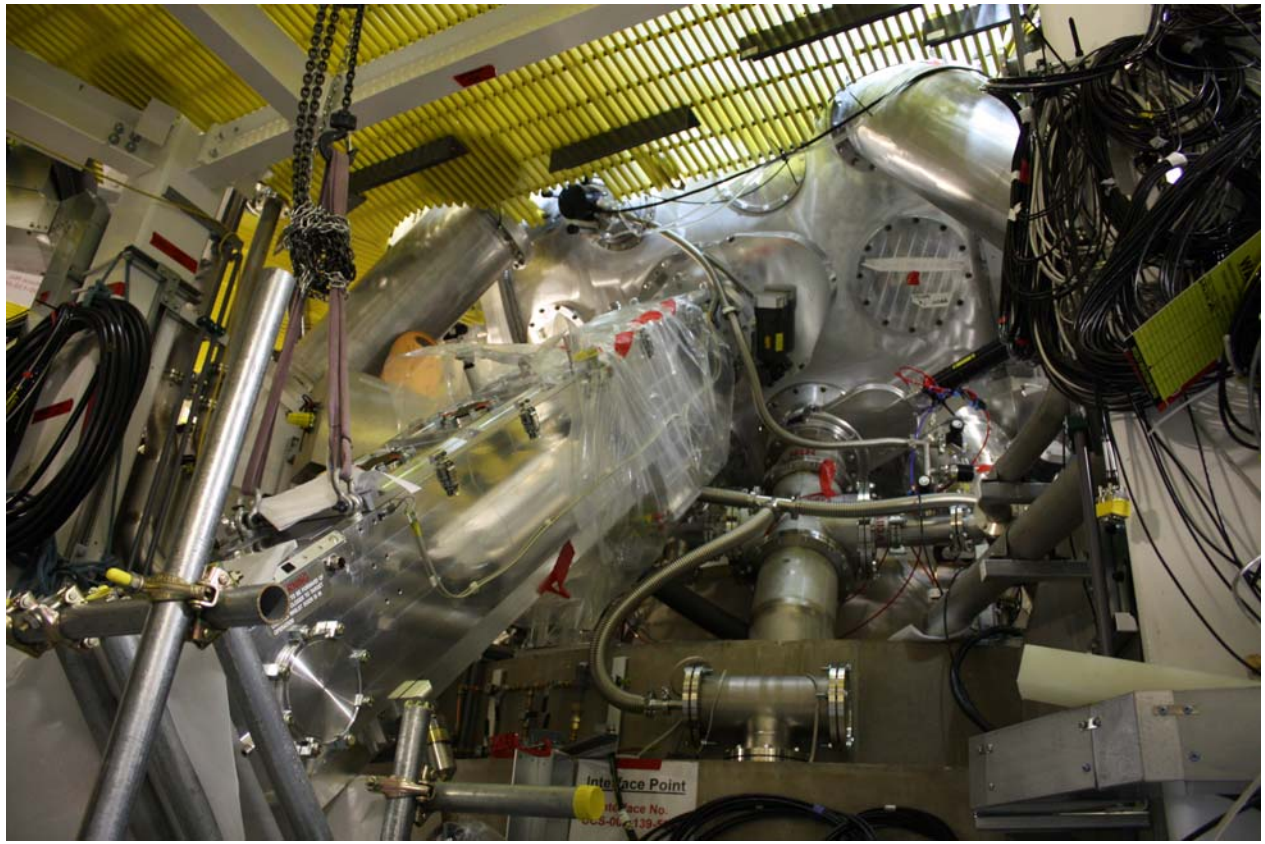
Target diagnostics list

For 1st target shots:

- **Optical streak camera**
- **K_b x-ray microscope**
- **TLD array**
- **X-ray pinhole camera**

Plus for final delivery:

- **Dante/PCD array**
- **Filter fluorescer**
- **SRS/SBS backscatter: LP,SP**
- **TIM gated x-ray detector**
- **TIM x-ray streak camera**
- **n ToF, n yield**
- **Time integrated (film) spectrometers**
- **Hard x-ray spectrometer**
- **Transmission grating spectrometer**
- **Thomson parabola**
- **XUV grating spectrometer**
- **CR39**
- **Faraday cups**
- **Electron spectrometer**



Project Progress

- All major installations complete
- Pulse generation commissioned
- LP PAM and SP rod amp commissioned
- LP and SP energetics milestones demonstrated in laser hall

Integrated Commissioning Milestones

18	Long pulse infra-red energy demonstrated (500J) Complete	31/05/2010
19	Short pulse infra-red demonstrated (300J uncompressed) Complete	30/06/2010
20	Single short pulse and long pulse synchronization (+/- 50ps) (Project Completion)	31/12/2010
61	10 LP at 80% max energy (400J 3w each), 2 SP at 0.5PW each, synchronous, ready to start experiments	31/03/2012