Ultra-high intensity-high contrast 300-TW laser at 0.1 Hz repetition rate (Optics Express, Vol. 16, Issue 3, pp. 2109-2114 2008)

V.Yanovsky , G. Kalinchenko, V. Chvykov, P. Rousseau, T. Planchon, J. Nees, G. Cheriaux[1], G.Mourou[1], K. Krushelnick , S. Kneip[2]

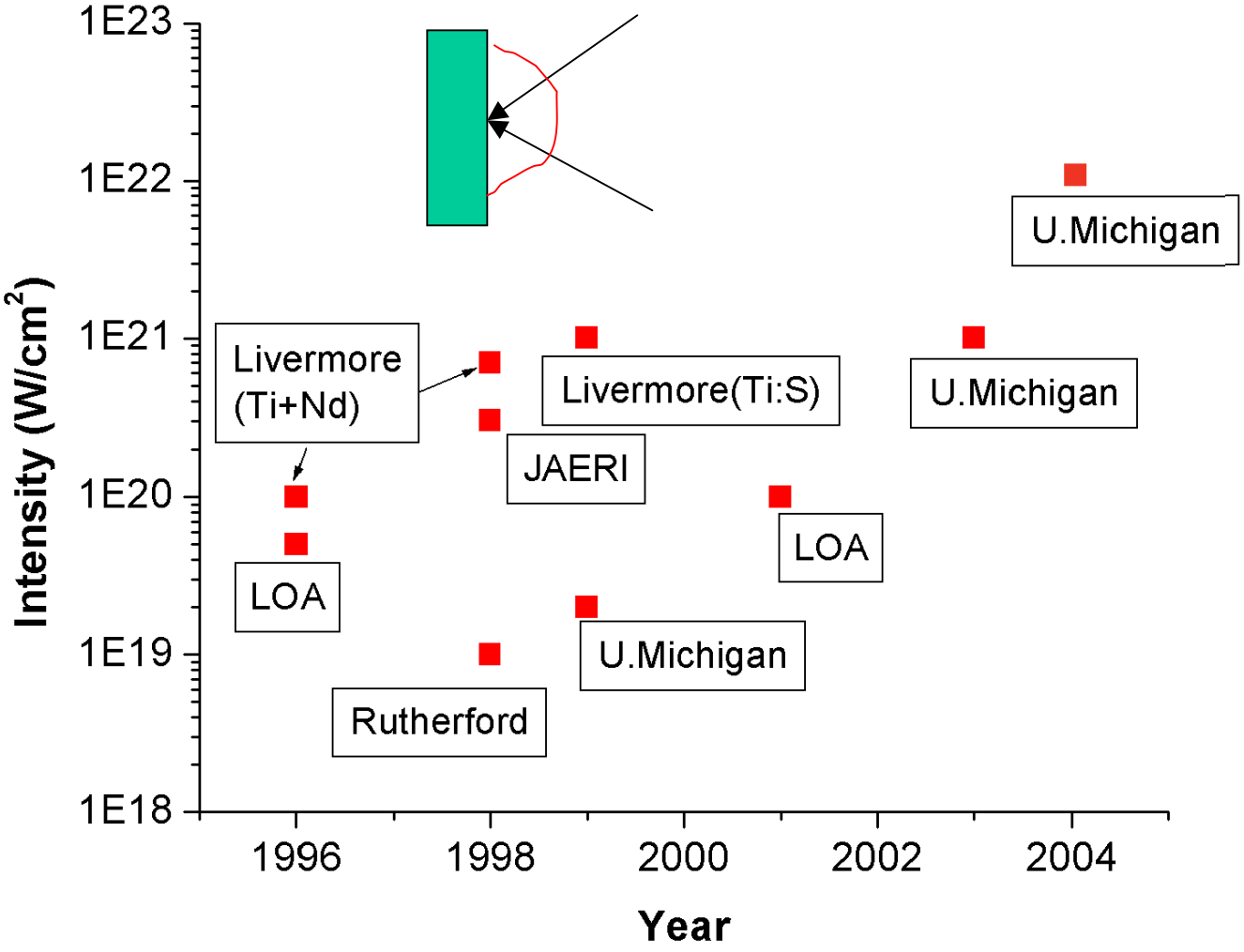
(Center for Ultrafast Optical Science at the University of Michigan, [1]-LOA, - [2]Imperial College)

ICUIL 2008, Shaghai-Tongli, China
Oct 28, 2008

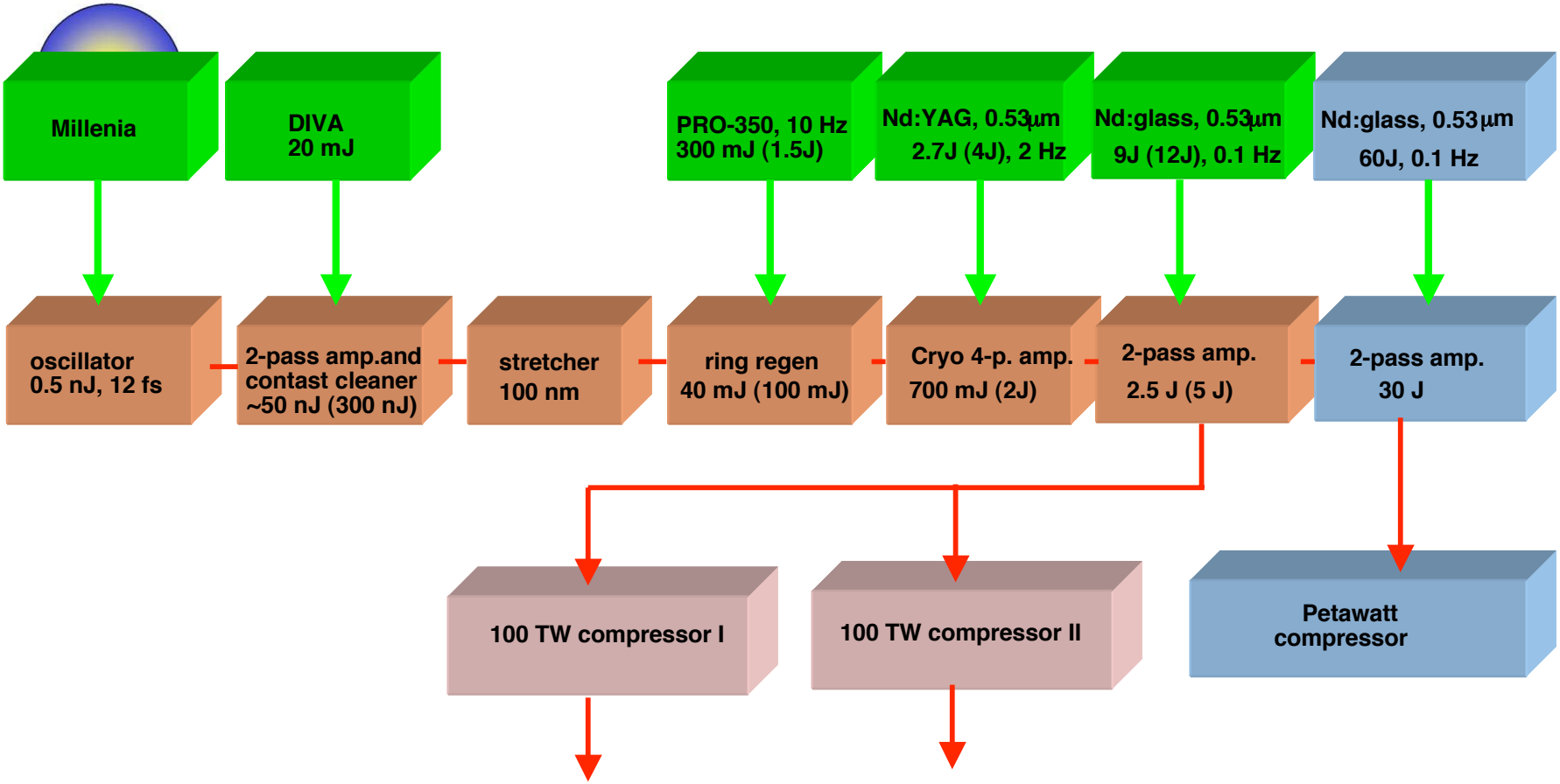
Outline

- Intro -high intensity
- Optical layout of HERCULES laser
- Focusing into wavelengh-limited focal spot
- Contrast
- Energy upgrade
- Preliminary experimental results on solids at 10^{22}W/cm^2 and on betatron X-ray source
- Conclusion

Intensity approaches ultrarelativistic regime- further increase needs more power

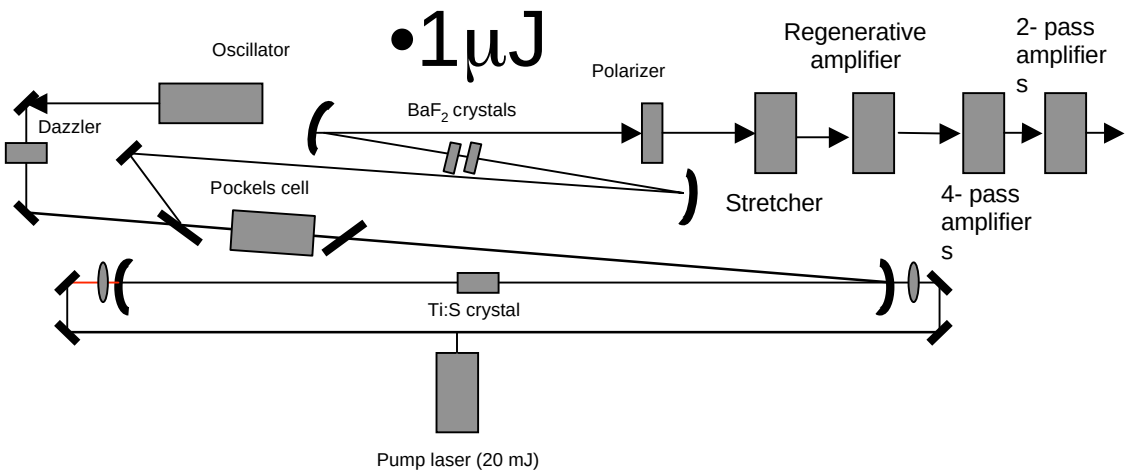


HERCULES laser layout



Simple contrast cleaner based on modified XPW method implemented on HERCULES

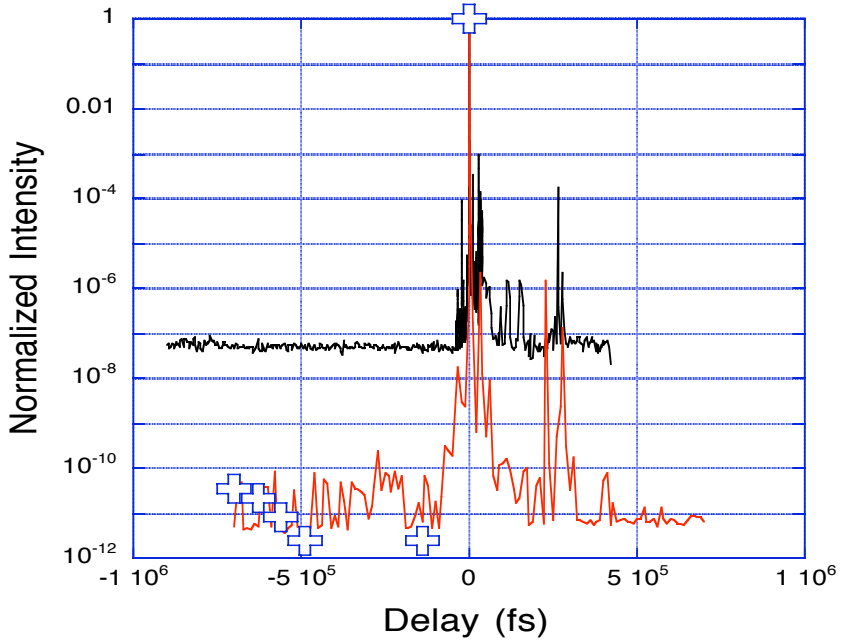
- The set up is scalable by at least an order of magnitude in energy



Record contrast of 10^{11} demonstrated at 50 TW

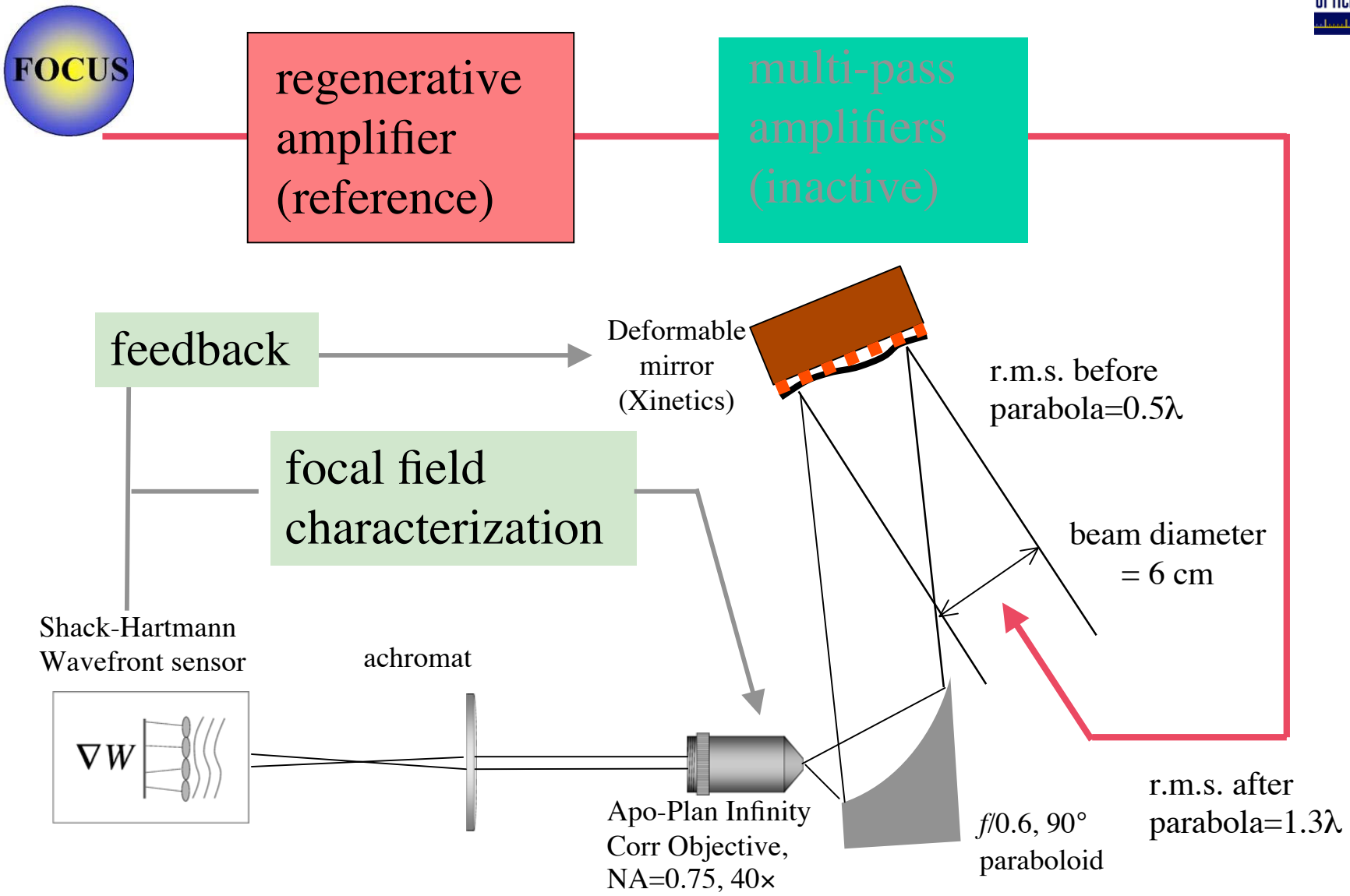
(Opt. Lett., **31**, 1456, 2006)

- ~10^{8} before
- ~ 10^{11} after

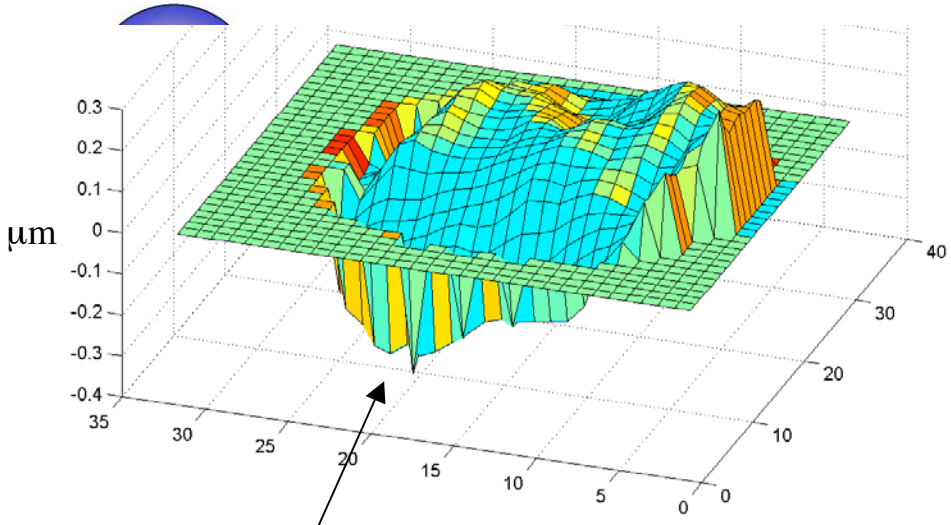


Third-order autocorrelation with (red curve-10TW power, crosses-50TW power) and without (black curve- regenerative amplifier only) cleaner. In order to get a contrast value, the intensity from the third-order autocorrelation has to be divided by 4- a ratio of the temporal resolution of the autocorrelator to the pulsewidth. The peaks of red curve at 10^{-10}-10^{-11} level are due to single photoelectrons, corresponding to ~4 photons (quantum efficiency of the photomultiplier photocathode ~25%)

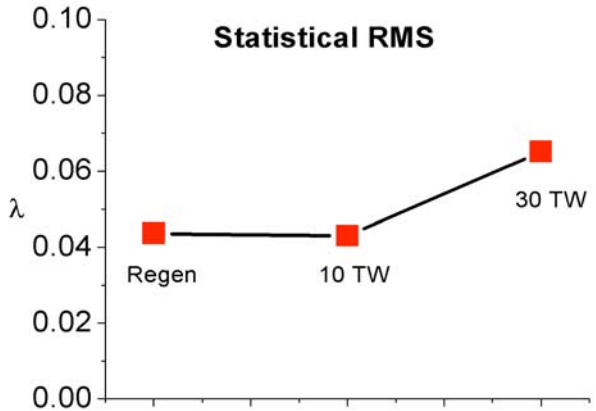
Aberration correction of reference beam and paraboloid

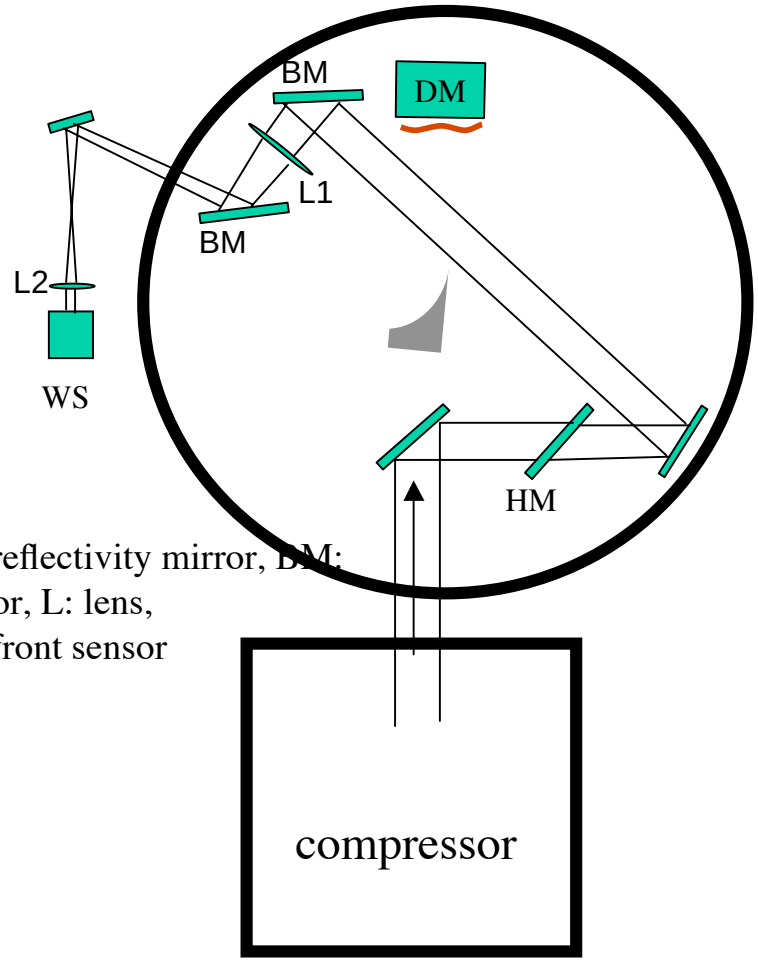


Characterization of relative wavefront at 45 TW against reference beam.



Relative wavefront of 45 TW beam
RMS=0.123 μm





HM: high reflectivity mirror, BM: blank mirror, L: lens, WS: wavefront sensor

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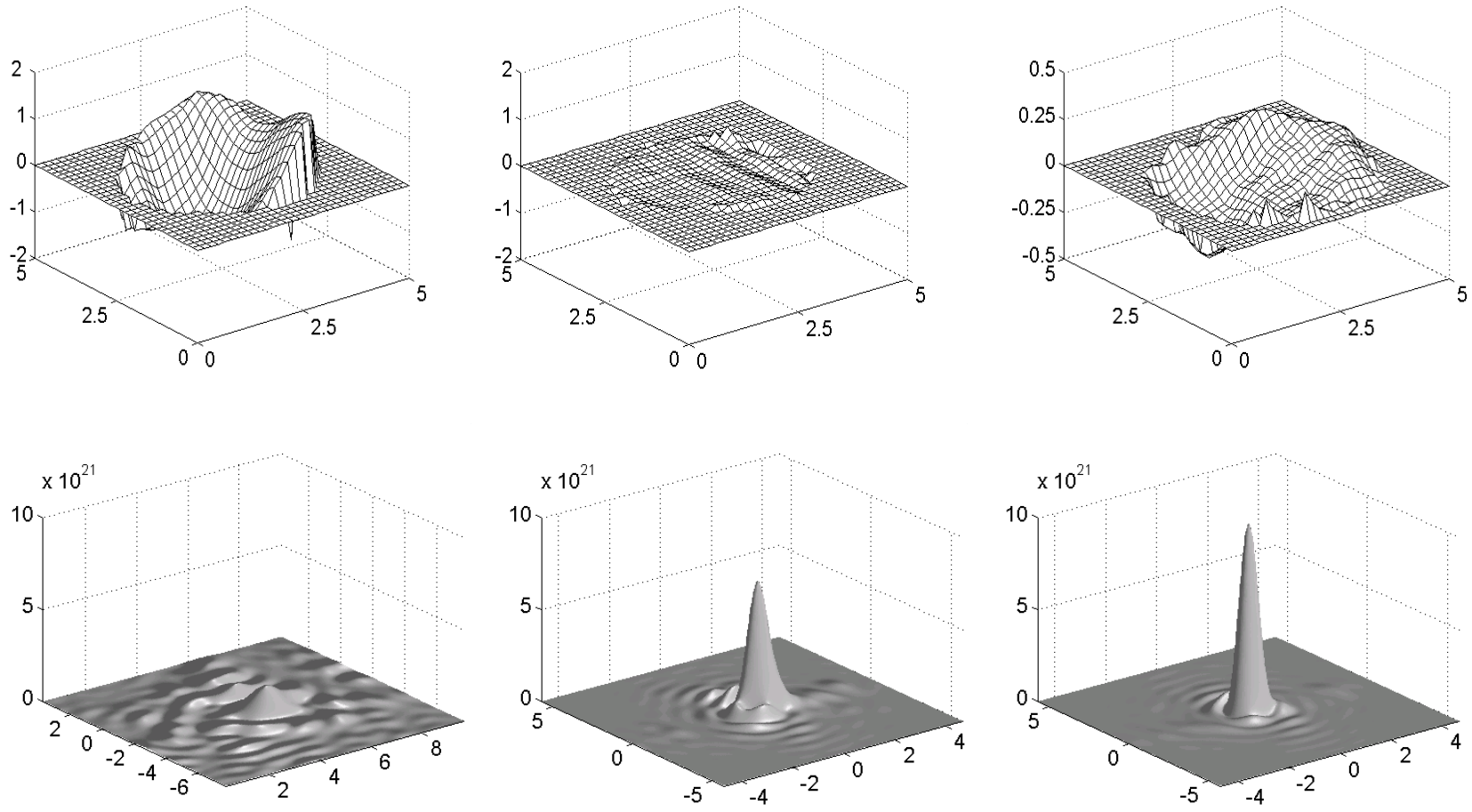
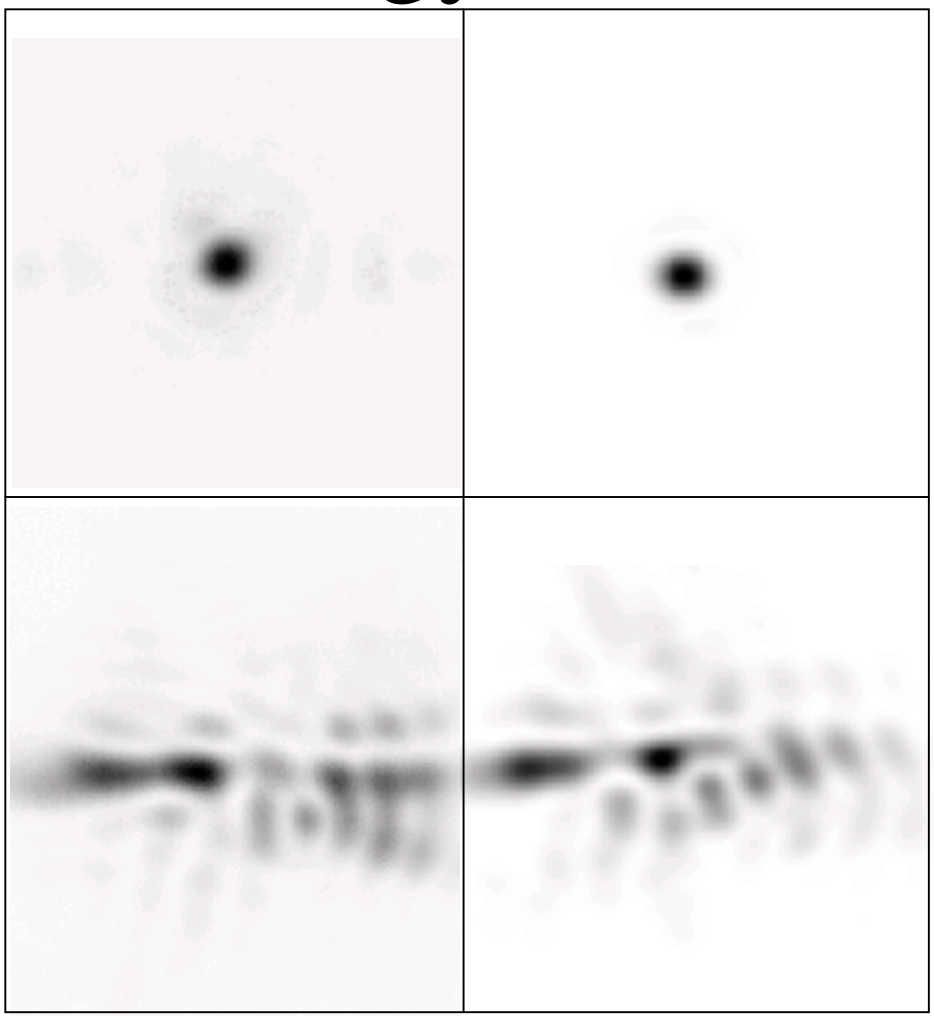
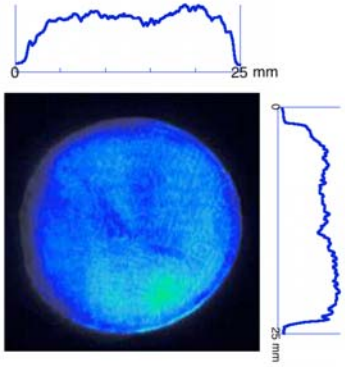
10^{22} W/cm^2 achieved at output power~45 TW
(Opt.Lett. **29**, 2837, 2004)

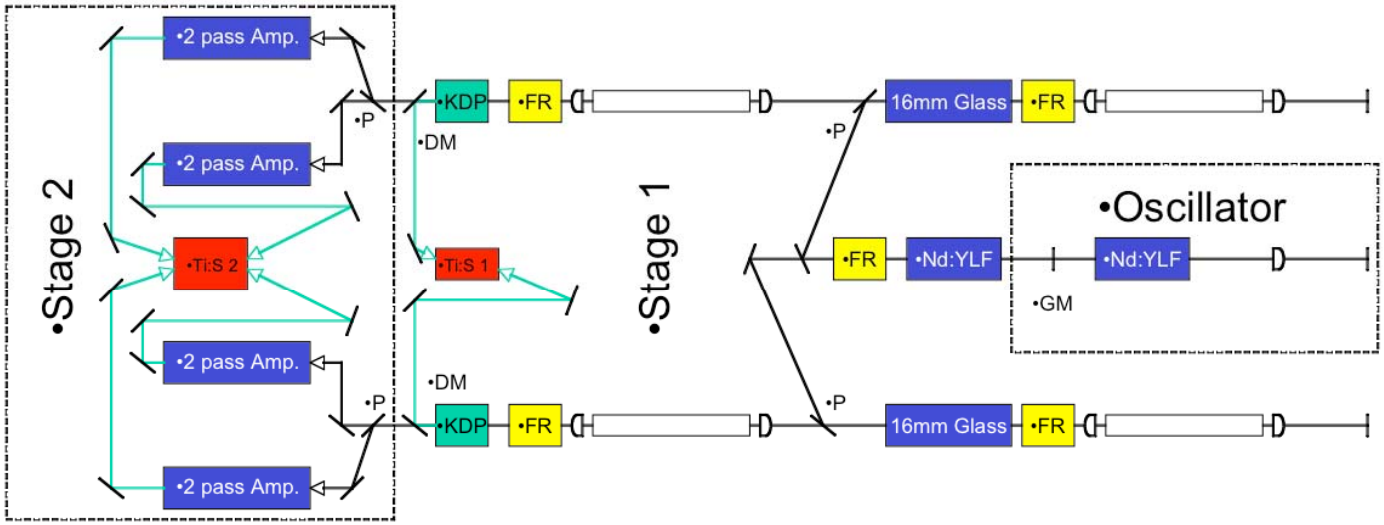


Focal spot measurement at low energy match calculations

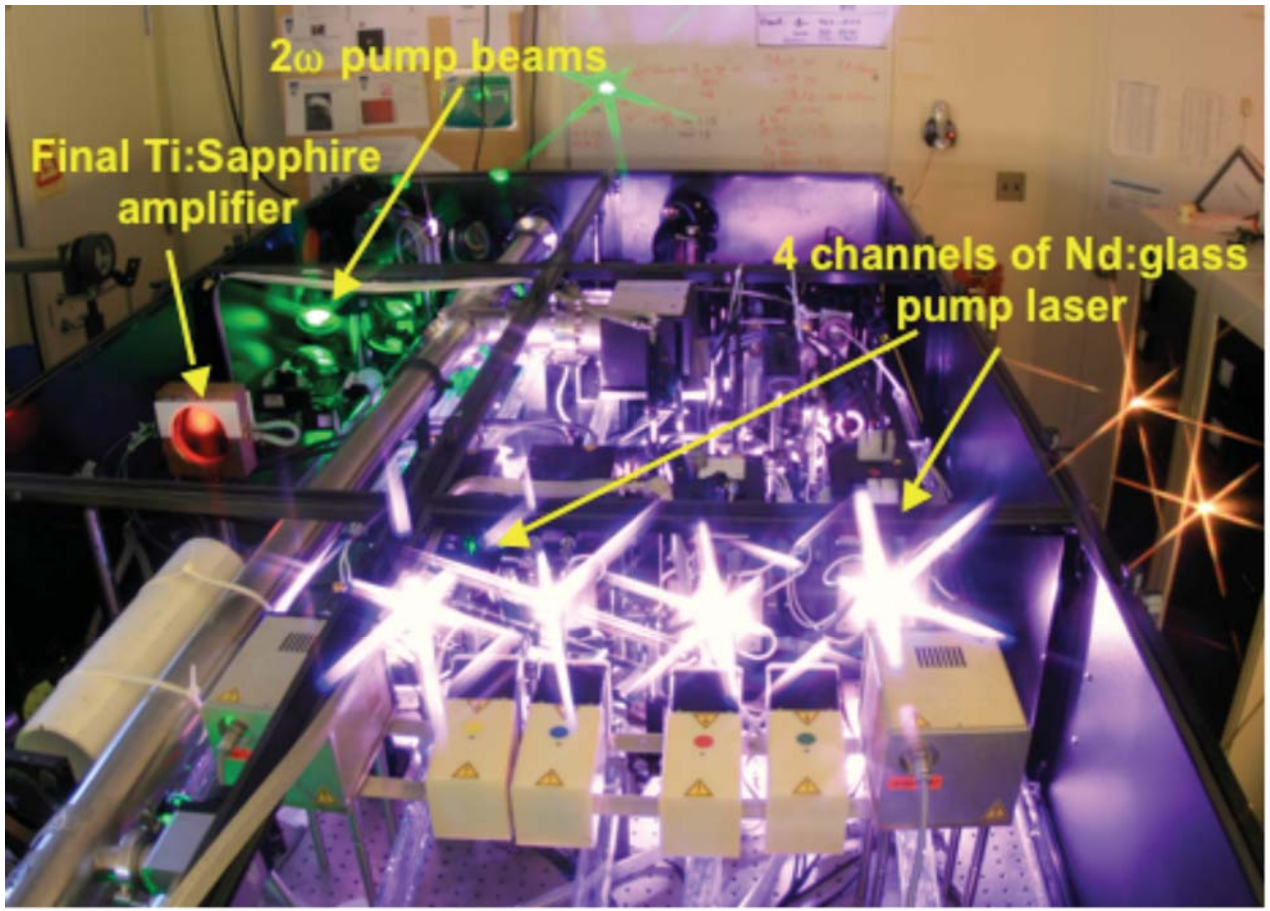


Booster amplifier added, pump laser (**Appl.Opt.** 47, 1968-1972, 2008)

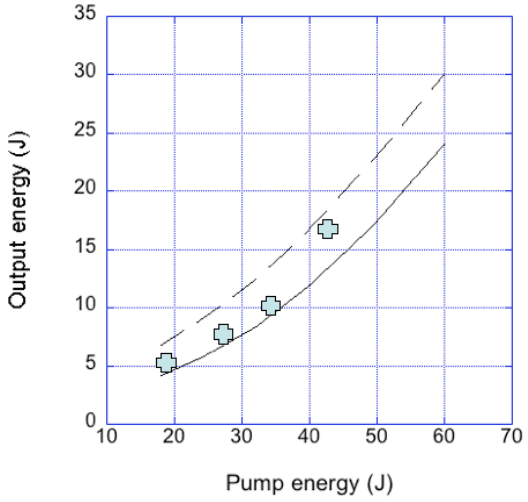


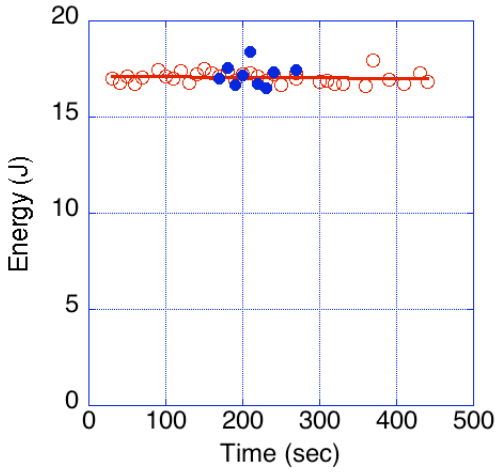


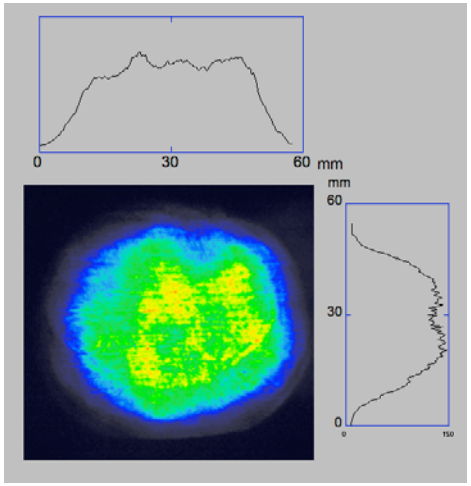
The highest power (300 TW) repetitive laser



Output energy approaches 20 J level







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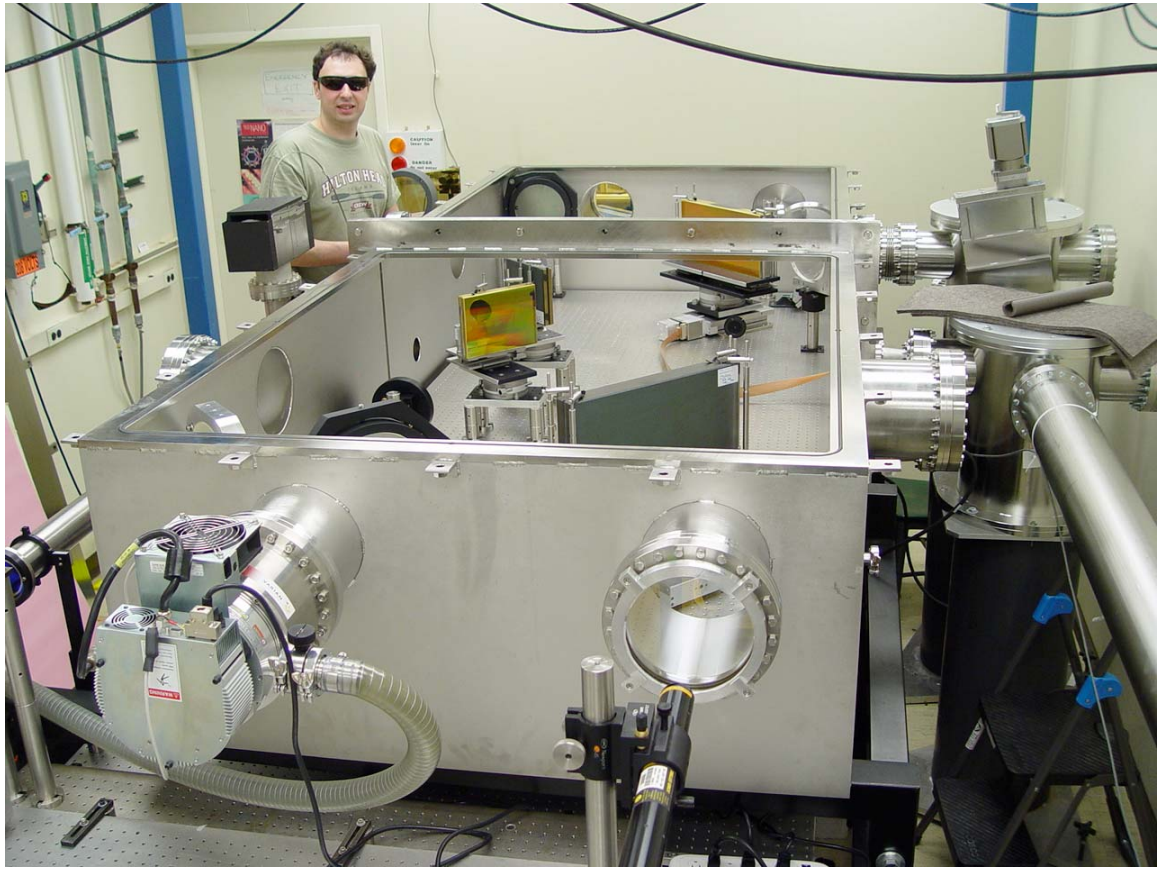
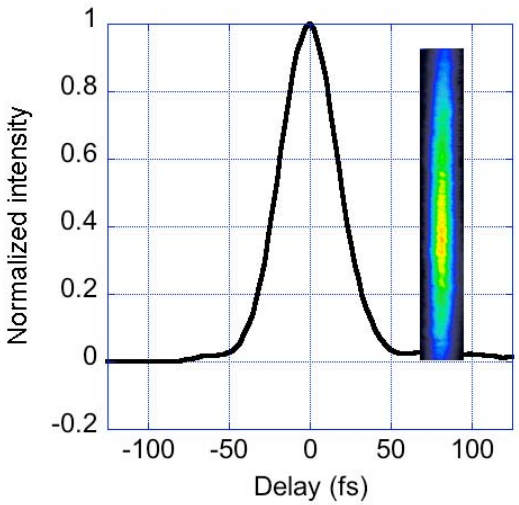
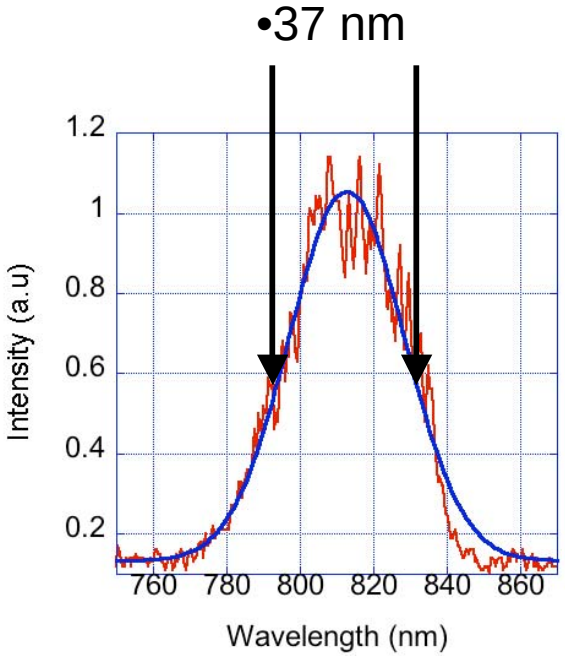
4-grating compressor



No spatial variation of group delay of 30 fs pulse, (achromat lenses in relays)





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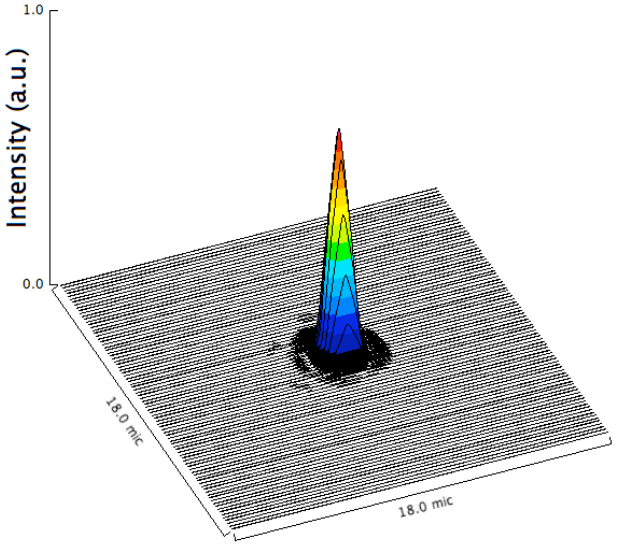
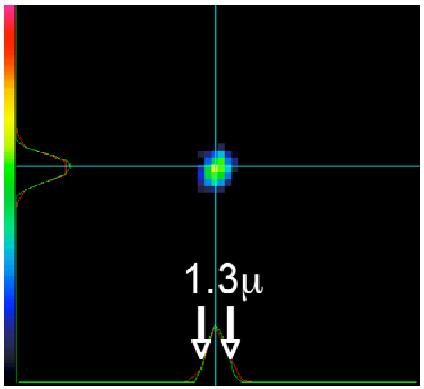
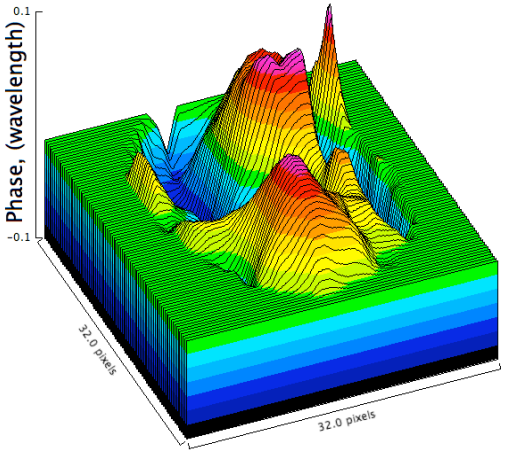
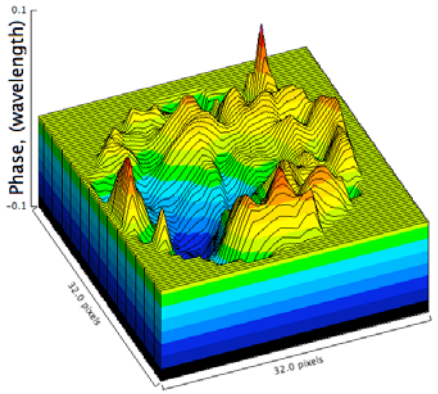
Beam focused into 1.3 μ with F/1 parabola

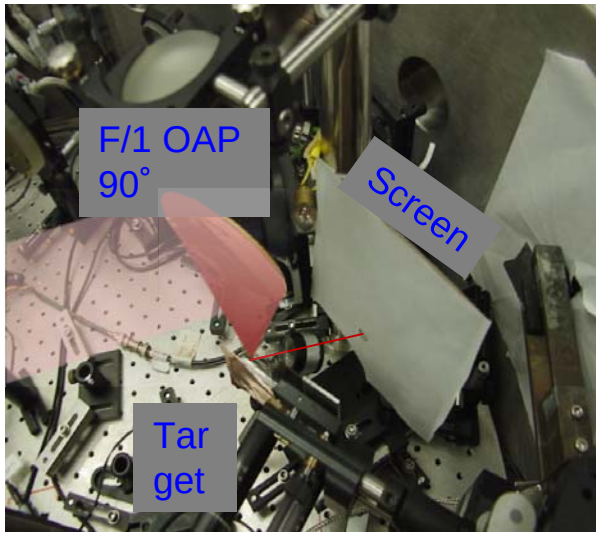


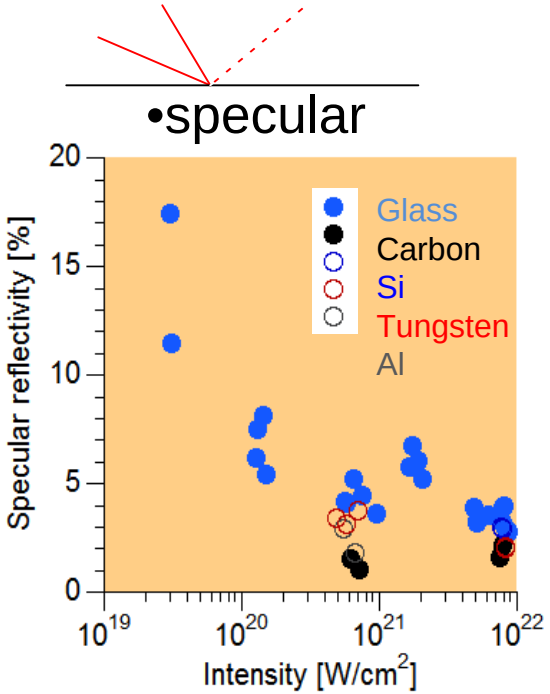


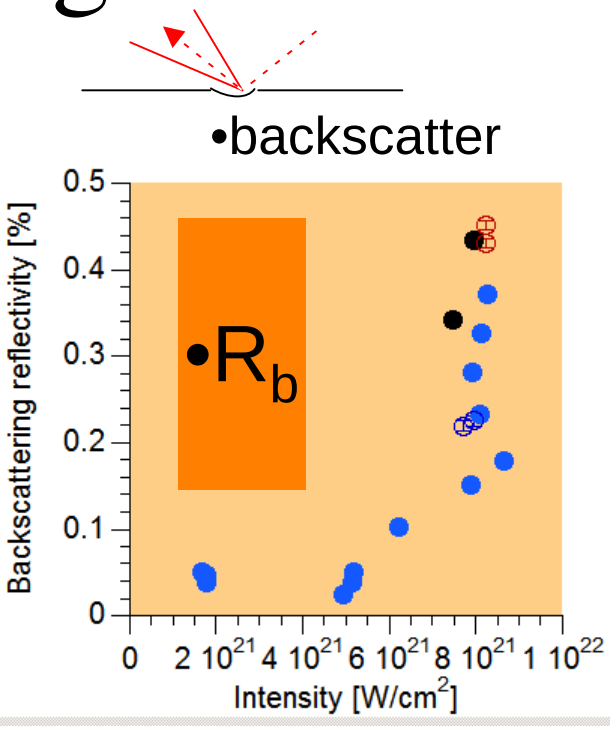




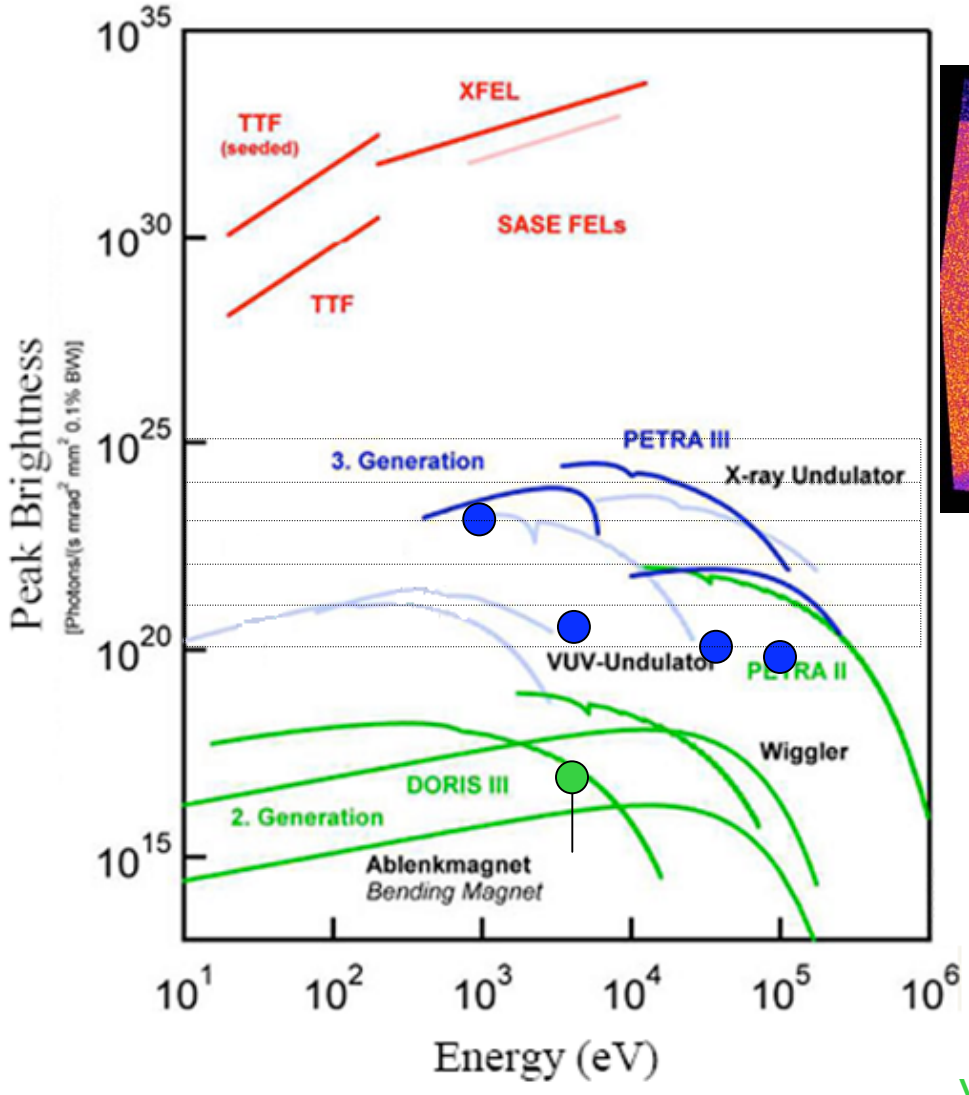
Preliminary experiments at 10^{22}W/cm^2 show evidence of increased absorption and hole boring

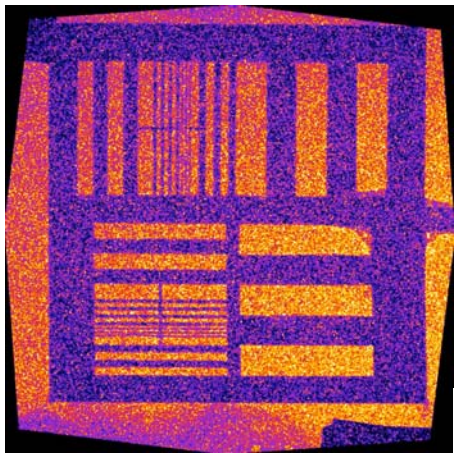


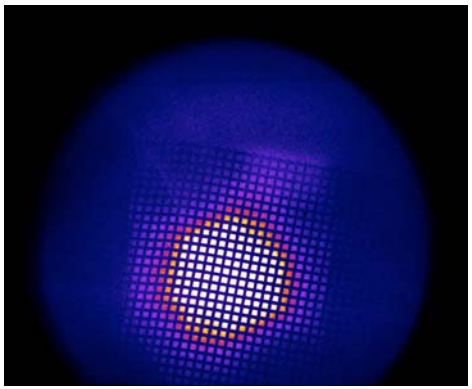


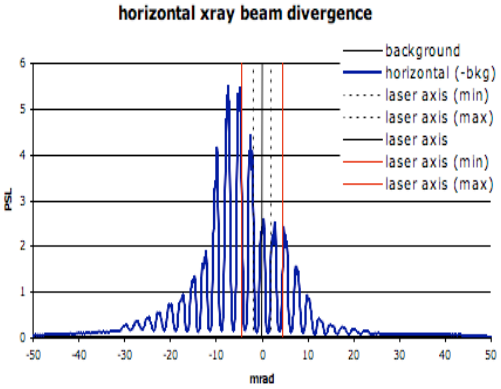


Ultrabright femtosecond X-ray source









- 10μ-feature test object

Hercules ,
S. Kneip, et. al., in preparation

Vulcan Petawatt,
S. Kneip, et. al., PRL 100, 105006 (2008)

Summary

- The first Petawatt-scale laser at 0.1 Hz repetition rate
- The first experiments at intensities ~10^{22}W/cm^2 with f/1 parabola show evidence of decreased specular reflectivity and increased back-reflection that could be explained by hole boring
- Preliminary experiments on betatron X-rays show high brightness and micron-scale source size