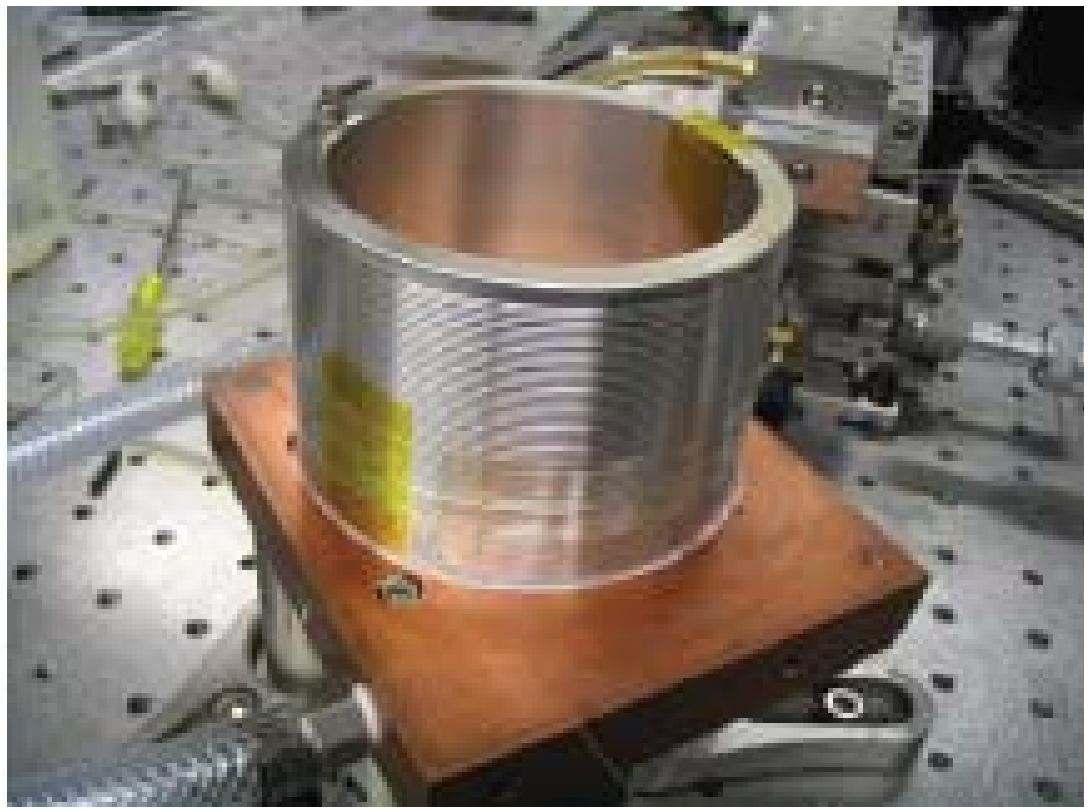
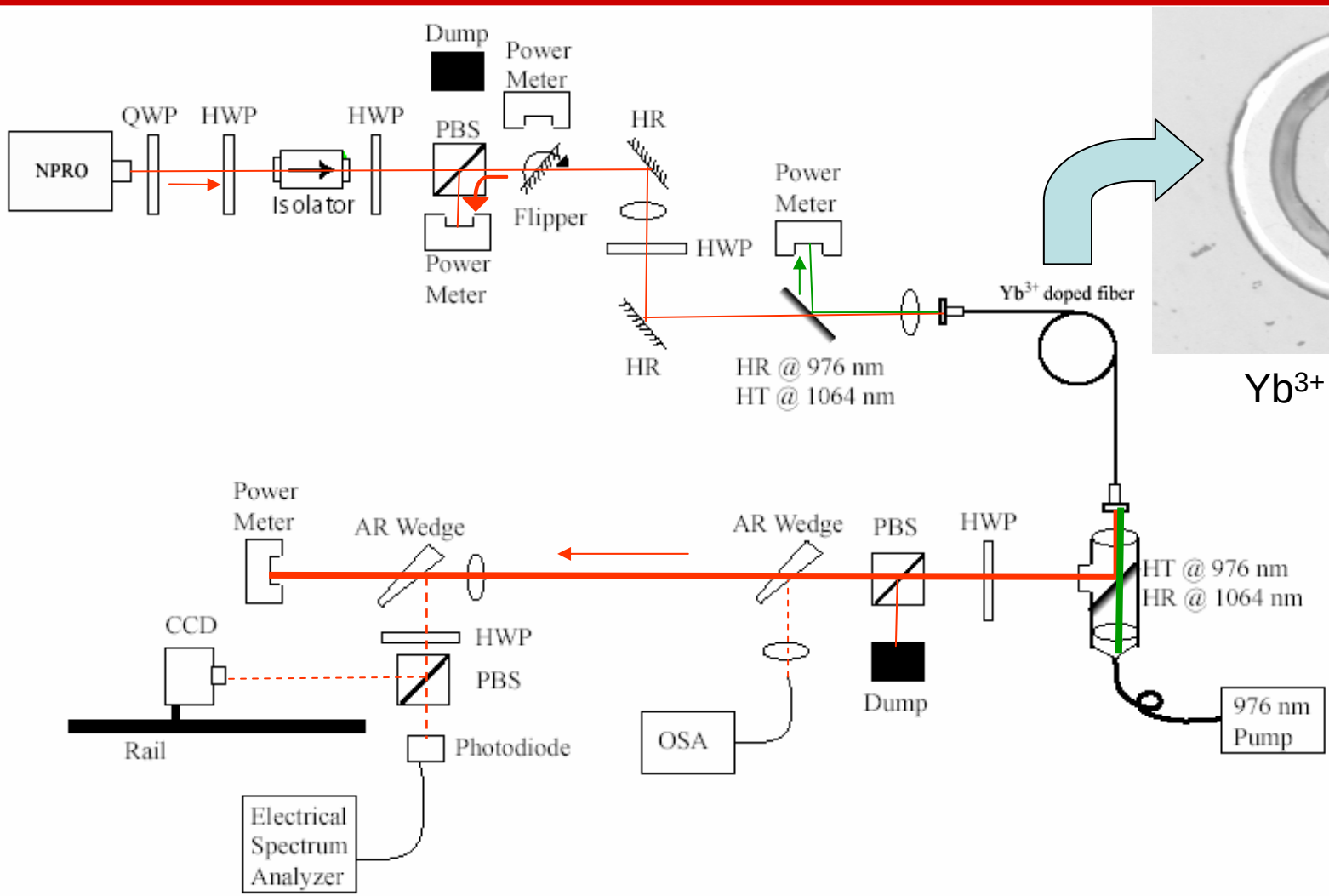
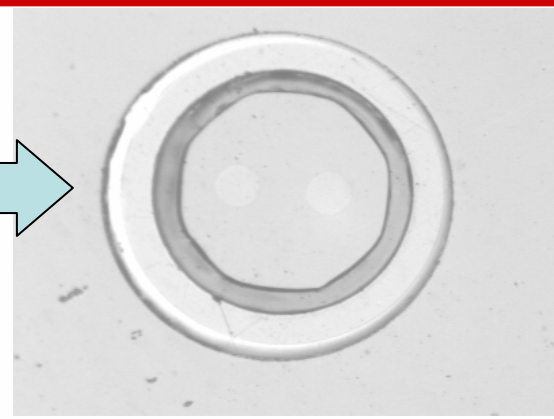
High Power, Single Frequency Ytterbium Fiber Amplifier



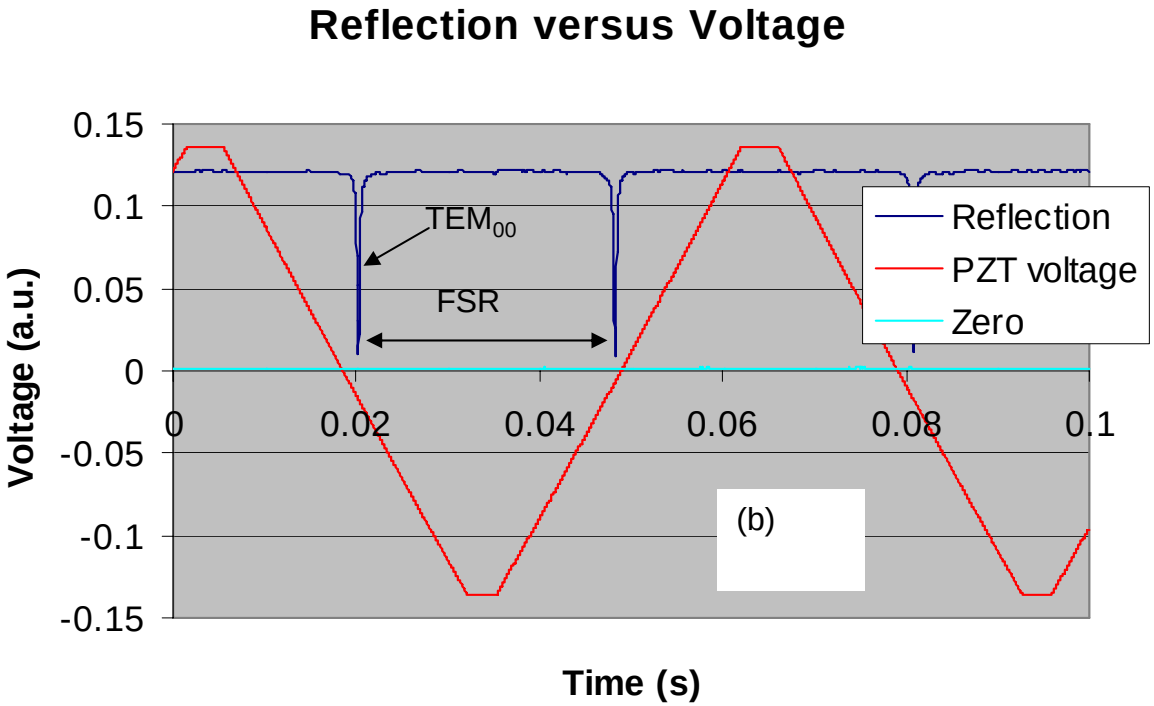
High Power Fiber Amplifier Setup

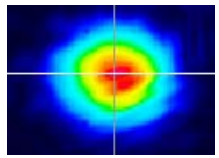




Yb^{3+} doped fiber

High Power Fiber Amplifier Results



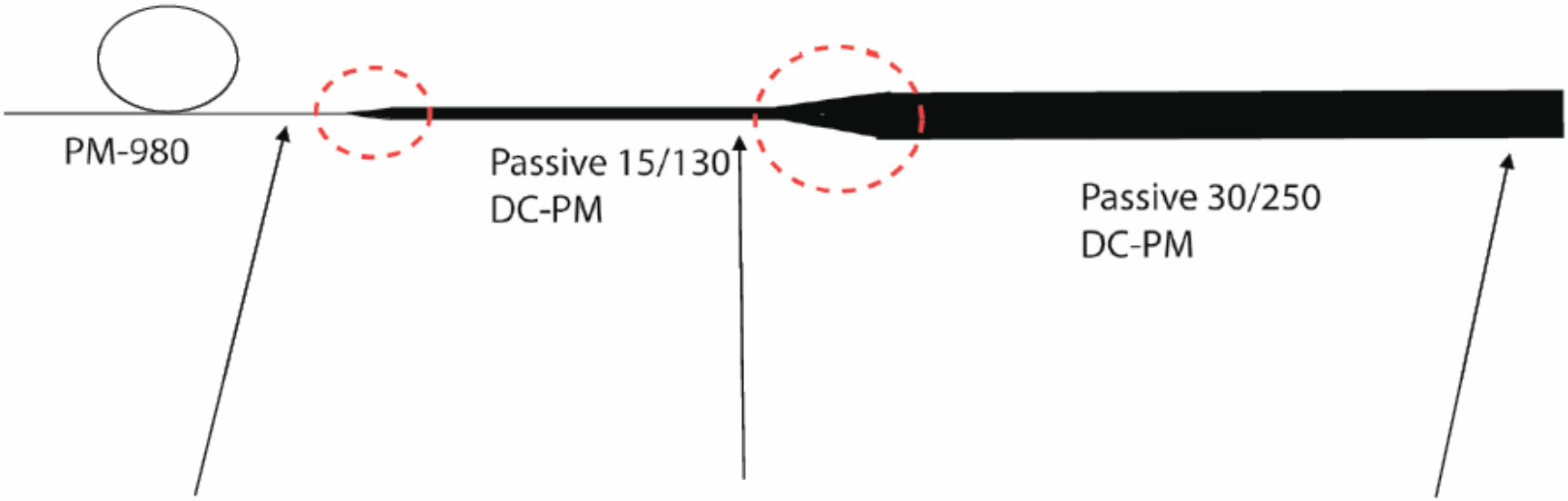


$M^2 < 1.05$

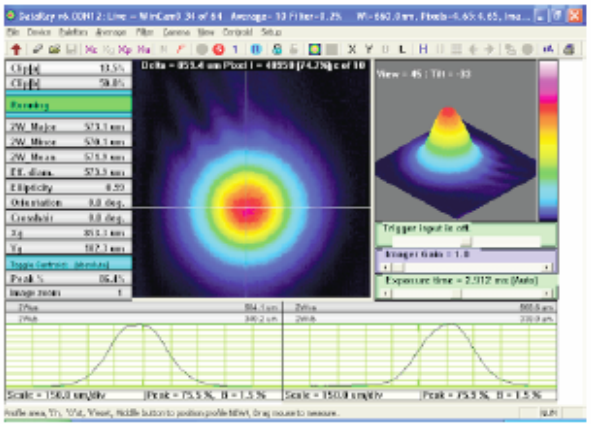
Analysis of mode cleaner reflection spectrum indicates that less than 1.5% of the output power is contained in the higher order modes at 10 W level

136 W of output power achieved **but** state of polarization fluctuates at high powers on the ~5 second timescale

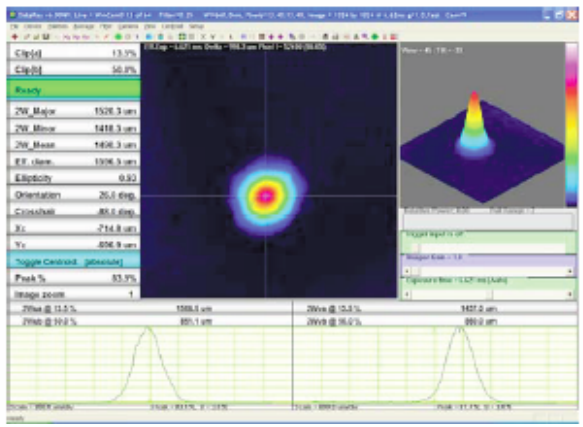
Increasing Reliability – Tapers



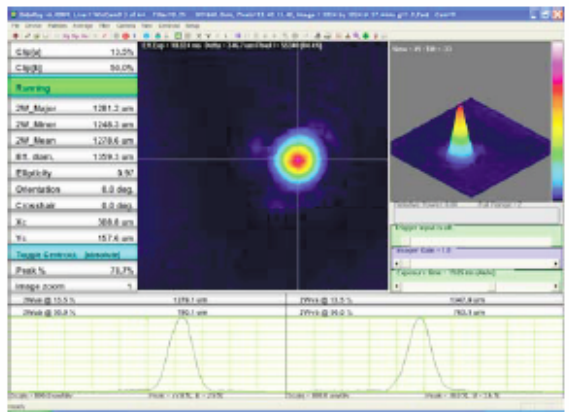
PER = 35 dB



PER = 26 dB

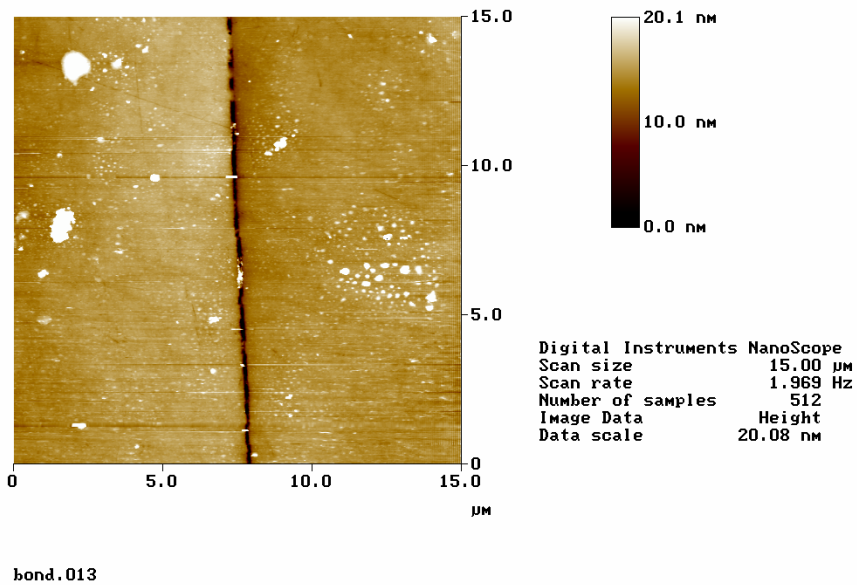


PER = 23 dB

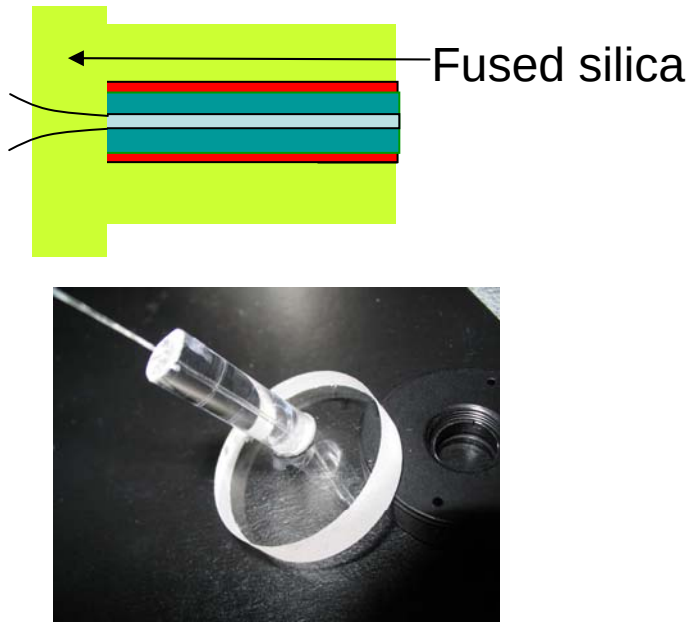


Increasing Reliability -- Silicate Bonding

- No high temperature processes
- Bond is as strong as substrate in silica/silica bonds
- Low optical absorption



Courtesy of Sheila Rowan

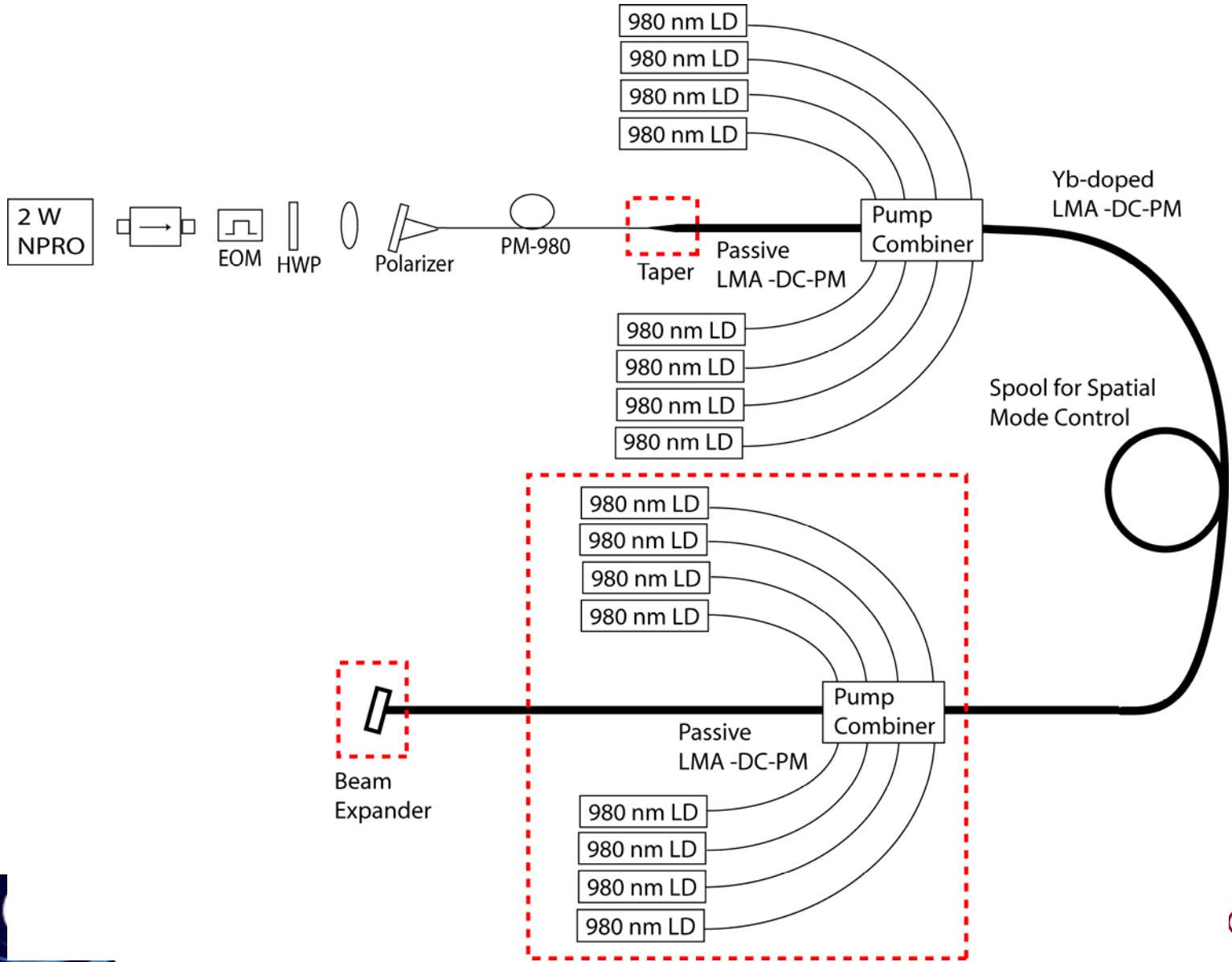


Fiber in capillary bonded to optical flat

Bond reflection below -50 dB.

10-W front end

Vision of the Future



10-W front end

Goals

- ~10 W of power
- Use only SMF
- All integrated source
- Convective cooling
- Power fluctuations of +/- 2% over 40 s
- MTTF > 20000 hours
- Reliable, easy to use

Thus-far

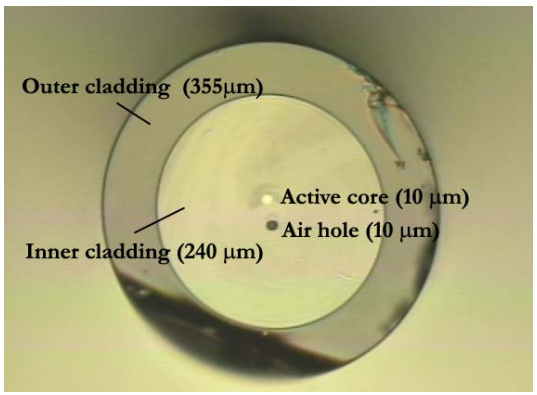
- Built electronics to prevent Q-switching
- Total pump power of 25 W
- Integrated system
- 4.5 W of power with initial fiber

Phosphate fiber sources

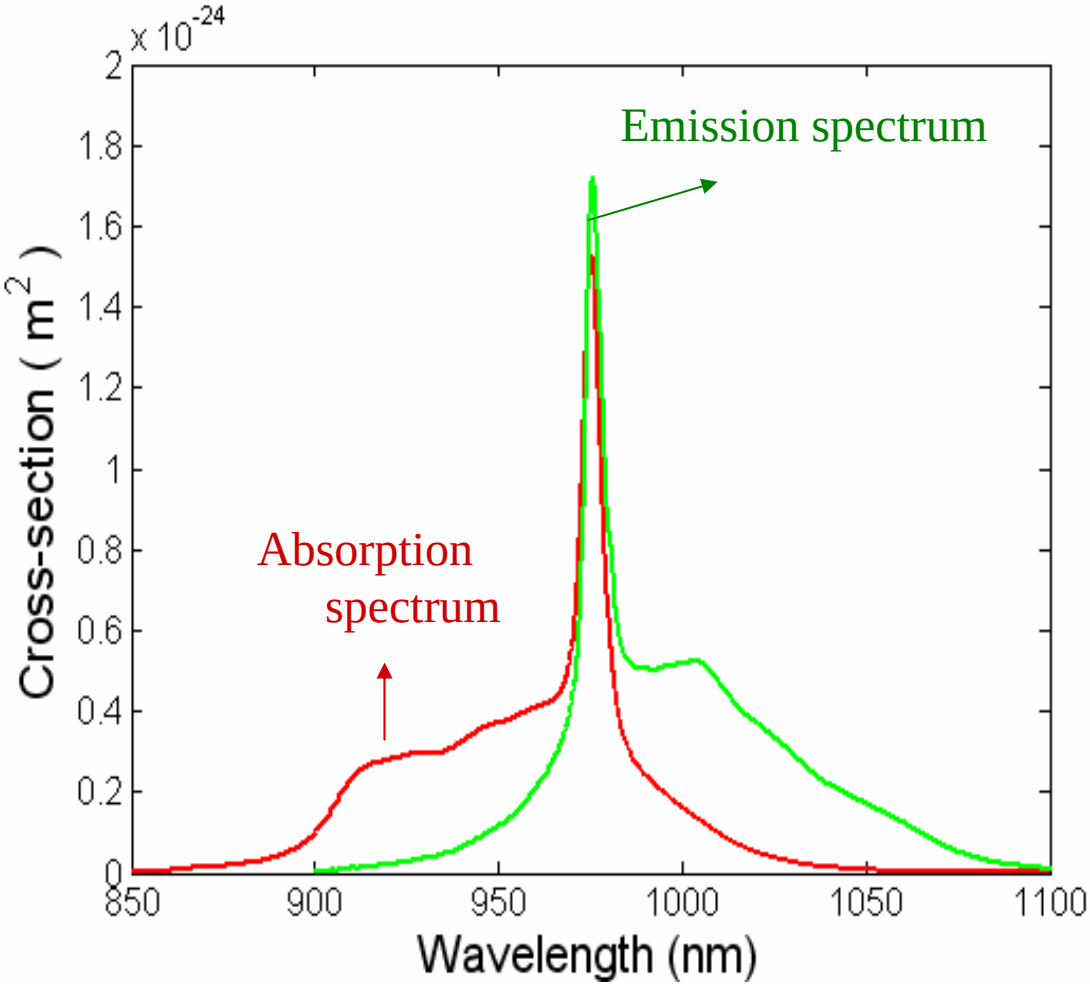
Double-Clad Phosphate Fiber

Fiber fabrication:

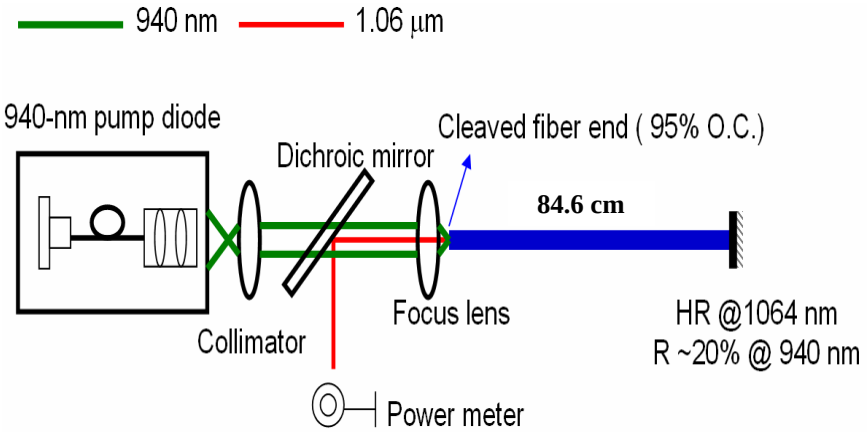
- Rod-in tube technique
- High Al_2O_3 concentration
- Eliminated the alkali ions

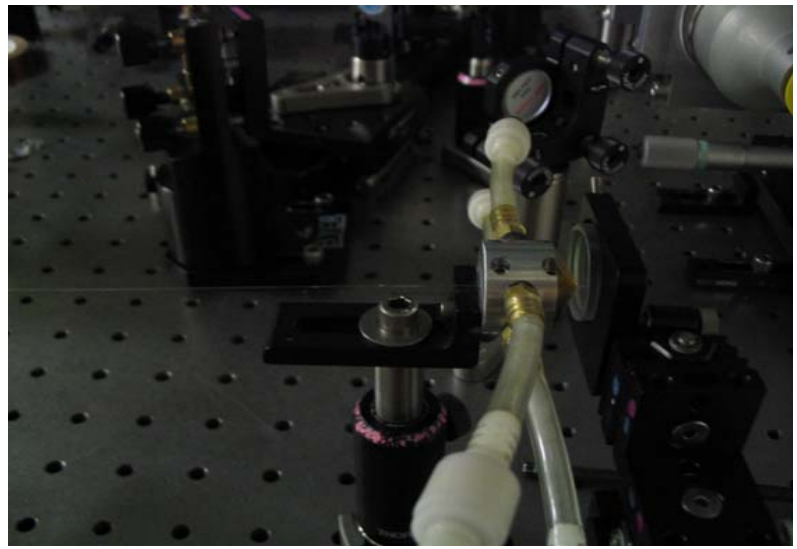


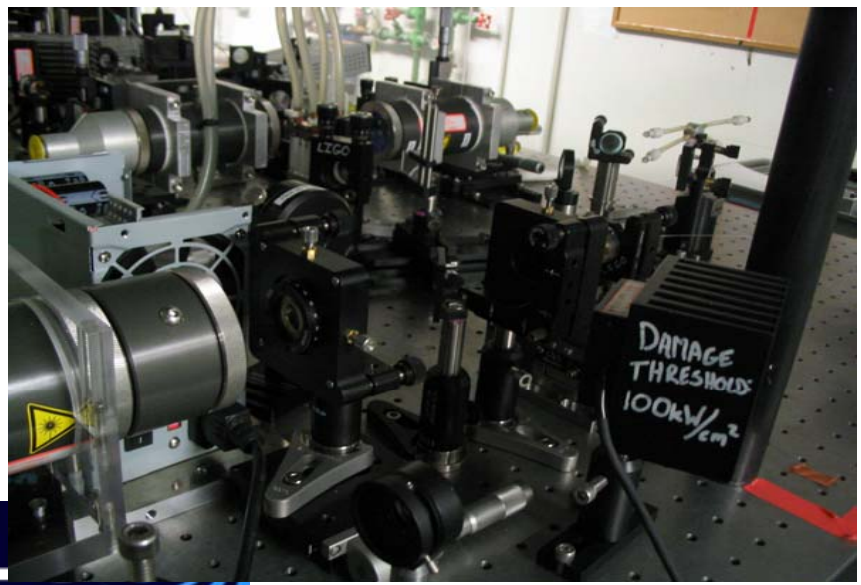
12 wt% of Yb2O3
3-dB/m passive scattering loss



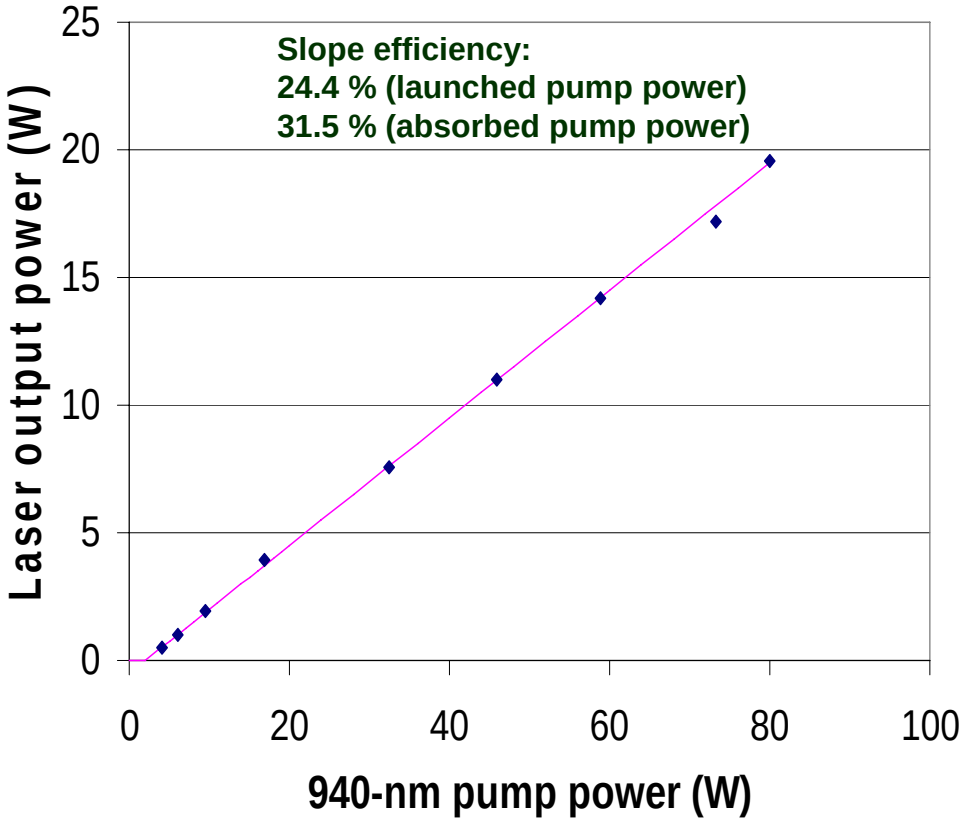
Experimental setup

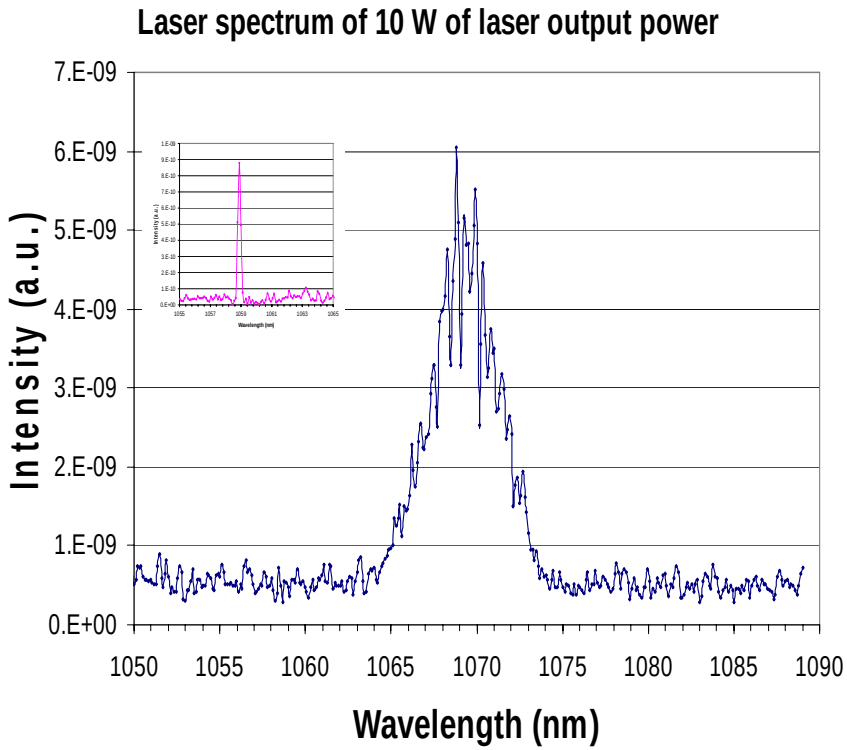






19.5-W Phosphate Fiber Laser (I)





The slope efficiency can be improved by pumping with 975 nm and decreasing the passive propagation on loss

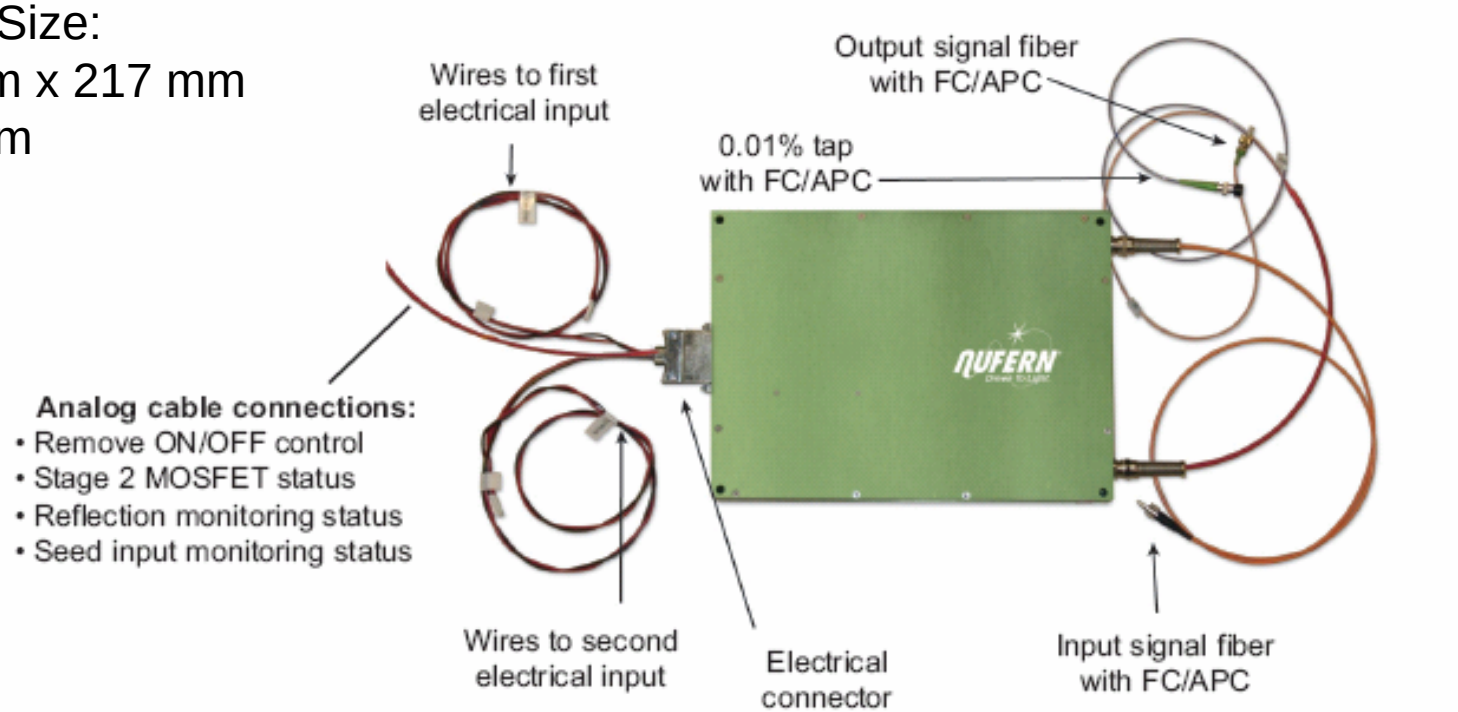
Phosphate prospects

- SBS gain co-efficient looks to be 2x lower than silica (2.34 e-11 m/W)
- Photodarkening threshold appears to be orders of magnitude above silica

Nufern 10-W fiber amplifier characterization

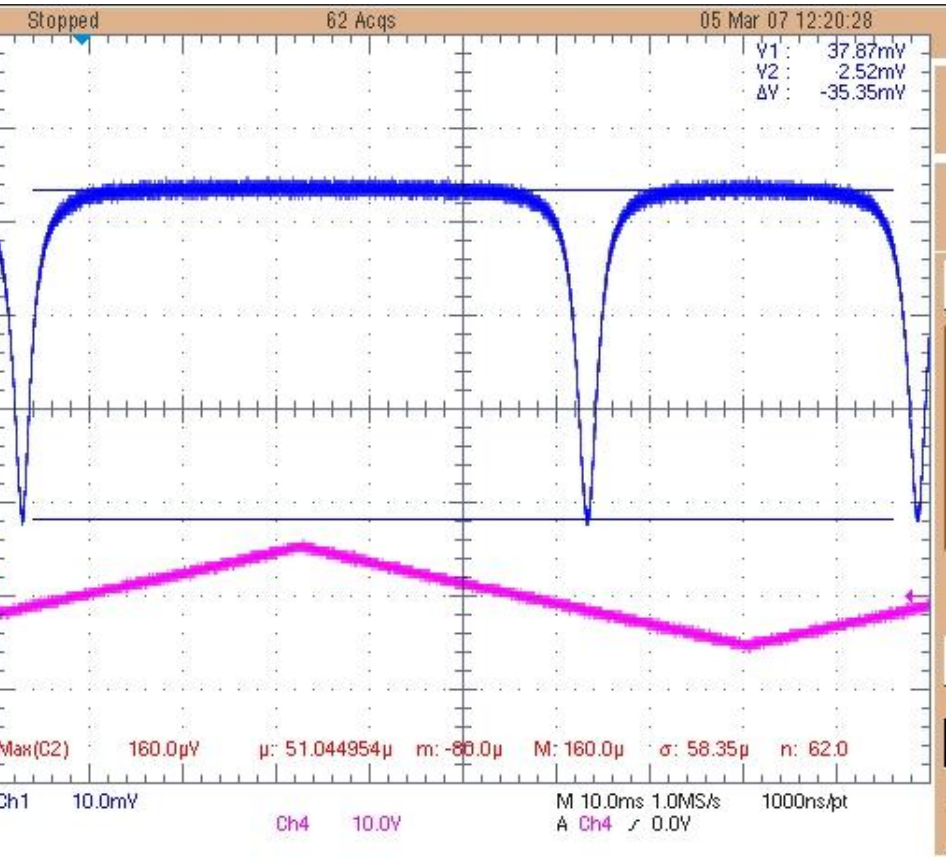
Nufern 10W PM Amp Layout

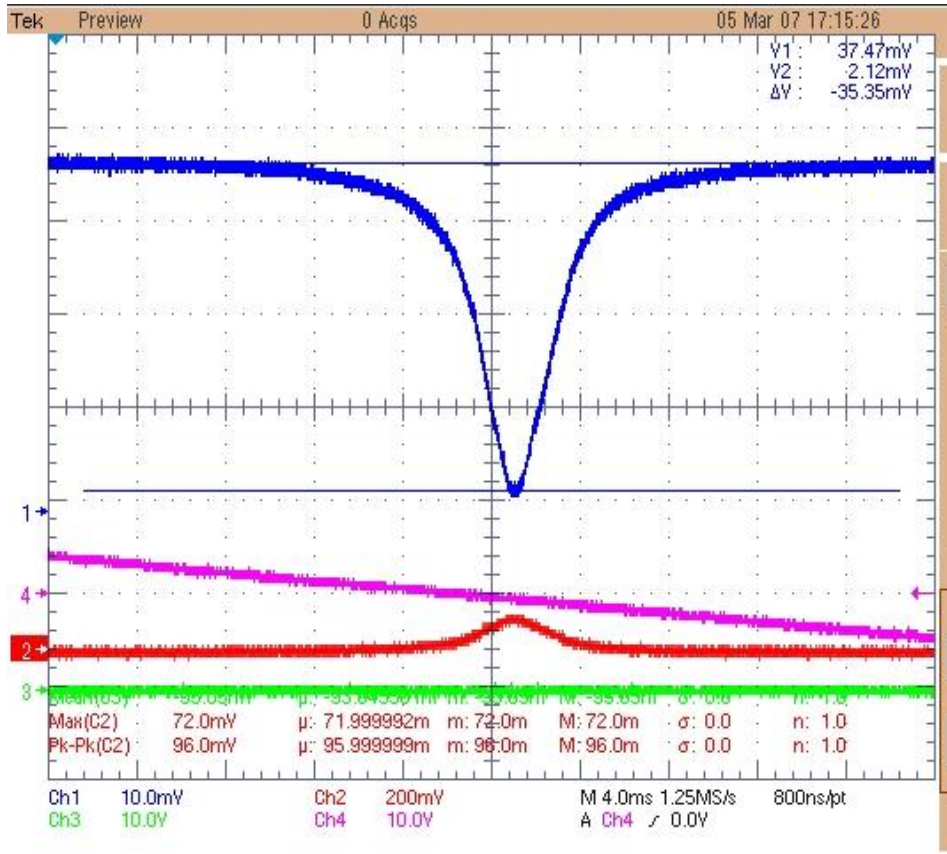
Actual Size:
294 mm x 217 mm
x 50 mm



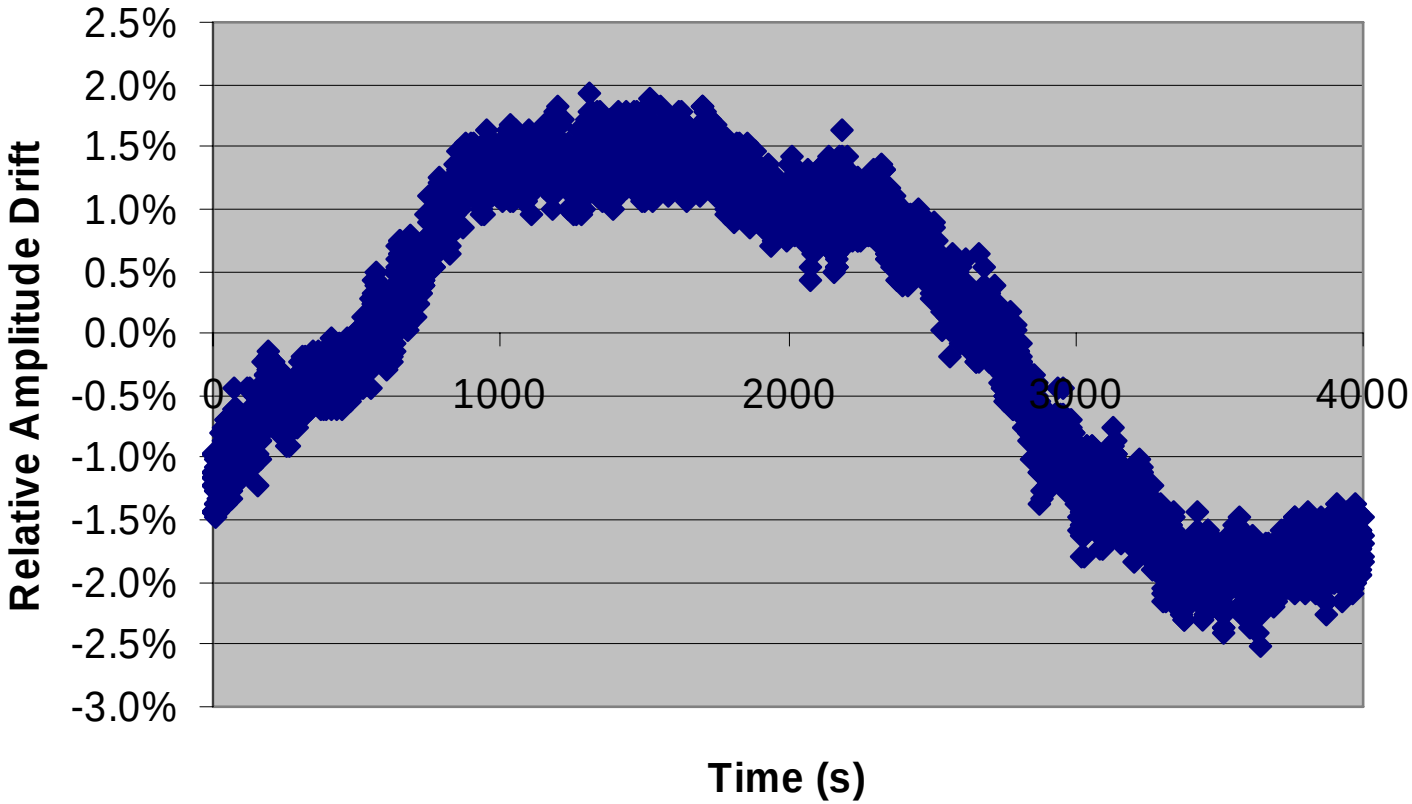
Reprinted from: www.nufern.com/images/sub_assemblies_class/assembly_class_pdf7.pdf

Nufern 10-W Amplifier

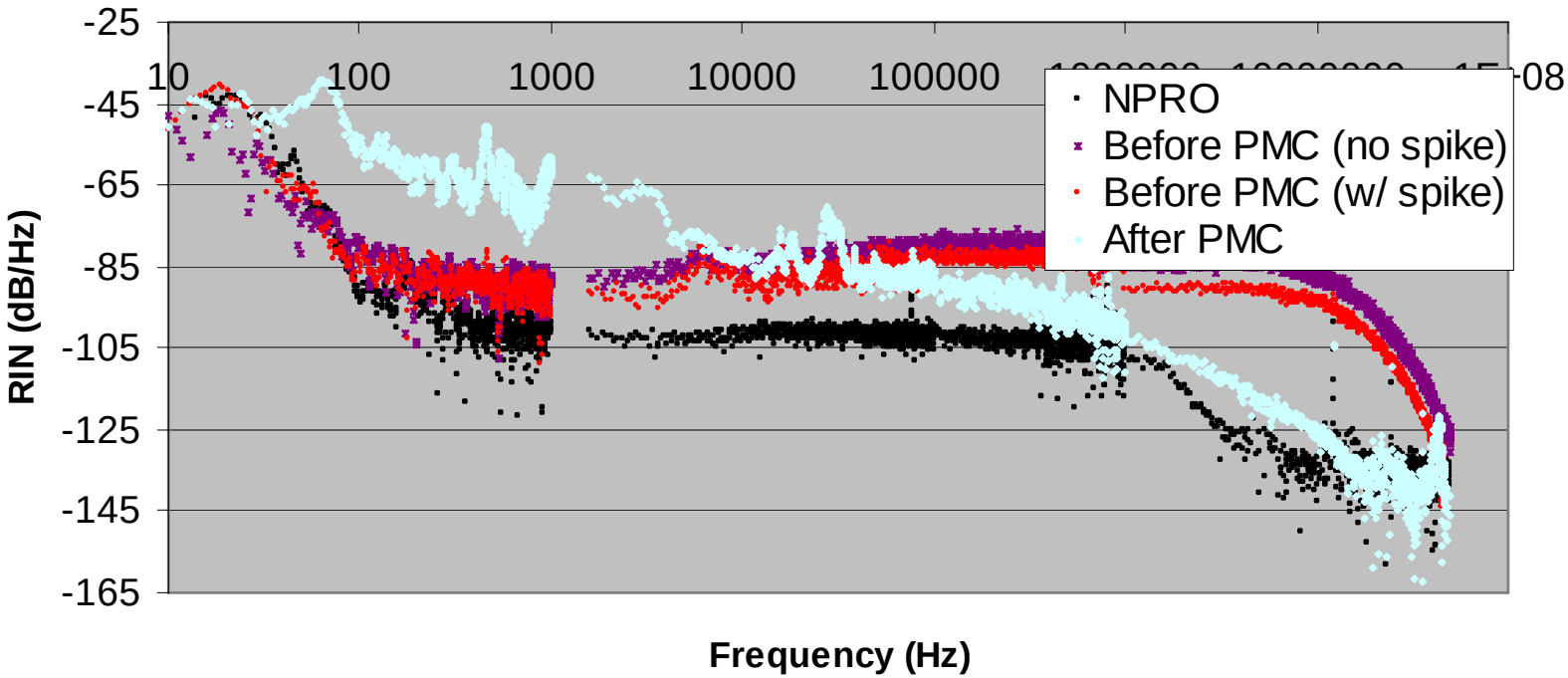




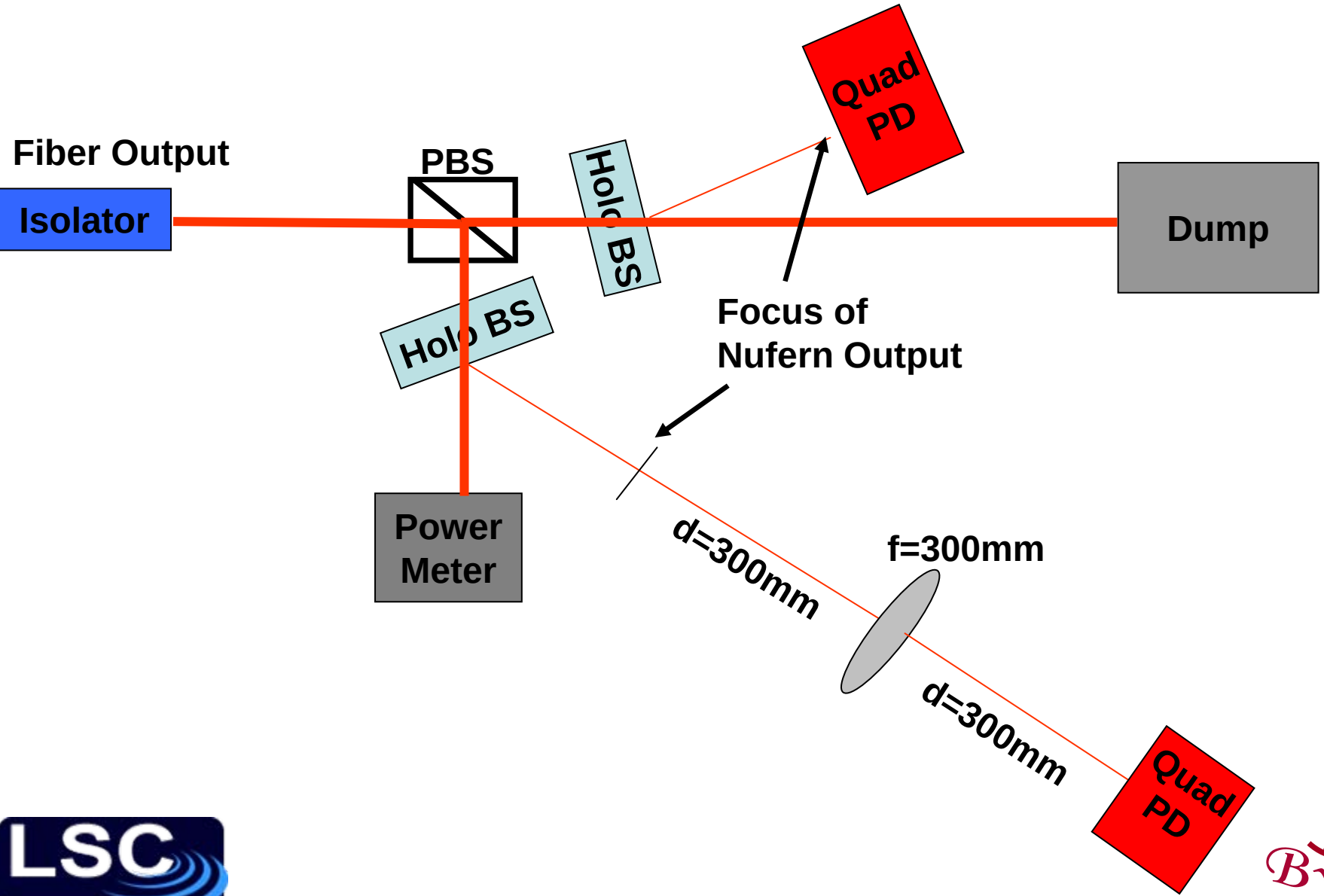
Nufern 10-W Amplifier



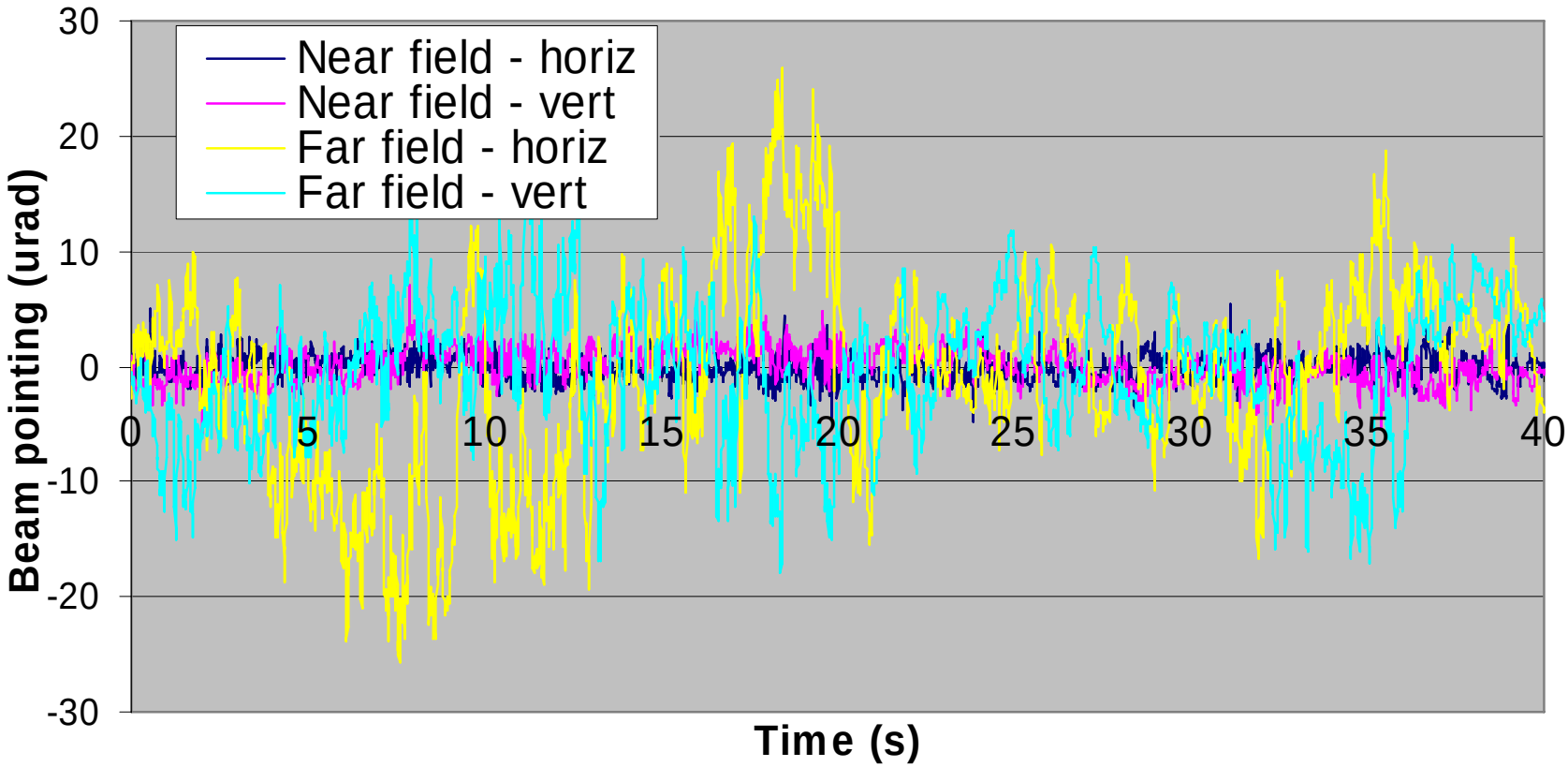
Nufern 10-W Amplifier



Beam pointing measurement setup

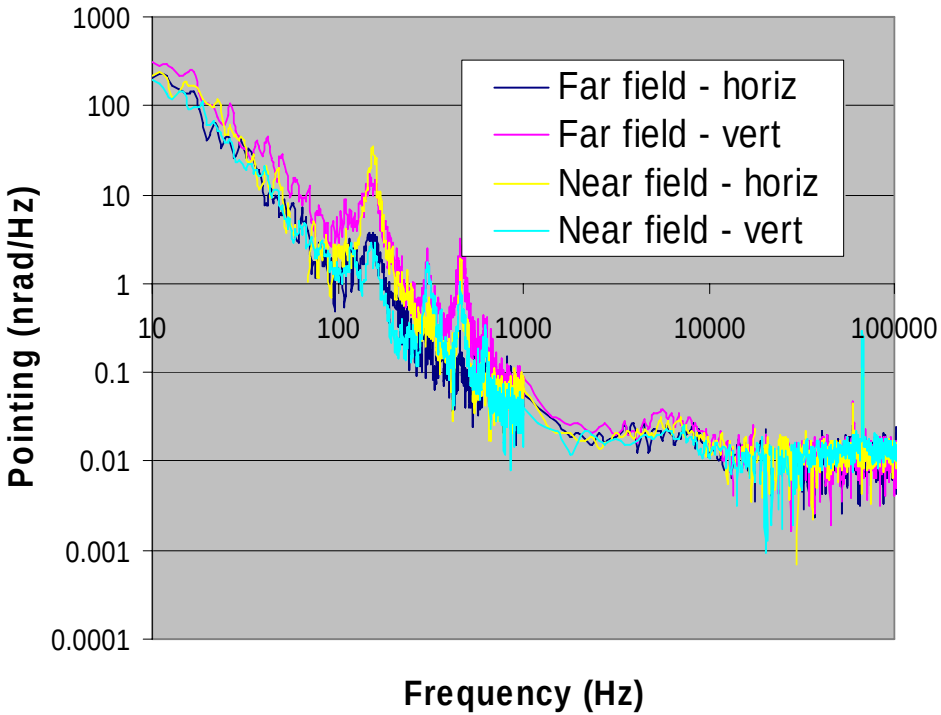


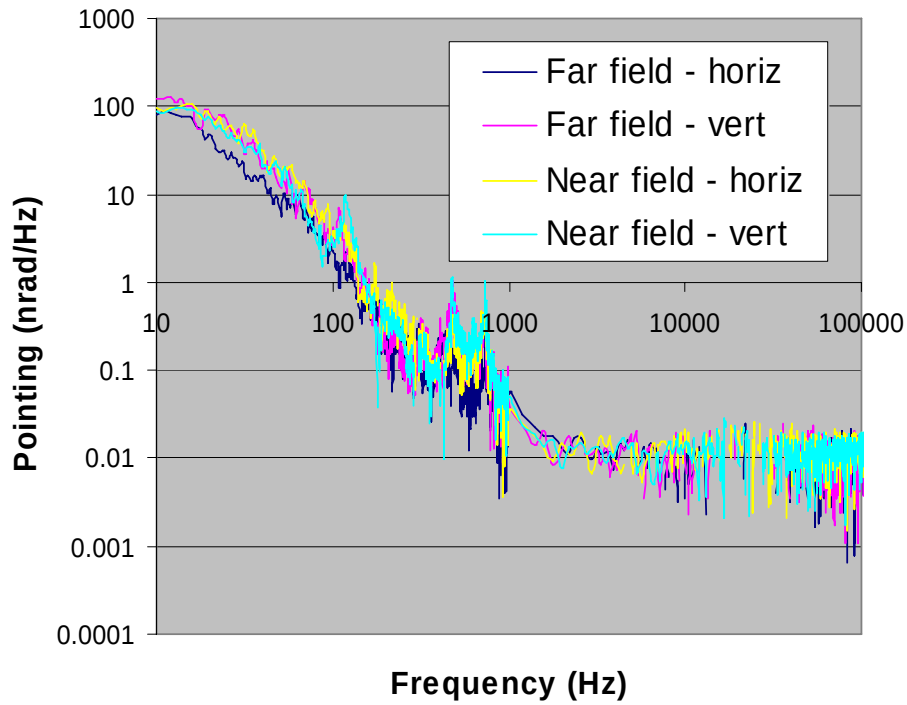
Nufern beam pointing



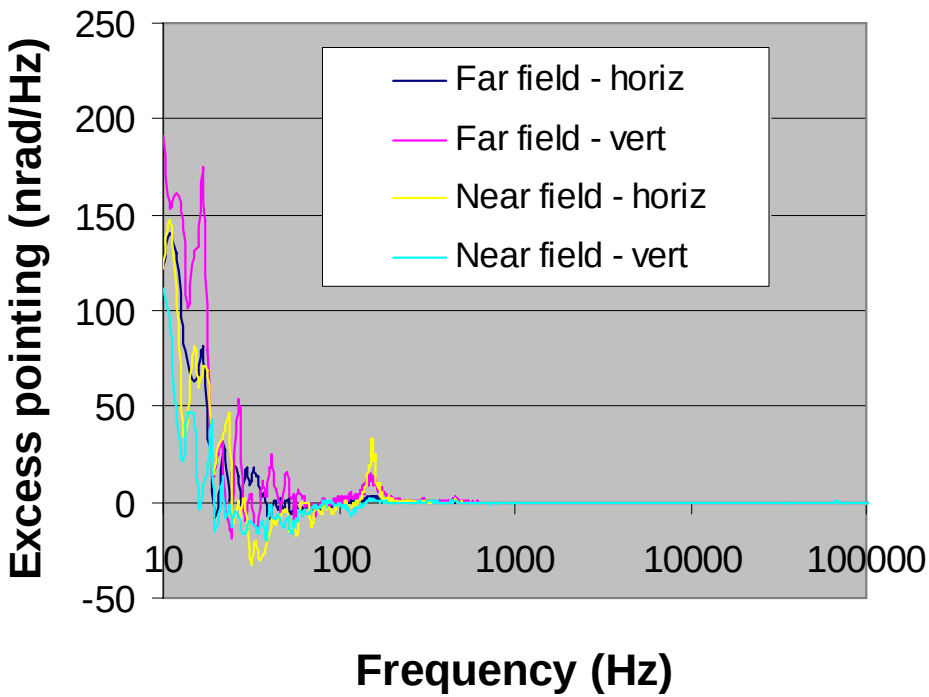
This compares with ±3 μrad over 40 s for 1030 nm SMF-coupled laser source

Nufern 10-W amplifier

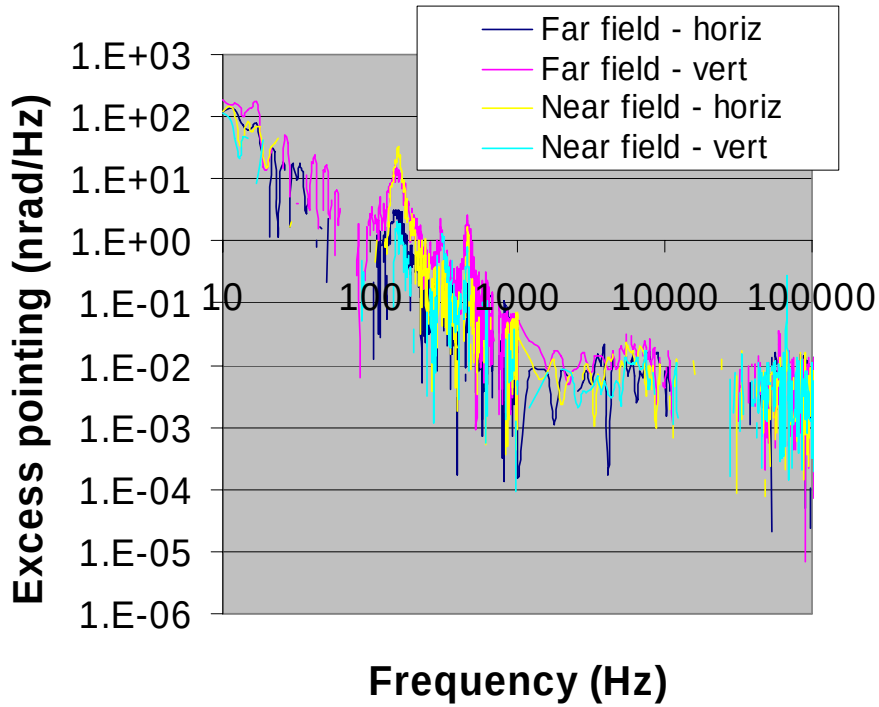




Nufern 10-W Amplifier



Linear scale



Logarithmic scale

Conclusions and Future Work

- 100-W class fiber amplifier will be built and tested this coming year
- 10-W front-end will be built and characterized in the next few months (will enable slab work to continue) and 30-W version will be designed and built this coming year
- 25-W single frequency Yb-doped fiber phosphate amplifier will be built this coming year and scaling to >100 W will be investigated
- Nufern 10-W source was characterized and initial analysis finds it to be acceptable but a true single mode fiber source would be preferable