



Laboratory for Adaptive Optics



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Center for Adaptive Optics**



Purposes of the LAO



- **Develop Adaptive optics techniques for extremely large ground-based telescopes**
- **Develop and build planet finder instrument using “extreme” adaptive optics techniques**
- **Test and evaluate new components/technologies as they become available**
- **Provide a laboratory where students and postdocs can become trained in adaptive optics hardware and software**



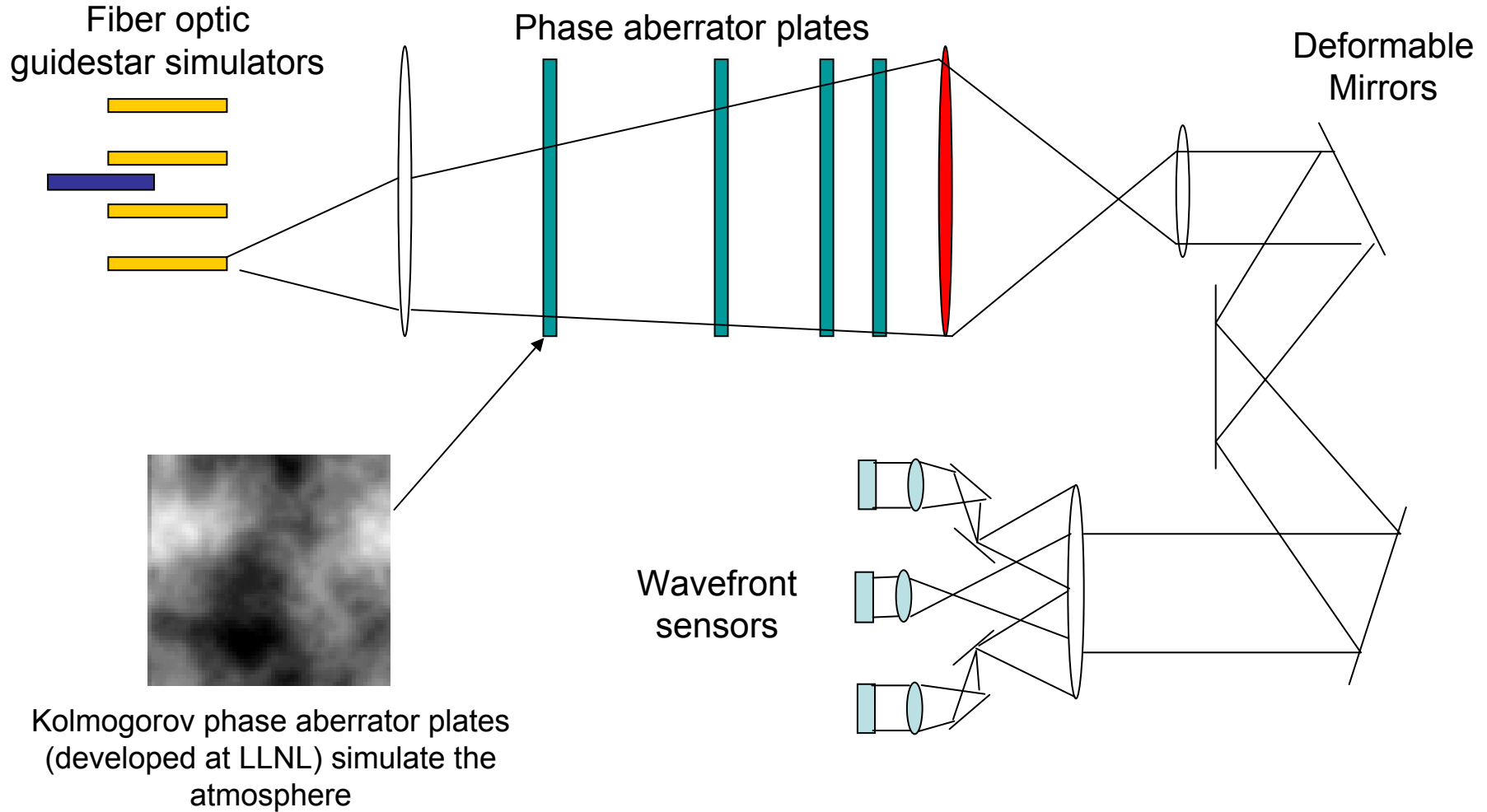
MCAO Lab test configuration and scaling issues



- **Scale 30 m primary and ~40 km of atmosphere onto a lab bench**
- **Laser guidestar simulator, including sodium layer height (elongation)**
- **Atmospheric phase aberrator plates**
- **AO relay**
- **Deformable mirrors – (e.g. liquid crystal SLMs, MEMs)**
- **Wavefront sensors**
- **Allowed to scale time, wavelength ($\lambda = 0.5 \mu$)**



Typical Layout to simulate MCAO





Scaling Diffraction and Scintillation effects from Earth to laboratory scales



The key diffraction parameter: Fresnel number

$$n = \frac{a}{\sqrt{\lambda L}}$$

a ← aperture or subaperture size
 wavelength → $\sqrt{\lambda L}$ ← propagation distance

Determines:

- Raleigh range (geometric/diffractive transition - 'far-field')
- Depth of focus
- Fresnel zone size
- Resolution
- Scintillation variance

Scaling to preserve diffraction (M is transverse magnification from earth to lab scale):

$$a' = Ma \quad L' = M^2 L \frac{\lambda}{\lambda_t}$$

Diffraction-scaling at fixed wavelength preserves the Lagrange invariant:

$$\text{field angle} \rightarrow \theta' = \frac{a'}{L'} = M^{-1}\theta \quad \Xi = \theta'a' = \theta a$$

Not necessarily what we want to do since it may preclude the use of micro mirrors in the testbed => need to compromise on Fresnel number



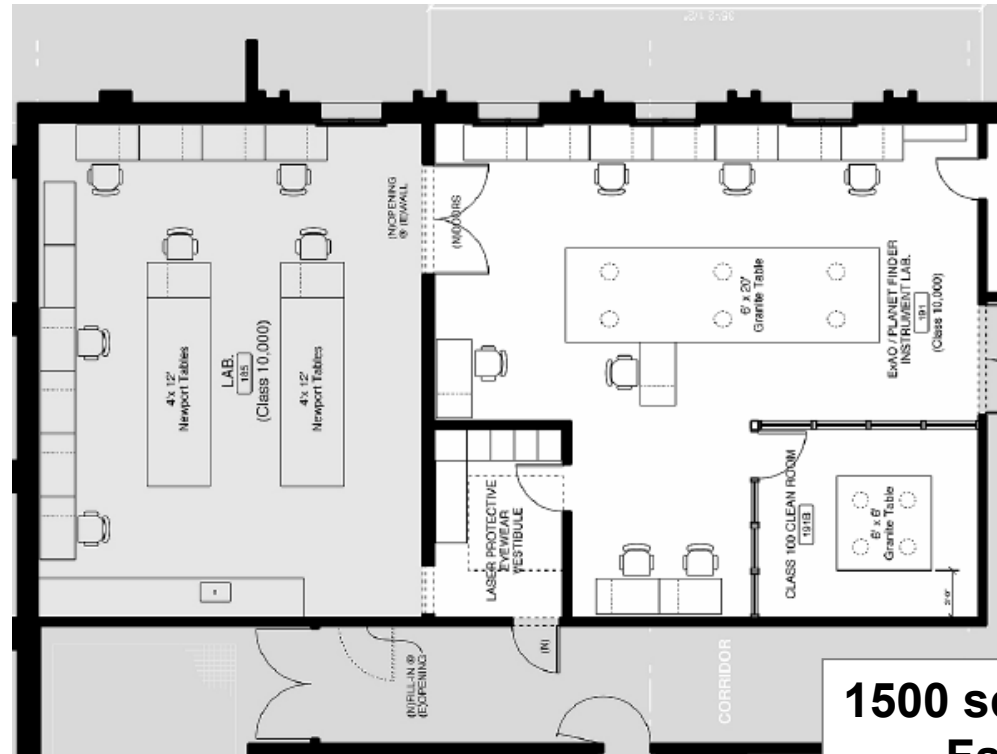
Example lab scaling



	ELT AO system	Laboratory	
Aperture diameter, D	30 m	100 mm	300 x
Atmospheric path, L	15 km	3 m	71 ² x
Wavelength, λ	1 μ	0.5 μ	
Field angle, θ	1'	17'	
Subaperture size, d	30 cm	1 mm	
Coherence cell, $r_0(\lambda)$	46 cm	1.5 mm	
DM size	300 mm	10 mm	
Angle at DM	100'	167' = 2.8 deg	
Fresnel number, $D/(\lambda L)^{1/2}$	245	82	Compromise in Fresnel number
Scintillation variance, $\sigma\chi^2 = 0.288 (\sqrt{\lambda L}/r_0)^{5/3}$	0.03	0.2	
Scintillation Strehl, $\exp(-\sigma\chi^2)$	0.97	0.82	Results in slightly increased scintillation
Equivalent WF err	28 nm	35 nm	



Laboratory for Adaptive Optics at UC Santa Cruz

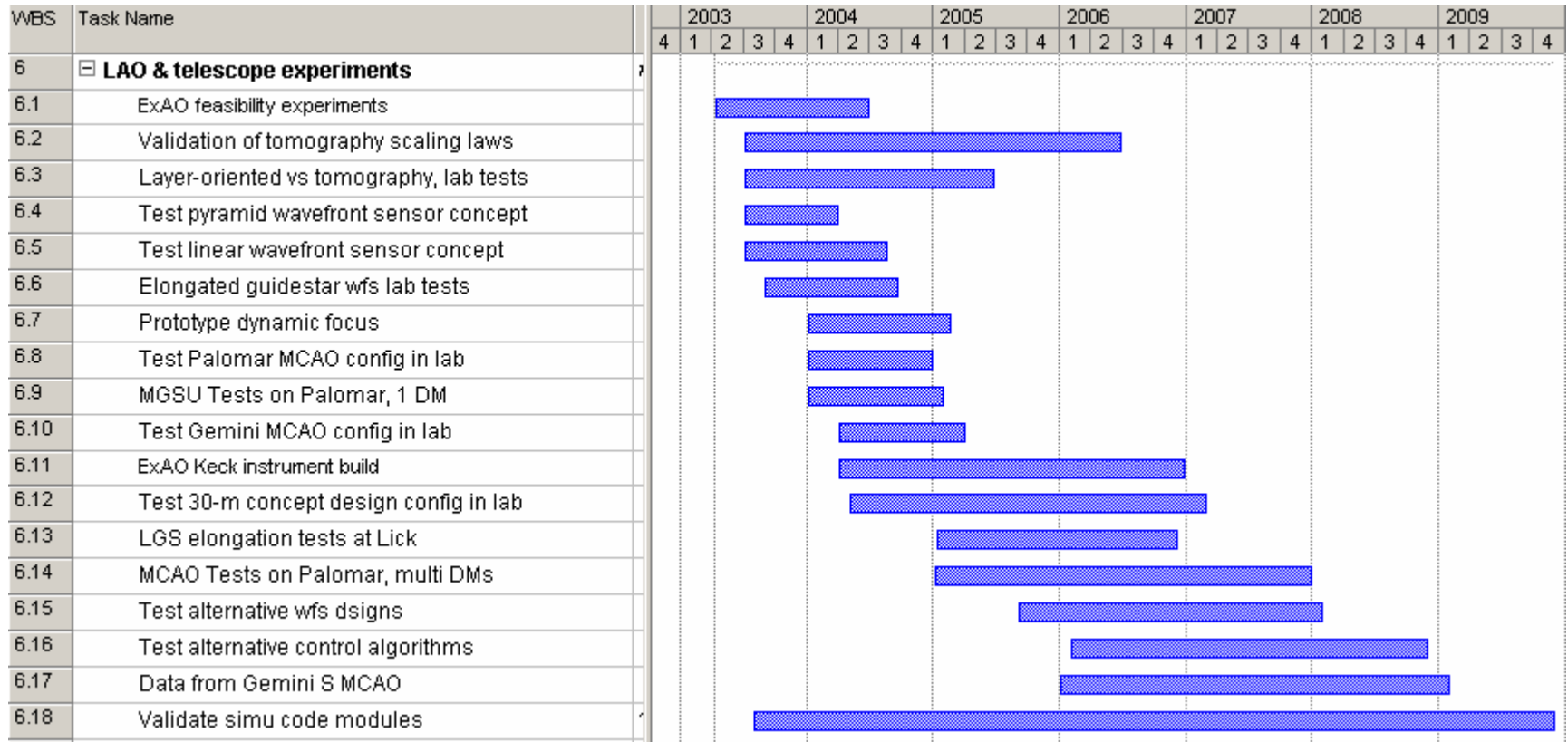


**1500 sq ft Laboratory
Facility Plan**

- **Funded by the Moore Foundation for 5 years**
- **Phase 1 of facility available this summer**
- **Houses both MCAO and ExAO development**
- **Will be used to test new hardware concepts and validate models and simulations**



5 year plan: MCAO experiments planned for LAO





Summary



- LAO will significantly augment CfAO capabilities
- Testbeds for MCAO, ExAO, component testing (e.g. MEMS, new wavefront sensor concepts)
- Place where grad students can get hands-on hardware experience
- Visitor program for CfAO researchers, industrial community, other users
- Will become integral part of UC Observatories after CfAO and LAO grants have ended