

# The UC Center for Adaptive Optics: A proposed new center within the IGPP



**Claire Max**  
**Director, NSF CfAO**  
**October 23rd, 2007**

# Agenda

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**10:00 AM**      **Introductions and statements of interest**

**10:45 AM**      **The CfAO, Past and Future**

    Activities under current NSF funding

    Discussion of potential future roles, including  
    input from “homework assignments”

**11:45 AM**      **Work on proposal for UCOP funding  
(working lunch)**

    Content, budgets, timeline, writing assignments

**1:00 PM**      **Adjourn**

# Introductions and statements of interest

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- Round-table, 2 minutes per person
- Please describe your own CfAO-related interests, and those of others on your campus.
- Future directions for the CfAO: Your favorite 2 things that have been most valuable to you about the CfAO in the past, and two 2 things you would like to see a UC CfAO undertake in the future.
- Later we'll sum up what people have said they are interested in for a UC CfAO.

# Notes

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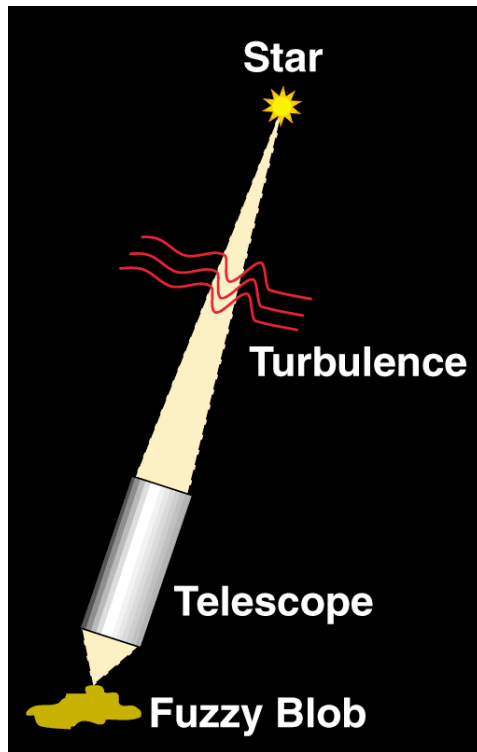
# The CfAO, past and future

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- Activities under current NSF funding
- Discussion of potential future roles

# Turbulence in the atmosphere limits the performance of large ground-based telescopes



- Turbulence is why stars twinkle
- More important for astronomy, turbulence spreads out the light from a star; makes it a blob rather than a point

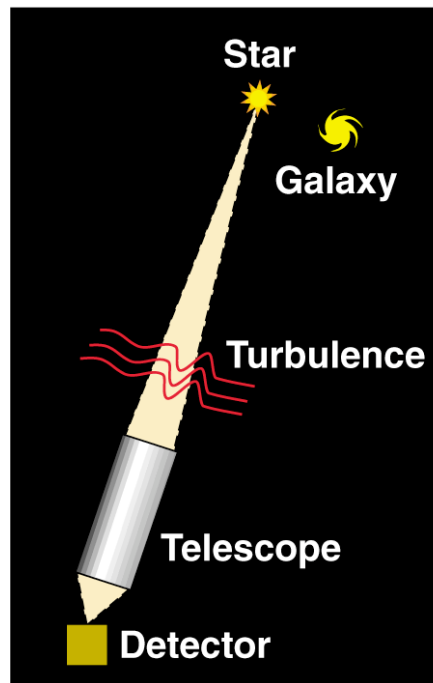
Even the largest ground-based astronomical telescopes have no better resolution than an 8" telescope!

# AO for Astronomy: How to correct for atmospheric blurring



Measure details of blurring from “guide star” near the object you want to observe

(a)



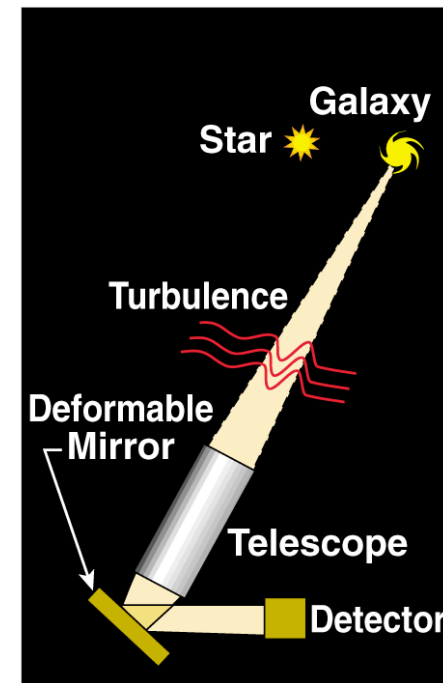
Calculate (on a computer) the shape to apply to deformable mirror to correct blurring

(b)



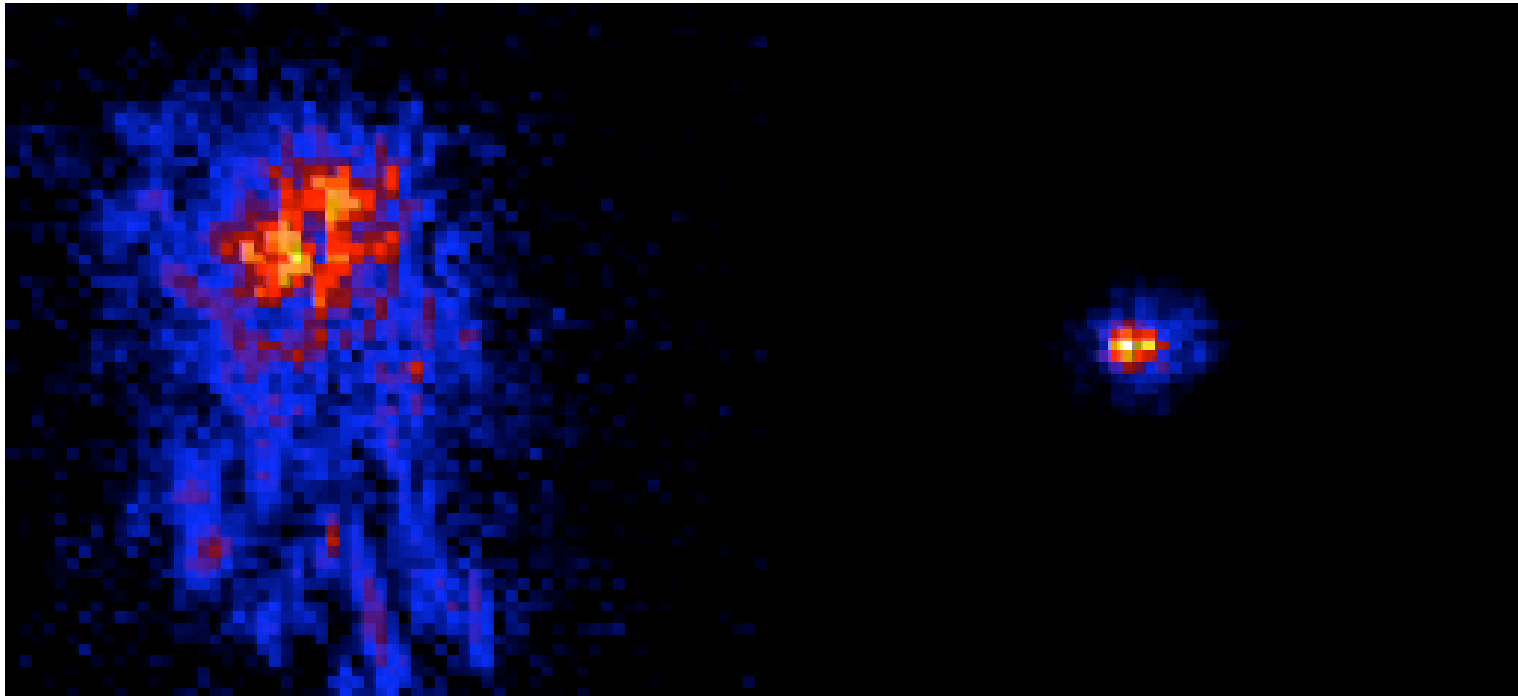
Light from both guide star and astronomical object is reflected from deformable mirror; distortions are removed

(c)



# Infra-red images of a star, from Lick Observatory adaptive optics system

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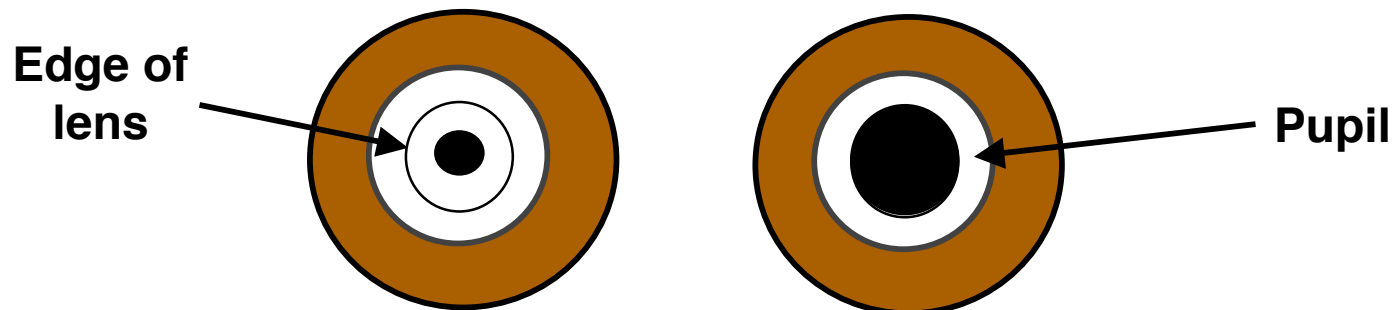
No adaptive optics

With adaptive optics

## Why is adaptive optics needed for the human eye?



- Around edges of lens and cornea, imperfections cause distortion
- In bright light, pupil is much smaller than size of lens, so distortions don't matter much
- But when pupil is large, incoming light passes through the distorted regions



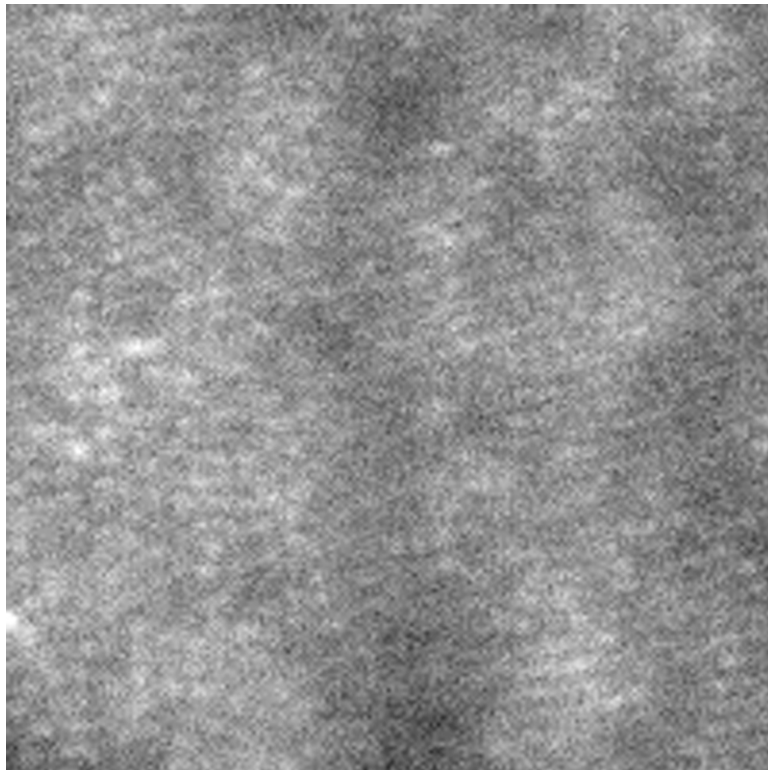
- Results: Poorer night vision (flares, halos around streetlights). Can't image the retina very clearly (for medical applications)

# AO yields a major improvement in retinal imaging

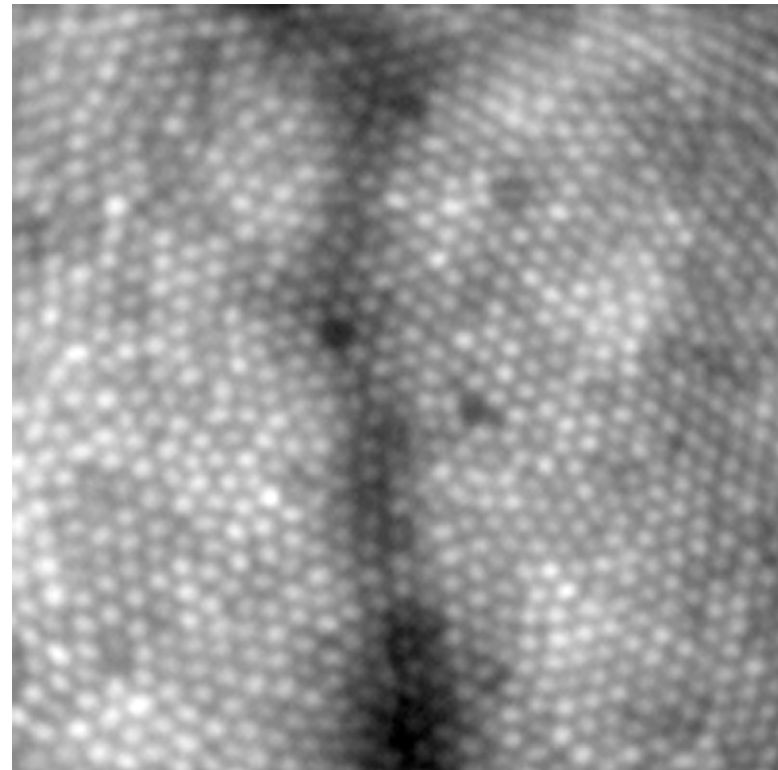
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Without AO



With AO: resolve individual cones



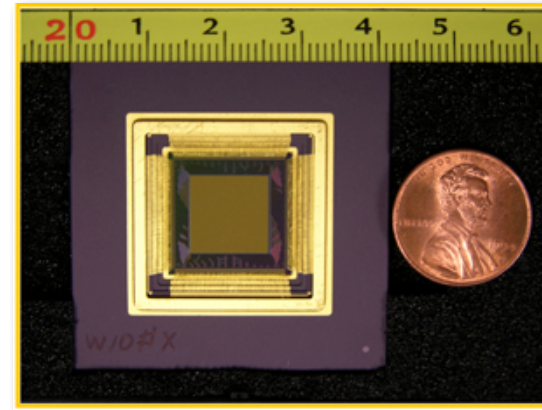
Prof Austin Roorda, UC Berkeley

# AO for vision science is a direct spin-off of AO for astronomy

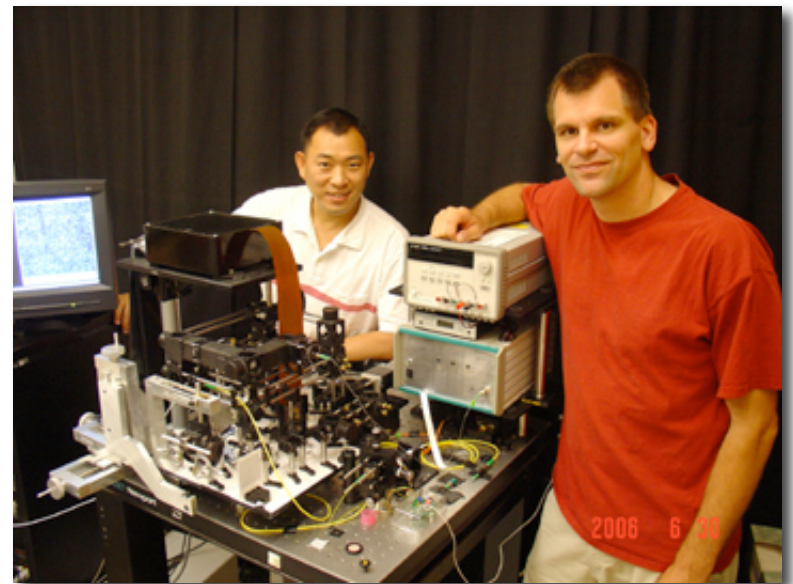
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- Components are being developed jointly
- System optimization for vision is being done with the help of the astronomers
- As result of CfAO, number of UC vision science AO labs went from zero to three, with more on the way



Micro deformable mirrors



Roorda lab, UC Berkeley

# CfAO is a National Science Foundation “Science and Technology Center”

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- Embark upon long-term, multi-disciplinary science and technology research
  - Funded for 10 years (Nov 1999 - Nov 2009)
- Explore more effective ways to educate students
  - Innovative education programs, integrated with research
- Develop mechanisms to ensure timely transition of research and education advances into service to society

# The CfAO Today

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- Adaptive optics for astronomy and vision science
  - Factor of 50 improvement in astro spatial resolution on Keck Telescopes
  - Imaging the living human retina
- A dozen each: universities, labs and research institutes, industrial associates
- Headquarters at UCSC
- CfAO Themes:
  1. Education
  2. AO for Extremely Large Telescopes
  3. Extreme AO for Planet-finding
  4. AO for Vision Science

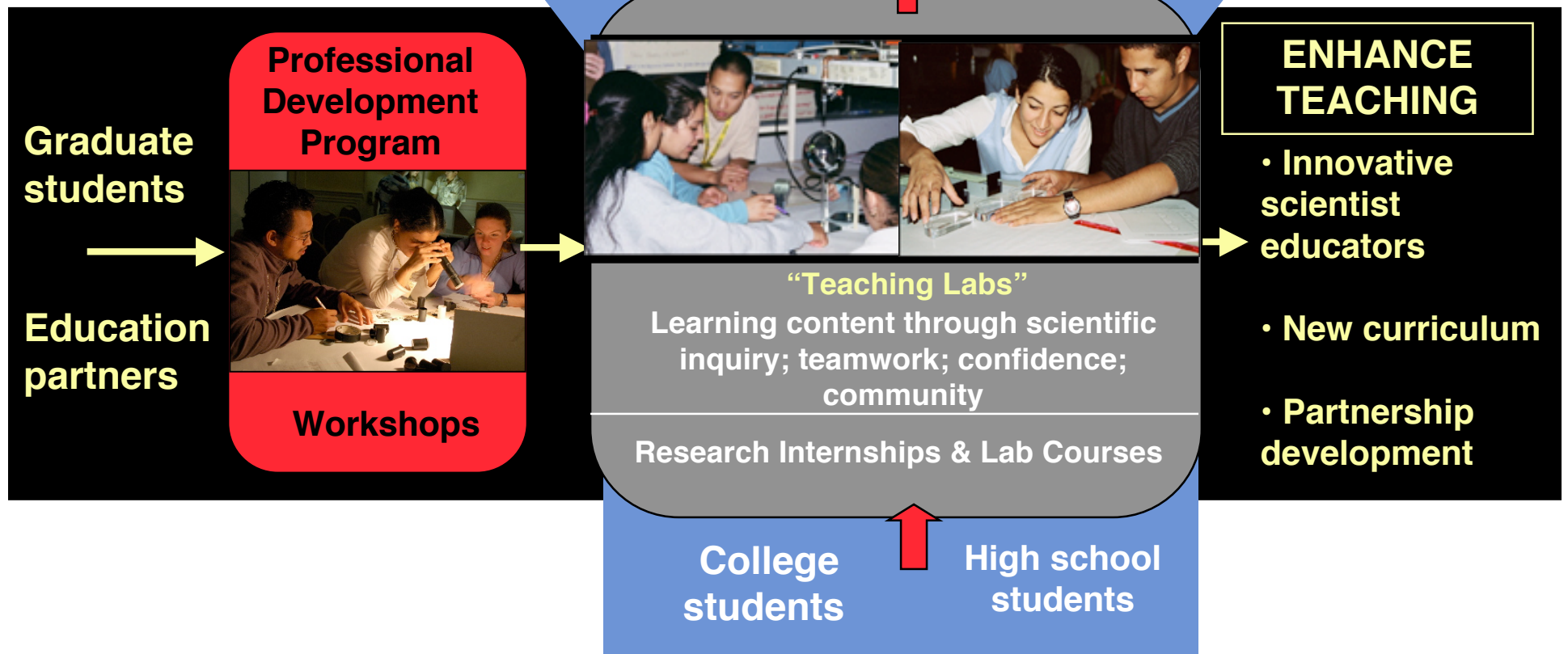
# Theme 1: Education

## Two Integrated Strands Serving UC and Hawaii



### INCREASE DIVERISTY IN CfAO FIELDS

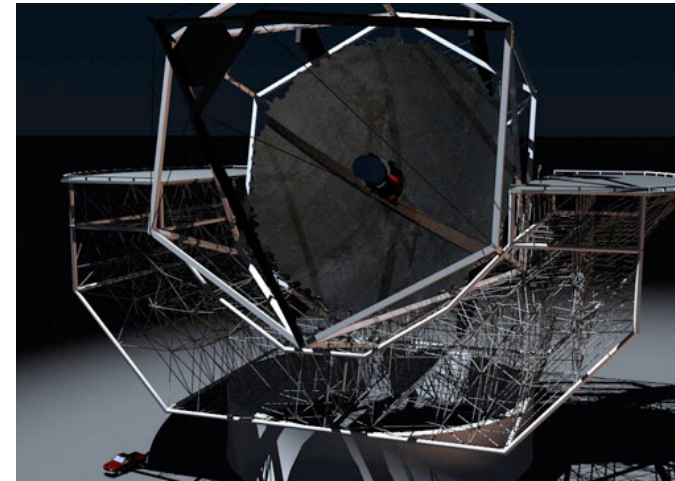
- Research and/or technician experience
- Confidence, sense of belonging, access



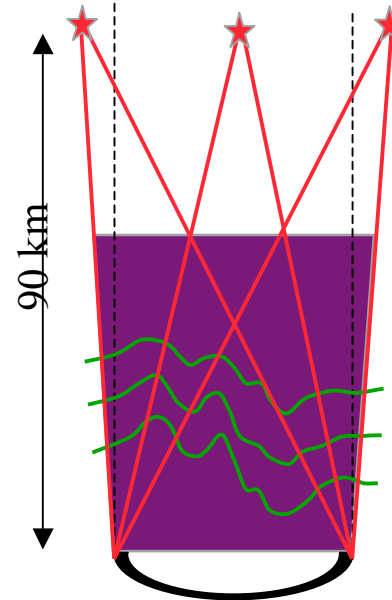
## Theme 2: AO for the next generation of Extremely Large Telescopes



- Thirty Meter Telescope project (UC, Caltech, Canada)
- Giant Magellan Telescope
- Others



- Use multiple laser guide stars to measure turbulence throughout the whole cylinder of air above the telescope (tomography)



# Theme 3: “Extreme AO” to image planets around nearby stars

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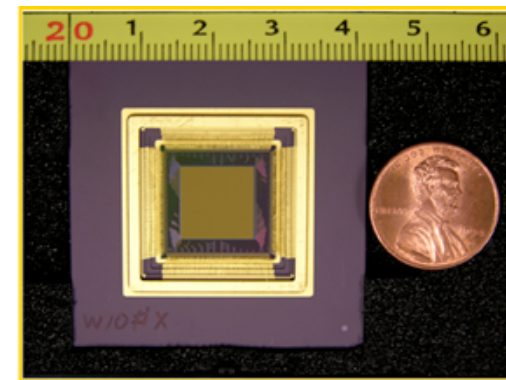
- More than 200 solar systems have been discovered (largely by UC astronomers)
- Goal now is to image their planets
- CfAO developed concept for “Gemini Planet Imager”
- Now funded by Gemini Observatory (\$24M total)
- CfAO: basic science and AO technology needed; planning for big survey once GPI is complete



# CfAO has pioneered use of MEMS deformable mirrors for adaptive optics systems



- Now used in several vision systems
- For Astro: Currently testing 1000 actuator MEMS deformable mirrors
- Awaiting delivery of a 4000 actuator device
- Prof. Joel Kubby (UCSC) is pursuing new MEMS higher-stroke concepts
- UCO/Lick “VILLAGES” expt: testing MEMS on telescope



32x32 actuator MEMS DM  
(Boston Micromachines Corp)



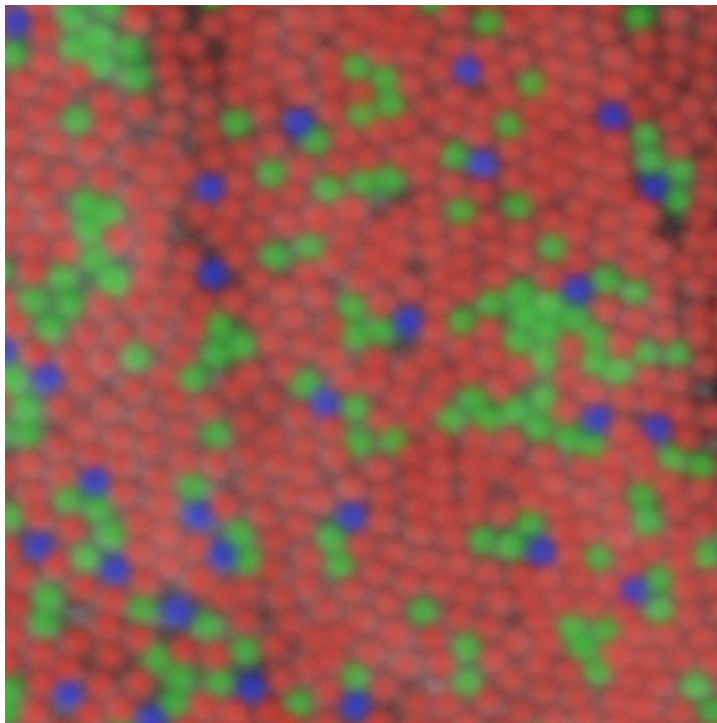
MEMS electrostatic actuator concept  
(Tom Bifano, BMC)

# AO's impact on studies of color vision

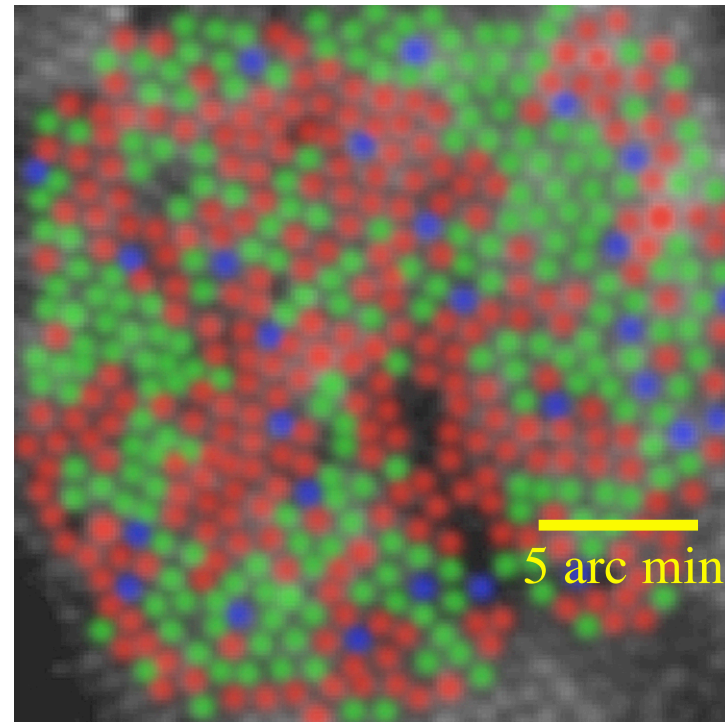
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Person number 1



Person number 2



Note how different cone patterns are in 2 different people!  
Both have “normal” color vision.

# CfAO Has Spawned 12 Vision Science AO Instruments

## Vision Correction



Rochester AO  
Ophthalmoscope I

## Retinal Imaging

Pre-CfAO

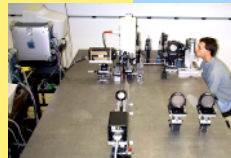
CfAO  
begins



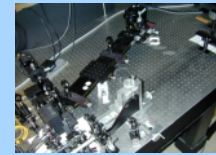
LLNL/Rochester  
MEMS AO  
Phoropter



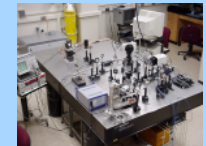
LLNL/Davis LC  
AO Phoropter



Rochester AO  
Ophthalmoscope II

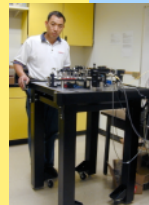


Houston AO  
Scanning Laser  
Ophthalmoscope



Indiana AO  
Coherence-Gated  
Camera

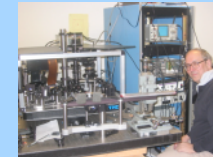
Bioengineering Research  
Partnerships begin



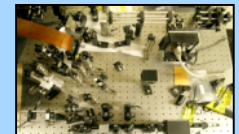
Berkeley AOSLO



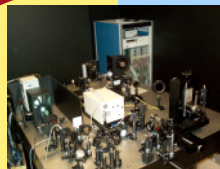
Rochester AOSLO



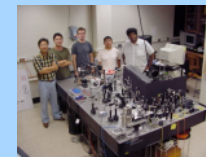
Indiana AOSLO



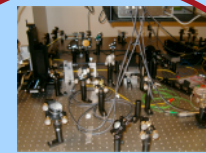
LLNL AOSLO



Davis/LLNL  
AO Ophthalmoscope

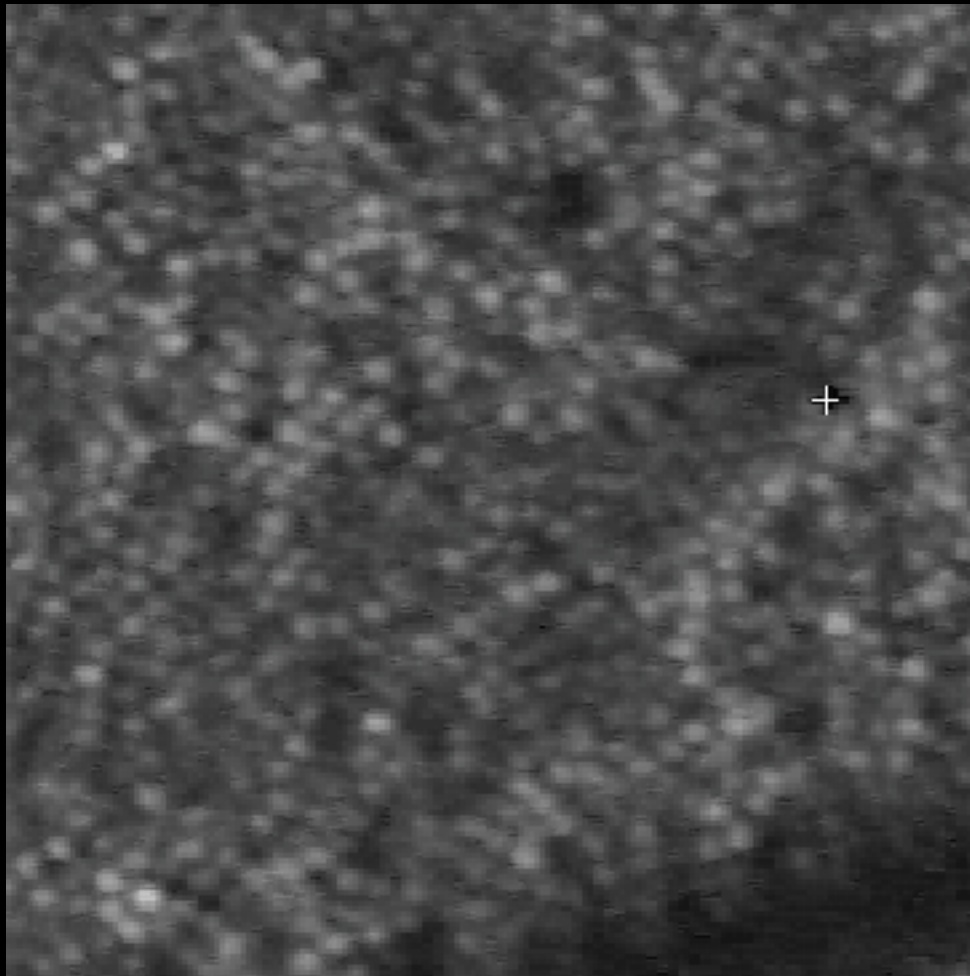


Indiana  
Spectral AO OCT



Davis/LLNL  
AO OCT

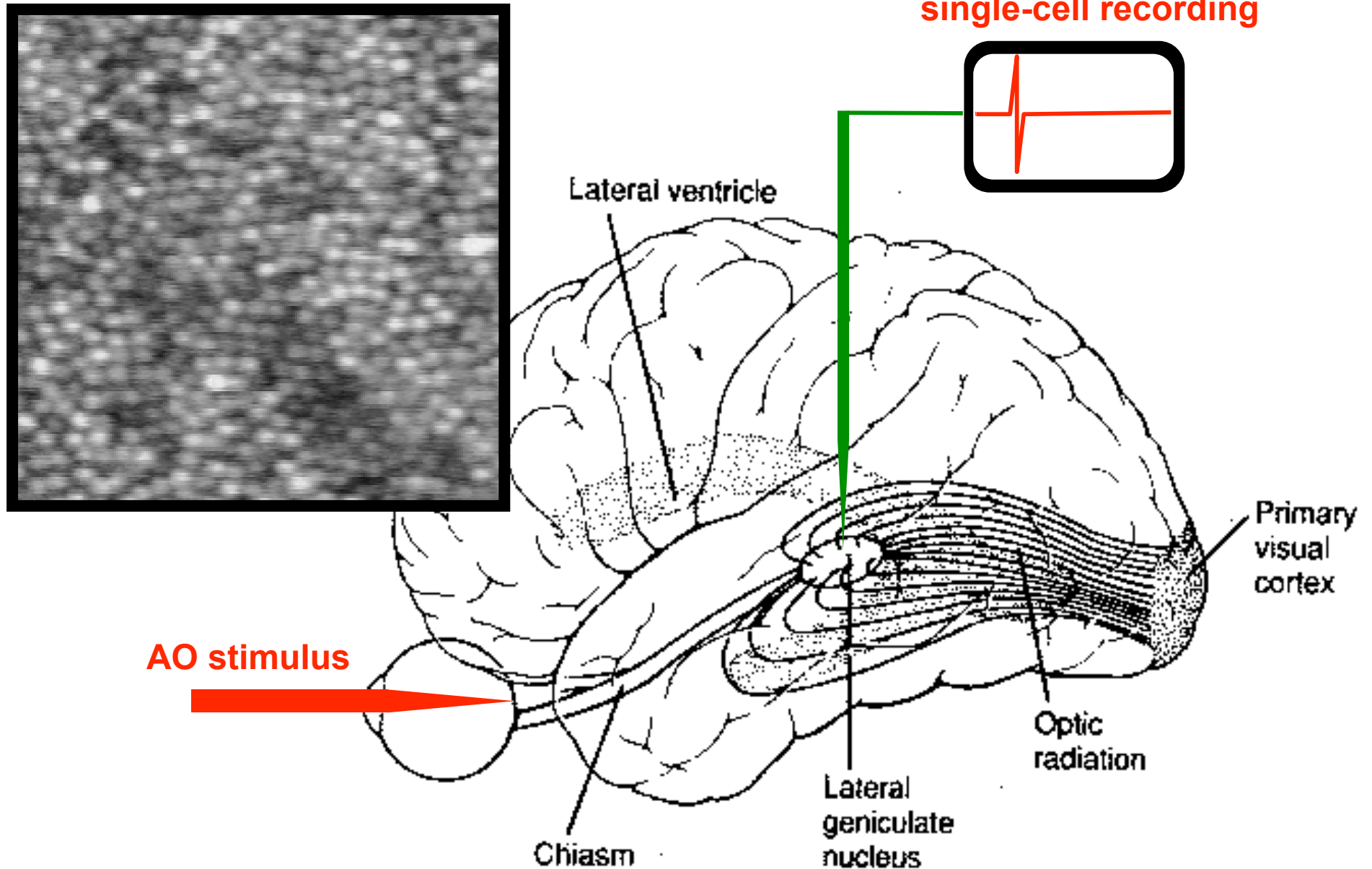
# AOSLO - Stabilized Stimulus Delivery



human subject - raw video - stabilized stimulus

# Stabilized Stimulus Delivery and Electrophysiology

macaque – stabilized movie & stimulus



# Potential future roles for UC CfAO

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- **Survey of our membership:**
  - PIs anticipate that they will be able to bring in external research funds for hardware and software development
  - **Key area of “value added” for CfAO: creating a flourishing *research community*.**
- **Survey of our graduate students:**
  - Strong enthusiasm for our education programs, which we plan to continue past the end of NSF STC funding
  - Clear desire for “professional development” activities:
    - **Program aimed at developing skills such as communication, proposal writing, planning career options, and leadership for grad students**

# What should future role of CfAO be?

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- Input from “homework assignments”
- Questions posed to breakout groups
- Report back

## Direct quote: themes that were repeated again and again

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- “CfAO has been a great success!!!! The things that are most striking to me are that it provides a great learning center for grads/postdoc/faculty in a new area of research. This gives students an opportunity they would never get at a single campus as each campus brings its own unique set skills/expertise/faculty. The cross-fertilization has been a tremendous asset. It helps recruit graduate students and faculty.”

# Input from “homework assignments”

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- Broad consensus on most valuable thing in NSF CfAO: holding retreats and workshops, creating “AO Community”
- Need for a UC “critical mass” in AO
- Continue to facilitate communication and collaboration in the AO community
- CfAO Summer Schools: “I’ll keep sending my new grad students year after year”
- Tutorial workshops on astronomical AO observing and data reduction techniques
- Recruiting of new top notch grad students:
  - “I would like CfAO to help my campus recruit and train grad students by fostering collaborations at a multicampus level”

# Input from “homework assignments” cont’d

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- “Mobility funds” (an EU concept) for grad students to visit other campuses and labs (weeks to months)
- Cross-field sharing of ideas:
  - “In my limited contact with CfAO I have been impressed to see how effectively insights about challenging conceptual and technical problems can be shared between investigators whose particular applications may be very different.”
- Coordination of software development
- Help CfAO members find new external funding
- Establish a UC-wide Laboratory for Ophthalmic Adaptive Optics (LOAO)
  - Start with common software, move on to hardware lab

## Input from “homework assignments” cont’d

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- “Laser workshop at the CfAO retreats has been invaluable; I hope you will continue it in the future.”
- “Most valuable for me has been the network that the CfAO has provided for my students. The summer school has been useful not only for the knowledge that they gained, but also for the networking with students from other campuses. It also helps them to feel like they are part of something big. And being able to send one of my students to work at the LAO for over a year was an incredible asset to me.”
- Increased opportunities for young AO faculty to be hired at UC campuses

## Input from “homework assignments” cont’d

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- “I would like to see the retreats have focus sessions where technical users of AO systems could get together with AO system builders and transfer knowledge.”
- “The AO summer school labs were very successful and it would be great if we could keep these around somehow.”
- Quite a few comments on a strong desire to continue the multi-campus graduate course in AO that Max teaches.

# LLNL-specific input

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- **NSF CfAO:**
  - Environment for putting together broad collaboration between technologists and scientists at a variety of institutions
  - Access to students (undergraduate and graduate) and other young scientists
  - (Both are particularly valuable in that they provide opportunities outside LLNL's strict security-driven rules)
- **Future opportunities:**
  - More direct hosting of graduate students carrying out instrument-oriented thesis work located at LLNL
  - Increased opportunities for young AO faculty to be hired at UC campuses

## Break-out groups: possible topics

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- Models for how to implement seed funding of new projects?
- How do groups who go out and get grants externally then relate to the UC CfAO? What are the expectations and benefits of CfAO membership?
- What is best way to implement “mobility funds” for grad students to spend time on other campuses/labs?
- What are realistic UC-CfAO roles in a UC-wide Laboratory for Ophthalmic Adaptive Optics (LOAO)?

# Report-back from break-out groups

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# Annual budget request

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	<i>Activity</i>	<i>Funding per year</i>
<b>Core funding request</b>		
	Retreats and workshops (2 retreats at UCSC or equivalent, plus 4 one-day workshops)	\$80K
	Multi-campus projects (approx. 10 grad students supported for 6 months each)	\$120K
	Professional Development Program for graduate students	\$50
	Administration (1.5 office staff)	\$80K
<b>Summer School co-funding</b>	AO Summer School (co-funding)	\$50K
<b>Grand total</b>		\$380K

Should we present two budget options?

# Writing assignments

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