



Astronomy in Arizona and Intelligent Outdoor Lighting

Dr. Buell T. Jannuzi
Director, Kitt Peak National Observatory



MAG Management Committee Meeting
October 8, 2008



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(contributing to today's presentation)

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Robert Millis, Director, **Lowell Observatory**

Paul Smith, **Steward Observatory**, U of A, ASU & NAU

Rogier Windhorst, **School of Earth & Space Exploration**, Arizona State University

And the students, employees, and suppliers of Arizona's astronomy industry.

MAG Management Committee Meeting

October 8, 2008



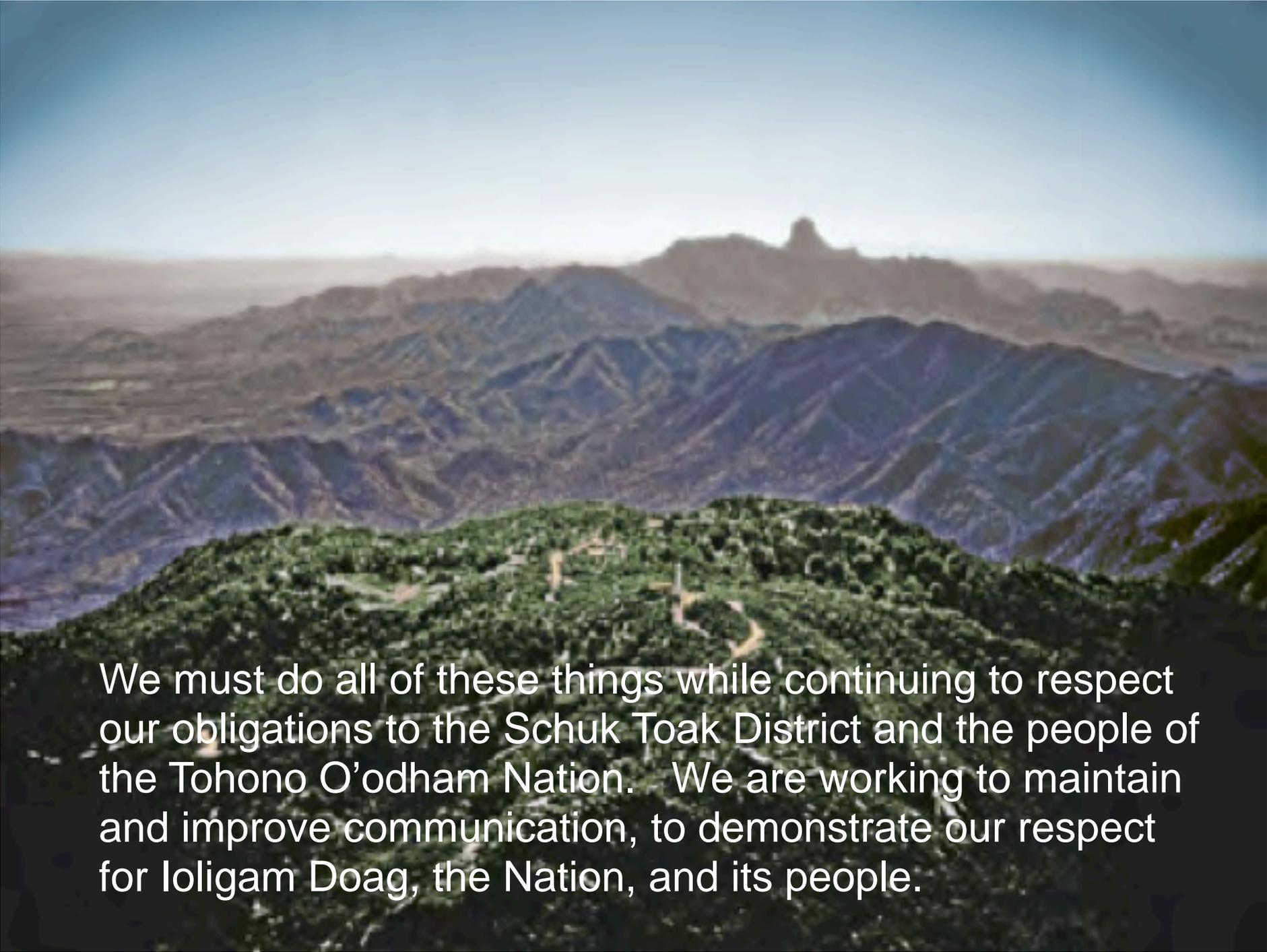
50th Anniversary of the National Observatory



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Our mission is to support forefront astronomical research and education by and for everyone, based on the merit of their ideas.

A wide-angle landscape photograph showing a series of mountain ridges. In the foreground, a ridge is covered in dense green forest. The middle ground shows several layers of mountain ranges, with the colors transitioning from green to brown and then to a hazy, light blue-grey. A single, sharp mountain peak is visible in the far distance against a clear, pale blue sky.

We must do all of these things while continuing to respect our obligations to the Schuk Toak District and the people of the Tohono O'odham Nation. We are working to maintain and improve communication, to demonstrate our respect for Ioligam Doag, the Nation, and its people.

Kitt Peak, Ioligam Doag or Iolkam Duag, still a great site for astronomical research and education.

All the reasons it was picked after an extensive search for sites in the late 1950s are still true:

Clear (and Dark) Skies

Good Seeing

Near Necessary Support from major Universities and Industry

About 90 minutes from major Airport

**Infrastructure Supports 26 Telescopes operated by
More than 30 Institutions**



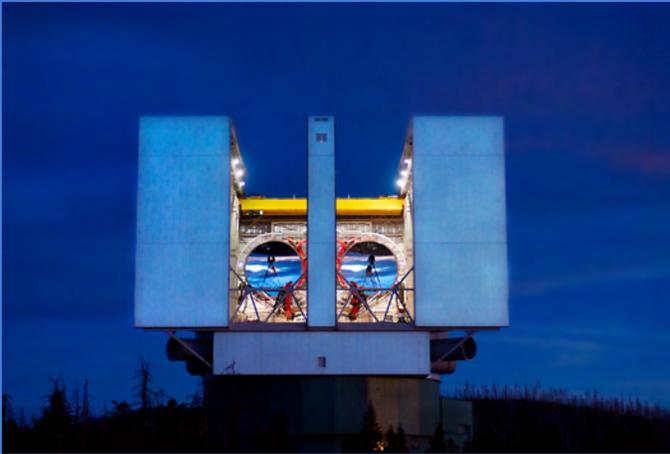


VERITAS -- High Energy Observatory

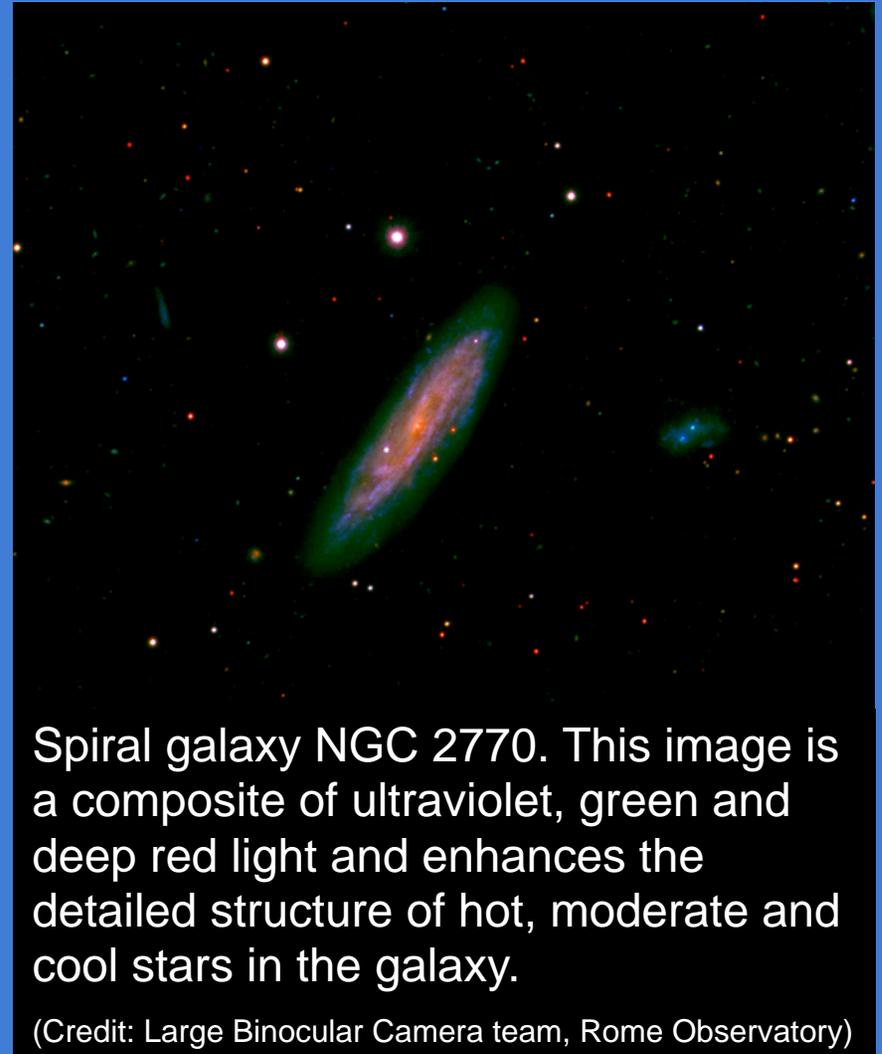
- VERITAS
 - 20 million dollar new observatory
 - International Partnership
 - Funded Primarily by Department of Energy and the National Science Foundation



World's Largest Telescope Achieves First Binocular Light



The Large Binocular Telescope on Mount Graham, Ariz., has taken celestial images using its twin side-by-side, 8.4-meter (27.6 foot) primary mirrors together, achieving first "binocular" light. March 6, 2008



Spiral galaxy NGC 2770. This image is a composite of ultraviolet, green and deep red light and enhances the detailed structure of hot, moderate and cool stars in the galaxy.

(Credit: Large Binocular Camera team, Rome Observatory)

4.2 meter Discovery Channel Telescope under construction in Northern Arizona



Rendering of the DCT facility and dome

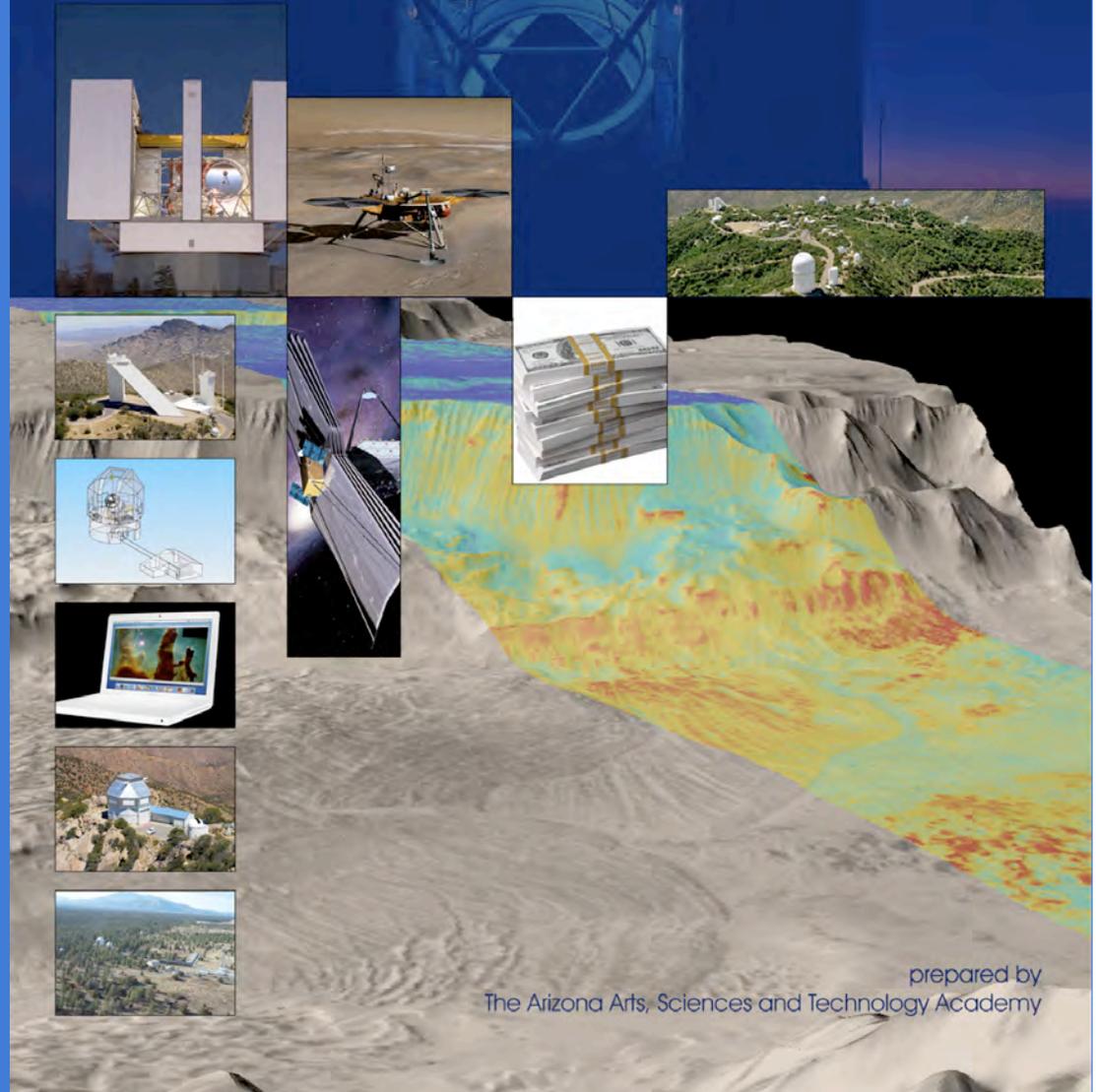
Forty miles southeast of Flagstaff, atop a cinder cone at a site known as Happy Jack, the 4.2 meter Discovery Channel Telescope is under construction. Developed by Lowell Observatory in partnership with Discovery Communications, Inc., the DCT will be operational in 2010. It will be a powerful tool for research areas including the search for Near Earth Objects (NEOs), extrasolar planets, and exploration of the newly discovered Kuiper Belt. It will also expand opportunities for public outreach and education in the exciting world of science and technology.



Stargazing nets \$250 mil a year for Ariz. economy

The Arizona Republic
January 17, 2008.

Astronomy, Planetary Sciences, and Space Sciences Research Opportunities to Advance Arizona's Economic Growth



prepared by
The Arizona Arts, Sciences and Technology Academy

Astronomy is worth billions to Arizona

This study found substantial capital investment (in excess of \$1 billion) in, and economic return (nearly a quarter of a billion dollars annually) from APSS research in Arizona. The data also suggest the untapped potential of these research fields to expand the State's economic base. The study revealed levels of active research funding that well exceed other fields in the State, such as bioscience funding from the National Institutes of Health.

GENERAL DYNAMICS

SPACE TECHNOLOGIES



GODDARD
SPACE FLIGHT CENTER

FERMI Gamma-Ray Space Telescope

- Assembled in Gilbert, Arizona
- Most recent of NASA's Space Observatories
- \$690 Billion Dollar Observatory



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NASA picks ASU team to guide study of search for life



This conceptual image of a eukaryote cell with a supernova exploding in its nucleus symbolizes the idea that the chemical elements that make up living things are produced in stars and stellar explosions, encapsulating the range of research in the project. Credit: Nahks Tr'Ehnl, School of Earth and Space Exploration

Humans have long pondered the possibility that life exists beyond Earth. The quest for habitable worlds has focused on searching for water, but "following the water" turns out to be too general a criterion. The list of planets and satellites that possess liquid water is growing faster than can be explored. As one of the new NASA Astrobiology Institute teams, Arizona State University researchers intend to boost extraterrestrial exploration to the next stage by refining the criteria that guide the search for life.

The multidisciplinary field of astrobiology explores the origin, evolution, distribution, and future of life on Earth and in the universe. The need for experts in areas as diverse as Earth and planetary science, astrophysics, microbiology, cosmochemistry, and evolutionary biology, gave rise to the NASA Astrobiology Institute (NAI). Established as part of NASA's Astrobiology Program, the NAI developed as a partnership between NASA and teams located at academic institutions, research laboratories, and NASA centers across the U.S. More

than 700 scientists and educators are associated with the NAI.

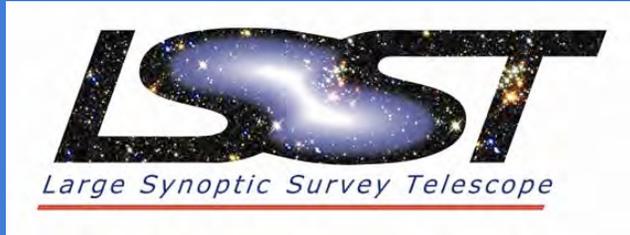
NASA announced Oct. 2 that ASU's School of Earth and Space Exploration is one of 10 research teams from across the country to be awarded five-year grants, averaging \$7 million each. ASU previously operated as an NAI team and was a charter member of the NAI when the program was founded in 1998. The team is centered in the School of Earth and Space Exploration, an academic unit in ASU's College of Liberal Arts and Sciences, but also involves several faculty members from other college units including the School of Life Sciences, the Department of Chemistry

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Steward Observatory Mirror Lab Awarded Contract for Large Synoptic Survey Telescope Mirror

The LSST Corporation has awarded a \$2.3 million contract to the University of Arizona Steward Observatory Mirror Lab to purchase the glass and begin engineering work for the 8.4-meter diameter main mirror for the Large Synoptic Survey Telescope (LSST)...

Acquiring the LSST primary mirror was made possible by a generous, private pledge from Arizona businessman Richard Caris.

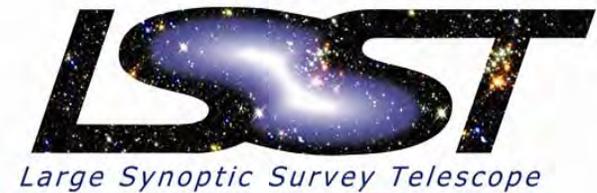
January 2005

You don't have to be an Arizona benefactor to support astronomy

EMBARGOED FOR RELEASE: January 3, 2008

RELEASE LSSTC-06

LSST Receives \$30 Million from Charles Simonyi and Bill Gates

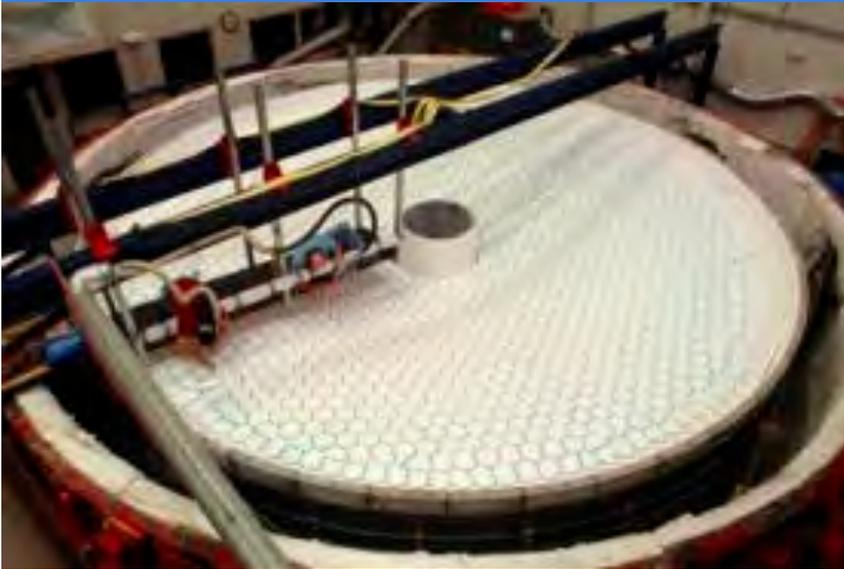


The Large Synoptic Survey Telescope (LSST) Project is pleased to announce receipt of two major gifts: \$20M from the Charles Simonyi Fund for Arts and Sciences and \$10M from Microsoft founder Bill Gates.

Under development since 2000, the LSST is a public-private partnership. This gift enables the construction of LSST's three large mirrors; these mirrors take over five years to manufacture. The first stages of production for the two largest mirrors are now beginning at the Mirror Laboratory at the University of Arizona in Tucson, Arizona. Other key elements of the LSST system will also be aided by this commitment...

UA Mirror Lab to Cast Two Mirrors in One for the LSST

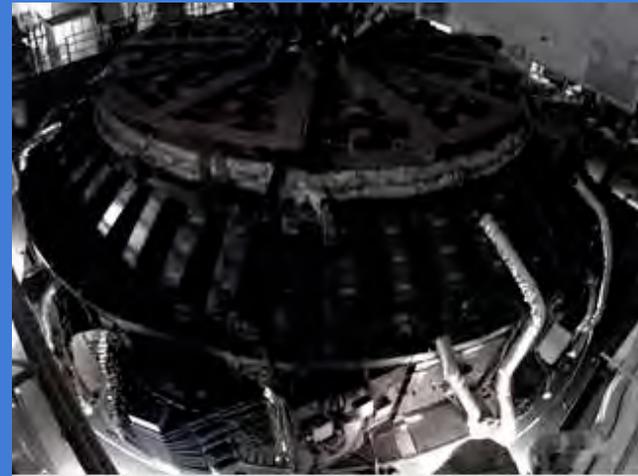
Mirror Lab workers load 51,900 pounds of glass into mirror mold.
March 17, 2008.



Steward Observatory Mirror Lab workers installed 1,160 ceramic cores in the mirror mold that was made for casting the primary and tertiary mirrors as a single piece of glass for the LSST.

(Ray Bertram, Steward Observatory)

The mirror high fire was successful reaching a high temperature of approximately 1165°C (2125° F) over March 28th and 29th. The LSST mirror is now annealing and cooling gradually to room temperature in the slowly rotating oven of the Steward Observatory Mirror Lab. Technicians will remove it for grinding and polishing in mid-August.



2008-03-23 14:00:01 Copyright: LSST Corporation

Recommendation 4

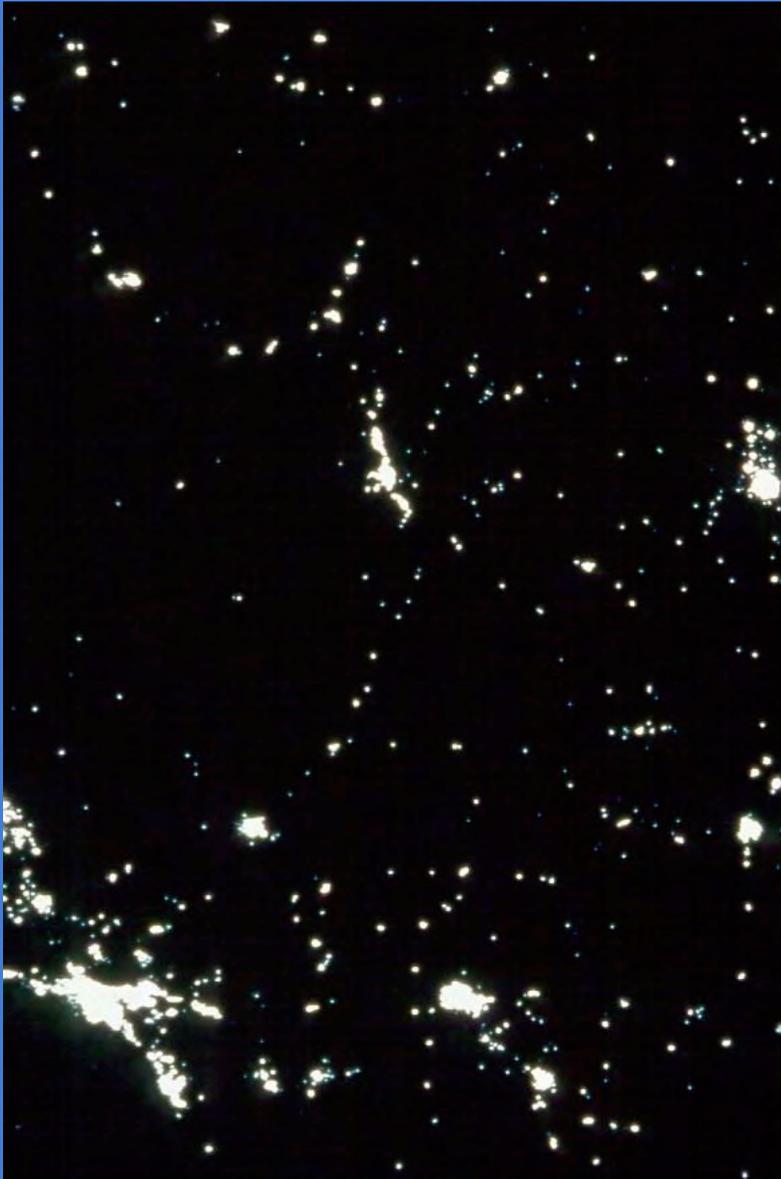
The Arizona Legislature, counties, municipalities and Tribal Nations should revisit the adequacy and enforcement of existing statutes and ordinances in a new effort to reduce light pollution associated with rapid industrial and population growth as well as old lighting installed before effective codes were in place.

Arizona Title 49, Chapter 7 calls for the elimination of mercury vapor lighting fixtures by 2011. All counties in the State and many municipalities have used the 1973 State law to enact light control ordinances. However the sheer rate of population growth, particularly in Maricopa County, and more recently in Pinal County ... threaten to undo that protection.

North America at Night



Southwestern United States, home of many of the large telescopes in the continental United States.



Lights as seen from above, as from the International Space Station, for example, looking down. Here the landscape outside of the cities looks dark. But this is misleading... it is not dark here.

... you can be 50 or 100 or 150 miles from the Phoenix metropolitan area and still see the effects of the city lights



Image of Phoenix at night taken from the International Space Station
(~220 miles above) (NASA, ISS CEO project)

Space Station over Kitt Peak Observatory ~8 p.m. Wednesday, April 11, 2007



The International Space Station (ISS) made a nice pass over Kitt Peak for the 2nd night in a row. Here it is seen trailing through the constellation Cassiopeia and over the 36 inch Spacewatch Telescope dome (with the 90 inch Bok telescope and 4-meter Mayall Telescope domes at right). **The orange glow is not twilight - that is the glow of city lights from Phoenix and Casa Grande.** This image was taken with my 24mm lens with an exposure of 30 seconds at f/1.8, ISO 200. (Jim Scotti, LPL)

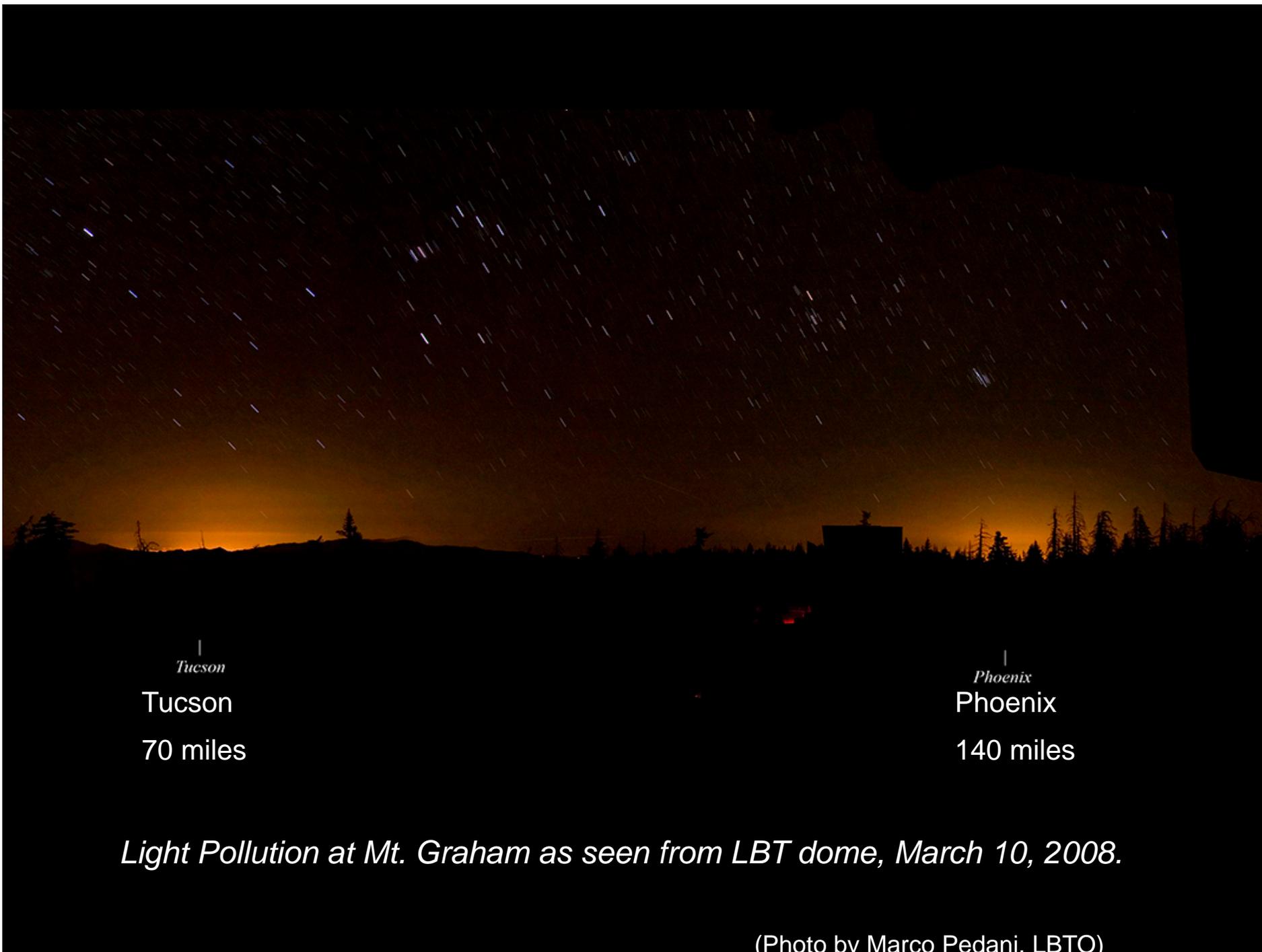


Phoenix/Casa Grande sky glow as seen from Kitt Peak National Obs.
March 28, 2008. (KPNO photo by J. Glaspey)



Light Pollution at Mt. Graham as seen from LBT dome, March 10, 2008.

(Photo by Marco Pedani, LBTO)



|
Tucson
Tucson
70 miles

|
Phoenix
Phoenix
140 miles

Light Pollution at Mt. Graham as seen from LBT dome, March 10, 2008.

(Photo by Marco Pedani, LBTO)

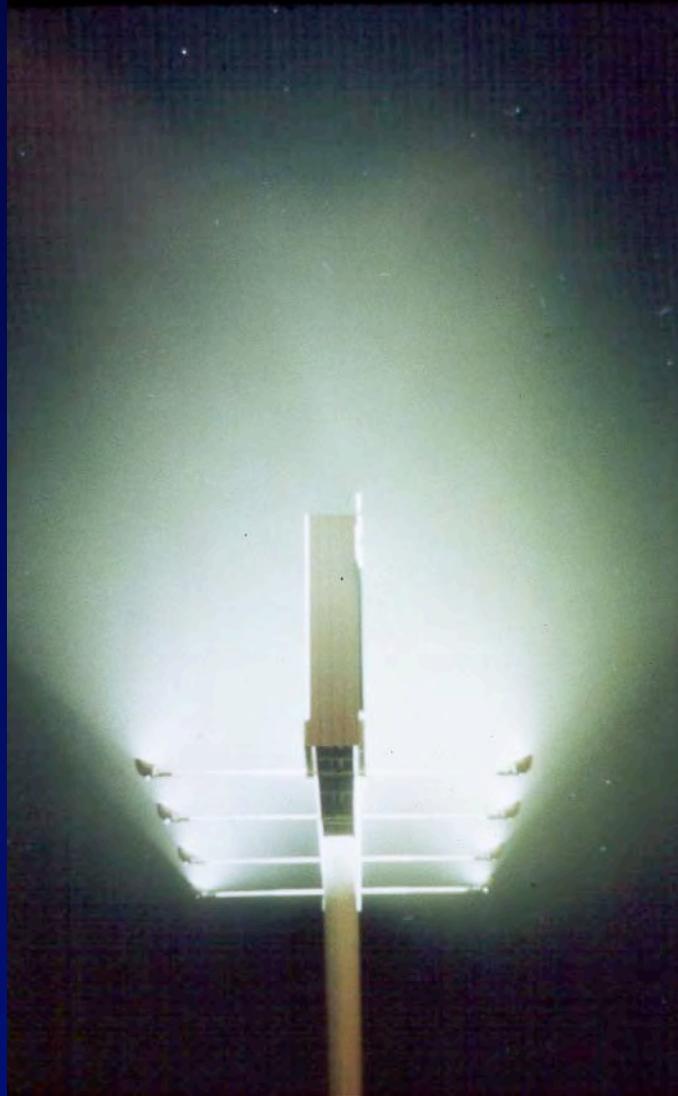
Phoenix from Flagstaff, 125 miles away

\$

(USNO)



A bottom lit billboard, seen from the side.



© International Dark-Sky Association

Note the student on the walkway.



She moved about four feet.



© International Dark-Sky Association

Here we see her again on the walkway.



Again, she moved close to the pole.



A view of a parking lot, one lit by glary lighting.



Same view, but with a flash photograph to show where he is.

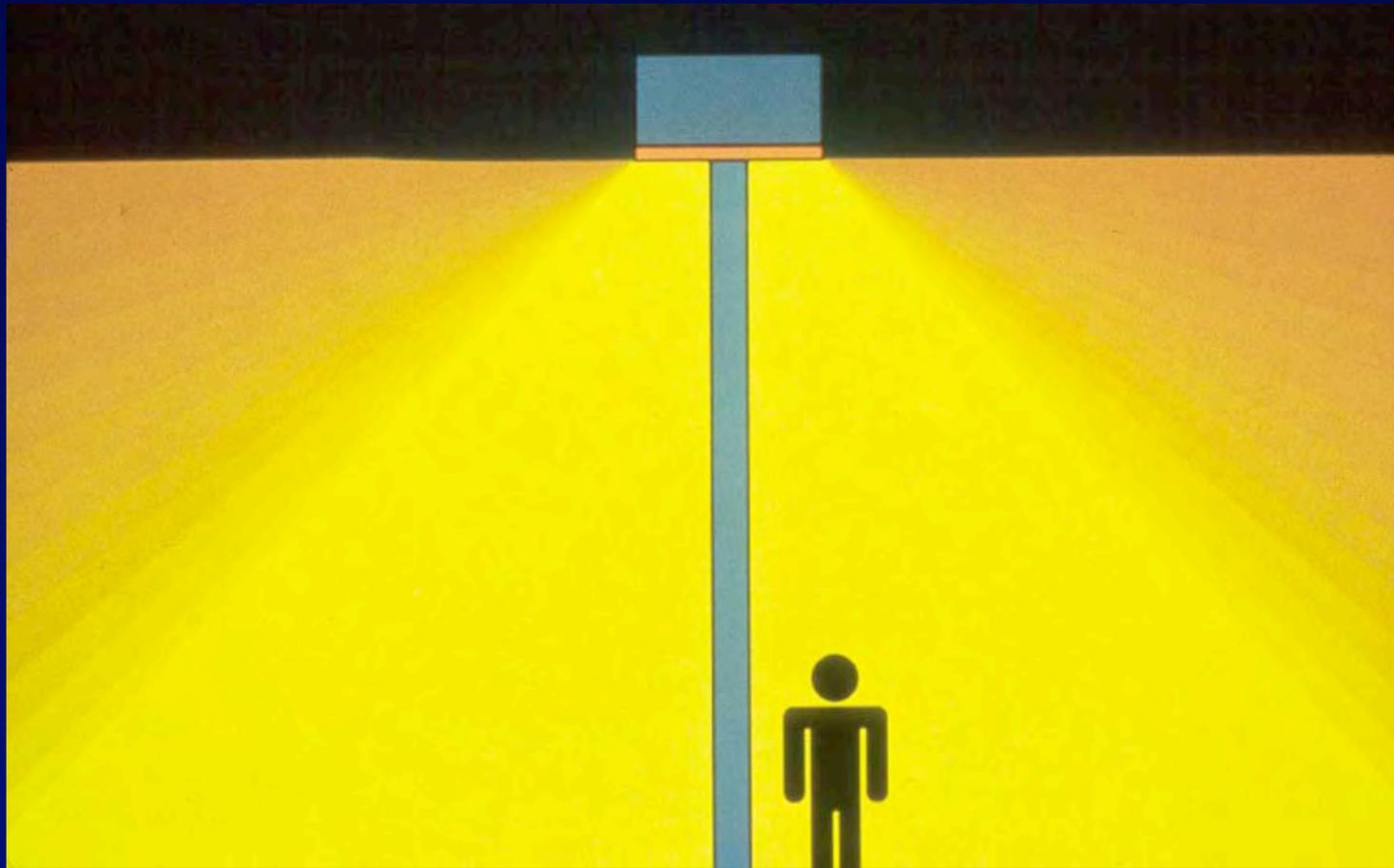


New technologies provide new opportunities and new challenges.

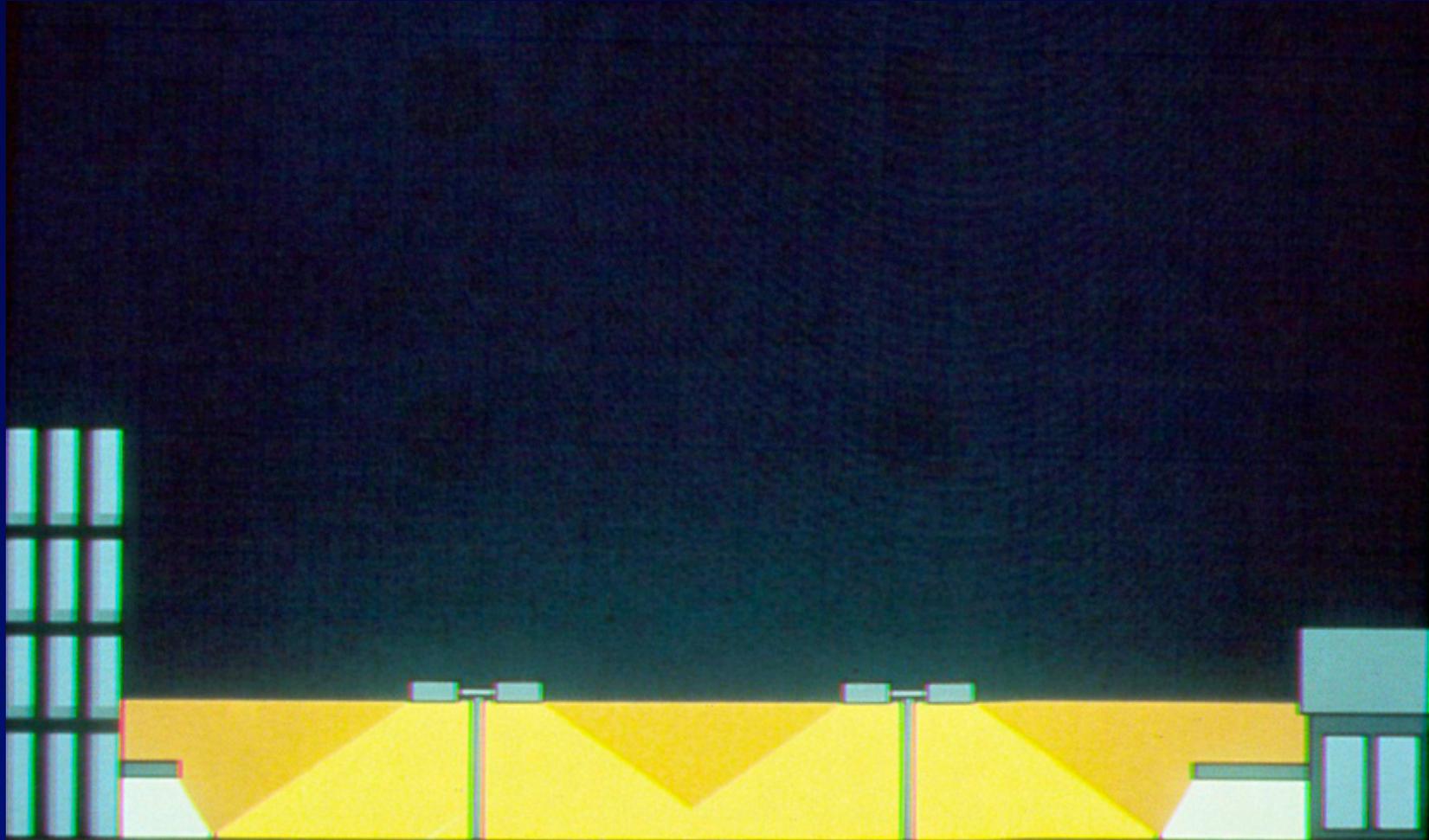
LED billboards being installed on the 202 Freeway in Tempe



A full cut-off lighting fixture with no direct up light and essentially no glare. All light is used, not wasted.

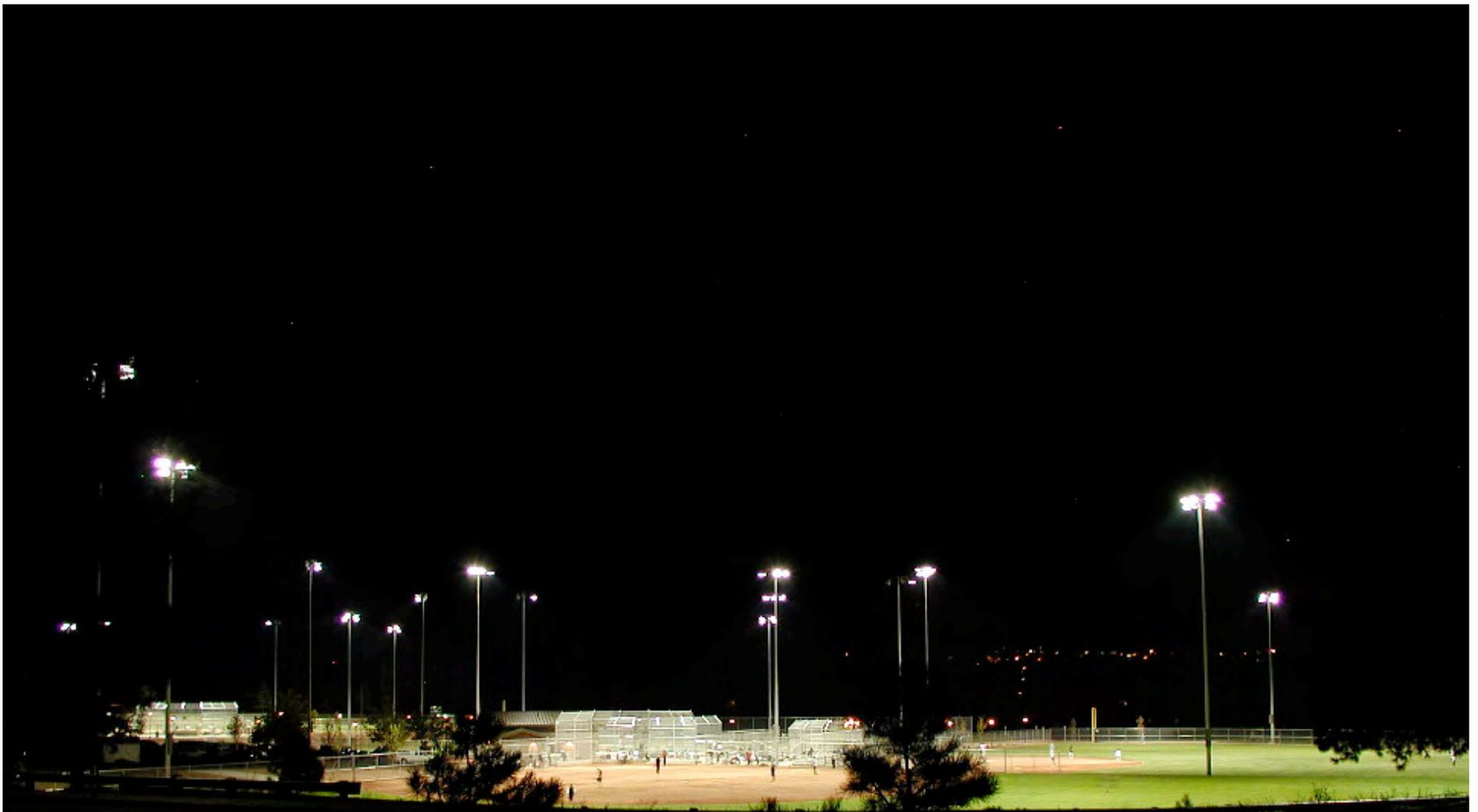


Optimal design! Note the added light near the entrances. The "task" there is greater than on the path where a lower lighting level is appropriate.





Thorpe Park, City of Flagstaff
1970's vintage sport lighting
Note glare and spill lighting



Thorpe Park, City of Flagstaff
Modern sport lighting circa 2006

Benefits:

Light levels on playing field are twice previous.
Players and spectators can see better.
No light trespass into surrounding neighborhood.
Better energy efficiency.
Everyone wins.



Top-mounted billboard lighting

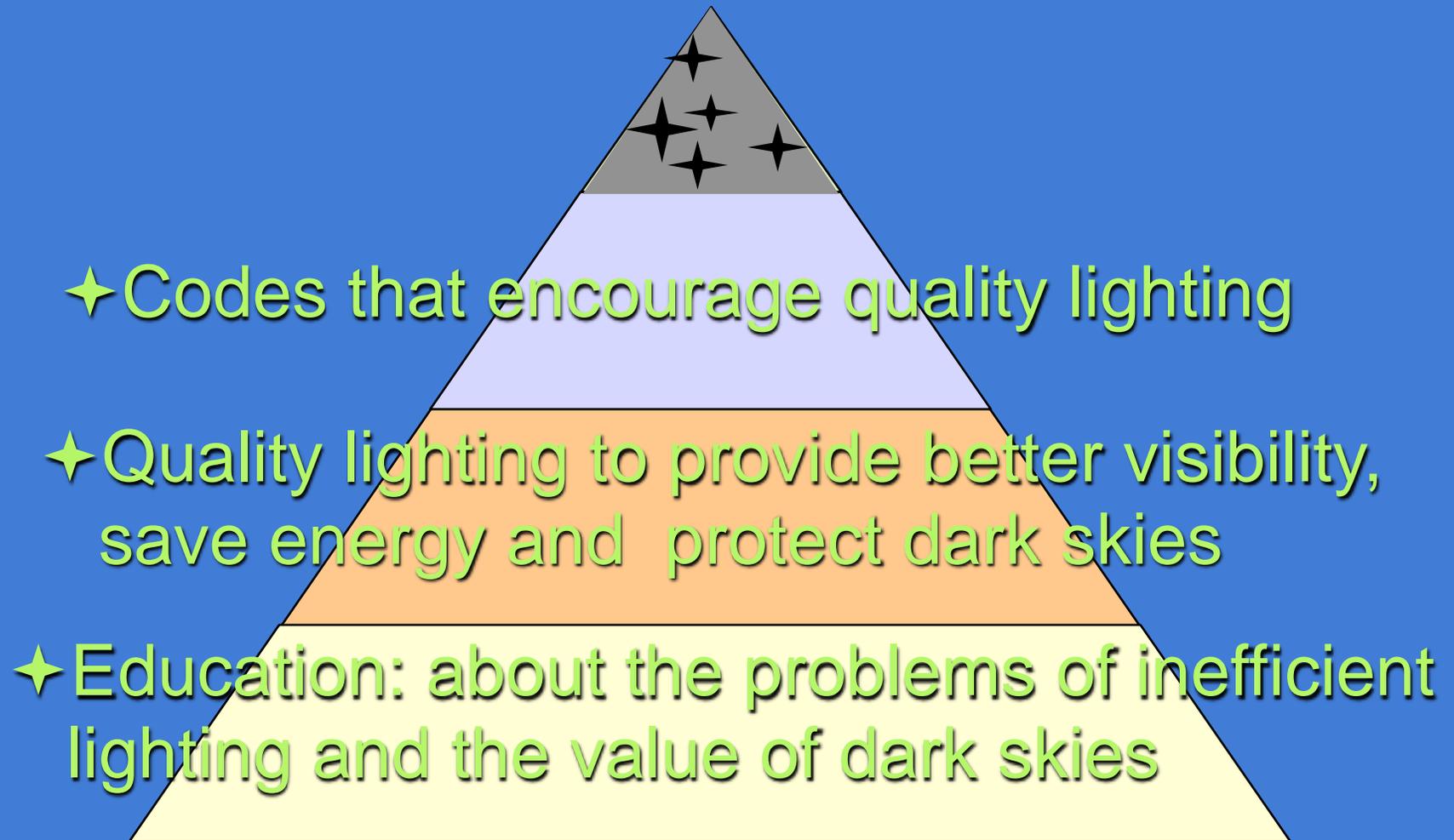
Smarter Lighting



- Which do you think makes more sense?

Photos courtesy of Chris Monrad

What is the solution?





Where do we go from here?

Form a working group of interested parties?

Is the Maricopa Association of Governments an efficient way to reach many jurisdictions?

The Astronomy Community stands ready to help.

The International Dark-Sky Association has a wealth of resources including a light fixture testing program.
www.darksky.org

***Reduced Energy Use and Carbon Dioxide Emissions
from
Improved Outdoor Lighting Efficiency
in Arizona***

Christian B. Luginbuhl, US Naval Observatory Flagstaff Station
G. Wesley Lockwood, Lowell Observatory
10 January 2008

Summary

We estimate potential energy savings and carbon dioxide emission reductions if lighting standards similar to Flagstaff's could be applied to all commercial outdoor lighting within the state.

The results show that statewide energy use would be reduced by at least 360,000 MWh/yr. This figure corresponds to a reduction of 190 kilotons of CO₂ emissions per year with an energy cost savings of \$30 million per year.



A Protected Night Sky Over Flagstaff

(Credit and Copyright: Dan & Cindy Duriscoe, FDSC, Lowell Obs., USNO)