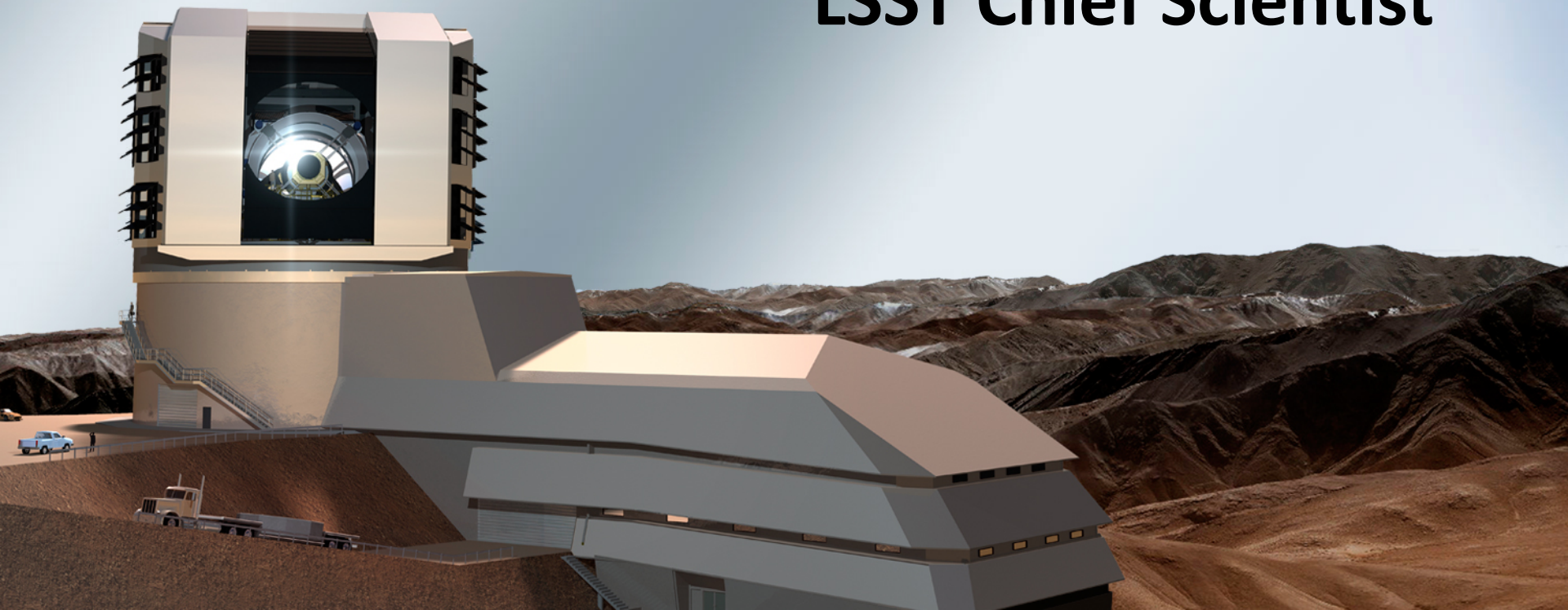
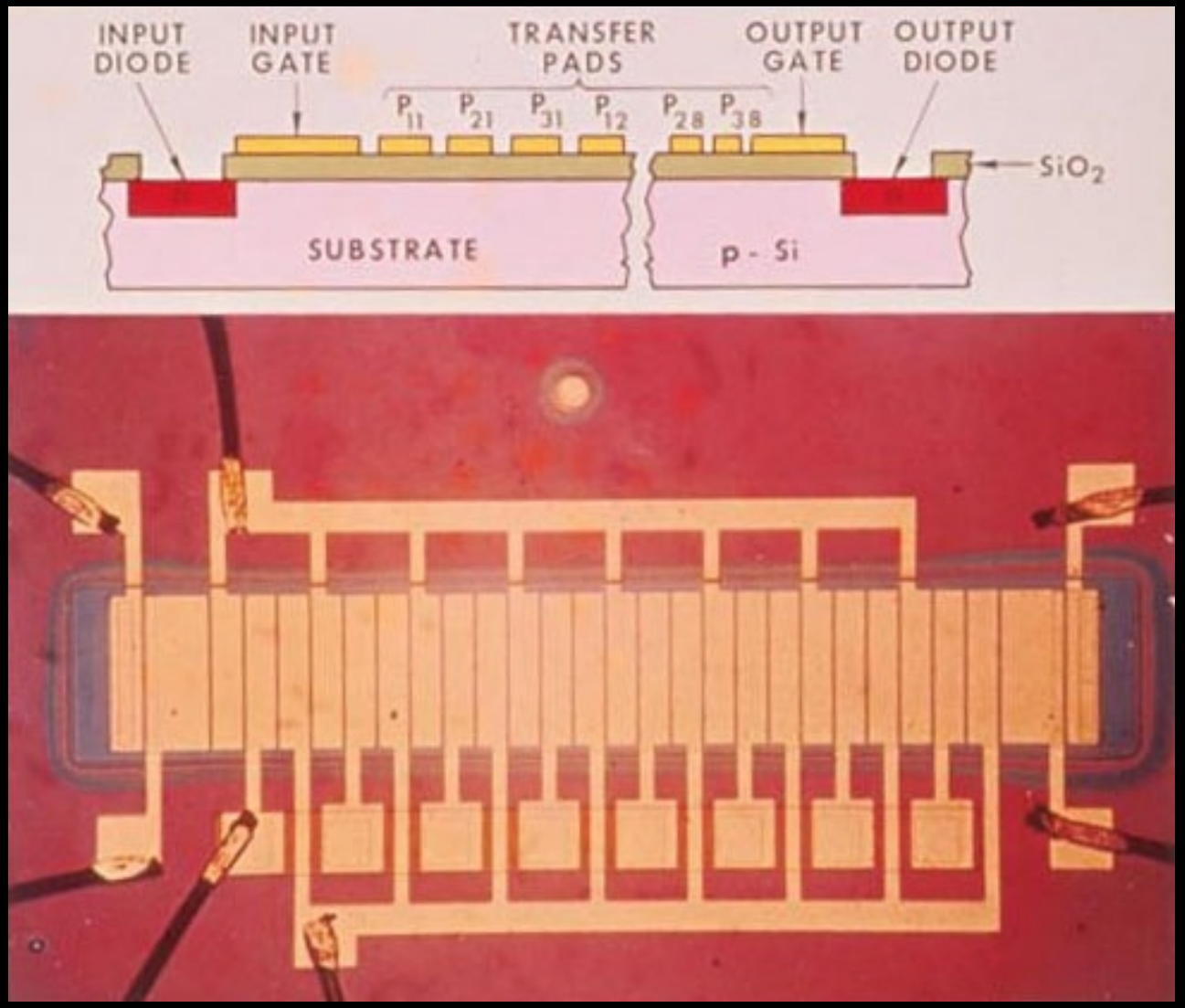
# LSST 1996-2018

Tony Tyson
University of California, Davis
LSST Chief Scientist



# Progress in CCD focal planes

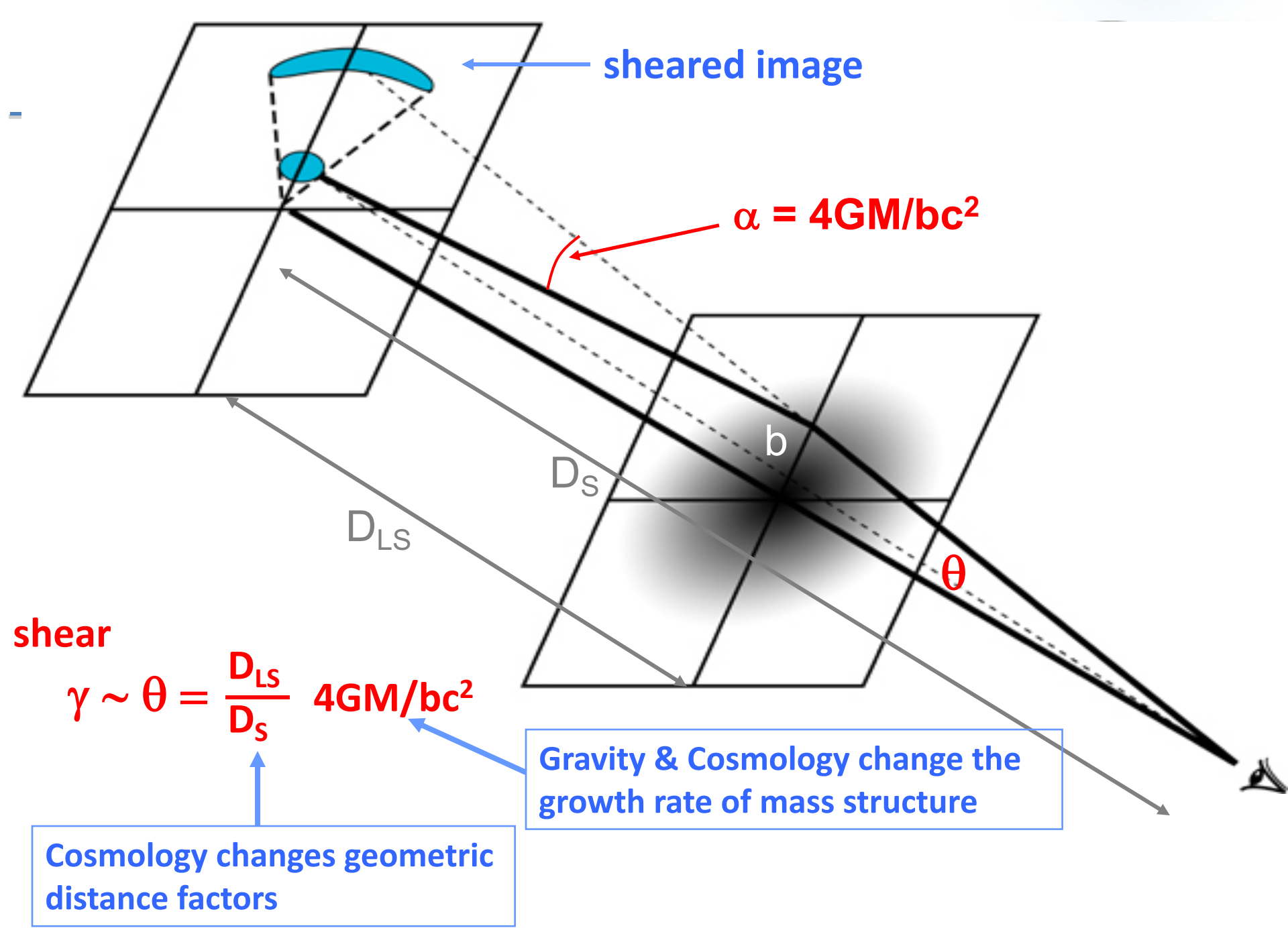



1969

# Weak lensing experiments: deep CCD exposures

2800 galaxies in 50 acmin$^2$

# Sloan Digital Sky Survey




shear

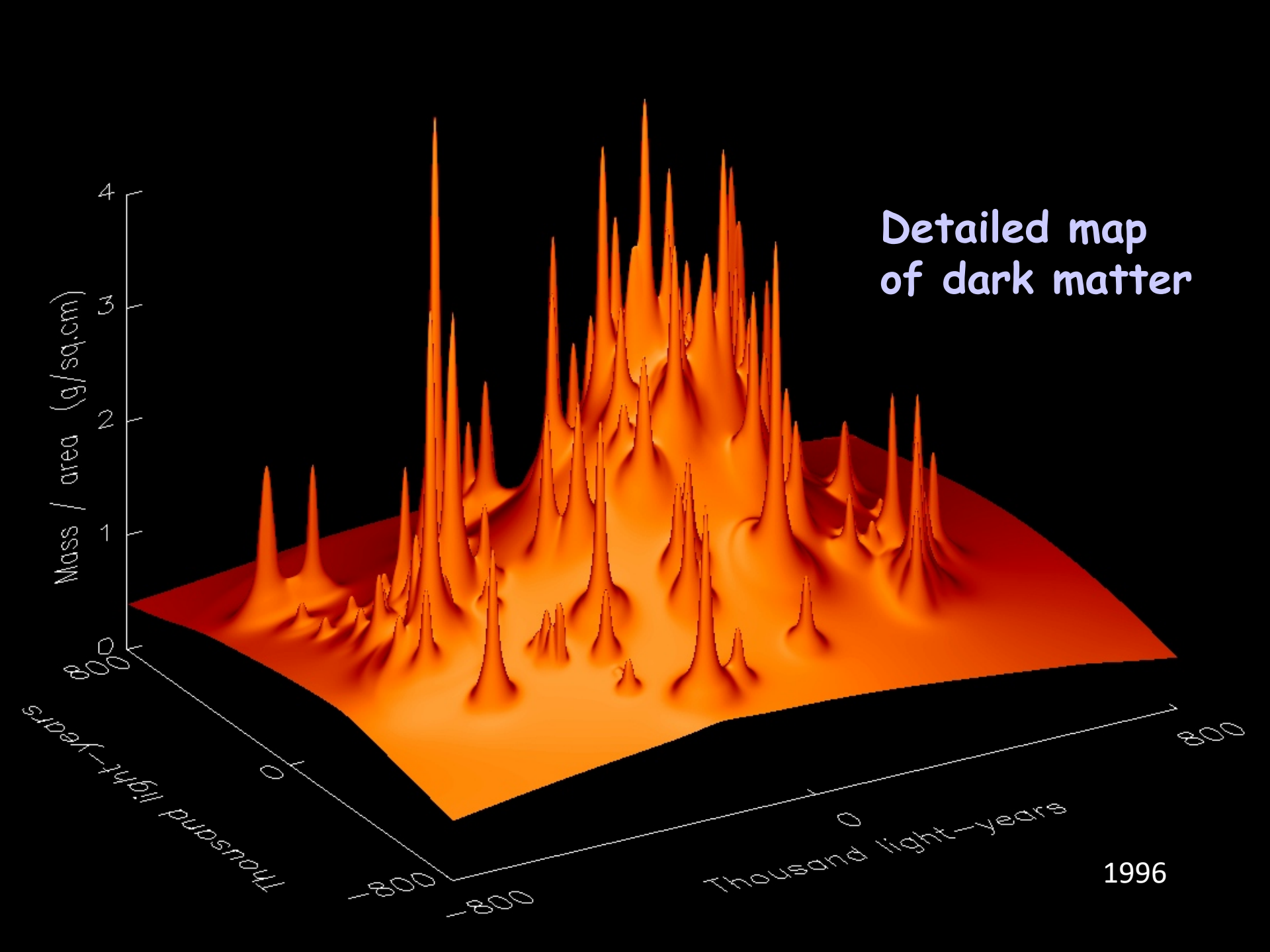
$$\gamma \sim \theta = \frac{D_{LS}}{D_S} \, 4GM/bc^2$$

Gravity & Cosmology change the growth rate of mass structure

Cosmology changes geometric distance factors

# Big Throughput Camera

1995


Detailed map
of dark matter
Mass / area (g/sq.cm)
4
3
2
1
800
0
-800
Thousand light-years
-800
0
800
Thousand light-years
1996


What if we could survey the faint sky rapidly?

# What would it take?

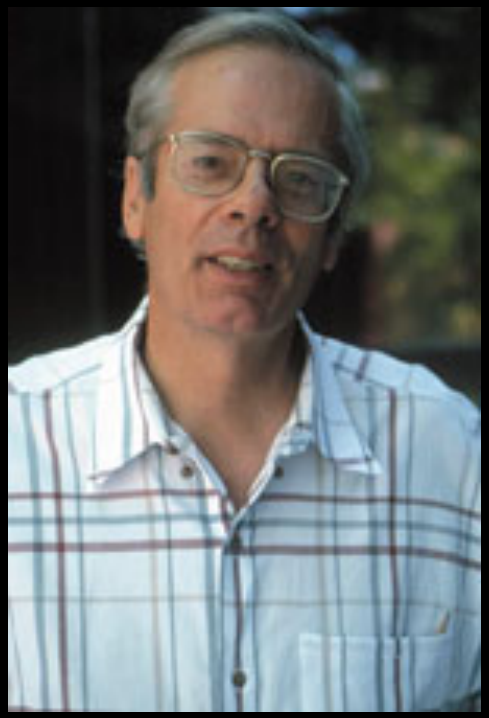
# Plans: *Dark Matter Telescope*

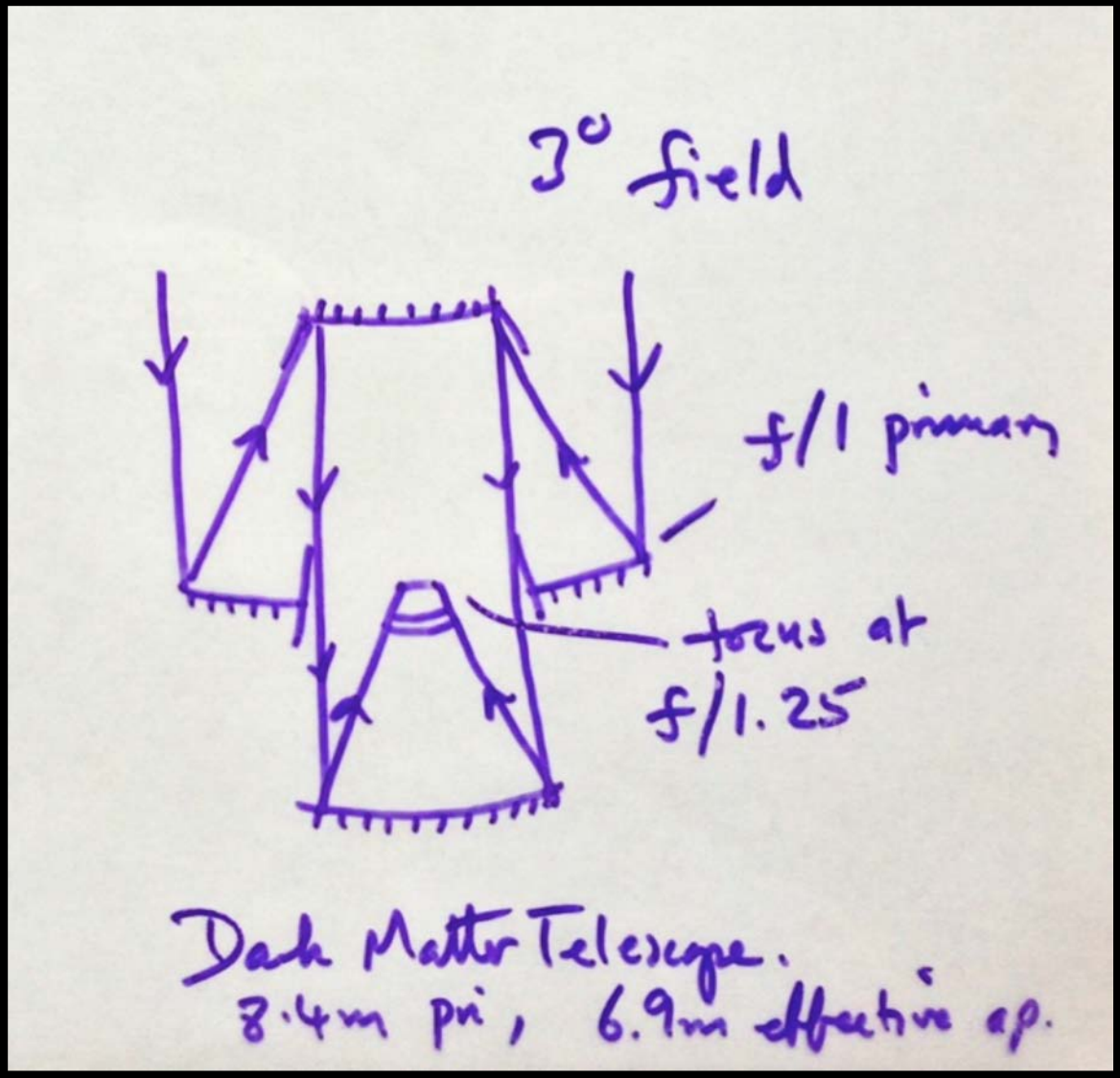

Challenges:

- ~3 Gigapixel focal plane, fast readout
- Wide field optics, etendue ~300 $m^2$ $deg^2$

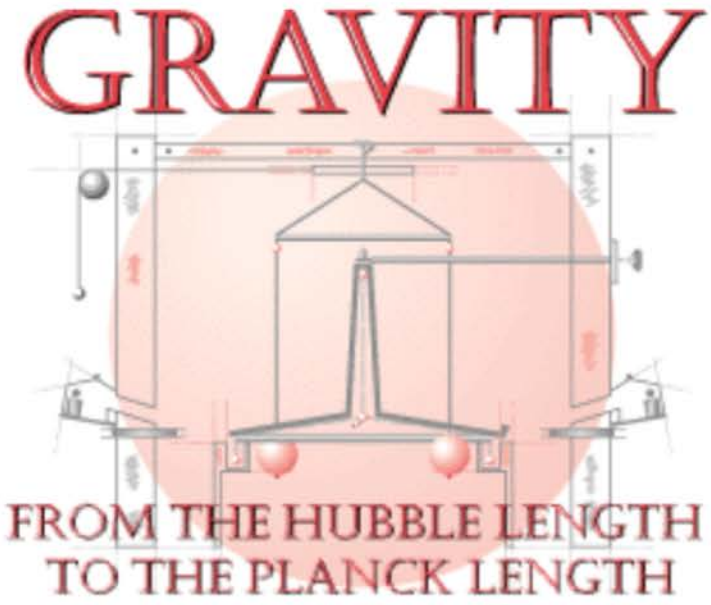
1998

# High etendue optics





# *Weak lensing and the Dark Matter Telescope*

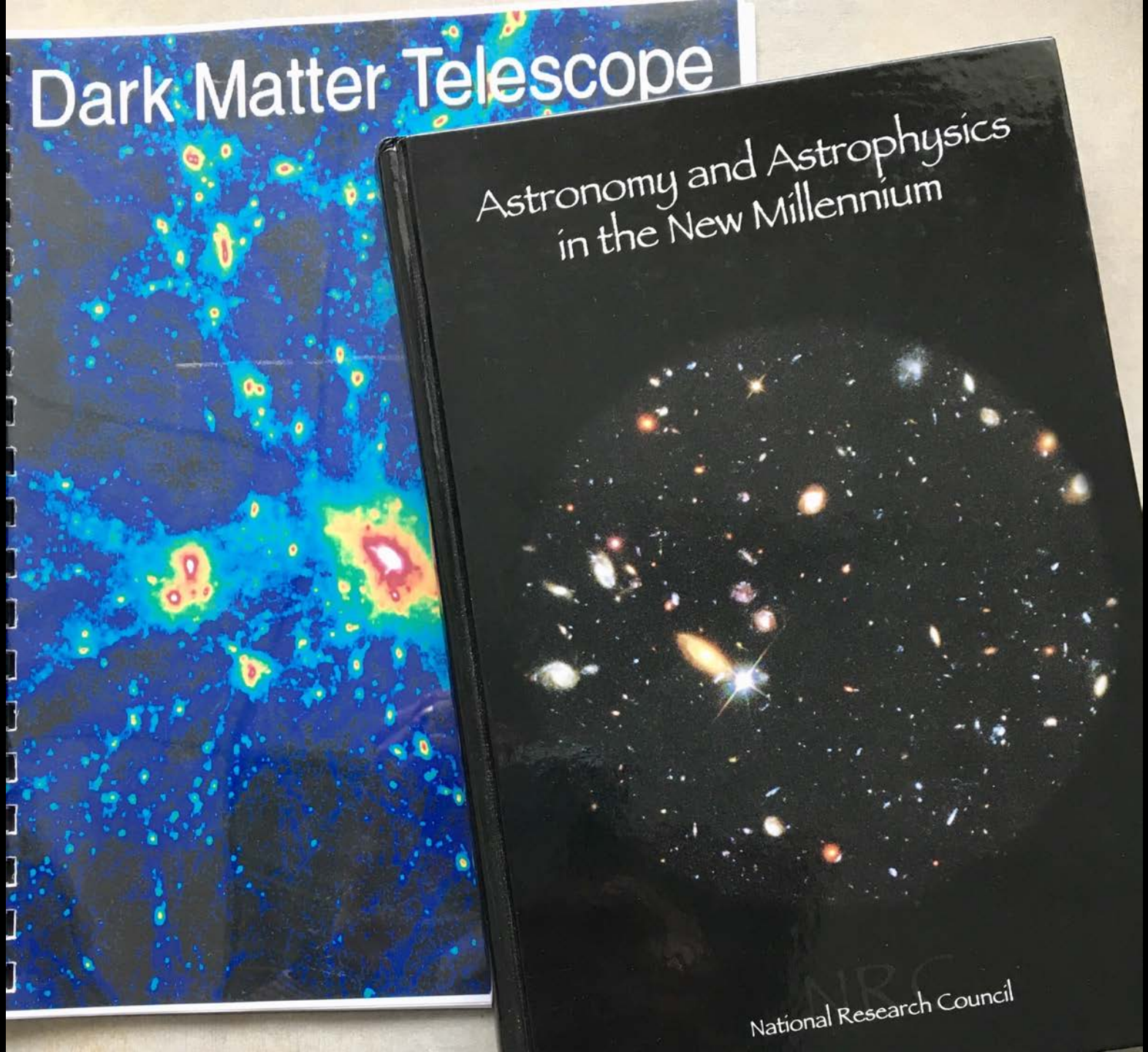


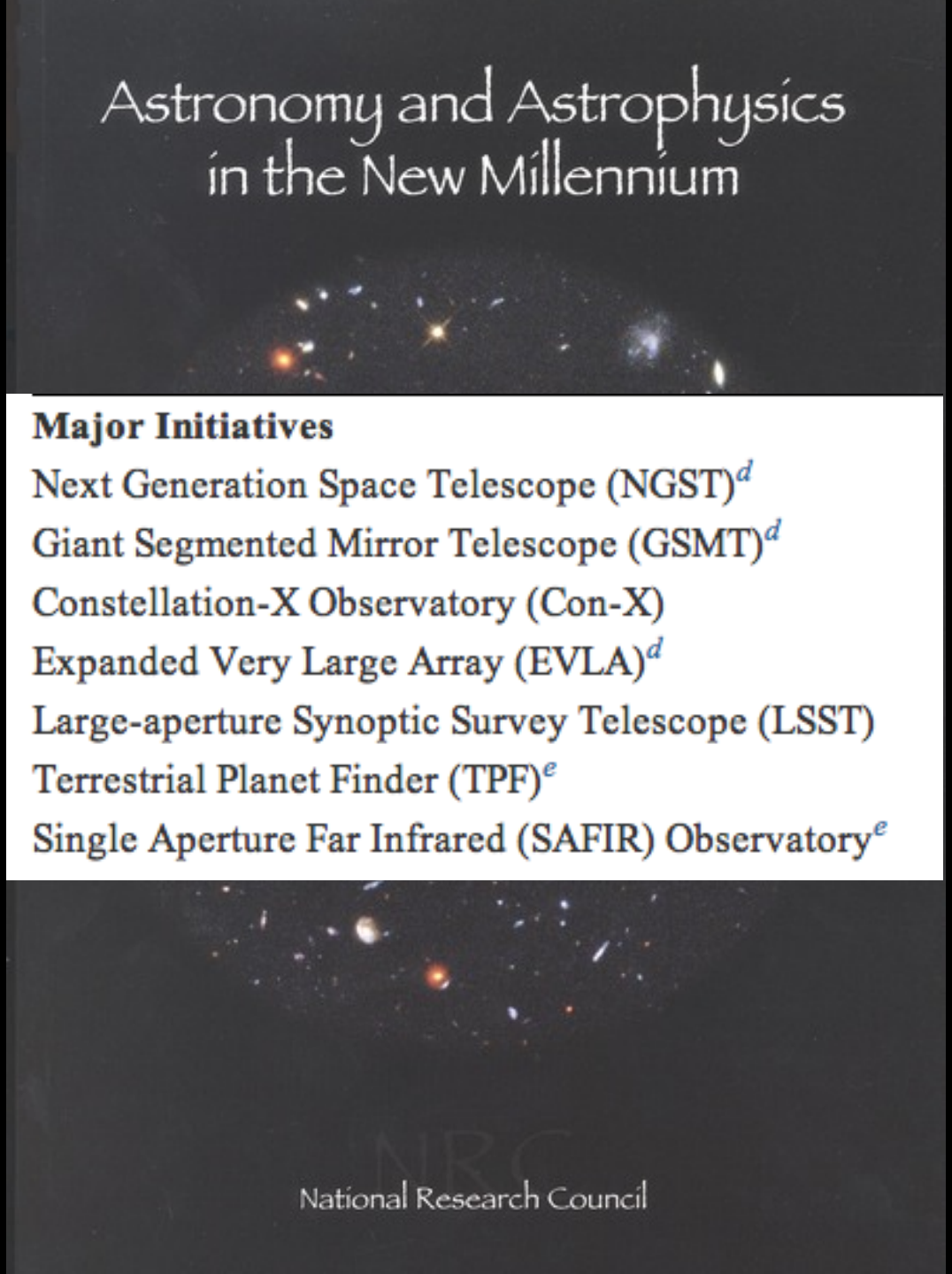

**XXVI SLAC Summer Institute on Particle Physics**

**Gravity**

**From the Hubble Length to the Planck Length**

August 3-14, 1998
Stanford Linear Accelerator Center
Stanford, California, U.S.A.


Dark Matter Telescope
Astronomy and Astrophysics in the New Millennium
National Research Council


Astronomy and Astrophysics
in the New Millennium
Major Initiatives
Next Generation Space Telescope (NGST)[d]
Giant Segmented Mirror Telescope (GSMT)[d]
Constellation-X Observatory (Con-X)
Expanded Very Large Array (EVLA)[d]
Large-aperture Synoptic Survey Telescope (LSST)
Terrestrial Planet Finder (TPF)[e]
Single Aperture Far Infrared (SAFIR) Observatory[e]
National Research Council

2000

# Aspen Center for Physics

2001

# WIDE-FIELD WORKSHOP
## Friday, June 7th
### on the Patio

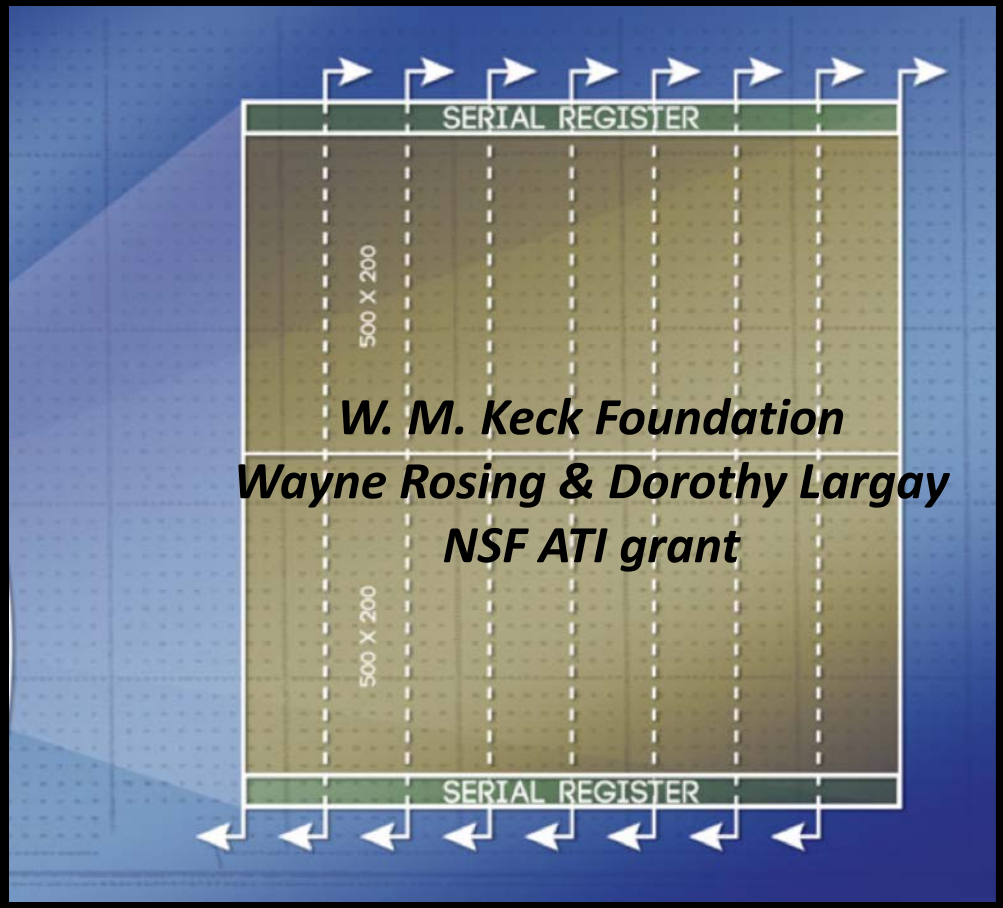
9:30am

Detecting Optical Transients
- Depth, time/area trade-offs
- Pipeline techniques - *Axelrod*
  *Stubbs*

10:30am
- LSST Optics
- Image quality - *Angel*
- Photometric acruracy - *Lupton*
- FOM - *Tyson*
- Color redshifts - *Connolly*
- Matrix

Aspen
2001

# LSST CCD design

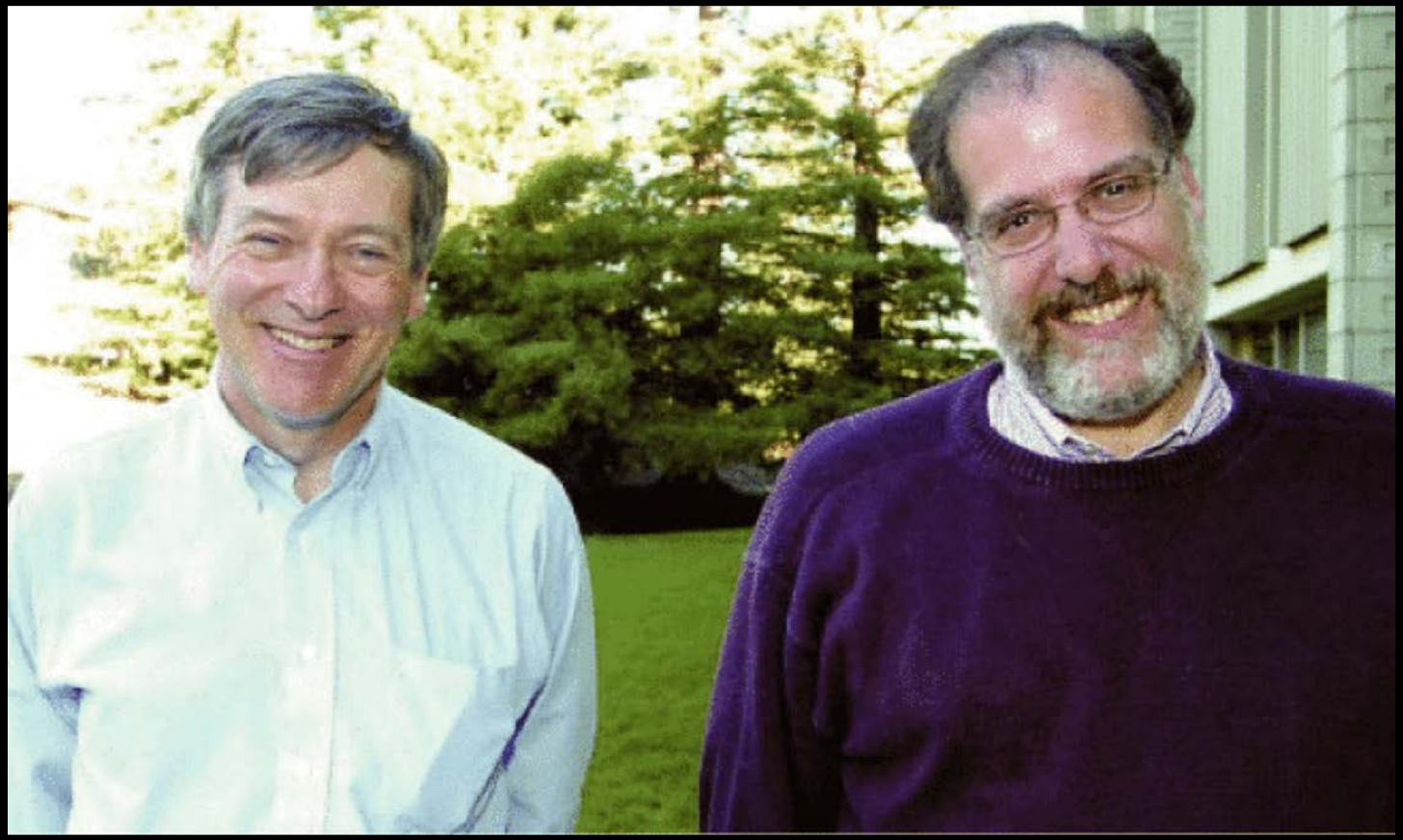



*W. M. Keck Foundation*

*Wayne Rosing & Dorothy Largay*

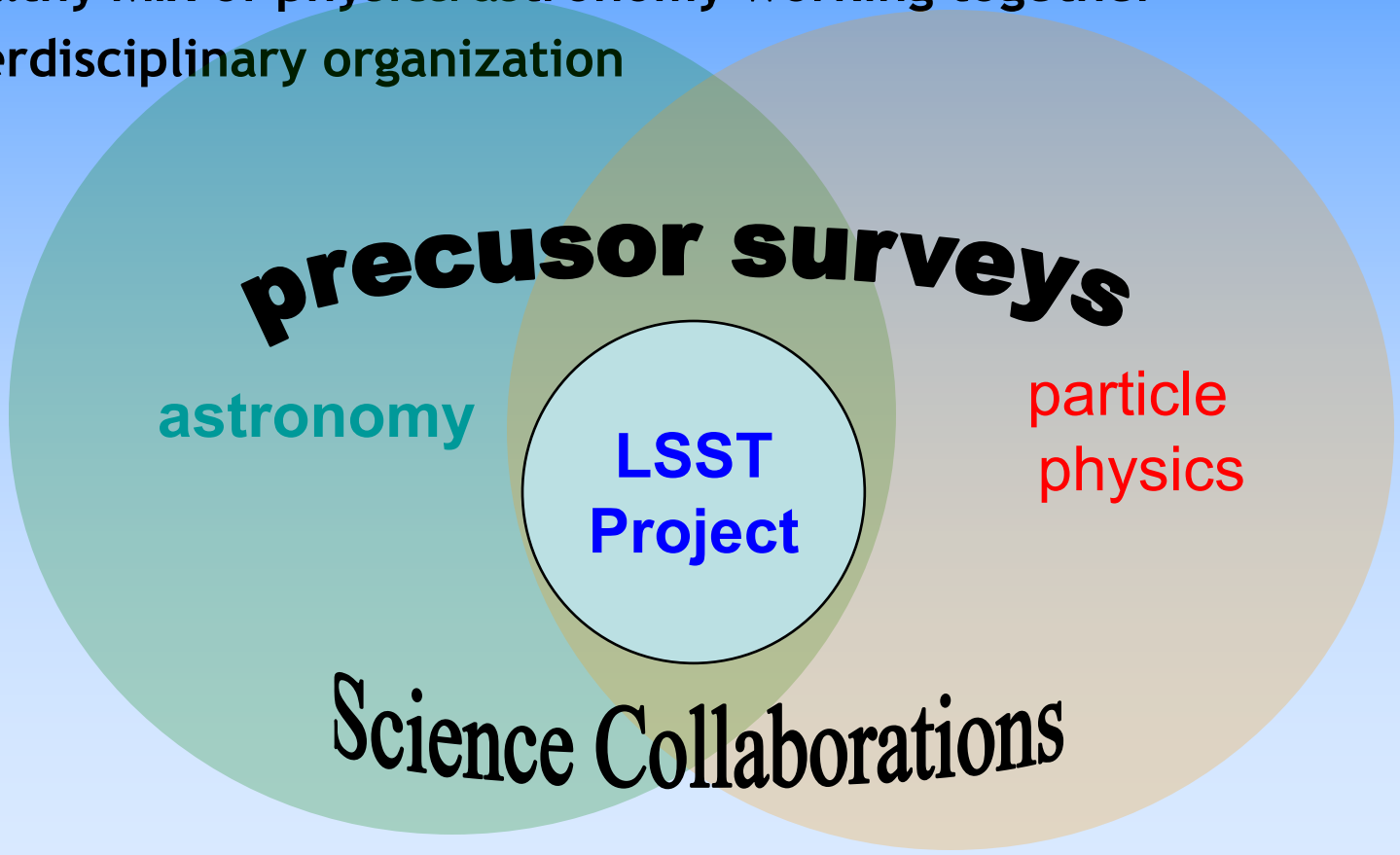
*NSF ATI grant*

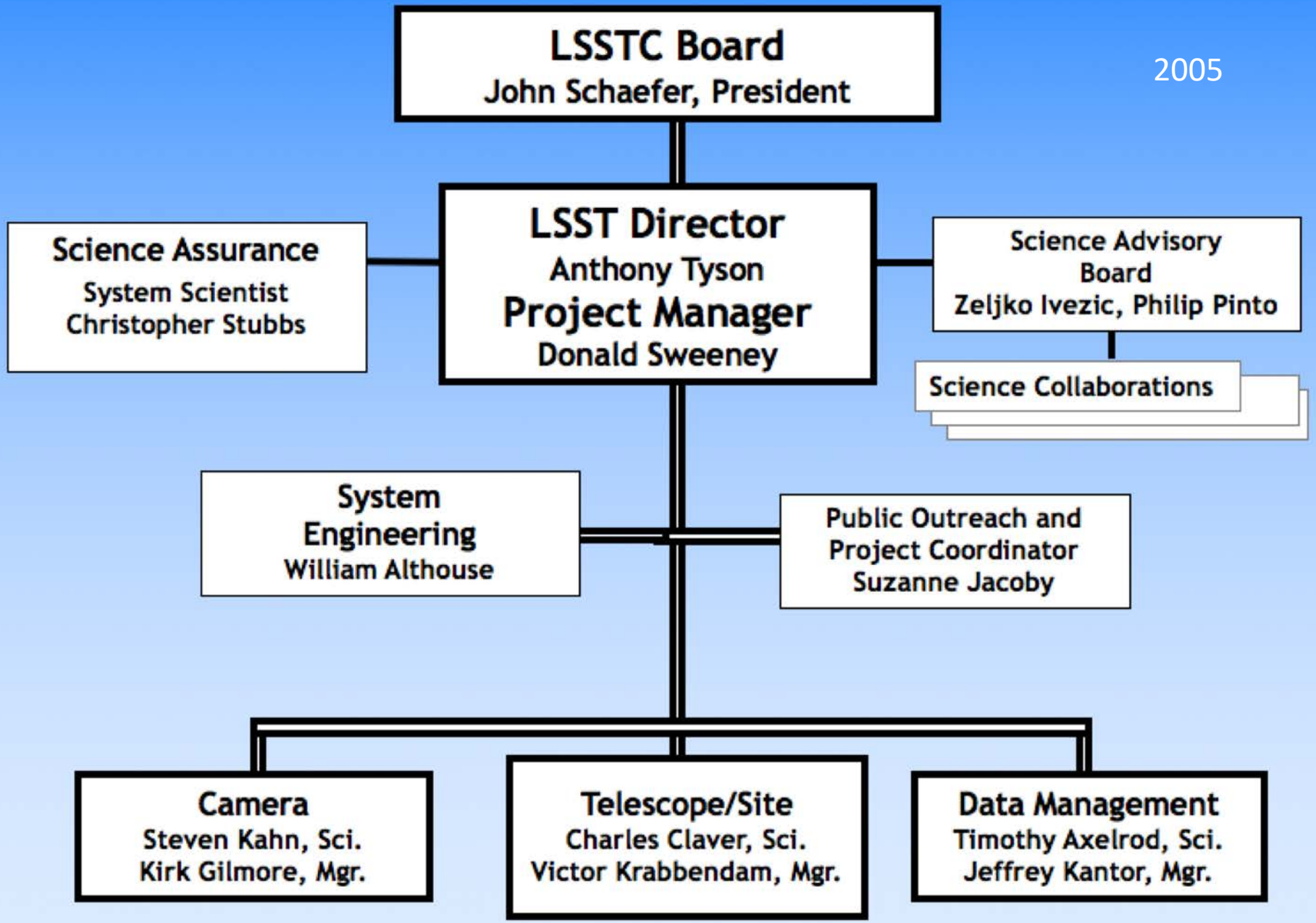
# KIPAC 2003

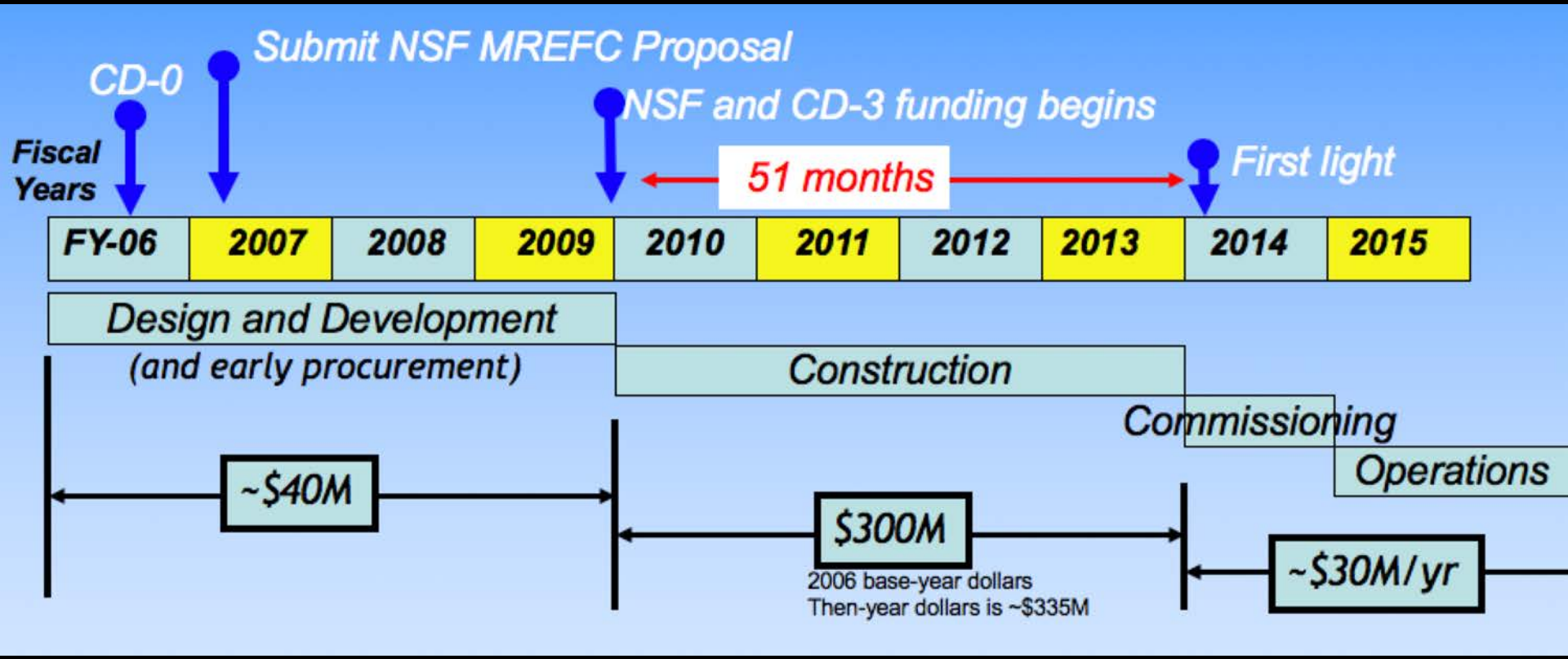


# Dark Energy and the HEP Community

- Bring HEP community into LSST – science opportunity
- Invigorate transition via data from precursor surveys
- Healthy Mix of physics/astronomy working together
- Interdisciplinary organization




LSSTC Board
John Schaefer, President
2005
LSST Director
Anthony Tyson
Project Manager
Donald Sweeney
Science Assurance
System Scientist
Christopher Stubbs
Science Advisory
Board
Zeljko Ivezic, Philip Pinto
Science Collaborations
System
Engineering
William Althouse
Public Outreach and
Project Coordinator
Suzanne Jacoby
Camera
Steven Kahn, Sci.
Kirk Gilmore, Mgr.
Telescope/Site
Charles Claver, Sci.
Victor Krabbendam, Mgr.
Data Management
Timothy Axelrod, Sci.
Jeffrey Kantor, Mgr.


Submit NSF MREFC Proposal
CD-0
NSF and CD-3 funding begins
Fiscal Years
51 months
First light
FY-06
2007
2008
2009
2010
2011
2012
2013
2014
2015
Design and Development
(and early procurement)
Construction
Commissioning
Operations
~$40M
$300M
2006 base-year dollars
Then-year dollars is ~$335M
~$30M/yr

2005

# LSST Wide-Fast-Deep survey

A survey of 37 billion objects

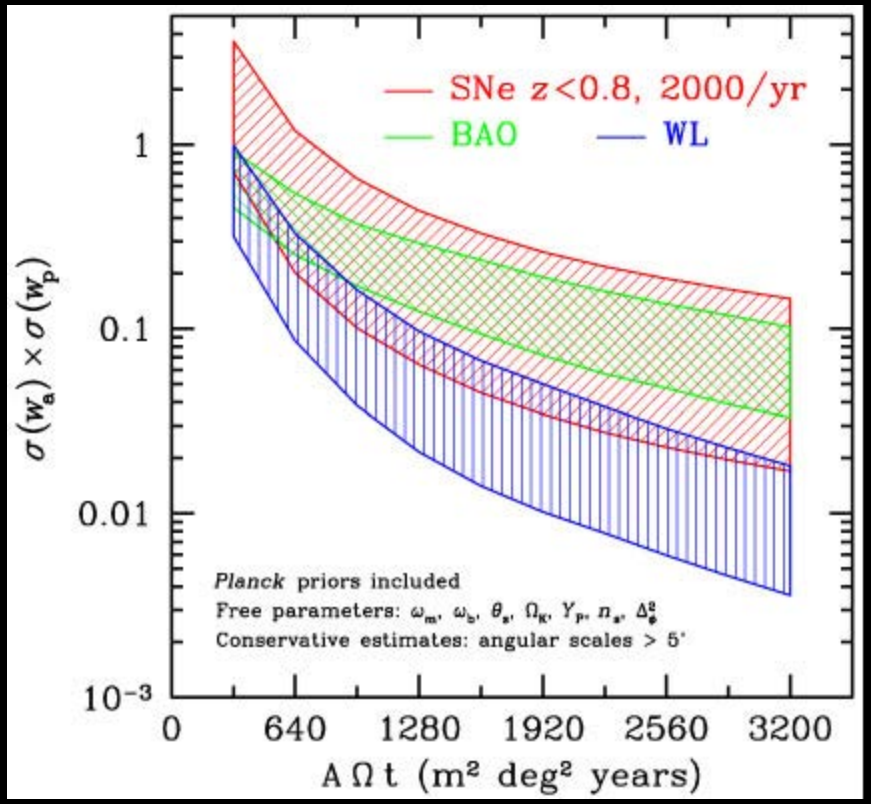
in space and time

*Each sky patch will be visited over 800 times:*

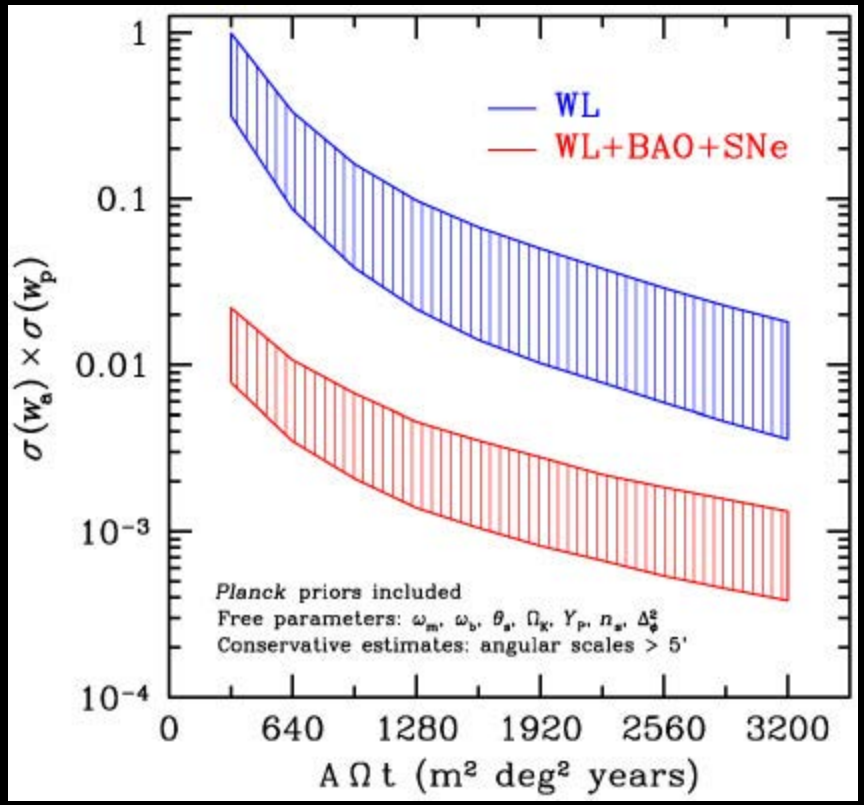
*30 trillion measurements*

# Dark Energy Precision vs Integrated Luminosity

Separate DE Probes




Combined



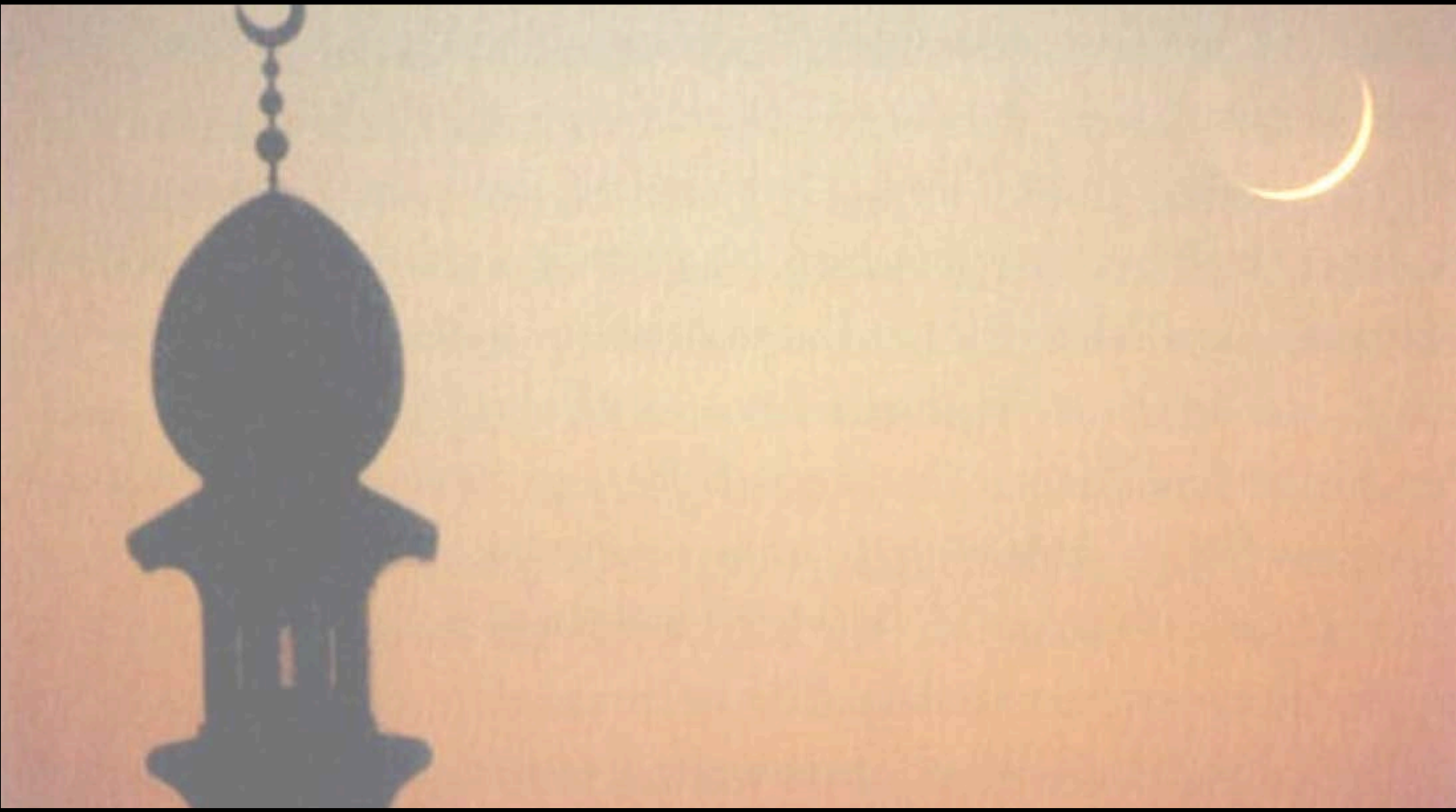

Hu Zhan 2006

2002
2003
2004
2005
2006
2007
2008
2009


# OCT

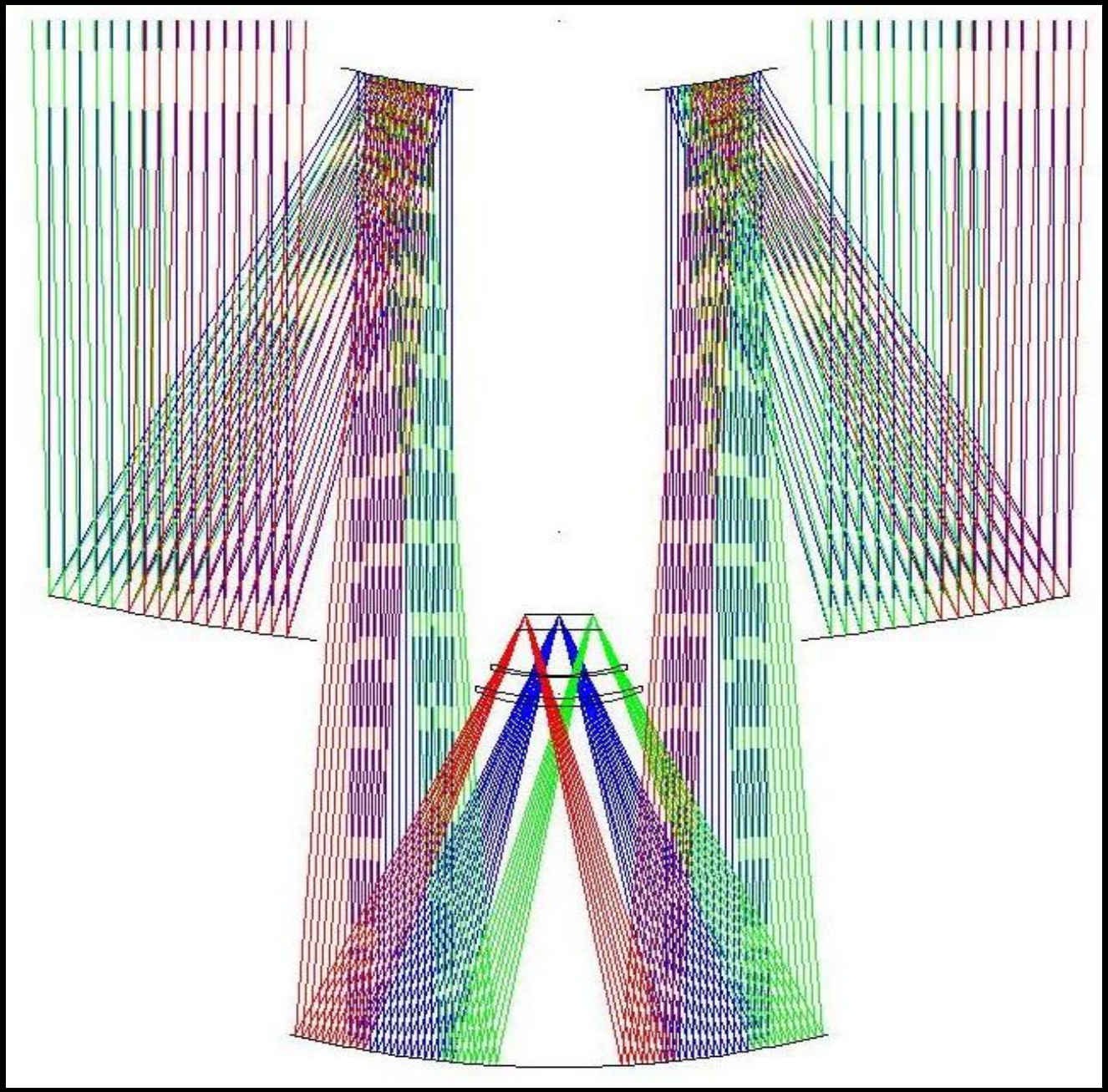
# ORGANIZED CRIME TELESCOPE

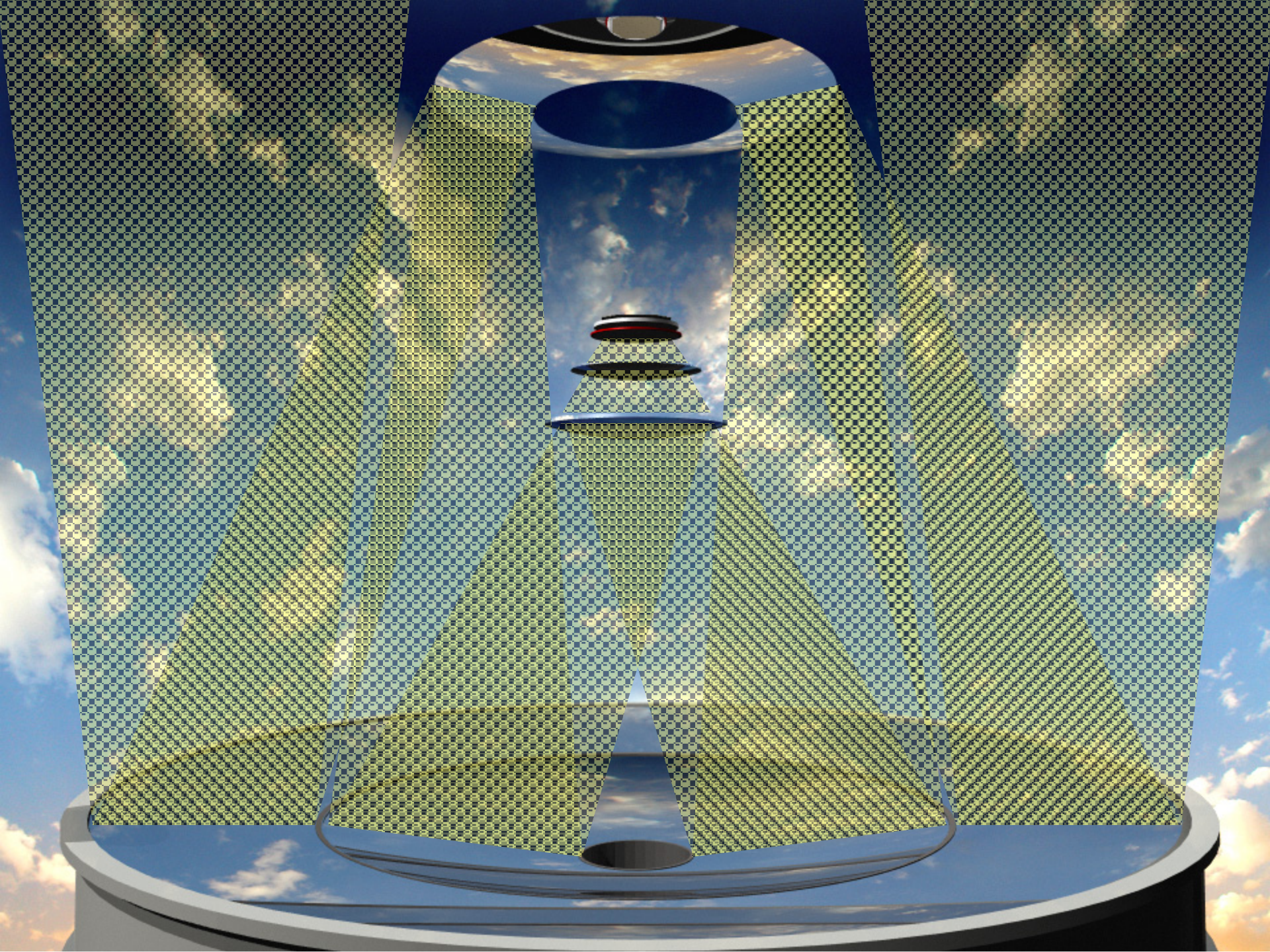
# October 2008

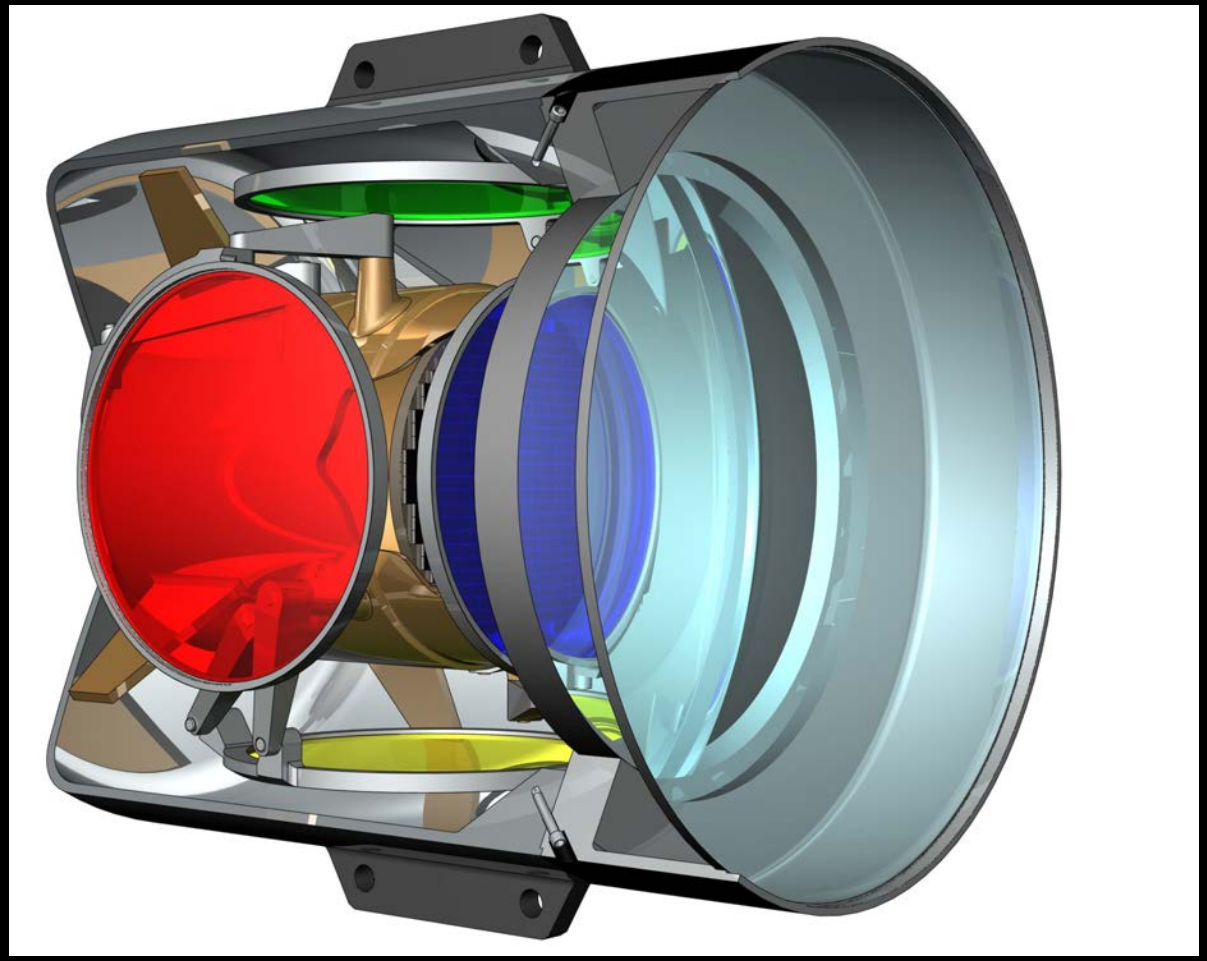


Shaikh Khalid bin Hamad Al Khalifa

# March 2009







2004


LSST
Large Synoptic Survey Telescope
CONSTRUCTION OF THE
RGE SYNOPTIC SURVEY TELESCOPE
osal submitted to the National Science Foundation
Large Synoptic Survey Telescope Corporation (LSSTC)
February 2007
LSST
Paul O'Connor
BNL

2007

# Email from Charles Simonyi @ NSF CDR


Subject **Support of the Telescope**

Tags Important

Dear Tony,

Bill and I agreed to support the telescope.

September 17, 2007

# Steward Mirror Lab 2008

# “Genome project” approach to astronomy

- Avoid cost of building a new facility running a new experiment every time we ask a new science question

- One exhaustive survey of the optical universe
- A 3.2 Giga pixel image every 18 sec for 10 years
- Calibrated trusted data

- *Exascale data enables many “experiments”*

# LSST
## Science Book

Large Synoptic Survey Telescope

Version 2.0, November 2009

# All Hands Meeting

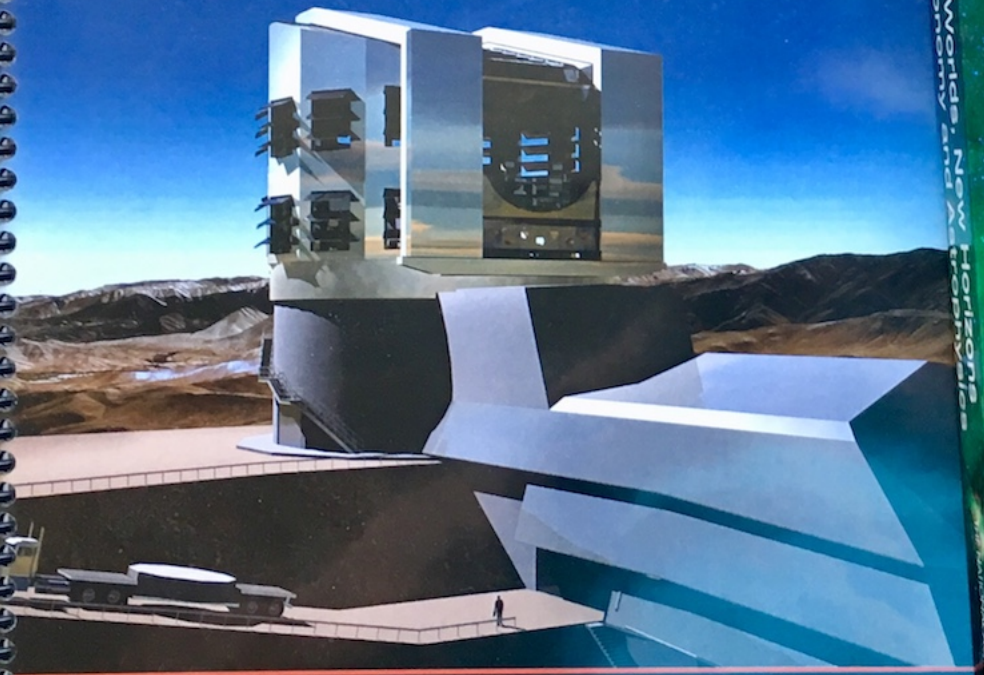

August 13, 2010

LSST

Large Synoptic Survey Telescope

# CONSTRUCTION OF THE LARGE SYNOPTIC SURVEY TELESCOPE

Proposal submitted to the National Science Foundation
by the Large Synoptic Survey Telescope Corporation (LSSTC)
February 2011



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Adler Planetarium
Brookhaven National Laboratory
California Institute of Technology
Carnegie Mellon University
Chile
Cornell University
Drexel University
Fermi National Accelerator Laboratory
George Mason University
Google Inc.
Harvard-Smithsonian Center for Astrophysics
Institut de Physique Nucleaire et de Physique des Particules (IN2P3)
Johns Hopkins University
Kavli Institute for Particle Astrophysics and Cosmology at Stanford University
Las Cumbres Observatory Global Telescope Network, Inc.
Lawrence Livermore National Laboratory
Los Alamos National Laboratory
National Optical Astronomy Observatory
Princeton University
Purdue University
Research Corporation for Science Advancement
Rutgers University
SLAC National Accelerator Laboratory
Space Telescope Science Institute
Texas A & M University
The Pennsylvania State University
The University of Arizona
University of California, Davis
University of California, Irvine
University of Illinois at Urbana-Champaign
University of Michigan
University of Pennsylvania
University of Pittsburgh
University of Washington
Vanderbilt University

New Worlds, New Horizons in Astronomy and Astrophysics

# New Worlds, New Horizons

## in Astronomy and Astrophysics

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

# LSST@Europe 2013

# Director Kahn

2013


LSST
Large Synoptic Survey Telescope
First Stone • Primera Piedra
2015-04-14
Cerro Pachón, Chile

2015

# Asteroids, Inc @ NASA

2015

# DOE-NSF Joint Status Review 2017

2018

2018


Data Rights and Access Policies
Proposed Definitions and Policies
LSST

2018


NSF
Office of Science
U.S. DEPARTMENT OF ENERGY

Linda Davidson/The Washington Post, via Getty Images