The Large Aperture Mirror Array Telescope

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Agenda

- 10:00 – 10:45 Overview of Large Aperture Mirror Array (Lanzetta)
- 10:45 – 11:30 Conceptual Design of Large Aperture Mirror Array (Hickson)
- 11:30 – 12:00 Worked Example: Distant Supernovae (Chen)
- 12:00 – 12:30 Project Plan (Sprouse)
- 12:30 – 1:20 lunch

Agenda (continued)

- 1:20 – 1:30 The View from Stony Brook (Solomon)
- 1:30 – 2:00 Discussion of Science Priorities
- 2:00 – 3:00 Discussion of Technical Questions and Answers (led by Hickson)
- 3:00 – 4:00 Discussion of Possible Plans of Action (led by Lanzetta)

Our perspective

- We are receptive to input at any time
- Our scientific interests center on extragalactic astronomy (distant galaxies and supernovae and quasar absorption lines), but we believe the telescope is of broad utility
- Key design criteria of the telescope (e.g. maximum zenith angle, choice of instrumentation, mode of operation) are fluid and subject to revision

Why do universities build astronomical observing facilities?

- Tradition
  - In US, 80% of telescope “glass” owned by universities or private observatories
- High-profile, high-prestige endeavor
- Thriving physical science
  - Pace of progress at least as rapid today as in 1930’s and 1960’s
- Field is driven by advances in instrumentation

Astronomical breakthroughs of the 1990's

- Extra-solar planets
- Very distant galaxies
- Anisotropy of the microwave background
- Cosmological parameters and acceleration of the expansion rate
- Massive black holes in normal galaxies
- Identification of gamma-ray bursters

Important telescopes of the 1990’s

- Hubble Space Telescope
  - 2.3 m diameter primary mirror
  - Earth orbit
- Keck I and II
  - 10 m diameter primary mirrors
  - Mauna Kea, Hawaii, 14,000 ft elevation

Current generation of telescopes

Telescope	Primary Mirror Diameter (m)	Partners
Keck I	10	Cal Tech, UC
Keck II	10	Cal Tech, UC, NASA
VLT 1	8	Europe
VLT 2	8	Europe
VLT 3	8	Europe
VLT 4	8	Europe
HET	11	UT, Penn State
Subaru	8	Japan
Gemini N	8	USA, Canada, UK, et al.
Gemini S	8	USA, Canada, UK, et al.
LBT 1	8	UA, Ohio State
LBT 2	8	UA, Ohio State
SALT	11	South Africa, Penn State, et al.

Planned next generation of telescopes

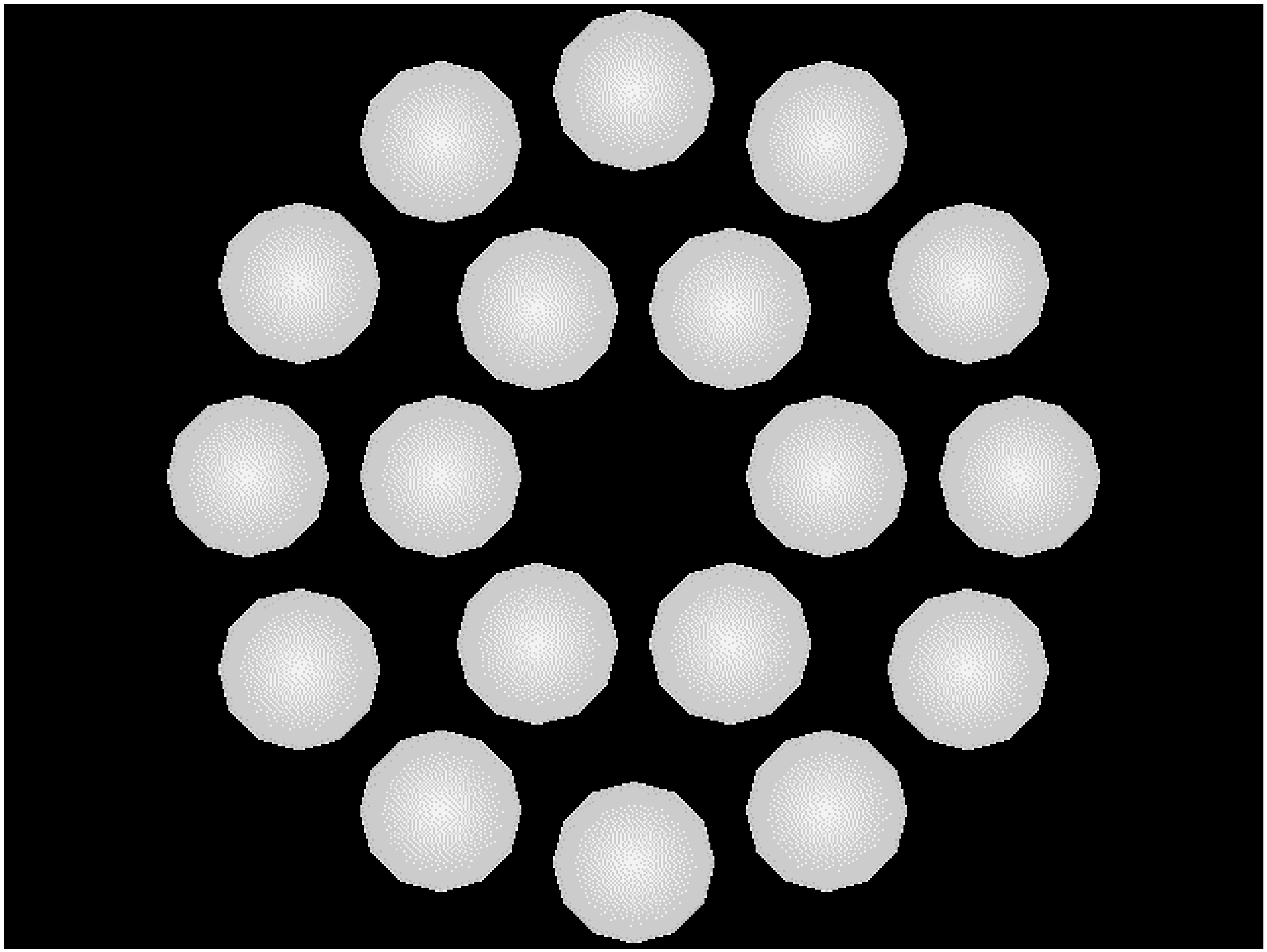
Telescope	Primary Mirror Diameter (m)	Partners
NGST	6	NASA, ESA
ELT	25	UT, Penn State
GSMT	30	USA
CELT	30 – 50	Cal Tech, UC
MAXAT	30 – 50	USA
OWL	100	Europe

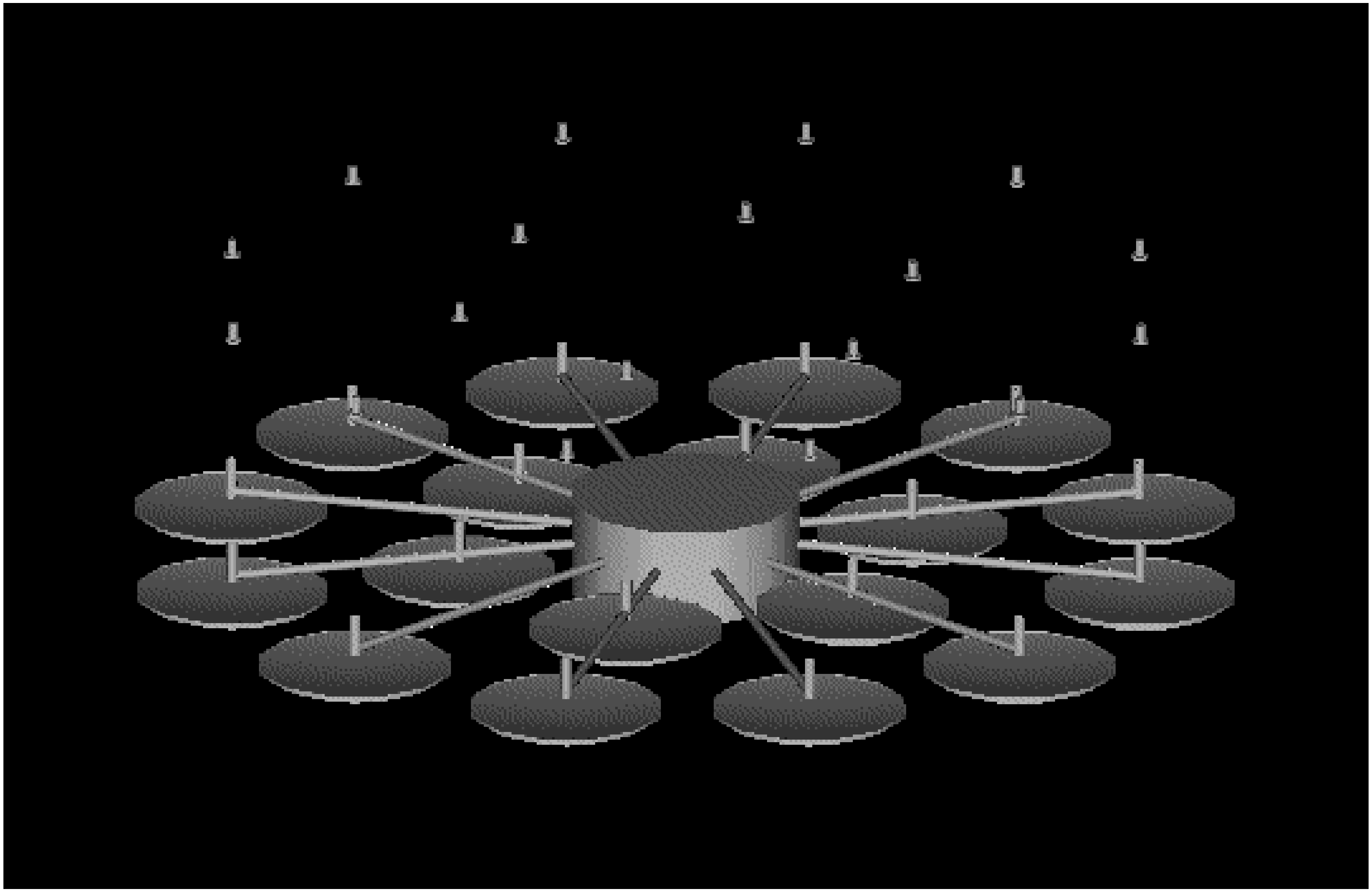
Costs of current and planned telescopes

Telescope	**Cost**
HST	$2 billion
Keck I	$100 million
NGST	> $1 billion
CELT	> $500 million
OWL	many $ billion

Large Aperture Mirror Array (LAMA)

- Concept developed jointly at University of British Columbia and SUNY Stony Brook
- *Distributed aperture configuration*
- *Limited pointing and tracking abilities*
- *Liquid mercury primary mirrors*
- Estimated cost: $50 million





Baseline configuration of LAMA

- Eighteen 10 m diameter primary mirrors, each equipped with tracking relay optics
- Each beam relayed to (1) adaptive optics and (2) beam combining optics; beams combined incoherently (or coherently)
- Combined beam focused to optical/infrared dichroic *V*, *R*, *I*, *J*, *H*, *K* camera
- Light-gathering ability of 42 m telescope, angular resolution of 10 m (or 60 m) telescope

Baseline tracking relay optics of LAMA

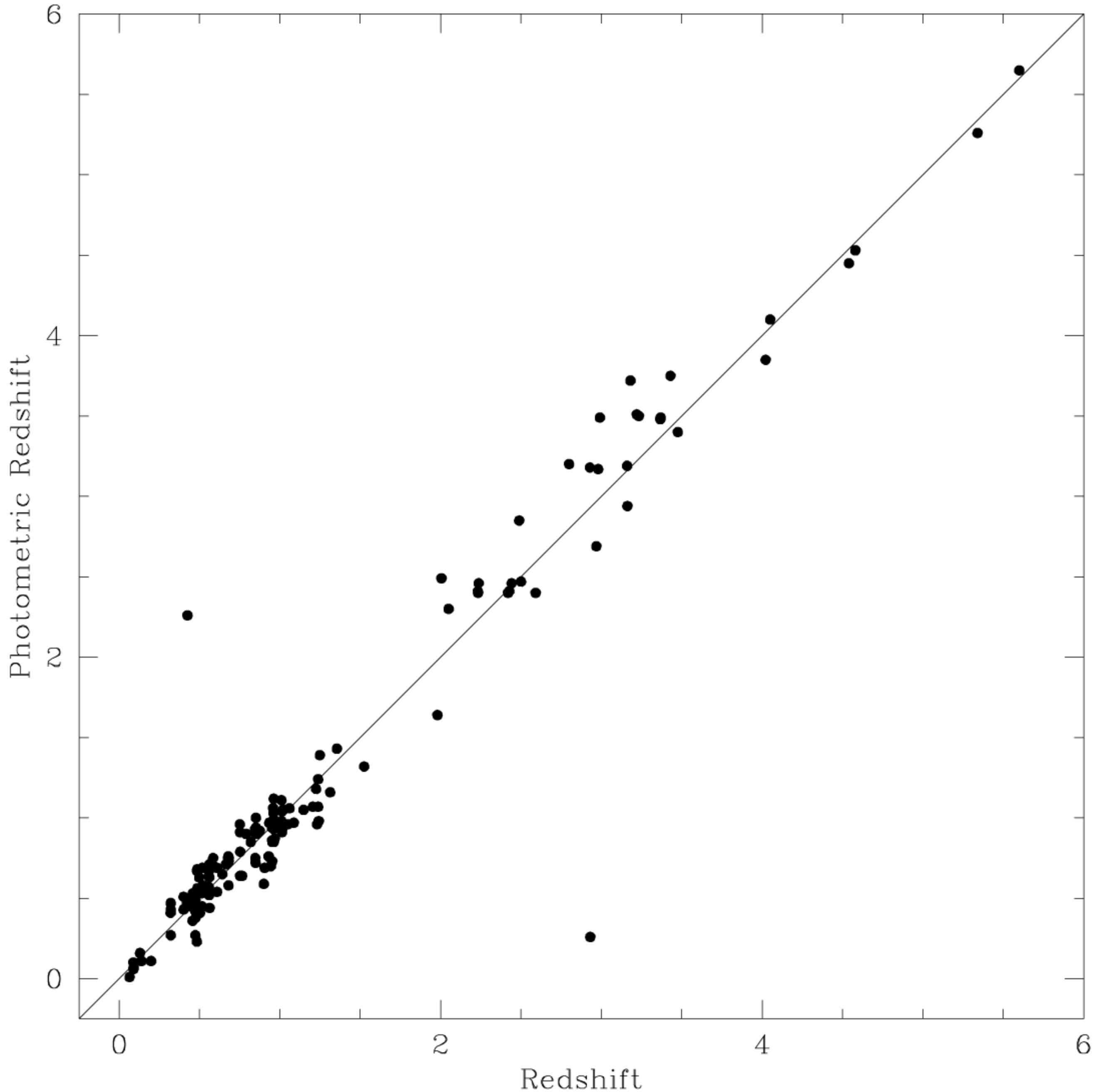
- Based on published design by Hickson 2002 (MNRAS, in press)
- Instantaneous field of view: 1 arcmin^2
- Accessible field of view: ±4 deg off axis

Baseline detector of LAMA

	Optical	**Infrared**
Number of pixels	4K x 4K	2K x 2K
Pixel angular size	0.00625 arcsec	0.0125 arcsec
Field of view	30 x 30 $arcsec^2$	30 x 30 $arcsec^2$

Baseline operation of LAMA

- Phase reference star acquired 0–15 minutes before transit and tracked until 0–15 minutes after transit; next phase reference star acquired 0–15 minutes before transit, etc.
- Same fields observed night after night for one or two years
- Observations establish galaxy spectral energy distributions and photometric redshifts and detect variable and transient events


Photometric Redshift
Redshift
0
2
4
6
0
2
4
6

Baseline point source sensitivity of LAMA

	10 s	**600 s**	**45,000 s**
V	22.4	25.6	28.0
R	28.3	30.5	32.8
I	28.3	30.5	32.8
J	27.1	29.3	31.6
H	26.3	28.5	30.9
K	25.8	28.0	30.4

To point or not to point?

- *Proposition: It is not obvious to what zenith angle a large-aperture telescope should be built to point*
- Deep wide-field surveys
  - Example: Distant galaxies and supernovae
  - No advantage to large zenith angle pointing
- Bright source surveys
  - Example: Quasar absorption line spectroscopy
  - Advantage to large zenith angle pointing

$$m_2 - m_1 = \frac{1}{b} \log \frac{\Omega_1}{\Omega_2}$$

Wide-field or narrow-field?

- For Nyquist-sampled, pixel-limited observations of background-limited sources, product of area times depth is independent of angular resolution
- Solid angle per exposure:

$$\Omega = N^2 \mathbf{q}^2$$

- Time per exposure:

$$t \propto \frac{B}{F^2}\left(\frac{S}{N}\right)^2 \mathbf{q}^2$$

- *LAMA is a wide- or narrow-field telescope*

Sufficient phase reference stars?

magnitude	density (deg^{-2})	accessible number	accessible area (deg^2)
12	13	31,700	2.2
13	27	64,800	4.5
14	67	160,800	11.2
15	135	324,000	22.5

OH blocking

- We have been thinking about possibilities of gas-phase OH blocking…
- …and others have been thinking about other possibilities of OH blocking