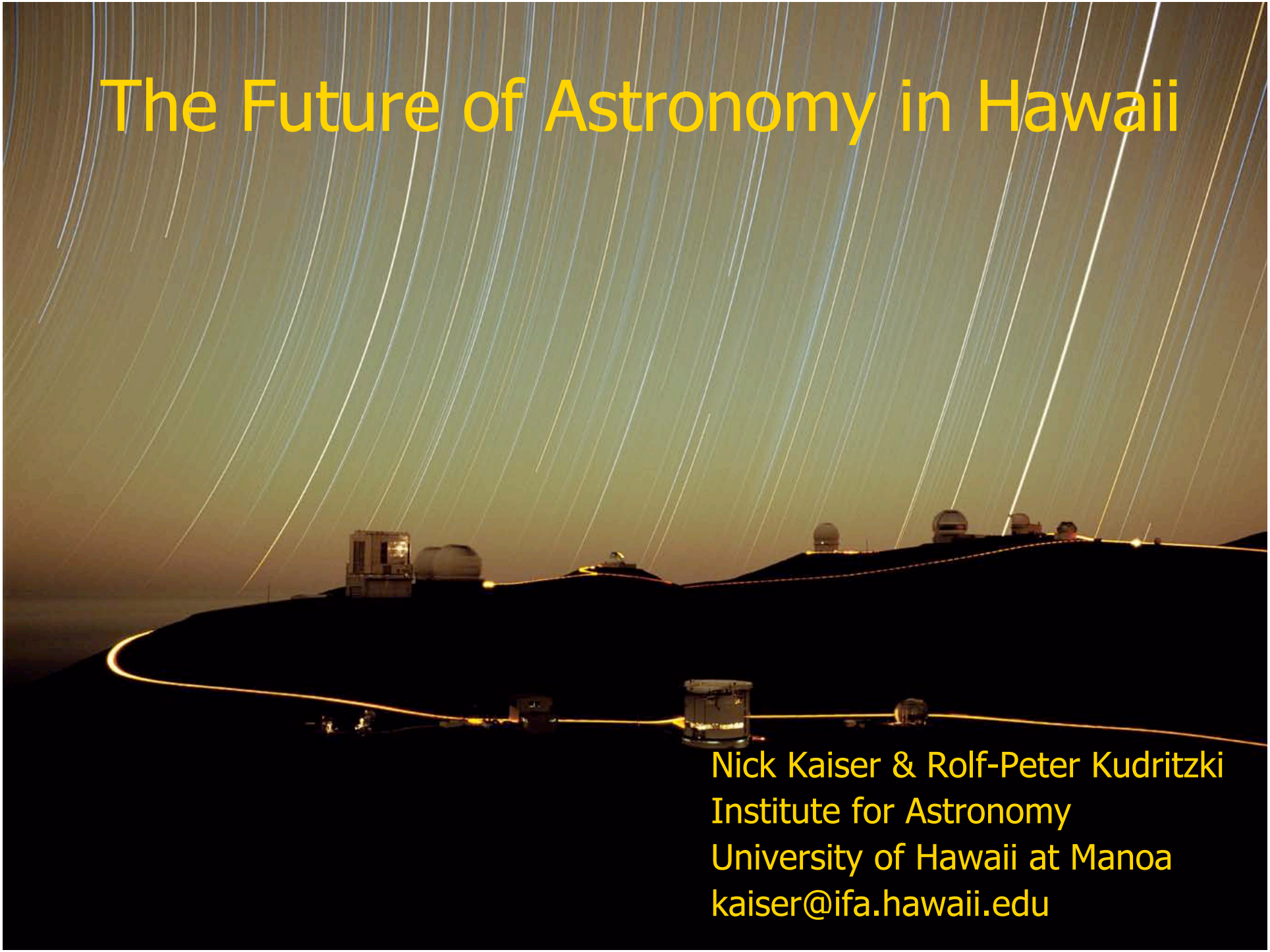
The Future of Astronomy in Hawaii



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Why astronomy ?

- mother of all sciences
- has revolutionized thinking of humans like no other science
- fundamental contributions to present science
- big science at the cutting edge of technology
- most popular science → enormous visibility

What is the origin of life?

Where are we going?

Is there life elsewhere?

Where do we come from?

Astronomy is the vehicle...

- **To provide Hawaii with scientific, educational, technological and cultural partnerships...**

  Countries: Australia, Argentina, Brazil, Canada, Chile, France, Japan, Taiwan, UK, Netherlands...

  Agencies: NASA,NSF,AFRL,NSERC, PPARC,AURA

  Universities: Berkeley, CalTech, Harvard, San Diego, UCLA, Texas...

Astronomy is the vehicle...

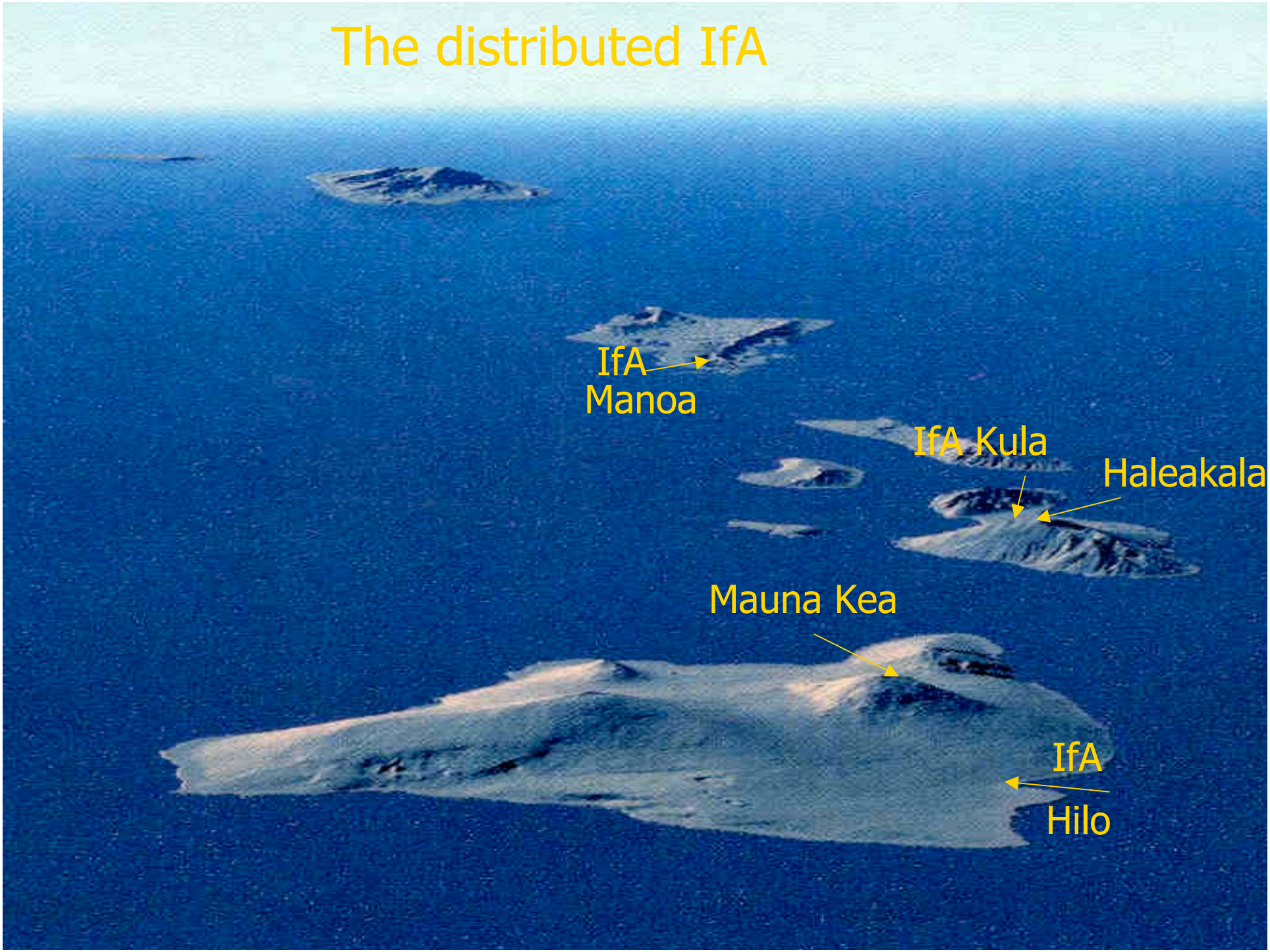
- to attract hightech business in electronics, optics, precision mechanics, information technology and, thus,
- to diversify the Hawaii economy
- at the moment: - 600 quality jobs

  - economic impact $150 million/yr
- to stimulate public interest in high level science
- to motivate a younger generation for education in science, engineering and technology

Institute for Astronomy

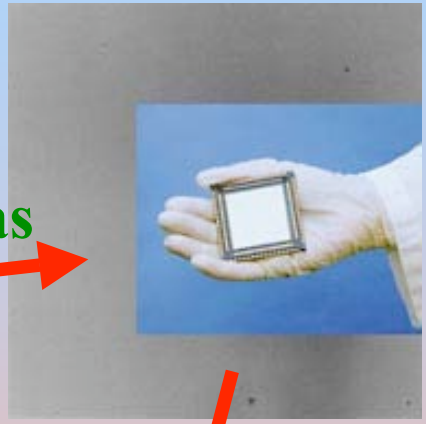
- 280 staff, 80 scientists
- 40 tenure track faculty
- 35 PhD students
- 1000 undergraduate students/yr in Manoa
- 2 observatory sites: Mauna Kea and Haleakala
- base facilities distributed over 3 islands

The distributed IfA

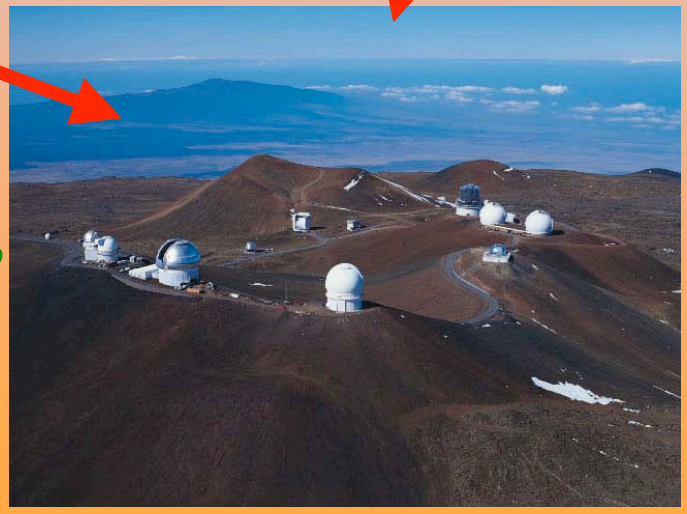


What the IfA does in Hilo

new technologies:
IR-detectors,
Adaptive Optics,
spectrographs, cameras



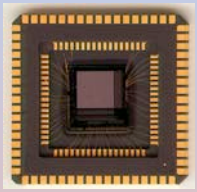
operation of telescopes:
IfA 88”, IfA 24” , IRTF
collaboration with UH Hilo astronomy:
joint appointments,UHH offices in IfA,
IfA 24” → UHH new telescope
outreach:
infrastructure $1billion observatory:



IfA "Hawaii" infrared detectors

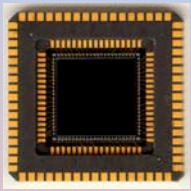
NICMOS

1987



16,384 pixels
70,000 FETs
CDS: <50e-

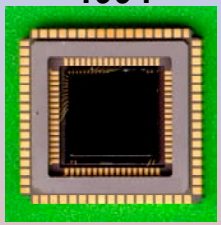
1990



65,536 pixels
250,000 FETs
CDS: <30e-

PICNIC

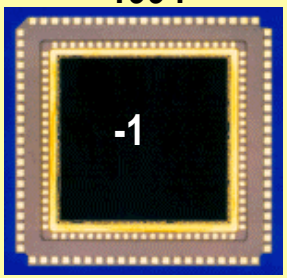
1994



65,536 pixels
250,000 FETs
CDS: <20e-

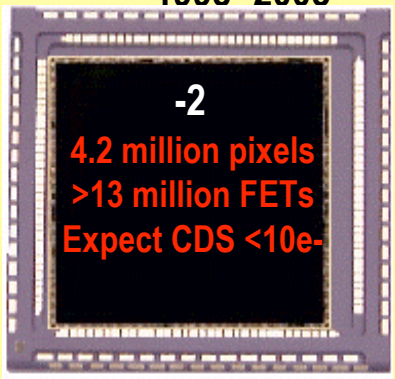
HAWAII

1994

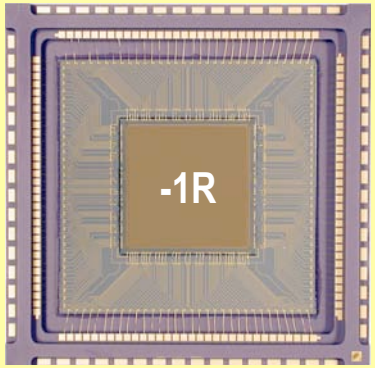


1.05 million pixels
>3.4 million FETs
CDS: <10e-

1998 -2003



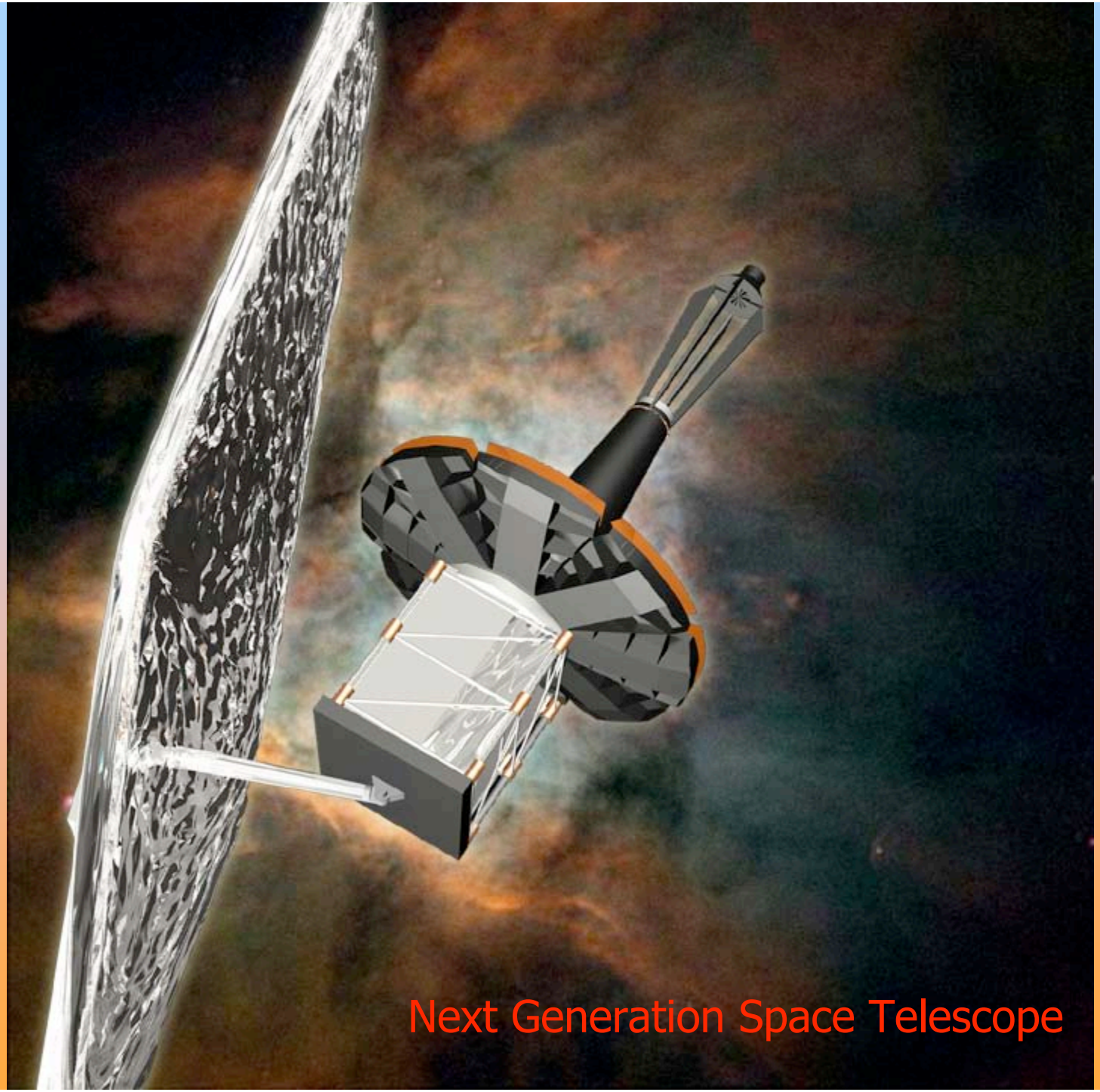
2000-2003



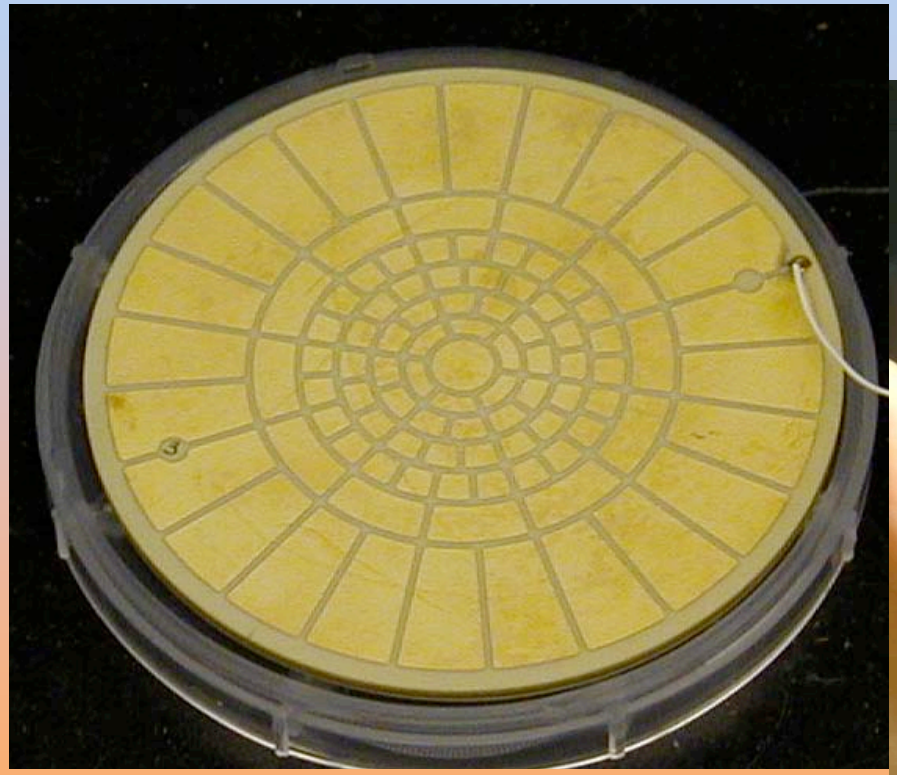
CDS: <TBD e-

HAWAII-2RG

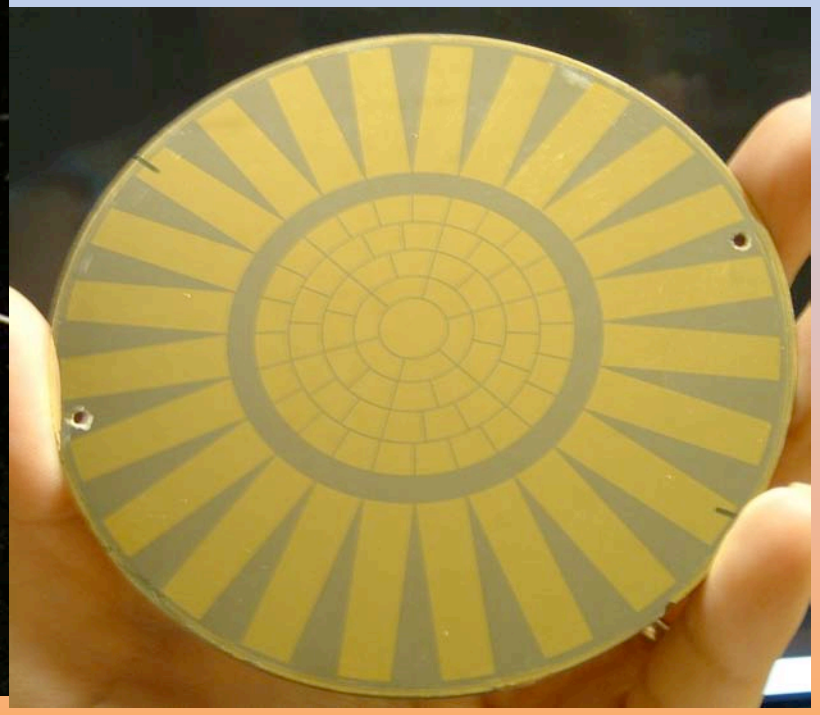
Selected by NASA for the Next Generation Space Telescope !!!


Next Generation Space Telescope

Adaptive Optics

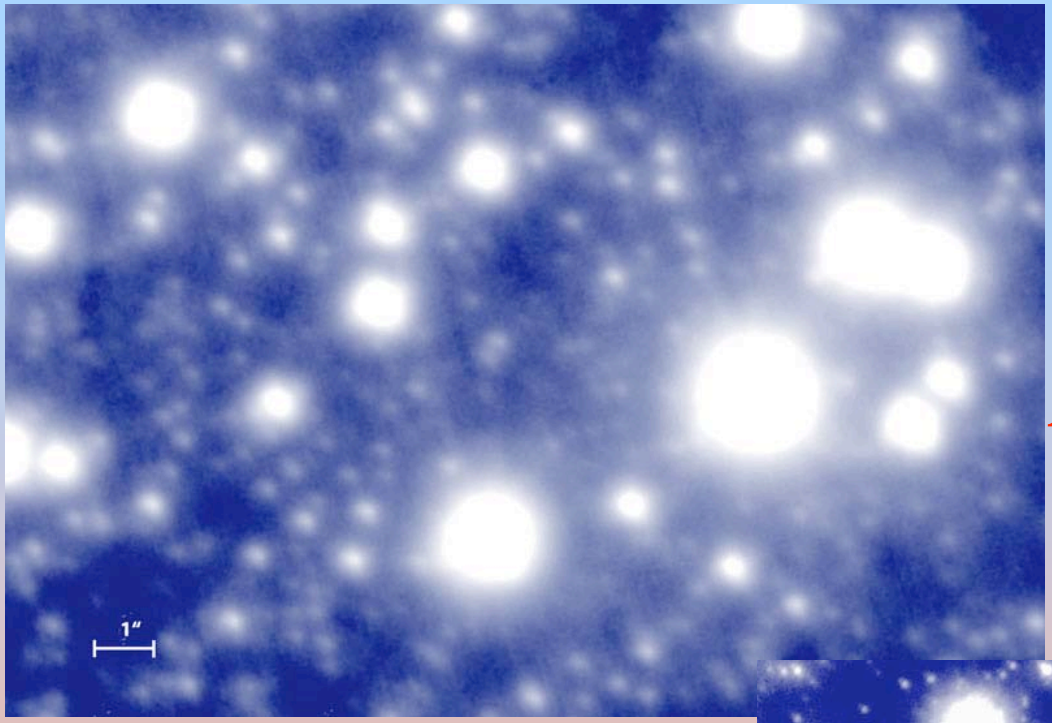


Original H-85 DM



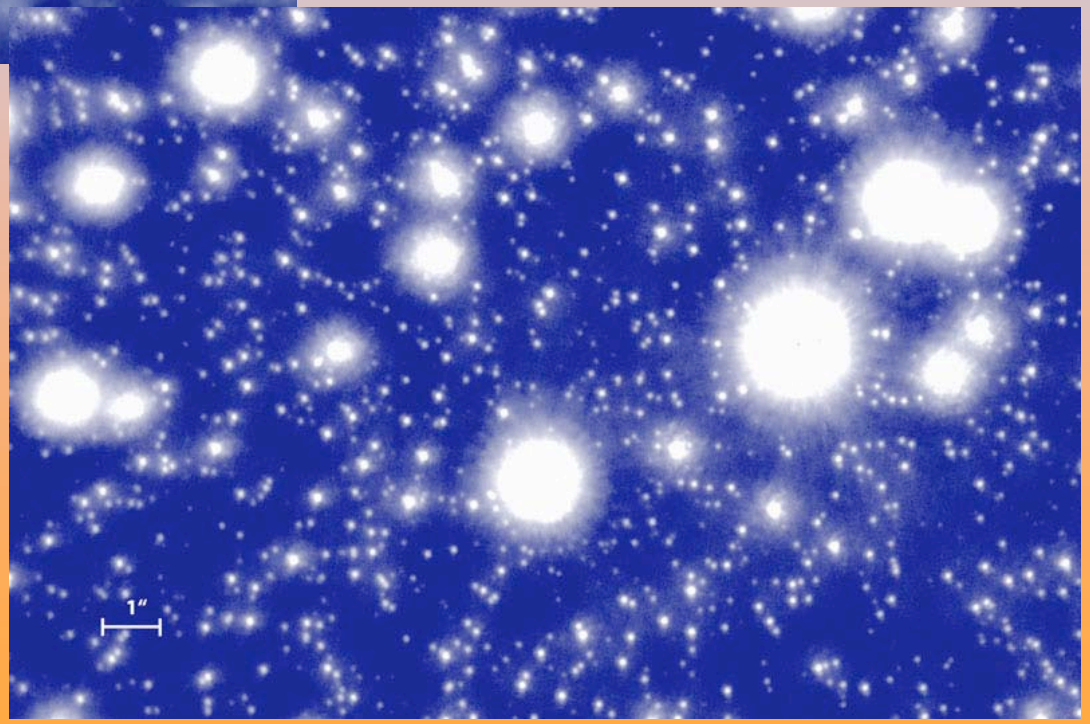
New H-85 DM

IfA builds new AO system for 8m Gemini telescope !!!



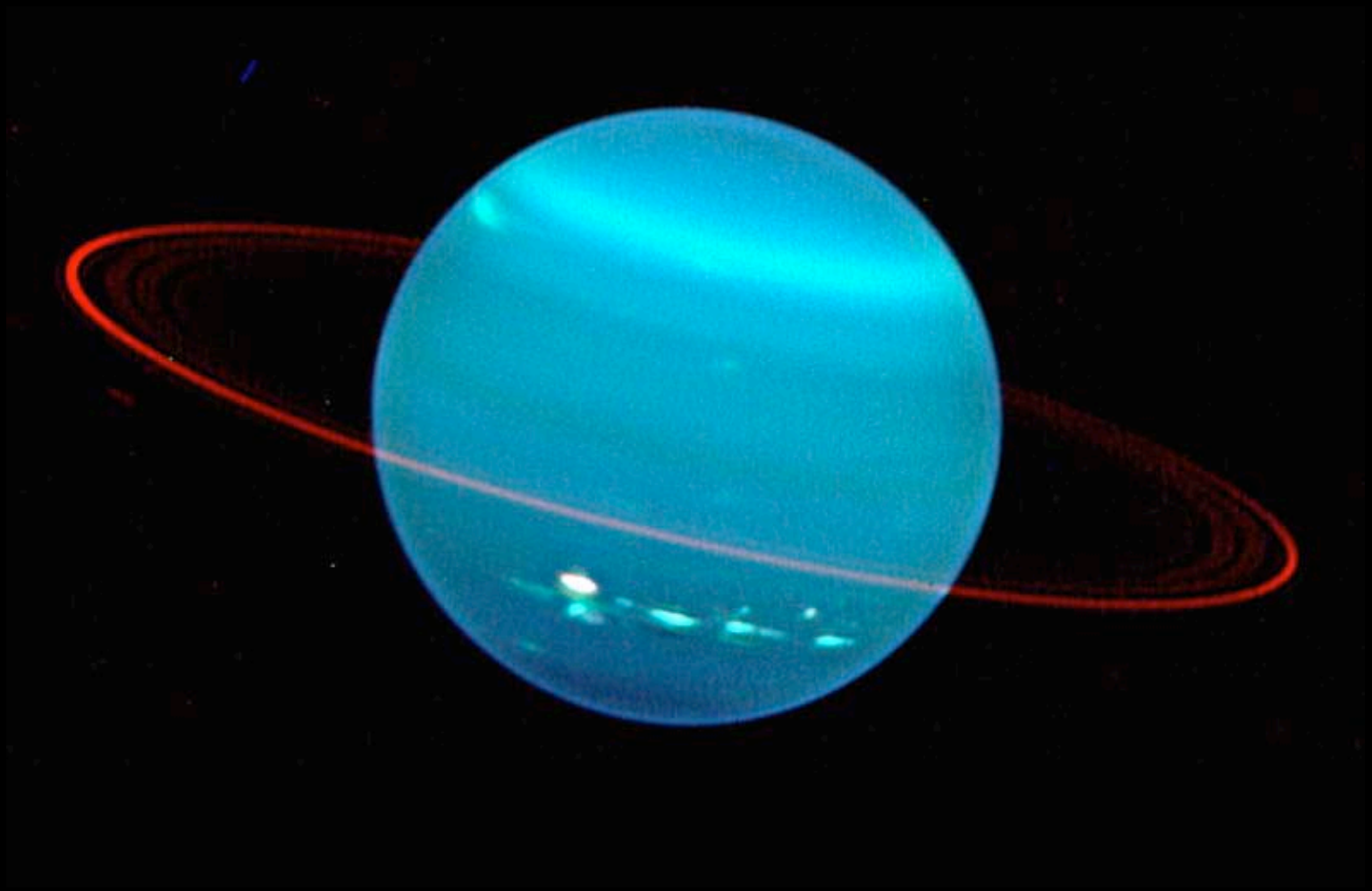
without

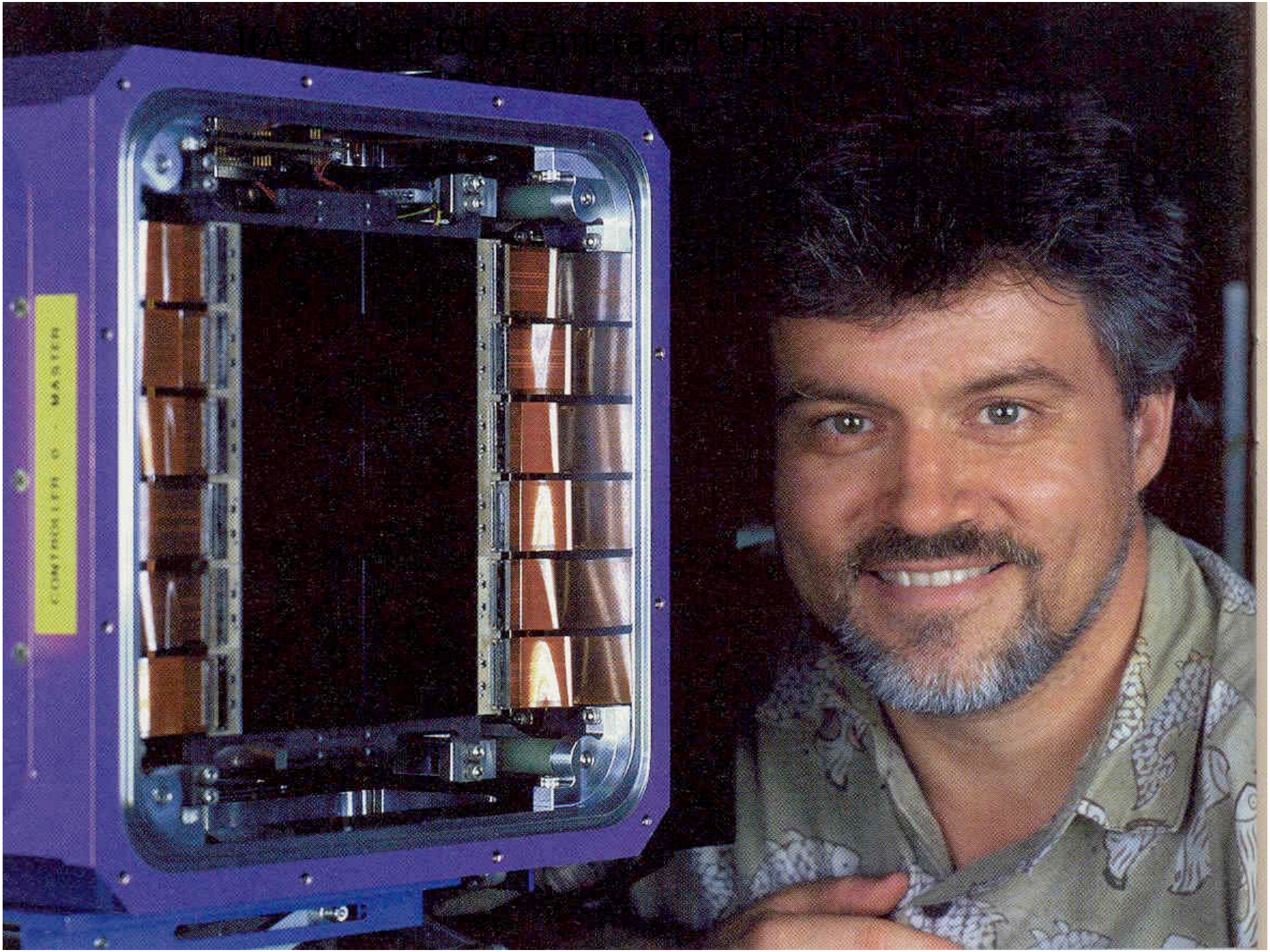
Adaptive Optics



with

Uranus Keck AO



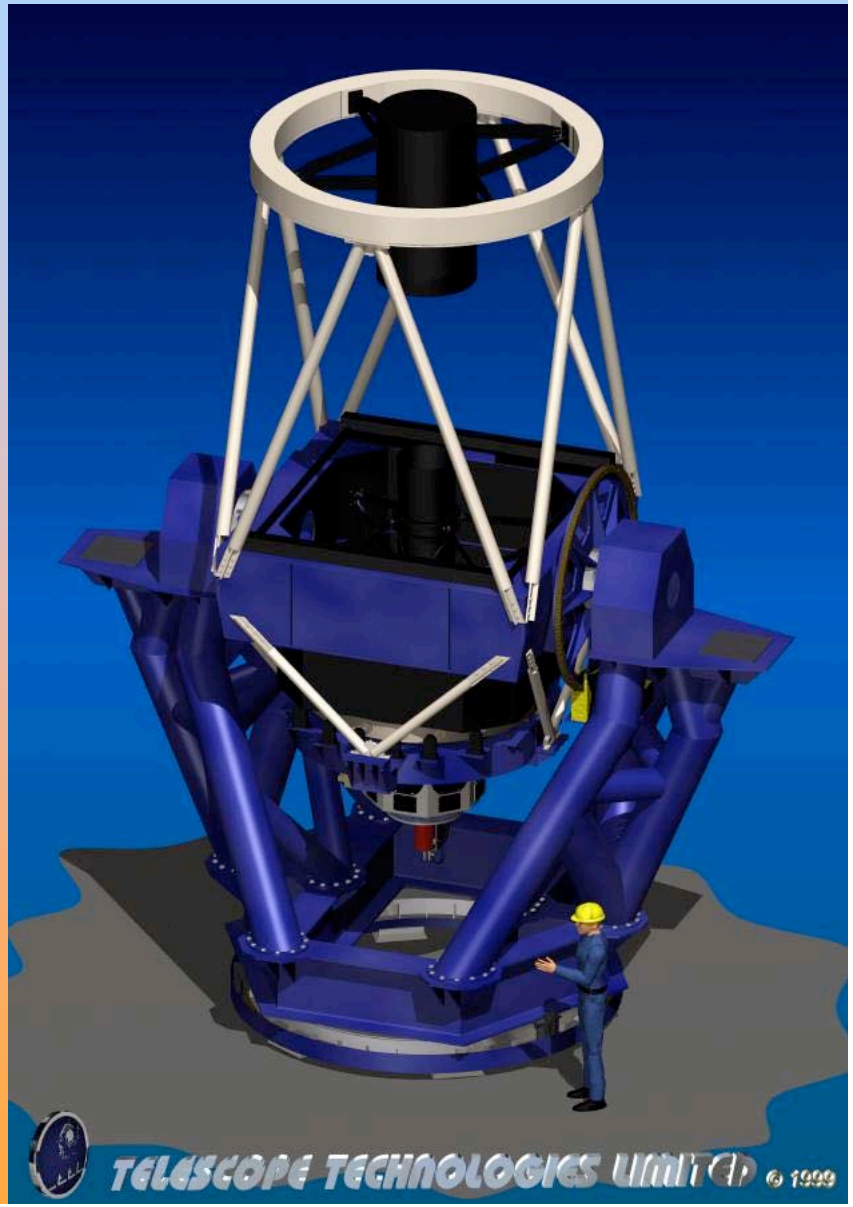

MEGACAM CCD - MASTER

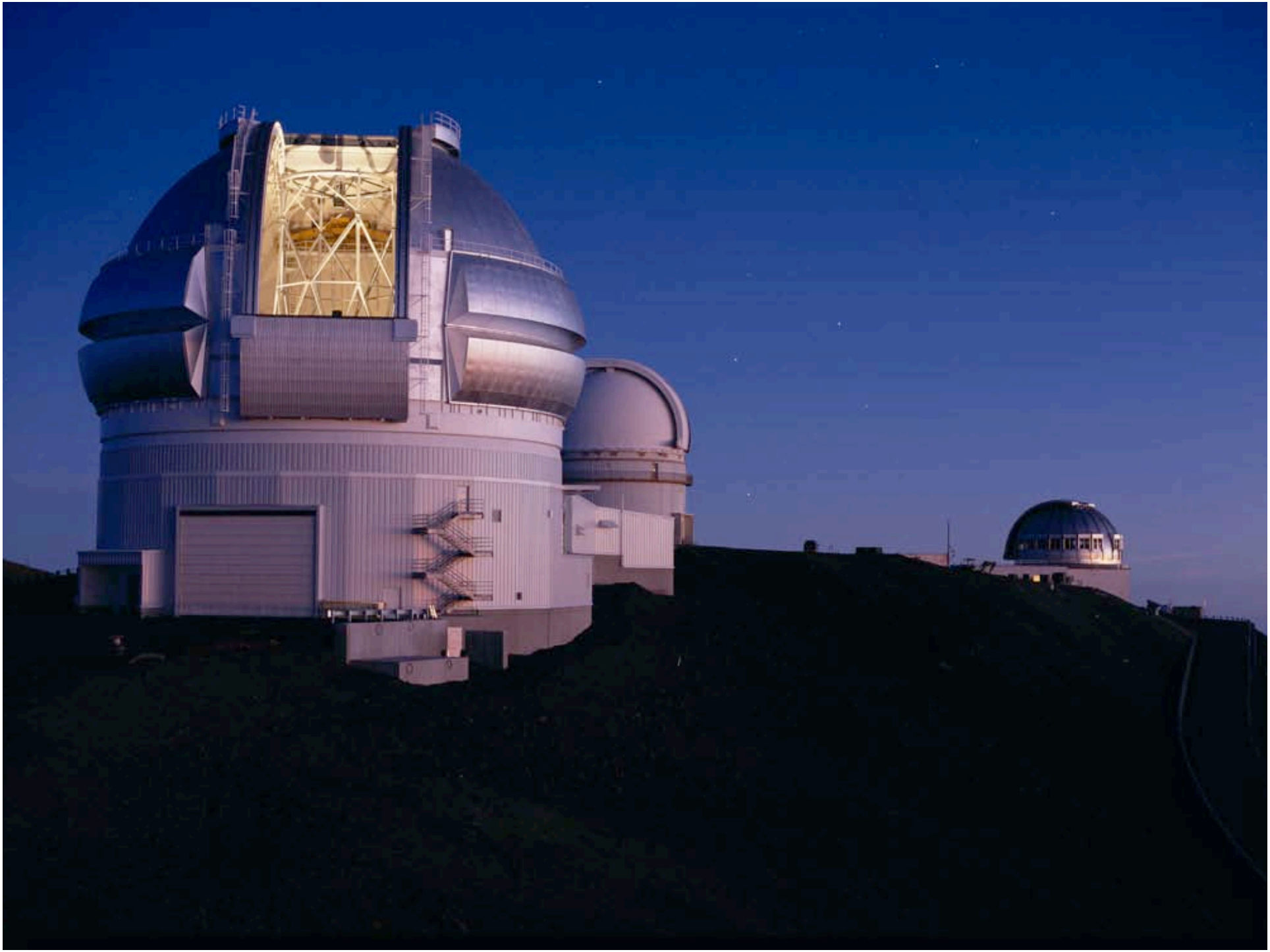

IfA Outreach
Open House in Manoa
IfA
Faculty
PhD student

The Faulkes Telescope

The Faulkes Telescope

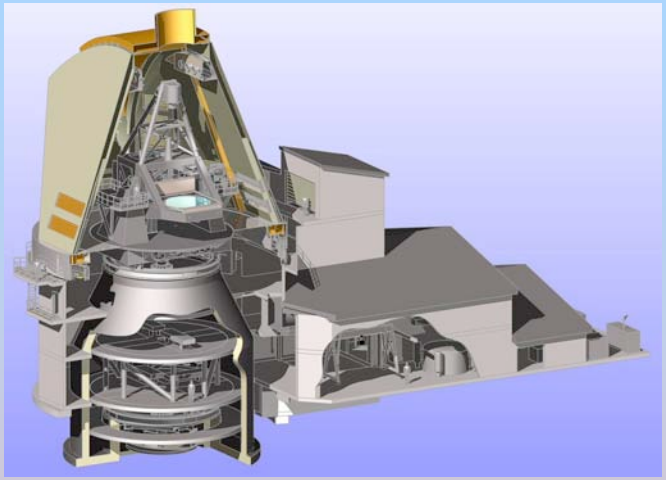
- world's largest (2m) outreach and education telescope
- available for school students in Hawaii and UK in their class through Internet
- the IfA's gift to the children of Hawaii
- First light in summer 2003
- operational winter of 2004
- dedication spring 2005

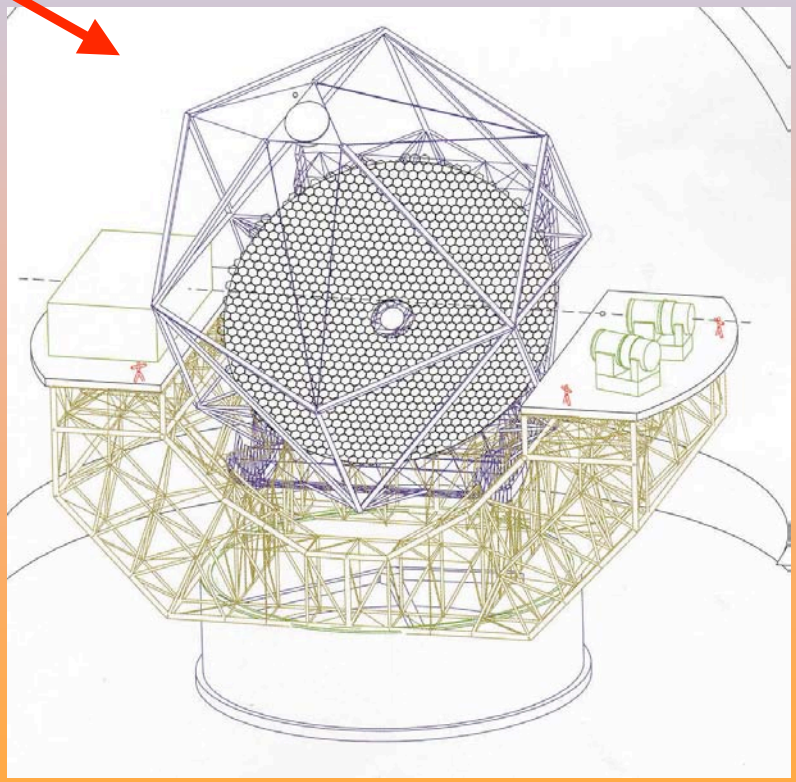


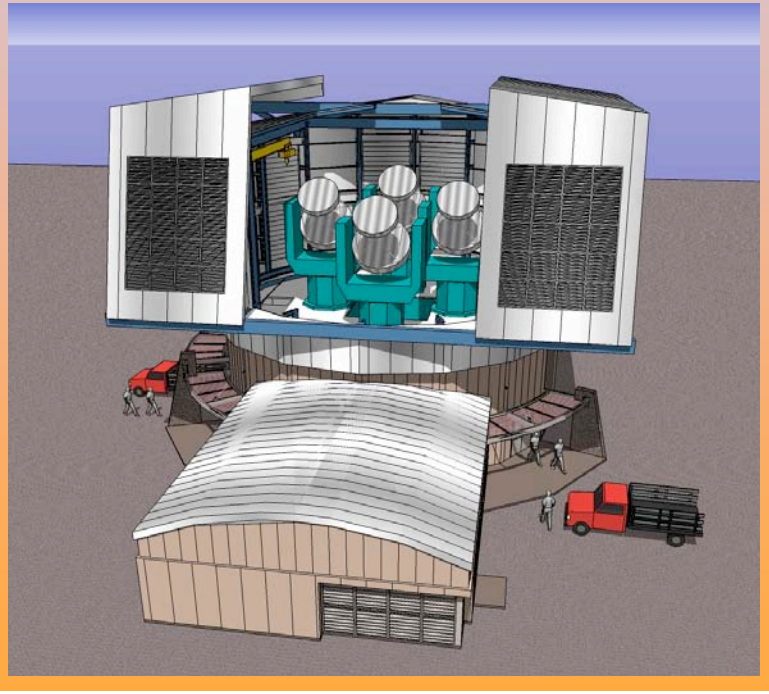


What the IfA will do in the future

- ATST: the largest solar telescope in the world
- TMT: the largest telescope in the world
- Pan-Starrs killer asteroid detection



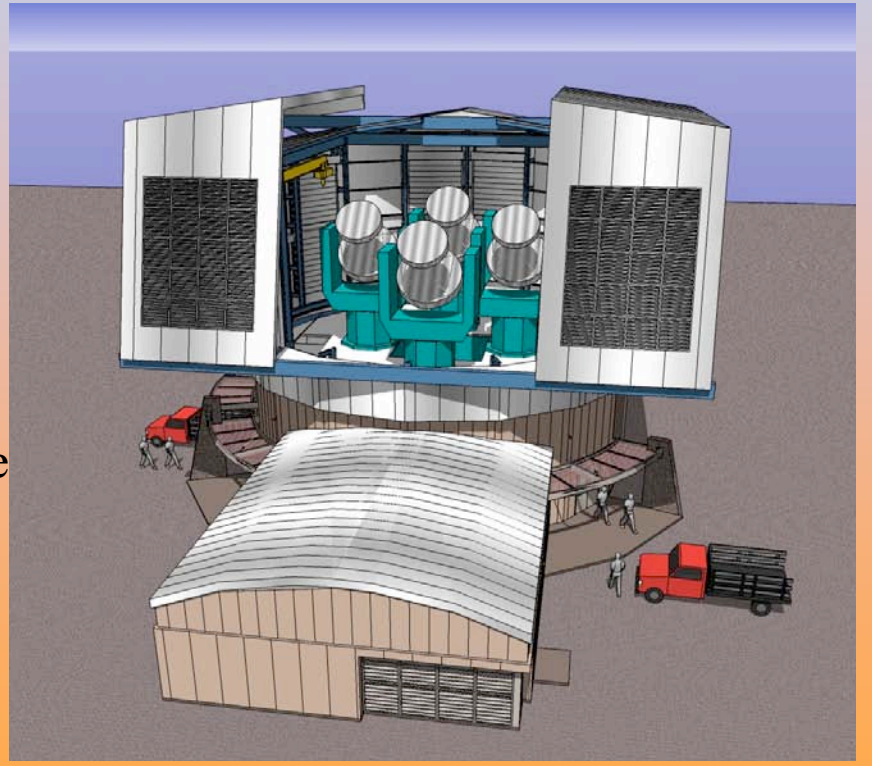




Pan-STARRS

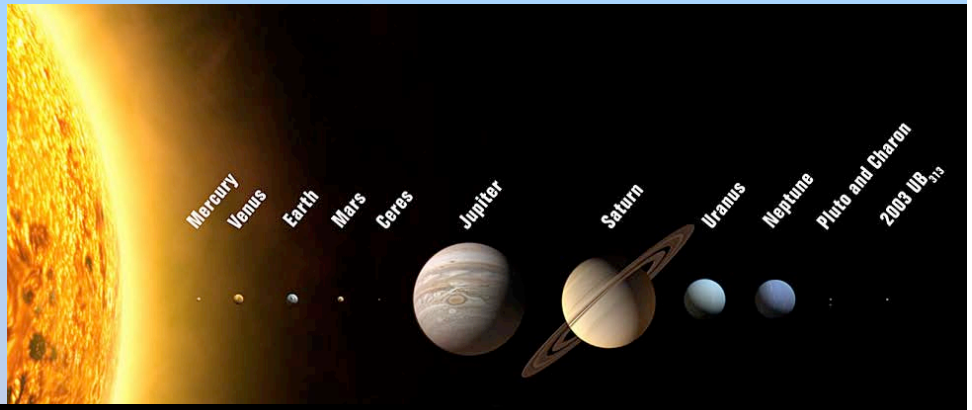
- Scan the sky rapidly, and with sensitivity to detect faint objects
  - Detect asteroids, comets multiple times and determine orbits
  - See if any will collide in next century or so
  - Can't be done with existing telescopes
    - Can detect faint objects, but can't cover sky area rapidly

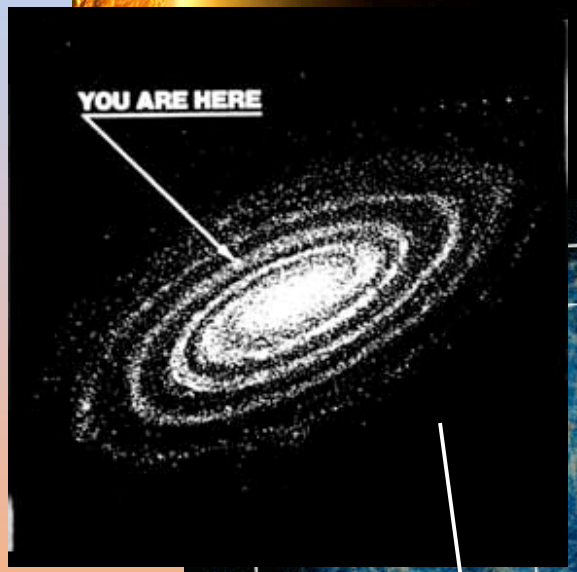
- The Pan-STARRS solution
  - Site in Hawaii
    - Excellent image quality
  - Combine data from several telescopes
    - Low cost, rapid construction, lower risk compared to monolithic large telescope
    - Technical advantages for data collection & processing
    - Very wide field of view of ~40 times are of the full moon
  - Billion pixel CCD cameras
    - Needed to cover the area
    - Rapid read-out
  - Massively parallel data processing & archiving systems (Petabytes of data)

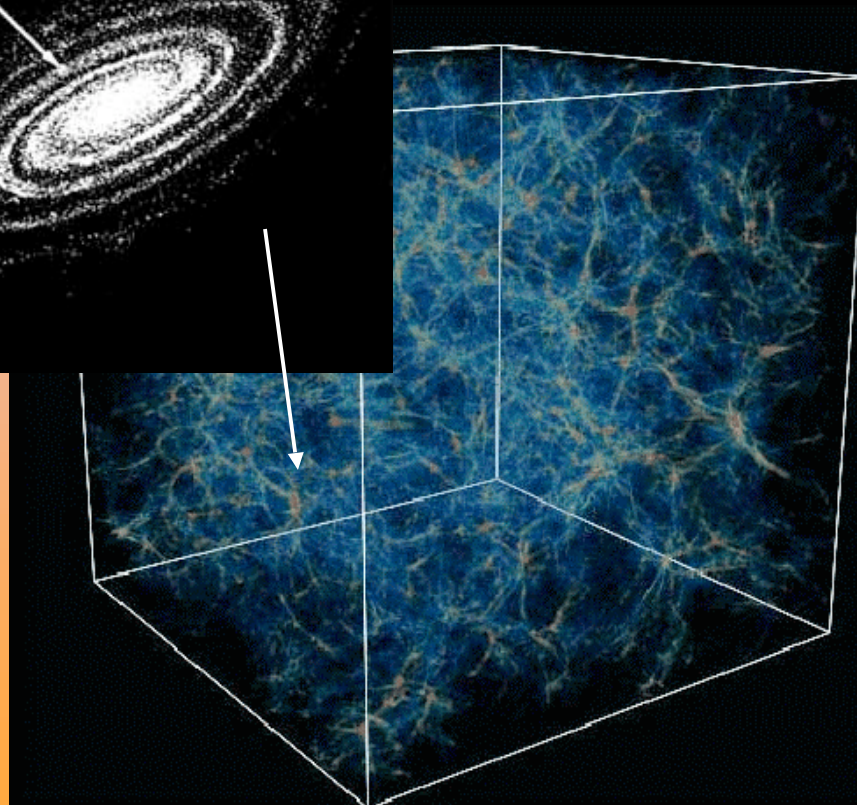


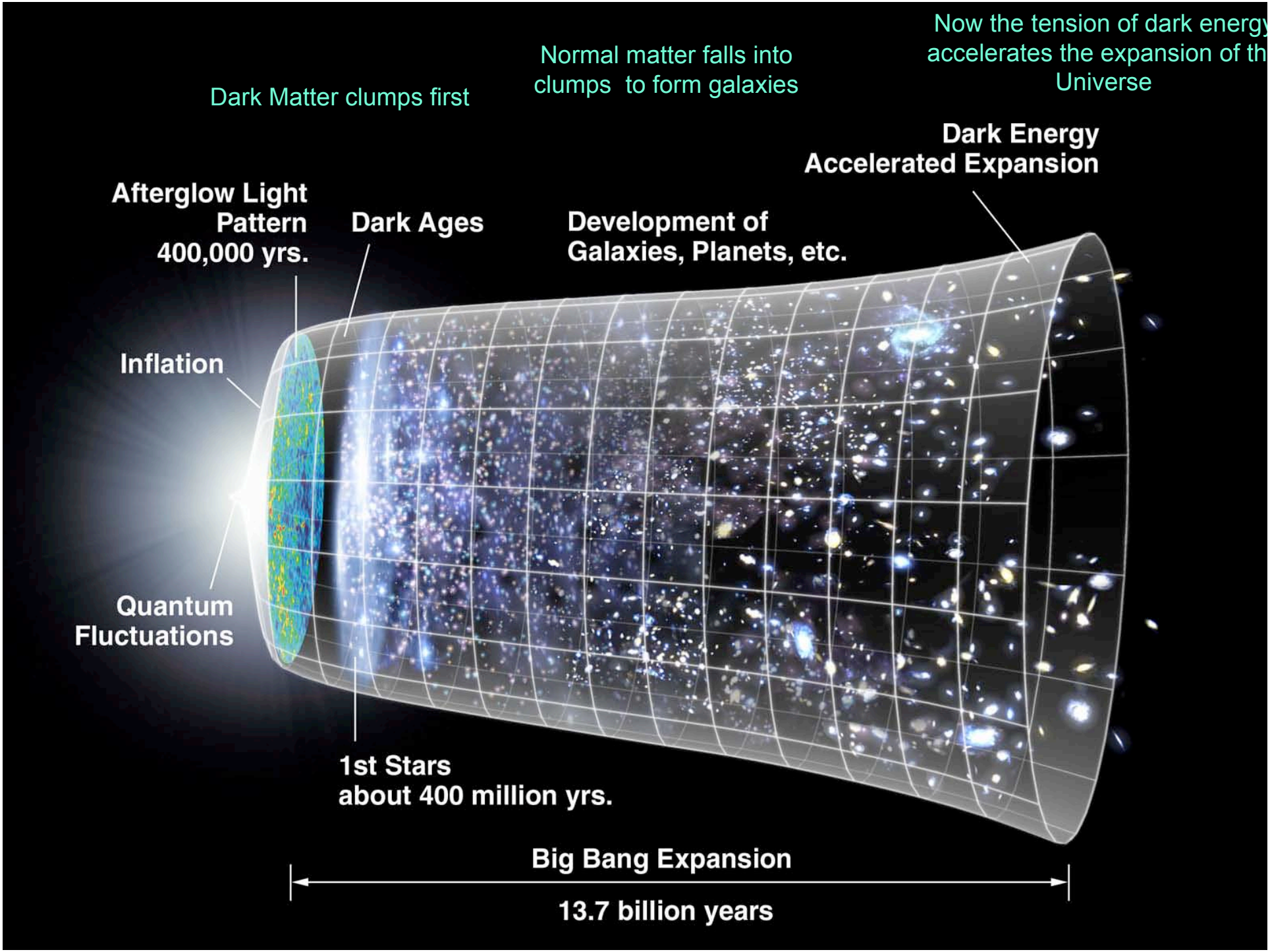
Orientation

- Solar System (Sun, Mercury, Venus, Earth, Mars, Jupiter…)
  - Our Sun is one star of a 100 billion in the Milky Way Galaxy
- Our Solar System is located In the Orion arm of the Milky Way Galaxy
- The Milky Way Galaxy is in the suburbs of the Virgo Supercluster of Galaxies
- The Virgo Supercluster is one of about a million superclusters that extend as far as we can see…
- So, how did we get here?

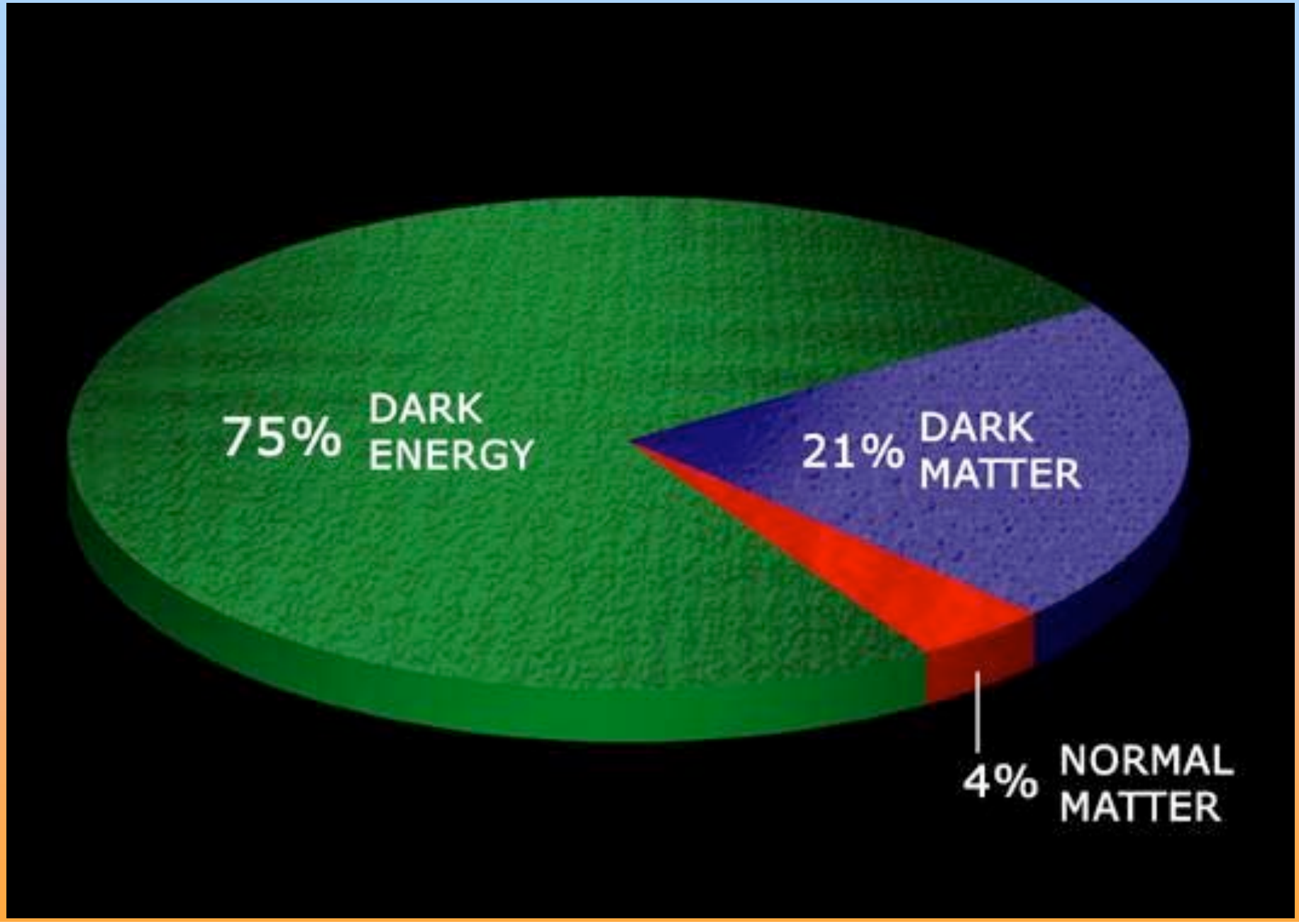




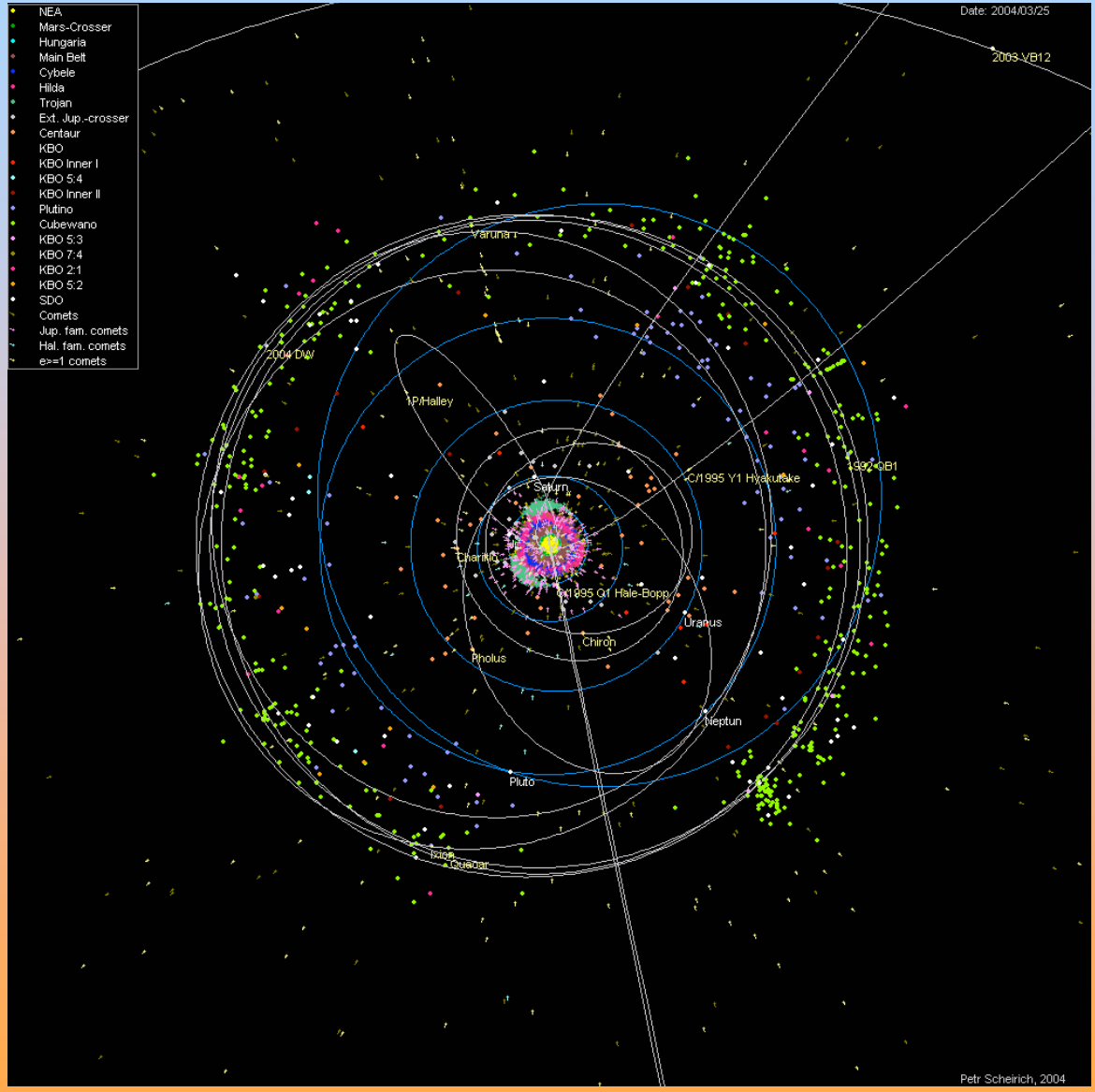



Dark Matter clumps first
Normal matter falls into clumps to form galaxies
Now the tension of dark energy accelerates the expansion of th Universe
Dark Energy Accelerated Expansion
Afterglow Light Pattern 400,000 yrs.
Dark Ages
Development of Galaxies, Planets, etc.
Inflation
Quantum Fluctuations
1st Stars about 400 million yrs.
Big Bang Expansion
13.7 billion years

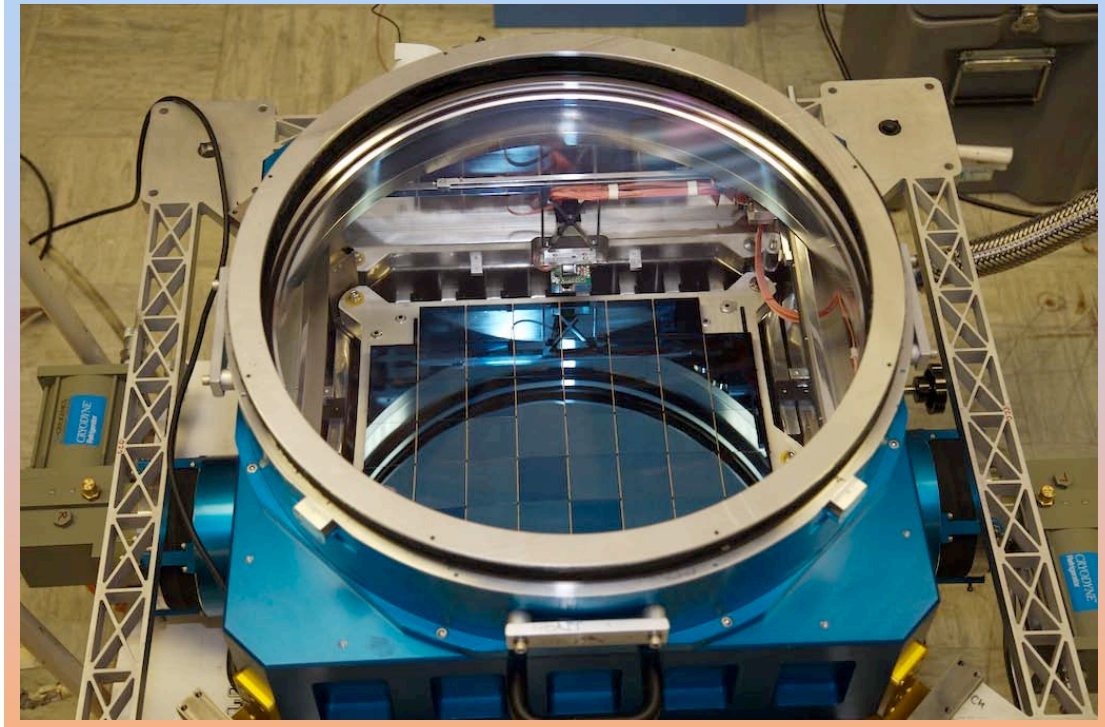
The Cosmic Conundrum:



The Solar System



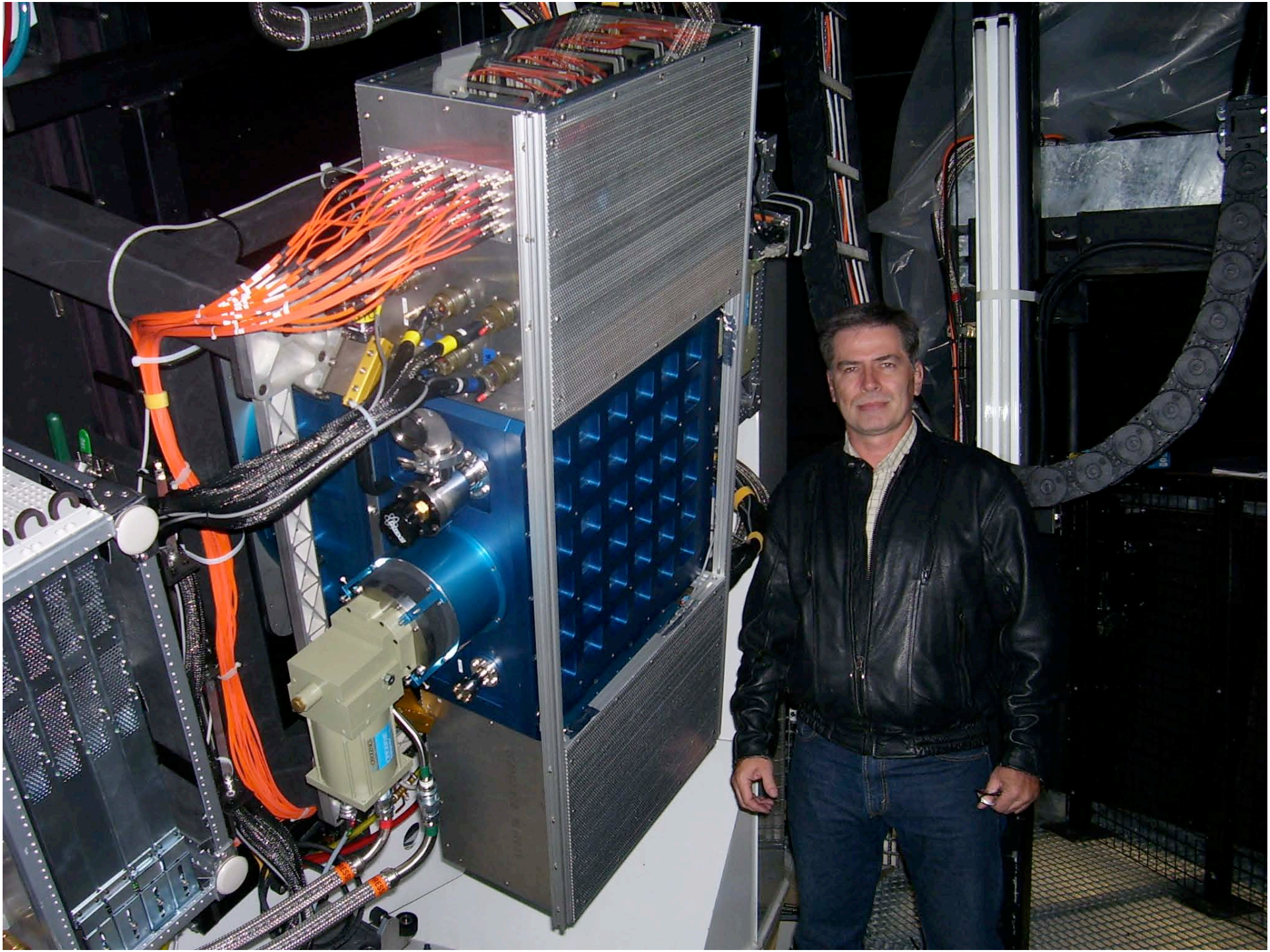
Pan-STARRS Status: PS1 Currently Being Commissioned



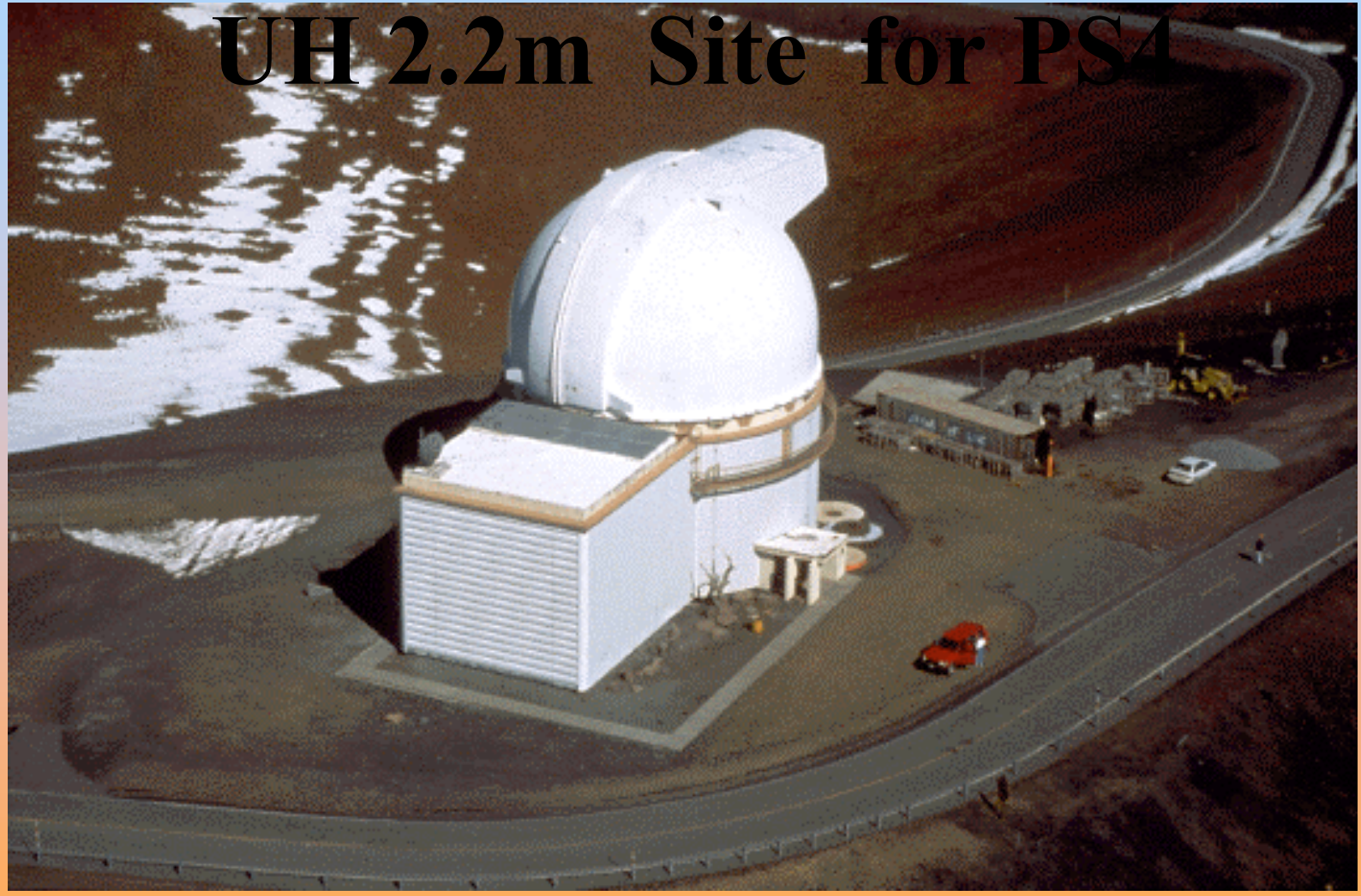
Pan-STARRS GPC1: World's largest number of pixels in a single camera

Pan-STARRS PS1 Observatory on Haleakala

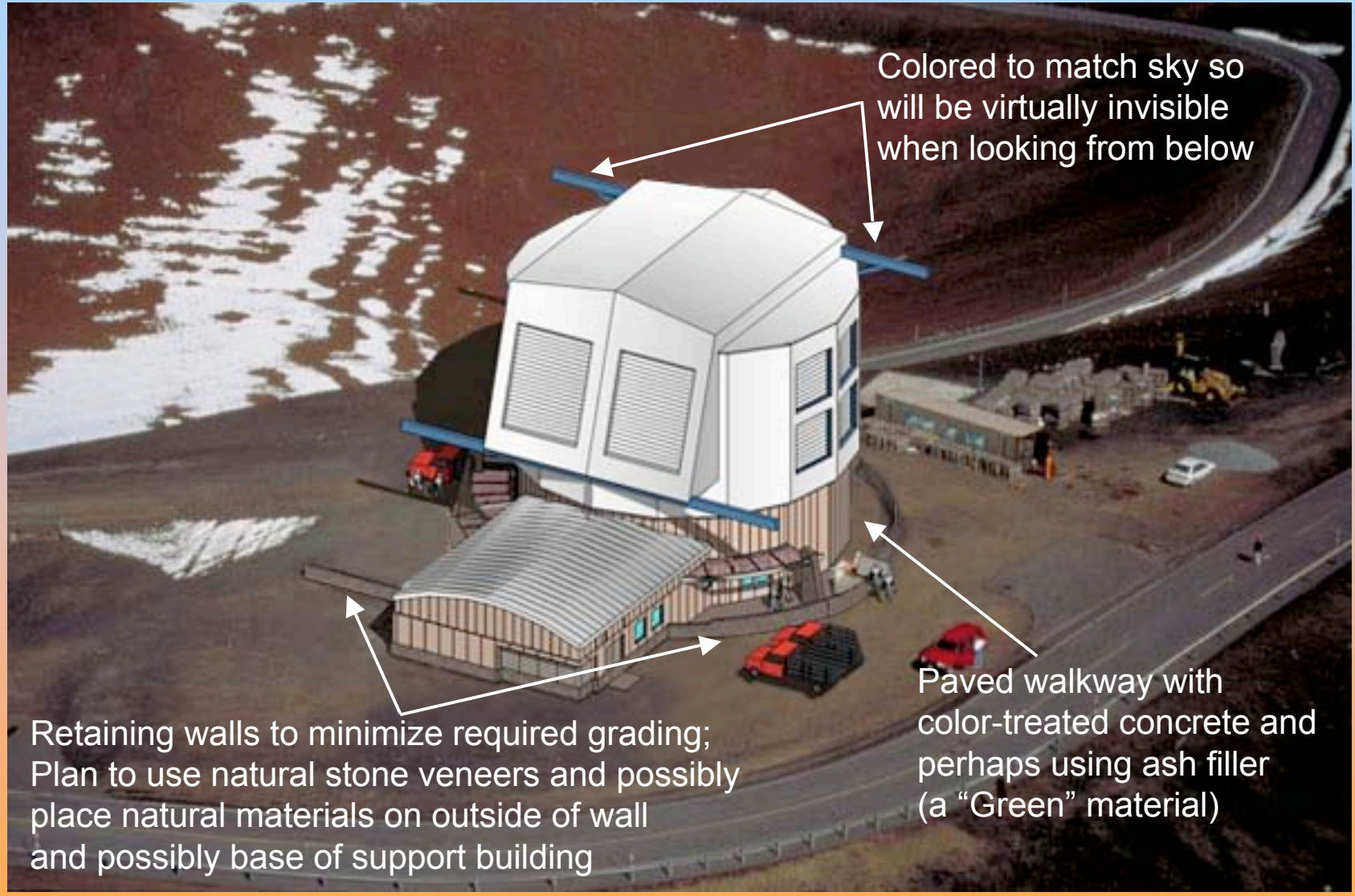

FRONT
FRONT



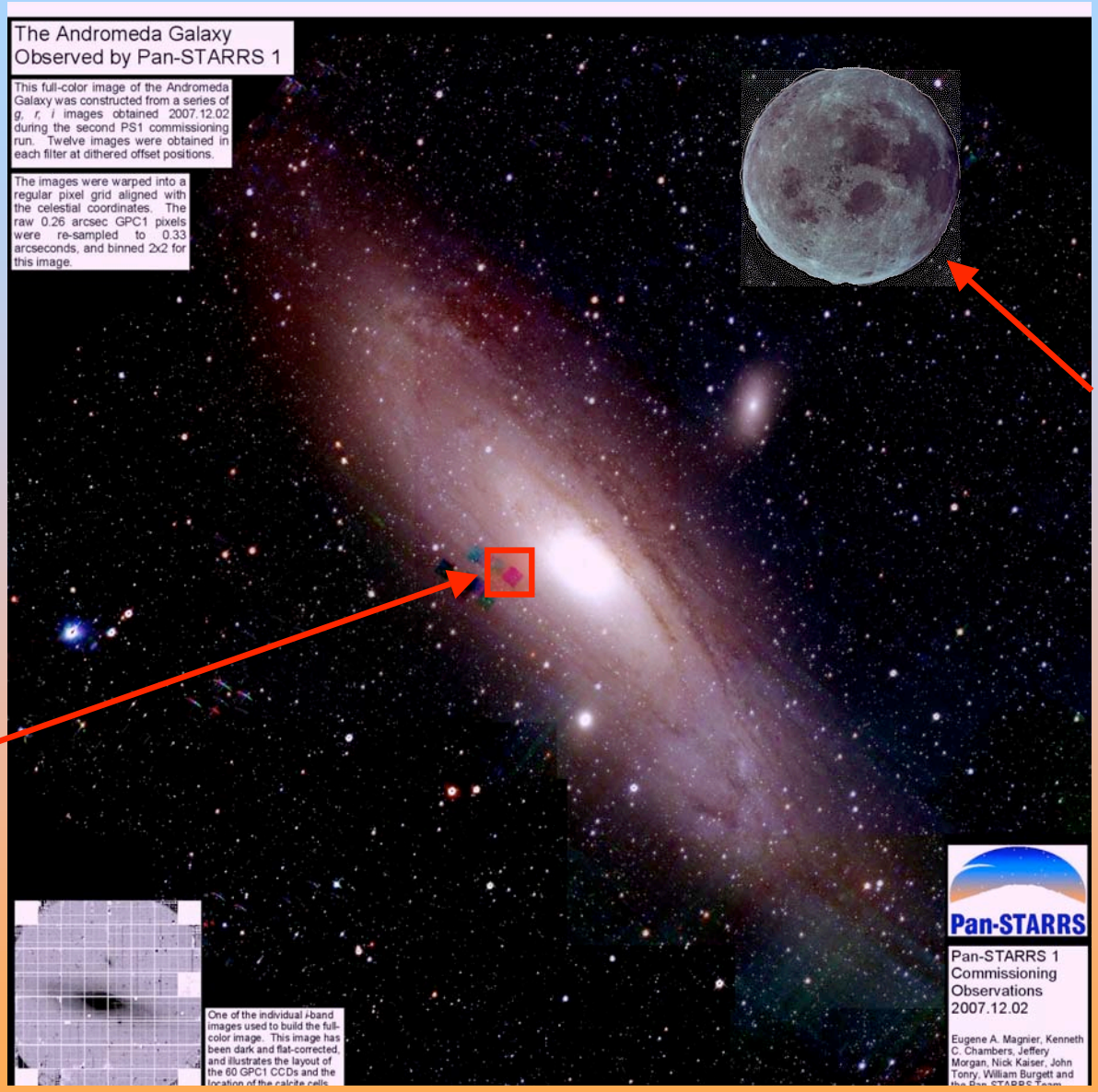
UH 2.2m Site for PS4



Proposed PS4 Site

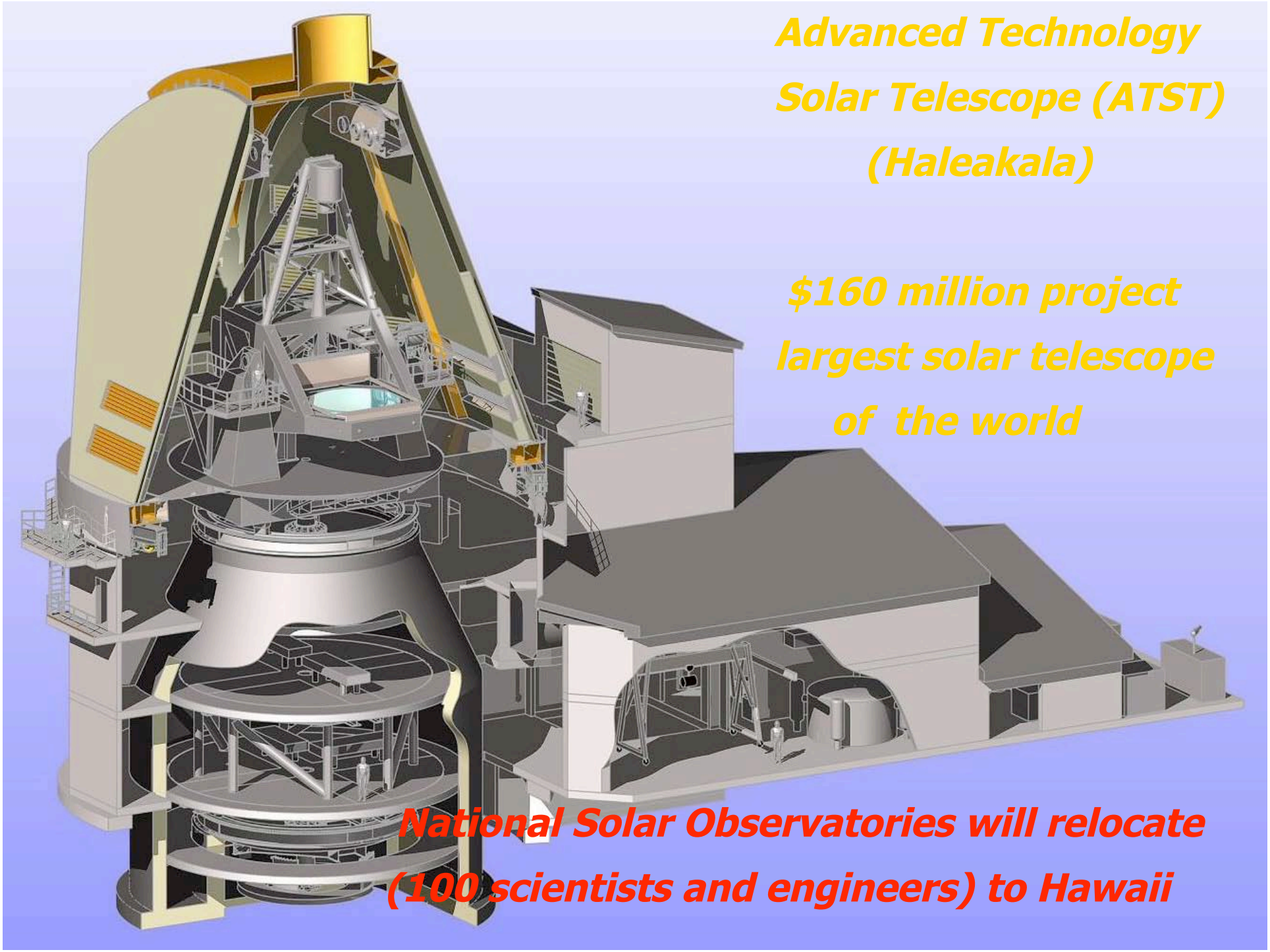


PS1 Commissioning Image – M31 inside GPC FOV



0.5º diameter of Moon only small fraction of GPC FoV

FoV of standard world class research telescope



Advanced Technology Solar Telescope (ATST) (Haleakala)

$160 million project largest solar telescope of the world

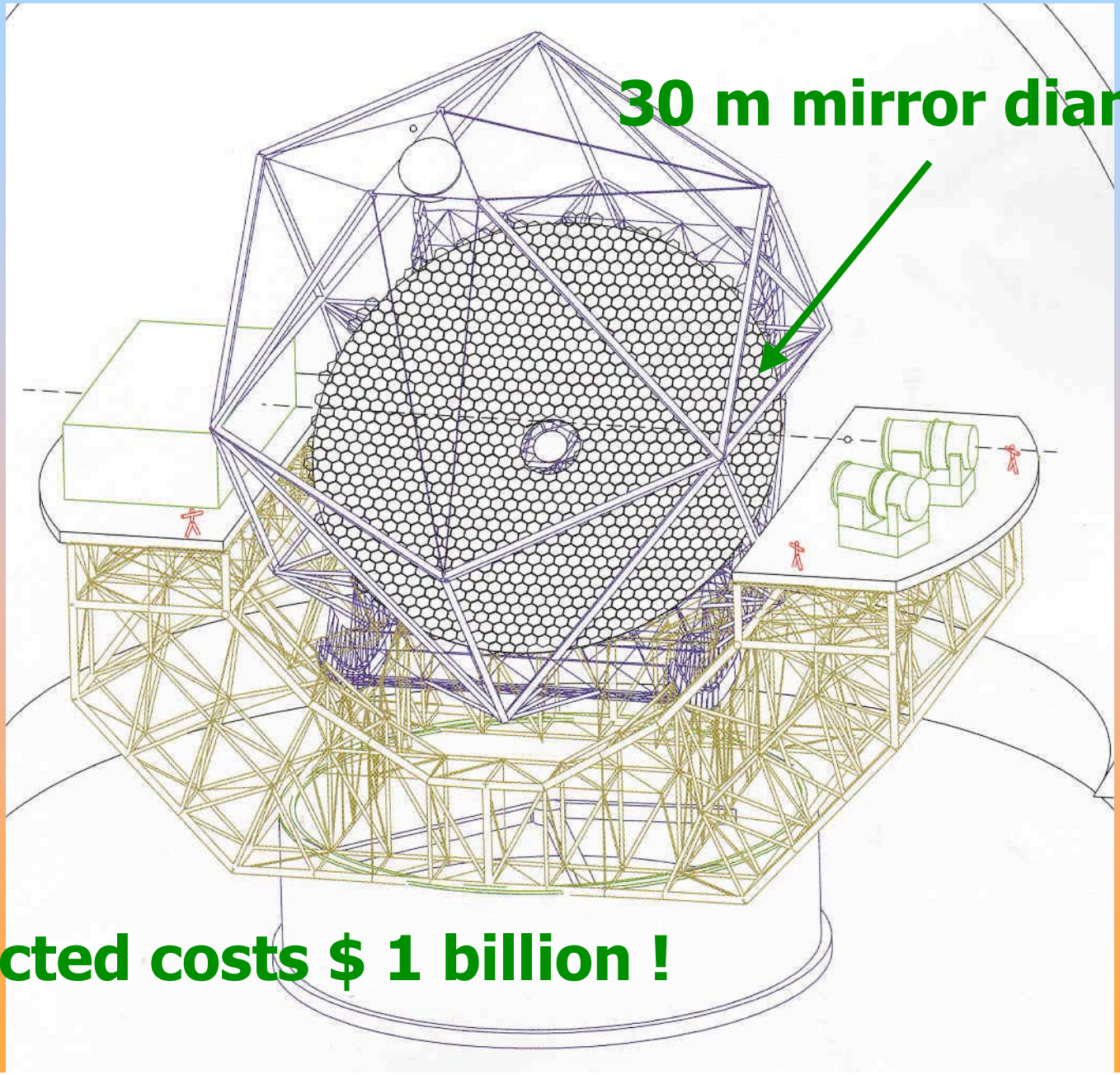
National Solar Observatories will relocate (100 scientists and engineers) to Hawaii


NSO
AURA
NSF
Advanced
Technology
Solar
Telescope
NJIT

The world's most powerful telescope

- The next generation telescope after
  Keck/Gemini/Subaru
- 10m mirror diameter →
  30m mirror diameter
- will extend our vision towards
  → planets around other stars
  → most distant galaxies in the universe
- part of the UH Master Plan for Mauna Kea

the world's largest telescope - TMT



Projected costs $ 1 billion !

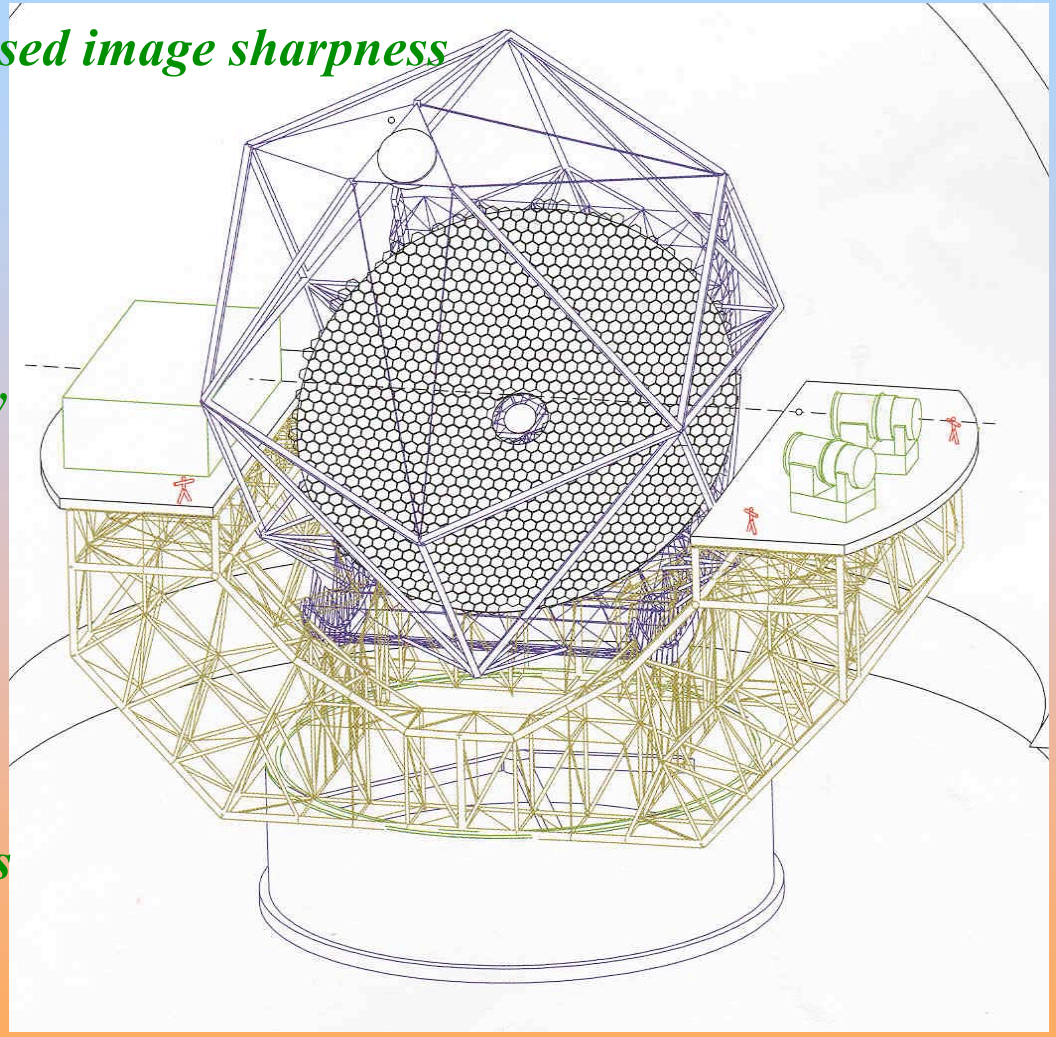
Fundamental advantage

larger light collecting power + increased image sharpness

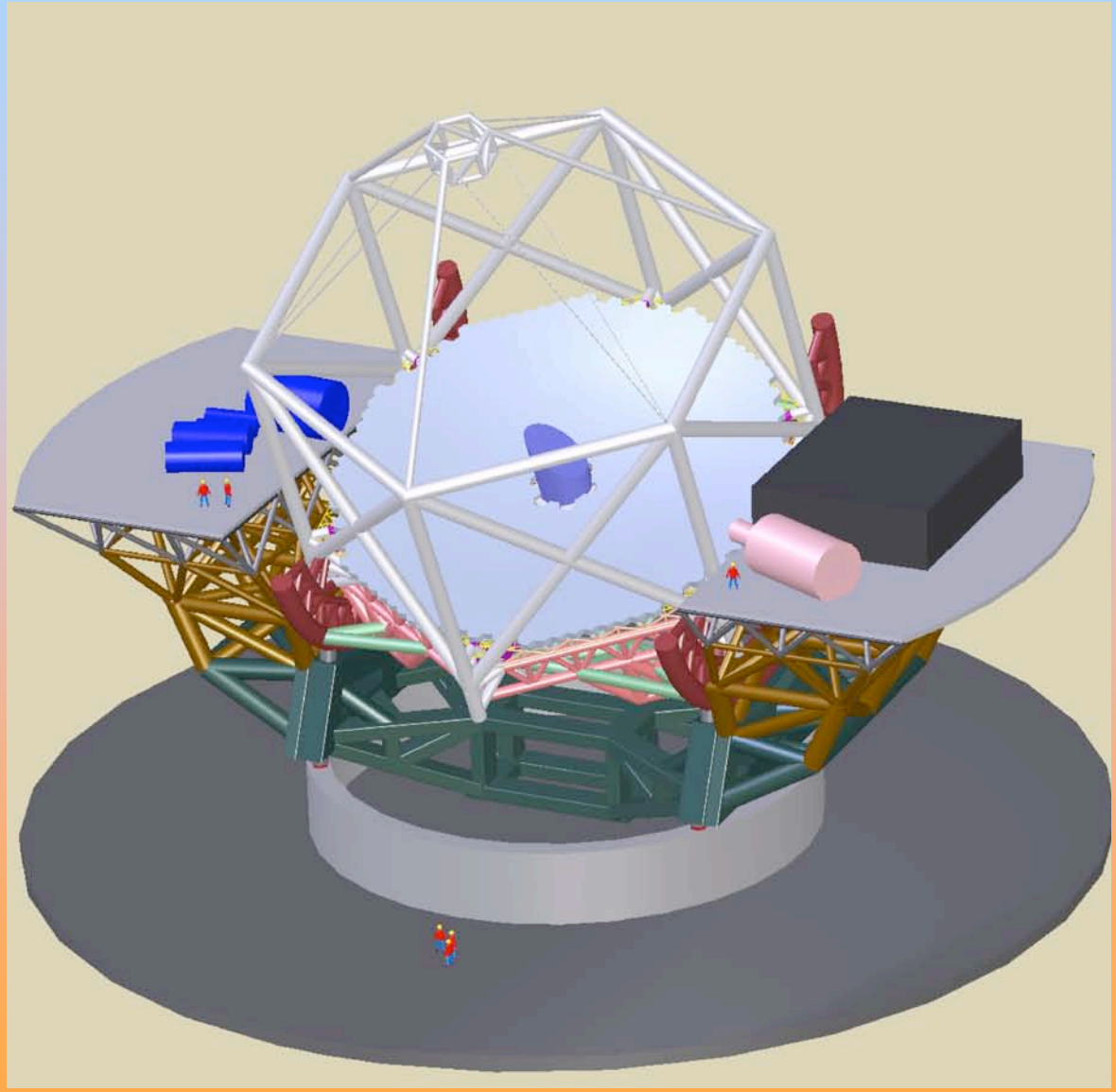
fainter objects

more distant → *look back in time* → *evolution of universe* → *nature of dark matter dark energy*

smaller objects nearby → *planets around other stars* → *physics of formation of planetary systems* → *conditions of origins of life*



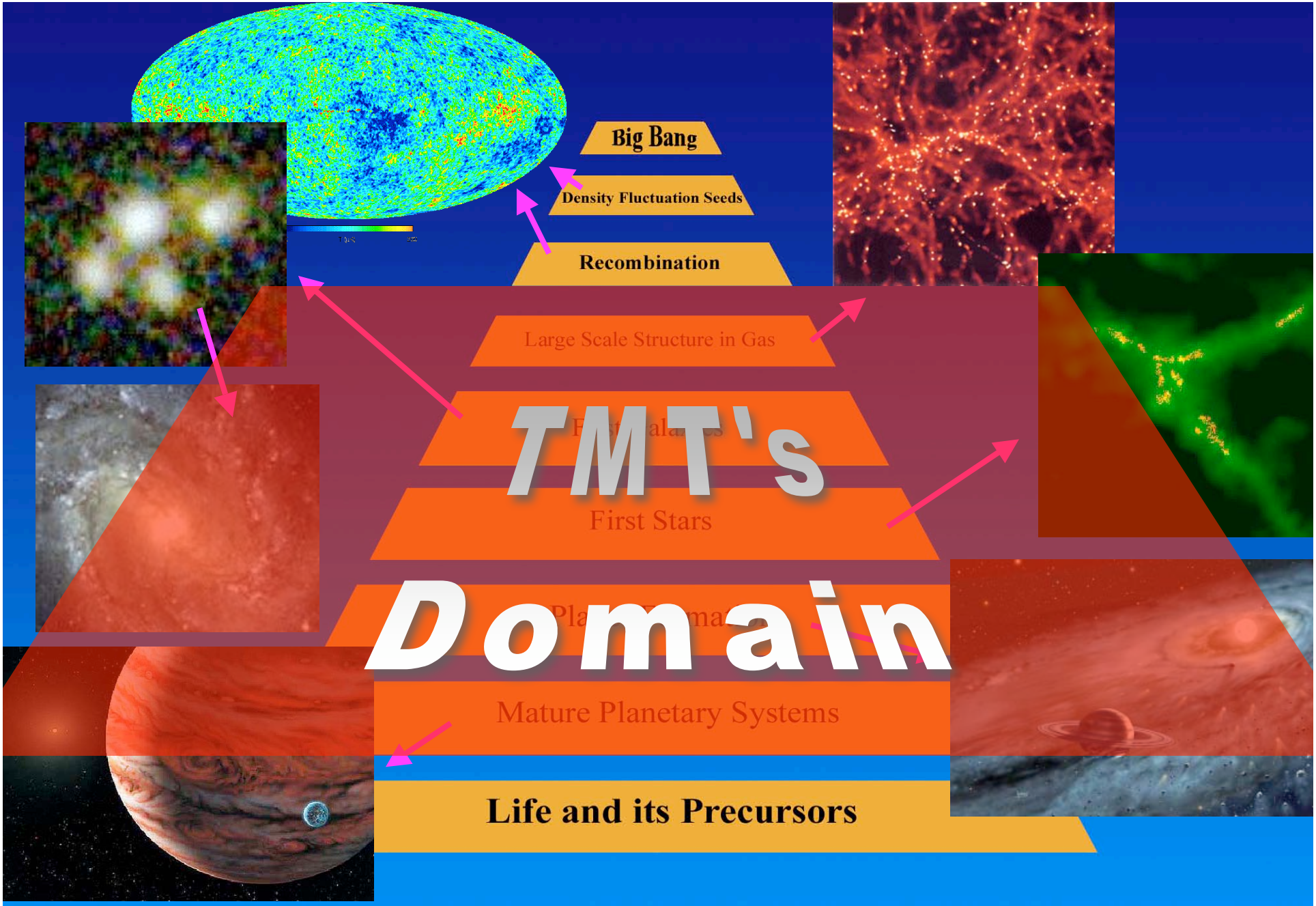
TMT Design



Site on Mauna Kea

Northern Plateau

- below summit
- less visibility
- less cultural and economic impact
- foreseen in year 2000 Master Plan of UH



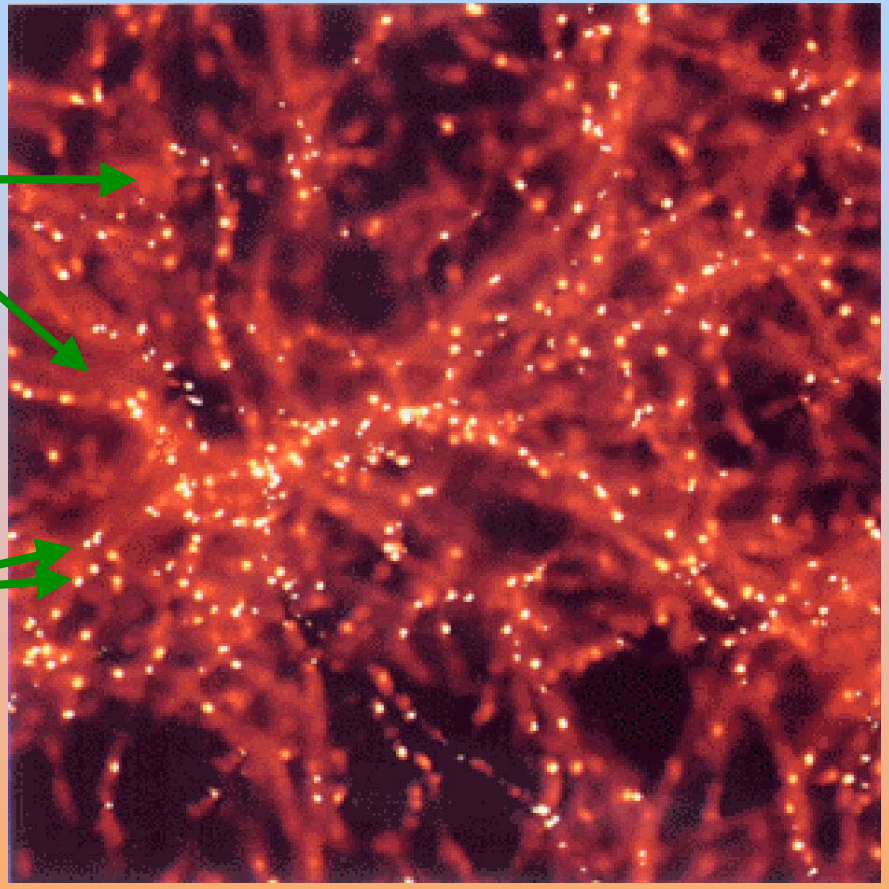
Connecting the First Nanoseconds to the Origin of Life

Exploring the process of planet formation

Artist conception of a proto-planetary disk with young planets and asteroids

Predicted cosmic web of intergalactic gas and galaxies 13 billion years ago

Intergalactic gas



High density clumps concentrated by dark matter → galaxies

Structure depends strongly on nature of
dark matter
dark energy

We need to observe
3D-structure of
cosmic web
at z = 3.5

GSMT will have the power to reveal the 3D-structure and physics of the cosmic web!!