The search for Near Earth Objects — why dark skies are critically important

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Searching for asteroids and comets

- The NASA Near Earth Object Observation program supports efforts across the United States to detect and characterize Near Earth Objects
- Near Earth Objects are defined as objects that have perihelion (closest distance to the Sun) of less than 1.3 Astronomical Units (1 AU is the distance from Earth to the Sun)

Asteroids

IDA

OAHU

Comets

Near Earth Objects

- Earth continues to be hit by asteroids and comets
  - Asteroids are the dominant risk
- The asteroids come from the asteroid belt
  - Solar heating causes slow migration of asteroid orbits and some orbits more into resonant locations
  - Interactions with the gravity of Jupiter cause major orbit changes, moving asteroids close to Earth

Near Earth Objects

- Near Earth Asteroids have relatively short lives (typically around a million years) before they impact the Sun or Earth (or other planets), or are ejected
  - But they are constantly being replenished from the resonances in the asteroid belt

Manicouagan crater

- 214 million years old
- Original diameter 100km (now visible diameter 72km)
- 5 km diameter impactor

Chicxulub crater

- 10 km diameter asteroid hit
- 100 Teratons of TNT
- 66 million years ago
- Mass extinction of dinosaurs

Effects

- Cloud of super-heated dust, ash and steam
- Excavated material, ejected from the atmosphere will re-enter, heating Earth's surface and igniting wildfires
- Global earthquakes and volcanic activity
- Dust covering the whole Earth making a harsh environment for living things
- Disruption of photosynthesis, interrupting the food chain

Meteor Crater, Arizona

- 50,000 years old
- 50 meter asteroid

Tunguska event

- June 30, 1908 in Siberia
- Impactor was likely a few tens of meters across
- Impact energy was likely 10-15 Megatons of TNT (about 1,000 times as powerful as Hiroshima nuclear weapon)
- We expect an impact of this size roughly once per century

Tunguska

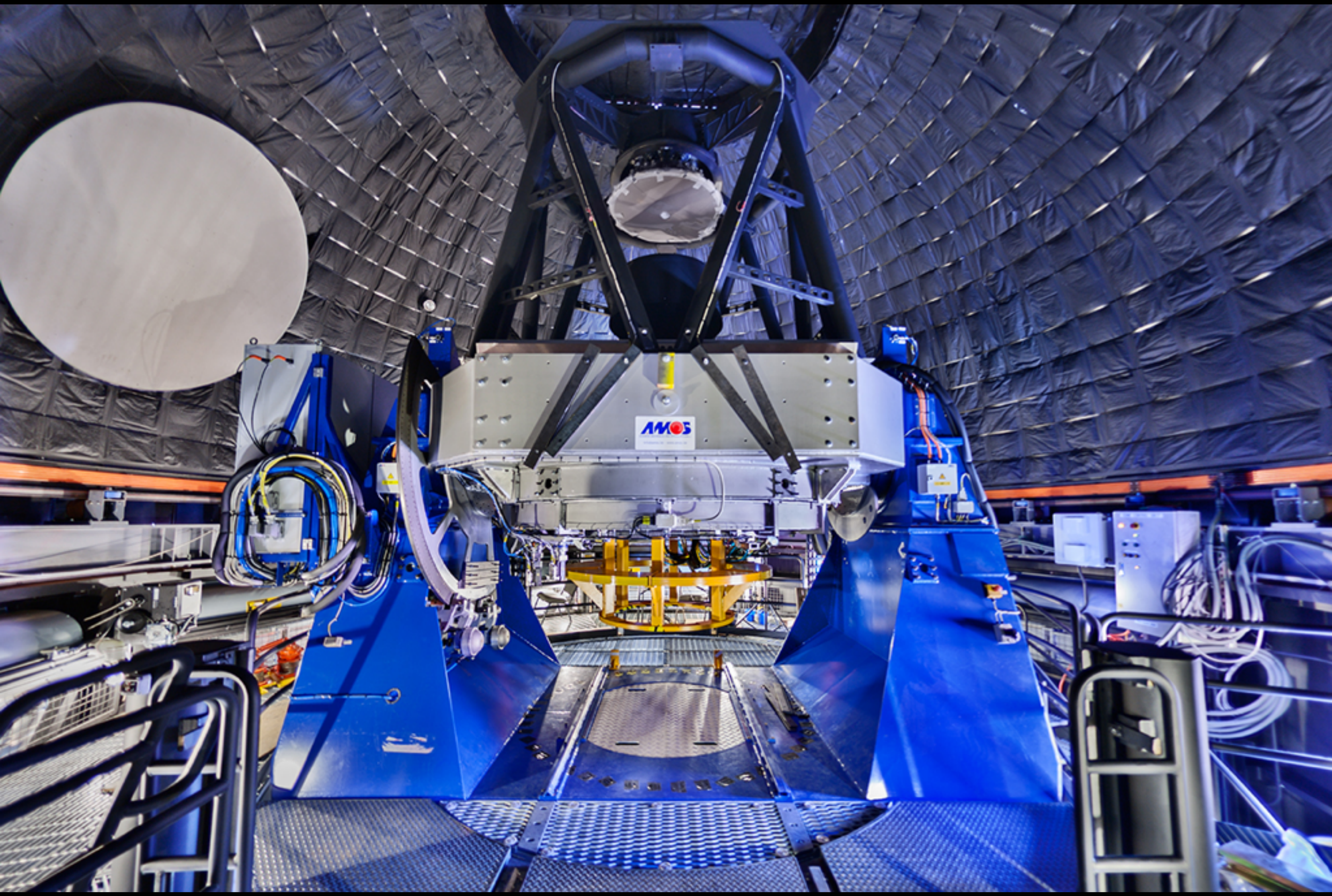
February 15, 2013

СпецСервис

The Pan-STARRS telescopes

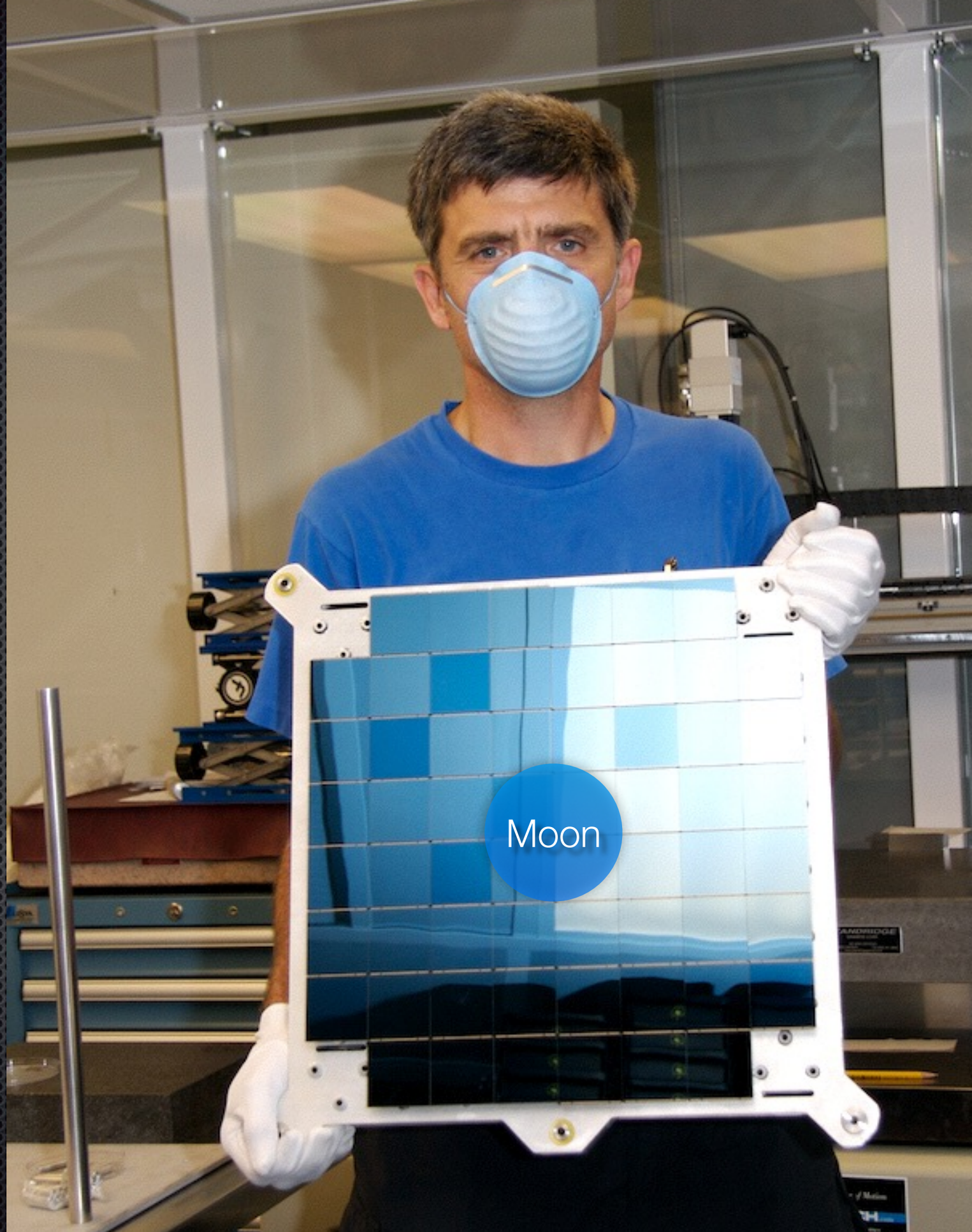
- Two 1.8-meter diameter telescopes at Haleakala observatory in Maui
- First telescope operational in 2009, second telescope being finished now
- Largest digital cameras in the world
- Four images are taken separated by about 20 minutes to look for moving objects
- We try to cover as much of the sky as we can each month, with some repeats

Photo by Rob Ratkowski © 2010 PS1 Science Consortium.


AMOS

Gigapixel camera

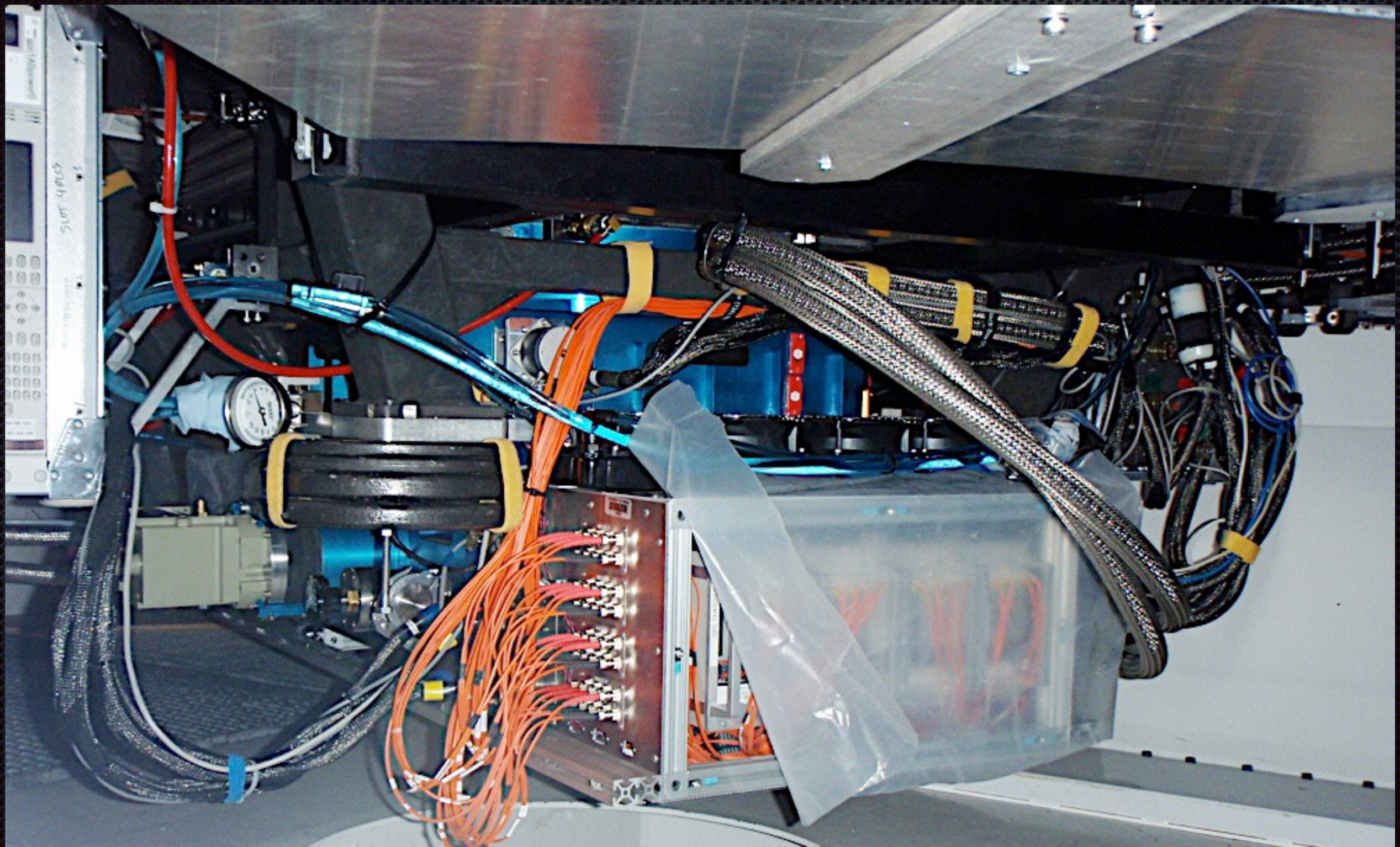
- 1,382,400,000 pixels
- 7 square degree field-of-view



Gigapixel camera

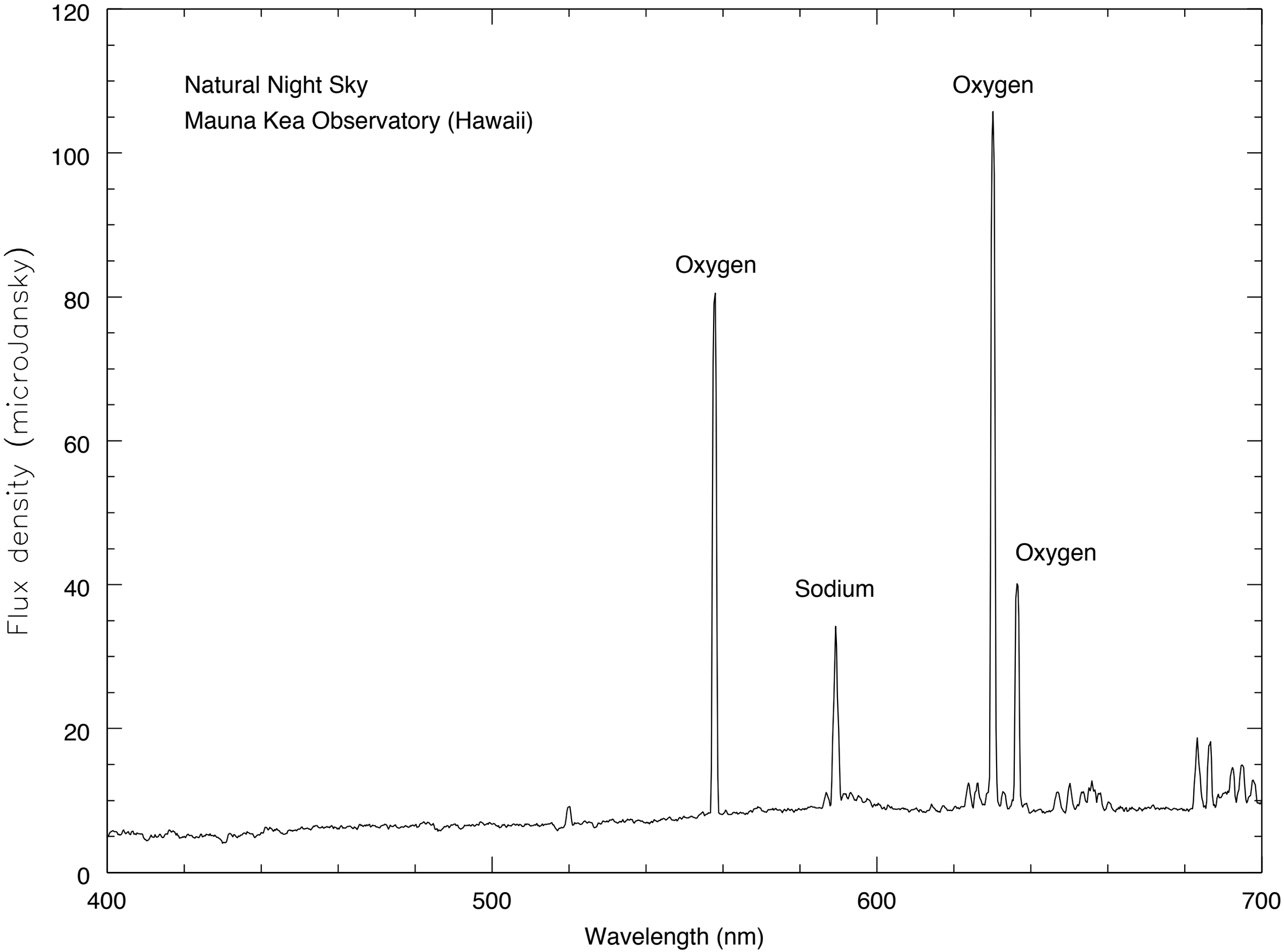
- 3 Gigabytes per image
- 1 image every 40 seconds
- 3 Terabytes per night

Gigapixel camera



Near Earth Object Searches

- The two major search efforts for Near Earth Objects are:
  - Pan-STARRS in Hawaii
  - Catalina Sky Survey in Arizona
- Both surveys use very wide filters in order to maximize sensitivity
  - Pan-STARRS uses a 400–820 nm filter which eliminates bright infrared atmospheric emission


Natural Night Sky
Mauna Kea Observatory (Hawaii)
Oxygen
Oxygen
Sodium
Oxygen
Flux density (microJansky)
120
100
80
60
40
20
0
400
500
600
700
Wavelength (nm)

Near Earth Object Searches

- Catalina suffers from light pollution from Tucson, which results in a decrease in sensitivity
- Pan-STARRS is influenced by light pollution from Maui County and from Honolulu, which makes the sky brighter in the northwest, where it decreases our sensitivity
- When the moon is bright, Pan-STARRS must use a red or infrared filter, cutting the sensitivity by 1/5 to 1/4, and Catalina shuts down

Near Earth Object Searches

- To date, almost 13,000 Near Earth Asteroids have been discovered
- Of these, almost 1,600 are classified as Potentially Hazardous Asteroids (large, pass close to Earth)
- Of the discovered NEAs, there are 585 objects for which impacts cannot be ruled out in the next 100 years (but impacts are very unlikely)

Near Earth Object Searches

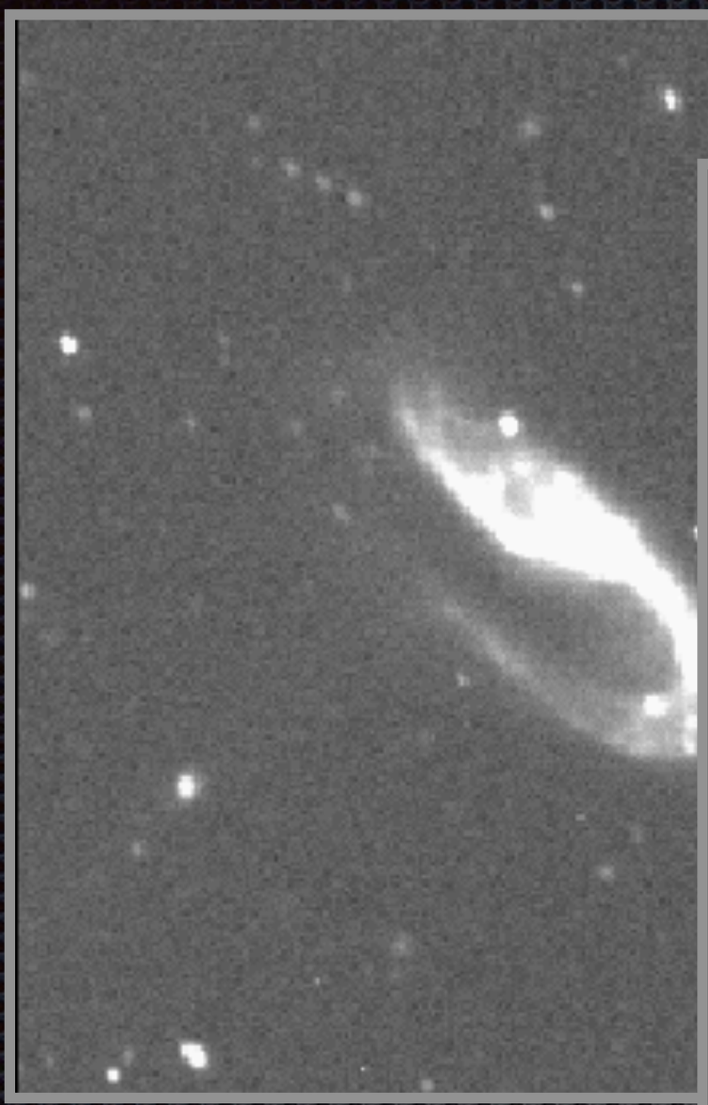
- There are many more smaller objects than larger objects; large objects are more dangerous
- Congress mandated that NASA discover 90% of the the Near Earth Objects larger than 1 km in diameter
  - This mandate is now believed to have been met, but each year we continue to discover 10+ NEOs of this size
- Our inventory of the smaller objects is very incomplete

How do we search for Near Earth Objects

- Most surveys take a sequence of four images, and look for objects that move
- The motion of all moving objects is assessed to determine whether it is unusual
- All objects with unusual motion are immediately sent to the Minor Planet Center at Harvard for further evaluation

ASTEROID IMAGING

12:00am



12:30am

1:00am

How do we search for Near Earth Objects

- Objects of particular interest are:
  - Fast moving
  - Slow moving
  - Moving in a strange direction (most asteroids move west)
  - Not moving in a straight line
  - Fuzzy (comet)

How do we discover Near Earth Objects

- If an object submitted to the Minor Planet Center cannot be matched to a known object, and it is likely to be a Near Earth Object (or comet), it is posted to the NEO Confirmation Page
  - Predicted positions for each object are provided
  - The object must be confirmed by other telescopes in order to determine its orbit and its risk to Earth

How do we discover Near Earth Objects

- Telescopes across the planet contribute to the followup efforts and orbit determination
  - Many of these telescopes are affected by light pollution, which decreases their sensitivity
- As of today:
  - Arizona – summer monsoon/thunderstorms
  - Chile – winter storm - 1+ meter of snow

How do we discover Near Earth Objects

- Amateur astronomers make a strong contribution to NEO followup and orbit determination
- Many of their observatory sites are affected by light pollution
- We particularly need help with the fainter NEOs, and light pollution hampers all efforts to detect fainter NEOs

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2008 TC3

- Asteroid 2008 TC3 was discovered less than 24 hours before it hit Earth
- Discovered by the Catalina Sky Survey
- 4-meter diameter (80 tons)
- Exploded in the atmosphere over Sudan
- Meteorite fragments have been recovered

2014 AA

- Asteroid 2014 AA was observed shortly before it hit Earth
- The only observations came from the Catalina Sky Survey
- It hit Earth over the Atlantic Ocean

What do we do if we detect an object that will hit Earth?

- Terminal impact
  - No opportunity to deflect
  - Warning of up to a week possible
    - We can see larger objects further away, so we can give more warning
    - Only one or two days warning for smaller objects
- We are blind to objects approaching from the Sun

What do we do if we detect an object that will hit Earth?

- The ATLAS telescopes are designed to look for objects that may be about to hit
  - Two 20-inch telescopes (Haleakala, Mauna Loa)
    - Being commissioned now
    - They will survey the entire sky, every few nights
- The International Asteroid Warning Network has been established to facilitate communication in the event that an impact will occur

What do we do about larger objects?

- Precise orbit measurements can allow prediction of future impacts of larger objects
- In the event that an impact is likely to occur, possible deflection methods include
  - Kinetic Impactor
  - Directed energy
  - Gravity tractor
  - Nuclear weapons

What do we do about larger objects?

- Kinetic impactor technology is maturing
  - Deep impact spacecraft targeted Comet 9P/Tempel
  - Asteroid Impact and Deflection Assessment mission is proposed, and combines:
    - ESA Asteroid Impact Mission and
    - NASA Double Asteroid Deflection Test

Continuing strong efforts to protect the dark night sky from light pollution are essential for the search for Near Earth Objects, and for mitigating the threat that they pose.