

# The Risk From Space

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# Outline

- **Near Earth Objects**
  - What are Near Earth Objects?
  - What are the hazards?
  - Is the Earth at risk?
  - What are the issues?
- **Space Weather**
- **Planetary Protection**

**What are Near Earth Objects?**



**COMET**

**or**

**ASTEROID**

**with orbit within 0.3 AU of Earth**

**1 AU = 150,000,000 km**

**Potentially Hazardous if within 0.05 AU (7,500,000 km) and size > 150m**

# Short and Long Period Comets originate from Outer Solar System

KUIPER BELT

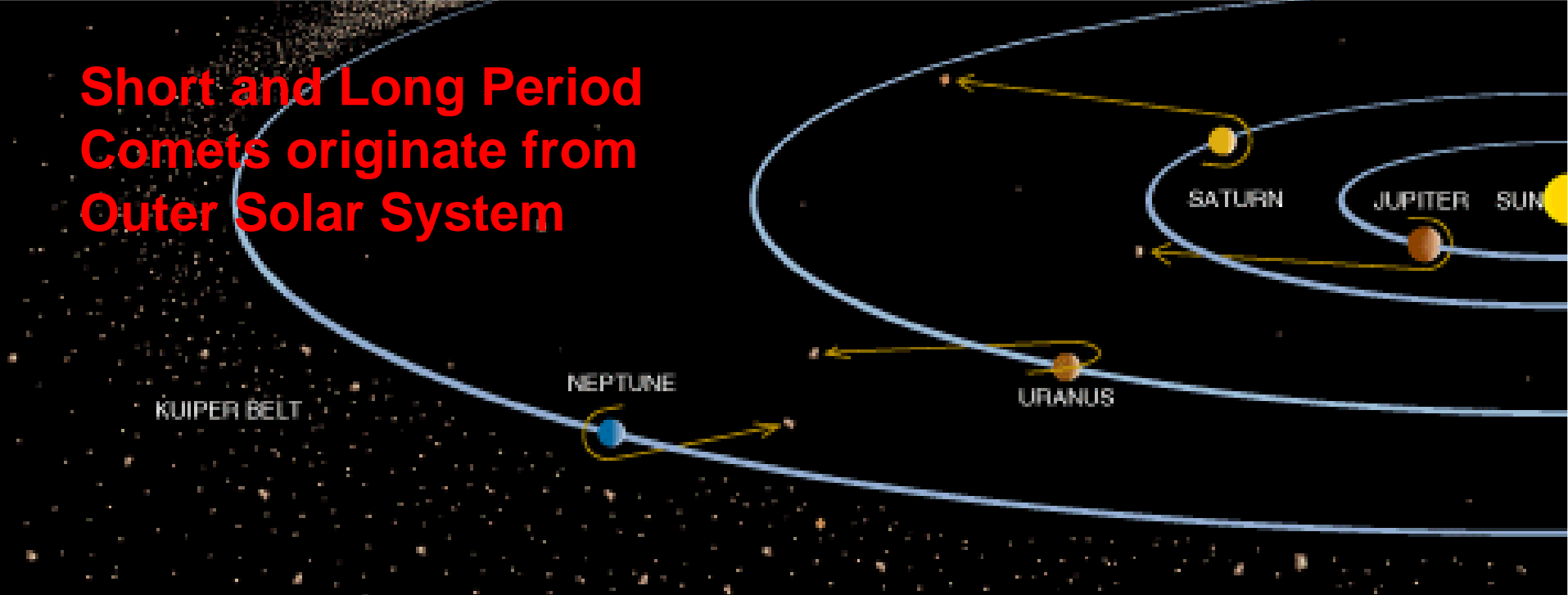
NEPTUNE

URANUS

SATURN

JUPITER

SUN



**Near Earth Asteroids are  
believed to originate from  
Inner Solar System**

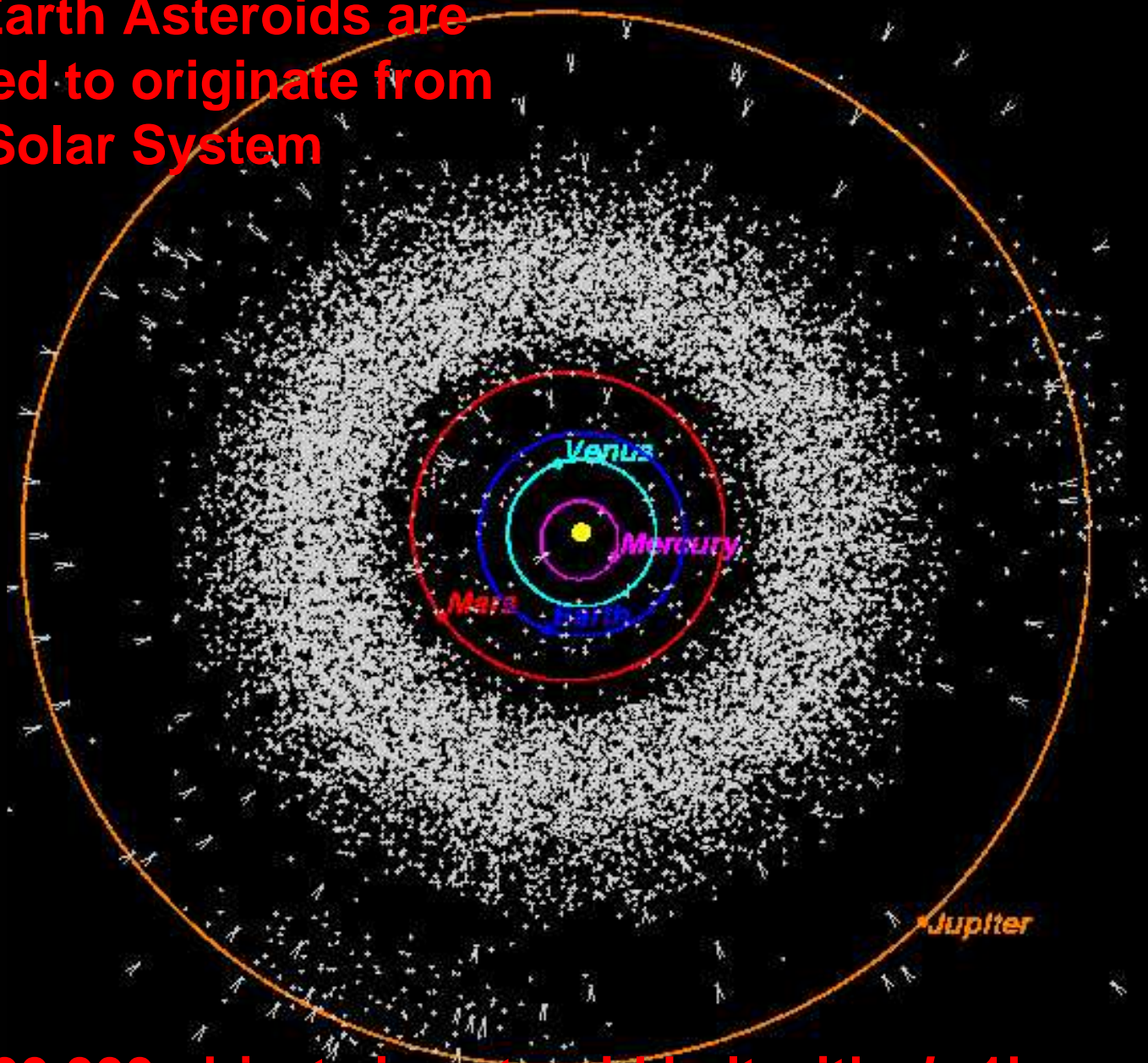
*Mercury*

*Venus*

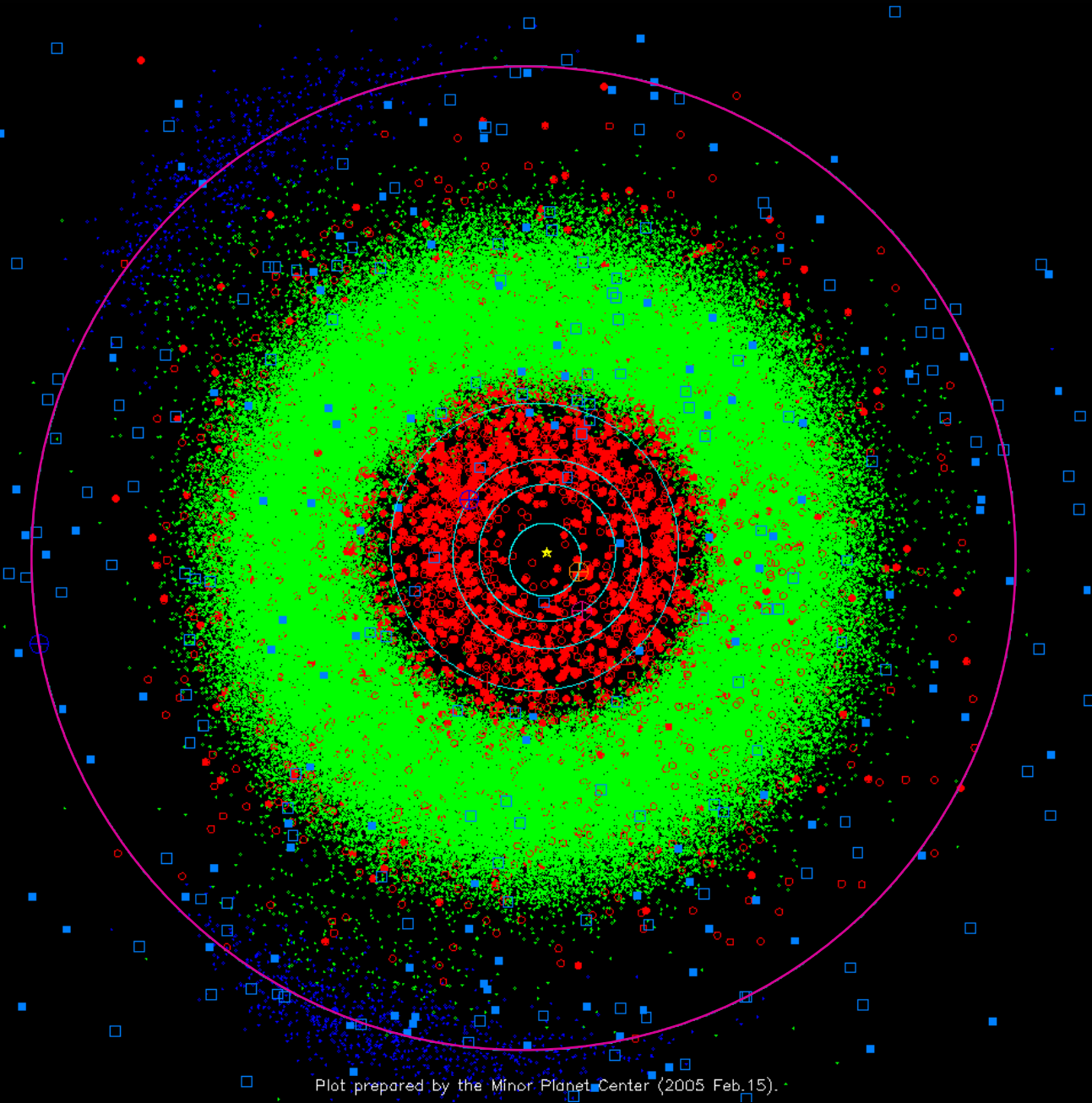
*Earth*

*Mars*

*Jupiter*



**1,000,000 objects in asteroid belt with  $d > 1\text{km}$**



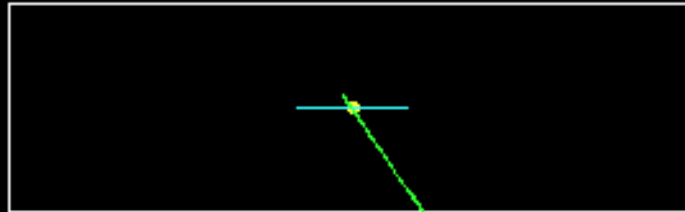
**Only a small percentage of comets and asteroids are NEOs**

Plot prepared by the Minor Planet Center (2005 Feb.15).

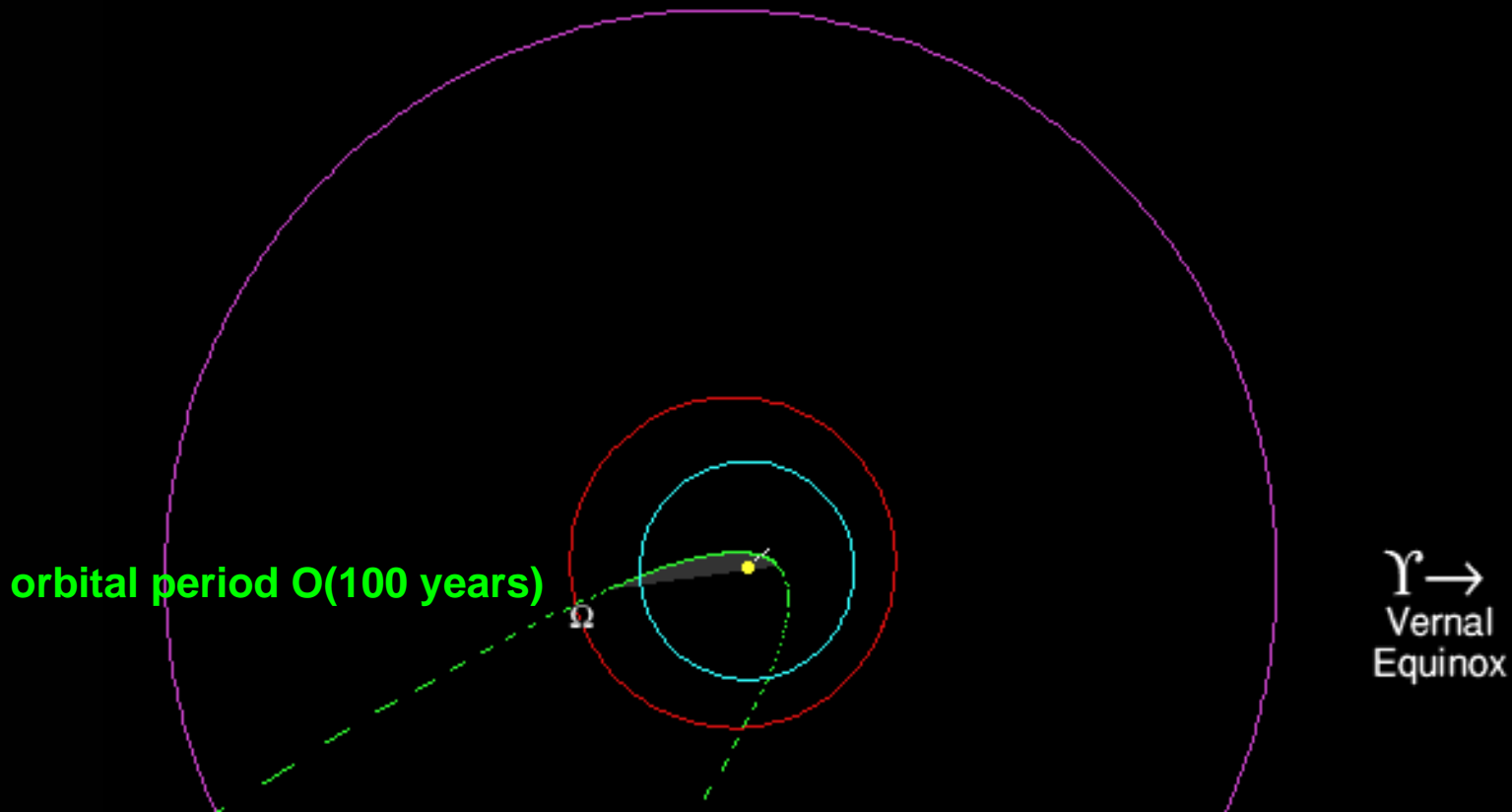
# LONG PERIOD COMETS

## C/1996 B2 (Hyakutake)

Ecliptic View Along The Asc.-Desc. Nodal Line



North Ecliptic Polar View

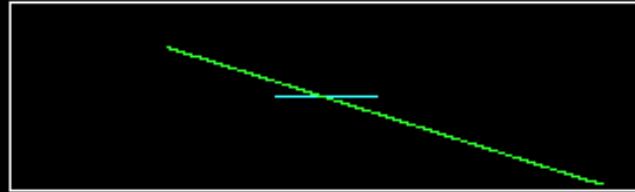




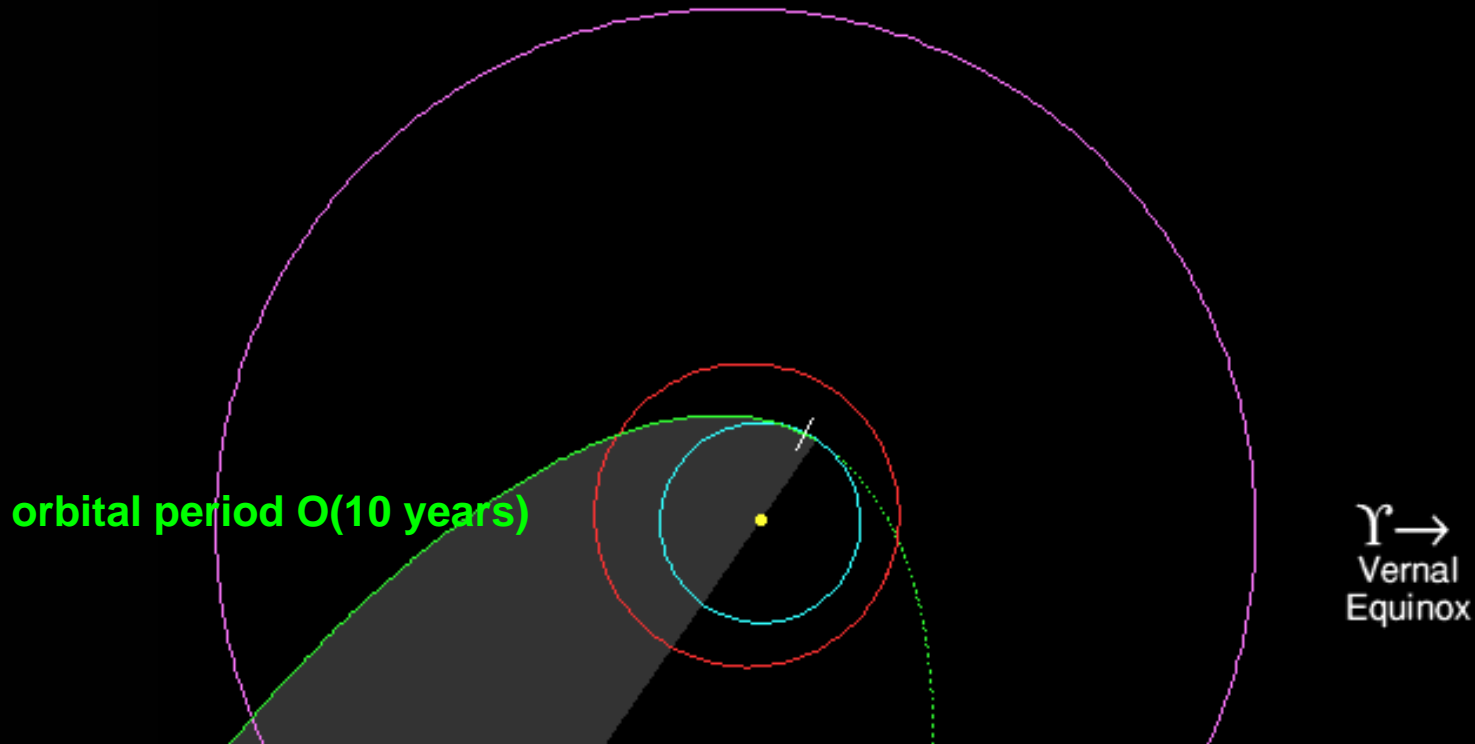
# SHORT PERIOD COMETS

## 55P/Tempel-Tuttle

Ecliptic View Along The Asc.-Desc. Nodal Line



North Ecliptic Polar View



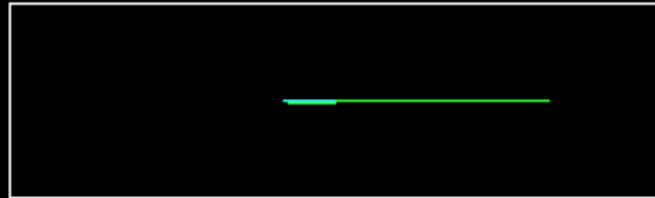
orbital period  $O(10 \text{ years})$

$\Upsilon \rightarrow$   
Vernal  
Equinox

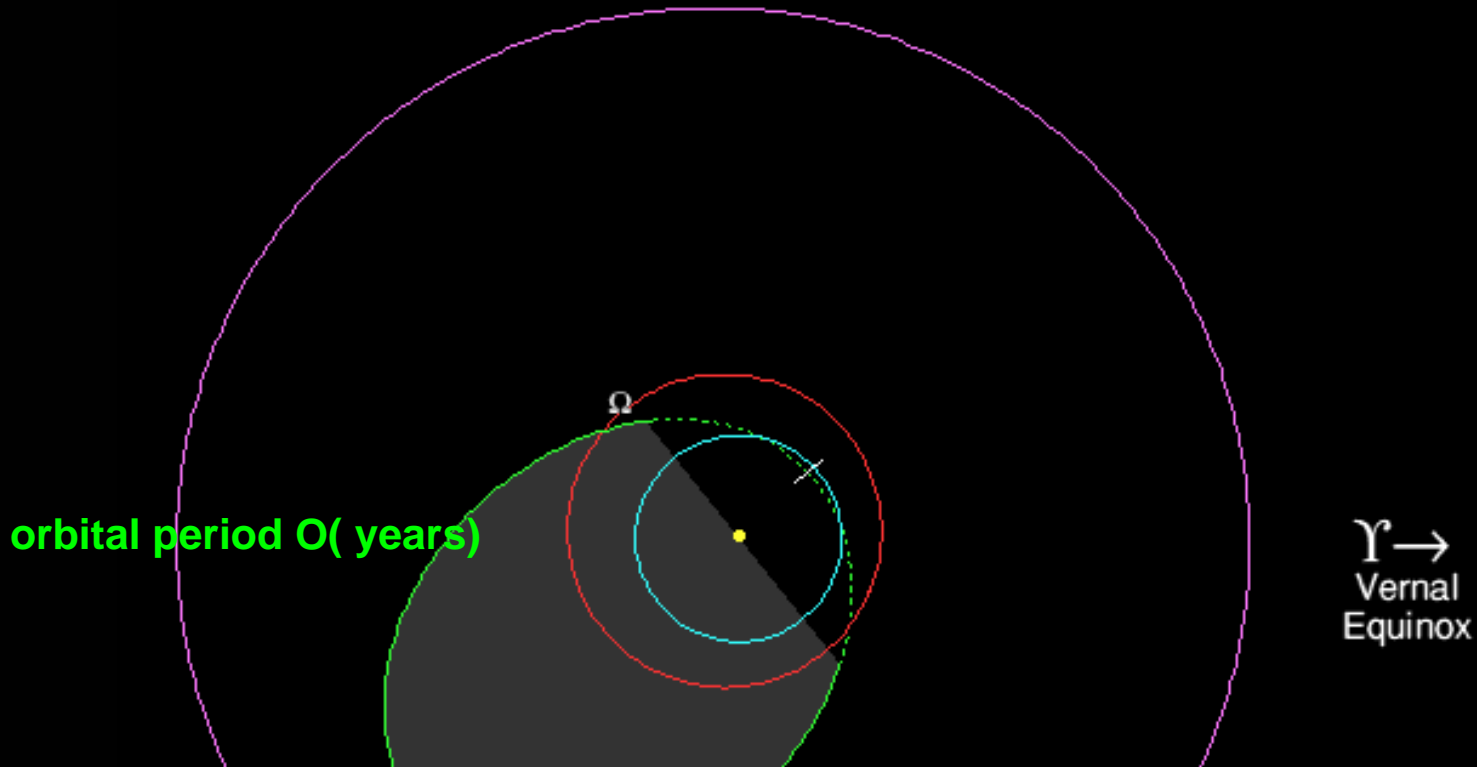
# NEAR EARTH ASTEROIDS

## (4179) Toutatis

Ecliptic View Along The Asc.-Desc. Nodal Line



North Ecliptic Polar View



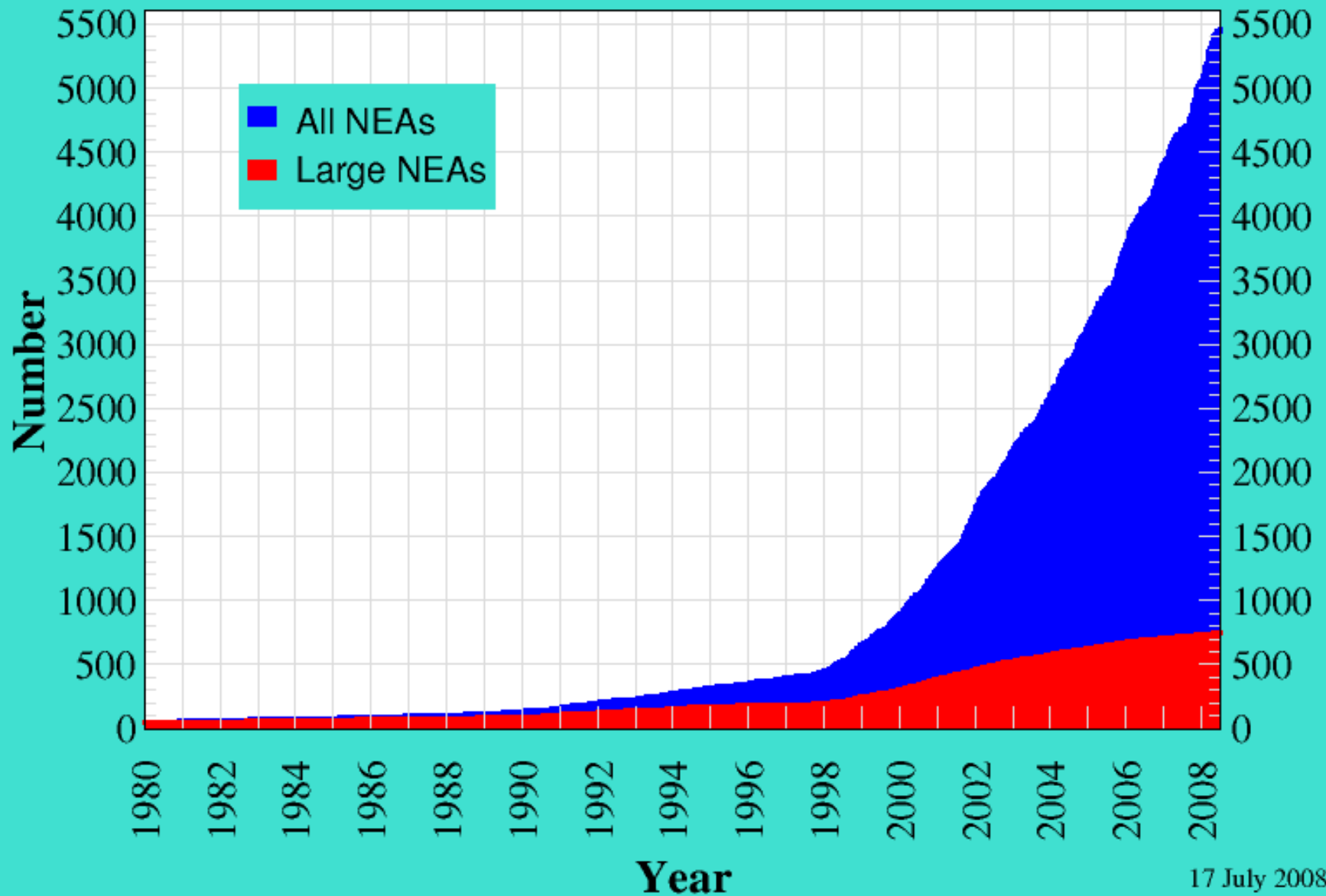


**Comets and asteroids are detected from ground by their motion relative to star background**



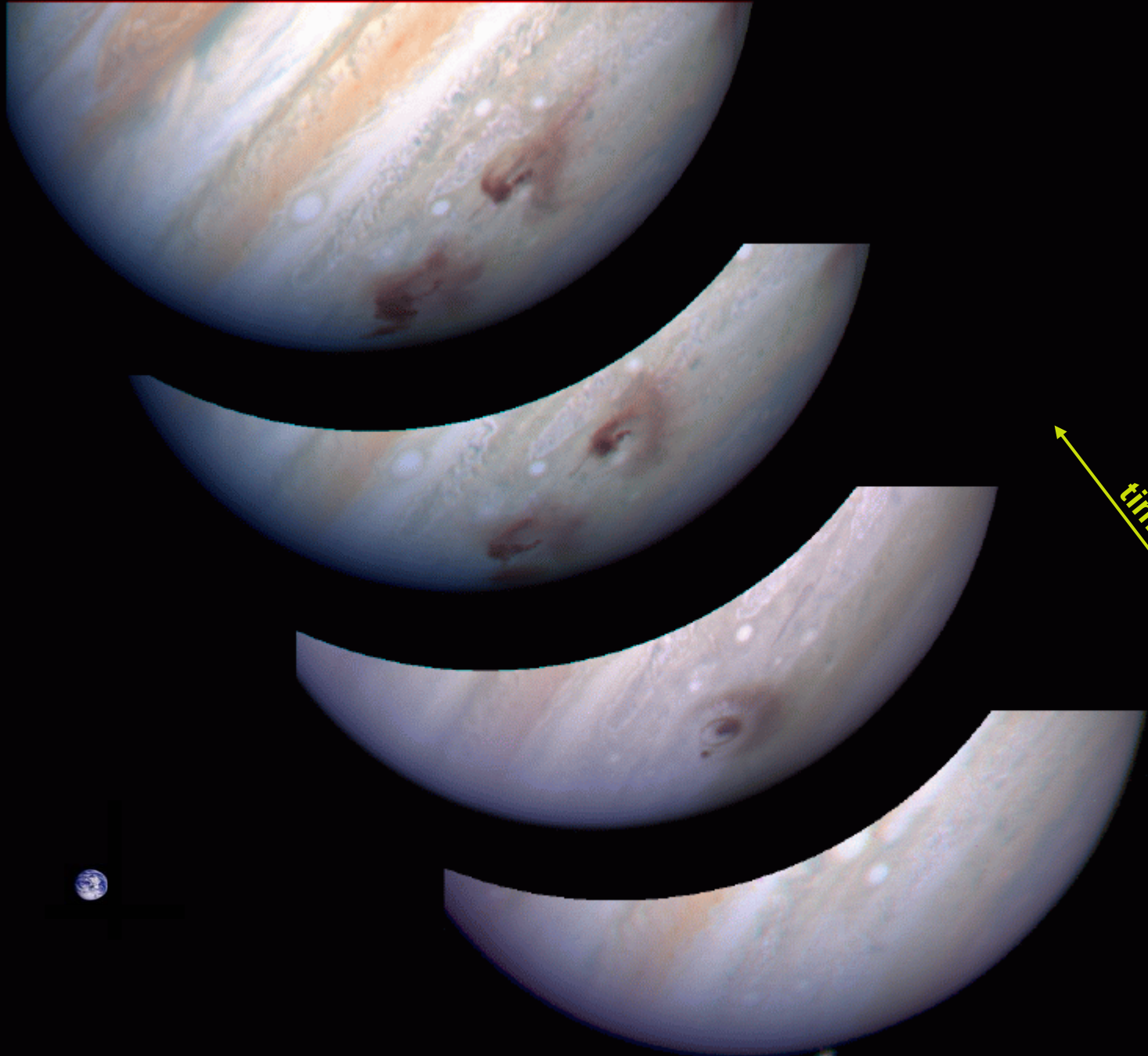
# Known Near-Earth Asteroids

1980-Jan through 2008-Jun



**What are the hazards?**

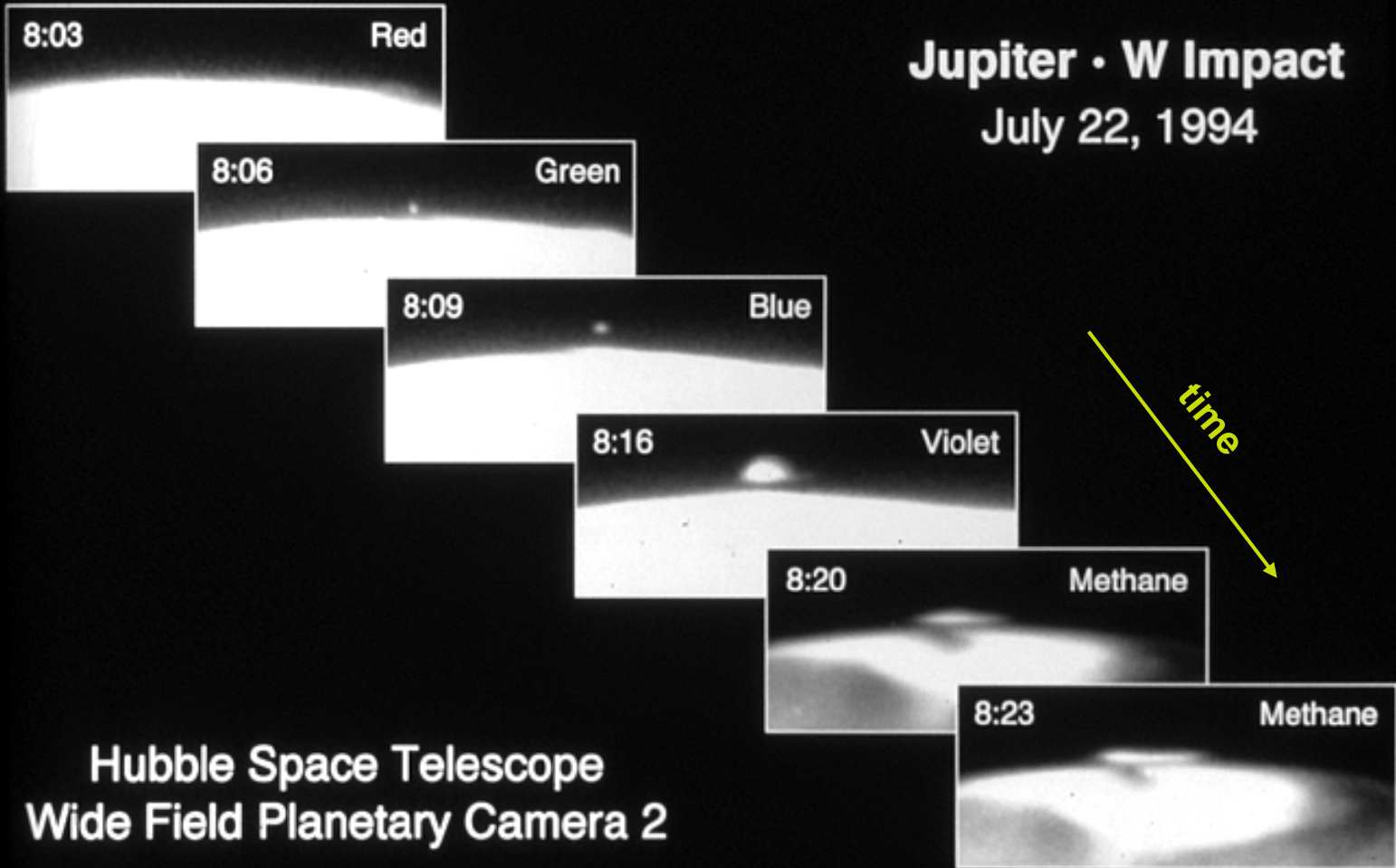




time

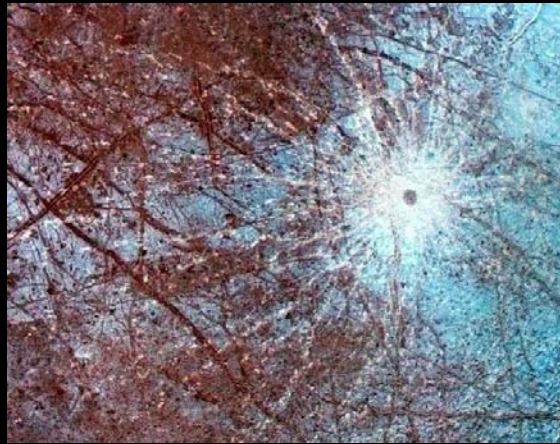
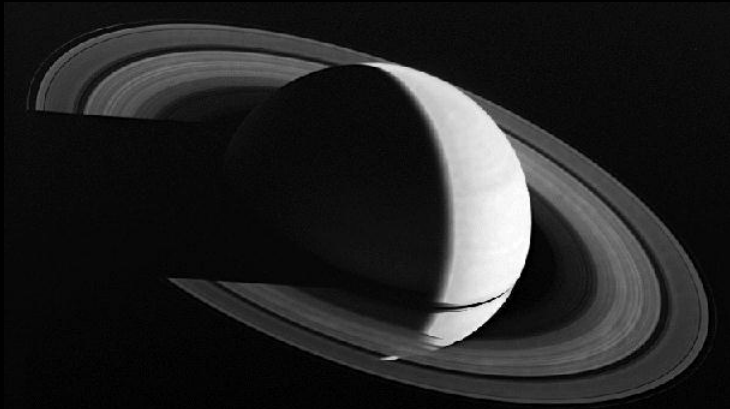


**Jupiter · W Impact**  
July 22, 1994



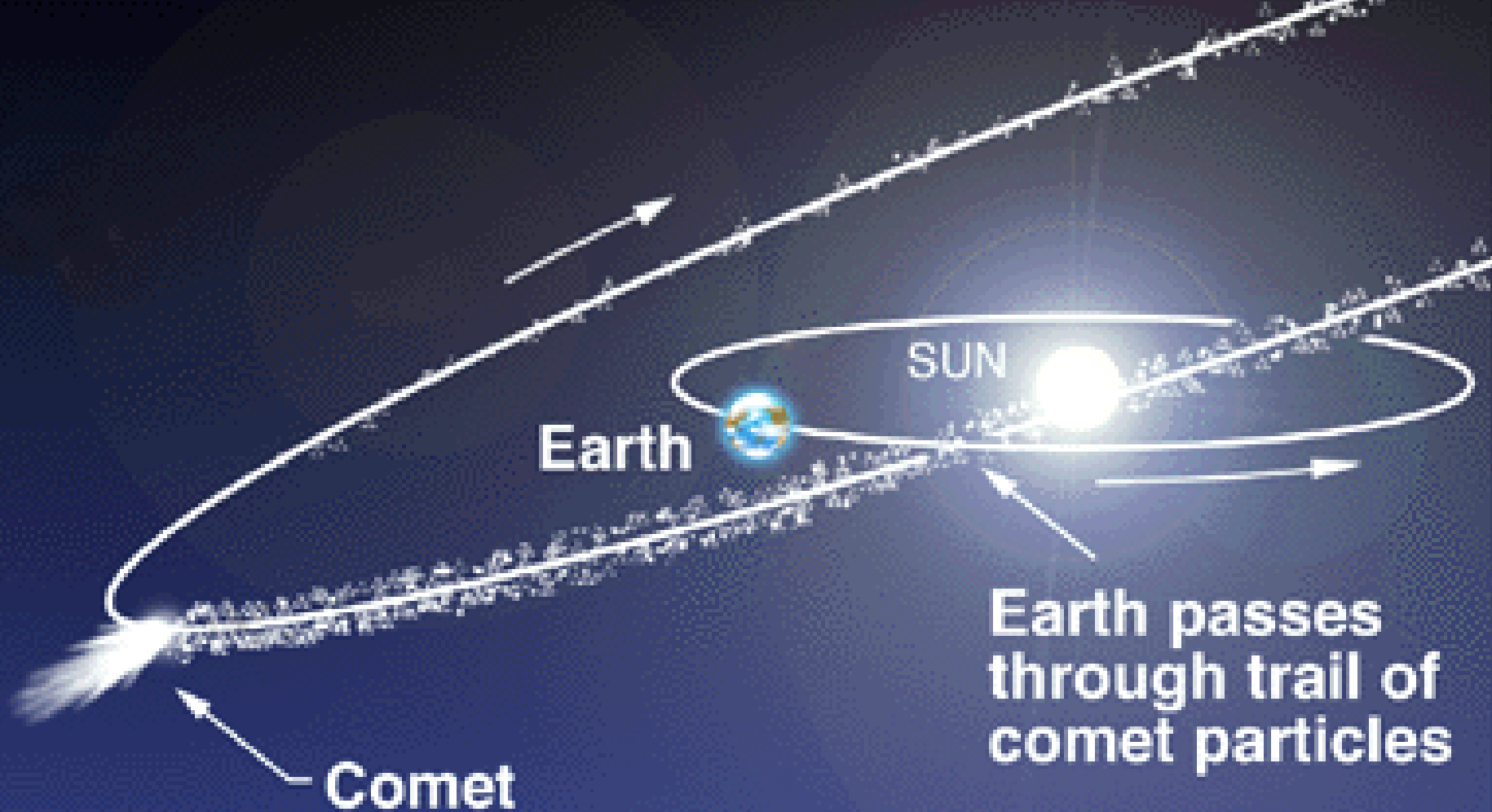
Hubble Space Telescope  
Wide Field Planetary Camera 2





**Is the Earth at risk from NEOs?**

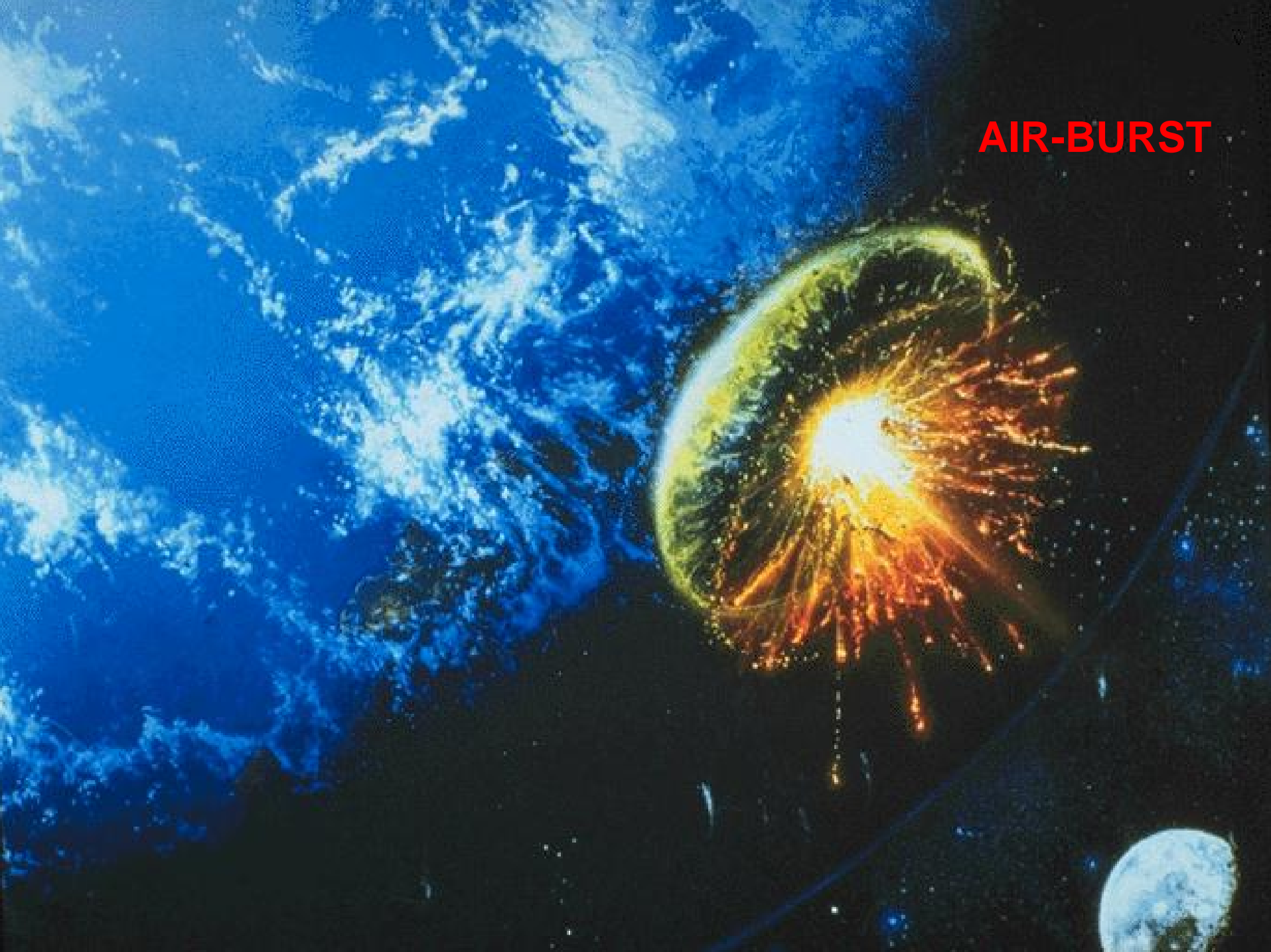




**Earth encounter with Leonids on  
November 17**



**AIR-BURST**



**Tunguska, Siberia**  
**1908, stone asteroid**  
**2000 sq km of forest flattened**



**Barringer Crater, Arizona**  
**49,000 years ago**  
**nickel-iron asteroid**

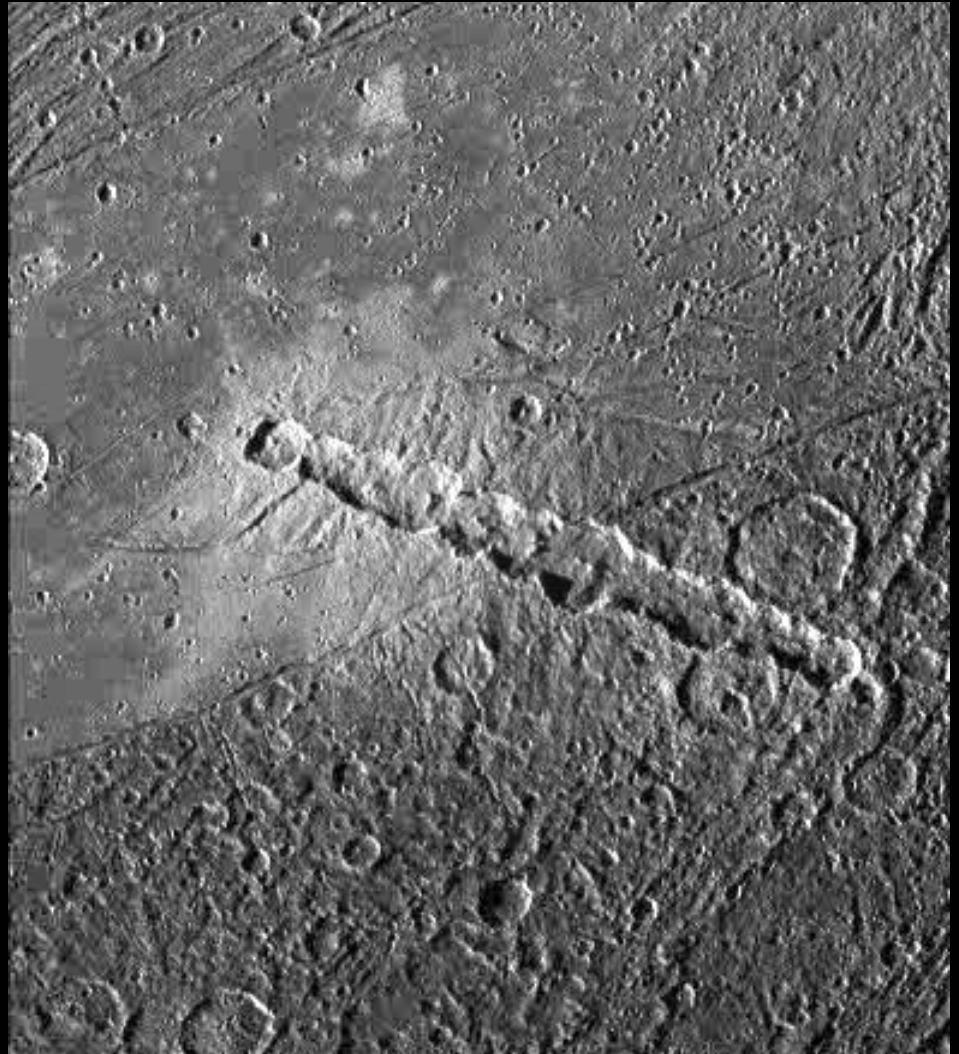






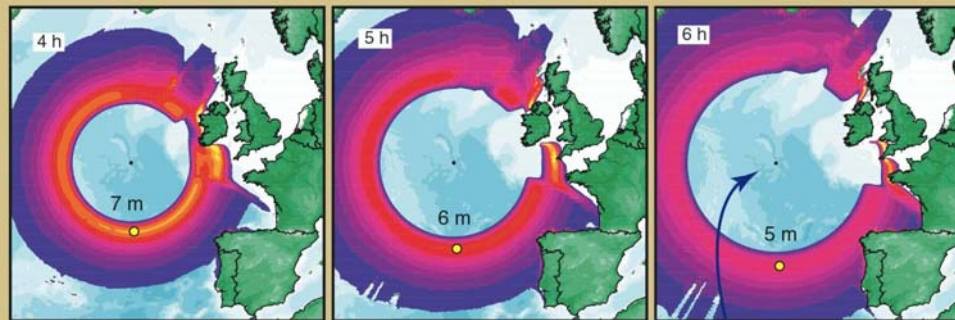
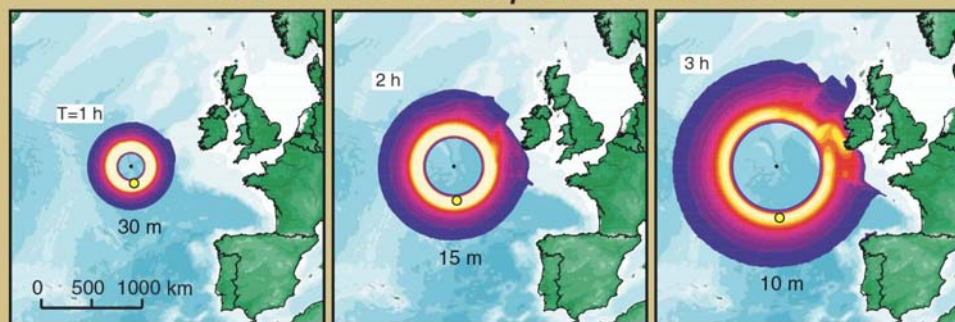


**Multiple impacts are common (e.g. Moon and Gannymede)**





## North Atlantic Impact Tsunami



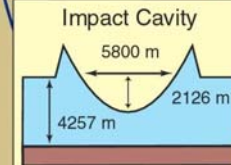
Impactor Diameter= 200 m    Water Depth at Impact= 4257 m

Tsunami Energy=  $2.8 \times 10^{17}$  J     $T_{\min} = 50s$

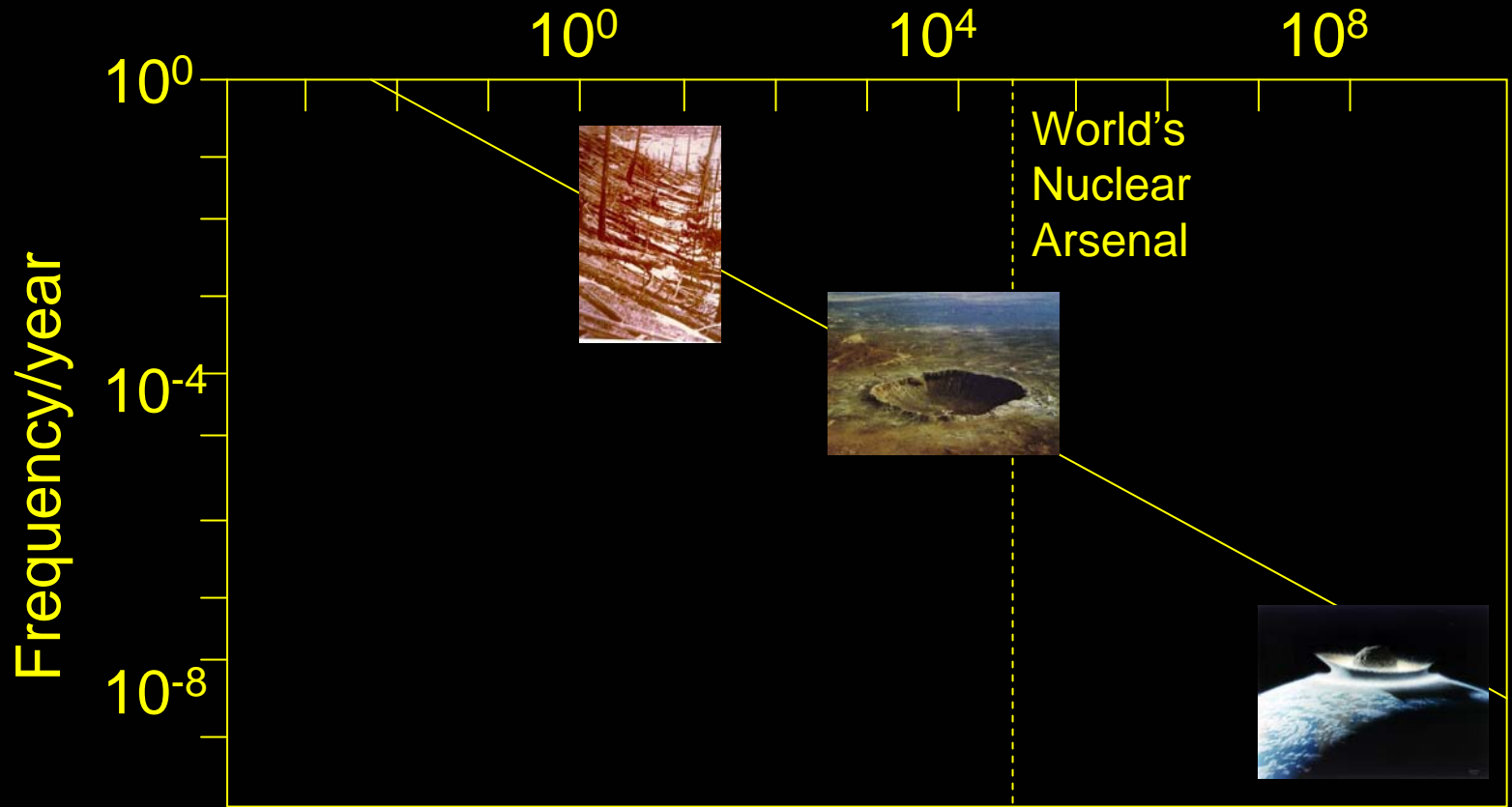
1.5    3.0    4.5    6.0    7.5    9.0    >9.75



Tsunami Envelope Height in Meters



# Megatons TNT Equivalent

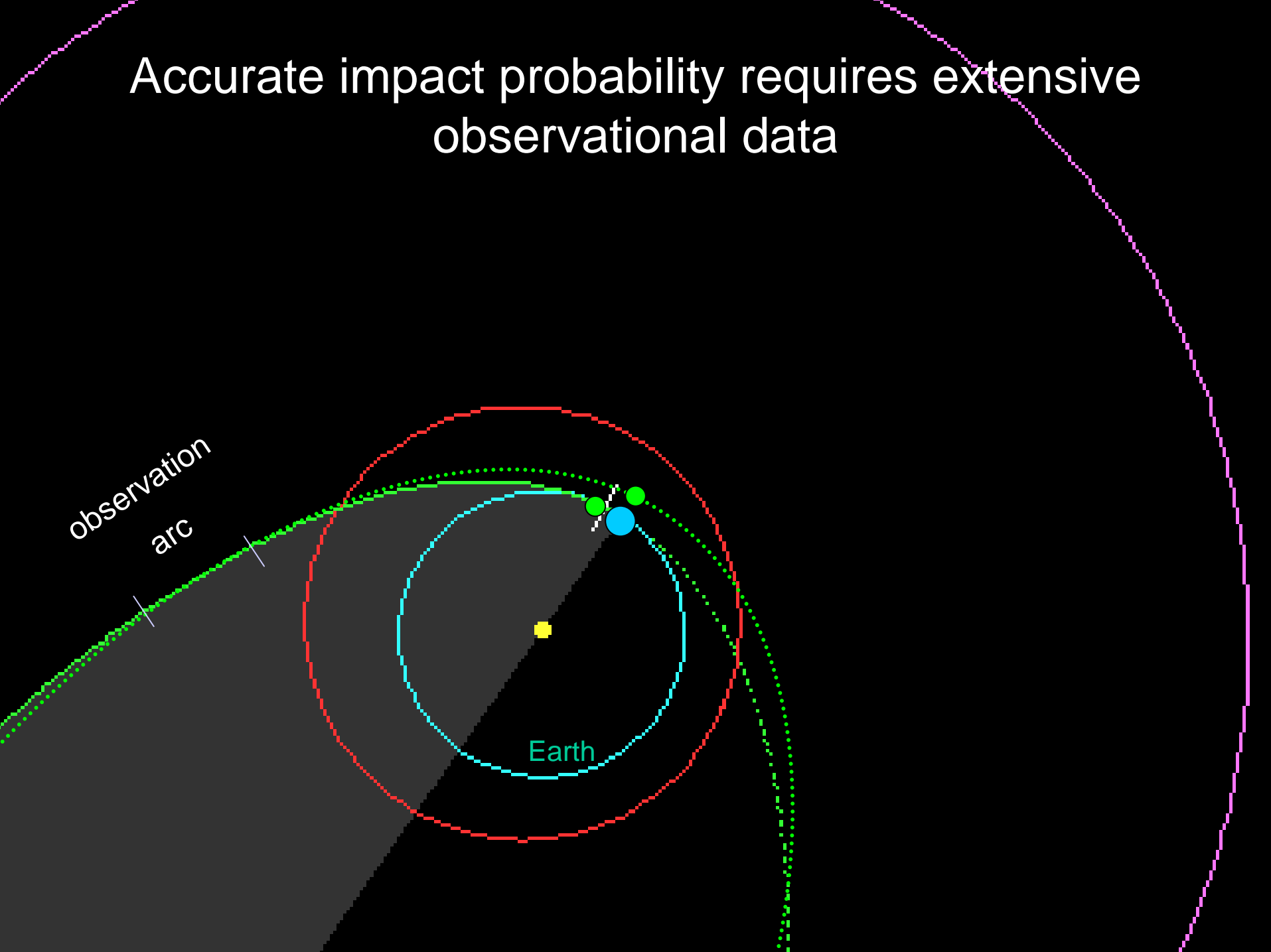


Major uncertainty is frequency, small data set

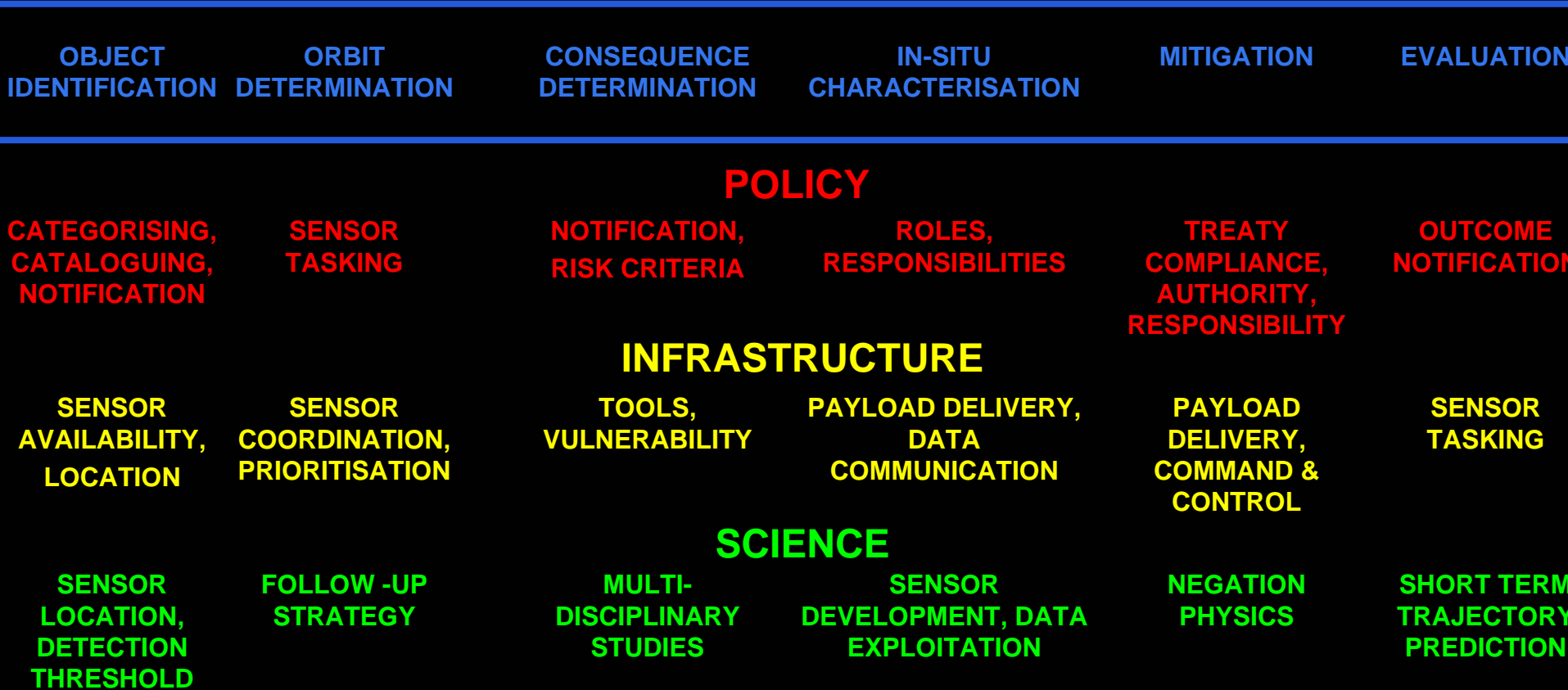
**Meteor Impact Crater  
Peru 2007**



# Accurate impact probability requires extensive observational data



# NEO risk management issues to be addressed







# Summary

- NEO impacts with Earth will occur in the future
- These are rare but catastrophic events
- Few countries understand the risks to their populations
- Infrastructure exists and is applied to observe larger asteroids
- Infrastructure is not available to observe smaller asteroids or long period comets
- Infrastructure does not exist to negate hazardous NEOs
- Response time may vary from months to 100's of years
- NEO science is perceived as low priority
- Governments view NEOs as a global problem
  - US leads global effort (its contribution is greater than rest of world put together)
  - Requires international solution but no international policy in place
  - Limited national awareness, few countries have science-based national policy
  - Time to address NEOs based on cognizance rather than ignorance?
  - Time to share responsibility and effort?