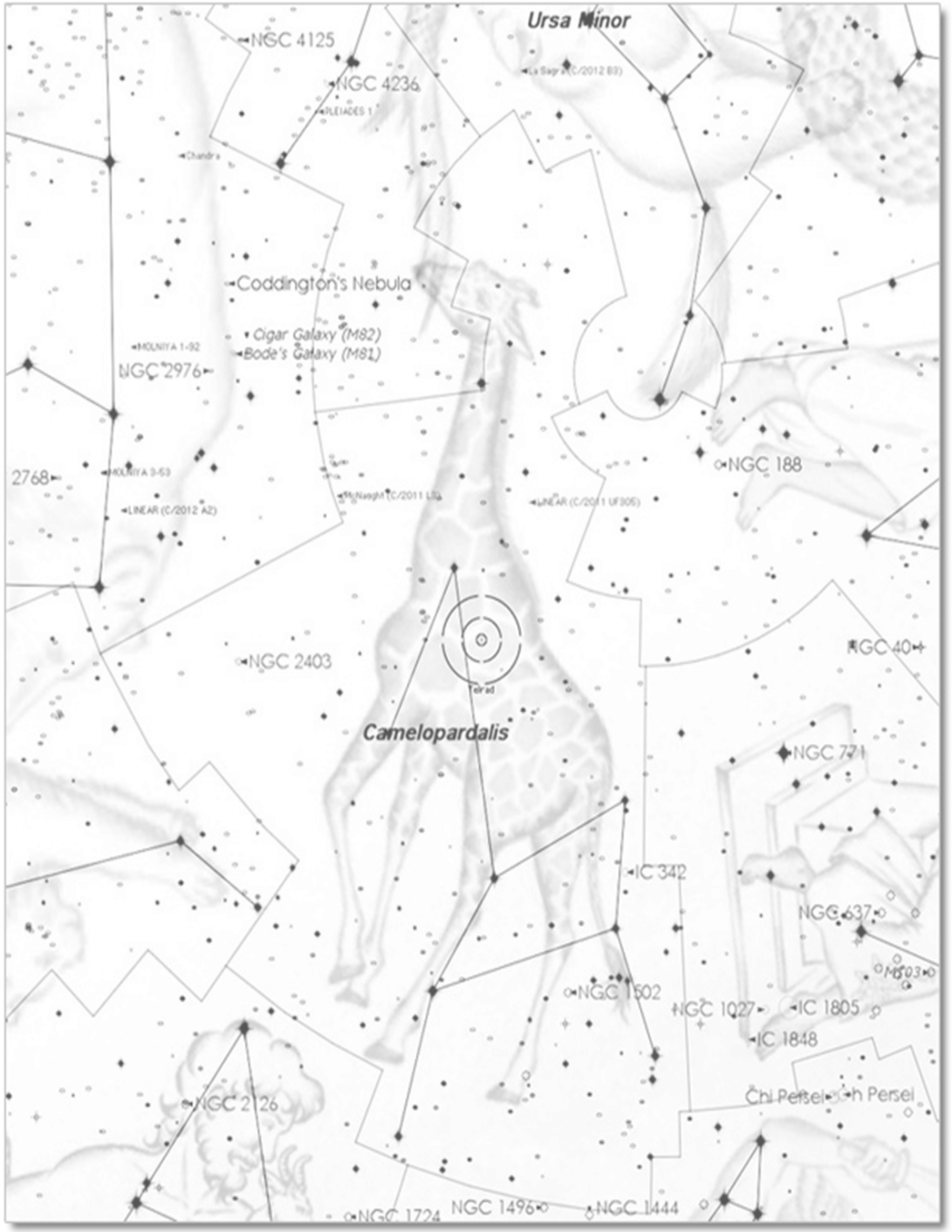

The 2014 May Camelopardalid Meteor Shower

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Overview

On May 24, 2014 Earth will encounter multiple streams of debris laid down by Comet 209P LINEAR.

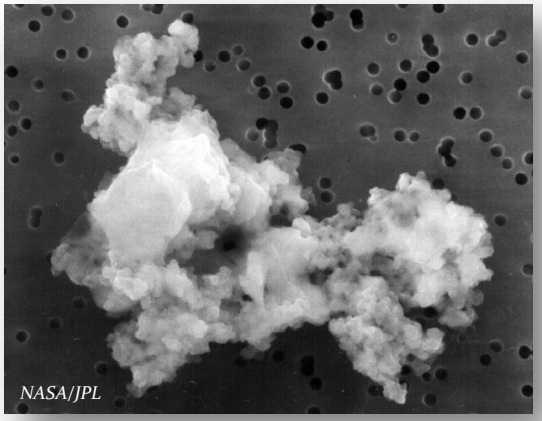
This will likely produce a new meteor shower, never before seen.

Rates predicted to be from 100 to 1000 meteors per hour between 2 and 4 AM EDT, so we are dealing with a meteor outburst, potentially a storm. Peak rate of ~200 per hour best current estimate.

Difficult to calibrate models due to lack of past observations.

Models indicate mm size particles in stream, so potential risk to Earth orbiting spacecraft.

General Terms



Meteoroids

- Chunks of rock and ice out in space left behind by comets and asteroids.
- About the size of a boulder or smaller.
- Smaller than an asteroid.

Meteors

- Streaks of light that you see as a meteoroid *ablates*, or burns up, in the Earth's atmosphere.
- Commonly called a 'shooting star' or 'falling star'.

Meteorites

- What is left of the meteoroid if it survives the trip through the atmosphere and hits the Earth.
- Made of silicate minerals and/or iron-nickel.

Risk to Spacecraft

Penetration

Meteoroids travel fast, 11-71 km/s.

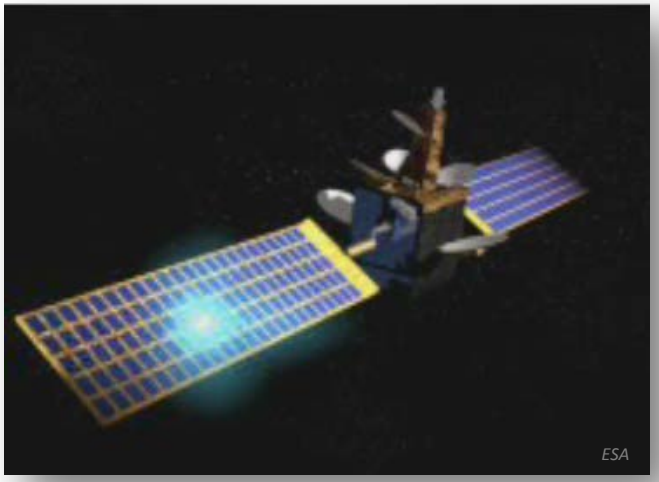
They have a lot of energy.

BEFORE being shot with a 5 cm aluminum ball moving at 6 km/s

AFTER being shot with a 5 cm aluminum ball moving at 6 km/s

Plasma

A meteoroid generates a charged plasma capable of producing a current pulse or spike



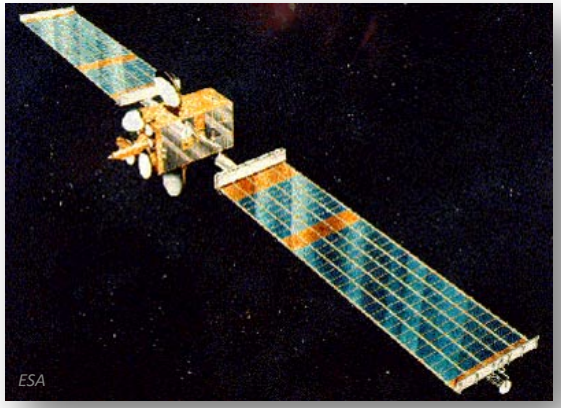
Spacecraft Affected by Meteoroids

Mariner IV

NASA planetary exploration spacecraft

Encountered meteoroid stream between the orbits of Earth and Mars in Sept 1967

Thermal shield damage



Olympus

ESA communication satellite

Struck by a Perseid near the time of the shower peak in August 1993

Sent tumbling, fuel exhausted, end of mission

Chandra

NASA X-ray observatory

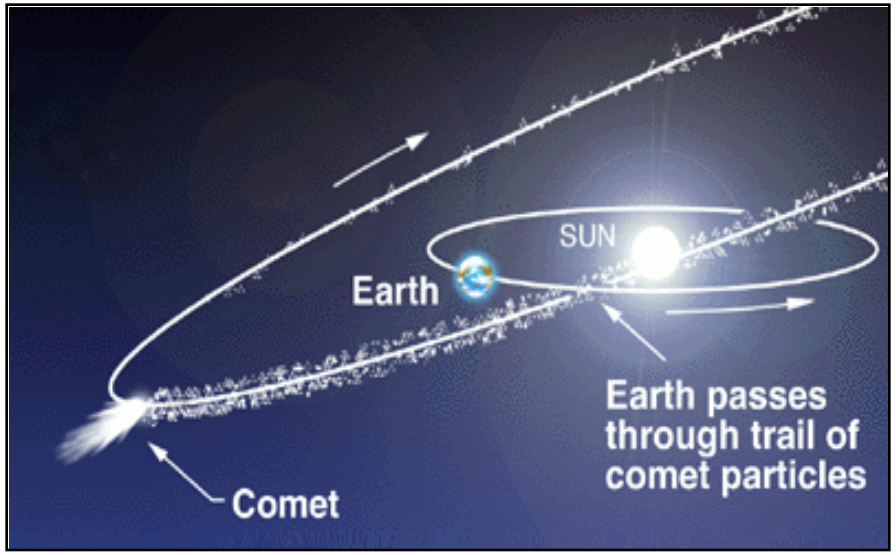
Struck by a Leonid or sporadic(?) near the time of Leonid shower peak in November 2003

Temporary wobble

Meteoroid Streams

- Consist of particles ejected from the parent comet during its orbit around the Sun.
- Over time
  - slight differences between the velocities of the comet and particles and
  - perturbations caused by planetary gravity and solar radiation pressure

  change the orbit of the stream so that it no longer follows the exact path of the comet.



- When Earth passes through a meteoroid stream it produces a meteor shower on Earth.

Meteoroid Stream Modeling

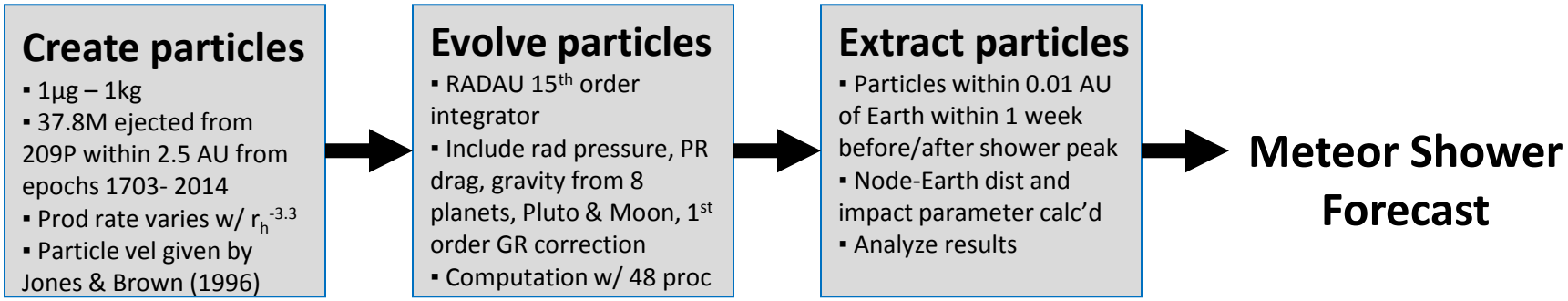
What

Model of particle ejection and subsequent evolution from comets.

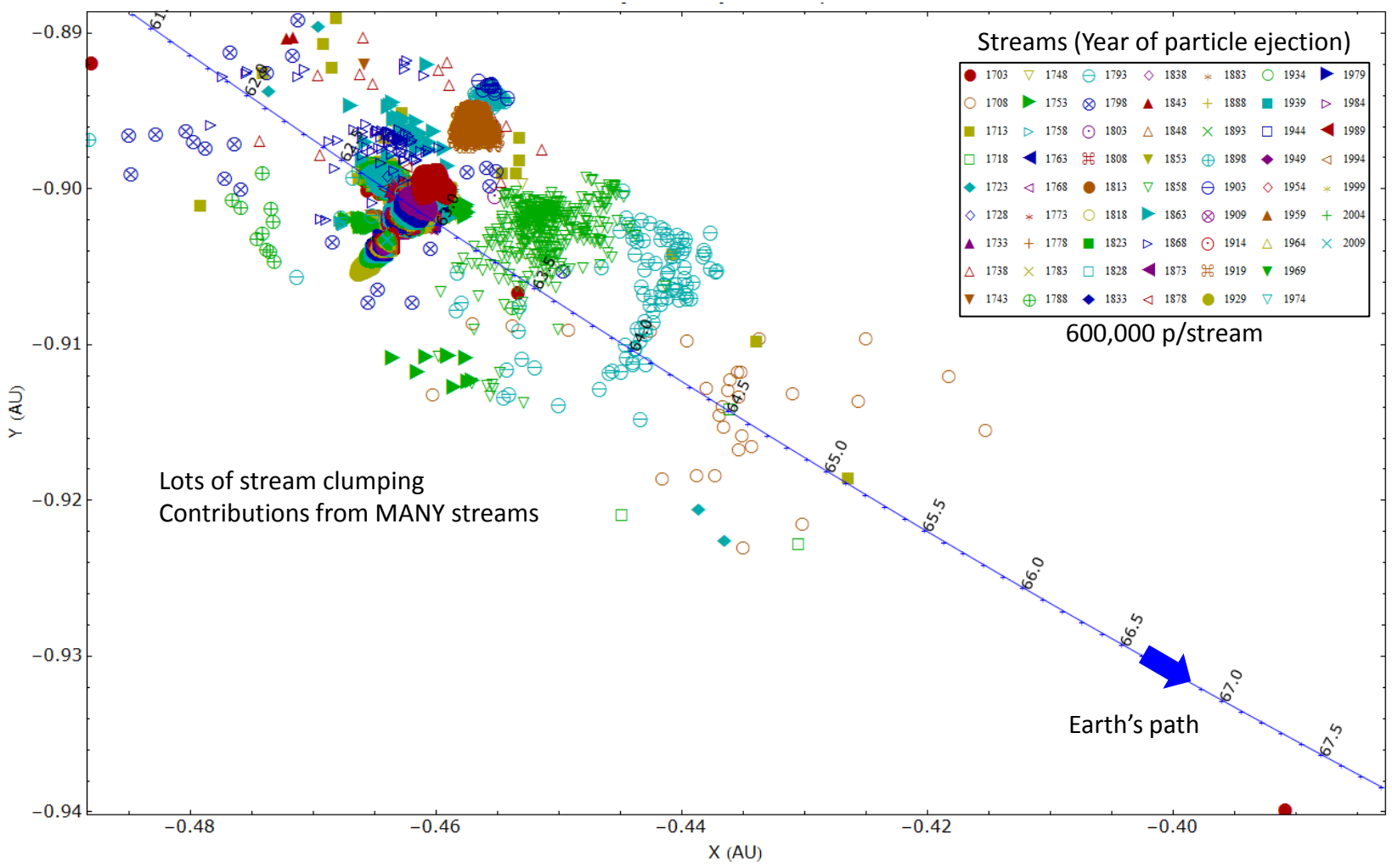
Why

To provide accurate meteor shower forecasts to spacecraft operators for hazard mitigation and mission planning purposes.

How

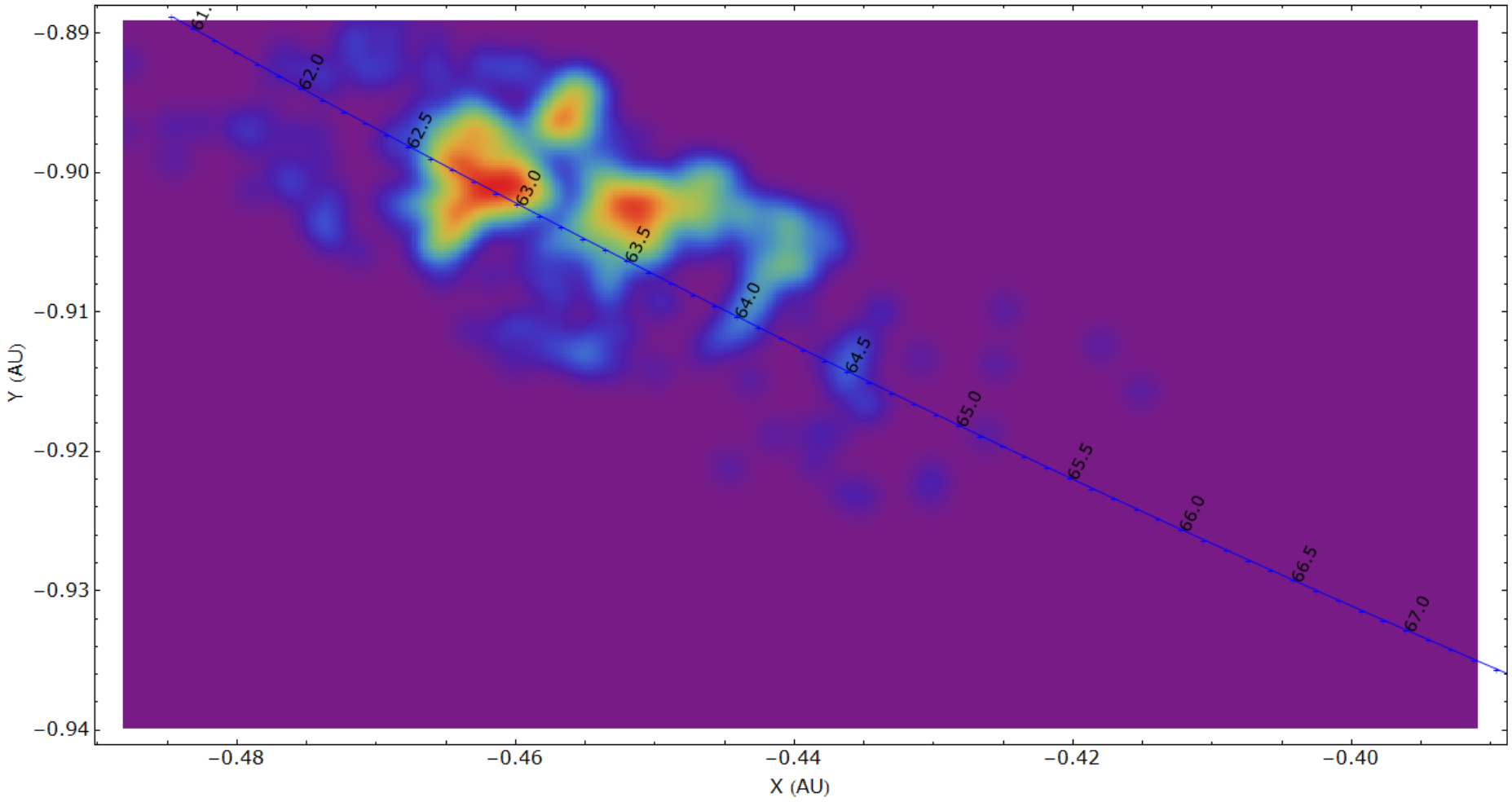


2014 May Camelopardalids Meteoroid Stream Locations

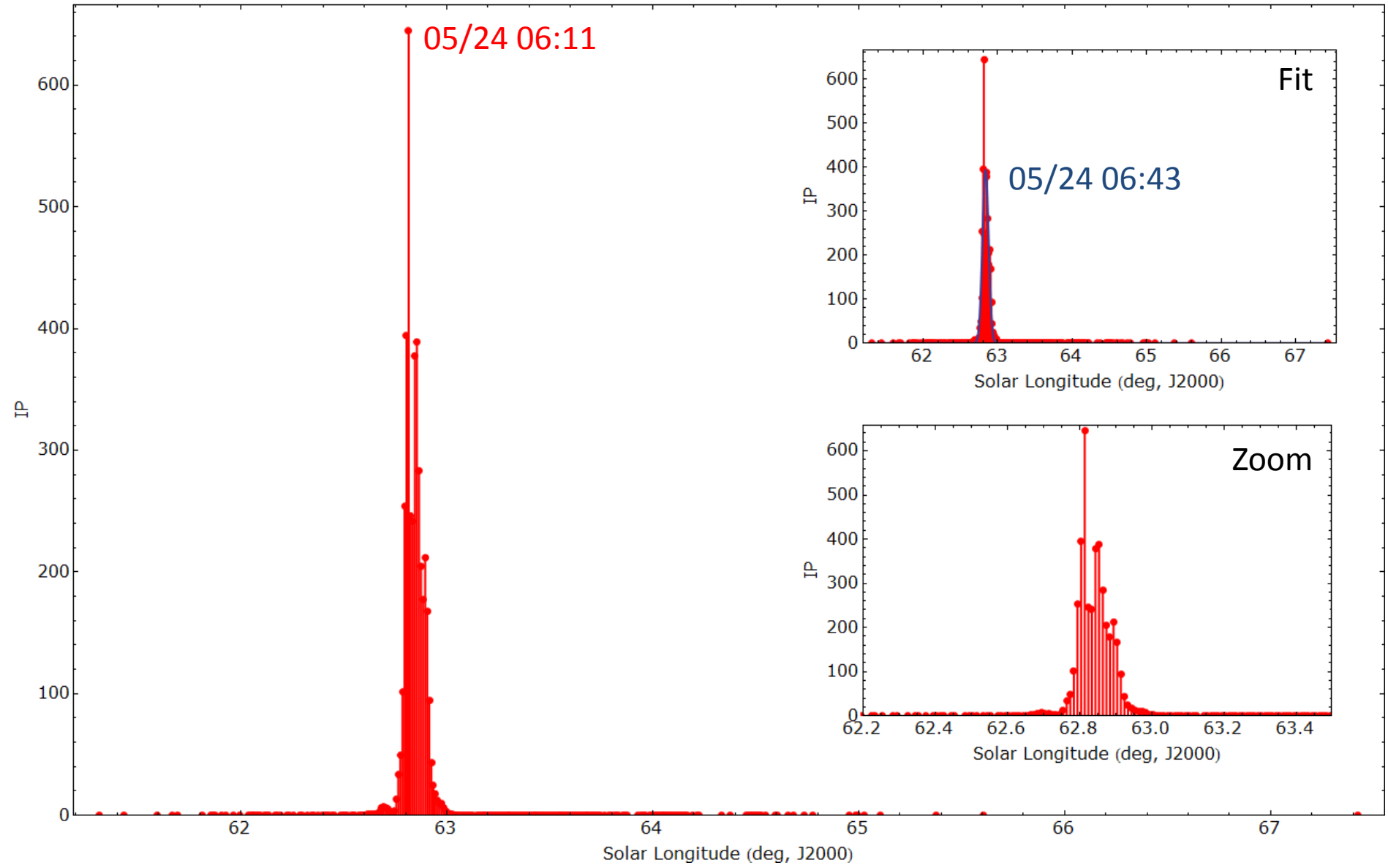


Space parameter = 0.01 AU
Time parameter = 2014,05-18 to 05-30

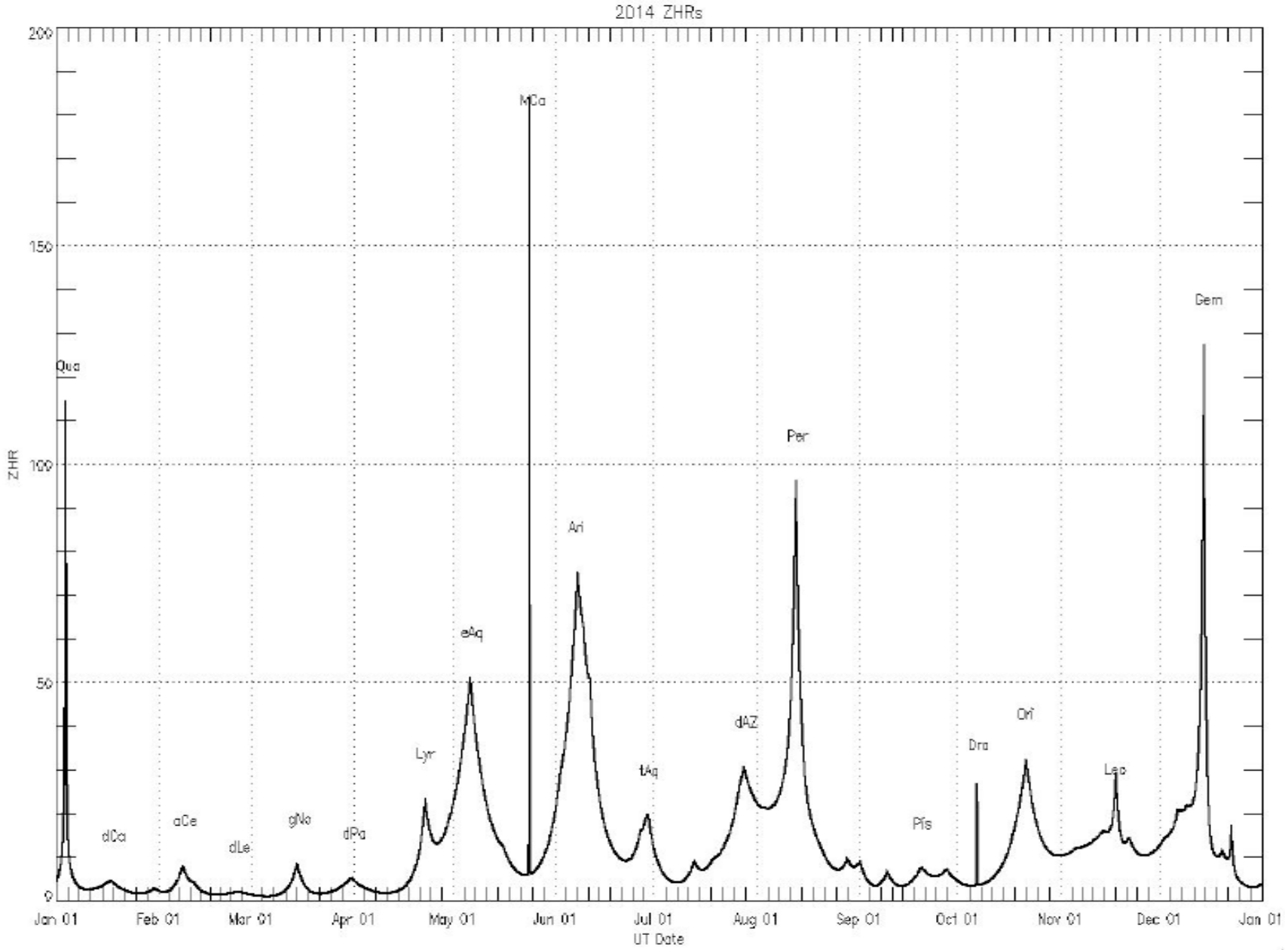
2014 May Camelopardalids Heat Map



2014 May Camelopardalids Activity Profile



Meteor Shower Activity Comparison



209P Efficiently Delivers Particles to Earth in 2014

Shower	% Simulated particles at Earth
2014 209Pids	0.96%
1970 209Pids	0.02%
2003 Leonids	0.00%
2002 Leonids	0.00%
2001 Leonids	0.01%
2000 Leonids	0.01%
1999 Leonids	0.00%
1998 Leonids	0.02%
1966 Leonids	0.00%
2011 Draconids	0.01%

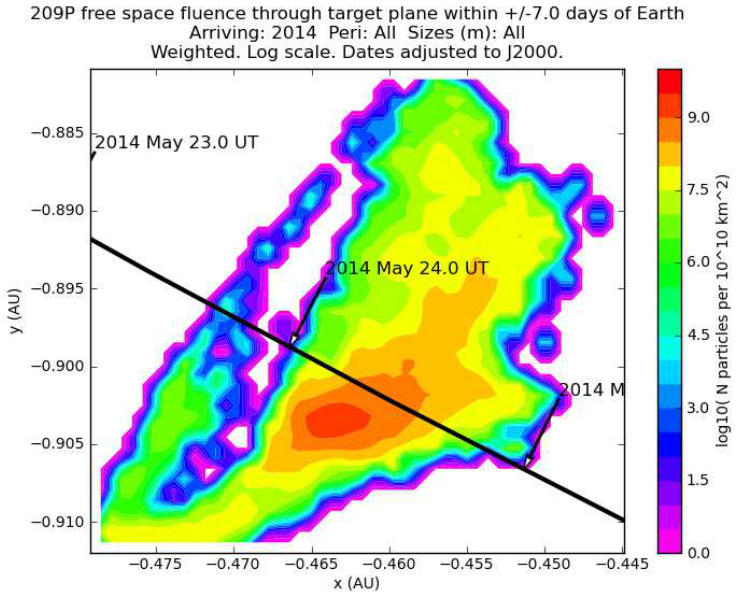
← Wow

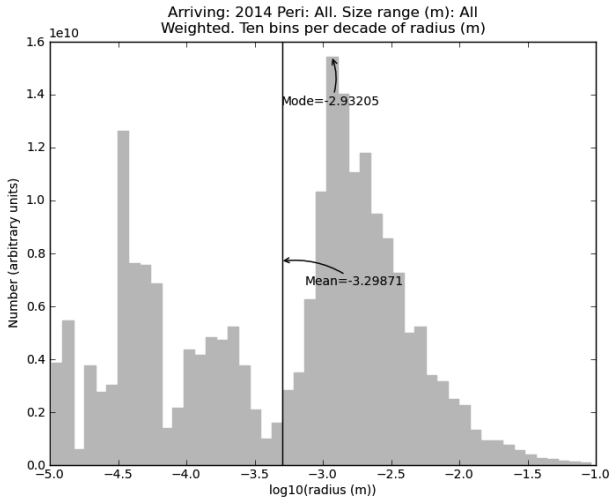
Modeling Difficulties

- This shower has never been seen before
  - The model can't be calibrated
  - We don't know how well the model describes the shower time or, critically, the rate
- Despite model post-predictions of activity in the past, no historical observations matching this shower have been found
- The parent comet doesn't appear to be very active now; we don't know how active the comet was in the past

Agreement with other Models

Ye & Wiegert

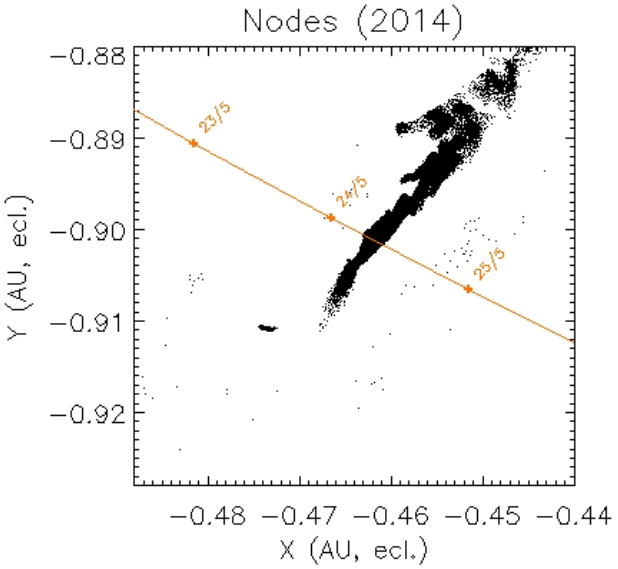


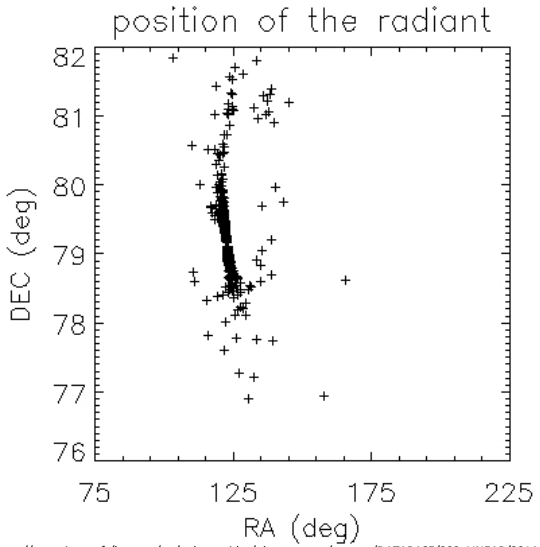


mm-sized particles pose hazard to spacecraft

Ye, Q. and Wiegert, P.A. 2013. "Will Comet 209P/LINEAR Generate the Next Meteor Storm?" MNRAS.

Vaubaillon





$\alpha = 125°$
$\delta = +79°$

http://www.imcce.fr/langues/en/ephemerides/phenomenes/meteor/DATABASE/209_LINEAR/2014/index.php

May Camelopardalids Modeling Summary

Model	Time on May 24 (UT)	ZHR (#/hr)
Lyytinen & Jenniskens (1929)	3:19	
Lyytinen & Jenniskens (1979)	6:04	
MSFC (Mar/Dec 2013, peak 1)	6:11	200
Ye & Wiegert (2013)	6:29	200 storm unlikely
Lyytinen & Jenniskens (1818, 1853)	6:33	
MSFC (Dec 2013, roughfit)	6:42	
MSFC (Mar 2013, peak 2)	6:56	
Lyytinen & Jenniskens (1903, max)	6:59	
Lyytinen & Jenniskens (1909)	7:15	
Maslov (1898-1919; 1903)	7:18	200-300
Maslov (max)	7:21	100
Vaubaillon	7:40	100-400
Lyytinen & Jenniskens (1914)	7:49	
Maslov (1763-1783)	7:55	50-150
MSFC (Mar 2013, peak 3)	8:10	

Radiant

$\alpha = 125°$

$\delta = +79°$

Speed

$V_g = 16$ km/s

Take-aways

- The May Camelopardalids are a new meteor shower, never observed before.
- Expected to peak May 24, 2014 06-08 UTC.
- Meteor rates may be high, best estimate is a peak rate of ~200 per hour.
- Models are difficult to calibrate due to lack of observations.
- May potentially pose a risk to spacecraft.