Evidence for recent impact ejecta plume on a main-belt asteroid

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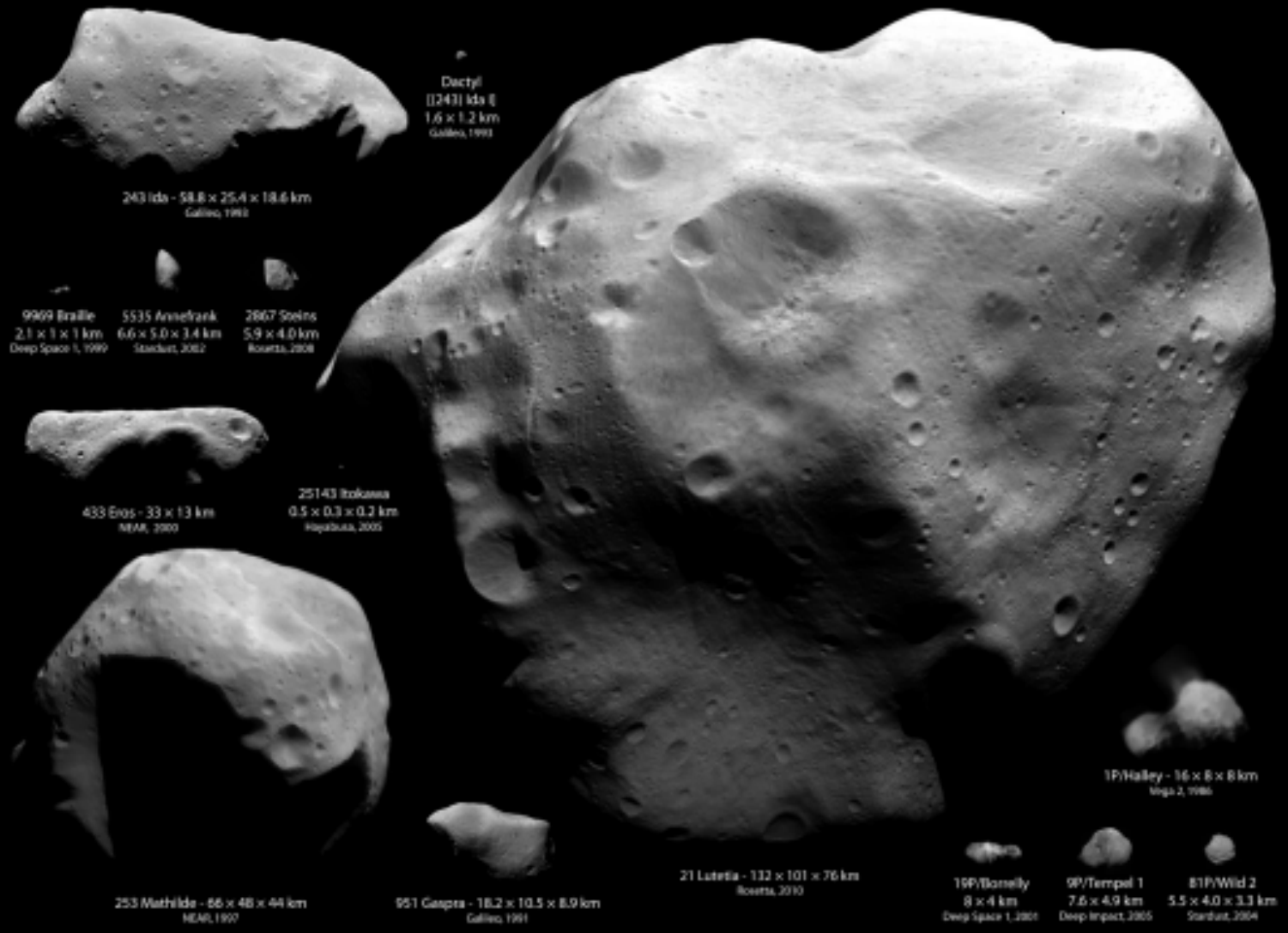
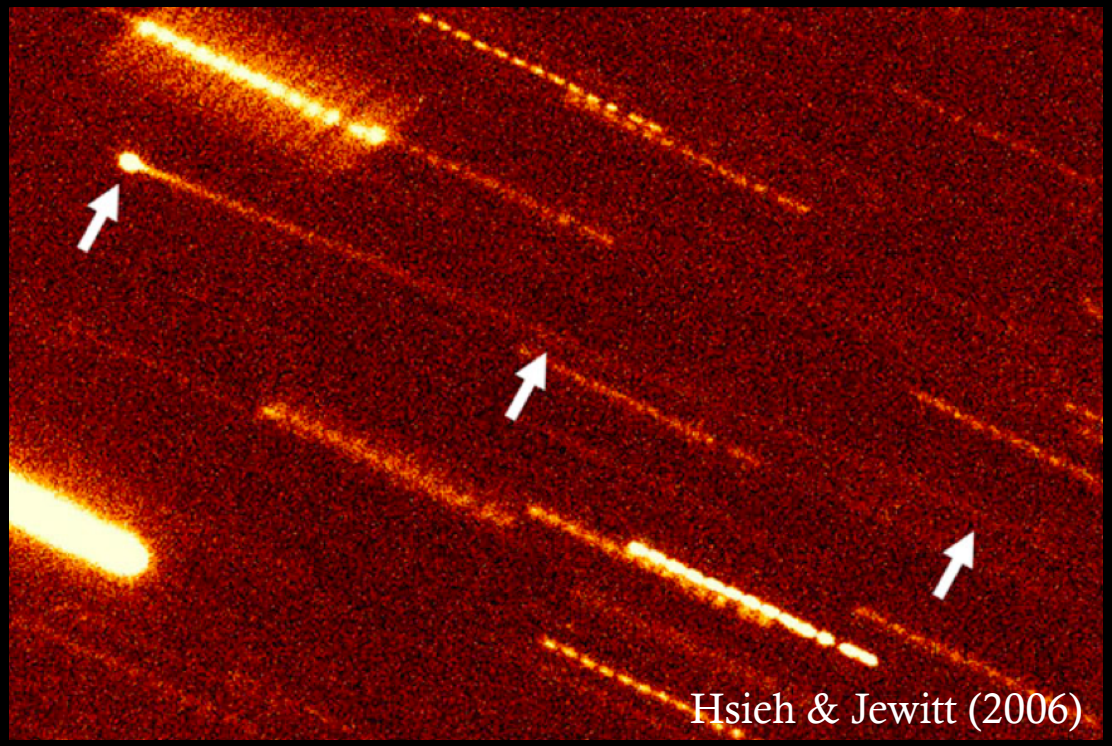
INTRODUCTION (1)
Collisional Evolution of Asteroids



INTRODUCTION (2)
Main-Belt Comets:

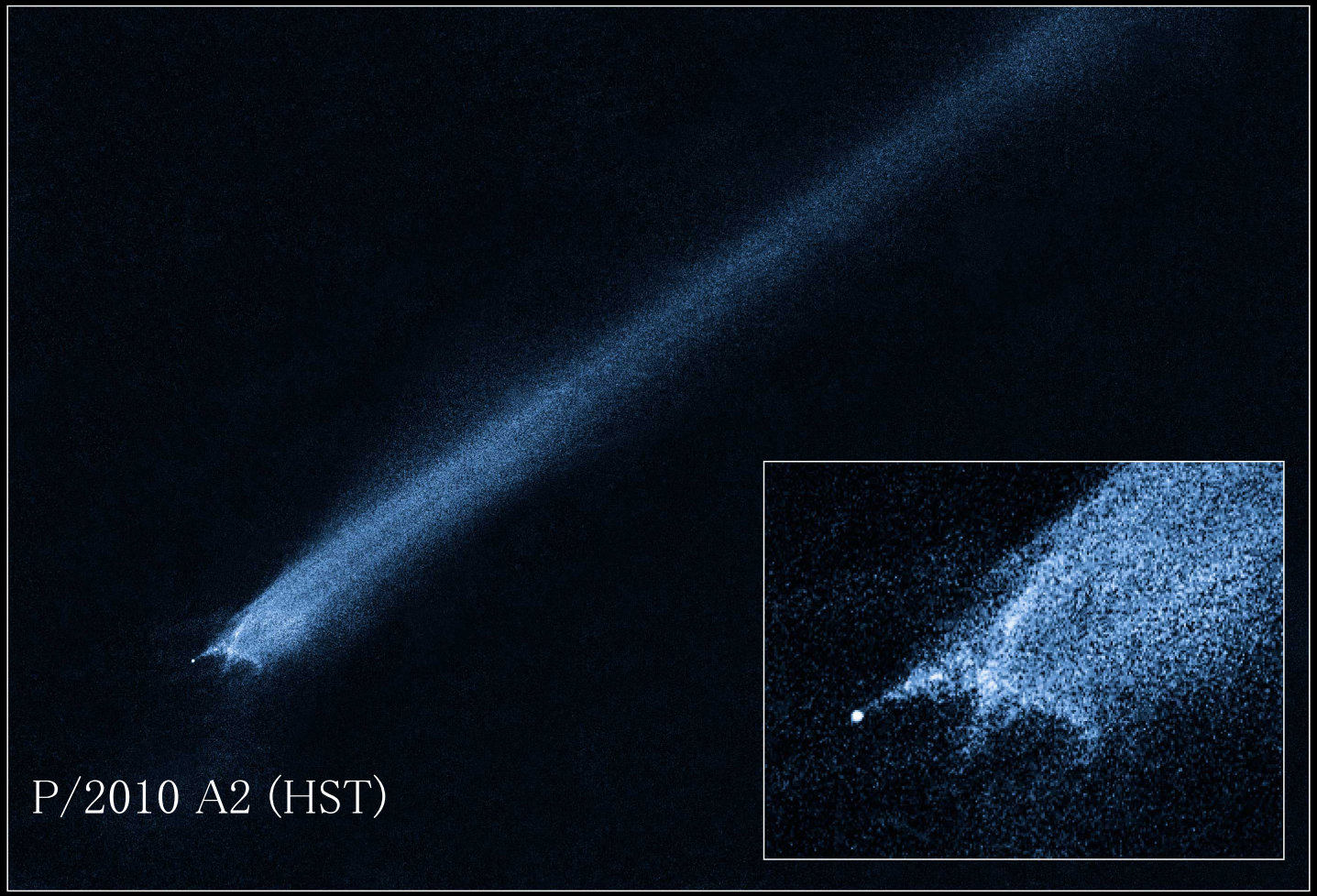


- So far, seven asteroids are known as dust emitters
- Most of them released dust particles around their perihelion passages
  → Sublimation of ice

Orbital Elements of MBCs (as of 2011 August)

	a [AU]	e	i [°]	T_J
133P/Elst-Pizarro	3.16	0.16	1.4	3.18
176P/LINEAR	3.20	0.19	0.2	3.17
P/2005 U1 (READ)	3.17	0.25	1.3	3.15
P/2008 R1 (Garradd)	2.73	0.34	15.9	3.22
P/2010 A2	2.29	0.12	5.3	3.58
P/2010 R2	3.10	0.15	21.4	3.10
(596) Scheila	2.92	0.16	14.7	3.21

INTRODUCTION (3)
Potential Recent Impact: MBC P/2010 A2



Jewitt et al. Nature 467, 817 (2010)

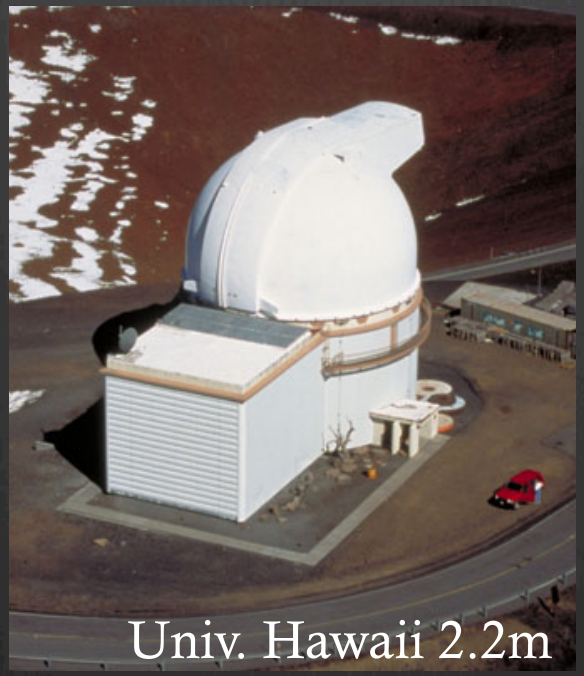
Asteroid (596) Scheila

- Orbit: Outer Main-belt (a=2.93 AU)
- Spectral type: T or D-type
- Diameter: 120 (km)
- Escape velocity: 55 (m/s)
- Rotational period: 15.848 (hr)
- Remarks: Sudden comet-like activity on 2010 December 11

Observations

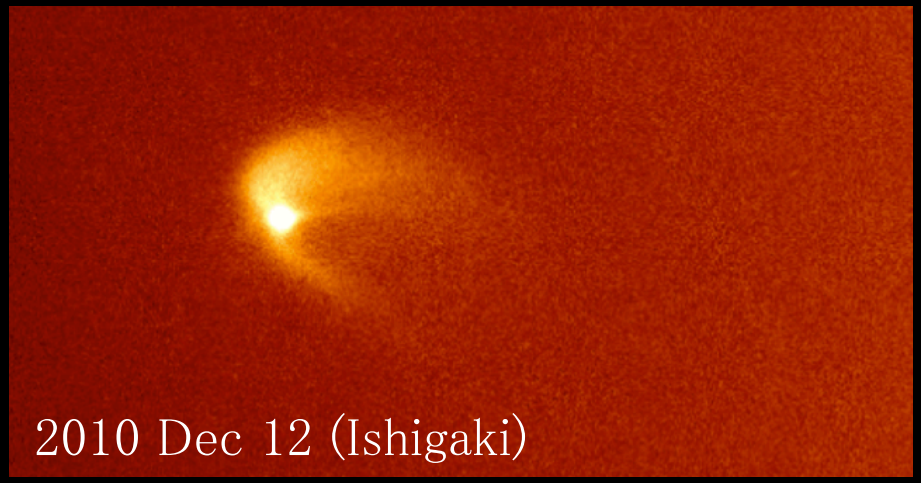
- We made observations of (596) Scheila from 2010 December 12 to 2011 March 1 by ground telescopes with optical imagers.

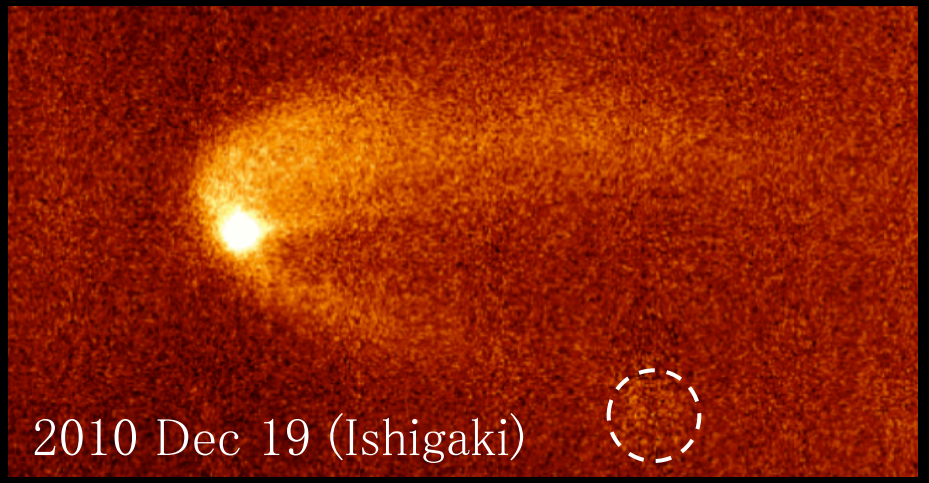
Ishigakijima 1m

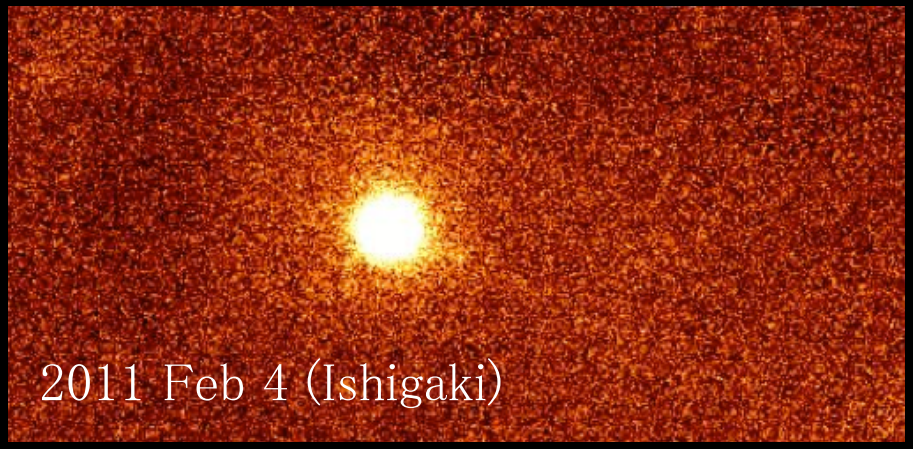

Univ. Hawaii 2.2m

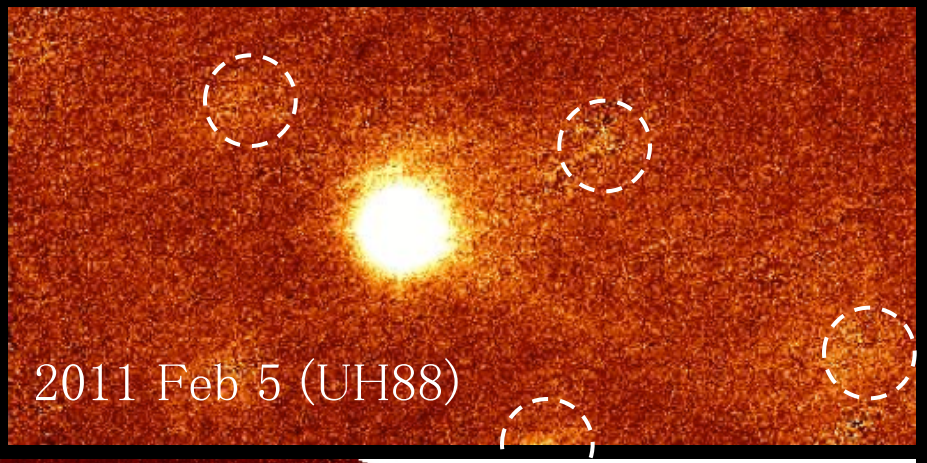

Subaru 8m

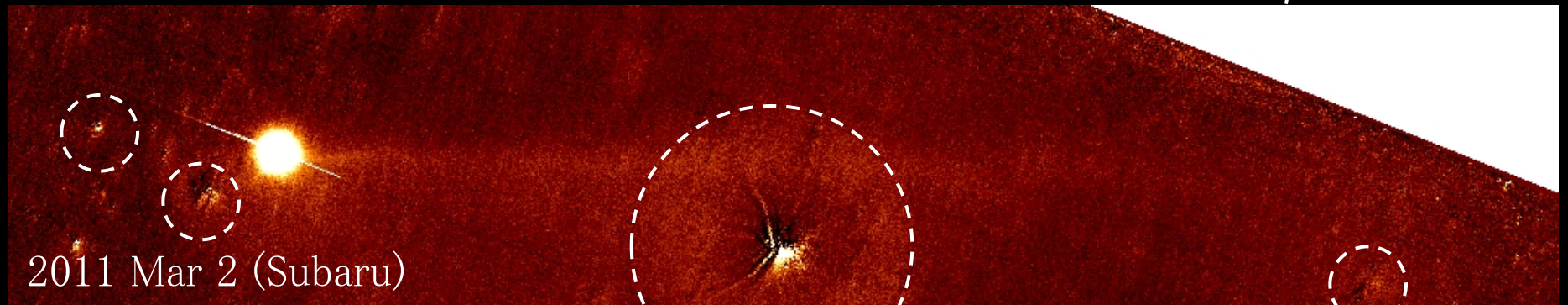
Results (1) Observed Images



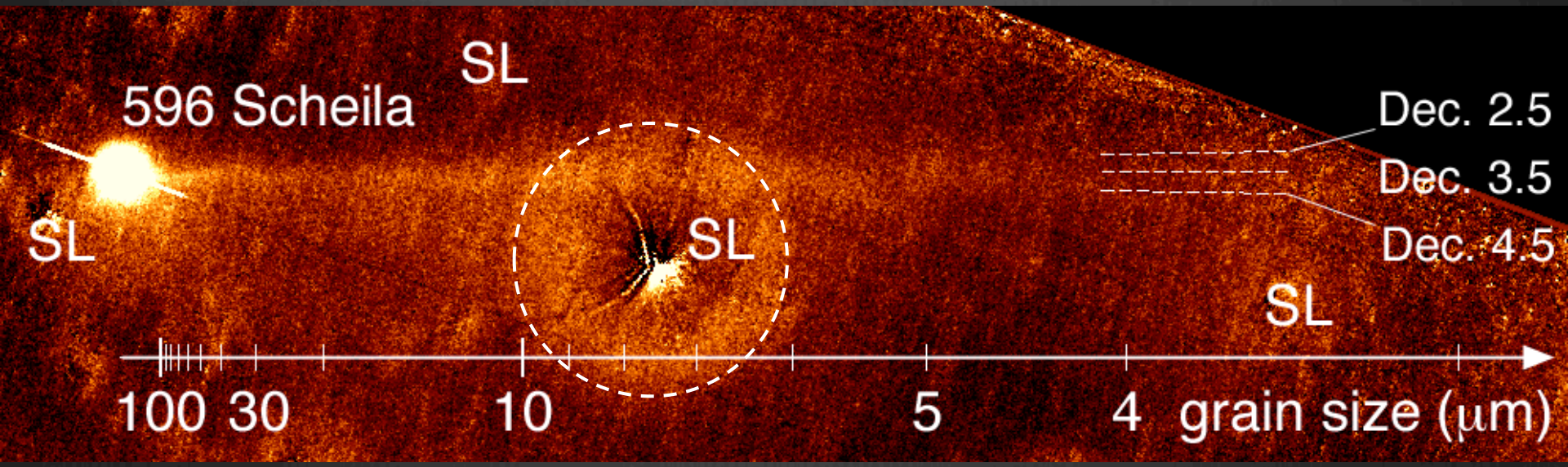








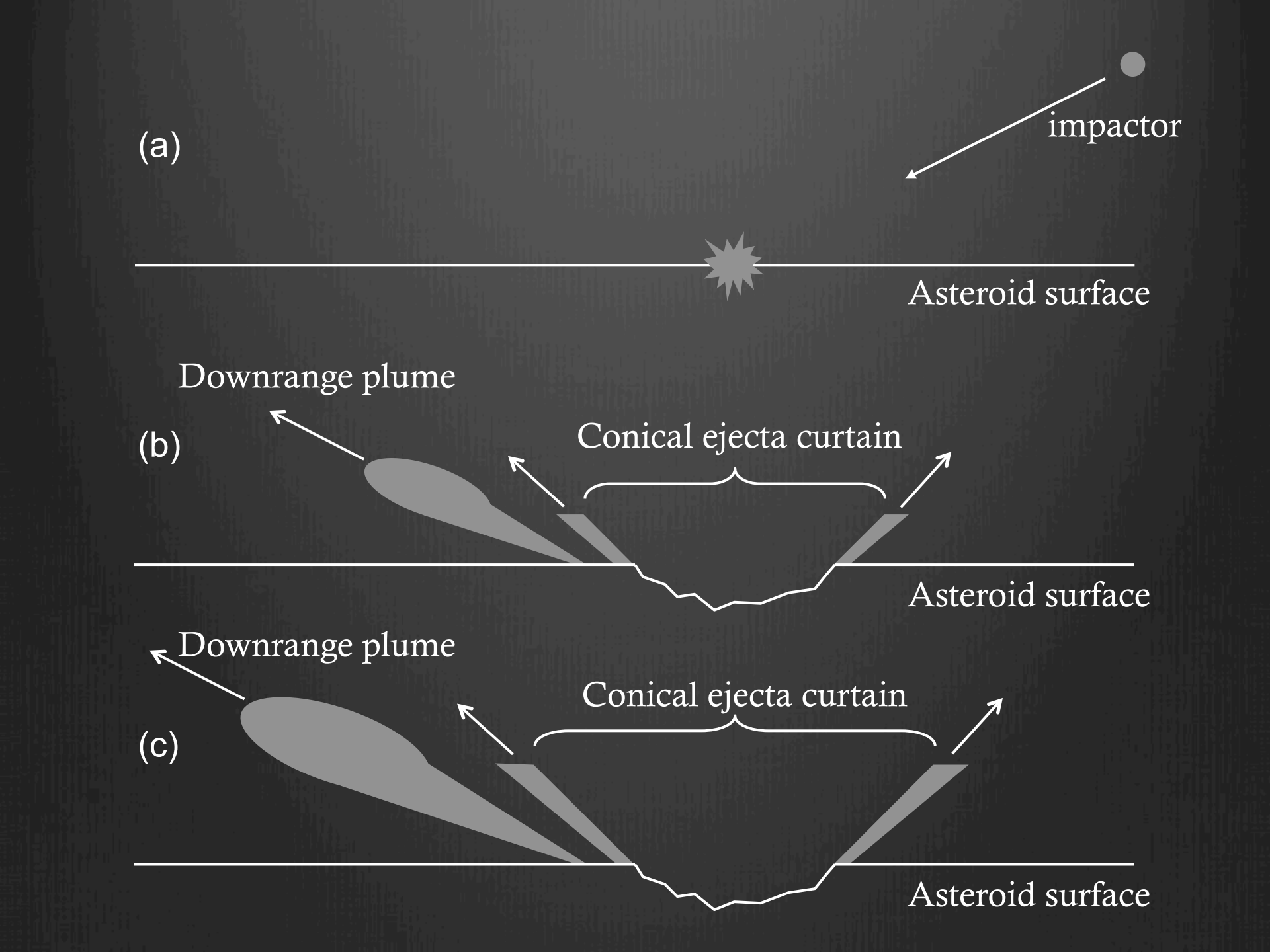
Results (2) Dust Ejection Date



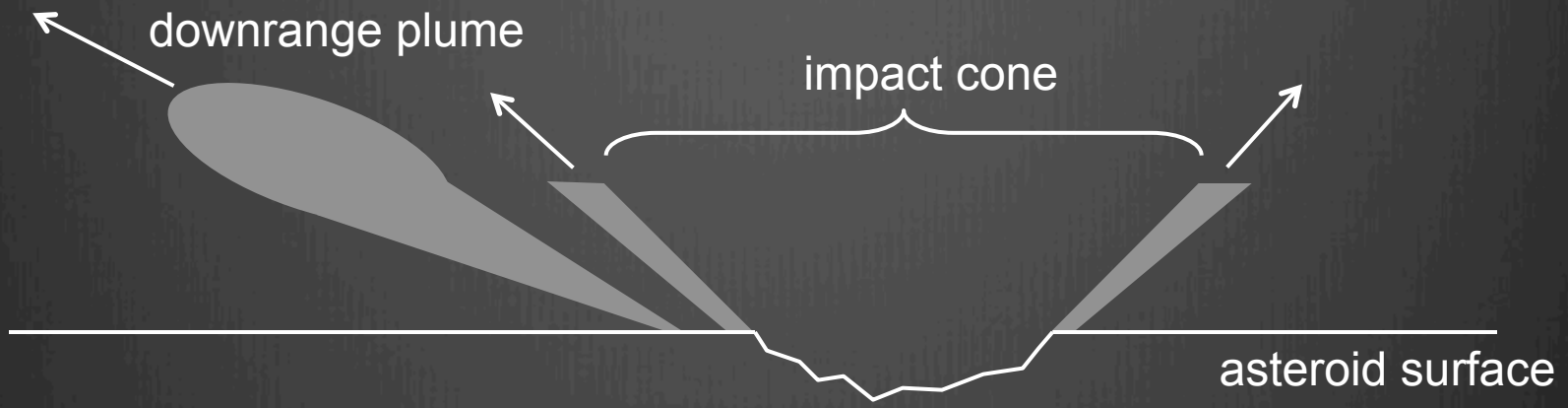
- Synchrone
- Dust emission date: 2010 Dec 3.5
- Maximum particle size: 100 micron

Dust Emission Mechanism

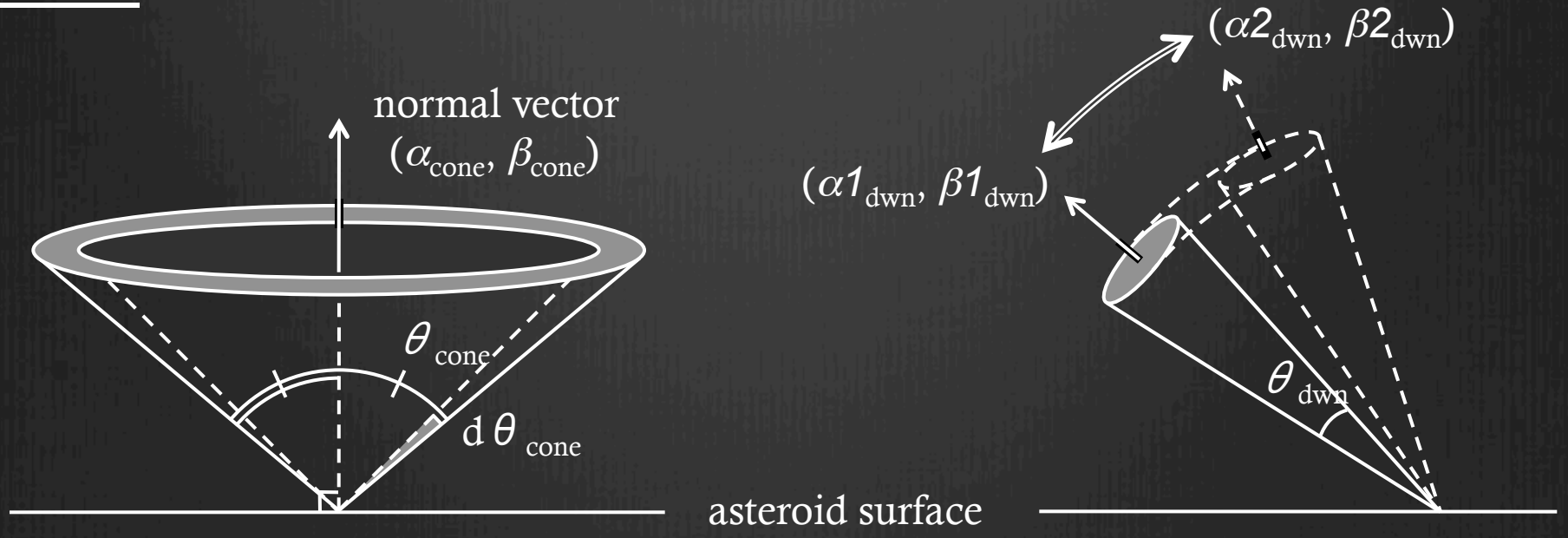
- No gases were detected by the Swift UV observations, suggesting that the outburst was not triggered by the sublimation of ice (Bodewits et al. 2011).
- Scheila is slow rotator (15.848 hours): the comet-like activity was not driven by a rotational spin-up (Holsapple & Housen 2007).
- Scheila is large asteroid (120 km in diameter): it is too large to launch up to 100 micron particles by electrostatics (Lee 1996).
- Therefore, we conclude '*impact collision*' is the mechanism for dust emission.
- However, we did not address the mysterious morphology of the triple dust cloud so far.

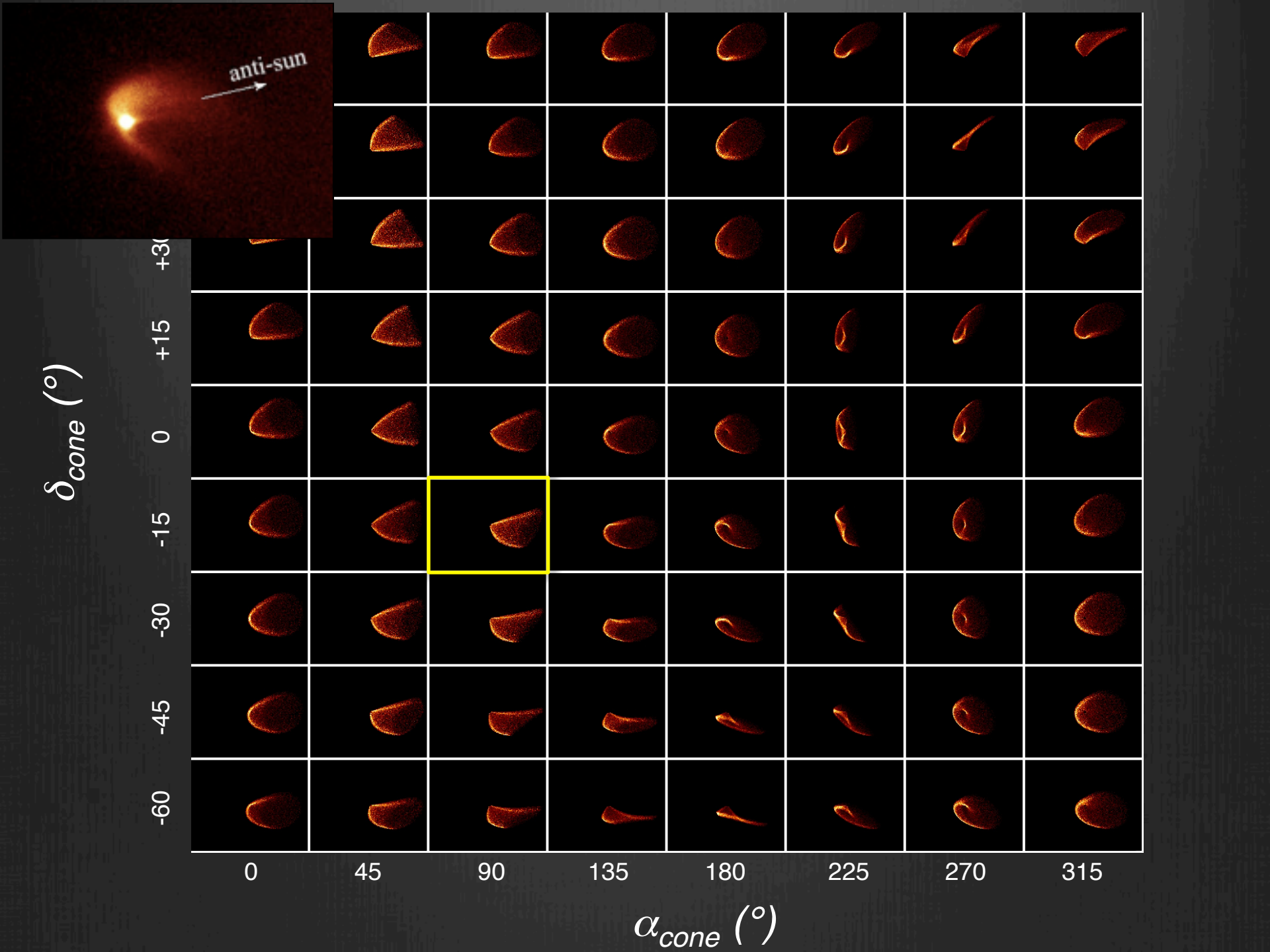

(a)
impactor
Asteroid surface
Downrange plume
(b)
Conical ejecta curtain
Asteroid surface
Downrange plume
Conical ejecta curtain
(c)
Asteroid surface

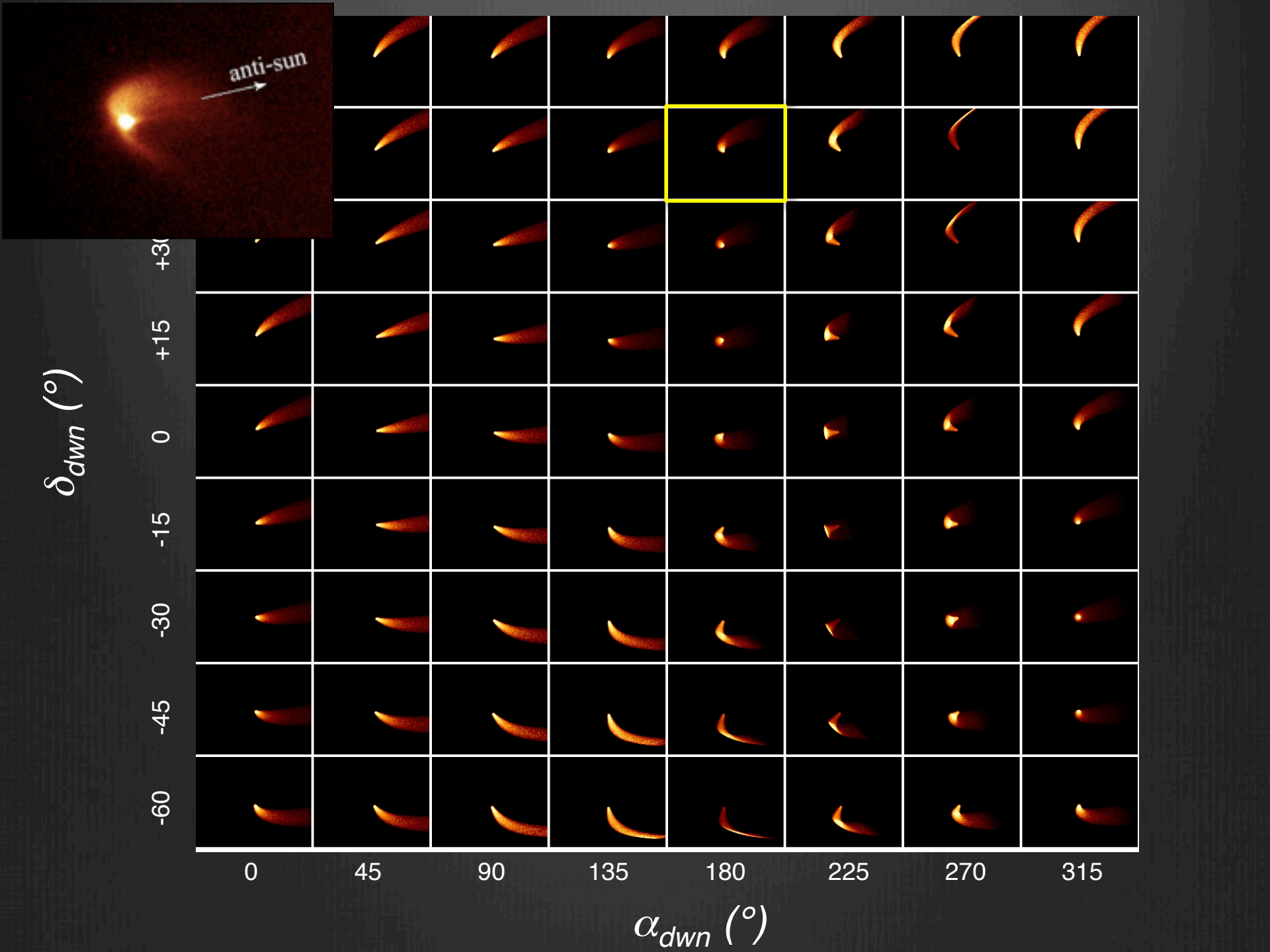
reality



model




anti-sun
+30
+15
0
-15
-30
-45
-60
δ_{cone} (°)
0
45
90
135
180
225
270
315
α_{cone} (°)


anti-sun
+30
+15
0
-15
-30
-45
-60
δ_{dwn} (°)
0
45
90
135
180
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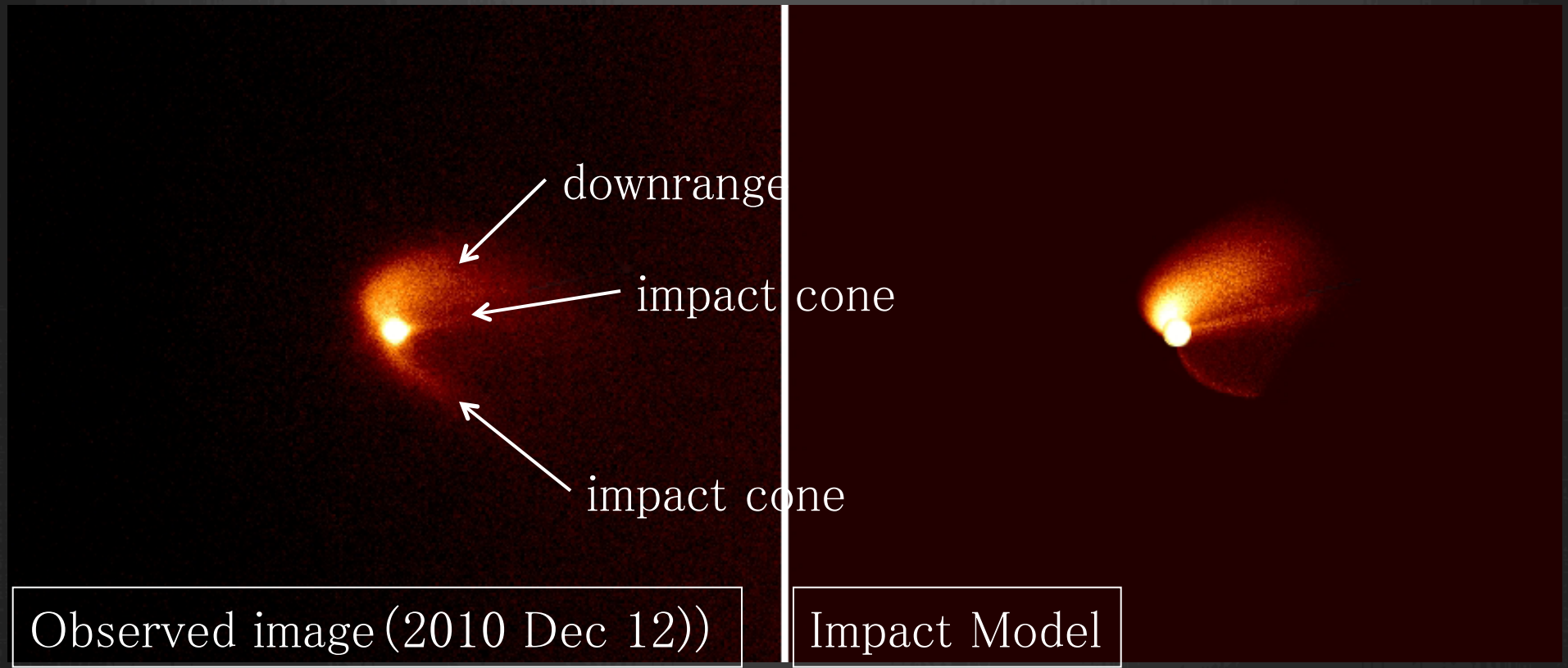
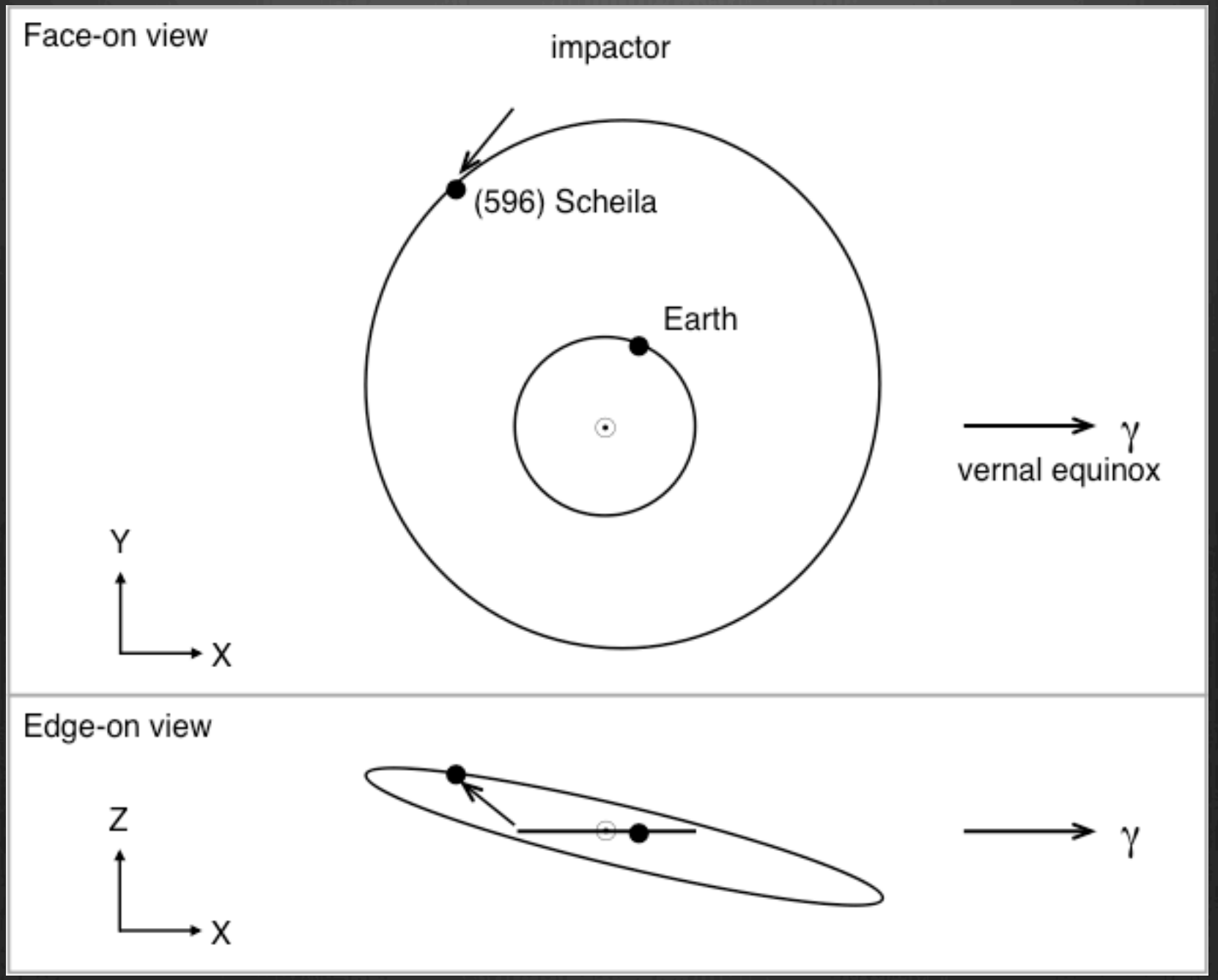
270
315
α_{dwn} (°)


downrange
impact cone
impact cone
Observed image (2010 Dec 12))
Impact Model


Face-on view
impactor
(596) Scheila
Earth
γ
vernal equinox
Y
X
Edge-on view
Z
X
γ

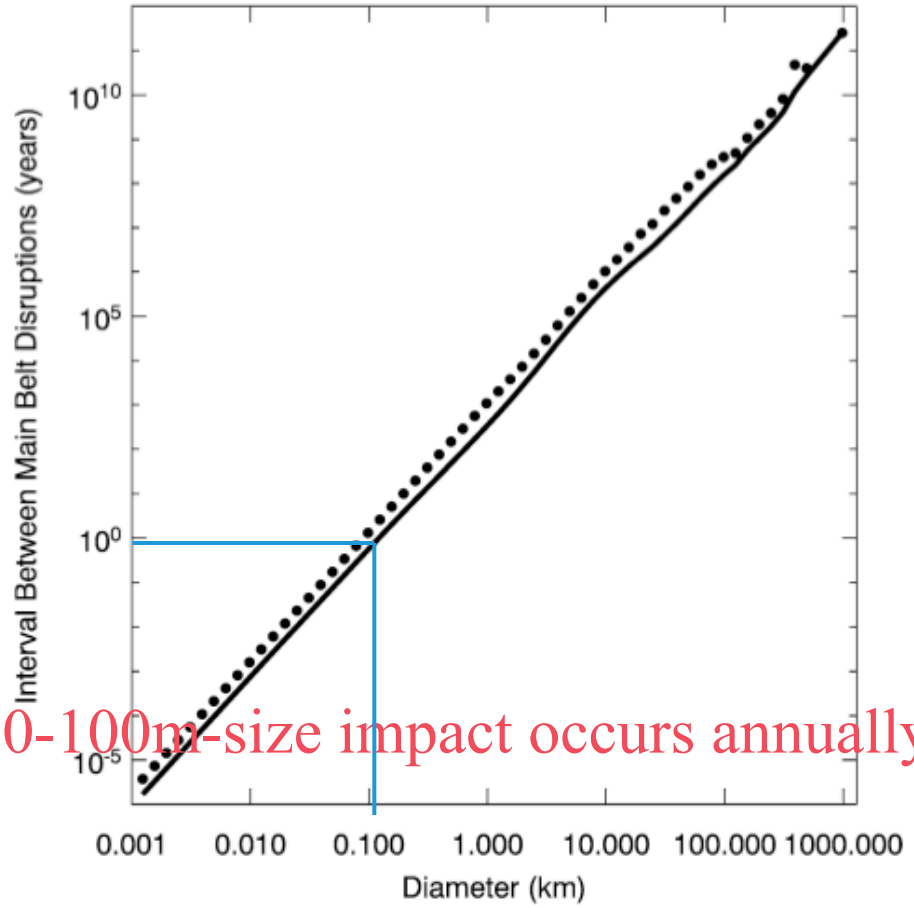
Summary

- Thanks to Subaru for 1-hr observation, we determined the impact time for the first time.
- Peculiar triple dust tail can be explained by an oblique impact
- Impact date: 2010 Dec 2 12UT --- Dec 3 10UT
- Impactor's diameter: 20-50m (Subaru dome size)
- Crater's diameter: 500-800 m (NAOJ Mitaka campus)
- Surface tensile strength: 0.1-0.3 Mpa

  (as low as Tagish-lake meteorite)

[References]
- Ishiguro et al. 2011, Astrophysical Journal Letters 740, L11
- Ishiguro et al. 2011, Astrophysical Journal Letters, 741, L24

When is the next?



10-100m-size impact occurs annually!?

Fig. 15. The interval between disruption events taking place across the main belt as a function of size. The black dots are the interval in each logarithmic size bin, while the solid line is the interval for asteroids larger than a given diameter.

Bottke et al. Icarus 175, 111–140 (2005)

Acknowledgements:
This work could not have been conducted without the assistance of Subaru telescope. We would like to sincerely thank the observatory stuff for their consideration and prompt response of this matter.