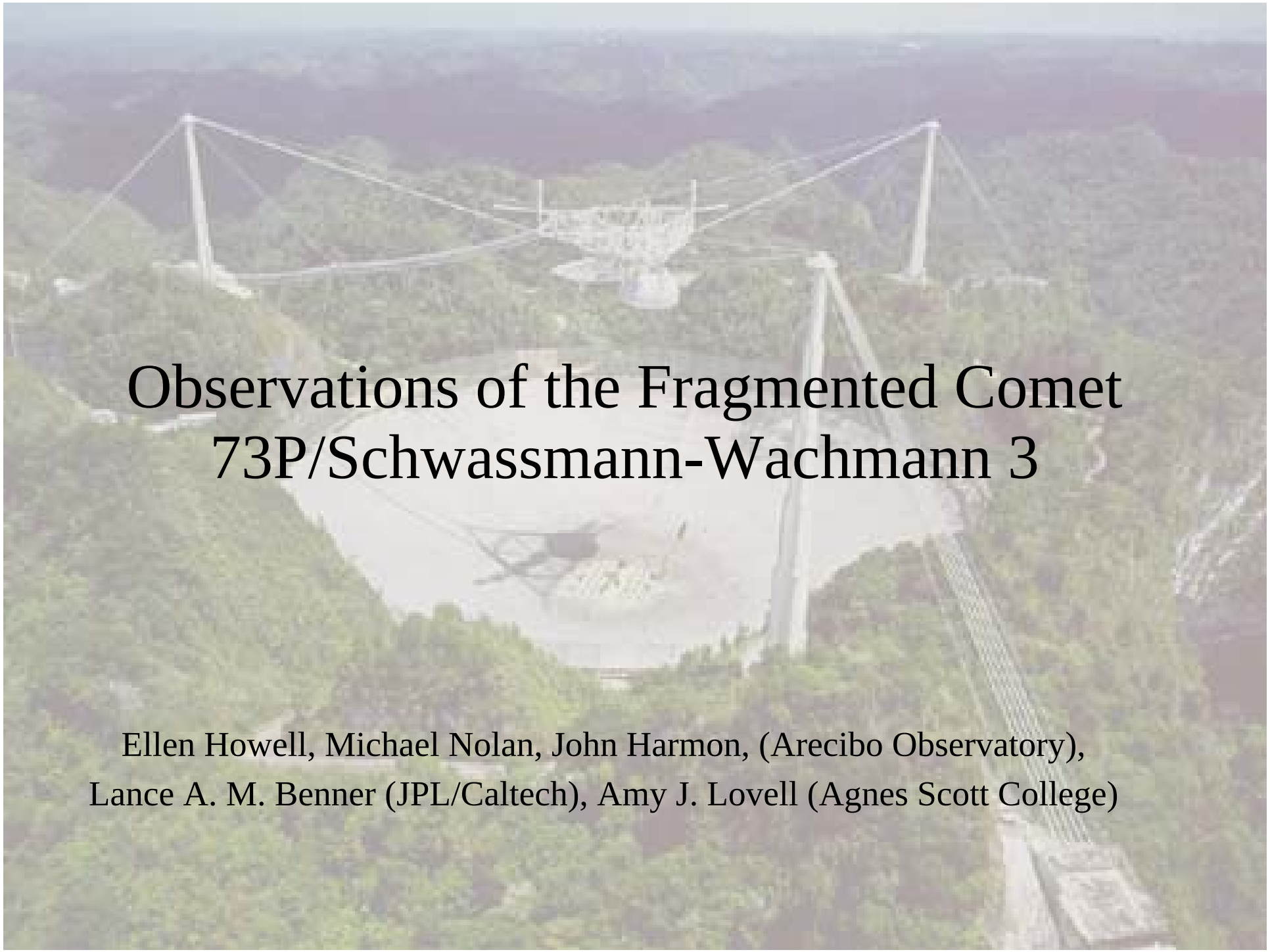


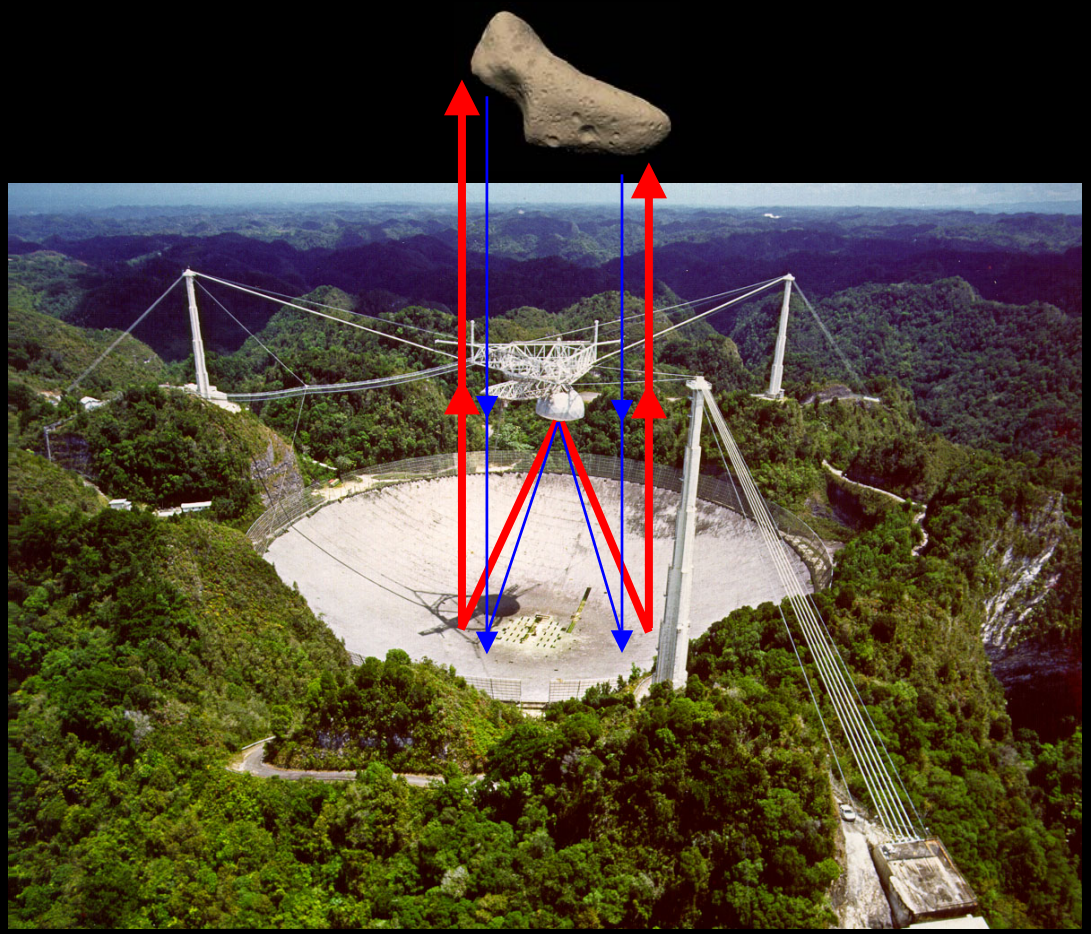
Observations of the Fragmented Comet 73P/Schwassmann-Wachmann 3

Ellen Howell, Michael Nolan, John Harmon, (Arecibo Observatory),
Lance A. M. Benner (JPL/Caltech), Amy J. Lovell (Agnes Scott College)

- HST image of fragment B on April 18
- Image is equal to the Arecibo field of view

- Radar detection of both the nucleus and the dust coma
- Radar images of fragments B and C of 73P/SW 3
  - Measure sizes, shape, spin rate
- Obtained the first radar image of the fragment B coma.
  - What does a radar image of a coma mean?
- Observed 18-cm OH spectral lines in coma maps
  - water production rate and outflow velocity

radar astronomy



The basics:

A radar transmitter transmits radio waves at a known frequency for a certain time interval.

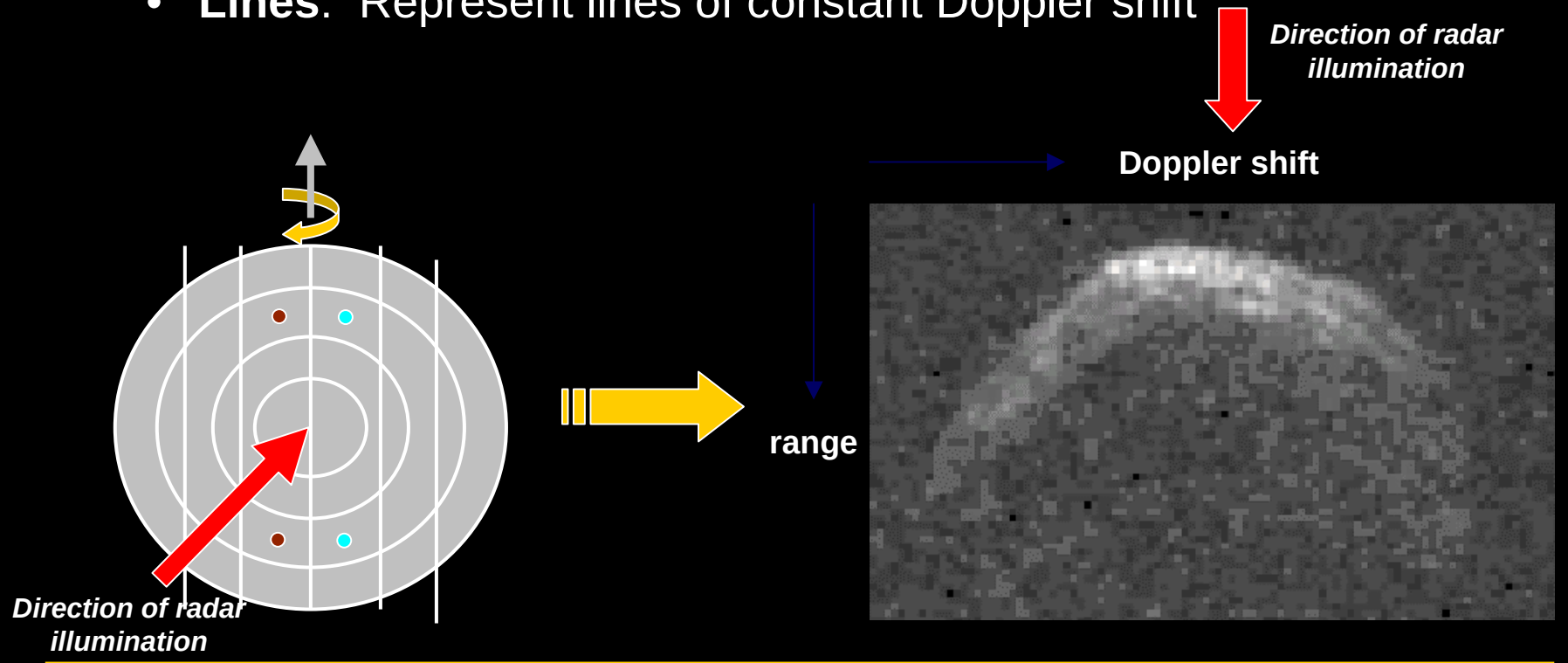
The waves hit the object, bounce off of it, and return to the telescope. The receiver, now moved into the focus of the telescope, detects the weak echo.

Transmitted wave

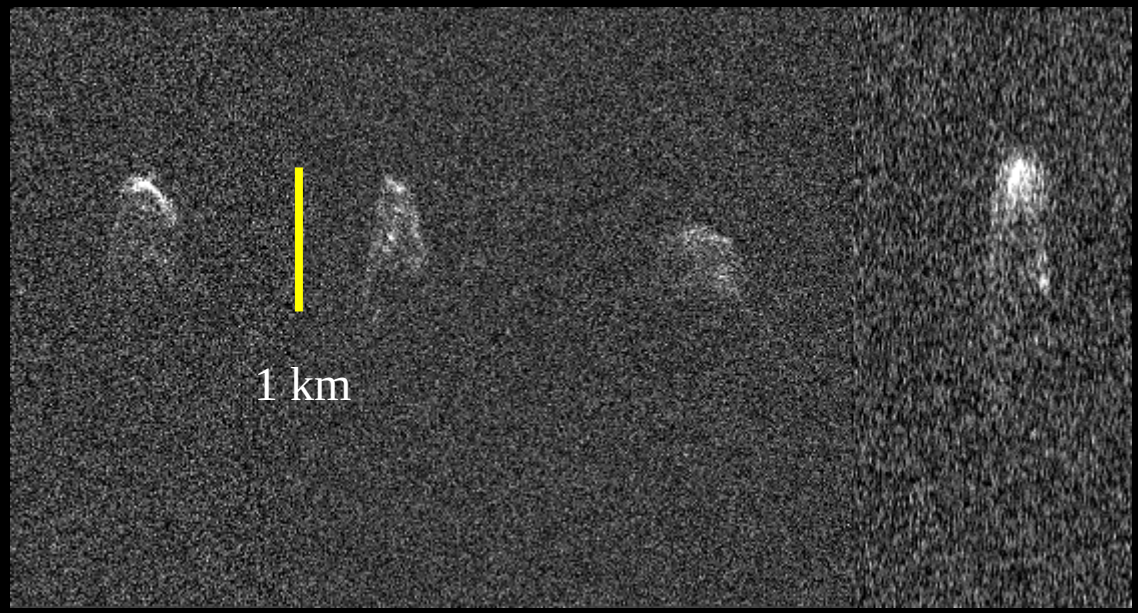
Echo from distant object

asteroid images

- Delay Doppler images map a 3D object into a 2D image
  - **Circles**: Represent lines of constant range
  - **Lines**: Represent lines of constant Doppler shift



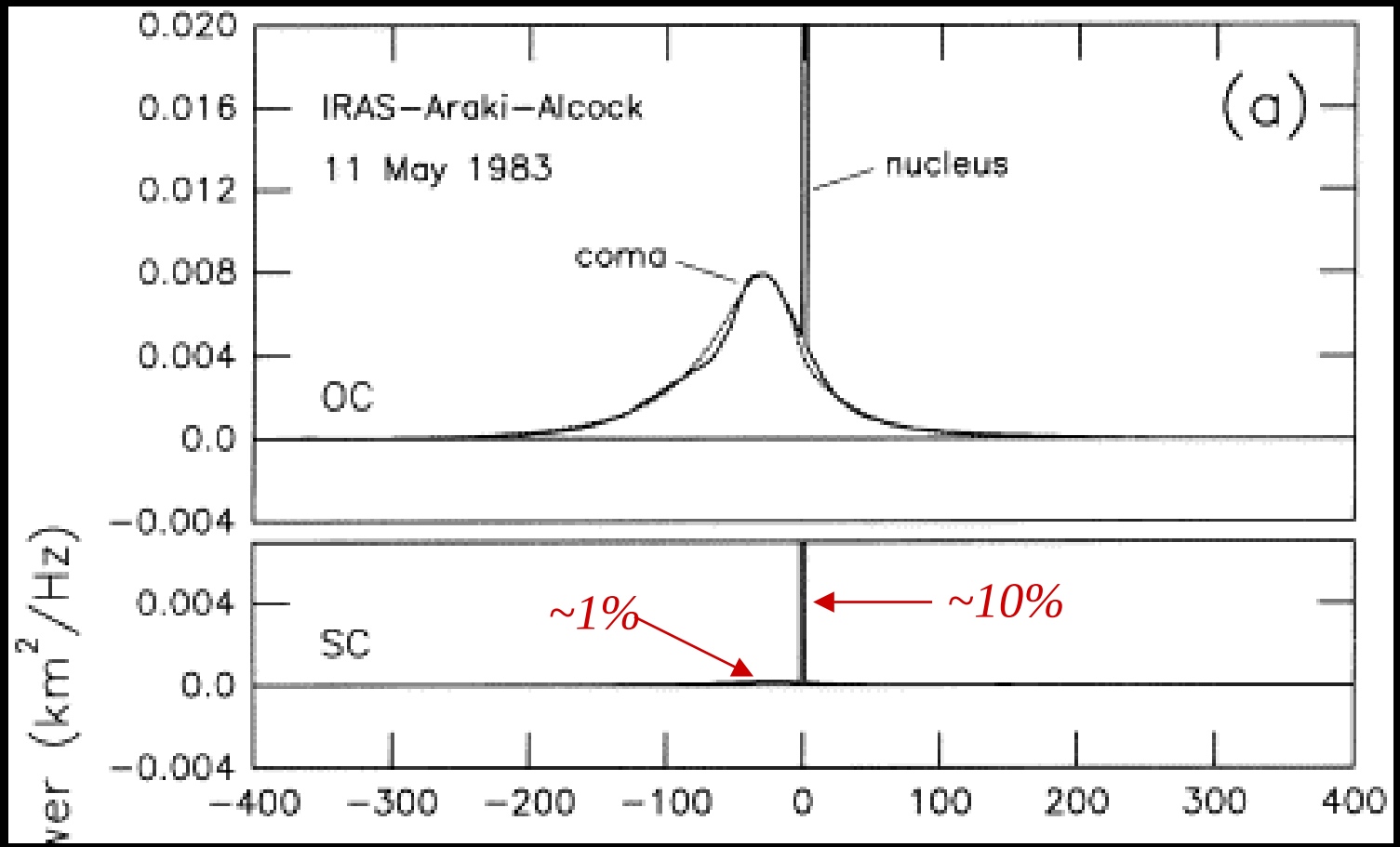
- Images constrain size and rotation
  - Diameter >~ 1 km
  - Rotation period > 10 h



May 11 May 12 May 15 May 17

- Diameter ~400m
- Looks unlike any other object we have seen

May 15 May 17


0.020
0.016
0.012
0.008
0.004
0.0
−0.004
IRAS−Araki−Alcock
11 May 1983
(a)
nucleus
coma
OC
SC
~1%
~10%
0.004
0.0
−0.004
−400
−300
−200
−100
0
100
200
300
400
ver (km²/Hz)

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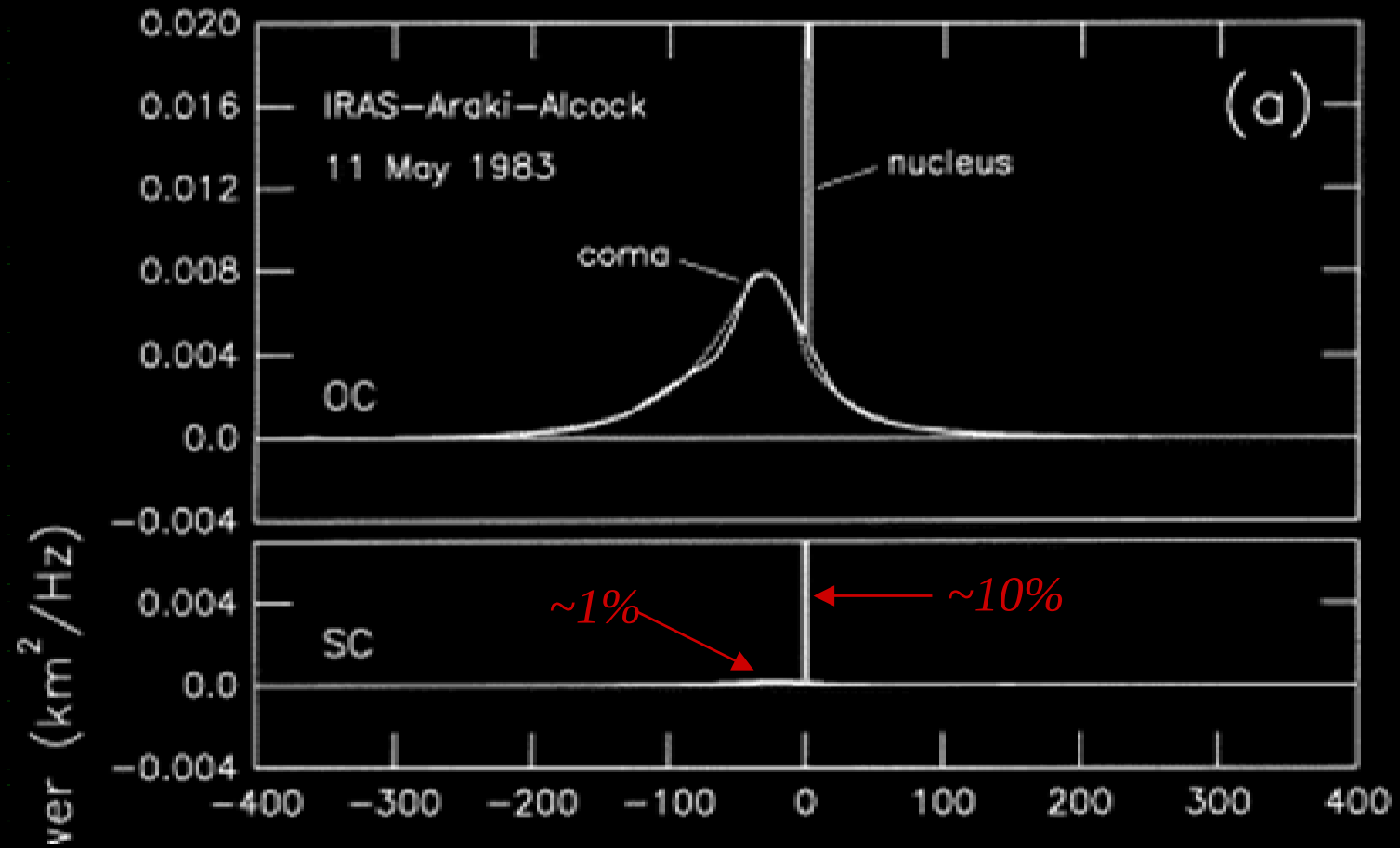
IRAS–Araki–Alcock
11 May 1983
(a)
nucleus
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~1%
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0.020
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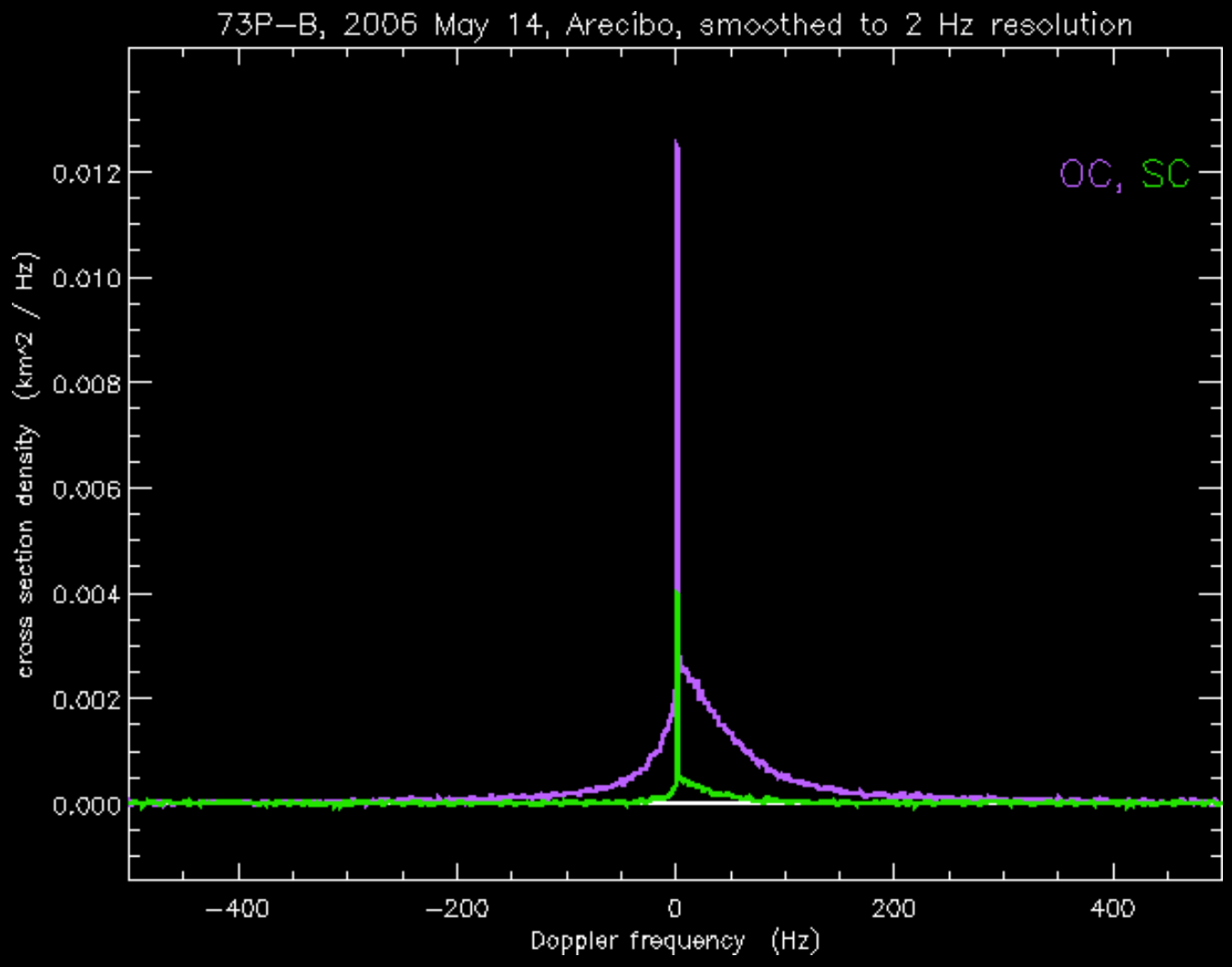
0.012
0.008
0.004
0.0
−0.004
0.004
0.0
−0.004
−400
−300
−200
−100
0
100
200
300
400
yer (km²/Hz)

CD 2007


73P–B, 2006 May 14, Arecibo, smoothed to 2 Hz resolution
OC, SC
cross section density (km^2 / Hz)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
–400
–200
0
200
400
Doppler frequency (Hz)

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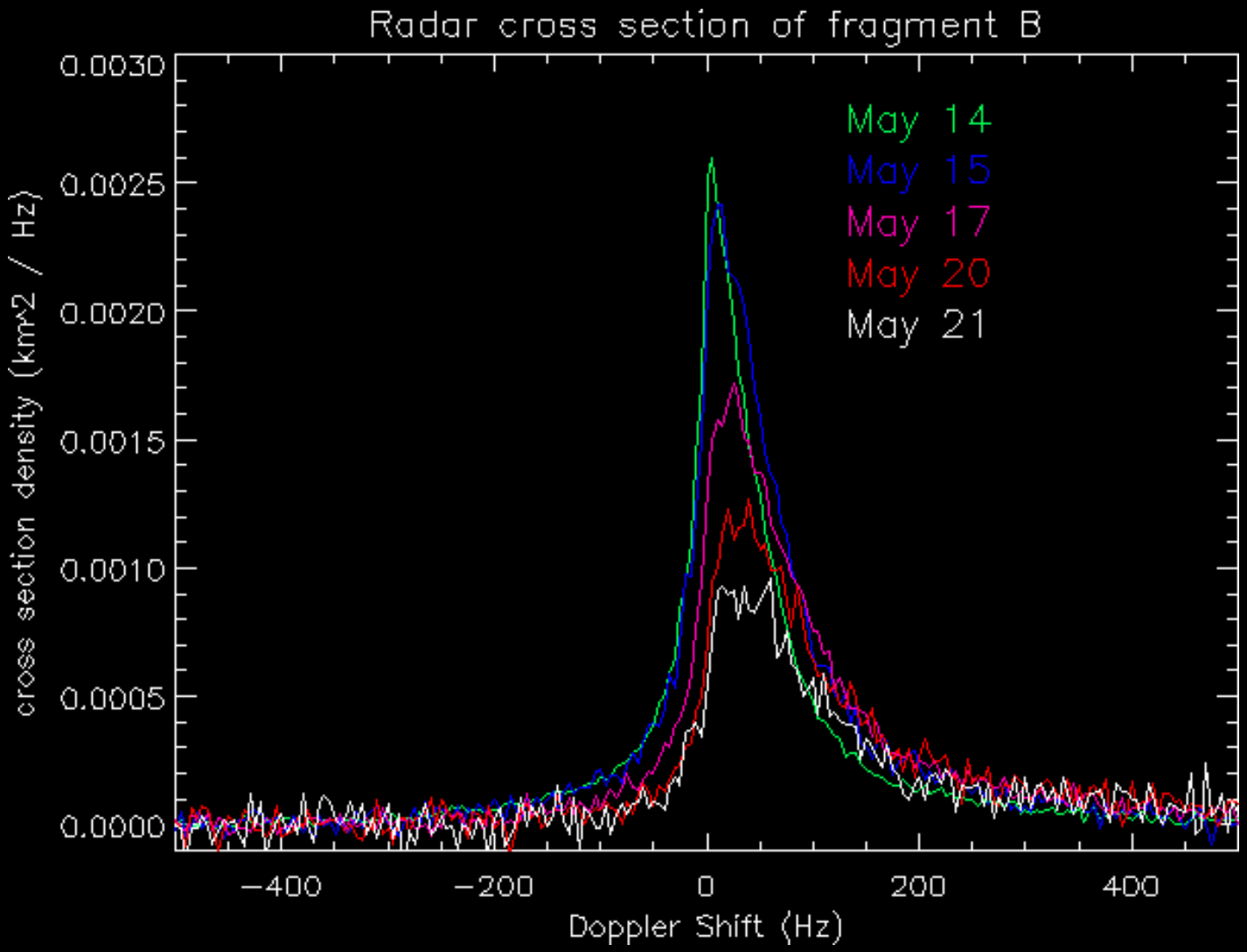
- To have a measurable SC echo, the particle size must be at least $\lambda/2\pi$
  - 2 cm in size at Arecibo
  - 0.5 cm at Goldstone
- With 73P/SW3, we can measure this proxy for particle size as a function of velocity and wavelength.
- 73P/SW3 had a number of breakup events, possibly releasing large “dust grains”



Away from observer Toward observer

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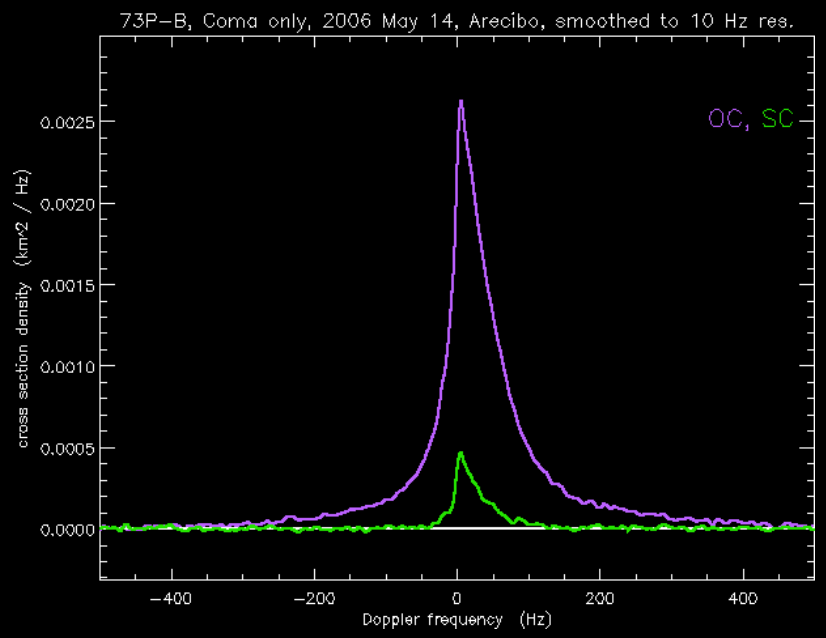
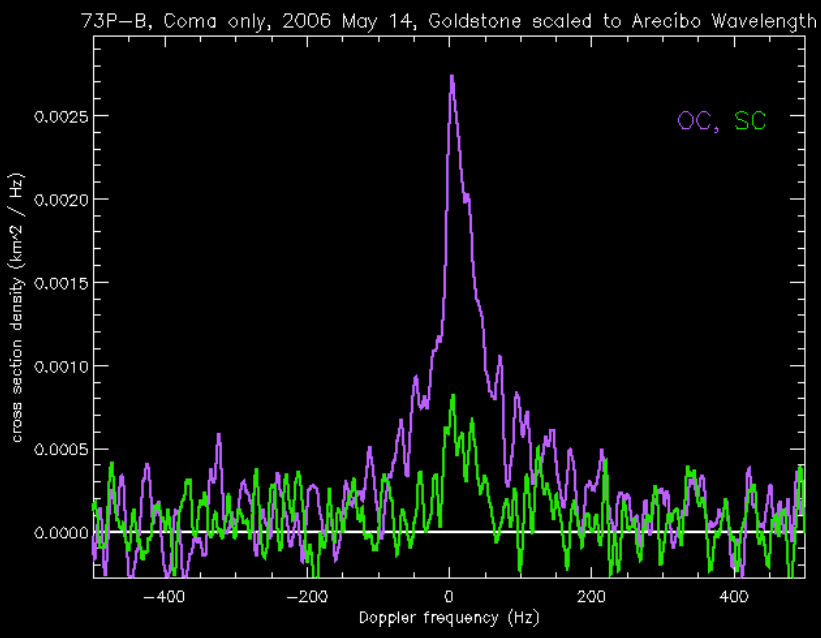


Arecibo 12.6cm
31 min



Goldstone 3.5cm
95 min

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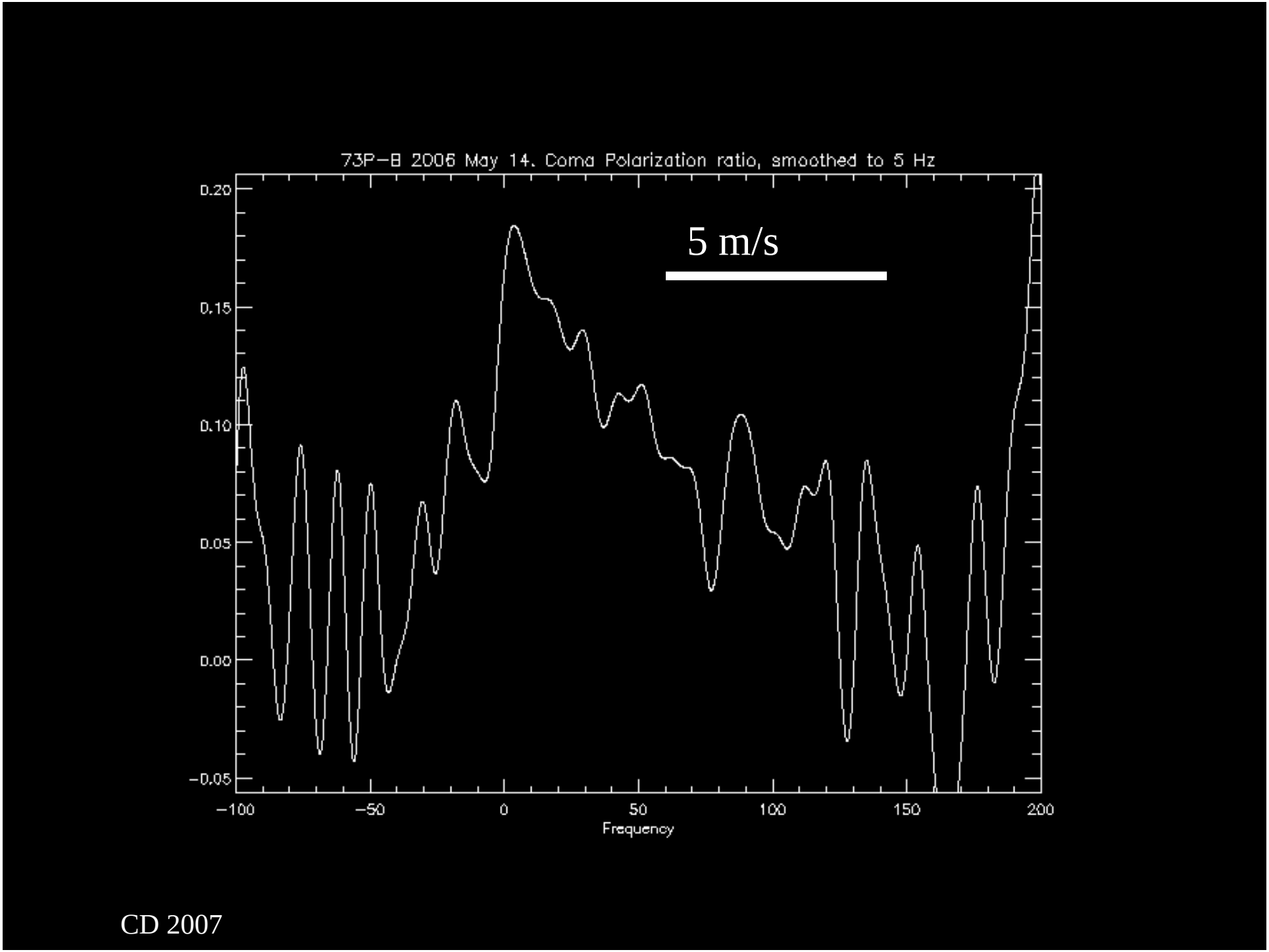
73P-B 2006 May 14. Coma Polarization ratio, smoothed to 5 Hz
5 m/s
0.20
0.15
0.10
0.05
0.00
-0.05
-100
-50
0
50
100
150
200
Frequency

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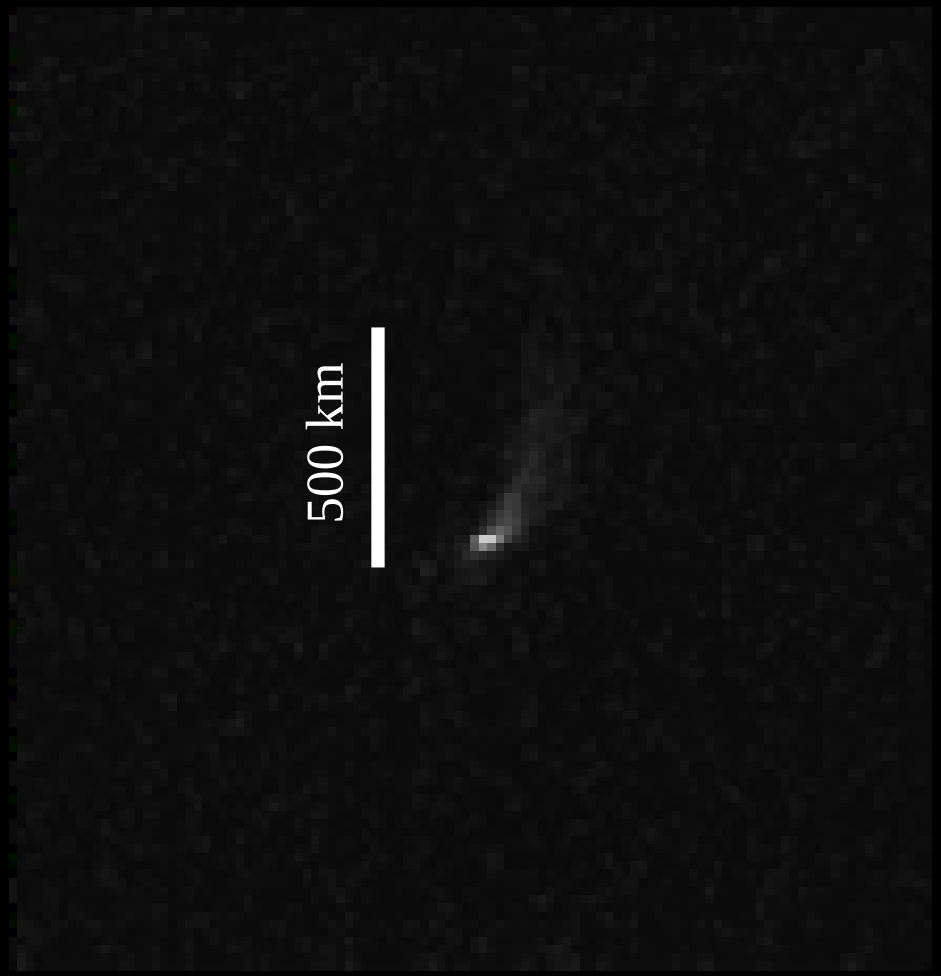

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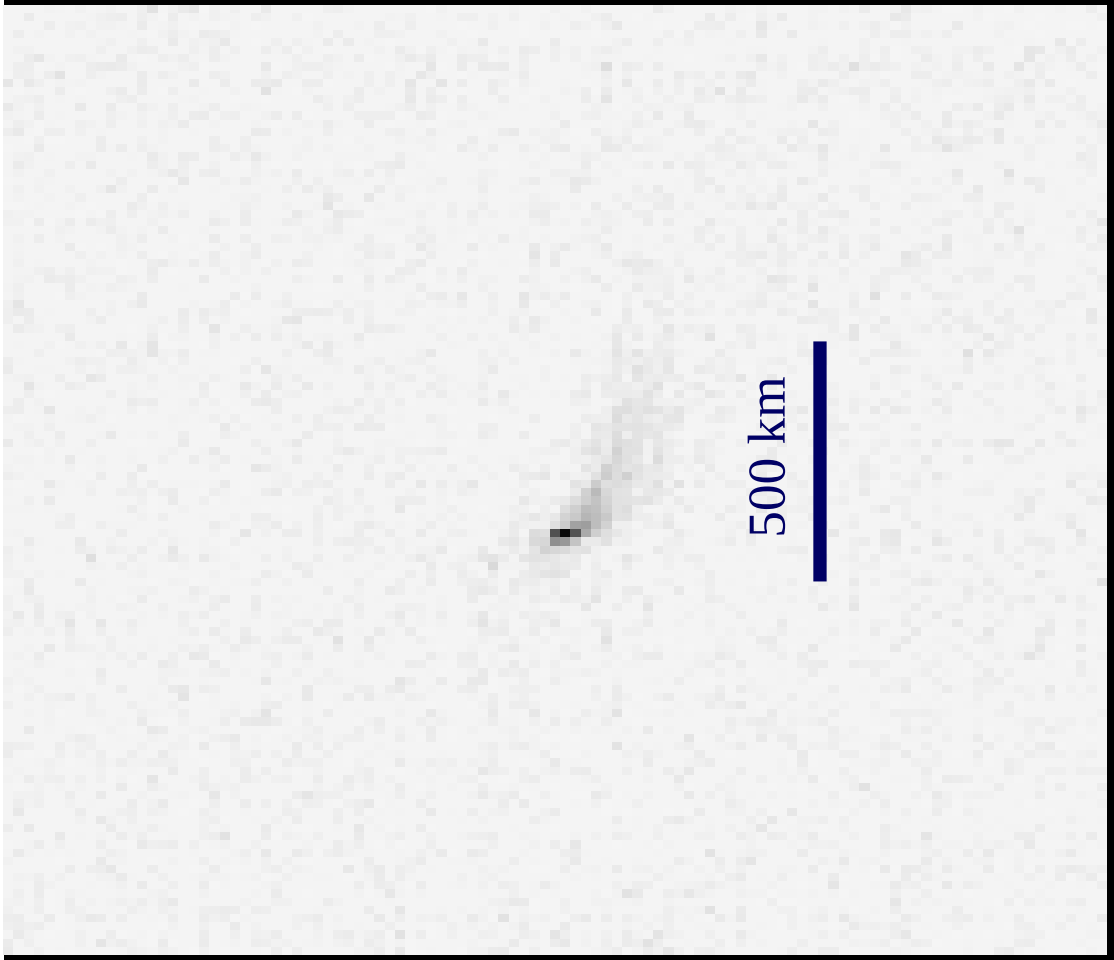
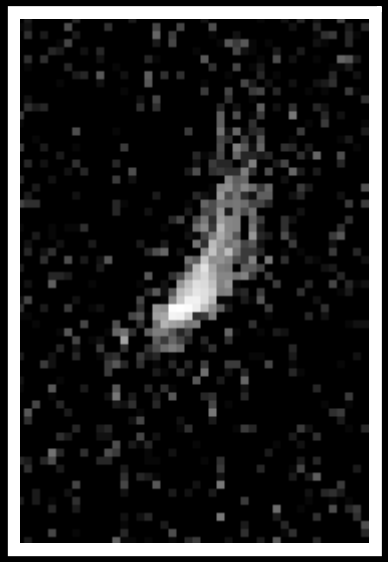
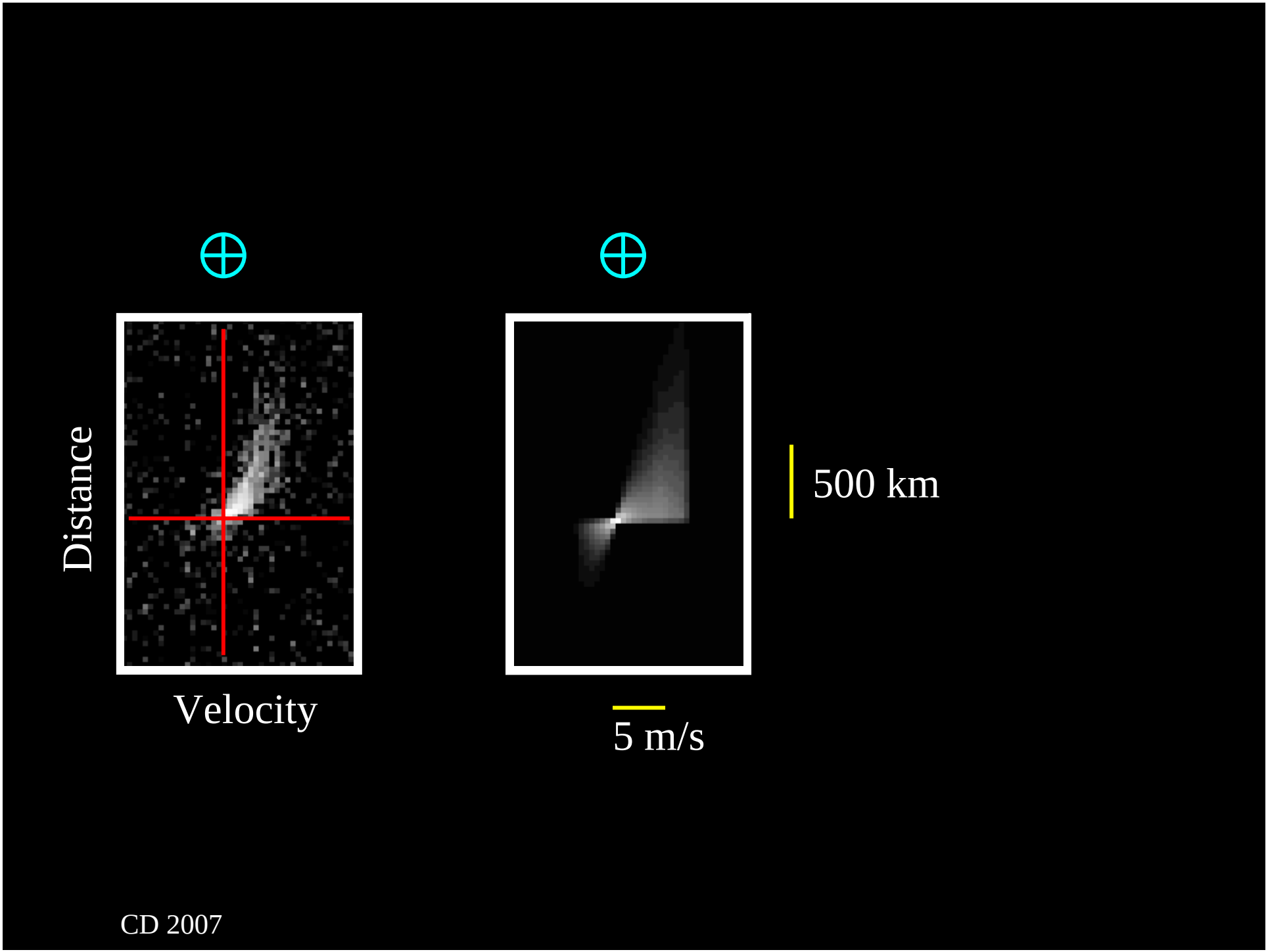
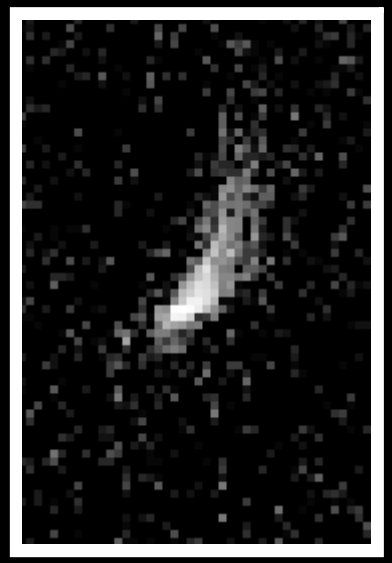


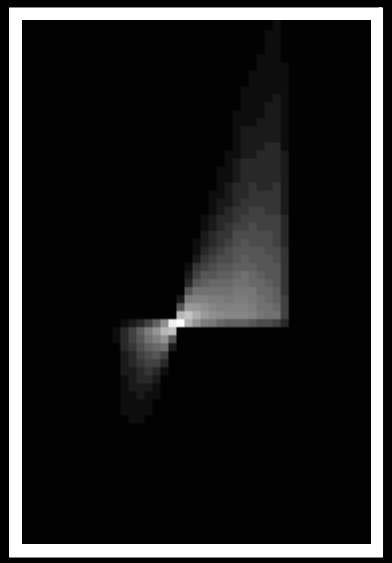
CD 2007



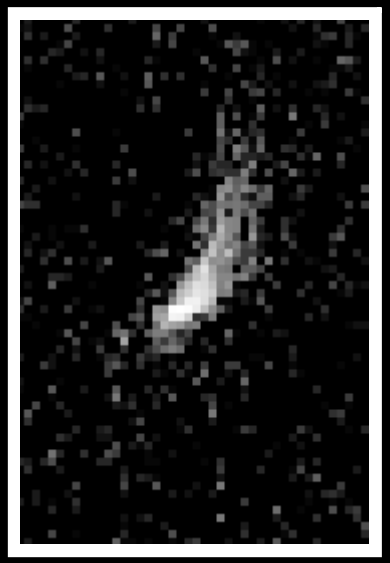
CD 2007

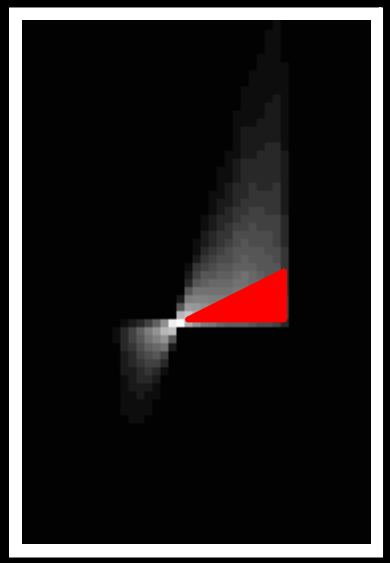

Distance
Velocity
500 km
5 m/s
CD 2007



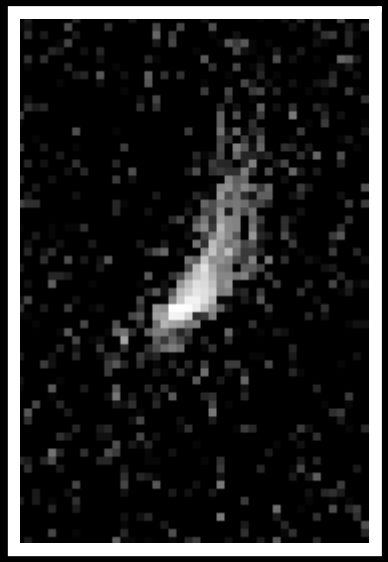


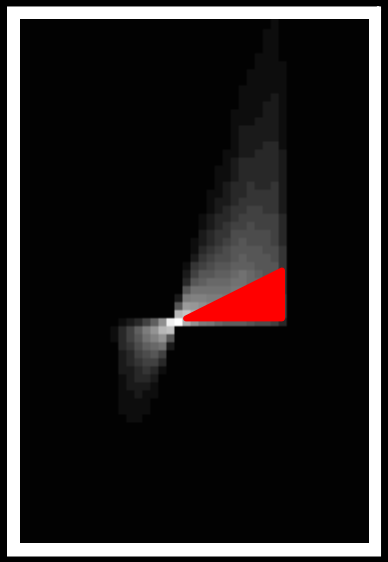
CD 2007



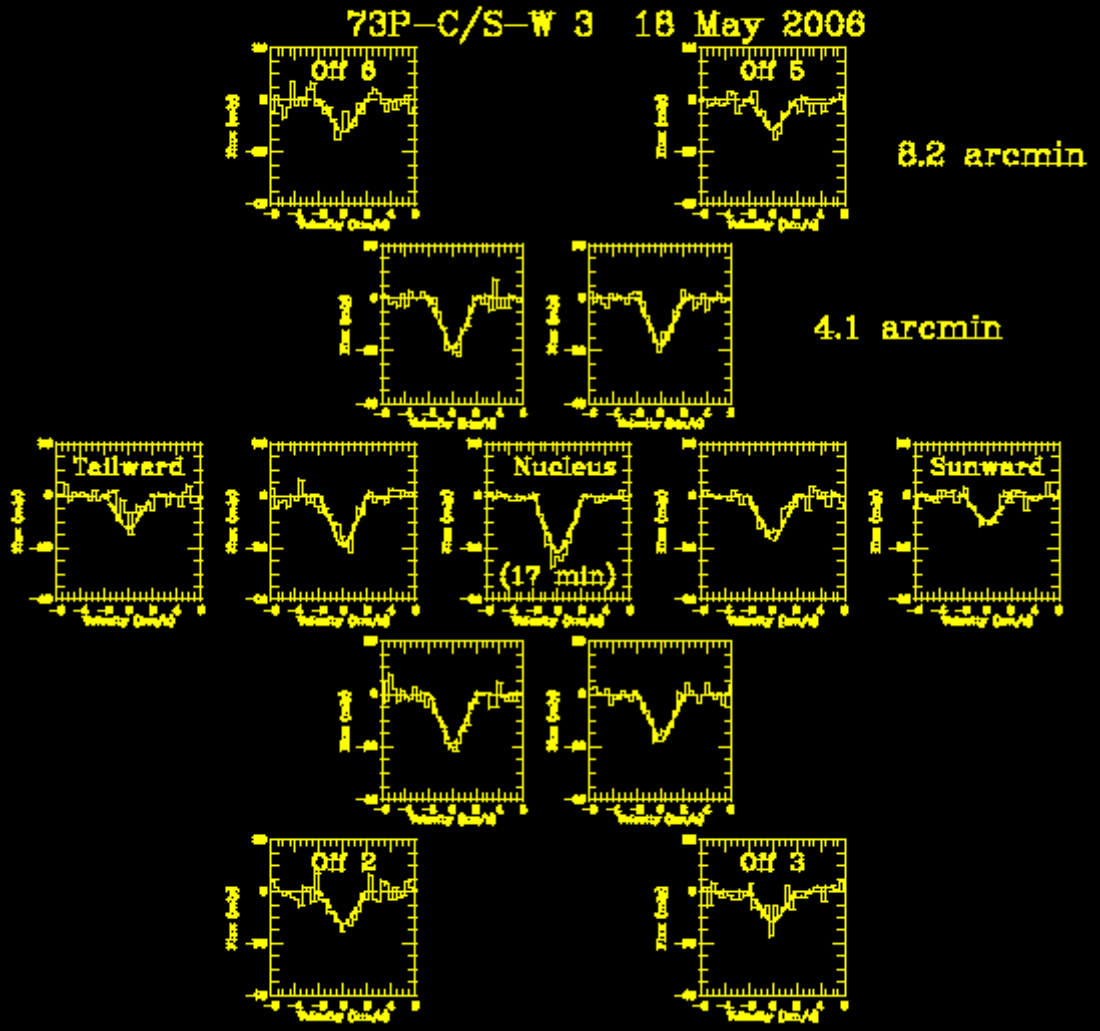


- Missing coma particles at all velocities near the nucleus.
- Recently ejected dust is missing (about six hours worth)





1. An outburst just finished
2. Large chunks disintegrate, increasing cross-section
3. Chunks are accelerating
   - Gas drag
   - Rocket force


73P-C/S-W 3 18 May 2006
Off 6
Off 5
8.2 arcmin
4.1 arcmin
Tailward
Nucleus
(17 min)
Sunward
Off 2
Off 3

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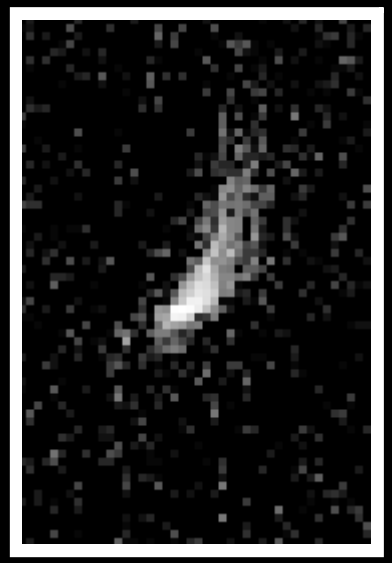
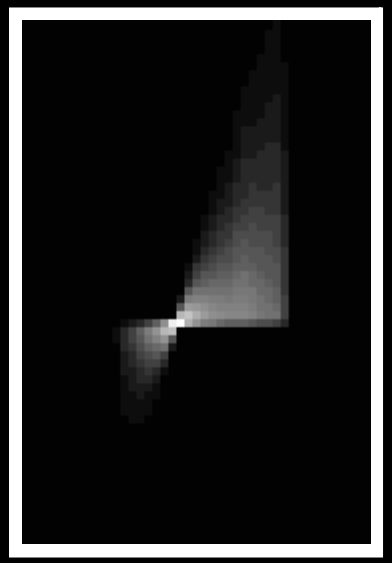
- Coma of fragment B changed more than coma of fragment C over the ~week observed
- Material leaves in big chunks at low velocity and later breaks further into cm-sized bits (at least 6 hours later)
- Does image of fragment B indicate large chunks in temporary orbit? Maybe, but why not in front, only behind?
- Observations of 8P/Tuttle in Jan 2008, but probably no more coma images for a few years (unless a LP comet comes within <0.10 AU)

- Funding from NSF for astronomy is uncertain (75% astronomy, 5% planetary radar, 20% aeronomy)
- NASA and NSF are talking about how to continue the planetary radar program beyond 1 Oct 2007.
- We are painting the telescope and planning for 20+ years of operation
- Community pressure has been helpful and effective (keep up the good work!)





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