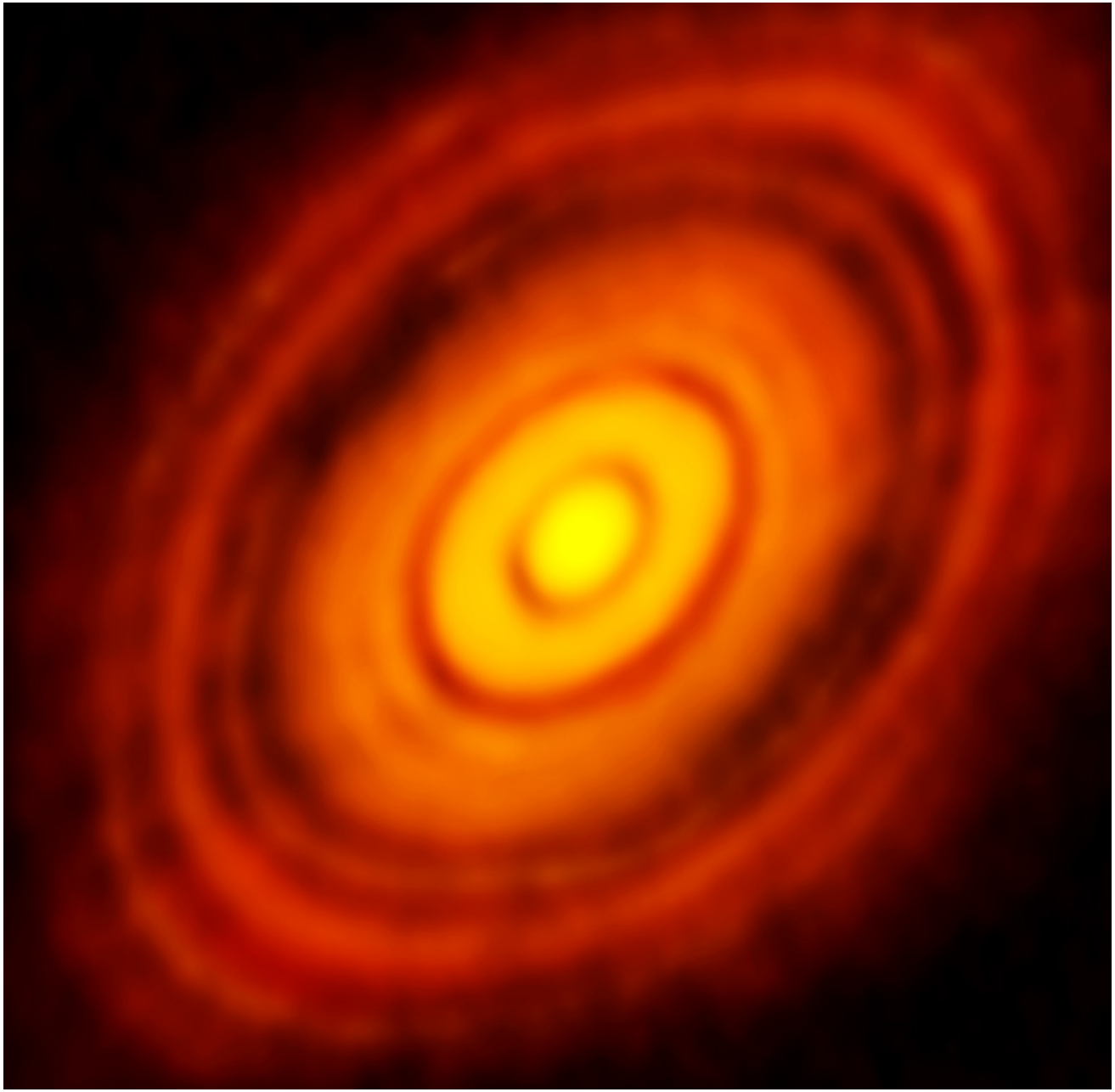
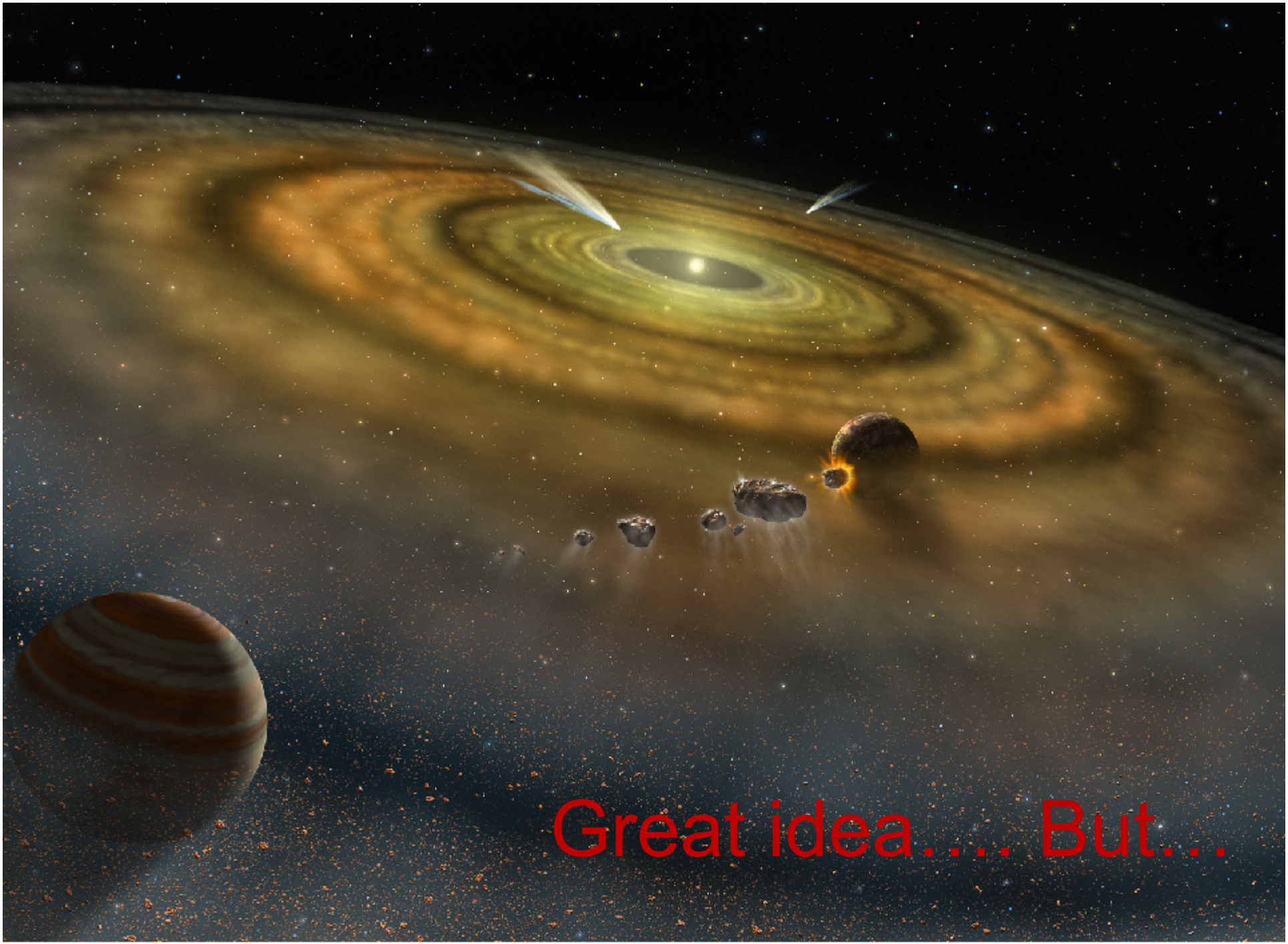
Passive Single-Dish Observations of Small Bodies

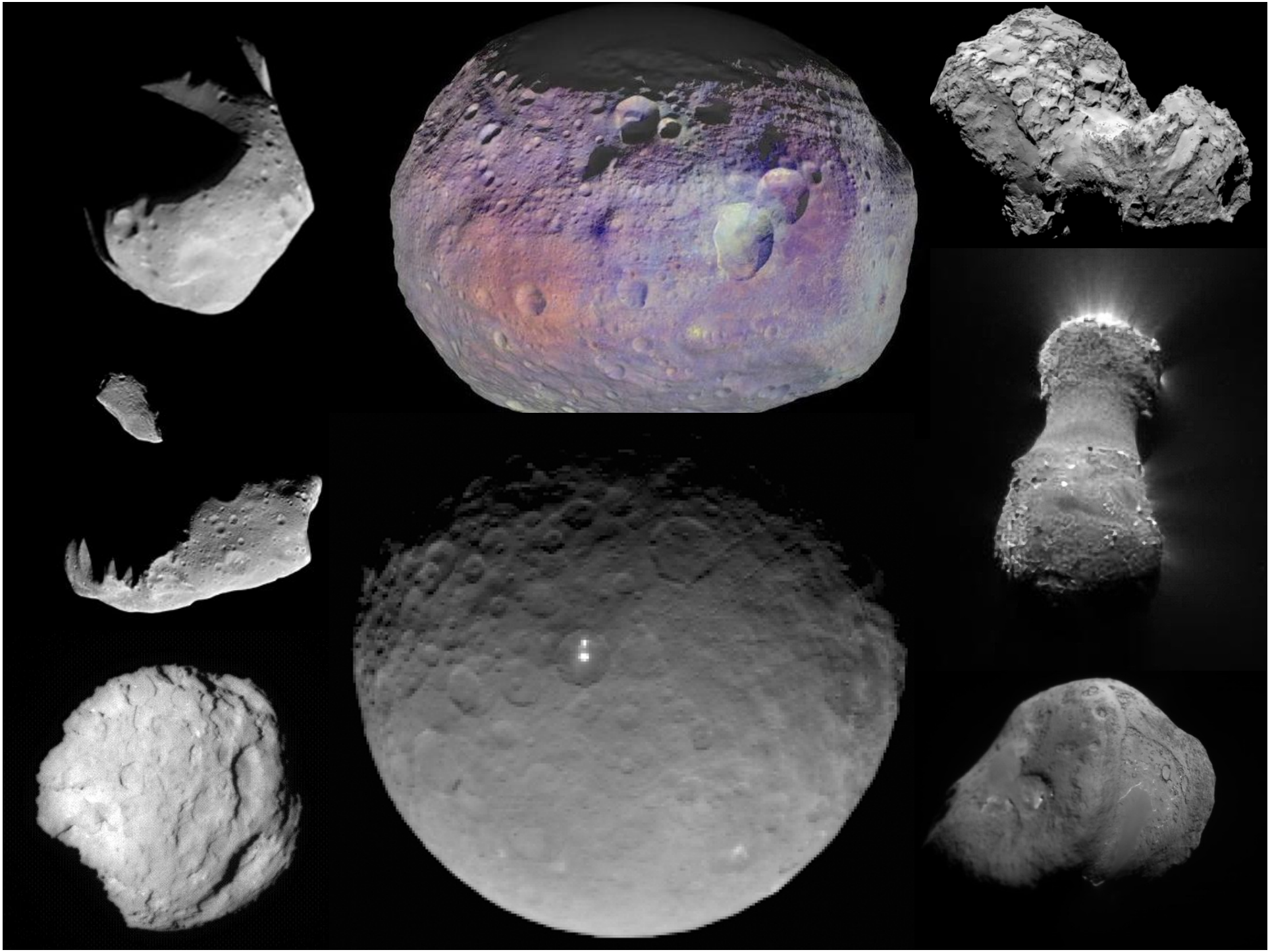
Amy Lovell, Agnes Scott College

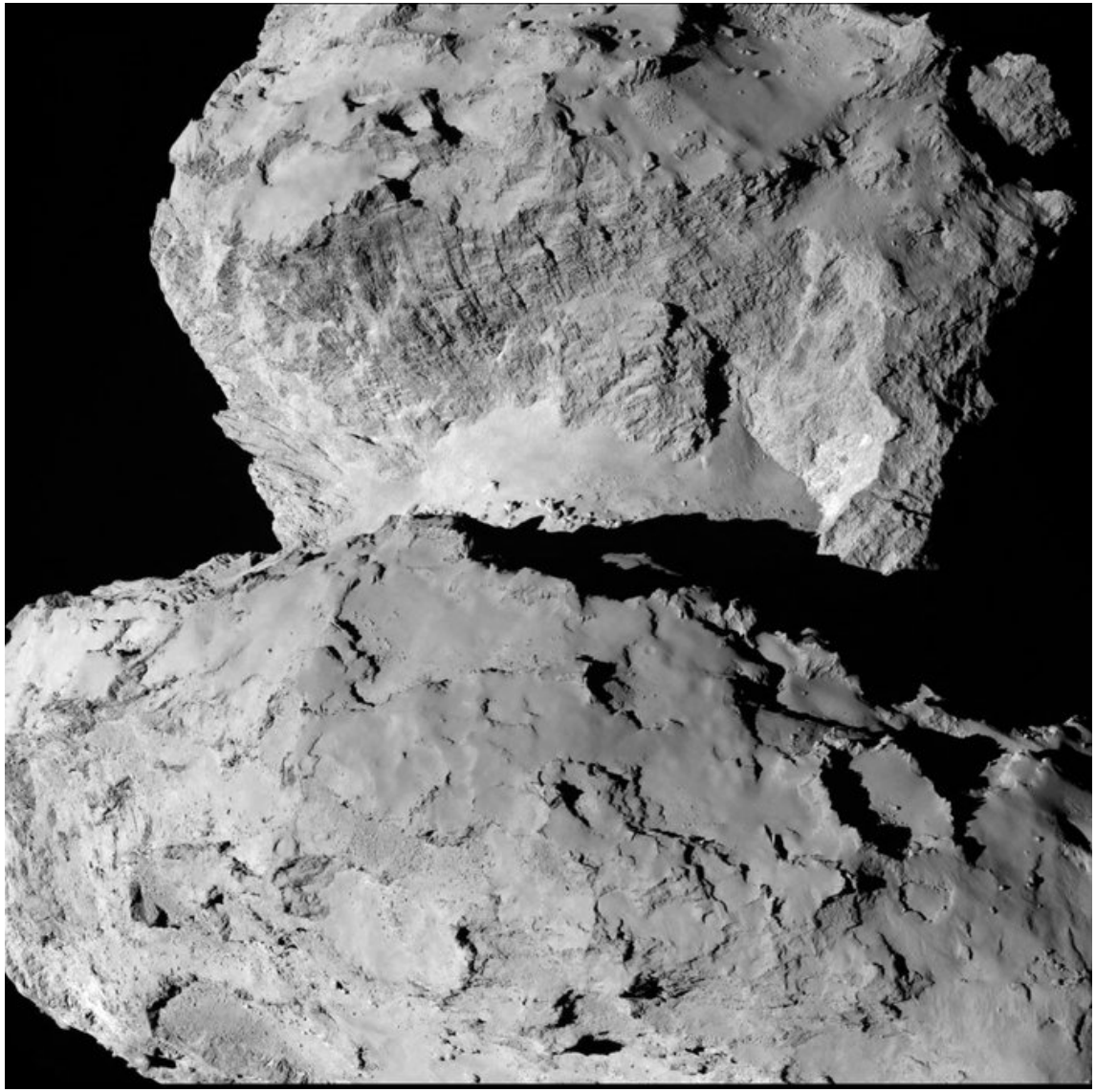


Why small bodies??

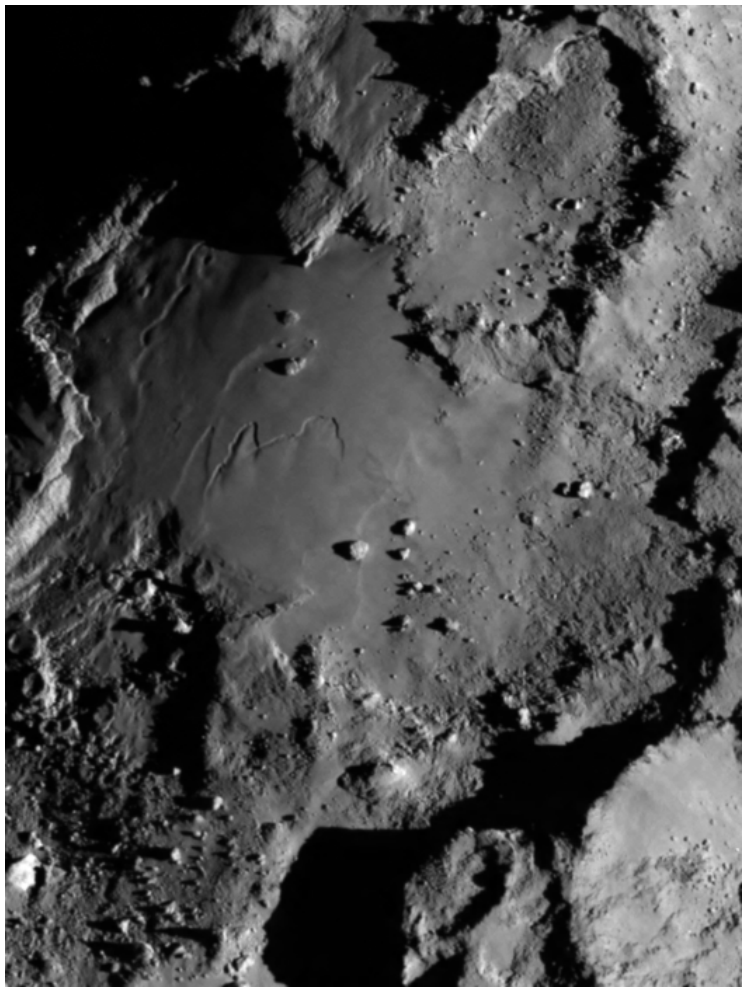
- Thermal history
- Collisions
- Mixing


Great idea…. But…

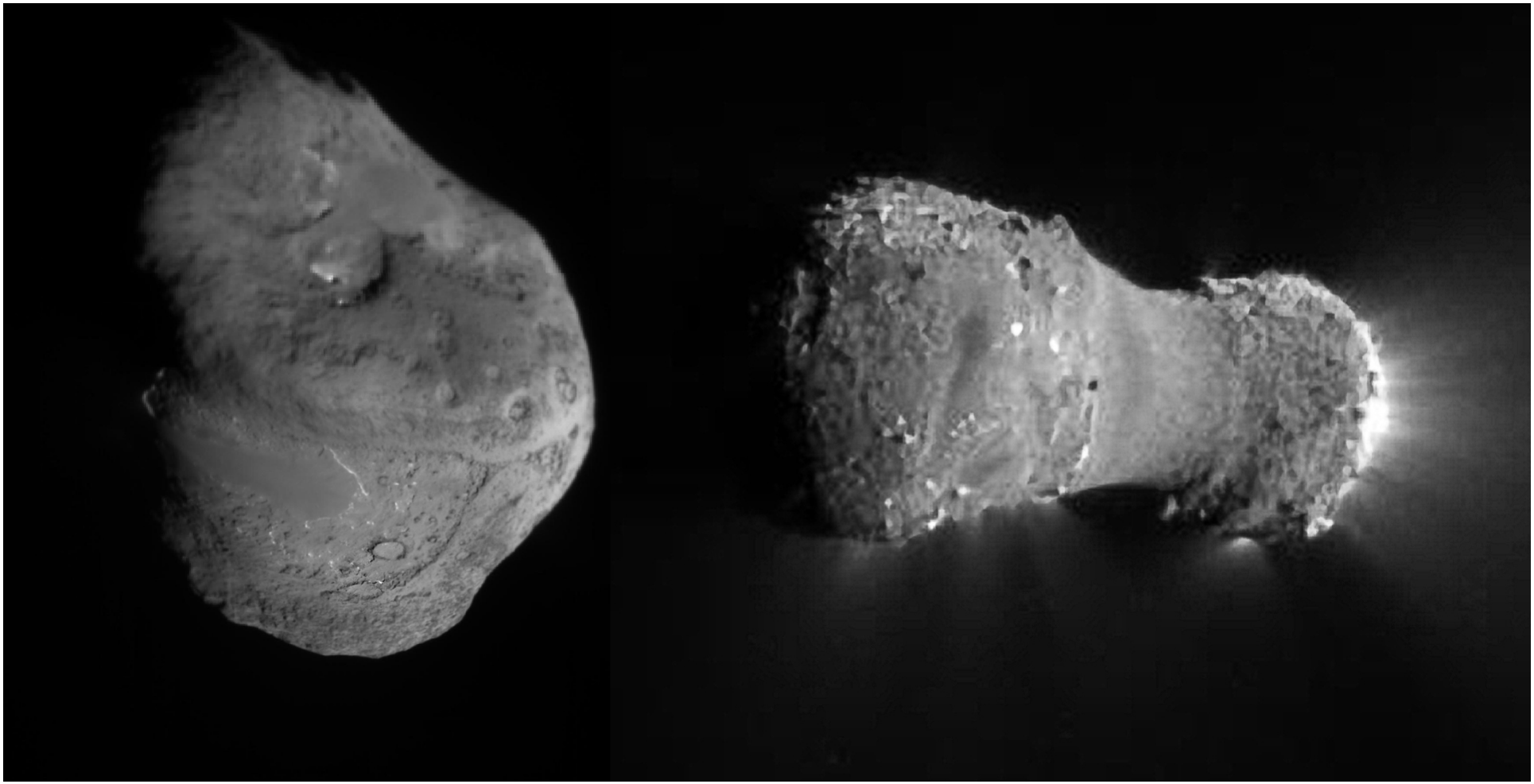


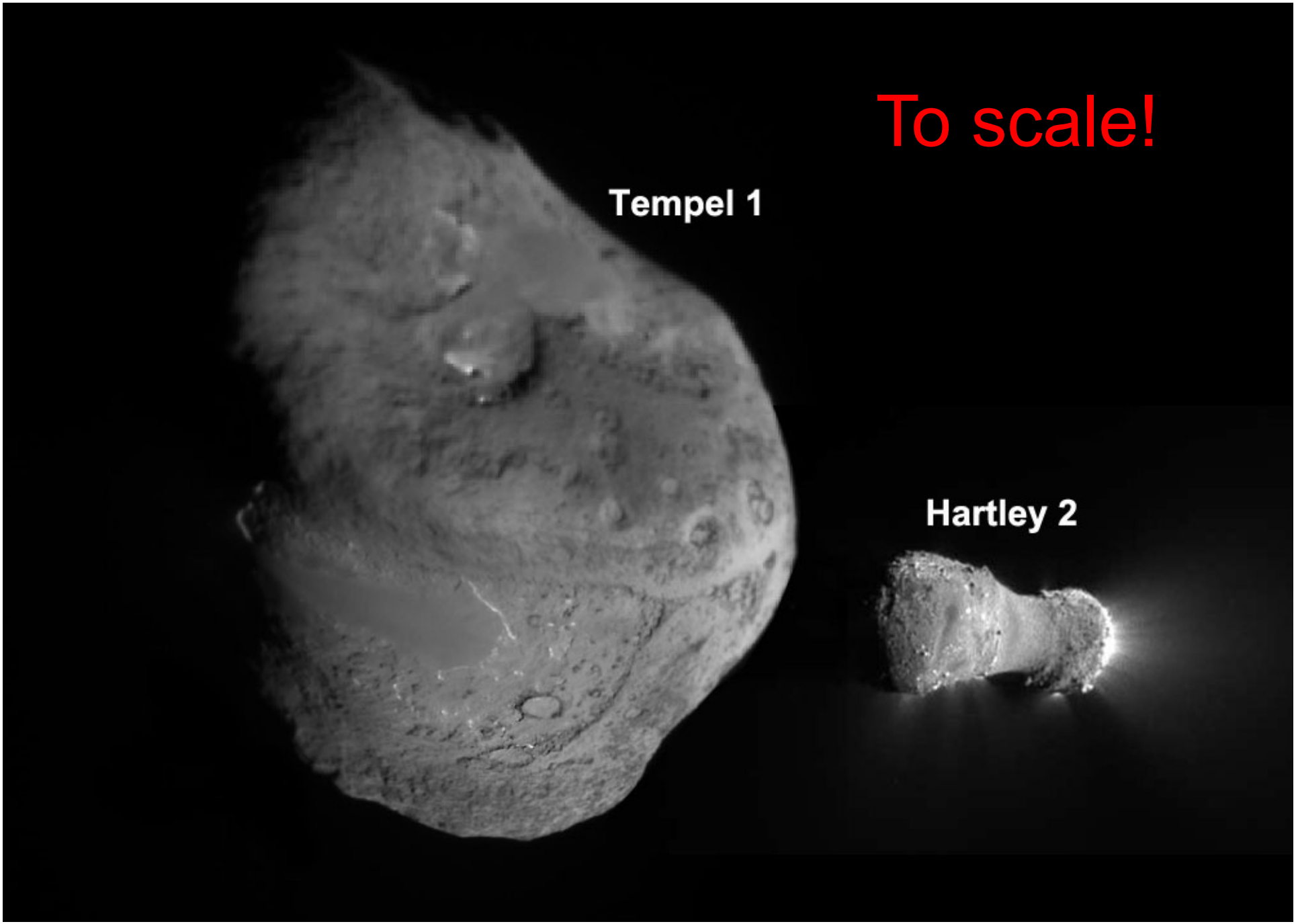


67P/ Churyumov-Gerasimenko



Deep Impact/EPOXI



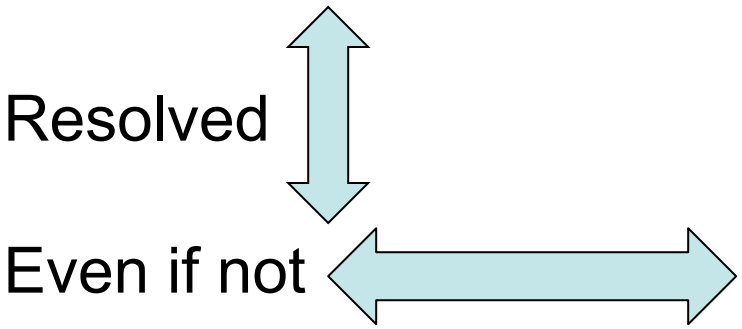

To scale!
Tempel 1
Hartley 2

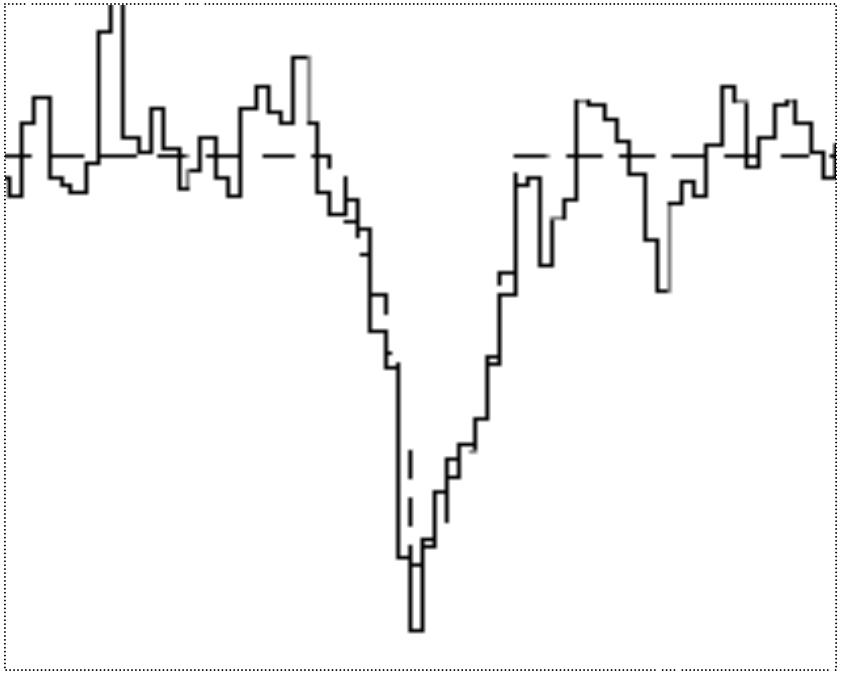
Why Radio?

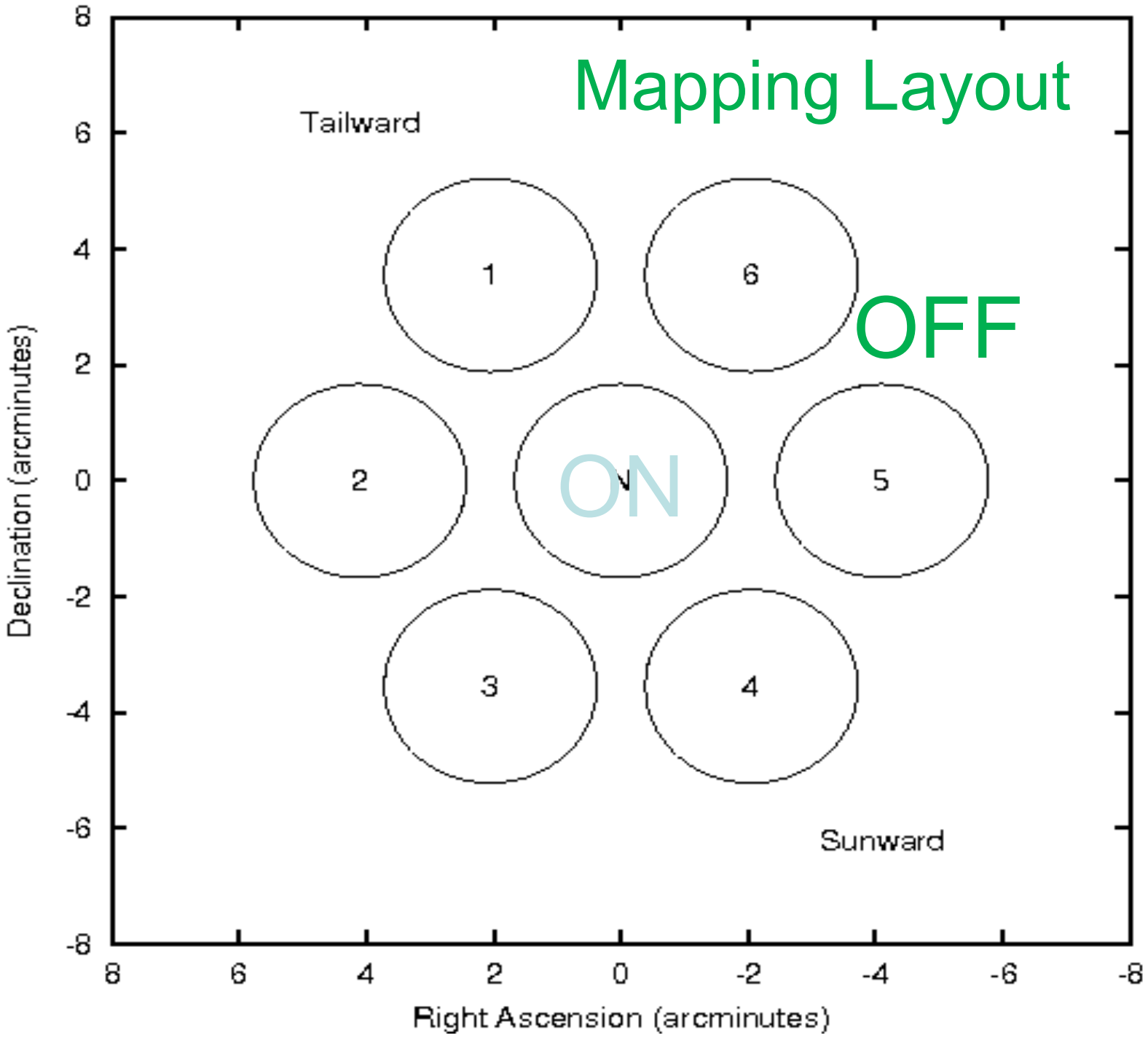
Long molecule life = large coma

"Parent" molecules from volatiles

High spectral/velocity resolution



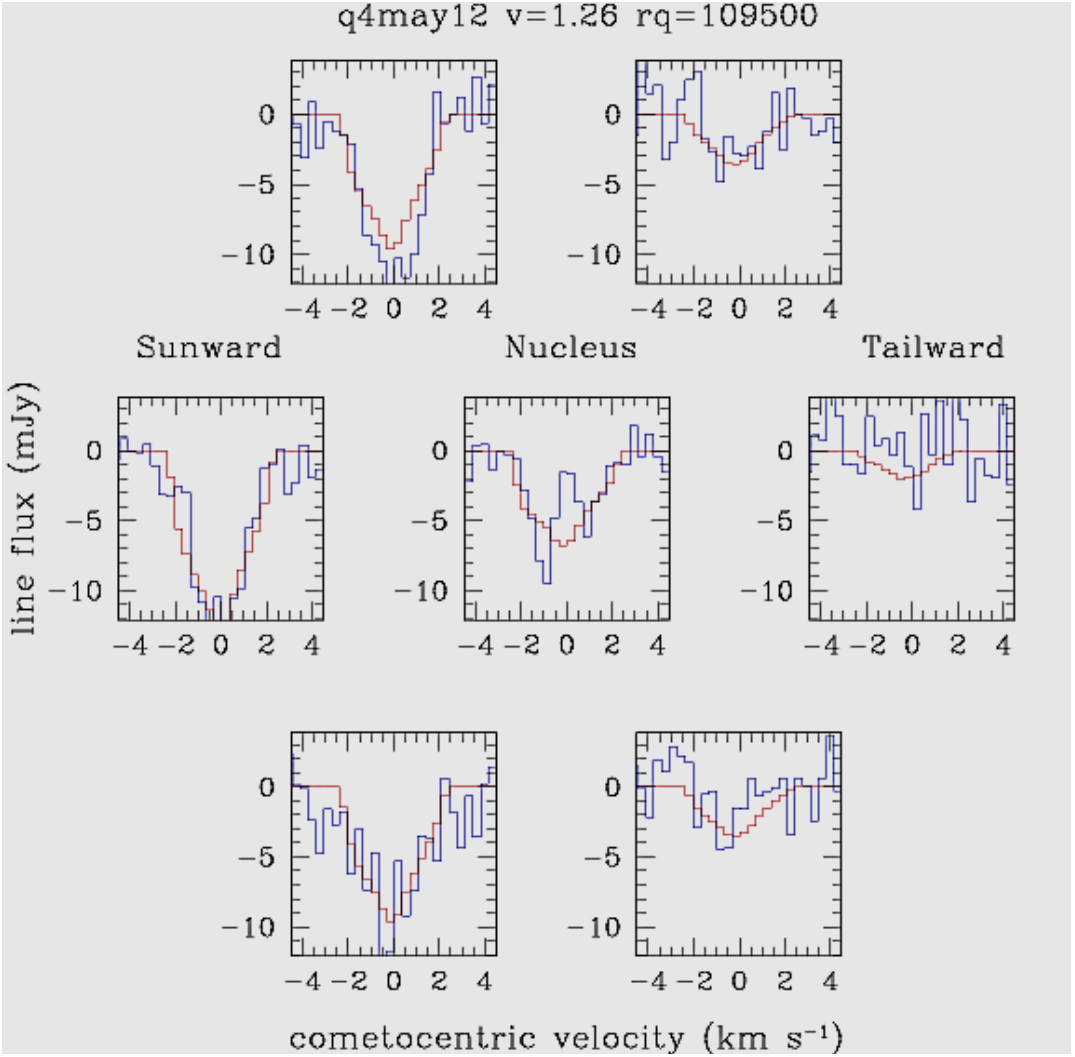



Mapping Layout
Tailward
1
6
OFF
2
ON
5
3
4
Sunward
Declination (arcminutes)
Right Ascension (arcminutes)
8
6
4
2
0
-2
-4
-6
-8

Observational Goals

Radio spectra (and maps) can constrain:

- Production rates
- Outflow velocities
- Asymmetries
- Coma density

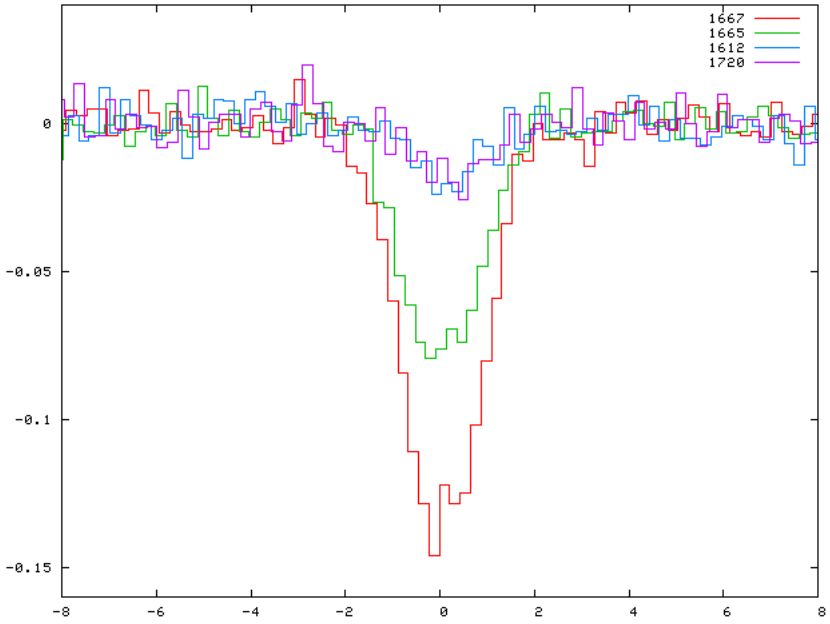


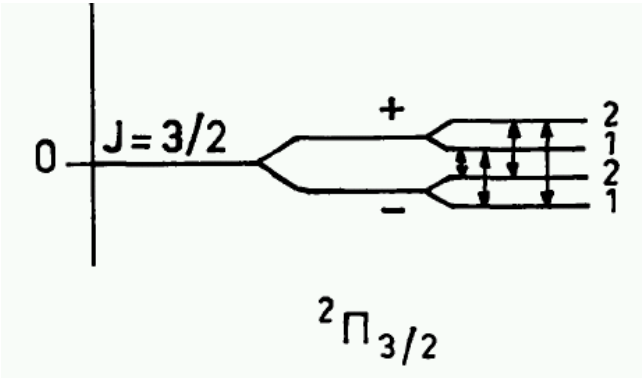
OH Radio Bands

OH 18cm Λ-doublet

1667, 1665 MHz primary

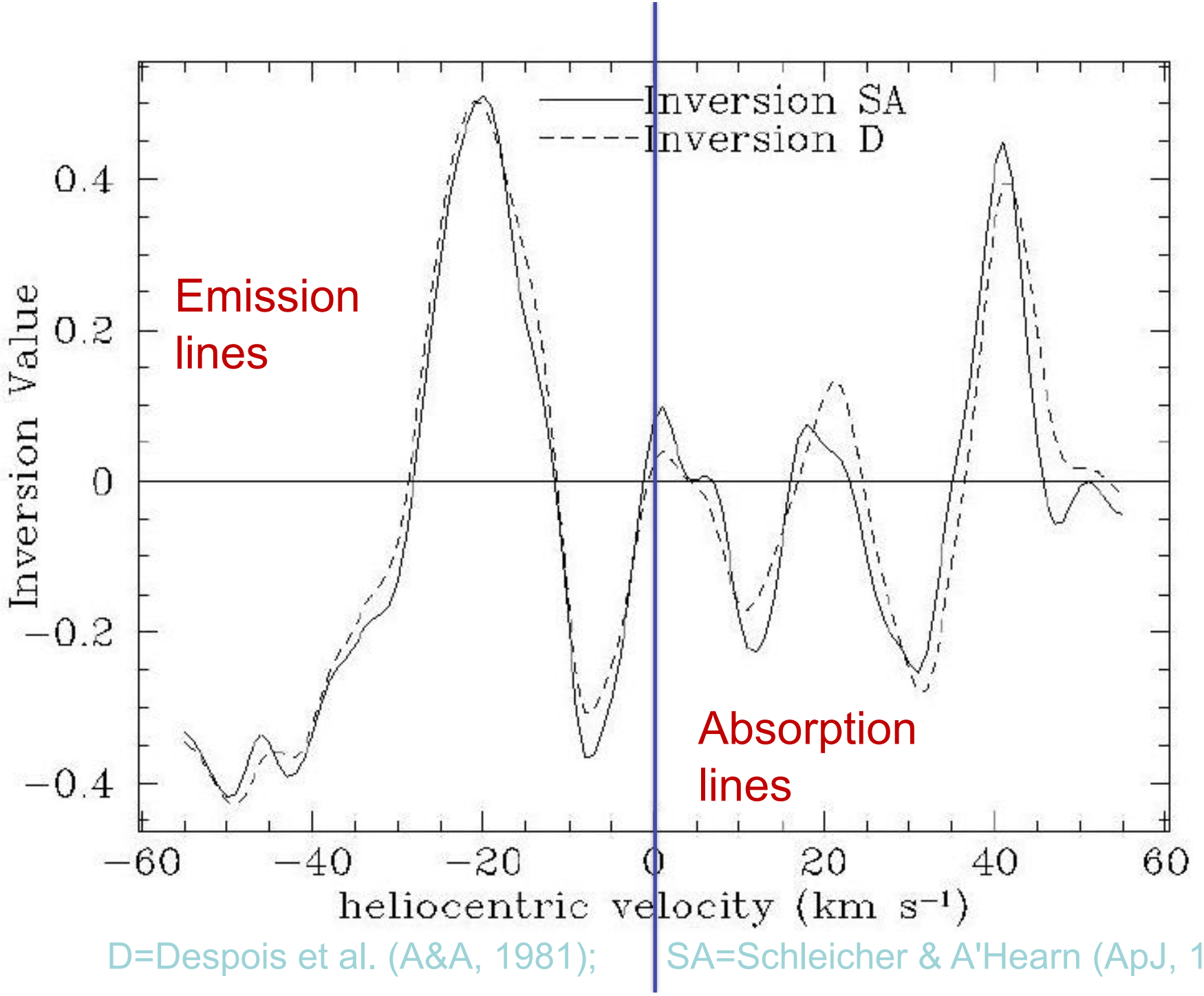
1612, 1720 weaker



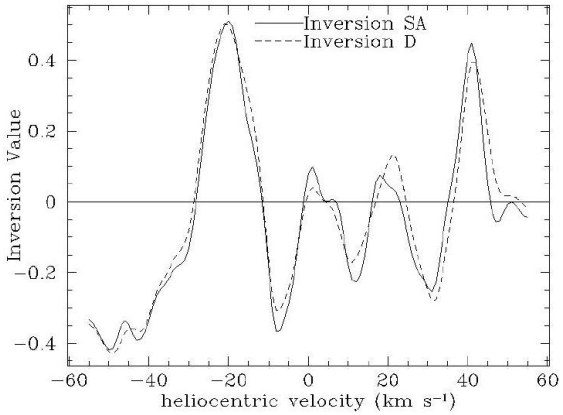


Pumped by solar UV

amplifies or absorbs background



D=Despois et al. (A&A, 1981); SA=Schleicher & A'Hearn (ApJ, 1988)



$$H_2O \rightarrow OH + H$$

Extent depends on lifetime, outflow

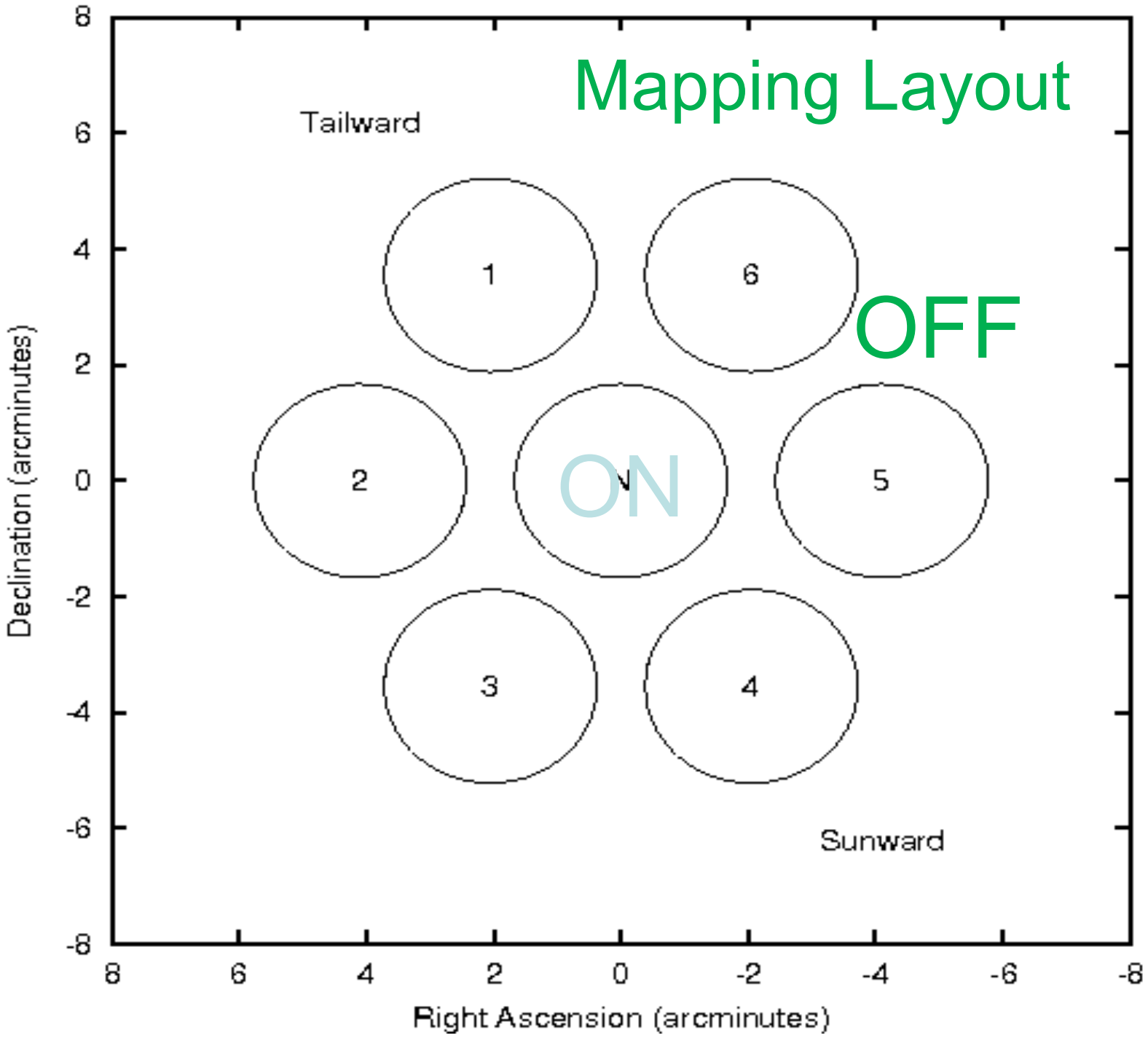
UV

Blueshift to sun

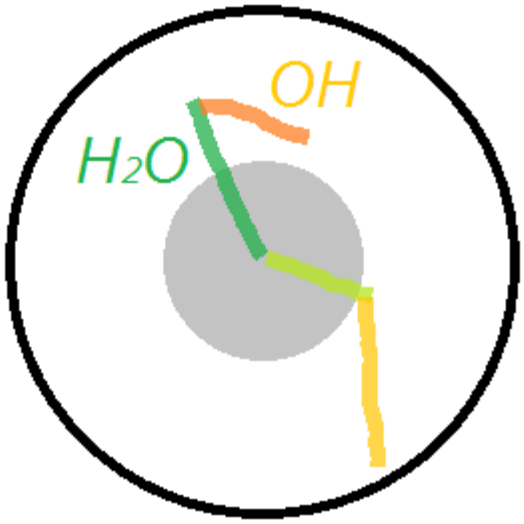
Redshift to sun

Dense inner coma (thermal/collisional) maser quenched

UV


Mapping Layout
Tailward
1
6
OFF
2
ON
5
3
4
Sunward
Declination (arcminutes)
Right Ascension (arcminutes)
8
6
4
2
0
-2
-4
-6
-8

H2O dissociates (statistically) into OH & H
OH flies in a random direction, +1.05 km/s
Binned into a spectrum



Free parameters: outflow velocity, quenching r_Q

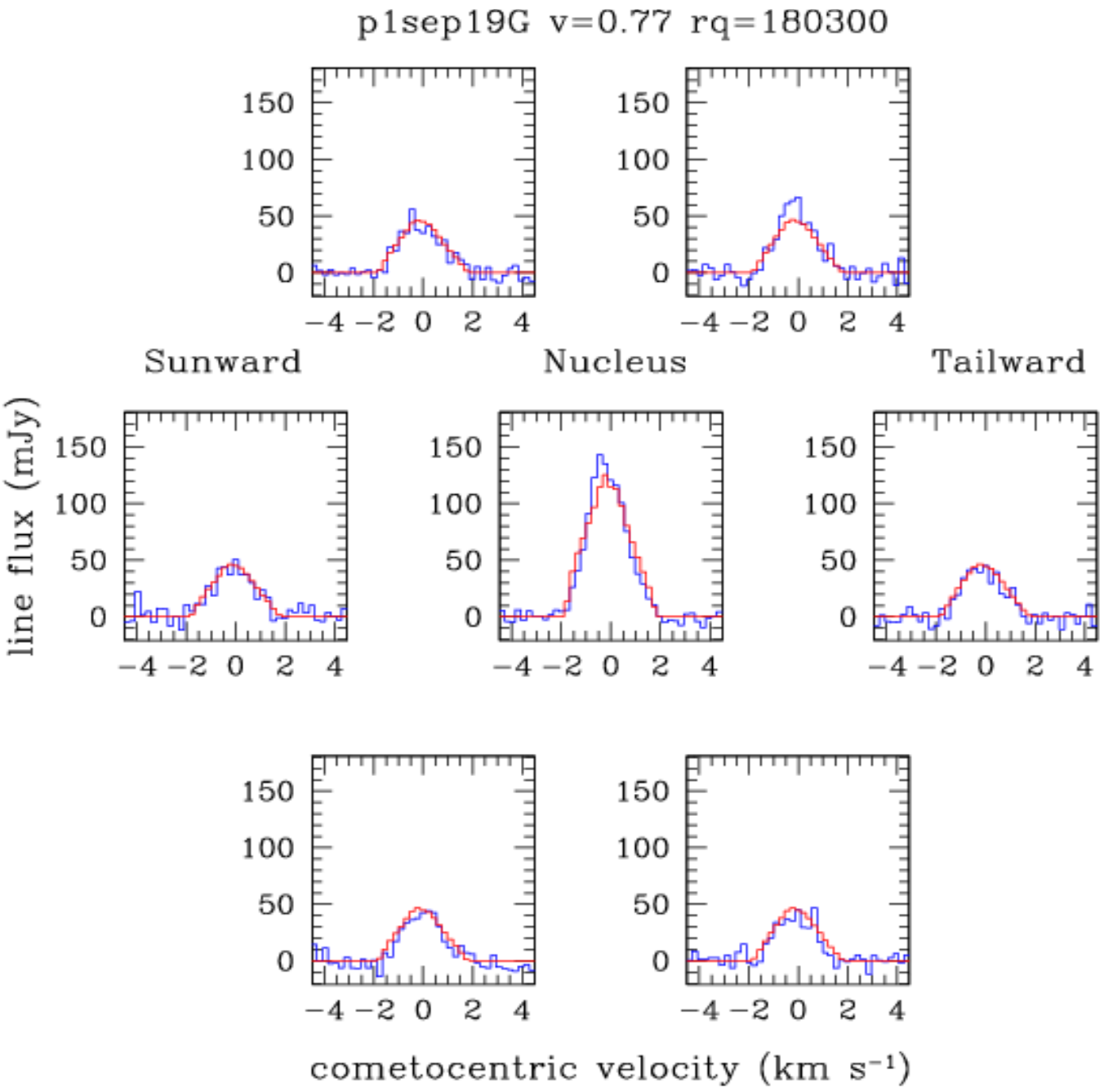
Day/Night independent

Lifetime: 82000s (H_2O ~1 day) 150,000s (OH 1.7d)

19 Sep GBT

r_H = 2 AU 8’

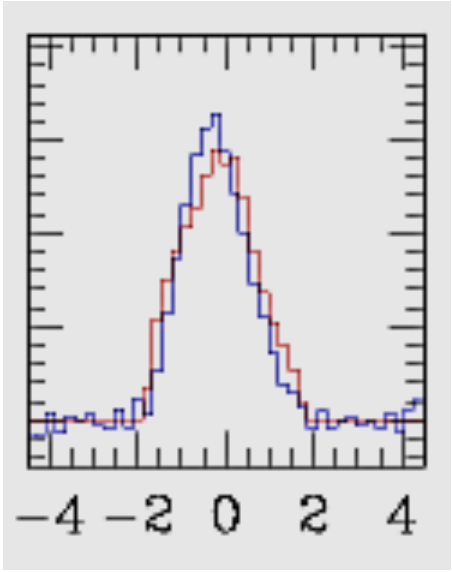
516,000km



Outflow Velocity & Gas Production

Production rate Q

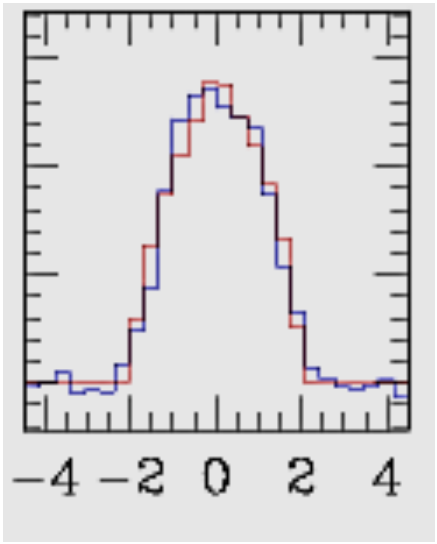
– # molecules/second from observed column density



Velocities (widths) 0.5–2.5 km/s

Low velocity for low-Q or distant

$Q<10^{29}$ mol s^{-1} r >1.0 km s^{-1}



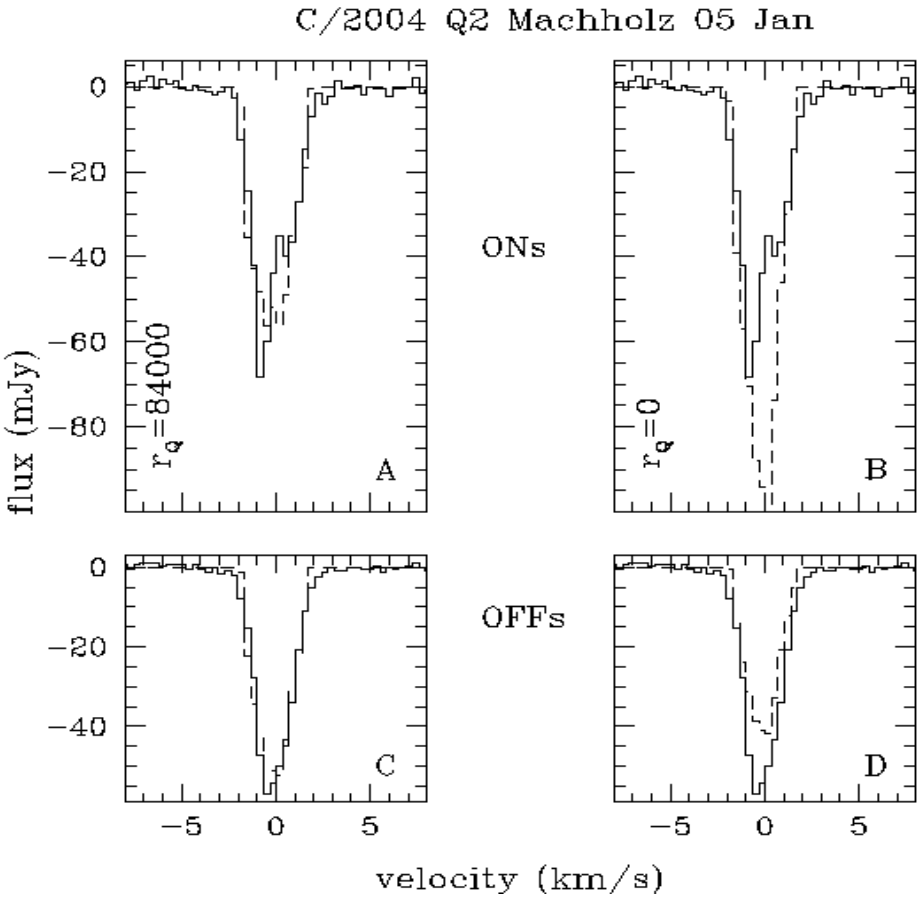
Large variations near sun, large Q

Collisional Quenching ⇨ Density

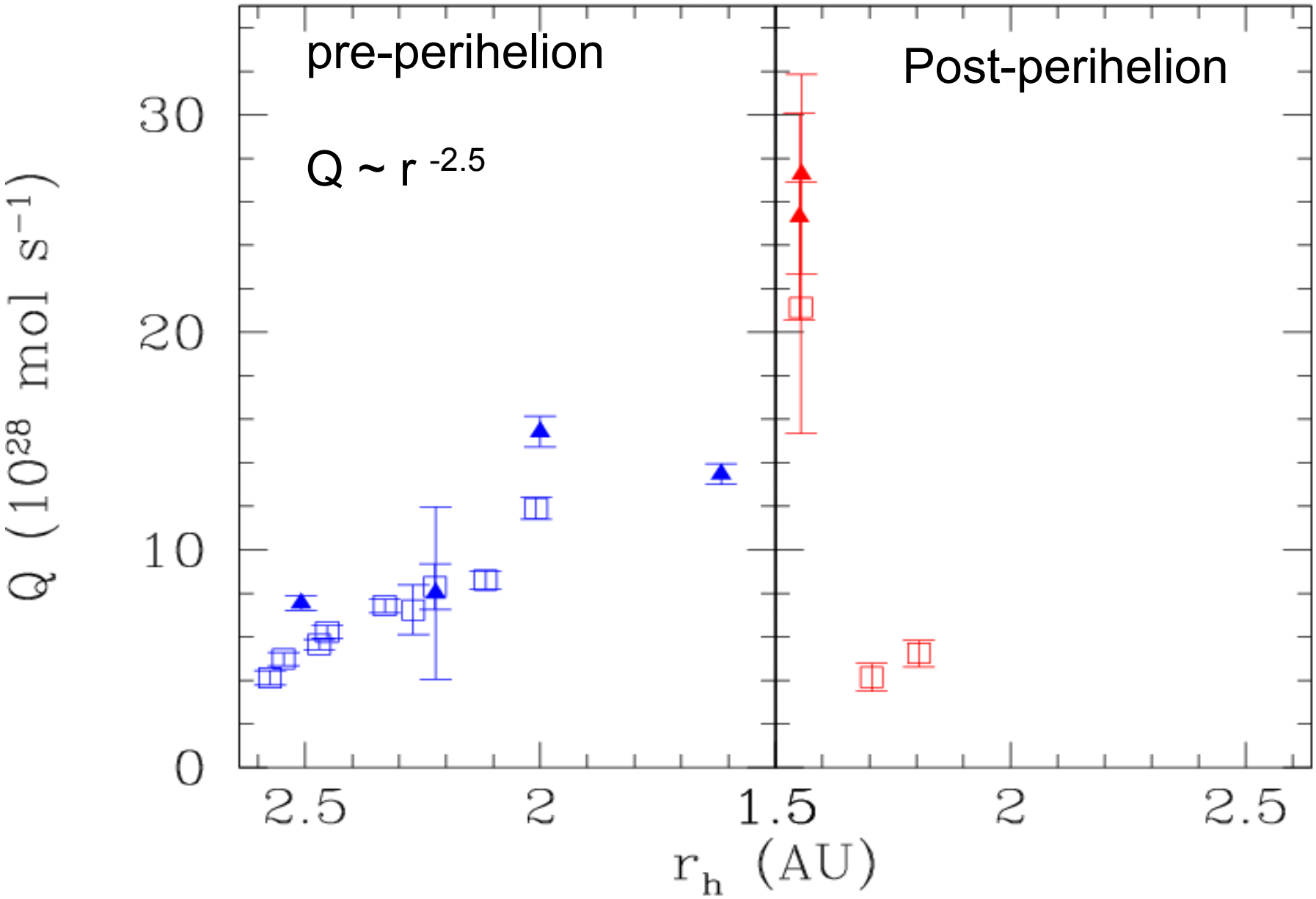
At high density, OH is thermalized

- -no pumping sustained
- -"ons" suppressed
- -"offs" enhanced
- -Production rates under-estimated

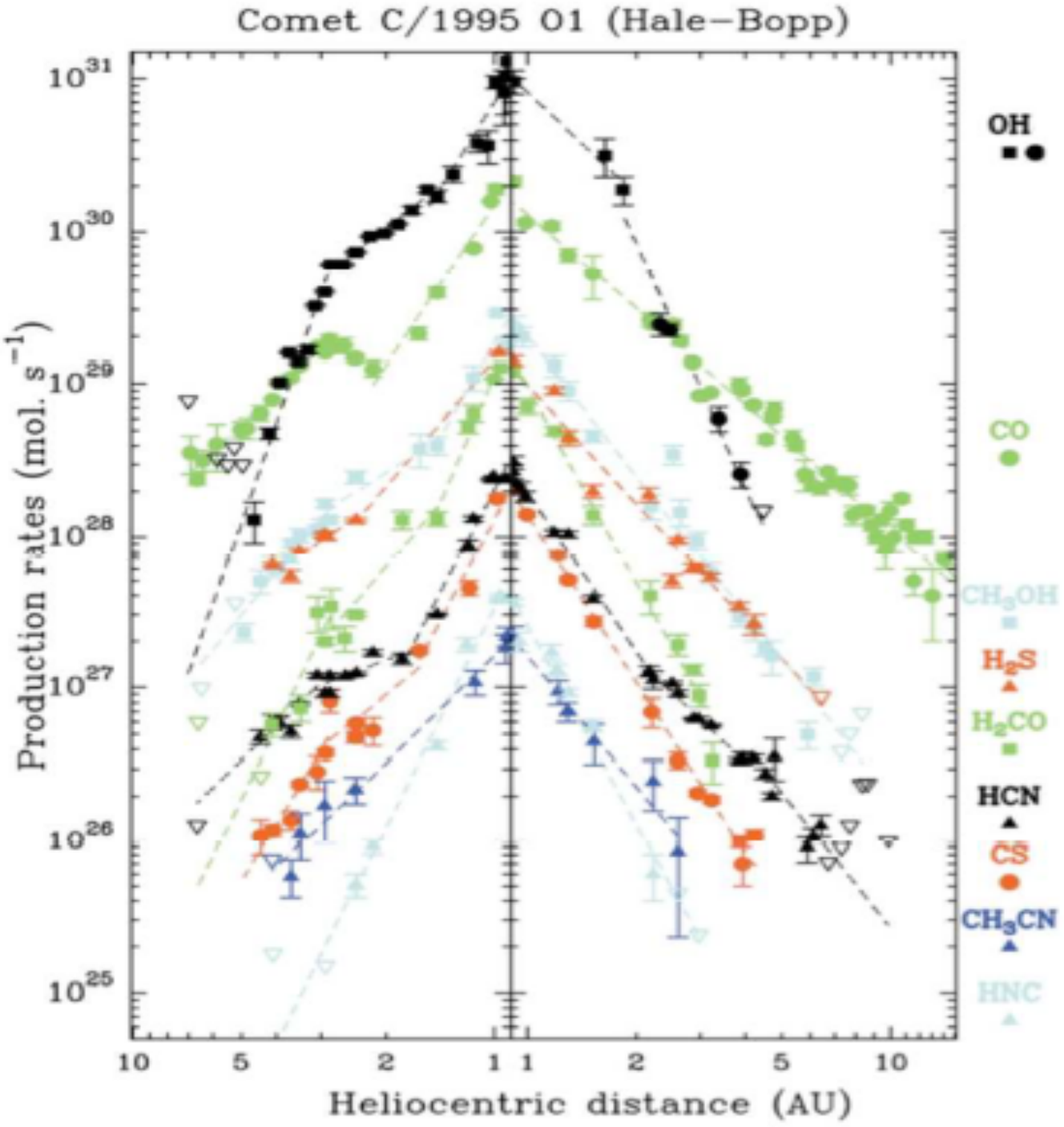
This can be measured!

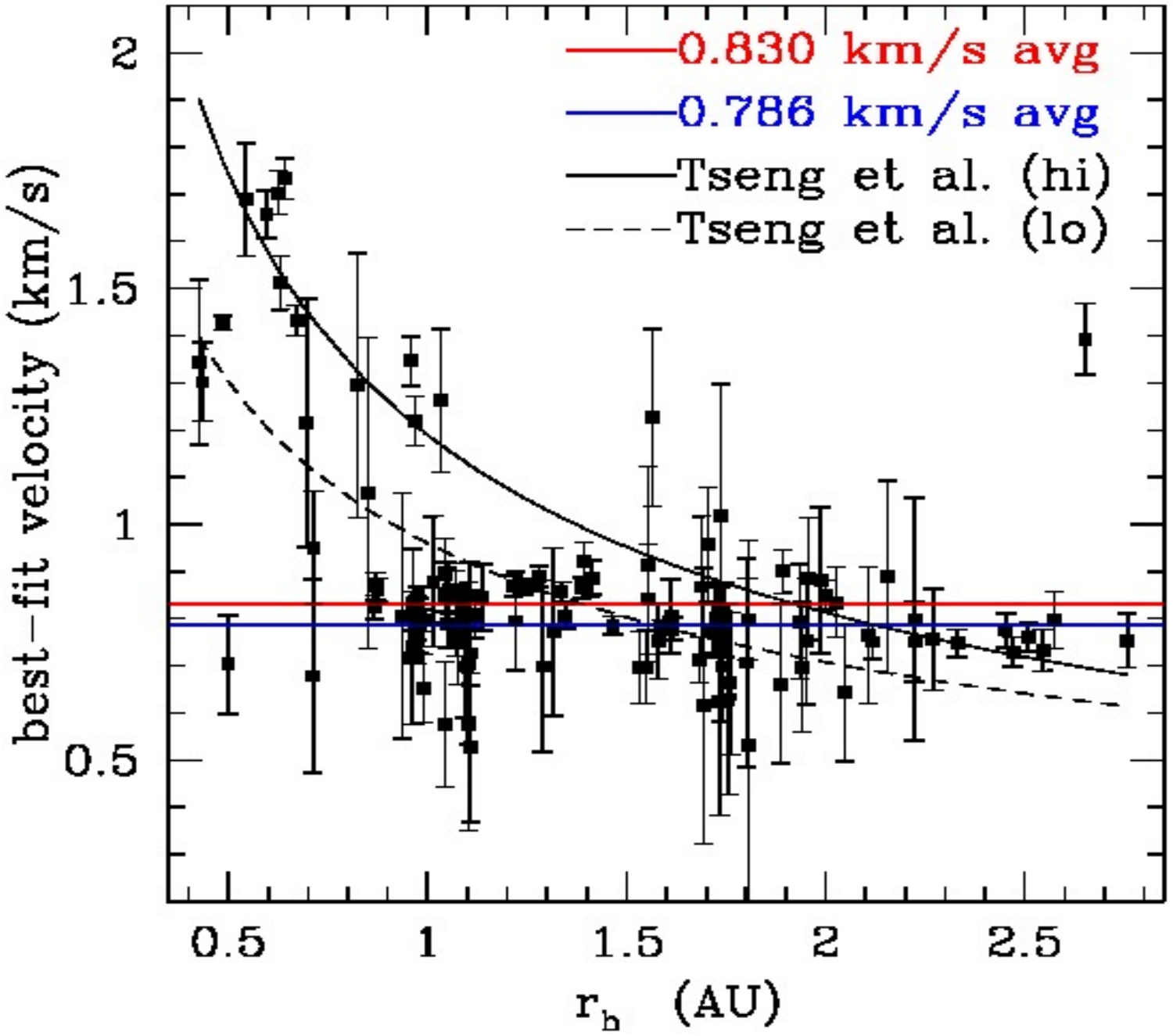


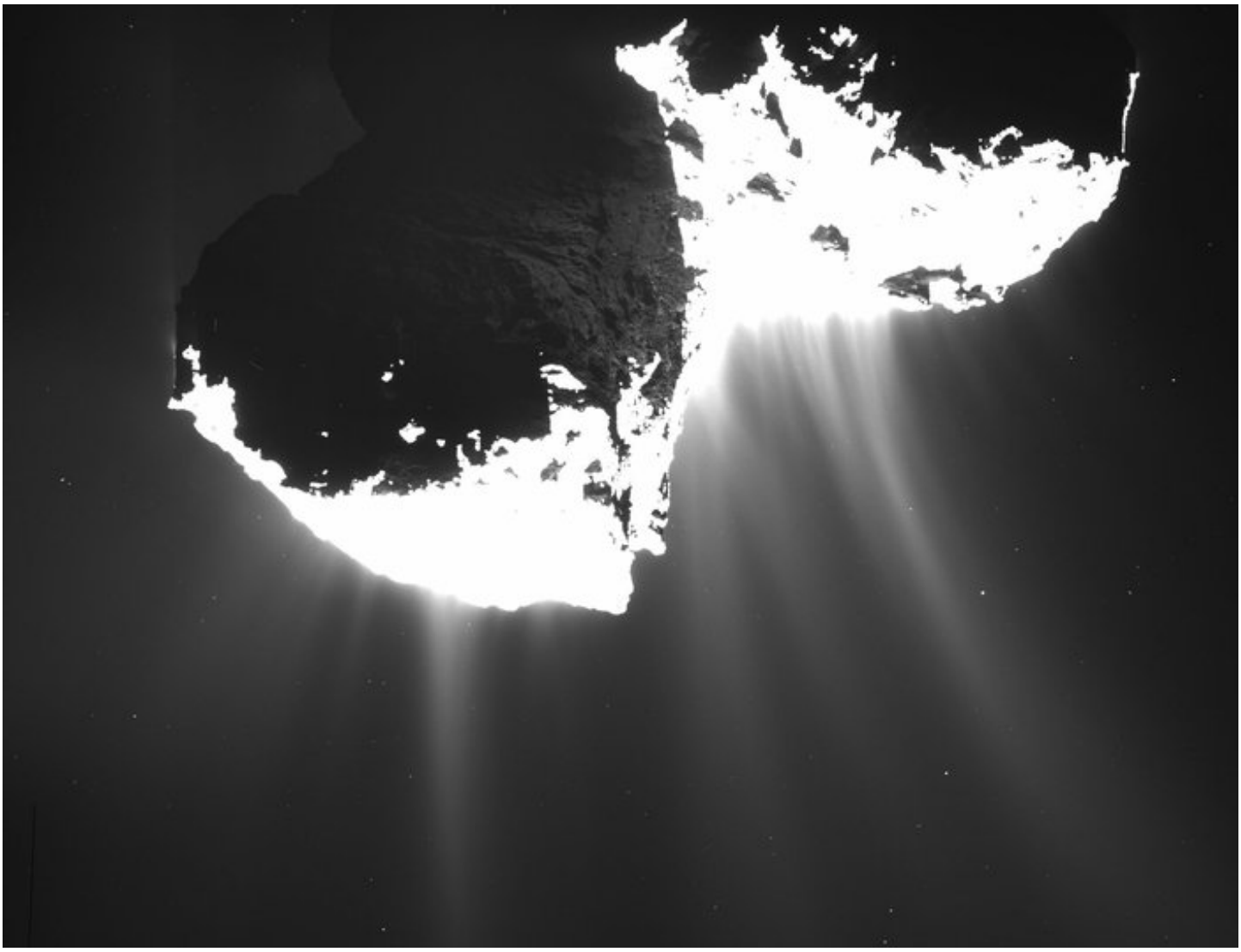
Gas Production variability

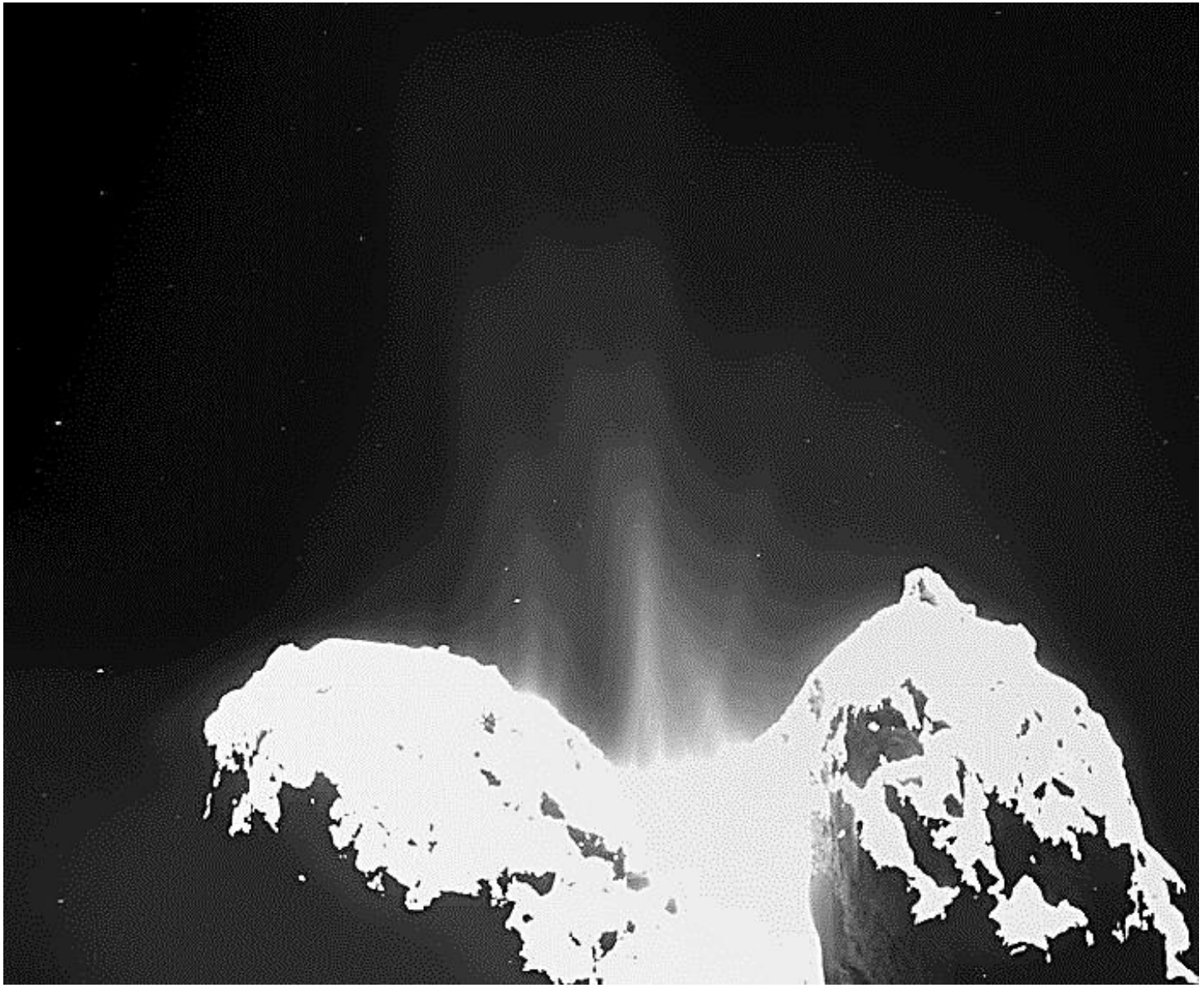


Gas Production (+mm)




0.830 km/s avg
0.786 km/s avg
Tseng et al. (hi)
Tseng et al. (lo)
best−fit velocity (km/s)
0.5
1
1.5
2
0.5
1
1.5
2
2.5
r_h (AU)





Extended Emission

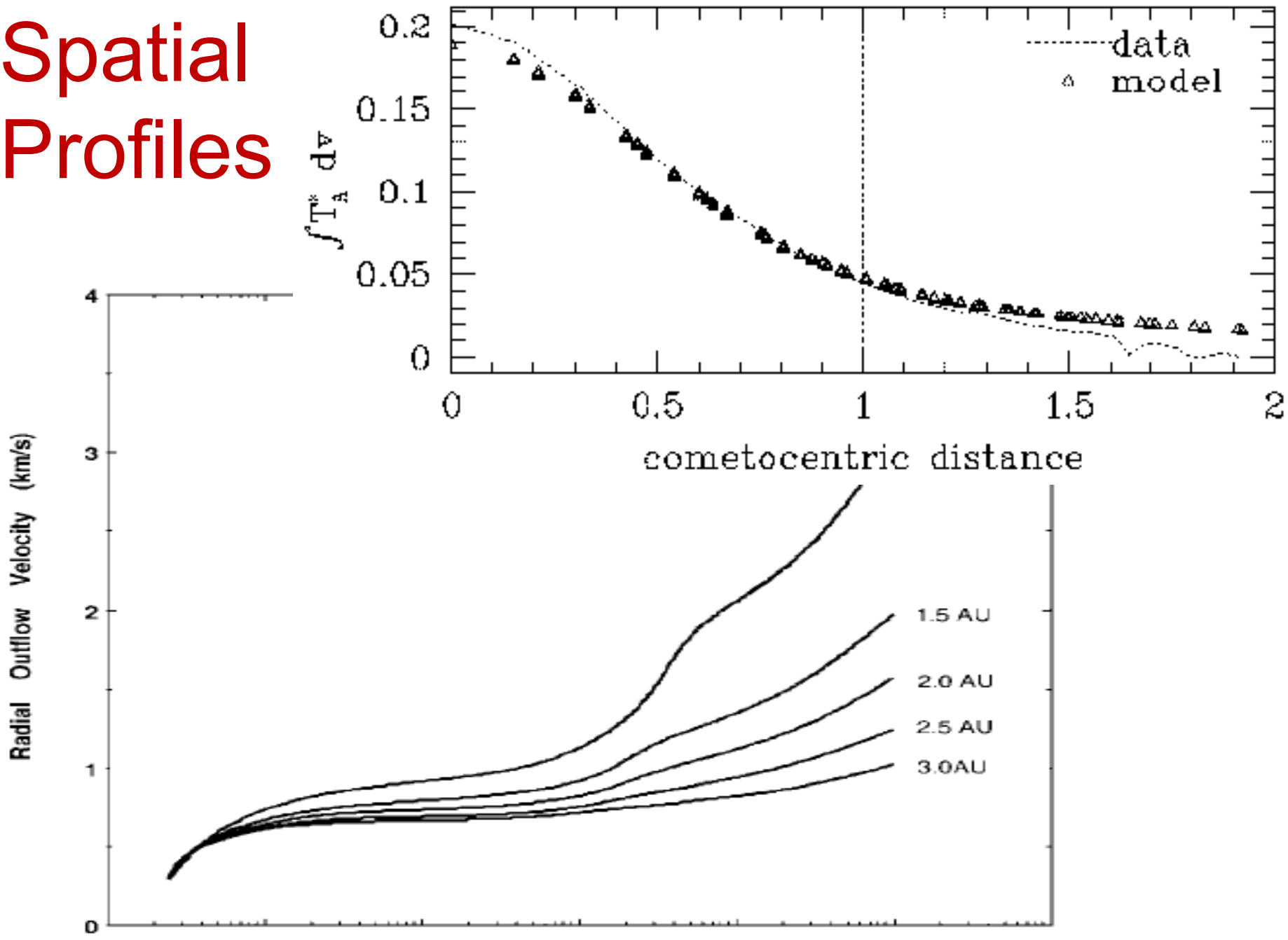
Extent of Emission determined by

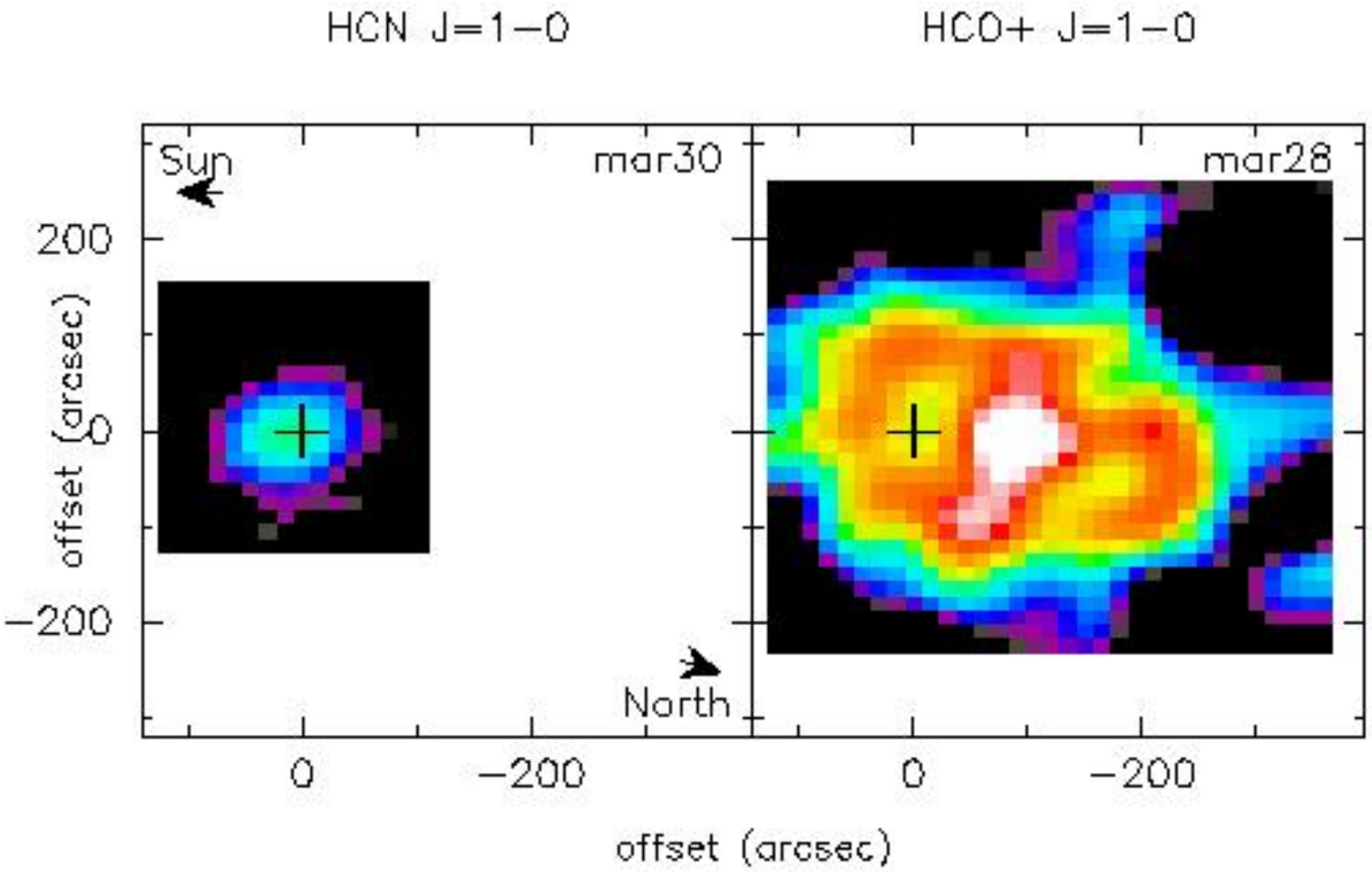
- Photo-dissociation lifetime
- Outflow velocity
- Excitation profile (collision zone)

These in turn influence gas production rate

  - # of molecules required to produce observed column density

Spatial Profiles




HCN J=1−0
HCO+ J=1−0
Sun
mar30
mar28
North
200
0
−200
offset (arcsec)
0
−200
0
−200
offset (arcsec)

“Traditional” Observations of Asteroids

Photometry
  General Brightness/colors

Astrometry

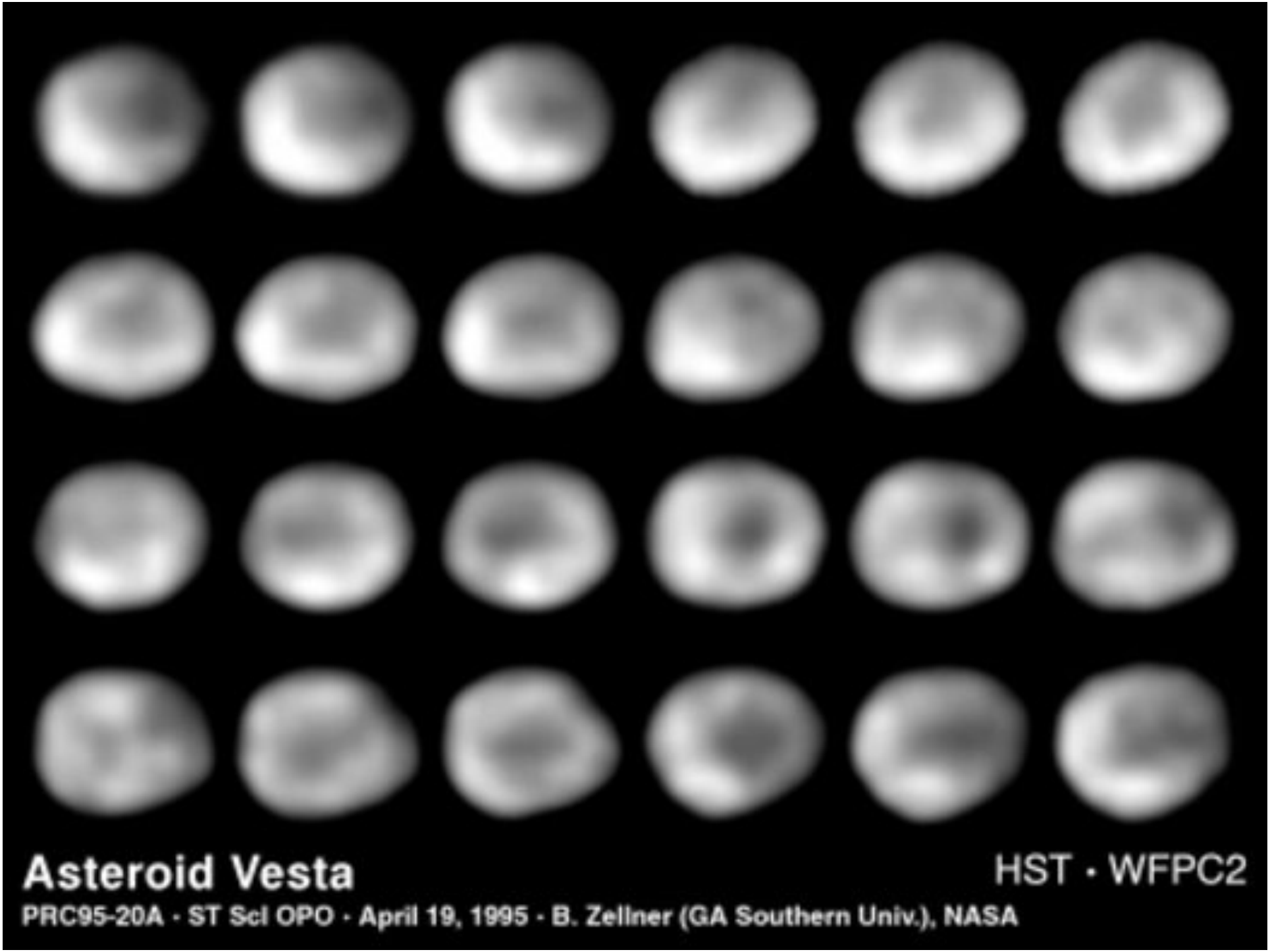
Lightcurves

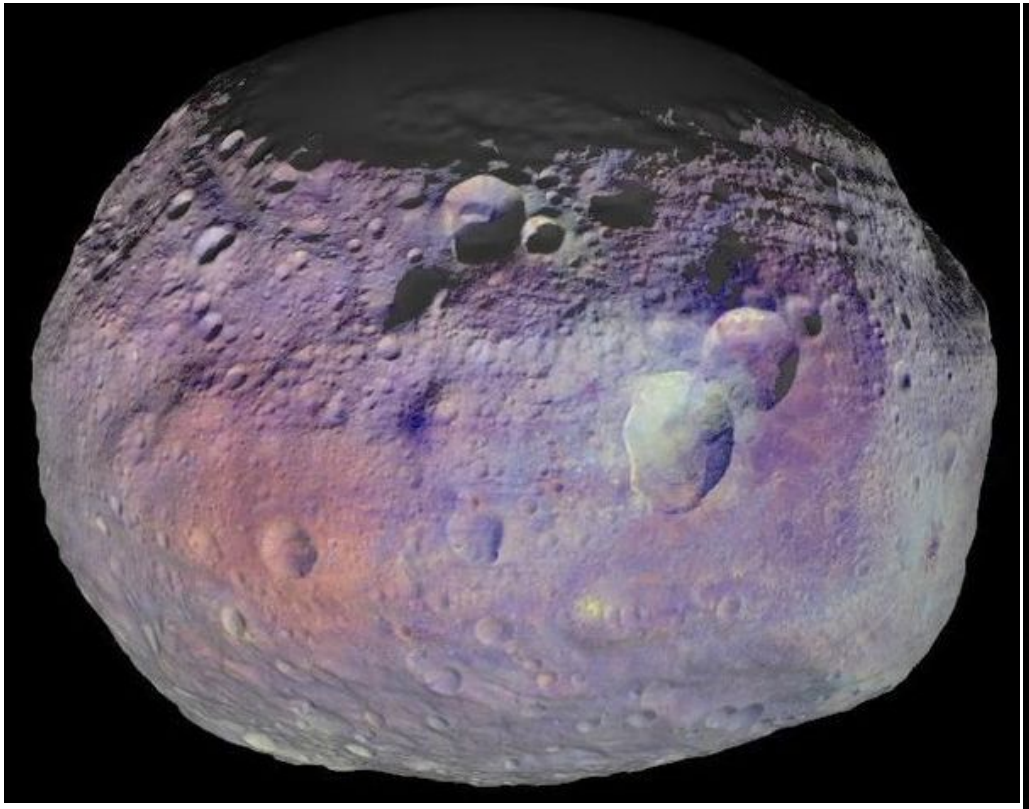
Why thermal lightcurves?

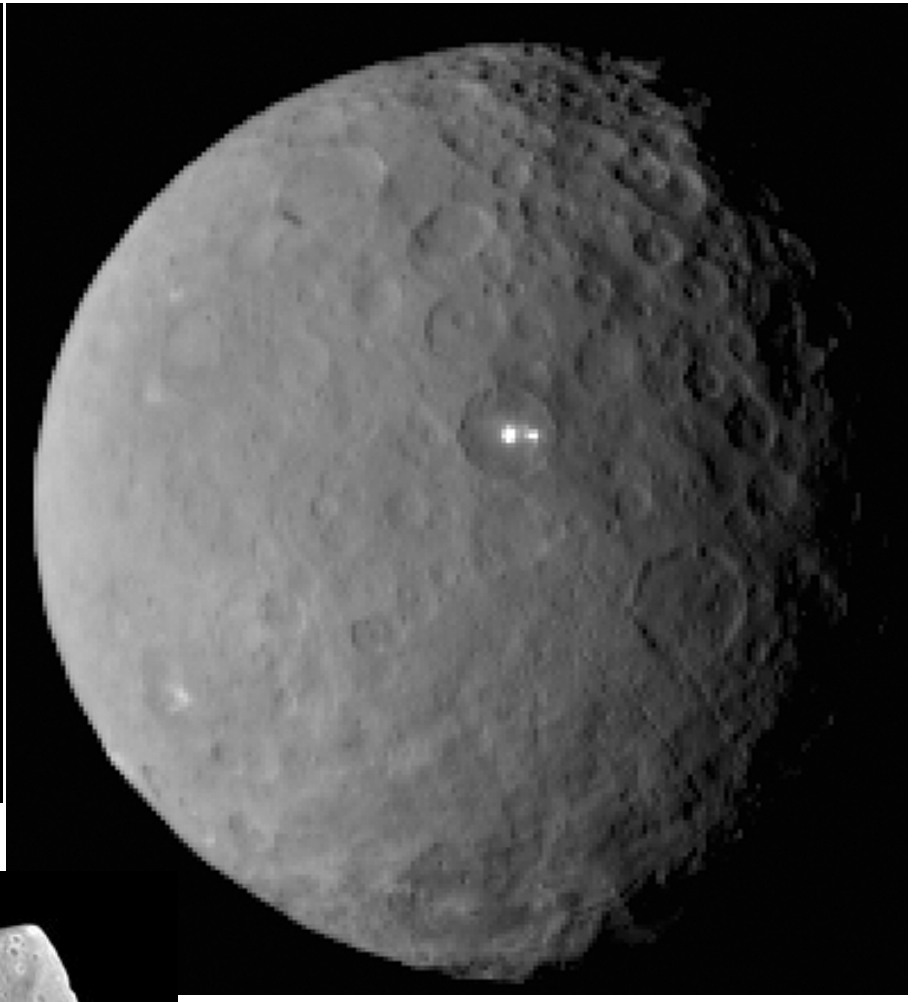
Little rotational thermal data

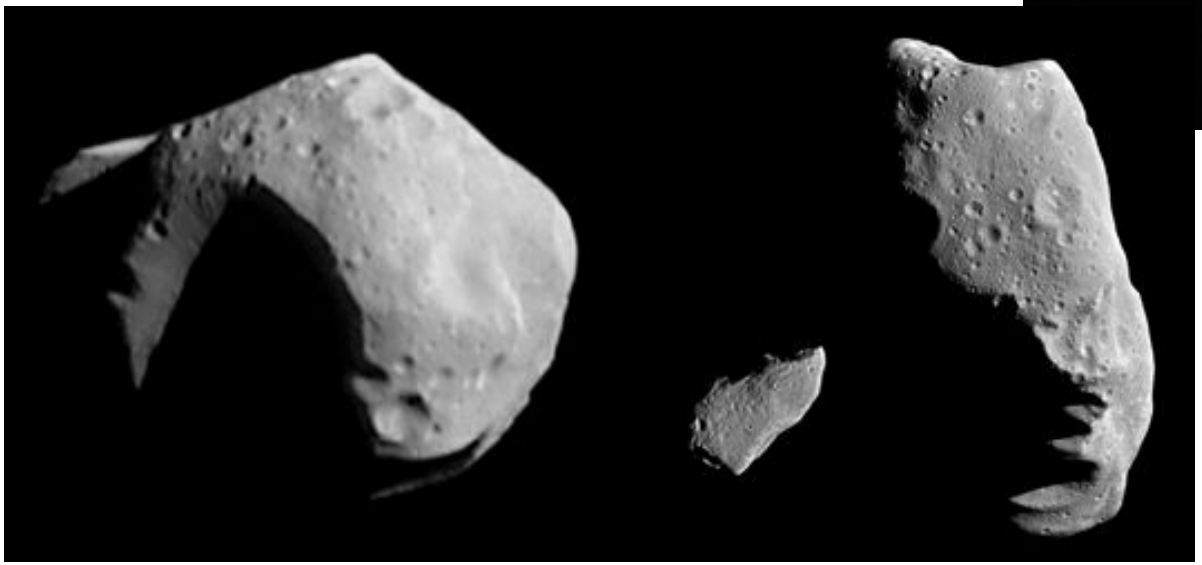
Spacecraft images resolve (ground truth)
RADAR adds size/spin/type data

mm & sub-mm technology (bolometers)


Asteroid Vesta
HST · WFPC2
PRC95-20A · ST ScI OPO · April 19, 1995 · B. Zellner (GA Southern Univ.), NASA







Ceres video…

Continuum is good too!

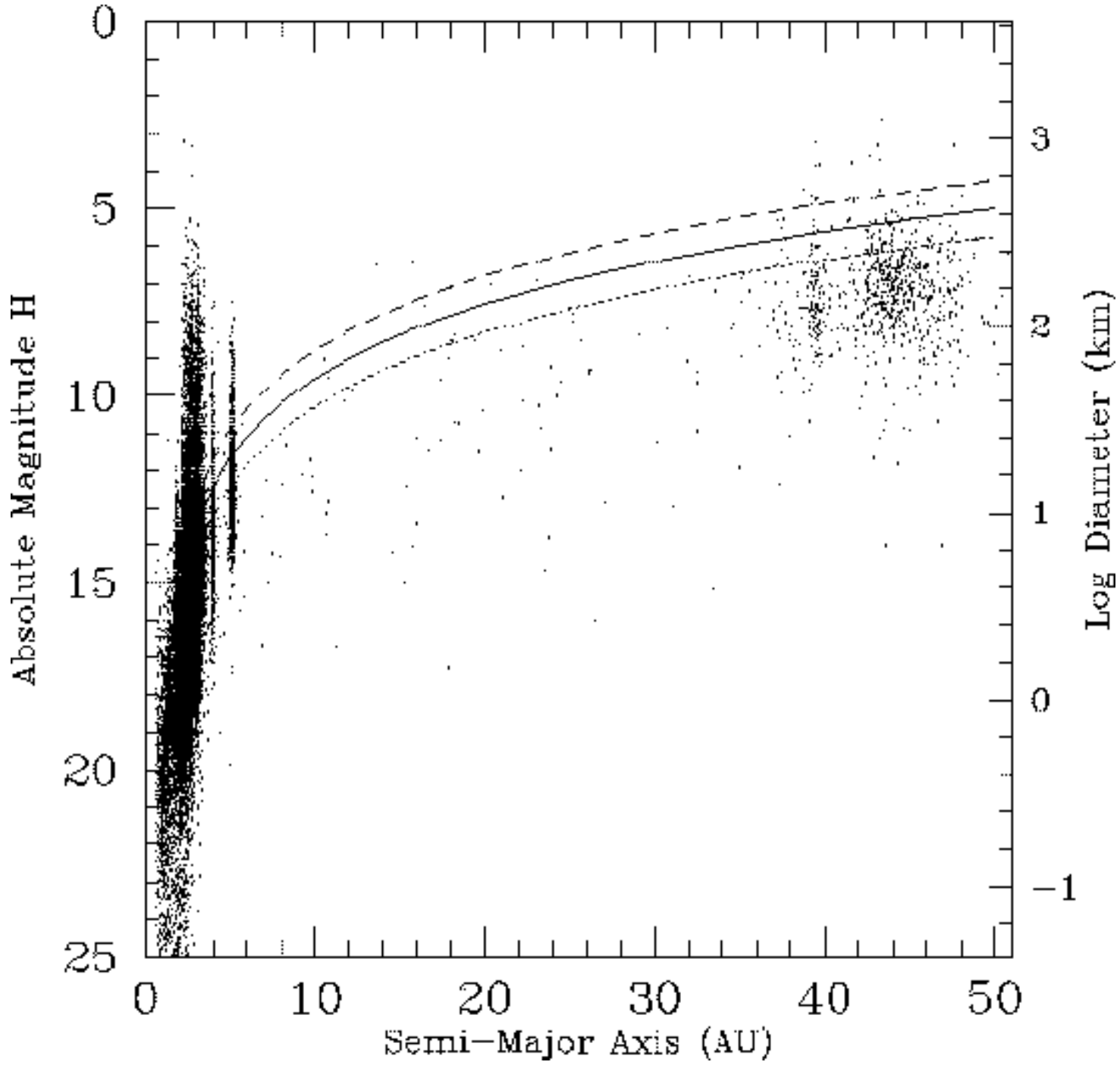
mm-scale dust

Large size, larger mass
Source of extended coma emissions?

Future Observations

Rotationally-resolved coma maps
Simultaneous parent/daughter maps
Large-particle dust continuum
NEO Thermal lightcurves

One month to New Horizons Pluto!


Absolute Magnitude H
0
5
10
15
20
25
Log Diameter (km)
3
2
1
0
−1
0
10
20
30
40
50
Semi−Major Axis (AU)