THE SPLITTING OF DOUBLE-COMPONENT ACTIVE ASTEROID P/2016 J1 (PANSTARRS)

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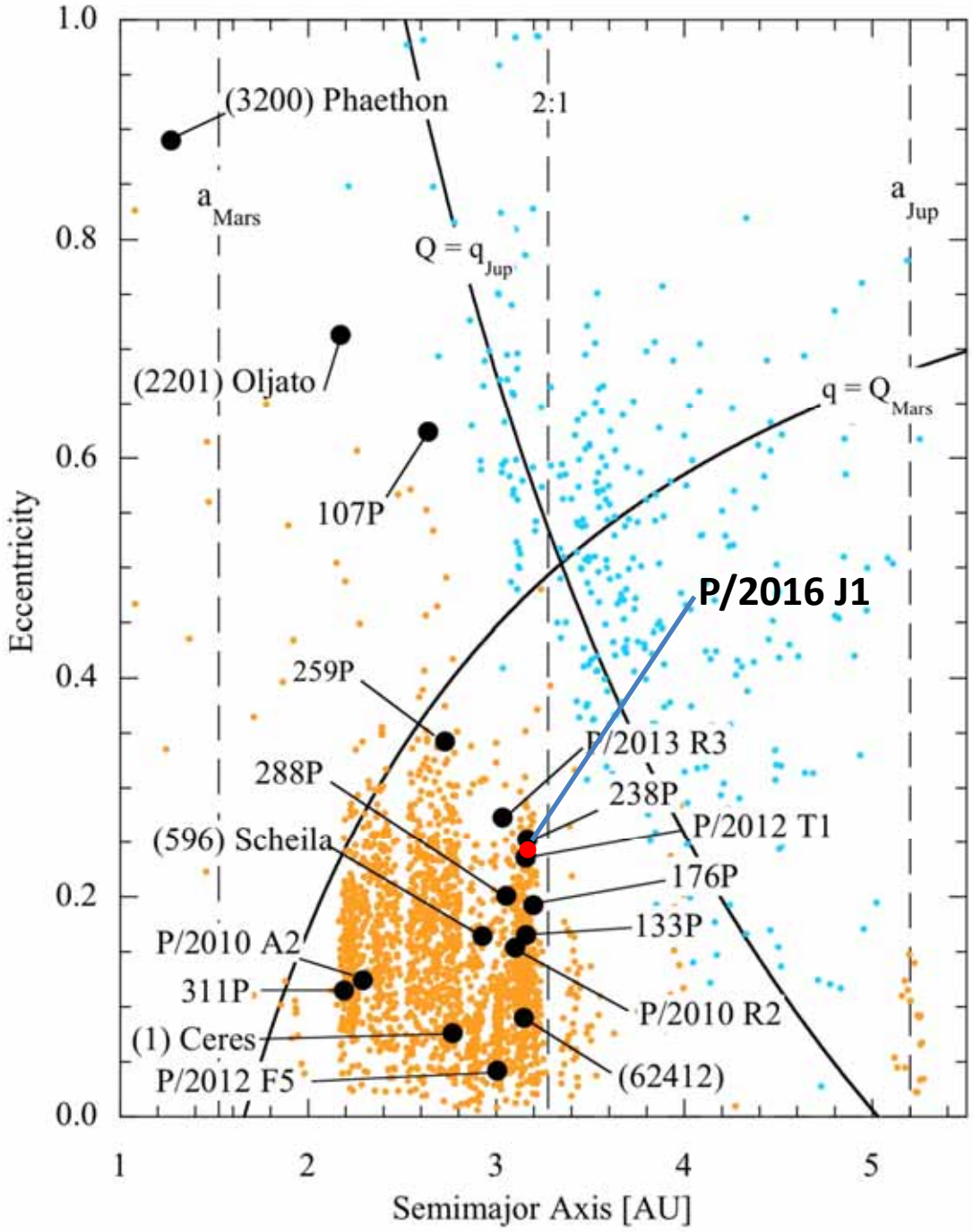
IAA-CSIC IAC GRANTECAN UNIV. BELGRADO PANSTARRS JPL

Discovery: 2016 May 5.5 UT with the 1.8 m Pan-STARRS1 telescope (Weryk & Wainscoat,2016)

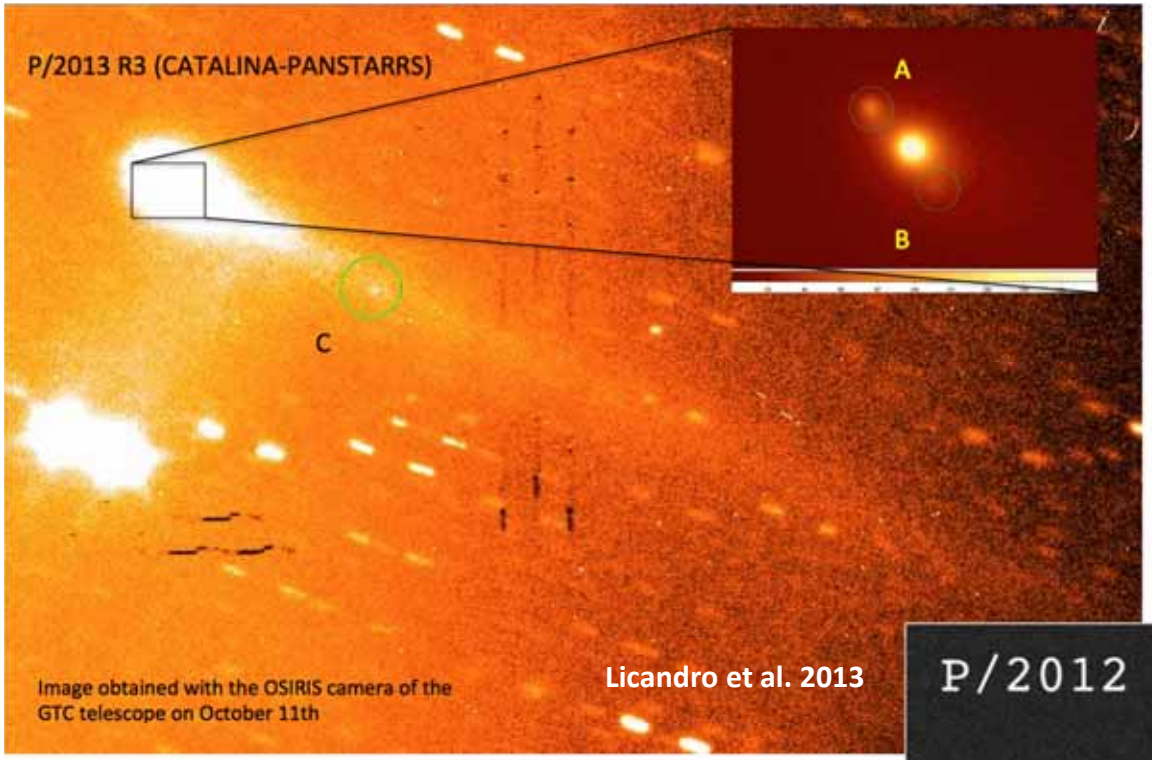
Follow-up observations showed a second “comet” in the field

From the orbital elements, P/2016 J1 is a main-belt asteroid pair, outer belt, $T_J>3$ (short-period comets have $2<T_J<3$)

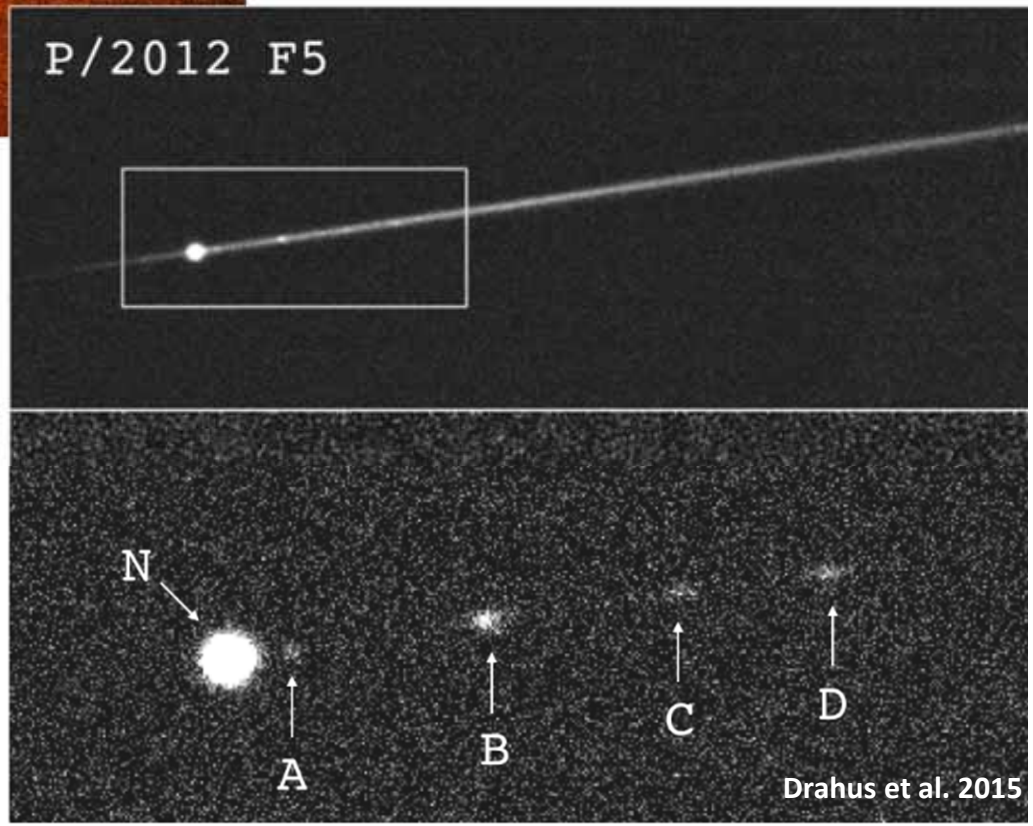


Updated from Jewitt, 2012

Splitting active asteroids

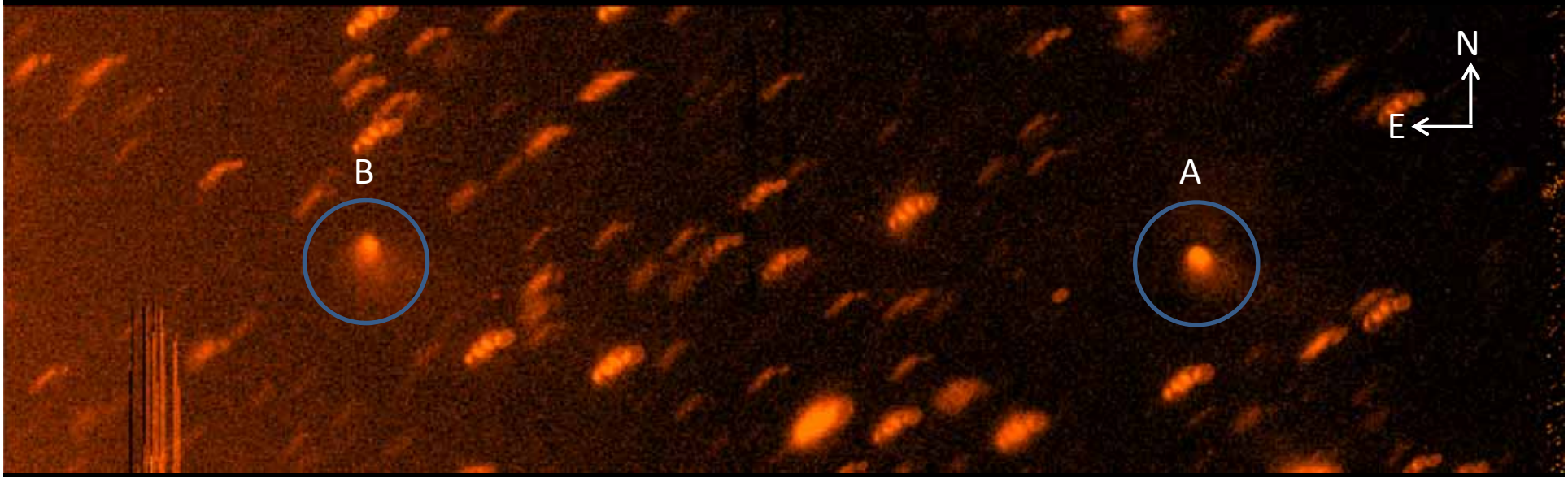


Licandro et al. 2013

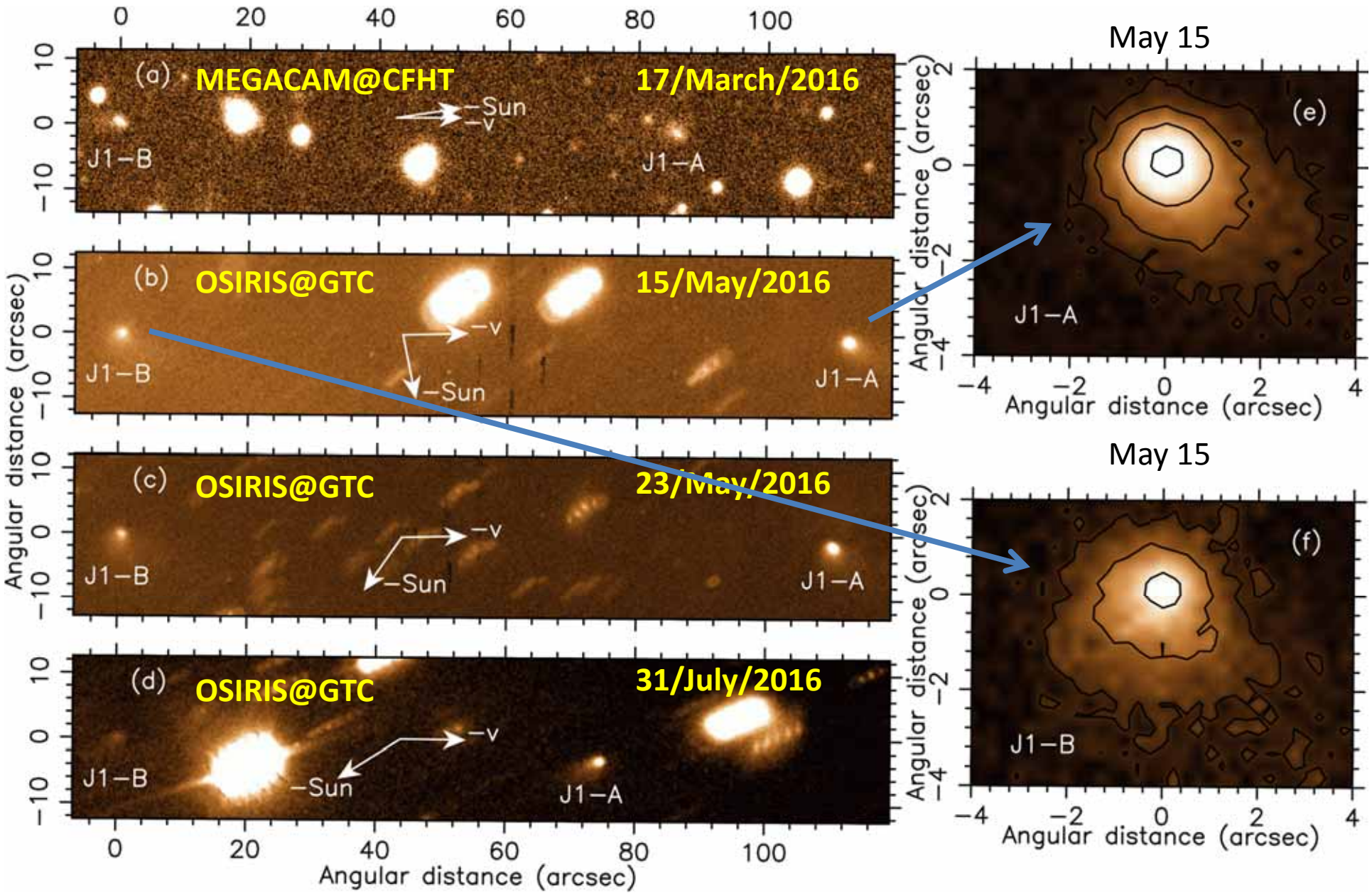


Drahus et al. 2015

P/2016 J1 OSIRIS@GTC May 29, 2016



118,000 km


(a) MEGACAM@CFHT
17/March/2016
Sun
−v
J1−B
J1−A
(b) OSIRIS@GTC
15/May/2016
−v
−Sun
J1−B
J1−A
(c) OSIRIS@GTC
23/May/2016
−v
−Sun
J1−B
J1−A
(d) OSIRIS@GTC
31/July/2016
−v
−Sun
J1−B
J1−A
Angular distance (arcsec)
0
20
40
60
80
100
10
0
−10
May 15
(e)
J1−A
May 15
(f)
J1−B
−4
−2
0
2
4

SIZE OF NUCLEI

Bowell (1989) formalism (G=0.15, C-type): H=19.2 (J1-A), H=19.4 (J1-B)

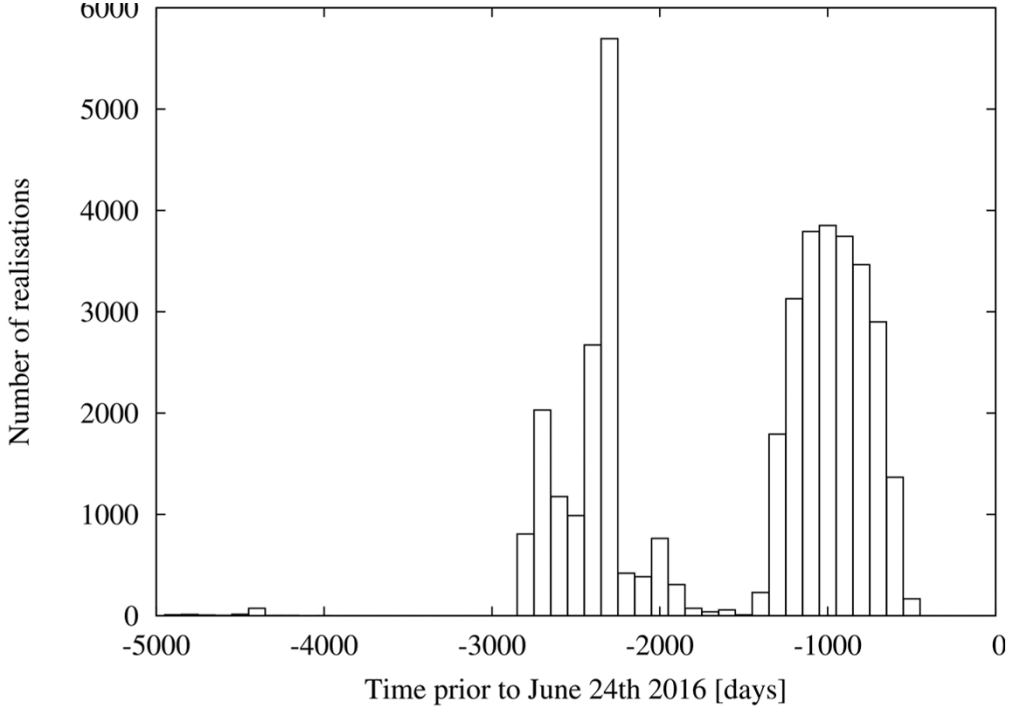
H-diameter relationship (Harris & Lagerros (2002): $D = \frac{1329}{\sqrt{p}} 10^{-0.2H}$ (km)

p ≈ 0.04 (C-type)

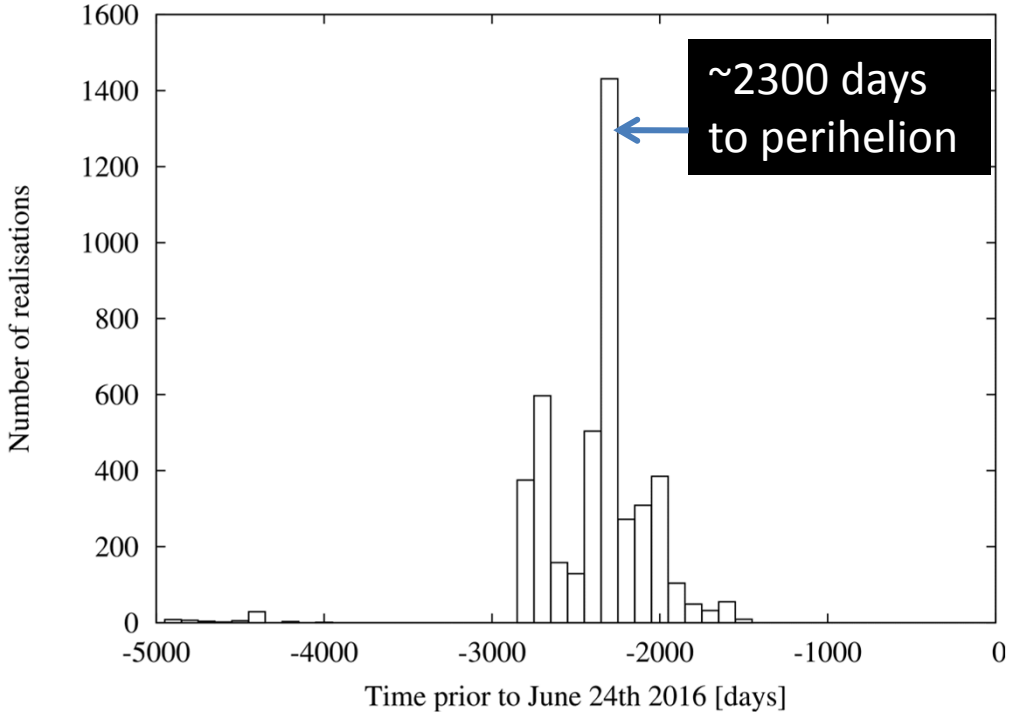
D < 1 km (stringent upper limit) Escape velocity ≈0.3 to 0.6 m/s [ρ≈1 to 3 g/cm^3]

ORBITAL DYNAMICS

- To assess the common origin of the asteroids, backward integration of their orbits
- Orbit9 integrator in OrbitFit package (Milani et al.)
- 4×10^4 clone combinations from the multivariate normal distribution, defined by the orbital covariance matrix
- Orbital elements from JPL Small Node Database
- Orbits propagated 100 years backward in time



Frequency distribution of dates of closest approach between J1-A and J1-B clone pairs



Frequency distribution for pairs of clones that approached **closer than 1500 km**

Relative velocity ≈0.8 m/s

Splitting mechanism uncertain

Separation event ≈2300 days (≈6 years) before current perihelion

Since the orbital period is 5.65 years, it happened near perihelion during the previous orbit.

Splitting mechanism uncertain:
Rotational fission (YORP effect), catastrophic collision ?

The separation event is not apparently linked to the observed activity

How to confirm this ? → Dust tail modeling

MONTE CARLO DUST TAIL/COMA MODEL (Moreno et al. 2009)

DYNAMICAL/RADIATIVE CODE

- COMPUTE **POSITION IN THE SKY PLANE** OF PARTICLES EJECTED FROM NUCLEUS
- CALCULATE **SIMULATED TAIL BRIGHTNESS** FROM LIGHT SCATTERING PROPERTIES OF DUST GRAINS

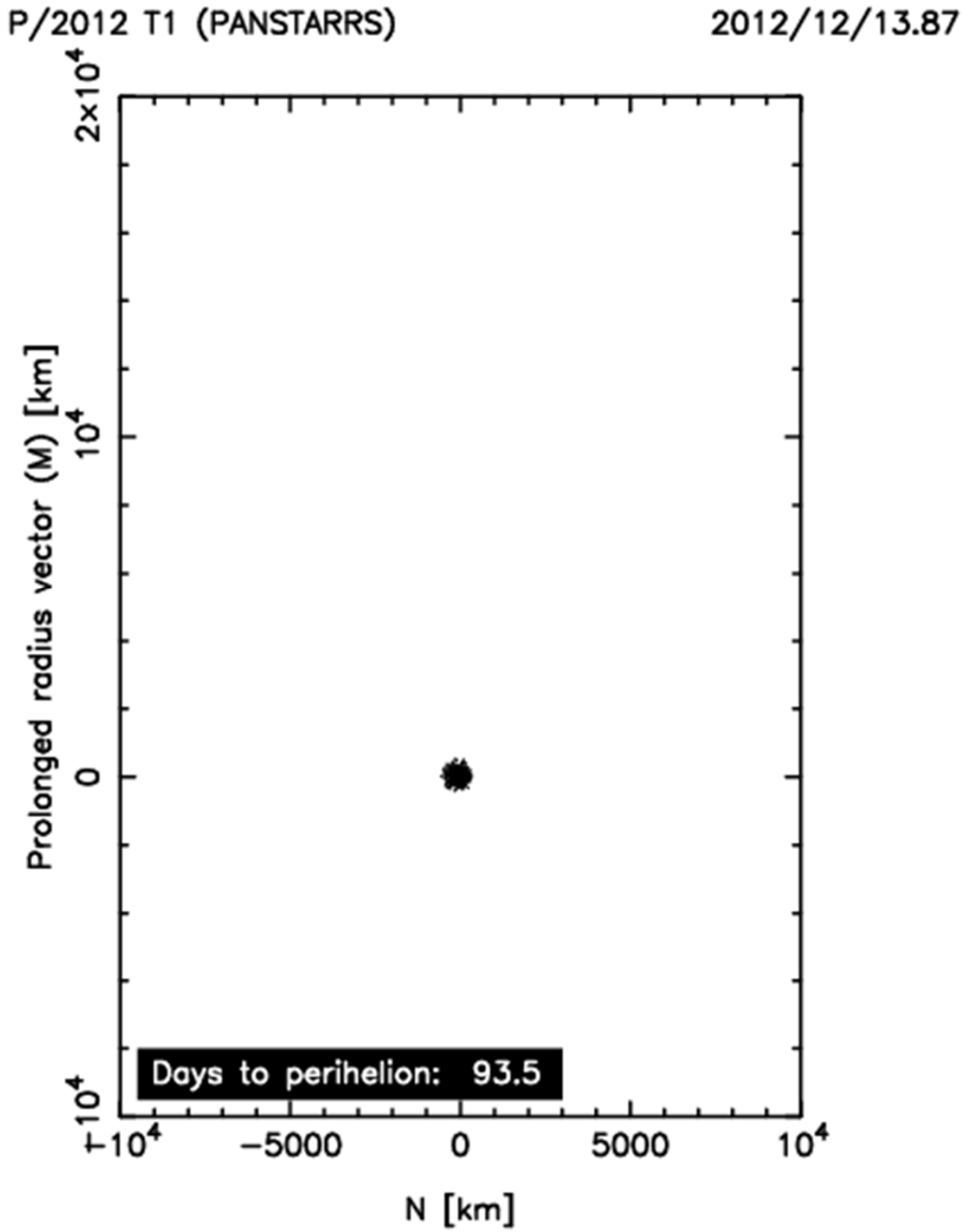
MODEL PARAMETERS:

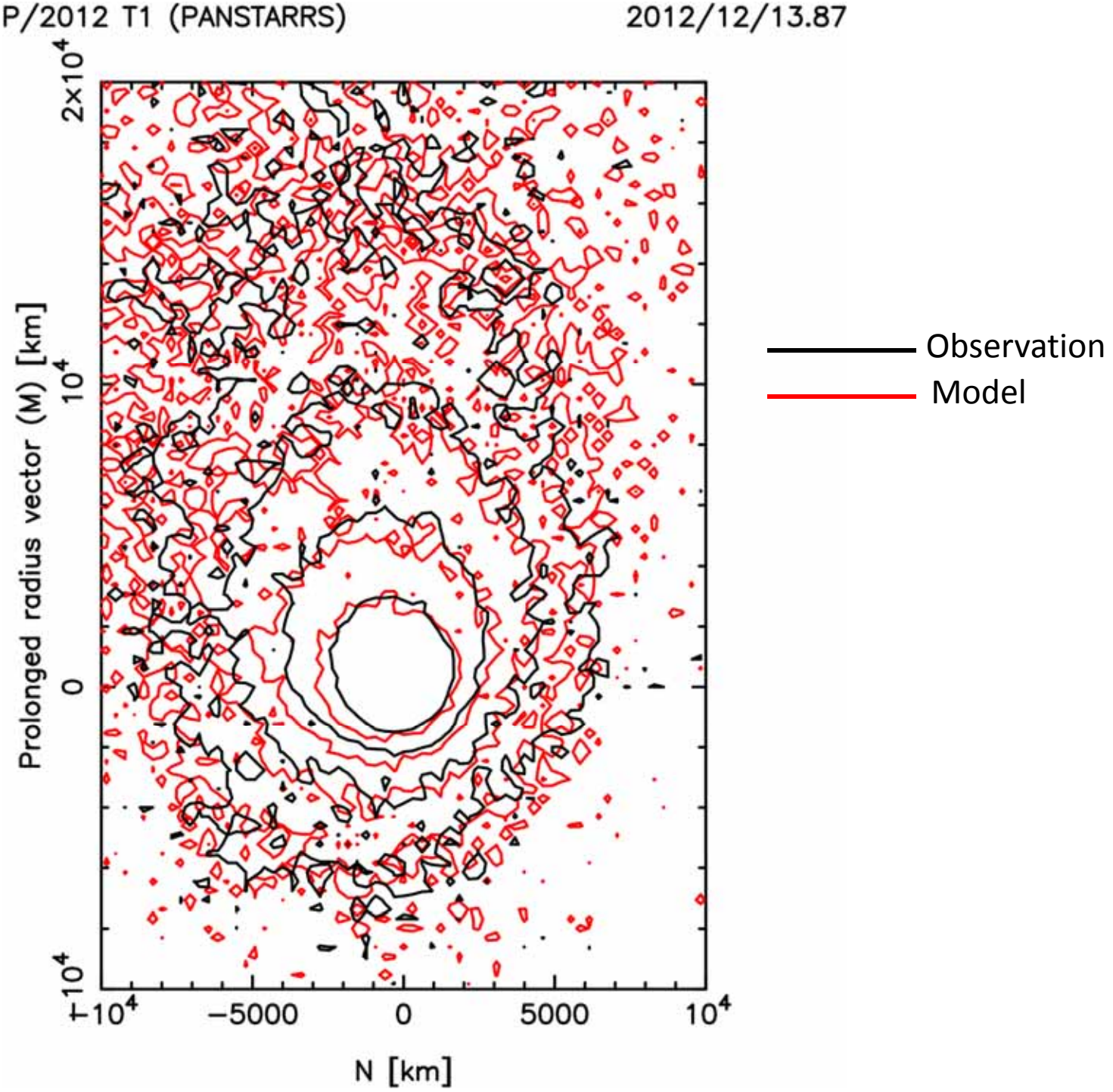
1)DEPENDENCE OF EJECTION VELOCITY OF GRAINS AS FUNCTIONS OF SIZE: $v=v_0/r^{1/\gamma}$
2)SIZE DISTRIBUTION: $\mathbf{n(r)}=Cr^{-\alpha}$, GRAINS DISTRIBUTED IN SIZES FROM μm TO cm
3)MASS LOSS RATE: $dm/dt=A\ \exp(-[(t-t_0)/\sigma]^2)$,

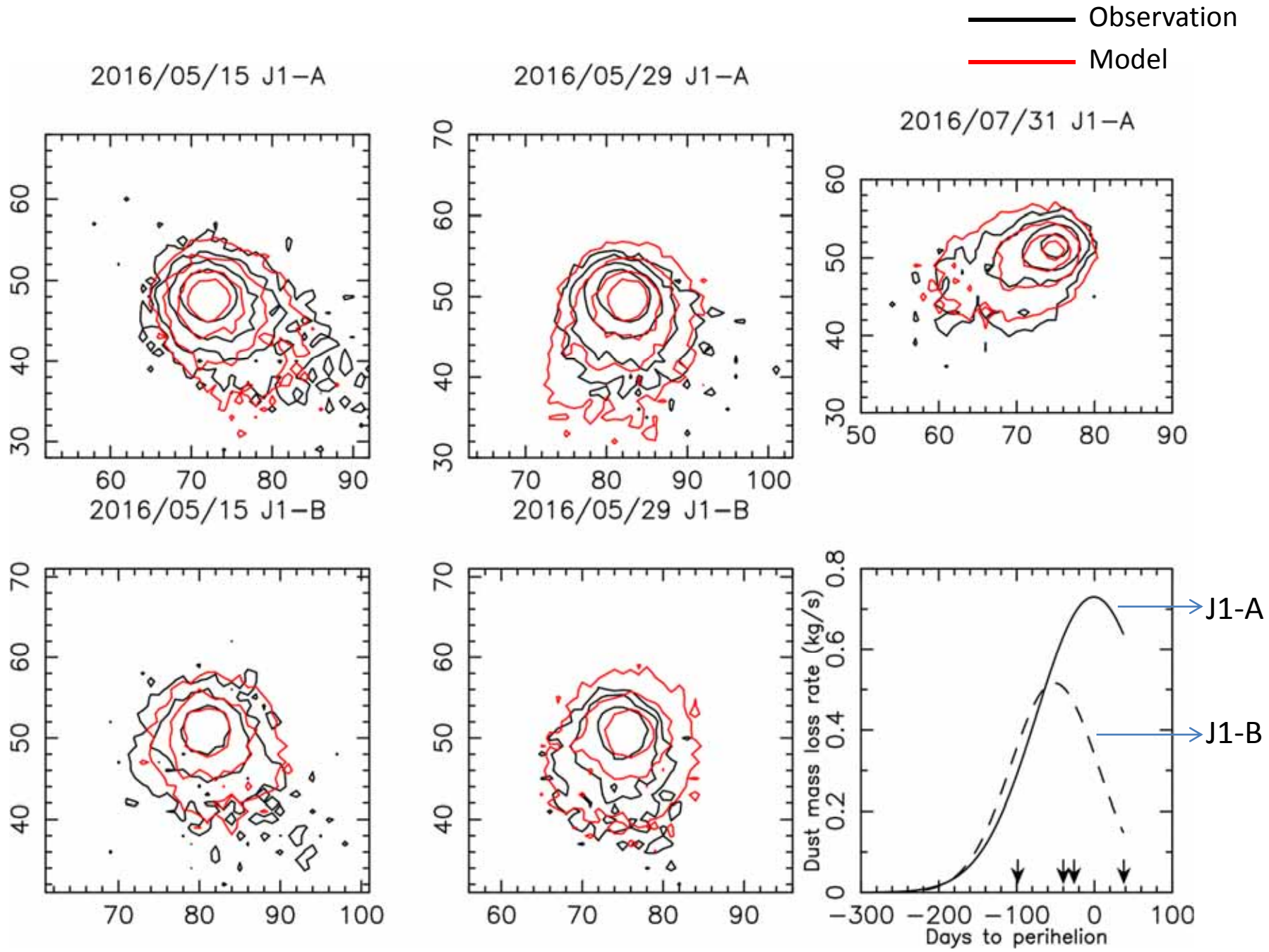
Fitting parameters of the model: A, t_0, σ, v_0, γ (for each fragment)

Multidimensional minimization method: Downhill Simplex method

At each iteration step, synthetic and observed tails are compared and standard deviation is computed


P/2012 T1 (PANSTARRS)
2012/12/13.87
Prolonged radius vector (M) [km]
2×10^4
10^4
0
−10^4
−10^4
−5000
0
5000
10^4
N [km]
Days to perihelion: 93.5


P/2012 T1 (PANSTARRS)
2012/12/13.87
Prolonged radius vector (M) [km]
N [km]
2×10^4
10^4
0
−10^4
−10^4
−5000
0
5000
10^4
Observation
Model


Observation
Model
2016/05/15 J1−A
2016/05/29 J1−A
2016/07/31 J1−A
2016/05/15 J1−B
2016/05/29 J1−B
Dust mass loss rate (kg/s)
Days to perihelion
J1-A
J1-B

CONCLUSIONS ON P/2016 J1 SPLITTING

• Splitting event (unspecified mechanism) near perihelion during previous orbit

• Both fragments became activated at the same time, some 250 days to the current perihelion passage

• Total dust loss: 8×10^6 kg (J1-A) and 6×10^6 kg (J1-B)

• Particle terminal velocities in the range 0.6-0.9 m/s, compatible with escape velocities of ≈500 m radius bodies

• Activity lasting 6 to 9 months

SPLITTING EVENT AND DUST ACTIVITY UNRELATED

ACTIVITY MOST LIKELY INDUCED BY ICE SUBLIMATION

***More details**: Moreno et al., ApJ, 837, L3 (2017)*