# The Small Solar System Body Science by Using PTF Data

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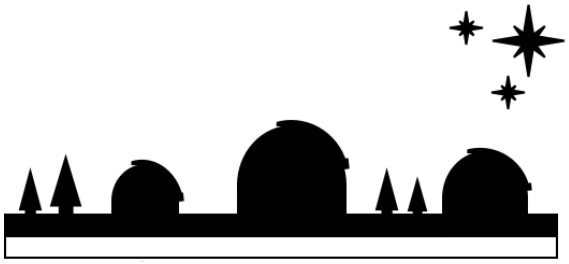


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# The SSSB Projects

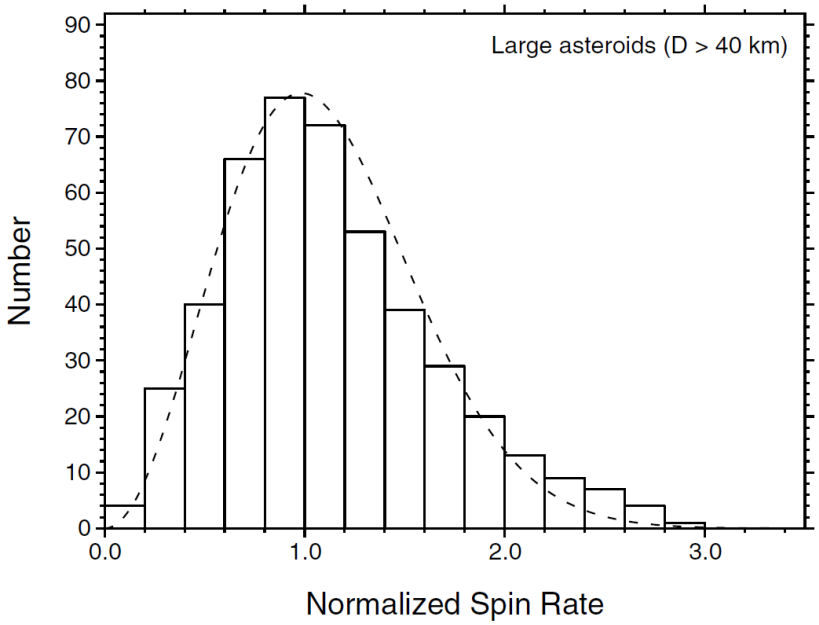
- **The Asteroid Spin Rate Study**
  - Chang, Chan-Kao (Rex)
- **The Phase-curve relation (H-G Analysis)**
  - Cheng, Yu-Chi
- **The Moving Object Detecting Pipeline**
  - Lin, Hsing-Wen (Edward) + CSIE dept.
- **The PTF Asteroid Lightcurve Database**
  - Chang, Chan-Kao (Rex)

# Q for Asteroid Rotation (1)

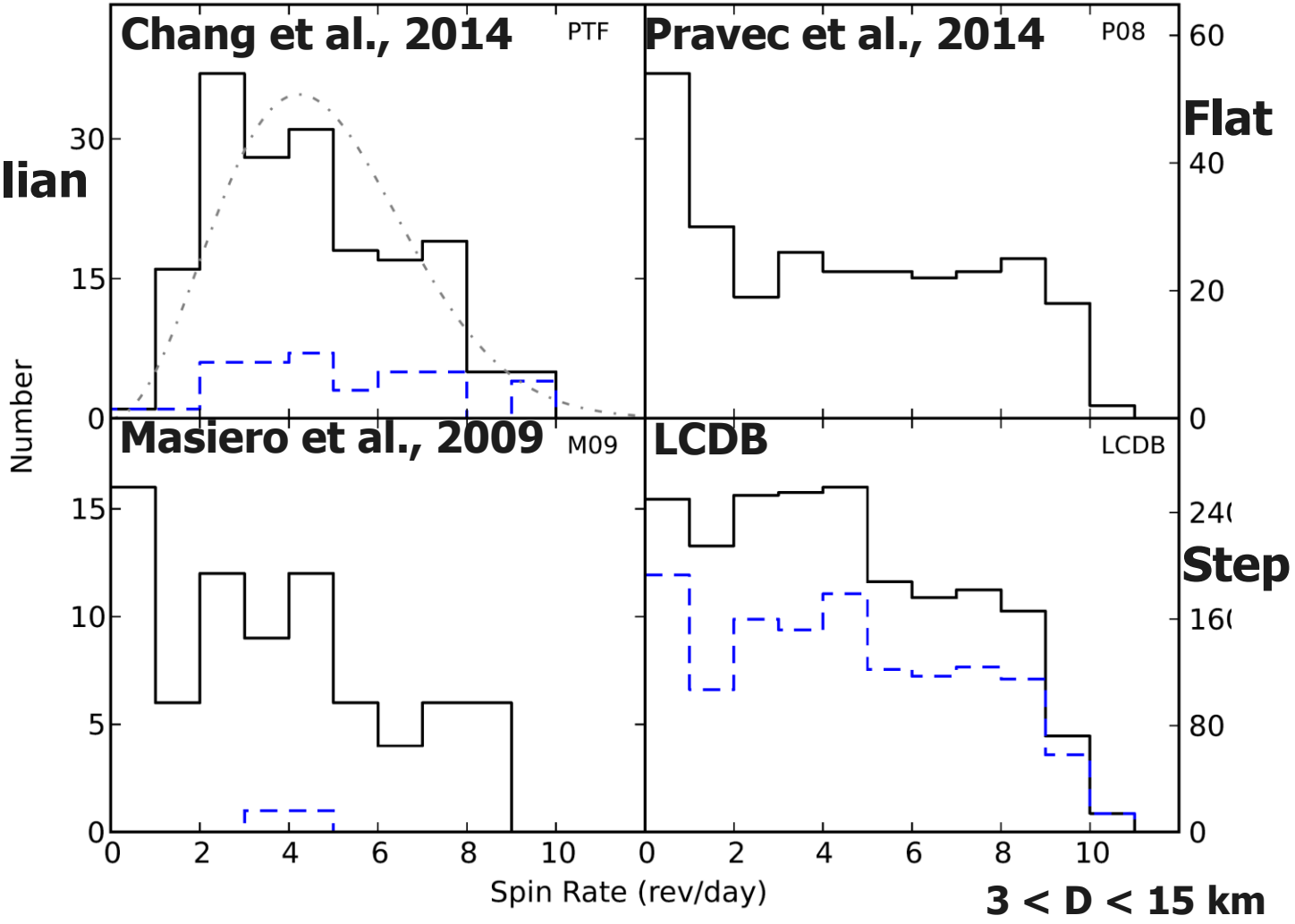
- **The Spin Rate Distribution**
  - D > 40 km
    - ➔ Maxwellian distribution (Pravec et al., 2002)
    - ➔ Collisionally evolved system (Salo, 1987)
  - D < 10 km
    - ➔ Deviated from Maxwellian ??

      (excesses of vary slow/fast rotator; Vokrouhlicky, 2002)
    - ➔ YORP effect

      (angular momentum change due to sunlight absorption and re-emission)



# Q for Asteroid Rotation (1)

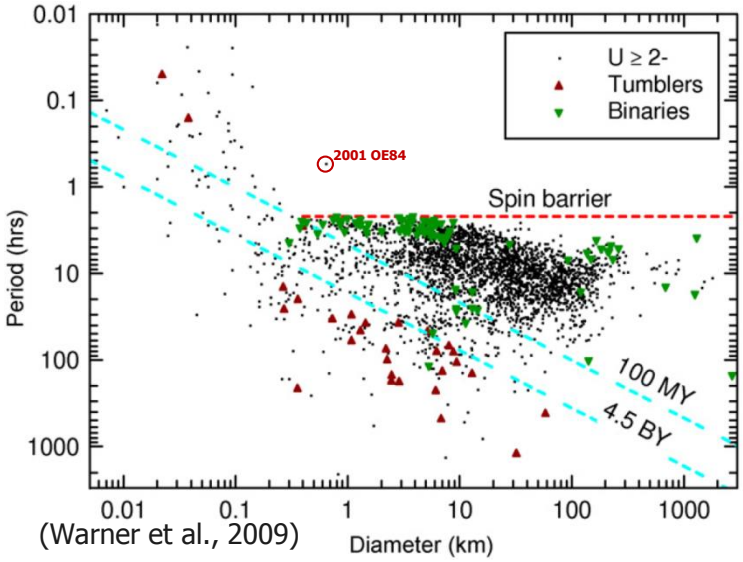



de-Maxwellian

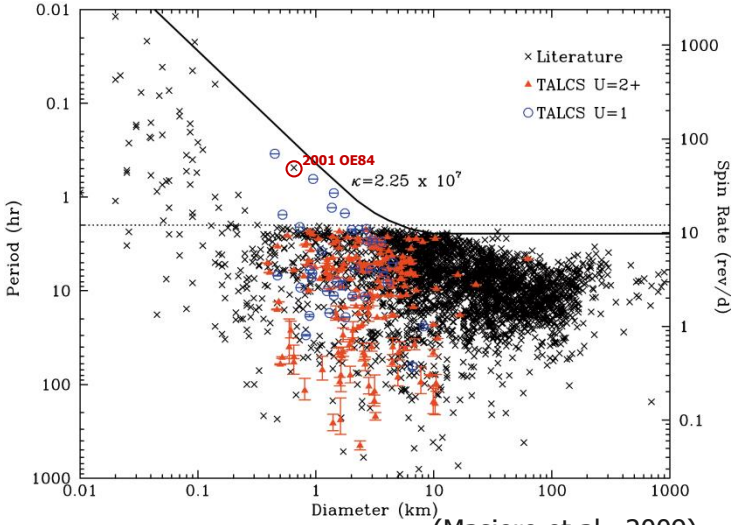
# Q for Asteroid Rotation (2)

## The Spin Rate Limit

- **Rubble pile & monolithic**
  (Harris, 1996)
  - spin-barrier at ~ 2 hours for D>150m
    (Gravitationally bounded)
  - super-fast-rotators (P<2hr) for D<150m
    (monolith)
- **Size-dependent strength**
  (Holsapple, 2007)
  - spin-barrier at ~ 2 hours for D>10km
    (Gravitationally bounded)
  - **super-fast-rotators for D<5km**
    (tensile and cohesive; a transition from small to larger objects)



(Warner et al., 2009)



(Masiero et al., 2009)

# Observations

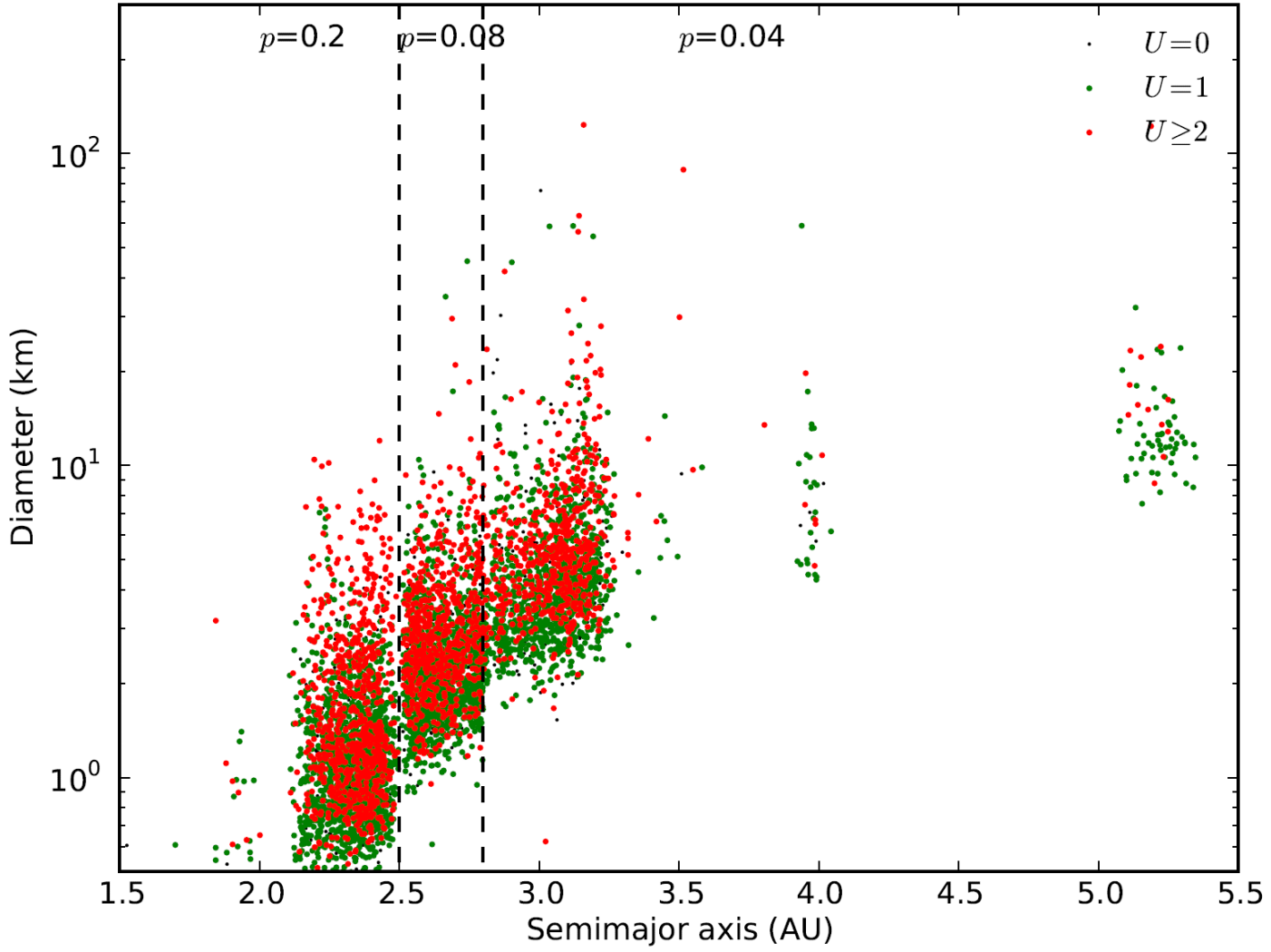
- 12 fields
- 4 adjacent nights
- On the ecliptic plane

| Feb, 2013 | ( ) | ( ) | Feb 15 Δt, Nexp | Feb 16 Δt, Nexp | Feb 17 Δt, Nexp | Feb 18 Δt, Nexp |
|---|---|---|---|---|---|---|
| 3654 | 101.02 | 21.38 | 3.4, 10 | 5.1, 16 | 6.8, 19 | 6.4, 19 |
| 3655 | 104.69 | 21.38 | 3.4, 10 | 5.3, 15 | 6.8, 19 | 6.4, 19 |
| 3656 | 108.37 | 21.38 | 3.4, 10 | 5.3, 15 | 7.2, 20 | 6.7, 20 |
| 3657 | 112.04 | 21.38 | 3.4, 10 | 5.4, 15 | 7.2, 20 | 7.1, 21 |
| 3658 | 115.71 | 21.38 | 3.4, 10 | 5.5, 16 | 7.6, 21 | 7.4, 22 |
| 3749 | 90.93 | 23.62 | 3.4, 10 | 5.3, 14 | 6.4, 18 | 6.0, 18 |
| 3750 | 94.64 | 23.62 | 3.4, 10 | 5.1, 15 | 6.4, 18 | 6.0, 18 |
| 3751 | 98.35 | 23.62 | 3.4, 10 | 5.1, 15 | 6.8, 19 | 6.4, 19 |
| 3752 | 102.06 | 23.62 | 3.4, 10 | 5.0, 14 | 6.8, 19 | 6.7, 20 |
| 3753 | 105.77 | 23.62 | 3.4, 10 | 5.1, 15 | 7.2, 20 | 6.7, 20 |
| 3754 | 109.48 | 23.62 | 3.4, 10 | 5.1, 15 | 7.6, 21 | 7.1, 21 |
| 3755 | 113.20 | 23.62 | 3.4, 10 | 5.4, 15 | 7.6, 21 | 7.4, 22 |

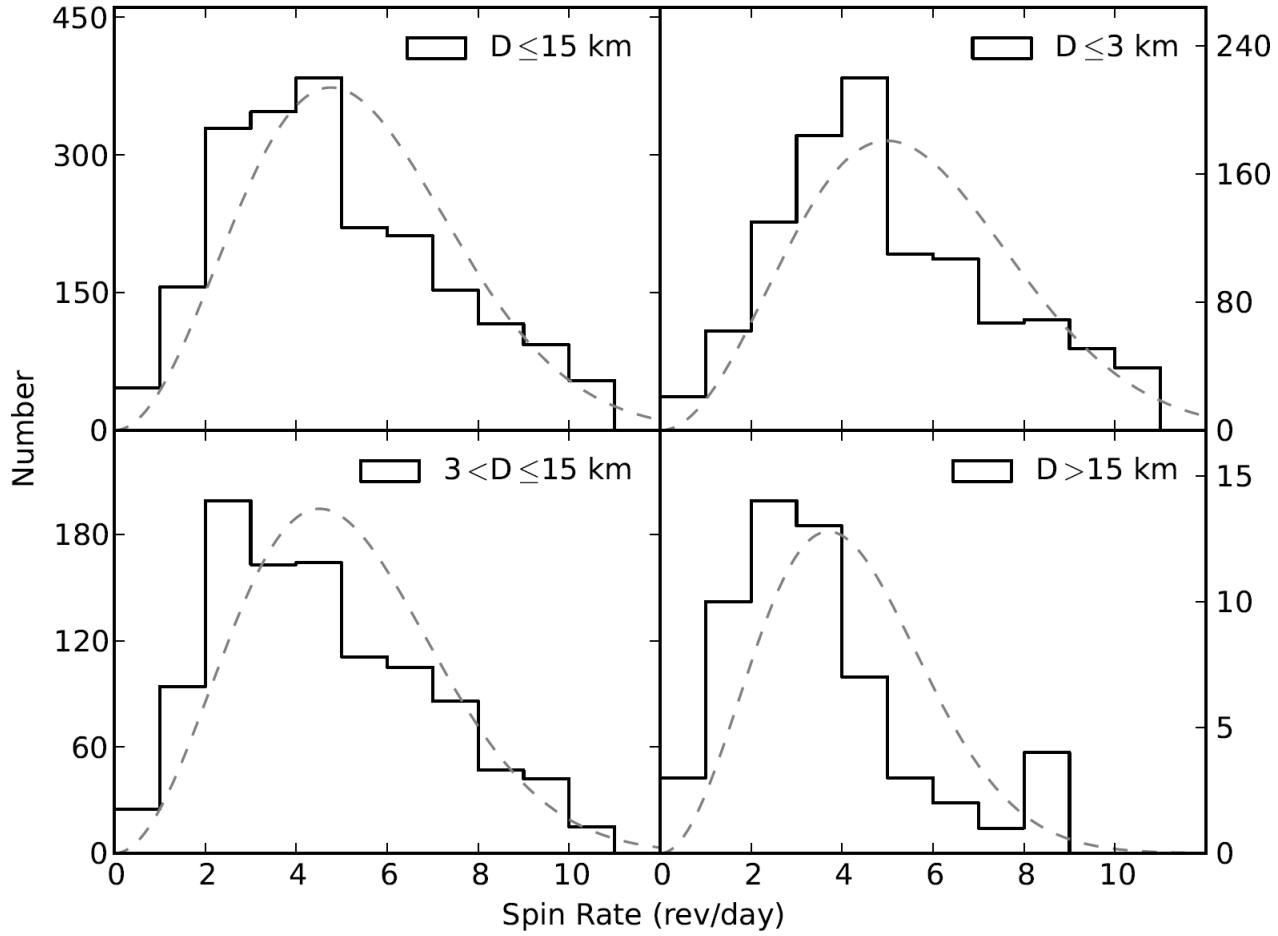
| Jan, 2014 | c. ) | | Jan 6 Δt, Nexp | Jan 7 Δt, Nexp | Jan 8 Δt, Nexp | Jan 9 Δt, Nexp |
|---|---|---|---|---|---|---|
| 3559 | 117.00 | 19.12 | 9.6, 28 | 9.8, 30 | 5.1, 16 | 9.7, 12 |
| 3560 | 120.60 | 19.12 | 9.7, 29 | 9.8, 30 | 5.1, 16 | 9.7, 12 |
| 3561 | 124.20 | 19.12 | 9.3, 28 | 9.4, 29 | 5.5, 17 | 9.6, 11 |
| 3562 | 127.80 | 19.12 | 9.3, 28 | 9.1, 28 | 5.5, 17 | 8.2, 11 |
| 3563 | 131.40 | 19.12 | 9.2, 28 | 8.8, 27 | 5.1, 16 | 8.2, 9 |
| 3564 | 135.00 | 19.12 | 8.9, 27 | 8.7, 27 | 5.1, 16 | 8.2, 9 |
| 3565 | 138.60 | 19.12 | 8.5, 26 | 8.4, 26 | 5.1, 16 | 7.8, 8 |
| 3658 | 115.71 | 21.38 | 9.7, 29 | 9.8, 30 | 5.1, 16 | 9.7, 10 |
| 3659 | 119.39 | 21.38 | 9.7, 28 | 9.8, 30 | 5.1, 16 | 9.8, 10 |
| 3660 | 123.06 | 21.38 | 9.6, 29 | 9.4, 29 | 5.1, 16 | 10.0, 11 |
| 3661 | 126.73 | 21.38 | 9.3, 28 | 9.5, 29 | 5.1, 16 | 9.8, 10 |
| 3662 | 130.41 | 21.38 | 9.3, 28 | 9.1, 28 | 5.1, 16 | 7.8, 9 |

| Feb, 2014 | | | Feb 20 Δt, Nexp | Feb 21 Δt, Nexp | Feb 22 Δt, Nexp | Feb 23 Δt, Nexp |
|---|---|---|---|---|---|---|
| 3158 | 143.65 | 10.12 | 7.9, 19 | 7.6, 22 | 7.9, 22 | 7.2, 20 |
| 3159 | 147.12 | 10.12 | 8.0, 17 | 7.3, 20 | 7.9, 21 | 7.7, 22 |
| 3160 | 150.58 | 10.12 | 7.6, 18 | 7.7, 21 | 7.7, 22 | 7.7, 22 |
| 3161 | 154.04 | 10.12 | 8.0, 20 | 8.0, 22 | 7.9, 23 | 7.9, 23 |
| 3162 | 157.50 | 10.12 | 8.3, 20 | 7.9, 22 | 8.0, 24 | 7.9, 23 |
| 3163 | 160.96 | 10.12 | 8.0, 19 | 7.8, 22 | 8.0, 24 | 8.0, 24 |
| 3261 | 141.55 | 12.38 | 7.7, 20 | 7.6, 21 | 8.2, 23 | 7.1, 20 |
| 3262 | 145.05 | 12.38 | 8.1, 20 | 7.9, 23 | 8.2, 23 | 7.5, 20 |
| 3263 | 148.54 | 12.38 | 8.2, 20 | 7.6, 22 | 8.1, 23 | 7.7, 21 |
| 3264 | 152.04 | 12.38 | 7.9, 20 | 8.0, 23 | 8.2, 24 | 8.2, 24 |
| 3265 | 155.53 | 12.38 | 8.7, 19 | 8.0, 22 | 8.1, 24 | 8.2, 23 |
| 3266 | 159.03 | 12.38 | 8.0, 21 | 8.2, 23 | 8.1, 25 | 8.2, 24 |

# ~2,220 Good Rotation Periods

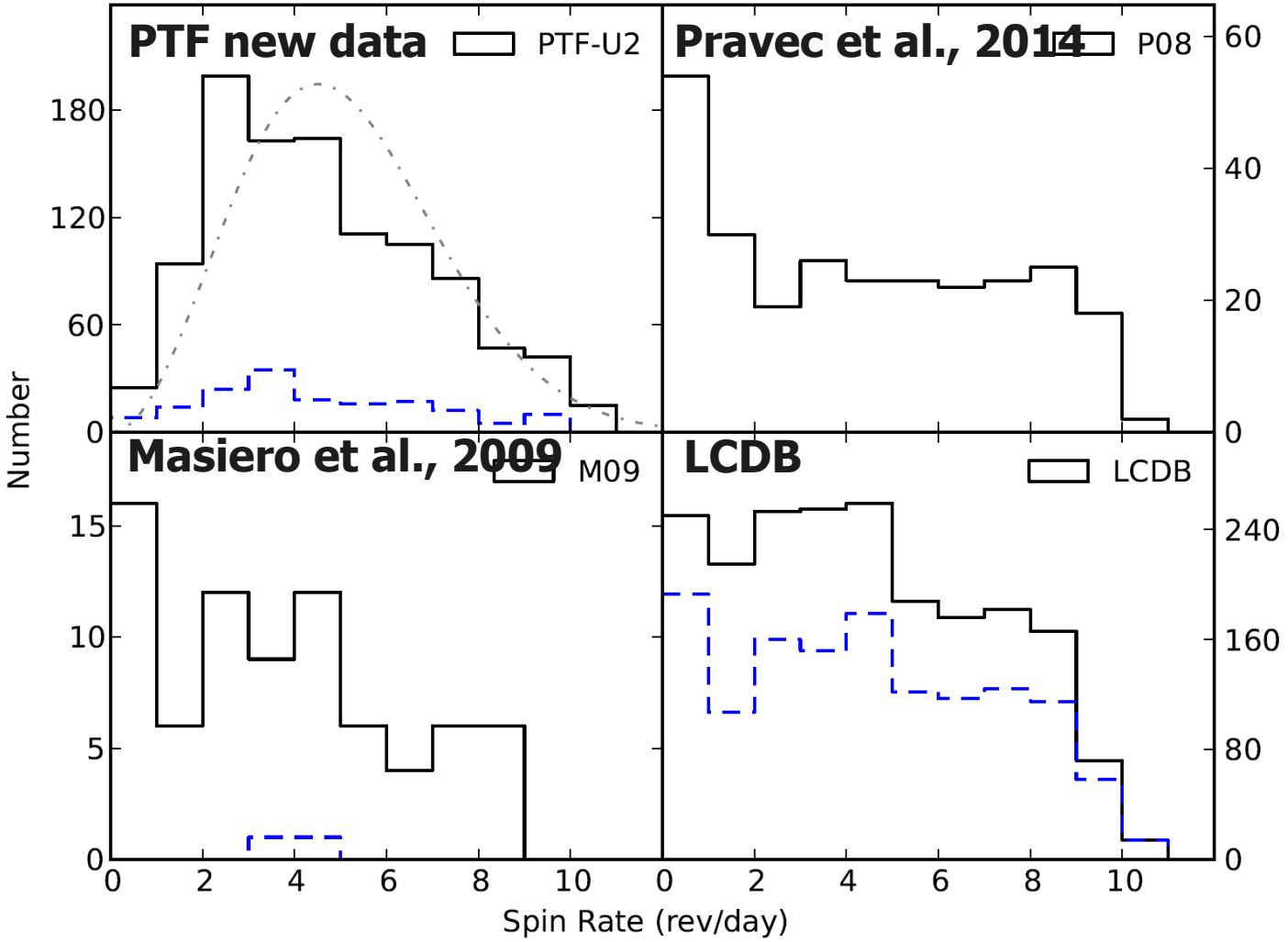


# The PTF Spin Rate Distribution vs Diameters

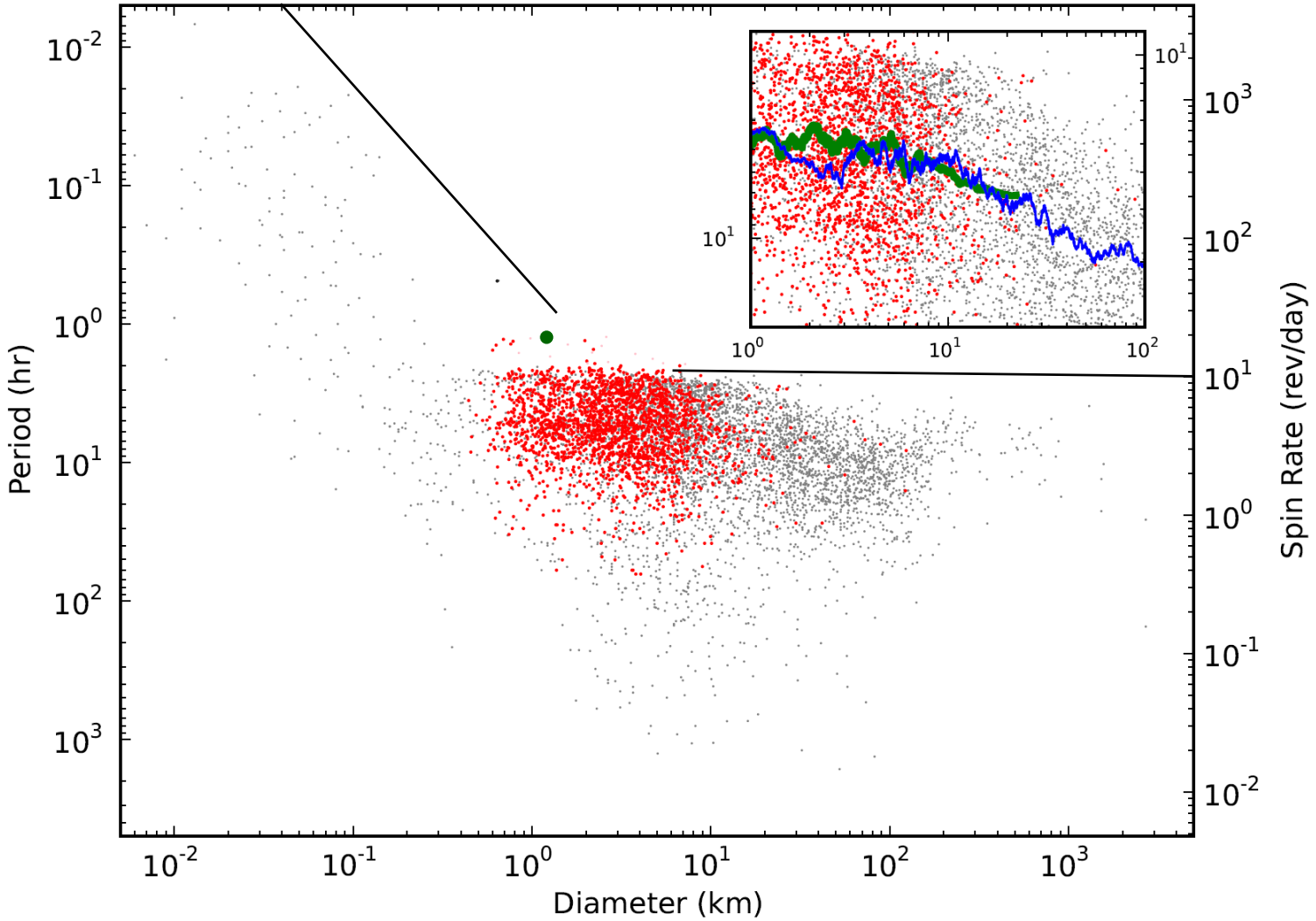



**Deviated-Maxwellian at small asteroids.**

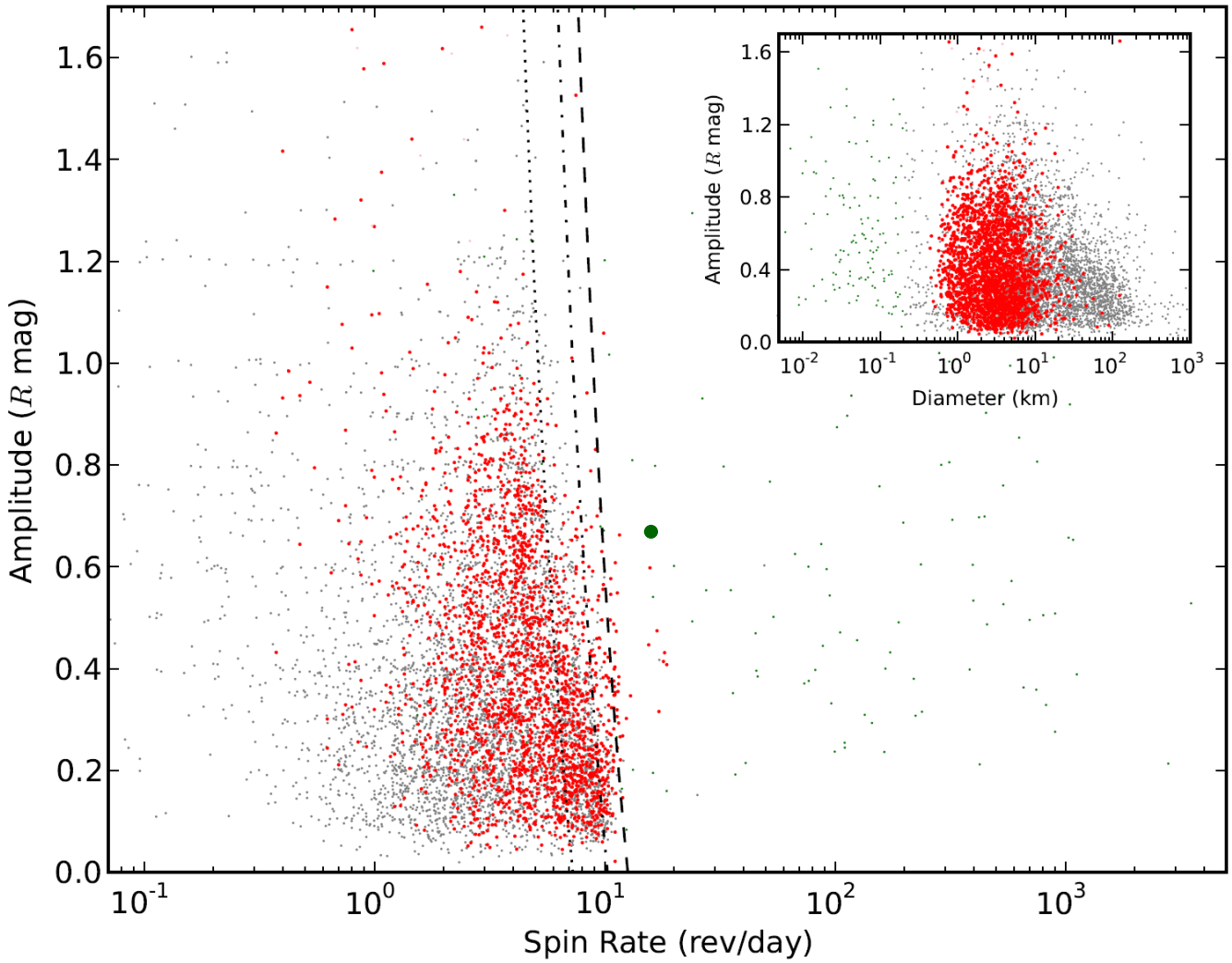
# The PTF Spin Rate Distribution comparing w/ others



# The Spin Rate Limit – PTF (1)

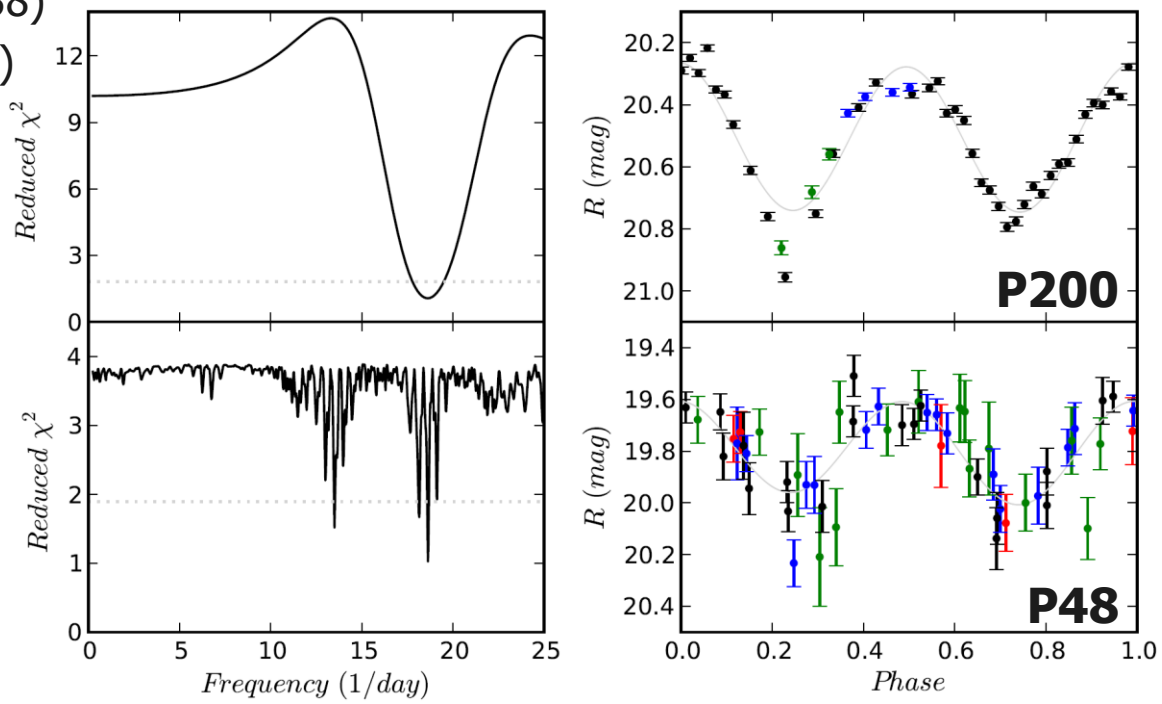


# The Spin Rate Limit – PTF(2)



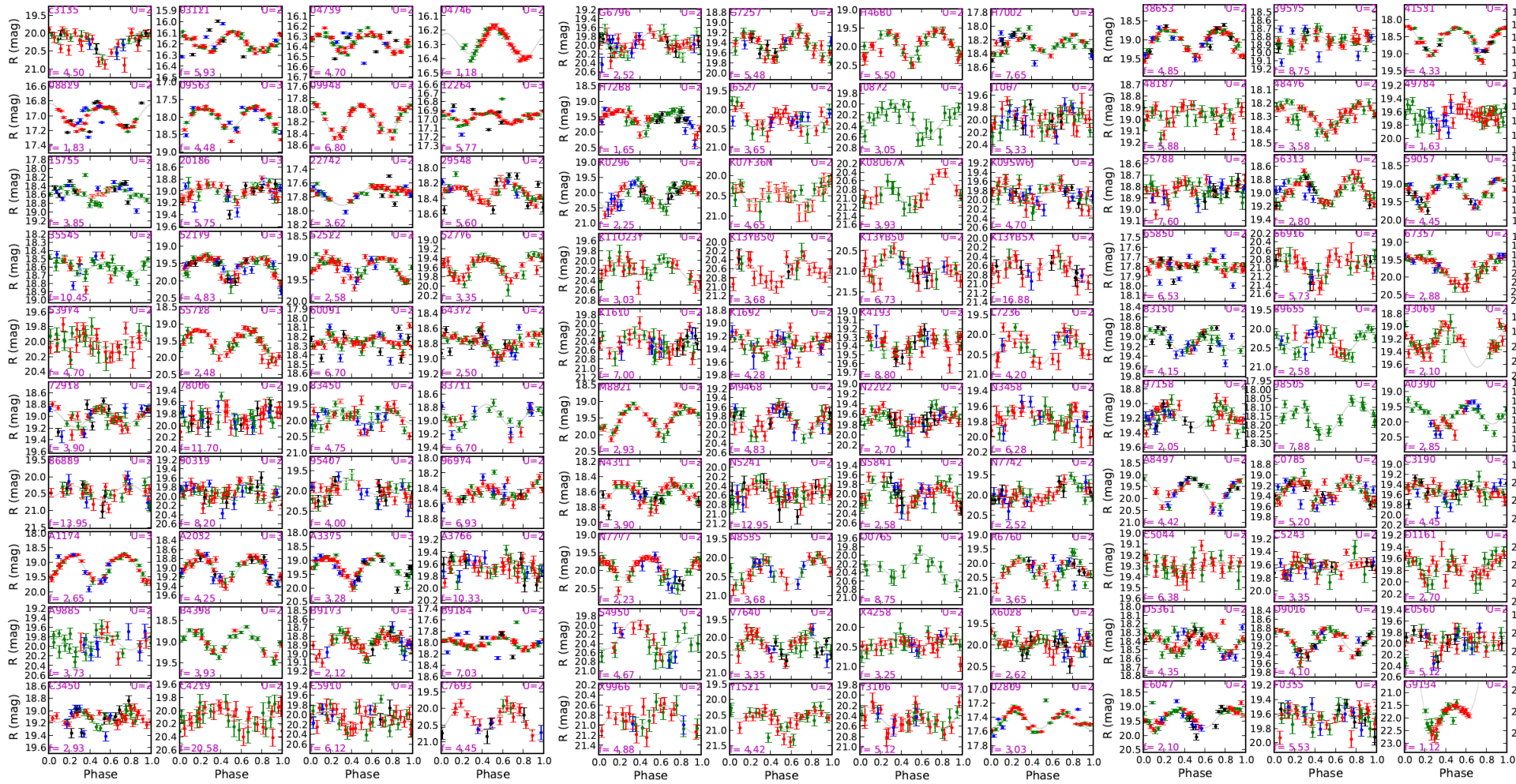
# The sub-km Super-Fast-Rotator

- **The PTF super-fast-rotator**
  - A S-type main belt asteroid
  - D ~ 0.8 km
  - P = 1.29 hours (f = 18.6 rev/day)
  - A ~ 0.7 R mag (b/a ~ 1.38)
  - Density ~ 6 g/cm$^3$ (metal)
  - A huge monolithic object
    (2x Taipei 101)
    (4x TF running track)

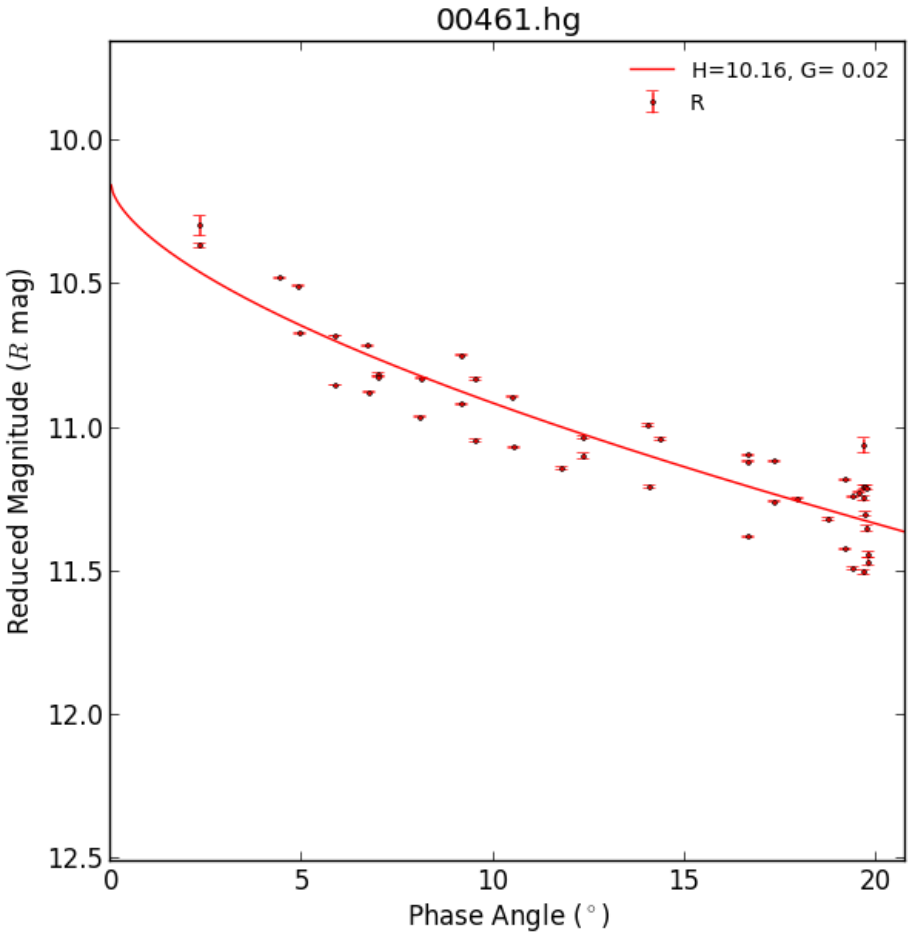


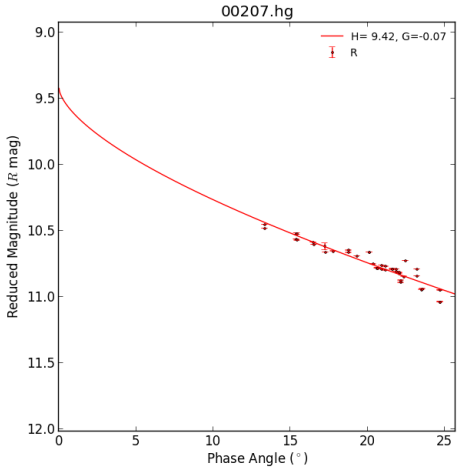
# The sub-km Super-Fast-Rotator

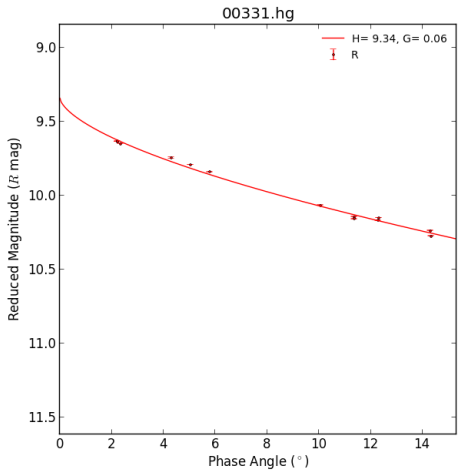
# Thanks .....

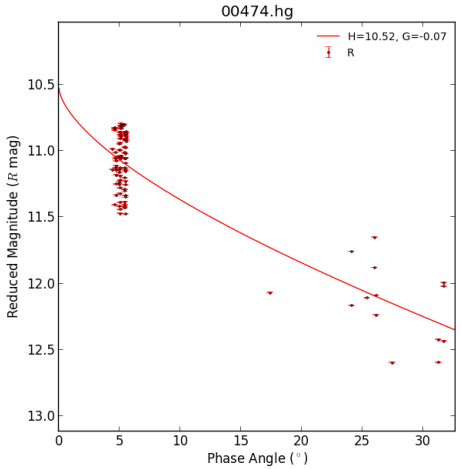


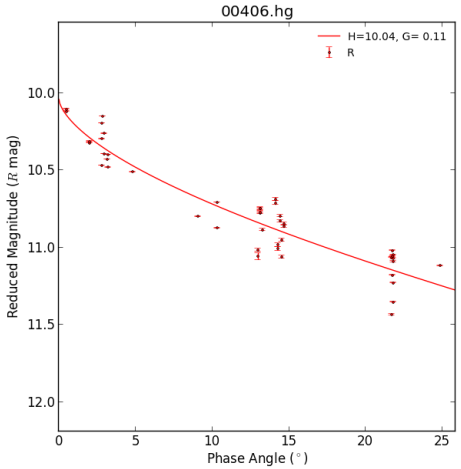
# The H-G Relation



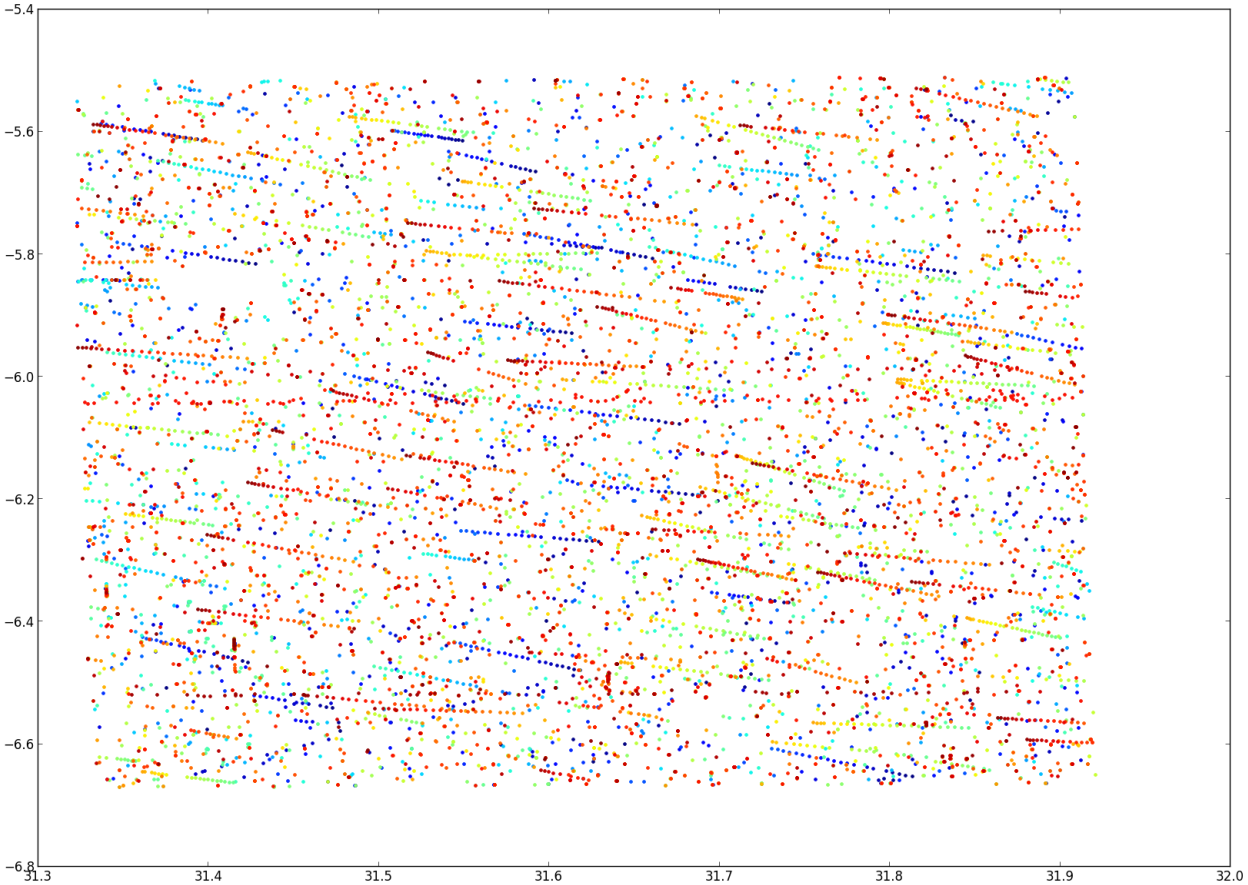



# The Moving Object Pipeline

**Using the "Hough Transfer" to link detections belonging to the same "line"**




**Field 3266, CCD 0, Feb 20-21, 2014**

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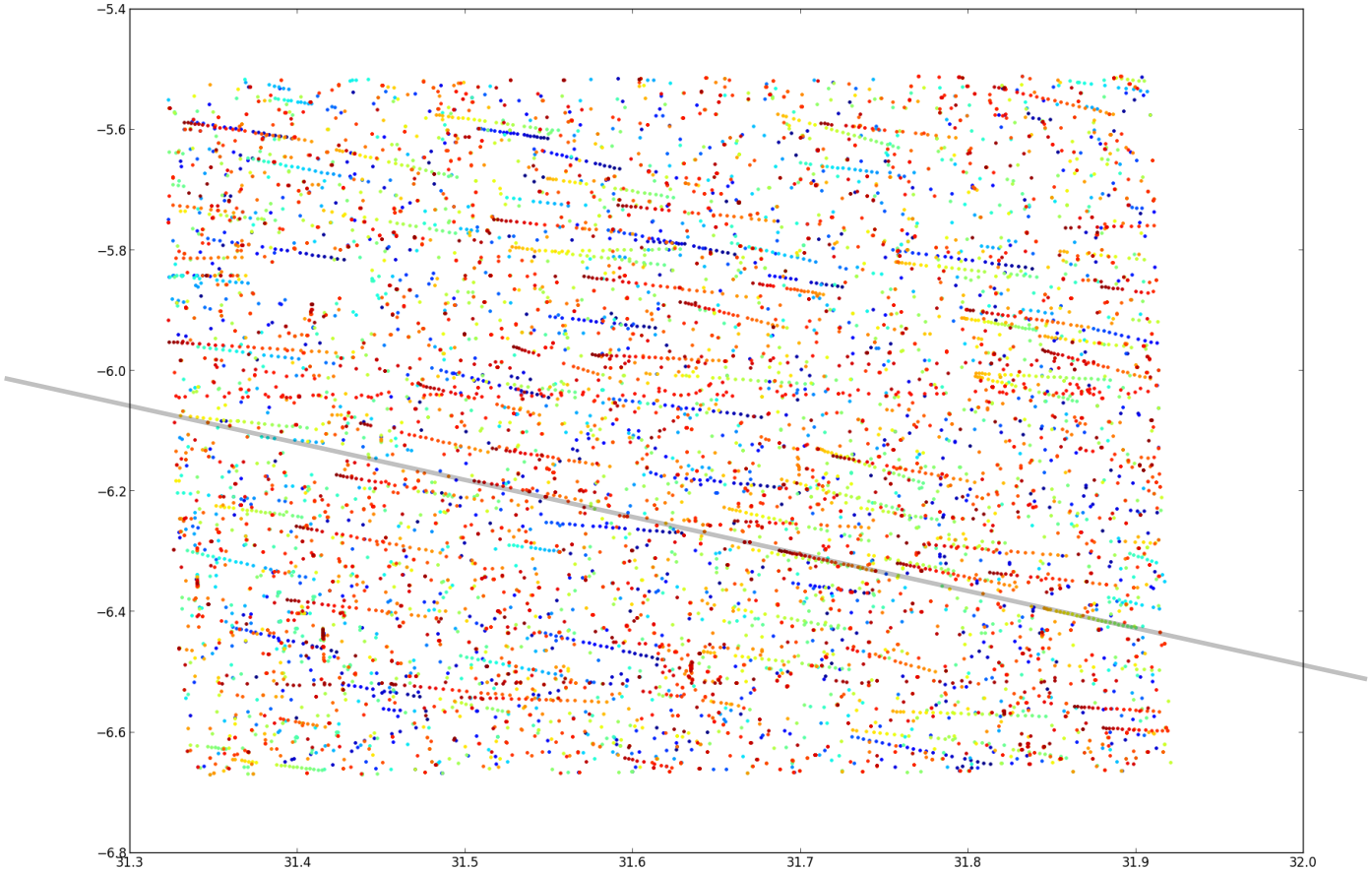
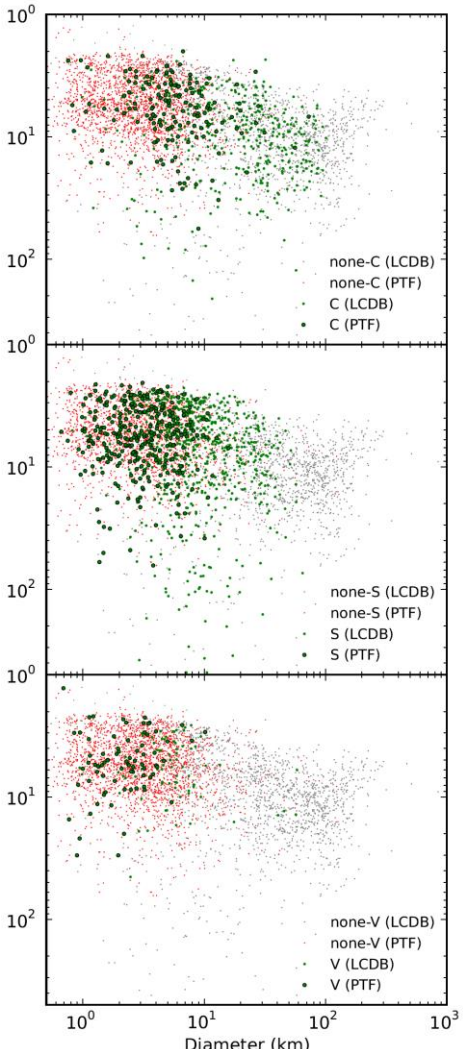
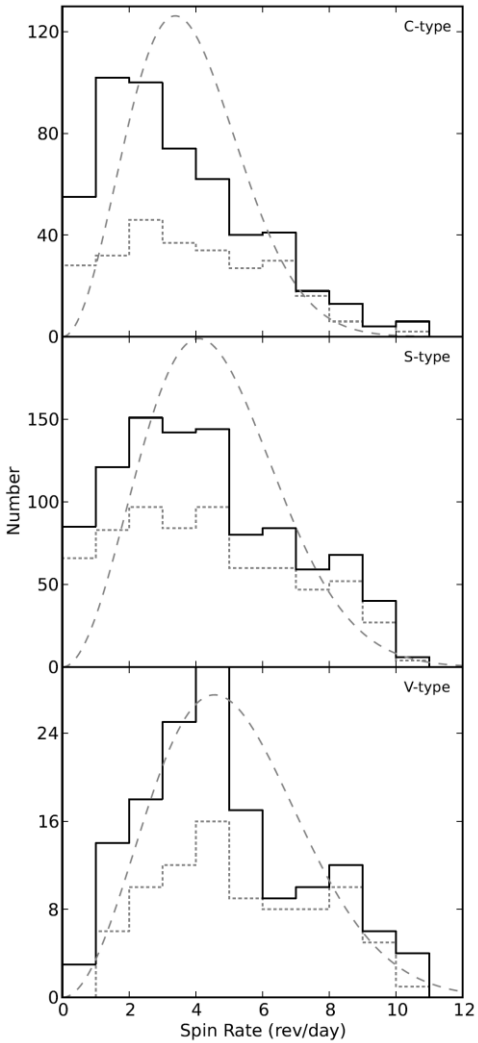
**Using the "Hough Transfer" to link detections belonging to the same "line"**




**Field 3266, CCD 0, Feb 20-21, 2014**

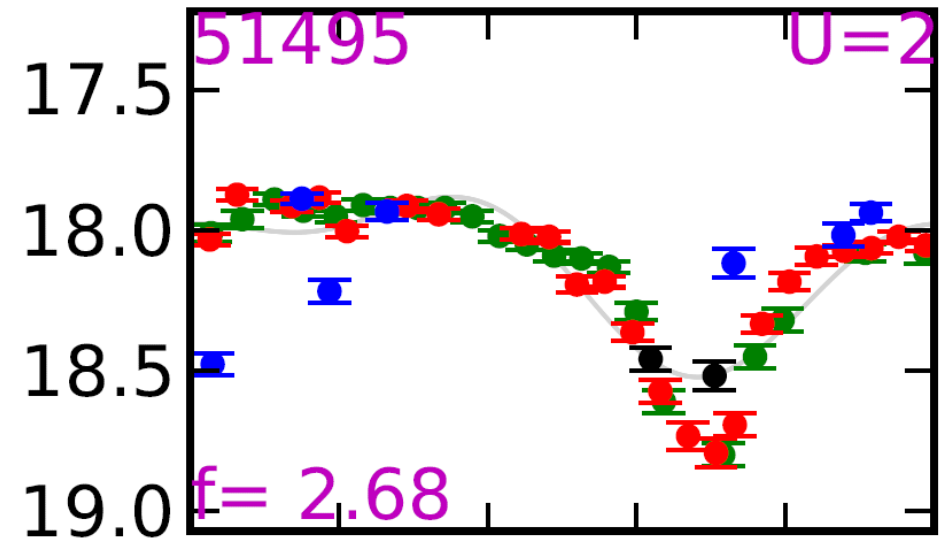
# Spin Rate vs Taxonomy

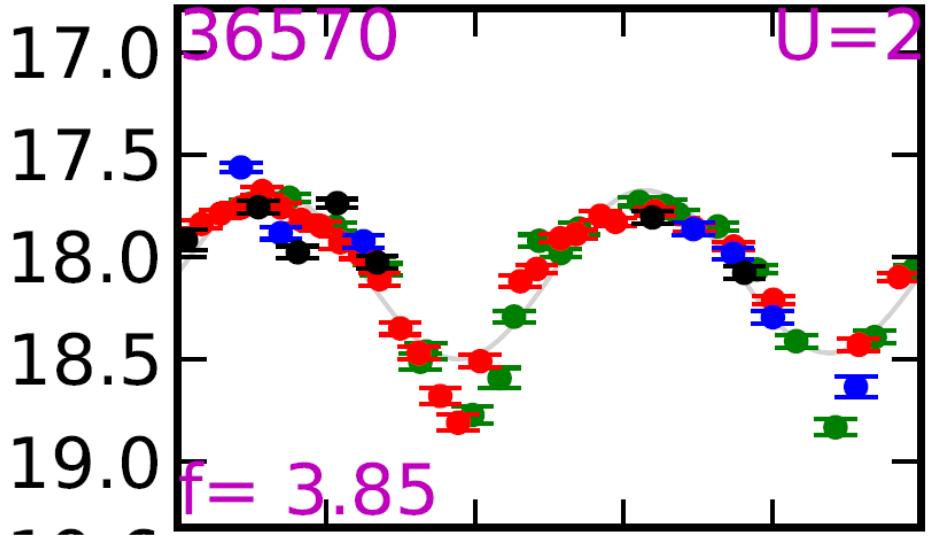


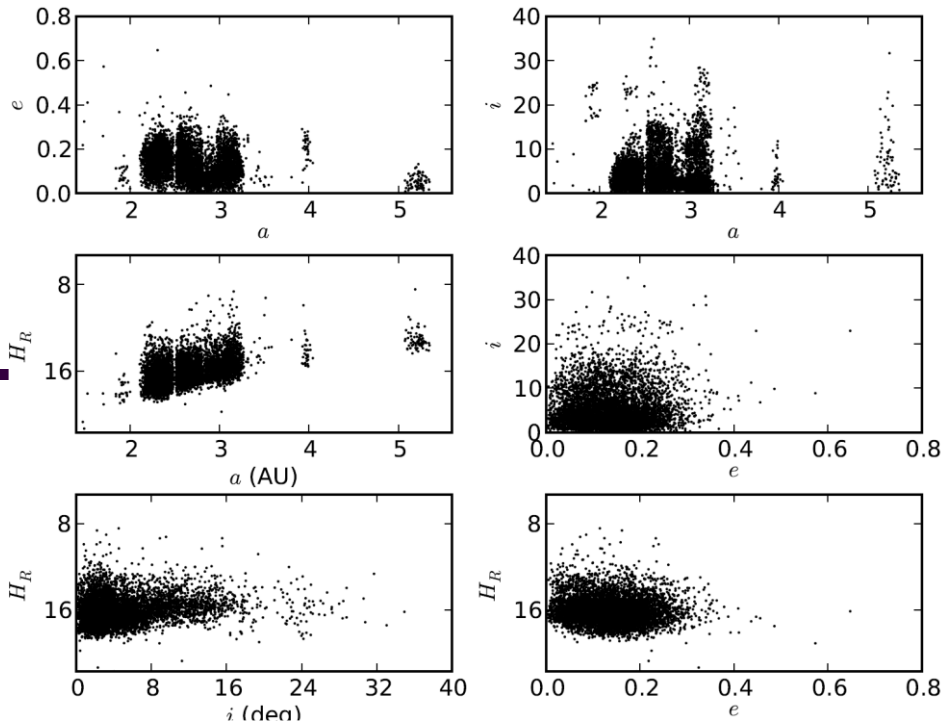



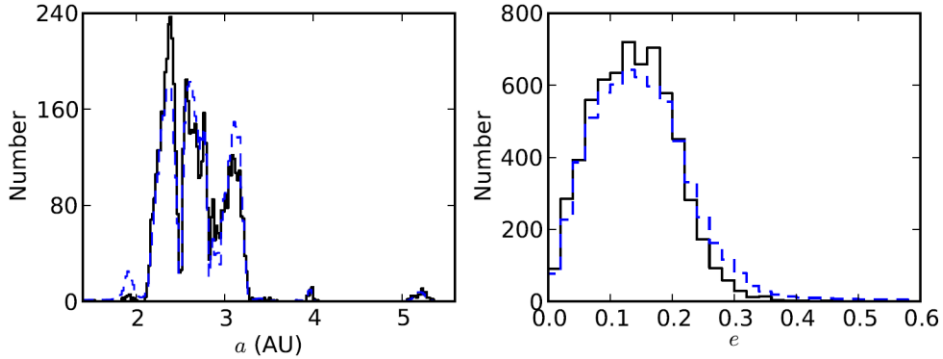
# Binary Asteroid

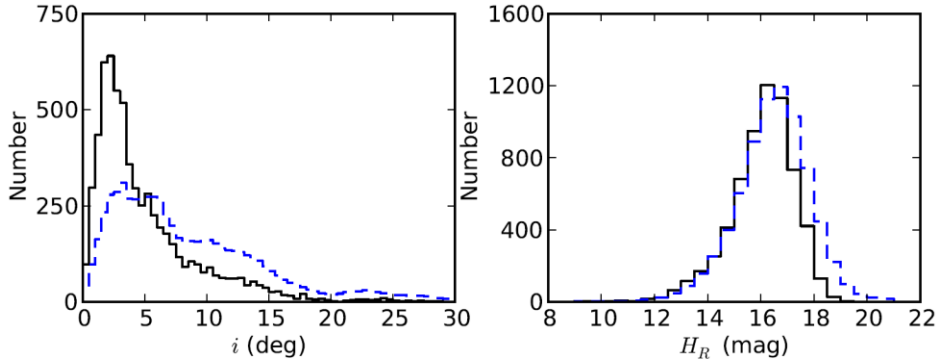
- **Binary asteroids** (e.g. Polishook, Brosch & Prialnik 2011)
  - Deep V-shaped minima and wide inverted-U-shaped maxima (Pravec et al., 2006)
  - Determination of the mass and/or density of the asteroids (Gnat & Sari, 2010)
  - Fractions in different environments to reveal formation model

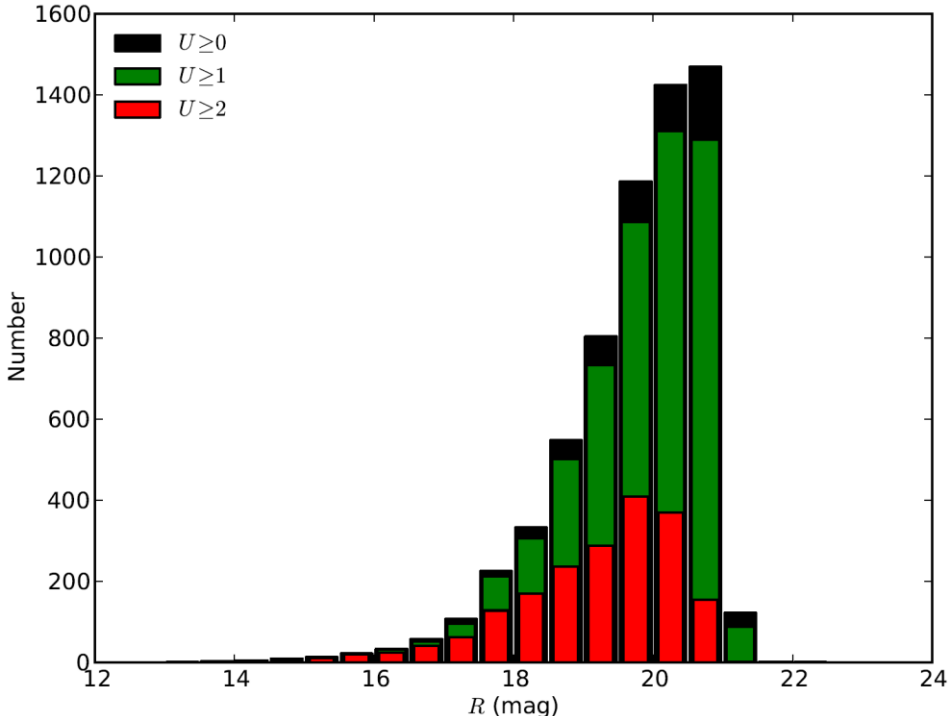



e
a
i
a
$H_R$
a (AU)
i
e
$H_R$
i (deg)
$H_R$
e


Number
a (AU)
Number
e


Number
i (deg)
Number
$H_R$ (mag)


$U \geq 0$
$U \geq 1$
$U \geq 2$
Number
R (mag)

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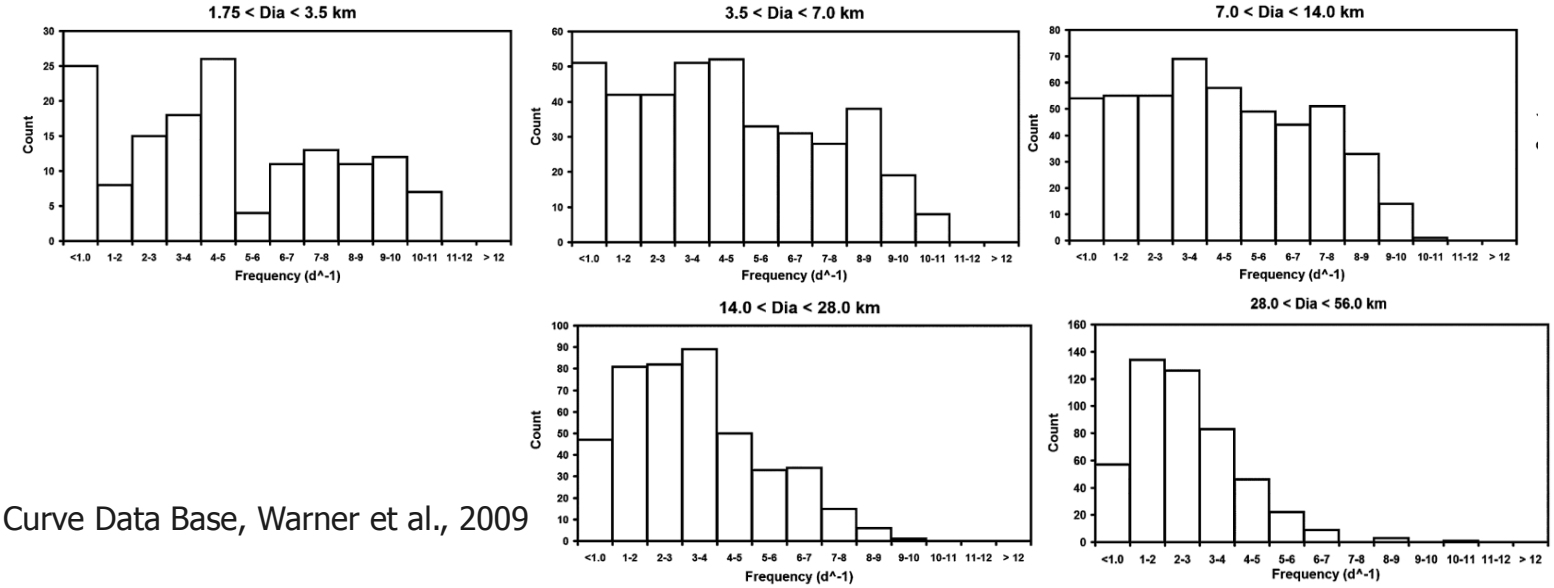


Light Curve Data Base, Warner et al., 2009