NEO Lightcurves from the Mission Accessible Near-Earth Object Survey (MANOS)

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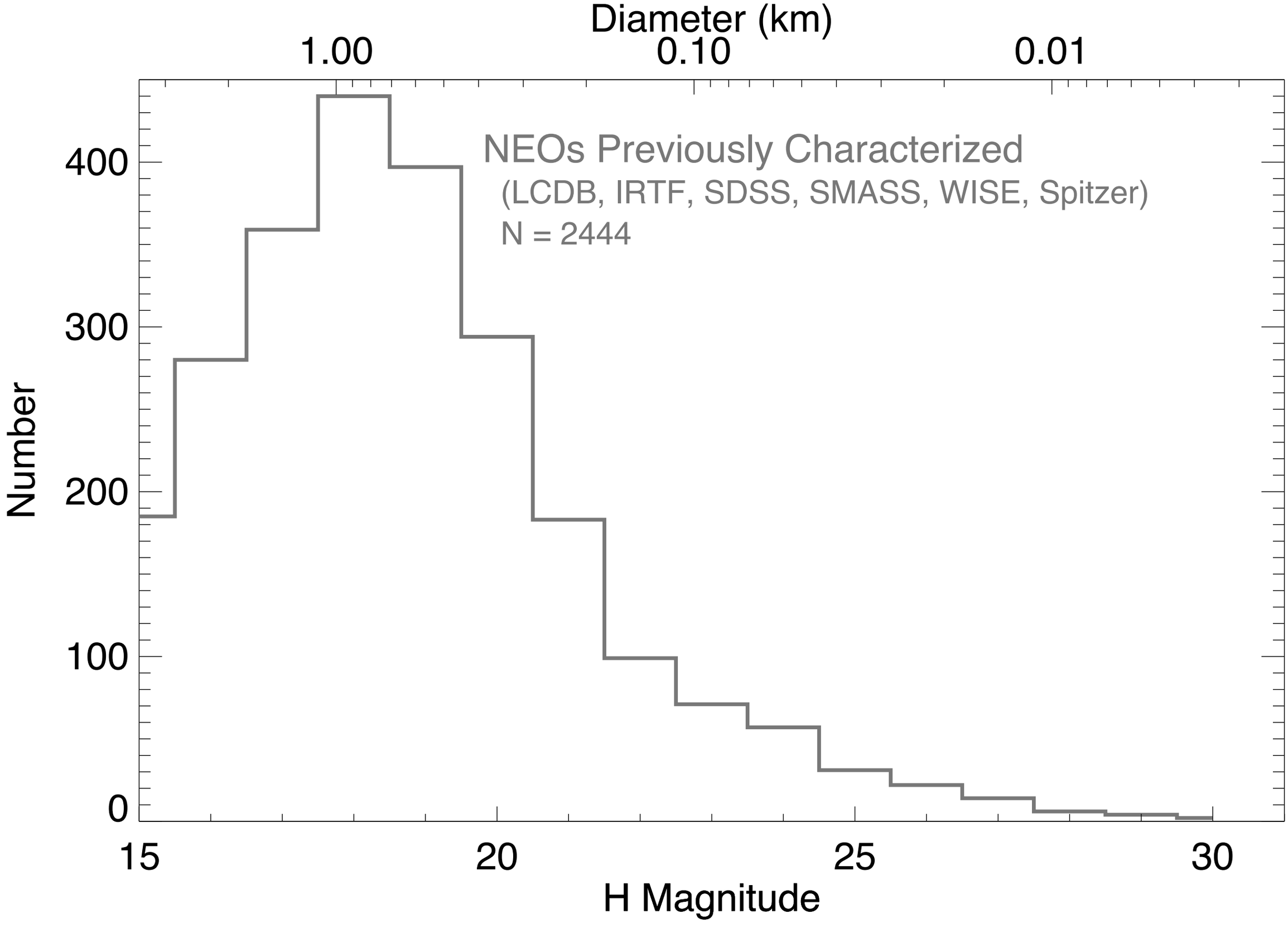
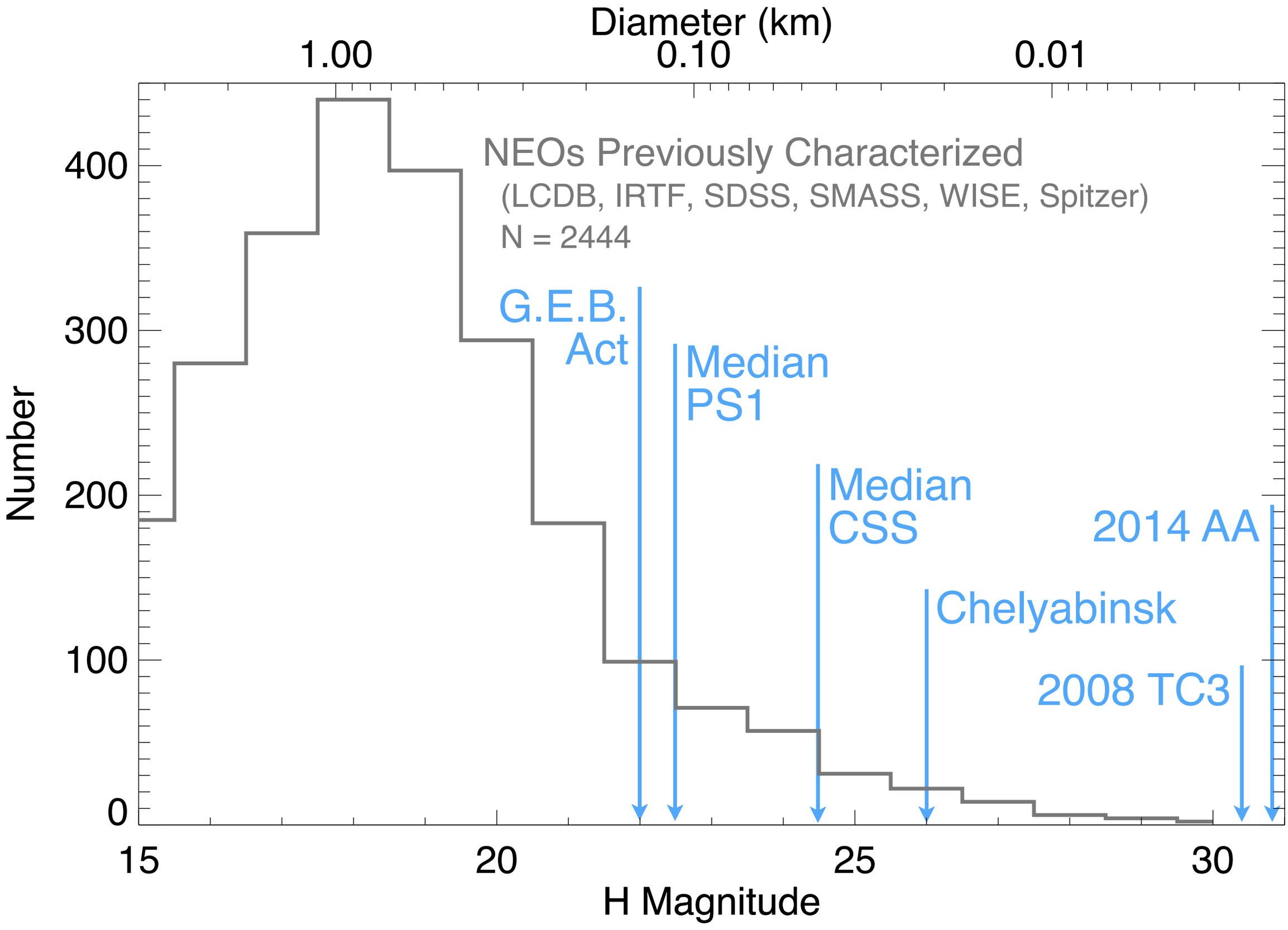
Didymos Observers Workshop
19 June 2018

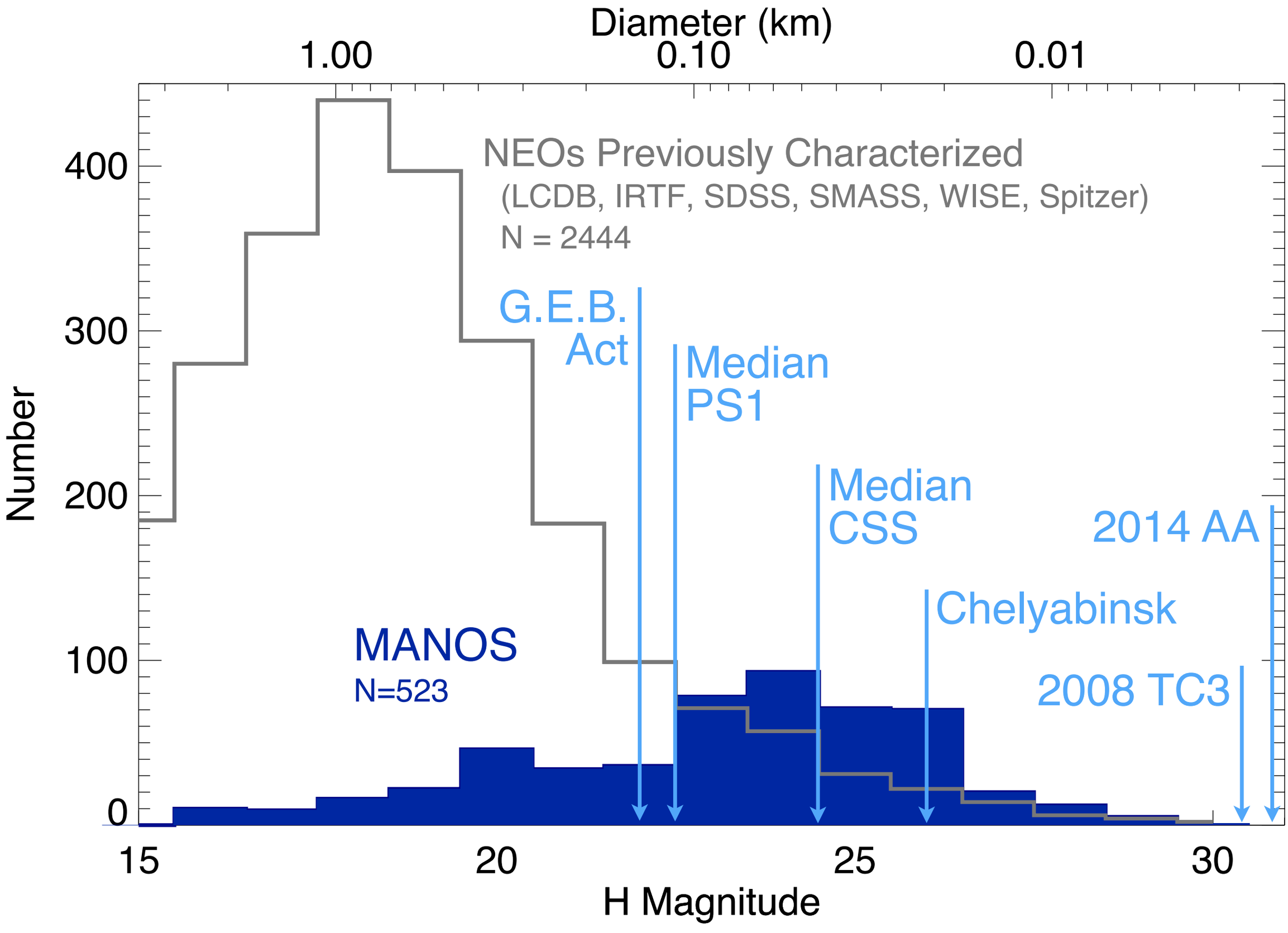
what is MANOS?

- **Physical characterization survey** of NEOs
  - *astrometry, photometry, spectroscopy*
- **Targets:** $\Delta v < 7$ km/s, $H > 22$, $V < 22$
  ~10% newly discovered NEOs
- **Assets:** Lowell DCT, Gemini N+S, SOAR, KP4m, IRTF
  ~6 nights / month (remote, queue, classical)

- **MANOS v1** *(2014-2017)*, **MANOS v2** *(2017-2020)*
  - >600 objects observed
  - *manos.lowell.edu*


Diameter (km)
1.00
0.10
0.01
NEOs Previously Characterized
(LCDB, IRTF, SDSS, SMASS, WISE, Spitzer)
N = 2444
Number
400
300
200
100
0
15
20
25
30
H Magnitude


Diameter (km)
1.00
0.10
0.01
NEOs Previously Characterized
(LCDB, IRTF, SDSS, SMASS, WISE, Spitzer)
N = 2444
G.E.B.
Act
Median
PS1
Median
CSS
2014 AA
Chelyabinsk
2008 TC3
Number
400
300
200
100
0
15
20
25
30
H Magnitude


Diameter (km)
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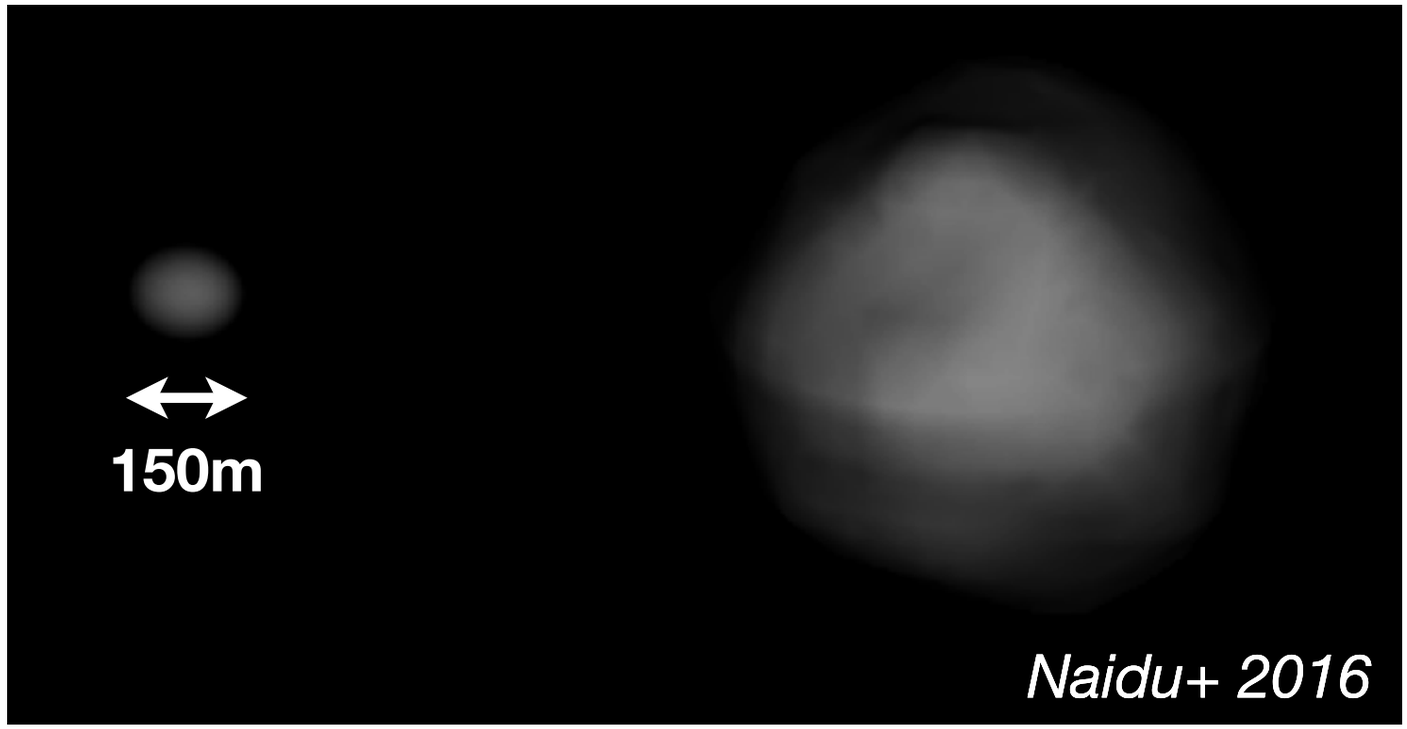
NEOs Previously Characterized
(LCDB, IRTF, SDSS, SMASS, WISE, Spitzer)
N = 2444
G.E.B.
Act
Median
PS1
Median
CSS
2014 AA
Chelyabinsk
2008 TC3
MANOS
N=523
Number
400
300
200
100
0
15
20
25
30
H Magnitude

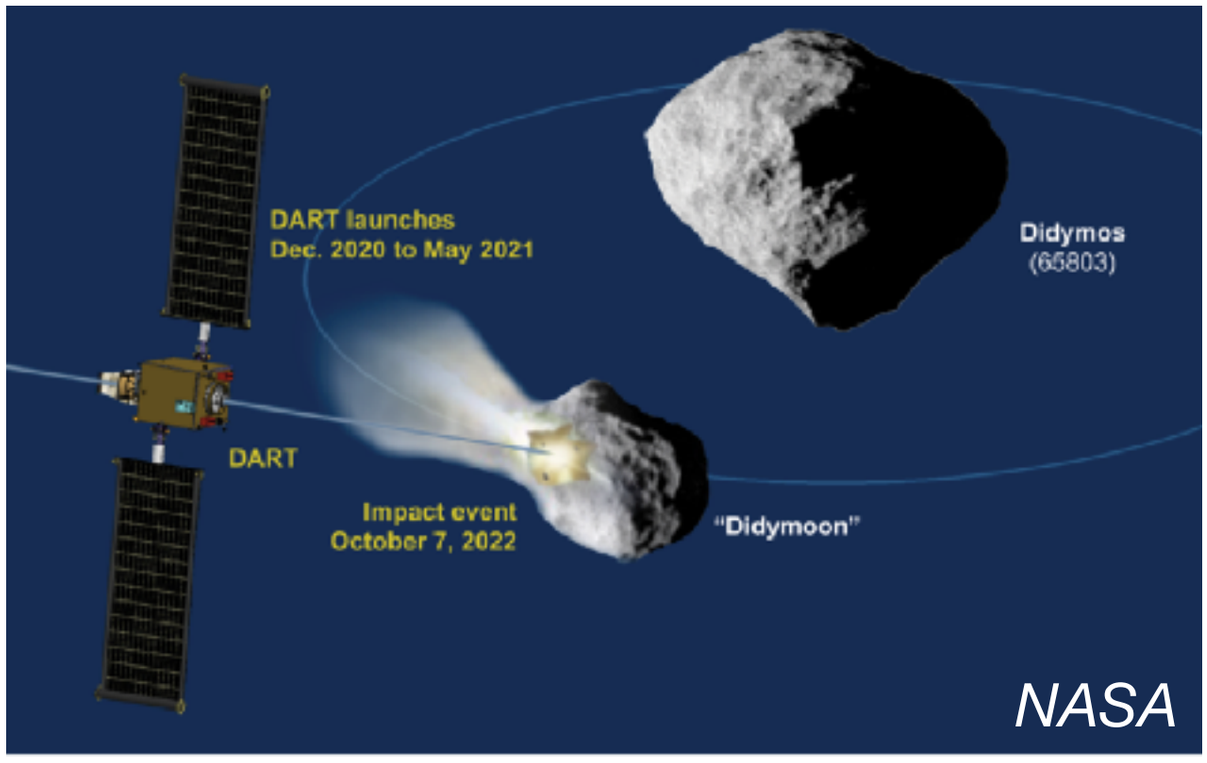
relevance to Didymos

- MANOS targets comparable in size to Didymoon



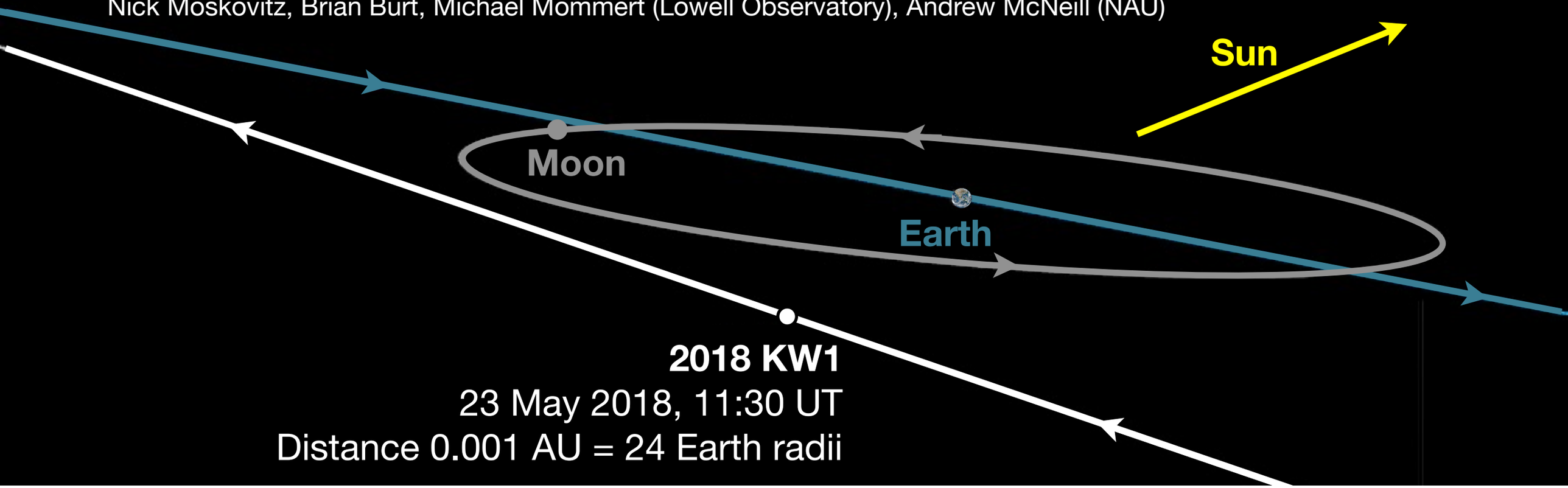
- Didymos is amongst the most spacecraft accessible of known NEO binaries (Δv = 5.1 km/s)

- *DART = impact mitigation test*. An actual impactor will be an object like the MANOS targets.

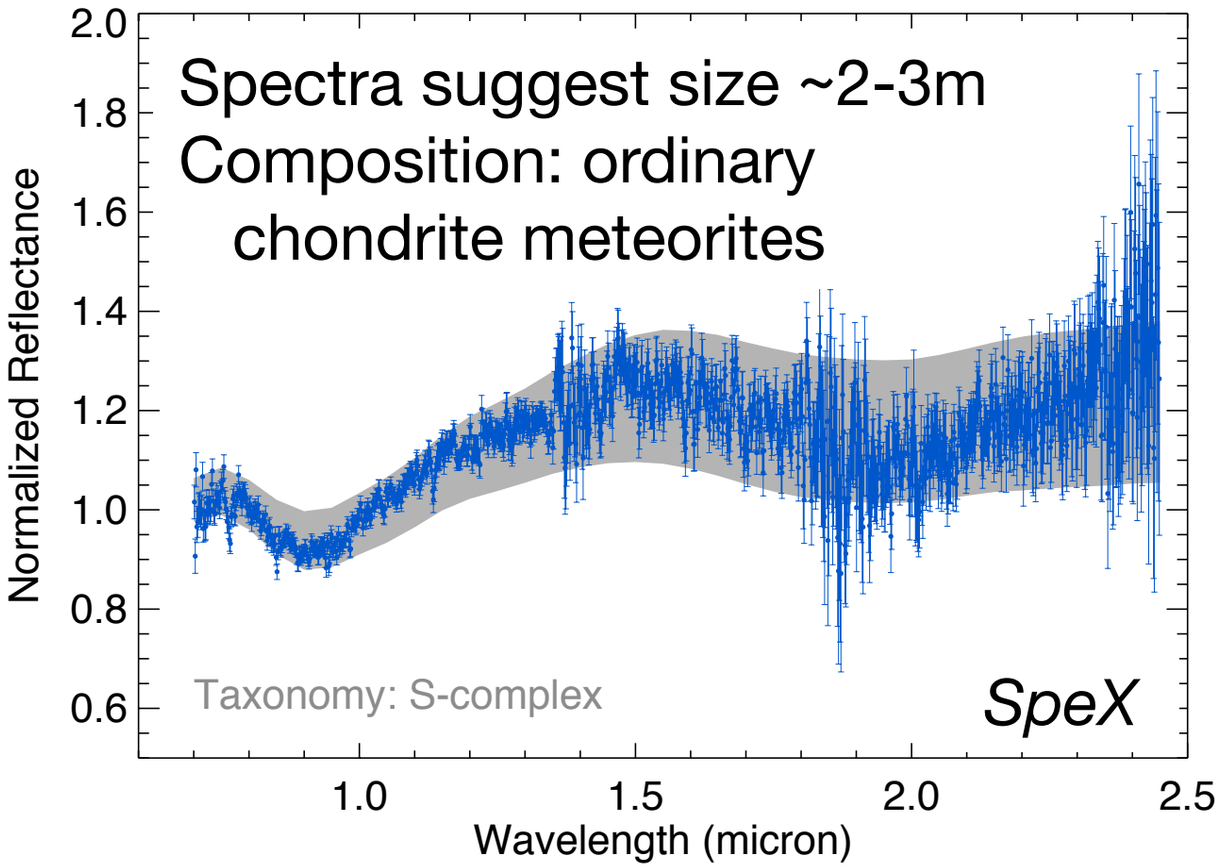


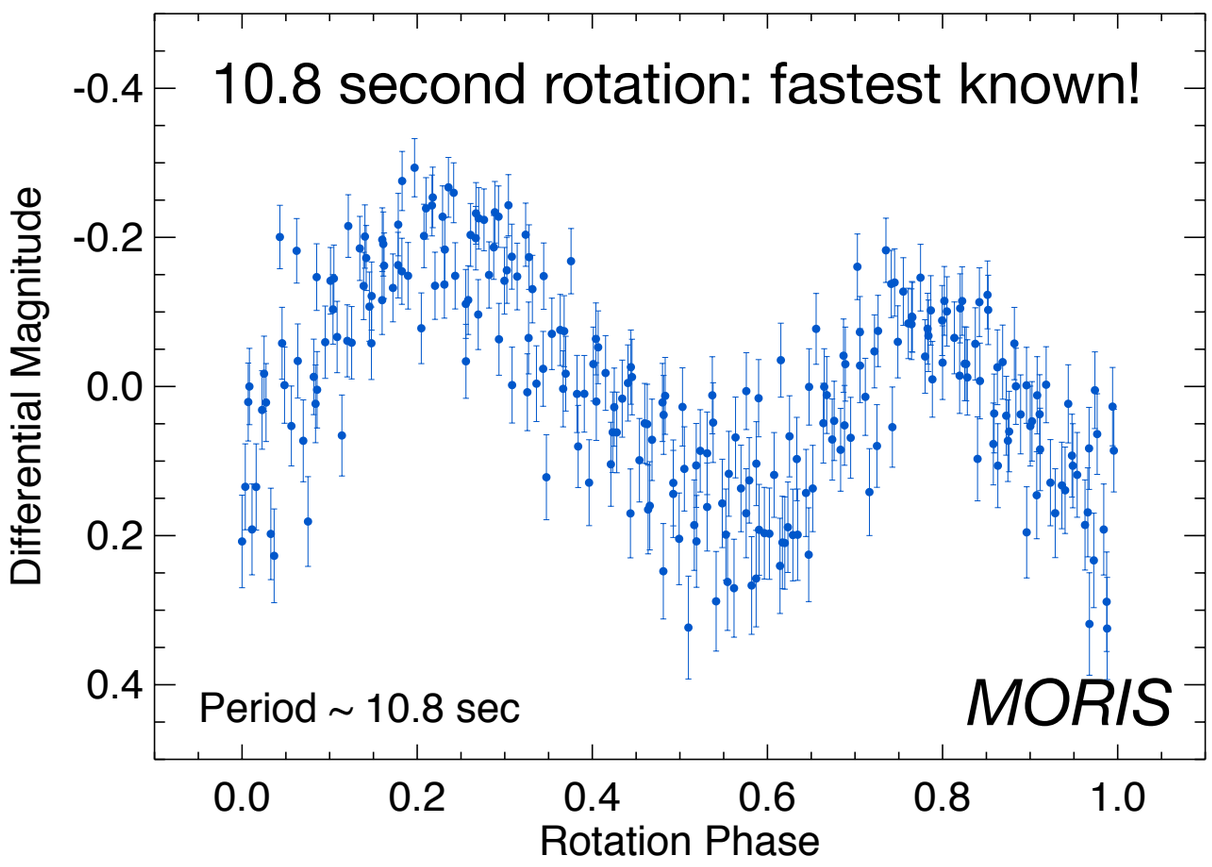
IRTF Response to Near-Earth Flyby of 2018 KW1

Nick Moskovitz, Brian Burt, Michael Mommert (Lowell Observatory), Andrew McNeill (NAU)



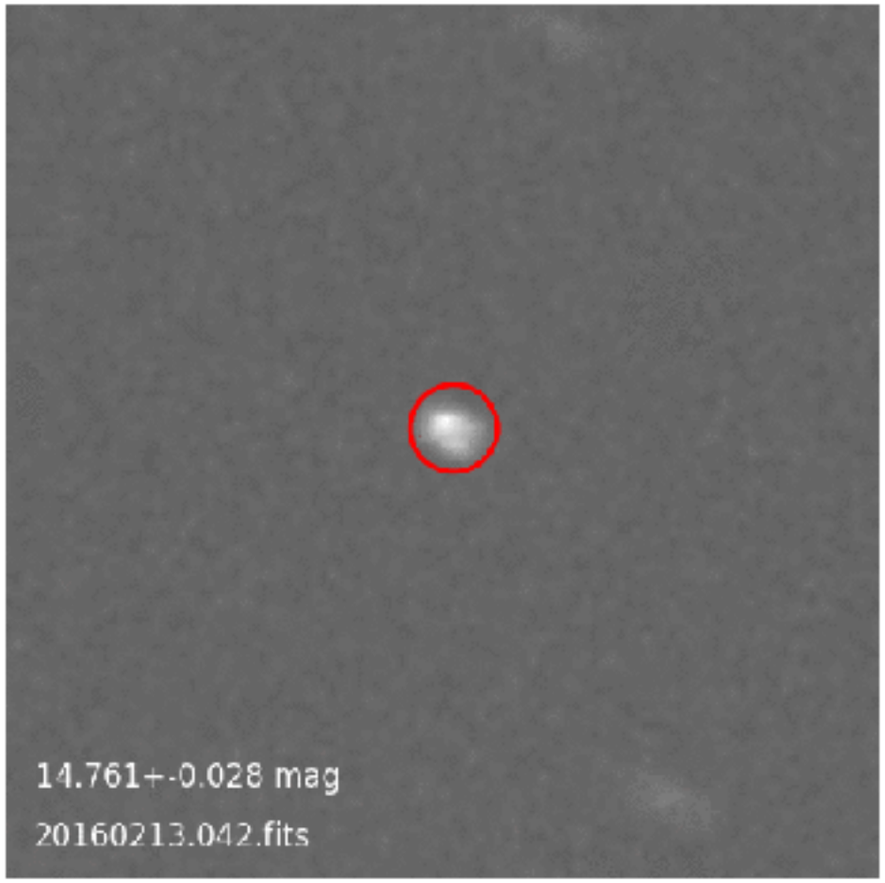
If impactor, energy would have been ~1 kT. Spectral data reduce energy uncertainty ~8x.

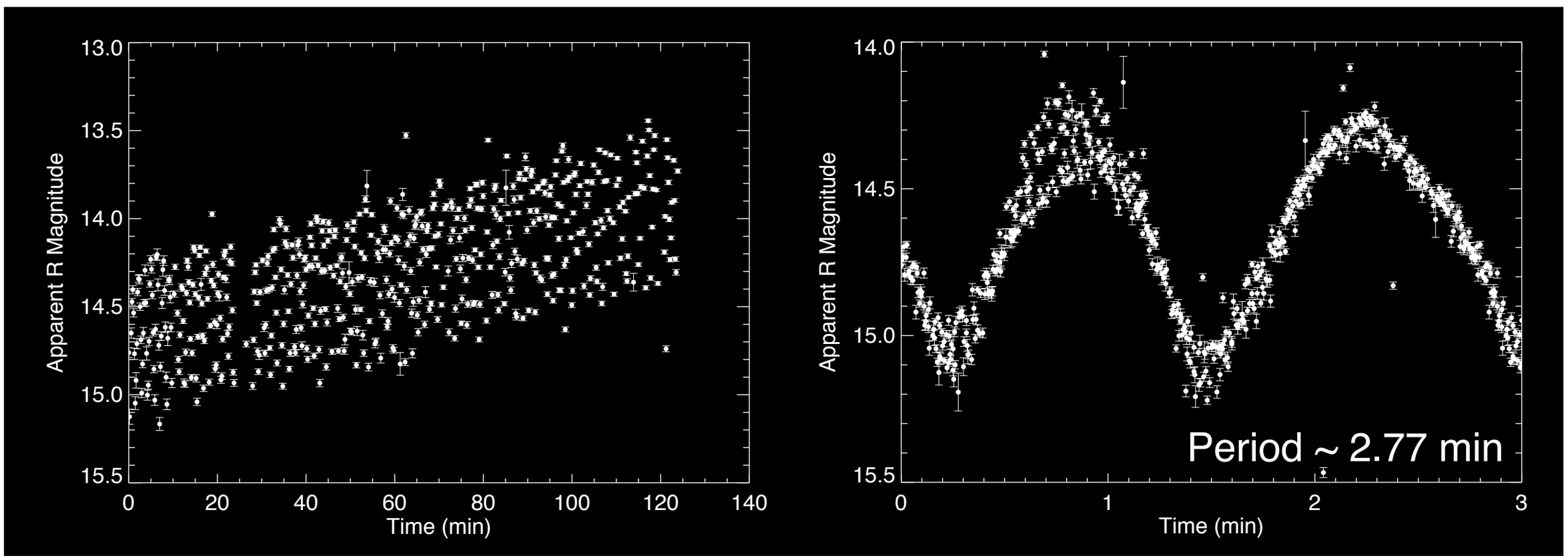




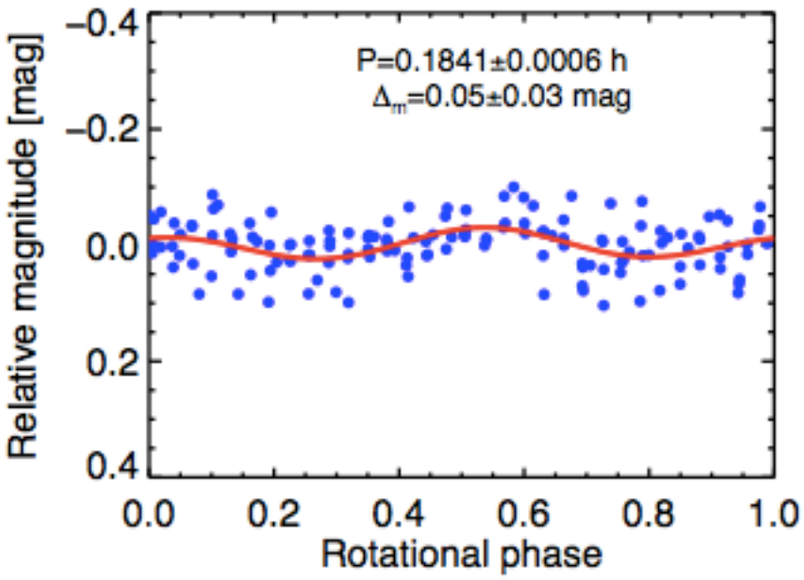
photometry pipeline

- Developed in Python by **Michael Mommert (Lowell)**
- Open source: *github.com/mommermi/photometrypipeline*
- Auto WCS registration (Gaia): σ_{ast} **~ 0.1”**
- Auto curve of growth analysis
- Auto photometric calibration (Pan-STARRS, SDSS, URAT-1, 2MASS): σ_{phot} **< 0.05 mag**
- Auto target identification

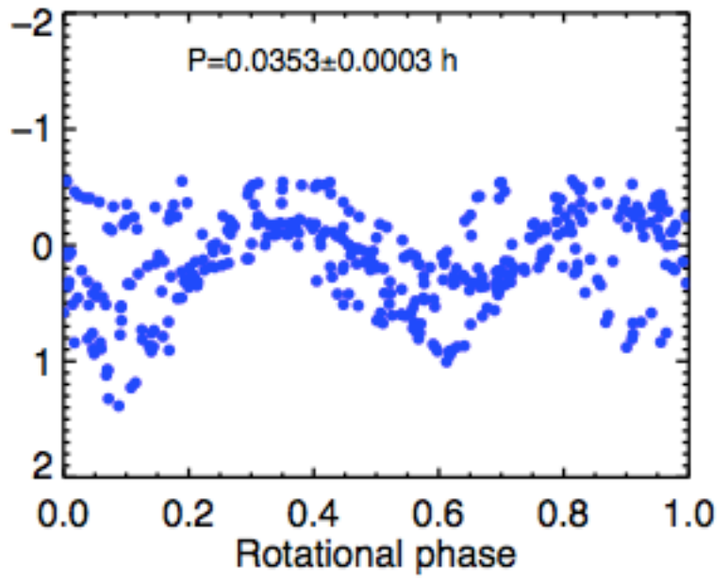




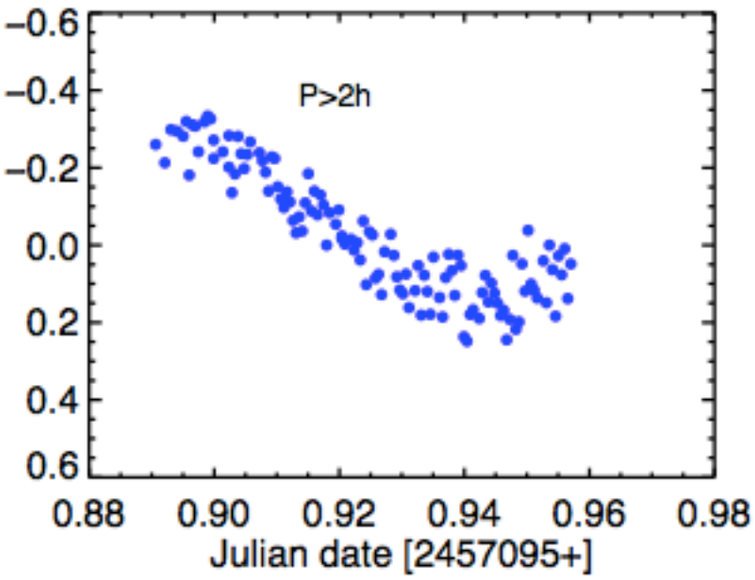
2015 CF, DCT/LMI



2015 CG, DCT/LMI



2015 ET, MAYALL/MOSAIC



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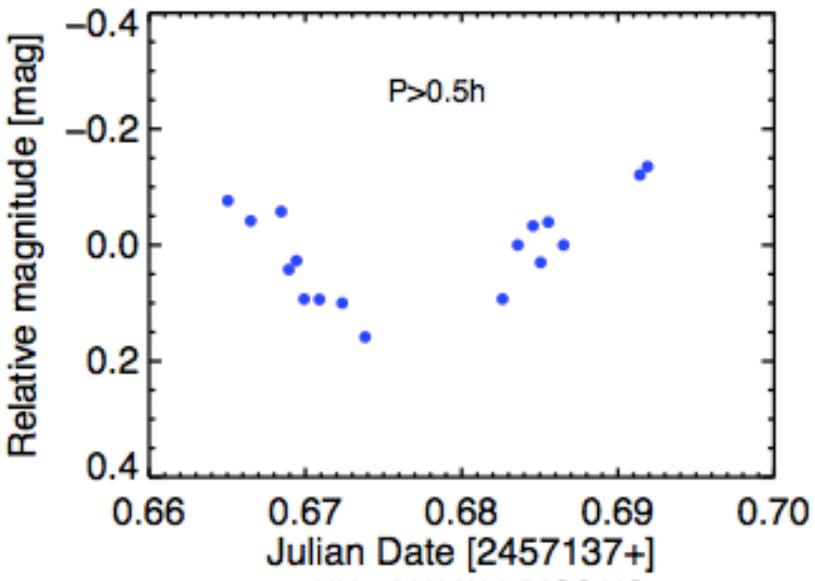

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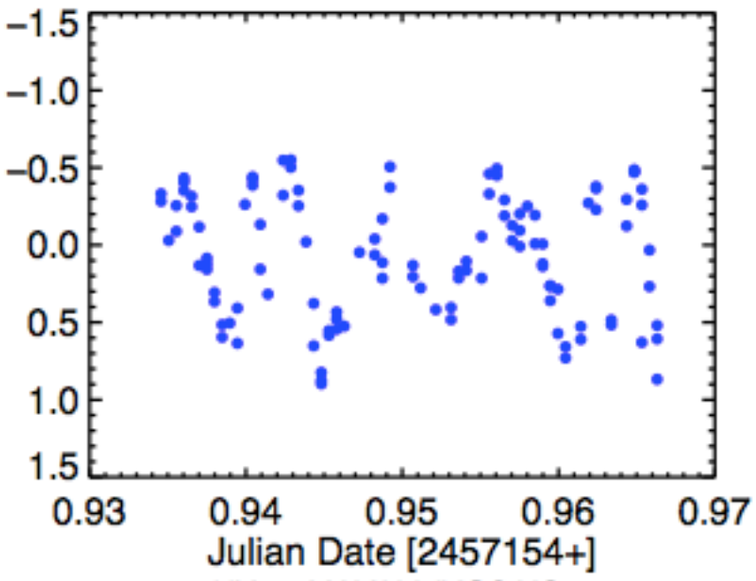

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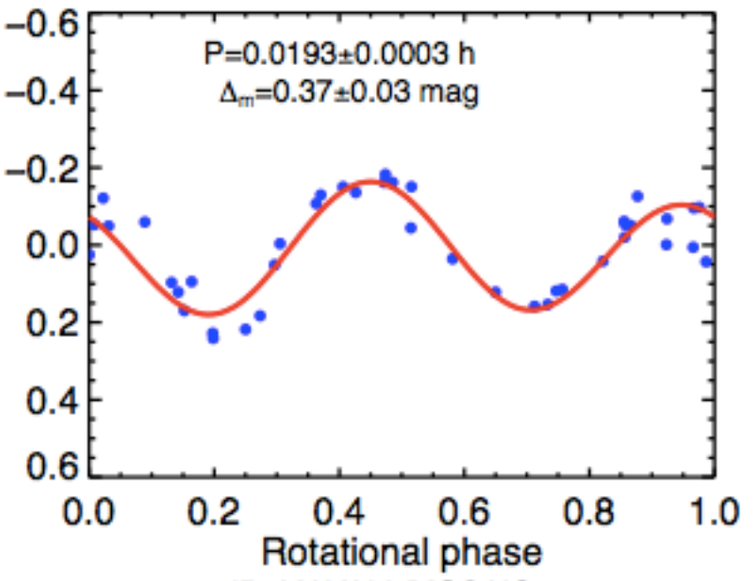

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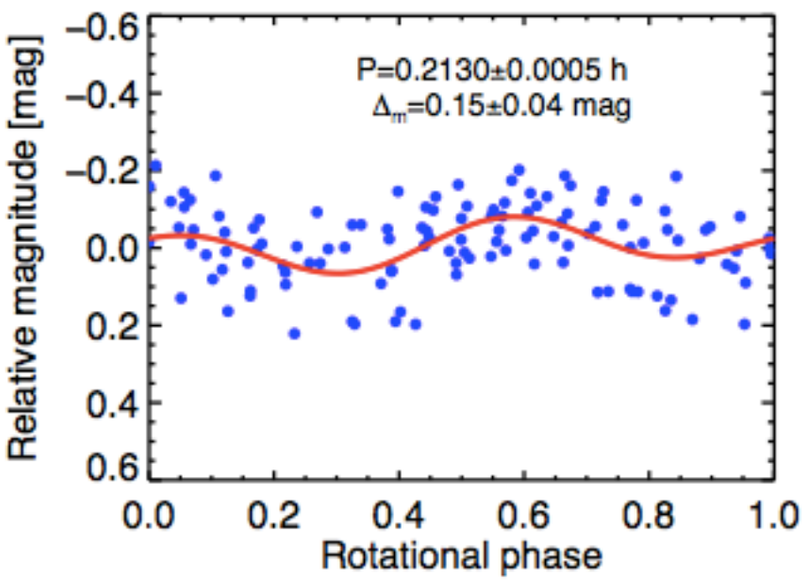

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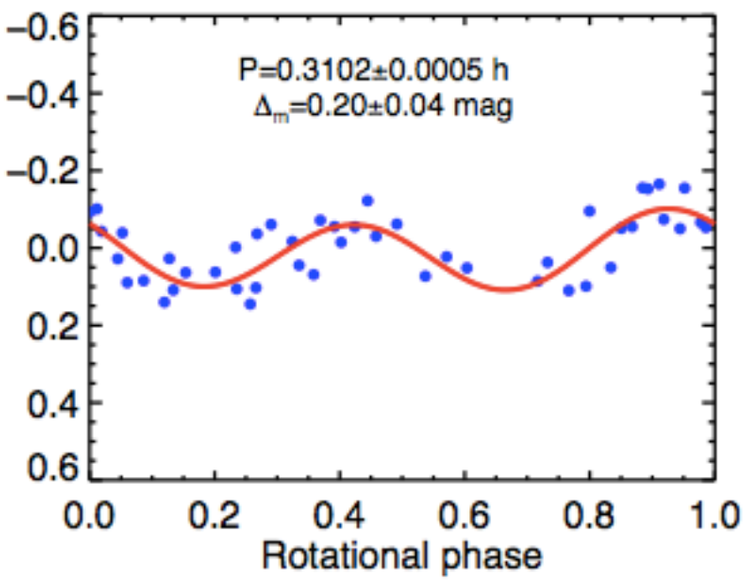

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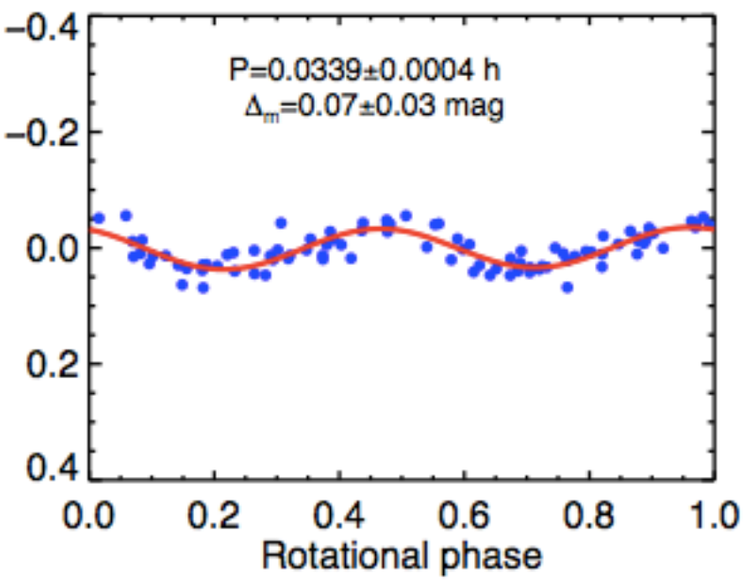
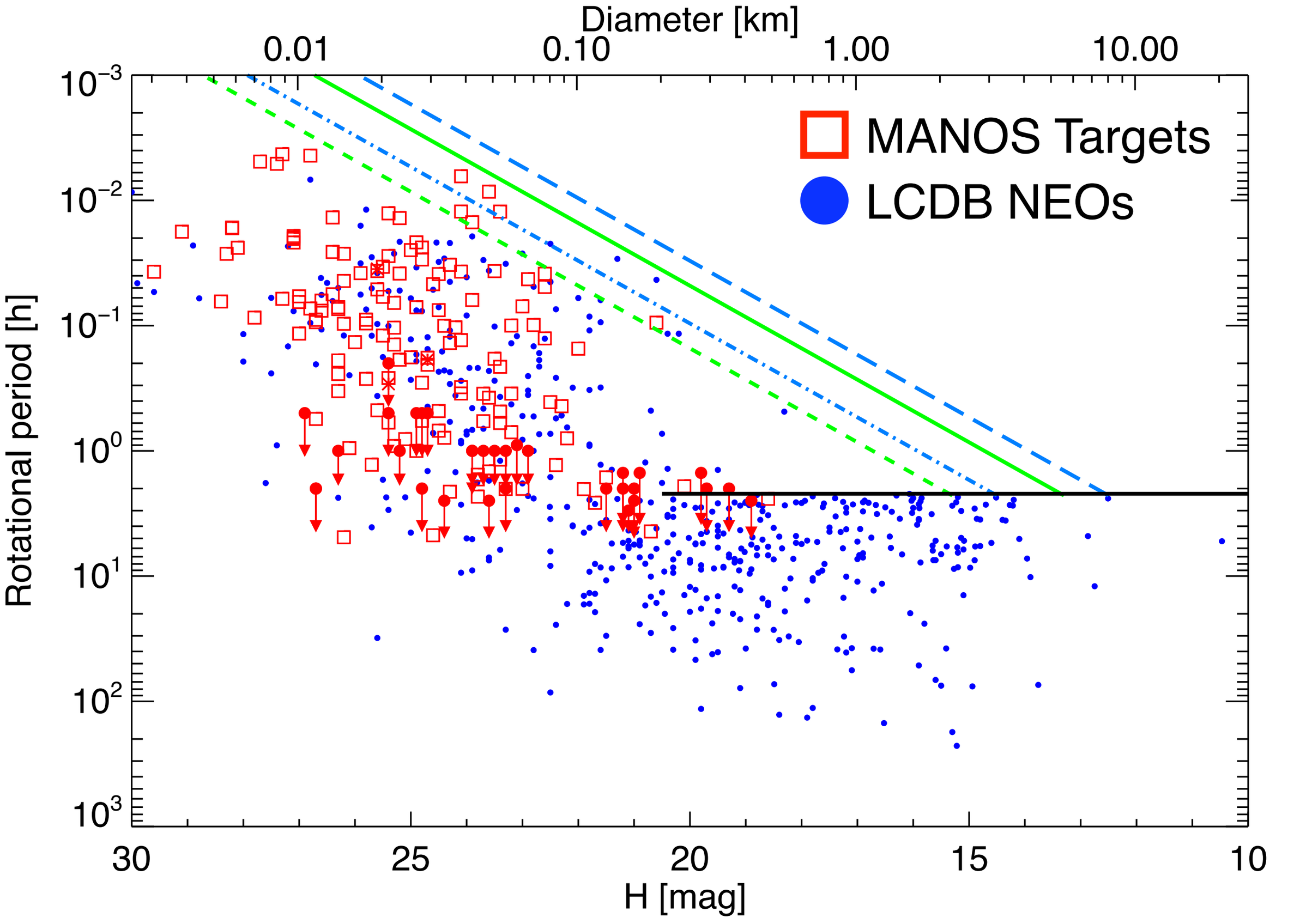
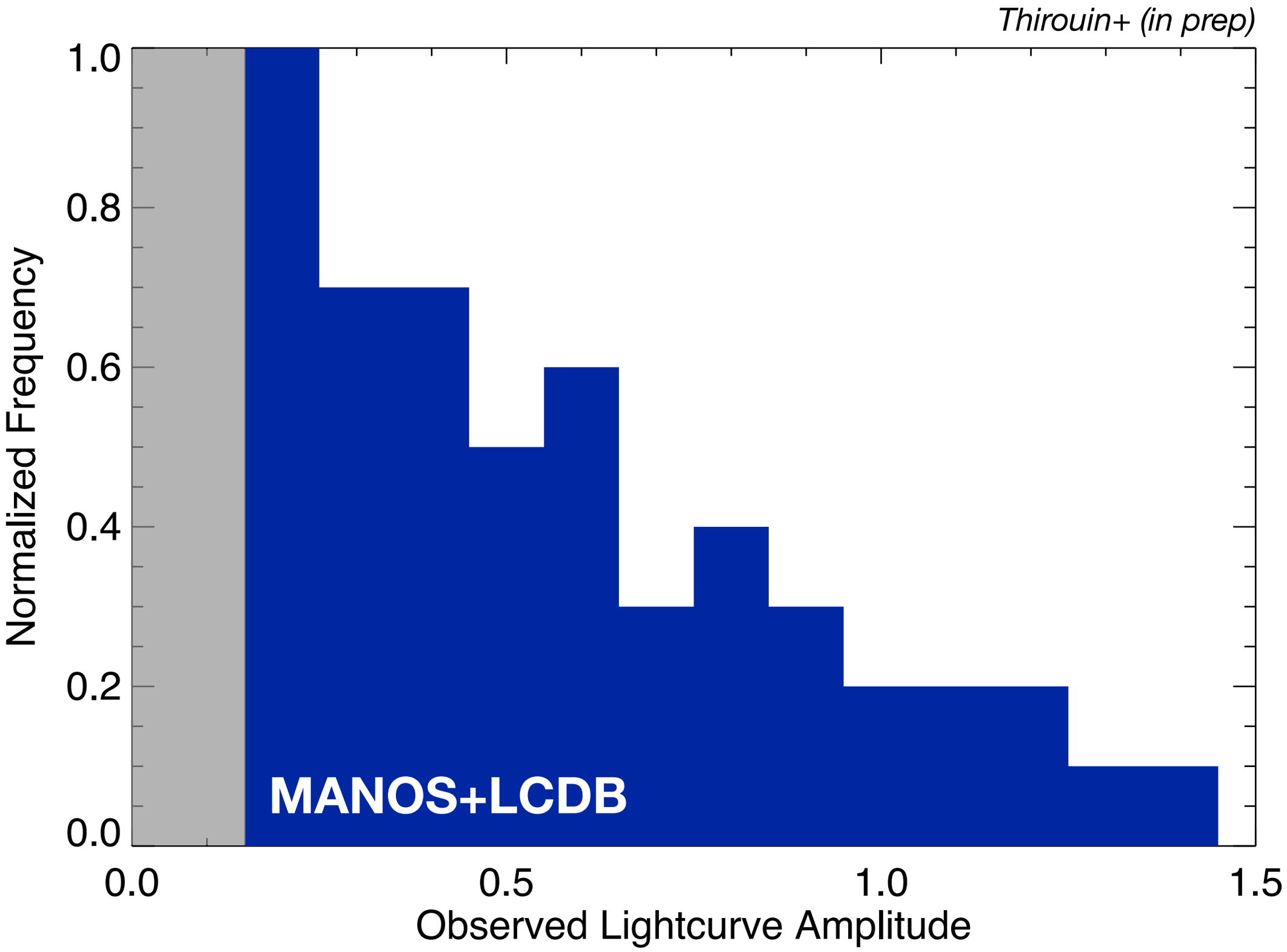




Thirouin+ (2017), Thirouin+ (in prep)

lightcurve amplitudes



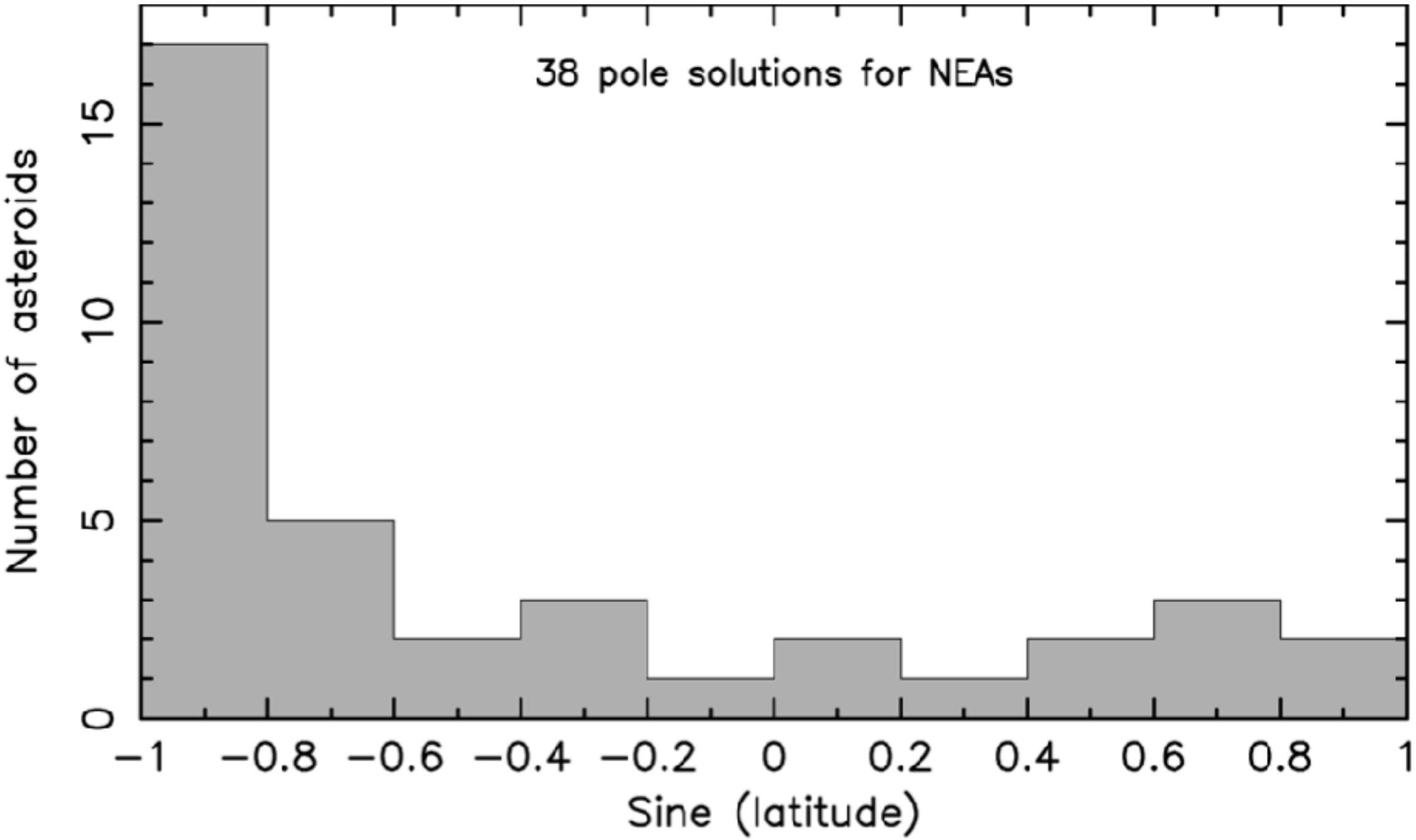
amplitude model ←

- Spin pole distribution
- Observing geometry
- Morphology distribution

amplitude model

- **Spin pole distribution**
- Observing geometry
- Morphology distribution

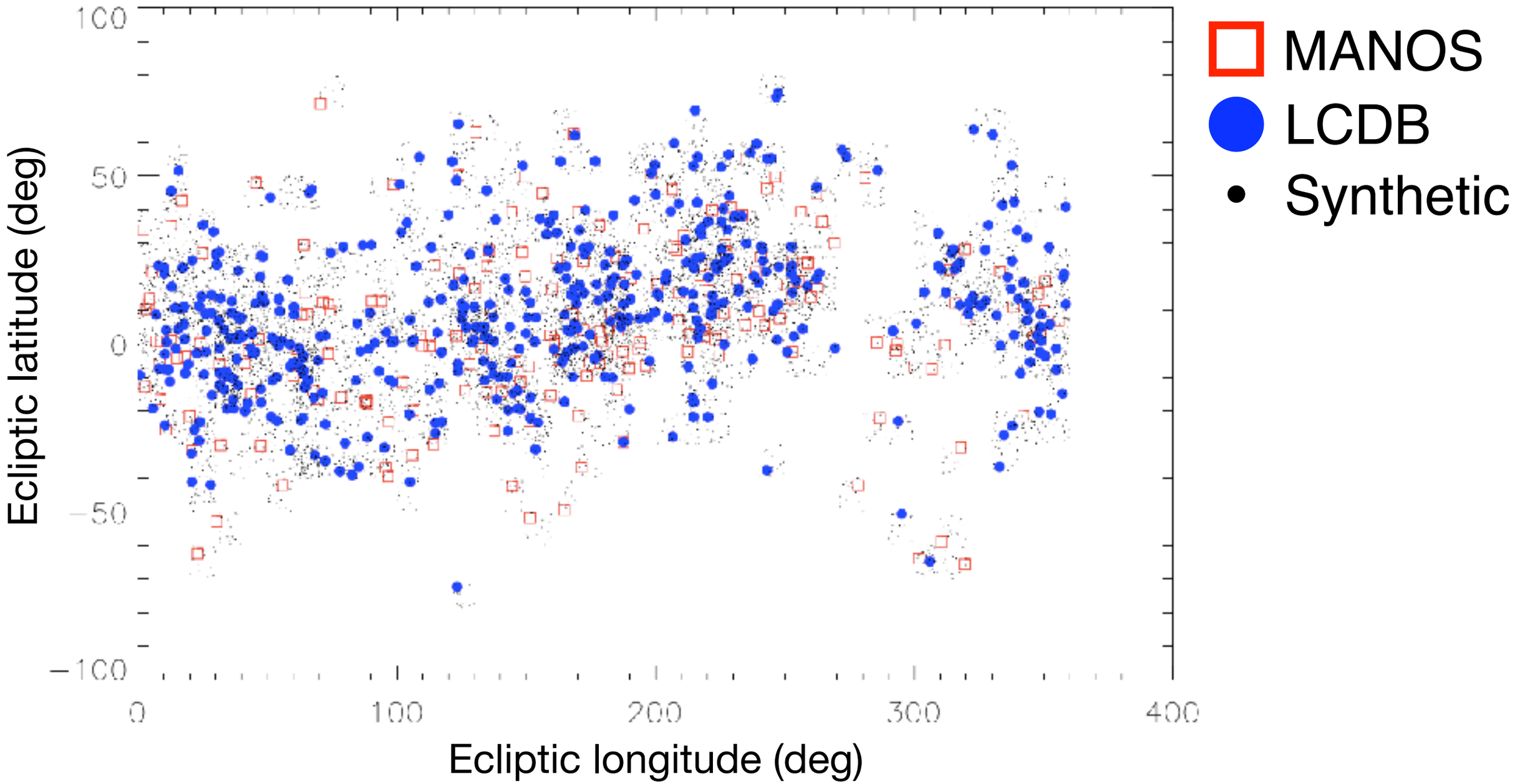
(Vokrouhlicky et al. 2015)



amplitude model

Spin pole distribution
Observing geometry
Morphology distribution

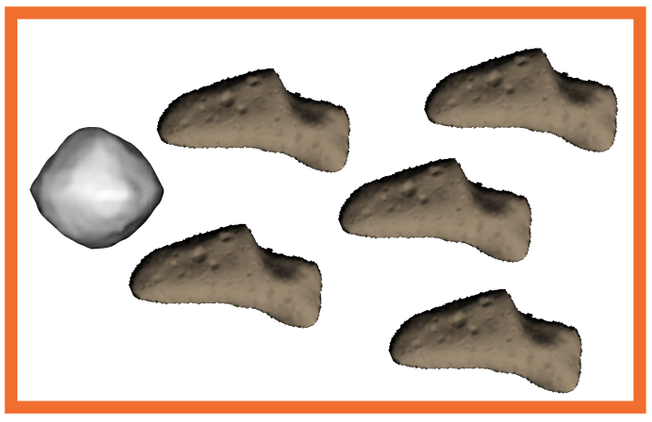
(Vokrouhlicky et al. 2015)



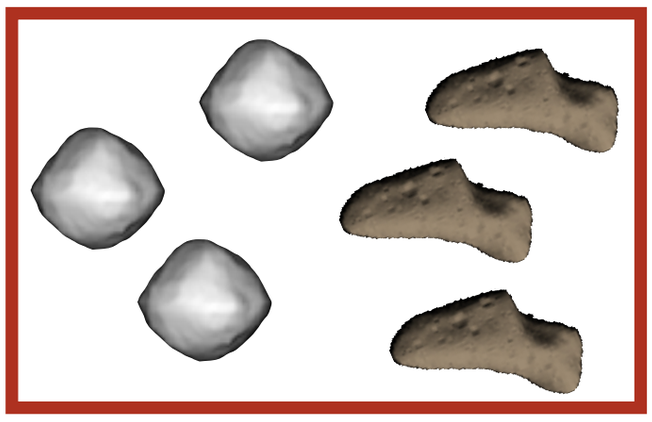
amplitude model

- Spin pole distribution *(Vokrouhlicky et al. 2015)*
- Observing geometry *(MANOS+LCDB sample)*
- **Morphology distribution**

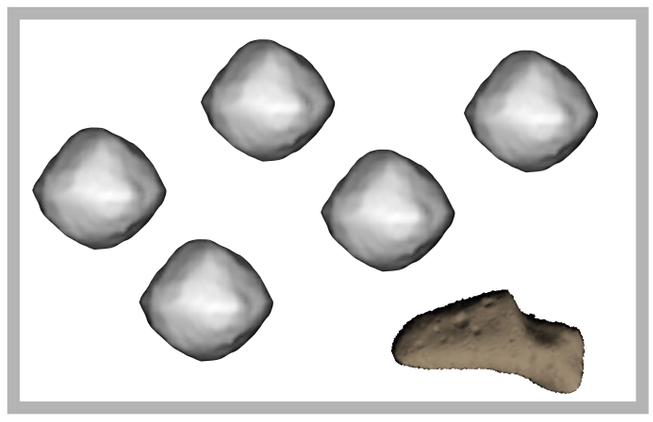
Model #1

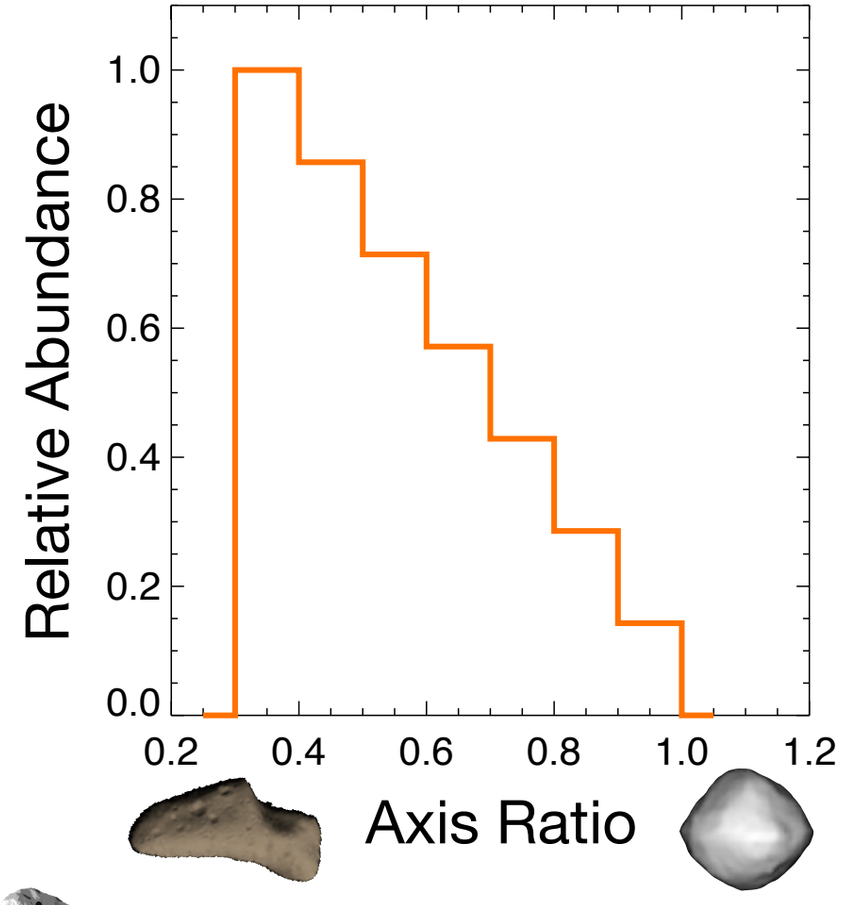


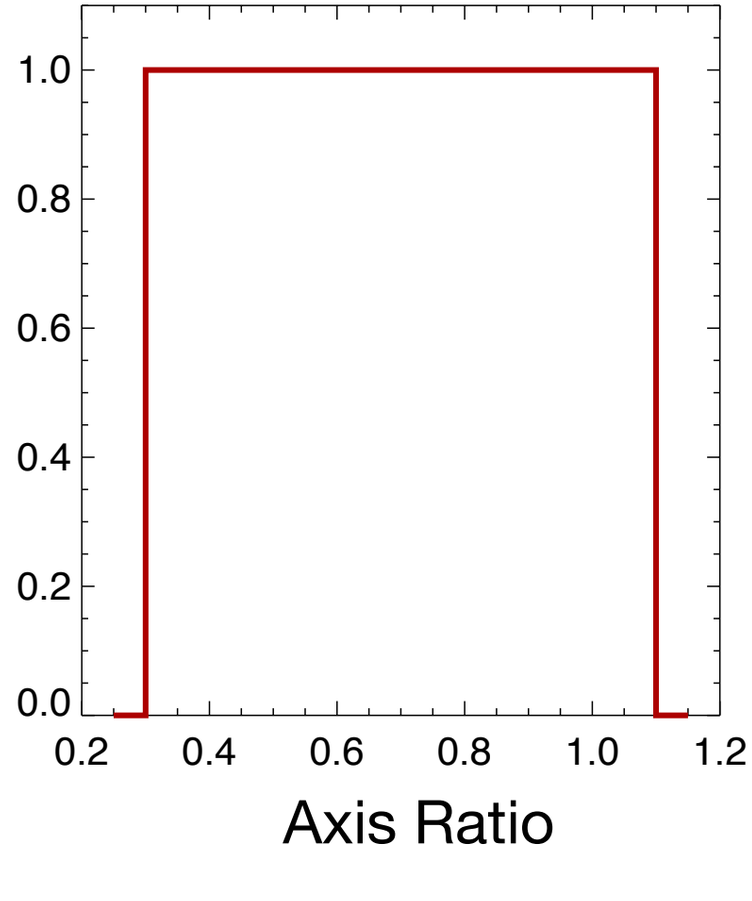
Model #2

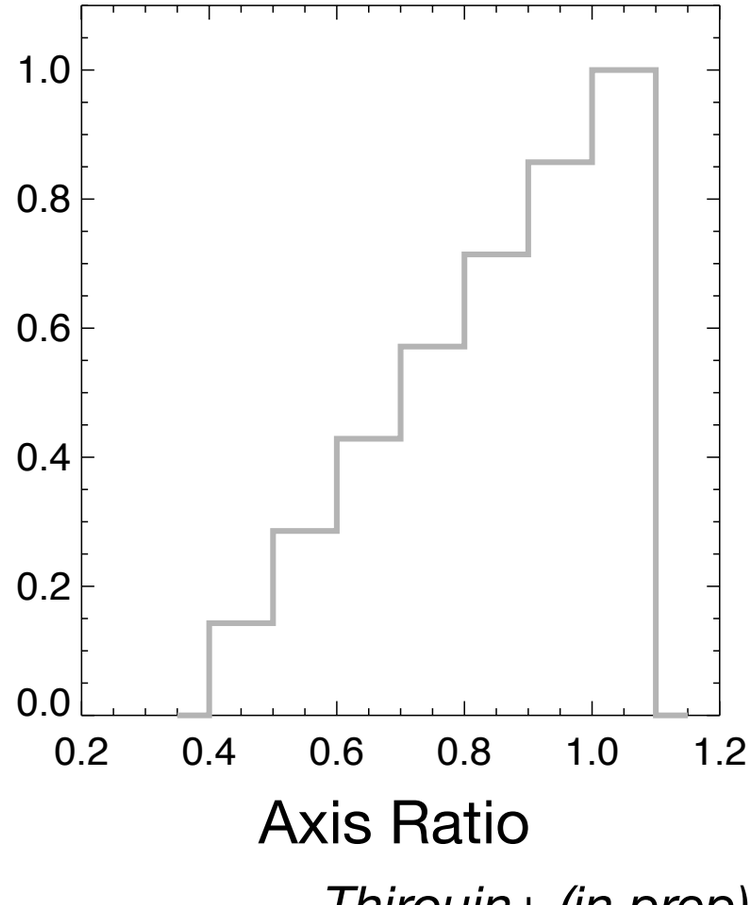


Model #3



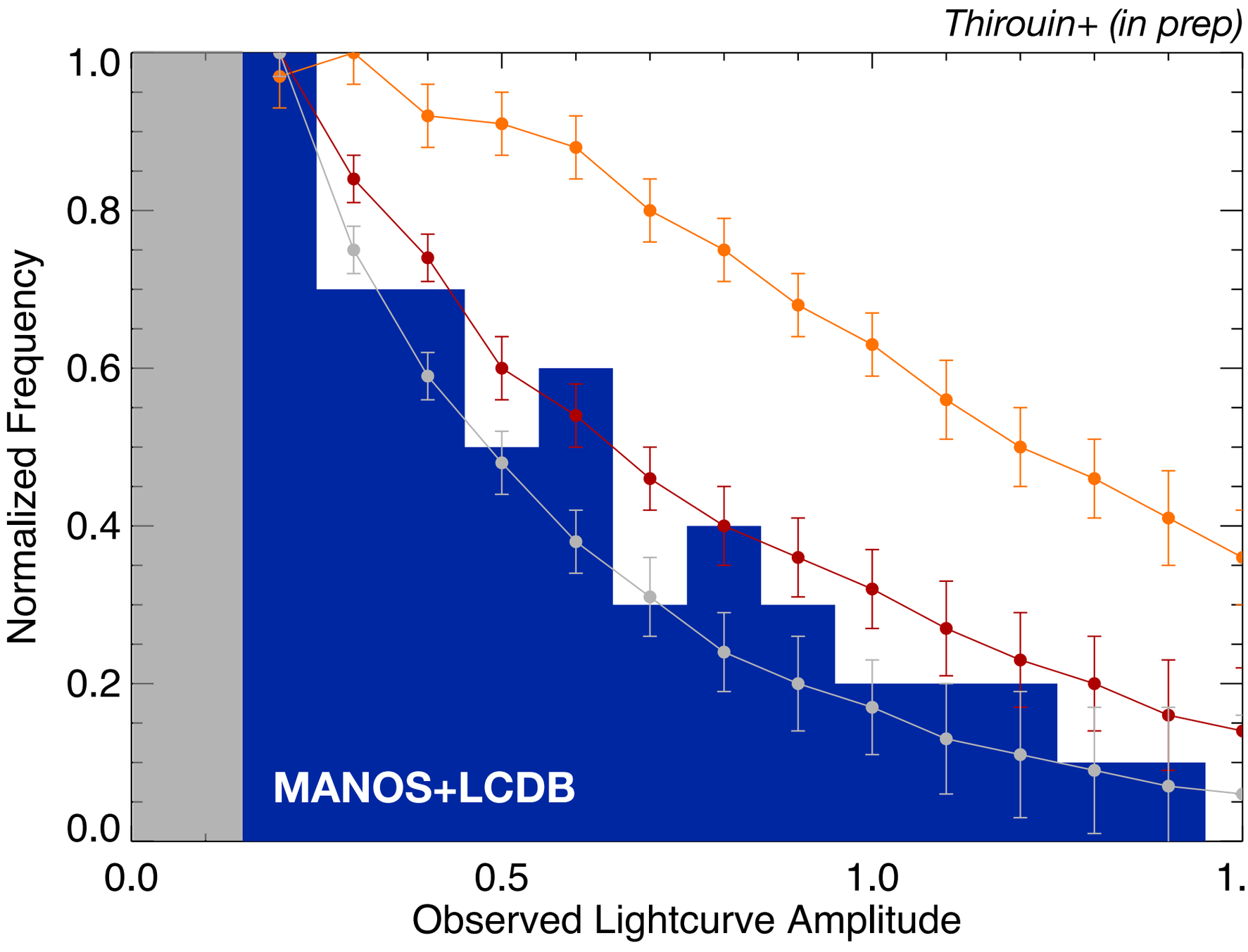




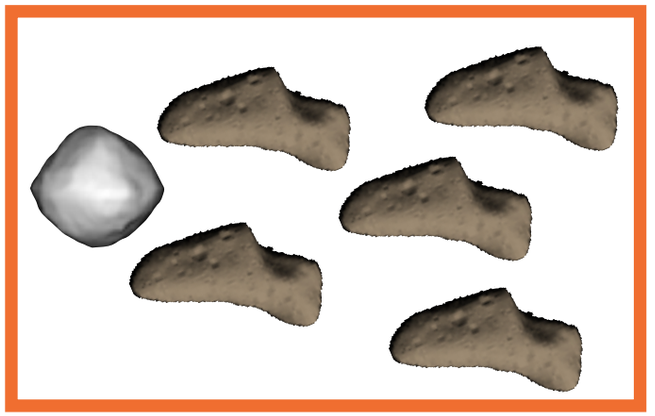


Thirouin+ (in prep)

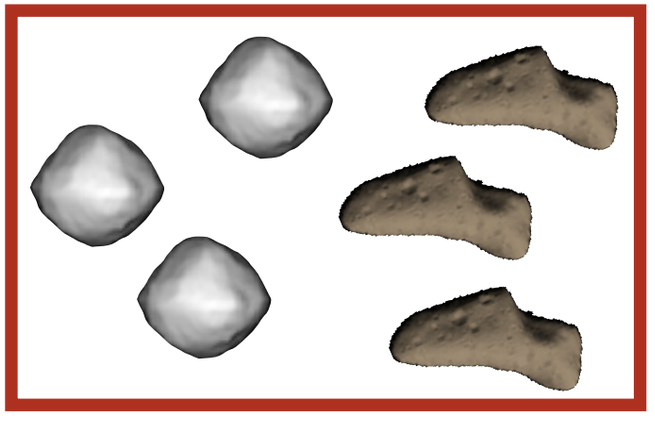
lightcurve amplitudes - model vs. observations



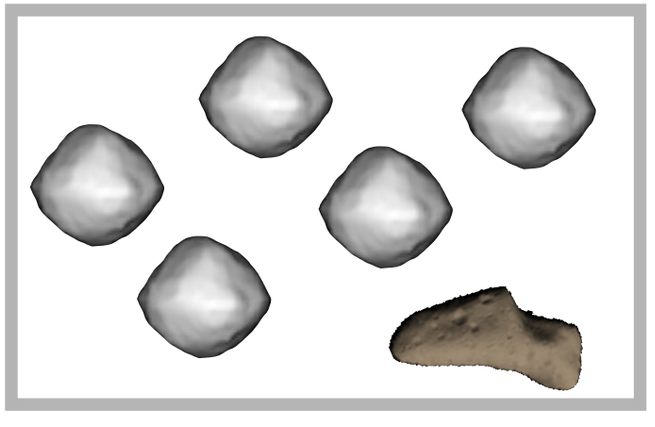
Model #1



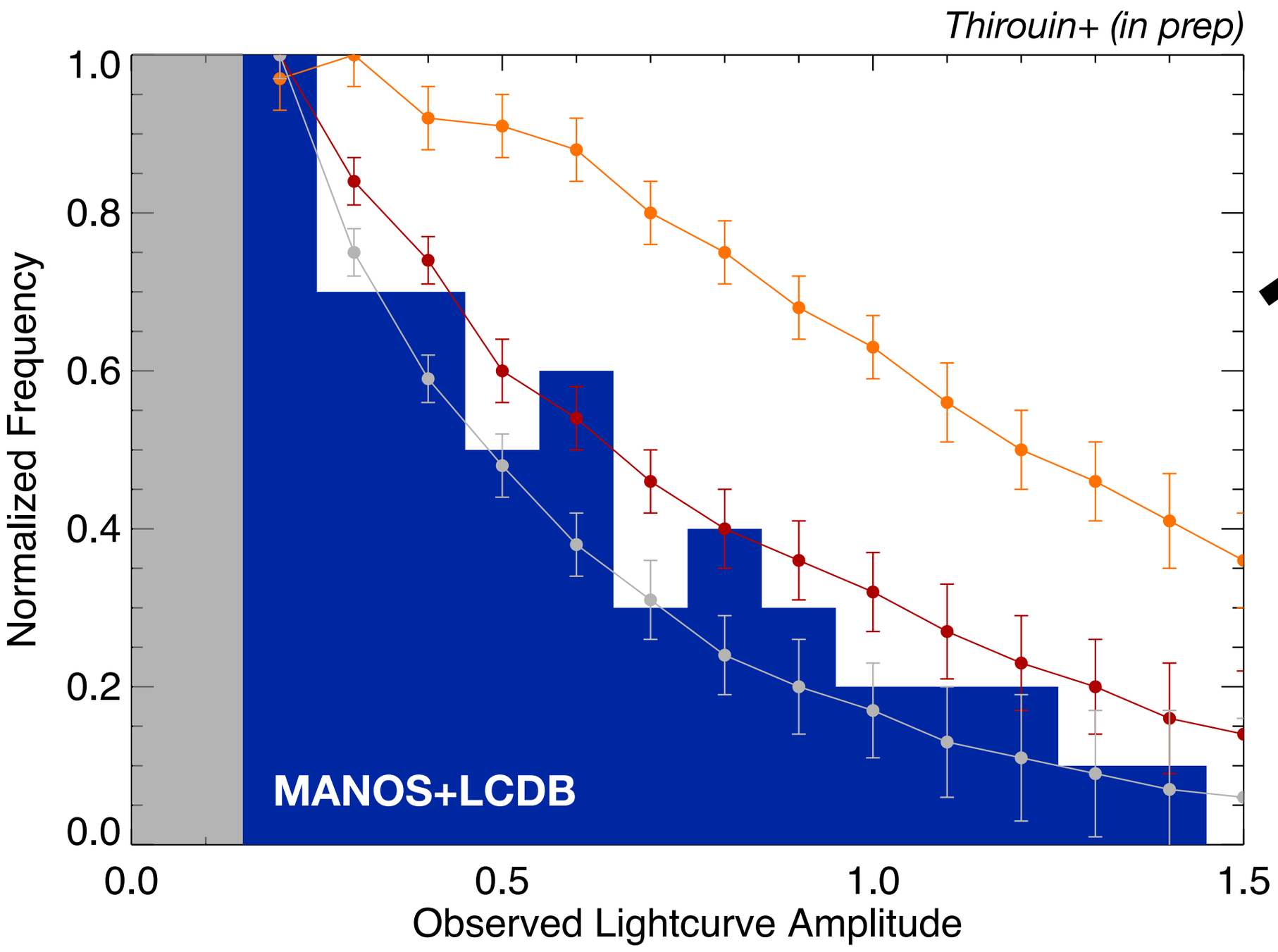
Model #2



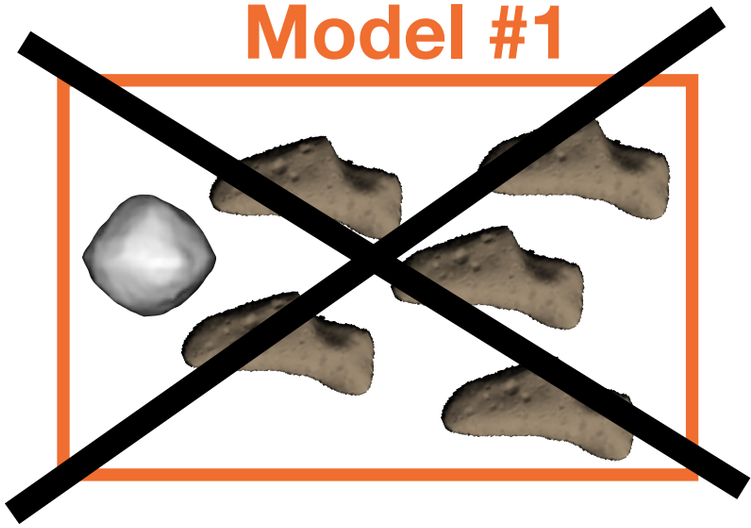
Model #3



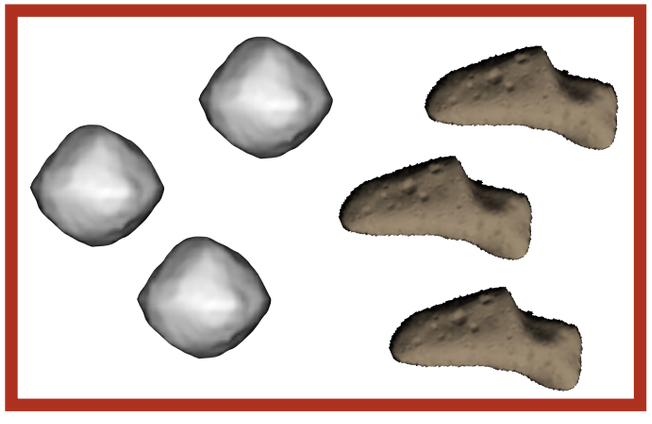
lightcurve amplitudes - model vs. observations



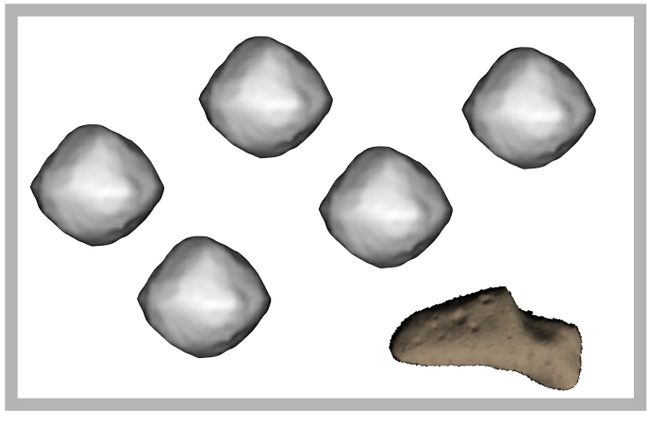
Model #1



Model #2



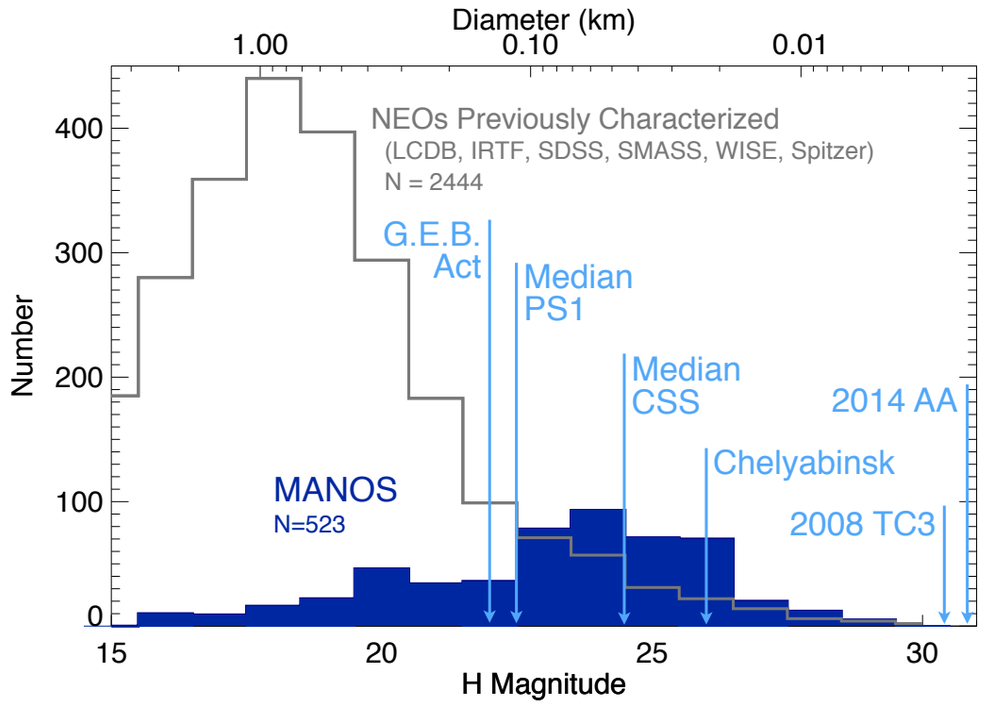
Model #3



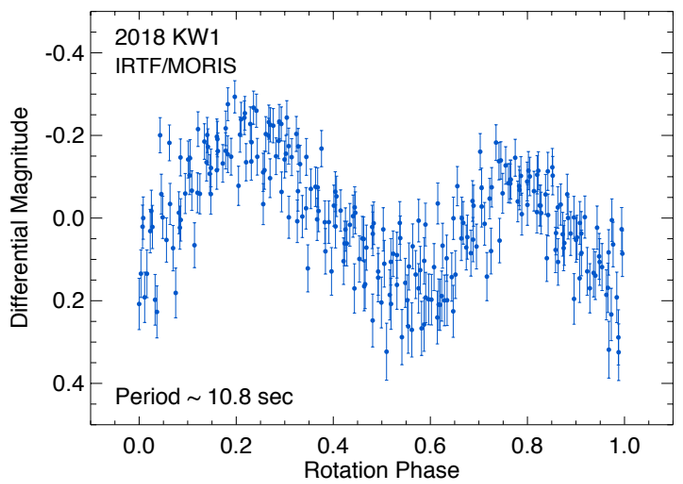
summary

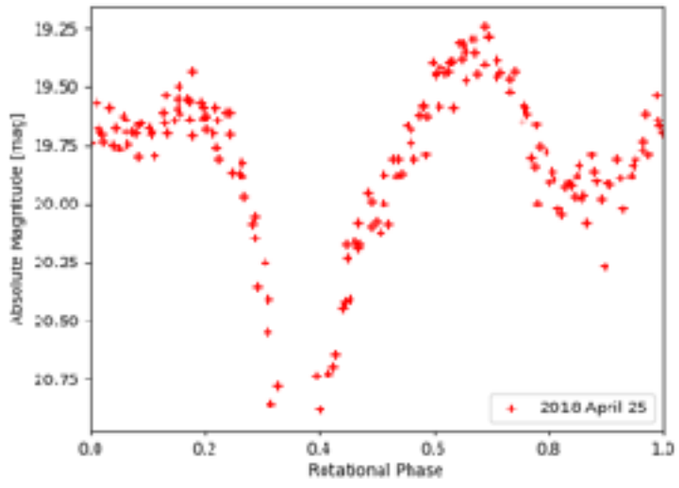
Mission Accessible Near-Earth Object Survey (MANOS)

- Physically characterized > 600, sub-km NEOs



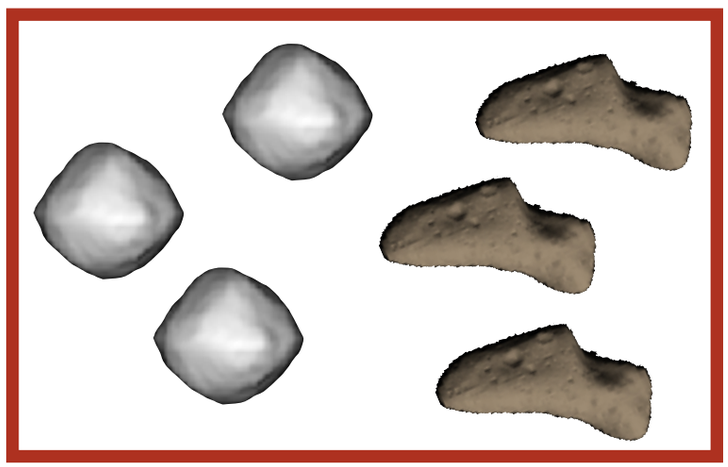
Wide diversity of measured light curves





NEO morphology distribution

- equal number of spheres and elongated objects best fit data



Acknowledgement: NASA NEO Observations Program (2014-2017, 2017-2020)