# RAPID RESPONSE RADAR: ARECIBO AND 2019 OK

Luisa. F. Zambrano-Marin[1, 2], Ellen. S. Howell[3], Maxime Devogèle[1], Sean E. Marshall[1], Dylan Hickson[1], Anne K. Virkki[1], Flaviane C. F. Venditti[1], Edgard G. Rivera-Valentín[4], Patrick A. Taylor[4], Victor Negron[1], Israel Cabrera[1], Juan Marrero[1]

[1]*Arecibo Observatory, University of Central Florida, Arecibo, Puerto Rico*

[2]*Universidad de Granada, Escuela Internacional de Posgrado, Granada, Spain*

[3]*Lunar and Planetary Laboratory, University of Arizona, Arizona, USA*

[4]*Lunar and Planetary Institute, USRA, Houston, TX, USA.*

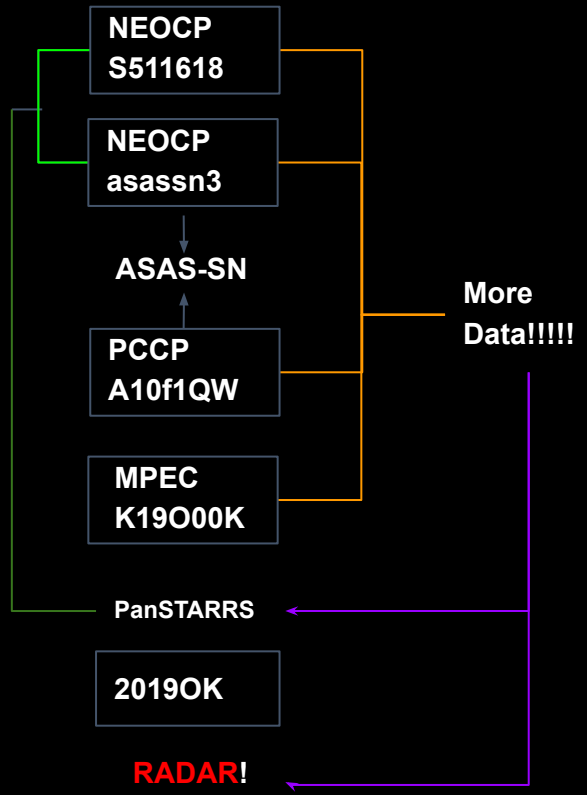
PDC 2021 @Vienna, Austria & Web

luisafz@aosa.naic.edu

# Discovery

- 2019 OK was discovered by amateur astronomers Cristovao Jacques, Eduardo Pimentel and Joao Ribeiro de Barros at Brazil's **SONEAR Observatory** on **2019 July 24**, right before its closest approach.
- Designated by the **Minor Planet Center Near Earth Object Confirmation Page** (NEOCP) as **S511618,** and as **K19O00K** in the **Minor Planet Center** (MPEC).
- Next, the A**ll-Sky Automated Survey for Supernovae** (ASAS-SN) detected the object as a moving target in their survey and submitted the data to the NEOCP as: asassn3, and to the **Possible Comet Confirmation Page** (PCCP) as A10f1QW.
- Requests for additional observations led to the detection of the target in **PanSTARRS** data, which confirmed that **both NEOCP entries S511618 and asassn3** were the same object.
  - Detangling of initial discovery started by Bill Gray*

**https://projectpluto.com/temp/2019ok.html*



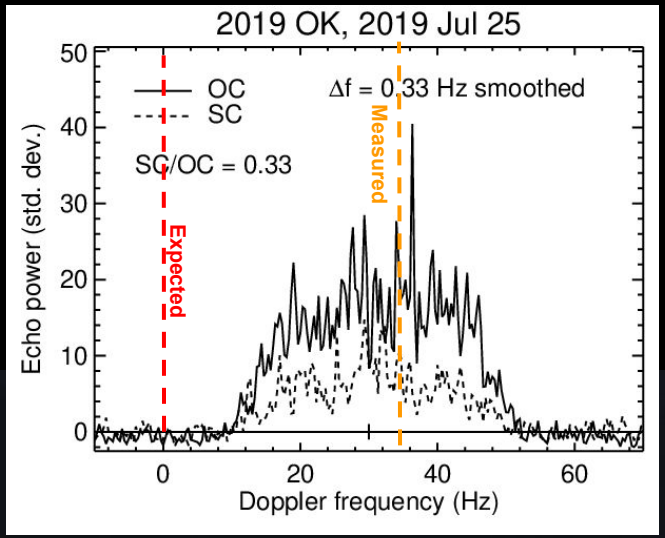
# RADAR OBSERVATIONS OF NEA 2019 OK

#TeamRadar

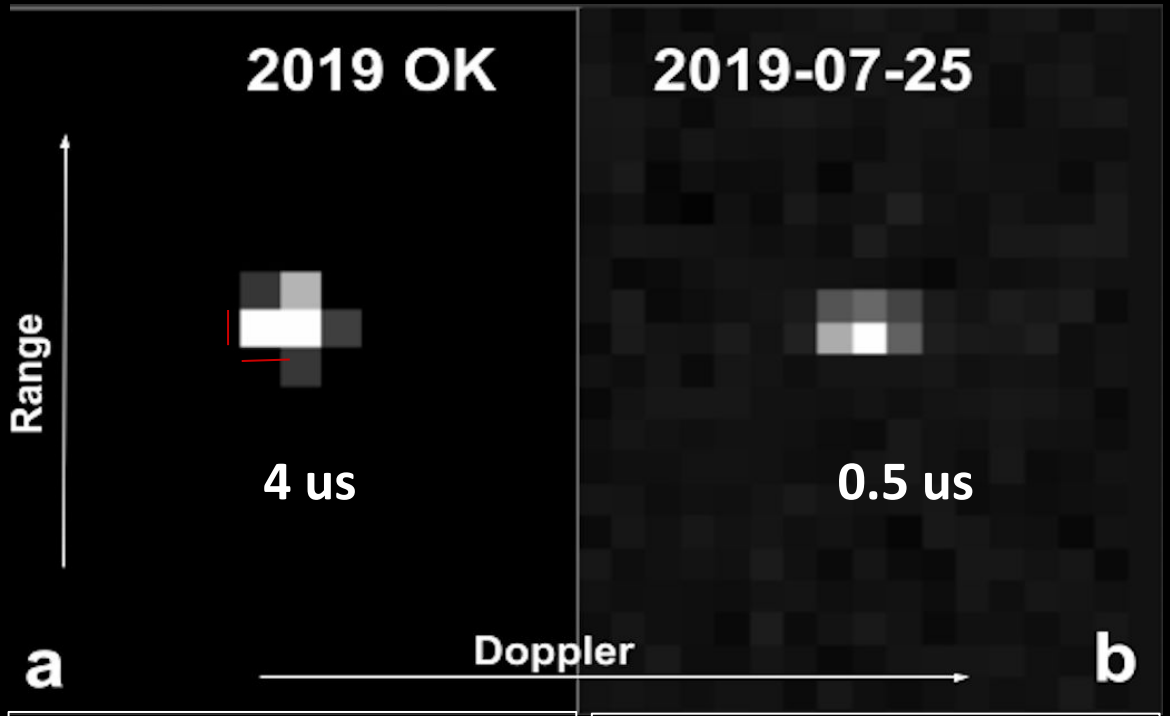
- Discovered right before its closest approach 0.187 LD (0.00048 au) June 24 2019 (SONEAR)
- Observed with AO June 25, when it was at a nominal distance of 3.5 LD (0.0091 au) from Earth and just over 14 hours after close approach and about 41 hours from discovery.
- Located in Doppler-Frequency, submitted a +31 Hz Doppler correction to JPL Orbit Determination Software (OSOD) to generate new ephemeris

$$P_r = \frac{P_T G_A^2 \lambda^2 \sigma}{(4\pi)^2 r^4 P_n L}$$

- Corrected Line-of-sight distance by 112 km and Line-of-sight velocity by 2 m/s
- Circular Polarization Ratio: 0.33 ± 0.03
- Measured Bandwidth: 39.3 Hz
- Rotation period: 0.052 hr (D = 75 m) to 0.14 hr (D = 200 m)



# Range-Doppler




**4 us resolution:**
**300 m/px in range**
**15.27/px Hz in Doppler**
***Line-of-sight distance correction:***
**21.81 us (-3.280 km)**

**0.5 us resolution:**
**75 m/px in range**
**1.9 Hz/px in Doppler**
***Line-of-sight distance correction:***
**-22.59 us (-3.386 km)**

Diameter from Optical data:

➔ 50 - 250 m

*(geometric albedo of 0.014 - 0.3 for H =23.3 ± .263 )*

Diameter Range-Doppler:

➔ Initial upper limit: 300 m

➔ Initial lower limit: 75 m

*( geometric albedo low as 0.2%!!)*

➔ Object was unresolved, in both data sets, unable to derive shape.

➔ Radar astrometry reduced Doppler and delay uncertainties by 99.93%

➔ The next Earth encounter was determined to be in 2093 at 0.052 au.



luisafz@aosa.naic.edu

# Cohesion

We calculated the Drucker-Prager cohesion criterion (Holsapple 2007)

$$\frac{1}{6}\left[(\bar{\sigma}_x-\bar{\sigma}_y)^2+(\bar{\sigma}_y-\bar{\sigma}_z)^2+(\bar{\sigma}_z-\bar{\sigma}_x)^2\right] \leqslant \left[k-s(\bar{\sigma}_x+\bar{\sigma}_y+\bar{\sigma}_z)\right]^2$$

For a sphere and an ellipsoid, at different densities and min and max rotation periods obtaining:

**~1200 Pa for ellipsoid 75-200** m at density of **1 g cm$^3$**

**~1400-1500 Pa for sphere** at same density and size

**Up to 3600 Pa** for the case of ellipsoids at density **3 g cm$^3$**
**> 4500 Pa** for sphere at same density.