Solar System Objects
Polarimetric Science using PUNCH

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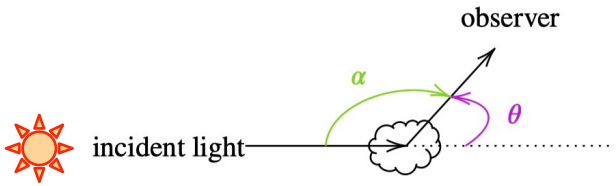
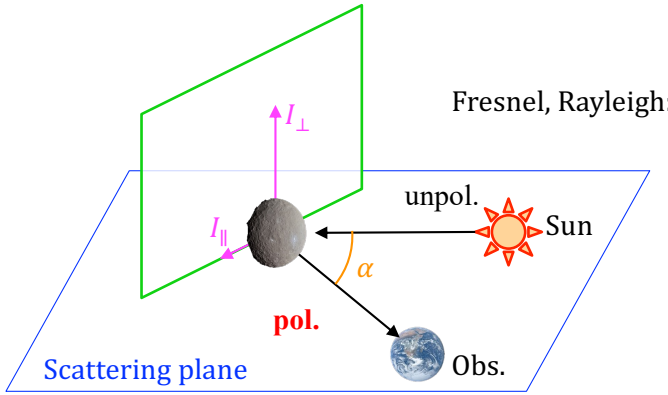
Intro: Polarimetry in SolSys Small Bodies Sci.

- Polarimetric <u>phase</u> curve (PPC)
  - Pol. as phase angle $P_r = P_r(\alpha)[\%]$
  - Phase angle α = 180° − scat. ang.



$$P_r = \frac{I_\perp - I_\parallel}{I_\perp + I_\parallel} = -\frac{Q}{I}$$



Fresnel, Rayleigh: $I_\parallel < I_\perp$

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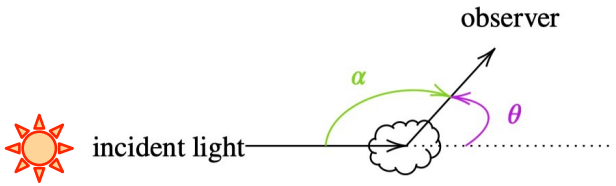

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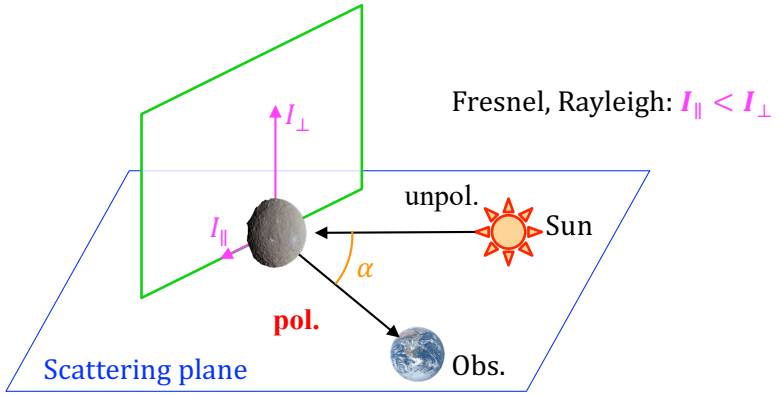

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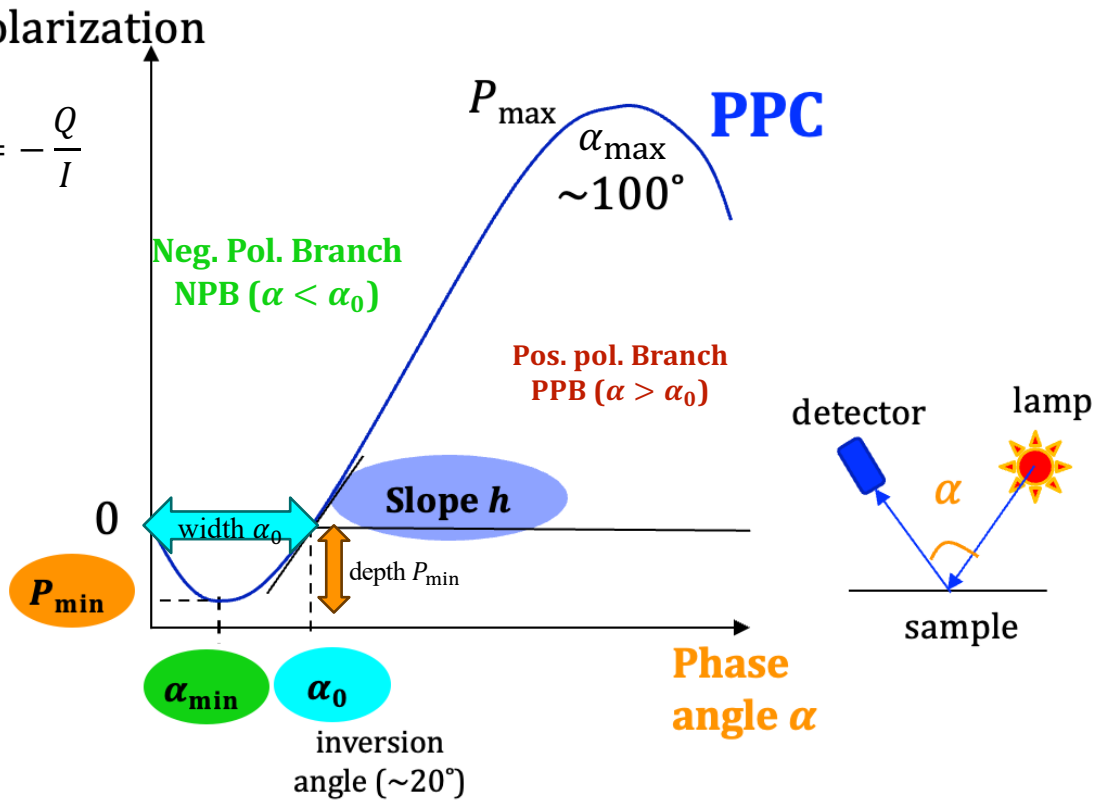
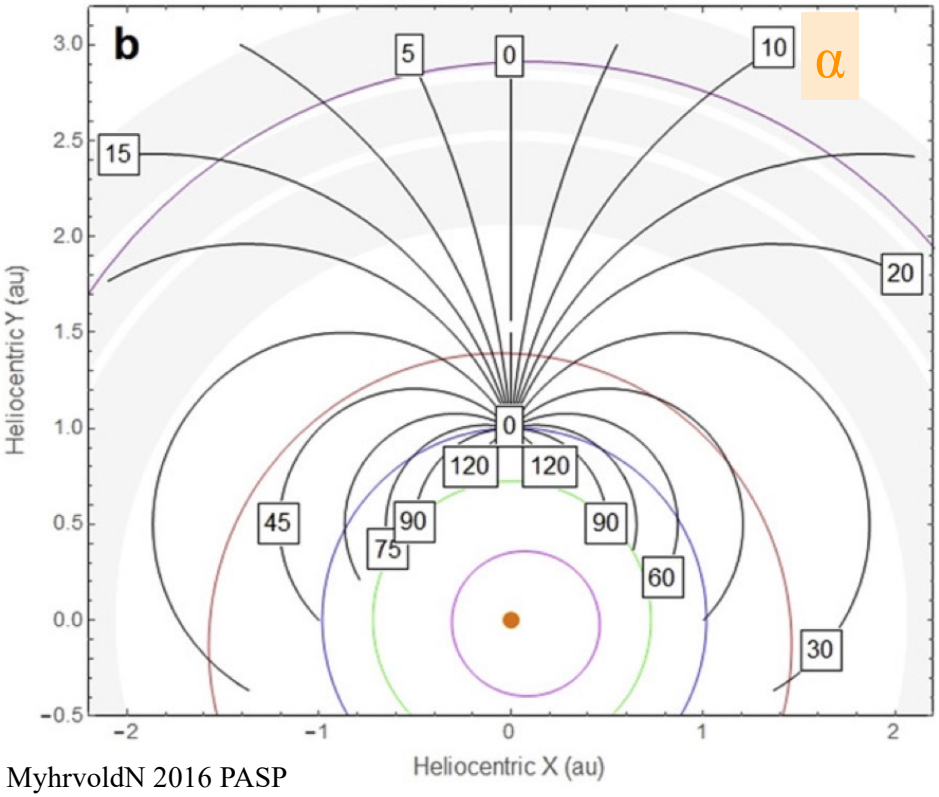


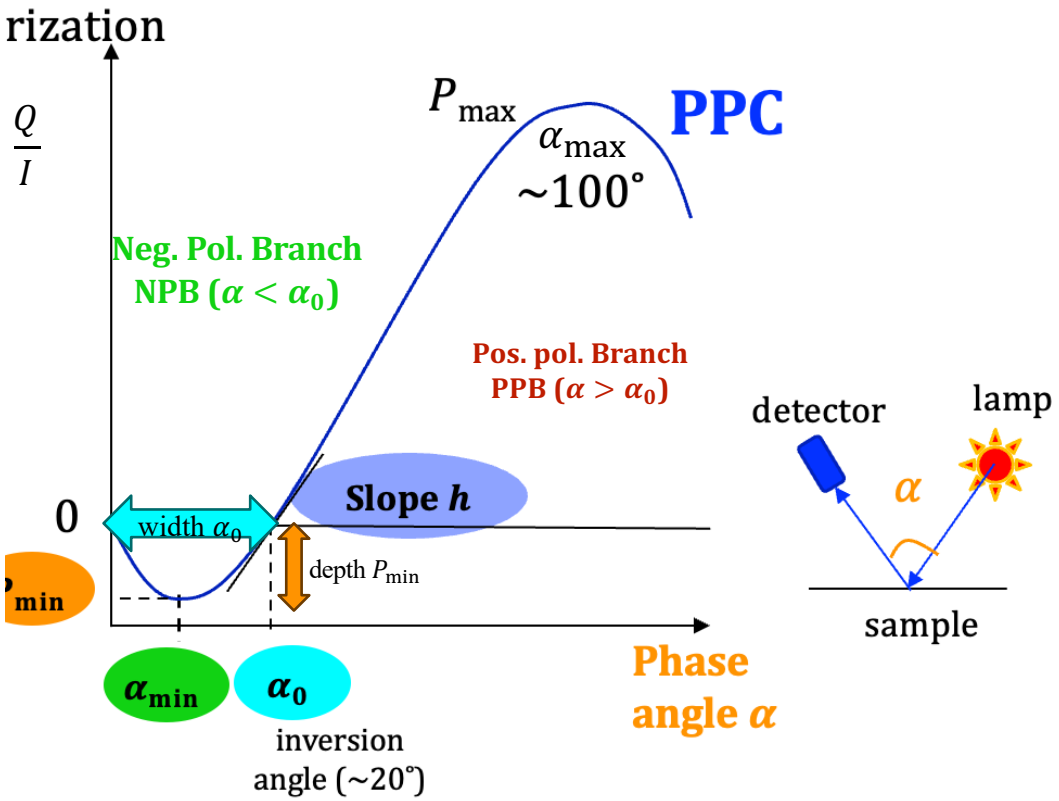
Why PUNCH?

- Main belt (Mars-Jupiter): $\alpha \lesssim 30°$
- Pmax is available only for planets, Moon, and 5-ish asteroids so far

Not many options to do both
1. Near-Sun pointing
2. Polarimeter



MyhrvoldN 2016 PASP

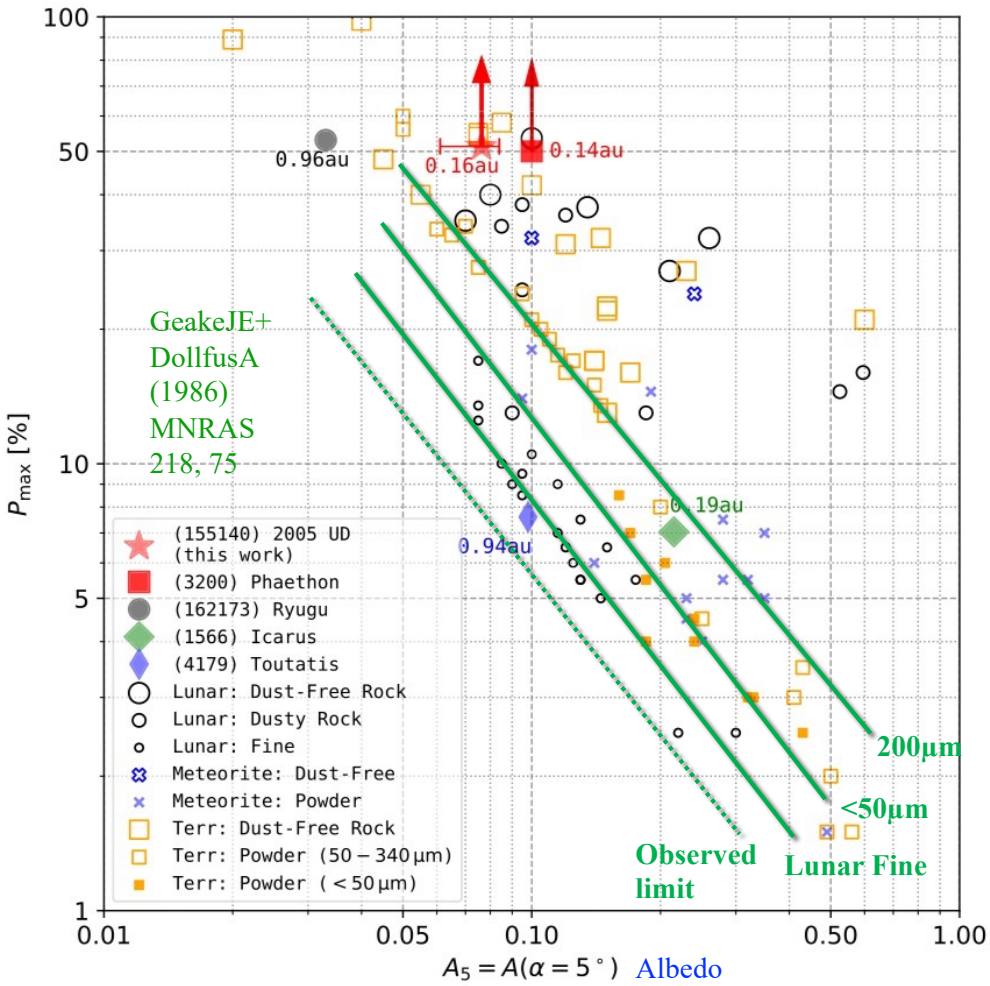


Why Pmax?

- One of few ways to discuss grain sizes (μm-mm)
  - Thermal modeling (MIR thermal radiation) ← Theory
  - Polarimetry at high α (Pmax) ← Empirical
    (IshiguroM, **BachYP**+ 2022 MNRAS,
    ItoT+ (incl. BachYP) 2018 NatCo, 9, 2486)
  - Multi-λ NIR polarimetry at low α
    (**BachYP**+ 2024 A&A, 684, 80
    BachYP+ 2024 A&A, 684, 81)

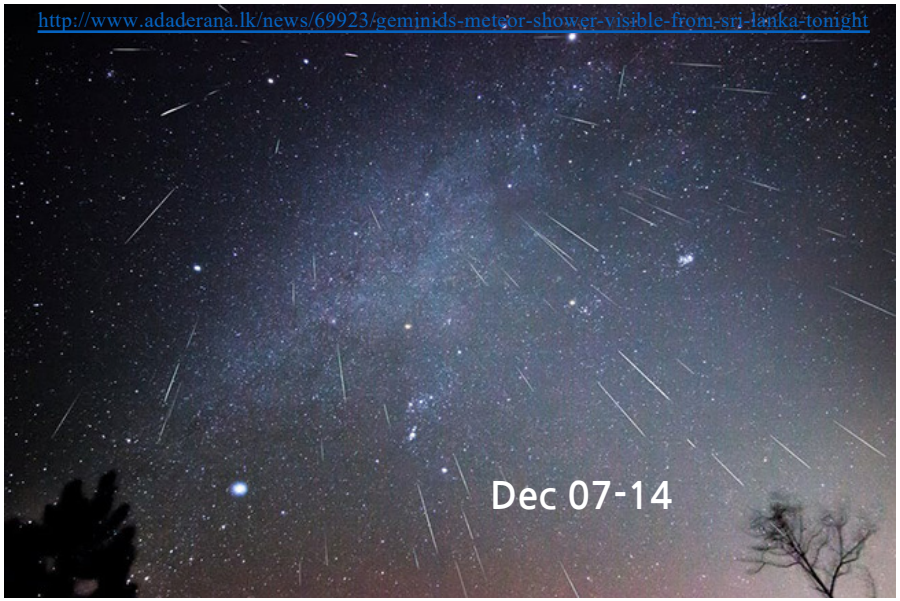
- Unfavorable geometry to get it (both ground & space)
  → Few asteroids
  → Input from PUNCH (even N=1) will be critical

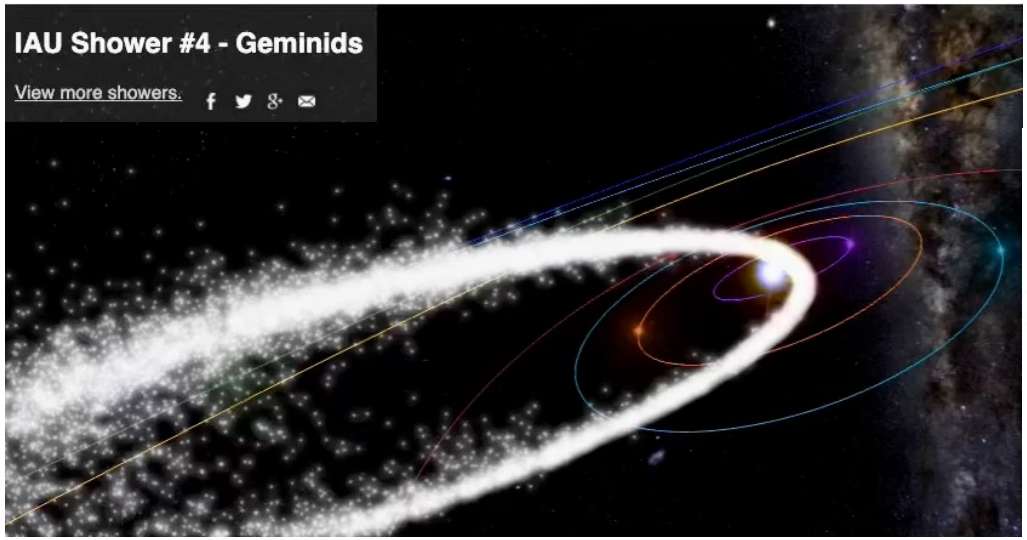
IshiguroM, **BachYP** + 2022 MNRAS

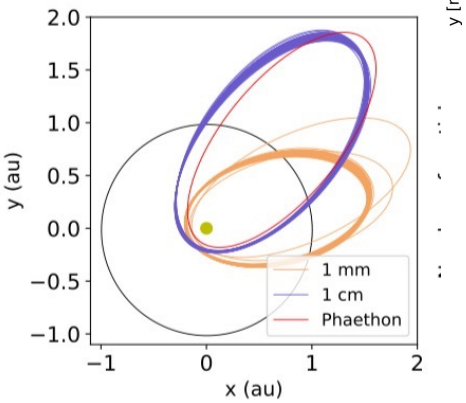


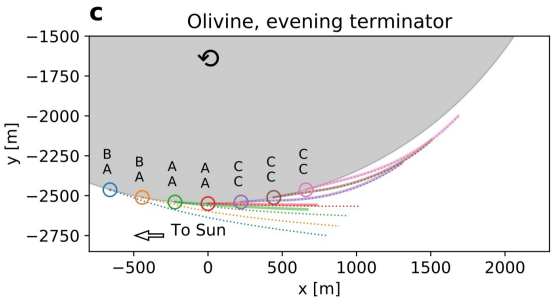
Case of Phaethon

- **(3200) Phaethon**
  - Geminids meteor shower parent body
  - JAXA DESTINY+ mission target (flyby 2030)
  - One of the **largest** (**brightest**) NEOs (5+km)







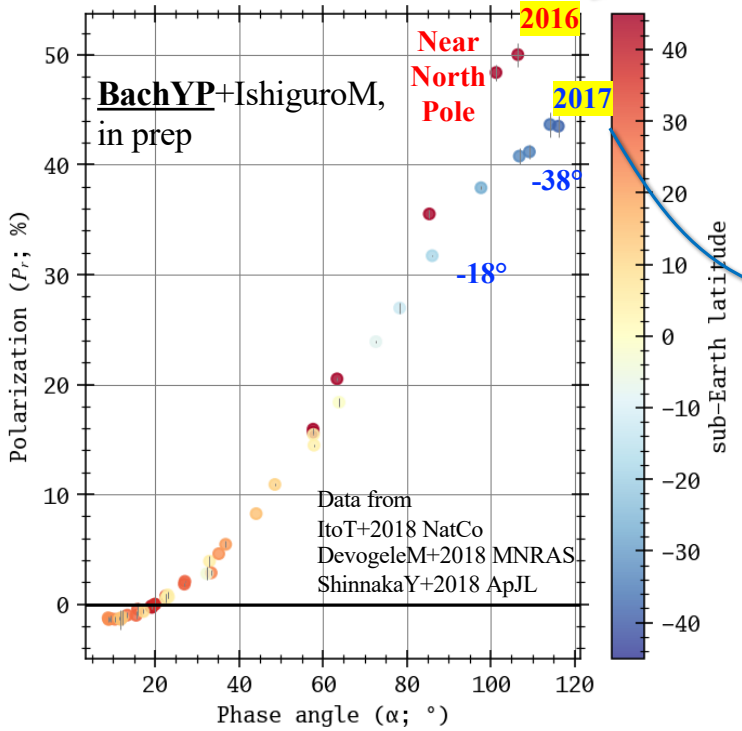


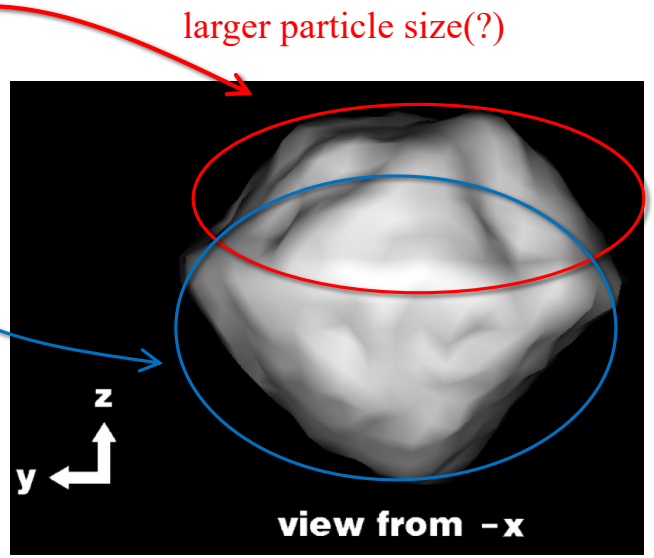
BachYP+IshiguroM (2021)
A&A, 654, 113

JoH+IshiguroM (2024)
A&A, 683, 68

Brightest NEO with Previous Pol Data

- **(3200) Phaethon**
- Polarimetric dichotomy(!)





Independently from thermal modeling

A coarse-grained (≳ 500 μm) northern
&
A fine-grained (≲ 300 μm) southern

MacLennanE+2022, Icar, 388, 115226

Shape model image adopted from MarshallS, (D+SWT2022)
"from radar occultation and light-curve observations"

Expectation for PUNCH Observations

- Preparation for precovery is also important
  - **LSST**: number of known asteroids will increase from 1.4M → 5M
  - **NEO Surveyor**: 90% complete for D>300m NEOs

High-α data

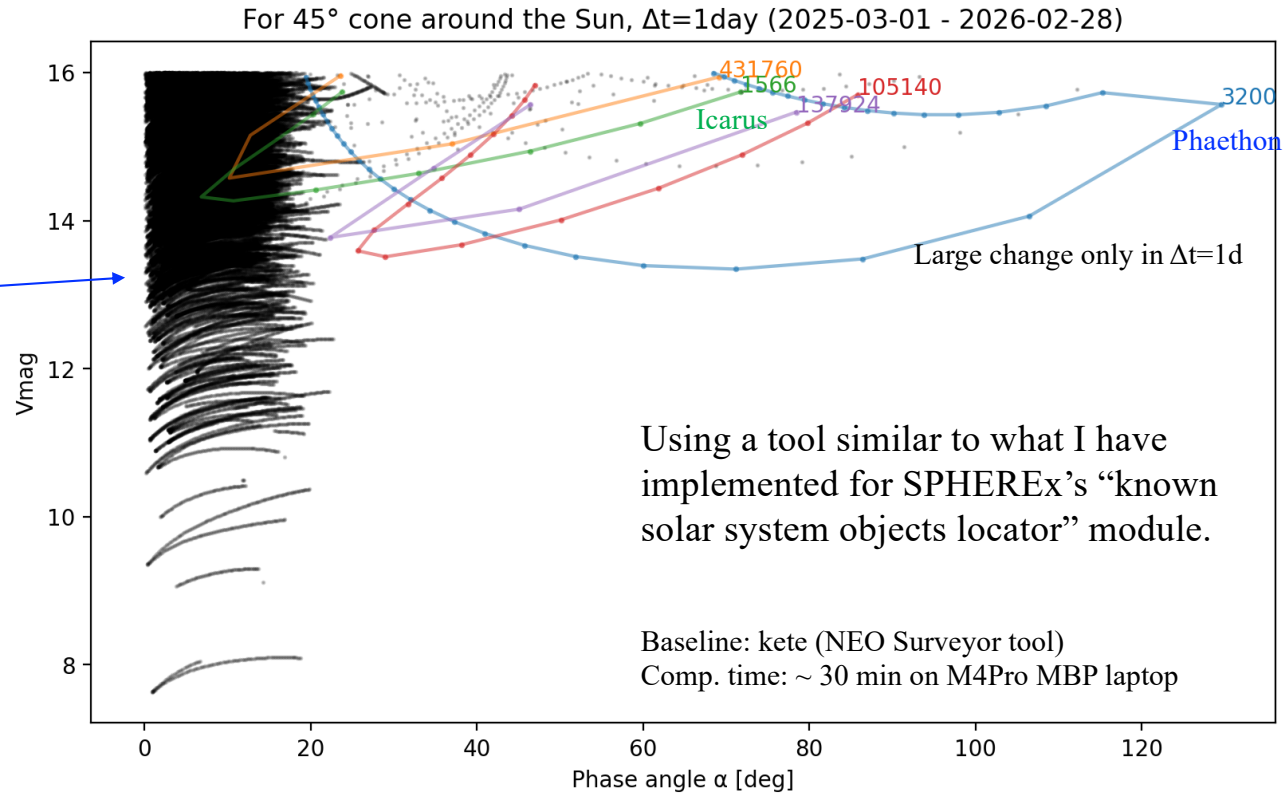
So far, only <10 asteroids available.
Adding a few is fantastic.

Huge small-α dataset

At least 1 data during the 1st year
- V<14: 231 asteroids
- V<15: 497 asteroids

Cf. APD has only 520 unique asteroids and 5,000 data points for the last 50 years.
Many have <5 points and/or too low S/N.

(for low-α, σP ≲ 0.1%p is desired)



Summary

- High-α polarimetry is useful to dicern grain sizes (≪ image resolution of in situ data)

- Not many data so far because of unfavorable observational requirements
  - Close to the sun
  - **PUNCH** is a wide FoV polarimeter observing near-Sun area
  - → Perfect for this type of science (Great bonus!)
  - Any single data at high-α will be a low-hanging fruit (including publication)

Small additional effort
Great contribution to
Small Bodies science society

- A huge small-α dataset
  - ~ Double the database number in 1-2 yrs.

- Plus: Comets! ← very bright, but telescope time is always the limit.

- Computational tools already available from SPHEREx experience
  - N.B. NASA JPL & IAU MPC APIs cannot be used for this purpose.