



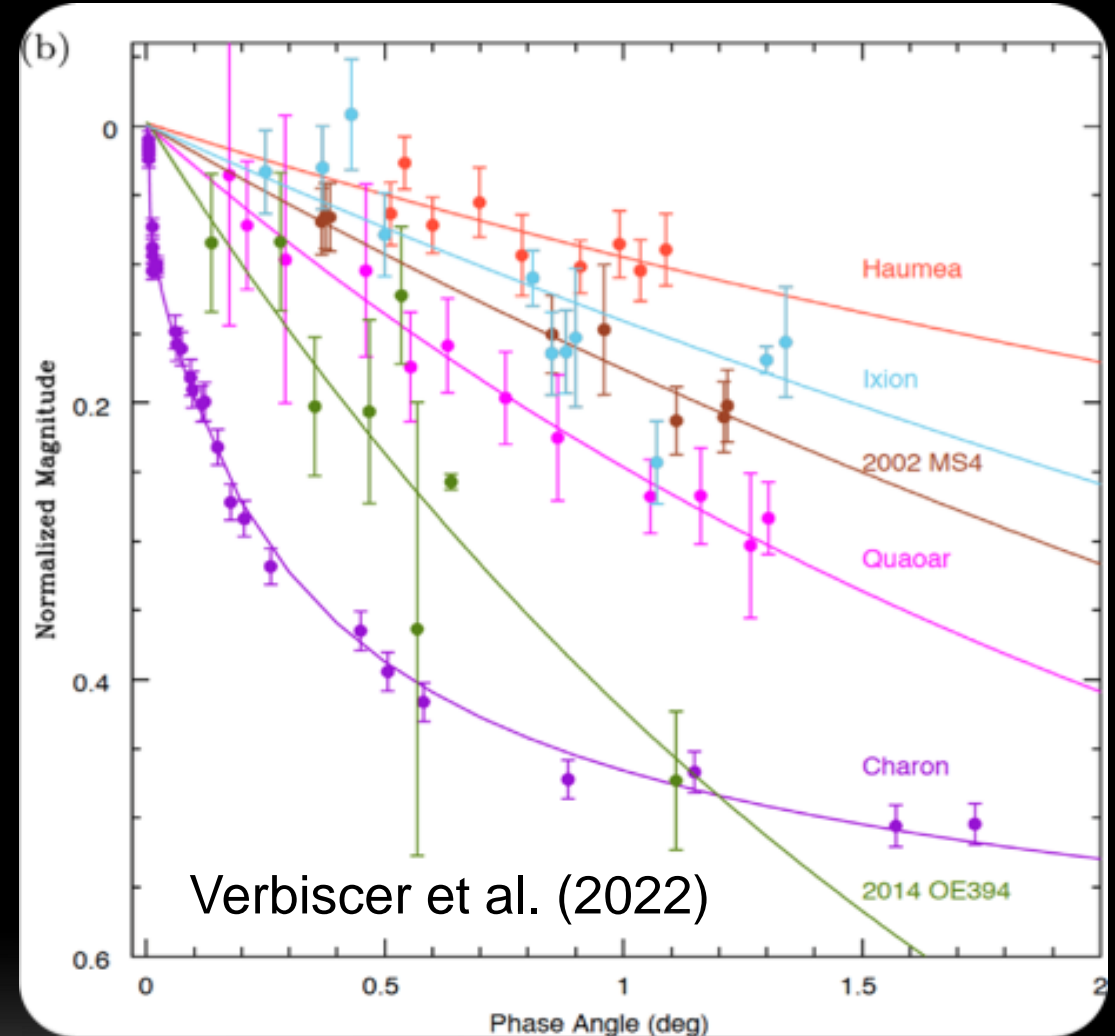
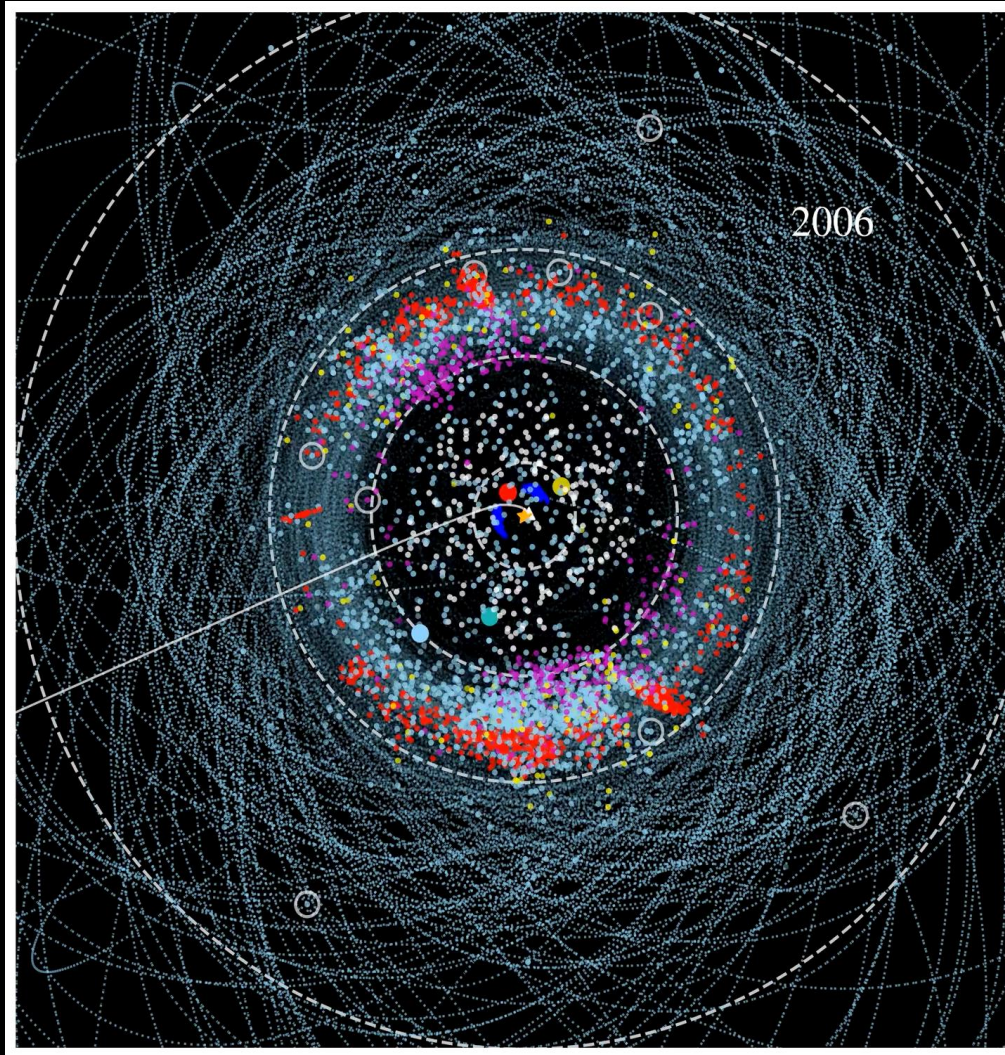
New Horizons KBO Detections

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The Kuiper Belt

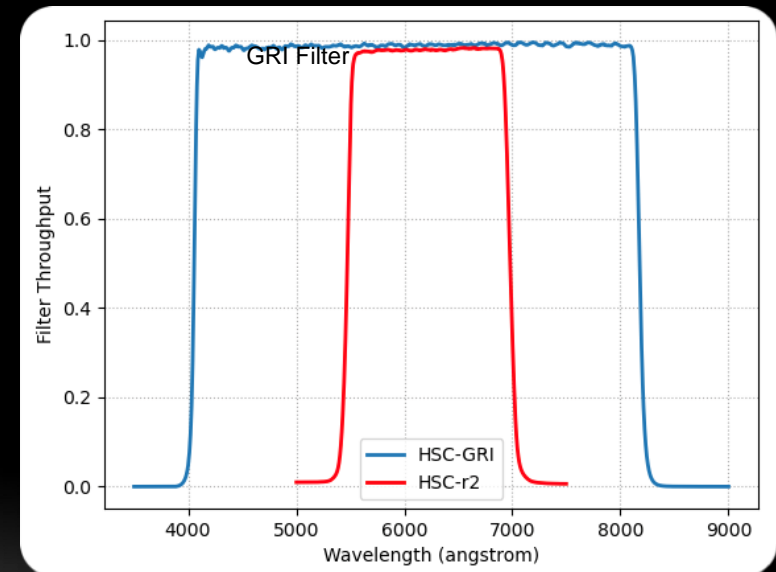
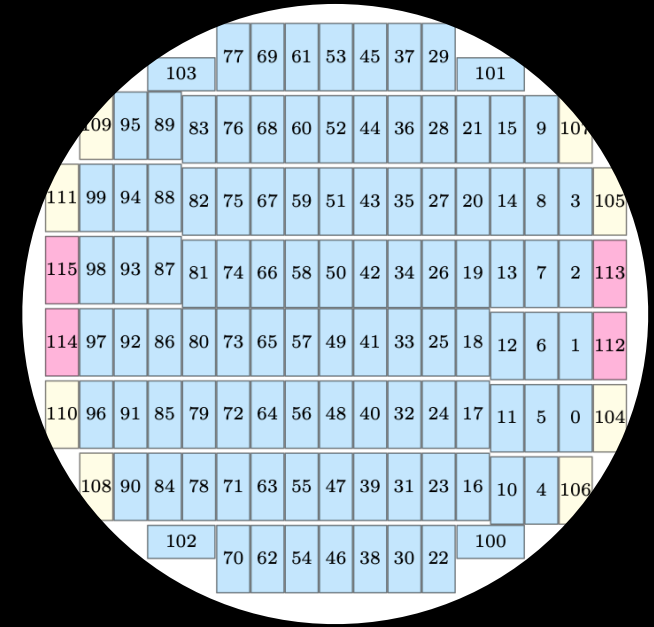




The Search For Distant KBOs



- ✦ started in 2020
- ✦ 34 half nights to date
- ✦ 5 new LORRI targets (2023-2026 observations)
- ✦ 240 new KBOs



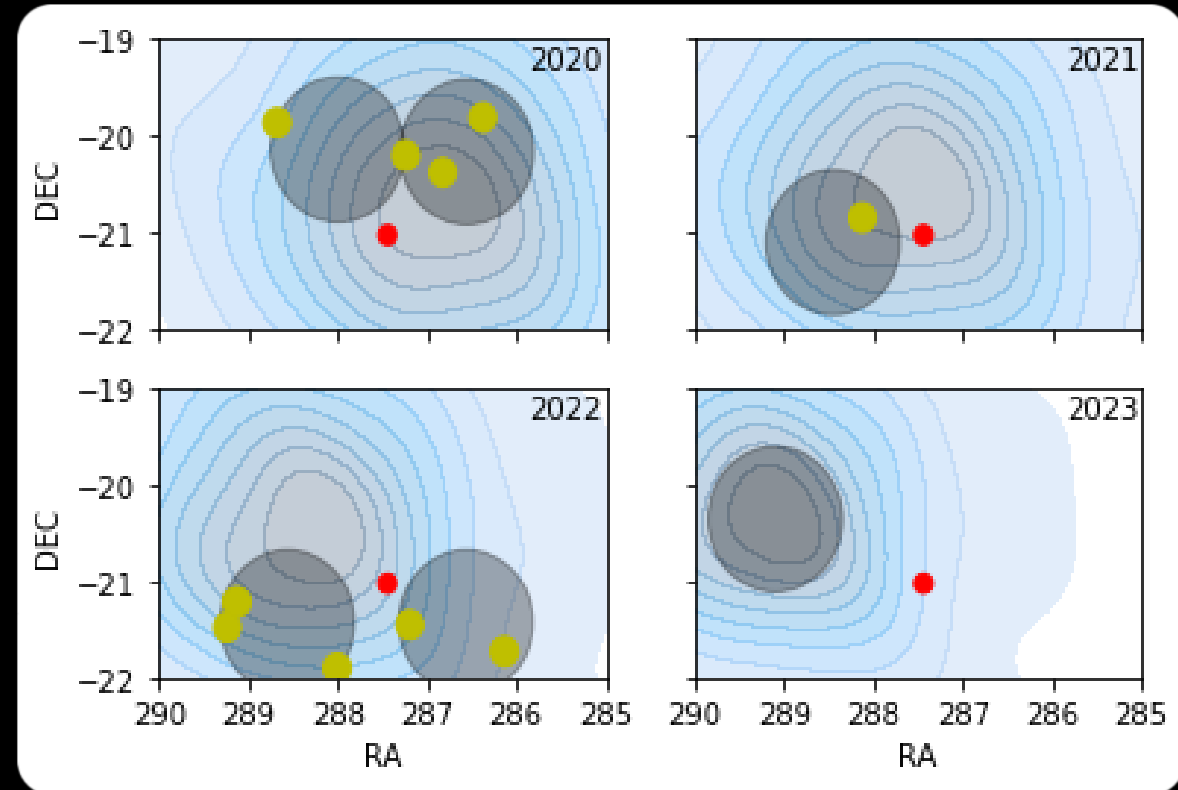


The Search For Distant KBOs



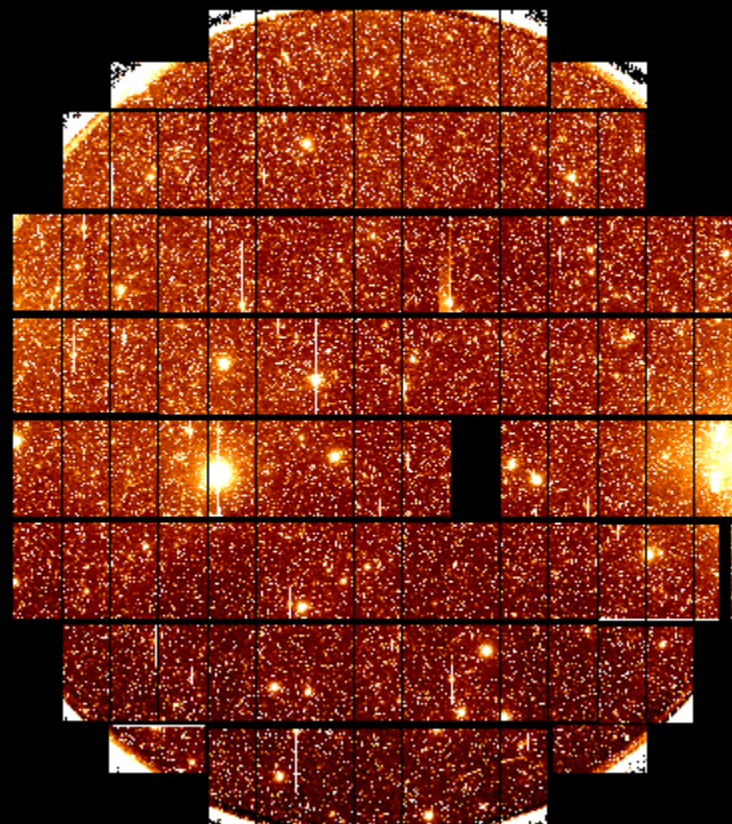
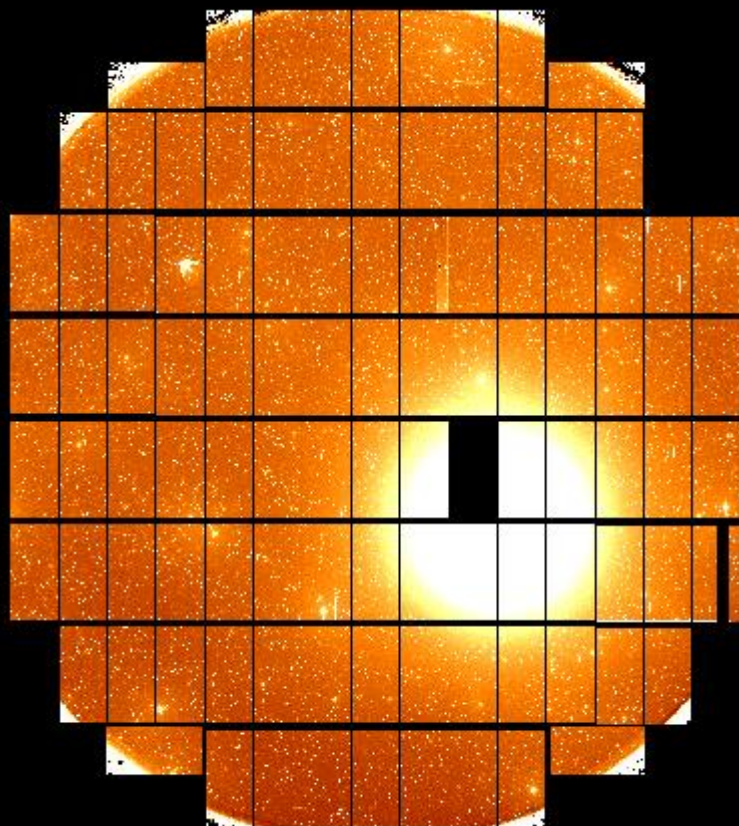
The process:

1. Observation Planning
2. Reductions + Subtractions using LSST pipeline
3. Shift-and-stack search
4. Machine Learning Source Rejection





Its full of stars!



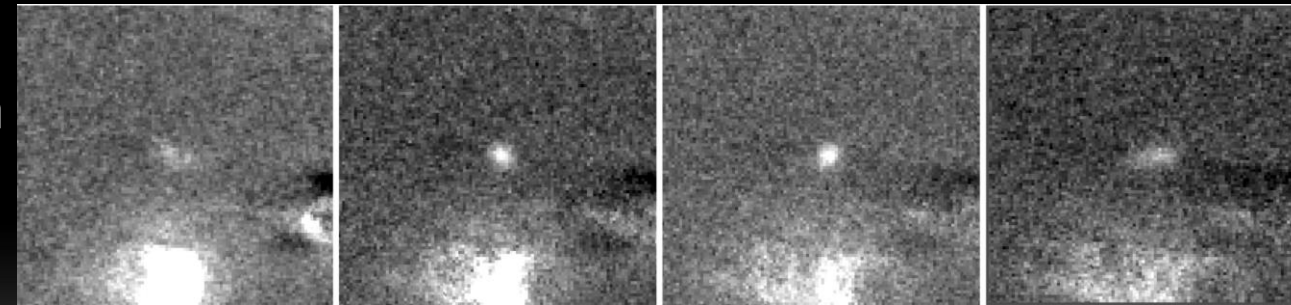
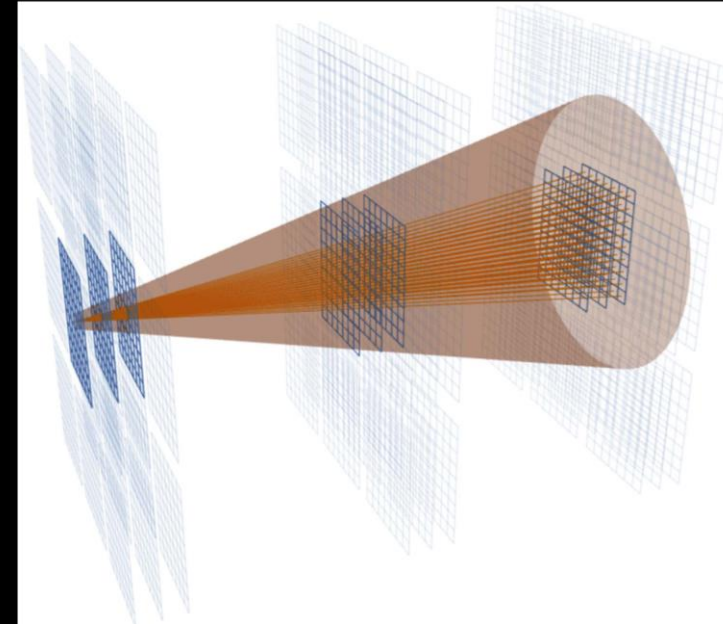


The Search For Distant KBOs



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1.5 "/hr

2.0 "/hr

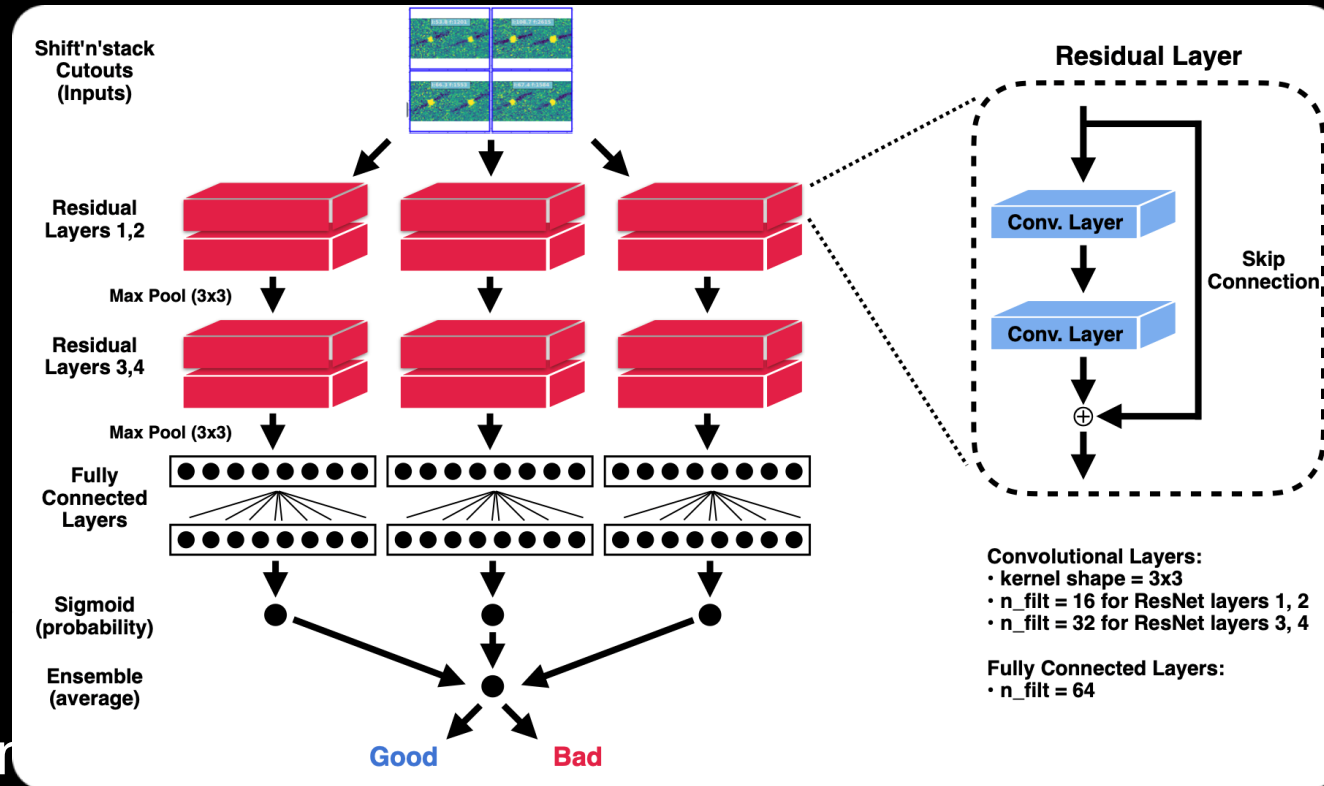


The Search For Distant KBOs



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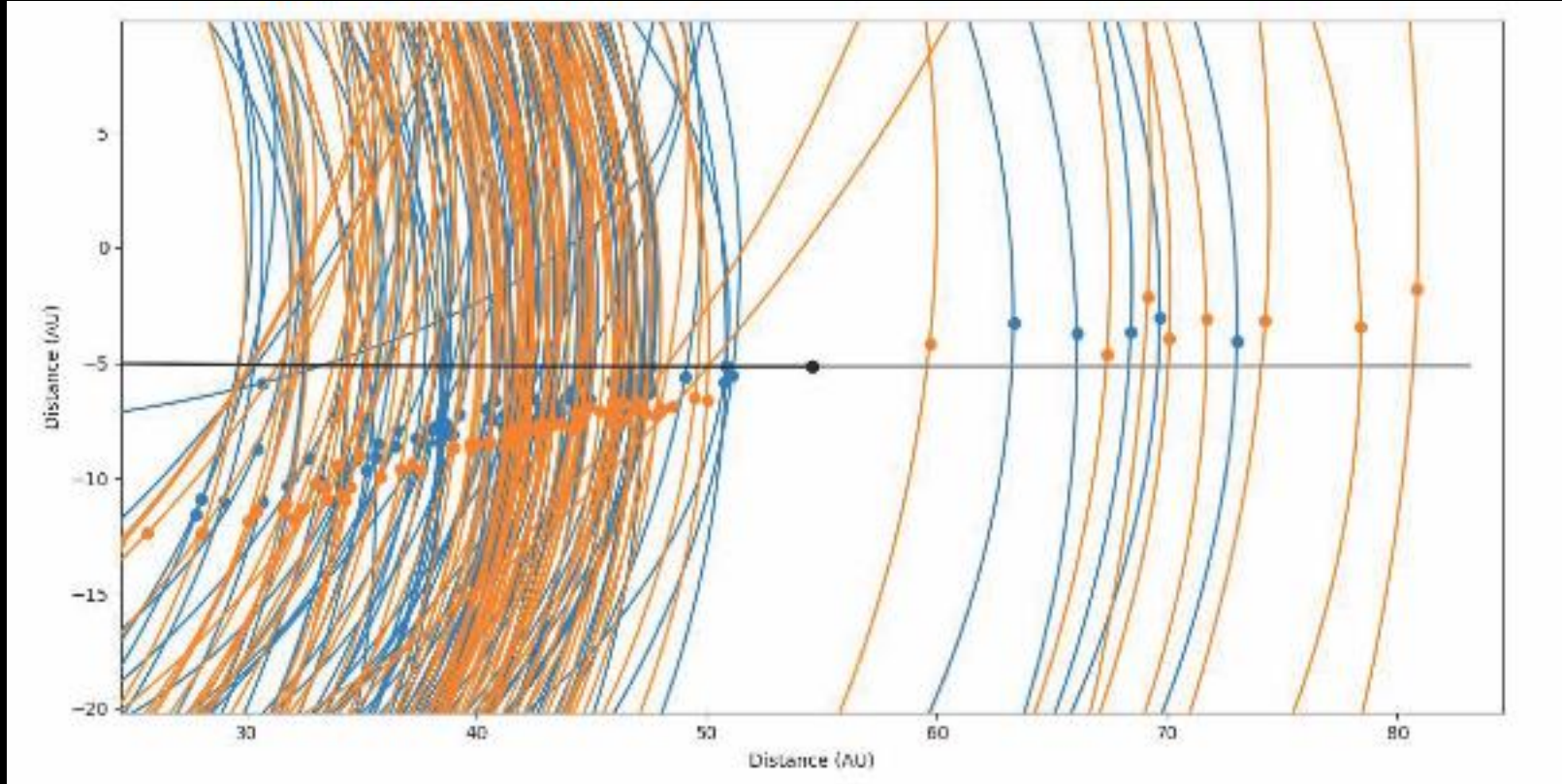




A Second Gap in the Kuiper Belt?



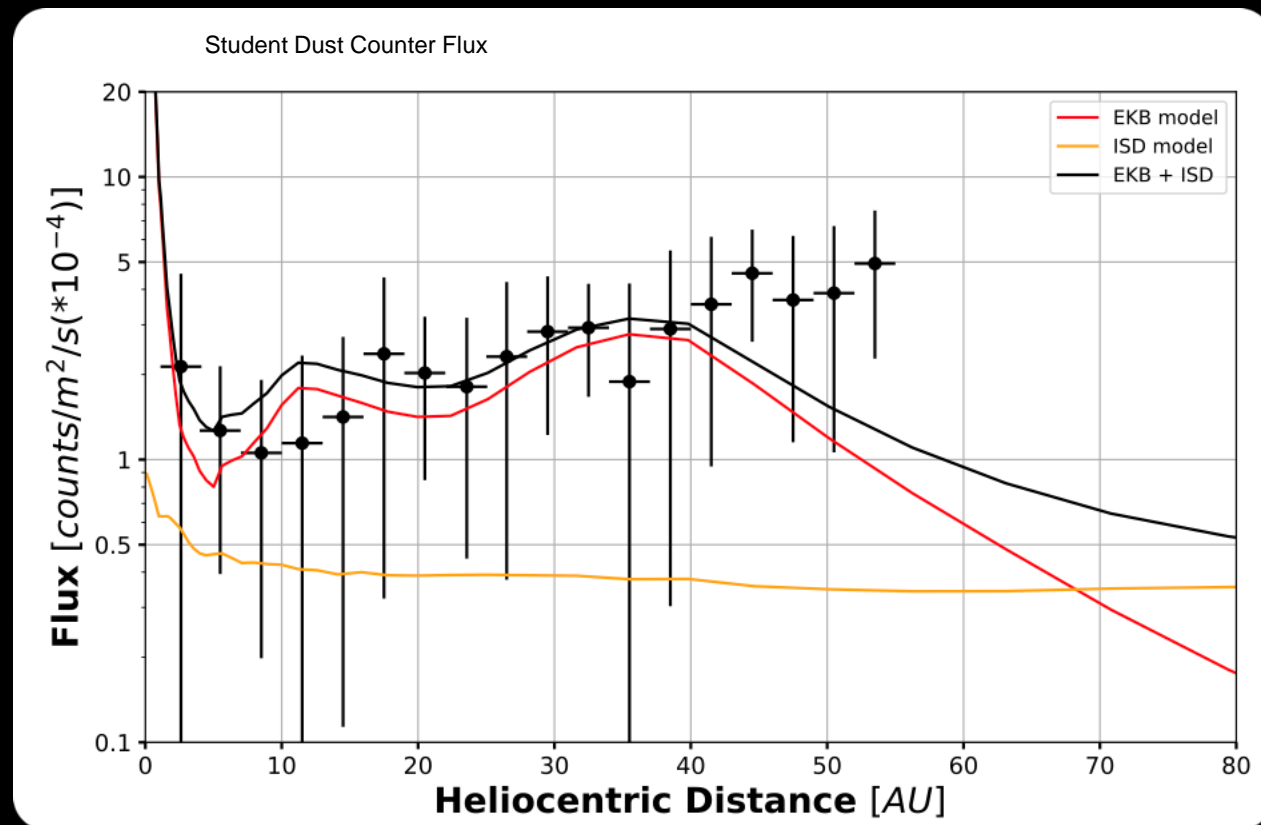
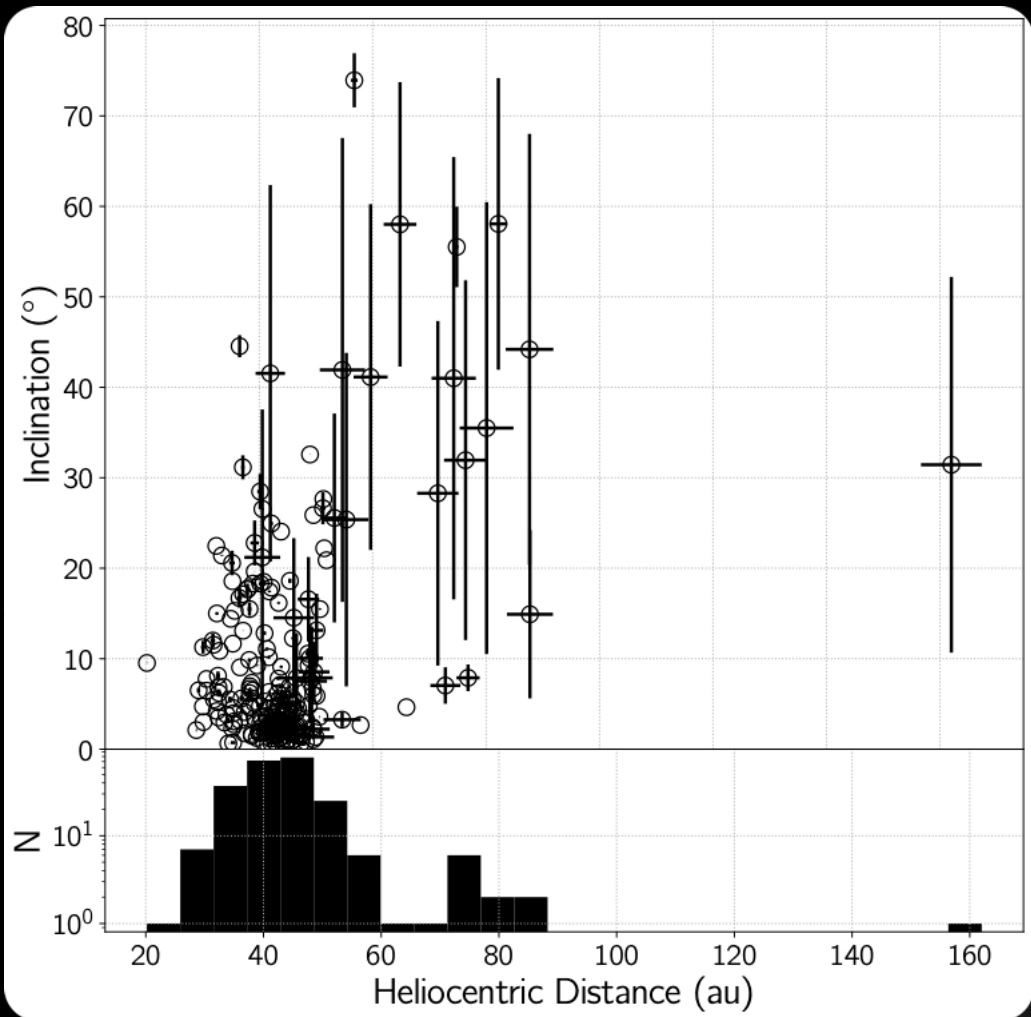
Subaru Observations



A team of international scientists used Subaru observations and have found a dozen more KBOs in the 60-80 au region and a tantalizing gap in the 50-60 au range. Diagram shows Kuiper Belt Objects detected from the Subaru 2021 (blue) and 2022 (orange) observations. The horizontal black line is the trajectory of New Horizons, the black dot represents the spacecraft's position on 2022-12-15. The colored dots show the locations of the discoveries at the point on their orbits when the New Horizons is closest to them. For reference, New Horizons is at 58 au (Jan 2024). Alternative explanations could include a clustering of orbits that are resonant with Neptune. However, there's more...



240 Newly Discovered KBOs

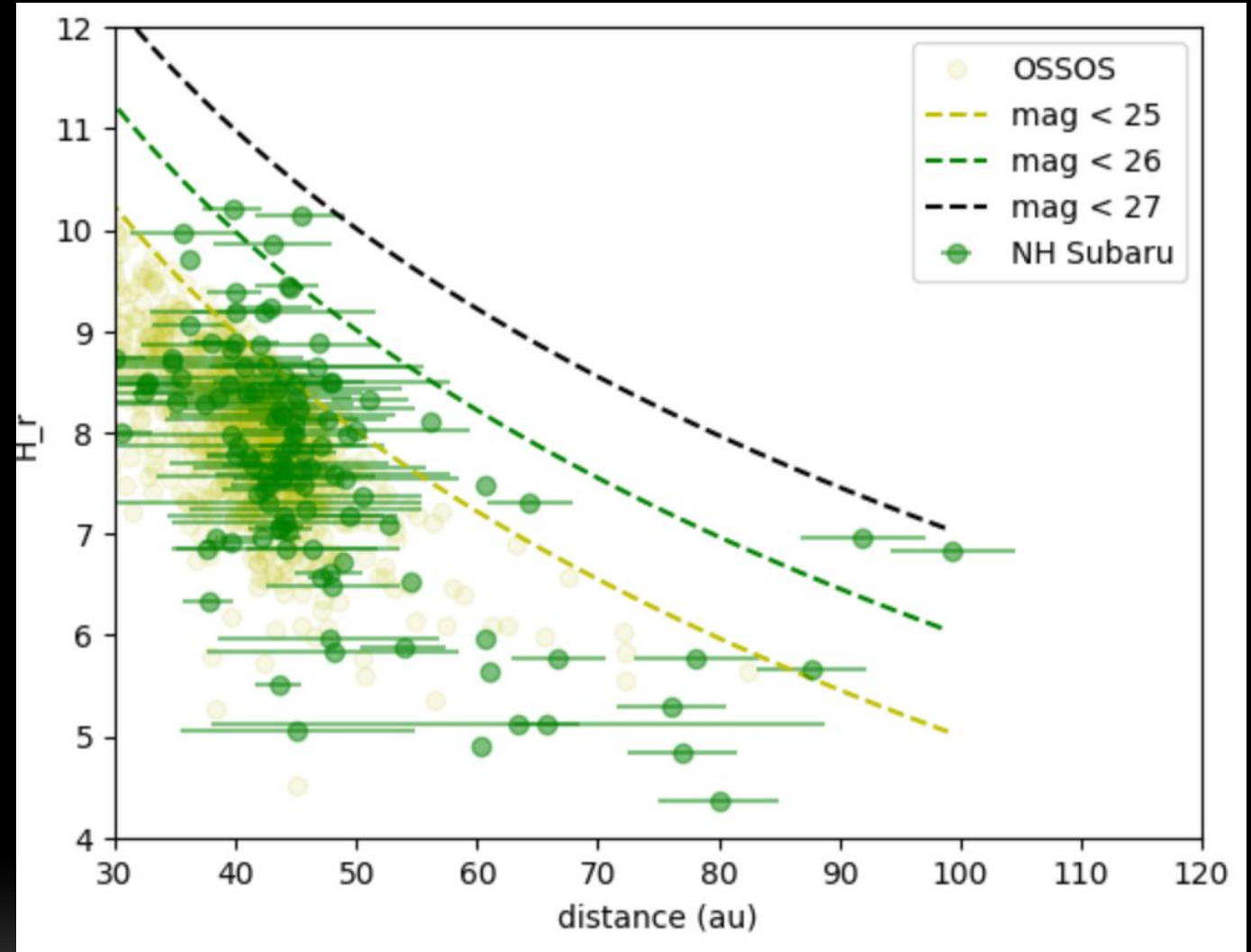




Distance Distributoin is unique.



We appear to be probing a different distant population, no fully consistent with expecatoin.

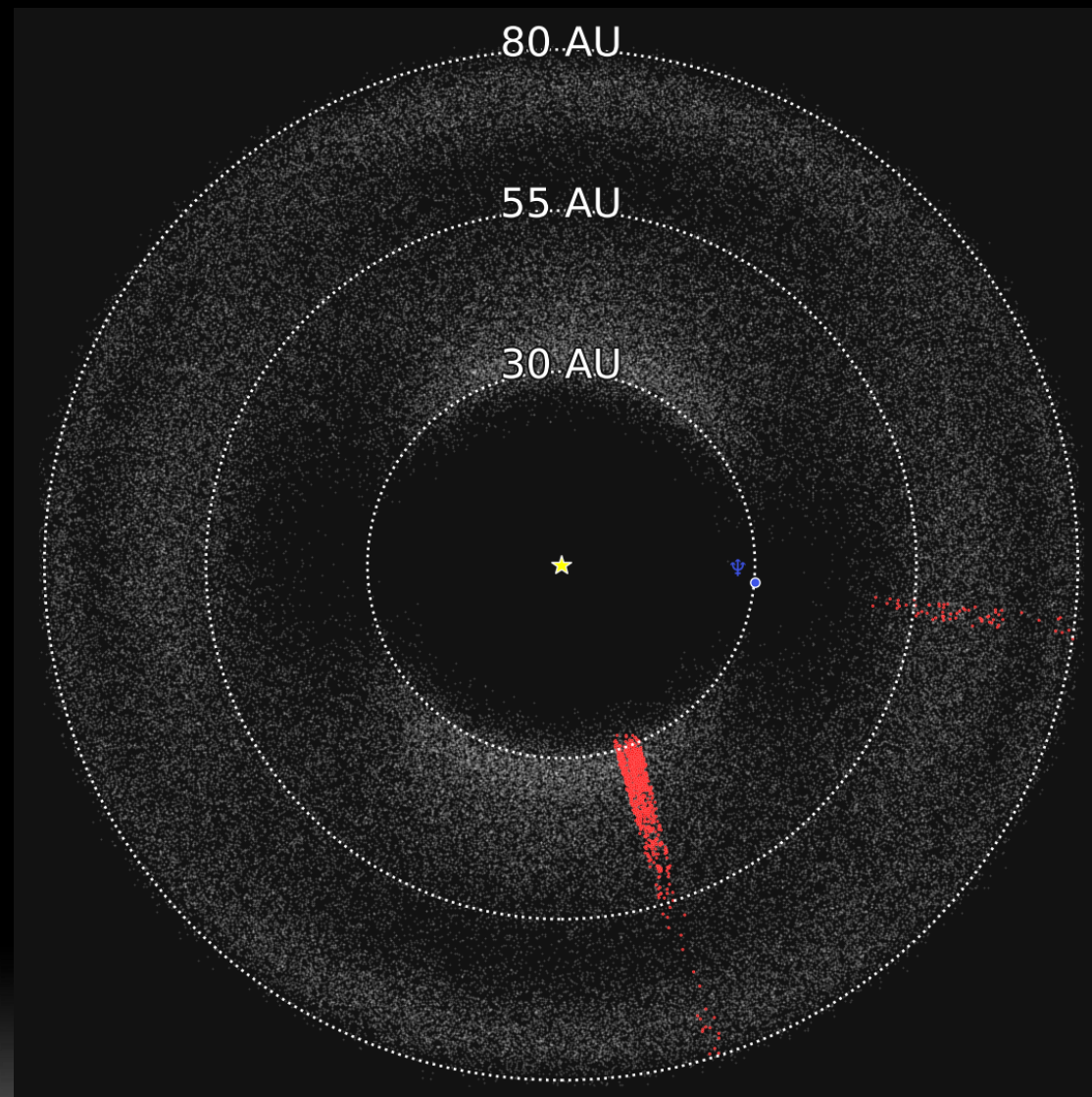




5:2 resonance at aphelion?



- Top-down view of instantaneous solar system.
- White dots are the positions of objects in the 5:2 Neptune resonance.
- 5:2 has unusual orbital structure.
- New Horizons search field LoS is towards the apo-centre of this population.
- Is that what we are seeing?

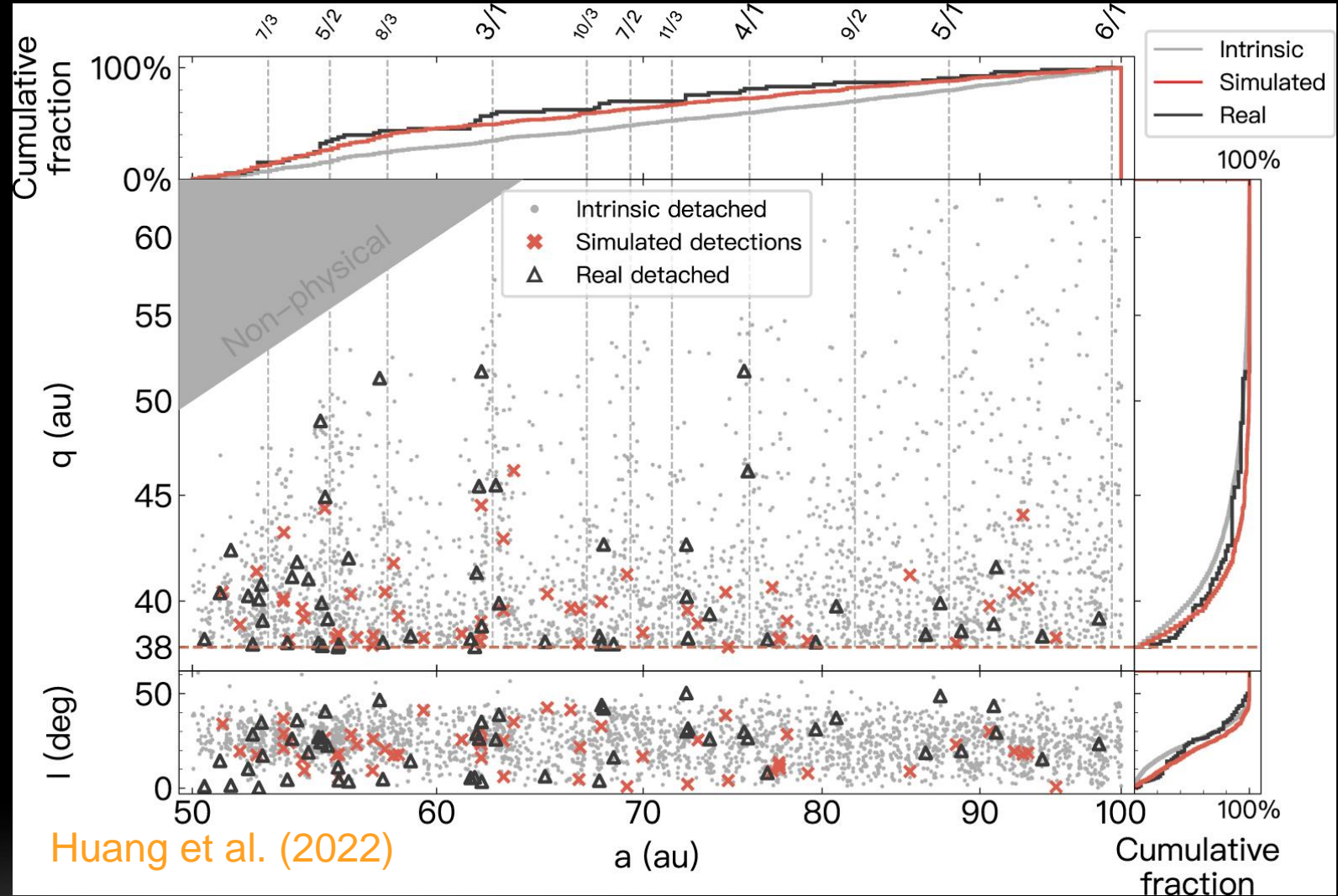




Signature of a Rogue Planet



- A 2 Earth mass object lodge at $a \sim 300 \text{ au}$ for 100 Myr
- Lifts the perihelion of KBOs.
- Final stopping place of KBOs set by semi-major axis of the Rogue

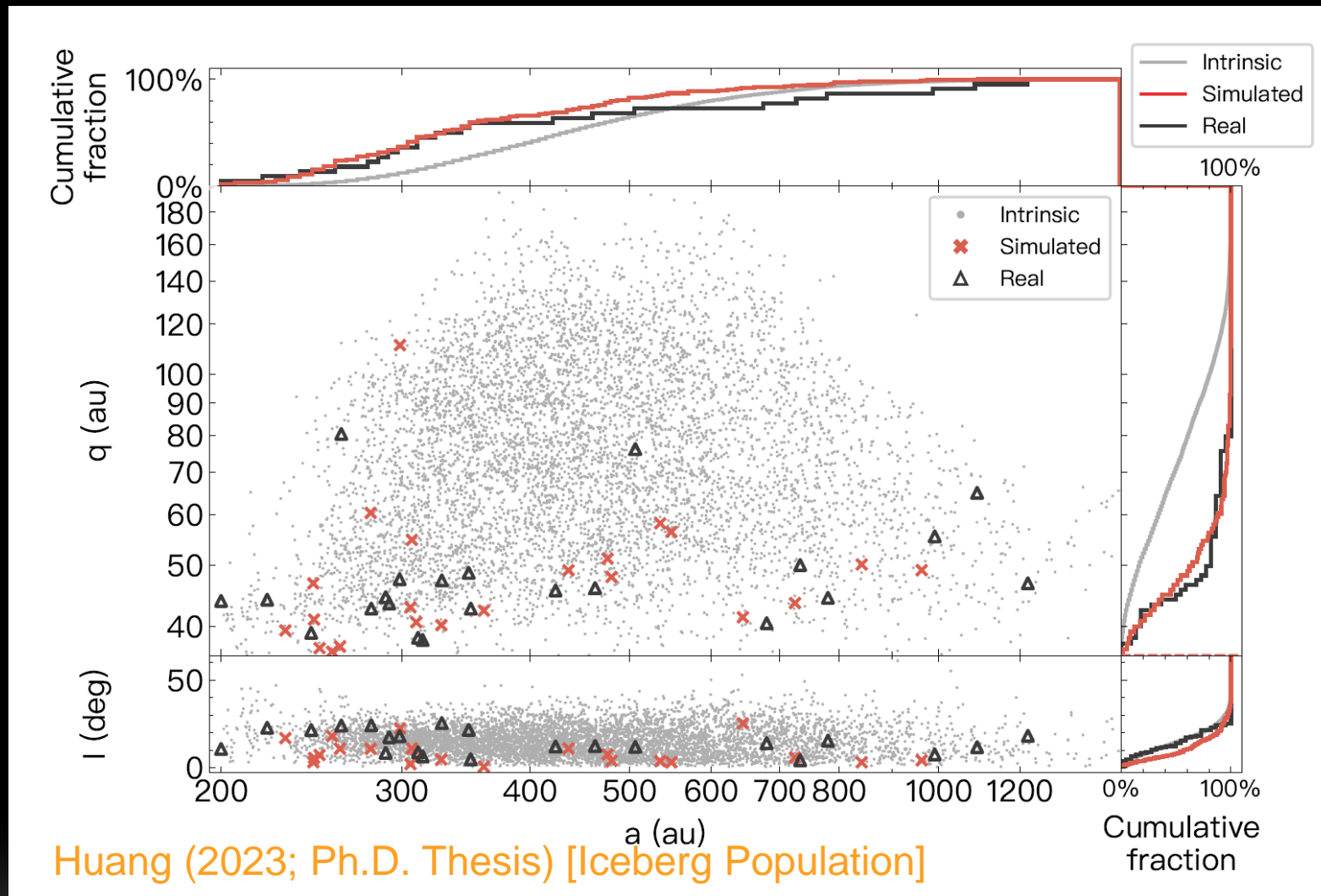




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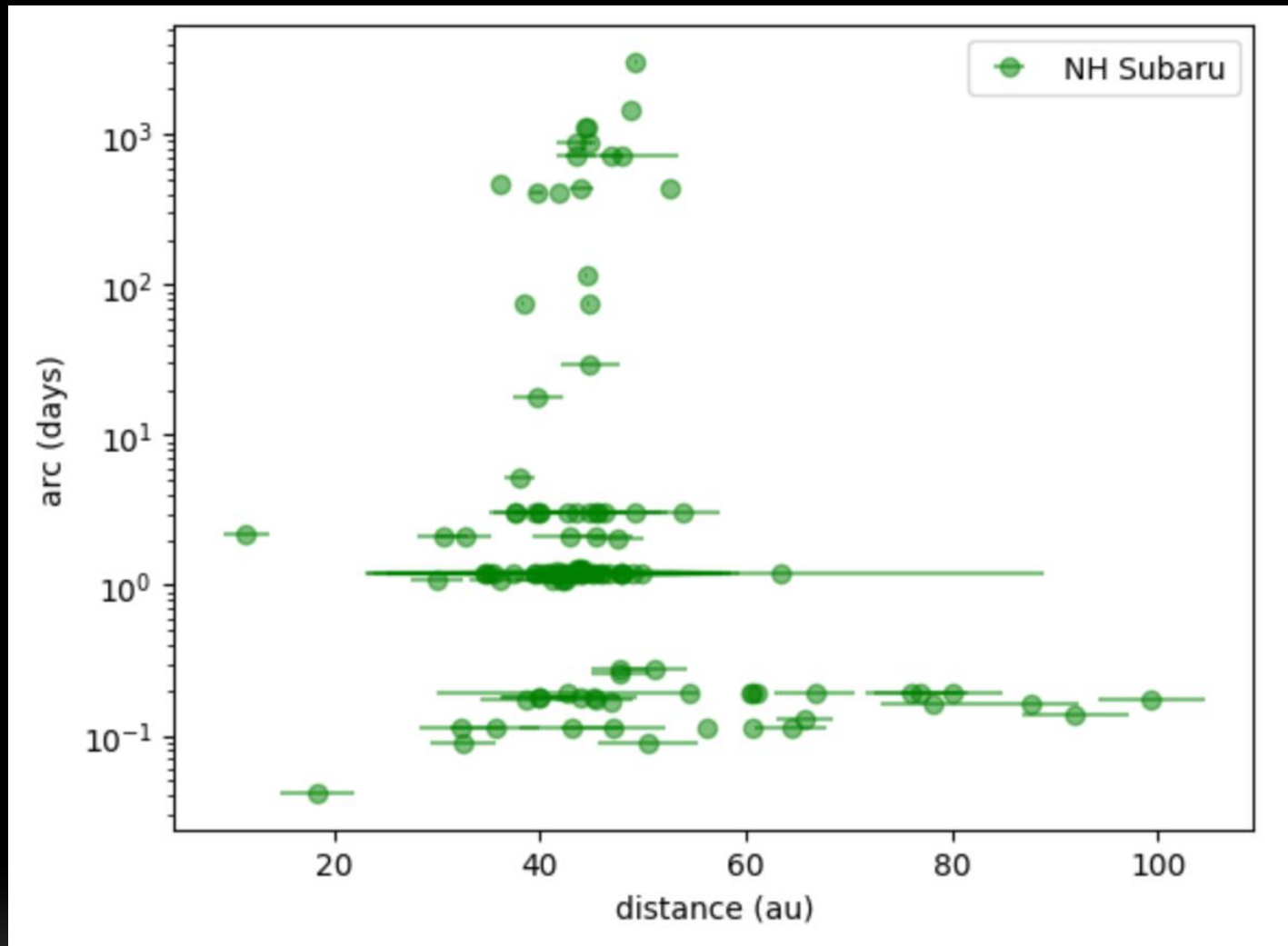
Huang (2023; Ph.D. Thesis) [Iceberg Population]



Need longer arcs for classification



Tracking these distant and very faint sources is an enormous challenge.

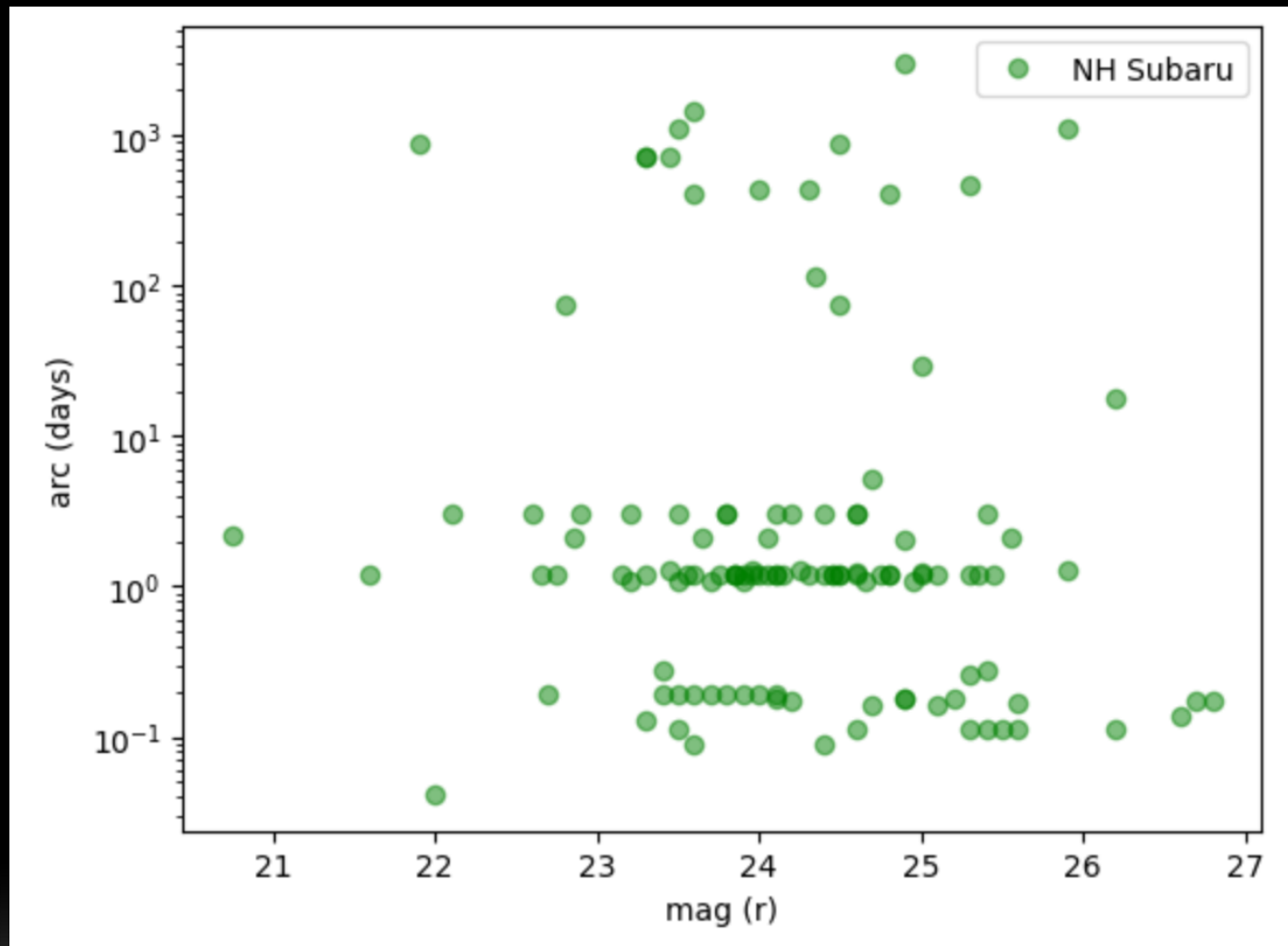




Tracking is challenging



Distance is not what makes them hard to track, we are working a new level of low signal and high crowding.





2024 Plan



9 half nights purchased for 2024A/B

June 2x half nights July 5x half nights August and Sept to be scheduled

Full re-search of the data improved subtraction with LSST v25 and a rebuild and retrain of the neural network



LORRI Observations of 2021 KS11

