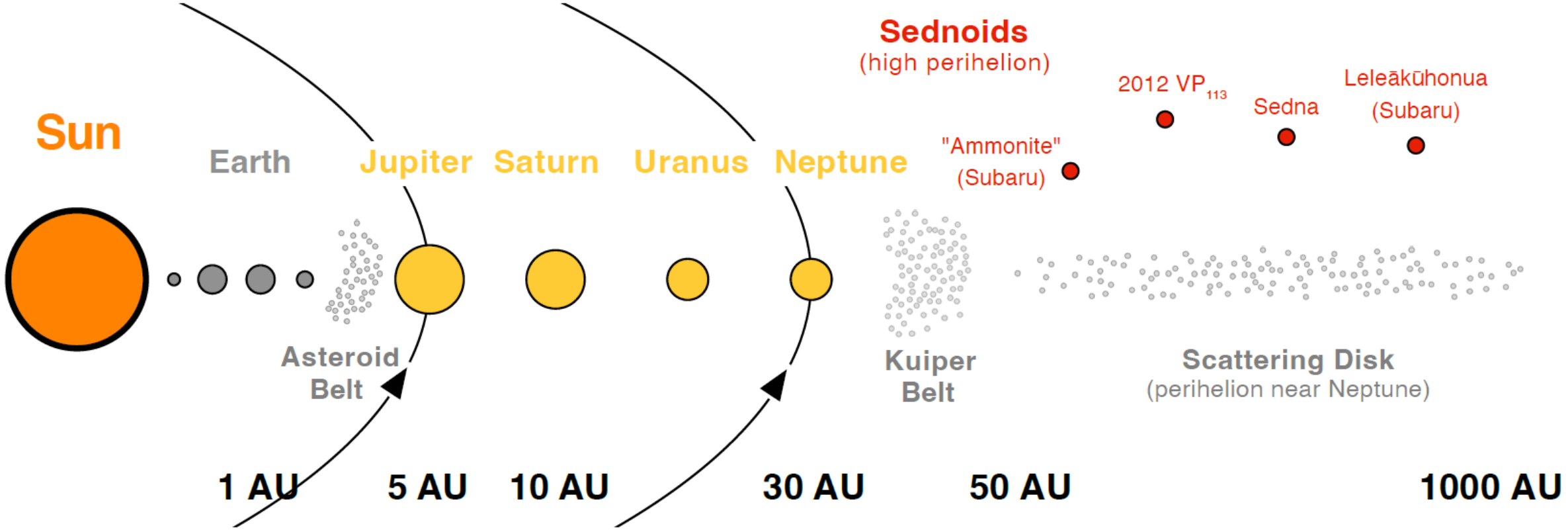
NRC·CNRC

NRC.CANADA.CA

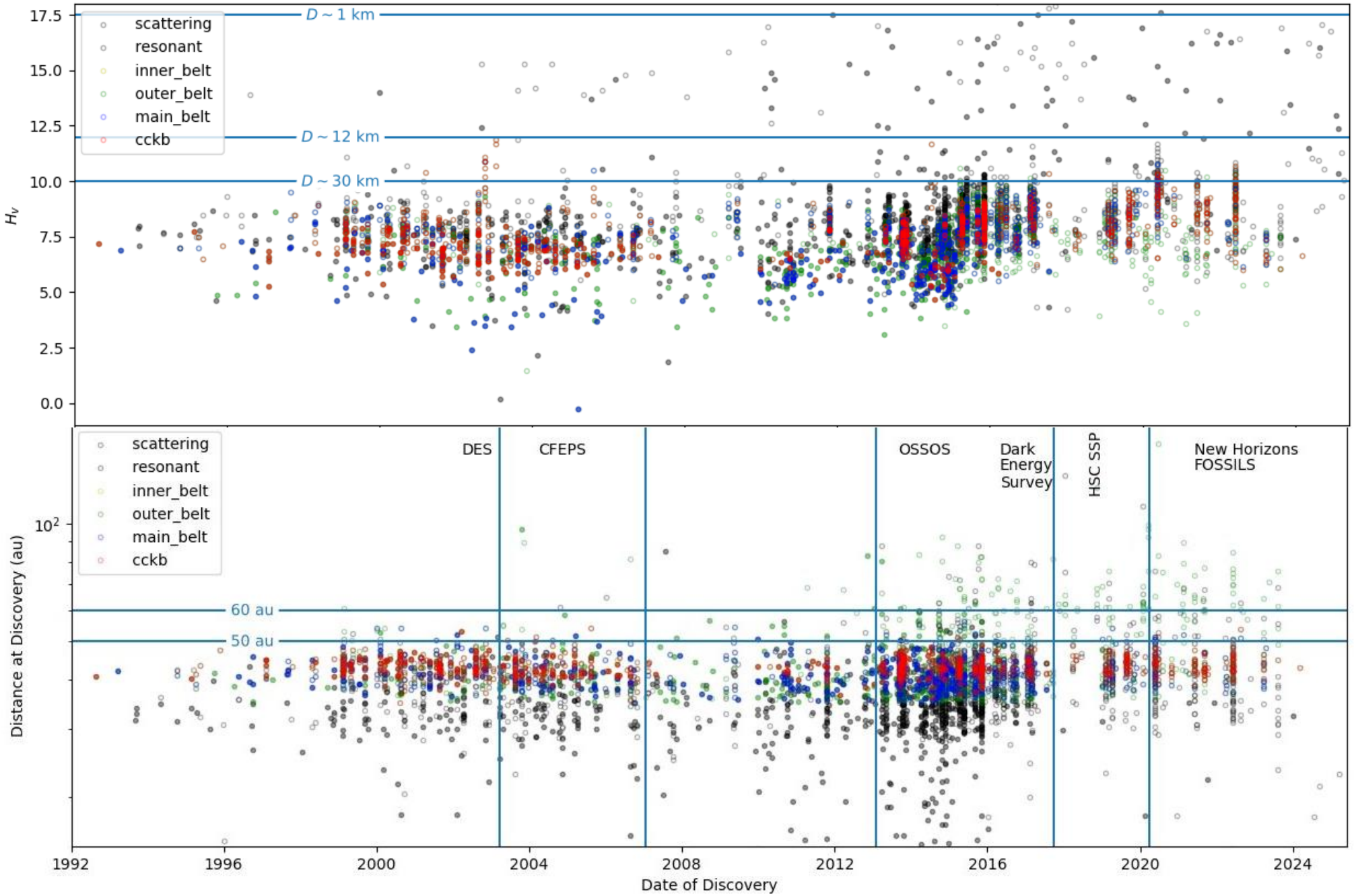
New Horizons, FOSSIL and LSST and CANFAR

JJ Kavelaars

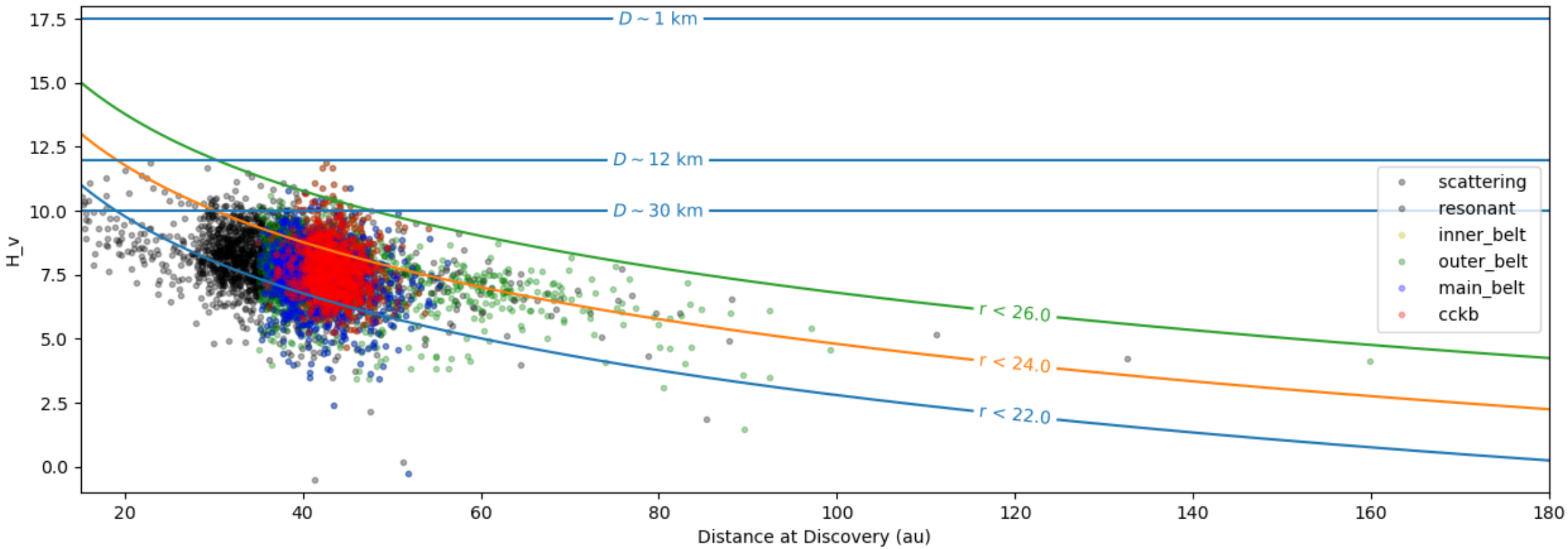
Canadian Astronomy Data Centre



Huang et al. 2025


scattering
resonant
inner_belt
outer_belt
main_belt
cckb
D ~ 1 km
D ~ 12 km
D ~ 30 km
H_v
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
DES
CFEPS
OSSOS
Dark Energy Survey
HSC SSP
New Horizons FOSSILS
60 au
50 au
10^2
Distance at Discovery (au)
1992
1996
2000
2004
2008
2012
2016
2020
2024
Date of Discovery

Discovery Limits : Size^2 x Distance^4



The Distant Kuiper belt

TNOs on orbits with large-*Pericenter.*

Stability: Minor orbital changes over 4.5 Gyrs

Mechanism required to place object there

Only few such objects are known:

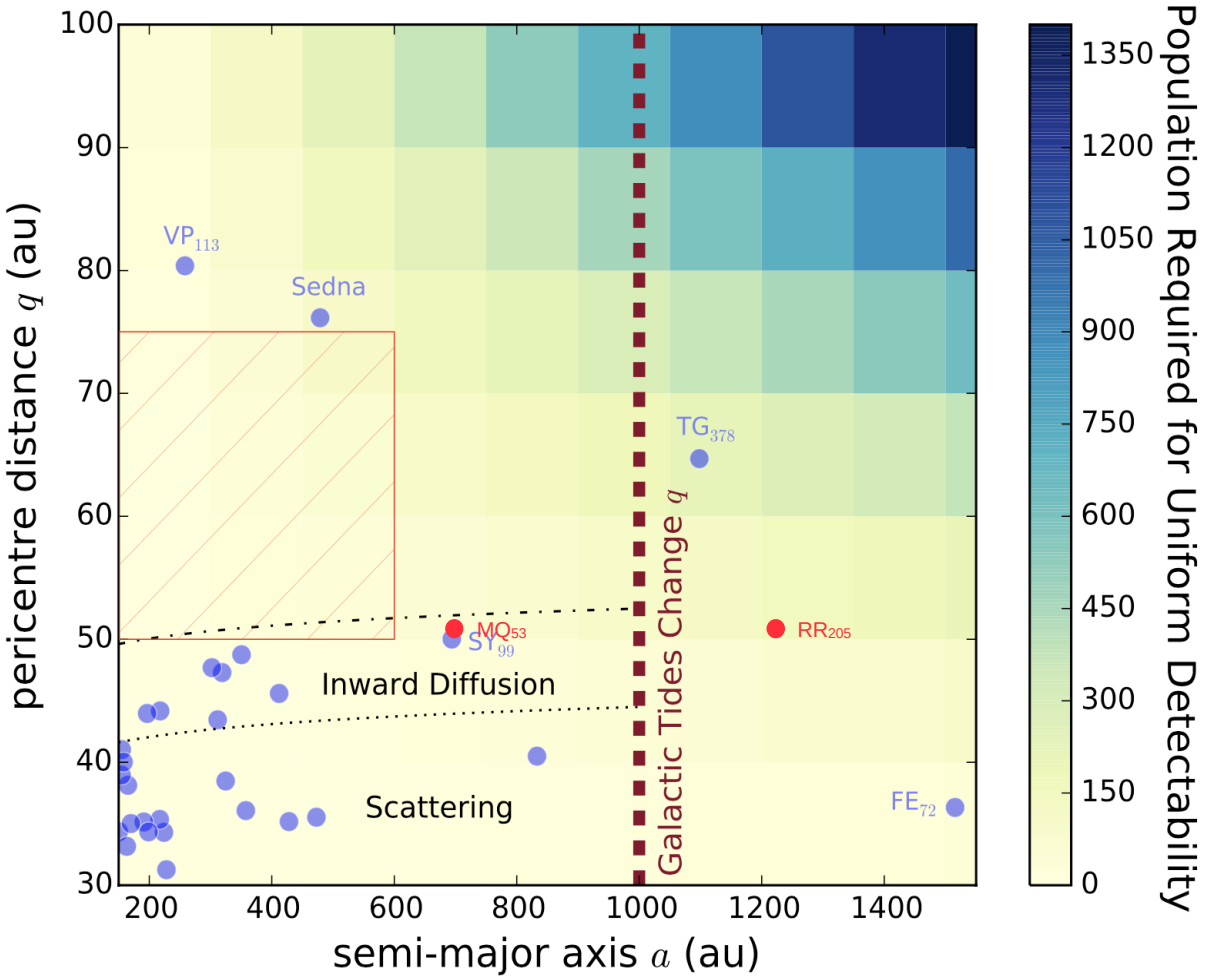
- Sedna, 2012 VP_{113}, Leleākūhonua and etc?

Debate : possible scenarios with perturbers

Rogue/current planet

Sun in Star cluster/Stellar migration

capture of **extrasolar** object



Kavelaars+18 updated

Canadian Advanced Network for Astronomical Research

- Inception in 2008
- Cloud platform for data and compute intensive astronomy
- Canadian Astronomy Data Centre (CADC)
- Digital Research Alliance Canada
- 1.0: Virtual Machines, Batch
- 2.0: Containers (Science Platform)

CADC

National Research Council Canada

Canadian Space Agency

University of Victoria

University of British Columbia

CANARIE

Compute Canada

Digital Research Alliance Canada

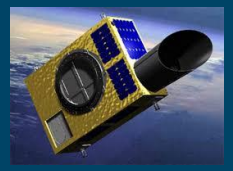
A General Purpose Astronomy Platform

CFHT

JCMT

ALMA

Subaru



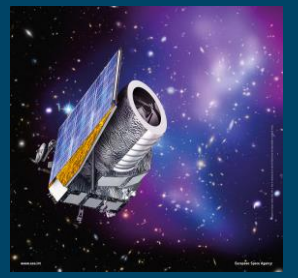
NEOSSat

JWST

ASKAP

Gemini

Euclid



Rubin IDAC

VERA C. RUBIN OBSERVATORY

X11 Desktop

LSST Pipeline

CARTA

User Database (YOuCat)

FireFly

CASA

Machine Learning - GPU

ALADIN

KUEUE

Large Data Cubes

New Horizons

chime/frb

CANUCS

SRCNet

SKAO

OSSOS

CFIS/UNIONS

FOSSIL

CHIME FRB

CLASSY

CASTOR

2019
ALMA

"Discovering and measuring the most energetic processes in the universe, probing the fundamental structures of matter, mapping the cosmic origins, exploring the nature of dark matter halos, discovering exoplanets and determining the processes of planet formation. All done on a single infrastructure that enables collaboration, sharing and dissemination."

2025+
116 Science Projects

CANFAR Philosophy and Future

Philosophy. - Single compute platform for range of observational astronomy problems for Radio to Optical to X-Ray, for timeseries, imaging and spectra.

Opportunity - Open to projects connected with Canadian national observatories

Capacity – Currently a few 1000 cores and PB, growing by factor of 50 in storage and compute to support SKA science users but still available for non-SKA projects.

Active Uses – Chime FRB, CIRADA/POSSUM, UNIONS, etc.

Core part of Canada's LSST contribution to provide the Public LSST Archive.

Currently usable by Canadian LSST data rights holders.

Subaru HSC and the LSST Science Pipeline

LSST Science Pipeline is highly flexible data processing pipeline for CCD based imaging projects.

Developed from Subaru's HSC pipeline but has evolved to the Rubin/LSST science case.

LSST Science Pipeline is ACTIVELY developed, large community contributing (about 100 code committers). Requires a disciplined development process.

List of facilities with 'obs' packages that are distributed by LSST project and supported by the community.

e.g. the New Horizons distant KBO project has added 'gri' filter characteristics to the LSST obs_subaru package.

Usage by New Horizons, FOSSIL (and CLASSY)

Instrument Signature Removal (ISR) [bias, flat, fringe]

Image Characterization:

- Photometric [tied to PanStarrs]
- Astrometric [tied to Gaia DR4]

Modified the LSST supplied **obs_subaru** to support New Horizons supplied gri filter.

Modified the LSST supplied **obs_cfht** package to support ‘40’ CCDs and gri filter.

Added Keplarian orbit capacity to **inject_source** module.

Developed ‘pipeline yaml’ file specific to project requirements.

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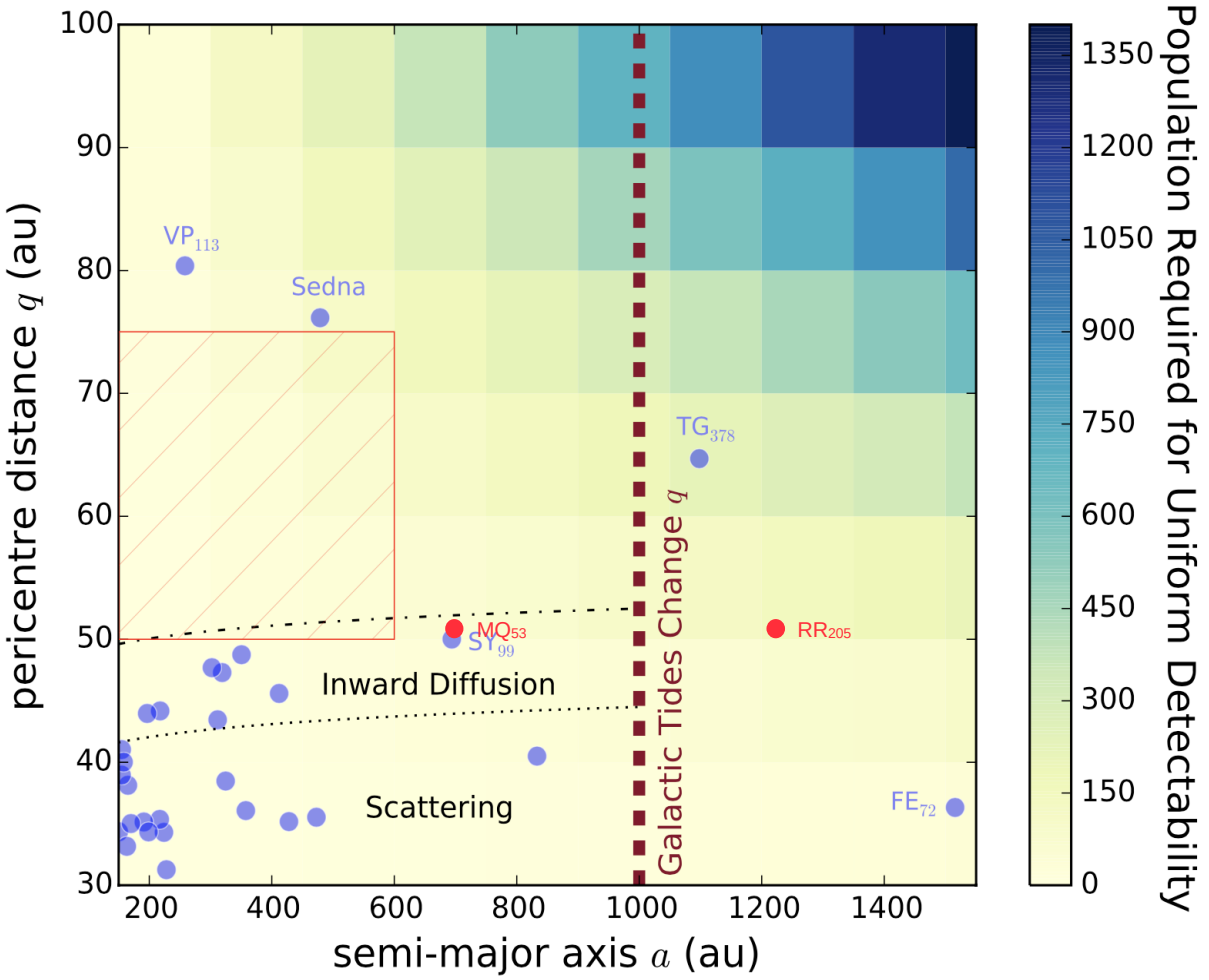


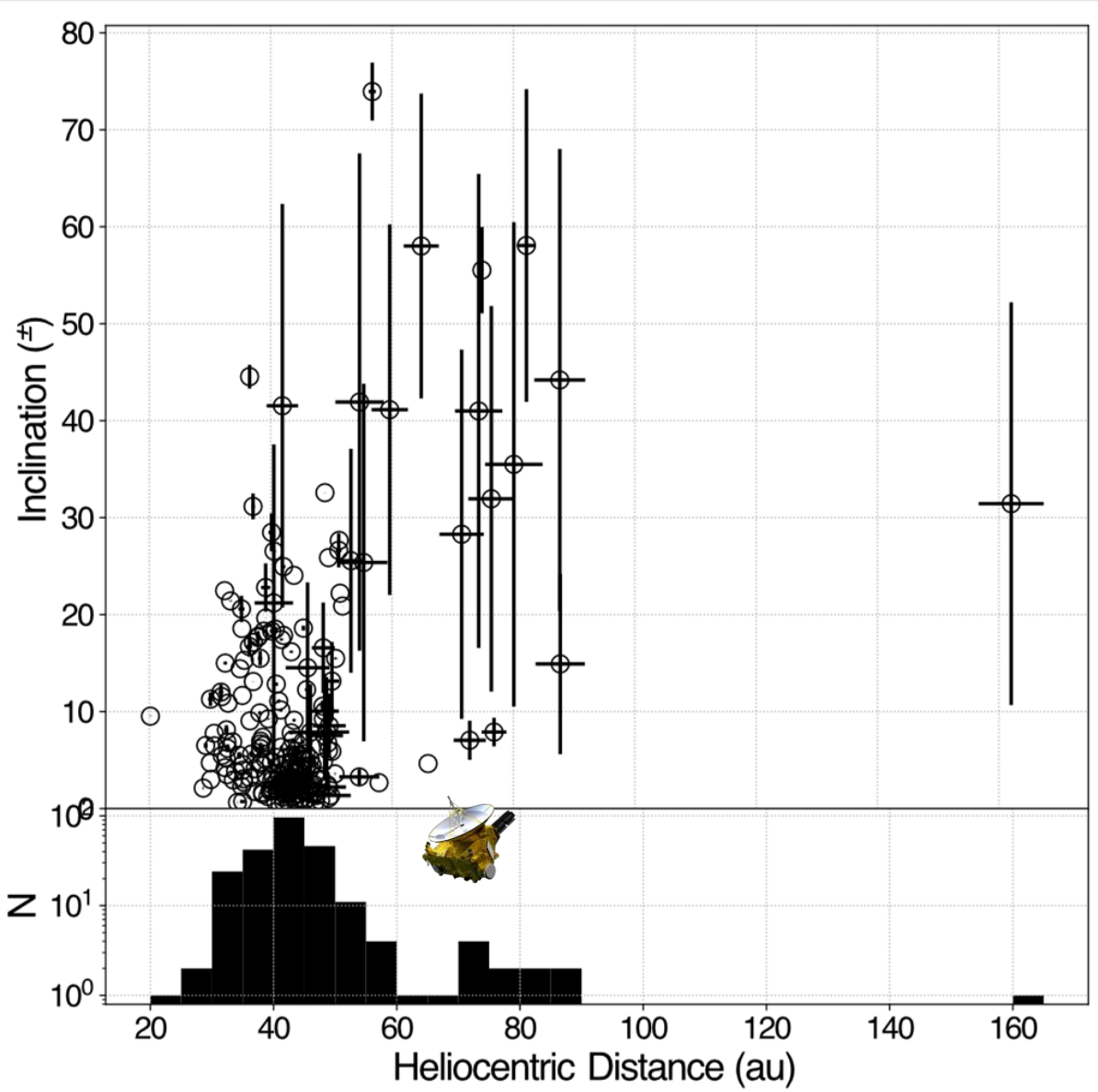
Kavelaars+18 updated

New Horizons Subaru Search

Deep searches using HSC

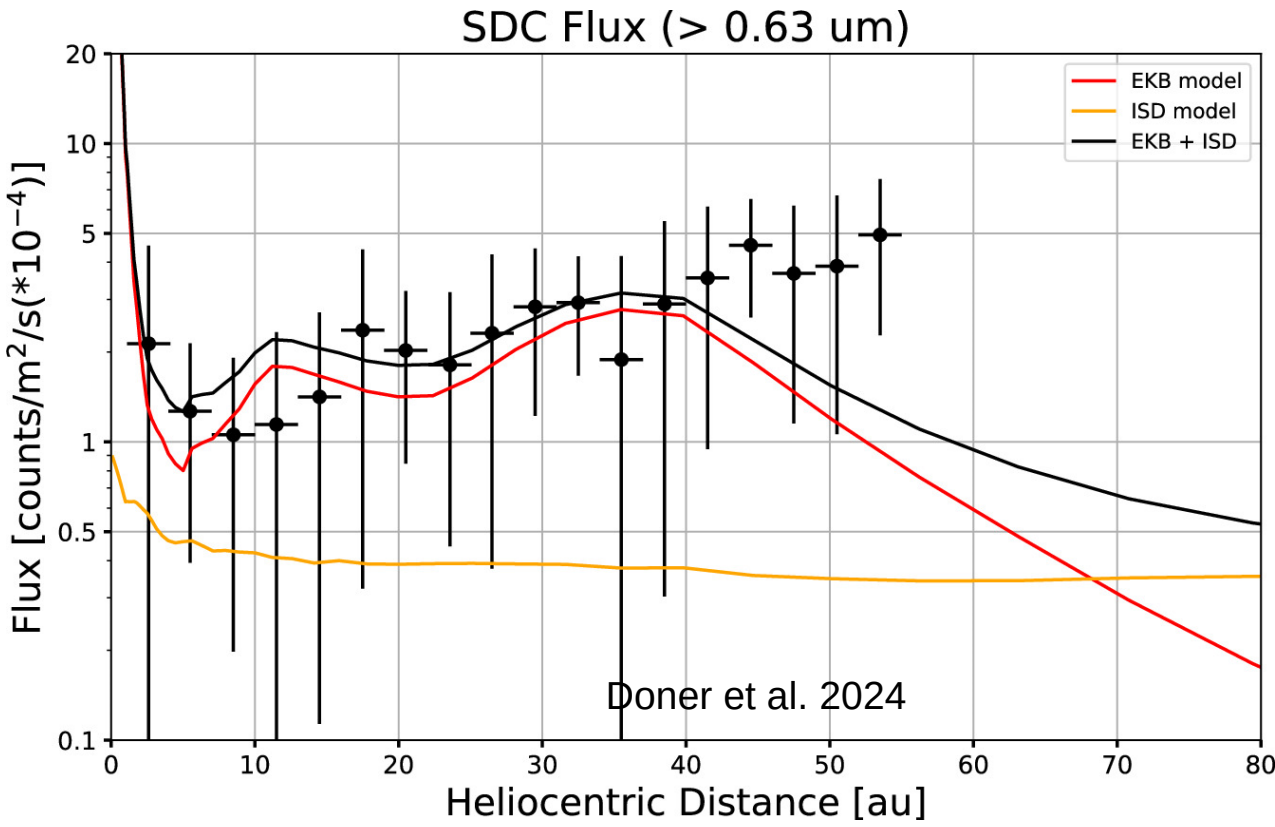
2020-24 found hundreds of KBOs

More extended than expected.



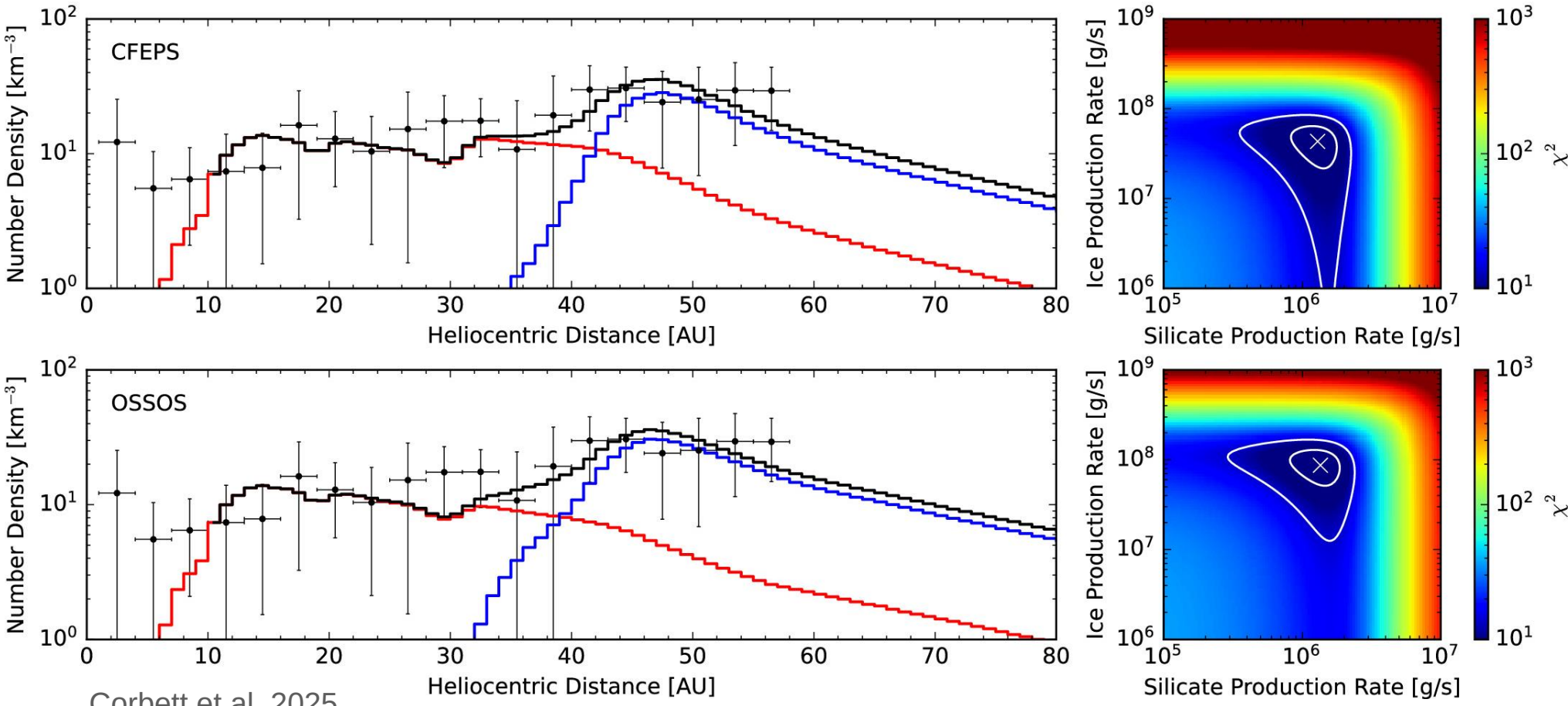
Broad Structure of the Solar System

- ***New Horizons*' Student Dust Counter measures elevated amounts of dust well beyond the expected drop off**
- **Could hint at a much higher than expected population of objects beyond 60 AU**
- **Need deep drilling survey to test this**



Broad Structure of the Solar System

VERY ice?



Corbett et al. 2025

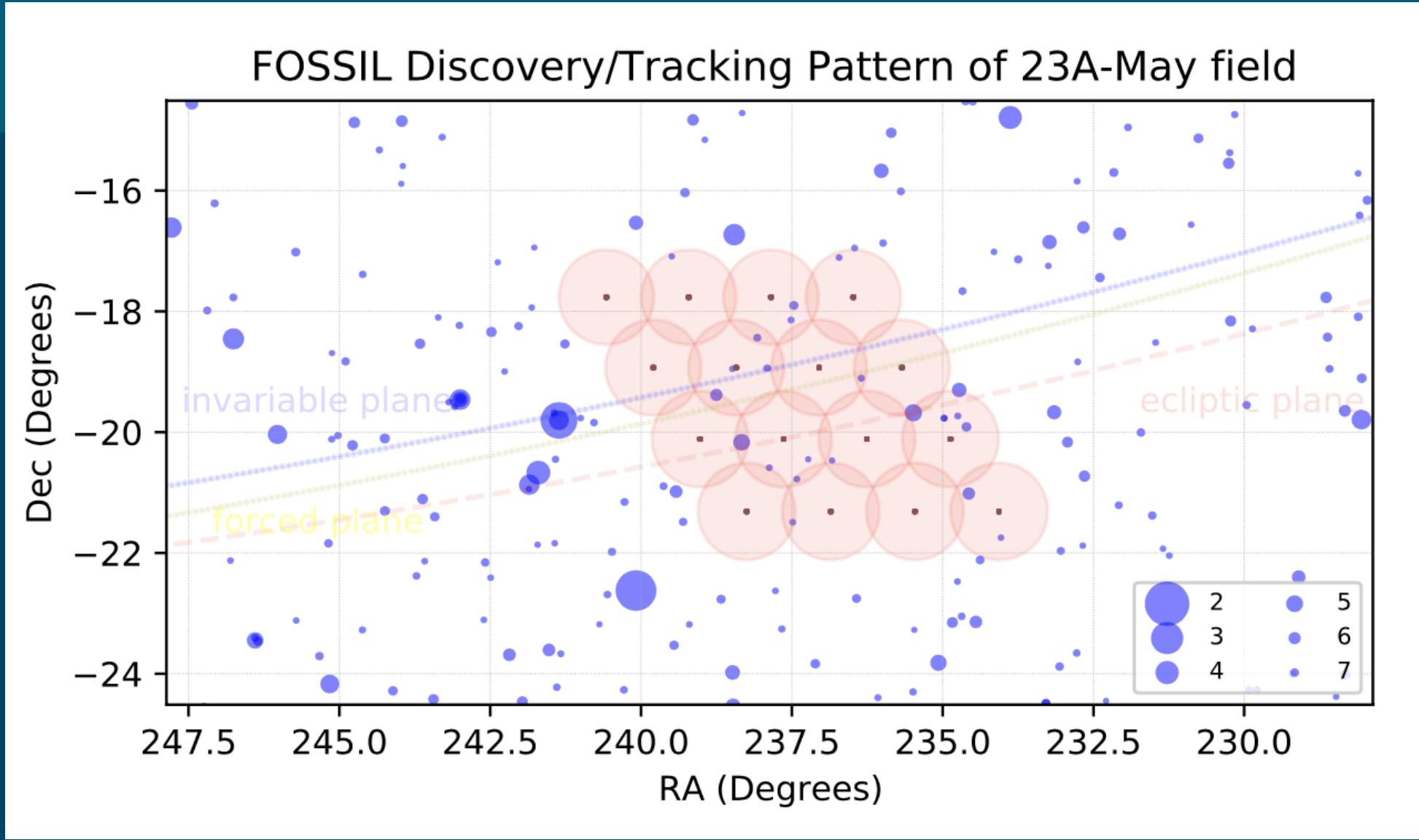
FOSSIL I & II

FOSSIL II:

25 deg2, multi-triplets

Expand # of large-q TNOs.

Fainter size distribution of resonant pop.



Discovery of Ammonite

Key Characteris

a = 251 au,

i = 10.98 de

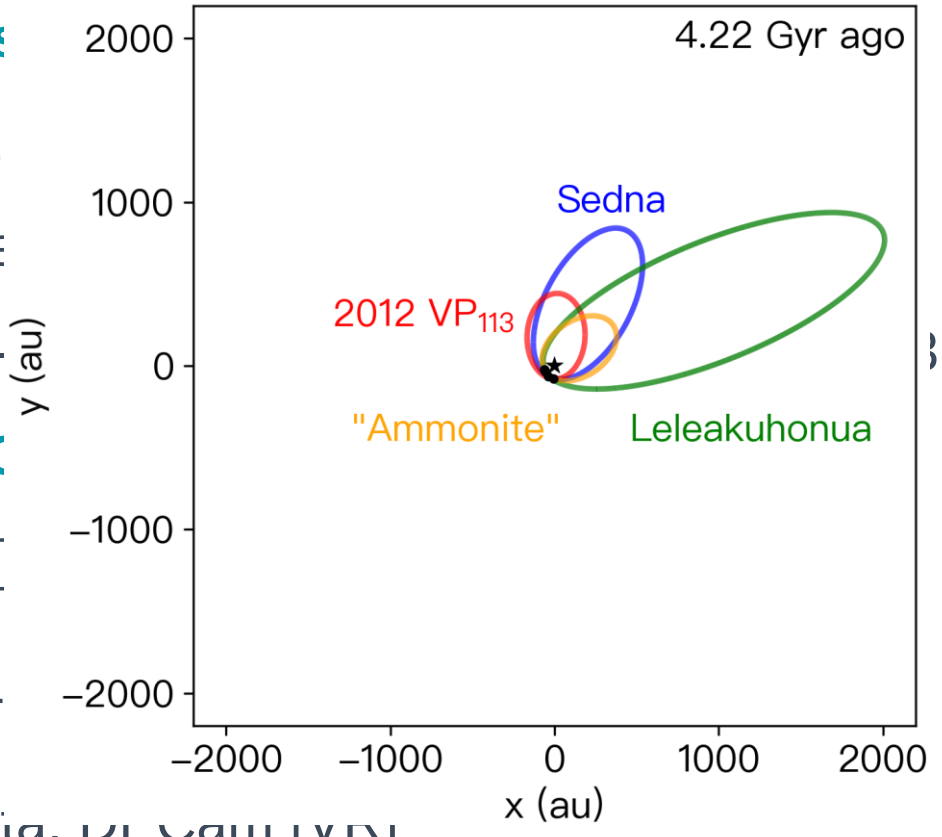
3th-largest-

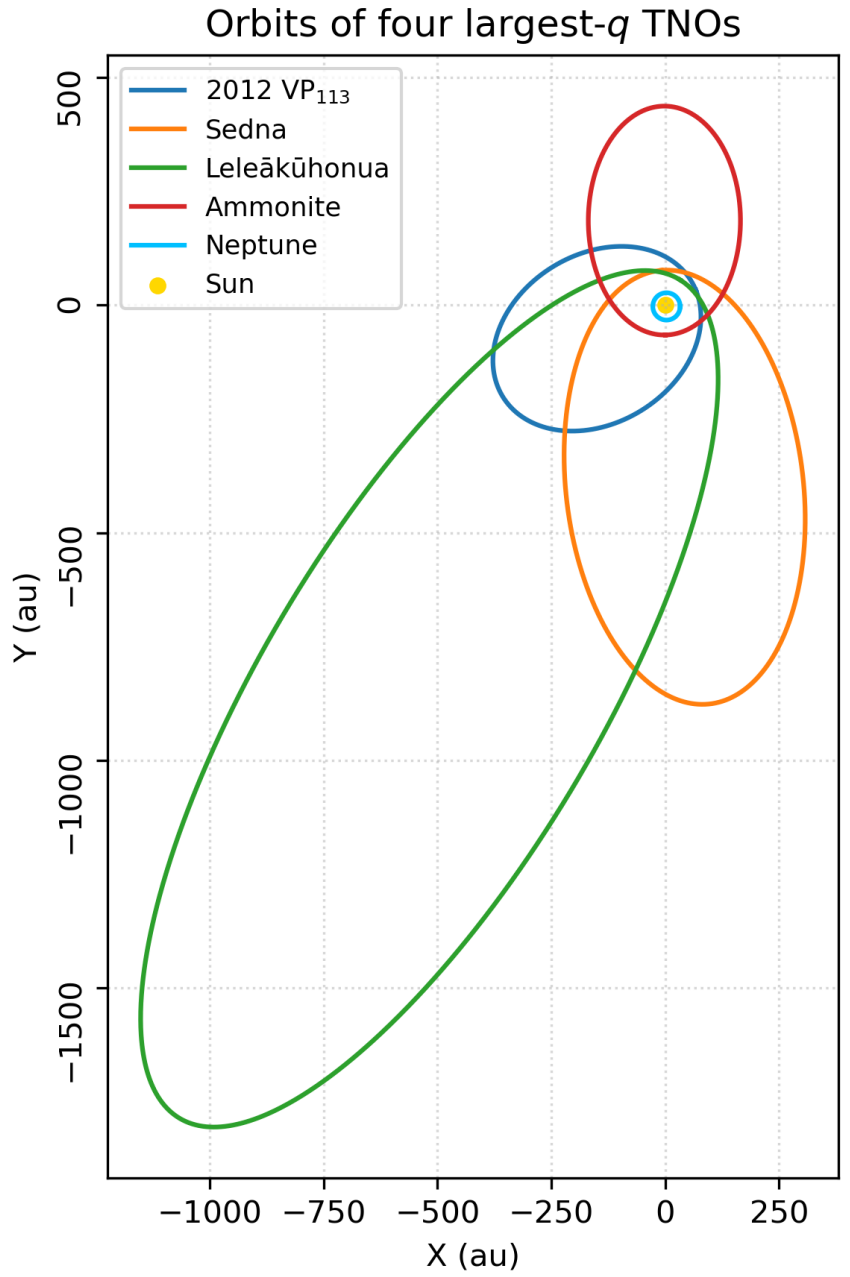
Observational C

Precovery [
Subaru.

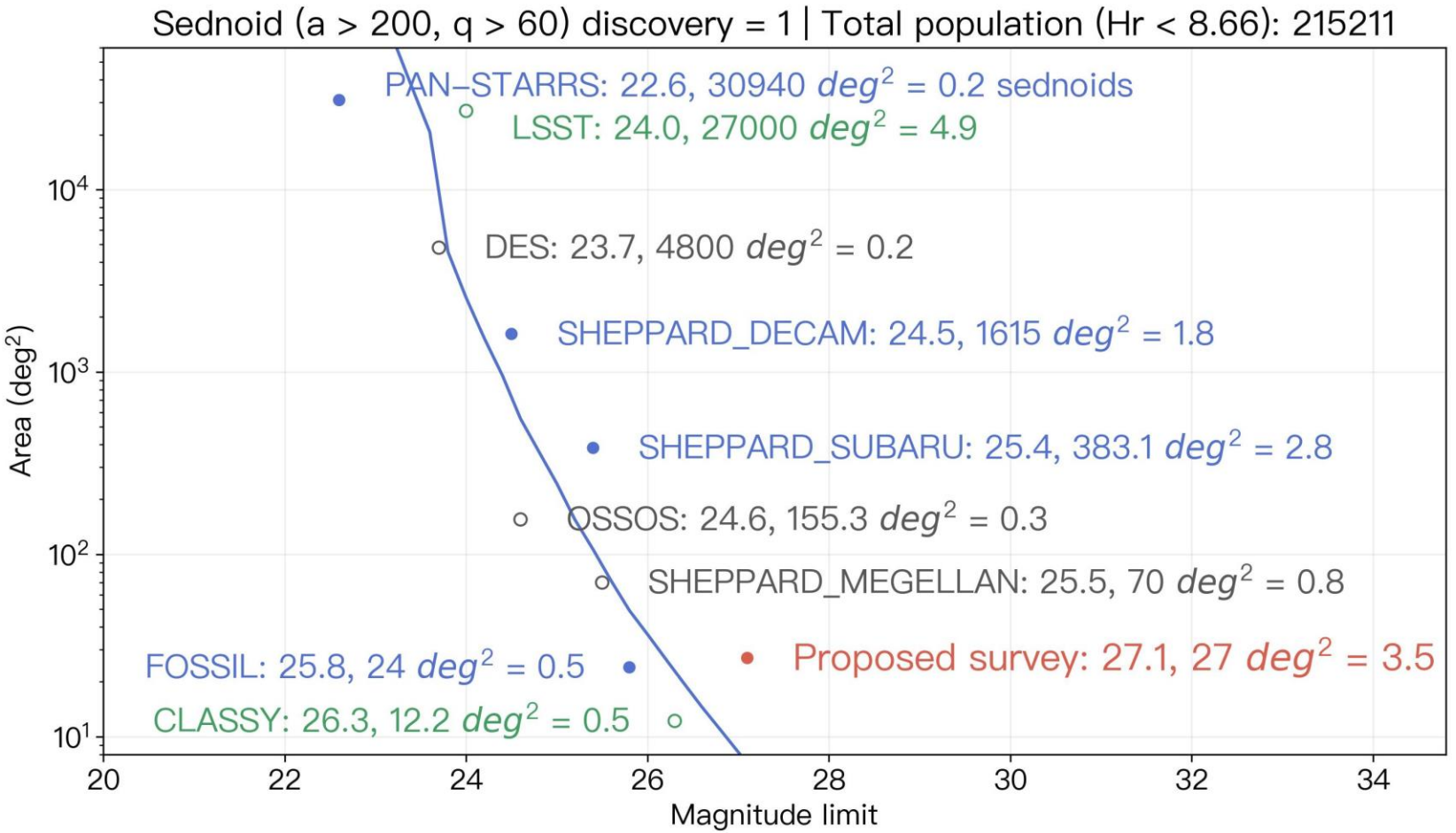
CFHT DDT

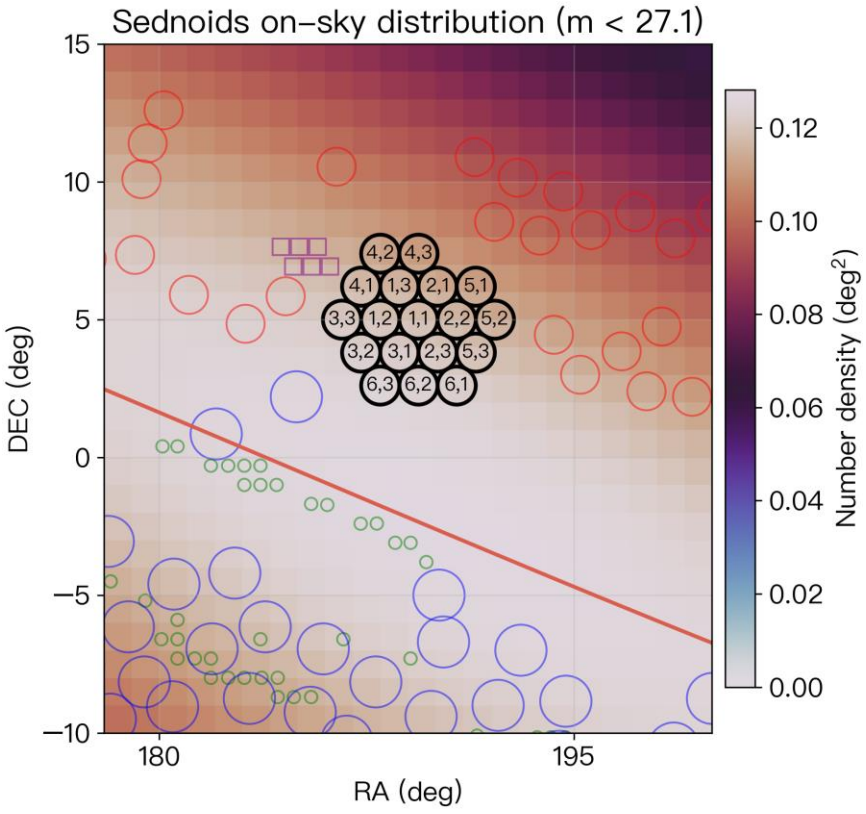
Archival data: DECam [VR]





Sednoids: Probing the Next Frontier of the Outer Solar System.





Yukun Huang et al.