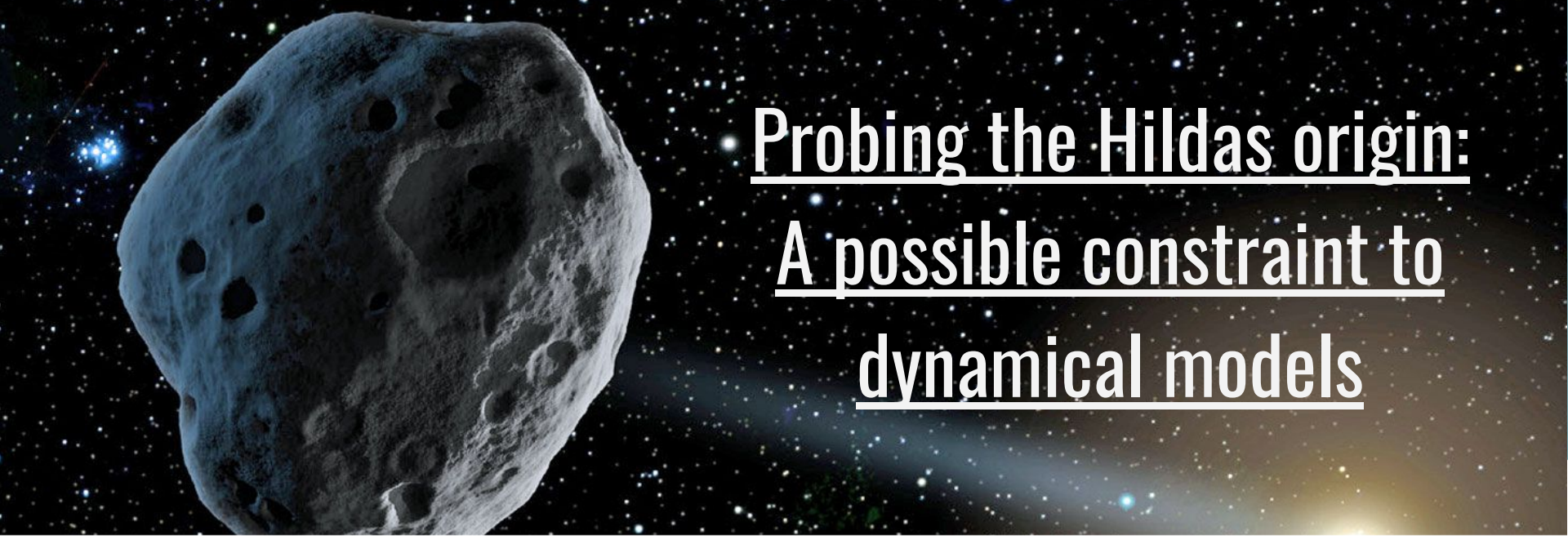

Probing the Hildas origin: A possible constraint to dynamical models

FLORIDA SPACE INSTITUTE

UNIVERSITY OF CENTRAL FLORIDA 1963

Mário N. De Prá

Post-doctoral Associate

Early Career talk - SBAG

Questions on the last decadal survey

- What are the initial conditions of the Solar System?
- Which processes ruled the formation and evolution of the Solar System?
- Did the giant planets migrate?
- What were the primordial sources of organic matter and water supply?

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- PRIMitive Asteroids Spectroscopic Survey
- Effort lead by Dr. Pinilla-Alonso and Dr. De Leon
- Ground-Based observations
- Study the spectroscopic properties of primitive bodies across the Solar System
- From the Main-Belt to the resonant populations Hildas and Trojans

PRIMitive Asteroids Spectroscopy Survey - Library (PRIMASS-L)

- In process of uploading to PDS (Funded by NNH17ZDA001N-PDART)
- More than 600 spectra of Primitive Asteroids
- Tables and figures with results from more than 10 papers and 3 Ph.D thesis
  - see all PRIMASS papers at: https://cana.readthedocs.io/en/latest/about.html#primass-papers

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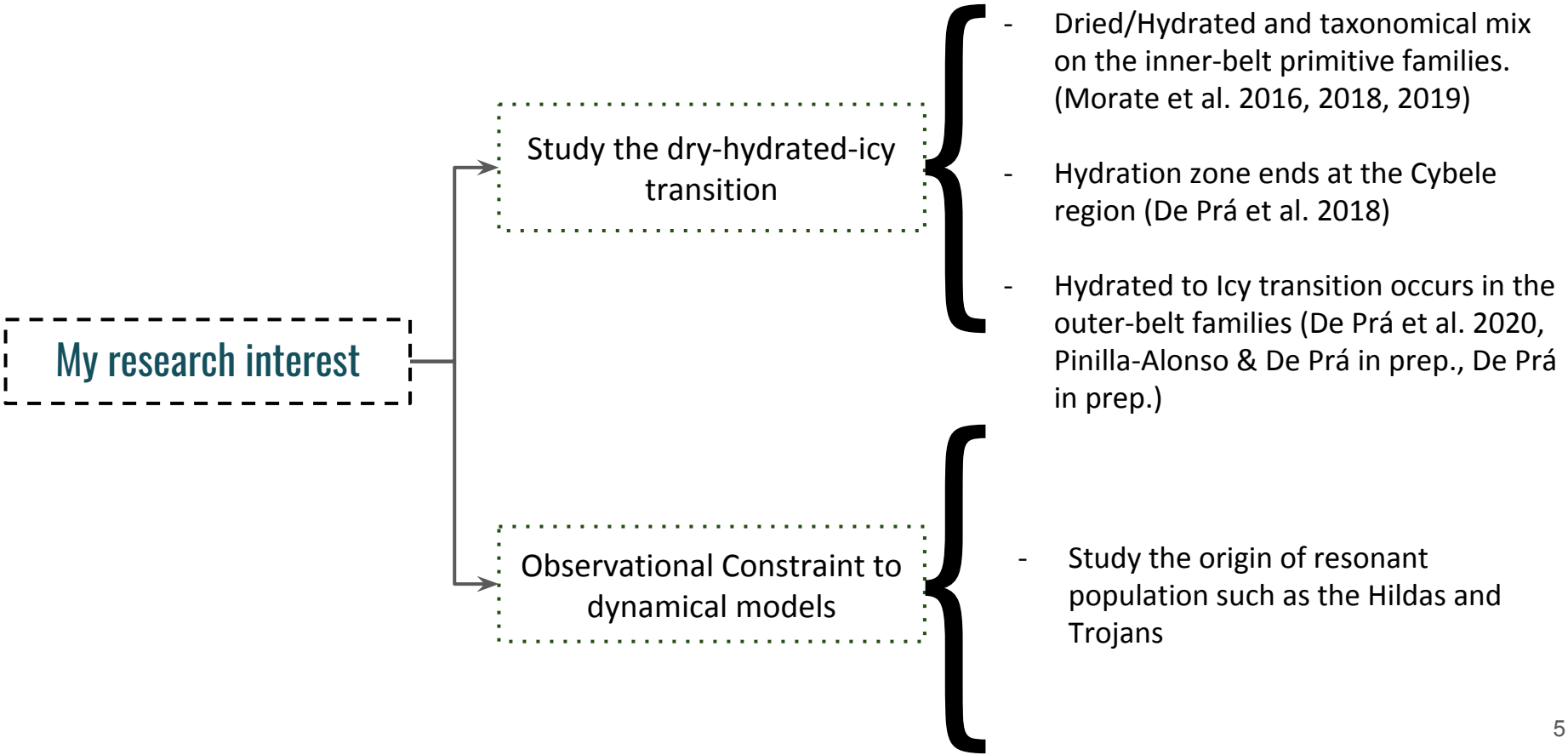
Codes for ANalysis of Asteroids

- Tools for analysis of PRIMASS data
  - Python 3
  - Methodologies for handling spectra, taxonomy, slope and band analysis (and more)
- Code available at: https://github.com/depra/cana
- Documentation: https://cana.readthedocs.io


My research interest
Study the dry-hydrated-icy transition
- Dried/Hydrated and taxonomical mix on the inner-belt primitive families. (Morate et al. 2016, 2018, 2019)
- Hydration zone ends at the Cybele region (De Prá et al. 2018)
- Hydrated to Icy transition occurs in the outer-belt families (De Prá et al. 2020, Pinilla-Alonso & De Prá in prep., De Prá in prep.)
Observational Constraint to dynamical models
- Study the origin of resonant population such as the Hildas and Trojans

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Observational Constraint to dynamical models

- Study the origin of resonant population such as the Hildas and Trojans

Probing the Hildas origin: A possible constraint to dynamical models

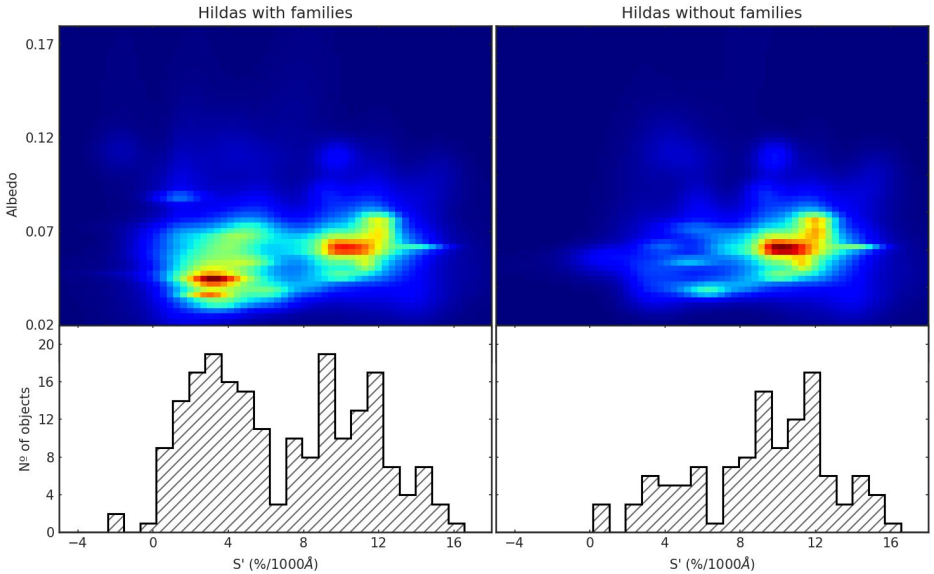
The Hilda population

- In 3:2 resonance with Jupiter (Stable orbits - Nesvorný & Ferraz-Mello, 1997)

- Dynamical models suggest that the region was depleted and re-populated with objects formed at greater distances (Broz & Vokrouhlicky, 2008)
  - Hildas would have similar origin to TNOs, Centaurs and Trojans

- Contain 2 dynamical families: Hilda and Schubart
  - Hilda is an ancient family with age estimated at 4 GY (Broz et al. 2010)

- Bimodal color distribution: P & D taxonomy (De Prá et al. 2018)



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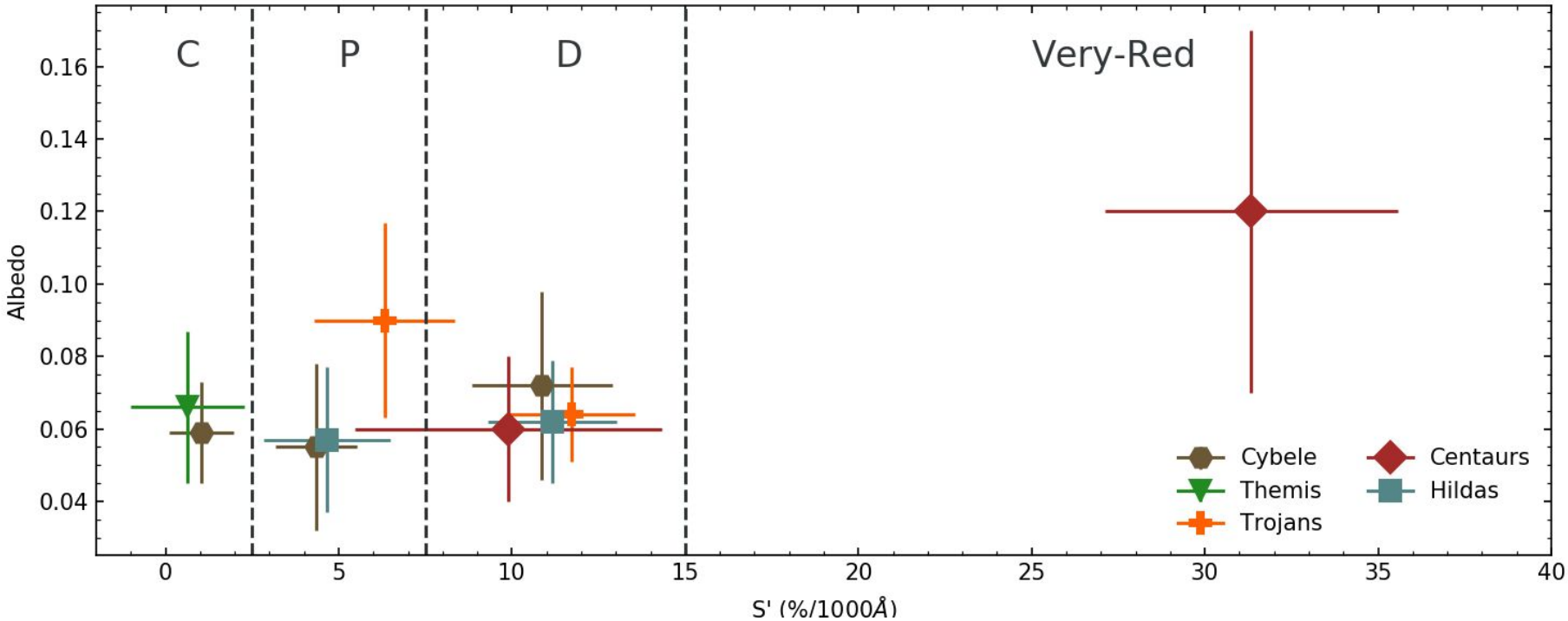

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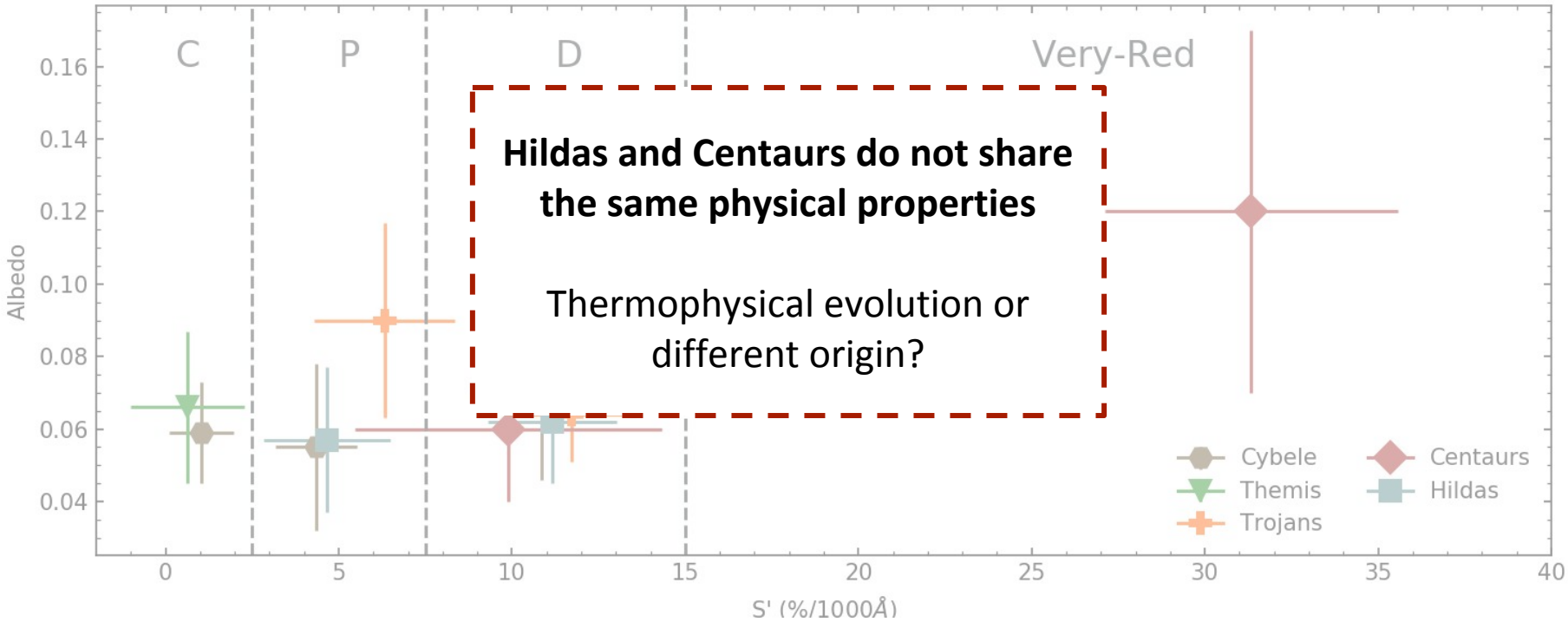

Hildas and Centaurs do not share the same physical properties

Thermophysical evolution or different origin?

Quasi-Hildas: The missing link between Hildas and Centaurs

The Quasi-Hildas

- **Occupy the same region as the Hildas but are not trapped in the resonance (Unstable orbits)**

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- **Hildas Escapees?**

Collisions could remove Hildas from the resonance (Di Sisto et al. 2005) + Only a few percentage of small-sized (<0.1 km) (Broz et al. 2008) + Intrinsic collisional probability: Hildas = (Main-Belt)/3 Dahlgren (1998) = **Not an effective mechanism, especially for >1 kilometer sized objects**

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- **Centaur interlopes?**

A fraction of the Centaurs will evolve to temporary quasi-Hildas orbits (Fernández et al., 2018) + At least a hundred objects >1 km (D. Nesvorný - p. c.) + 277 QHs candidates (Gil-Hutton & García-Migani, 2016) = **Effective mechanism!**

The Quasi-Hildas

- Occupy the same reg (Unstable orbits)

- **Hildas Escapees?**

Collisions could remove Hildas from the resonance (Di Sisto et al. 2005)

Dynamical evolution of Centaurs is the most likely mechanism for producing Quasi-Hildas

(Specially for >1km sized objects.)

=

Not an effective mechanism, especially for <1 kilometer sized objects

- **Centaur interlopes?**

A fraction of the Centaurs will evolve to temporary quasi-Hildas orbits (Fernández et al., 2018)

Quasi-Hildas can inform how the surface of a Centaur evolves in a Hilda environment

(D. Nesvorný - p. c.)

García-Migani, 2016)

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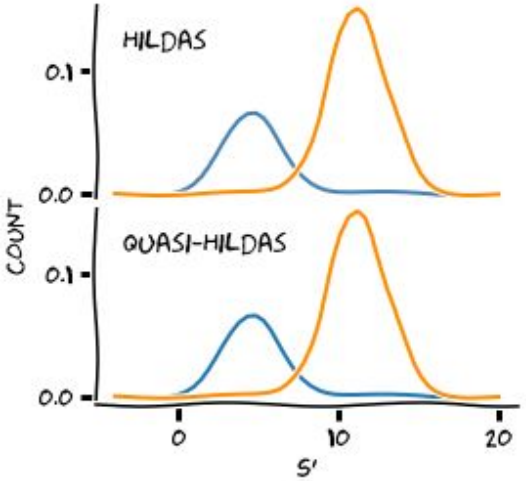
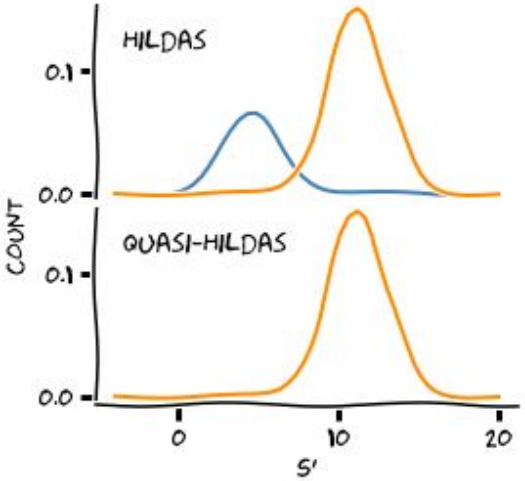
Effective mechanism!

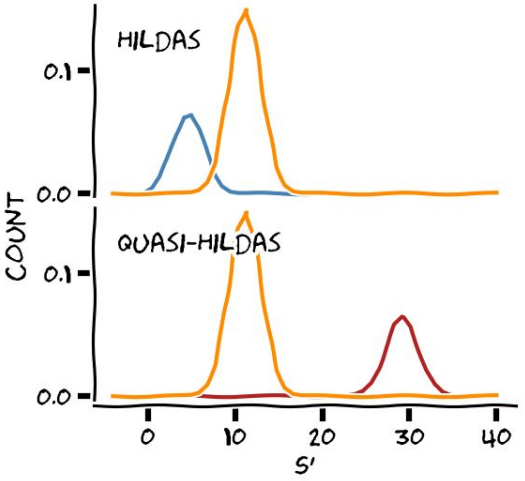
What could be the Quasi-Hildas colors?



Scenarium - 1

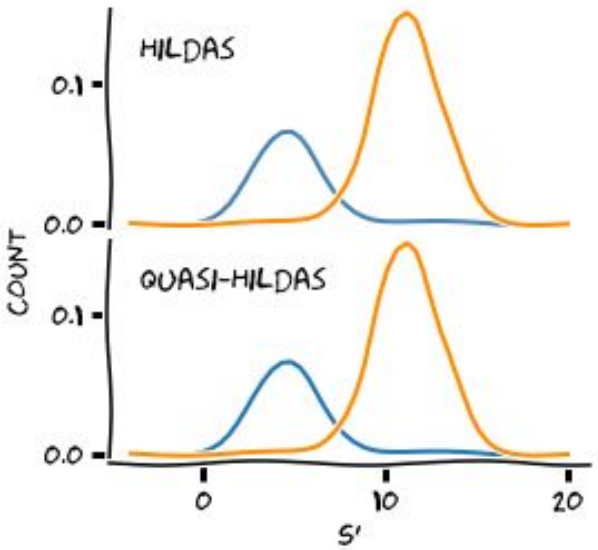


Scenarium - 2



Scenarium - 3

Scenarium - 1



Observational Result:
The Hildas and Quasi-Hildas Surface colors are indistinguishable

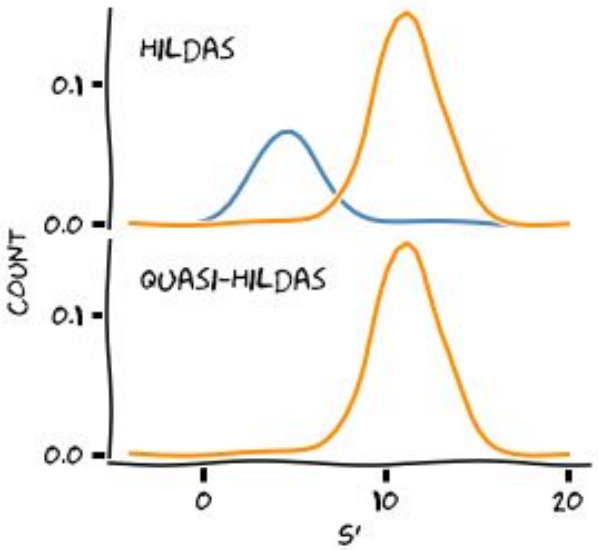
Implications:

A Centaur surface becomes similar to a Hilda-like surface when at the same heliocentric distance

Hildas and Centaurs can have the same origin

Conclusion:
Agreement with Nice model

Scenarium - 2



Observational Result:
Quasi-Hildas are not bimodal, but contain only one of the Hildas lobes.

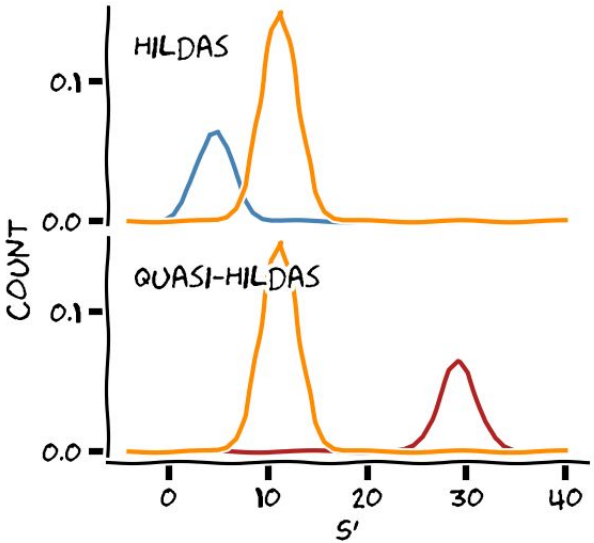
Implications:

The surface evolution of a Centaur does not reproduce the actual Hilda population

Hildas and Centaurs can not have the same origin

Conclusion:
Disagreement with dynamical models.
Could a fraction of the Hilda be primordial?
New scenario that the models could test

Scenarium - 3



Observational Result:
Quasi-Hildas are bimodal, but resembles the centaur colors

Implications:

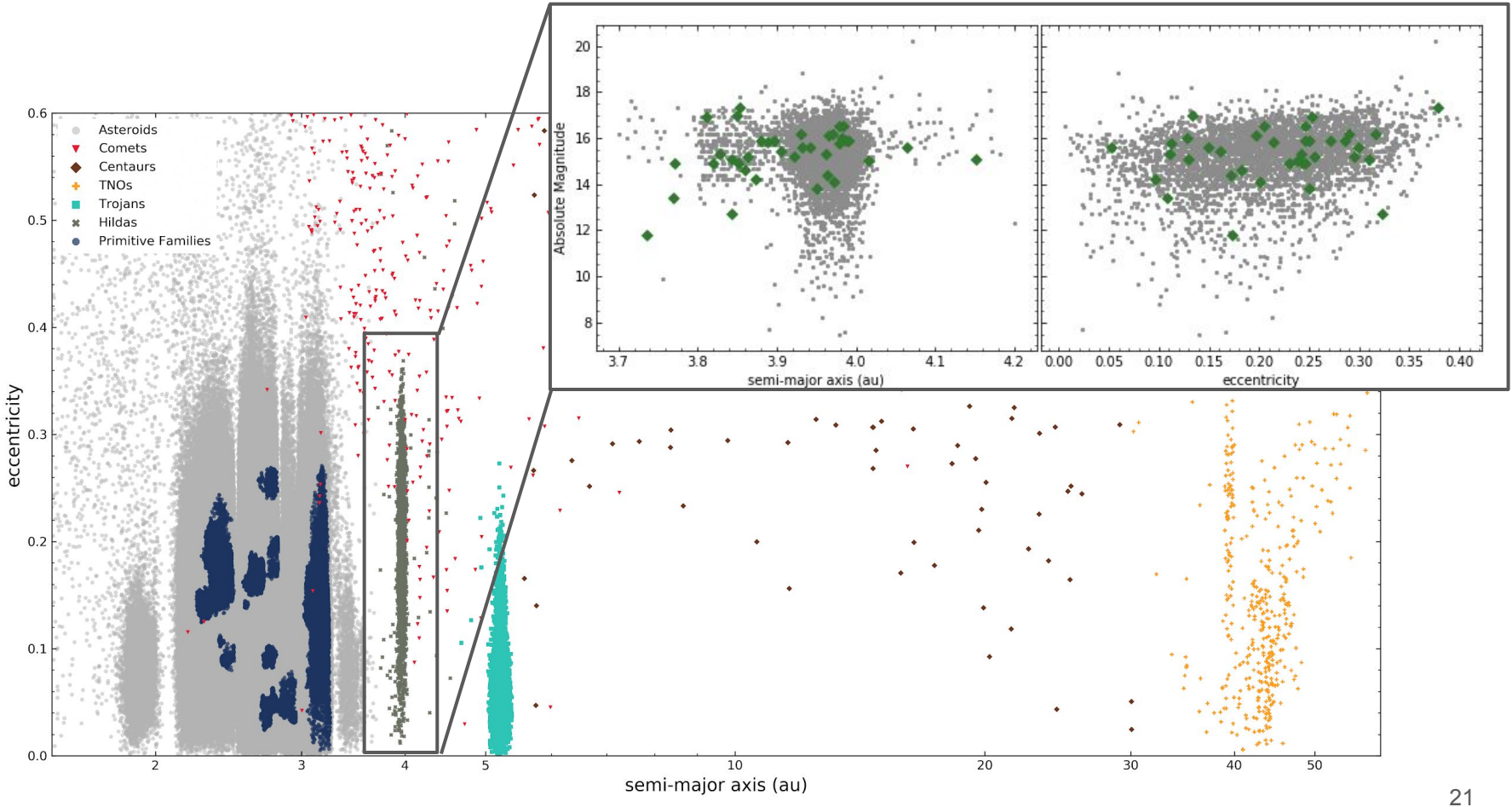
The thermophysical evolution of a Centaur is rather slow

Conclusion:
Inconclusive if Hildas and Centaurs could have the same origin
Useful information for the thermophysical models and to understand Centaurs evolution

Identifying Quasi-Hildas: preliminary work

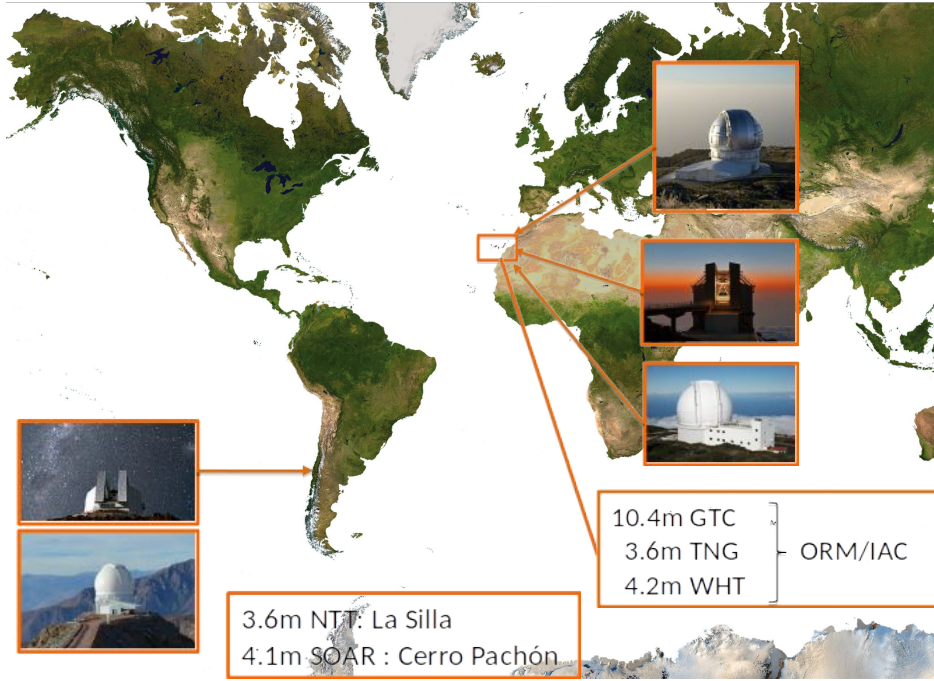
- **Dynamical study of all objects in the Hilda zone**
  - $3.7 < a < 4.2$ au, $e < 0.4$ and $i < 30^{\circ}$
  - Discarded objects with high orbital uncertainties
    - 3533 objects
  - 10 clones of each object within the uncertainties
  - N-body integration over 10^6 years

- **Criteria for Quasi-Hildas selection:**
  - Significant change in the orbital parameters (Primary targets)
    - 48 objects -> All will return to the Centaur región
  - Large amplitudes of libration (secondary targets)
    - 153 objects -> Integration over longer periods can remove them from the resonance


Asteroids
Comets
Centaurs
TNOs
Trojans
Hildas
Primitive Families
eccentricity
semi-major axis (au)
Absolute Magnitude
semi-major axis (au)
eccentricity

Experimental Design

- Observations using photometric filters (g r i)
  - Estimation of visible slope
  - Analysis low-activity
- Use of Ground-Based Facilities
  - 3.5-10m class telescopes
- Observational program will start in 2020 (this semester)
  - Extension until 2023
- Funding proposal under evaluation (*Solar System Observations call*)



Questions on the last decadal survey

Studying the Quasi-Hildas to probe the Hildas origin

A step

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