

Trans-Neptunian Objects - TNOs

TURNING BACK THE CLOCK 4.5 GYR TO REVEAL THE SOLAR SYSTEM AT FORMATION -- MAKING SIMULATIONS FAIRER

SUSANNE PFALZNER, AMITH GOVIND, SIMON PORTEGIES ZWART, STEFAN HACHINGER, FRANK WAGNER, MARCO BISCHOFF

FAIR PRINCIPLES OF MODERN RESEARCH DATA MANAGEMENT



Findable



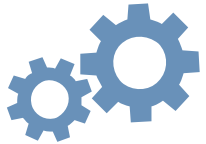
Accessible



Large simulations collaborations sometimes fulfil these criteria already, but often you hear:

„I have to get my paper out, not my data for others to scoop me.“

Interoperable



Reusable

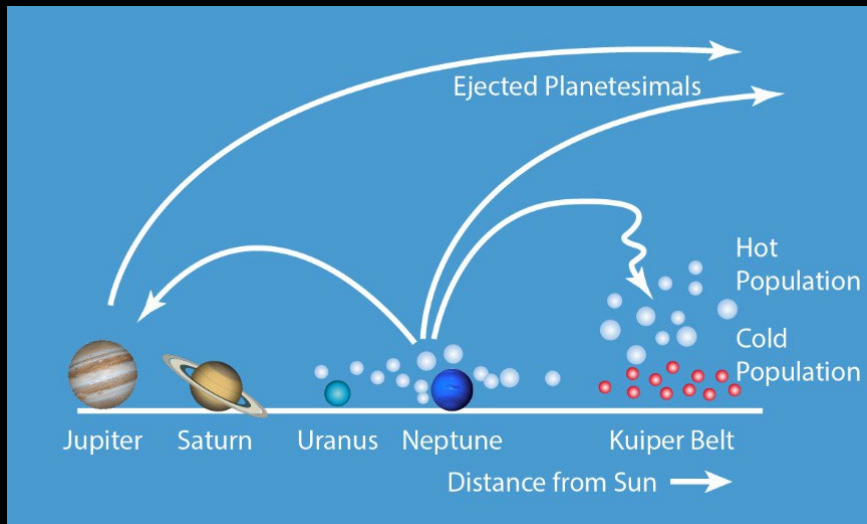


„Are they even serious, should I publish PBs of data?“

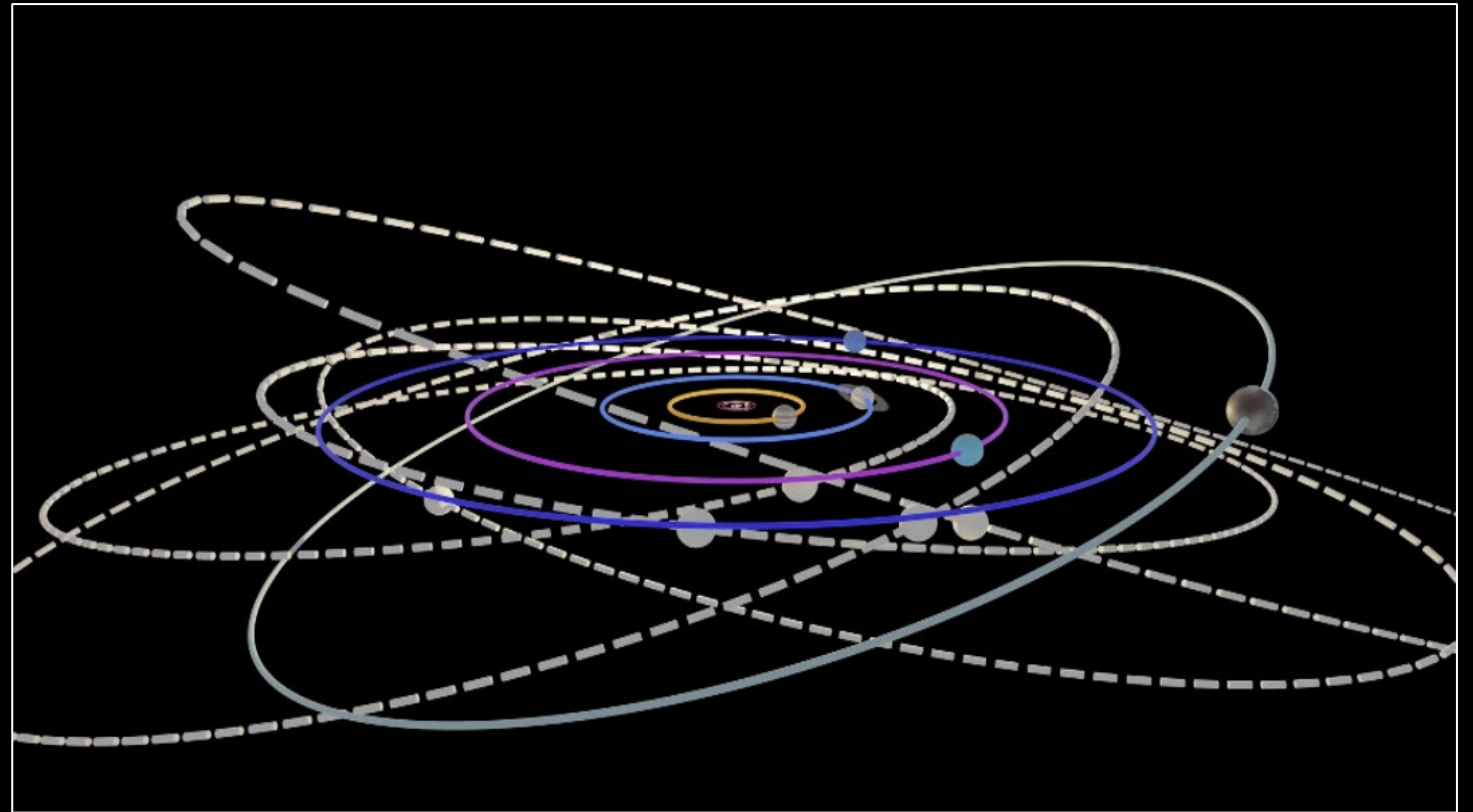
„I have no time for this nonsense, I need to work.“

TRANS-NEPTUNIAN OBJECTS: WITNESSES OF PAST

Most TNOs on eccentric, inclined orbits



Research focused on TNOs being scattered outwards from inner solar system.



TRANS-NEPTUNIAN OBJECTS: WITNESSES OF PAST

Most TNOs on eccentric, inclined orbits

Unexplained:

TNOs at extremely large distance ($r_p > 60$ au)

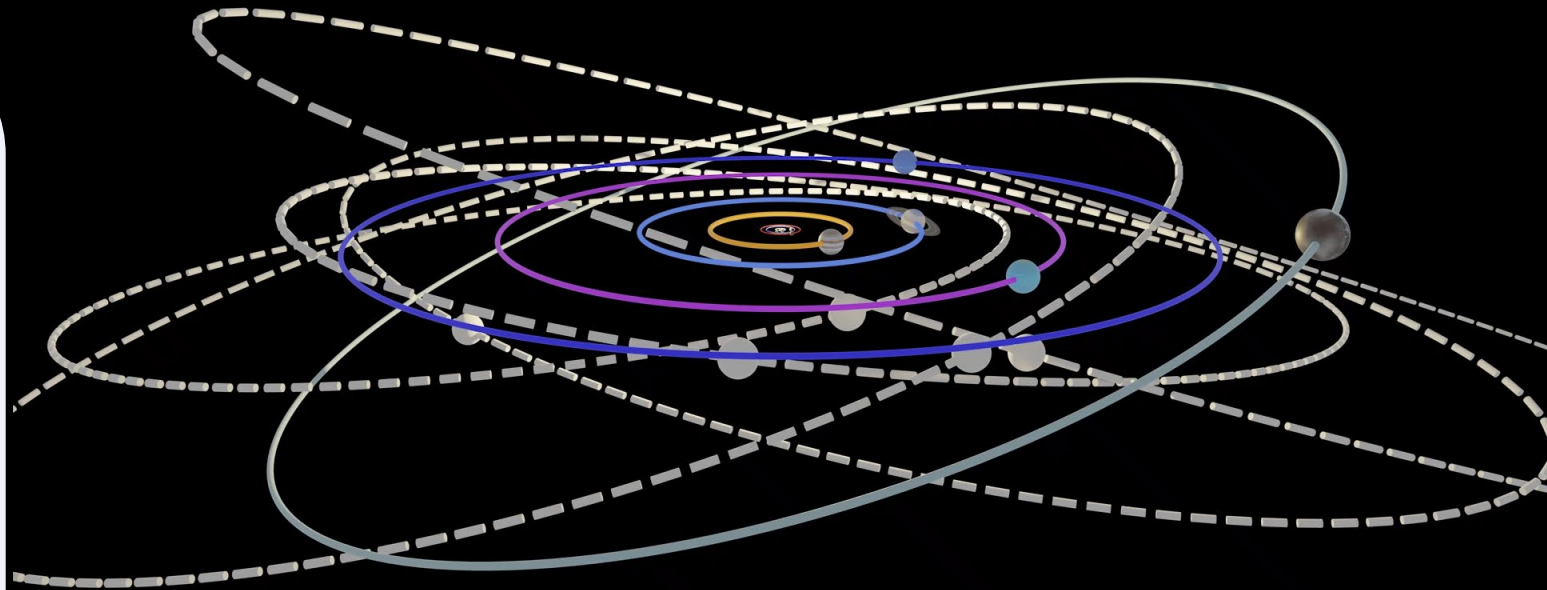
— Sedna-like objects

TNOs orbiting in opposite direction as planets

— retrograde TNOs

External force as reason for Sedna-like objects

- Planet Nine
- Stellar flyby



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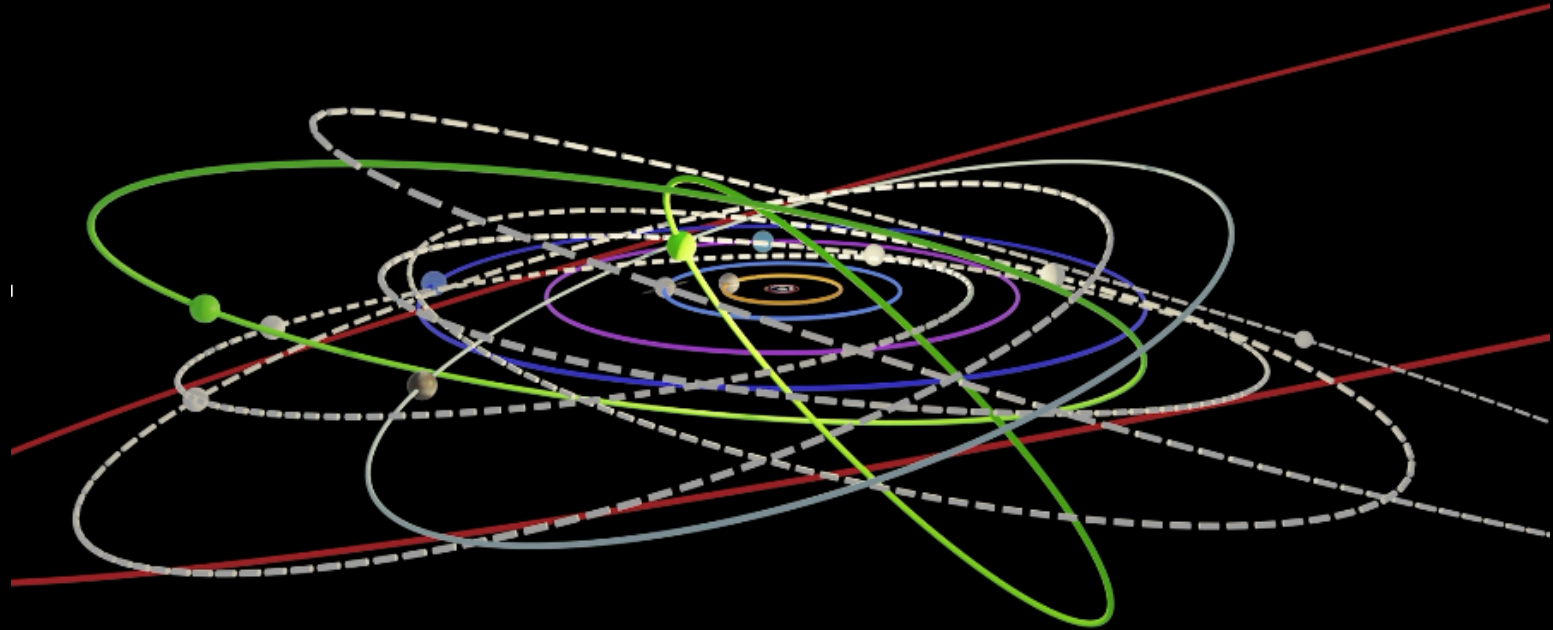
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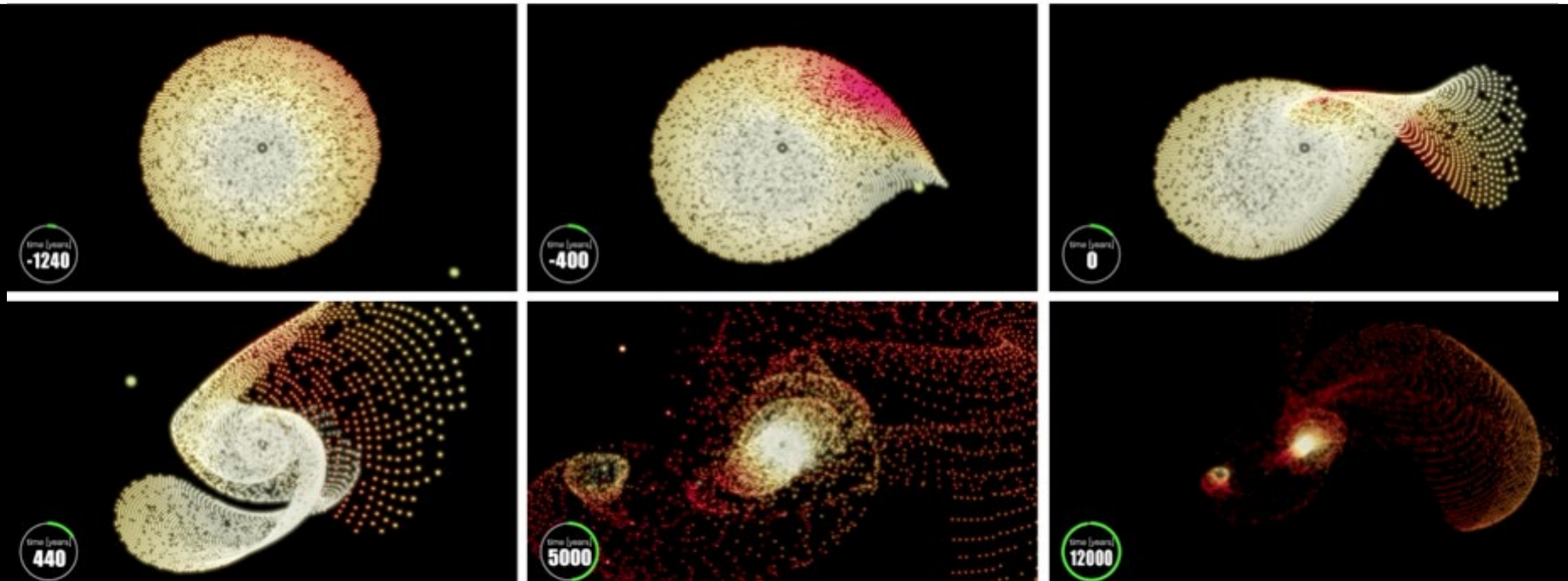
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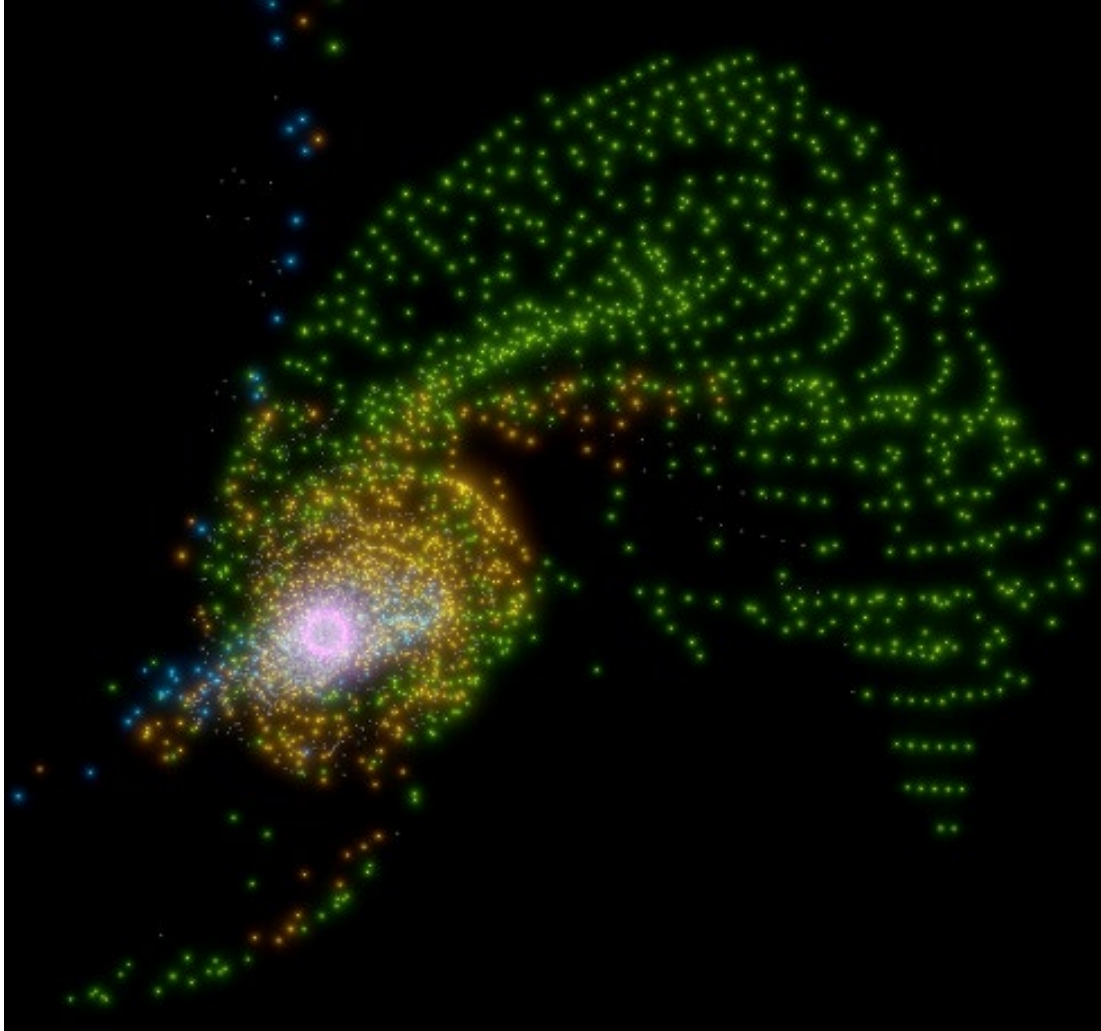


POTENTIAL FLYBY TO THE SUN



S.Pfalzner, A Govind, S. Portegies Zwart (Nature Astronomy, online)

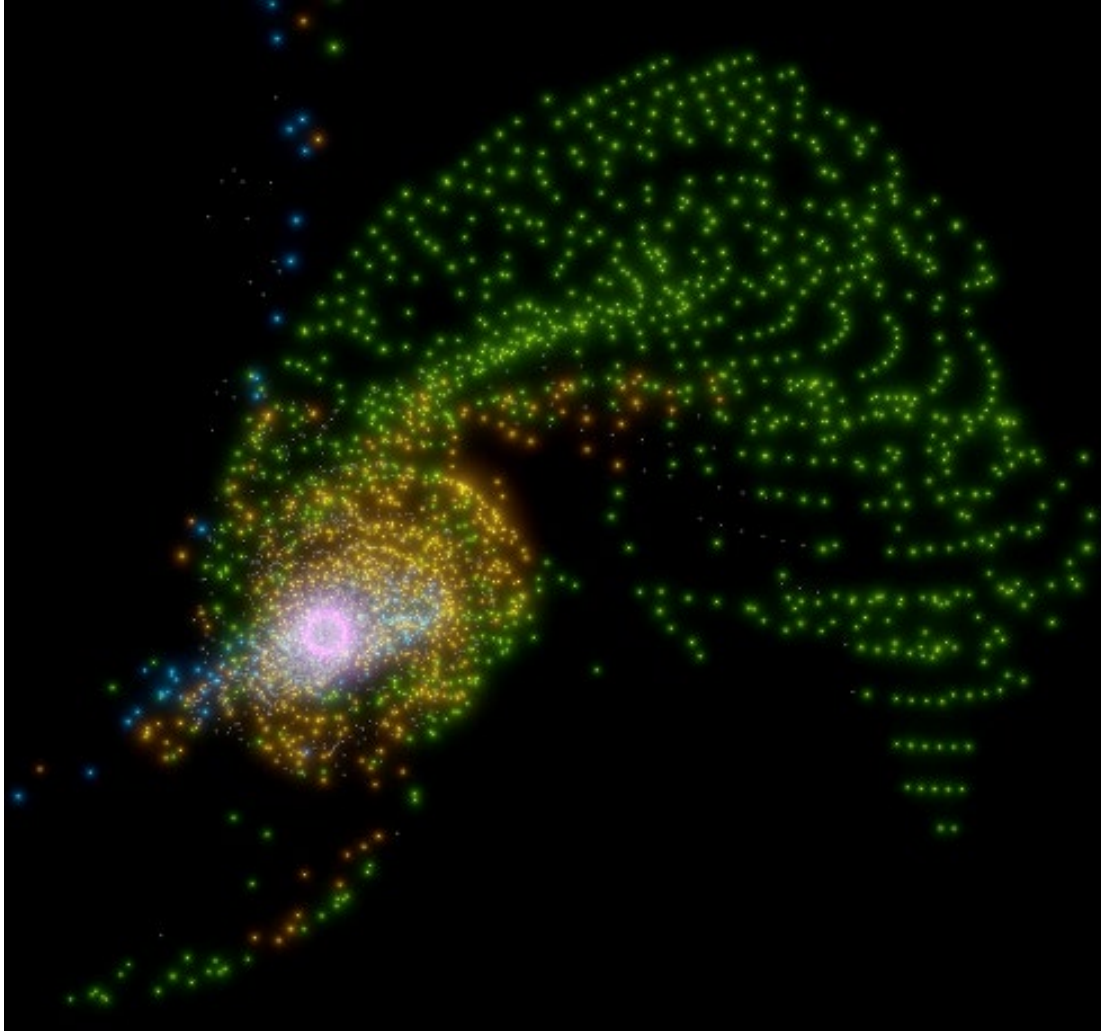
ALTERNATIVE: FLYBY AS STAND-ALONE CAUSE



- Extensive parameter study:
- **6000 simulations**
- Varying periastron distance, mass of perturber, inclination and angle of periastron
- **Looking for the perfect match to observed TNO**

- Perturber mass: $0.8 M_{\text{sun}}$
- Perihelion distance: 110 au

SPECIFIC FLYBY PRODUCES

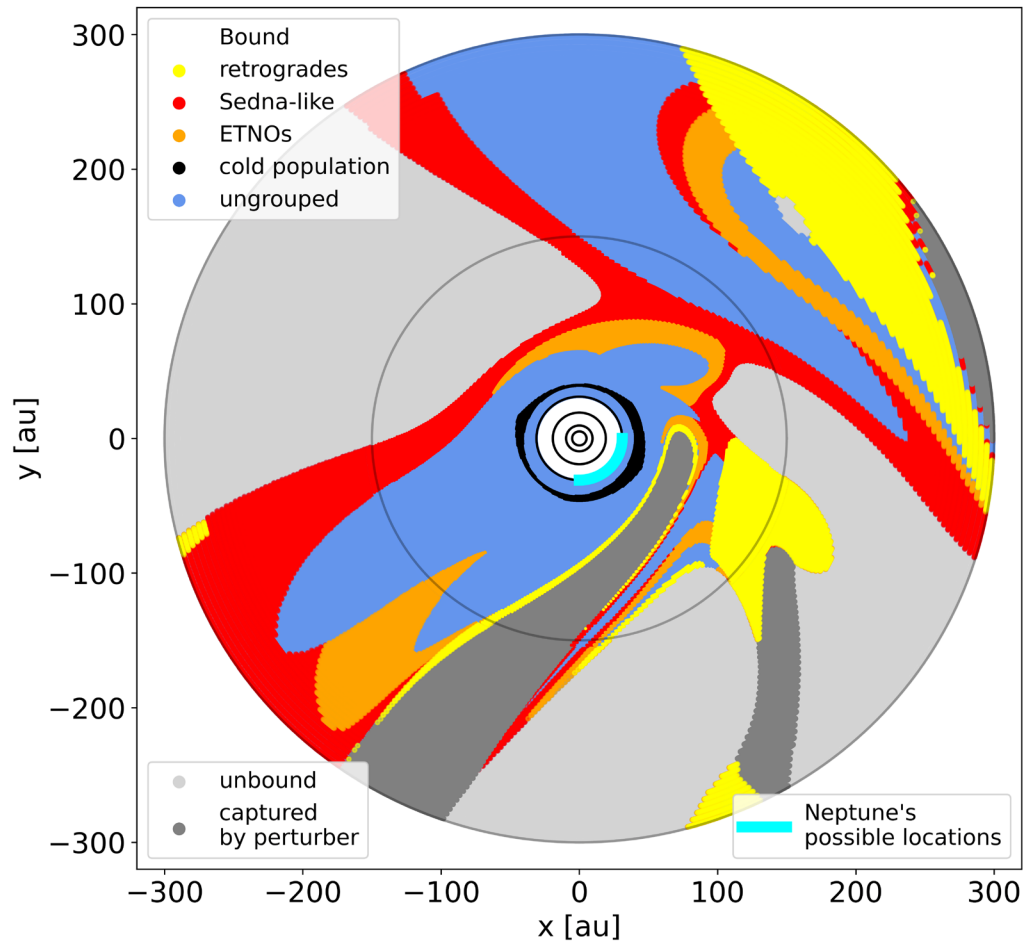


All TNO families are recovered

- **Hot Kuiper belt**
- **Cold Kuiper belt**
- **Sedna-like objects**
- **Retrograde TNOs**

Quantitative match to observed populations

ORIGIN OF THE DYNAMIC GROUPS



TNO origin can be traced back to position in disc

Fate of TNOs complex

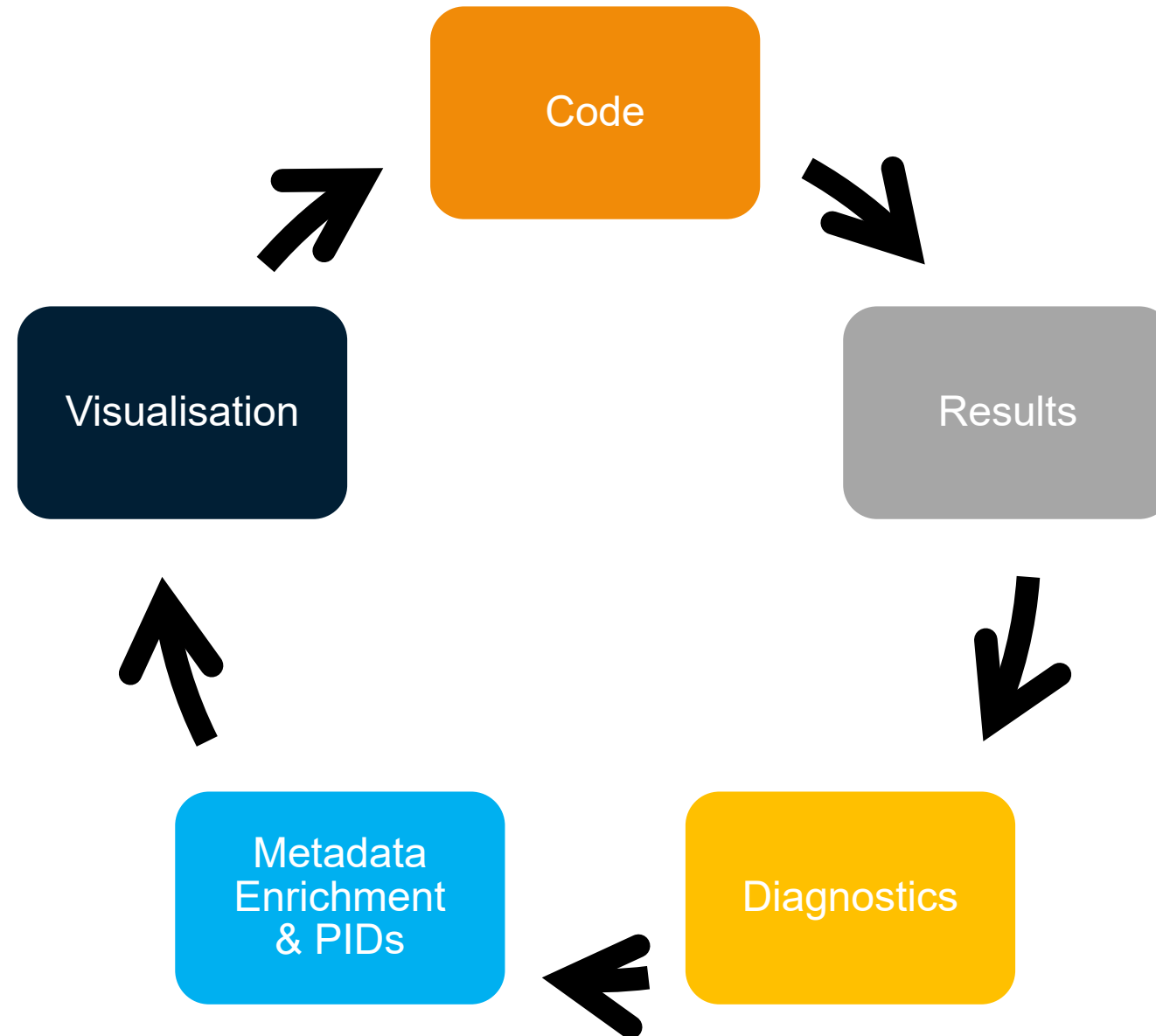
Region inside Neptune unperturbed

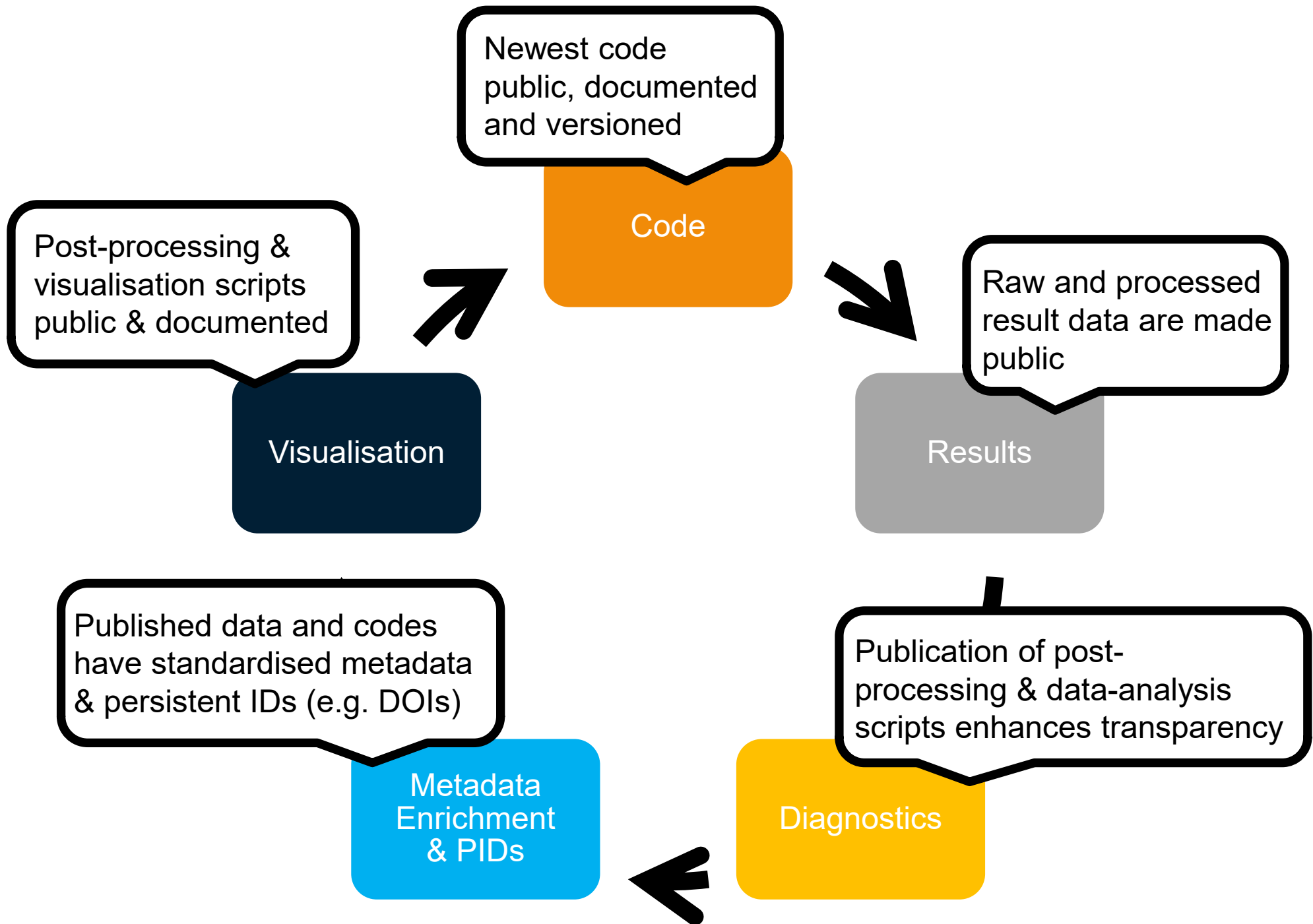
Eventually, properties and composition of the primordial solar system can be determined

S.Pfalzner et al. ApJ, 2018

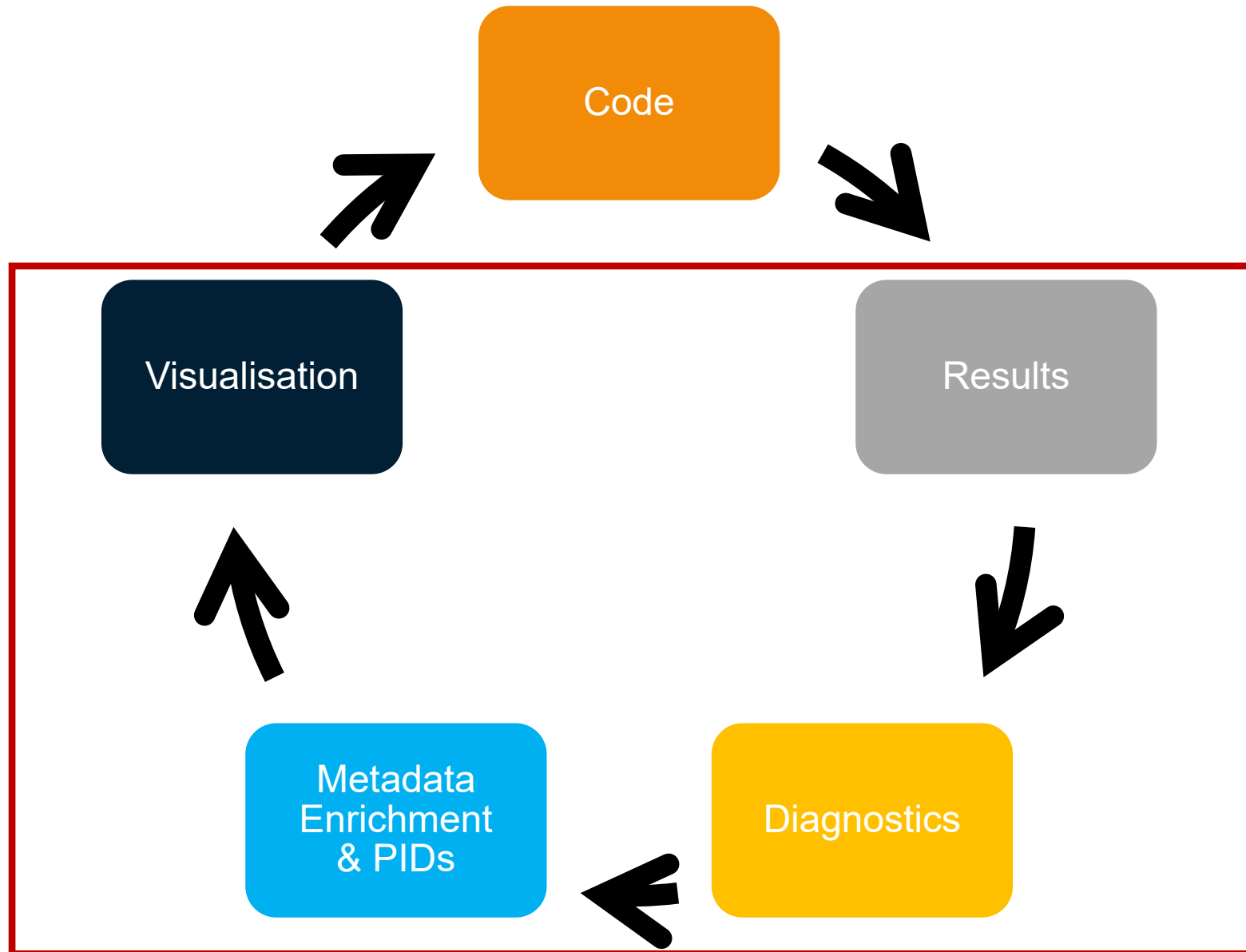
S.Pfalzner, A Govind, S. Portegies Zwart (Nature Astronomy published online)

FAIRNESS IN THE „DATA LIFECYCLE“ – ASPECTS AND STATUS





FAIRNESS IN THE „DATA LIFECYCLE“ – ASPECTS AND STATUS



DESTINY DATABASE AS EXAMPLE

<https://destiny.fz-juelich.de/>

DESTINY

Database for the *E*ffects of *S*Tellar encounters on *d*isks and *p*la*N*etary *s*ys*T*ems

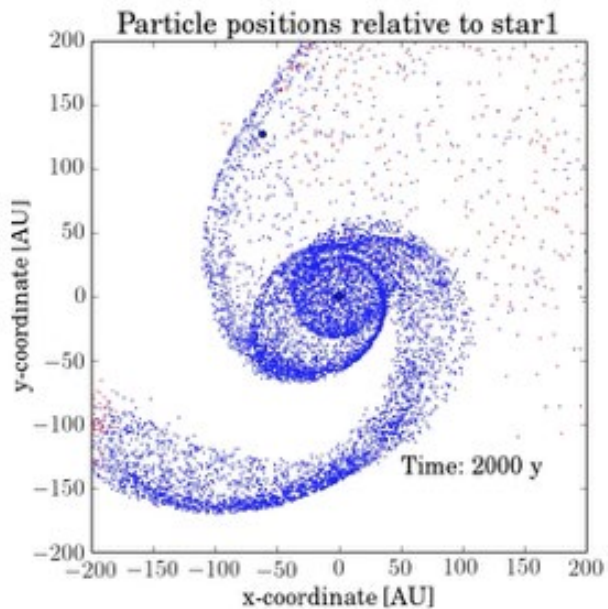
Home

Datasets

Graphic Tool ▾

Fly-by

References



Description

Most stars form not in isolation, but in clusters. They are initially surrounded by a protoplanetary disk(s). Both the disk as well as planetary systems are affected by the environment due to close fly-bys. The effect of such fly-bys on the disk and planetary system is the subject of this database. You can download the data itself and perform simulations.

Datasets

There are two datasets:

- download the → graphic tool provided to visualize the properties after a fly-by
- use the → graphic tool provided to visualize the properties after a fly-by

↓ download datasets

↓ download documentation

→ graphic tool provided to visualize the properties after a fly-by

DESTINY DATABASE AS EXAMPLE

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DESTINY

Database for the *E*ffects of *S*Tellar encounters on *d*/isks and *pl*aNetary *s*Ystems

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Graphic Tool ▾

Fly-by

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Contact

Properties after a fly-by

> Info

Model Parameters

Mass ratio

(perturber mass / host mass)

0.5



Angle of periastron

(degrees)

70



Orbital inclination

(degrees)

55



Periastron distance

(au)



100

Disk size

(au)



150

Plot Settings

Property X-Axis

semimajoraxis



Logarithmic

Property Y-Axis

eccentricity



Logarithmic

Property Color-Axis

inclination



Logarithmic

Limits X-Axis

(leave empty for auto)

min

- max



Limits Y-Axis

(leave empty for auto)

min

- max



Limits Color-Axis

(leave empty for auto)

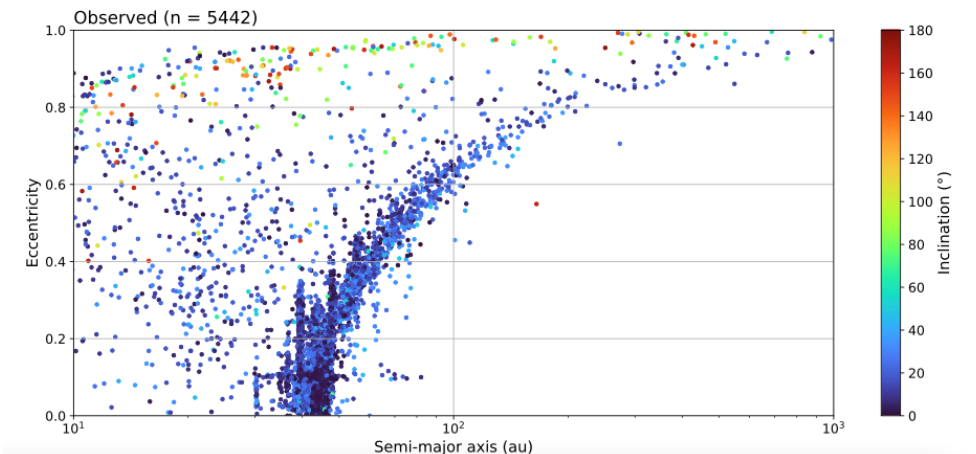
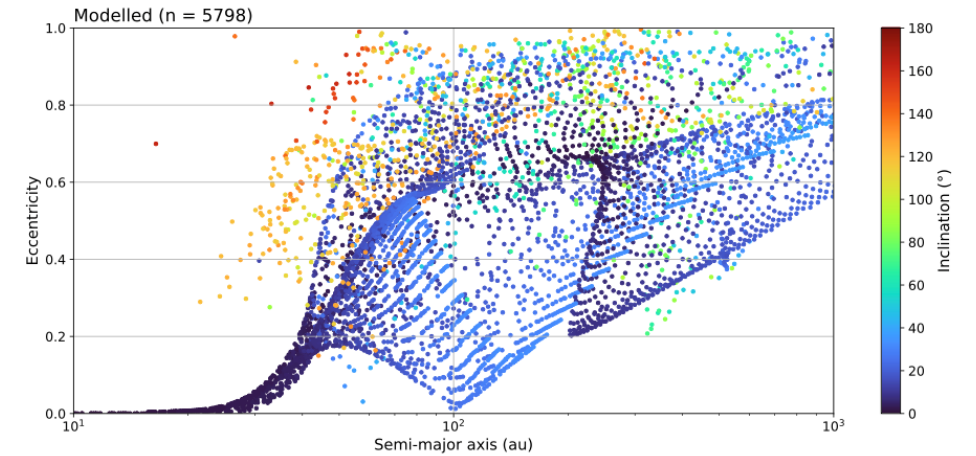
min

- max



Submit

Reset



DESTINY DATABASE AS EXAMPLE

<https://destiny.fz-juelich.de/>

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Logarithmic

Limits X-Axis

(leave empty for auto)

min

- max

✕

Limits Y-Axis

(leave empty for auto)

min

- max

✕

Limits Color-Axis

(leave empty for auto)

min

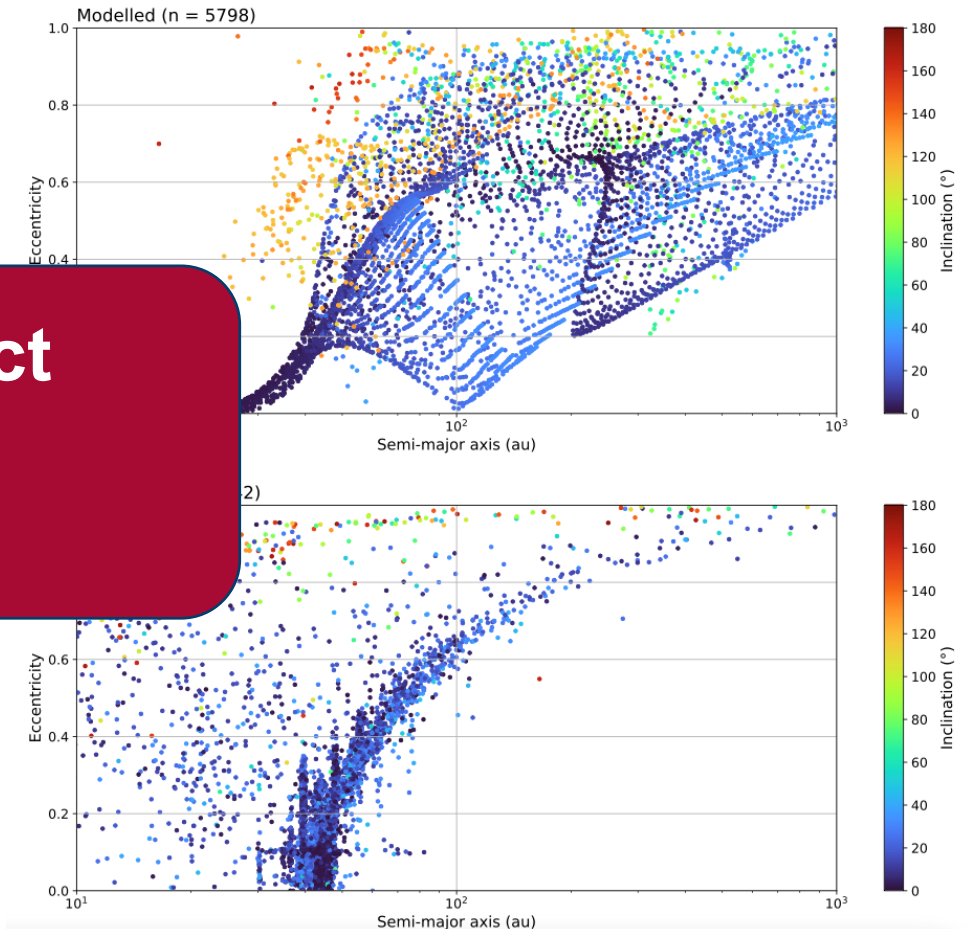
- max

✕

Submit

Reset

Student project
6h/week
6 month



SUMMARY

A specific stellar flyby can produce

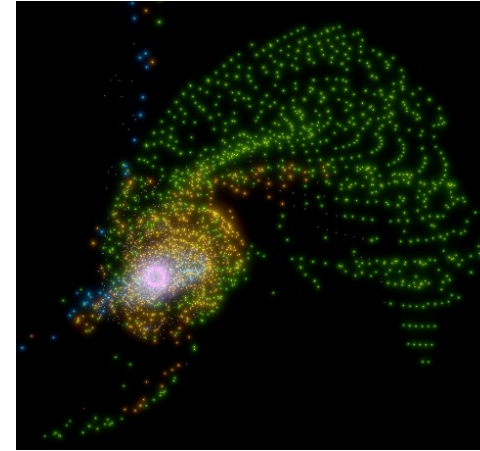
1. Hot Kuiper belt
2. Cold Kuiper belt
3. Sedna-like objects
4. retrograde TNOs

in the right quantities at the right places.

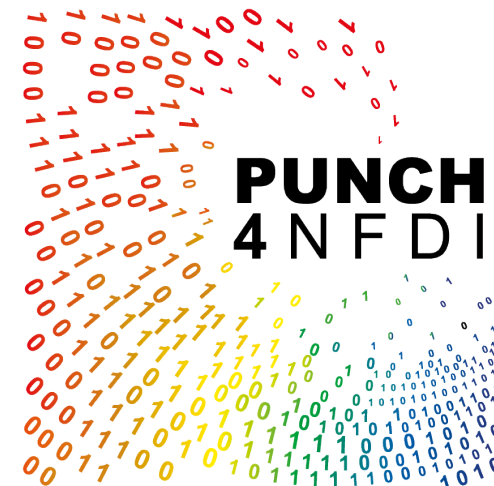
It is equally important to make simulations FAIRer

1. Open access to codes is only first step
2. True FAIRness includes results and diagnostics
3. Examples for doing it on a small budget

From codes we have learnt, open access promotes own work massively



<https://youtu.be/fOel5aWCRJs>



<https://www.punch4nfdi.de>

TECHNICALLY, IT IS POSSIBLE...

Proposed Metadata-Enrichment and Data-Publication Workflow in InHP

