CATCH Update for the Small Bodies Node Users' Group

Michael S. P. Kelley, Dan Darg, Gerbs Bauer, Pat Lawton (University of Maryland)
PDS Small Bodies Node Users' Group
06 October 2022

CATCH-Up for the SmUG

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Introduce the CATCH concept.

Introduce our approach to spatial indexing.

Detail a survey query.

CATCH:
Comet Asteroid Telescopic Catalog Hub

Designed to quickly find comets and asteroids in wide-field time-domain survey data.

Searchable

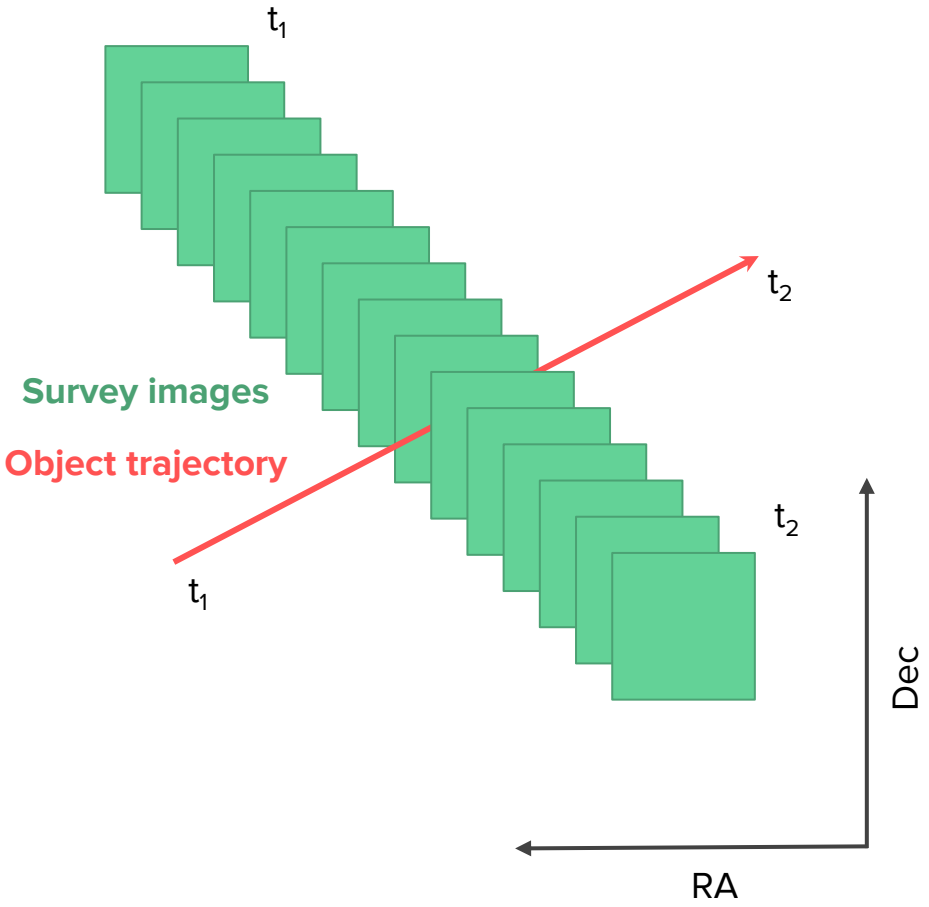
Accessible

`Generalizable`

Spatial Indexing

Needle in the haystack

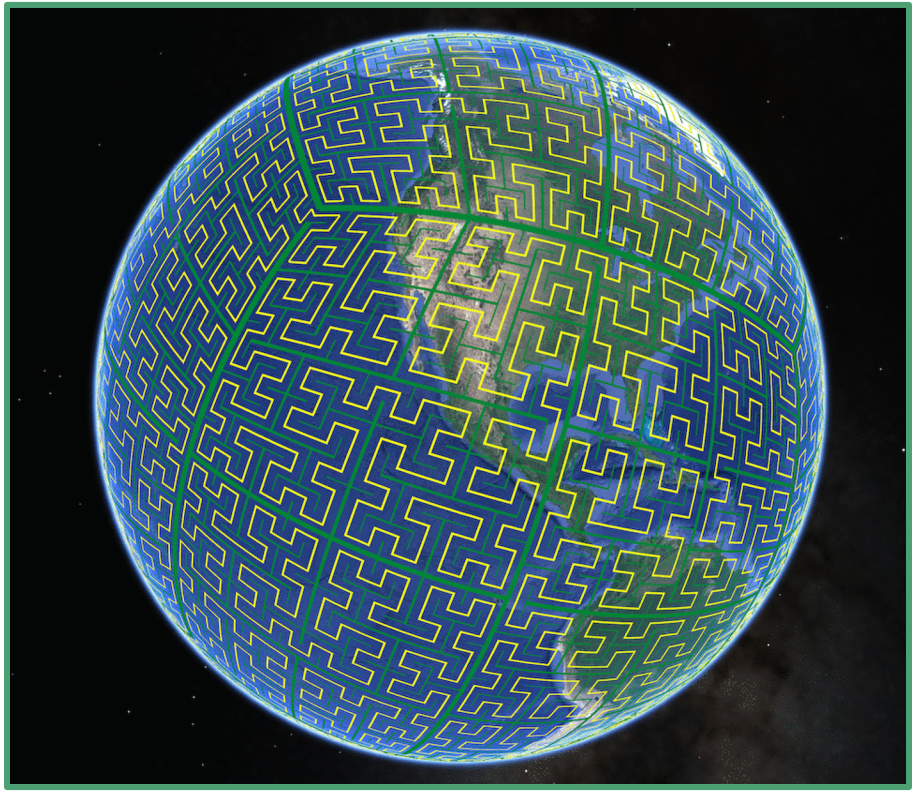
- Efficient search algorithms are foremost about eliminating objects that do not match, leaving a few objects to examine in detail.
- CATCH uses an approach motivated by geolocation searches, e.g., to find the nearest COVID testing sites in Google Maps.



S2 geometry (CATCH v1)

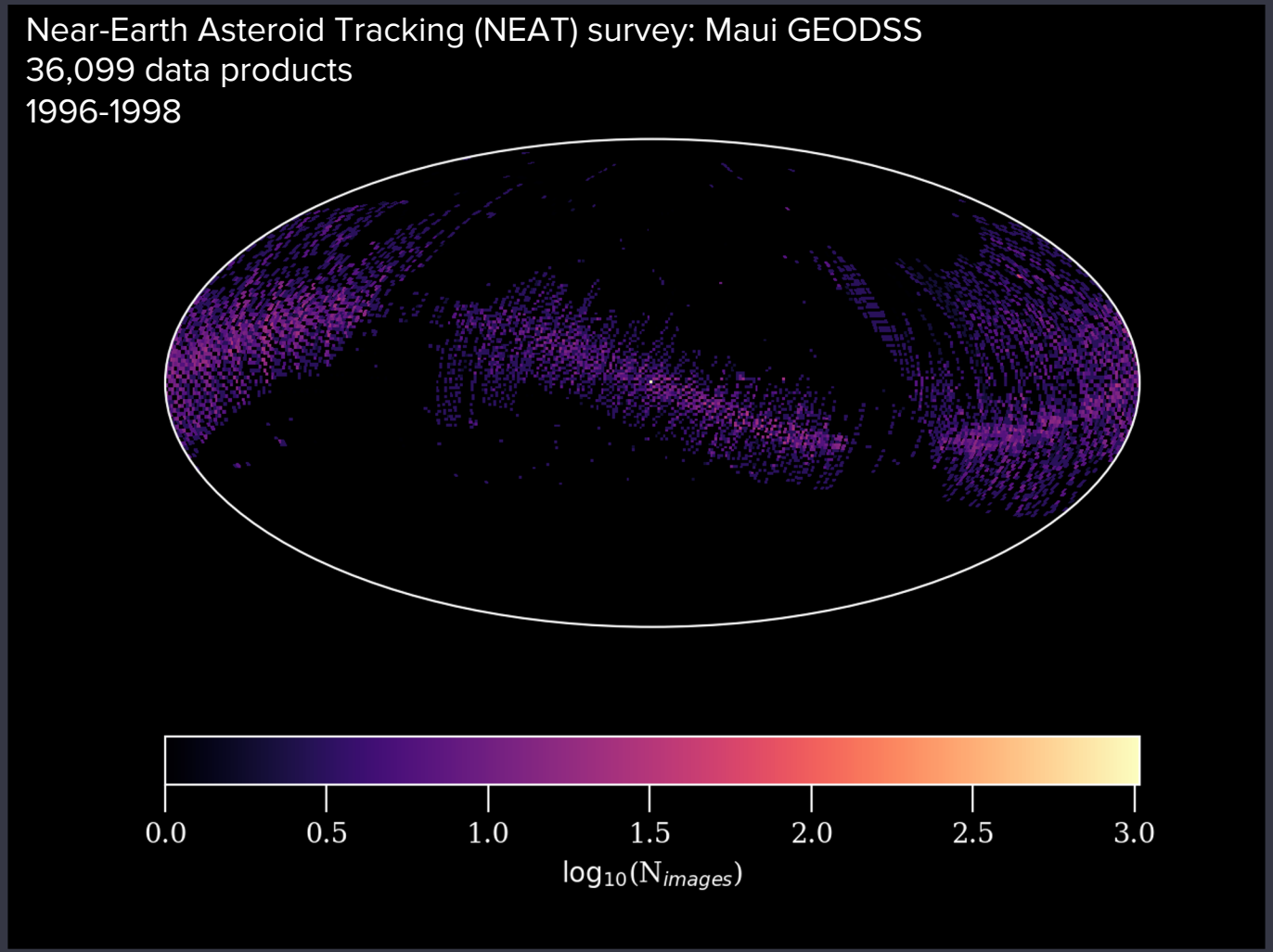
Google's S2 library indexes the sphere with a space-filling (fractal) curve. Benefits:

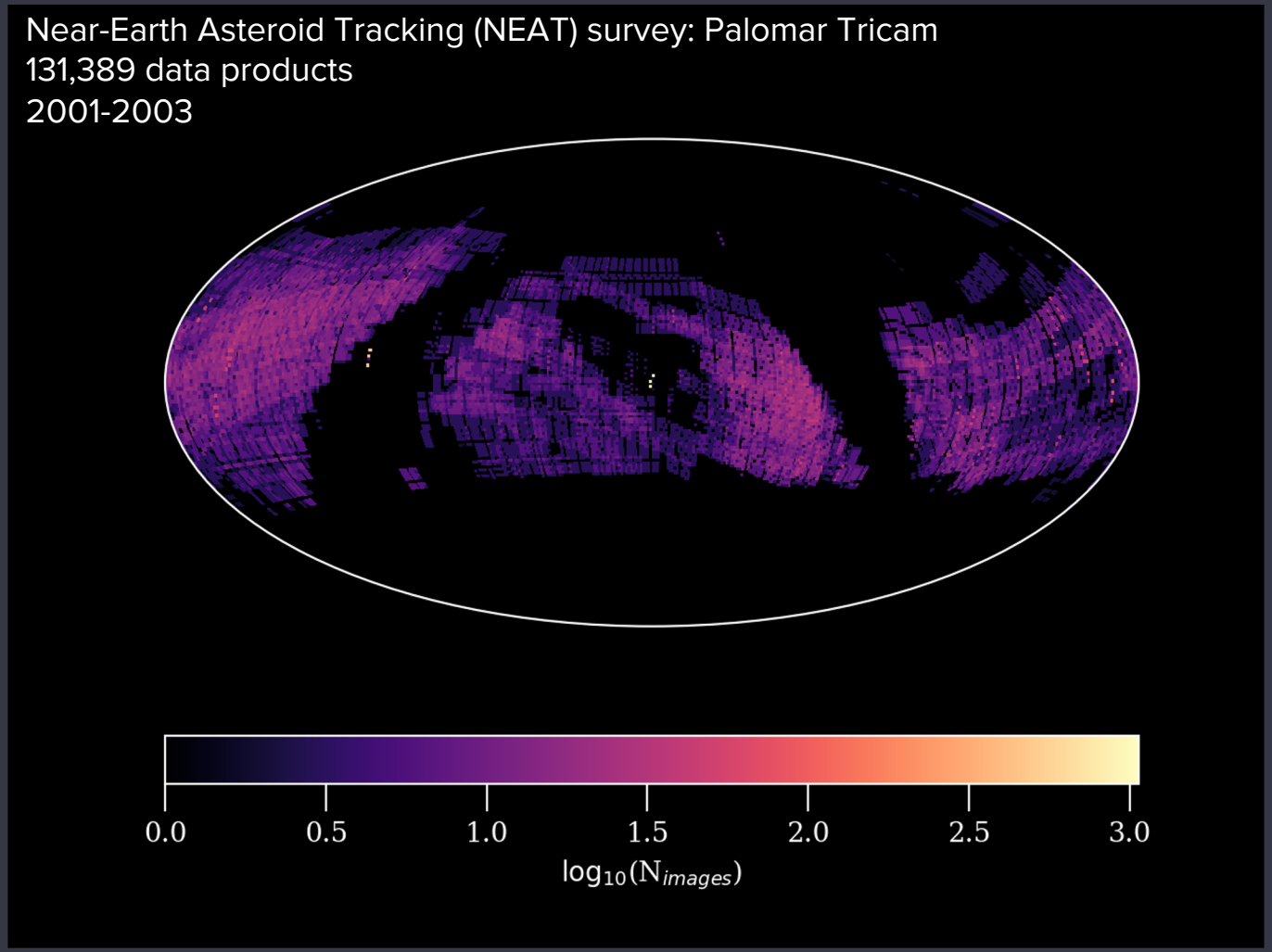
- The (Hilbert) curve maximizes locality.
- Cell boundaries are geodesics.
- E-W flip from Earth to Celestial Sphere does not affect results.
- 100x faster than equivalent Hierarchical Triangular Mesh (HTM) indexing.

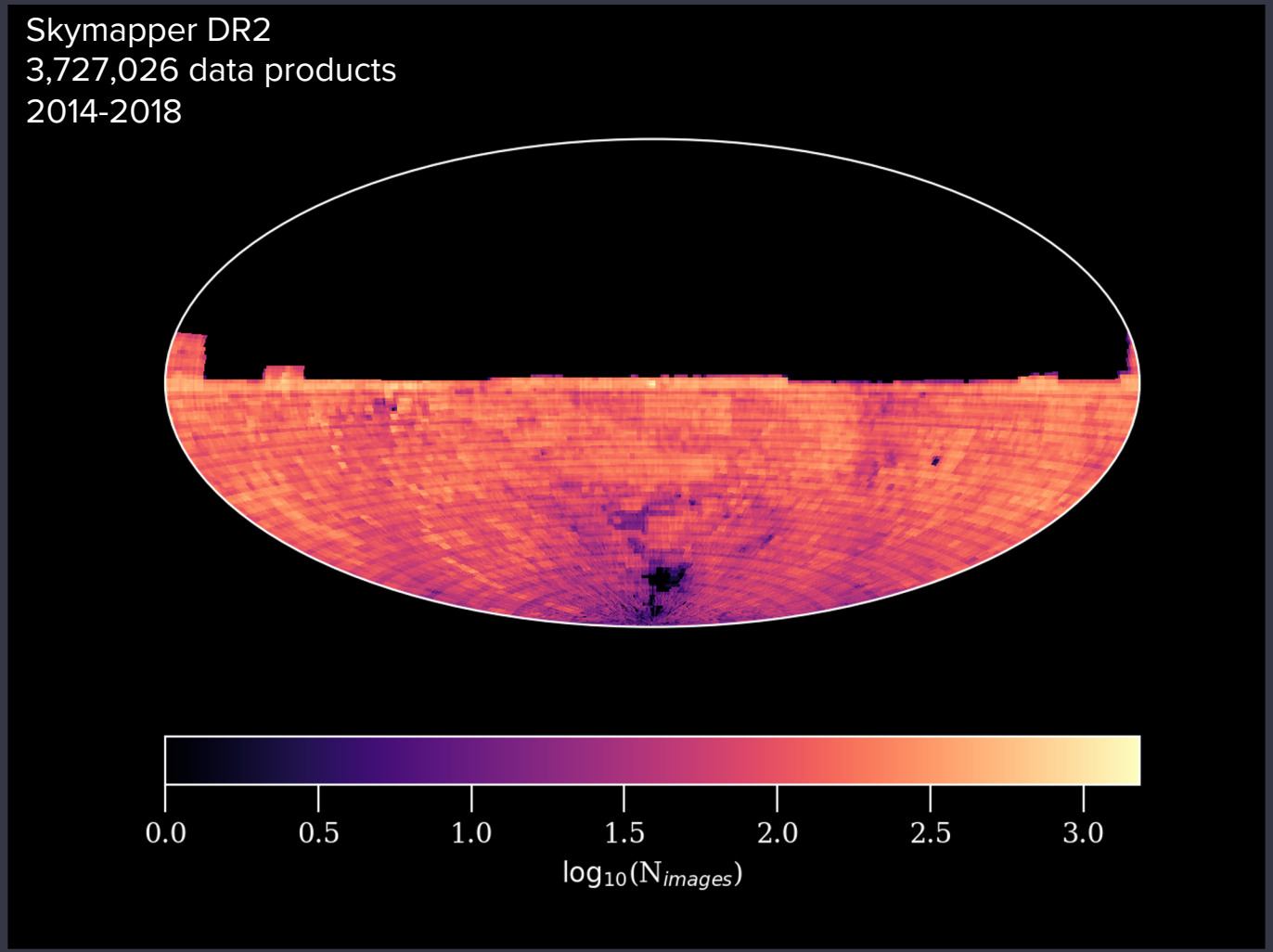


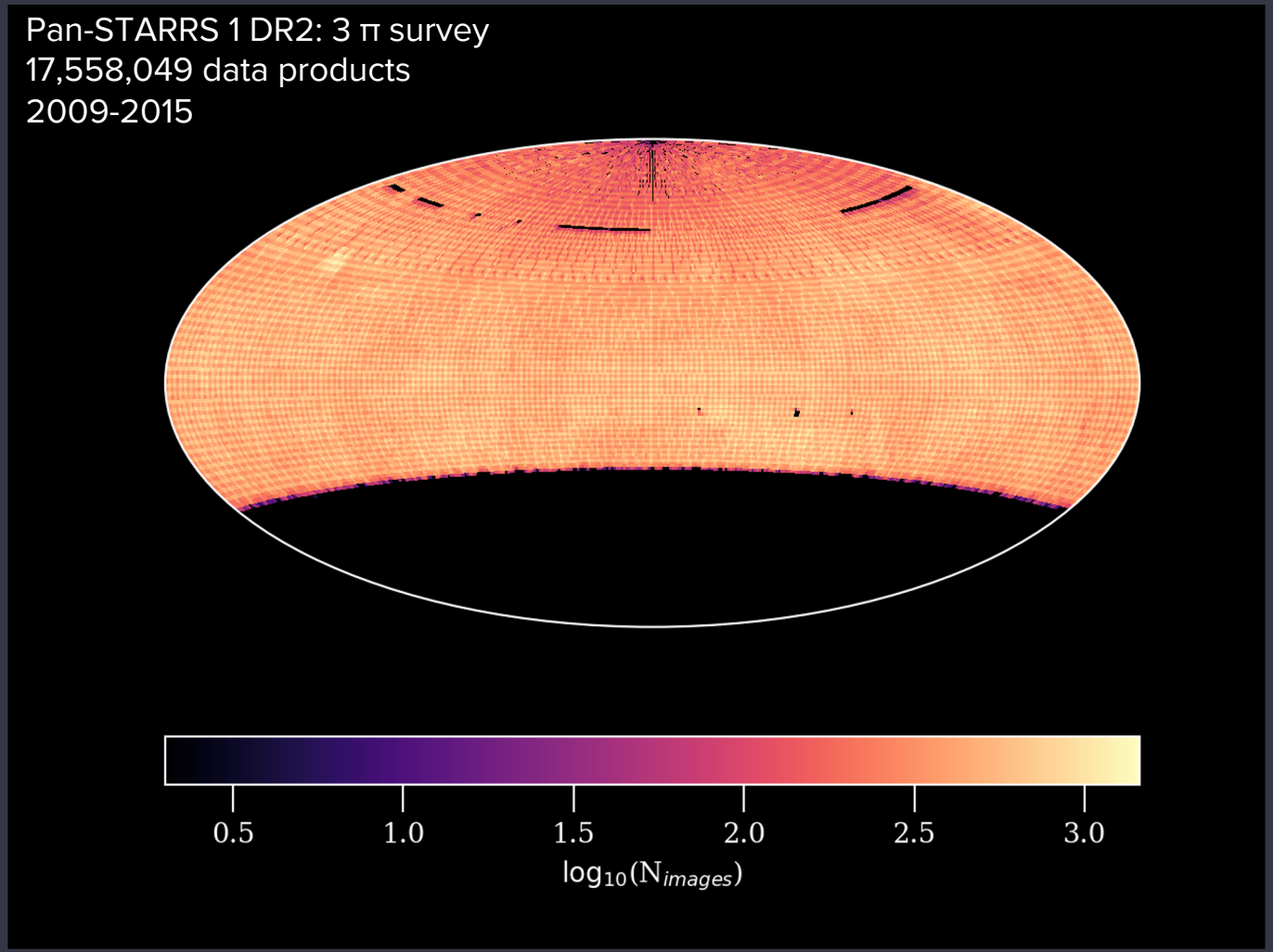
s2geometry.io

Surveys Indexed

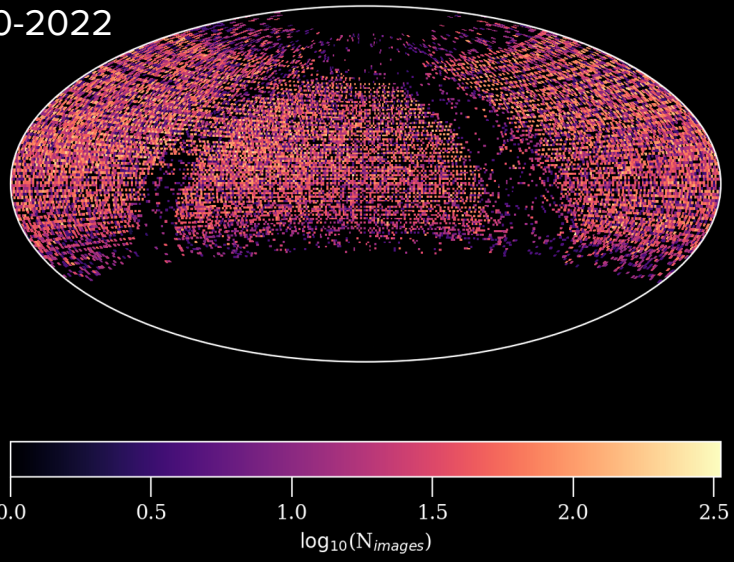

Near-Earth Asteroid Tracking (NEAT) survey: Maui GEODSS
36,099 data products
1996-1998
0.0
0.5
1.0
1.5
2.0
2.5
3.0
log10(Nimages)


Near-Earth Asteroid Tracking (NEAT) survey: Palomar Tricam
131,389 data products
2001-2003
0.0
0.5
1.0
1.5
2.0
2.5
3.0
log10(Nimages)

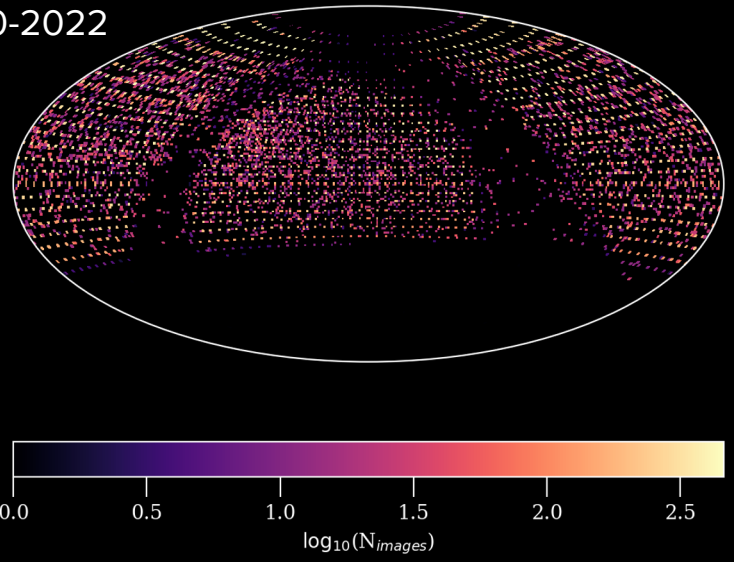

Skymapper DR2
3,727,026 data products
2014-2018
0.0
0.5
1.0
1.5
2.0
2.5
3.0
log10(Nimages)

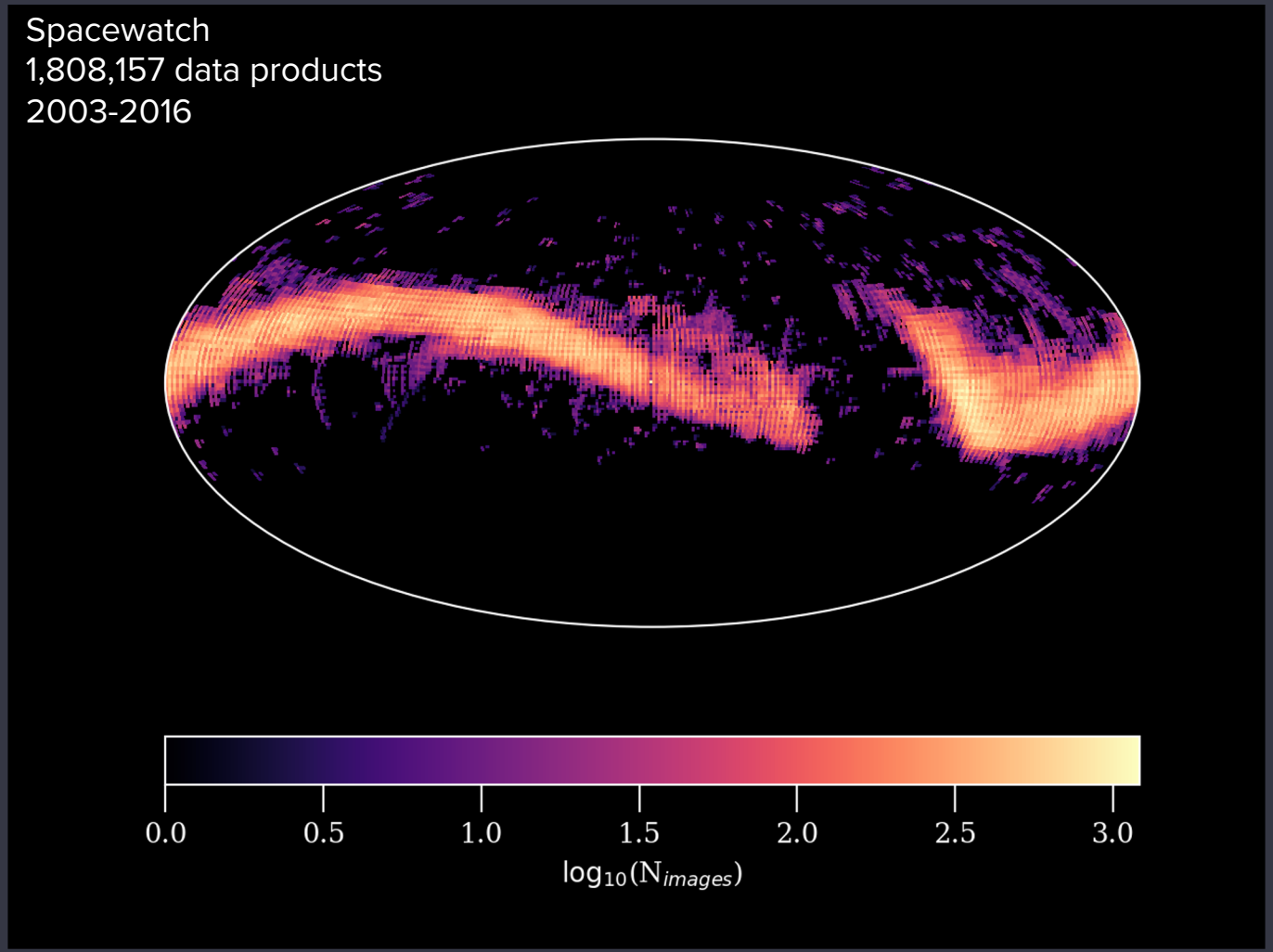

Pan-STARRS 1 DR2: 3 π survey
17,558,049 data products
2009-2015
0.5
1.0
1.5
2.0
2.5
3.0
log10(Nimages)

Catalina Sky Survey: Mt Bigelow
423,797 data products
2020-2022

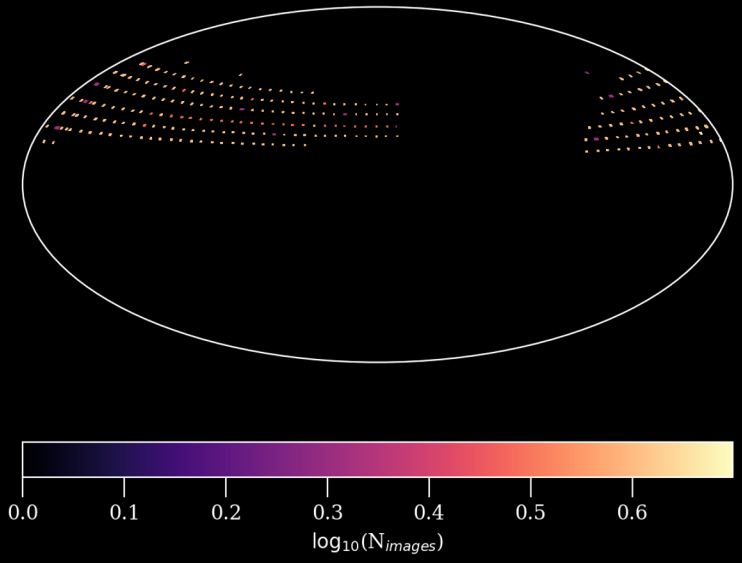


Catalina Sky Survey: Mt Lemmon
629,153 data products
2020-2022

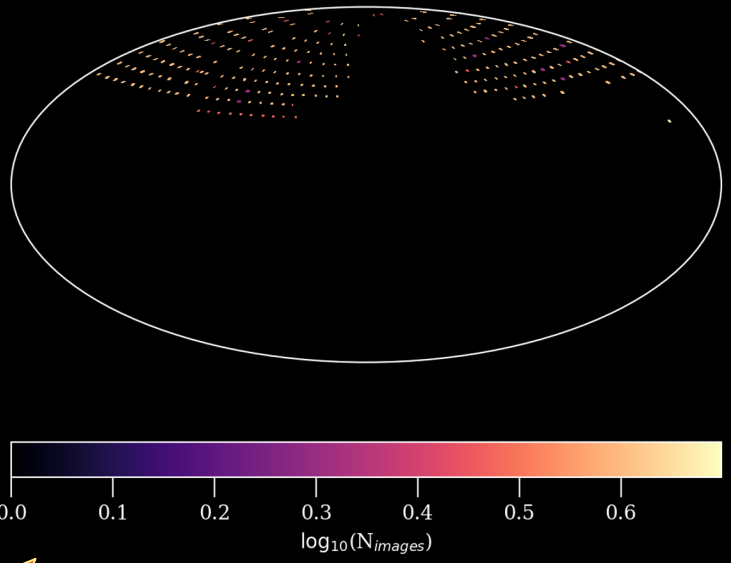



Spacewatch
1,808,157 data products
2003-2016
0.0
0.5
1.0
1.5
2.0
2.5
3.0
log10(Nimages)

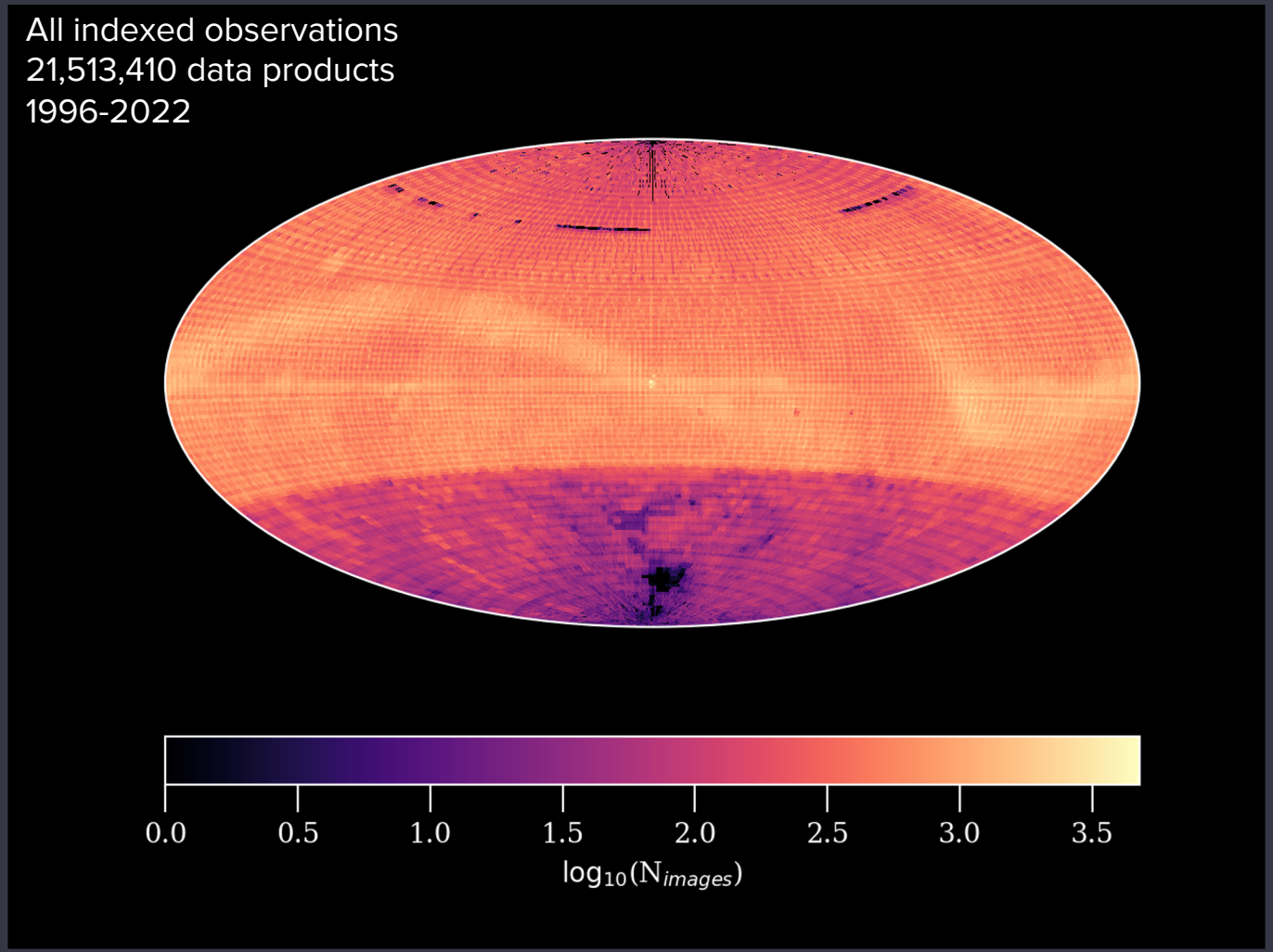
ATLAS: Mauna Loa (review data set)



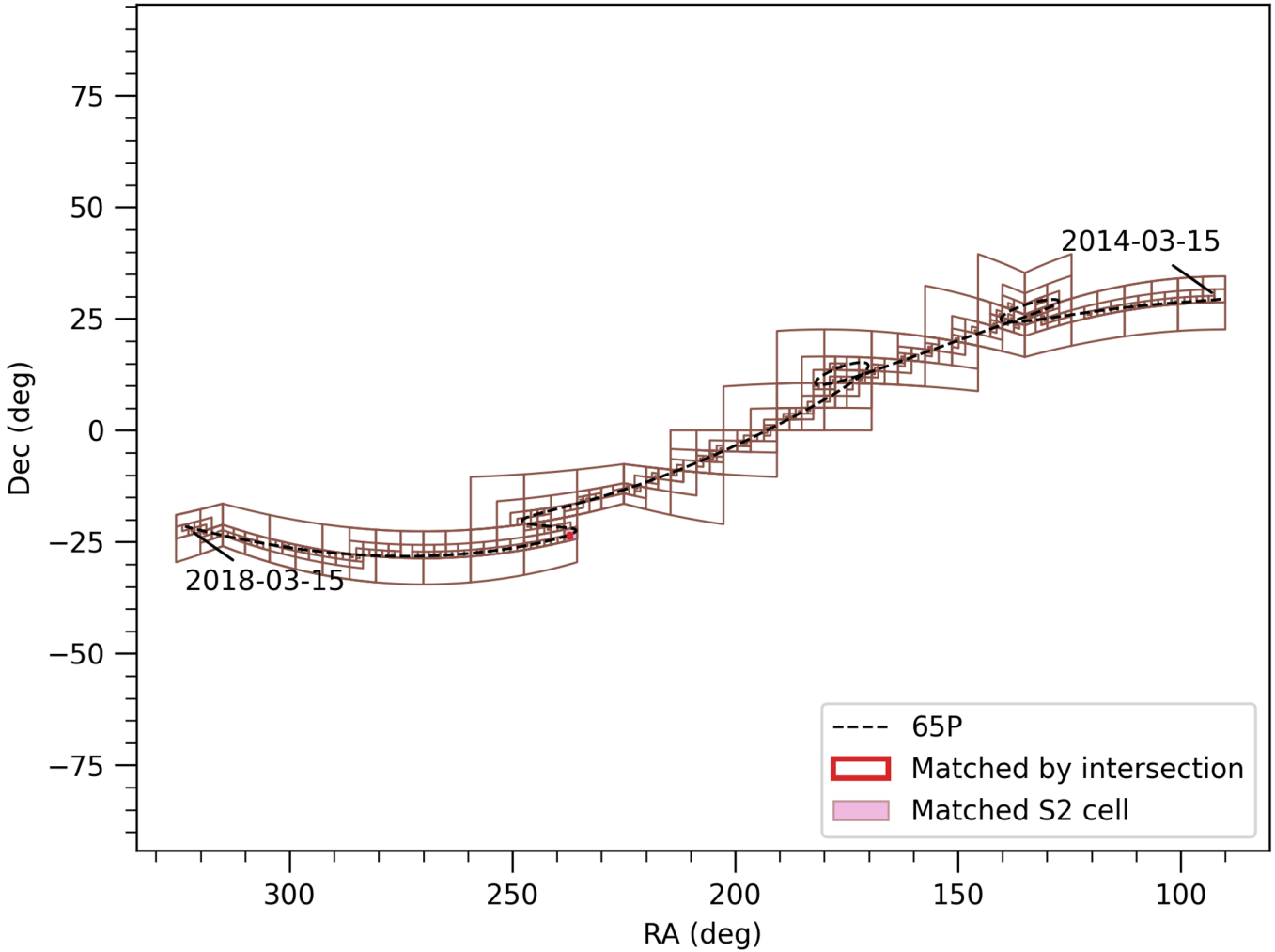
ATLAS: Haleakala (review data set)



Coming soon!


All indexed observations
21,513,410 data products
1996-2022
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
log10(Nimages)

Query the SkyMapper Southern Survey



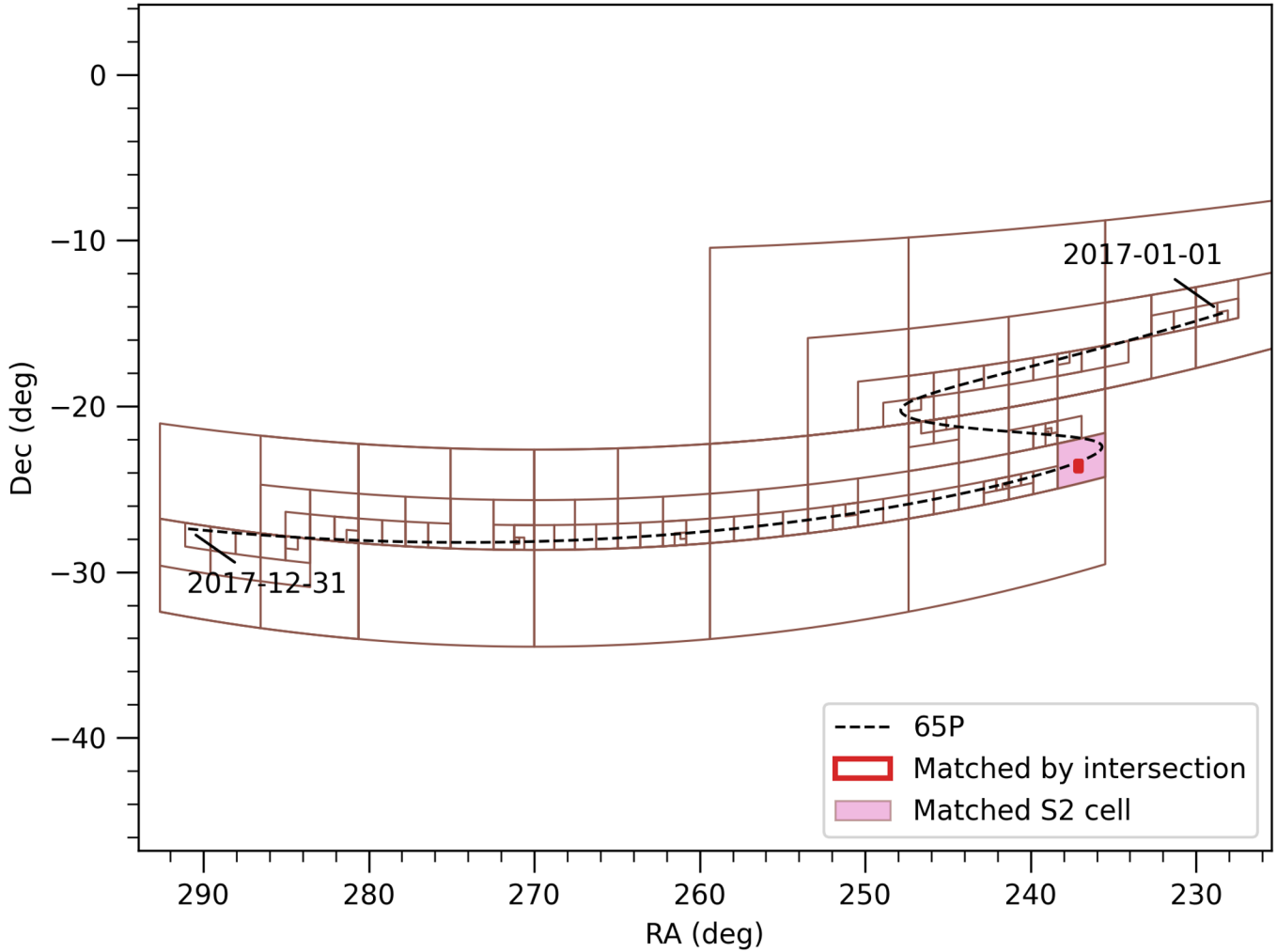
Search for comet 65P/Gunn in the SkyMapper Southern Survey Data Release 2

This example uses cell sizes ranging from 1' to 10°.

The ephemeris is described by the cells outlined in brown.

The red outline is the final matched observation.

The pink cell was used to make the final match.



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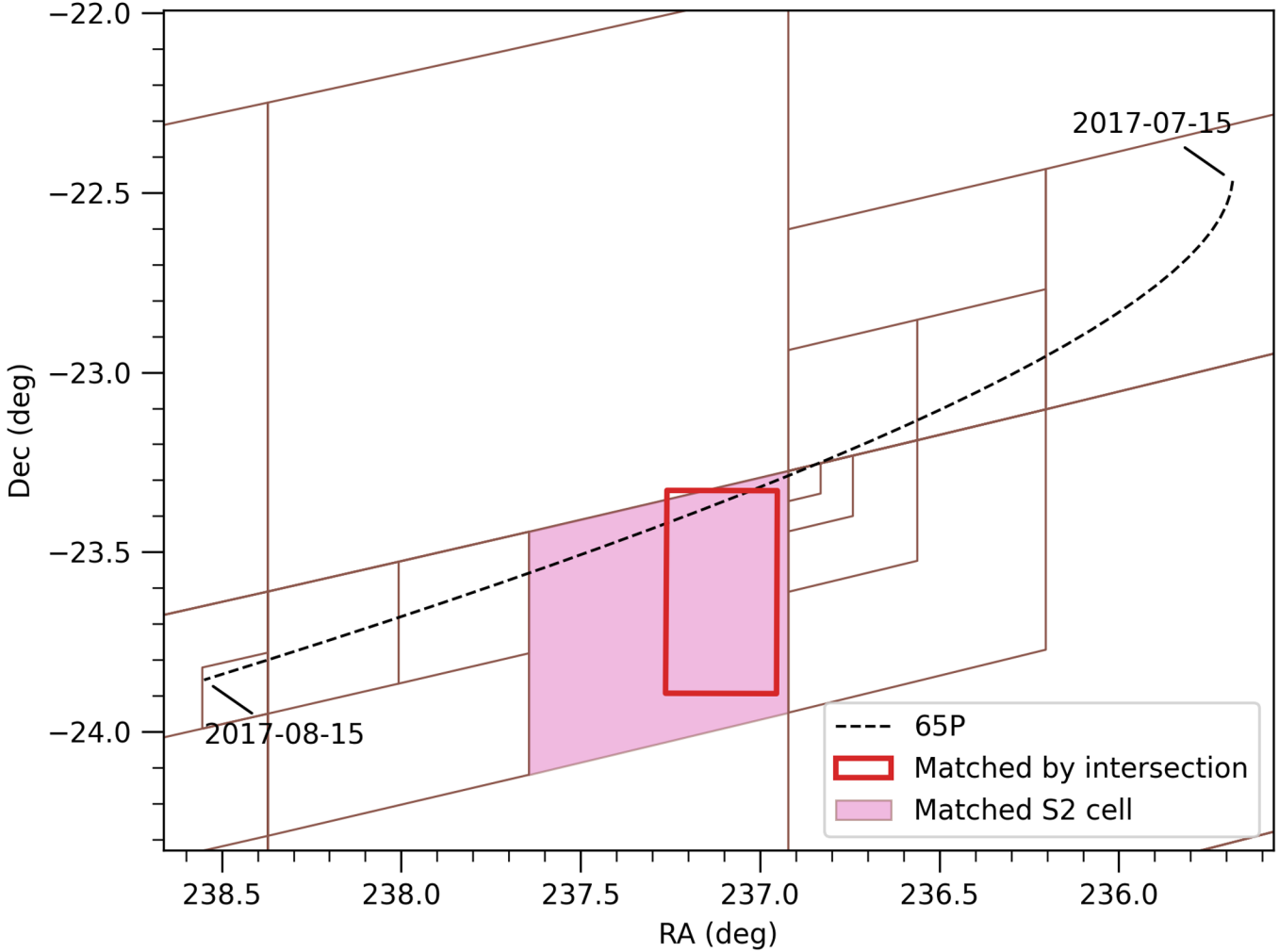

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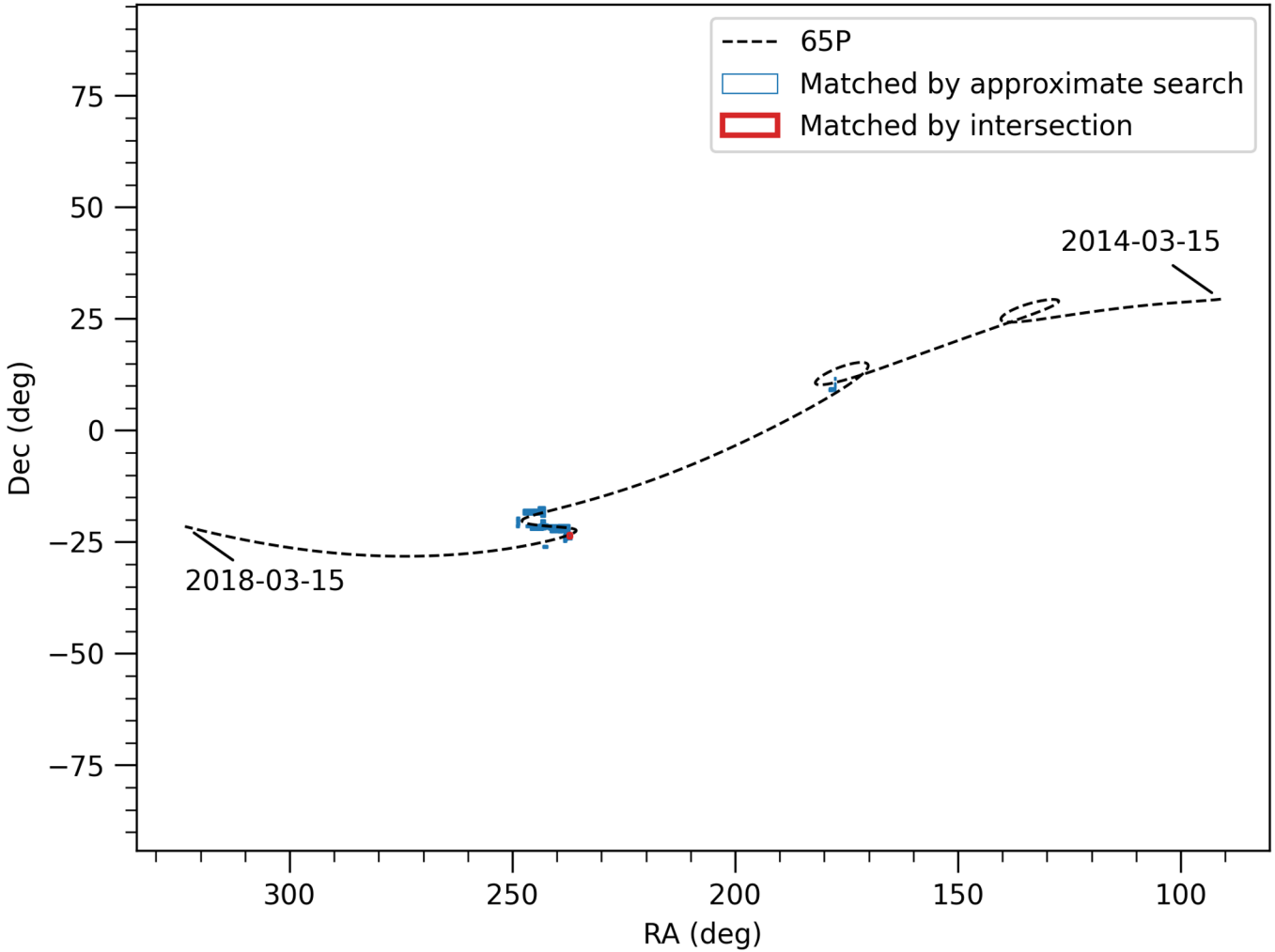
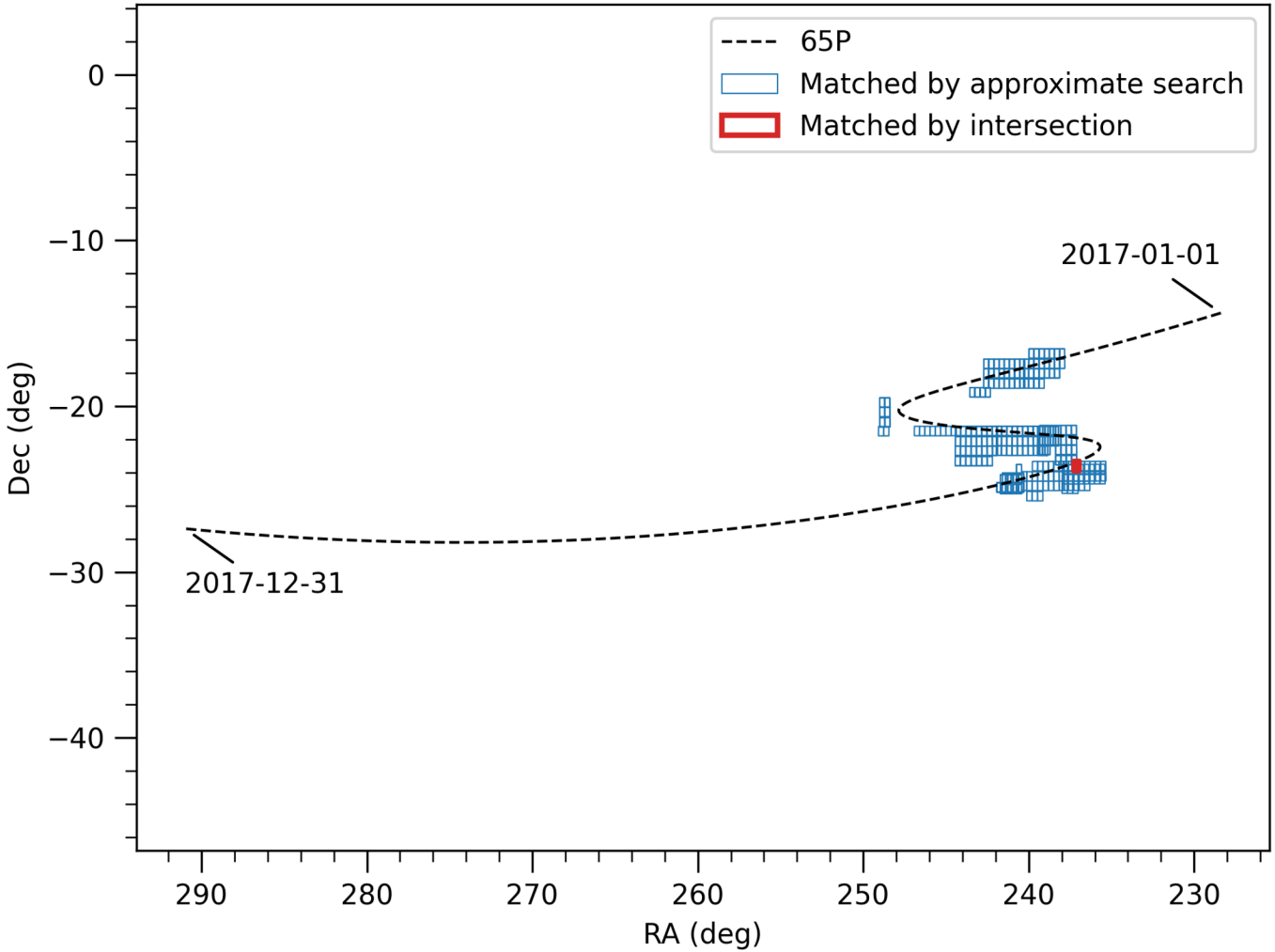


Search for comet 65P/Gunn in the SkyMapper Southern Survey Data Release 2

The blue outlines are candidate observations.

The red outline is the final matched observation.



Search for comet 65P/Gunn in the SkyMapper Southern Survey Data Release 2

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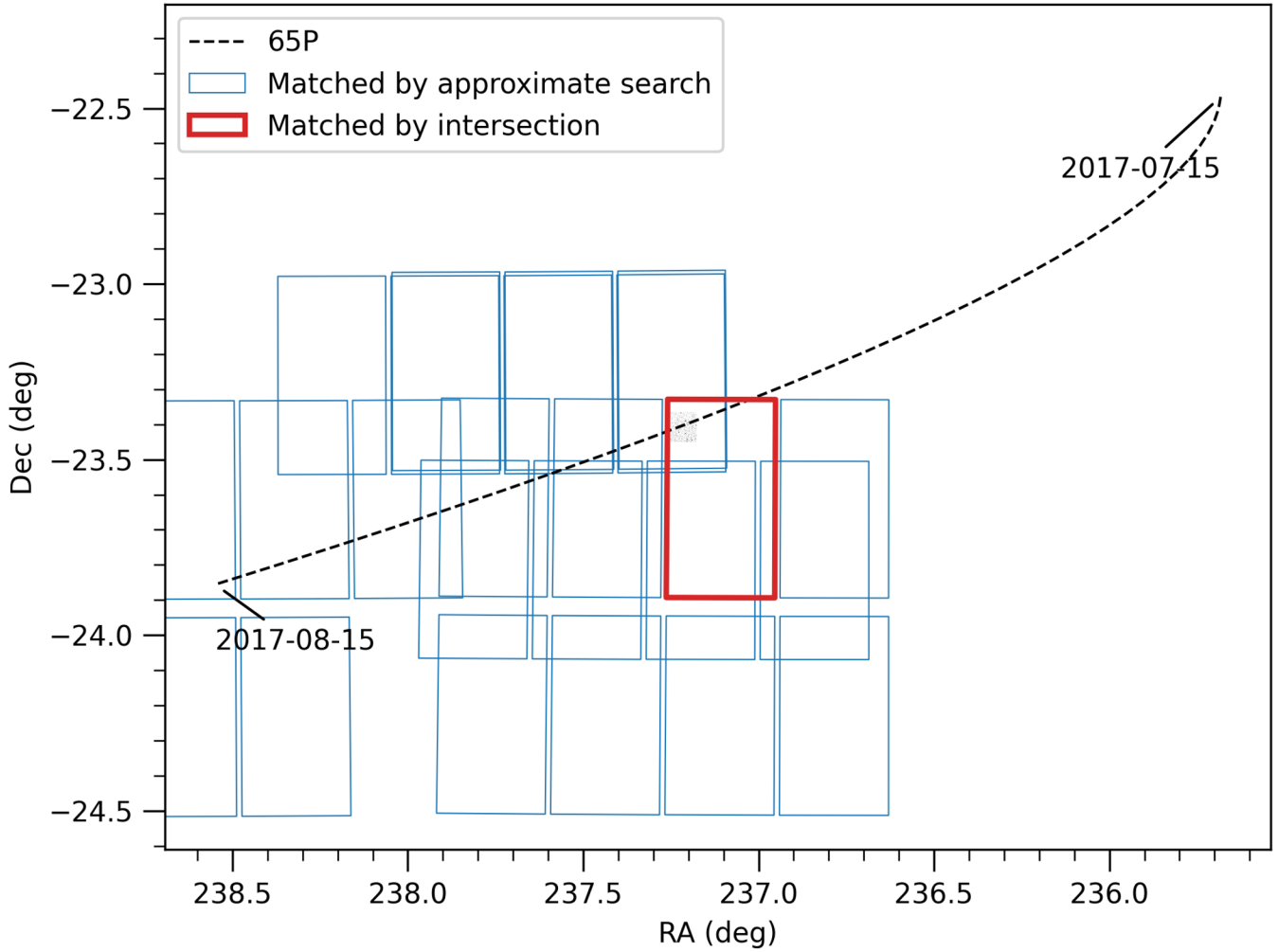
The red outline is the final matched observation.



Search for comet 65P/Gunn in the SkyMapper Southern Survey Data Release 2

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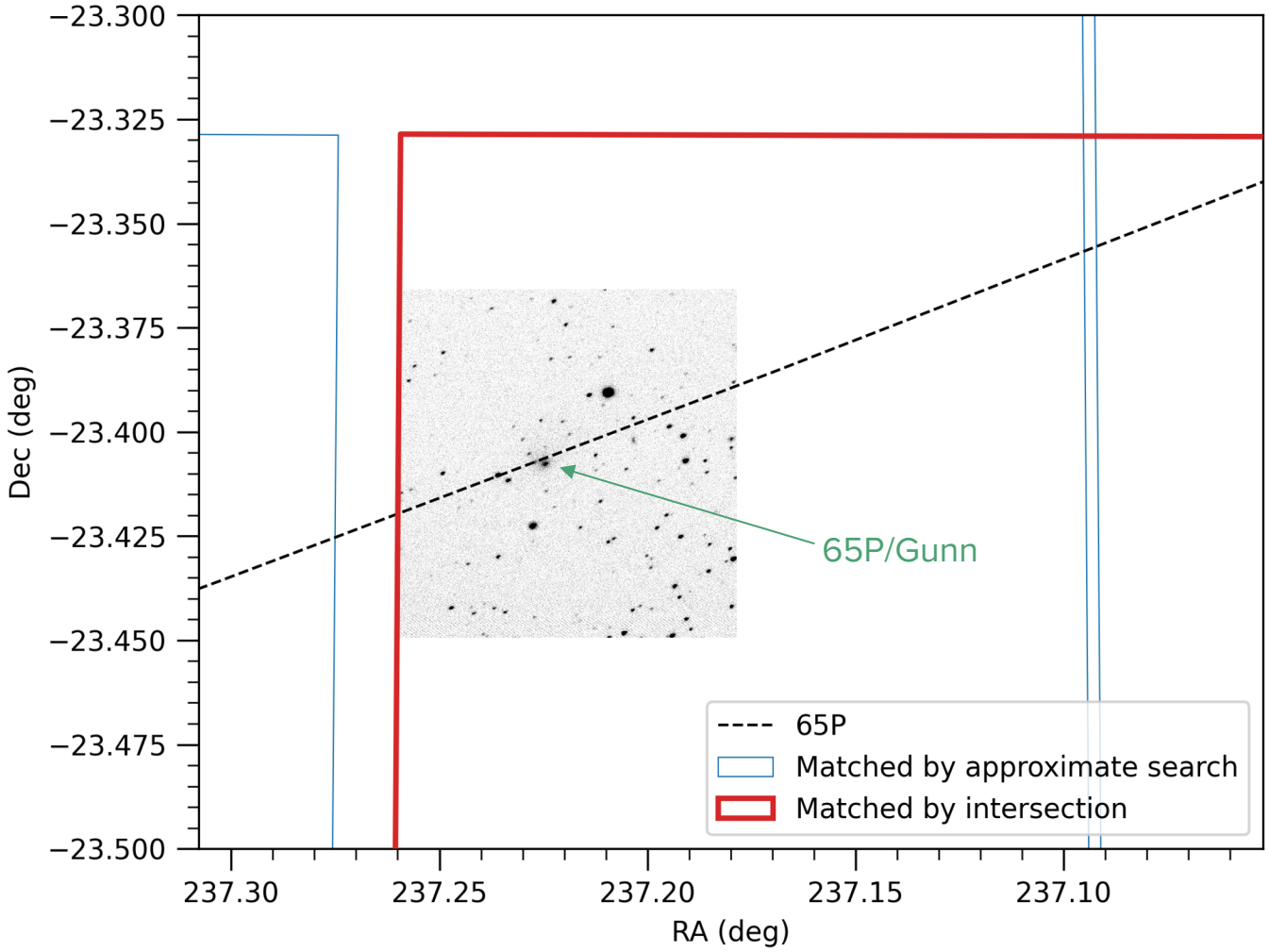
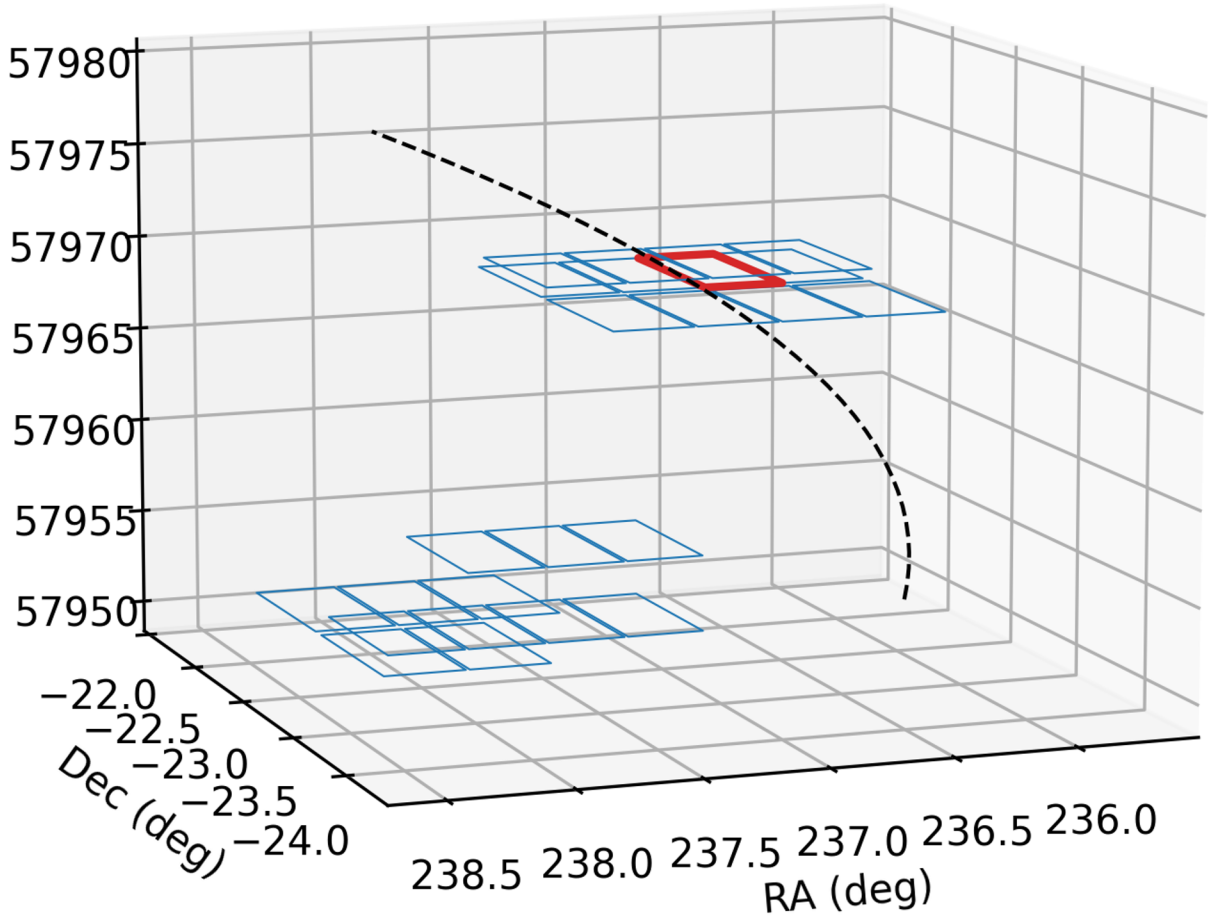
The red outline is the final matched observation.



Search for comet 65P/Gunn in the SkyMapper Southern Survey Data Release 2

The blue outlines are candidate observations.

The red outline is the final matched observation.



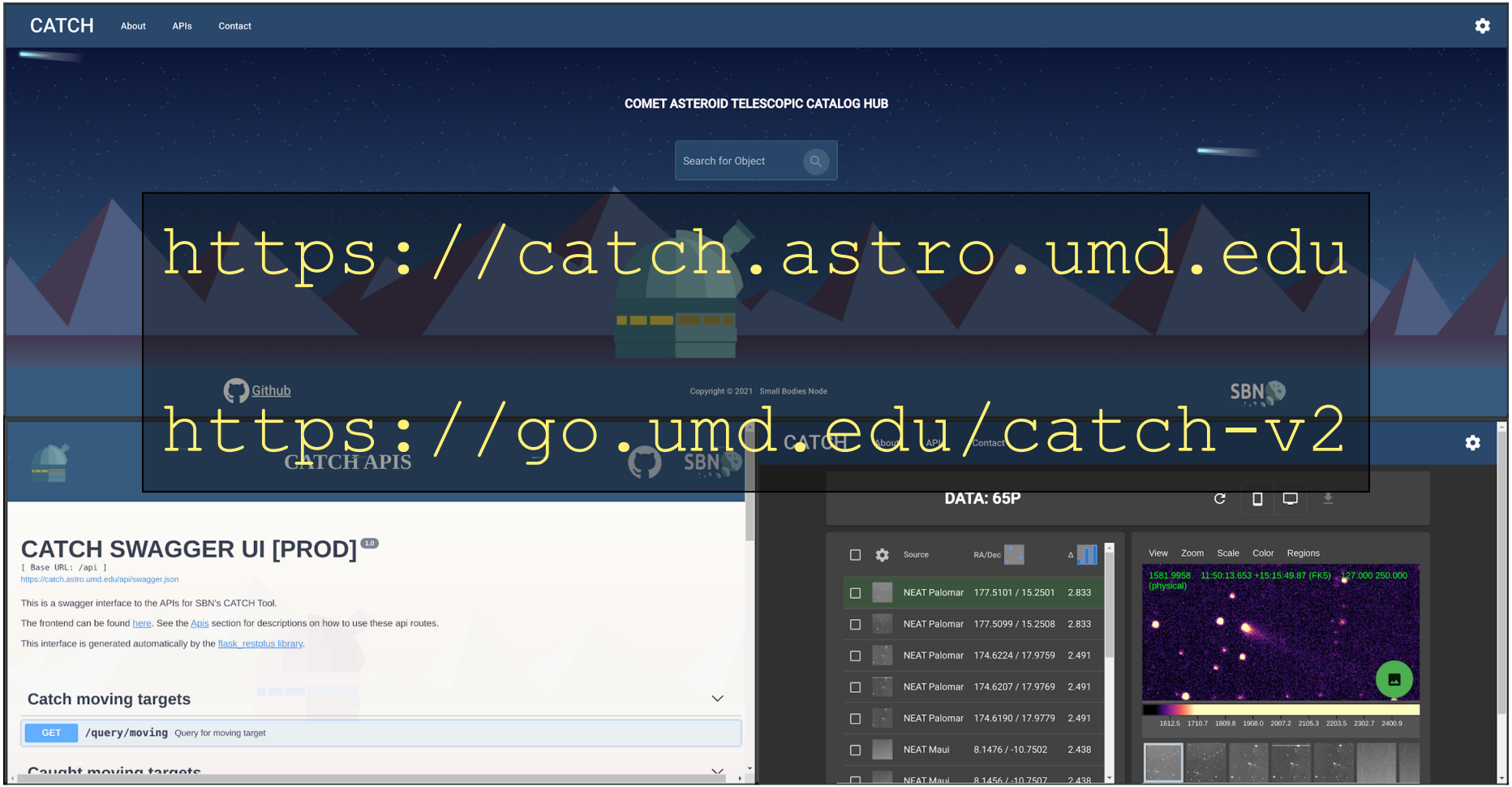
Search for comet 65P/Gunn in the SkyMapper Southern Survey Data Release 2

The blue outlines are candidate observations.

The red outline is the final matched observation.

Each observation is tested for intersection with the ephemeris in a three-dimensional space:

- Right ascension
- Declination
- Time


CATCH
About
APIs
Contact
COMET ASTEROID TELESCOPIC CATALOG HUB
Search for Object
https://catch.astro.umd.edu
Github
Copyright © 2021 Small Bodies Node
SBN
https://go.umd.edu/catch-v2
CATCH APIS
CATCH SWAGGER UI [PROD]
1.0
[Base URL: /api]
https://catch.astro.umd.edu/api/swagger.json
This is a swagger interface to the APIs for SBN's CATCH Tool.
The frontend can be found here. See the Apis section for descriptions on how to use these api routes.
This interface is generated automatically by the flask_restplus library.
Catch moving targets
GET
/query/moving
Query for moving target
DATA: 65P
Source
RA/Dec
NEAT Palomar 177.5101 / 15.2501 2.833
NEAT Palomar 177.5099 / 15.2508 2.833
NEAT Palomar 174.6224 / 17.9759 2.491
NEAT Palomar 174.6207 / 17.9769 2.491
NEAT Palomar 174.6190 / 17.9779 2.491
NEAT Maui 8.1476 / -10.7502 2.438
View
Zoom
Scale
Color
Regions
1581.9958 11:50:13.653 +15:15:49.87 (FK5) 127.000 250.000
(physical)
1612.5 1710.7 1809.8 1908.0 2007.2 2105.3 2203.5 2302.7 2400.9

Future Developments

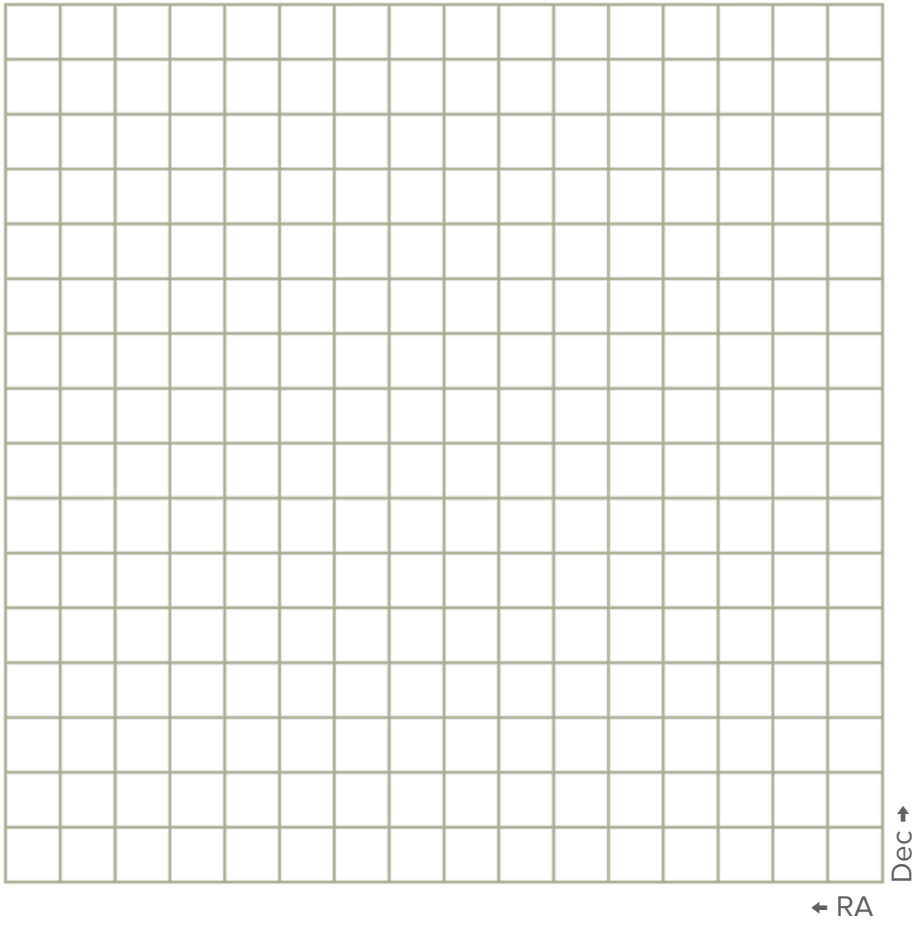
- ***More surveys:***
  - ATLAS, ~~Catalina Sky Survey~~, ~~Spacewatch~~.
- `Sidereal queries:`
  - Astrophysical applications, transient sky.
  - IVOA Simple Image Access protocol (separate tool).
- **Minor Planet Center integration:**
  - Candidate object searches (NEOCP & PCCP).
  - Considering MPC observation database visualization.
- **User-defined orbital elements**

Acknowledgements

With help from:

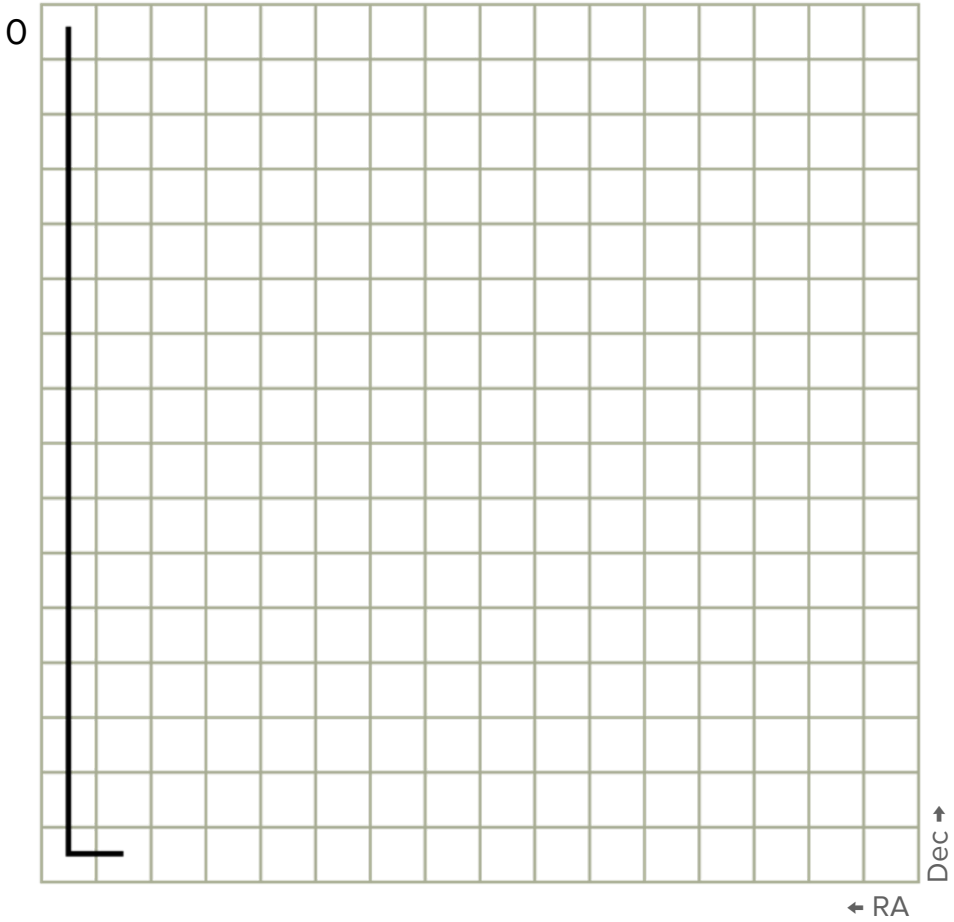
- Rick White, STScI (PanSTARRS 1 DR2)

Extras

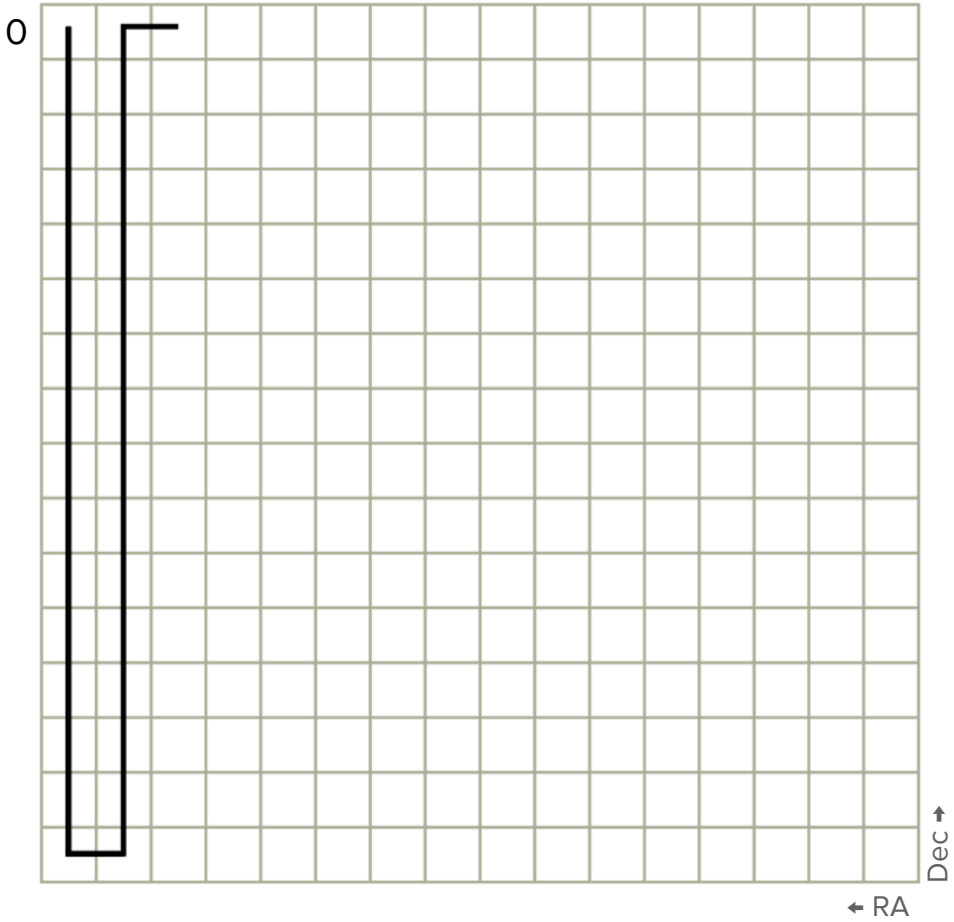


Goal: Map 2D spherical coordinates to a 1D value.

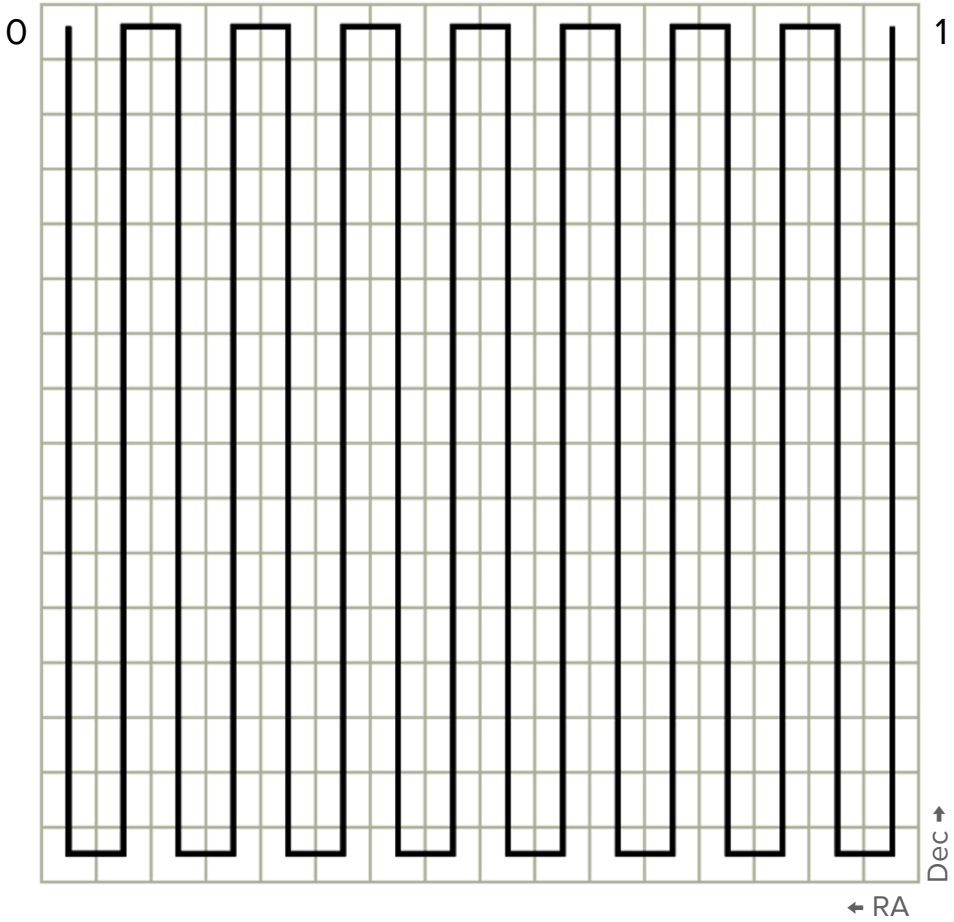
Why: Databases are generally good at finding results based on 1D data ordering.



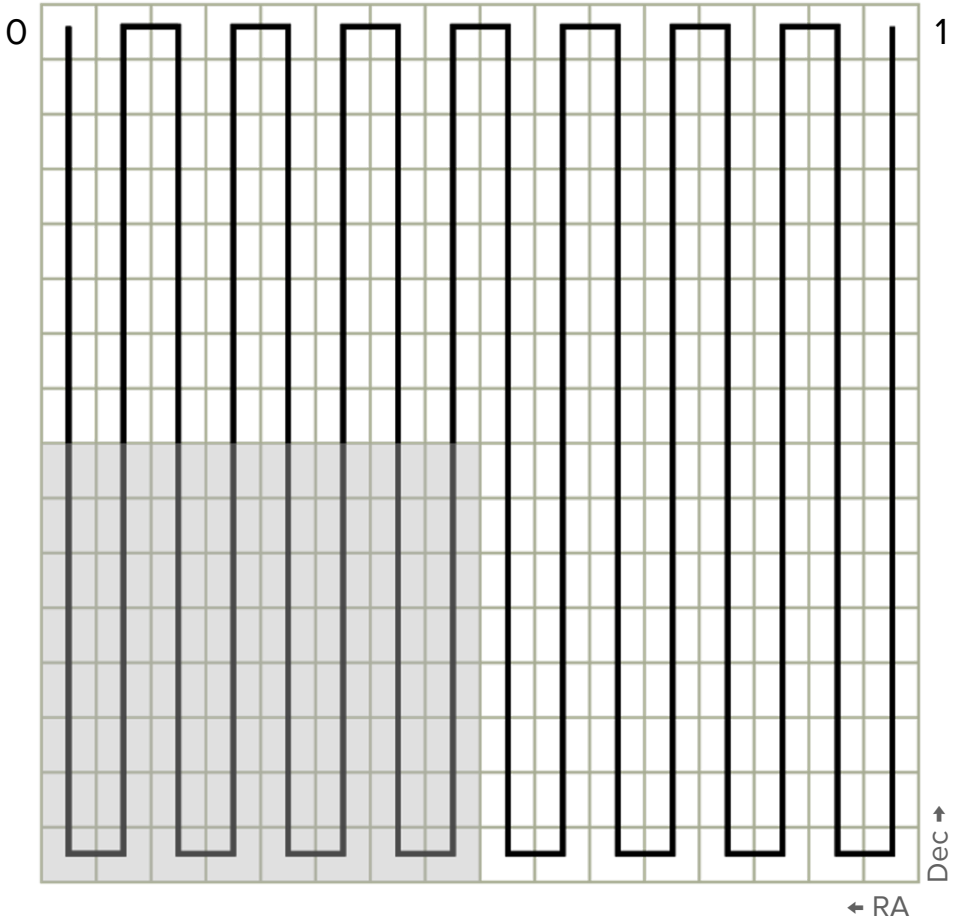
First attempt: Index along declination, then right ascension.



First attempt: Index along declination, then right ascension.

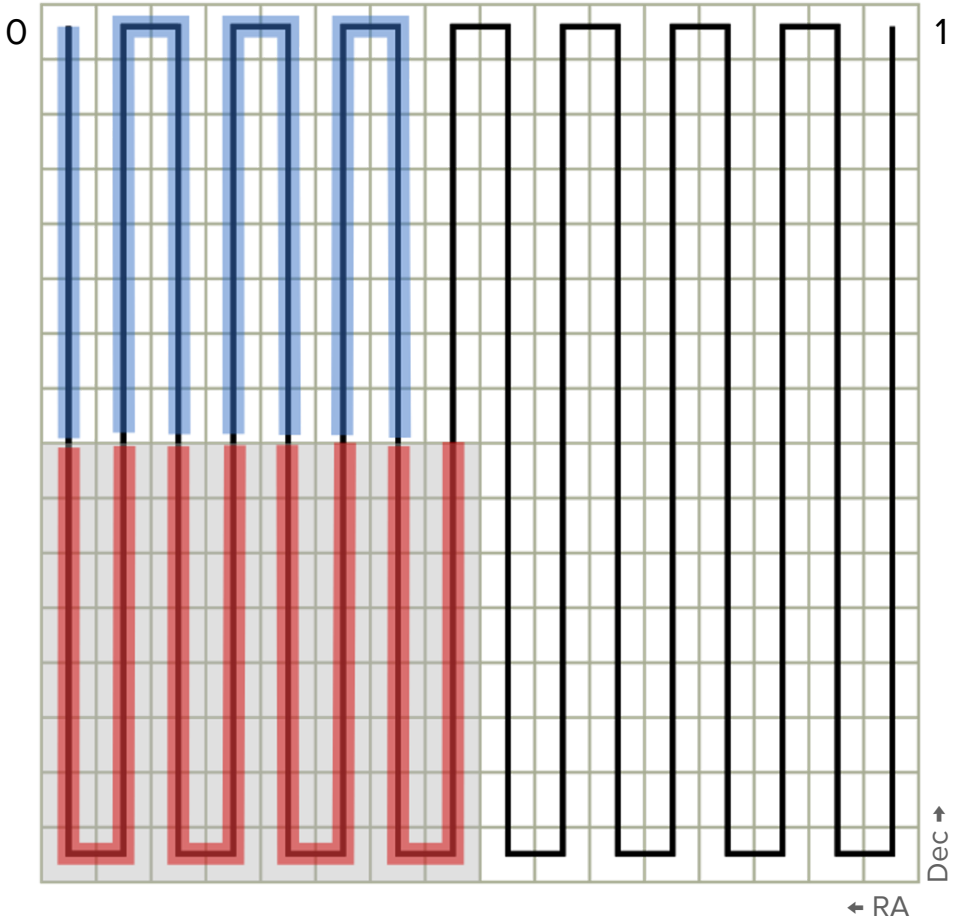


First attempt: Index along declination, then right ascension.



First attempt: Index along declination, then right ascension.

Query: Object somewhere in the lower left corner.

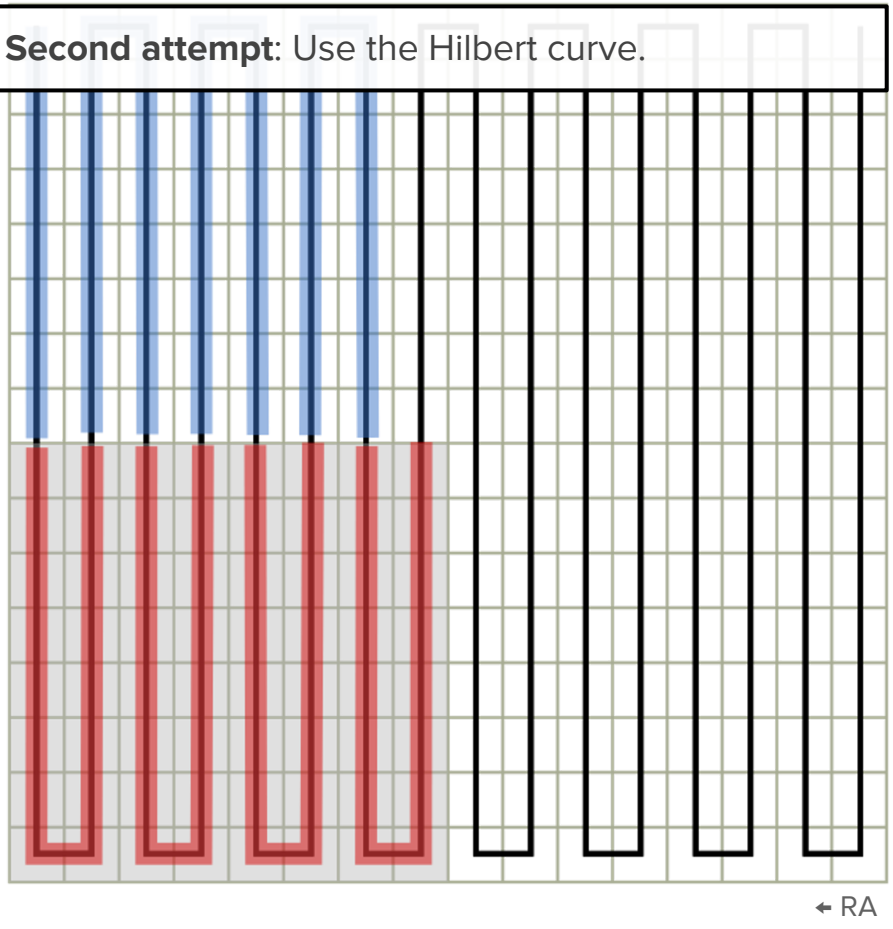


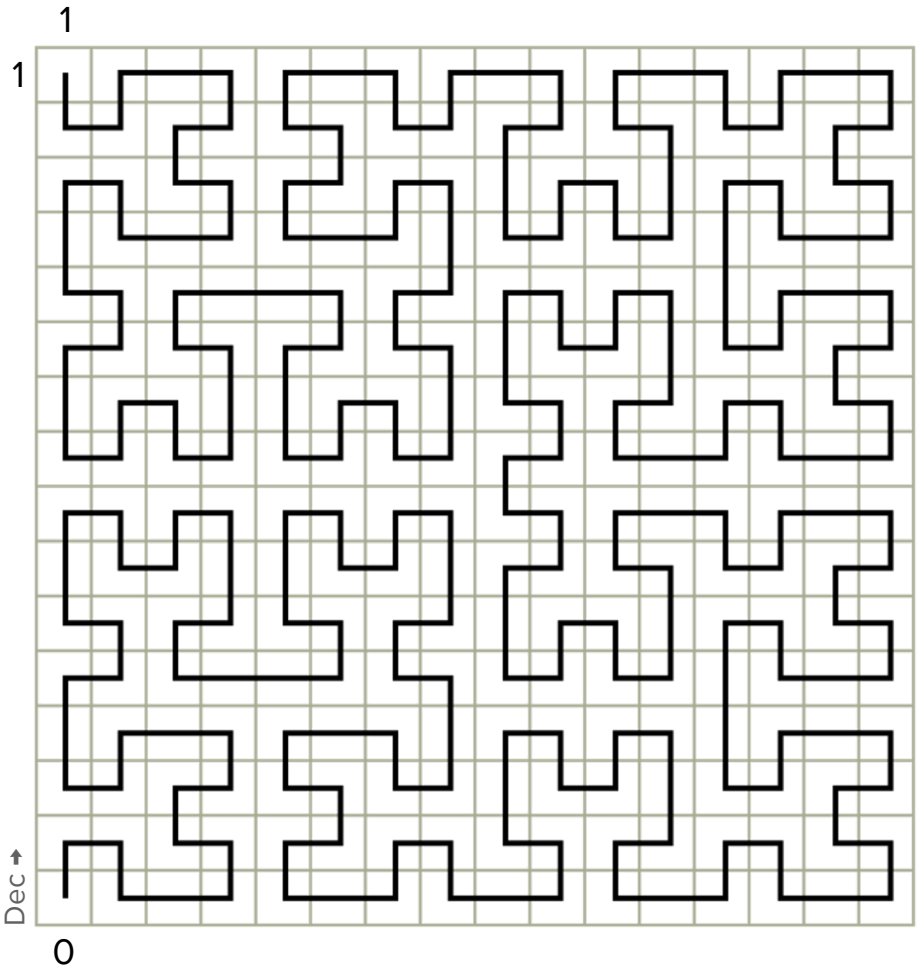
First attempt: Index along declination, then right ascension.

Query: Object somewhere in the lower left corner.

Results: Potential matches are separated by long stretches of irrelevant data. This can cause delays reading data from the hard disk.

Second attempt: Use the Hilbert curve.





Second attempt: Use the Hilbert curve.

Results: One continuous section of the database is read.