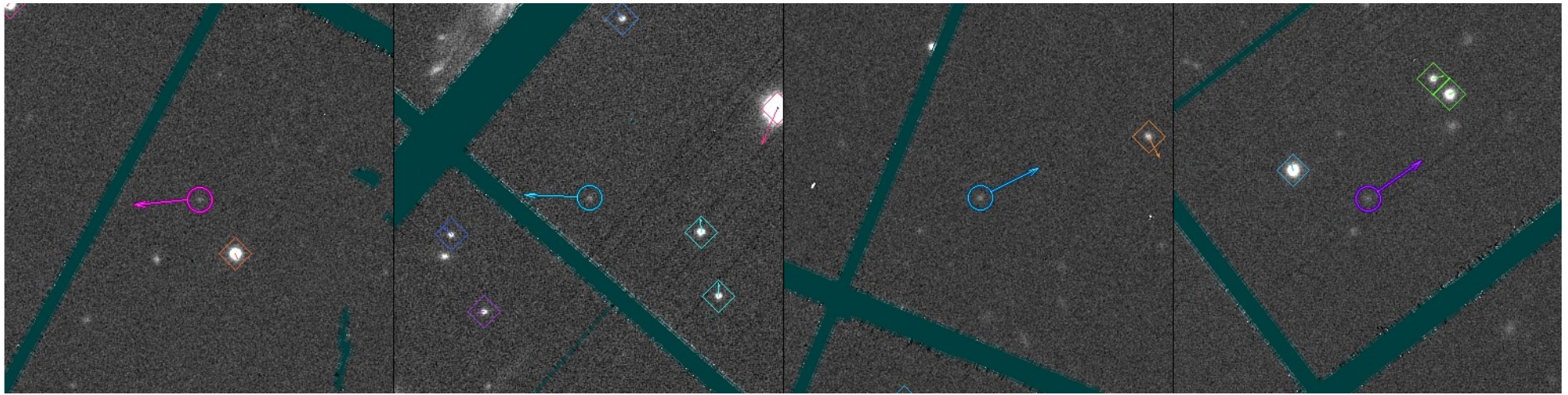

Near Earth Objects in the Recent Isolated Tracklet File

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The Isolated Tracklet File (ITF)

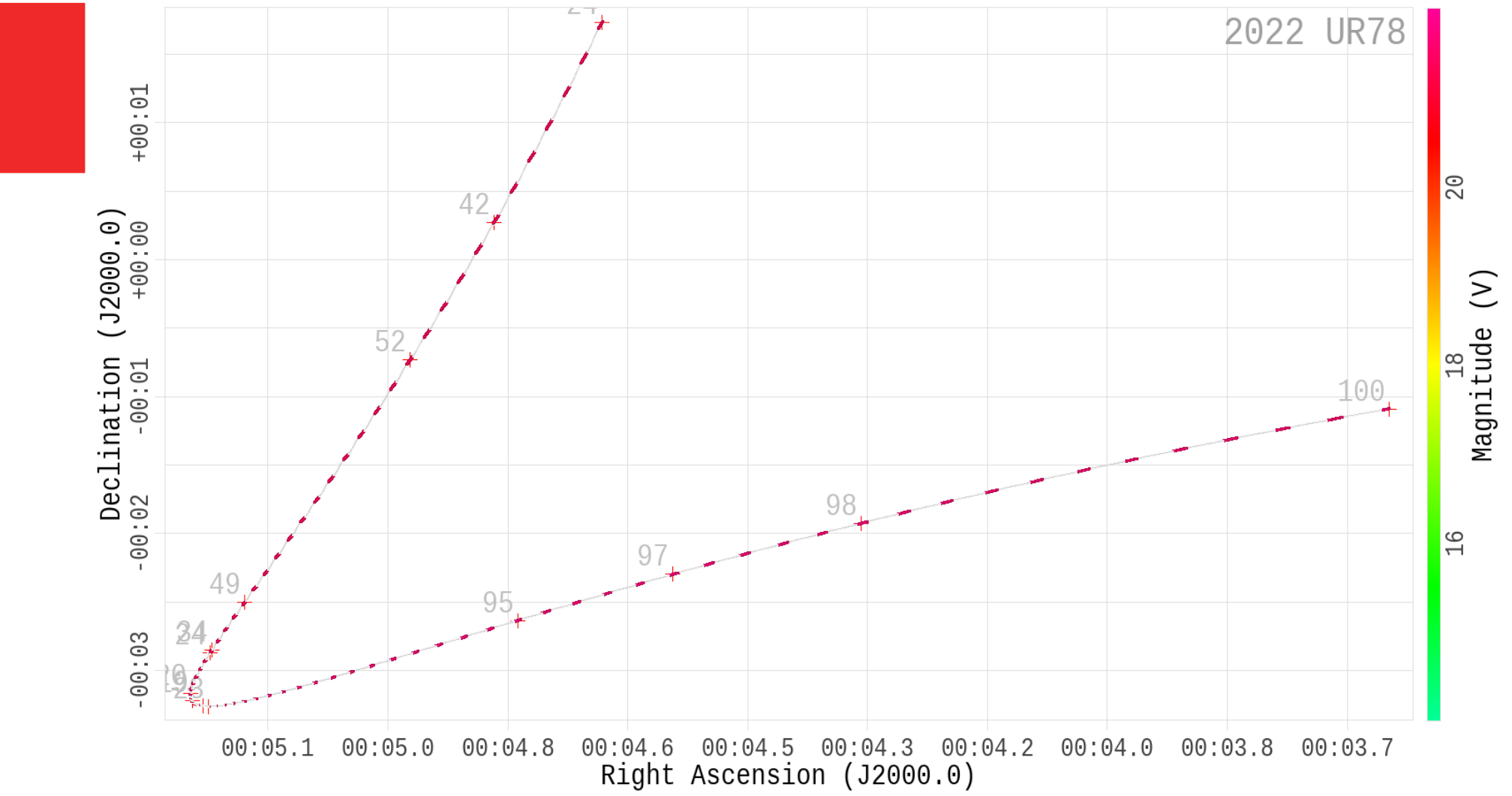
- The astrometry/photometry of several successive asteroid/comet measurements are termed a ‘tracklet’
- They are ranked with a NEO ‘digest2’ score
  - Quantitative estimate [0-100] of it being an NEO
  - >65 allows for posting to the NEO Confirmation Page
- Otherwise unidentified tracklets are relegated to the ITF
  - Rich repository of unlinked astrometry
  - The majority are from Pan-STARRS and Catalina
  - 3.1 million tracklets vs 1.3 million known objects

The Isolated Tracklet File (ITF)

Tracklets	Code	Observatory / Location
1 271 900	F51	Pan-STARRS 1, Haleakala
540 916	G96	Mt. Lemmon Survey
351 164	F52	Pan-STARRS 2, Haleakala
350 650	W84	Cerro Tololo-DECam
125 596	691	Steward Observatory, KP-SW
59 414	703	Catalina Sky Survey
50 316	V00	Kitt Peak-Bok
36 574	695	Kitt Peak
36 027	807	Cerro Tololo, La Serena
34 828	644	Palomar Mountain/NEAT

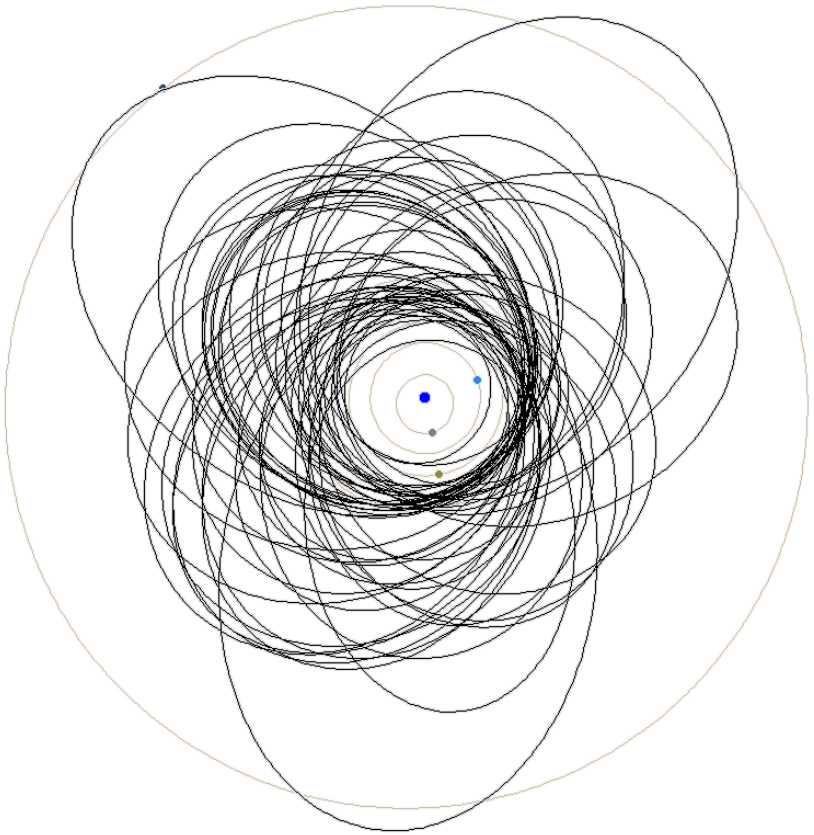
Method

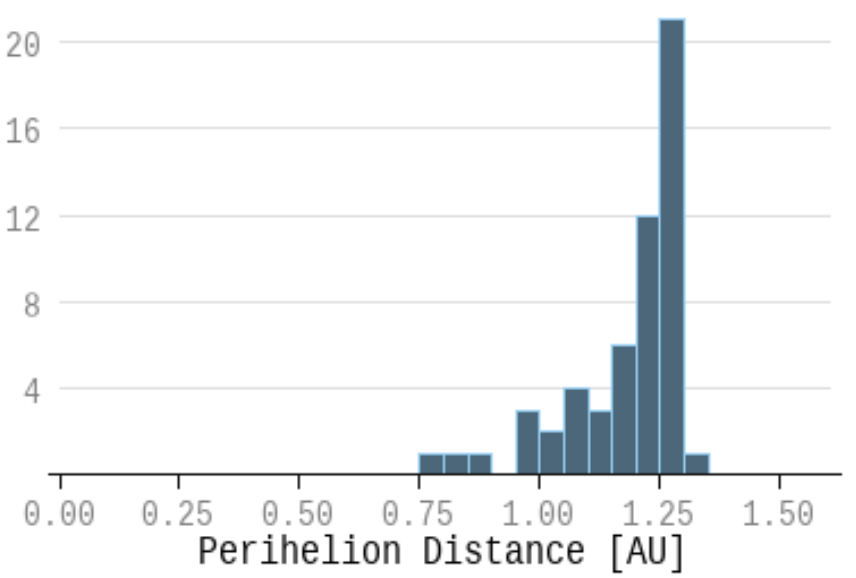
- Once per day, we retrieve the ITF astrometry
  - Split recent data into two groups, score 0-9 and 10+
  - Search for tracklet pairs with similar position angle
  - Fit a test orbit, then check for residual trends
  - Search for more tracklets in the complete ITF
- Submit linkages to the MPC id-pipeline
  - Automatic for non-NEOs with 5+ tracklets
  - NEOs for 3+ tracklets sent via email summary
    - Manual verification and image archive search

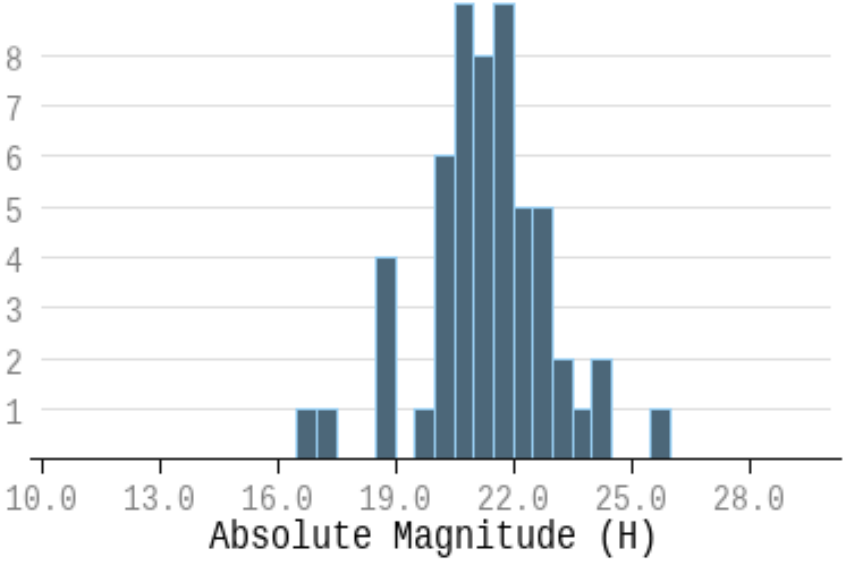

2022 UR78
Declination (J2000.0)
+00:01
+00:00
-00:01
-00:02
-00:03
Right Ascension (J2000.0)
00:05.1
00:05.0
00:04.8
00:04.6
00:04.5
00:04.3
00:04.2
00:04.0
00:03.8
00:03.7
Magnitude (V)
16
18
20
24
49
42
52
95
97
98
100

Results

- 58 total NEOs have been found, 19 in 2022
  - But also numerous lower scoring linkages
  - Found (99942) Apophis during its IAWN campaign
- Most recent NEO: 2023 EG_3 H=23.0, q = 1.18
  - Also 2019 GO_{146} (1.4 km) and 2021 AF_8 (PHA)
  - Numerous others, often before their score increased
- Up to ~2000 non-NEO linkages per month
  - Likely many unlinked Mars Crossers in the ITF




20
16
12
8
4
0.00
0.25
0.50
0.75
1.00
1.25
1.50
Perihelion Distance [AU]

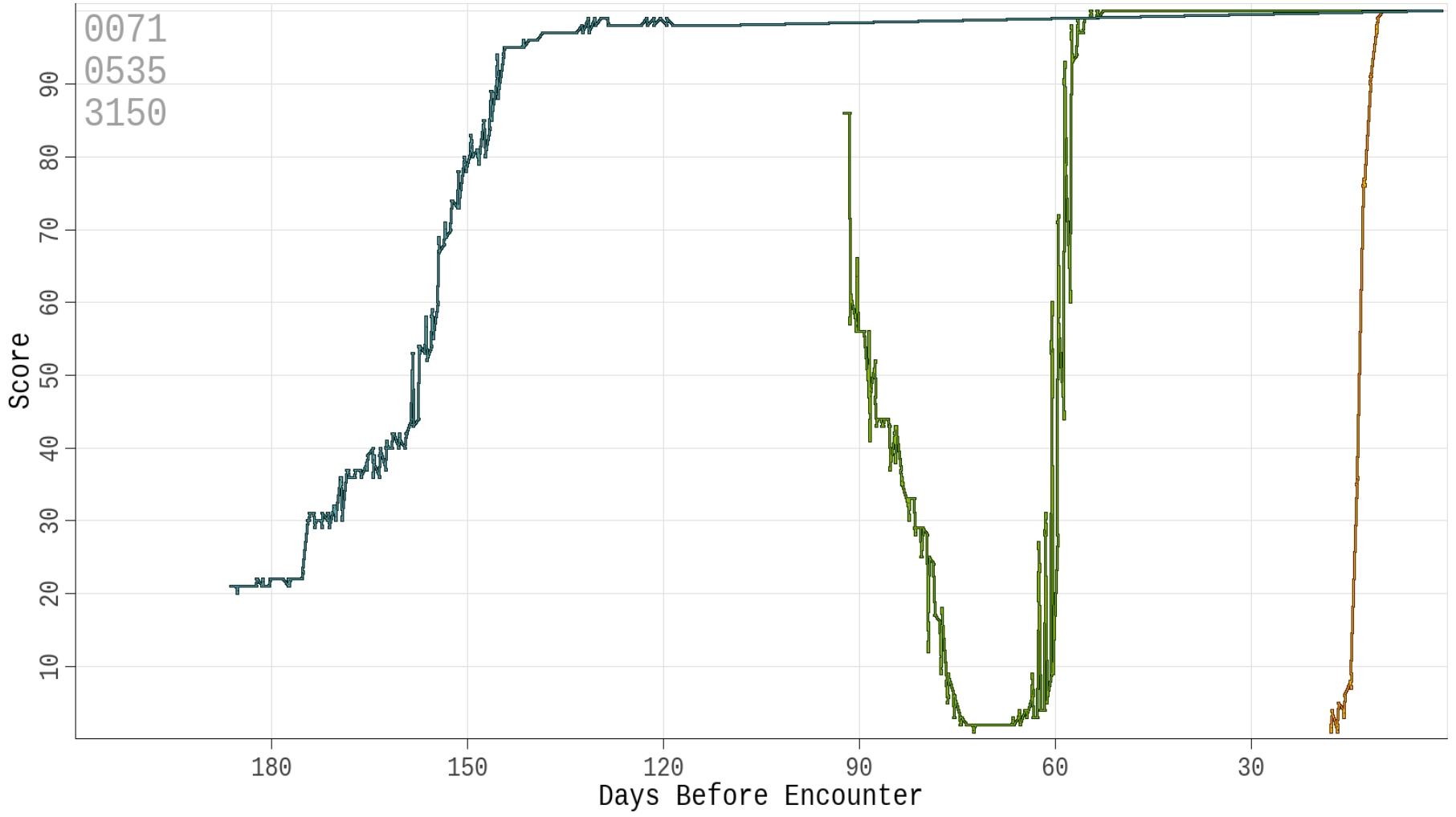

8
7
6
5
4
3
2
1
10.0
13.0
16.0
19.0
22.0
25.0
28.0
Absolute Magnitude (H)

Results

Year	Month	Submitted Linkages
2022	July	369
2022	August	1313
2022	September	2160
2022	October	2525
2022	November	1584
2022	December	721
2023	January	381
2023	February	143

Simulations

- What kinds of objects is our search sensitive to?
  - Can simulate the trajectories that approach Earth
  - Wainscoat et al. (2022) study of 2019 OK
  - Otherwise all objects approach 100 score
- Simulations still a work in progress


0071
0535
3150
Score
10
20
30
40
50
60
70
80
90
180
150
120
90
60
30
Days Before Encounter

Limitations

- Search parameters are tunable
  - Ideal choice might be difficult to set
    - 2023 DZ_2 for example
- Need tracklets to actually be found
  - SNR cut-offs: data may exist, but in image archives
- Multiple tracklets (3+ for NEOs) are required
  - Could use two with more verification
  - Or could we better test single tracklets ?
    - Objects close to the Earth can show curvature
    - See PDC talk by Veres et al.

Summary

- The Isolated Tracklet File (ITF) is a rich repository of data
  - Contains 3.1 million unlinked tracklets
  - There are 1.3 million current designations
- Two categories of interest for this work:
  - Finding Earth approachers early, allowing for follow-up
  - Finding objects that would never post to NEOCP
- Our method to automatically link recent tracklets is improved
  - Lower score objects handled automatically
  - But need to better assess single tracklets or pairs