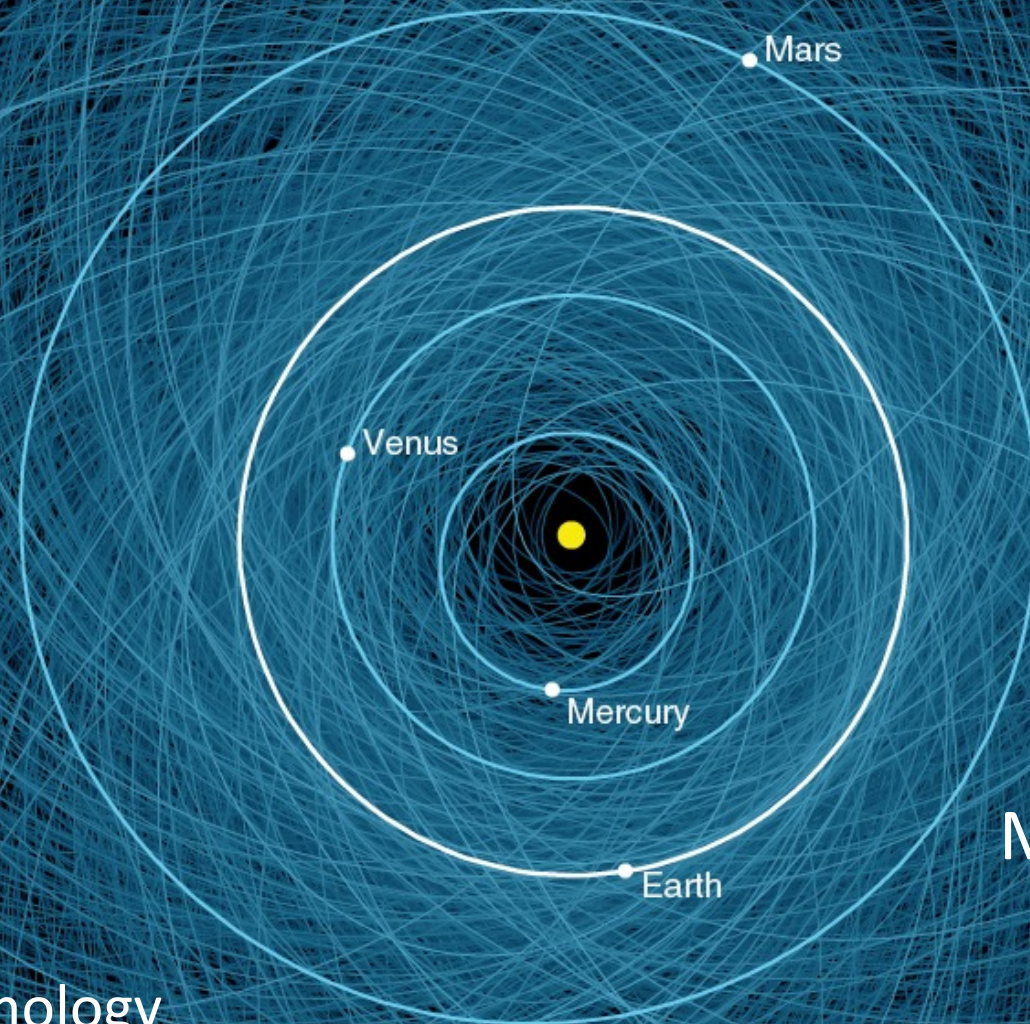


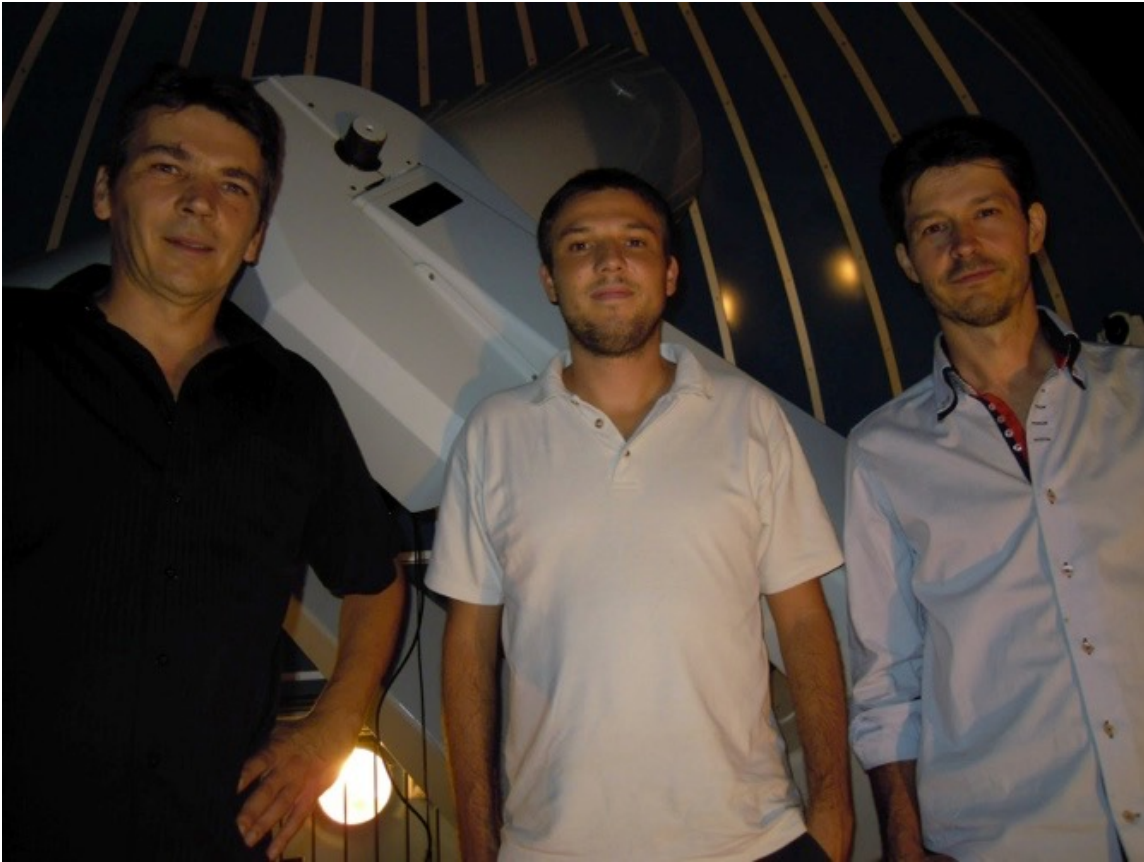
# Community best practices



Daive Farnocchia  
Jet Propulsion Laboratory  
California Institute of Technology

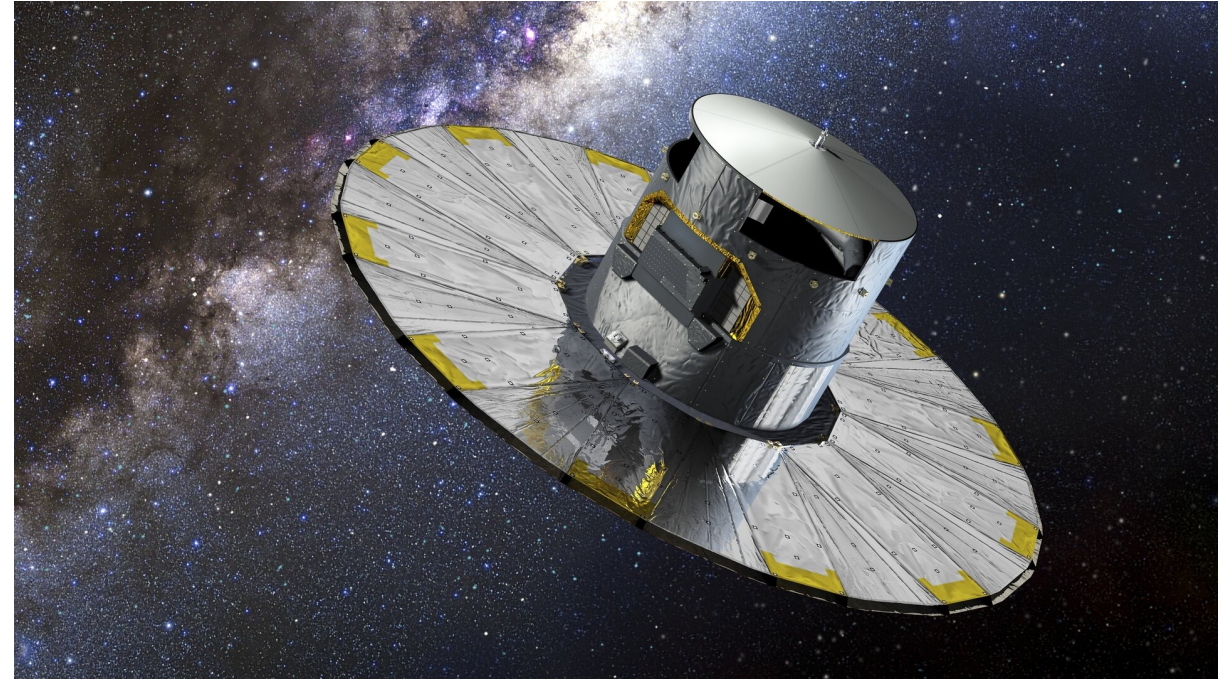
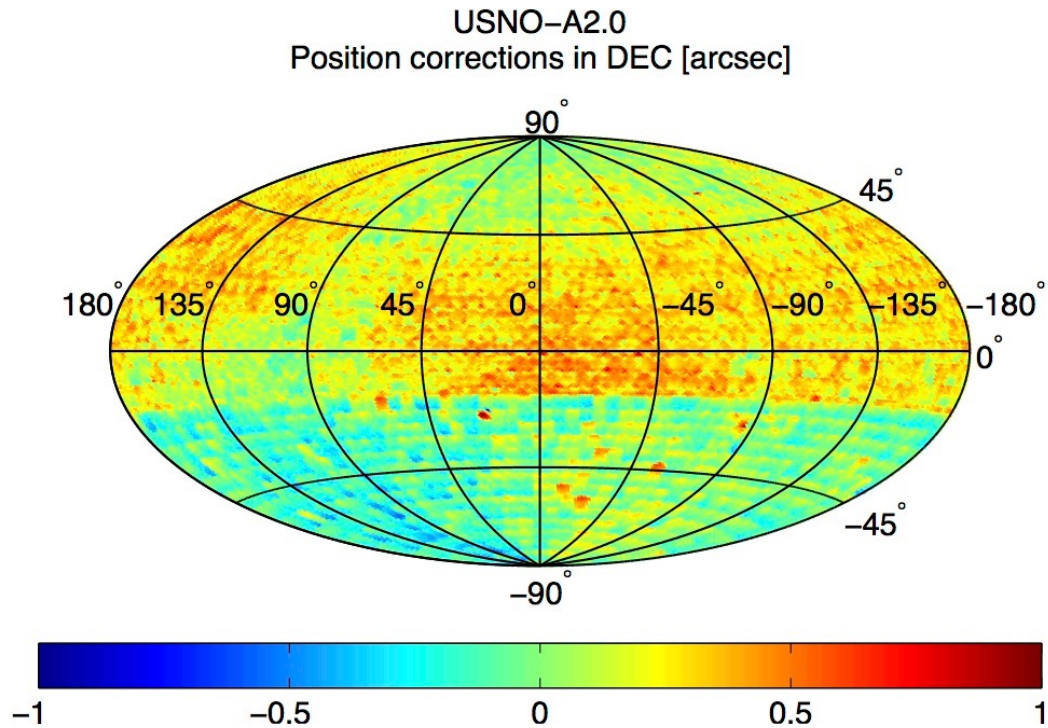
Matt Payne, Federica Spoto  
Minor Planet Center





**Near Earth Objects office**

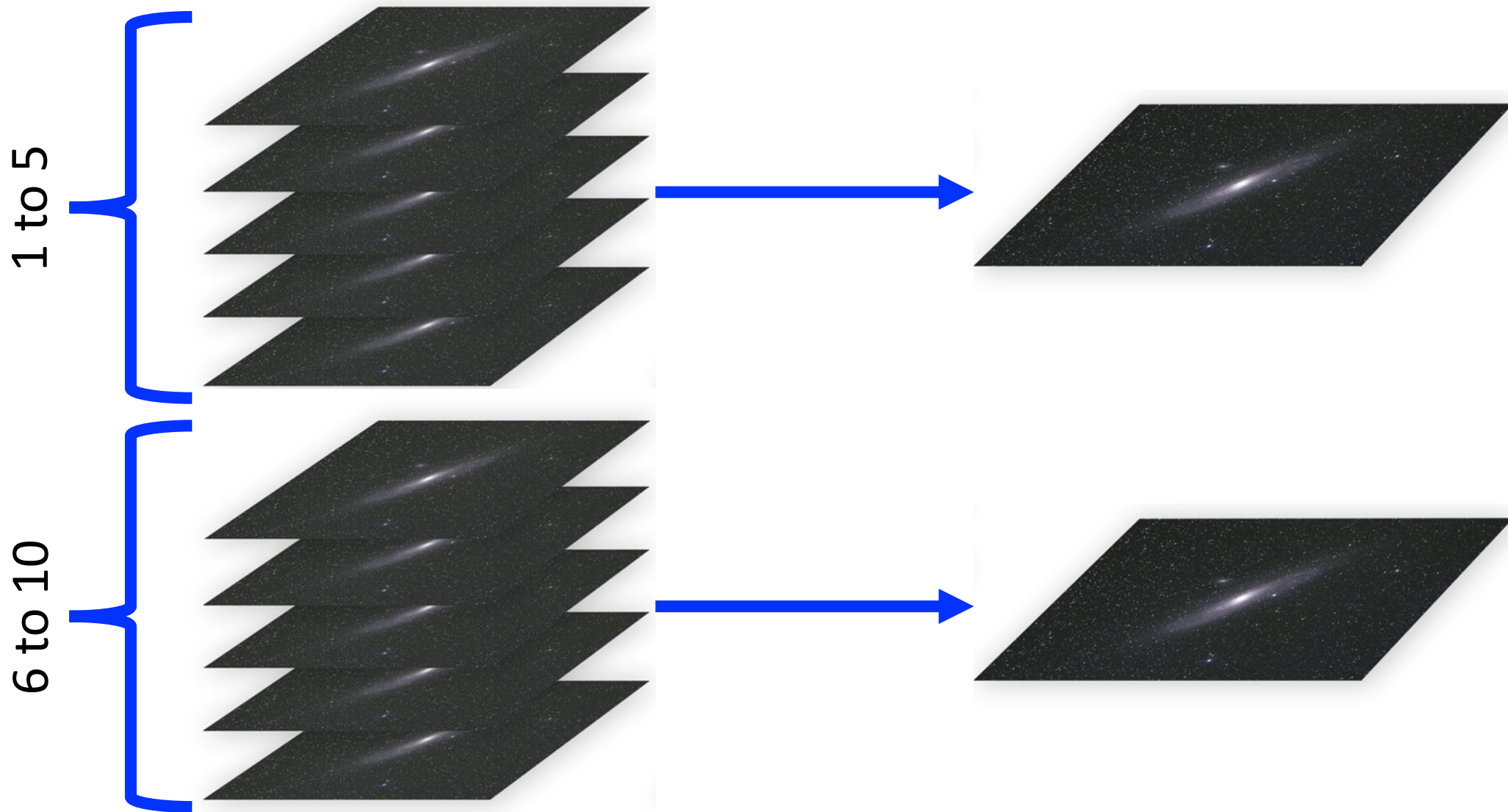
# Star catalog



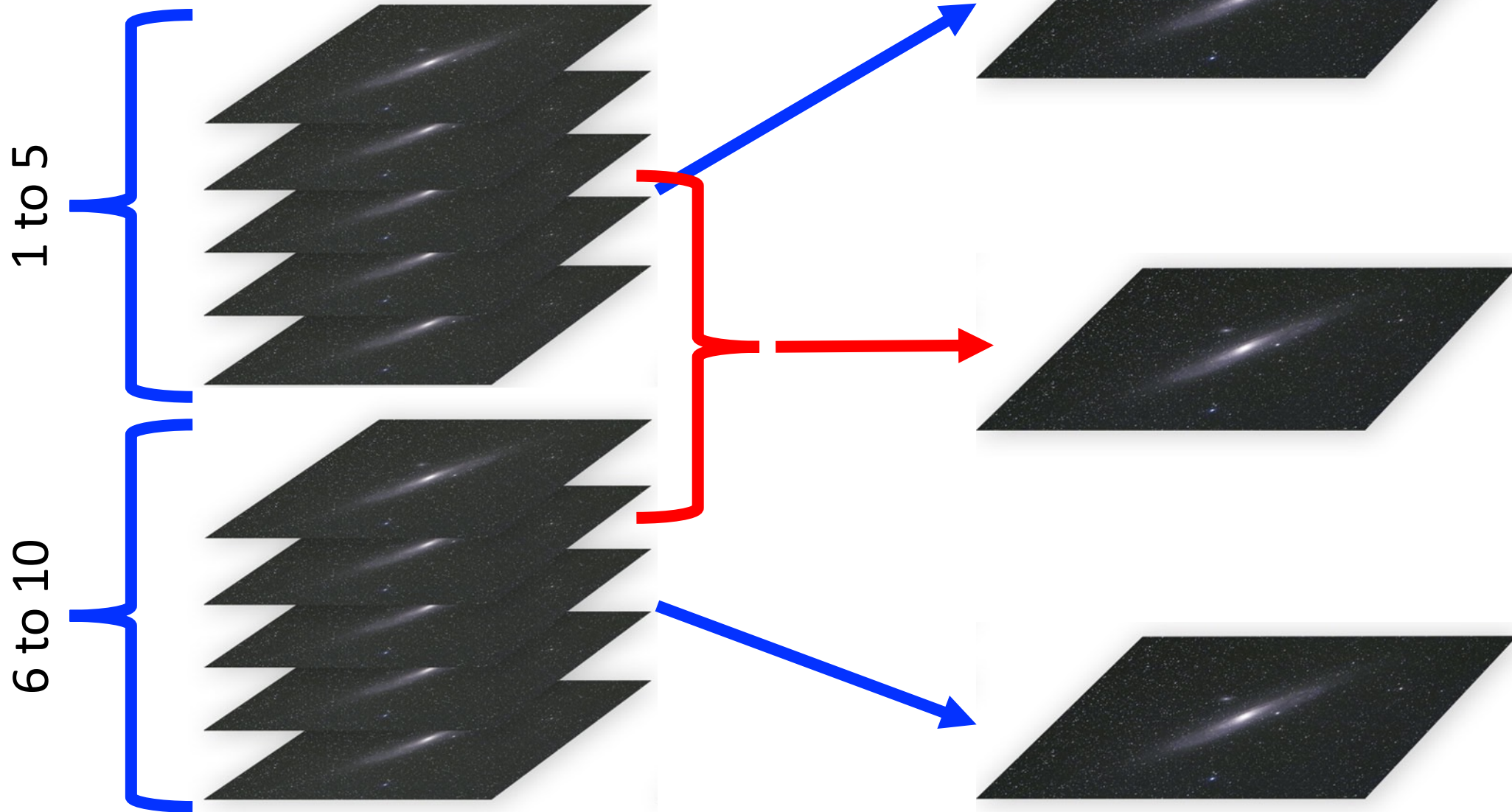
Use Gaia DR2 or later, remove star catalog as source of error



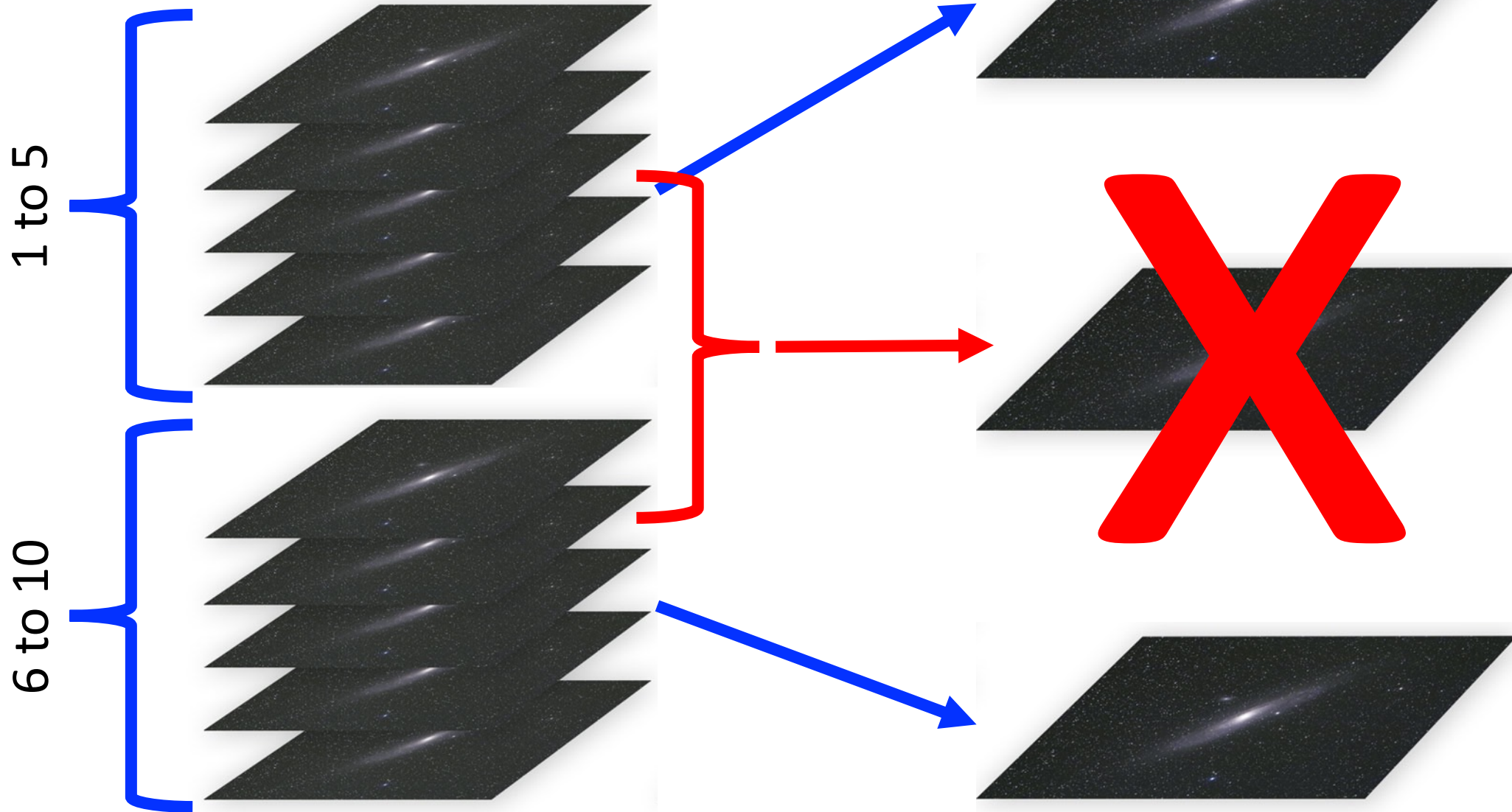
# Stacking



# Stacking



# Stacking

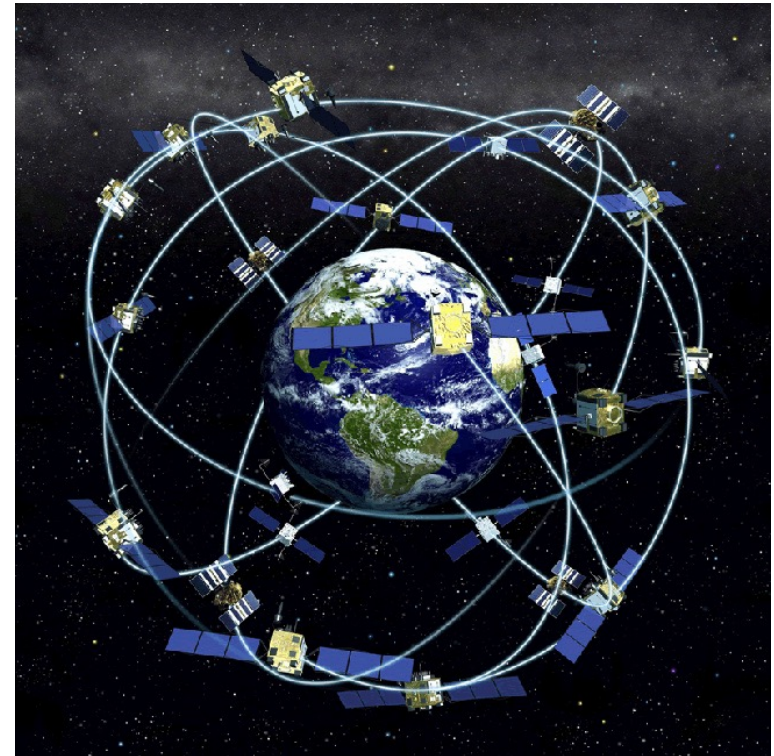
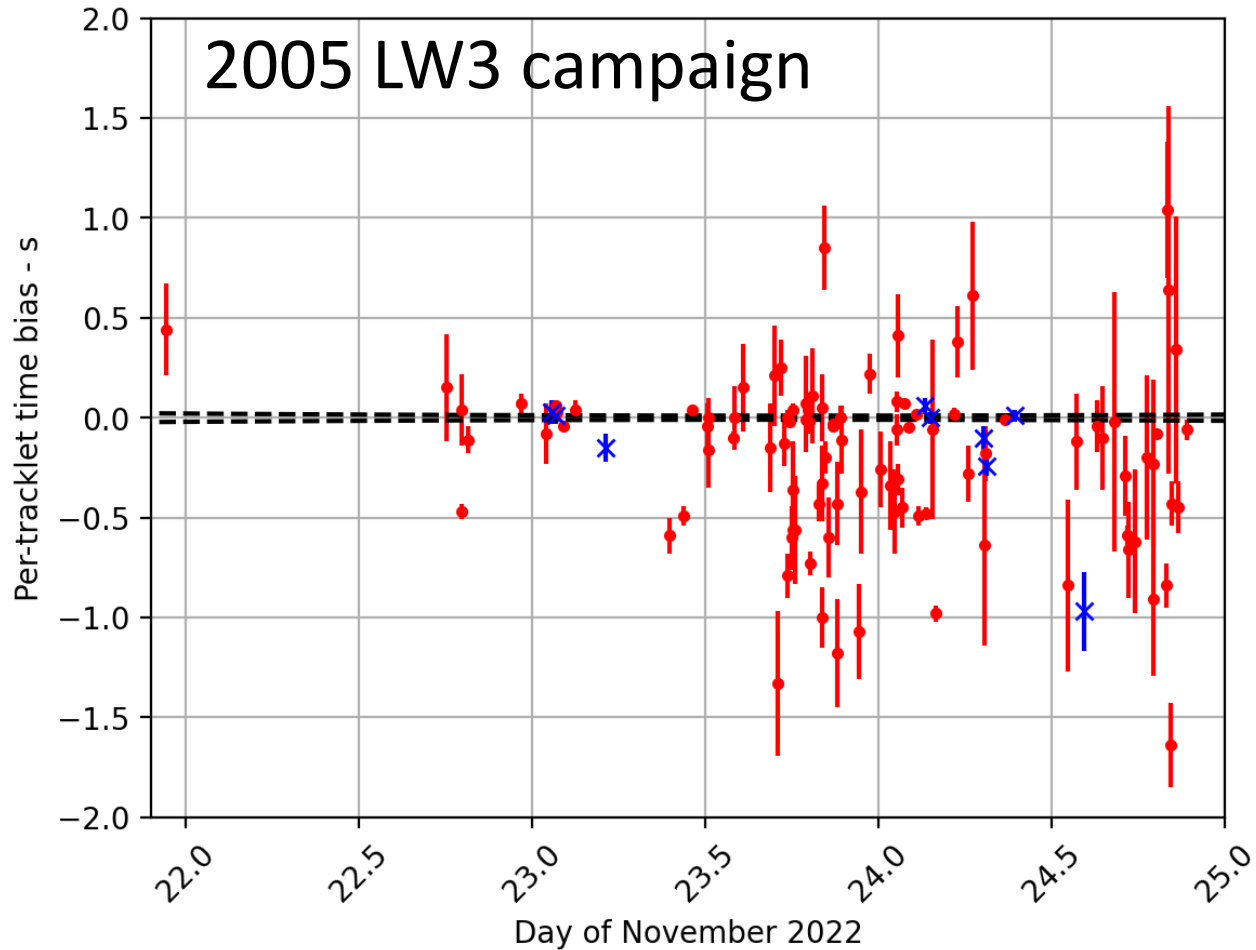




# Timing

Timing errors, especially if systematic, can bias the orbit solution.

Calibrate time using GNSS satellites:  
[www.projectpluto.com/gps\\_find.htm](http://www.projectpluto.com/gps_find.htm)



# Report uncertainties

## ADES

Per fortuna che Galileo non ha avuto la pretesa (assurda) di capire tutte queste cose quando effettuava i suoi famosi esperimenti, altrimenti non avrebbe fatto molti passi avanti. Per fortuna che Bohr non ha avuto la pretesa di spiegare le righe spettrali dell'atomo di piombo ma molto più modestamente si è occupato dell'atomo di idrogeno, altrimenti chissà se sarebbe nata la Meccanica quantistica! Ho detto "per fortuna che ...", ma in realtà non è una questione di fortuna, è una questione di metodologia, di cui Galileo era ben consapevole, anzi ce l'ha insegnata proprio Lui: sia nella fisica sperimentale che nell'analisi teorica dei fenomeni bisogna cercare di minimizzare (negli esperimenti), trascurare (nell'analisi teorica) tutti quegli effetti che consideriamo secondari rispetto al problema che ci interessa: p.es. ridurre al massimo l'effetto della resistenza dell'aria, a meno che non sia proprio questo l'aspetto del problema che ci interessa. Scherzosamente si dice che il primo principio della fisica è "meglio un cattivo numero che nessun numero" (cioè tante volte se non si è disposti a fare delle approssimazioni non si riesce ad ottenere alcun risultato), al quale io però aggiungerei il secondo principio "se un cattivo numero può essere migliorato, deve essere migliorato".

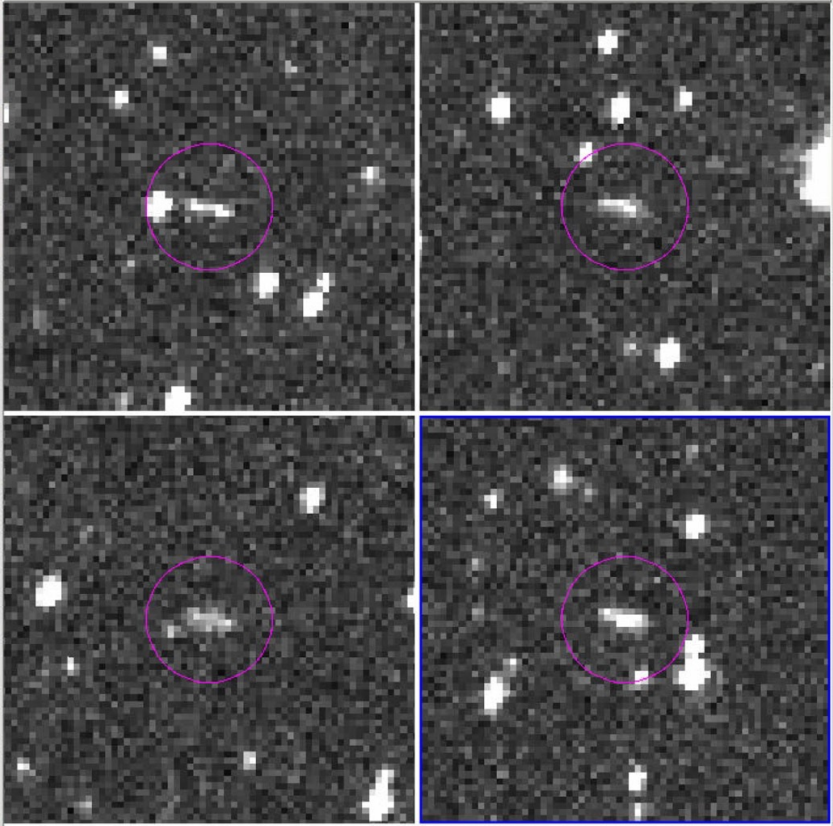
- "A bad number is better than no number"
- "If a bad number can be improved, it must be improved"

```
<optical>
  <provID>2019 XS</provID>
  <trkSub>K19X00S</trkSub>
  <obsID>LT92eH6z0000EQNg010000001</obsID>
  <trkID>00000G93mS</trkID>
  <mode>CCD</mode>
  <stn>W86</stn>
  <obsTime>2021-11-09T03:15:34.43Z</obsTime>
  <ra>77.472957</ra>
  <dec>-59.406403</dec>
  <rmsRA>0.21</rmsRA>
  <rmsDec>0.21</rmsDec>
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  <mag>14.1</mag>
  <rmsMag>0.096</rmsMag>
  <band>G</band>
  <photCat>Gaia2</photCat>
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  <logSNR>1.0170</logSNR>
```



# Number of observations

125 observations in 2 hours!



In general: three to five over an hour per night

K23H060	C2023	06	26.75399	15	29	07.53	+04	46	30.8	18.7	RVEM154XXX
K23H060	C2023	06	26.75588	15	29	07.42	+04	46	18.2	18.6	RVEM154XXX
K23H060	C2023	06	26.75661	15	29	07.41	+04	46	13.7	18.7	RVEM154XXX
K23H060	C2023	06	26.75733	15	29	07.37	+04	46	08.5	18.6	RVEM154XXX
K23H060	C2023	06	26.75806	15	29	07.33	+04	46	03.9	18.6	RVEM154XXX
K23H060	C2023	06	26.75878	15	29	07.29	+04	45	58.9	18.6	RVEM154XXX
K23H060	C2023	06	26.75951	15	29	07.23	+04	45	54.1	18.7	RVEM154XXX
K23H060	C2023	06	26.76023	15	29	07.19	+04	45	49.0	18.6	RVEM154XXX
K23H060	C2023	06	26.76096	15	29	07.18	+04	45	44.3	18.7	RVEM154XXX
K23H060	C2023	06	26.76168	15	29	07.15	+04	45	39.8	18.7	RVEM154XXX
K23H060	C2023	06	26.76241	15	29	07.07	+04	45	34.7	18.7	RVEM154XXX
K23H060	C2023	06	26.76313	15	29	07.06	+04	45	29.5	18.7	RVEM154XXX
K23H060	C2023	06	26.76386	15	29	07.00	+04	45	24.6	18.7	RVEM154XXX
K23H060	C2023	06	26.76458	15	29	06.96	+04	45	20.0	18.7	RVEM154XXX
K23H060	C2023	06	26.76531	15	29	06.95	+04	45	15.4	18.6	RVEM154XXX
K23H060	C2023	06	26.76603	15	29	06.90	+04	45	10.5	18.6	RVEM154XXX
K23H060	C2023	06	26.76675	15	29	06.87	+04	45	05.5	18.7	RVEM154XXX
K23H060	C2023	06	26.76748	15	29	06.83	+04	45	00.9	18.7	RVEM154XXX
K23H060	C2023	06	26.76820	15	29	06.80	+04	44	55.7	18.7	RVEM154XXX
K23H060	C2023	06	26.76893	15	29	06.76	+04	44	50.7	18.6	RVEM154XXX
K23H060	C2023	06	26.76965	15	29	06.72	+04	44	46.0	18.6	RVEM154XXX
K23H060	C2023	06	26.77038	15	29	06.69	+04	44	41.3	18.5	RVEM154XXX
K23H060	C2023	06	26.77110	15	29	06.62	+04	44	36.4	18.6	RVEM154XXX
K23H060	C2023	06	26.77183	15	29	06.61	+04	44	31.6	18.7	RVEM154XXX
K23H060	C2023	06	26.77255	15	29	06.56	+04	44	26.3	18.8	RVEM154XXX
K23H060	C2023	06	26.77328	15	29	06.53	+04	44	21.6	18.8	RVEM154XXX
K23H060	C2023	06	26.77400	15	29	06.50	+04	44	16.8	18.6	RVEM154XXX
K23H060	C2023	06	26.77473	15	29	06.45	+04	44	11.8	18.7	RVEM154XXX
K23H060	C2023	06	26.77545	15	29	06.42	+04	44	07.3	18.7	RVEM154XXX
K23H060	C2023	06	26.77617	15	29	06.39	+04	44	02.2	18.7	RVEM154XXX
K23H060	C2023	06	26.77690	15	29	06.35	+04	43	57.4	18.7	RVEM154XXX
K23H060	C2023	06	26.77835	15	29	06.27	+04	43	47.4	18.8	RVEM154XXX
K23H060	C2023	06	26.77907	15	29	06.24	+04	43	42.8	18.8	RVEM154XXX
K23H060	C2023	06	26.77979	15	29	06.22	+04	43	37.7	18.7	RVEM154XXX

# Do not use fits to select observations

```
Orbital elements: 2003 UR9
Perihelion 2003 Jun 12.246280 +/- 1.09 TT = 5:54:38 (JD 2452802.746280)
Epoch 2003 Nov 22.0 TT = JDT 2452965.5 Find_Orb
M 29.01335280 +/- 0.18 (J2000 ecliptic)
n 0.17826537 +/- 0.000116 Peri. 137.80524 +/- 0.33
a 3.12673723 +/- 0.00136 Node 201.82164 +/- 0.0049
e 0.2346315 +/- 0.000649 Incl. 15.96727 +/- 0.014
P 5.53 H 16.8 G 0.15 U 6.7
q 2.39310614 +/- 0.00154 Q 3.86036832 +/- 0.00339
From 19 observations 2003 Oct. 20-Nov. 22; mean residual 1".02
```

0310 20.15650	843	00 37 59.66	+06 26 40.6	.03+	.47+
0310 20.16641	843	00 37 59.36	+06 26 35.3	.37+	2.1+
0310 20.18725	843	00 37 58.81	+06 26 20.6	2.3+	2.0+
0310 21.12594	843	00 37 30.38	+06 15 26.0	1.1-	.56+
0310 21.13581	843	00 37 30.14	+06 15 18.7	.06-	.08+
0310 21.14642	843	00 37 29.80	+06 15 12.4	.12-	1.1+
0310 21.15495	843	00 37 29.53	+06 15 05.5	.11-	.11+
0310 23.15645	843	00 36 31.83	+05 52 13.9	1.1-	2.0-
0310 23.16685	843	00 36 31.56	+05 52 06.2	.53-	2.7-
0310 23.17716	843	00 36 31.26	+05 52 00.0	.42-	1.9-
0310 24.22870	704	00 36 02.63	+05 40 15.7	.30+	.52-
0310 24.24044	704	00 36 02.30	+05 40 07.9	.41+	.50-
0310 24.25242	704	00 36 01.93	+05 39 59.7	.02+	.71-
0310 30.13499	843	00 33 44.18	+04 37 37.9	.12-	1.1+
0310 30.15101	843	00 33 43.84	+04 37 28.3	.03+	1.2+
0310 30.16703	843	00 33 43.50	+04 37 18.8	.18+	1.4+
0311 22.06304	843	00 32 01.25	+01 45 38.9	.16-	.29-
0311 22.07731	843	00 32 01.40	+01 45 34.8	.02-	.30-
0311 22.09158	843	00 32 01.56	+01 45 31.2	.27+	.19+

A fit could be a good sanity check but observations need to be independent of ephemeris or fits.

- The selected sample may not reflect the true uncertainty of the data
- Bias toward the fitted orbit

Select based on the observation itself (highest SNR, smallest uncertainty, avoid star interference, etc)



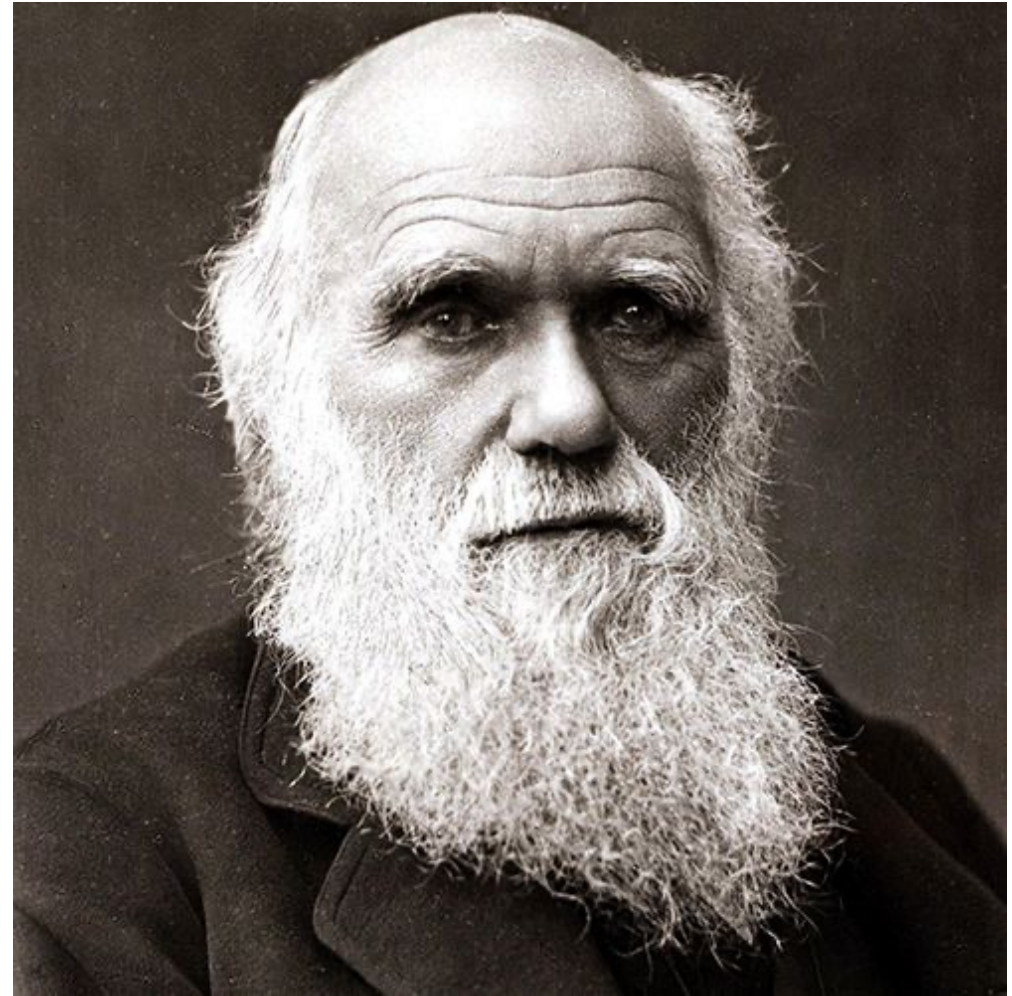
# Marginal detections

Carefully examine marginal detections, especially from archival images.

Reported only for detections with a sufficiently high signal-to-noise ratio to withstand external independent review.

Synthetic tracking software, such as Tycho Tracker, often requires significant experience to avoid submitting stacked noise.

*False facts are highly injurious to the progress of science, for they often endure long. . . , C. Darwin, The Origin of Man, 1871.*



# Target selection

Make sure the observations are useful:

- NEOCP
- Virtual Impactors
- Recoveries
- Large uncertainties

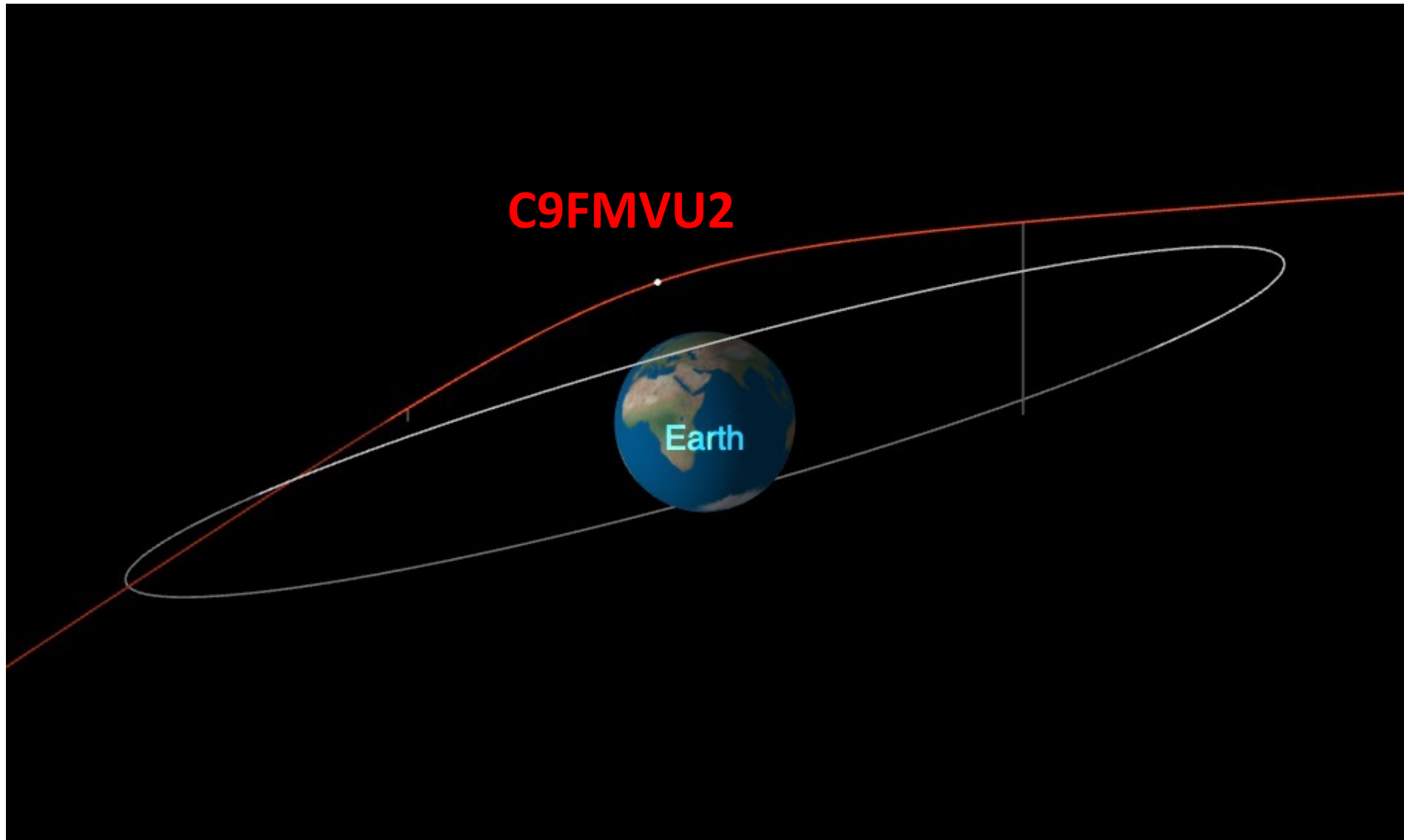




# Additional recommendations

- Reporting magnitudes is optional but highly desired
- Apply for an observatory code for all permanent sites
- Gravitational light bending should not be removed from the measured positions but is rather modeled by the fitting software.
- Differential color refraction should be corrected for by the observer.
- Use Jira to contact the MPC!

# Unconfirmed objects





# Unconfirmed objects



# Unconfirmed objects

- As a community we have become much better at detecting and predicting short term impact and near misses from the NEOCP
- However, NEOCP objects remain tentative and unconfirmed until designated. The MPC determines when the object is confirmed and the discovery MPEC issued. Until then public statements are to be avoided, though internal discussion is okay.
- In some cases, objects are clearly real, non-artificial, and impact (or close approach) prediction certain before MPEC. In those cases, working with the MPC (Jira would be best) is the right approach.



# Sharing results from Scout

## Scout: NEOCP Hazard Assessment

[Introduction](#) [Data Table](#) [Object Data](#) [Ephemeris](#)

### Data Table

Scout data are about *unconfirmed objects* and all information should therefore be treated as *potentially unreliable*.

The following table contains [NEOCP](#) objects analyzed by [Scout](#). Because of the generally short observation arcs and the uncertain quality of the astrometry, the reported impact ratings and scores are meant to identify interesting objects rather than provide a rigorous probability assessment.

**Table Filter:** Enter desired filter parameter values then press the "Apply Filter" button.

NEO Score (min)	<input type="text"/>	V-mag (range)	<input type="text"/>	RA (range)	<input type="text"/>
POS Unc. (range)	<input type="text"/>	Elong. (min)	<input type="text"/>	Dec (range)	<input type="text"/>
POS Unc.+1 (range)	<input type="text"/>	Rate (max)	<input type="text"/>	<input type="button" value="Apply Filter"/>	<input type="button" value="Reset"/>

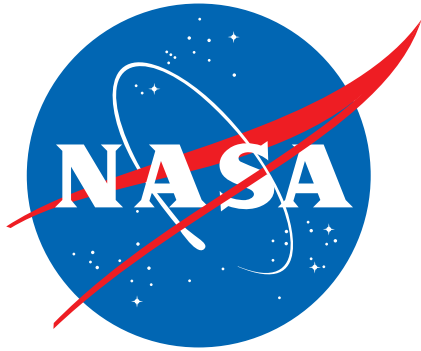
Showing 1 to 83 of 83 entries

Search:

Object	#obs	Arc (h)	RA (hh:mm)	Dec. (deg.)	V (mag)	Rate ("/min.)	Elong. (deg.)	POS Unc. (')	POS Unc.+1 (')	H	Impact Rating	CA Dist. (LD)	MOID (au)	V <sub>int</sub> (km/s)	NEO	NEO > 1km	PHA	IEO	Geo.	T <sub>J</sub> < 3	RMS	Last Update (UTC)
<a href="#">3JA7B21</a>	3	0.23	01:30	+28	20.1	12.8	158	4600	4300	24.5		20	0.04	38.3	100	0	0	0	0	37	0.00	2023-10-11 07:21
<a href="#">ELE0745</a>	3	0.14	01:48	+42	20.0	16.7	142	3700	3200	25.1		11	0.03	25.0	100	0	0	0	0	41	0.29	2023-10-10 19:28
<a href="#">P11LgSb</a>	3	0.61	02:53	+04	21.5	5.0	155	3000	5000	28.3	0	1.3	0.0003	13.3	100	0	0	0	0	21	0.01	2023-10-10 22:01
<a href="#">SWC0398</a>	3	0.65	02:13	+05	20.2	2.1	165	1700	3900	23.2	0	23	0.05		92	0	0	0	0	49	0.00	2023-10-07 06:17
<a href="#">RdSH194</a>	3	0.70	22:45	+41	21.7	0.9	133	500	3800	22.2	0		0.08		84	0	3	0	0	52	0.26	2023-09-25 11:57
<a href="#">C0JKWR5</a>	8	21.46	05:35	-19	23.2	3.7	110	470	490	24.1	0		0.1		100	0	0	0	0	39	0.25	2023-09-21 10:27
<a href="#">1bn89s</a>	6	408.49	15:38	+15	22.6	3.4	43	390	440	21.0	0		0.1		100	0	0	0	0	16	0.40	2023-09-09 04:17
<a href="#">P11KESE</a>	3	0.87	22:02	-02	23.0	1.4	131	250	270	23.9	0	15	0.01	30.7	100	0	1	0	0	31	0.00	2023-10-04 10:17
<a href="#">P11KNfr</a>	3	1.05	01:25	+42	21.7	2.9	145	230	290	24.0	0		0.09		94	0	0	0	0	30	0.00	2023-10-05 16:52
<a href="#">P11L1BU</a>	4	0.89	10:31	+06	25.4	1.3	43	150	110	27.5	0	0.21	0.0003	13.6	100	0	0	0	0	76	1.92	2023-10-08 13:23
<a href="#">P11KmIu</a>	5	24.48	09:18	+27	22.4	2.2	67	110	130	20.0	0		0.1		95	0	25	6	0	20	0.30	2023-09-28 06:14
<a href="#">P11L7c6</a>	3	0.85	21:42	-09	22.4	2.5	125	65	90	23.2	0	32	0.02	34.1	100	0	6	0	0	33	0.00	2023-10-09 11:31
<a href="#">P21KKp2</a>	6	2.62	00:27	-12	22.1	3.2	157	58	72	22.0	0		0.4		55	0	0	0	0	50	0.48	2023-10-05 17:59
<a href="#">P11JWp2</a>	7	20.52	21:54	+17	23.1	0.6	131	57	62	20.4	0		0.4		29	0	2	0	0	28	0.82	2023-09-19 03:57
<a href="#">P21L9Mh</a>	4	0.93	01:41	+26	22.3	2.7	160	56	86	24.5	0		0.1		88	0	0	0	0	41	0.79	2023-10-10 01:35
<a href="#">v08oct1</a>	2	0.05	15:55	-19	21.0	1.6	41	46	59	19.1			0.2		99	6	22	45	0	17	0.00	2023-10-10 18:52

Only point to the information that is available on the public website.

Anything else is confidential and to be treated as such.



# **Jet Propulsion Laboratory**

## California Institute of Technology

The research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration (80NM0018D0004).

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