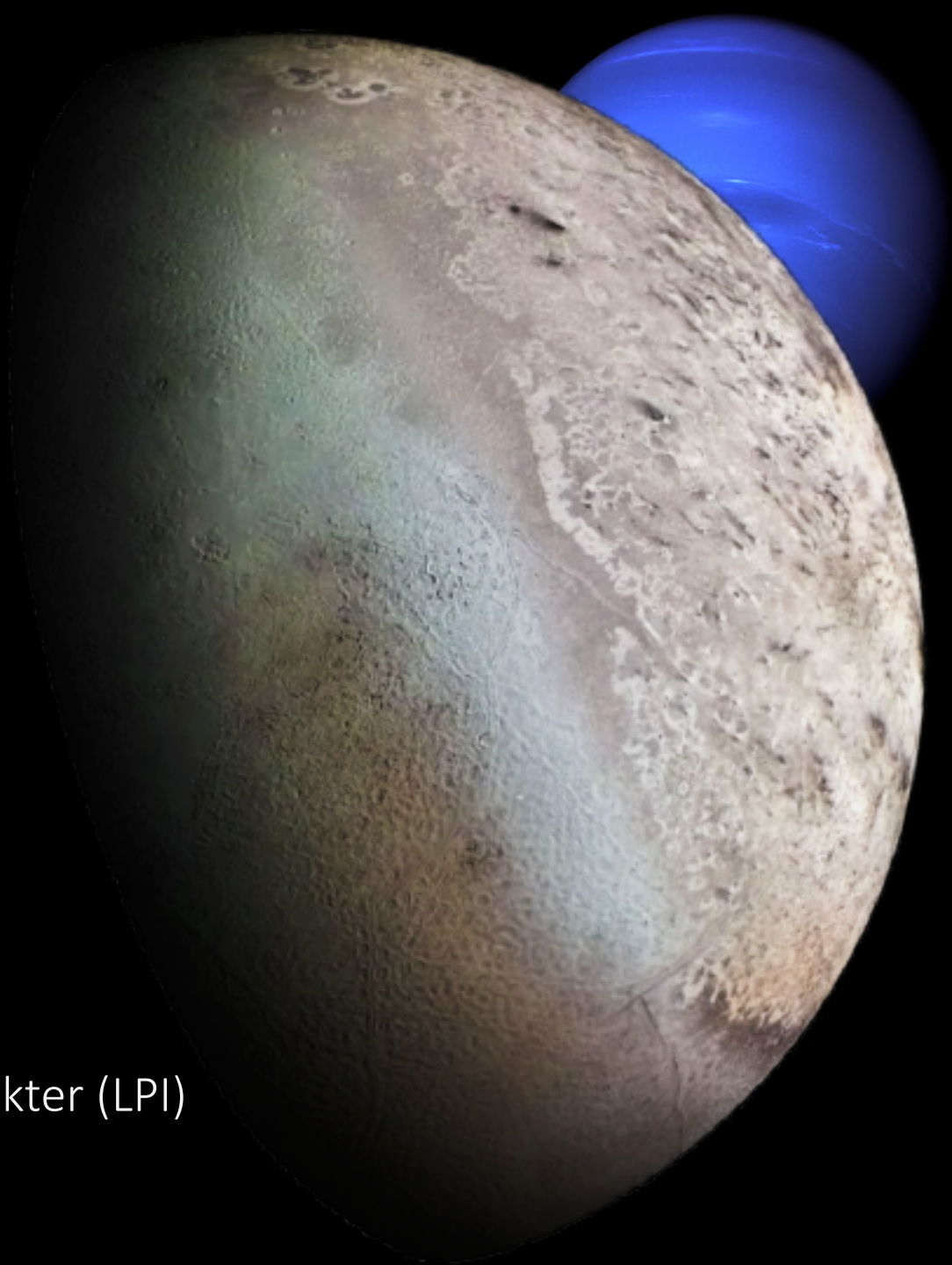
TRIDENT



Small Body Enhancements

Dr. Carly J.A. Howett (SwRI)

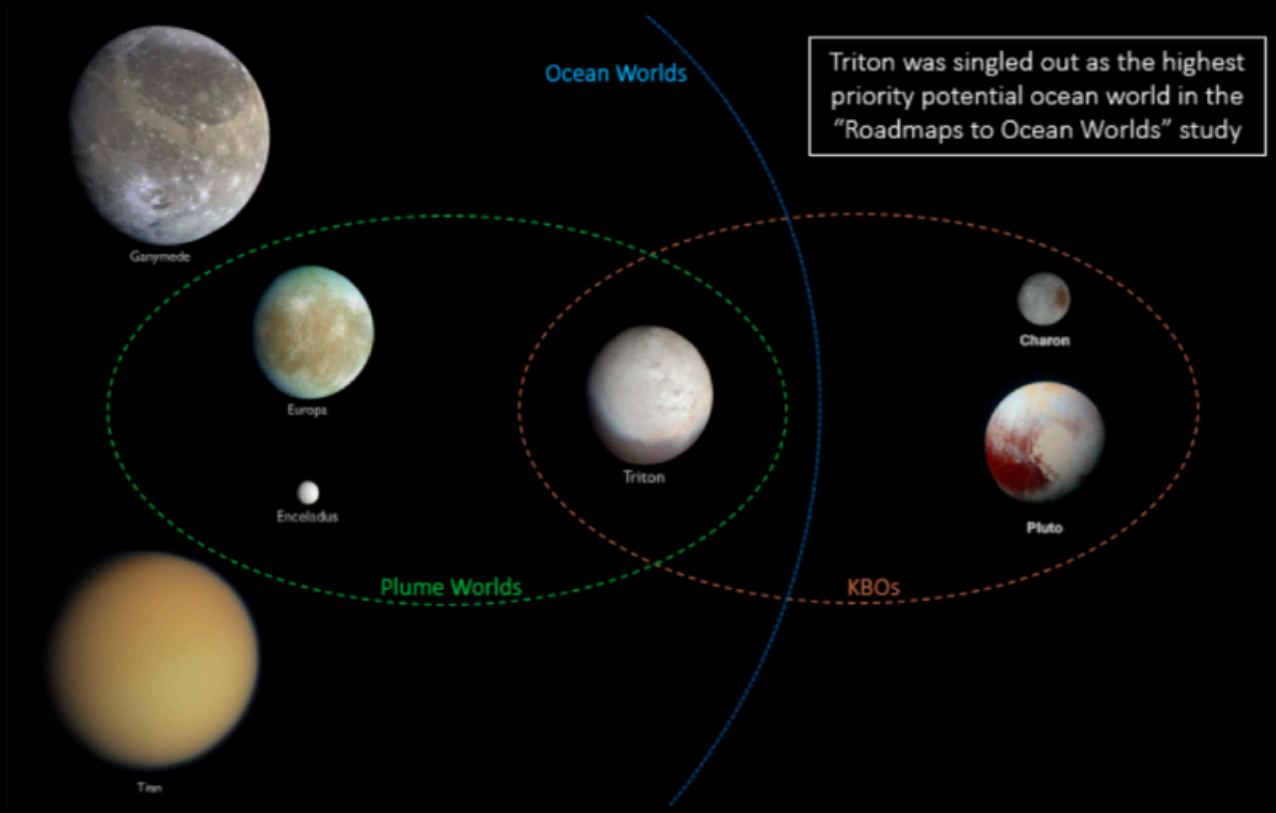
Drs. K.L. Mitchell (JPL) and L. Prockter (LPI)

The Trident Team

Trident: An ambitious Discovery 2019 proposal to 30 AU

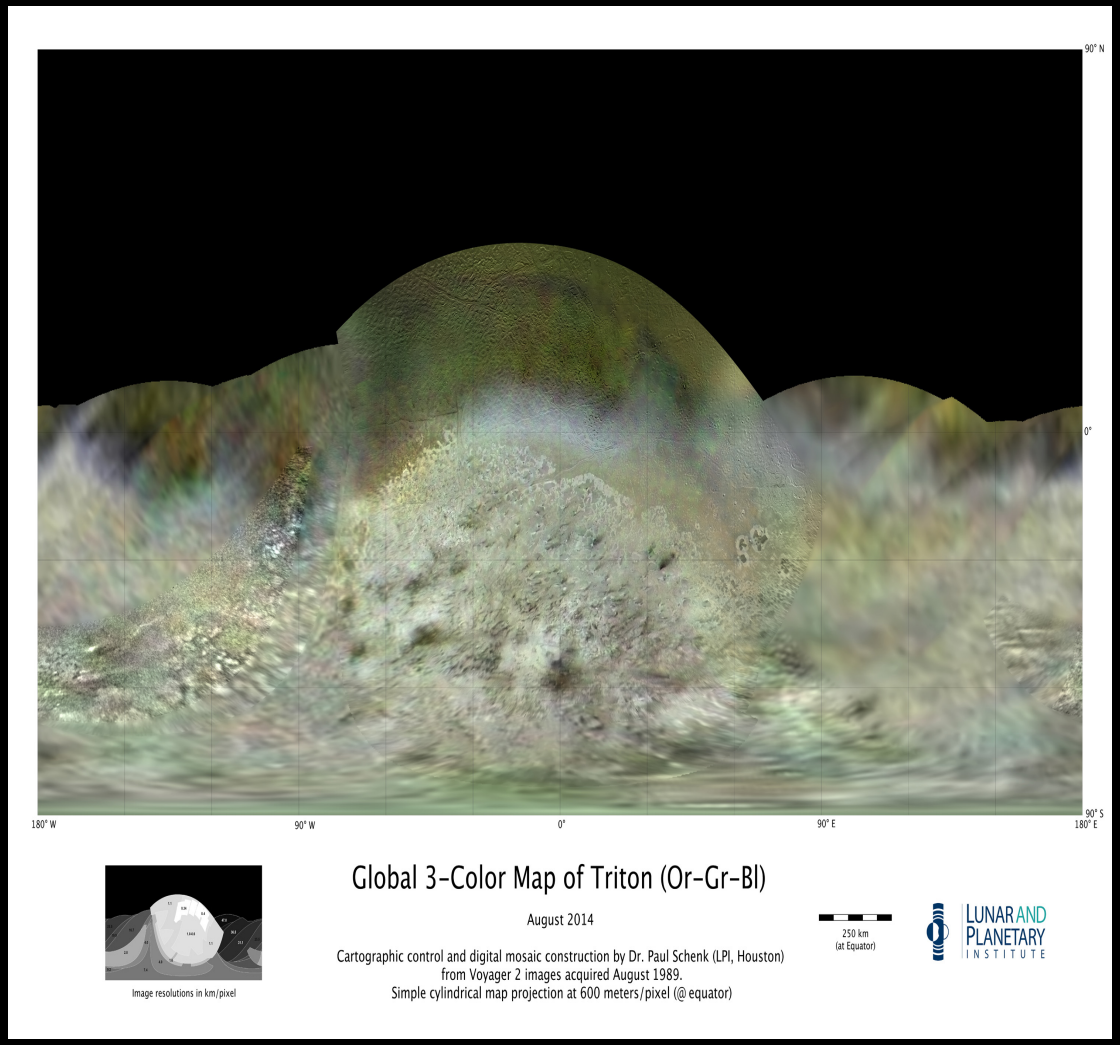
Returning to Triton one season after Voyager 2

- Solar System's 7th largest moon & largest KBO
- Capture into inclined retrograde orbit likely catastrophic (e.g. McKinnon, 1984)
- Extreme obliquity tides → ocean (Nimmo & Spencer, 2015)?



Trident: An ambitious Discovery 2019 proposal to 30 AU

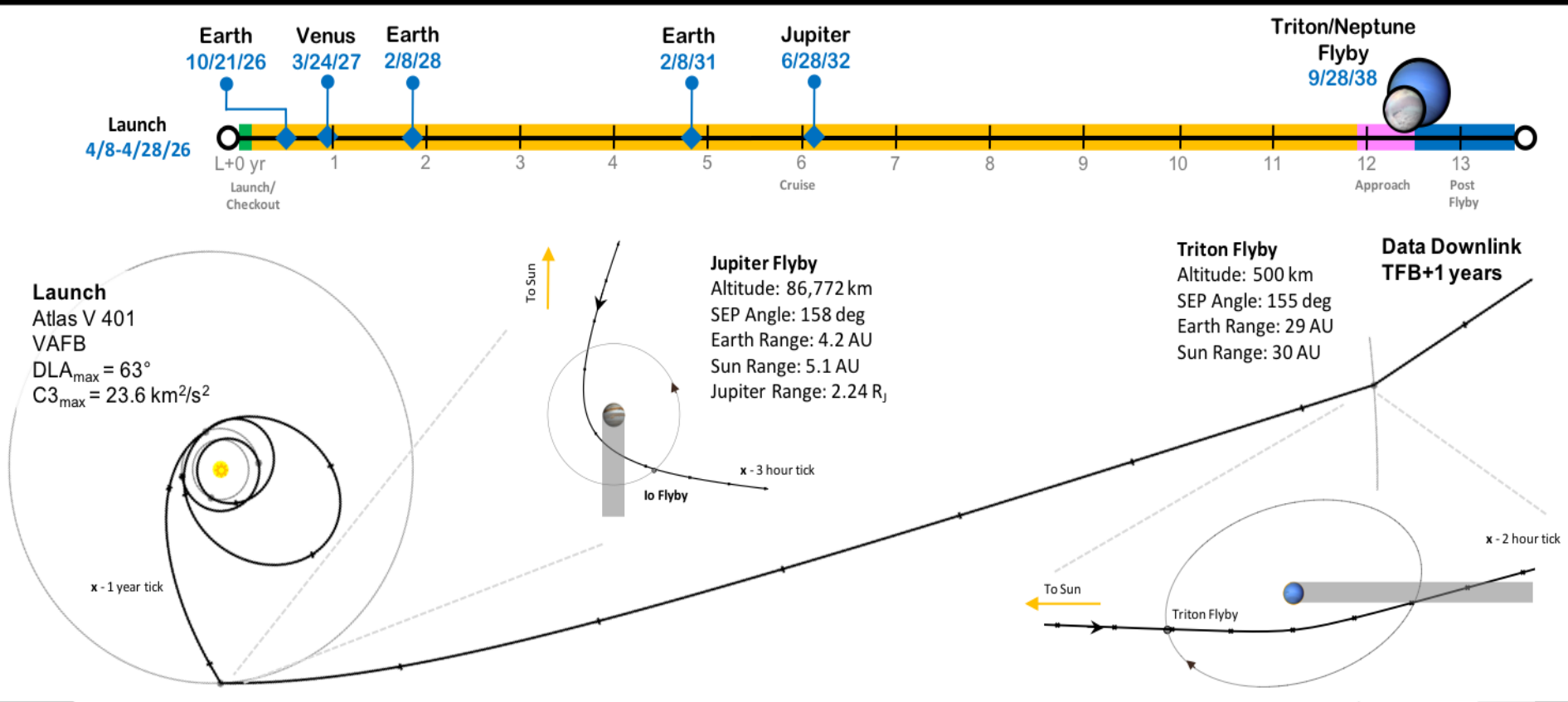
- With only 29 images and no compositional spectroscopy, Triton is:
  - The largest unmapped surface in the Solar System
  - Challenging to interpret with most feature types of unknown or disputed origin
- Trident will perform multiple science investigations, including ocean detection, determining ionosphere origin, detailed IR/visible mapping and resolving plume origins …



Mission Design Consideration

Ballistic trajectory with no deterministic maneuvers

- The baseline trajectory is ballistic from launch to the Triton flyby. Remote sensing instruments tuned for long-range observations give excellent opportunities.
  - Jupiter system encounter presents opportunities, but there are challenges due to radiation.
  - Small changes to the nominal trajectory prior to the Triton flyby can causes large growth in ΔV.
  - Post Triton Flyby, KBOs can be targeted with little ΔV by changing the Triton flyby date/time, but keeping the orbit geometry the same.



Encounter List

Several opportunities for outstanding bonus science

- Given current baseline trajectory:

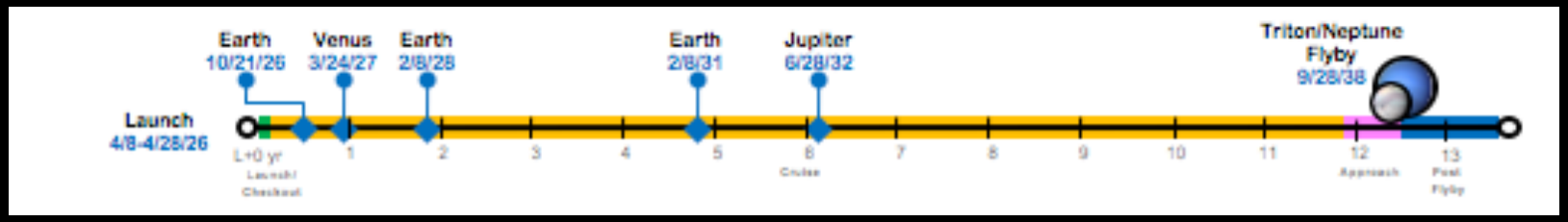
BODY	Date of C/A (ET)	C/A Range (km)	Diameter (km)	NAC px (km)
JUPITER-SYSTEM				
Metis	*6/27/32 12:03*	*68,298*	*40*	*0.137*
Callisto	*6/27/32 14:39*	*685,595*	*4,821*	*1.371*
Adrastea	*6/28/32 0:53*	*219,767*	*20*	*0.44*
Ganymede	*6/28/32 2:36*	*659,982*	*5,268*	*1.32*
Europa	*6/28/32 6:47*	*485,336*	*3,122*	*0.971*
Thebe	*6/28/32 10:42*	*288,277*	*100*	*0.577*
Io	6/28/32 15:37	15,587	3,643	0.031
NEPTUNE MOONS				
Nereid	9/28/38 15:29	4,861,030	340	9.722
Proteus	9/28/38 21:21	63,953	420	0.128
KBOS				
e.g. 2006 QL181 2001	2/11/41 20:29	64,274,844	154	128.55

- All of these timings are subject to change
- Centaur, Comet, TNO and KBO encounter opportunities are being actively investigated by the team

Comets

- List of closest approach with comets the Solar System Dynamics (SSD) website

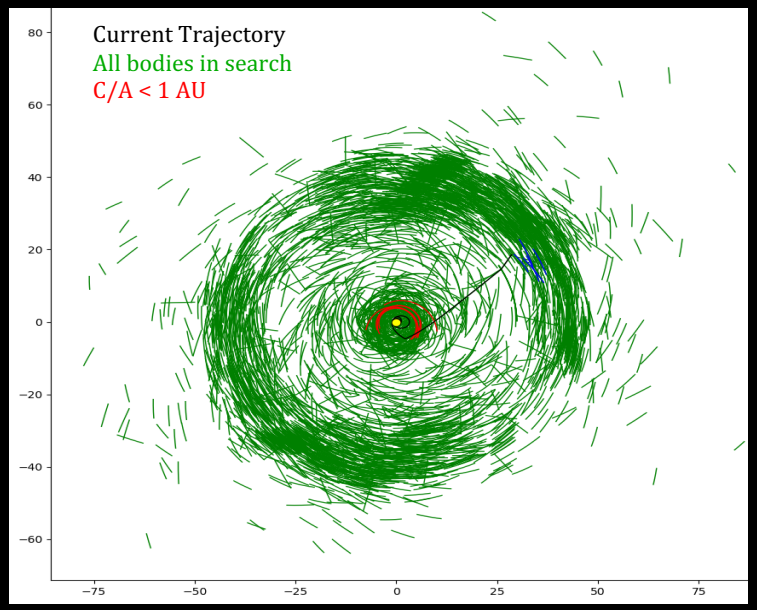
Spice Body ID	Body Name	Date of C/A (ET)	C/A Range (km)
1000378	152P/Helin-Lawrence	14-OCT-2031 08:40:08.2166 ET	7,641,049
1000271	P/1999 RO28 (LONEOS)	23-JUL-2031 07:01:23.9925 ET	17,806,786
1003007	335P/Gibbs	19-OCT-2032 23:48:39.0381 ET	27,011,107
1000703	D/1766 G1 (Helfenzrieder)	17-APR-2027 18:35:34.5931 ET	29,835,999
1003263	364P/PANSTARRS	27-MAR-2028 15:44:49.2444 ET	30,864,423
1001656	169P/NEAT	23-JAN-2031 16:50:46.4140 ET	32,270,896
1000337	P/2001 H5 (NEAT)	14-OCT-2032 20:29:59.5433 ET	34,408,351
1000508	320P/McNaught	25-MAY-2026 17:18:48.9615 ET	34,531,227



Centaurs

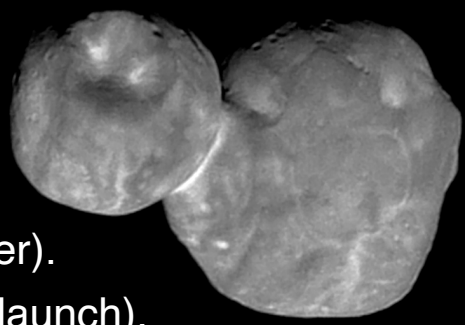
- **Initial recon**: Even distant data improves knowledge, but maybe increments w.r.t. JWST.
- No good "deterministic" targets. Currently ~500 known, but probably only ~1% have been mapped. More opportunities likely for distant, disk-resolved observations.
- No spatially-resolved IR Spectroscopy available.
  - Well-documented red-blue spectrum of surface colors.
  - Likely surface organics, so >2.5 μm particularly useful.

Body ID	Body Name	Date of C/A (ET)	C/A Range (km)	C/A Range (AU)
3531654	2010 BV62	11/18/32	66,827,592	0.4467
3721165	2015 KJ153	9/4/31	72,502,034	0.4846
3600676	2011 WA24	4/27/29	72,782,123	0.4865
3633713	2013 EN69	3/14/33	72,905,355	0.4873
3628995	2013 DK	3/24/33	80,287,079	0.5367
3667711	2013 CT160	12/30/32	102,436,540	0.6847
3740746	2016 AM67	3/1/33	114,331,995	0.7643
2389820	2011 WU92	1/30/34	126,528,801	0.8458
3794672	2014 EX156	5/10/33	126,634,275	0.8465

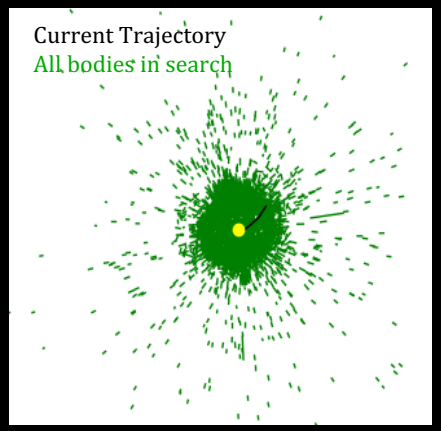


TNOs

- **Initial recon:** TNO encounters are feasible.
- Currently ~1000 known TNOs, but probably only ~1% mapped. More options will open up.
- New Horizons proof-of-concept: Arrokoth, type "cubewano (cold)" contact binary.
  - New Horizons data limited in spatial resolution and spectral range.
  - Like Centaurs, populations vary from blue to red colors.
  - Likely surface organics, so >2.5 μm particularly useful.
- Trident proof-of-concept: 2006 QL_{181}.
  - Cubewano (cold) type (~150 km), like Arrokoth (30-45 km diameter).
  - 64,000,000 km encounter in Feb 2041, near 40 AU (14.5-yr after launch).
  - Delay to Triton encounter (~70 m/s delta-v) enables targeted 10000 km flyby.



Spice Body ID	Body Name	Date of C/A (ET)	C/A Range (km)	C/A Range (AU)
3378785	2006 QL181	11-FEB-2041 20:29:38.6107 ET	64274844	0.430
3092431	2001 QO297	26-JUL-2041 07:16:02.6433 ET	172917021	1.156
3092452	2001 QQ322	24-JUN-2041 07:47:28.7280 ET	179586242	1.201
3160763	2003 QT91	21-OCT-2041 18:58:38.8250 ET	214024551	1.431
3830984	2015 RX277	18-SEP-2041 07:05:25.9089 ET	220044023	1.471
3835620	2015 RL279	15-SEP-2041 03:14:30.8896 ET	280647709	1.876
3835655	2015 RT280	09-NOV-2041 09:55:10.2248 ET	283092293	1.892
3255350	2004 PC112	13-SEP-2041 03:03:56.7132 ET	298301961	1.994



Conclusions

- Trident represents an exciting opportunity to explore Neptune's captured KBO Triton
- Multiple opportunities for Centaur, TNO and Comet flybys are possible
  - We are still working on the exact details!