DART

NASA

Dimorphos orbit solution 527

June 9, 2023

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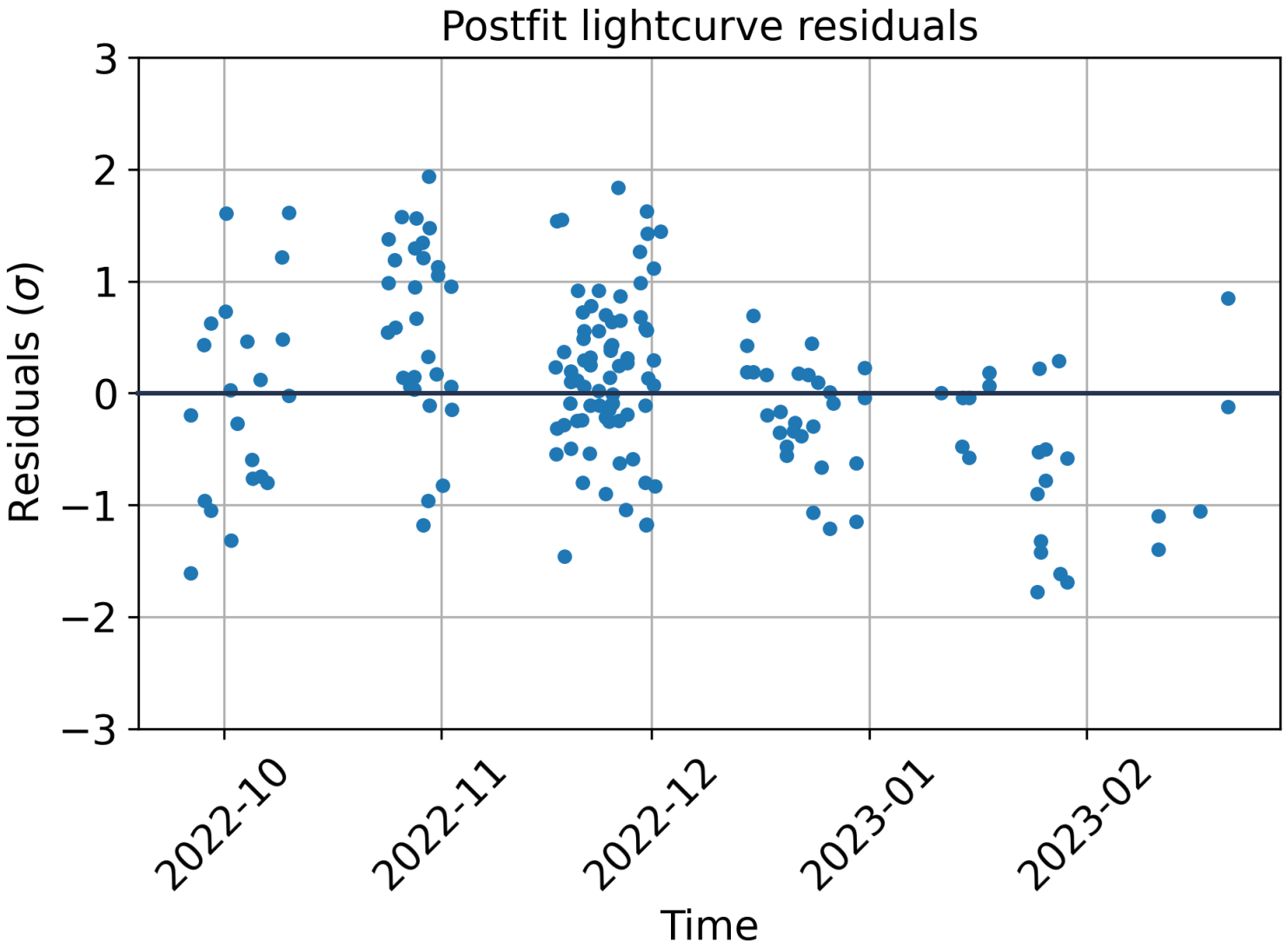
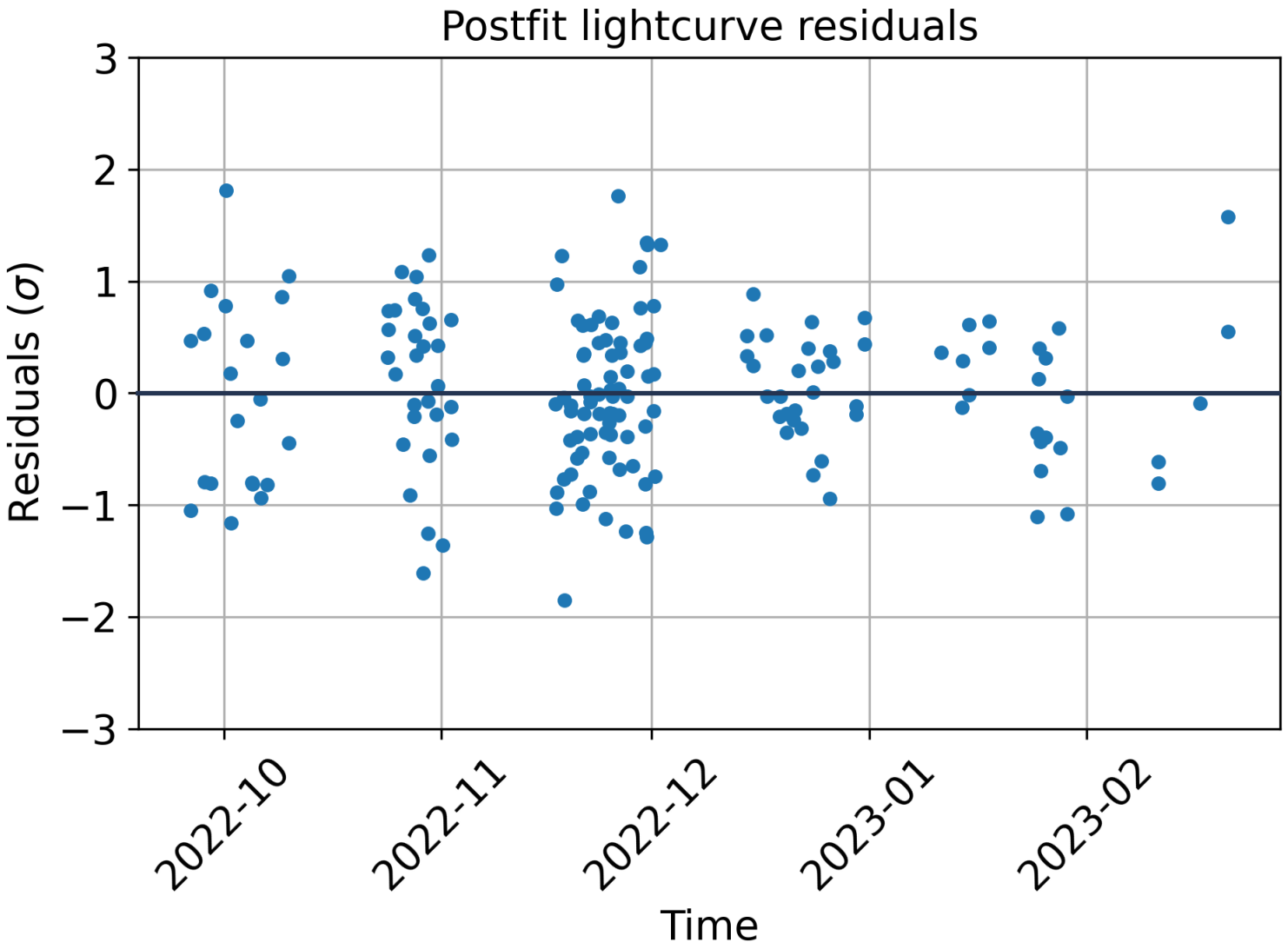
Solution 523 (delivered May 25)

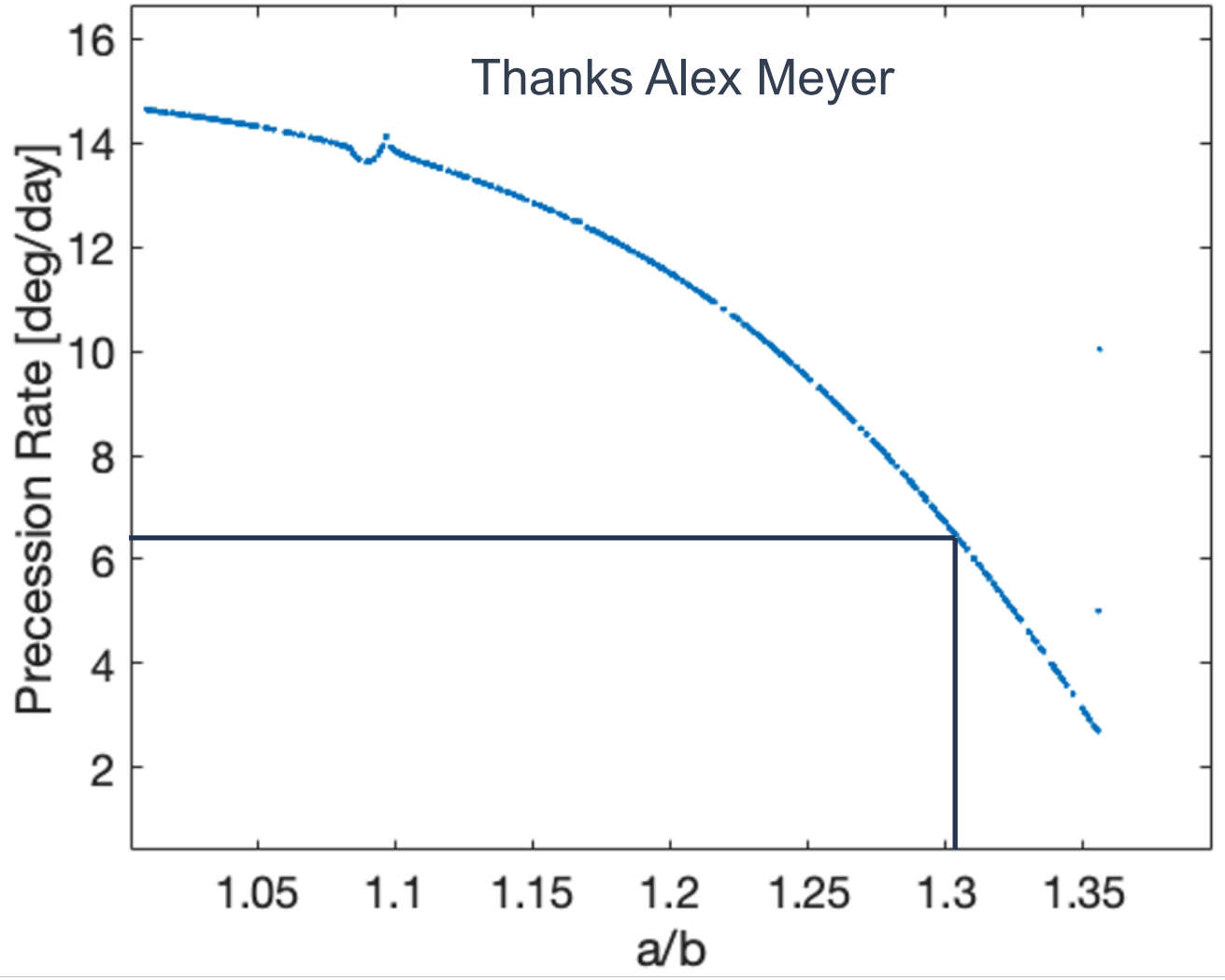


Solution 527 (latest)

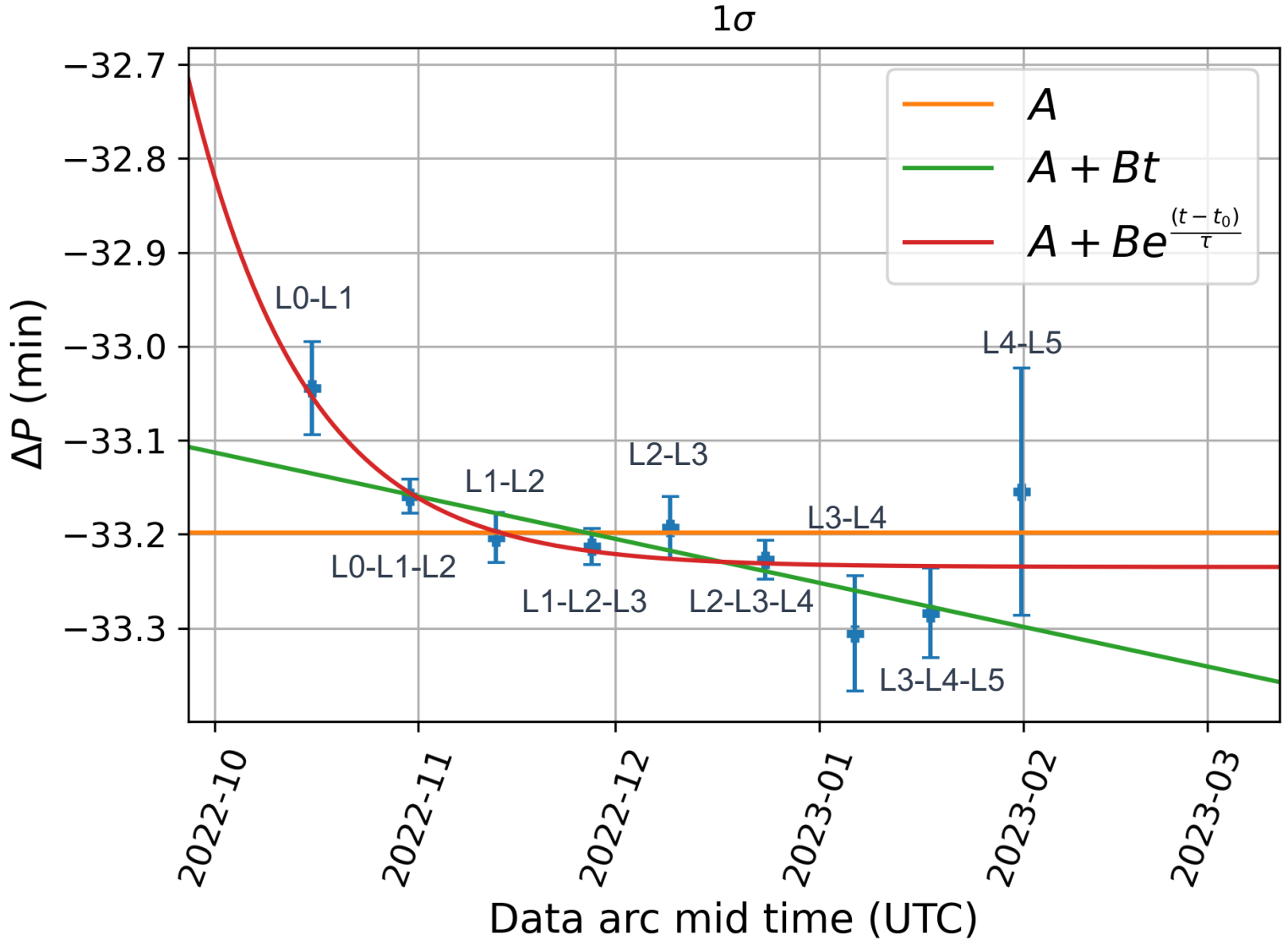


Issues with s523: incorrect J2

- Our model assumed that the apsidal precession was due to the J2 of Didymos alone.
- However secondary elongation can cause apsidal regression, which would partly offset the apsidal precession due to J2.
- We can compute the precession rate as a function of Dimorphos' elongation assuming the shape-based J2.
- Conclude that elongation (a/b) is ~1.3.
- As a result, the estimated J2 was an underestimate: It is a factor of ~2 smaller than the J2 computed from a uniform density Didymos.
- The estimated J2 was used in the computation of GM_sys, causing the computed GM_sys to be an overestimate.
- So we recommended scaling GM_sys down by ~1% to 4.04166824e-8 km^3/s^2 to account for this.



Orbital period seems to be changing



- Fits to sub-arcs suggest changing period
  - Exponential fit looks best

New new new post-impact dynamical model

- Pre-impact orbit is still characterized by λ, β, a, M_0, n_0, and $\dot{n}$.
- Post-impact orbit is now characterized by parameters ΔV_T, $\Delta \mathrm{V_R}$, J_2, $\boldsymbol{a, b, c}$, $\boldsymbol{A}$, **and** $\boldsymbol{\tau}$.
- ΔV_T and $\Delta \mathrm{V_R}$ are transverse and radial components of the change in the velocity of Dimorphos due to the DART impact.
- J_2 is the oblateness parameter of Didymos.
- $\boldsymbol{a, b, c}$ are semi-axes of Dimorphos.
- **A volume constraint is also placed to conserve Dimorphos' volume.**
- $\boldsymbol{A}$ **and** $\boldsymbol{\tau}$ are the transverse drag coefficient and drag timescale **(angular deceleration)** $= \boldsymbol{A \times e^{-(t-t_0)/\tau}}$
- Position of Dimorphos remains unchanged at the instant of impact.
- We can estimate all **14** parameters.
- Our approach maintains position continuity across impact
- Estimating ΔV_R allows for an impact point not at apoapsis

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Estimated parameters:

```
T0    = 2022 SEP 26 23:14:24.183 UTC
OPlon = 3.1058503369253230 6304e+02 ± 2.1141475926335990 8203e+00 degrees
OPlat =-7.9827727158320726 6303e+01 ± 3.4115781970931863 2651e-01 degrees
QR    = 1.2417672424055070 6568e+00 ± 1.4235319160934831 1841e-02 km
Per   = 11.921481102059653 16765742 ± 1.5802038190564848 4825e-05 h
Ndot  = 5.1911395783994219 2495e-18 ± 6.4086620633213582 4631e-19 rad/sec^2
DVR   = 4.2109519612802232 9161e-07 ± 3.8316735577255037 2131e-07 km/sec
DVT   =-2.7998766847597730 8577e-06 ± 3.4661055405417930 0490e-08 km/sec
J2    = 9.0460007374249945 5332e-02 ± 3.3202907831973091 3682e-03
a     = 9.1413396544830896 6062e-02 ± 3.0176508795387688 3289e-03 km          a/b = 1.3 ± 0.06
b     = 7.0036881872832190 6875e-02 ± 2.3059206046761970 6585e-03 km          a/c = 1.5 ± 0.1
c     = 6.1464215811982671 2004e-02 ± 4.2759851203504036 3016e-03 km          b/c = 1.1 ± 0.1
dragA = 1.7307782588864804 8118e-14 ± 6.9499347838293742 3281e-15 rad/s^2
dragT = 1.9309841462400246 5700e+01 ± 4.5983376742008017 5015e+00 days
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Note: A priori values: 1) J2 = 0.09 ± 0.009, 2) DVR = 0.4 ± 0.4 mm/s, 3) a = 89 ± 5 m 4) c = 58 ± 5 m, 5) dragT = 20 ± 5 days

A priori on J2 is from Didymos shape. A priori on a and c are from Daly et al. (2023) but allow for reshaping with the volume constrained to within 10% of the Daly et al. (2023) value of 0.00181 km^3

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Derived parameters:

EC+ = 3.144756843422889108 77e-02 ± 1.671232870201373992 70e-04

P+ = 11.368499734616584362 35666 ± 2.988158281371333224 04e-04 h

DP =-3.317888204658412831 80e+01 ± 1.816499925642460142 04e-02 min

LPdot = 6.119099999999999539 57e+00 ± 1.675790937588756690 51e-01 deg/day (Longitude of pericenter)

GM = 4.037722357396054289 90e-08 ± 1.398255823941541136 78e-09 km^3/s^2

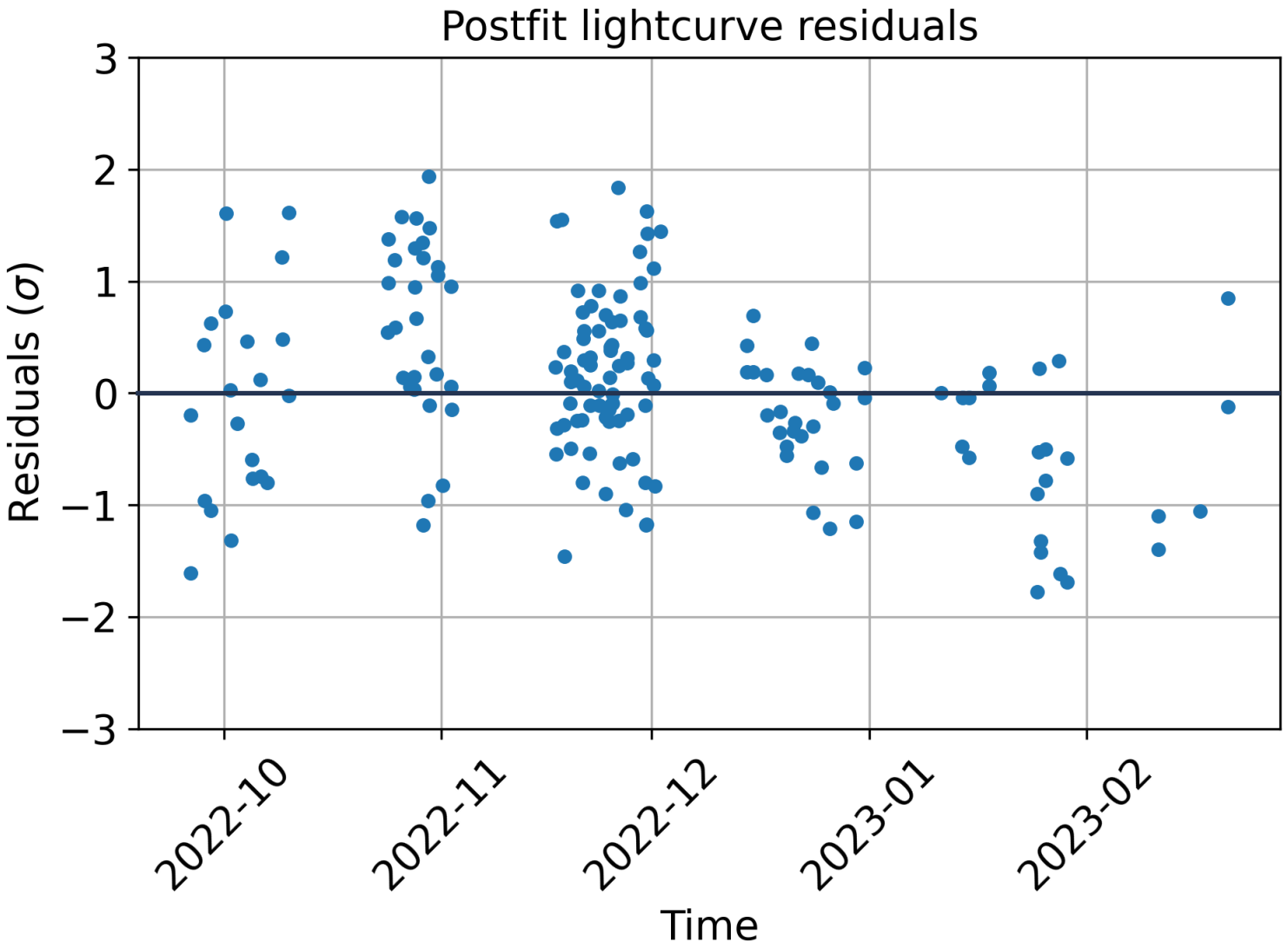
Vol2 = 1.648343055408737741 28e-03 ± 1.267423605750551387 96e-04 km^3

Notes:

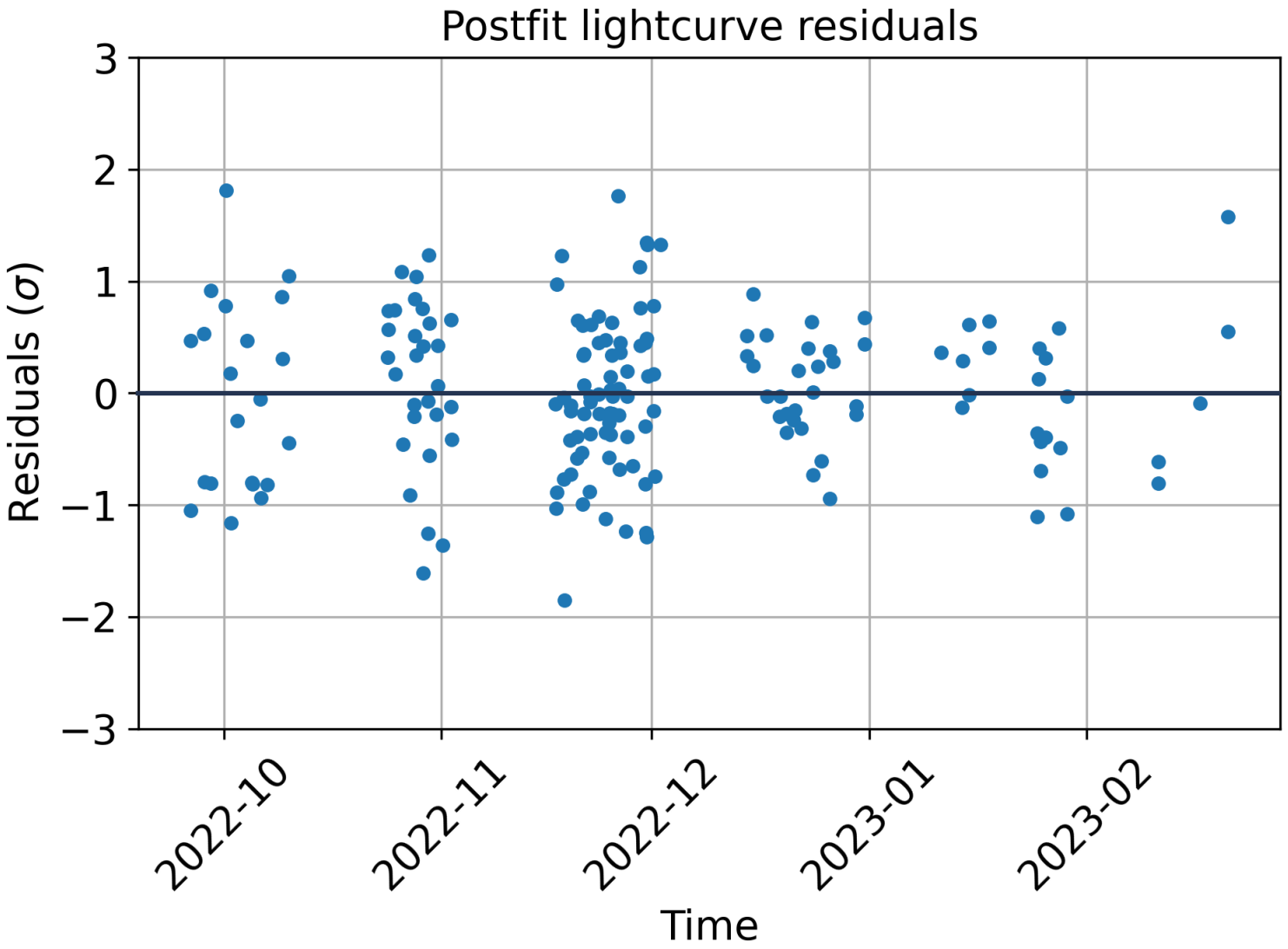
1) Post-impact period is difficult to measure because it has large periodic variations superimposed on the exponential change due to drag. The reported period is an average over ~200 orbits.

2) Post-impact eccentricity is an average over ~200 orbits.

Solution 523 (delivered May 25)



Solution 527 (latest)



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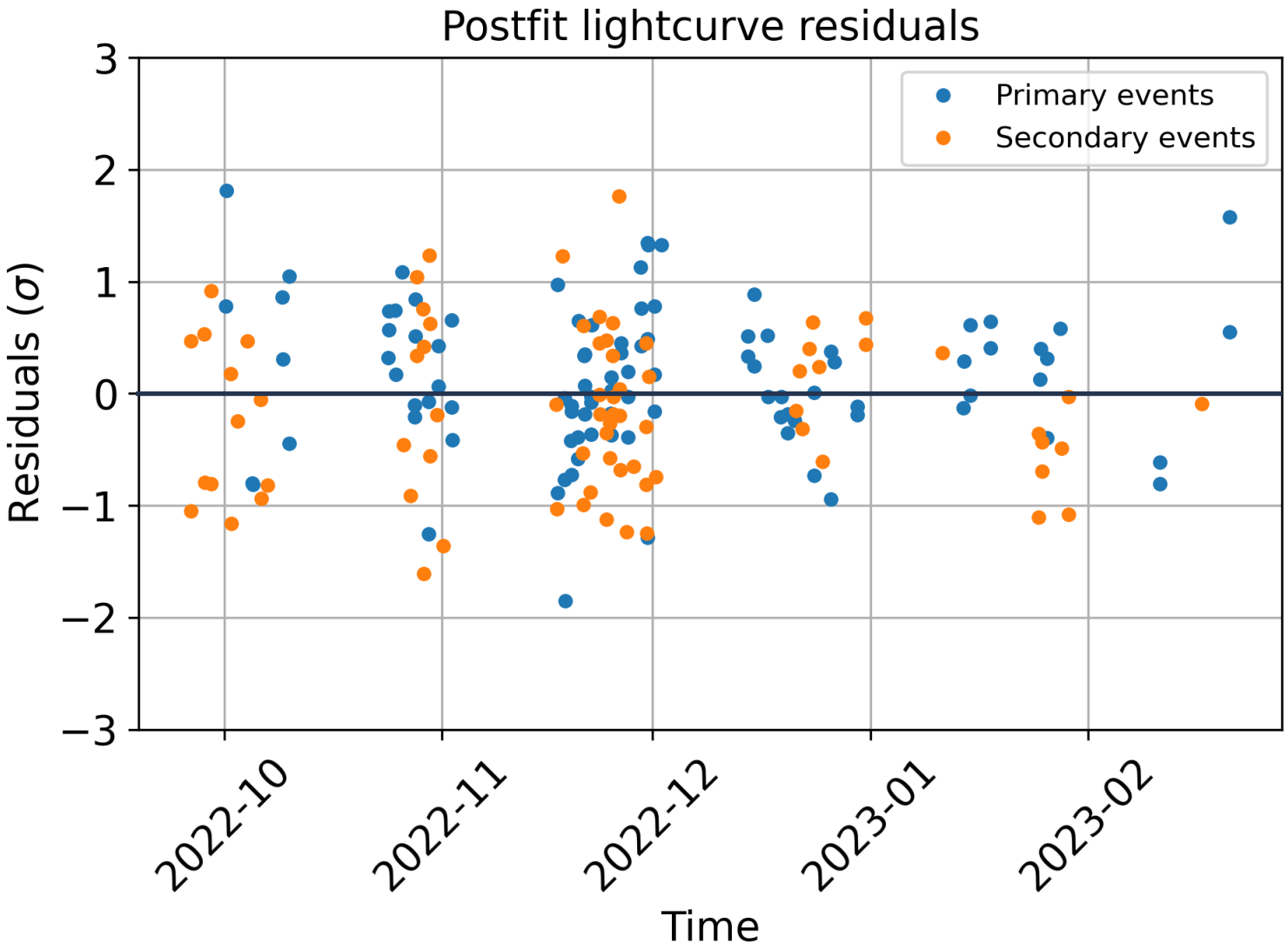

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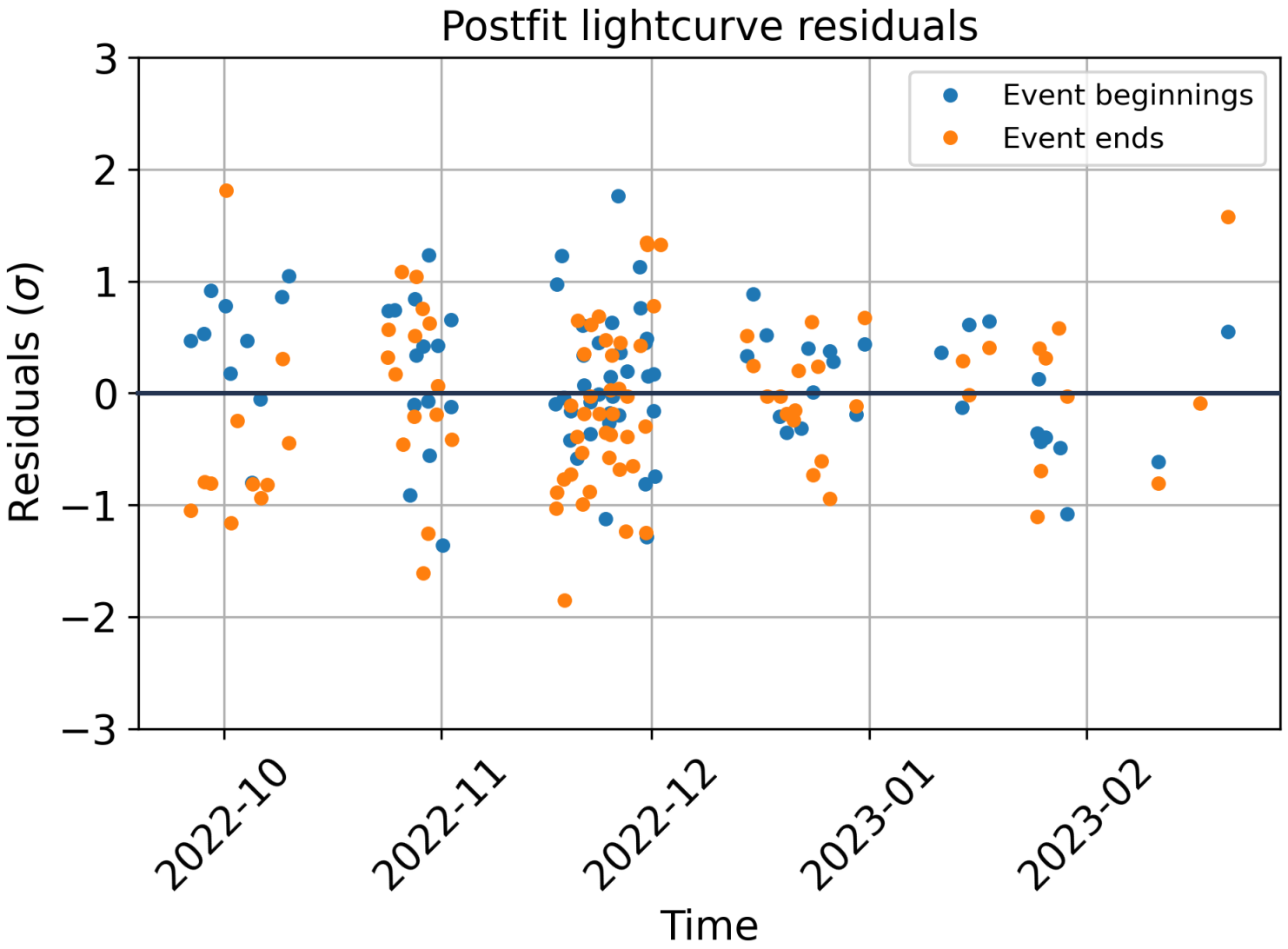

Delivery

- https://ssd.jpl.nasa.gov/ftp/eph/small_bodies/dart/dimorphos/
- SPK file: ‘dimorphos_s527.bsp’
  - Contains pre-impact as well as post-impact trajectories.
  - This SPK file avoids discontinuity between the pre- and post-impact orbits by computing post-impact elements based on the DART impact velocity vector and the estimated period change.
- PCK file: ‘dimorphos_s527-preimpact.tpc’
  - Describes the orientation of Dimorphos.
  - Valid for times prior to the DART impact at 2022 SEP 26 23:14:24.183 UTC