VAMORCAD - VALIDATION OF ASTEROID MODELLS BY OCCULATION RESULTS

Results from Observation of Asteroids:

Till appr. 1900 – Position and brightness
1901: v. Oppolzer showed that (433) Eros performed brightness fluctuations of "almost one magnitude"
1906: H.N. Russell: “ON THE LIGHT-VARIATIONS OF ASTEROIDS AND SATELLITES“, conclusion: not possible to get the shape
Since 1970: Taxonomie based on spectroscopy, photometry and polarimetrie, IR-flux → Albedo and calculated diameter
Since 1983(?) 2D simulation of chords → observations fitting an ellipse
Since 1991: visits by spacecrafts → till today 17 objects
2001: M. Kaasalainen&Torppa: Optimization Methods for Asteroid Lightcurve Inversion. → Shape Determination
2009: J. Durech, V. Sidorin, M. Kaasalainen: DAMIT = a database of asteroid models
Since 2009: 2D simulation of chords → observations fitting a view to the model in DAMIT and similar sources
2023: spatial representation possible with VAMORCAD

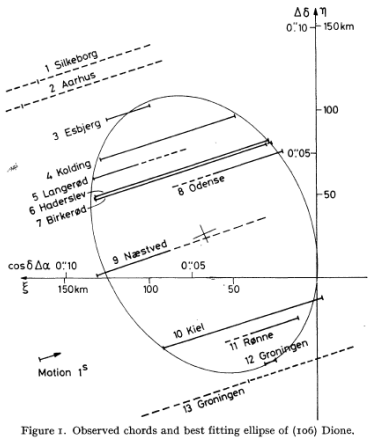
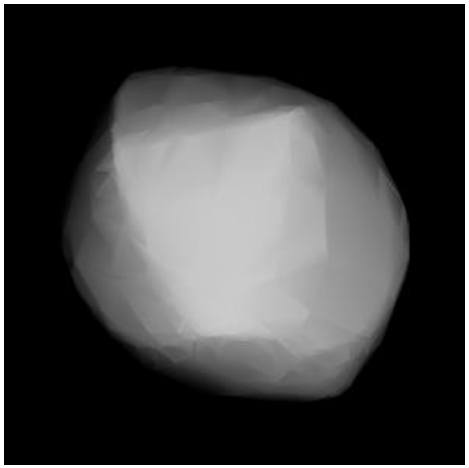
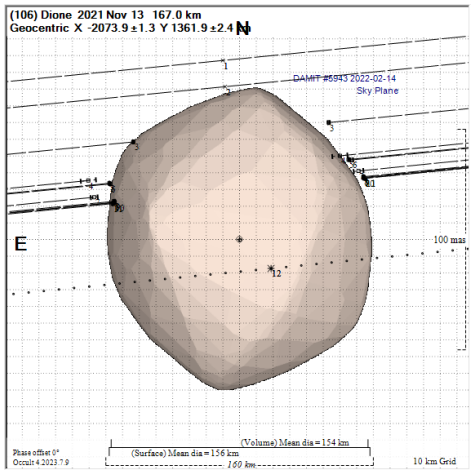


Figure 1. Observed chords and best fitting ellipse of (106) Dione.

AN 1983

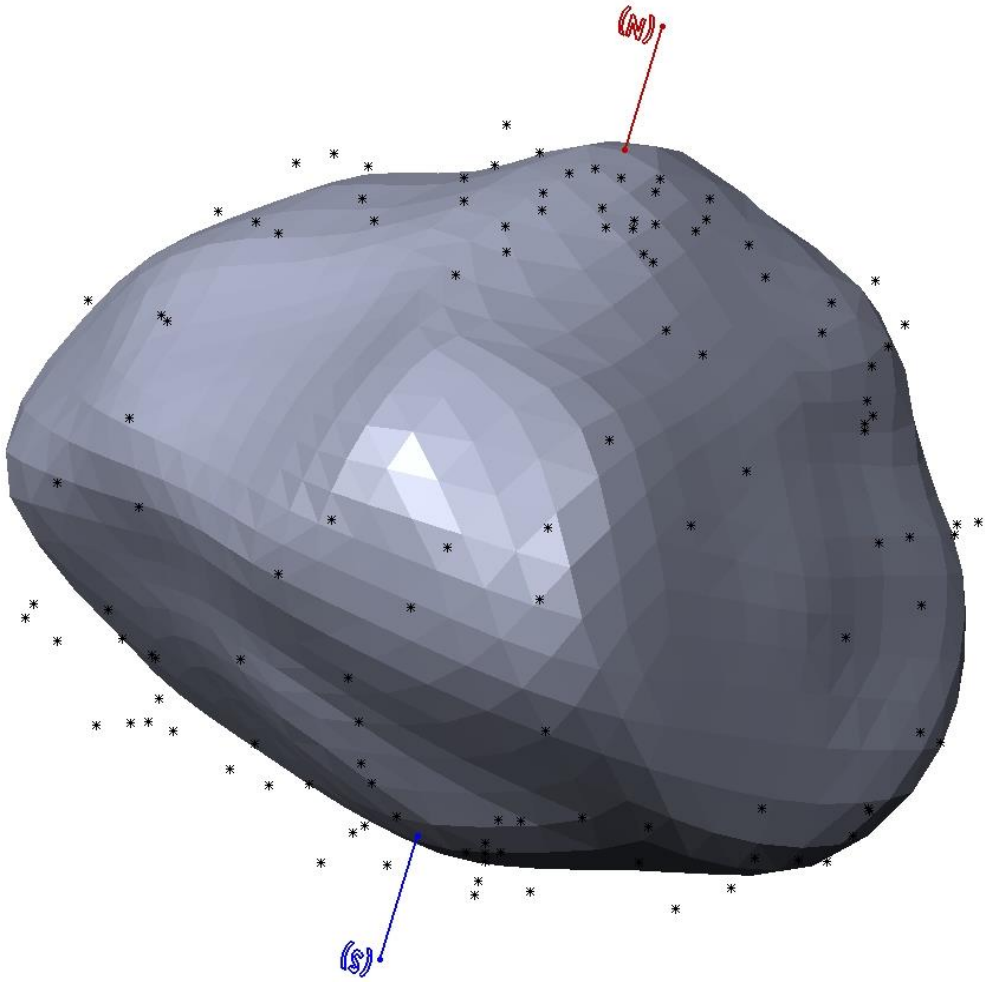


DAMIT



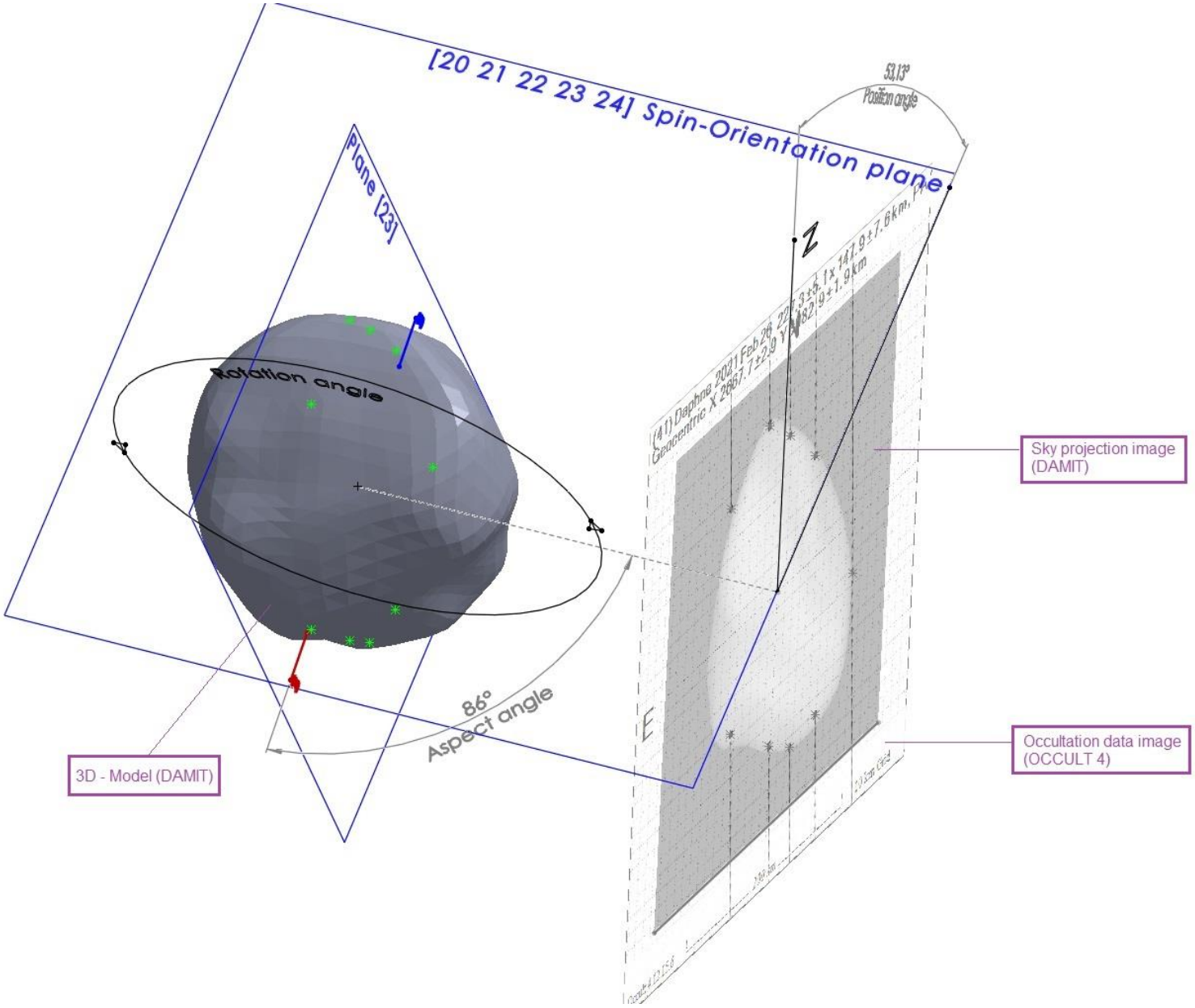
DAMIT + OCCULT

Spatial representation of occultation events by using 3D-models of asteroids - derived from light curves measurements



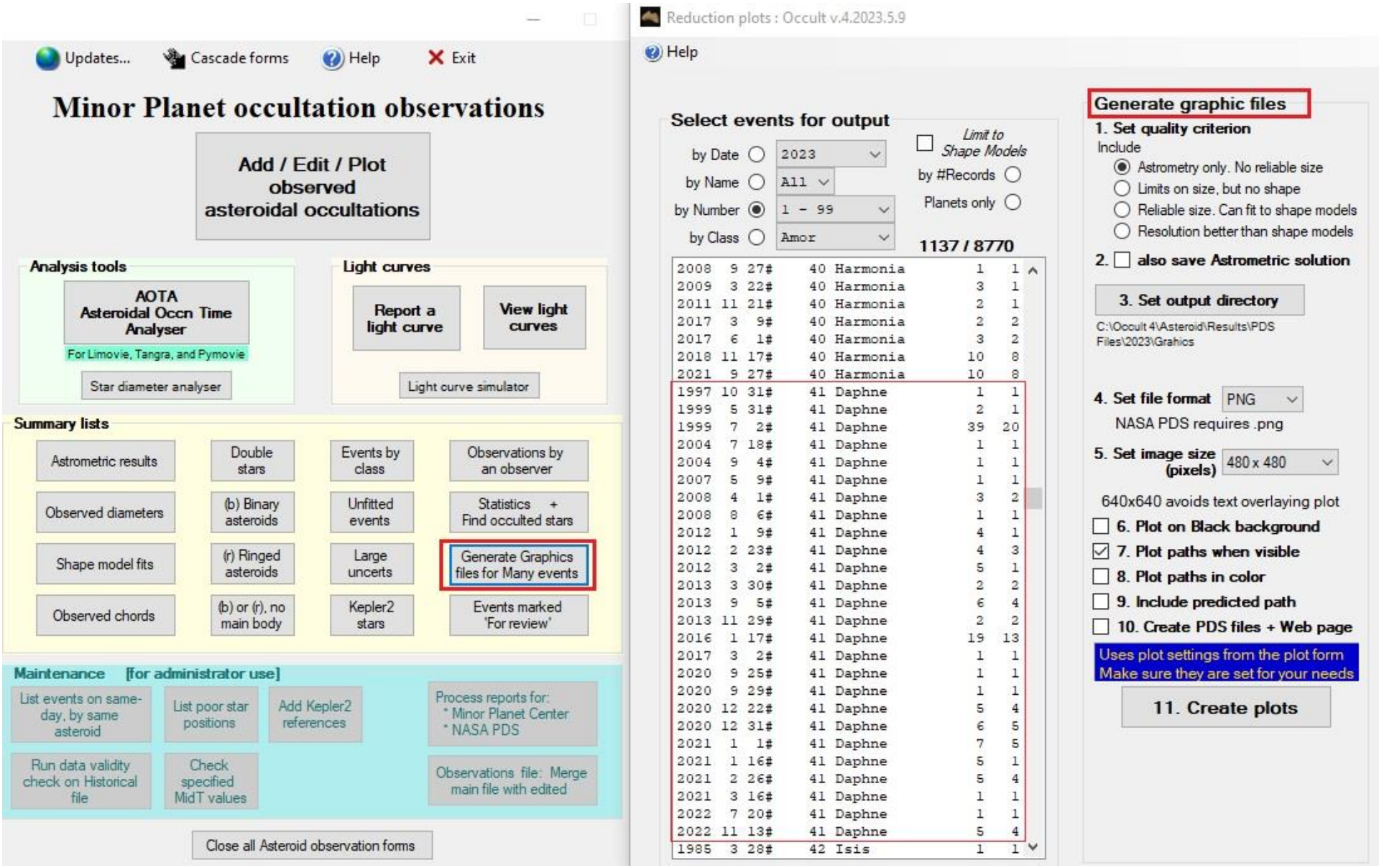
(41) Daphne

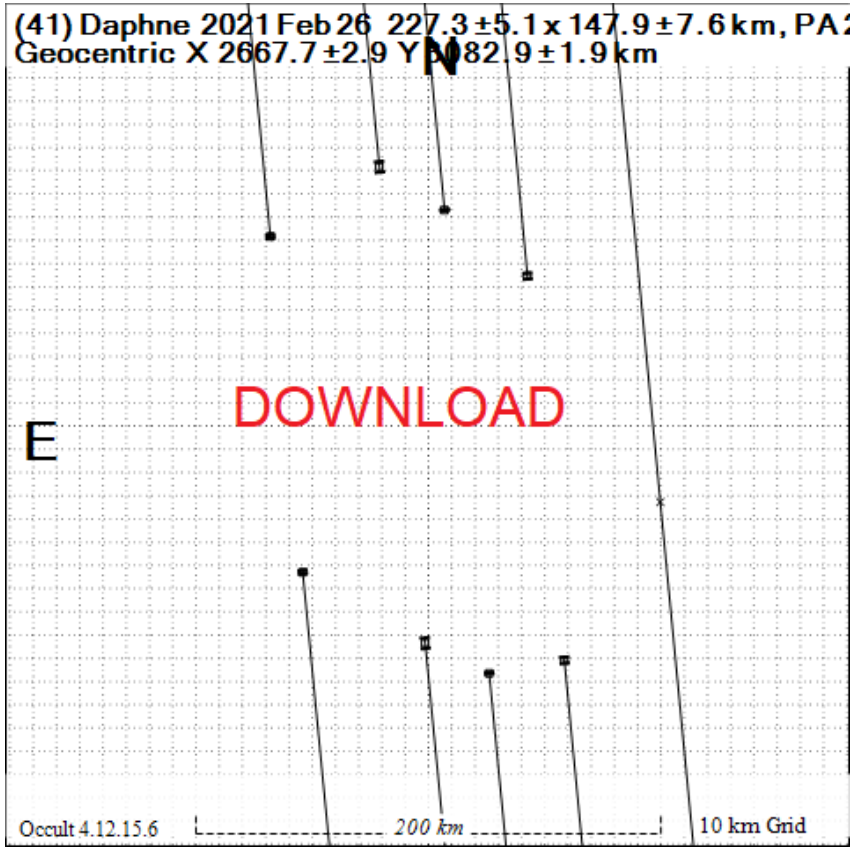
Occultation events from OCCULT4-Database combined with DAMIT 3D-model 1793 (All events [24] are shown)



General view of the process structure

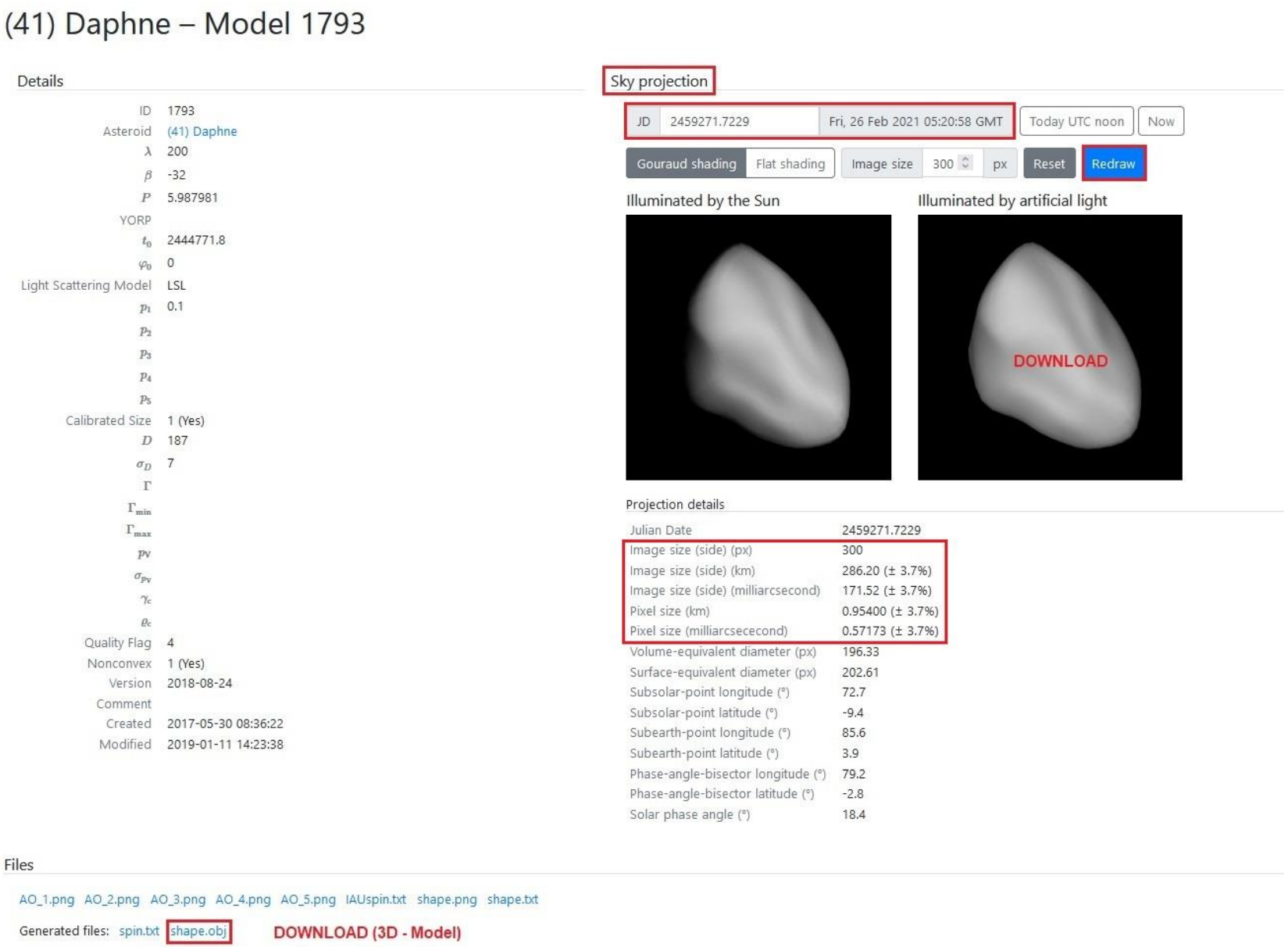
1. Download of occultation data images (OCCULT 4)

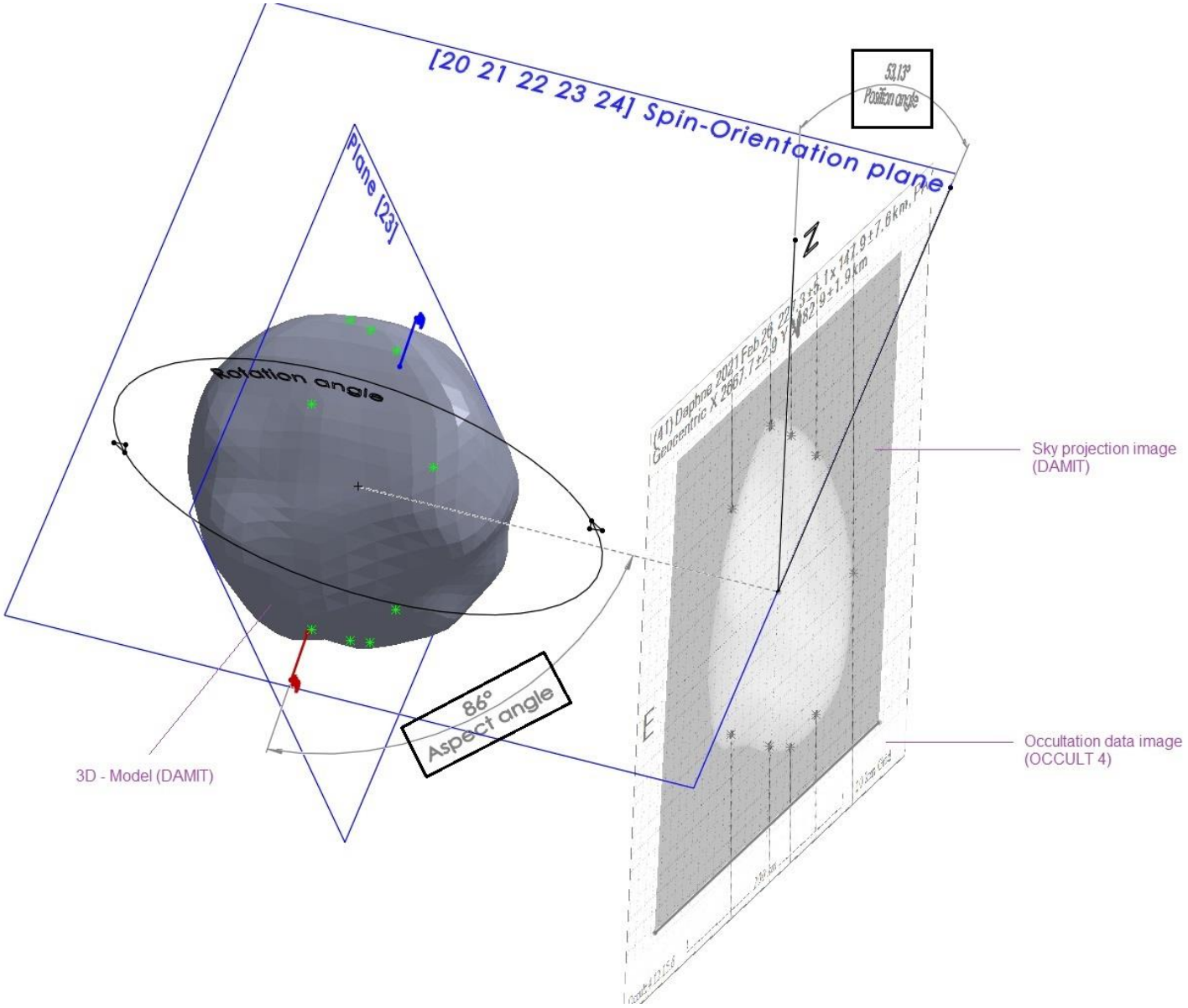




Downloaded occultation data image for event [23] (png-file 480x480), optical appearance depending on the set parameters

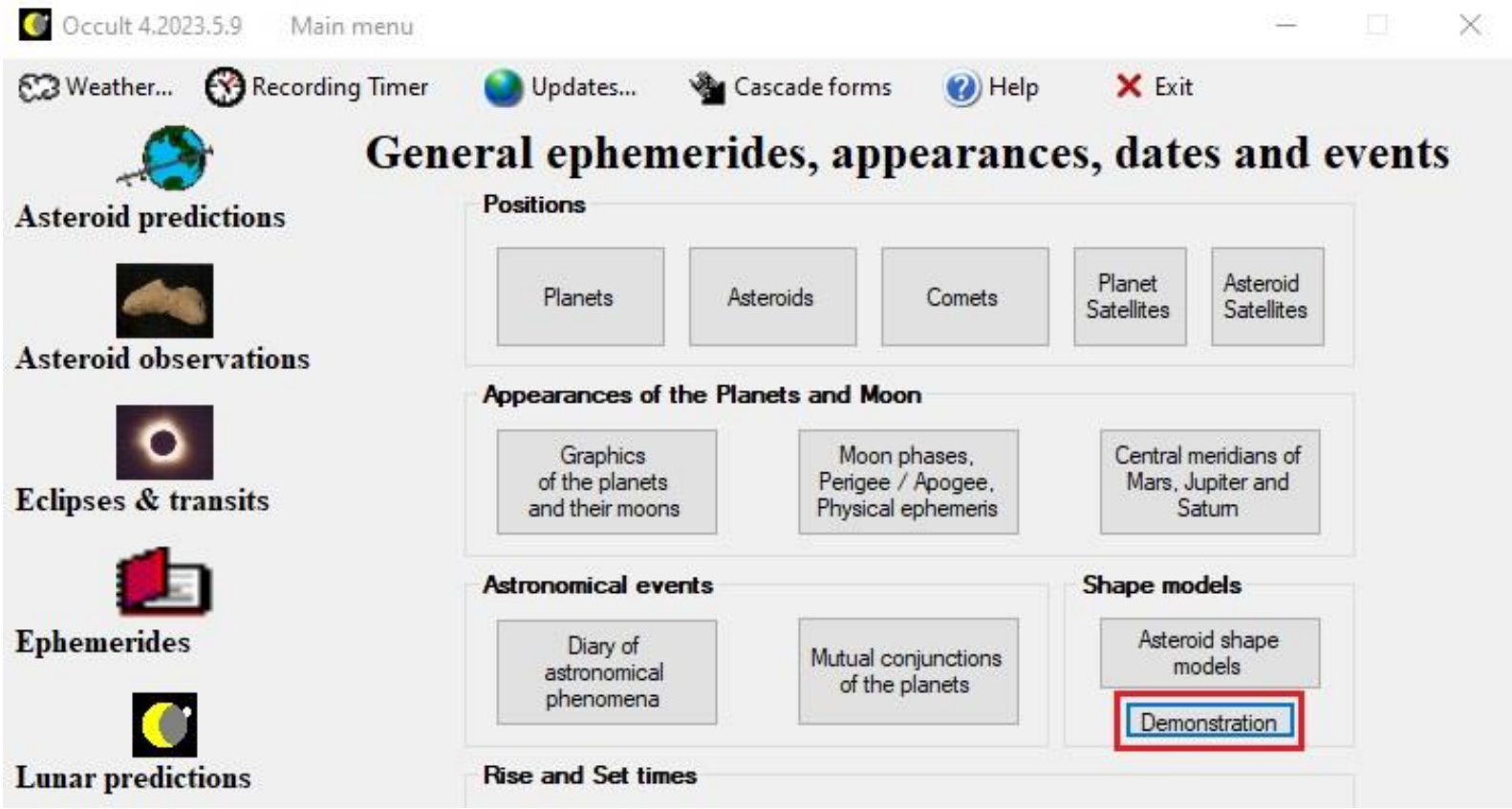
2. Download of sky projection images and 3D - models (DAMIT) **(https://astro.troja.mff.cuni.cz/projects/damit/)**





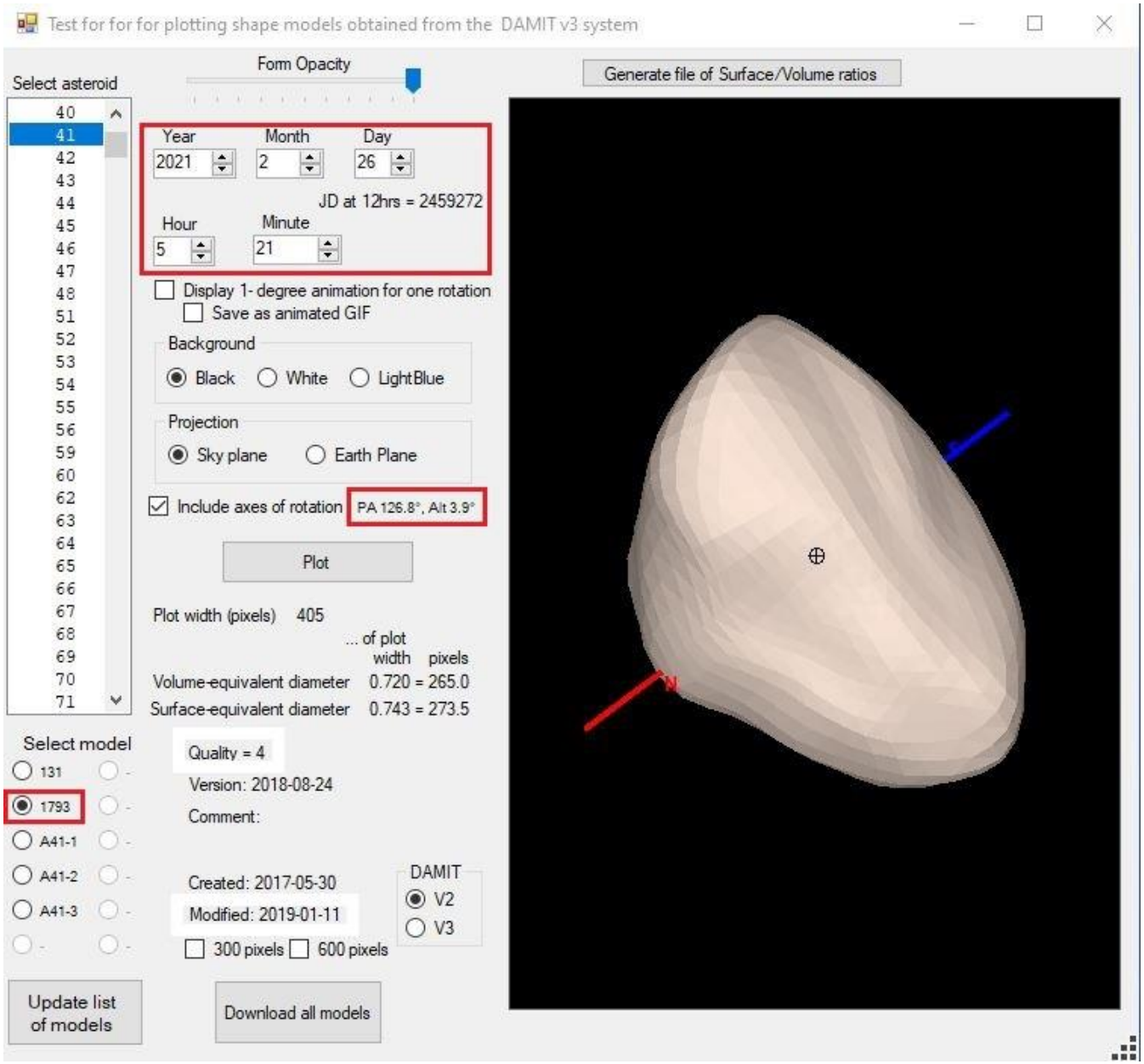
General view of the process structure (Scale: 1:1.000.000, i.e. 1 km = 1 mm in virtual space)

3. Determination of the angle parameters adapted to work with a 3D-Design program (CAD)



Position angle (PA) = - (180° - PA) West **/ (PA - 180°)** East

Aspect angle (Aspect) = 90° - Alt


Test for for for plotting shape models obtained from the DAMIT v3 system
Select asteroid
40
41
42
43
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56
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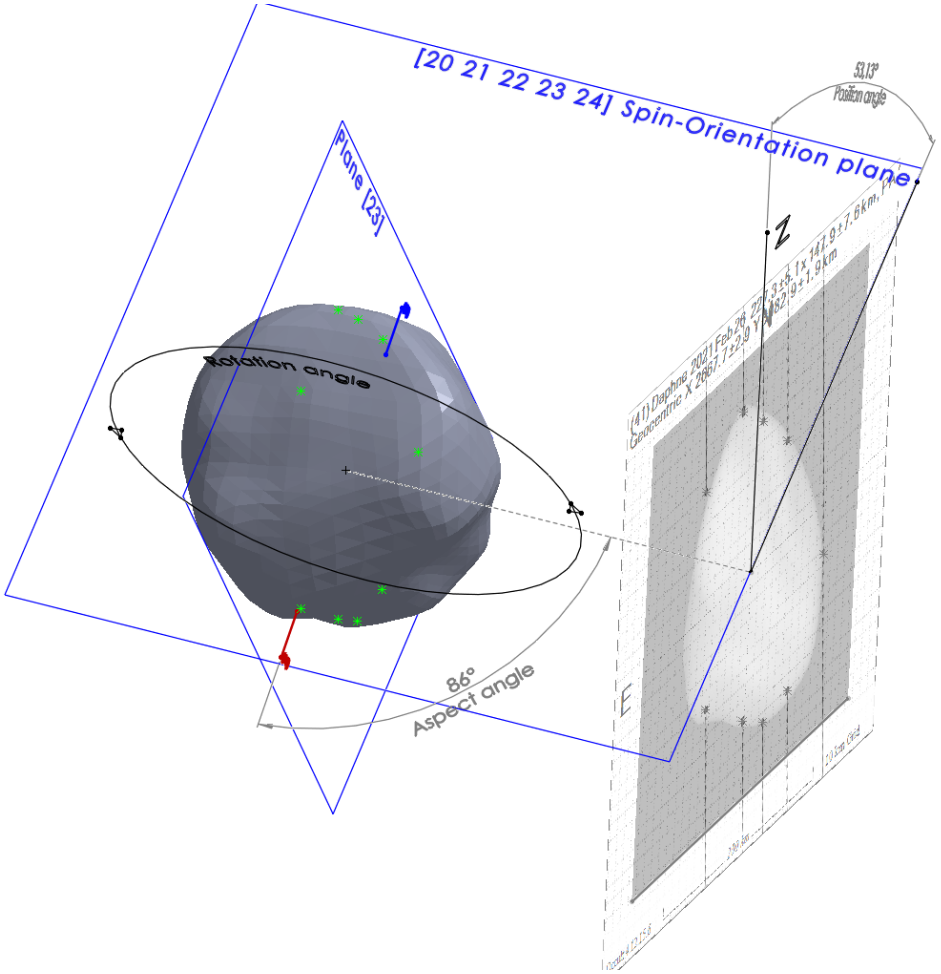
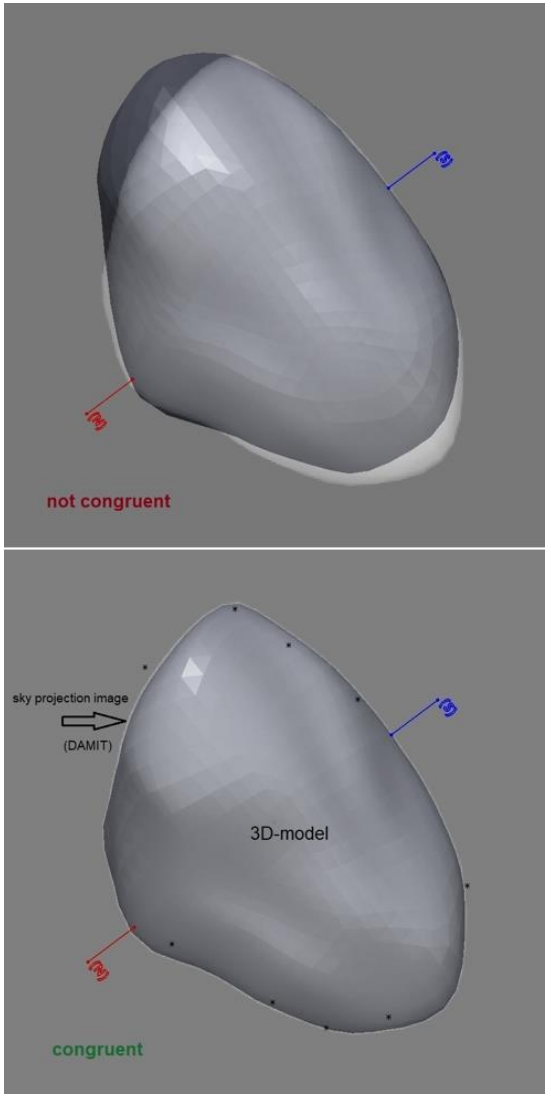
60
62
63
64
65
66
67
68
69
70
71
Form Opacity
Year
2021
Month
2
Day
26
JD at 12hrs = 2459272
Hour
5
Minute
21
Display 1- degree animation for one rotation
Save as animated GIF
Background
Black
White
LightBlue
Projection
Sky plane
Earth Plane
Include axes of rotation
PA 126.8°, Alt 3.9°
Plot
Plot width (pixels) 405
... of plot width
pixels
Volume-equivalent diameter 0.720 = 265.0
Surface-equivalent diameter 0.743 = 273.5
Select model
131
1793
A41-1
A41-2
A41-3
Quality = 4
Version: 2018-08-24
Comment:
Created: 2017-05-30
Modified: 2019-01-11
300 pixels
600 pixels
DAMIT
V2
V3
Update list of models
Download all models
Generate file of Surface/Volume ratios

4. Correct positioning and checking the 3D-model in space and transfer the occultation data into the 3D-design program (black points)



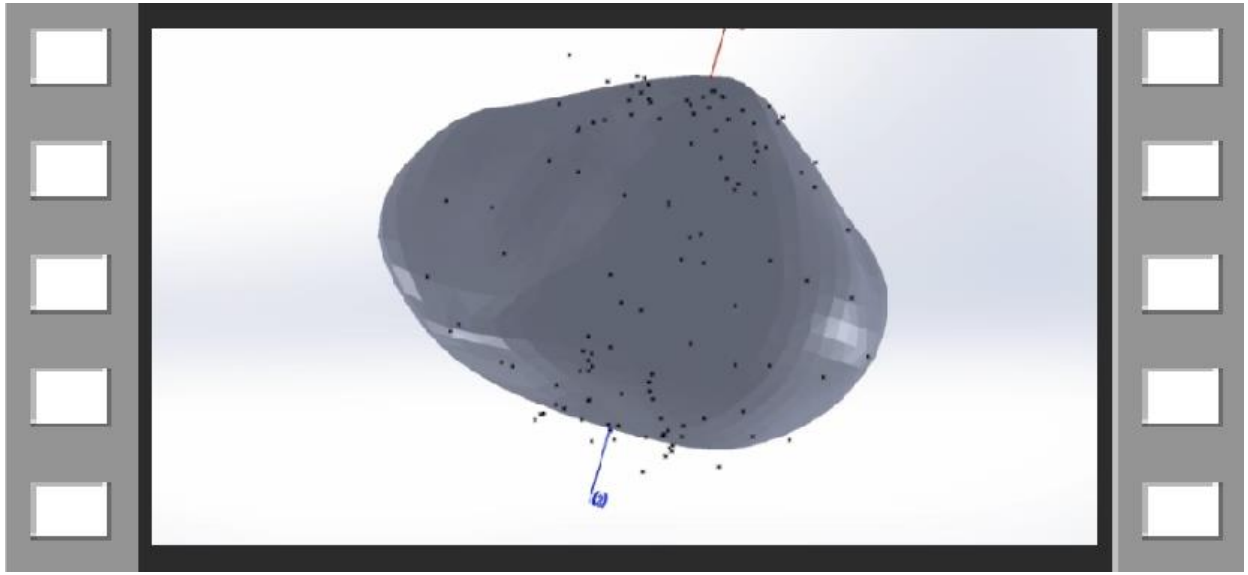


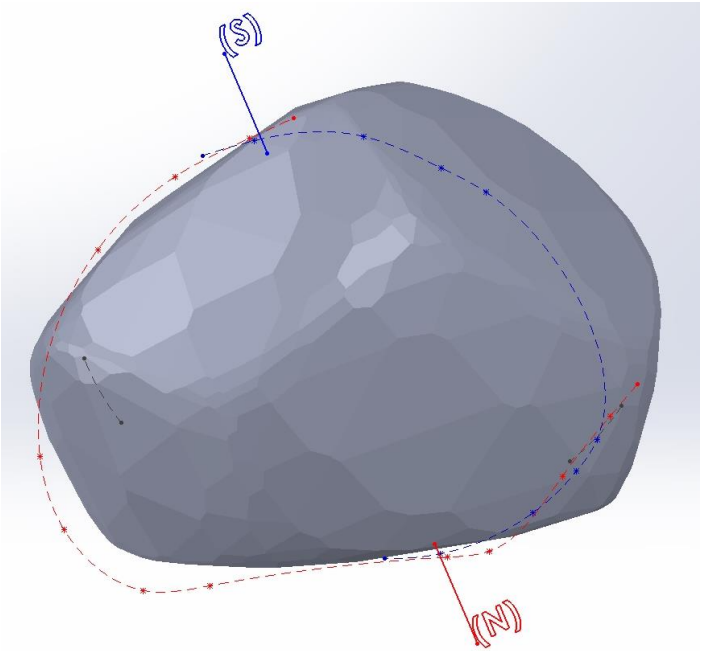
5. Projection of occultation points (green points) parallel on a central plane across the center point of the model

A. Graphical output data

After steps 1 to 5 have been done for each event, based on the functionality of the given 3D- design program,
a **mp4-file** (model rotates) and **images** from any perspective can be created, for giving a complete / special overview.

https://www.iota-es.de/vamor/(41)_Simulation.mp4





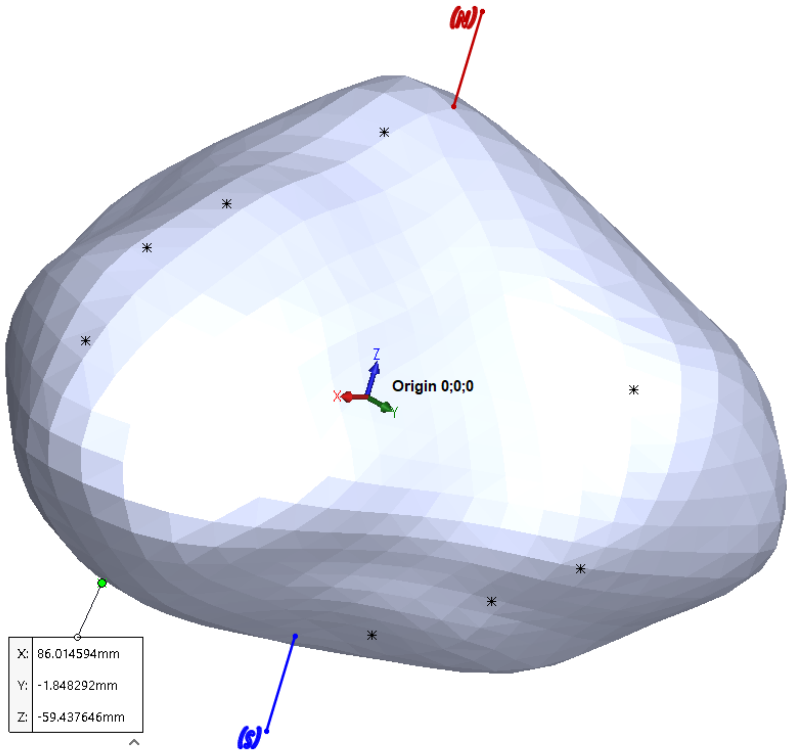
Features are:

- 3 - Dimensional representation of all / selected occultation events
- Highlighting of specific occultation events by color or/and lines (splines)

B. Numerical output data

A professional 3D-design program allows the calculation of various parameters via an embedded programming language.

X-, Y-, Z- coordinates (numerical basis)

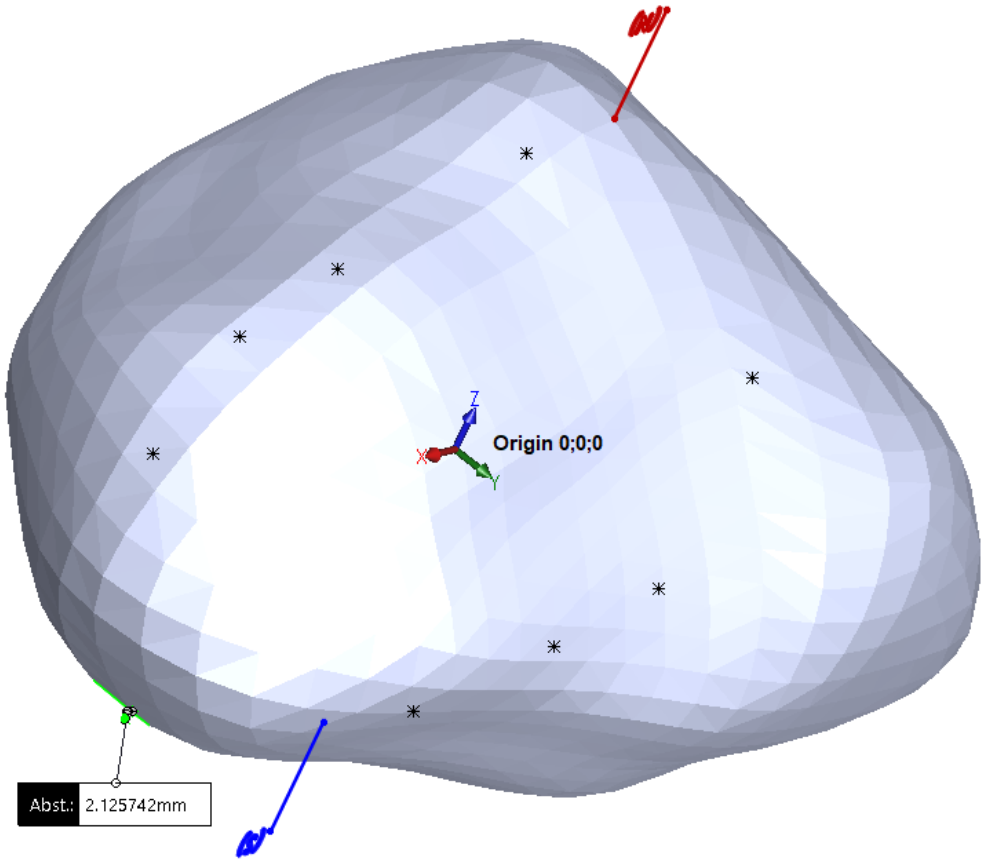



```
     -80.171767     -51.95379     -39.166028
     -79.425206     -50.658477     -46.39952
     -71.496528     -44.173534     -55.137239
     -61.780727     -38.343839     -46.023505
     -0.641995     8.37518     -82.625319
[22]
     25.096243     -13.671377     -79.571131
     -23.783906     13.118514     79.681621
[23]
     115.429171     -9.017937     13.500377
     100.399287     -9.999298     42.493565
     73.248925     -9.093863     56.661013
     18.014199     -6.873734     80.089207
     -103.854871     6.883995     5.395978
     -100.001539     10.458471     -49.440834
     -68.406833     9.022418     -60.472092
     -24.656796     6.77154     -72.004911
     86.014594     -1.848292     -59.437646
[24]
     51.155329     67.845459     -16.675148
     -50.466704     -66.953868     16.603428
```

Coordinates for events [22], [23] and [24] (in chronological order)

Coordinates X,Y,Z of occultation points at the specified positions

Closest distances to the surface of the model and their statistical distribution




```
#[22] *2*
                5,781255
                1,959543
                                3,870399
                                                4,316406
#[23] *9*
                5,613474
                0,204266
                2,533058
                5,444009
                8,588125
                1,463298
                1,691404
                1,306431
                2,125742
                                3,218868
                                                4,117577
#[24] *2*
                1,065445
                9,303801
                                5,184623
                                                6,621778
#  ____________________________________________________________

# Total:                        8,798387        12,579059

                                mean values     RMS
```

Calculation of the arithmetic and quadratic mean values (RMS - root mean square)

Analysis of the 3D-model

```
# (41) Daphne (1793)

# Number of vertices: 902
# Number of faces: 1800
# Number of edges: 2700
# Calculation of Euler's polyhydron theorem = 2  (when 2 then in accordance with the theorem)

# Diameter (volume-based): 187,295 km
# Diameter (surface-based): 193,289 km

 -0,000073              10,775237              86,923035
 10,752237              0,012047               88,737221
 -0,000073              0,012047               90,591125
 -0,000073              -10,927783              92,601799
 -10,980663              0,012047               89,148842
 14,960337              -14,230153              89,421906
```

Coordinates X,Y,Z of vertices of the 3D-model

Calculation further, possible parameters:

- Volume related diameter
- Surface related diameter

END OF THE WORKFLOW

CONCLUDING REMARKS - VAMORCAD

Data maintenance:

- Creation of the first data set relatively time-consuming, but user-friendly
- Easy addition of further single and/or multiple events possible
- Adjustment of statistical calculations at any time, also possible for selected events only

Valuations for further discussions:

- Valuation of the quality of single (multiple) occultation events in terms of entire statistical distribution
- Estimation of possible and realistic changes in size and / or shape of the model under consideration of the DAMIT-quality flag and its processing status, described on **https://astro.troja.mff.cuni.cz/projects/damit/**.

Next steps:

- Collection of spatial representation for specific, selected asteroids on **https://www.iota-es.de** (updateable)
- Identification of special asteroids and definition of possible further parameters for their description in collaboration with other colleagues