Displaying data on shape models

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(sequel to my IVOA presentation last year, on imaging spectrometry)

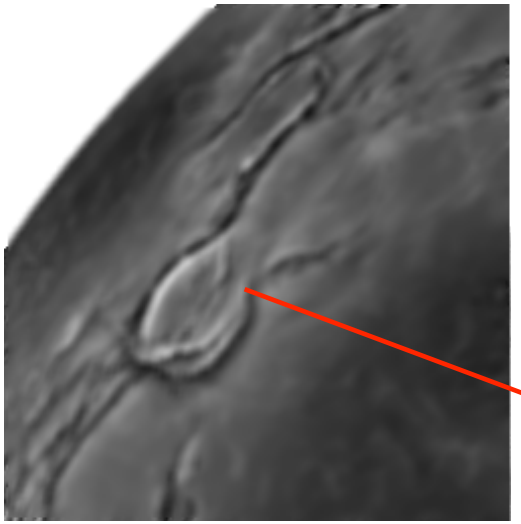
Application to measurements on small bodies

Support of:
- past missions (Hayabusa 1 and 2, Osiris-REX, Rosetta…)
- missions to come (including MMX to Phobos)

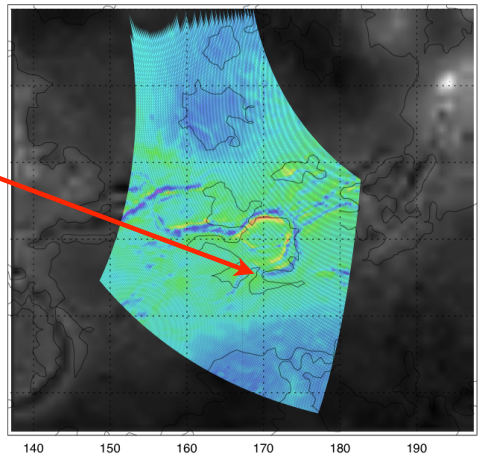
Imaging spectrometry

Coordinates - projection on body

Extra info required *for each pixel*:
- Coordinates + wvl vector (to plot data)
- Illumination angles (to analyse data)
- each pixel has an extended footprint (for comparison with HR imaging)



VIRTIS-M VenusExpress



Cube slice: spatial dimensions (~ single wavelength image)

Projected image on surface (~ map)

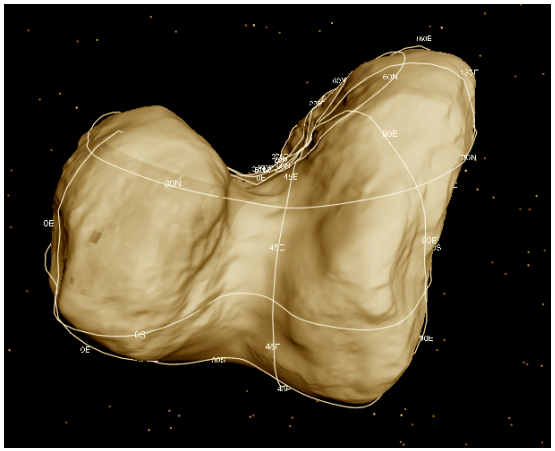
Imaging spectrometry

Coordinates - projection on body

Particularly important for irregular small bodies…

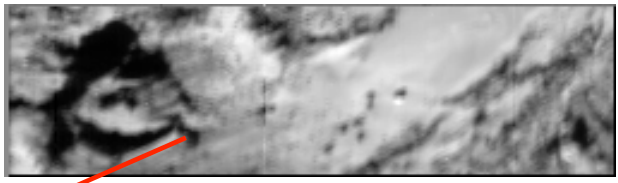
Coordinates and angles typically computed by the teams with SPICE (JPL), on a pixel basis

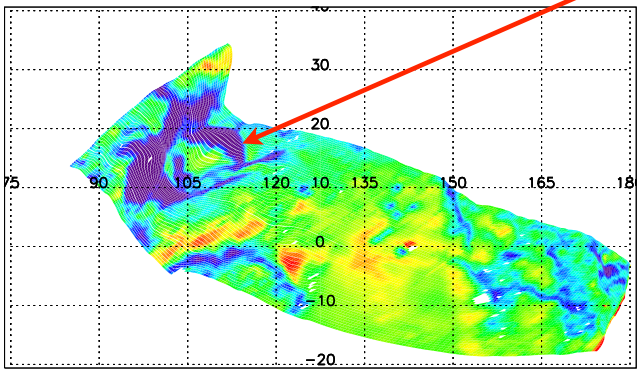
Visualisation may be tricky



VIRTIS-M Rosetta

Cube slice: spatial dimensions (~ single wavelength image)





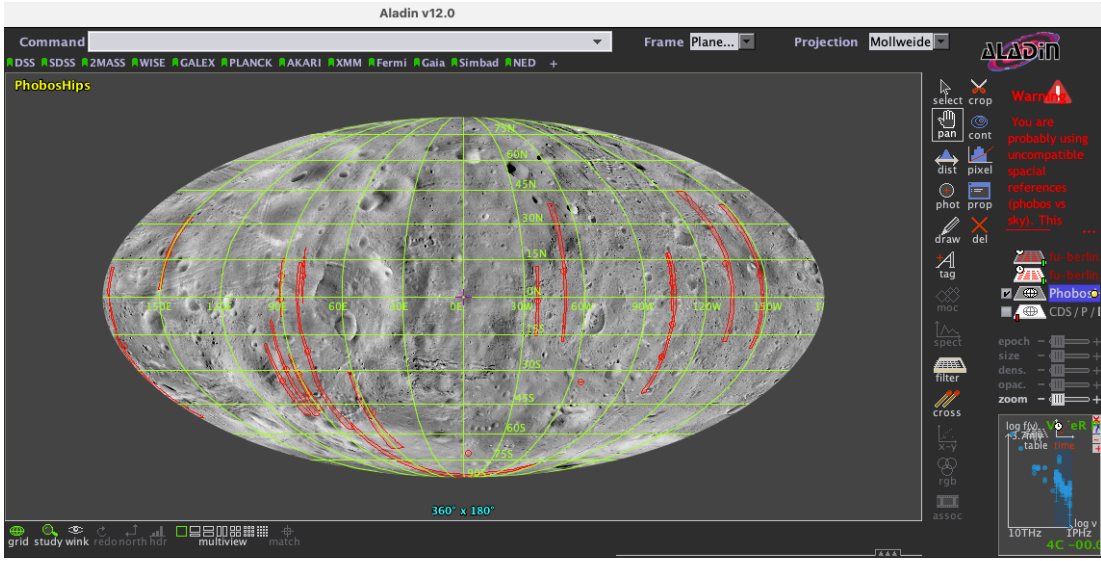
Projected image on shape model (~ map)

Shape models

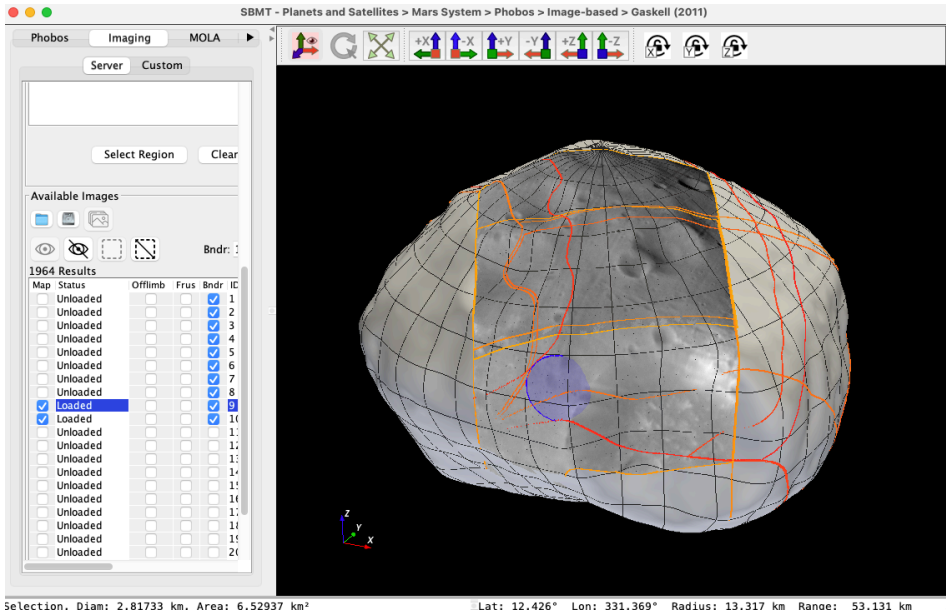
2D maps can be acceptable
(*if* lon/lat coordinates are OK)
— but spherical 3D plots are misleading…

Tools to plot data in 3D?
Mostly Small Bodies Mapping Tool from JHUAPL, but
- data precomputed / prepared
- stored on their server

Phobos HiPS and footprints in Aladin

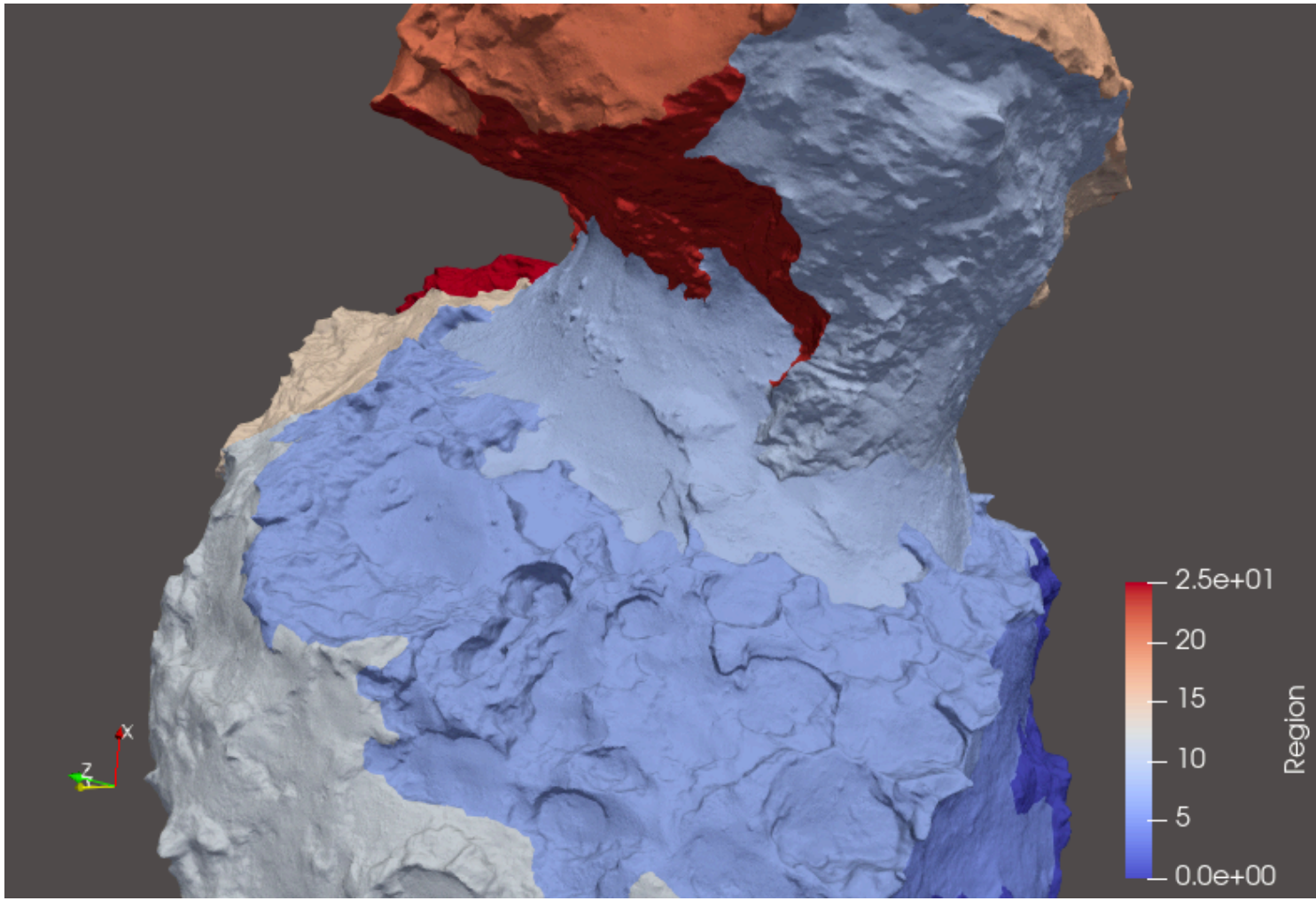


Phobos images and footprints in SBMT



Shape models

67P 5M facets shape in Paraview,
with geologic units

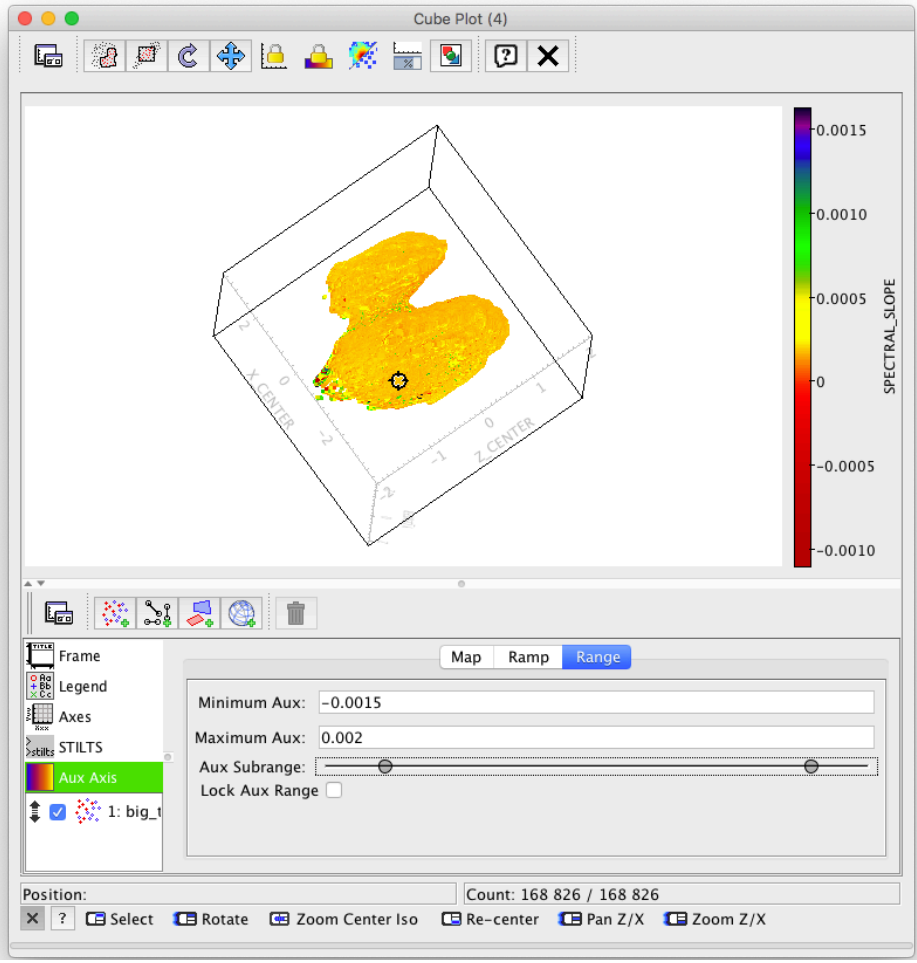


Dedicated 3D tools

Paraview
- is extremely rapid
- supports full resolution
- but not very flexible to overplot external data

TOPCAT?

VIRTIS-M Rosetta integrated table on 67P
Rousseau & Erard 2017



We know TOPCAT has a capacity to address this problem with derived data

(the shape model is embedded in the data)

Not optimized for 3D, but very appealing:

- no data sharing
- data can be modified/computed on the fly
- versatile: many parameters in the same file
- subsets
- cross-matches between tables
- many other display functions available
- VO-connected

TOPCAT use case

Steps:
- Plot complete shape model in 3D
- Overplot point data on a region
- Overplot many points data
- Overplot images
- Quicklook and publication-ready modes

Most 3D shape models use plate formats:
Section1: vertices with 3D coordinates
Section2: plates (usually triangular) with vertices from section1
(some are restrictions of powerful 3D design formats)
=> Do not enter TOPCAT directly, need reorganisation

+ SPICE Digital Shape Kernel type2 - used to project data on target bodies

Displaying complete shape models

Shape model reorganized as regular array of vertices (section1 only)

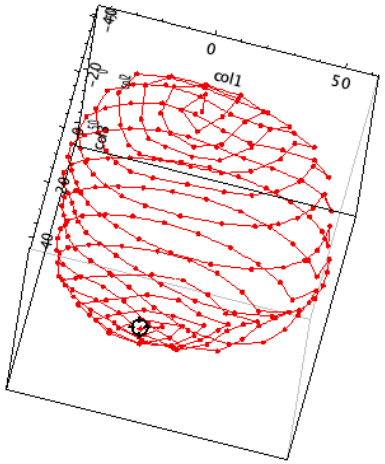
low density/few vertices: from light curve inversion

add connecting lines

high density: from flyby/orbital images

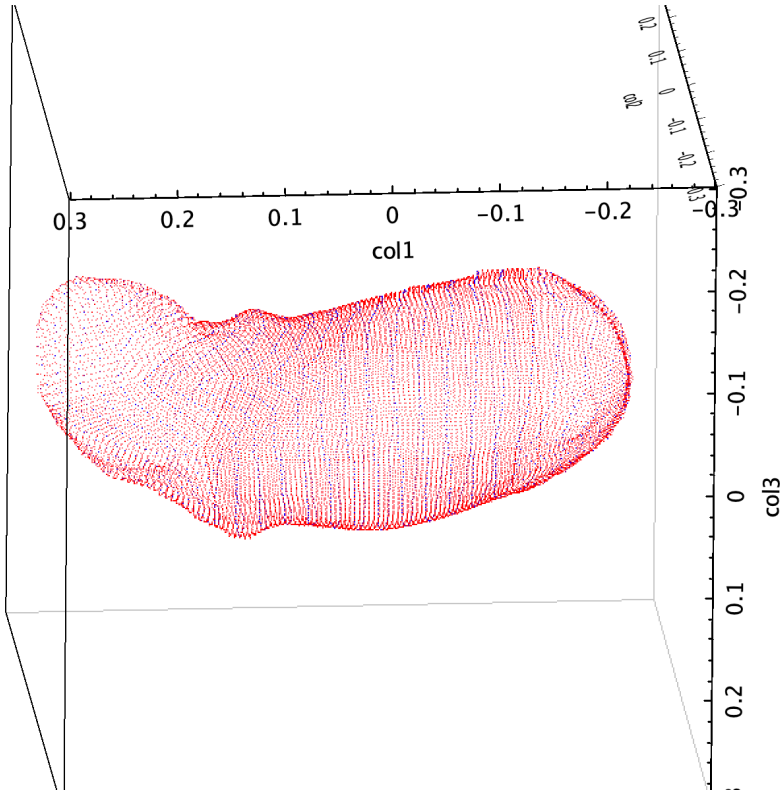
decimate via sample subset to make it lighter

Plots directly in Cube plot but need to specify x/y/z dimensions (default dim are wrong - is it a bug?)



Lutetia from ground, pre-Rosetta
258 vertices

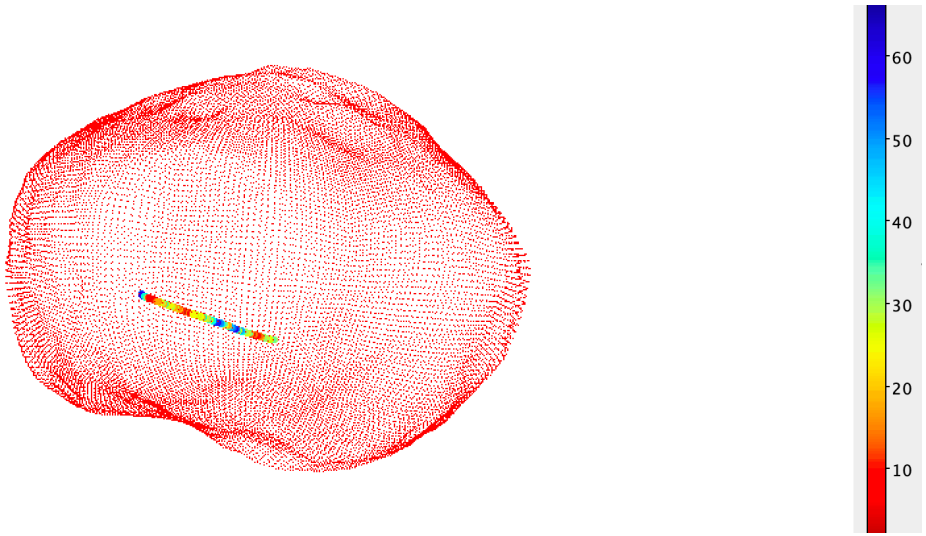
Itokawa from Hayabusa ~25,000 vertices
1/10 subset in blue



Overplotting data

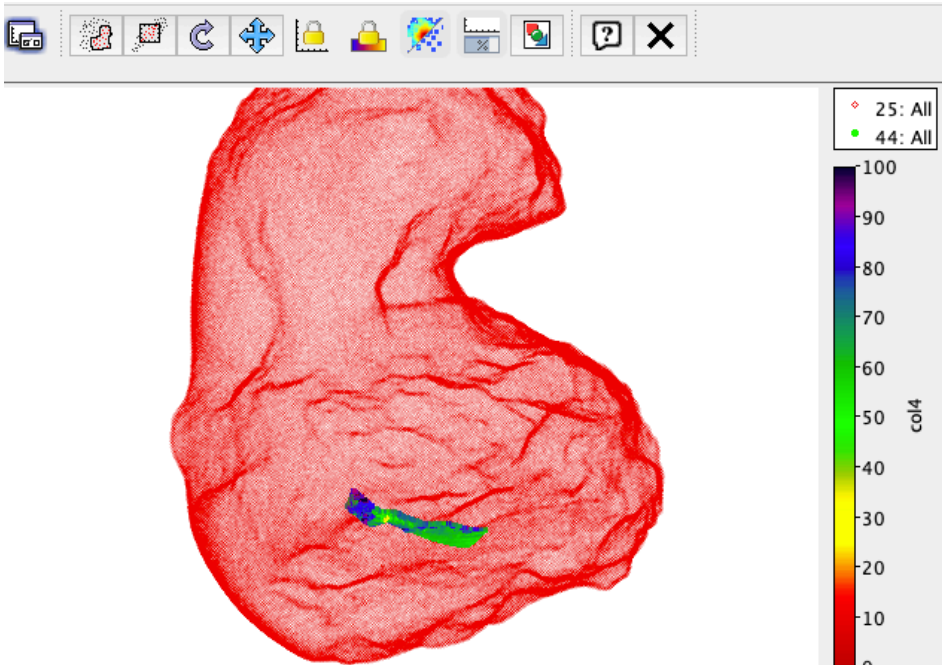
Using the central vertex to plot measurements: row = 3 coordinates + data

- Use another Mark form with Aux shading
- May need to adapt symbol size
- OK for quicklook, still rapid



Dummy data on Phobos 25,000 vertices

one VIRTIS-M cube on 67P, 130,000 vertices

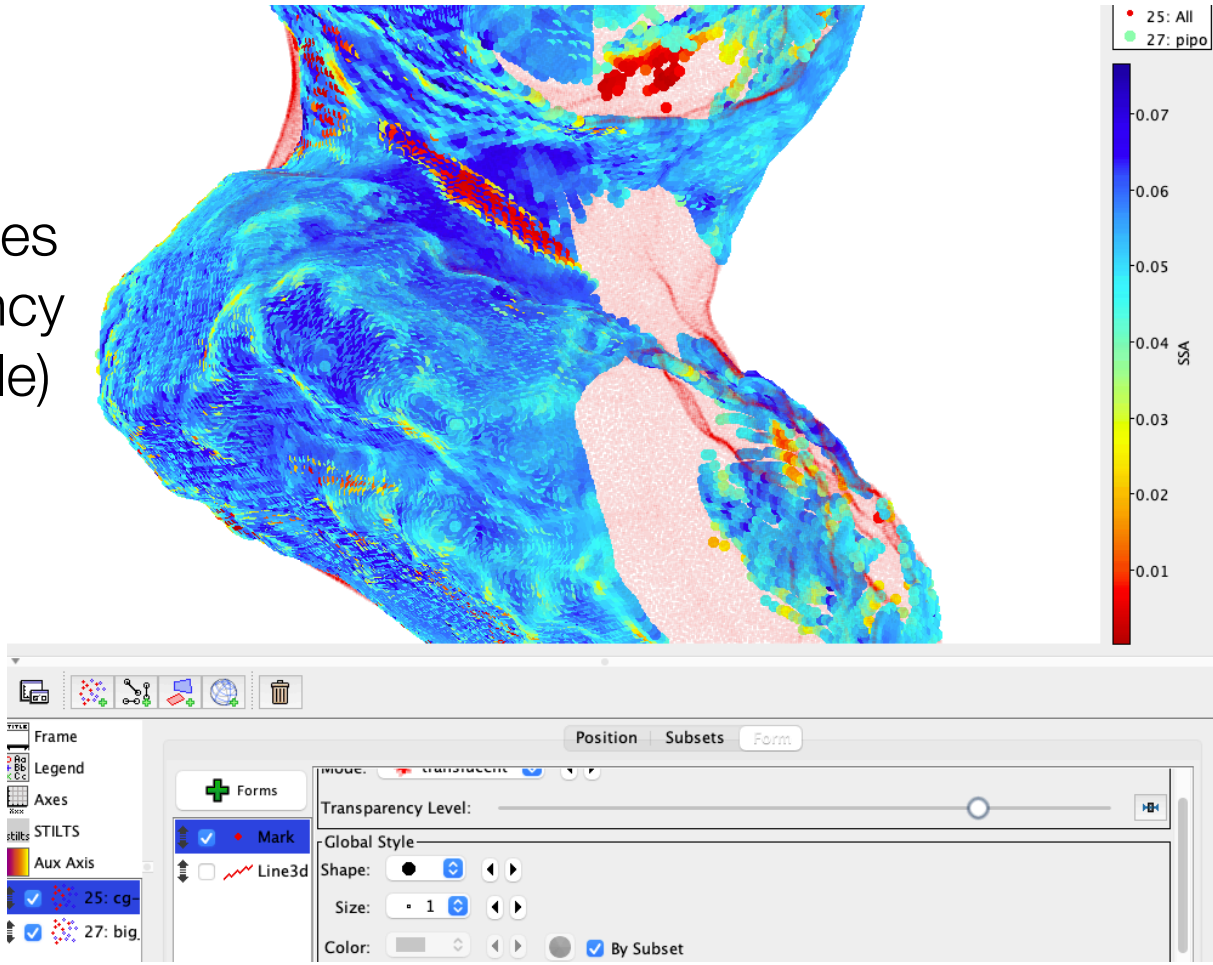


Overplotting data

1 week of prepared VIRTIS-M data on 67P
(single scattering albedo ~ 1 μm)
130,000 vertices
170,000 data points

Same with large file/many observations:

- Still easy to set a plot
- 3D manipulations become slow-ish
- The array may contain various quantities
- OK for quicklook, but semi-transparency becomes hard to read (far-side still visible)



Clean plots

Right way to do: plot data on plates, not vertices:

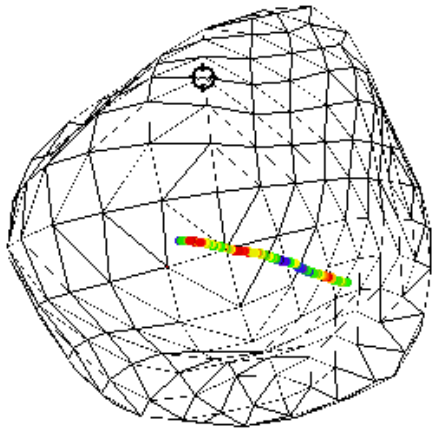
- Global shape as plate => Polygonal form or Polygon control

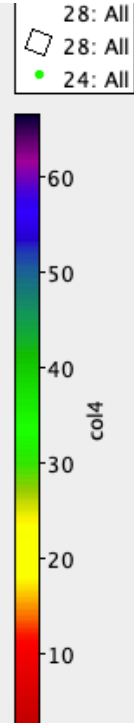
and keep them opaque

1- Data as previously, on vertices (light)

2- Data is best plotted also on plates for accuracy:
   either shape model plates (plate# makes it light)
   or actual footprint (new plates)

Last solution is probably more demanding
— to be tested with larger datasets & images





Dummy data on small Lutetia shape model
Shape as opaque plates (not vertices)

Clean plots

Right way to do: plot data on plates, not vertices:

- Global shape as plate => Polygonal form or Polygon control

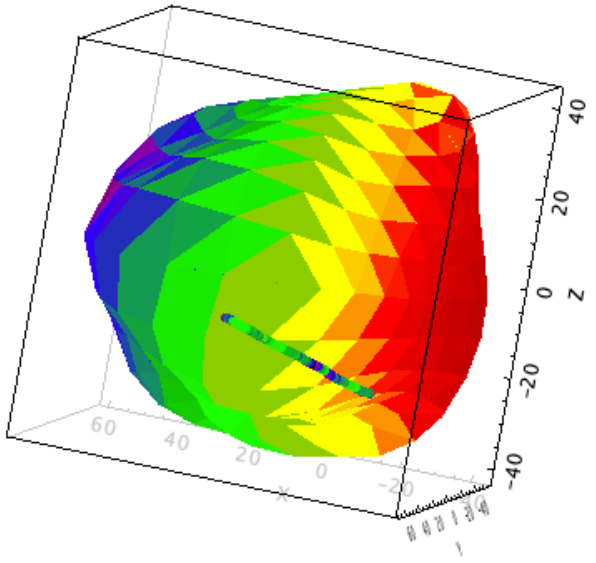
Can be used to overplot albedo, illumination, or to highlight the mesh

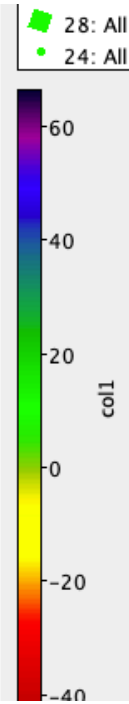
Requires another reorganization of input table:

row = plate # (for table match)

+ 9 coordinates (3 vertices delimitating the plate)

+ possibly albedo or incidence angle





Same with illumination angle on shape plates

Conclusions

TOPCAT is very capable! Can be used at least as quicklook for space experiments
Tutorial in preparation: https://github.com/epn-vespa/tutorials

Issues:

- A single color table available for two quantities ;(
- Ingesting current formats directly would make it simpler:
  .ver format => table of vertex coordinates, or plate coordinates
  SPICE dsk format => table