

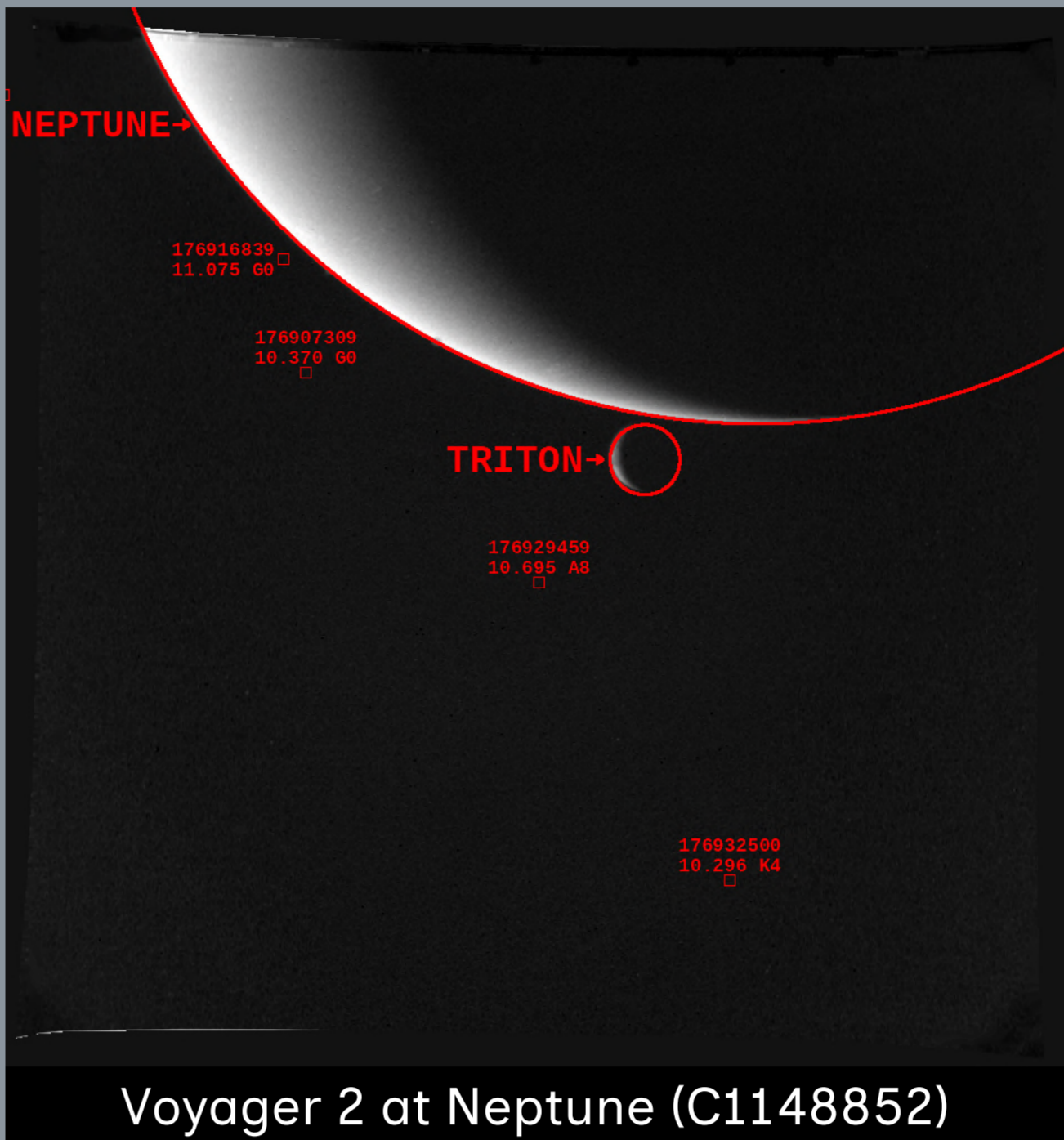
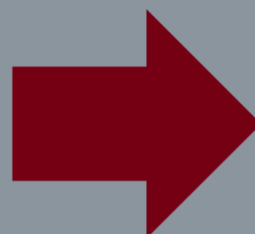
Pre-Computed Navigation and Backplanes in Support of Legacy Outer Planet Missions

Introduction

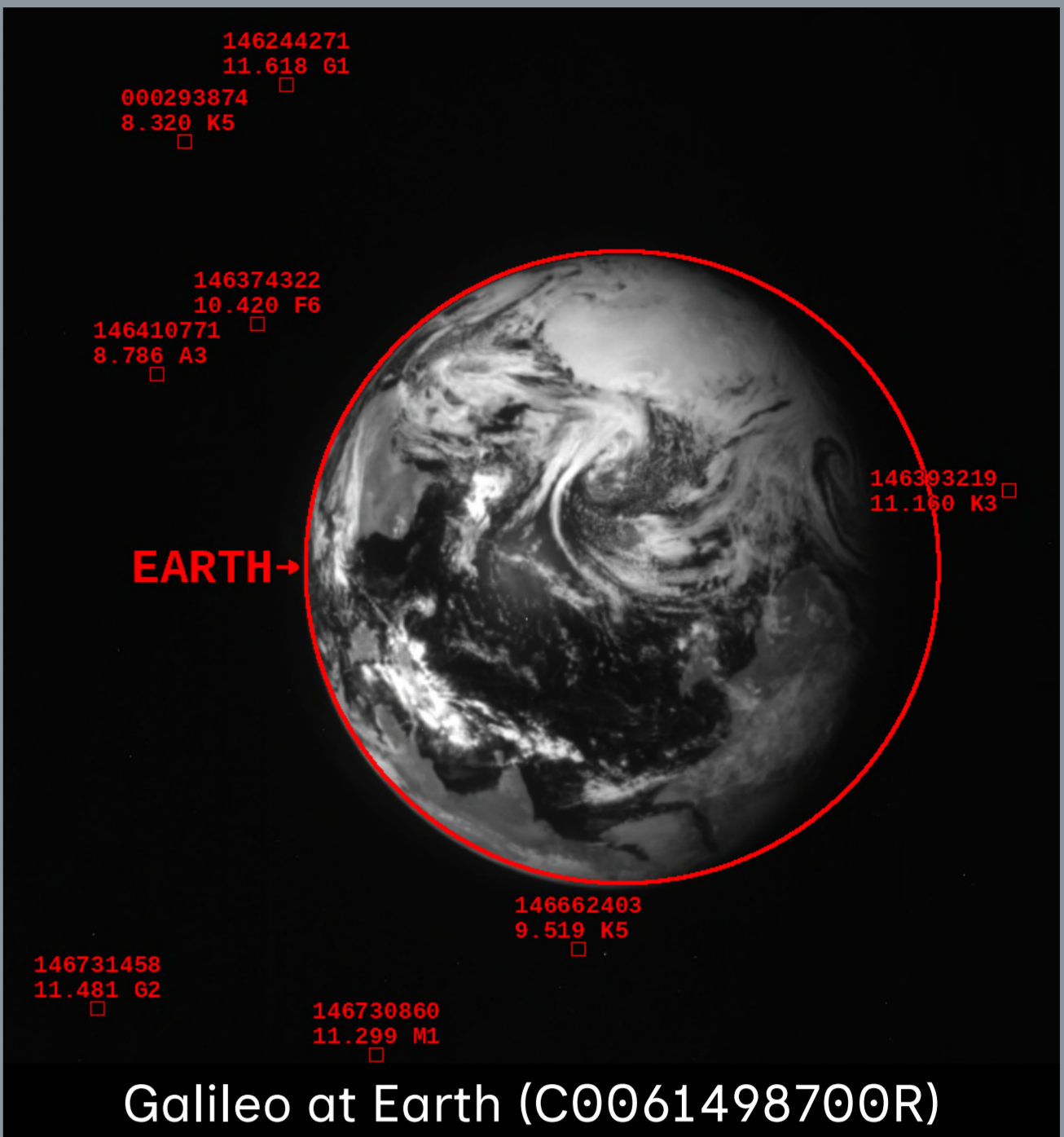
- Legacy missions such as Voyager, Galileo, Cassini, and New Horizons have provided a treasure trove of historic and irreplaceable data about the outer planets.
- Making these datasets available to future researchers in the most accessible and analysis-ready manner possible is important to preserving their value.
- Our project aims to make these datasets easier and more efficient to use by solving two tedious and time-consuming tasks that must be performed by most researchers: **image navigation** and **geometric metadata generation**.

Methodology

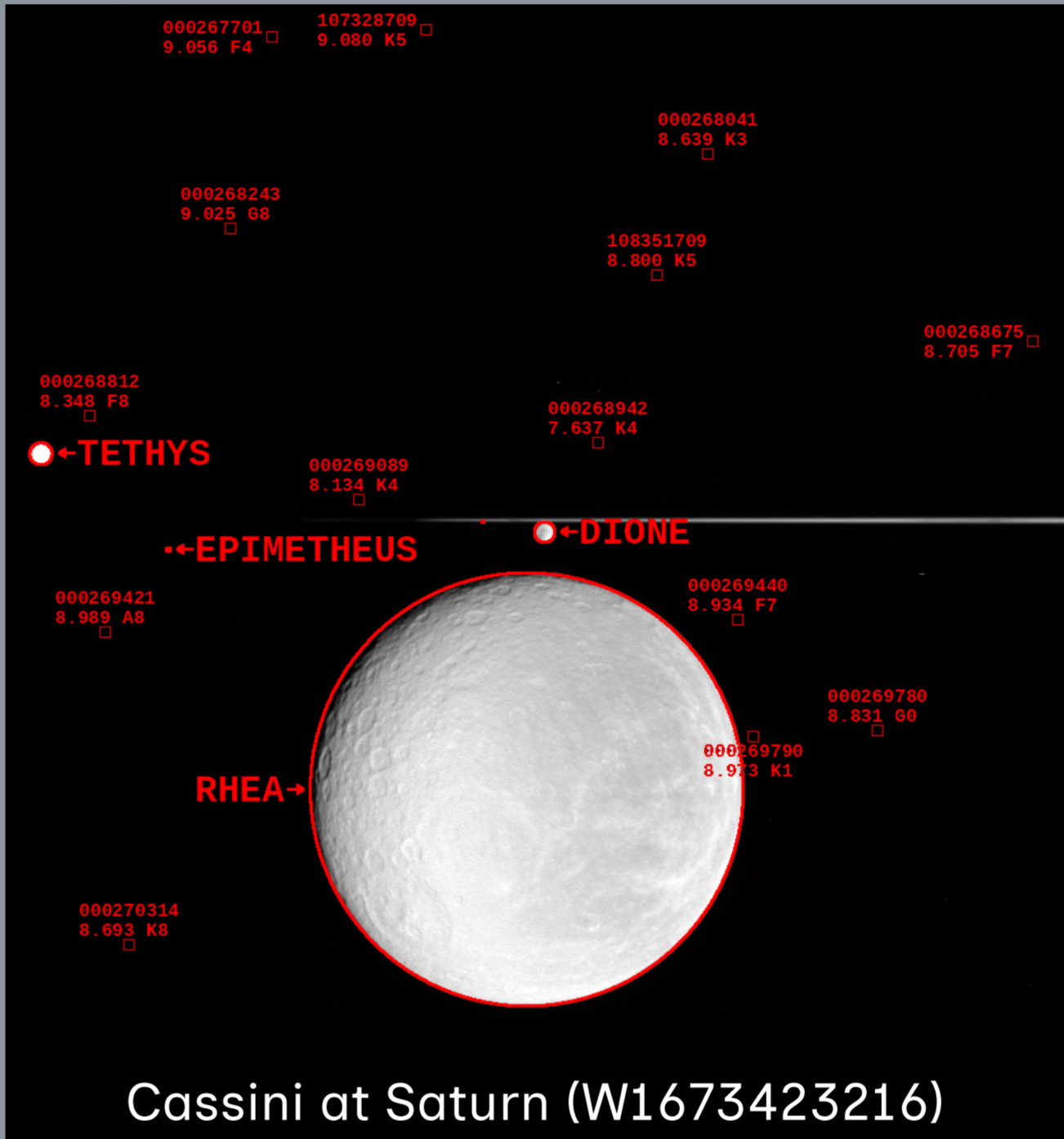
- We navigate images by modeling what we expect to be in the image and then using 2-D correlation to find the optimal offset that aligns the image with the model. Our models can include:
 - Stars (from UCAC4, Tycho, and the Yale Bright Star Catalog)
 - Bodies (planets and their satellites)
 - Ring features (including ones that are time-varying or multi-modal)
 - Titan's atmospheric shape
- Using the new offsets, we create replacement SPICE C kernels that can be used in existing software but contain precision pointing.
- We also create **summary diagrams** (see images at right) that show the contents of the image and the model used to match it. This allows the researcher to verify that the navigation is correct, and also serves as a useful reference to easily see what is in each image.
- All SPICE kernels and summary diagrams will be archived with the PDS.
- Our goal is to navigate all observations taken by Voyager ISS, Galileo SSI, Cassini ISS, and New Horizons LORRI that contain navigable features.



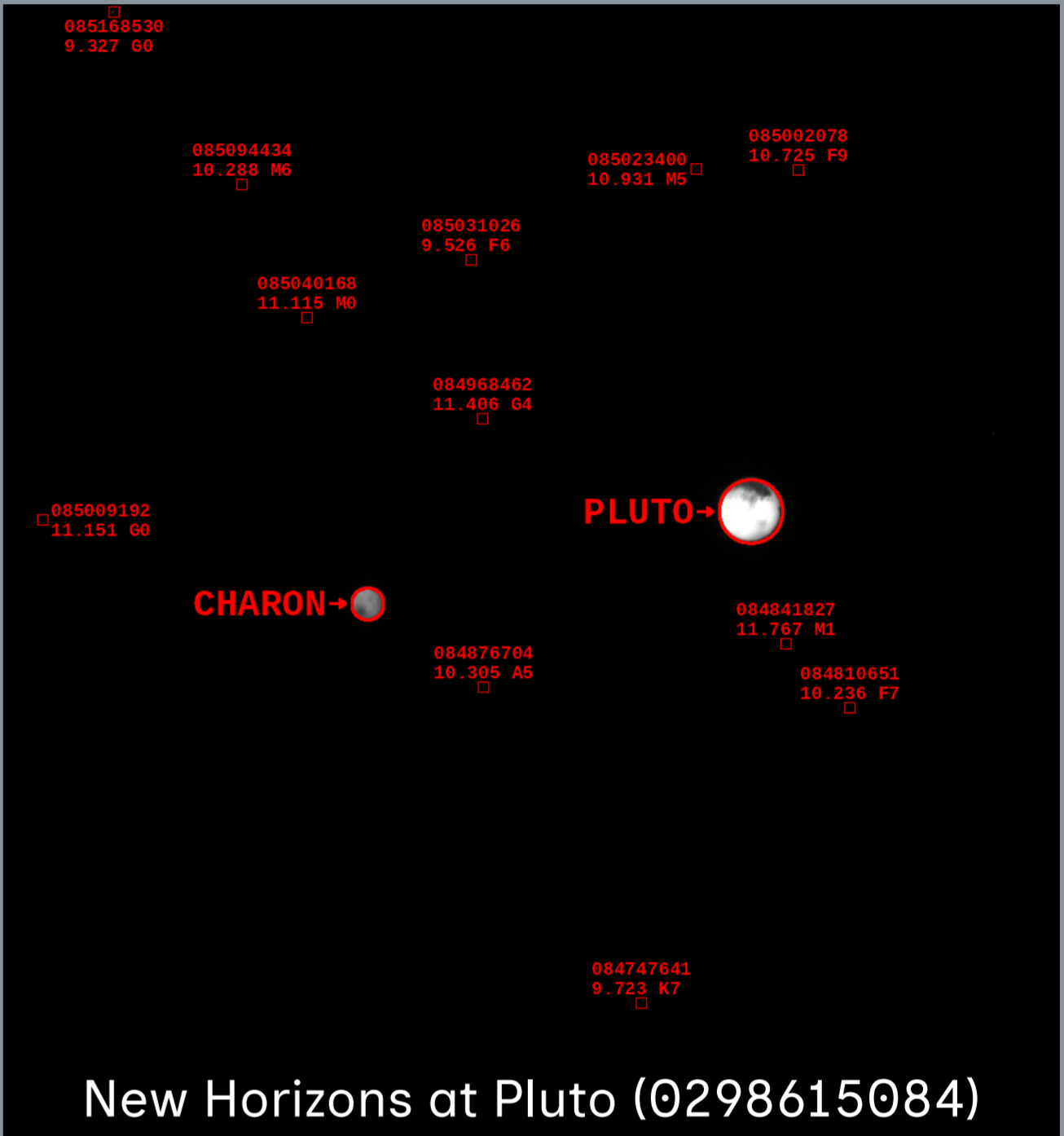
Voyager 2 at Neptune (C1148852)



Galileo at Earth (C0061498700R)



Cassini at Saturn (W1673423216)



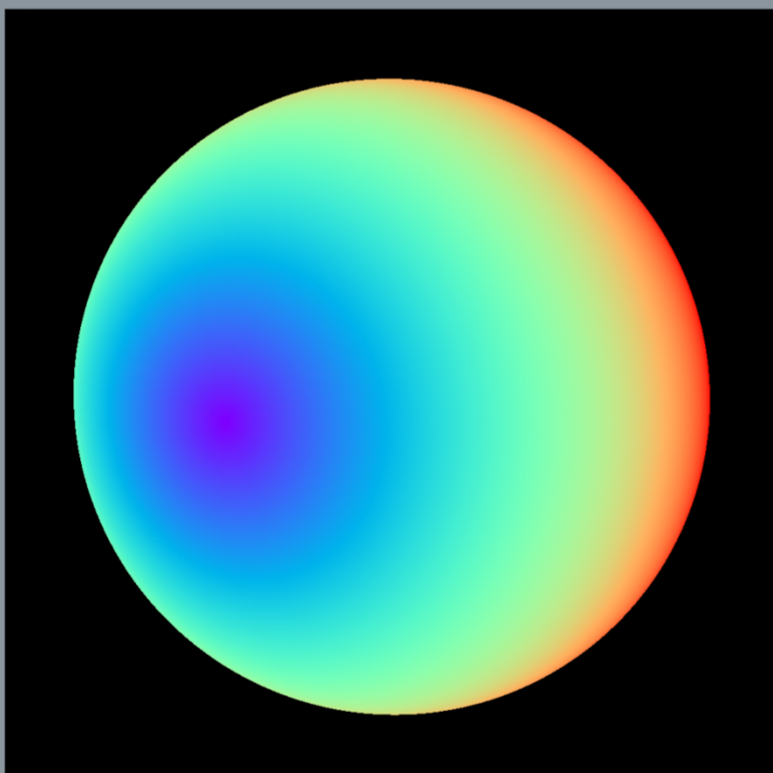
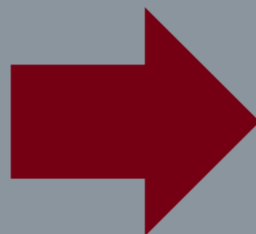
New Horizons at Pluto (0298615084)

Geometric Backplanes

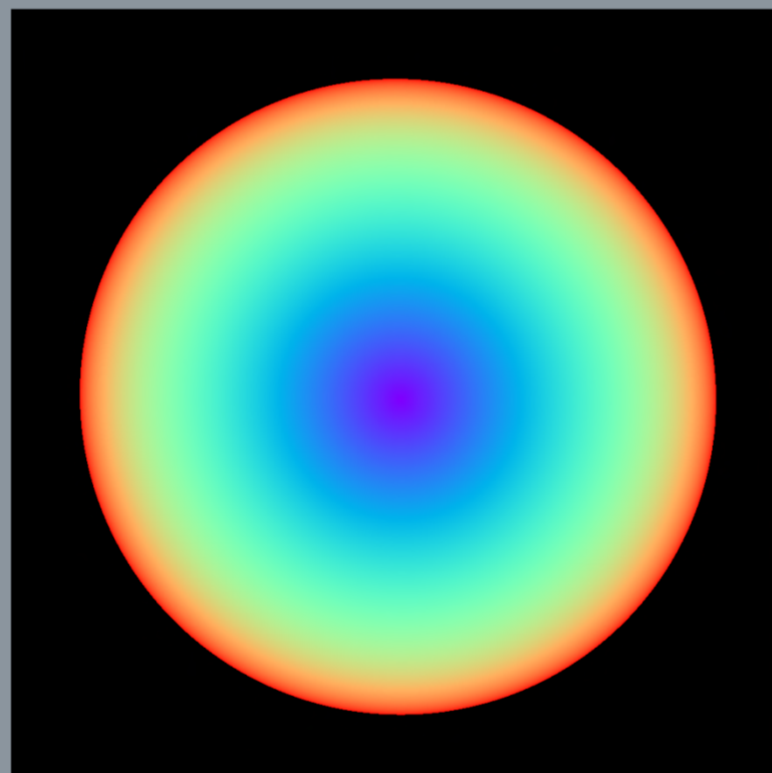
- In addition to new SPICE kernels and summary images, we plan to create and archive a set of **backplanes** for each image.
- These backplanes will consist of, for each body in the field of view, latitude, longitude, and surface resolution, and for the ring plane, radius, longitude, and resolution; we also include incidence, emission, and phase angles for both.
- These pre-computed backplanes can entirely eliminate the need for many scientists to learn the SPICE toolkit.



Cassini ISS - Mimas



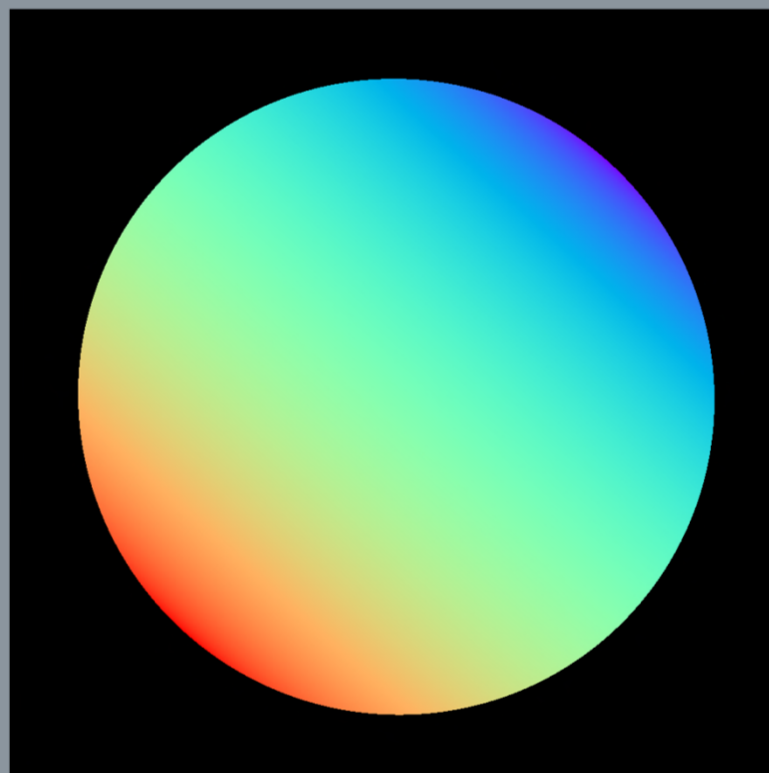
Incidence Angle



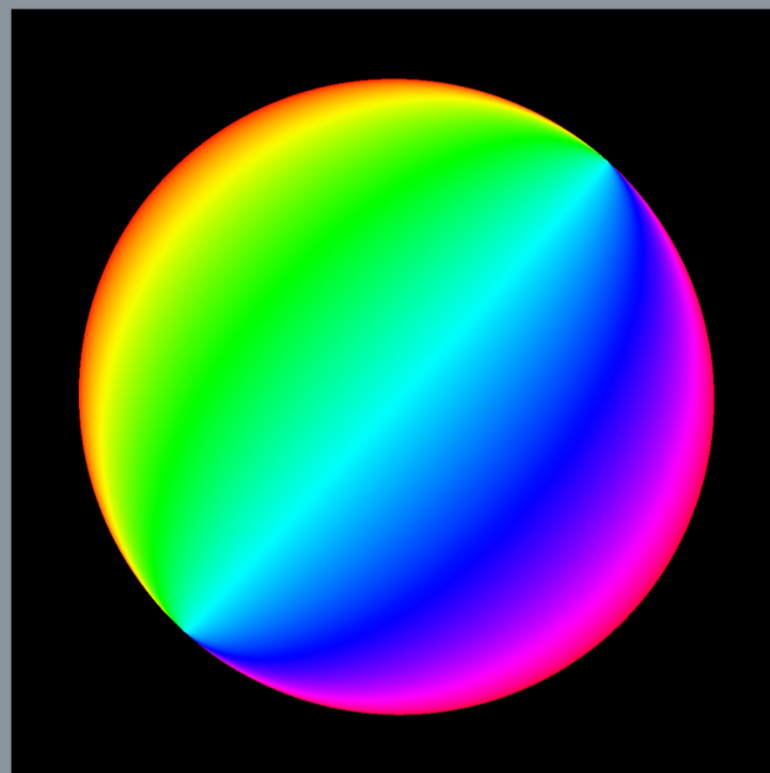
Emission Angle



Phase Angle



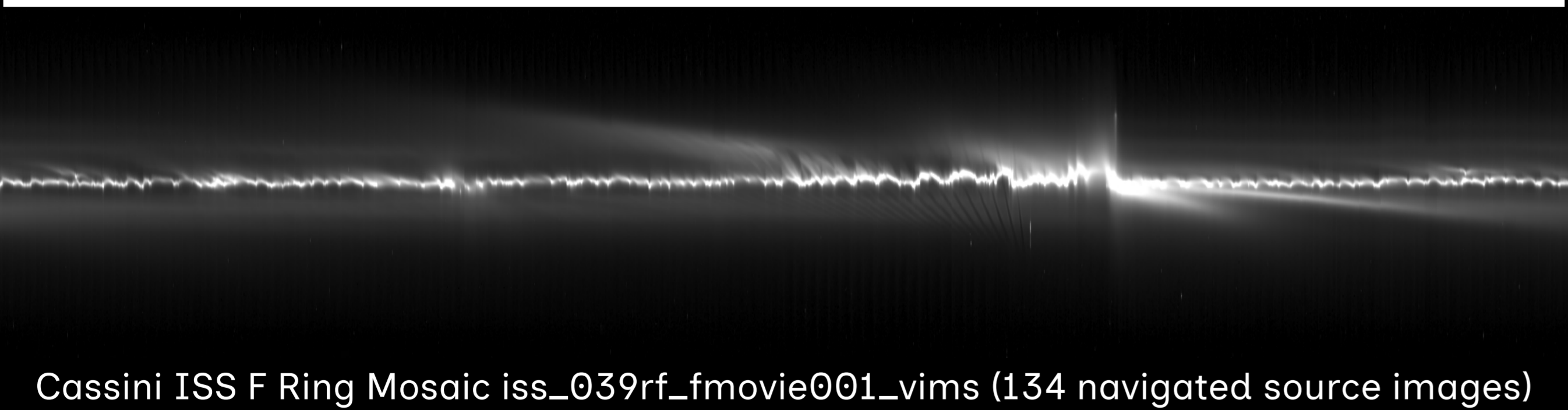
Latitude



Longitude

Example Research Application #1: Saturn's F Ring

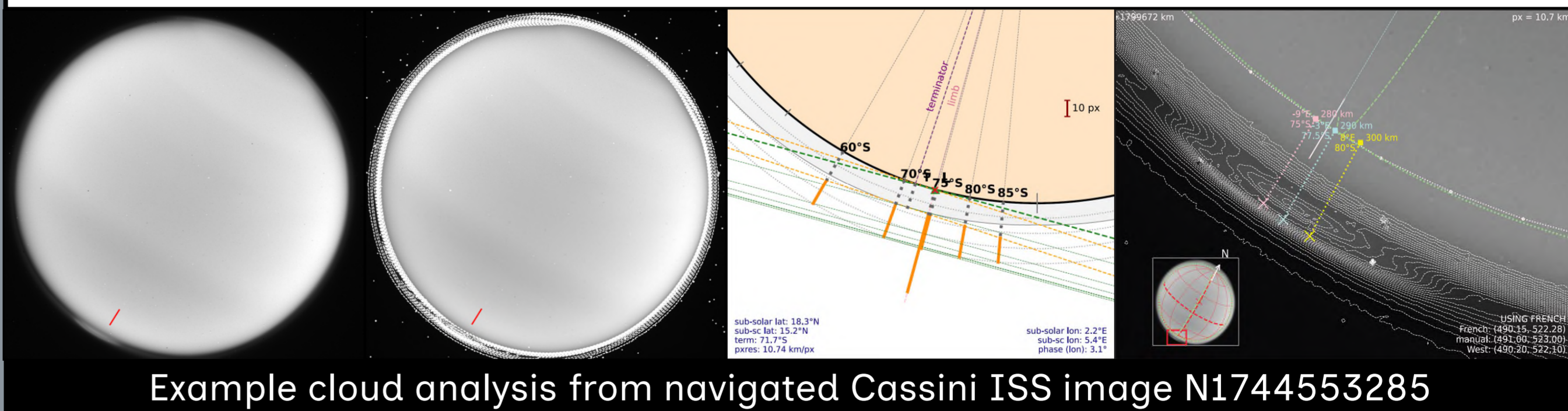
- An early version of this software was used to navigate over 20,000 Cassini ISS images of Saturn's F ring.
- Navigated images were reprojected onto a regular radius/longitude grid and stitched together to form mosaics.
- More than 300 mosaics and their associated reprojected images are being archived with the PDS Ring-Moon Systems Node.
- Scientific analysis of the mosaics is ongoing.
- See French *et al.* 2024, DPS #204.03; Lessard *et al.* 2022, DPS #317.01.



Cassini ISS F Ring Mosaic iss_039rf_fmovie001_vims (134 navigated source images)

Example Research Application #2: Titan's Clouds

- An early version of this software was used to navigate Cassini ISS images of Titan.
- Navigated images were used in the analysis of a south polar cloud.
- Precision navigation enabled the discovery that the cloud descended and expanded over this time period, providing data for modeling of Titan's atmosphere.
- See Hanson *et al.* 2025, GRL e2024GL113415.
- Also watch the presentation on Wednesday! EPSC-DPS2025-2211



Example cloud analysis from navigated Cassini ISS image N1744553285

→ → → We Want You! ← ← ←

Our project will be running for the next two years and early community input is extremely important!

→ Relative importance of various types of images

→ Evaluation of early results

→ Contents and format of summary images and backplanes

If you have a research project that would benefit from precision navigation of one of these four legacy missions, please get in touch with us to see if we can collaborate.

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We acknowledge NASA PDART/NFDAP grant #80NSSC25K7039 for funding this project.