T108: CASSINI'S CONTORTIONIST FLYBY OF TITAN. C. A. Wood[1], R. Lorenz[2], S. Wall[3], Y. Anderson[3], R. West[3] and the Cassini Radar Team [1]Planetary Science Institute, Tucson, AZ 85719, cwood@psi.edu. [2] JHU Applied Physics Laboratory, Laurel, MD. [3] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA.

Introduction: The Cassini spacecraft makes its 109th close flyby (T108!) of Titan on January 11, 2015. The observation design for this pass, perhaps more so than most, has been complicated by the desire to follow up on recent discoveries (notably, radar observations of Titan's seas on T104), as well as challenging attitude constraints to avoid solar heating of optical remote sensing instruments. T108 will be the last radar view of the northern seas until T126 in 2017. We will make the first public presentation of results from this pass at the meeting.

The traverse starts with SAR imaging from near the equator, travels north along the 20° of longitude meridian, and then switches to altimetry across Punga Mare and surrounding terrain near the north pole. After this long altimetry pass, SAR imaging is resumed briefly from 80° to 70°N, inspecting Ligeia Mare, and then back to more altimetry heading south to 55°N, and finally returning to SAR for the rest of the pass. This rather complicated sequence, the result of extensive scientific optimization and redesign, will allow quantitative investigation of Punga Mare (the last of Titan's three seas to be examined with altimetry), a re-observation of the 'magic island' [1], a prominent area of variable radar properties in Ligeia Mare, as well as new SAR coverage. The relatively long altimetry observations are conducted in part because while the spacecraft attitude during SAR observations is inflexible, altimetry allows freedom around the nadir (spacecraft –Z) axis, and so heating of CIRS and VIMS instrument radiators, a problem in the present season of Cassini flybys, can be reduced to acceptable levels.

The SAR mode creates images over swaths 200 – 300 km wide with about 350-2000 m resolution. SAR imaging of the same area along different passes provides stereo imaging for construction of regional topography maps, and tiepoint matching also constrains Titan's rotation state. Altimetry, acquired by a vertical pinging of the surface with a burst of radar, gives a high-precision (but narrow) topographic profile on land, and has proven to be a sensitive means of constraining wave activity on Titan's liquid surfaces [2]. Remarkably, altimetry observations have also proven able to detect the bottom of Titan's seas [3]. In the rest of this abstract, we describe the observations planned (Fig.1) and their rationale.

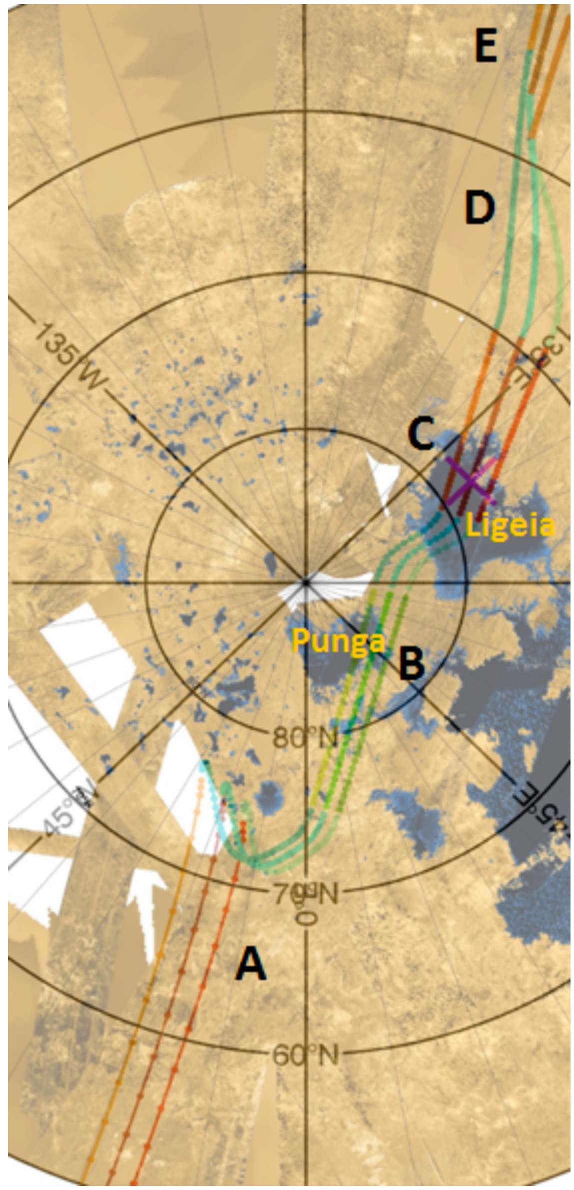

Fig.1 Polar view of TItan. Inbound SAR (A) is followed by a turn to nadir altimetry (B) over ~72N to 85N across part of Punga Mare. A turn to SAR over Ligeia (C) is then followed by a turn (D) to avoid heating, and then altimetry outbound (E). The beam centers converge during turn D due to the rotation about –Z to avoid heating.

First SAR Segment (A): Imaging of a ~200 km wide swath of *terra incognita* occurs along the longitudes of 15°-20° between the equator and 30°N, before continuing over previously imaged lakeland landscapes up to 70°N. The near equator zone starts with new coverage of Quivira, which is bright, material perhaps similar to Xanadu, and then passes across the impact crater Sinlap, which, with the one previous pass, will allow stereogrammetric production of a topographic map of the 80 km wide crater.

Coverage continues northward over previously unseen parts of Elpis Macula, a region of bright narrow linear features (old mountain belts?) mostly covered by a gray featureless material of uncertain origin. For the remainder of this pass from about 35° to 75° north, stereo coverage is obtained over previously imaged terrain. The northern end of the SAR imaging includes round depressions of proposed volcanic origin – additional stereo may help refine interpretations.

Punga Altimetry Pass (B): One of the unexpected scientific achievements of prior Cassini altimetry was that the radar beam can penetrate the methane/ethane filling the lakes, allowing determinations of depth and floor shape as well as the loss tangent of the fluid [2], which relates to the methane concentration. Previous passes across Ligeia and an estuary draining into Kraken found gently dipping bottom surfaces and depths of 160 and 35 m, respectively. The T108 data take across an edge of Punga completes Cassini's nadir bathymetry observations of Titan's seas. Because the specular reflection from exceptionally smooth (liquid) surfaces can be ~2 orders of magnitude brighter than from land, special care is being taken to adjust the attenuator settings of the altimeter to optimize the data quality.

Magic Island SAR Pass (C): Another surprising discovery from prior Radar imagery was detection of a brightening [1] in Ligeia Mare informally called the Magic Island. This patch of sea has been viewed before and since, and the "island" has radar properties and shape that are time-variant (analysis has excluded data processing artifacts of data) : local wind-wave roughening ('catspaw'), non-local surface roughening due to tidal or wind-driven currents focussed by shorelines/islands, or suspended sediments, are all possible explanations

Exiting Ligeia, the SAR beams pass over highly eroded material, crossing a zone of liquid-filled depressions such as the Vänern and Severn lakes.

Turn (D): Because of the northern summer geometry, it is necessary to switch to altimetry mode by 60°N, 135°E and turn to avoid overheating of other instruments. SAR data acquisition will continue during the turn, although image quality is usually poor.

Outbound Altimetry (E): Outbound altimetry continues down to ~ 35°N, 140°E, constraining Titan's global shape and local topography. .

HiSAR Regional Views: HiSAR [4] is an innovative single-beam SAR observation that acquires imaging when the Cassini spacecraft is too far from Titan for normal SAR operation. HiSAR images typically have lower resolution, but many more looks and thus lower speckle noise. There is both inbound and outbound HiSAR imaging, acquired before and after the main SAR and altimetry activity. Inbound HiSAR covers a poorly-seen area around 345°W, 15°N of bright material interspersed with dark dunes. The outbound imaging is centered at about 150°W, 50°N. This is a bland area with some circular depressions. More than half of this outbound HiSAR acquisition will be of previously un-imaged terrain, helping to fill coverage gaps.

We acknowledge the Cassini operations and science teams for accommodating our late replanning of these observations in order to maximize the scientific return of this, one of the few remaining RADAR flybys of Titan.

References: [1] Hofgartner, J. et al., Nature Geoscience, 7, 493-496, 2014. [2] Zebker, H. et al., Geophys. Res. Lett, 10.1002/ 2013GL058877, 2014.
[3] Mastrogiuseppe, M., et al., Geophys. Res. Lett., 10.1002/ 2013GL058618, 2014 [4] West, R. A. et al., IEEE Trans. Geosci. Rem. Sensing. 47, 1777-1795, 2009