OBSERVATIONS OF STELLAR OCCULTATIONS TO LOOK FOR PLUMES FROM DIONE AND TETHYS. C. J. Hansen[1], A. R. Hendrix[1], and L. W. Esposito[2], [1]Planetary Science Institute, 1700 Fort Lowell, Suite 106, Tucson, AZ 85719 (cjhansen@psi.edu), [2]University of Colorado, Boulder, CO.

Introduction: The Ultraviolet Imaging Spectrograph (UVIS) on the Cassini spacecraft has observed numerous occultations of stars by Enceladus' plume to characerize the composition, mass flux and structure of Enceladus' ongoing eruptive activity [1]. This powerful technique was also deployed to look for eruptive activity at Saturn's moons Dione and Tethys.

Dione. Dione's surface geology, not saturated with impact craters, shows evidence for re-surfacing. Cassini's magnetometer detected mass-loading of the environment close to Dione (0.72 kg/sec), more than can be attributed to sputtering of the surface, albeit at a much lower level than Enceladus [2]. In 2004 Cassini's Visible and Infrared Mapping Spectrometer (VIMS) detected enhanced brightening around the limb [3]. This transient event has not been seen again. Collectively these observations were suggestive of eruptive activity at Dione, making it worthwhile to use UVIS to search for erupting plumes.

Tethys. Near the end of the Cassini mission odd red streaks were observed to stain the surface of Tethys [4]. Seemingly unrelated to any surface feature, they were hypothesized to be some sort of subtle volatile release, also amenable to investigation via occultations.

Dione Occultation Observations: Dione's gravity is roughly twice that of Enceladus. Escape velocity is 510 km/sec. The maximum height of a plume with molecules with velocity just under escape velocity at 500 m/sec would be ~540 km. Perhaps more realistically, at a fissure surface temperature of 100K, escaping gas thermal velocity would be 342 m/sec, giving a plume height of ~250 km.

With this in mind we scheduled UVIS observations of 10 stellar occultations. One was lost due to downlink issues. The geographic distribution of the occultation sites is shown in Figure 1. Ingress and egress coordinates for the occultations are listed in Table 1. Each symbol in Figure 1 represents an ingress or egress point. The colors simply refer to when in the mission the occultation was observed; red symbols show the occultation that was lost. The circle shows the area over which a ray piercing a plume should show absorption by plume gases, i.e. the occultation would not necessarily need to pierce the eruption point – it could be further away and still detect an umbrella-shaped distribution of gas arcing back to the surface.

Each stellar occultation was observed using the UVIS Far Ultraviolet channel (FUV) and the High Speed Photometer (HSP).

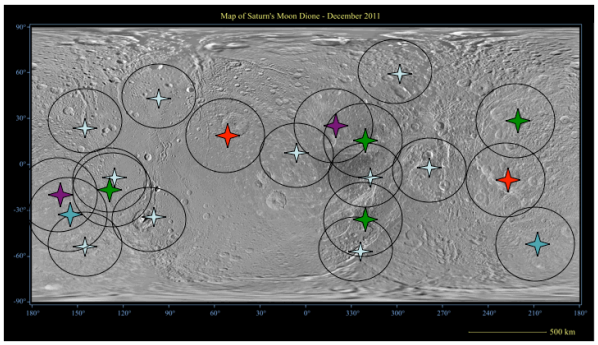

Figure 1. The ingress and egress of the star occultations are shown by the colored symbols. The circles show the locus radius over which we would expect to detect an absorption by the plume, ~250 km. Any source on or within the indicated circle should have been detectable.

Table 1. Occultation Coordinates

Date	Star		Latitude	Longitude (W)
12/2005	66 Oph	Ingress	-53.8	148.1
		Egress	-52.4	327.9
5/2007	Alp Leo	Ingress	48.5	94.9
		Egress	61.9	304.3
9/2009	Eps CMa	Ingress	11.5	2.5
		Egress	26.3	163.1
7/2012	Alp Vir	Ingress	-4.7	137.9
		Egress	-4.5	321
8/2012	Kap Ori	Ingress	-32.0	104
		Egress	1.5	287
4/2013	Alp Lyr	Ingress	-33.3	154.1
		Egress	-54.5	208
2/2016	Alp Vir	Ingress	-22.4	166.6
		Egress	24.4	346
3/2016	Alp Vir	Ingress	17.8	53.3
	(lost)	Egress	-8.5	230.4
2/2017	Bet Cru	Ingress	-21.7	128.8
		Egress	19.3	319
4/2017	Alp Eri	Ingress	30.8	212
		Egress	-36.7	329

Dione data analysis. Figure 2 shows an example of the FUV data obtained in the April 2017 occultation of alpha Eridani. The integration time for the FUV was 2 sec. The spectrum is summed over wavelength and plotted vs time. We know from Enceladus observations that UVIS can detect water vapor column densities down to 10^{14} molecules/cm^2; any eruption (if it is happening at all) would have to be at a level less than that to escape detection. We see no gas absorption signature in either the FUV or the corresponding HSP data. Data from all 9 occultations were processed similarly.

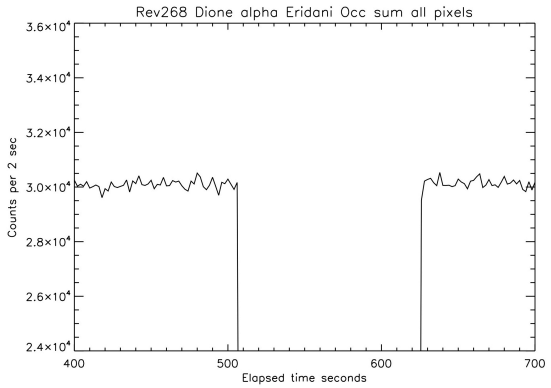

Figure 2. The FUV data profile from the 2017 occultation of alpha Eridani shows no absorption prior to the ingress or after egress that would be indicative of gas from an eruption.

Dione Results: None of the Dione occultations observed show any indication of eruptive activity. This is not a severe constraint on Dione's potential for cryovolcanism, but does indicate that at the time of the stellar occultation in the places that the ray to the star pierced there was not an ongoing eruption.

This is an example of a low probability but high payoff type of observation. Had we detected an eruption with UVIS the entire suite of Cassini's instruments would have been deployed to investigate the source and nature of Dione's cryovolcanism.

Tethys Results: UVIS observed 3 stellar occultations by Tethys, listed in Table 2. The ingress of 66 Ophiuchus was very close to one of the red streaks. FUV data for this occultation is shown in Figure 3.

No gas absorption was detected on any of the occultations. The upper limit column density depends on the composition; for possible gases such as NH_3, C_2H_4, or CH_3OH the upper limit is ~10^{15} cm^{-2}.

We also estimated particulate content that could be detected by UVIS. The optical depth detectable is limited by noise. We used the FUV summed over wavelength to calculate a noise equivalent optical depth limit of 0.04. Assuming the particles are ice with a radius of 2 *u*m the upper limit for particulate column density is ~10^{-5} gm/cm^2.

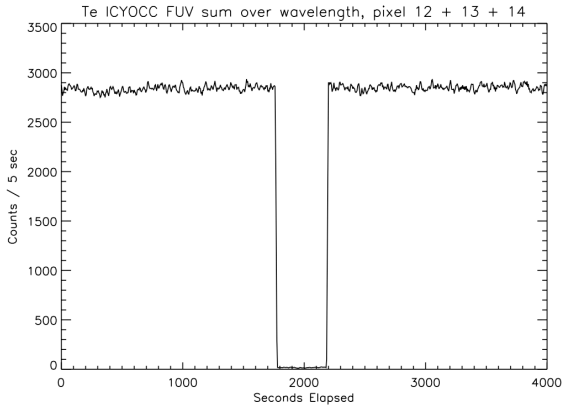

Figure 3. FUV data is summed over wavelength and plotted vs. time for the 66 Oph occultation. No absorbing gas is detected at ingress or egress.

Table 2. Tethys Occultation Coordinates

Date	**Star**		**Latitude**	**Longitude (W)**
9/2005	Bet Tau	Ingress	8.7	327.3
		Egress	-23.3	157.5
5/2006	66 Oph	Ingress	22.8	33.8
		Egress	28.0	213.7
6/2017	Eps Ori	Ingress	8.1	116.5
		Egress	34.7	294.0

References: [1] Hansen, C. J. et al. (2017) *GRL* 44:672. [2] Khurana, K. et al. (2007) *AGU SM*, Abstract P43A-03. [3] Clark, R. et al. (2008), *Icarus* 193:372. [4] Schenk, P. (2015) *AGU FM*, Abstract P21B-02.