



15076 - The Recent Mass Loss History of the Red Hypergiant VY CMa

Cycle: 25, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

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VISITS

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
01	(1) V-VY-CMA (2) VY-CMA-KNOTS-W1 (3) VY-CMA-KNOTS-W2 (4) VY-CMA-KNOTS-E1 CCDFLAT WAVE	STIS/CCD	1	19-Jul-2017 13:01:19.0	yes

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
02	(1) V-VY-CMA (5) VYCMA-KNOTS-S1 (6) VYCMA-KNOTS-S2 (7) VYCMA-KNOTS-S3 CCDFLAT WAVE	STIS/CCD	1	19-Jul-2017 13:01:23.0	yes

2 Total Orbits Used

ABSTRACT

The high mass loss episodes observed in evolved massive stars across the HR Diagram remain a mystery. With its very visible discrete ejecta, VY CMa is the perfect star to explore the origin of these events in the evolved yellow and red supergiants. VY CMa's high mass loss rate and its unusual chemistry suggest that it is near the end of the red supergiant stage or possibly in a second short-lived red supergiant stage. Its HST/WFPC2 images are distinguished by prominent large-scale arcs and clumps of knots with minimum masses of 3×10^{-3} Msun. They were ejected in separate events over the past 800 years in different directions by localized processes from different regions on the star. The physical mechanism that drives these high mass loss events is not understood, but the evidence increasingly suggests that surface activity and magnetic fields are important. The circumstellar ejecta is also filled with numerous small knots and filaments suggesting that this mass loss process has been more frequent. ALMA measurements of the polarization in the dust closest to the star reveals grains aligned by the local magnetic field via a process that must be occurring on relatively short time scales. This material contains dust from the most recent mass loss events. Our proposed observations of the small knots and filaments closest to the star are designed to probe VY CMa's innermost circumstellar ejecta, the frequency of the recent ejections, and set limits on the timescales for the mass loss process.

OBSERVING DESCRIPTION

VY CMa is a very luminous red supergiant with a complex extended circumstellar ejecta. The purpose of these observations is to measure the Doppler velocities of several knots close to the star that are very likely from its more recent mass loss events. The knots are distributed around the star less than 0.5 arcsec to the east and west and in two groups or clumps about one arcsec to the south. Some of the knots are about 0.1 arcsec across while others are more diffuse. To cover the knots requires two different slit orientations and therefore two visits.

Proposal 15076 - EW Knots (01) - The Recent Mass Loss History of the Red Hypergiant VY CMa

Wed Jul 19 17:01:25 GMT 2017

Visit	Proposal 15076, EW Knots (01), implementation Diagnostic Status: No Diagnostics Scientific Instruments: STIS/CCD Special Requirements: ORIENT 61.35D TO 65.35 D; ORIENT 241.35D TO 245.35 D					
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(1)	V-VY-CMA	RA: 07 22 58.3288 (110.7430367d) Dec: -25 46 3.24 (-25.76757d) Equinox: J2000		V=7.95+/-0.5	Reference Frame: ICRS
	<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Extended=NO					
	(2)	VYCMA-KNOTS-W1	Offset from V-VY-CMA RA Offset: -7.528E-5 Degrees Dec Offset: 0.0 Arcsec		V=(?) 1.5e-13 ergs/cm ² /sec ⁻¹ /A	Offset Position (VYCMA-KNOTS-W1)
	<i>Comments: Two knots and diffuse ejecta 0.27 arcsec west of the star. Flux is for the brightest knot at 6560A, 50 times fainter than the star.</i> Offset is given in degrees due to uncertainty whether or not offset in RA is corrected for cos decl. Offset in RA in sec of time is 0.02s, corrected for cos dec it is 0.018s Extended=NO					
	(3)	VYCMA-KNOTS-W2	Offset from V-VY-CMA RA Offset: -1.5222E-4 Degrees Dec Offset: 0.0 Arcsec		V=(?) 4e-14 ergs/cm ² /sec ⁻¹ /A	Offset Position (VYCMA-KNOTS-W2)
	<i>Comments: A knot 0.55 arcsec west of the star, flux measured at 6560A.</i> Offset is given in degrees due to uncertainty whether or not offset in RA is corrected for cos decl. Offset in RA in sec of time is 0.04s, corrected for cos dec it is 0.036s Extended=NO					
	(4)	VYCMA-KNOTS-E1	Offset from V-VY-CMA RA Offset: 1.3083E-4 Degrees Dec Offset: 0.0 Arcsec		V=(?) 4e-15 ergs/cm ² /sec ⁻¹ /A	Offset Position (VYCMA-KNOTS-E1)
	<i>Comments: Diffuse ejecta and knot 0.47 arcsec east of the star, 1000 times fainter than star, flux measured at 6560A.</i> Offset is given in degrees due to uncertainty whether or not offset in RA is corrected for cos decl. Offset in RA in sec of time is 0.035s, corrected for cos dec it is 0.0315s Extended=NO					

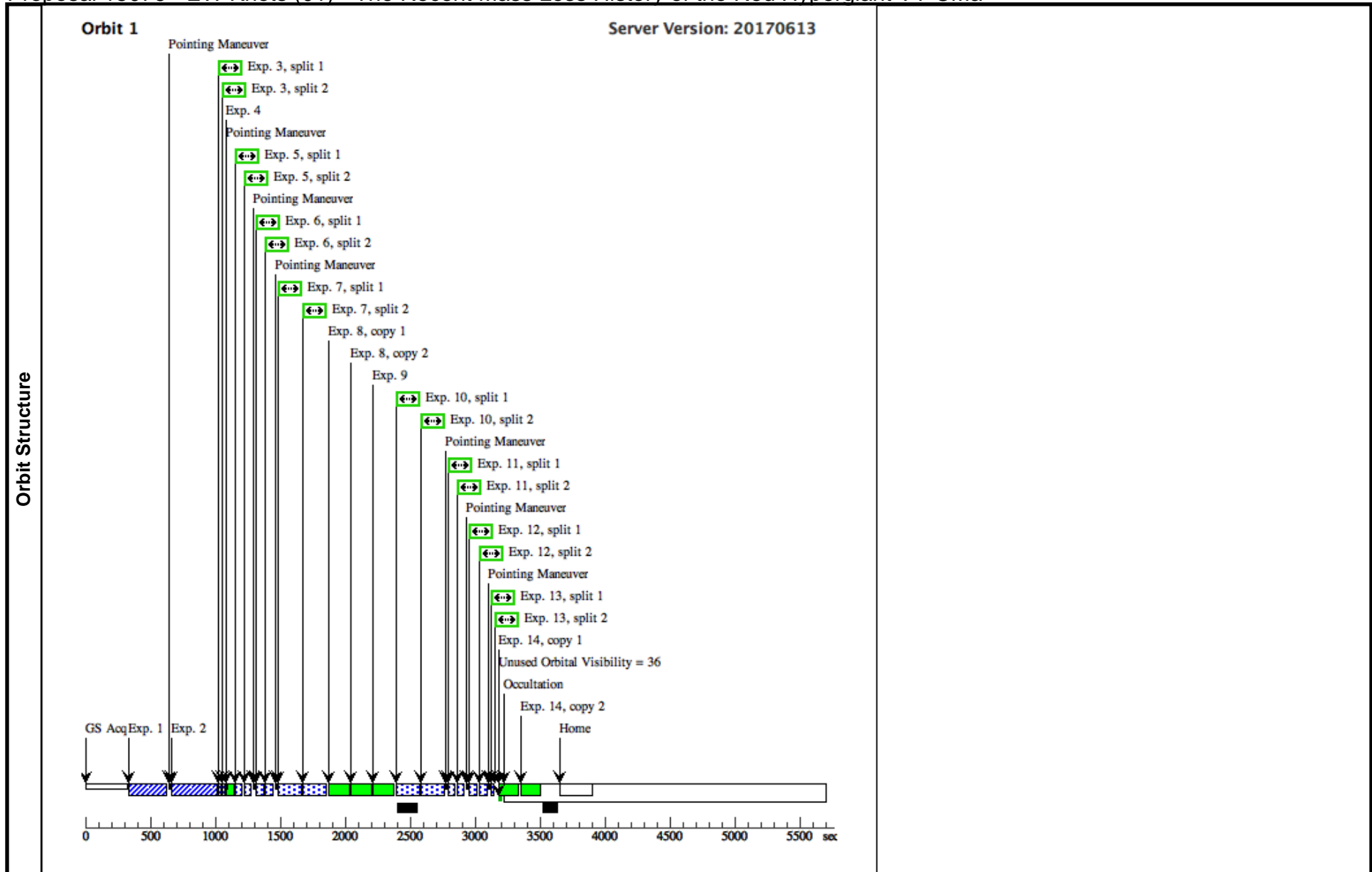
Proposal 15076 - EW Knots (01) - The Recent Mass Loss History of the Red Hypergiant VY CMA

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ACQ	(1) V-VY-CMA	STIS/CCD, ACQ, F25ND3	MIRROR				0.3 Secs (0.3 Secs) [==>]	[1]
<p><i>Comments: VY CMA is extremely bright especially in the red where the detector is sensitive. The ETC for the acquisition with the mirror and F25ND3 gave a S/N of 100 with a 0.3 sec exposure time. Time to saturation is 9.8s. We have observed eta Car numerous times with successful acquisitions using very short integration times like this. You can adjust the integration time if you think it necessary.</i></p>									
2	Peak up	(1) V-VY-CMA	STIS/CCD, ACQ/PEAK, 52X0.1	G750M 8561 A				0.5 Secs (0.5 Secs) [==>]	[1]
<p><i>Comments: A precise peakup is required because we will be offsetting to nearby knots and filaments within 1 arcsec of the star. The apparent position of the star is wavelength dependent. For that reason we are doing the peakup at one of the wavelengths where we will be observing, ~ 8500A. We chose this tilt because the spectrum is continuum with some absorption lines. The 7795 tilt is dominated by VERY strong emission of K I. The ETC for spectroscopy with the 52 x 0.1 slit and the 8561 tilt gives a S/N of 56 with a 0.5 sec integration time. Saturation is at 15 sec. The flux of VY CMA at ~8500A is 1.18e-11 erg/s/cm2/A based on its SED. You can adjust this time if necessary.</i></p>									
3	VY CMA	(1) V-VY-CMA	STIS/CCD, ACCUM, 52X0.1	G750M 8561 A	SIZEAXIS2=300; WAVECAL=NO; GAIN=4			2 Secs (2 Secs) [==>(Split 1)] [==>(Split 2)]	[1]
<p><i>Comments: Very short exposure on central star VY CMA</i></p>									
4	Wavecal	WAVE	STIS/CCD, ACCUM, 52X0.1	G750M 8561 A				[==>]	[1]
<p><i>Comments: wavelength calibration for 8561A</i></p>									
5	Knots W1	(2) VY CMA-KNOT S-W1	STIS/CCD, ACCUM, 52X0.1	G750M 8561 A	CR-SPLIT=2; SIZEAXIS2=300; WAVECAL=NO			80 Secs (80 Secs) [==>(Split 1)] [==>(Split 2)]	[1]
<p><i>Comments: Two bright knots plus fainter ejecta within 0.3 arcsec west of the star.</i></p>									
6	Knots W2	(3) VY CMA-KNOT S-W2	STIS/CCD, ACCUM, 52X0.1	G750M 8561 A	CR-SPLIT=2; SIZEAXIS2=300			100 Secs (100 Secs) [==>(Split 1)] [==>(Split 2)]	[1]
<p><i>Comments: Faint knot and ejecta 0.5 arcsec west of the star.</i></p>									
7	Knots E1	(4) VY CMA-KNOT S-E1	STIS/CCD, ACCUM, 52X0.1	G750M 8561 A	CR-SPLIT=2; SIZEAXIS2=400			320 Secs (320 Secs) [==>(Split 1)] [==>(Split 2)]	[1]
<p><i>Comments: Faint knot and ejecta 0.5 arcsec west of the star..</i></p>									
8	CCDFLAT	CCDFLAT	STIS/CCD, ACCUM, 52X0.1	G750M 8561 A				[==>(Copy 1)] [==>(Copy 2)]	[1]
<p><i>Comments: CCDFLAT for 8561A</i></p>									
9	Wavecal	WAVE	STIS/CCD, ACCUM, 52X0.1	G750M 7795 A				[==>]	[1]
<p><i>Comments: wavelength calibration for 7795A</i></p>									
10	Knots E1	(4) VY CMA-KNOT S-E1	STIS/CCD, ACCUM, 52X0.1	G750M 7795 A	CR-SPLIT=2; SIZEAXIS2=400			320 Secs (320 Secs) [==>(Split 1)] [==>(Split 2)]	[1]
<p><i>Comments: Faint knot and ejecta 0.5 arcsec west of the star.</i></p>									
11	Knots W1	(2) VY CMA-KNOT S-W1	STIS/CCD, ACCUM, 52X0.1	G750M 7795 A	CR-SPLIT=2; SIZEAXIS2=300			80 Secs (80 Secs) [==>(Split 1)] [==>(Split 2)]	[1]
<p><i>Comments: Two bright knots plus fainter ejecta within 0.3 arcsec west of the star.</i></p>									

Exposures

Proposal 15076 - EW Knots (01) - The Recent Mass Loss History of the Red Hypergiant VY CMa

12	Knots W2 S-W2	(3) VYCMa-KNOT	STIS/CCD, ACCUM, 52X0.1	G750M 7795 A	CR-SPLIT=2; SIZEAXIS2=300	100 Secs (100 Secs)	
						[==>(Split 1)]	[1]
						[==>(Split 2)]	
<i>Comments: Faint knot and ejecta 0.5 arcsec west of the star.</i>							
13	VY CMa	(1) V-VY-CMA	STIS/CCD, ACCUM, 52X0.1	G750M 7795 A	SIZEAXIS2=300; GAIN=4	1 Secs (1 Secs)	
						[==>(Split 1)]	[1]
						[==>(Split 2)]	
<i>Comments: Very short exposure on central star VY CMa at 7795A</i>							
14	CCDFLAT	CCDFLAT	STIS/CCD, ACCUM, 52X0.1	G750M 7795 A		[==>(Copy 1)]	
						[==>(Copy 2)]	[1]
<i>Comments: CCDFLAT for 7795A</i>							



Proposal 15076 - S and SW Knots (02) - The Recent Mass Loss History of the Red Hypergiant VY CMa

Wed Jul 19 17:01:25 GMT 2017

Visit	Proposal 15076, S and SW Knots (02), implementation Diagnostic Status: No Diagnostics Scientific Instruments: STIS/CCD Special Requirements: ORIENT 168.35D TO 172.35 D; ORIENT 348.35D TO 352.35 D					
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(1)	V-VY-CMA	RA: 07 22 58.3288 (110.7430367d) Dec: -25 46 3.24 (-25.76757d) Equinox: J2000		V=7.95+/-0.5	Reference Frame: ICRS
	<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Extended=NO					
	(5)	VYCMA-KNOTS-S1	Offset from V-VY-CMA RA Offset: 0.0 Secs Dec Offset: -0.716 Arcsec		V=(?) 4e-14 ergs/cm ² /sec ¹ /A	Offset Position (VYCMA-KNOTS-S1)
	<i>Comments: Knots in the S and SW clumps 0.7 arcsec south of the star. 100 - 300 times fainter than star at 6560A.</i> Extended=NO					
	(6)	VYCMA-KNOTS-S2	Offset from V-VY-CMA RA Offset: 0.0 Secs Dec Offset: -1.088 Arcsec		V=(?) 4e-14 ergs/cm ² /sec ¹ /A	Offset Position (VYCMA-KNOTS-S2)
	<i>Comments: Knots in the S and SW clump 1 arcsec south of the star. 100 -300 times fainter than star at 6560A</i> Extended=NO					
	(7)	VYCMA-KNOTS-S3	Offset from V-VY-CMA RA Offset: 0.0 Secs Dec Offset: -1.425 Arcsec		V=(?) 4e-14 ergs/cm ² /sec ¹ /A	Offset Position (VYCMA-KNOTS-S3)
	<i>Comments: Knots in the S and SW clumps 1.4 arcsec south of the star. 100 - 300 times fainter than star at 6560A.</i> Extended=NO					

Proposal 15076 - S and SW Knots (02) - The Recent Mass Loss History of the Red Hypergiant VY CMa

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ACQ	(1) V-VY-CMA	STIS/CCD, ACQ, F25ND3	MIRROR				0.3 Secs (0.3 Secs) [==>]	[1]
<p><i>Comments: VYCMa is extremely bright especially in the red where the detector is sensitive. The ETC for the acquisition with the mirror and F25ND3 gave a S/N of 100 with a 0.3 sec exposure time. Time to saturation is 9.8s. We have observed eta Car numerous times with successful acquisitions using very short integration times like this. You can adjust the integration time if you think it necessary.</i></p>									
2	Peak up	(1) V-VY-CMA	STIS/CCD, ACQ/PEAK, 52X0.1	G750M 8561 A				0.5 Secs (0.5 Secs) [==>]	[1]
<p><i>Comments: A precise peakup is required because we will be offsetting to nearby knots and filaments within 1 arcsec of the star. The apparent position of the star is wavelength dependent. For that reason we are doing the peakup at one of the wavelengths where we will be observing, ~ 8500A. We chose this tilt because the spectrum is continuum with some absorption lines. The 7795 tilt is dominated by VERY strong emission of K I. The ETC for spectroscopy with the 52 x 0.1 slit and the 8561 tilt gives a S/N of 56 with a 0.5 sec integration time. Saturation is at 15 sec. The flux of VY CMa at ~8500A is 1.18e-11 erg/s/cm2/A based on its SED. You can adjust this time if necessary.</i></p>									
3	VY CMa	(1) V-VY-CMA	STIS/CCD, ACCUM, 52X0.2	G750M 8561 A	WAVECAL=NO; GAIN=4; SIZEAXIS2=300			2 Secs (2 Secs) [==>(Split 1)] [==>(Split 2)]	[1]
<p><i>Comments: Very short exposure on central star VY CMa</i></p>									
4	Wavecal	WAVE	STIS/CCD, ACCUM, 52X0.2	G750M 8561 A				[==>]	[1]
<p><i>Comments: wavelength calibration for 8561A</i></p>									
5	Knots S1	(5) VYCMa-KNOT S-S1	STIS/CCD, ACCUM, 52X0.2	G750M 8561 A	CR-SPLIT=2; SIZEAXIS2=300			100 Secs (160 Secs) [==>80.0 Secs (Split 1)] [==>80.0 Secs (Split 2)]	[1]
<p><i>Comments: Several knots along slit 0.7 arcsec south of star.</i></p>									
6	Knots S2	(6) VYCMa-KNOT S-S2	STIS/CCD, ACCUM, 52X0.2	G750M 8561 A	CR-SPLIT=2; SIZEAXIS2=300			160 Secs (160 Secs) [==>(Split 1)] [==>(Split 2)]	[1]
<p><i>Comments: Faint knots 1 arcsec south of the star.</i></p>									
7	Knots S3	(7) VYCMa-KNOT S-S3	STIS/CCD, ACCUM, 52X0.2	G750M 8561 A	CR-SPLIT=2; SIZEAXIS2=300			200 Secs (200 Secs) [==>(Split 1)] [==>(Split 2)]	[1]
<p><i>Comments: Faint knots 1.4 arcsec south of the star.</i></p>									
8	CCDFLAT	CCDFLAT	STIS/CCD, ACCUM, 52X0.2	G750M 8561 A				[==>(Copy 1)] [==>(Copy 2)]	[1]
<p><i>Comments: CCDFLAT for 8561A</i></p>									
9	Wavecal	WAVE	STIS/CCD, ACCUM, 52X0.2	G750M 7795 A				[==>]	[1]
<p><i>Comments: wavelength calibration for 7795A</i></p>									
10	Knots S3	(7) VYCMa-KNOT S-S3	STIS/CCD, ACCUM, 52X0.2	G750M 7795 A	CR-SPLIT=2; SIZEAXIS2=300			200 Secs (200 Secs) [==>(Split 1)] [==>(Split 2)]	[1]
<p><i>Comments: Faint knots 1.4 arcsec south of the star.</i></p>									
11	Knots S2	(6) VYCMa-KNOT S-S2	STIS/CCD, ACCUM, 52X0.2	G750M 7795 A	CR-SPLIT=2; SIZEAXIS2=300			160 Secs (160 Secs) [==>(Split 1)] [==>(Split 2)]	[1]
<p><i>Comments: Faint knots 1 arcsec south of the star.</i></p>									

Exposures

Proposal 15076 - S and SW Knots (02) - The Recent Mass Loss History of the Red Hyperqiant VY CMa

12	Knots S1 S-S1	(5) VYCMa-KNOT	STIS/CCD, ACCUM, 52X0.2	G750M 7795 A	CR-SPLIT=2; SIZEAXIS2=300	100 Secs (160 Secs)	
						[==>80.0 Secs (Split 1)]	[1]
						[==>80.0 Secs (Split 2)]	
<i>Comments: Several knots along slit 0.7 arcsec south of star.</i>							
13	VY CMa	(1) V-VY-CMA	STIS/CCD, ACCUM, 52X0.2	G750M 7795 A	SIZEAXIS2=300; GAIN=4	1 Secs (1 Secs)	
						[==>(Split 1)]	[1]
						[==>(Split 2)]	
<i>Comments: Very short exposure on central star VY CMa at 7795A</i>							
14	CCDFLAT	CCDFLAT	STIS/CCD, ACCUM, 52X0.2	G750M 7795 A		[==>(Copy 1)]	
						[==>(Copy 2)]	[1]
<i>Comments: CCDFLAT for 7795A</i>							

