13848 - Massive Stars and their Siblings: the Extreme End of the Companion Mass Function

Cycle: 22, Proposal Category: GO

(Availability Mode: SUPPORTED)

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VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) TR14-OFFSET1 (3) TR14-MAG6	WFC3/IR	1	04-Nov-2014 21:07:11.0	yes
02	(2) TR14-OFFSET2 (4) TR14-MAG8	WFC3/IR	1	04-Nov-2014 21:07:17.0	yes

2 Total Orbits Used

ABSTRACT

The gold-rush for detecting exoplanets has lead to an exponential improvement of optimization algorithms for high-contrast imaging optimized for HST. We propose to exploit these to probe the virtually unexplored population of low mass stars in the very close vicinity of young massive stars in order to

I. progress our understanding of how low-mass stars form and survive under the influence of the ionizing radiation of their massive host and
II. provide urgently needed constraints on competing theories of massive star formation by measuring their multiplicity.

The high spatial and temporal stability of HST's point spread function is essential for the detection of very faint companions down to sub-arcsecond separations even in crowded regions at contrast up to delta-mag ~ 10, i.e. flux ratios up to 10,000. Furthermore the characterization of the low mass companions calls for wavelength bands largely affected by absorption by H2O in the earth's atmosphere. To achieve this goal we propose to use WFC3/IR to observe two adjacent fields in the center of the very young, nearby star cluster Trumpler 14, which harbors a rich population of massive stars.

OBSERVING DESCRIPTION

Our goal is to identify with WFC3/IR (sub)-stellar companions candidates to massive stars in the stellar nursery Tr14 in two medium band filters F127M and F139M. In cycle 21 we have four orbits, which will be used in the following manner.

- We maximize the number of stars detected by using a mosaicking strategy where we cover two pointings with only minimal overlap between each. Each pointing will be carried out in a single orbit i.e. F127M: 1+1, F139M: 1+1. These exposures have been optimized to target specifically the stars that are between 10-13 mag, where we saturate the inner ~0.2" of the PSF of each star in each exposure.

- Additionally within each orbit we have inserted several short exposures using medium (256) and small (64) subarrays. The medium subarray exposure is optimized for stars between 8-10 mag and the small subarray exposure is specifically targeting the two brightest stars (one of which has an inferred mass of about 120 solar masses) using the same strategy as in the full frame images.
- We will reduce our data using the Karhunen-Loeve Image Processing (KLIP) algorithm described in Soummer, Pueyo and Larking (2012). This algorithm uses a library of reference PSF in order to build a set of eigen-modes representative of the statistical properties of the telescope+instrument quasi-static response.
- The KLIP algorithm works optimally on Nyquist samples PSFs, which will not be the case for the raw WFC3 data. We will thus dither our data and recombine them using an optimized Fourier based image recombination algorithm which will yield a Nyquist sampled dataset at better than half the WFC3 plate scale.

Our preliminary results on a parent program indicate that with this approach one can detect point sources at contrast levels greater than 10 mags in non-crowded regions. We predict that we will be able to make use of the stars in our combined mosaic as references thus negating the need for additional reference PSFs. In addition our strategy has been to maximize the number of dithers (min. 9 per pattern) thus getting exquisite pixel sampling. This will allow us greater freedom while analyzing the data in determining the number of exposure to combine.

Orbit packing: (we have repeated the pattern exactly for both filters)

- "bright sources", J ~ 6 mag:

The inner 0.2" saturates in ~0.2s. For this extreme regime we decided to go with the RAPID 64 pixel sub-array, NSAMP=14 giving a total exposure time of ~0.8s. The stars are observed twice using a nine point SPIRAL pattern giving us 18 images.
Note: we are requesting a "DARK" inserted before the start of the exposure, this will inform the existence and severity of any persistence artifacts from prior exposures.

- "medium sources", J ~ 9 mag:

We are observing a single region adjacent to the brightest stars with a 256 pixel subarray, RAPID with NSAMP=10 giving ~3s per exposure. We

have two 9-pt SPIRAL dither pattern exposures for the field; in addition we packed five exposures (no dithers) to fill-in the orbit and get deeper in this region, giving a total of 23 images.
Note: we are requesting a "DARK" inserted before the start of the exposure, this will inform the existence and severity of any persistence artifacts from prior exposures.

- "faint sources", J ~ 12 mag:

These are the sources that will be observed using the full-frame images, STEP25 and NSAMP=6 giving ~50s per exposure. This exposure time will saturate ~0.1"-0.2" at the end of the exposure. Since the star will not be saturated in the 0th read, we will be able to carry out precise astrometry. We have a single exposure followed by a "DARK" and an 8-pt SPIRAL, giving a total of 18 images per field. We will be creating a 2-pt mosaic, the first point being observed in orbit 1, and the second in orbit 2 (2 orbits per filter).
Note: we are requesting a "DARK" inserted after the first exposure, this will inform the existence and severity of any persistence artifact from the single ~50s which might affect the astrometry measurements.
(The inserted DARKs were deemed not necessary and are not included.)

-------- Realtime Justification --------

This proposal has been awarded 6 orbits total (4 in cy 21 and 2 in cy 22). To maximize the proper motion baseline (between orbits in cy 21 and 22) we are requesting the orbits in cycle 21 be observed before Dec 01 2013.

We are requesting all four orbits be linked and observed back-to-back. This is to ensure uniformity in the PSFs across the two orbits with the same filter. As well as, to ensure the exact same field and orientation are observed in both filters.

------ Calibration Justification -------

In the proposal we are saturating the core of the stars to ensure sufficient flux in the PSF wings. To understand the effects of the saturation we are requesting that dark frames be inserted in the visits.

Visit

Proposal 13848, F139M (01), implementation Wed Nov 05 02:07:19 GMT 2014

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: ORIENT 230D TO 240 D; AFTER 31-DEC-2014:00:00:00

Comments: In this orbit we are observing the first full-frame field and the two brightest stars (64 px sub-array), in the F139M filter.

To maximize the proper motion baseline (between orbits in cy 21 and 22) we are requesting the orbits in cycle 22 be observed after Dec 31 2014. We are also requesting that both orbits be linked together and observed consecutively.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=SPIRAL	Coordinate Frame=POS-TARG		(4-5)
	Purpose=DITHER	Pattern Orientation=18.0		
	Number Of Points=9	Angle Between Sides=		
	Point Spacing=0.065	Center Pattern=false		
	Line Spacing=			
(3)	Pattern Type=SPIRAL	Coordinate Frame=POS-TARG		(2)
	Purpose=DITHER	Pattern Orientation=18.0		
	Number Of Points=8	Angle Between Sides=		
	Point Spacing=0.065	Center Pattern=false		
	Line Spacing=			

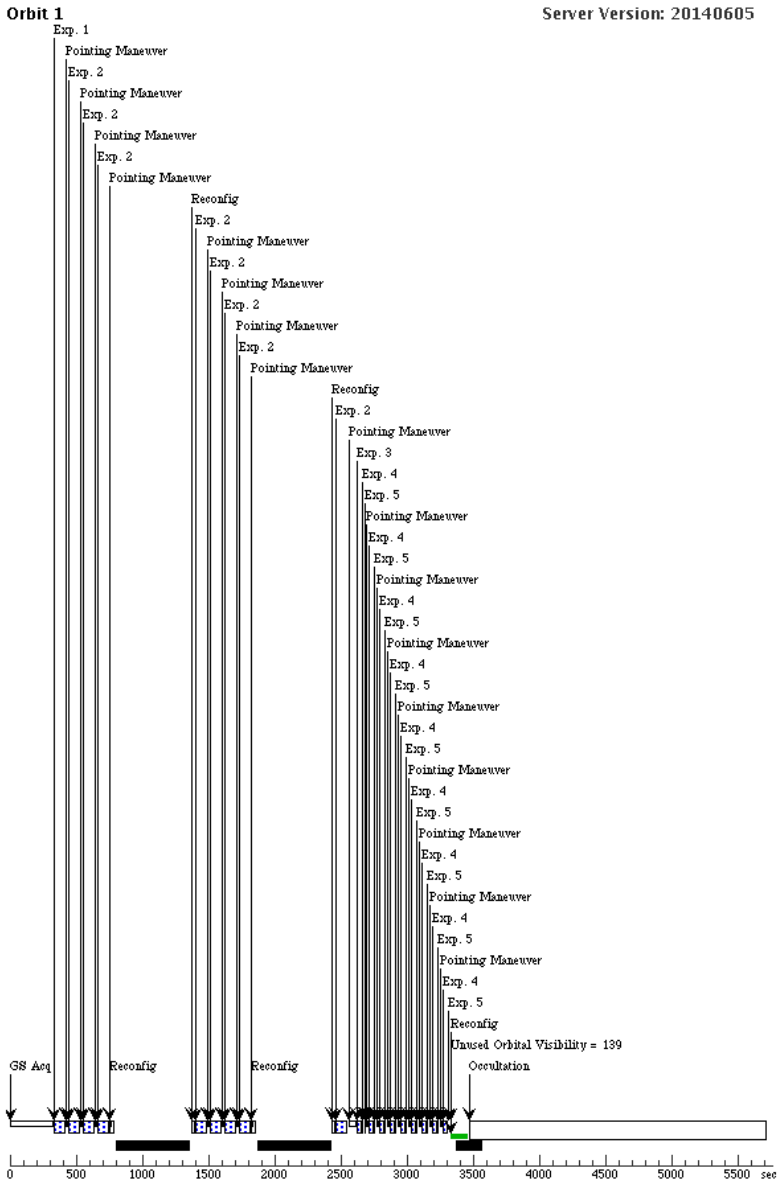
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	TR14-OFFSET1	RA: 10 43 46.0299 (160.9417912d)		V=5.5	Reference Frame: ICRS
		Dec: -59 33 29.10 (-59.55808d)			
		Equinox: J2000			
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.					
(3)	TR14-MAG6	RA: 10 43 57.5342 (160.9897258d)		V=5.5	Reference Frame: ICRS
		Dec: -59 32 52.35 (-59.54787d)			
		Equinox: J2000			
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.					

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Full - 1st dither	(1) TR14-OFFSET1	WFC3/IR, MULTIACCUM, IR	F139M	NSAMP=6; SAMP-SEQ=STEP25	POS TARG -0.13,-0.13		49.230226 Secs (49.23 Secs) *[==>]*	 ***[1]***
2	Full - 1st dither	(1) TR14-OFFSET1	WFC3/IR, MULTIACCUM, IR	F139M	NSAMP=6; SAMP-SEQ=STEP25		Pattern 3, Exps 2-2 in F139M (01) (3)	49.230226 Secs (393.842 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]*	 ***[1]***
3	64px - 2 central stars	(3) TR14-MAG6	WFC3/IR, MULTIACCUM, IRSUB64-FIX	F139M	NSAMP=14; SAMP-SEQ=RAPID			0.850836 Secs (0.851 Secs) *[==>]*	 ***[1]***
4	64px - 2 central stars	(3) TR14-MAG6	WFC3/IR, MULTIACCUM, IRSUB64-FIX	F139M	NSAMP=14; SAMP-SEQ=RAPID		Pattern 2, Exps 4-5 in F139M (01) (2)	0.850836 Secs (7.658 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]* *[==>(Pattern 9)]*	 ***[1]***
5	64px - 2 central stars	(3) TR14-MAG6	WFC3/IR, MULTIACCUM, IRSUB64-FIX	F139M	NSAMP=14; SAMP-SEQ=RAPID		Pattern 2, Exps 4-5 in F139M (01) (2)	0.850836 Secs (7.658 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]* *[==>(Pattern 9)]*	 ***[1]***

Orbit Structure



Visit

Proposal 13848, F139M (02), implementation Wed Nov 05 02:07:19 GMT 2014

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: SAME ORIENT AS 01; SEQ 01,02 WITHIN 1.1 Orbits

Comments: In this orbit we are observing the second full-frame field and the stars between 8-10 mag (256 px sub-array), in the F139M filter.

To maximize the proper motion baseline (between orbits in cy 21 and 22) we are requesting the orbits in cycle 22 be observed after Dec 31 2014. We are also requesting that both orbits be linked together and observed consecutively.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=SPIRAL	Coordinate Frame=POS-TARG		(8-9)
	Purpose=DITHER	Pattern Orientation=18.0		
	Number Of Points=9	Angle Between Sides=		
	Point Spacing=0.065	Center Pattern=false		
	Line Spacing=			
(3)	Pattern Type=SPIRAL	Coordinate Frame=POS-TARG		(2)
	Purpose=DITHER	Pattern Orientation=18.0		
	Number Of Points=8	Angle Between Sides=		
	Point Spacing=0.065	Center Pattern=false		
	Line Spacing=			

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	TR14-OFFSET2	RA: 10 43 54.4131 (160.9767212d)		V=5.5	Reference Frame: ICRS
		Dec: -59 34 23.59 (-59.57322d)			
		Equinox: J2000			
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.					
(4)	TR14-MAG8	RA: 10 43 54.8981 (160.9787421d)		V=5.5	Reference Frame: ICRS
		Dec: -59 32 44.01 (-59.54556d)			
		Equinox: J2000			
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.					

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Full - 2nd dither	(2) TR14-OFFSET2	WFC3/IR, MULTIACCUM, IR	F139M	NSAMP=6; SAMP-SEQ=STEP25	POS TARG -0.13,-0.13		49.230226 Secs (49.23 Secs) *[==>]*	 ***[1]***
2	Full - 2nd dither	(2) TR14-OFFSET2	WFC3/IR, MULTIACCUM, IR	F139M	NSAMP=6; SAMP-SEQ=STEP25		Pattern 3, Exps 2-2 in F139M (02) (3)	49.230226 Secs (393.842 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]*	 ***[1]***
3	256px - 8-10 mag stars	(4) TR14-MAG8	WFC3/IR, MULTIACCUM, IRSUB256	F139M	NSAMP=10; SAMP-SEQ=RAPID			2.77815 Secs (2.778 Secs) *[==>]*	 ***[1]***
4	256px - 8-10 mag stars	(4) TR14-MAG8	WFC3/IR, MULTIACCUM, IRSUB256	F139M	NSAMP=10; SAMP-SEQ=RAPID			2.77815 Secs (2.778 Secs) *[==>]*	 ***[1]***
5	256px - 8-10 mag stars	(4) TR14-MAG8	WFC3/IR, MULTIACCUM, IRSUB256	F139M	NSAMP=10; SAMP-SEQ=RAPID			2.77815 Secs (2.778 Secs) *[==>]*	 ***[1]***
6	256px - 8-10 mag stars	(4) TR14-MAG8	WFC3/IR, MULTIACCUM, IRSUB256	F139M	NSAMP=10; SAMP-SEQ=RAPID			2.77815 Secs (2.778 Secs) *[==>]*	 ***[1]***
7	256px - 8-10 mag stars	(4) TR14-MAG8	WFC3/IR, MULTIACCUM, IRSUB256	F139M	NSAMP=10; SAMP-SEQ=RAPID			2.77815 Secs (2.778 Secs) *[==>]*	 ***[1]***
8	256px - 8-10 mag stars	(4) TR14-MAG8	WFC3/IR, MULTIACCUM, IRSUB256	F139M	NSAMP=10; SAMP-SEQ=RAPID		Pattern 2, Exps 8-9 in F139M (02) (2)	2.77815 Secs (25.003 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]* *[==>(Pattern 9)]*	 ***[1]***

	9	256px - 8-10 (4) TR14-MAG8 mag stars	WFC3/IR, MULTIACCUM, IRSUB256	F139M	NSAMP=10; SAMP-SEQ=RAPID	Pattern 2, Exps 8-9 in F139M (02) (2)	2.77815 Secs (25.003 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]* *[==>(Pattern 6)]* *[==>(Pattern 7)]* *[==>(Pattern 8)]* *[==>(Pattern 9)]*	***[1]***

Orbit Structure