



2045 - Testing the Physical Origin of the Initial Mass Function and Circumstellar Disk Destruction with Massive Clusters at the Galactic Center

Cycle: 1, Proposal Category: GO

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OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	1	Arches	NIRCam Imaging	(1) NAME-ARCHES-CLUSTER
	2	Quintuplet	NIRCam Imaging	(2) NAME-QUINTUPLET-CLUSTER
	3	Quintuplet	NIRCam Imaging	(2) NAME-QUINTUPLET-CLUSTER

ABSTRACT

JWST Proposal 2045 (Created: Monday, July 15, 2024 at 4:00:29 PM Eastern Standard Time) - Overview

The Galactic center (GC) offers a unique opportunity to conduct detailed and resolved studies of star formation in an extreme starburst-like environment. We propose to use JWST NIRCcam to perform the deepest ever study of the Arches and Quintuplet clusters, two young (<5 Myr) and massive ($10^4 M_{\text{sun}}$) clusters near the GC. These observations will allow us to identify cluster members to sub-solar masses ($M > 0.4 M_{\text{sun}}$) for the first time, distinguishing between competing models for how the Initial Mass Function (IMF) behaves in such environments. This provides a critical benchmark for star formation theory, as the IMF is shaped by the physical processes driving star formation, and informs our understanding of unresolved stellar populations at high redshifts where starbursts were common. In addition, simultaneous long-wavelength observations will provide a census of infrared excess sources ~ 3 mags deeper than previous studies, from which we will test predictions regarding how strongly environmental conditions (such as external photoionization and dynamical interactions) influence circumstellar disk lifetimes. The combination of high spatial resolution, sensitivity, and field of view makes JWST uniquely suited to achieve these goals, which will impact many additional areas of astrophysics such as galaxy mass evolution, cosmic star formation, compact object production and merger rates in galactic nuclei, and planet formation in different environments.

2021/09: Updates in response to discussion with NIRCcam contact scientist (Mario Gennaro):

1. Readout Pattern

Arches Original setup: 2 groups/4 integrations (BRIGHT1)

Arches Updated setup: 8 groups/1 integration (BRIGHT1)

Quintuplet original setup: 2 groups/2 iterations (BRIGHT1)

Quintuplet updated setup: 4 groups/1 iteration (BRIGHT1)

Mario commented that the use of only 2 groups per integration is not recommended because the up-the-ramp fit could fail with cosmic ray hits and other artifacts. It is also a less efficient observing strategy because we lose a lot of overhead from the reset between integrations. Instead, he recommended we use an 8 groups/1 integration setup for the Arches, which is charged the same amount of observing time but yields much higher SNR. I confirmed this using the JWST ETC.

2. Dither Pattern

For both clusters:

Original setup: intramodulex, 6 primary dithers, 2 sub-dithers (12 exposures total)

Updated setup: intramodulebox, 4 primary dithers, 3 sub-dithers (12 exposures total)

Mario commented that we should consider having more sub-pixel dither positions for improved astrometry, and also that intramodulebox is a more compact dither pattern than intramodulex if the goal is to provide uniform coverage over the chip gaps in the NIRCcam detector. In response, I changed the pattern and decreased the number of primary dithers to 4 (the minimum number of dithers required to cover the chip gaps) and added an additional sub-dither per pointing.

----> Overall, these changes should improve the efficiency of our observations without increasing the total charged time. Thanks Mario!

2021/10/19: Added small offsets to pointing such that the center of the clusters do not fall in the center of the NIRCcam field. This is because the central region has lower data coverage in the short-wavelength channel with the chosen dither pattern. This will be fine for SNR purposes, but for astrometry, it will be better to have more data in the center of the field where there are more cluster stars.

We have designed the offsets so that they move along the direction of cluster motion. This provides an added bonus of looking for extended radial density features indicative of tidal tails.

2023/06/12: Made two changes:

1. Added the NIRCcam A module to obtain an off-cluster field simultaneously with the cluster field in the B-module (previously, the program only calls for the B-module). Pointing shifted to B short (on B4) so B-module is still centered on each cluster.

2. Shifted the pointing offset of the Quintuplet cluster from the current value of (-12.0", -13") to a new value of (13.0", 13.0"), to increase the overlap with the existing HST data. This was possible because we know the observations will be taken at PA ~ 90 given observing window of Aug - Sept 2023.

These minor changes were approved over e-mail with Mario Gennaro and Blair Porterfield.

2023/08/24

Duplicated visit 2:1, since it was initially skipped due to Guide Star Acquisition failure. TTRB approved the request to redo the visit (WOPR 88862)

OBSERVING DESCRIPTION

We request NIRCam observations (2.6 hrs total, including overheads) of the Arches and Quintuplet order to study the low-mass IMF and circumstellar disk destruction in the clusters. This represents the first of two astrometric epochs needed to reliably separate cluster members from field stars. The repeat epoch will be requested 5 years from now, the nominal lifetime of JWST. By establishing the time baseline in cycle 1, we maximize the time baseline between the observations and thus the required telescope time is minimized and maximally efficient. These observations will allow us to conclusively distinguish between theories on which physical processes shape the IMF in starburst-like environments and assess how strongly the circumstellar disk populations have been impacted by the harsh conditions.

The F212N and F323N filters will be used for each cluster. Only the B Module is required to obtain full spatial coverage of the clusters. Twelve individual dither positions will be used in order to cover the short-wavelength chip gap and provide sub-pixel sampling of the point-spread function to improve astrometric accuracy. Astrometry will be obtained in the F212N filter, where the proposed observations are designed to provide sufficient astrometric accuracy for accurate cluster membership selection to $F212N = 21.0$ mag, the predicted confusion limit in the fields. This will allow us to identify cluster members for $M > 0.4 M_{\text{sun}}$, a critical range for distinguishing between possible IMF models. The F323N observations will be used for photometry, as the F212N - F323N color will allow us to identify circumstellar disk candidates via infrared-excess emission down to sub-solar masses. This will allow us to compare the disk population in these clusters to populations of similar mass in local clusters for the first time, quantifying the impact of the extreme environment on disk lifetimes.

Proposal 2045 - Targets - Testing the Physical Origin of the Initial Mass Function and Circumstellar Disk Destruction with Massive Clu...

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	NAME-ARCHES-CLUSTER	RA: 17 45 50.4470 (266.4601958d) Dec: -28 49 20.64 (-28.82240d) Equinox: J2000 <i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Category=Stellar Cluster Description=[Globular star clusters]</i>	Epoch of Position: 2015.5	
(2)	NAME-QUINTUPLET-CLUSTER	RA: 17 46 15.0213 (266.5625887d) Dec: -28 49 39.43 (-28.82762d) Equinox: J2000 <i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Category=Stellar Cluster Description=[Globular star clusters]</i>	Epoch of Position: 2015.5		

Proposal 2045 - Observation 1 - Testing the Physical Origin of the Initial Mass Function and Circumstellar Disk Destruction with Massi...

Mon Jul 15 21:00:29 GMT 2024

Observation	<p>Proposal 2045, Observation 1: Arches</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRCcam Imaging</p> <p><i>Comments: Additional relevant ETC calculations: 53998.3, 53998.4, 53998.6, 53998.9</i></p>									
Diagnostics	(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.									
Fixed Targets	#	Name	Target Coordinates		Targ. Coord. Corrections			Miscellaneous		
	(1)	NAME-ARCHES-CLUSTER	RA: 17 45 50.4470 (266.4601958d) Dec: -28 49 20.64 (-28.82240d) Equinox: J2000		Epoch of Position: 2015.5					
	<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=Stellar Cluster</i></p> <p><i>Description=[Globular star clusters]</i></p>									
Template	Module		Subarray			Target Placement				
	ALL		FULL			Module B (B4 corner)				
Dithers	#	Primary Dither Type		Primary Dithers	Subpixel Dither Type		Dither Size	Subpixel Positions		
	1	INTRAMODULEBOX		4	STANDARD			3		
Spectral Elements	#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
	1	F212N	F323N+F322W2	BRIGHT1	8	1	12	12	1932.619	53998.2
Special Requirements	<p>Offset -10.0 arcsec, -10.0 arcsec</p> <p>Fiducial Point Override NRCBS_FULL</p>									

Proposal 2045 - Observation 2 - Testing the Physical Origin of the Initial Mass Function and Circumstellar Disk Destruction with Massi...

Mon Jul 15 21:00:29 GMT 2024

Observation	<p>Proposal 2045, Observation 2: Quintuplet</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRCcam Imaging</p> <p><i>Comments: Additional relevant ETC calculations: 53998.15, 53998.3, 53998.4, 53998.9</i></p>									
Diagnostics	(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.									
Fixed Targets	#	Name	Target Coordinates		Targ. Coord. Corrections			Miscellaneous		
	(2)	NAME-QUINTUPLET-CLUSTER	RA: 17 46 15.0213 (266.5625887d) Dec: -28 49 39.43 (-28.82762d) Equinox: J2000		Epoch of Position: 2015.5					
	<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=Stellar Cluster</i></p> <p><i>Description=[Globular star clusters]</i></p>									
Template	Module		Subarray			Target Placement				
	ALL		FULL			Module B (B4 corner)				
Dithers	#	Primary Dither Type		Primary Dithers	Subpixel Dither Type		Dither Size	Subpixel Positions		
	1	INTRAMODULEBOX		4	STANDARD			3		
Spectral Elements	#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
	1	F212N	F323N+F322W2	BRIGHT1	4	1	12	12	901.889	53998.10
Special Requirements	<p>Offset 13.0 arcsec, 13.0 arcsec</p> <p>Fiducial Point Override NRCBS_FULL</p>									

Proposal 2045 - Observation 3 - Testing the Physical Origin of the Initial Mass Function and Circumstellar Disk Destruction with Massi...

Mon Jul 15 21:00:29 GMT 2024

Observation	<p>Proposal 2045, Observation 3: Quintuplet</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRCcam Imaging</p> <p><i>Comments: Additional relevant ETC calculations: 53998.15, 53998.3, 53998.4, 53998.9</i></p>									
Diagnostics	(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.									
Fixed Targets	#	Name	Target Coordinates		Targ. Coord. Corrections			Miscellaneous		
	(2)	NAME-QUINTUPLET-CLUSTER	RA: 17 46 15.0213 (266.5625887d) Dec: -28 49 39.43 (-28.82762d) Equinox: J2000		Epoch of Position: 2015.5					
	<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=Stellar Cluster</i></p> <p><i>Description=[Globular star clusters]</i></p>									
Template	Module		Subarray			Target Placement				
	ALL		FULL			Module B (B4 corner)				
Dithers	#	Primary Dither Type		Primary Dithers	Subpixel Dither Type		Dither Size	Subpixel Positions		
	1	INTRAMODULEBOX		4	STANDARD			3		
Spectral Elements	#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
	1	F212N	F323N+F322W2	BRIGHT1	4	1	12	12	901.889	53998.10
Special Requirements	<p>Offset 13.0 arcsec, 13.0 arcsec</p> <p>Fiducial Point Override NRCBS_FULL</p>									