



17608 - Mapping HI 21cm emission from two FRB host galaxies at $z \sim 0.045$

Cycle: 31, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

<i>Name</i>	<i>Institution</i>
Balpreet Kaur (PI) (Contact)	National Centre for Radio Astrophysics, TIFR
Dr. Nissim Kanekar (CoI) (Contact)	National Centre for Radio Astrophysics, TIFR
Dr. Marc Rafelski (CoI) (Contact)	Space Telescope Science Institute
Dr. Jason X. Prochaska (CoI) (AdminUSPI) (Contact)	University of California - Santa Cruz

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) FRB-211127I	WFC3/UVIS	1	17-Jan-2025 14:00:44.0	yes
03	(1) FRB-211127I	WFC3/UVIS	1	17-Jan-2025 14:00:44.0	yes
02	(2) FRB-20220207C	WFC3/UVIS	1	17-Jan-2025 14:00:44.0	yes

3 Total Orbits Used

ABSTRACT

The origin of fast radio bursts (FRBs), the luminous, cosmologically-distant, millisecond-duration radio pulses, is a mystery today. Understanding FRBs requires understanding the environments in which the bursts form. Most studies have hitherto focussed on the stellar component of the FRB hosts, with no information on the neutral hydrogen, the primary fuel for star-formation. Our GMRT HI 21cm images of the host galaxy of FRB20180916B indicate that the FRB host is a gas-rich galaxy, with a highly disturbed HI distribution, both signatures of a recent minor merger that is likely to have led to the birth of the FRB progenitor. Recently, two FRBs, FRB20211127I and 20220207C, have been localized to star-forming disk galaxies, at $z=0.0469$ and $z=0.04304$, respectively, making them excellent candidates for HI 21cm mapping studies. We propose to use the

JVLA L-band receivers in C-array to map the HI 21cm emission from the two FRB hosts, to test the hypothesis that the FRB progenitors formed due to star formation activity triggered by galaxy-galaxy interactions. We also request a single HST-WFC3 orbit with the F300X filter for each galaxy, to test whether the two FRBs lie at locations of elevated recent star-formation activity within the host galaxies.

OBSERVING DESCRIPTION

Recently, two FRBs, FRB20211127I and 20220207C, have been localized to star-forming disk galaxies, at $z=0.0469$ and $z=0.04304$, respectively, making them excellent candidates for HI 21cm mapping studies. To complement the HI 21cm emission from the two FRB hosts, we obtain WFC3/UVIS imaging with the F300X filter to test whether the two FRBs lie at locations of elevated recent star-formation activity within the host galaxies. The imaging data would also enable a search for the stellar counterparts of any HI companions discovered in the JVLA data. We aim to detect an SFR surface density of $0.05 M_{\text{Sun}}/\text{yr}/\text{arcsecond}^2$ at ≥ 5 sigma significance for each galaxy, within a region of 1 arcsecond^2 around each FRB.

We explain our sensitivity calculations for the $z=0.0430$ host galaxy of FRB 20220207C (a very similar argument applies to the $z=0.0469$ host galaxy of FRB 20211127I), as it has a significantly higher extinction from the Milky Way [$E(B-V)=0.7$ mag.] than the other target. At $z\sim 0.0430$, an SFR of $0.05 M_{\text{Sun}}/\text{yr}$ corresponds to an AB magnitude of 21.7 mag, using the SFR calibration of Kennicutt & Evans (2012, ARA&A, 50, 531) and the standard Planck Lambda-CDM cosmology. The minimum exposure time for each target is 1 orbit, which corresponds roughly to an integration time of 2400s. In order to obtain images clean of cosmic rays and image artefacts, we require a minimum of three dither positions. Hence, we will obtain three exposures, requiring us to utilize 16e- post-flash to have a sufficiently high background of 20e-per pixel, so as to capture all the photons with the degradation of the charge transfer efficiency (CTE). We measure the magnitude reached in 2400s of exposure (i.e. 1 orbit) for each target using the WFC3/UVIS online Exposure Time Calculator (ETC) assuming a flat spectrum in F_{ν} , normalized to the FUV (for proper SFR estimates) and then corrected for the Milky Way extinction. We reach a sensitivity of $0.01 M_{\text{Sun}}/\text{yr}/\text{arcsecond}^2$ at ≥ 5 sigma significance for FRB 20220207C; the sensitivity is an order of magnitude better for FRB 20211127I, due to the lower Milky Way extinction [$E(B-V)=0.06$] along this sightline. We hence conclude that 1 orbit per target of HST/WFC3 time with the F300X filter is sufficient to achieve our target sensitivity of detecting an SFR surface density $\geq 0.05 M_{\text{Sun}}/\text{yr}/\text{arcsecond}^2$ for the $z=0.0430$ FRB host galaxy. Note that we will reach significantly higher S/N on the host galaxy of FRB 20211127I, which will allow us to carry out even more detailed morphological measurements on this FRB host galaxy.

In order to obtain images clean of cosmic rays and image artifacts and sampling the PSF phase, we use a minimum of four dither positions. Given the short exposure times in F300X, this requires us to utilize 14e- post-flash to reach $>20e-$ per pixel. To maximize UV throughput and minimize our

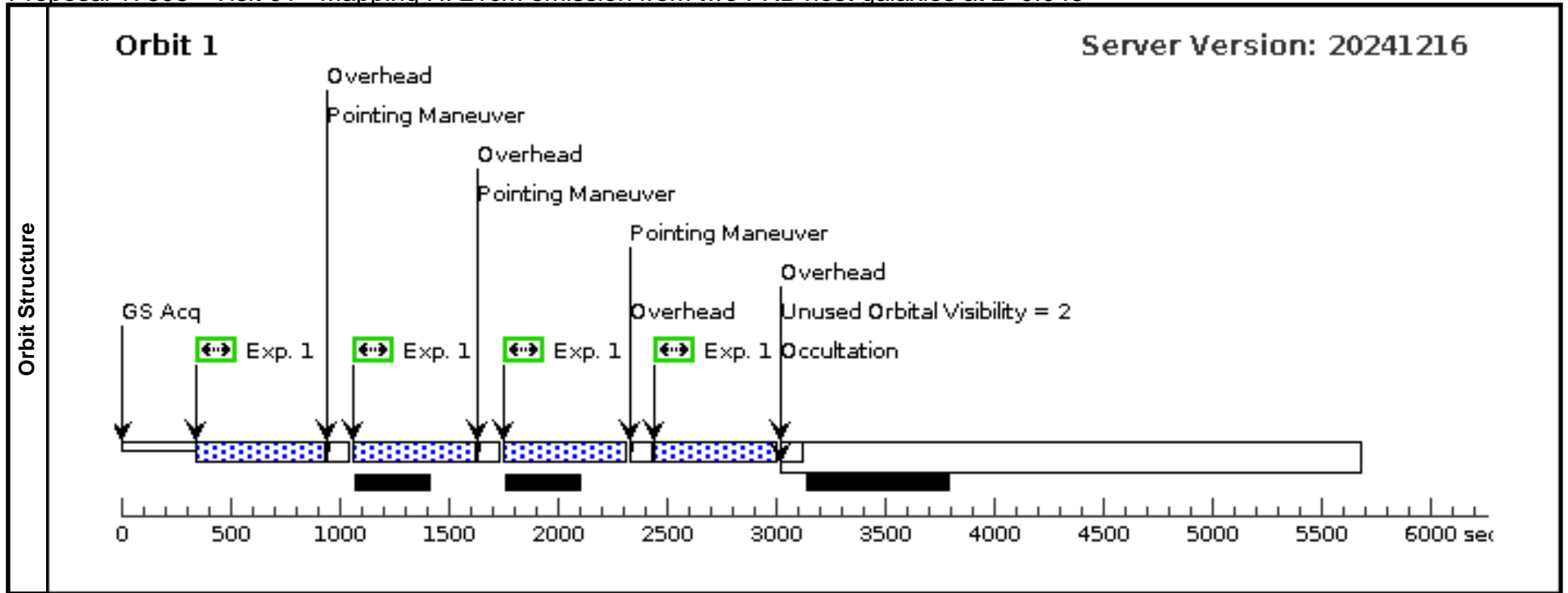
pixel-based CTE correction, we place the target on chip 2 close to the readout. We use a dither pattern that is 5 times the standard box pattern to remove residual background patterns and enable sky darks.

We do not place any orient constraints on the program, which makes this easy to schedule. We therefore do not foresee any issues if we have to go to 1 gyro mode.

Proposal 17608 - Visit 01 - Mapping HI 21cm emission from two FRB host galaxies at z~0.045

Fri Jan 17 19:00:45 GMT 2025

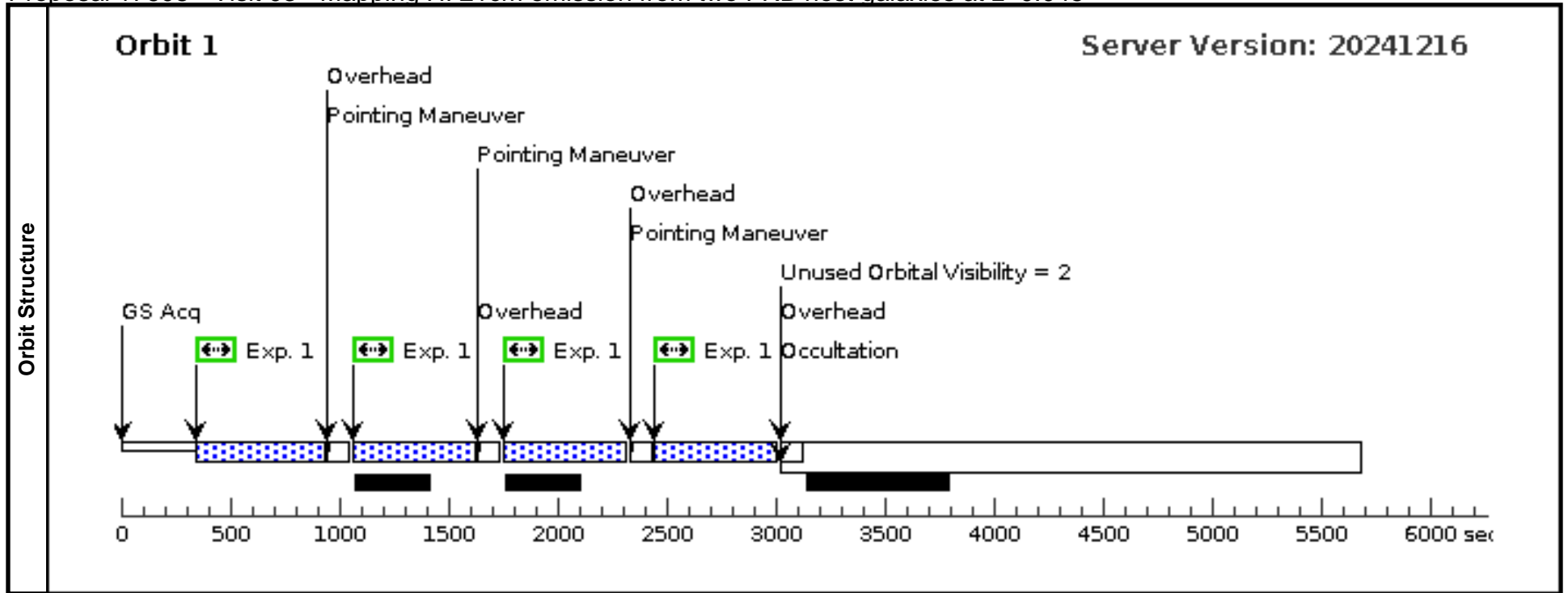
Visit	Proposal 17608, Visit 01, failed Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: (none)										
	Patterns	#	Primary Pattern				Secondary Pattern			Exposures	
(2)		Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.865 Line Spacing=0.56				Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false			(1)		
Fixed Targets	#	Name	Target Coordinates		Targ. Coord. Corrections		Fluxes	Miscellaneous			
	(1)	FRB-211127I	RA: 13 19 14.0800 (199.8086667d) Dec: -18 50 16.70 (-18.83797d) Equinox: J2000		Epoch of Position: 2000		V=15.3	Reference Frame: ICRS			
Comments: Category=GALAXY Description=[RADIO GALAXY] Extended=YES											
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]		Orbit
	1	(1) FRB-211127I	(1) FRB-211127I	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F300X	FLASH=14		Pattern 2, Exps 1-1 in Visit 01 (2)	560 Secs (2240 Secs)		[1]
									[=>(Pattern 1)]		
									[=>(Pattern 2)]		
									[=>(Pattern 3)]		
									[=>(Pattern 4)]		



Proposal 17608 - Visit 03 - Mapping HI 21cm emission from two FRB host galaxies at z~0.045

Fri Jan 17 19:00:45 GMT 2025

Visit	Proposal 17608, Visit 03 Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures					
		(2)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.865 Line Spacing=0.56	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false		(1)				
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	FRB-211127I	RA: 13 19 14.0800 (199.8086667d) Dec: -18 50 16.70 (-18.83797d) Equinox: J2000	Epoch of Position: 2000	V=15.3	Reference Frame: ICRS				
	<i>Comments:</i> Category=GALAXY Description=[RADIO GALAXY] Extended=YES									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(1) FRB-211127I	(1) FRB-211127I	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F300X	FLASH=14		Pattern 2, Exps 1-1 in Visit 03 (2)	560 Secs (2240 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]



Proposal 17608 - Visit 02 - Mapping HI 21cm emission from two FRB host galaxies at z~0.045

Visit	Proposal 17608, Visit 02, completed Fri Jan 17 19:00:45 GMT 2025 Diagnostic Status: Warning Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	(Visit 02) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN									
Diagnosics										
Patterns	#	Primary Pattern	Secondary Pattern		Exposures					
	(2)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.865 Line Spacing=0.56	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false		(1)					
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(2)	FRB-20220207C	RA: 20 40 47.8860 (310.1995250d) Dec: +72 52 56.38 (72.88233d) Equinox: J2000	Epoch of Position: 2000	V=21.7	Reference Frame: SIMBAD				
Comments: Category=GALAXY Description=[RADIO GALAXY] Extended=YES										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(2) FRB-20220207C	(2) FRB-20220207C	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F300X	FLASH=14		Pattern 2, Exps 1-1 in Visit 02 (2)	683 Secs (2732 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]

