arXiv:2001.10275

Periodic activity from a fast radio burst source

The CHIME/FRB Collaboration, Amiri, M.[1], Andersen, B. C.[2,3], Bandura, K. M.[4,5], Bhardwaj, M.[2,3], Boyle, P. J.[2,3], Brar, C.[2,3], Chawla, P.[2,3], Chen, T.[6], Cliche, J. F.[2,3], Cubranic, D.[1], Deng, M.[1], Denman, N. T.[7], Dobbs, M.[2,3], Dong, F. Q.[1], Fandino, M.[1], Fonseca, E.[2,3], Gaensler, B. M.[8,9], Giri, U.[10,11], Good, D. C.[1], Halpern, M.[1], Hessels, J. W. T.[12,13], Hill, A. S.[14,15], Höfer, C.[1], Josephy, A.[2,3], Kania, J. W.[16], Karuppusamy, R.[17], Kaspi, V. M.[2,3], Keimpema, A.[18], Kirsten, F.[19], Landecker, T. L.[15], Lang, D. A.[10,11], Leung, C.[6,20], Li, D. Z.[21,22,17,8]*, Lin, H.-H.[21,17], Marcote, B.[18], Masui, K. W.[6,20], Mckinven, R.[8,9], Mena-Parra, J.[6], Merryfield, M.[2,3], Michilli, D.[2,3], Milutinovic, N.[1,15], Mirhosseini, A.[1], Naidu, A.[2,3], Newburgh, L. B.[23], Ng, C.[8], Nimmo, K.[12,13], Paragi, Z.[18], Patel, C.[8,2,3], Pen, U.-L.[21,8,24,10,17], Pinsonneault-Marotte, T.[1], Pleunis, Z.[2,3], Rafiei-Ravandi, M.[10], Rahman, M.[8], Ransom, S. M.[25], Renard, A.[8], Sanghavi, P.[4,5], Scholz, P.[8,15], Shaw, J. R.[1], Shin, K.[6,20], Siegel, S. R.[2,3], Singh, S.[2,3], Smegal, R. J.[1], Smith, K. M.[10], Stairs, I. H.[1], Tendulkar, S. P.[2,3], Tretyakov, I.[8,22], Vanderlinde, K.[8,9], Wang, H.[6,20], Wang, X.[26], Wulf, D.[2,3], Yadav, P.[1], Zwaniga, A. V.[2,3]

CHIME/FRB telescope.

400−800 MHz; 1024 receivers; ~250 sq. deg field of view
1000-processor high-performance GPGPU cluster

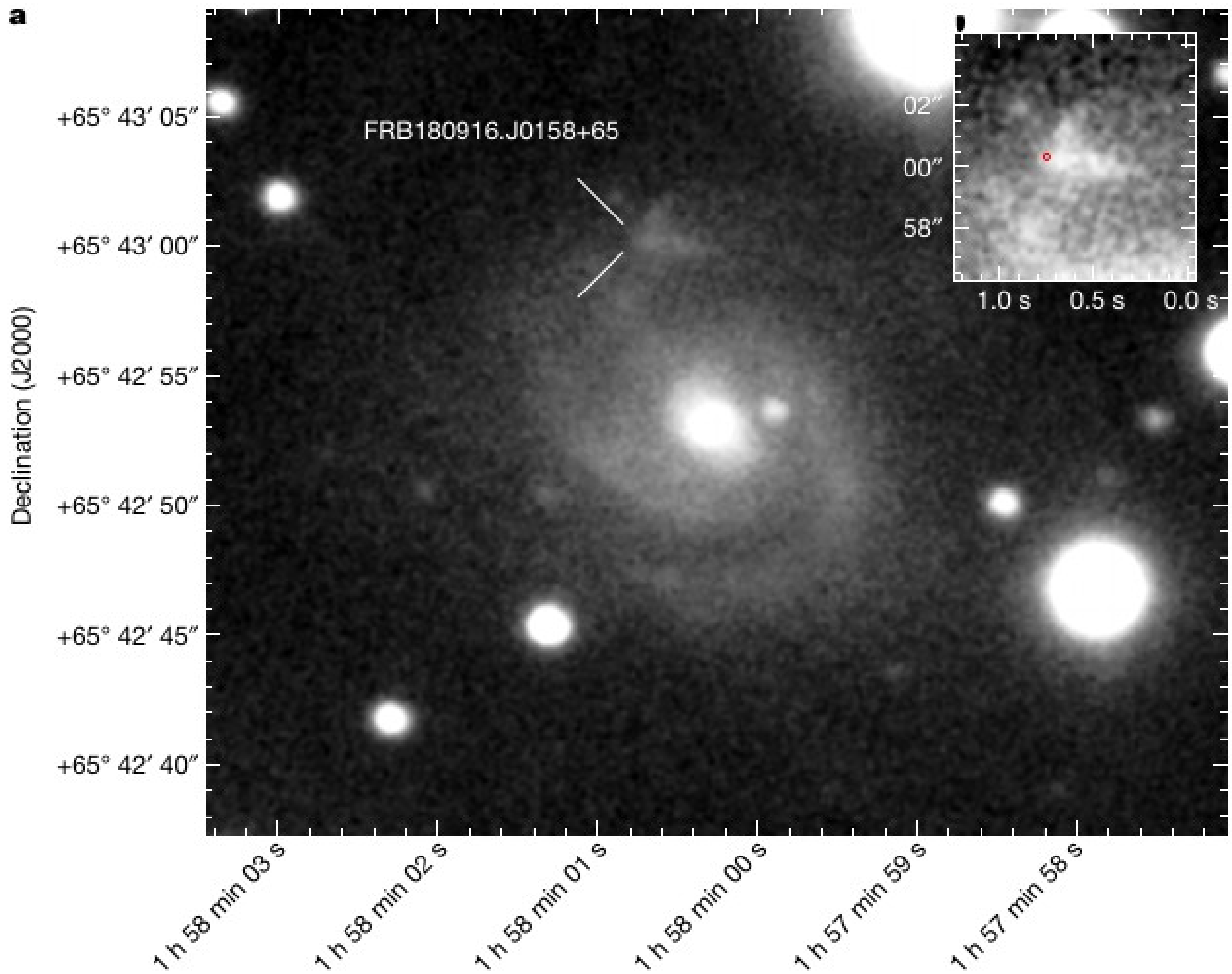
CHIME/FRB Collaboration *et al.* CHIME/FRB Detection of Eight New Repeating Fast Radio Burst Sources. *Astrophys. J. Letters* **885**, L24 (2019). 1908.03507.

FRB 180916.J0158+65

redshift 0.0337±0.0002

From September 2018 to November 2019, CHIME/FRB has detected a total of 28 bursts

16.35 ± 0.18 day periodicity



MJD	DM ($pc\ cm^{-3}$)	Total Width (ms)	Fluence (Jy ms)	Peak Flux (Jy)
		Previously Published Bursts[4]		
58377.42972096	349.2±0.2	1.40±0.07	>2.3±1.2	>1.4±0.6
58410.34656422[a]	349.0±0.6	4.1±0.3	>3.5±1.3	>0.6±0.3
58410.34656495[a]	349.0±0.6	4.4±0.9	>2.0±0.8	>0.3±0.2
58426.29413444	349.5±0.3	1.37±0.07	>2.8±0.9	>1.4±0.5
58426.30088378	349.6±0.2[b]	6.3±1.1	6.8±3.0	1.0±0.6
58442.25174905	349.9±0.6	1.10±0.09	8.0±2.2	2.9±1.1
58474.17007574	349.1±0.1	4.95±0.4 / 1.51±0.3 / 3.7±0.3 / 2.8±0.3	9.6±2.6 / 15±4 / 16.5±4.5 / 7.2±1.8	1.9±0.6 / 6.3±1.8 / 3.5±1.0 / 0.9±0.4
58475.16454902	349.7±0.7	1.67±0.05 / 6.3±0.4	10.4±2.9 / 3.6±1.5	1.9±0.6 / 0.5±0.3
58477.16557196	348.9±0.7	3.8±0.3	3.1±2.4	1.4±0.8
58478.15889115	348.8±0.8	0.87±0.3 / 3.6±0.4	2.9±0.8 / 1.6±0.5	1.9±0.6 / 0.7±0.3
58509.06654412	349.8±0.5	2.53±0.13	6.4±1.2	1.7±0.5
		Bursts from This Work		
58621.75641235	349.8±0.7[b]	2.5±0.6	1.0±0.3	0.4±0.2
58621.76154355	350.2±0.3	1.96±0.16	7.7±1.8	1.6±0.5
58622.74024356	348.9±0.1	0.58±0.08 / 0.9±0.1	>1.3±0.5 / >2.2±0.9	>0.8±0.4 / >0.8±0.5
58622.75315853	349.4±0.2	8.0±0.7 / 2.63±0.16	3.1±1.4 / 5.3±2.4	0.9±0.5 / 1.0±0.6
58622.75441645	349.3±0.4	3.6±0.4	4.4±2.0	1.1±0.7
58637.71187752	349.9±0.5	1.9±0.2	2.1±0.8	1.6±0.8
58638.71347350	348.82±0.05[c]	1.00±0.05	37±9	6.3±1.9
58639.70267121	349.7±0.2	2.34±0.08	>7.0±1.5	>1.3±0.4
58639.70713864	348.86±0.5[c]	3.72±0.13 / 4.1±0.4	11.5±4.0 / 5.4±2.7	2.3±0.7 / 1.1±0.5
58704.53530987	349.6±0.3	3.43±0.14	7.3±1.2	1.2±0.3
58705.53461219	349.3±0.9[b]	4.3±1.6	>1.7±0.3	>0.4±0.2
58720.49302597	349.0±0.1	1.83±0.03	24±4	4.9±1.0
58720.49551788[a]	349.7±0.4	7.8±1.3	2.8±0.9	0.6±0.3
58720.49551860[a]	349.7±0.4	5.1±0.8	1.4±0.6	0.5±0.3
58720.49669723	349.5±0.5	1.3±0.3	>2.6±0.5	>0.9±0.3
58786.31947315	349.7±0.7[b]	3.1±0.7	2.3±0.8	0.9±0.8
58786.32497962	349.1±0.4[b]	3.6±0.4	>2.3±0.5	>0.5±0.2

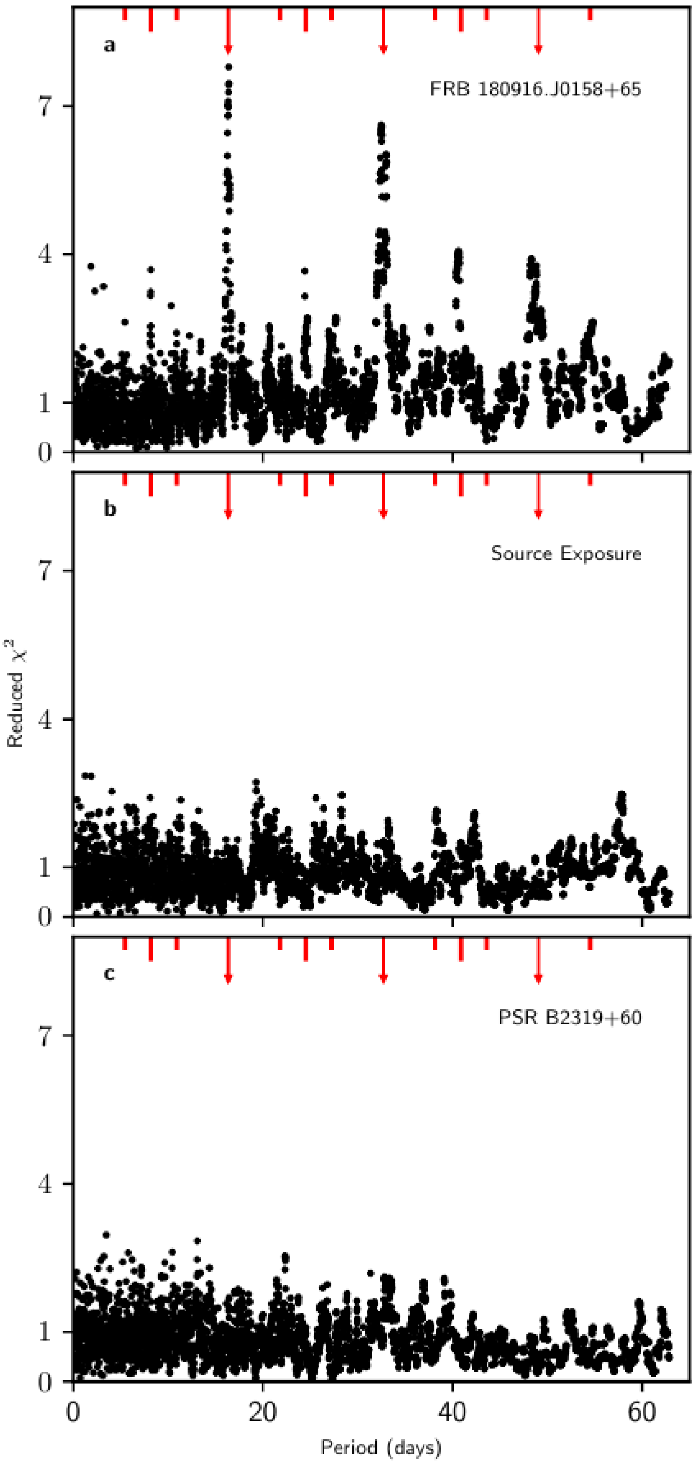
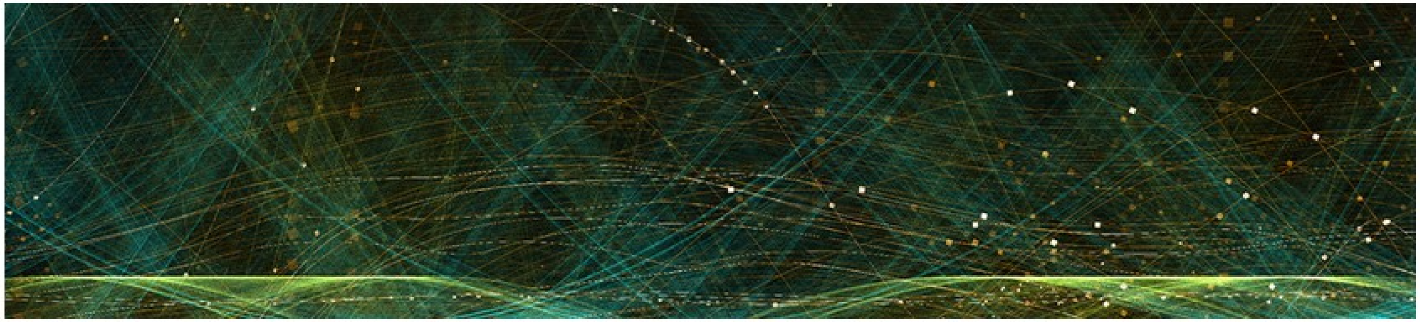


Figure 1: **Periodograms of FRB 180916.J0158+65 and control samples. a**: the reduced χ^2 with respect to a uniform distribution of burst arrival times for different folding periods for FRB 180916.J0158+65 detected by CHIME/FRB. Only samples separated by a sidereal day are considered independent in this approach. Details of the calculation of χ^2 and other approaches are presented in Methods. **b**: the periodogram of mock burst arrival times randomly sampled according to the daily exposure to FRB 180916.J0158+65 within the FWHM of the telescopes synthesized beams at 600 MHz. **c**: the periodogram of randomly selected pulses of Galactic radio pulsar B2319+60 detected by the same instrument and software. The arrows indicate the first 3 subharmonics of the 16.35-day periodicity, while the vertical lines mark the harmonics of 1/2 period (longer lines) and 1/3 period (shorter lines).



OPEN DATA ARCHIVE

Breakthrough Listen data are stored in technical formats that require specialized software to analyze, and file sizes can be several gigabytes. Before downloading files from our public archive, we recommend you familiarize yourself with how the data are stored. A good place to start is with the educational materials provided by Berkeley SETI Research Center.

Access analysis results and description from The Breakthrough Listen Search for Advanced Life: 1.1-1.9 GHz observations of 692 Nearby Stars.

A beta interface with additional search options is also available at seti.berkeley.edu/opendata.

SEARCH FORM

Project	All Projects	
File type	All File Types	

Sky coordinates:

Right Ascension (in degrees)		+/-
Declination (in degrees)		+/-
Time (in MJD)		+/-
Center Frequency (in MHz)		+/-
Target Name		

SEARCH

https://breakthroughinitiatives.org/opendatasearch

Breakthrough Listen: Data Release 2 - February 2020

- Overview
- Open Data
- Press Release

Overview - Public Data Release 2 - February 2020

Since the Public Data Release 1 in April 2019 we have doubled the amount of data available from our archive.

This release includes the following data sets:

- Over 400 hours of galactic plane observations (along with observations of the Large and Small Magellanic Clouds, as well as the Fornax cluser) using the Parkes multibeam receiver - there is a sky map showing the telescope pointings in this release
- Earth transit zone data used in the analysis described in Sheikh, et al.
- Observations of Comet Borisov using the L/S/C/X band receivers at Green Bank.
- C band observations of the galactic center taken at Green Bank.
- Additional observational cadences of nearby stars, beyond those used in the analysis depicted in Price, et al. (2020), that were recorded using the L/S band receivers at Green Bank.

We invite the public to read the two papers accompanying the data release and the scientific analysis, and for those with technical skills, to download some of the datasets, to explore them, and to perform their own analyses.

Much of our software is publicly available, including blimpy, a tool for loading filterbank, hdf5, and raw format data files, and turboSETI, a tool for performing Doppler drift searches.

For detailed information about the various data formats we use, along with current standards and conventions, please see the paper: "The Breakthrough Listen Search for Intelligent Life: Public Data, Formats, Reduction and Archiving" - Lebofsky, et al.

BERKELEY SETI RESEARCH CENTER

Background Photo by Jenya Chernoff

http://seti.berkeley.edu/bldr2/

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The Astronomical Journal 159,3 (2020) 86

The Breakthrough Listen Search for Intelligent Life: Observations of 1327 Nearby Stars over 1.10–3.45 GHz

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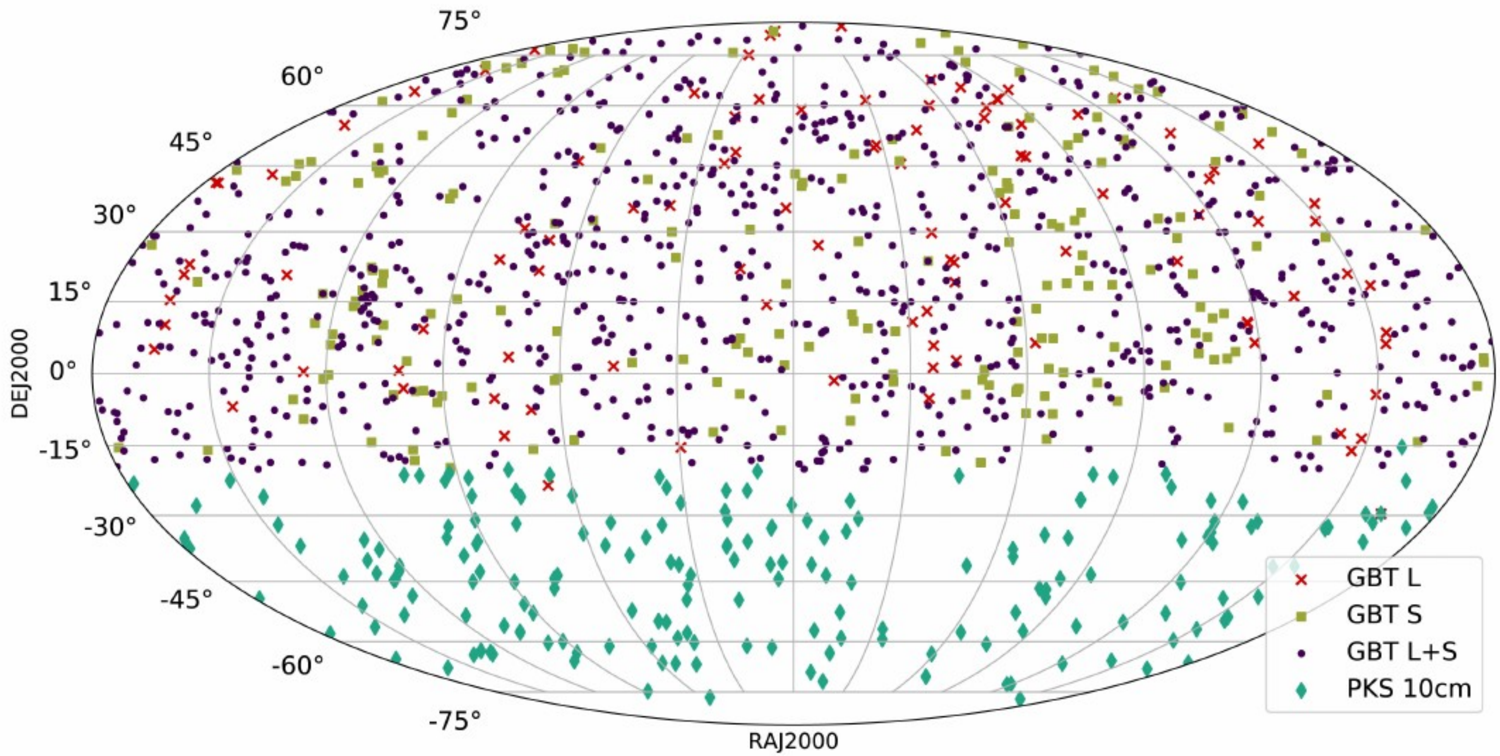

Figure 1. Distribution of observed sources in equatorial coordinates, taken from the 1702-star sample of Isaacson et al. (2017). Sources observed with Green Bank at both L-band and S-band are plotted in purple; sources only observed at L-band are plotted with red crosses; sources only observed at S-band are plotted with yellow squares; and sources observed with Parkes at 10cm are plotted with aqua diamonds.

5(T) + 5(B) + 5(T) + 5(B) + 5(T) + 5(B) = 15 min (Target) + 15 min (Background)

arXiv:2002.06162

The Breakthrough Listen Search for Intelligent Life: A 3.95–8.00 GHz Search for Radio Technosignatures in the Restricted Earth Transit Zone

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ABSTRACT

We report on a search for artificial narrowband signals of 20 stars within the restricted Earth Transit Zone as a part of the ten-year Breakthrough Listen (BL) search for extraterrestrial intelligence. The restricted Earth Transit Zone is the region of the sky from which an observer would see the Earth transit the Sun with an impact parameter of less than 0.5. This region of the sky is geometrically unique, providing a potential way for an extraterrestrial intelligence to discover the Solar System. The targets were nearby (7–143 pc) and the search covered an electromagnetic frequency range of 3.95–8.00 GHz. We used the Robert C. Byrd Green Bank Telescope to perform these observations with the standard BL data recorder. We searched these data for artificial narrowband (~Hz) signals with Doppler drift rates of ± 20 Hz s^{-1}. We found one set of potential candidate signals on the target HIP 109656 which was then found to be consistent with known properties of anthropogenic radio frequency interference. We find no evidence for radio technosignatures from extraterrestrial intelligence in our observations. The observing campaign achieved a minimum detectable flux which would have allowed detections of emissions that were 10^{-3} to 0.88 times as powerful as the signaling capability of the Arecibo radar transmitter, for the nearest and furthest stars respectively. We conclude that at least 8% of the systems in the restricted Earth Transit Zone within 150 pc do not possess the type of transmitters searched in this survey. To our knowledge, this is the first targeted search for extraterrestrial intelligence of the restricted Earth Transit Zone. All data used in this paper are publicly available via the Breakthrough Listen Public Data

Table 1. The list of 20 targets observed in this work.

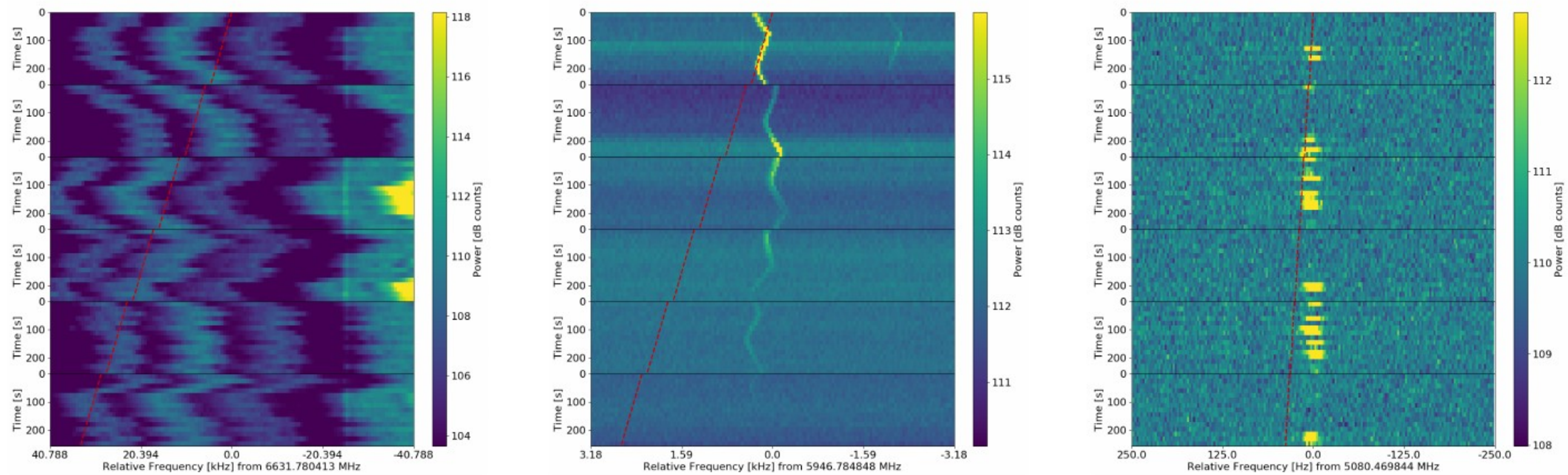
ID	RA (hr)	Dec (deg)	Distance (pc)	μ_{RA} (mas)	μ_{Dec} (mas)	V mag.	Sp. Type	EIRP$_{min}$ (GW)	EIRP$_{min}$ (L_A)
HIP 3765	00 48 23.0	+05 16 50.2	$7.4350^{+0.0049}_{-0.0049}$	755.6	-1141.8	5.74^{β}	K2.5V$^{\alpha}$	47	0.002
HIP 95417	19 24 34.2	-22 03 43.8	$27.6284^{+0.0476}_{-0.0476}$	-230.8	-451.6	10.899^{γ}	K8V$^{\alpha}$	653	0.033
HIP 64688	13 15 30.8	-08 03 18.5	$40.7145^{+0.1079}_{-0.1079}$	49.5	58.7	8.06^{ϵ}	G5V$^{\delta}$	1417	0.071
HIP 34271	07 06 16.8	+22 40 00.6	$43.1941^{+0.0961}_{-0.0961}$	-92.4	-78.8	8.39^{ξ}	G2V^{o}	1595	0.080
HIP 33497	06 57 46.3	+22 53 33.2	$44.6959^{+0.1414}_{-0.1414}$	-144.2	-142.0	7.75^{ξ}	G0$^{\zeta}$	1708	0.086
HIP 15381	03 18 20.0	+18 10 17.8	$47.4030^{+0.1074}_{-0.1074}$	-83.1	-103.8	7.540^{η}	G0$^{\zeta}$	1921	0.096
HIP 9607	02 03 33.0	+12 35 05.0	$47.6268^{+0.0903}_{-0.0903}$	377.3	-55.7	13.475^{ϵ}	K7V$^{\theta}$	1939	0.097
HIP 43418	08 50 36.9	+17 41 21.5	$50.1645^{+0.1004}_{-0.1004}$	-158.4	-61.2	9.51^{ξ}	K0$^{\pi}$	2151	0.107
HIP 83662	17 05 59.6	-22 51 24.3	$50.3563^{+0.1270}_{-0.1270}$	39.8	-325.7	10.00^{ϵ}	K2$^{\iota}$	2167	0.108
HD 174995	18 54 12.7	-22 54 24.9	$53.1762^{+0.1657}_{-0.1657}$	-166.1	-362.4	8.62^{γ}	G9$^{\iota}$	2417	0.121
HIP 111332	22 33 21.5	-09 03 48.8	$61.0706^{+0.2268}_{-0.2268}$	297.7	-61.0	8.86^{ξ}	G3V$^{\delta}$	3188	0.159
HIP 118159	23 58 04.5	-00 07 41.5	$66.3060^{+0.2286}_{-0.2286}$	-43.8	-18.4	9.16^{ξ}	G5Vn$^{\delta}$	3758	0.160
HIP 16136	03 27 55.3	+18 52 56.4	$66.8400^{+0.2216}_{-0.2216}$	14.3	-60.6	8.48^{ϵ}	G0$^{\pi}$	3818	0.191
HIP 88631	18 05 46.7	-23 31 03.8	$84.1206^{+0.3474}_{-0.3474}$	25.9	-212.7	9.28^{ξ}	G6/8V$^{\kappa}$	6048	0.303
HIP 46339	09 26 49.4	+14 55 40.7	$85.6076^{+0.4690}_{-0.4690}$	21.9	-92.6	8.38^{ξ}	G0$^{\zeta}$	6264	0.313
HIP 109656	22 12 51.0	-10 55 34.2	$89.49^{+85}_{-44.951}$ $^{\rho}$	180.4^{λ}	-183.0^{λ}	10.80^{ϵ}	K2V$^{\mu}$	6845	0.342
HIP 82986	16 57 30.2	-22 38 37.1	$127.4259^{+1.0830}_{-1.0830}$	-3.1	-30.1	9.78^{ϵ}	G0V$^{\kappa}$	13878	0.694
HIP 61349	12 34 13.3	-03 43 16.2	$136.6195^{+1.0807}_{-1.0807}$	13.4	-57.8	8.57^{ϵ}	F5V$^{\delta}$	15952	0.798
HIP 65642	13 27 29.7	-09 11 33.7	$137.1272^{+1.4009}_{-1.4009}$	-54.9	-11.9	9.48^{ϵ}	G5V$^{\delta}$	16071	0.803
HIP 19054	04 04 56.5	+20 51 23.3	$143.4597^{+1.0373}_{-1.0373}$	12.8	-52.1	8.98^{ϵ}	G0$^{\nu}$	17590	0.880

References—$^{\alpha}$Gray et al. (2006), $^{\beta}$van Belle & von Braun (2009), $^{\gamma}$Zacharias et al. (2012), $^{\delta}$Houk & Swift (1999), $^{\epsilon}$Høg et al. (2000), $^{\zeta}$Cannon & Pickering (1993), $^{\eta}$Oja (1987), $^{\theta}$ Stephenson (1986), $^{\iota}$Bidelman (1985), $^{\kappa}$Houk & Smith-Moore (1988), $^{\lambda}$Prusti et al. (2016), $^{\mu}$Dressing et al. (2017), $^{\nu}$Nesterov et al. (1995), $^{\xi}$van Leeuwen (2007), ^{o}Lockwood & Thompson (2009), $^{\pi}$Heckmann (1975), $^{\rho}$Kunder et al. (2017)

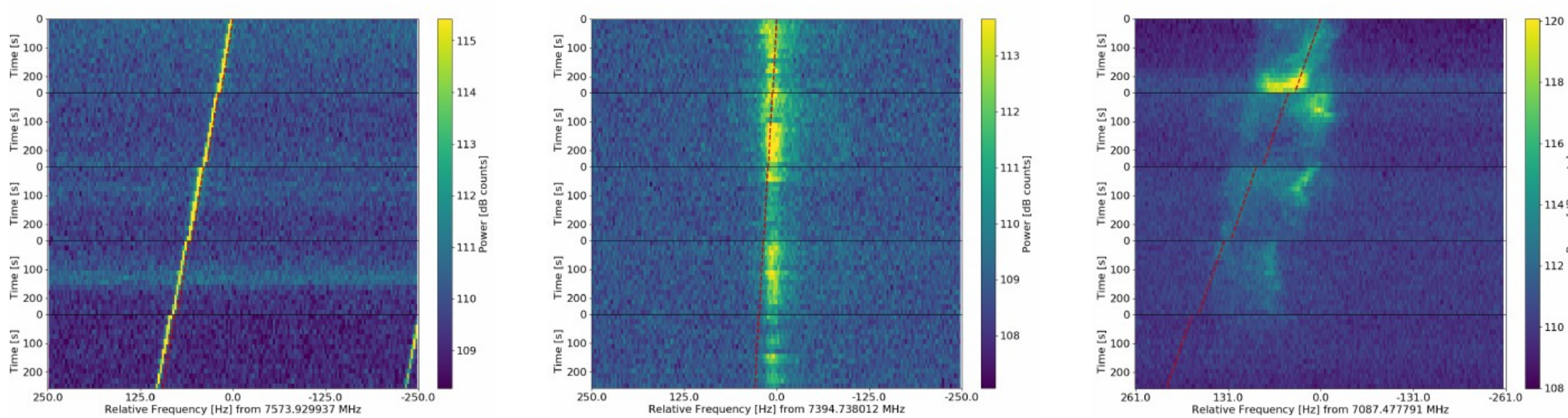
NOTE—For each target, we include its identifier (ID), right ascension in hours (RA), declination in degrees (Dec), distance in parsecs (Distance), proper motion in right ascension and declination in milliarcseconds (μ_{RA} and μ_{Dec}), apparent visual magnitude, and spectral type. We also show minimum detectable Equivalent Isotropically Radiated Powers (EIRPs) for transmitters at each target (calculated in Section 3). Column 9 gives this value in gigawatts and Column 10 gives this same value in units of L_A, where $L_A = L_{Arecibo}$ = 20TW (Siemion et al. 2013). All right ascensions, declinations, parallax distances, and proper motions are sourced from GAIA DR2 (Brown et al. 2018) except where otherwise indicated.

Target	Flagged By	# of Events	Frequencies (MHz)	Drift Rates (Hz/s)	SNRs
HIP 65642	AH	4	6631.73, 7968.67	0.00, 0.01	24, 37
HIP 96440 and HIP 95417	OND	12 and 5	7655.18–7656.41	0.05–0.07	10–20
HIP 88982	AH and OND	271	4506.04–4526.98	0.01	10–20
LTT 88982	OND	94	5190.30–5213.93	±0.01	10–180

Table 4. The four potential candidate sets identified by the two filters. AH stands for "All-Hit Filter" and OND stands for "Only Non-Zero Drift Filter".



(d) (e) (f)



arXiv:2002.02130

First SETI Observations with China's Five-hundred-meter Aperture Spherical radio Telescope (FAST)

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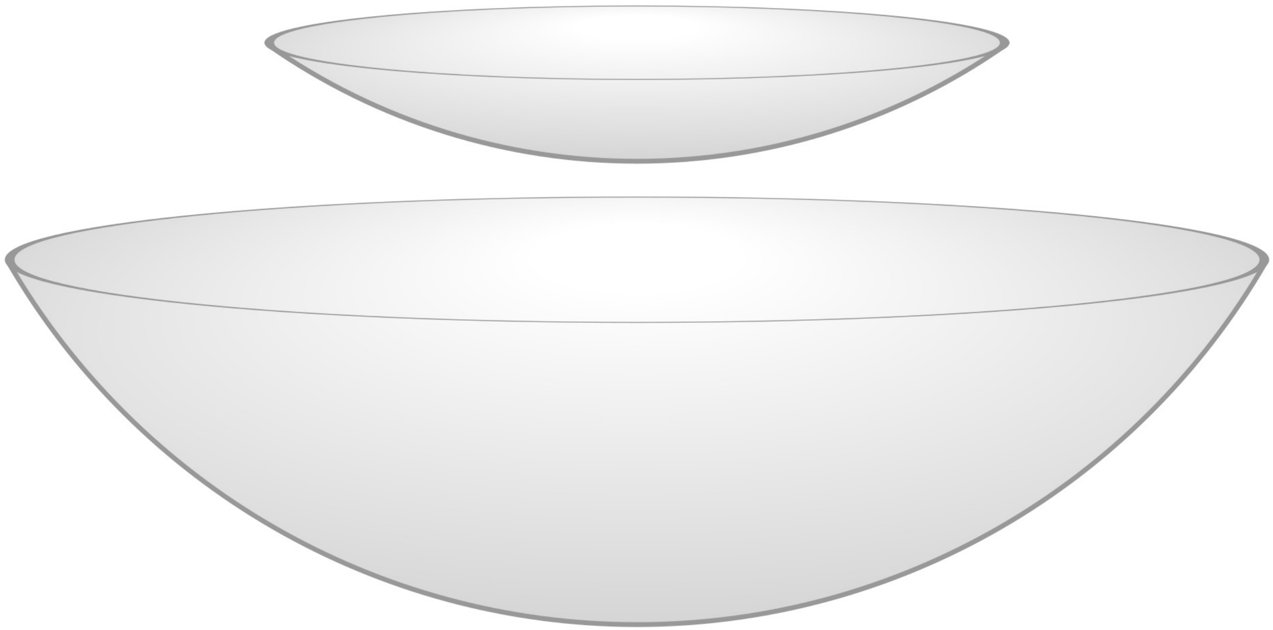
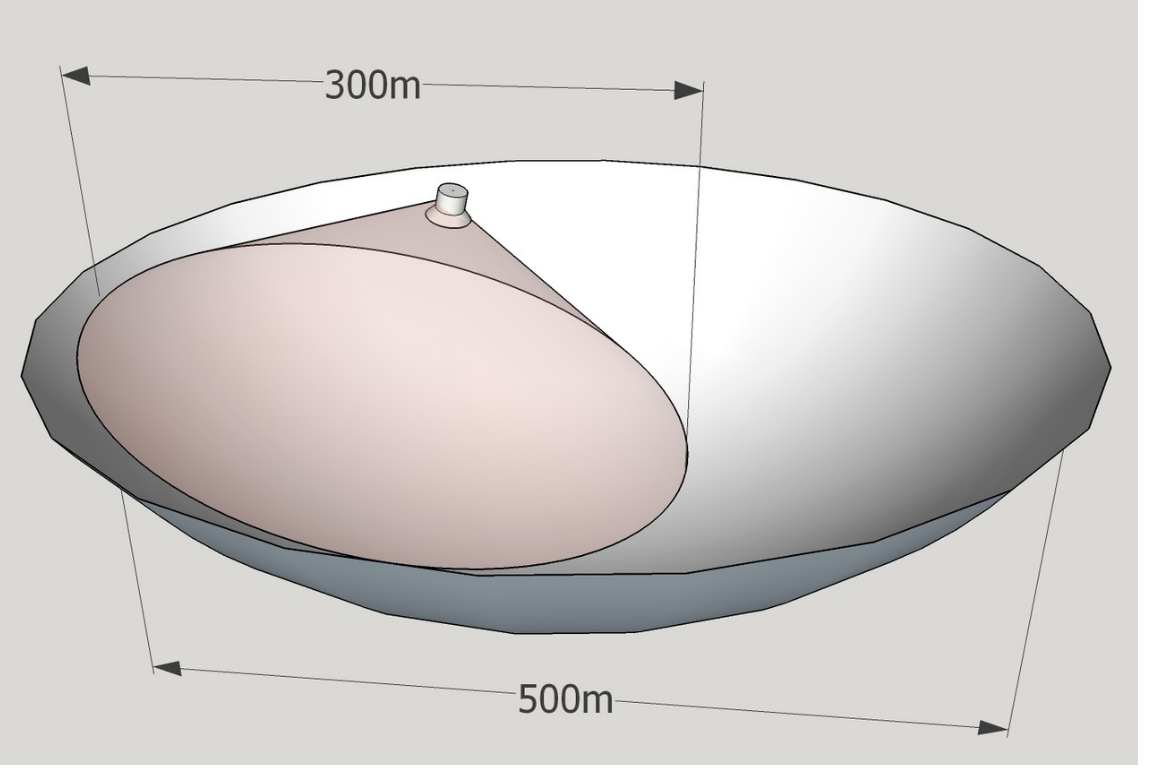
ABSTRACT

The Search for Extraterrestrial Intelligence (SETI) attempts to address the possibility of the presence of technological civilizations beyond the Earth. Benefiting from high sensitivity, large sky coverage, an innovative feed cabin for China's Five-hundred-meter Aperture Spherical radio Telescope (FAST), we performed the SETI first observations with FAST's newly commisioned 19-beam receiver; we report preliminary results in this paper. Using the data stream produced by the SERENDIP VI realtime multibeam SETI spectrometer installed at FAST, as well as its off-line data processing pipelines, we identify and remove four kinds of radio frequency interference(RFI): zone, broadband, multi-beam, and drifting, utilizing the Nebula SETI software pipeline combined with machine learning algorithms. After RFI mitigation, the Nebula pipeline identifies and ranks interesting narrow band candidate ET signals, scoring candidates by the number of times candidate signals have been seen at roughly the same sky position and same frequency, signal strength, proximity to a nearby star or object of interest, along with several other scoring criteria. We show four example candidates groups that demonstrate these RFI mitigation and candidate selection. This preliminary testing on FAST data helps to validate our SETI instrumentation techniques as well as our data processing pipeline.



В одном наблюдении используется 300м апертура
±26.4° от зенита



Получает финансирование от BreakThroght Listen
Только 1 день наблюдений, 19 июля 2019 г.

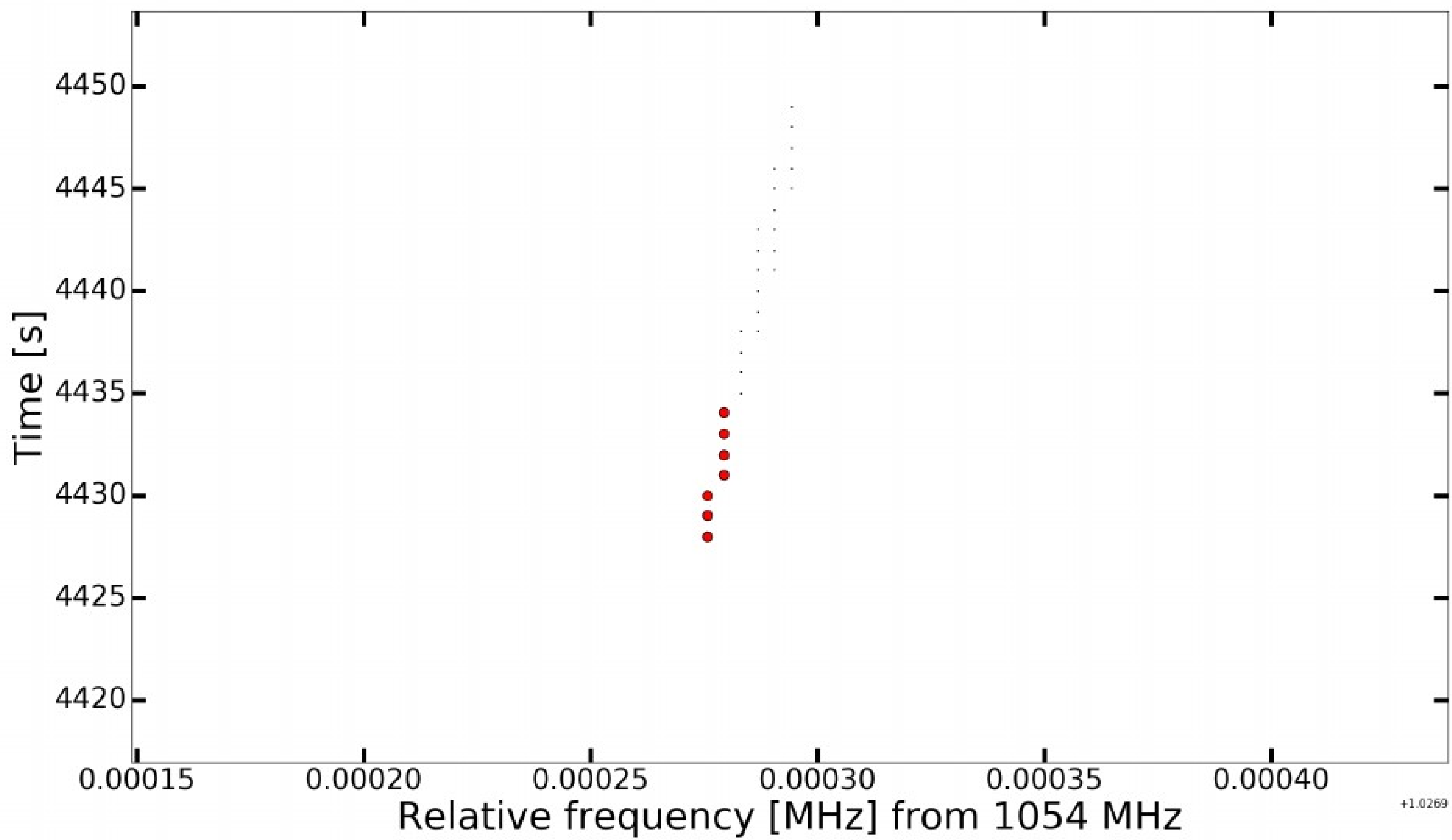


Figure 19. Zoom in of candidates in Figure 18. Group 1 in top panel only occupies one frequency channel. And Group 2 in bottom panel occupies six successive channels, totally ~18.6 Hz of bandwidth. Note that Group 2 is in two colors, because only the red points are found by the SETI pipeline while black points are from the raw data.

arXiv:2001.06683
Проект, 498 страниц

In 2016, NASA began considering Large strategic science missions

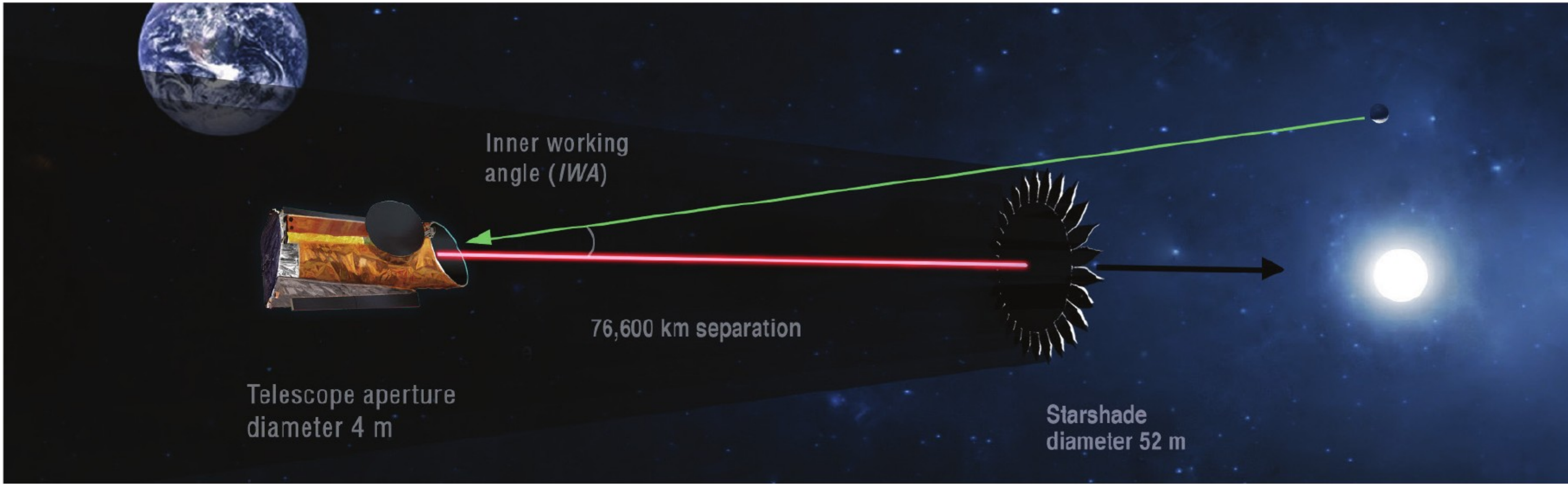
- Habitable Exoplanet Imaging Mission (HabEx)
- Large UV Optical Infrared Surveyor (LUVOIR)
- Origins Space Telescope,
- Lynx X-ray Surveyor.

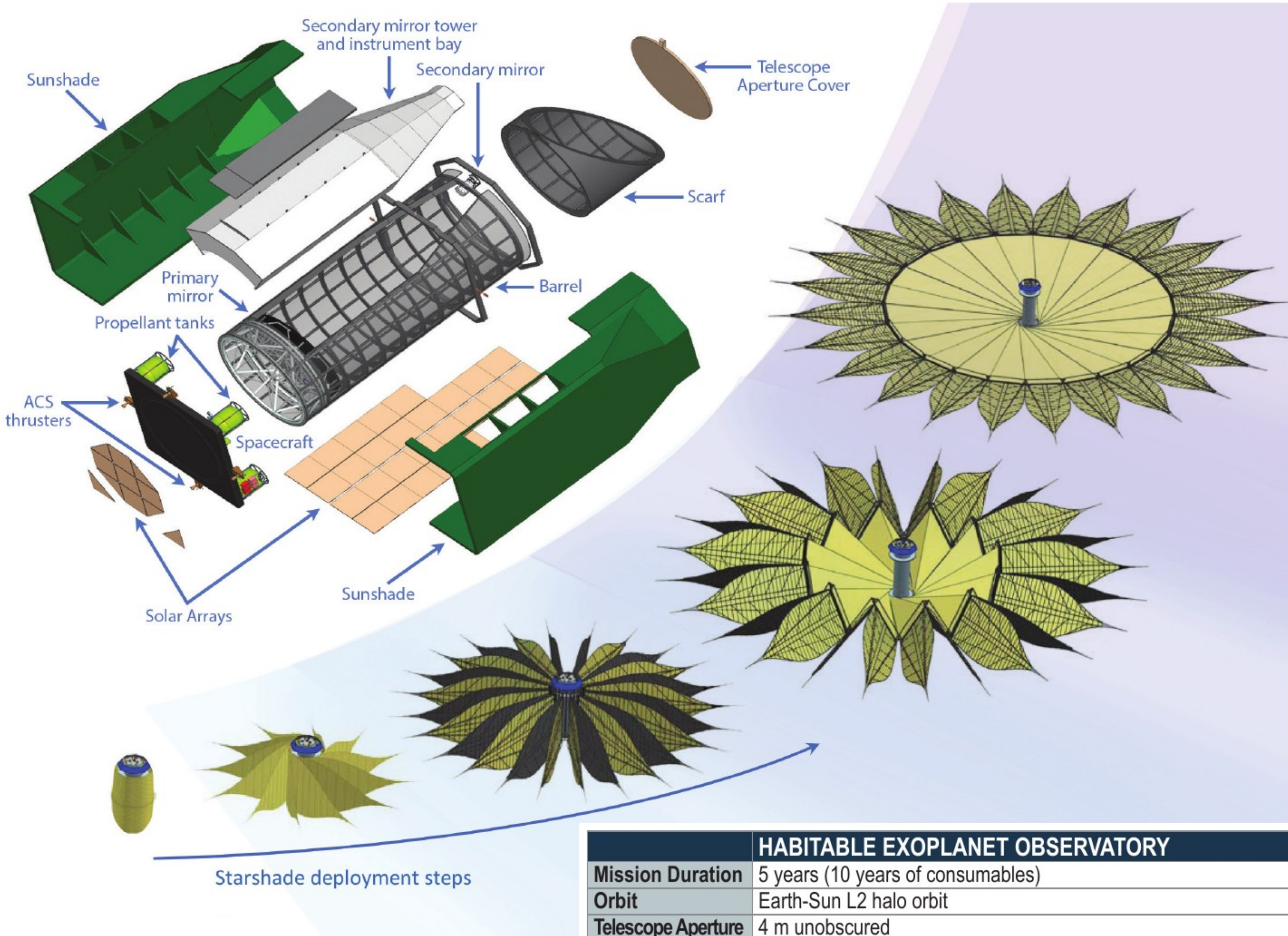
Отбор - конец 2020, Запуск - примерно 2035.

The Habitable Exoplanet Imaging Mission (HabEx)

A mission to directly image planetary systems around Sun-like stars.
HabEx will be sensitive to all types of planets;
Main goal is to directly image Earth-size rocky exoplanets,
and characterize their atmospheric content.

Солнечно-земная точка Лагранжа L2
Монолитное зеркало 4 м
Wavelengths 0.3 – 2.5 μm, depending on the cost and complexity
В системе присутствуют одновременно коронограф и система starshade





	HABITABLE EXOPLANET OBSERVATORY
Mission Duration	5 years (10 years of consumables)
Orbit	Earth-Sun L2 halo orbit
Telescope Aperture	4 m unobscured
Telescope Type	Off-axis three-mirror anastigmat
Primary Mirror	Monolithic; glass-ceramic substrate; Al + MgF_2 coating
Instruments (4)	Exoplanet science: Coronagraph (HCG), Starshade (SSI) Observatory science: UV spectrograph (UVS), Workhorse Camera (HWC)
Attitude Control	Slewing; hydrazine thrusters; Pointing: microthrusters

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

Exo-MerCat: a merged exoplanet catalog with Virtual Observatory connection.

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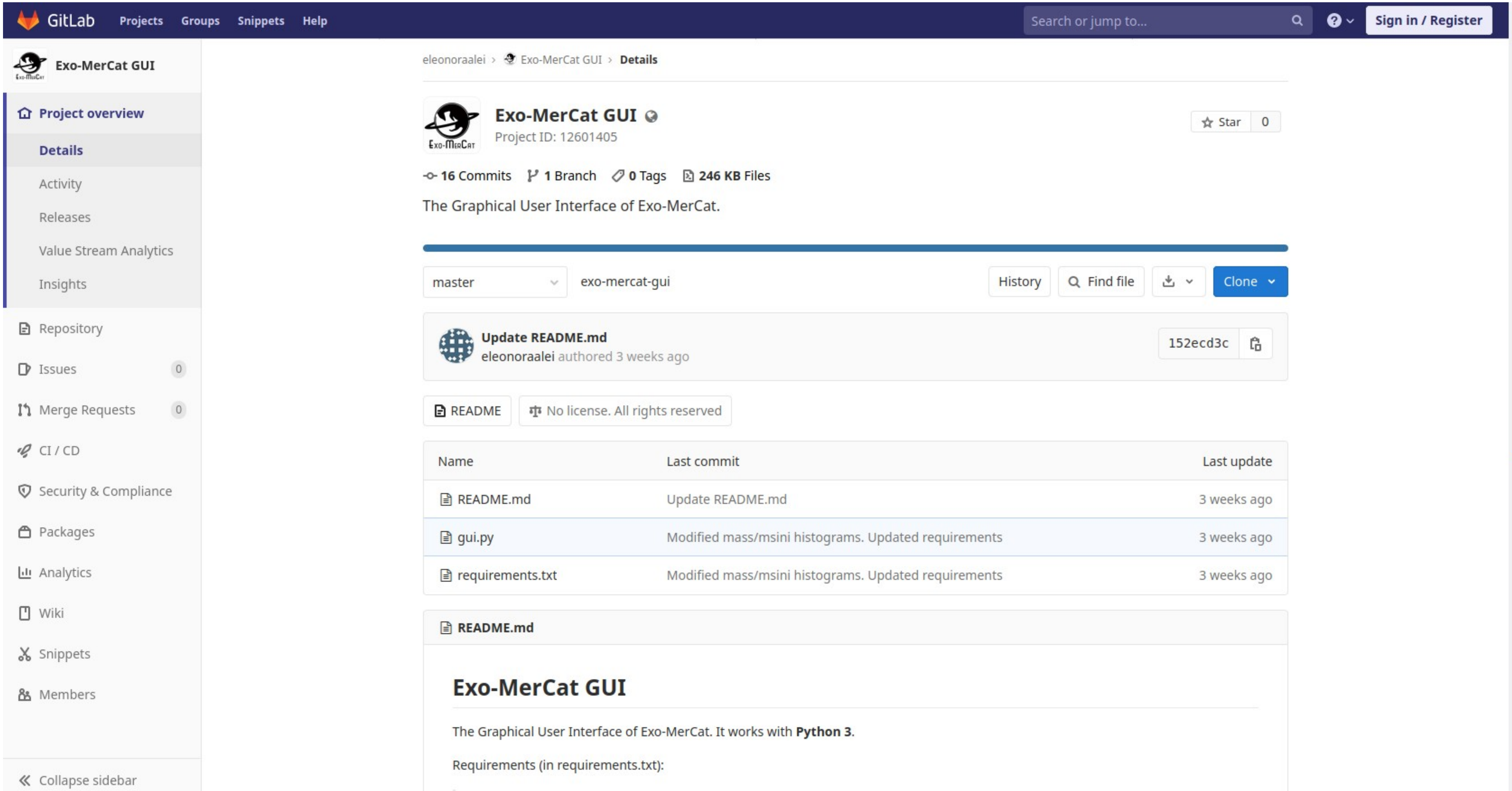
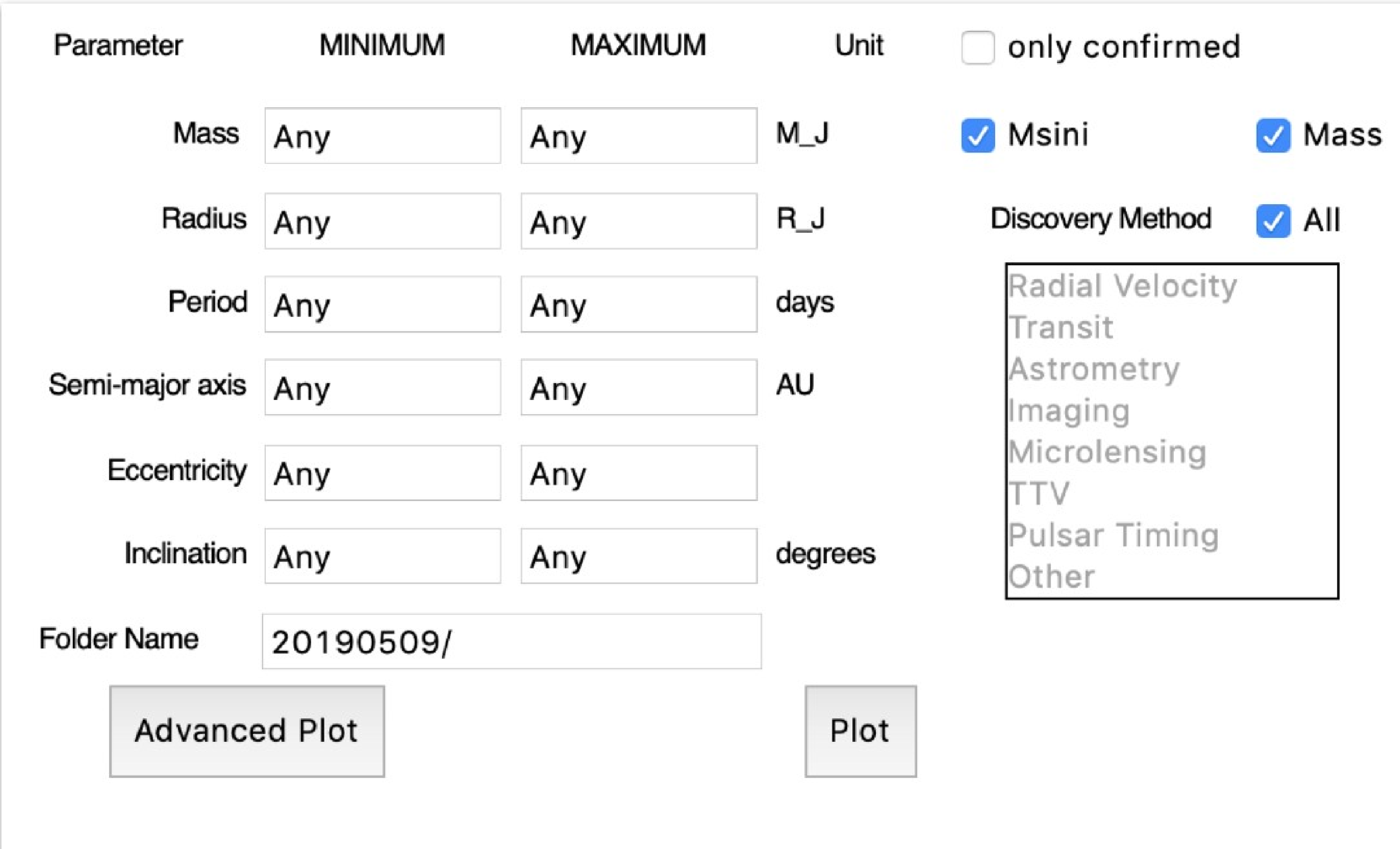
Abstract

The heterogeneity of papers dealing with the discovery and characterization of exoplanets makes every attempt to maintain a uniform exoplanet catalog almost impossible. Four sources currently available online (NASA Exoplanet Archive, Exoplanet Orbit Database, Exoplanet Encyclopaedia, and Open Exoplanet Catalogue) are commonly used by the community, but they can hardly be compared, due to discrepancies in notations and selection criteria. Exo-MerCat is a Python code that collects and selects the most precise measurement for all interesting planetary and orbital parameters contained in the four databases, accounting for the presence of multiple aliases for the same target. It can download information about the host star as well by the use of Virtual Observatory ConeSearch connections to the major archives such as SIMBAD and those available in VizieR. A Graphical User Interface is provided to filter data based on the user's constraints and generate automatic plots that are commonly used in the exoplanetary community. With Exo-MerCat, we retrieved a unique catalog that merges information from the four main databases, standardizing the output and handling notation differences issues. Exo-MerCat can correct as many issues that prevent a direct correspondence between multiple items in the four databases as possible, with the available data. The catalog is available as a VO resource for everyone to use and it is periodically updated, according to the update rates of the source catalogs.

arXiv:2002.01834

https://gitlab.com/eleonoraalei/exo-mercat-gui




Parameter
MINIMUM
MAXIMUM
Unit
only confirmed
Mass
Any
Any
M_J
Msini
Mass
Radius
Any
Any
R_J
Discovery Method
All
Period
Any
Any
days
Semi-major axis
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Any
AU
Eccentricity
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Any
degrees
Radial Velocity
Transit
Astrometry
Imaging
Microlensing
TTV
Pulsar Timing
Other
Folder Name
20190509/
Advanced Plot
Plot

arXiv:2001.00673

There's No Place Like Home (in Our Own Solar System): Searching for ET Near White Dwarfs.

John Gertz[1,2]

Abstract: The preponderance of white dwarfs in the Milky Way were formed from the remnants of stars of the same or somewhat higher mass as the Sun, i.e., from G-stars. We know that life can exist around G-stars. Any technologically advanced civilization residing within the habitable zone of a G-star will face grave peril when its star transitions from the main sequence and successively enters sub-giant, red giant, planetary nebula, and white dwarf stages. In fact, if the civilization takes no action it will face certain extinction. The two alternatives to passive extinction are (a) migrate away from the parent star in order to colonize another star system, or (b) find a viable solution within one's own solar system. It is argued in this paper that migration of an entire biological population or even a small part of a population is virtually impossible, but in any event, far more difficult than remaining in one's home solar system where the problem of continued survival can best be solved. This leads to the conclusion that sub-giants, red giants, planetary nebula, and white dwarfs are the best possible candidate targets for SETI observations. Search strategies are suggested.

1. Скорее всего межзвездное путешествие с целью колонизации неосуществимо.

2. Если осуществимо, то цель выглядит бессмысленной, либо даже «запрещенной»

3. Имеет смысл оставаться в своей системе — ресурсов и т. д. достаточно

4. Однако звезда сойдет с главной последовательности

5. Около звезды, сошедшей с главной последовательности, можно выжить, однако это означает прохождение фильтра на высокоразвитость

Вывод: Самые высокоразвитые цивилизации могут быть обнаружены около красных гигантов и белых карликов - там надо их и искать