FAST science cases and data

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(National Astronomical Observatories, Chinese Academy of Sciences)

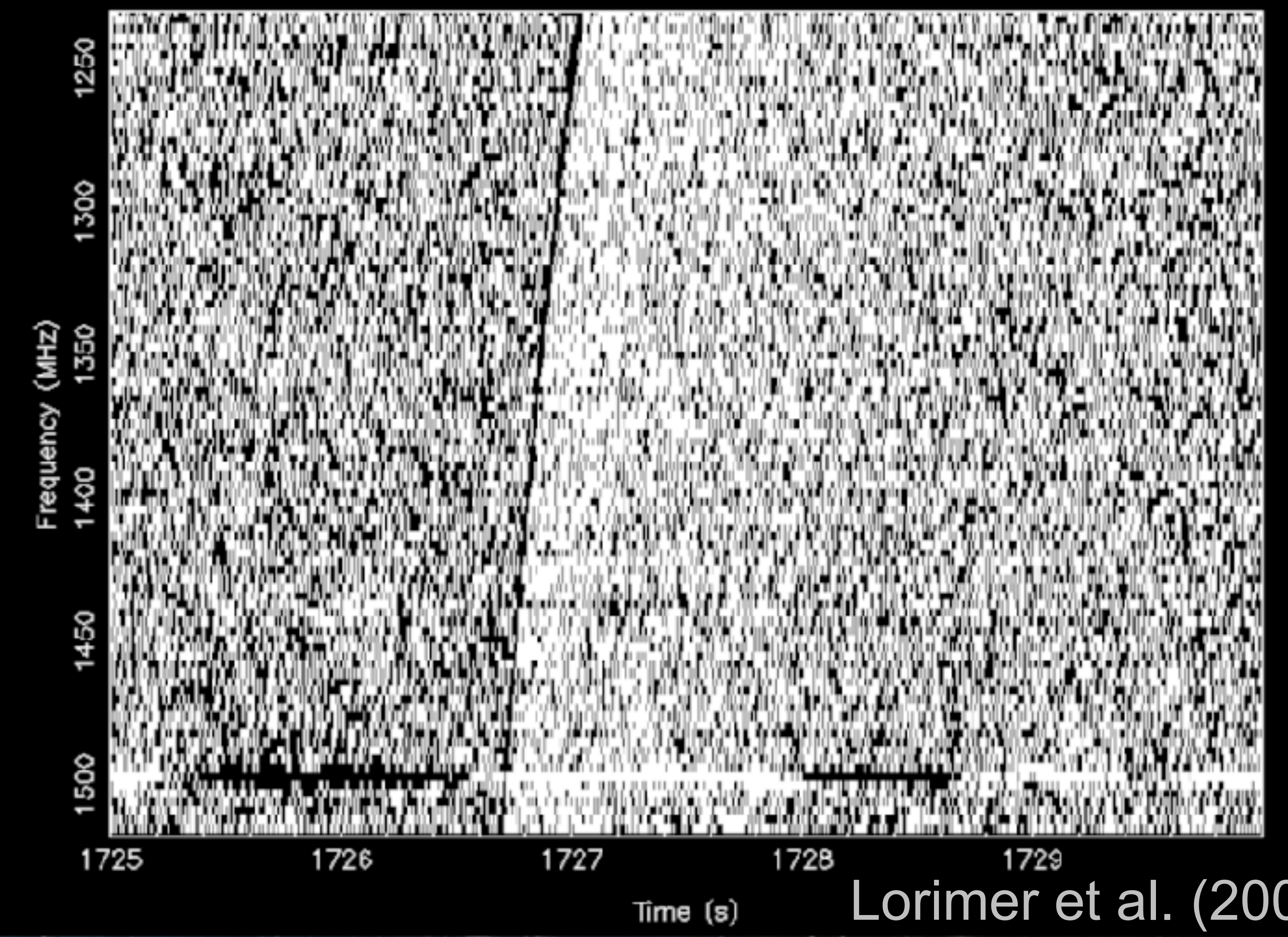
Mar 8, 2022 @ VO single dish meeting

Five-hundred-meter Aperture Spherical radio Telescope

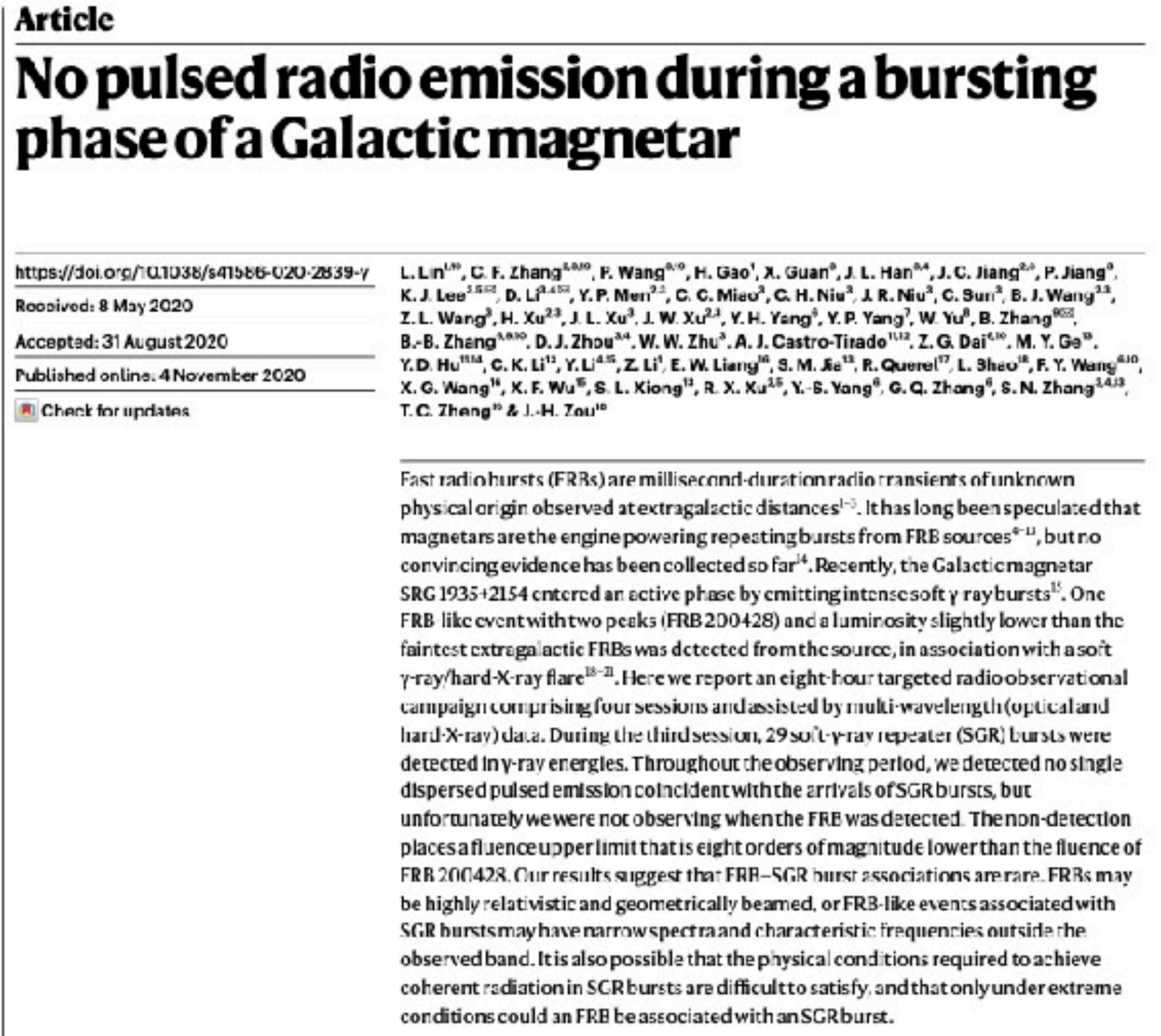
2016年9月落成启用


Danielle Futselaar

FRB



Lorimer et al. (2007)



Article

No pulsed radio emission during a bursting phase of a Galactic magnetar

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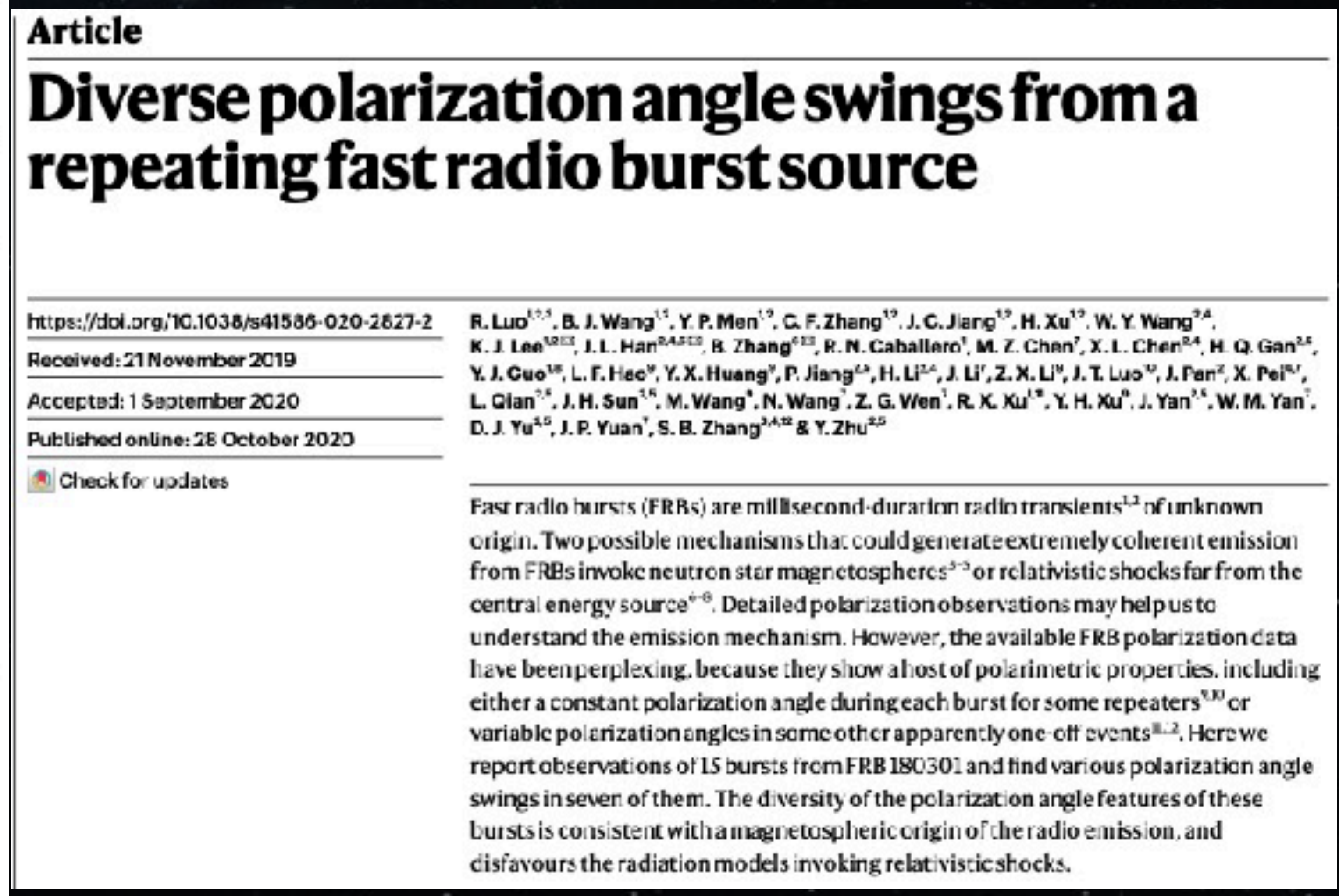
L. Lin[1,10], C. F. Zhang[2,3,10], P. Wang[2,10], H. Gao[1], X. Guan[2], J. L. Han[2,4], J. C. Jiang[2,4], P. Jiang[2], K. J. Lee[3,5,22], D. Li[2,4,22], Y. P. Men[2,3], C. C. Miao[2], C. H. Niu[2], J. R. Niu[2], C. Sun[2], B. J. Wang[2,3], Z. L. Wang[2], H. Xu[2,3], J. L. Xu[2], J. W. Xu[2,3], Y. H. Yang[6], Y. P. Yang[7], W. Yu[8], B. Zhang[9,22], B.-B. Zhang[6,8,10], D. J. Zhou[2,4], W. W. Zhu[2], A. J. Castro-Tirado[11,12], Z. G. Dai[6,10], M. Y. Ge[13], Y. D. Hu[11,14], C. K. Li[13], Y. Li[4,15], Z. Li[1], E. W. Liang[16], S. M. Jia[13], R. Querel[17], L. Shao[18], F. Y. Wang[6,10], X. G. Wang[16], X. F. Wu[15], S. L. Xiong[13], R. X. Xu[3,5], Y.-S. Yang[6], G. Q. Zhang[6], S. N. Zhang[3,4,13], T. C. Zheng[19] & J.-H. Zou[19]

Fast radio bursts (FRBs) are millisecond-duration radio transients of unknown physical origin observed at extragalactic distances[1–3]. It has long been speculated that magnetars are the engine powering repeating bursts from FRB sources[4–13], but no convincing evidence has been collected so far[14]. Recently, the Galactic magnetar SRG 1935+2154 entered an active phase by emitting intense soft γ ray bursts[15]. One FRB-like event with two peaks (FRB 200428) and a luminosity slightly lower than the faintest extragalactic FRBs was detected from the source, in association with a soft γ-ray/hard-X-ray flare[18–21]. Here we report an eight-hour targeted radio observational campaign comprising four sessions and assisted by multi-wavelength (optical and hard-X-ray) data. During the third session, 29 soft-γ-ray repeater (SGR) bursts were detected in γ-ray energies. Throughout the observing period, we detected no single dispersed pulsed emission coincident with the arrivals of SGR bursts, but unfortunately we were not observing when the FRB was detected. The non-detection places a fluence upper limit that is eight orders of magnitude lower than the fluence of FRB 200428. Our results suggest that FRB–SGR burst associations are rare. FRBs may be highly relativistic and geometrically beamed, or FRB-like events associated with SGR bursts may have narrow spectra and characteristic frequencies outside the observed band. It is also possible that the physical conditions required to achieve coherent radiation in SGR bursts are difficult to satisfy, and that only under extreme conditions could an FRB be associated with an SGR burst.



Article

Diverse polarization angle swings from a repeating fast radio burst source

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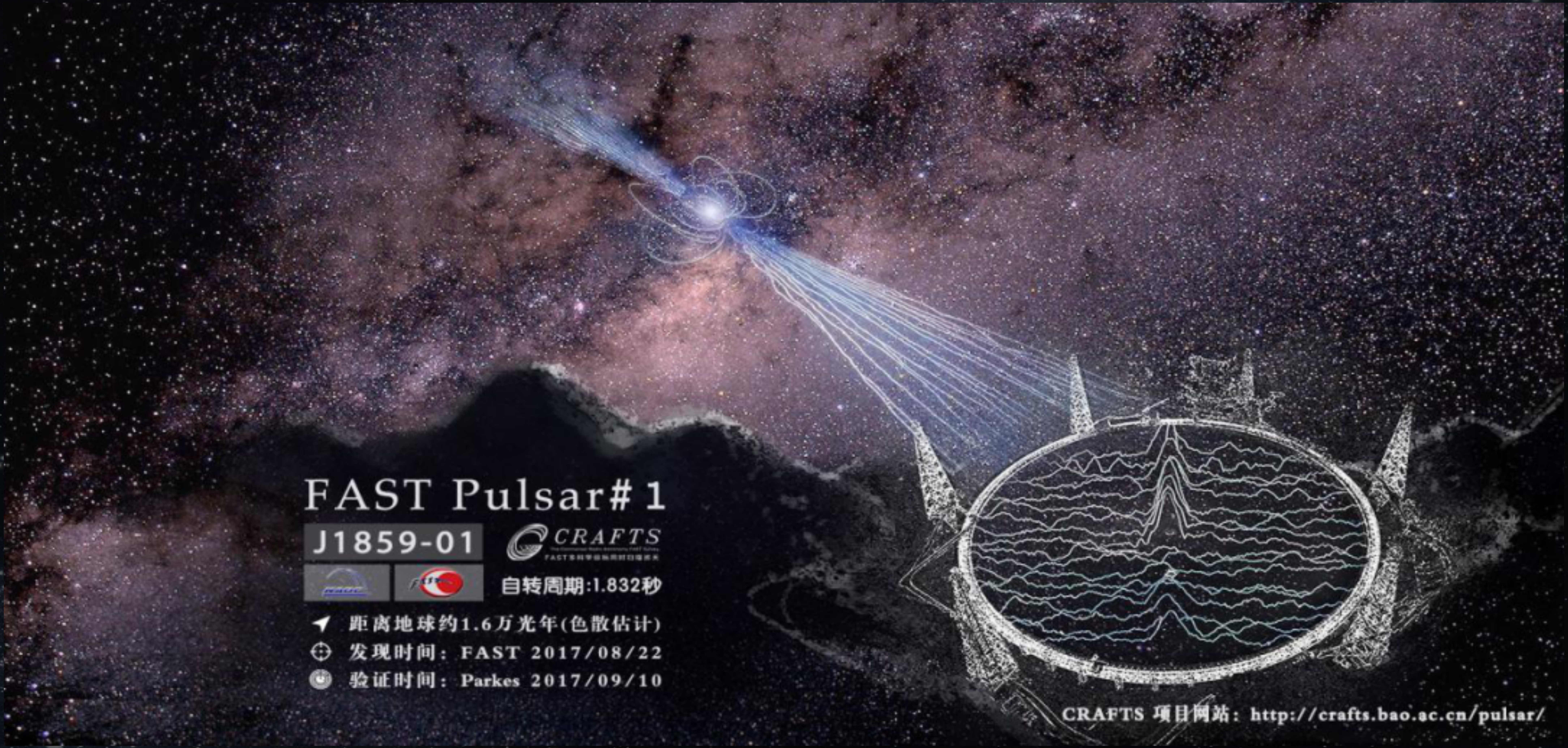
R. Luo[1,2,3], B. J. Wang[1,3], Y. P. Men[1,2], C. F. Zhang[1,2], J. C. Jiang[1,2], H. Xu[1,2], W. Y. Wang[2,4], K. J. Lee[1,2,13], J. L. Han[2,4,5,13], B. Zhang[6,13], R. N. Caballero[1], M. Z. Chen[7], X. L. Chen[2,4], H. Q. Gan[2,5], Y. J. Guo[1,8], L. F. Hao[9], Y. X. Huang[9], P. Jiang[2,5], H. Li[2,4], J. Li[7], Z. X. Li[9], J. T. Luo[10], J. Pan[2], X. Pei[8,7], L. Qian[2,5], J. H. Sun[2,5], M. Wang[9], N. Wang[7], Z. G. Wen[7], R. X. Xu[1,3], Y. H. Xu[9], J. Yan[2,5], W. M. Yan[7], D. J. Yu[2,5], J. P. Yuan[7], S. B. Zhang[2,4,12] & Y. Zhu[2,5]

Fast radio bursts (FRBs) are millisecond-duration radio transients[1,2] of unknown origin. Two possible mechanisms that could generate extremely coherent emission from FRBs invoke neutron star magnetospheres[3–5] or relativistic shocks far from the central energy source[6–8]. Detailed polarization observations may help us to understand the emission mechanism. However, the available FRB polarization data have been perplexing, because they show a host of polarimetric properties, including either a constant polarization angle during each burst for some repeaters[9,10] or variable polarization angles in some other apparently one-off events[11,12]. Here we report observations of 15 bursts from FRB 180301 and find various polarization angle swings in seven of them. The diversity of the polarization angle features of these bursts is consistent with a magnetospheric origin of the radio emission, and disfavours the radiation models invoking relativistic shocks.

Pulsar



FAST Pulsar#1

J1859-01

CRAFTS

自转周期:1.832秒

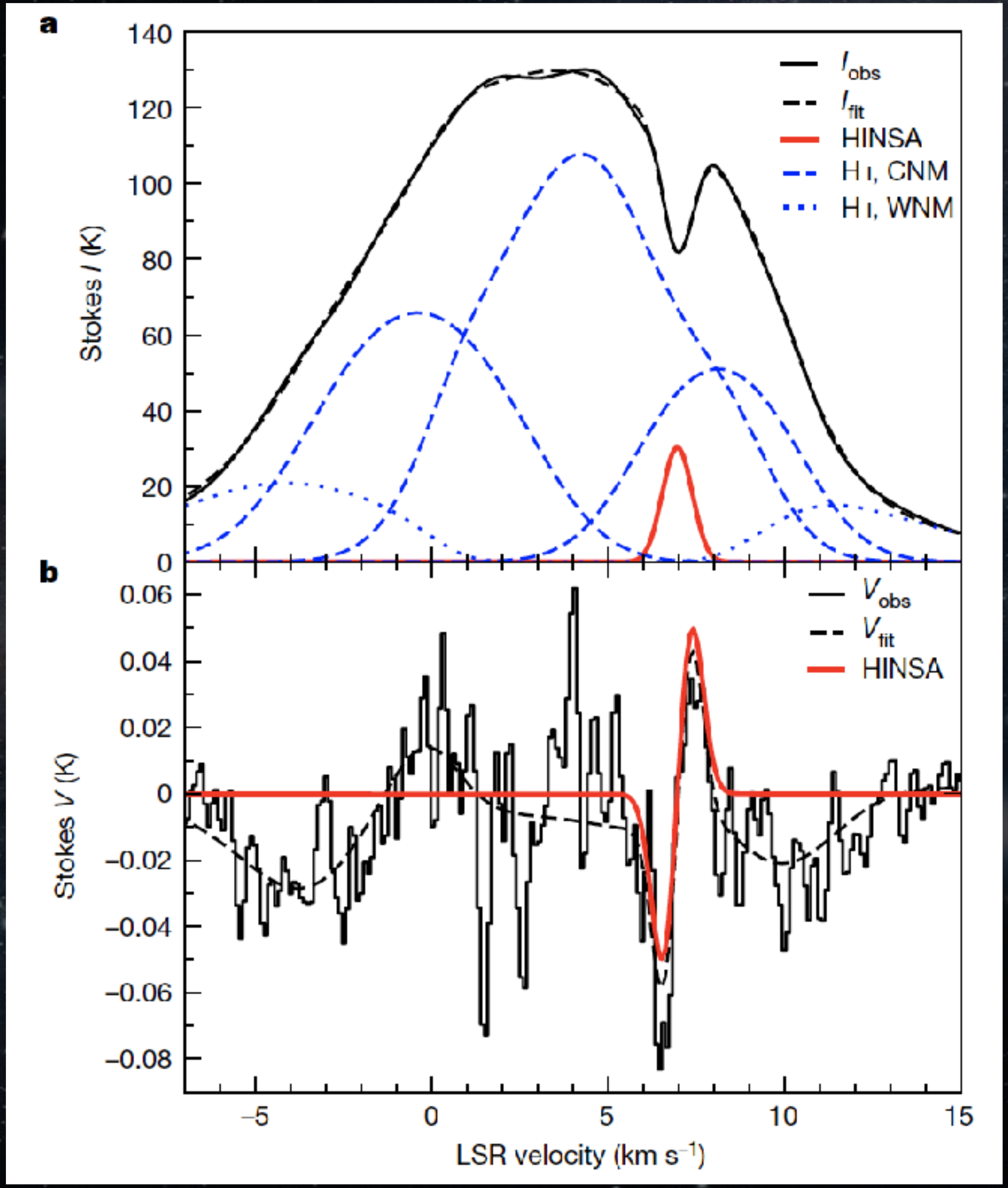
距离地球约1.6万光年(色散估计)

发现时间：FAST 2017/08/22

验证时间：Parkes 2017/09/10

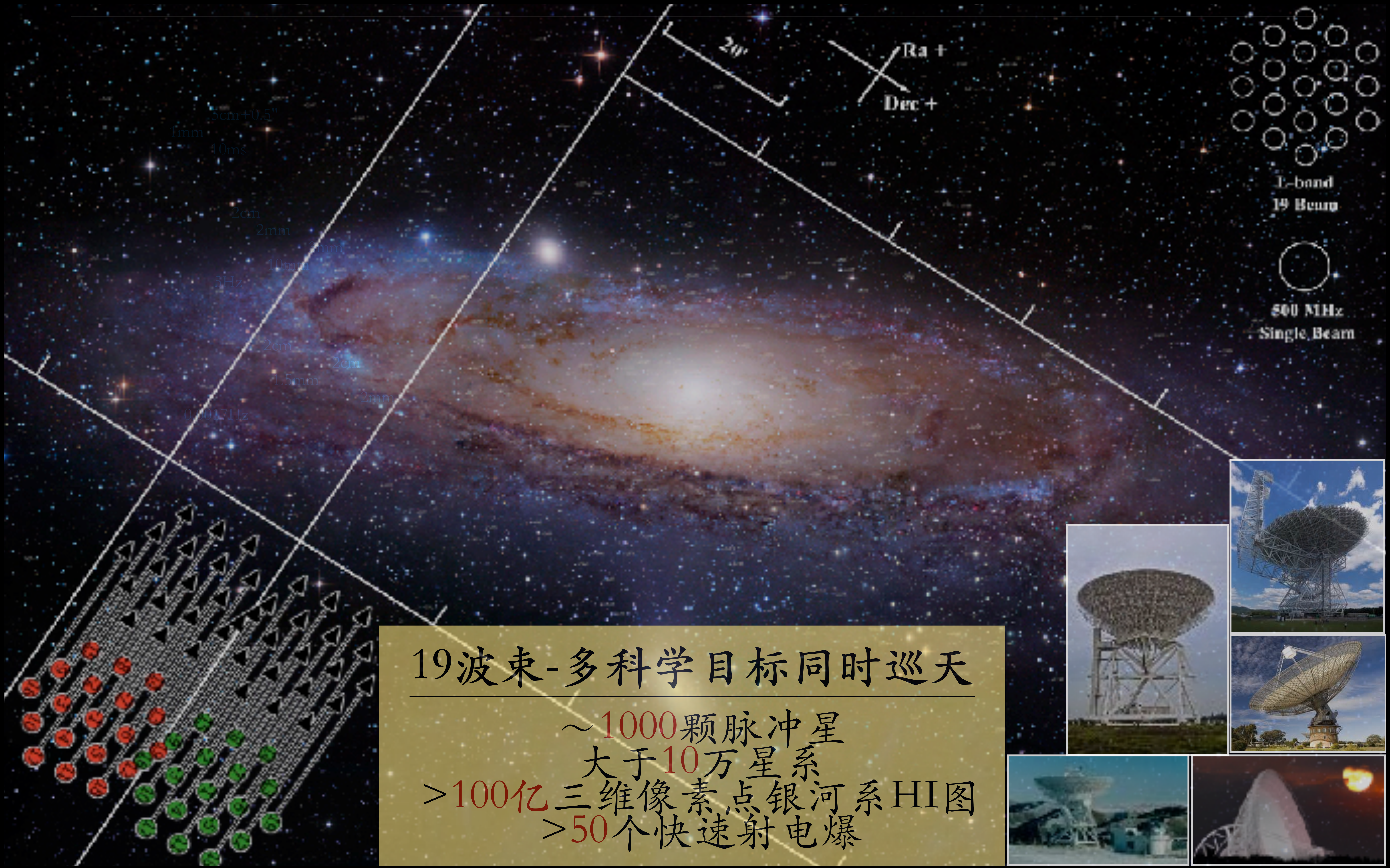
CRAFTS 项目网站：http://crafts.bao.ac.cn/pulsar/

HI



Ching et al. (2022; Nature)

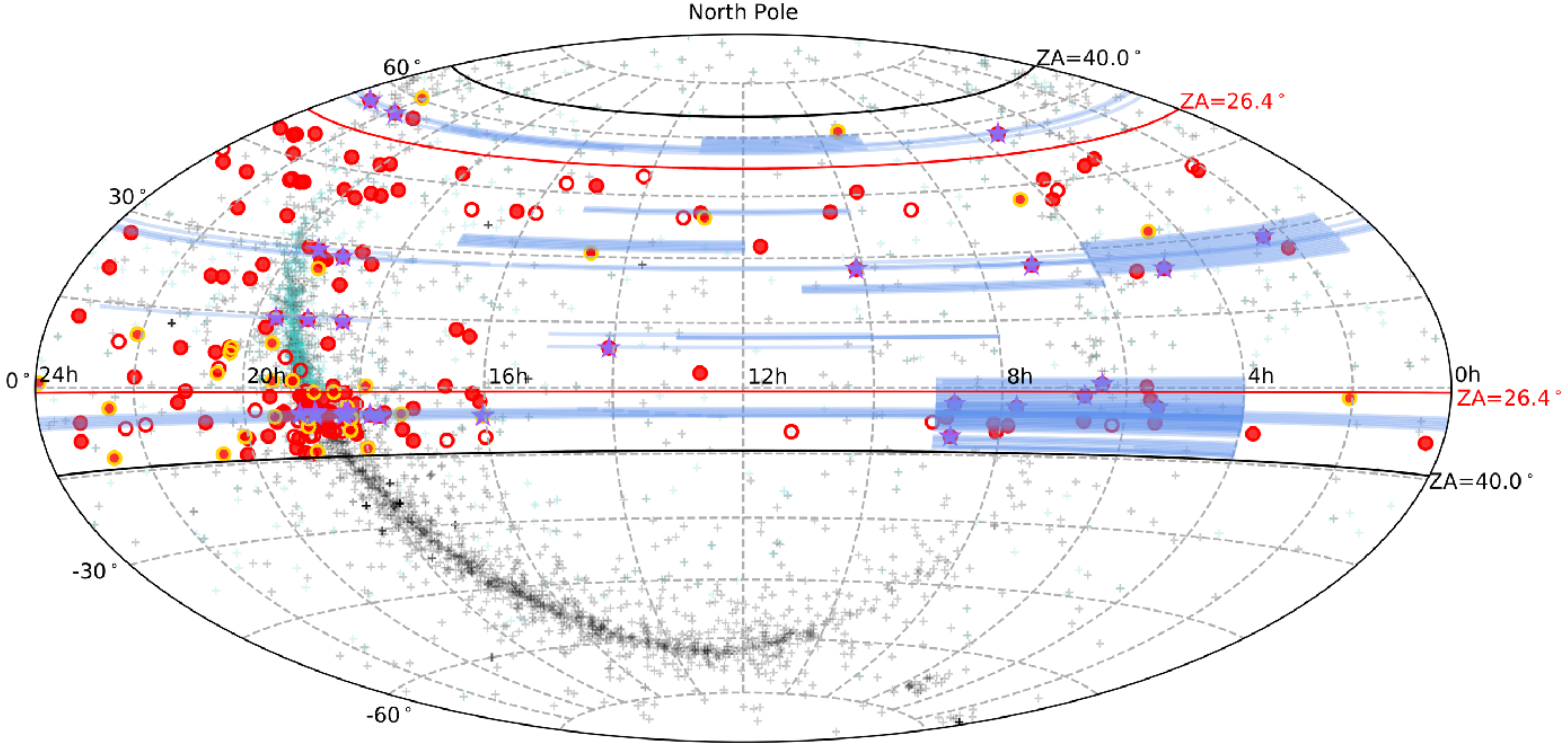
Commensal Radio Astronomy FAST Survey



19波束-多科学目标同时巡天

～1000颗脉冲星
大于10万星系
>100亿三维像素点银河系HI图
>50个快速射电爆

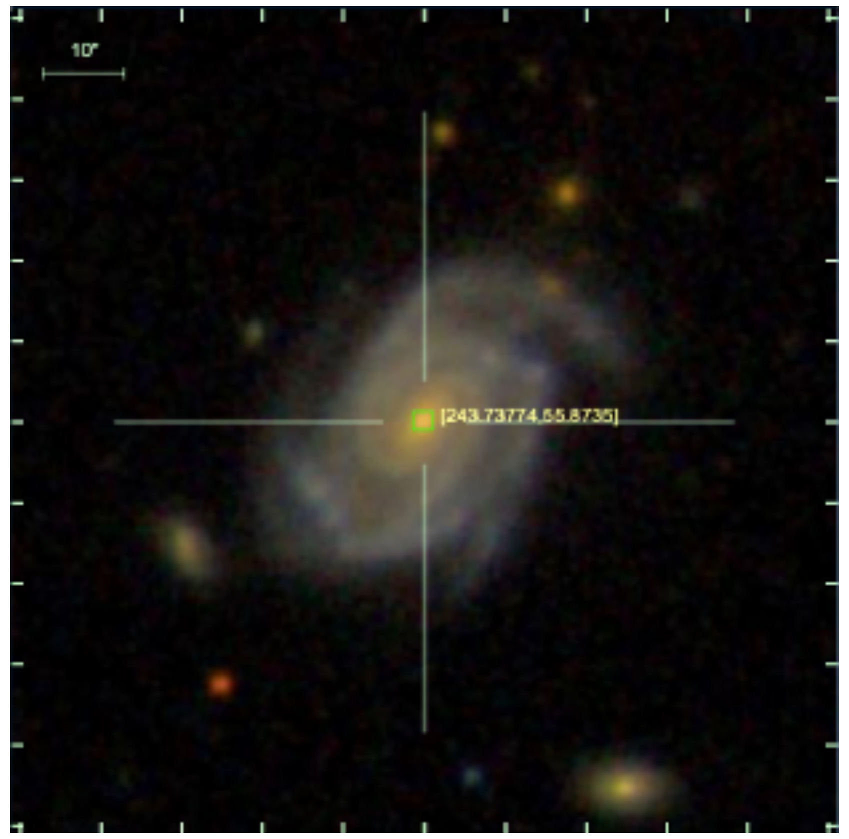
Li et al. (2018)

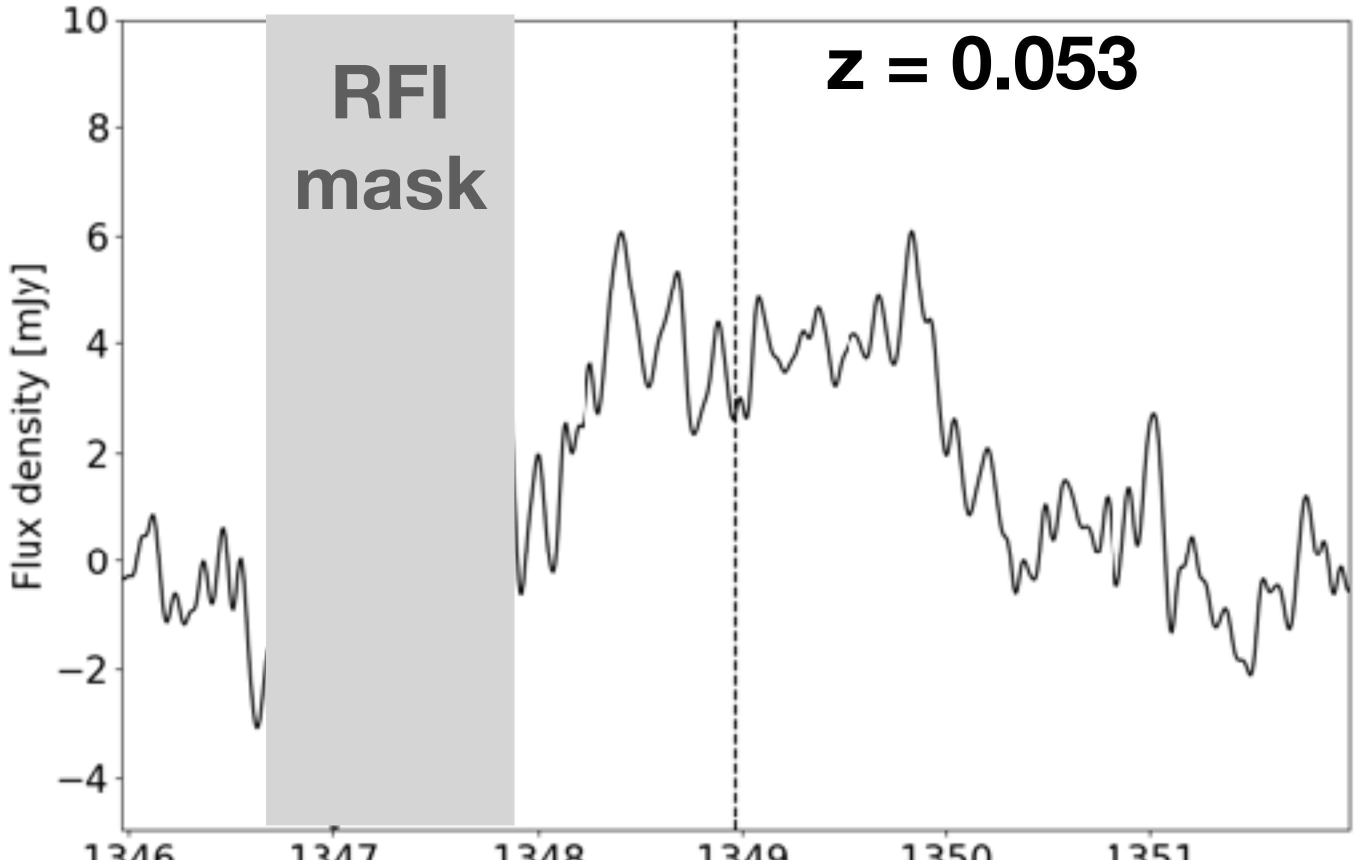


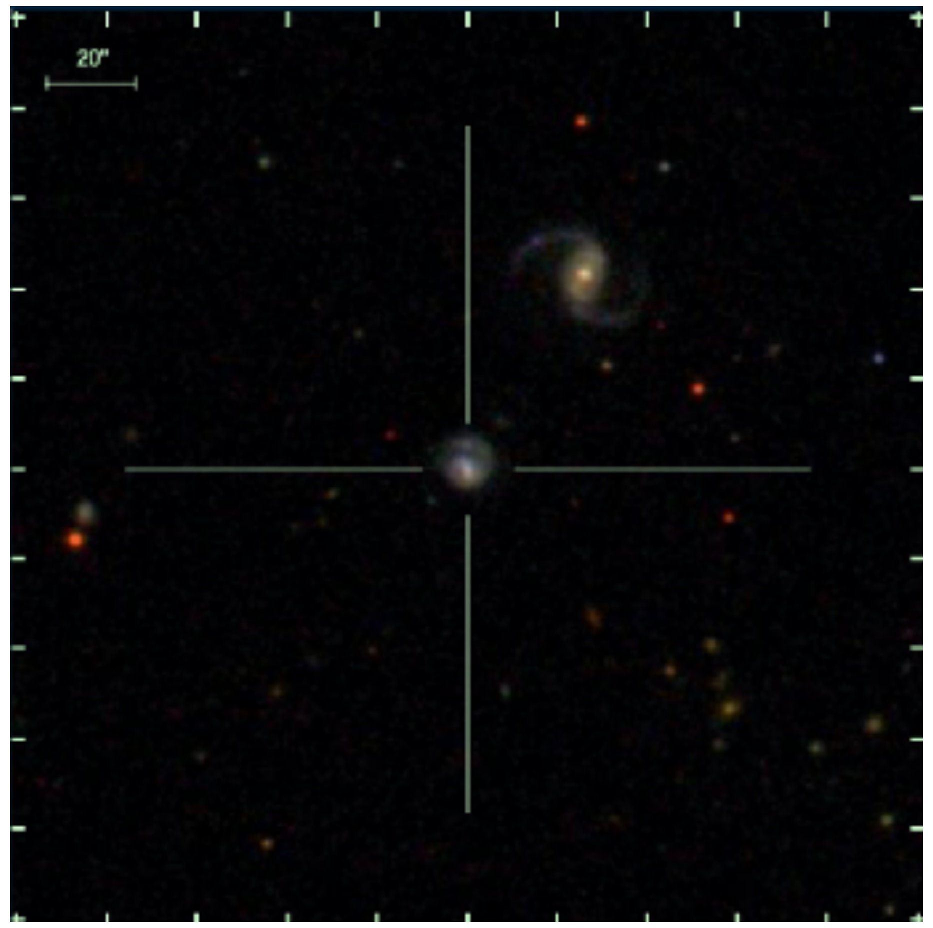
Finished Drift-scans of CRAFTS

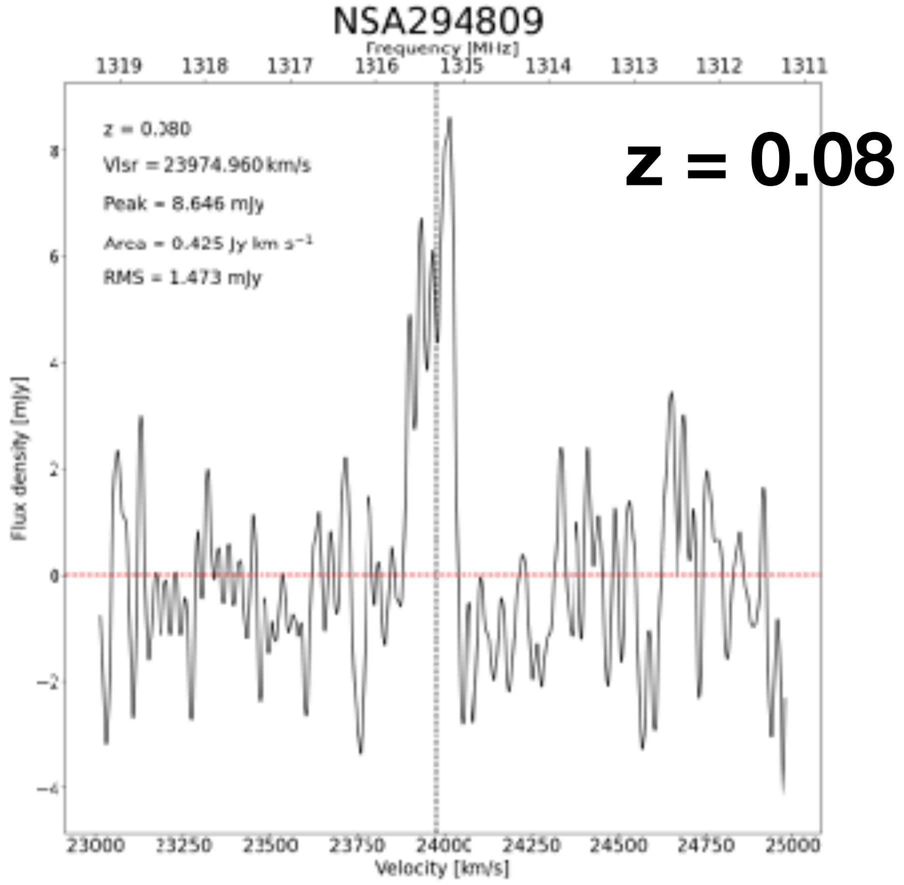
SDSS galaxies in a single CRAFTS pass

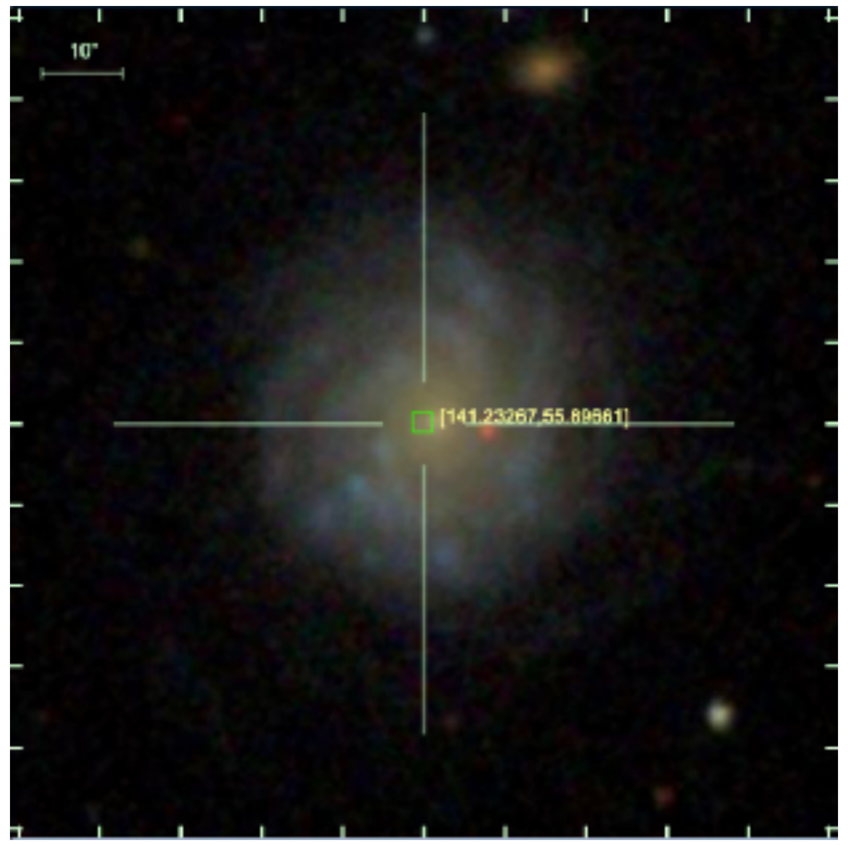
- CRAFTS can cover Dec > +36° as well as z > 0.06 galaxies, which could not be covered by ALFALFA.
- A preliminary CRAFTS data processing shows that a single 5-hour driftscan could detect tens of SDSS galaxies with optical spectra. Here are a few examples from a stripe with Dec ~ +55° :

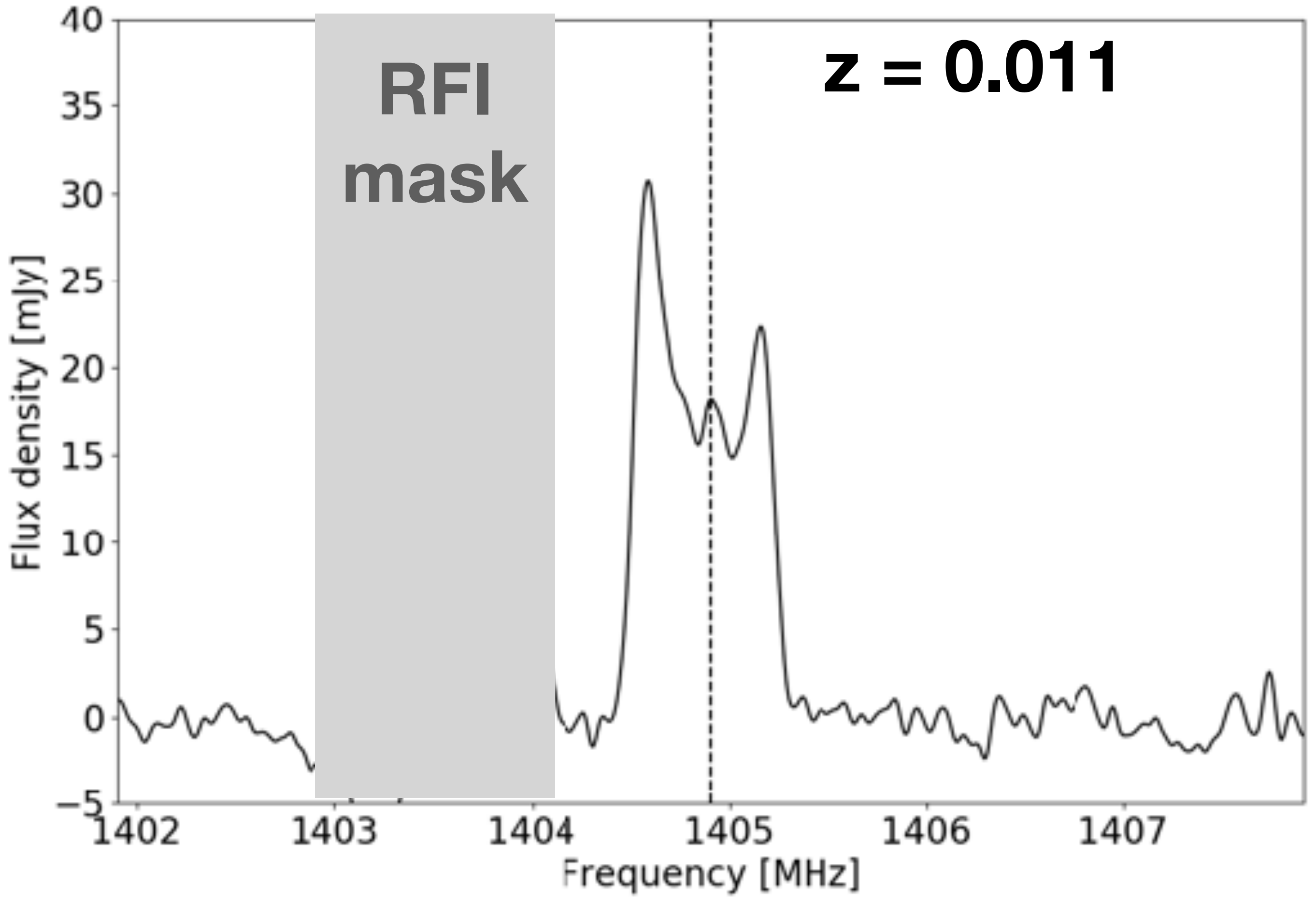


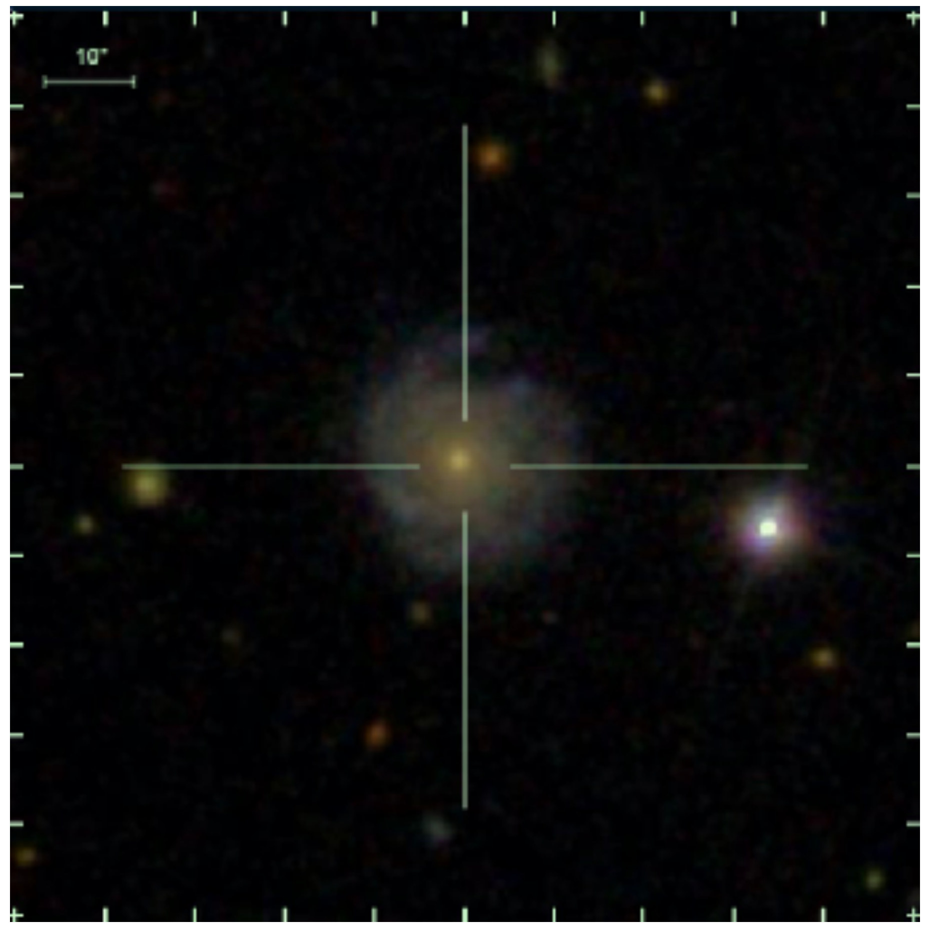


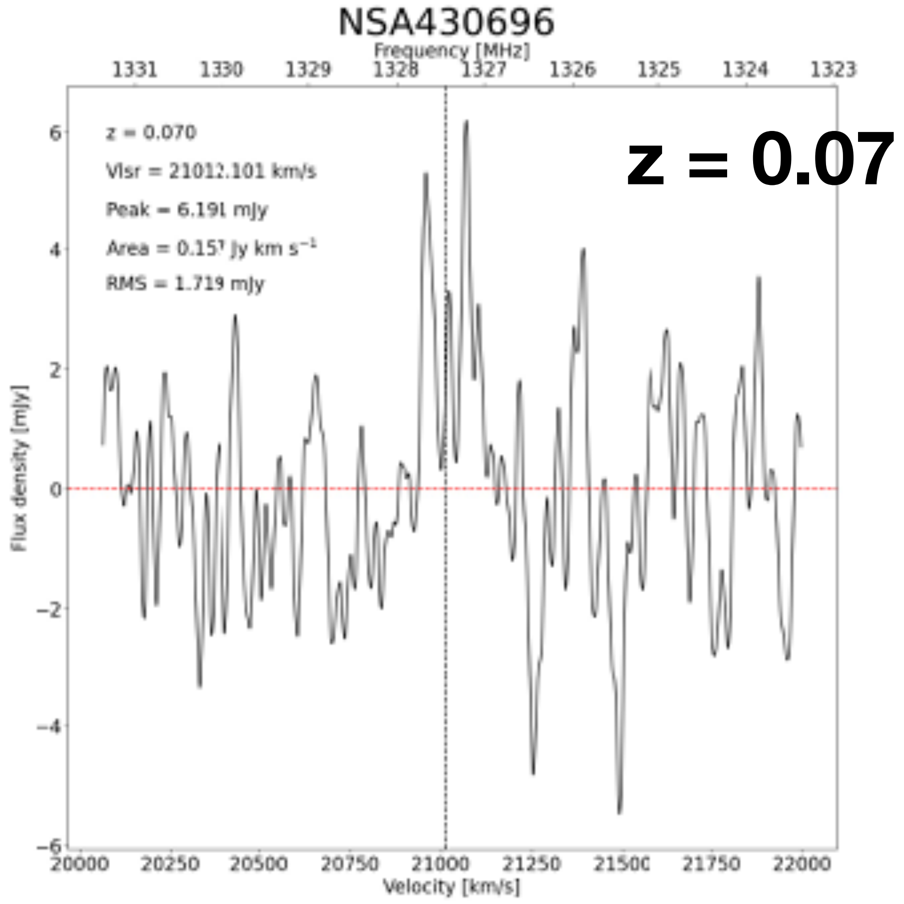




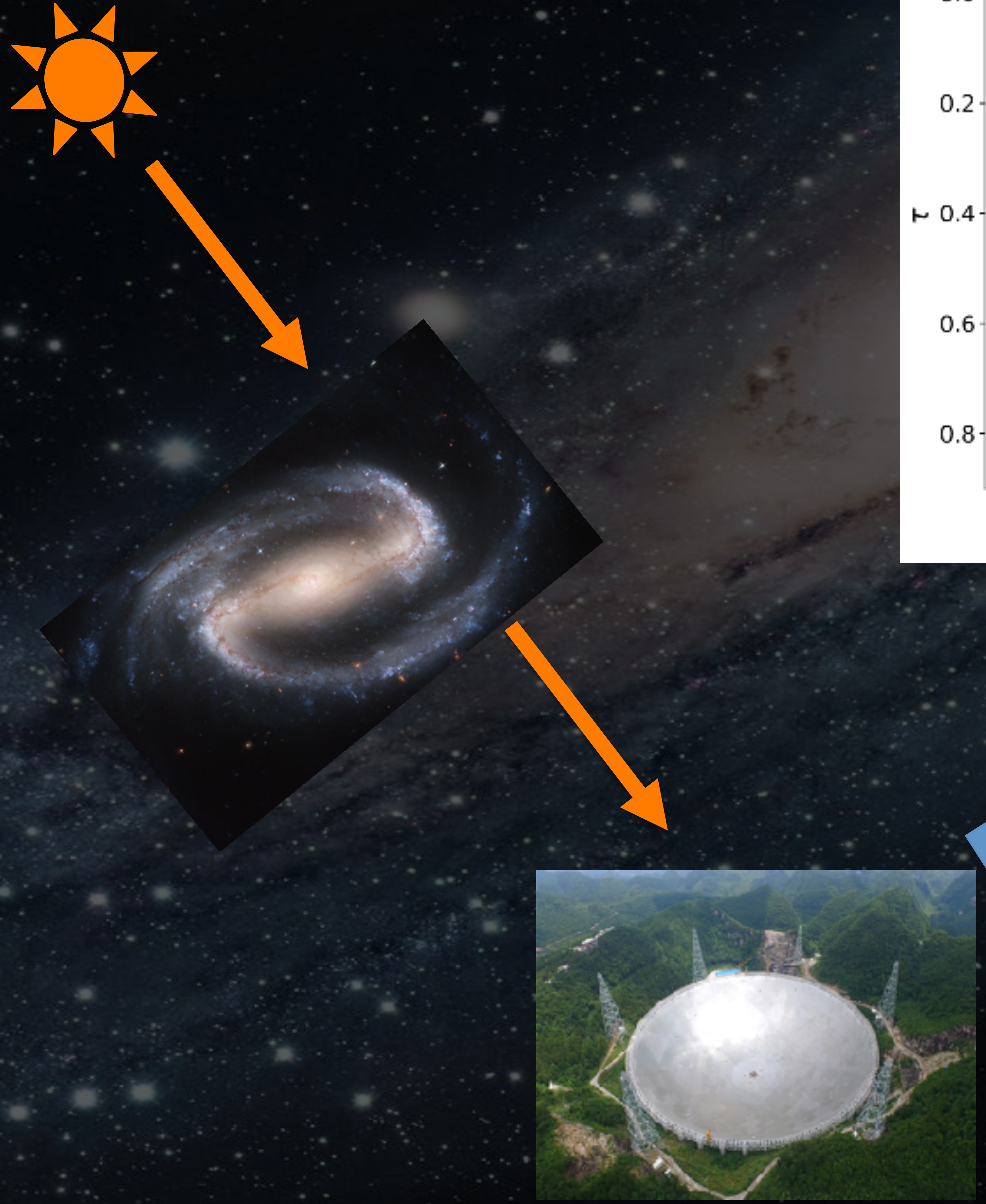


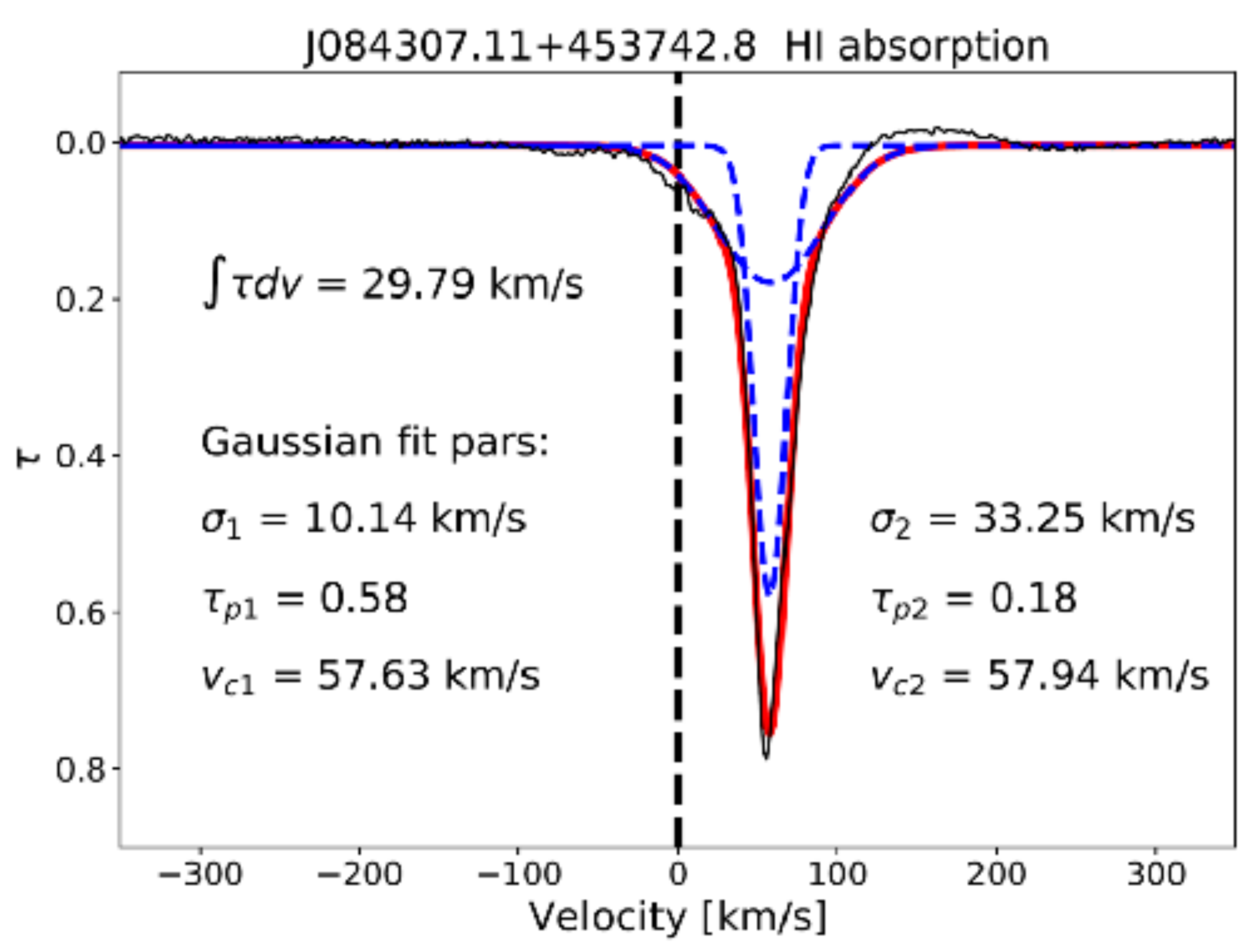






HI absorption

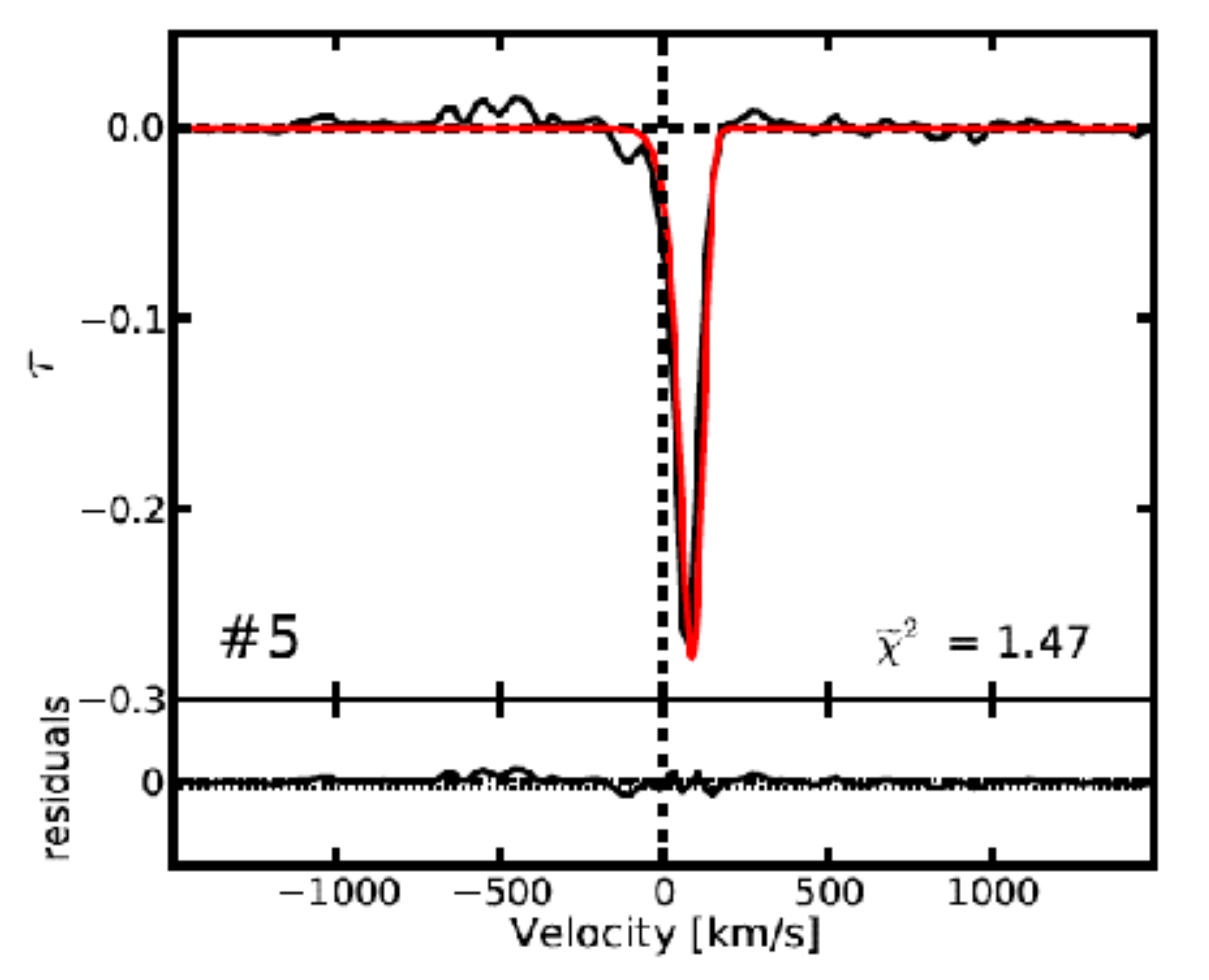




FAST in 30min

Zheng et al. (2020)

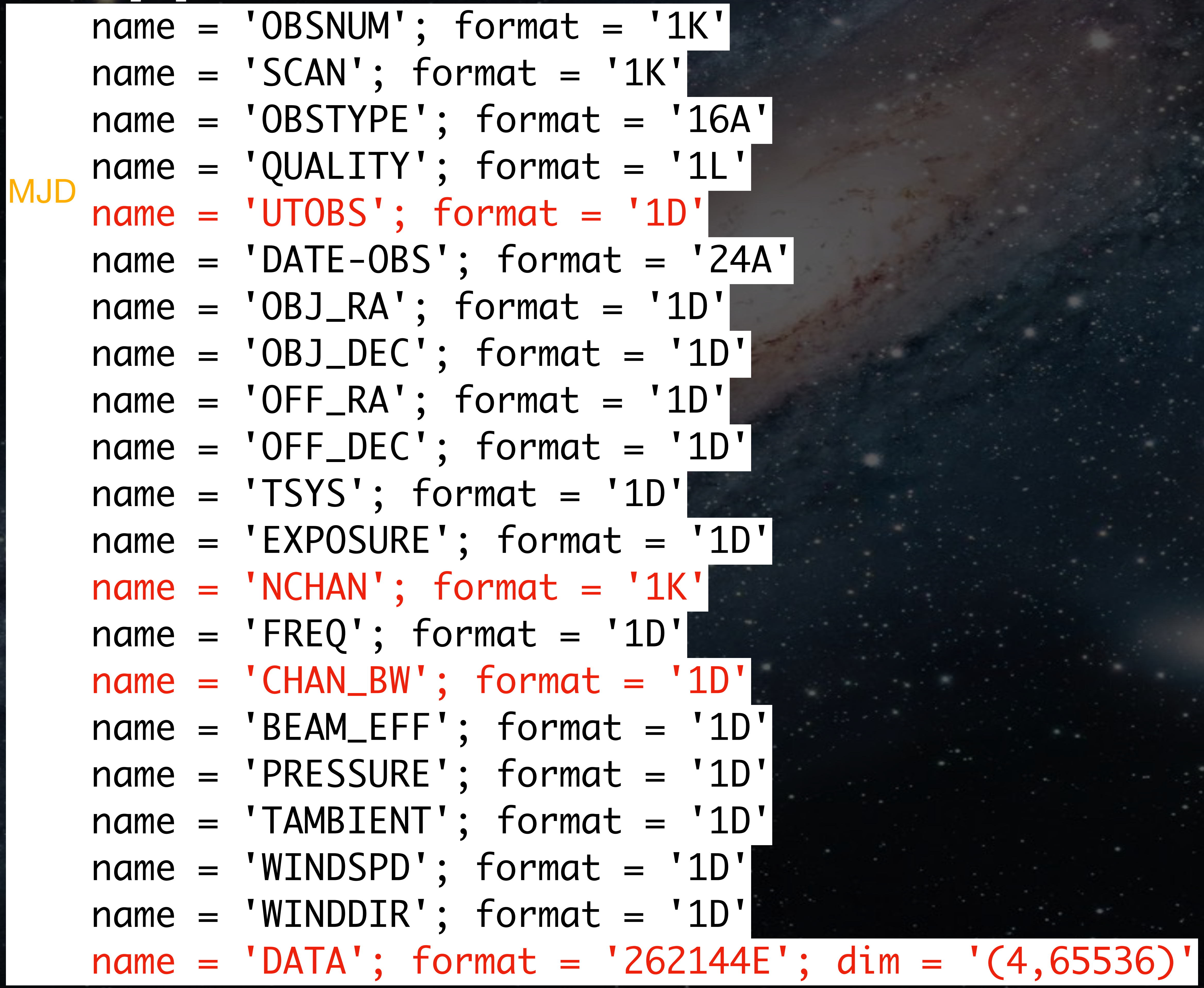
Velocity [km/s]



WSRT 4hrs (Gereb+2014)

Spectral data

- hdu[1].columns



MJD

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    name = 'OBJ_DEC'; format = '1D'
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    name = 'OFF_DEC'; format = '1D'
    name = 'TSYS'; format = '1D'
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    name = 'NCHAN'; format = '1K'
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(2048, 65536, 4)
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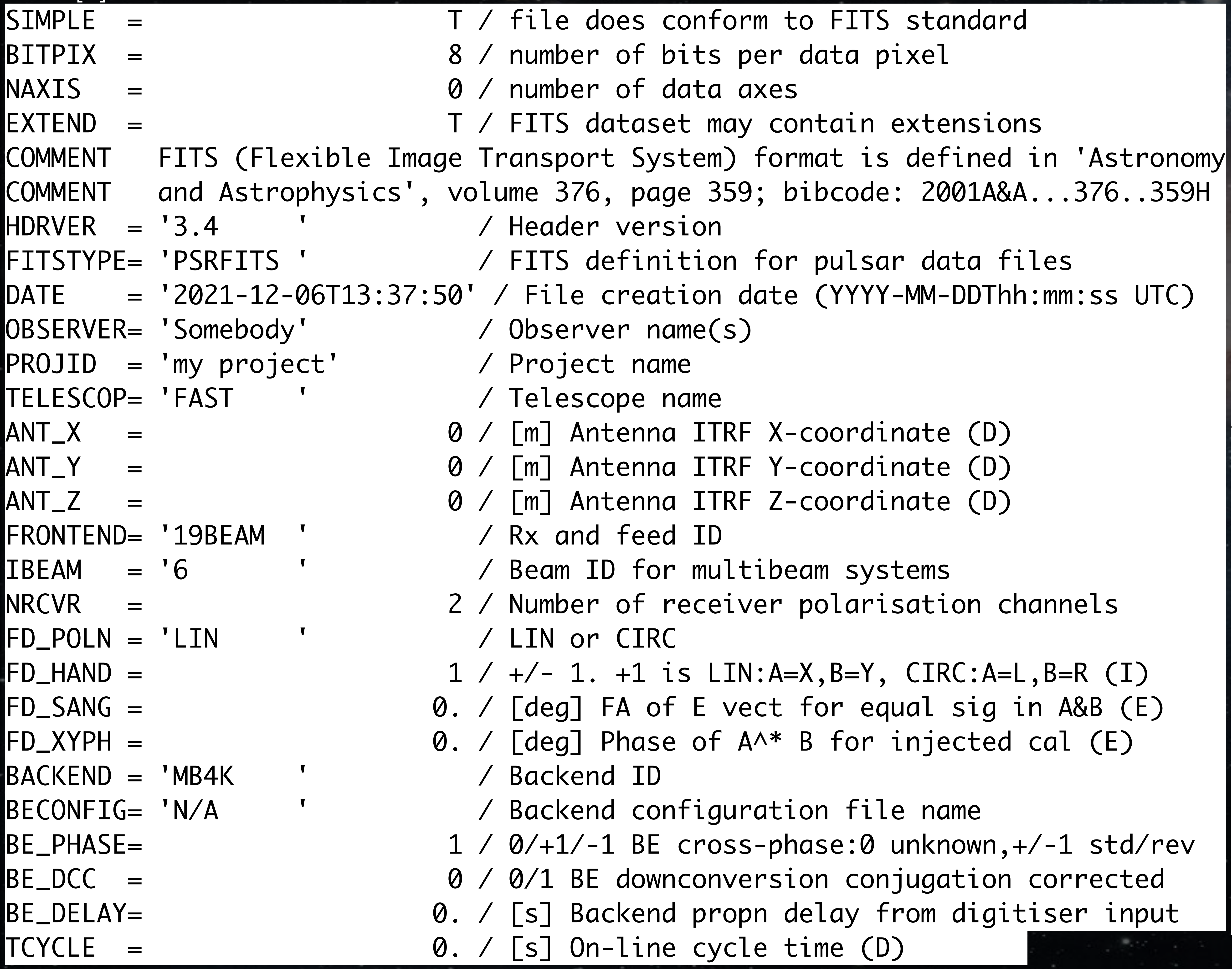
PSR data

- hdu[0].header



```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                    8 / number of bits per data pixel
NAXIS   =                    0 / number of data axes
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
HDRVER  = '3.4     '           / Header version
FITSTYPE= 'PSRFITS '           / FITS definition for pulsar data files
DATE    = '2021-12-06T13:37:50' / File creation date (YYYY-MM-DDThh:mm:ss UTC)
OBSERVER= 'Somebody'           / Observer name(s)
PROJID  = 'my project'         / Project name
TELESCOP= 'FAST    '           / Telescope name
ANT_X   =                    0 / [m] Antenna ITRF X-coordinate (D)
ANT_Y   =                    0 / [m] Antenna ITRF Y-coordinate (D)
ANT_Z   =                    0 / [m] Antenna ITRF Z-coordinate (D)
FRONTEND= '19BEAM  '           / Rx and feed ID
IBEAM   = '6       '           / Beam ID for multibeam systems
NRCVR   =                    2 / Number of receiver polarisation channels
FD_POLN = 'LIN     '           / LIN or CIRC
FD_HAND =                    1 / +/- 1. +1 is LIN:A=X,B=Y, CIRC:A=L,B=R (I)
FD_SANG =                   0. / [deg] FA of E vect for equal sig in A&B (E)
FD_XYPH =                   0. / [deg] Phase of A^* B for injected cal (E)
BACKEND = 'MB4K    '           / Backend ID
BECONFIG= 'N/A     '           / Backend configuration file name
BE_PHASE=                    1 / 0/+1/-1 BE cross-phase:0 unknown,+/-1 std/rev
BE_DCC  =                    0 / 0/1 BE downconversion conjugation corrected
BE_DELAY=                   0. / [s] Backend propn delay from digitiser input
TCYCLE  =                   0. / [s] On-line cycle time (D)
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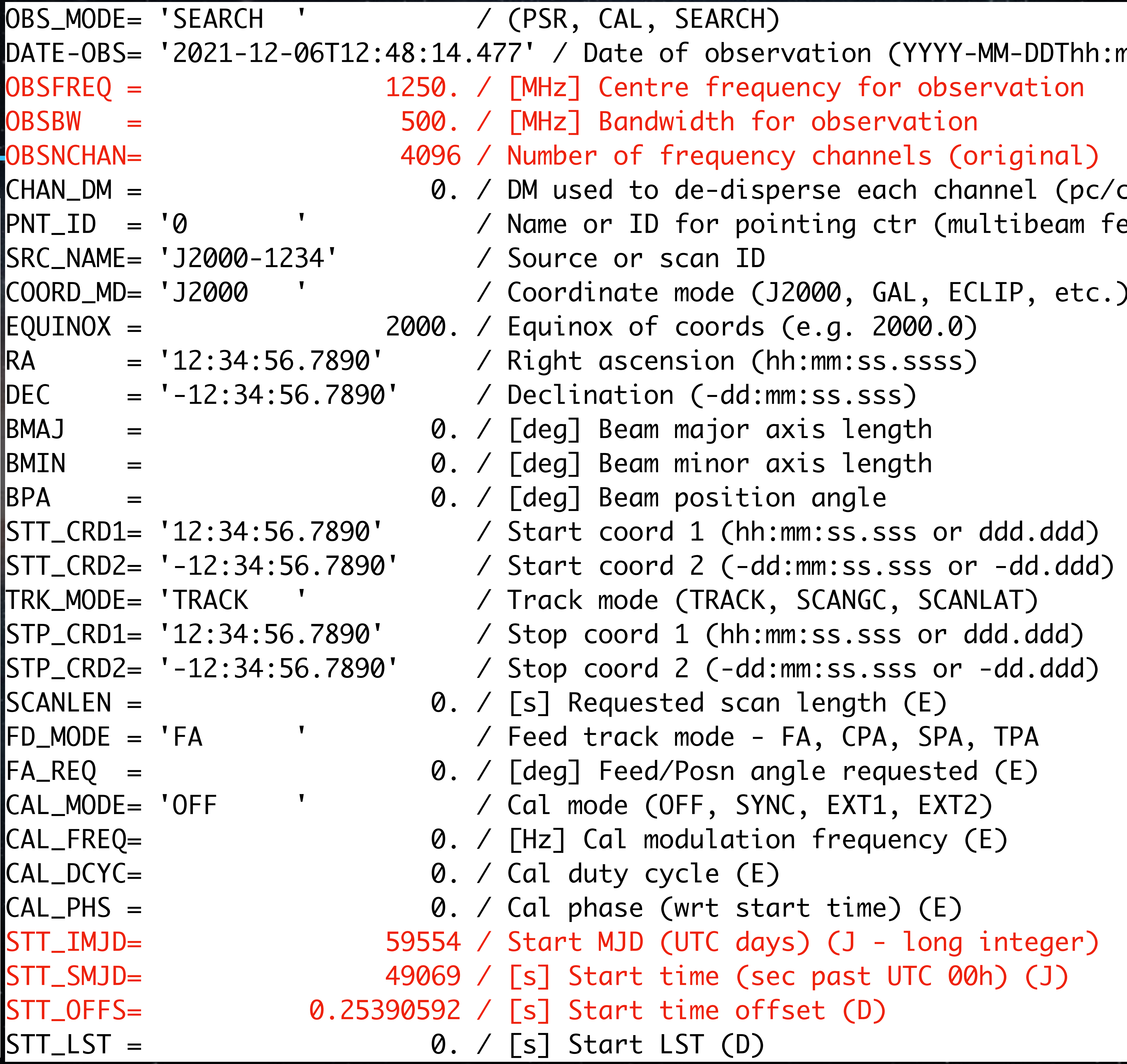

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OBS_MODE= 'SEARCH  '           / (PSR, CAL, SEARCH)
DATE-OBS= '2021-12-06T12:48:14.477' / Date of observation (YYYY-MM-DDThh:m
OBSFREQ =                1250. / [MHz] Centre frequency for observation
OBSBW   =                 500. / [MHz] Bandwidth for observation
OBSNCHAN=                 4096 / Number of frequency channels (original)
CHAN_DM =                   0. / DM used to de-disperse each channel (pc/c
PNT_ID  = '0       '           / Name or ID for pointing ctr (multibeam fe
SRC_NAME= 'J2000-1234'         / Source or scan ID
COORD_MD= 'J2000   '           / Coordinate mode (J2000, GAL, ECLIP, etc.)
EQUINOX =                2000. / Equinox of coords (e.g. 2000.0)
RA      = '12:34:56.7890'      / Right ascension (hh:mm:ss.ssss)
DEC     = '-12:34:56.7890'     / Declination (-dd:mm:ss.sss)
BMAJ    =                   0. / [deg] Beam major axis length
BMIN    =                   0. / [deg] Beam minor axis length
BPA     =                   0. / [deg] Beam position angle
STT_CRD1= '12:34:56.7890'      / Start coord 1 (hh:mm:ss.sss or ddd.ddd)
STT_CRD2= '-12:34:56.7890'     / Start coord 2 (-dd:mm:ss.sss or -dd.ddd)
TRK_MODE= 'TRACK   '           / Track mode (TRACK, SCANGC, SCANLAT)
STP_CRD1= '12:34:56.7890'      / Stop coord 1 (hh:mm:ss.sss or ddd.ddd)
STP_CRD2= '-12:34:56.7890'     / Stop coord 2 (-dd:mm:ss.sss or -dd.ddd)
SCANLEN =                   0. / [s] Requested scan length (E)
FD_MODE = 'FA      '           / Feed track mode - FA, CPA, SPA, TPA
FA_REQ  =                   0. / [deg] Feed/Posn angle requested (E)
CAL_MODE= 'OFF     '           / Cal mode (OFF, SYNC, EXT1, EXT2)
CAL_FREQ=                   0. / [Hz] Cal modulation frequency (E)
CAL_DCYC=                   0. / Cal duty cycle (E)
CAL_PHS =                   0. / Cal phase (wrt start time) (E)
STT_IMJD=                59554 / Start MJD (UTC days) (J - long integer)
STT_SMJD=                49069 / [s] Start time (sec past UTC 00h) (J)
STT_OFFS=           0.25390592 / [s] Start time offset (D)
STT_LST =                   0. / [s] Start LST (D)
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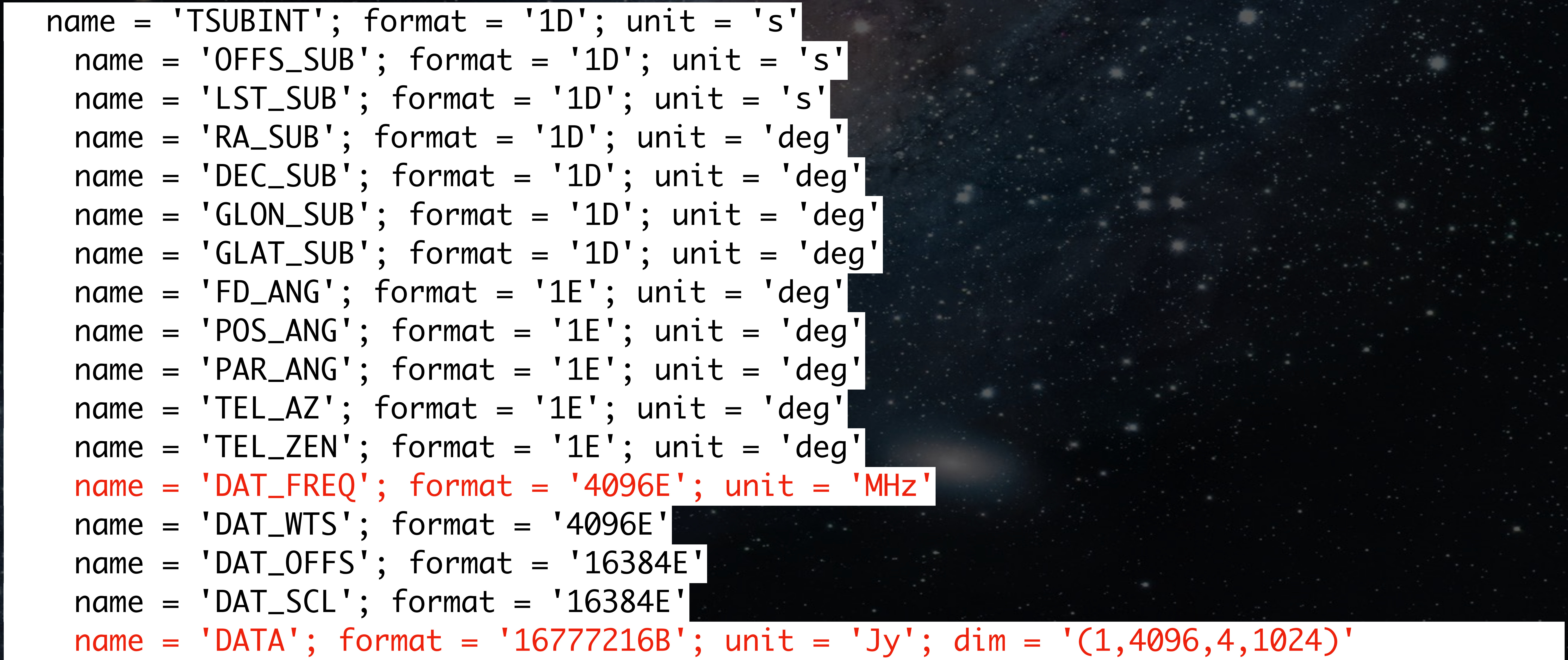
PSR data

- hdu[1].columns



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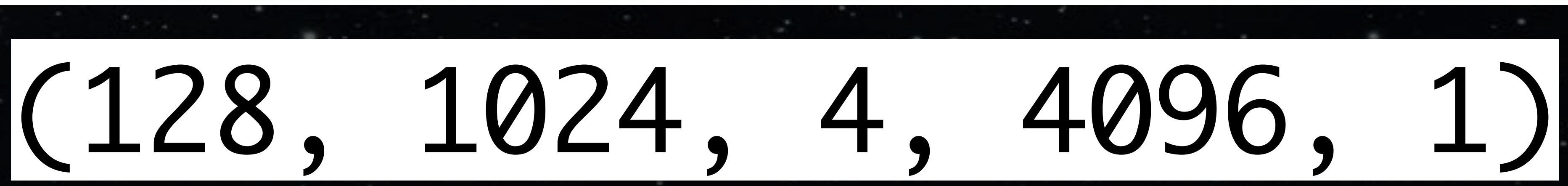

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(128, 1024, 4, 4096, 1)
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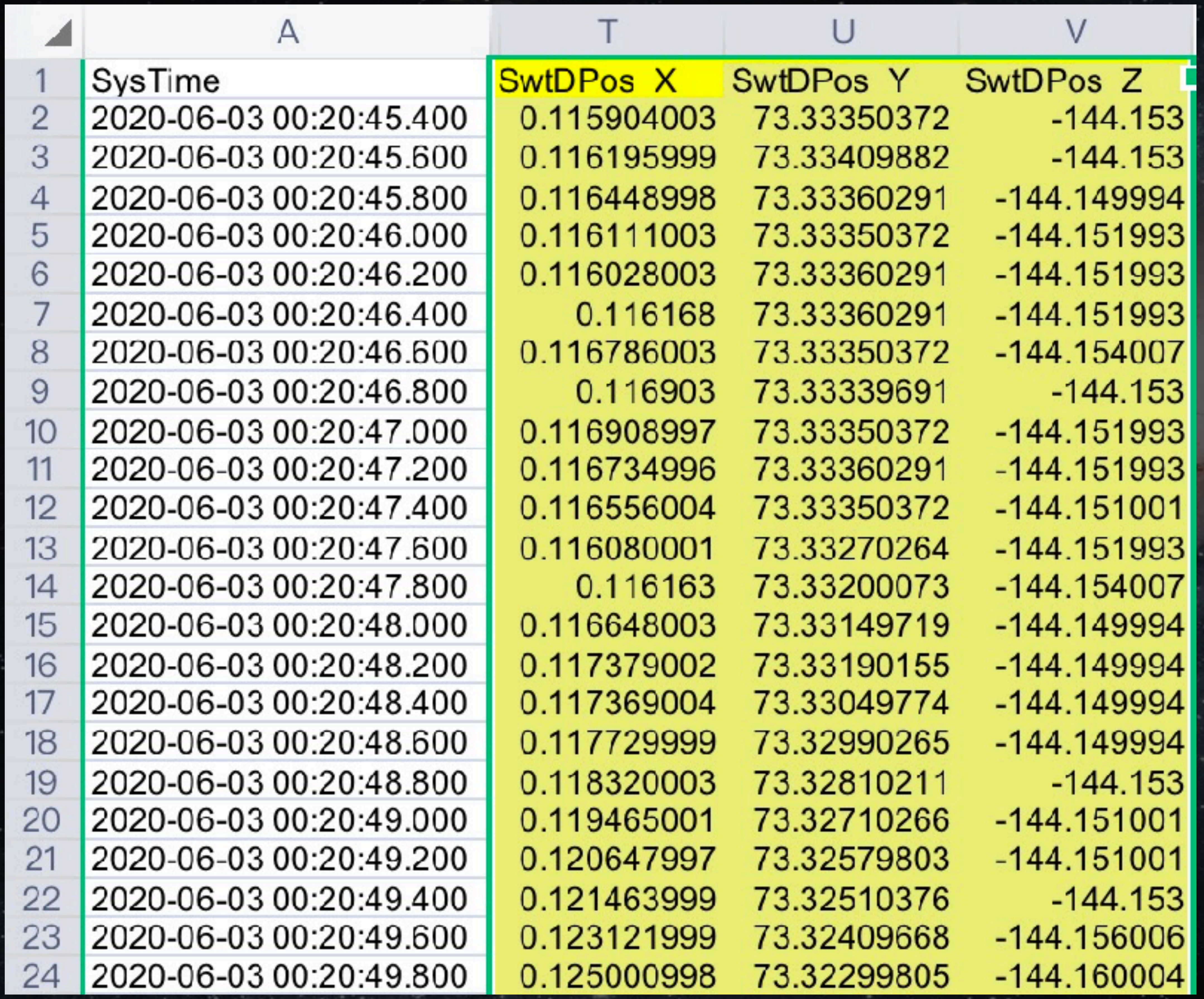
KY file



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3	2020-06-03 00:20:45.600	0.116195999	73.33409882	-144.153
4	2020-06-03 00:20:45.800	0.116448998	73.33360291	-144.149994
5	2020-06-03 00:20:46.000	0.116111003	73.33350372	-144.151993
6	2020-06-03 00:20:46.200	0.116028003	73.33360291	-144.151993
7	2020-06-03 00:20:46.400	0.116168	73.33360291	-144.151993
8	2020-06-03 00:20:46.600	0.116786003	73.33350372	-144.154007
9	2020-06-03 00:20:46.800	0.116903	73.33339691	-144.153
10	2020-06-03 00:20:47.000	0.116908997	73.33350372	-144.151993
11	2020-06-03 00:20:47.200	0.116734996	73.33360291	-144.151993
12	2020-06-03 00:20:47.400	0.116556004	73.33350372	-144.151001
13	2020-06-03 00:20:47.600	0.116080001	73.33270264	-144.151993
14	2020-06-03 00:20:47.800	0.116163	73.33200073	-144.154007
15	2020-06-03 00:20:48.000	0.116648003	73.33149719	-144.149994
16	2020-06-03 00:20:48.200	0.117379002	73.33190155	-144.149994
17	2020-06-03 00:20:48.400	0.117369004	73.33049774	-144.149994
18	2020-06-03 00:20:48.600	0.117729999	73.32990265	-144.149994
19	2020-06-03 00:20:48.800	0.118320003	73.32810211	-144.153
20	2020-06-03 00:20:49.000	0.119465001	73.32710266	-144.151001
21	2020-06-03 00:20:49.200	0.120647997	73.32579803	-144.151001
22	2020-06-03 00:20:49.400	0.121463999	73.32510376	-144.153
23	2020-06-03 00:20:49.600	0.123121999	73.32409668	-144.156006
24	2020-06-03 00:20:49.800	0.125000998	73.32299805	-144.160004