

The new FRBs discovered in CRAFTS

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FAST Fellowship, NAOC, ISM Group

JiNan,2021,July

Content

- FRB Search pipeline in CRAFTS
- The one-off events in 2018
- An interesting new repeater: FRB190520
- The on going process and results

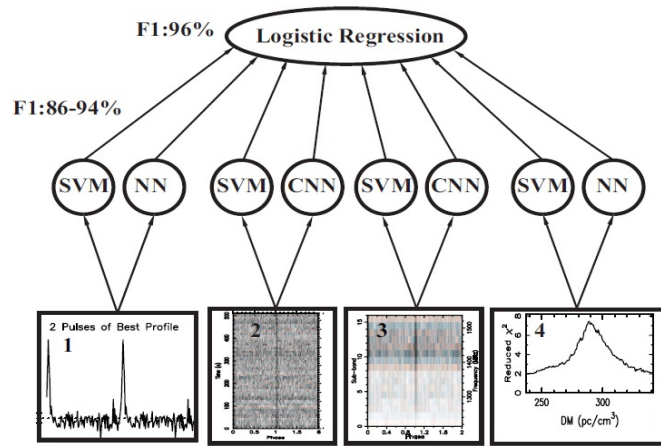
The Commensal Radio Astronomy FAST Survey (CRAFTS)

- Multi scientific goals
 - Pulsar
 - Galaxy HI
 - Extra-galactic HI
 - Transients
- Wide-band Receiver (August 2017)
- 19-Beams Receiver (May 2018) (1-1.5GHz)
- PRS backend
 - $\Delta t \sim 196\mu s / 98\mu s$
 - $\Delta f \sim 0.122 \text{ MHz}$ (4096 Channels)
 - 300GB per hour
- PSRFITS Data are archived (Weiwei Zhu)
 - 1bit filterbank (Before 2020)
 - 2bits psrfits (Science early 2020)
 - Non Stocks recorded

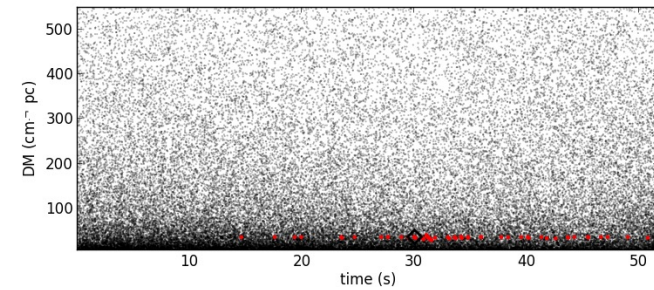
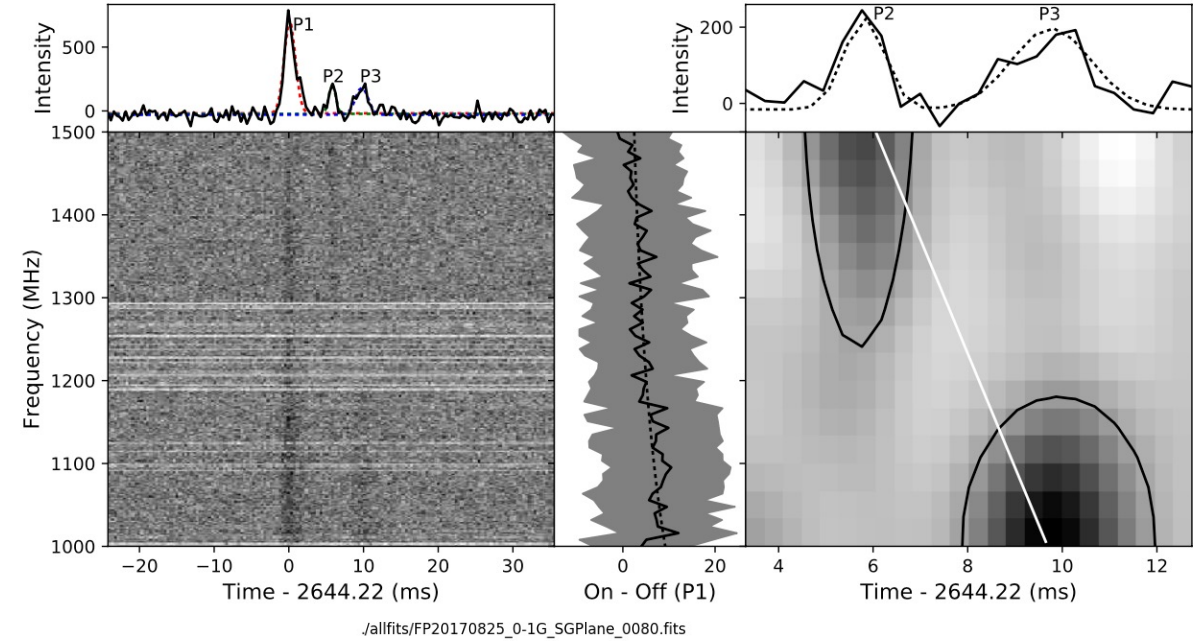


First FRB in CRAFTS

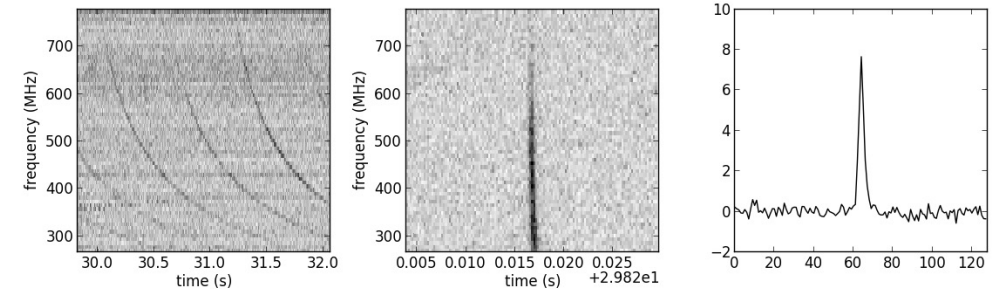
- FRB 181123 (Weiwei Zhu et al, 2020, ApJL)
- GPU-based AI single-pulse search pipeline
- May 2018 to November 2018 (~1500 hours)



PICS: Pulsar Imaged-based Classification System
Zhu et al. 2014, ApJ, 781, 117



Source Name: J2000-1234
 TOA 57990.467907555541
 DM 36.43 $\text{cm}^{-3} \text{ pc}$
 Time 30.028800 s
 RA 12:34:56.7890
 Dec -12:34:56.7890
 Time Resolution 3.2 ms
 Pulse width 12.800 ms
 Sigma 9.66



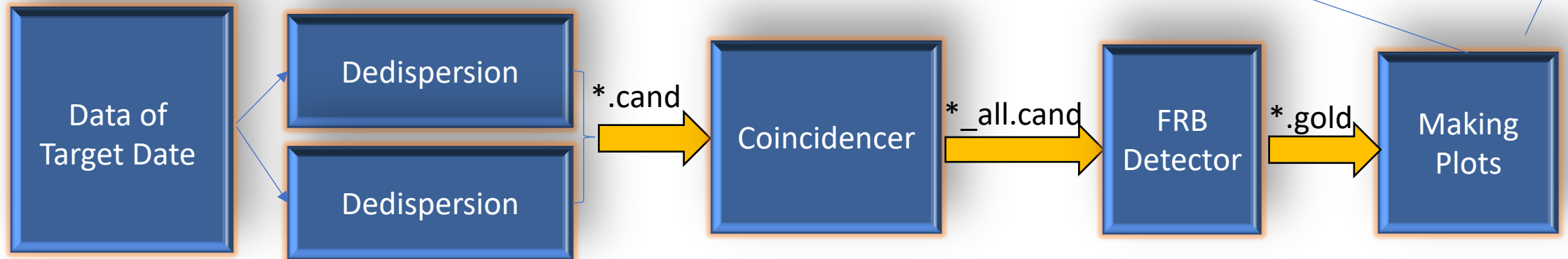
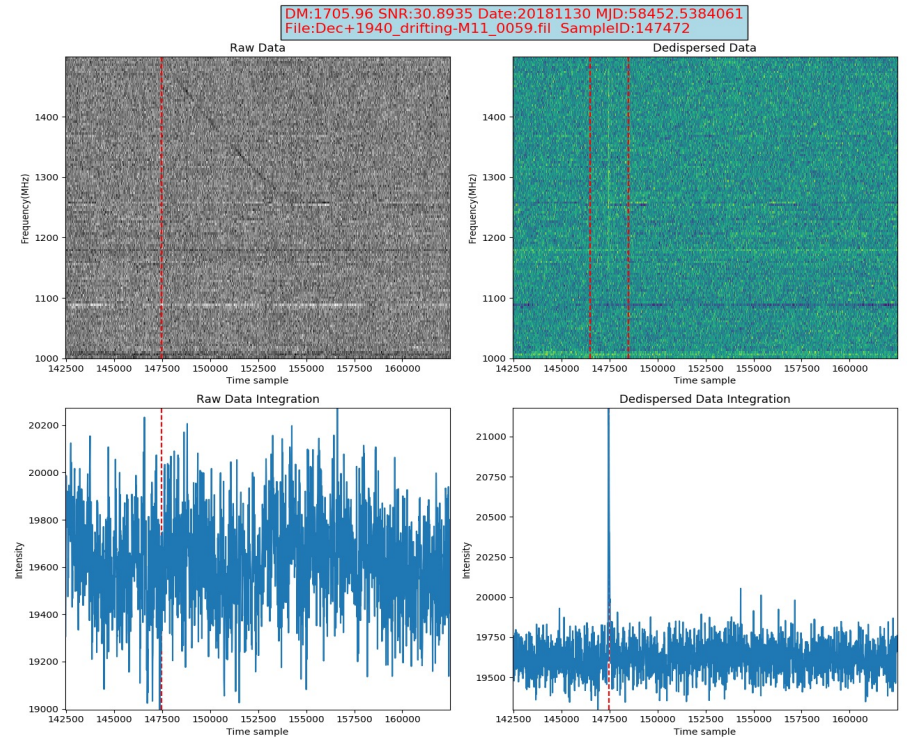
Heimdall Pipeline in CRAFTS

- Drifting Data
 - 19 beams Drifting Data
 - 1-bit filterbank (Weiwei Zhu)
- Data Processing servers
 - X-series: 1-21 Servers
 - 2 CPU × 18 Cores.
 - Memory 755G
 - 2×GPU : RTX2080

```

We Gonna use X-serise GPU Server:[ 6 7 8 9 12 13 14 15 16 17 18 19 20 ]
Project: 201910/
Date List: 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21
22 24 25 26 27 28 30 31
-----
Server topology:
=====
Server Total Number: 13
Date List Total Number: 29
Date 01 --> Server: X6
Date 02 --> Server: X7
Date 03 --> Server: X8
Date 04 --> Server: X9
Date 05 --> Server: X12
Date 06 --> Server: X13
Date 07 --> Server: X14
Date 08 --> Server: X15
Date 09 --> Server: X16
Date 10 --> Server: X17
Date 11 --> Server: X18
Date 12 --> Server: X19
Date 13 --> Server: X20
Date 14 --> Server: X6
Date 15 --> Server: X7
Date 16 --> Server: X8
Date 17 --> Server: X9
Date 18 --> Server: X12
Date 19 --> Server: X13
Date 20 --> Server: X14
Date 21 --> Server: X15
Date 22 --> Server: X16
Date 24 --> Server: X17
Date 25 --> Server: X18
Date 26 --> Server: X19
Date 27 --> Server: X20
Date 28 --> Server: X6
Date 30 --> Server: X7
Date 31 --> Server: X8
=====
    
```

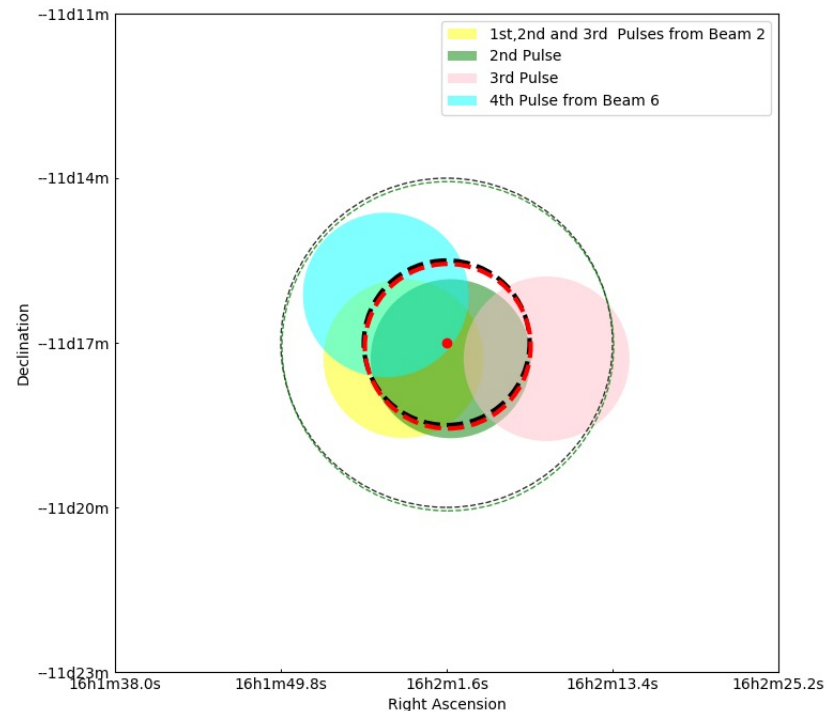
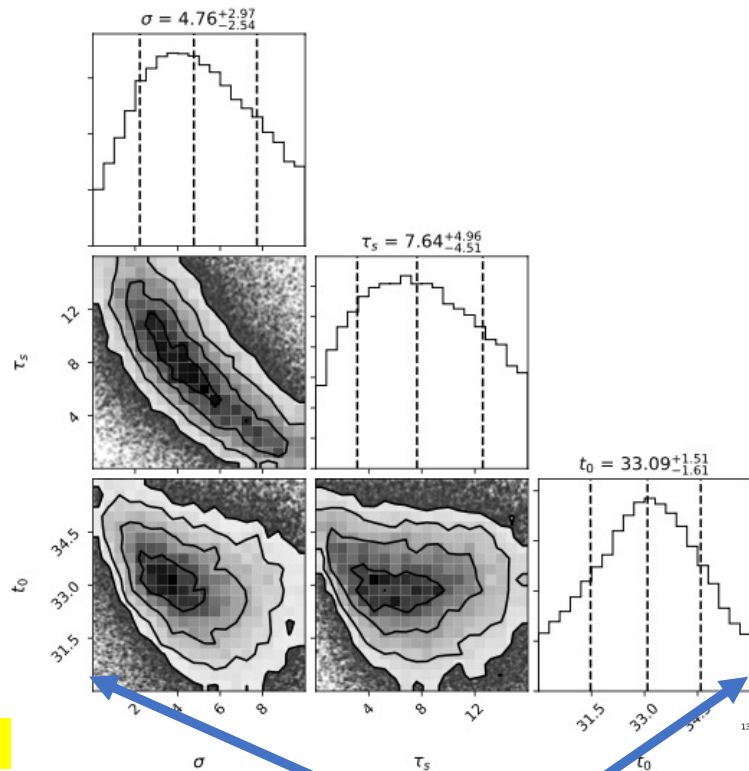
FAST_Miner Pipe



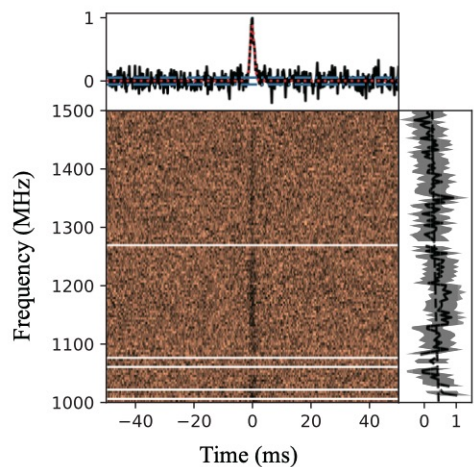
https://github.com/peterniuzai/FAST_Miner

CRAFTS FRBs

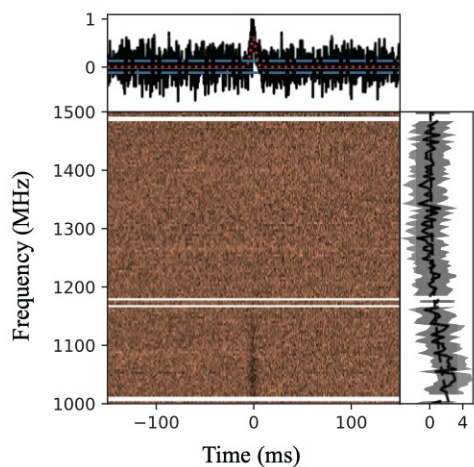
- Date: 201806-202002
- 4 New FRBs were Found
 - FRB181017.J0036+11
 - FRB181117
 - FRB181130
 - FRB190520 (repeater)



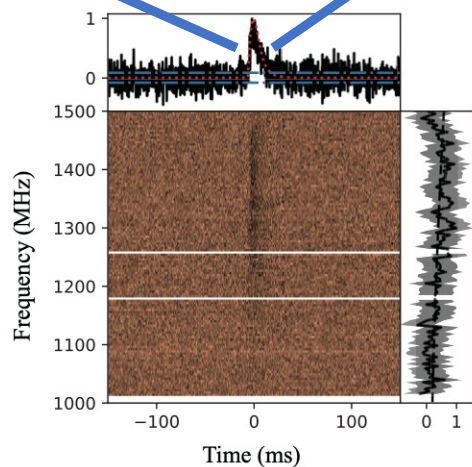
(Niu et al. 2021, ApJL, 909:L8)



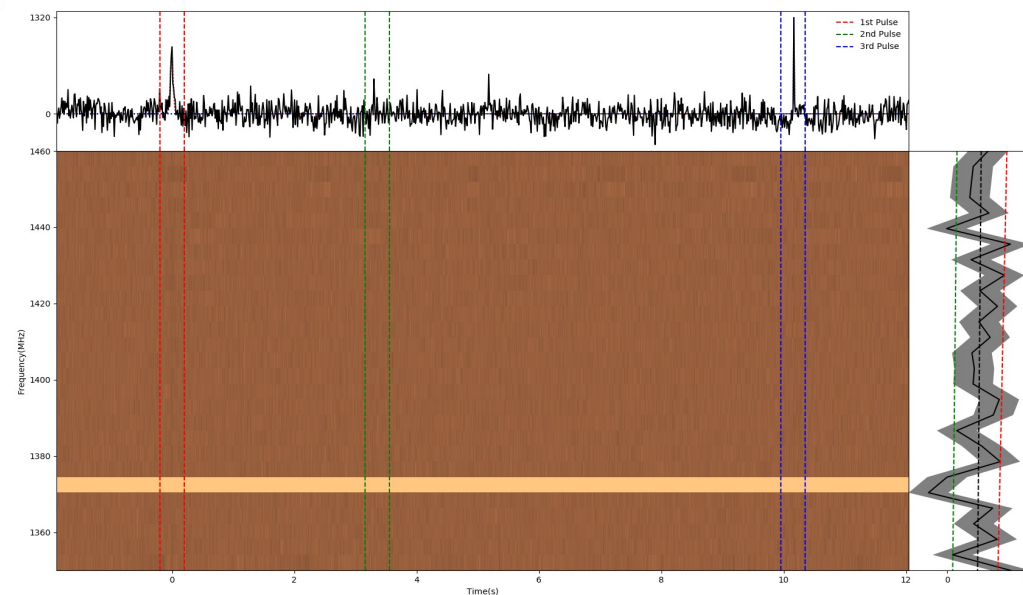
(a) FRB 181017.J0036+11



(b) FRB 181118

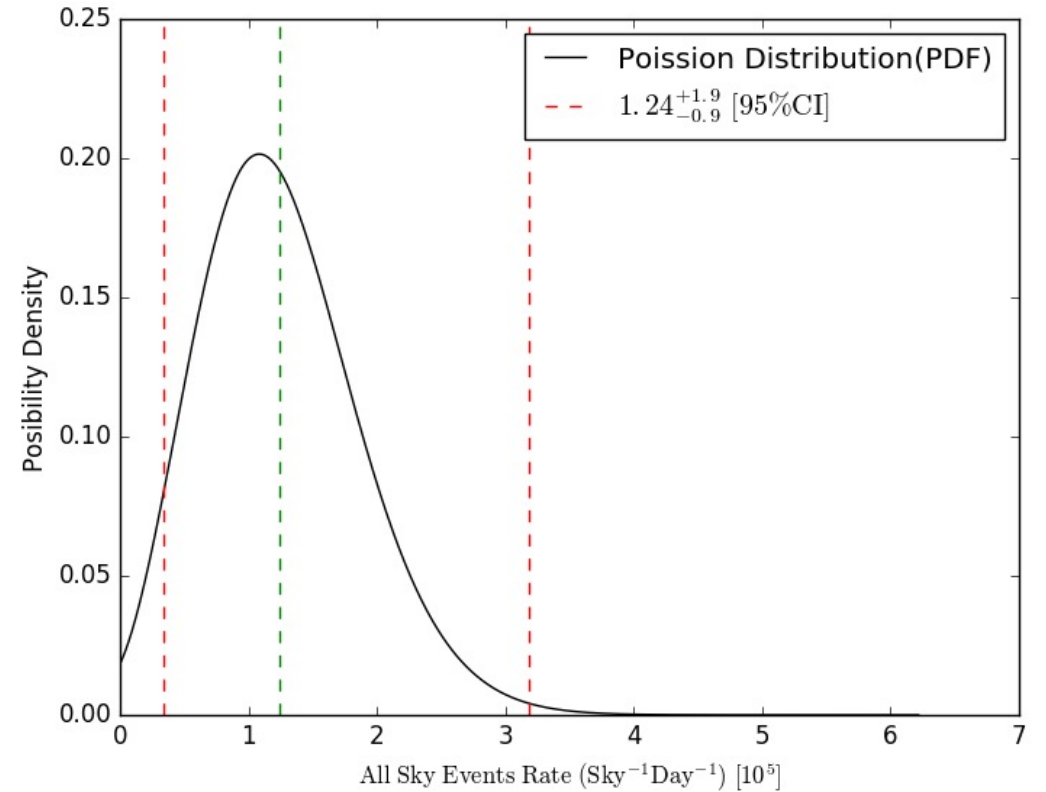
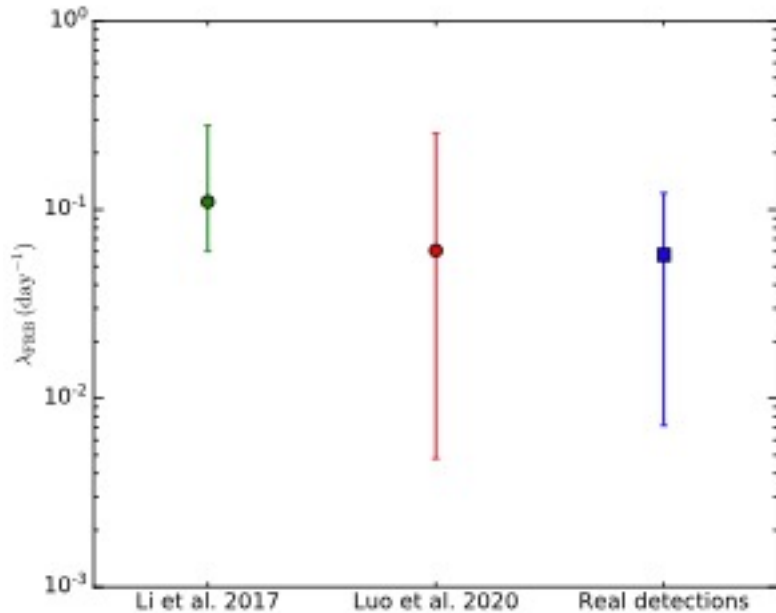


(c) FRB 181130



CRAFTS FRBs: Bursts Rate

- Roughly Finish 201806-202002
 - Insufficient complete FRB search after 2019
 - Candidates filter incomplete
 - Data process is incomplete for dozens of days
 - Confident for 1667.2 +9 Hours (Before 2019)



FAST Event Rate: $5.8 \times 10^{-2} \text{ day}^{-1}$
All Sky Event Rate: $1.24_{-0.90}^{+1.94} \times 10^5 \text{ day}^{-1}\text{sky}^{-1}$
(Above 14.6 mJy ms, including FRB 181123)

Properties of CRAFTS FRBs

Table 1. Properties of three new FRBs detected in CRAFTS

FRB YYMMDD(.J2000)	FRB 181017.J0036+11	FRB 181118	FRB 181130
Measured Parameters			
Event MJD at 1.5 GHz	58408.665197	58440.877654	58452.542674
FAST Beam ID (M01 – M19)	M14	M07	M11
Right Ascension (J2000)	00 ^h 36 ^m 29 ^s .8	07 ^h 56 ^m 41 ^s .87	00 ^h 39 ^m 07 ^s .85
Declination (J2000)	11°19′59″.8	16°08′56″.7	19°24′31″.7
Galactic Coordinates (l, b)	117°.9, −51°.4	205°.2, 21°.5	118°.9, −43°.4
Dispersion Measure (pc cm ^{−3})	1845.2±1	1187.7±3.3	1705.5±6.5
Emission Freq. (GHz)	1.0 – 1.5	1.00 – 1.12	1.16 – 1.50
Dispersion smear (ms) ^a	1.0	1.0	0.7
Measured width (ms) ^b	1.43±0.25	5.3±3.72	9.52 ^{+5.94} _{−5.08}
Scattering effect at 1.25GHz (ms)	< 0.5	< 2.08	7.64 ^{+4.96} _{−4.51}
Measured S/N	14.3	11.0	30.9
Observed peak flux density (mJy)	~ 34.1	~ 14.2	~ 20.6
Measured fluence (Jy ms) ^c	0.042	0.064	0.168
Inferred Parameters^d			
DM _{Gal} (pc cm ^{−3}) ^e	34.62 , 25.91	71.53 , 88.30	38.16 , 29.69
Estimate redshift (z) ^f	2.01 ^{+0.04} _{−0.04} , 2.02 ^{+0.04} _{−0.04}	1.17 ^{+0.05} _{−0.06} , 1.15 ^{+0.05} _{−0.06}	1.83 ^{+0.04} _{−0.05} , 1.84 ^{+0.04} _{−0.04}
Max. comoving distance (Gpc)	5.4	4.0	5.1
Max. luminosity distance (Gpc)	16.5	8.7	14.8
Max. isotropic energy (10 ⁴⁰ erg) ^g	0.45	0.26	1.5
Average luminosity (10 ⁴³ erg s ^{−1})	0.3	0.05	0.16

^a The referenced frequency for smear calculation takes center of the emission frequency band.

^b Full pulse width at the half maximum from Gaussian fitted profile. Note that the intrinsic width can be much narrower for FRB181017 since we do not save the raw data (Qiu et al. 2020).

^c Take the gain at the center of the beam.

^d The parameters for Cosmology model are from Planck Collaboration et al. (2020).

^e DM_{Gal} denotes the DM contribution from the Galaxy, and is calculated using the NE2001 and the YMW16 model, respectively.

^f Redshifts inferred from the extra-galactic DM calculated using the NE2001 and the YMW16 model, respectively. The corresponding deduction and error analysis can be found in Appendix A.

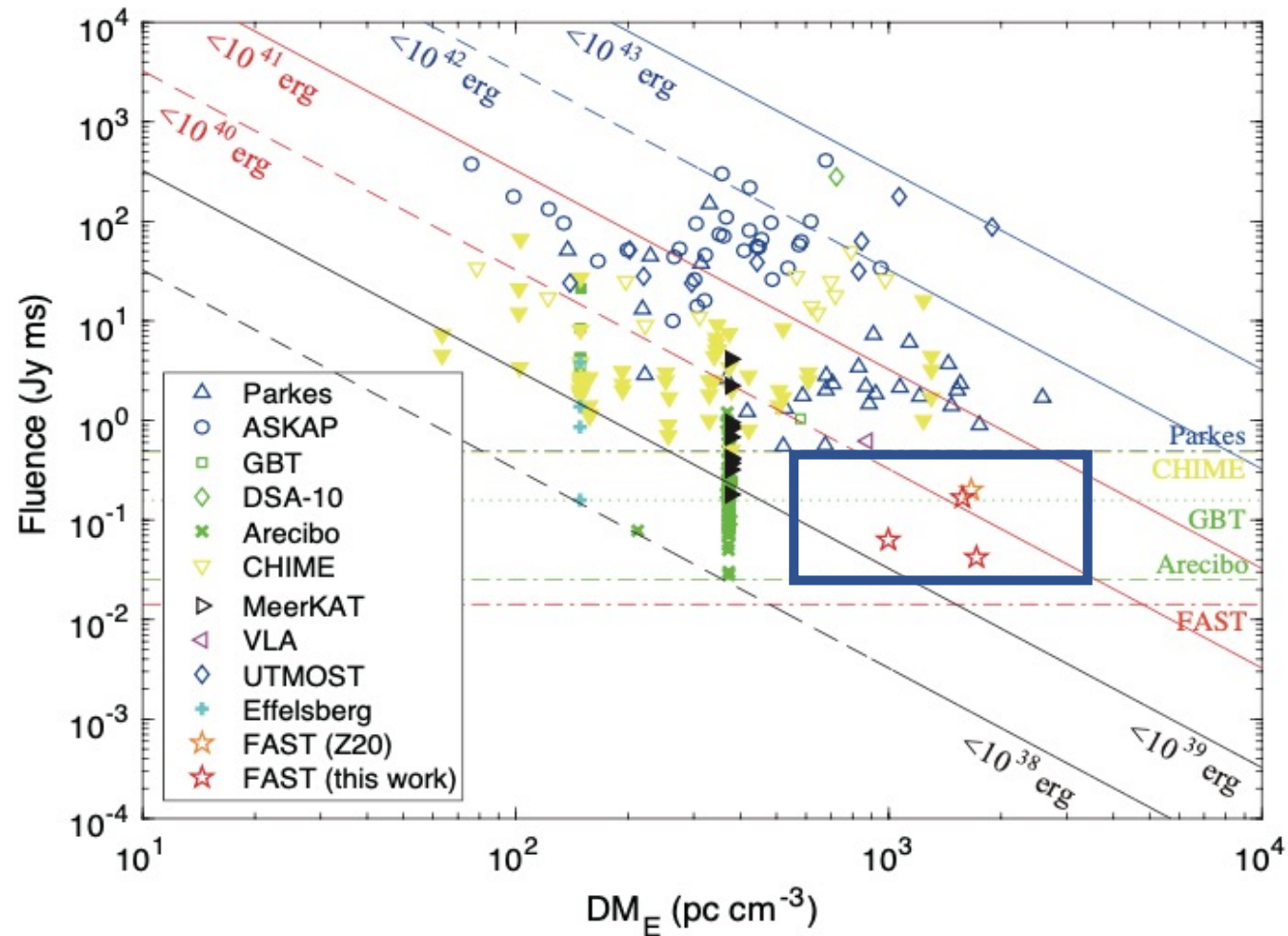
^g Calculated by assuming a flat spectrum within a width of 1 GHz tentatively, due to a lack of complete spectrum measurement for FRBs currently.

(Niu et al. 2021, ApJL, 909:L8)

Fluence and Flux distribution of All published bursts

“The survey demonstrates that there is a relationship between burst dispersion and brightness and that the high-fluence bursts are the nearby analogues of the more distant events found in higher- sensitivity, narrower-field surveys “

----R. M. Shannon, et al. ,2018)



(Niu et al. 2021, ApJL, 909:L8)

FAST Ability to detect high-DM FRB

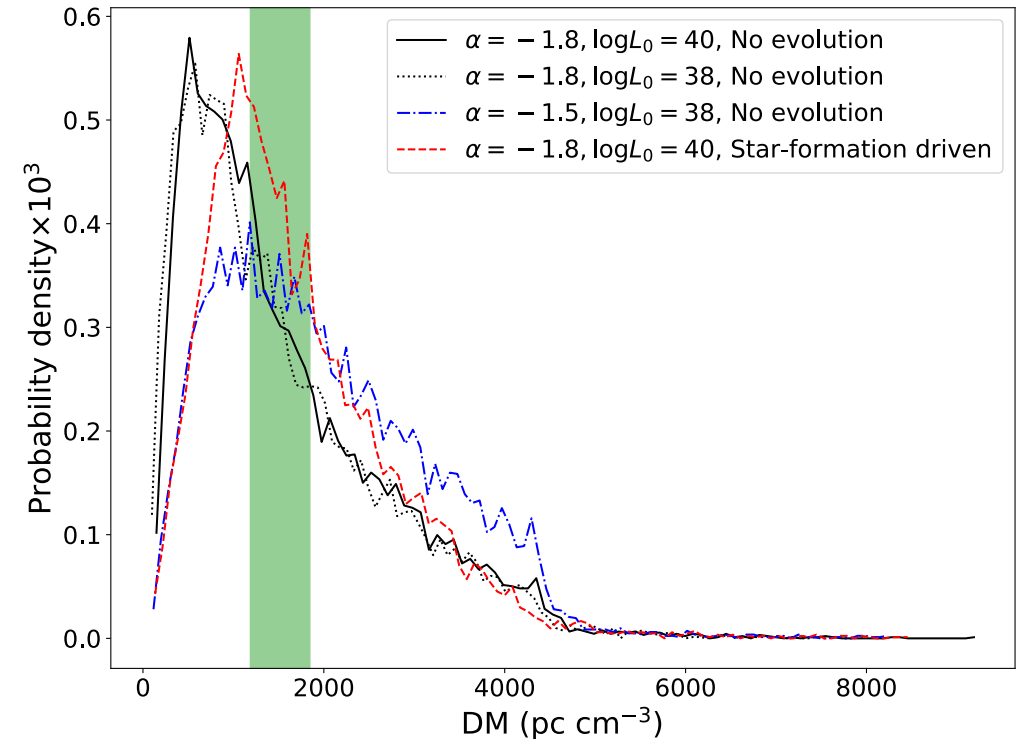
$$\phi(L) dL = \phi^* \left(\frac{L}{L^*} \right)^\alpha e^{-\frac{L}{L^*}} d \left(\frac{L}{L^*} \right)$$

(Luo et al, 2018,2020)

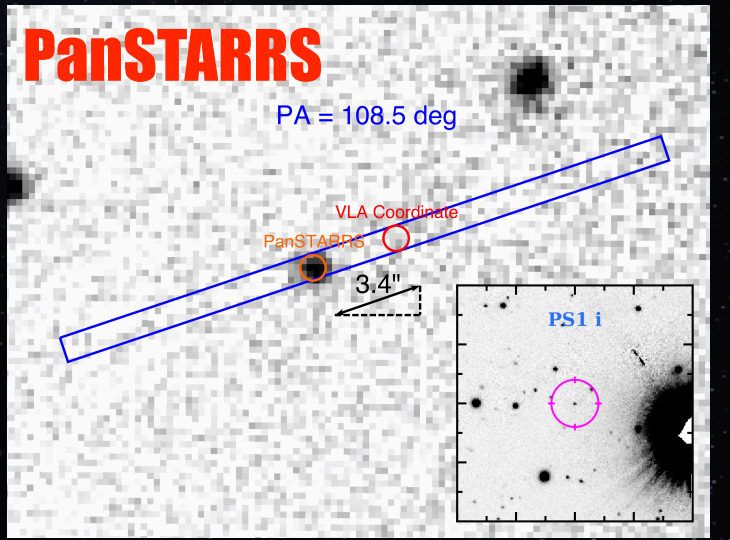
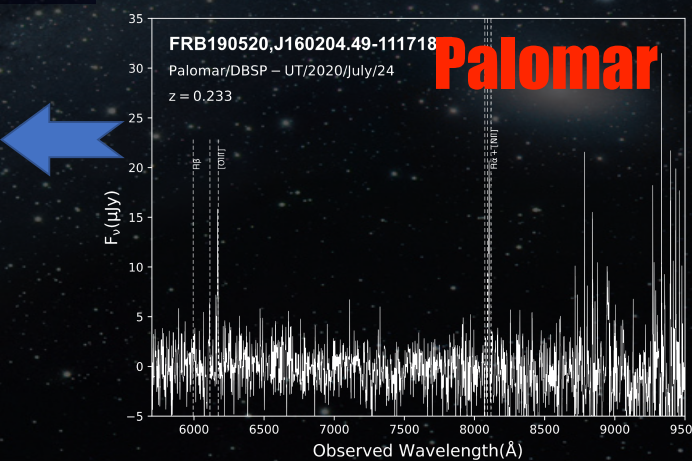
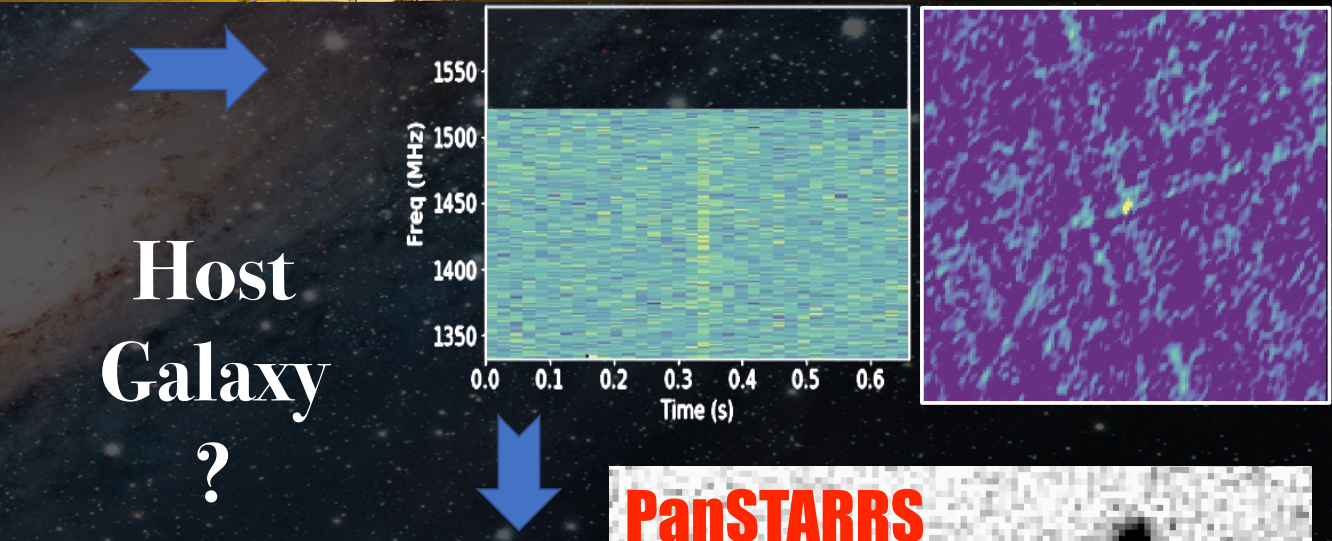
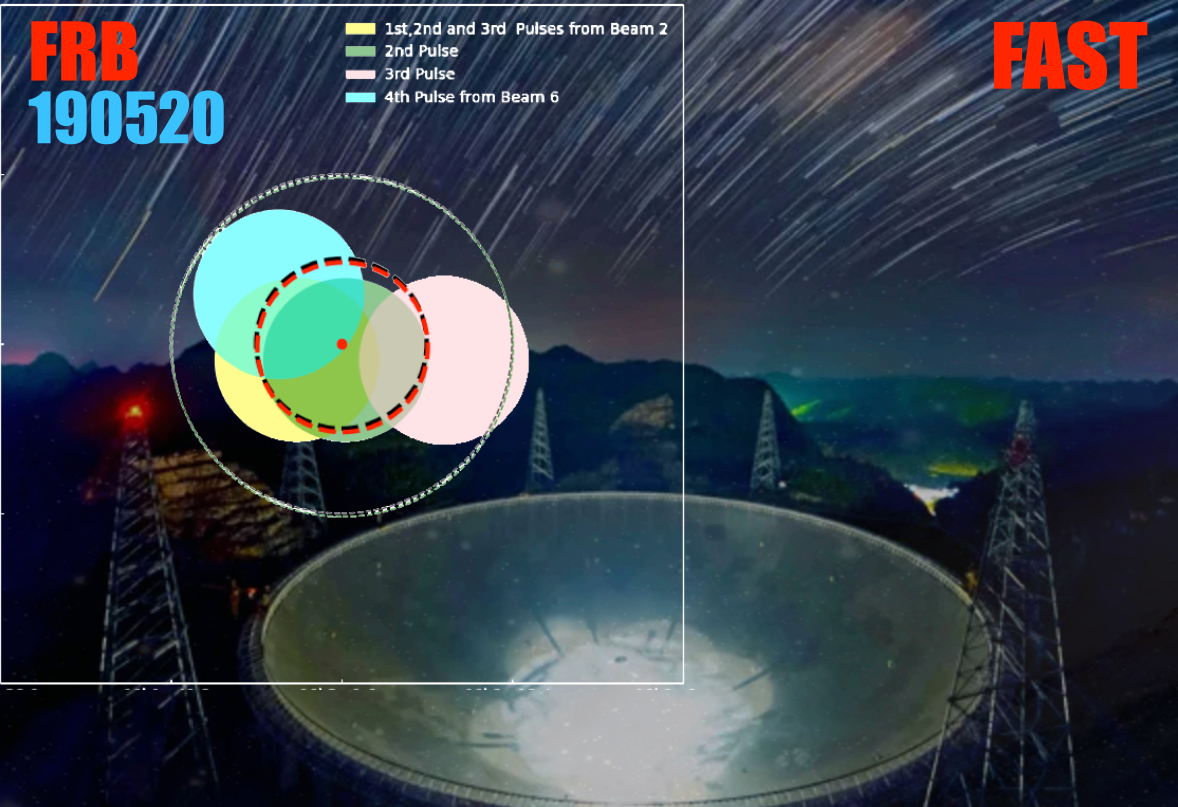
10⁴ Samples !

$$S(L, z, w) \leftrightarrow S'(DM, Fluence)$$

- PDF of FAST-FRB's DM is more sensitive to α than L_0
- FAST will have significant detection probability (>10%) for DM > 3000 pc cm⁻³



(Niu et al. 2021, ApJL, 909:L8)



Interesting New Repeater: FRB190520

(Niu et al. Submitted)

FRB 190520: Collaboration:

FAST: D. Li, C.-H. Niu, W.-F. Yu, J.M. Yao, P. Wang, Y.-K. Zhang, Y. Feng, B. Zhang, W.-W. Zhu, D.-J. Zhou, Y.-P. Men, J.-R. Niu, C.-C. Miao, M. Yuan, W.-Y. Wang, Rui Luo, Y.-L. Yue, M.-Y. Xue, et al.

Effelsberg: Marilyn Cruces, Di Li, Chenhui Niu, W-W Zhu, et al.

EVN: Marilyn Cruces, Bo Zhang, Di Li, You-Ling Yue, Chenhui Niu et al. & EVN Collaboration

VLA: Casey Law, Shami Chatterjee, Kshitij Aggarwal, Wen-Fei Yu, Sarah Burke-Spolaor, et al.

VLBA: Wen-Fei Yu, Casey Law, Shami Chatterjee, Yong-Jun Chen, Xian Zhang, Kshitij Aggarwal, et al.

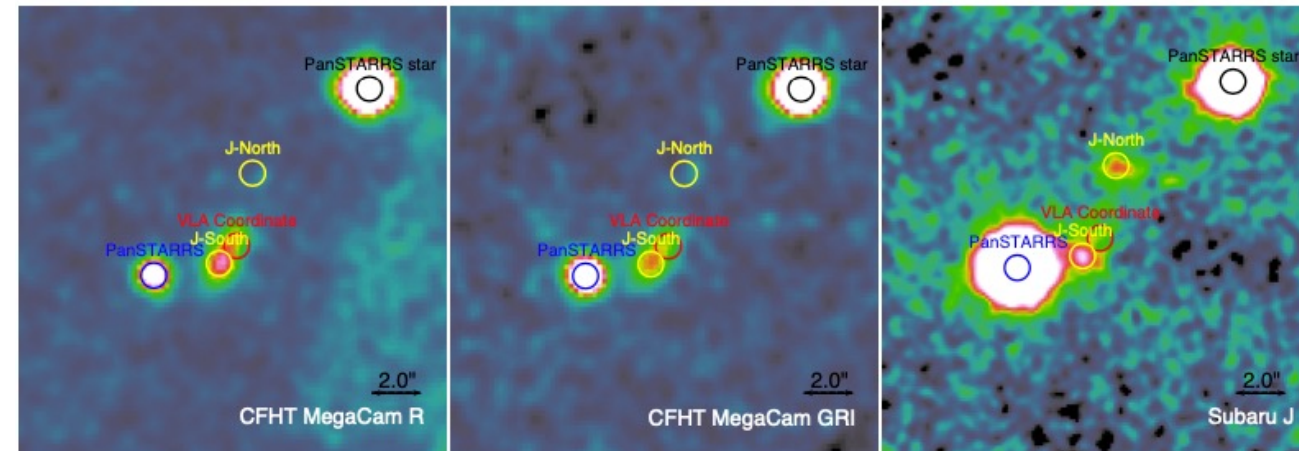
Parks: Shi Dai, Yi-Feng, Chen-Hui Niu. Di Li et al.

Optical Identification: Chao-Wei Tsai, Chris Bochenek Yuu Niino, Shami Chatterjee, et al.

DM_{Obs} : 1200 pc cm⁻³

Gb: ~30°

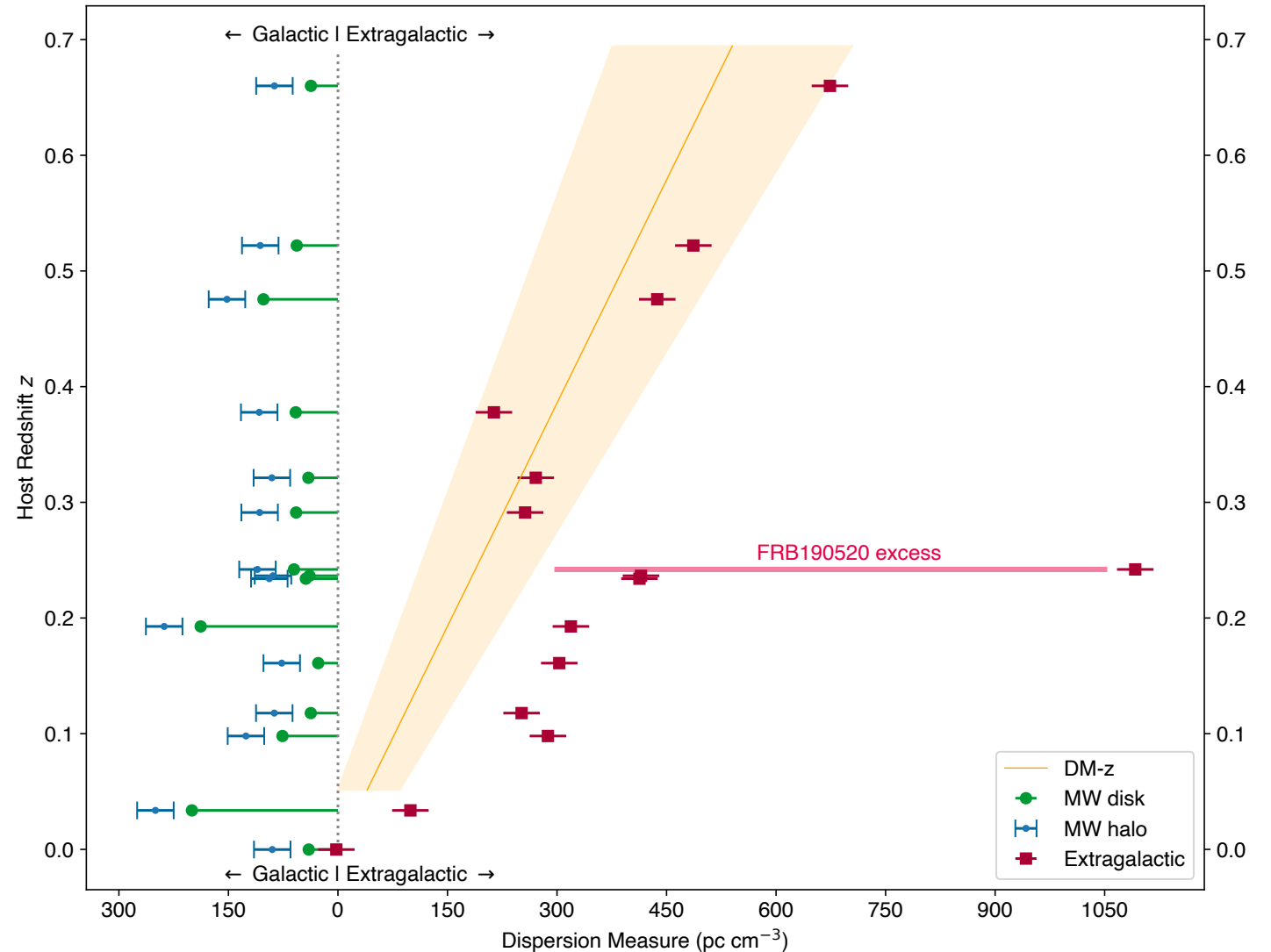
z: 0.241



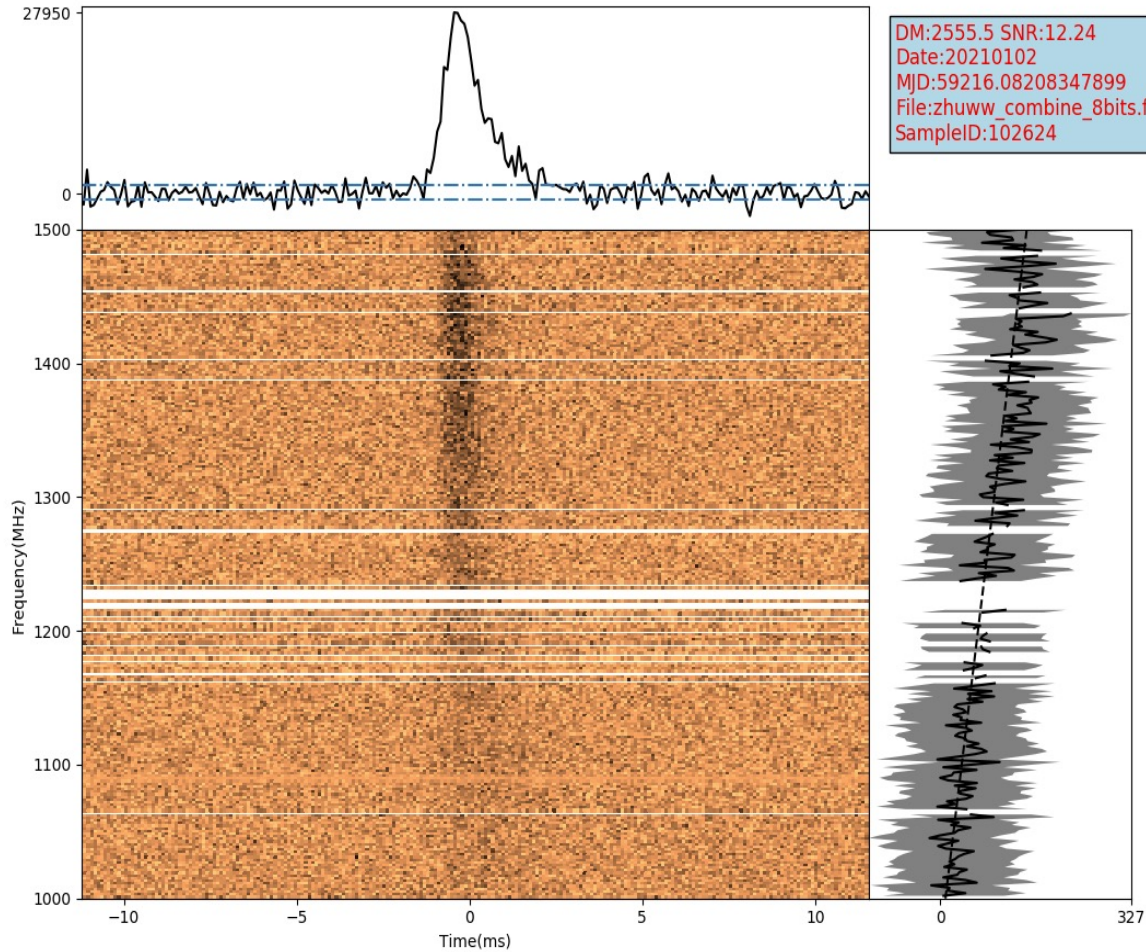
Interesting New Repeater: FRB190520

(Niu et al Submitted)

- ~200 bursts detected by FAST
- Associated with compact PRS
- $DM_{\text{host}} \sim 912 \text{ pc cm}^{-3}$
- $RM \sim 3000 \text{ rad m}^{-2}(\text{C-band})$
- Scatter time scale: ~10 ms
- Predominant Scintillation
- No period was found



New FRB Candidates FRB210102



Ra: 15:52:52.35,
Dec: 33:11:14
Gl: 53.126,Gb:50.62

Halo DM:30.00(cm^{-3} pc)
DM_MK:26 (cm^{-3} pc)
DM_IGM:2299.5(cm^{-3} pc)
DM_Obs:2555.5(cm^{-3} pc)
DM_Host(Obs):200.00(cm^{-3} pc)
Estimated redshift $z = 2.689$

Discovered by Weiwei-Zhu

Summary

- Total 6 new FRBs were detected from CRAFTS
- All those FRBs show low fluence ($<0.2 \text{ Jy ms}$) and high DM ($>1000 \text{ pc cm}^{-3}$). Extrapolate the DM_E – Fluence to more distant and low fluence region
- The FRB 181017.J0036+11 has the lowest fluence among the one-off events
- The FRB 190520 is a new interesting active repeater.
 - One of the most active repeaters
 - Highest DM_{host}
 - Second FRB associated with compact PRS.
 - High RM.



THANKS !