Fast Radio Burst and Magnetar Observations with the Stockert Telescope

Wolfgang Herrmann

Credits

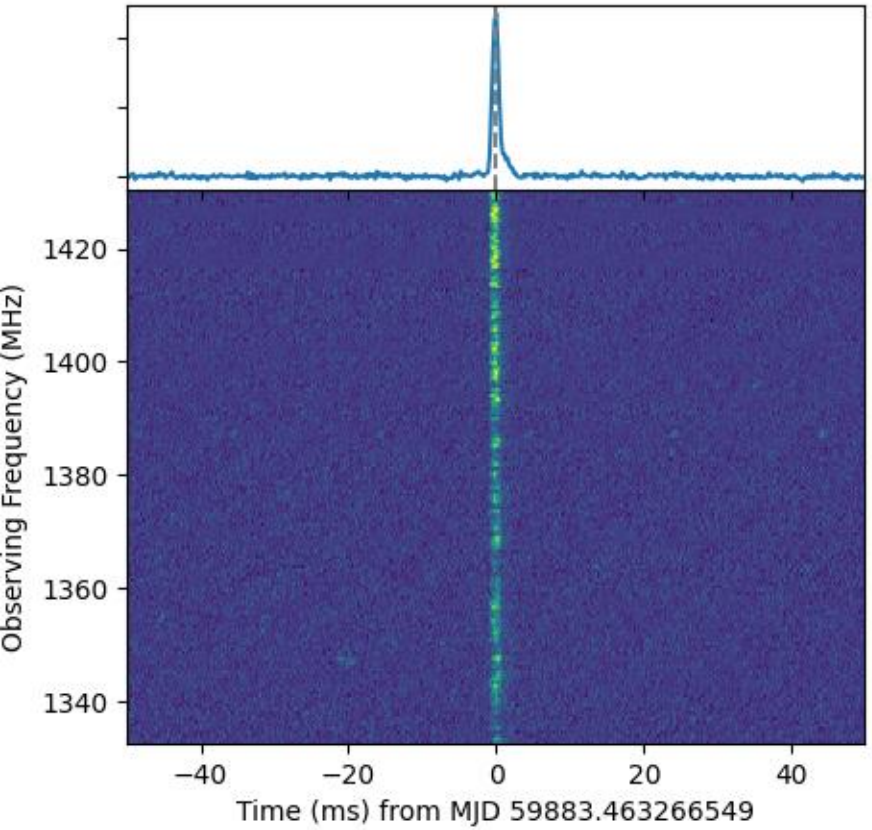
- This presentation uses material from
  „Studying the properties of the magnetar XTE J1810-197 using Stockert telescope data”
  Master thesis, Marlon Bause, 2021
- This presentation is based on ~ 4500 hours of observations conducted by the operations team of the Astropeiler Stockert observatory
- Many of these hours have been contributed by Bert Engelskirchen, who passed away this year. I would like to devote this presentation to his memory

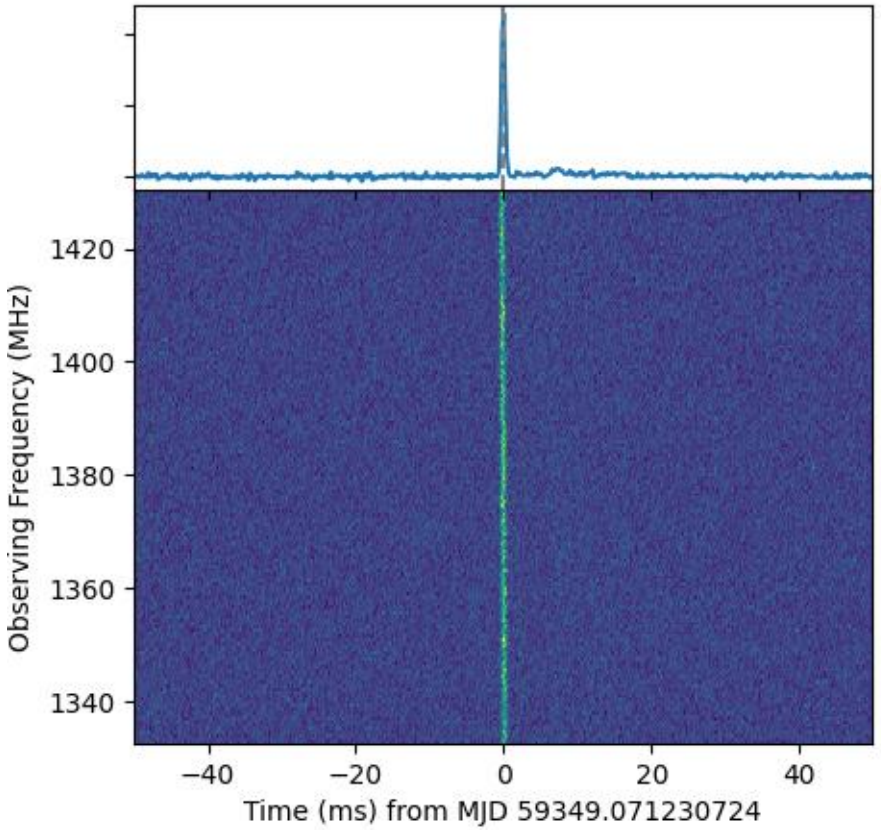
The Observation Campaigns

- XTE 1809-197, about 1500 hours observation time
  Magnetar, ~ 10.000 light years distance
- FRB20201124A, about 1200 hours observation time
  repeat fast radio burst, ~ 1.3 billion years light travel time distance
- FRB20220912A, about 1800 hours observation time
  repeat fast radio burst, ~ 1.0 billion years light travel time distance

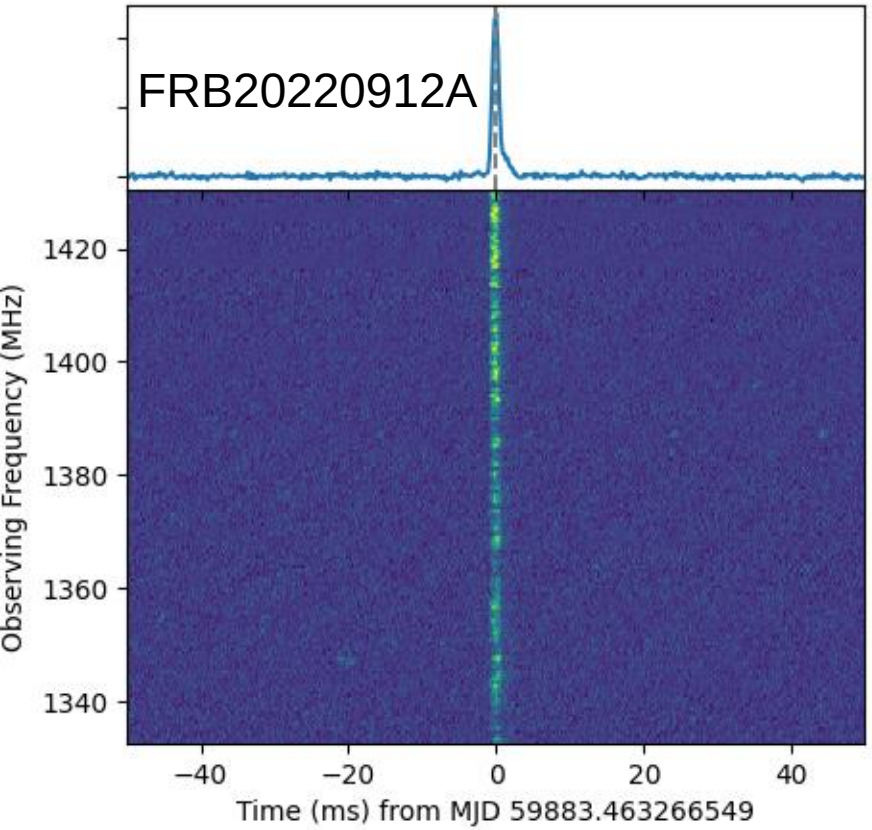
Aim: Find similarities and dissimilarities between Magnetars and Repeat Fast Radio Bursts

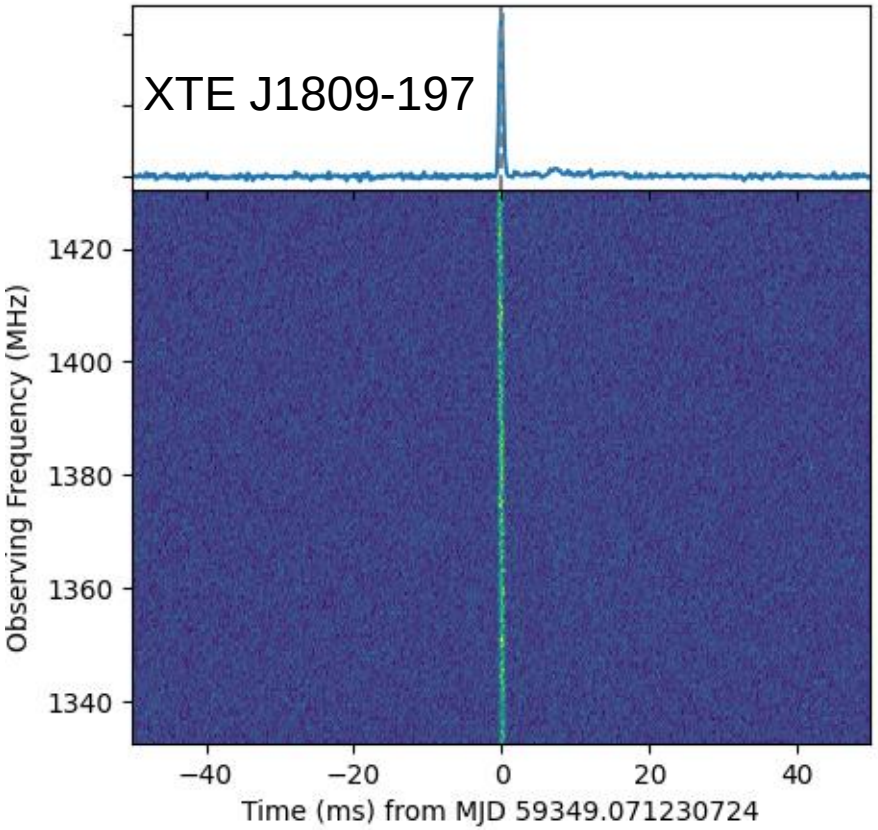
FRBs and Magnetars: Two sides of the same coin?



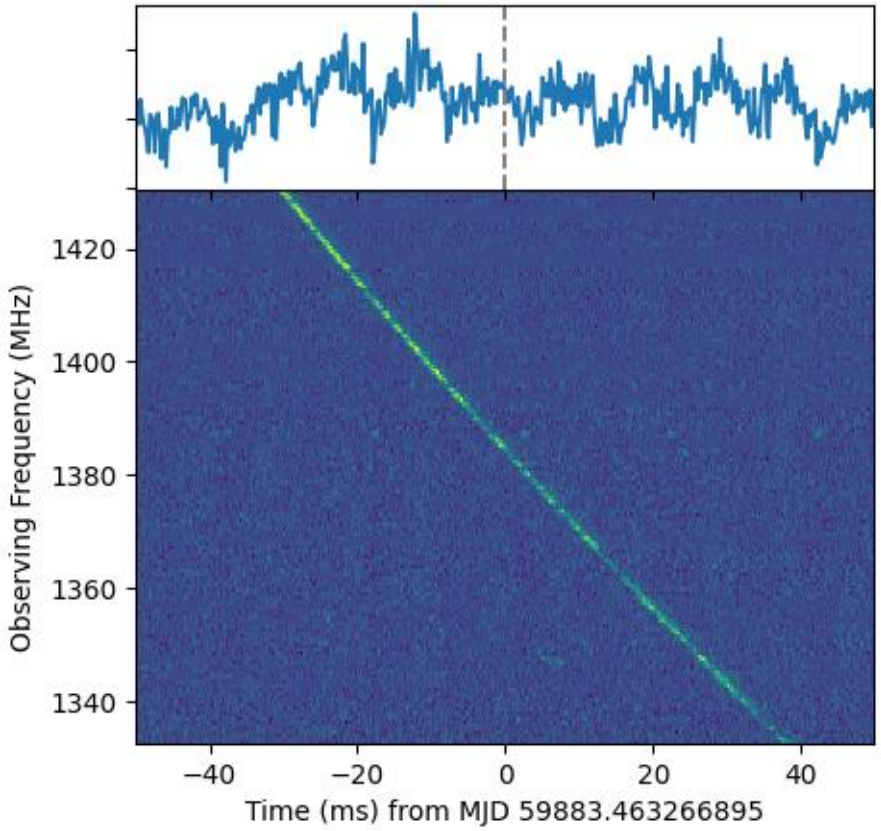


FRBs and Magnetars: Two sides of the same coin?





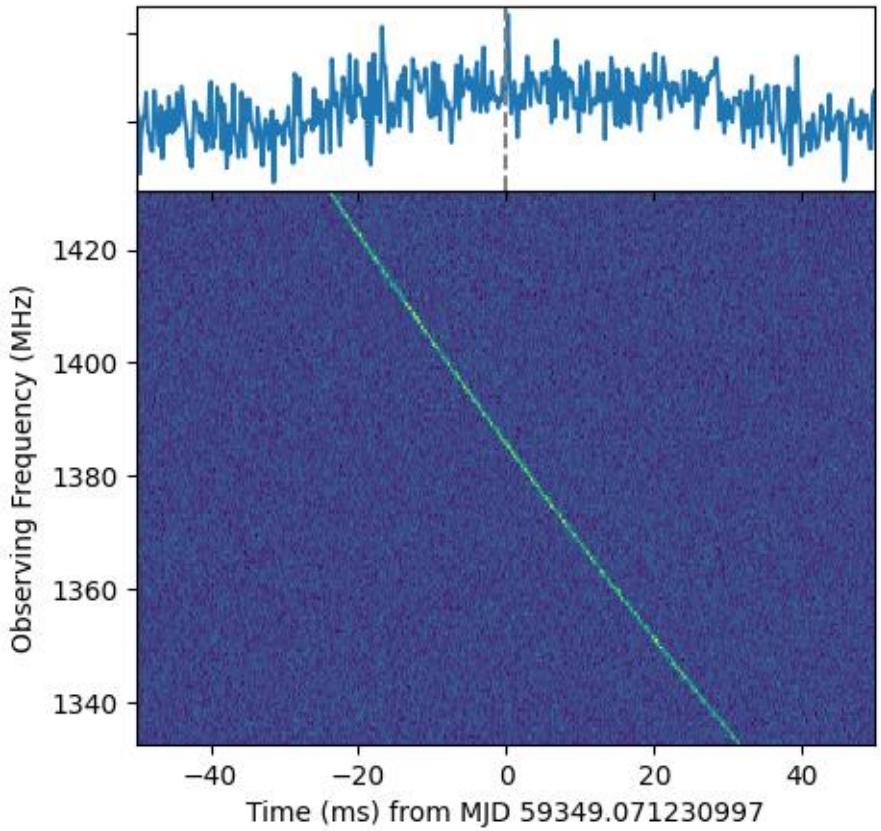
How to tell a galactic source from an extragalactic source?



DM 219

Lat = -10.7

How to tell a galactic source from an extragalactic source?



DM 178

Lat = -0.15

Dispersion measure galactic/extragalactic

Calculated with pyGEDM by Price, D.C et. al.

Motivation for the Magnetar – FRB Link

High luminosity pulses seen from SGR 1935+2154

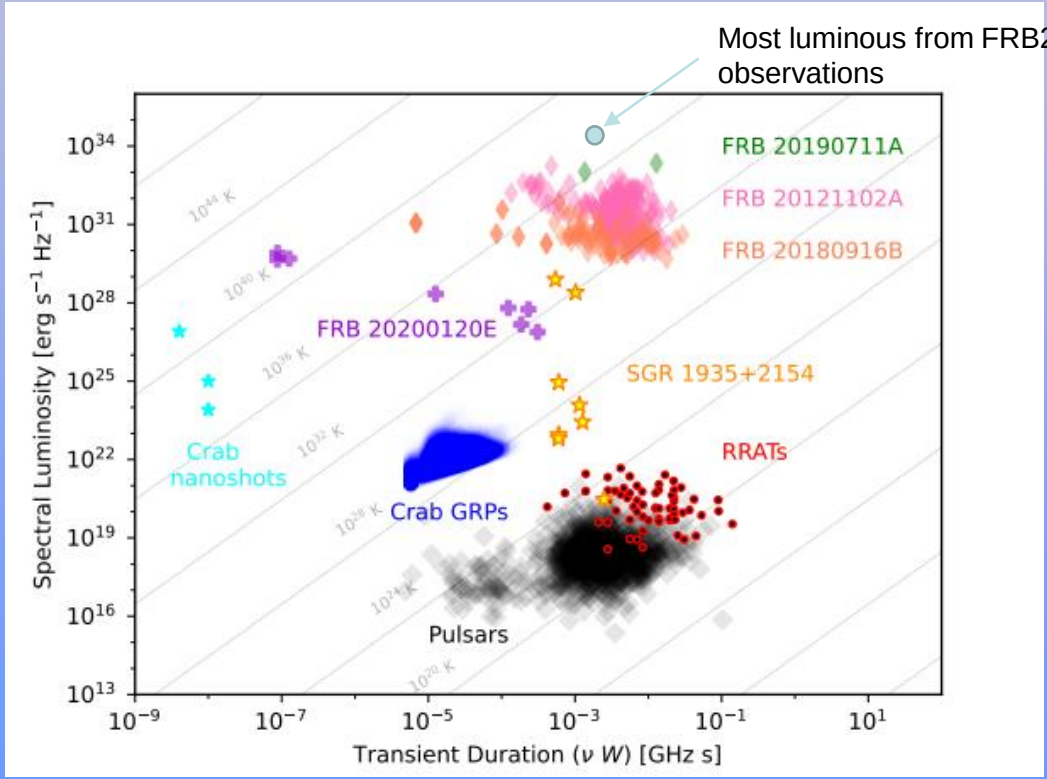
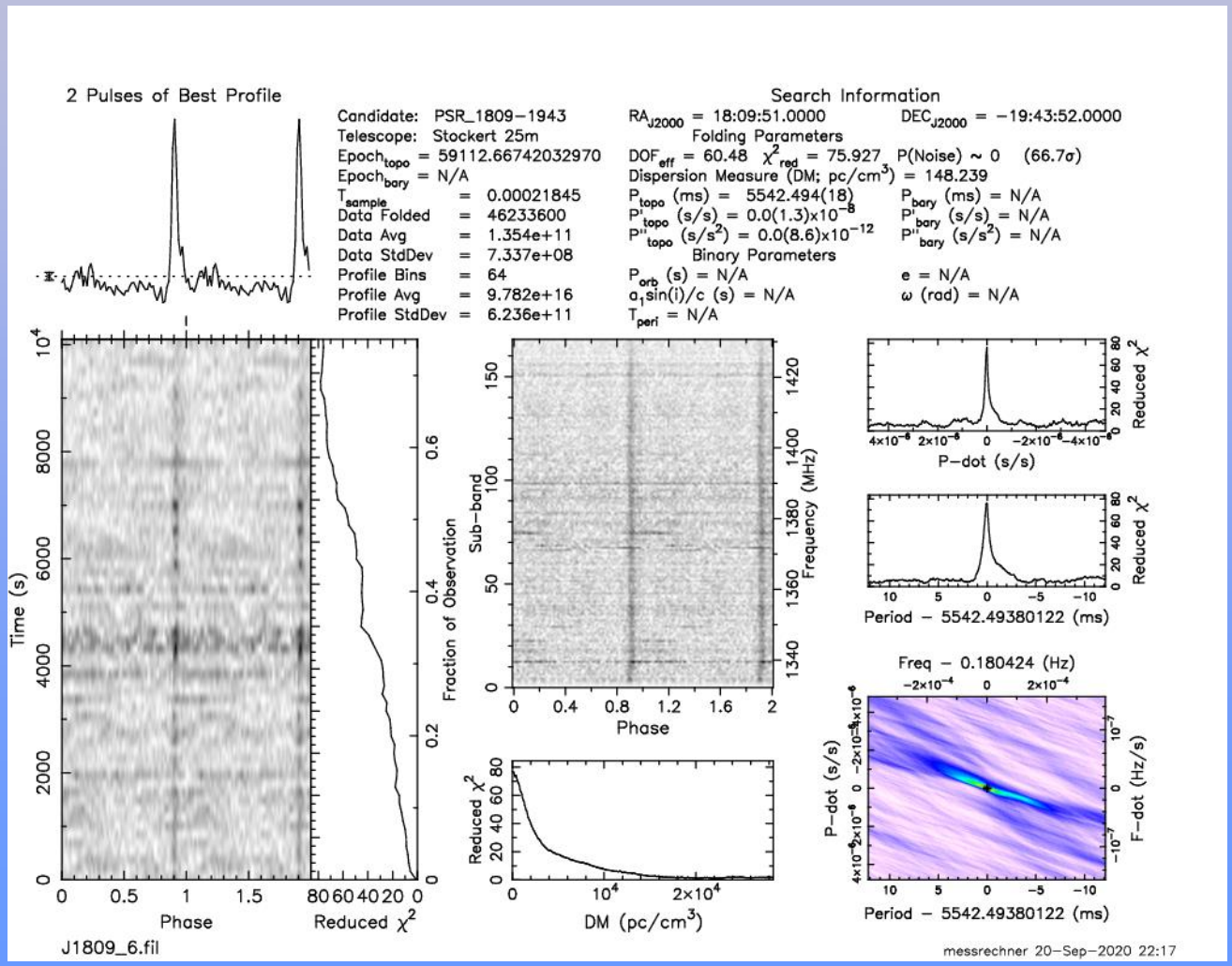


Figure from: Nimmo, K., Hessels, J. W. T., Kirsten, F., et al. 2022a, Burst timescales and luminosities as links between young pulsars and fast radio bursts, Nature Astronomy, 6, 393

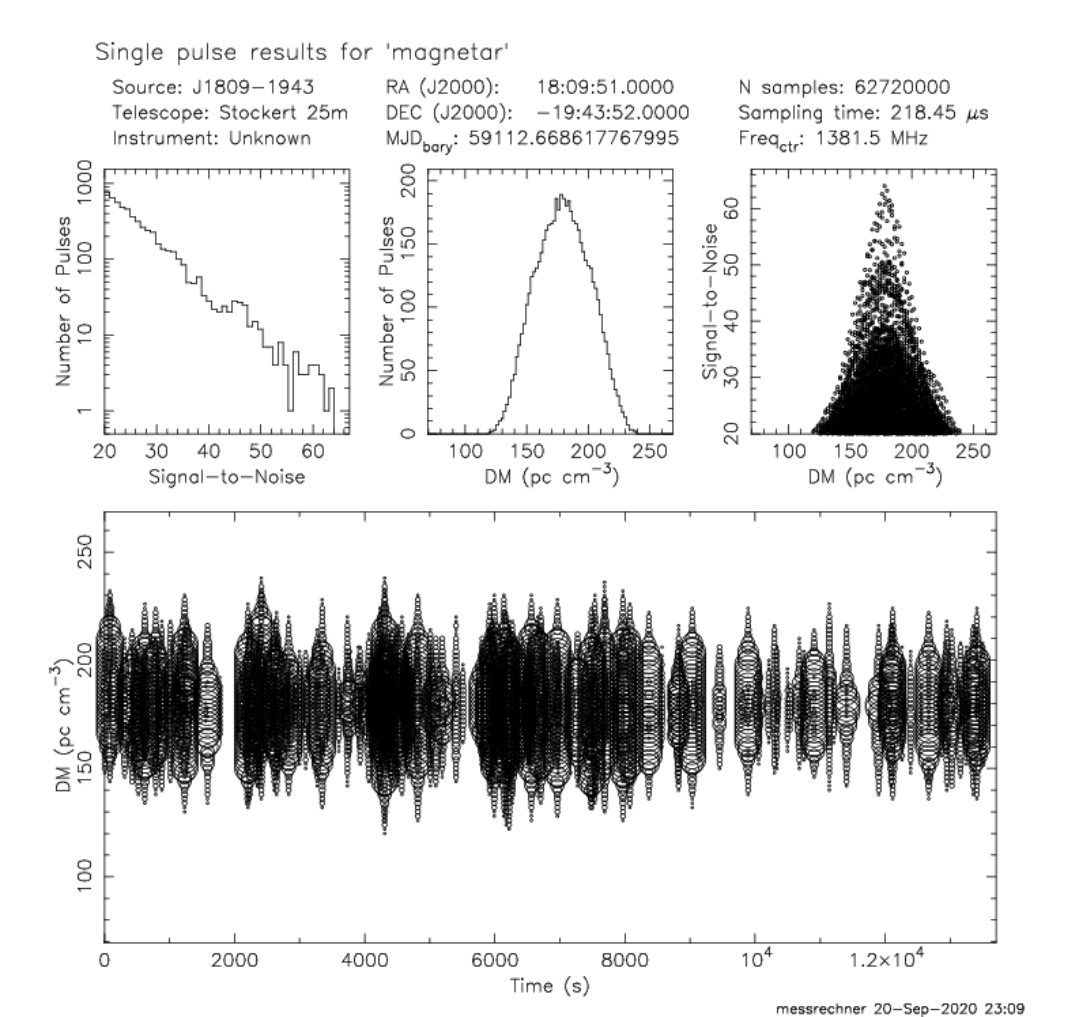
XTE J1809-197 observation campaign

Average profile: Just like from a pulsar

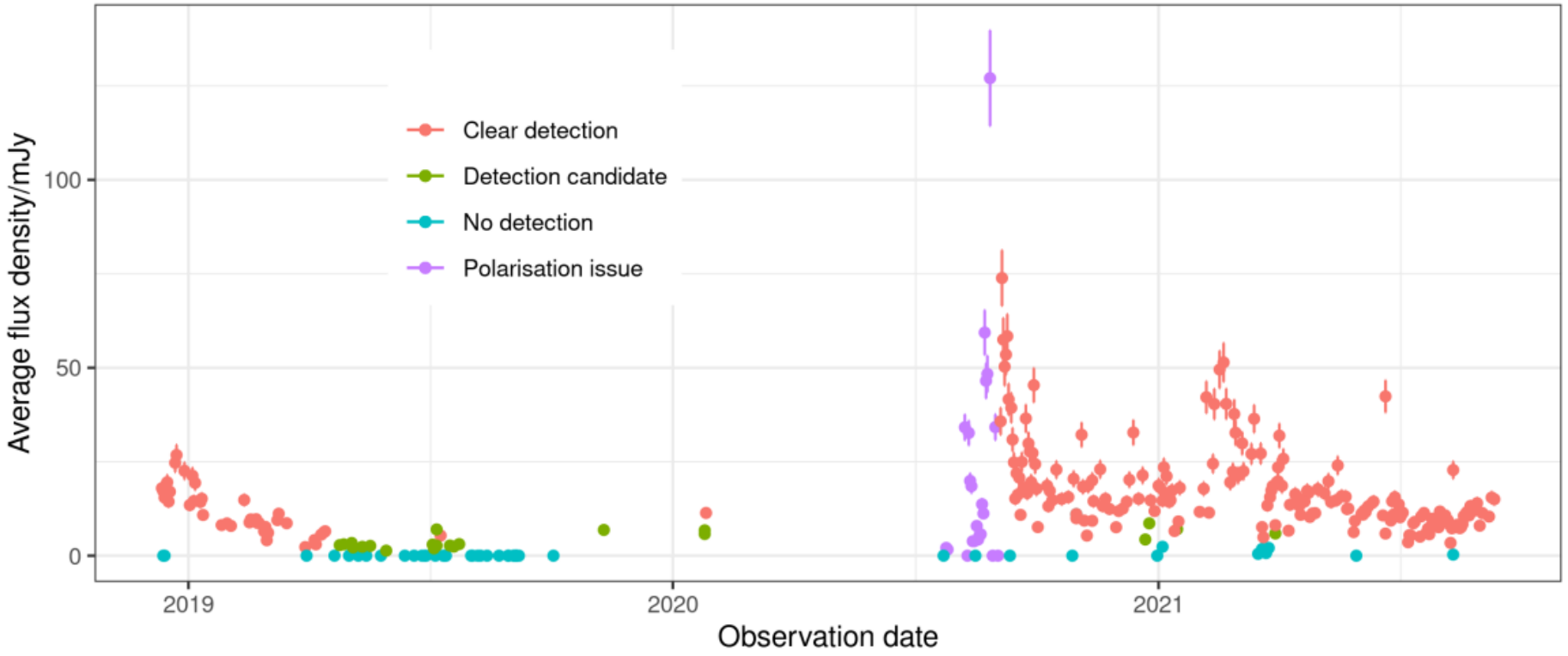


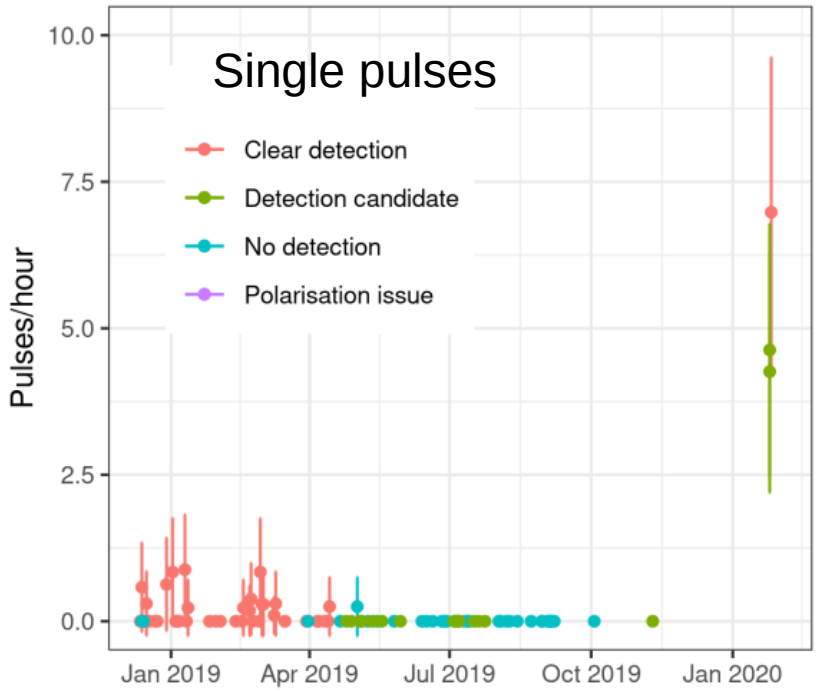
XTE J1809-197 observation campaign

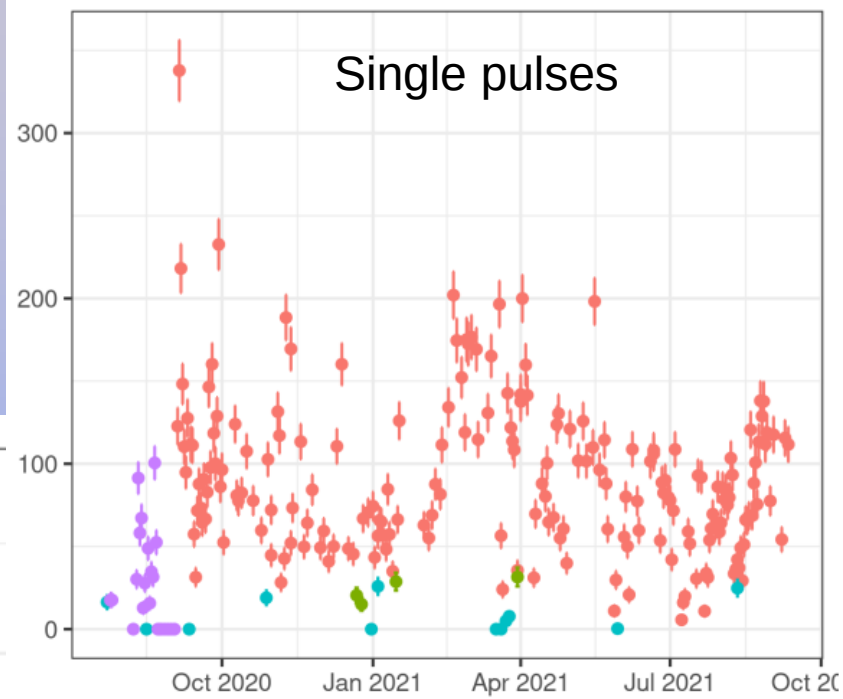
Single pulses with SNR > 20

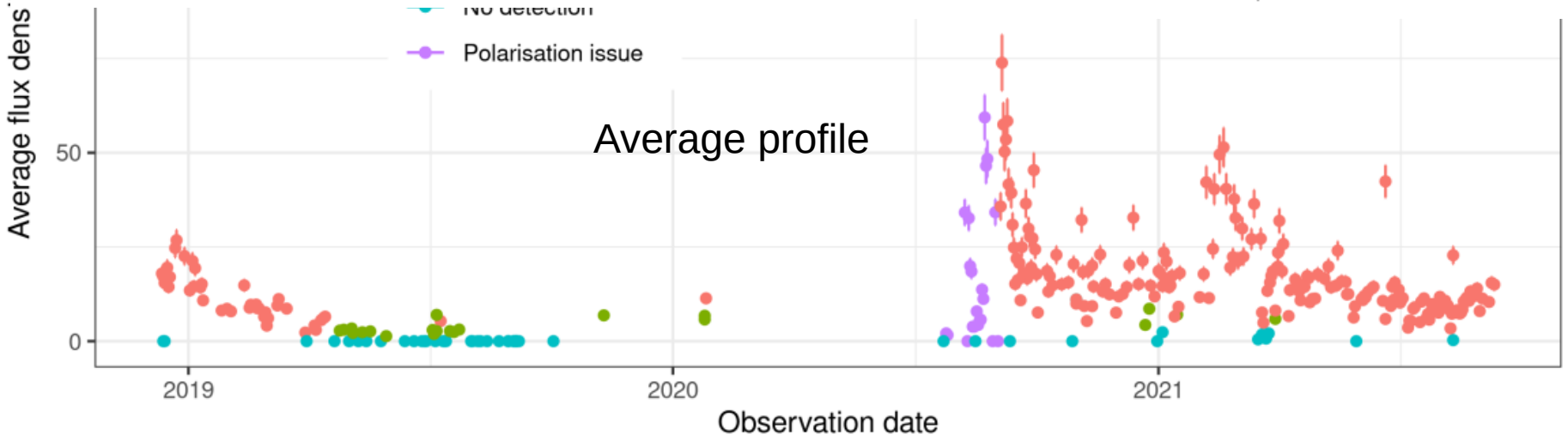


XTE J1809-197 observation campaign
Evolution of average profile flux density

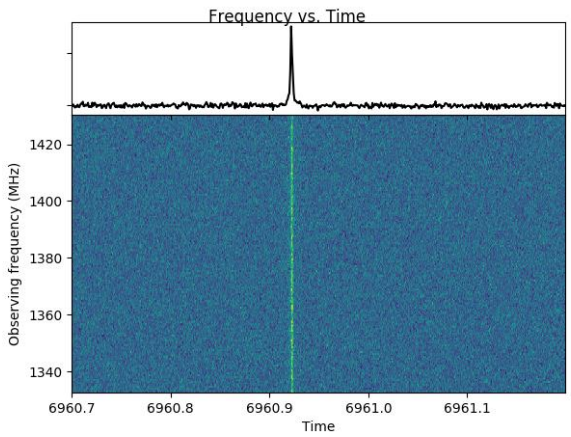


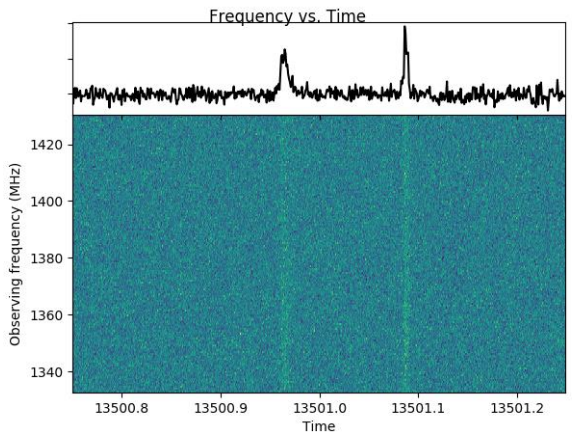

Single pulses
Clear detection
Detection candidate
No detection
Polarisation issue
Pulses/hour
10.0
7.5
5.0
2.5
0.0
Jan 2019
Apr 2019
Jul 2019
Oct 2019
Jan 2020

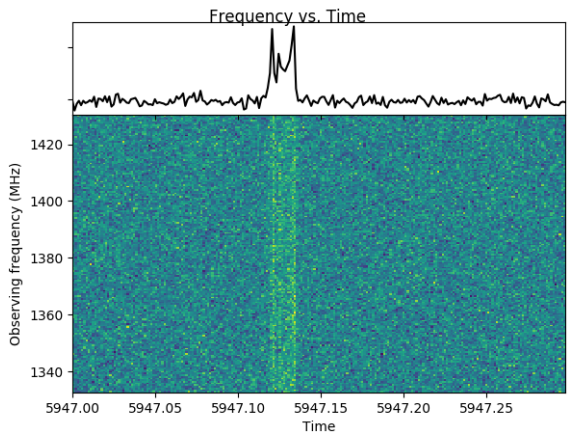

Single pulses
300
200
100
0
Oct 2020
Jan 2021
Apr 2021
Jul 2021
Oct 20

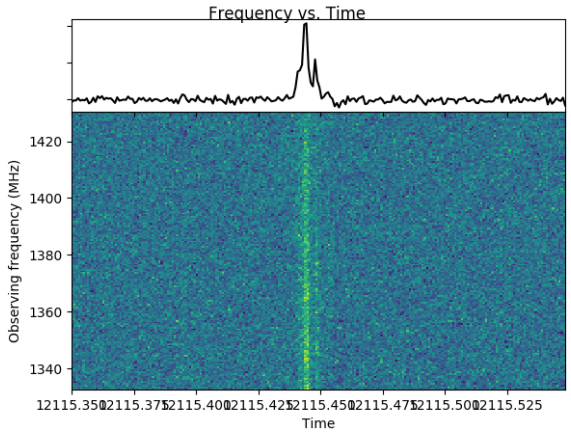

Polarisation issue
Average profile
Average flux dens
50
0
2019
2020
2021
Observation date

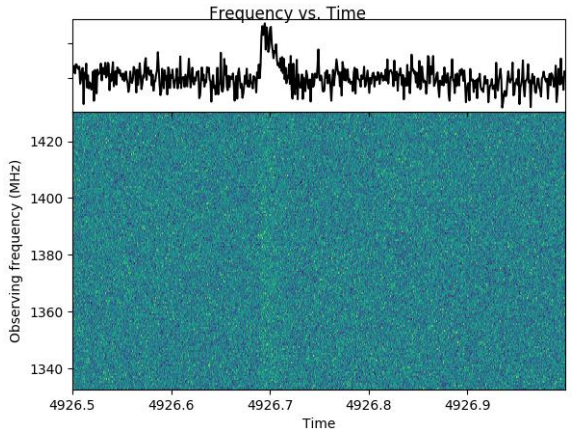
XTE J1809-197 observation campaign
Great variation of pulse profiles

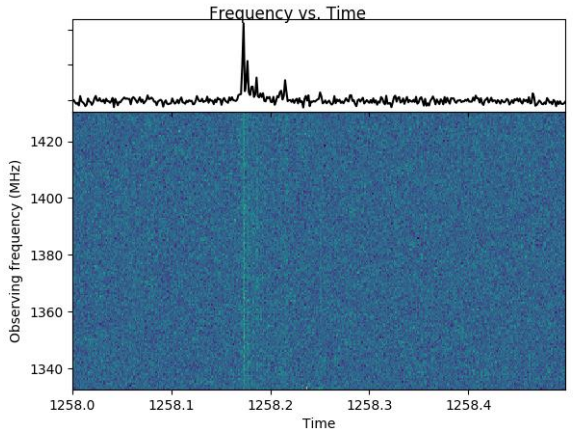




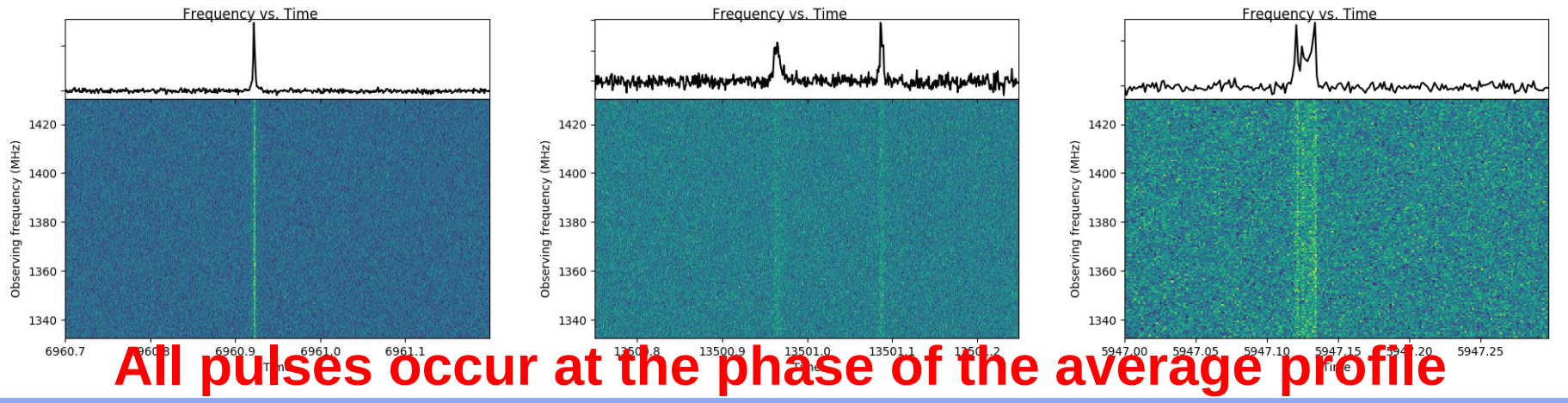




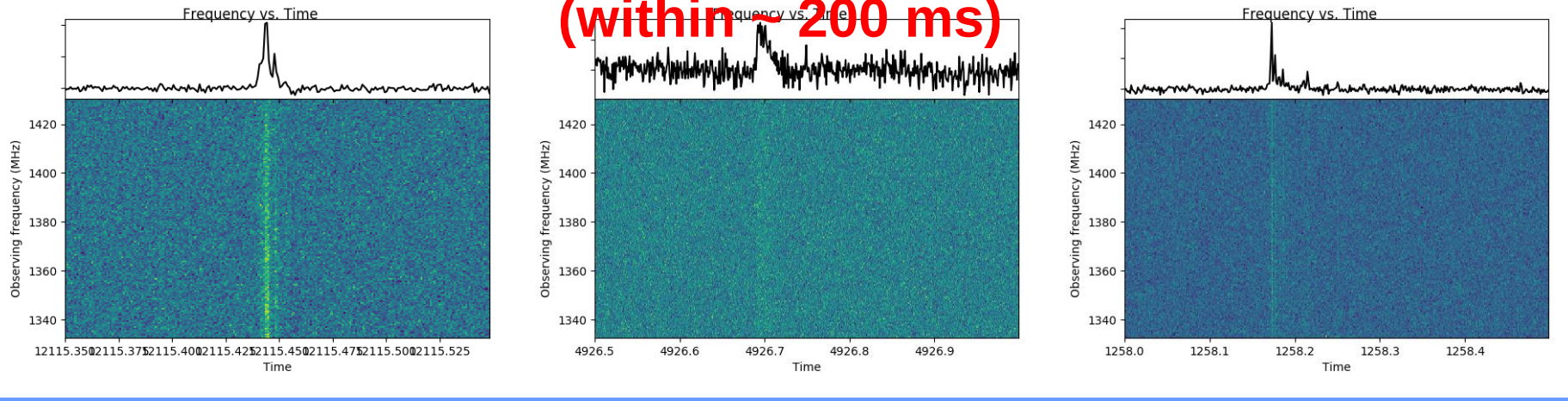




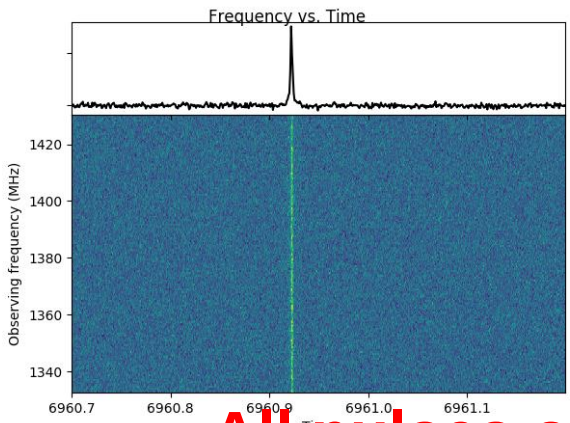
XTE J1809-197 observation campaign
Great variation of pulse profiles

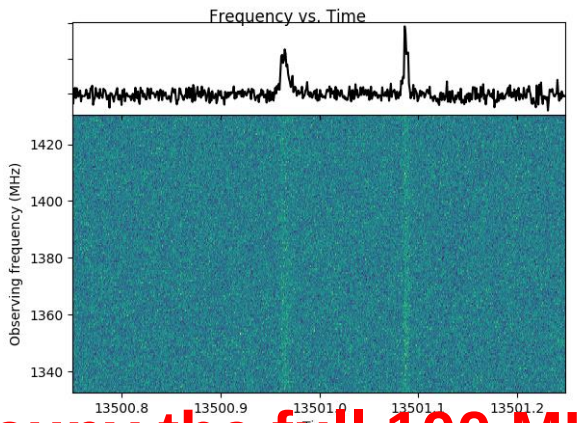


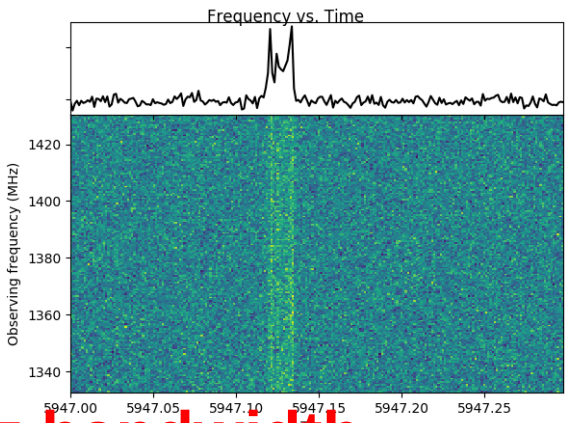
All pulses occur at the phase of the average profile (within ~ 200 ms)



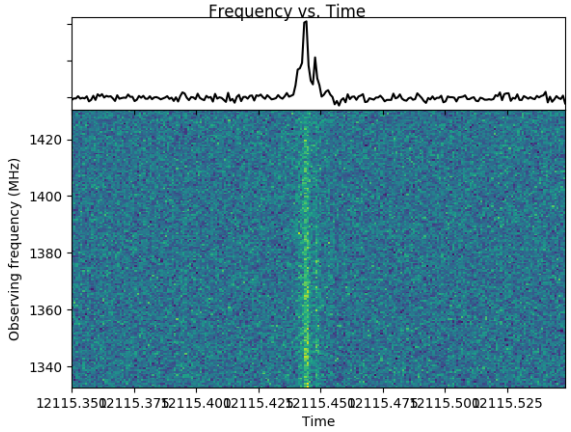
XTE J1809-197 observation campaign
Great variation of pulse profiles

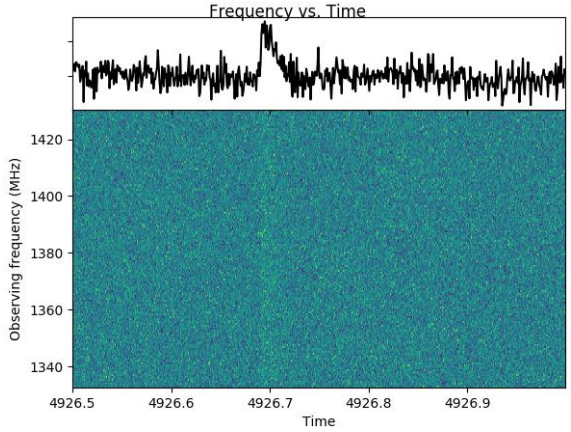


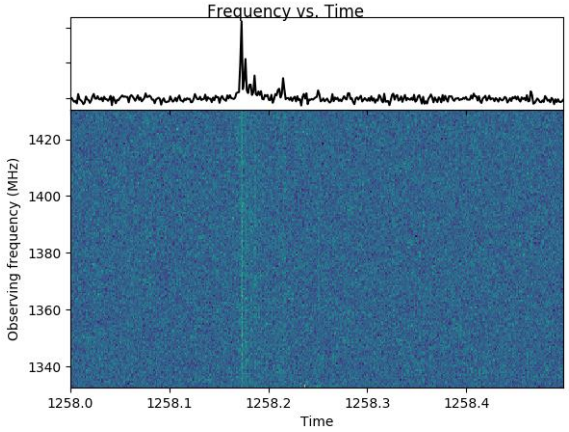




All pulses occupy the full 100 MHz bandwidth



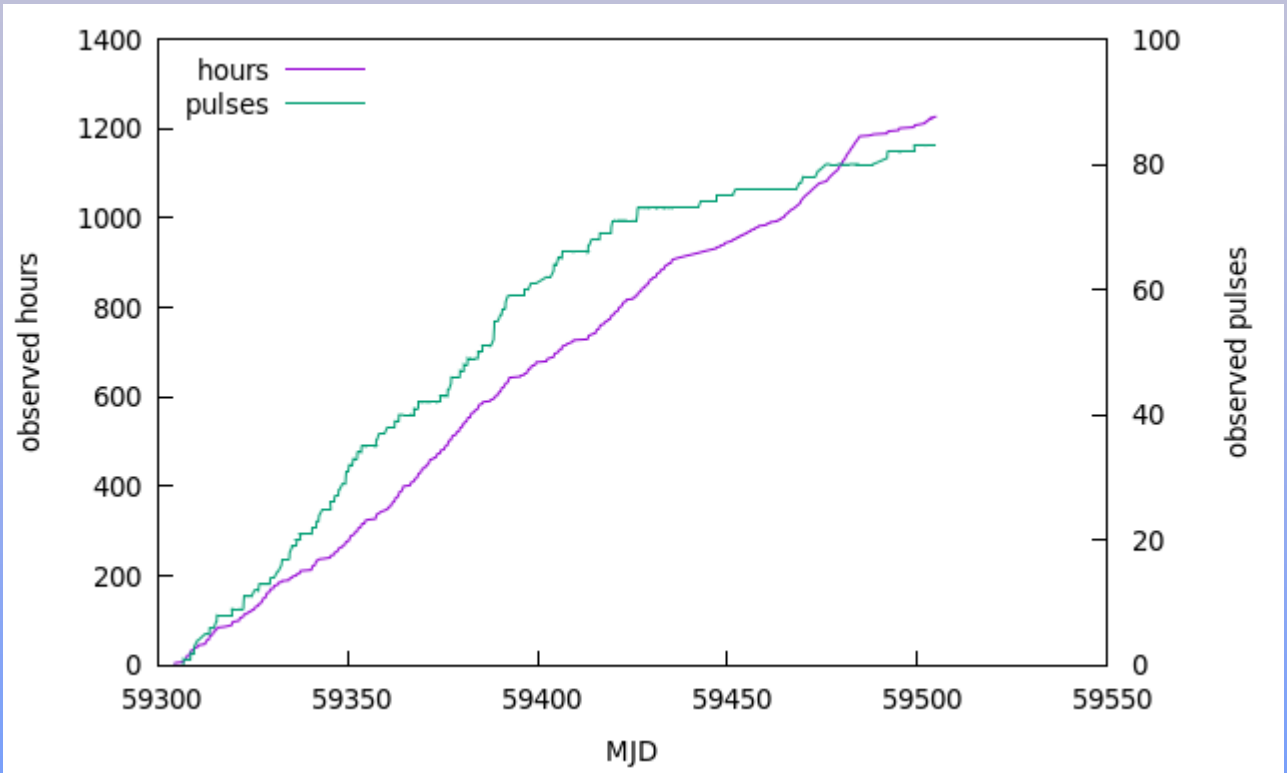




Main takeawys from the magnetar observation

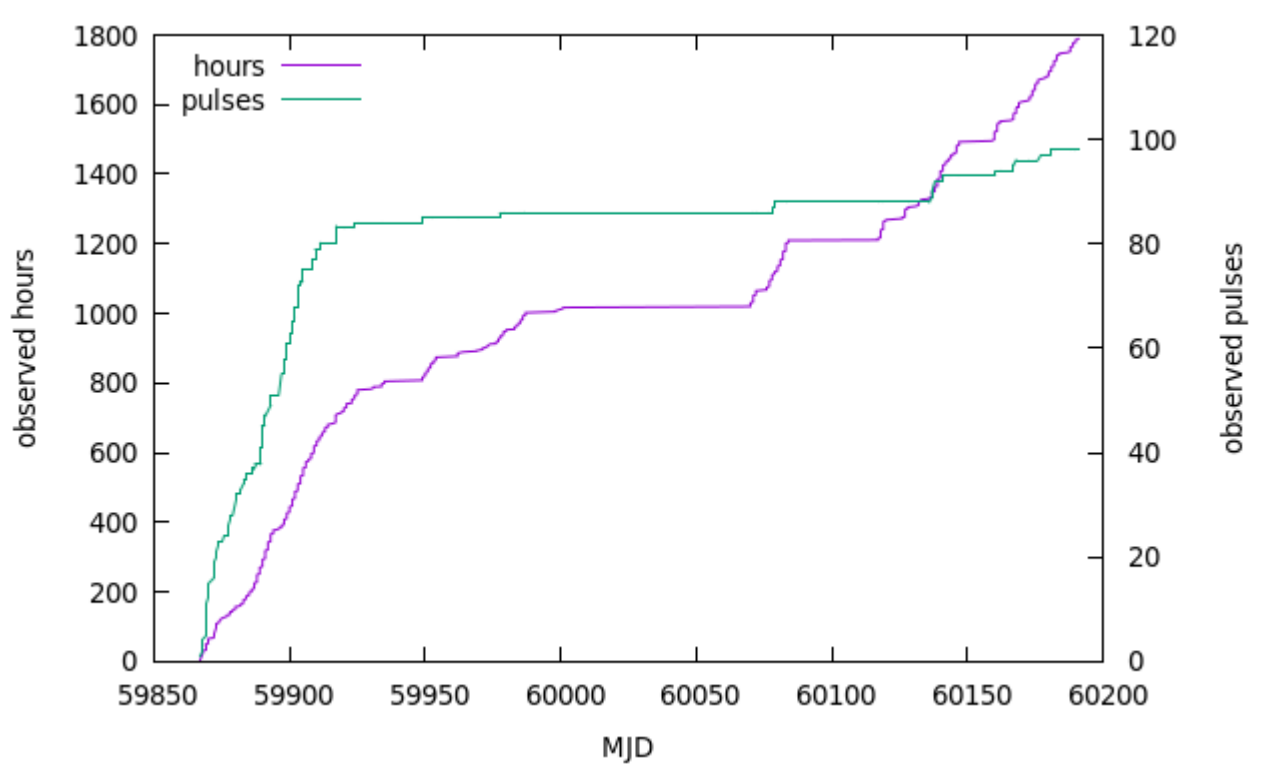
- Average pulse profile with a period of ~ 5.4 seconds
- Many bright single pulses detected (several 10.000)
- Episodes of high and low activity
- All single pulses occur at the phase of the average profile (within 200 ms)
- Single pulses come in various shapes, typcial width changes over time
- While # of single pulses generally correlate with the average flux density of the average profile, there are significantly different phases (episodic behaviour)
- All single pulses cover the full frequency band of the Stockert telescope (1330 – 1430 MHz)
- No clear detection of a „sad trombone“
- Occurance of „sudden dropouts“

FRB20201124A Observing Campaign



- From May 17th, 2020 to Oct. 17th, 2021 ~ 1200 observing hours
- 83 FRB pulses detected
- More details at https://arxiv.org/abs/2306.15505

FRB20220912A Observing Campaign



- From Oct. 15th, 2022 to date ~ 1800 observing hours
- 98 FRB pulses detected, thereof 83 in the first 41 days
- => 85% of pulses in 39% of the observing time

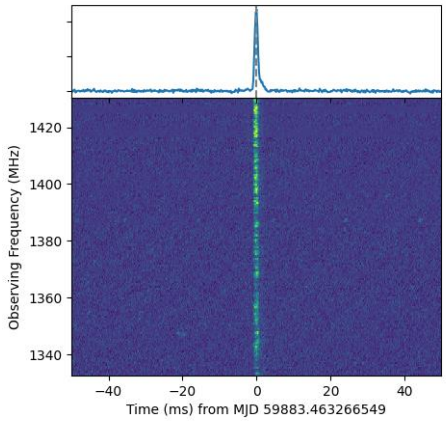
Any periodicity?

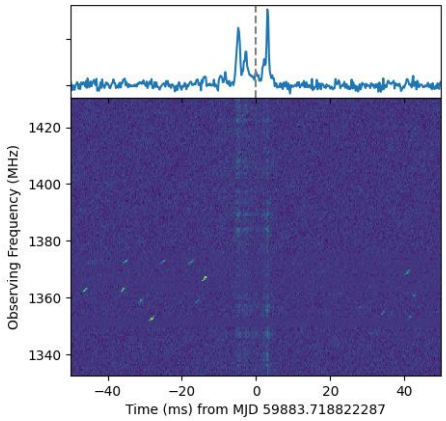
- Shortest wait time for FRB20220912A Δ t: 12.56 s (+/- 50 ms)
- Runners up
  - Δ t: 364.68 s = 29 * 12.58 s
  - Δ t: 569.30 s = 45 * 12.65 s
  - Δ t: 769.69 s = 61 * 12.61 s
- Folding with ~ 12.56 s does not reveal something convincing
- No study in the literature of any repeat FRB has found a periodicity *)

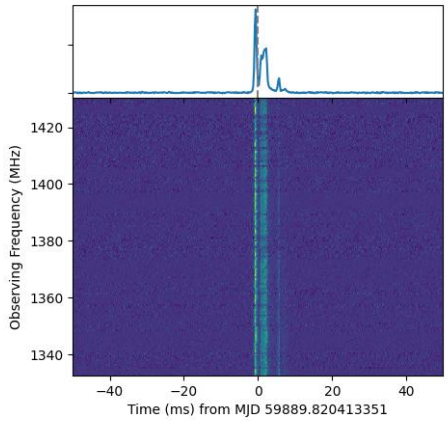
=> No evidence for periodicity in our data

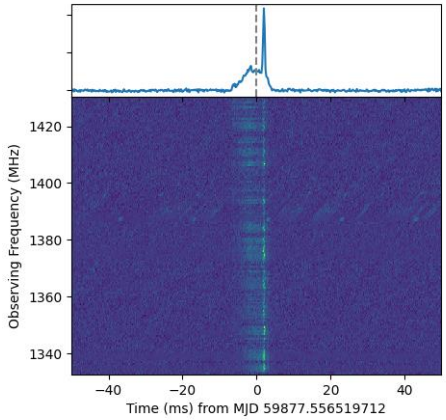
*) see for example:
FAST Observations of an Extremely Active Episode of FRB 20201124A. IV. Spin Period Search
Jia-Rui Niu *et al* 2022 *Res. Astron. Astrophys.* 22 124004

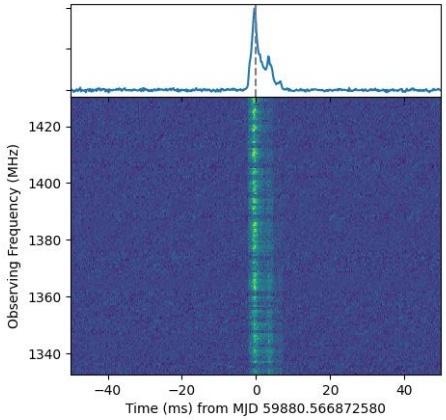
FRBs: Variety of pulse shapes

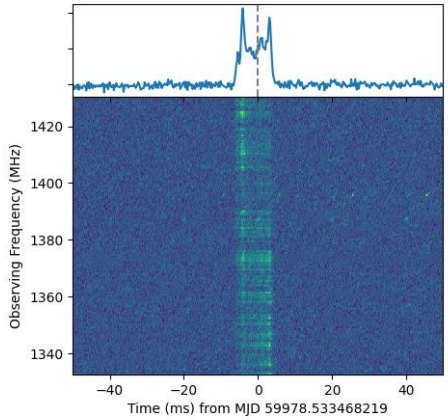




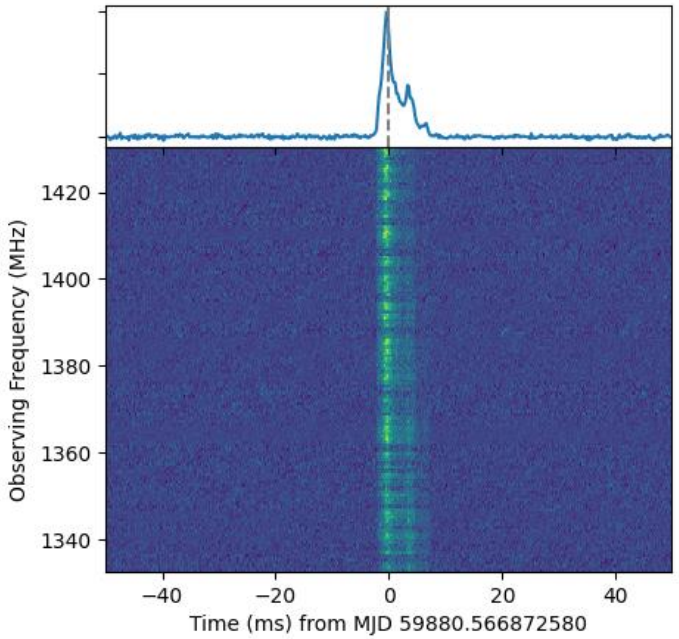


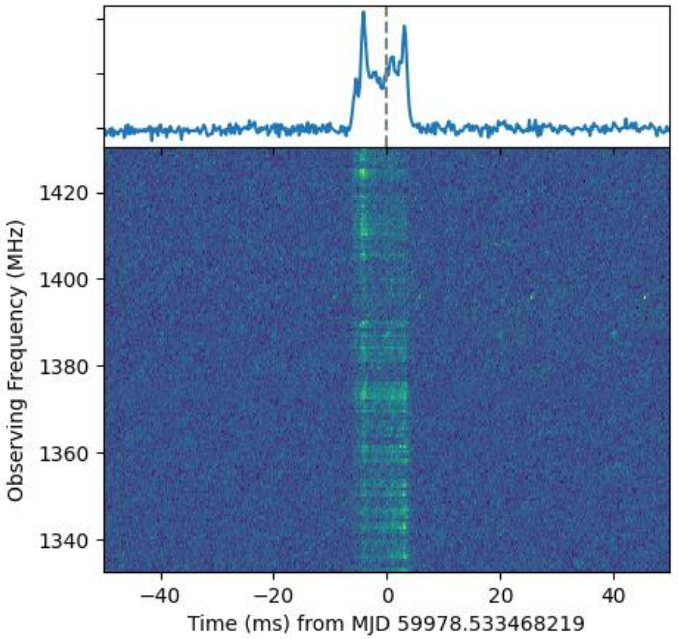




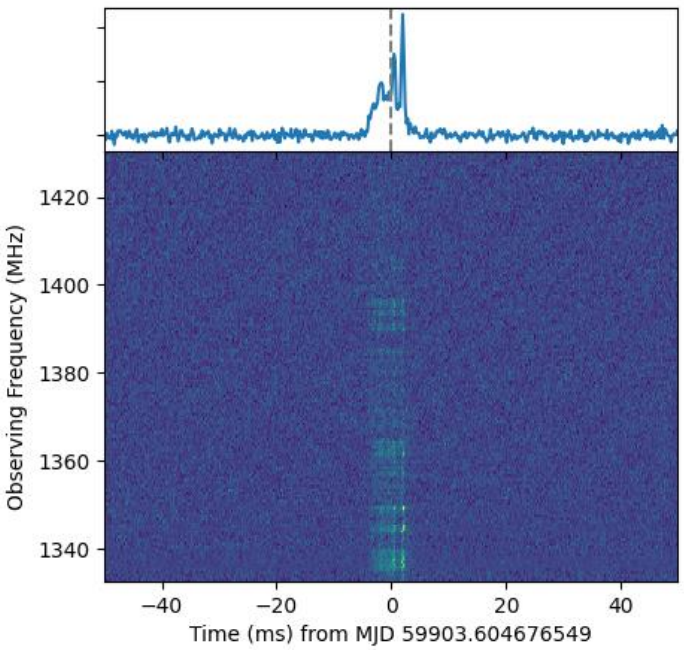


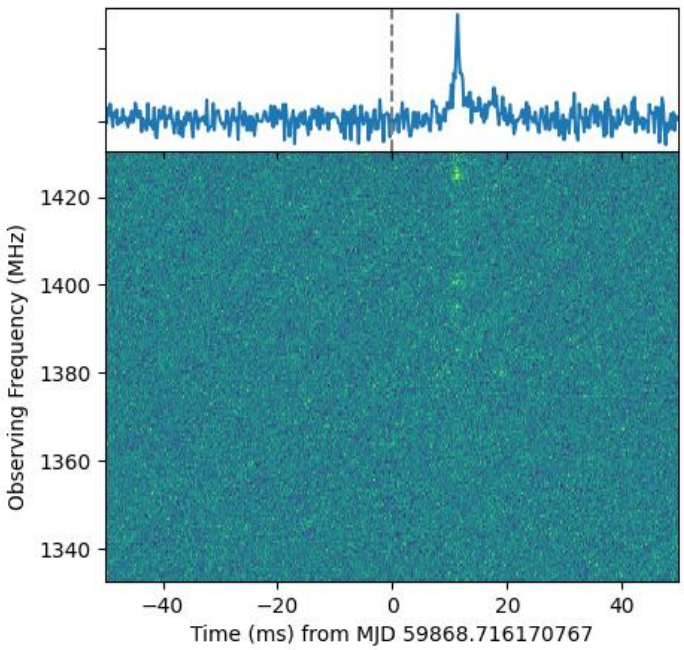
FRB: „Sad Trombone“





FRB: Limited Bandwidth





FRBs vs. Magnetars from Stockert Observations

Characteristic	Fast Radio Burst	Magnetar
Episodic behaviour	☺	☺
Folded profile (Period)	☹	☺
Variation in pulse shape	☺	☺
Sad trombone effect	☺	☹
Always covering full frequency band	☹	☺

Special thanks to

The Astropeiler operations team for many many hours of observation time