Instruments for large area FRB surveys

And what you find if you had one

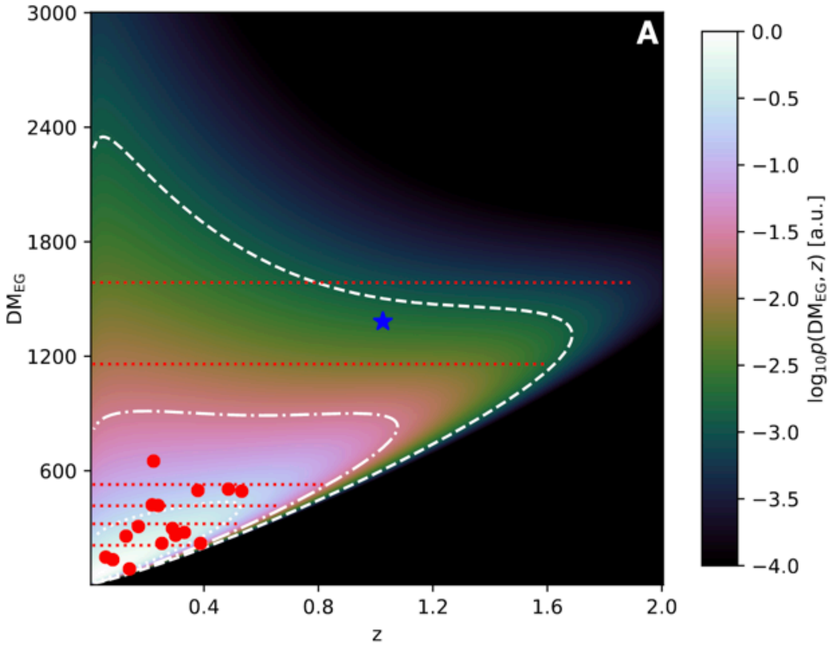
Keith Bannister - Sep 2022

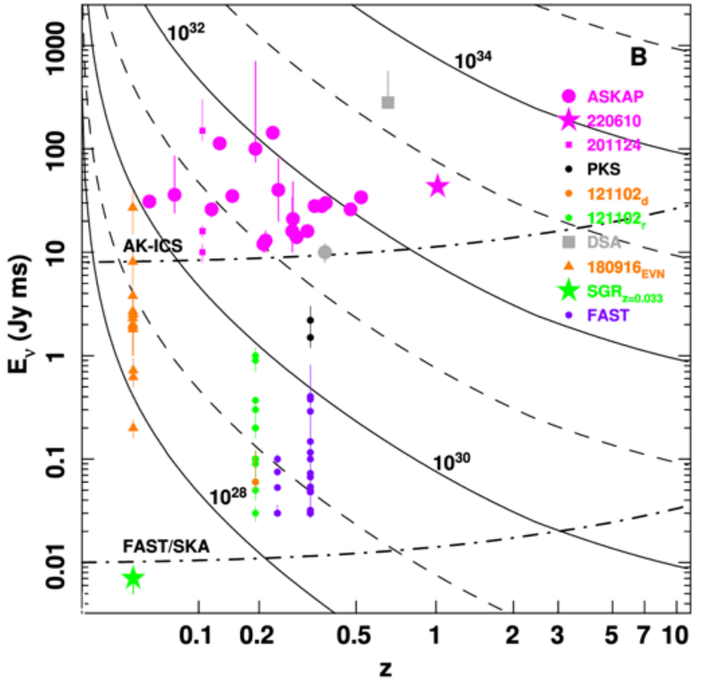
FRBs are fun because we want to solve mysteries

- How do they shine?
- What makes them?
- What can they tell us about the Universe?

FRBs near and far

- FRBs with known redshifts are largely 0.1 <z < 1
- The nearby, notable exceptions have been the most informative for progenitors. E.g.
  - **FRB 20200120E (M81 globular cluster)** -> FRBs can come from old stellar populations
  - **SGR 1935+2154 (Milky Way)** -> Magnetars can shine in a similar way to FRBs, only 30 times less bright



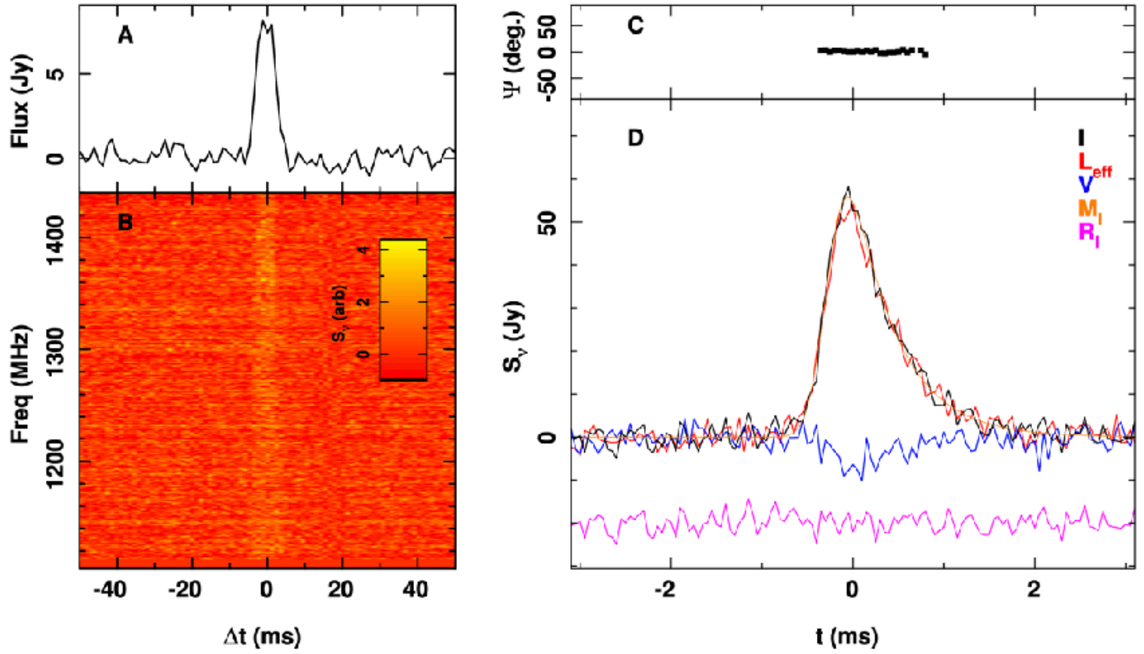


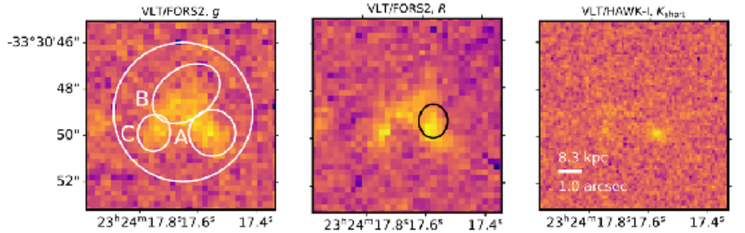
Ryder+22 arXiv: 2210.04680

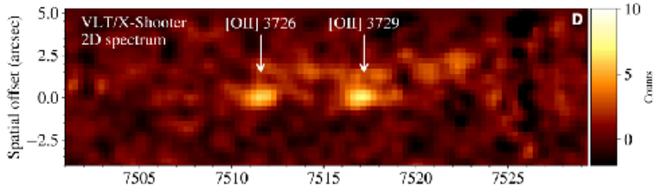
Breaking news:

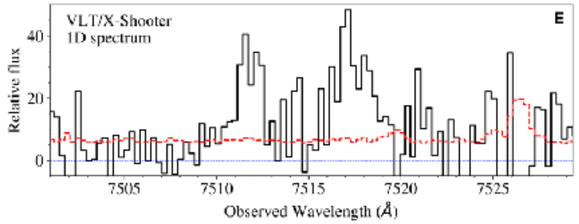
FRB220610A at z=1

- Excess DM=650 pc/cm3 = 1300 pc/cm3 in the host frame
- RM=215 rad/m2
- Scattering Tau: 0.55ms (observer frame) = 1.88 ms (rest frame)
- Energy density: 6.4e32 erg/Hz.









FRBs are fun because we want to solve mysteries

- What makes them? = **Closer** the better
- How do they shine? = **Closer** the better
- What can they tell us about the Universe?
  - Small scale structure: **Closer** the better (< 1 Gpc or so??)
  - Large scale structure: **Further** the better

Large area surveys are good because they find

- The nearest FRBs, so you can study:
  - Progenitor itself, and its environment
  - Identify prompt & afterglow emission
  - Make a map of the intergalactic neighbourhood
  - DM halo
- Rarest / Brightest FRBs
  - Constraints on how they shine

But how do you do large area surveys?

Wide area instruments

Happening

Future possibilities

System	GReX	ASKAP MkII (AA)	CryoPAF (64m)	CryoPAF (AA)	ASKAP MkIII PAF	"Aperture Optimised PAF"	SKA-low
Frequency	1.25-1.5 GHz	0.7-1.8 GHz	0.7-2 GHz	0.7-2 GHz	0.7-2 GHz	0.7-2 GHz (neg.)	4-350 MHz
Elements	1	96x2	98x2	98x2	98x2	98x2	512x2
Time Resolution (msec)	0.01	1	0.064	0.064	1	0.064	10
Processed Bandwidth (MHz)	250	336	300	300	336	300	10-40
Tsys	25K	65K	20K	15K	25K	25K	300K (sky)
Effective Area (m^2) @ 1GHz	0.04	1.3	2100	1.0	1.3	3.2	1000
Number of beams	1	36	72	72	36	72	(3600)
FoV (deg^2)	20000	5000	1.9	10000	5000	3500	11909
Predicted rate	~1/10yr?	1/yr	~1/day	1/month	Few/year	1/month	Few/week

With thanks to Ron Ekers and Alex Dunning

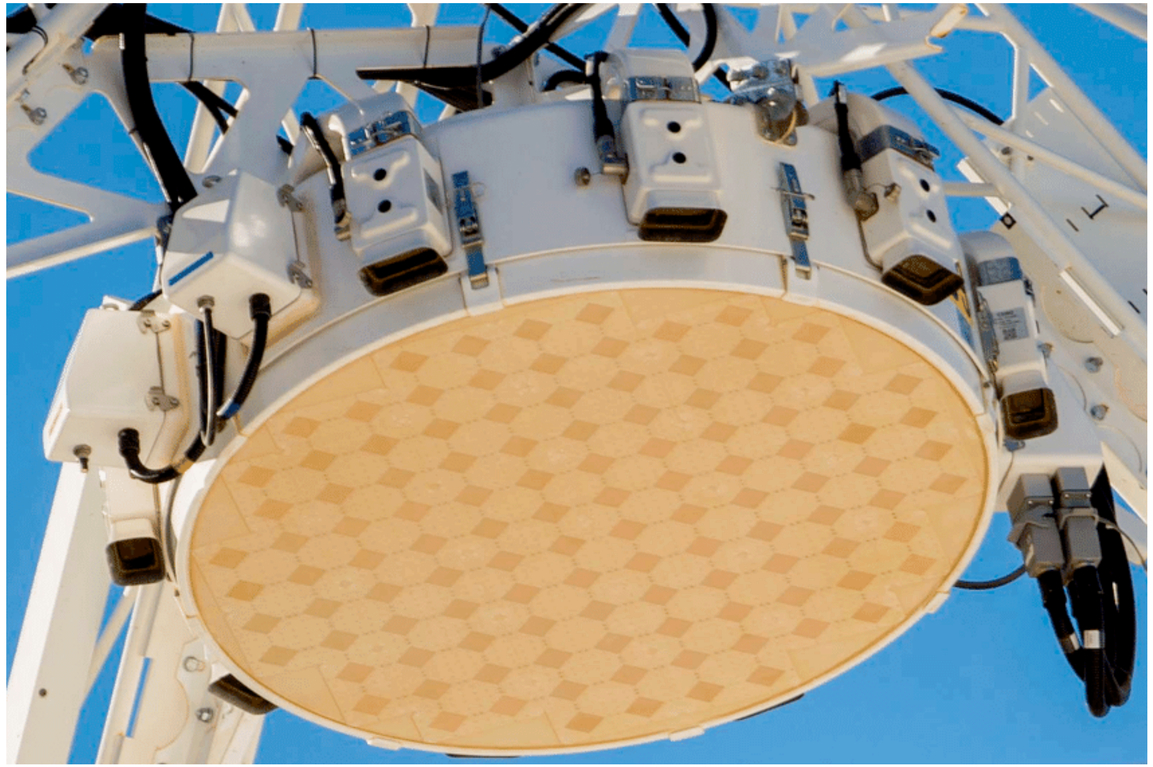
Single dipole

- E.g. GReX / STARE2
- Large FoV but limited sensitivity
- See Liam for details on GREX
- STARE2 obviously worked!

STARE2. Credit: NASA/JPL-Caltech

ASKAP MkII PAF

- The PAF behind ASKAP
- Opportunity: There are unused PAFs with backends at:
  - Effelsberg
  - Jodrell Bank
- All it would take is someone to wheel them out and switch them on and you'd be collecting data
- Rate is low: (1/year) but maybe you're feeling lucky?



CryoPAF

- Will be commissioned at Murriyang 64m (Parkes) early 2023
- On the dish: ~ 1 FRB per day
- Aperture array: ~ 1 FRB per month
- We’re hoping get some commissioning time in Aperture Array mode to see what we find - care to join in? If we find something, we’ll be coming back for more.
- Comes with a brand new digital backend

Quasar PAF

- Designed for satellite tracking
- Key point: 2-3 GHz Frequency range
- Pushing towards wide area at higher frequency - interested Jason?

ASKAP MkIII PAF

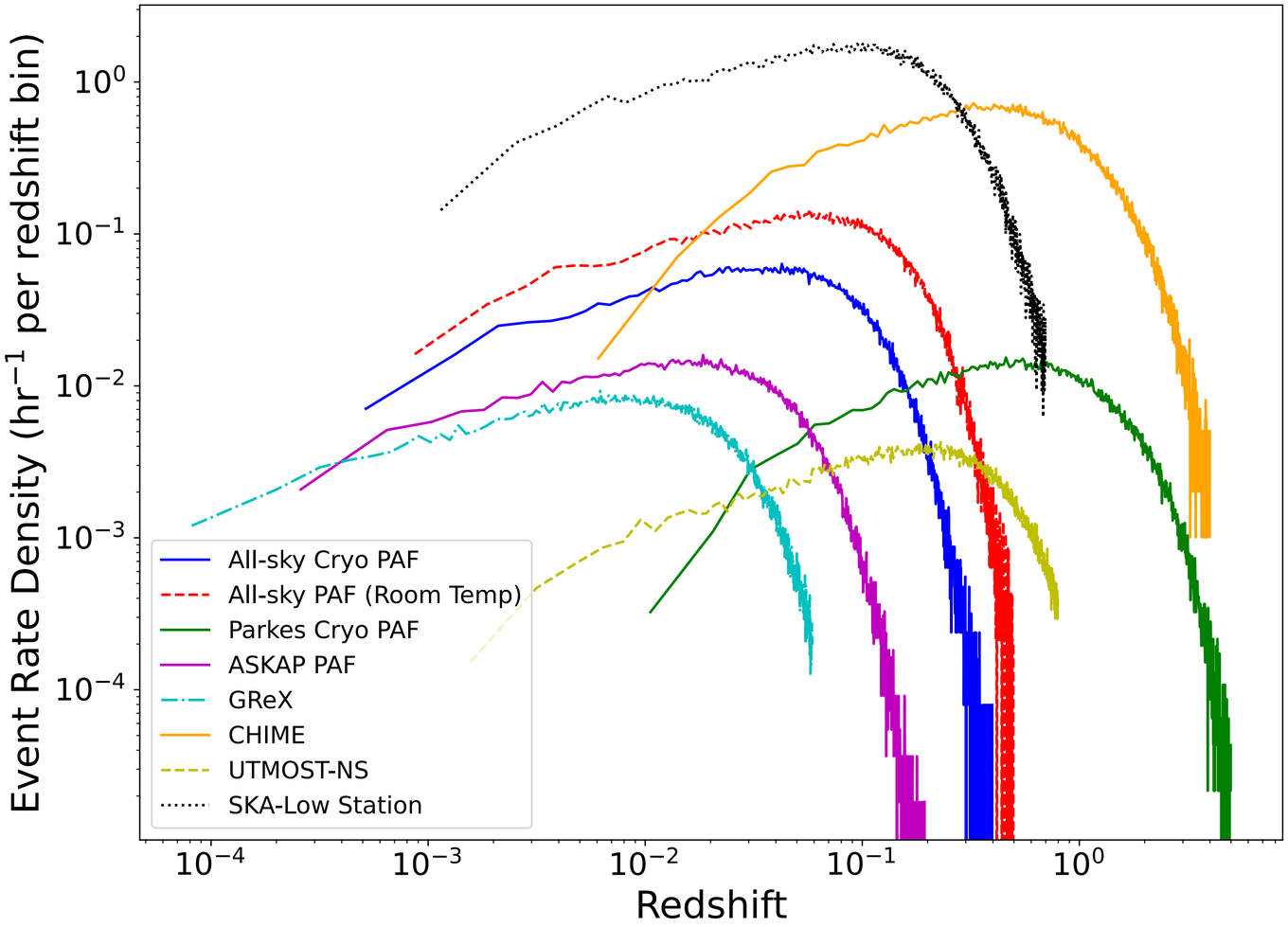
- ~ 1 GHz
- Potential upgrade to the ASKAP PAF
- Room temperature, targeting 25K Tsys
- Optimised for dish mode, but can be tested in Aperture Array
- Compatible with either ASKAP or CryoPAF beam former

“Aperture Optimised PAF”

- Make something room temperature (25K)
- Compatible with new CryoPAF digital backend. Limits: 2x98 ports, 72 beams, 300 MHz (double bandwidth is easy, its just double $)
- Choose your own adventure: 3:1 bandwidth anywhere from 0.1 to 2 GHz, optimise for collecting area (large spacings) or FoV (small spacings).
- The engineers want to do this.

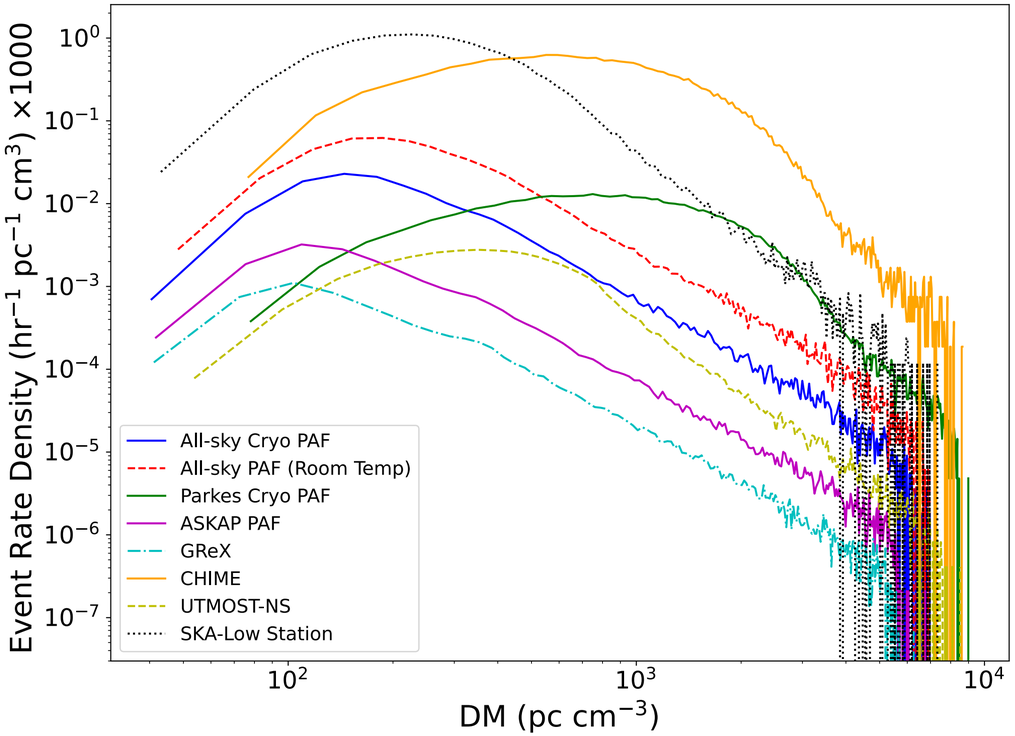
What do you find?

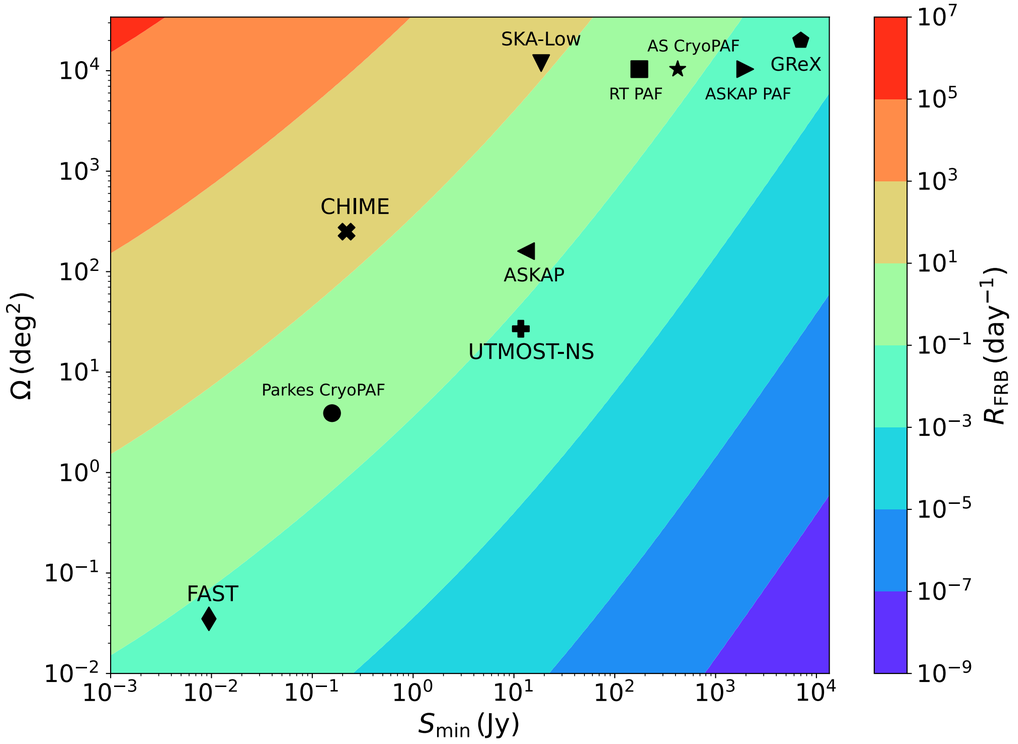
- Moderate to large dishes find FRBs 0.1 < z < 1
- PAFs find FRBs z < 0.1
- The main difference is in rates
- Basically you want a few CryoPAFs if you can be bothered to pay/maintain or a few room temperature PAFs if you're patient



Credit: Rui Luo

DM distribution & ~rates





Credit: Rui Luo

The ASKAP/CRAFT Coherent upgrade

Keith Bannister - keith.bannister@csiro.au
@pleasefftme

With: Xinping Deng, Li Bang
On behalf of the CRAFT collaboration

Localising an FRB/day by shoving 2 million Youtube viewers into a fridge

Keith Bannister - keith.bannister@csiro.au
@pleasefftme

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De-dispersing 2.5 Million beams in real time gives me gray hair

Keith Bannister - keith.bannister@csiro.au
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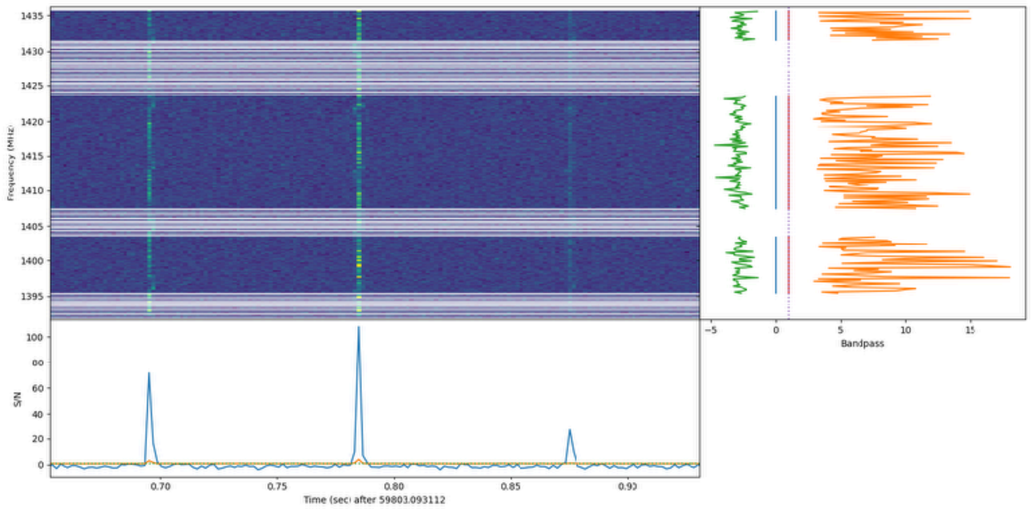

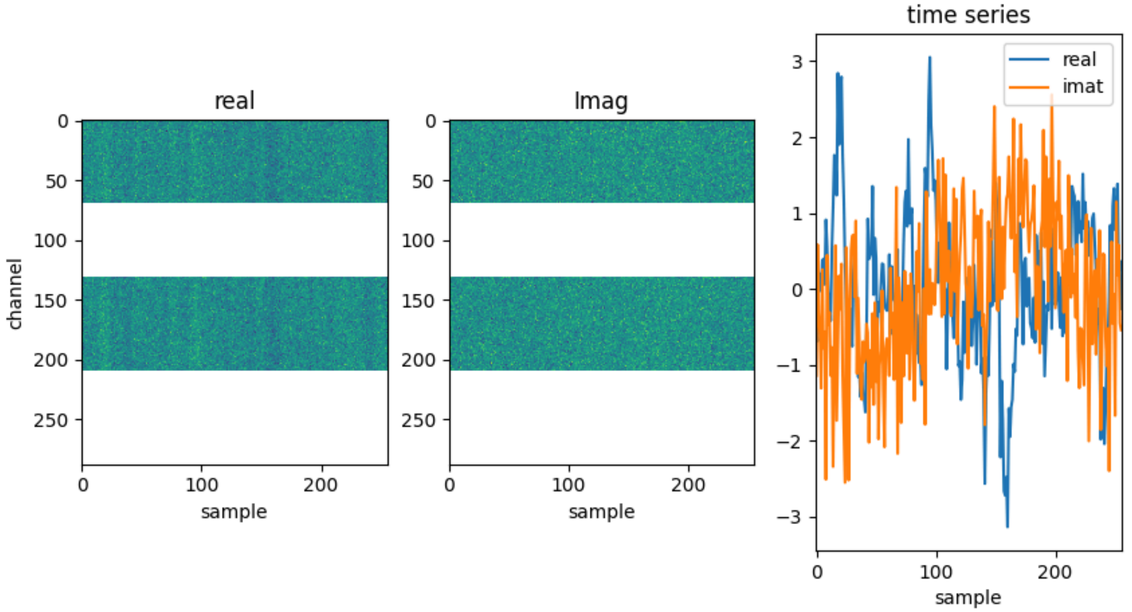

In commissioning…