

Tied-array beam flatfielding Re-searching LOTAAS

...and the path to real-time transient searches with EuroFlash

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ANTON PANNEKOEK
INSTITUTE



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Established by the European Commission

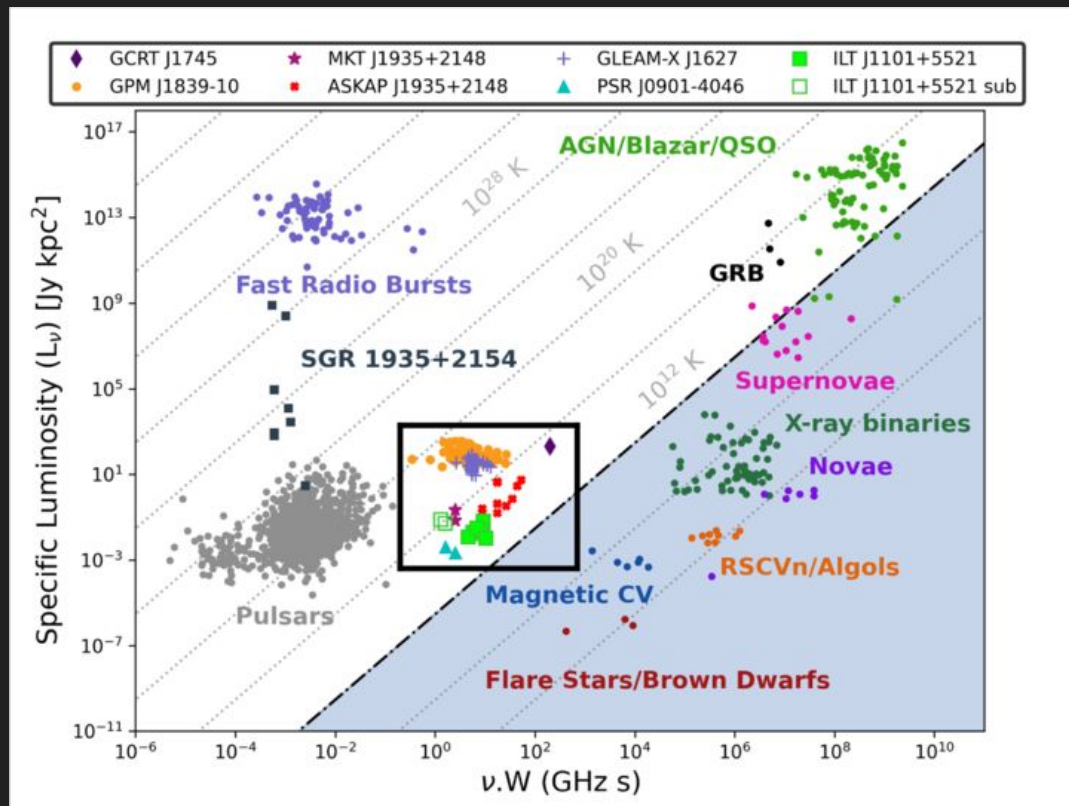


This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme ('EuroFlash'; Grant agreement No. 101098079)

Image credit: LOFAR/ASTRON

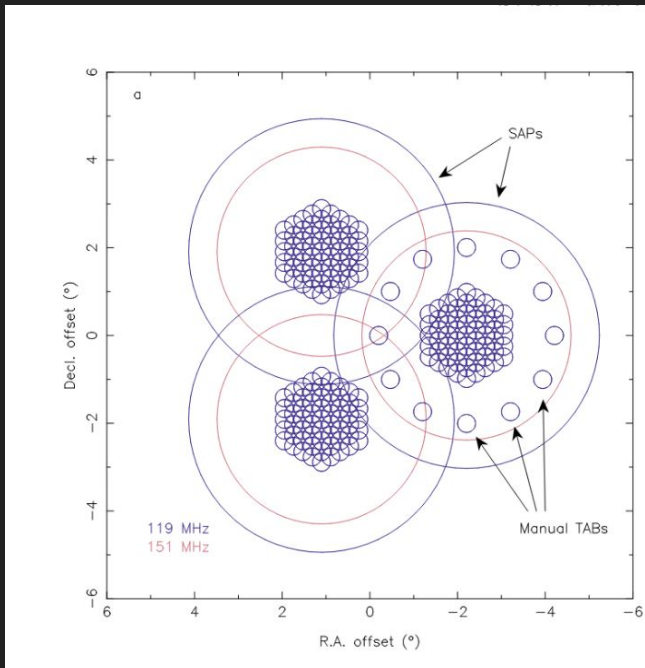
The objects of interest

- **FRBs** → ms bursts, extreme luminosities
- **Pulsars** → broad population, from ms to tens of seconds
- **Long-period transients** → newly emerging population
- **LOFAR**: uniquely sensitive to dispersion, scattering, absorption



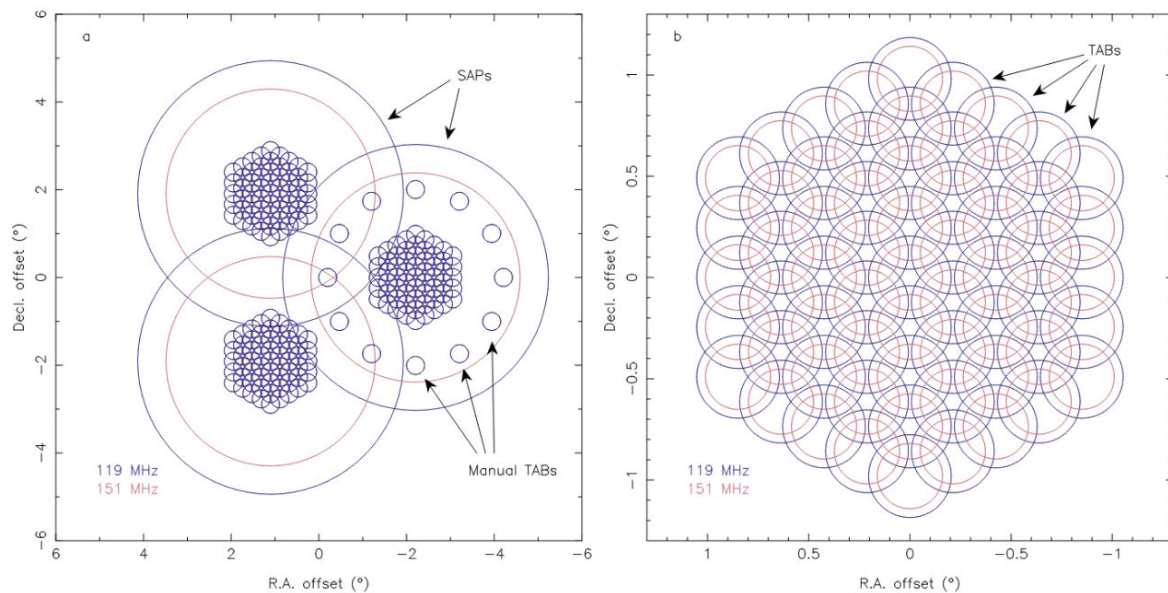
De Ruiter et al. 2024

Original LOTAAS Setup



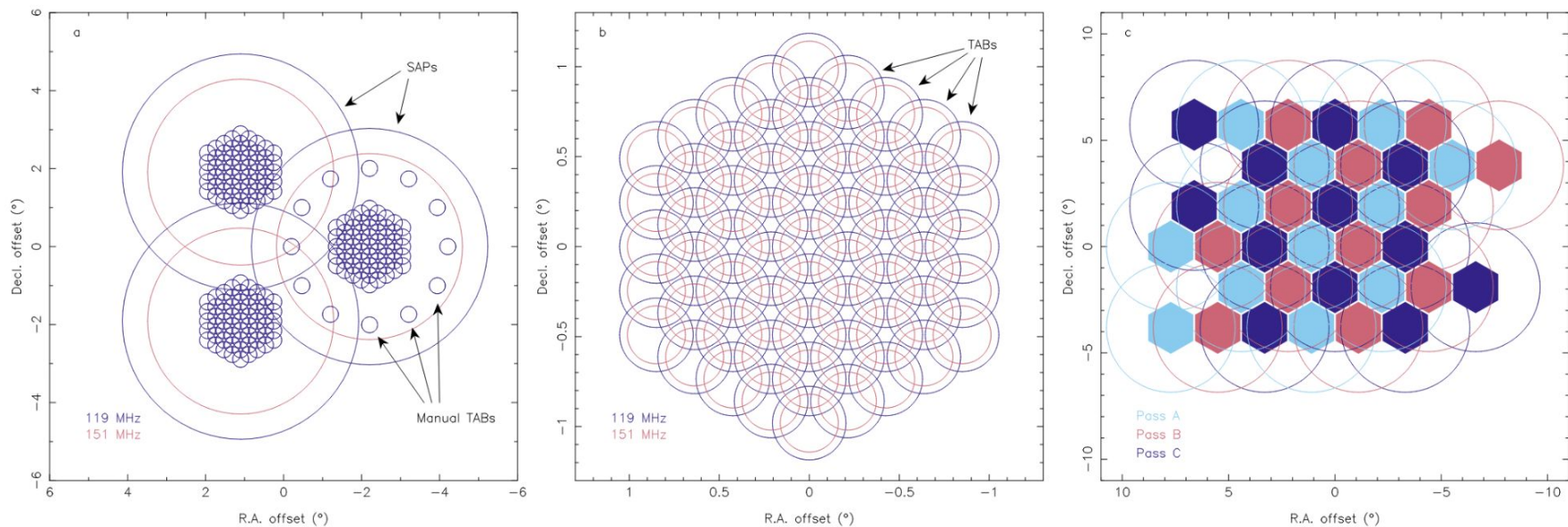
Sanidas et al. 2019

Original LOTAAS Setup



Sanidas et al. 2019

Original LOTAAS Setup



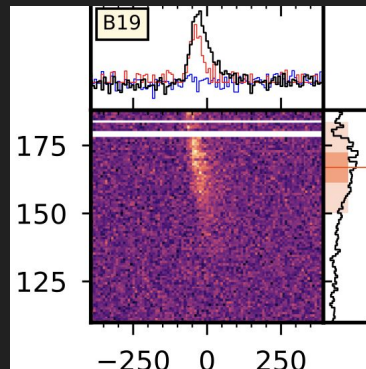
Sanidas et al. 2019

Why reprocess?

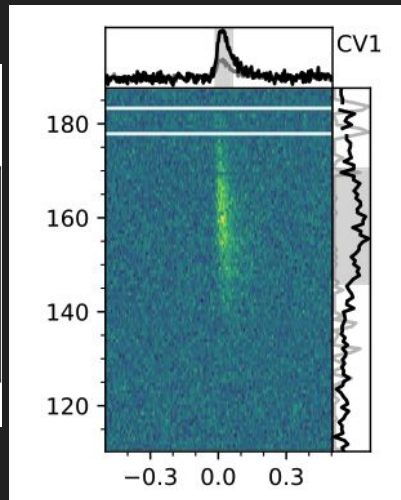
Original single-pulse search had limitations

Transient landscape has changed since LOTAAS

⇒ Signals may still be hiding in there



Gopinath et al. 2024



Pleunis et al. 2020

Maybe even more importantly?

Storage and data management

○ Data Archive

Members

Rate per 10 TB per 5 years*	784 euro
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*This equates to 15.86 euro per 1 TB per year

1.7 PB

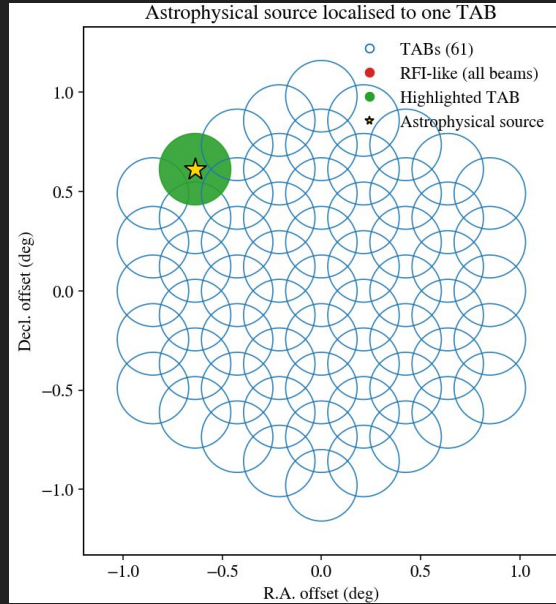
100 TB



~ 16 x reduction

Flatfielding as a concept

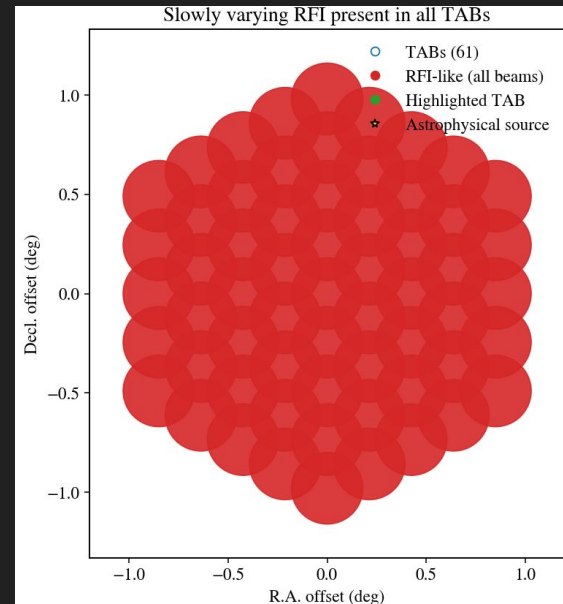
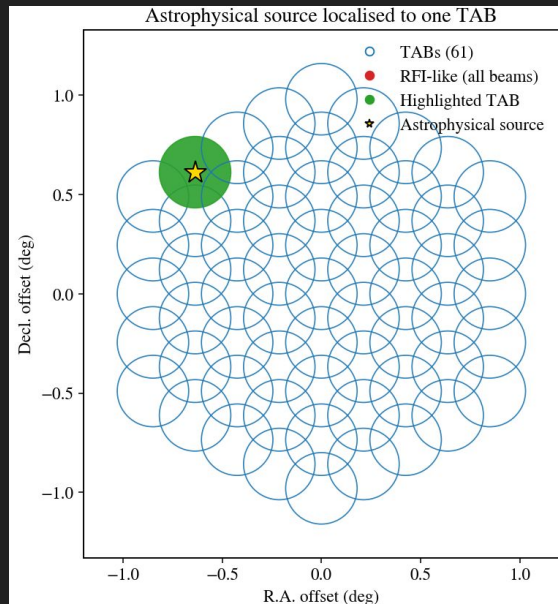
Astrophysical sources in the far field

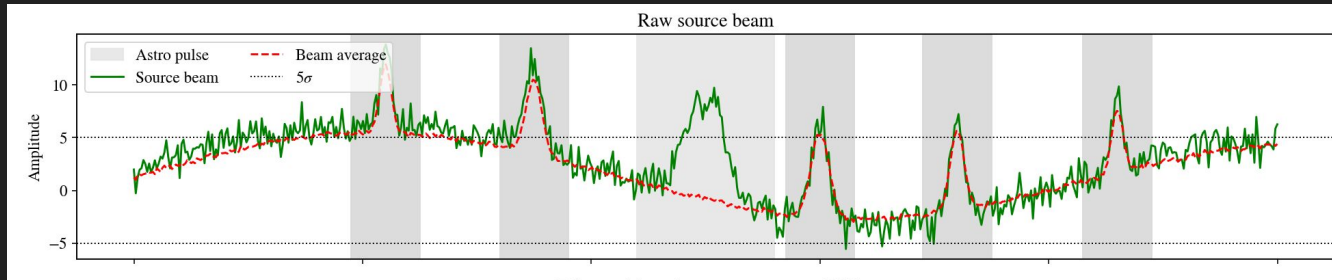


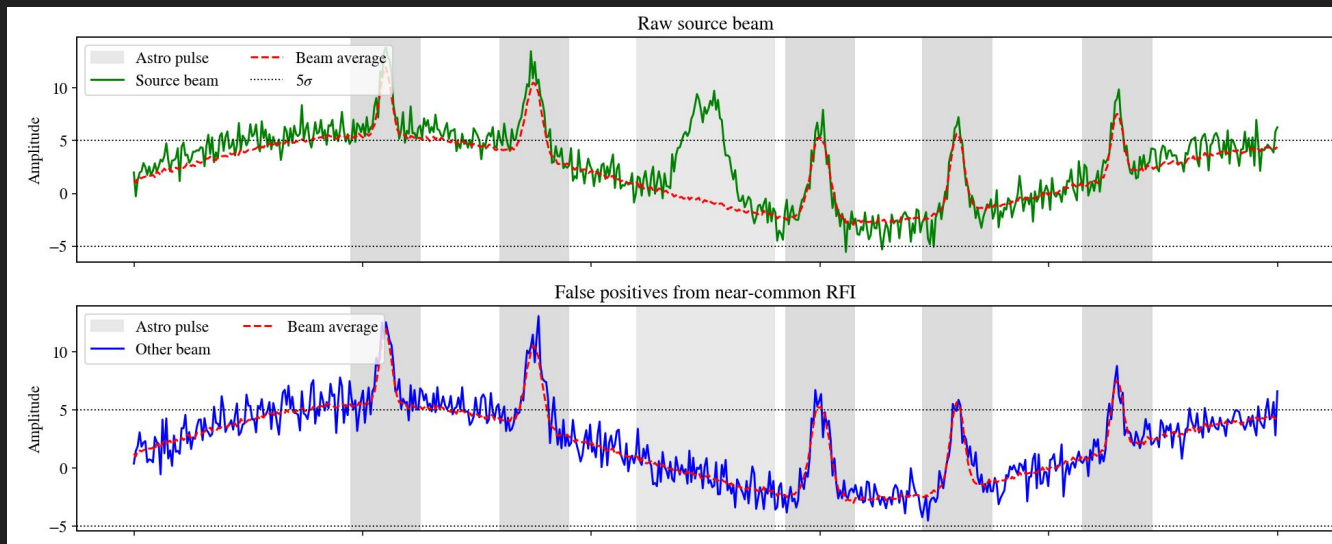
Flatfielding as a concept

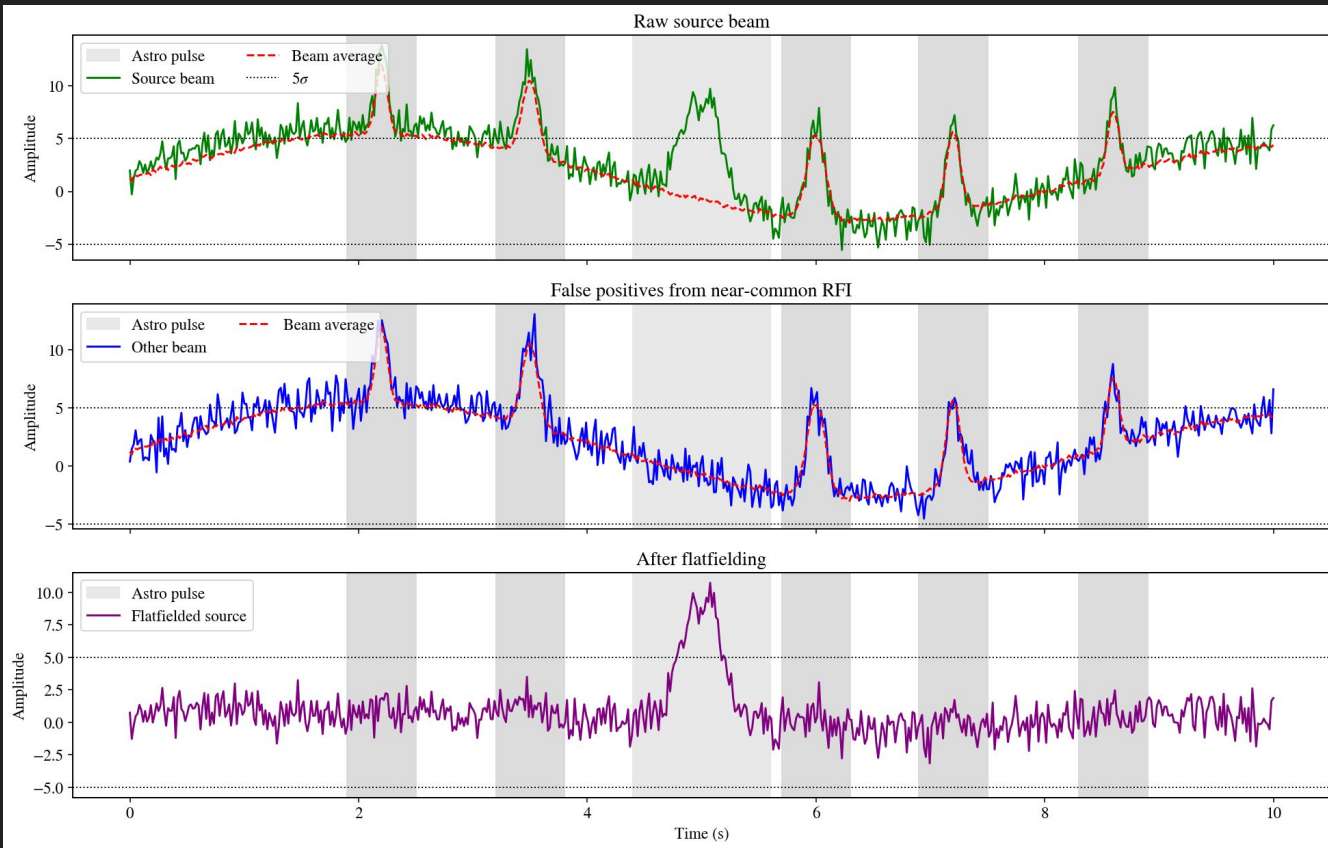
Astrophysical sources
in the far field

RFI & baseline
variations near field

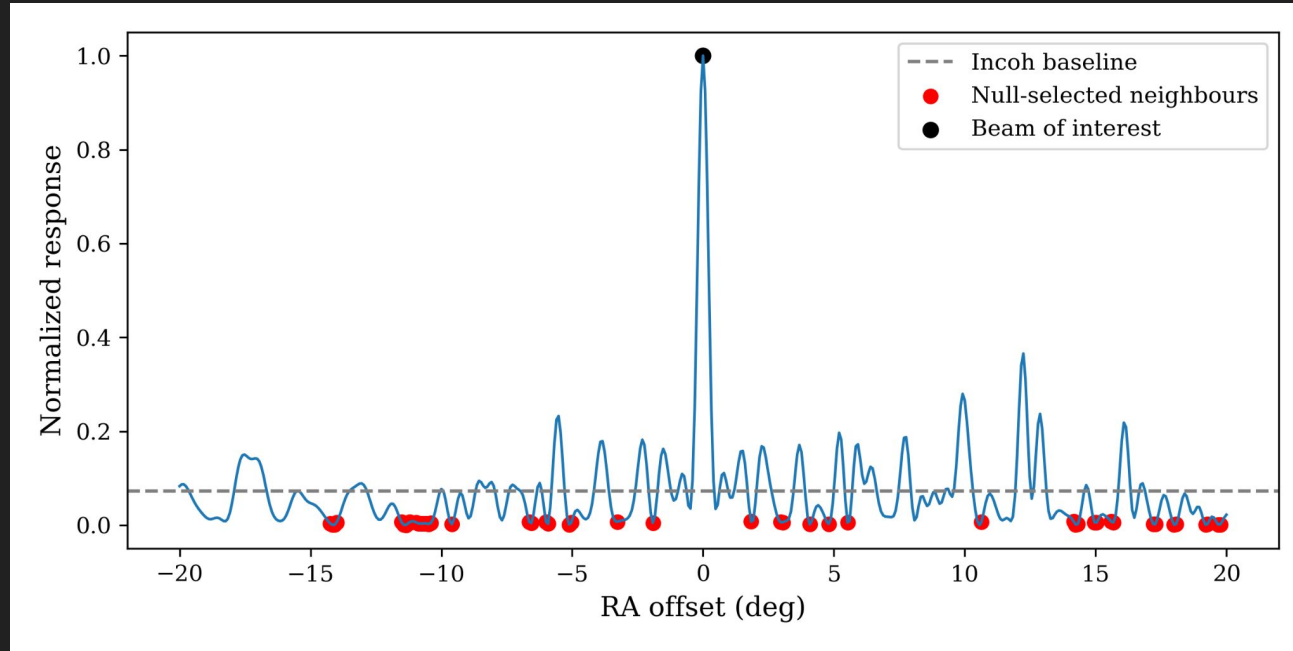




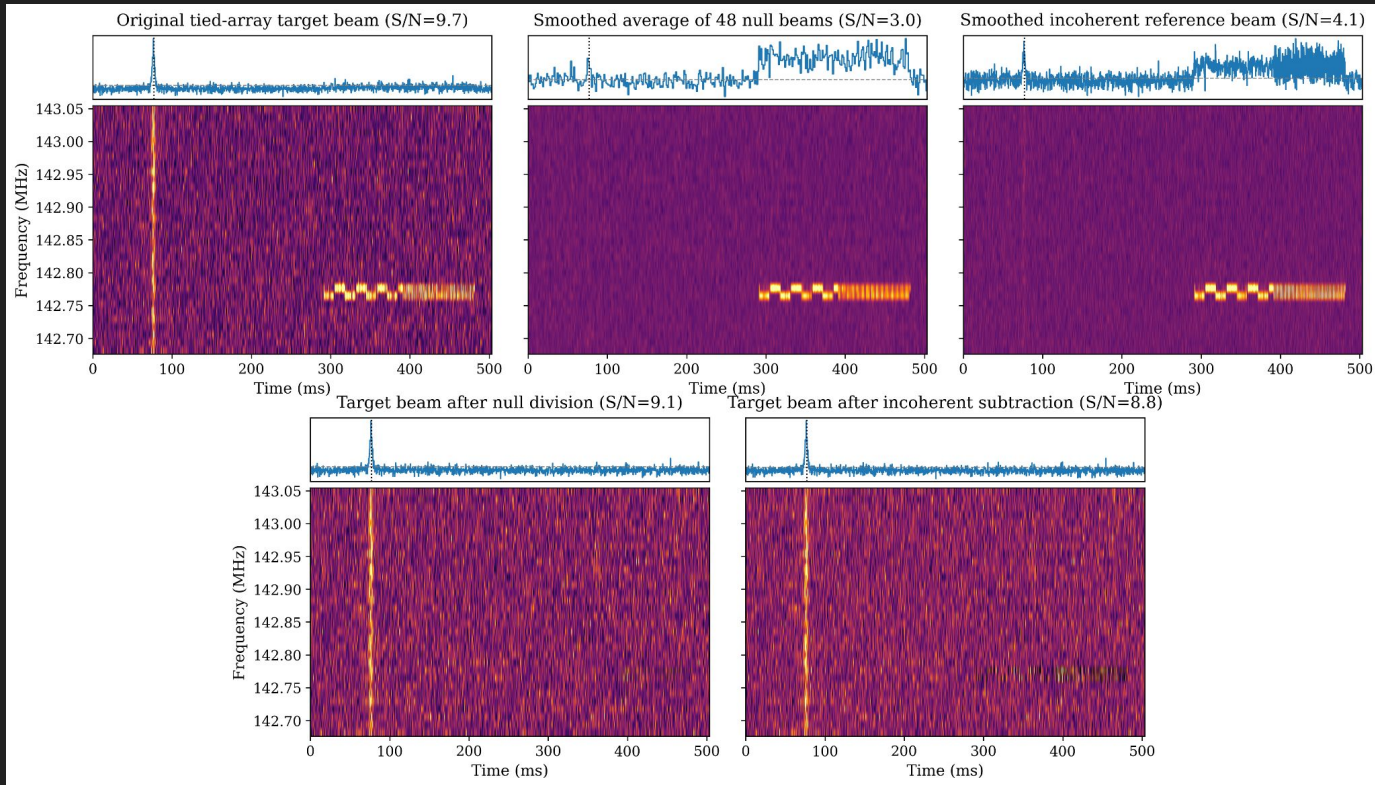




Optimizing the flatfield

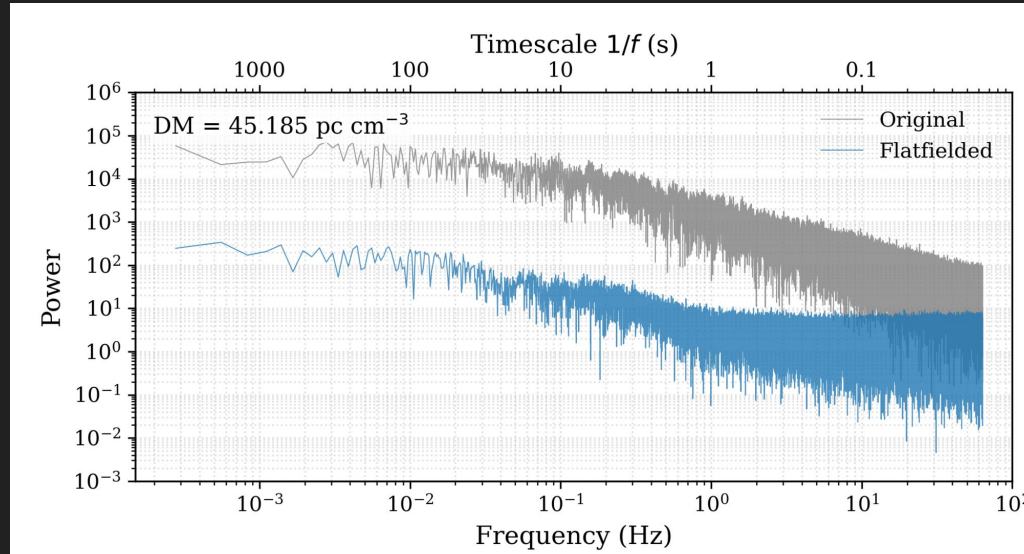


Kuiper+ 2026

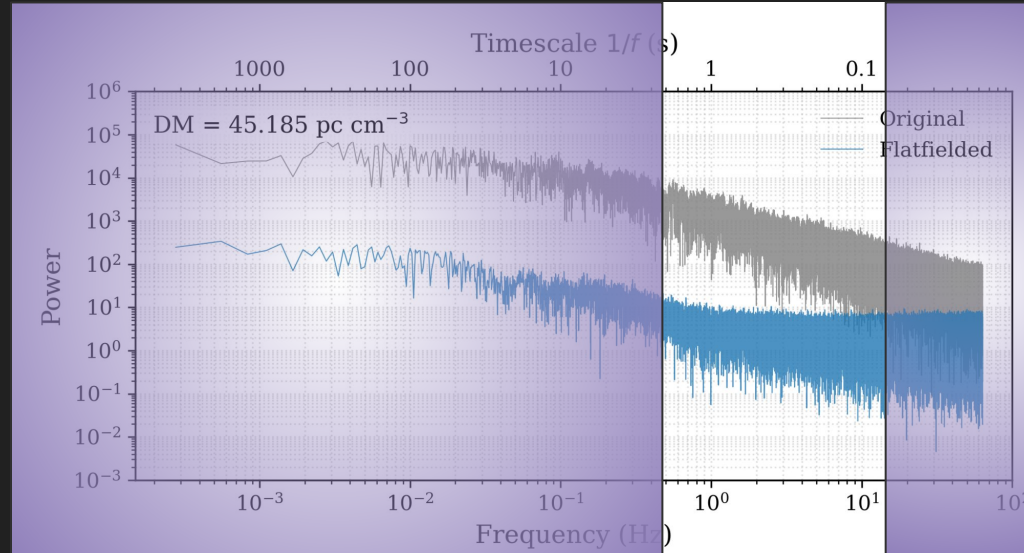


Kuiper+ 2026

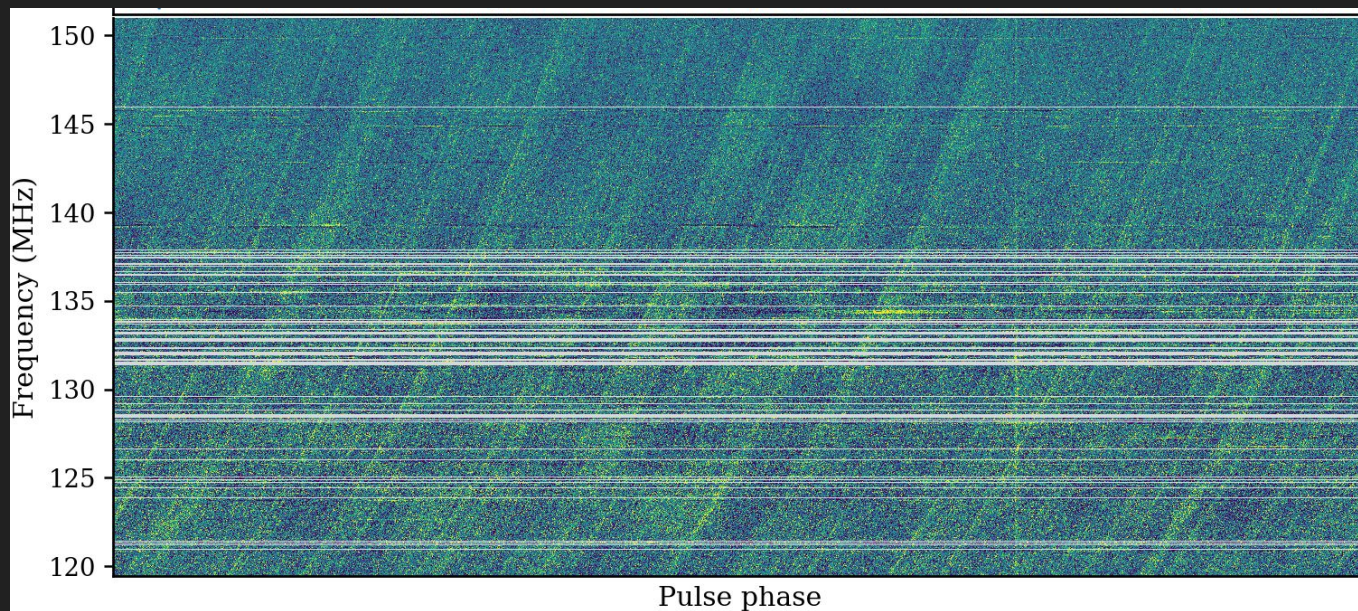
Now with LOTAAS data



Now with LOTAAS data

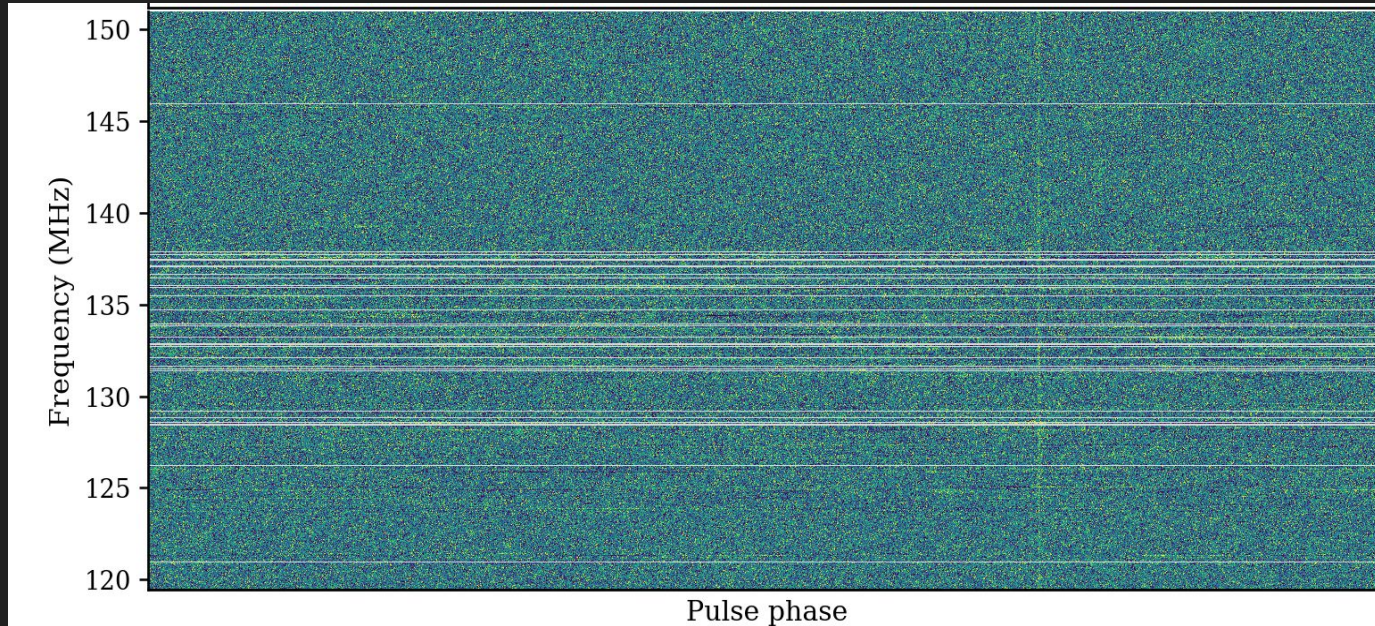


Now with LOTAAS data



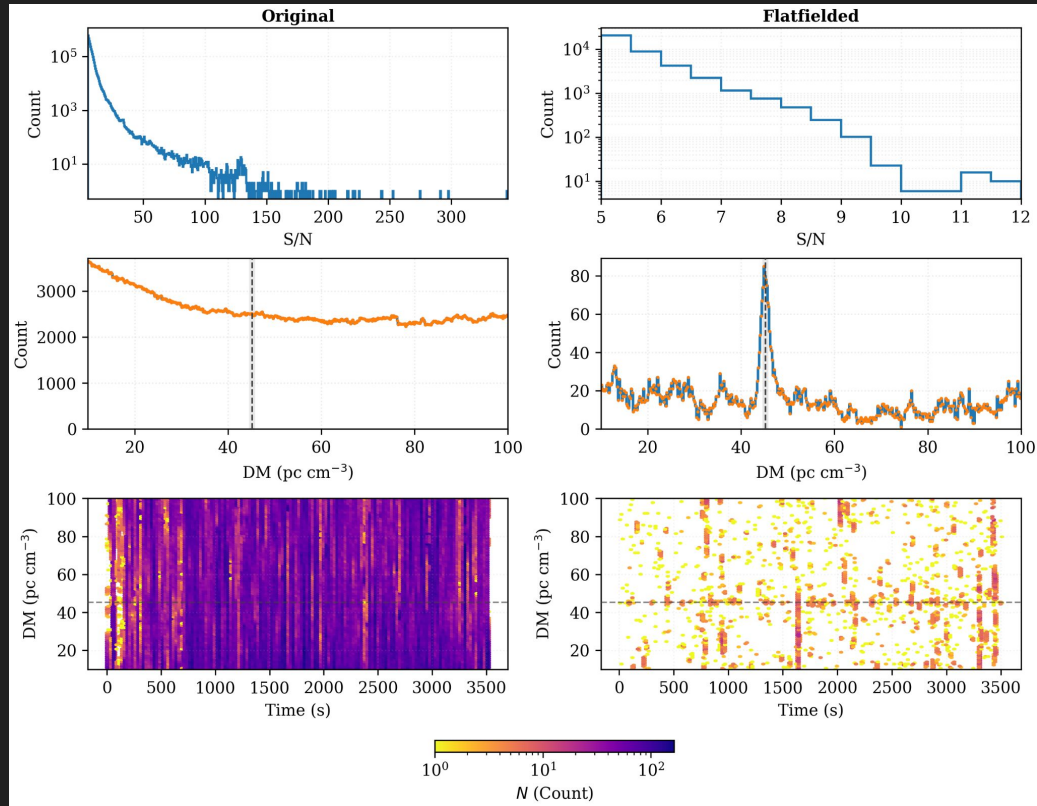
Good channels post-fold: 586 / 648

Now with LOTAAS data

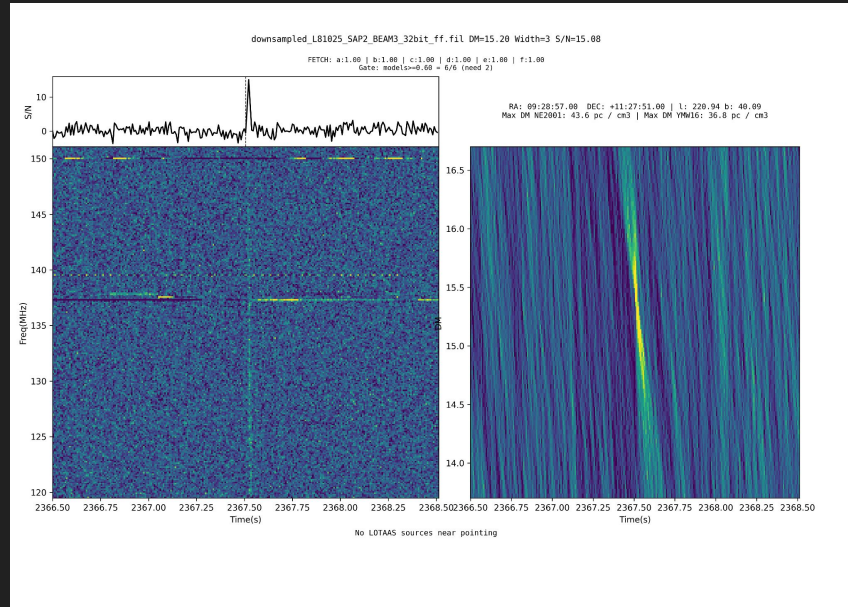


Good channels post-fold: 618  648

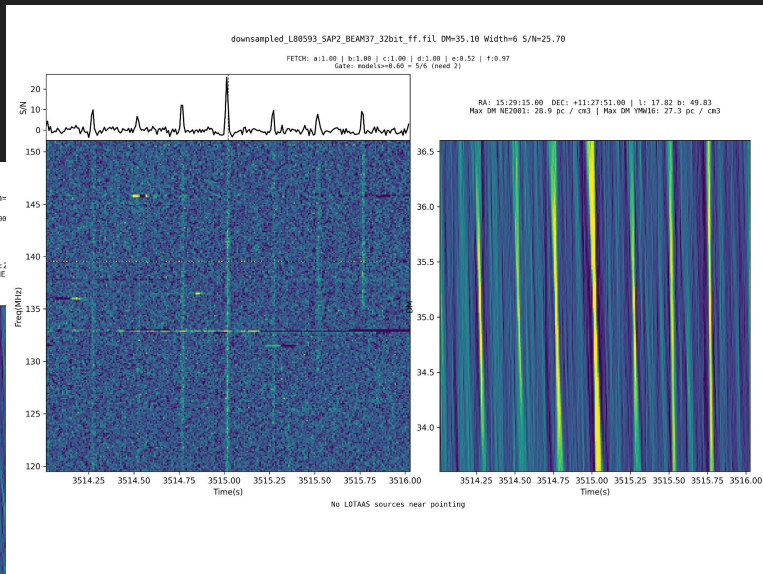
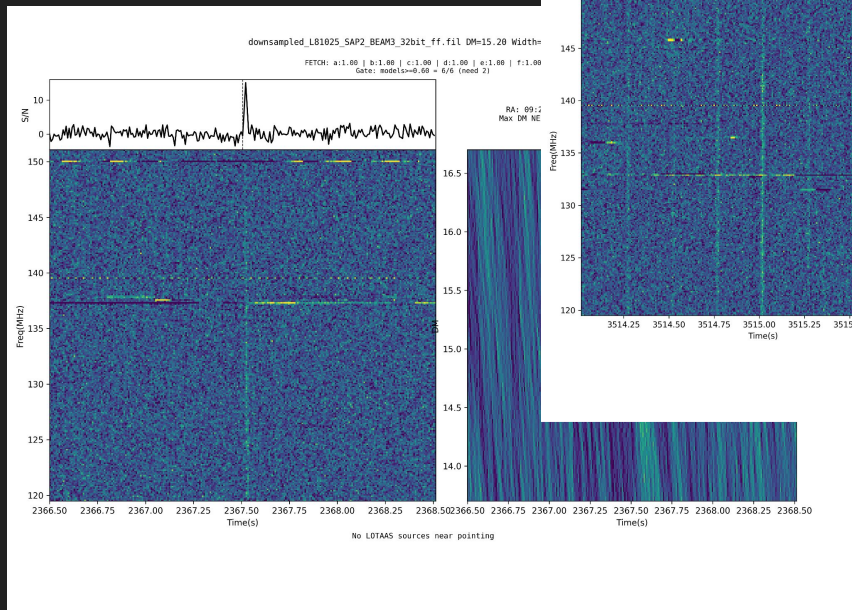
From millions to thousands



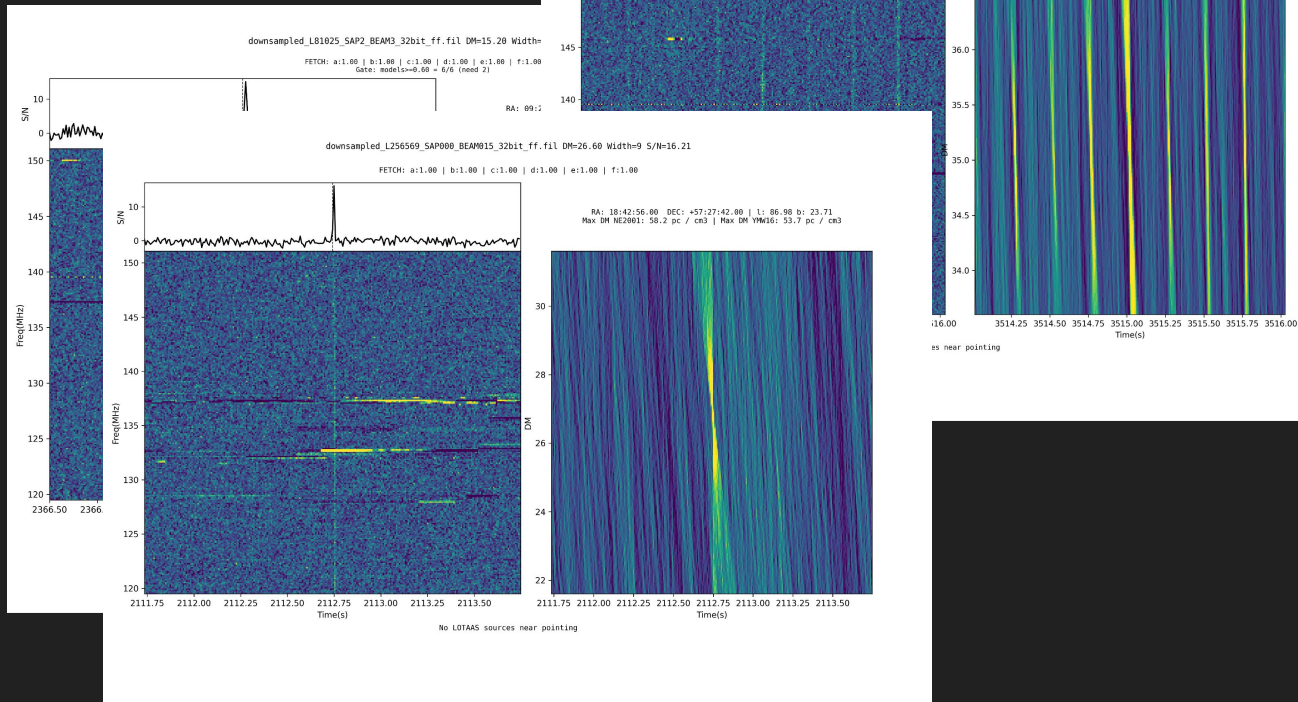
Lots of redetections



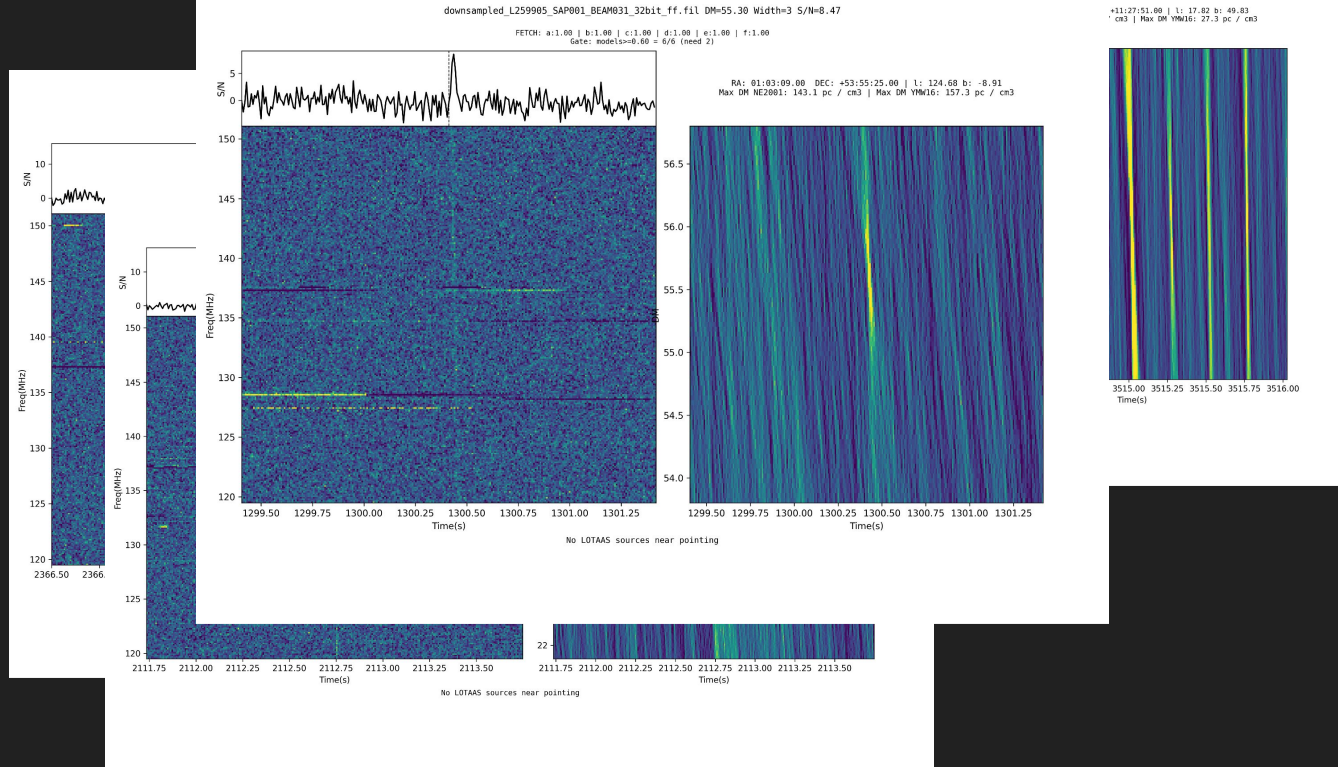
Lots of redetections



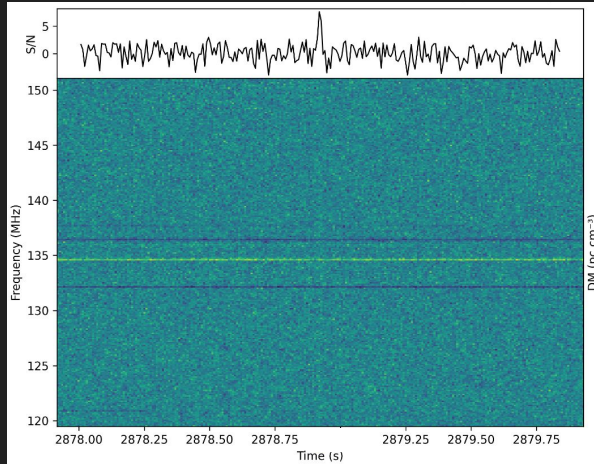
Lots of redetections



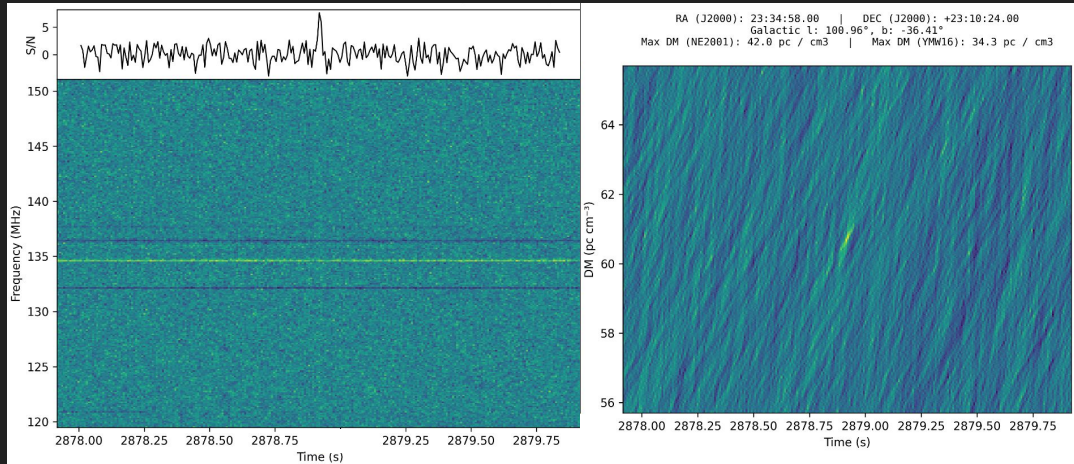
Lots of redetections



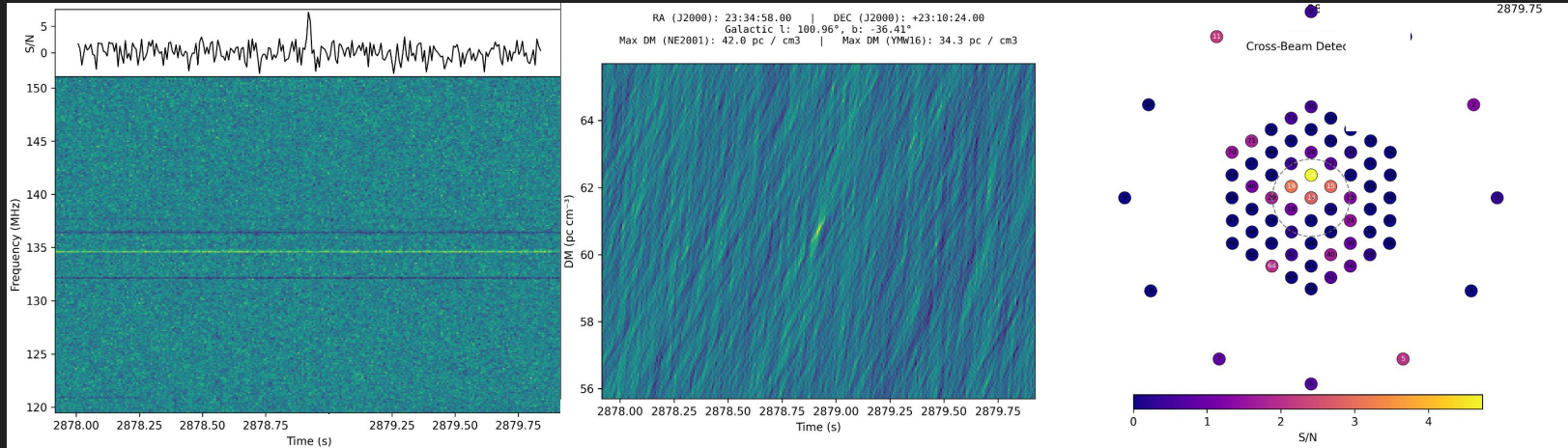
A (tentative) new detection



A (tentative) new detection



A (tentative) new detection



What lies ahead?

- LOFAR 2.0: EuroFlash backend - clone of COBALT3
- Wide-field searches: up to ~1000 tied-array beams
- Single-pulse searches up to extragalactic DMs (>1000)
- Running in parallel with LOFAR 2.0 observations
- Can we use flatfielding in real time?
- More efficiently use computing resources

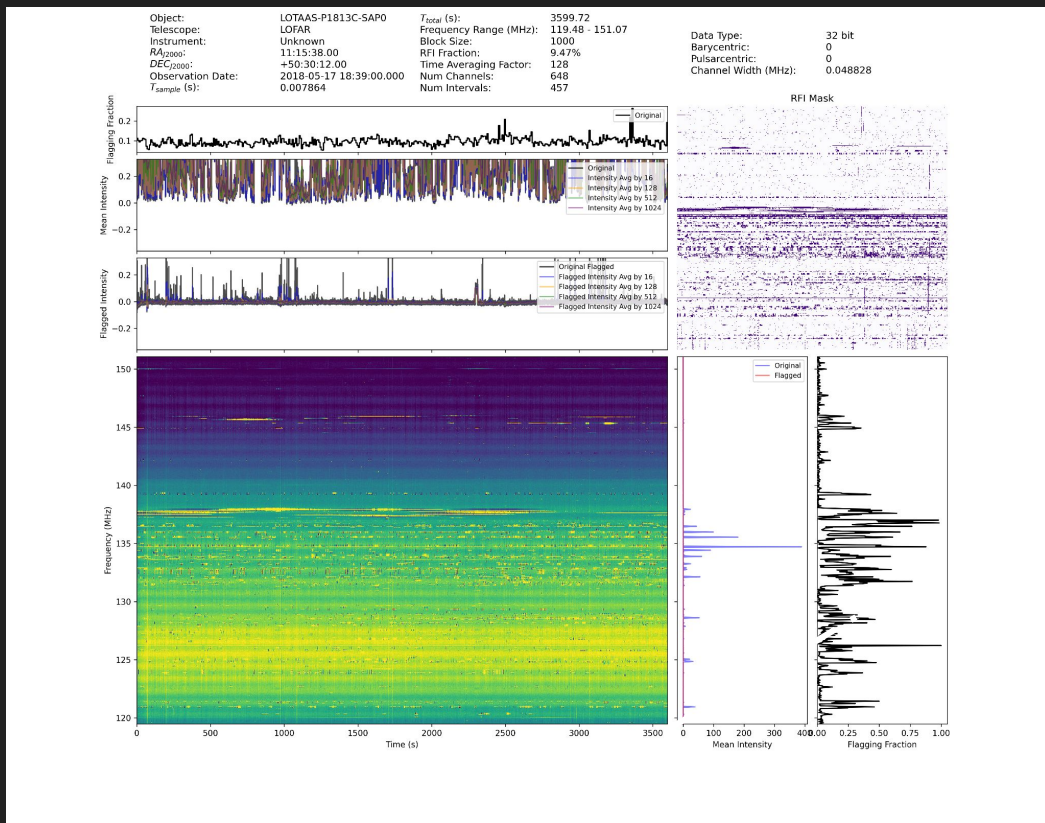


Takeaways

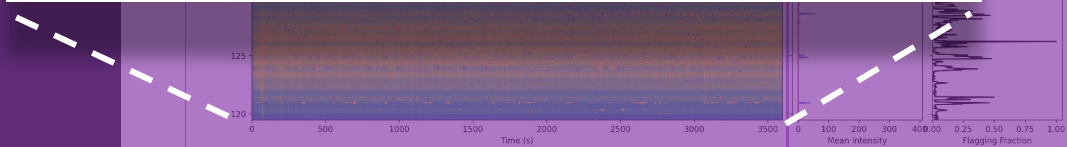
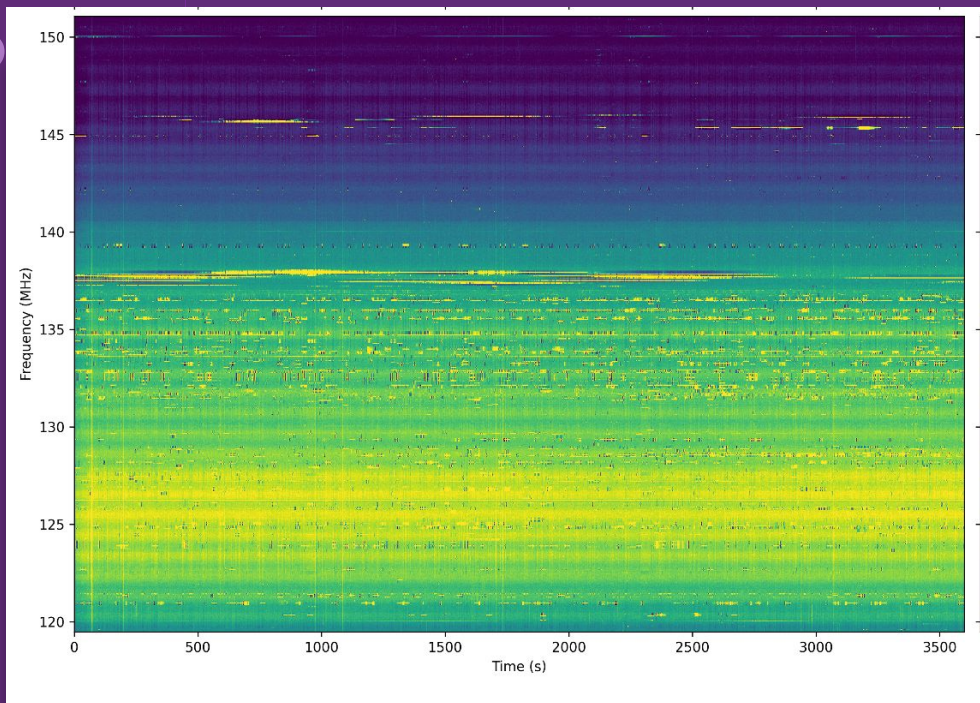
- Flatfielding slashes false positives ($\sim 200\times$)
- Recovers known pulsars & reveals new signals
- Pipeline on EuroFlash $\rightarrow$ full LOTAAS in ~ 1 yr
- LOFAR 2.0 + EuroFlash $\rightarrow$ scalable commensal searches



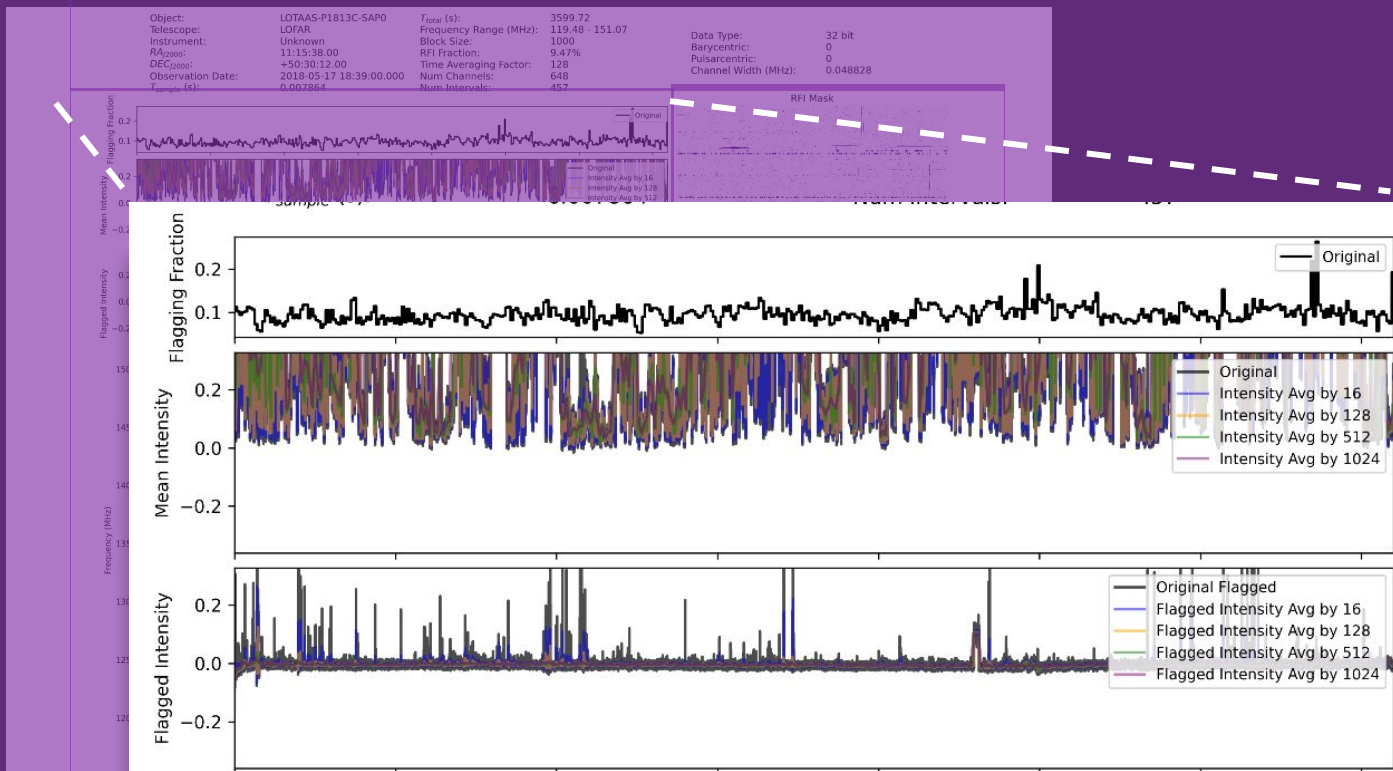
How does the real data look?



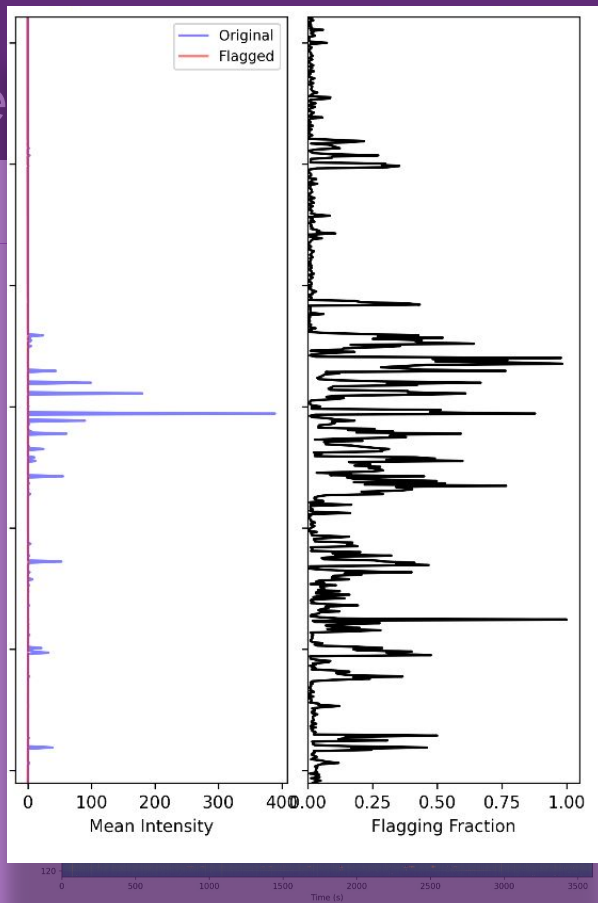
How do



How does the real data look?

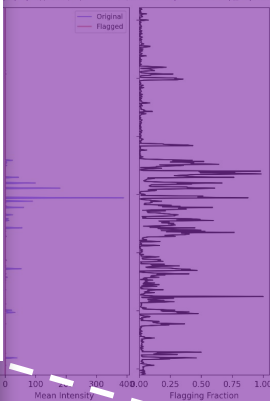


How does the



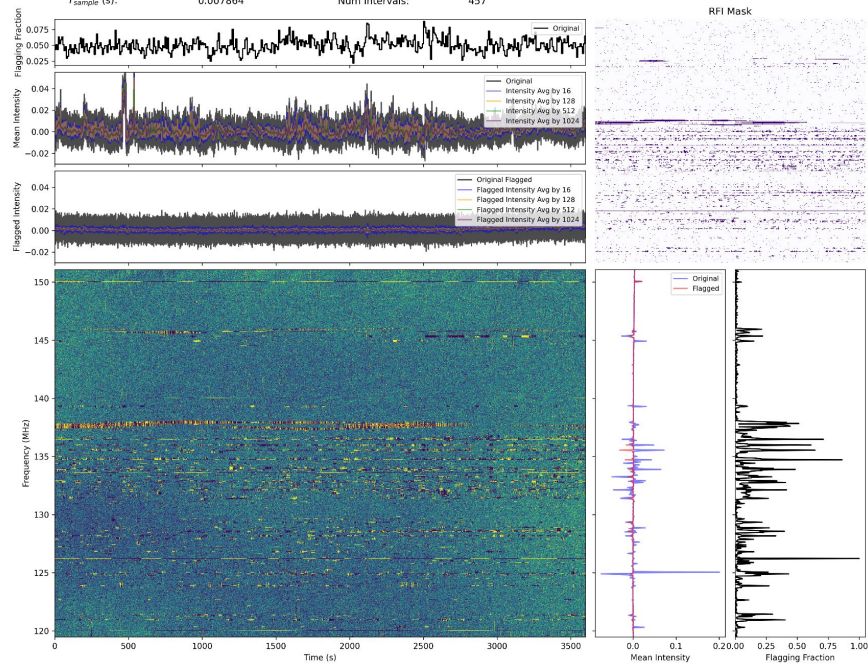
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Barycentric: 0
Pulsarcentric: 0
Channel Width (MHz): 0.048828

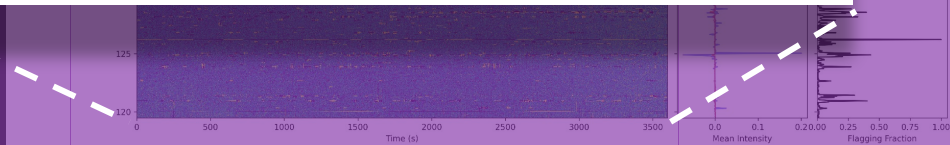
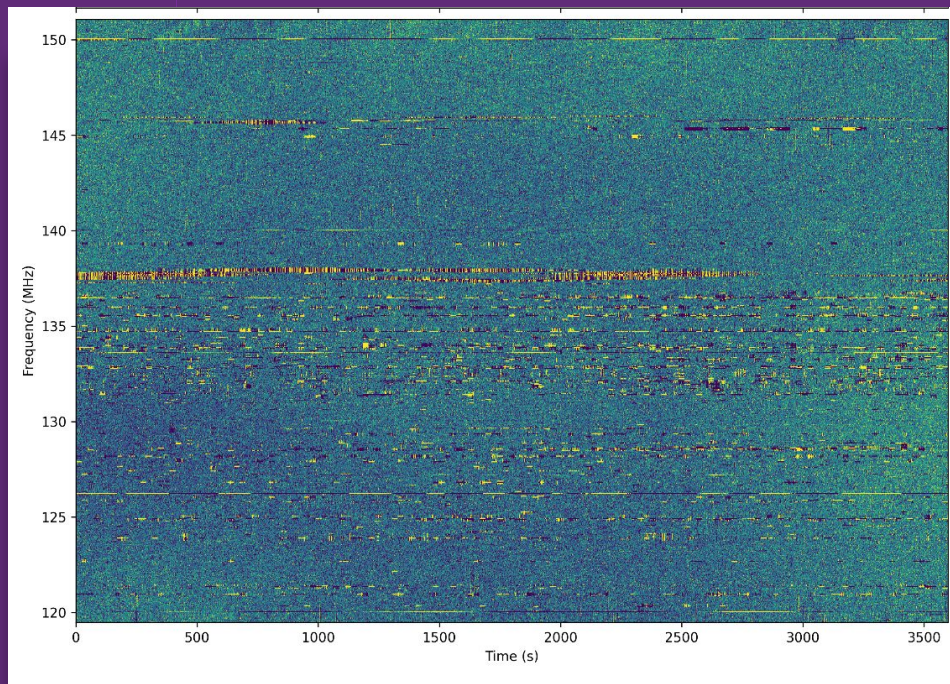
RPT MARK



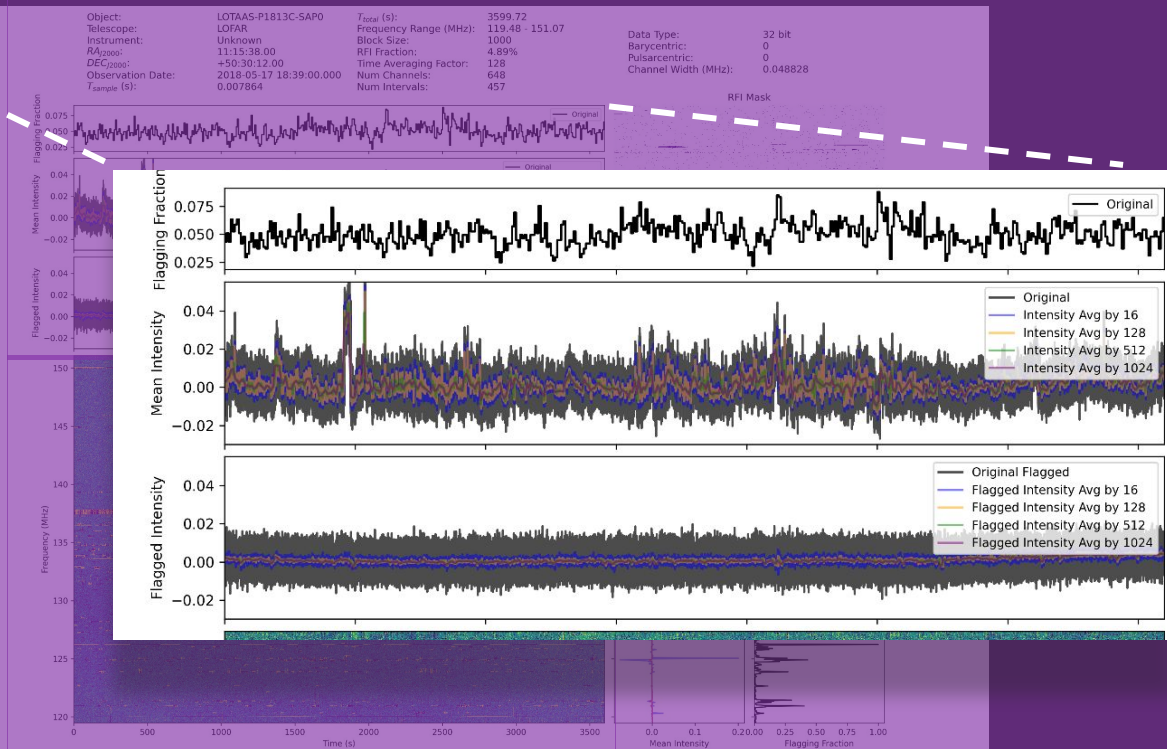
Object: LOTAAS-P1813C-SAP0 T_{total} (s): 3599.72
 Telescope: LOFAR Frequency Range (MHz): 119.48 - 151.07
 Instrument: Unknown Block Size: 1000
 RA_{2000} : 11:15:38.00 RFI Fraction: 4.89%
 DEC_{2000} : +50:30:12.00 Time Averaging Factor: 128
 Observation Date: 2018-05-17 18:39:00.000 Num Channels: 648
 T_{sample} (s): 0.007864 Num Intervals: 457

Data Type: 32 bit
 Barycentric: 0
 Pulsarcentric: 0
 Channel Width (MHz): 0.048828

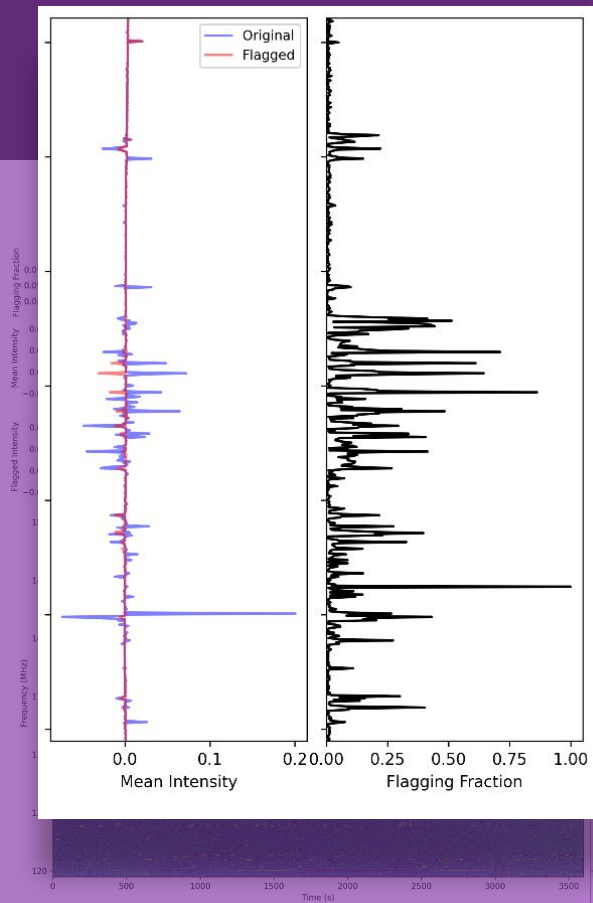




Text HERE

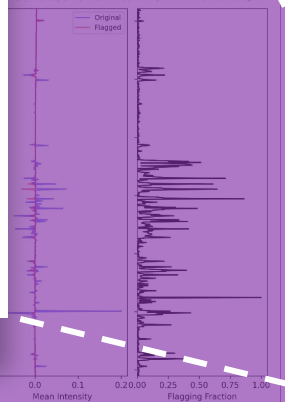


Text HERE



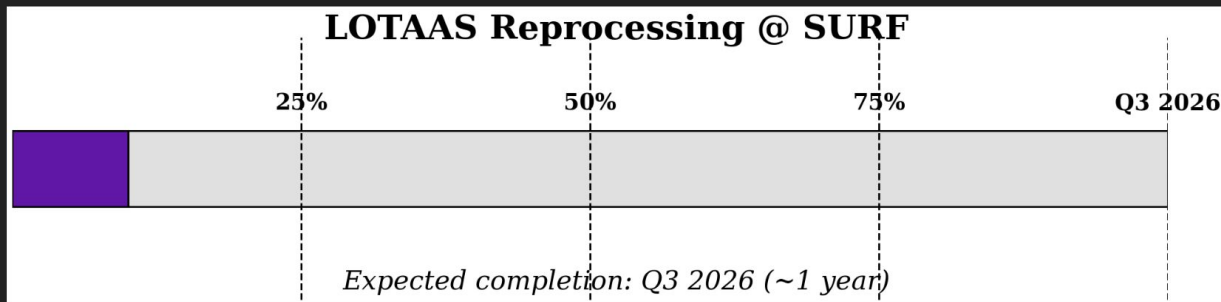
Data Type: 32 bit
Barycentric: 0
Pulsarcentric: 0
Channel Width (MHz): 0.048828

RFI Mask



Processing progress

Pipeline running on SPIDER



Full reprocessing: ~20000 GPU hours + 1000000 CPU hours

