A Modified RFI Flagger for Transient Radio Signals

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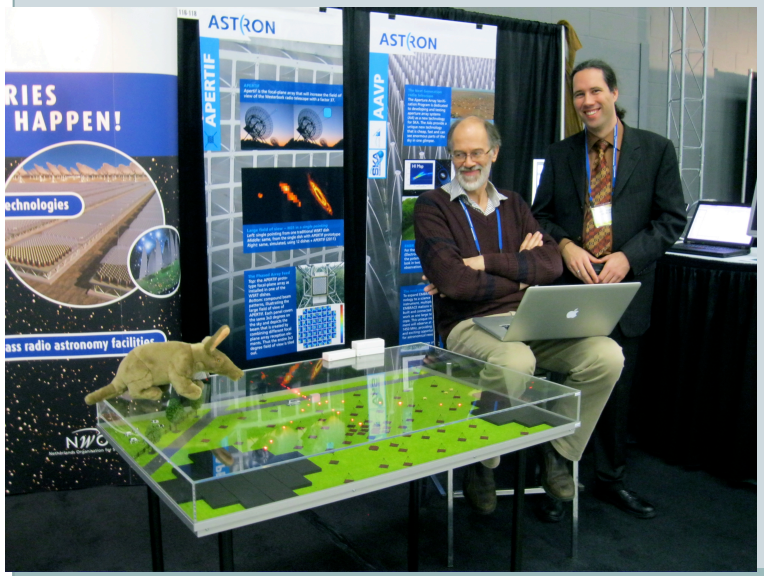

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Transient Signals

- Transient signals are quick bursts of radiation from extreme sources
- Example: Fast Radio Bursts (FRBs), first discovered in 2007 by Lorimer et al @Parkes Observatory
- Burst was of a few millisecond duration, from outside the galactic plane
- Possible origins: neutron star mergers, GRBs, newly formed magnetars, black hole collapse of unstable magnetars…

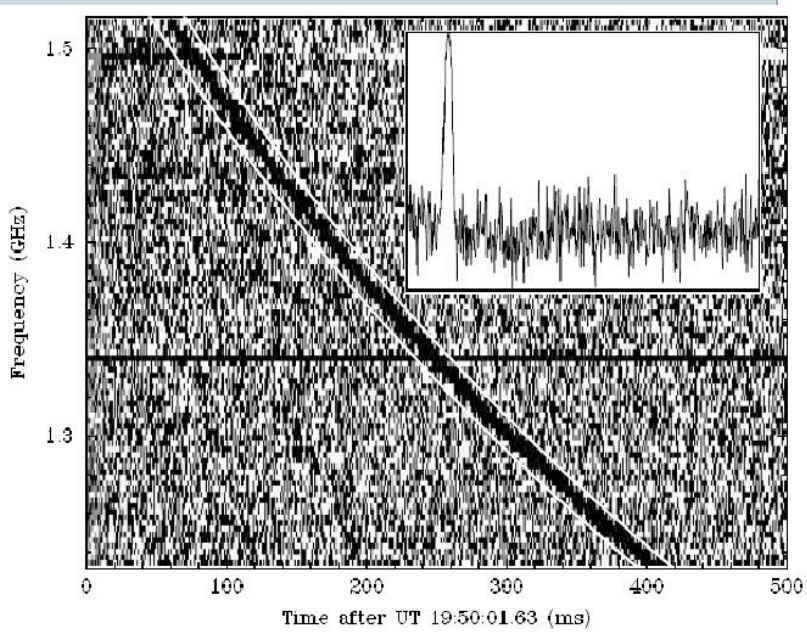


Image credit: Lorimer et al. (2007)

Fast Radio Bursts (FRBs)

- There are ~6 FRBs confirmed so far, from Parkes Observatory
- All are brief and bright, z= 0.5 to 1, with no coincident X-Ray, GRB signatures
- For LOFAR frequencies, pulse would have a few second duration

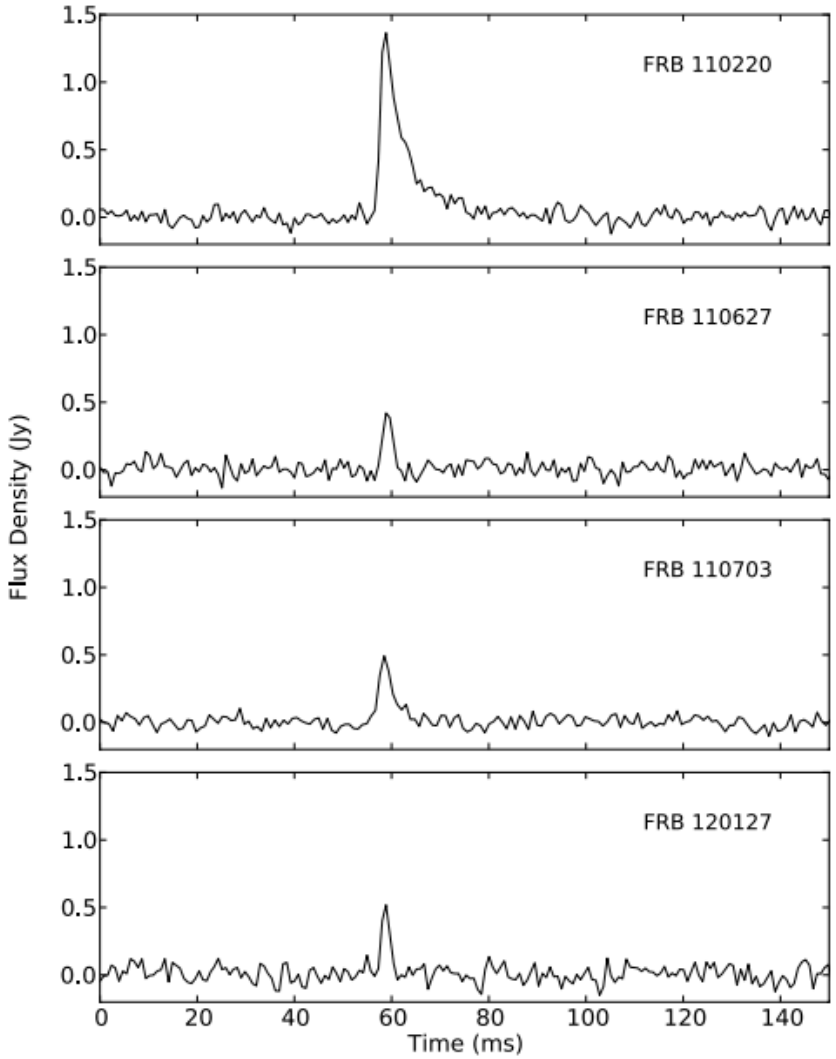
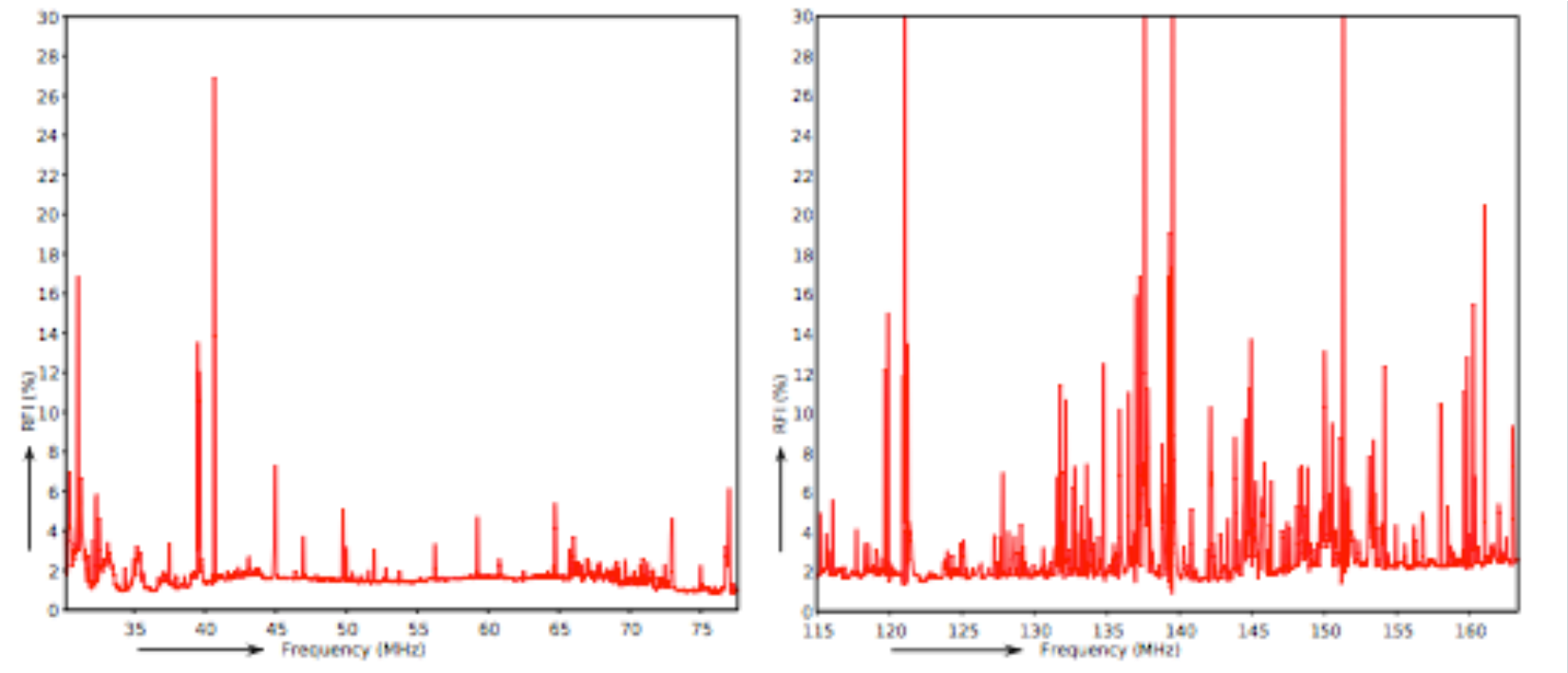


Image credit: Thornton et al. (2013)

LOFAR RFI Environment



- RFI occupancy is 1.8% in the low band, 3.2% in the high band
- No major occupancy difference between daytime and nighttime observations

Image credit: Offringa et al. (2012)

Introducing AOFlagger

- Default automatic flagging method used by LOFAR
- Works with amplitude information of one polarization of a single sub-band
- It relies on thresholding, where cutoffs depend on their surrounding signal levels

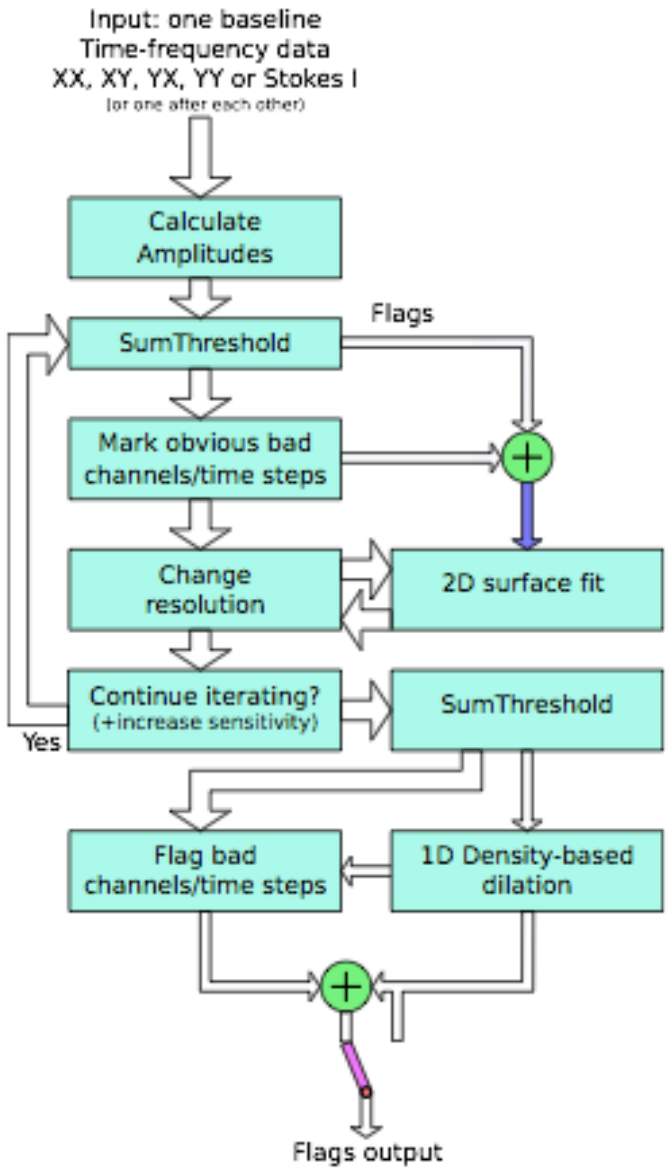


Image credit: Offringa et al.

Transients vs AOFlagger

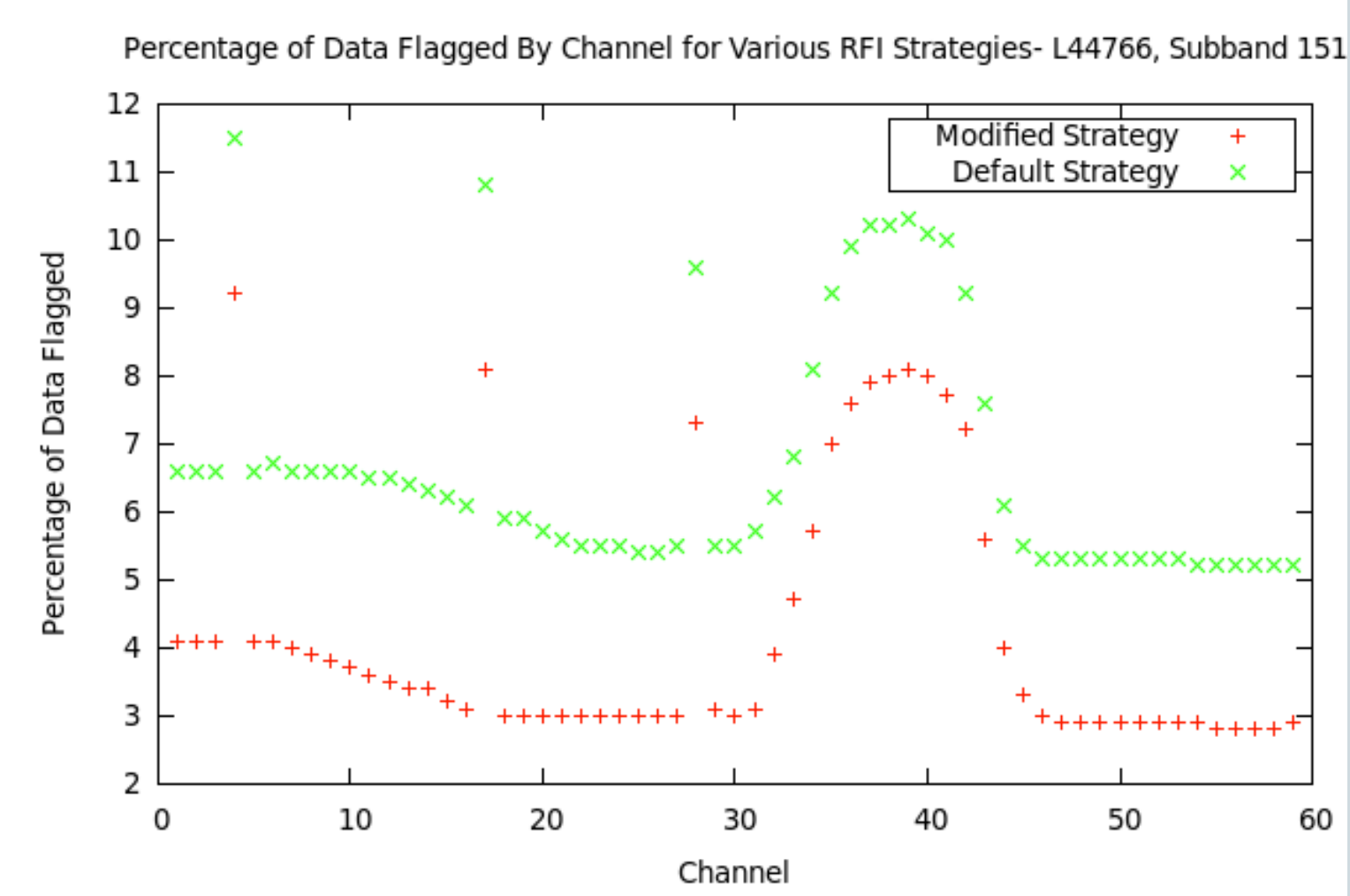
- The default flagger is designed to catch all the RFI, even if some non-contaminated data gets flagged
- AOFlagger uses time selection steps which compare RMS values, and automatically flags anything with a sigma > 3.5 in order to quickly reach convergence

This may not be ideal for observations containing transients

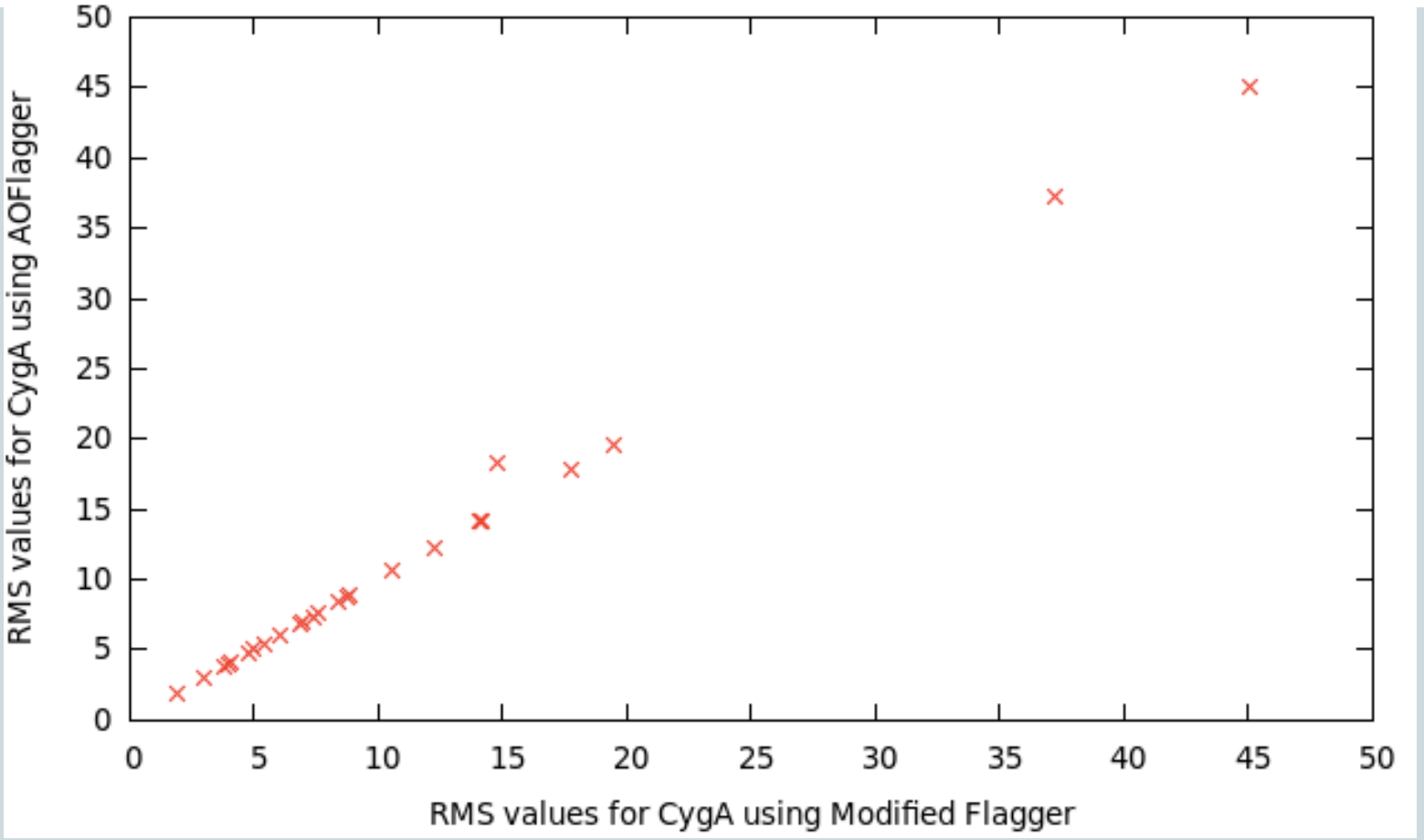
Modified AOFlagger

- Modified AOFlagger to run more quickly, detect transient signals
- Changes include deleting time selection, ignore thresholding in frequency, decrease “sliding window” resolution in time
- Tests were done in two parts: first on transient search data which showed high RFI percentages flagged in processing, second on simulations of transient signals

Flagging RFI



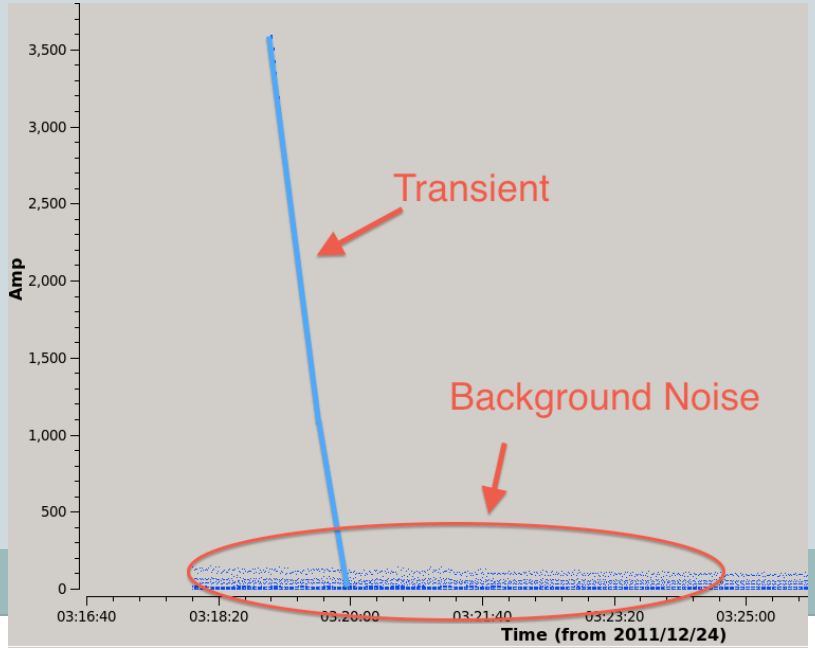
RMS Levels



RMS background noise level for high-RFI measurement sets when measured for default versus modified flagger

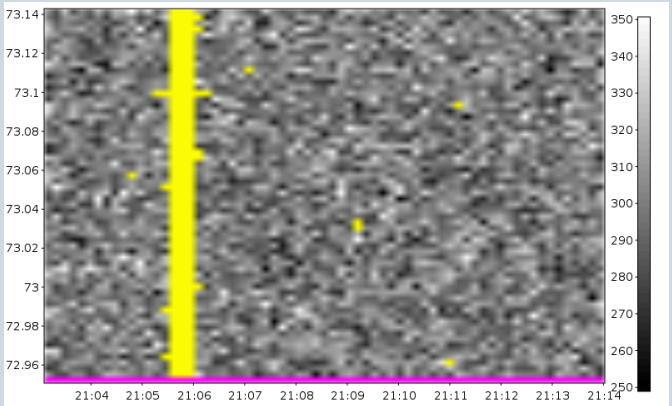
Simulations

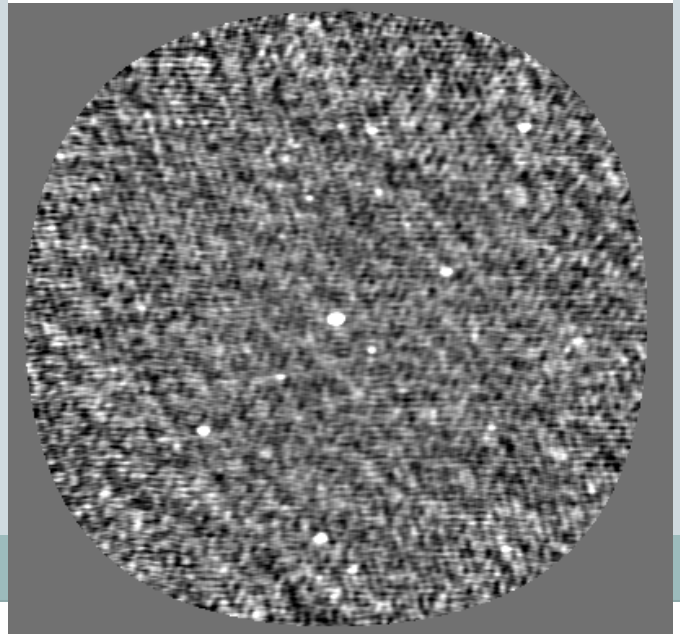
- Used inject.py script to inject random noise into a typical measurement set
- Take time slices of transient source over time to make a sky model each second- calibrate each second to inject the transient signal into the measurement set



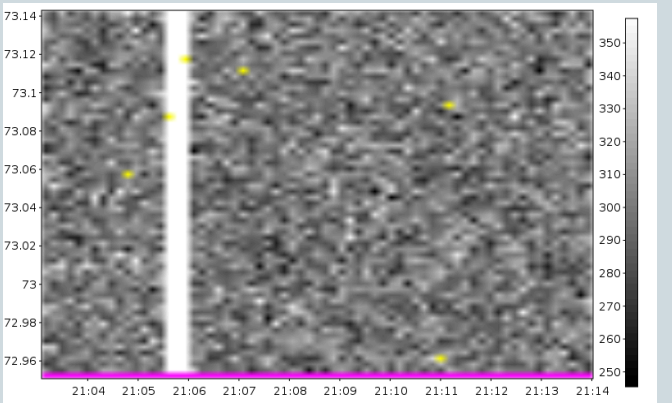
Simulations- Step Functions

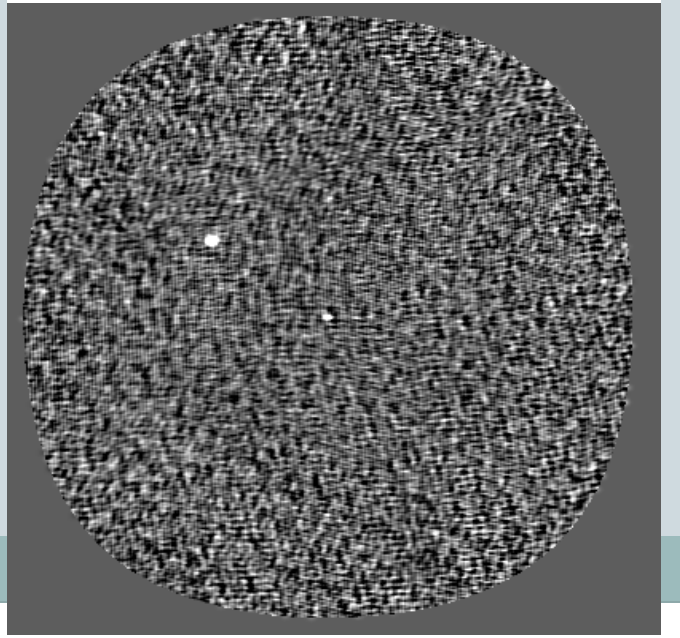
Default Flagger Simulations



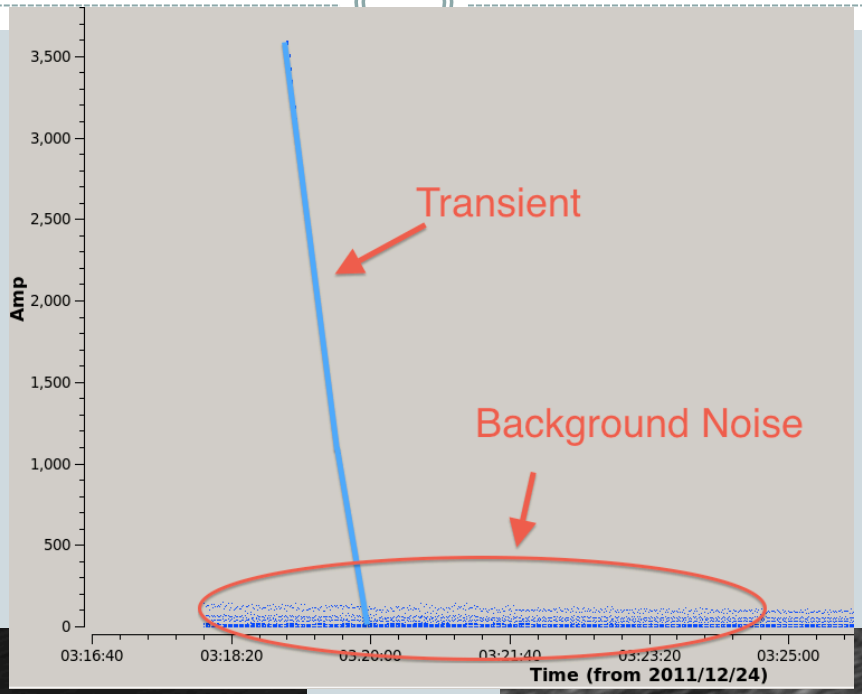


Modified Flagger Simulations



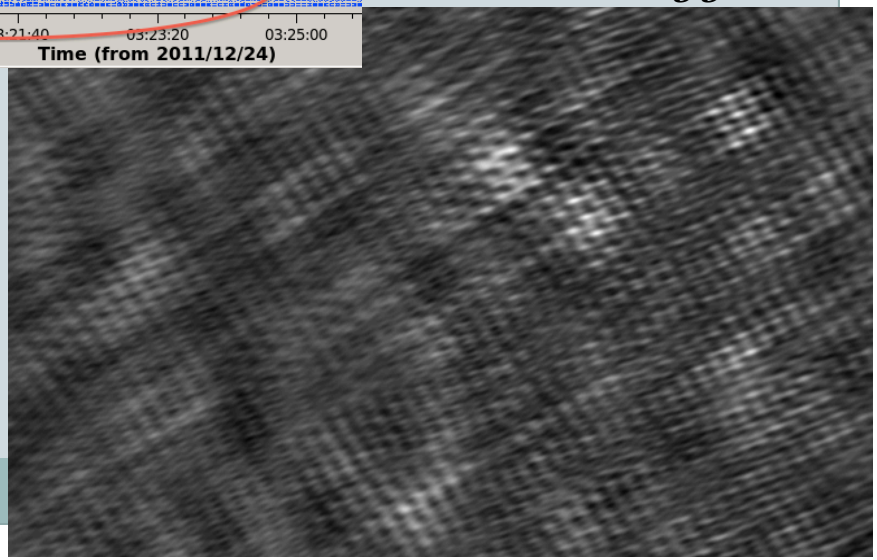


Simulations- FREDs



Not flagged

Flagged



Flagger Summary

- The current LOFAR default (AOFlagger) is likely flagging brief transient radio sources… meaning transient searches will not currently see them
- A modified flagger for transient radio sources (which does not affect background RMS levels) flags some, but not all, transients
- Unanswered questions for the modified flagger:
  - Why are FREDs flagged, but step functions aren't? Are there some profiles that aren't flagged?
  - Can the flagger be modified further to detect these signals?

Future Work

- Implement a modified RFI flagger for transient radio searches for LOFAR
- Look back at the data to see what we're missing- do transient sources have a signature vs RFI? Do they image to a point source?
- Apply RFI flagging algorithms to other radio telescopes as well- ex Arcminute Microkelvin Imager (AMI)

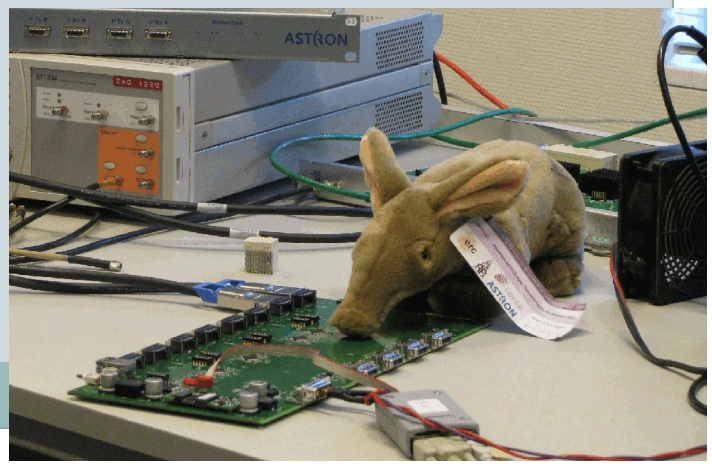


Image credit: ASTRON Daily Image