Dynamical archive prototype: short-duration radio events

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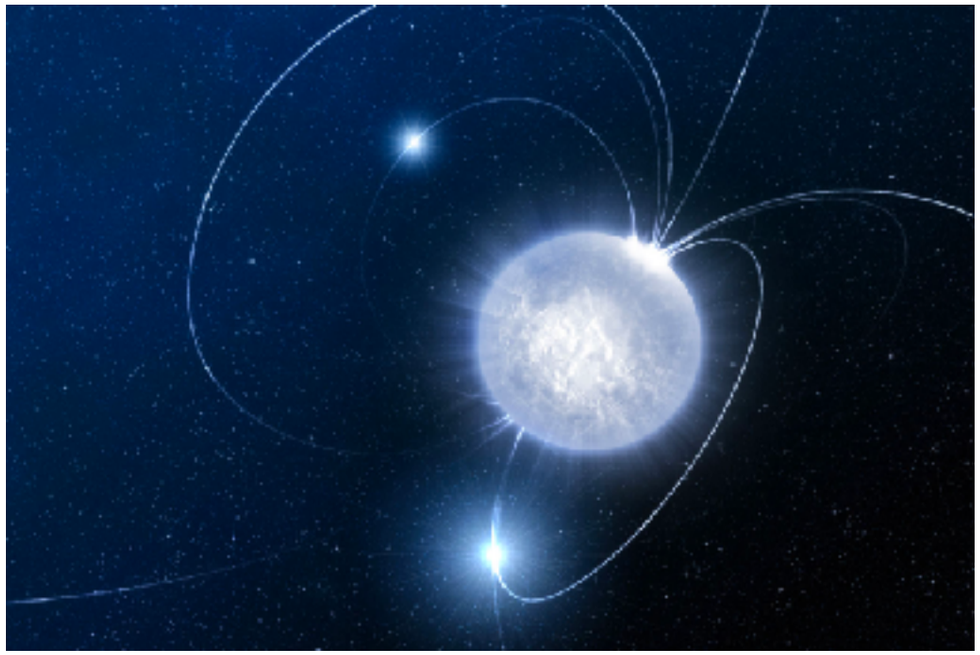
Science motivation

- Searching for radio signals with short-term variability
  - Radio pulsars
  - Fast radio bursts (FRBs)
  - Other:
    - e.g. exoplanets, SETI
    - Unknown?



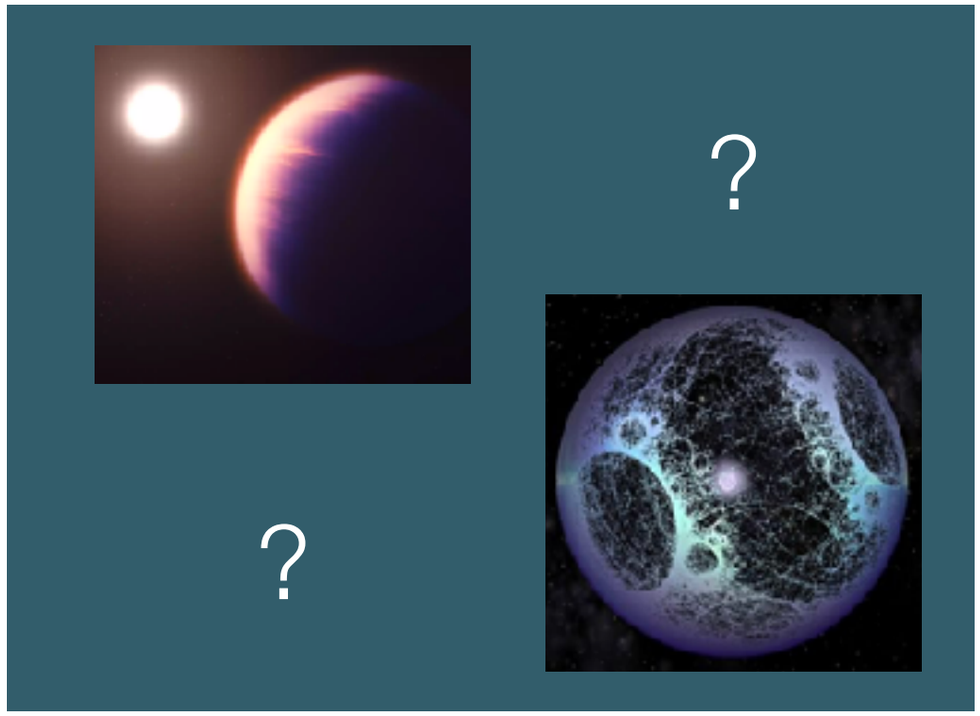
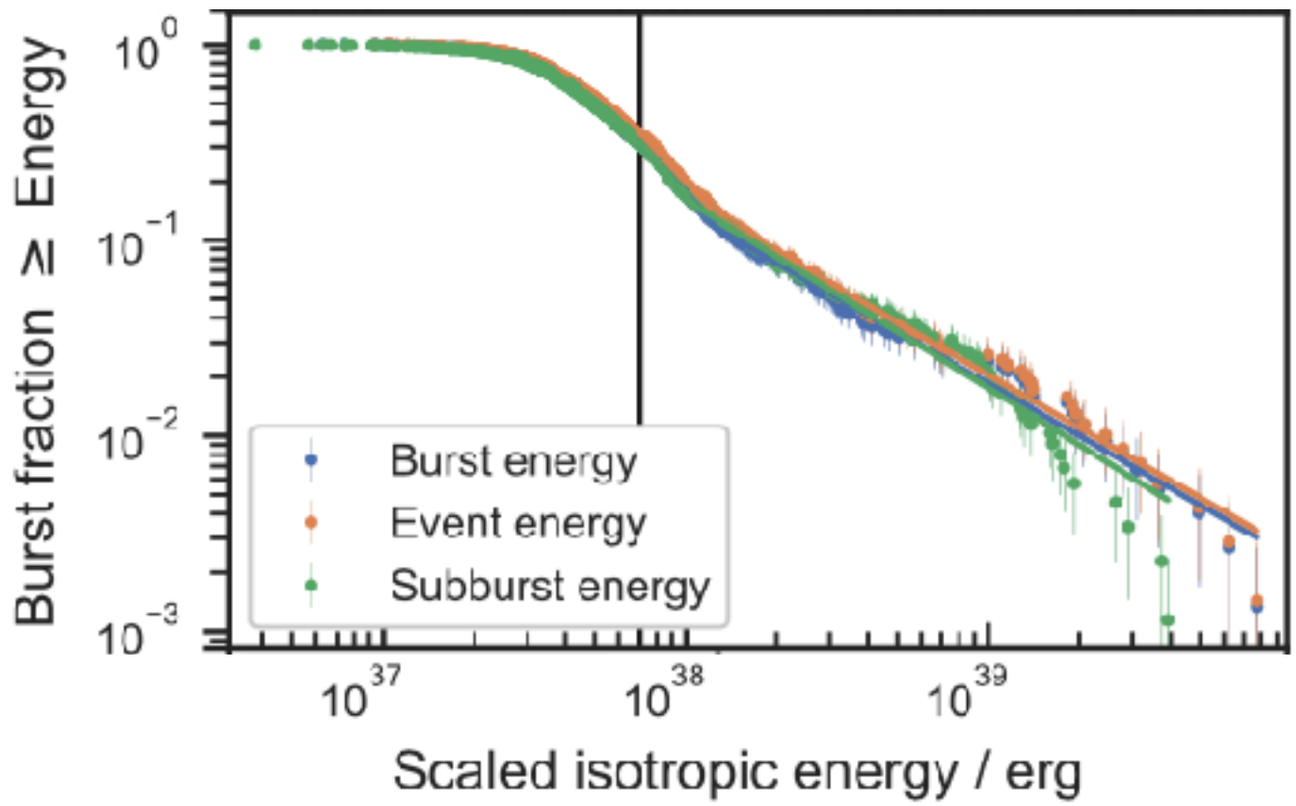


Image credits:
ESO/L.Calçada
NASA, ESA, CSA, Olmsted
SENTIENTDEVELOPMENTS.COM

Energy distributions

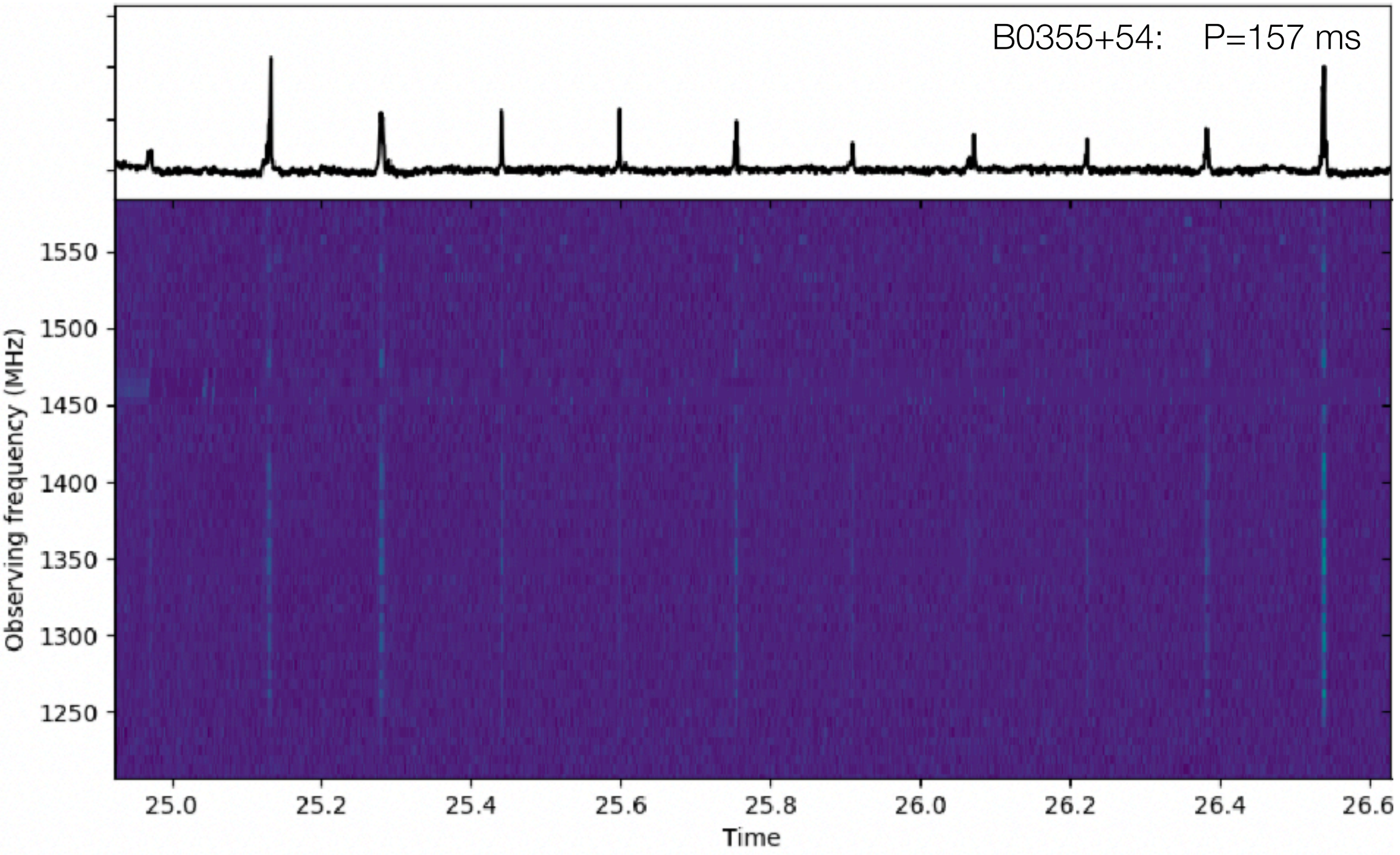
- Compare to…
  - possible Galactic analogs (magnetars, giant pulses, etc)
  - theoretical predictions
- Understanding detection completeness important

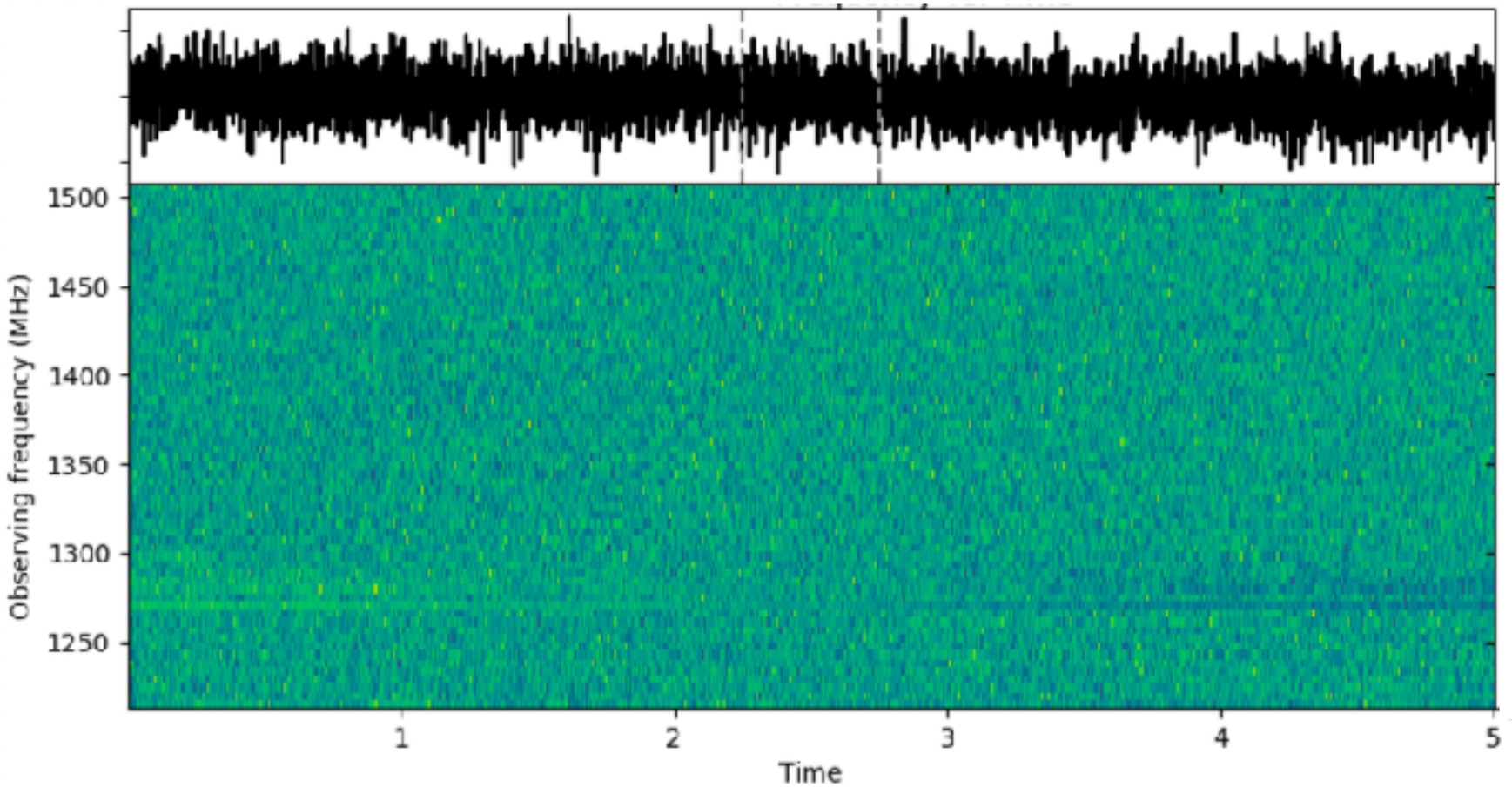
FRB 20121102A with Arecibo



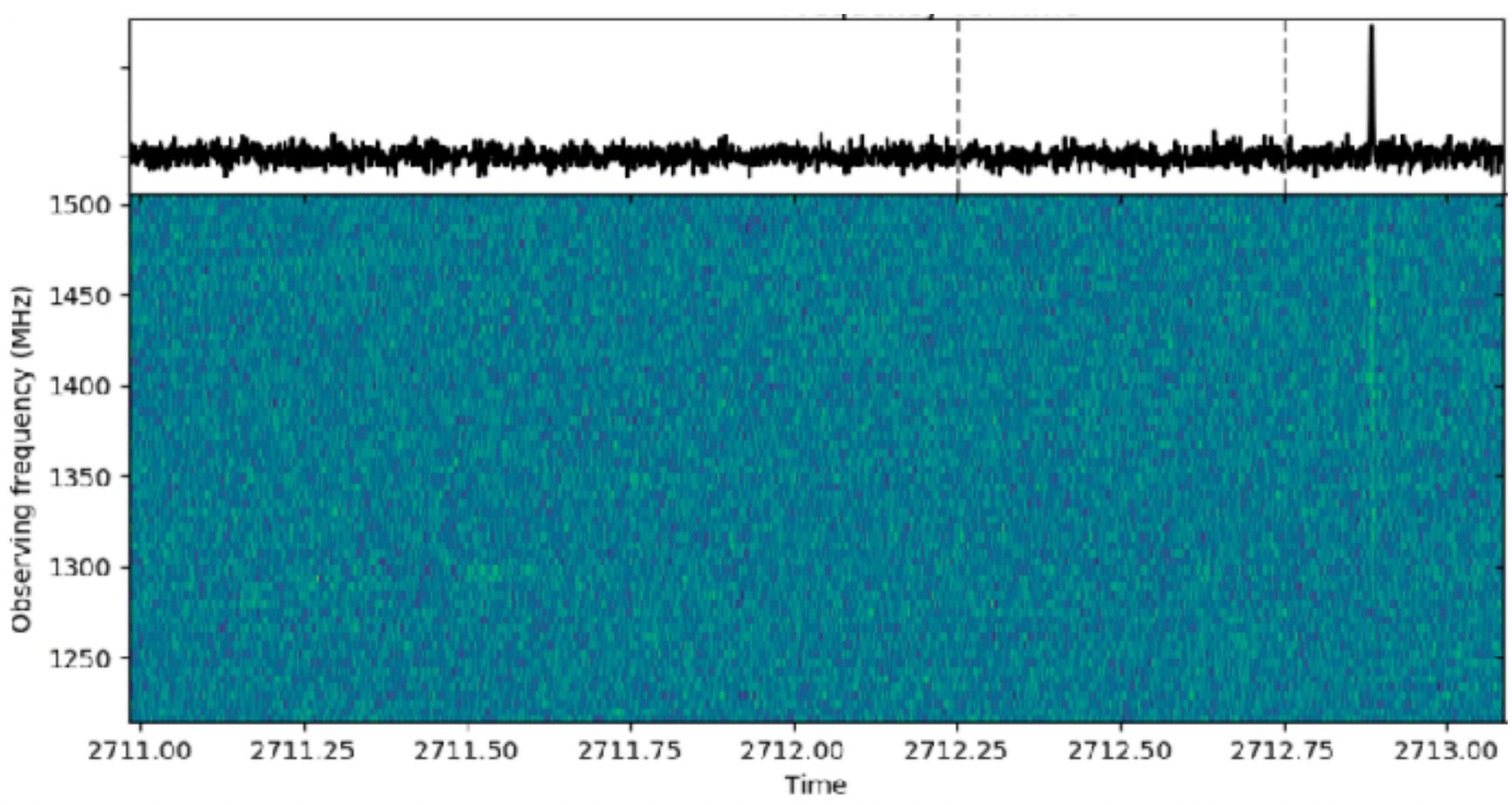
Jahns et al., 2023, MNRAS, 519

Example of data used in searching



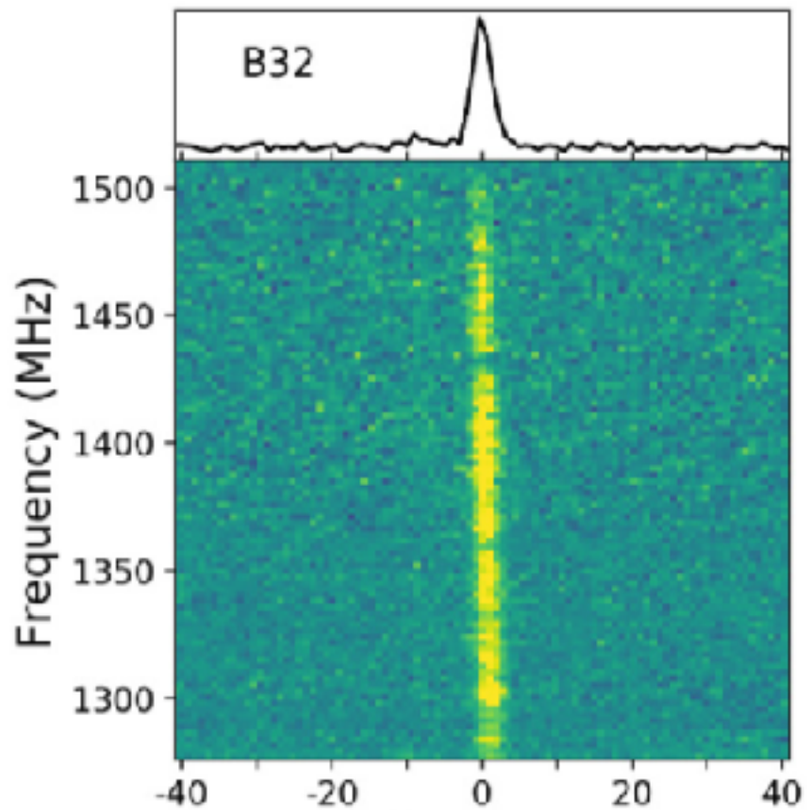


… 2711 seconds later

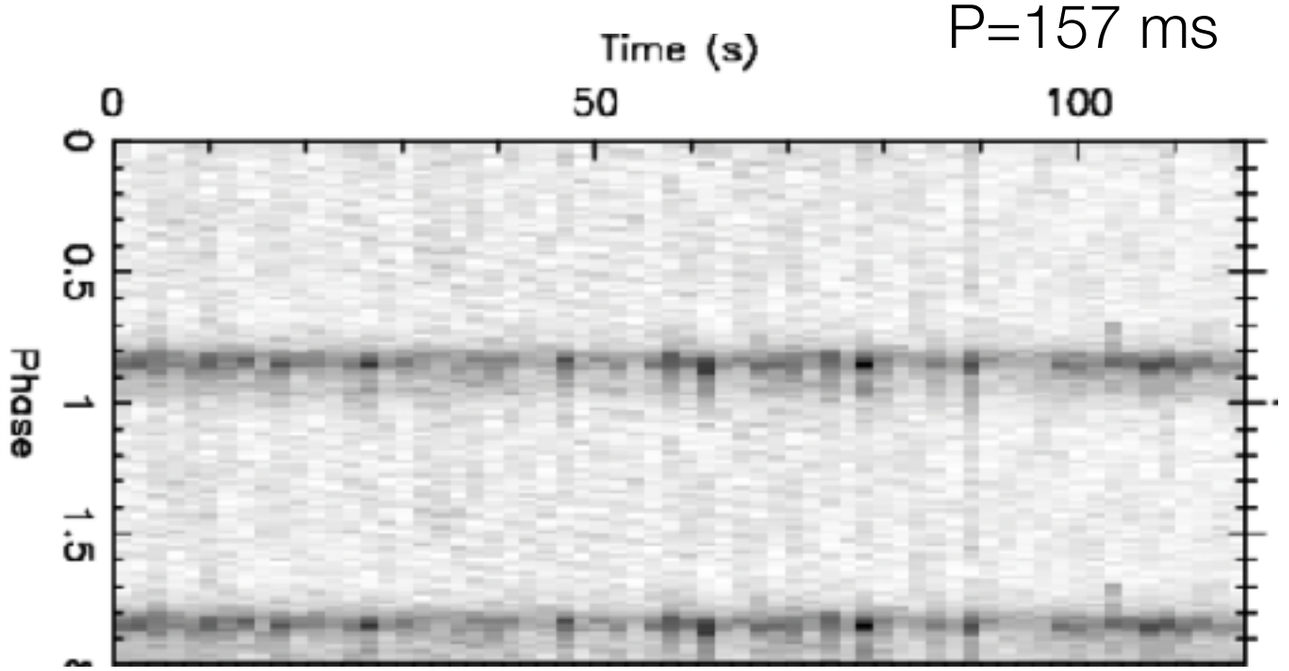


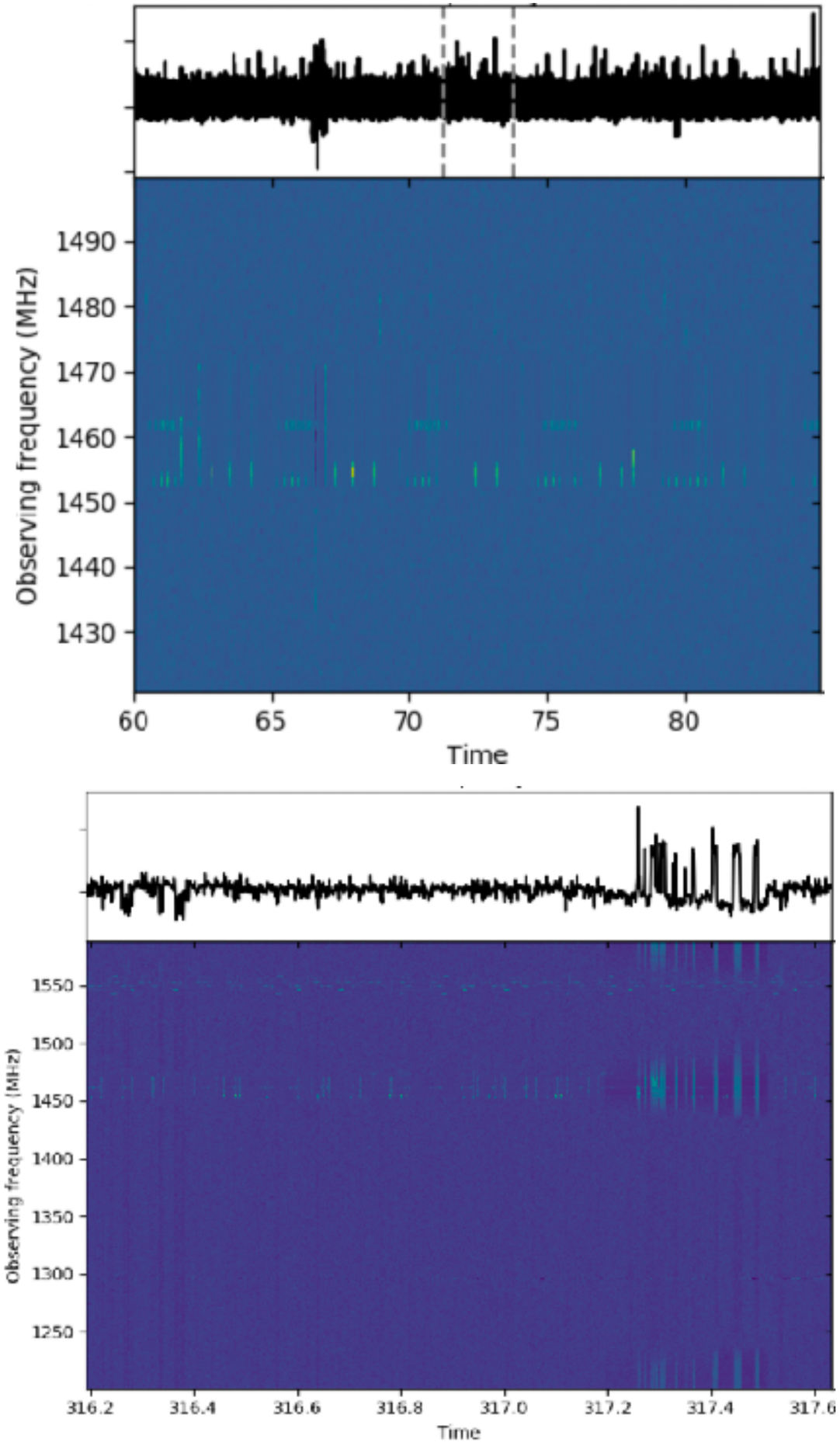
Search filters

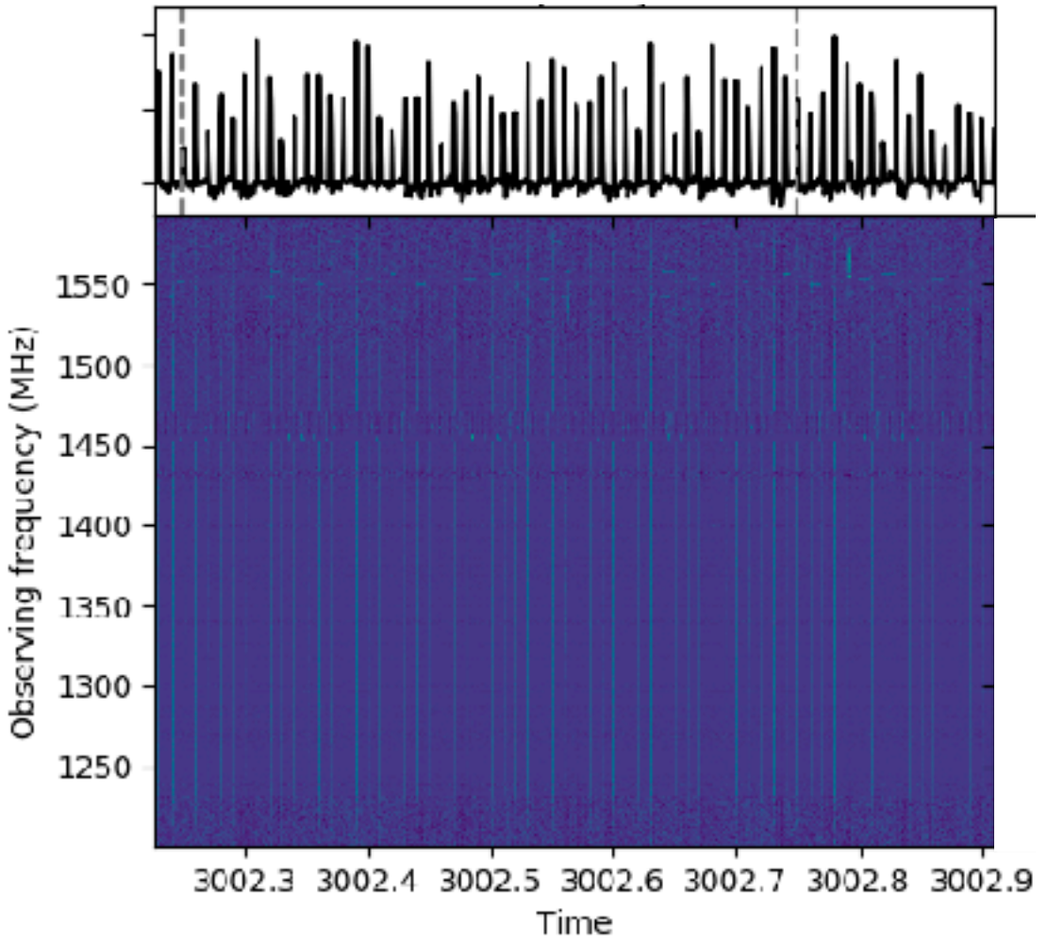
- FRB: dispersed pulses with statistically S/N on timescales of micro- to milliseconds
  - WP 2: Ramesh + Andrey
- Pulsars: dispersed periodic signals
- Others:
  - e.g. exoplanets, SETI:
    at best an educated guess
  - Unknown signals/sources: ??
- How should we construct dynamic archives that enable entirely new filters?



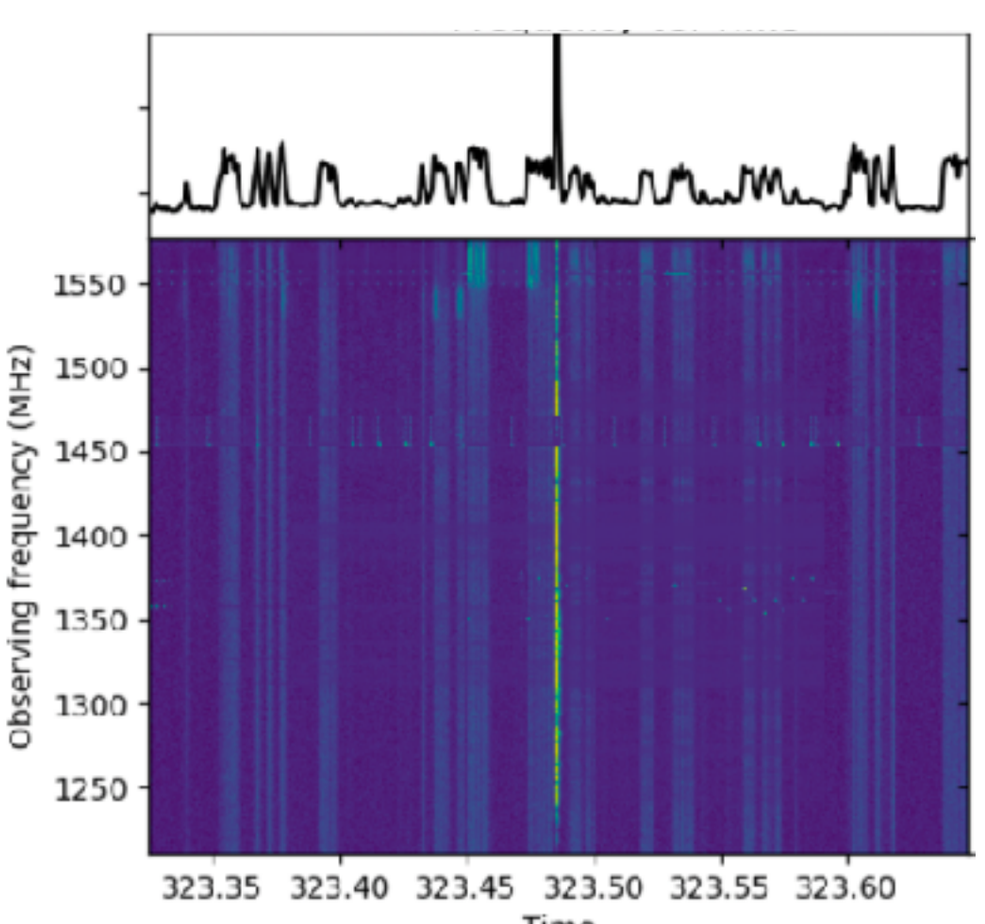
B0355+54:
P=157 ms




Observing frequency (MHz)
1490
1480
1470
1460
1450
1440
1430
60
65
70
75
80
Time


Observing frequency (MHz)
1550
1500
1450
1400
1350
1300
1250
3002.3
3002.4
3002.5
3002.6
3002.7
3002.8
3002.9
Time

Observing frequency (MHz)
1550
1500
1450
1400
1350
1300
1250
316.2
316.4
316.6
316.8
317.0
317.2
317.4
317.6
Time


Observing frequency (MHz)
1550
1500
1450
1400
1350
1300
1250
323.35
323.40
323.45
323.50
323.55
323.60
Time

Voltage Data

Searched Data

Dynamic filter

Dynamic archive

Voltage dump

FRB

RFI

Noise

Metadata

Mimic realtime data streams

Create dynamic filter

Estimate information loss

Estimate completeness

Estimate running costs of filters

Functionality #1: Database

- Database of labeled events (e.g. “FRB”, “pulsar”, “RFI”, “noise”) + metadata
    - In order to enable further functionality
        - How much RFI to save? What RFI
        - Should we keep some noise?
- Back of our mind: may need to be clever if database gets large

Functionality #1A: signal simulator

- Inject signals into data to test dynamic filters
  - (Ideally, injected into telescope system)

Functionality #2: Training / re-training of filters

- Train new or re-train existing dynamic filters as RFI situation or knowledge of population changes
    - Quantify information loss (recall, accuracy, false positive rate, true negative rate, etc.)
    - How do we decide that the re-trained model is better and should be implemented?
    - Is the new model biased by the events in the database, which were discovered by another model?

Functionality #3: statistically complete samples

- Goal: combine samples of events found by different filters
  - How many events classified as pulses in Data A with Filter A would have been classified as pulses by Filter B?
  - What events in Data A were missed by Filter A but would have been found by Filter B?

Functionality #4: quantify “RFI weather”

- The impact of RFI is not included in calculations of sensitivity or completeness of a sample

- Define “RFI weather” metric that allows a more realistic estimate of sensitivity throughout a survey

- How can this be fed back into a dynamic filter?