



LOFAR Searches for Radio Exoplanets



Jake D. Turner

University of Virginia



AAS 232

June 6, 2018

Twitter:

@Astro_journey

Collaborators:

Philippe Zarka (LESIA – Paris Observatory)

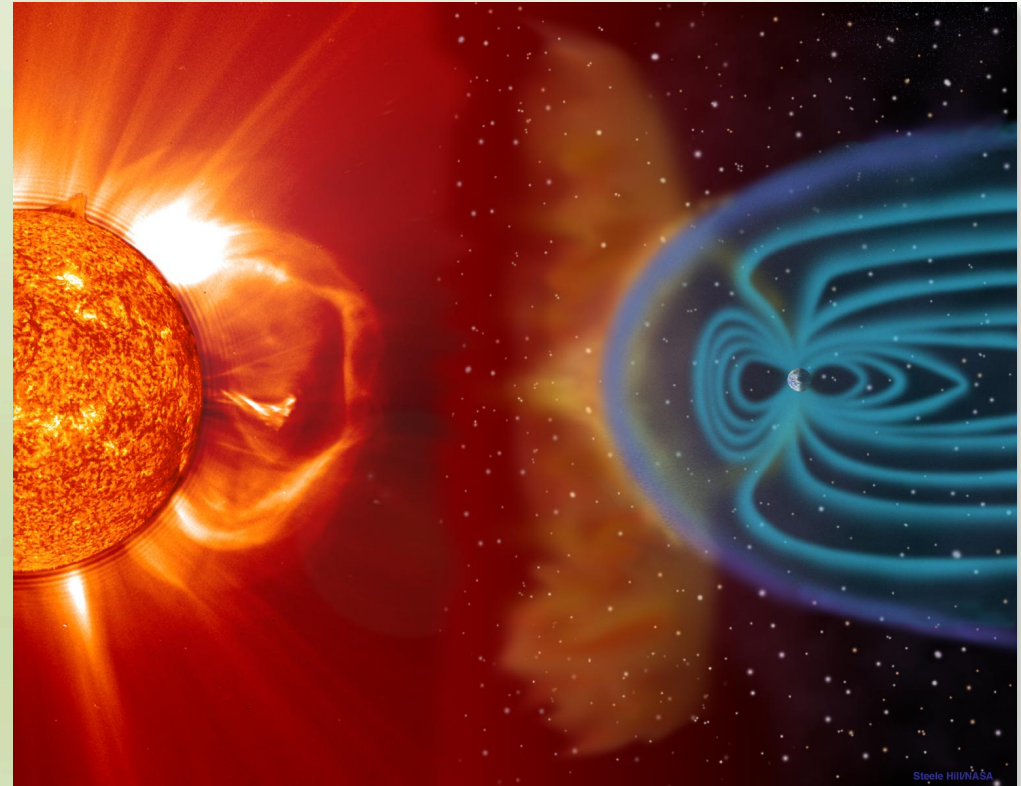
Jean-Mathias Grießmeier (LPC2E)



Exoplanet Magnetic Fields

Motivation

- Interior structure
- Star-planet interactions
- Ohmic dissipation
- Solar System comparison
- Habitability

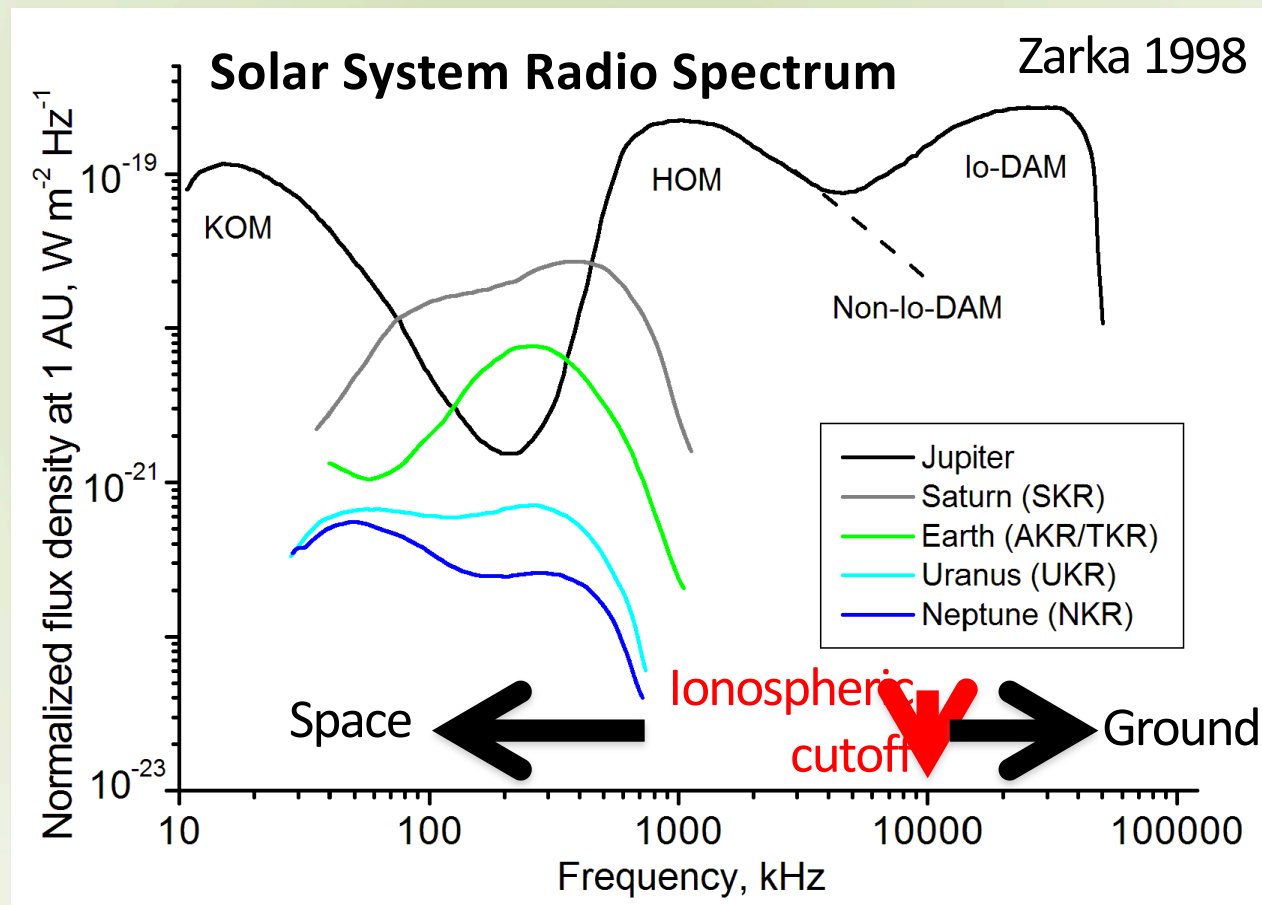


Lazio+ 2010, Grießmeier+ 2005, Rauscher+ 2010,
Hess & Zarka 2011, Grießmeier 2015, Zarka+2015

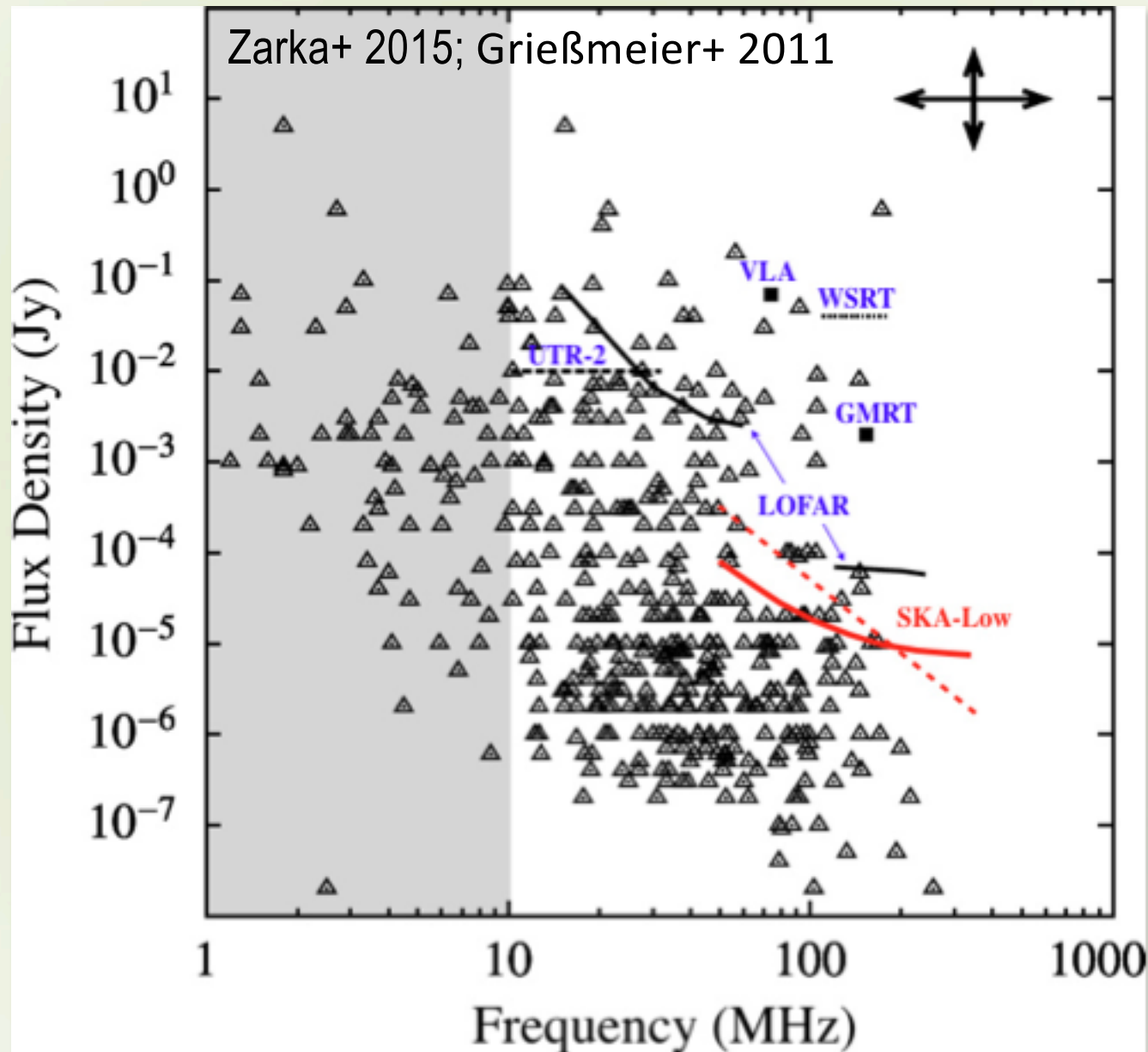
“To be habitable, a planet needs warmth, water, and it needs to be sheltered from a young, violent sun.” Jose-Dias Nascimento (2016, APJL, 820, L15)

Radio Observations

- Best method to study planetary magnetic fields (Grießmeier 2015)
- Electron cyclotron emission



Radio Flux & Frequency Predictions



LOFAR Observations

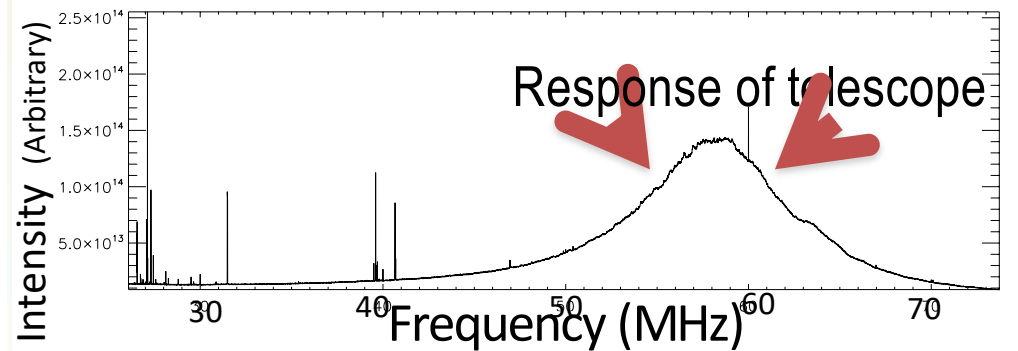
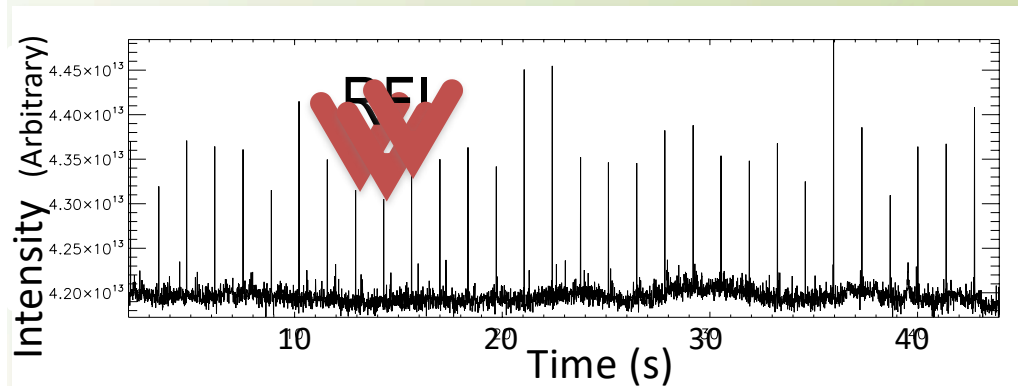
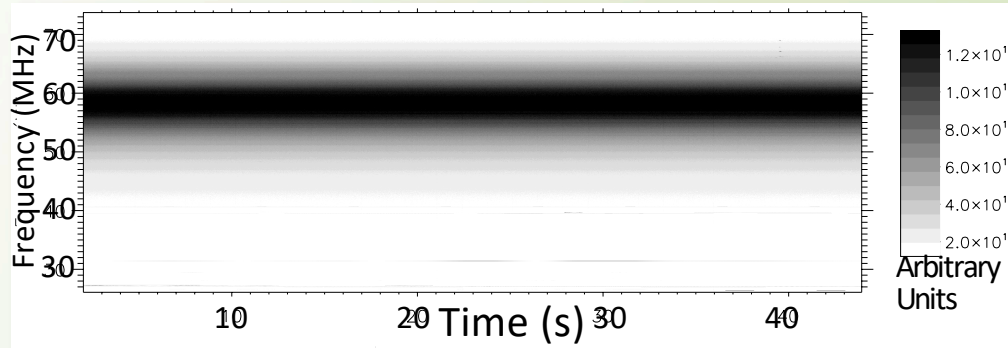
- 16-73 MHz
- IQUV
- 10 msec & 3 kHz
- 22 mJy sensitivity: 2 mins over full band
- Observational Campaign:
 - 3 Beams (ON & 2 OFF)
 - 4 exoplanets so far
 - Over full orbital coverage



Turner+ 2017

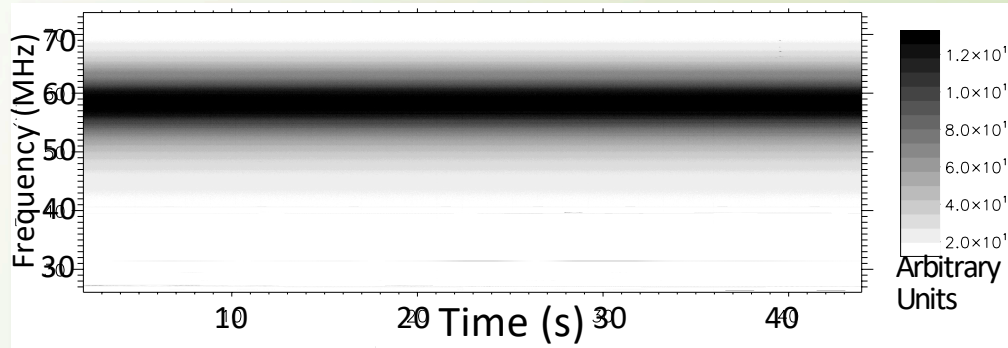
LOFAR Pipeline

Raw

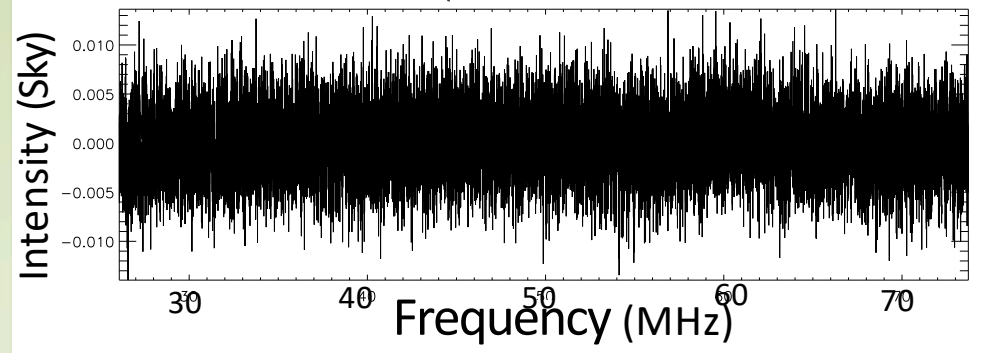
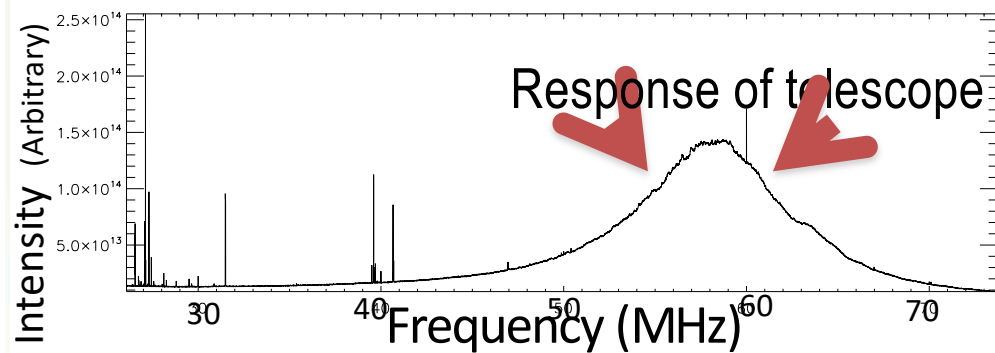
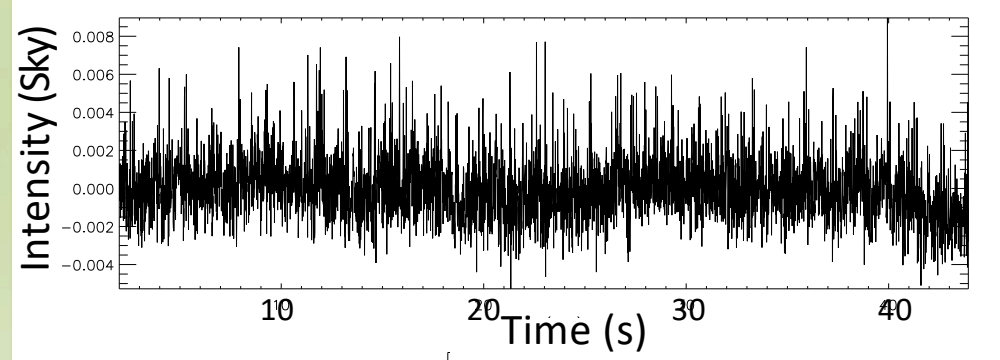
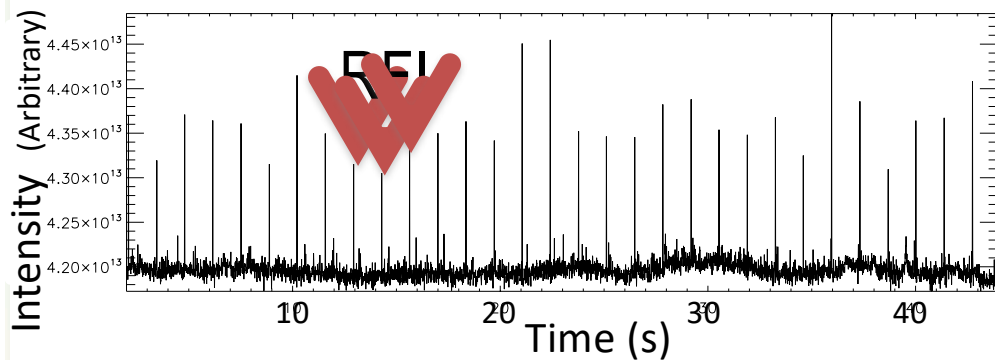
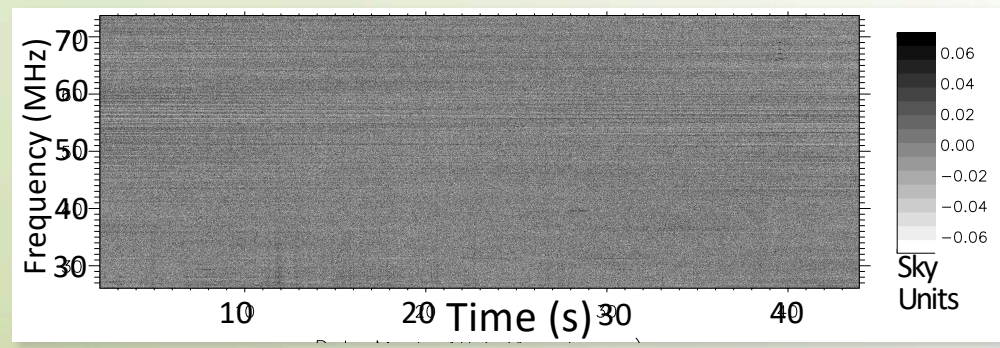


LOFAR Pipeline

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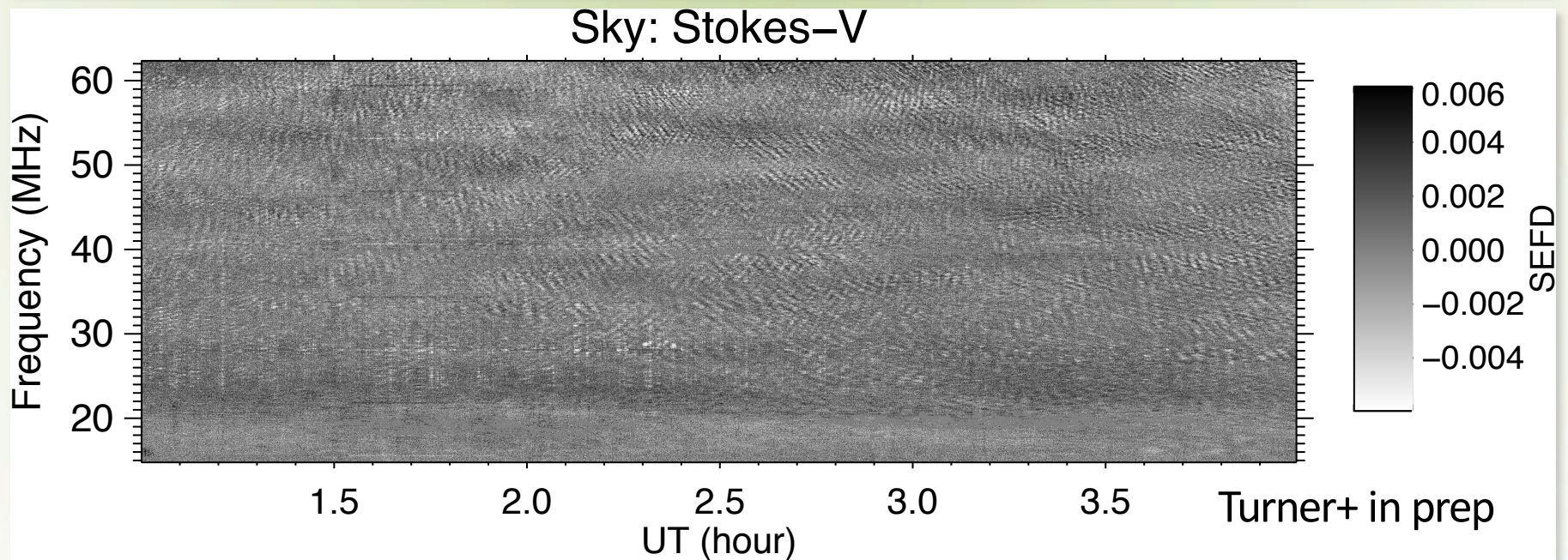
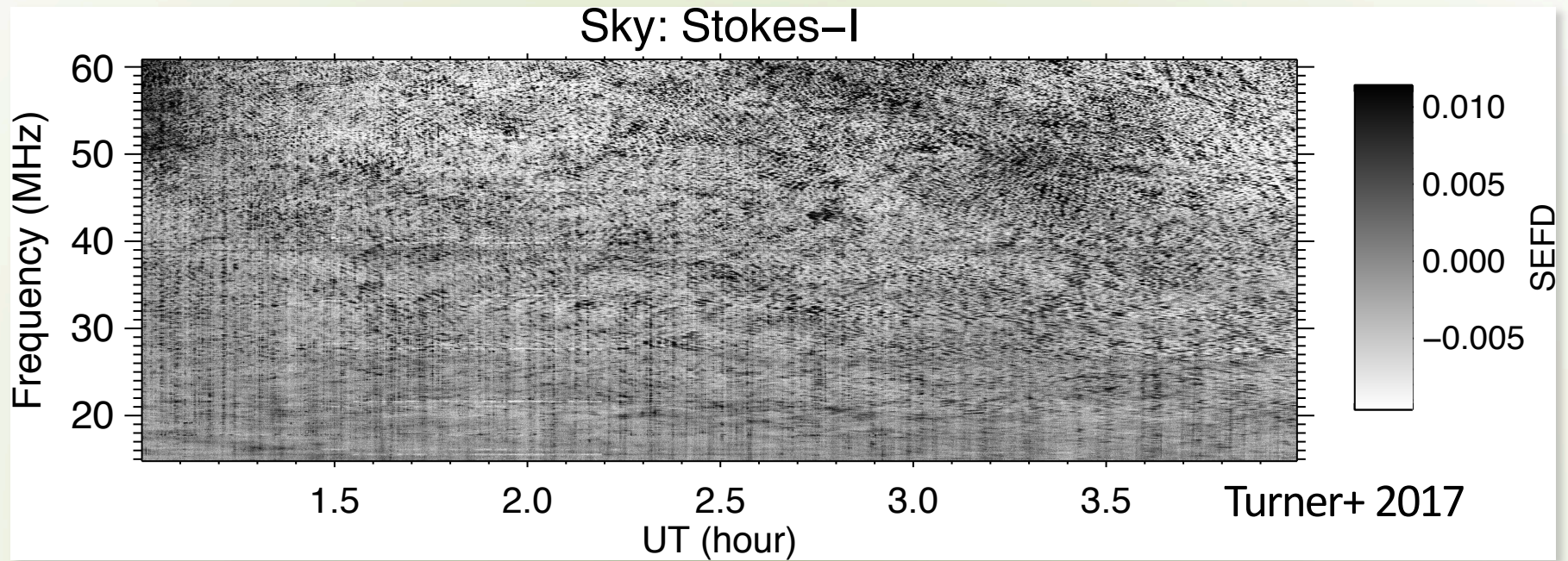


Normalized+ RFI mitigation

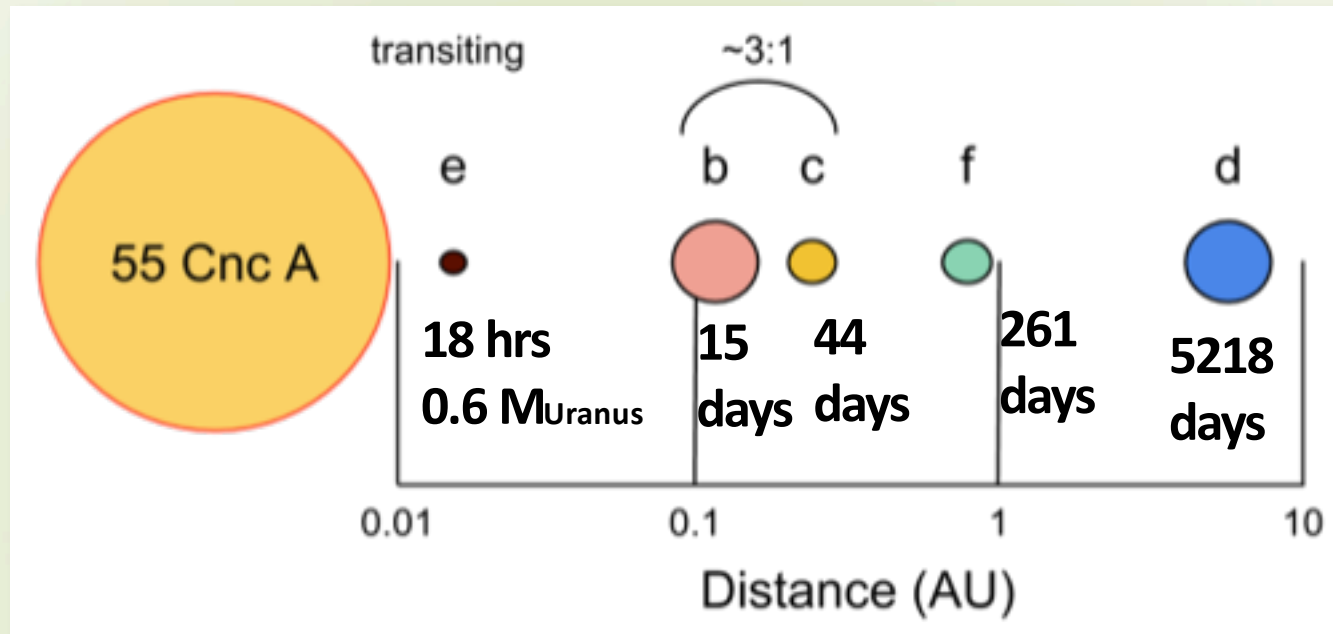


Turner+ 2017

Dynamic Spectra

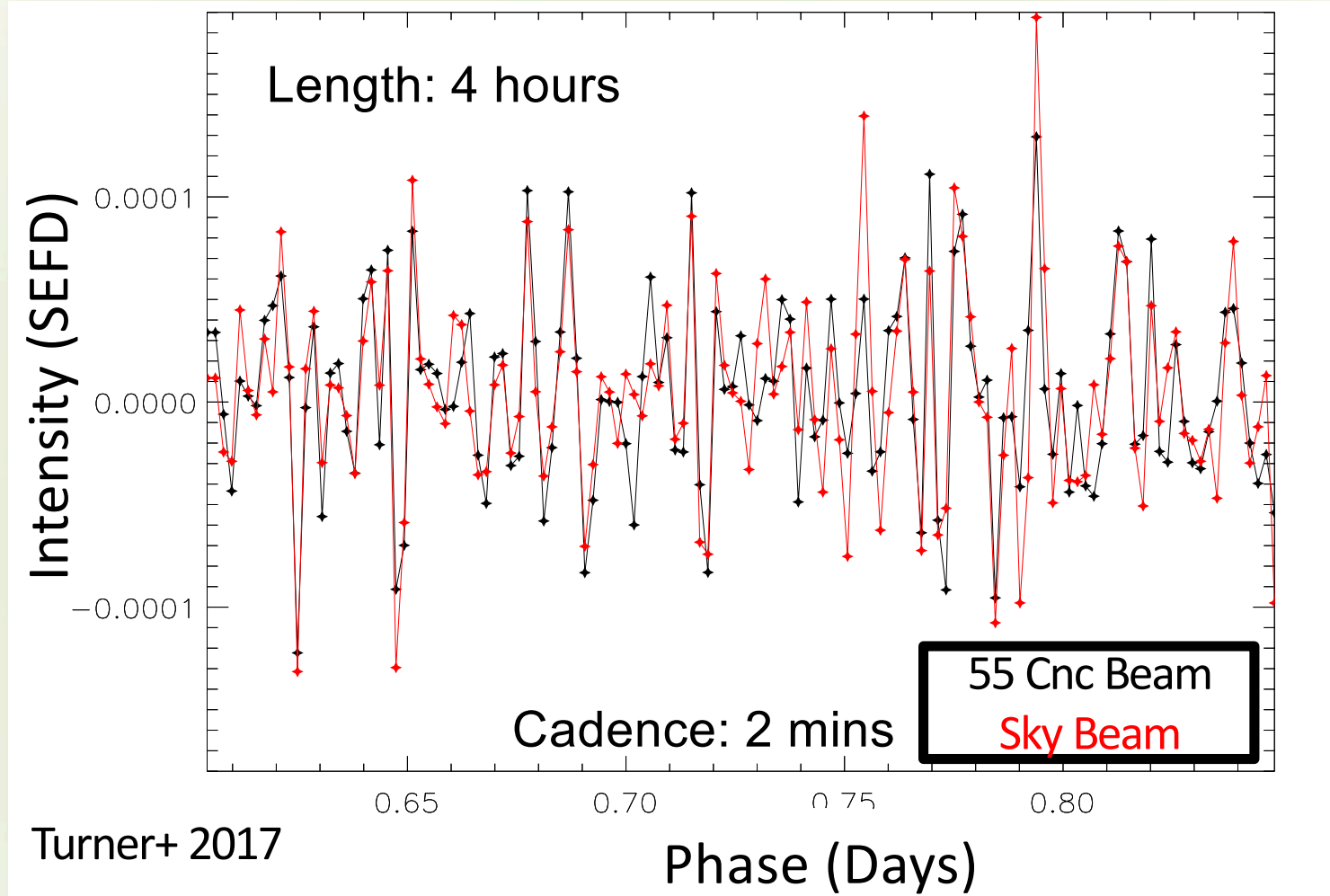


55 Cnc Planetary System



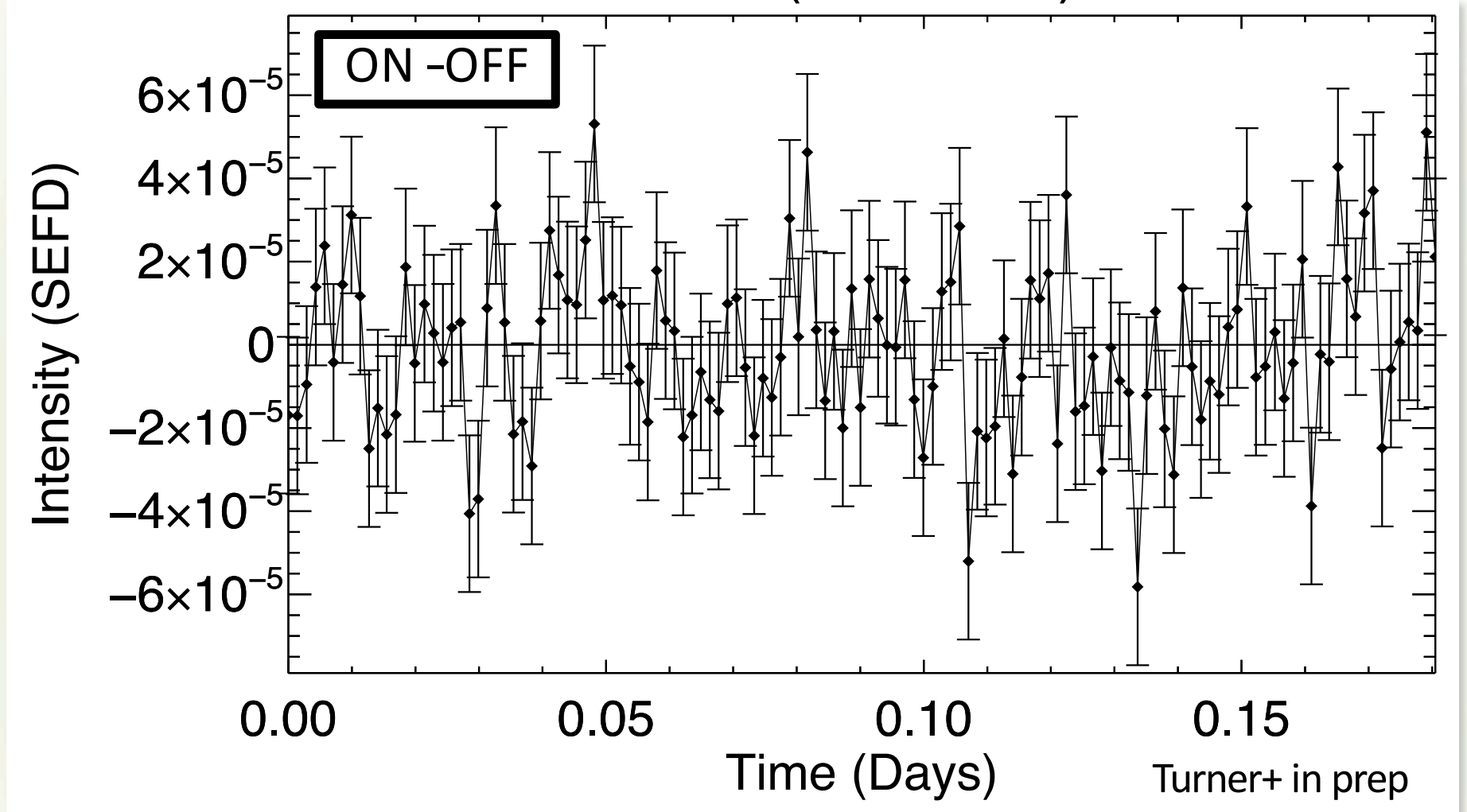
- One of best targets for radio observations due small orbital distance, proximity (12.3 pc), and multiplicity (Grießmeier+ 2007).
- Emission from 55 Cnc e possible: tens of MHz with flux densities up to hundreds of mJy (Grießmeier+ 2007, Jardine+ 2008).

55 Cnc Results (Stokes-I)



- No emission from 55 Cnc in Stokes-I
- 3σ upper limit \rightarrow 2.6 Jy (50x theoretical

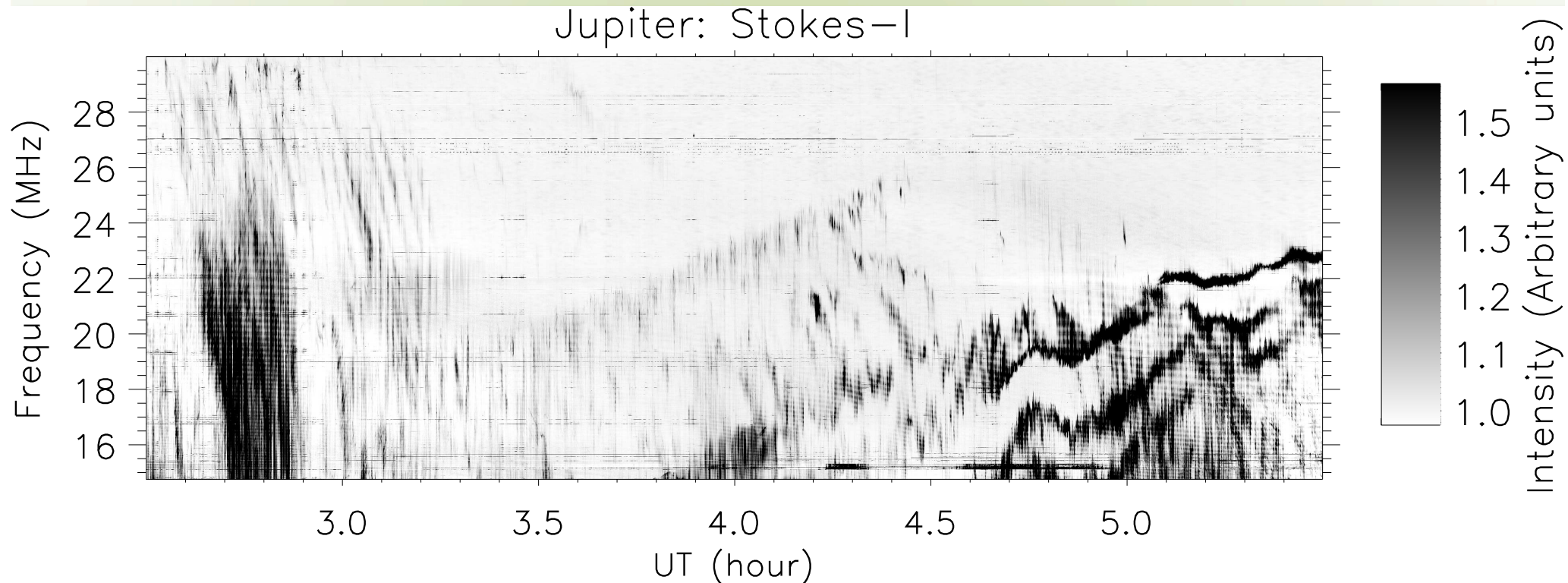
55 Cnc Results (Stokes-V)



- No emission from 55 Cnc in Stokes-V
- 3σ upper limit \rightarrow 100 mJy (**2x** theoretical sensitivity)

Jupiter as an Exoplanet

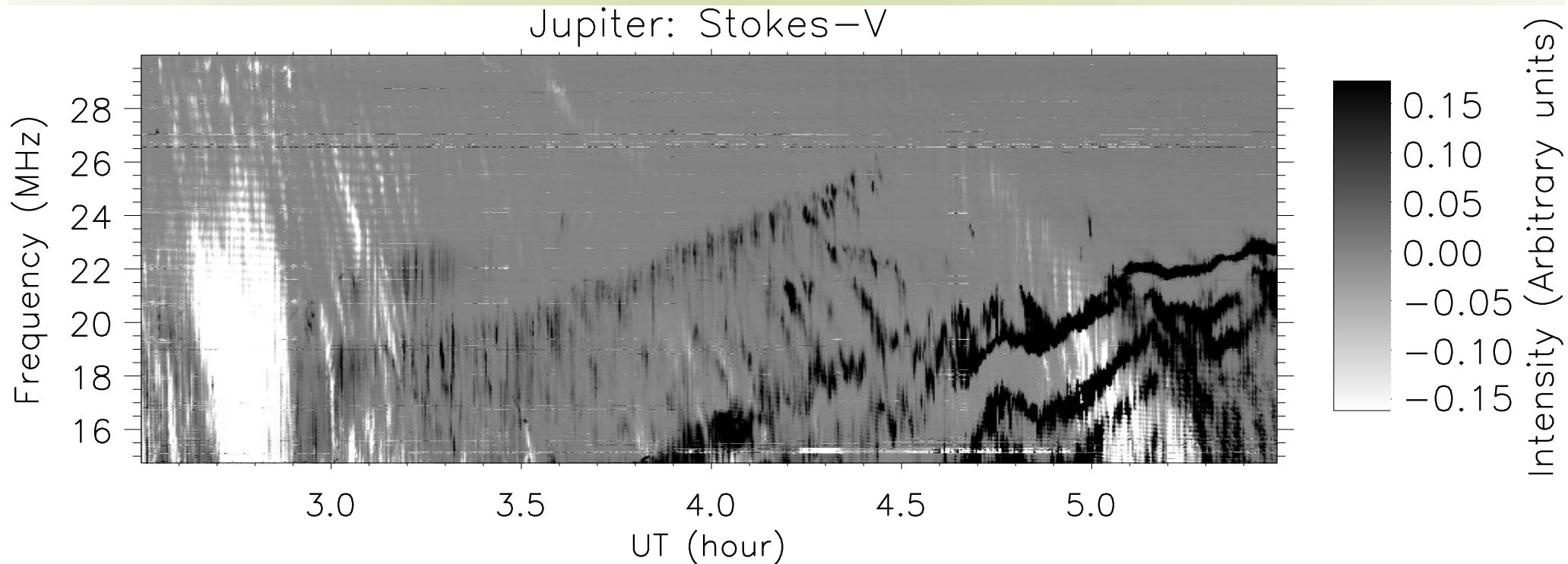
- Scale Jupiter radio emission as if it was exoplanet
- Find an upper limit of detectability
- Guide in exoplanet search



Turner+ 2018 (submitted)

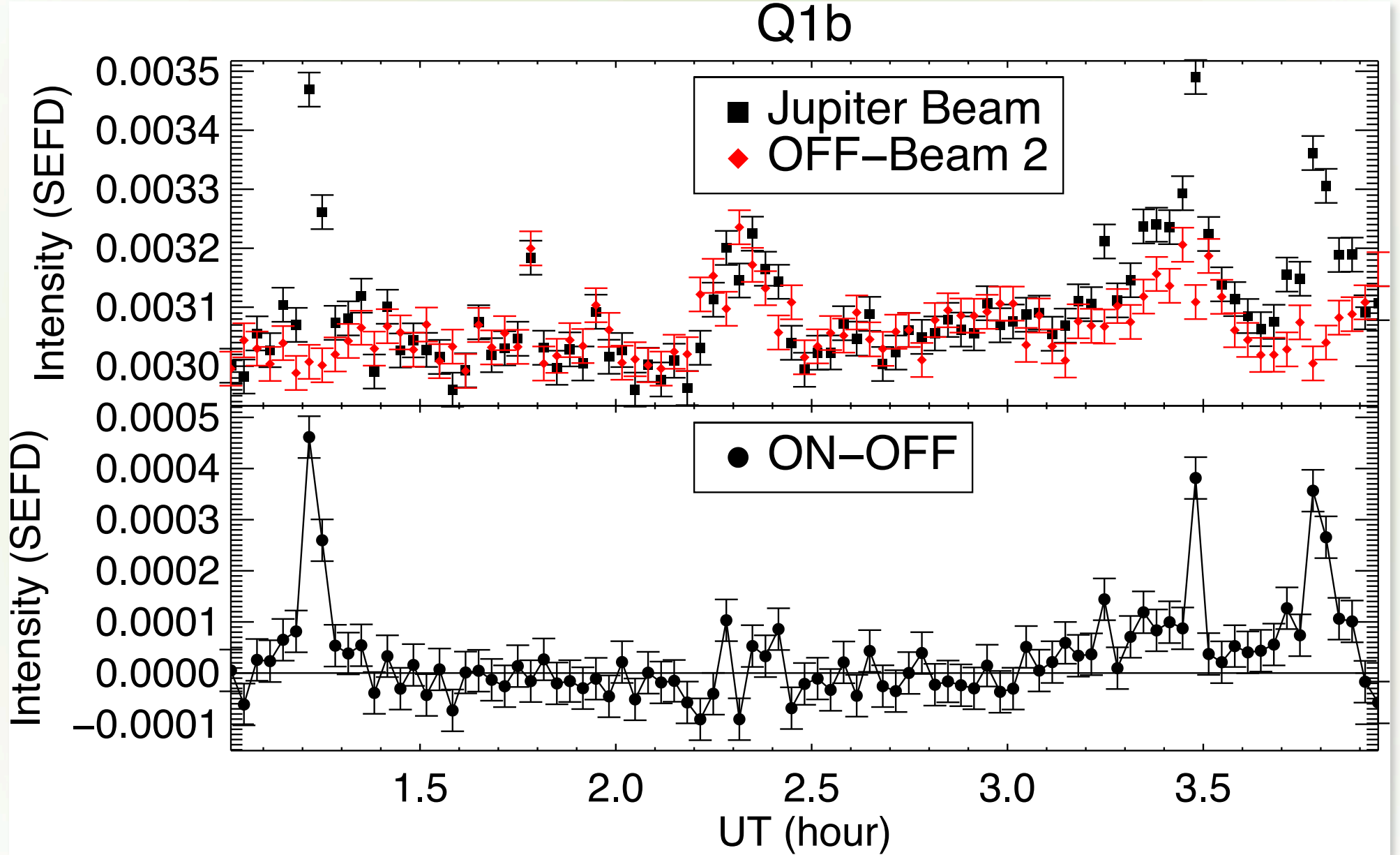
Jupiter as an Exoplanet

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Turner+ 2018 (submitted)

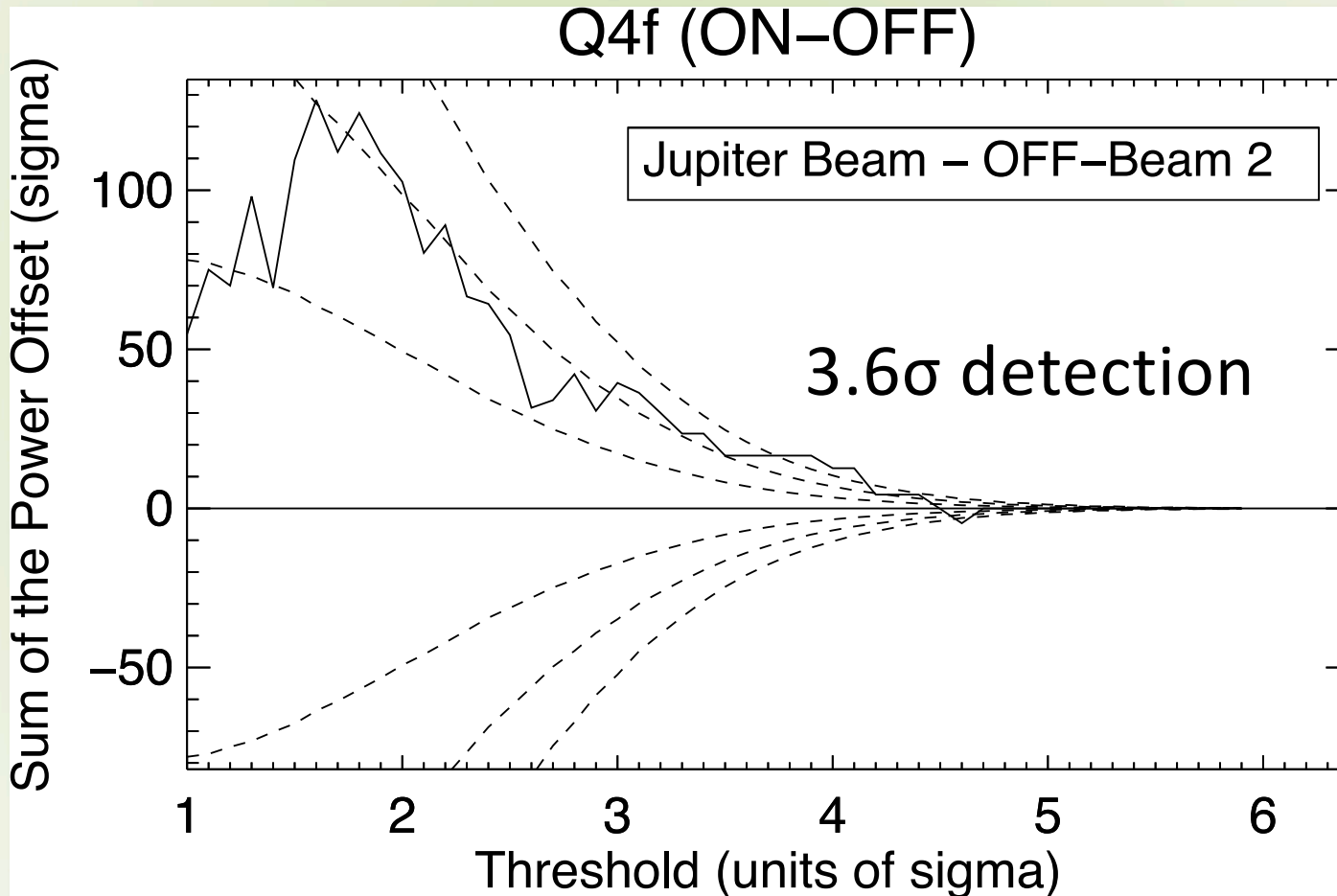
Observables (Example)



Turner+ 2018 (submitted)

Detection Limits

- **Stokes-I**: 10^6 x Jupiter max bursts @20 pc
- **Stokes-V**: 10^5 x Jupiter max bursts @20 pc



Turner+ 2018 (submitted)

Dynamic Spectra from Imaging

V830Tau

Loh+ 2017 (in prep)

Direction Dependent Calibration

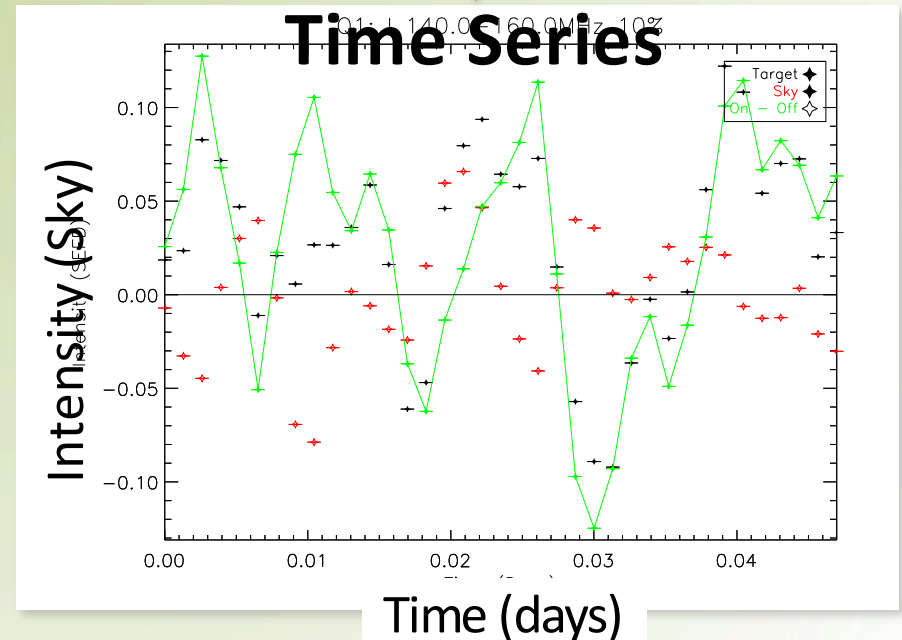
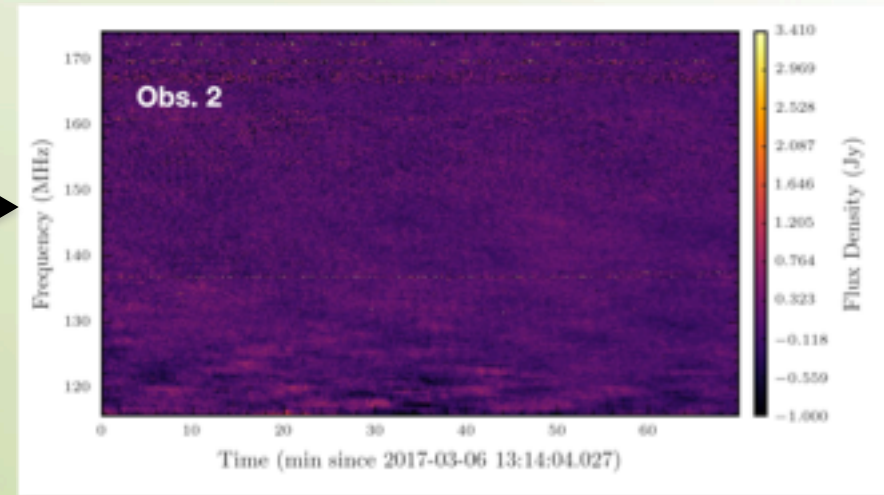
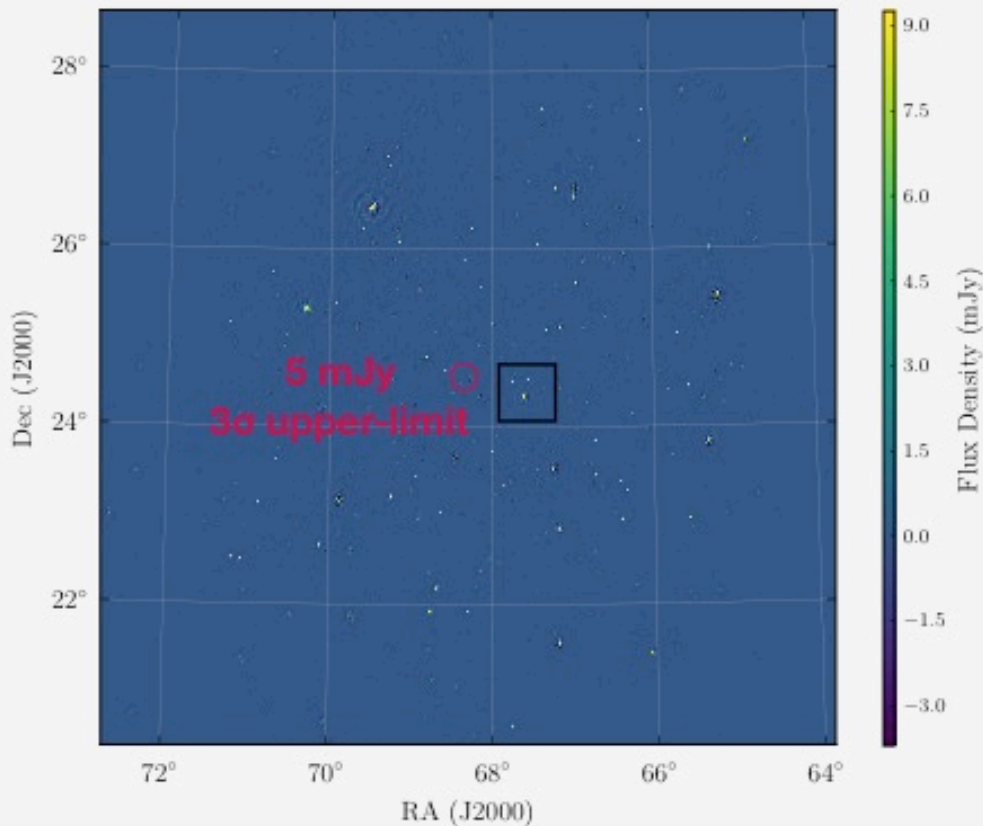


Image curiosity of Alan Loh (LESIA)
LOFAR HBA (120-190 MHz)

Conclusions

- Stokes-I and Stokes-V LOFAR pipelines now done
- 3σ upper limit on 55 Cnc radio emission in Stokes-V of 100 mJy (2x thermal noise)
- Scaled Jupiter radio emission as if it was exoplanet (Jupiter as an exoplanet)
- Find upper limit of 10^5 x Jupiter max bursts @ 20 pc (Stokes-V)

Questions?

jt6an@virginia.edu