SETI with NenuFAR

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SETI: Search for ExtraTerrestrial Intelligence

- Biosignatures vs. Technosignatures
- Radio signatures: deliberate vs. unintentional
- Most searches conducted at L-band
- Search for narrowband transmissions
  - Detectability vs energy efficiency optimum
  - Energy detection = easy implementation
- NenuFAR covers uncharted part of spectrum
Targeted Radio Search for Technosignatures

• Search for radio transmissions from distant civilizations
• RFI mitigation (*needle in a needle stack*)
• Remove ‘local’ RFI (physically and satellites, ABACAD)
• Identification of Doppler effects (Local standard of rest)
• Identification of anomalies (RFI-like, ML-based approaches)
• Look for persistency
• Conduct independent observations
SETIBK – NenuFAR SETI back-end

- Obs de Paris + Breakthrough Listen (UC Berkeley)
- Purchased in July 2020
- 144 TB storage
- 1x RTX 2080 Ti GPU
- 2x Intel Xeon Silver 4210
- 96 GB DDR4
- ES13 : 164 telescope hours alloc btw 2019-07 and 2021-11
## Observing time

<table>
<thead>
<tr>
<th>ES Semester</th>
<th>Dates</th>
<th># of hours</th>
<th>Hours / slot</th>
<th>Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>2019/07-2019/12</td>
<td>12</td>
<td>12</td>
<td>Keppler</td>
</tr>
<tr>
<td>S2</td>
<td>2020/01-2020/06</td>
<td>48</td>
<td>12</td>
<td>Keppler</td>
</tr>
<tr>
<td>S3</td>
<td>2020/06-2020/11</td>
<td>36</td>
<td>2</td>
<td>Keppler</td>
</tr>
<tr>
<td>S4</td>
<td>2020/12-2021/05</td>
<td>36</td>
<td>2</td>
<td>TESS</td>
</tr>
<tr>
<td>S5</td>
<td>2021/06-2021/11</td>
<td>32</td>
<td>2</td>
<td>TESS</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>164</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total observed (incl. test time)</strong></td>
<td></td>
<td><strong>176</strong></td>
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<td></td>
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</tbody>
</table>
39.8 – 67.7 MHz

144 beamlets: 204 .. 347
30 MHz x 5 targets x 10 mins = 1.2 TB
Processing pipeline

- **Front-end**: 83 Mini Arrays, 5 analog beams
- **LaNewBa**: 144 beamlets, 40-69 MHz
- **UnDySPuTeD**: Waveform recording NenuFAR RAW
- **SETIBK**

Python GPU offline pipeline:
- Fine channelization + data integration: 1.49 Hz / 671 ms
- Total power
- Beamlets splicing
- Conversion to Filterbank File (60 GB / FIL)
- Raw files deletion
Data analysis

- Data integration
- Baseline estimation and subtraction (median filter)
- RMS estimation (MAD)
- Peak detection ($\geq 13.5 \sigma$)
- Data base
Doppler drift search

- UC Berkeley Blimpy / TurboSETI software
- GPU search for drifting signals
- Logical search between on-/off-target observations
SETI with NenuFAR

• Commensal observation option in progress
• Data reduction pipeline requires further optimization
• TESS survey to be completed in S7
• SETI with NenuFAR paper expected in 2022

• Open to collaborate with NenuFAR community

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