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Jodrell Bank Observatory

SETI Surveys - an Interferometric approach.

Mike Garrett

Sir Bernard Lovell Chair, Prof. of Astrophysics,

Director Jodrell Bank Centre for Astrophysics (JBCA).

SETI Survey Instruments

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- Most SETI surveys in the radio use large single dishes e.g. GBT, Parkes (Breakthrough Listen).

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- SETI surveys with distributed arrays (e.g. MeerKAT) typically employ "*beam-forming*" *techniques:*

  Makes the telescope look like a single dish…

  - Keeps the data rate manageable,
  - Analysis s/w can be reused,
  - Directivity increased (arcmin => arcsec),
  - *Collapses the Field-of-View.*

- Is there another, potentially better way?

SETI Interferometry

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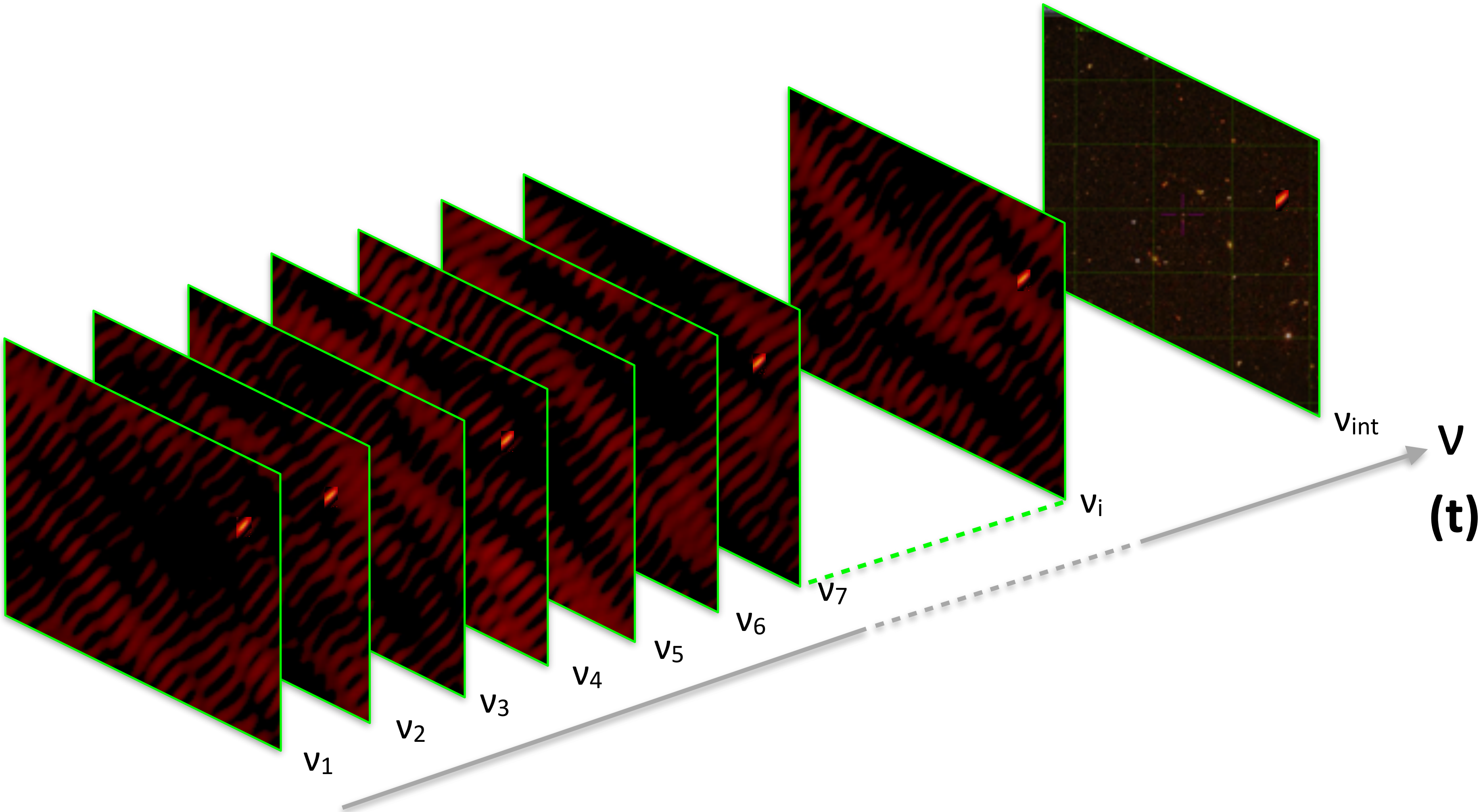
Interferometry offers some natural advantages:

- Natural filter for Radio Frequency Interference (RFI) e.g. Rampadarath et al. 2012.
- Independent baselines provide redundancy and increase confidence levels of a potential detection.
- SETI's requirement for high frequency and time resolution == Wide-field VLBI (10s Hz/msec).
- Thousands of targets in the field-of-view of the antenna beam are accessible.
- Interferometric analysis techniques can be employed.
- Milliarcsecond positions can pin-point the location of a potential SETI signal.

- SETI signal position is invariant (while just about everything might be changing)



SETI Interferometric Analysis

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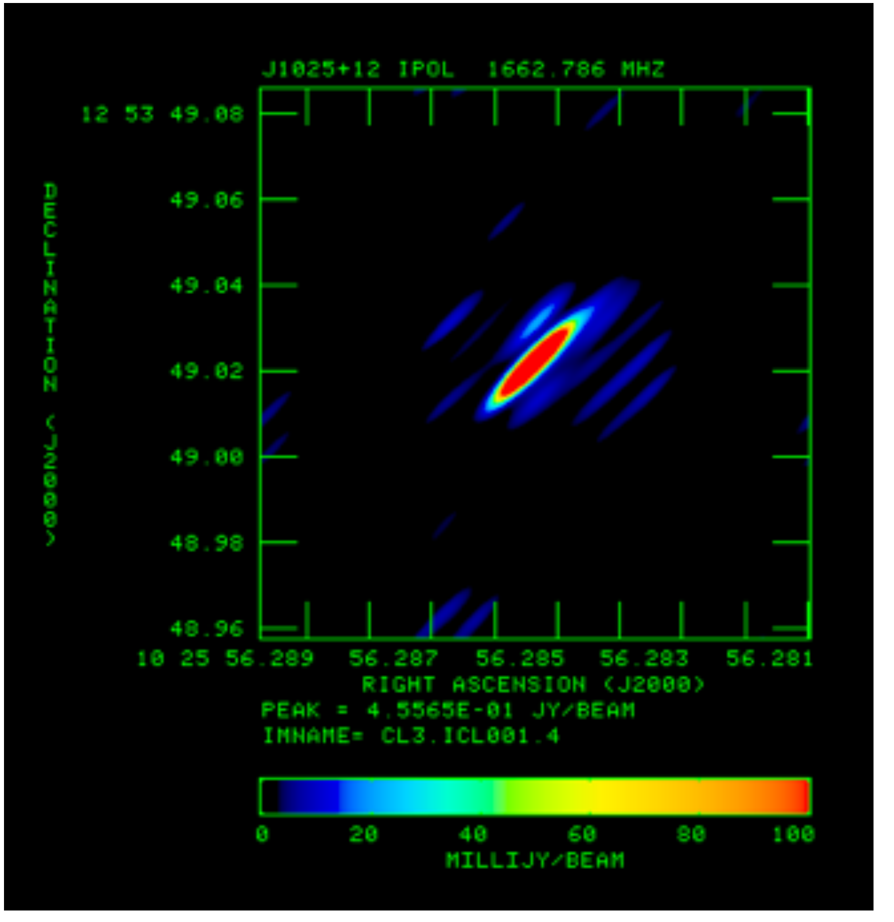
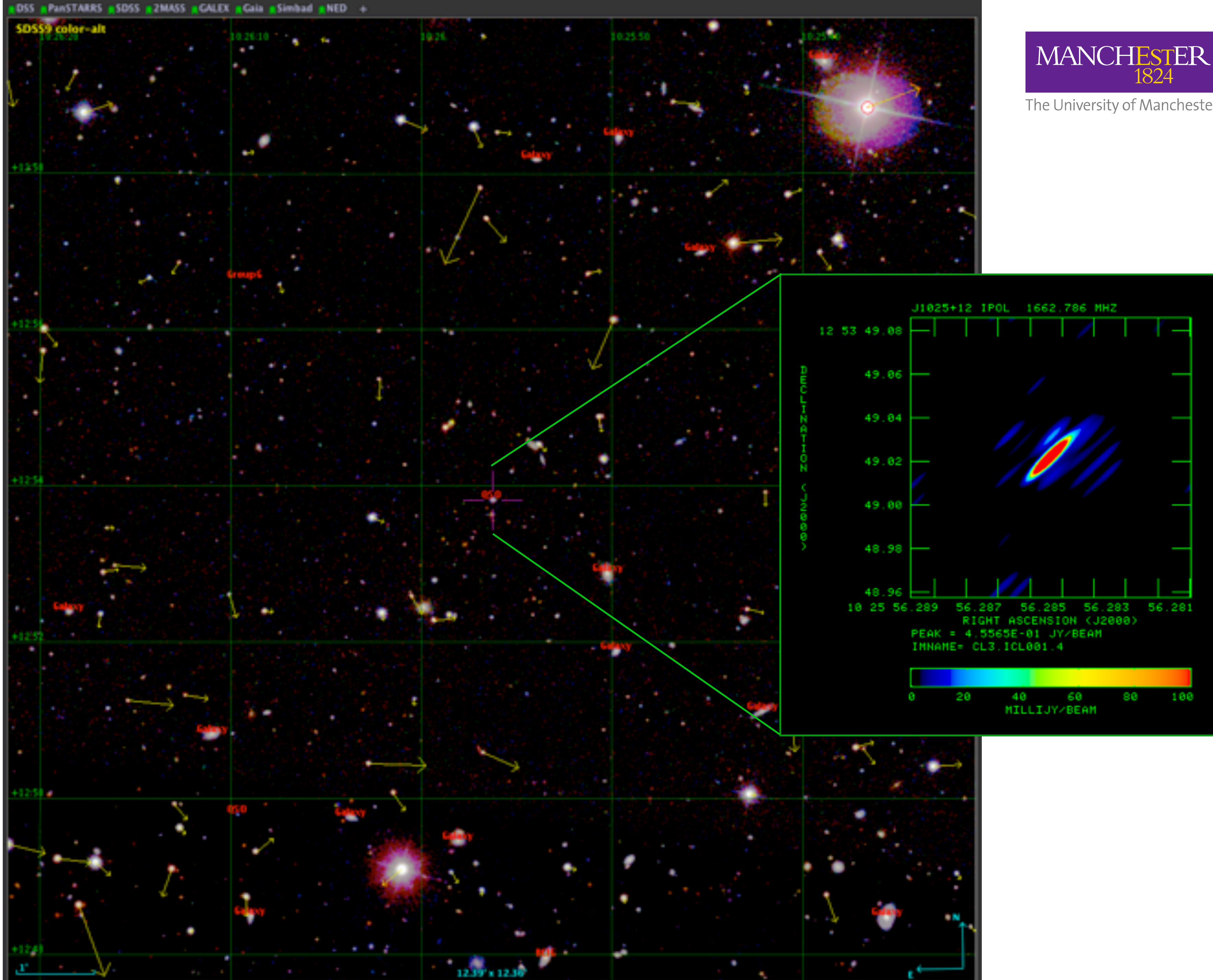
Demonstrator project - EVN archive (ED038):

- J1025+1253 - calibrator (QSO at z=0.663).
- Correlated with good spectral and temporal resolution (31kHz & 1/4 sec).
- Total on-source time 507 seconds.



EVN - 9 stations, λ18cm, 507 secs of data, rms noise ~ 1.5 mJy/beam.



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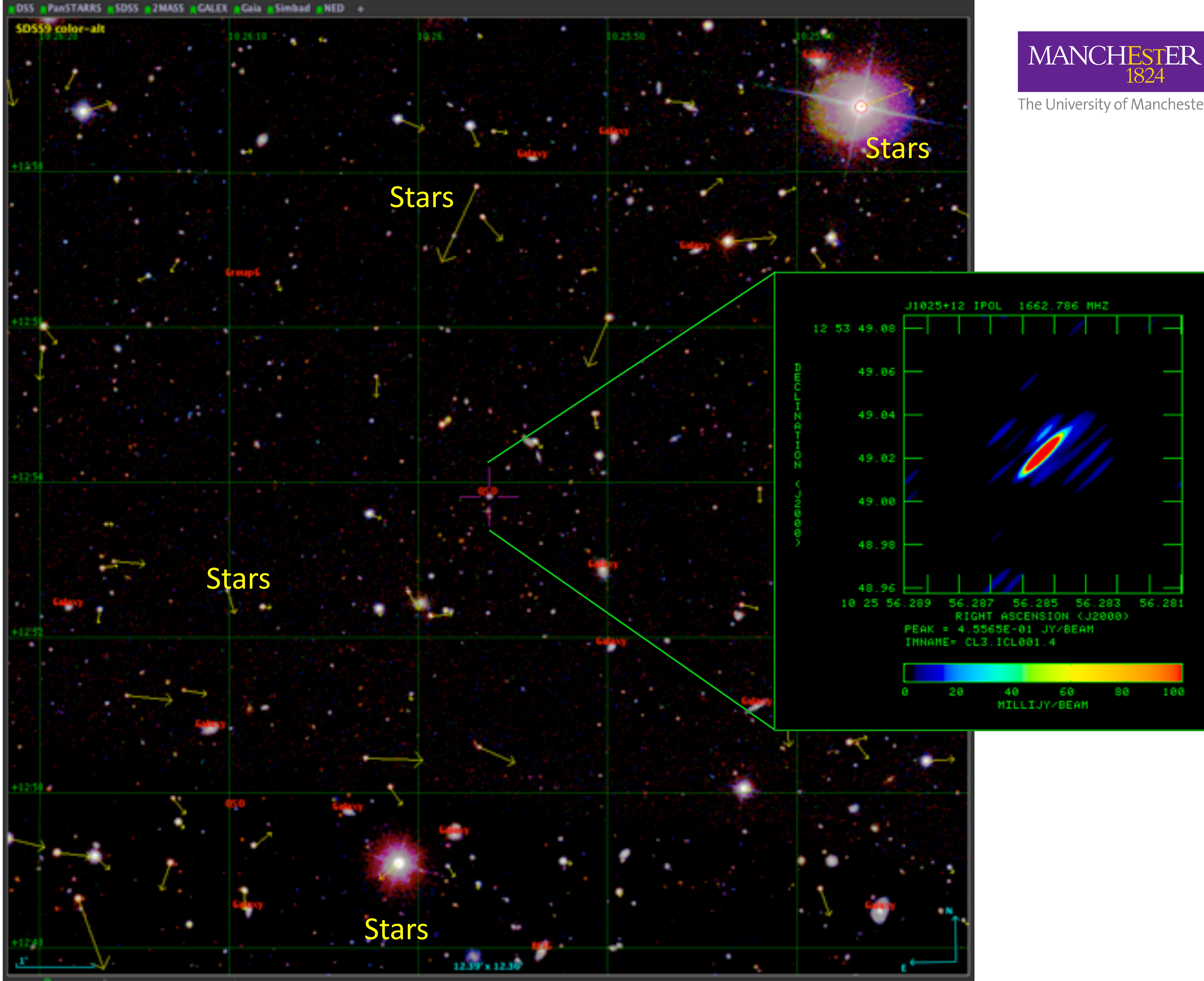

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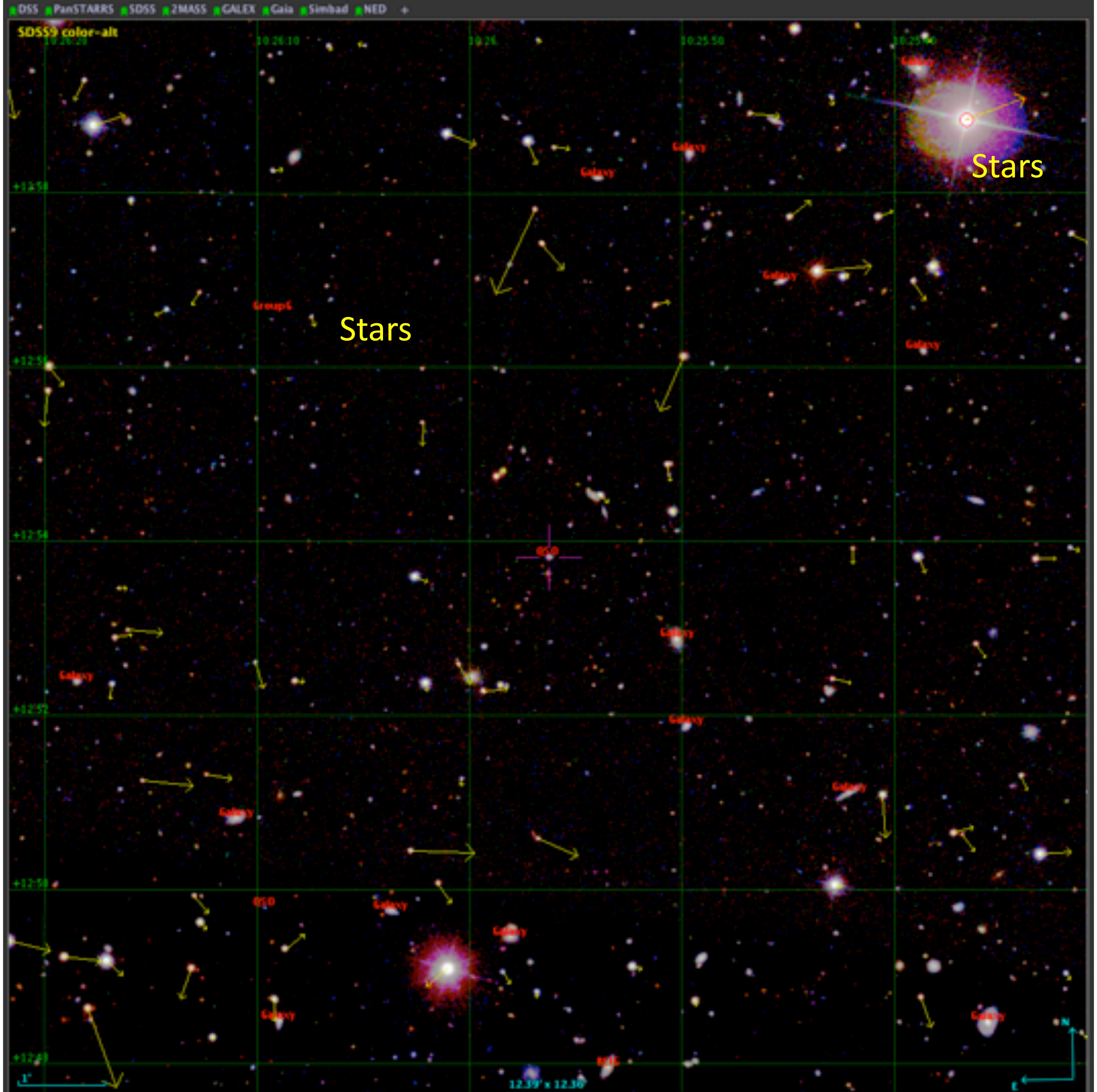

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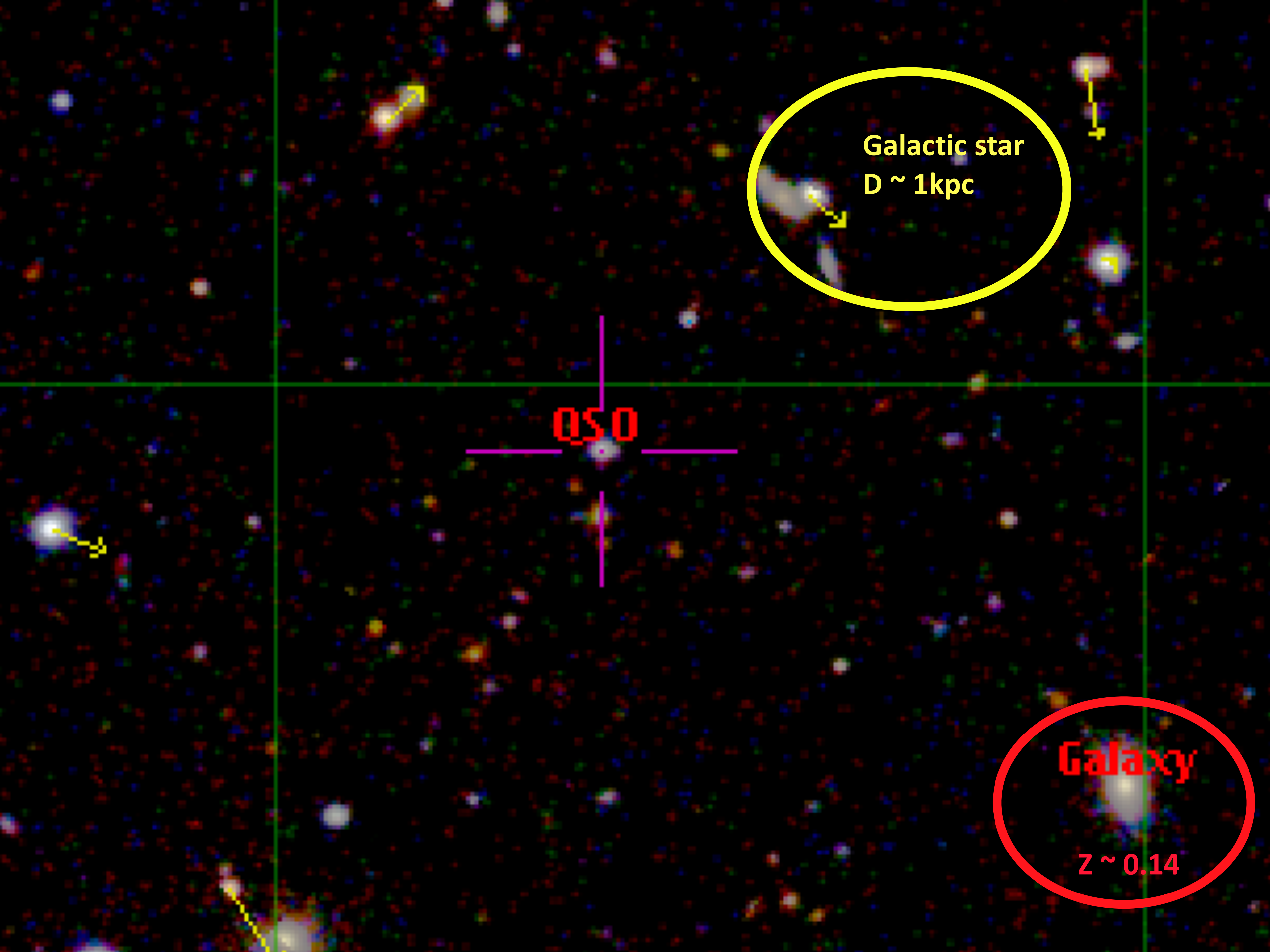
Galactic star
D ~ 1kpc
QSO
Galaxy
Z ~ 0.14

J1025+1253 uv-subtracted.

- r.m.s. 0.0007 Jy/beam

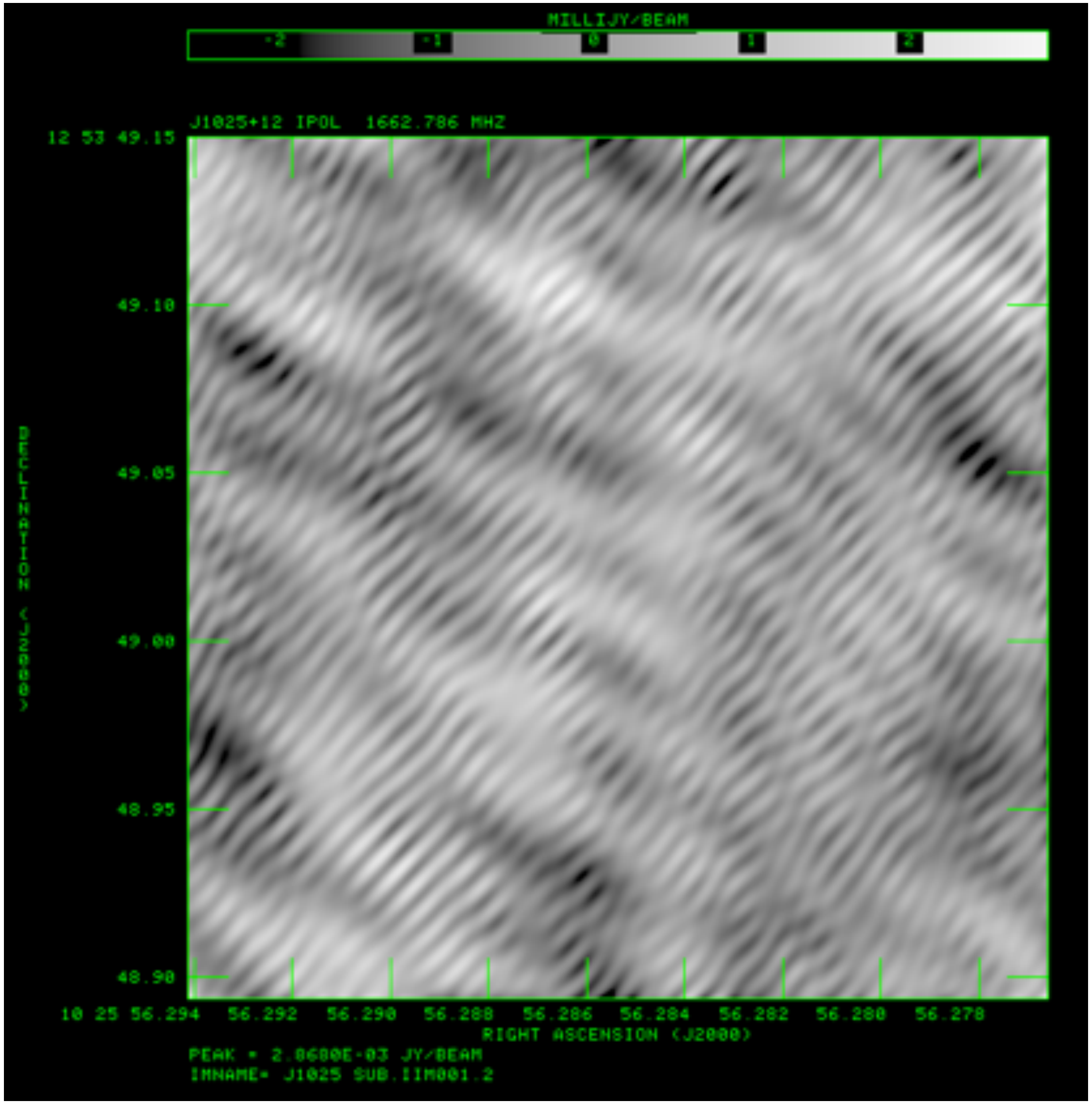

Table 1. Observational set up.

Parameter	Value
Frequency range	1.59-1.72 GHz
Total bandwidth	128 MHz (LCP & RCP)
Number of channels	8192 (LCP& RCP)
Channel width	31.25
Time on source	510 sec
Integration time	0.25 sec

Freq. channelisation is too course to worry about Doppler drifting… ;(

1] Collapse data across all baselines/(times):

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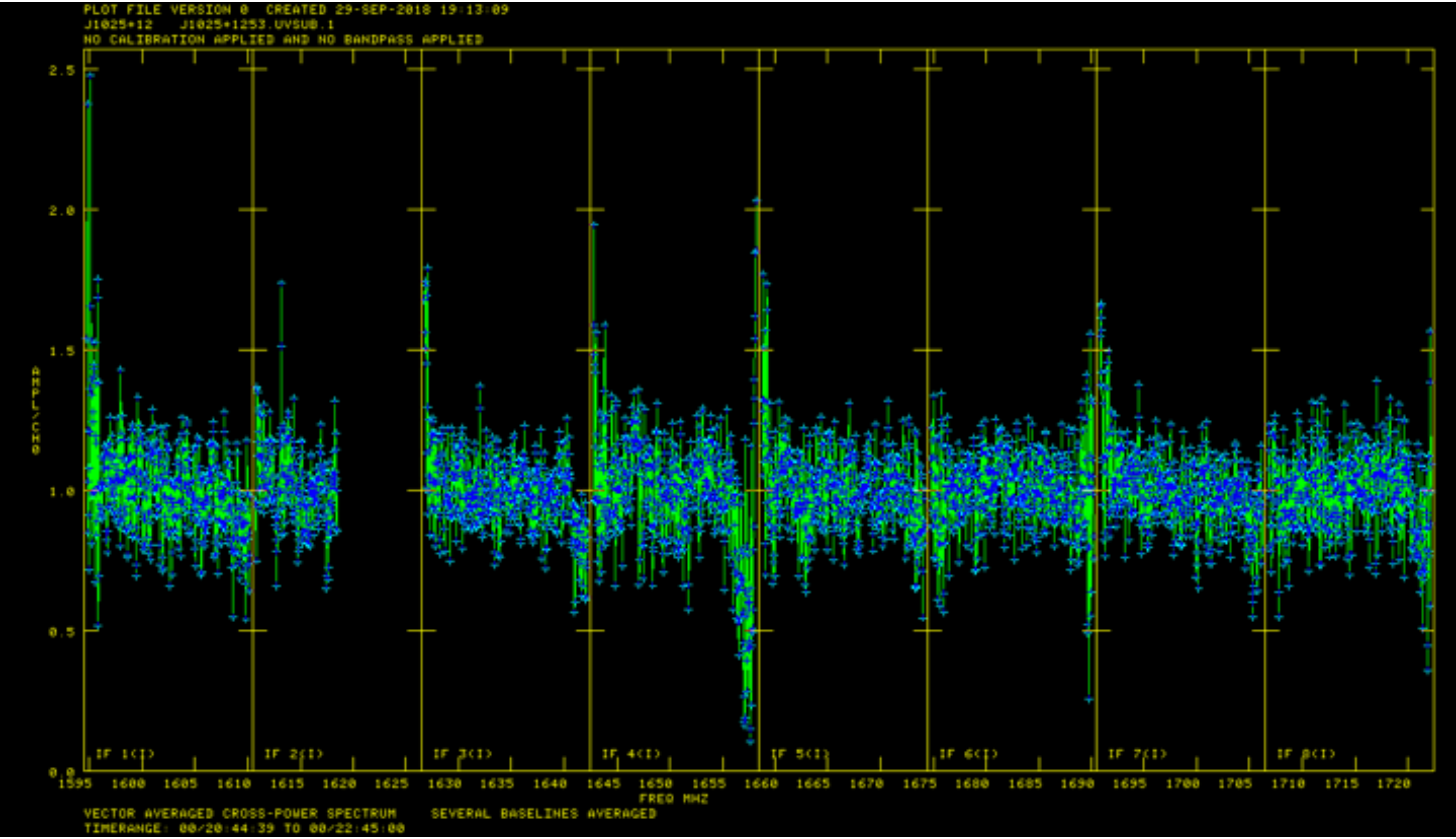
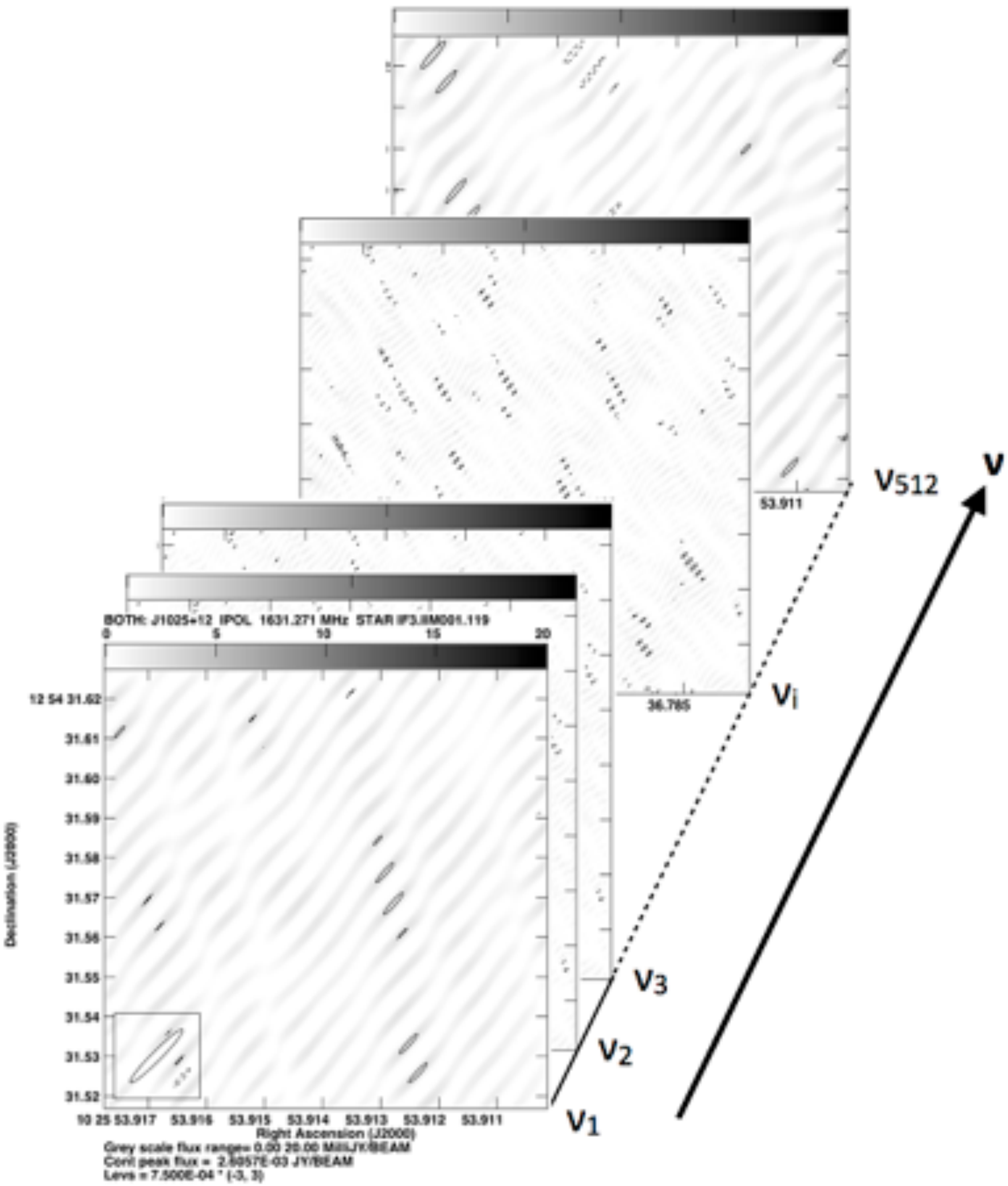
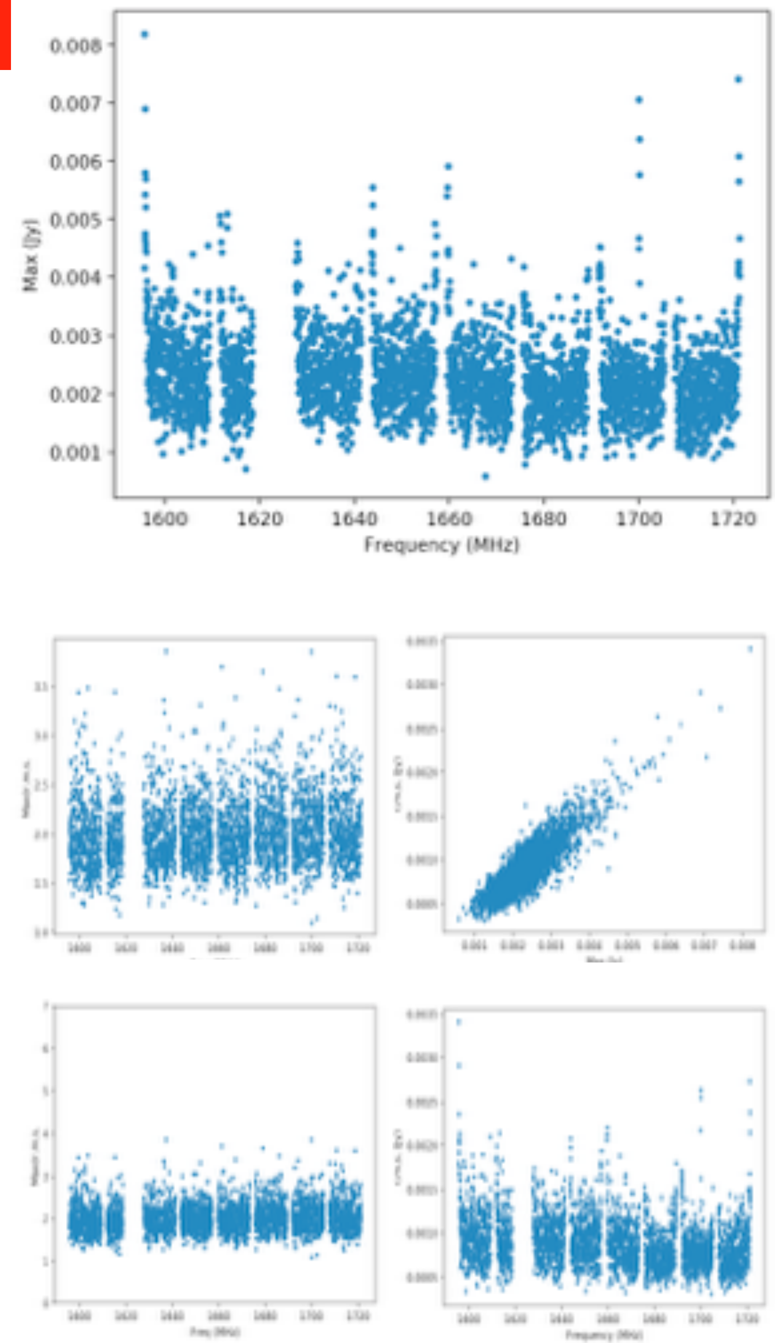
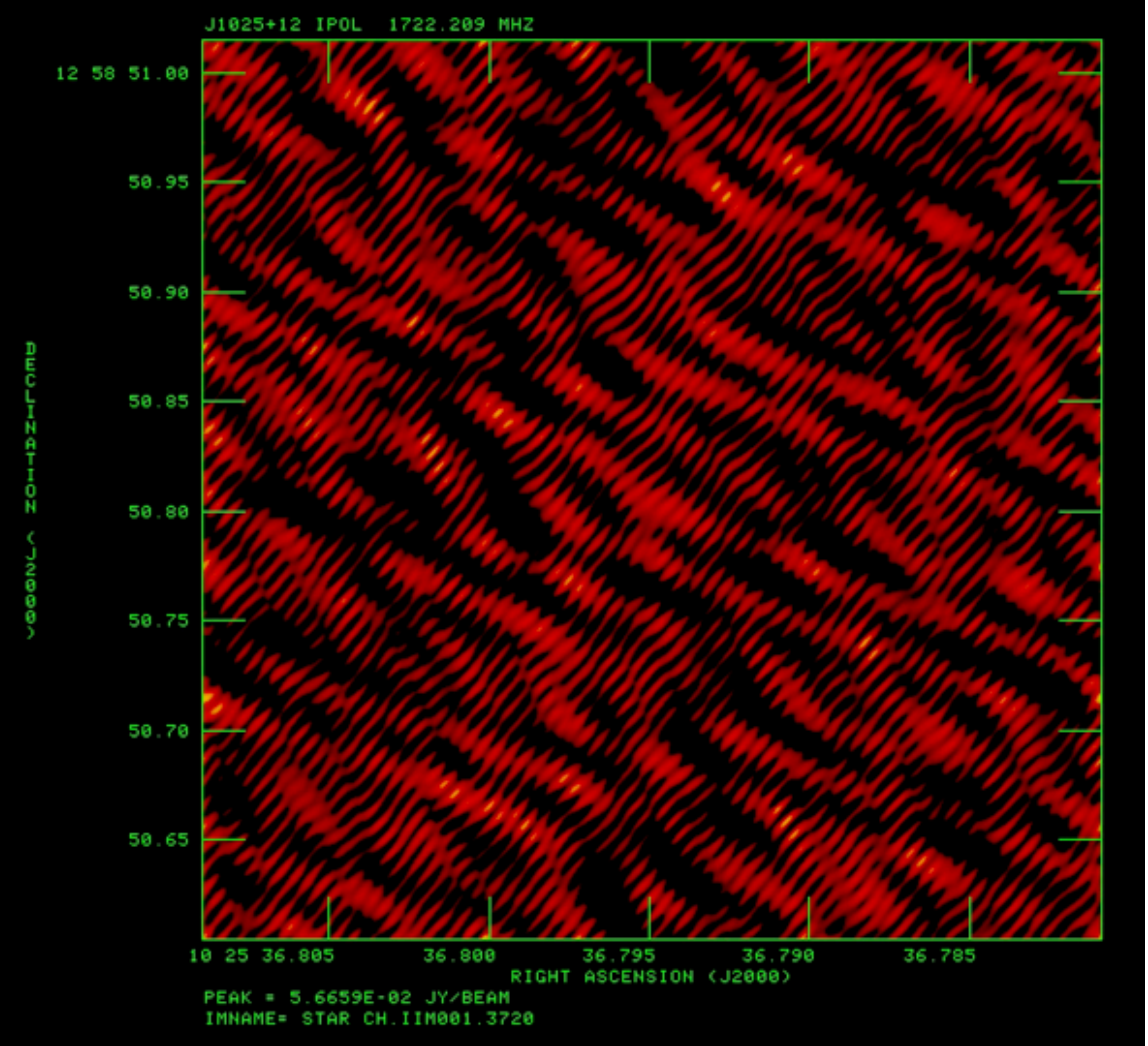


2] Image cube - vs frequency:







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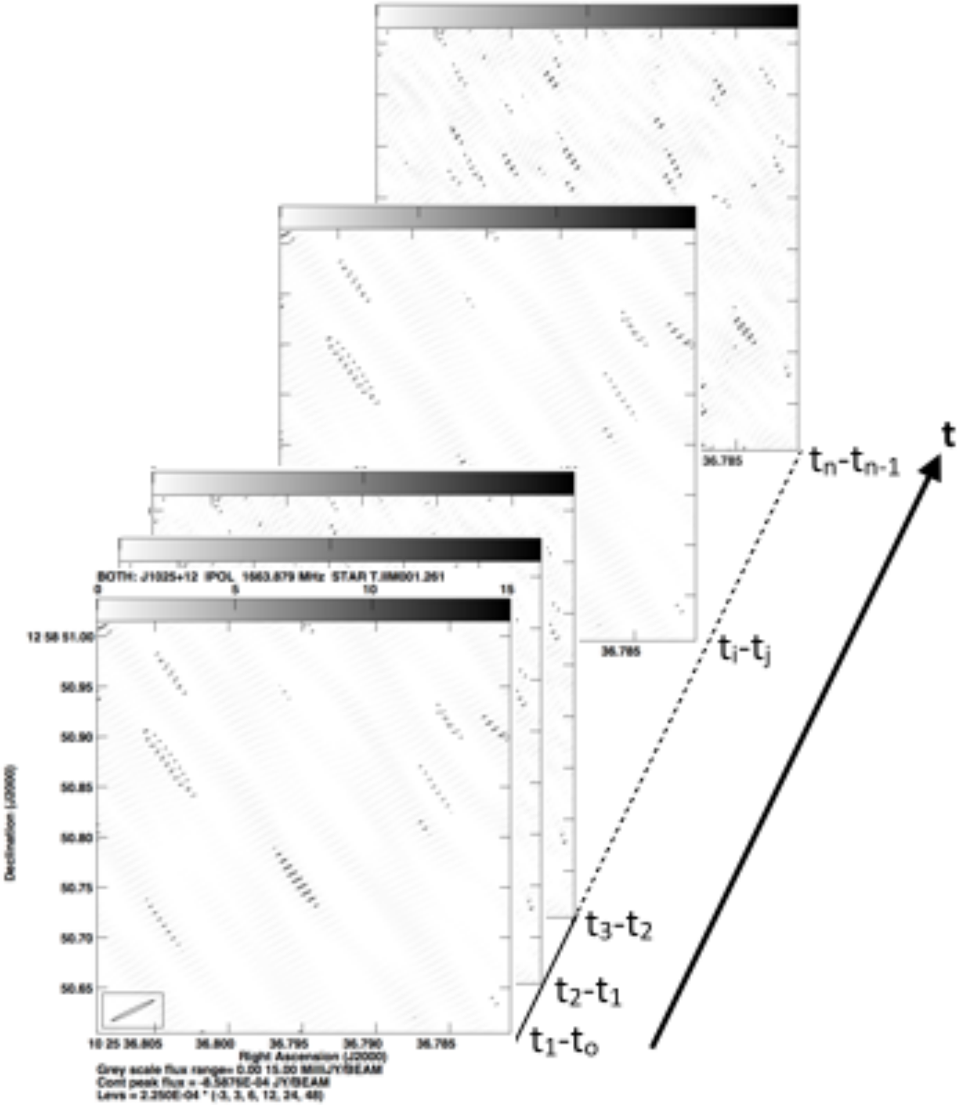
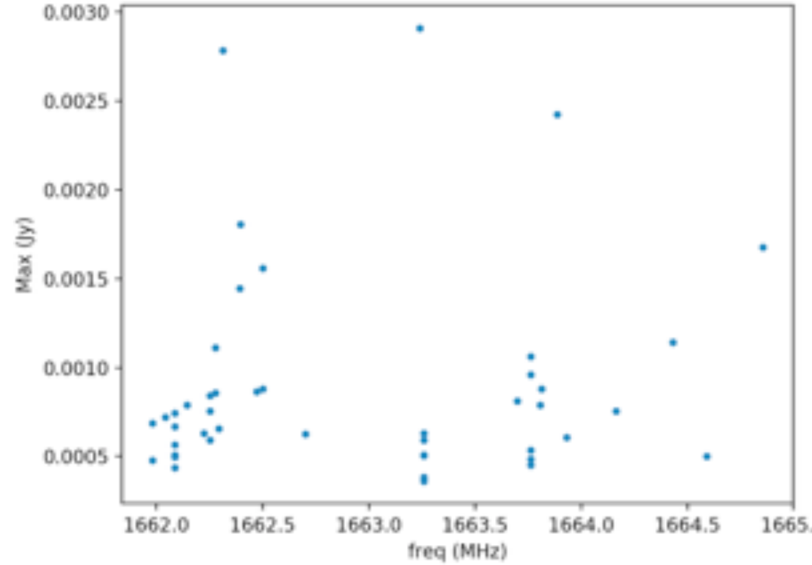
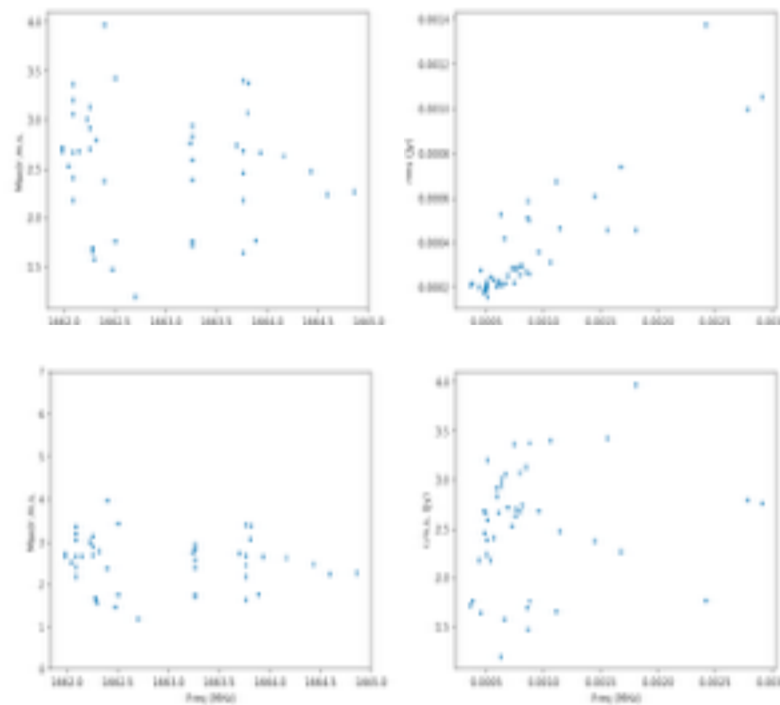
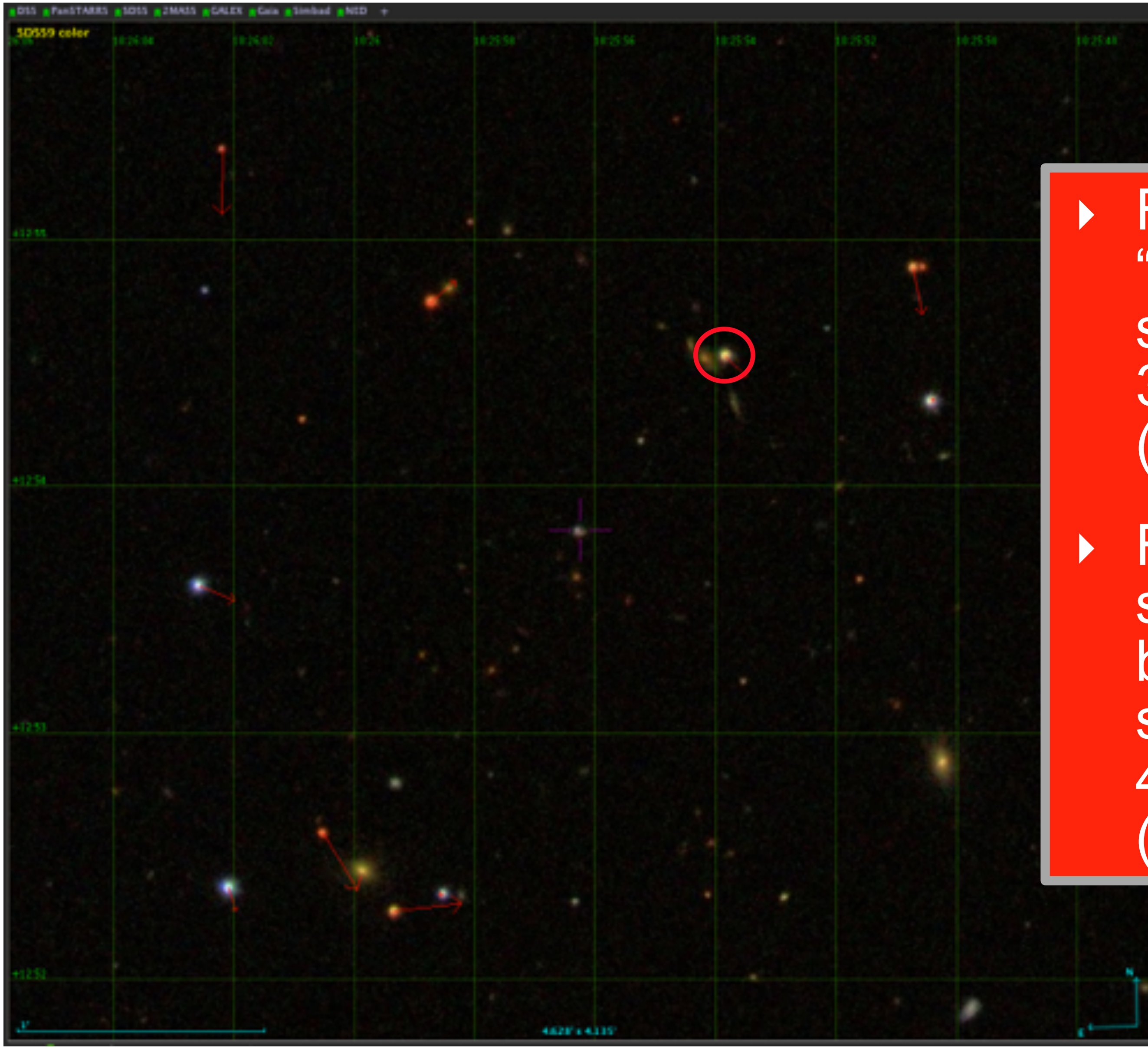
3] Image cube - vs time:







Results



- For star no “narrow-band” signals > $3.5x10^{16}$ W (EIRP).
- For 10 second segments, no broad-band signals > $4.8x10^{19}$ W (EIRP)

Results

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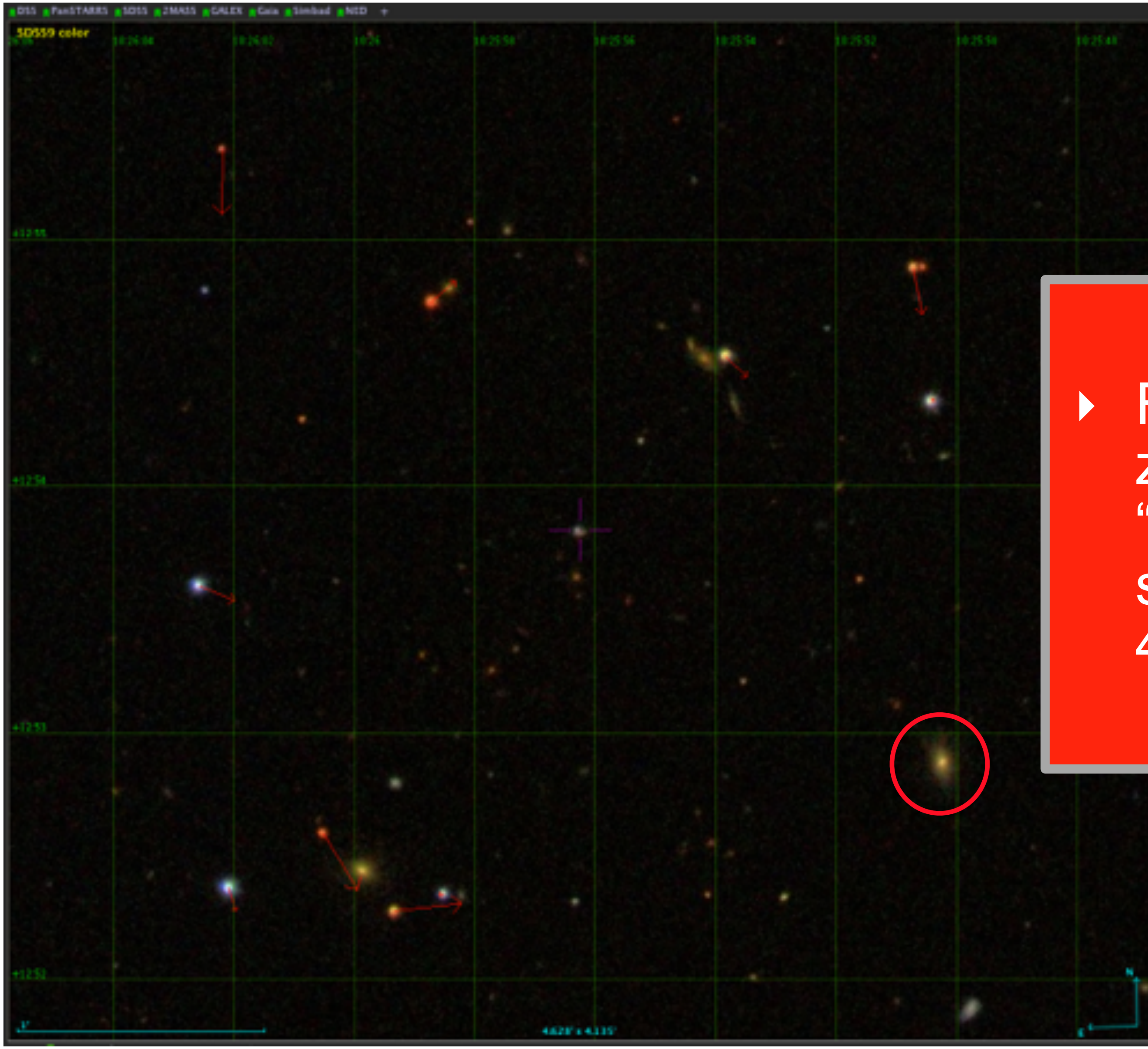
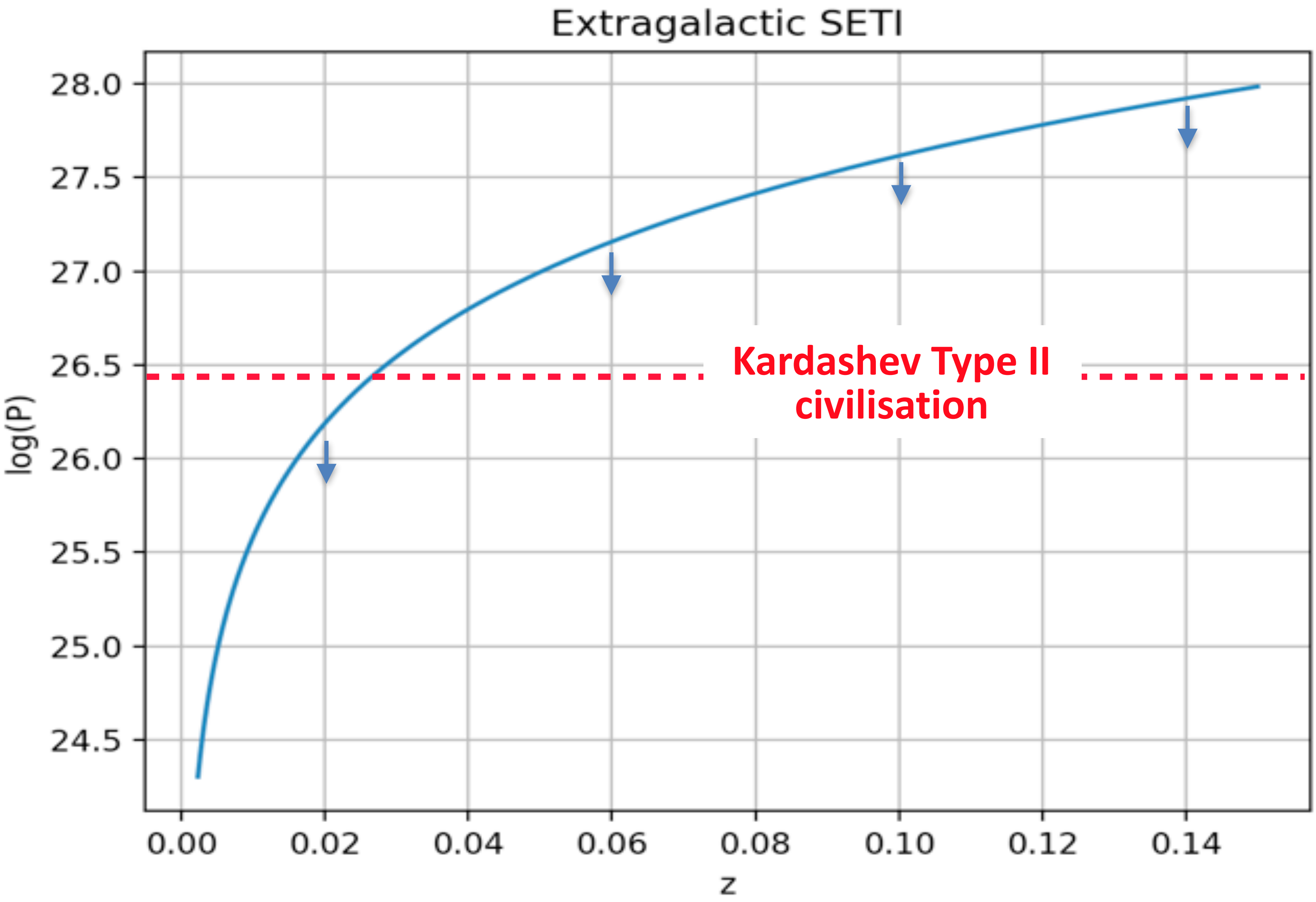


- For galaxy at z=0.14, no "narrow-band" signals > $4.5x10^{27}$ (EIRP)!

Extragalactic SETI - EVN limits:



Extragalactic SETI

- These are EIRP power values - real transmitters will also have large forward gains (e.g. Arecibo 60 dbi)
- Much better, higher (frequency) resolution VLBI data sets with longer on-source integration times are possible.
- Power requirements are not beyond the capabilities of Kardarshev Type I/II civlisations…?

SETI & VLBI:

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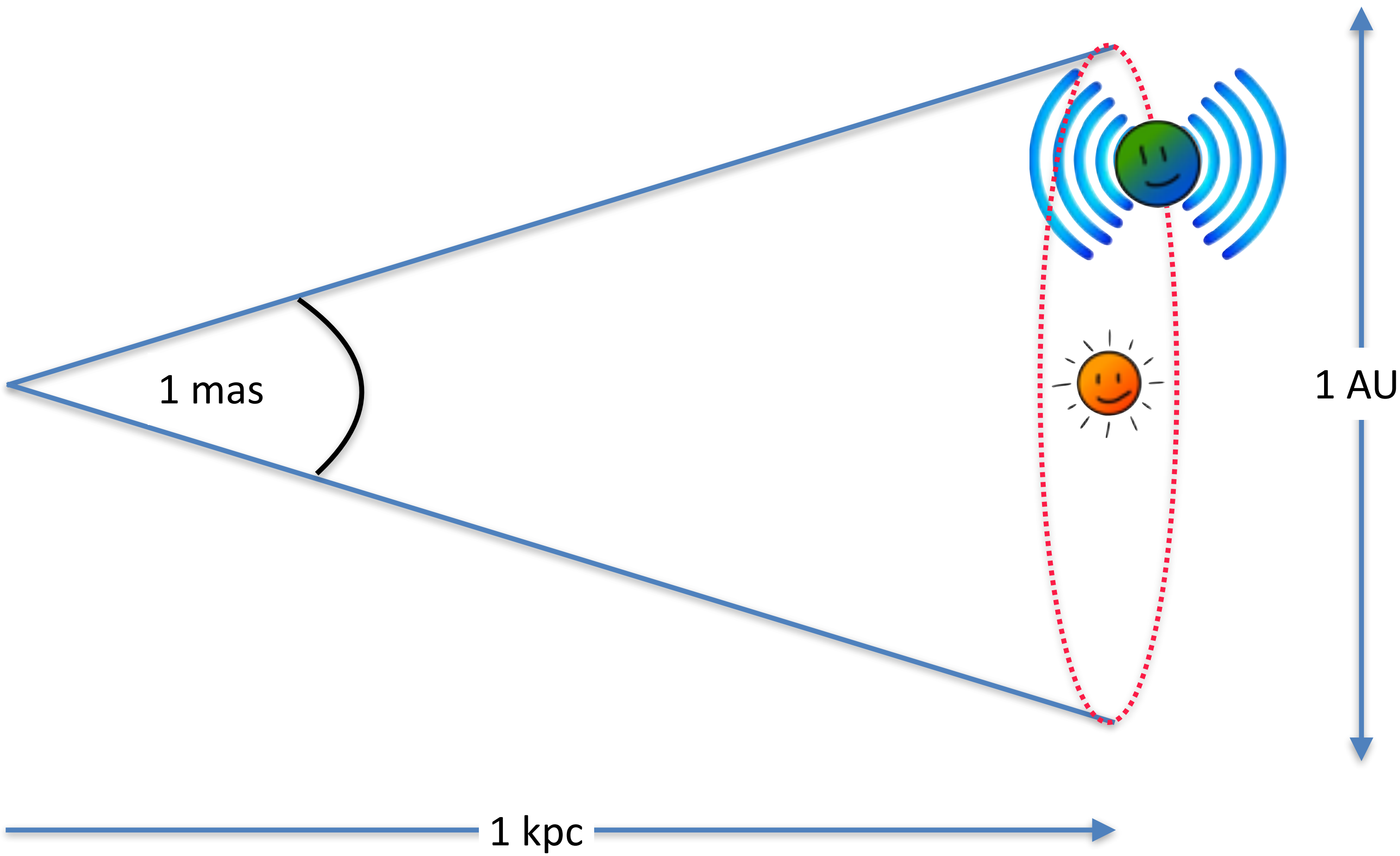
Pin-pointing the location of SETI transmitters around stars…



‣ SETI & VLBI:

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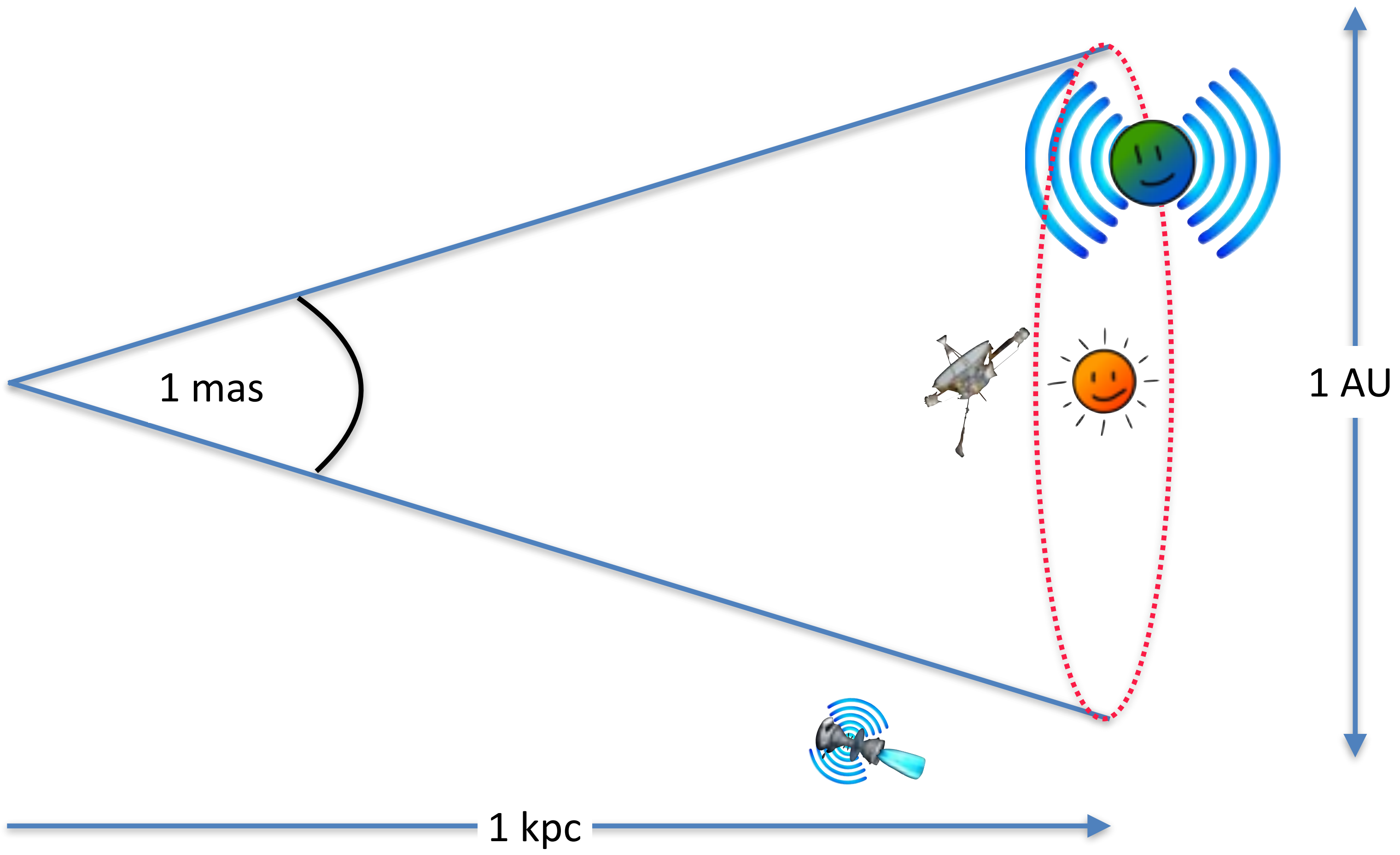

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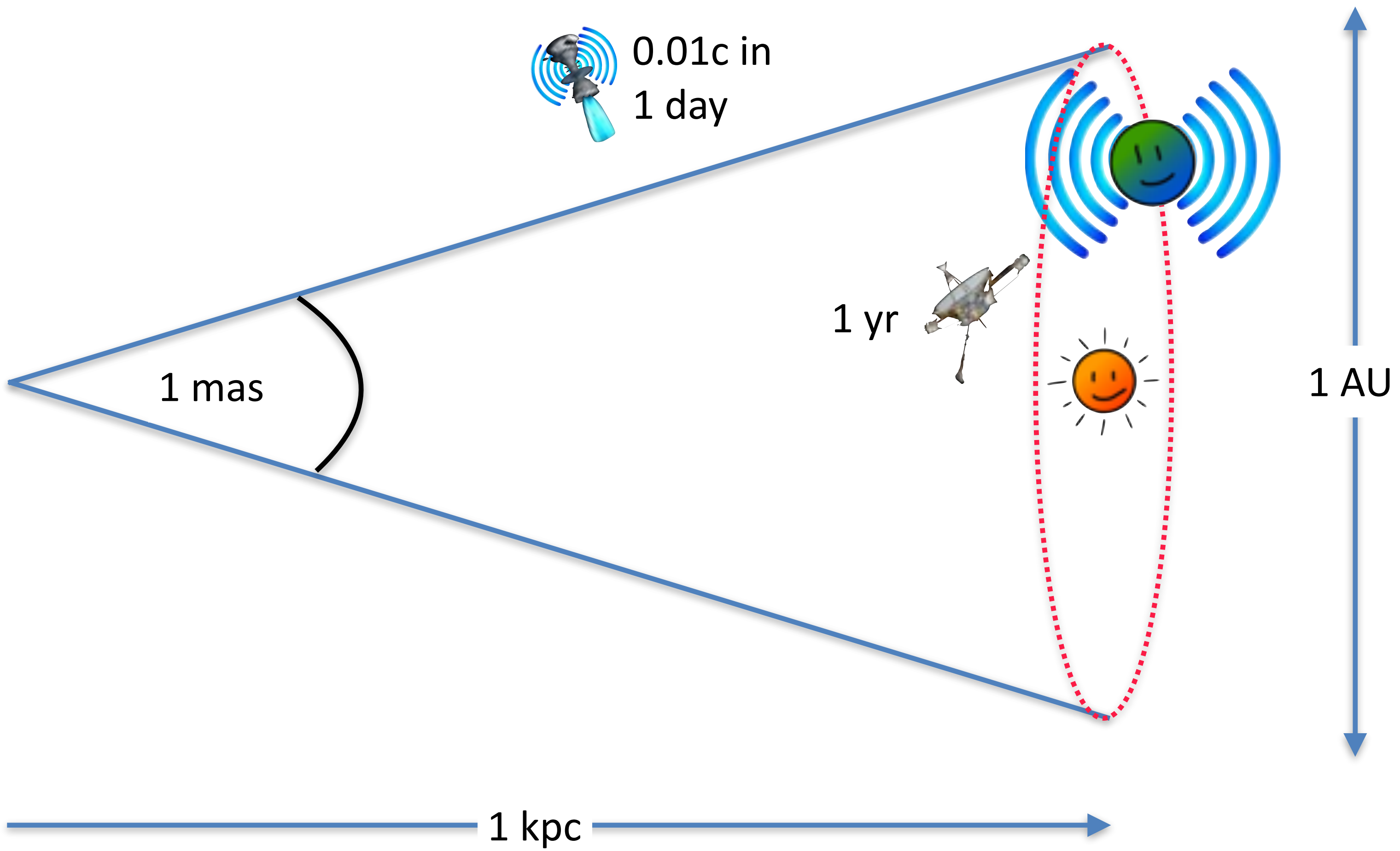
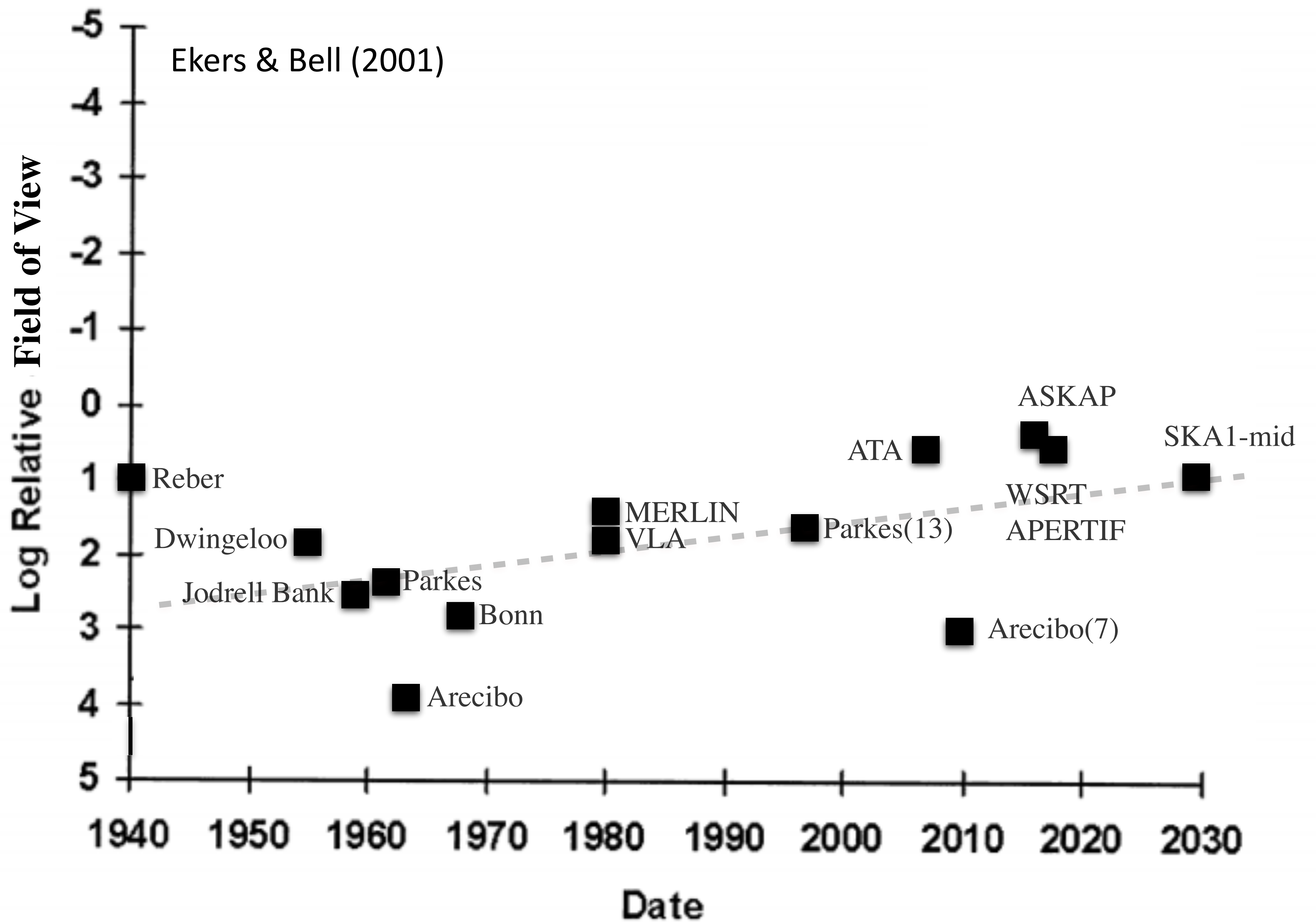


- Modest gains in field-of-view at cm wavelengths…



Summary

SETI surveys using interferometers and interferometer techniques should be investigated further.

VLBI offers many advantages, greatly reducing false-positives, and increasing confidence and robustness in the results.

Interferometry also permits the use of techniques such as frequency stacking, machine learning, etc.

A VLBI SETI capability is something to aim for with thousands of potential targets in the field-of-view.

Extragalactic radio SETI is maybe not so crazy afrerall !?

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@Mike_Garrett

Thank you!

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