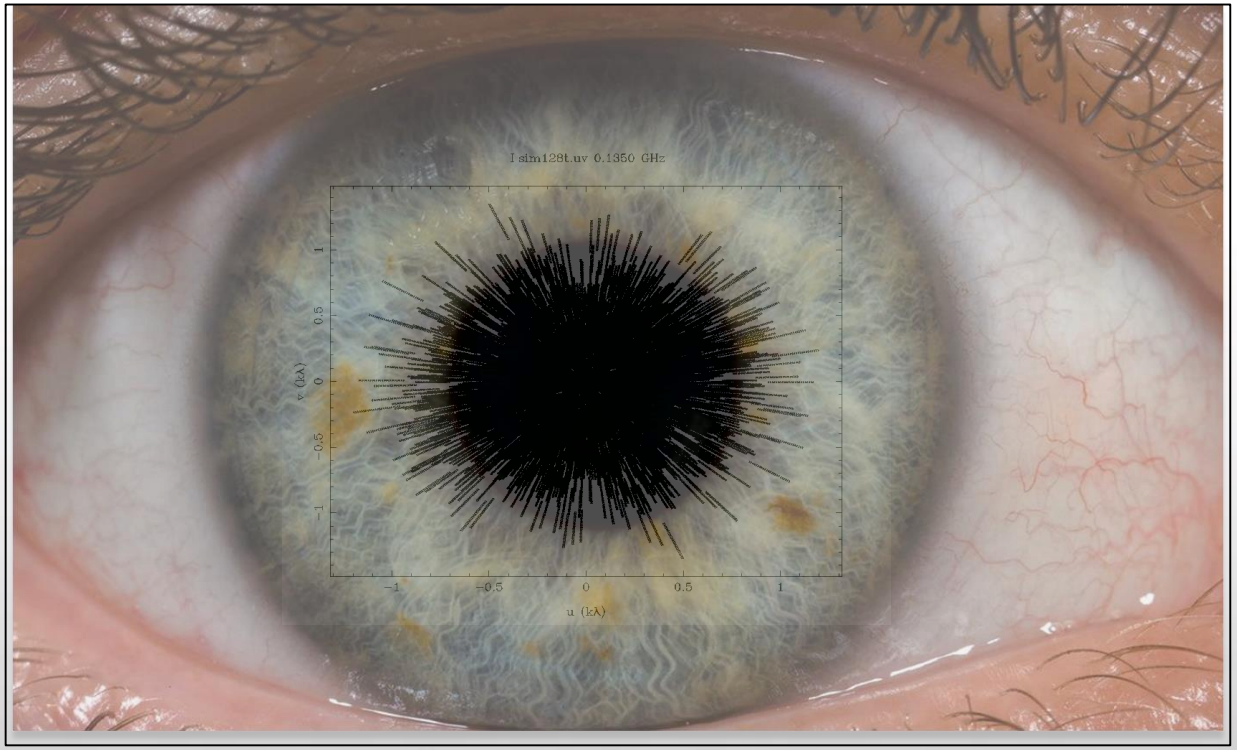
IPS Surveys: Performing a Census of compact low-frequency Radio Sources



John Morgan, Rajan Chhetri,

Ron Ekers, Elaine Sadler

Overview

- Overview of Interplanetary Scintillation
- Overview of the Murchison Widefield Array
- IPS with the MWA
- The MWA Phase II IPS Survey
- GPS/CSS sources in the Phase II Survey
- Future Work

A Discovery of IPS

Discovered by Margaret Clarke

"If some mechanism similar to that which causes scintillations is operating, the lateral scale of the irregularities must be on the scale of 1km and if no fluctuations are observed when the source diameter is greater than about 5" it can be estimated that the irregularities must be more than 30,000 km away … **it is not inconceivable that the phenomenon is associated with solar corona effects**" Margaret Clarke (PhD Thesis 1964)]

Extremely useful filter for astrophysics

"…interplanetary scintillation **may be a powerful and convenient technique to measuring angular diameters of magnitude <1" "** Hewish et al. (Nature 1964)

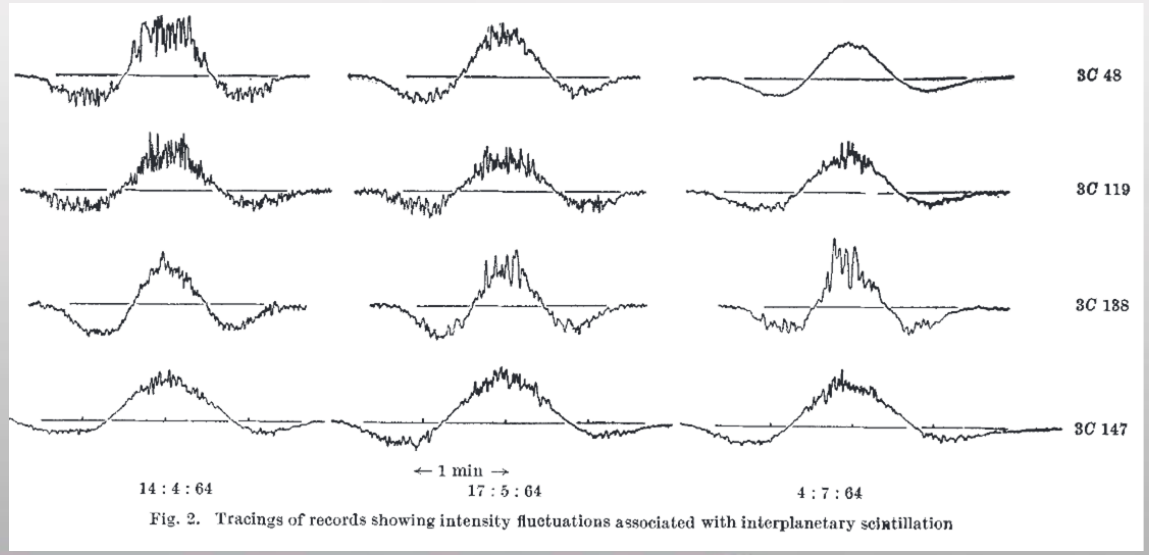


Fig. 2. Tracings of records showing intensity fluctuations associated with interplanetary scintillation

Cambridge IPS Array

Instrument was commissioned at the dawn of the VLBI / high-frequency era.

IPS has barely been used for astrophysical studies since 1970s

About the Murchison Widefield Array

www.mwatelescope.org

GOVERNMENT OF WESTERN AUSTRALIA
CSIRO
UNIVERSITY OF TASMANIA
THE UNIVERSITY OF MELBOURNE
Curtin University
ICRAR International Centre for Radio Astronomy Research
HAYSTACK OBSERVATORY
THE UNIVERSITY OF WESTERN AUSTRALIA
Australian Government
ANU THE AUSTRALIAN NATIONAL UNIVERSITY
THE UNIVERSITY OF SYDNEY
CfA
MKI
TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI VICTORIA UNIVERSITY OF WELLINGTON
SWINBURNE UNIVERSITY OF TECHNOLOGY

Murchison Radio Observatory

Murchison Radio-astronomy Observatory (127km^2)

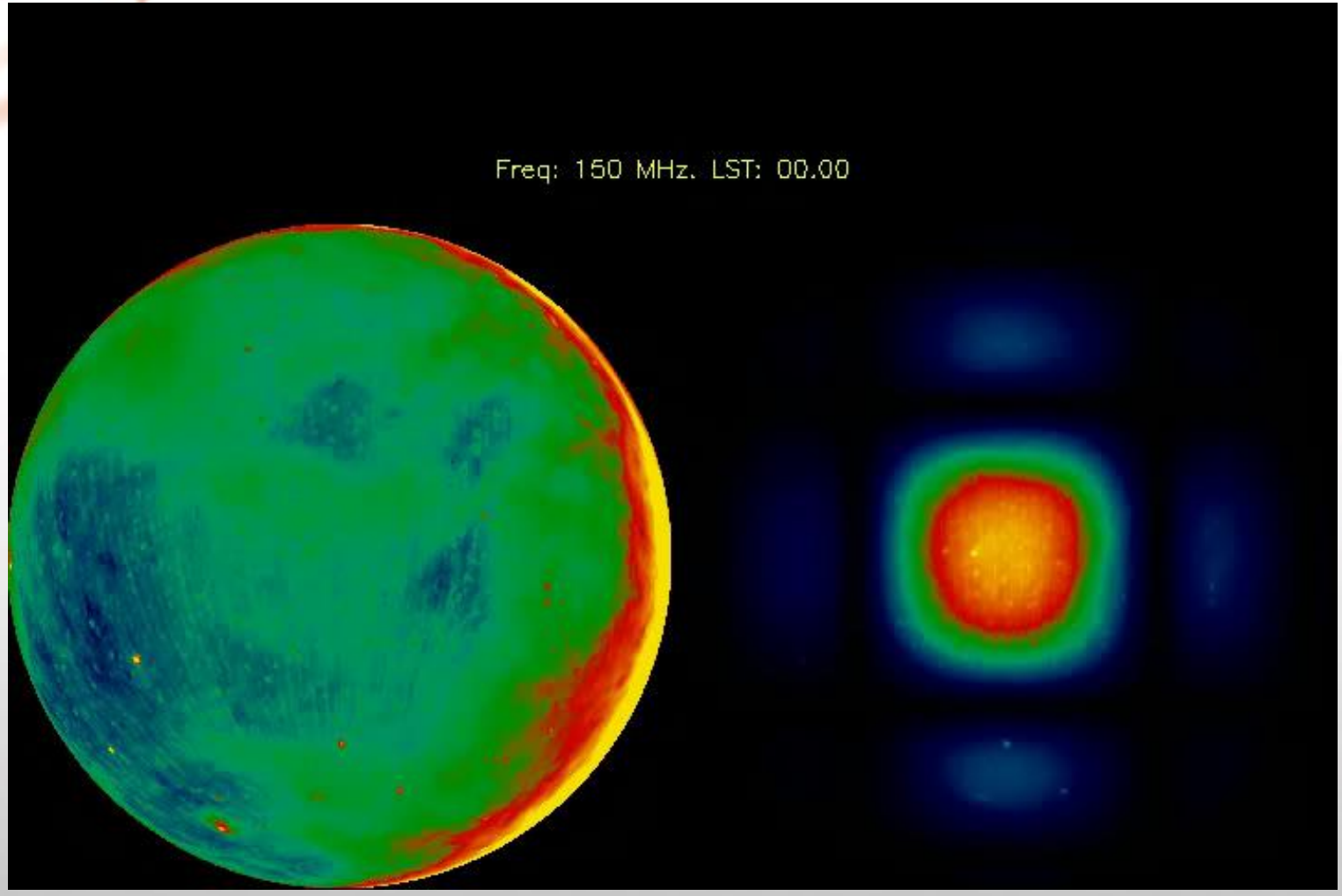
Radio Quiet Coordination Zone (260km radius)

Western Australia

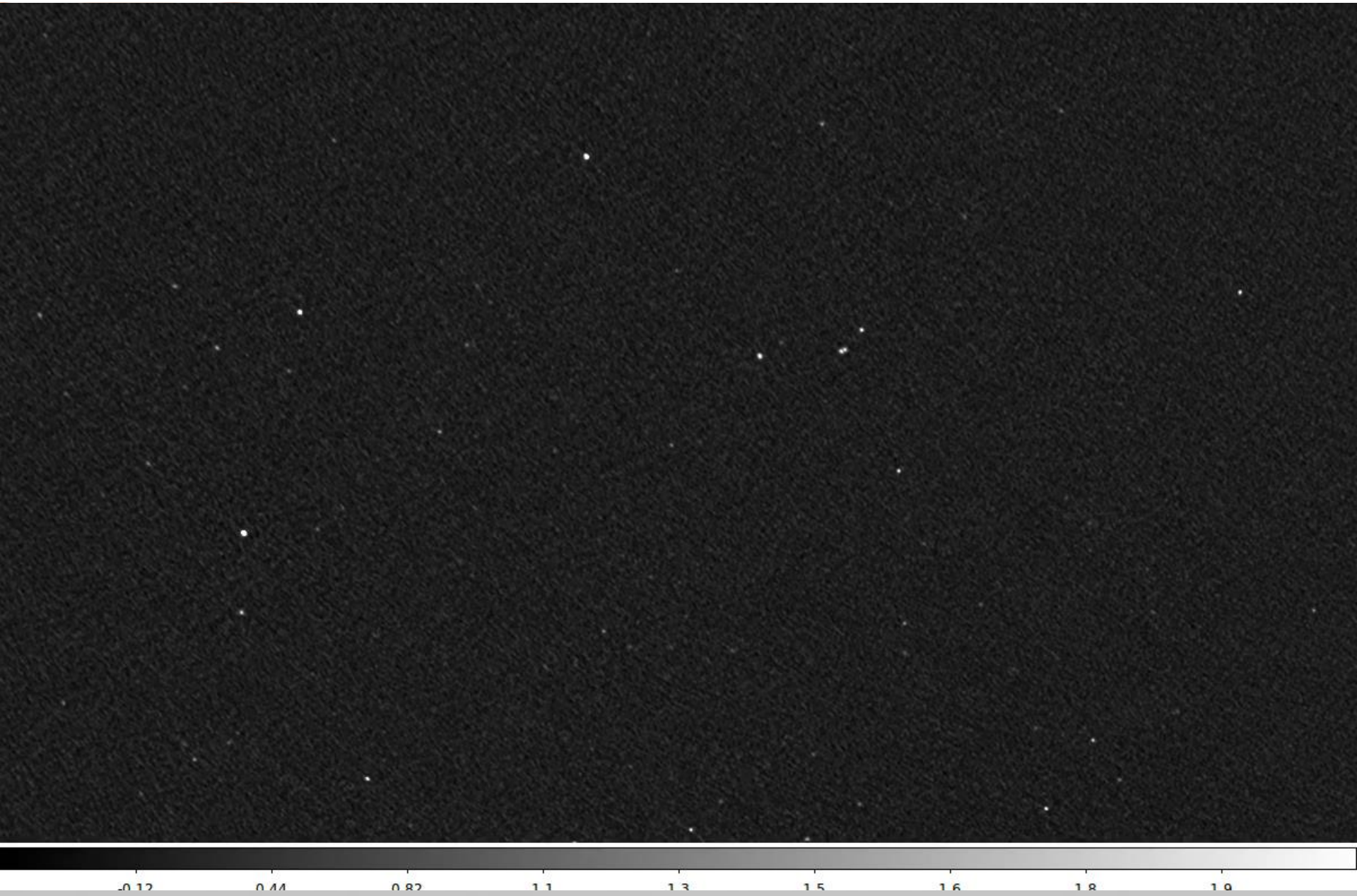
Geraldton

Perth

Huge Field of View!

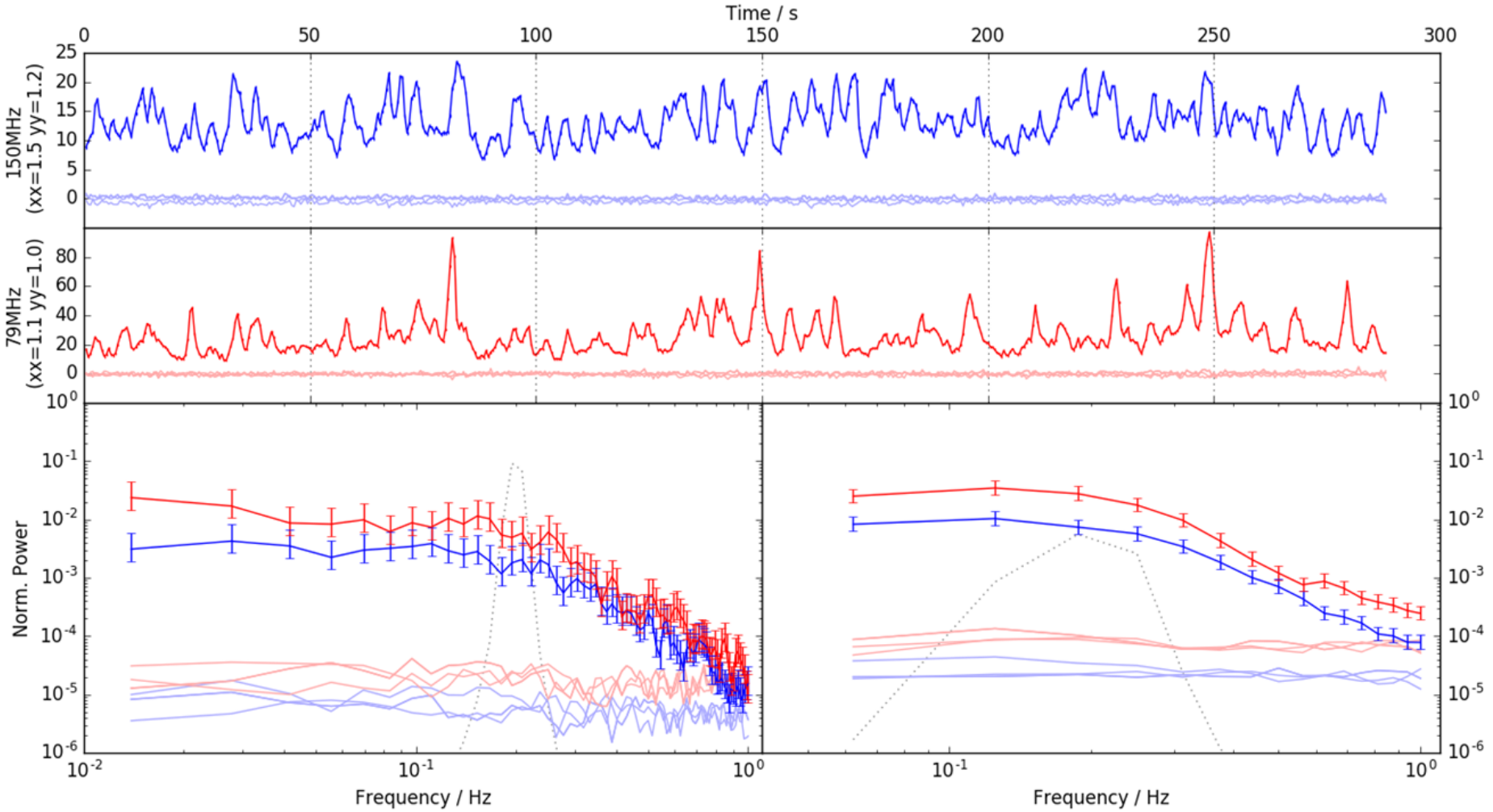


Left: Haslam all-sky 408MHz Right: As seen by MWA (autoscale)

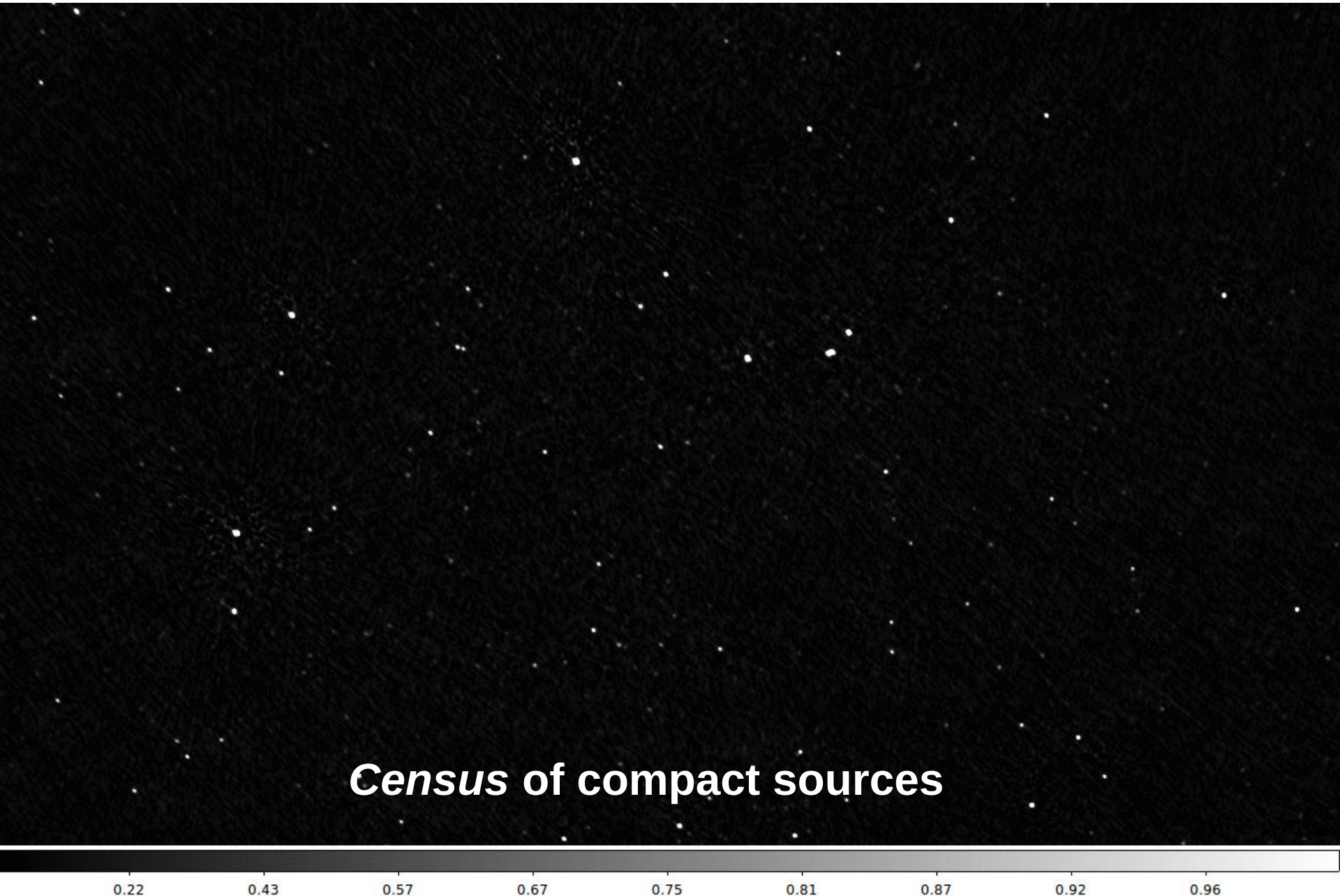


8˚×5˚ field; 1 minute of data (4×real time)

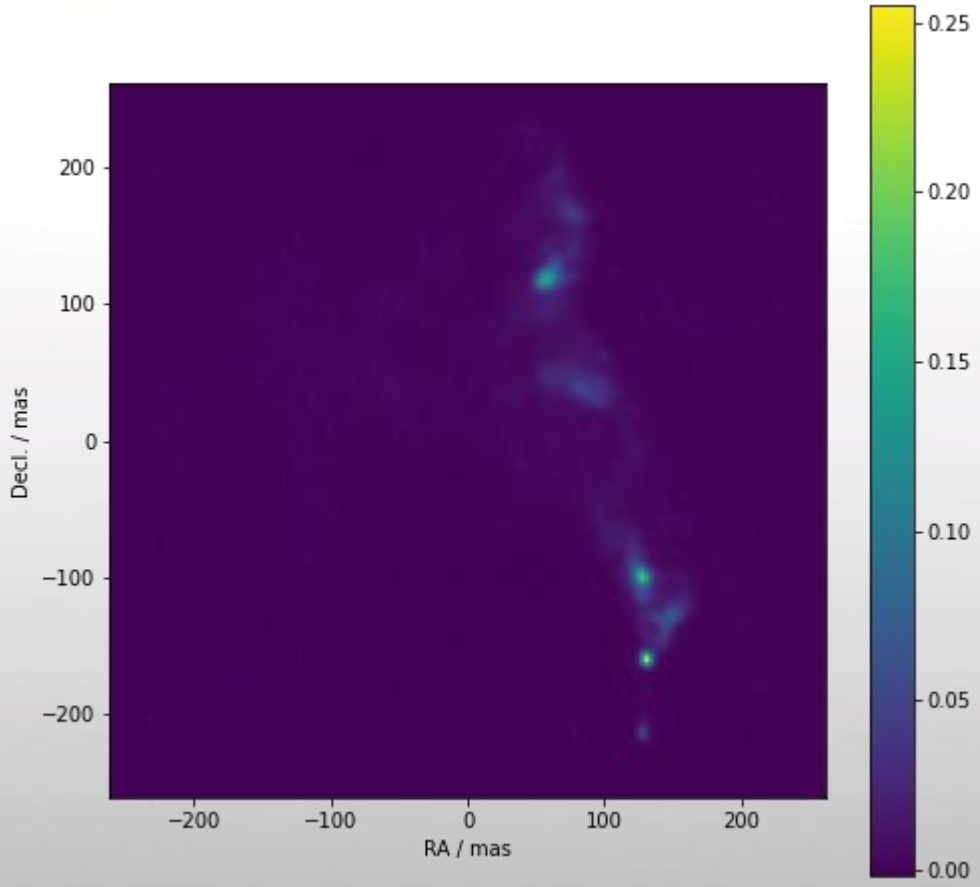
Matched filter

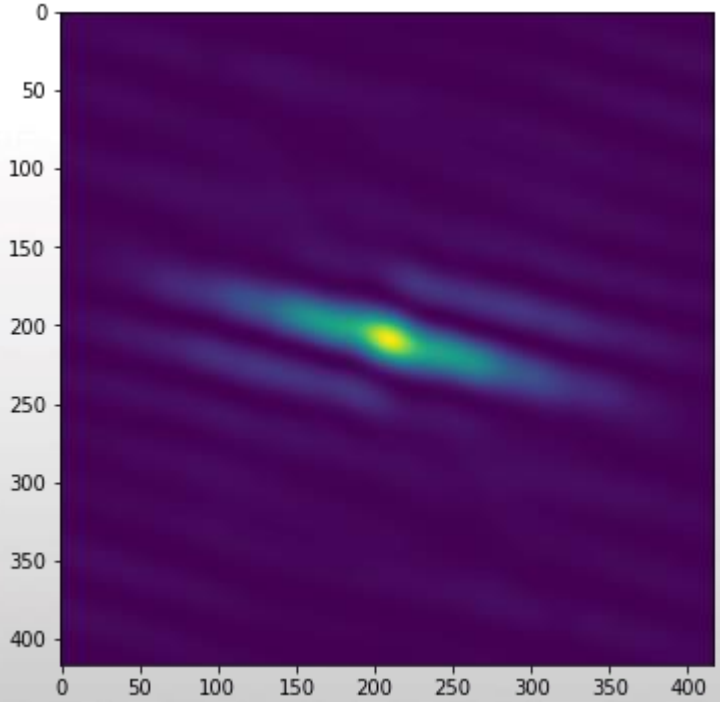


Mean Image vs RMS Image



What do IPS scintillation indices actually measure?

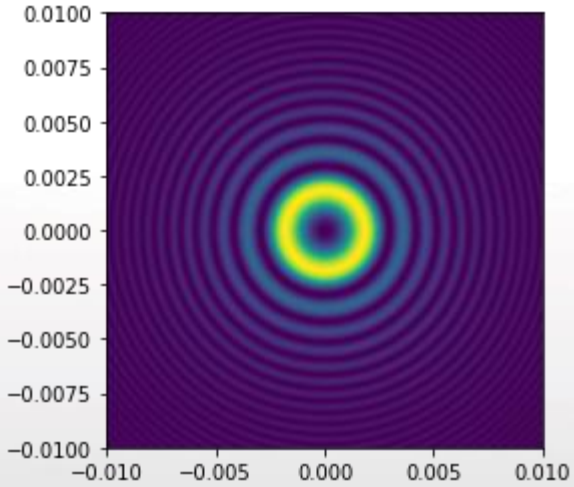




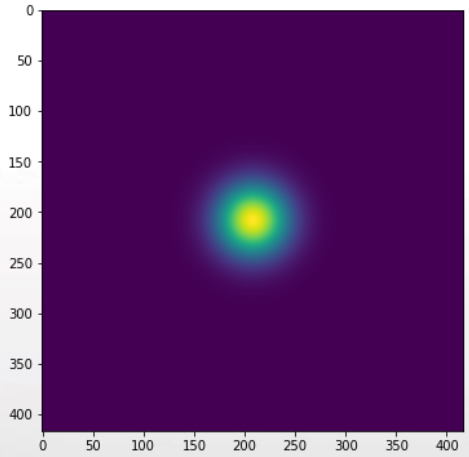
3C48 VLBA image (An et al.)

What do IPS scintillation indices actually measure?

Normalised Scintillation index=

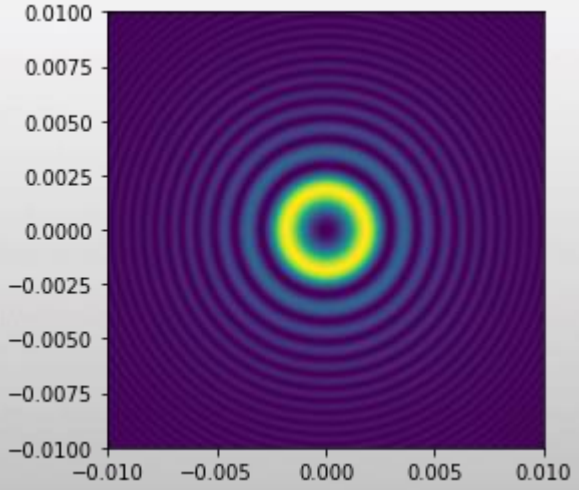


×



Double Integral

Double integral



Fresnel **filter**

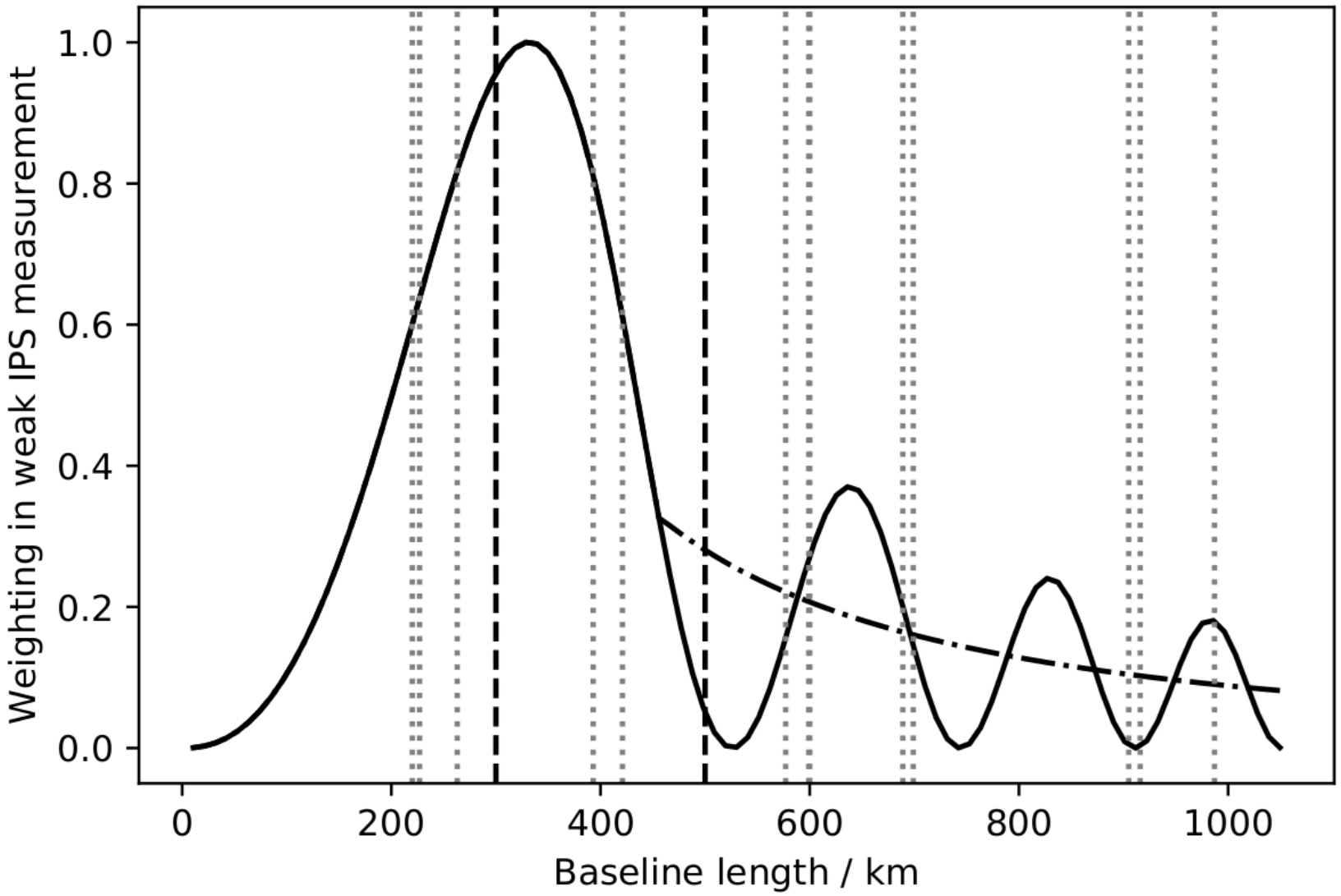
×

turbulence power spectrum

Source visibility amplitude squared

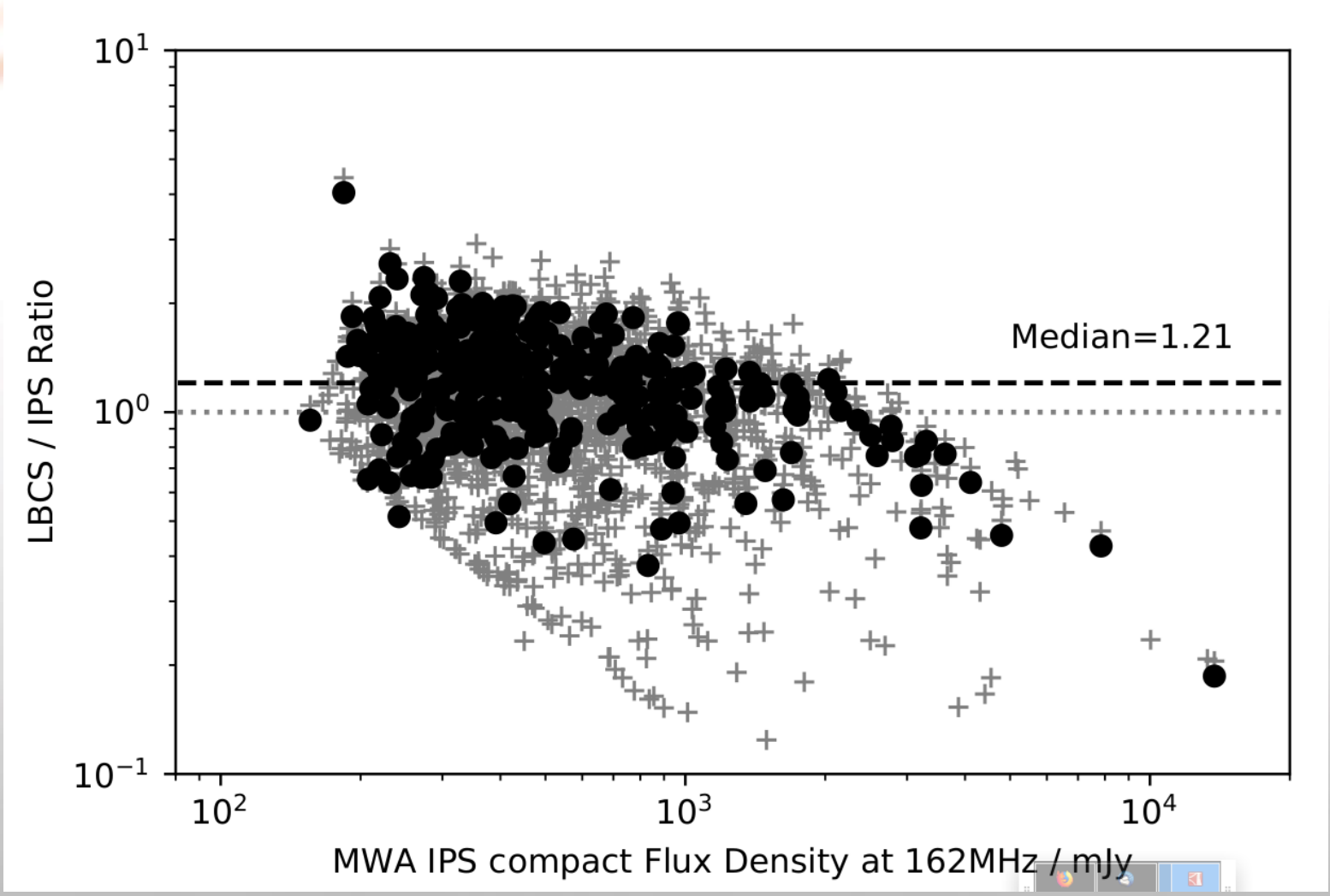
Square root

IPS Weighting of UV Plane



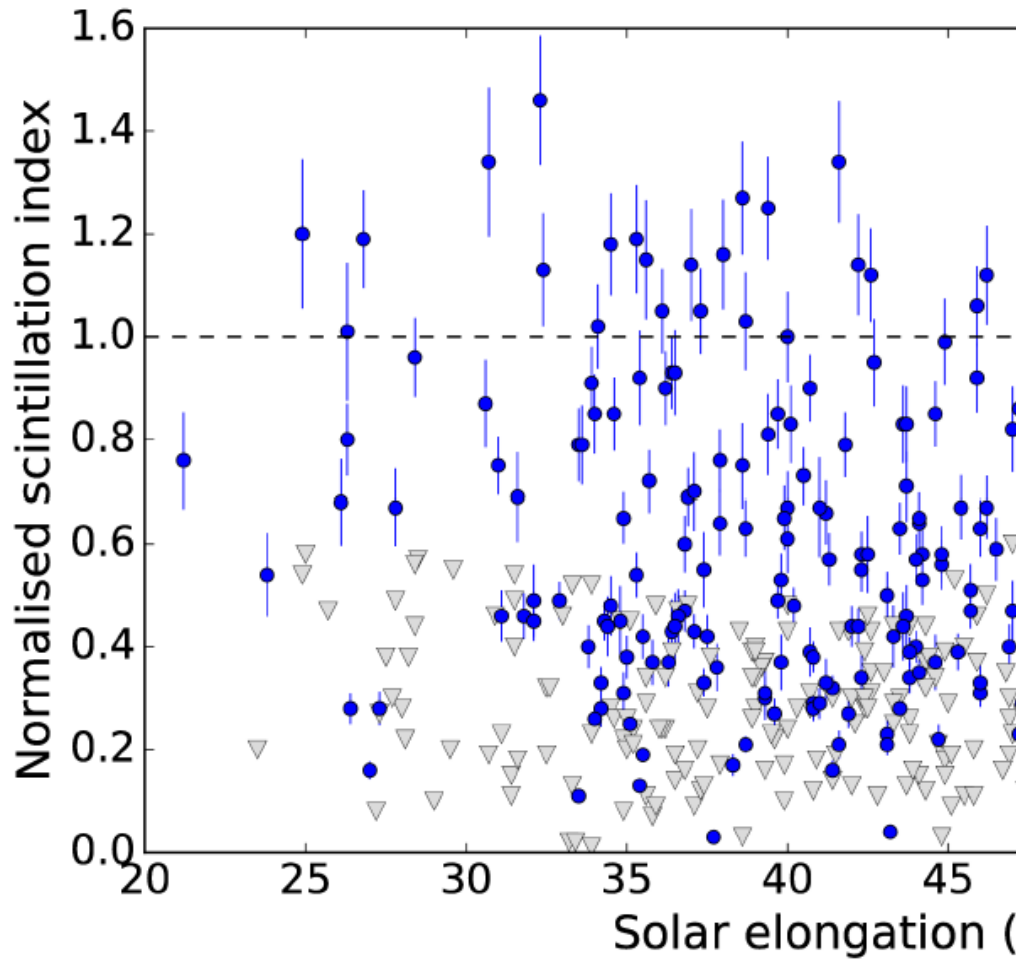
Jackson et al. (submitted) following Narayan (1992)

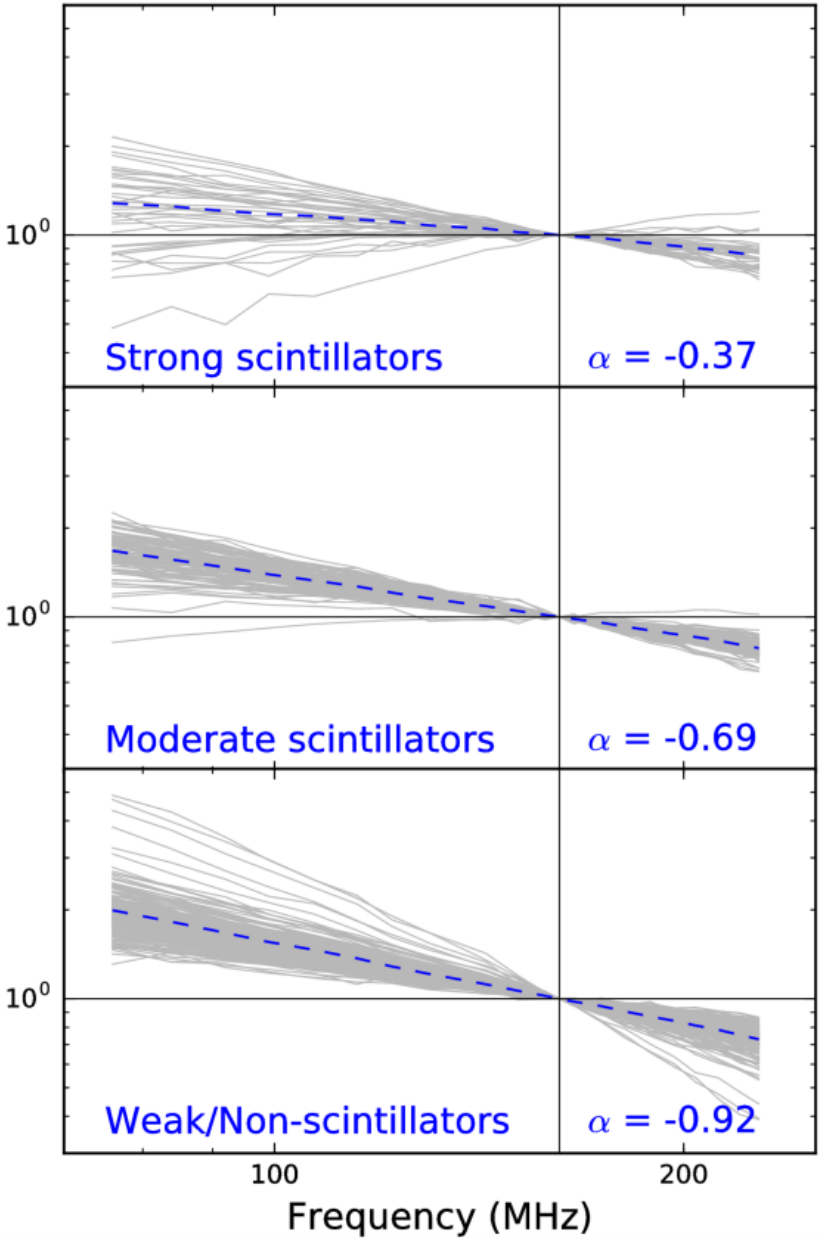
Comparison to International Lofar



Jackson et al. (submitted)

“Normalised” Scintillation Index

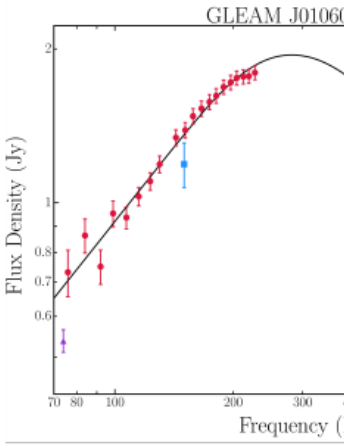




Chhetri+ 2018 (IPS2)
~10% of sources scintillate

Large fraction of peaked sources

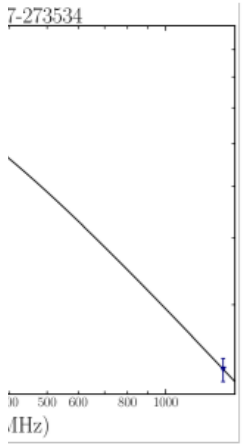
Strong Scintillators



Among strong scintillators

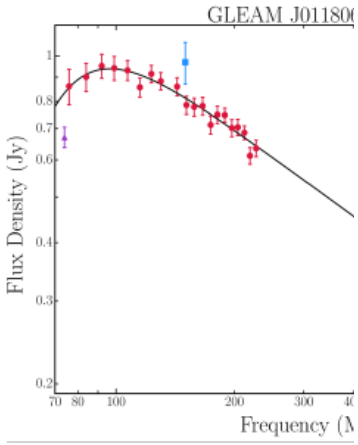
1:1:1

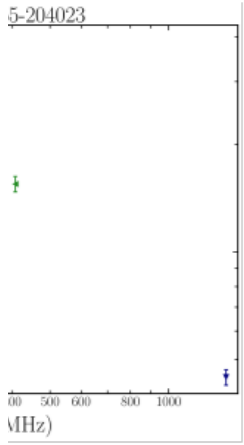
flat:steeper:compact



Stark contrast with:

- General low-frequency source population
- Compact source population at higher frequencies

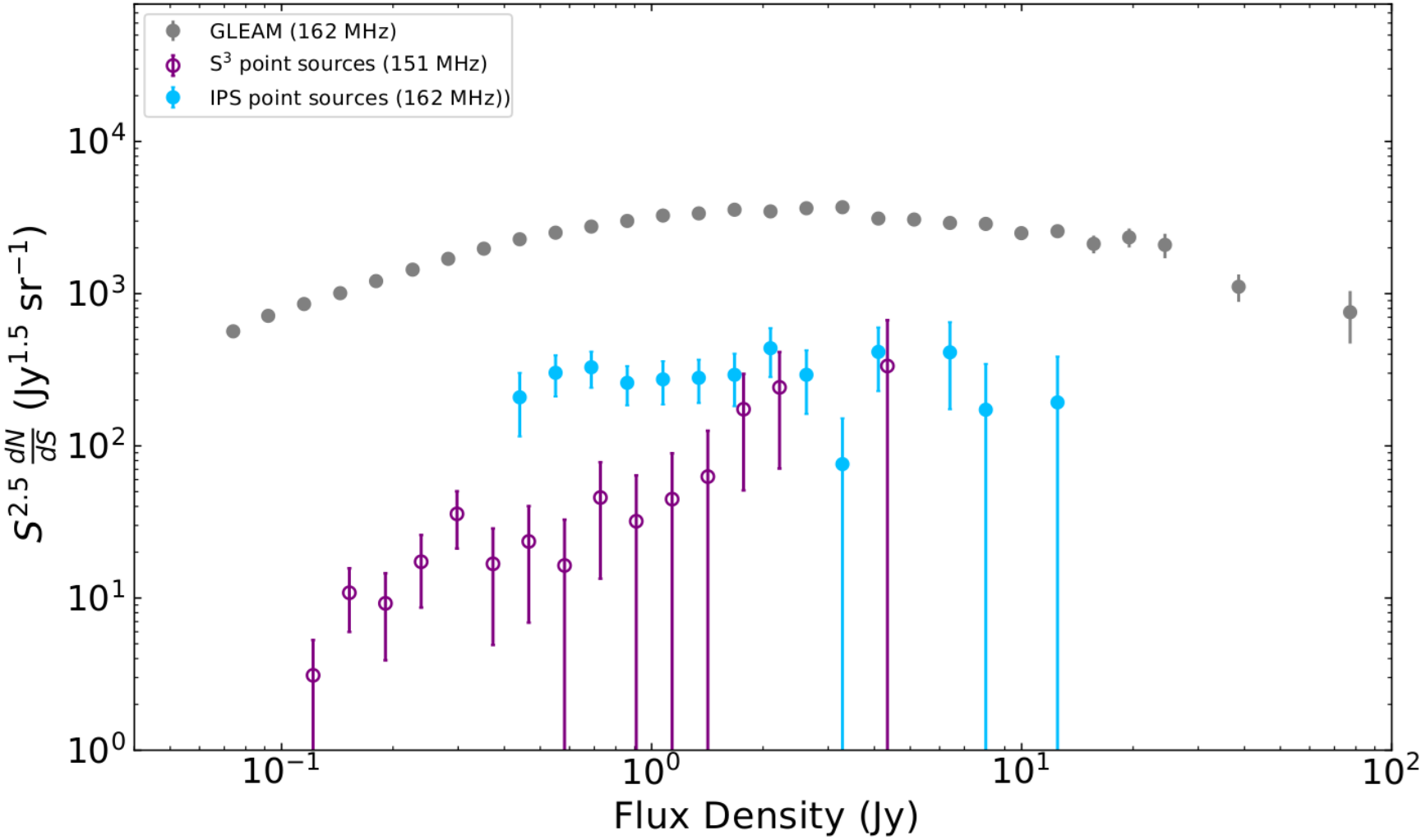




Chhetri et a

allingham

Source Counts

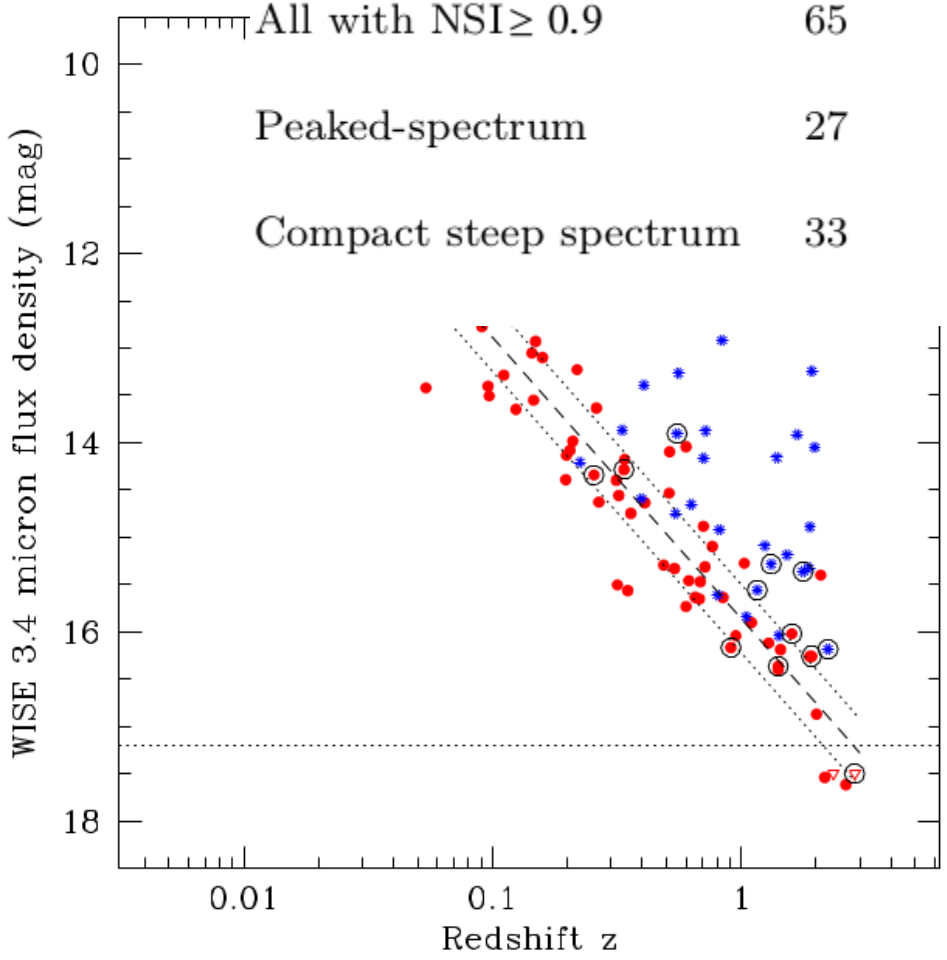


Chhetri+ 2018b

IR Properties and Redshifts

Expanded compact sample

All with NSI≥ 0.9	65	16.33 ±0.19	1.44 ±0.26	37%
Peaked-spectrum	27	16.66 ±0.34	1.86 ±0.53	48%
Compact steep spectrum	33	16.38 ±0.25	1.50 ±0.33	33%



Sadler+ 2018

IPS Phase I

All of the preceding is from a single 5

See www.icrar.org/ips for links to our

IPS Phase II

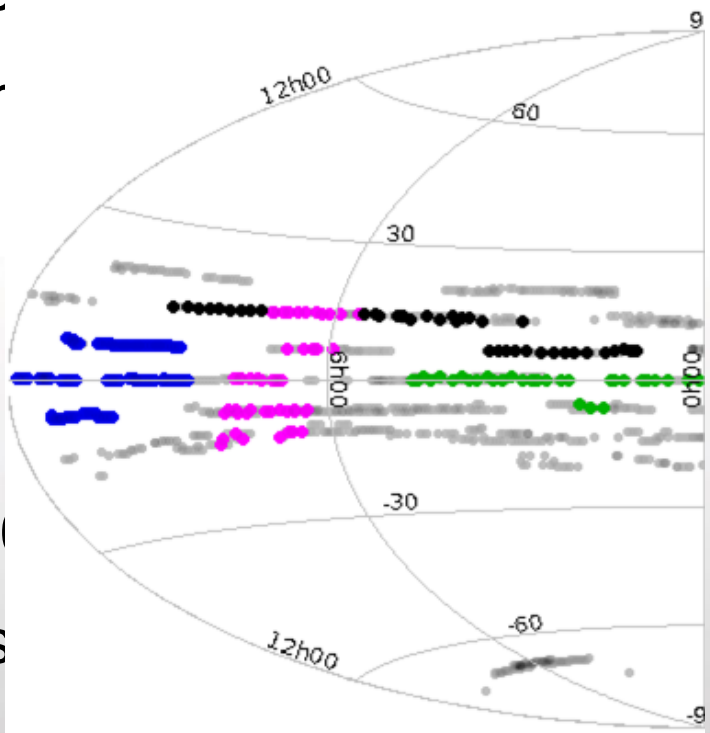
Over 2000 observations taken over 2

~250 observations processed into a s

Work in progress

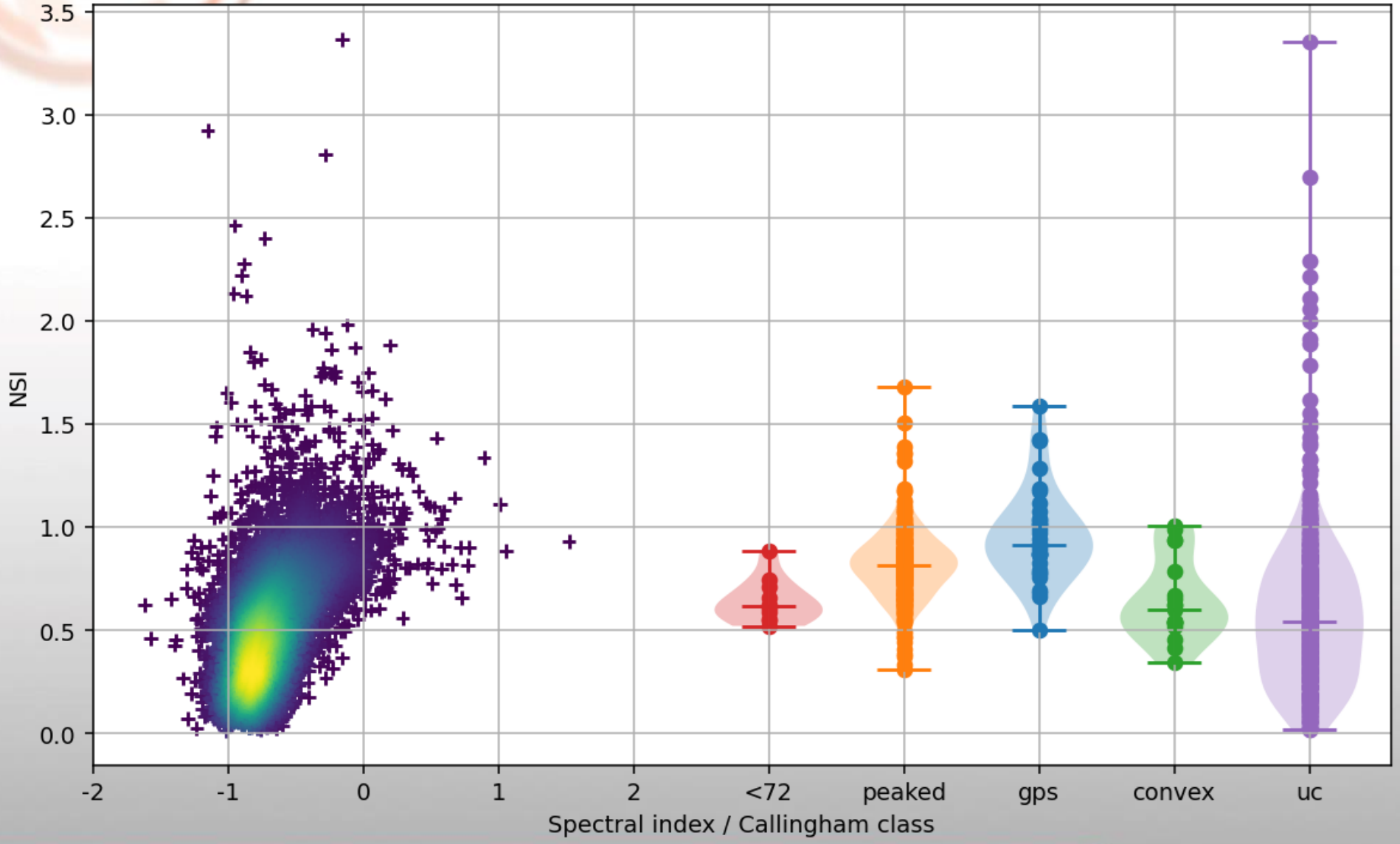
Catalogue is reliable

Slightly biased at low end

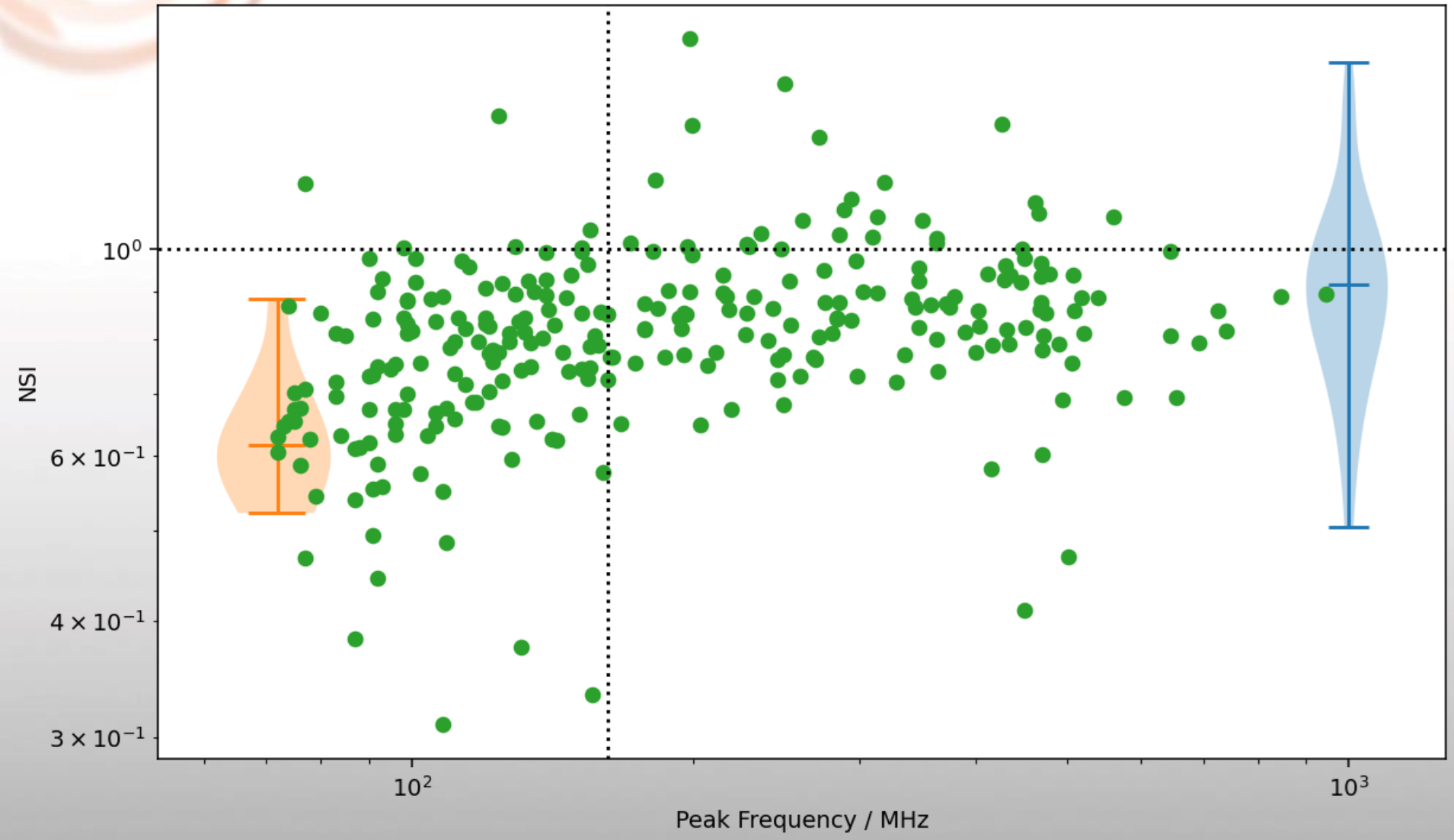


Phase II pointings (non-grey points Have been processed)

Full Phase II IPS Catalogue



Callingham+(2017) IPS overlap



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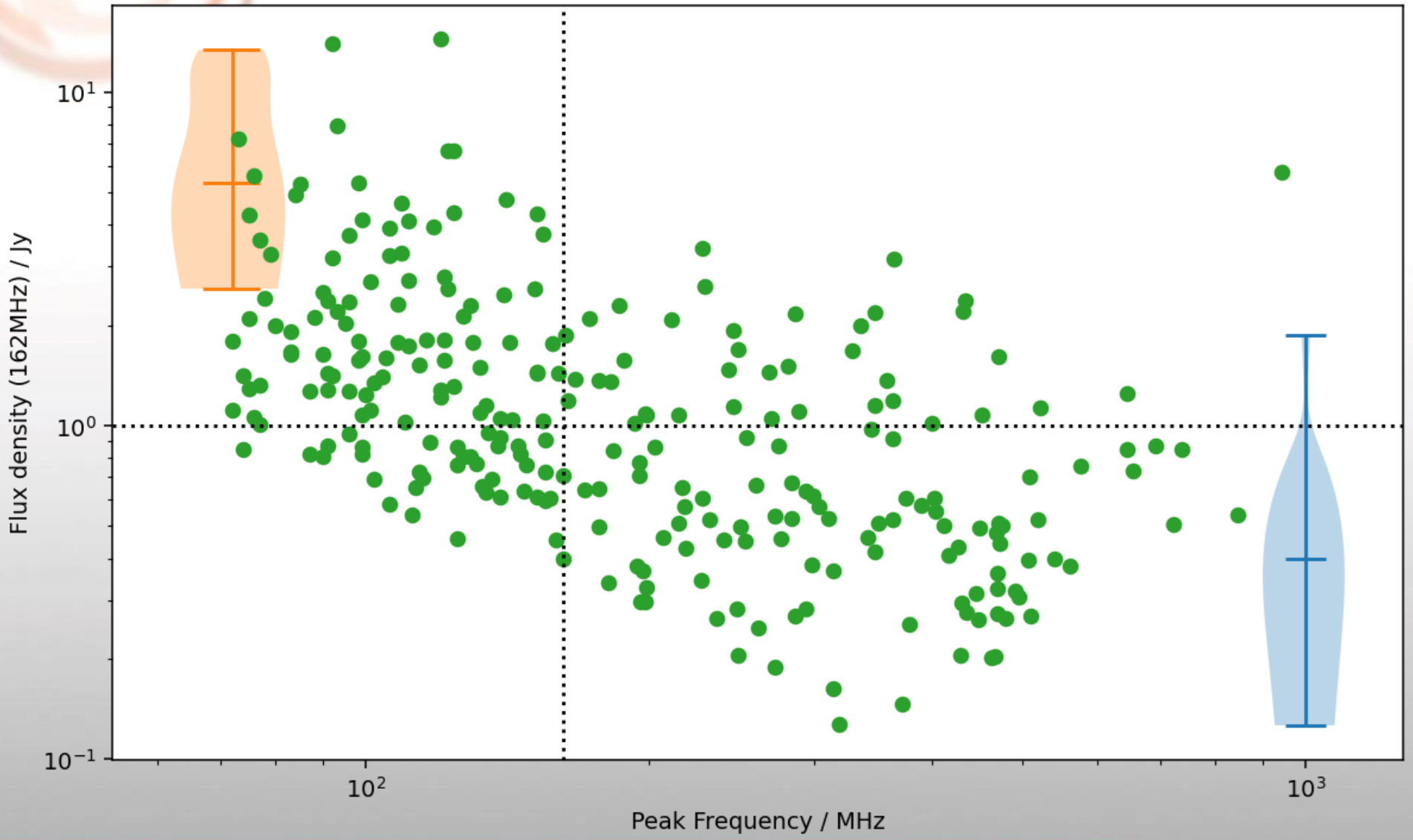

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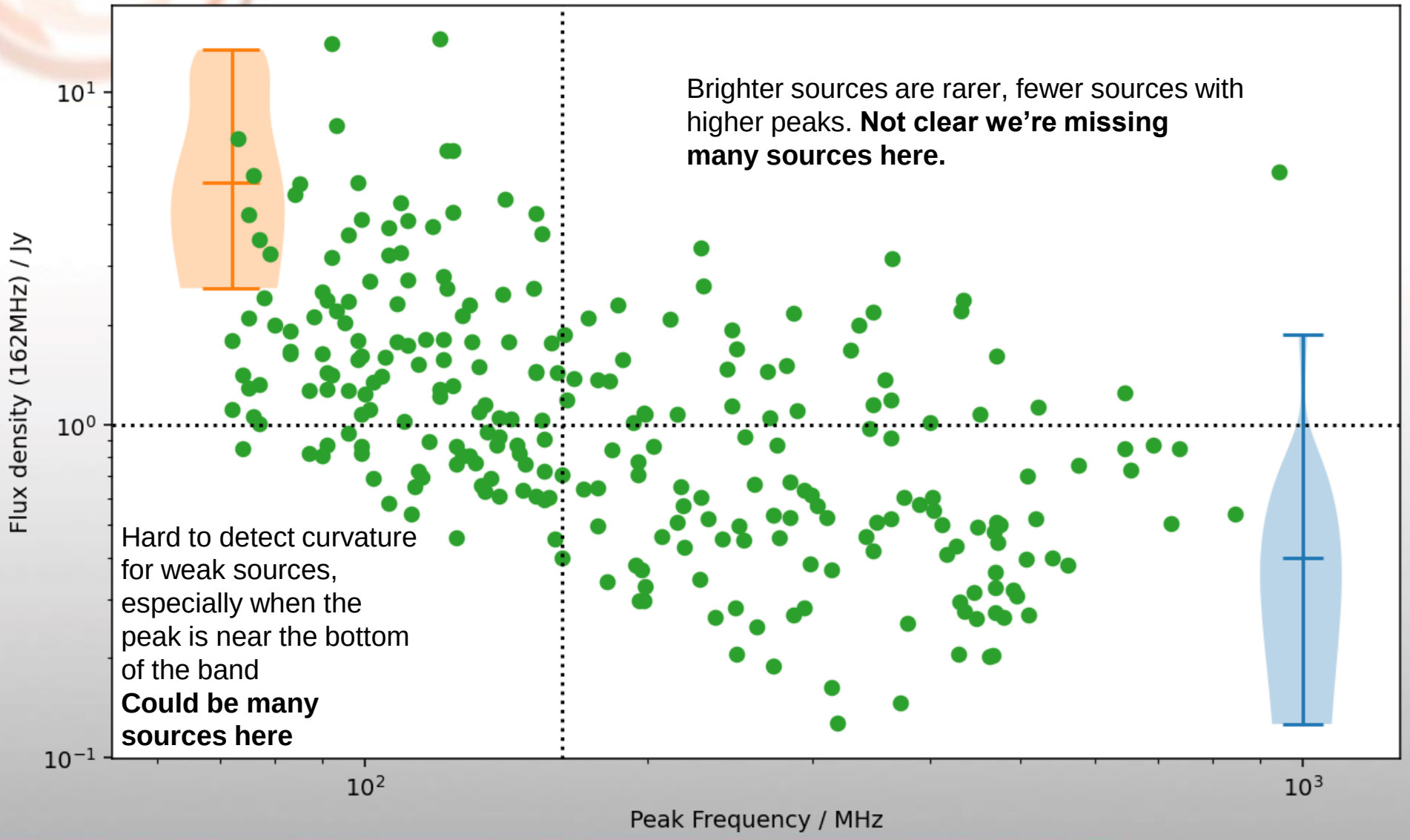


Provisional Conclusions

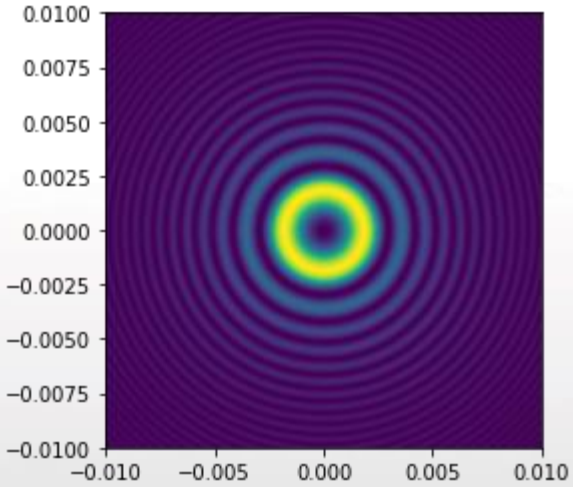
- We have redshifts (or redshift estimates) for many of our sources

But

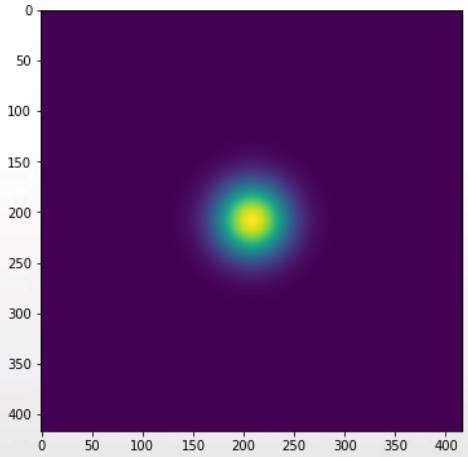
- Strong selection effects (across two different surveys!) make it difficult to make solid conclusions
- Needs careful analysis to understand any relationships between
  - Peak frequency
  - Linear Size
  - Source Power

The next step in IPS analysis

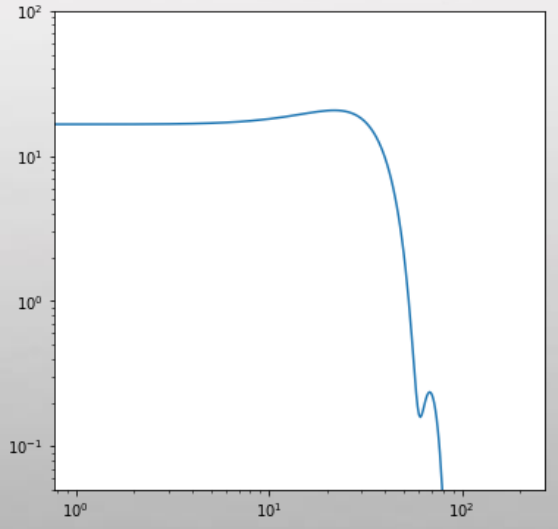
Normalised Scintillation index:-



×



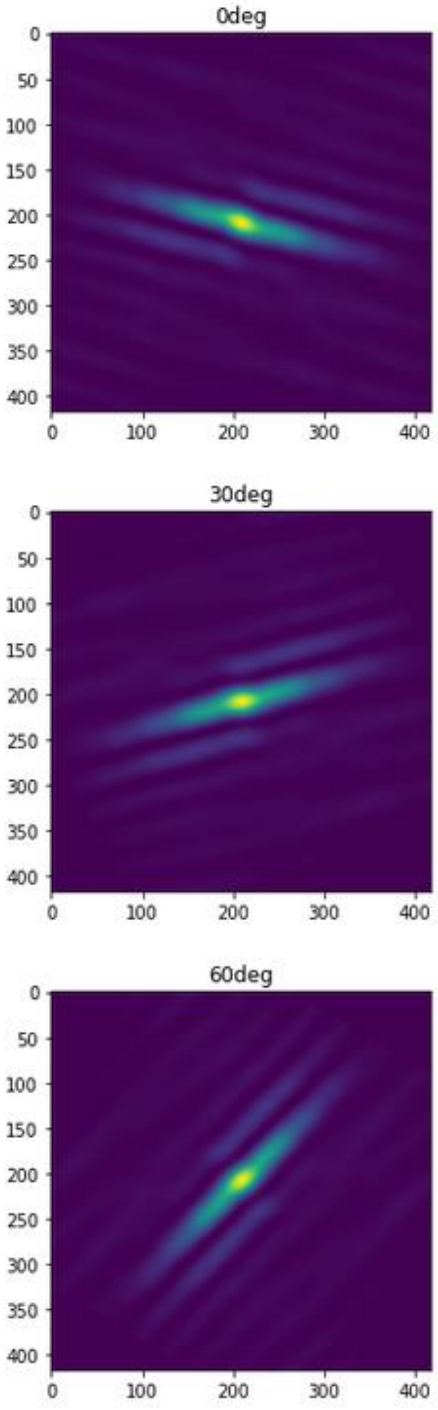
Integrate along y axis

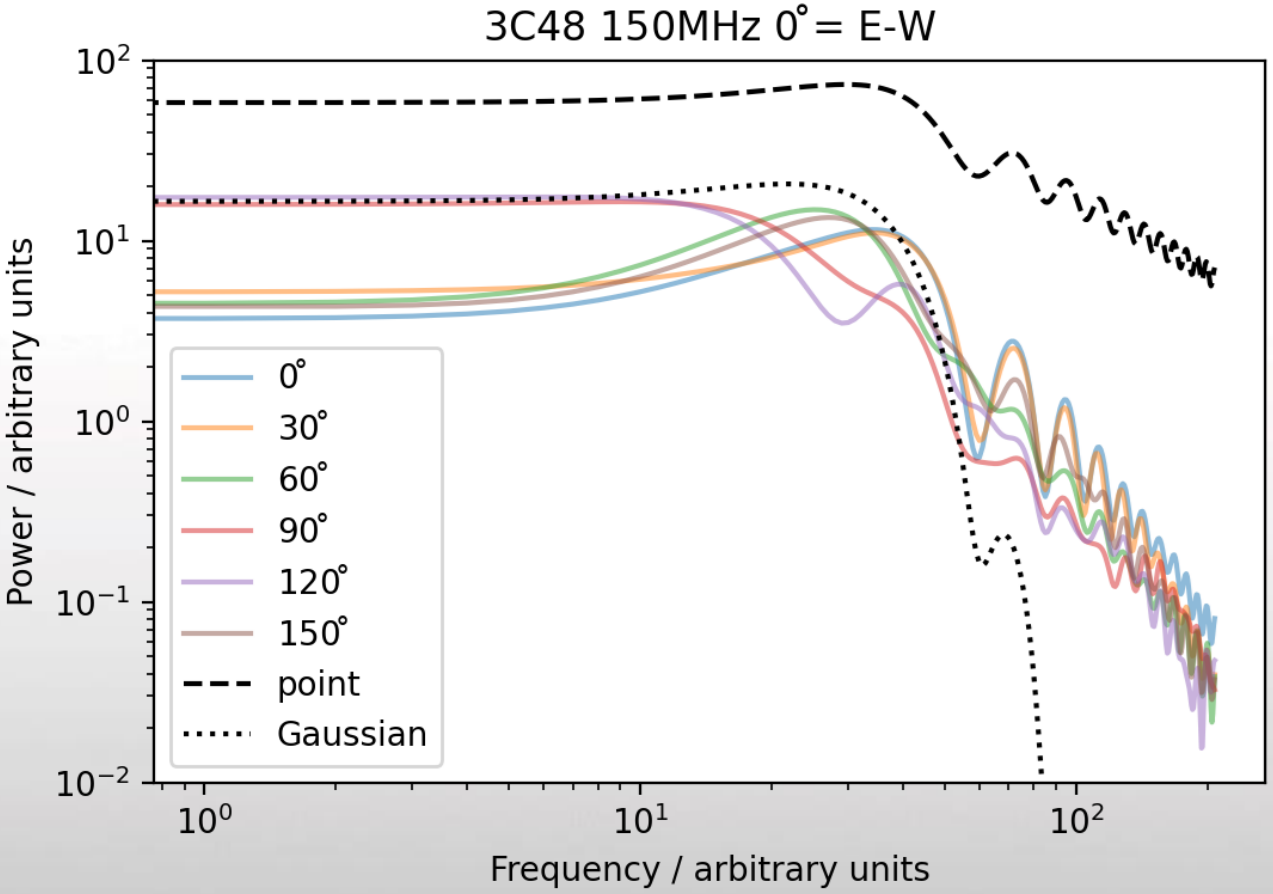


Fresnel **filter**
×
turbulence power spectrum

Source visibility amplitude squared

Simulated Power Spectrum





Conclusions and Future Work

- IPS can uniquely select based on compactness without any selection (census of compact sources)
  - GPS/CSS sources in the context of all compact extra-galactic sources
- GLEAM-X will provide a deeper parent sample
- Lower-frequency observations could be particularly important in identifying low-frequency peakers
- Lots of work to do to fully understand selection effects and biases.