The First All-sky Blind Survey in Circular Polarisation(?)

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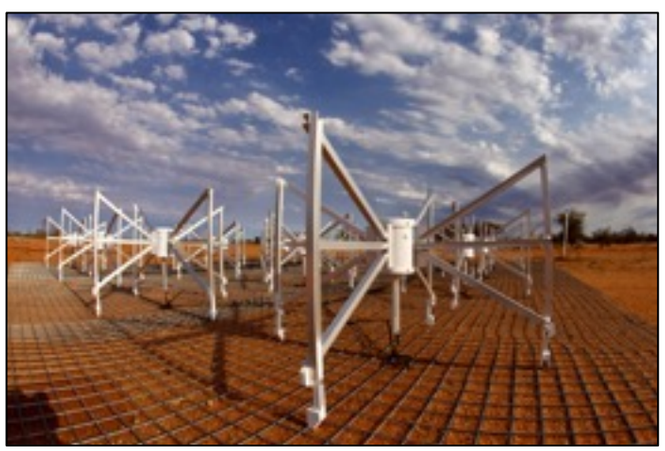
www.caastro.org

Science at Low Frequencies IV (Sydney)

13 December 2017



CSIRO; Swinburne

Overview

- Why do a survey in circular polarisation (CP)?
- The MWA?
- The challenges.
- The opportunities.

Why do a CP survey?
CP is rare in nature

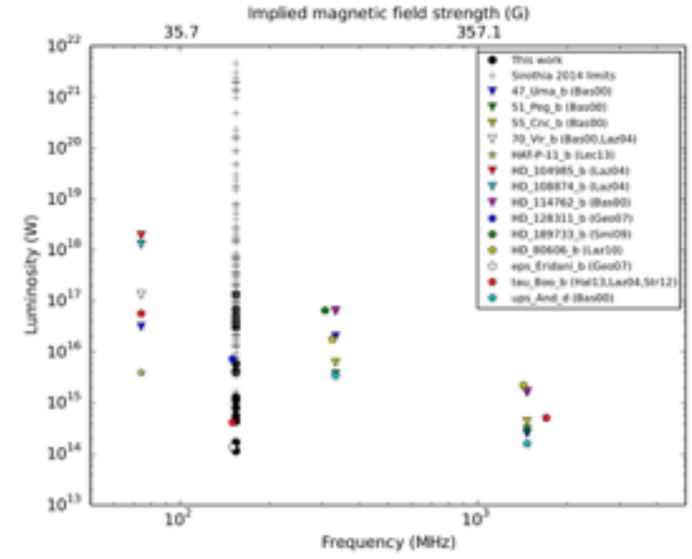
Gagnon, Y.L. et al 2015, *Circularly Polarized Light as a Communication Signal in Mantis Shrimps*, Current Biology, 25, 23

Publications on astronomical sources: 0

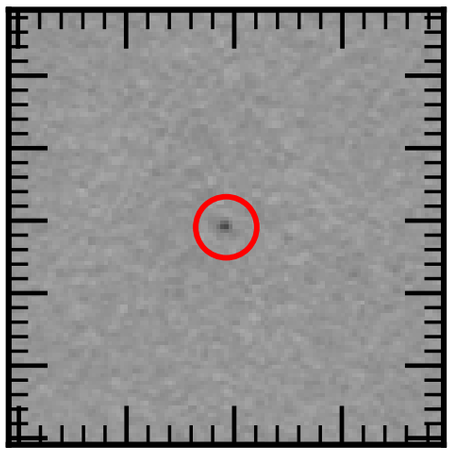
Conclusion: Mantis shrimp and Fiddler Crabs are not great astronomers

How, M.J. et al 2015, *Target Detection is Enhanced by Polarisation Vision in a Fiddler Crab*, Current Biology, 25, 23

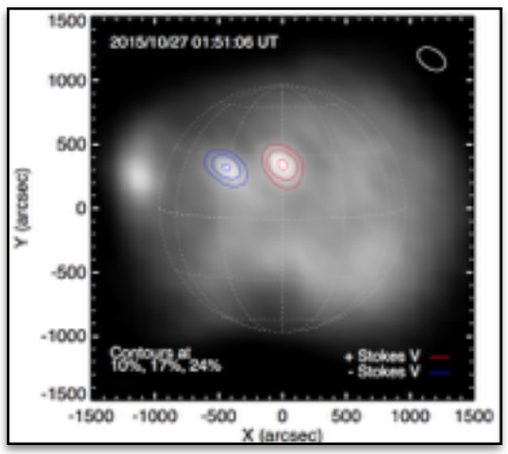
Why do a CP survey?



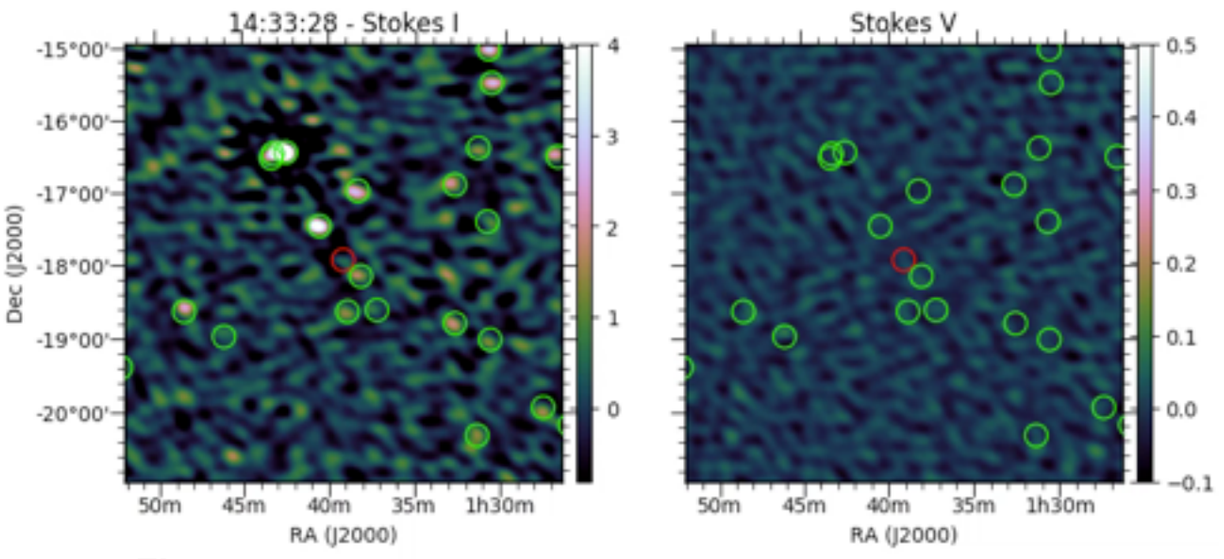
Planets & Exoplanets
Seaquist (1969)
Murphy et al. (2015)
Lynch et al. (2017)
Lenc et al. (2017)



Pulsars
You & Han (2006)
Noutsos et al. (2015)
Johnston & Kerr (2017)
Lenc et al. (2017, and in prep)

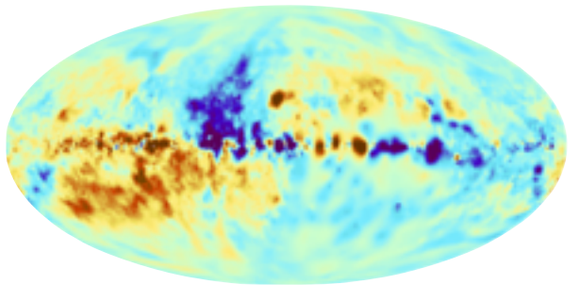


Solar
Lenc et al. (2017)
McCauley et al. (in prep)

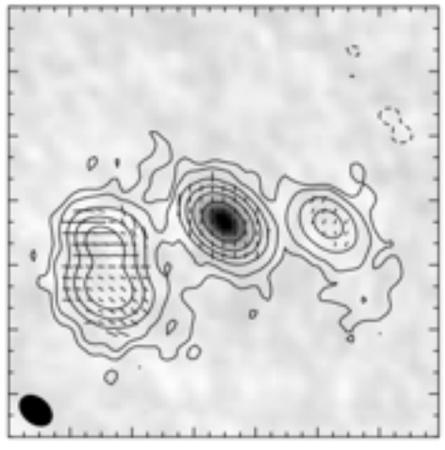


Flare stars
Lynch et al. (2017)
Lenc et al. (2017)

Weakly polarised

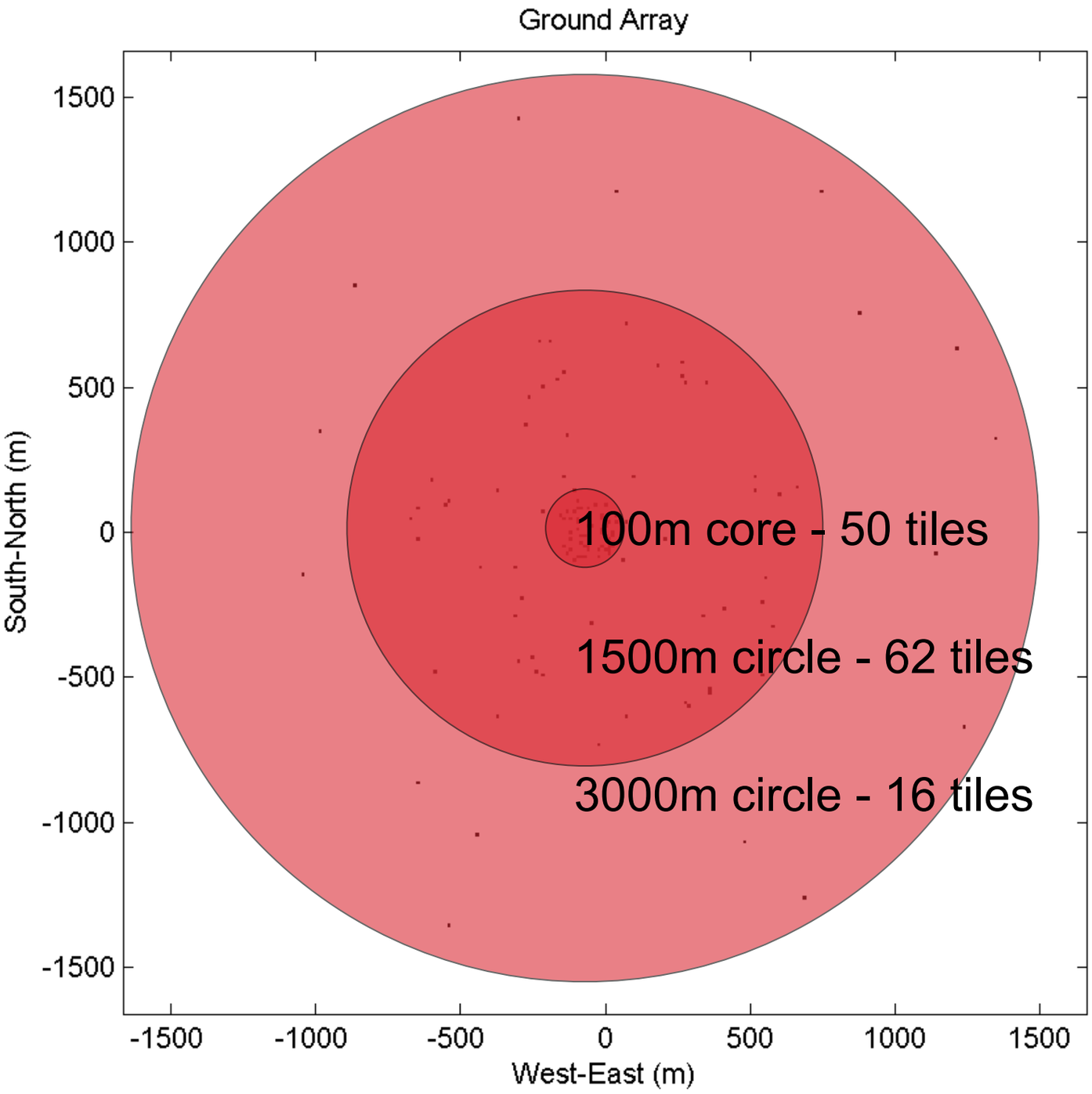


Galactic?
Enßlin et al. (2017)

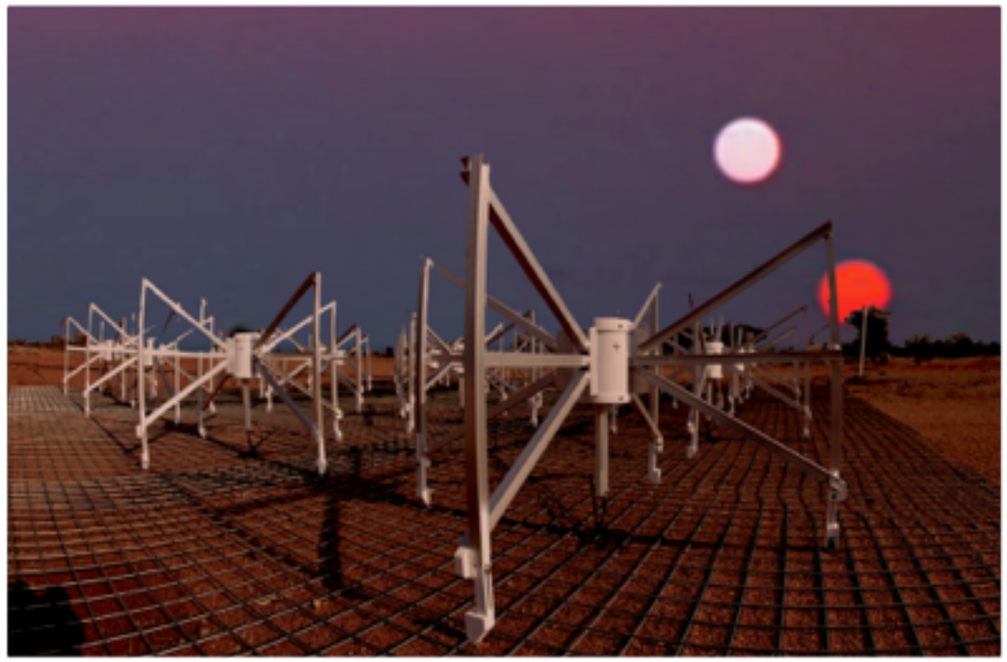


AGN
Seaquist (1969), Komesaroff et al. (1984)
Rayner et al. (2000), Maccquart et al. (2000)
Aller & Aller (2012), Myserlis et al. (2017), etc.

The Murchison Widefield Array (Phase 1)



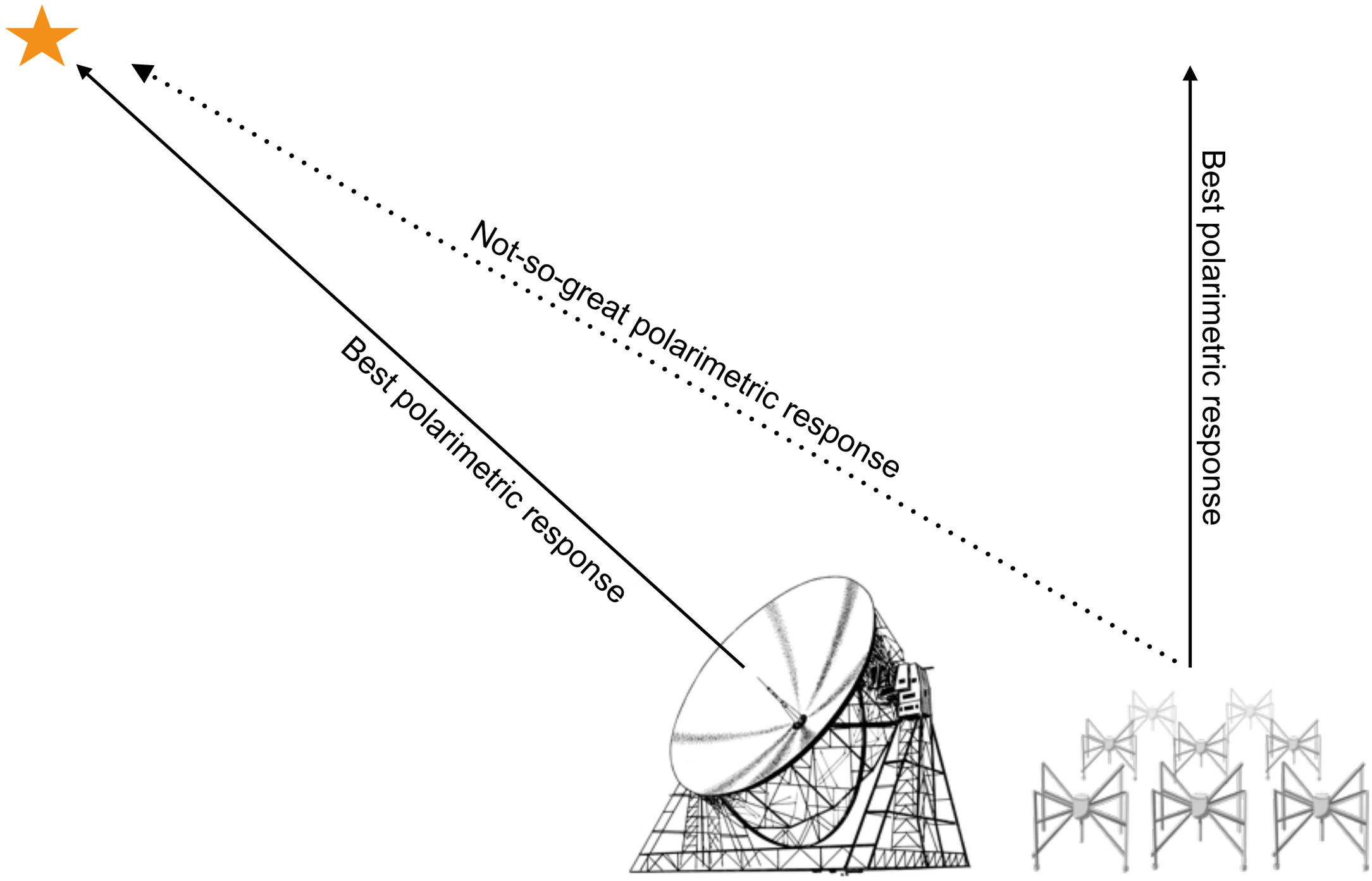
Full array = 128 tiles (128 T)



Murchison Widefield Array, Tatooine

- Electronically “steered”
- 16 dual-pol. dipoles
- Simple design
- 72-231 MHz range
- 15°-50° field-of-view
- Precursor to SKA Low
- ~Co-located with ASKAP

Challenge: The Beam
The downside of no moving parts



Challenge: The Beam
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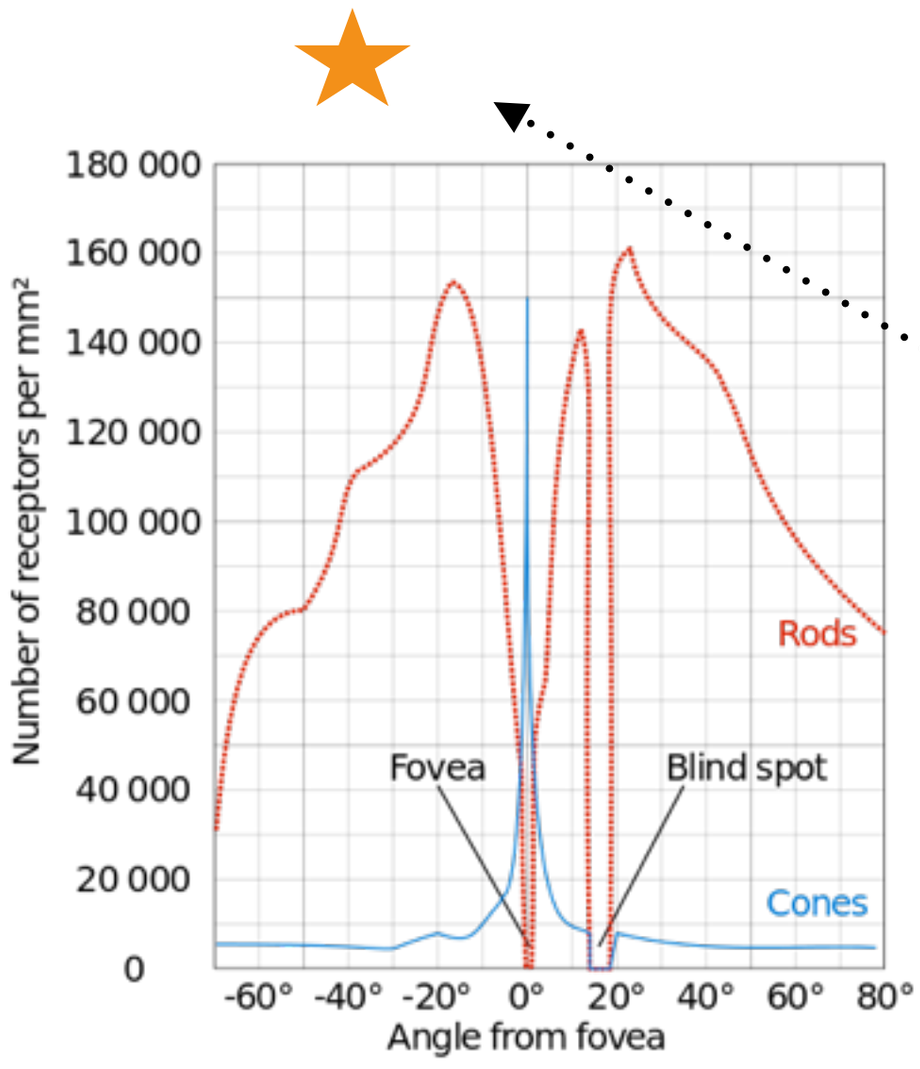
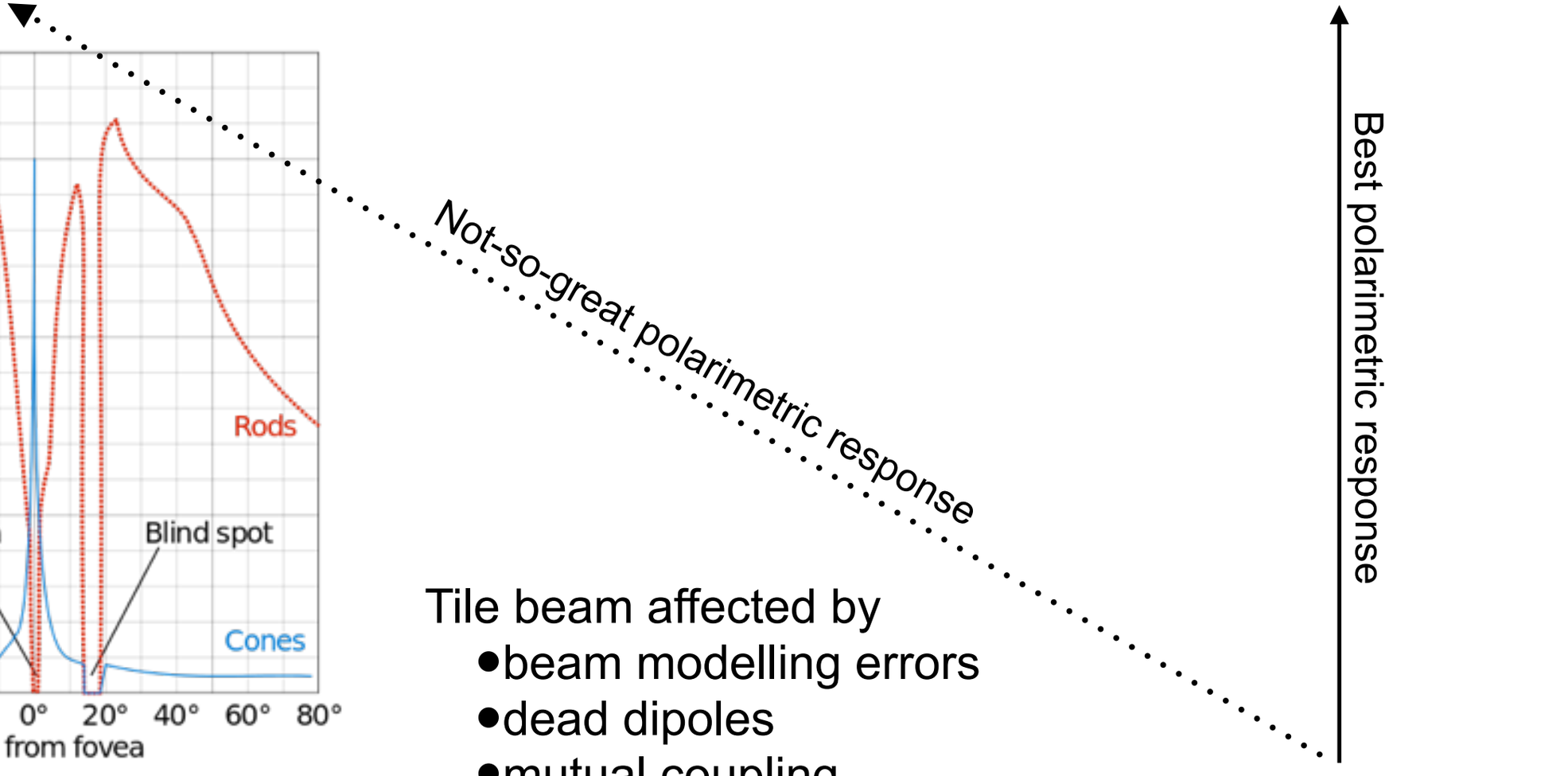
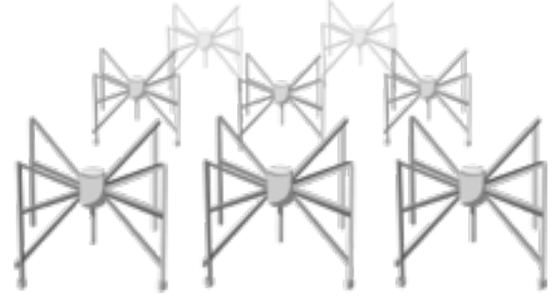


Stokes Eye



Tile beam affected by

- beam modelling errors
- dead dipoles
- mutual coupling
- frequency
- instrumental polarisation
- tile orientation errors



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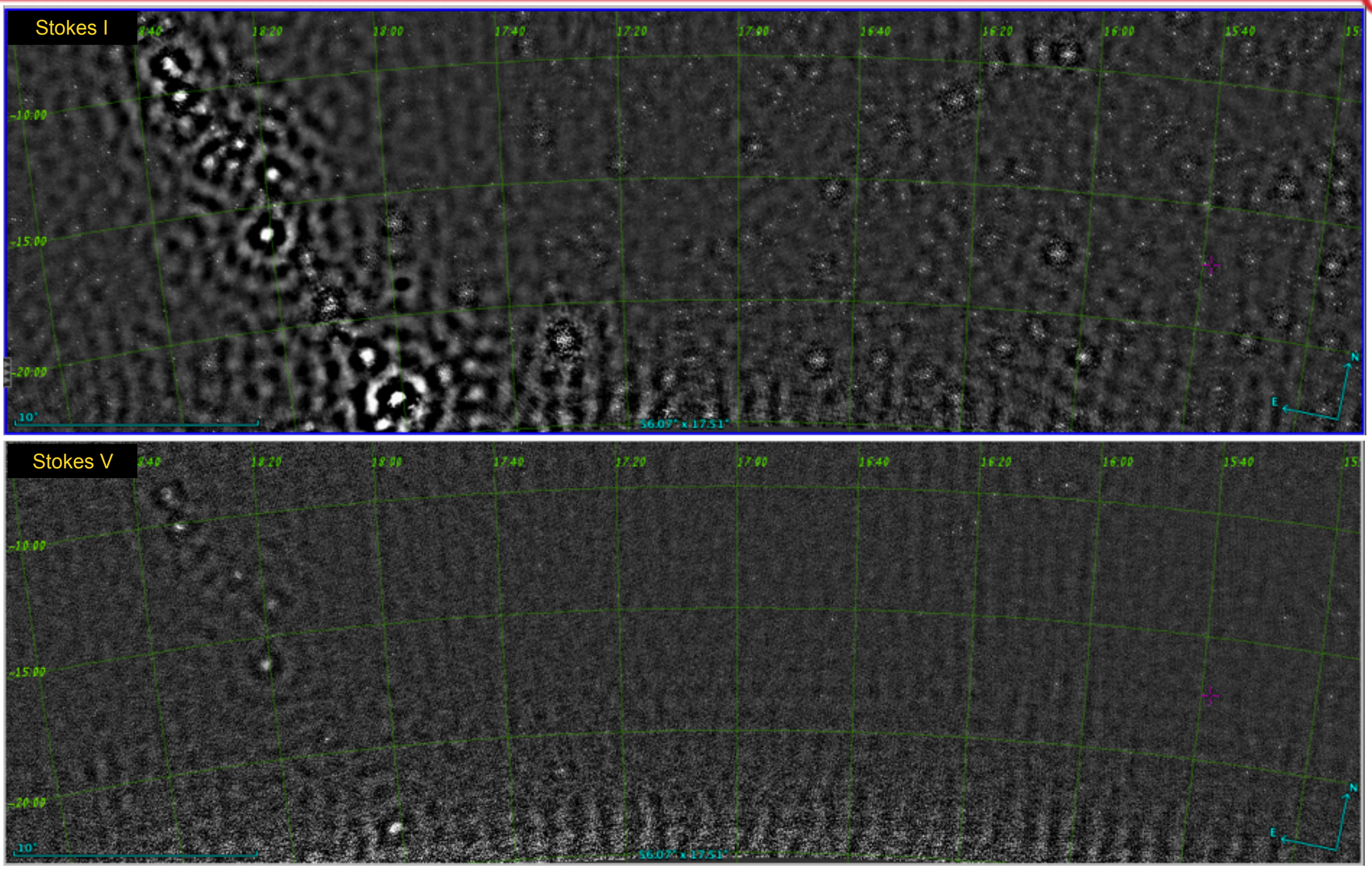
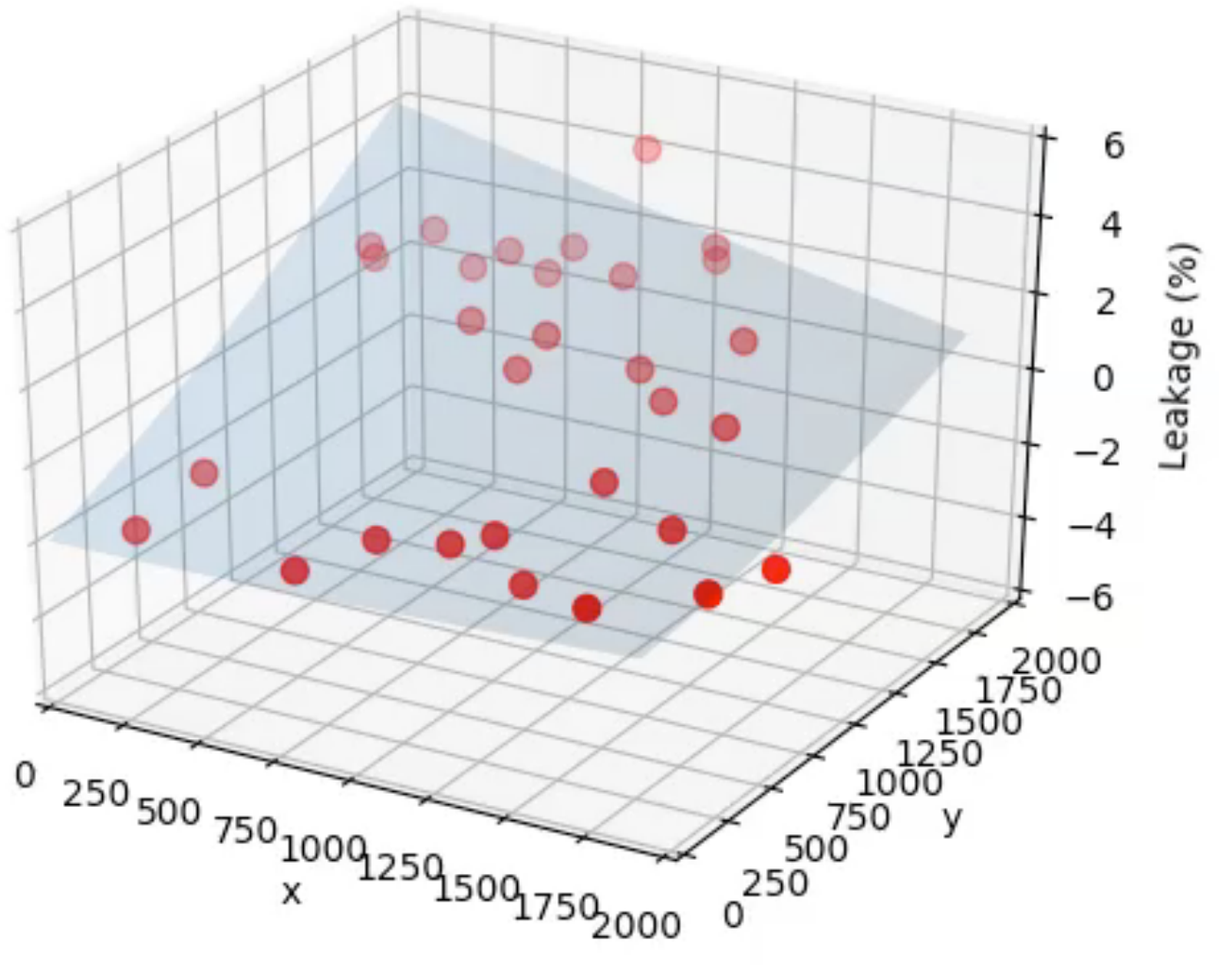
Polarisation Leakage



Reducing effects of Leakage “Drift and Shift”

Stokes V Leakage in “Drift and Shift” Scan (~5 h, 11 beam pointings)

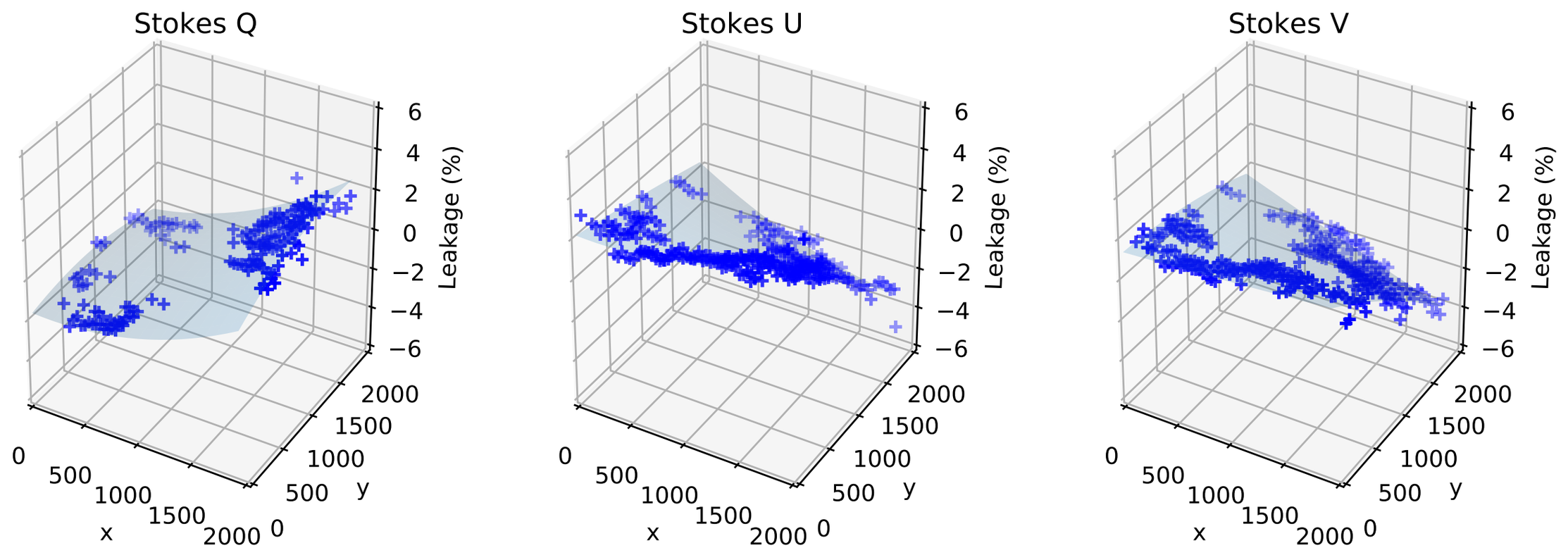


(Lynch et al. 2017, Lenc et al. 2017)

Reducing effects of Leakage “Drift and Shift”

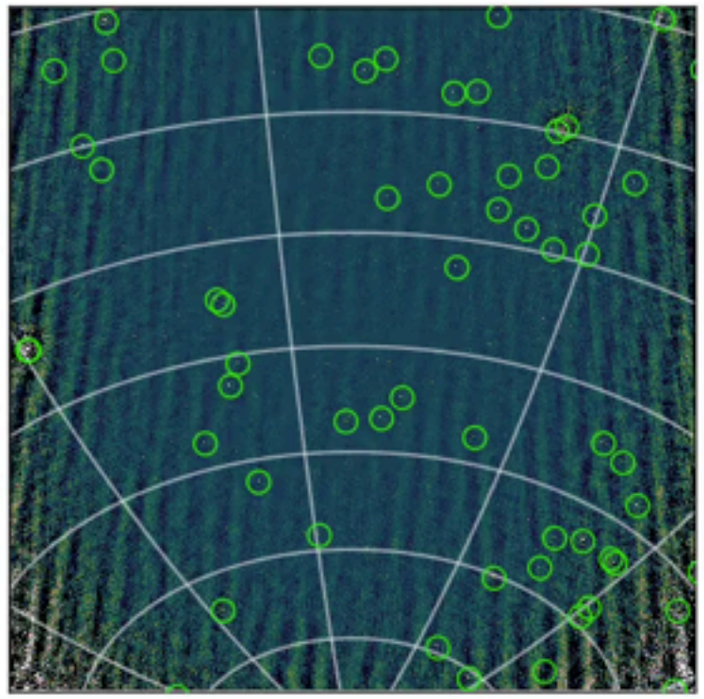
Behaviour dependent on:

- Stokes parameter
- Frequency
- Beam-pointing
- Initial calibration

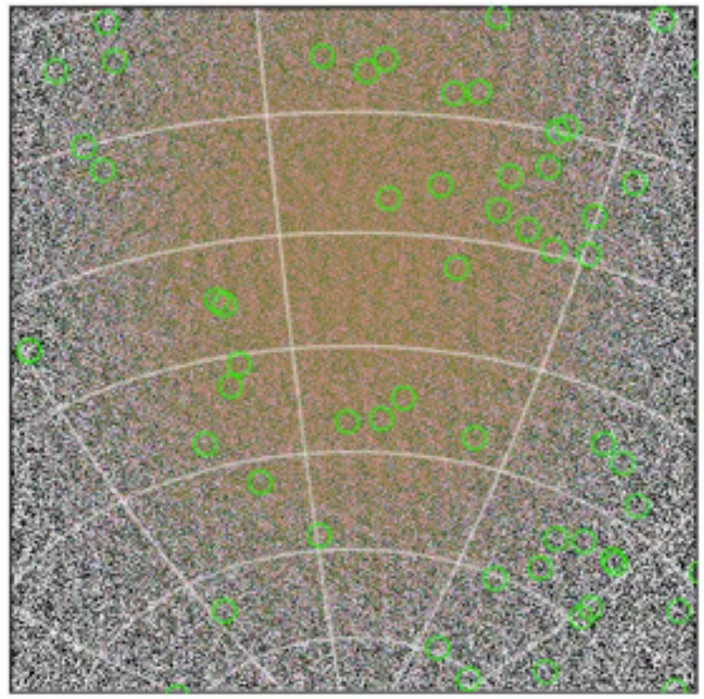


(Lynch et al. 2017, Lenc et al. 2017)

Reducing effects of Leakage
Drift scan

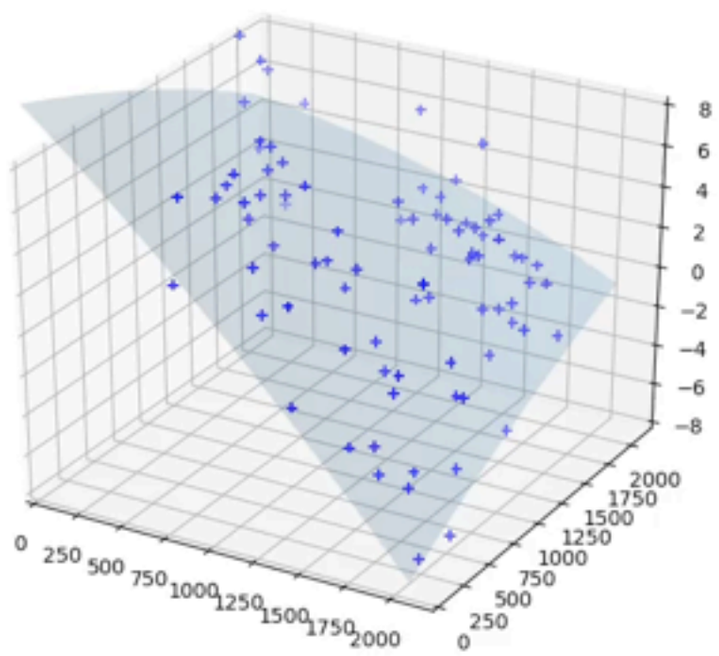


Stokes I



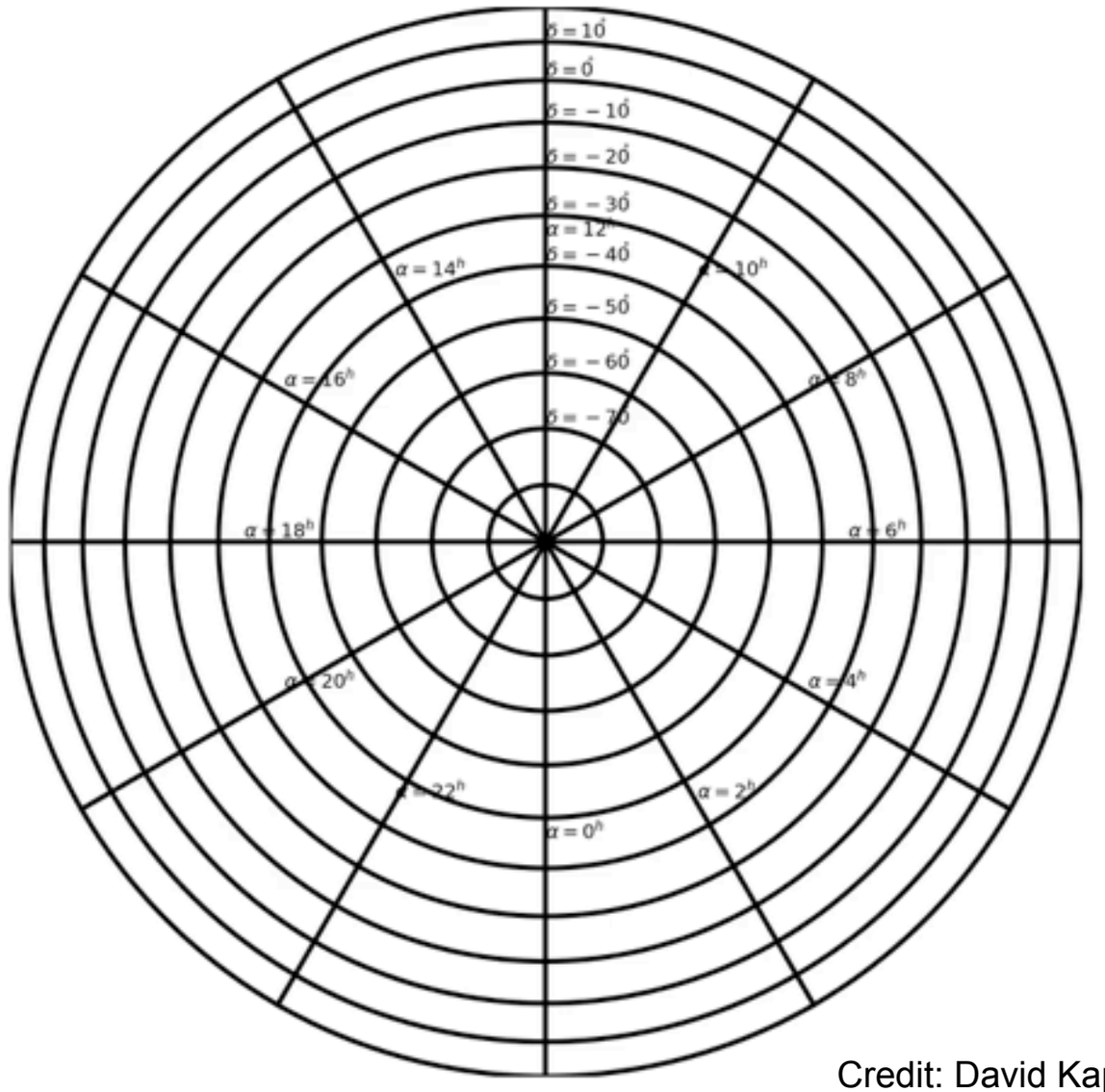
Stokes V

Bright sample sources



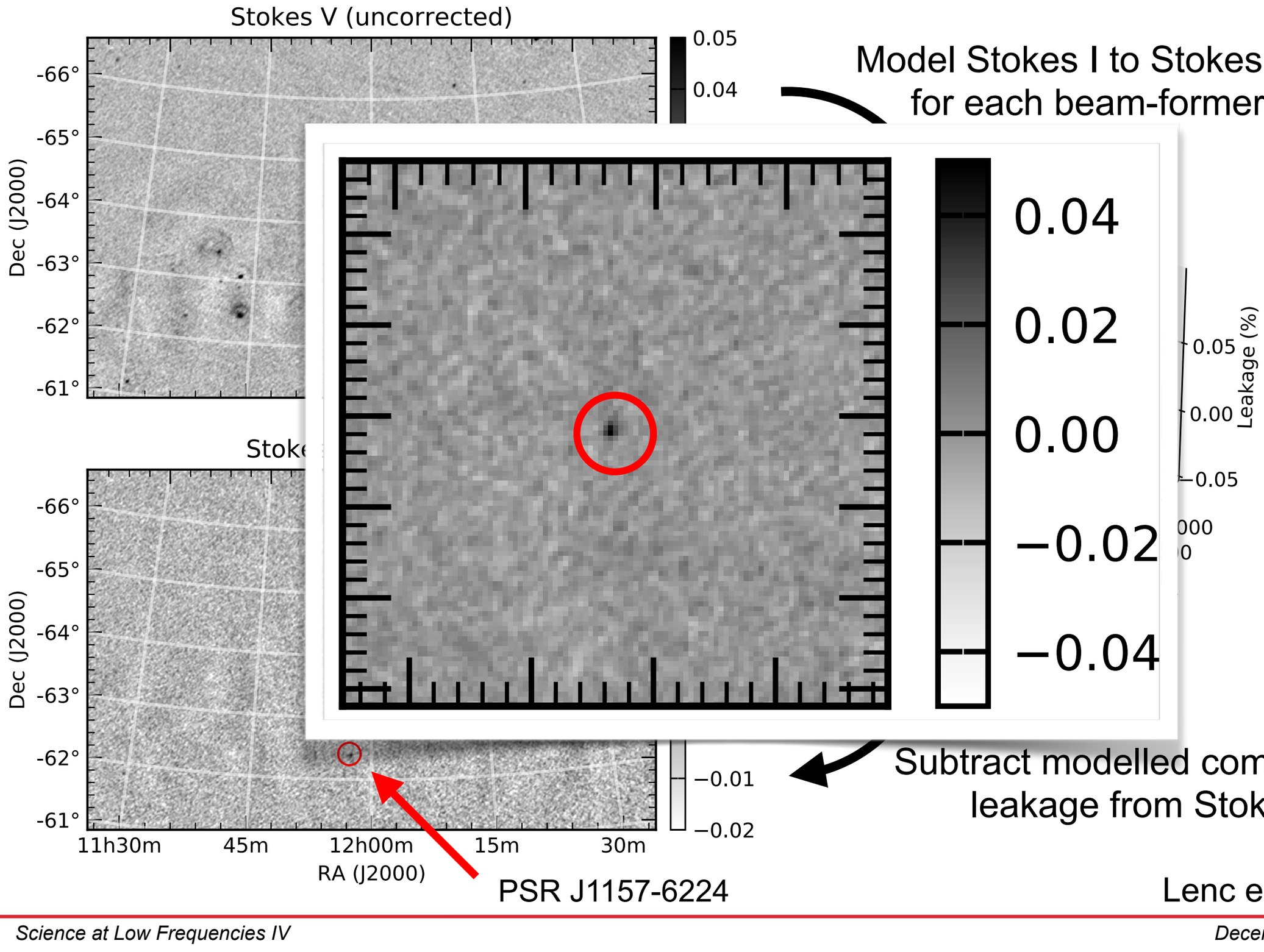
Fit of Stokes V / Stokes I

Sky Survey
GLEAM reprocessed



Credit: David Kaplan

All-sky CP survey In a Nutshell



Lenc et al. (in prep)

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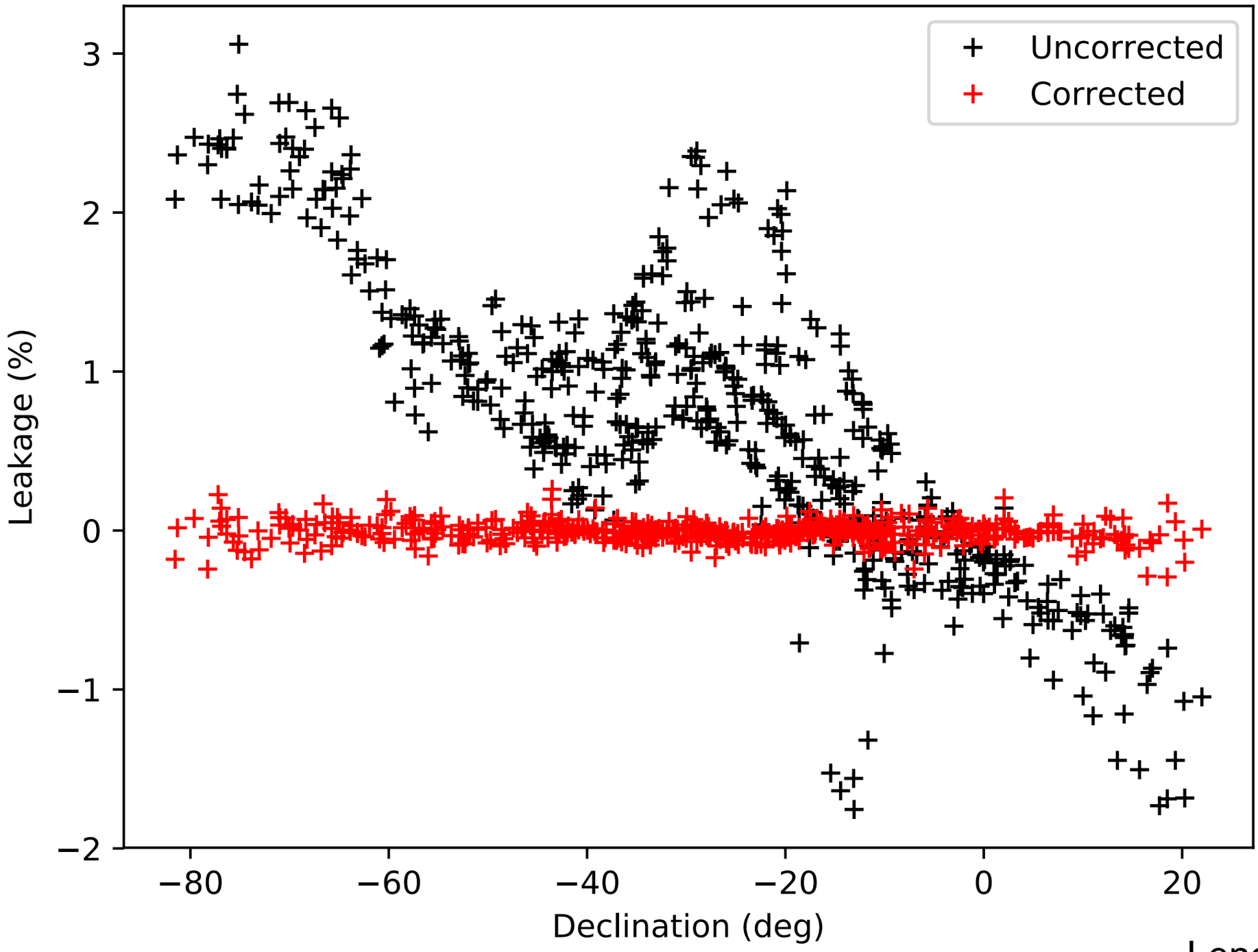
Removing Leakage
All-sky circular polarisation survey



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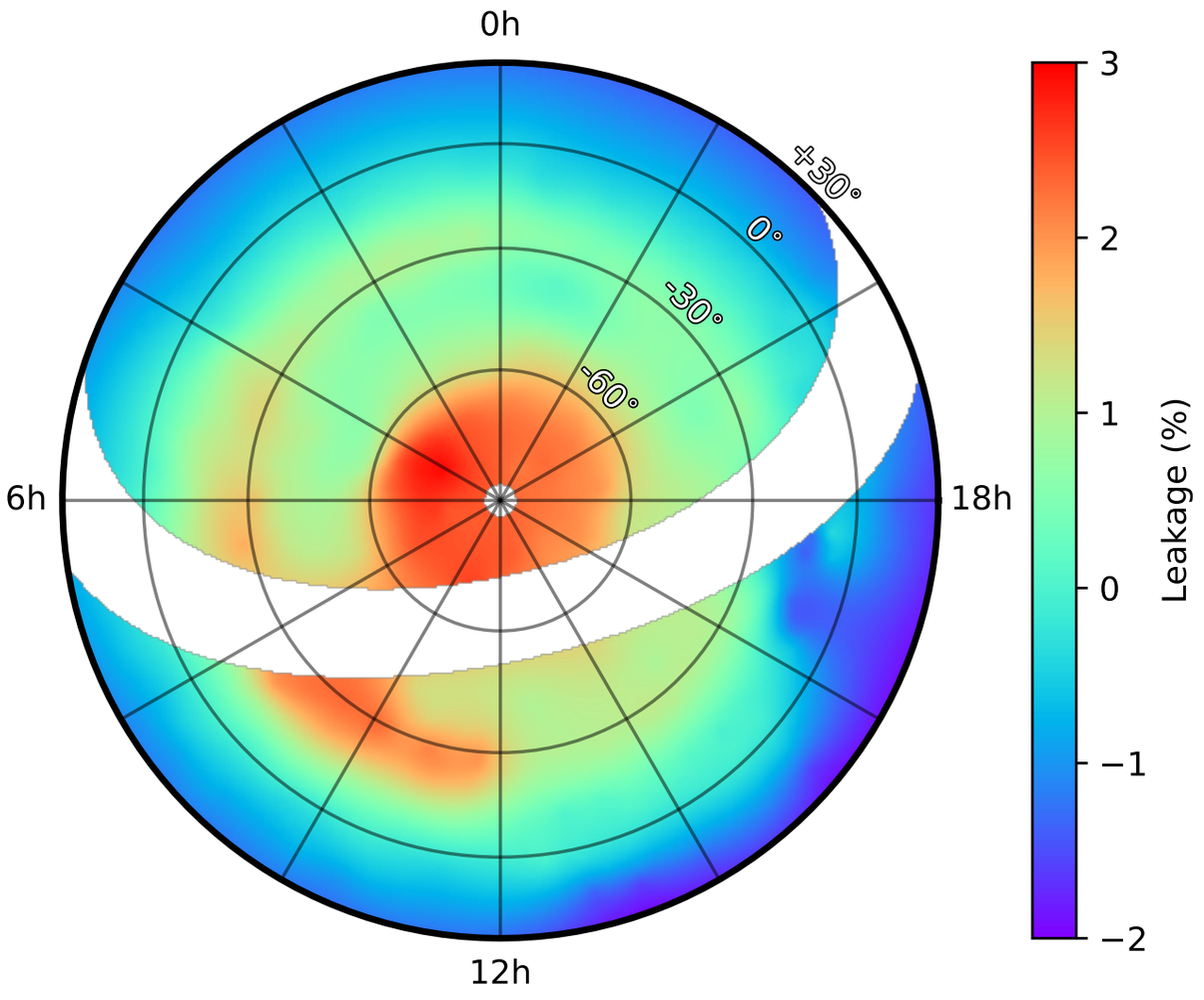
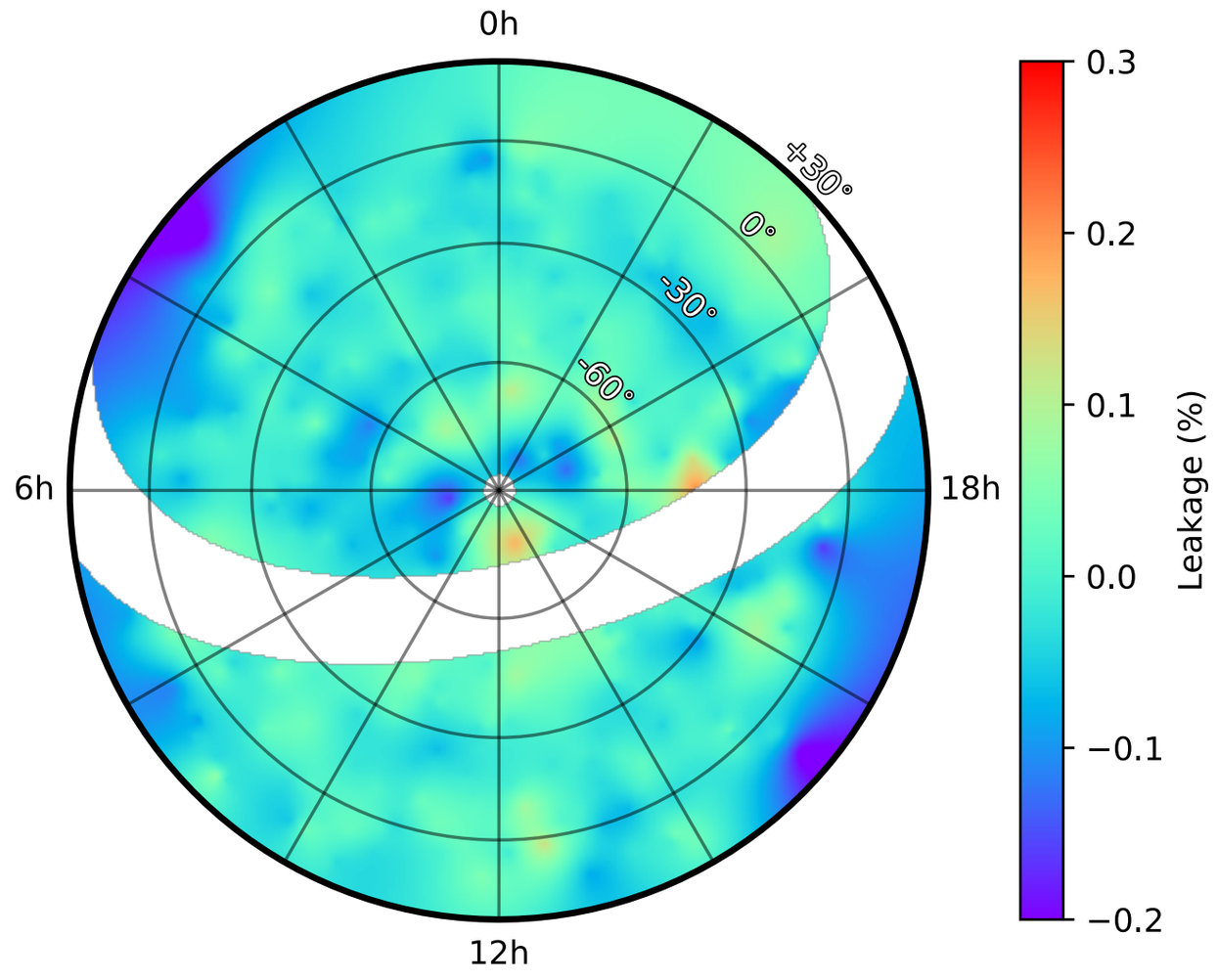
All-sky CP Leakage



Stokes V Leakage
Before Correction



Stokes V Leakage
After Correction

Lenc et al. (in prep)

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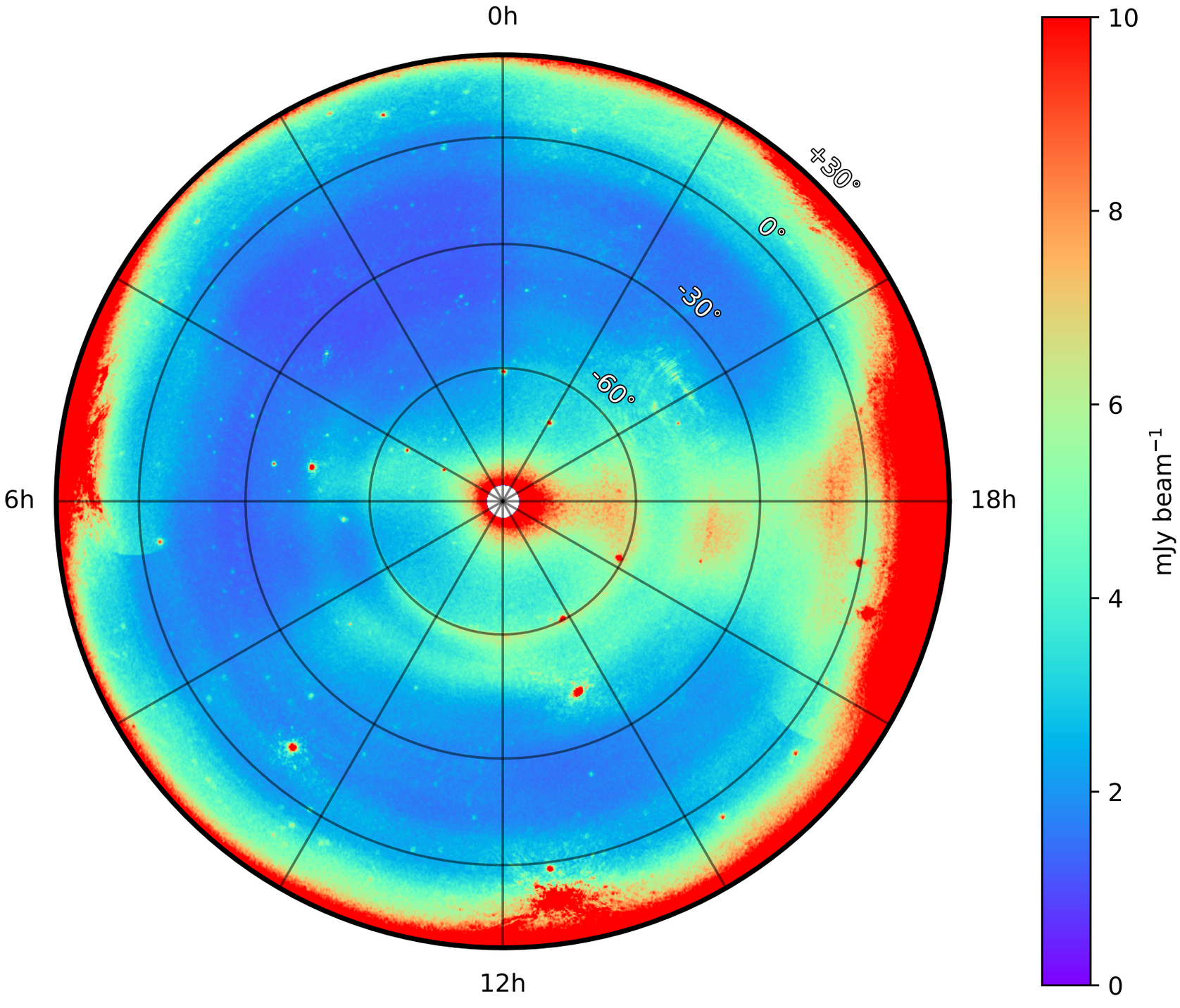
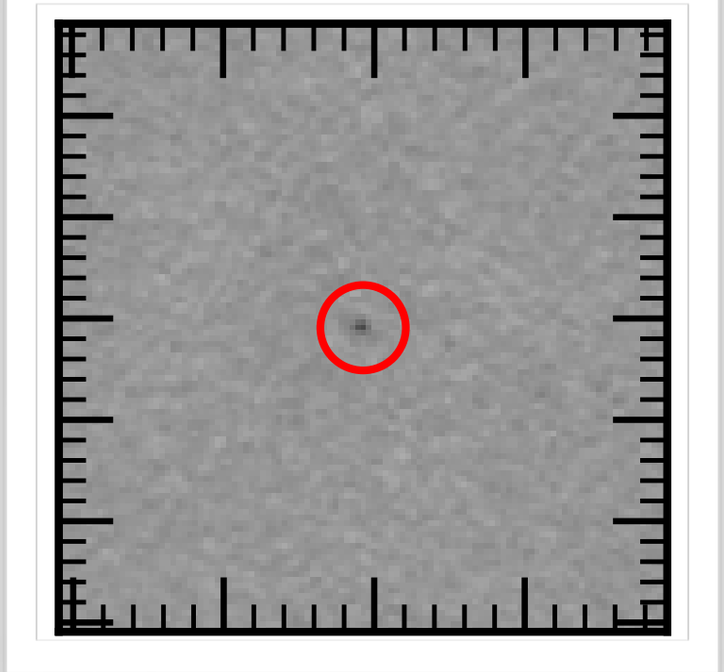
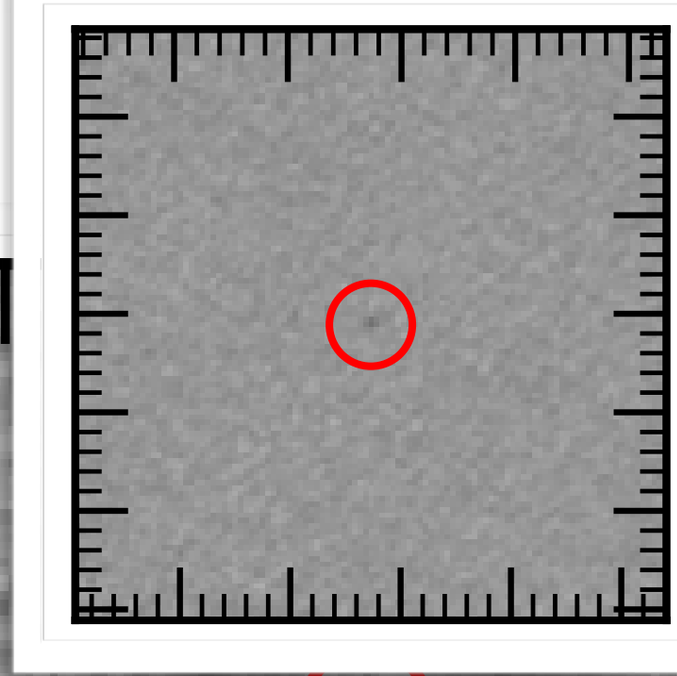
All-sky CP Survey Sensitivity Map

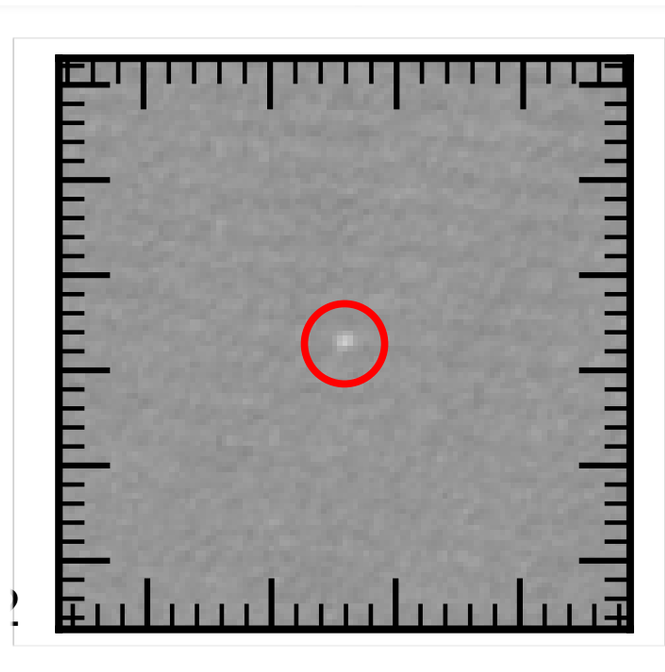


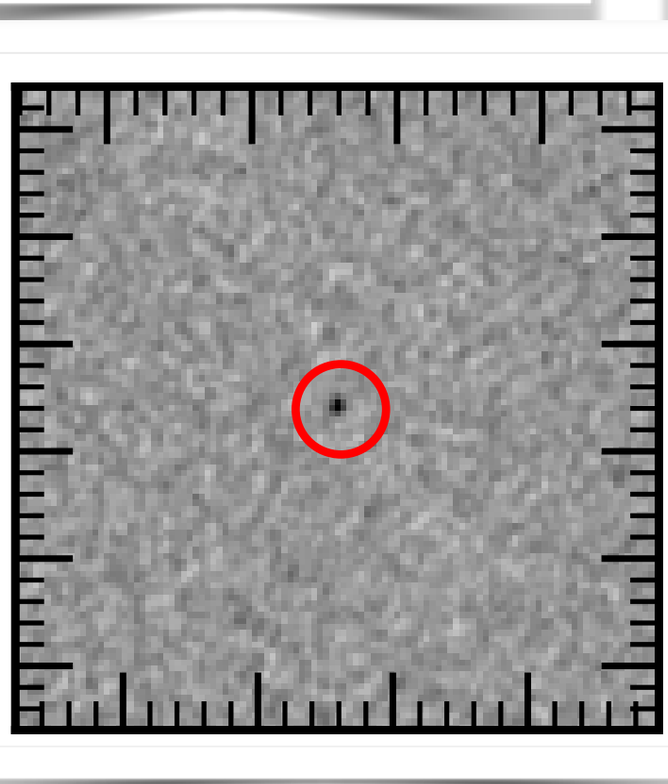
Lenc et al. (in prep)

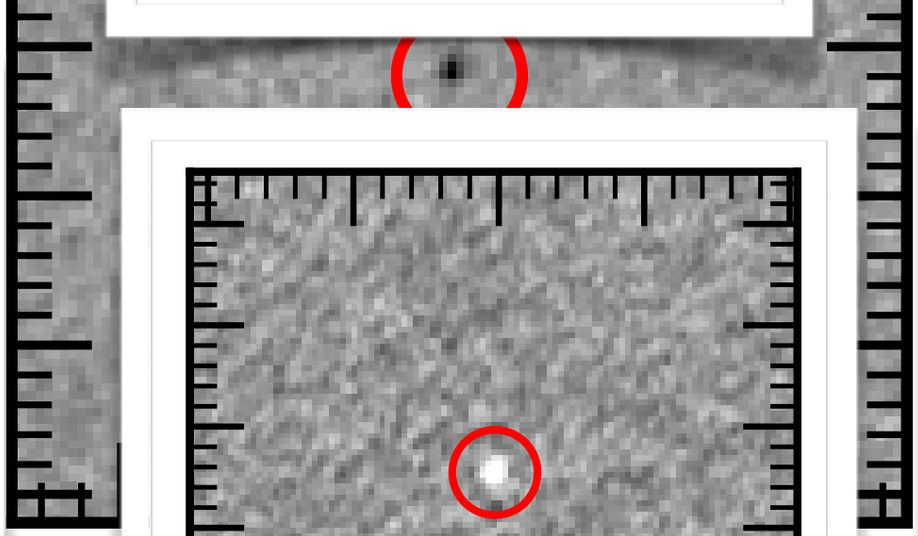
More Pulsars (14 >6 sigma - blind) (+18 >4 sigma - targeted)

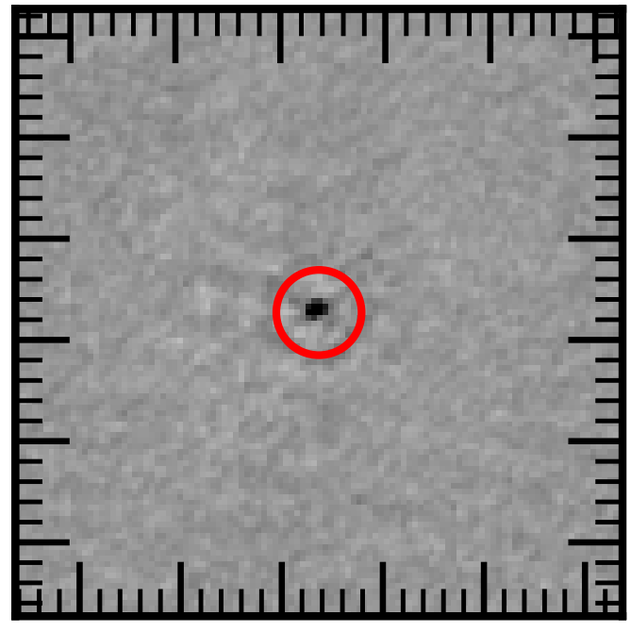




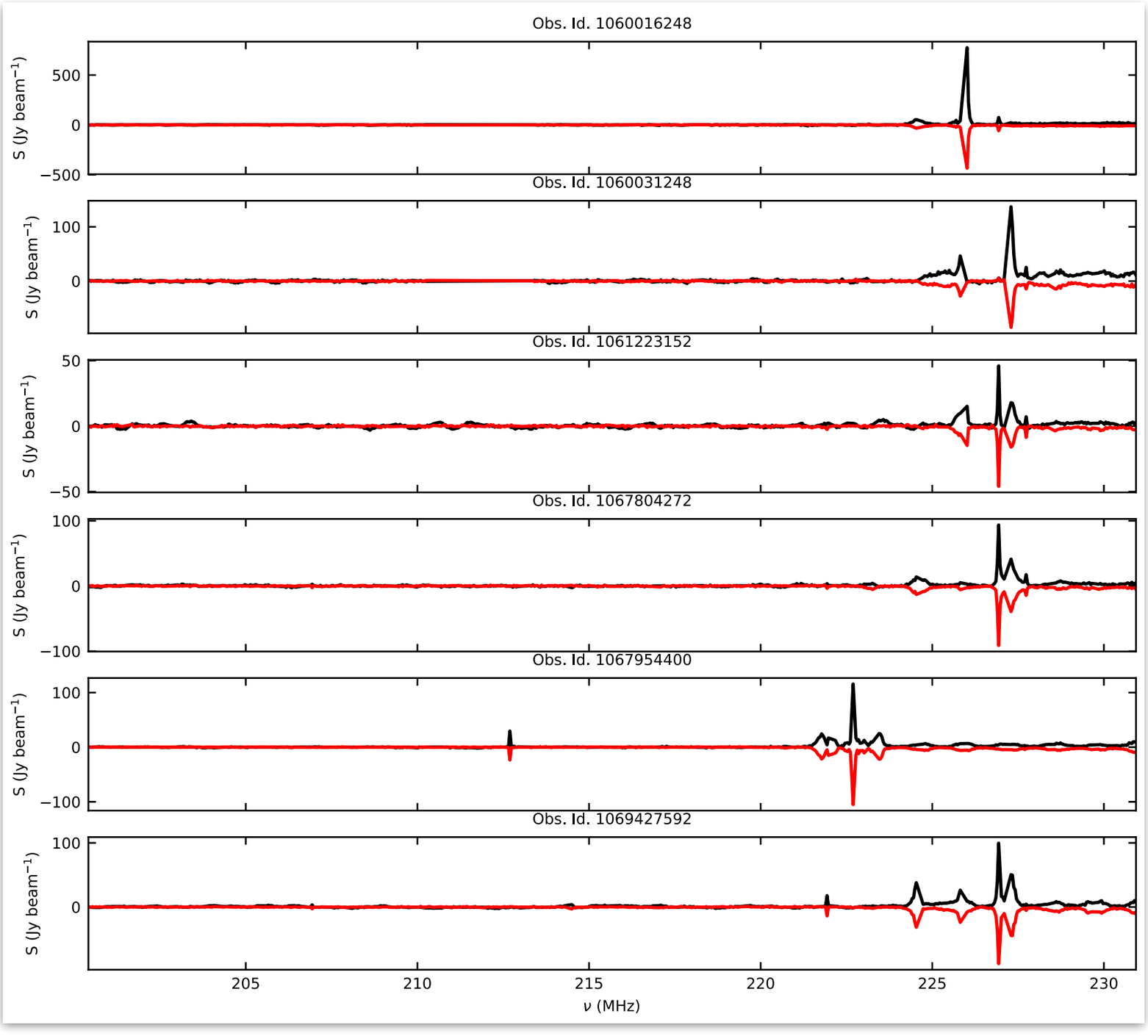


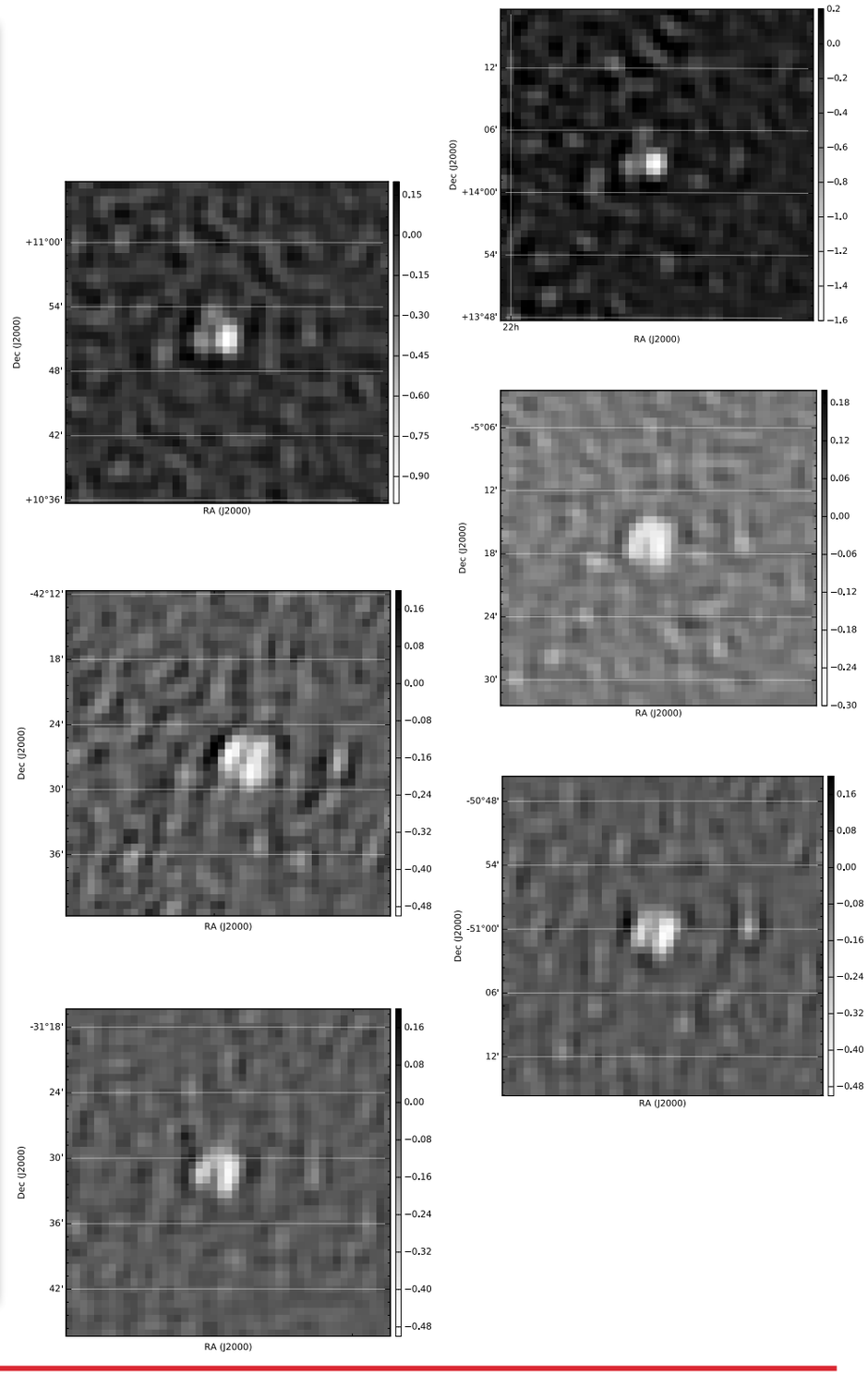






Transients? (Lenc et al. in prep.)





Summary

- Completed “Proof of concept” survey in circular polarisation using existing MWA observations.
- Can model and subtract out leakage on a per-beam basis by mapping leakage in diffuse emission and/or unpolarised sources.
- Achieve 1mJy/beam sensitivity (almost order-of-magnitude deeper than GLEAM survey).
- Detect pulsars.
- MWA upgrade should provide improved sensitivity.
- Applicable to linear polarisation too - see talk by Chris Risley