GLEAM science from the first year of observations

Paul Hancock
+   the GLEAM TEAM
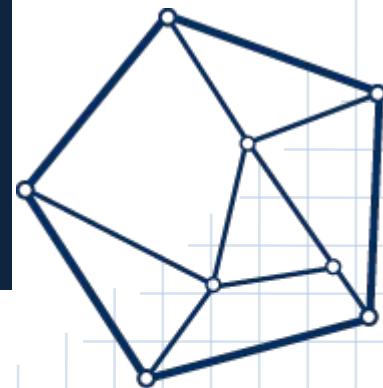
The GLEAM Team

Martin Bell (CSIRO)
Joe Callingham (USyd)
K. S. Dwarakanath (RRI)
Bi-Qing For (ICRAR/UWA)
Tom Franzen (ICRAR/Curtin)
Bryan Gaensler (USyd/Toronto)
Paul Hancock (ICRAR/Curtin)
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Natasha Hurley-Walker (ICRAR/Curtin)
Carole Jackson (ICRAR/Curtin)
Melanie Johnston-Hollitt (VUW)

Anna Kapinska (ICRAR/UWA)
Emil Lenc (USyd)
Ben McKinley (UMelb)
John Morgan (ICRAR/Curtin)
Andre Offringa (ASTRON)
Pietro Procopio (UMelb)
Lister Staveley-Smith (ICRAR/UWA)
Randall Wayth (ICRAR/Curtin)
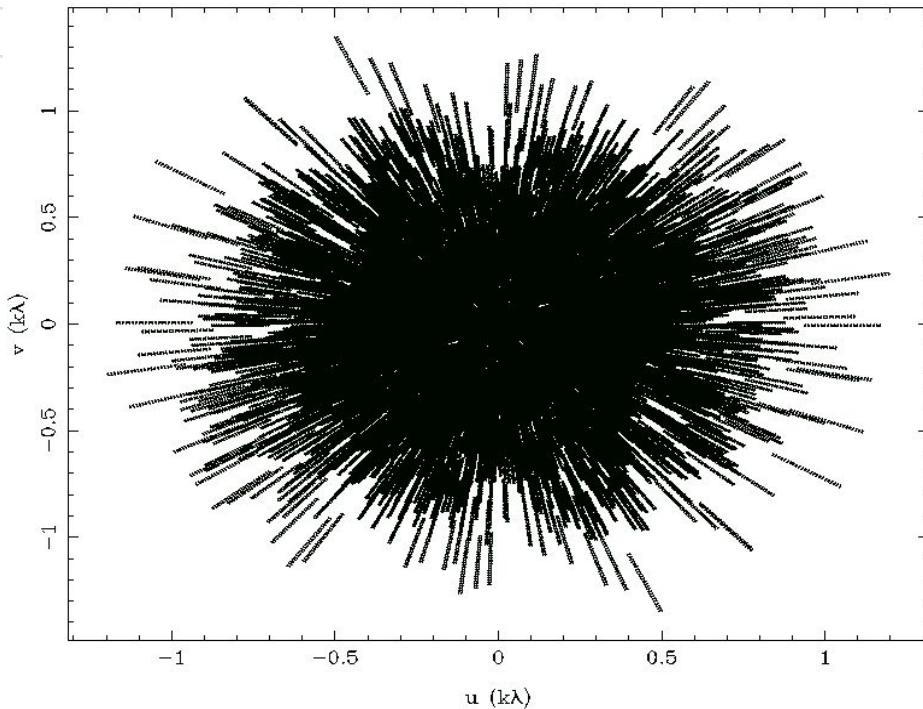Chen Wu (ICRAR/UWA)
Cathie Zheng (VUW)

The MWA

recall
Randall's talk from
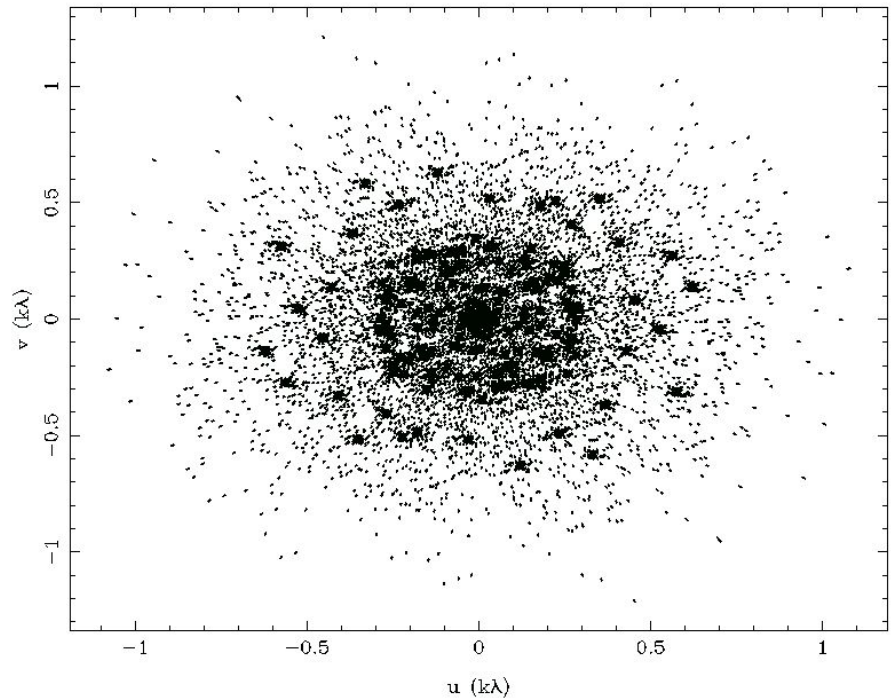yesterday

or read 2013PASA...
30....7T

x 128 + Correlator = The MWA

MWA (u,v) coverage

I sim128t.uv 0.1350 GHz

I sim128t_1cc.uv 0.1350 GHz

Snapshot, full bandwidth   Snapshot, monochromatic

⇒ Snapshot imaging!

Imaging strategy

## Snapshot imaging!

In a 2-minute snapshot, MWA is close to coplanar
- Small w-terms can be fixed with appropriate imager
- We're using WSClean (Offringa et al, 2014) which includes our current best beam model
- Mosaic via image-plane co-addition
  - after correcting for bulk ionospheric shifts and primary beam

GLEAM survey strategy

- Meridian drift scans as 2-minute snapshots, cycling through frequencies
- 7 DEC bands: 18.6, 1.6, -13.0, -26.7, -40.2, -55.0, -72.0
  - Bands have significant overlap to allow primary beam response to be interpolated over the whole meridian
- 5 freq bands covering 73-230 MHz, in 30.72 MHz chunks
  - Can be divided into 20x ~8 MHz sub bands
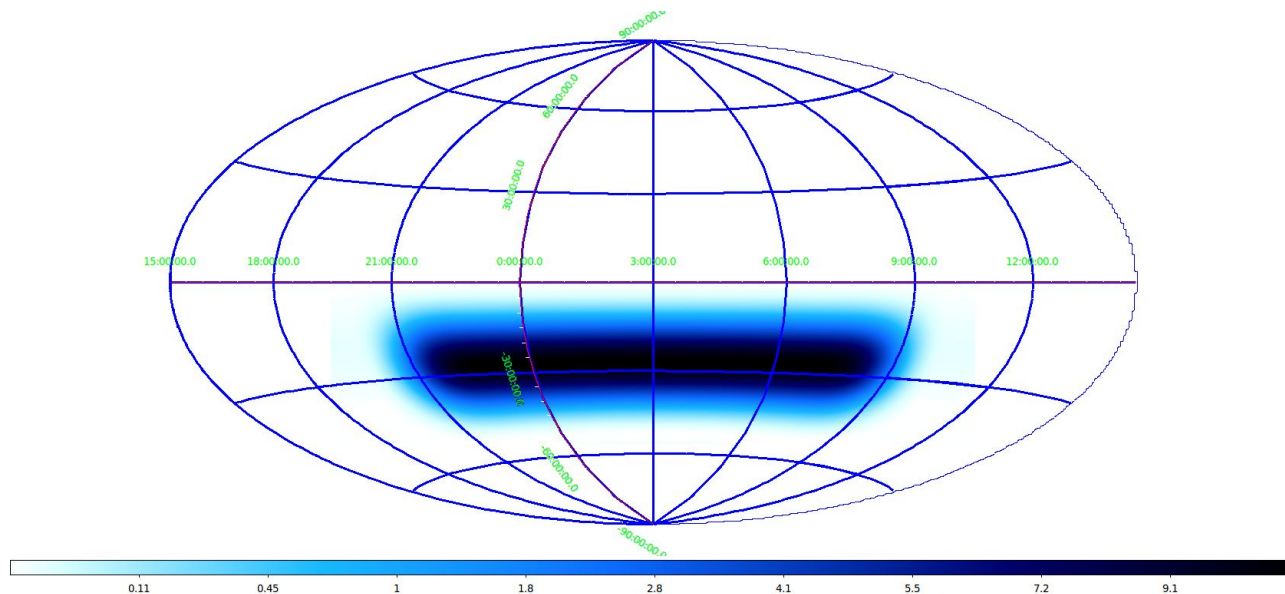
GLEAM Year 1 Obs
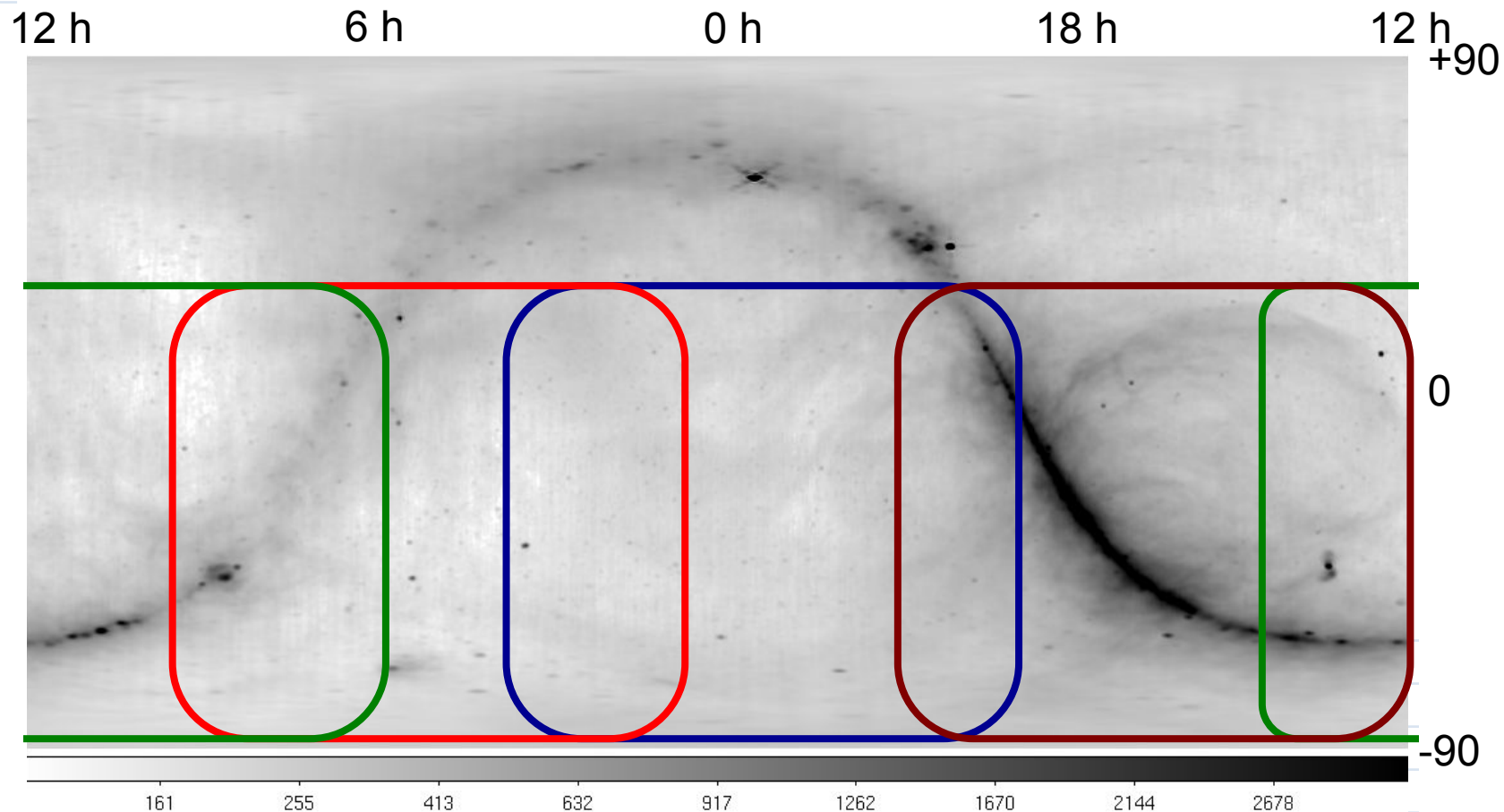
GLEAM 1.3 Mar 2014   GLEAM 1.2 Nov 2013   GLEAM 1.1 Aug 2013   GLEAM 1.4 Jun 2014

GLEAM vs the world

Table 4: Summary of radio surveys below 1 GHz substantially covering the southern hemisphere

Survey	Freq (MHz)	Resolution (arcmin)	Max size (arcmin)	Coverage	Stokes I cutoff (Jy)
MRC[a]	408	$2.6 \times 2.9 \sec(\delta + 35.5°)$	~ 30	$+18.5 > \delta > -85, |b| > 3$	0.7
SUMSS[b]	843	$0.75 \times 0.75 \operatorname{cosec}|\delta|$	163	$\delta < -30$	0.006 - 0.01
VLSS(r)[c]	74	1.25	$\sim 23^*$	$\delta > -40$	~ 0.5
TGSS[d]	150	0.33		$\delta > -30$	~ 0.03
PAPER32[e]	145	26	~ 300	$\delta < 10$	10
MSH[f]	86	50	n/a	$\delta < 10$	20
GLEAM	72-231	$2.5 \times 2.2 \sec(\delta + 26.7°)^\dagger$	~ 600	$\delta < +25$	$\sim 0.1^\dagger$

Wide bandwidth, moderate resolution, sensitive, all southern sky survey, with good low surface brightness sensitivity.

More details

GLEAM: The GaLactic and Extragalactic All-sky MWA survey.

2015PASA...32...25W

R. B. Wayth[1,2], E. Lenc[3,2], M. E. Bell[4,2], J. R. Callingham[3,2,4], K. S. Dwarakanath[5], T. M. O. Franzen[1], B.-Q. For[6], B. Gaensler[3,7,2], P. Hancock[1,2], L. Hindson[8], N. Hurley-Walker[1], C. A. Jackson[1,2], M. Johnston-Hollitt[8], A. D. Kapińska[6,2], B. McKinley[9,2], J. Morgan[1], A. R. Offringa[10], P. Procopio[9,2], L. Staveley-Smith[6,2], C. Wu[6], Q. Zheng[8], C. M. Trott,[1,2] G. Bernardi[11,12,13], J. D. Bowman[14], F. Briggs[15], R. J. Cappallo[16], B. E. Corey[16], A. A. Deshpande[5], D. Emrich[1], R. Goeke[17], L. J. Greenhill[13], B. J. Hazelton[18], D. L. Kaplan[19], J. C. Kasper[13,20], E. Kratzenberg[16], C. J. Lonsdale[16], M. J. Lynch[1], S. R. McWhirter[16], D. A. Mitchell[4,2], M. F. Morales[18], E. Morgan[17], D. Oberoi[21], S. M. Ord[1,2], T. Prabu[5], A. E. E. Rogers[16], A. Roshi[22], N. Udaya Shankar[5], K. S. Srivani[5], R. Subrahmanyan[5,2], S. J. Tingay[1,2], M. Waterson[1], R. L. Webster[9,2], A. R. Whitney[16], A. Williams[1], C. L. Williams[17]

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[11]Square Kilometre Array South Africa (SKA SA), 3rd Floor, The Park, Park Road, Pinelands, 7405, South Africa
[12]Department of Physics and Electronics, Rhodes University, PO Box 94, Grahamstown, 6140, South Africa

GLEAM near-term products

- Survey description paper 2015PASA...32...25W
- Polarised compact source catalogue: 2016 (Lenc)
- Southern Galactic plane map: 2016 (Hindson)
- Extragalactic (|b| > 10) compact source catalogue (Stokes I): 2016 (Hurley-Walker)

- Raw data are coming out of proprietary period
  - Collaborate with a GLEAM-Team-er for some help

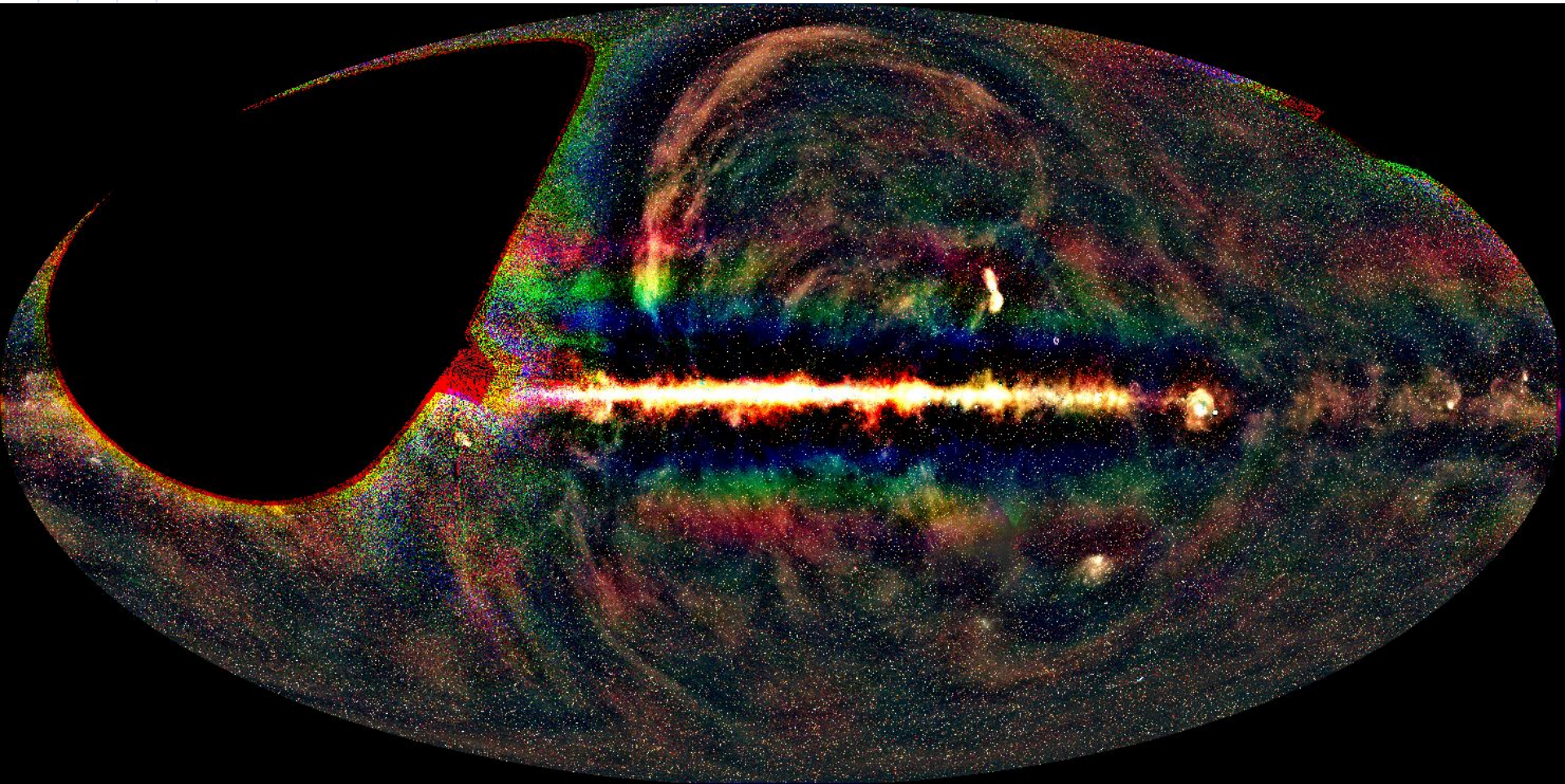22 new SNRs in strip from GLON 345 to 255

New SNR

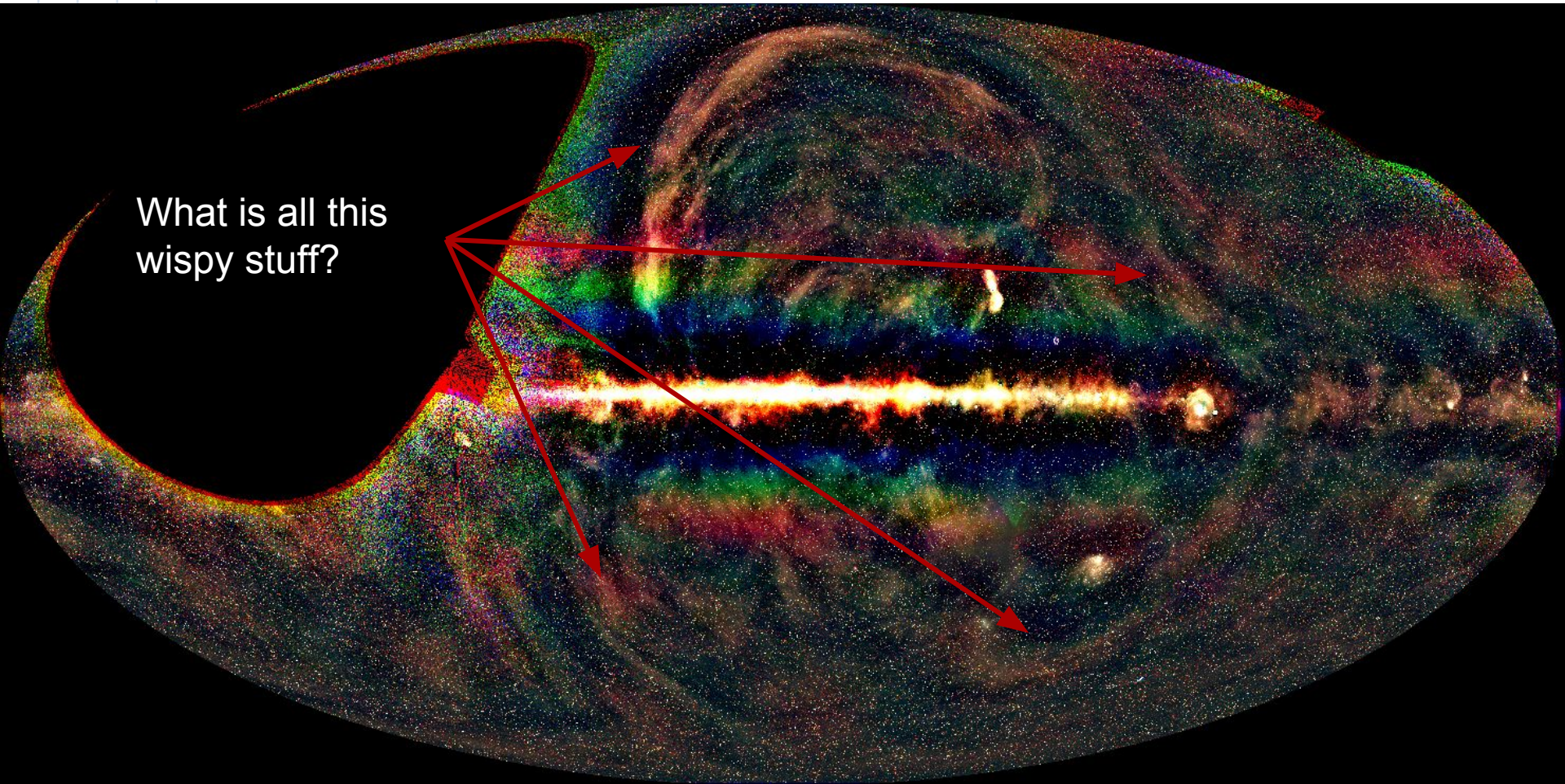3-colour images from Luke Hindson (Victoria University of Wellington). 2016 in prep

The Radio Sky a-la GLEAM

Unparalleled in freq coverage, FoV, surface brightness, cadence

Credit: Natasha H-W

The Radio Sky a-la GLEAM

What is all this wispy stuff?

Credit: Natasha H-W

The Radio Sky a-la GLEAM

What is all this wispy stuff?

http://www.jb.man.ac.uk/research/cosmos/haslam_map/

The Radio Sky a-la GLEAM

What is all this wispy stuff?

Credit: Natasha H-W

http://www.jb.man.ac.uk/research/cosmos/haslam_map/

The Radio Sky a-la GLEAM

This is all real emission!

http://www.jb.man.ac.uk/research/cosmos/haslam_map/
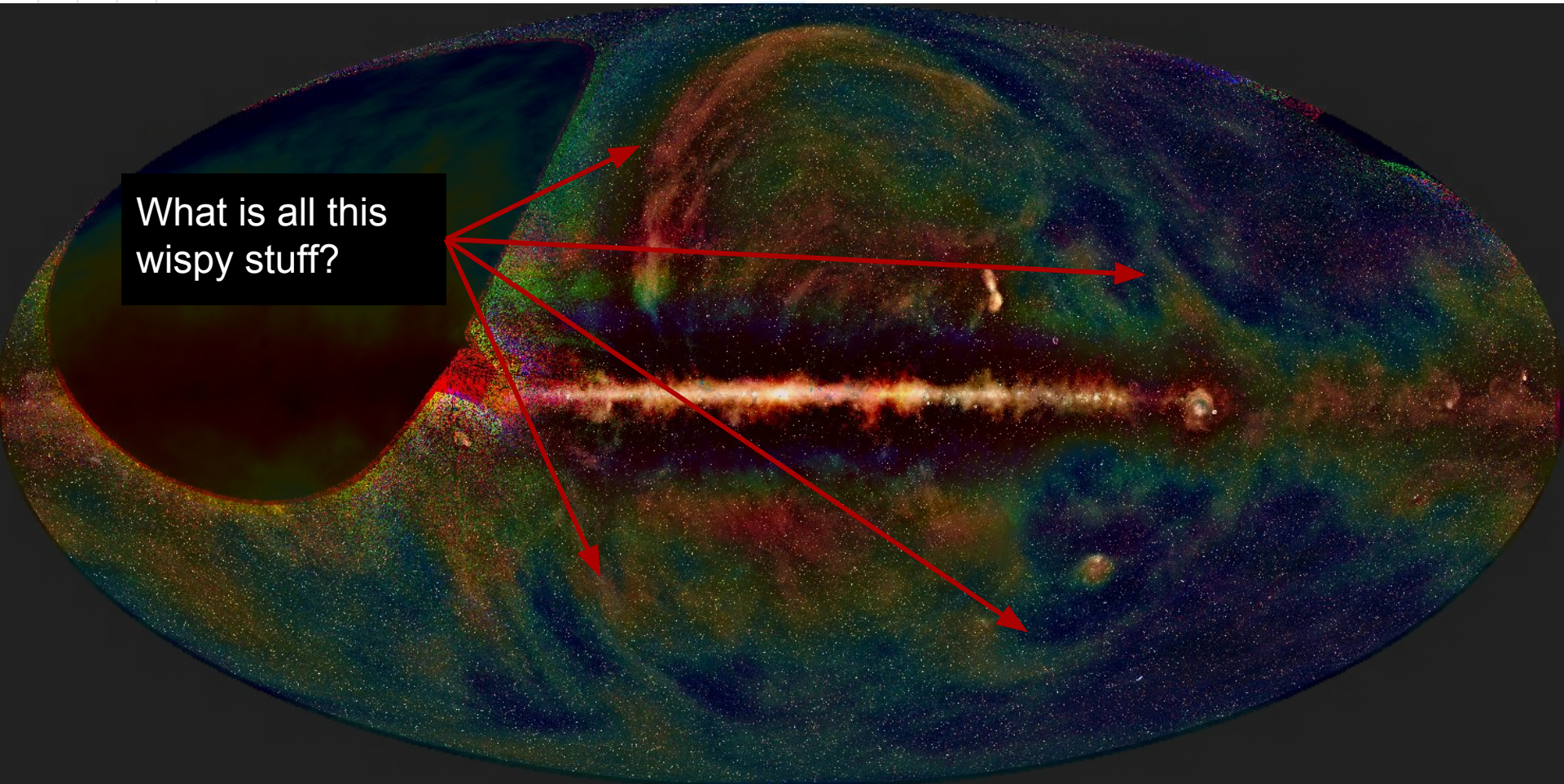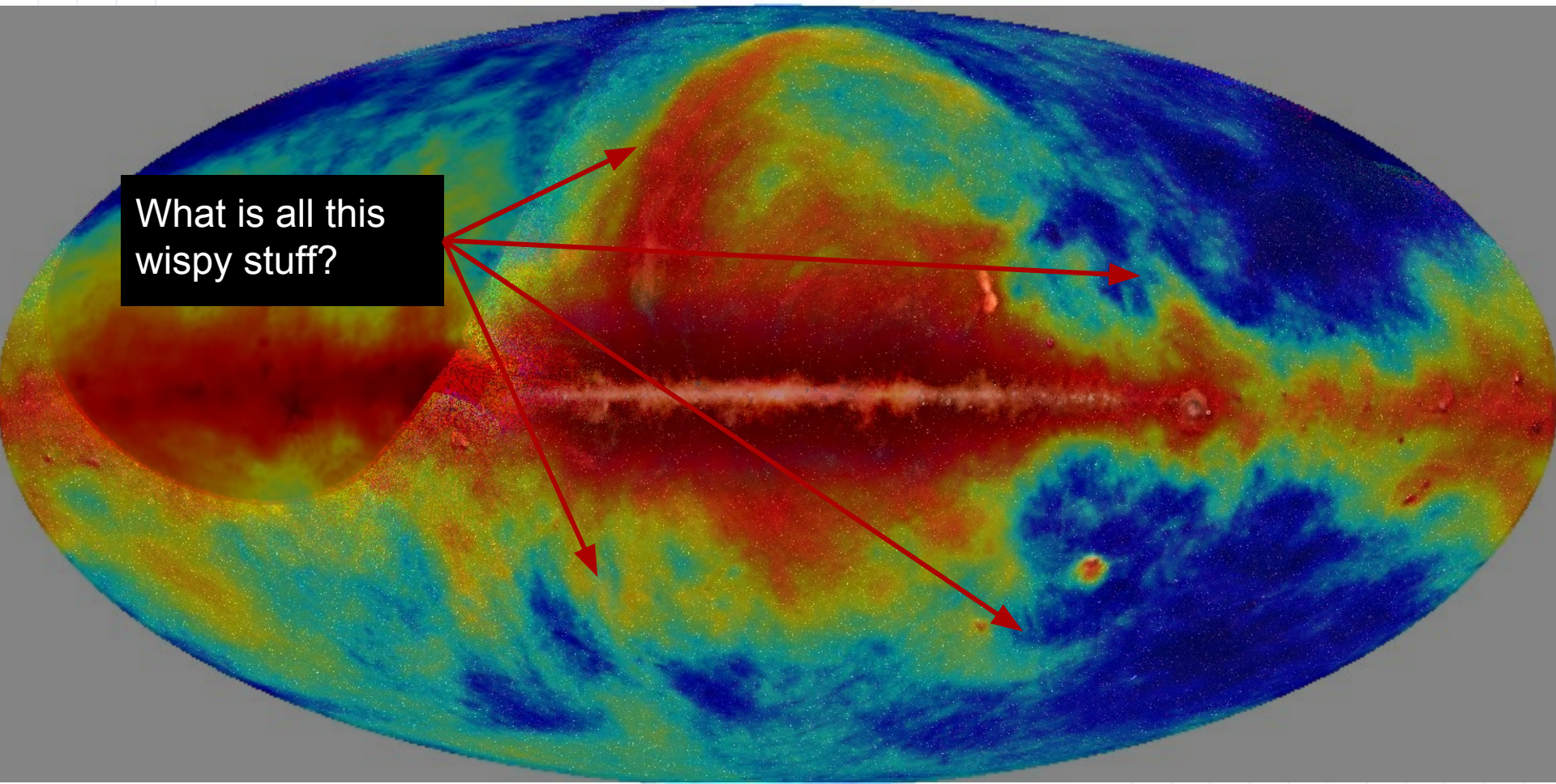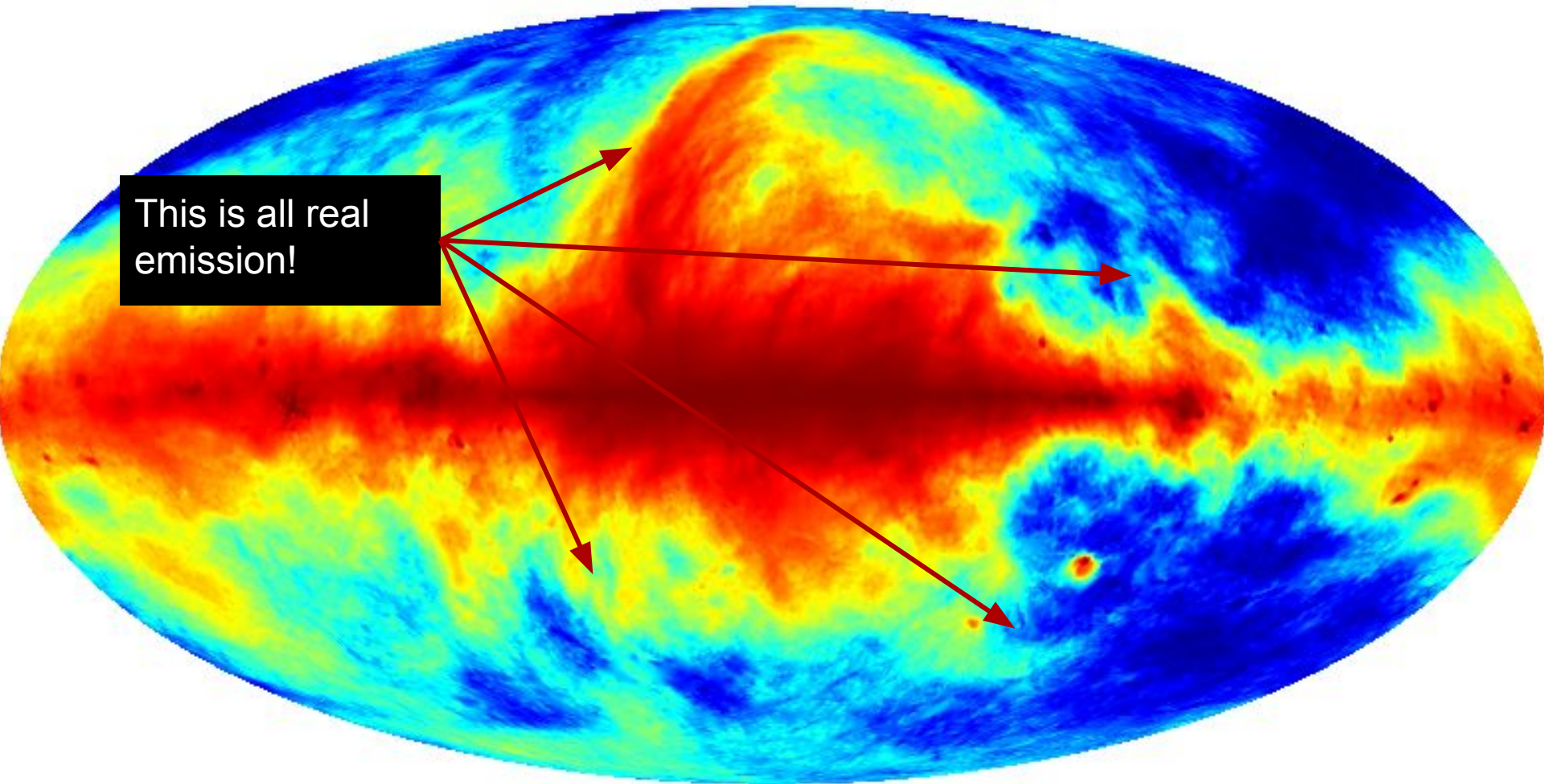
GLEAM Extragalactic source catalogue

Hurley-Walker et al. in prep

- Full analysis of GLEAM year 1 data
  - focus on compact sources
- Using WSClean (Offringa)
- Using Aegean (Hancock, incl lots of special mods)
- With bulk ionosphere corrections (Morgan)
- With primary beam corrections (Callingham, Kapinska)
- Challenges:
  - bright sources
  - primary beam
  - ionosphere
  - changing effective PSF

Source finding - Aegean

This repository — Search

PaulHancock / **Aegean**

The Aegean source finding program and associated tools

Aegean
- **Find** sources
- **Characterise** sources
- Sources can be **gaussians** or **blobs**
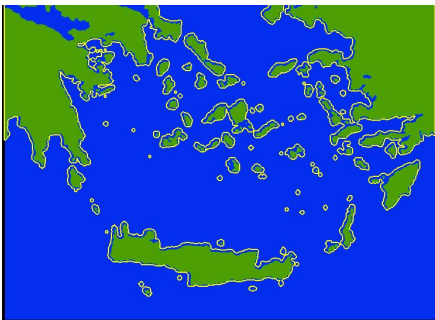
BANE
- **Characterise background**
- Characterise **noise**
- Do it **right**
- Do it **fast**
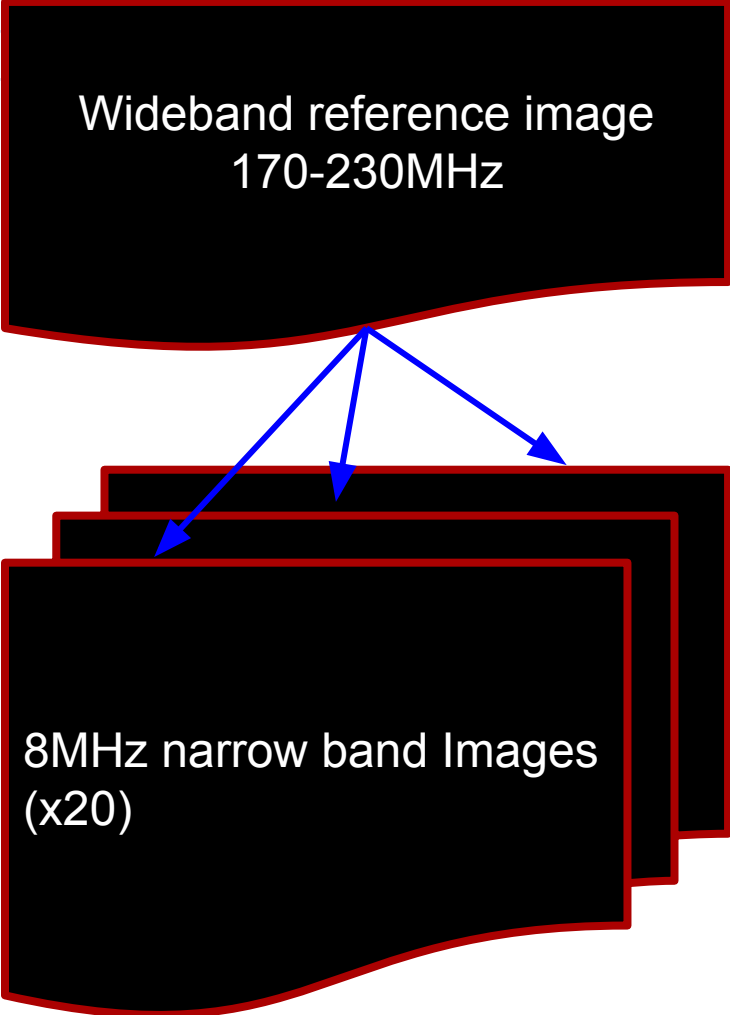
MIMAS
- **Describe** regions
- **Combine** regions
- **Mask** images
- **Constrain** Aegean
- Write **MOC** files
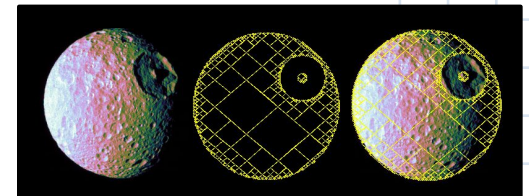
Catalog Strategy

Wideband reference image
170-230MHz

8MHz narrow band Images
(x20)

Create reference catalog from a deep, wideband, reference image

For each narrow band image do a fit with priors from the reference catalog

Catalog contains
- all sources from deep image
- fluxes from each sub band for each source
- ZERO false cross ids

Poster - The GLEAM survey: Images to Catalogs

SED for every source!

MRC 0008-421

Old Model + New data =
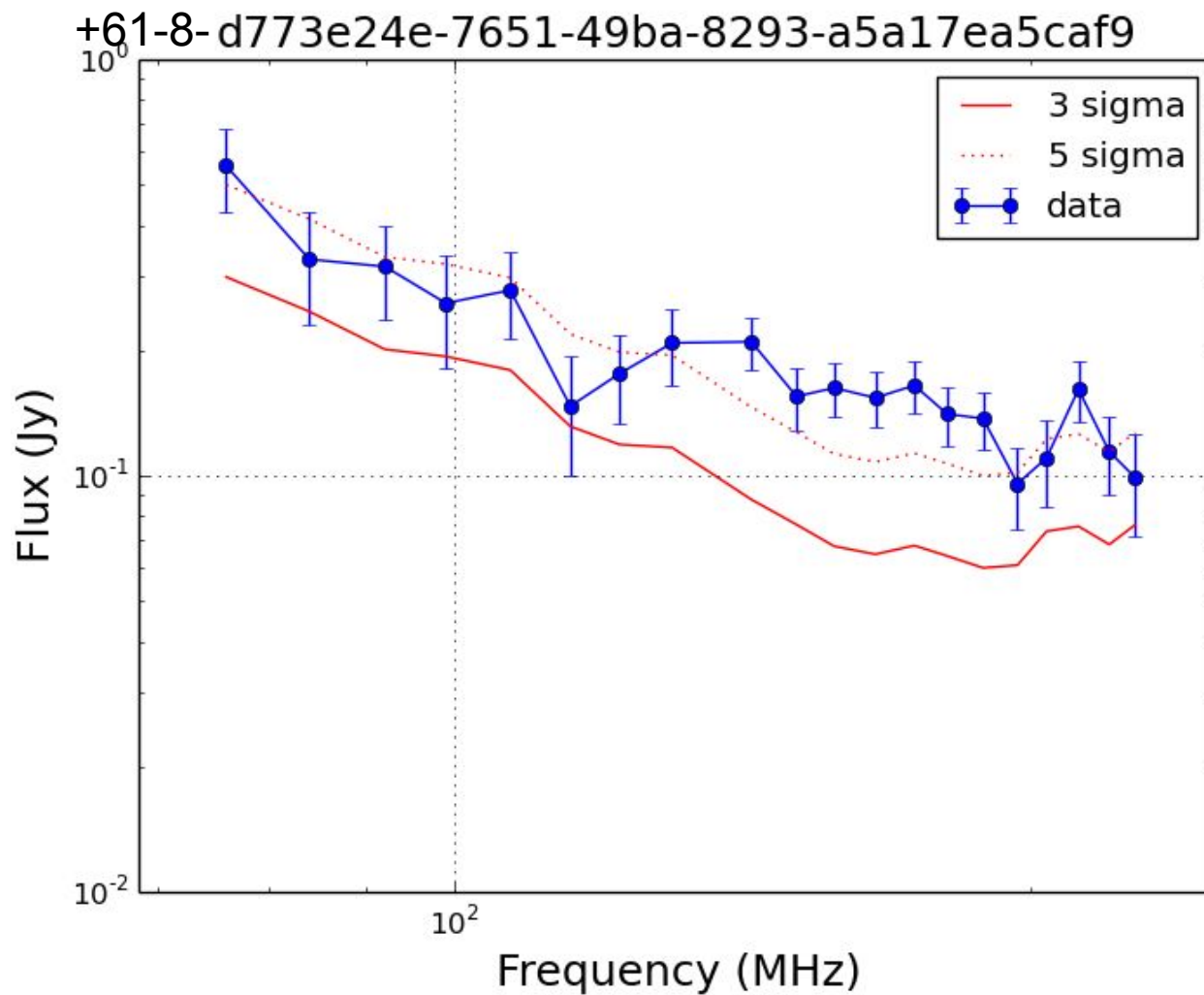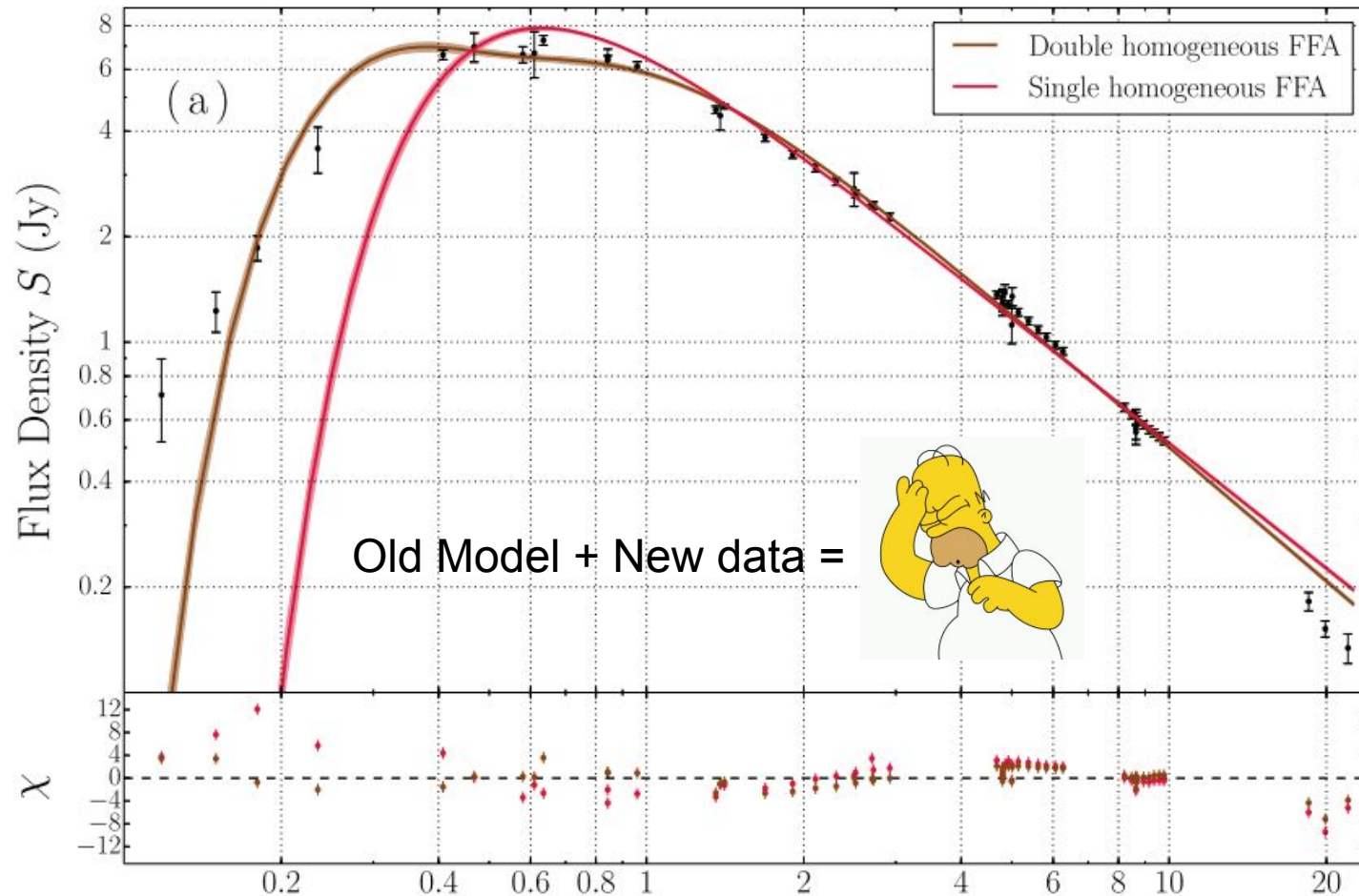
See Jo Callingham's talk after lunch today

MRC 0008-421

Old Model + New data = New Model
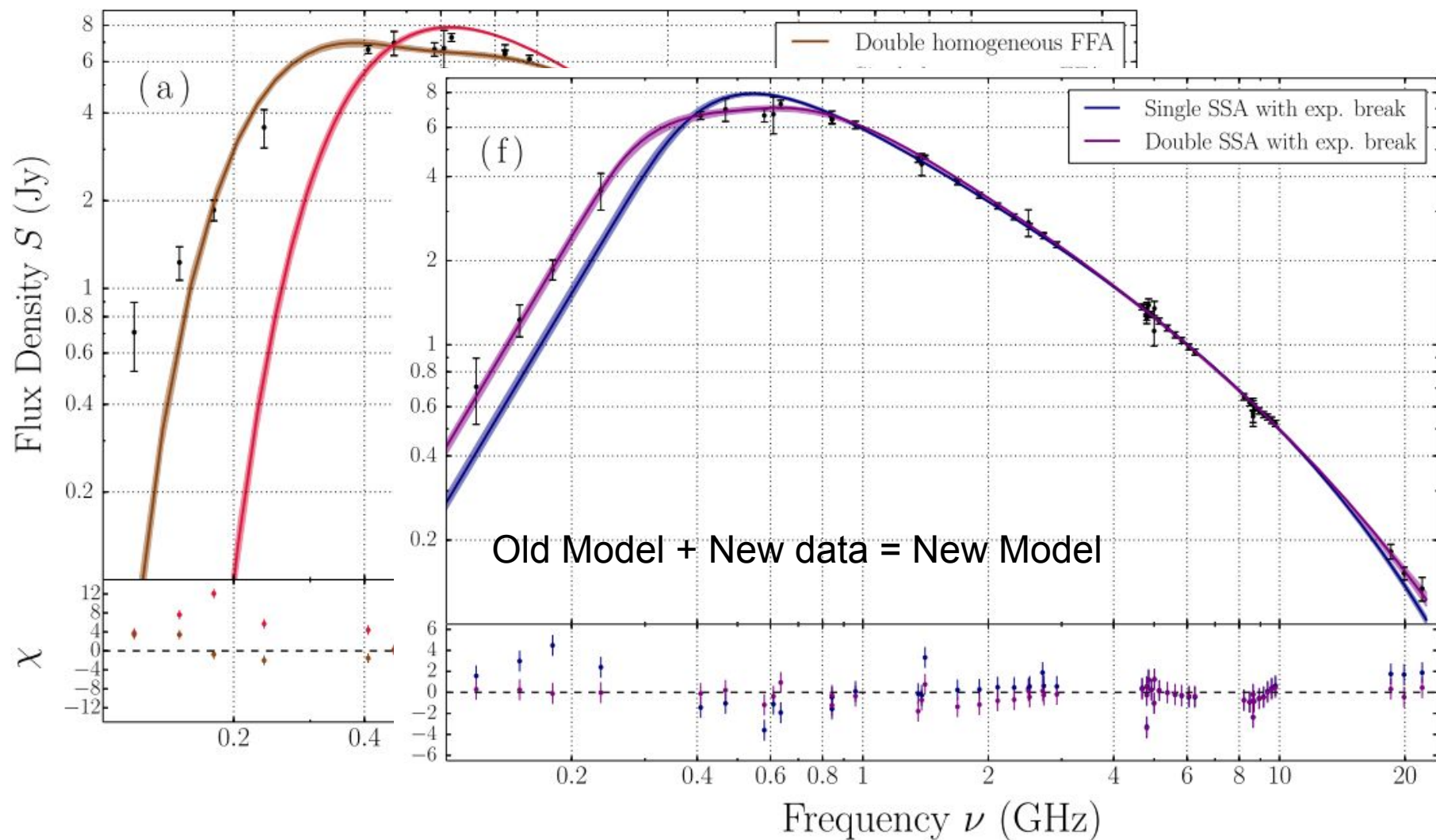
GLEAM – a legacy dataset for the MWA

Coming soon to a VO-server near you!
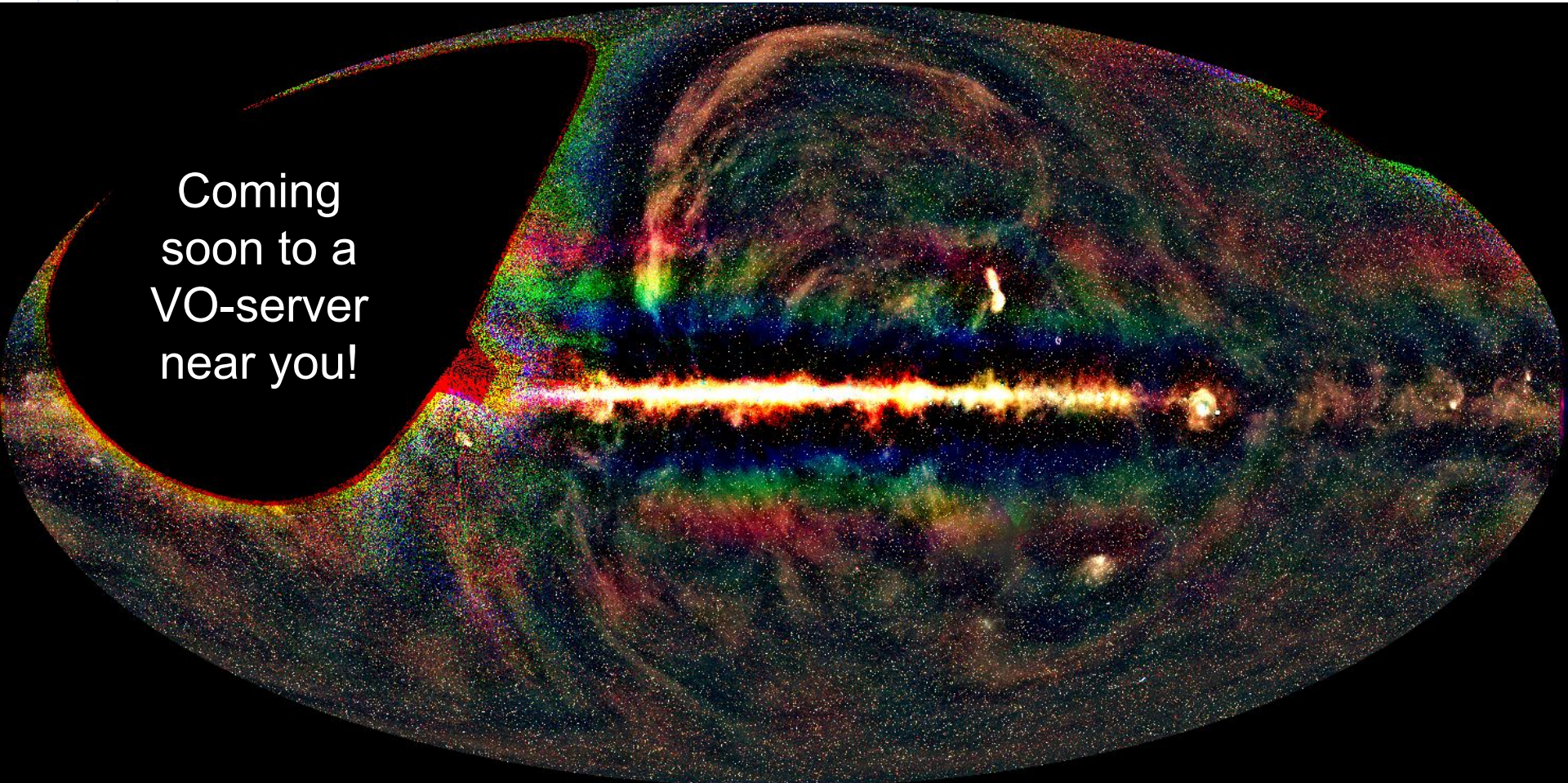
GLEAM: One survey to rule them all

I'm kind of a big deal
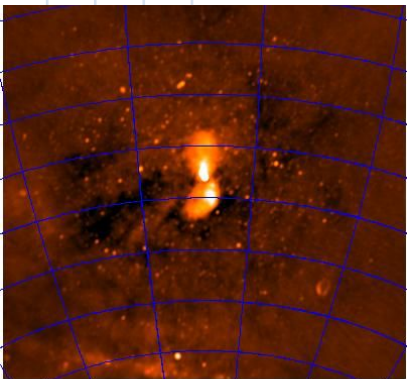
Radio galaxies & AGN

1 Mpc

Galaxy clusters
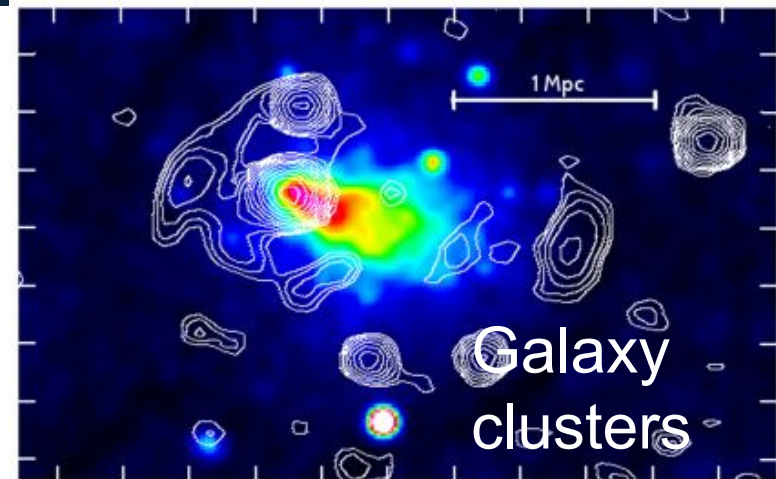
Your science here.
Ask us how.
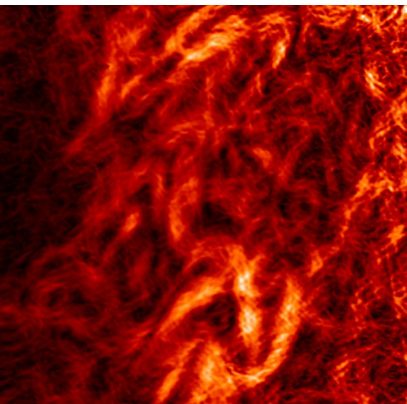
Diffuse Galaxy & B field

LMC/SMC

-0.15 0.2 0.55 0.9 1.3 1.6 1.9 2.3 2.7
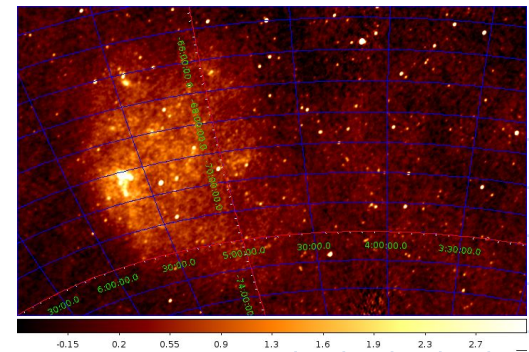
SNRs & HII regions

GLEAM² future – Year 2

- Twice the observing time vs year 1.

- Increased/different (u,v) coverage

    ○ Alternate between HA +1 and HA -1 every ~6 weeks

- Same 7 DEC bands:

    ○ +18.6, +1.6, -13.0, -26.7, -40.2, -55.0, -72.0

- Same 5 freq ranges covering 73-230 MHz

- Improved frequency resolution: 10 kHz

- Decreased time resolution: 2s (vs 0.5s)
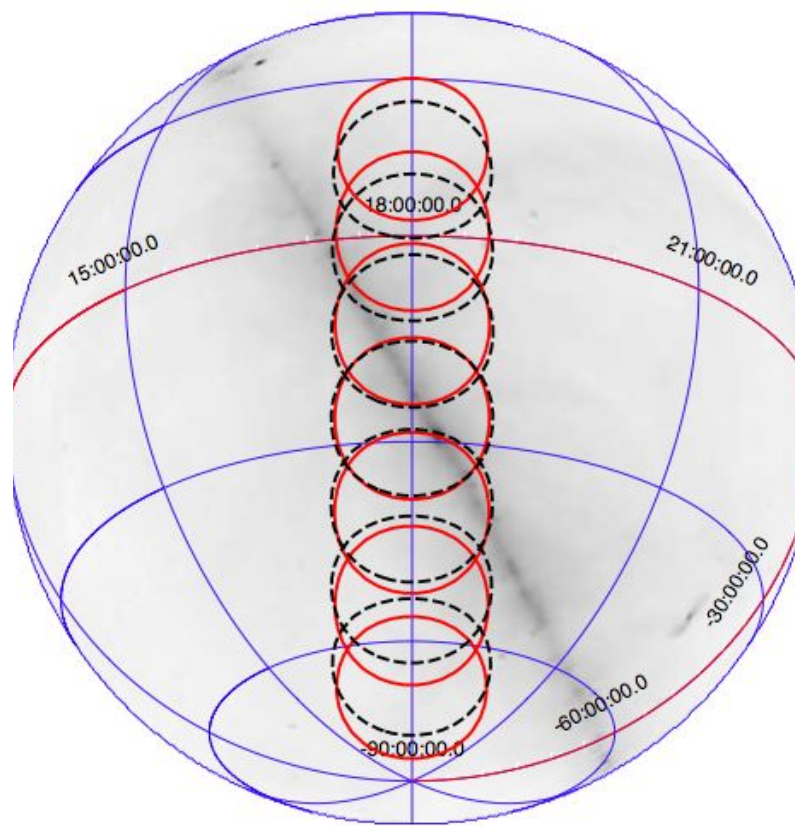
Sensitivity vs LST (meridian)
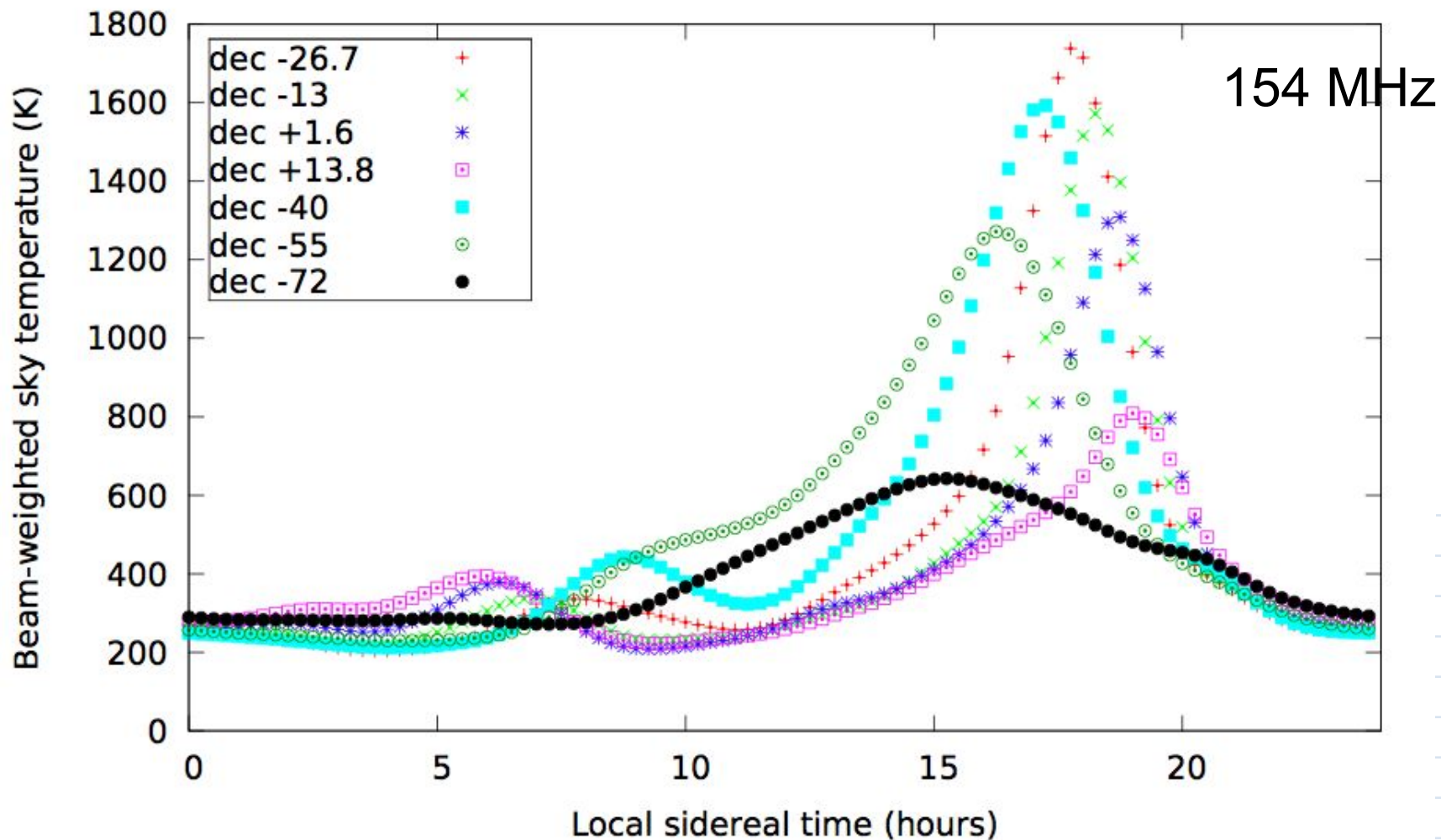
154 MHz

GLEAM meridian beams

Half-power contours
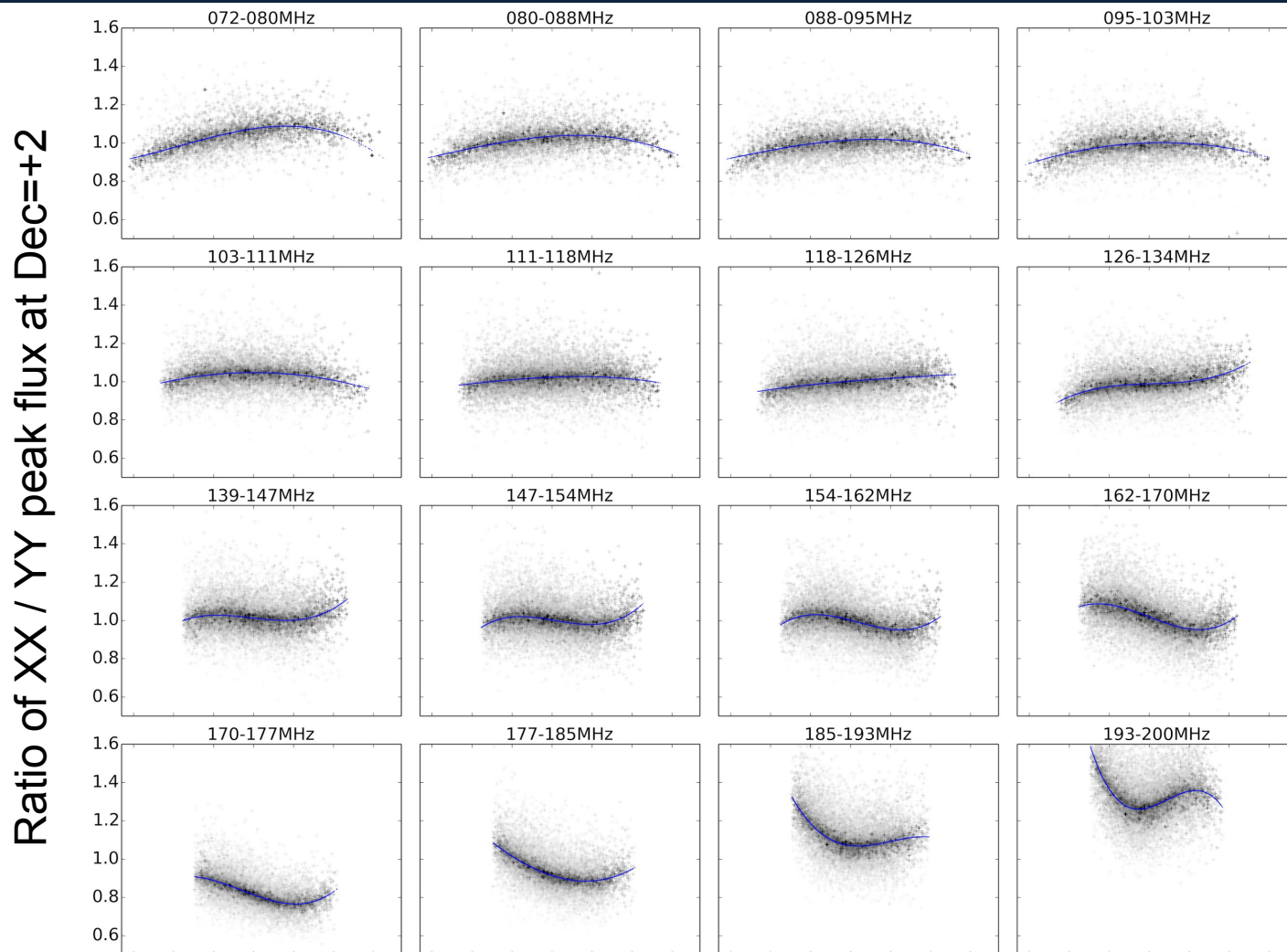
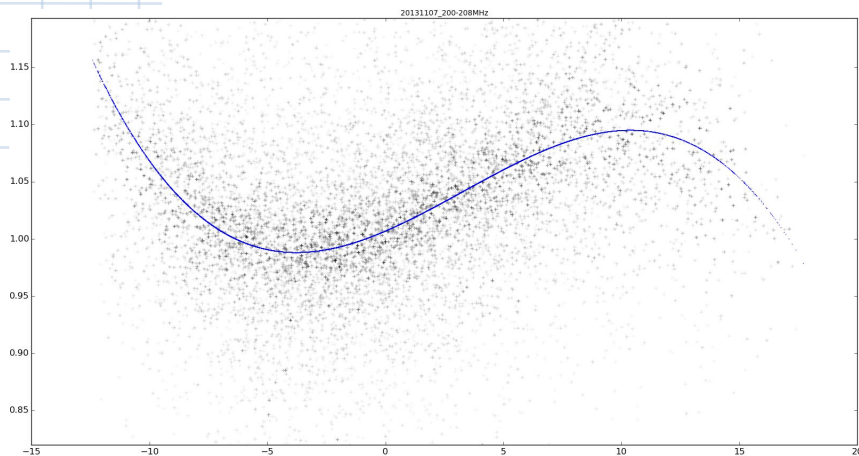‘XX’ (east-west) dipoles
- - - ‘YY’ (north-south) dipoles
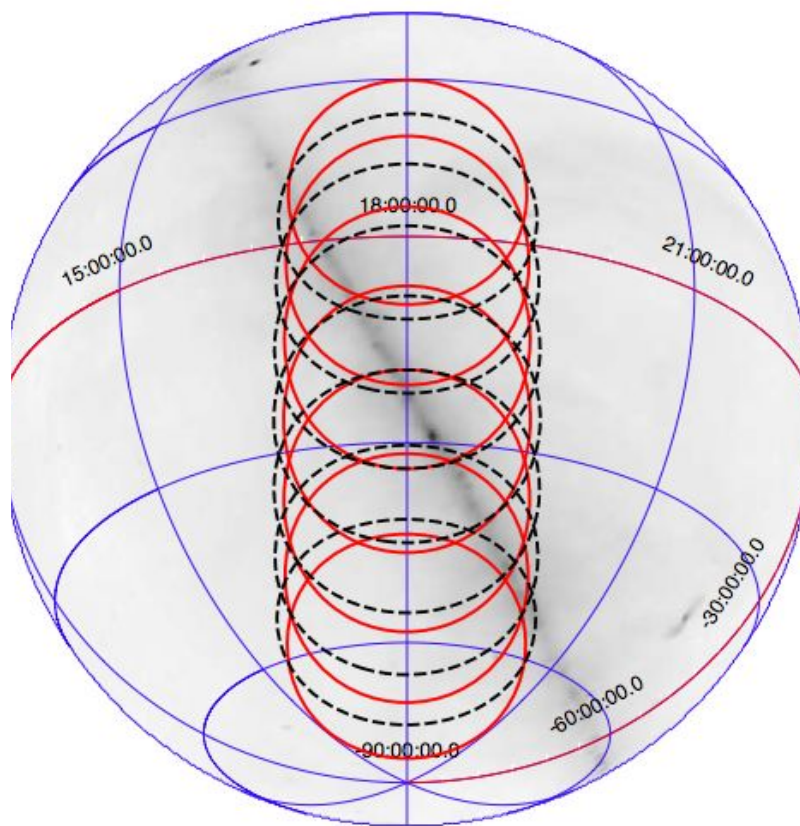
88 MHz

154 MHz

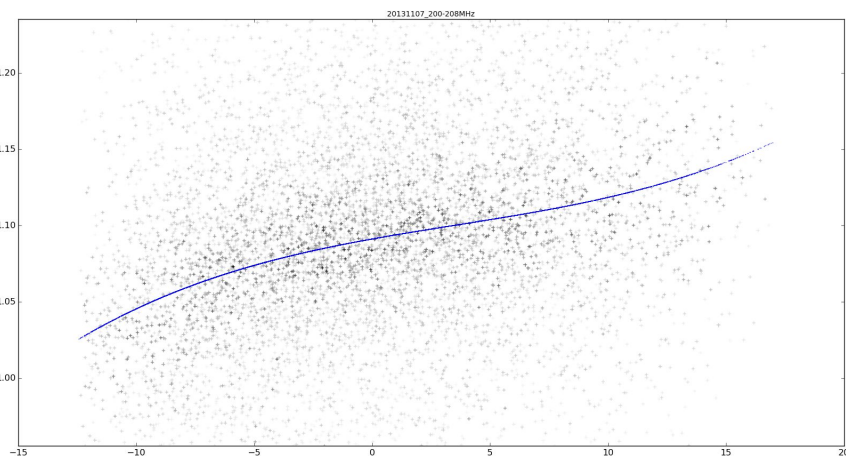# 2nd order beam corrections (XX/YY)

Hurley-Walker et al. in prep

2nd order beam corrections (XX/YY)

Measured

"Predicted"

Old Beam Model

New Beam Model

Ratio XX/YY ->

Declination ->