

S-PASS: a new view of the polarized Sky

Polarized Foregrounds for CMB – Garching

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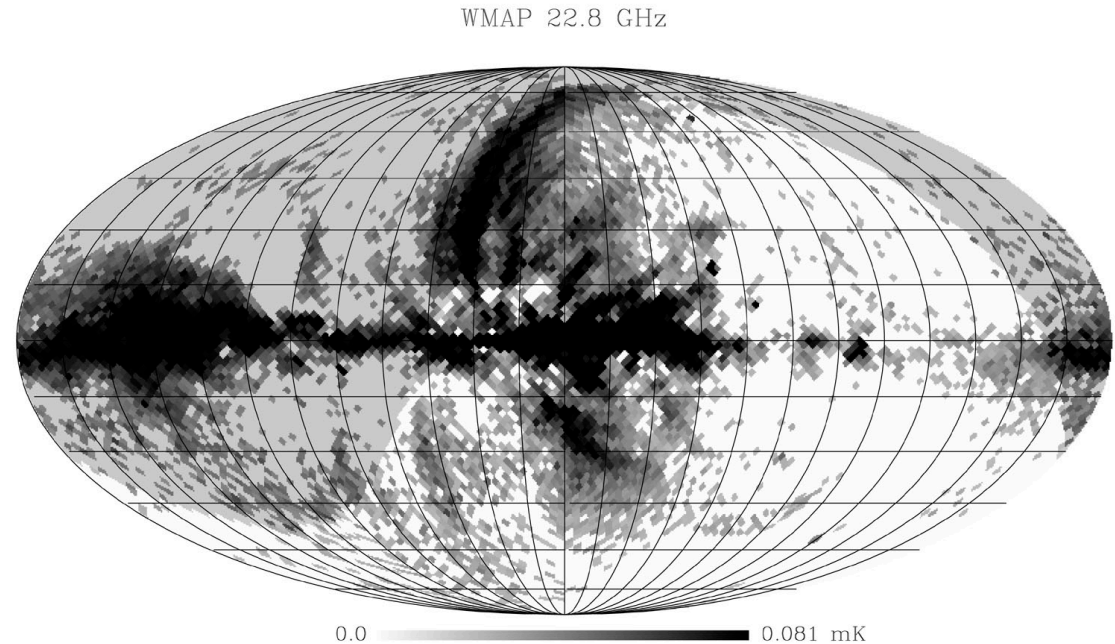


S-PASS: S-band Polarization All Sky Survey

- To survey the polarized emission of the entire southern sky at 2.3 GHz

- Dec < 0° (unshaded area);
- PARKES: 2.3 GHz ;
- 224 MHz BW (100+ ch);
- FWHM = 9';
- $\sigma_{\text{beam}} < 1.0$ mK;

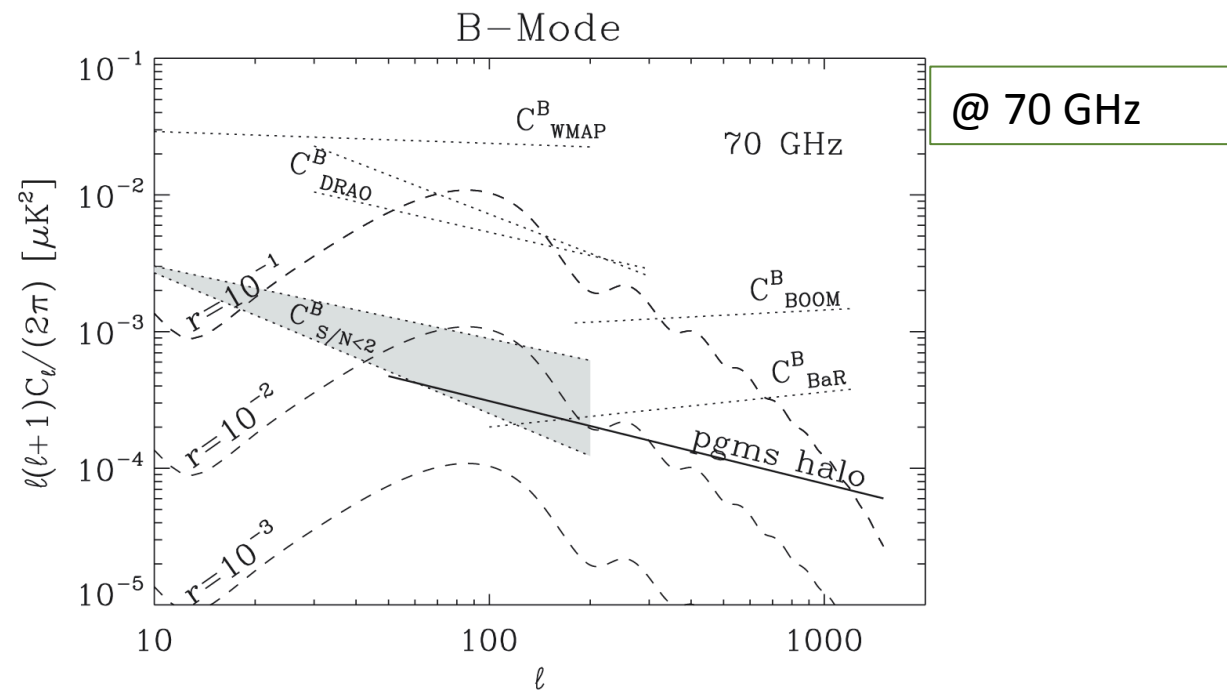
- 2000 h
- 175 nights in 2.5 yrs (!)



- Started Oct 07, **completed in January 2010**
- **Goals: synchrotron emission, Galactic magnetic field, CMB foregrounds**

Galactic Synchrotron Foreground

- **All high Galactic latitudes:** Galactic synch emission at 70 GHz equivalent to CMB B-mode with **T/S ~ 0.3**
- **even higher than the current upper limit (T/S < 0.2, 95% c.l.)**
- PGMS: lowest emission regions: T/S ~ 3×10^{-3} [15% sky frac.] [Carretti et al., MNRAS, 2010]

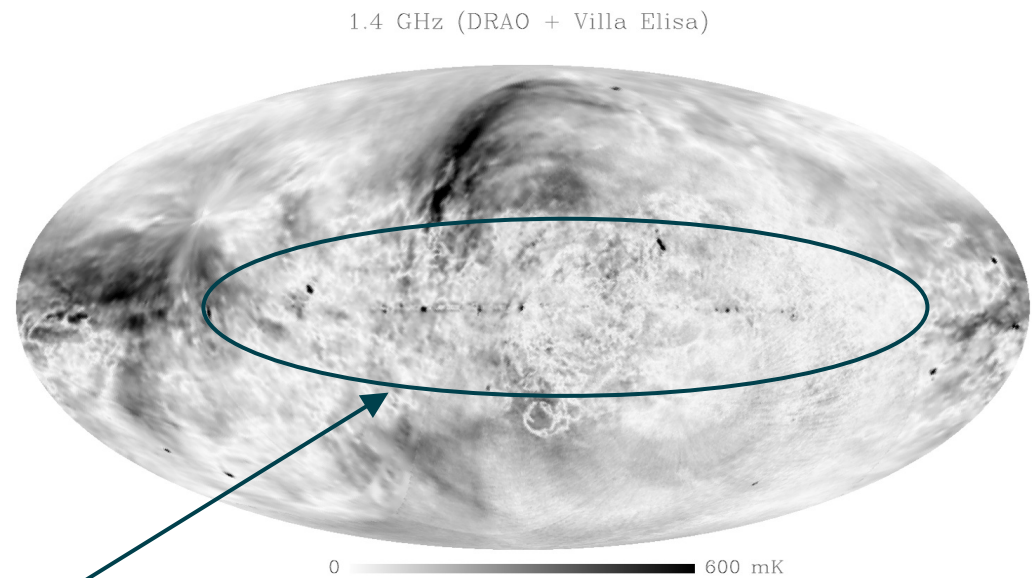


Polarization surveys: 1.4 GHz

- ALL SKY maps at **1.4 GHz**, FWHM $\sim 36'$
- Single channel surveys: no RM measures.
- FR modifications:
 - Galactic Disc strongly depolarized $|b| < 30^\circ$
 - FR modification at $|b| < 50^\circ$



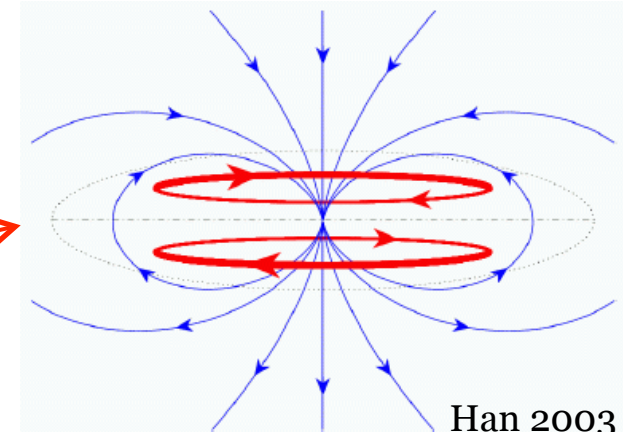
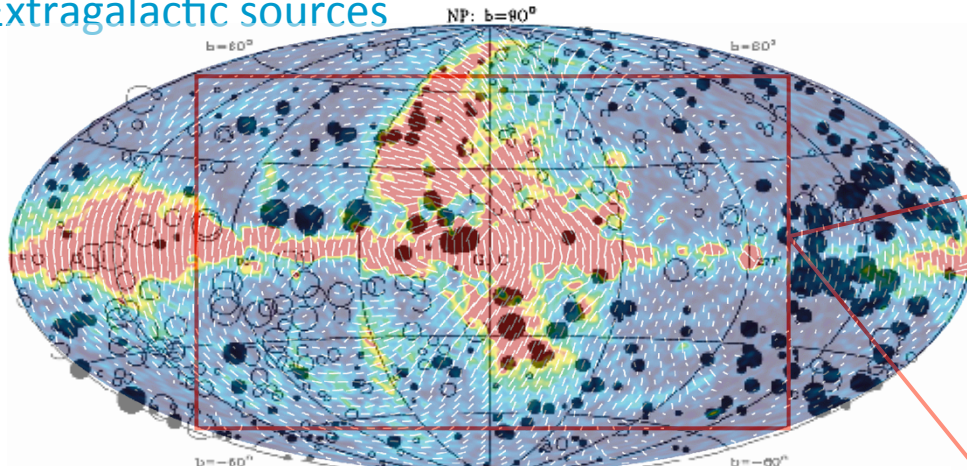
- **1.4 GHz: not sufficient**



depolarization

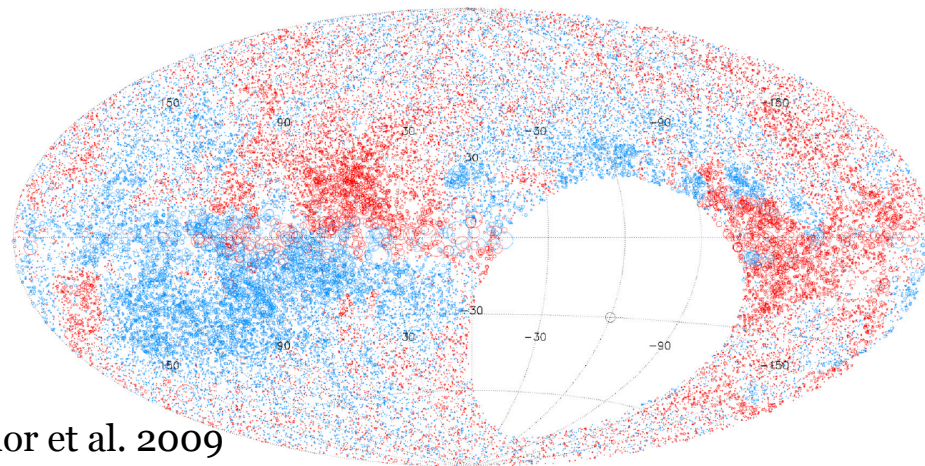
Anti-symmetry in the inner Galaxy: local structure or signature of dynamo?

Extragalactic sources



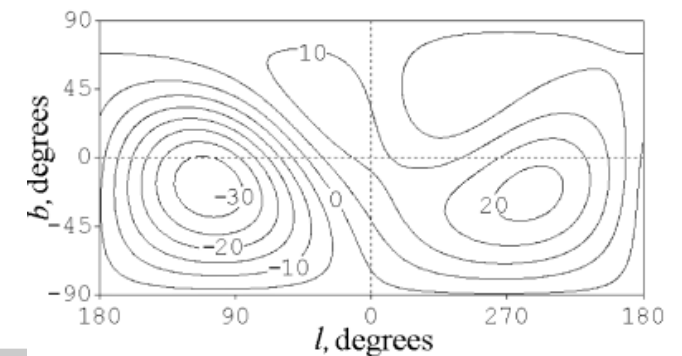
Han 2003

An A0 dynamo...



Taylor et al. 2009

...or an even field and the North Polar Spur? Frick et al 20



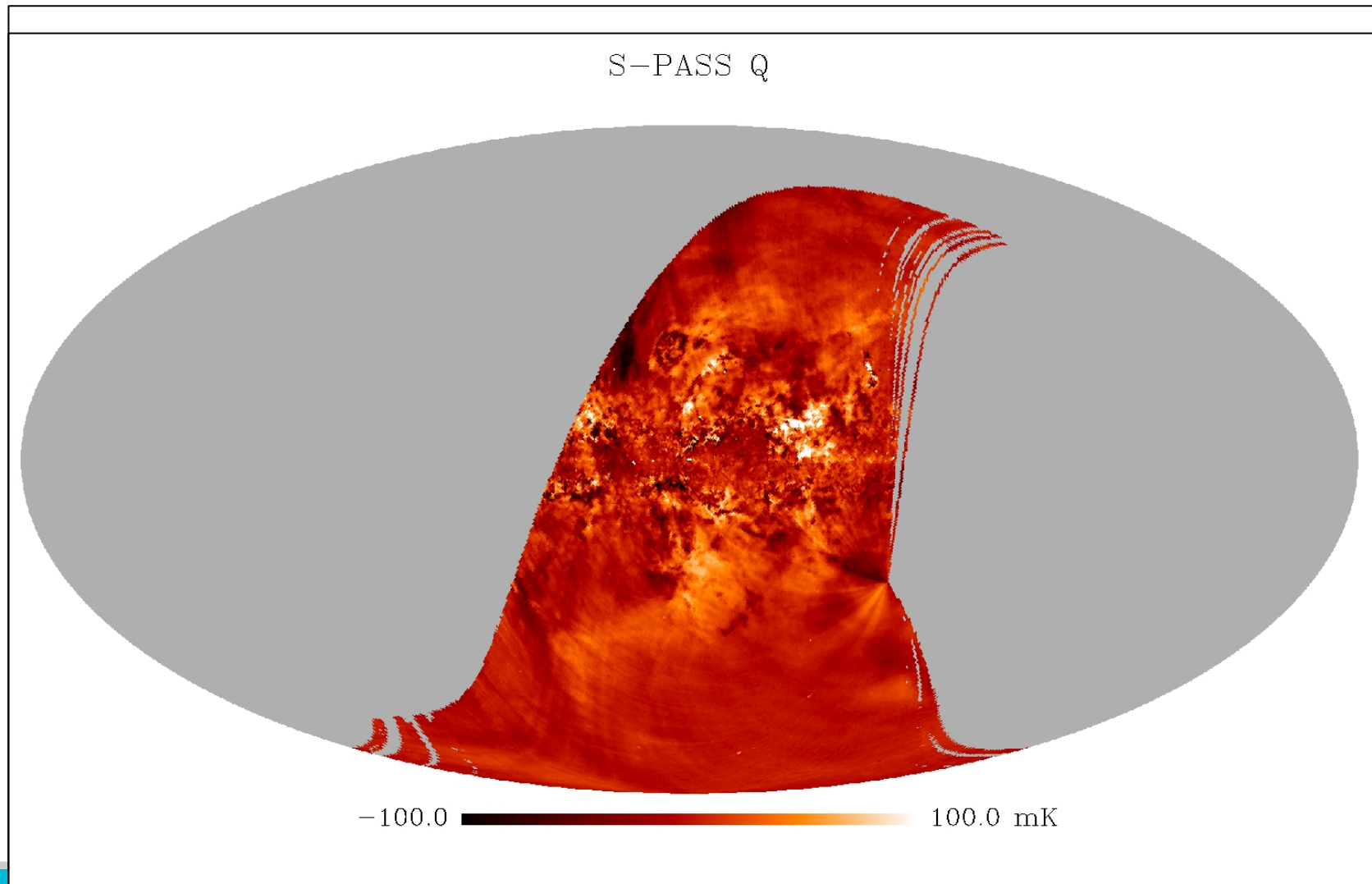
Scanning strategy: requirements

- High speed (10+ deg/min)
 - coverage = 20,000 deg²
 - beam = 9' => px = 4.5'
 - one pixel (!)
- ground emission
 - EL dependant
- absolute calibration

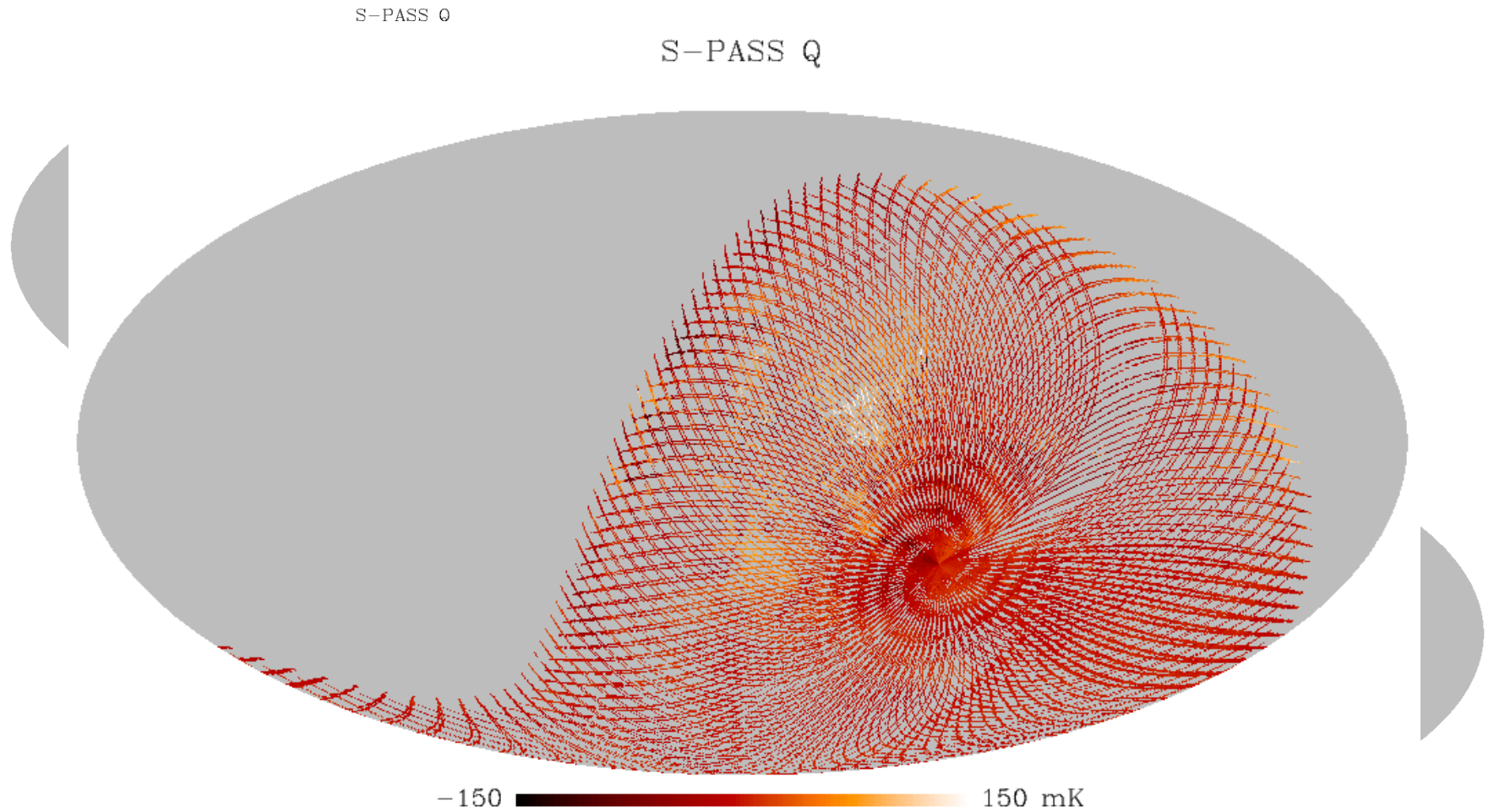
Mapping: long AZ scans

- small area basket weaving: **not an option for S-PASS**
 - ground emission contamination (EL dependant)
 - high speed requires significant overhead for short scans (10° - 20°)
 - short scans: mean emission on area scale is lost
- New **exotic/non-standard scanning strategies** has been developed for S-PASS
 - **AZ scans**
 - Long AZ scans at South Pole EL to cover all Dec in one haul ($\sim 115^{\circ}$)
 - uses the Sky rotation to observe all RA 24 hrs.
 - each day/night a zig-zag track is observed in the sky
 - one zig-zag per night: accurate start timing is required

Mapping: All-sky class surveys

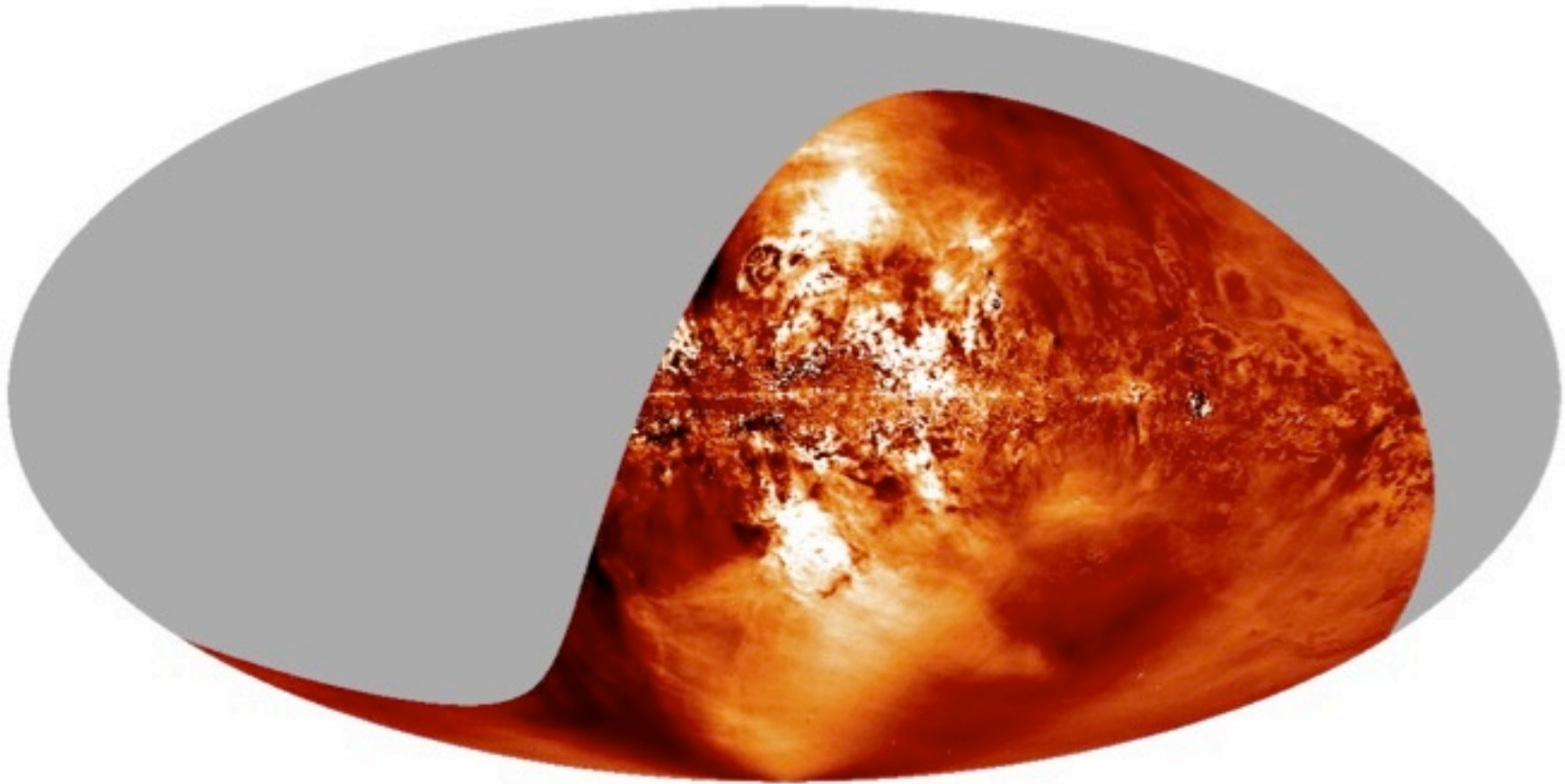


Basket weaving with AZ scans



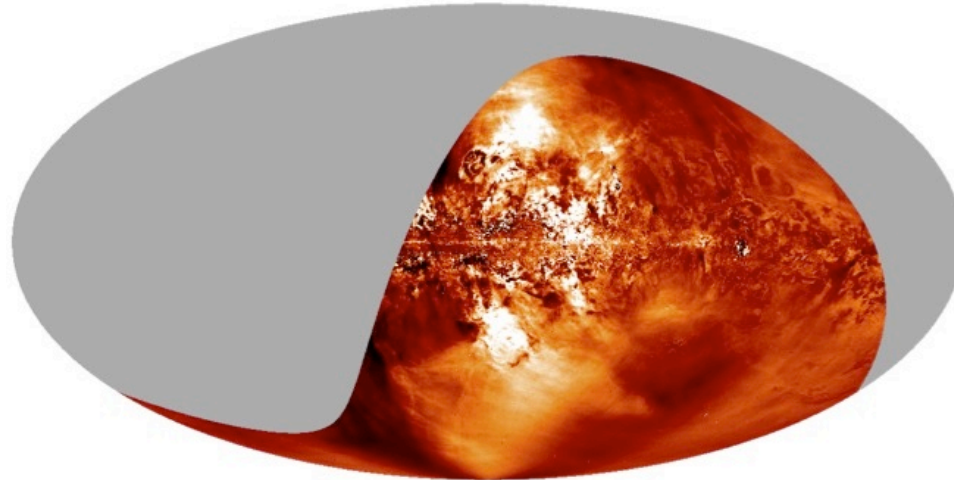
S-PASS: polarization maps

S-PASS: Stokes Q



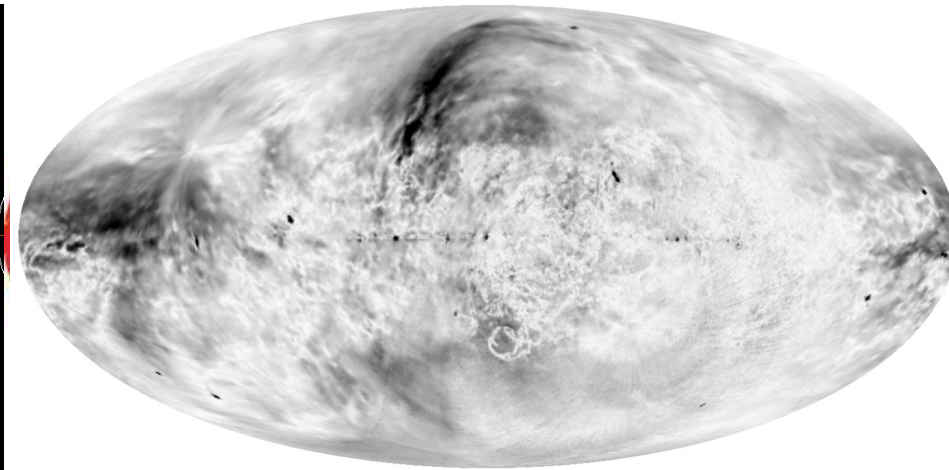
S-PASS and other data sets

S-PASS: Stokes Q



1.4 GHz (DRAO + Villa Elisa)

SHASSA: H_{α}
WMAP 22.8 GHz



0 600 mK



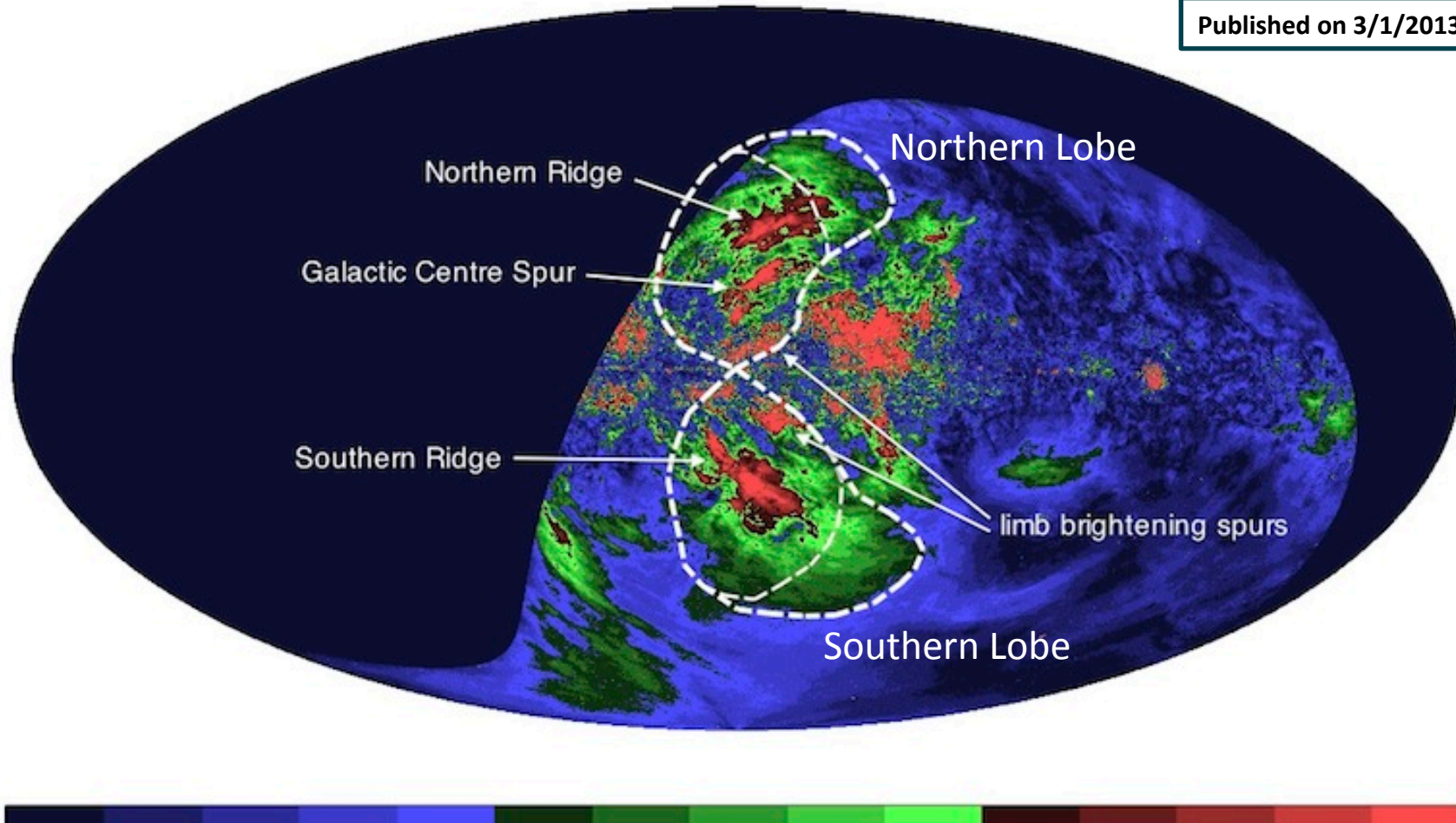
Science Results

A new twist on the Fermi Bubbles

Massive polarized outflows from the GC

Carretti et al. 2013, Nature, 493, 66

Published on 3/1/2013

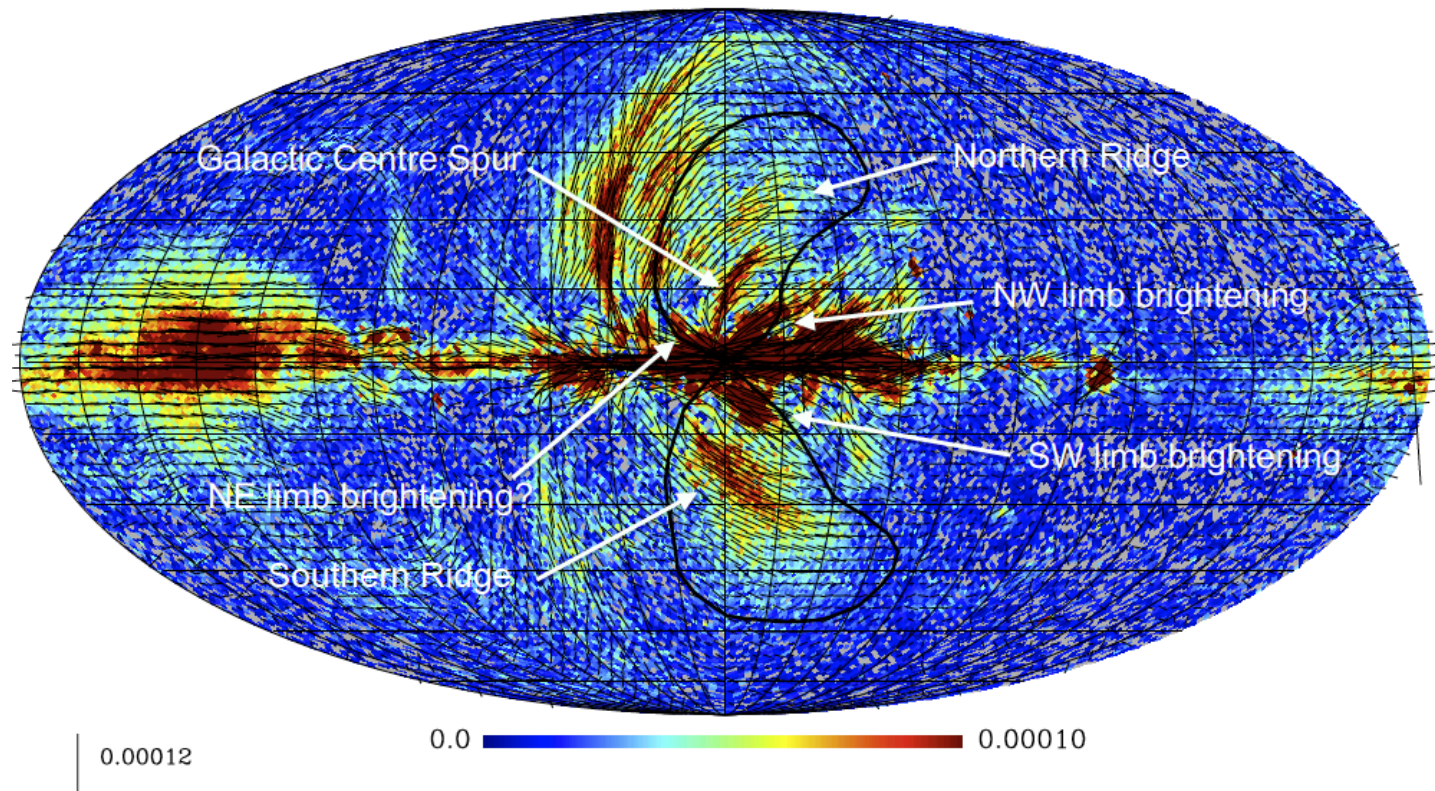


Massive polarized outflows from the GC (2)

Carretti et al. 2013, Nature, 493, 66

Published on 3/1/2013

WMAP PI + magnetic angle



Significant points

Carretti et al. 2013, Nature, 493, 66

Published on 3/1/2013

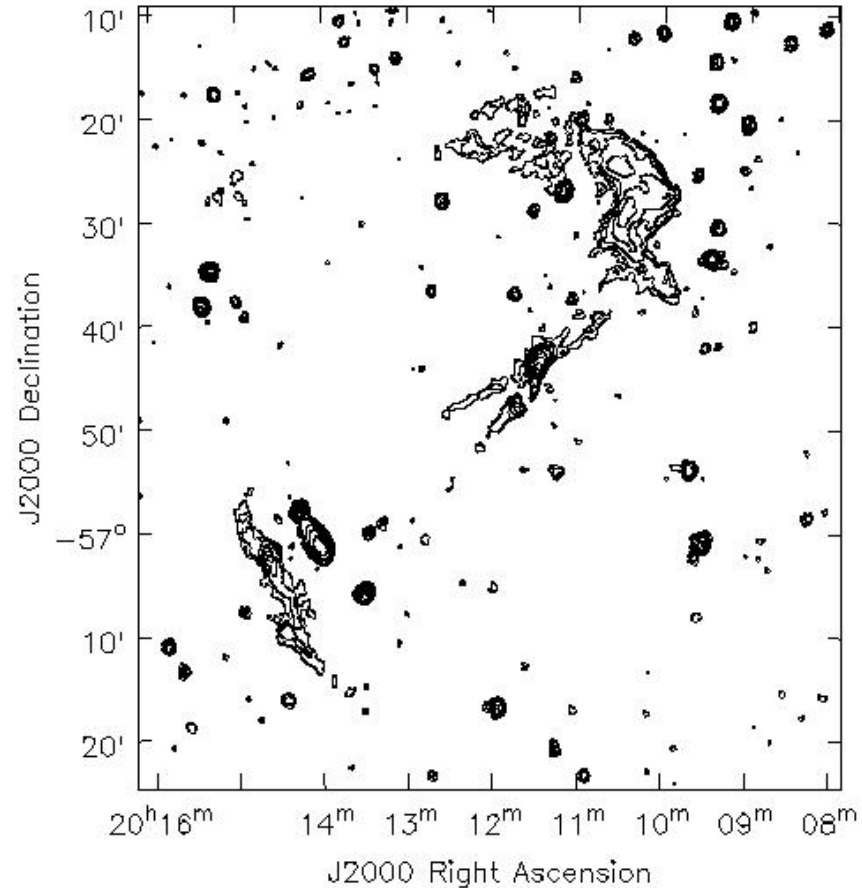
- High polarization fraction, 25-30%
⇒ highly ordered magnetic field
- Magnetic fields 6-12 μG for Lobes, $\sim 15 \mu\text{G}$ for Ridges
- $U_B[\text{Lobes}] \sim (1 - 3) \times 10^{55} \text{ erg}$
- Massive energy and strong B transported into the Halo
- Spectral index steepening at higher lats
- Star-forming driven outflows (not quasar-like outburst)

Science Results

Diffuse emission from galaxy clusters: A3667

Abell 3667

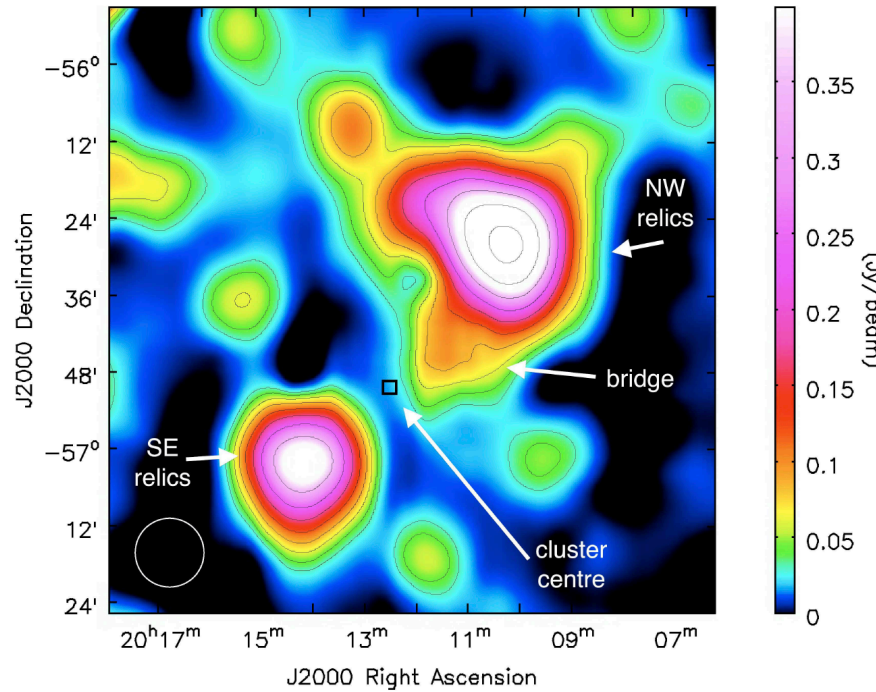
- Galaxy cluster A3667
- Post major merger cluster
- Two relics supposed to be outgoing front shocks
- No ICM extended emission



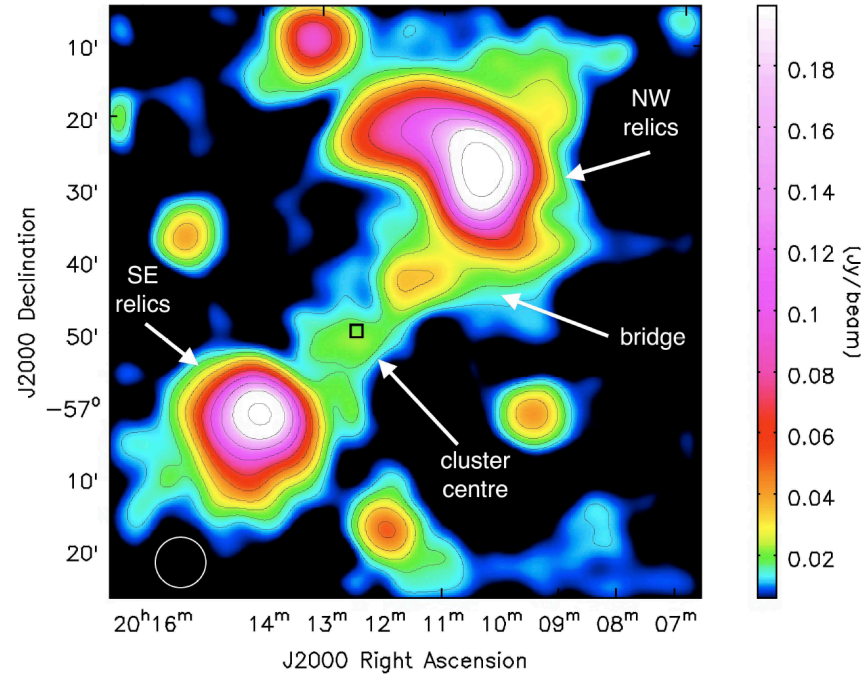
SUMSS image (843 MHz)

Bridge in A3667: Parkes images

Carretti et al., 2013, MNRAS, accepted, arXiv:1205.1082



2.3 GHz S-PASS

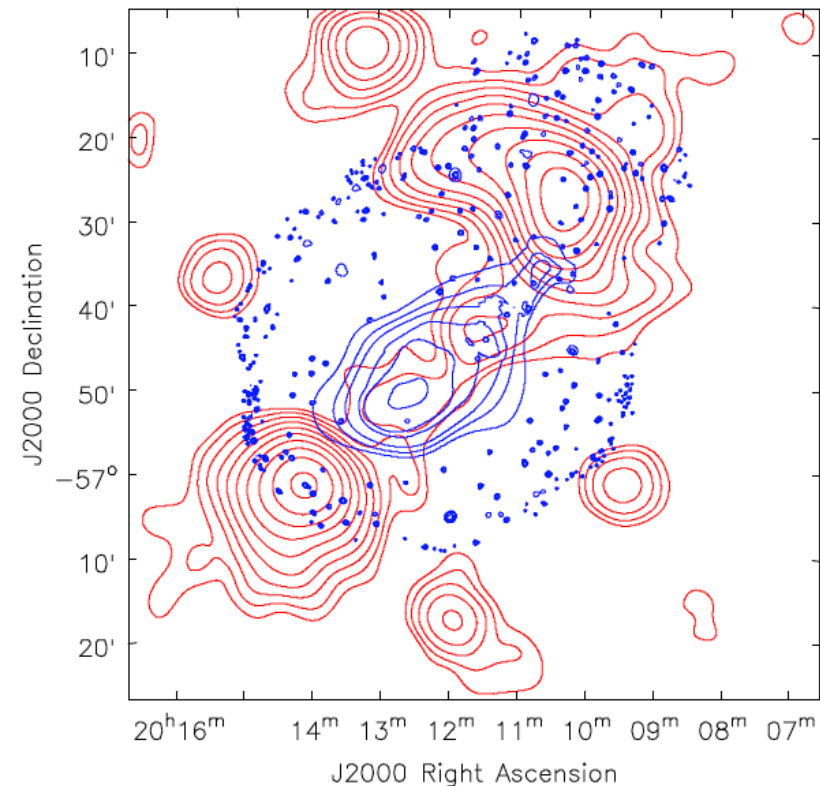


3.3 GHz (Parkes)

Bridge in A3667: turbulent wake of shock wave

- first clear detection of a bridge associated both with an outlying cluster relic and an X-ray bridge
- most compelling direct evidence for an association between ICM turbulence and diffuse synchrotron emission
- Bridge traces turbulent wake trailing the shock (predicted by cosmological/cluster simulations)
- Naturally explained in model of turbulent re-acceleration
- Bridge field: 2.2 μG
- Single-dish obs essential

Carretti et al., 2013, MNRAS, accepted



S-PASS: more work in progress

- More work in progress
- Survey paper
- CMB foregrounds
- Gum Nebula
- Stokes I
- Compact sources RMs
- Comic Web
- ...

Conclusions

- S-PASS: new view of the polarized sky
- Special observing strategy
- Maps: bright extended emission at high Gal lats => CMB foregrounds
- Great Galactic science
- Great extragalactic science
- New space of parameters => Discovering the unexpected