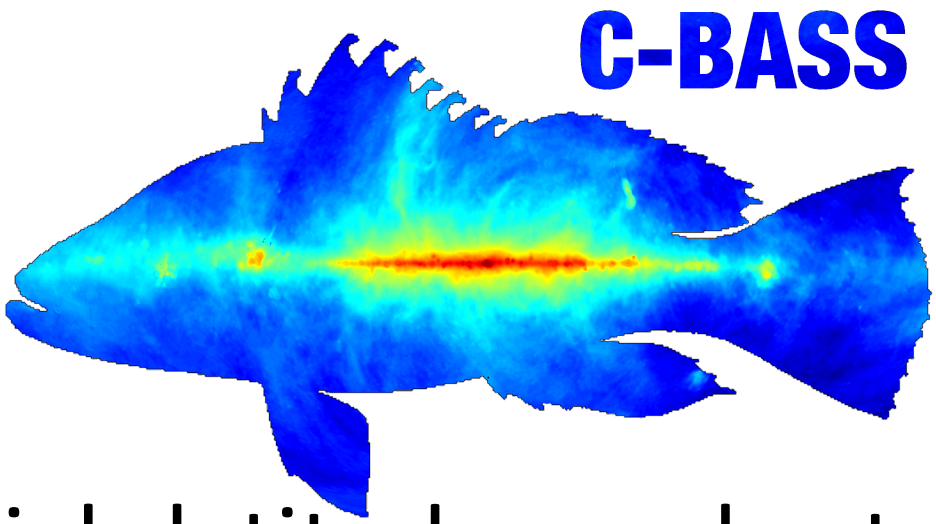
The University of Manchester
Jodrell Bank Observatory



High-latitude synchrotron polarization

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For the C-BASS collaboration

Abstract

- High latitude ($b > 30°$) synchrotron emission away from the prominent spurs and loops is weakly polarized, implying strong “tangled” component.
- In the same regions, the polarization vectors are remarkably well-organized, showing little small-scale structure not due to noise, implying weak “tangled” component.
- Illustrated by preliminary C-BASS data
  - Contains residual systematics
  - Similar points could be made from earlier surveys right back to Brouw & Spoelstra (1976)

C-BASS

- Map the whole sky at 5 GHz (C-band) in (I,Q,U)
- Galactic Synchrotron, free-free, AME emission
- Galactic Magnetic field
- CMB Foreground modelling & subtraction
- Northern survey: 28 Nov 2012 - 3 April 2015
- Just under 1 year of data collected
- Clear detection of polarized flux in nearly every beam, as required.
- South: Survey starting July 2019

North – DONE!

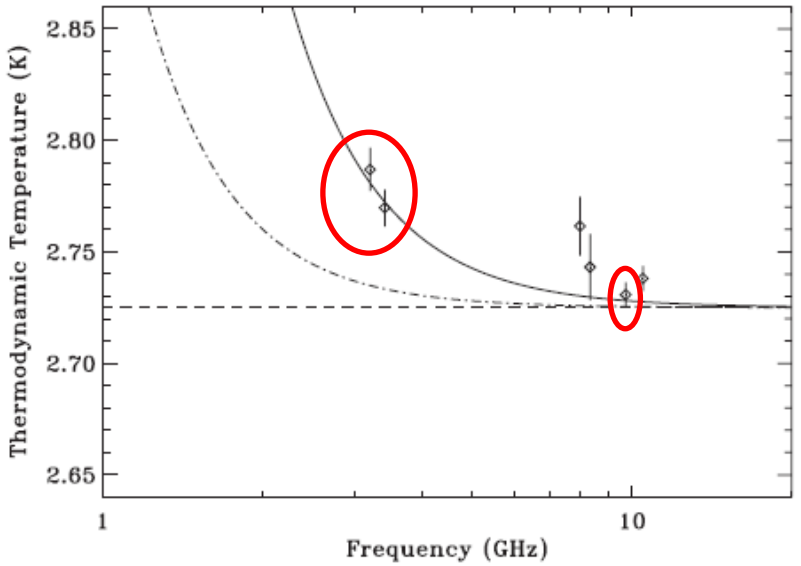
South – GREMLINS!

- Northern survey covers sky from pole to $\delta = -15°$
  - Expect publication this year
  - Night-time only data
  - Improved maps with all-sky release

Absolute Zero Level

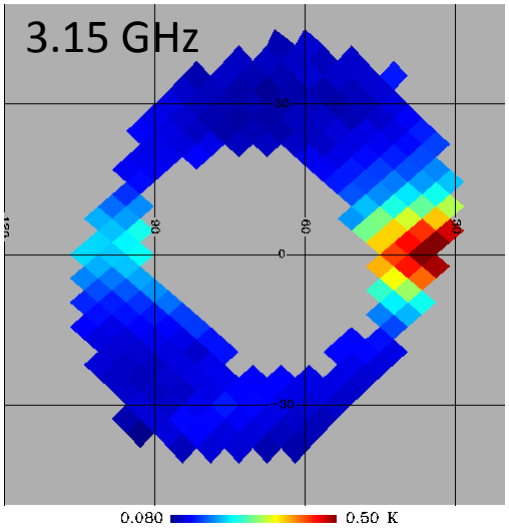
- C-BASS continuously compares observed total intensity to internal cold load
  - suppresses $1/f$ noise
  - Not accurate enough to set absolute zero level
  - Data zero level is discarded by the destriping map-maker, DESCART (Sutton et al 2010)
- Instead, set zero level using ARCADE2 absolute measurements (Fixsen et al. 2011)
  - 6 channels from 3 to 10.5 GHz
  - Interpolate to C-BASS centre frequency of 4.78 GHz.

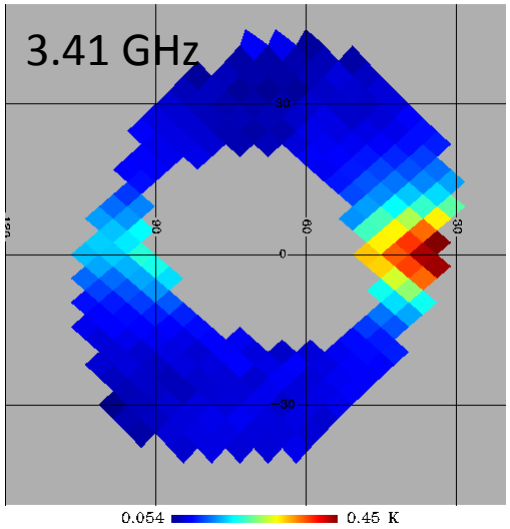
ARCADE2 data (Seiffert et al 2011)

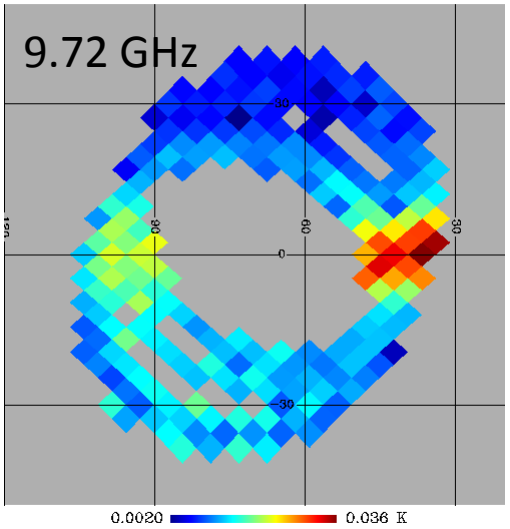


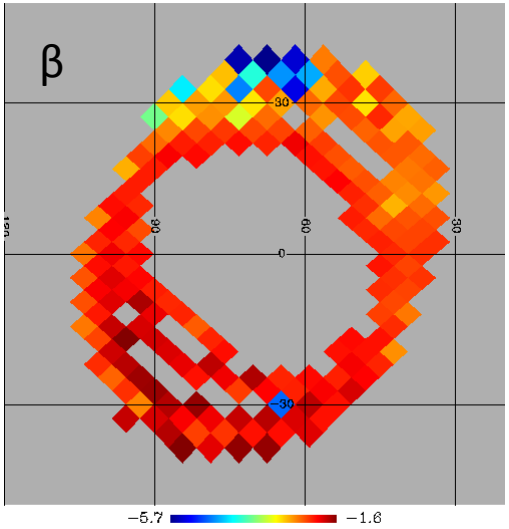
- Offsets between channels are systematic and much larger than the noise.
- 8.0 GHz channel high by 22 mK
- Used 3 channels with most consistent offsets

ARCADE2 Model

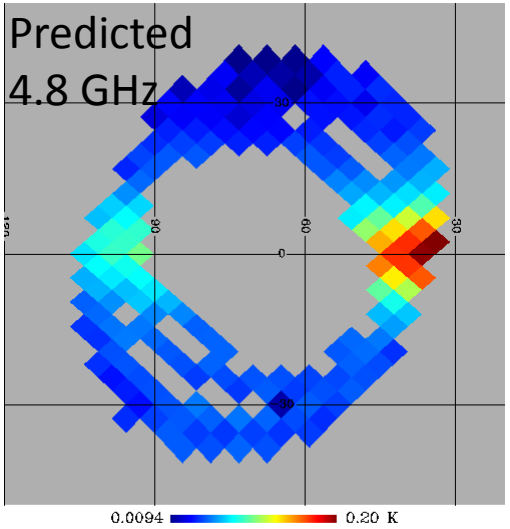


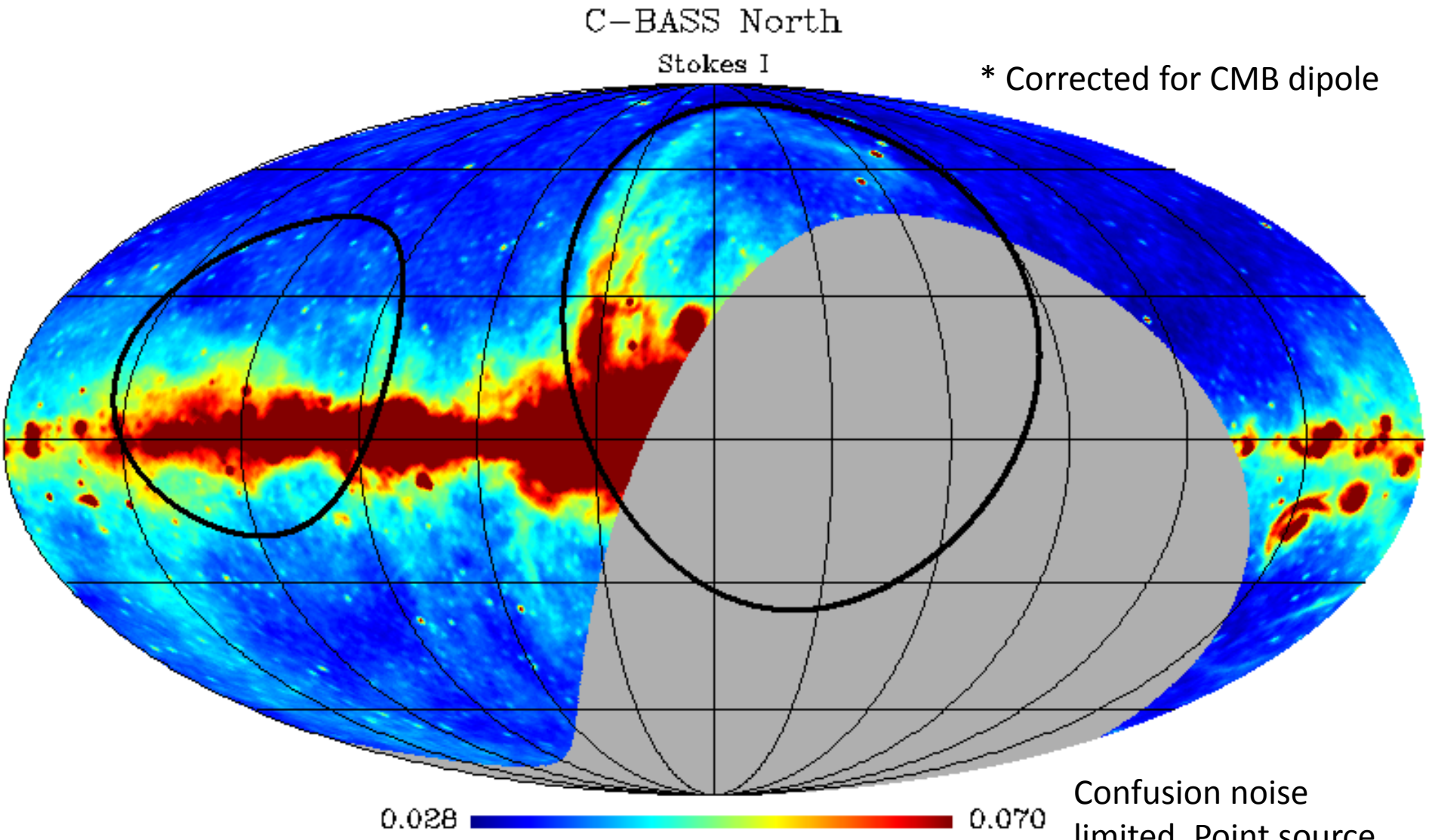






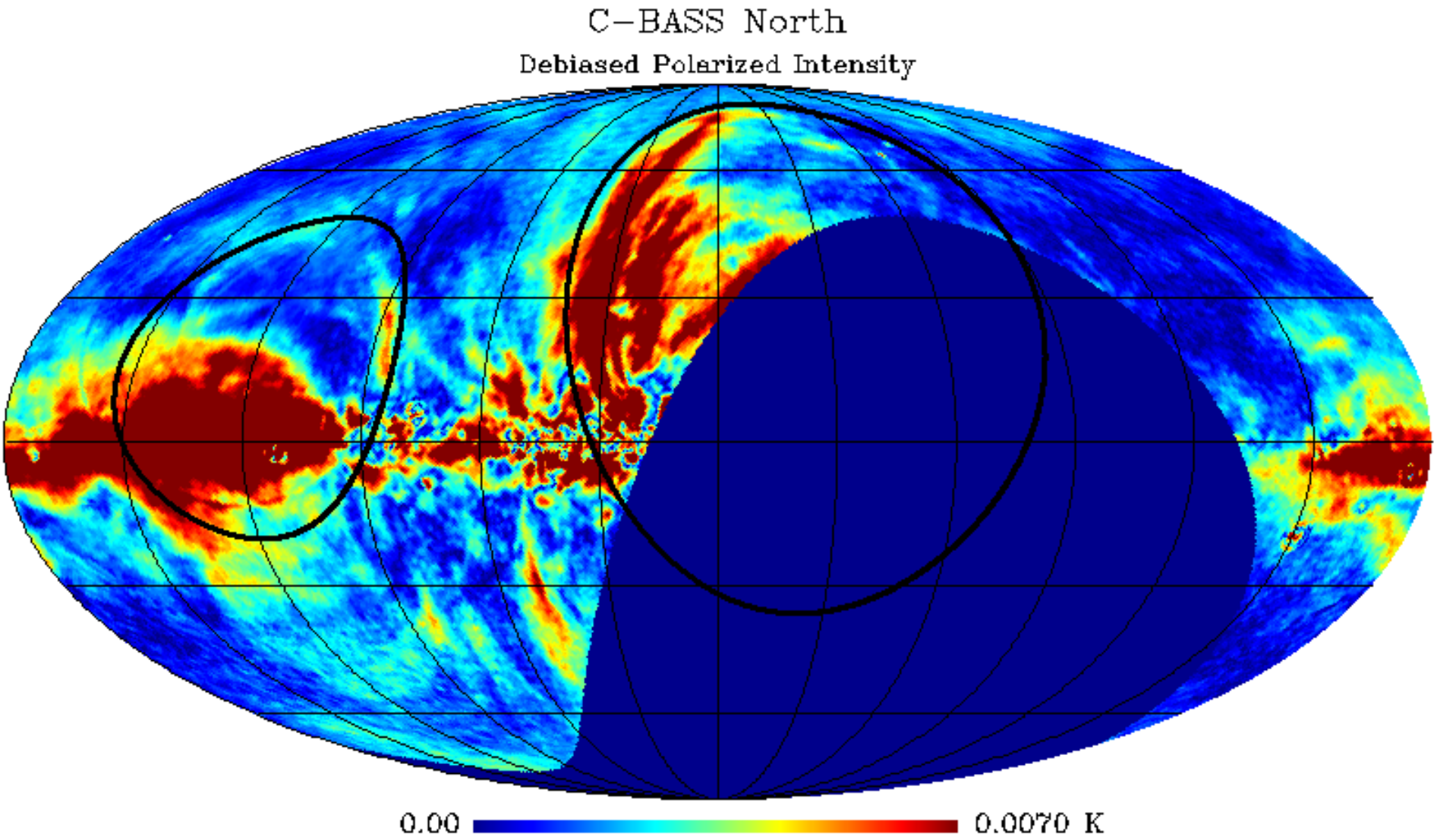
- Fitted spectral index is noisy ($-5.7 > \beta > -1.6$)
- $\langle\beta\rangle = -2.22$
- Comparing different combinations of ARCADE data, zero level at 4.8 GHz determined to ± 5mK.

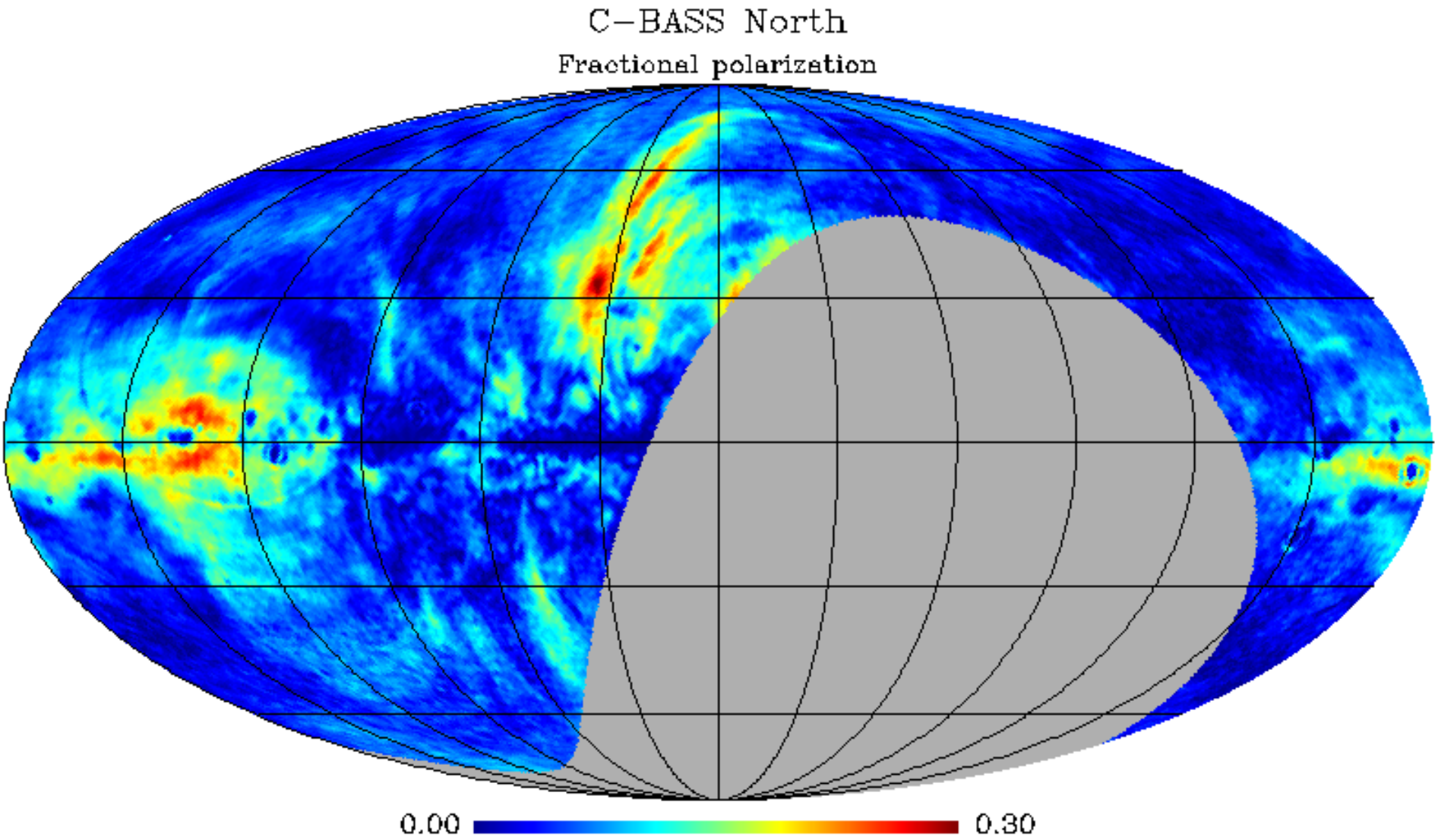




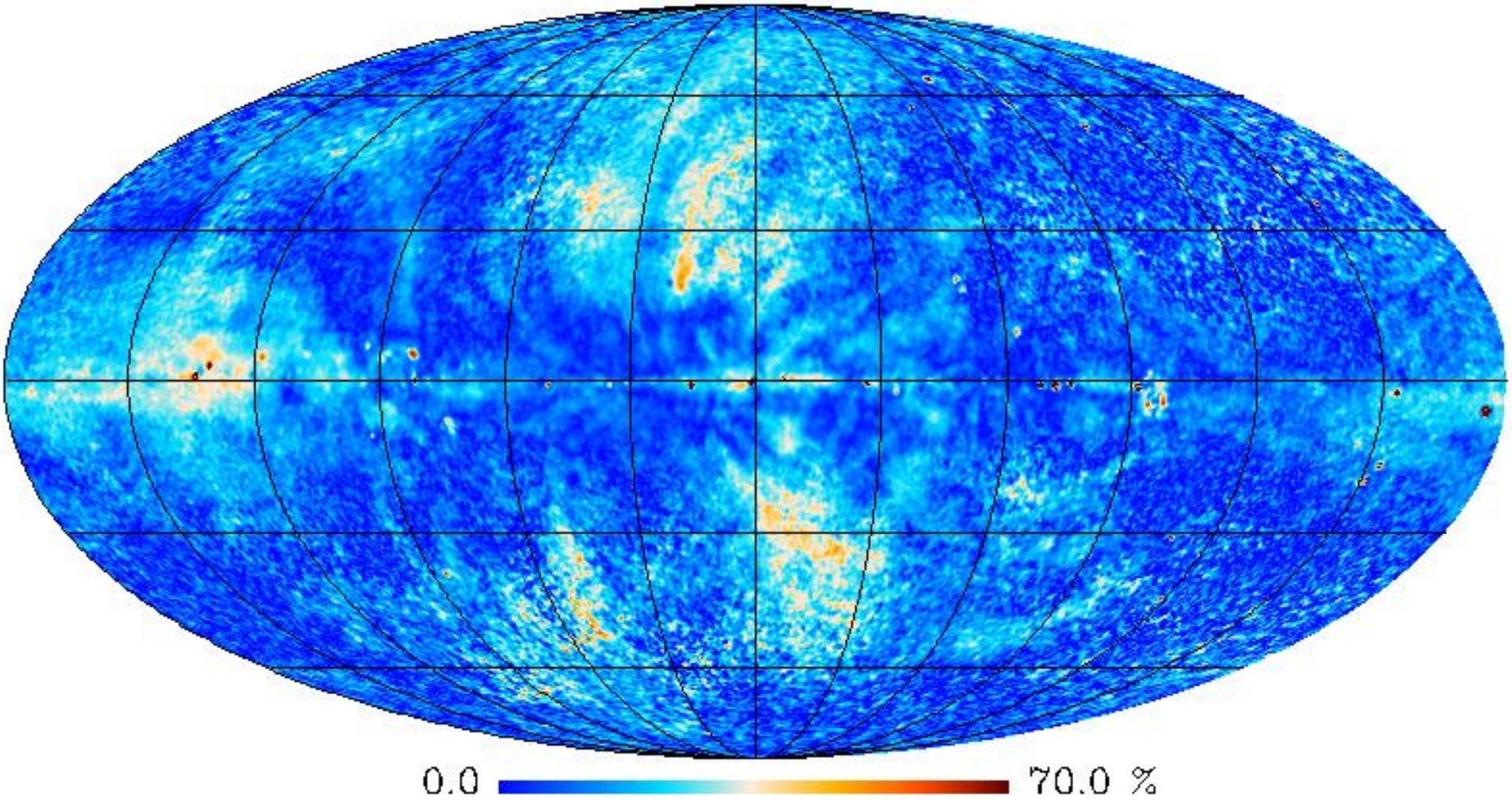
* Corrected for CMB dipole

Confusion noise limited. Point source background ~ 2.5 mK


C−BASS North
Debiased Polarized Intensity
0.00
0.0070 K

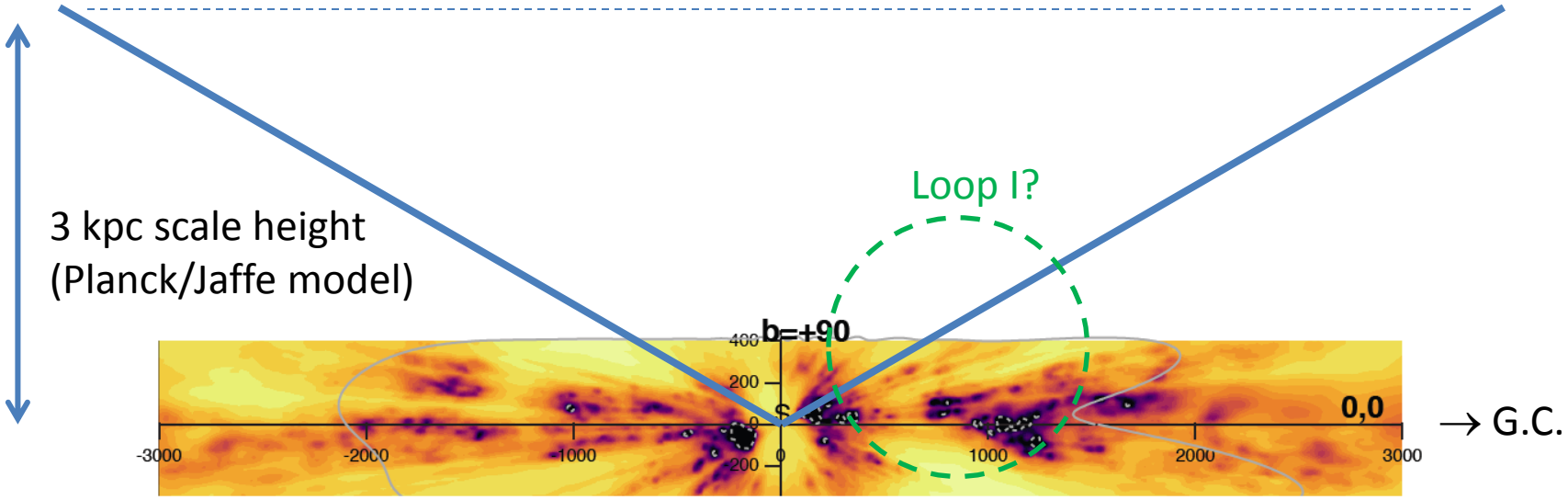

C−BASS North
Fractional polarization
0.00
0.30

Planck/WMAP 28 GHz polarization



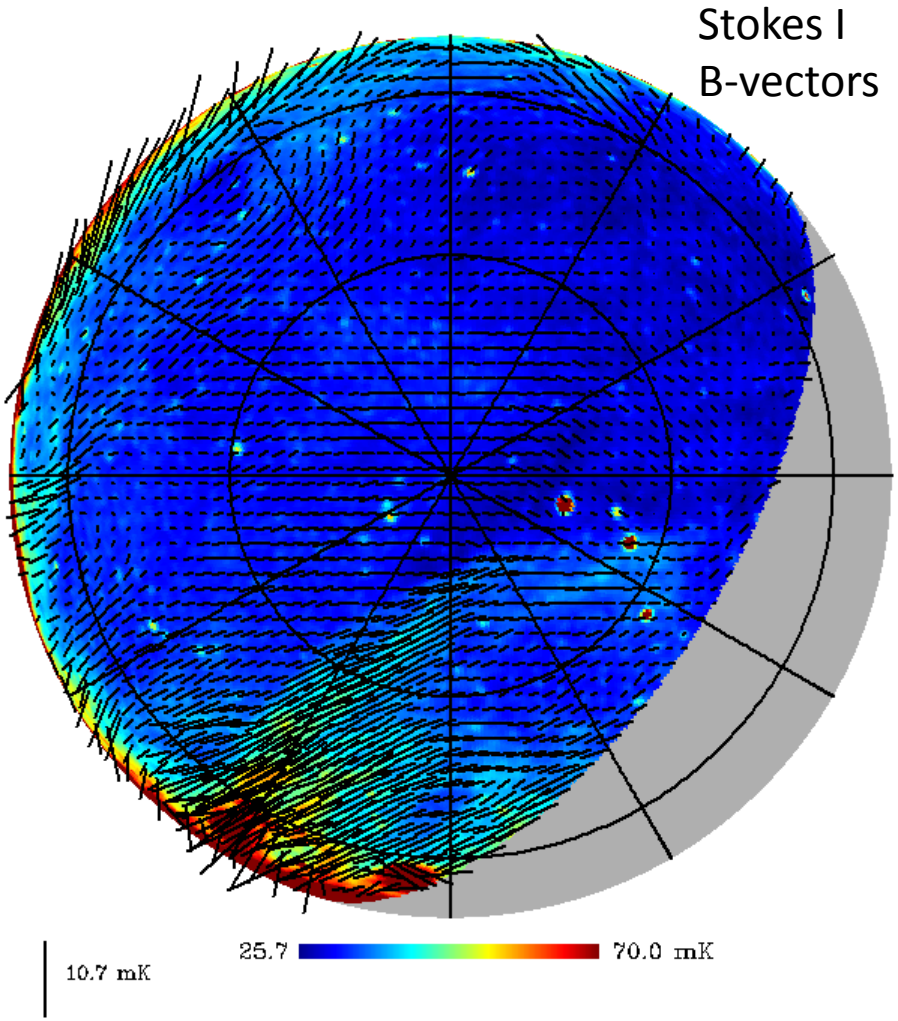
Planck 2015 Results XXV

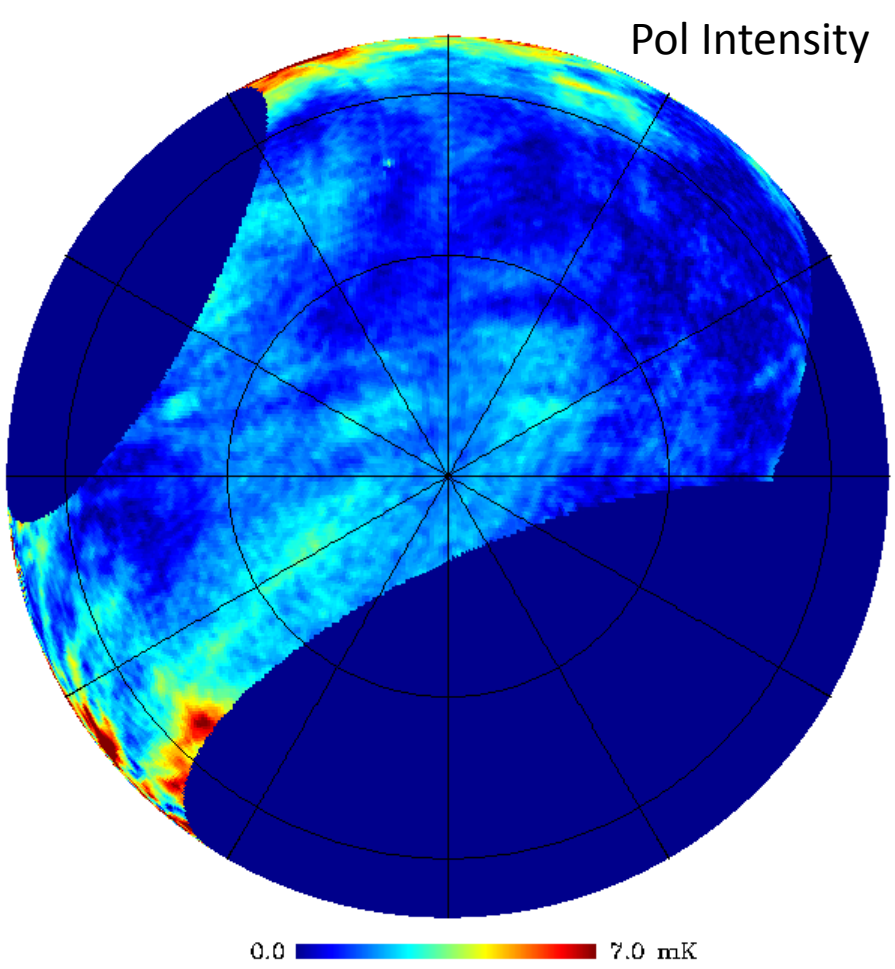
Orientation



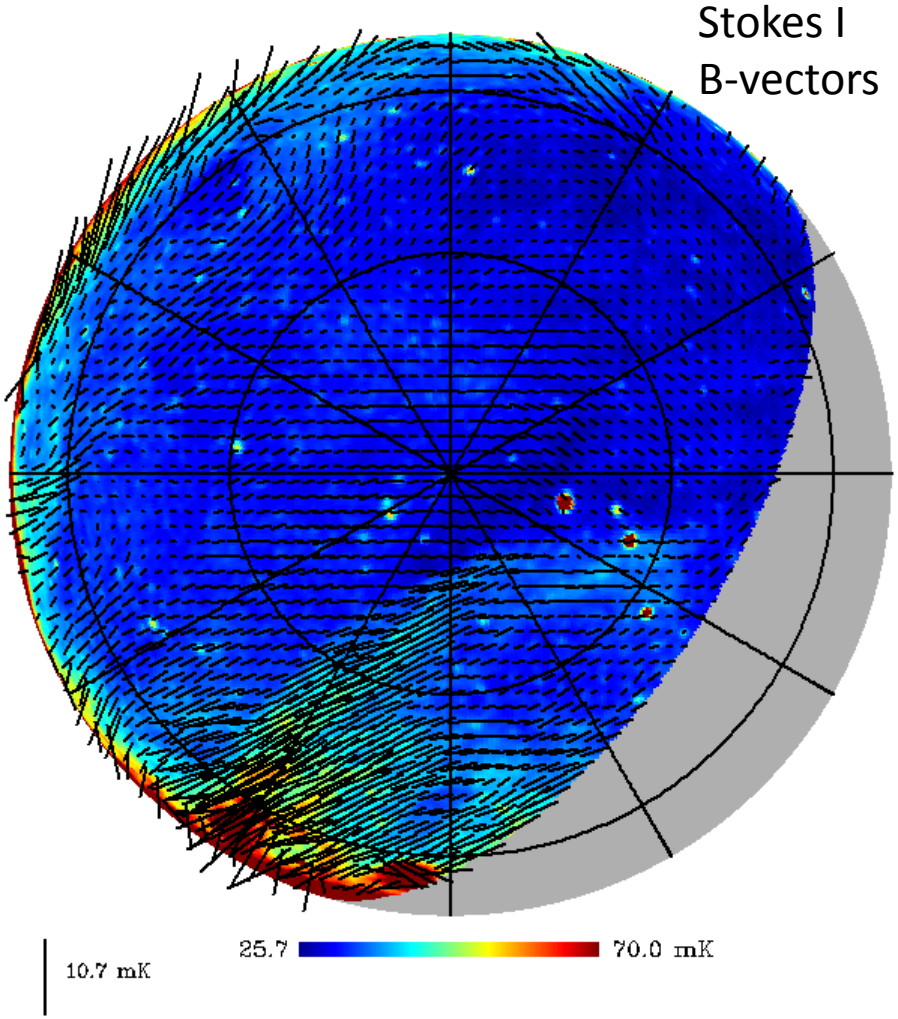
- 1° resolution = structure at 2% of scale height (≤ 50 pc)
- I expected this to resolve at least outer scale of turbulent structure in the halo.
- 3D extinction map from Lallement et al (2019)

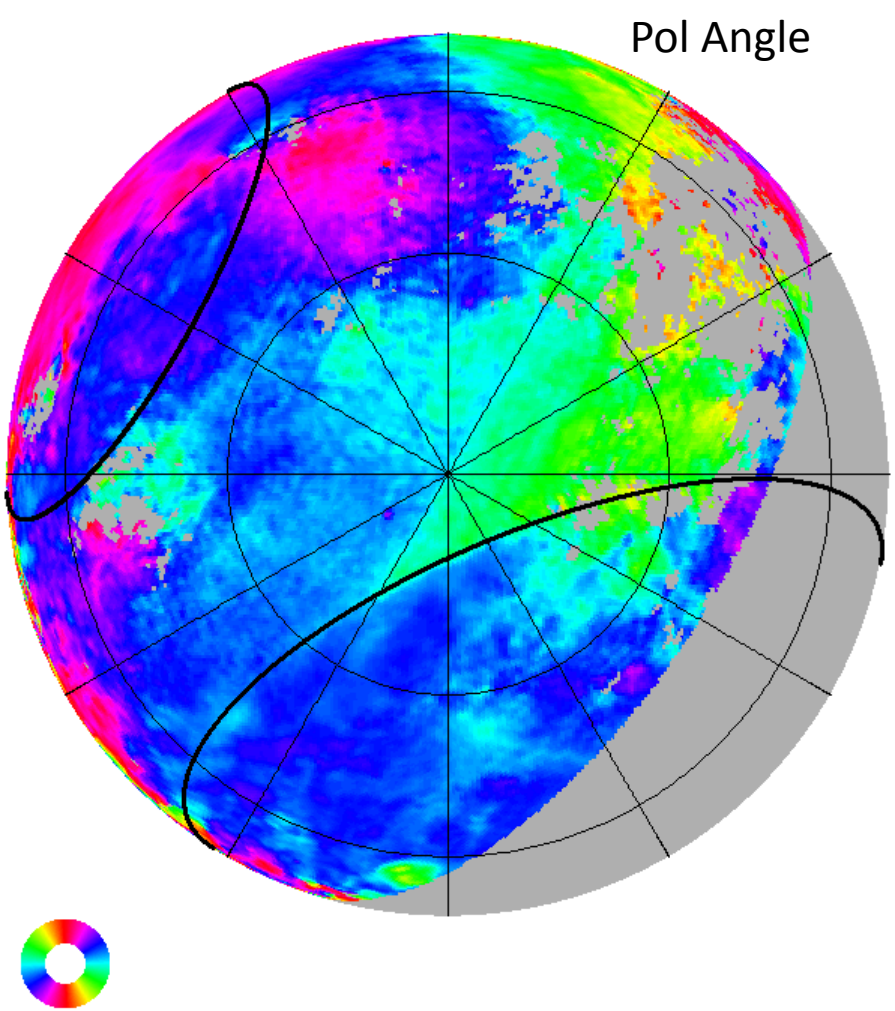
North Galactic Pole projection





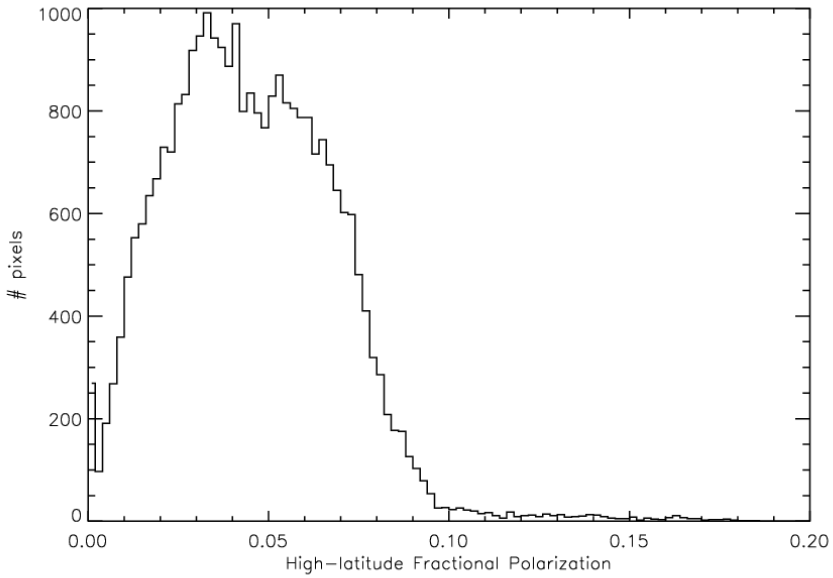
North Galactic Pole projection





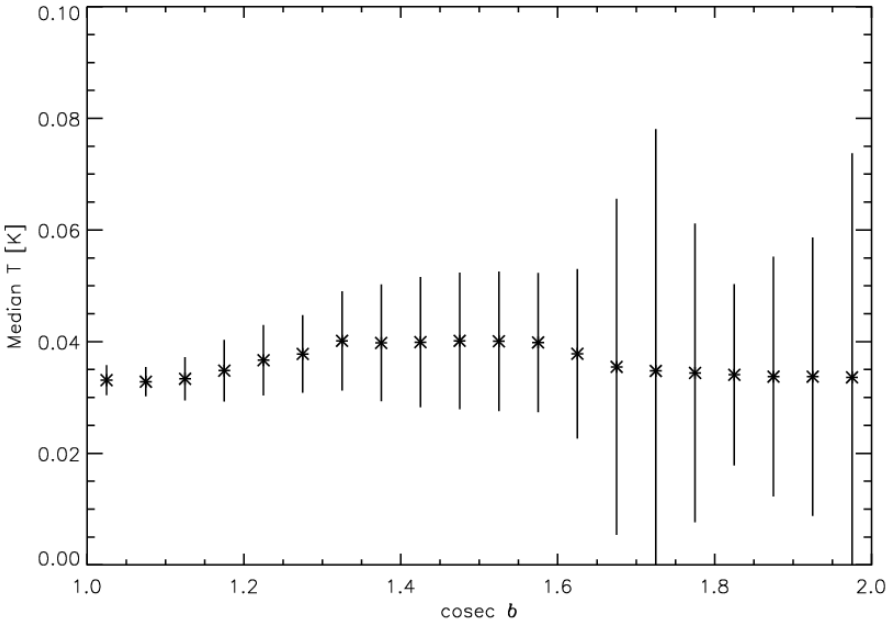
Low fractional polarization

- Median polarization in our high-latitude zone is 4.3%
- Nearly all pixels < 10%
- Strong contrast with polarization in the Spurs, and Fan region (up to 30%)
- Is there an extra unpolarized background?



Failure of slab model

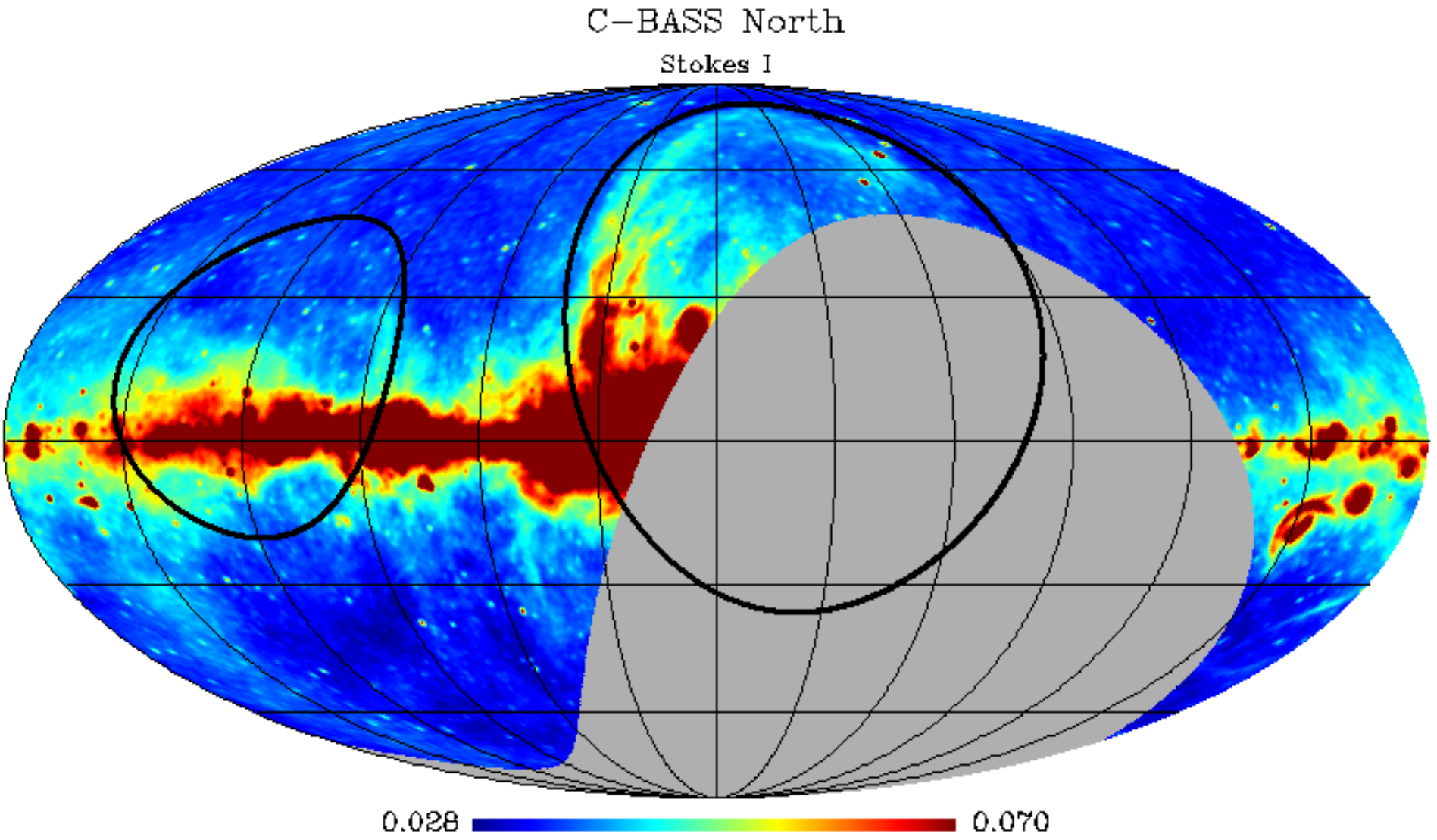
- Plane-parallel galactic disk implies brightness $T \propto \csc b$
- Reasonable fit to distribution of Pop I layer (HI, dust, CII)
- Shklovsky (1952): terrible fit to Galactic syncrotron emission.
- Actual excess of emission near Galactic poles
- Minimum synchrotron brightness near $b \approx 30°$



- ARCADE interprets sky as slab + isotropic background, but "ARCADE" (Shklovsky) excess is *not* isotropic!
- Local structure…where?

Conclusions

- High latitude polarization is weak but ordered
- Order needs better quantification… structure function.
  - Work in progress (parallel transport!)
- Interpretations:
  1. Large scale difference between ordered and turbulent field. Turbulence outer scale < 2% of scale height.
  2. Two components, one nearly unpolarized
     - E.g. emission from synchrotron shell around local bubble?
  3. Two components with nearly-orthogonal polarization (Sun & Reich disk vs halo?)


C−BASS North
Stokes I
0.028
0.070