

'Reionization' Experiment: PAPER

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Berkeley Radio Astronomy Laboratory programs introduction
“innovation & exploration”

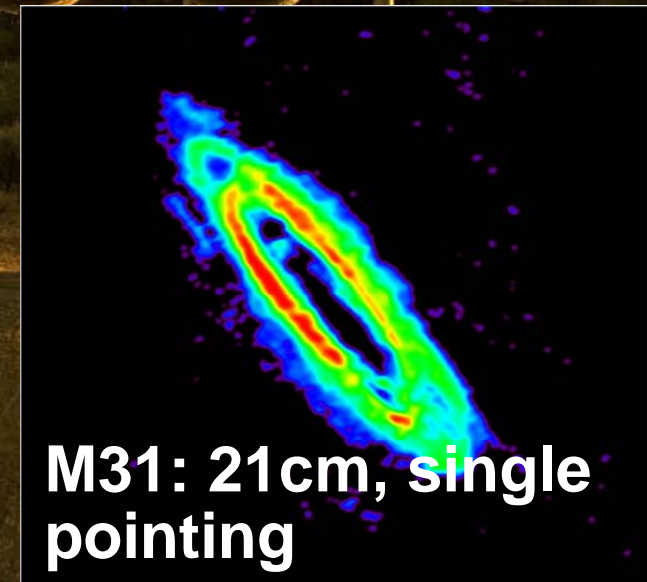
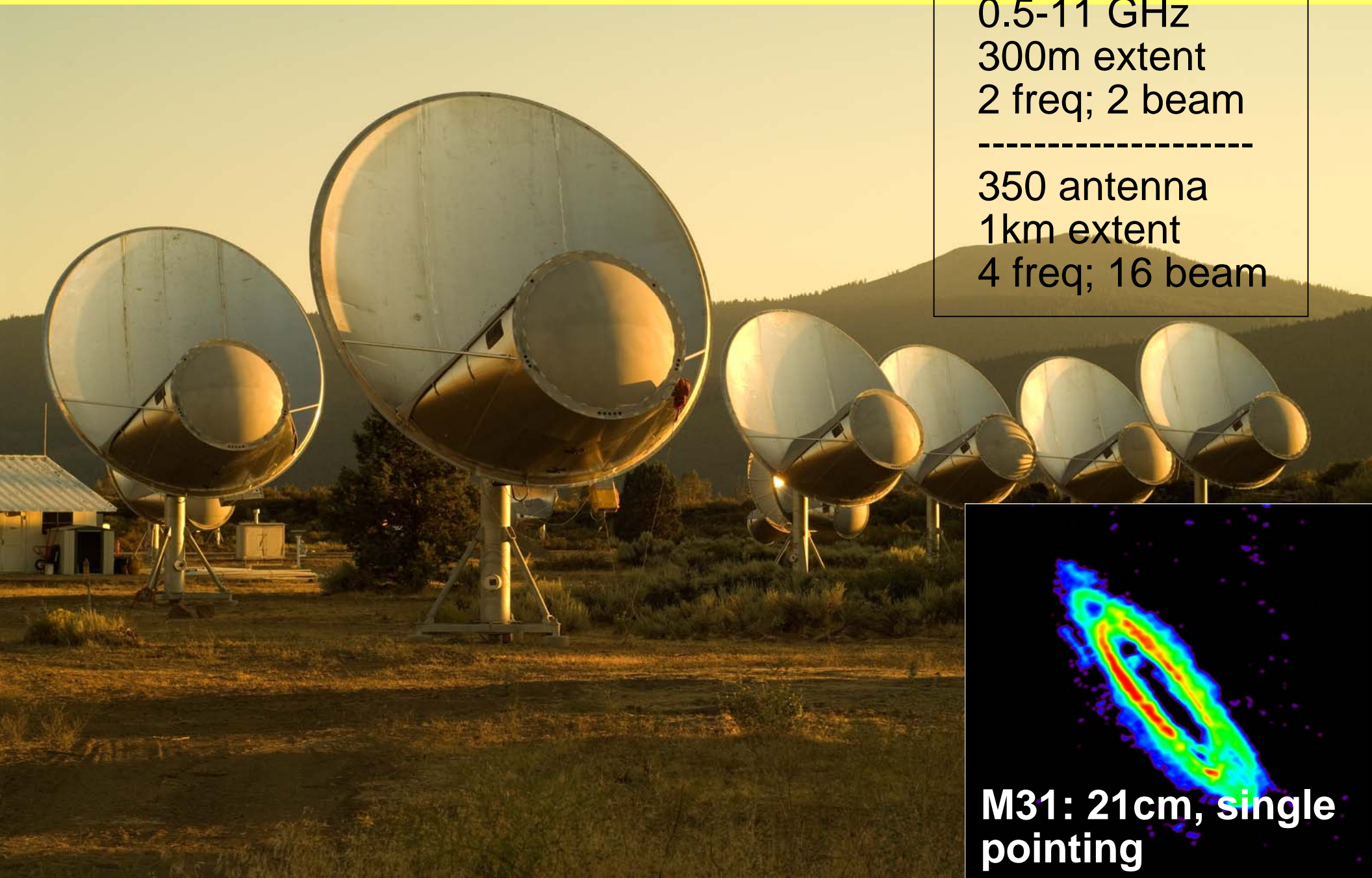
PAPER: Precision Array to Probe the Epoch of Reionization

- *Epoch of Reionization (also next talk by Xuelei Chen)*
- *Green Bank test array: PGB*
- *Western Australia deployment: PWA*
- *Future*

Allen Telescope Array

42 6m antenna
0.5-11 GHz
300m extent
2 freq; 2 beam

350 antenna
1km extent
4 freq; 16 beam



M31: 21cm, single pointing

CARMA: Combined Array for Research in Millimeter Astronomy

6 @ 10m + 9 @ 6m
75-115 GHz; 230 GHz
Star/Planet formation
Galaxy evolution
mm adaptive optics





The goal of CASPER is to streamline and reduce the current radio astronomy instrumentation design flow through the development of an open-source, platform-independent design approach. This incorporates reconfigurable, modular, easily upgradable hardware with standard, parameterized design libraries that abstract away the underlying details of the system. Design simplifies to creation of block diagrams of components from standard libraries and the designer.

HARDWARE: ADC, FPGA Board, Switch, CPU

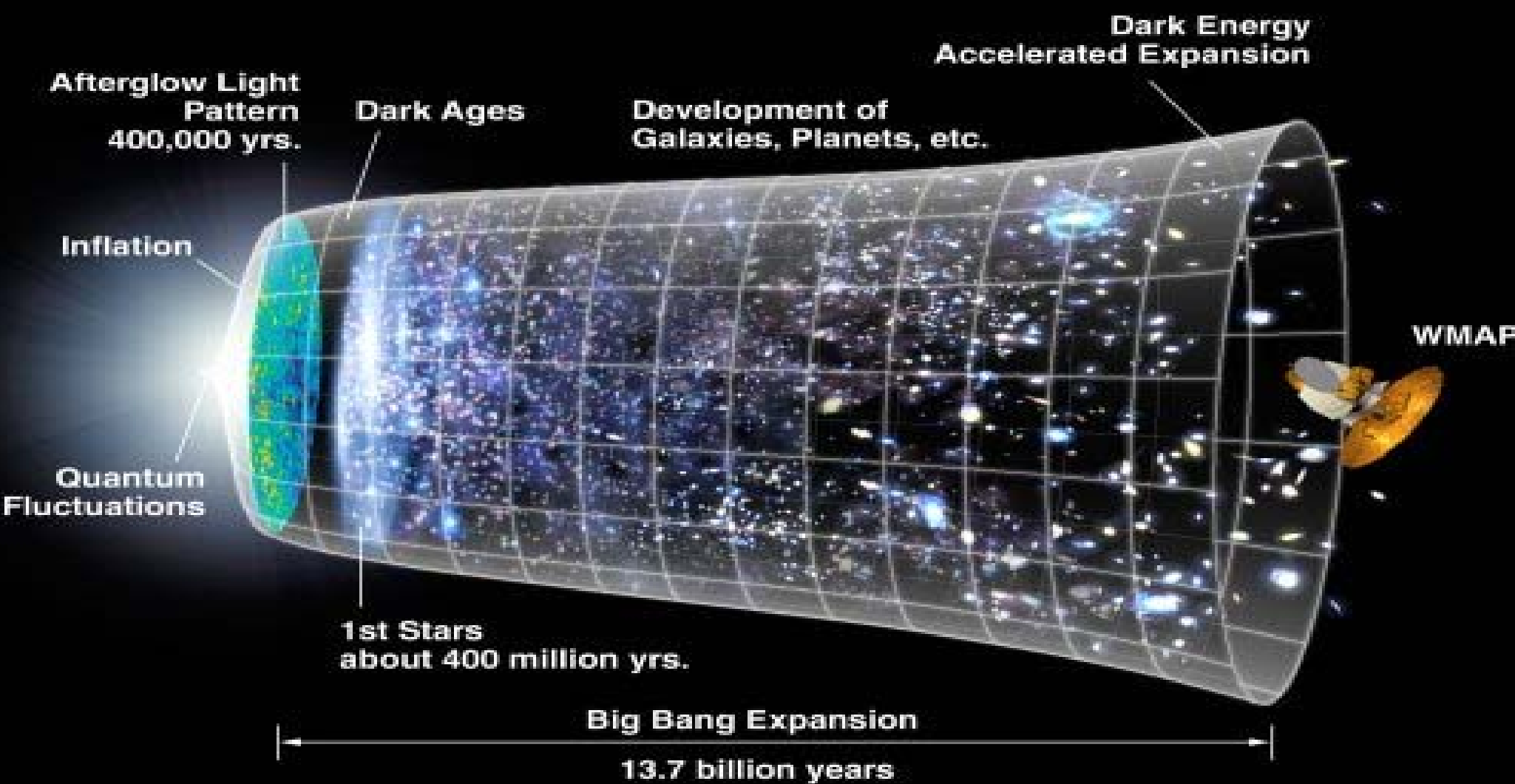
DESIGNS: Spectrometer, Correlator, Beamformer, Pulsarometer, Realtime Imager

PRECISION ARRAY TO PROBE THE EPOCH OF REIONIZATION

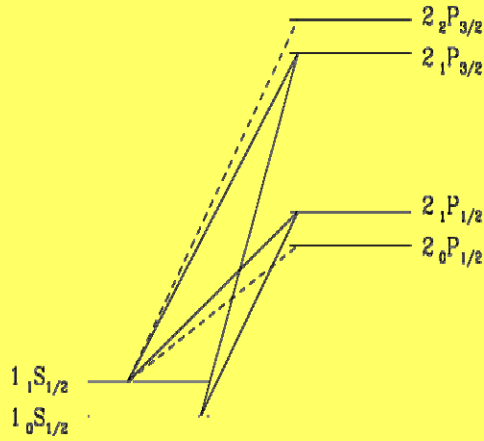
PAPER Team:

R. Bradley (Co PI), E. Mastrantonio, C. Parashare, N. Gugliucci,
D. Boyd, P. Reis (*NRAO & UVA*); A. Parsons, M.
Wright, D. Werthimer, CASPER group
(*UC Berkeley*); D. Herne, M. Lynch (*Curtin Univ*);
C. Carilli, A. Datta (*NRAO Socorro*); J. Aguirre (*U Colorado*)

Our experiment is working toward detection of this excited 21cm line in the “swiss cheese” like 21cm brightness temperature structure: image the sky at many frequencies, difference in angle and in frequency (red shift or time), form a statistical summary to find signal.



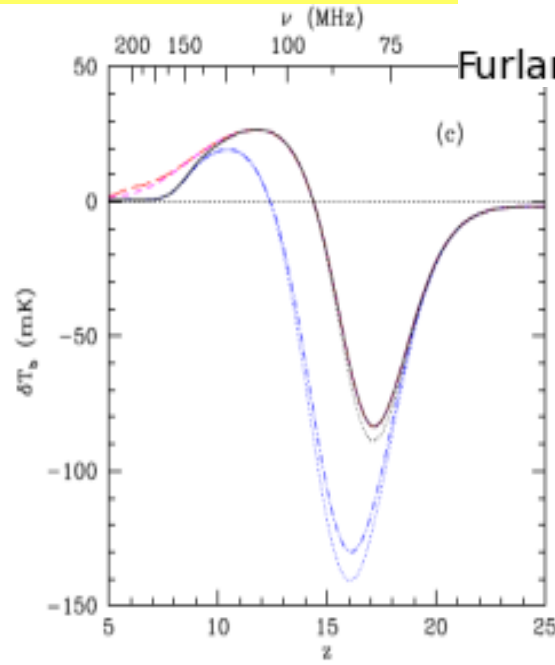
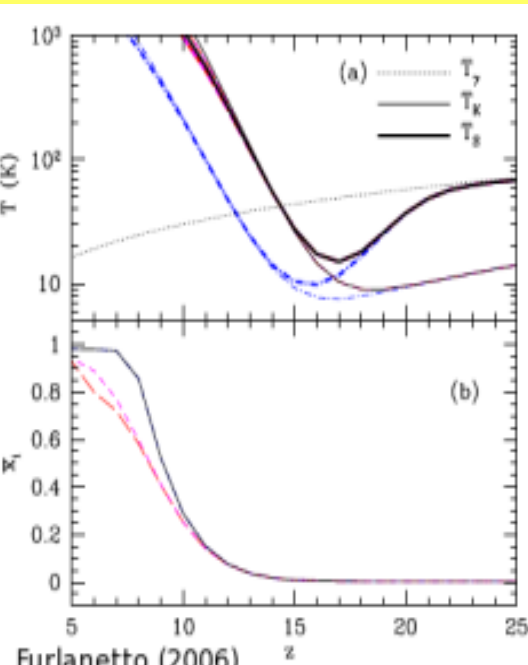
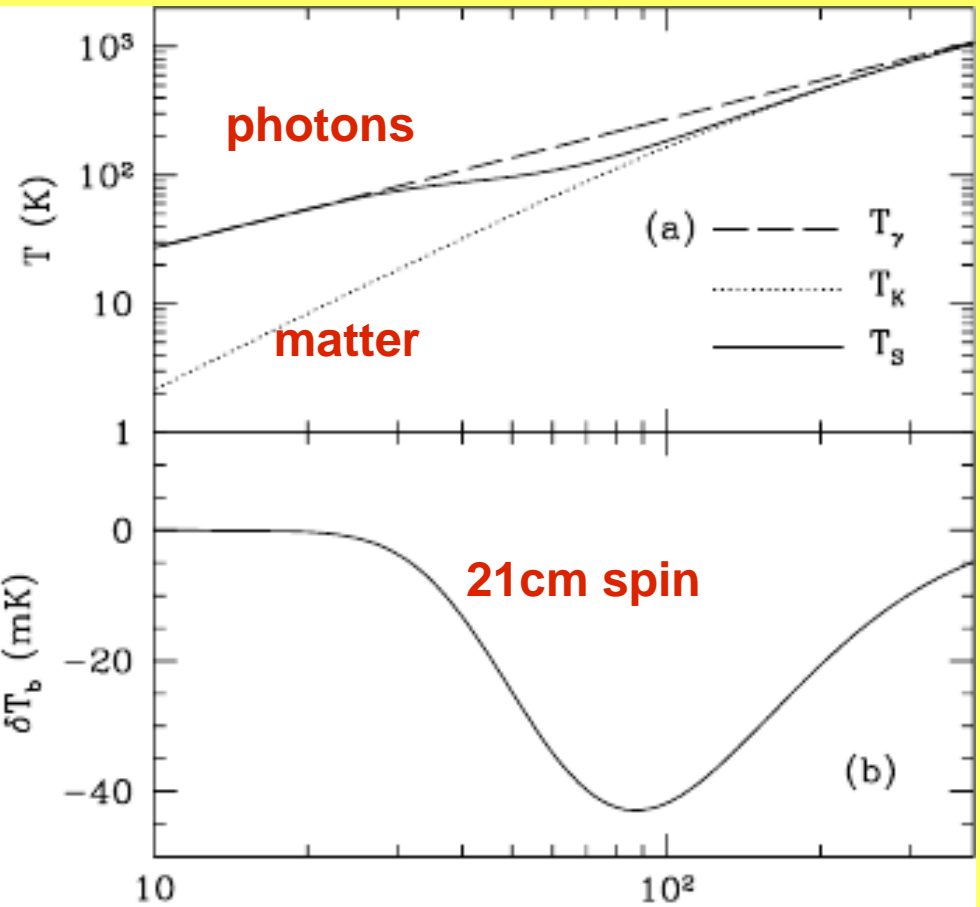
21 cm Spin Temp



Wouthuysen Field Effect

$$T_\gamma \propto (1+z)$$

$$T_K \propto (1+z)^2$$

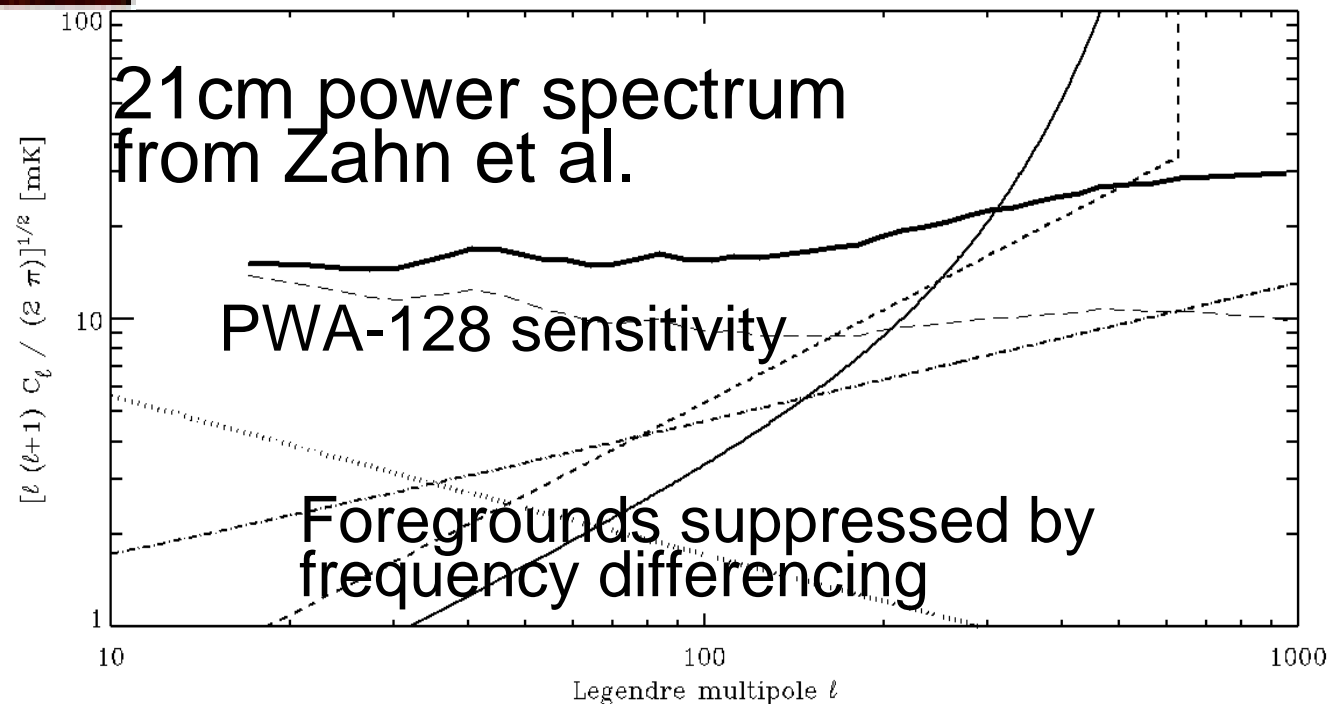
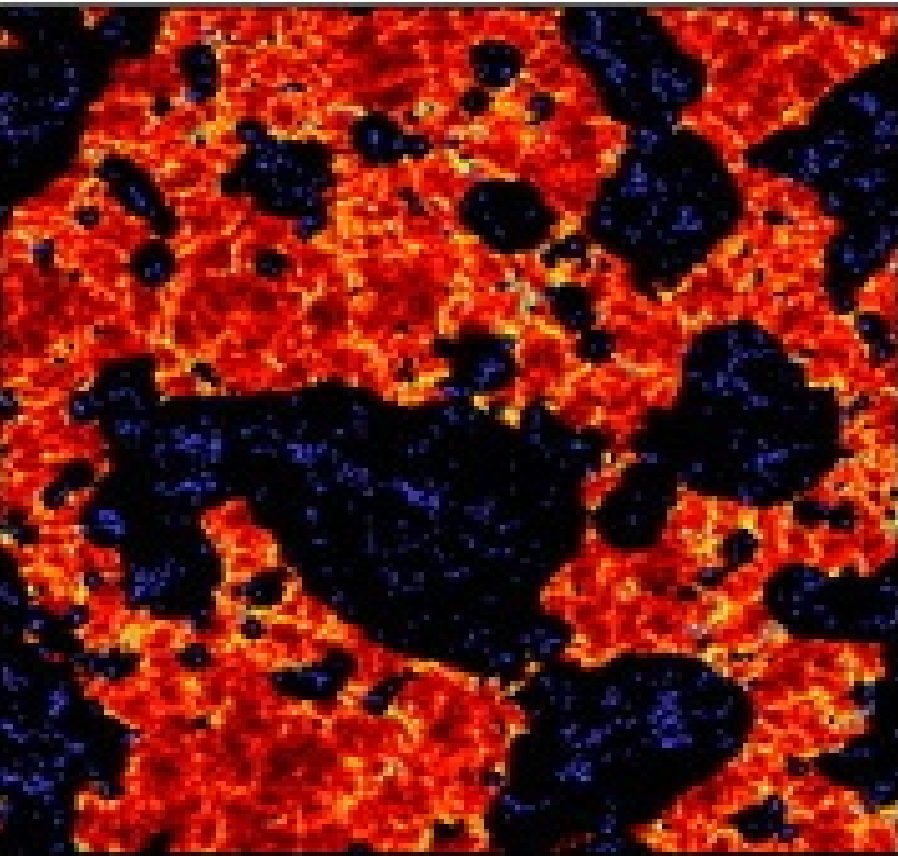


Furlanetto, Oh, Briggs (2006)

rkshop

Hydrogen Reionization Simulation and Power Spectrum

Morphology of 21cm bubbles in late stage, $z \sim 7$, of reionization when the neutral fraction is approximately 50% (Zahn et al. 2007ApJ...654...12Z). The size of the box is $66 \text{ Mpc } h^{-1}$ on a side and $0.25 \text{ Mpc } h^{-1}$ deep.



“PAPER” PROGRESS

- Start in 2004; NSF funding: 2005-2007 correlator development grant; 2006-2008 experiment “starter” grant, including WA deployment; other funding via parallel projects (correlator, FASR) and Carilli MPG award; pending 2008-2011 NSF.
- PAPER in Green Bank: **PGB**. This has evolved from 2-antenna interferometer in 2004 August to 8-antenna array in 2006; 16-antenna array 2008 May; also, single-antenna test facility.
- PAPER in Western Australia: **PWA**. 4-dipole array deployed: 2007 July.
- PGB 8-antenna 2008 March with revised design

John Richards-lease holder; Ron Beresford, CSIRO; DB



PWA-4 — Top Shed, Boolardy Station



Ant 1

Ant 2

Correlator Hut

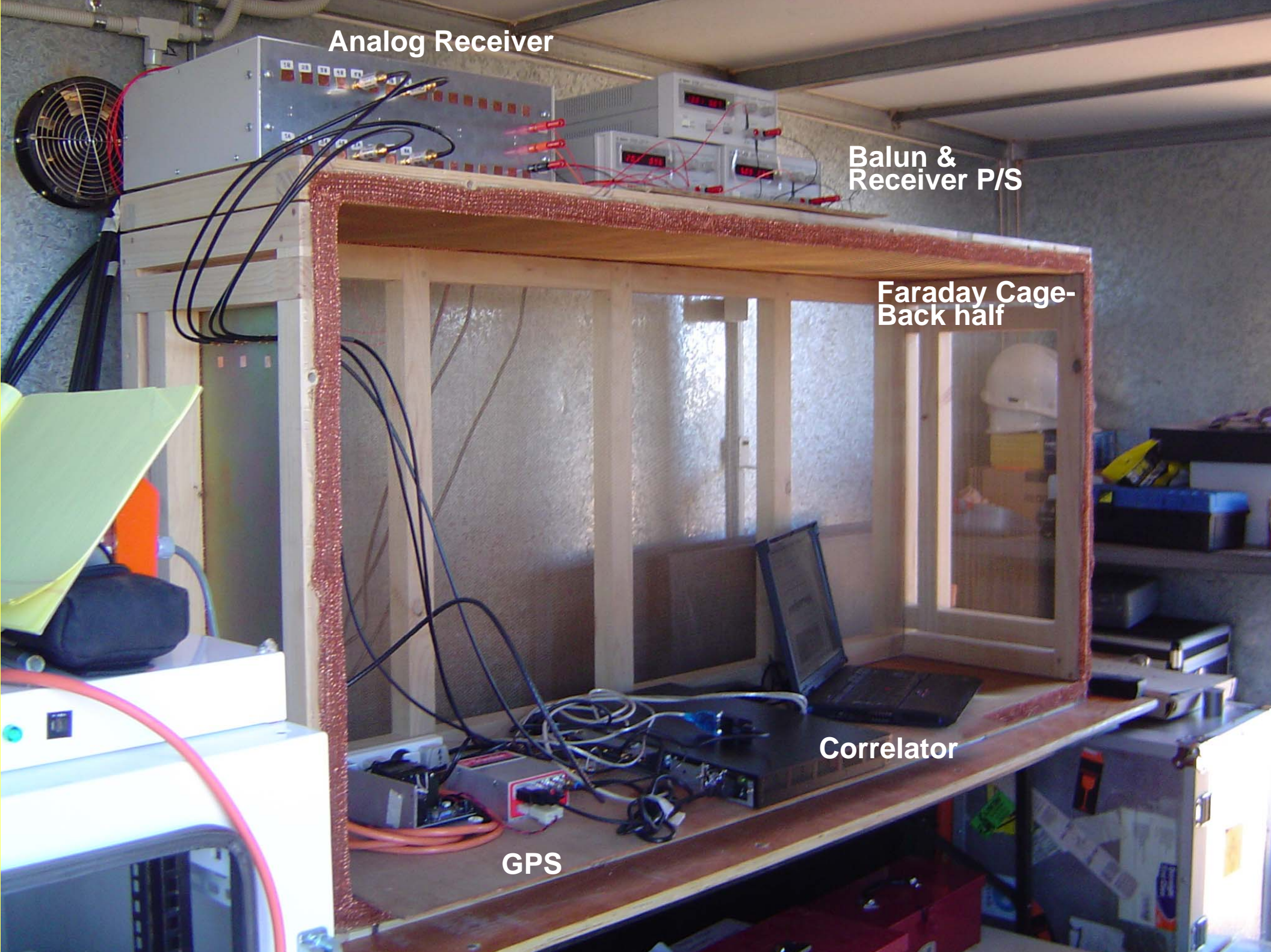
Analog Receiver

Balun &
Receiver P/S

Faraday Cage-
Back half

Correlator

GPS



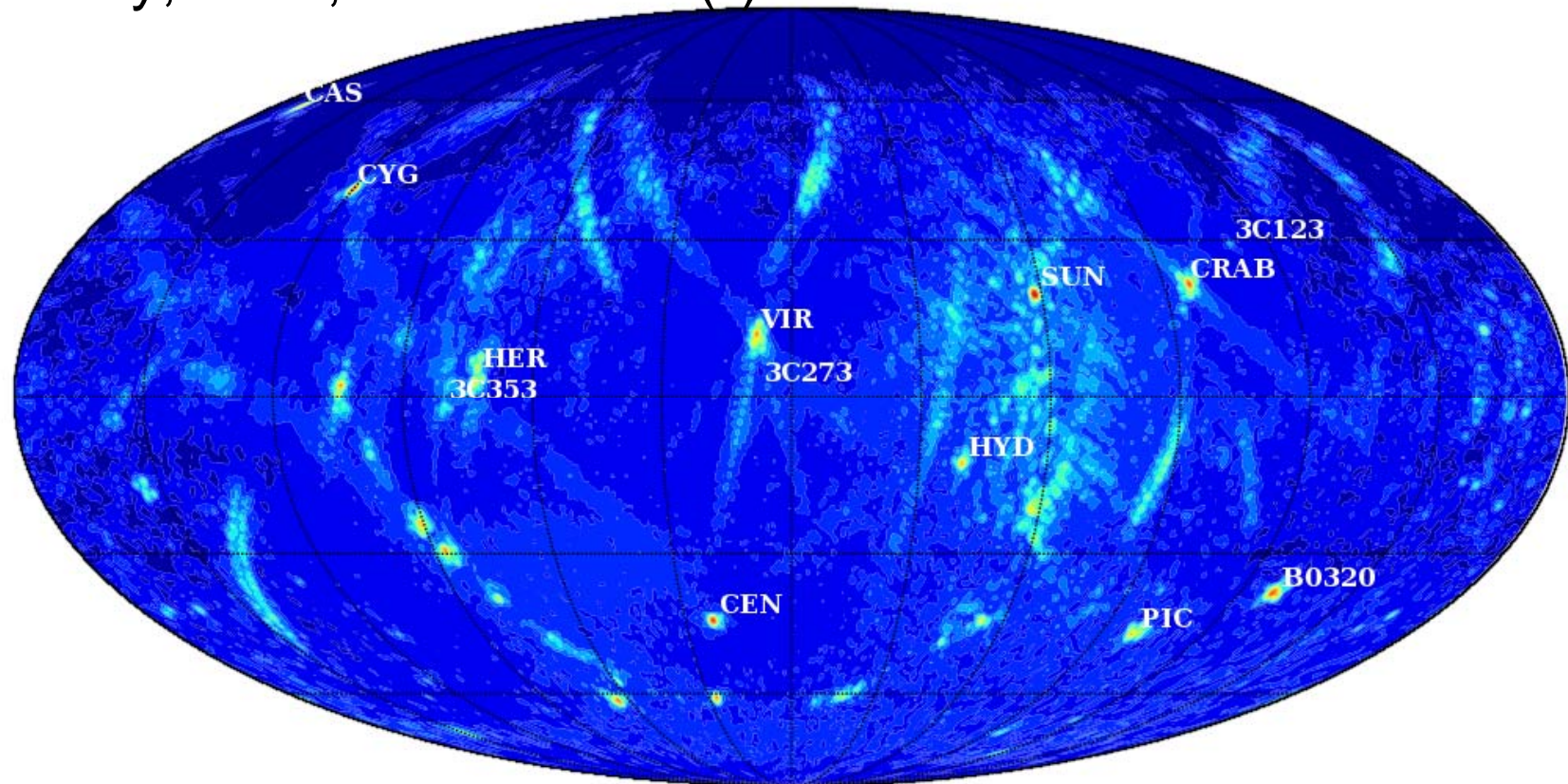
PAPER in Western Australia—2007 July

125-190 MHz

4 Dipole

24 hour integration

MFS, all-sky, facet, w-transform (*)



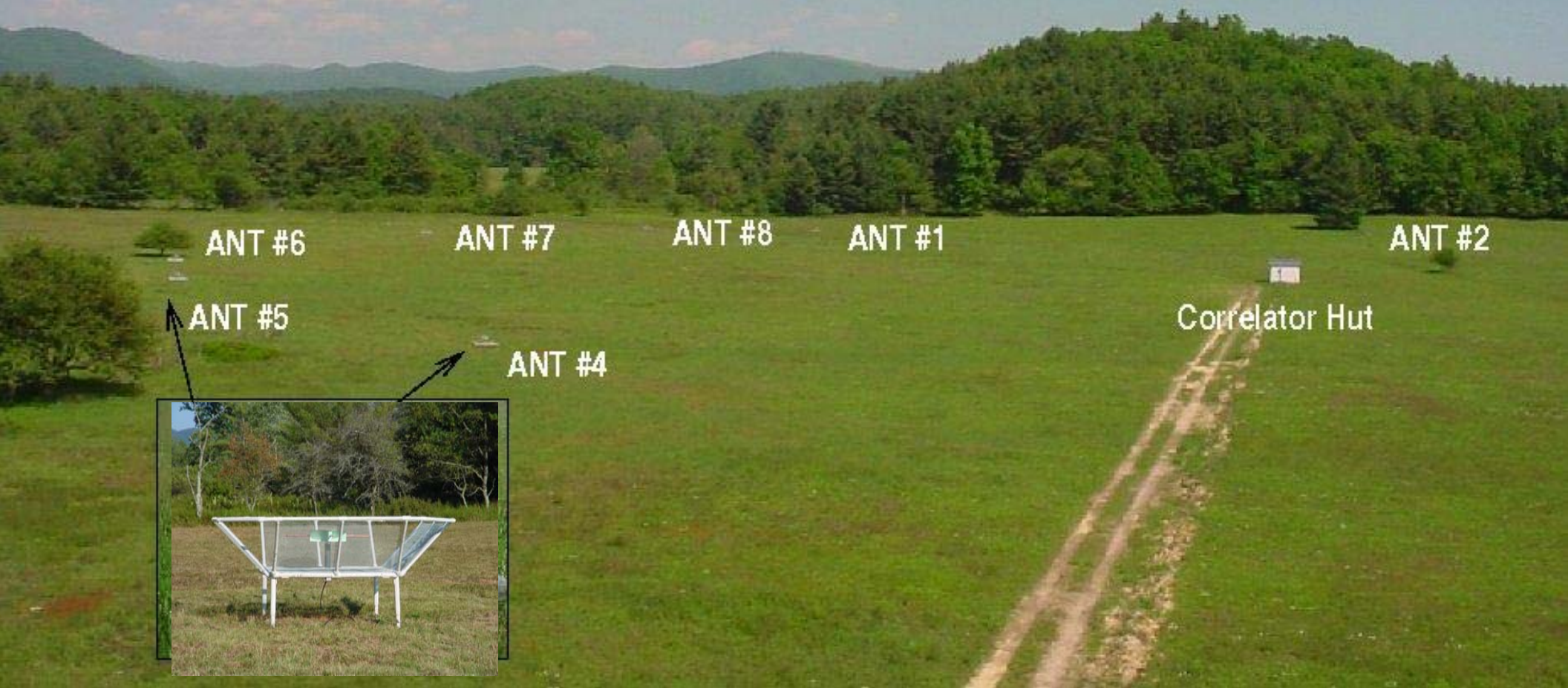
RMS away from strong sources: ~ 1 Jy/ ~ 1 K

(*) AIPY – Astronomical Imaging in Python – Aaron Parsons

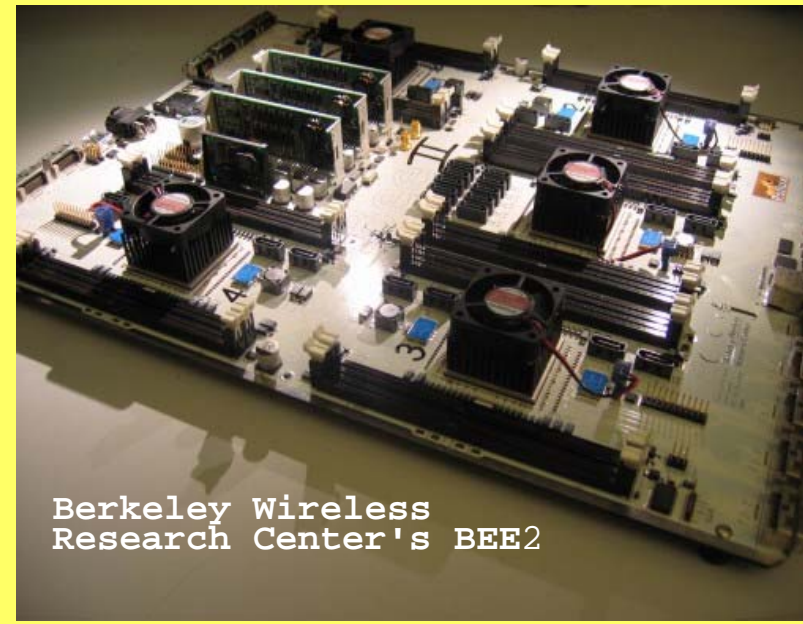
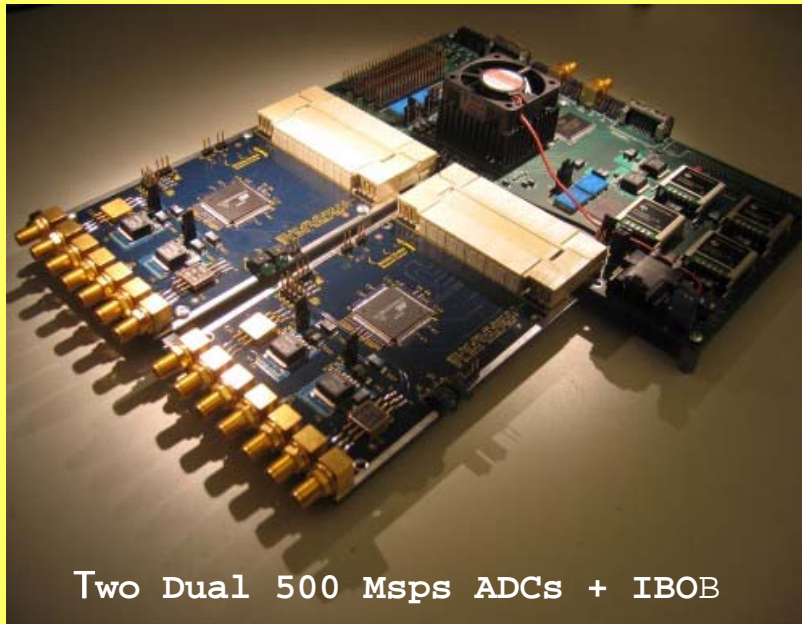
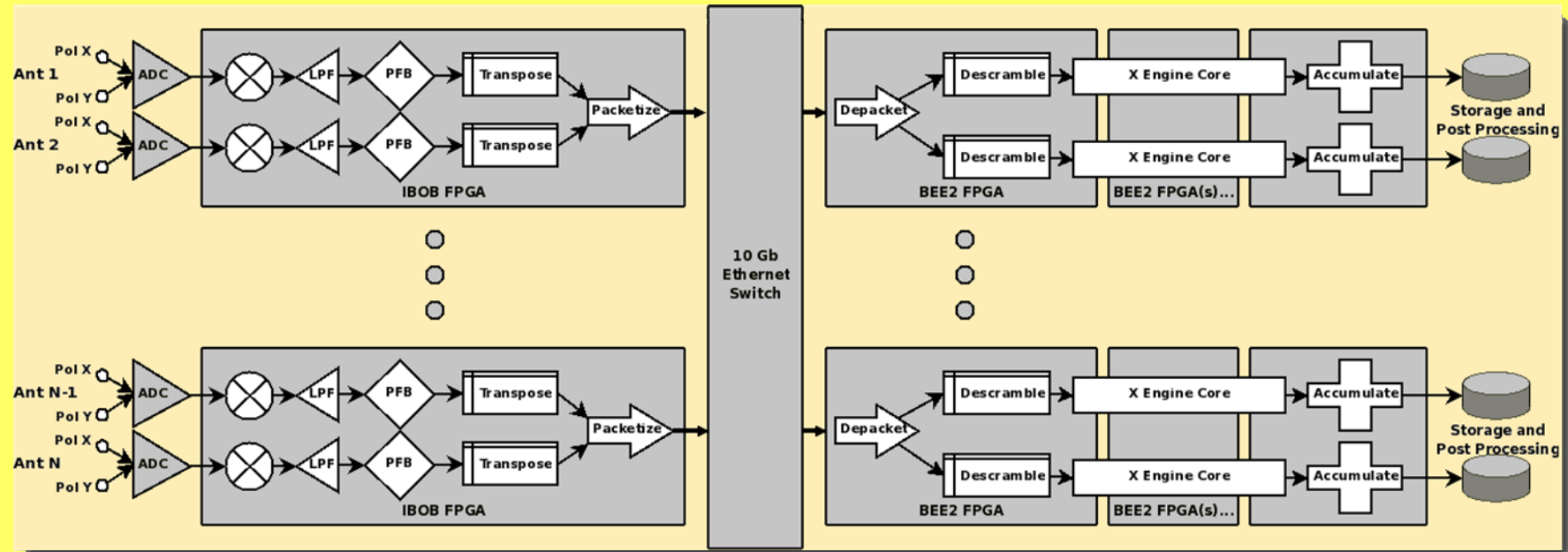
PRECISION ARRAY TO PROBE EPOCH OF REIONIZATION

GALFORD MEADOW -- NRAO: GREEN BANK, WV

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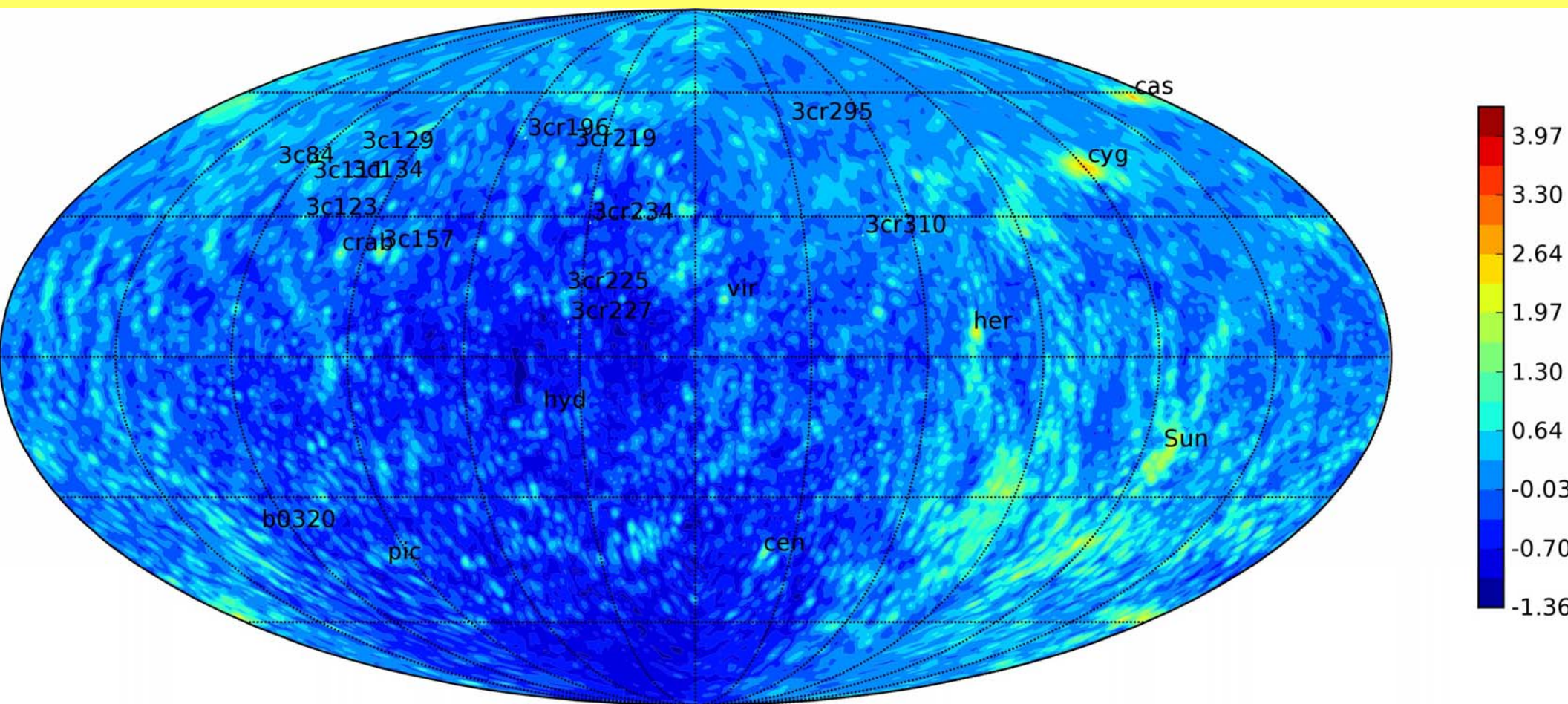


PAPER/CASPER Packetized Correlator



PAPER in Green Bank—2008 Mar

130-170 MHz
7 Dipole
24-hour integration



SUMMARY

- Step by step approach successful
- Green Bank test array essential
- AIPY and related calibration/imaging just starting: beam fitting; polarization soon
- Gearing up for PWA-32 deployment 2008 Sep
- Funding looks good for buildout to PWA-128 in years ahead: power spectrum detectability dependent on configuration, foreground removal, other systematics.
- Long term: 100M USD effort decision middecade.

谢谢你

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