EDGES:
(Experiment to Detect the Global EOR Signature)
Status Report

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EDGES: System Overview

- Single dipole, FOV = 120 deg
- Instantaneous bandwidth = 50-250 MHz
- Spectral resolution = 32 kHz → 130 kHz
- Temporal resolution = 1 s
- Data volume = 50 MB/hour
- Data storage = USB flash drive
- Internal noise comparison switch
- No ionospheric calibration
EDGES: System Overview

- Balun
- "Four-point" antenna
- Ground screen
- ADC
- Amplifiers, switch, and comparison source
- Balun
Switch
From antenna
To 2nd stage
LNA
Noise source
Acqiris AC240: 8-bit, 1 GS/s
EDGES: 21 cm Science

- Constrain $T_{21}(z)$
  - Test for fast reionization only ($\Delta z \leq 2$)
  - In effect, constrain derivative of $T_{21}(z)$ to $<1$ mK/MHz

Furlanetto 2006
EDGES: Technique

- EOR “step” ramps over 20 MHz
- fit without EOR
  - residual to 9th order polynomial fit to (sky noise + receiver + EOR) x EZNEC model of the fat dipole response
Why Global 21 cm?

• *(Basically)* same science as 1st generation arrays
  – Short term: $\sigma_{21}(z)$ vs. $\Delta T_{21}(z) \rightarrow x_{\text{HI}}(z)$

• “Simpler” than imaging/power spectrum
  – Average over large solid angle
  – Signal fills aperture of any antenna
  – Ignore ionospheric distortions
  – Polarized foregrounds reduced
  – Foregrounds easier to model (less precision required)

• Pathfinders for arrays
  – Inform decisions on frequencies to target to with arrays

• Long term: Reach high-z (>15) sooner
EDGES: Challenges

• Still need to separate signal from foregrounds with high DR
  – Differences in spectral structure less significant
  – Much less information available (need models)

• Difficult to calibrate absolute response of radiometer to better than 1%

• No empty fields for comparison (on/off target)

• Differential measurements are easier in angle than frequency
  – Instrument properties invariant to sky position, but not spectral translation: \( G, B, T_{rcv} \rightarrow G(\nu), B(\nu), T_{rcv}(\nu) \)
  – “mixes” sky and instrumental effects
EDGES: Smoothness

First measured spectrum partially calibrated, western Australia

$T_{\text{sky}}$ [K]

Frequency [MHz]

1.5 sky hours

Bowman, Rogers & Hewitt 2008
EDGES: Smoothness

Residuals after 7th order polynomial fit to spectrum

$rms$ vs. integration time

Measured $rms = 75 \, \text{mK}$ (Instrumentally limited)

Black line: smoothed to 2.5 MHz

**Preliminary Upper limit:** $\Delta T_{21} < 450 \, \text{mK}$ for rapid reionization at $z = 8$

Bowman, Rogers & Hewitt 2008
EDGES: Drift Scans

Rogers & Bowman 2008
EDGES: Status

- Jan 2006  Project start
- Dec 2006  “First light” in Western Australia
- Spring 2007 Preliminary analysis and characterization

Analog to digital converter limiting component:
Replace with UC Berkeley/CASPER iBob2-based system and/or scanning low-bandwidth up-down converting system

- Spring 2008 Implemented up-down receiver
- Summer 2008+ Improve signal extraction techniques
  (with R. Barkana et al.)
- Aug/Sep 2008 Interim deployment in California/Nevada
- 2009-2012 Seeking NSF ATI funding this November to integrate iBob2 and conduct series of observations and technology refinement
EDGES: Summary

• Preliminary constraint:
  \( \Delta T_{21} < 450 \) mK (if reionization occurred abruptly at \( z \approx 8 \))
  Likely to improve in the next few weeks

• Demonstrated viable approach
  First run within order of magnitude (75 mK [rms] compared to \( \leq 7.5 \) mK)

• Clear paths to improve performance
  – New receiver system
  – Increase bandwidth of antenna impedance match
  – Deploy to very remote sites
  – Improve constraint fitting techniques (matched filters, etc.)

• Should determine duration of reionization or constrain to:
  \( \Delta z \geq 2 \) or better