## Progress on HIRAX, the Hydrogen Intensity and Real-Time Analysis eXperiment

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# What are we looking at?



#### Can probe with 21cm (not just for EOR)!

#### **Baryon Acoustic Oscillations (BAOs)**

- Characteristic length scale set when CMB was formed.
- Truly precise measurements all at low redshift
- Successful measurements will help constrain dark energy!

**Intensity Mapping:** Low spatial, high frequency resolution images

Increase volume of data



Challenge:

measurements contaminated by bright sources (galaxy!) emitting in band of interest

plot by Phil Korngut (Caltech)

#### Hydrogen Intensity and Real-time Analysis eXperiment

**Goal:** measure BAOs with Hi intensity mapping to constrain Dark Energy equation of state.

"Hydrogen Intensity" = BAO

"Real-time analysis" = FRBs



(Funded by South Africa)



Prototyping:

# **HIRAX Specifications**

Range: 400-800MHz (.8<z<2.5)

Resolution: 390kHz; 1024 channels

Collecting area: 28,000m<sup>2</sup>

System temp: 50K (goal)



Goal: 1024 dish array

# Calibration

Goal: map beam to 1 part in 10<sup>-4</sup>

Challenge: dishes are stationary

Solution: drone

- Far field = 200m max  $\rightarrow$  attainable!
- Demonstrated by HERA, etc.
- Considerations:
  - i. broadband noise source
  - ii. drone carriable
  - iii. remove RFI from drone
  - iv. retrieve data





J. R. Shaw et al., Phys. Rev. D 91, 083514, (2015)

## Hardware



T<sub>sys</sub> dominated by initial LNA—challenging to measure!

# Measuring T<sub>sys</sub>



#### Measurements obtained from autocorrelation data



# Measuring T<sub>sys</sub>



Measurements obtained in Karoo Dessert (SKA site/future HIRAX location)





# Measuring T<sub>sys</sub>

Next step: build testbed for more controlled measurement of  $T_{\text{sys}}$  in Newburgh lab at Yale



### Science Forecasts: BAO



### Science Forecasts: Calibrating LSST Redshift Error



## Science Forecasts: Fast Radio Bursts (FRBs)

- Bright ms pulses of unknown origin
- ~25 published bursts, but total event rate estimated 10<sup>4</sup> over full sky



- 8-dish outriggers: Botswana, HartRAO, etc.
- HIRAX projected to find dozens per day



## **HIRAX: Current Status**

- Eight-element array up and running!
- See fringes in first data





# Conclusion

#### HIRAX

- 21cm intensity mapping experiment
- Based in and funded by South Africa
- Will measure BAOs to constrain Dark Energy EOS parameters
- Useful for calibrating LSST redshift measurements, detection of FRBs

Next steps

- Finalize dish, hardware design
- Accurate measurement of Tsys
- Preliminary drone measurements
- On site improvements: weather proofing, radomes, etc

For more details, see Newburgh et al., arXiv:1607.02059 (2016) or our website: <u>http://www.acru.ukzn.ac.za/~hirax/</u>



## Thank you!

