

21^{cm} Experiment for the 21st Century

Where Do We Stand?

What We Said

- Science Motivation
 - “nearly ideal” DE BAO measurement to high redshift
 - unique opportunity to do Stage IV experiment at low cost
- Collaboration
 - largely in place, wide interest, little funding
- 5 Magic Numbers
 - we know what we need to measure
- Requirements & Design
 - we know what we need to build to measure it
- Telescope Simulation and Foreground Subtraction
 - foregrounds can be removed (other people find that too)

Your Charge

1. Science reach

- a. Is the science case strong and aligned with Fermilab goals? Is it likely to achieve 'mission need' at DOE?
 - Studies of Dark Energy are an important part of DOE mission. BAO is one of the 3 main approaches for measuring DE evolution, and the only one that can detect early ($z \sim 4$) dark energy.

Your Charge

1. Science reach

- b. Does this effort have a reasonable chance to achieve these science goals? Specifically, is there evidence that the problem of foreground subtraction can be surmounted?
 - Radio BAO experiment is an (early) Stage IV experiment. It will reach accuracy comparable to BigBOSS or JDEM.
 - Foreground contamination appears to be less severe than is often thought (thanks to Dave). Proof-of-concept demonstration has already been done (HIPASS, GBT).

Your Charge

1. Science reach

c. What role will Fermilab have in extraction of the science? Are personnel identified that will play a major role in the science?

- We can contribute in almost every part of the project: antenna design, back-end electronics, data management, data analysis, project management, presentation to the Nobel Committee.

Your Charge

2. Technical approach

- a. Is the 21cm survey competitive in reach, cost and schedule with other techniques proposed to study baryon acoustic oscillations? Specifically, how does it compare with other BAO efforts FNAL might consider (JDEM, BigBOSS, LSST)?
 - Radio BAO is superior to (photometric) LSST BAO. It is comparable to BigBOSS and JDEM*.
 - It is much cheaper for the same gain, and can be accomplished on a much shorter time-scale.

(* exact comparison depends on the final design and funding)

Your Charge

2. Technical approach

- b. Is the specific technique explored by the R&D effort at FNAL (cylindrical radio telescope array) the best approach to a 21 cm survey?
 - It is one of the two competitive approaches. The very best method can only be determined by building prototypes.

Your Charge

2. Technical approach

- c. Assess the technical progress made to date. What resources were used and is the current technical status promising?
- There are two prototype cylinders at Pittsburgh, used for testing electronics.
 - We have a selection of possible sites.
 - We are ready to do the conceptual design.
 - Little Fermilab resources besides scientists' time has been used so far.

Your Charge

2. Technical approach

- d. What is the expected technical role at FNAL? Does the lab have the required facilities and personnel to fulfill this role, or would we have to import radio astronomy expertise?
- We will contribute to antenna design, receiver design, back-end electronics, data management, data analysis.
 - It is desirable to have more local radio astronomy expertise - a joint appointment/consultant (a-la Rich Kron or Rai Weiss).

Your Charge

3. Collaboration and funding

- a. Has a strong collaboration emerged, capable of mounting an experiment? What is the role of FNAL in this collaboration? Is there a project-oriented management structure being formed?
 - The project is organized and has a management structure.
 - FNAL is a major player in the collaboration (McGinnis is the Instrument Scientist).
 - The only similar effort we are aware of has not yet been formally organized.

Your Charge

3. Collaboration and funding

b. Has sufficient progress been made towards a conceptual design that a target date can be identified? Is the proposed schedule and budget reasonable for completing R&D and moving forward with a project?

- The conceptual design can be completed by the end of the year.

Your Charge

3. Collaboration and funding

- c. What is the cost of such a project, and what are the planned funding sources? Is the cost estimate credible at this stage?
- The cost is estimated of about \$20M, plus \$2M/year in operations for 5 years.
 - We expect a combination of DOE, NSF, and foreign funding, depending on the final site selection.

Your Charge

3. Collaboration and funding

d. Has sufficient progress been made that this effort can go forward towards external review?

- Absolutely!