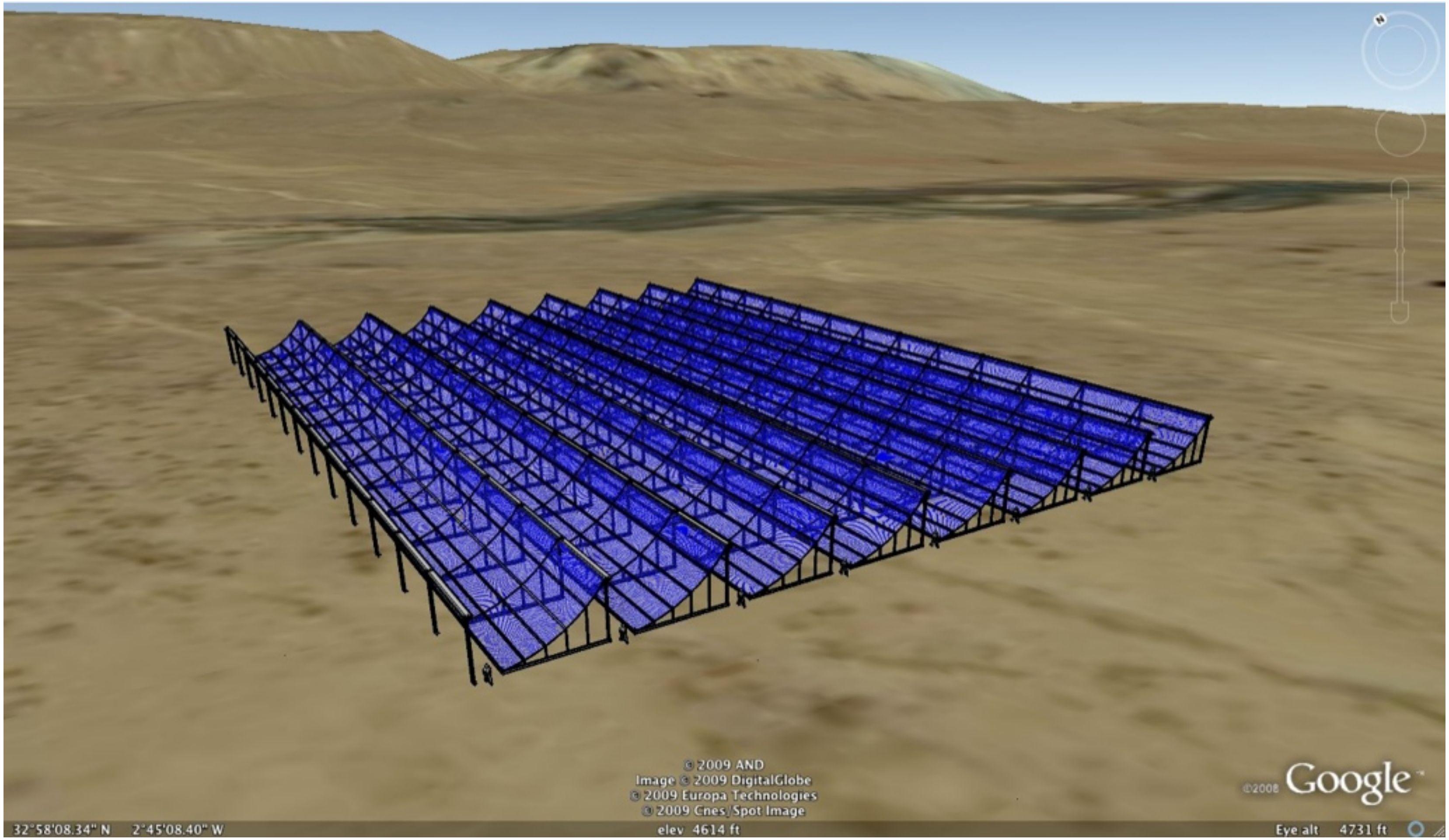
Probing Dark Energy with Intensity Mapping of HI 21cm Emission



for CRT (loose) collaboration
Carnegie-Mellon, Saclay, Ifrane, Toronto, UBC, CSIRO, Wisconsin, Fermilab, ...

Albert Stebbins
Fermilab

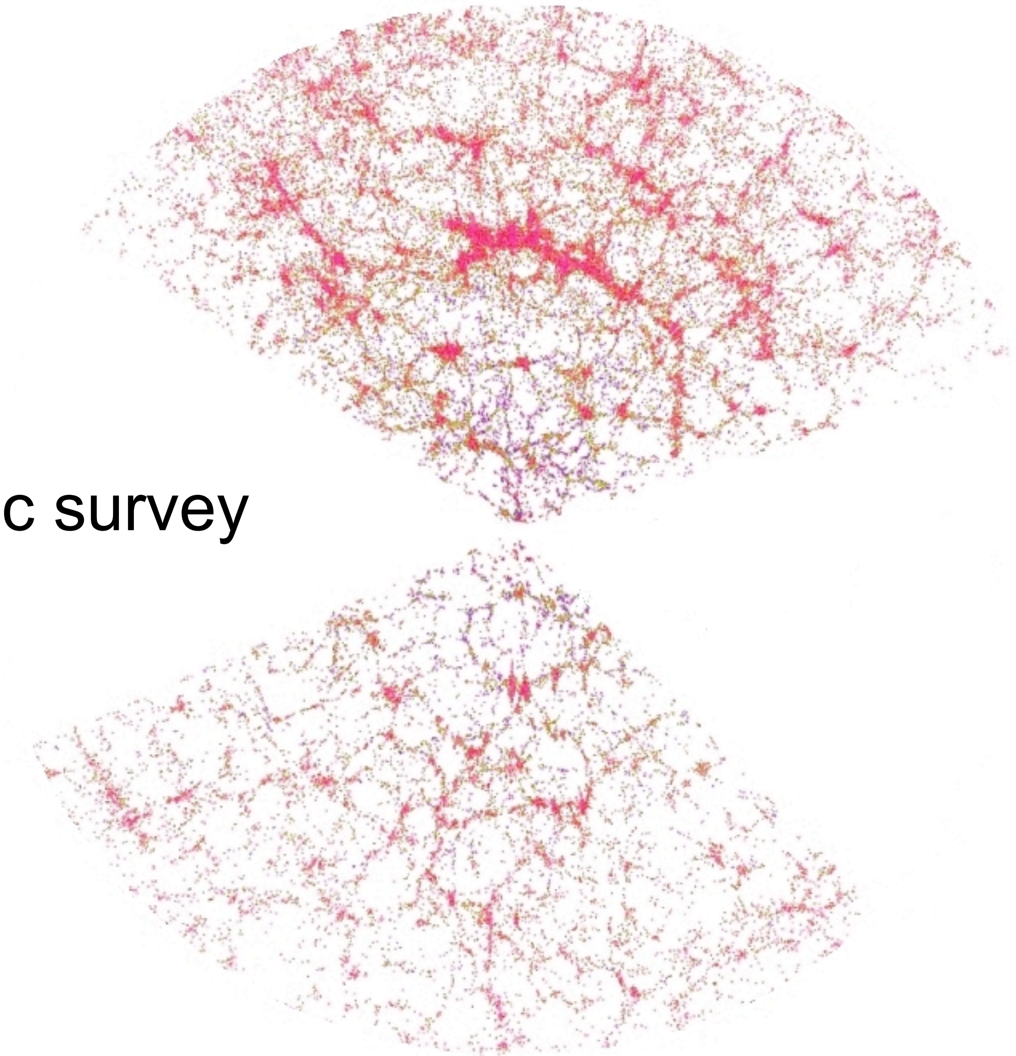
Introduction

Determining the apparent size/shape of LSSs as a function of z is a powerful method for determining expansion history of our universe.

This method typically thought to be used with optical/IR galaxy redshift surveys.

One may be able to obtain better (or at least cheaper) results using 21cm intensity mapping techniques (Peterson et al. 2006, Wang et al. 2006).

LSS in Optical / IR

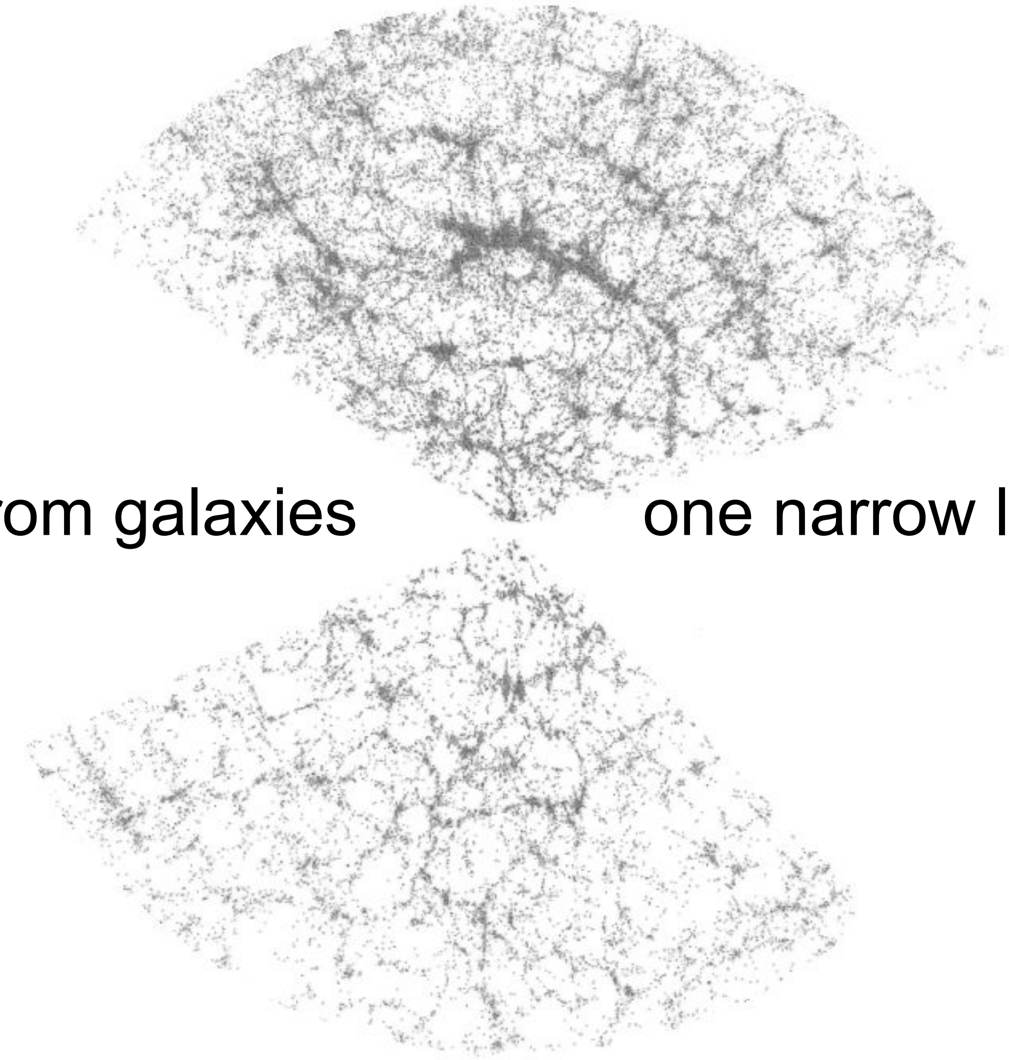


spectroscopic survey

multi-band: COLOR - get galaxy types

LSS in 21cm

all emission from galaxies



one narrow line emission

no colors - just redshifts: GRAYSCALE

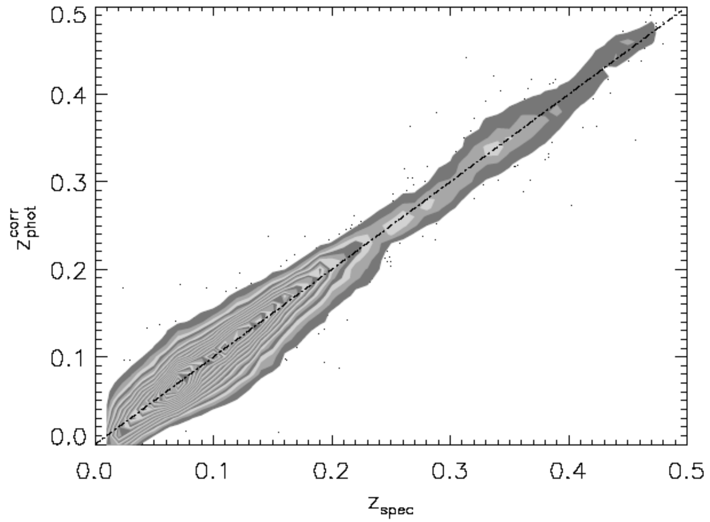
Redshift Resolution

Unlike Optical / IR for 21cm

Redshift Determination is Easy and Cheap

- FFT RF spectral analyzer of incoming signal (1GHz).
- Imaging and spectroscopy in same observation.

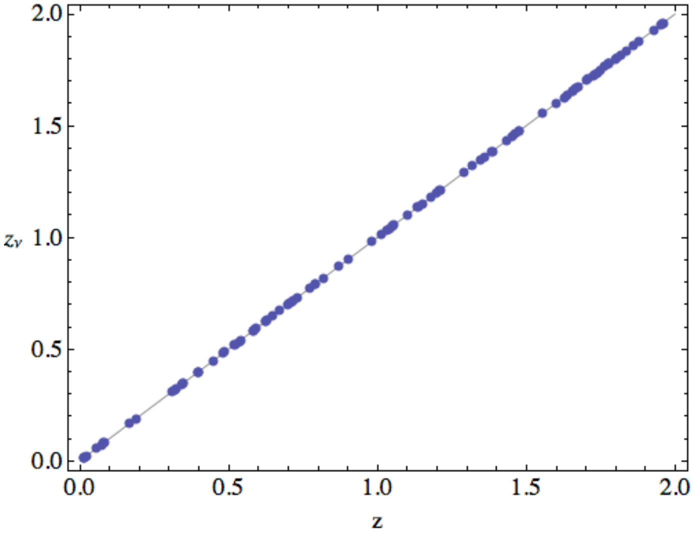
cheap photometric z



D'Abrusco 2007

versus

cheap radio z



good radial resolution

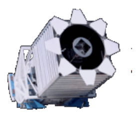
Angular Resolution

Unlike Optical / IR for 21cm

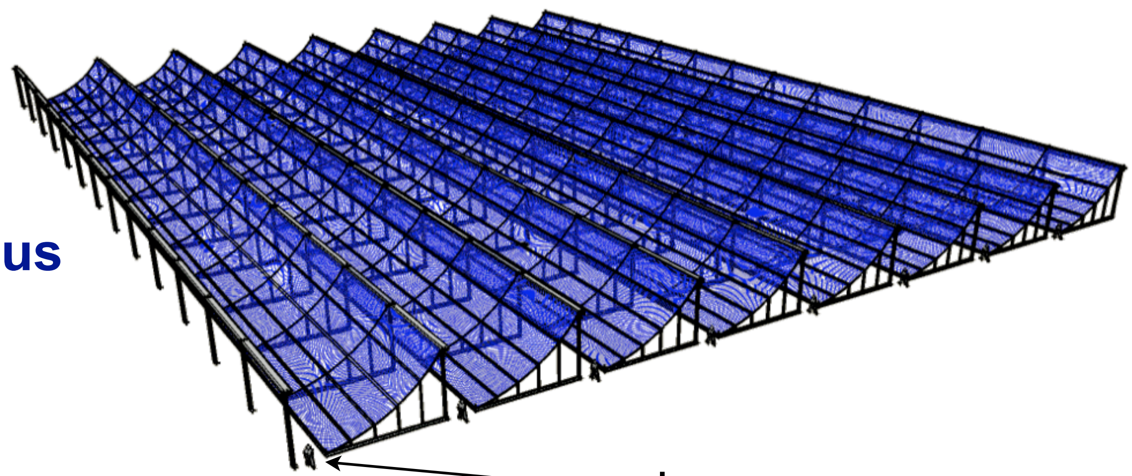
Angular Resolution More Challenging

Because of long wavelength (>21cm) angular resolution more challenging.

Need huge telescope!



versus

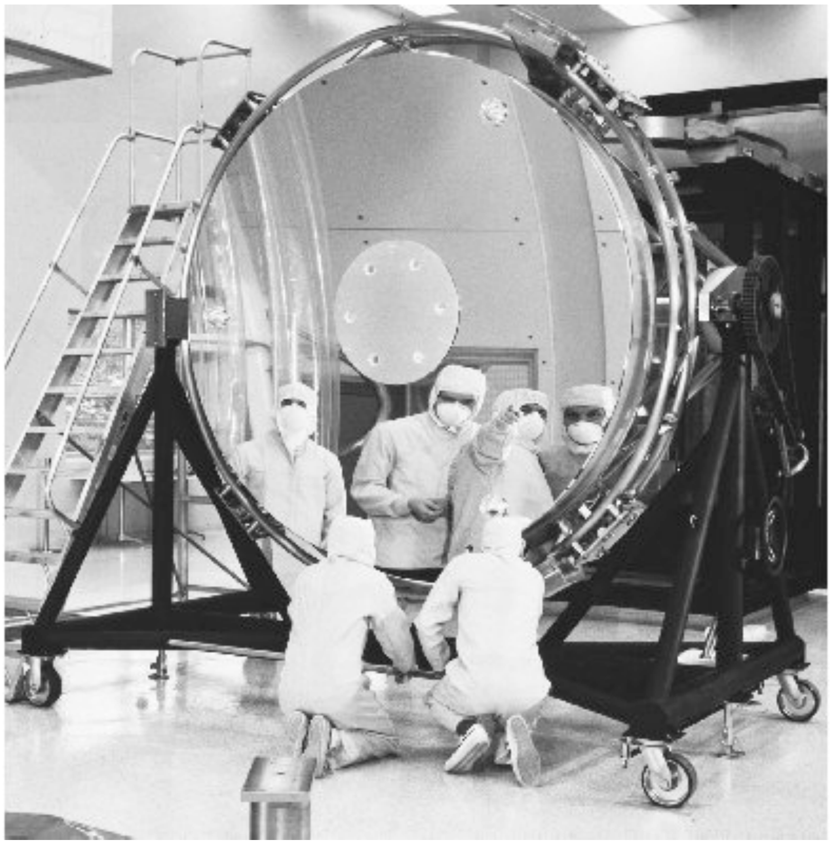


SDSS 2.5 m

human

poor angular resolution (10’ for ~$10M)

but Imaging Optics is Inexpensive



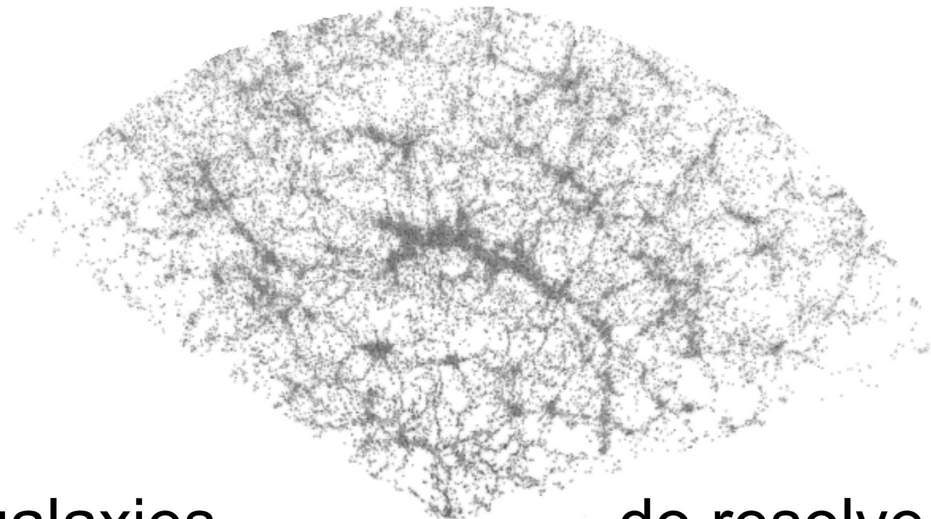
N.B. probably need to do a
little better than chicken wire

polished glass **versus** chicken wire

<micron

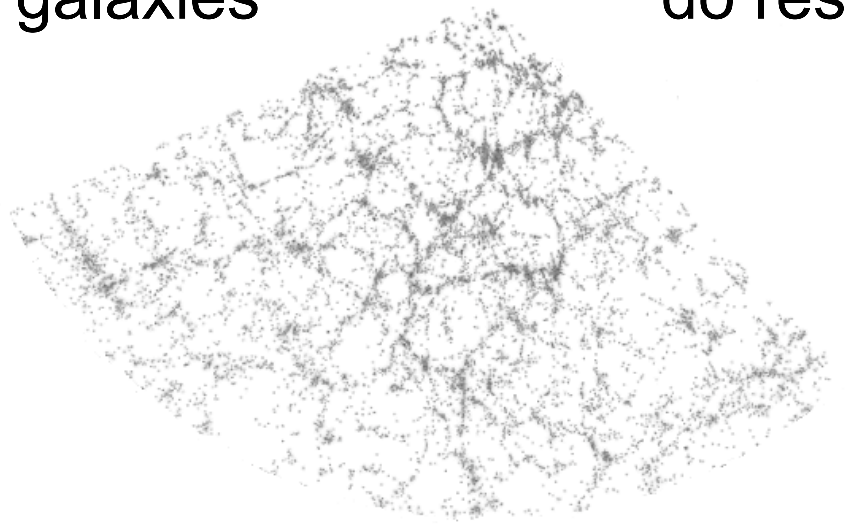
>decimeter

INTENSITY MAPPING



do not resolve galaxies

do resolve LSS



Expensive to resolve individual galaxies (e.g. SKA)

instead map mean 21cm emission

INTENSITY MAPPING

do not resolve galaxies

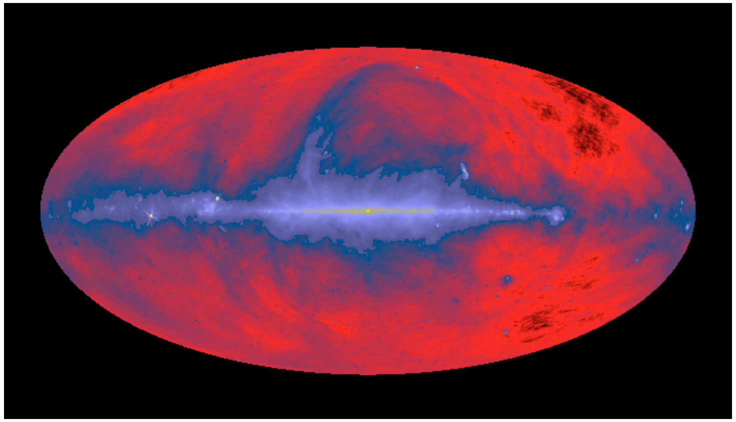
do resolve LSS

Expensive to resolve individual galaxies (e.g. SKA)

instead map mean 21cm emission (3d)

Foregrounds Seem Large

- LSS signal (~100μK)
- Galactic emission (~10K)
- Galactic / extragalactic point sources
- RFI (radio frequency interference
  - Cell phones / TV stations / ...



Foregrounds Actually Small

Fortunately (synchrotron & free-free) emission from Galaxy and point sources have very smooth spectrum.

- For 21cm, frequency maps onto radial distance.
- For large radial wavenumber the foregrounds are highly suppressed (by many orders of magnitude).
- This is independent of the electron energy distribution function or magnetic field configuration.

So astrophysical foregrounds are expected to be smaller than signal on “scales” relevant to BAO.

Has Anyone Done This Before?

A positive signal was found in cross-correlation between HIPASS intensity map and 2df galaxy survey (Pen et al. 2008)

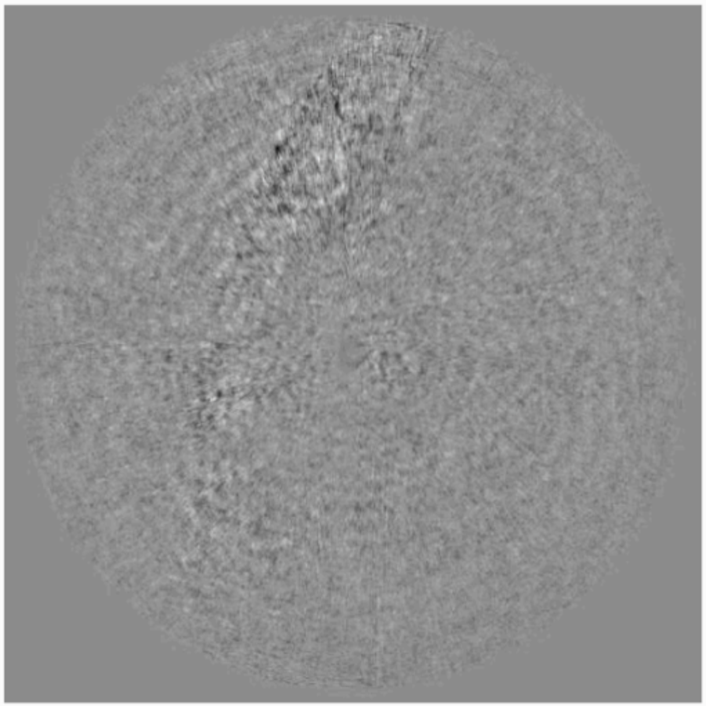


Figure 1. The HIPASS data cube $R < 127h^{-1}$ Mpc, projected in a cartesian coordinate system towards the south pole.

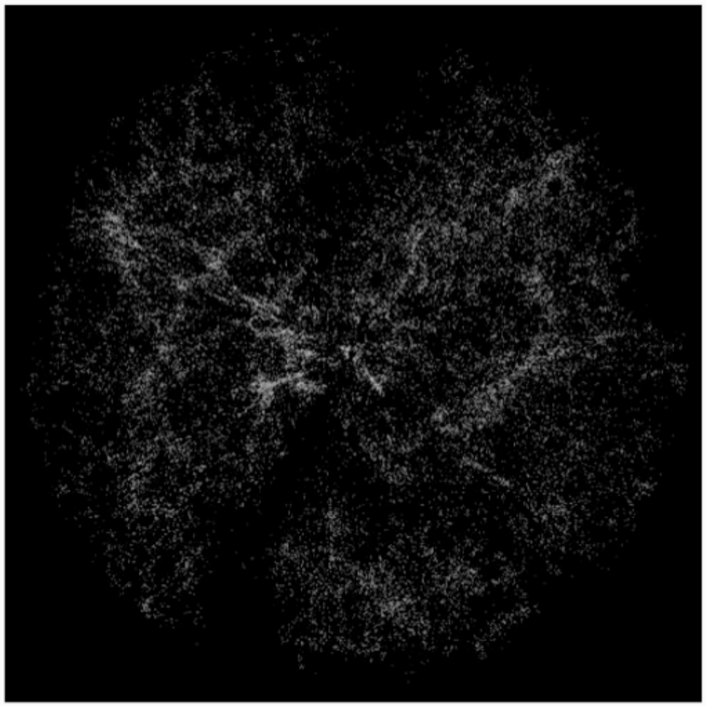


Figure 2. The 6dFGS catalog for $R < 127h^{-1}$ Mpc, also projected towards the south pole. The missing wedges are the galactic plane.

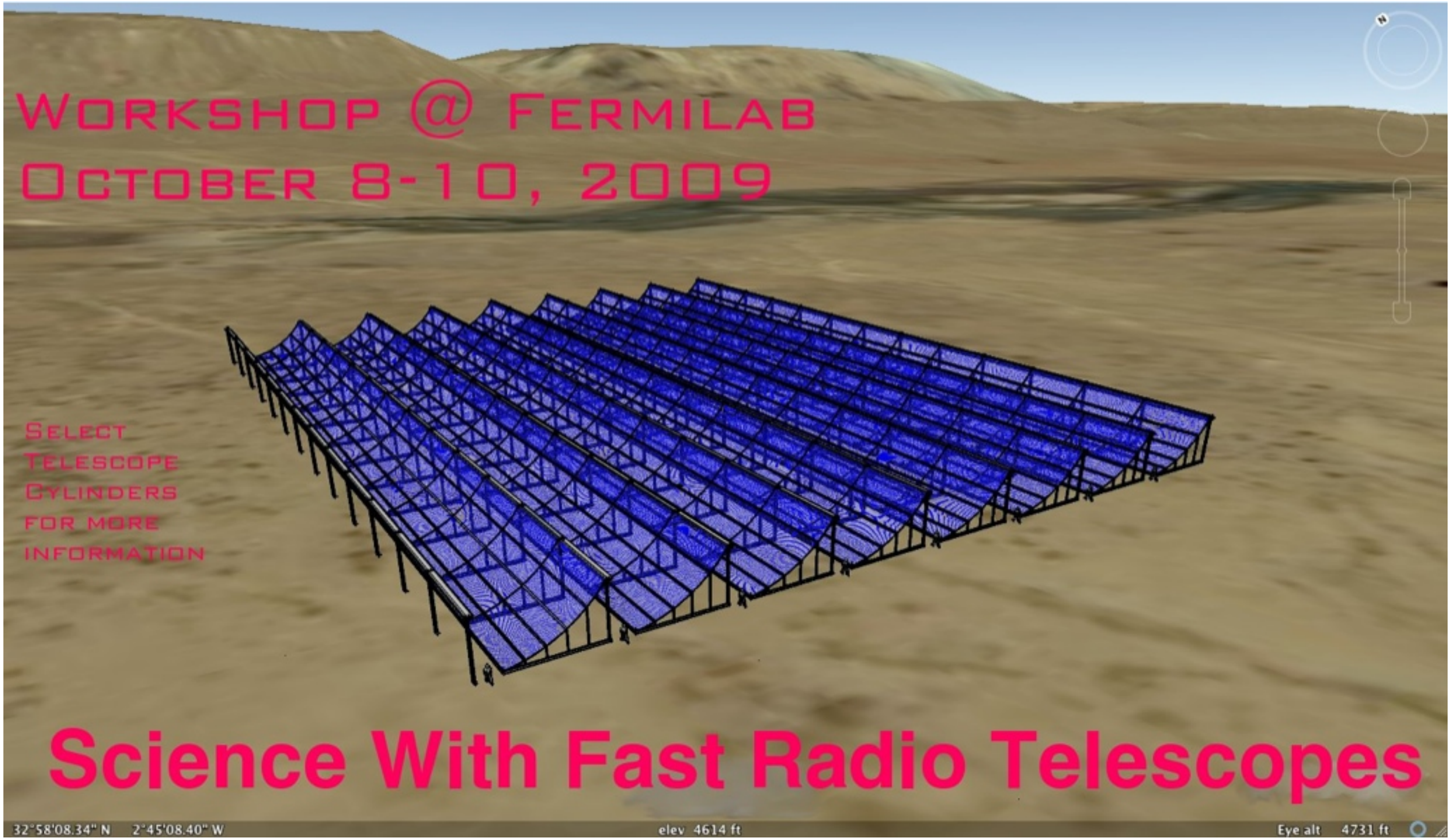
For DE one would need auto-correlation!

DE Prospects

There are different concepts for how to do a 21cm BAO survey, but generally speaking

- Unlike optical / IR - high redshifts are relatively easy map (*e.g.* z ~ 0.5 - 2)
- Unlike optical / IR - very large survey areas are also easy (*e.g.* 2π steradians).
- We expect a Stage-III+ DE probe might cost $20M.

For More Information



http://www-astro-theory.fnal.gov/events/conferences-files/SwFRT09/