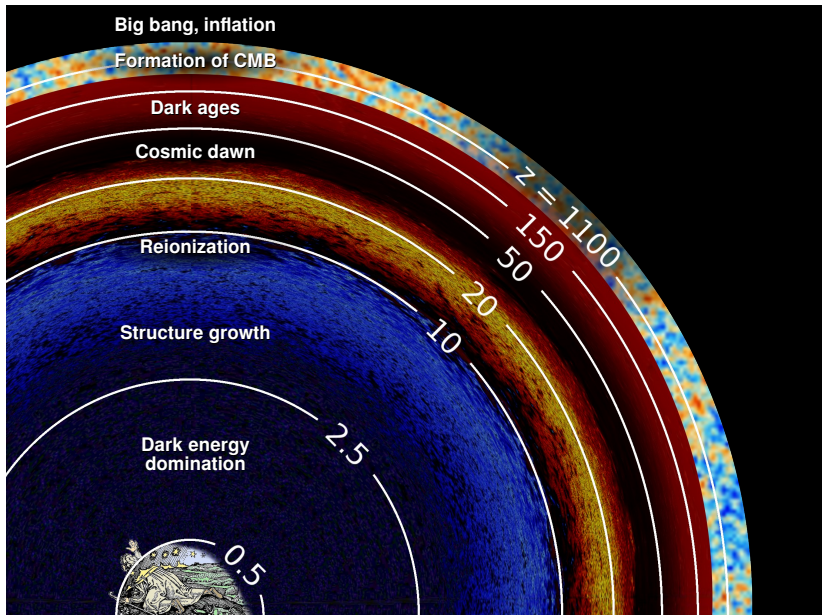


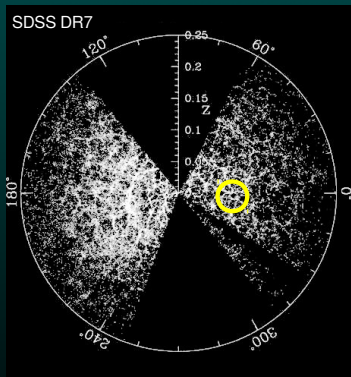
HIRAX **(Hydrogen Intensity and Real-time Analysis eXperiment)**

(presented by Martin Bucher APC, Université Paris 7, Paris France)

25 June 2018, LAL, Orsay, France



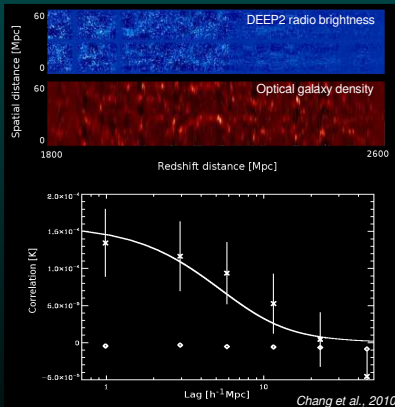
BAOs with hydrogen intensity mapping



We want large volumes (large sky, large z range) for precision cosmology

...but counting individual galaxies is hard, and getting to high redshifts is challenging

150 Mpc scale is big (degree scale)



Throw away resolution: use HI intensity mapping to measure matter distribution AND obtain redshift information.

Use BAO peak as a standard ruler to chart the universe's expansion history, probe dark energy.

Required specs for BAO intensity mapping



- Maximize sensitivity on scales of interest
→ Use compact array geometry
- Redshift range of interest: $0.8 < z < 2.5$ to capture dark energy domination at $z \sim 2$
→ Required frequencies: 400 – 800 MHz
- BAO 150 Mpc angular scale: 3 – 1.3 degrees at $0.8 < z < 2.5$
→ Required baseline lengths: 15 – 60 meters
- BAO scale along line of sight: 20 – 12 MHz at $0.8 < z < 2.5$
→ Required freq resolution: minimum ~ 100 channels, more for foregrounds and higher order peaks
- BAO signal level: ~ 0.1 mK
→ Low system temperature, large collecting area

The Hydrogen Intensity and Real-time Analysis eXperiment

Science goals:

Measure baryon acoustic oscillations with HI intensity mapping

Characterize dark energy

Radio transient searches

Pulsar searches

Neutral hydrogen absorbers

Diffuse polarization of the Galaxy

Instrumental approach:

1024 close-packed 6-m dishes

Dishes are stationary but can be tilted

Operating frequency: 400 – 800 MHz,
equivalent redshift = 0.8 – 2.5

Working closely with CHIME:
channelize with FPGA ICE boards,
correlation with GPUs

Location: SKA/Karoo (site agreement
in progress)

The acronym:



Rock hyrax / dassie



<http://www.acru.ukzn.ac.za/~hirax>

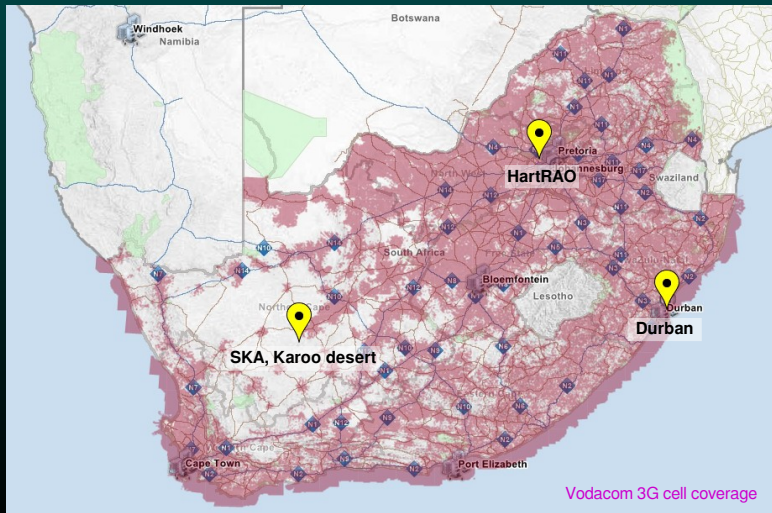
Complementarity with CHIME



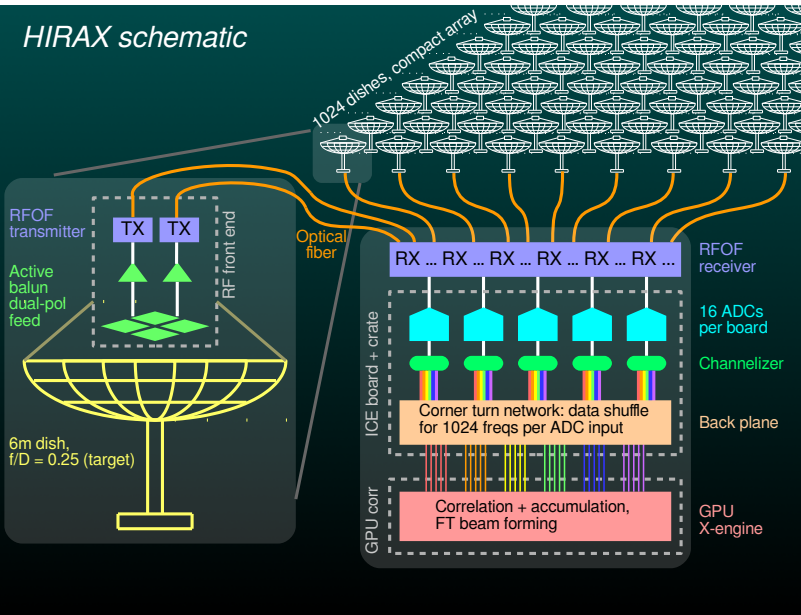
	CHIME	HIRAX
Site	DRAO, Canada	Karoo (lower RFI, no snow)
Telescope	Cylinder array	Dish array (different systematics)
Field of view	100° NS, 1° – 2° EW	5° – 10° deg
Beam size	0.23° – 0.53°	0.1° – 0.2°
Collecting area	8000 m ²	28,000 m ²
Sky coverage	North	South

↑
Optical surveys in the south, esp. LSST: cross-correlate for foreground mitigation and other science. More pulsars in the south.

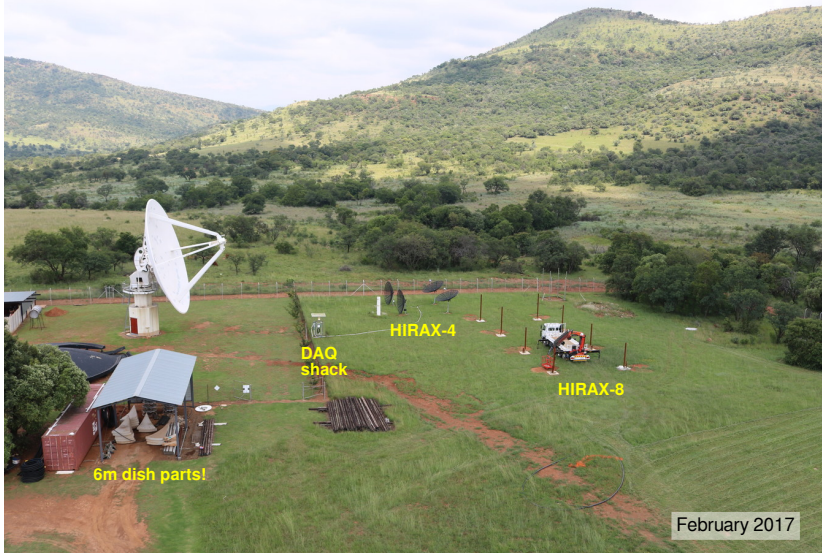
Where we are in South Africa



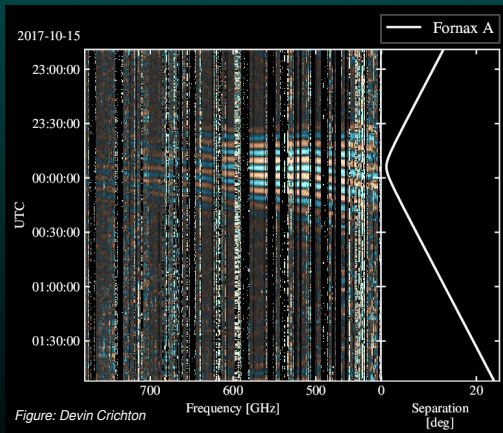
HIRAX schematic



HartRAO eight element 6m prototype



HIRAX-8 commissioning in progress

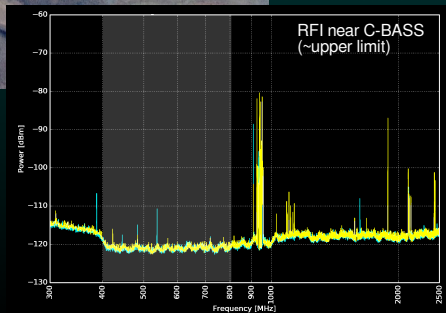


- All dishes instrumented, commissioning and troubleshooting in progress
- First tests of active-balun feeds, RFOF modules, ICE board, GPU correlator
- We've seen fringes! But lots of work ahead...
- Current plan: buildout to 32 dishes at HartRAO for further subsystem tests

Next phase: 128 element array in the Karoo

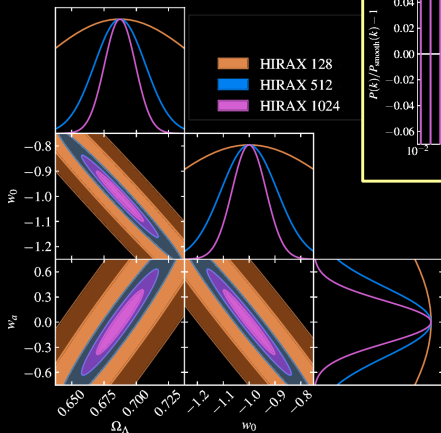


- Full HIRAX site: Karoo desert, working with SKA to finalize
- Representative RFI levels at Klerefontein look great, UHF TV in the area has been turned off
- HIRAX-128 construction estimated start in 2019, eventual expansion to 512, 1024

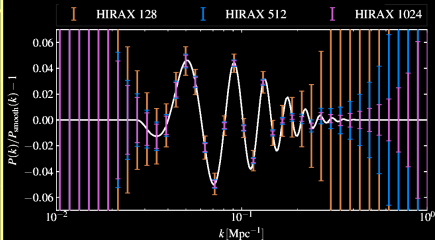


Parameter forecasts

Dark energy constraints 4 year survey (50% eff.), 15,000 deg²



BAO power spectrum constraints



Dark energy figure of merit:

HIRAX 128 : 9

HIRAX 512 : 103

HIRAX 1024 : 285

Analysis by
Devin Crichton

Fast radio bursts

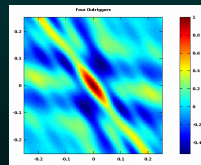
- Fast radio bursts: short (~ms), bright (~Jy) radio transients. Distances are likely cosmological because of observed dispersion.
- Fast de-dispersion code developed for HIRAX and tested on archival GBT data: bonus detection!
- HIRAX: estimated ~10 FRB detections per day, possible coordinated observations with HERA

Outrigger stations:

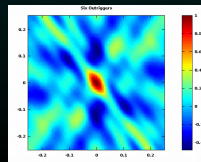
~1000 km baselines for VLBI positions for HIRAX events



4 outriggers



6 outriggers



Summary & future prospects



- HIRAX will do hydrogen intensity mapping to study BAOs and the universe's expansion history at $0.8 < z < 2.5$
- Eight element prototype is being commissioned at HartRAO, have obtained first fringes
- Next phase: 128 elements in the Karoo, aiming for 2019
- Outtrigger station site testing has begun

Possibilities for Expanded French Involvement

- ▶ International partners welcome: Canada, France (now Ken and Martin), India, Switzerland, United Kingdom, United States, Taiwan
- ▶ Synergies in studying common science/analysis/instrumental issue
- ▶ HIRAX Collaboration very open to new members. Financial/in kind contribution highly desirable. Invitation to discuss.