D3A: The **D**eep **D**ish **D**evelopment **A**rray

Dallas Wulf
McGill Space Institute
Great Lakes Cosmology Workshop
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In Collaboration With:

McGill

NRC·CNRC Canada

UNIVERSITY OF TORONTO

"Every time we introduce a new tool, it always leads to new and unexpected discoveries, because Nature's imagination is richer than ours."

— Freeman Dyson

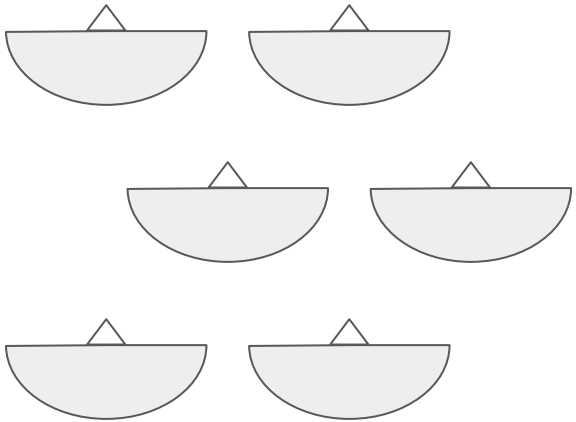
2016

2019

- Close-packed interferometer arrays are changing the way we do 21cm science
- CHIME is demonstrating what can be done with the world's largest radio correlator
- Now we're turning our attention to the front end, on redundancy performance

Why we care about redundancy

- Close-packed interferometer arrays provide unparalleled mapping speed by combining large field of view with high sensitivity...
- But, calibrating hundreds or even thousands of receivers poses a major challenge
- Redundant baselines allow calibration using unknown and complicated sky signals[1]...
- But, requires that redundant baselines are actually redundant



1. Adrian Liu et al., MNRAS 408, 1029 (2010)

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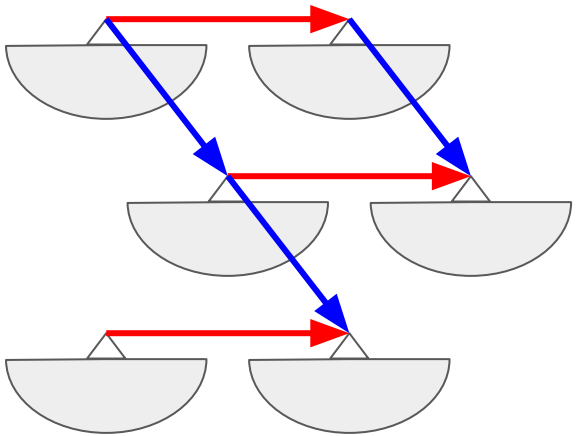

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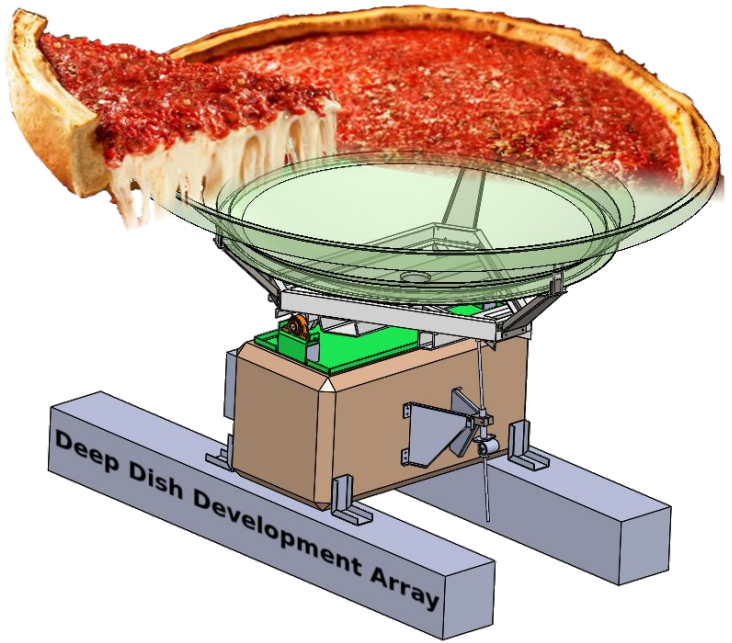
D3A Overview

(Sorry, New York)

- 2-element interferometer located at the DRAO
- Collaboration between universities and the NRC
- Testbed for future 21cm experiments (HIRAX/CHORD)
- Emphasis on meeting redundancy requirements for close-packed interferometer arrays



HIRAX: The **H**ydrogen **I**ntensity and **R**eal-time **A**nalysis e**X**periment

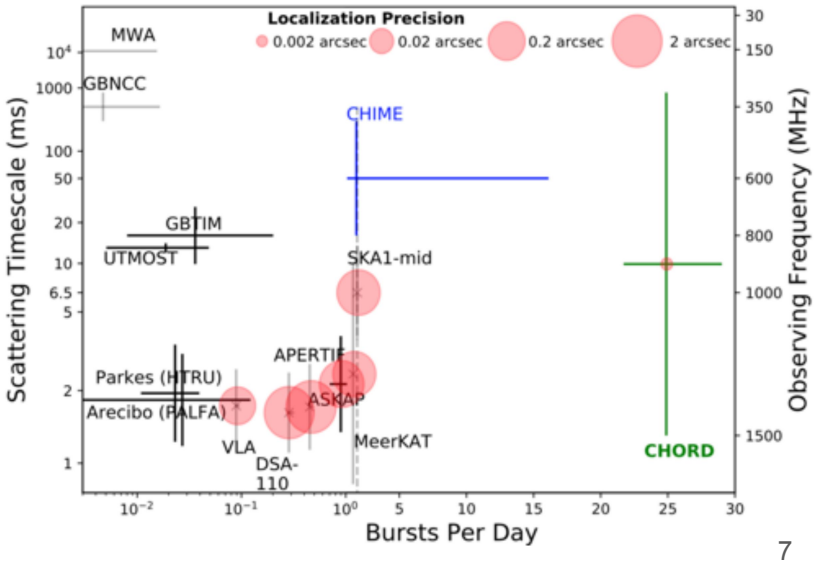
- Close-packed array of ≤1024 6m dishes
- 400-800 MHz (z=0.8–2.5)
- SKA site in Karoo Desert, South Africa
- Outrigger stations at ~1000 km baselines for FRB localization
- Construction on the first 256 dishes planned to begin within a year

- BAO/Dark Energy
- Fast Radio Bursts
- Pulsar Monitoring

CHORD: The **C**anadian **H**I **O**bservatory and **R**adio-transient **D**etector

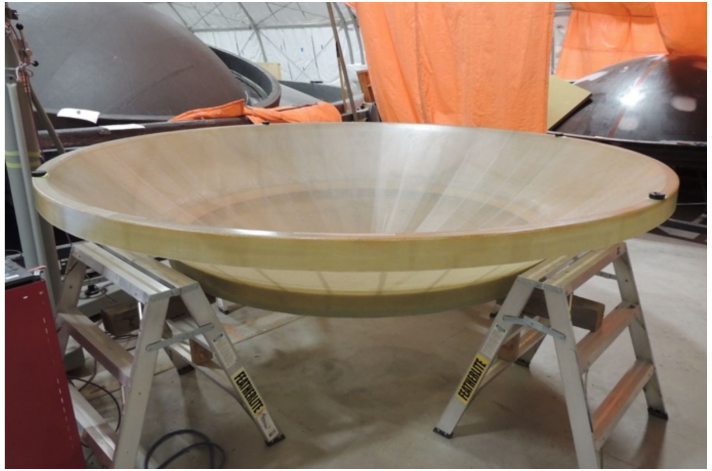
- Close-packed array of 512 6m dishes
- 300-1500 MHz (z=0–3.7)
- CHIME site at DRAO
- Bandwidth-matched outriggers at ~1000 km baselines
- Compared to CHIME:
  - 2x collecting area
  - 3x bandwidth
  - √2 lower noise

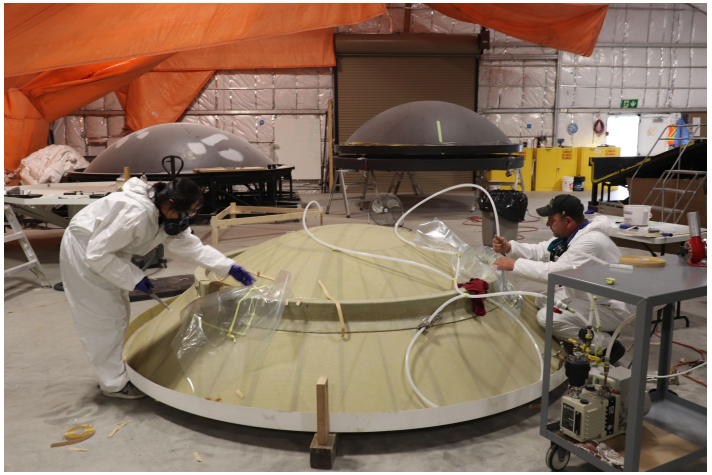
- Fast Radio Bursts
- Matter Distribution
- Fundamental Physics

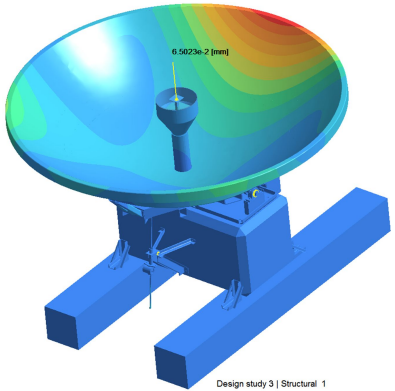


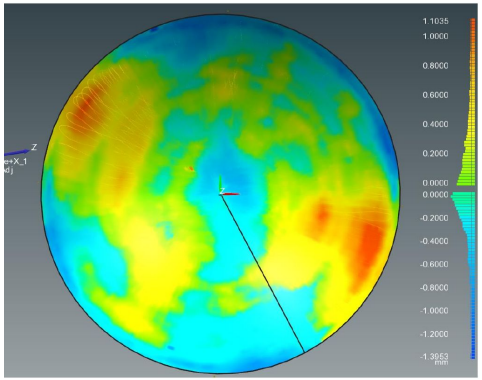
Composite Dishes

- Inexpensive and scalable
- Sub-mm surface precision ($\lesssim \lambda/1000$)
- “Deep Dish” geometry (f/0.25) reduces cross talk and ground spillover









Wideband Feed

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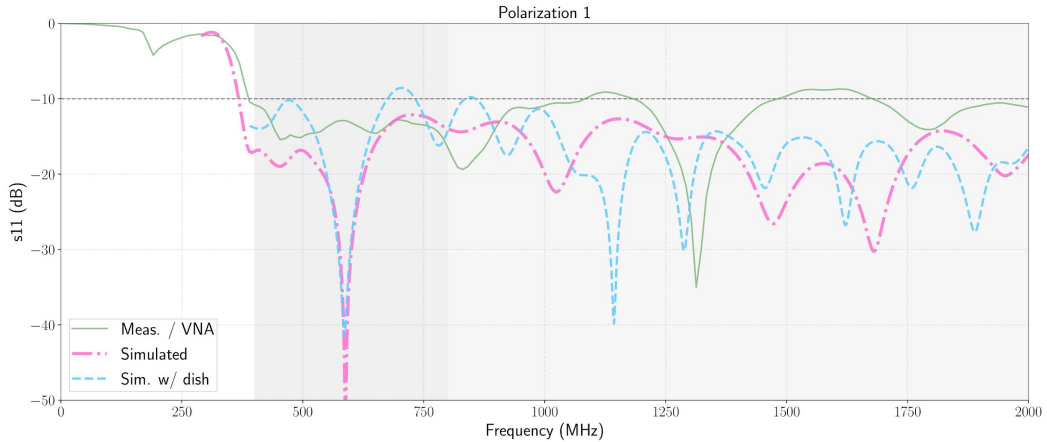
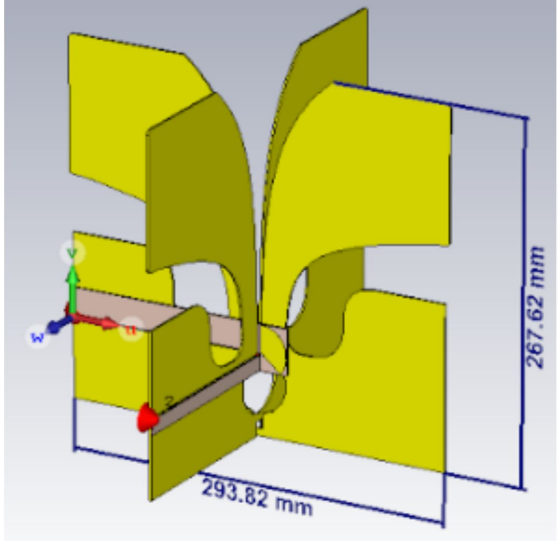
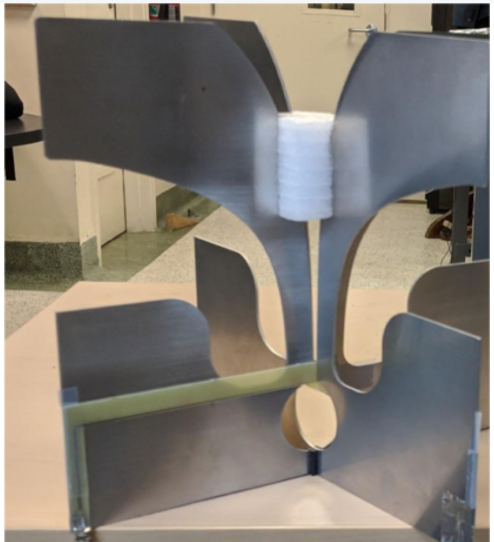
- Intrinsically broadband Vivaldi-style
- Excellent dish illumination
- $\lesssim$ -10 dB return loss 300–1500 MHz
- Laser-cut aluminum construction is precise and inexpensive

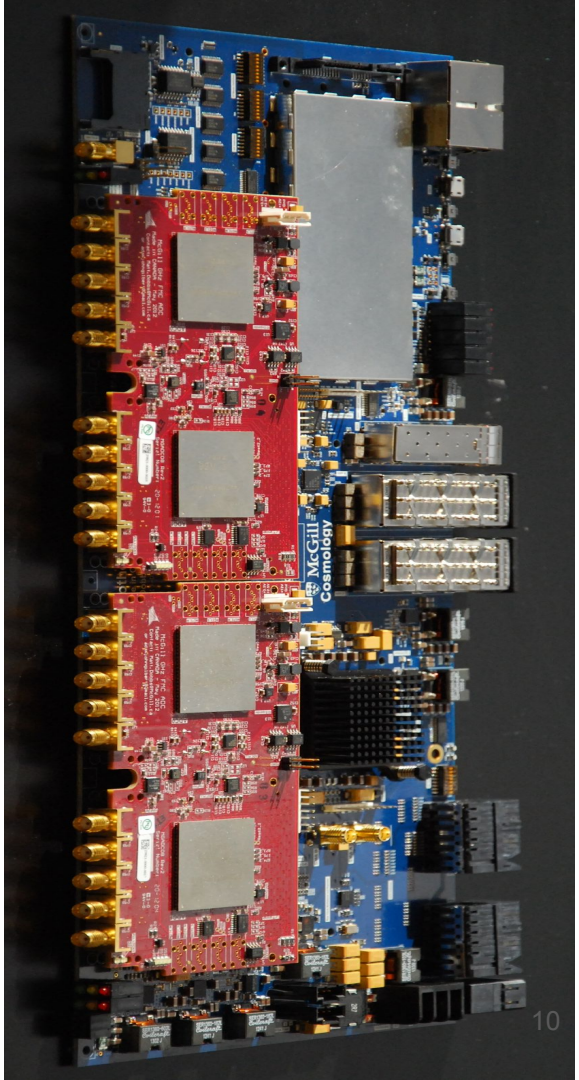






Electronic Backend

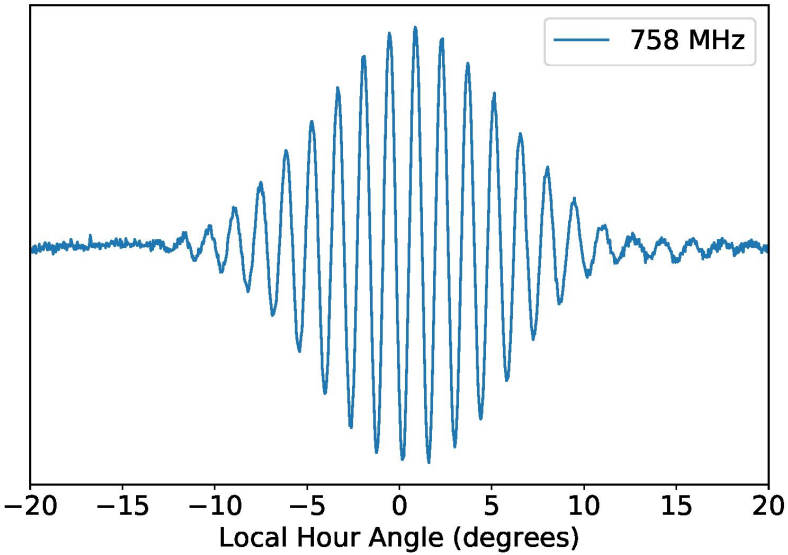
- Commercially available analog components with noise temperature of ~25K
- Signals digitized and channelized by ICE System (CHIME/HIRAX/CHORD)
- Correlation also performed in FPGA
- Testbed for firmware and software development



Dominion Radio Astrophysical Observatory

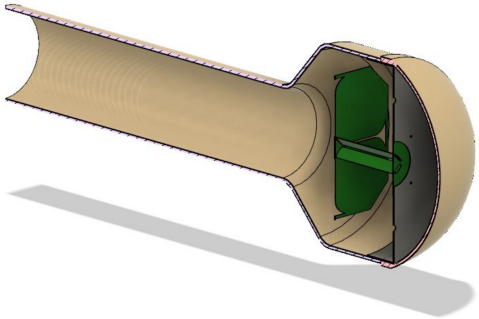
Status

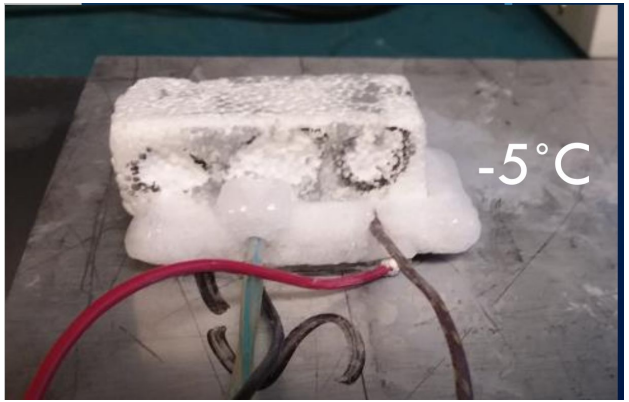
- Both dishes instrumented and on-sky
- One dish with first prototype of wideband feed
- First fringes from transit of Cygnus A on July 18, 2019
- Developing metrology for arcminute pointing precision
- Planned beam mapping with Galt 26m in the coming months

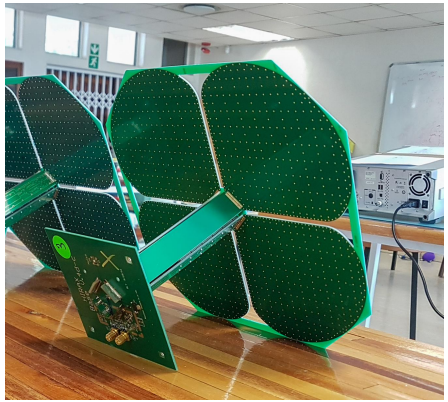


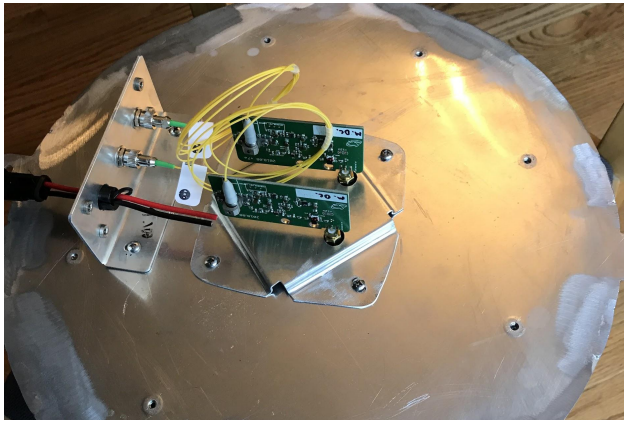
Future Technologies

- Feed Supports
- Cooled LNAs
- Fiber Optic Modules
- Active Feeds
- Dish Mounts
- Drone Mapping
- ???

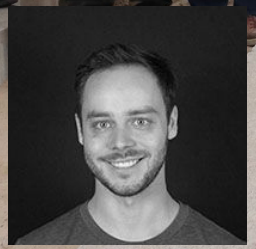








D3A Team



D3A Team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