International Centre for Radio Astronomy Research

The University of Western Australia
Achieving International Excellence

Curtin University of Technology

ICRAR is a partnership between The University of Western Australia and Curtin University of Technology

A Wideband, Multibeam Spectrometer for Parkes

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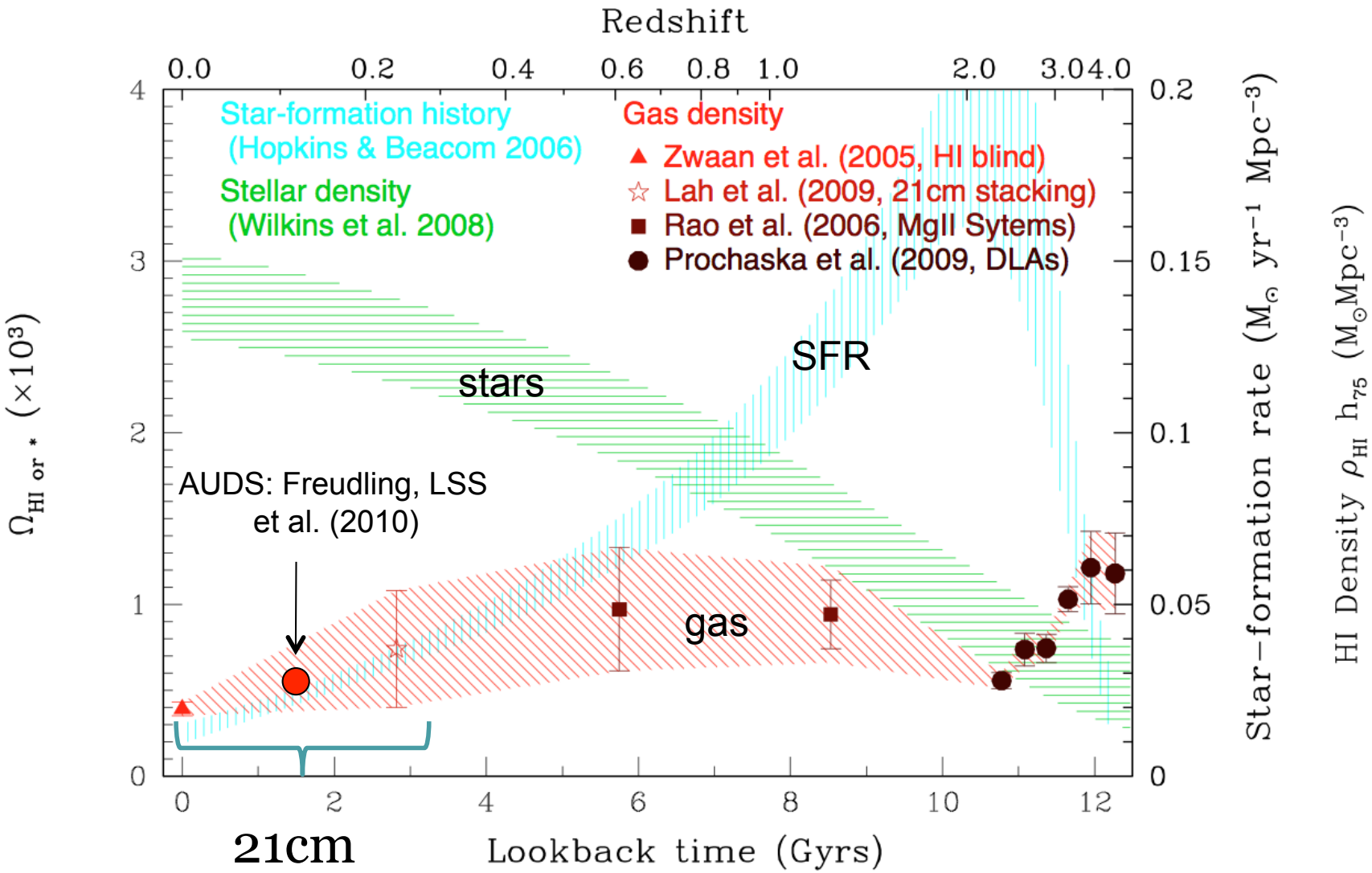
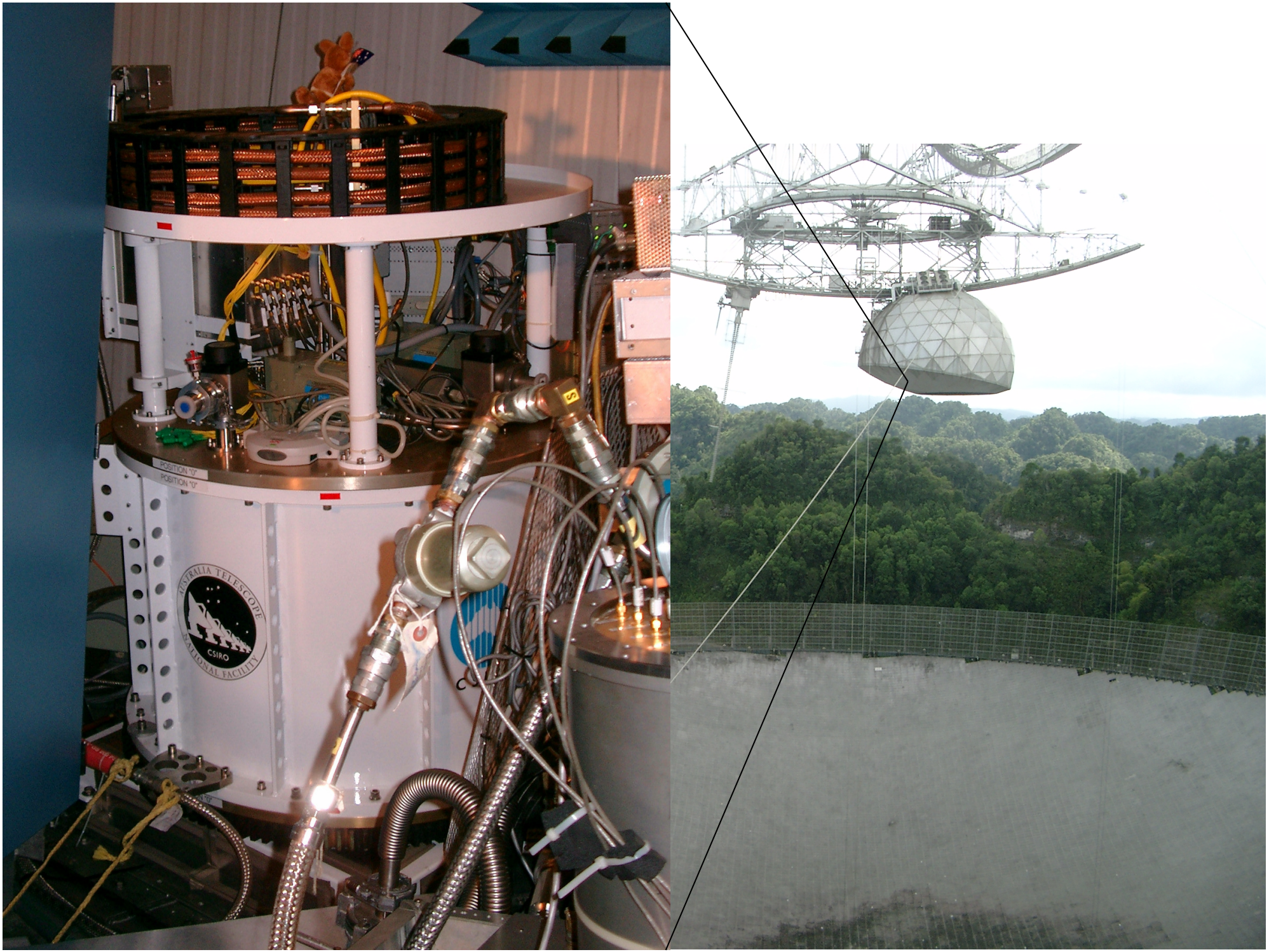
Outline

- Gas evolution in galaxies
- Proposal for a wideband multibeam spectrometer at Parkes
- RFI

Galaxy Evolution



Simon Driver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AUSTRALIA TELESCOPE
CSIRO
NATIONAL FACILITY

- Cosmic variance (small volumes)
- S/N ratio (long integrations)
- Radio Frequency Interference

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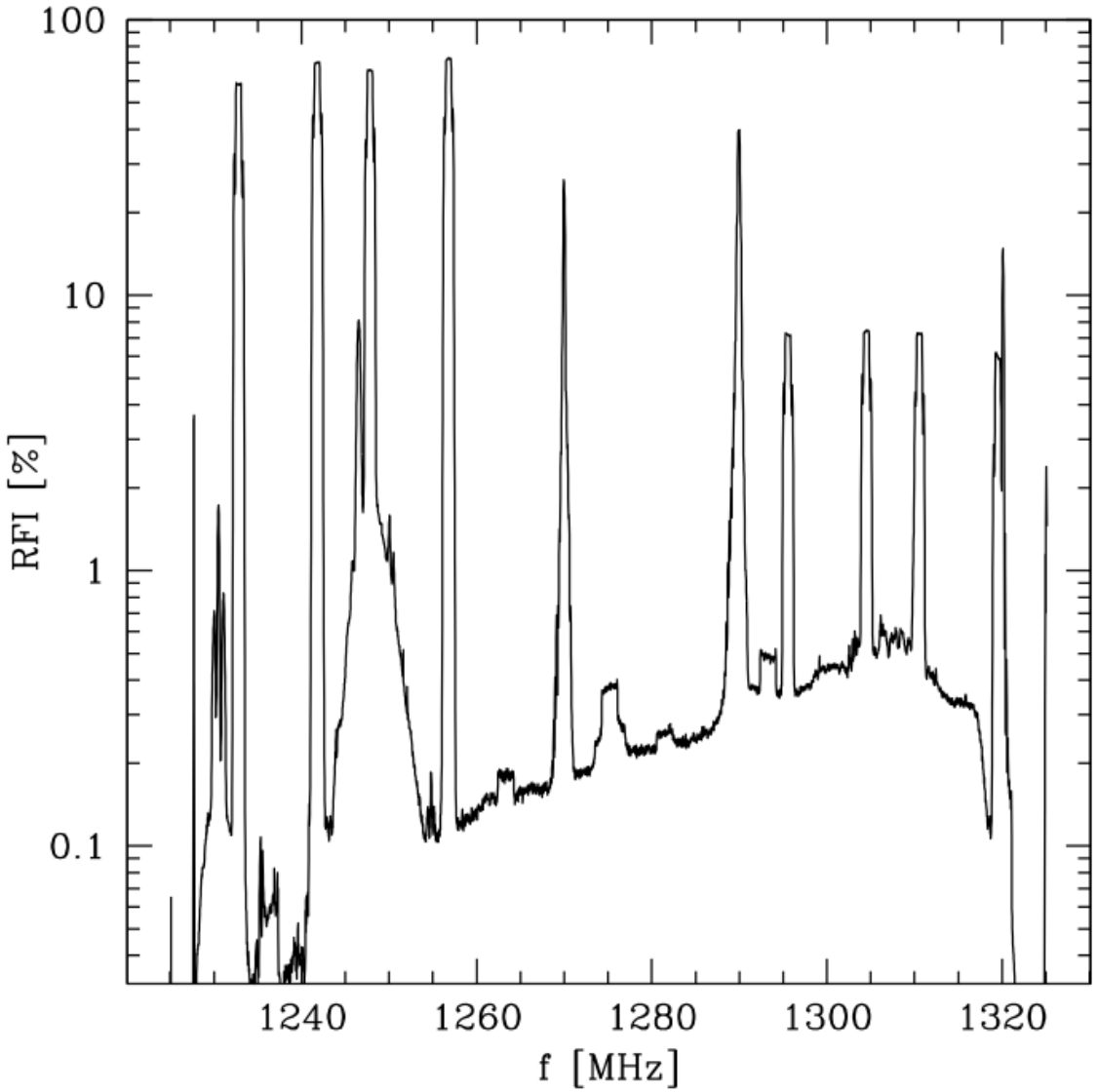
RFI occupancy @ Arecibo



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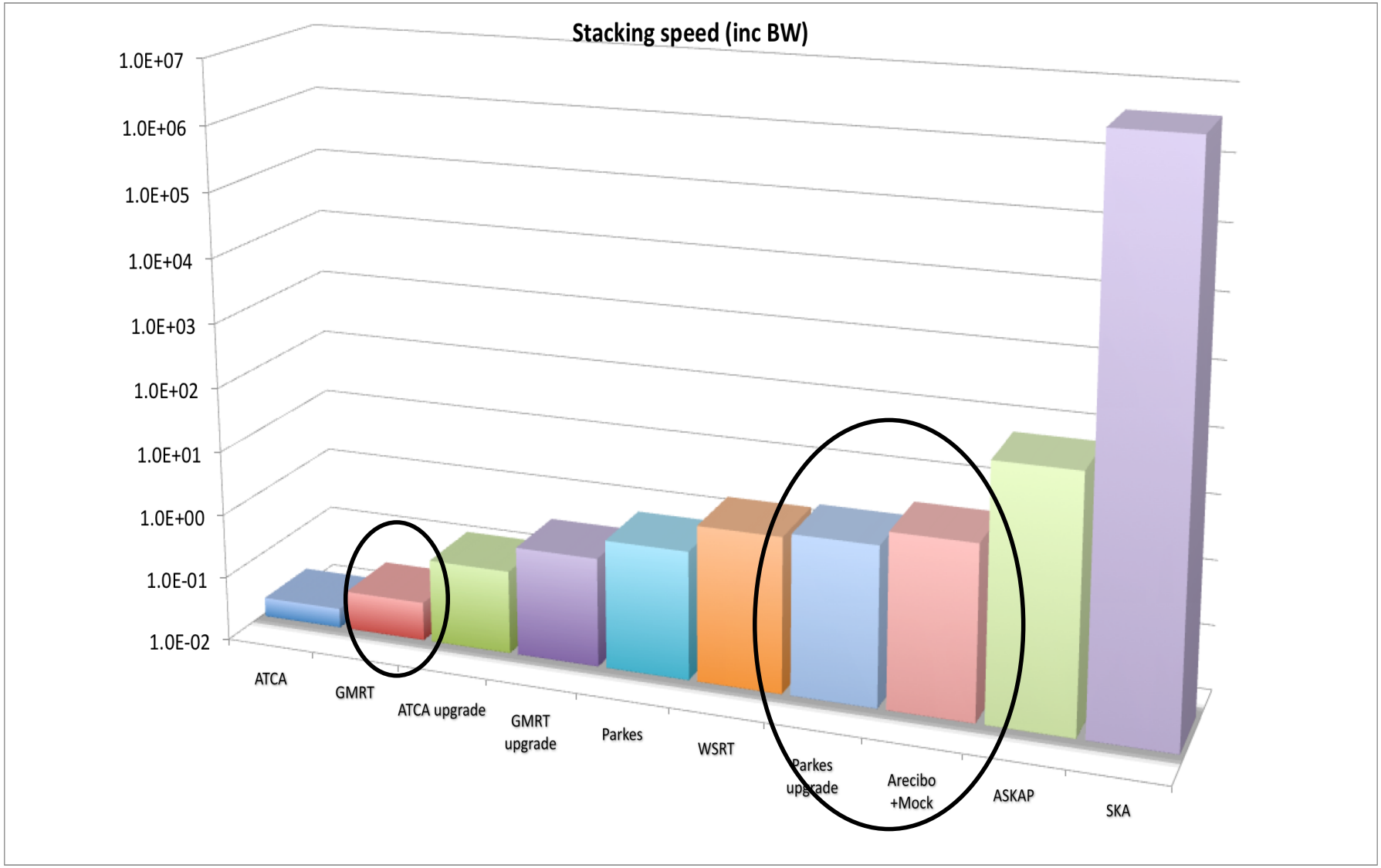
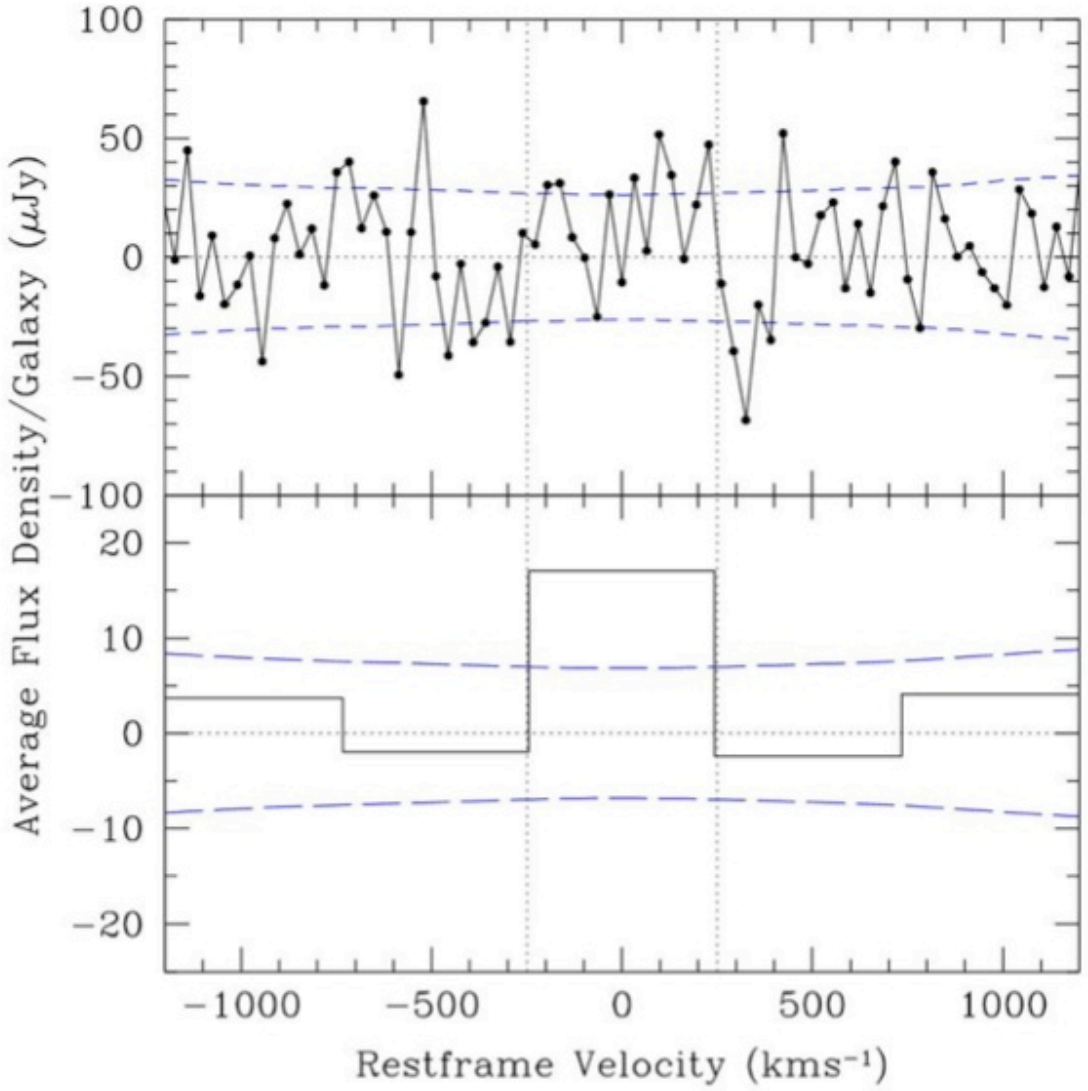
Stacking Speed



121 galaxy GMRT stack: galaxies at z=0.24

Lah et al. (2007)



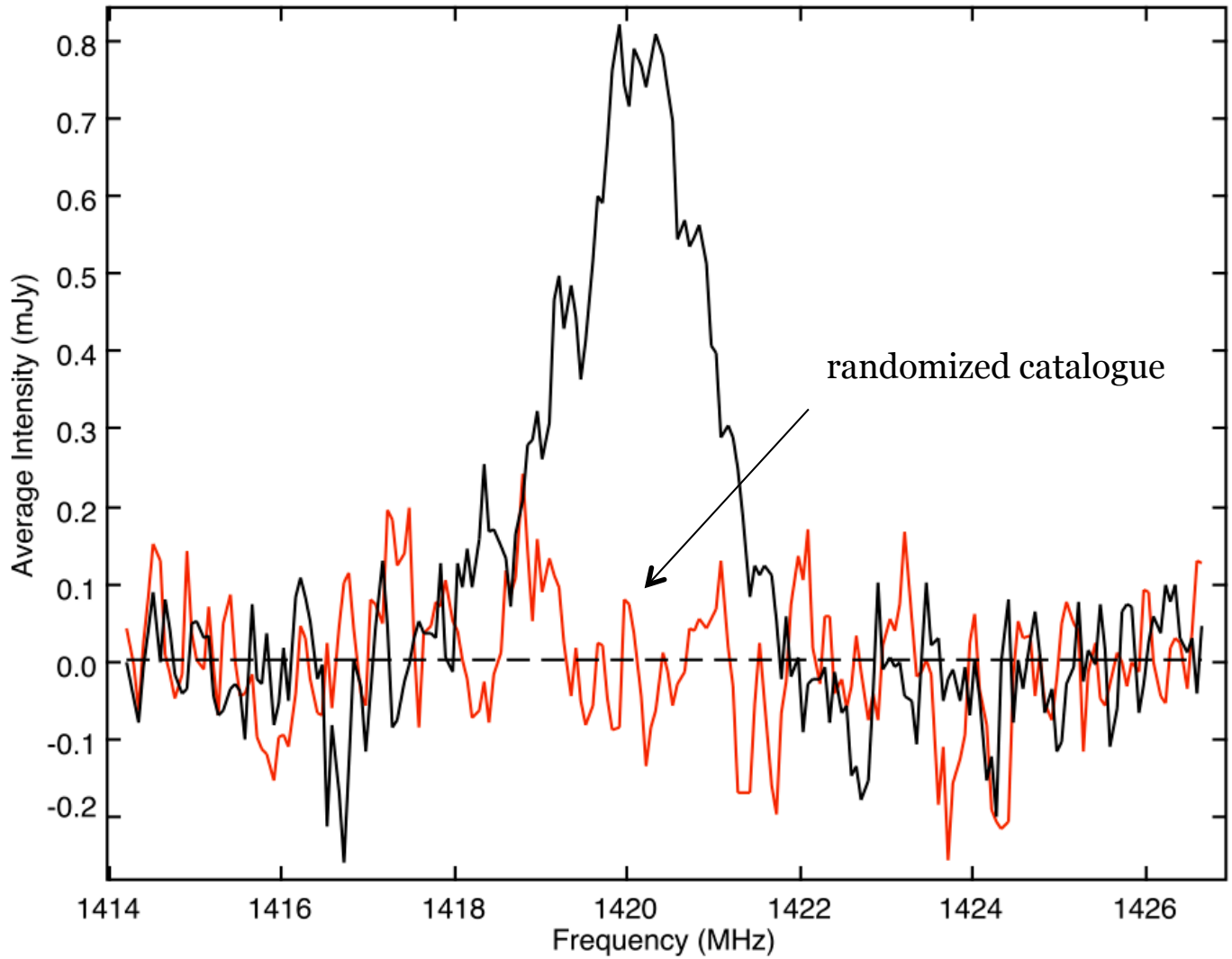
neutral hydrogen gas measurement

using 121 redshifts

$M_{HI} = (2.26 \pm 0.90) \times 10^9 M_\odot$

0.36 ± 0.14 M*

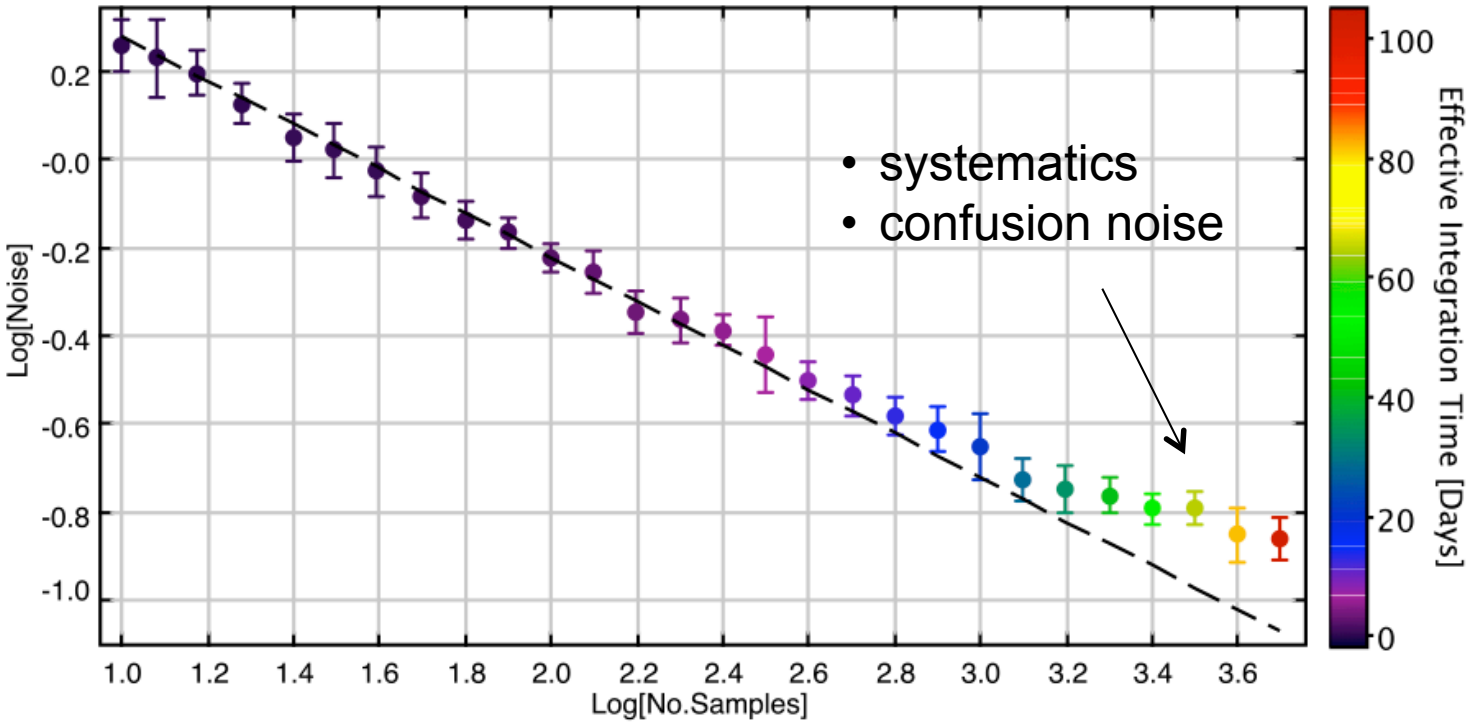
A stacked HI signal at z=0.1 with Parkes (GAMA9 field; Delhaize et al.)



Deep HI integrations by stacking

Delhaize

- Noise decreases as $\sqrt{t}$ for up to 60 days!



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Issues with multibeam correlator

- Bandwidth of 64 MHz corresponds to only $\Delta z=0.04$
- Spectral resolution of 0.1 MHz too coarse
- Dynamic range
- Robustness against RFI

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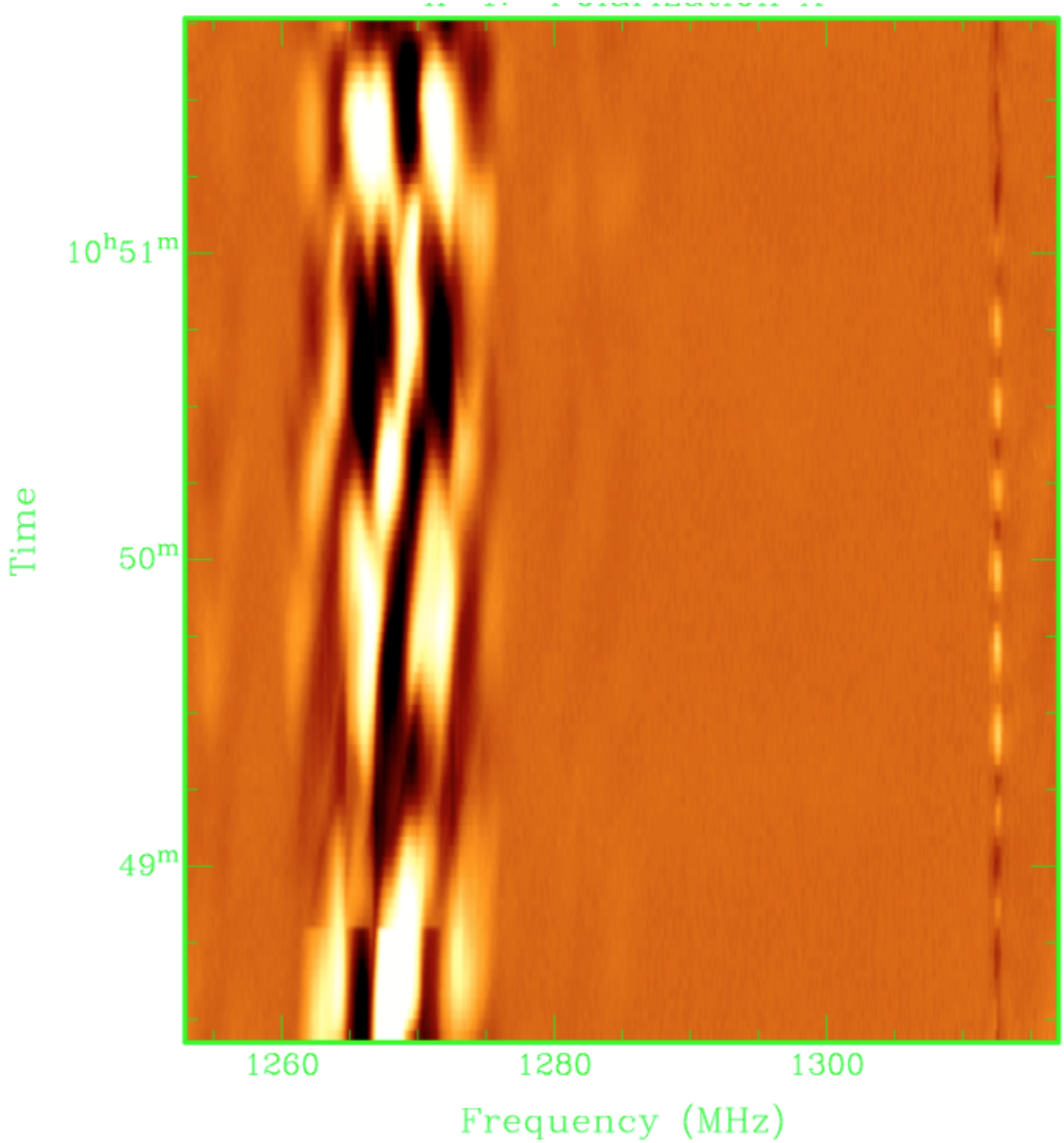
1270MHz RFI @ Parkes



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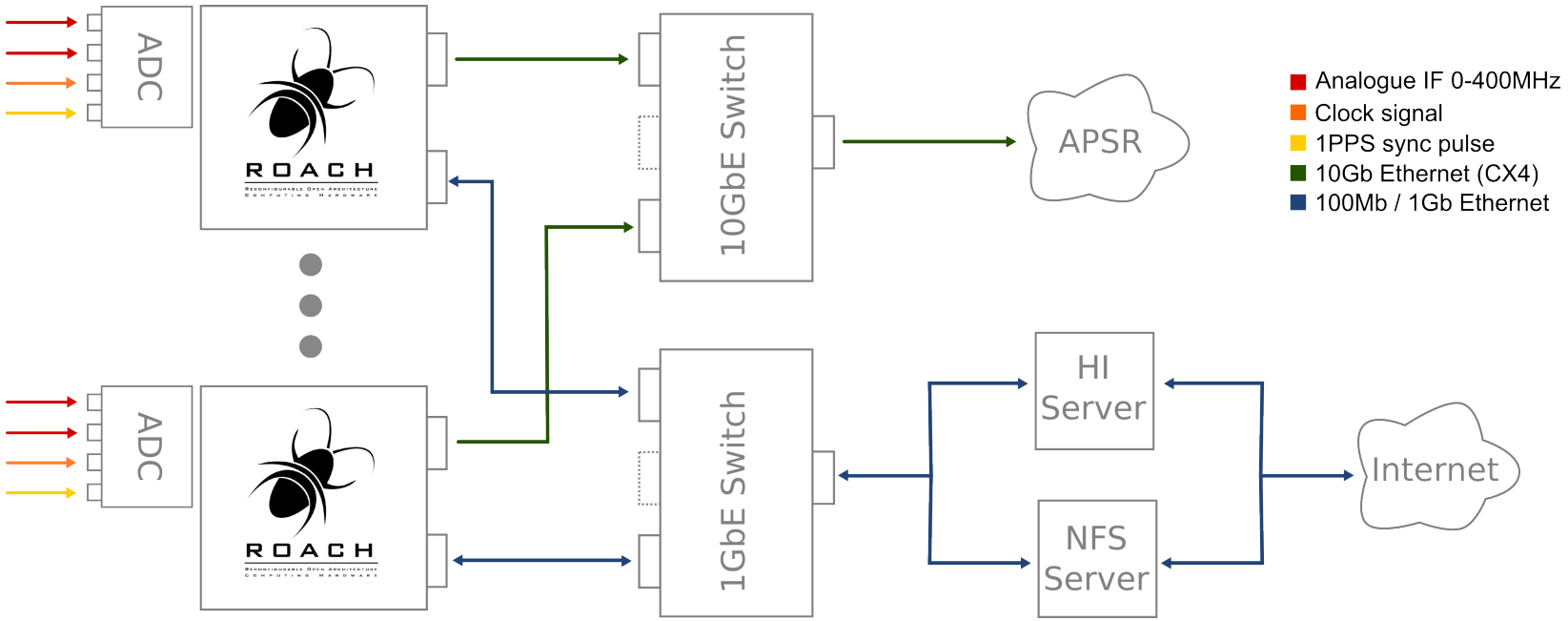
Proposal

- New multibeam spectrometer/filterbank
- Bandwidth of 200 MHz, or greater (~500 MHz possible, but available 21cm redshifted band is only 1220-1420 MHz).
- Multi-bit for better efficiency and dynamic range
- RFI suppression:
  - polyphase filters
  - bit-locking?
  - reference beam adaptive nulling?
  - beam cross-correlation?

ROACH solution

- Upgrade pulsar iBOBs to ROACH boards with Xilinx Vertex 5 FPGAs.
- ROACH=Reconfigurable Open Architecture Computer Hardware from CASPER (=Collaboration for Astronomy Signal Processing and Electronics Research).



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- **Hardware costs:**
  - ROACH boards (x16): $58k
  - FPGAs (x16): nil
  - Digitisers (x3): $5k
  - Rack, cables $7k
  - Computers, switch: $8k

  SUB-TOTAL **$78k**

Parkes Unified Backend (PUB?)

- Also add following pulsar costs:
  - GPU servers (x8): $67k (Matthew's talk)
  - 10GbE switch (x2): $32k

  SUB-TOTAL: $99k

  TOTAL: $177k

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ROACH advantages

- Cheap
- Well-tested (bugs known)
- Configurable
- Existing code base

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LIEF proposal

- Joint ICRAR/Swinburne/CASS/Oxford proposal hopefully to be submitted *today* to cover unified spectrometer hardware
- Includes $80k University cash + $135k in-kind support from CASS+Universities
- Includes 1 FTE engineer
- Timescale: end-2011?

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Possible ATUC discussion

- Support from ATUC? (whether or not LIEF successful)
- Other Parkes users (H_2O, methanol, continuum, polarimetry...)?
- ASKAP 32-beam correlator is an alternative solution:
  - similar capabilities (eg 300 MHz bandwidth)
  - see Carrad/Leach talk

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Summary

- Wideband, multibeam upgrade has benefits for z>0 HI observations:
  - Efficiency (8-bit)
  - Speed (3x available bandwidth)
  - Dynamic range
  - Robustness against RFI
- Cost-effective
- RFI adaptive cancellation possibilities to be explored
- ROACH/ASKAP technologies combine bandwidth, spectral resolution and dump rate
  - Unified Parkes spectrometer/filterbank