National Aeronautics and Space Administration

A Flexible Radio-Frequency Readout for Multiplexed Submillimeter-Wave Detectors

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Program: Strategic

Project Objective:

Sub-mm Detectors such as KIDs, TKIDs, and QCDs use high-Q radio-frequency resonances to accomplish dense frequency-domain multiplexing. However, progress in development of these detectors has been limited by the lack of availability of flexible warm readout electronics. Traditional systems use ROACH boards and require FPGA firmware expertise to modify. As an alternative, we designed a system that:

- Uses commercially available off-the-shelf (COTS) components
- Can be re-configured strictly with universally-used software languages (C++ & Python)
- Provides ≥150 MHz bandwidth

FY18/19 Results:

- Continued maturation of system based on Ettus Universal Software Radio Peripheral (USRP) – see Figure 1
- Demonstration of standard operating modes (Figure 2): 1) VNA scan, 2) multitone readout, 3) flexible signal generation such as chirp, 4) spectrum analyzer
- Implementation and test of new modes: 1) event-triggered data acquisition, 2) improved polyphase filterbank
- Demonstration with alternative COTS software radio hardware (from Per Vices)
- Release of opensource code on Github

Benefits to NASA and JPL (or significance of results):

- Readout is enabling the development of TKIDs and QCDs
- Readout is of interest to ground-based pathfinder telescopes:
  - BICEP Array
  - SuperSpec camera on LMT
  - TIME Spectrometer on Kitt Peak 12m telescope
- Readout power consumption limits the scale of flight missions
  - Results from on-going research on new algorithms may alleviate this concern.
- Readout development will assist future flight projects:
  - PICO (CMB Inflation Probe)
  - Galaxy Explorer Probe
  - SAFARI/SPICA
  - Origins (Far-IR Surveyor)

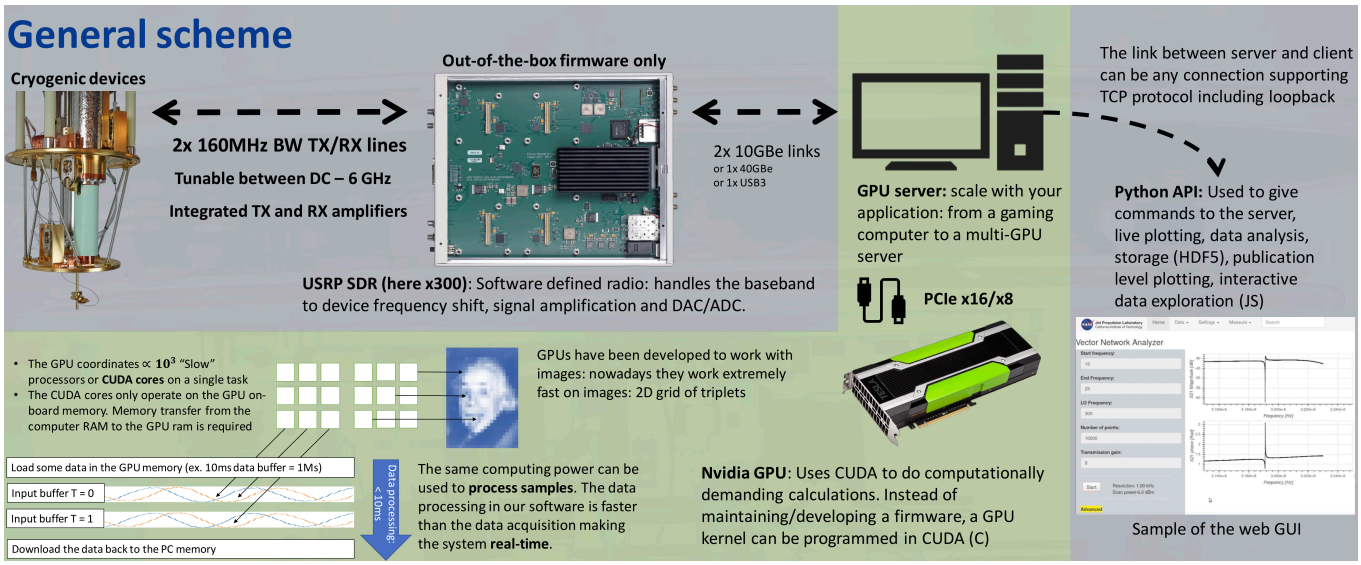

Fig. 1: Readout system architecture and basic features.

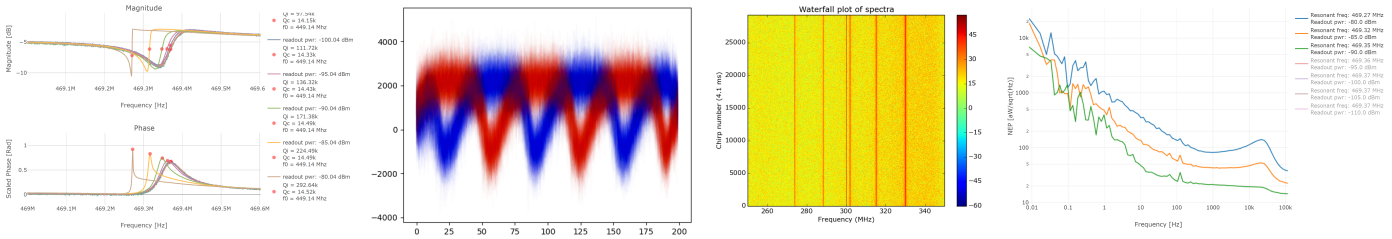

Fig. 2: Example output visualizations from standard operating modes. *Left*: Multiple VNA scans taken varying the readout power. After each scan, the resonator is fitted and the best readout point (red dot) is determined. *Left-center*: periodic response of QCD under bias ramp, for even (blue) and odd (red) number of quasiparticles in island. *Right-center*: Time record of spectra resulting from chirp readout, showing the response from 6 resonators. *Right*: Example noise plots from spectrum analyzer mode.

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Publication:

L. Minutolo, B. Steinbach, A. Wandui, & R. O'Brient, *IEEE Transactions on Applied Superconductivity*, 29:2912027 (2019) – "A Flexible GPU-Accelerated Radio-frequency Readout for Superconducting Detectors"

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Poster No. RPC-012