Outline: Detector and Readout

Specifications

Timeline for developing technology options

Cost

Downselects

For polarimeters, cryogenic mux, and readout electronics

- Homogenous downselect?
- Different choices by frequency?
- Different by site?
- Different by aperture?

Detector technology options

- Beam forming
- On-chip signal processing (filters, polarization, etc.)
- Multichroic filters
- Sensors: TES, MKID, (HEMT?)
- Readout. Mature: TDM, FDM. High MUX factor: microwave SQUID, MKID
- How important is integration of mux elements on the chip?
- Room-temperature electronics

Specifications

What are the detector specifications required for CMB-S4?

Answers will be driven by science, foregrounds, observing strategies and telescope design – beyond scope of this session.

Address a few broad questions:

- How much do detector specs differ for different telescope platforms (aperture, optical configuration)?
- Are small apertures well matched to mono-chromatic pixel architectures and all reflective optics well matched to wider bandwidth pixel architectures?
- Is there a compelling science case for pixels with more than 2 frequencies, given the increased risk and efficiency cost?
- What do we need to specify bandwidth, beam symmetry, etc.?

Timeline

CMB-S4 timeline is subject to evolution

Kathy Turner has announced a “small funding wedge” in 2018. The DOE is engaging.

It seems likely that significant funding won’t happen before 2020 from the DOE.

It makes sense to develop technology options *at least* until project funds turn on, and maybe longer.

- Reduces overall CMB-S4 cost
- Reduces CMB-S4 complexity
- Increases capabilities

What is the appropriate timescale for the development of technology options?

Cost

For detectors, cryogenic multiplexers, readout electronics, cost is a driver for CMB-S4. What are our cost targets for *production* of detector parts?

- O($100 / pixel) is too much
- O($10 / pixel) is good
- O($1 / pixel) is way past the point of diminishing returns to CMB-S4

Mass testing/characterization of detectors is also a critical cost driver.

What is the appropriate balance of investment early on to reduce production costs, system complexity, and test/characterization cost?

Downselects

For both detectors and MUX:

Does CMB-S4 use the same sensors, band-definition filters, beam-forming elements, cryogenic multiplexers, and readout electronics on all arrays?

- Political driver from DOE culture: downselect to one technology option.
- Political driver from an energetic and diverse community: use many technology options.
- Can we find the right balance of
    1. Science
    2. Risk
    3. Cost
    4. Politics

Totally homogeneous arrays?
Different choices by frequency?
Different by site?
Different by aperture?

Polarimeter technology options

Sensors
- TES
- MKID
- HEMT

Array architecture / beam forming
- Lenselets
- Feedhorns
- Phased planar antenna

Bandpass definition
- Multichroic? How strong is the driver for more than two frequencies?

Advantages / disadvantages
- Sensitivity – photon noise dominated + NET (efficiency)
- Fabrication complexity, yield, uniformity
- Optical efficiency, crosstalk
- Maturity

How can the community coordinate? What will the decision process look like?

Cryogenic multiplexer options

Mature MHz multiplexers
- TDM
- FDM

Emerging options
- MKID
- Microwave SQUID
- Parametric amplifier + GHz resonator
- KPUP + MHz FDM

How valuable is it to integrate multiplexing elements on the detector wafer?
- Significant reduction in integration complexity
- Necessary, or advantageous?

+ Room-temperature electronics
- Mature Canadian: TDM + FDM
- Immature American: ROACH, GPU, LCLS, etc.

Advantages / disadvantages
- Detector-limited noise (vs. preamp, DAC, digitizer noise)
- Cost
- Reliability
- Scalability

How can the community coordinate? What will the decision process look like?