“Implications for module design, testing, integration, and calibration”

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Detector Layout Workshop

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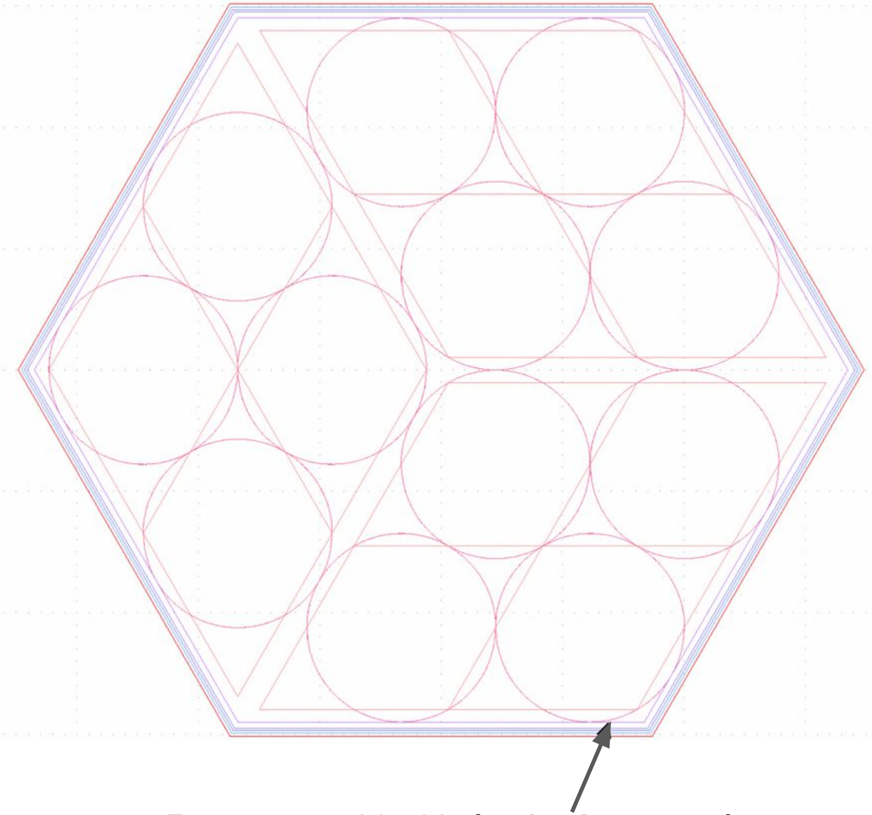
Module Design Impacts

- **Dark SQUIDs**
  - No impact on module design if small in number
- **Dark TESes** - Two possible locations:
  - Features ***inside the hexagon*** inscribed by the pixels has no impact on module design, provided impact on readout and number of bondpads is modest.
  - Features that extend ***outside the hexagon***, impact the module sizes, border inefficiency, and possibly SAT wafer pitch.
- **Border Efficiency:**
  - Width of border deadspace is fixed by wiring layout and bondpads. Additional dark features directly add to border deadspace, if they are outside the **active horn area** optical footprint.



Features outside this **(active horn area) hexagon** impact module design

Testing Use Cases for Dark TESs & SQUIDs

- **Optical Response:**
  - Measure P-optical on light pixels to estimate loading (e.g., SPT-3G).
  - Correct for thermal gradients in lab optical efficiency measurements with cold load (e.g., SO)
  - Characterize coupling mechanisms to TES (e.g., through OMT vs direct to TES vs cross-talk from other pixels) (e.g., SPTpol, BK, SPT-3G)
- **Noise:**
  - Characterize noise sources (e.g., phonon, readout) in the absence of photon noise
  - Combination of dark TESs and SQUIDs can separate generic source of pickup in the readout, on the TES island, or in the RF circuit (e.g., BICEP/Keck, SPT-3G)
  - Maps formed with data from dark SQUIDs test for magnetic pickup (e.g., BICEP/Keck)
- **Thermal:**
  - Probe thermal fluctuations and gradidents at the wafer with high sensitivity (e.g., ACTpol (flat-fielding), BICEP/Keck, SPT-3G (for debugging microphonic heating))
- See L. Moncelsi slides from Mar-2021 S4 Collab Meeting
- However, some of the above use cases are not singularly probed by dark TES or SQUIDs, and not simple to connect use cases to any explicit requirement on the number of Darks.

What requirements drive Darks?

- **Science analyses:**
  - No CMB science analysis has ever used darks, not required for any science analysis.
  - However, as described on last slide, they have proved useful as a sanity check at various stages during I&C or during observations.
- **Testing requirements:**
  - Key requirements to accept a detector module during production will likely be:
    - Wafer NET sensitivity (determined from noise and optical efficiency)
    - Median Optical efficiency
    - Median band-passes (frequency response)
  - Darks can help verify we are interpreting the measurements correctly (e.g., noise is dominated by photon noise; optical efficiency and detector response are dominated by direct coupling thru OMT)
- **MAT Recommendations:**
  - No use requires more than O(10) dark detectors or SQUIDs per wafer, but scattering them evenly around wafer would be beneficial (e.g., thermal gradients)
  - Keep dark pixels inside the optically active footprint of the detector wafer to minimize impact on border efficiency and module design
  - Include darks with both: a) “cut feedline” (sensitive to island pickup) and b) “no resistor” (sensitive to thermal and some RFI effects)