Parallel plate capacitor TiN KID array development for the Balloon Experiment for Galactic Infrared Science

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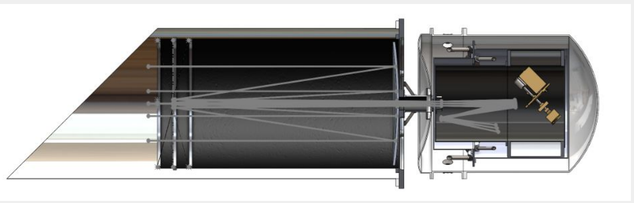
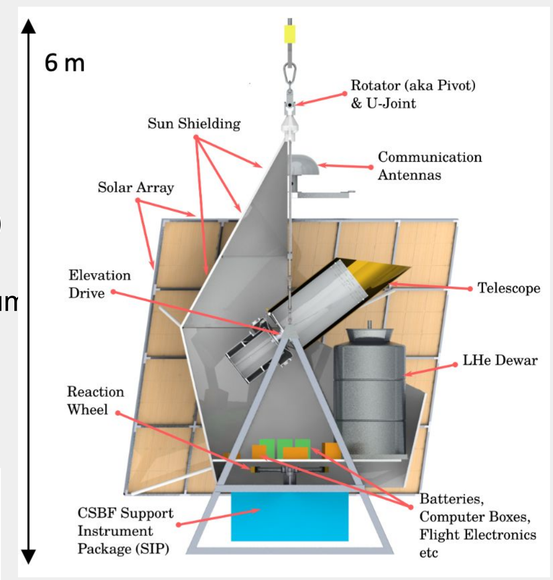
Notional design of the Balloon Experiment for Galactic Infrared Science

- Balloon Experiment for Galactic Infrared Science (BEGINS)
  - Radiation field and dust properties in harsh star-formation environments
- Telescope
  - 0.5 m Cassegrain, aluminum mirrors
  - 12 arcmin angular resolution at 25 μm
  - 0.2° x 0.1° diffraction limited field of view
- Cryostat
  - Liquid He backed 300 mK ^{4}He/^{3}He cooler
  - ~ 2,000 kinetic inductance detectors (KIDs)
  - R = λ/Δλ ~ 7 for λ = 25 – 65 μm
  - R = λ/Δλ ~ 3 – 6 for λ = 70, 100, 160, 250 μm
- Targeted Flights
  - Test flight: Fort Sumner, NM
  - Science flight: Esrange, Sweden



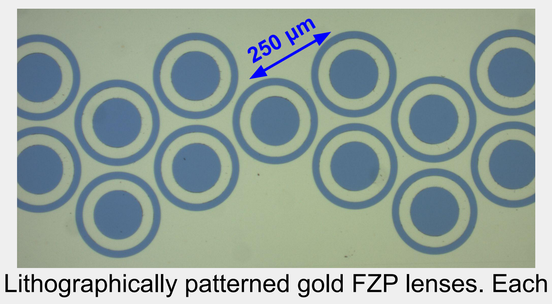
Conceptual 50-cm Cassegrain telescope with baffle tube and instrument cryostat.



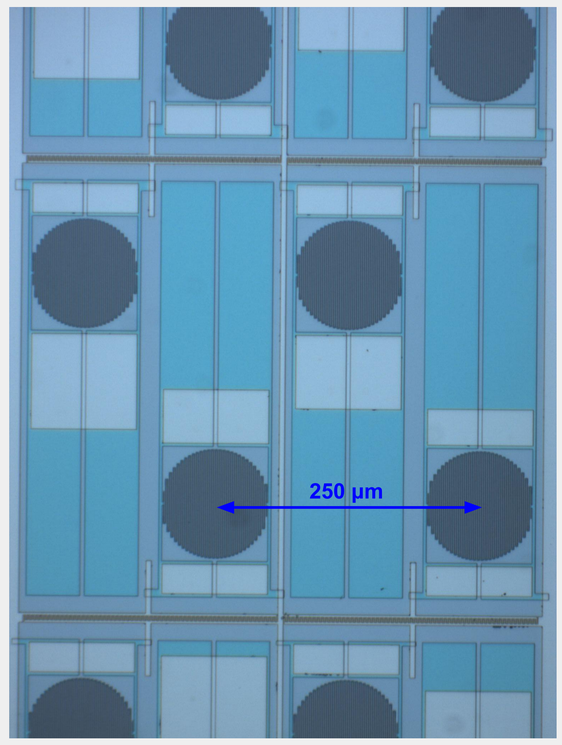
Conceptual BEGINS gondola from StarSpec Technologies with major components labeled.

Parallel Plate Capacitor Kinetic Inductance Detectors

- Titanium Nitride KIDs [2]
  - Meandered TiN inductor/absorber
- Parallel Plate Capacitor (PPC) [3]
  - Reduce two-level system noise
  - Reduce pixel footprint
  - Reduce EM field crosstalk
- Fresnel zone plate (FZP) lenses
  - For test chips
- Micromachined silicon microlenses
  - For flight arrays
- Continuously linear variable filters [4]
  - Enables 25 – 65 μm SED mapping



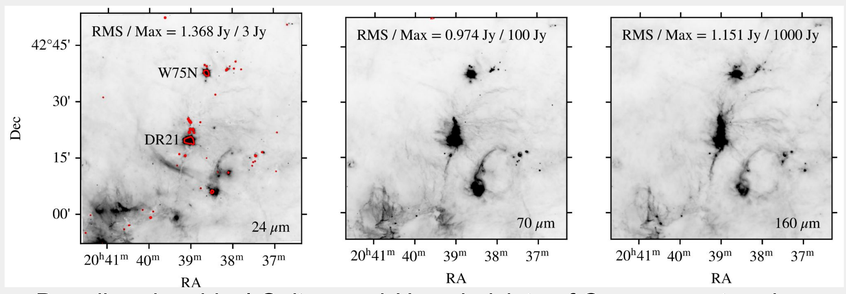
Lithographically patterned gold FZP lenses. Each set of rings comprises a FPZ lens and is aligned to a KID absorber on the chip's backside.



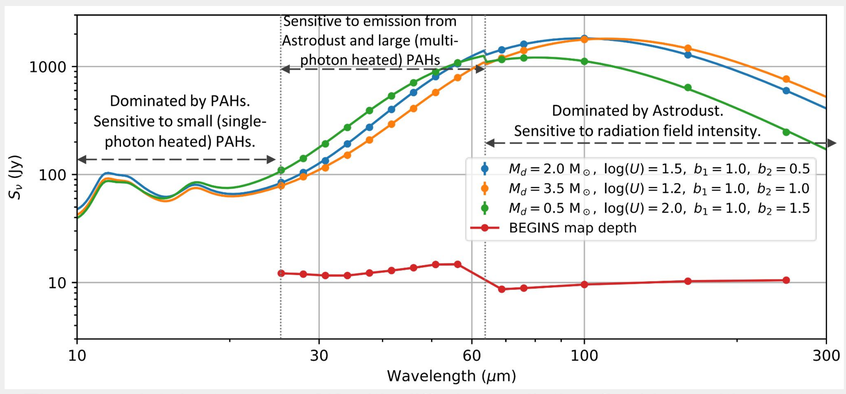
PPC KIDs. A meandered TiN inductor comprises the absorber. Unique capacitors define the unique resonant frequency of each detector.

Measuring dust + polycyclic aromatic hydrocarbons (PAHs) with BEGINS

- Spectral energy distributions (SEDs)
  - Cygnus complex
  - One square degree
  - Centered on DR21
- Measure
  - Radiation field intensity
  - Dust column density
  - Relative abundance of single- vs multi- photon heated PAHs
- Constrain interstellar dust evolution
- Test current dust emission models
- Probe grain distribution in a rich variety of star-formation environments



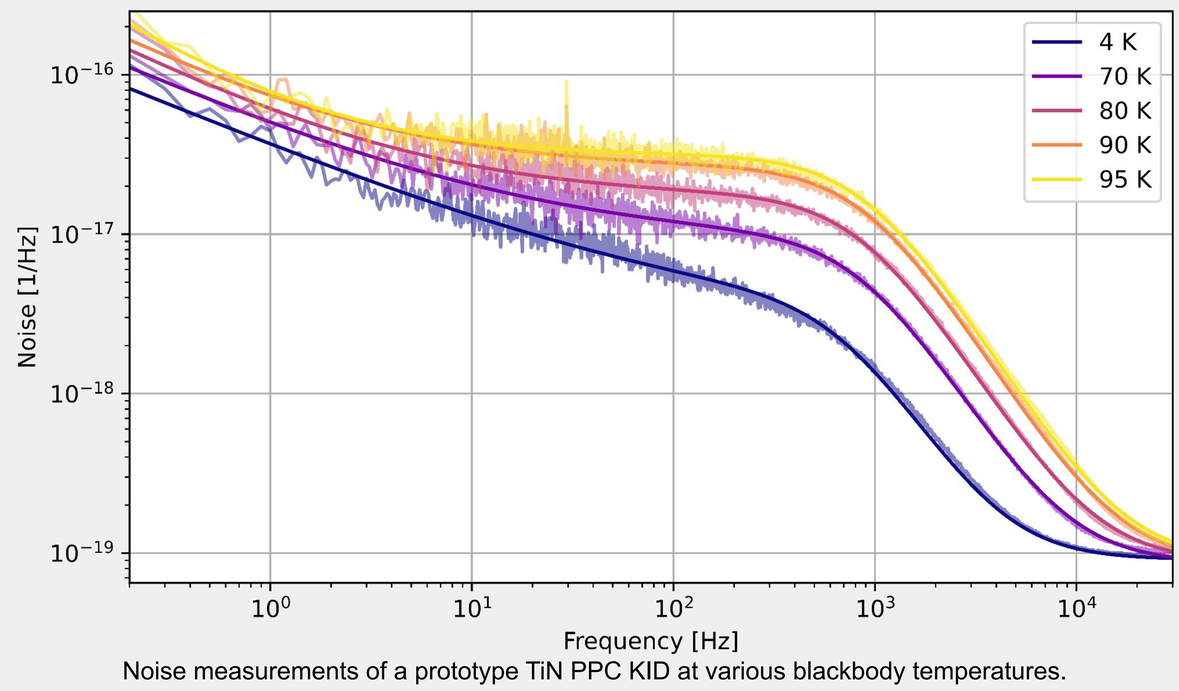
Broadband archival *Spitzer* and *Herschel* data of Cygnus, centered on DR21. BEGINS will map SEDs in this region with high SNR.



Three model dust spectra [1] with differing radiation field intensities, total dust masses, and relative PAH abundances. Expected BEGINs measurements will distinguish these spectra.

PPC TiN KID Noise Performance

- Array yield 180/192 ~ 94%
- Noise at target optical loadings
  - Cryogenic Blackbody
  - 30 μm bandpass filter
- Typical resonator freqs: 180 – 560 MHz
- NEP ~ 2 x 10^{-16} W/sqrt(Hz)
  - Blackbody at 95 K (~2 pW loading)
- Q_i ~ 65,000, Q_c ~ 34,000



Noise measurements of a prototype TiN PPC KID at various blackbody temperatures.

Conclusions and Next Steps

- Instrumentation development for BEGINS
  - TiN parallel plate capacitor KIDs
    - Calibrated blackbody measurements and NEP calculations coming soon
    - PPC TLS and crosstalk characterization coming soon
  - Optical coupling
    - Fresnel zone plate lenses work prototype KID measurements
    - 3D silicon micromachined microlens array development underway
  - Silicon-based continuously linear variable filters
    - Fixed bandpass filters working well (see poster [4])
    - Linear variable development in progress

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References

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