FERMILAB-POSTER-24-0234-STUDENT

Refinement and Modeling of a Blackbody-Based Calibration Method in the InfraBREAD Detector

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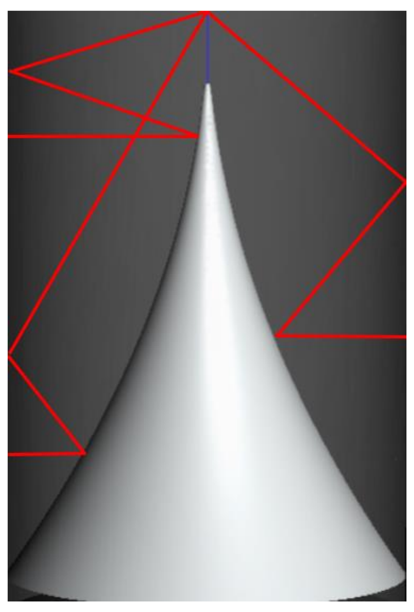
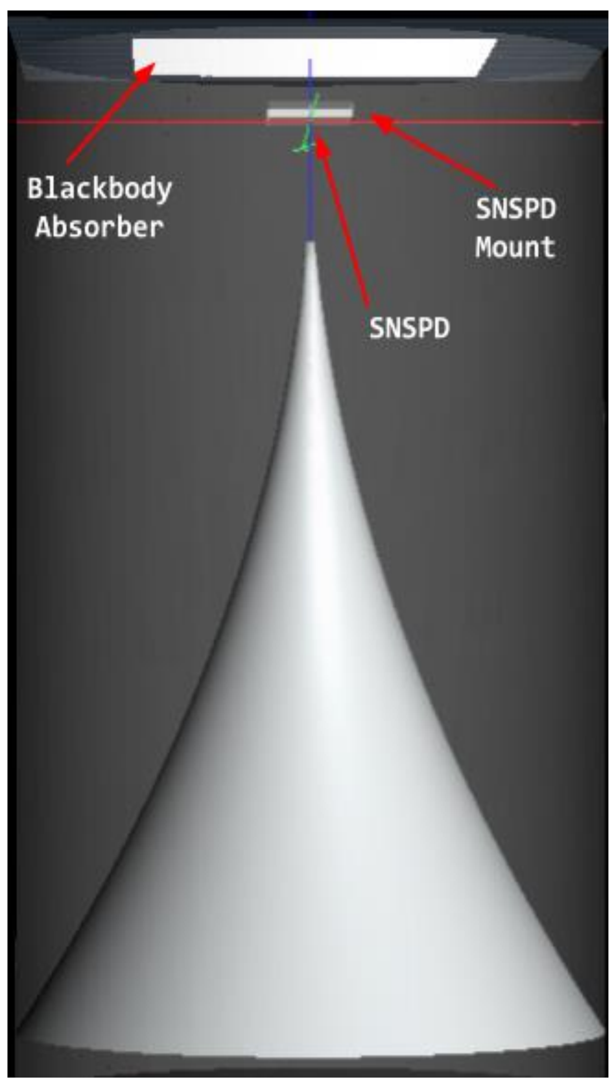
Axions and How BREAD Detects Them

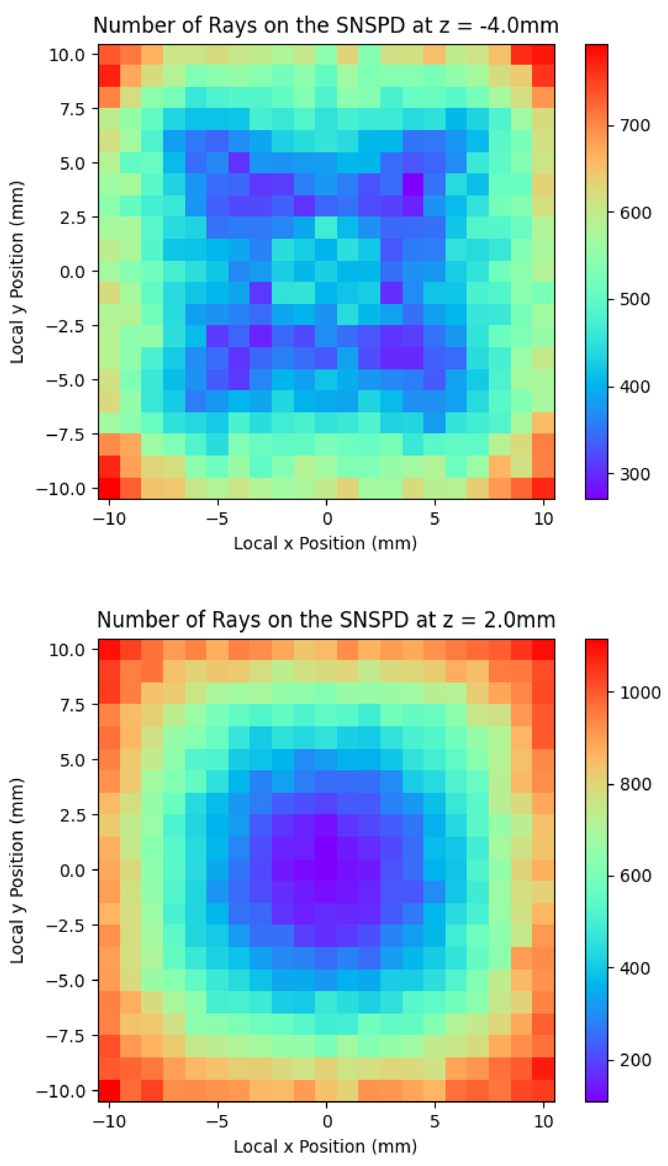
- The axion is a hypothetical particle first proposed in the 1970s to resolve the strong CP problem[1]
- Due to their properties, axion-like particles are a well-motivated dark matter candidate[5]
- The Broadband Reflector Experiment for Axion Detection (BREAD) searches for axion-to-photon conversion in a magnetic field[6]
- These converted photons are reflected, focused, and detected by a superconducting nanowire single photon detector (SNSPD)



A cutaway view of the BREAD reflector. Any photon emitted normal to the inner cylindrical surface gets focused to a singular point after two reflections.

Calibrating SNSPD Using Blackbody Radiation

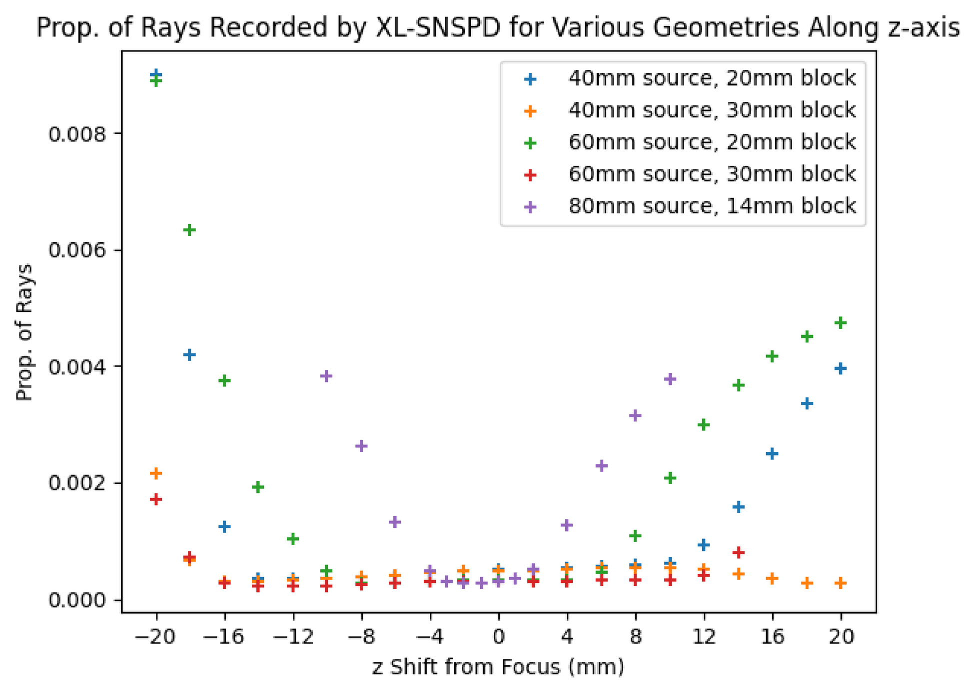




Left: Due to uneven thermal contraction when the detector is cooled to ~0.1K, the true focal spot of the detector may move slightly.

Right: Example 2D plots of the number of rays recorded by the SNSPD at two different detector positions.

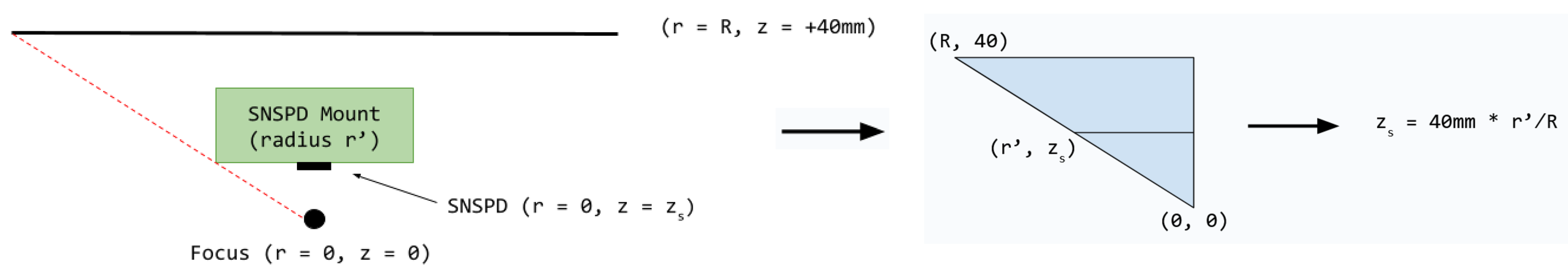
Varying the Size of the Absorber and Mount



The effect of the radius of the blackbody absorber and SNSPD mount were investigated using an unphysically large SNSPD. A minimum was not consistently observed at the focus, but a valley is seen.

Modeling the Size of the Valley

Prediction of z Position of Top of Valley

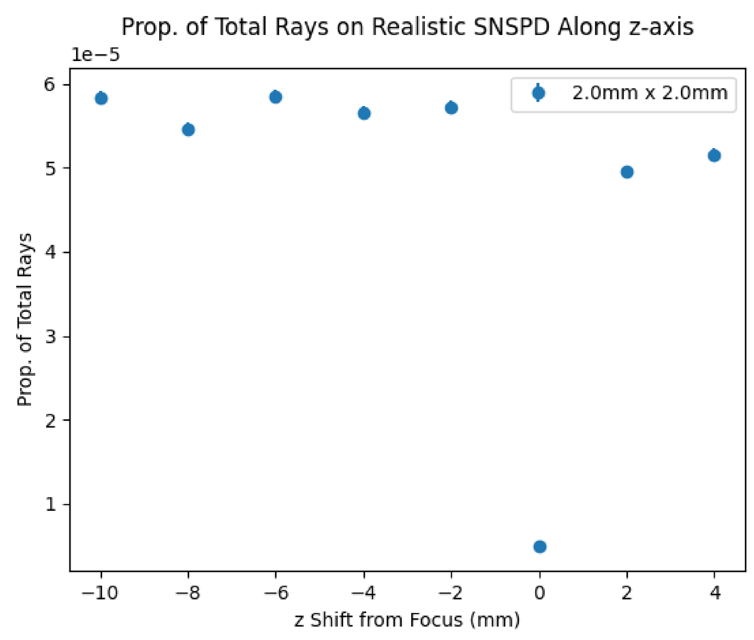


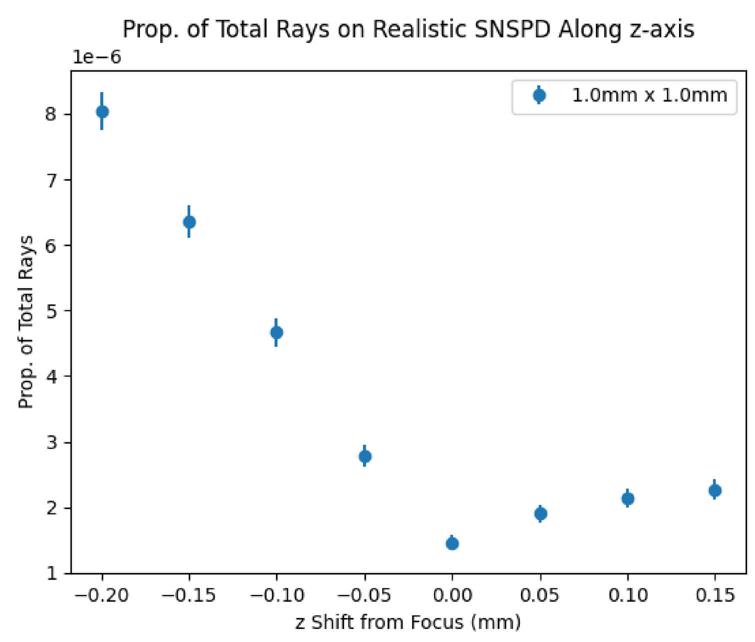
Observation

Source Radius / Block Radius	Predicted Top of Valley	Observed Top of Valley
40mm / 20mm	+20mm	+14mm
40mm / 30mm	+30mm	> +20mm
60mm / 20mm	+13.3mm	+8mm
60mm / 30mm	+20mm	+14mm
60mm / 15mm	+10mm	+4mm
80mm / 14mm	+7mm	+1mm

Data supports revised prediction of **(Top of Valley) = (Predicted Top) – 6mm**

Realistic Scale Simulations





Throw the old model out; calibration expectation confirmed to within 50 microns!

Citations

[1] R. D. Peccei and H. R. Quinn, "CP conservation in the presence of pseudoparticles," Phys. Rev. Lett. 38, 1440–1443 (1977).

[2] R. D. Peccei and H. R. Quinn, "Constraints imposed by CP conservation in the presence of pseudoparticles," Phys. Rev. D 16, 1791–1797 (1977).

[3] S. Weinberg, "A new light boson?" Phys. Rev. Lett. 40, 223–226 (1978).

[4] F. Wilczek, "Problem of Strong P and T Invariance in the Presence of Instantons," Phys. Rev. Lett. 40, 279–282 (1978).

[5] M. Dine, W. Fischler, and M. Srednicki, "A simple solution to the strong CP problem with a harmless axion," Physics Letters B 104, 199–202 (1981).

[6] S. Knirck, et.al. (BREAD Collaboration), "First results from a broadband search for dark photon dark matter in the 44 to 52 μeV range with a coaxial dish antenna," Phys. Rev. Lett. 132, 131004 (2024).

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