ADMX Run 1c HiRes Analysis

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This work is supported by U.S. Department of Energy Office of Science, Office of High Energy Physics

Introduction

Axions :
- Solve the strong CP problem
- Candidate for the cold dark matter

Detection - Primikoff conversion :
- Converted to microwave photons in a resonant cavity
- High *Q* factor
- Inside a strong magnet
- The ADMX collaboration exploits this method
- First proposed by P. Sikivie

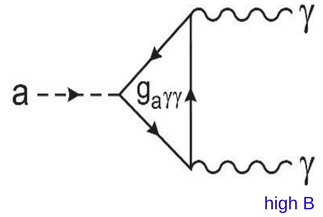


Diagram of an axion decaying to two photons

ADMX Generation - 2

- The mass of the axion is unknown
- The cavity is tuned using two tuning rods
- With $\hbar = c = 1$, the axions are seen at $\omega = m_a$
- $f = \omega/2\pi$ is the resonant frequency of the cavity and m_a is the axion mass
- The setup is cooled down to 150 mK to increase the signal to noise ratio (SNR)
- The SQUID amplifier amplifies the signal from $O(10^{-23})$ W to a readable value
- A typical *Q* factor of the microwave cavity is $O(10^5)$
- Current experiment uses a single cylindrical cavity to detect the axions

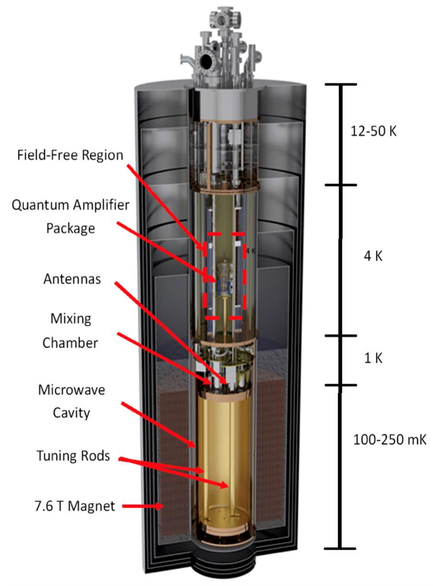
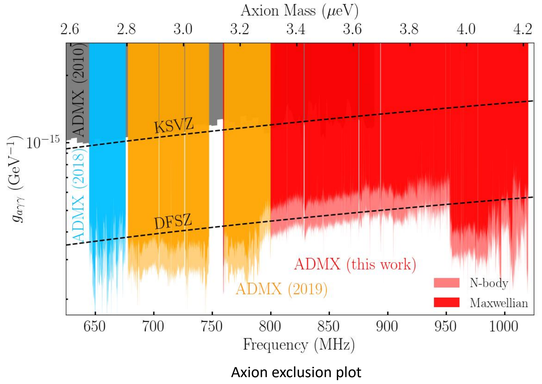


Illustration of the cavity

Run 1c Data

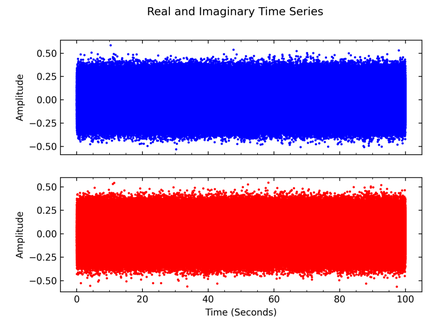
- Run 1c is the most recent data taking run
- The frequency range covered 800 MHz to 1 GHz
- High resolution search is expected to have a sensitivity greater than these searches.
- ADMX is the **first and only axion experiment** to reach the DFSZ sensitivity.



Axion exclusion plot

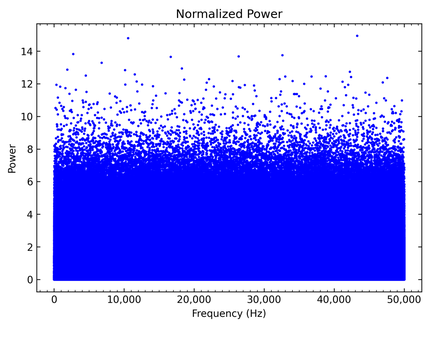
High-Resolution Analysis

- The High-Resolution (HiRes) analysis channel has a frequency resolution of 20 mHz
- HiRes' primary focus is searching for unvirialized axion flows
- These flows will have a width of 100 mHz or less
- During 1c, synthetic signals were injected to test the sensitivity
- Injections were made to mimic a Maxwellian shape in the Medium resolution search



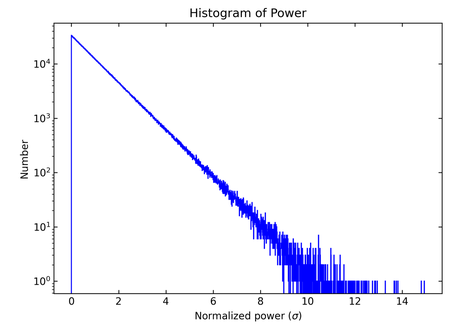
Analysis Procedure

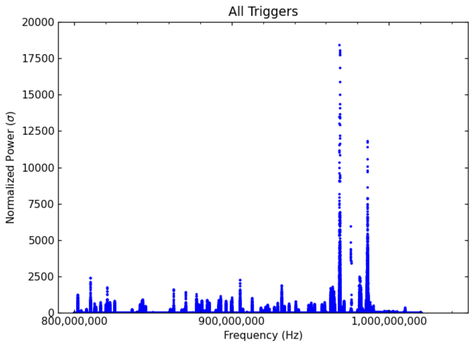
- The ADMX DAQ processes the data in real time and produces 5,000,000-point complex time series
- HiRes analyzes these offline
- First, the power spectrum of the time series is computed
- The resulting spectrum spans 0 kHz to 50 kHz
- Next, the spectrum is normalized by fitting and diving it by a polynomial
- Then, we scan for single frequency bins above the background, chosen to be 14σ
- These points form what we call our trigger list
- Lastly, we perform a series of cuts to the trigger list to produce a candidate list



Preliminary Results

- We ended with 2,901,986 triggers
- Keeping triggers with a cavity Q factor between 10,000 and 120,000 removes 7,267
- Removing triggers with a system noise temperature above 5K eliminates 14,608
- An L-Cut, requiring $1.8 * Q * \frac{|f-f0|}{f0} \leq 1$, removes 1,961,515
- Their combination leaves 935,984 triggers
- The next step is to remove non-persistent triggers





Publications

- "Dark Matter Axion Search Using a Josephson Traveling Wave Parametric Amplifier", C. Bartram et al. (submitted).
- "Search for "Invisible" Axion Dark Matter in the 3.3-4.2 μeV Mass Range", C. Bartram et al. Phys. Rev. Lett. 127, 261803 (2021).
- Extended Search for the Invisible Axion with the Axion Dark Matter Experiment , T. Braine *et al.,* Phys. Rev. let. 124(10),101303 (2020)
- Search for Invisible Axion Dark Matter with the Axion Dark Matter Experiment, N. Du *et al.*, Phys. Rev. Lett. **120**, 151301 (2018).
- Piezoelectrically Tuned Multimode Cavity Search for Axion Dark Matter, C. Boutan *et al.,* Phys. Rev. Lett. **121**, 261302 (2018).
- High resolution data analysis – Plans and prospects, S. Jois *et al.,* Book Chapter, Microwave cavities and detectors for Axion research, Springer, 2020.

Collaborators

- University of Florida[1]
- University of Washington[2] (ADMX site)
- Washington University at St. Louis
- University of California, Berkeley
- University of Western Australia
- Sheffield University
- Fermi National Accelerator Laboratory
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- National Radio Astronomy Observatory
- Pacific Northwest National Laboratory