Summary of Data Management Principles
Axion Dark Matter eXperiment (ADMX)
June 25, 2015

Experiment description:

- The Axion Dark-Matter eXperiment (ADMX) is a particle detector located at the University of Washington.
- The science goal of ADMX is to detect axions, a hypothetical elementary particle that may constitute the nearby dark-matter halo of our Milky Way galaxy.
- ADMX detects axions via their conversion into photons within a resonant cavity permeated by a strong static magnetic field. The cavity resonant frequency is tuned in small steps and the cavity output is amplified by a sensitive, ultra-low noise, microwave receiver. Emission from the cavity in excess of the thermal background is the signal of this conversion. Tuning is required because the photon energy is equal to the total energy of axion and the axion mass is not known with good precision.
- The main experiment components are a large 8 Tesla superconducting solenoid magnet (bore is 1/2 m diameter X 1 m long), a large tunable microwave resonant cavity within the magnet bore, cryogenic and gas systems supporting the ultra-low-temperature experiment environment and liquid-helium magnet bath, and three independent microwave receiver channels.
- Schedule: ADMX is presently commissioning its Second Generation (Gen 2) upgrade, the largest part of which is the incorporation of a dilution refrigerator into the detector. This Gen 2 upgrade is expected to reduce system noise by a factor of 20, thereby greatly increasing the experiment sensitivity. This Gen 2 ADMX detector will then be sensitive enough to detect axions with all plausible coupling strengths over a wide range of plausible axion masses. The commissioning will be followed by a search exploring axion masses from 2 $\mu eV/c^2$ to 20 $\mu eV/c^2$ and beyond, estimated to take three to five years of detector operations.

DOE's roles in the experiment:

- The DOE has a long history, going back to the mid-1990's, of supporting this dark-matter search technology.
- The DOE supports the Gen 2 upgrade and operations of the detector, including data analysis. This Gen 2 ADMX is the experiment configuration currently undergoing construction & commissioning.
- Prior DOE support was essential for developing the SQUID amplifiers, the enabling technology for this detector, and for acquiring the 8 T superconducting magnet central to the detector. DOE also supported the procurement and deployment of the gas and cryogenic plant for this detector.

Partnerships:

The Heising-Simons Foundation funds R&D for years 2 and 3 (and beyond) of the ADMX Gen 2 axion-search program. The University of Washington supported much of the site construction of the experiment. LDRD funds from Lawrence Livermore National Laboratory established the initial experiment capability and contributed support to earlier versions of ADMX.

Organization – Agency/Lab level

The main ADMX facilities are located in the Center for Experimental Nuclear Physics and Astrophysics (CENPA) at the University of Washington. This is a DOE-NP "Center of Excellence" and its laboratory infrastructure is well-suited to the scale of ADMX. Other collaborators have ADMX development sites.

Organization – Experiment level

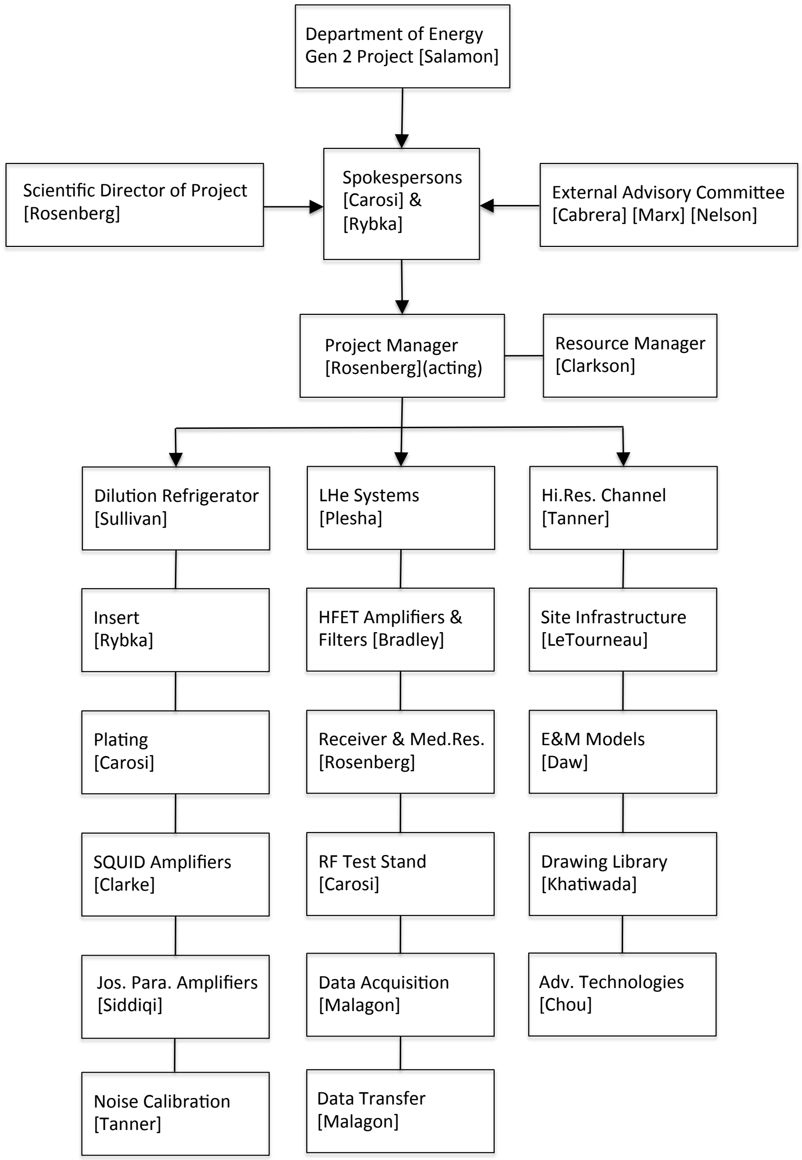
ADMX is organized according to a set of bylaws approved by existing members of the Collaboration. Participating research groups negotiate a MOU annually with ADMX management. The ADMX governing body is the "Executive Committee". Groups contribute one or more members to the Executive Committee, according to group size.

This Executive Committee has the responsibility to discuss scientific and procedural matters arising in the Collaboration. The Executive Committee is to be informed of all significant activities of committees of ADMX, and the Executive Committee votes on Collaboration policies and directions. In addition, the Executive Committee elects the ADMX Spokesperson(s).

Daily operations of ADMX are managed by the Spokesperson(s) overseeing a Project Manager. The Spokesperson(s) lead ADMX and are empowered to represent ADMX to the outside world.

The Executive Committee occasionally solicits outside advice from the ADMX External Advisory Committee.

Members of ADMX have defined project responsibilities, as shown in the organization chart below



Collaboration:

The ADMX collaboration consists of approximately 40 scientists at 7 institutions. The institutions are the University of Washington, the University of California at Berkeley, the University of Florida, Sheffield University (UK), Lawrence Livermore National Laboratory, Fermi National Laboratory, and the National Radio Astronomy Observatory. The number of collaborators and institutions will likely grow somewhat over the next year.

Data policy management:

We distinguish two data classes. The first is data from the ADMX detector that, when analyzed, would lead to an all-author ADMX paper. These data are under the stewardship of the ADMX Collaboration. The Collaboration, governed by the ADMX Executive Committee and with daily operations managed by the Spokesperson(s) and Project Manager, is responsible for setting data policy, archiving the data, making it available to the Collaboration for data analysis, and, eventually, making it public.

The second class of data results from R&D by one or more individuals or groups wholly or partially contained within the Collaboration, addressing advanced methods for axion detection, improved cavities, etc. These data are managed by the groups carrying out the research, following the data management policies of those groups and their institutions and following the publication rules of the Collaboration bylaws.

Data Description & Processing

The science data from ADMX is made up of the voltage time-series of radio-frequency (RF) emission from the ADMX cavity along with related metadata, state data, and environmental data. For a given frequency setting of the resonant cavity, the RF emission from the cavity consists of a narrow band of frequencies located within the 400 MHz-4 GHz tuning range of the cavity resonance. This RF emission is then down-converted by the receiver to MHz frequencies (IF) and sampled digitally. The data stream consists primarily of a long, sequential series of "scans". One scan consists of 10-100 seconds of data sampled at approximately 100 kHz, resulting in a 2-20 Mb data file containing 1-10 million points. This entire voltage time-series is saved for later high-resolution studies. As the measurement proceeds, the data acquisition system computes power spectra from each sequential 8 msec of data. These sequential spectra are averaged and saved. These numbers will change somewhat as hardware and frequency ranges change over the experiment operations.

The environmental data, state data and metadata consist of records of temperatures, magnetic field, cavity tuning parameters (frequency and Q), and other operating parameters.

The experiment thus produces more than 3 Tb of data per year of live time. Offline processing includes spectral analysis, shifting the spectra back to the cavity frequency or other frequency, and searching for persistent emission in excess of the background or frequency power correlations that could arise from conversion of axions to photons.

Data Products and Releases:

Raw data are available to the collaboration immediately. Results of analysis are available as they are complete and validated. The data are archived at CENPA and served to the collaboration. The experiment also has had a mirror of the data at the University of Florida. An Analysis Chair coordinates the various analyses. Approximately, data have been released in conferences after each year of operations, then submitted for publication; we expect this data-release cadence to continue into the future.

Plan for Serving Data to the Collaboration and Community:

All members of the Collaboration have free and equal access to any data taken by the Collaboration, but must abide by Collaboration bylaws for the use, distribution, and publication of results from the data. Members are obligated to inform the Spokesperson and the Analysis Chair of their plans to analyze data.

Data will be available only to the Collaboration until 2 years after the publication date of the first paper to analyze that set of data. Afterward it will be made available on the web to others. A rudimentary program for reading the data will be provided as well. We do not have dedicated staff to provide extensive user support, however.

Plan for Archiving Data:

All data will be digitally archived at the University of Washington Center for Experimental Nuclear Physics and Astrophysics (CENPA) for 5 years after the experiment ends. This archiving is under the existing CENPA policies and procedures. Data will be kept on external (USB) hard drives indefinitely.

Plan for Making Data Used in Publications Available:

Published data will be available in print or electronically from publishers, subject to subscription/printing charges and copyrights. We will work to provide other data with as few restrictions as possible. For example, preprints will be posted both on the ADMX website and on the arXiv, so as to ensure results are generally accessible without requiring journal subscriptions. Other data provided via ADMX websites will include a request to cite the most relevant publication(s) and notice of any copyright restrictions (e.g., how to obtain permission to reuse figures published in archival journals).

The raw data supporting a publication claiming observation of a signal from dark-matter axions will be made available immediately after publication.

Responsiveness to SC Statement on Digital Data Management

This data management plan fully follows SC Statement on Digital Data Management.

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