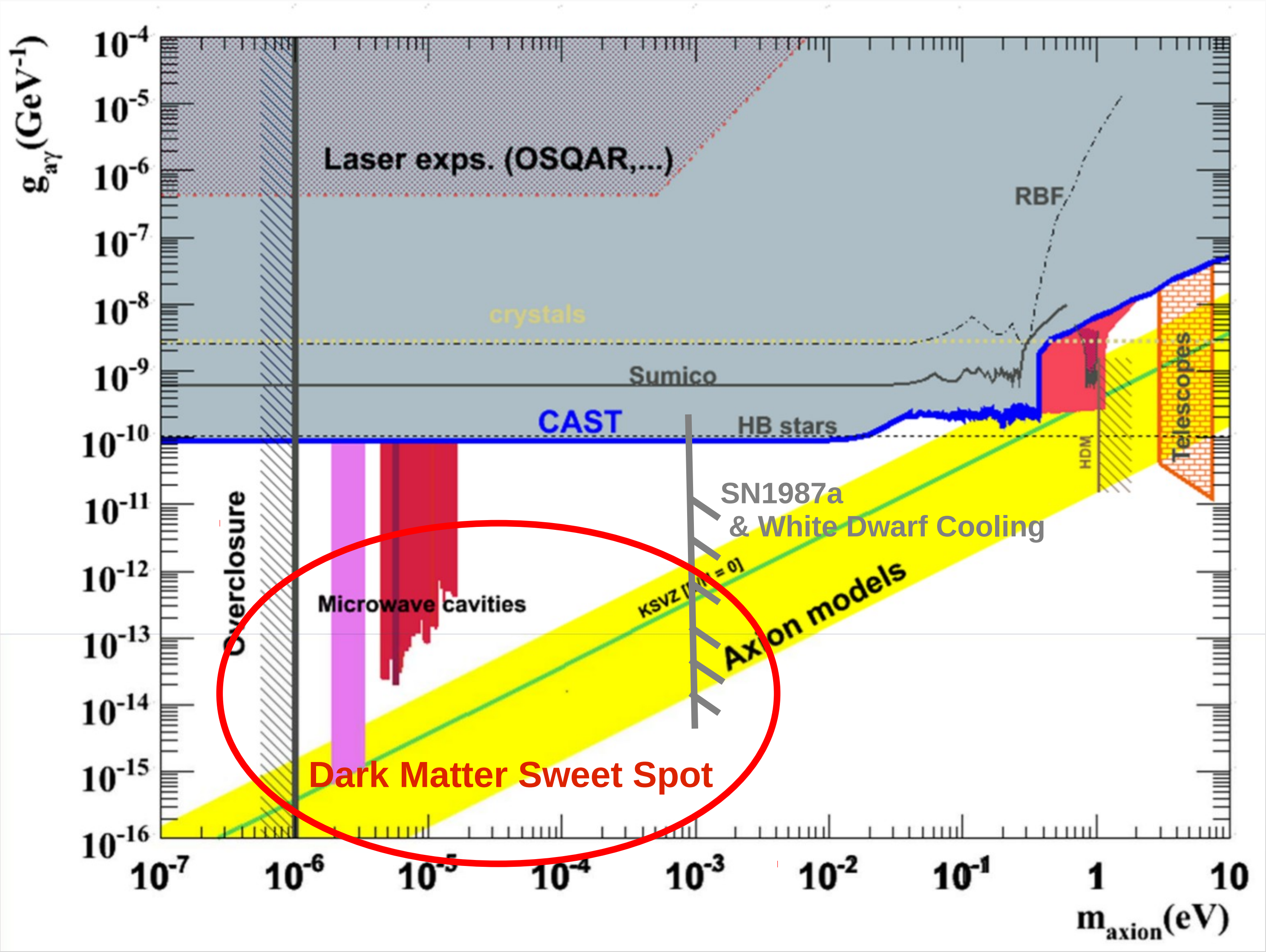
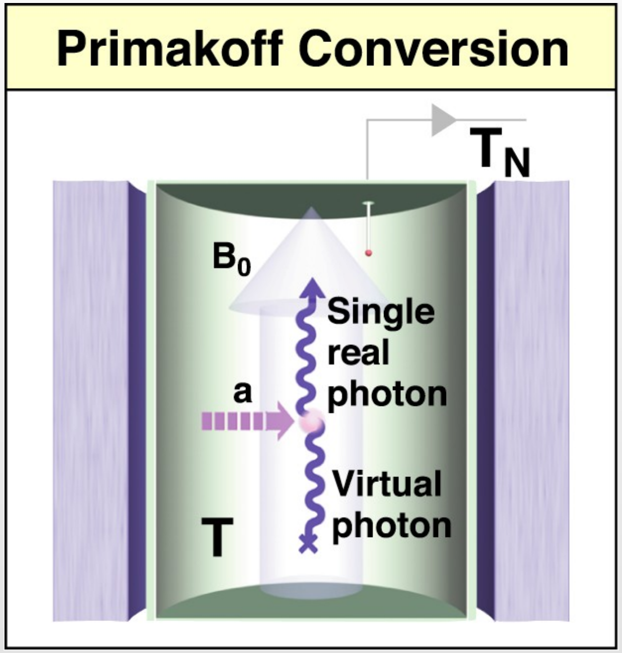
ADMX: Current Status

Gray Rybka
March 6, 2013
Pre-Snowmass Cosmic Frontier Meeting
SLAC

Experimental Constraints



Axion Haloscope



Dark Matter Axions will convert to photons in a magnetic field.

The measurement is enhanced if the photon's frequency corresponds to the cavity's resonant frequency.

See: Sikivie, Phys. Rev. Lett. 1983

You Want:
-Large Cavity Volume
-High Magnetic Field
-High Cavity Q

You Don't Want:
-High Thermal Noise
-High Amplifier Noise

ADMX

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LLNL
G. Carosi*, C. Hagmann, D. Kinion

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J. Hoskins, I. Stern, C. Martin,
P. Sikivie, N.S. Sullivan, D.B. Tanner

Yale
S. Lamoreaux

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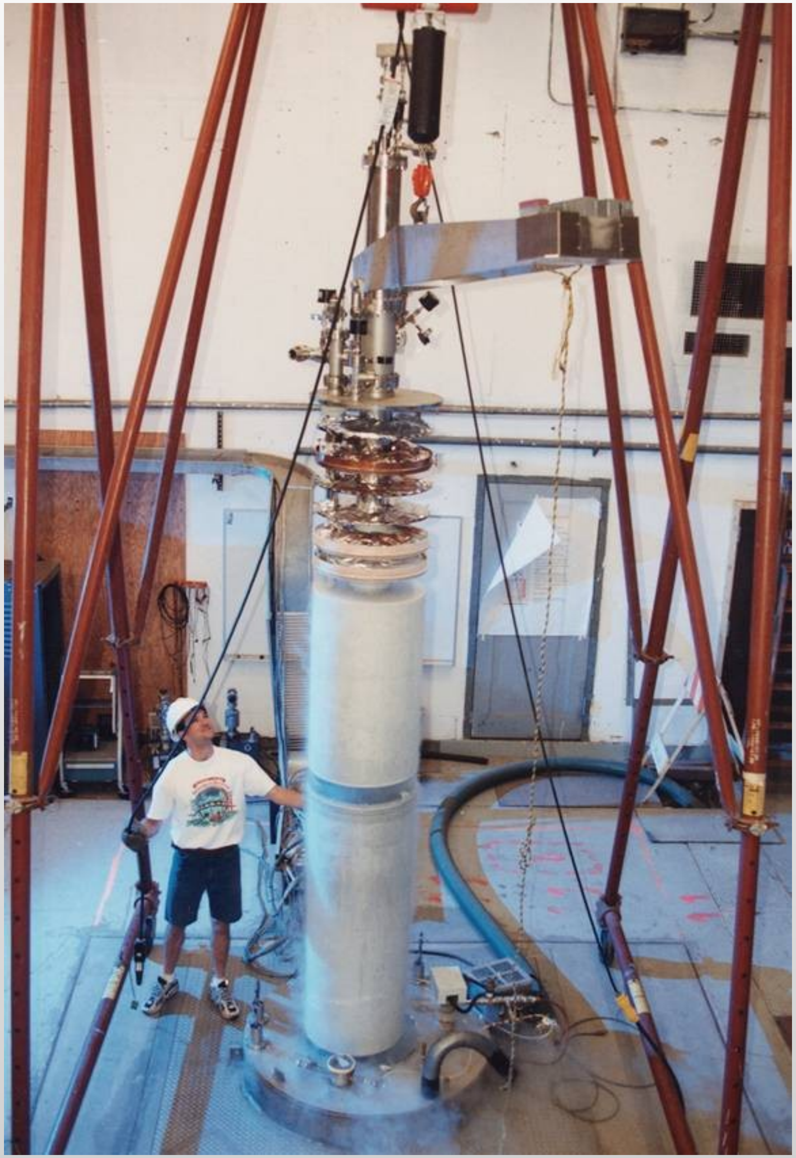
K. van Bibber

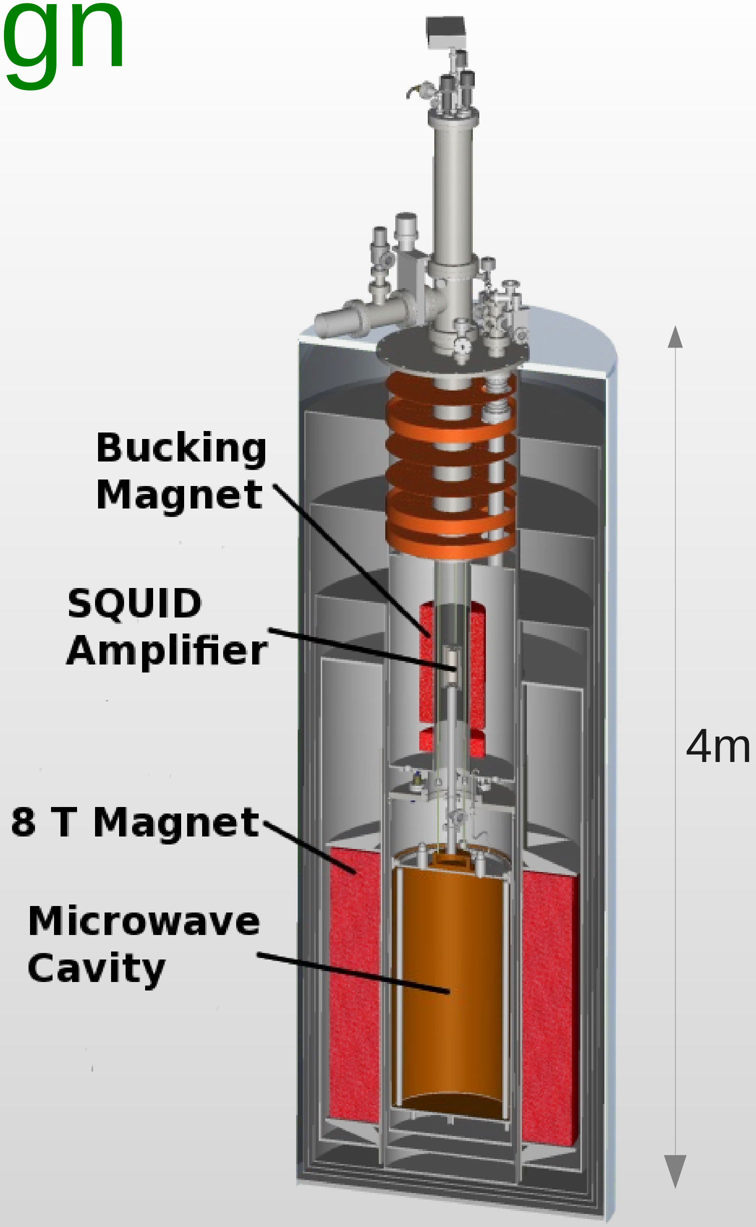
UC Berkeley
J. Clarke

NRAO
R.F. Bradley

*Co-spokespersons, Gen 2

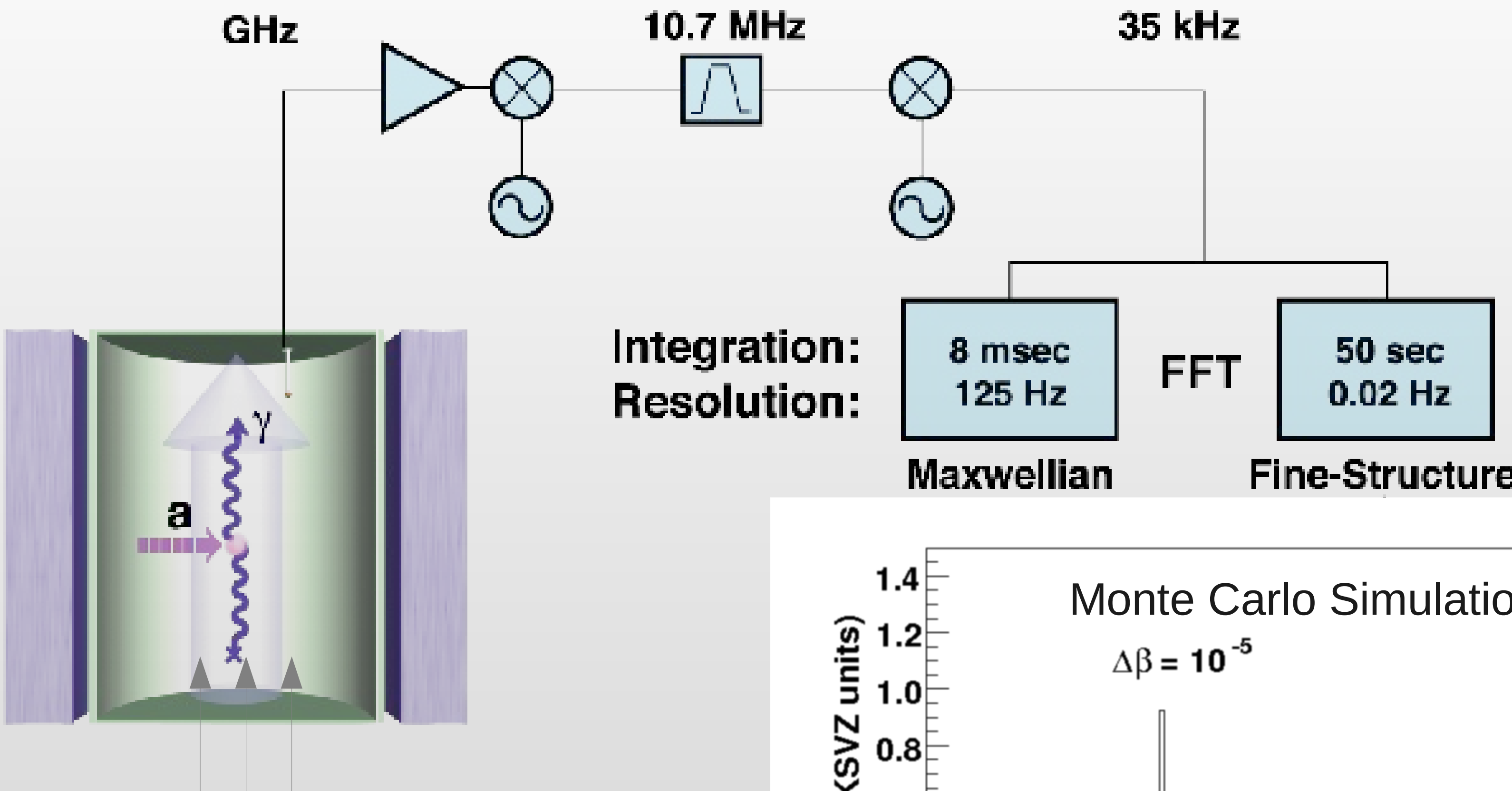
ADMX Design





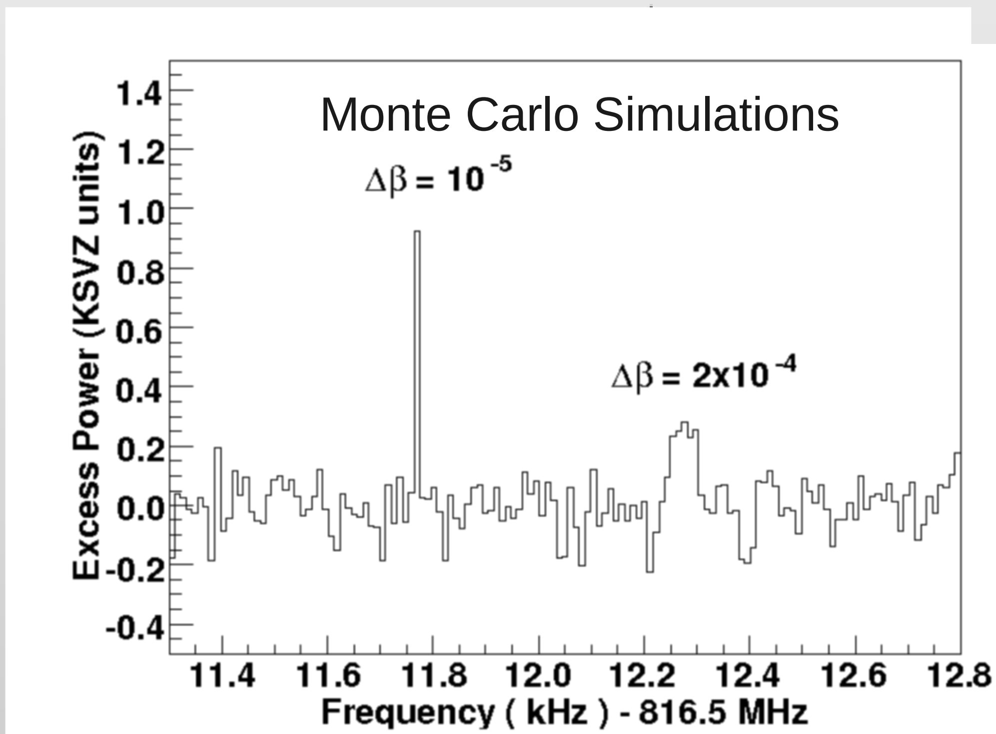
Cavity Frequency changed by moving metal rods (not shown) inside cavity

ADMX Receiver

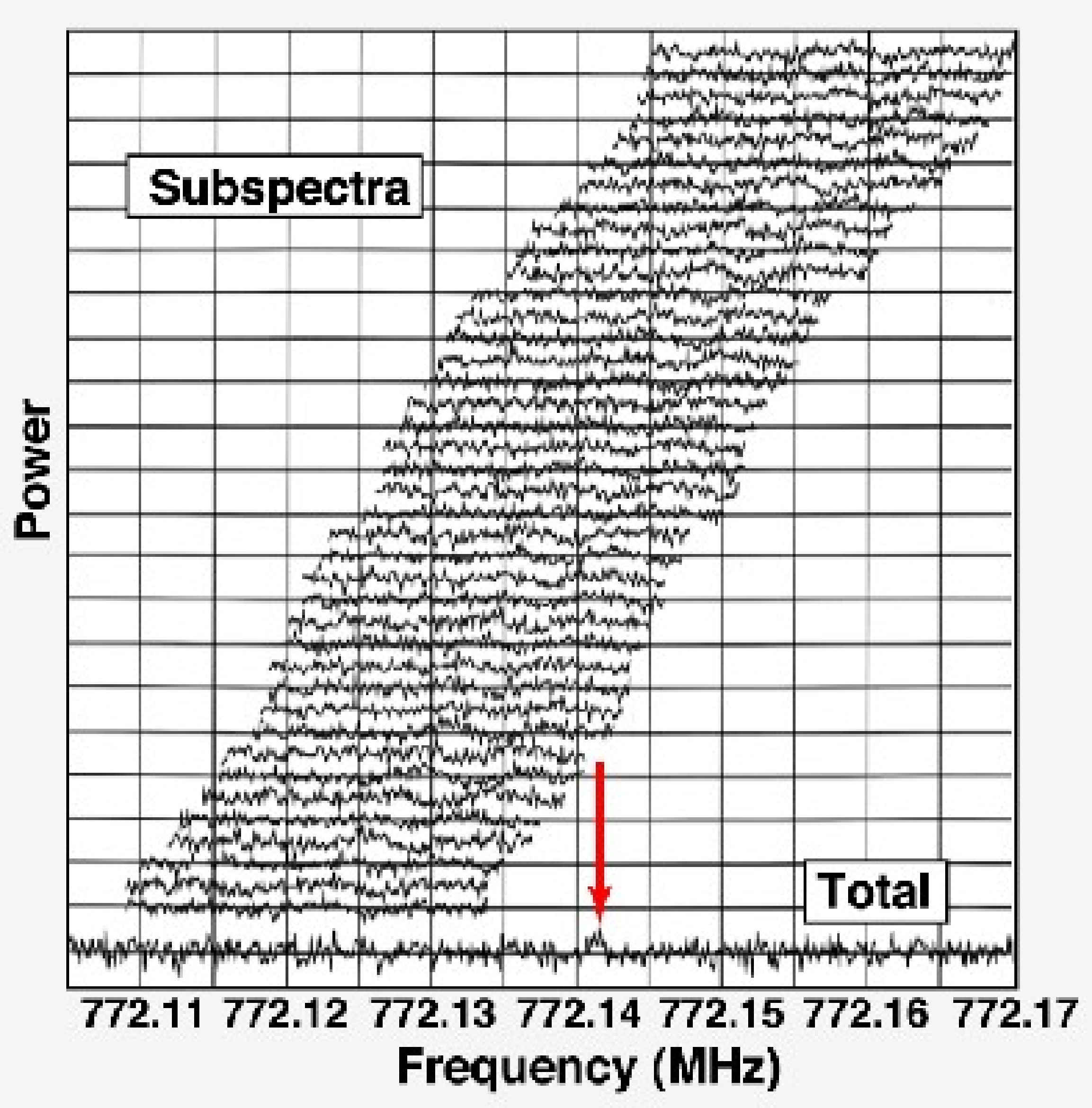


B=8 Tesla

Axions, stimulated by a magnetic field, decay into microwave photons which resonate in the cooled cavity and are amplified and read out



Axion Search Technique



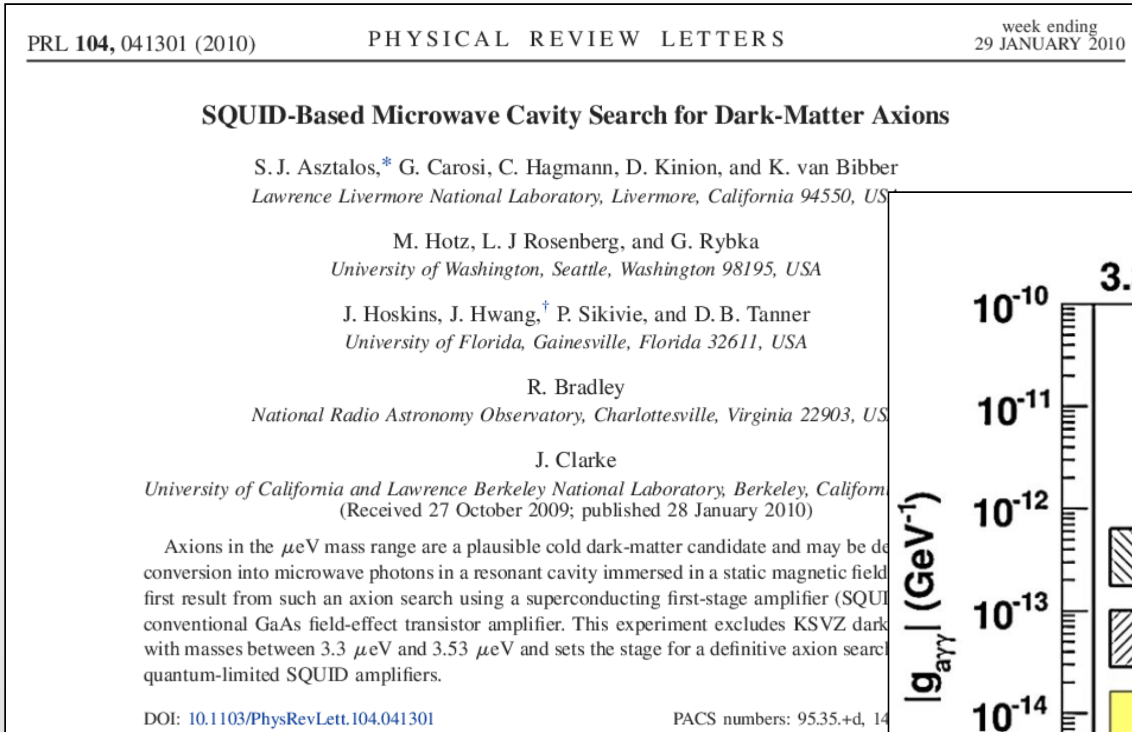
Cavity resonant frequency is tuned by two movable rods

Power spectra are measured at each rod position

Axion signal would appear as a constant power excess

Most backgrounds do not persist

ADMX Results So Far



PRL 104, 041301 (2010) PHYSICAL REVIEW LETTERS week ending 29 JANUARY 2010

SQUID-Based Microwave Cavity Search for Dark-Matter Axions

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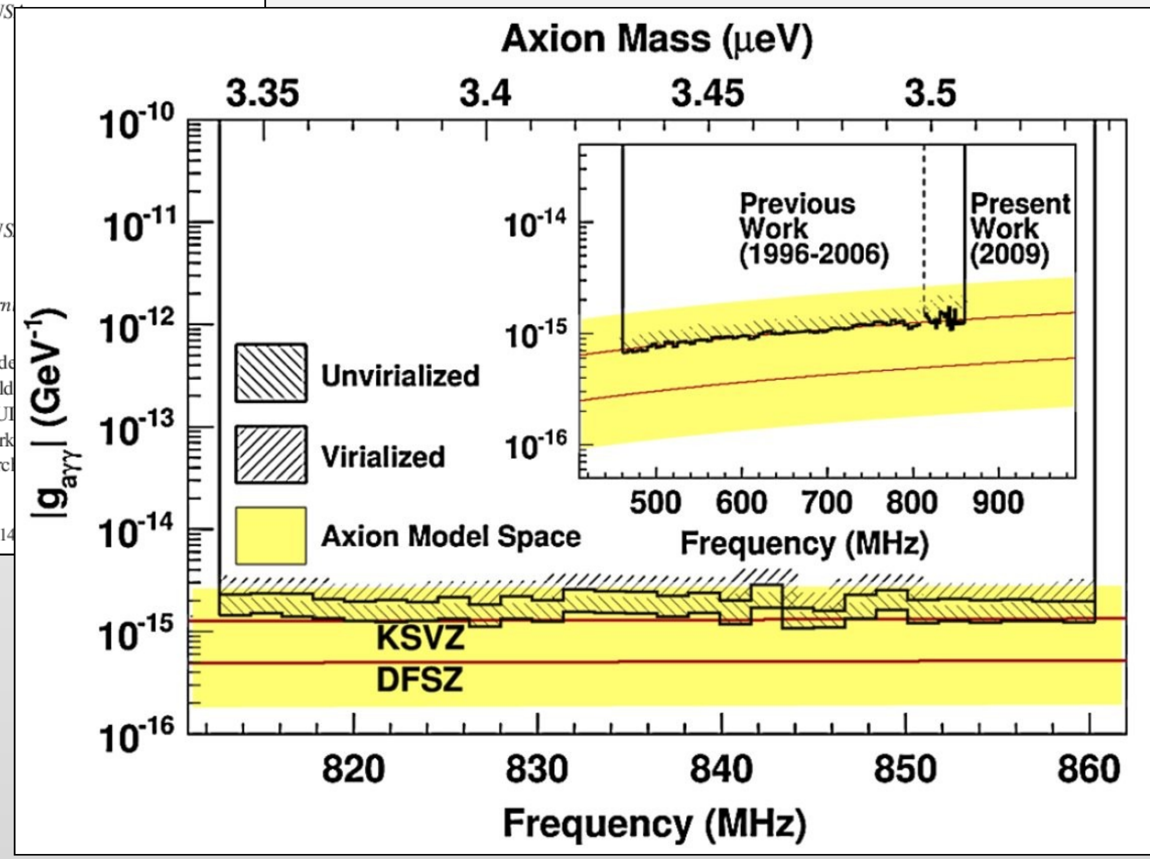
(Received 27 October 2009; published 28 January 2010)

Axions in the μeV mass range are a plausible cold dark-matter candidate and may be de conversion into microwave photons in a resonant cavity immersed in a static magnetic field first result from such an axion search using a superconducting first-stage amplifier (SQUI conventional GaAs field-effect transistor amplifier. This experiment excludes KSVZ dark with masses between 3.3 μeV and 3.53 μeV and sets the stage for a definitive axion searc quantum-limited SQUID amplifiers.

DOI: 10.1103/PhysRevLett.104.041301 PACS numbers: 95.35.+d, 14

Excludes optimistically coupled axions over 48 MHz



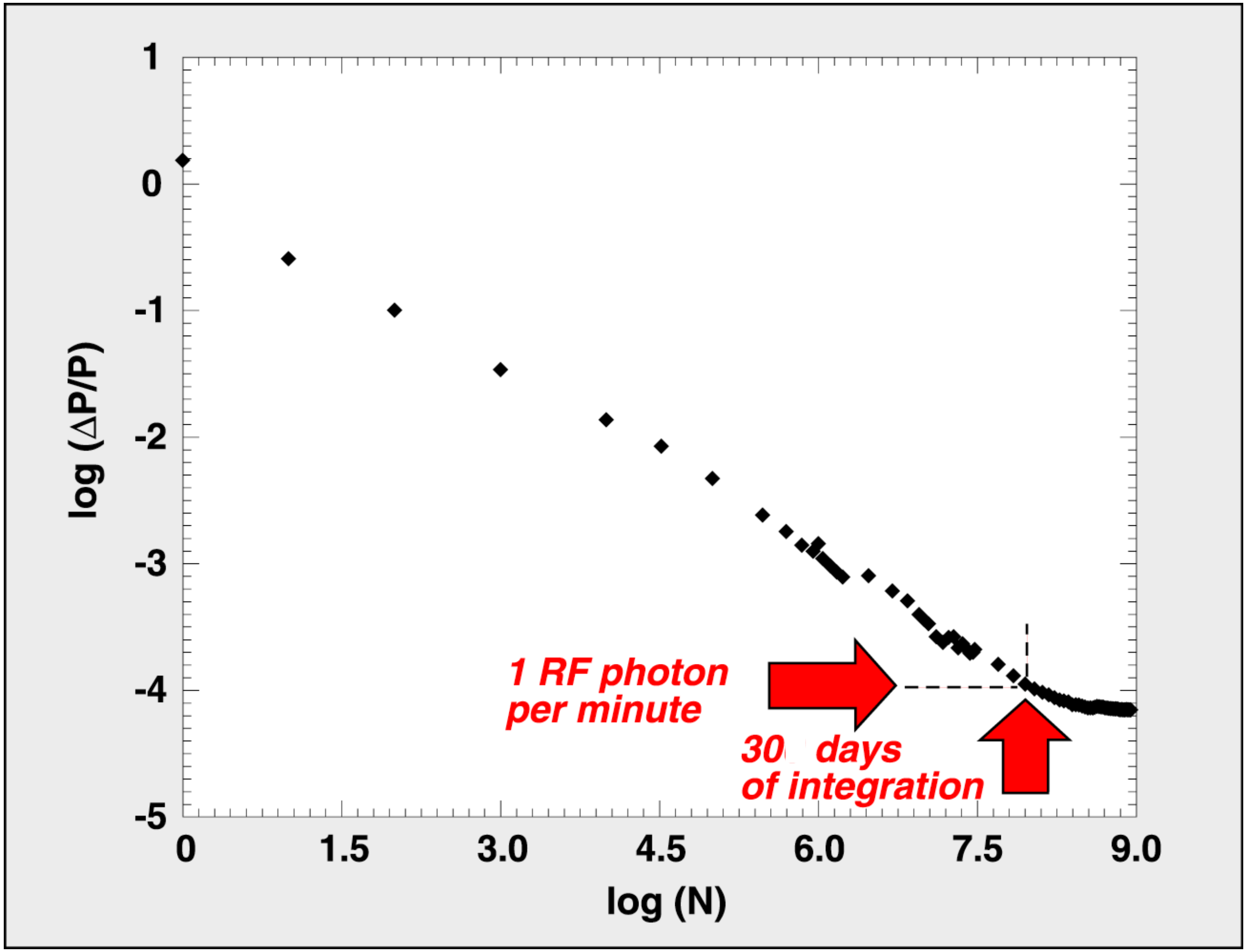
DOI: 10.1103/PhysRevLett.104.041301

Covered 812 – 860 MHz = 48 MHz
Total Run Time: 19 months
Continuous Data Collecting: 8 months

SQUID Amplifier operational (shielded) in high field region

860-890 MHz data yields similar limit, publication in progress

Power Sensitivity

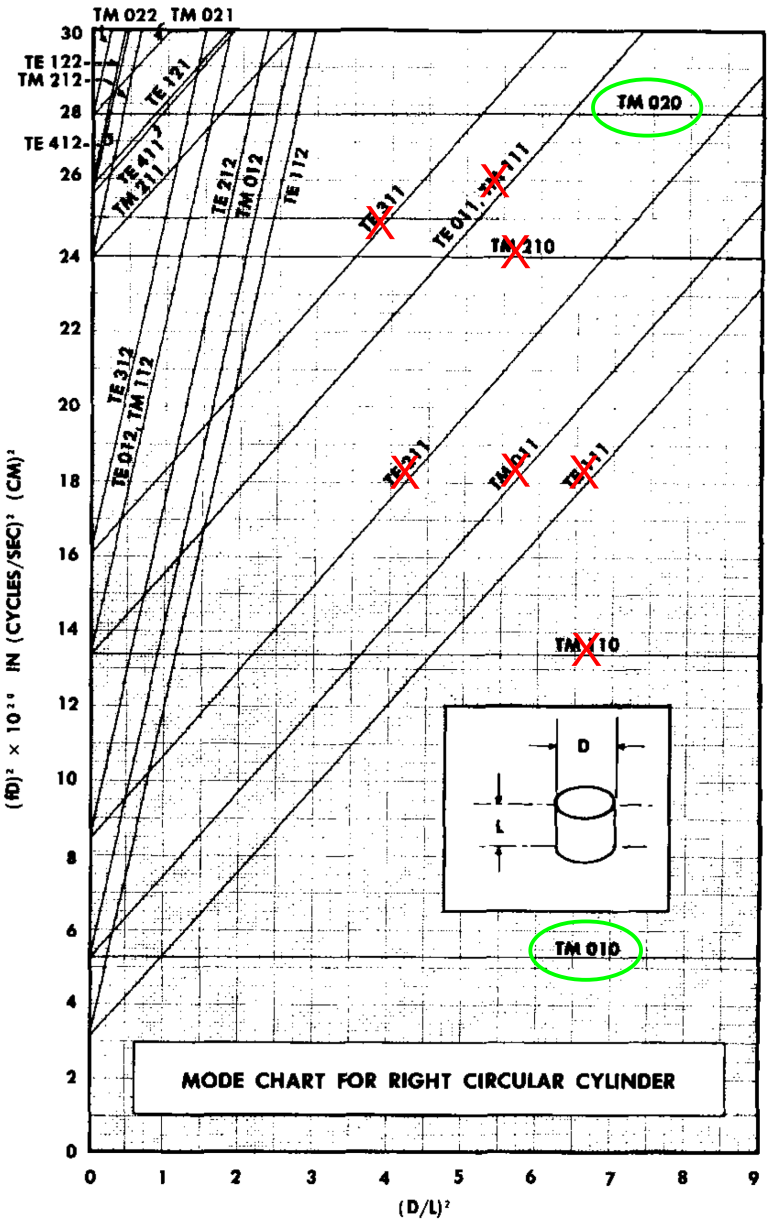


Systematics limited after 1 month integration

Sensitivity 0.01 Yoctowatt. Characteristic Axion Power: 100 Yoctowatts

Speed is the key issue, and to run faster, we need to run colder

Multiple Channel Improvements



The TM010 cavity mode is the most strongly coupled to an axion dark matter signal

Most cavity modes are insensitive to axion signal (useful background elimination tool)

Some cavity modes are still sensitive but with worse coupling.

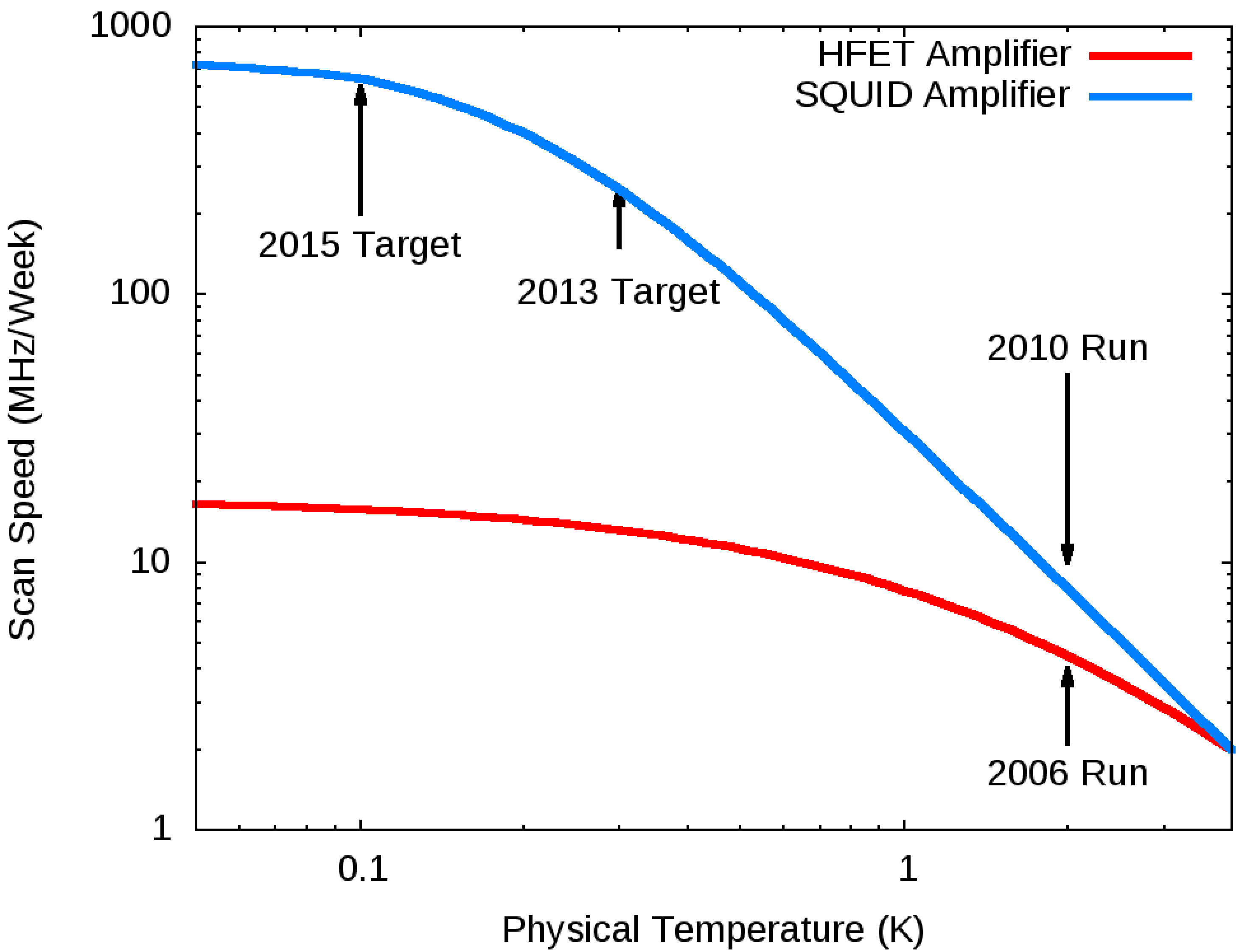
If we have spare sensitivity, we can use those modes to scan multiple axion masses at once

mode	relative frequency	first year tuning range (MHz)	relative power
TM_{010}	1.00	400-900	1.00
TM_{020}	2.30	920-2,100	0.41

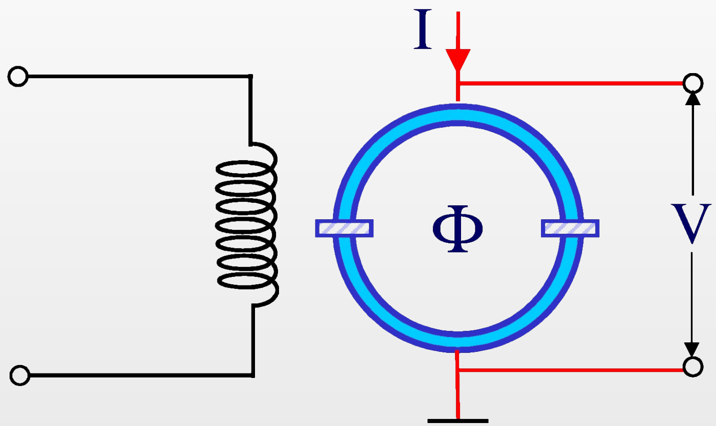
AXION

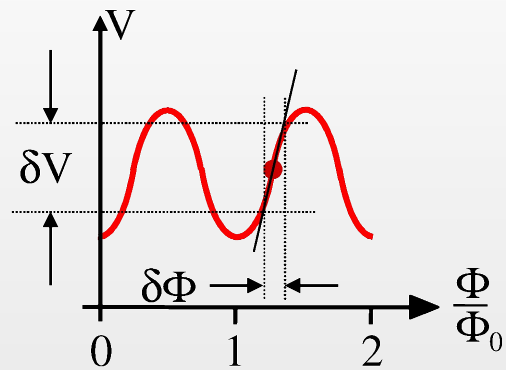
Cooling

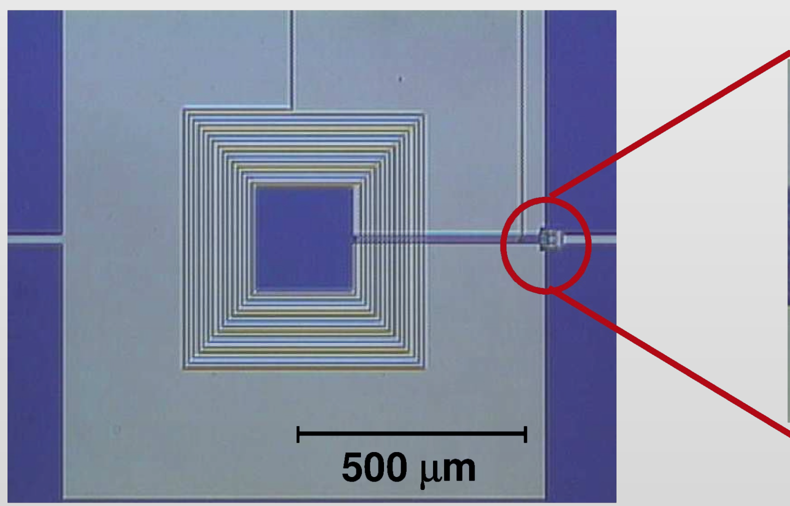
Dilution refrigerator will allow us to reach much colder temperatures, increasing scan speed tremendously



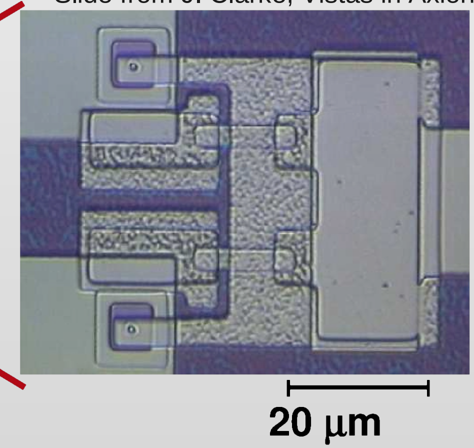
SQUID Amplifiers





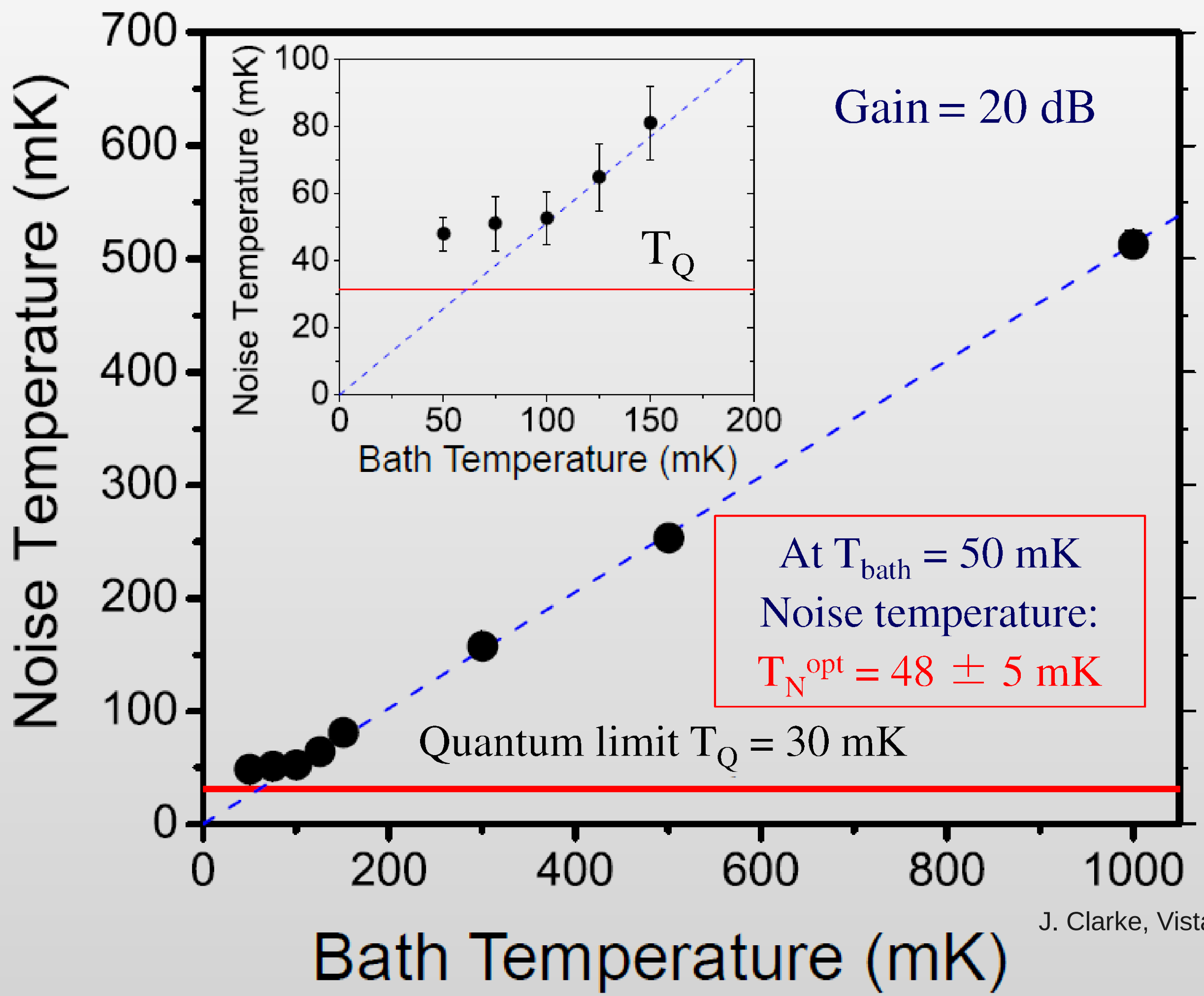


Slide from J. Clarke, Vistas in Axion Physics, 2012



Only operates in small, stable magnetic field

Amplifier Technology



J. Clarke, Vistas in Axion Physics, 2012

How ADMX Gen 2 Works In Pictures

Dump liquid helium in here

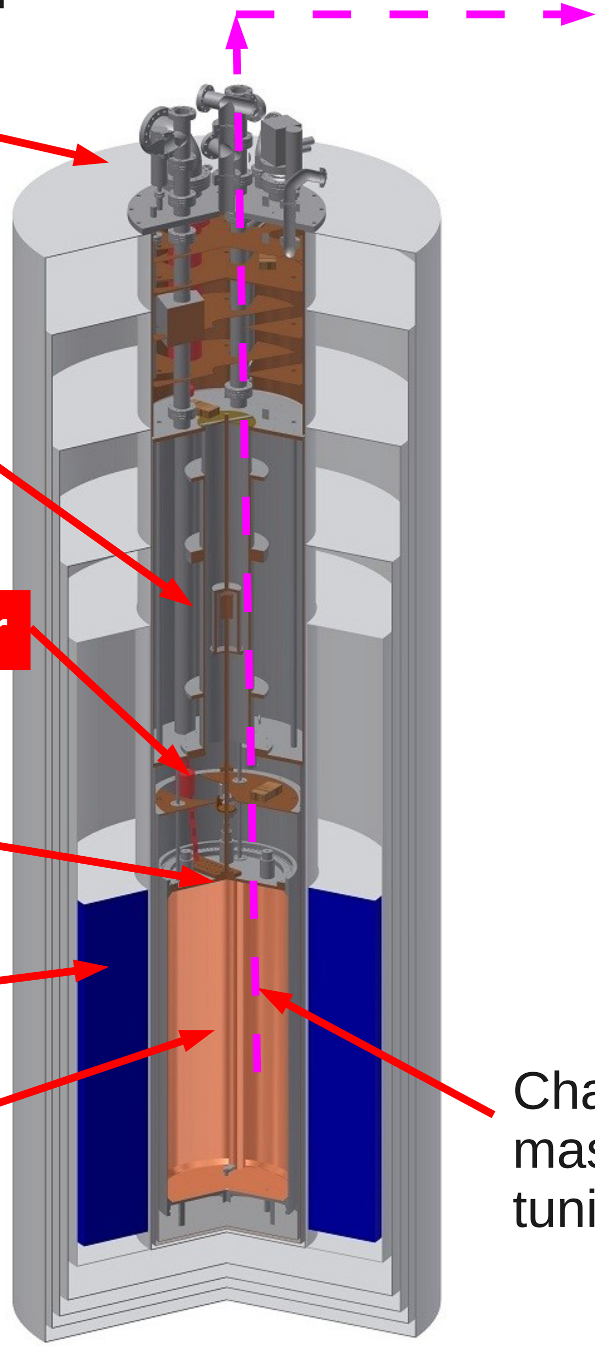
100 mK SQUID package

Dilution Refrigerator

Multiple Antennas

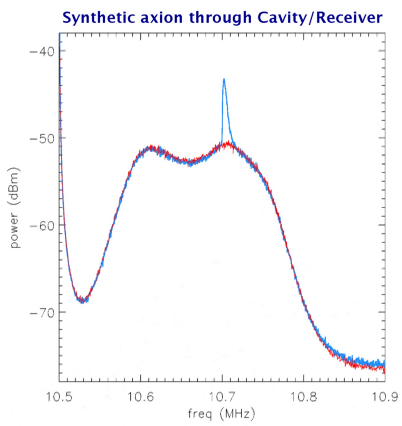
8 Telsa Magnet

Microwave cavity (axions go in here)



Amplify, mix signal from ~1 GHz to ~10.7 MHz, then digitize

Multiple Channels



Look for excess power in power spectrum

Change frequency/ mass sensitivity with tuning rods

ADMX Under Construction

July 2011

Sept 2011

Nov 2011

Feb 2012

Nov 2012

Feb 2013

ADMX Under Construction

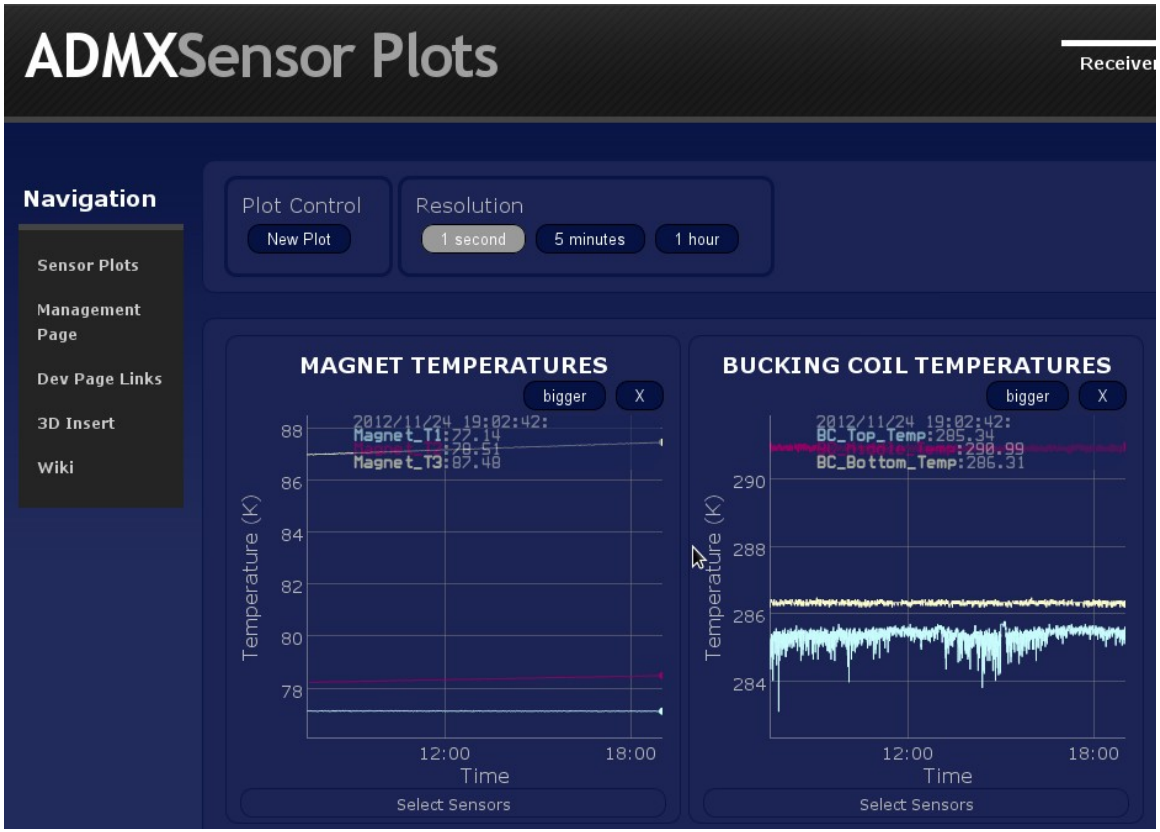
Bucking coil installation in new reservoir

New insert assembly

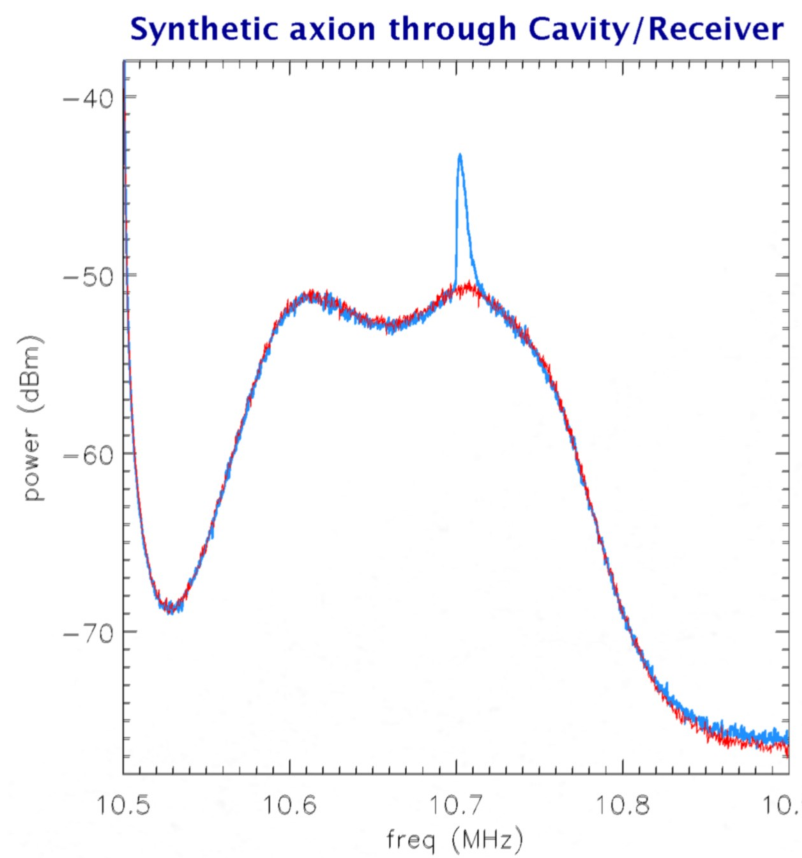
He Liquefier / pump hut construction

New gearboxes under test

ADMX Warm Commissioning Underway

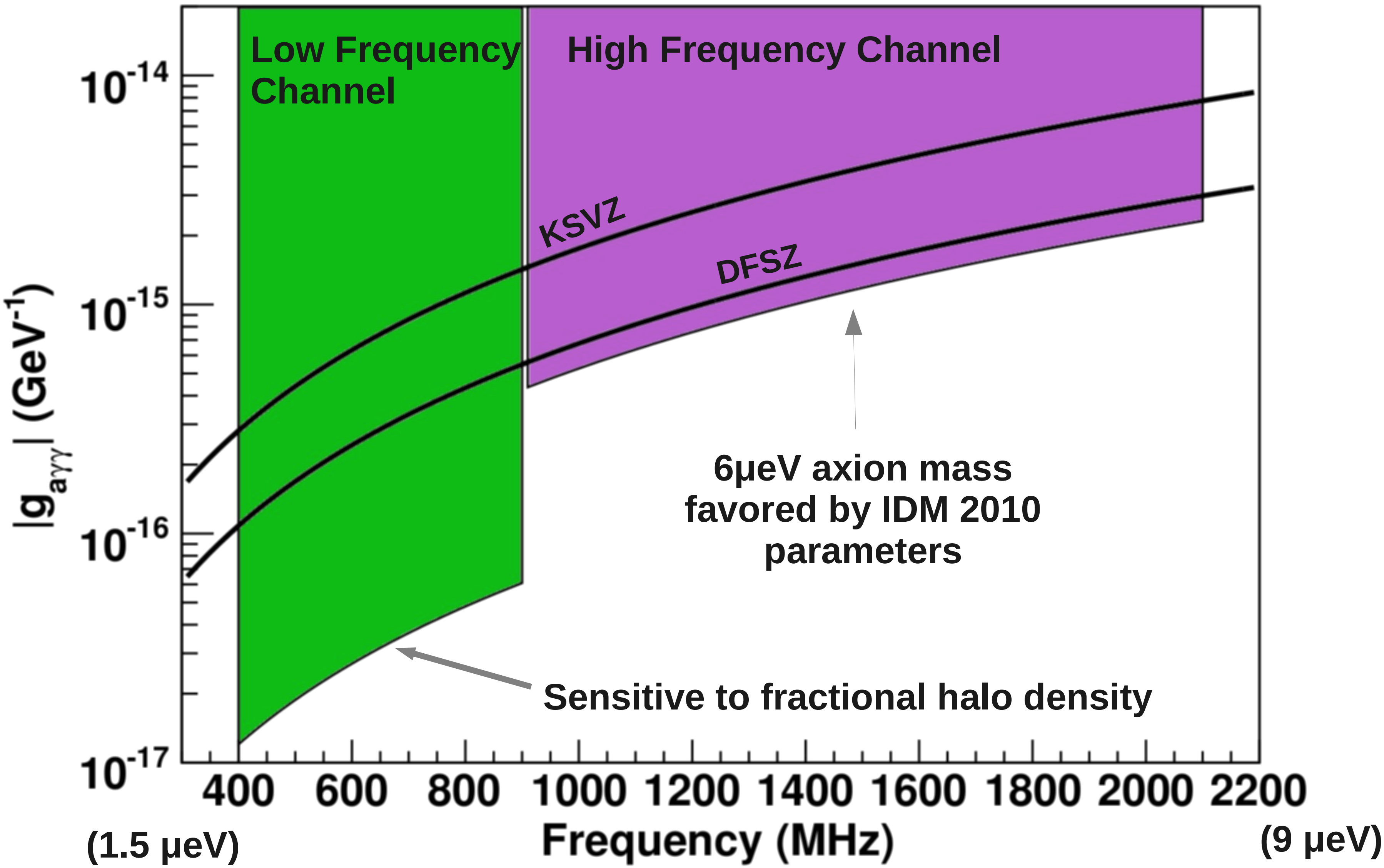


Temperature monitoring commissioning
Magnet at 77K, insert at 300K



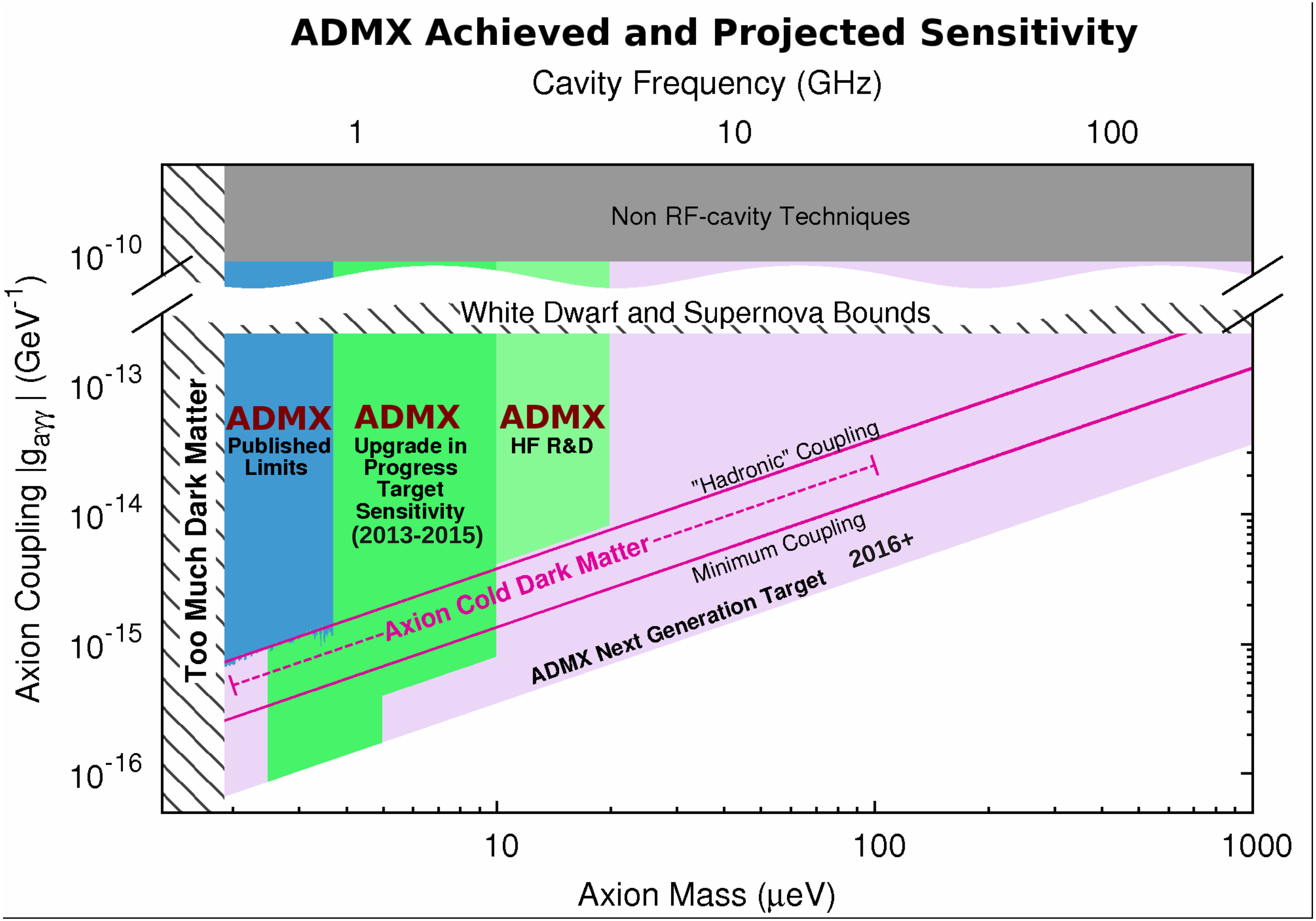
Synthesized axion signal signal
sent through real cavity and receiver

ADMX Near-Term Goals



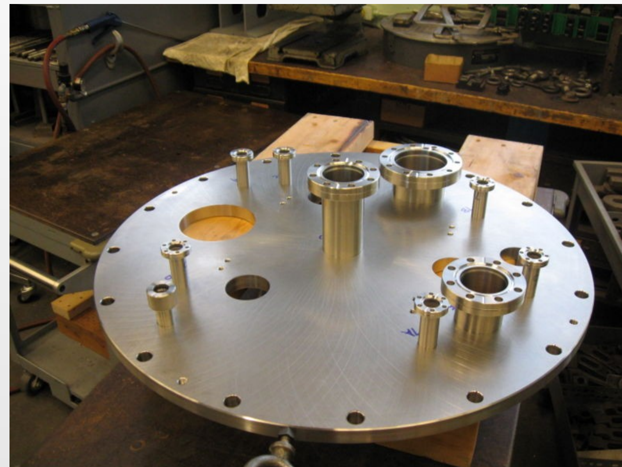
roughly 25% of the reasonable axion dark matter mass range. (on a log scale)

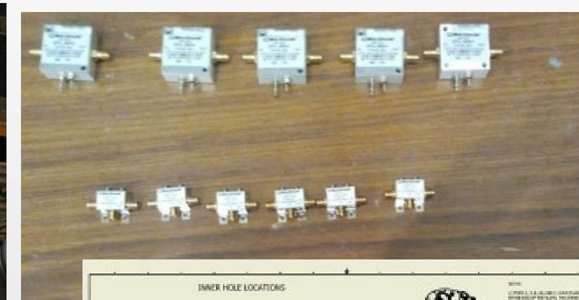
ADMX Moving Forward

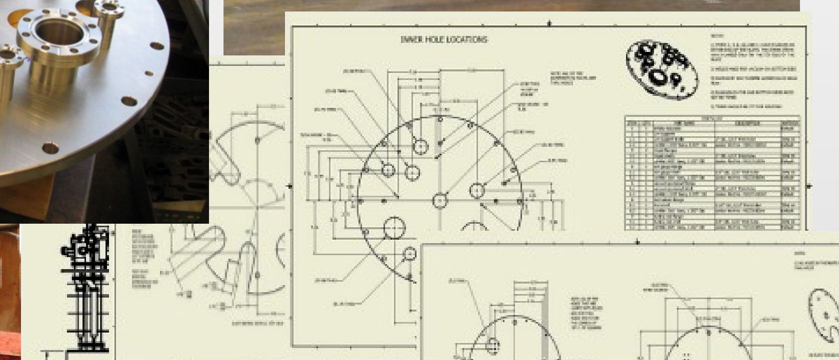


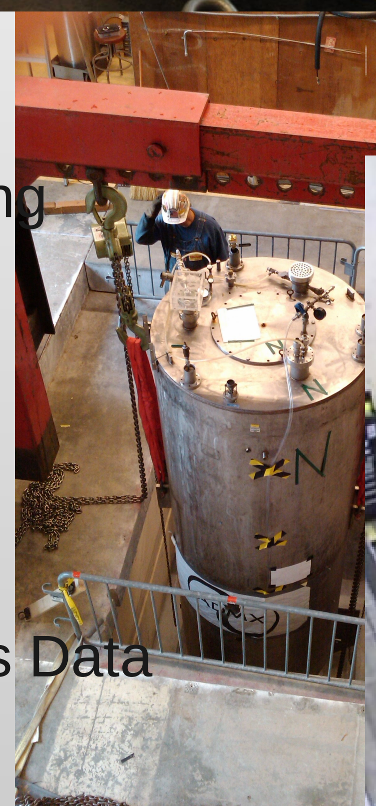
ADMX Under Construction

The next phase of ADMX is beginning commissioning









Helium Liquifier
Improved Cryogenics
Rod Location Tracking
Improved Thermometry
Real-Time Analysis
Clean Assembly Area
Better Cavity Modeling
HFET Bias Monitor
Dynamic SQUID Gain Monitoring
In-Situ Noise Calibration Suite
Tunable SQUIDs
Improved Receiver Chain
Digital Filtering
Better Timing Standard
Cavity Plating Upgrade
All High Resolution Time Series Data
New Magnet Leads