Advanced Axion Dark Matter detector

Really strong magnets,
lower temperatures,
and multiple cavities

DBT
University of Florida

for the ADMX collaboration
and the NHMFL

The signals are very weak

- Power from ADMX cavity goes as $B^2 V$

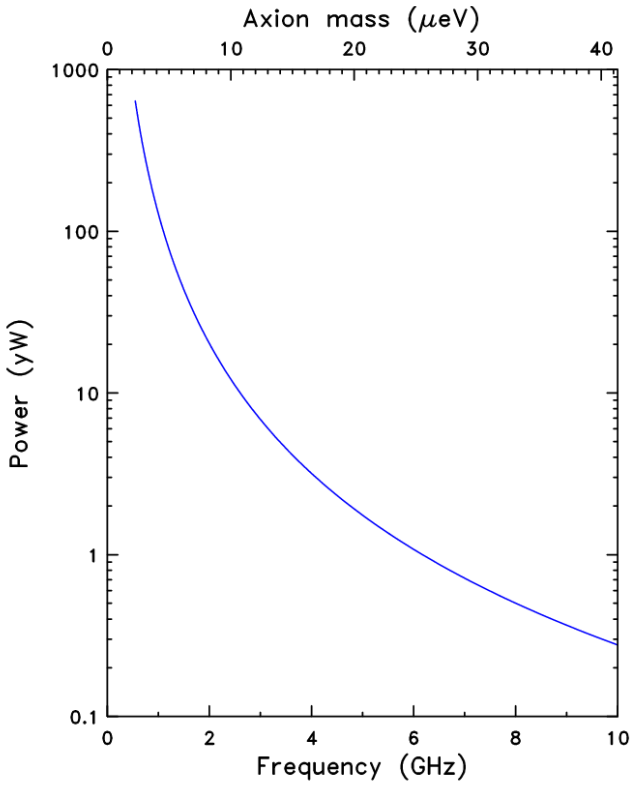
$$P = 130\ \mathrm{yW} \left(\frac{V}{200\ \ell}\right) \left(\frac{B_0}{8\ \mathrm{Tesla}}\right)^2 \left(\frac{C_{nl}}{0.5}\right) \left(\frac{g_\gamma}{0.36}\right)^2 \cdot \left(\frac{\rho_\mathrm{a}}{0.5\ \mathrm{yg/cm^3}}\right) \left(\frac{f_\mathrm{a}}{1\ \mathrm{GHz}}\right) \left(\frac{Q_\mathrm{L}}{100,000}\right)$$

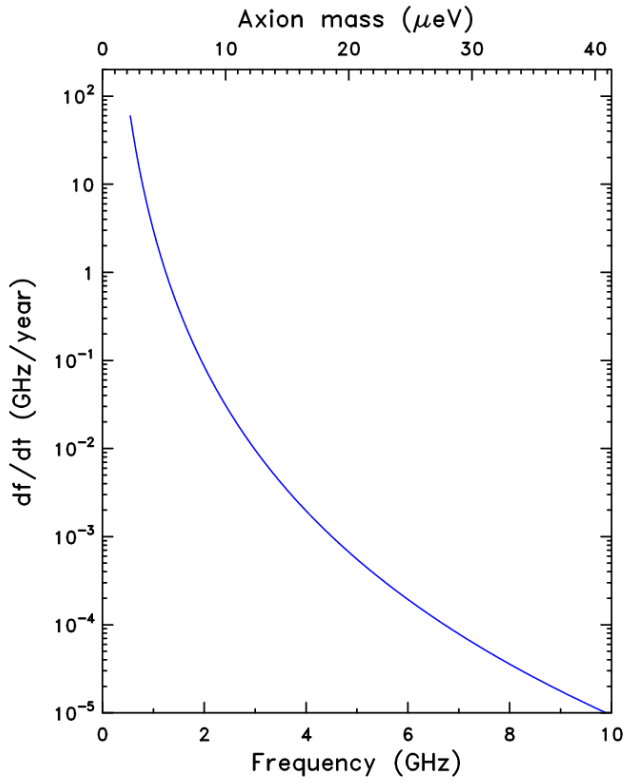
- 130 yW is about 200 photons/sec
- g_γ ~ 0.36 (DFSZ) while g_γ ~0.97 (KSVZ)
- Q_L ~ 120,000 (GHz/f)$^{2/3}$ (ASE) so bandwidth is 10 kHz

Strawman: Single cavity, 8 T field

$$\frac{r}{1\ \mathrm{cm}} = \frac{11.5\ \mathrm{GHz}}{f}$$

$$P = 130\ \mathrm{yW}\left(\frac{1\ \mathrm{GHz}}{f}\right)^{2.67}$$

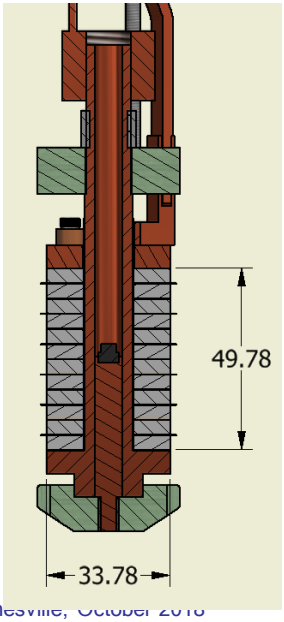


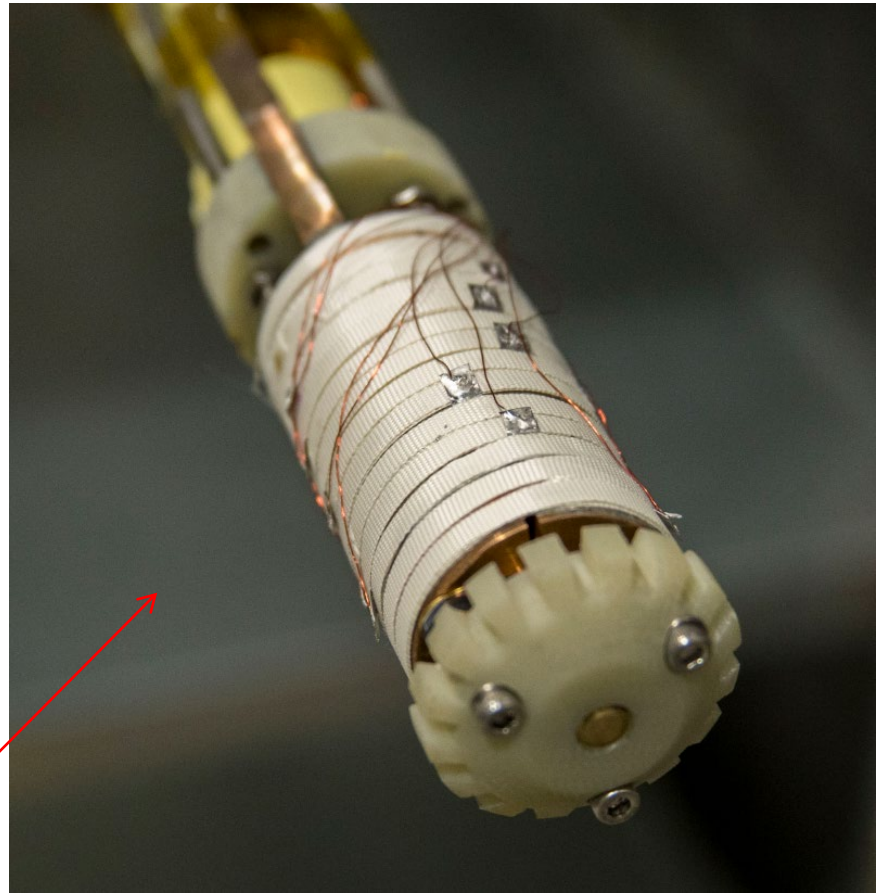


- Power and scan rate decrease as frequency goes up ☹. Just the opposite of what we want.
- Would have to give up on DFSZ above 1.4 GHz.
- New Magnet: Higher field ➔ Smaller volume ➔ Search higher frequencies

NHMFL No-Insulation Magnet Technology

- 42.5 T test magnet
  - Total central field = 42.5 T
    - No-insulation coil = 11.5 T
    - Resistive magnet = 31.0 T





Seungyong Hahn and Ian Dixon

32 T, 15 cm diameter NI ReBCO design from NHMFL

Magnet	Diam	TM_{010}	B	Cavities	Total V	Tnoise	P	Time for an octive
	cm	freq	T		liters	K	yW	months
ADMX	42	0.55	7.4	1	138	0.17	107	16
ADMX	17	1.3	7.4	4	95	0.19	240	14
"NMR"	5	4.3	18	1	0.3	0.17	3	38269
Bruker NMR	5	4.3	28	1	0.3	0.17	8	6536
NI ReBaCuO	15	1.5	32	1	7	0.17	134	15
NI ReBaCuO	6	3.6	32	4	5	0.24	297	20

- Should allow 1.5-10 GHz with 1, 4, 8 cavities
- Search rate about same as now with ADMX at 700 MHz.
- Increase to 40 T would improve rate substantially, to an octave in 8-9 months