High frequency (GHz and higher) ALP searches: opportunities and challenges

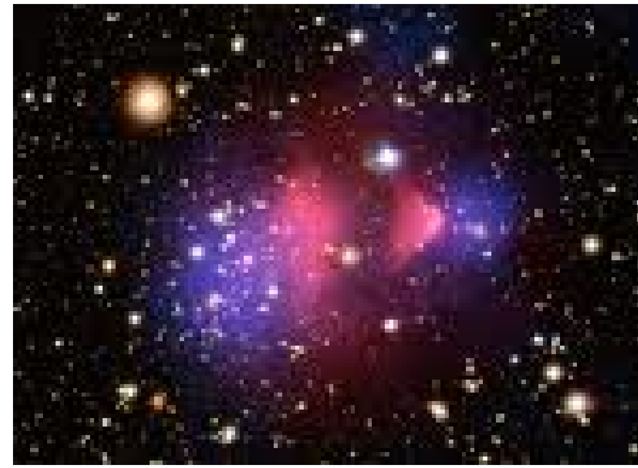
O.K. Baker
Yale University

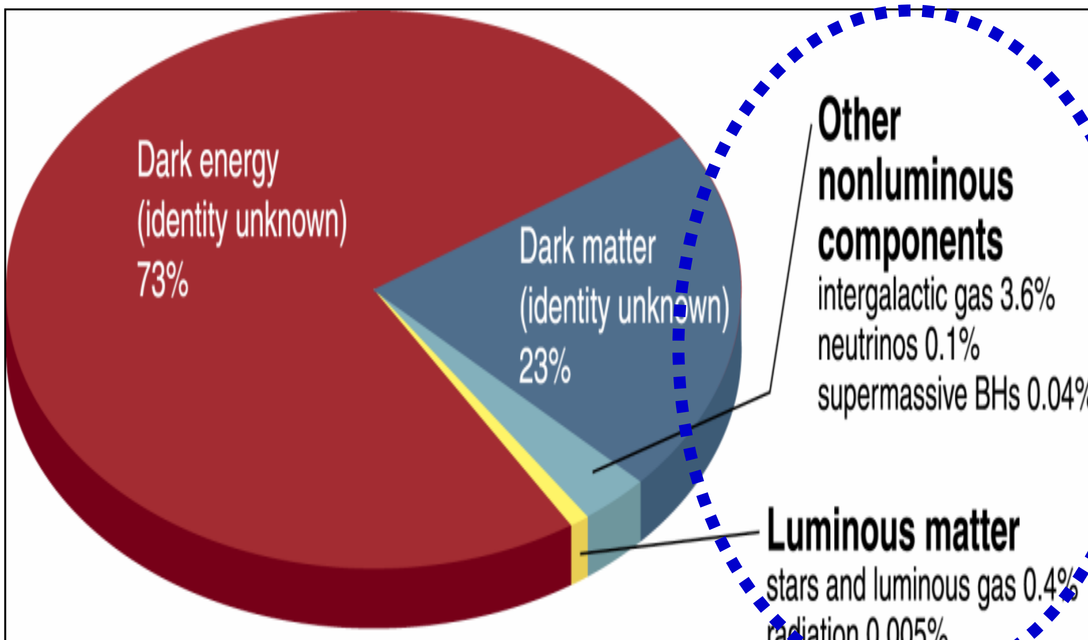
Patras-6

Zurich (2010)

DM candidates

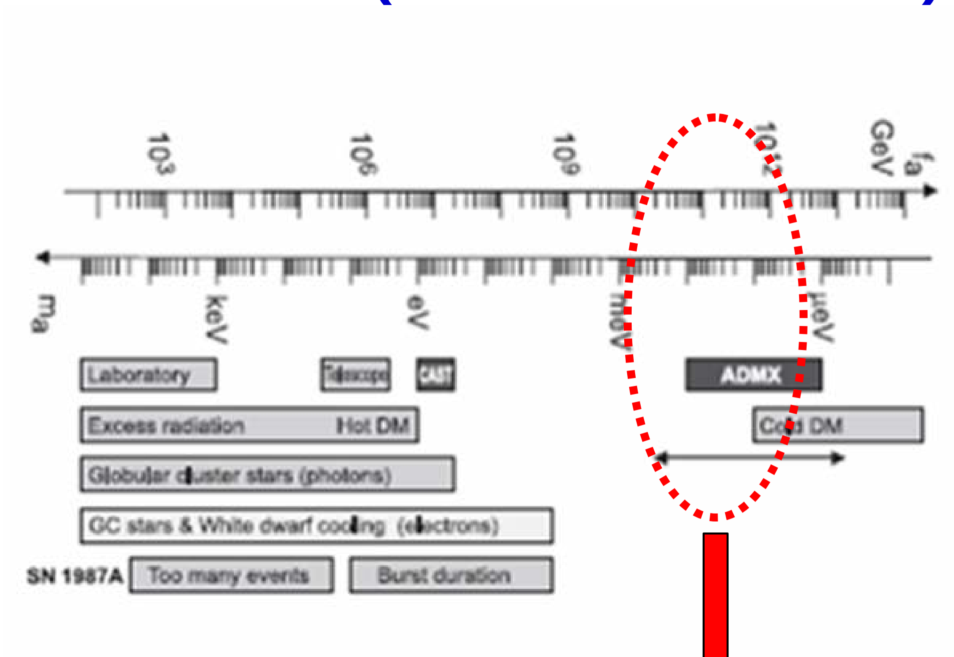
- most likely particle relic from the Big Bang
- — WIMPs
- — axions
- --- . . . ?





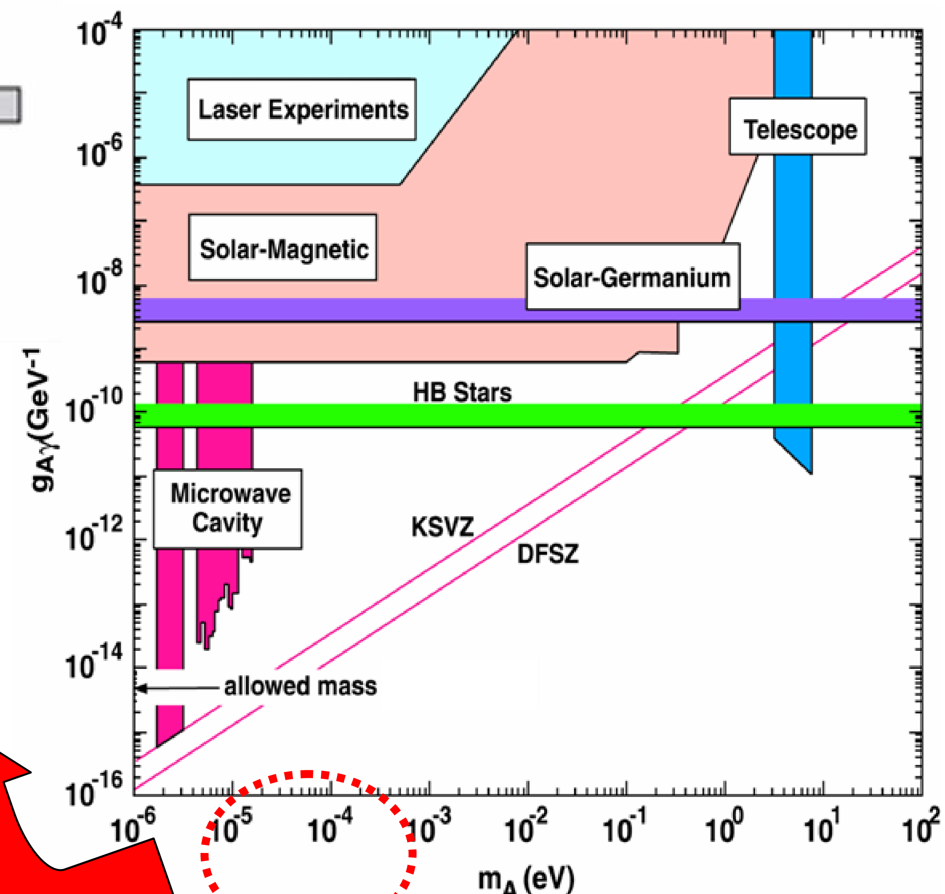
57 distinct particles

GHz (10^{-5} -10^{-4} eV) axion dark matter

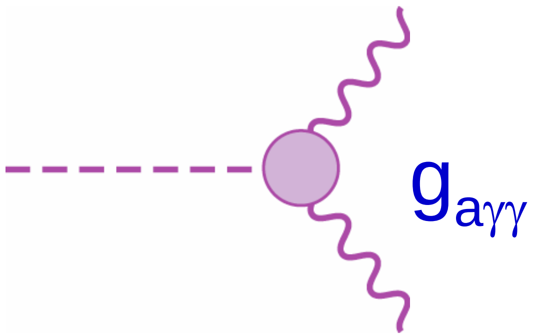


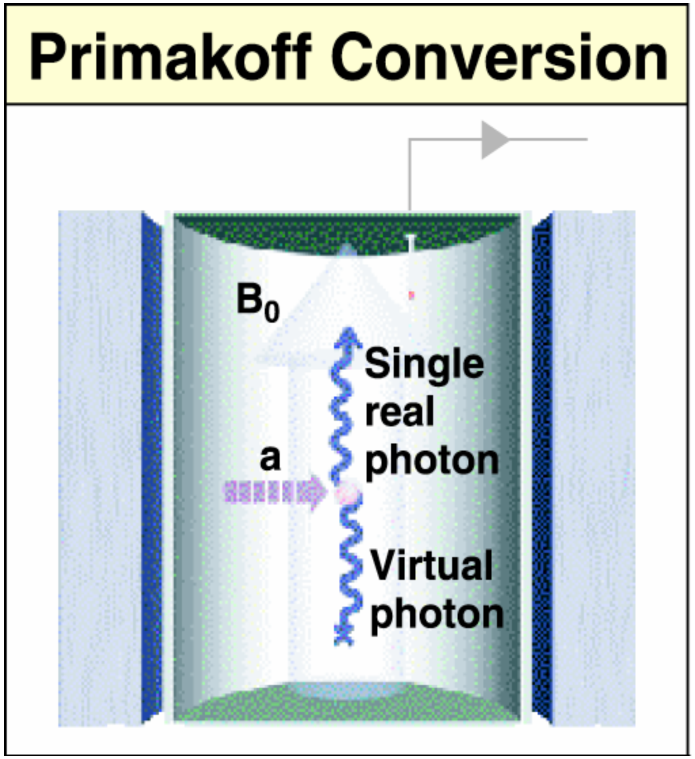
favored by axion DM

'sweet spot'



axion DM





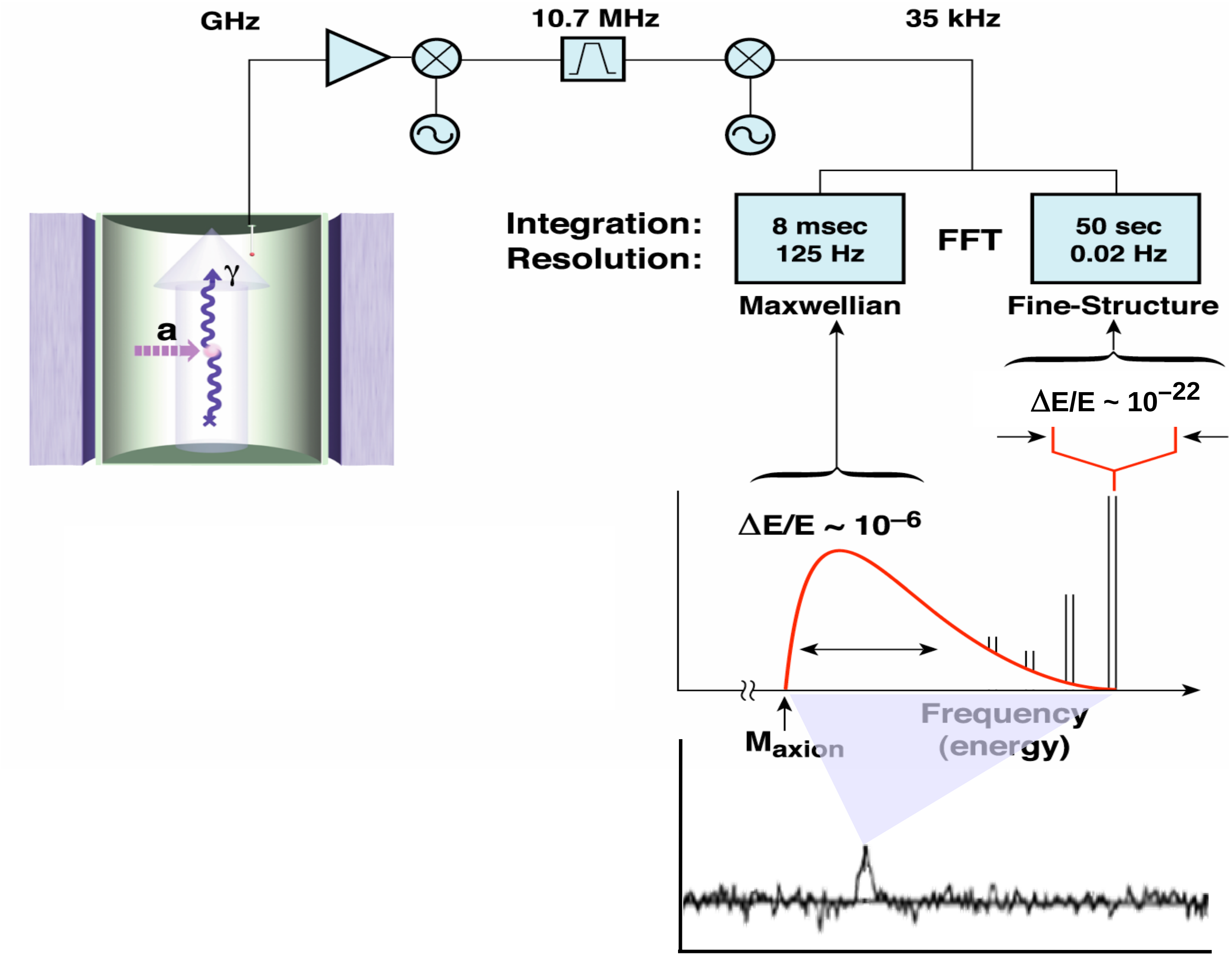
- ~ model independent
- virtual photon provided by high field magnet (benefit from industry)
- solves more than one problem
  - strong CP problem
  - DM problem
- galactic halo axions would have large number density,
- ~ 10^{13} -10^{14} cm^{-3}

ADMX example

'the gold standard'

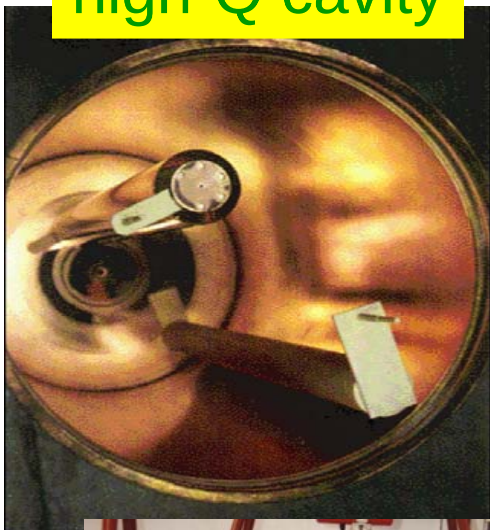
μeV (100s MHz) axion masses

implementation: ADMX

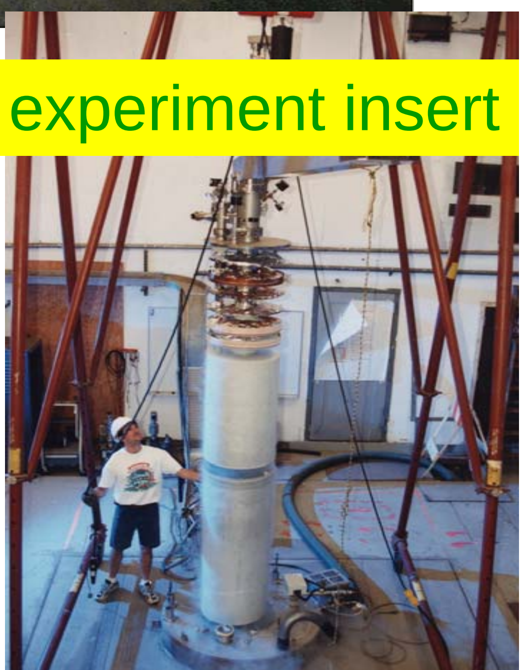


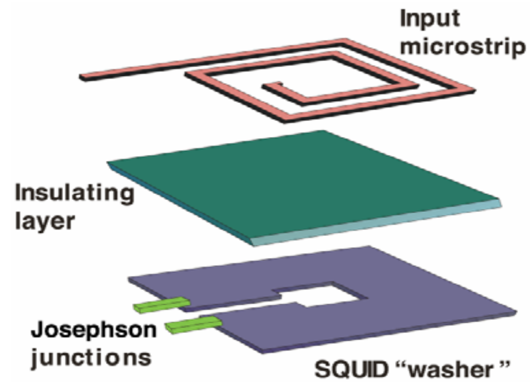
ADMX hardware and detection system

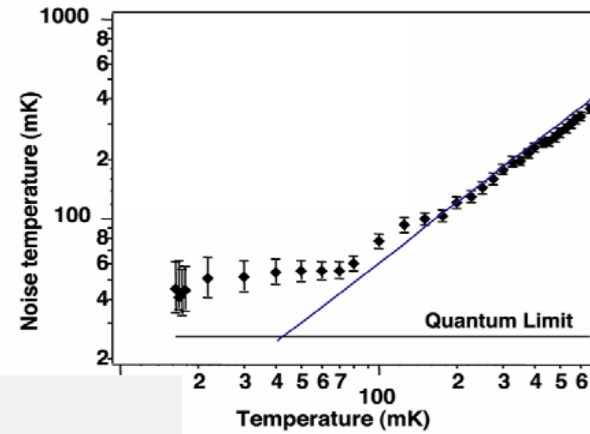
high-Q cavity



experiment insert







SQUID-based amplification

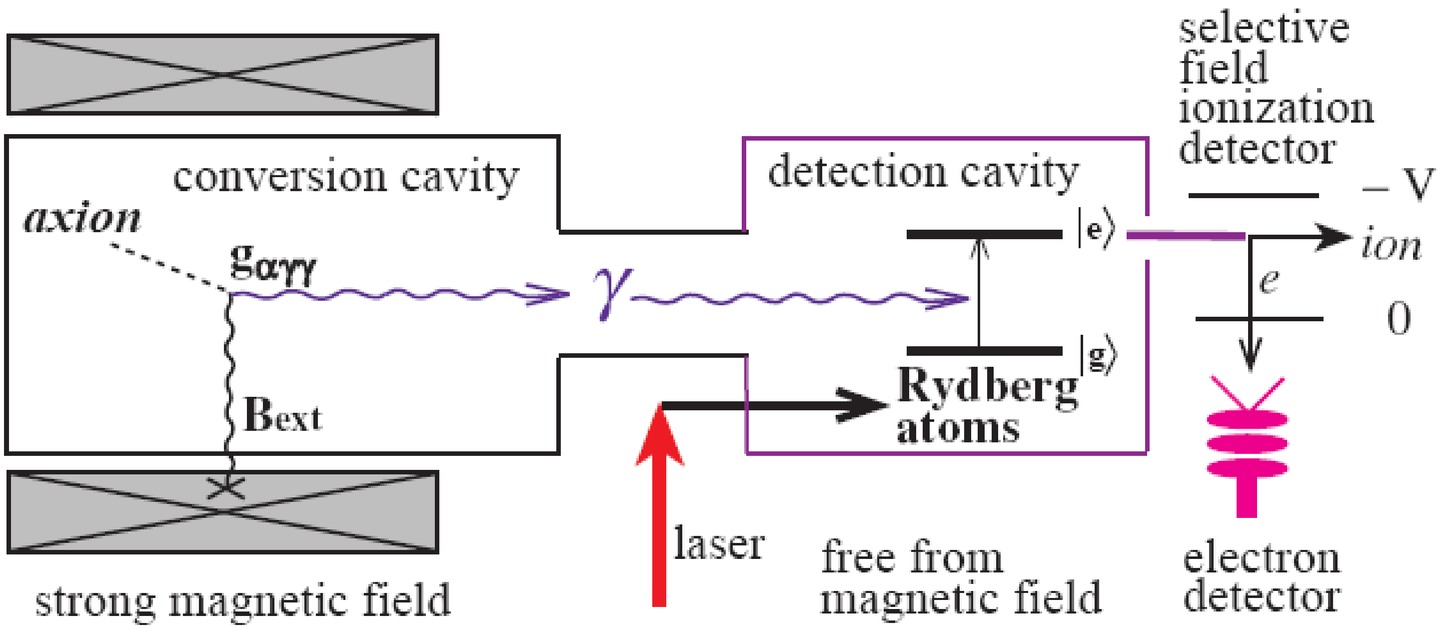
- **SQUIDs have been measured with T_N ~50 mK**
- **enormous increase in ADMX sensitivity**

Kyoto University and Rydberg atoms as detector

A coupled microwave-cavity system in the Rydberg-atom cavity detector for dark matter axions

M. Tada, Y. Kishimoto, M. Shibata, K. Kominato, I. Ogawa, H. Funahashi, K. Yamamoto, S. Matsuki

- Kyoto University-



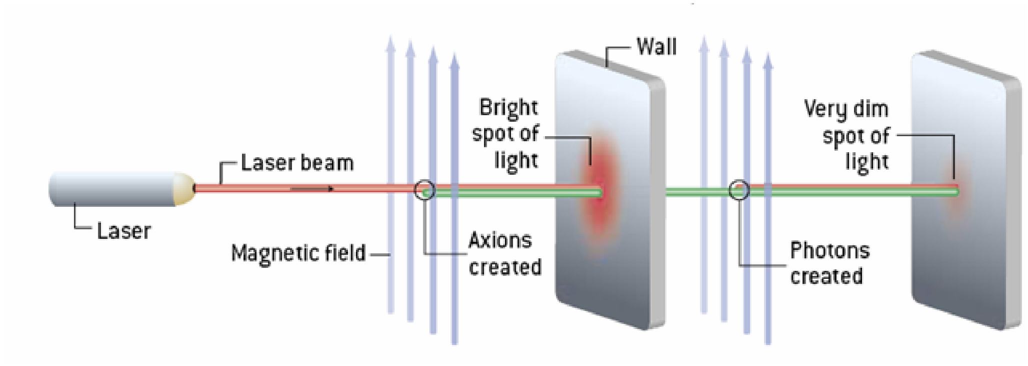
very high sensitivity for (converted) photon detection

microwave cavity experiment at Yale

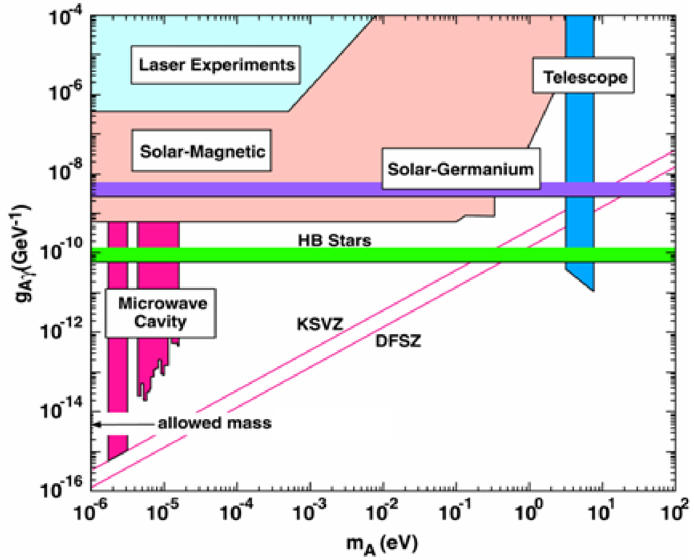
Penny Slocum's talk later today!

`Light Shining Through a Wall'

- Sikivie (1983); Ansel'm (1985); Van Bibber et al (1987)



relic halo axions

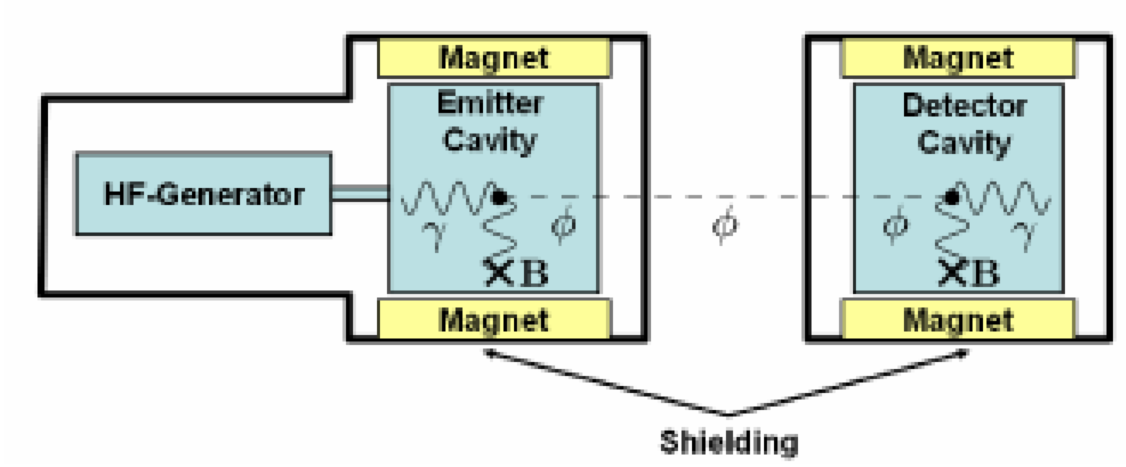


LSW experiments

• ALPS	DESY
• BMV	LULI
• GammeV	FNAL
• LIPSS	JLAB
• OSQAR	CERN
• PVLAS	INFN
• Q&A	Taiwan
• CAST	CERN
• Tokyo Axion Helioscope	Tokyo

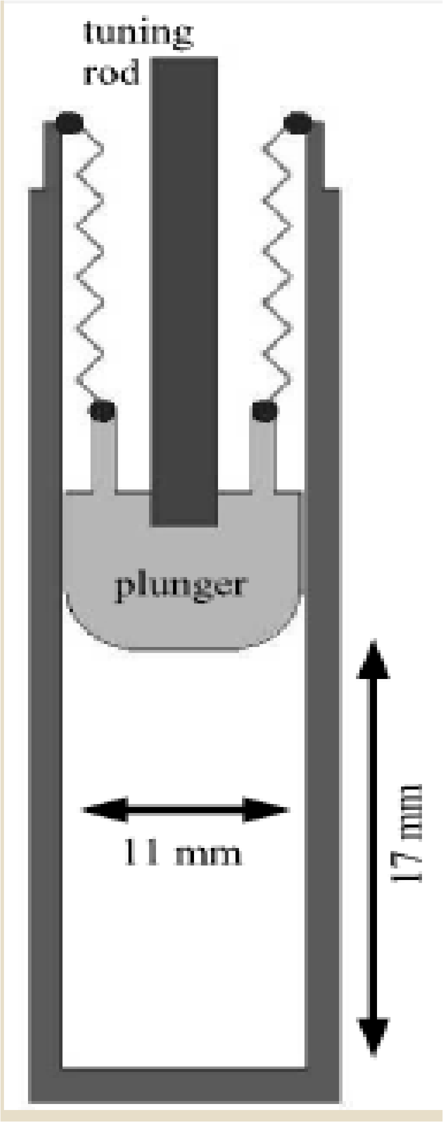
high-Q resonant cavity

Jaeckel and Ringwald ('07)



- motivated by Jaeckel and Ringwald idea
- use magnicon (rf source) at Yale
- high-Q resonance cavity

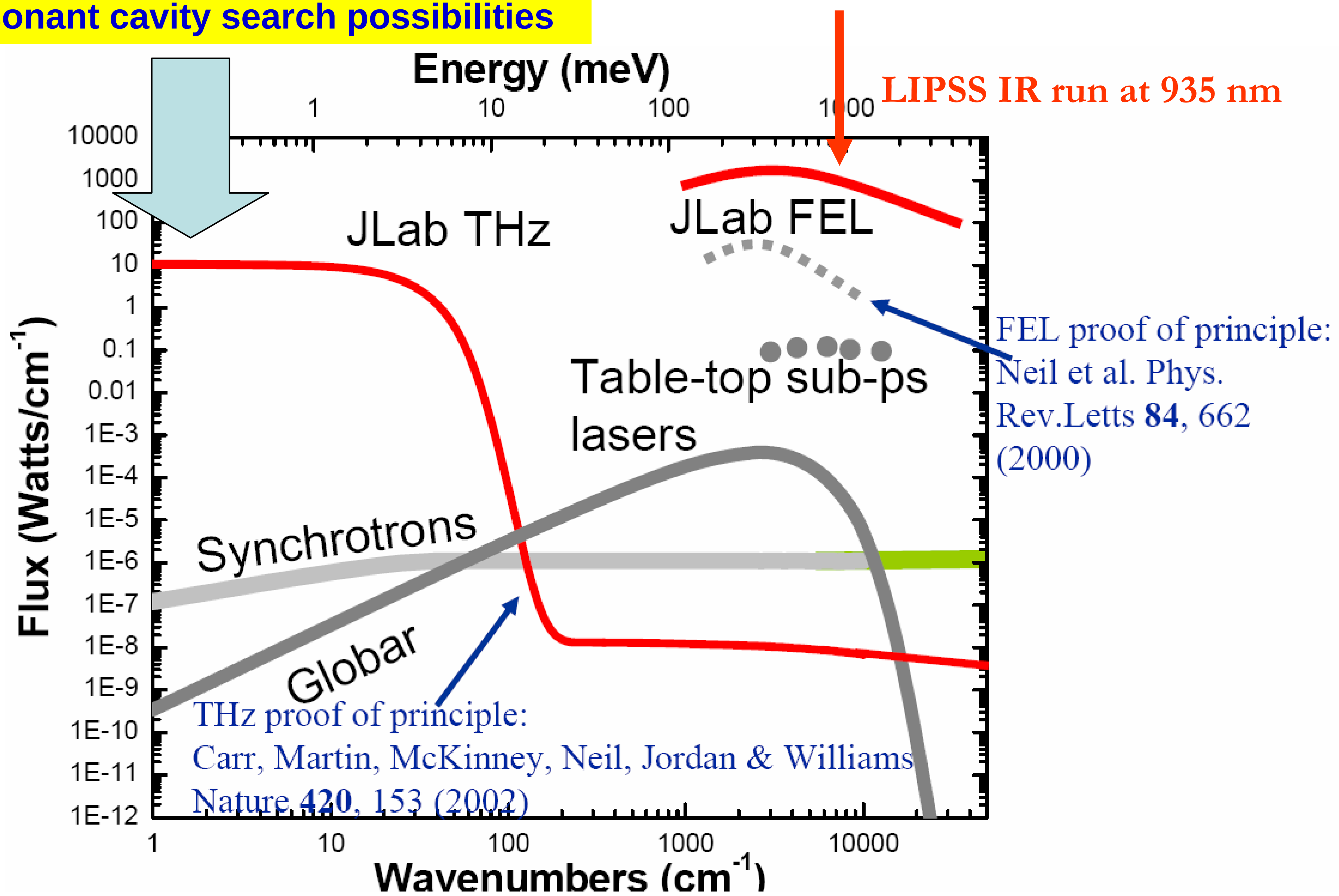
microwave cavity at Yale



- 34 GHz (initially)
- 1 cm diameter Cu resonant cavity
- tune using plunger
- immerse in 7T magnetic field
- simultaneous LSW and relic axion search

JLAB facility spectroscopic range

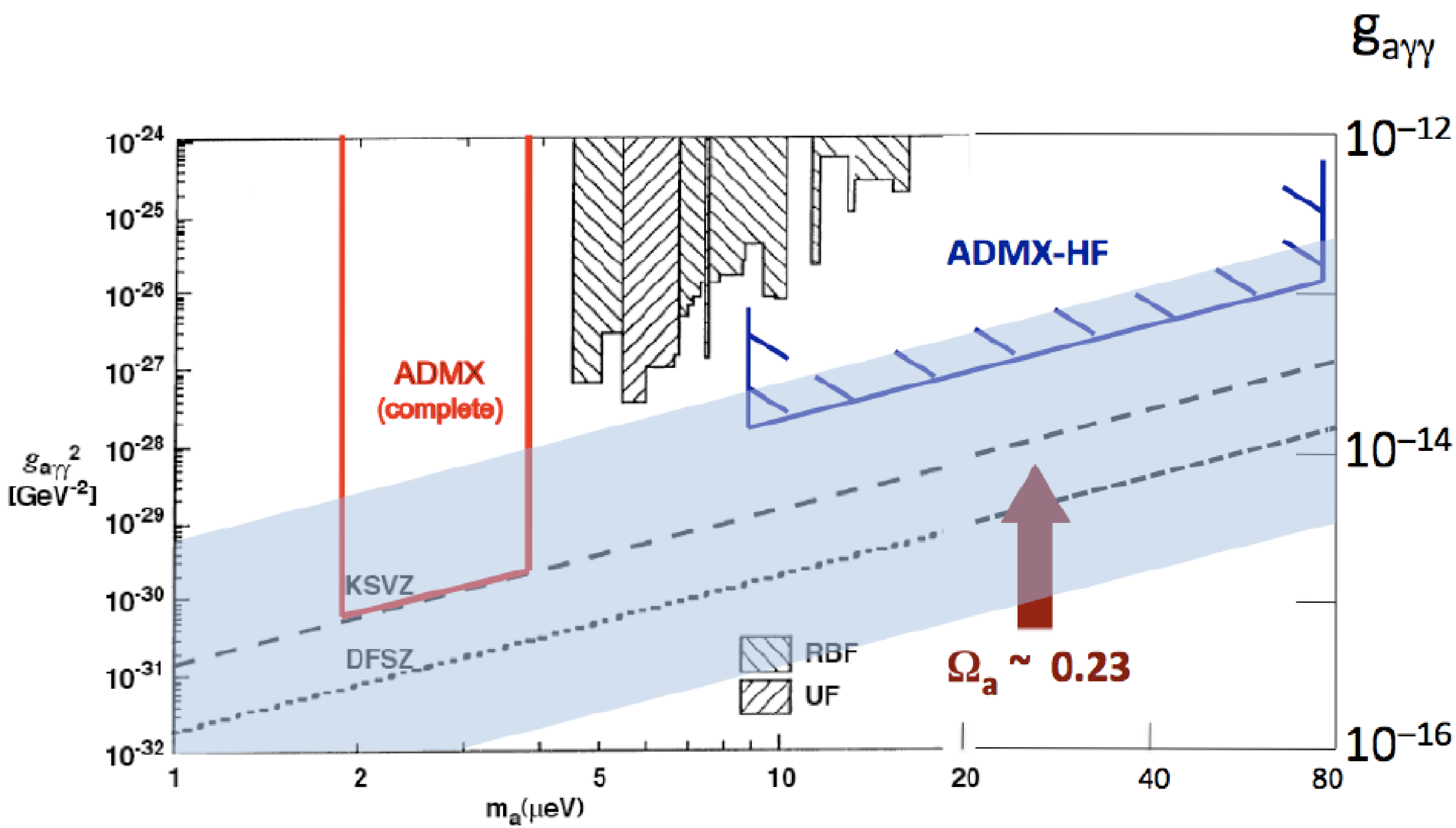
resonant cavity search possibilities



microwave cavity experiment at Yale

- 7 T magnetic field
- quality factor $4 \cdot 10^4$ ($Q_a = 10^6$)
- cavity volume 1 liter
- f = 3 GHz (for the present calculation)
- NET 3 ^{o}K
- form factor 0.7
- integration time ~3 years

a ‘trolling’ experiment



K. Van Bibber, pri ocmm (2010)

opportunities

- axions ~ 10^{-4} eV (10 GHz) favorite DM region
  - if dominant DM
- spin-2 particles in this mass range
  - E. Masso, Axions 2010, Univ of FL
- other BSM fields
  - paraphotons (Rhys Povey, John Hartnett, Michael Tobar, '10) chameleons, . . .
- gravity waves
  - may be best way to set new limits in this frequency range (J. Sandweiss, Yale)

summary

- the sweet spot for axion DM is ~ 1- 30 GHz.
- relic galactic halo axions include g^2, compared with g^4 for LSW experiments
- implementing a microwave cavity experiment (see P. Slocum's talk later today) in this frequency range
- possible sensitivity to other particles and fields

relic gravitational waves

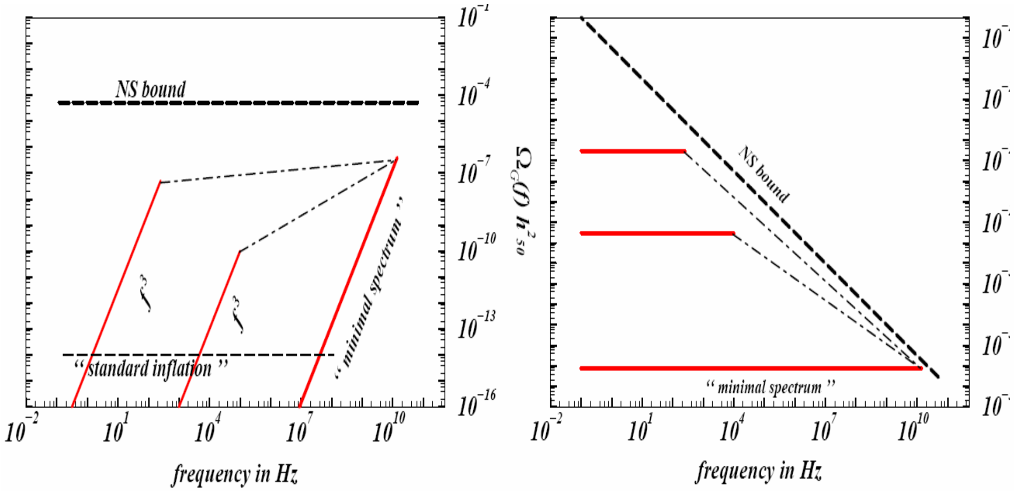
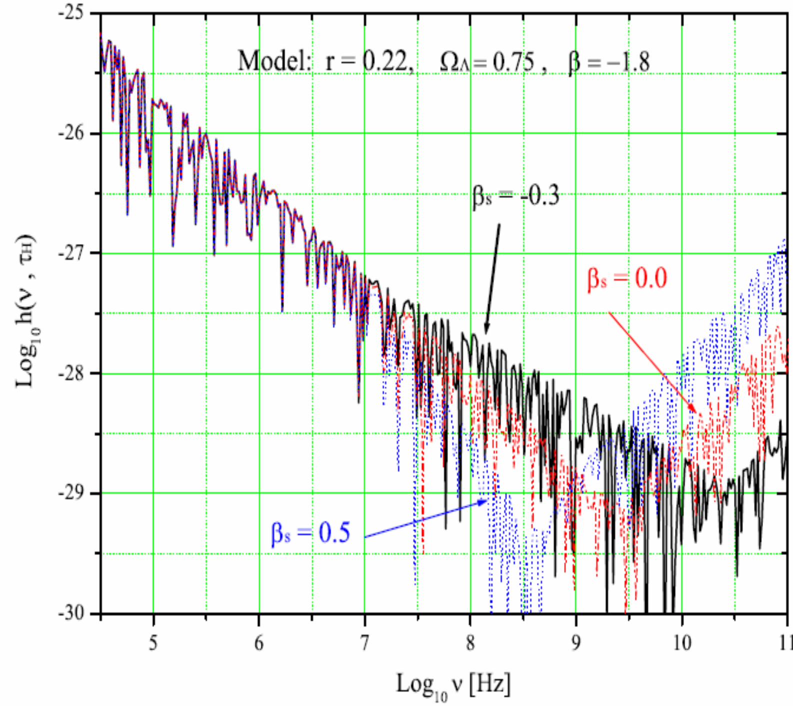


Figure 1. *Energy density* $\Omega_G(f) = \rho_G(f)/\rho_c$ *(left) and spectral amplitude (right) of gravitational waves (GW). The solid lines are possible spectra of GW produced during the dilaton-driven phase. The minimal spectrum provides a lower bound on energy density in GW produced during the dilaton-driven phase and the thick dashed line marks a nucleosynthesis upper bound. The dot-dashed lines are extrapolations of the spectrum into the string phase. The spectrum expected from slow-roll inflation is shown (left) for comparison.*



arXiv:hep-th/9604159
Ram Brustein

M. L. Tong, Y. Zhang
Chin. J. Astron. Astrophys. 8, 314, (2008)