

Axions at Nikhef?

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Used slides from Axel Lindner

Motivation - Physics

- **The QCD axion:**

- Solves the strong CP problem in SM, and couples to two photons
- People interested at Nikhef. What about ALPs?

- **Axion Like Particles - ALPs:**

- Does not solve open issue in SM but motivated by: astrophysical hints, cold DM candidate, and appears in string theory
- Small(er) group interested at Nikhef

- **Why WIMPs and WISPs**

- ALPs parameter space should be explored, other experiments (LHC, DM) show no BSM physics so far
- WIMPs and WISPs can both exist two leading DM candidates

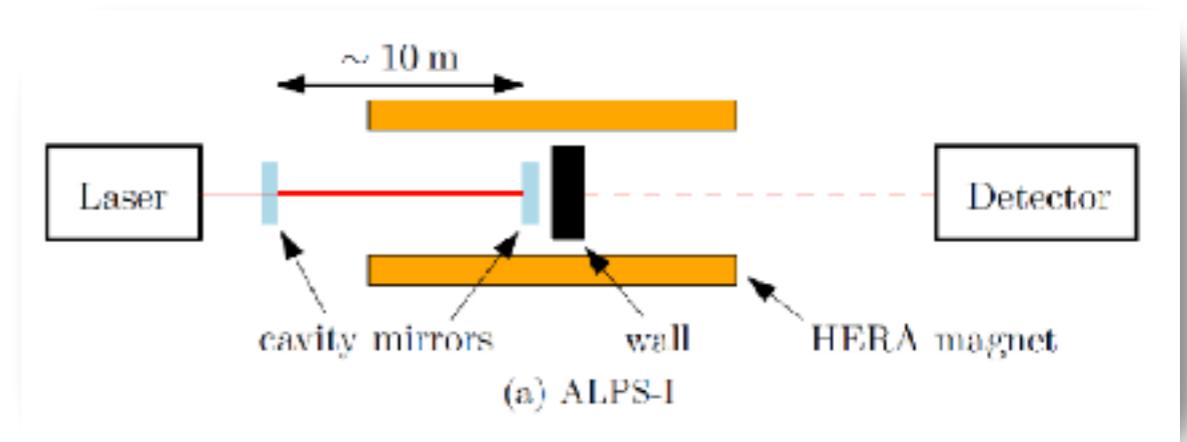
- *No WIMPs and no WISPs*

- *Our understanding of gravity is not complete, (e.g. Verlinde) and no need for DM*

Experimental Landscape

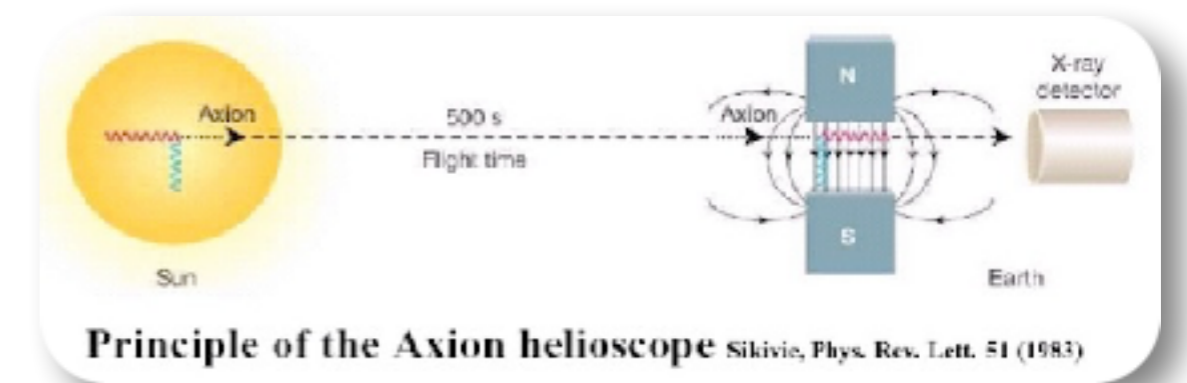
- **Purely laboratory experiments**

- “light-shining-through-walls” \Rightarrow optical photons



- **Helioscopes**

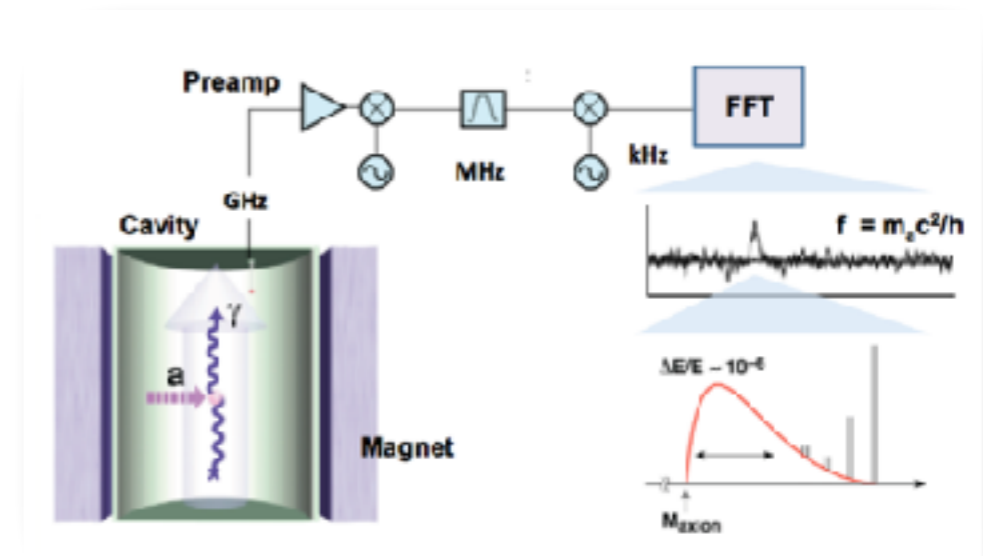
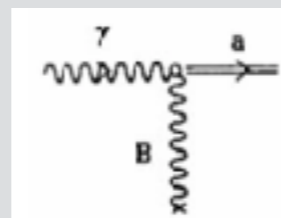
- WISPs emitted by the sun \Rightarrow X-rays



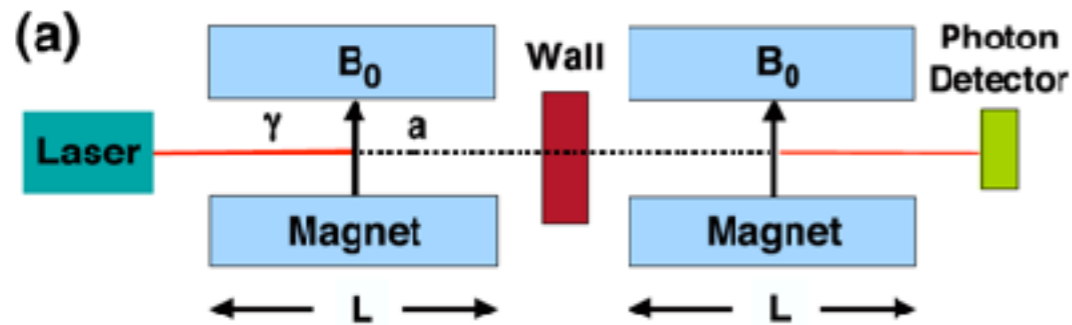
- **Haloscopes**

- Looking for axions in Milky Way halo (DM) \Rightarrow μ -waves

Primakoff effect



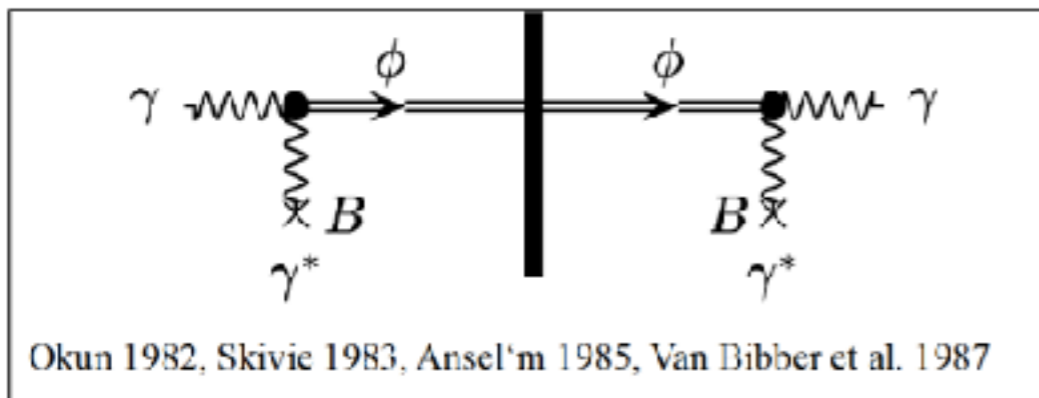
ALPS-2



Photon regeneration rate:

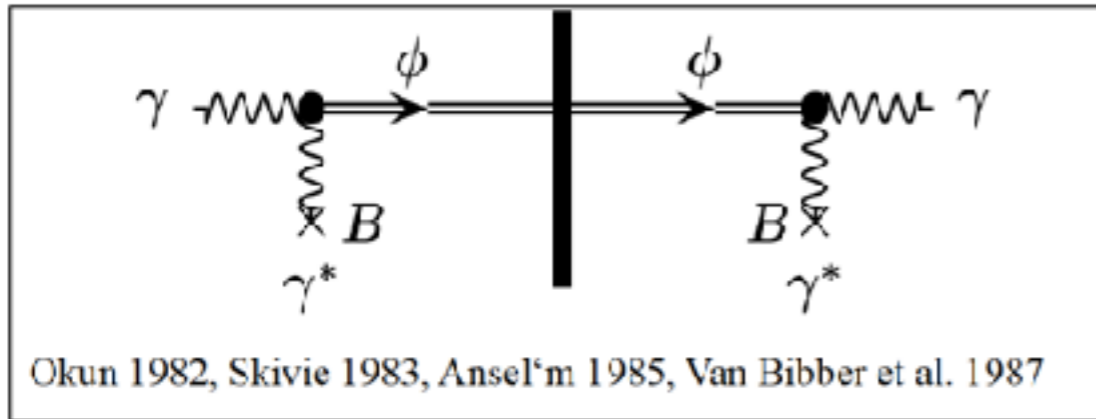
$$P_{\gamma \rightarrow \phi \rightarrow \gamma} = \frac{1}{16} \cdot (g_{a\gamma} B l)^4$$

$$= 6 \cdot 10^{-38} \cdot \left(\frac{g_{a\gamma}}{10^{-10} \text{GeV}^{-1}} \frac{B}{1 \text{T}} \frac{l}{10 \text{m}} \right)^4$$



| | 2015 | 2016 | 2017 | 2018 | 2019 | |
|------------------|-------------------|------|------|------|------|--|
| ALPS IIa | (without magnets) | | | | | <div style="display: flex; align-items: center;"> <div style="width: 15px; height: 15px; background-color: yellow; margin-right: 5px;"></div> Install. <div style="width: 15px; height: 15px; background-color: green; margin-left: 20px; margin-right: 5px;"></div> Runs </div> |
| risk assessments | | | | | | |
| ALPS IIc | | | | | | |

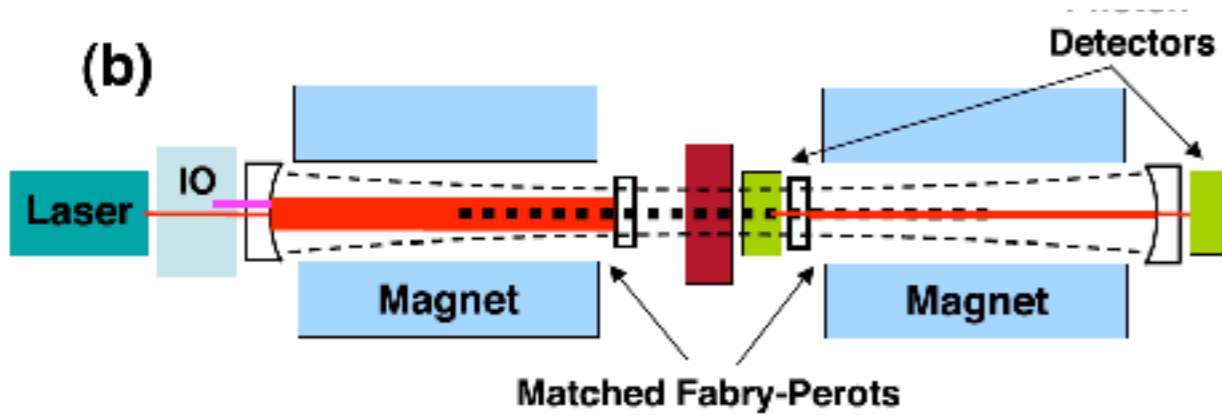
ALPS-2



Photon regeneration rate:

$$P_{\gamma \rightarrow \phi \rightarrow \gamma} = \frac{1}{16} \cdot \mathcal{F}_{PC} \mathcal{F}_{RC} \cdot (g_{\alpha\gamma\gamma} B l)^4$$

$$= 6 \cdot 10^{-38} \cdot \mathcal{F}_{PC} \mathcal{F}_{RC} \cdot \left(\frac{g_{\alpha\gamma\gamma}}{10^{-10} \text{GeV}^{-1}} \frac{B}{1 \text{T}} \frac{l}{10 \text{m}} \right)^4$$



Skivie PRL 98, 172002 (2007)

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| ALPS IIc | | | | | | |

Axel Lindner Oct 2016

Parameter space

- **Motivation**

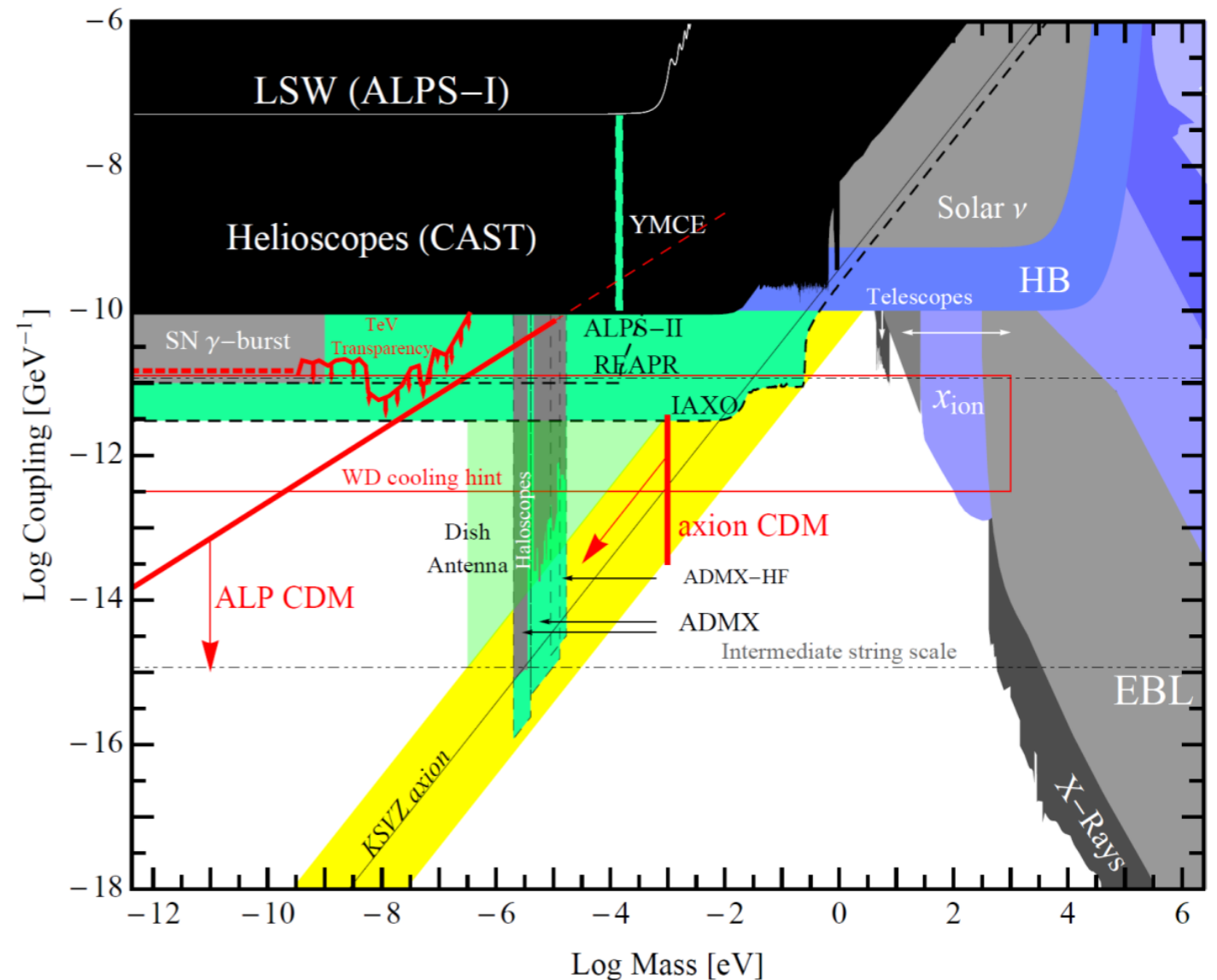
- QCD axion, Axion CDM, ALP CDM
- WD cooling hint , TeV transparency

- **Limits from astro-particle physics:**

- FermiLAT result?

Exclude: coupling $> 5 \cdot 10^{-12}$
 GeV^{-1} for ALP masses $0.5 < m_a$
 $< 5 \text{ neV}$

- SN γ -burst?



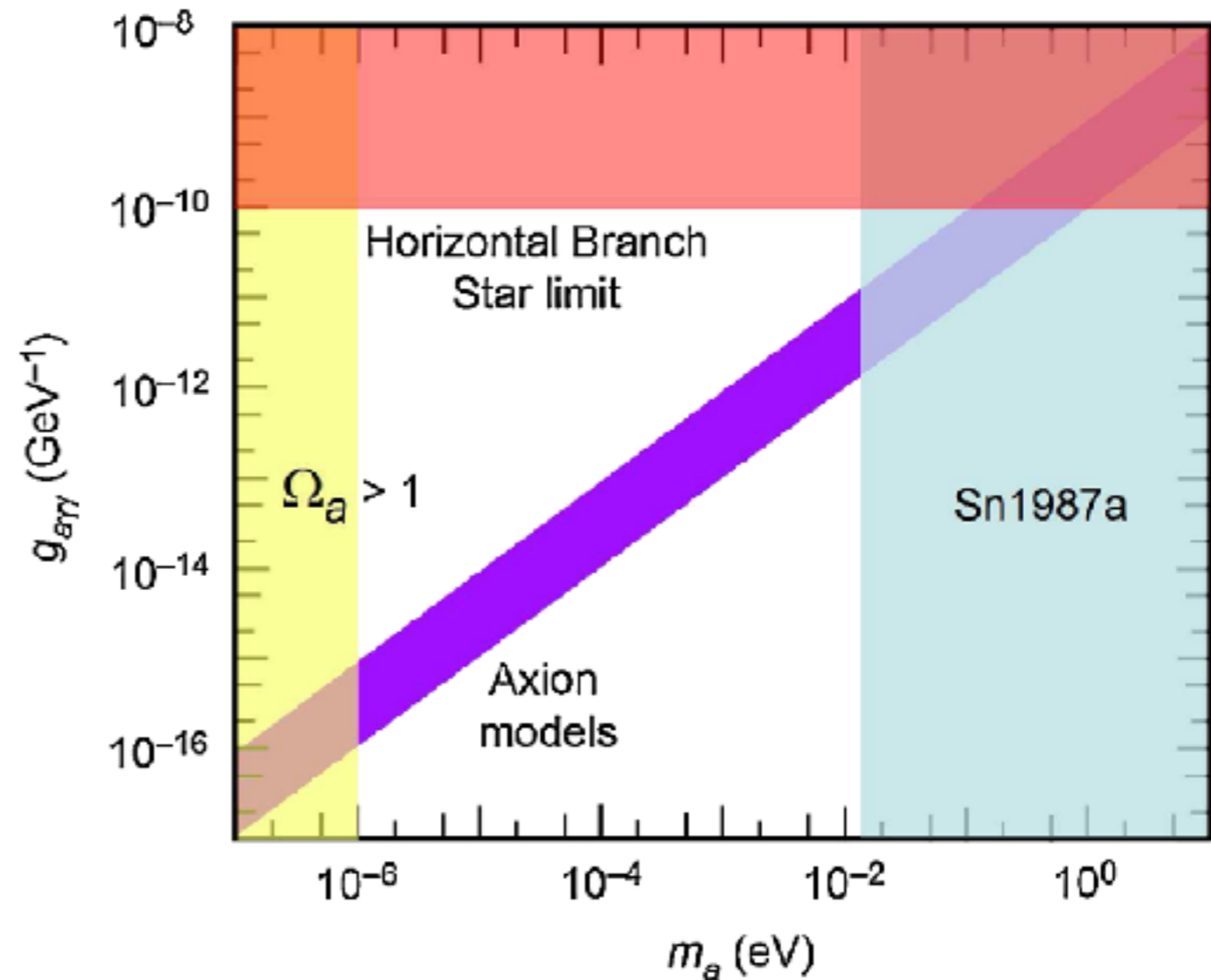
arXiv:1306.2841v1 [hep-ph] 12 Jun 2013

Dish antenna?

Parameter space

Constraints on axion mass and coupling

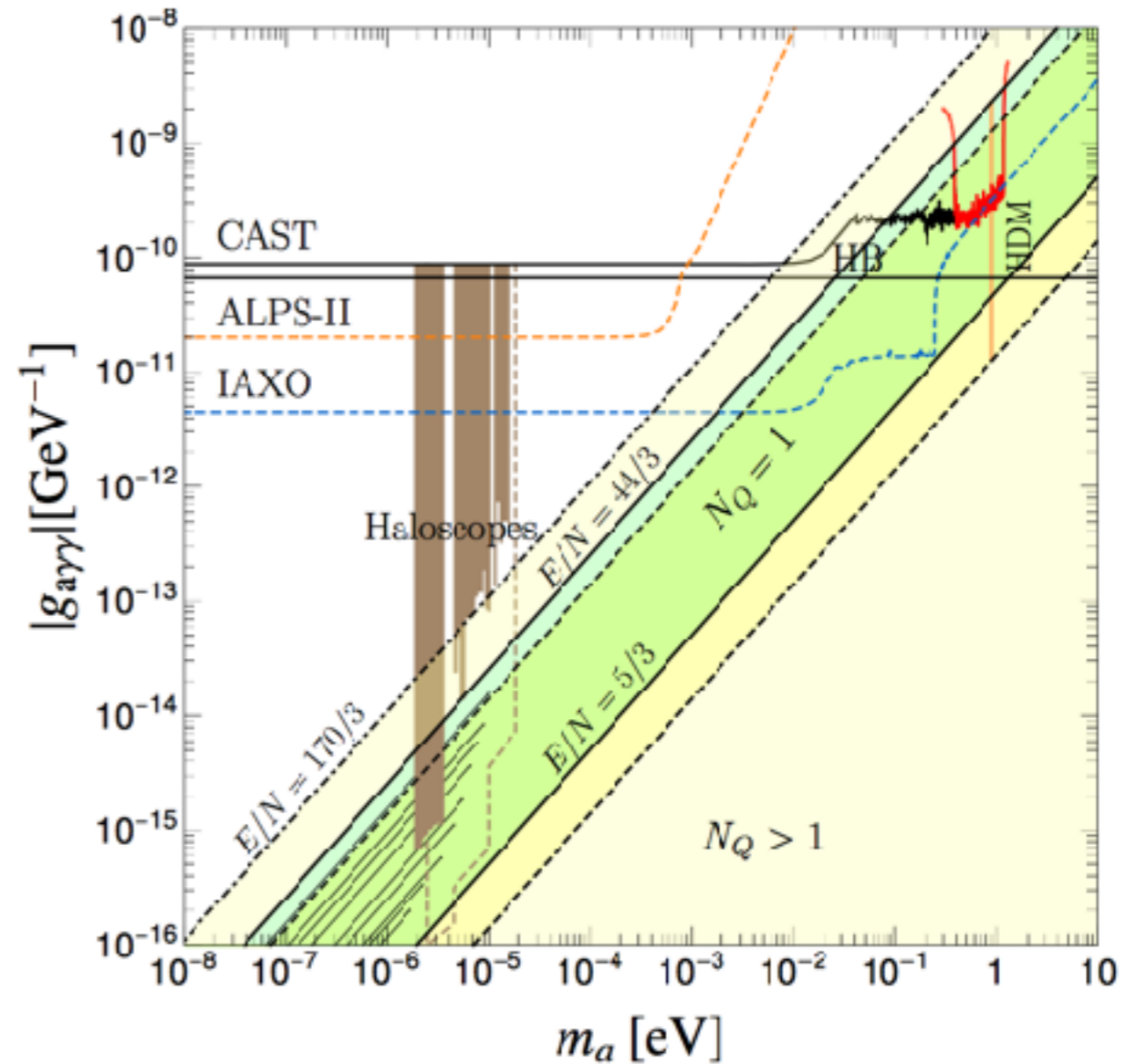
- Cosmological constraint ($\rho_a \sim 1/m_a$): many uncertainties - **yellow**
 - Laboratory experiments & stellar evolution (Type 2 supernovae) - **blue**
 - Stellar evolution (energy loss stars) - **red**
- ➔ Compare with previous slide?



Mueller *PHYSICAL REVIEW D* 80, 072004 (2009)

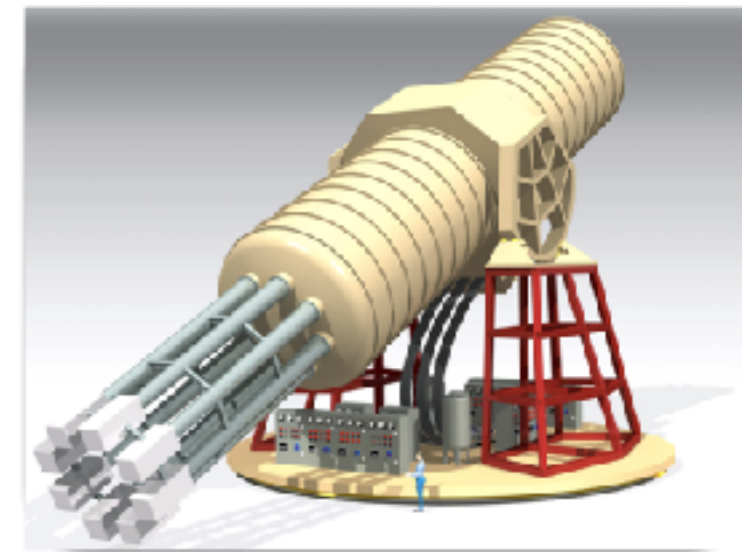
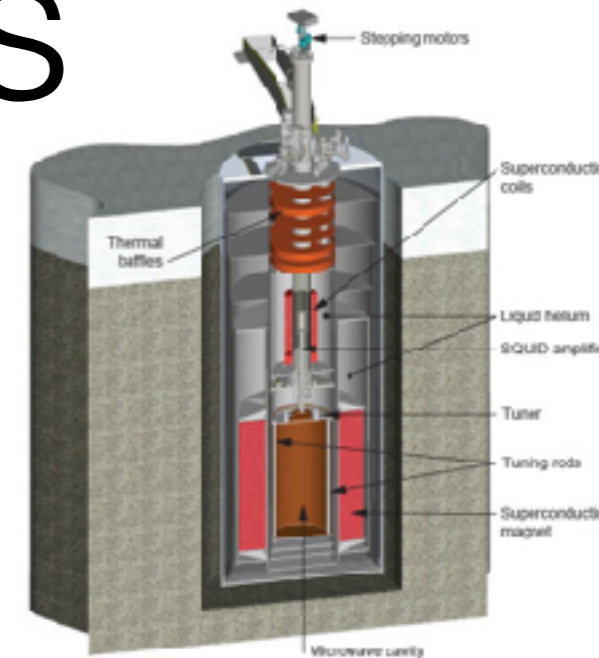
Parameter space?

- QCD axion band changes
- Freedom in parameter space of QCD axion?



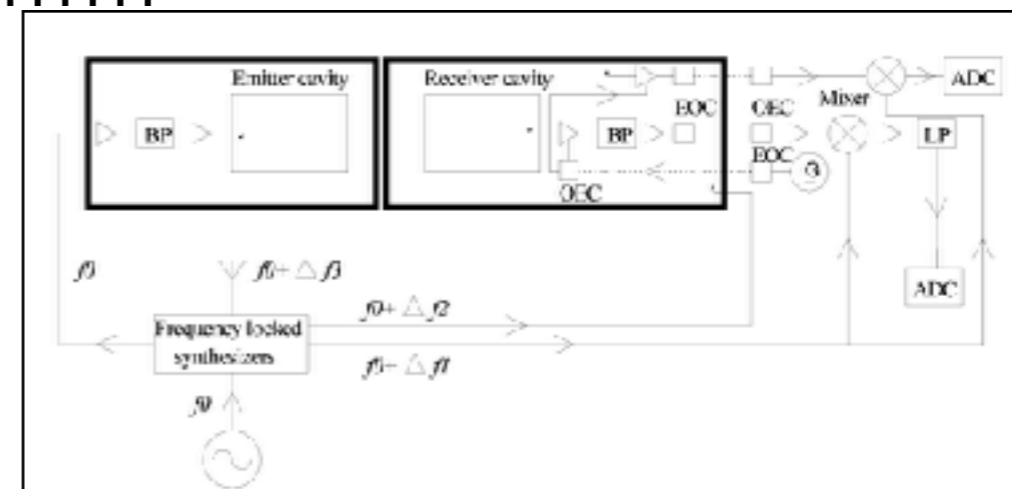
arXiv:1610.07593

Many experiments



- ADMX (US)- world leading
- Many experiments with different techniques.....
- What to choose:
 - Impact of ALPS-2?
 - Room to improve (LSW) experiments - sensitive for QCD axion?
 - Future experiments? ALPS2 IAXO.....

*Microwave cavity LSW experiment:
arXiv 0908.0759*



ALPS-2 @ Nikhef

Motivation

- Many **uncertainties** on ALPs parameter space and on nature of DM
- **Overlap** with instrumentation expertise - GW & DR&D
- Use ALPS-2 as start to **enter new & interesting field** @ low cost
- Limited **effort** - few staff part-time (25%)
- Collaborate on **new technologies**: e.g. SRON - Kinetic Inductance Detector (CMB)
- **Future experiments**: e.g. x-ray detector with GridPix and magnets (Ten Cate - CERN, Twente University) for IAXO

Contribution

- **Start helping** ALPS2 on instrumentation: manpower
- **Instrumentation** development (future) and **Theory**
- Link with **other programs** GW, LHC, eEDM, Xenon1T
- **Small activity** - not a major new program - part of a few smaller experiments - Vista25
- **Funding** - Start with *projectruimte*