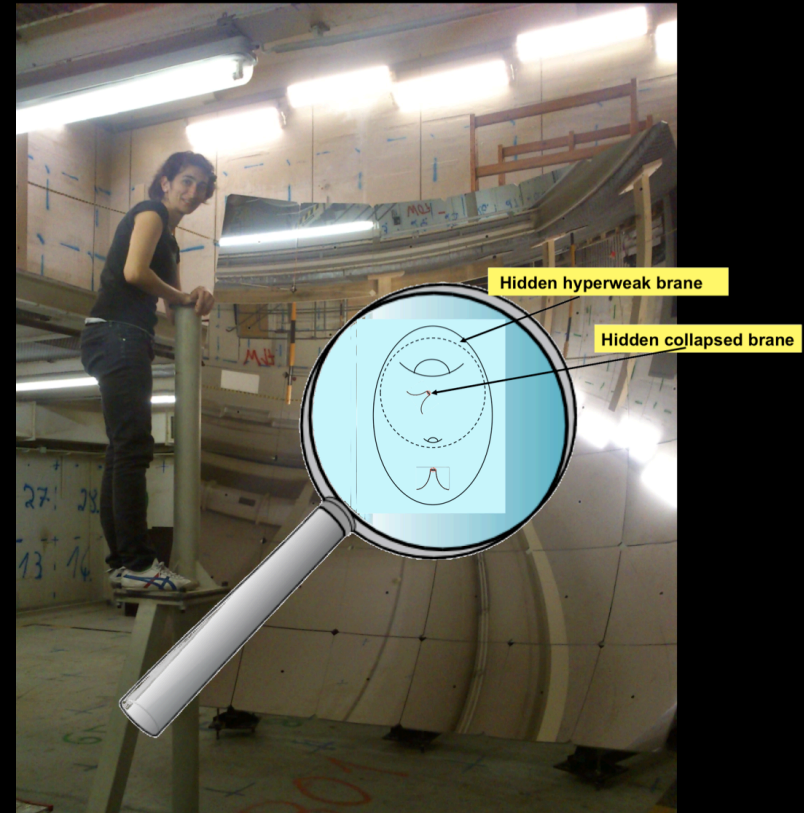


# Searching ALPs and HPs in new and old experiments

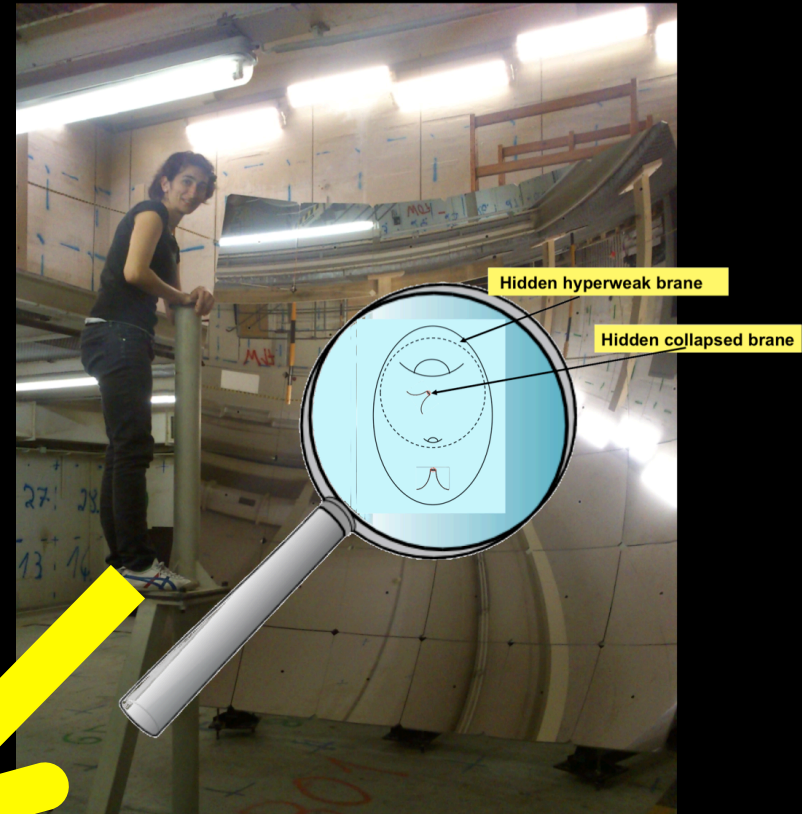
**J. Jaeckel**  
ITP Heidelberg



S. Abel, M. Cicoli, B. Doebrich, R. Engel, D. Horns,  
M. Goodsell, H. Gies, T. Hugle, V. Khoze, M. Klassen, S. Knirck,  
A. Lindner, A. Lobanov, J. Redondo, A. Ringwald, C. Wallace

# Searching ALPs and HPs in new and old experiments

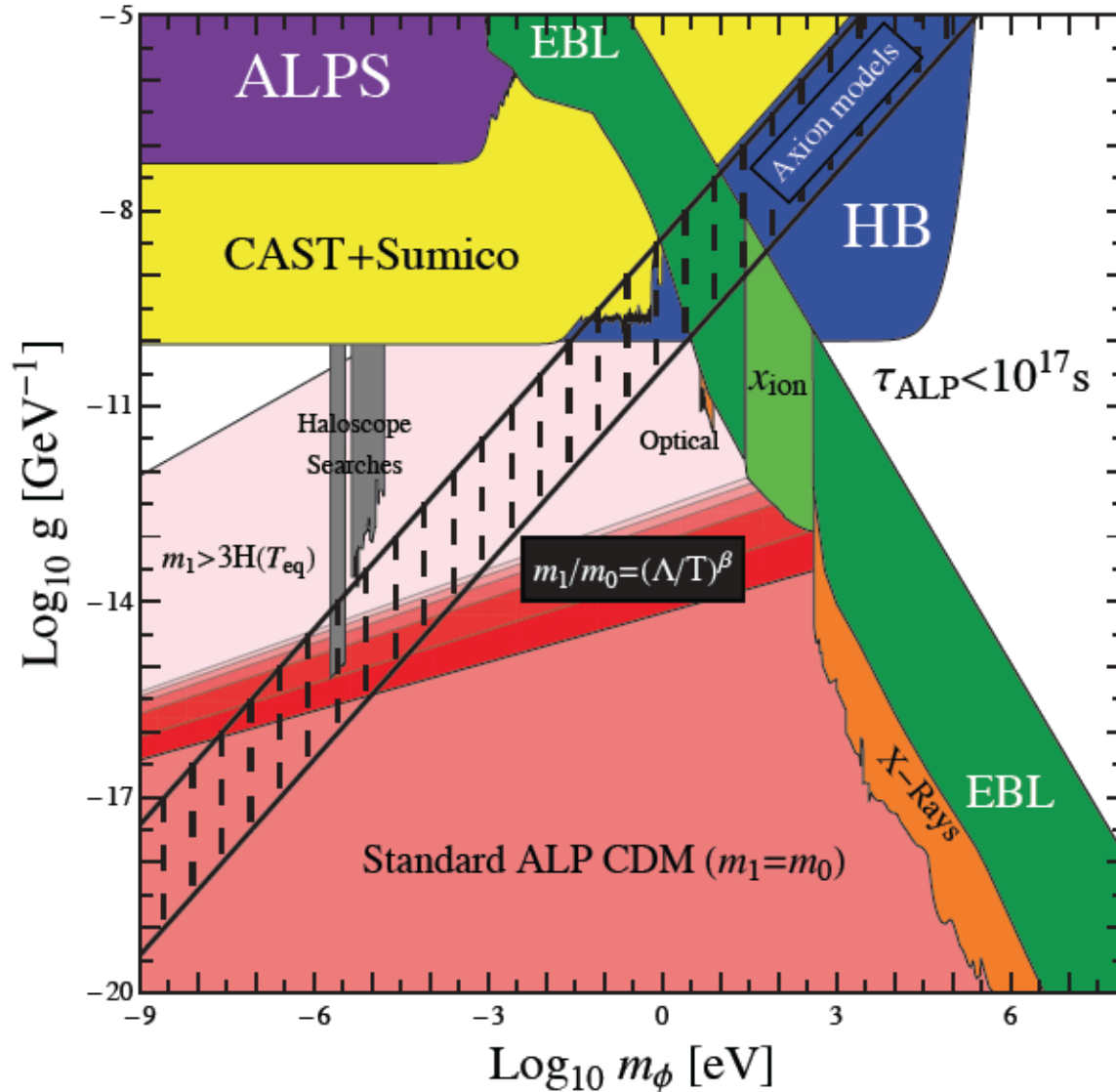
**J. Jaeckel**  
ITP Heidelberg



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A. Lindner, A. Lobanov, J. Redondo, A. Ringwald, C. Wallace

Dark Matter(s)

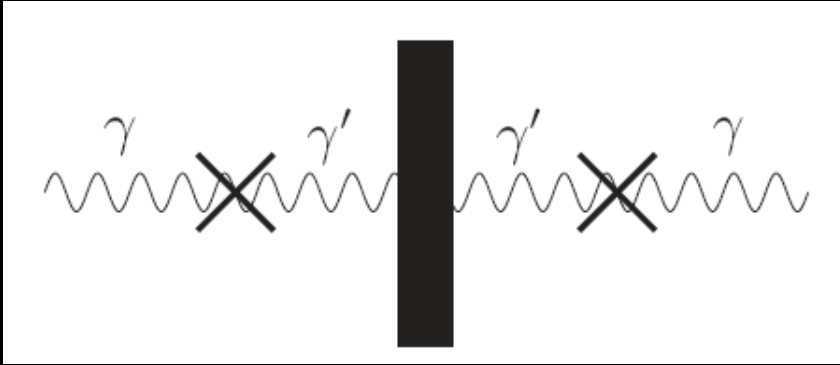
# Axion(-like particle) Dark Matter





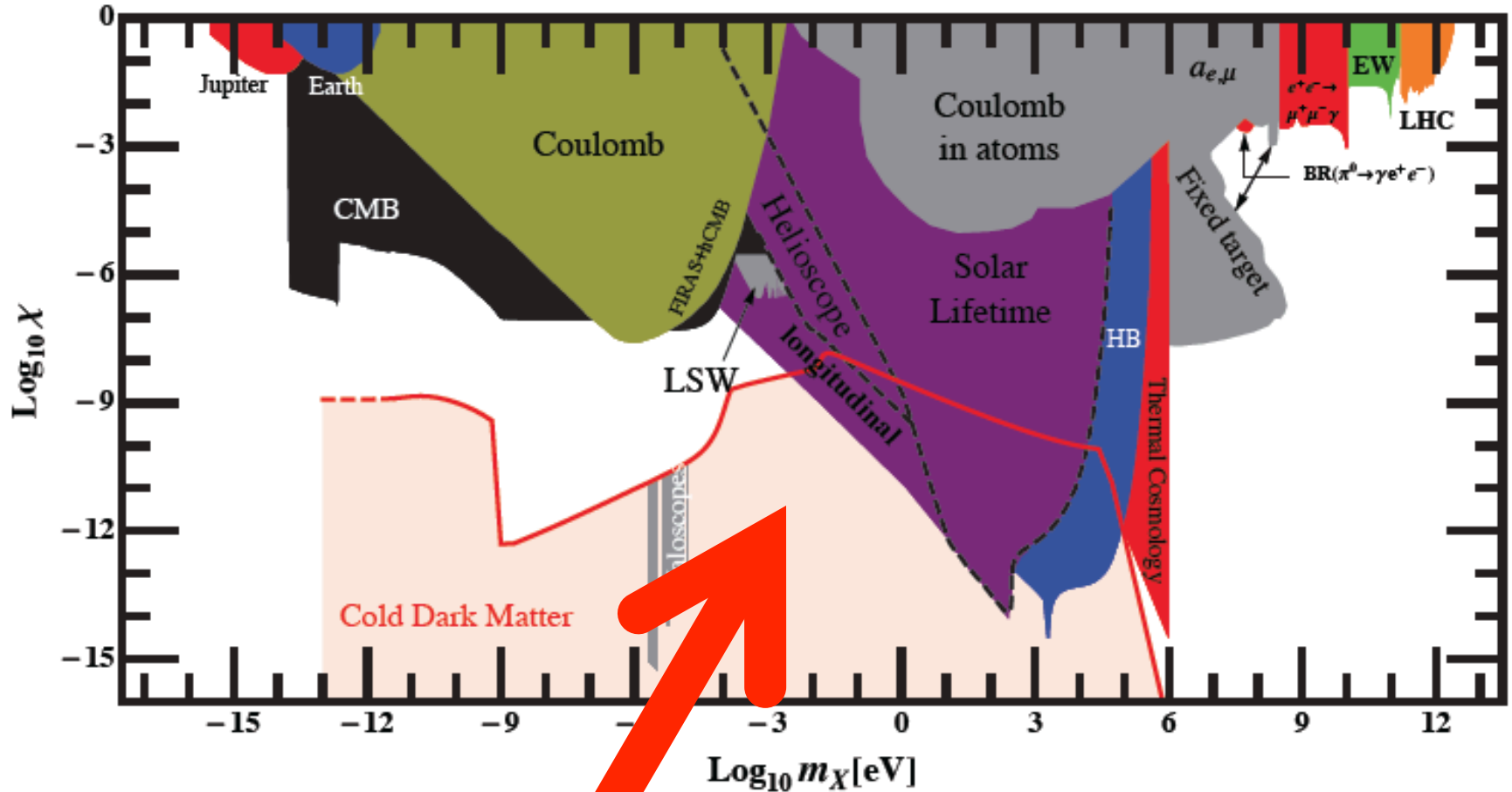
# Hidden photons

- Extra  $U(1)$  gauge bosons
- Interact by mixing with the photon



- Essentially all I say for ALPs can be adapted and works for HPs (often better)

# Hidden Photons...

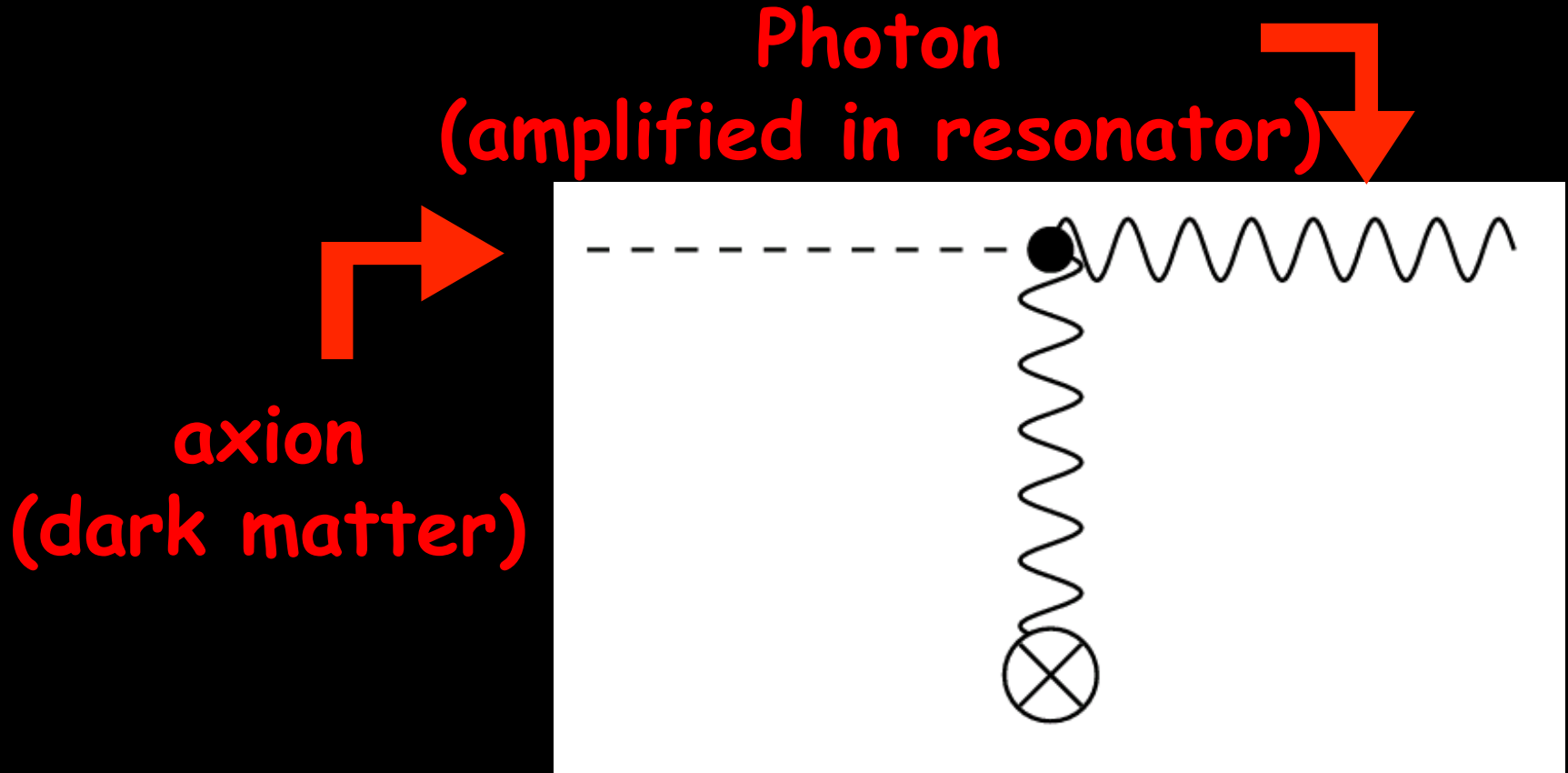


Can also be Dark Matter!

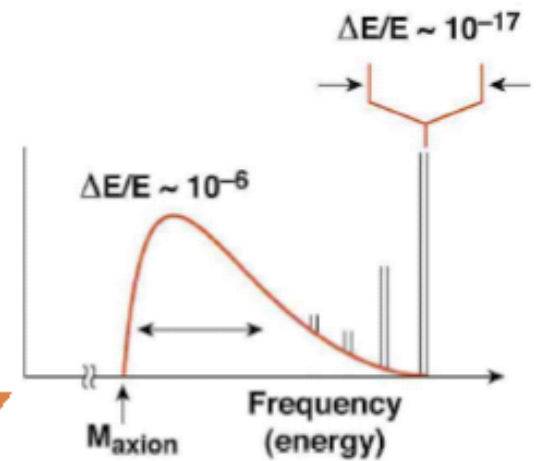
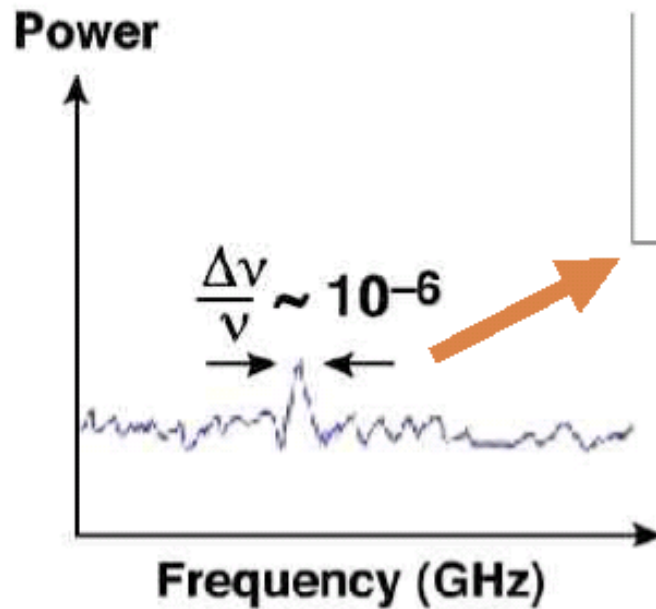
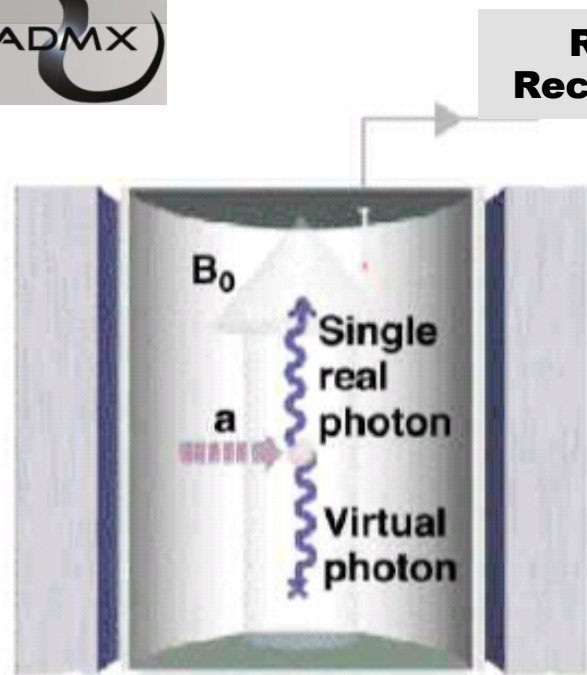
# Detecting ALP/WISP Dark Matter

# Use a plentiful source of axions

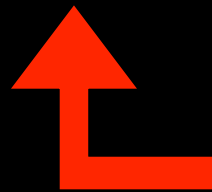
- Photon Regeneration



# Signal: Radiofrequency peak

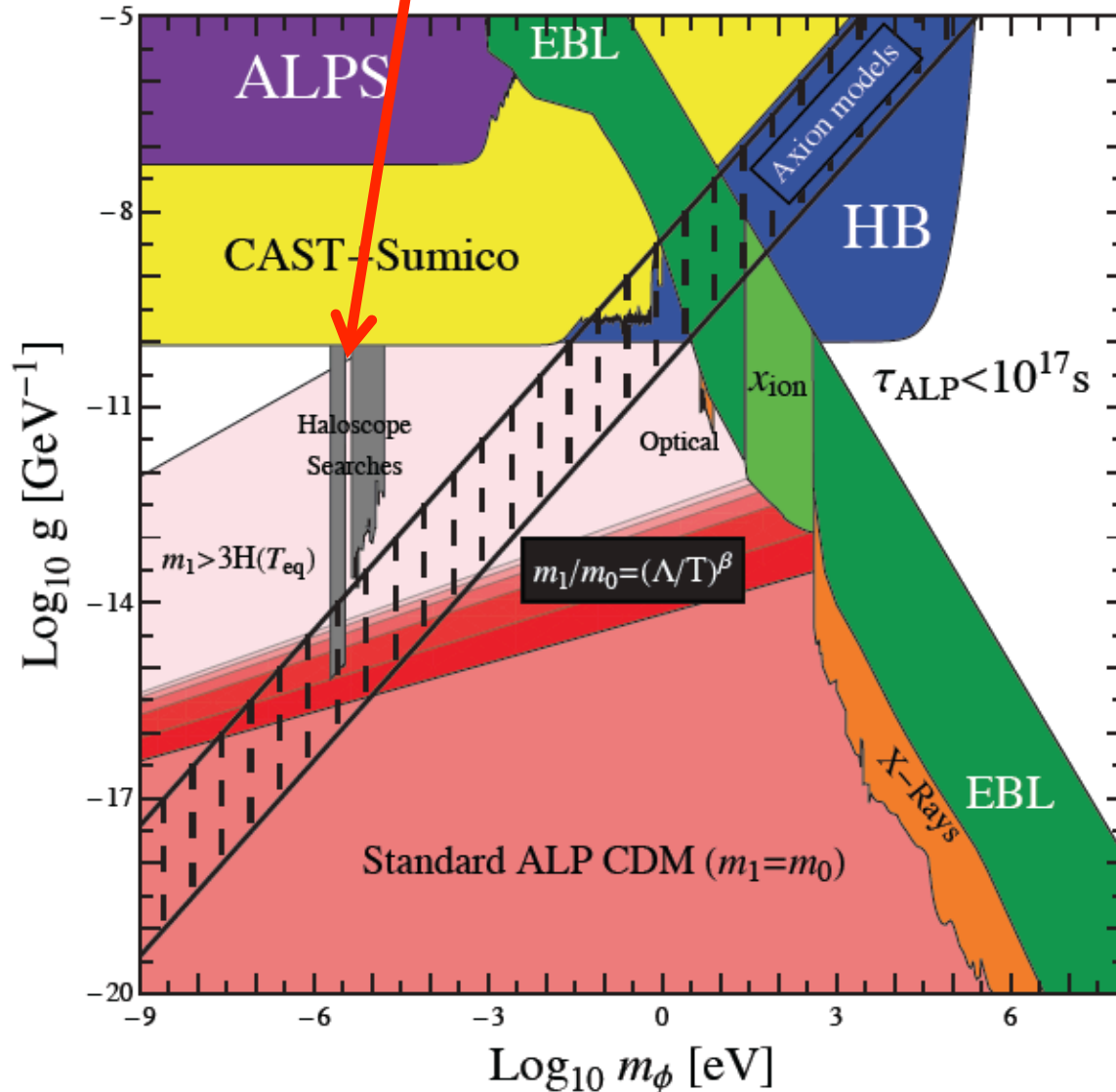


$$h\nu = m_a c^2 [1 + \mathcal{O}(\beta^2 \sim 10^{-6})]$$

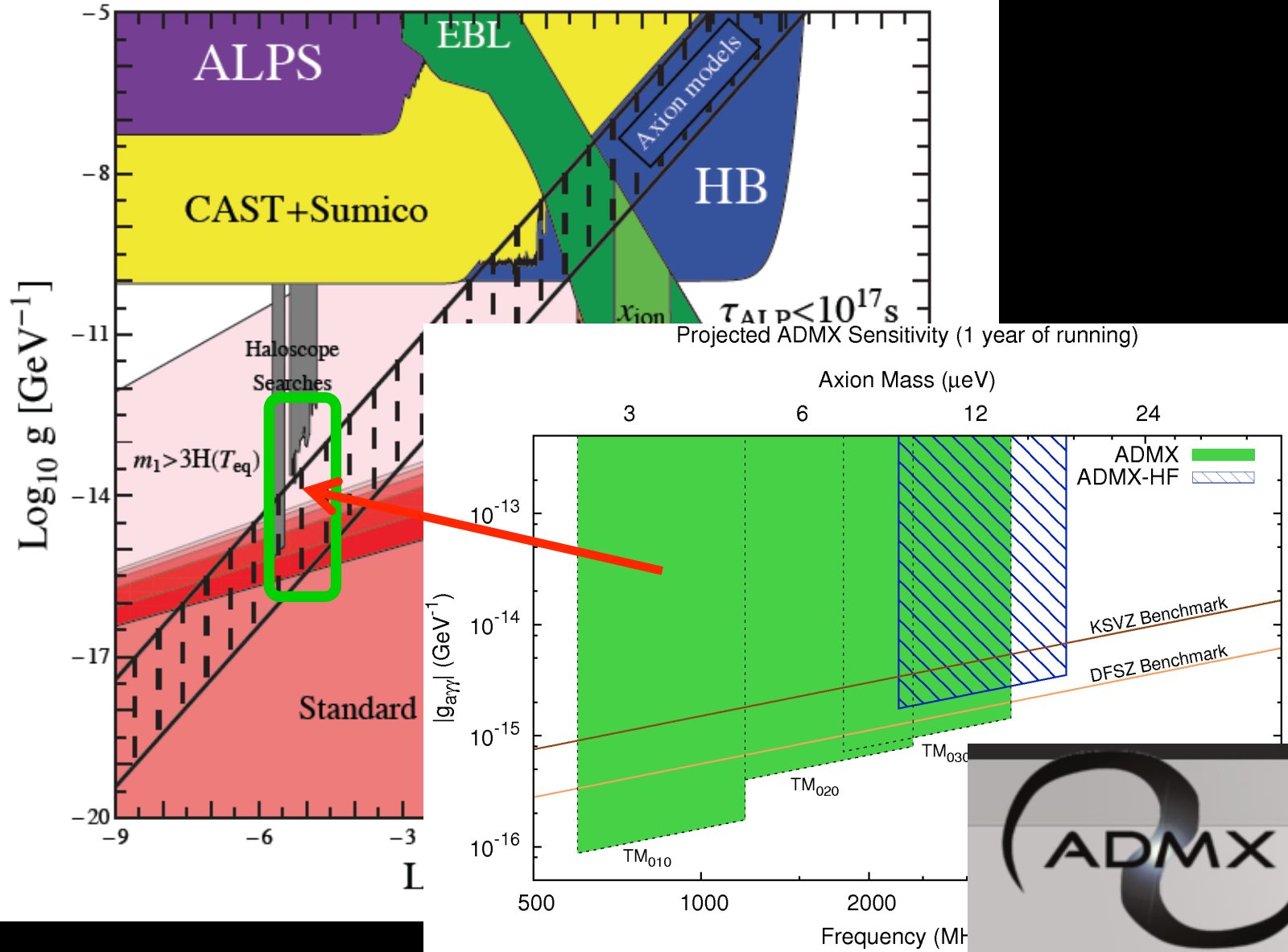


Virial velocity  
in galaxy halo!

# An extremely sensitive probe!!!

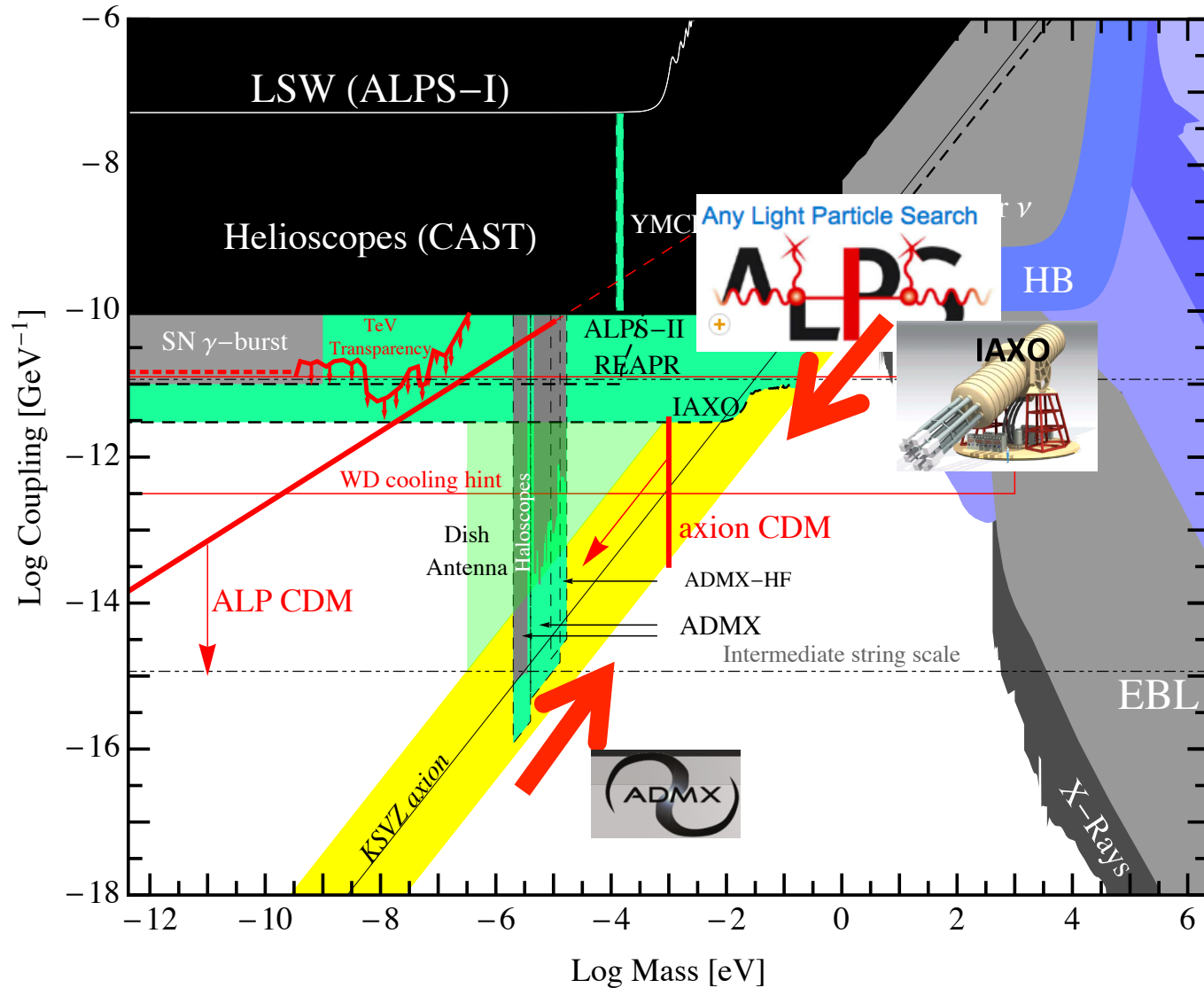


# An extremely sensitive probe!!!

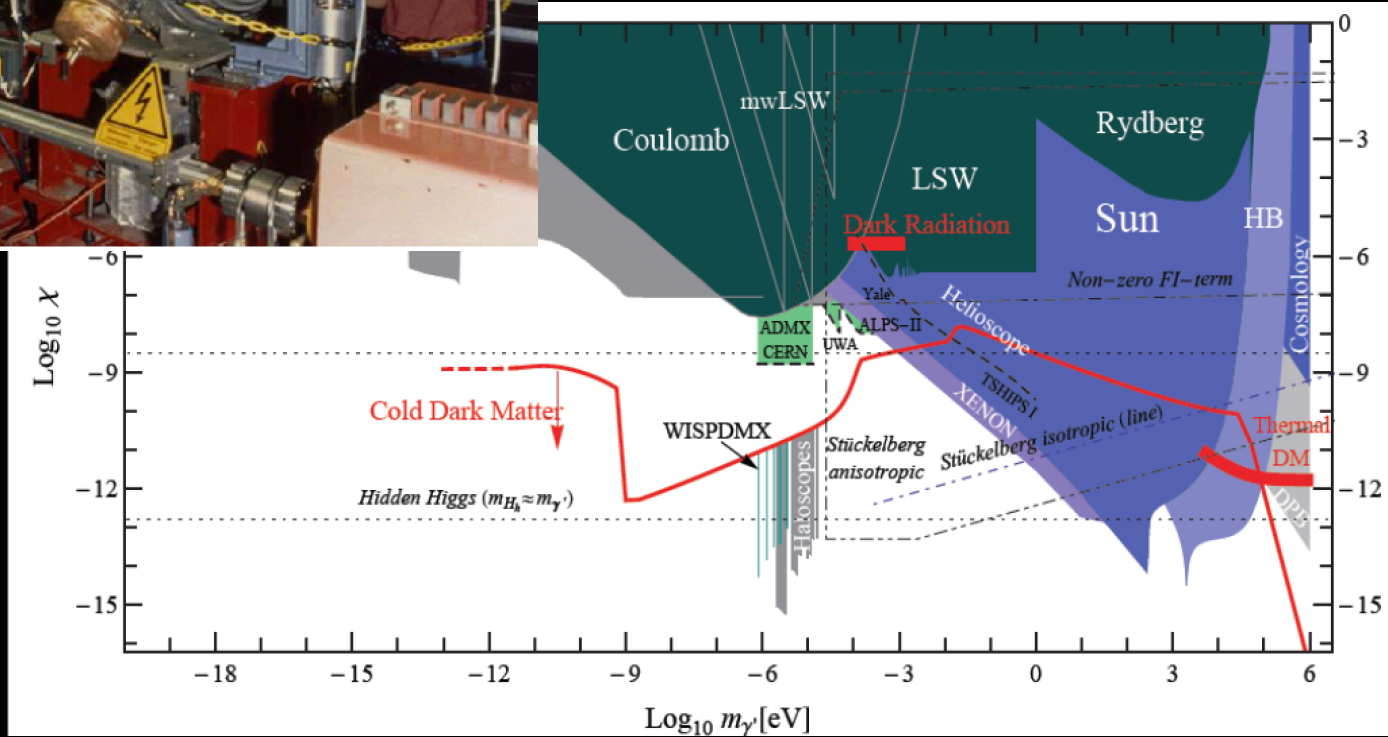
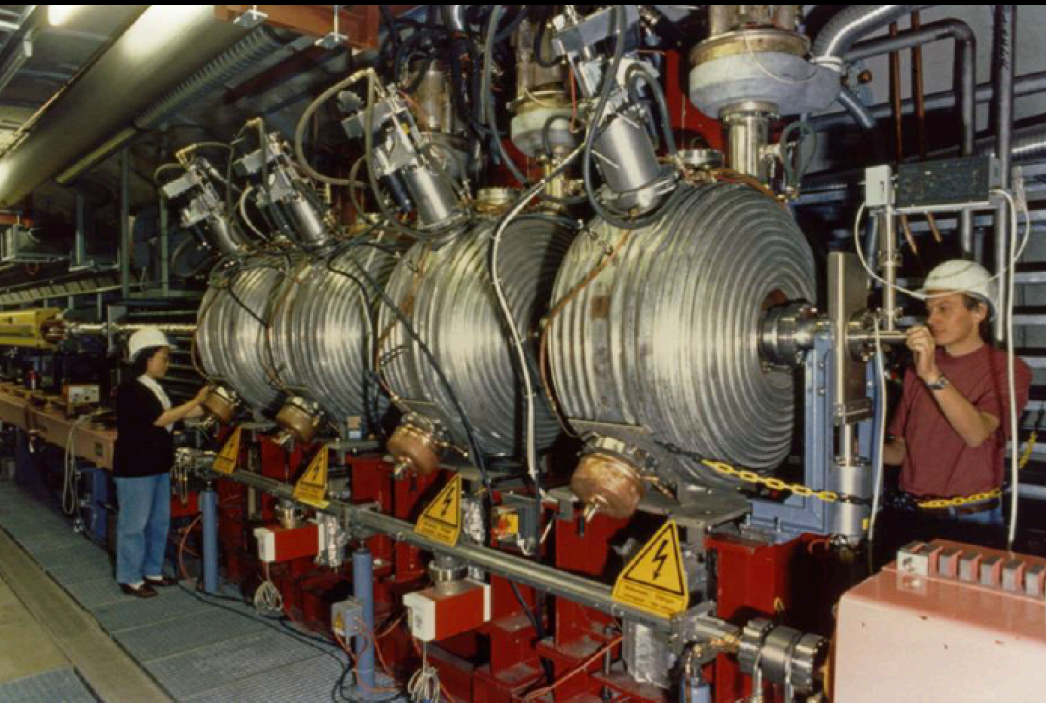




# Encircling the axion...



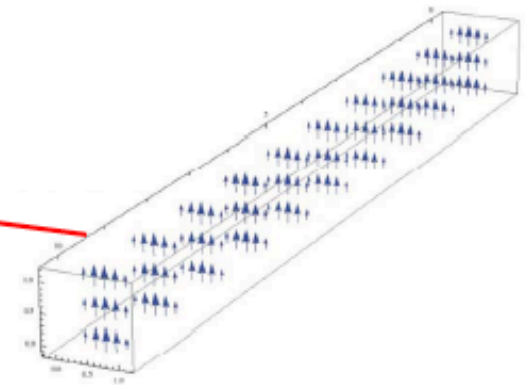
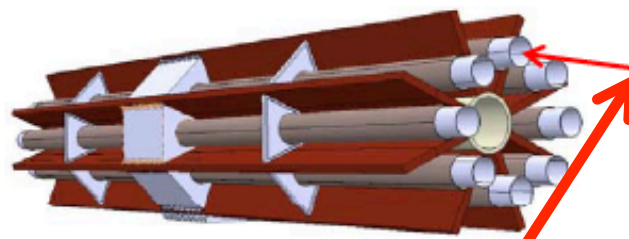
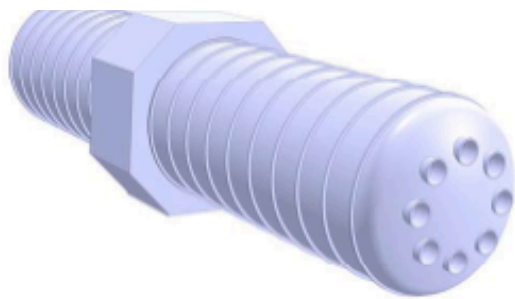
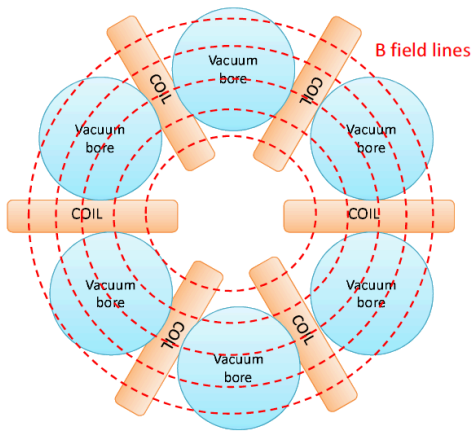
# @ DESY + Bonn: WISPDMMX



IAXO as facility

# IAXO facility

- IAXO provides large magnetized volume  
→ useful for ALP DM search

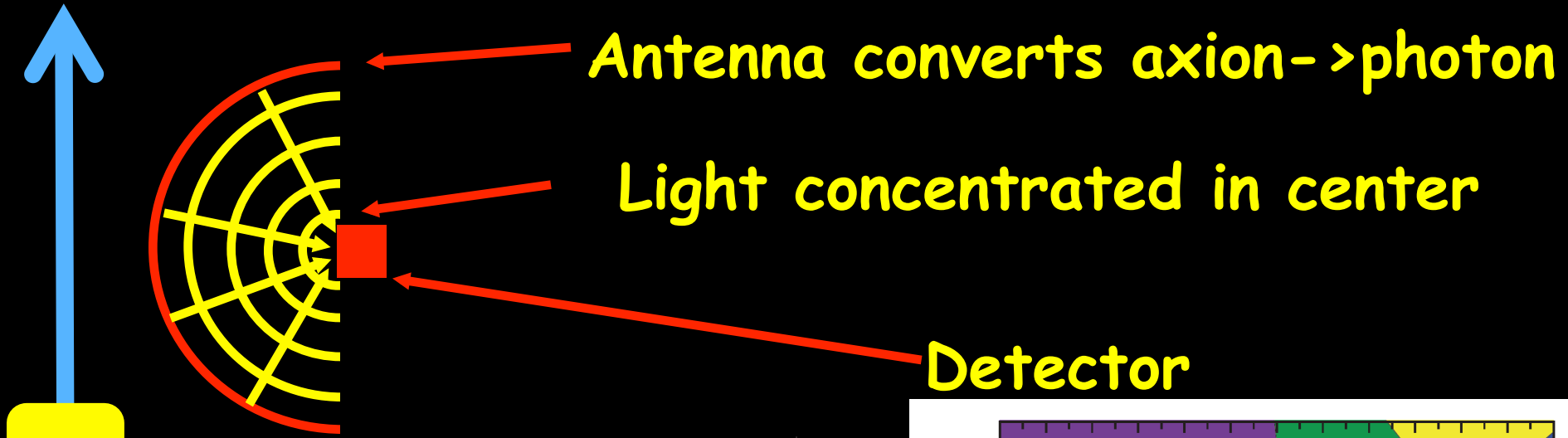


Igor G. Irastorza / Universidad de Zaragoza

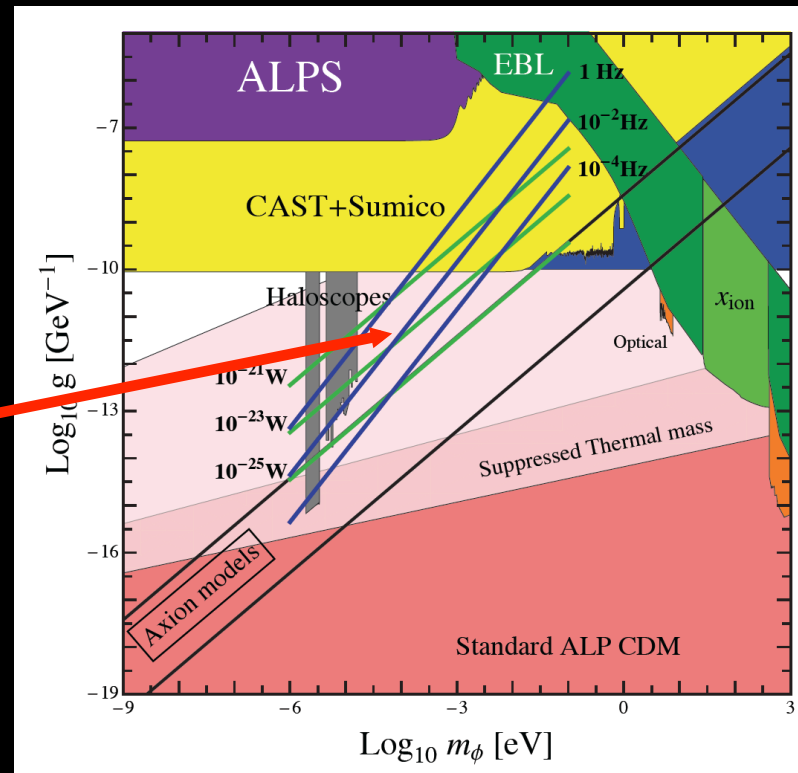
Insert long thin cavities

# Broadband Search Strategy

# Dark Matter Antenna



Probes here;  
very sensitive!!

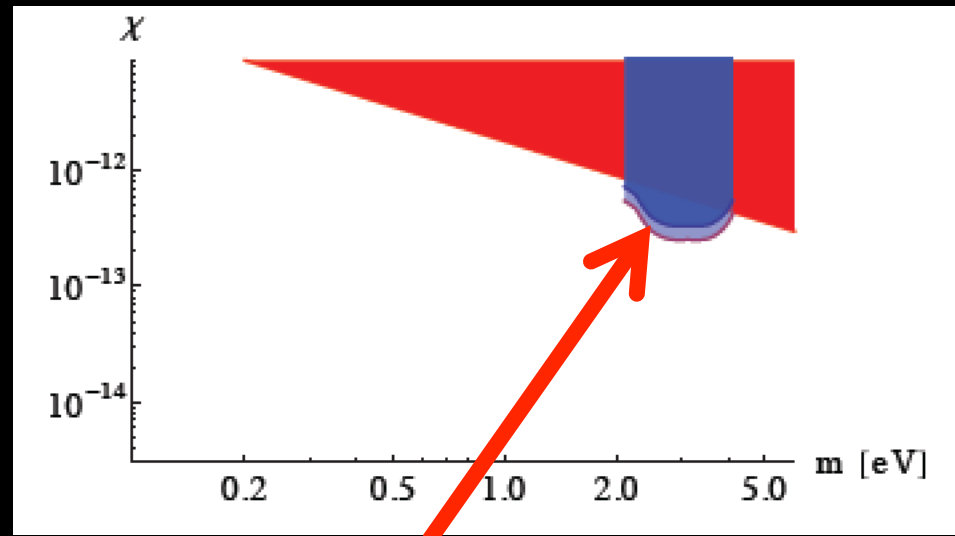


# The FUNK experiment

## Recycle Auger mirror



First measurements in the next few months



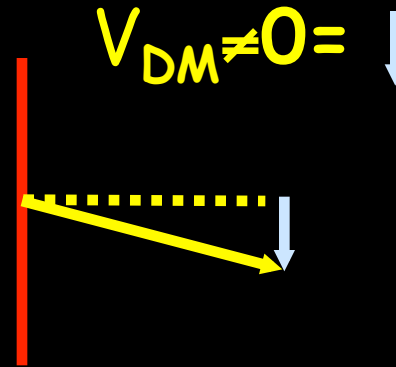
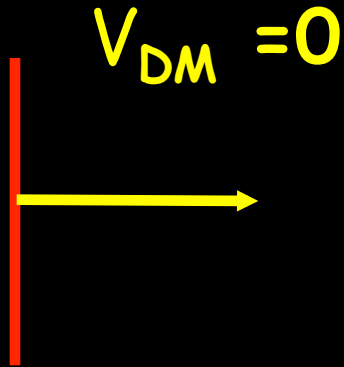
Could detect hidden photon DM!!!



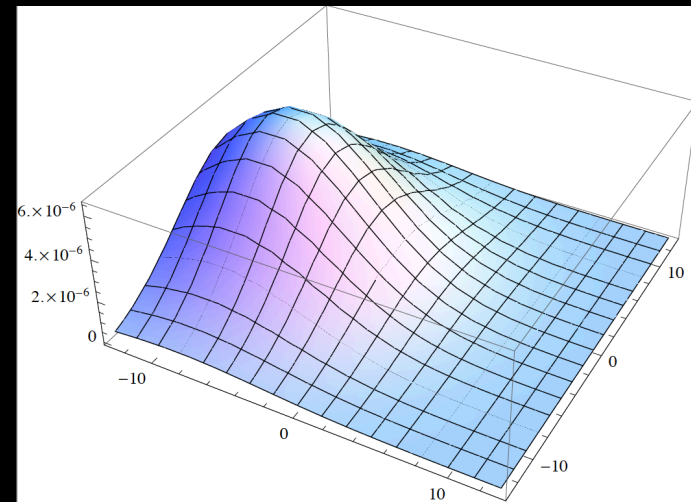
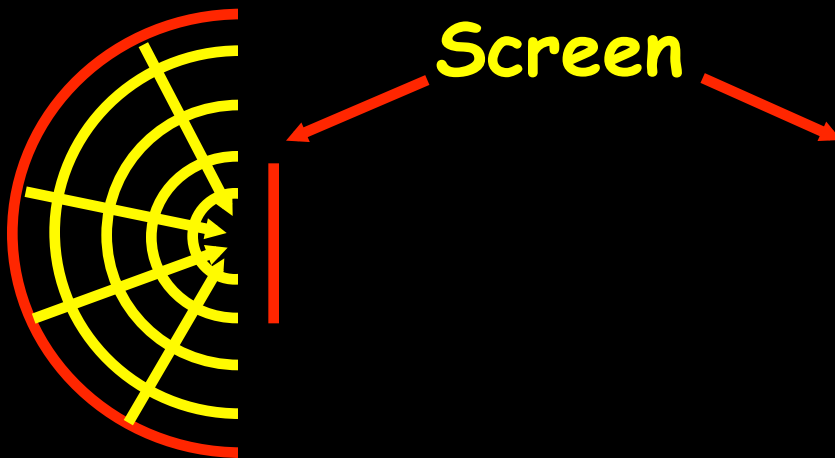


# A Dream for ~~Astrology~~ Astronomy

- Emission from moving dark matter



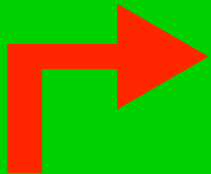
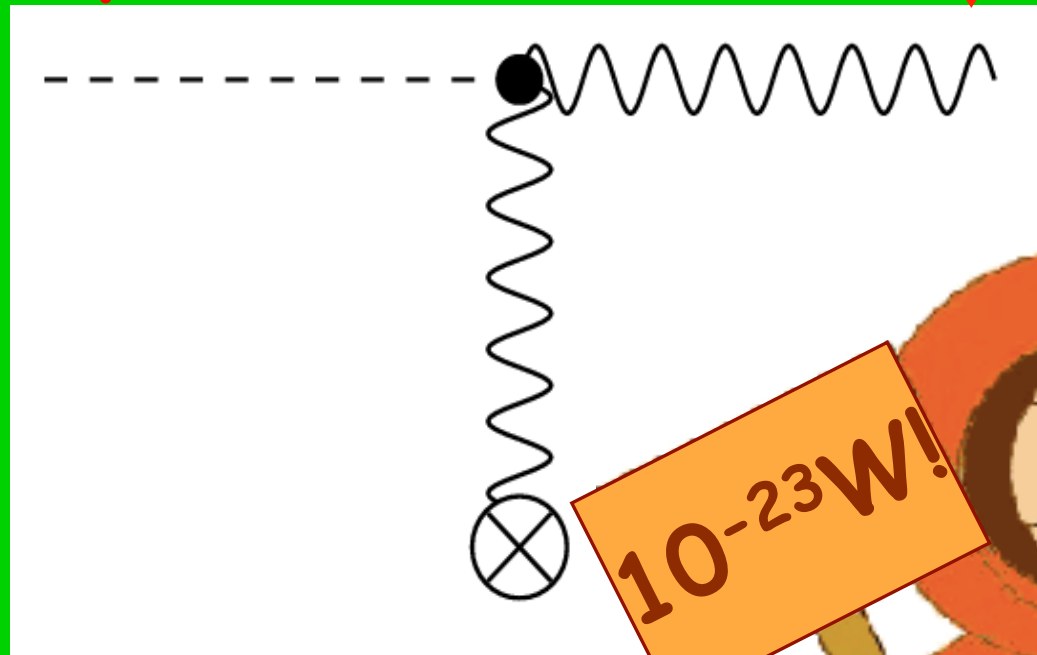
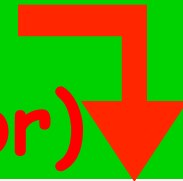
- A picture of the DM-velocity distribution



# Electricity from Dark Matter ;-).

- Photon Regeneration

Photon  
(amplified in resonator)



axion  
(dark matter)

$10^{-23}W!$



# Beyond Photon Couplings

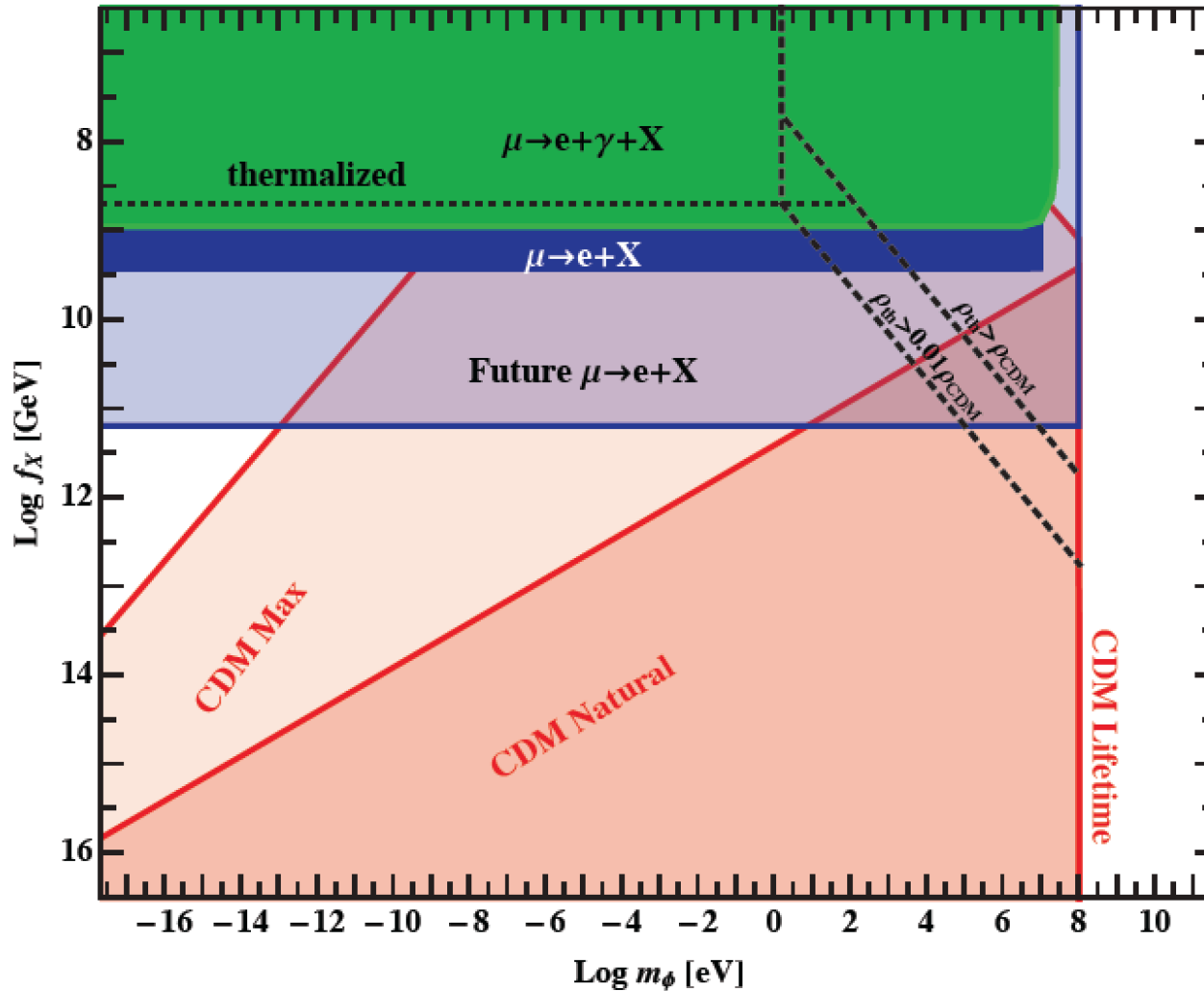
# Light bosons can couple to fermions

- Goldstone bosons naturally couple to fermions (charged under the symmetry)
- E.g. Family symmetry changing  $e$  into  $\mu$

$$(\partial_\mu \phi) \bar{\mu} \gamma^\mu e + h.c.$$

Interestingly these couplings are not very constrained from astrophysics!  
(not enough energy to make  $\mu$  s

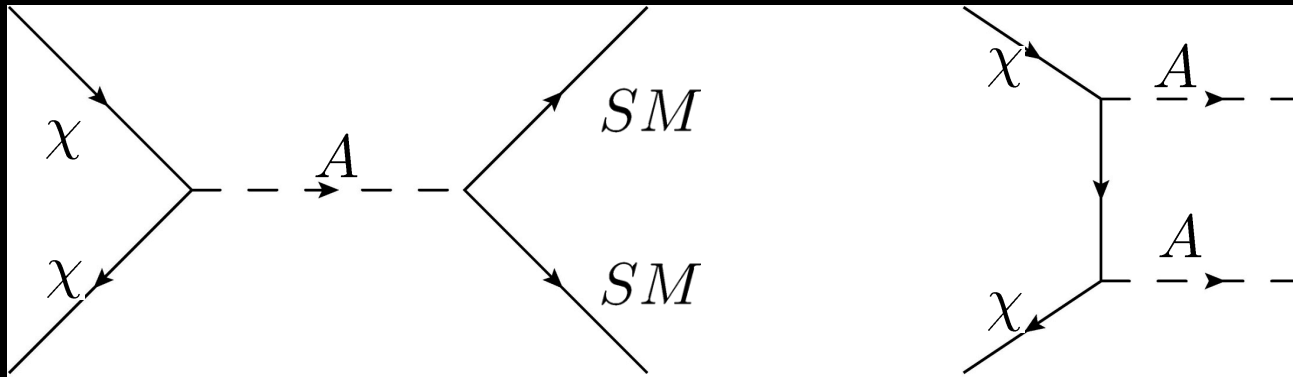
# Plenty of room for dark matter



ALPs as DM mediators

# ALPs can mediate to DM

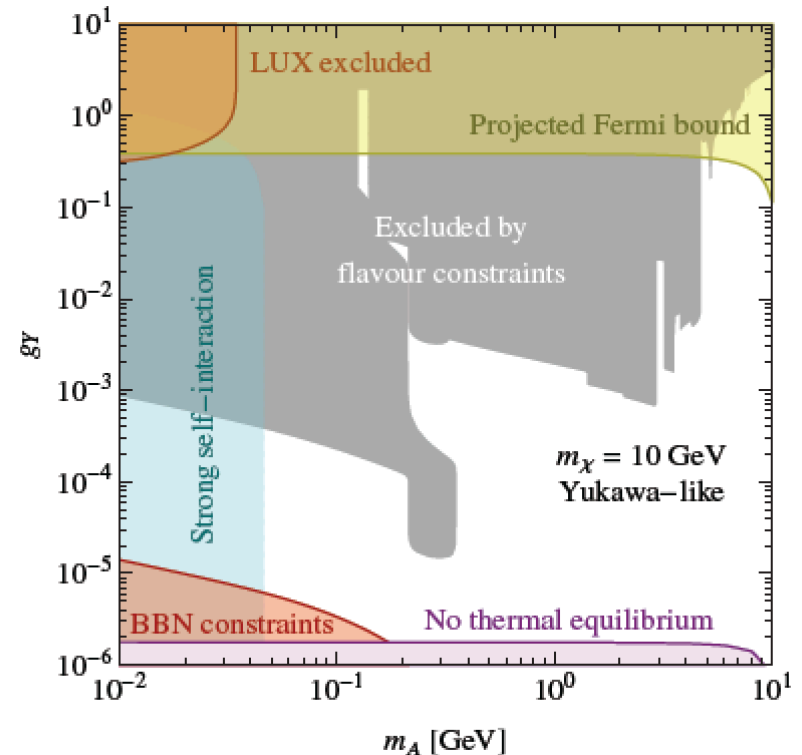
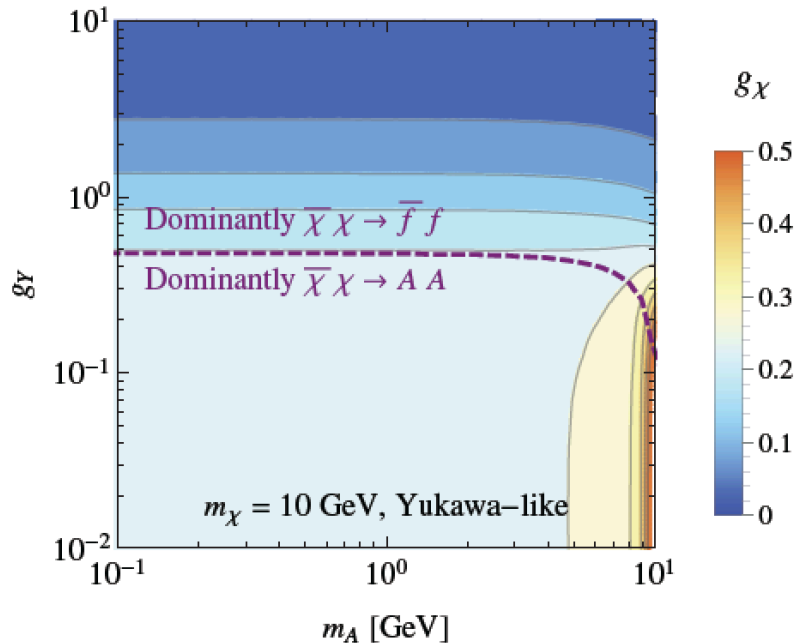
- Pseudo-scalar coupled ALPs can serve as mediator for light thermal DM
- Early Universe



- Direct detection strongly suppressed



# DM in an interesting area



## A taste of dark matter: Flavour constraints on pseudoscalar mediators

Matthew J. Dolan (SLAC), Christopher McCabe (U. Amsterdam, GRAPPA), Felix Kahlhoefer, Kai Schmidt-Hoberg (DESY)

Dec 16, 2014 - 52 pages

DESY-14-238

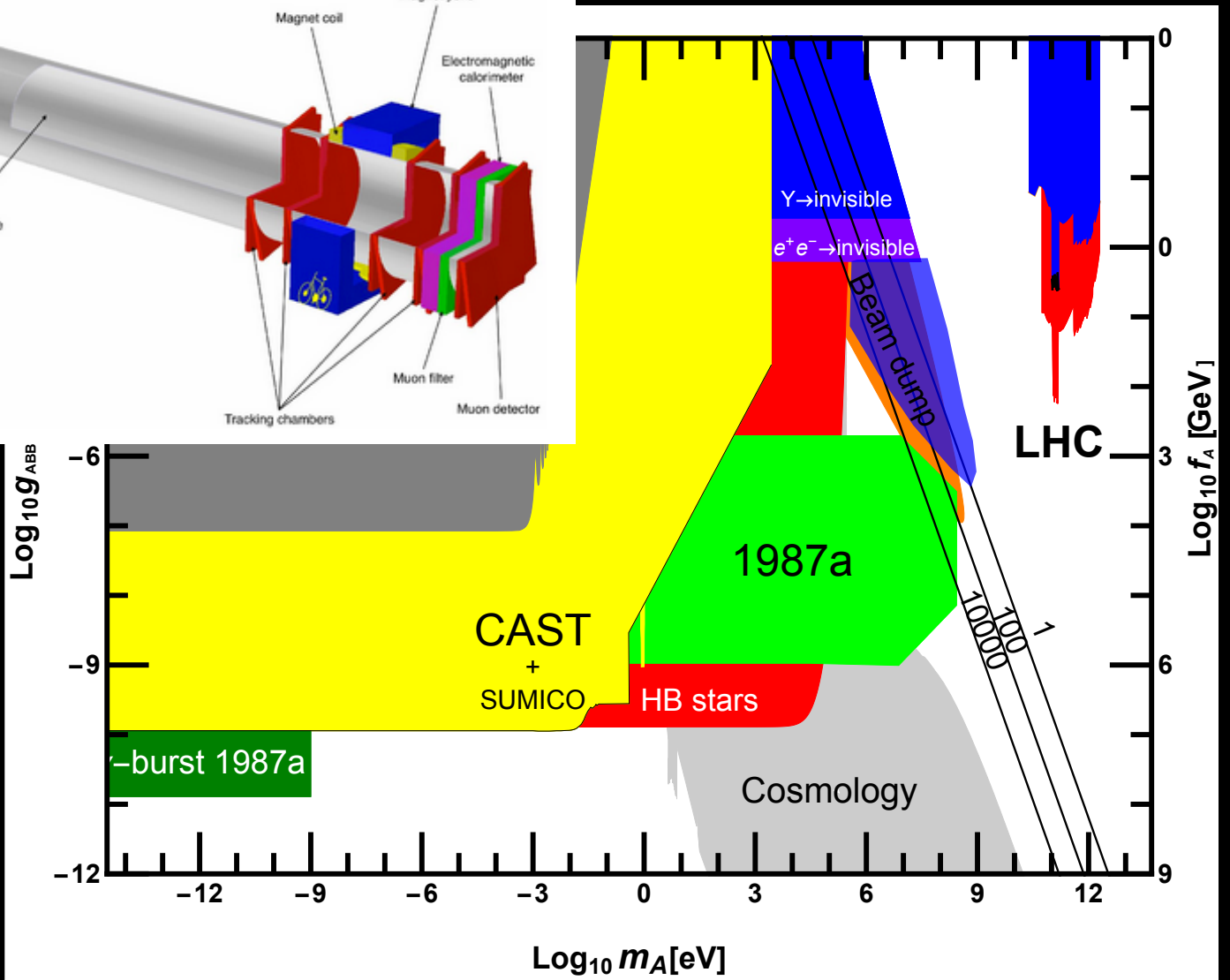
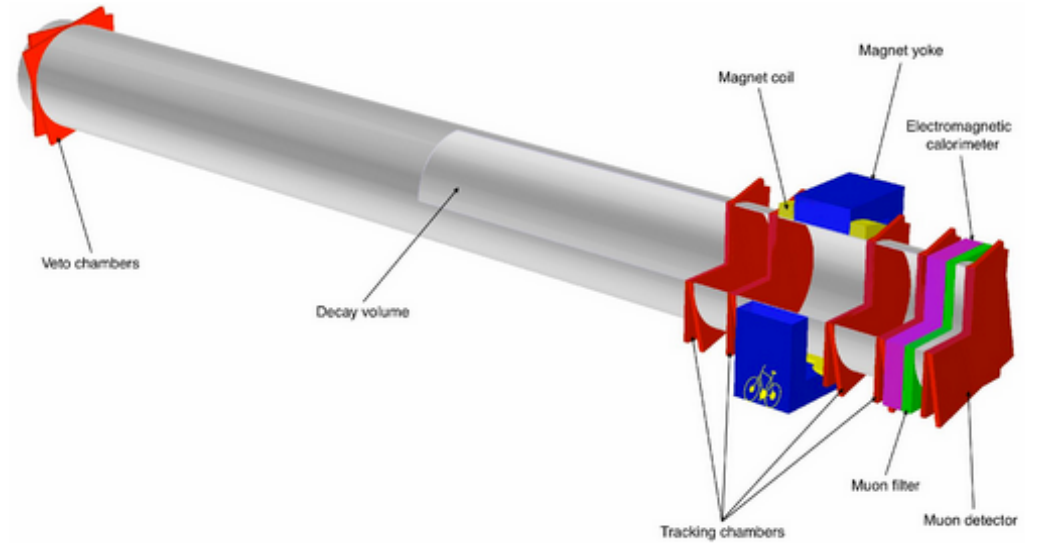
e-Print: [arXiv:1412.5174](https://arxiv.org/abs/1412.5174) [hep-ph] | [PDF](#)

# ALPs@SHIP

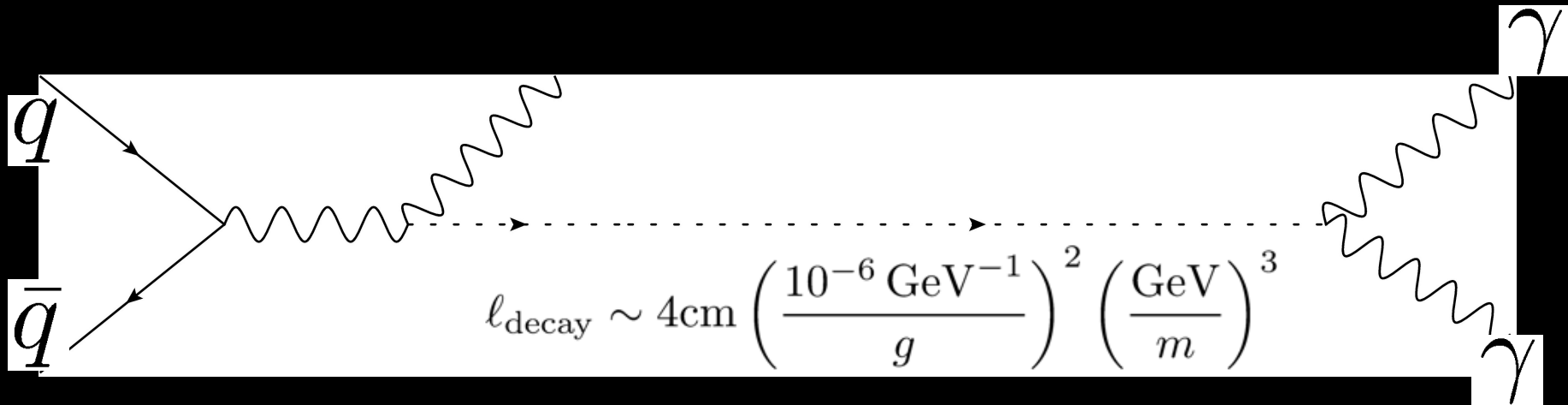


# Looking for heavier $\sim \text{GeV}$ ALPs

Experiment at the SPS to search for Hidden Particles

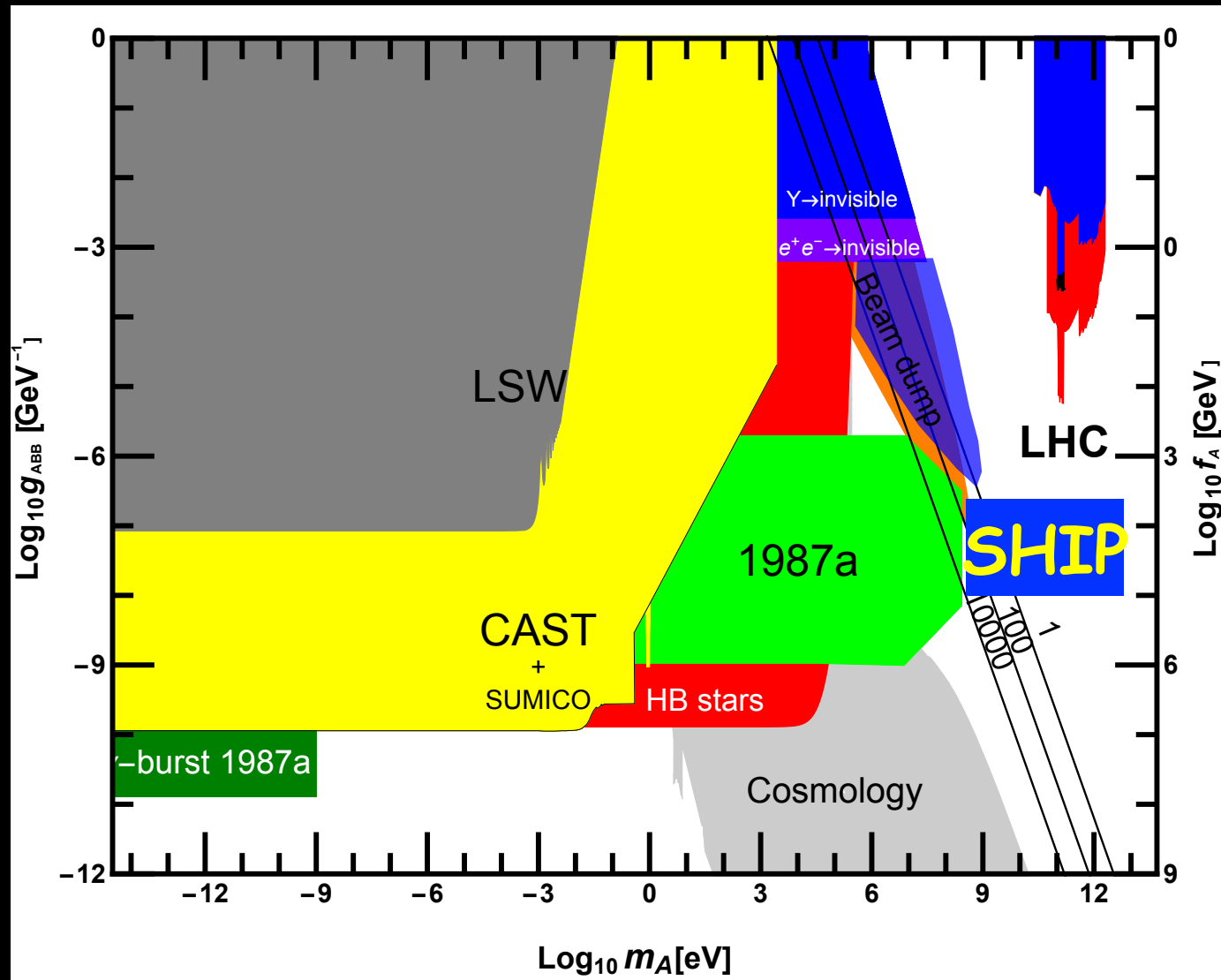


# Couplings to two photons

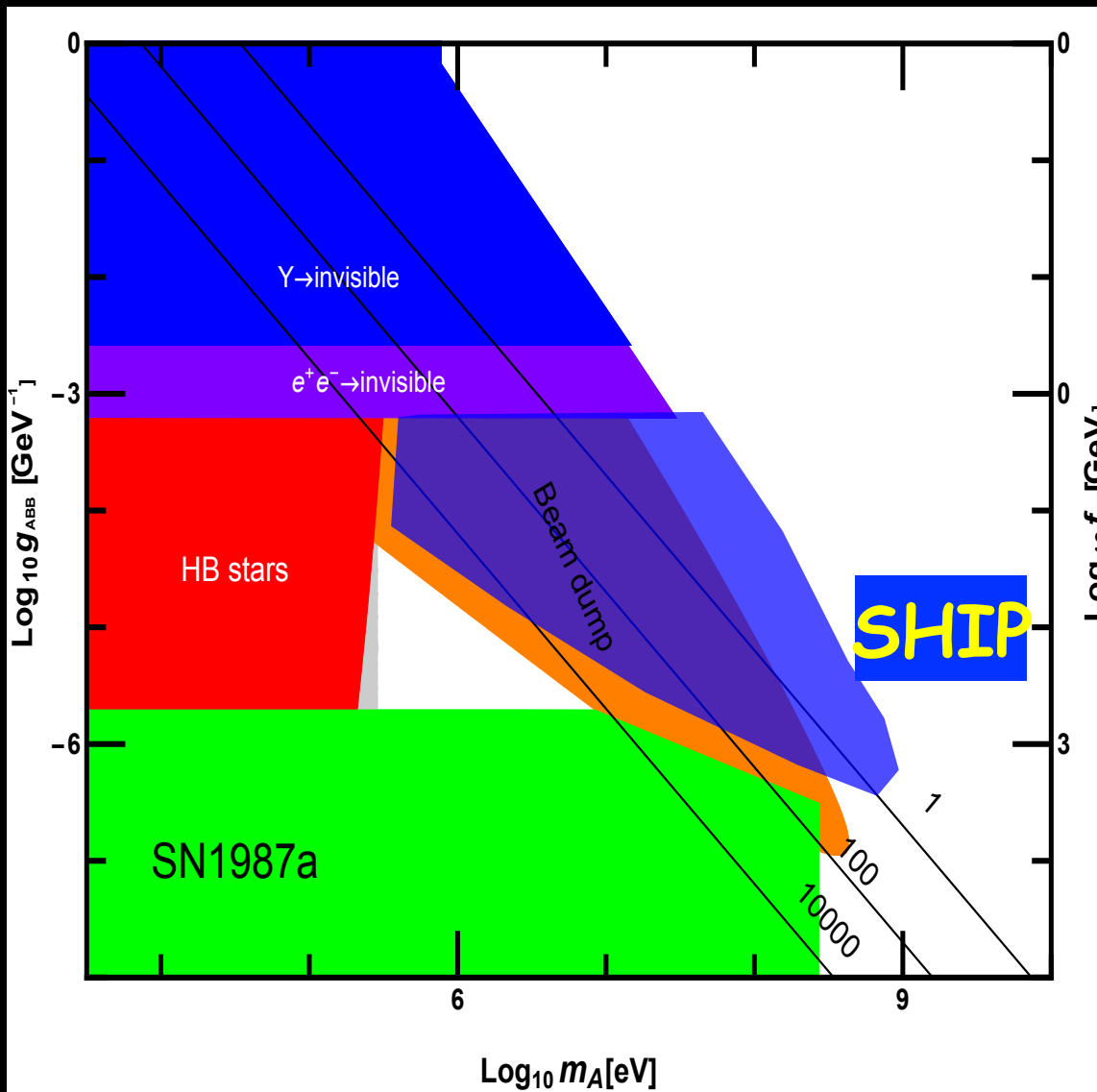


**Two-photon  
signal**

# Sensitivity



# Sensitivity



# Couplings to fermions

- Production via ALP-pion mixing

Replacing  $\partial^\mu \bar{q} \gamma_\mu \gamma^5 q$  by  $m_\pi^2 f_\pi \pi$



$$\frac{C_{Af} f_\pi}{2 f_A} m_\pi^2 \pi A$$

Off diagonal mass term  
→ mixing



$$\sigma_A = \kappa^2 \sigma_\pi$$

$$\kappa = \frac{C_{Af} f_\pi}{2 f_A} \frac{m_\pi^2}{m_\pi^2 - m_A^2}$$

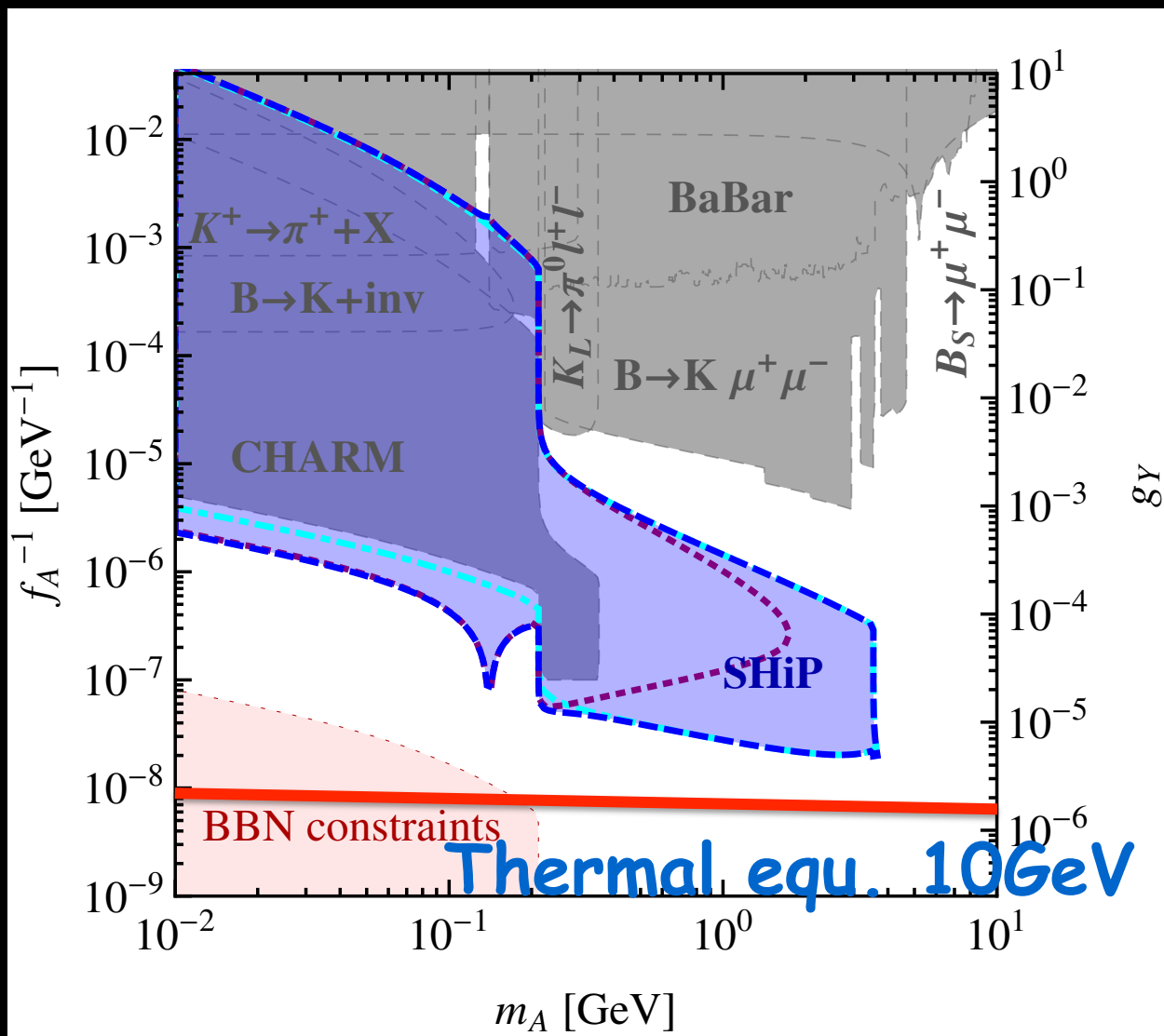


# Decay

- ALP can decay into  $\gamma\gamma, ee$  or  $\mu\mu$

# Sensitivity

Probes  
High  
underlying  
scale

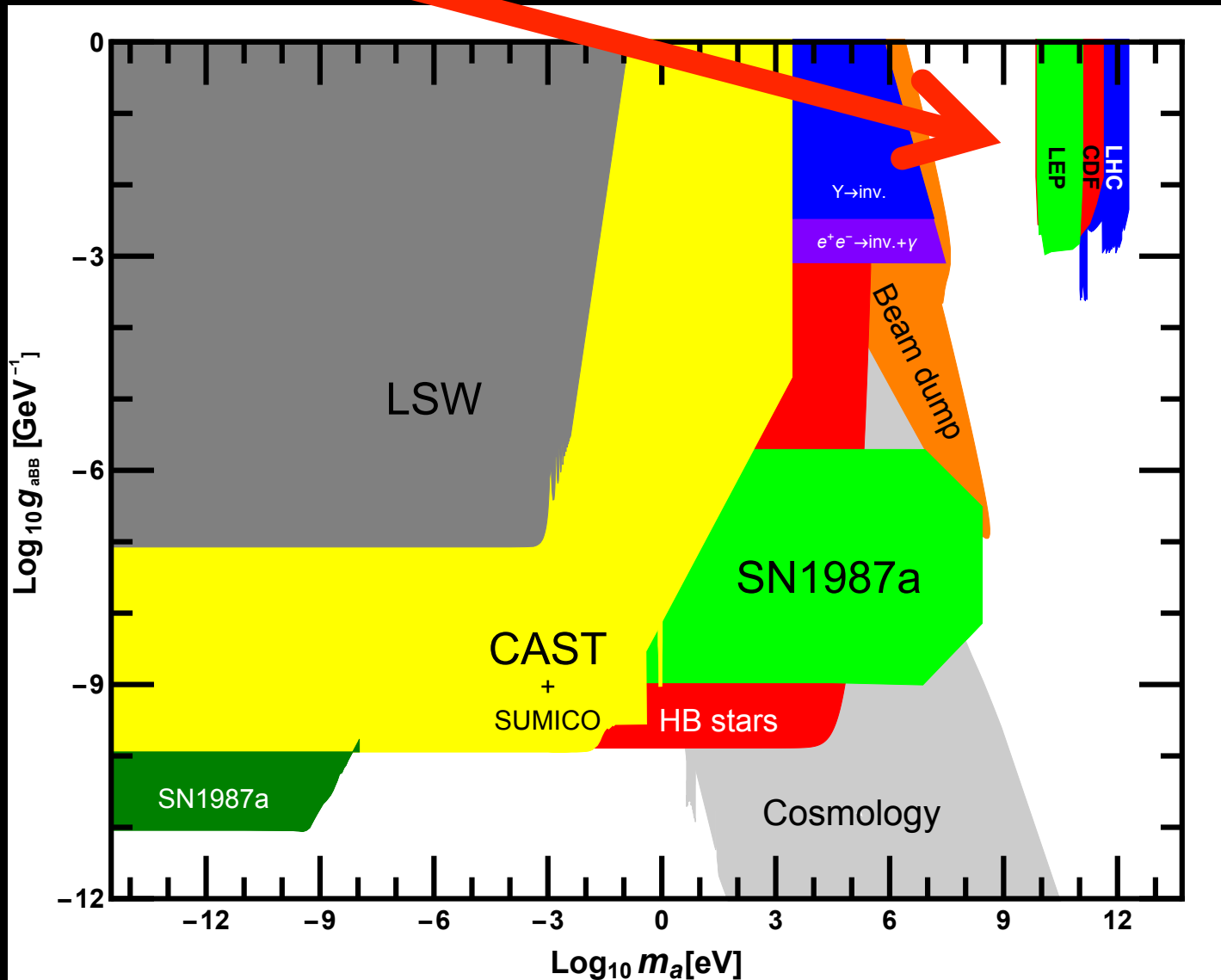


ALPs

@

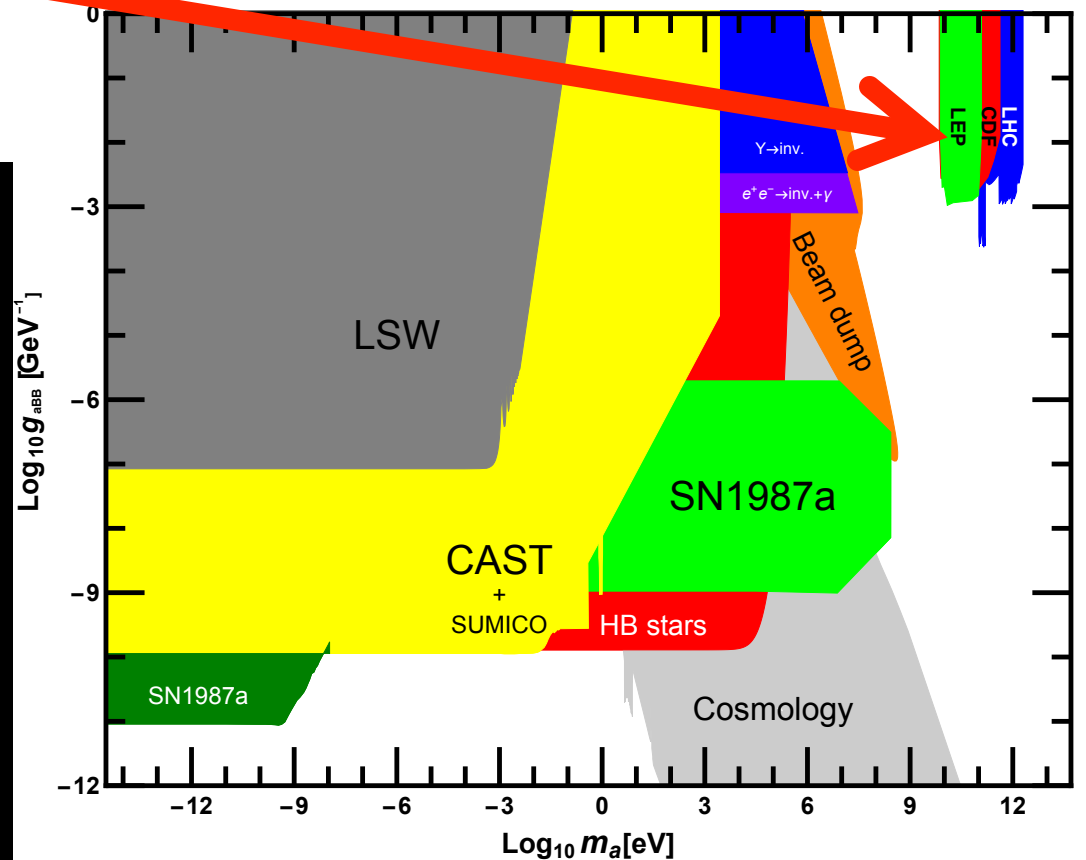
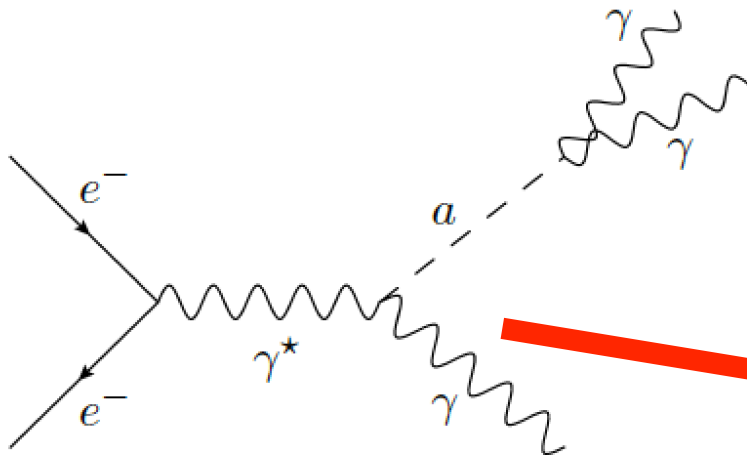
Old and New Colliders

# The Hole!!



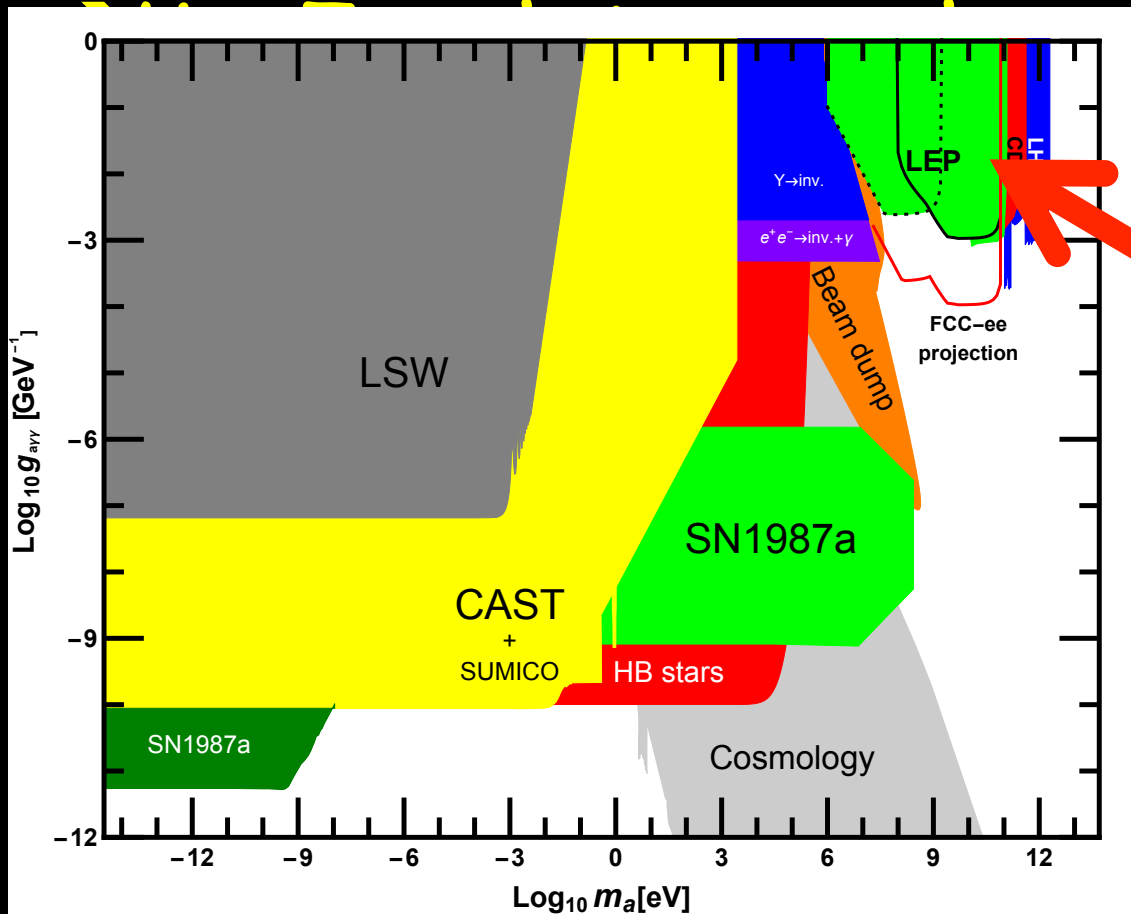
# ALPs @ LEP Three photon signature

K. Mimasu and V. Sanz, arXiv:1409.4792 [hep-ph].



# ALPs @ LEP Two photon signature...

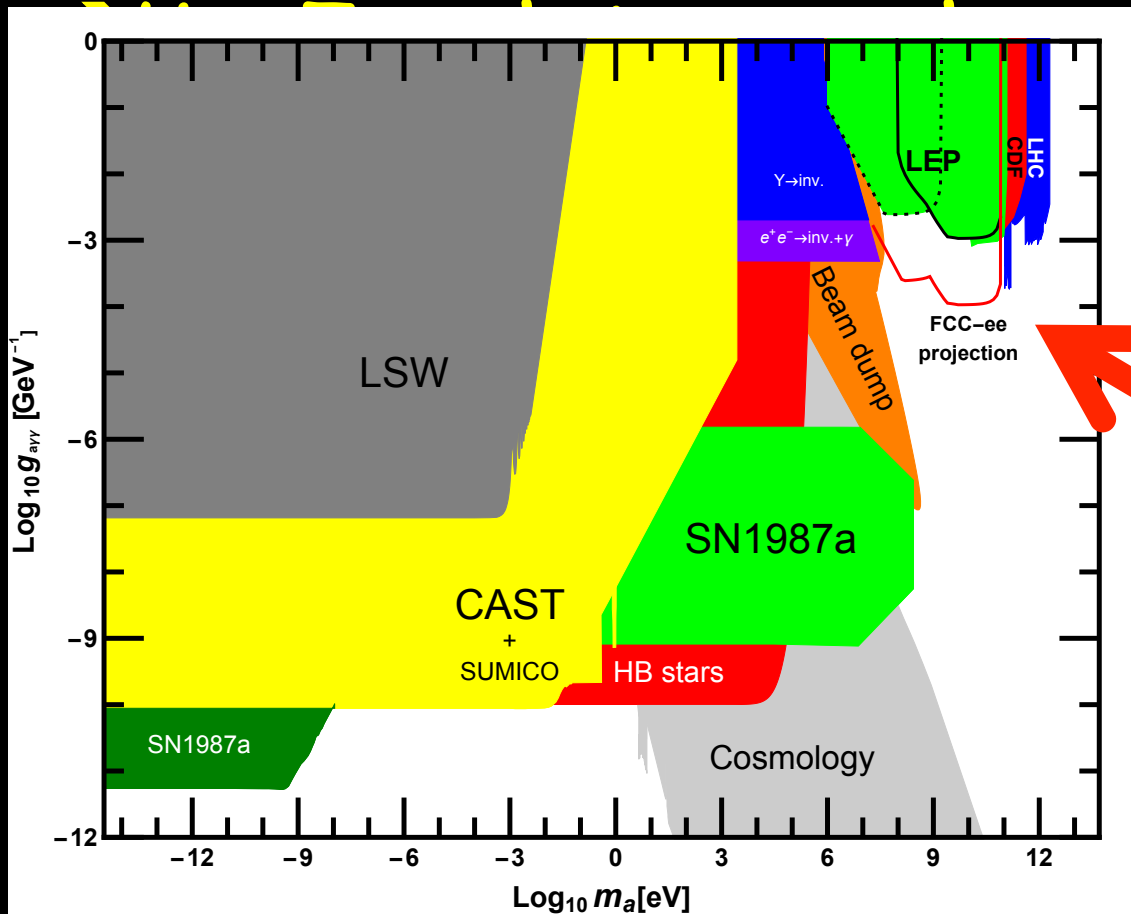
- Lower mass limit from photon separation
- This is not necessary:  $2=1$   
(for close photons)



Hole plugged!

# ALPs @ LEP Two photon signature...

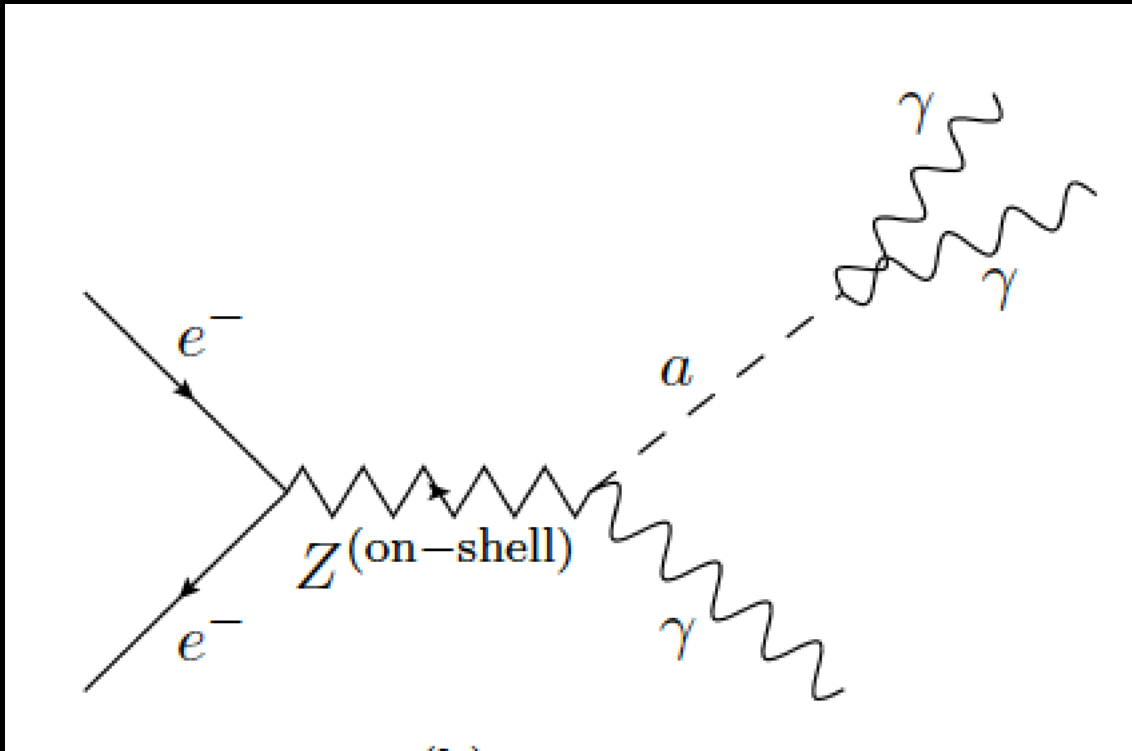
- Lower mass limit from photon separation
- This is not necessary:  $2=1$   
(for close photons)



# Can do even better

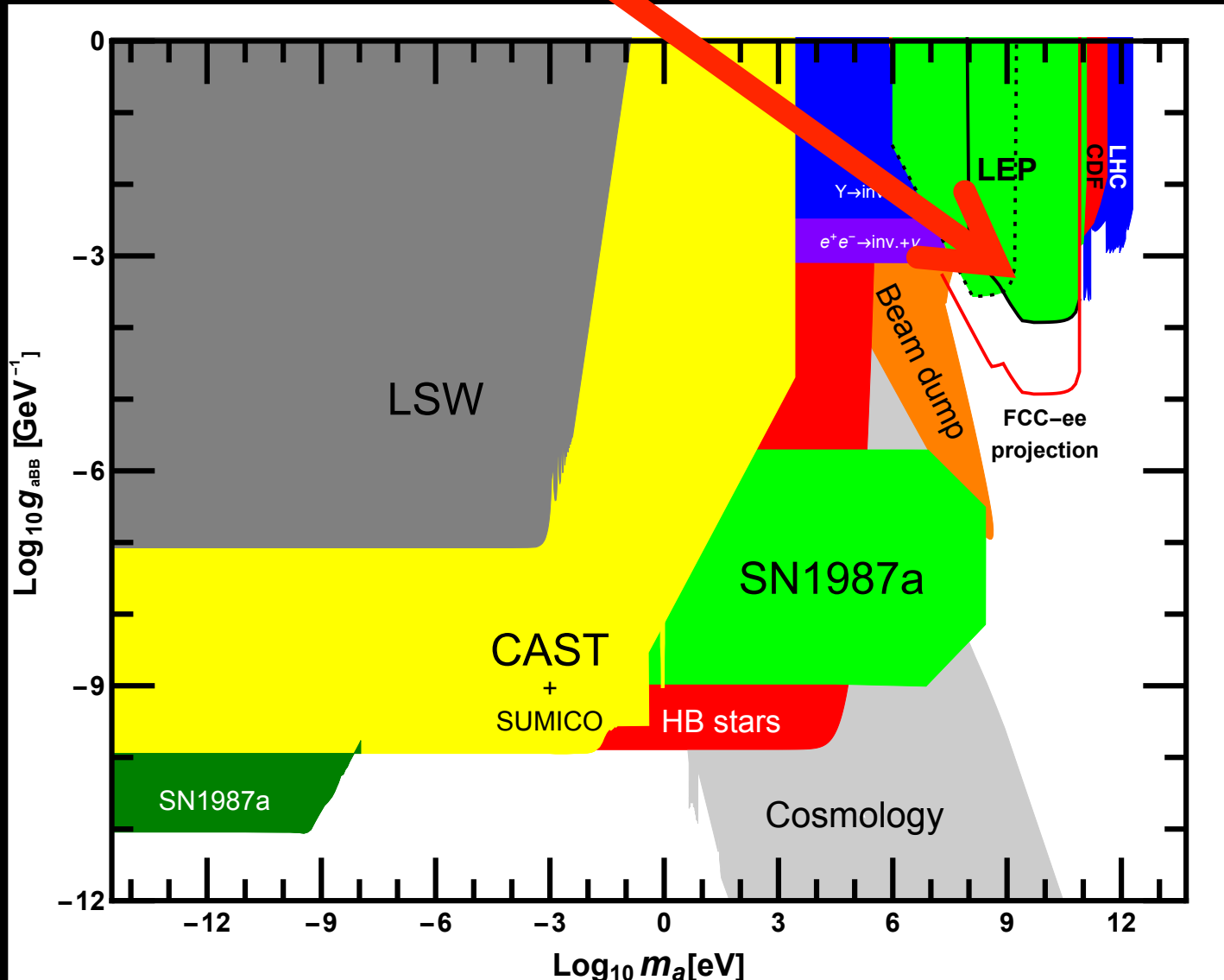
- Coupling usually to Hypercharge
- Allows process

$$-\frac{1}{4}g_{aBB}B^{\mu\nu}\tilde{B}_{\mu\nu}$$





Significantly better...



Conclusions

# Conclusions

- Extremely sensitive + cool

Dark Matter experiments



WISPDMMX

- Fixed Target @ MeV to GeV Energies



- Colliders can do their share: LEP, LHC, FCC

- Time to also look for different interactions (e.g. fermions, flavor changing etc)



- Stay tuned for discovery!!!!!!!!!!!!!!!!!!!!!!!!!!!!

Hidden sector

