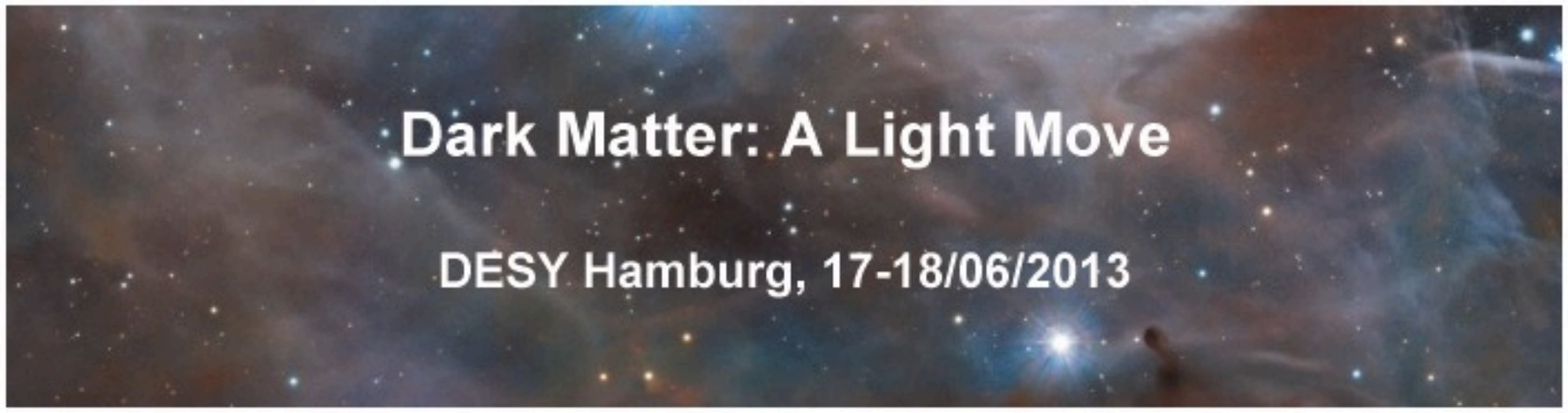
Summary of the workshop



The workshop on ultralight dark matter searches ***Dark Matter: A Light Move*** aims to explore and gather ideas about searching directly (and to a lesser extent indirectly) for Dark Matter candidates with sub-eV masses, most prominently the axion and other weakly interacting light particles (WISPs).

The workshop's aim is to provide a platform for elaborate discussions and foster collaborations and new experiments. We therefore foresee short presentations + up to 30min discussion time. All speakers are therefore highly encouraged to include in their talk also their own questions to the community and use the opportunity to discuss also "unfinished" ideas with colleagues from different disciplines.

During this two-day workshop, we foresee

- a brief theory overview for WISPY DM,
- general evidence for DM and peculiar features of WISPy DM, astrophysical evidence,
- existing axion DM setups,
- prospects of WISP DM setups (cavities, dish-searches...),
- relevant experimental techniques: magnetic challenges, detectors.

9th Patras workshop on weirdos, 28th June 2013
Javier Redondo (LMU & MPP Munich)

Key particles discovered:

Year	Particle	Spin	Continent	Discoverer*
1897	Electron	1/2	Old	Thomson
1919	Proton	1/2	Old	Rutherford
1937	Muon	1/2	New	Neddermeyer
1947	Pion	0	Old	Powell
1947	Kaon	0	Old	Butler/Rochester
1956	e-neutrino	1/2	New	Reines/Cowan
1962	muon-neutrino	1/2	New	Lederman
1969	Partons (uds-quarks)	1/2	New	SLAC
1974	J/Psi (c-quark)	1/2	New	Richter
1975	Tau	1/2	New	Perl
1977	Upsilon (b-quark)	1/2	New	Fermilab
1979	Gluon	1	Old	DESY !
1983	W,Z	1	Old	CERN
1995	t-quark	1/2	New	Fermilab
2000	Tau-neutrino	1/2	New	Fermilab
2012	Higgs	0	Old	CERN

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question ...

Do we really want to leave ADMX in the quest for QCD axion DM?

Outline ...

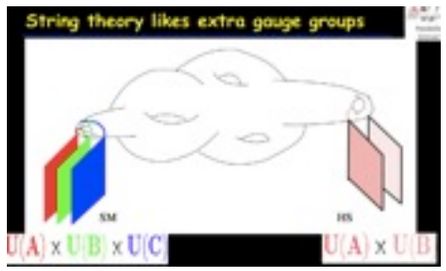
- Where do we stand?

- What can we do?

- What are we going to do?

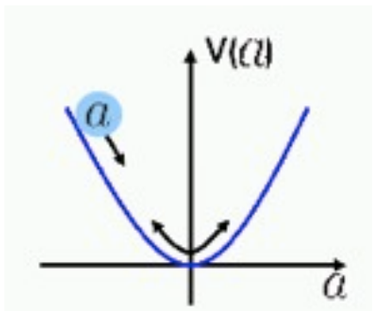
Where do we stand? - General aspects

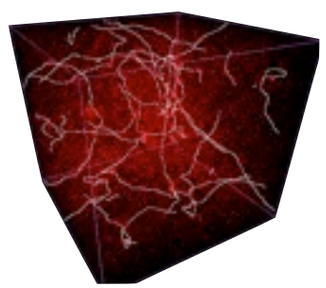
Axions, ALPs and Hidden photons appear naturally in extensions of the SM



The strong CP problem hints for the axion !!!

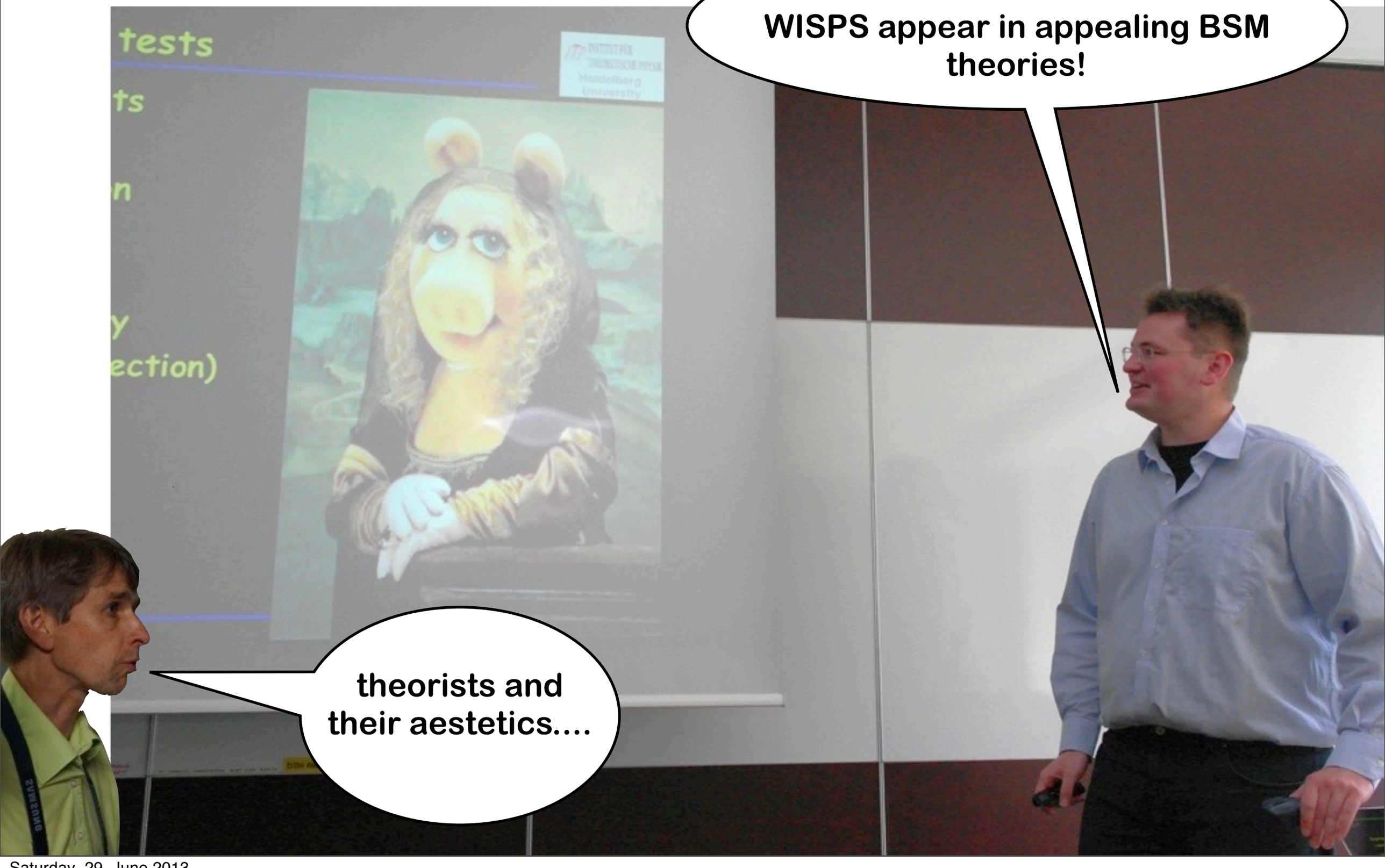
Dark matter is produced non-thermally



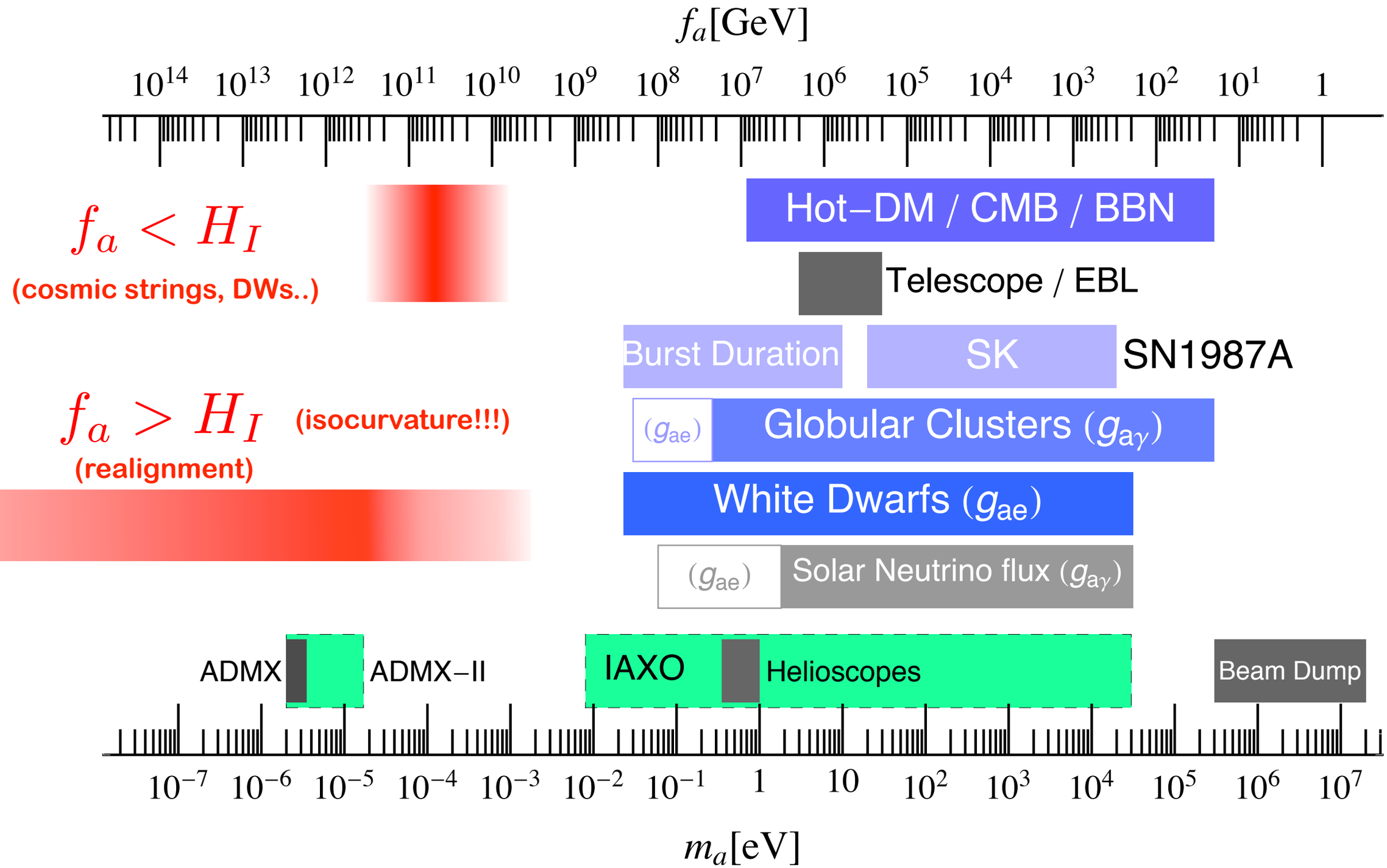


Weakly Interacting Slim Particles (WISPs) are well motivated!!

Where do we stand? - General aspects



Where do we stand? - 1 - QCD Axions



Where do we stand? - 2 - General ALPs

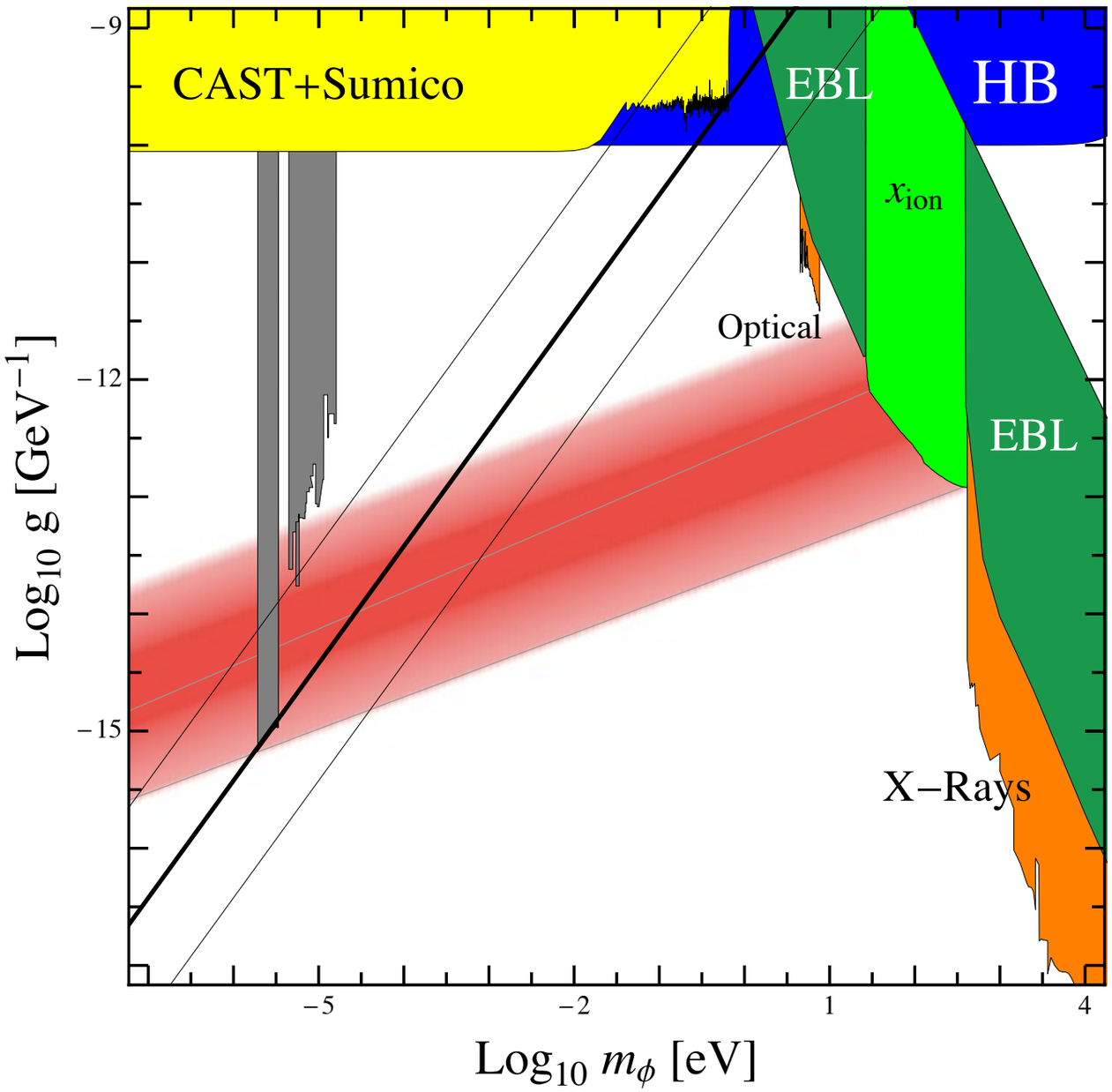
- Mass and coupling unrelated

$$g = \frac{\alpha}{2\pi f_a} \times O(1)$$

- Scenario 1

$$f_a < H_I$$

(cosmic strings, DWs..)



Where do we stand? - 2 - General ALPs

- Mass and coupling unrelated

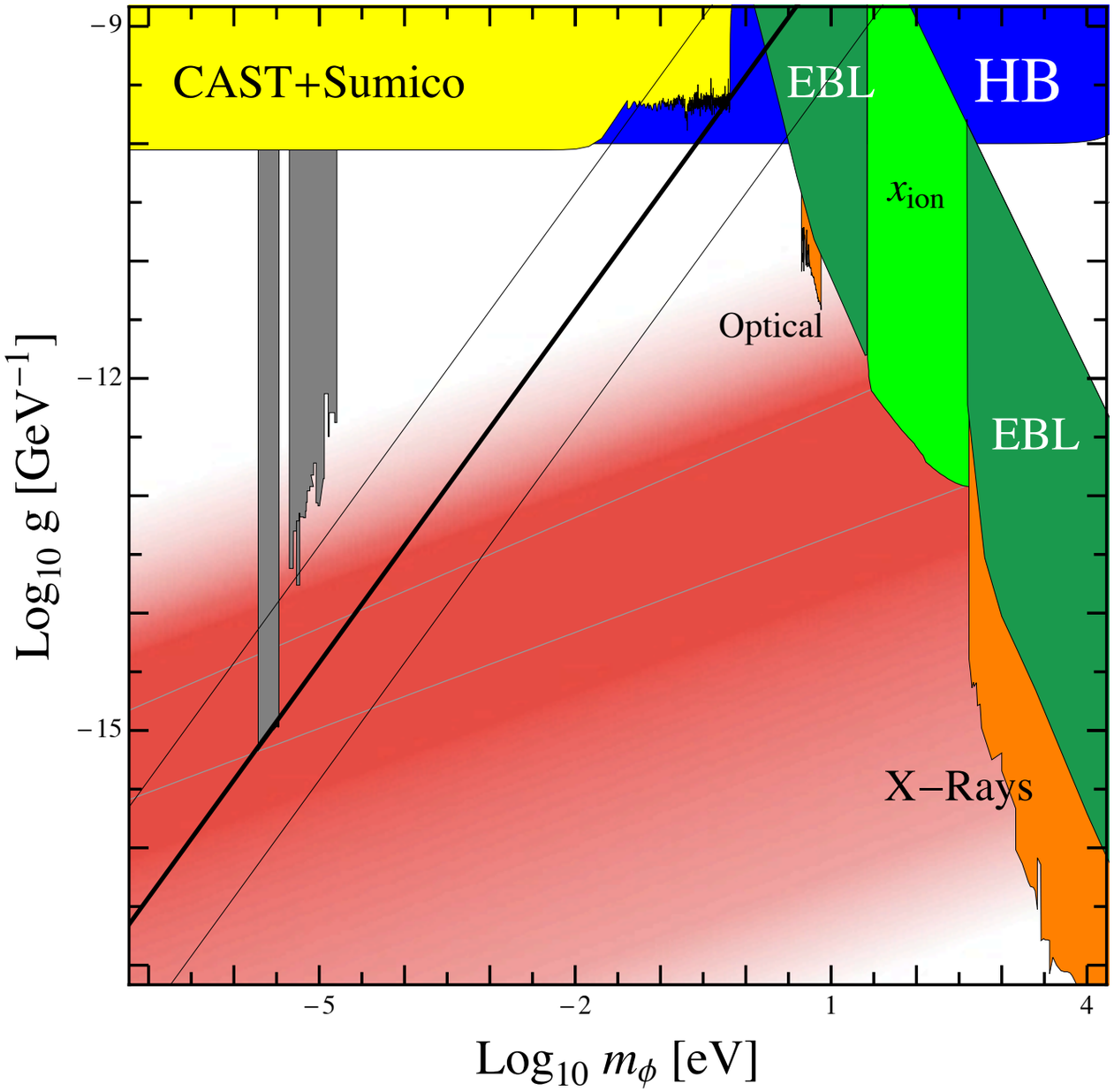
$$g = \frac{\alpha}{2\pi f_a} \times O(1)$$

- Scenario 2 (anthropic)

$$f_a > H_I$$

(realignment mechanism)

- Isocurvature constraints!!



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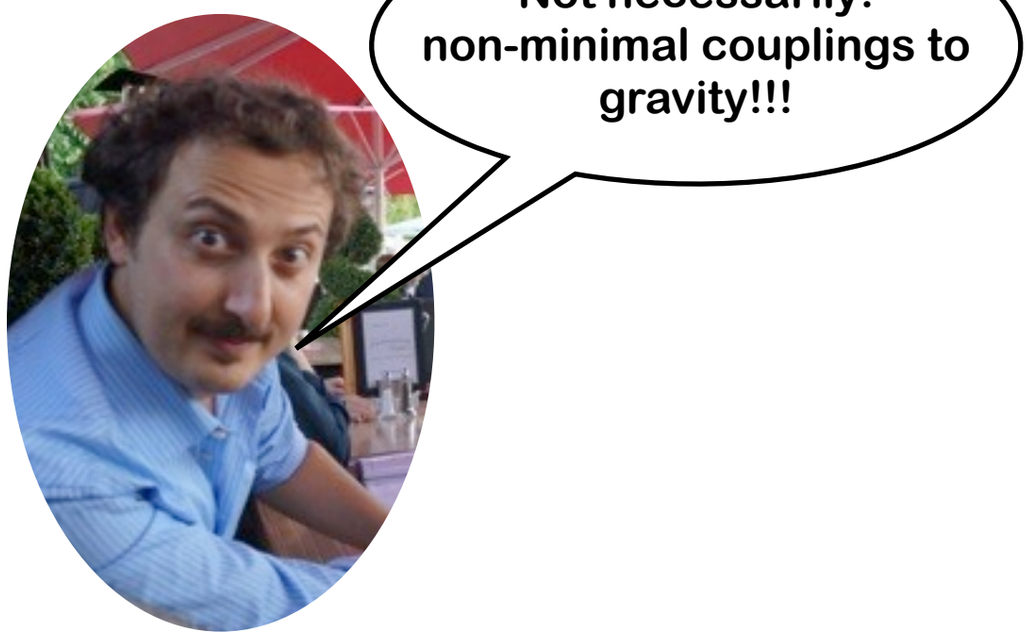
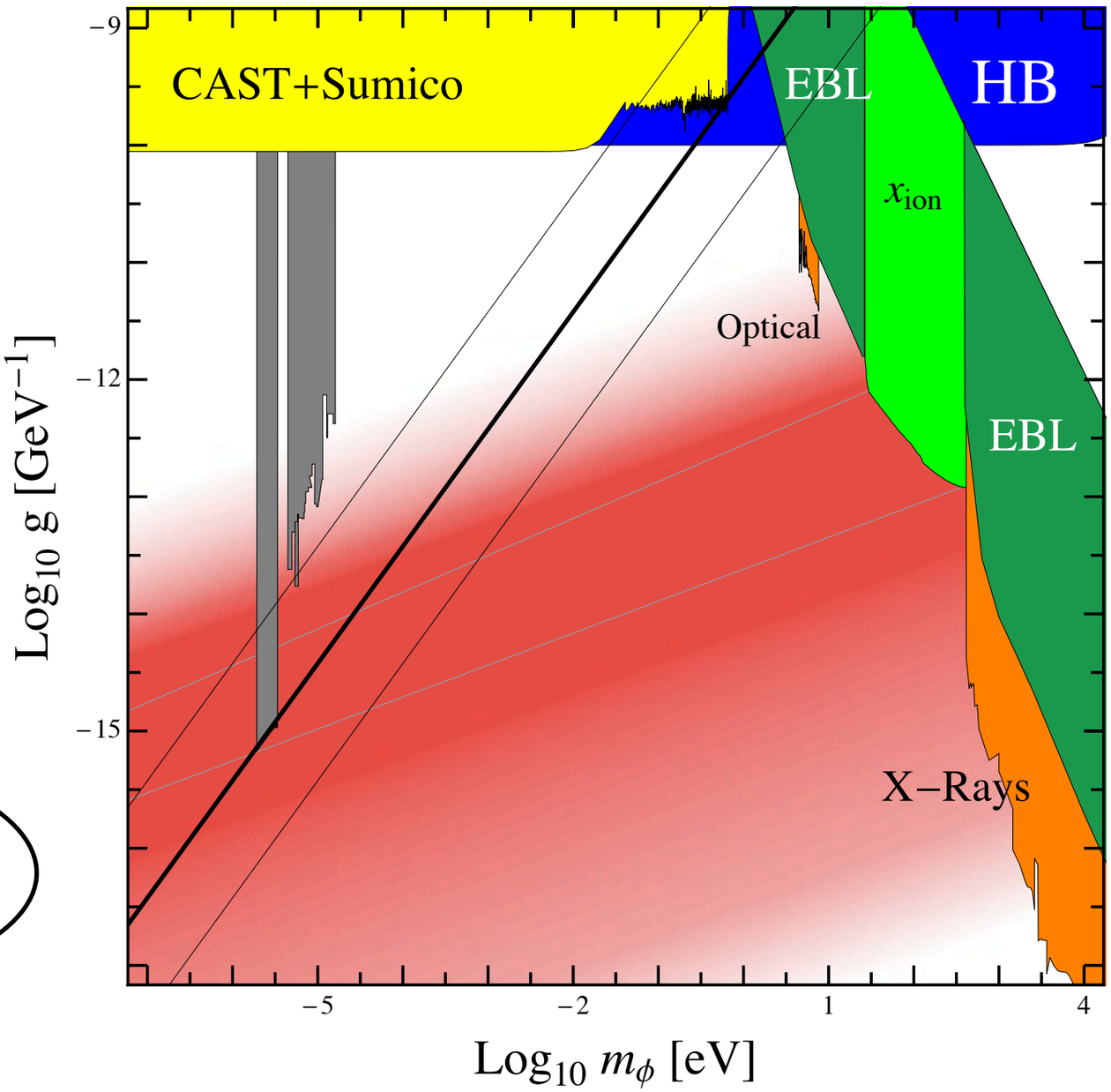
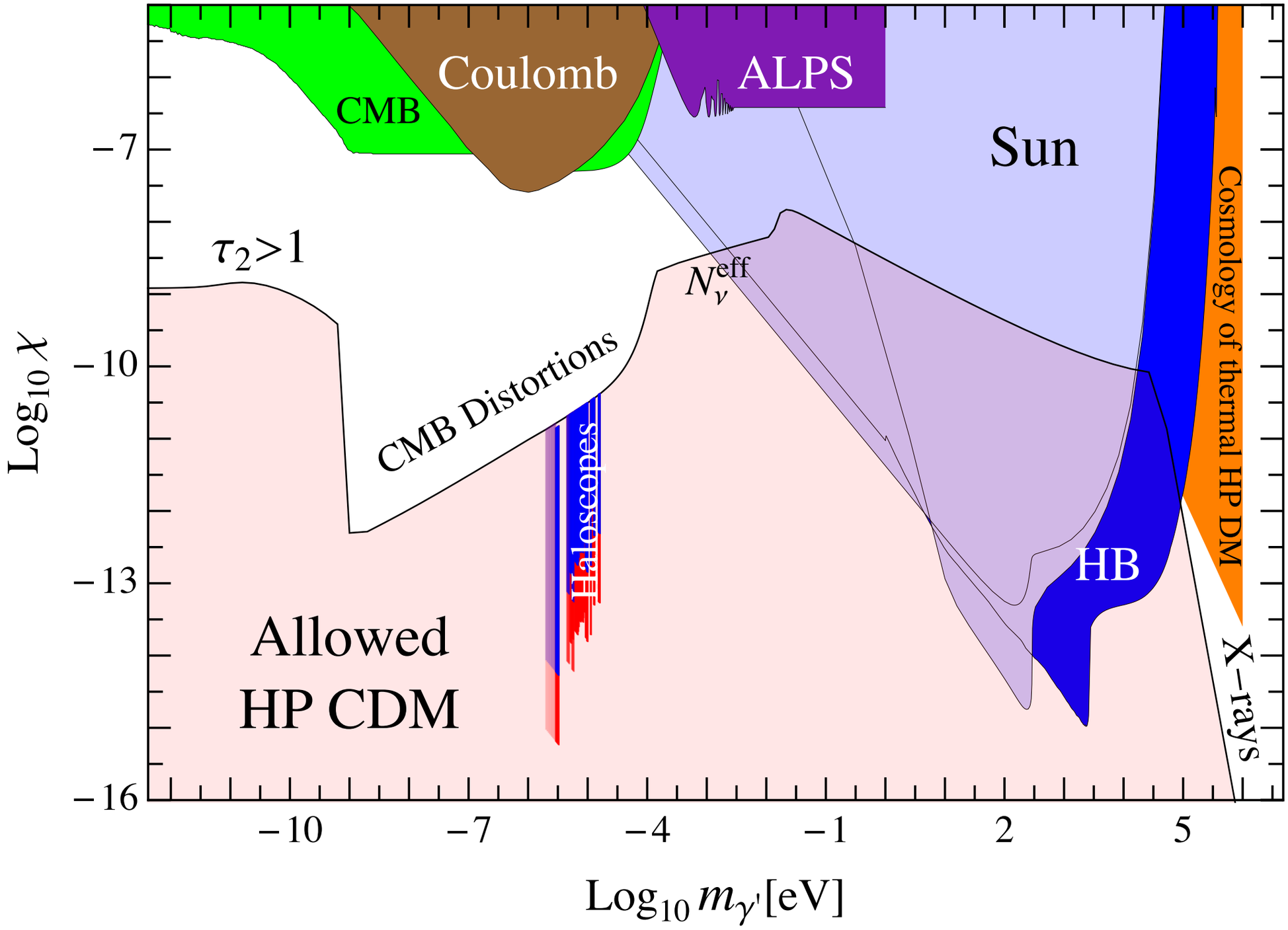


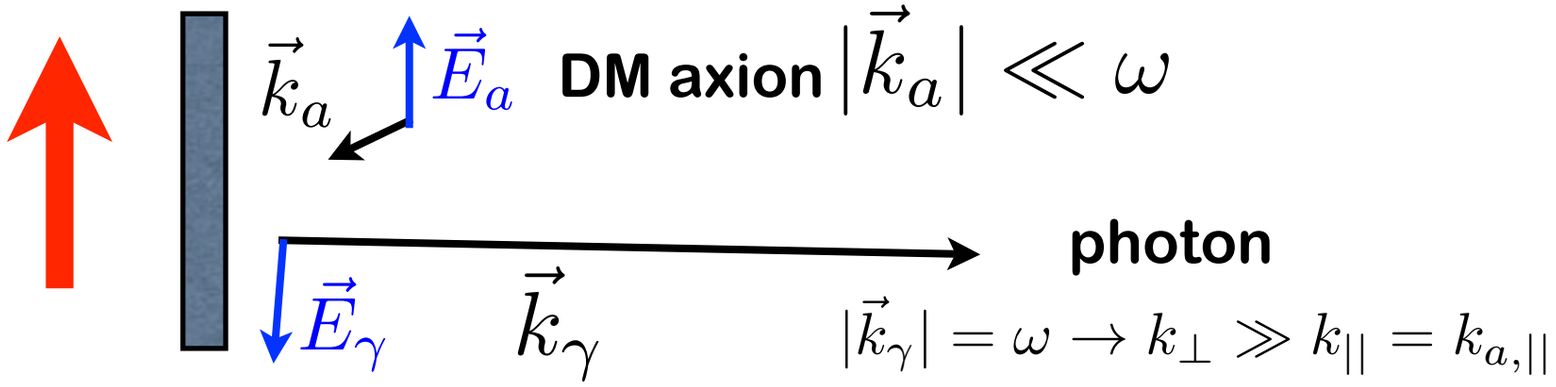


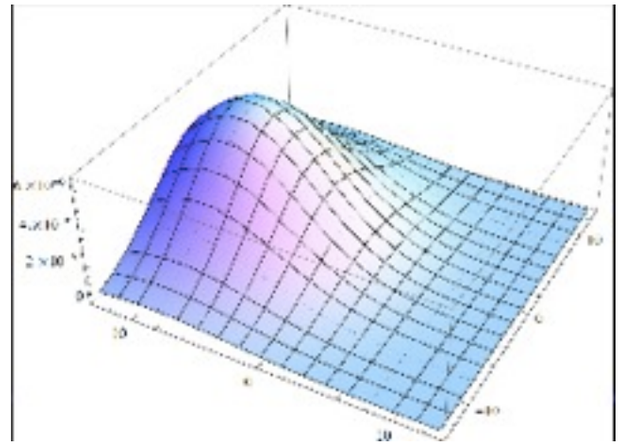
Where do we stand? - 3 - Hidden Photons



What can we do?

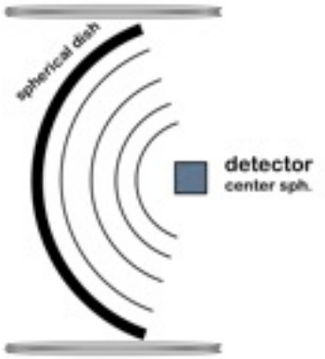
- Axions/ALPs/Hidden Photons are radiated from mirrors (they carry E-field)





velocity distribution

- We can measure this radiation from a dish antenna



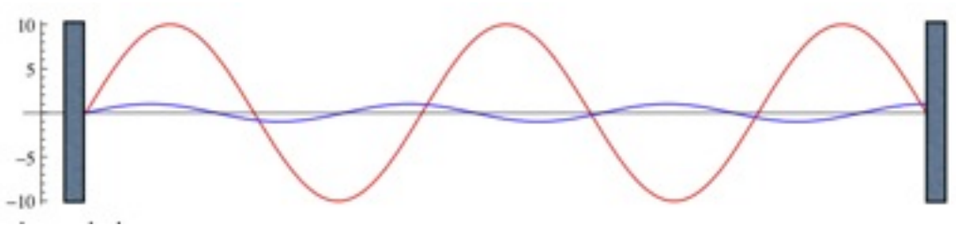
$$\frac{P_{\rm out}}{\rm Area} \simeq \chi^2 \rho_{\rm CDM} = 10^{-20}\,\frac{\rm W}{m^2}\left(\frac{\chi}{10^{-15}}\right)^2$$

$$\chi_{\rm ALP} = \frac{gB}{m_{\rm ALP}}$$

$$\chi_a \simeq 10^{-15}\,\frac{B}{10T}$$

Broadband experiment!!!!

- We can amplify this in a resonant cavity



$$\frac{P_{\rm out}}{\rm Area} \simeq \frac{1}{Q}\chi^2 \rho_{\rm CDM}$$

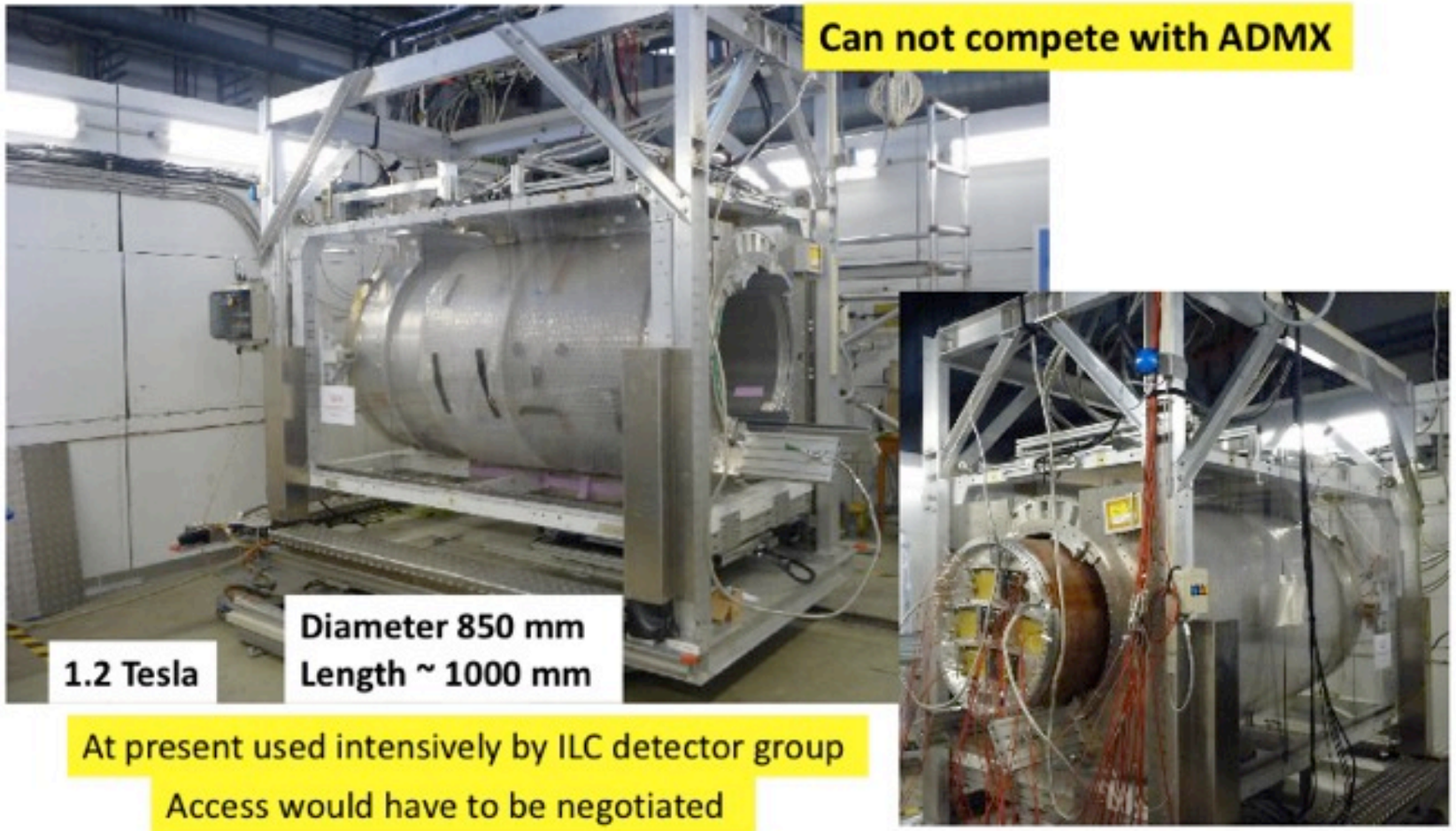
We don't know the WISP mass-> scan

What can we do? magnets

Based on Phys. Rev. D 85 (Feb 2012) 035018

Superconducting solenoids

PCMAG in DESY test beam Hall 2; in operation



Can not compete with ADMX

At present used intensively by ILC detector group

Access would have to be negotiated

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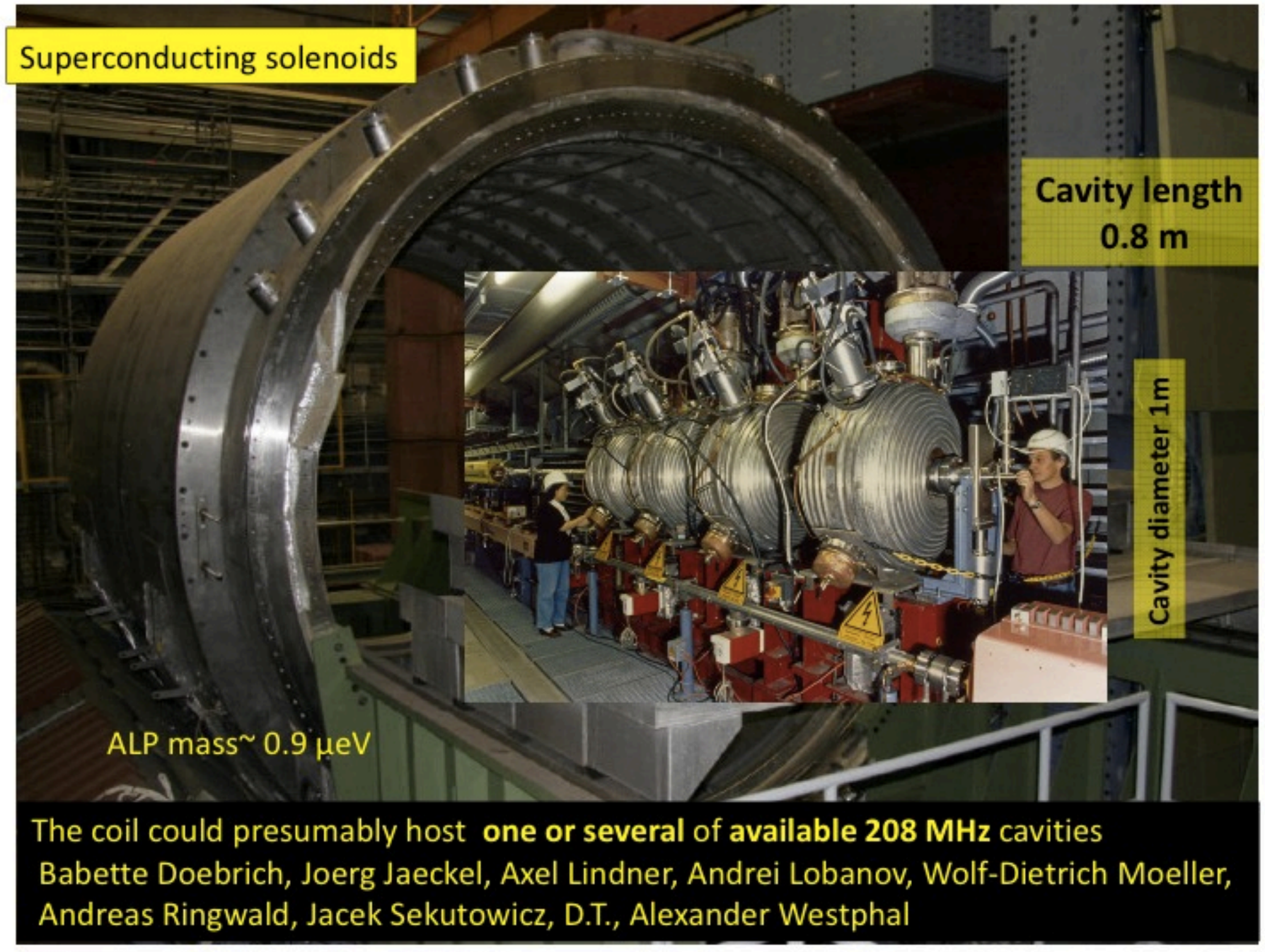

The coil could presumably host **one or several** of **available 208 MHz** cavities
Babette Doebrich, Joerg Jaeckel, Axel Lindner, Andrei Lobanov, Wolf-Dietrich Moeller, Andreas Ringwald, Jacek Sekutowicz, D.T., Alexander Westphal

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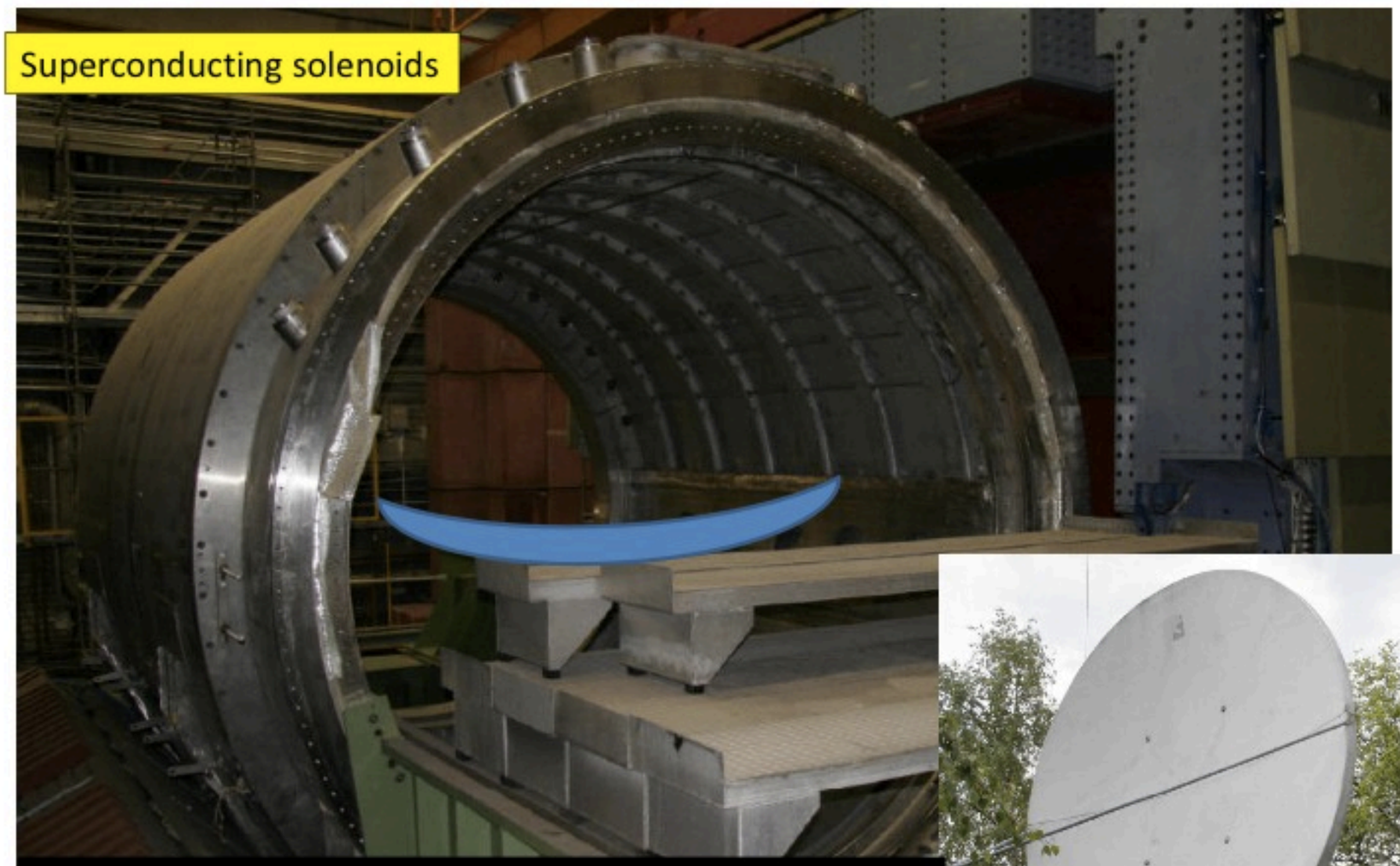

The coil could presumably host available dish antenna
see arXiv: 1212.2970
Dieter Horns, Joerg Jaeckel, Axel Lindner, Andrei Lobanov
Javier Redondo, Andreas Ringwald

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Can not compete with ADMX

Could presumably host
a 3 GHz cavities +shielding

Michael Betz, Fritz Caspers

When the cryogenics supply to the HERA hall north is reestablished for ALPS II the cryogenic connection of the solenoid is possible
>2017

What can we do? magnets

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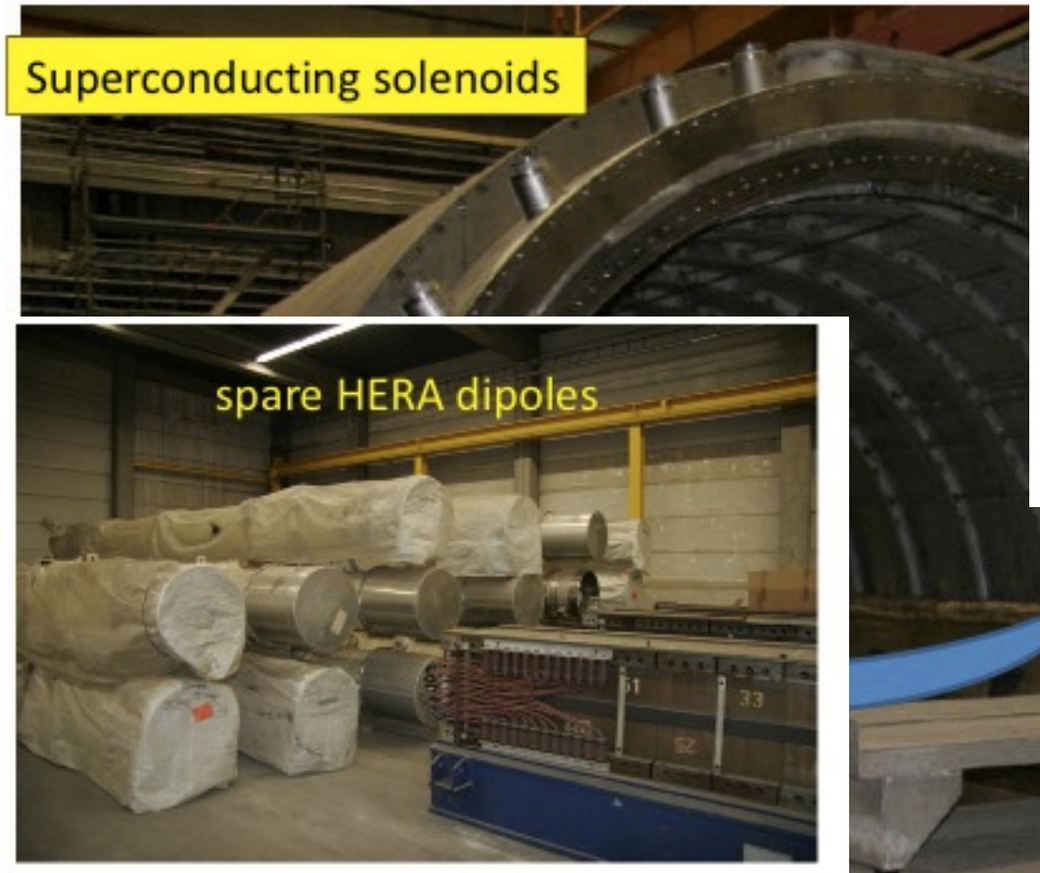

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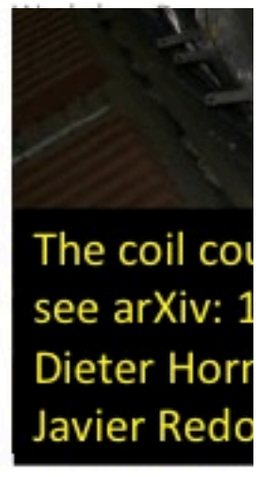

Superconducting solenoids

For the operation of a single dipole all the necessary infrastructure is available and operational at the original test bench

Magnetic Field @ 920 GeV	5,25	T
Magnetic length	8,83	m
Total length	9,77	m
Radius of curvature	585	m
Inner diameter of beam pipe	55,3	mm

cryogenics connected to cryogenics plant

vacuum system

power supply

dump resistors
dump switch
controls

the quench protection and interlock system will be rebuilt

Experimental schedule schedule has to be matched to the preparation of ALPS II

What can we do? magnets

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Superconducting solenoids

Can not compete with ADMX

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PCMAG in DESY test bea

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e and operational
n

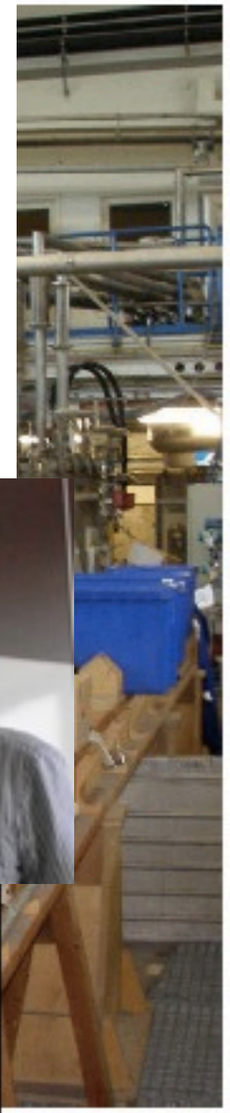
Conclusion:

There are opportunities for ALPs dark matter searches
with magnets available at DESY today:

with normal conducting dipoles, however **not competitive with ADMX**
with wiggler magnets ??
with a superconducting straightened HERA dipole

There are perspectives in a few years with

the superconducting H1 solenoid
strings of straightened HERA dipoles at the ALPS II setup



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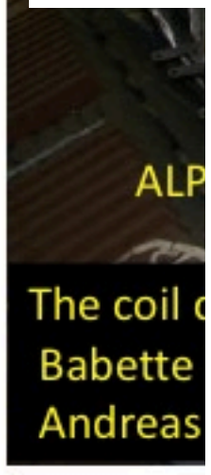

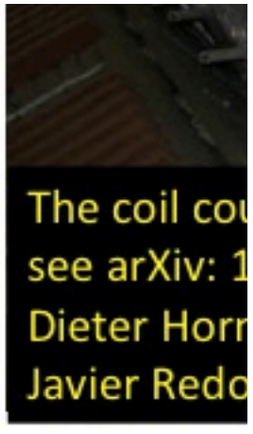

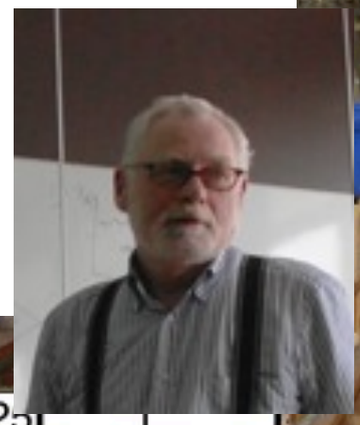

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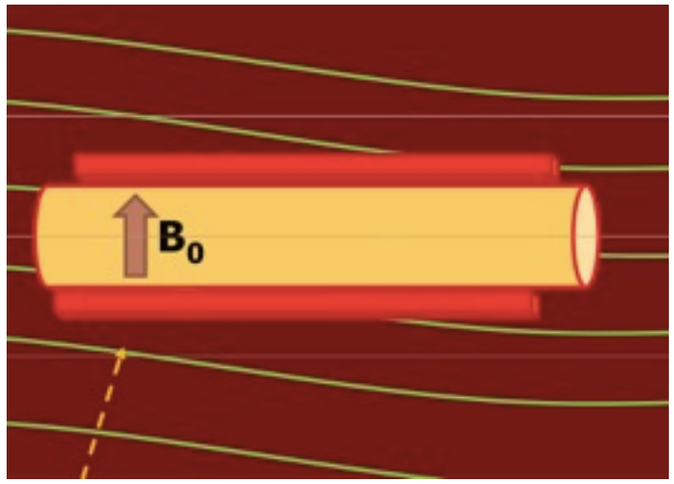
What can we do? magnets and IAXO



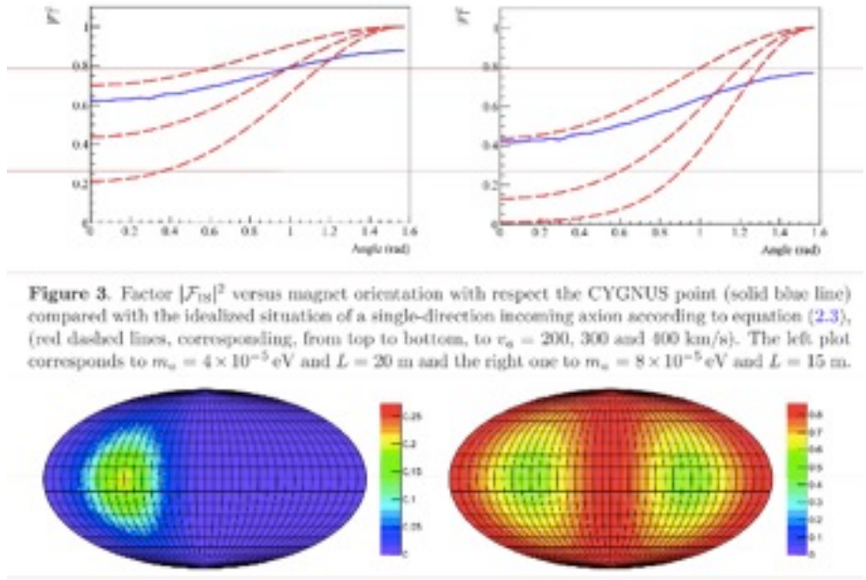
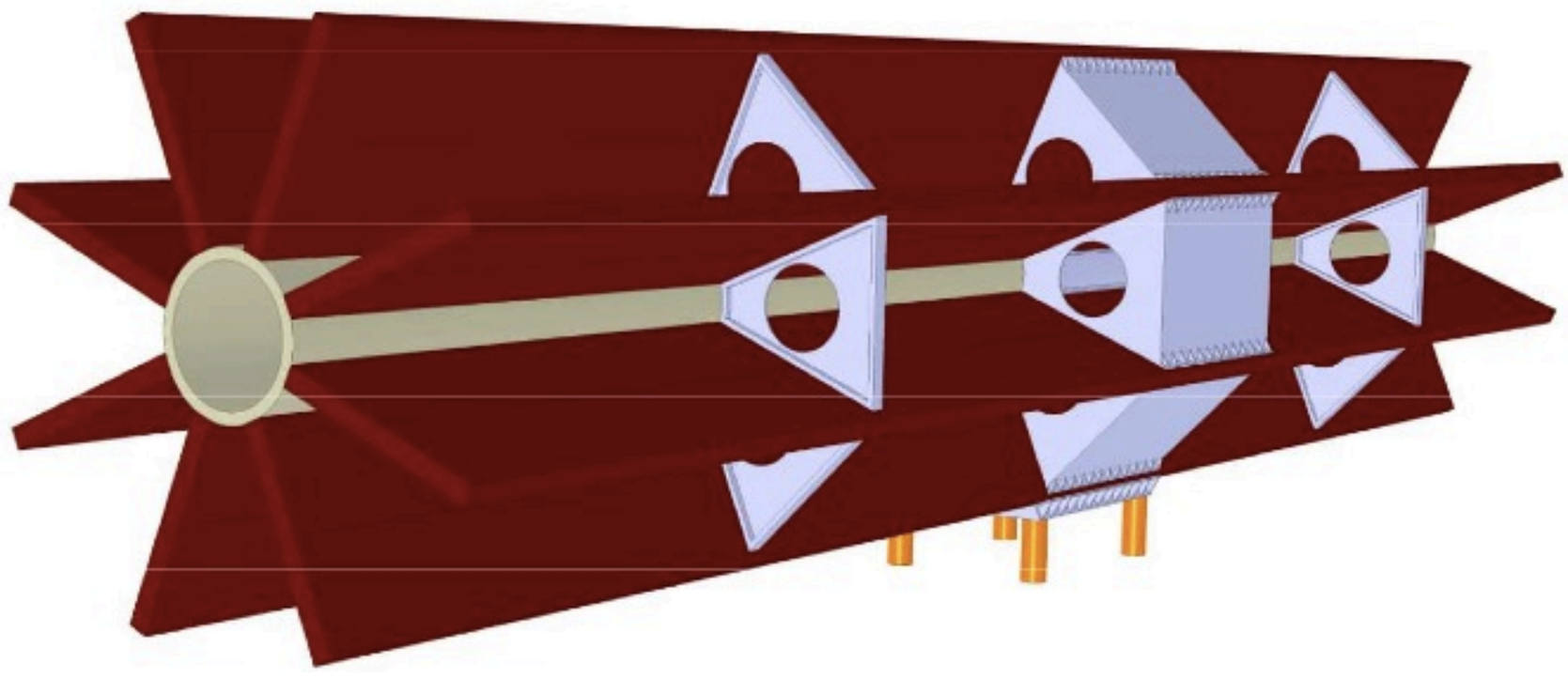


Figure 3. Factor $|\mathcal{F}_{lS}|^2$ versus magnet orientation with respect the CYGNUS point (solid blue line) compared with the idealized situation of a single-direction incoming axion according to equation (2.3), (red dashed lines, corresponding, from top to bottom, to $v_a = 200$, 300 and 400 km/s). The left plot corresponds to $m_a = 4 \times 10^{-5}$ eV and $L = 20$ m and the right one to $m_a = 8 \times 10^{-5}$ eV and $L = 15$ m.

directional information also for cavity experiments (Irastorza, Galan 2012)

IAXO

- Huge strong magnet
- Host many cavities
- Easier to implement now (design phase)
- Strengthens case



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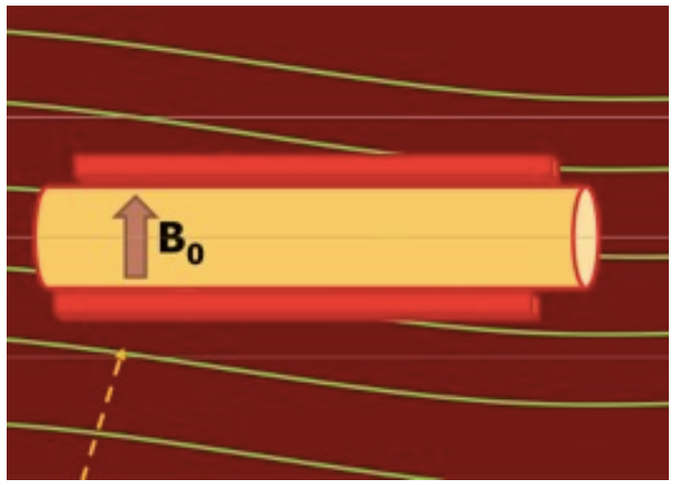

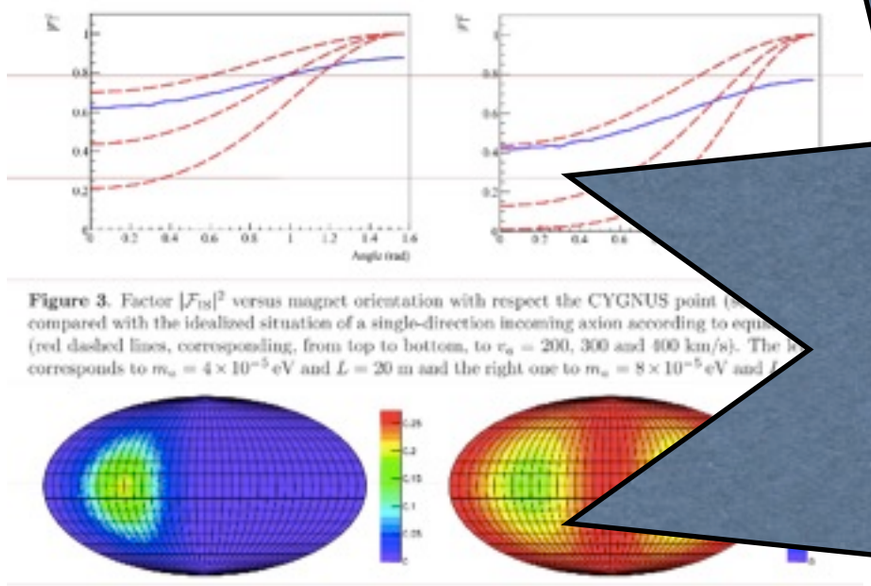

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DESY-Zaragoza collaborations on waveguide@ALPS ... IAXO?

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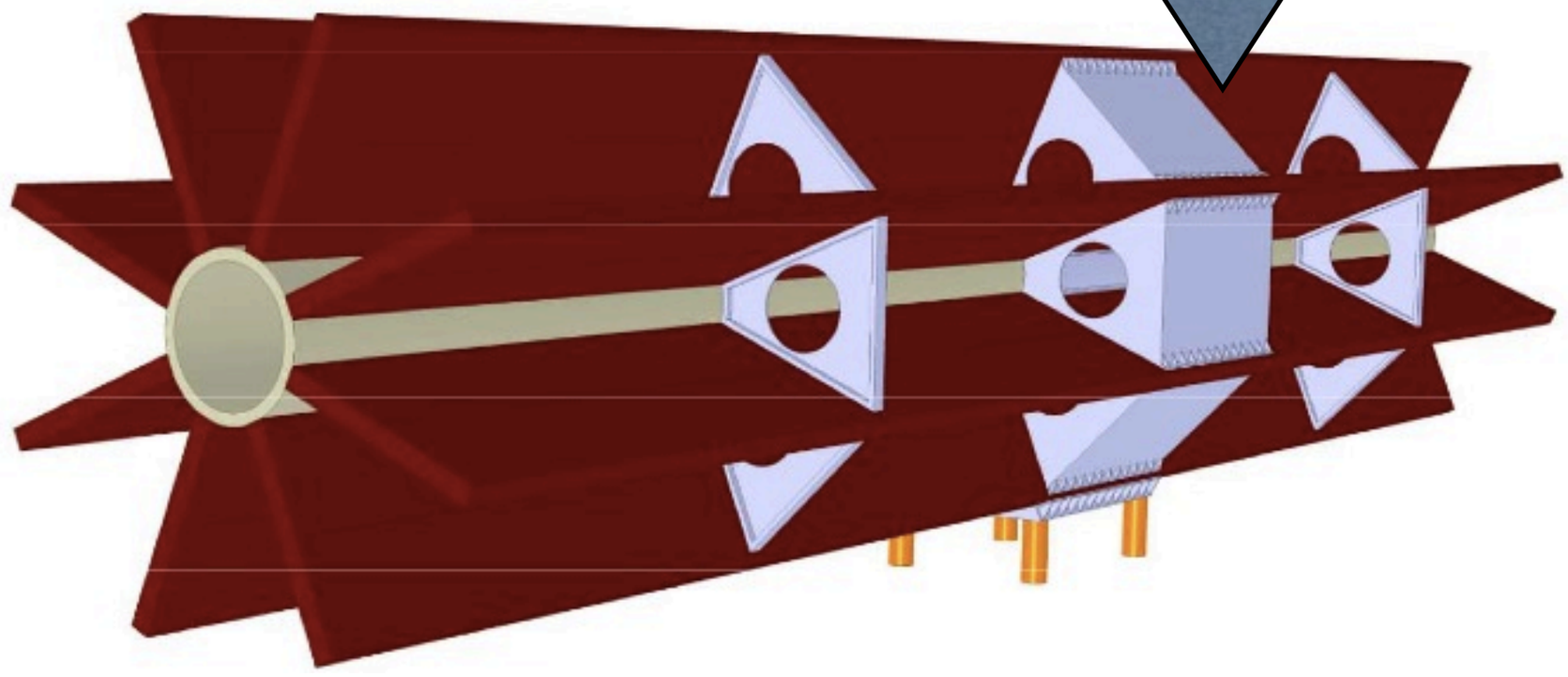
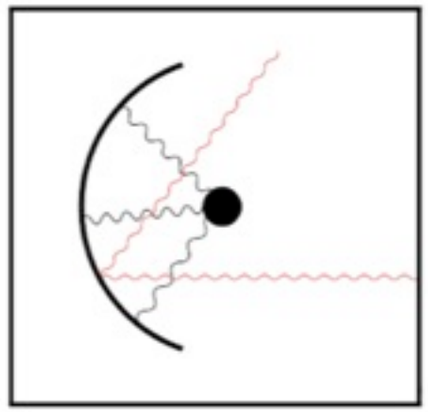
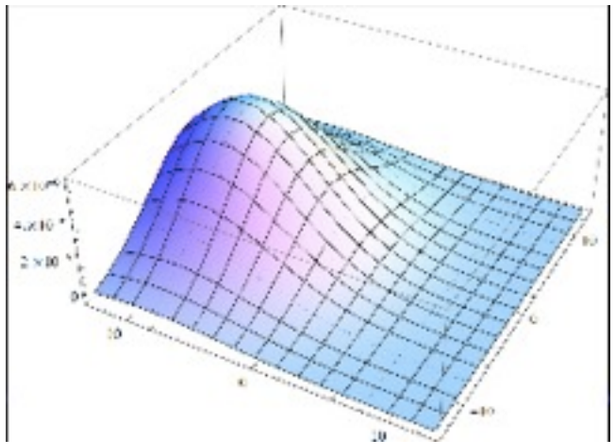
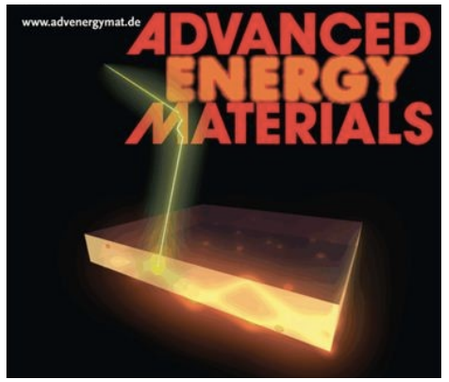


What can we do? detectors

Kowalski, (Bonn U.) Detectors for a Dish Experiment in the visible
CCDs, TES ... Photomultipliers favored for S/N (non-zero v gives a big spot)







Light concentration
K-shifting lightguides

Kreisa, Schäfer. (MPI-Radioastronomy)

Overview on (in)coherent detectors, horns, (noise from det. position)

Type	Freq. range	Active element	Cryogenics	Practical Sensitivity	BW
HEMT LNA	1 – 100GHz	Semiconductor	15K closed cycle	~ f/2.5 in K	3 octaves 40% (WG)
SIS mixer	100GHz – 1.2THz	Supercond. tunnel junct.	4K LHe or closed cycle	20….600 K	40% (fund. WG)
HEB mixer	1.4THz – 4THz	Supercond. weak link	4K LHe or closed cycle	700…2000 K	40% (fund. WG)
DC SQUID	≤ 3.8GHz	Supercond. interferom.	4K LHe, dilution refrigerator	0.5…1K ~50mK for dil. fridge	few % (Varactor tuning: octave)
Parametric Josephson amplifier	4-8GHz	JJ circuit	4K LHe, dilution refridgerator		octave

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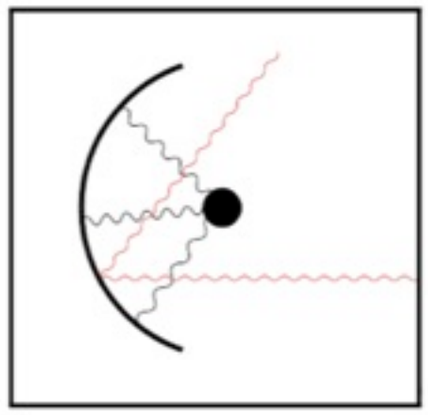

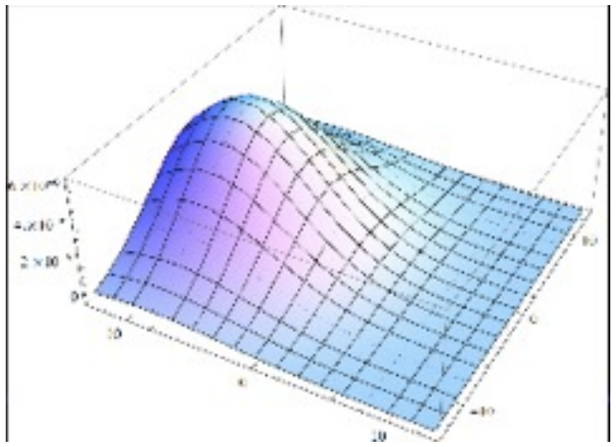

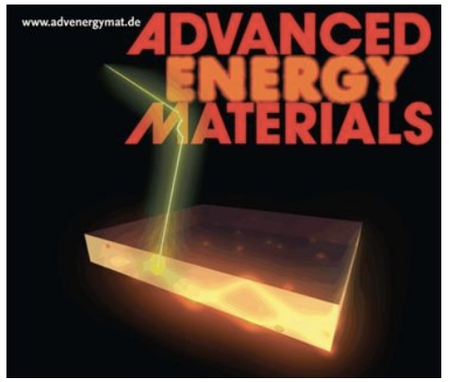

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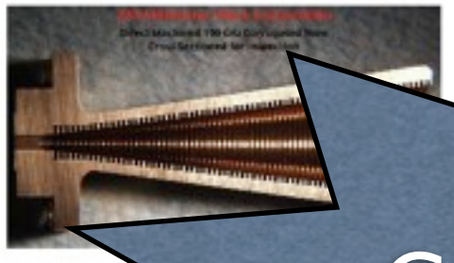
Type	Freq. range	Active element	Cryogenics	Practical Sensitivity	BW
HEMT LNA	1 – 100GHz	Semiconductor	15K closed cycle	~ f/2.5 in K	3 octaves 40% (WG)
SIS mixer	100GHz – 1.2THz	Supercond. tunnel junct.	4K LHe or closed cycle	20….600 K	40% (fund. WG)
HEB mixer	1.4THz – 4THz	Supercond. weak link	4K LHe or closed cycle	700…2000 K	40% (fund. WG)
DC SQUID	≤ 3.8GHz	Supercond. interferom.	4K LHe, dilution refrigerator	0.5…1K ~50mK for dil. fridge	few % (Varactor tuning: octave)
Parametric Josephson amplifier	4-8GHz	JJ circuit	4K LHe, dilution refridgerator		octave



Good synergy,
first collaborations!

we have plenty of mirrors ... but not optimal

... best built a dedicated set up (spherical, smooth, coolable, B)

what are we going to do? ... plenty!

- DESY already involved in WISPDMX (fut. hosting magnet)
  (See talk of A. Lobanov)

- CERN is also in (LSW cavity), interested in DM searches

- Good infrastructure in DESY/CERN (magnets, cryo) but user facility-spirited
  Need external collaborators!
  Not everything is immediately available (cryo... , SC magnets)

- Interest and synergy with the MPIR in Radio detectors and dish-related asp.

- U. Zaragoza/U. Valencia interested in designing waveguide experiment@ALPS
  (IAXO can host DM experiments)

- Bonn University/DESY, join forces for a Dish experiment@visible (... SUMICO!)

- We all have good ideas, but limited manpower

Conclusions

https://indico.desy.de/conferenceDisplay.py?confId=7975