WISP hunting
--
some new experimental ideas[1]

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**DESY

[1] by crazy theorists

AC/DC

Highway to minicharged particles

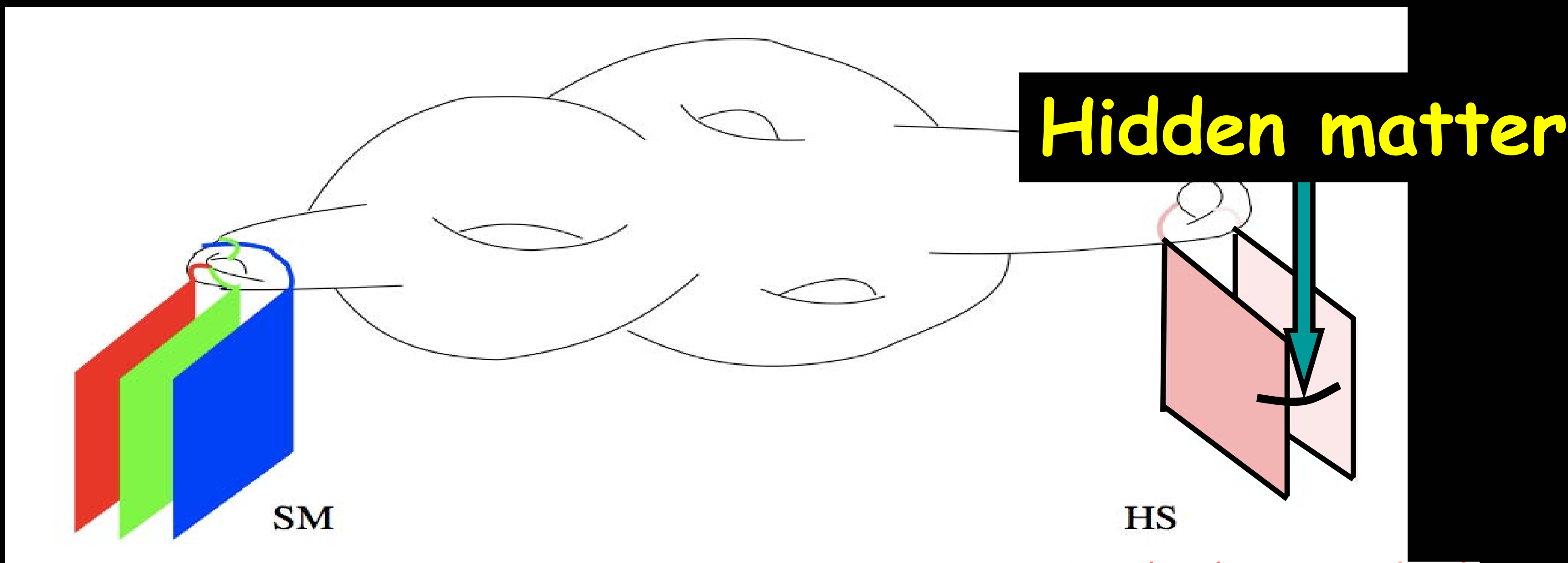
AC/DC

(accelerator cavity/dark current)

Highway to minicharged particles

Minicharged particles

- Minicharged particles are particles which have a small fraction of the electron electric charge
- Searching them tests fundamental ideas such as charge quantization
- May give insight into fundamental physics



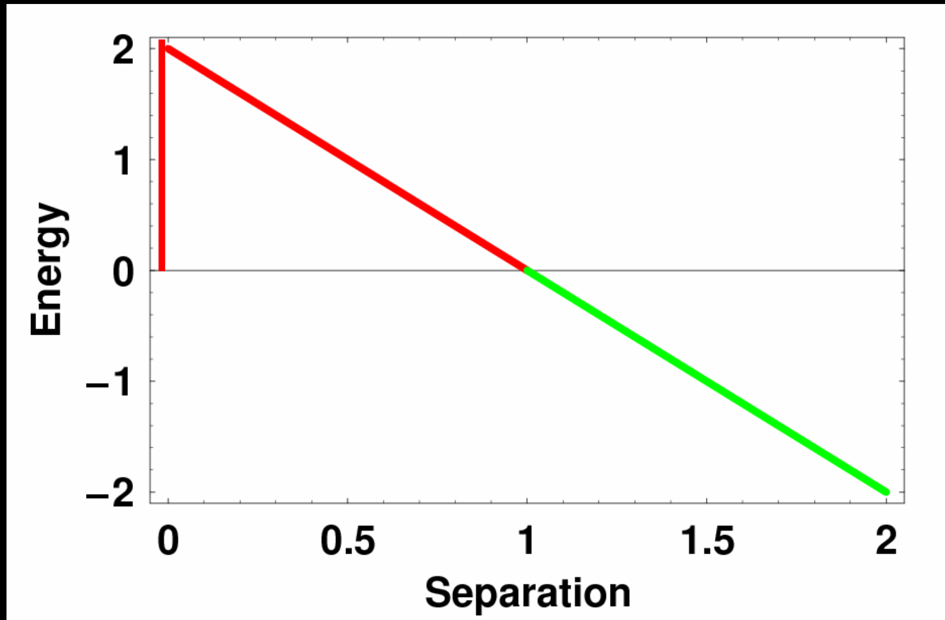
$U(A) \times U(B) \times U(C)$

$U(A) \times U(B)$

Schwinger Pair Production

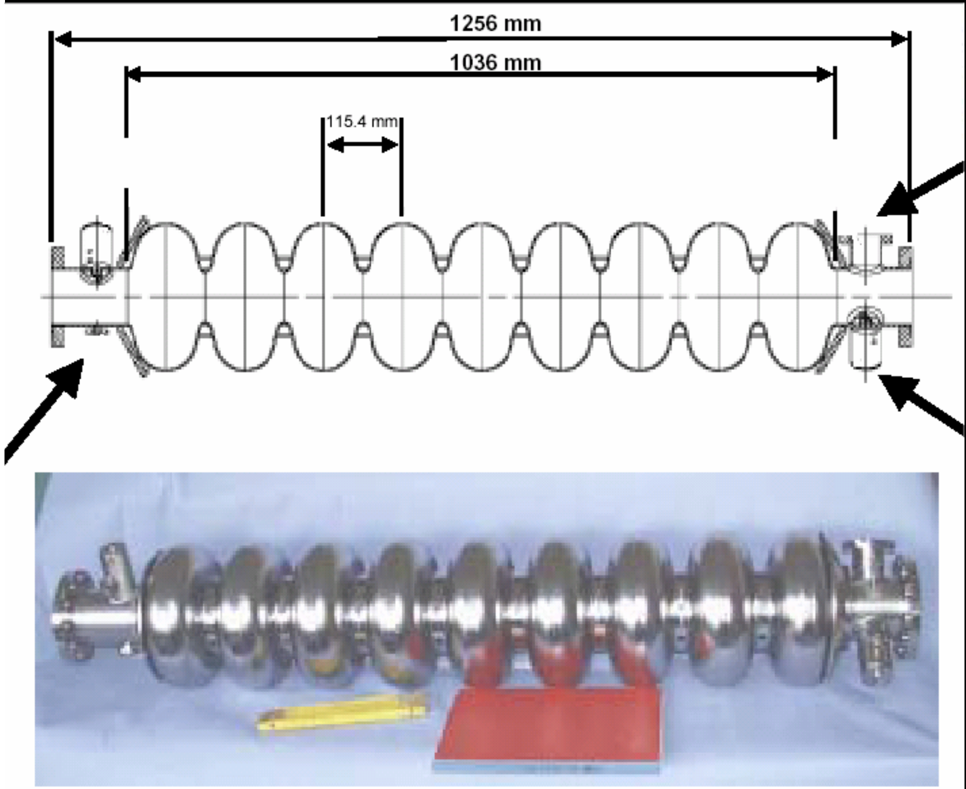
- Pair Production in a strong electric Field (without Laser)!
- Similar to tunneling:

Energy of `vacuum pair'



- An $\mathrm{f}, \bar{\mathrm{f}}$ -pair separated by a distance $d > \frac{2m_e}{\epsilon e \mathbf{E}}$ has less energy than no particles!

Acceleator cavities



One standard **9-cell TESLA accelerating structure**

$$\mathbf{E} \gtrsim 25\,\mathrm{MV/m} \approx 16\,\mathrm{eV}^2$$

must be &

$$\mathbf{E}_{crit} = \frac{m_\epsilon^2}{\epsilon e}$$

Sensitive to

$$\epsilon < 2 \times 10^{-6} \quad \text{for} \quad m_\epsilon < 0.01\,\mathrm{eV}$$

Finding the produced MCPs

- Effects of millicharged particles decreases with smaller ϵ

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Direct detection is difficult

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Look for macroscopic effects

Energy loss

- If many particles are produced we get a

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Macroscopic energy loss!

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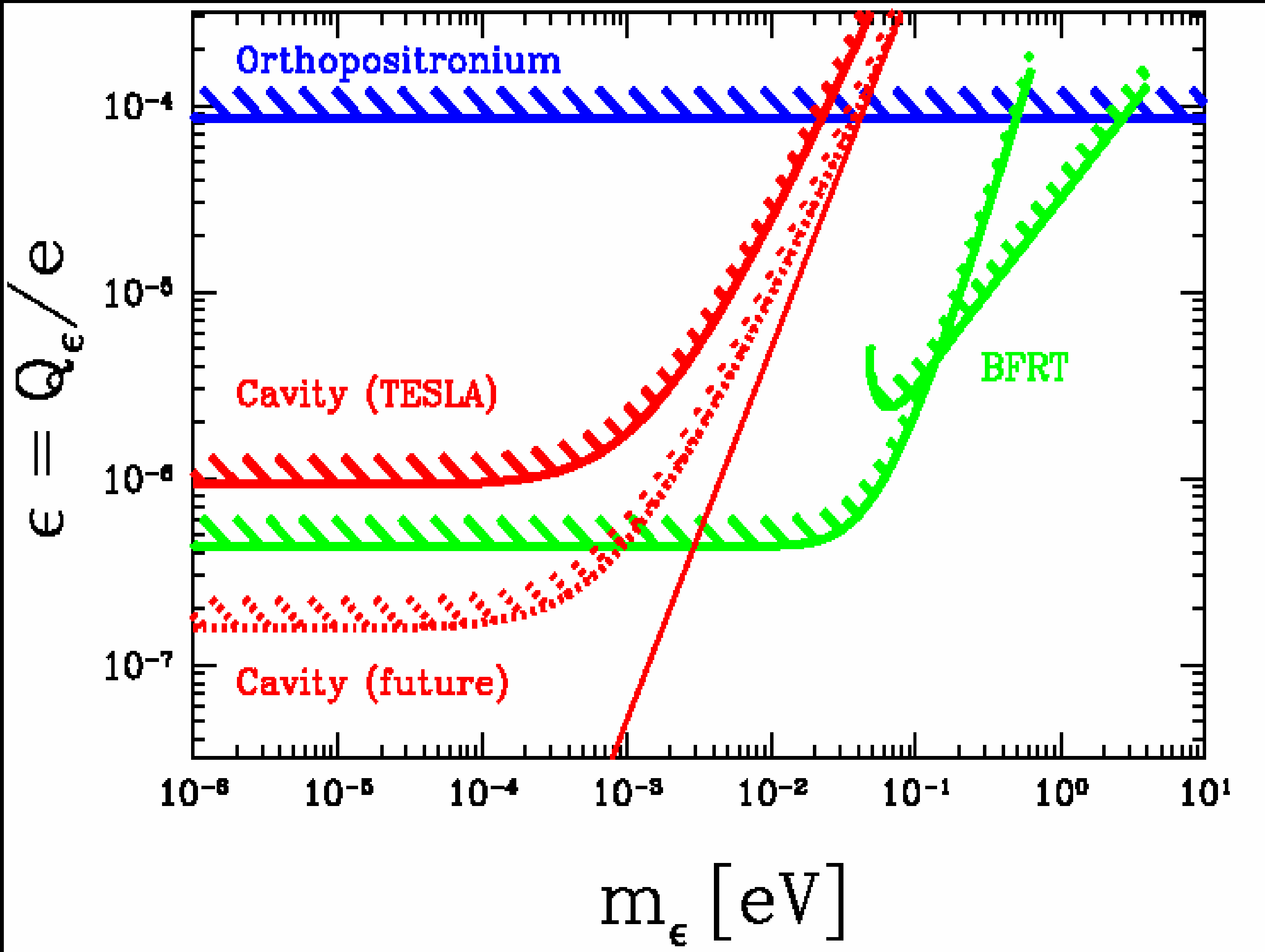
Can be measured

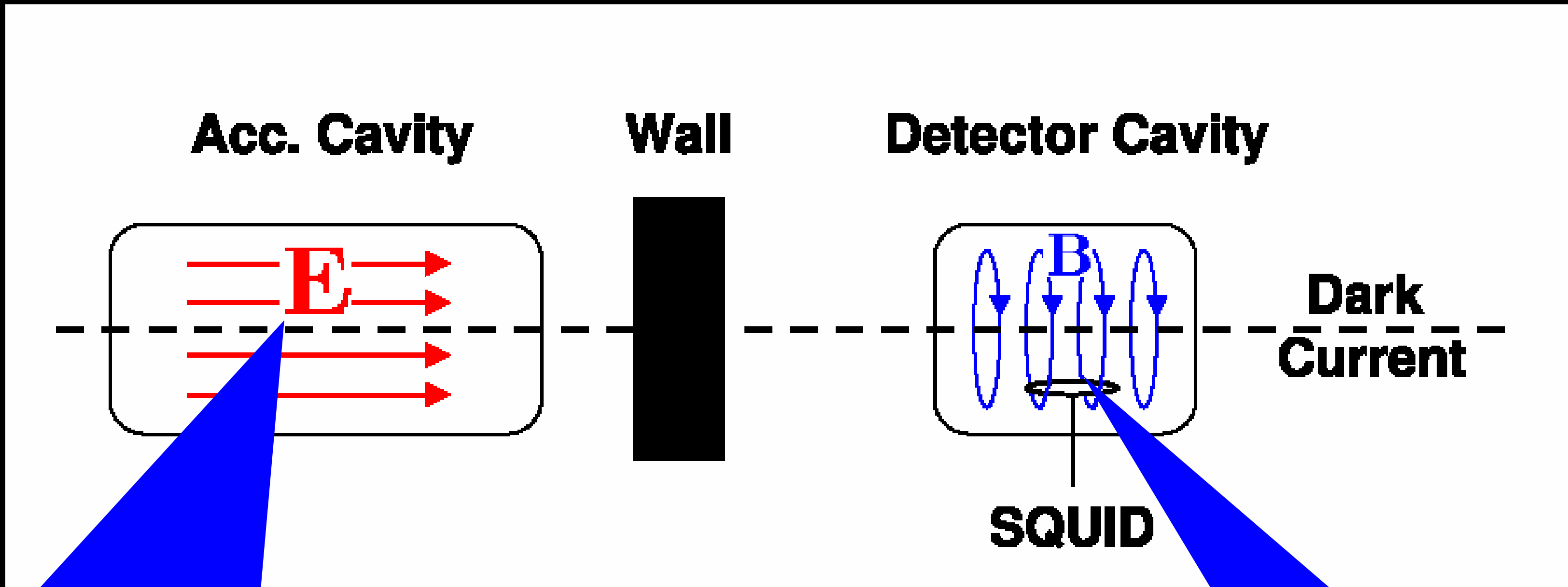
Quite strong bounds!



Not quite competitive with astrophysical bounds…

Nearly-direct detection...

Dark Current Shining through a Wall!



Minicharged particles produced in the cavity lead to a Dark Current

Dark Current detection

Advantages

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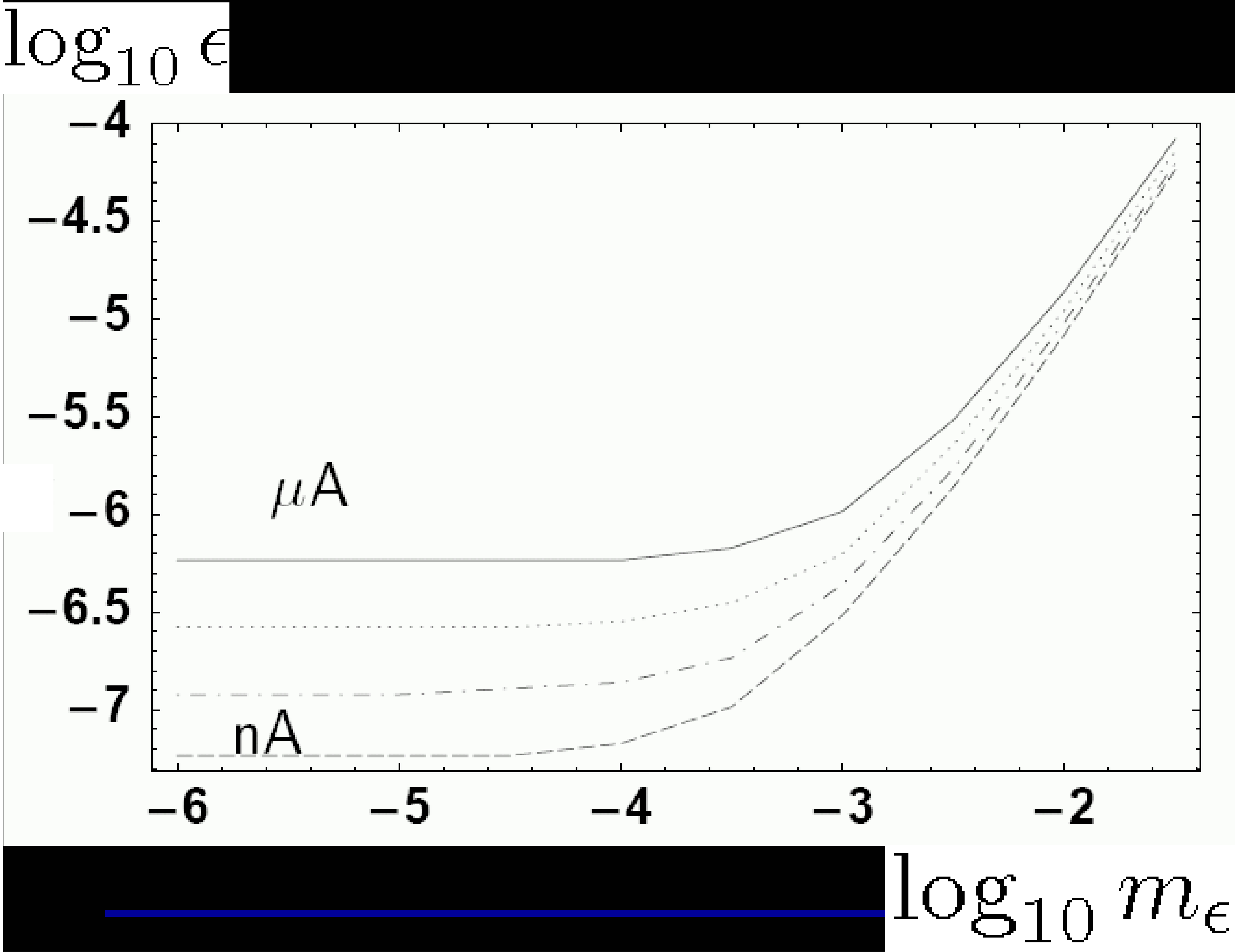
- It's a (nearly) direct detection
- It detects minicharged particles without making use of the hidden photons

All parts exist!

Cavity

Cryogenic Current Comparator

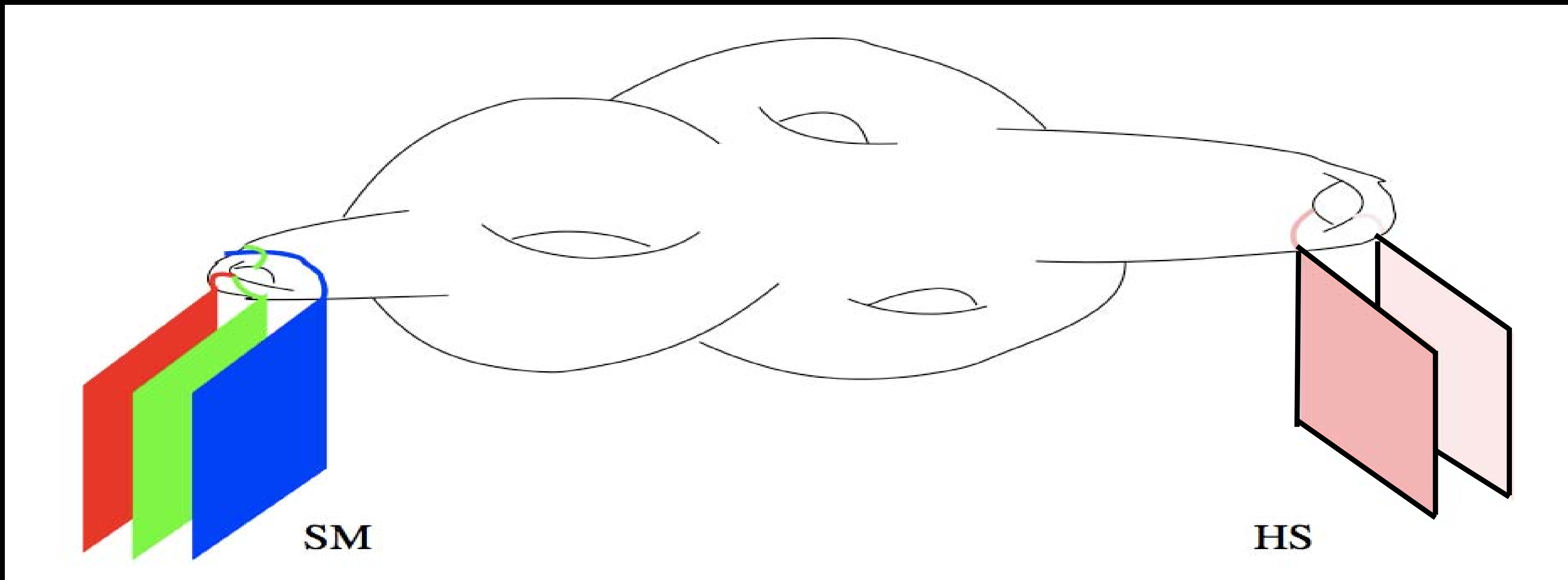
Sensitivity



Searching hidden photons inside a superconducting box

Hidden Photons

- Extra (light) U(1) gauge bosons
- Standard model particles carry no (tree-level) charge under them ➡ hidden!
- Tests hidden sectors of standard model extensions



$U(A) \times U(B) \times U(C)$ $U(A) \times U(B)$

Massive hidden photons

- Hidden Photons can mix with the ordinary photon
- Propagation eigenstates are not identical with interaction eigenstates

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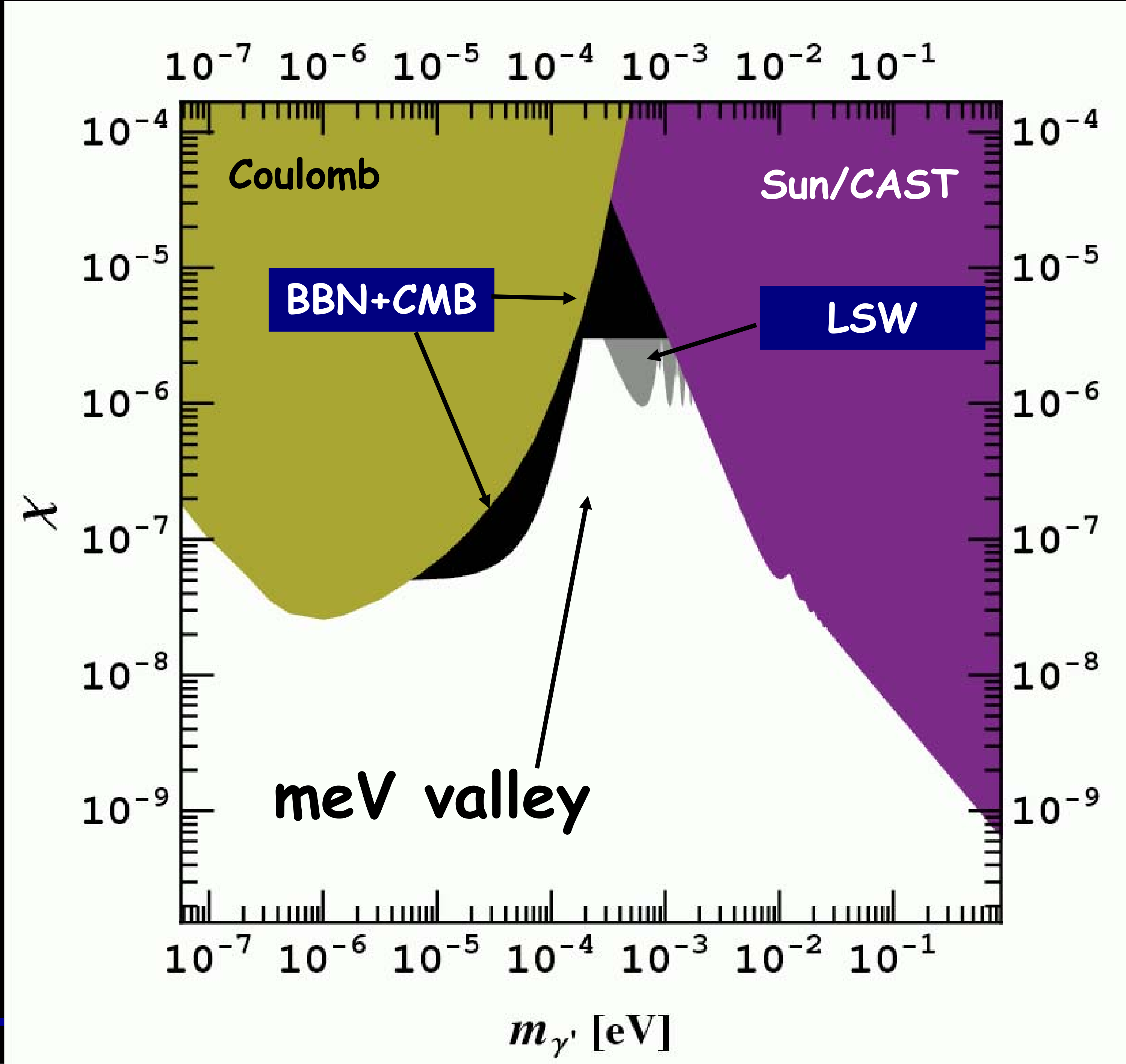
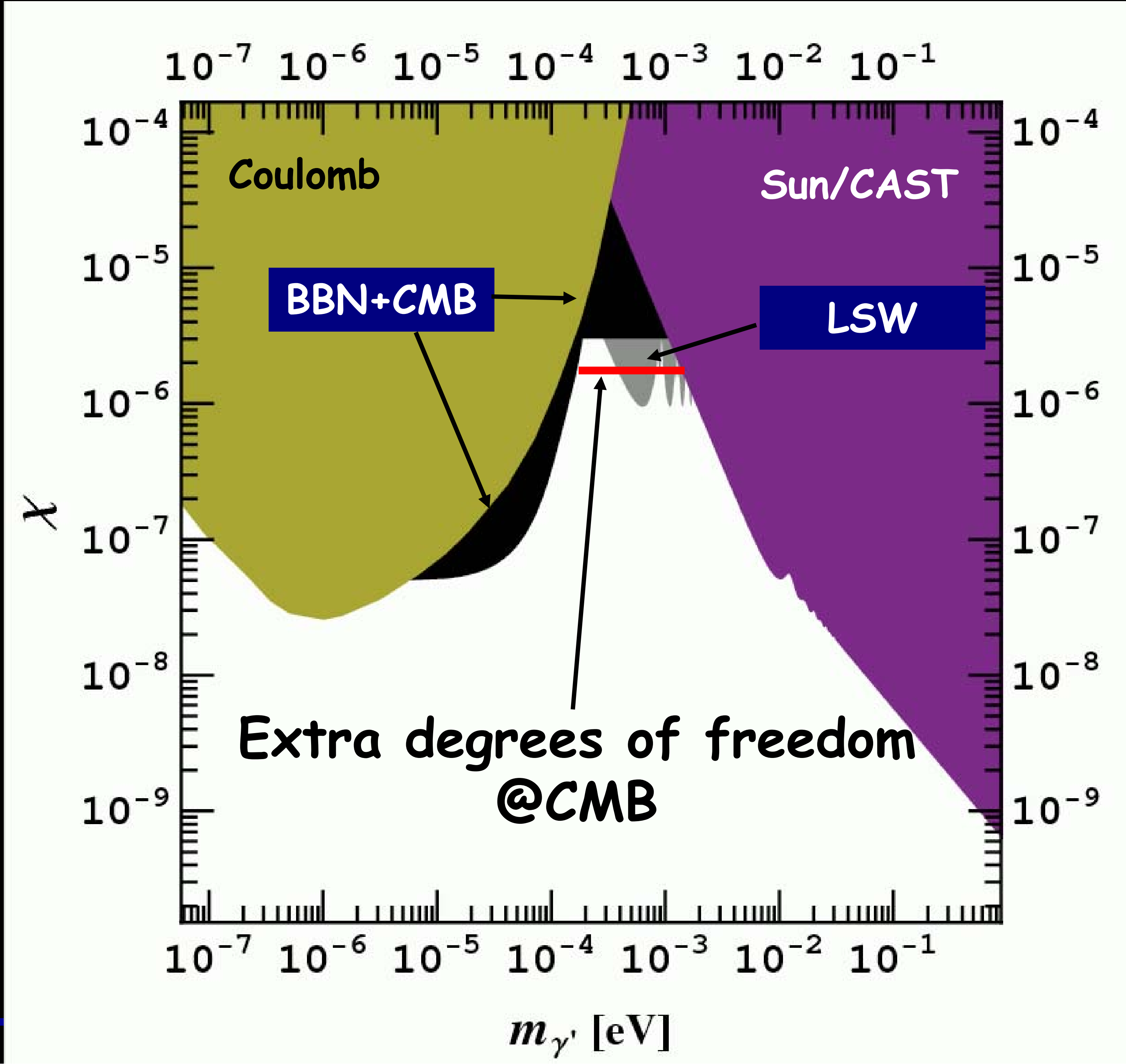
- Photon – Hidden photon oscillations
- Completely analogous to neutrino oscillations

Current bounds ➡ opportunities

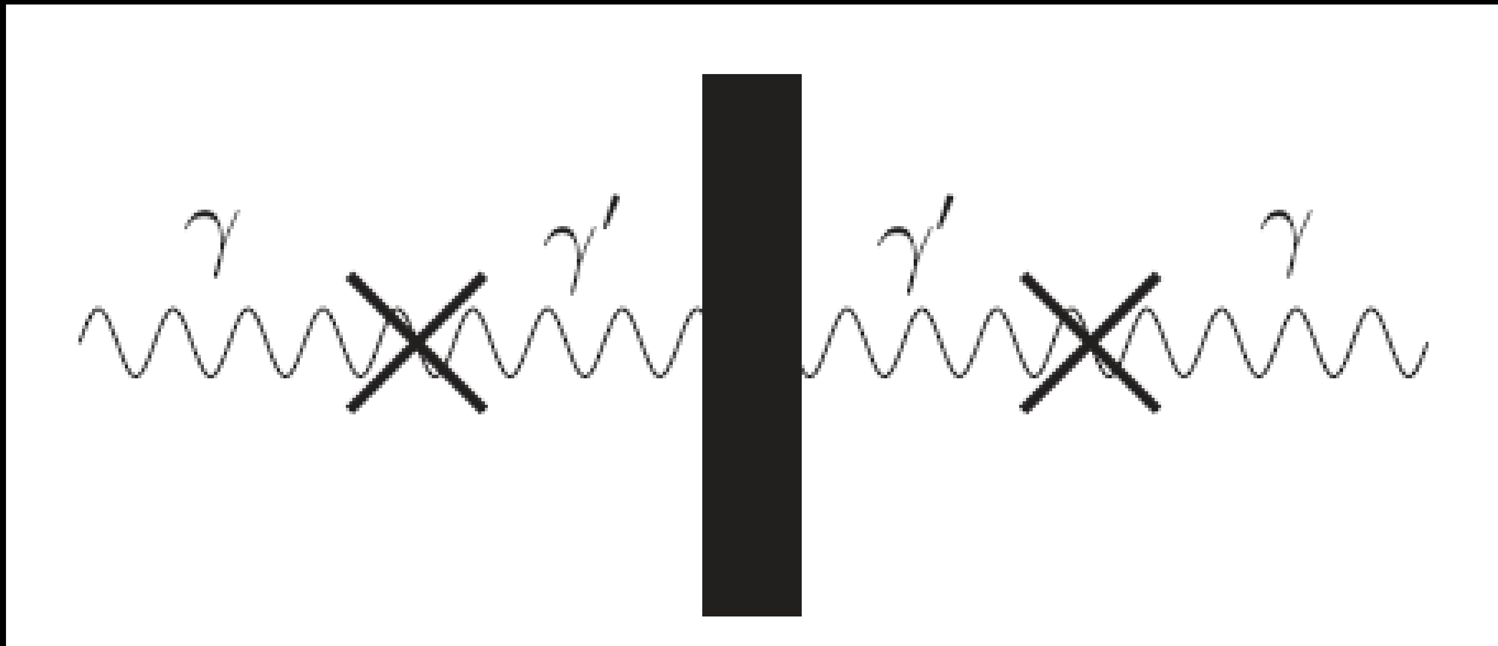


Current bounds ➡ opportunities



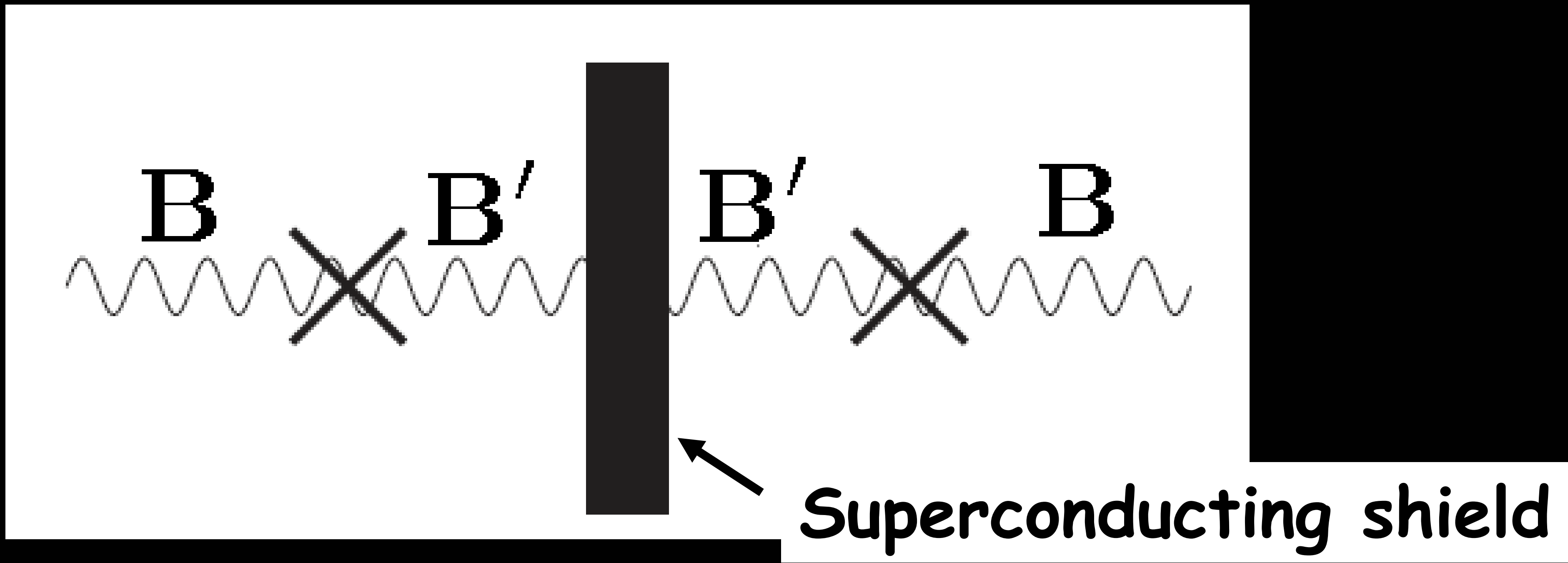
Basic idea

- Similar to `Light shining through walls':



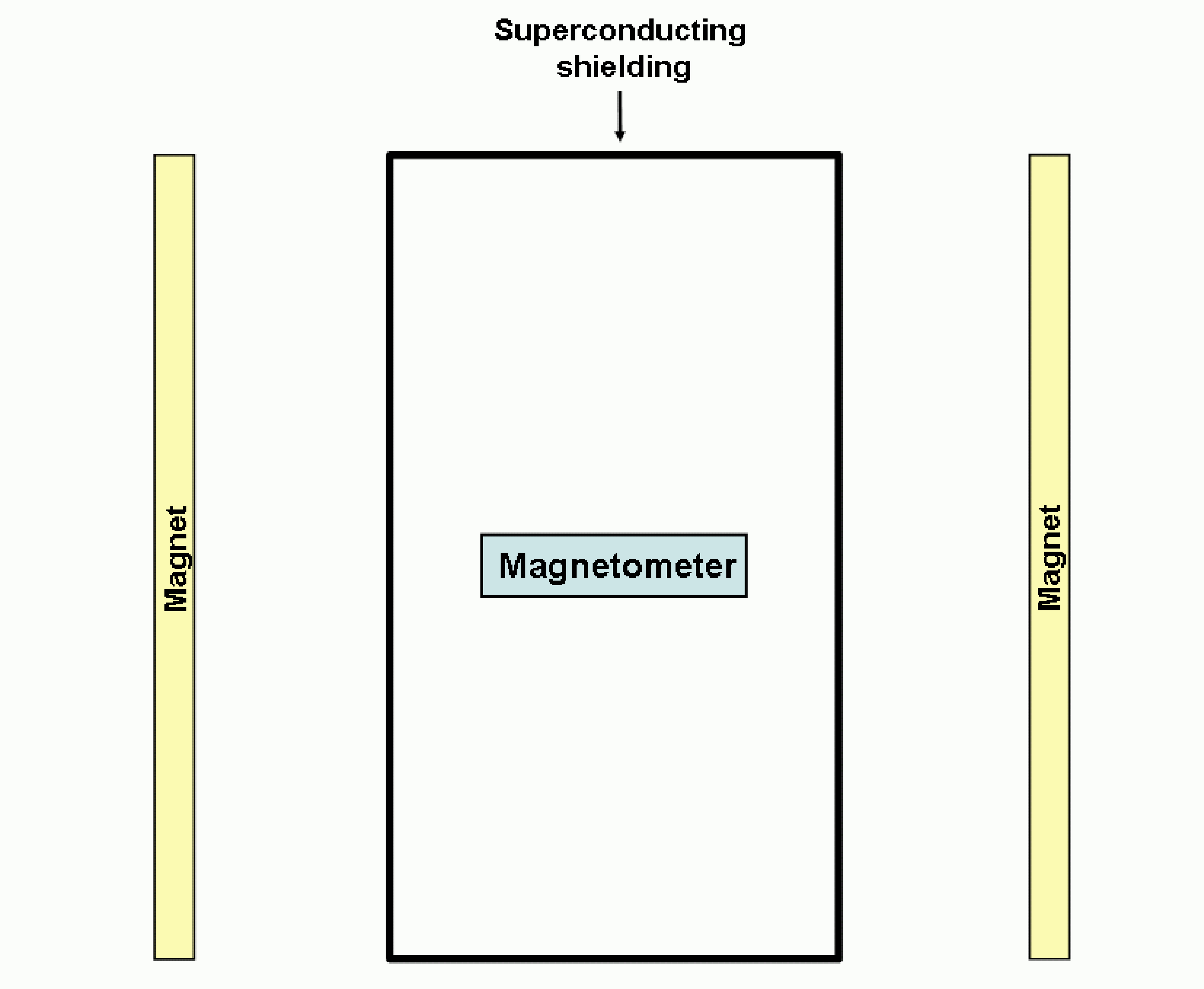
Basic idea

- Similar to Light shining through walls:

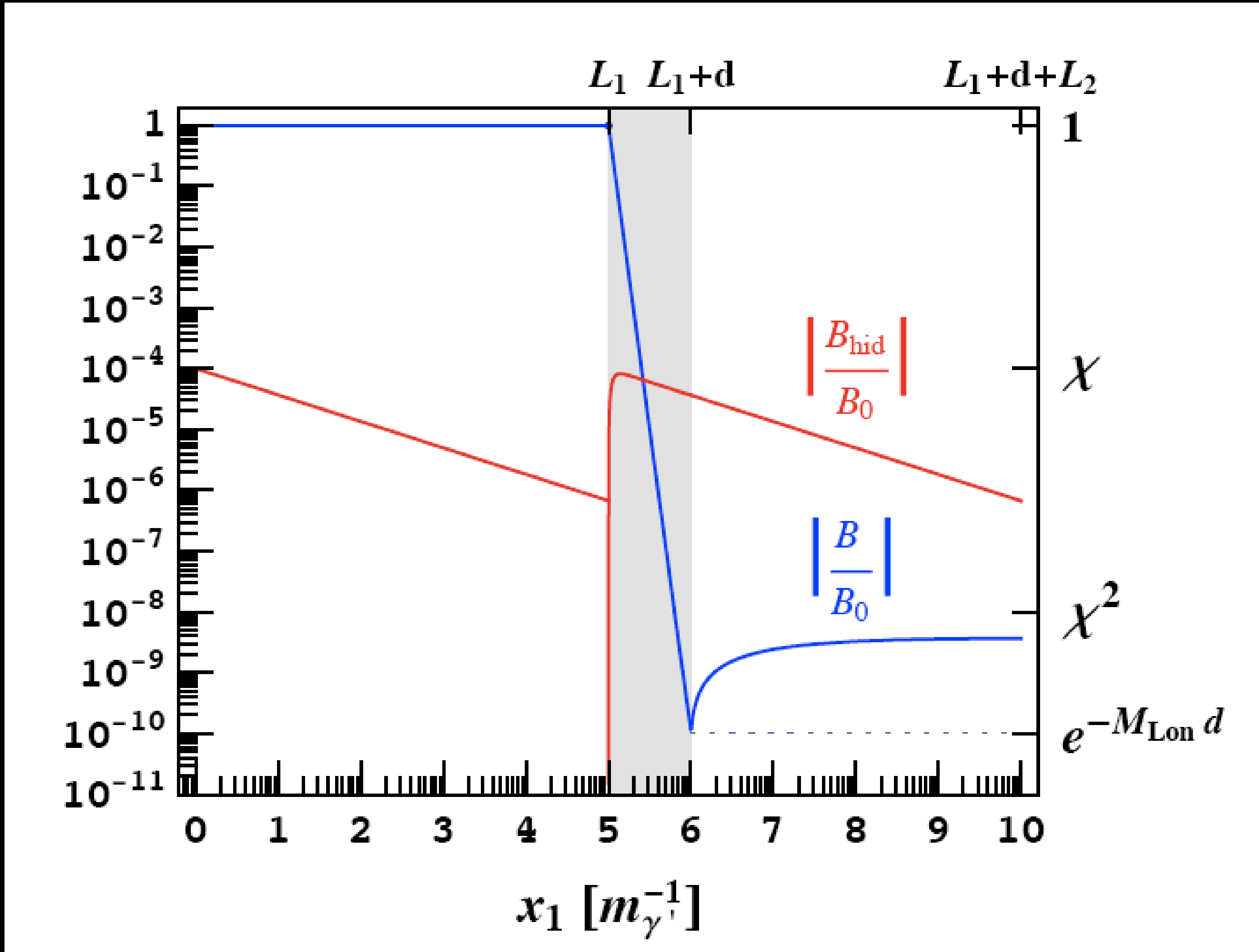


- But virtual instead of real photons,
- Magnetic field instead of Laser
- Superconductor is `wall'

Setup: The box



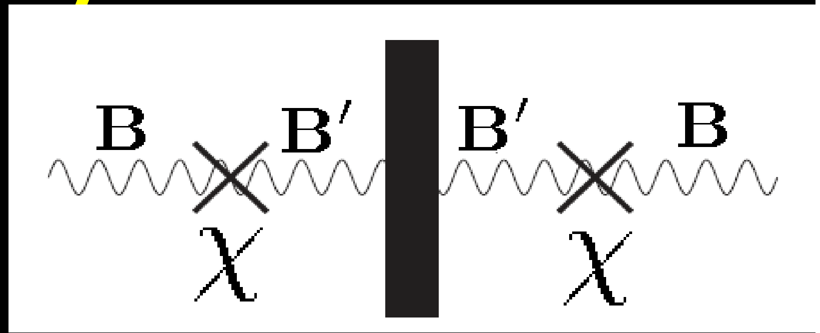
Magnetic fields from source to detector



Advantages

- Measures directly the field, i.e. amplitude instead of probability

$$\Rightarrow \text{signal} \sim \chi^2$$



- Can use fields as high as 0.1 T (higher fields not shielded by most superconductors)

- Can detect B as low as a few 10^{-18} T

⇒ **Expect sensitivity up to χ» few 10^{-9}!**

(possible disadvatage: may not work for axions!)

Sensitivity: Exactly where we want it ☺

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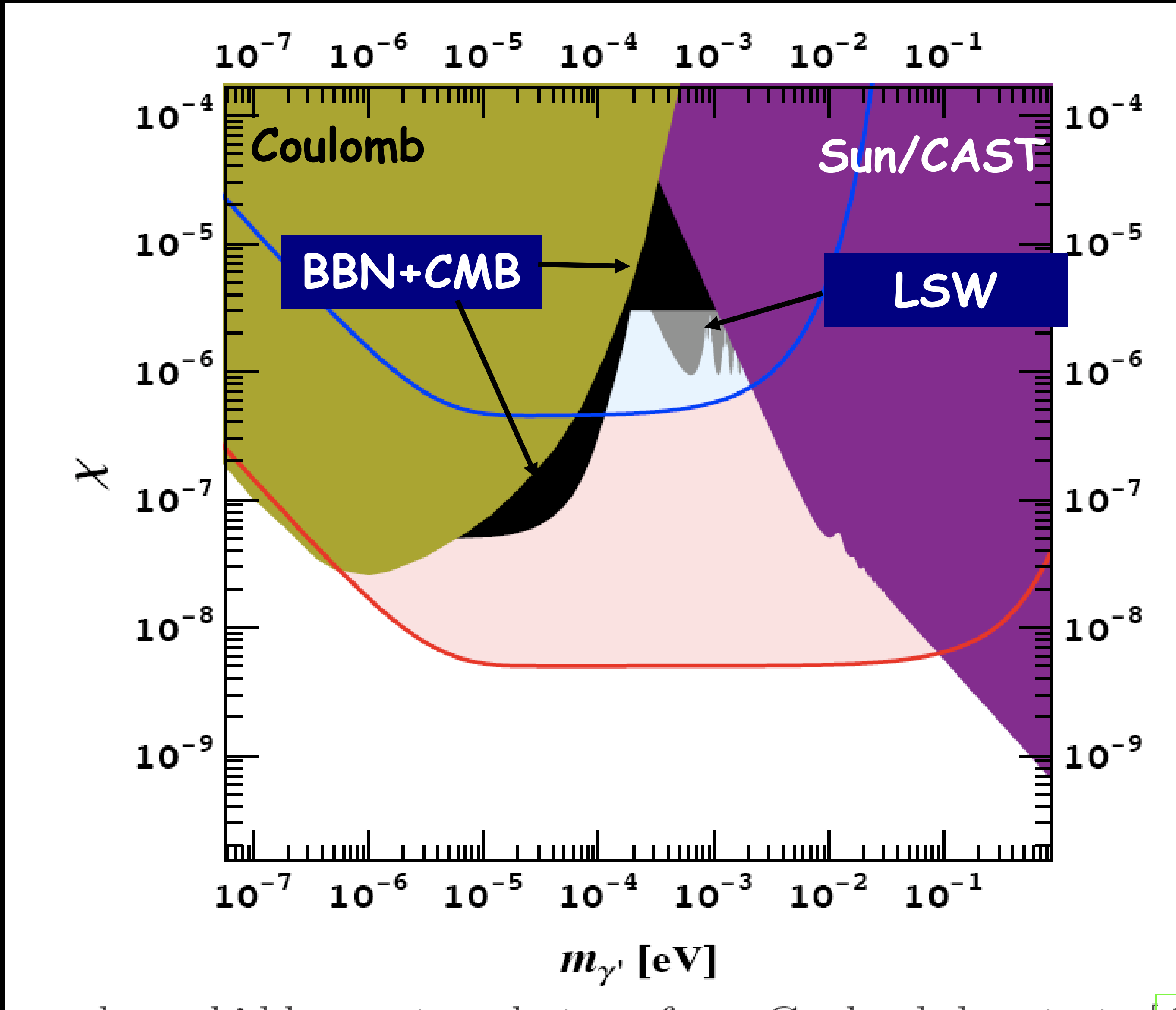
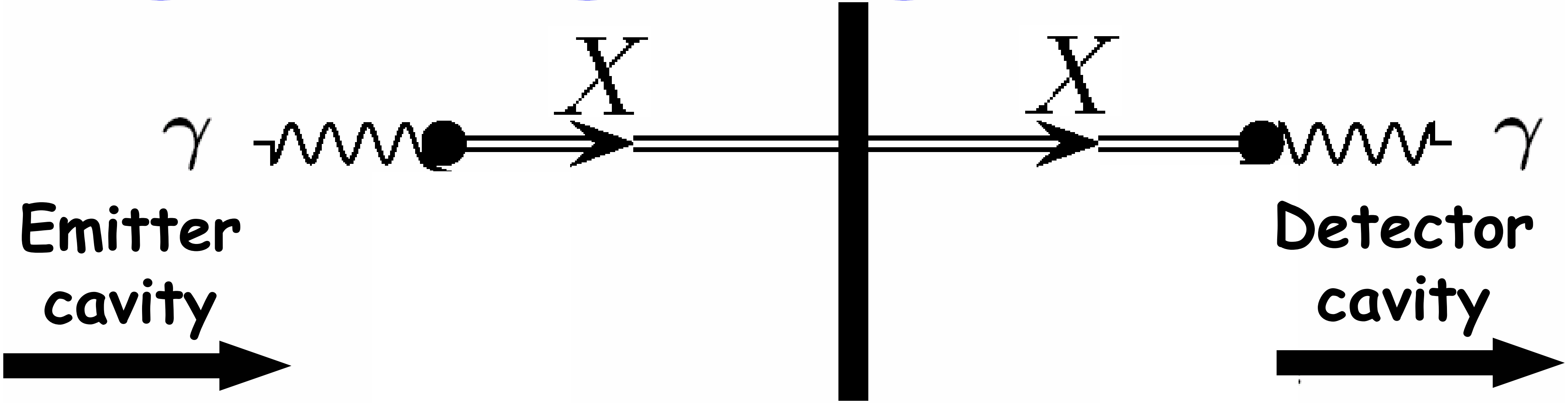


Could do better than astrophysics!!!

A cavity experiment

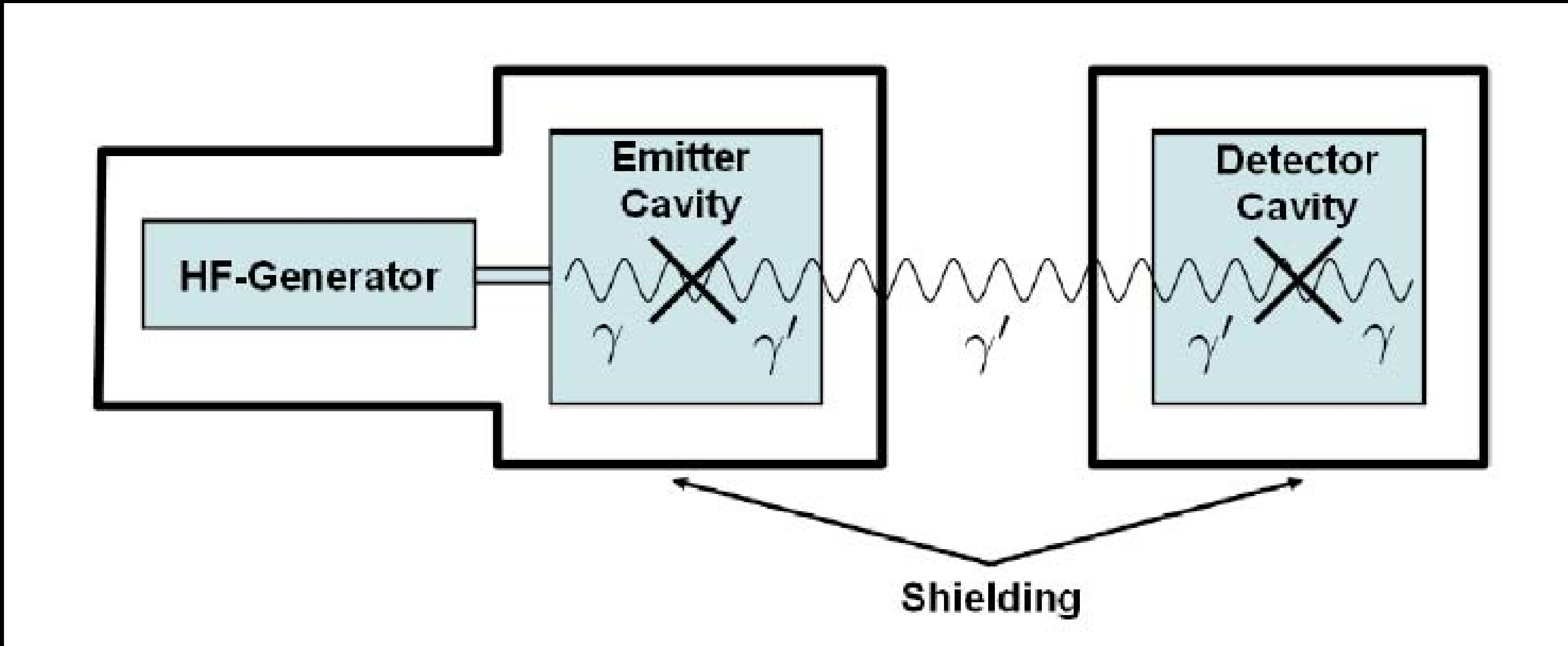
It's a Light shining through walls clone

"Light shining through a wall"



- Microwaves instead of laser

Setup



HF-Generator
Emitter
Cavity
γ
γ'
γ'
Detector
Cavity
γ'
γ
Shielding

Advantages

- Resonant cavity setup: Cavity in production and regeneration region

$$\text{signal} \sim Q_1 \times Q_2$$

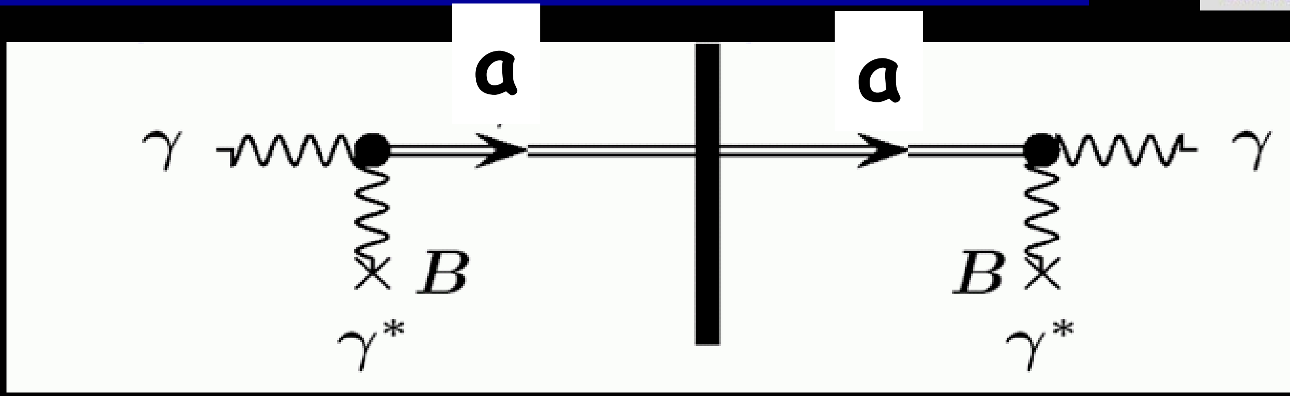
- Microwave cavities can have very high Q-factors~10^{11}!

- Sensitive to masses in the interesting μeV-meV range

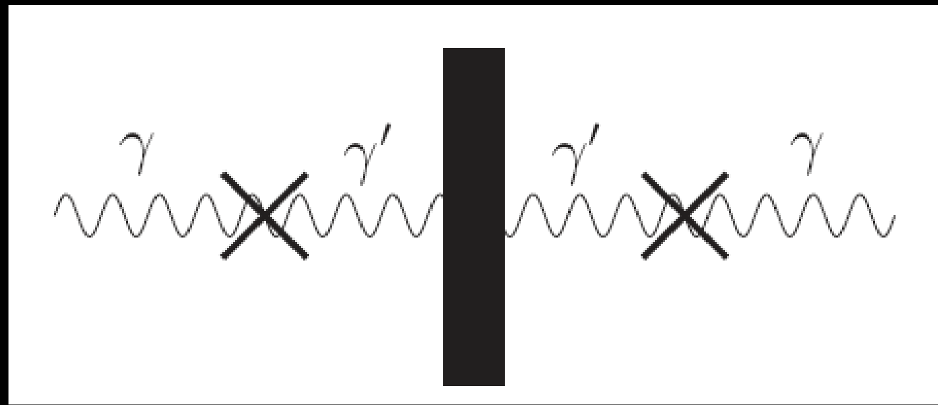
Sensitive to variety of WISPs

- Axions

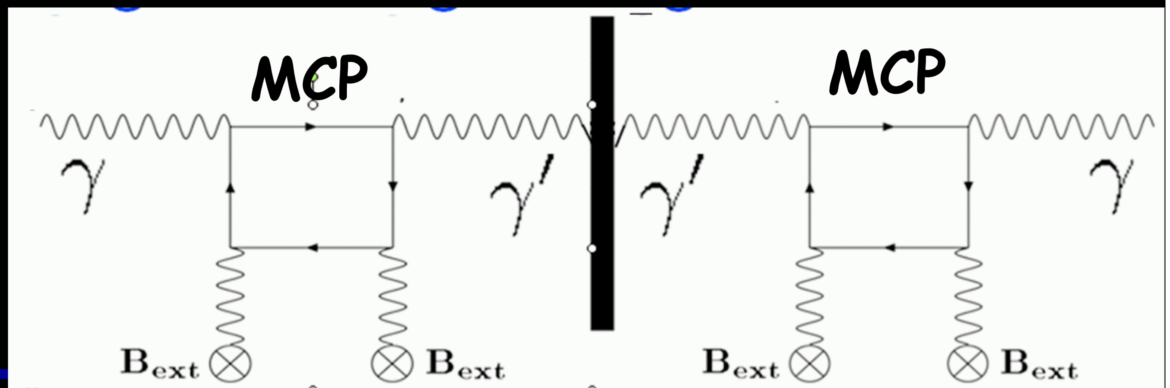
$$\frac{1}{M} a\tilde{F}F$$



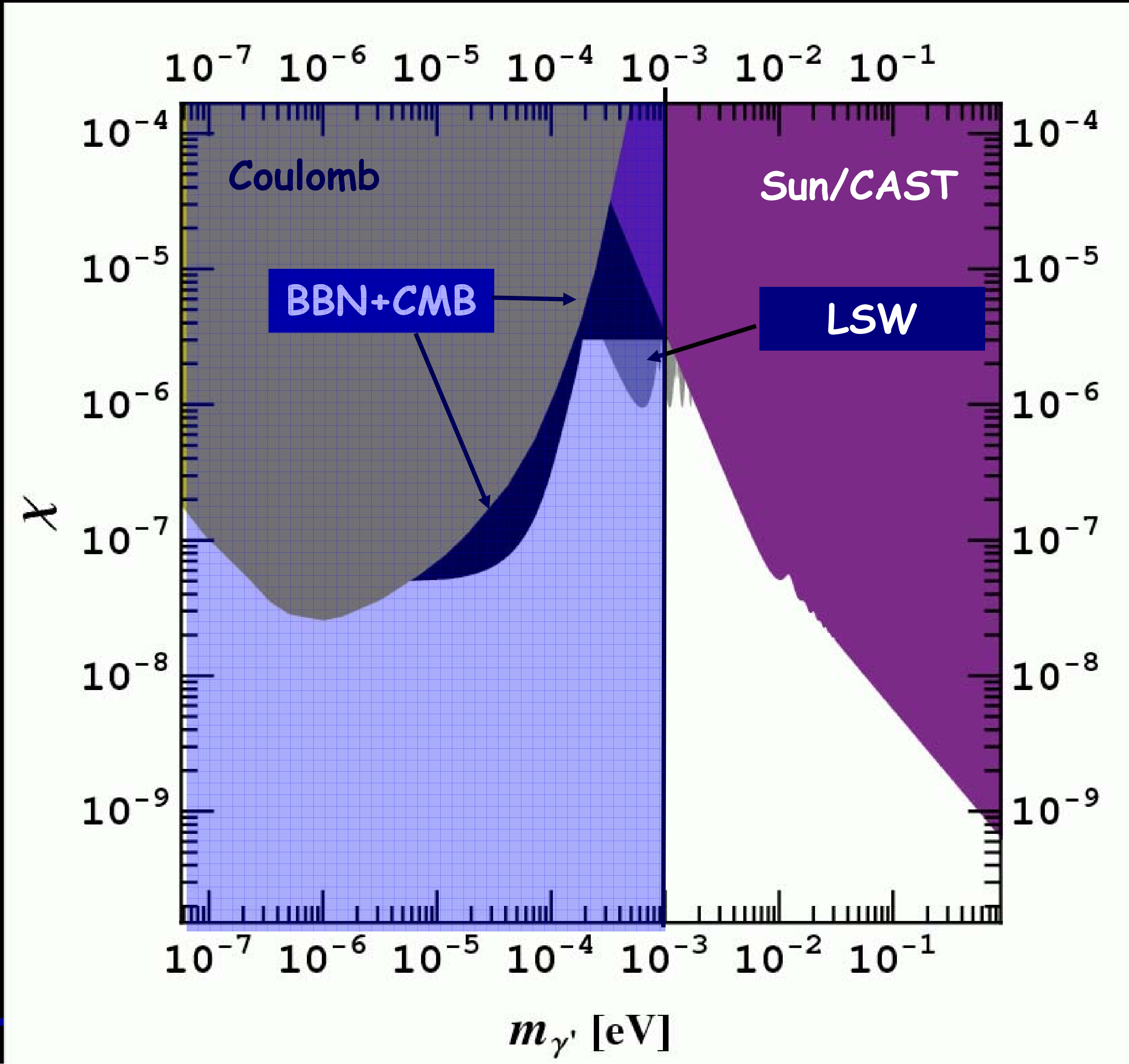
- Massive hidden photons (without B-field) =analog ν-oscillations



- Hidden photon + minicharged particle (MCP)



(theoretical) Sensitivity, e.g. hidden photons



Wildly optimistic proposal

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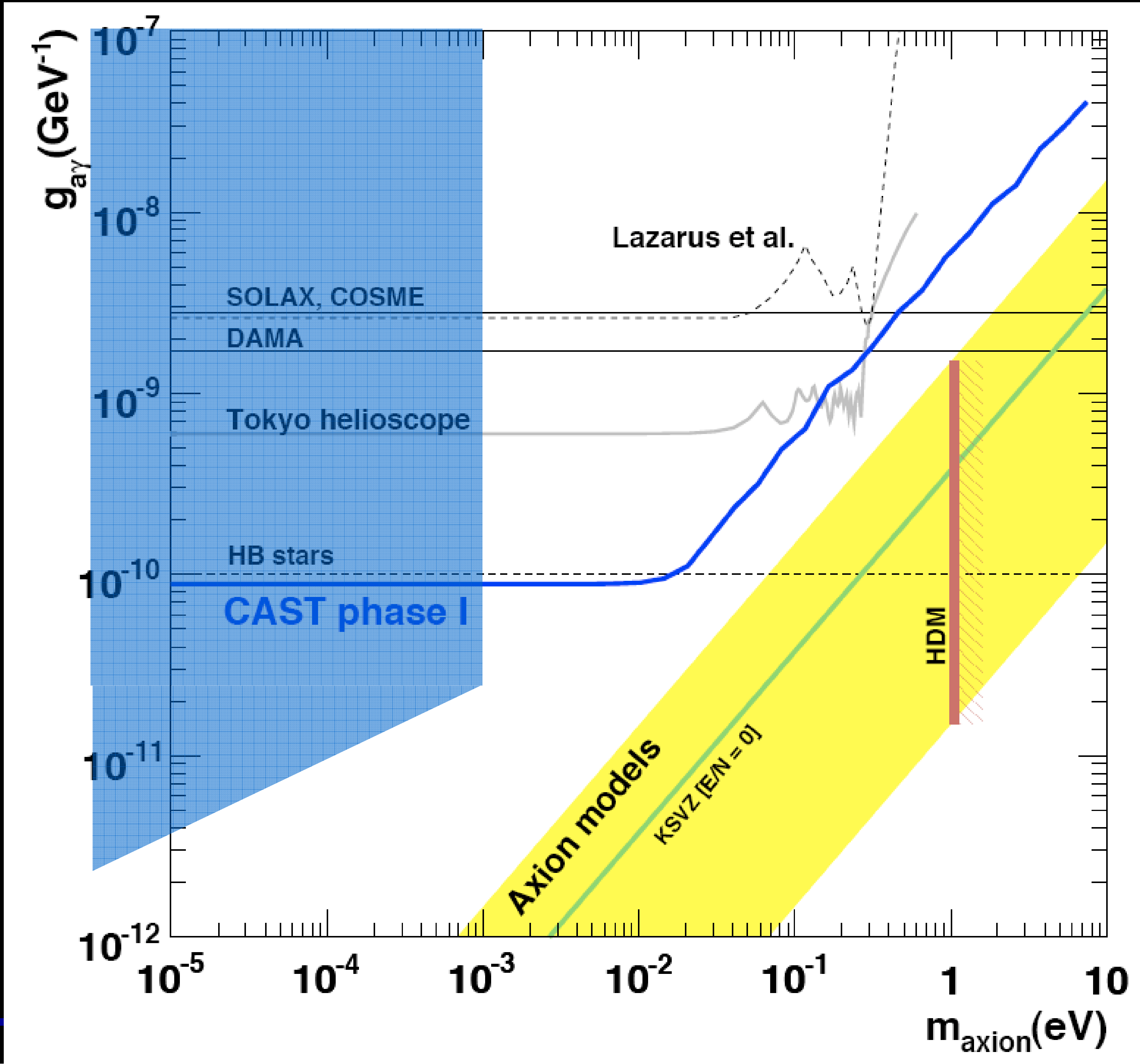

Wildly optimistic proposal

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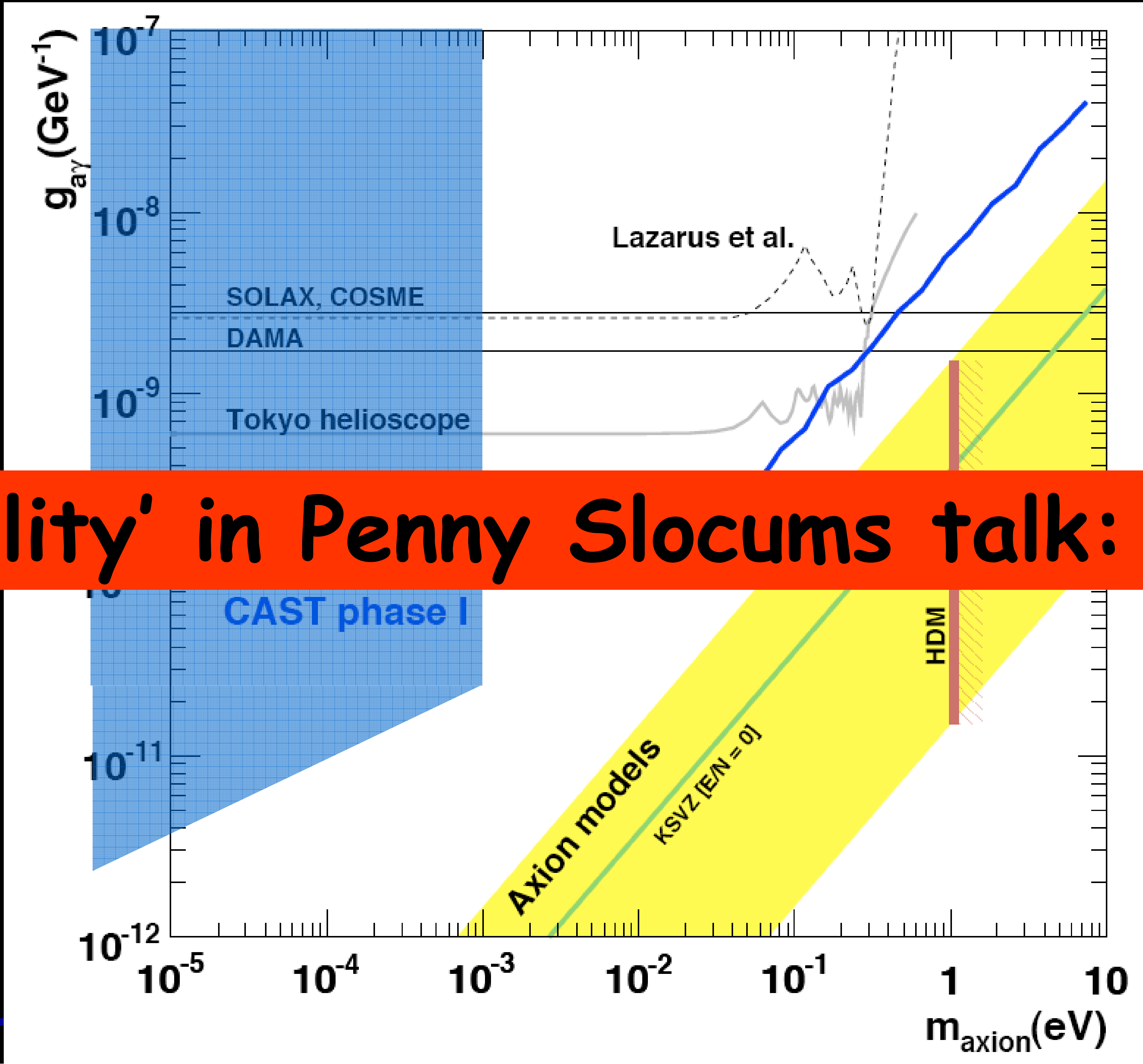

`Reality' in Penny Slocums talk: Now!

Conclusions

Conclusions

- AC/DC can provide (nearly) direct detection of minicharged particles
- A `Superconducting Box' experiment could explore the meV valley for `hidden photons'
- LSW with microwave cavities can provide a highly sensitive exploration of axions, and hidden photons

Conclusions

- All these experiments are small scale!
- They explore physics at ultra high energies and could detect hidden sectors

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Complementary to accelerators!

Conclusions

- All these experiments are small scale!

+

- They explore physics at ultra high energies and could detect hidden sectors

⇓

Complementary to accelerators!

⇓

Please build them 🙂 !

Theorists and "easy" experiments…

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…lets go WISP hunting