1st Axion Strategy Meeting

Introductory remarks

Konstantin Zioutas

CERN, January 27th 2009

Meeting on brainstorming &
Discussion on future axion searches

Bld. 40 / 4-C01

Tuesday, January 27th 2009 – CERN Building 40, room 4-C01	
10:00	**Opening of the meeting** Igor G. Irastorza
	Welcome from E. Tsesmelis (from the DG office)
10:05 – 10:20	**Introductory remarks** Konstantin Zioutas
10:20 – 10:45	**Astrophysical motivations for axion-like particles** Sergey Troitsky
10:45 – 11:15	**Solar X-ray searches for axions** Hugh Hudson
11:15 – 11:35	**On search for eV hidden photons from the Sun** Sergei Gninenko
Coffee break	
11:55 – 12:15	**A map of the low energy frontier: WISP opportunities beyond QCD axions** Javier Redondo
12:15 – 12:35	**Evading the CAST bound with chameleons** Phillipe Brax
12:35 – 12:55	**New prospects for CAST from the new Microbulk performance.** Thomas Papaevangelou
Lunch break	
14:15 – 14:35	**ALP detection via resonant regeneration at CAST** Giovanni Cantatore
14:35 – 14:45	**Cavity enhanced ALP-photon reconversion in the visible** Giovanni Cantatore
14:45 onwards	**ROUND TABLE DISCUSSION**

→ more?

Sergio BERTOLUCCI,
CERN Research Director
→ ~ 15 min

-----Original Message-----

From: **Hugh Hudson**

Sent: **21 May 2004** 02:52

To: Konstantin Zioutas

Subject: quiet Sun

Dear Dr Zioutas ,

I read your ApJ paper on axion detection with fascination. I'm a senior person in Berkeley with vast experience in Yohkoh soft X-ray observations and now RHESSI, so I thought I'd share one or two things that you've perhaps missed.

.....

Regards,

Hugh Hudson

From: **Karl Van Bibber**
Sent: **19 January 2009** 19:19
To: Konstantin Zioutas
Subject: Re:

Hello Konstantin,
Good to hear from you. I will try to feed ideas into the meeting through Hugh Hudson .. with the Space Sciences Lab people we are thinking about an idea for a dedicated mission with a **"CubeSat",** the tiny satellite design that's based on a 10x10x10 cm^3 format (or linear multiples thereof, i.e. you can put 5 of them together like Lego-blocks). As you may know, we also have a collaboration that has gotten off to a strong start to do **a resonantly-enhanced photon regeneration experiment at FNAL, utilizing a 6+6 arrangement of Tevatron dipoles,** with the laser+optics expertise provided by our Univ. Florida collaborators .. UF does both axions & LIGO which helps. Aaron Chou is the energetic young spokesperson at Fermilab, and the Lab is strongly supportive of the initiative. So far, the funding & cost estimates look more or less commensurate, so we're in pretty good shape to proceed. If the experiment would go as well as planned, it would get down to nearly **a factor of 10 below CAST, although only that well for masses of a 2-4 x 10^{-4} eV.**

Now hopefully with my new responsibilities I can focus even a little bit on doing science!

Best regards,

Karl

-----Original Message-----

From: **Keith Baker**

Sent: **25 January 2009** 21:55

To: Konstantin Zioutas

Subject: axion strategy meeting - preliminary agenda

Dear Konstantin,

Great to hear from you, as always! Hope that all is well. **This looks to be a great meeting.** Unfortunately, I have commitments here at Yale (several visitors that I invited here Tue - Thu of this week) that will prevent me from coming there for the Tue meeting. But I hope that I can get info about the results of discussions later.

We continue to make good progress here.

On the **Yale** campus (where we will implement a search for **WISP**s using microwave cavities in the mass range **up to a few time 10^(-4) eV**), we have a **7 Tesla** magnet set up and tested. We have tested the microwave source (**34 GHz**) and most parts of the electronics for the planned experiment here. We are in the (hopefully) final design stage for the microwave cavities that will be used in the expt.

At **Jefferson Lab** (where we continue the search for **ALPs** and **WISP**s using the high power Free Electron Laser), we have new mirrors in the optical cavity that we tested last week. These mirrors yield greater laser power for the LIPSS experiment at optical frequencies (935 nm laser light). We hope to make another WISP/ALP search measurement at JLab this Spring, but it depends on the FEL schedule at JLab. I will keep you informed.

So **we are still very much interested and active in this field of research!**

Hope to see you during my next visit to CERN.

Regards,

Keith

From: **Carlo Rizzo**
Sent: **26 January 2009** 12:05
To: Konstantin Zioutas
Cc: **battesti**@lncmp.org; **Mathilde**.Fouche@irsamc.ups-tlse.fr
Subject: axion strategy meeting - preliminary agenda

Dear Konstantin,

It is a pleasure for me to send you a couple of slides (in French) (ppt and pdf) to summarize our experimental goal.
...

First slide :
Our goal is to measure the **Vacuum Magnetic Birefringence**. I recall that this is an experimental challenge and a theoretical one since only α^3 QED corrections have been calculated.

Second slide :
If one measure VMB precisely, and the value found is in agreement with QED (and QED value has been further calculated), (from the ellipticity measurement) one can give **new limits on axions or chamaleons or ...**). I have sketched this possible limits at increasing precision. We are struggling to get the difficult level (see the slide). Maybe the very difficult is eventually reachable ... **the very very very difficult one is at the level of CAST limits**.

Obviously any disagreement between QED and experiment could be a signature of axion or chamaleons or ...

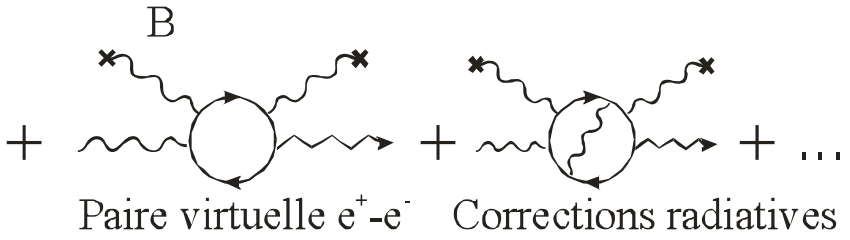
Some technicalities : As you may imagine, we are working hard. We have now a high finesse (> 100 000) cavity, and we have a preliminary result on Helium Cotton Mouton effect which looks reasonable. Our first runs in vacuum were obviously compatible with zero. A pulsed coil that has been designed to give more than 200 T^2m (let's say 25 T over 35 cm) is under construction. We should be able to locate three of them in our apparatus ... if we find money for the three power supplies.

I hope these few lines can be useful to you.

Ciao CARLO

Propagation de la lumière en présence d'un champ magnétique en électrodynamique quantique

Défi expérimental :



$$\Delta n = \frac{2}{15}\frac{\alpha^2\hbar^3}{m_e^4 c^5}\left(1+\frac{4050}{648\,\pi}\alpha\right)\frac{B^2}{\mu_0}$$

Constantes fondamentales : 2006 codata

$$\Delta n = \left[(4{,}031699 \pm 0{,}000005)\,10^{-24}\right]\left(\frac{B}{1T}\right)^2$$

V.I. Ritus, Sov. Phys. JETP 42, 774 (1975)

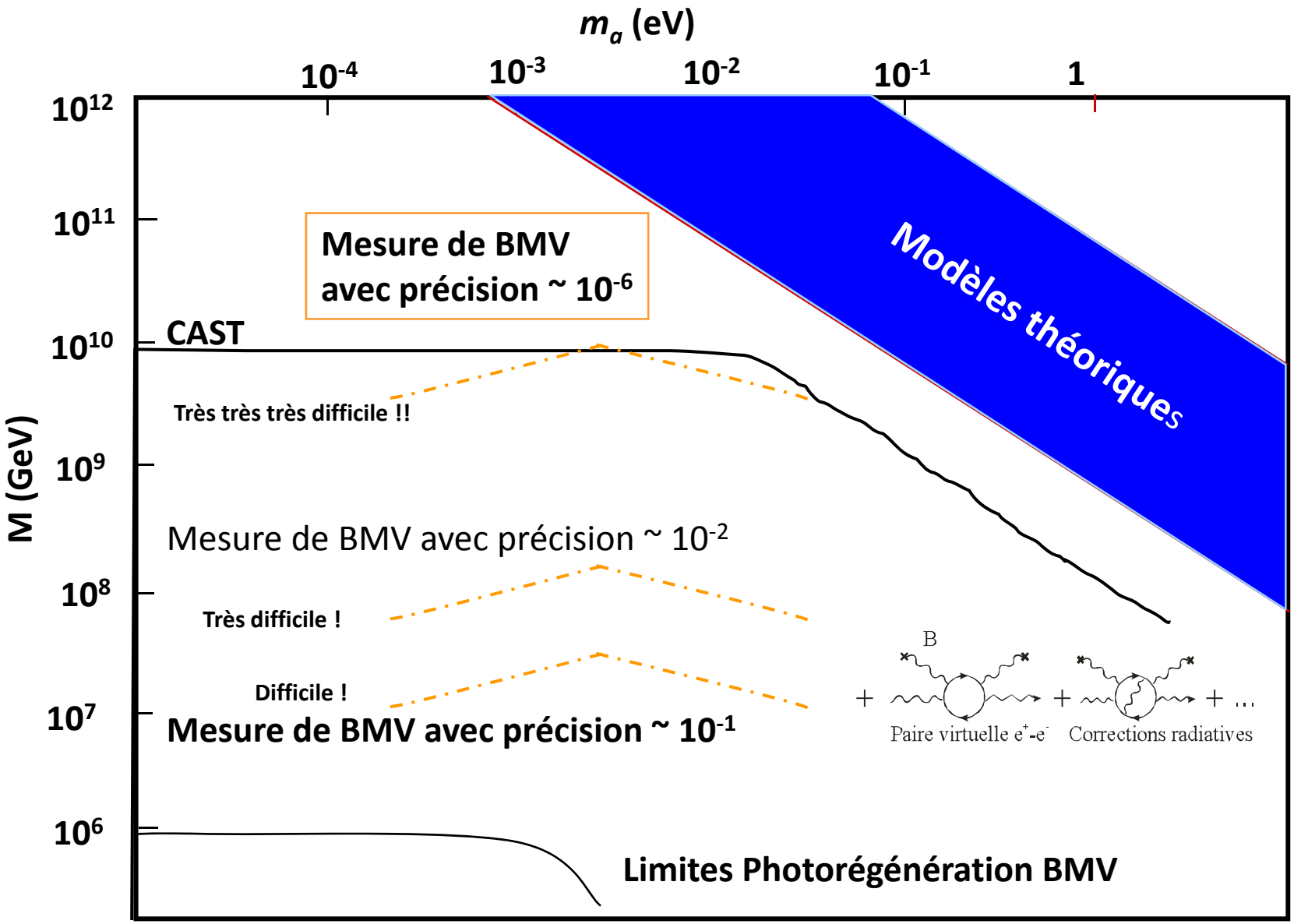
$O(\alpha^3)$

$O(\alpha^4)$ **?**

$O(\alpha^5)$ **?**

Défi théorique !

Le projet BMV



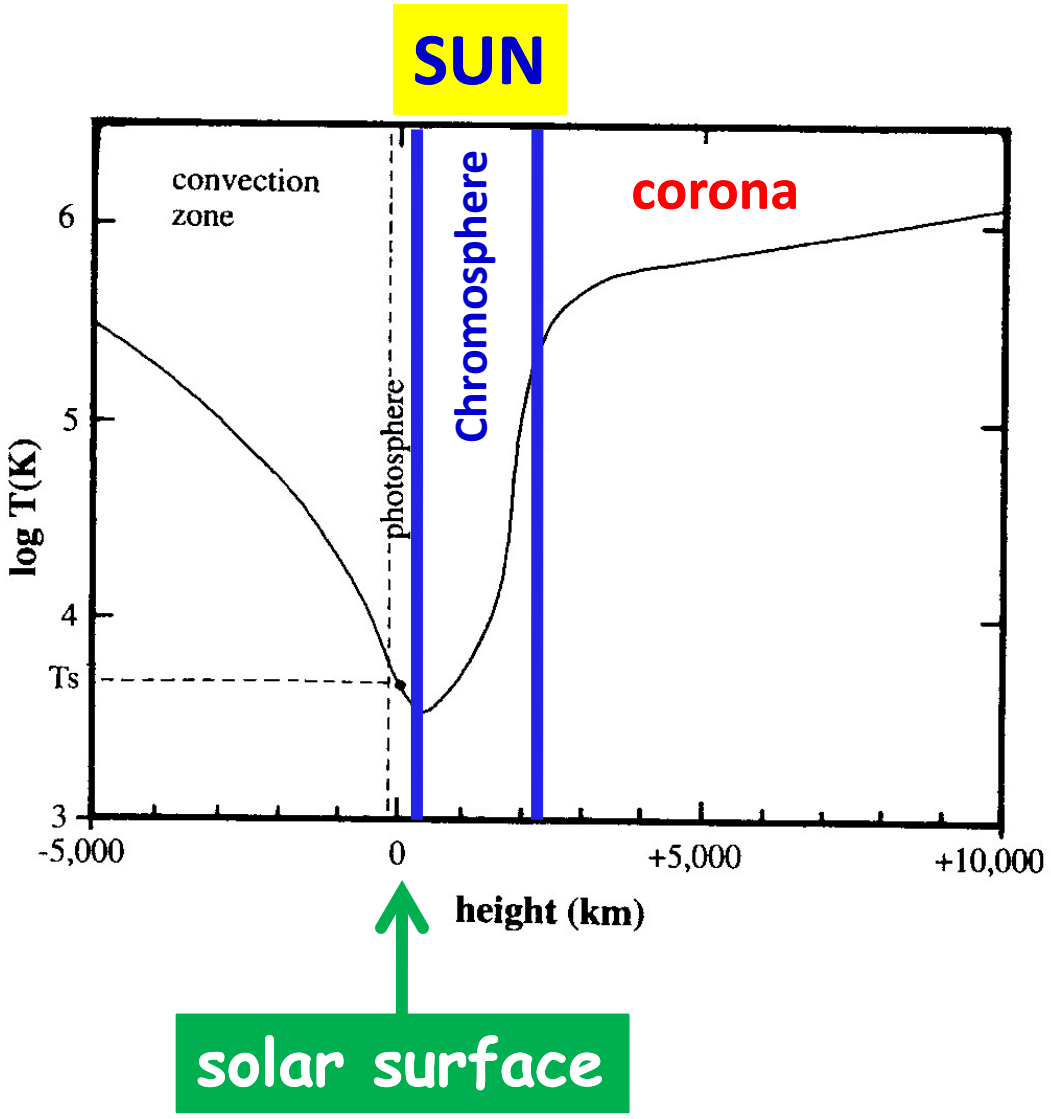
Future of axions + ALPS

~so far! but,
axion motivated.

- **CERN: to support non-accelerator physics**
  → opportunity + challenge ?!

Many types of axions & ALPs:

- **Relics** → $m < 10^{-5\pm1}$eV ... only in USA
- **Solar** → $m < 1$eV (BNL, Underground exp's, CAST, Tokyo)
  $|KK>$ → 2 prong in TPCs (underground).
- **Lab exp's** → (re)generation → **>6 exp's**
  → **new approaches?**
  e.g., with pulsed plasma generator
  → **B** & **dB/dz** → mimic Chromosphere?
  Under investigation with J. Jacoby + C. Teske
  + E. Guendelman's idea


SUN
convection
zone
photosphere
Chromosphere
corona
log T(K)
6
5
4
Ts
3
-5,000
0
+5,000
+10,000
height (km)
solar surface

Astrophysical Observations

e.g. **Sun:**

~best source for ν's, axions, ALPS,..., other exotica.

→ low (< few 100eV)
high (>1 keV)

→ ~best limits so far from star evolution

+

→ (in)direct signatures

→ **space missions:**

→ astrophysics → astroparticle physics

Examples:

..., **Yohkoh**, **GLAST**, **RHESSI**, **Hinode**, **SOHO**, ... , **PAMELA**

Microwave Background Constraints on Mixing of Photons with Hidden Photons

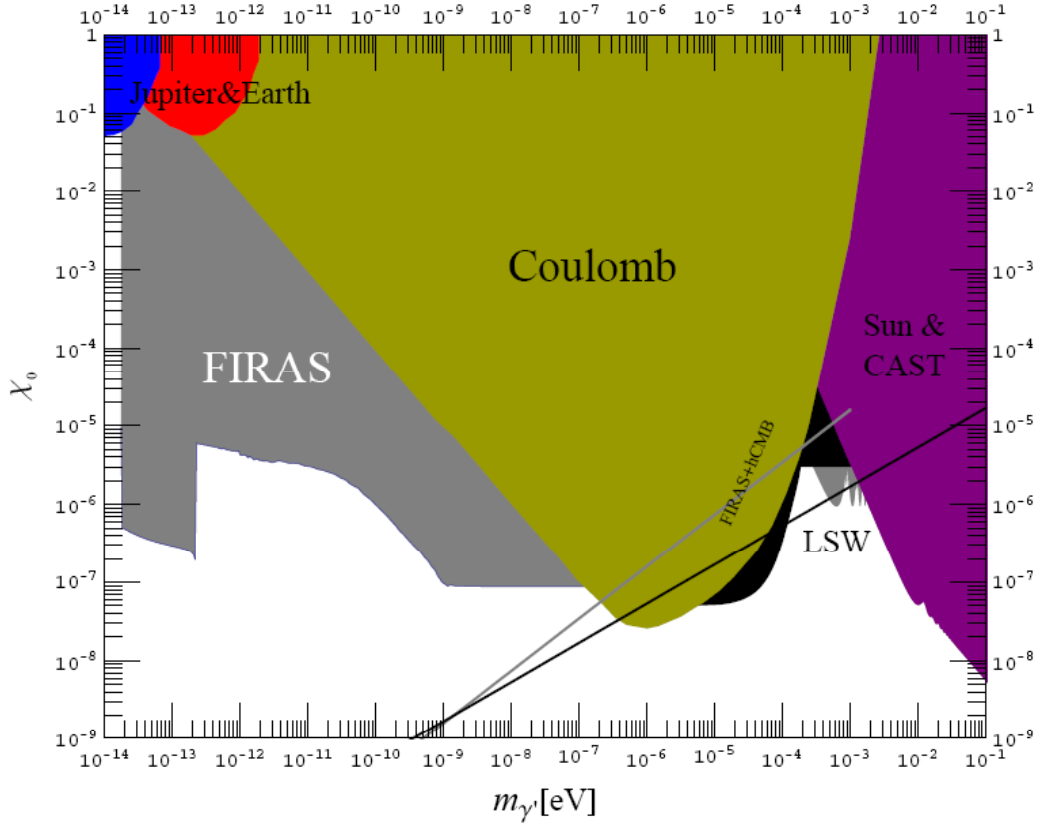


Figure 3. Bounds from resonant $\gamma \to \gamma_s$ depletion of the CMB blackbody as constrained by FIRAS data in this work (gray region) and in [8] (black region). The gray diagonal line separates the region where the resonance happens at small damping (left, this work) or at strong damping (right, cf. [8]). Plotted for comparison are bounds from tests of the Coulomb $1/r^2$ law [36, 37], magnetic fields of Jupiter and earth [38], photon-regeneration-experiments [39–44], arguments of the lifetime of the Sun and the CAST search of solar axions [7, 45]. The solid black line indicates the best possible bound Eq. (32) that can be obtained from astrophysical or cosmological sources whose photon flux is known to be unmodified by photon-HP mixing to order unity.

A. Mirizzi, J. Redondo, G. Sigl, http://xxx.lanl.gov/PS_cache/arxiv/pdf/0901/0901.0014v1.pdf

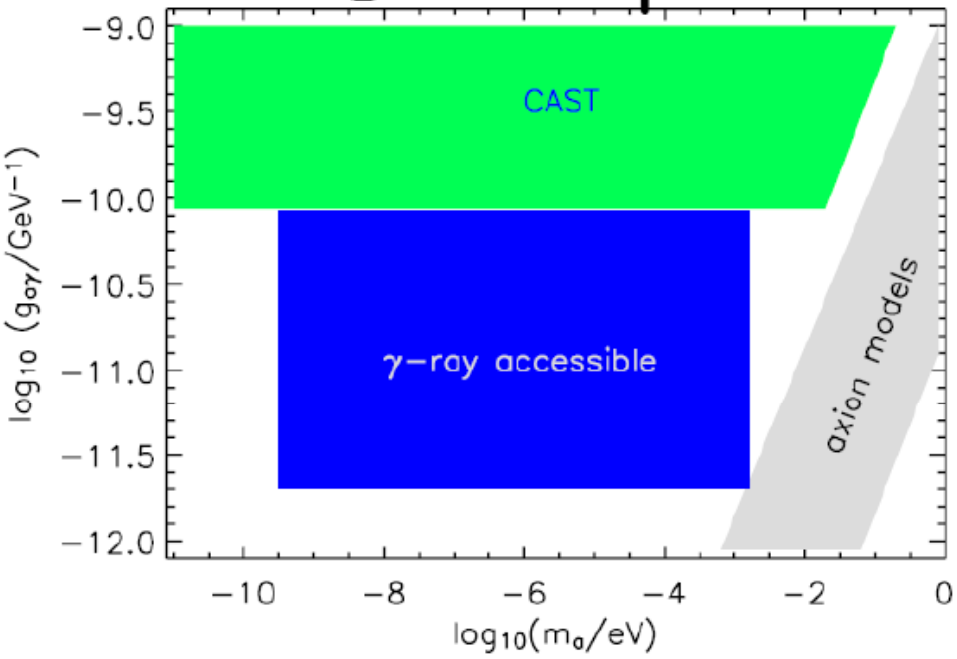
PRL 99, 231102 (2007) PHYSICAL REVIEW LETTERS week ending 7 DECEMBER 2007

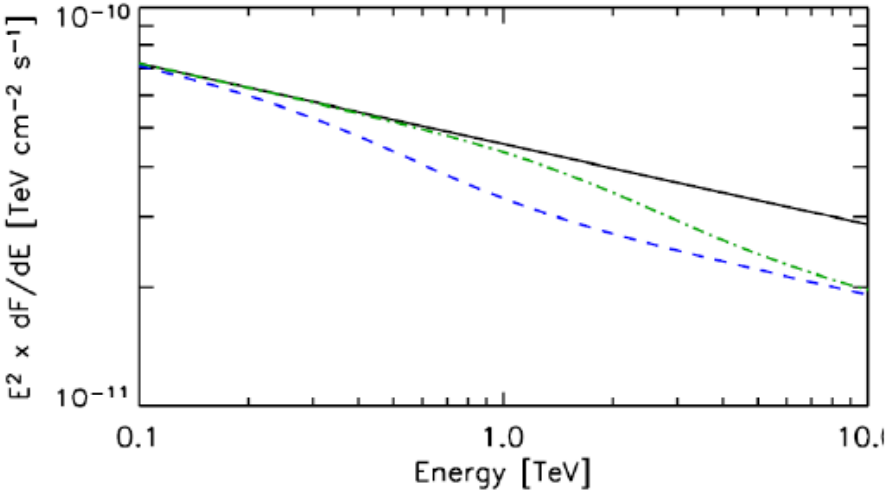
Detecting Axionlike Particles with Gamma Ray Telescopes

Dan Hooper and Pasquale D. Serpico

Center for Particle Astrophysics, Fermi National Accelerator Laboratory, Batavia, Illinois 60510-0500, USA

Exclusion plot





A typical power-law γ-ray spectrum (solid line) and its distortion for photon-ALP conversion with A=1/3 and critical energies E=500GeV (dashed) and E=2:5 TeV (dashed-dotted).

PAMELA

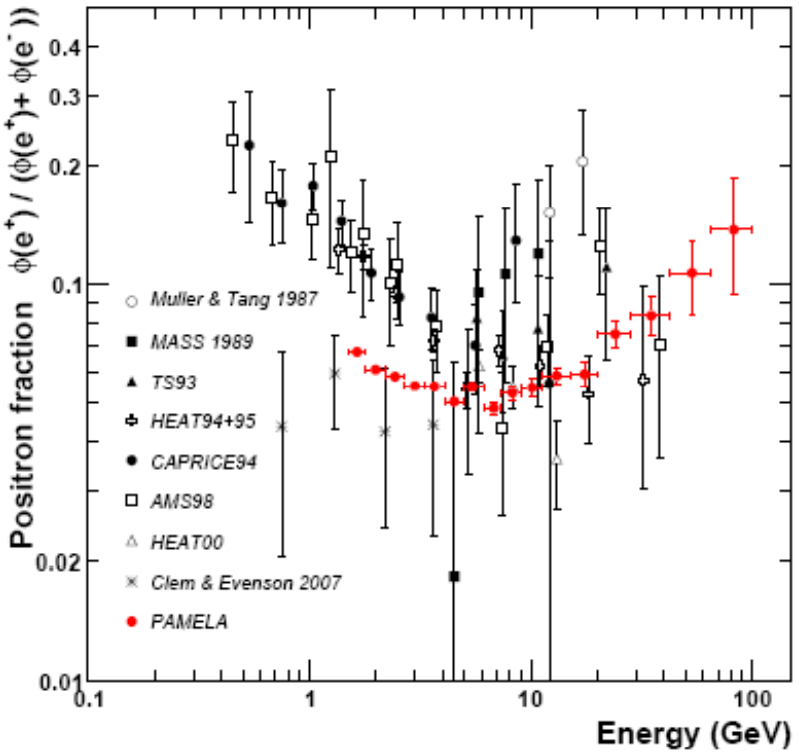
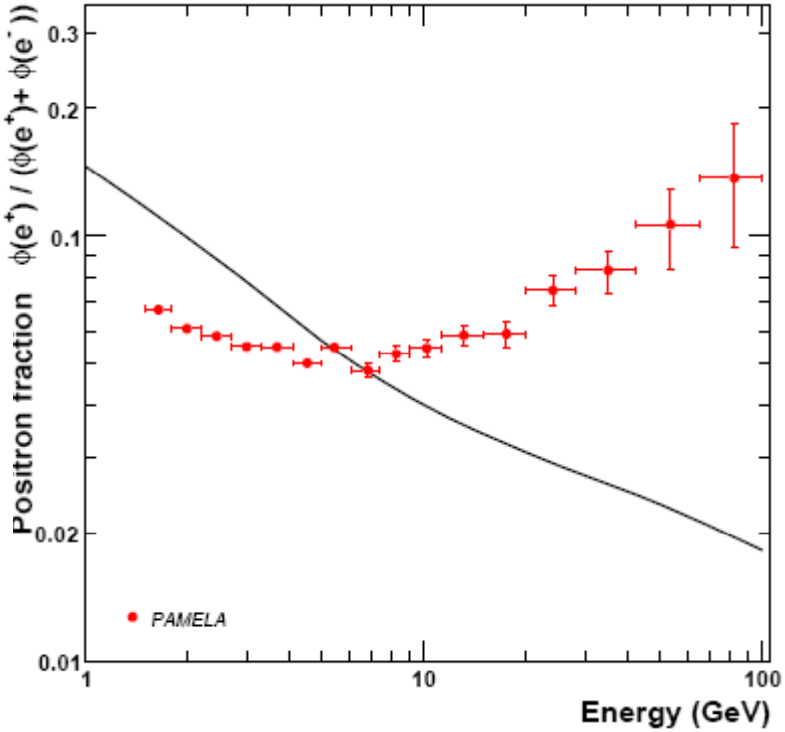


FIG. 3: PAMELA positron fraction with other experimental data. The positron fraction measured by the PAMELA experiment compared with other recent experimental data[24, 29, 30, 31, 32, 33, 34, 35]. One standard deviation error bars are shown. If not visible, they lie inside the data points.



4: PAMELA positron fraction with theoretical models. The PAMELA positron
n compared with theoretical model. The solid line shows a calculation by Moskalenko &
[39] for pure secondary production of positrons during the propagation of cosmic-rays in the
. One standard deviation error bars are shown. If not visible, they lie inside the data points.

➔ New results from astrophysical obs'
≠ underground exp's

http://pamela.roma2.infn.it/dmdocuments/positron_arXiv-0810-4995v1[astro-ph].pdf

PAMELA

Improvements not »better than previous measurements.

→ ~indicated the accurate measurement by PAMELA mission.

➔ required accuracy ➔ unknown

More theoretical work:

- suggestive
- inspiring
- motivating
- revealing

  .....

- JUSTIFY

➔ the physics in the low(est) mass frontier.

...thanks to space missions, also

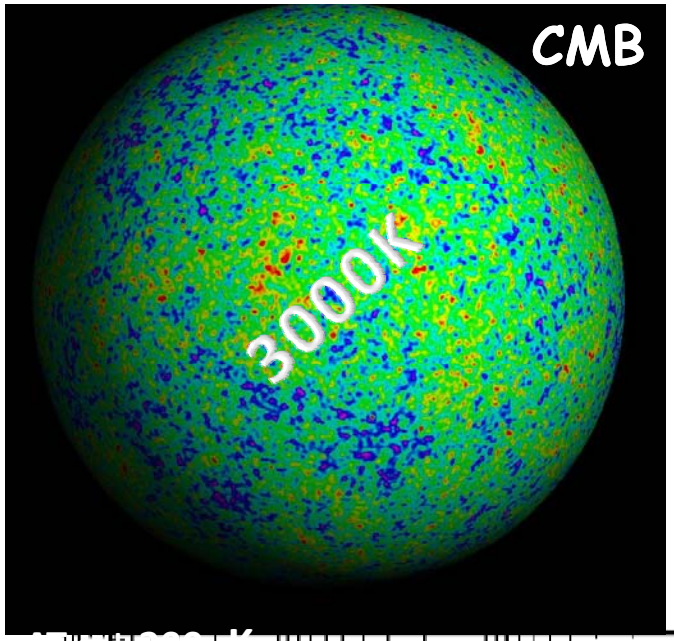
➔ observationally driven reasoning / motivation

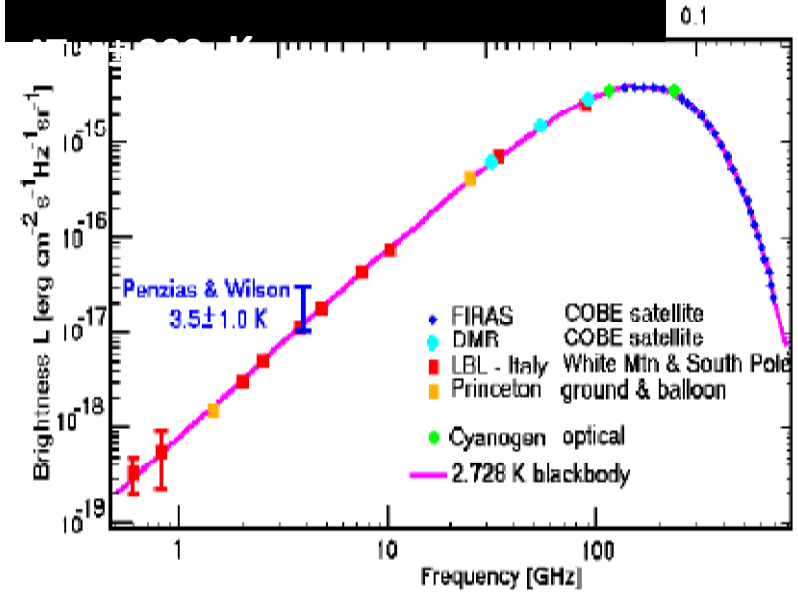
We have not run out of problems in

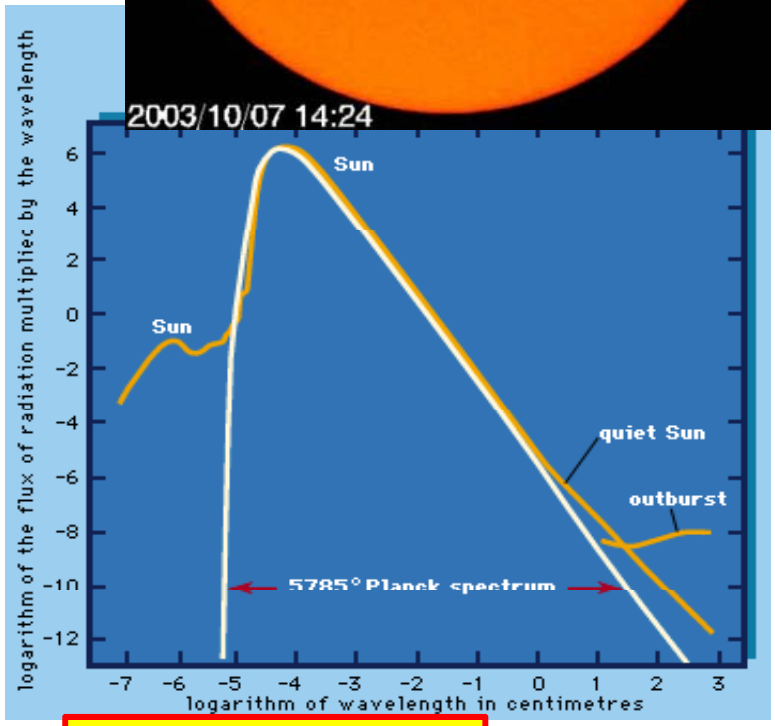
→ solar physics

+

→ cosmology







$\Delta T/T$ ~a few×10^{-5} → $\Delta T/T \sim 10^{3}$

New physics! → » new physics?!

… much TBD …