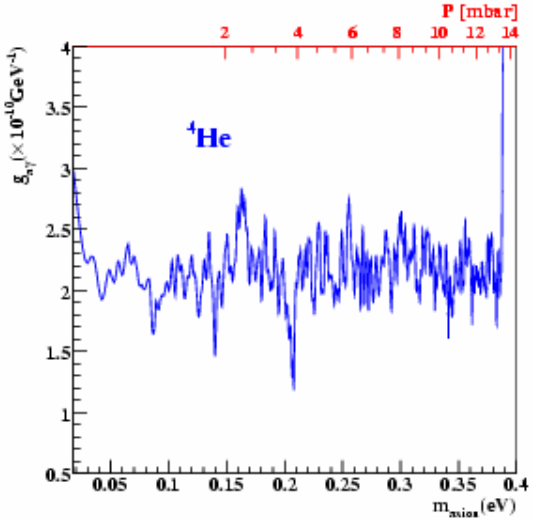
CAST

Search for Solar Axions



The CAST Collaboration

Athens, CERN, Chicago, Darmstadt, Frankfurt, Freiburg, Gainesville, Istanbul, Katlenburg-Lindau, Livermore, Moscow (INR), Munich (**MPE-MPP**), Patras, Pisa, Saclay, Thessaloniki, Trieste, Vancouver, Zagreb, Zaragoza

Operation, data taking: R. Kotthaus, T. Rashba, Y. Wong
Axion and solar physics: A. Mirizzi, G. Raffelt, T. Rashba, Y. Wong

Motivation to search for the AXION

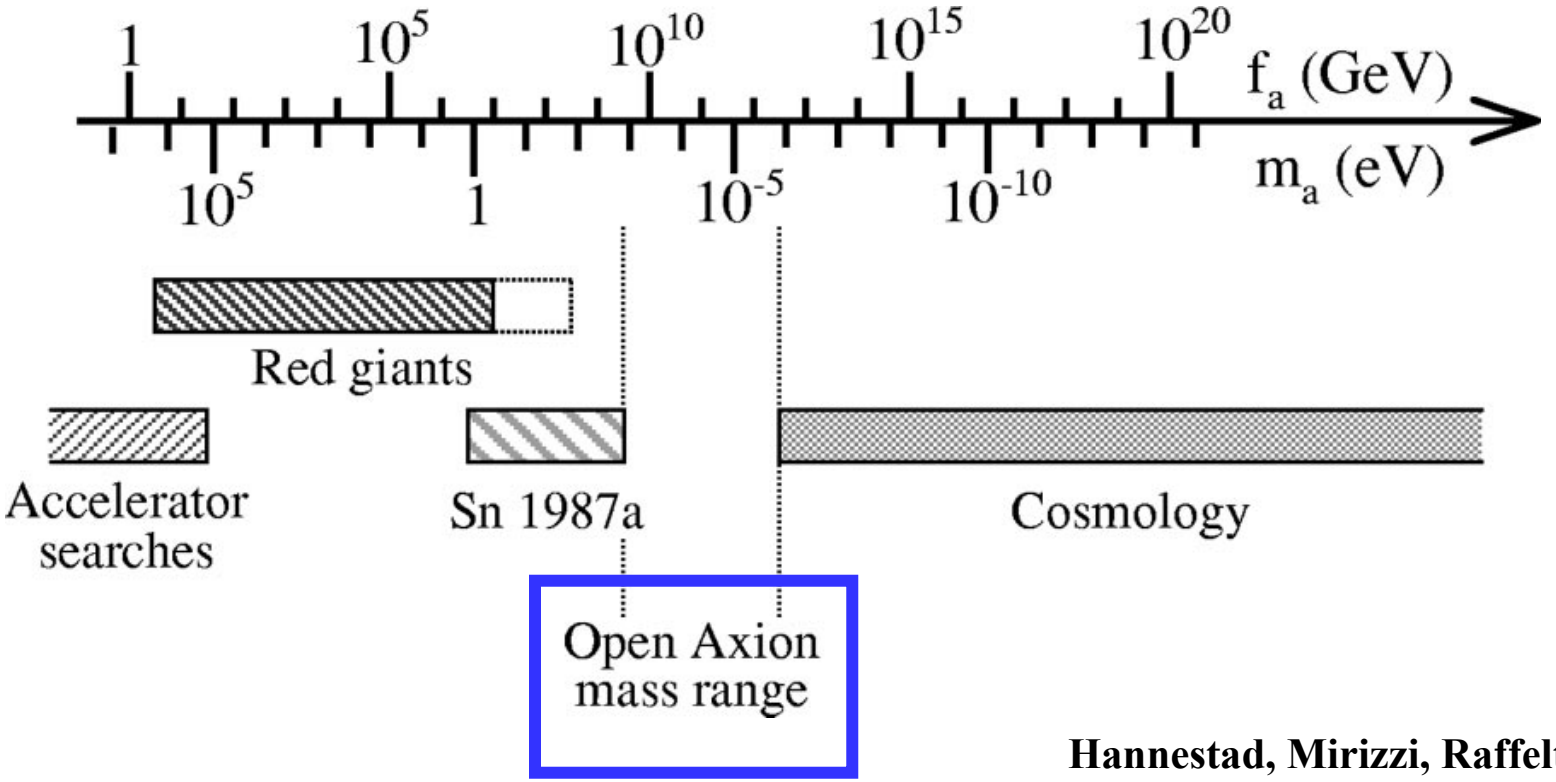
- solve the „Strong CP Problem“ (EDM(n) < 0.29×10^{-25} e·cm)
  (Peccei-Quinn mechanism)

- find a **DARK MATTER** candidate
  („invisible“ Axion)

- relation to e.m. properties of „Topological Insulators“
  Wilczek, 1987; Qi, Taylor, Zhang, Phys. Rev. B78, 195424 (2008); D. Hsieh et al, Nature 452, 970 (2008)

M. Franz: ***High-energy physics in a new guise***, ´Viewpoint´: Physics 1, 36 (2008)

The „invisible“ Axion



„hot“ ⟷ „cold“

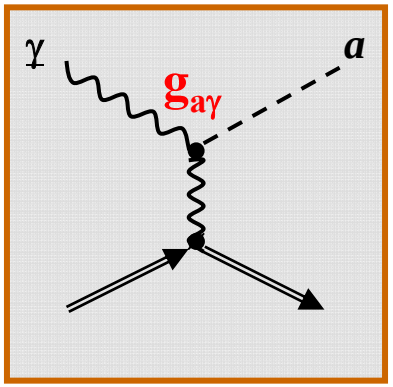
DM

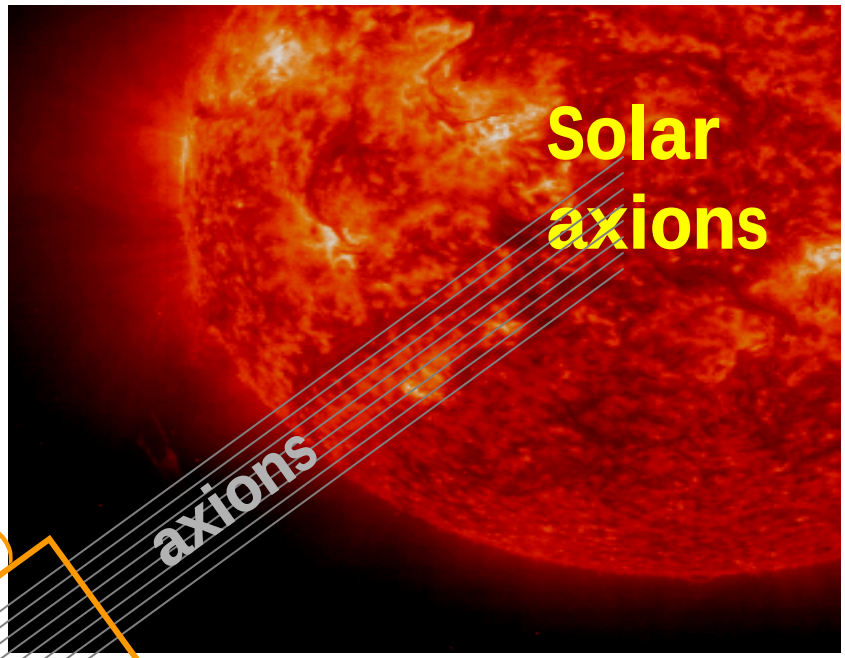
Hannestad, Mirizzi, Raffelt, Wong:
JCAP Vol. 0704 (2007) 015
JCAP Vol. 0804 (2008) 019

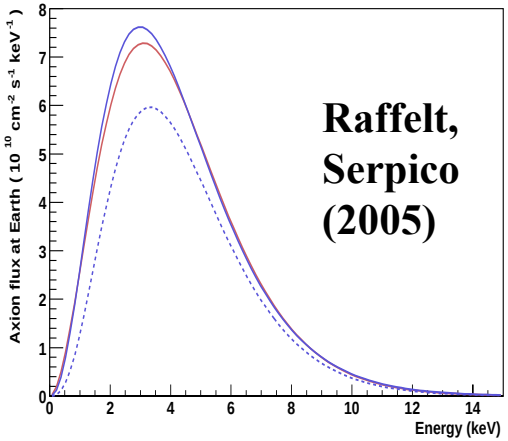
2005, ... ⟵ ⟶ **2003, 2004**

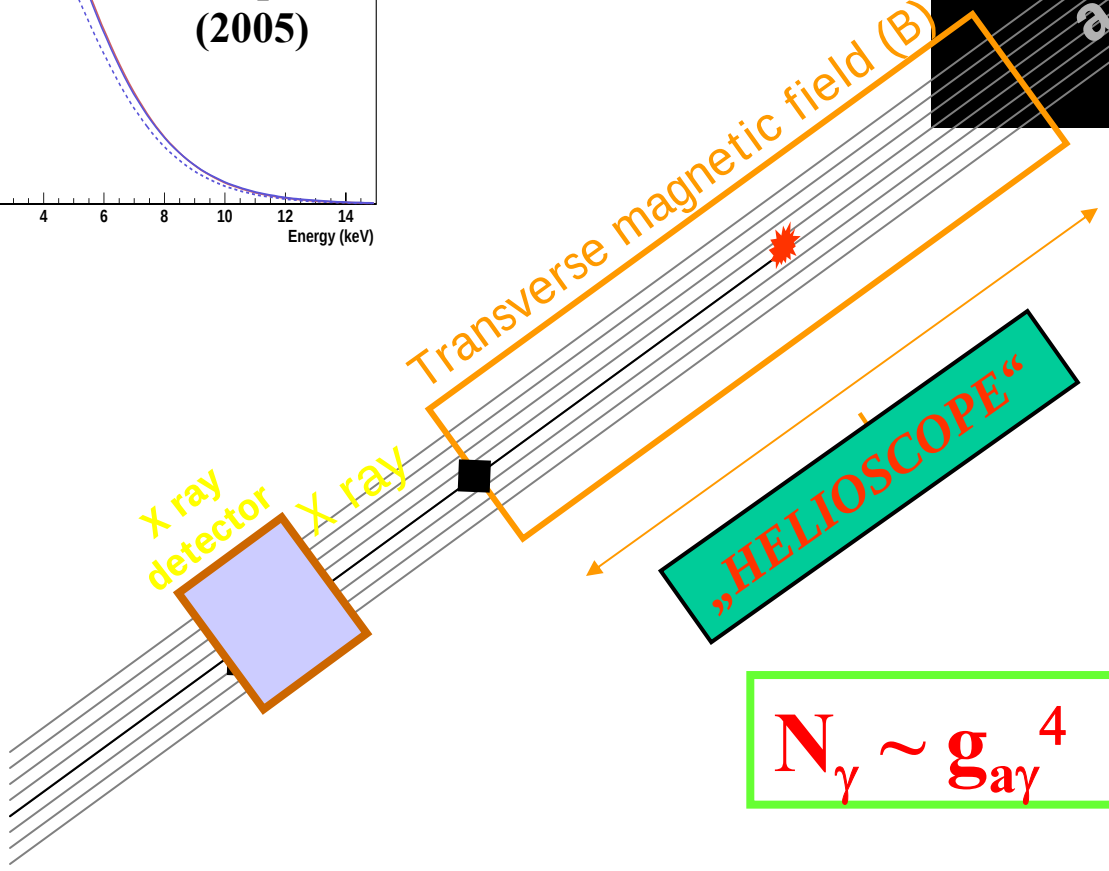
CAST

SOLAR AXION PRODUCTION

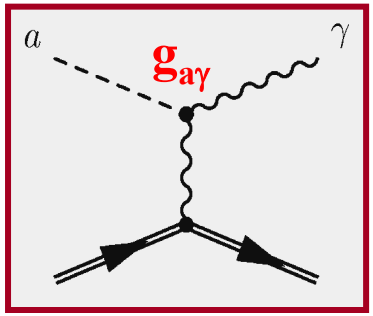








AXION PHOTON CONVERSION



$$N_\gamma \sim g_{a\gamma}^{\ 4}$$

Extending a-γ coherence to higher m_a values

Fill the magnetic channels with Helium gas ⟶ $m_\gamma > 0$

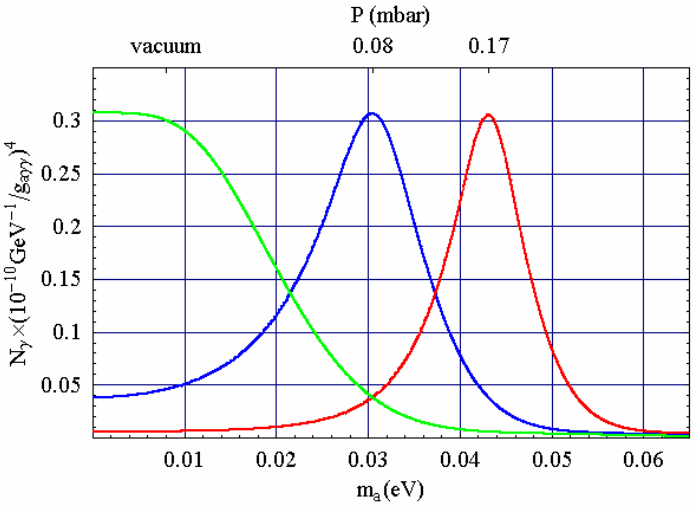
$$|q| = \frac{m_a^2 - m_\gamma^2}{2E} \qquad P(a \to \gamma) = \frac{g_{a\gamma\gamma}^2}{4}\left|\int_0^L B\, e^{iqz}\, dz\right|^2 \to \frac{g_{a\gamma\gamma}^2}{4}(BL)^2$$

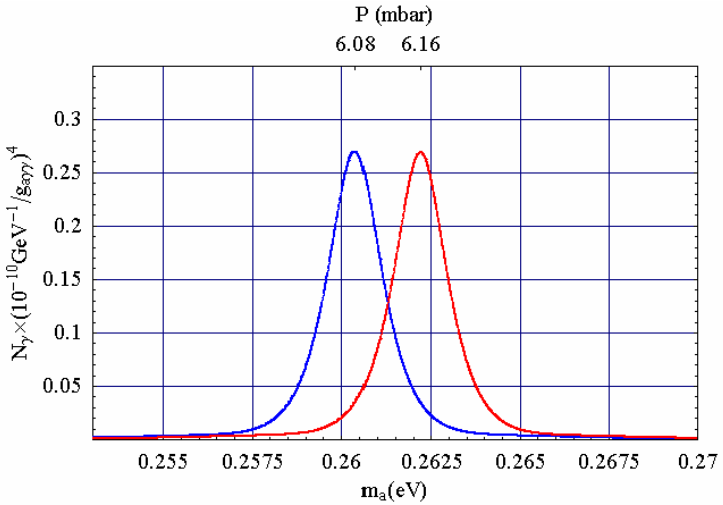
$$m_\gamma \approx \sqrt{\frac{4\pi\alpha N_e}{m_e}} = 28.9\sqrt{\frac{Z}{A}\rho}\ \ eV$$

N_e: number of electrons/cm^3

ρ: gas density (g/cm^3)

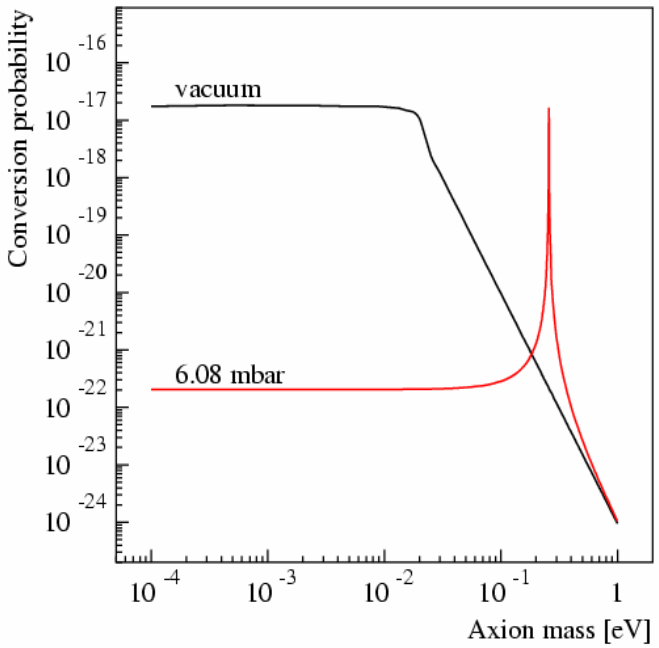
ρ< 0.38x10^{-3} g/cm^3 (He^4 vapour pressure at 1.8°K) ⟶ m_γ ~ 0.40 eV





CAST Phase II

search for eV-scale axions



Step 1: He^4 at T = 1.8 K, p < 14 mbar

$0.02 < m_a < 0.39$ eV

160 pressure settings ($\Delta p = 0.09$ mbar)

2 x 1.5 h sun tracking each setting

Nov. 2005 – Dec. 2006

Step 2: He^3 at T = 1.8 K, 14 < p < 120 mbar

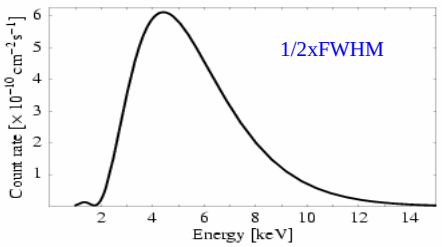
$m_a < 1.2$ eV

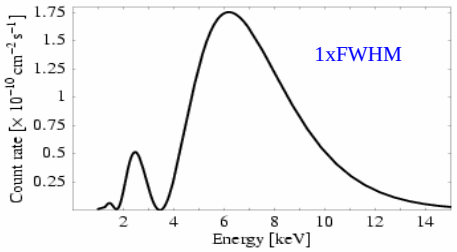
~ 1000 pressure settings!

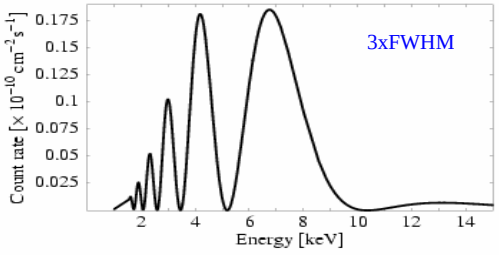
2 x 45 min sun tracking each setting

Jan. 2008 – 2010 (2008: 215 p-settings)

Off-resonance Spectra





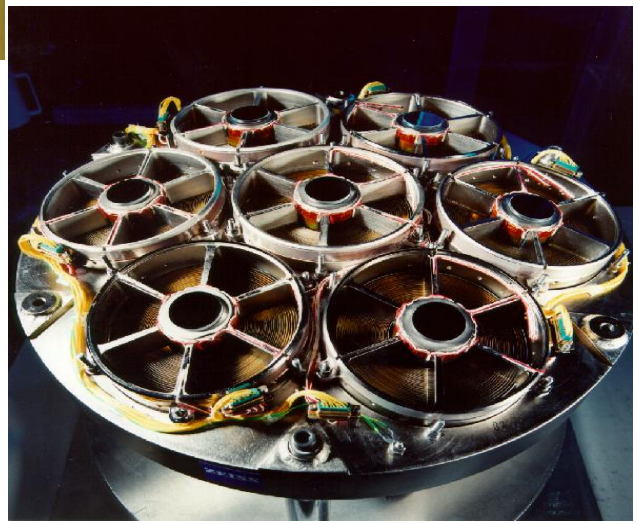


CAST Helioscope

LHC prototype dipole magnet

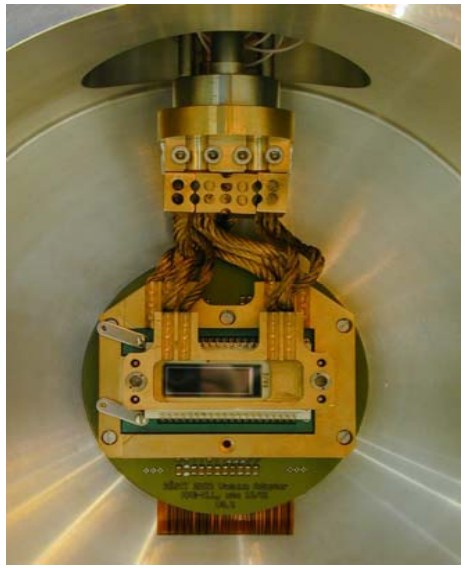
B = 9.0 Tesla

L = 9.26 m



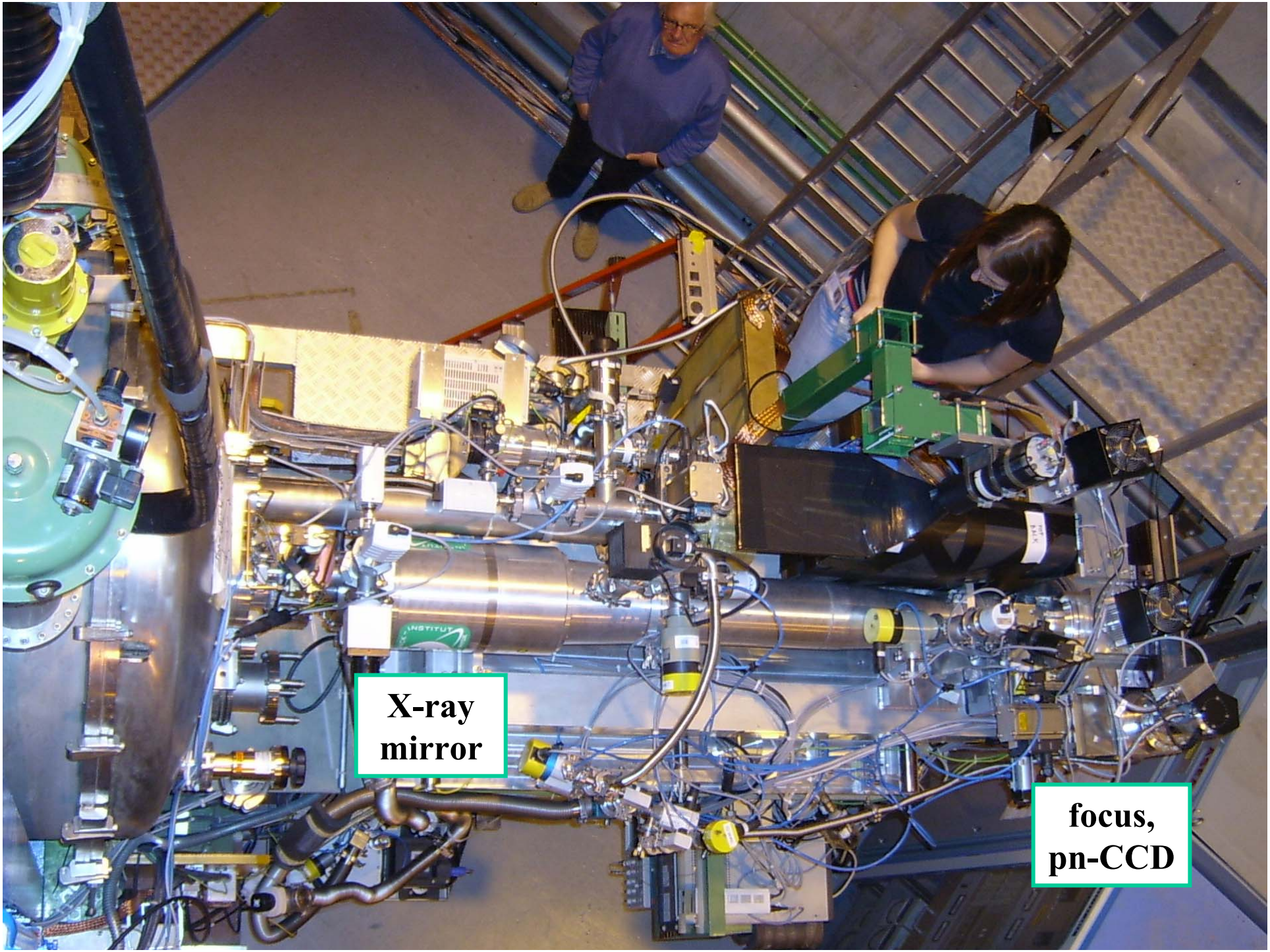
Wolter I X-ray mirror (ABRIXAS)

X-ray Telescope

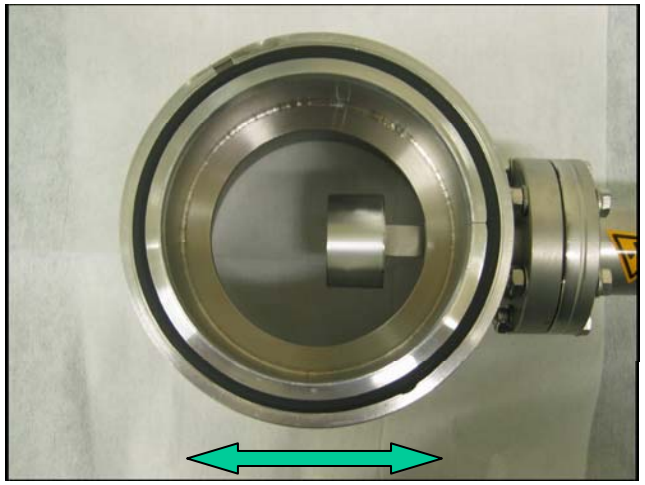


Axion sensitivity enhanced by $> 10^3$

pn-CCD (XMM-Newton)


X-ray
mirror
focus,
pn-CCD

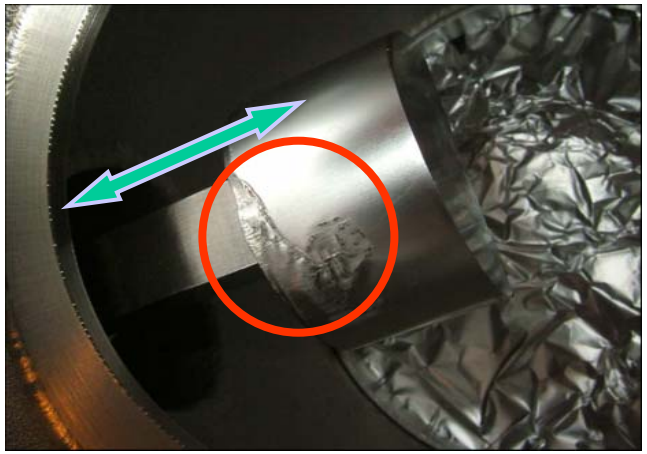
CAST Telescope

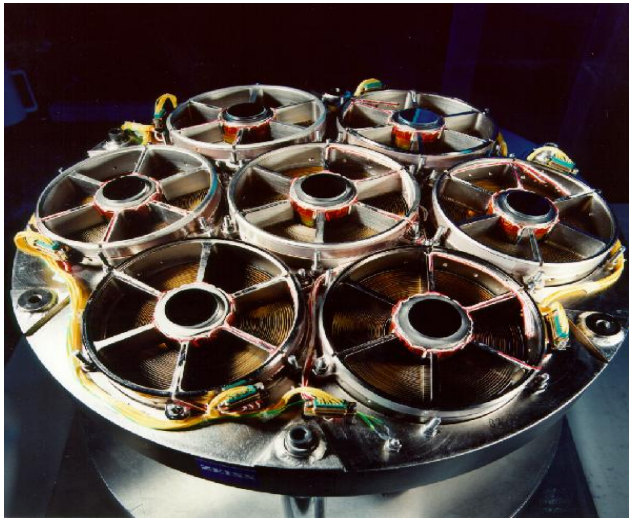


movement

Fe55 source

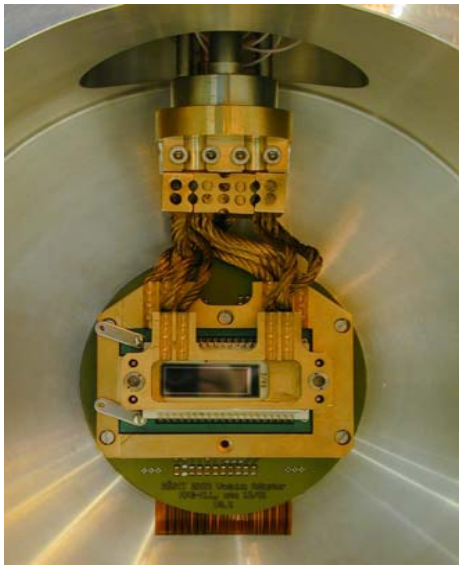
for daily CCD calibration





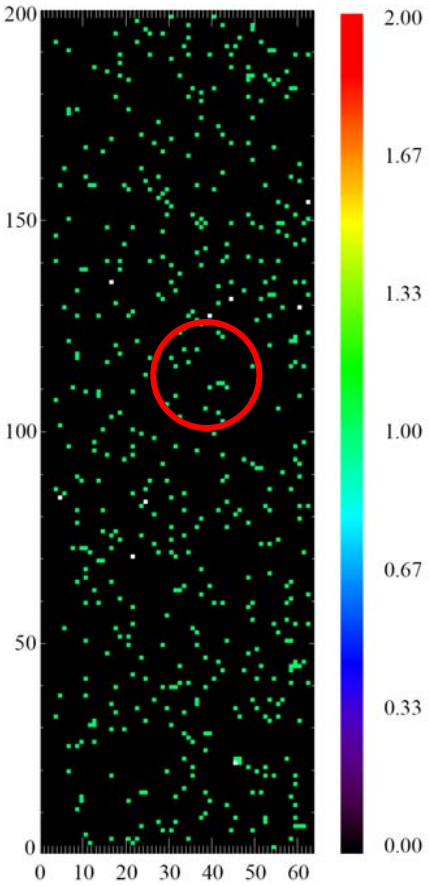
Wolter I X-ray mirror (ABRIXAS)

pn-CCD (XMM-Newton)

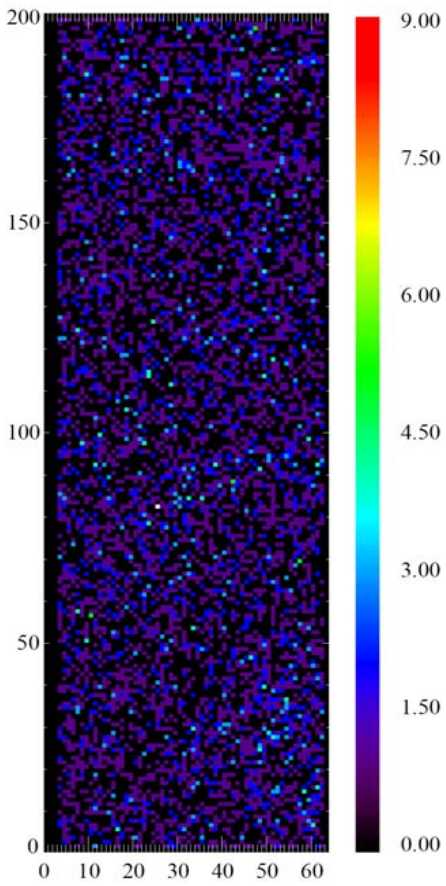


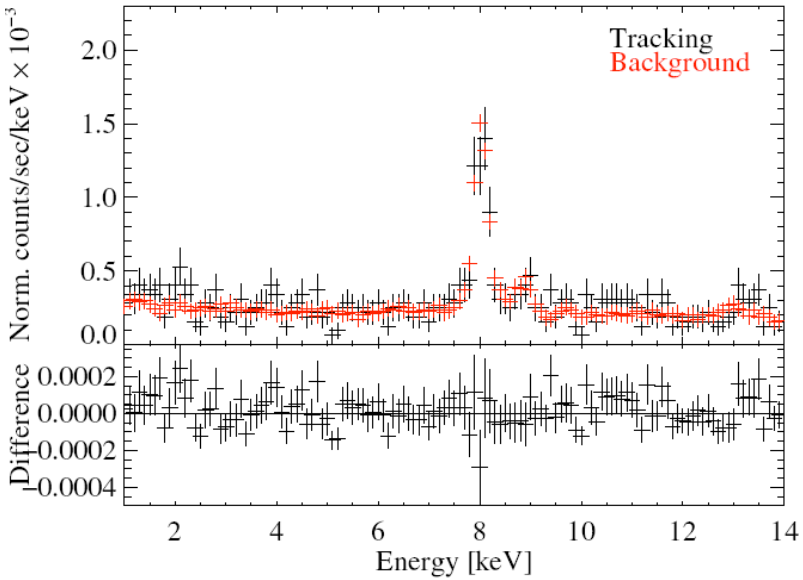
CCD performance 2008

Solar tracking
89.4 h



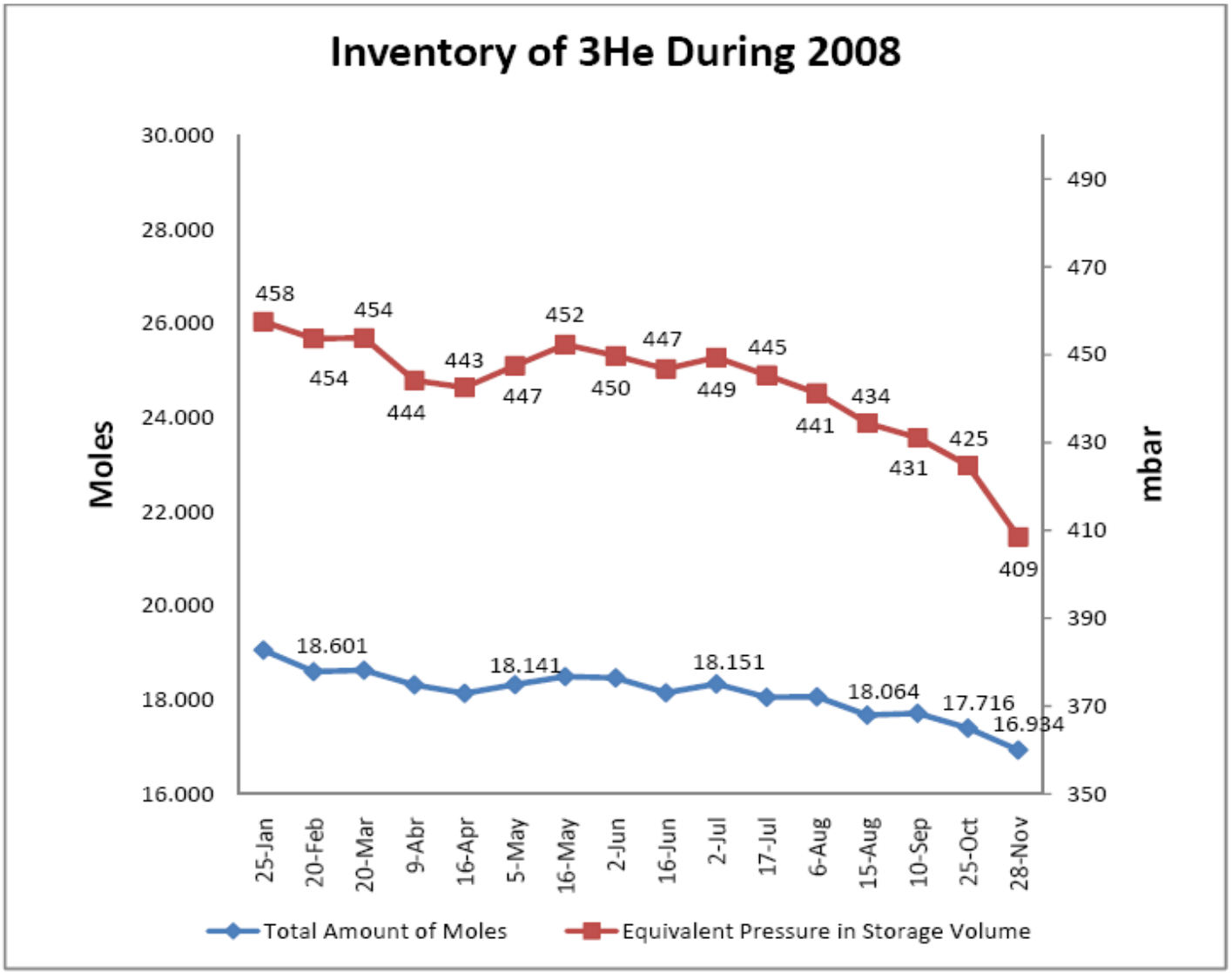
Background
1384.3 h





ROI: 1 – 7 keV

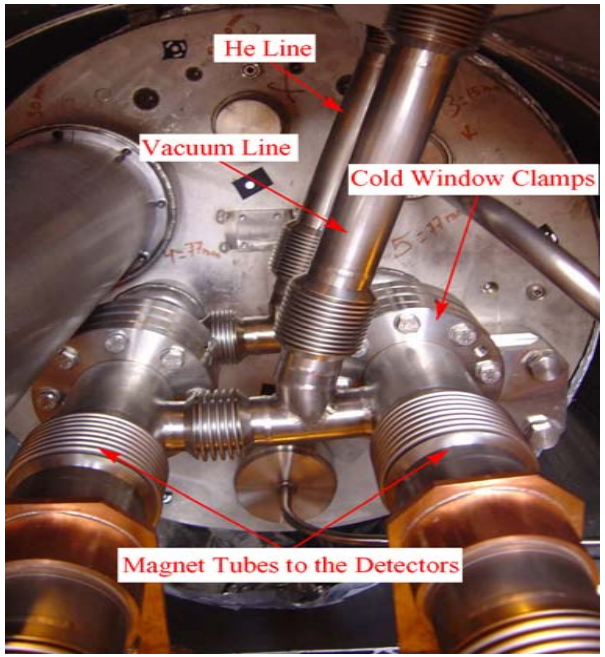
$(8.87 \pm 0.08) \times 10^{-5}$ cts/sec/cm^2/keV

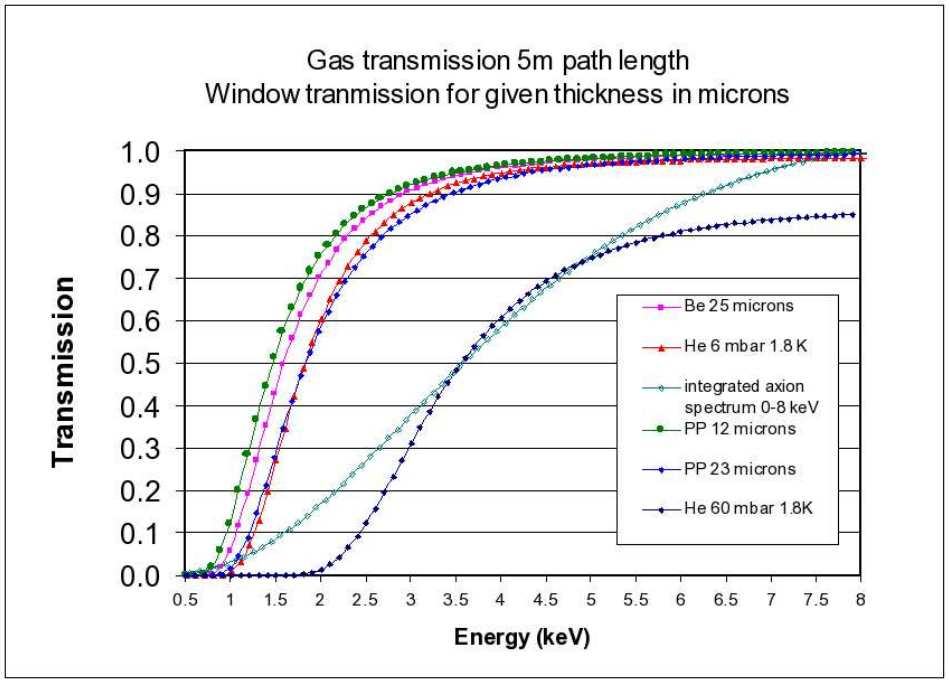


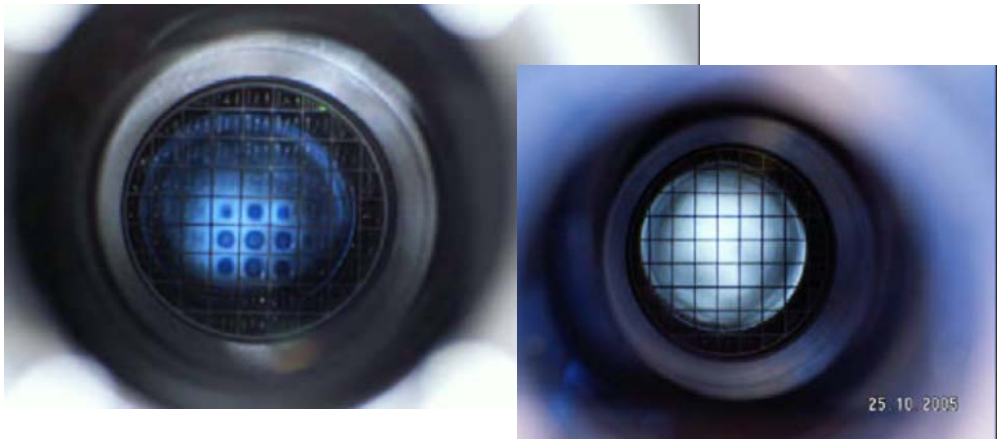
Total Amount of Moles: Is the sum of the corresponding number of moles of all the gas in every measurable volume of the system.

Equivalent Pressure in Storage Volume: Is the equivalent pressure of having the "total amount of moles" in the storage volume.

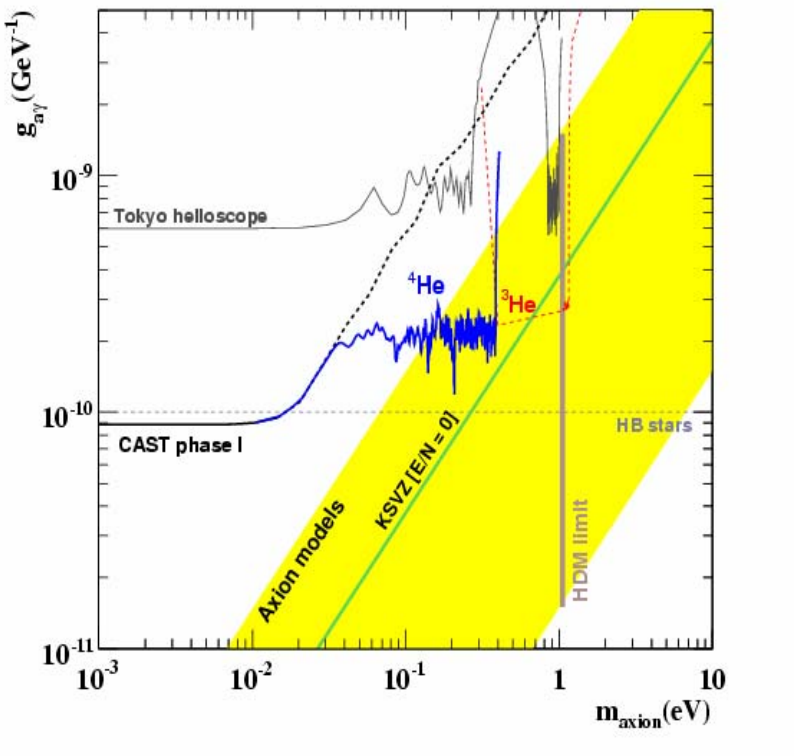
CAST Phase II: He cold windows

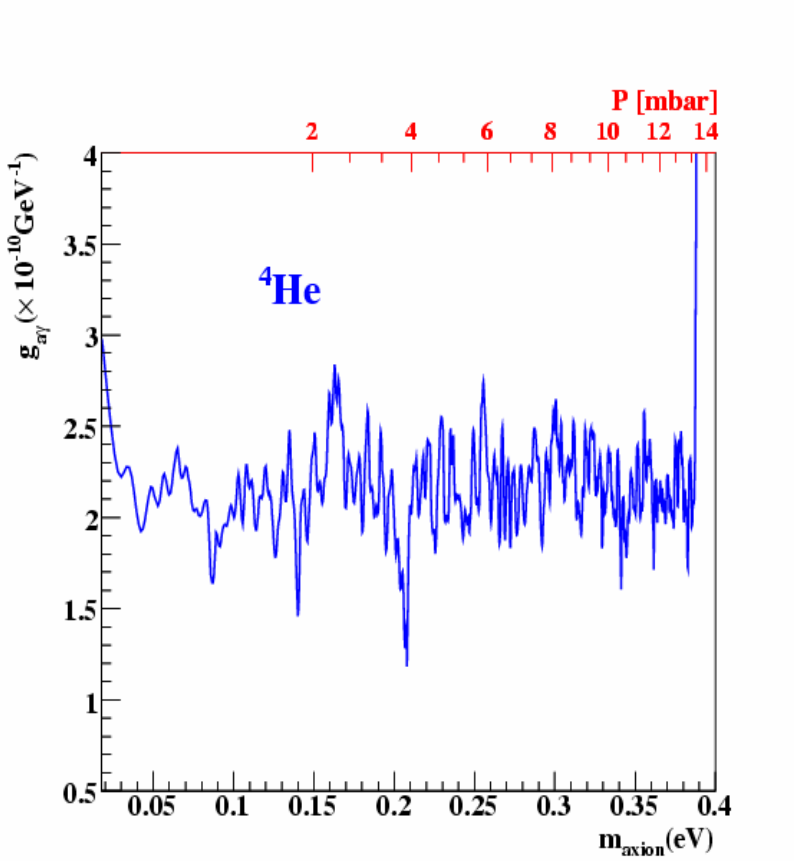






The invisible Axion

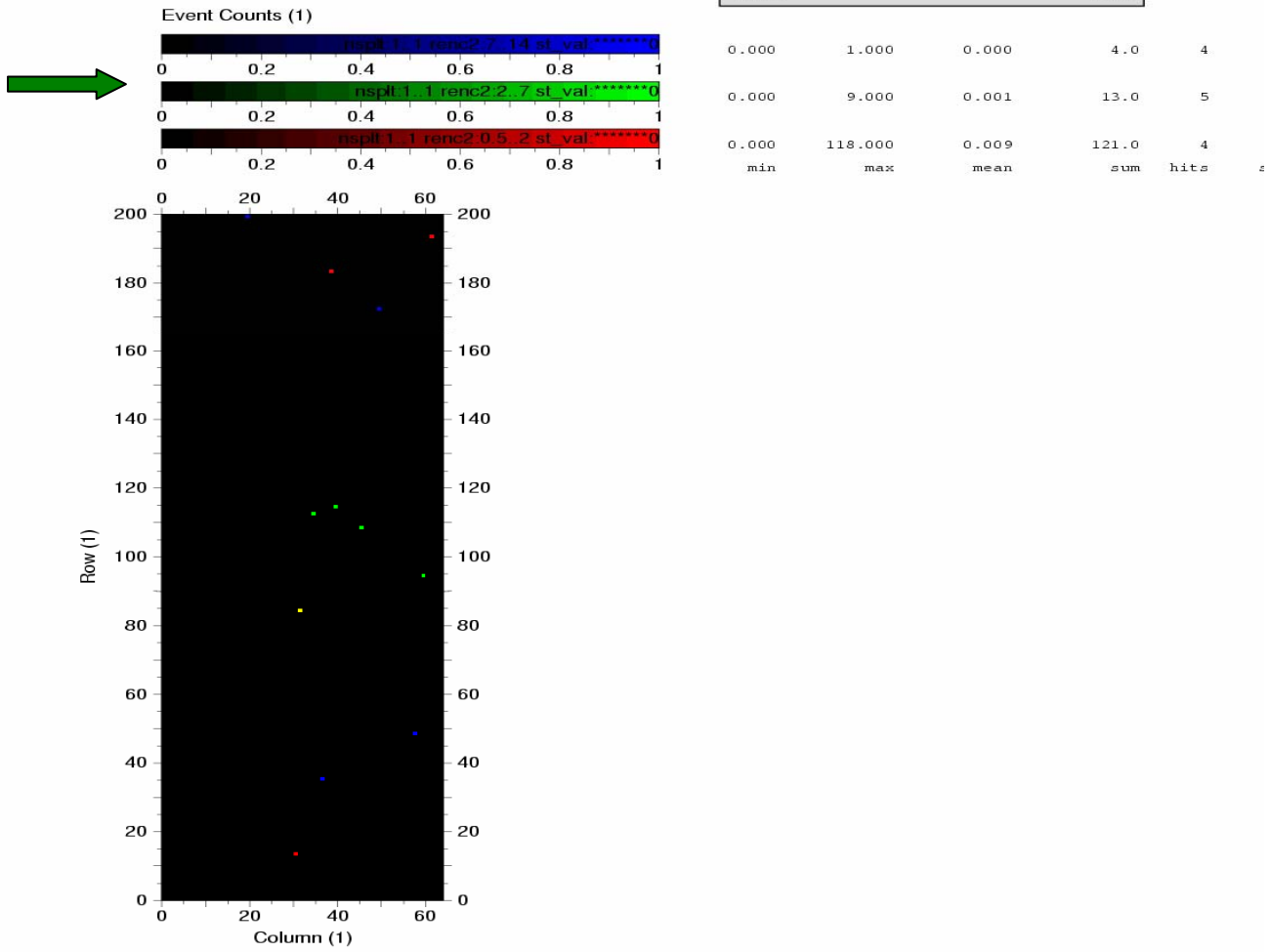




E. Arik et al (CAST Coll.): Probing eV-scale axions with CAST,
MPP-2008-138, hep-ex/0810.4482, JCAP (subm.)

He^4 90 min tracking result

ROI



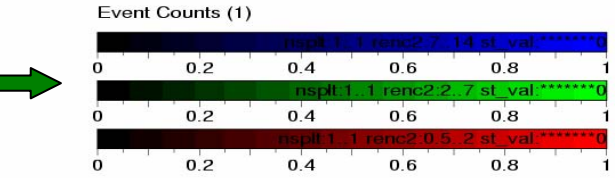
True Colour Event Image **C09_07_10_060530_02000**

EVTMAPE03 cast / kuster ||| FF / -130.0 degC / -

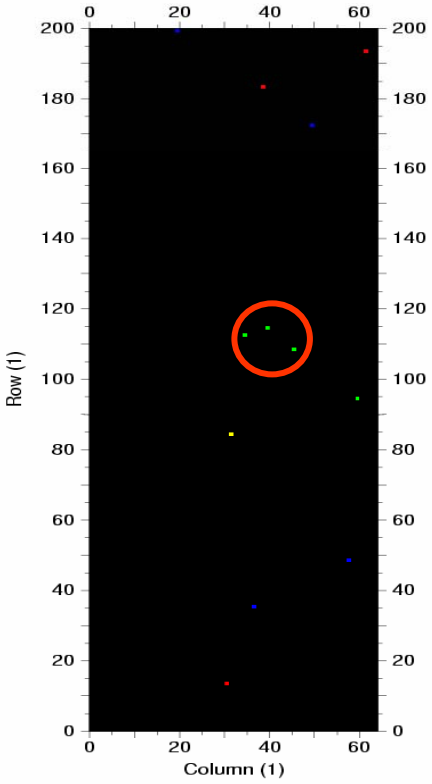
Source	-
CCD temperature (degC)	-130.0
Observation comment(s)	none
Start time	2006-05-30T02:55:48.845
End time	2006-05-30T04:26:01.776
Livetime (s)	5412.9
Cycle time (ms)	71.8
Frames (total/cal/softcal)	75420 0 0
Single Chip Info	9.?| 64|200|150|150| 0| 0| 0
Wafer Info	|111|Epi| | |300|16| |
Filter	- -
Window	1 64 1 200
Observer	kuster

90 min tracking result

ROI

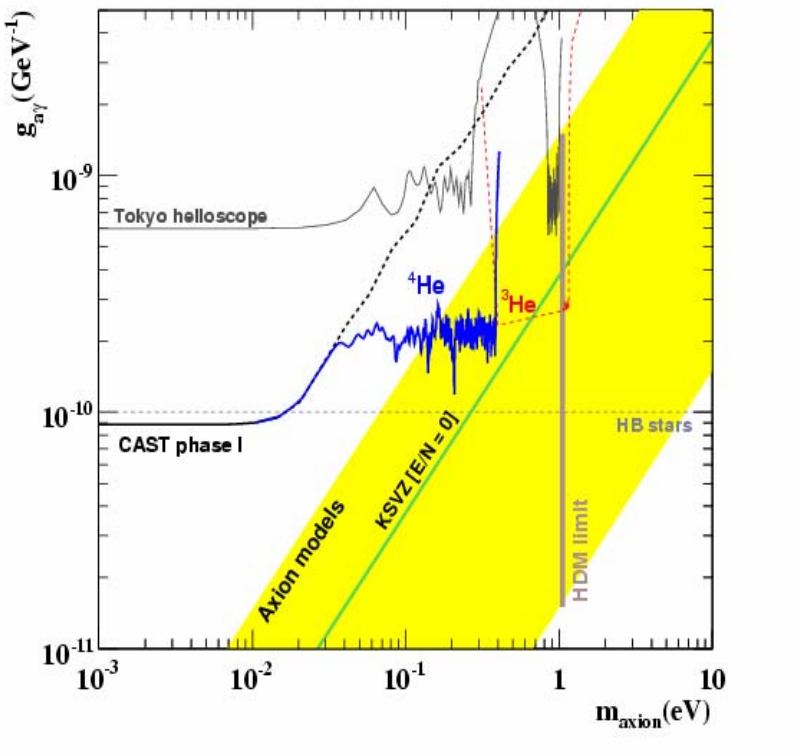


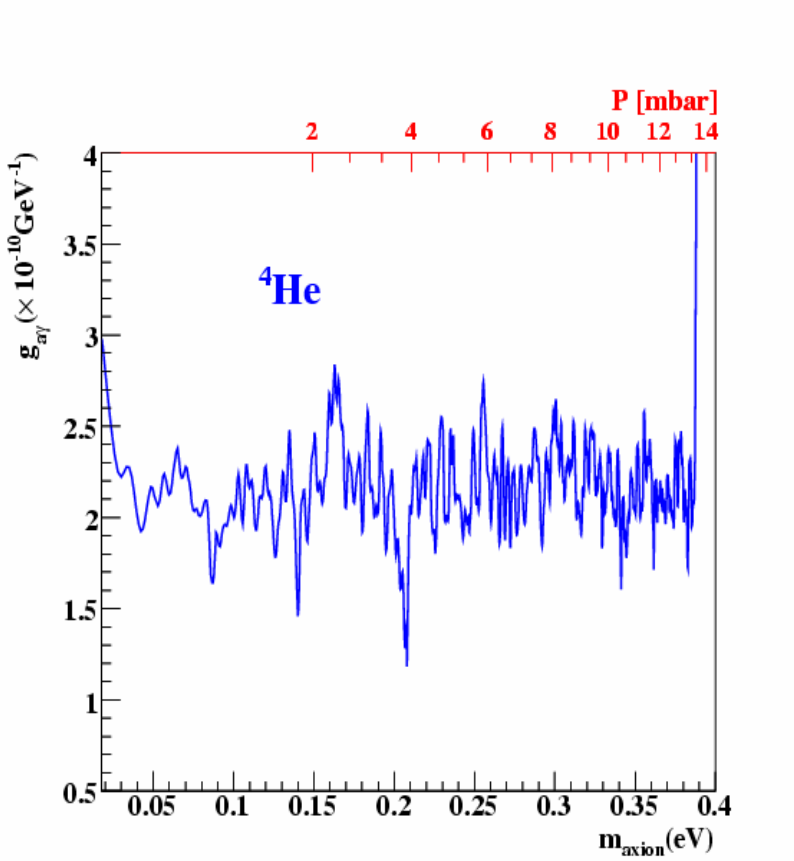
min	max	mean	sum	hits	
0.000	1.000	0.000	4.0	4	
0.000	9.000	0.001	13.0	5	
0.000	118.000	0.009	121.0	4	



„suspicious pressure“

The invisible Axion





E. Arik et al (CAST Coll.): Probing eV-scale axions with CAST,
MPP-2008-138, hep-ex/0810.4482, JCAP (subm.)

Recent CAST Publications

- **E. Arik et al (CAST Coll.):** *Probing eV-scale axions with CAST, JCAP(submitted),* ***MPP-2008-138, hep-ex/0810.4482***
- **Adriamonje et al (CAST Coll.):** *An improved limit on the axion-photon coupling from the CAST experiment,* ***JCAP 04 (2007) 010***
- **K. Zioutas et al (CAST Coll.):** *First results from the CERN Axion Solar Telescope,* ***Phys. Rev. Lett. 94 121301 (2005)***

- **CCD telescope: M. Kuster et al,** *The X-ray Telescope of CAST,* ***New J. Phys. 9 (2007), 169***
- **TPC detector: D. Autiero et al,** *The CAST Time Projection Chamber,*
- ***New J. Phys. 9 (2007), 171***
- **Micromegas detector: P. Abbon et al,** *The Micromegas detector of the CAST experiment,* ***New J. Phys.9 (2007), 170***