Hard X-rays from the quiet Sun

H. S. Hudson

Space Sciences Laboratory, University of California, Berkeley, USA

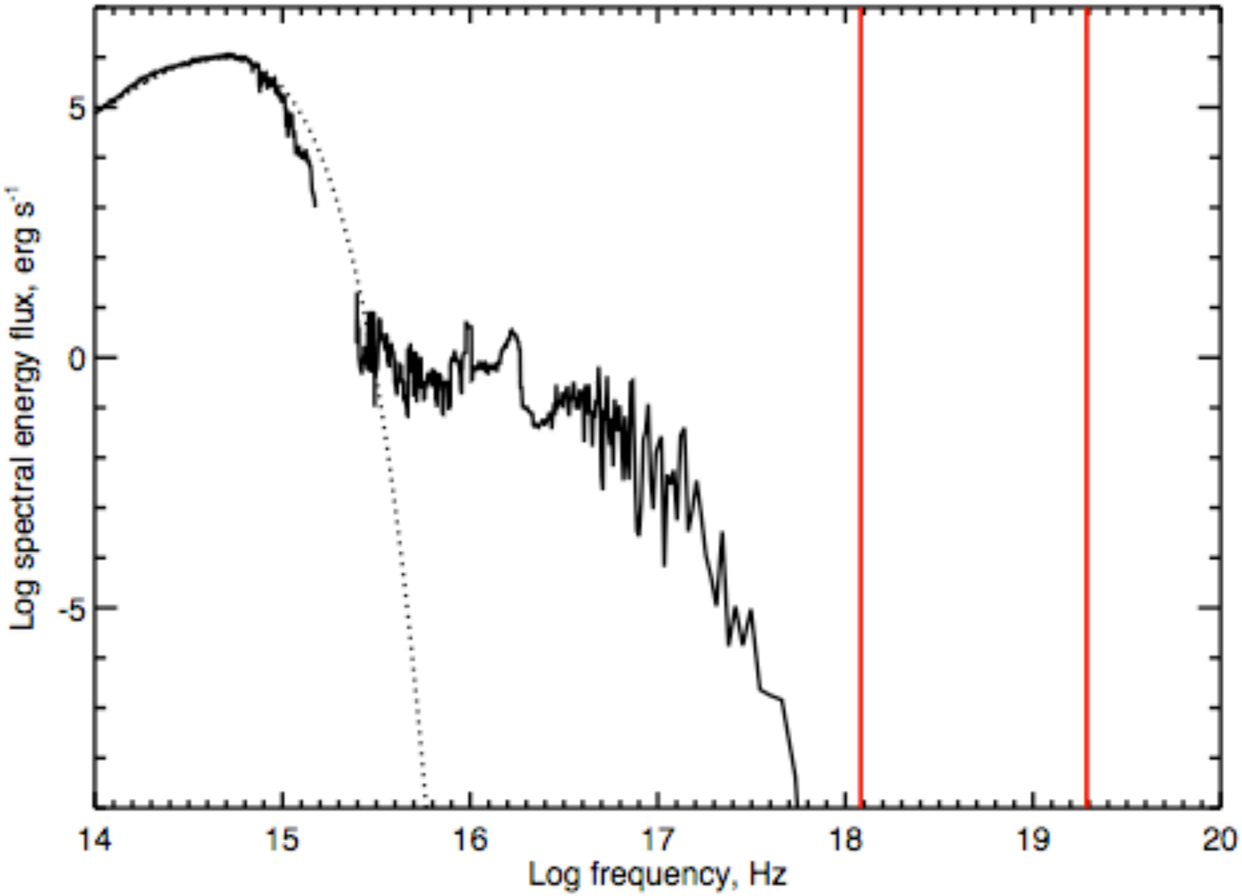
Hard X-rays from the quiet Sun

More exotic mechanisms

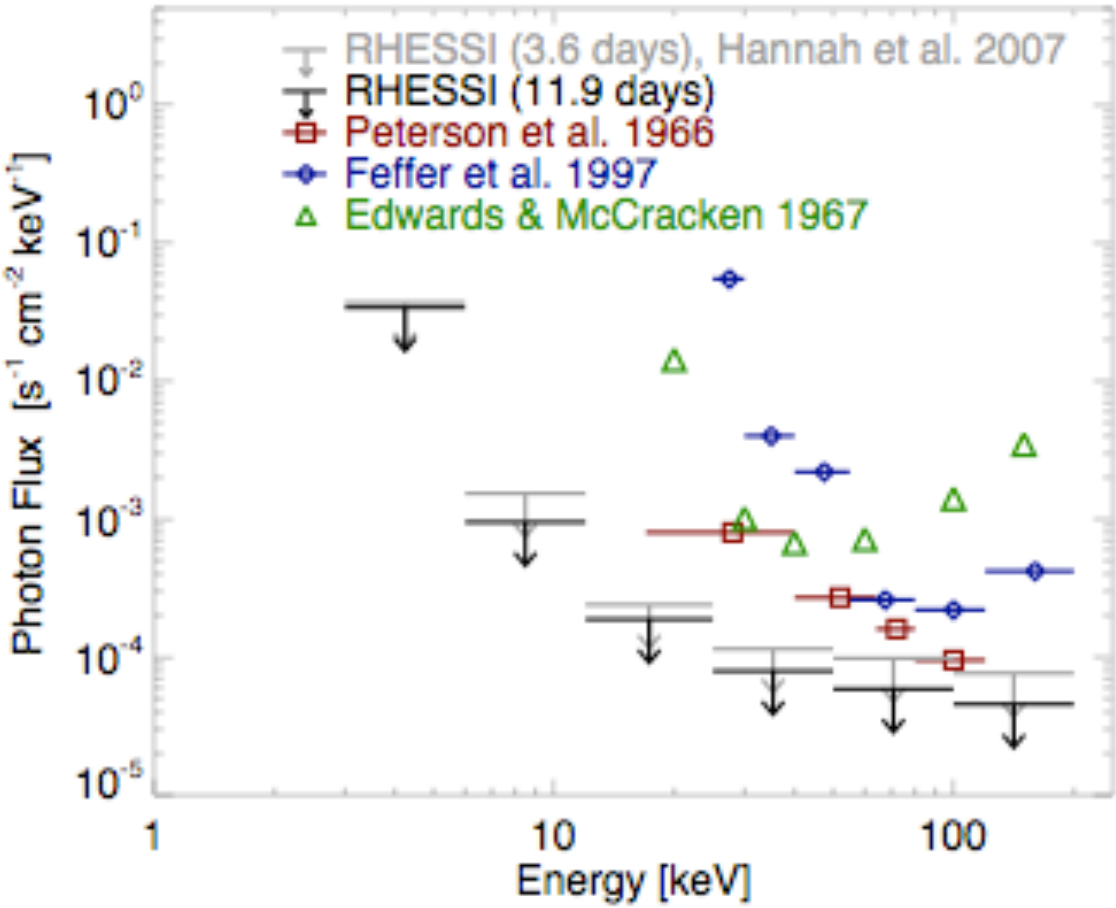
H. S. Hudson

Space Sciences Laboratory, University of California, Berkeley, USA

Quiet Sun SED

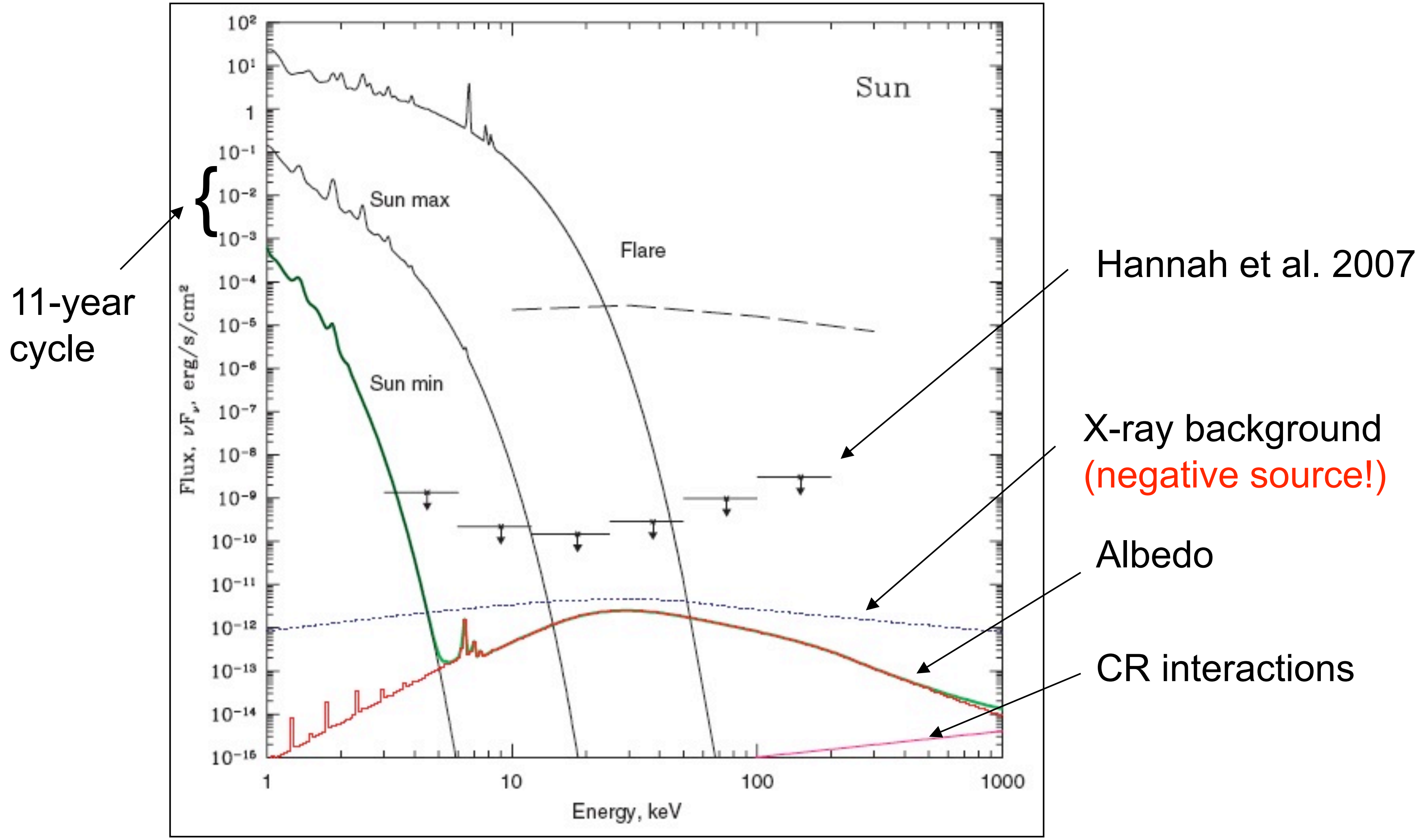


Quiet Sun in hard X-rays, current limits



http://sprg.ssl.berkeley.edu/~tohban/wiki/index.php/Quiet_Sun_III

Solar hard X-rays



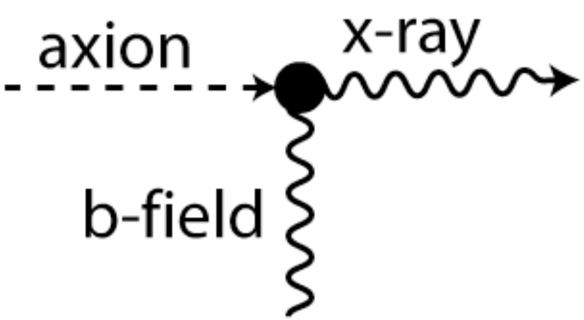
Churazov et al. 2008

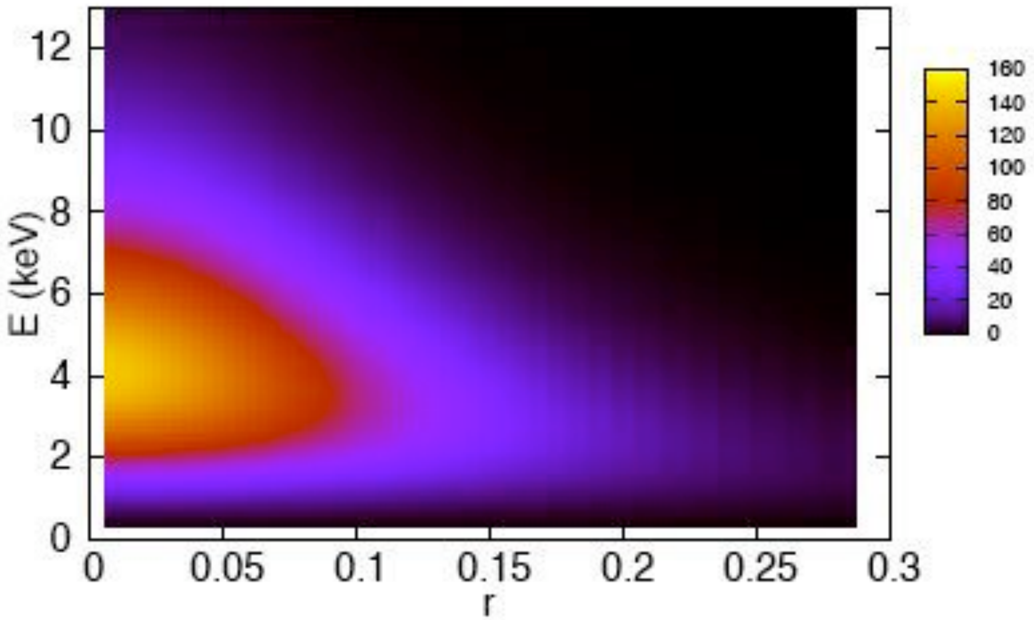
Exotic mechanisms

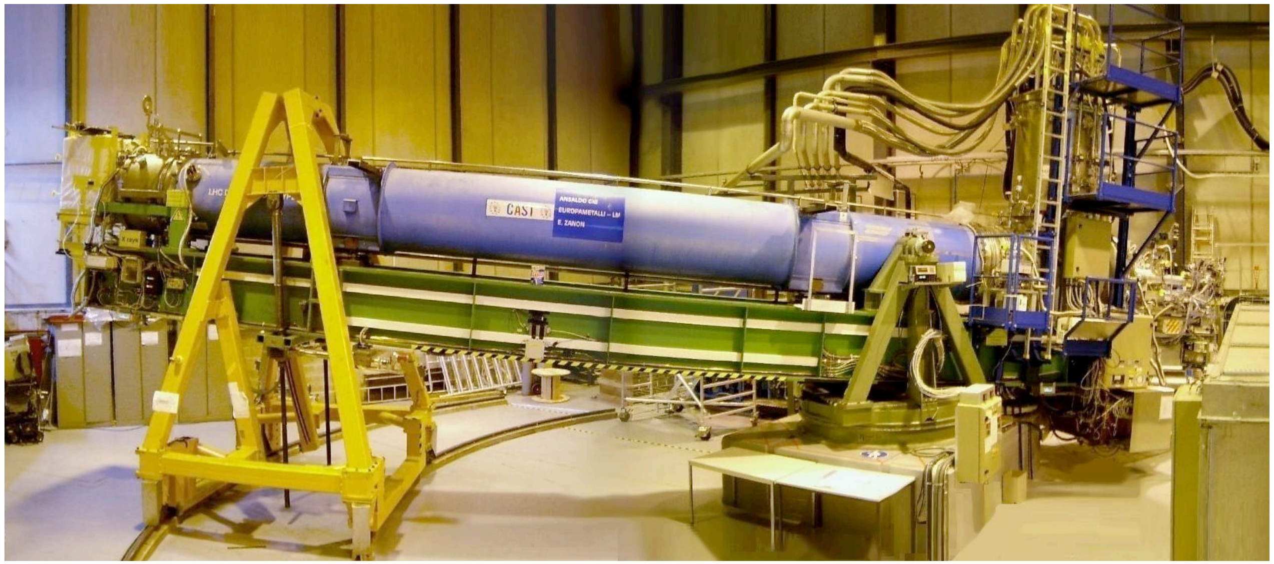
- Albedo from diffuse component (Churazov et al. 2008)
- Cosmic-ray secondaries (Seckel et al. 1991; MacKinnon 2007)
- *X-ray shadow*
- *Axions via Primakoff effect* (Carlson & Tseng 1996)*
- Inverse Compton source (Fermi γ-ray result)

**http://sprg.ssl.berkeley.edu/~tohban/nuggets/?page=article&article_id=50*

Axions from the solar core

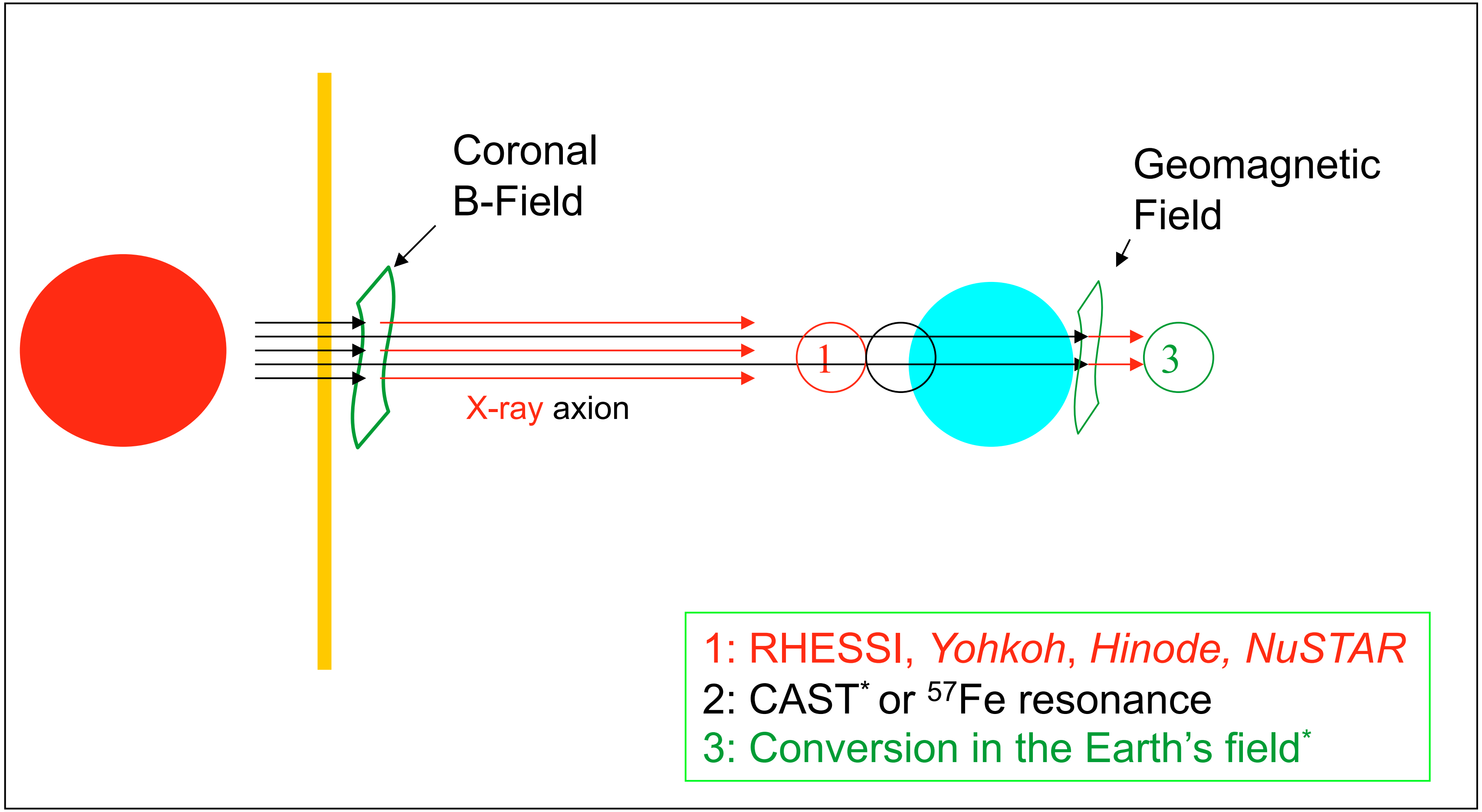






CAST (Cern Axion Solar Telescope)

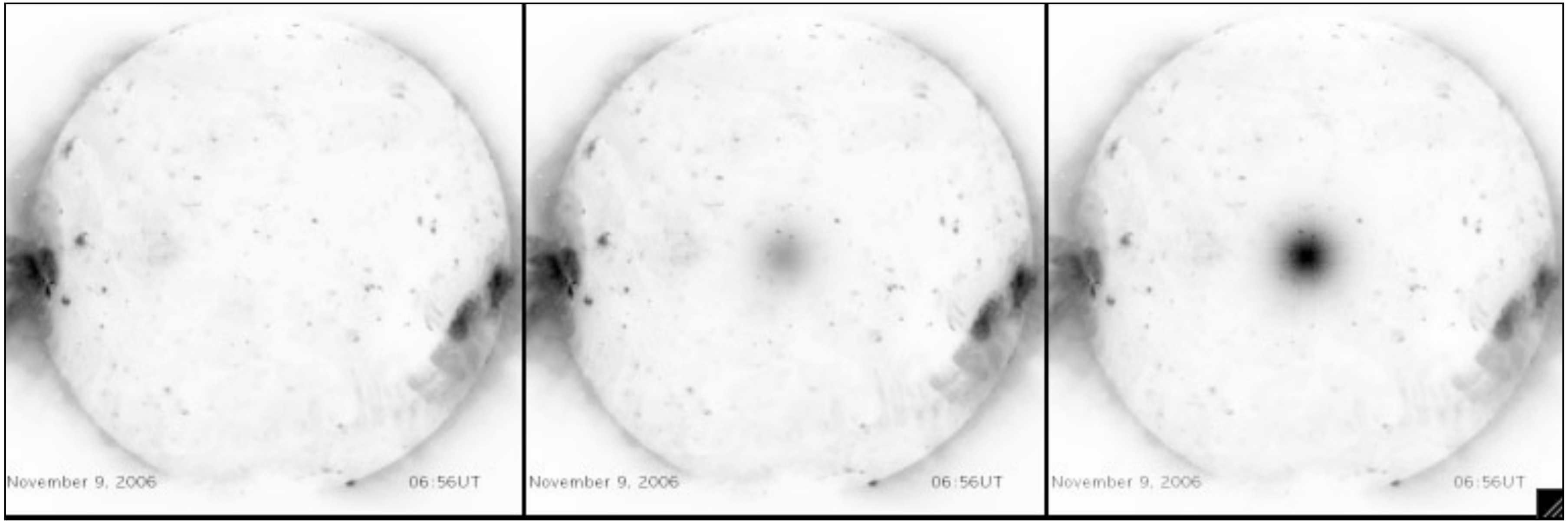
Geometries for solar axion detection



*Andriamonje et al. 2007

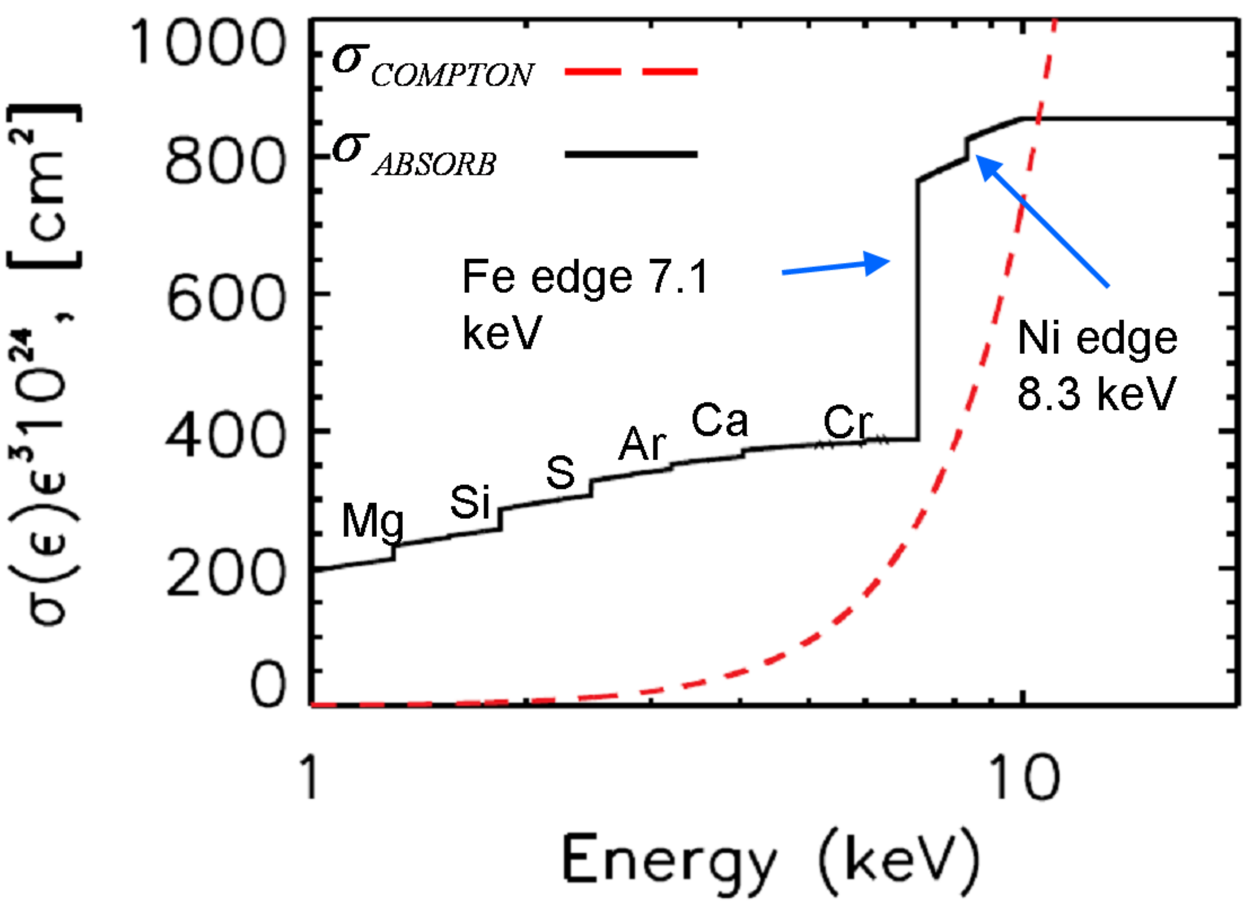
*Davoudiasl & Huber, 2005

What a solar image should look like with axions



There's no such thing A few axions Lots of axions

The X-ray shadow of the Sun

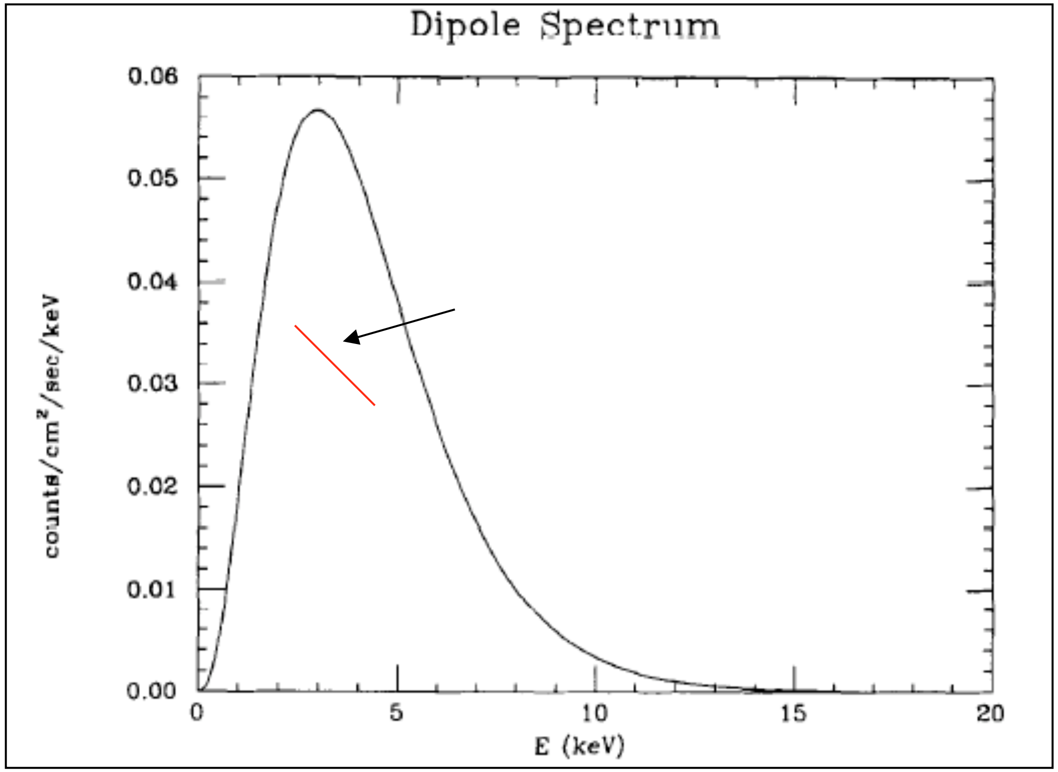


The true radius of the Sun

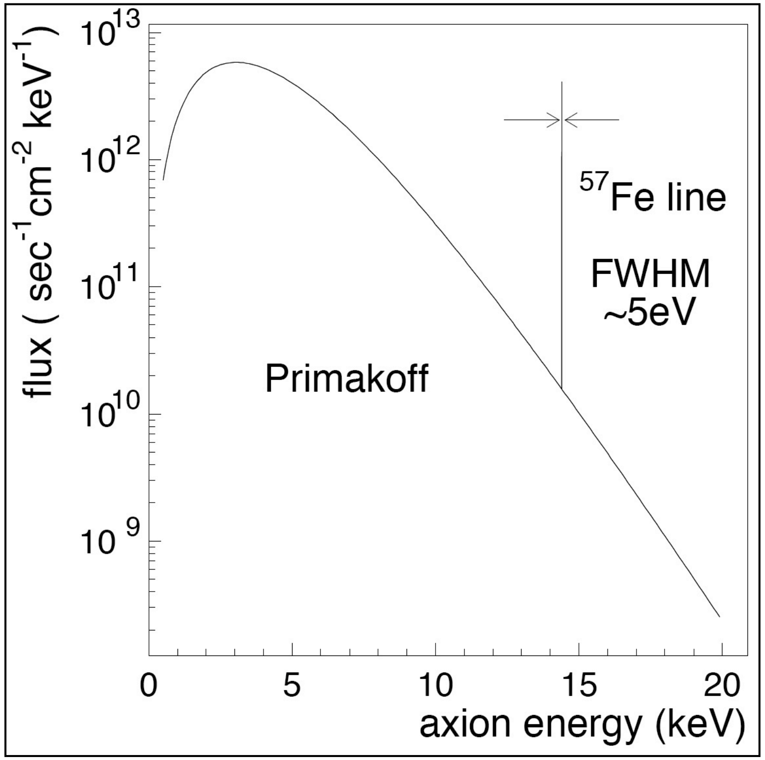
- Limb measurements at visible wavelengths are strongly model-dependent
- In the Thomson-scattering X-ray domain, a measurement of the location of the limb is easy to interpret
- This is topical in view of the seismology/abundances quandary
- NuSTAR can help by timing occultations
- It may also be possible to use the diffuse component somehow

More about axions….

Predicted solar fluxes



Carlson & Tseng (1996)



Moriyama (1996)

• The main ~5 keV emission, due to the thermal emission, is shown here for a specific value of the coupling constant g

• The 14.4 keV line is the γ-ray used in Mössbauer studies, here photonuclear

Conversion in the solar atmosphere

$$P = \frac{1}{4} g^2 |\boldsymbol{D}(x, y)|^2 .$$

$$\boldsymbol{D}(x, y) = \int_0^L \boldsymbol{B}_\perp(x, y, z)\, e^{i\theta(z)}\, dz$$

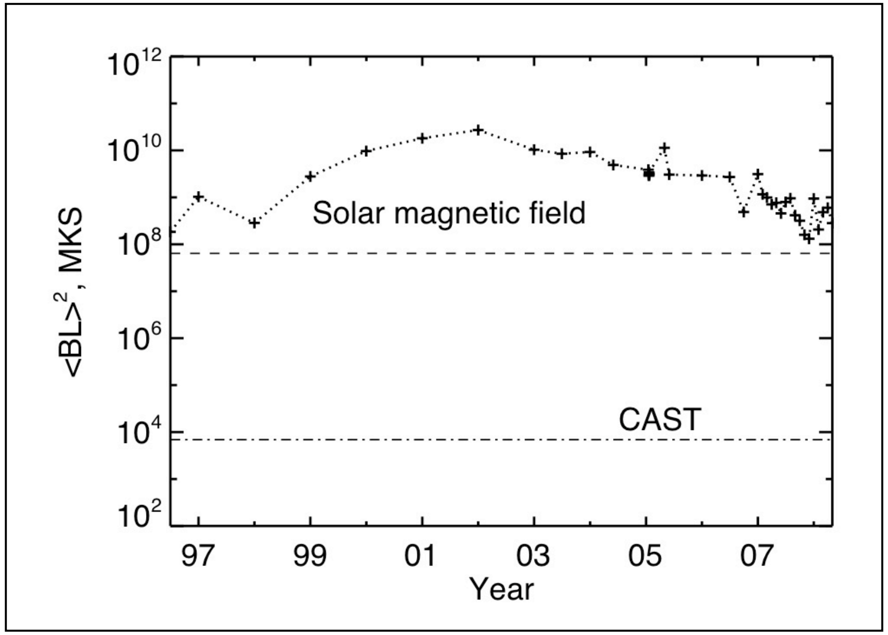
$$\theta(z) = \int_0^z \left(\frac{2\pi\alpha n_e(z')}{m_e E} - \frac{m^2}{2E} \right) dz'$$

Need <B_{perp}L>

Need n < n_0(m)

What (n, B) do we have?

PFSS Prediction for solar <BL>^{2} Strengths and Weaknesses



- The solar <BL>^{2} product is much larger than that achievable in laboratories
- The field is strongly variable in both space and time, and not well known quantitatively
- Strong fields drive solar activity, potentially confused with the axion signal or a source of background

Figure of Merit for X-ray and γ-ray observations

$$FOM = \sqrt{\epsilon A \Delta t / B \Delta E}$$

A	= detector area
Δt	= integration time
B	= background rate
ΔE	= energy range
ε	= efficiency