Astronomy with the hardest photon energies

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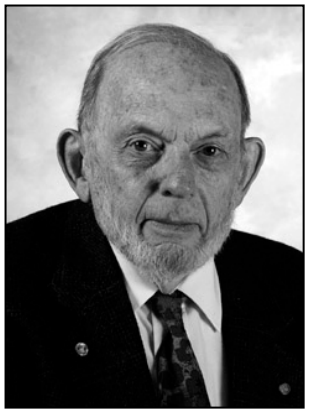
Academic Background

- Caltech (1962), UC Berkeley (1967)
- Kinsey Anderson (PhD Minnesota 1955)
- John Winckler (PhD Princeton 1946)
- Rudolph Ladenburg (PhD Munich 1906)
- Wilhelm Conrad Röntgen (PhD Zurich 1869)
- August A.E.E. Kundt (PhD Berlin 1864)
- Heinrich Gustav Magnus (PhD Berlin 1827)
- Miscellaneous German chemists…



Outline

- Gamma-ray astronomy (the “hardest energies”)
- Microflares
- The Sun at high energies

The Pb brick and Bob's bravery

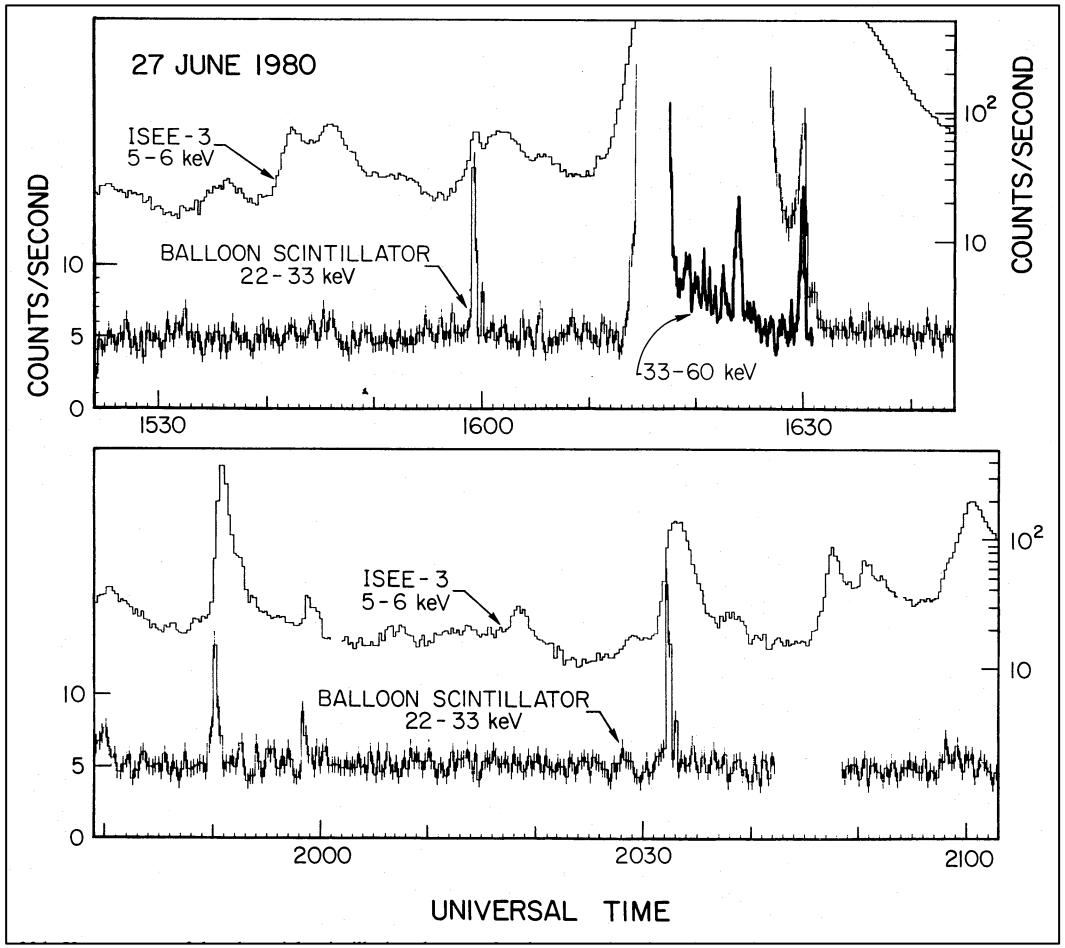
- At 2x4x8 inches, a Pb brick weighs almost 12 kg (some 26 pounds)
- Nothing (almost) reflects 2.223 MeV γ-rays
- The middle dimension of a lead brick corresponds to an absorption of $e^{-\tau} \sim 0.05$

  at this "hardest energy"
- As a collimator (the world's most primitive telescope) this corresponds to an optimum resolution of about 50 degrees!

The 1980 balloon

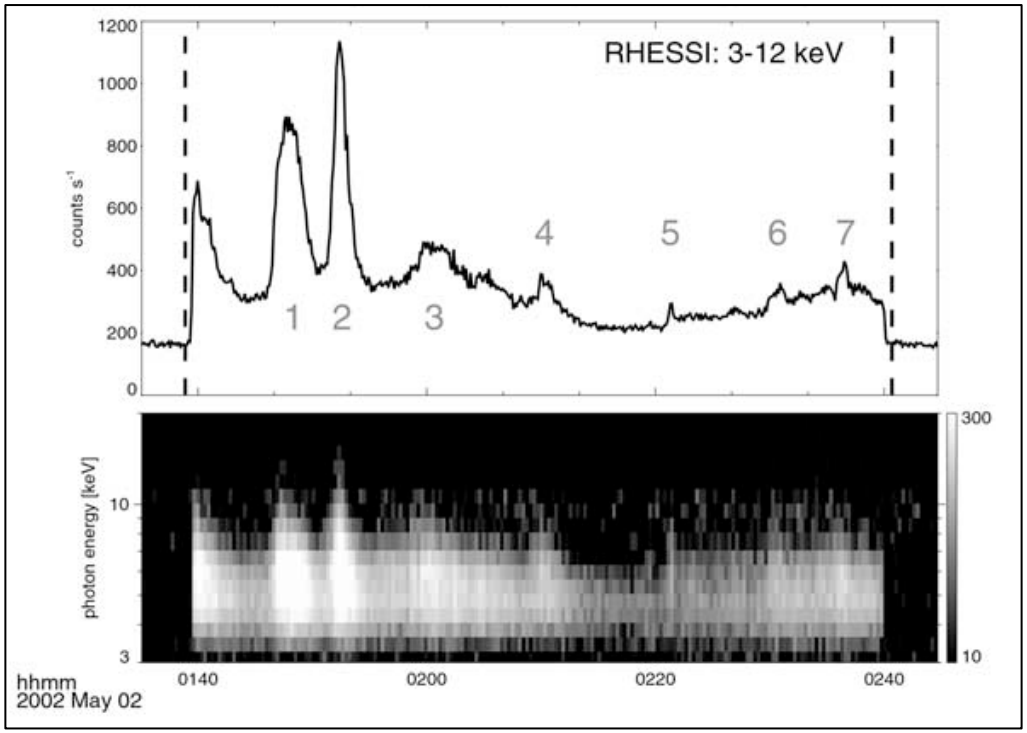
At a NASA facility not far from Bug Tussle, TX

The 1980 balloon

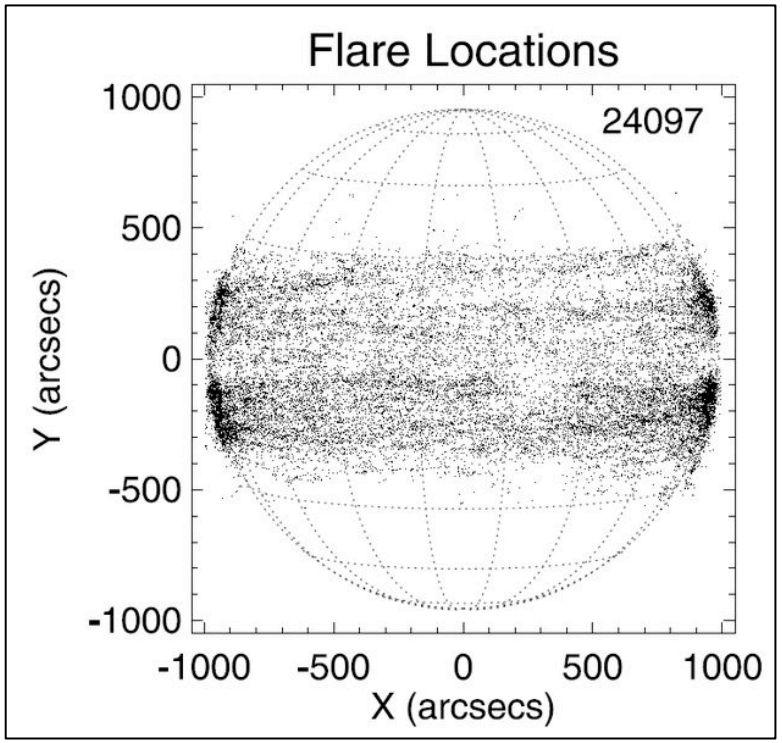


Lin et al., 1984

The RHESSI era



Krucker et al. 2002



Hannah et al. 2007

Microflares and Nanoflares

- We see a scale-free power law of flare energies
- There is the attractive idea that “heating” consists of swarms of tiny non-thermal events
- Given the 1980 balloon results, and RHESSI’s superior capabilities, could we see such non-thermal effects at high energies?

Interpretation

- RHESSI sees no microflares in the quiet Sun
- Coronal heating therefore requires different physics from that seen in flares – if episodic, then “nanoflares”
- Could we see non-thermal effects at high energies and infer the existence of nanoflares indirectly? Note that the Qiu et al. (2004) imply relativistic electrons for some A-class events!

Do flares ***heat*** the corona, or do they ***cool*** it?

- The corona is a low-beta plasma, and so its energy resides almost entirely in the B field.
- “Follow the energy:” this coronal B field is itself the item of greatest interest.
- Any flare (or CME) can only diminish this energy, and therefore, on long time scales, really *cools* the corona.

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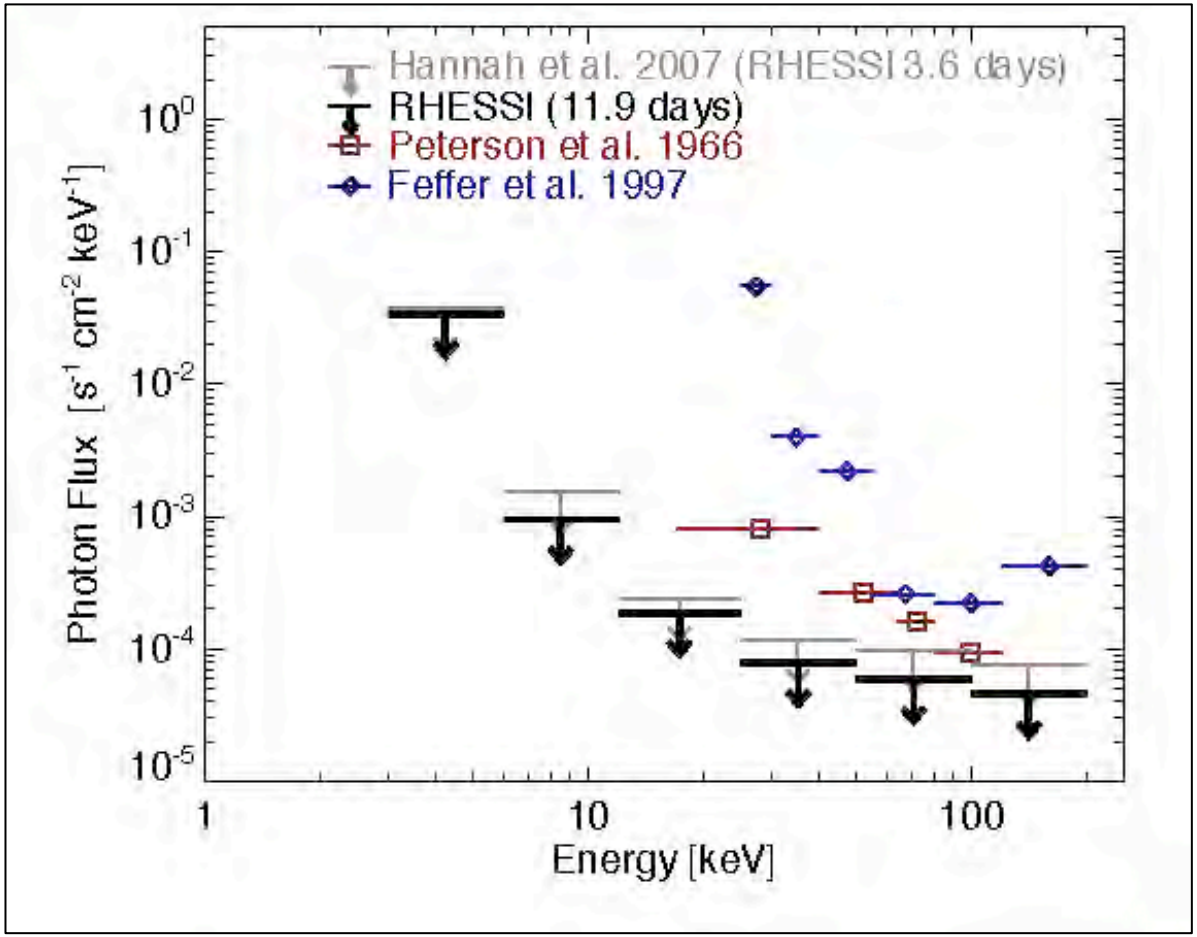
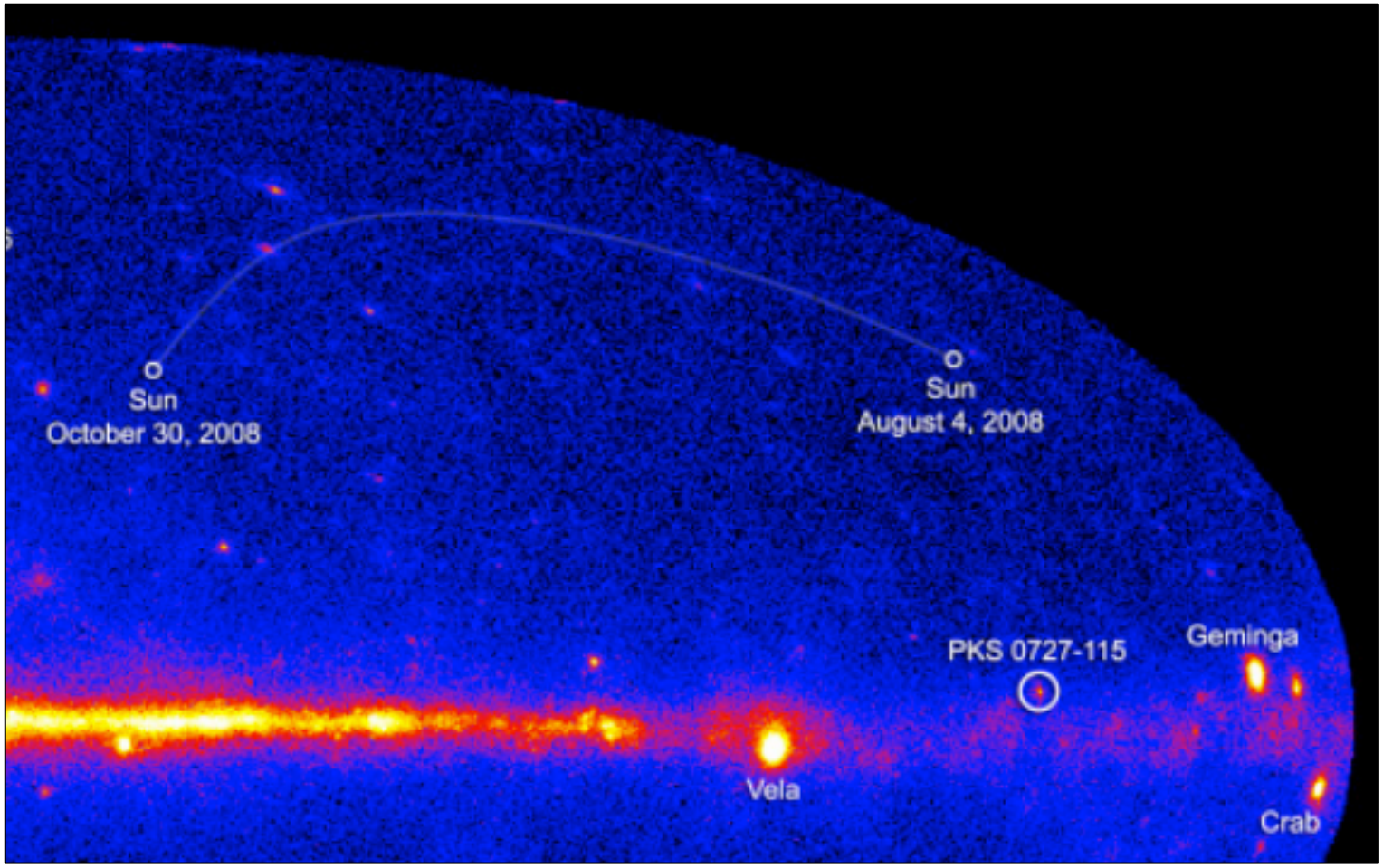
- *Bob needs to put this in his next grant proposal*

The Quiet Sun (RHESSI)



Hannah et al. 2010

The Quiet Sun (Fermi)



Conclusions

- A part of Bob’s career has been as a pioneer gamma-ray astronomer
- His academic heritage leads back through Minnesota cosmic rays, to Röntgen

Happy birthday, RHESSI!

Happy birthday, Bob!