



University
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HXR Microflares, Quiet Sun & Flare Statistics

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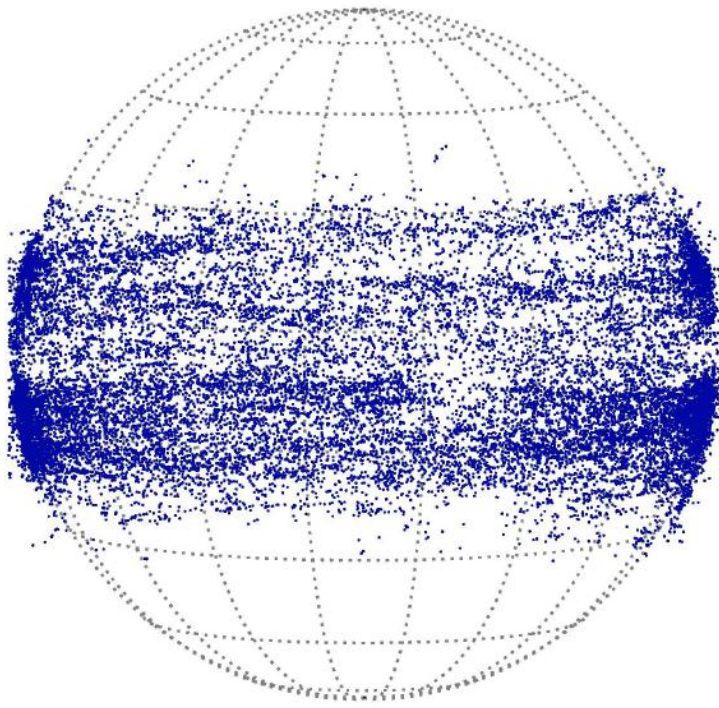


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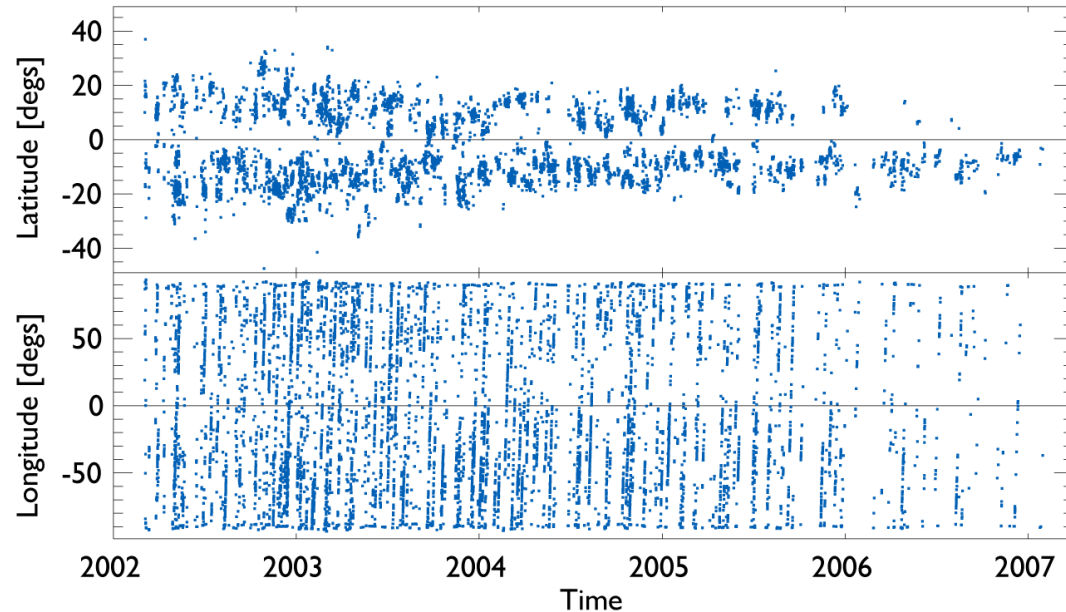
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- **We are interested in energy release in the solar atmosphere**
 - HXR prime diagnostic of accelerated electrons
- **Microflares (small, A/B-GOES Class flares) are useful as**
 1. “Simple proto-types” of processes in large flares
 - i.e. single impulsive burst of energy release
 - i.e. few loops of heated material instead of arcade
 2. Limits and scaling of energy release processes
 - How small can an active region flare be?
 - Is there a different process for smallest events (“nanoflare”)?
 - Is non-active region energy release similar to active region flares?
- **N.B.**
 - **Microflare** = small active region flare (< C-Class)
 - **Parker nanoflare** = basic unit of localised impulsive energy release
 - **Nanoflare** = brightening (< microflare) close to the observational limit so you don't really know what it is

- **All are associated with Active Regions**
 - >25,000, sub C-Class flares between 2002 to 2007.
 - Down to the smallest A1 GOES flares are all active region phenomena

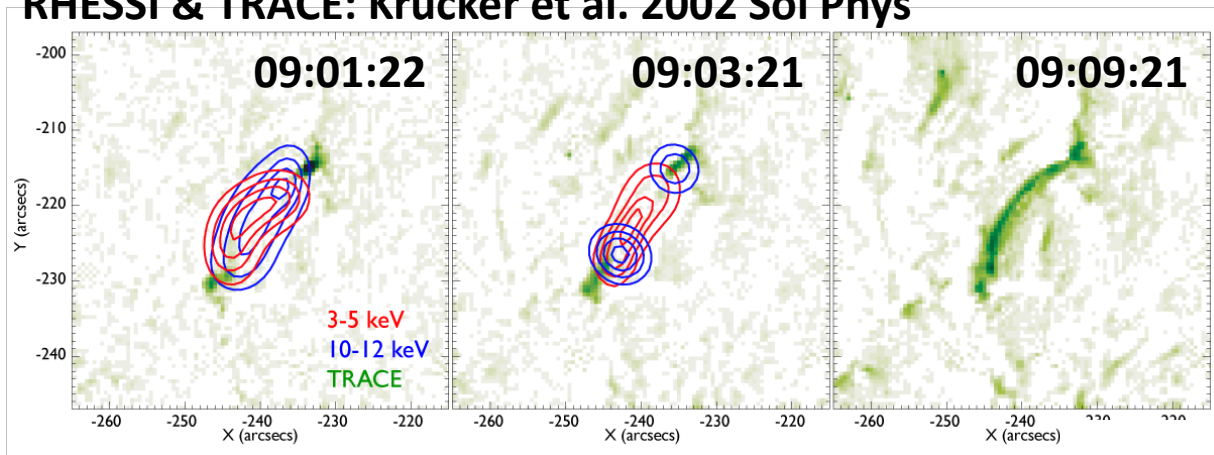


Christe et al. 2008 ApJ

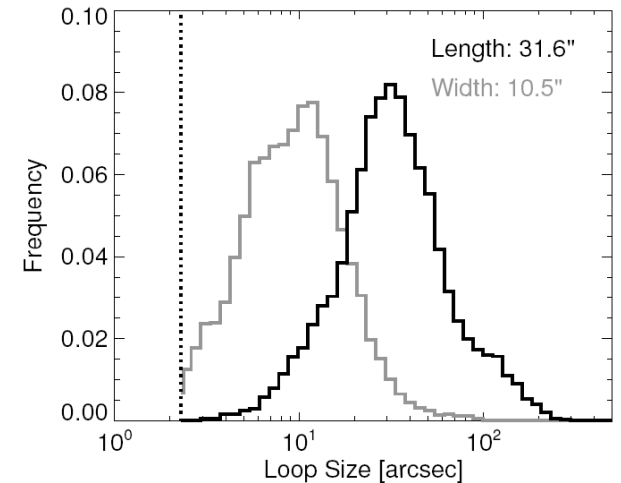
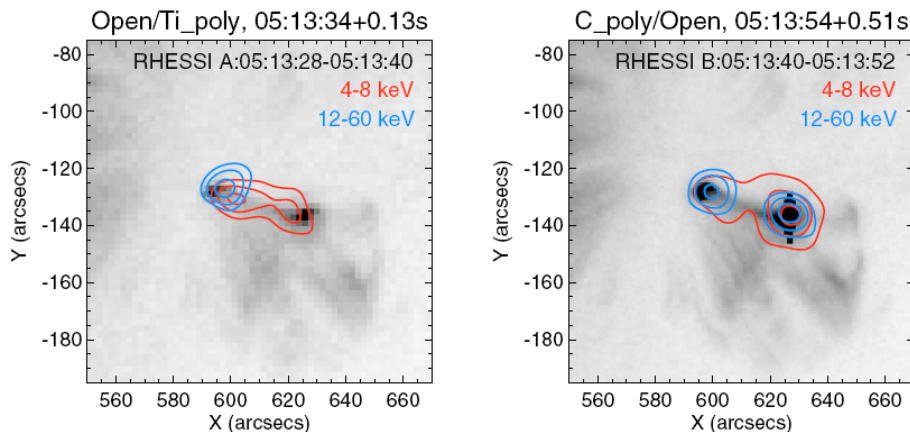


- Like large flares with HXR footpoints, then hot SXR/EUV loops
- Micro energy content but not necessarily small
 - On average the thermal loop length is about 30''

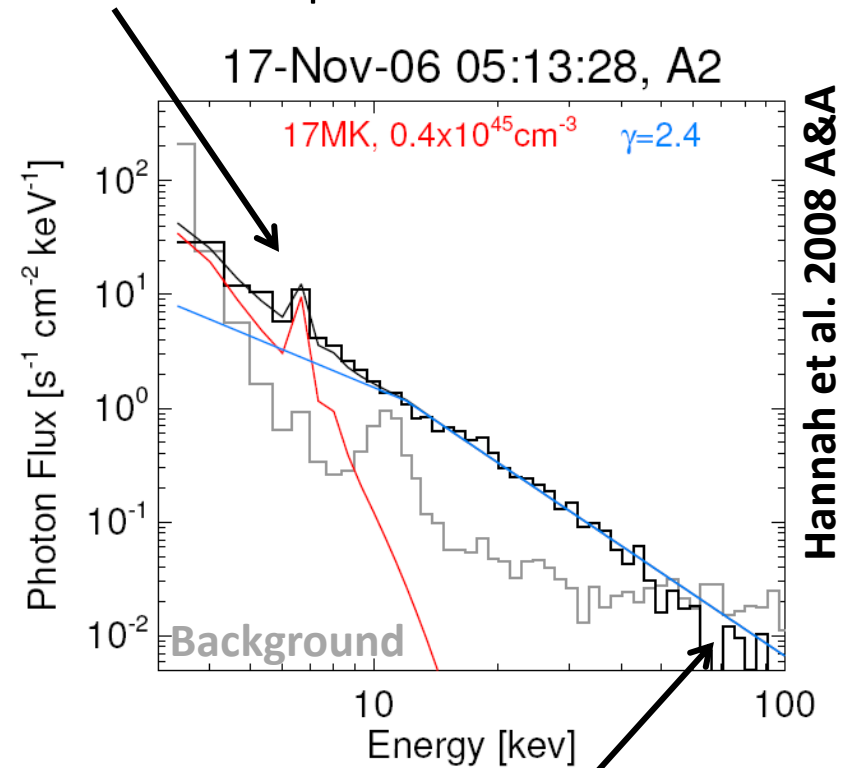
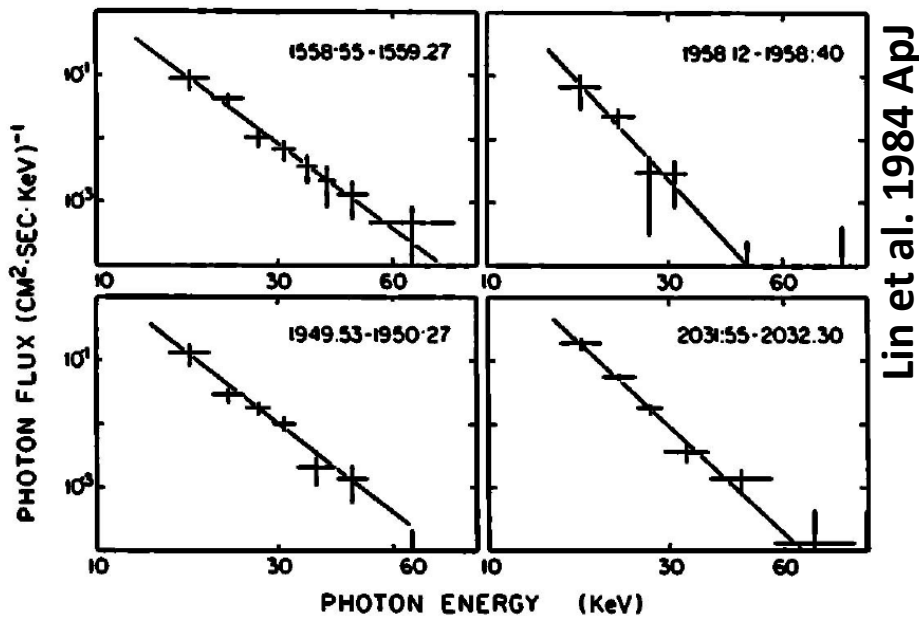
RHESSI & TRACE: Krucker et al. 2002 Sol Phys



RHESSI & XRT: Hannah et al. 2008 A&A

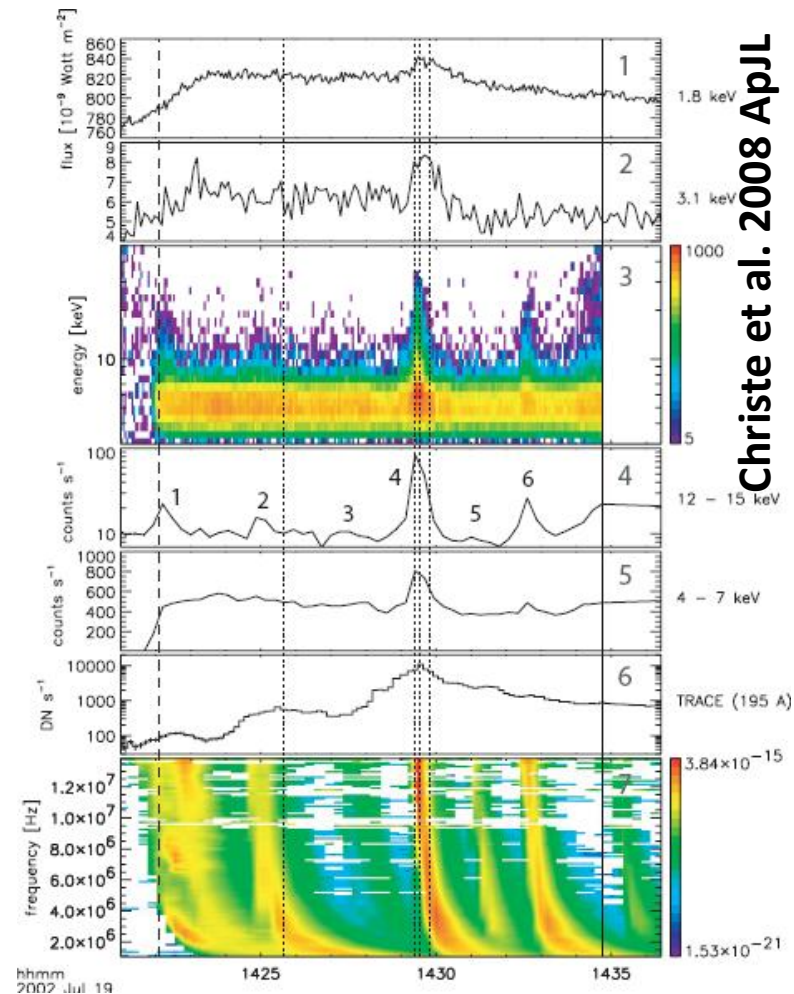
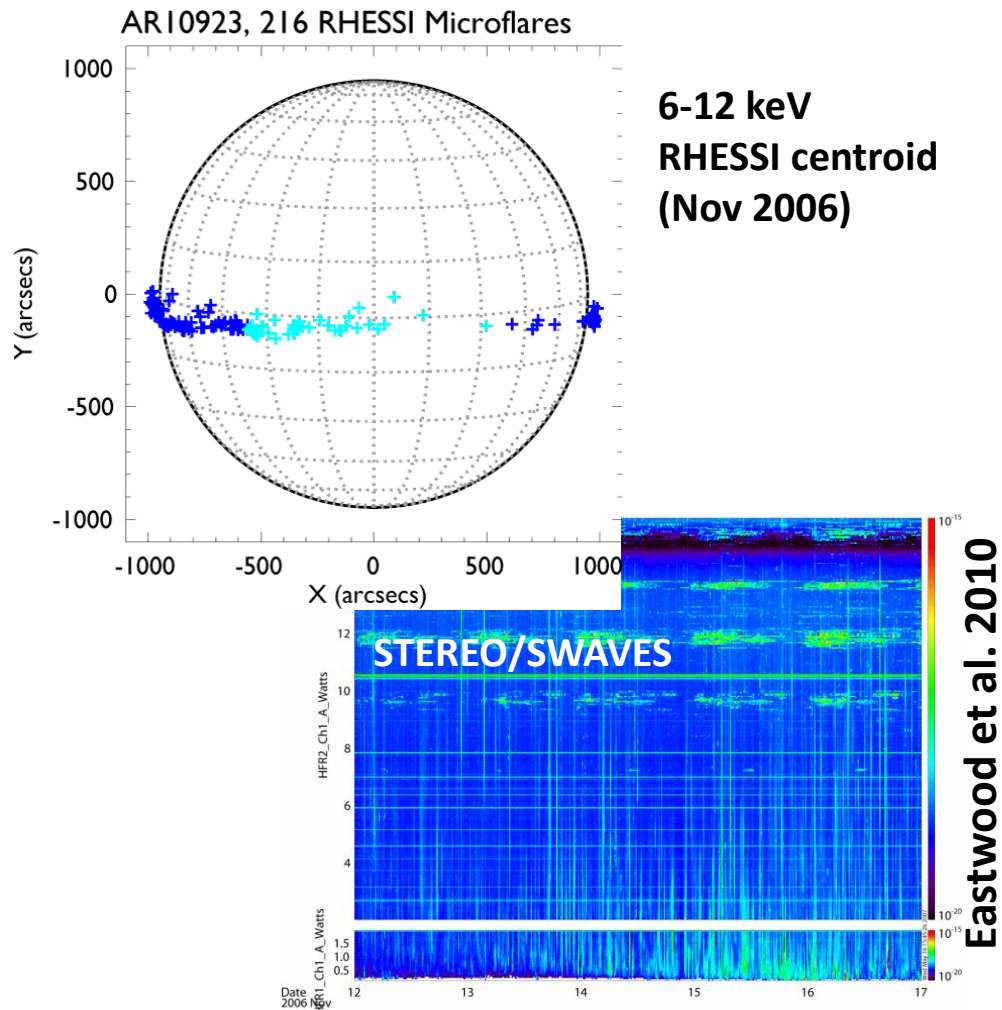


- Pre-RHESSI: >13 keV, crude energy bins but low background
- RHESSI: >3keV, far better energy resolution
 - Allows us to investigate energetics but difficulties due to uncertainties in the transition of thermal to non-thermal close to spectral features

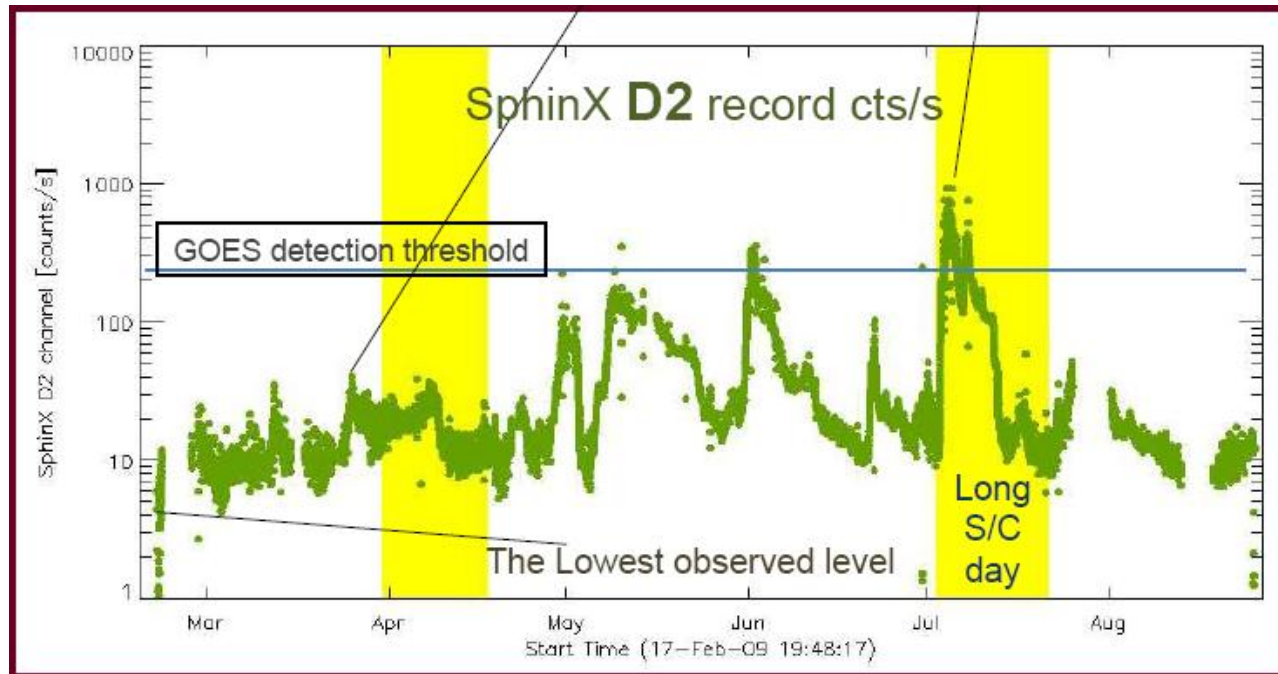


Non-thermal heads into instrument background

- Even tiny A-Class events accelerate electrons and have associated radio emission (outward energetic particles)



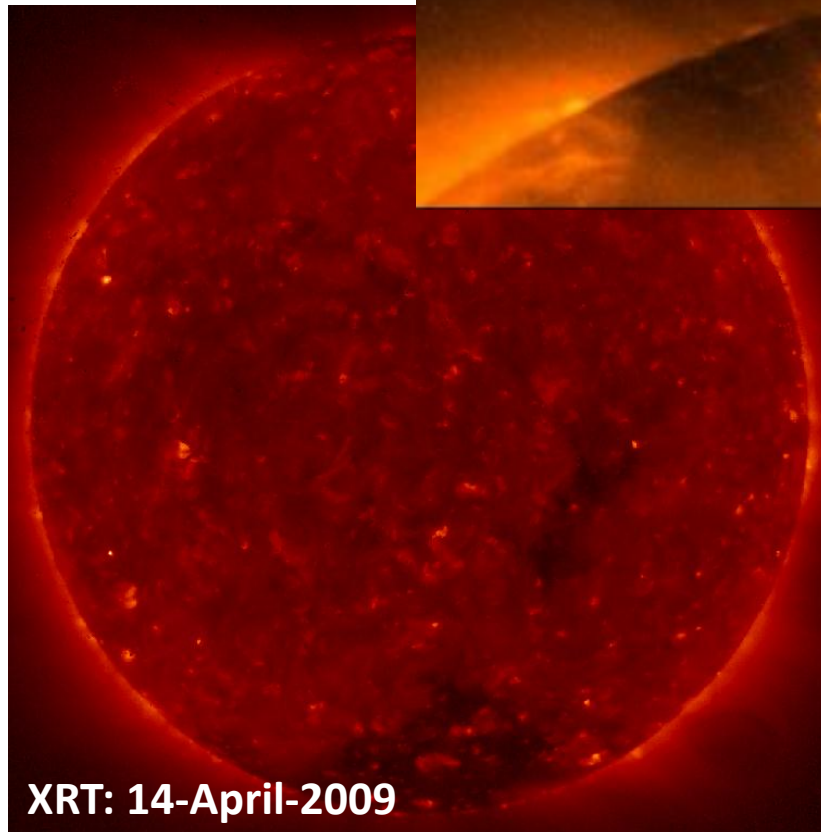
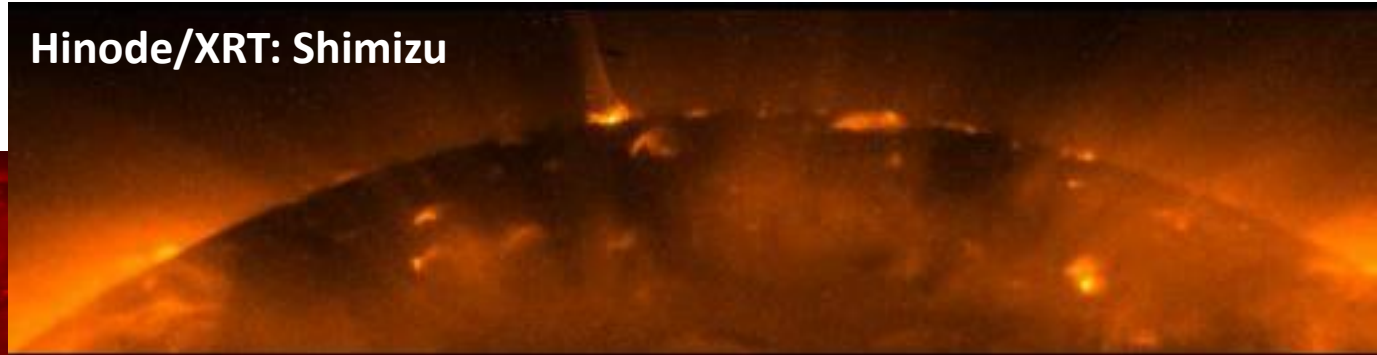
- **Hot emission from non-flaring active regions**
 - i.e. RHESSI: McTiernan 2009 ApJ, SphinX: Sylwester et al. 2010
- **Is the source of this very faint microflares?**
 - How small can an active region microflare be?
 - SphinX: small AR flares at least an order of magnitude fainter than GOES A1-Class (Sylwester et al. 2009)



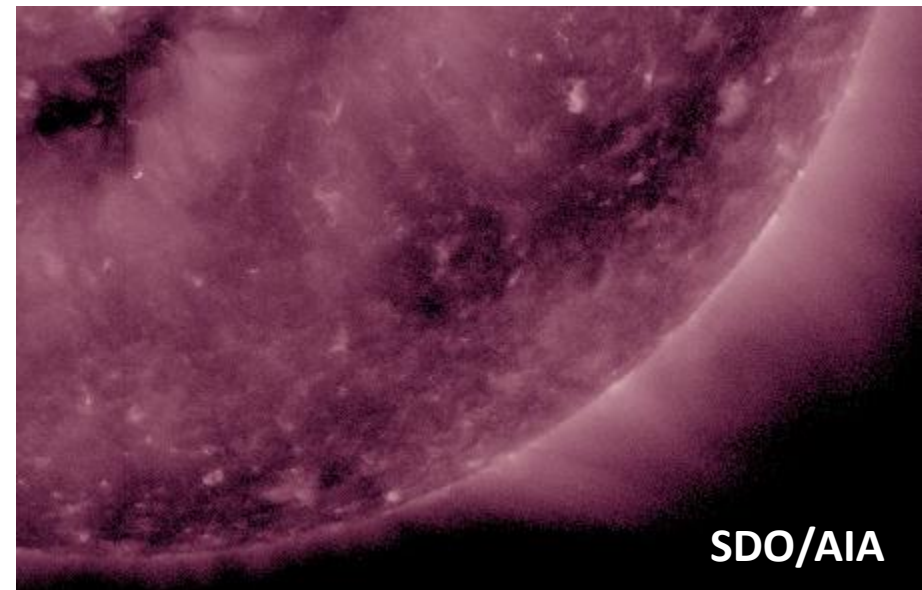
Sylwester et al. 2009

- **Is there particle acceleration outside of active regions?**
 - Energy release related to SXR/EUV bright points, jets, coronal heating?

Hinode/XRT: Shimizu

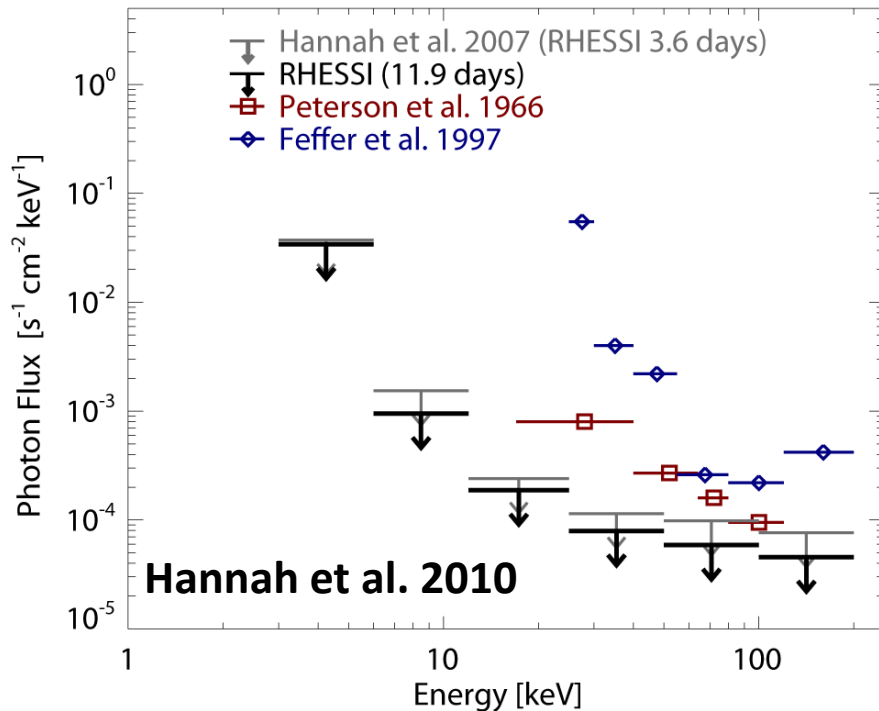


XRT: 14-April-2009

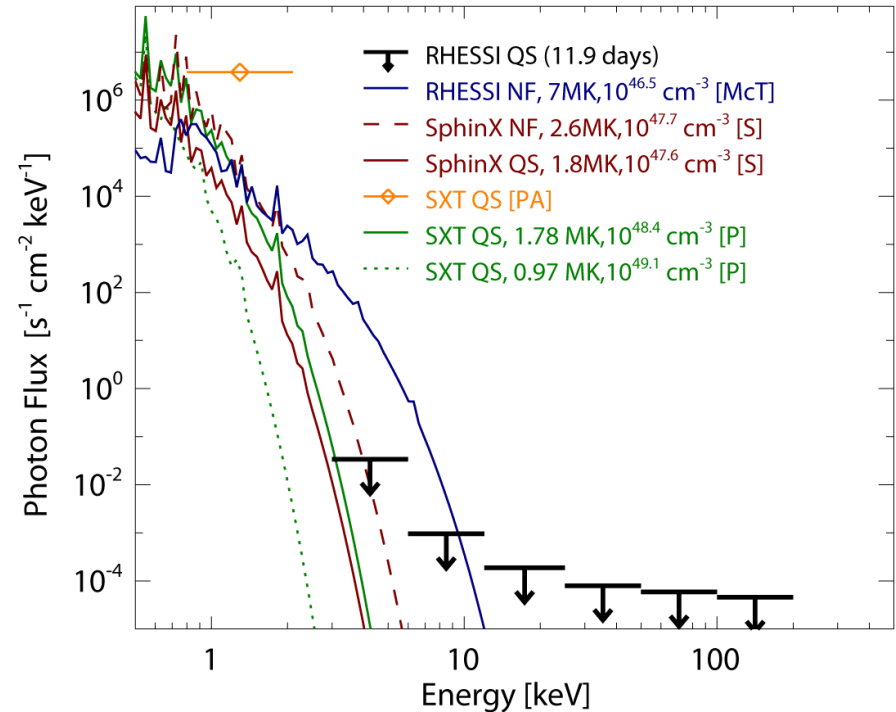


SDO/AIA

- **Only upper limits to emission from RHESSI**
 - Gives constraints to possible thermal and non-thermal populations

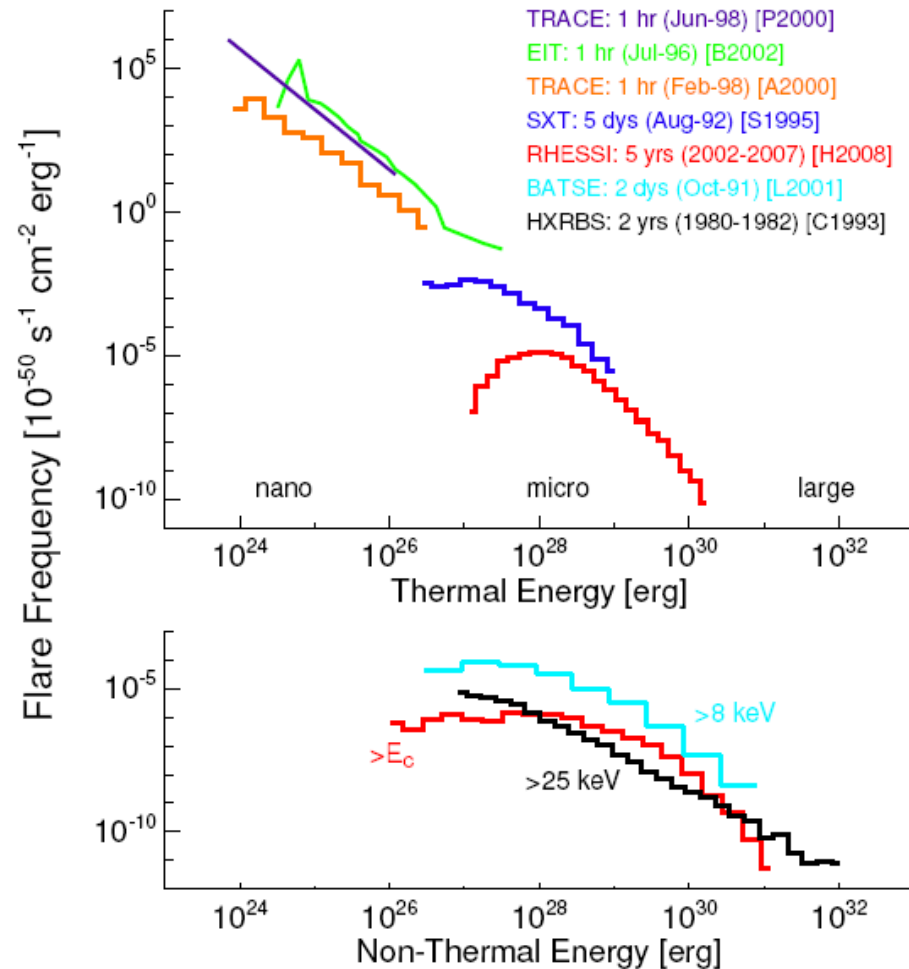


2 σ upper limits in comparison to previous limits



Comparison to previous observations of QS and Non-flaring AR thermal emission

- **Need to statistically study events on different scales**
 - Context for individual events
 - Investigate limits and scaling
- **Energy frequency distribution is often sought after**
 - Coronal heating: is $\alpha > 2$?
- **Although is such an energy comparison practical?**
 - Are EUV “nanoflares” just physically smaller AR flares?
 - Are we just demonstrating the different biases of each instrument and survey?



Hannah et al. 2010 SSRv

- **Is the physics of active region flaring energy release the same as non-active region release?**
 - How small can a microflare be?
 - Need higher sensitivity, higher temporal and energy resolution
- **Multi-messenger microflare observations crucial for using them as “simple proto-types”**
 - Need to accurately know where each instrument is pointing
 - Annoying to manually align an event, impractical for >thousands
 - Although how simple are these events?
- **For context/statistical studies need instruments that can robustly observe large to small (or no) flares**
 - Must be able to minimise (or understand very well) the instrumental bias