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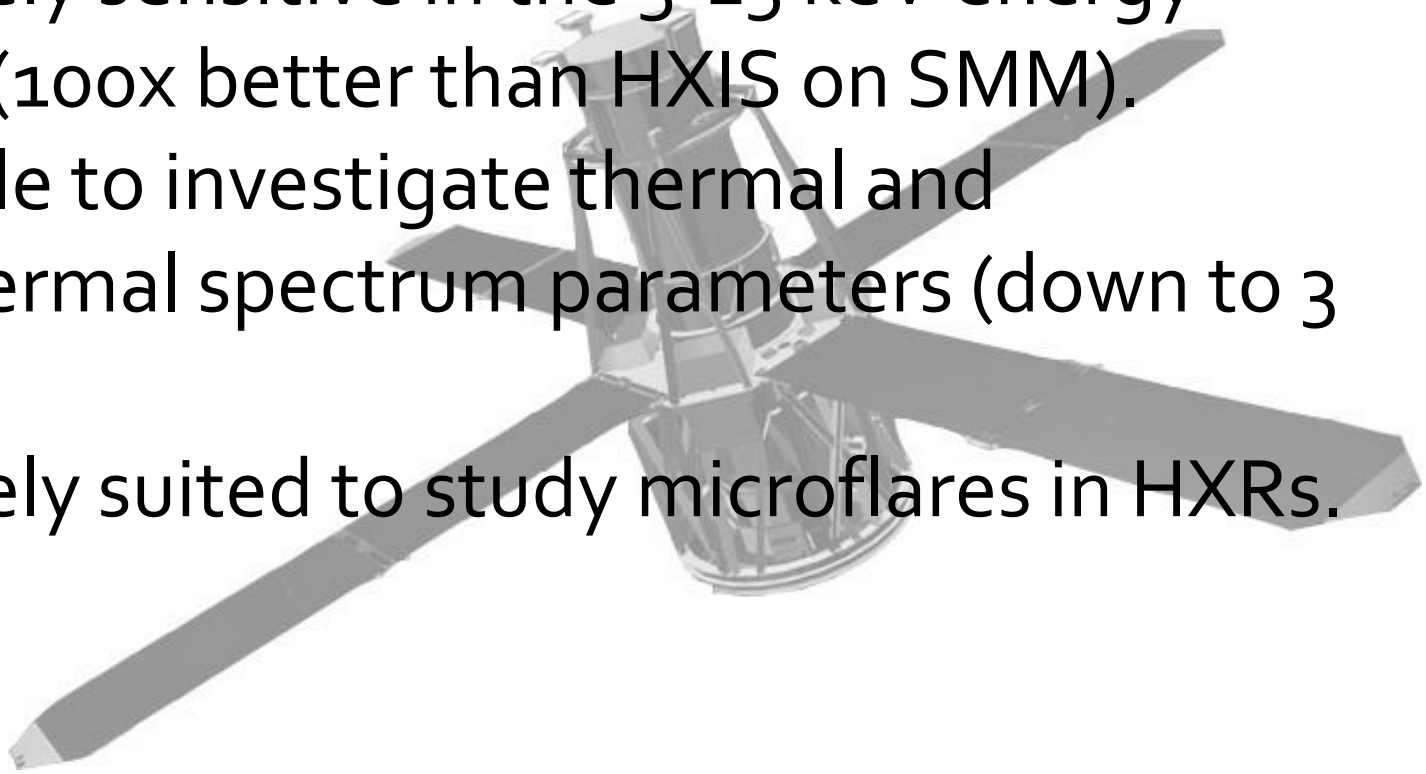
RHESSI Microflares

RHESSI Overview

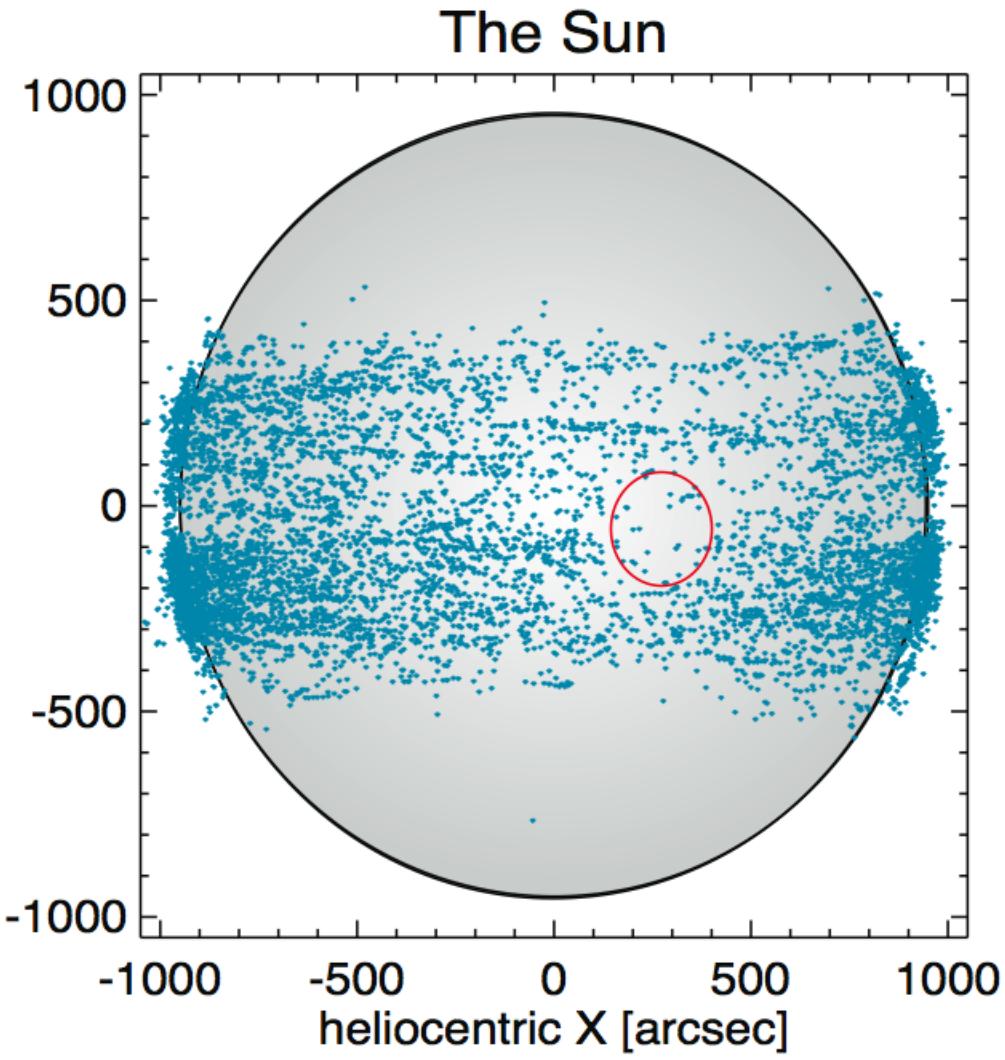
- High spatial (2.3 arcsec), energy (1 keV) and temporal (<1 sec) resolution
- Uniquely sensitive in the 3-15 keV energy range (100x better than HXIS on SMM).
- Possible to investigate thermal and nonthermal spectrum parameters (down to 3 keV).
- Uniquely suited to study microflares in HXRs.



RHESSI Microflare List

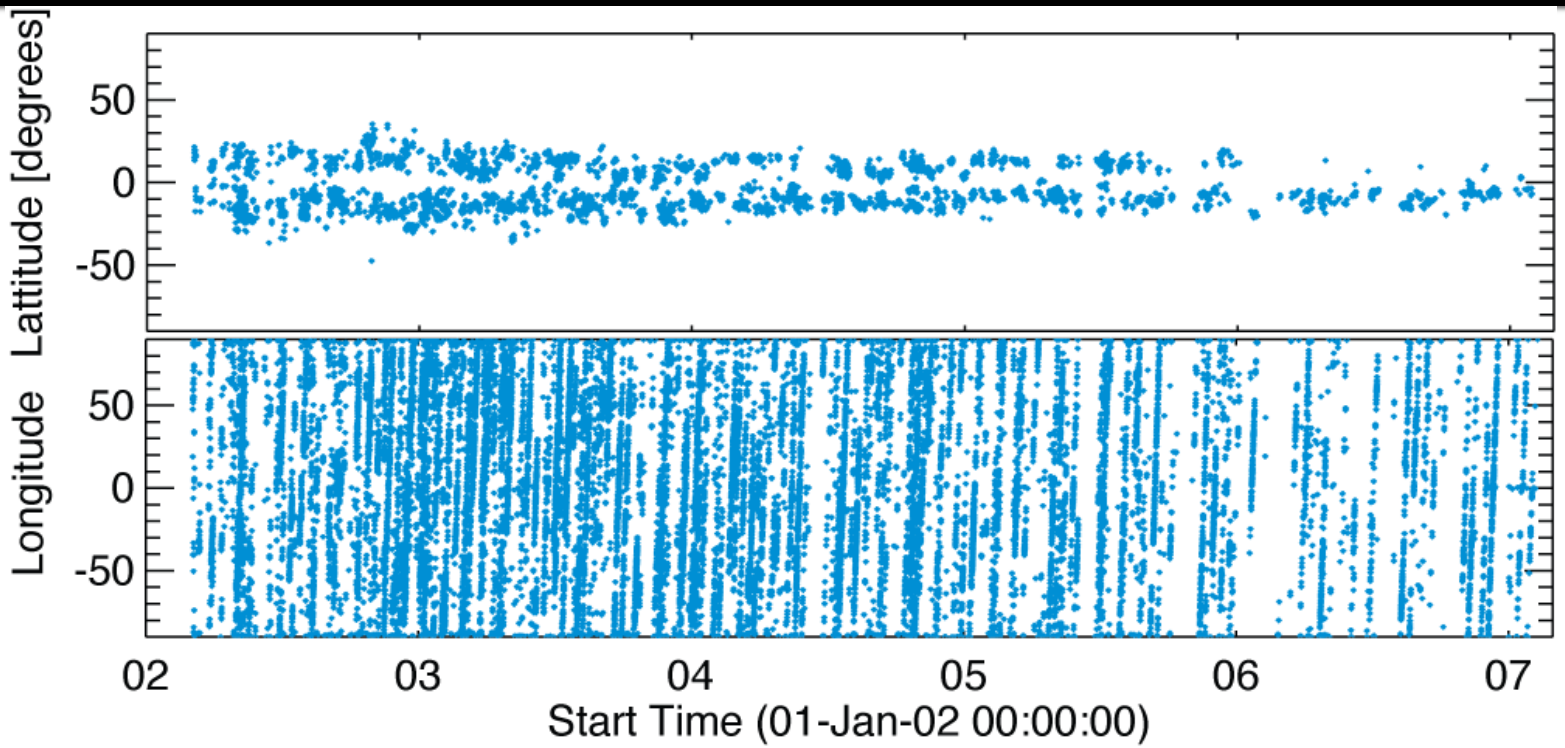
- Described in Christe et al. (2008) and analyzed in Christe et al. (2008) and Hannah et al. (2007).
- Created through a high sensitivity search in the 6-12 keV energy range (ignoring shutter times).
- Time range : March 2002 to March 2007.
- Found a total of 25,705 microflares.
- Positions for **24,799** events (confirmed solar microflares).
- List is available online, collaboration is welcome!

Microflare Positions



- Positions of 25,705 microflares *as observed*.
- Red circle: position of the spin axis [no imaging possible].
- Concentrated in active region bands.

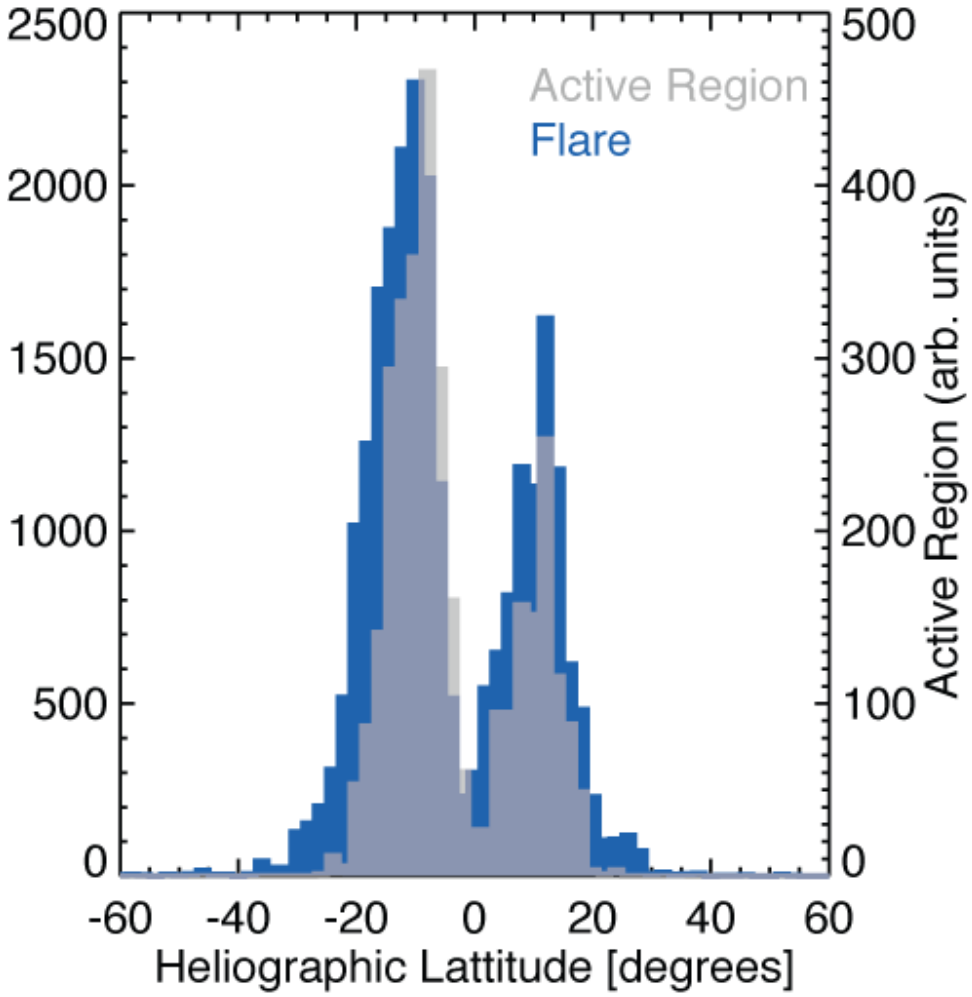
Microflare Locations



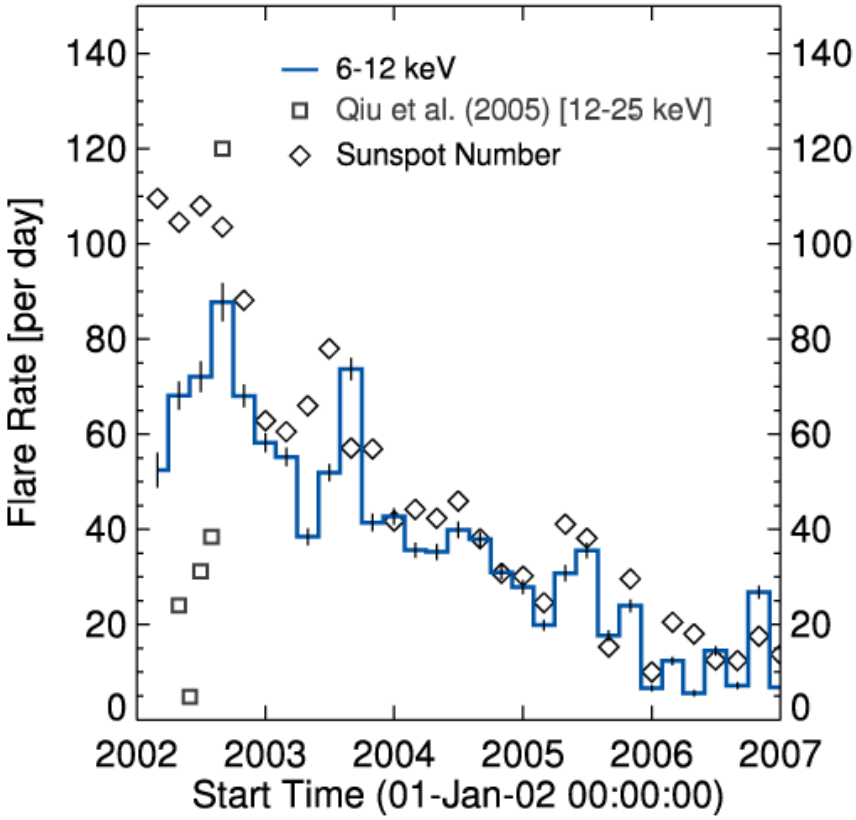
- Microflare latitudes are clearly related to active regions (faint butterfly diagram).
- Microflare longitudes show stripes as flaring active regions move across the disk.

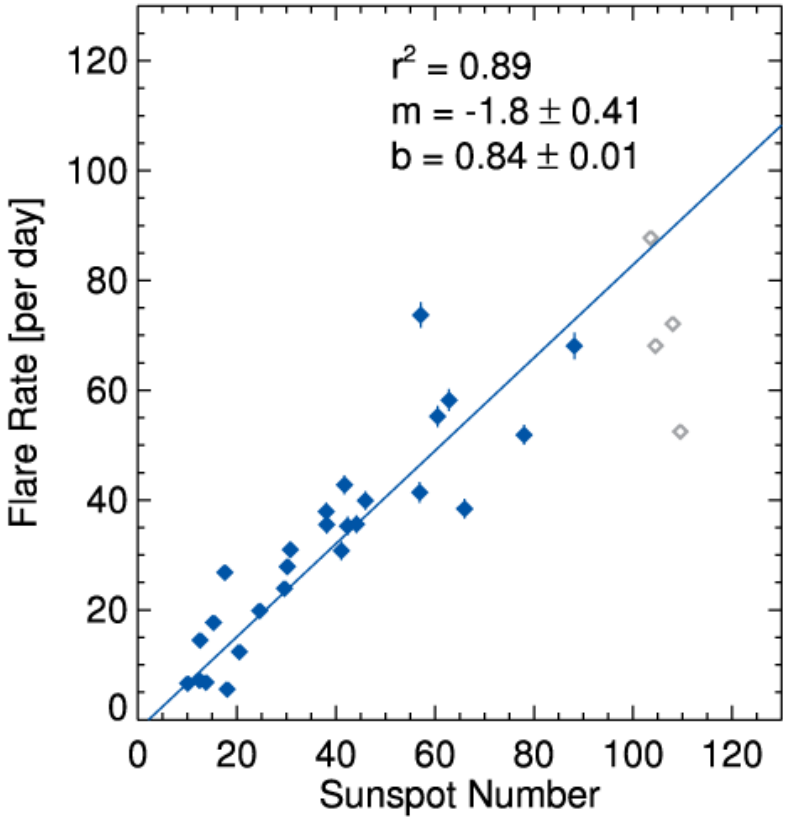
Microflares and Active Regions

- The number of microflares are well coordinated with active region density.
- RHESSI microflares are an active region-associated phenomona, like larger flares.



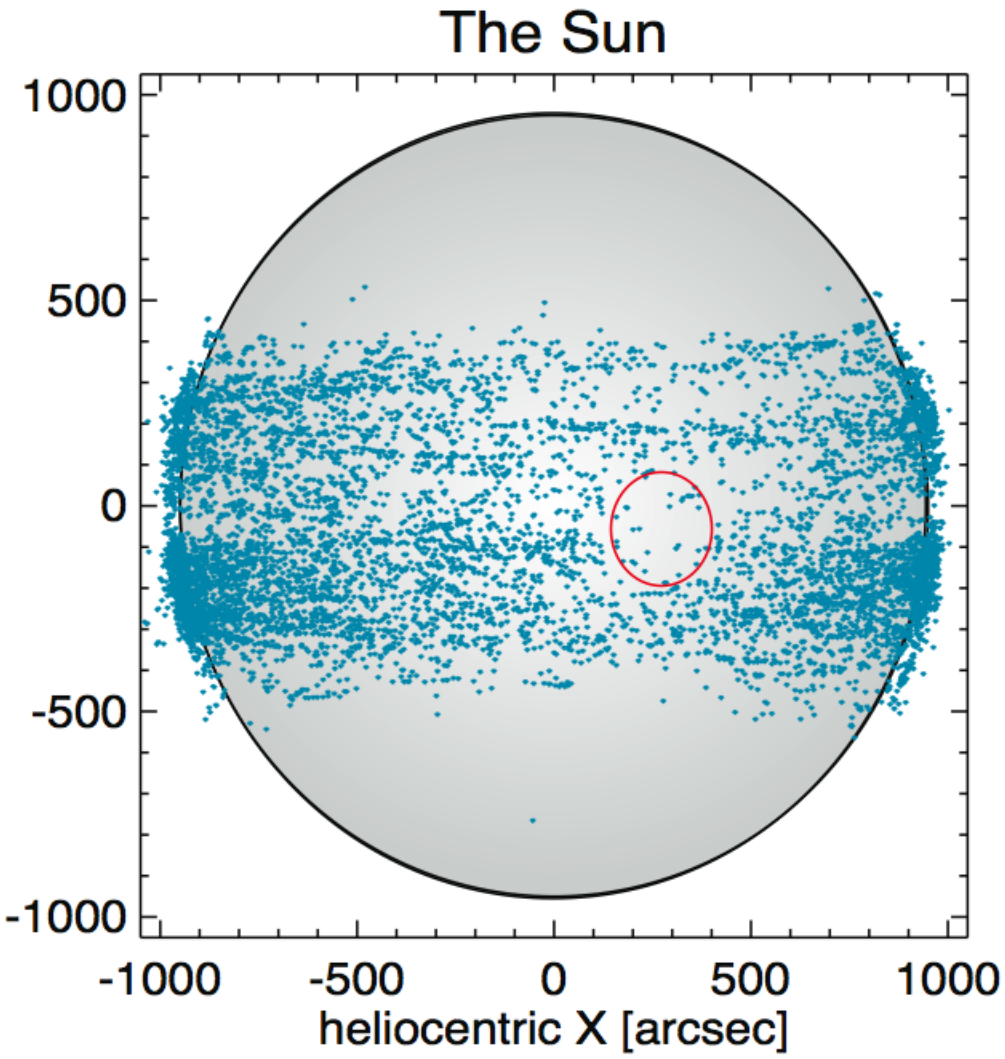
Flare Rate





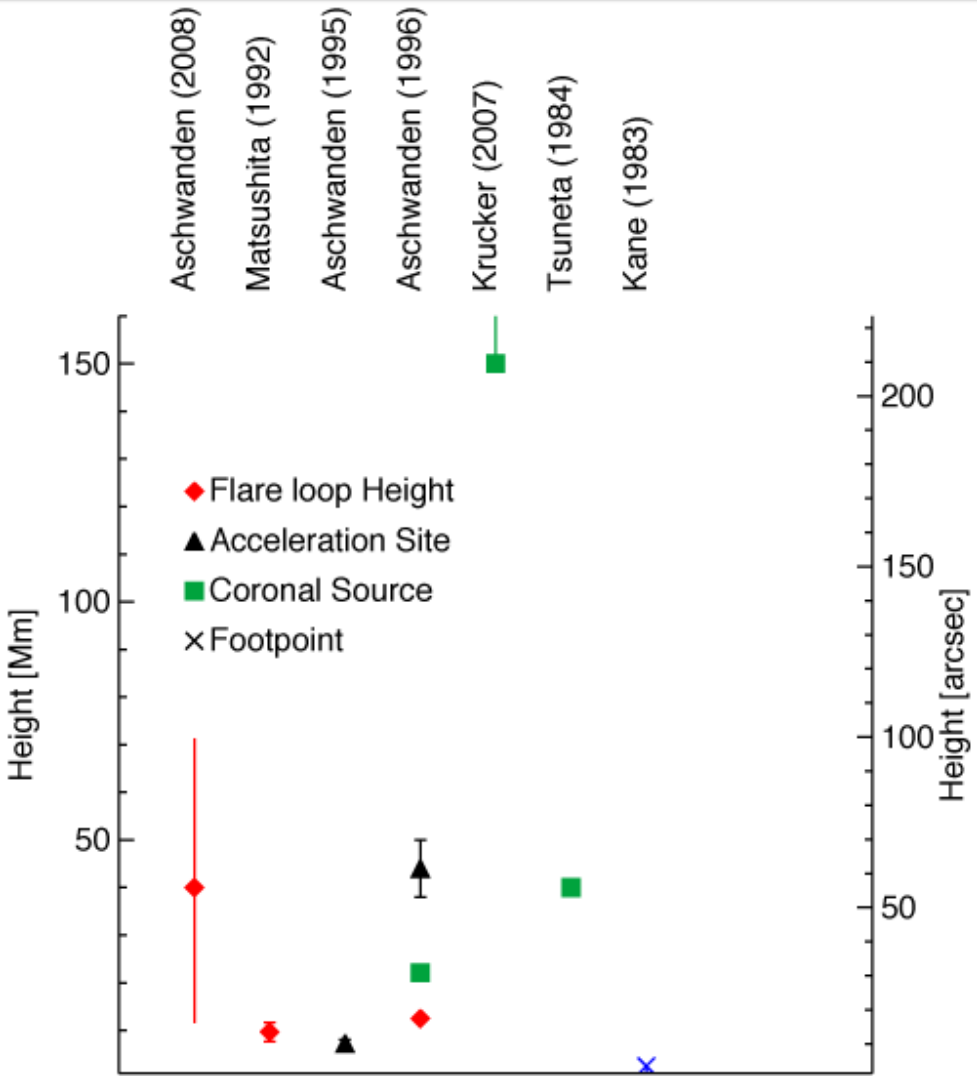
- Flare rate is very well correlated with sunspot number.

Microflare Positions

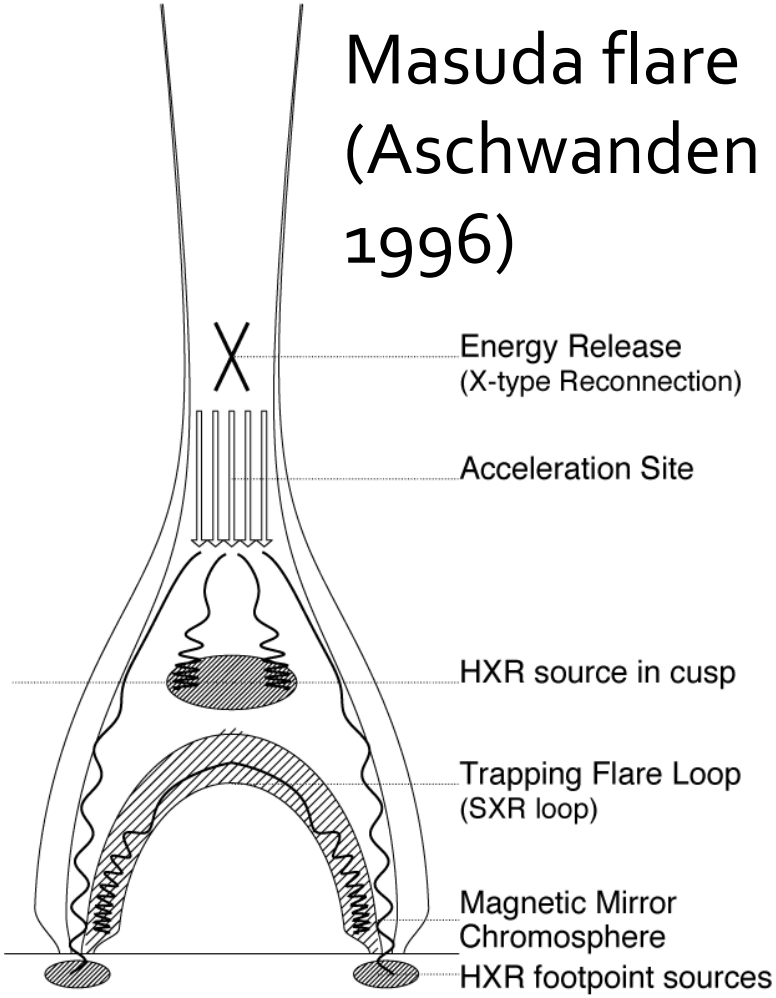


- Positions of 24,799 microflares *as observed*.
- Red circle represents the position of the spin axis (no imaging possible).
- Most flares occur at the limb.

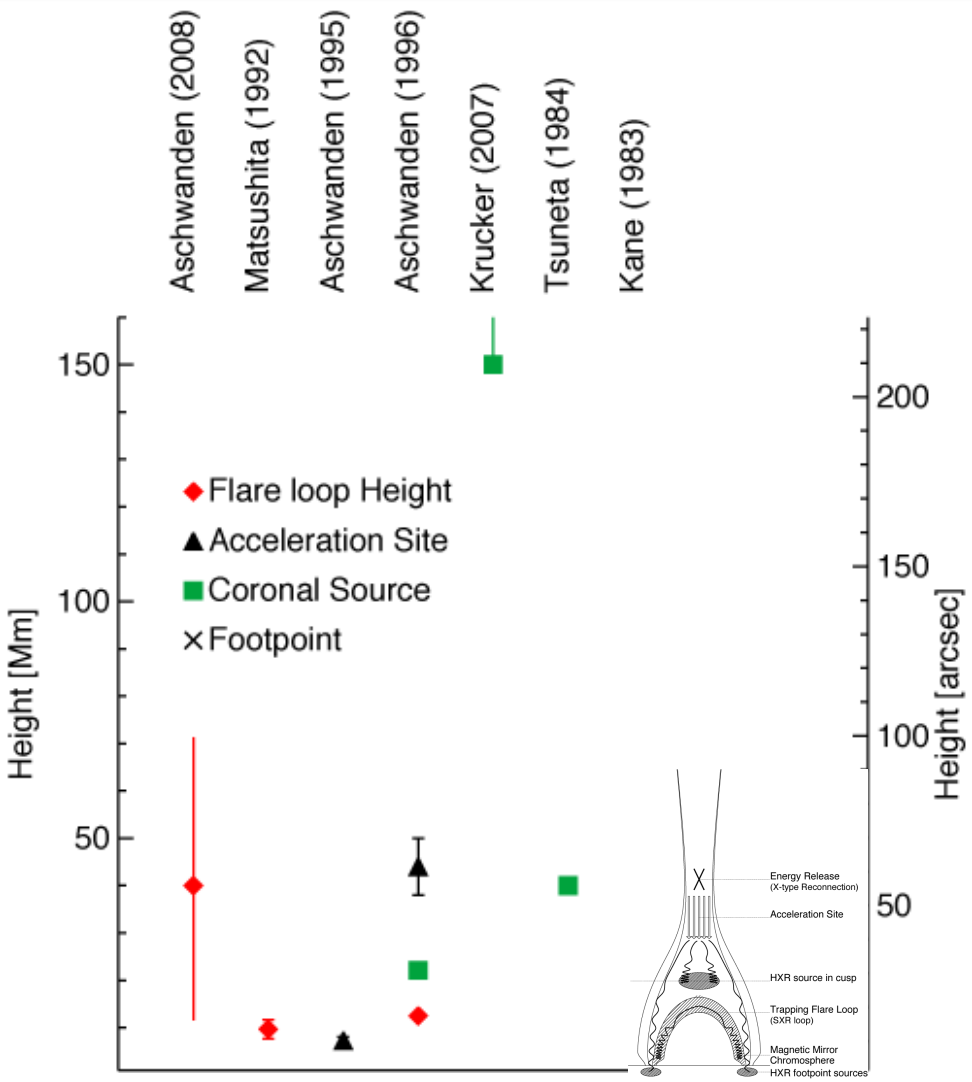
Flare Height Measurements



Masuda flare (Aschwanden 1996)



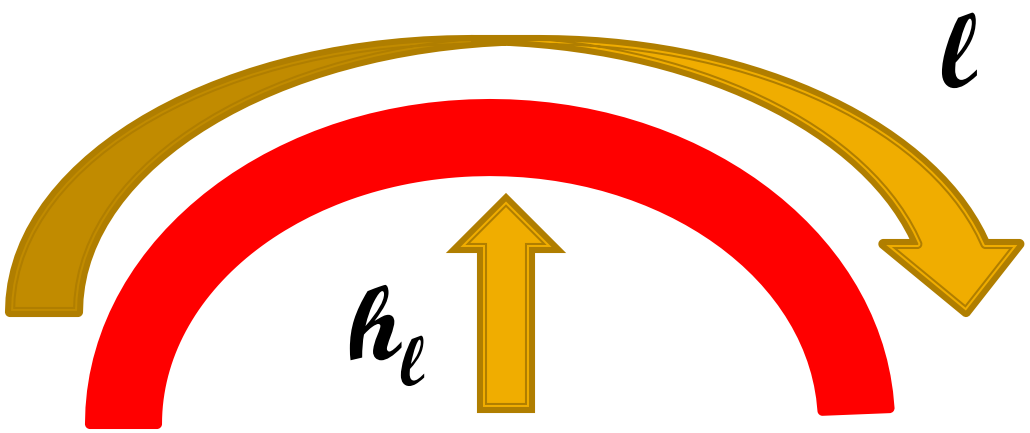
Flare Height Measurements

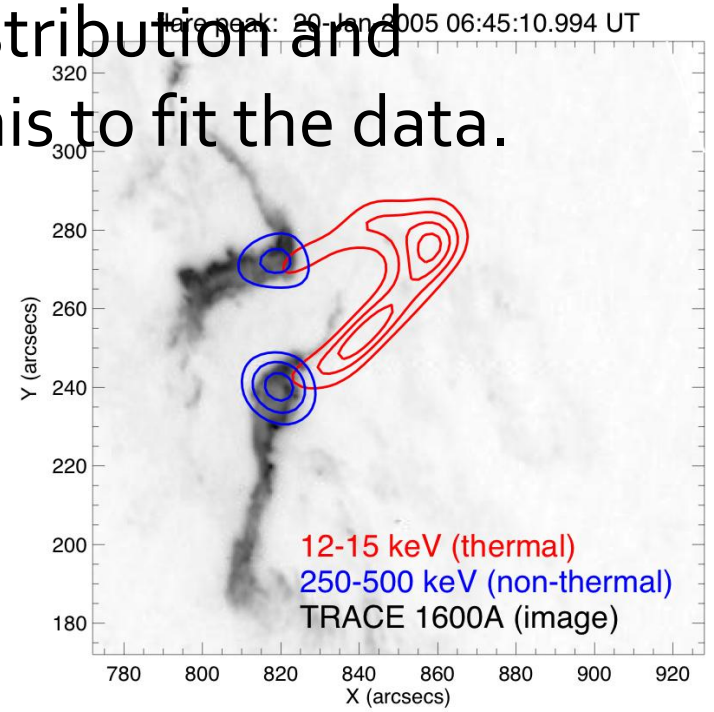


Masuda flare (Aschwanden 1996)

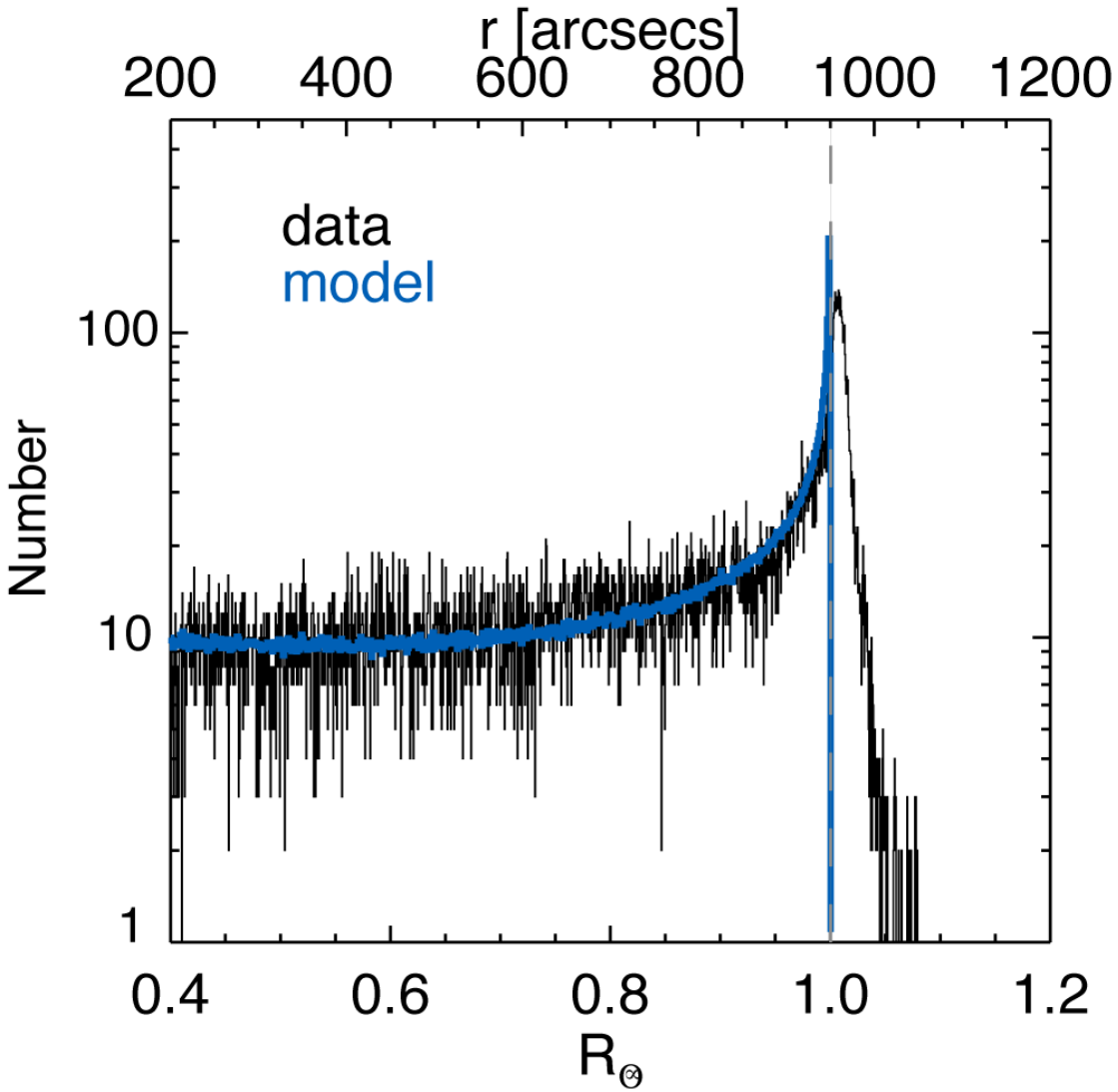
Flare Height Distribution

- Hidden within the 24,799 flare positions is the microflare height distribution.
- To derive the flare heights…
  - Simulate the flare height distribution and positions on the Sun. Use this to fit the data.



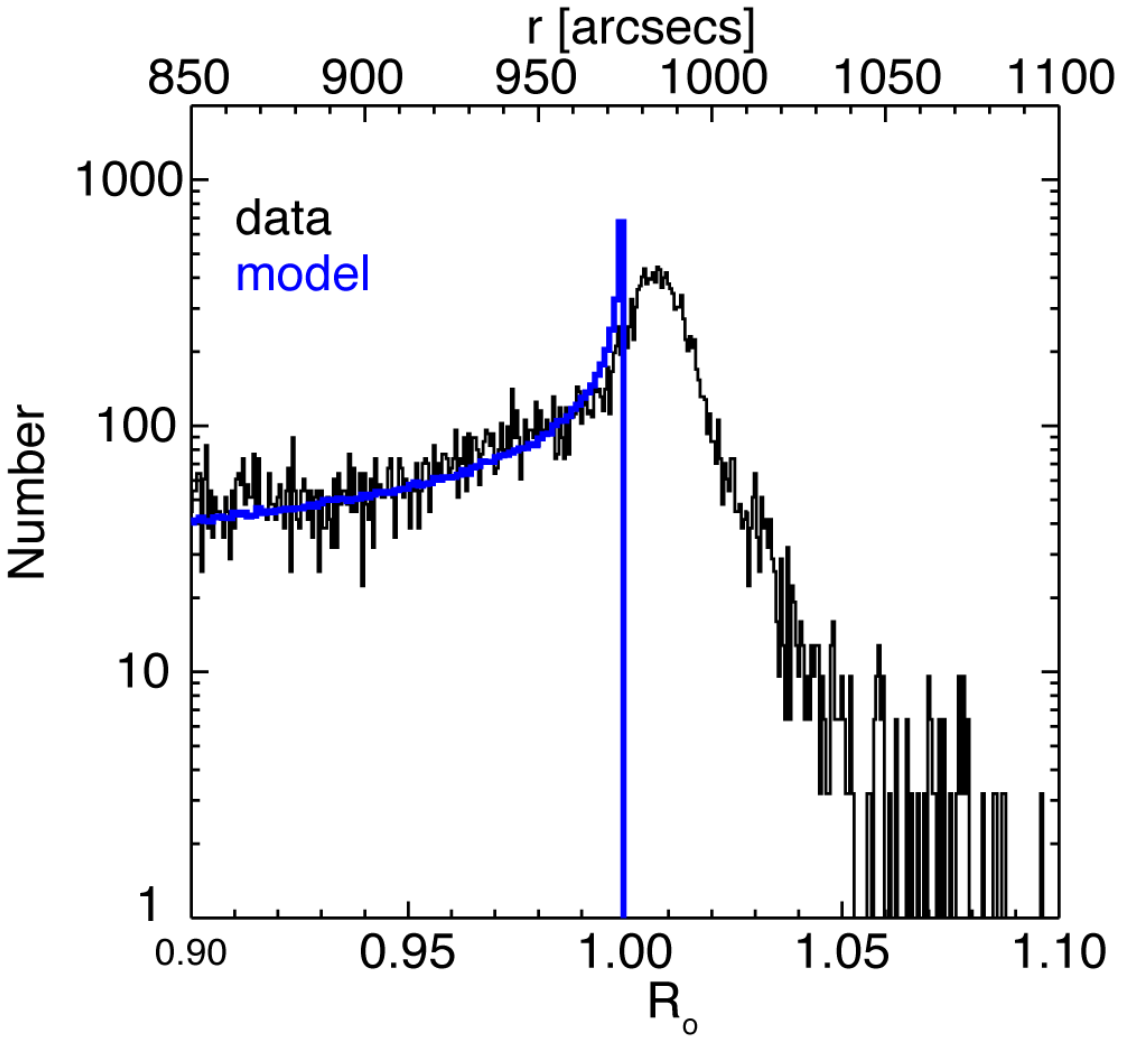


Radial Height Distribution



- 6-12 keV position data (**black**)
- Model distribution with no height (blue).

Radial Height Distribution



- 6-12 keV position data (**black**)
- Model distribution with no height (**blue**).

Finding Height Distribution

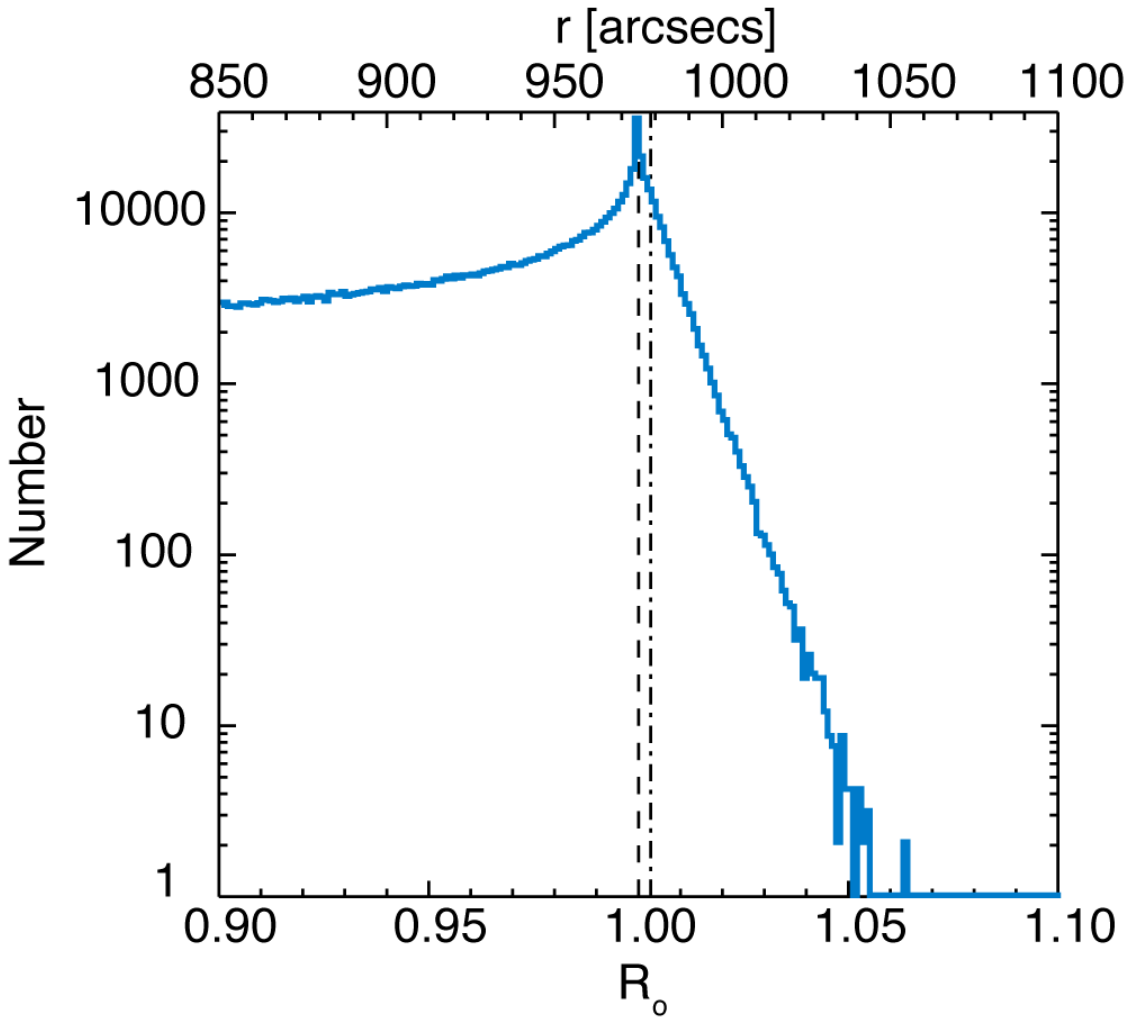
- In order to tease out the parent (height) distribution from the limb distribution performed Monte Carlo simulation.
  - Generate longitudes (uniform distribution).
  - Generate latitudes (according to observed microflare distribution).
  - Generate heights (dist. described next slide)
  - Find 3D coordinates, project on solar disk, measure distribution.

Height Distribution

$$P(h) = N_T \begin{cases} \dfrac{N_F}{N_T}\delta(h) & h = 0 \\ \dfrac{N_C}{N_T}\dfrac{1}{\lambda}\exp(-h/\lambda) & h > h_{\min} \end{cases}$$

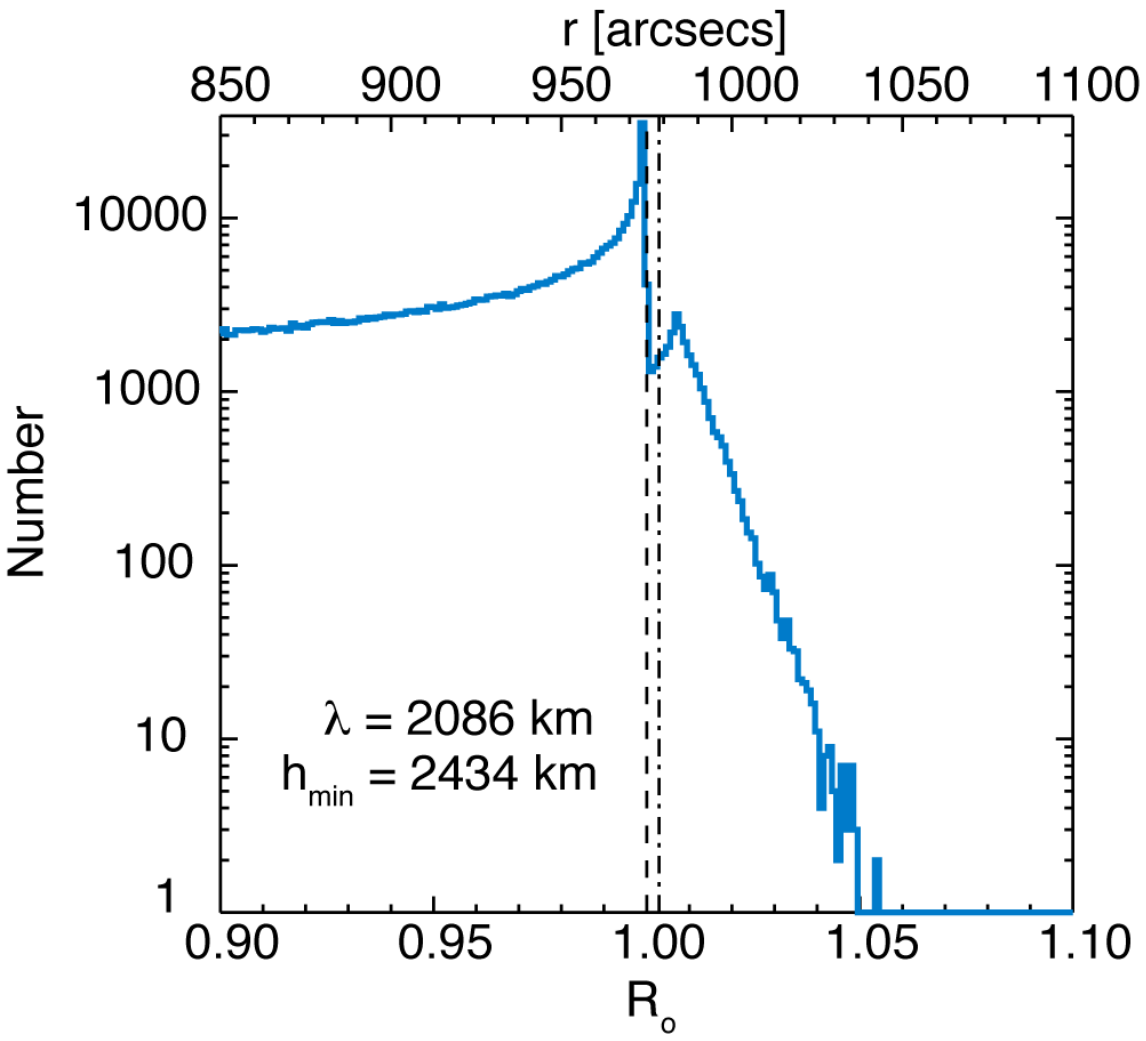
- Height minimum, h_{min}
- Scale heights, λ
- Number of coronal sources, N_c
- Number of photospheric (footpoints) sources, N_F

Model Example



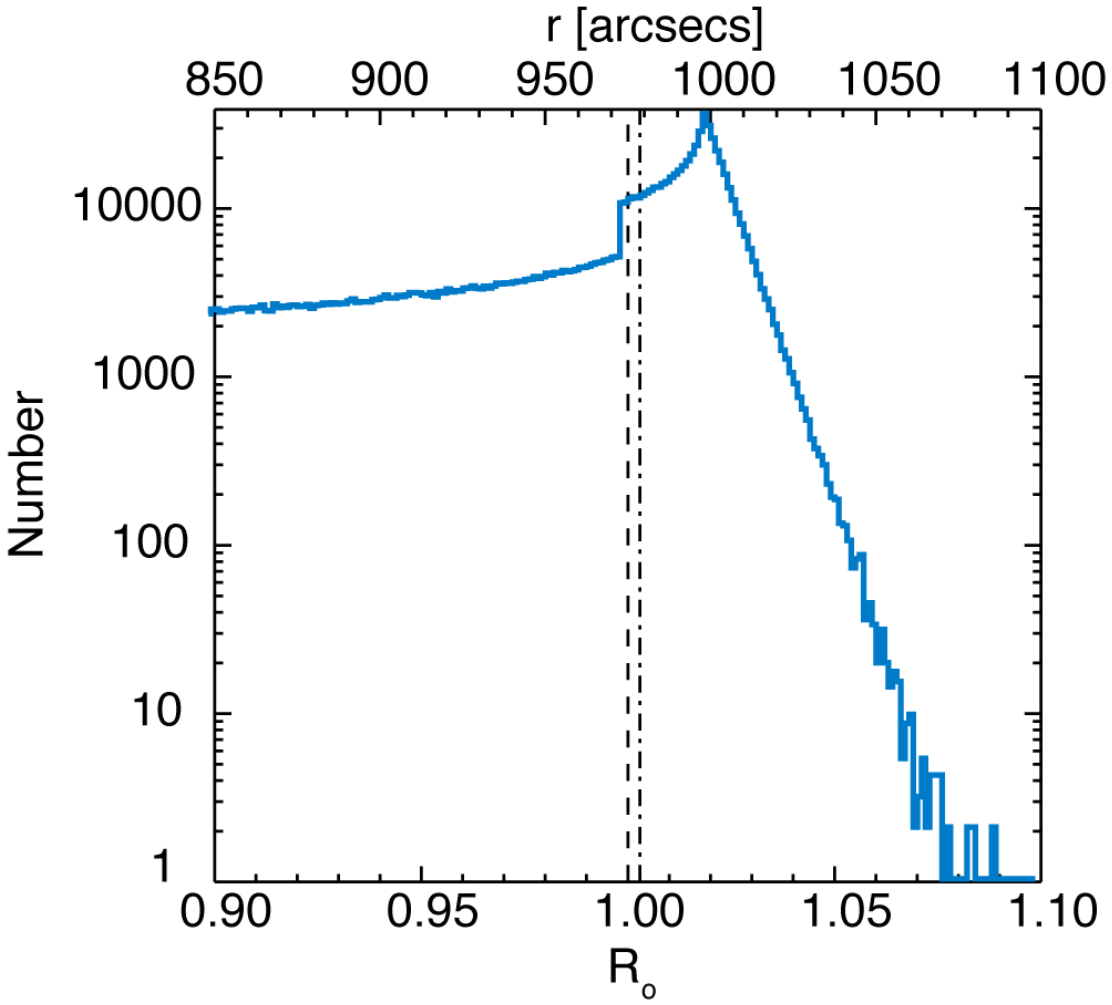
- 50% coronal source, 50% photospheric sources
- h_{min} = 0
- λ = 2086 km

Model Example



- 20% coronal source
- h_{min} = 2434 km
- λ = 2086 km

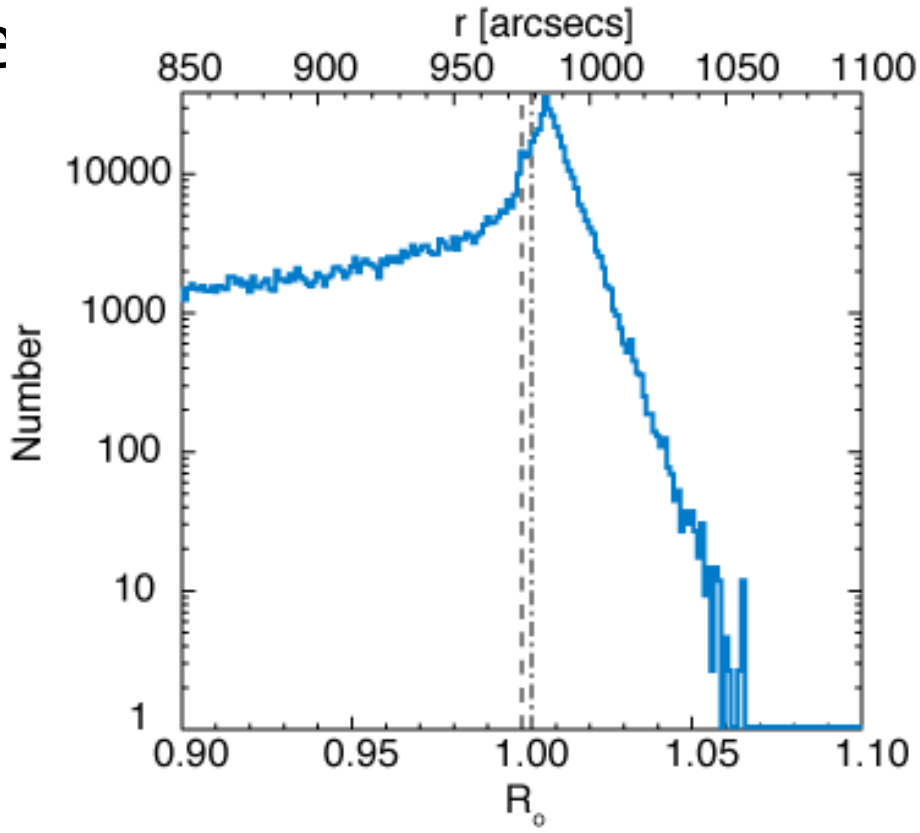
Model Example



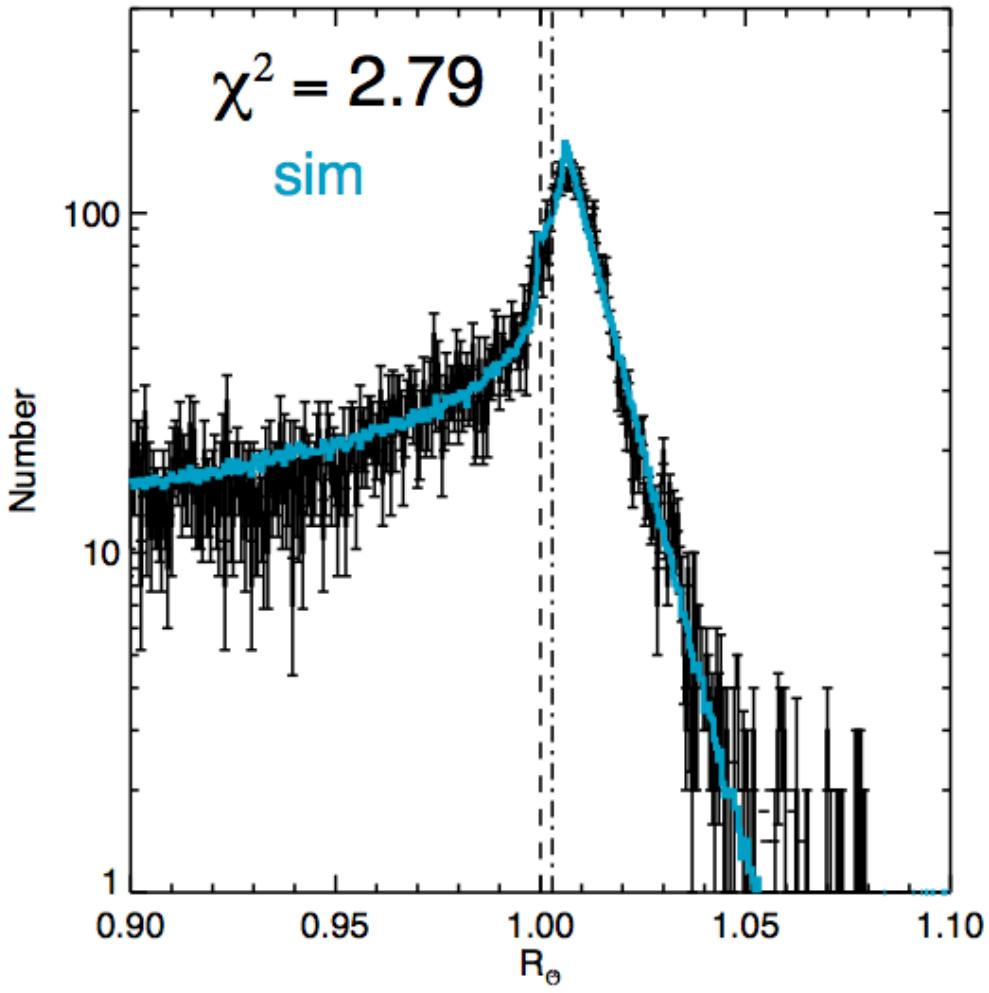
- 100% coronal source
- h_{min} = 7000 km
- λ = 2086 km

Model (Size)

- Finite size of sources effects the number of positions at the limb.
- Only occulted by the limb are affected.
- Model was expanded to include this effect.



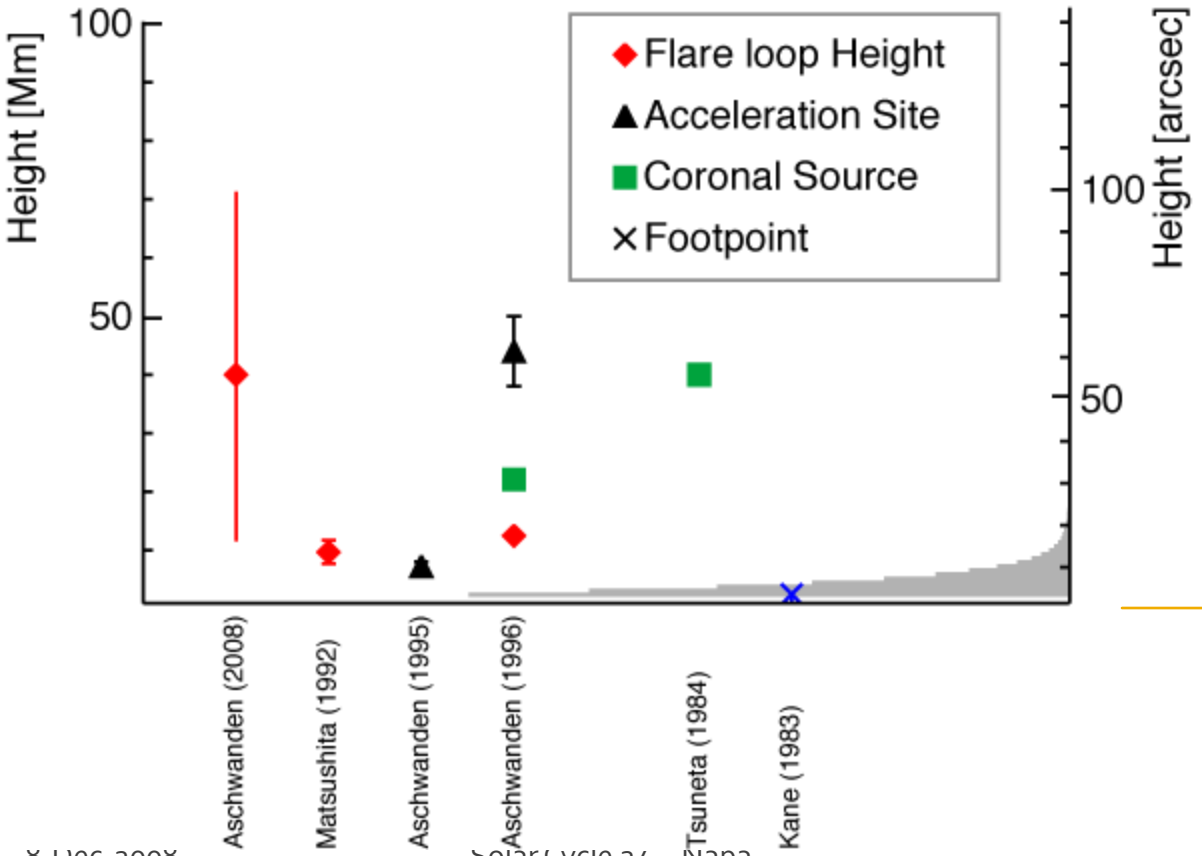
Best Fit



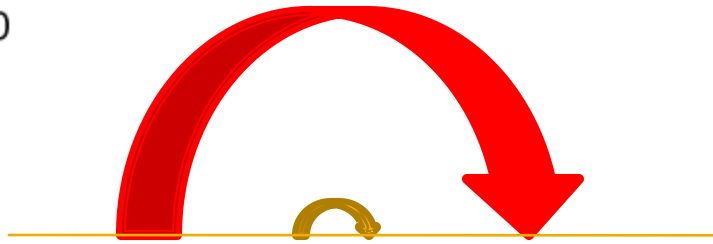
- 6-12 keV position data (**black**)
- Model (blue)
- Model parameters (next slide).

Flare Height Results

Energy (keV)	λ [km]	h_{min} [km]	% Coronal
6- 12 (thermal)	2080 ± 210	3120 ± 350	90 ± 2



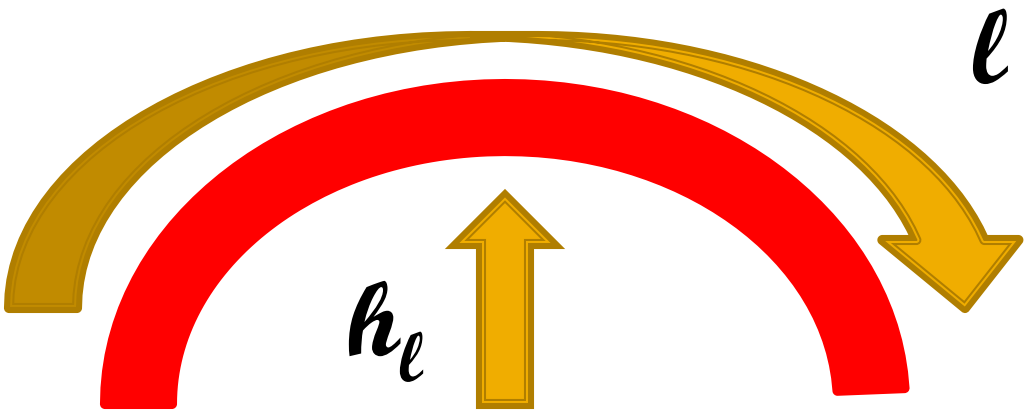
TRACE Loops

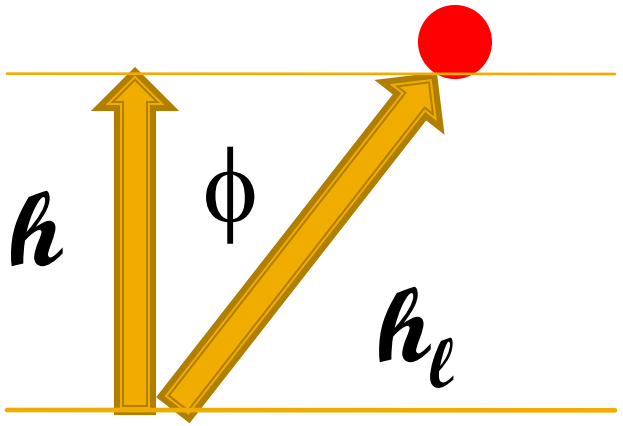


RHESSI
Microflare Loops

Loop Parameters

- Hannah (2007) loop length = 23 Mm (32″) implies loop height, h_ℓ, of 7.32 Mm (10.2″)





- Microflare height distribution implies loop inclination angle, ϕ, of approx. **44 degrees**.

Conclusions

- Most RHESSI thermal sources are coronal with an average height of approx. 5 Mm above the photosphere.
- The distribution of heights is exponentially distributed.
  - Scale height is approx. 3 Mm
  - Density scale height of the corona is 50 Mm.
- Average flare loop tilt angle is found to be <44 degrees.