Anticipating HESSI's Spatially Resolved View of Spectral Evolution

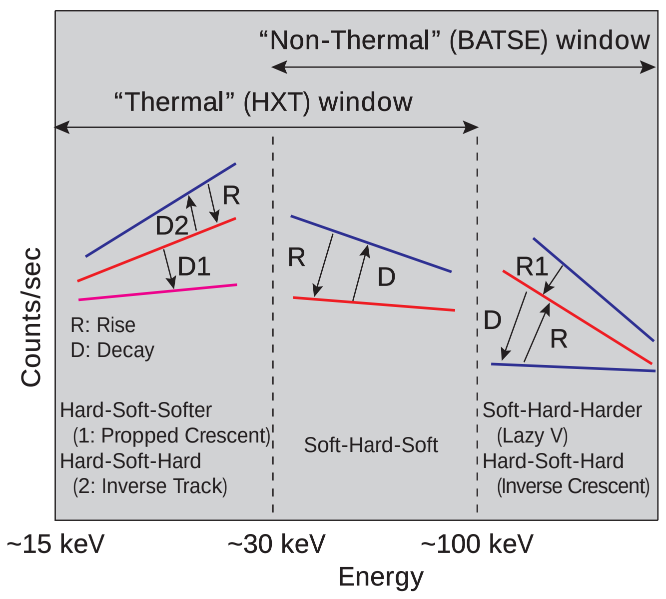
Elizabeth Newton
elizabeth.newton@msfc.nasa.gov
SD50, NASA Marshall Space Flight Center, Huntsville, AL 35812

Tom Metcalf
Lockheed Martin Co.

Tim Giblin
University of Alabama in Huntsville

Color-Color Diagrams Show Consistent Evolution Patterns in 3 Energy Bands

A Spectral Analogy for Patterns



Abstract: The spectral evolution of observed flares' hard X-ray emission is found to conform to certain patterns in color-color diagrams (CCDs). By combining the spectral resolution of BATSE data with the spatial resolution of HXT data, we are able to address the nature of flare energy release and anticipate what kind of observations HESSI may make of the energy release/ particle acceleration site in flares.

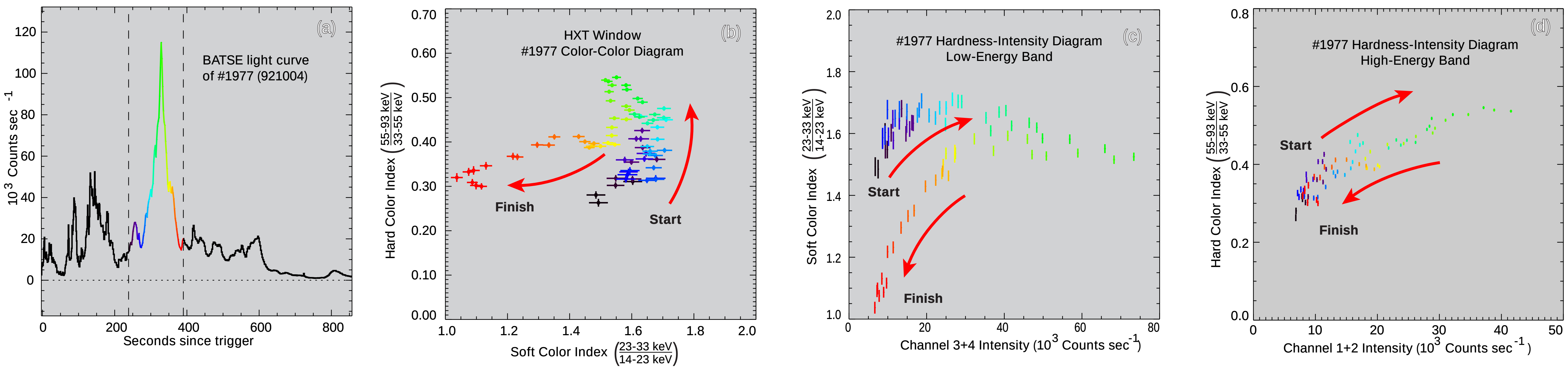
For preprints, please sign below or e-mail:
elizabeth.newton@msfc.nasa.gov

Two Examples of Spatially Unresolved Spectral Evolution (BATSE data in the HXT energy range)

For any light curve (a), a color-color diagram (b; plot of channel 4/channel 3 count ratio versus channel 2/channel 1) can be constructed. Time progression is encoded in the data points with color — as time progresses, the color changes from purple, through the blues, greens, yellow, and oranges, to the red. Hardness-intensity diagrams (c) & (d) portray the count ratio evolution independent of the peculiarities of the specific time profile and are used to define unique evolution patterns.

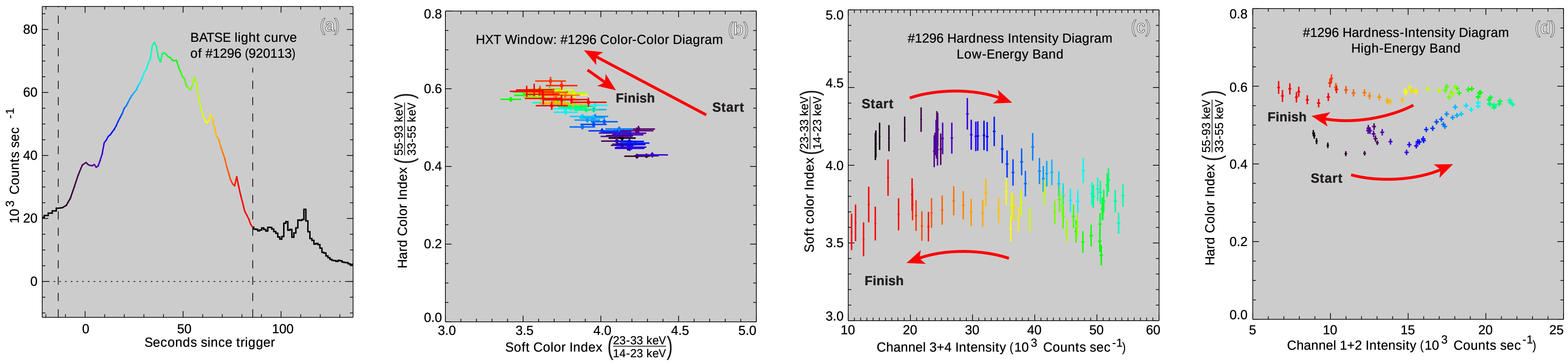
Case 1: Propped Crescent Pattern (~$^1/_3$ sample)

Color-color diagram of limb flare 921004 (2213:17) (a; #1977) takes the shape of a propped crescent (b). The low energy (14-33 keV) spectrum (c) hardens briefly and then softens gradually on the rise. After the peak emission it softens rapidly (hard-soft-softer evolution). In contrast, the high energy (33-93 keV) spectrum (d) hardens on the rise, reaching its hardest point at the peak of emission, before softening to its original level in the decay phase (a soft-hard-soft evolution).



Case 2: Inverse Track Pattern (~$^1/_3$ sample)

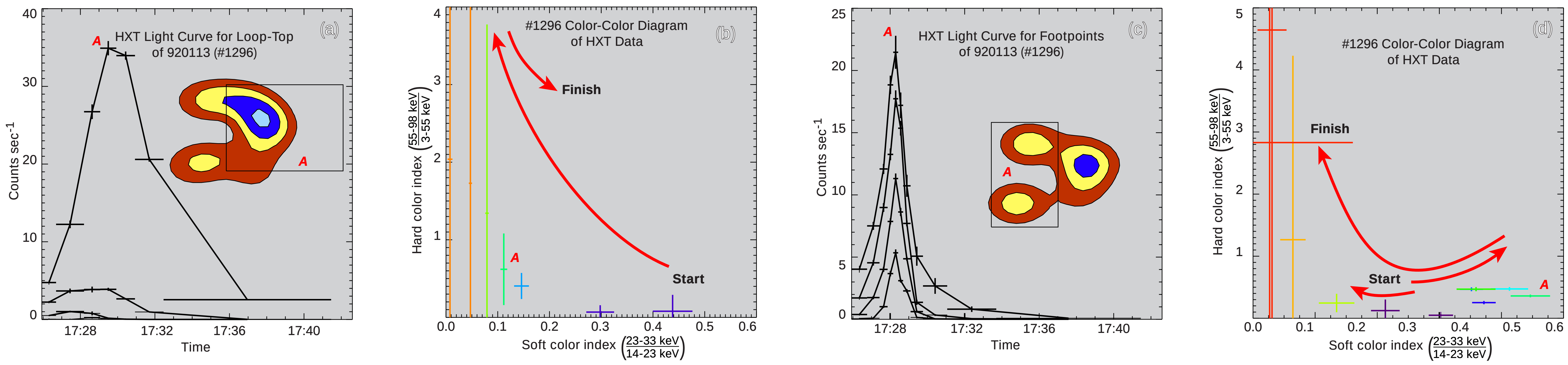
Color-color diagram of limb flare 920113 (1727:03) (a; #1296) follows an inverse track pattern (b). The low energy (14-33 keV) spectrum (c) begins hard, becoming soft on the rise and remaining soft on the decay (hard-soft evolution). The high energy (33-93 keV) spectrum (d) begins soft and hardens on the rise (soft-hard evolution).



These spectral evolution patterns correlate with peak rate, but no other flare property (duration, total counts, location). Flares with larger peak rates have low energy (14-33 keV) spectra which generally do not significantly soften after peak emission (inverse track pattern). The fact that multiple pulses from the same flare exhibit different evolution patterns indicates that changes in the magnetic geometry are driving the pattern. Spatially resolved data are critical for making sense of the patterns.

Spatially Resolved Spectral Evolution: Anticipating HESSI with HXT Data

HXT data are used to create color-color diagrams separately for the loop-top and footpoint regions of 920113. The loop-top's low energy spectrum (14-33 keV) softens (b) throughout the pulse (hard-soft-softer evolution). While the uncertainties are large, the loop-top's high energy spectrum (33-98 keV) appears to harden progressively with a slight softening at the end (soft-hard-soft evolution). In the case of the footpoint region (d), the low and high energy spectra oscillate several times between soft and hard values. At the peak in emission, the low energy spectrum (14-33 keV) is at its hardest; at the end of emission, the high energy spectrum appears to be at its hardest although uncertainties are large.



Spatially resolved data are important for interpreting spectral evolution patterns. The hardening of the loop-top's 33-98 keV spectrum may indicate a coronal trap. At the same time, the loop-top's 14-33 keV spectrum softens over the pulse. The footpoint spectral evolution is more complex, oscillating several times between soft and hard values. This behavior is also manifested in flare #1977's footpoint region, as well as in #1296's footpoints individually. The variations may arise from multiple injections of turbluence in the acceleration region.