

The **late/gradual/second phase** of flares and its implications for solar particle acceleration

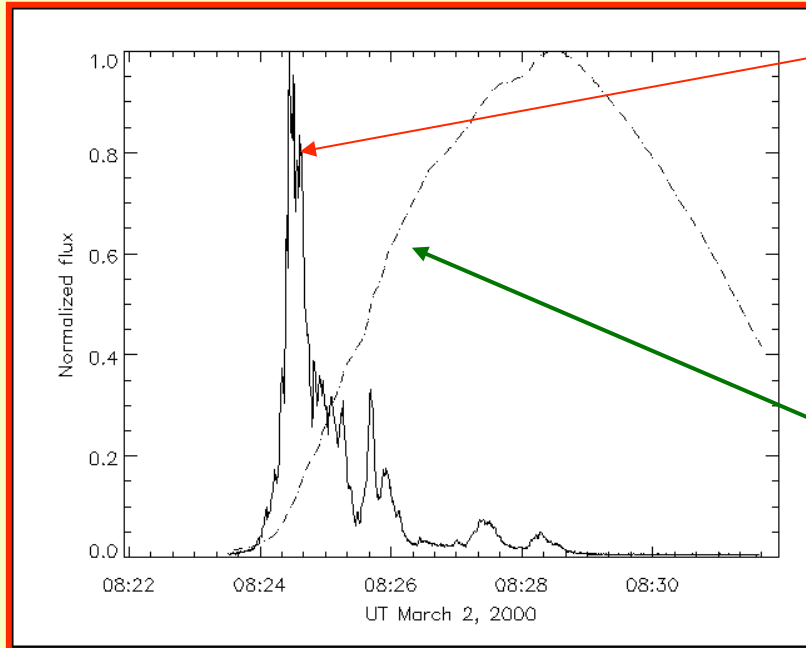
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The **early/gradual/zeroth phase** of flares and its implications for solar particle acceleration

RHESSI observations of e.g. 23 July 2002 (Lin et al 2003)

Impulsive phase and gradual phase: The Neupert Effect



- Impulsive phase* – primary energy release
- hard X-rays (10s of keV)
 - white light, UV, μ waves - broad spectrum
 - duration < few minutes
 - intermittent and bursty time profile, 100 ms
 - energy injection
 - soft-hard-soft spectral evolution

- Gradual phase* - response to input
- thermal emission (kT \sim 0.1-1 keV)
 - rise time \sim minutes
 - coronal reservoir

Impulsive phase:

- > few tenths of the total flare energy released (up to 10^{32} ergs)
- Significant role for non-thermal electrons
- CME acceleration

But we are interested in non-thermal processes, not boring thermal plasmas

Late non-thermal signatures

- Routine metric radio bursts (types II, III ℓ , IV)
 - Meudon siren presentation
- Coronal hard X-ray sources (Frost & Dennis 1971; Krucker et al 2008)
 - Meudon siren presentation
- Some SEP injections
- Energetic neutral atoms?
 - Mewaldt et al. 2009
- Late γ -ray sources (e.g., π_0)
 - Lord of the Fat Photons presentation
- Other?

In what sense non-thermal?

- Particles with energies way above kT
- Drastic mass motions (surges, sprays, jets, CMEs, seismic effects?)
- Low density, high corona
 - *In what contexts is T_e not equal to T_i ?*
 - *Where does the tail wag the dog?*
 - *How large can $\delta B/B$ be?*