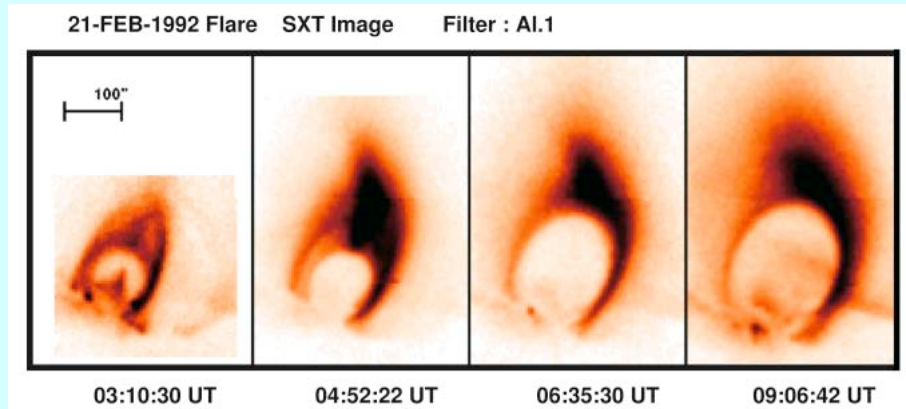


# **Observational features of flares**

## Long durational event flares (LDE flares)



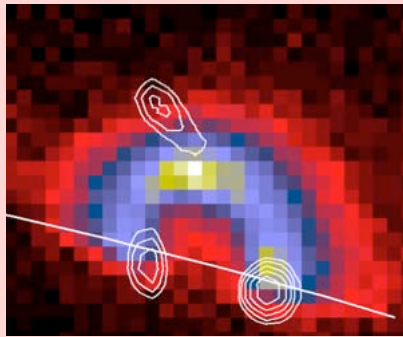
Tsuneta et al. (1992)

- **Long duration** (*several hours*)
- **Relatively large spatial size**  
( $\geq 100,000$  km)
- **Cusp-shaped structure**

Common feature:

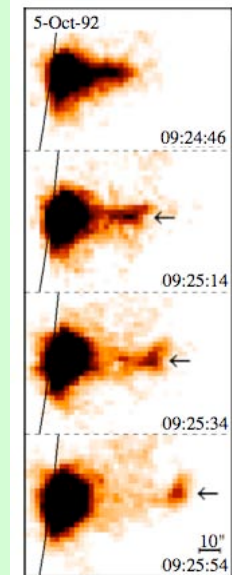
- **Plasmoid ejection** ( $v \geq 100$  km/s)

## Impulsive flares (compact flares)



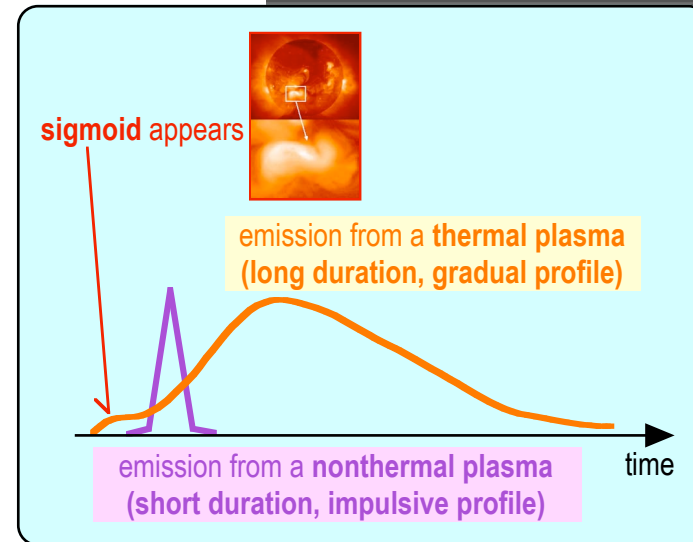
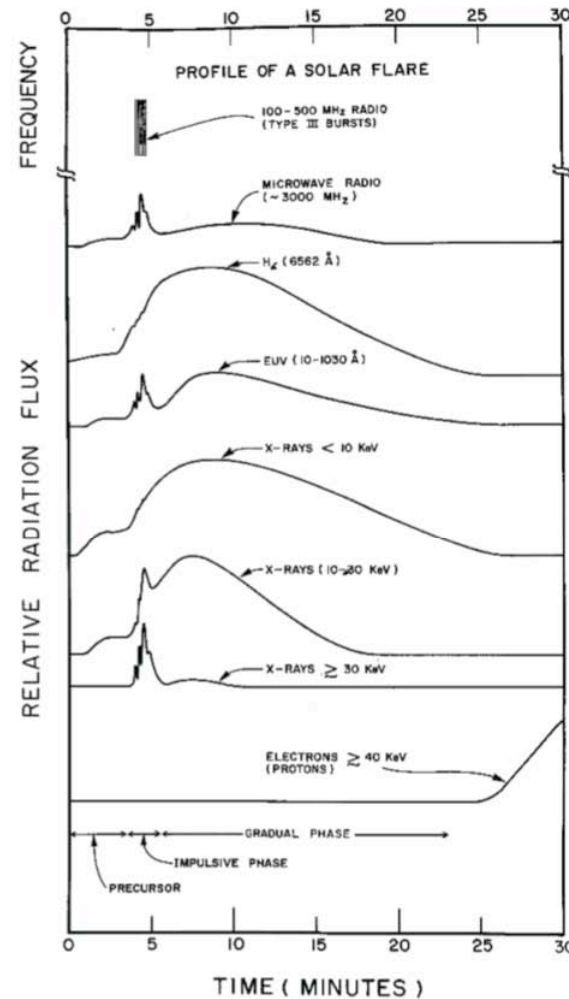
- **Short duration** (*less than an hour*)
- **Relatively small spatial size**  
( $\leq 100,000$  km)
- **No cusp-shaped structure**

Masuda et al. (1994)



Shibata (1998)

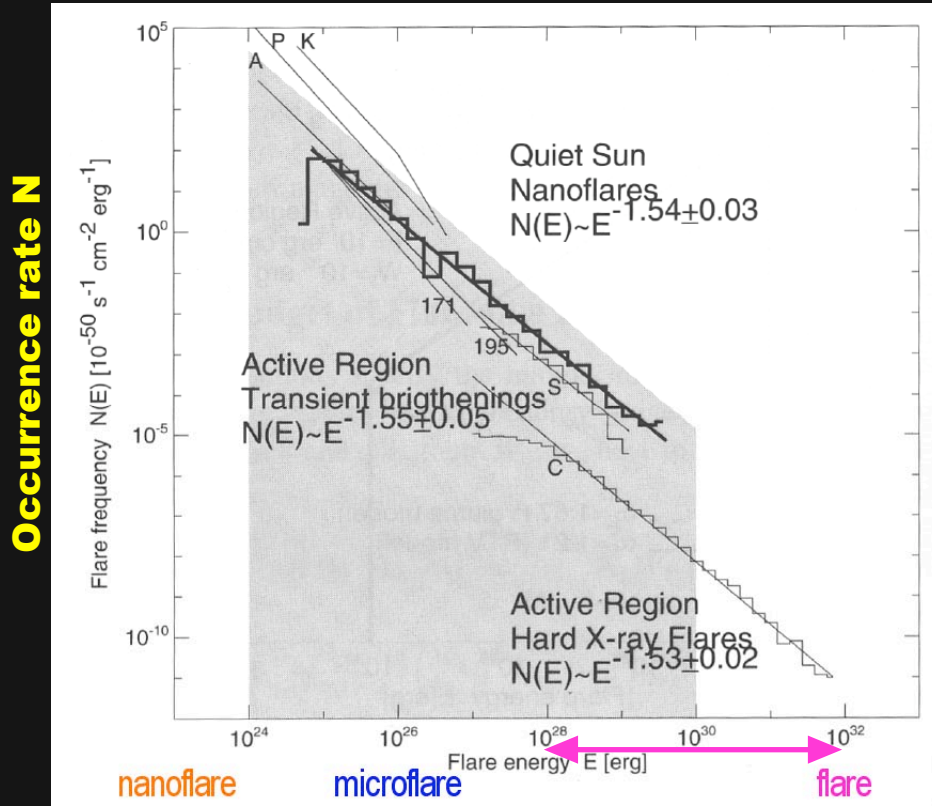
# Time profiles of emissions observed during a flare



These profiles suggest that **non-steady energy release** proceeds during a flare.

Figure 41: Typical time variation of emissions observed in various wavelengths during a flare (from Kane, 1974).

# Frequency distribution of flaring events (histogram)



**Occurrence rate N**

**Released energy E**

**Power-law distribution**  
 path-dependent process → path-independent process

$$N(E) \propto E^{-\alpha}$$

$$\alpha \sim 1.5$$

Aschwanden (2004)

**Power-law index  $\alpha$  → coronal heating**

# Evolution of a flare

Energy built-up phase

Preflare phase (toward the onset of a flare)

Energy-release (main) phase

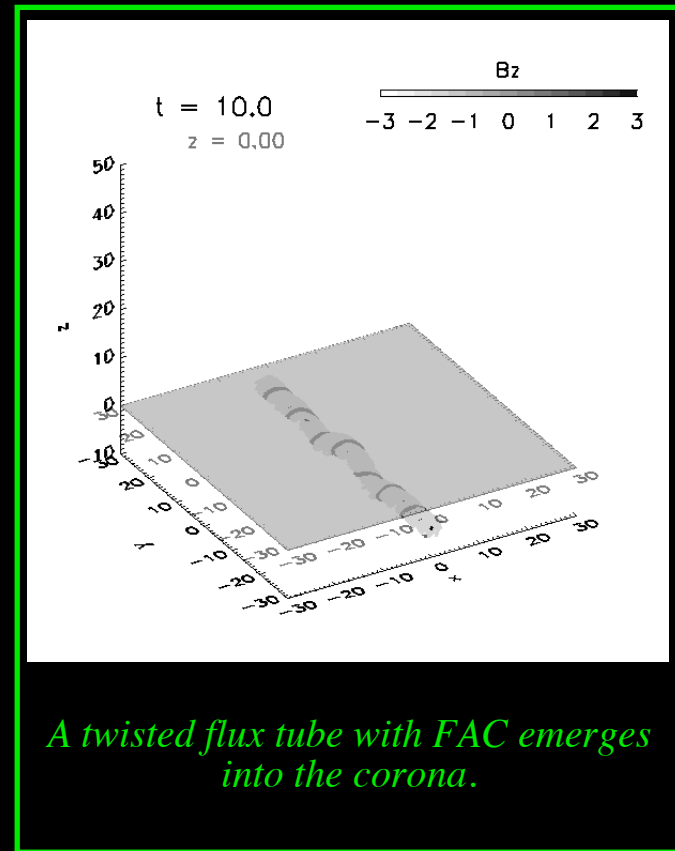
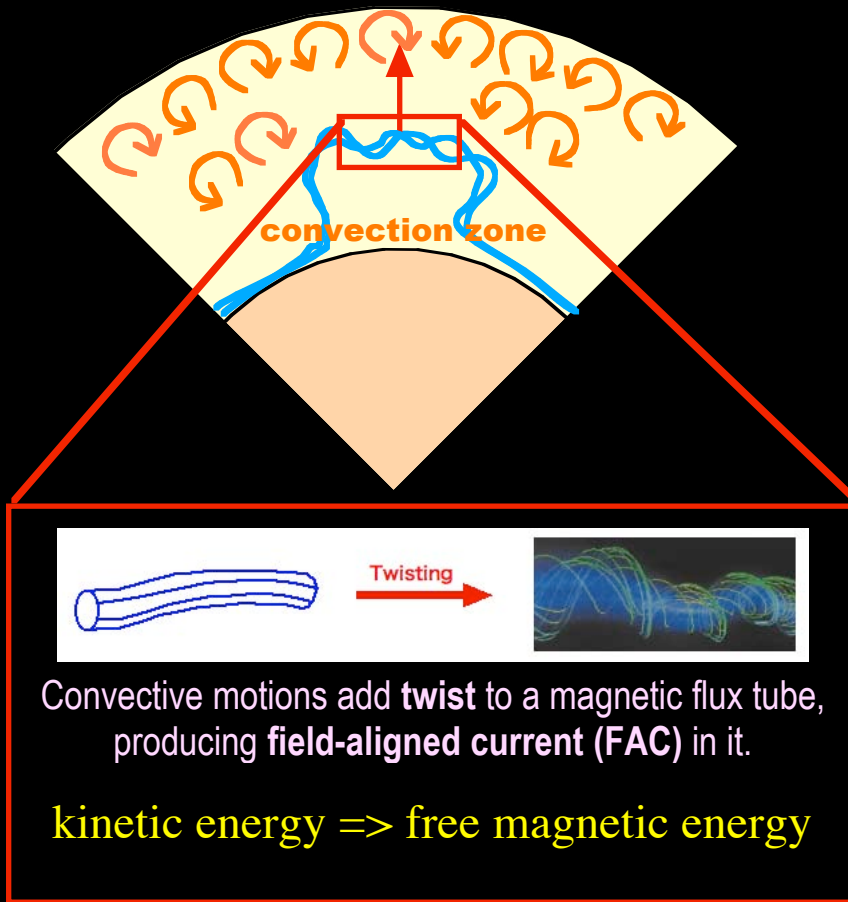
Post-flare phase

# Energy built-up phase

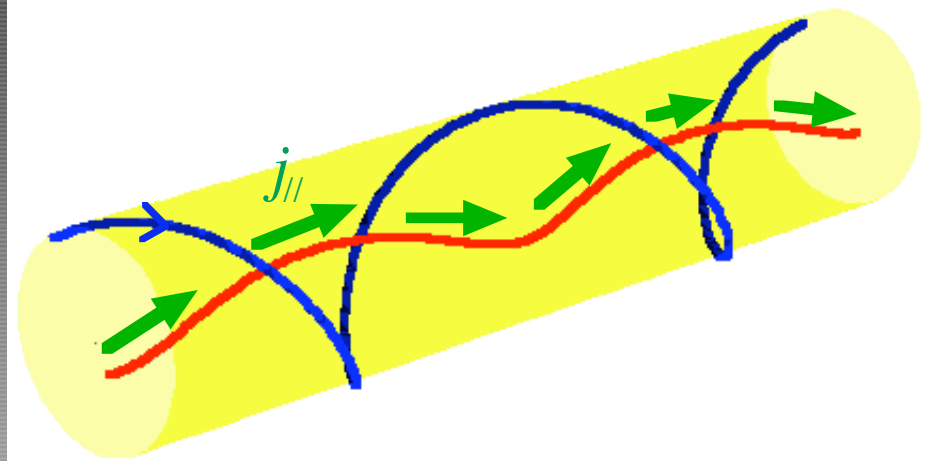
generate & transport free magnetic energy  
from solar interior to atmosphere

# How to generate & transport free magnetic energy to corona?

... Formation and emergence of a twisted flux tube



*Twisted flux tube is a carrier of free magnetic energy...*



**Twisted flux tube...** contains **FAC-based free magnetic energy**

**FAC** => *does not produce Lorentz force* that converts free magnetic energy to kinetic energy

**Stored in an emerging twisted flux tube**

# Preflare phase

prepare for the rapid release of  
free magnetic energy

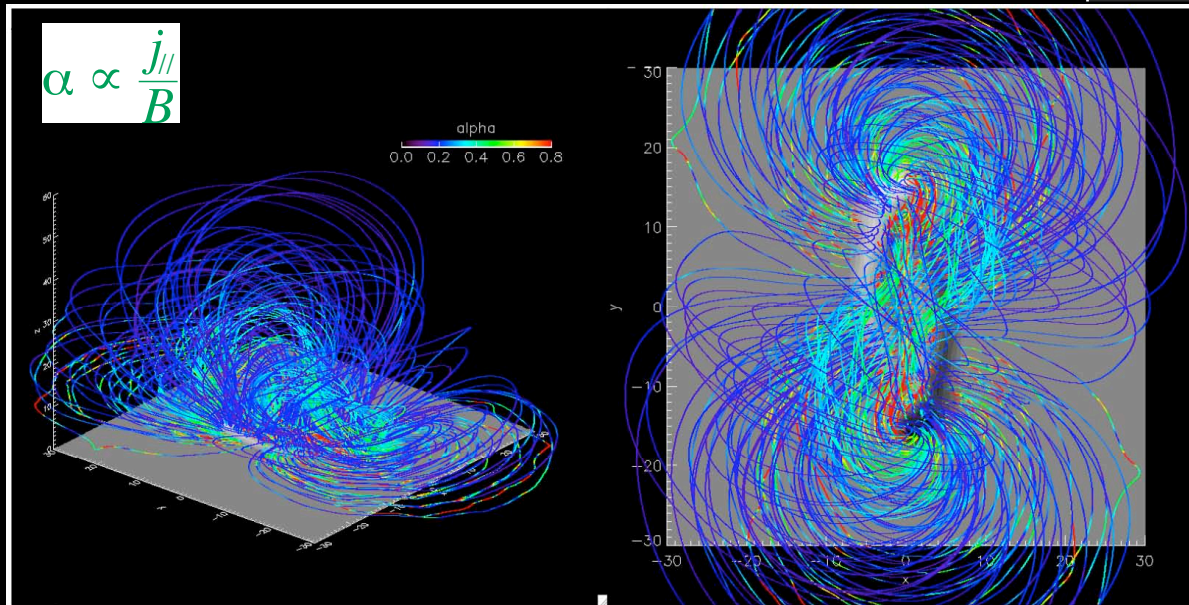
# Preflare structure

sigmoid

# Sigmoid... S-shaped coronal structure formed during preflare phase

=> could be composed of underlying field lines with strong field-aligned current along them

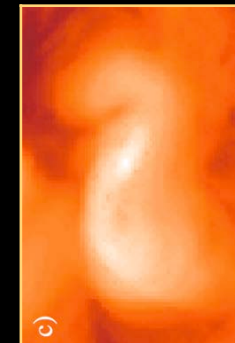
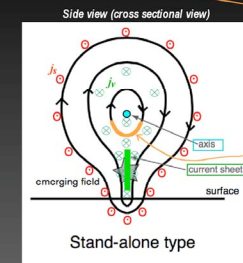
=> suggest that flux-tube axis reaches the corona, below which current sheet formation may proceed



Distribution of FAC Lee and Magara (2014)

## Appearance of a sigmoid (precursor of a flare)

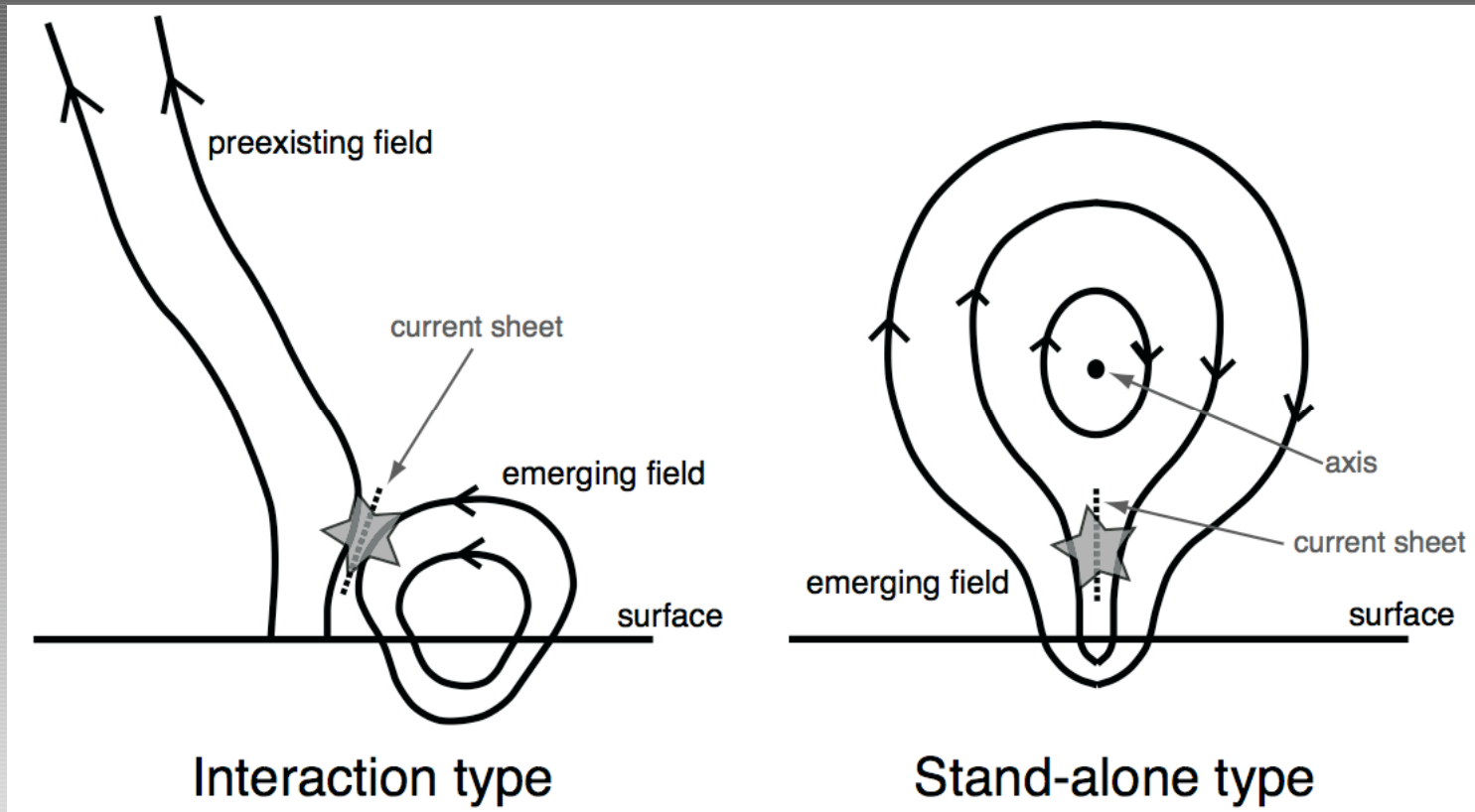
=> suggests emergence of underlying loop (and axis)



An inverse S-shaped sigmoid observed in soft X-ray (Yohkoh)

# Current sheet formation

## Two types of current sheet formation for a flare



Magara & Tsuneta (2008)