

MMS magnetotail energetic particle observations: the broad significance

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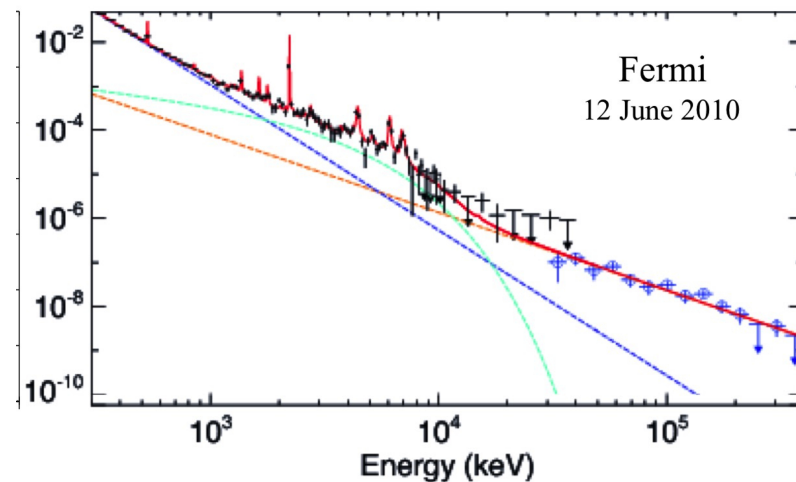
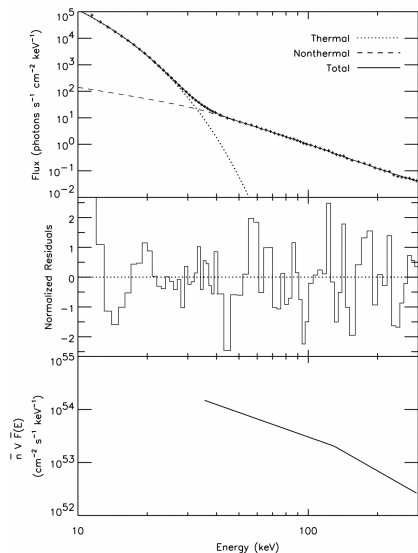
Uniqueness of MMS magnetotail data

- Observations required to establish the physics basis of energetic particle acceleration during magnetic reconnection
 - Simultaneous measurement of electron and ion spectra
 - Measurement of the local magnetic geometry, including the reconnecting magnetic field and the strength of the guide field
 - Measurement of the local Alfvén speed to evaluate the intrinsic reconnection energy scale $W_0 = m_i C_{Ar}^2$
 - Direct evaluation of particle acceleration mechanisms
- The magnetotail is the only reconnection environment where such measurements are possible and particle acceleration is robust

Diagnosing energetic particles in impulsive flares: the challenges

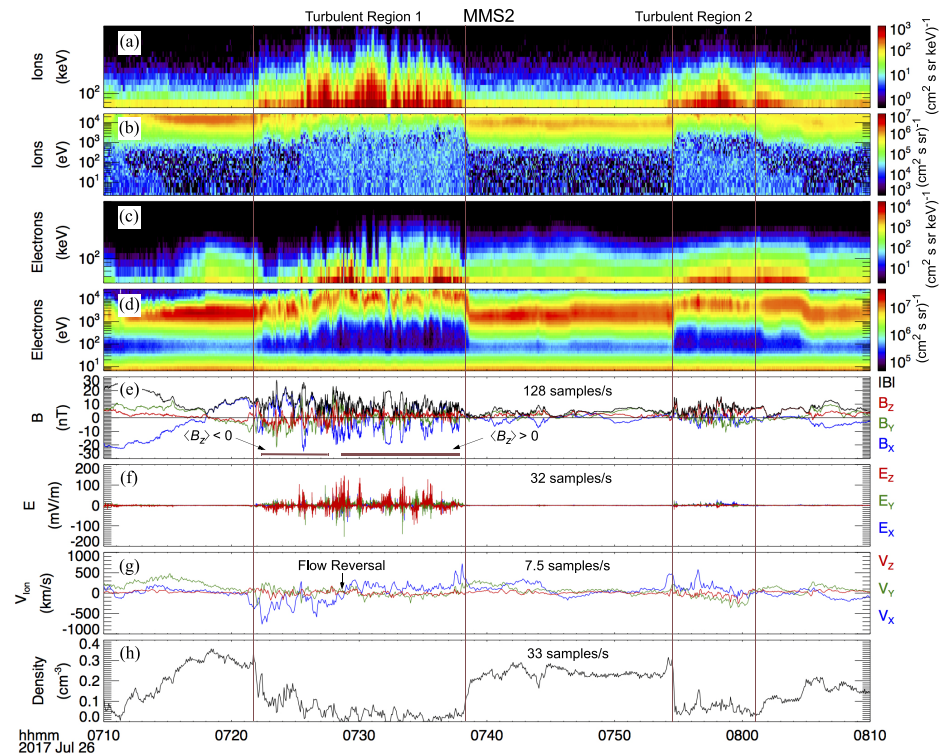
- Remote sensing is used to explore electron and ion acceleration in flares
 - EUV, x-ray, gamma-ray and gyrosynchrotron emission
- Energetic ion measurements limited to energies above an MeV
 - No direct measurement of ion energies down to 10's of keV where the ion powerlaw spectra are expected to start and which dominate the total energy
 - PSP and SO may be able to measure these low energies
- Magnetic geometry of flares is challenging to determine
- Intrinsic reconnection energy scale $W_0 = m_i C_{Ar}^2$ challenging to evaluate

RHESSI July 23 γ -ray flare



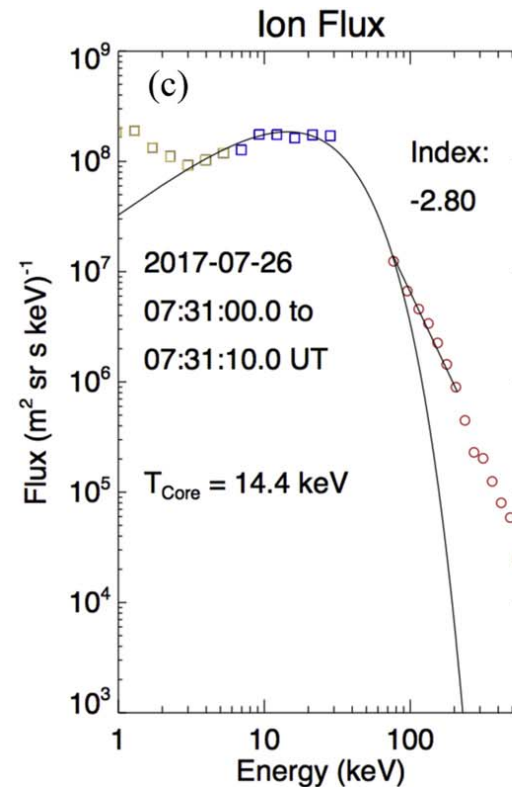
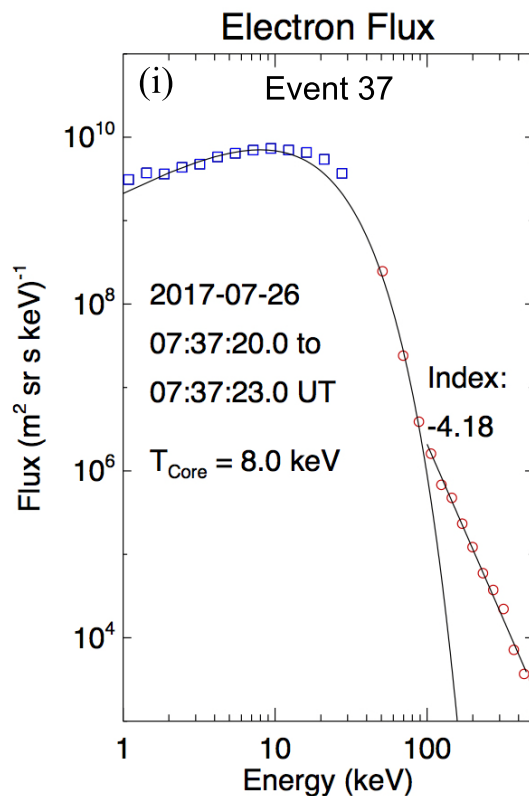
MMS energetic particle measurements

- MMS July 26, 2017, magnetotail reconnection event (Ergun+ 2018, 2020)
 - Ions and electrons with energies above 100keV
 - Intrinsic energy scale $W_0 = m_i C_{Ar}^2 \sim 24\text{keV}$



Characteristic electron and ion spectra

- Both electrons and protons exhibit well-defined powerlaw spectra as well as hot thermal components
 - Hot thermal component a fraction of W_0
 - Powerlaw spectra extend down to just above W_0



Conclusion

- MMS energetic particle measurements in magnetotail reconnection events are unique
- The data is a valuable resource for understanding particle acceleration during reconnection
 - Broad implications for the heliosphere and other astrophysical systems
 - Opportunities for benchmarking models of reconnection-driven particle acceleration