Working Group 2 Summary Report

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Et al.

Q1: *How do the spectral shape and its time dependence for various SEP species vary with source and interplanetary parameters, CMEs, and shocks?*

Q2: *Can event-to-event variation in composition be related to specific characteristics of the associated CMEs and flares?*

• The two questions are intimately connected so we considered them together.

• Give the wide range of energies we are now able to explore, the classification of events simply by Fe/O at a single energy ignores important information.

• Cohen presented spectral and compositional variations over SIS energy ranges (10-80 MeV/n). Tylka presented spectra and Fe/O over a wider energy range (100 keV/n - 400 MeV/n).

• We proposed two extreme types for the CDAW events based on spectral shape and the resulting energy dependence of Fe/O. We identified 6-10 events which exemplified each type for closer examination (many events remain in the 'muddle in the middle'). We encouraged WG1 to search for differentiating solar signatures. At the time of the WG1-WG2 joint session, no such signatures had been identified.

Type A (eg., 20Apr98, 14Jul00)

- Ellison-Ramaty spectra, except for transport-distortions at low energies
- Fe/O generally falls with increasing energy
- "Trivial" energy dependence in QFe , indicating acceleration occurred only in low-density regions.
- The largest events (at least in this Cycle) fall in this category.

Type B: (e.g., 15Apr01)

- Power-law spectra, apart from transport-distortions at low energies.
  - "knees" presumably at event higher energies
- Fe/O rises with increasing energy, due to harder Fe spectrum
- Strong energy dependence in QFe, perhaps due to stripping during acceleration in a high-density region

Q1 and Q2 continued...

• Concensus was expressed the Type A events are produced by strong shocks driven by fast CMEs. These events are the most important for many aspects of Geospace Impact. This is not to say that Type B events are unimportant.

• Lee showed that a plausible explanation for the spectral distinctions between Type A and B might be quasi-parallel and quasi-perpendicular shocks, respectively.

• The topology of magnetic field lines is important.

• A clear feature of the Type B events is a harder power law spectrum for Fe than O. It remains an open question how this comes about, but there are theoretical speculations in the literature that shock acceleration might be able to do this.

Q3: *What do time- and angular-variations in elemental abundance ratios reveal about Q/A (charge-to-mass) ratios and SEP transport properties?*

• Ng presented new LEMT observations of angular dependence of Fe/O (Reames and Ng, 2002) that suggest an important role for a reflecting boundary, presumably due to previous CMEs.

• Leske presented SIS capabilities of detecting anisotropies although SIS was not specifically designed to do this.

• Ng showed that the range of variability in Fe/O versus time at different energies can be understood. In particular, an initial decrease in Fe/O from an enhanced value is expected from the simplest considerations of diffusion theory. More complicated variability later in the event reflects the role of proton-amplified Alfven waves.

Q4: *Can we distinguish between the effects of temperatures and density of the source plasma from the energy dependence of the Fe charge state?*

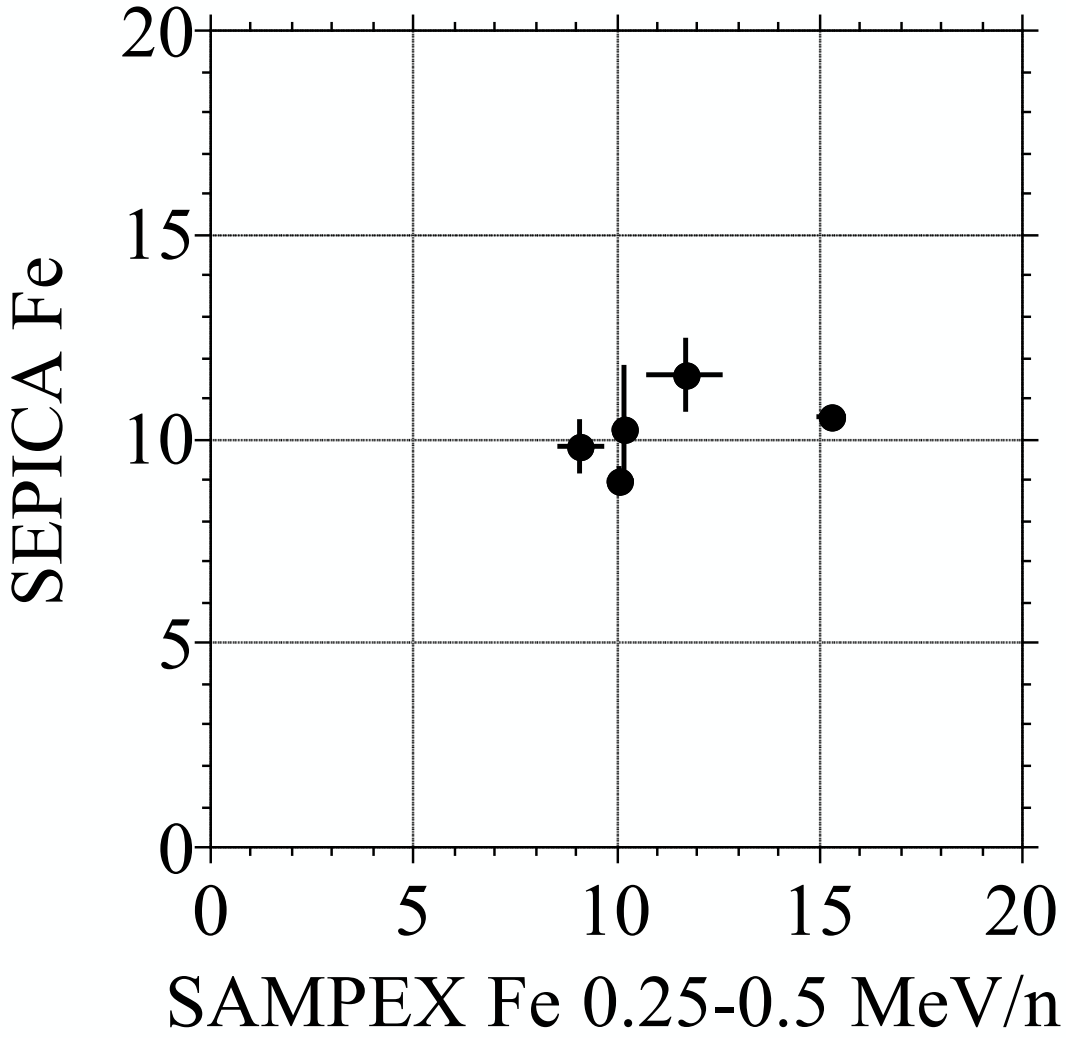
• Popecki reviewed previous charge state measurements and theoretical interpretation.

• It is clear that existing data are too sparse to answer this question. More measurements and indirect methods for inferring charge states are needed.

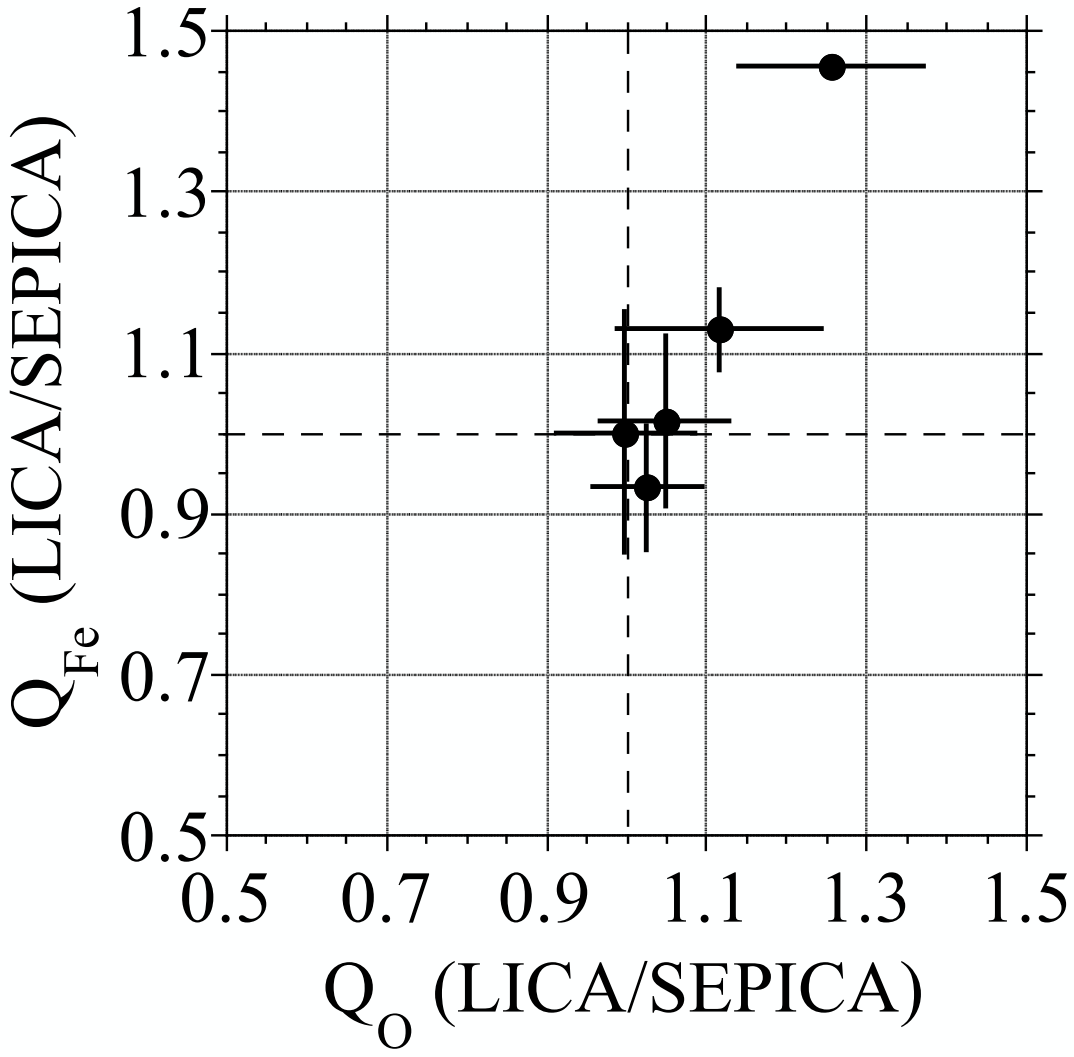
• Leske and Popecki compared MAST and SEPICA charge state results for 3 events. All 3 have an increase in Q_{Fe} with energy and they have a wide range in Fe/O at <1 MeV/n between the events.

• Two of the events are Type B and have similar Q_{Fe} vs Fe/O trends with energy, while the third was Type A and has a distinctly different Q_{Fe} vs Fe/O trend.

• LICA and SEPICA charge state determinations were compared. For most events the results were in agreement, but one event showed significant discrepancies which will be investigated further and may reveal interesting physics



- SEP charge state comparisons: ACE/SEPICA & SAMPEX/LICA
- Mark Popecki & Joe Mazur



- Differences in charge state measurements expressed as percentages
- 4 cases within ~10%

Q5: *What is the energy dependence of the streaming limit and how does it depend on plasma parameters of the region through which the particles propagate?*

- Streaming limit is a clear feature of large SEP events. Geospace-Impact modelers should take advantage of this fact in assessing space-radiation hazards.
- Lee presented theoretical analysis of the origin of the streaming limit in terms of proton-amplified waves.
- We discussed the idea of streaming limits for other species. Lee and Ng discussed theoretical aspects of this idea.
- The observed energy dependence of the streaming limit is not yet theoretically understood.
- It is not clear that we have sufficient data to understand the dependence on plasma parameters.