

# The Near-Earth Distribution of Fe/O from Solar Energetic Particle Events: Is It Bimodal?

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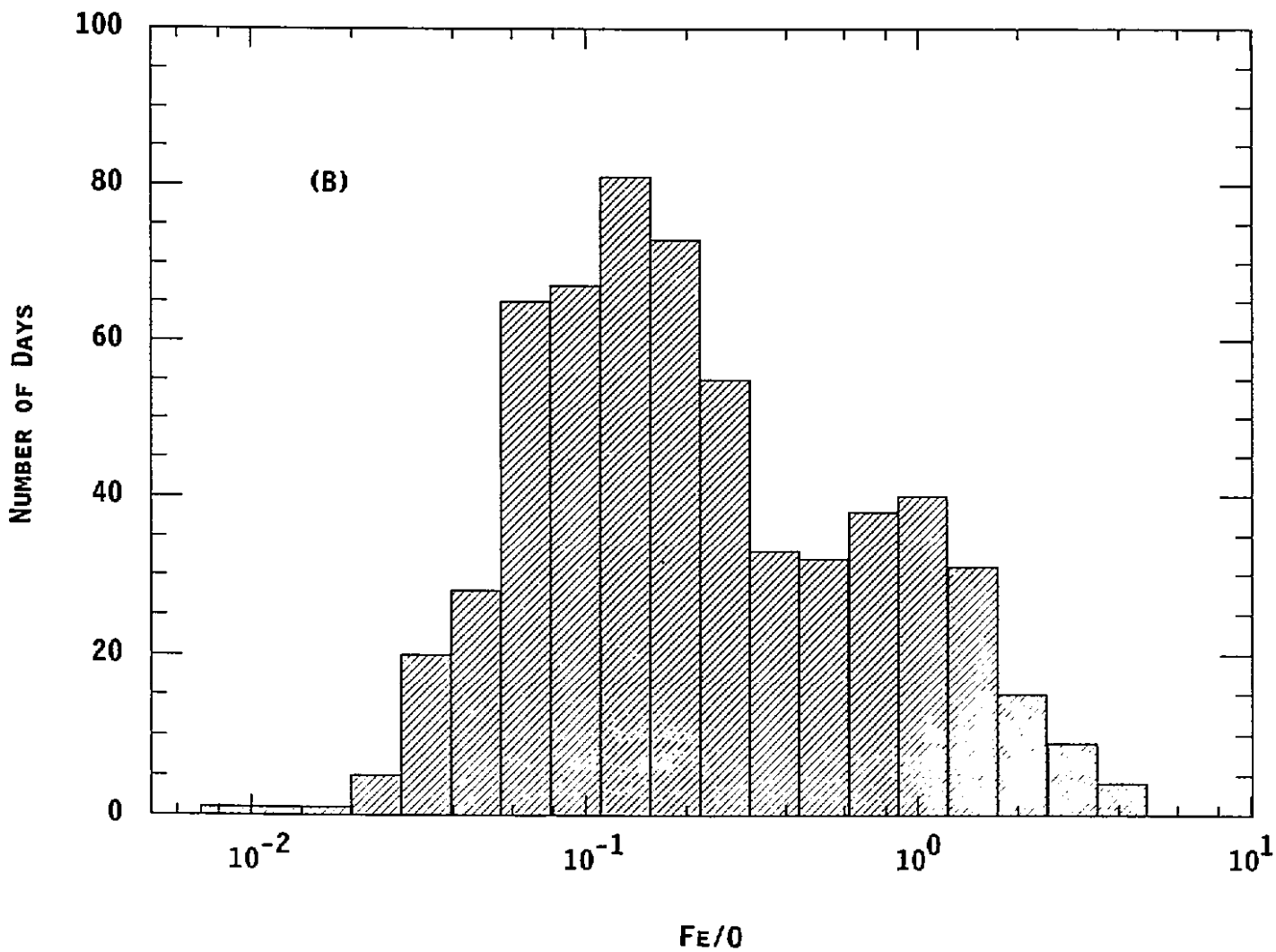
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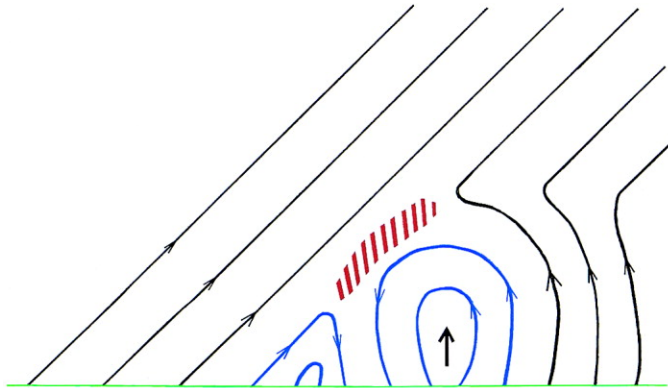
**Stereo Science Working Team Meeting  
Meredith, NH**

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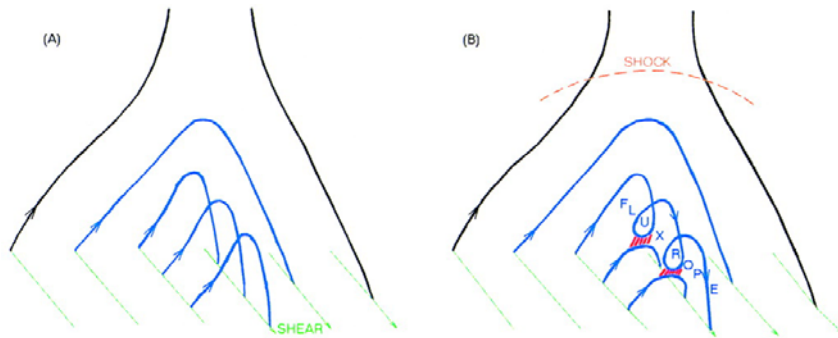
# Reames, 1988



# Reames, 2002: MAGNETIC TOPOLOGY OF IMPULSIVE AND GRADUAL SOLAR ENERGETIC PARTICLE EVENTS



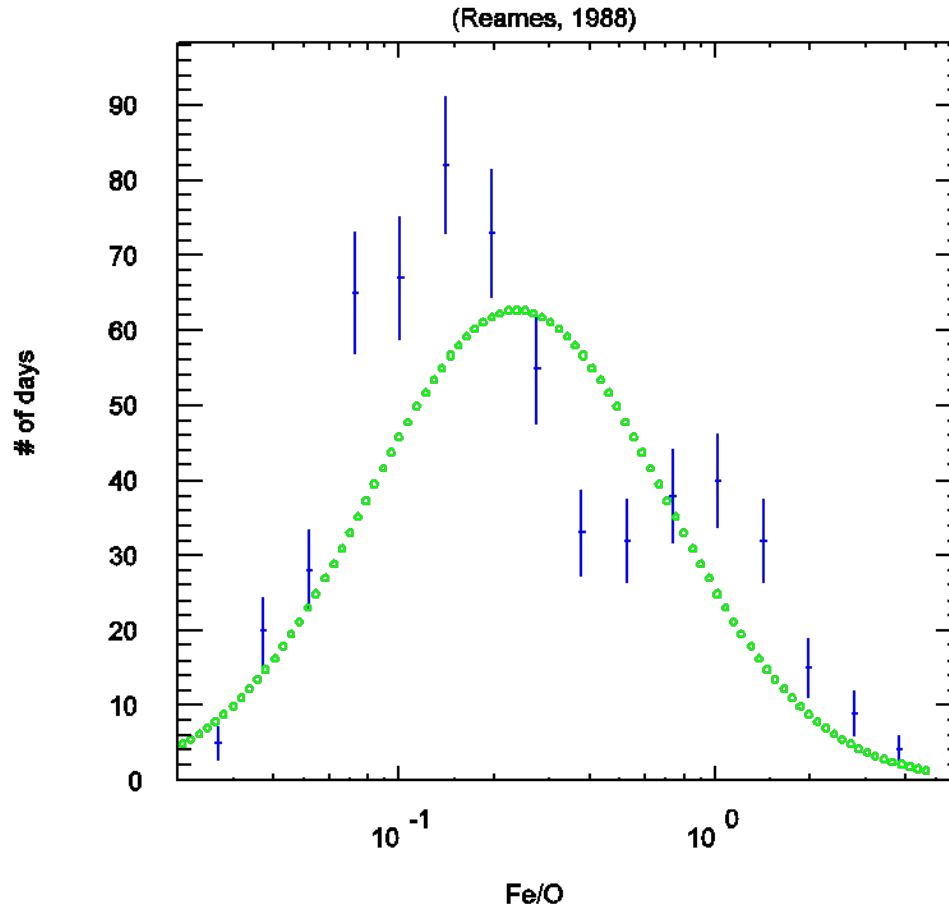
Model for flare acceleration in impulsive events (resonant stochastic acceleration + open field lines)



Model for shock acceleration in gradual events (particles accelerated by the flare are on closed field lines and cannot escape from the sun)

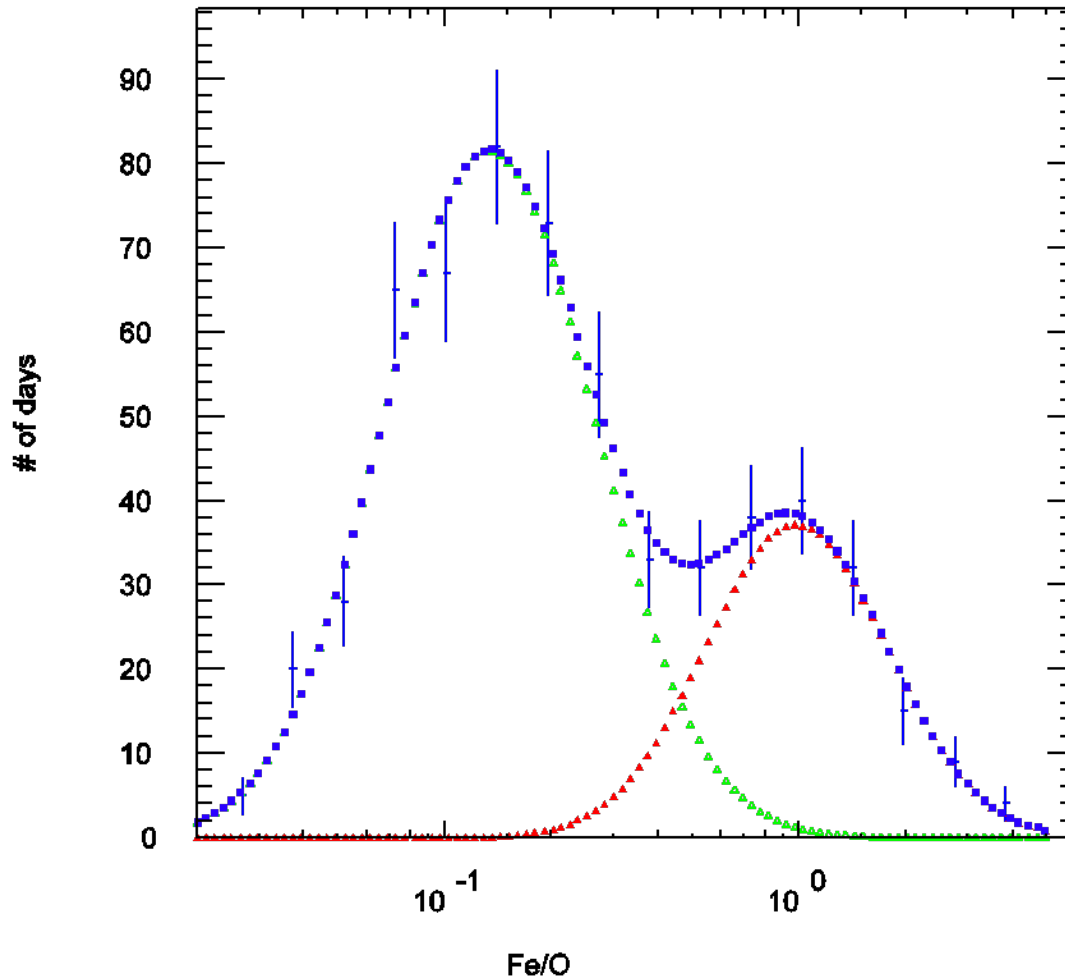
# Reames, 1988 – Fe/O Daily Averages (1.9 – 2.8 MeV/n)

reduced chi-square= 6.136



The distribution of daily averaged values of Fe/O as a function of the log of Fe/O. The reduced chi-square value indicates that a single Gaussian gives a poor fit to the data.

# Reames, 1988 – Daily Averages (1.9 – 2.8 MeV/n)

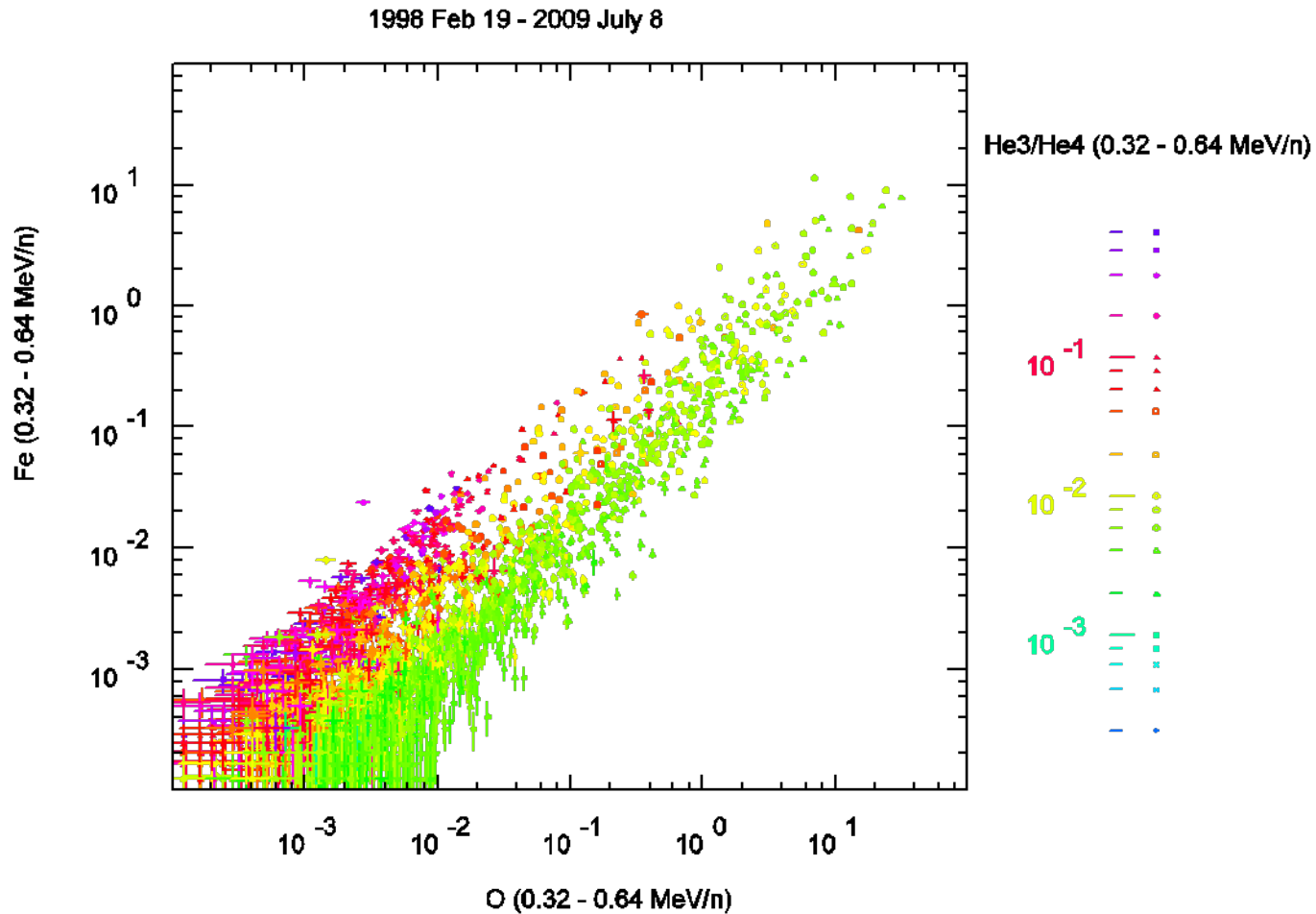


reduced chi-square= 0.69

peak 1:  $\bar{x} = 0.135$

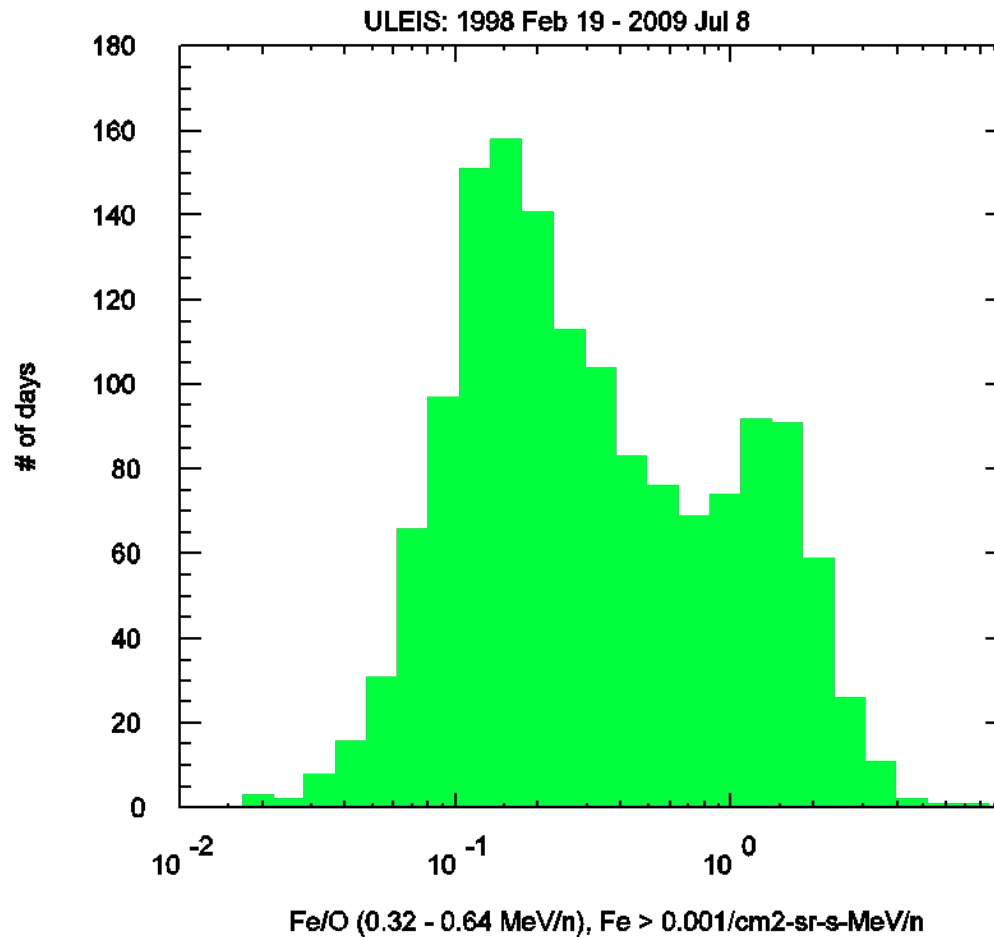
peak 2:  $\bar{x} = 1.02$

# ULEIS – Daily Averages (0.32 – 0.64 MeV/n)

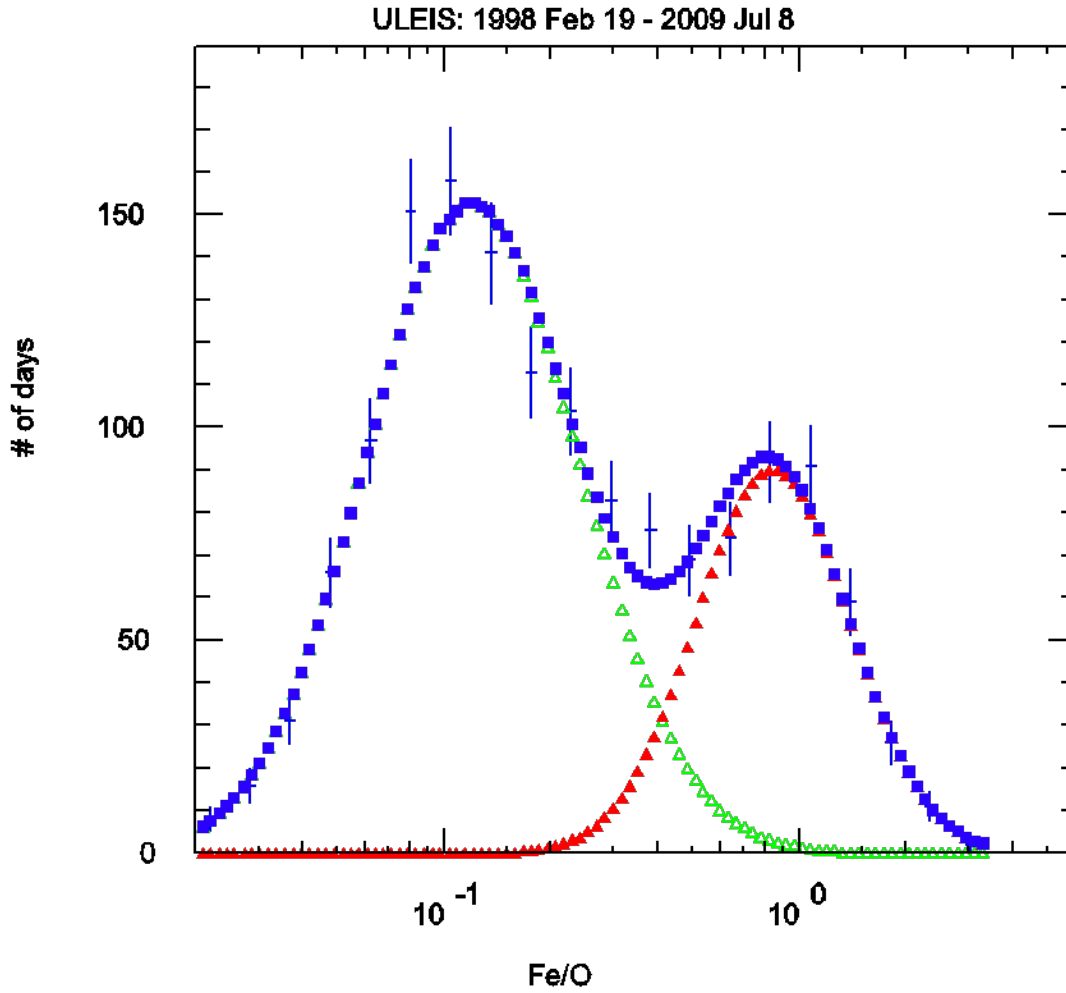


The z-axis in this plot is the  $^3\text{He}/^4\text{He}$  ratio using a logarithmic scale shown to the right of the figure.

# ULEIS – Daily Averages (0.32 – 0.64 MeV/n)



# ULEIS – Daily Averages (0.32 – 0.64 MeV/n)



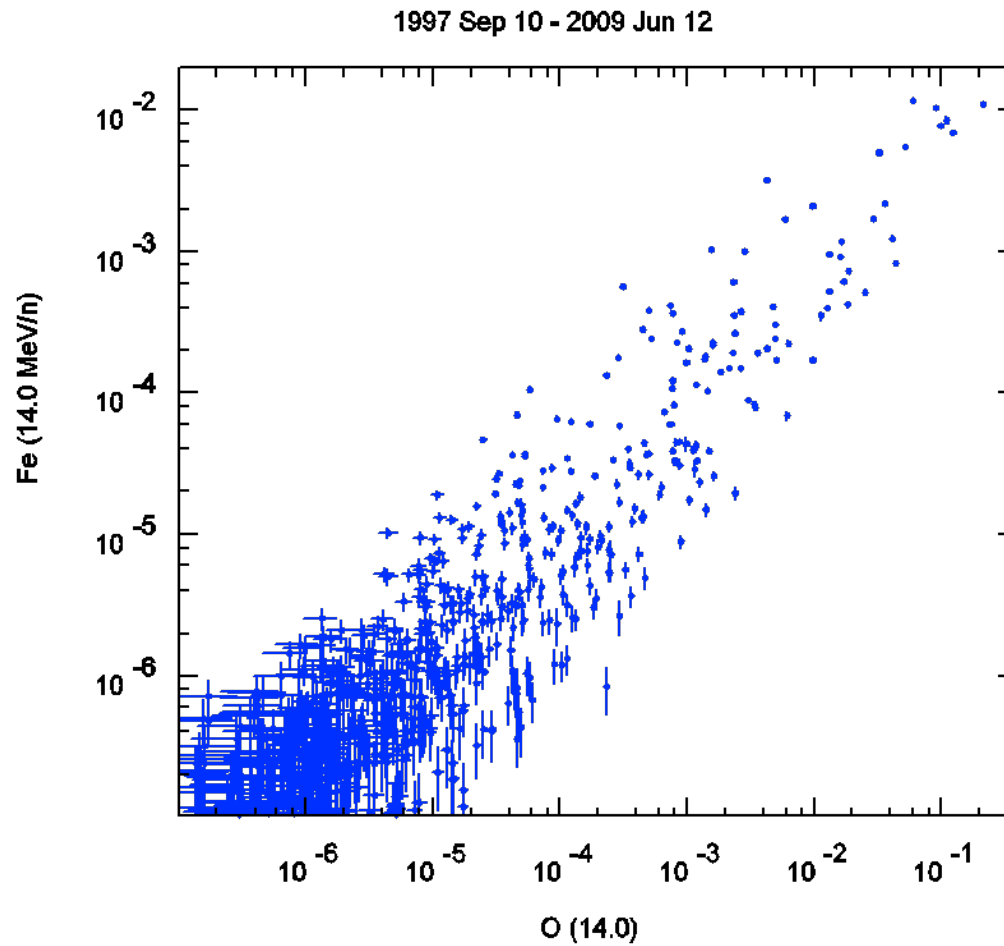
reduced chi2 = 1.07

peak 1: xbar = 0.12

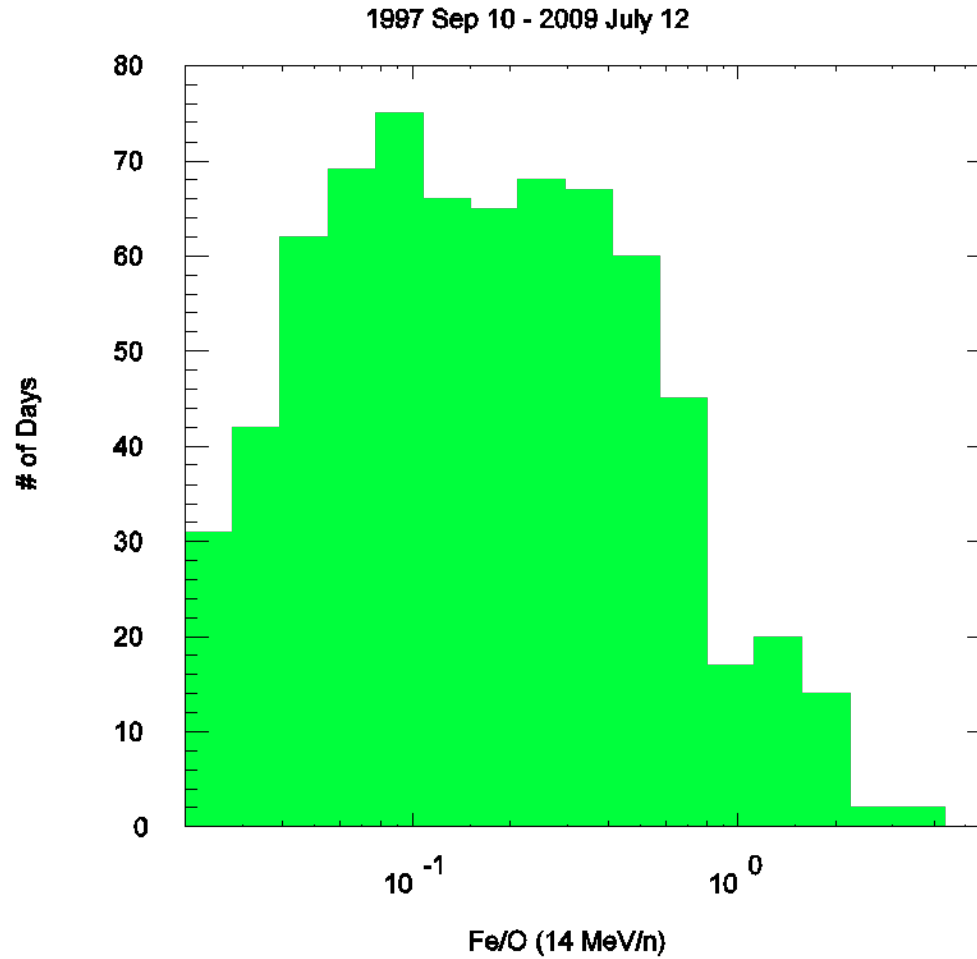
peak 2: xbar = 0.84



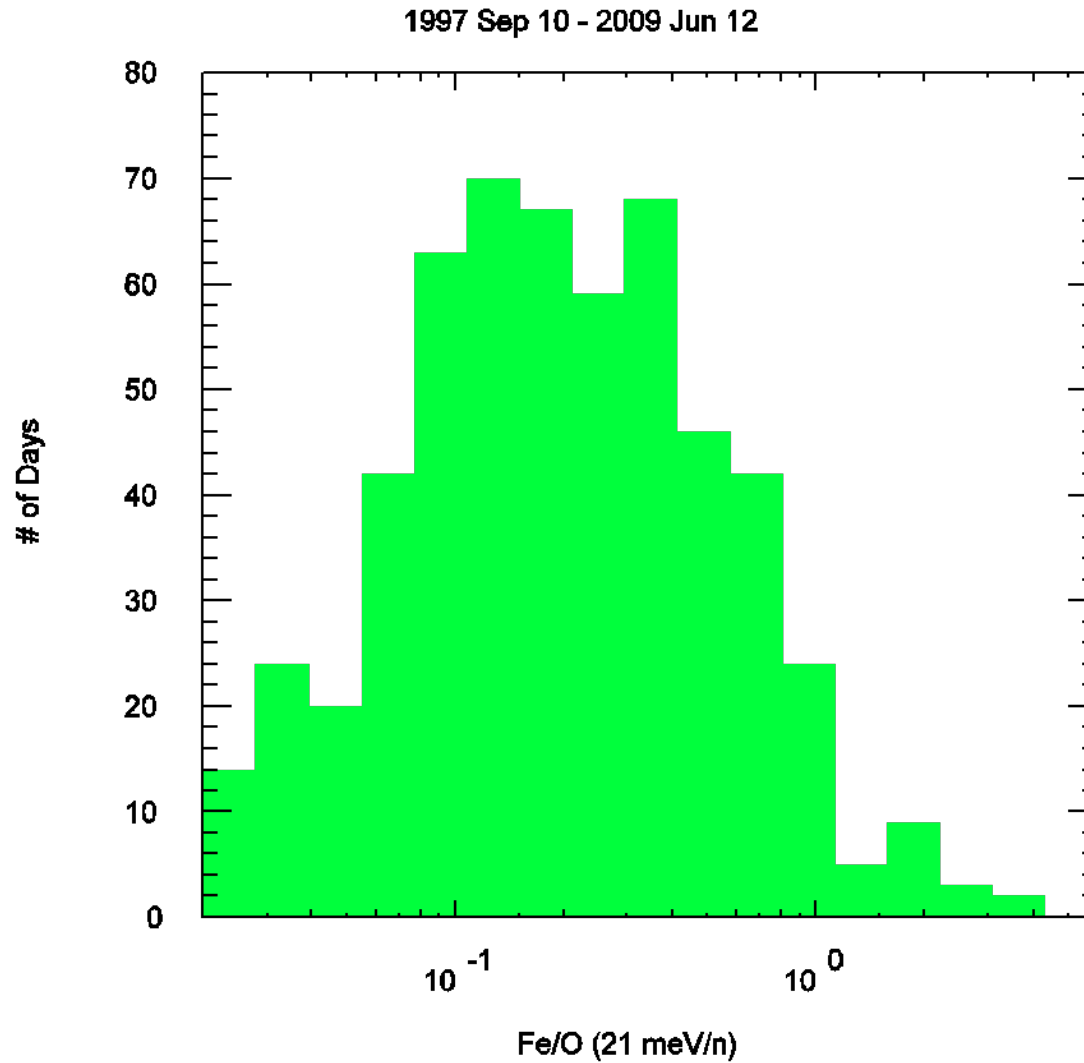
# SIS Daily Averages (14 MeV/n)



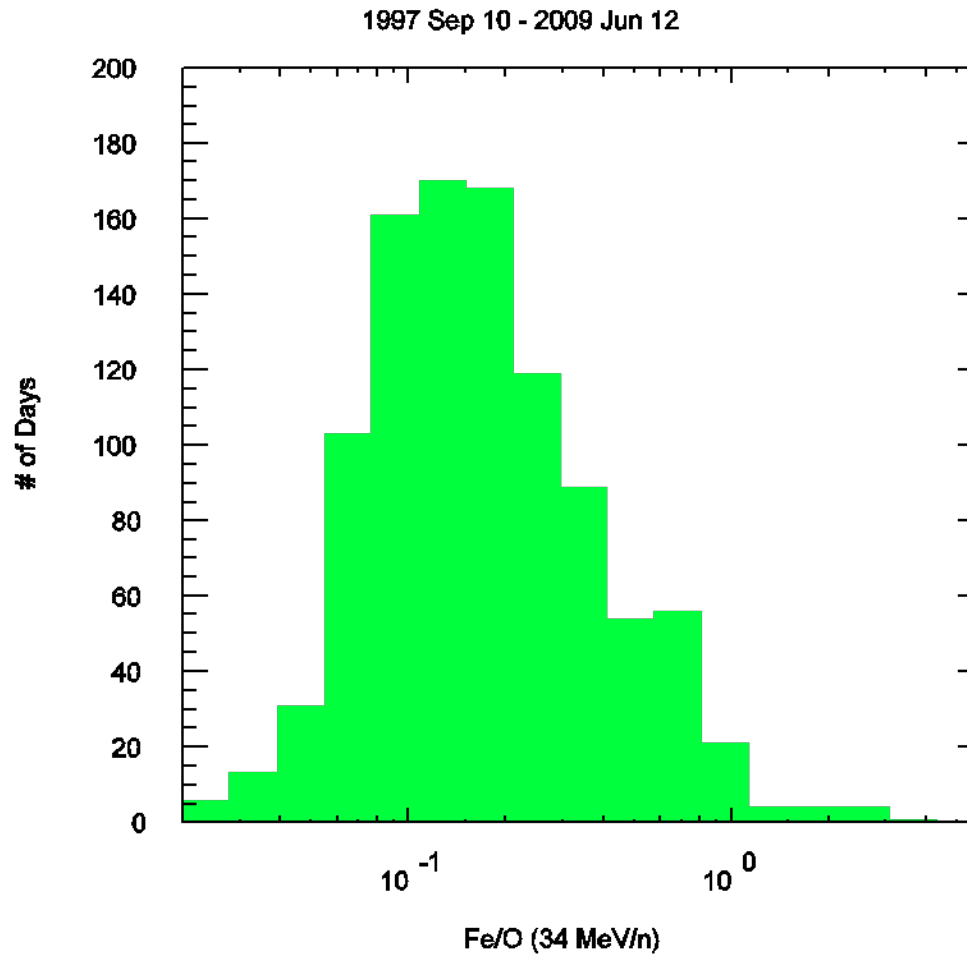
# SIS Daily Averages (14 MeV/n)



# SIS Daily Averages (21 MeV/n)



# SIS Daily Averages (34 MeV/n)



# Summary

- Fe/O was first shown to have a bimodal distribution 2 solar cycles ago (Reames, '88)
- There has been no independent confirmation of this key finding
- We have reported data from ACE/ULEIS and ACE/SIS which show a bimodal distribution at 0.32 – 0.64 MeV/n
- At higher energies there is at best a weak indication of bimodal distributions
- Possibly two peaks are merging into one as the energy increases
- It is apparent that the Fe/O distribution is energy-dependent



# ABSTRACT

We report on a new search for a bimodal Fe/O distribution using data from the SIS and ULEIS instruments on the Advanced Composition Explorer (ACE) spacecraft during solar cycle 23. Reames (1988) published results showing a bimodal distribution of Fe/O using daily averages of the Fe/O ratio from 1.9 – 2.8 MeV/n. To the best of our knowledge, no similar but independent distribution has been published, even though it is a key result. It has been widely interpreted as the basis for believing that Solar Energetic Particle (SEP) events have two distinct classes, gradual and impulsive events (e.g. see Reames (2002)). We begin by showing that the distribution found by Reames (1988) is not fit well by a single Gaussian but it is fit well by 2 separate gaussians, i.e. it is truly bimodal. We then present results from the ULEIS instrument which show a bimodal distribution of Fe/O in the energy range 0.32 – 0.64 MeV/n. This is fairly close to the energy range used by Reames (1988). At SIS energies there is no clear evidence of a bimodal distribution. We show the Fe/O distributions from SIS at 14, 21, and 34 MeV/n. It is apparent that the Fe/O distribution is energy-dependent.

# References

- Reames, D.V., Bimodal abundances in the energetic particles of solar and interplanetary origin, *Ap. J.* **330**, L71-L75 (1988).
- Reames, D.V., Magnetic topology of impulsive and gradual solar energetic particle events, *Ap. J.* **571**, L63-L66 (2002)
- Mewaldt, R.A., Cohen, C.M.S., and Mason, G.M., in the AIP Conference proceedings Geophysical Monograph 165, Gopalswamy, N., Mewaldt, R.A., and Torsti, J., editors, 115 – 125 (2006)



# Backup

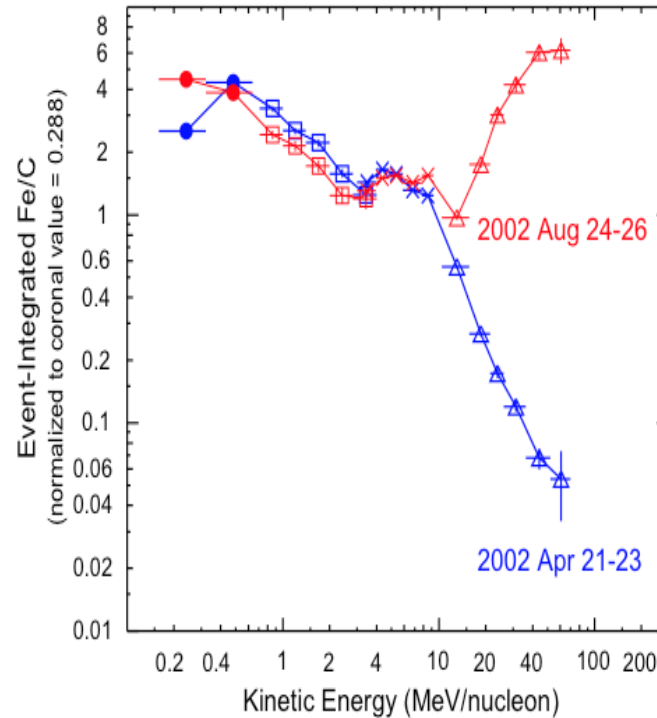


Fig. 1.— Event-integrated Fe/C (normalized to the nominal coronal value 0.288 (Reames 1995)) versus energy for the solar energetic particle (SEP) events of 2002 April 21 (blue) and 2002 August 24 (red). Data come from the Ultra Low-Energy Isotope Spectrometer (ULEIS; Mason et al. 1998; filled circles) on the Advanced Composition Explorer (*ACE*), the Electron Proton, and Alpha Monitor (EPAM; Gold et al. 1999; open squares) on *ACE*, the Low Energy Matrix Telescope (LEMT) in the Energetic Particle Acceleration, Composition, and Transport (EPACT) experiment (von Rosenvinge et al. 1995; crosses) on *Wind*, and the Solar Isotope Spectrometer (SIS; Stone et al. 1998a; open triangles) on *ACE*.