



Elemental abundance variations of Solar Energetic Particles at low energies as measured by WIND/ STEP over the last solar cycle

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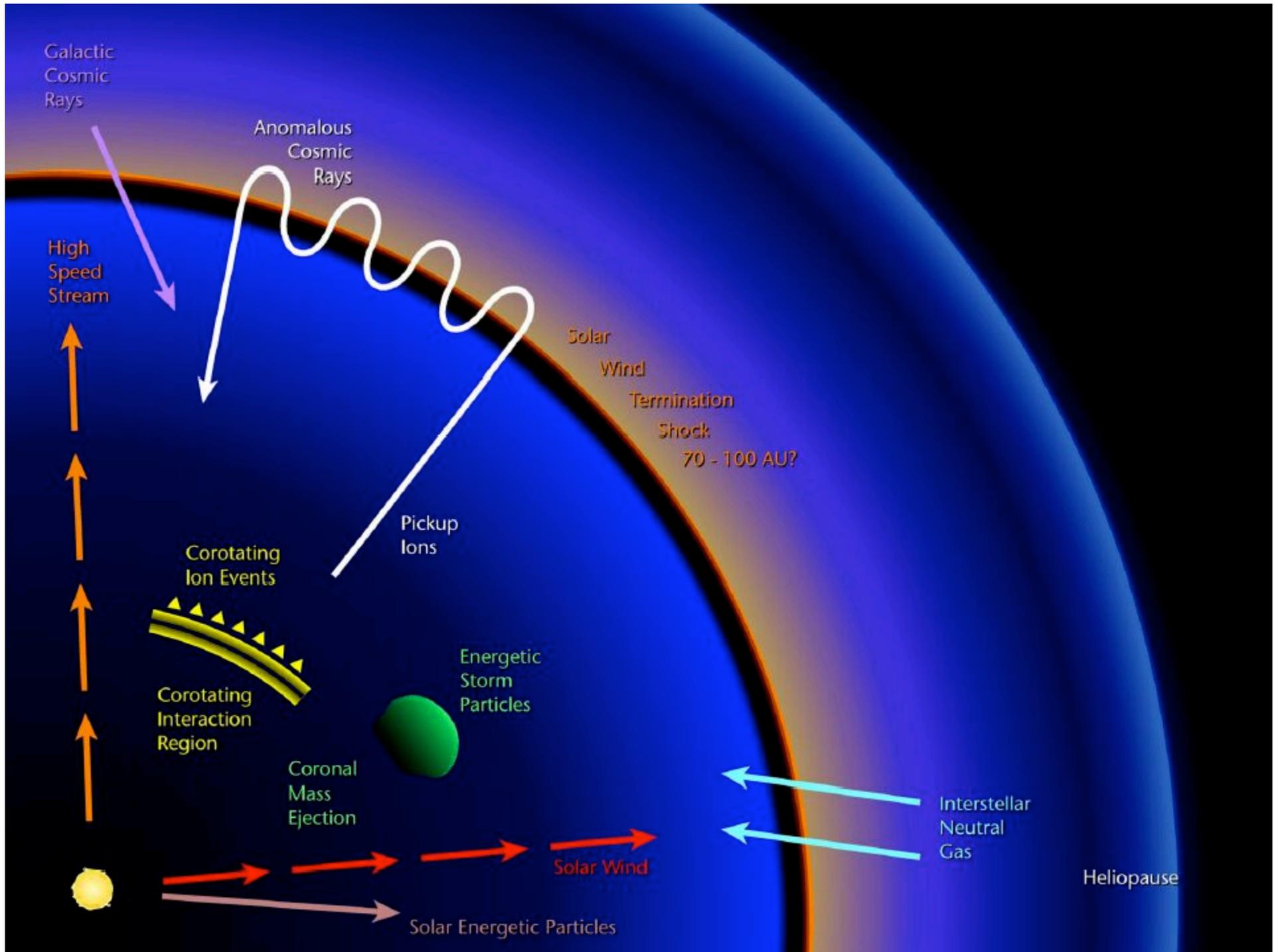
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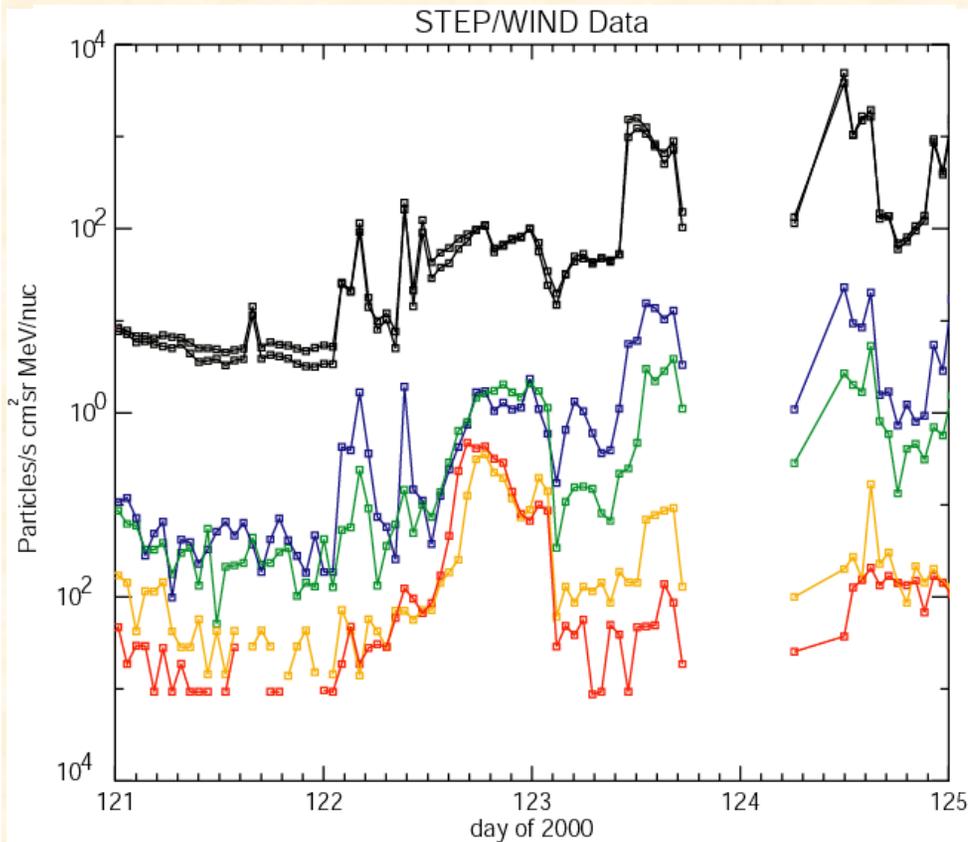
The Aerospace Corporation, El Segundo, CA



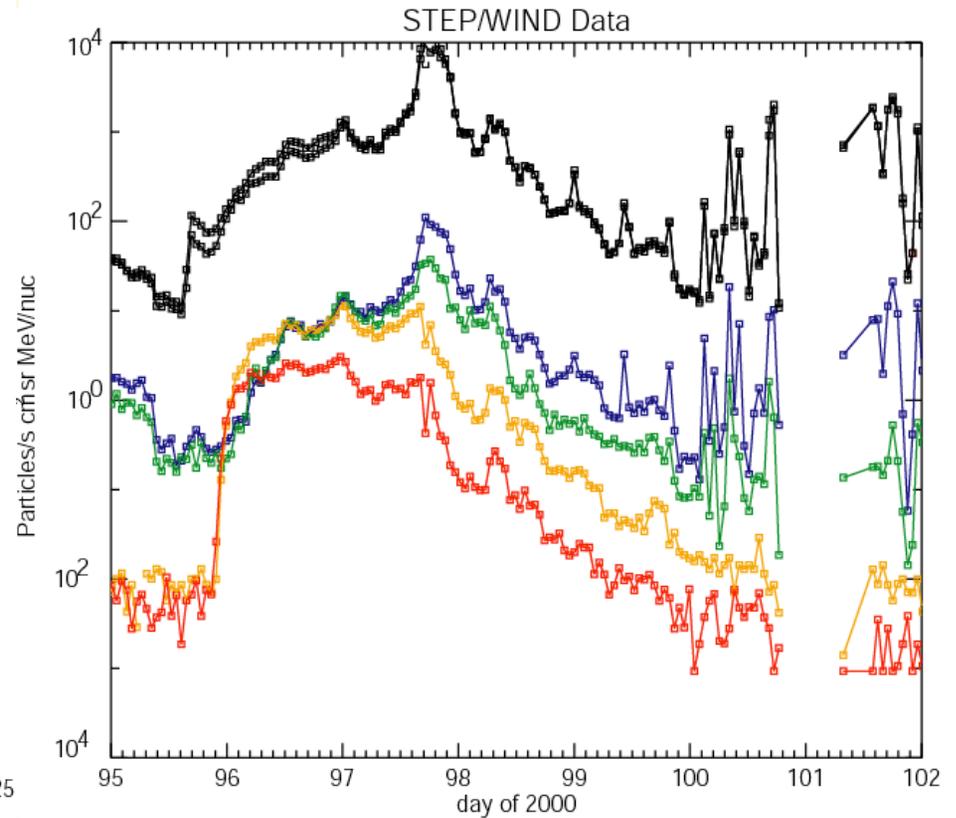
Solar Energetic Particle (SEP) Events

Fe: 0.02 MeV/nuc < 0.15 MeV/nuc
0.02 MeV/nuc < 0.15 MeV/nuc

CNO: 0.02 MeV/nuc < 0.15 MeV/nuc
0.02 MeV/nuc < 0.15 MeV/nuc



- Impulsive



- Gradual

Particle Instrumentation capabilities:

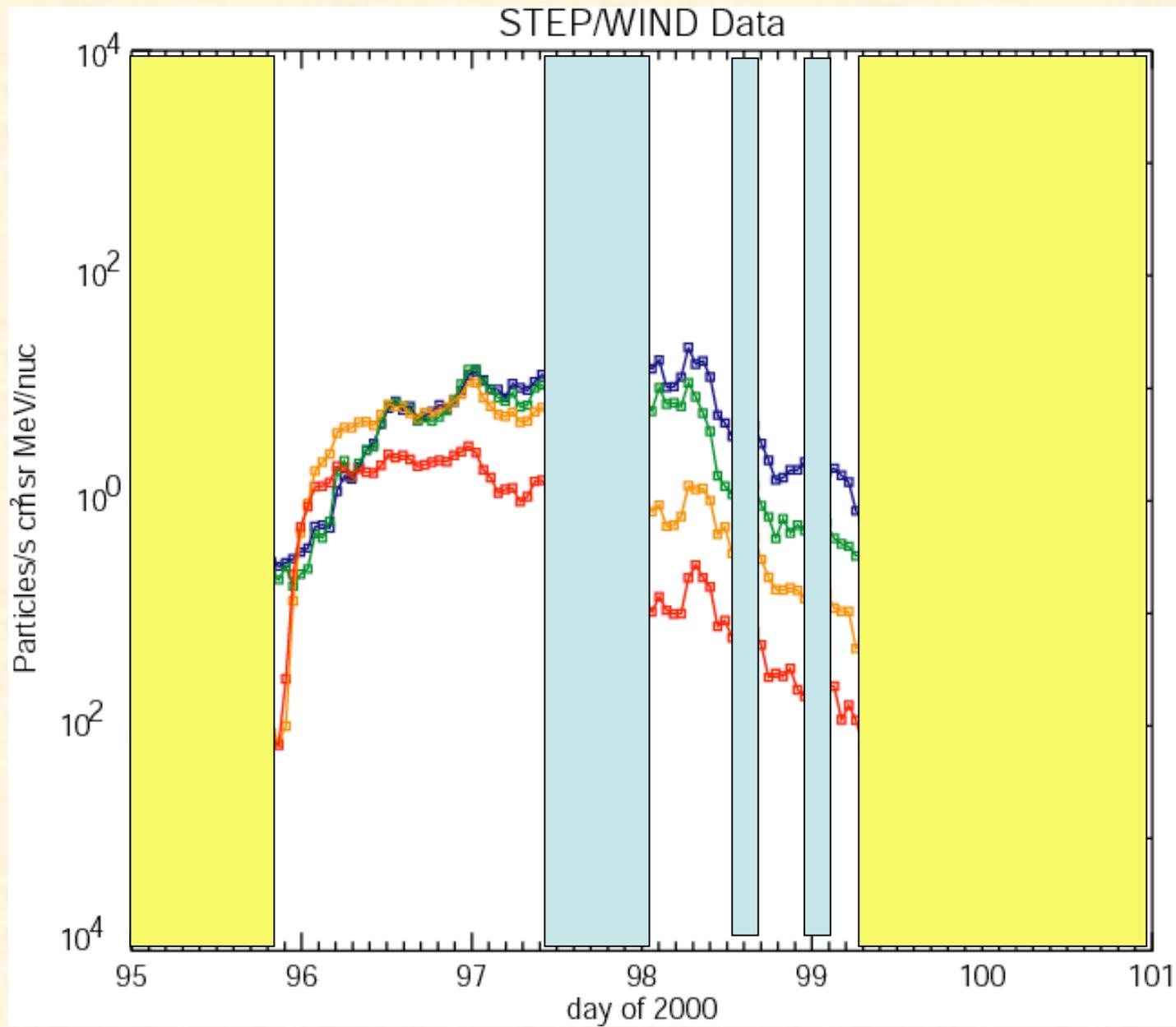
- Extended energy spectra, Isotopic Composition, Ionic Charge States.
- Simultaneous Observations of particles, CMEs, solar wind, radio emissions, and solar flares

Interesting problems:

- Seed populations of SEPs
- Acceleration and Propagation Mechanisms
- Spectral and Compositional behaviors.
- Elemental Variability within the same classes of events.

Elemental Abundance Variability

- Solar Cycle dependence
- Variations at low energies: Suprathermal material acceleration .
- Heliospheric Shock acceleration mechanisms
- Solar lift-off location dependence.
- A wider view of impulsive Vs Gradual behaviors.



Excluded: Shocks, upstream events, and saturation times

Instrumentation

Supra Thermal Energetic Particle Telescope (STEP):

Launched onboard WIND on November 1, 1994

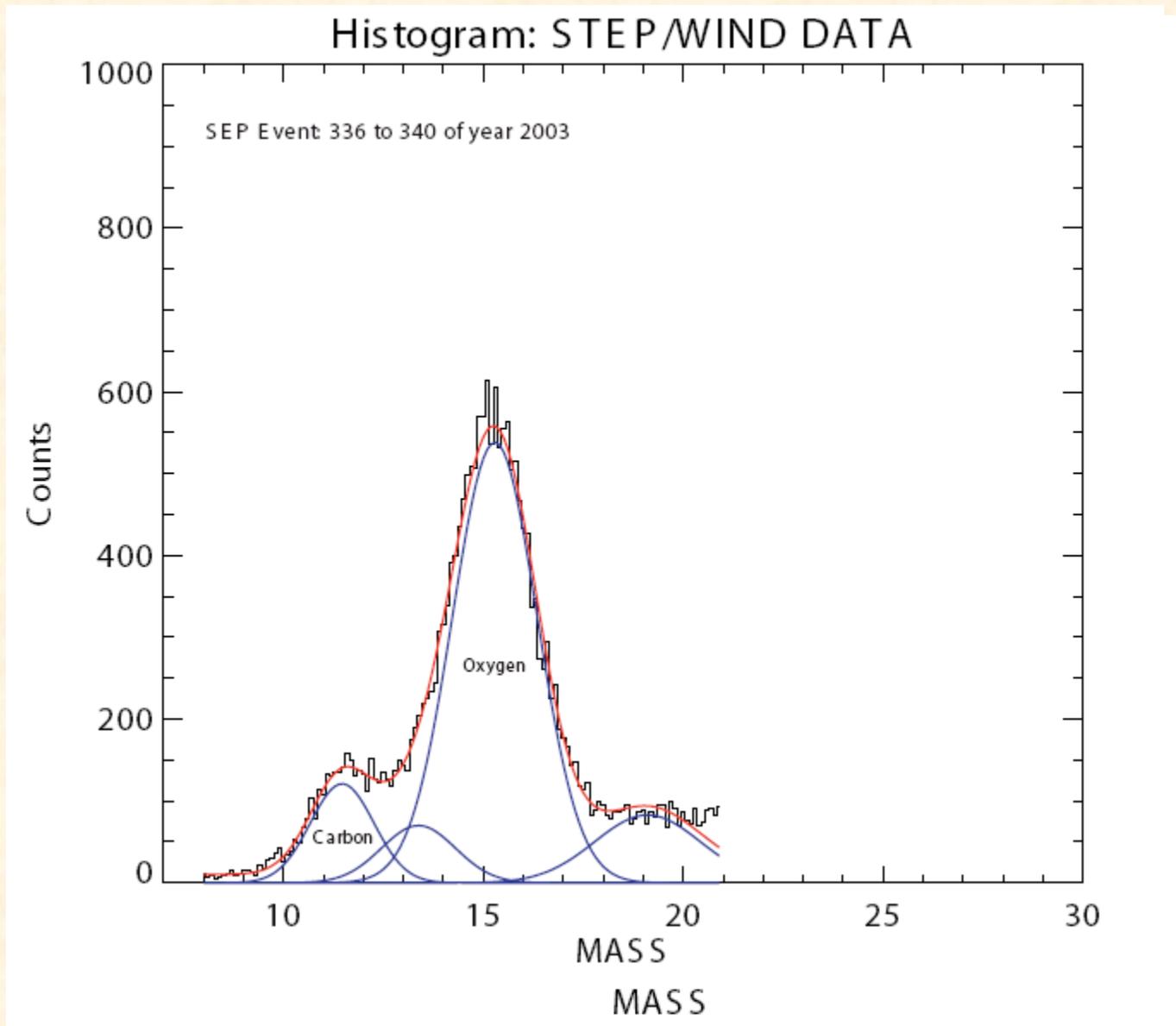
Time of Flight Mass Spectrometer

Measured species: Protons to Fe

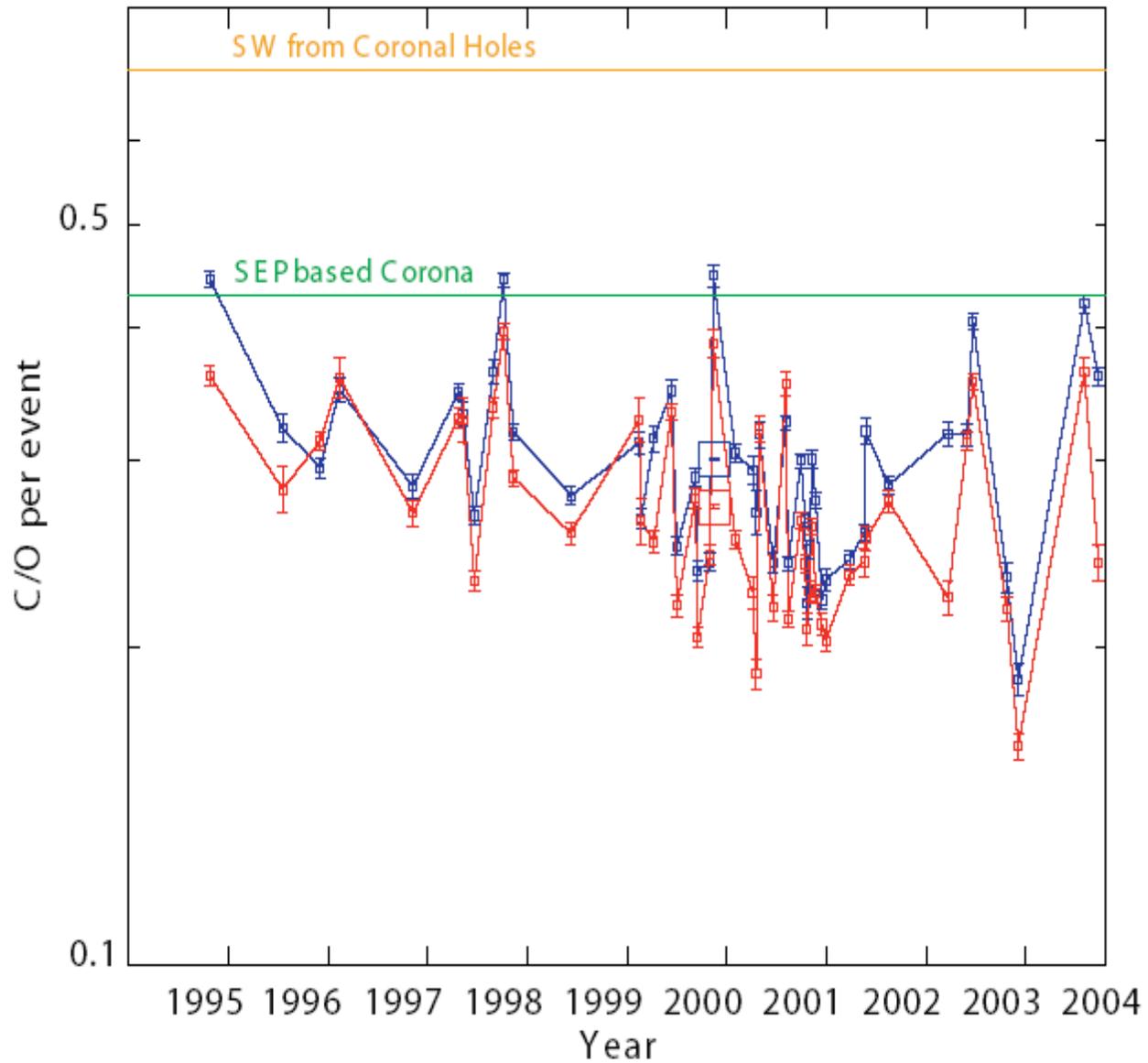
Energy range: ~30 keV to ~2 MeV/nuc

Instrument geometrical factor: $2 \times 0.4 \text{ cm}^2 \text{ sr}$

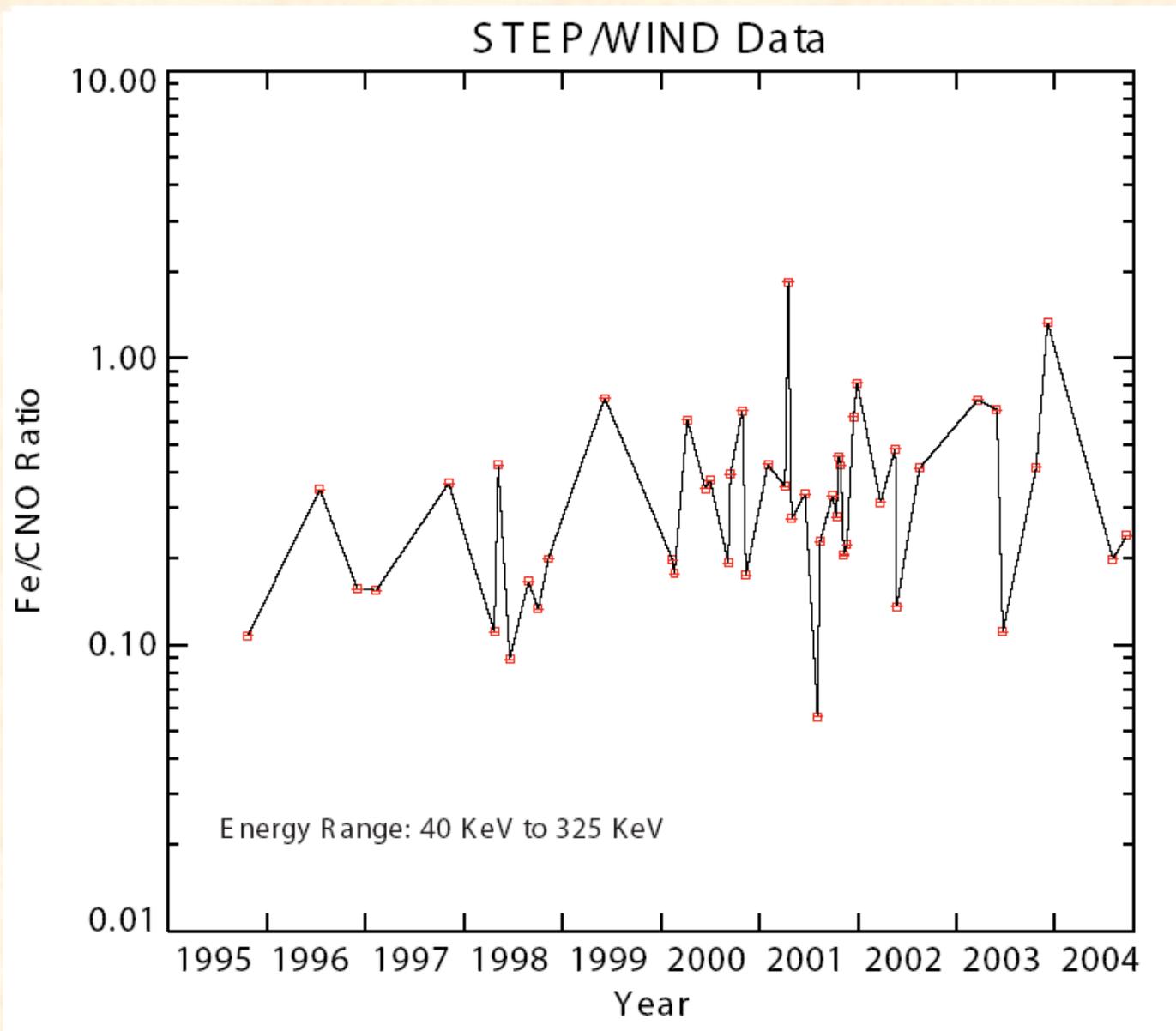
Extracting Carbon



STEP/WIND Data



Intensity Variations



Conclusions

Analysis shows that for gradual SEP events, the dependence of the C/O ratio ($0.04 \text{ MeV/nuc} < E < 0.5 \text{ MeV/nuc}$) abundance variation on the solar cycle is not clear due to the large individual event-to-event fluctuations exceeding a factor of two in some cases. However, the overall average is lower than the coronal values inferred from high energy measurements.

Low energy ($< 325 \text{ keV}$) Fe/CNO and NeS/CNO Abundance variation do not show cycle dependence. However, He/CNO shows an interesting feature at the peak of the solar maximum, more investigation need to be done.

Future work

We will identify source locations for the events and compare elemental abundance variability with source characteristics of the events (e.g. in coronal holes).

We will expand the energy range of the C/O up to few MeVs using ULEIS/ACE to see how it changes with the energy.

Using ULEIS, we will look for solar cycle variations in the SEP integrated fluxes at wider energy ranges.

We will expand our study to cover more elements and the recent time periods.

Thank you