Composition and spectral properties of the quiet-time suprathermal ion population

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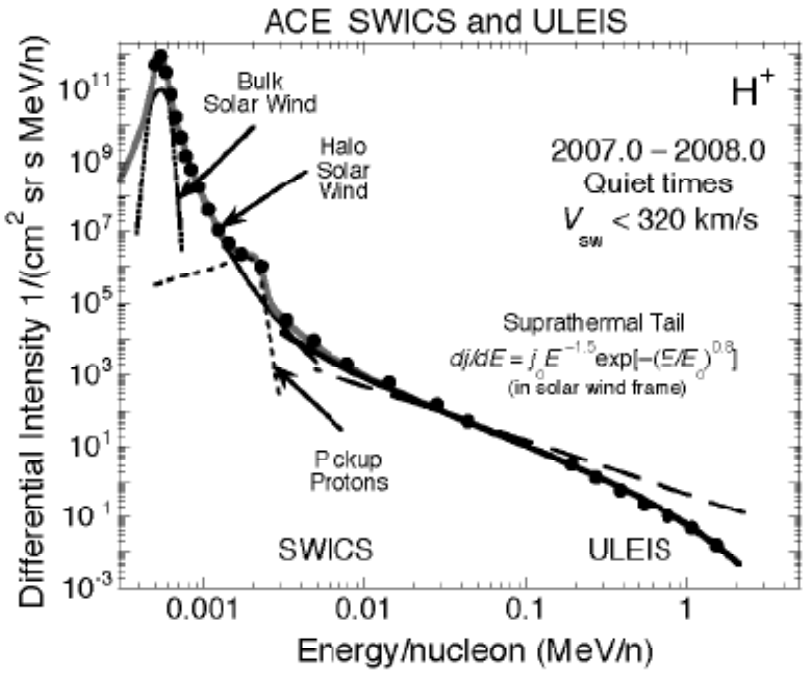


Figure 3. Differential intensity of protons at 1 AU measured with SWICS and ULEIS on ACE during quiet times in 2007. Quiet time periods were selected by requiring the solar wind speed to be below 320 km/s, during which times the tail particle intensities were at their lowest levels. The long-dashed line, shown for reference, is power law with spectral index –1.5.

Shown in Figure 3 is the differential intensity spectrum of protons measured from ~0.5 keV to ~1.5 MeV. The four components are clearly visible, but at 1 AU the proton core particles are predominantly the halo solar wind population and not the interstellar pickup protons whose detection at 1 AU is reported here for the first time.

The suprathermal tail, measured over an extensive energy range, shows a gentle rollover at an energy $E \approx 1$ MeV. The bold black curve, an isotropic model tail spectrum in the solar wind frame of the form

$$dj/dE = j_o E^{-1.5} \exp[-(E/E_o)^{0.63}] \quad (1)$$

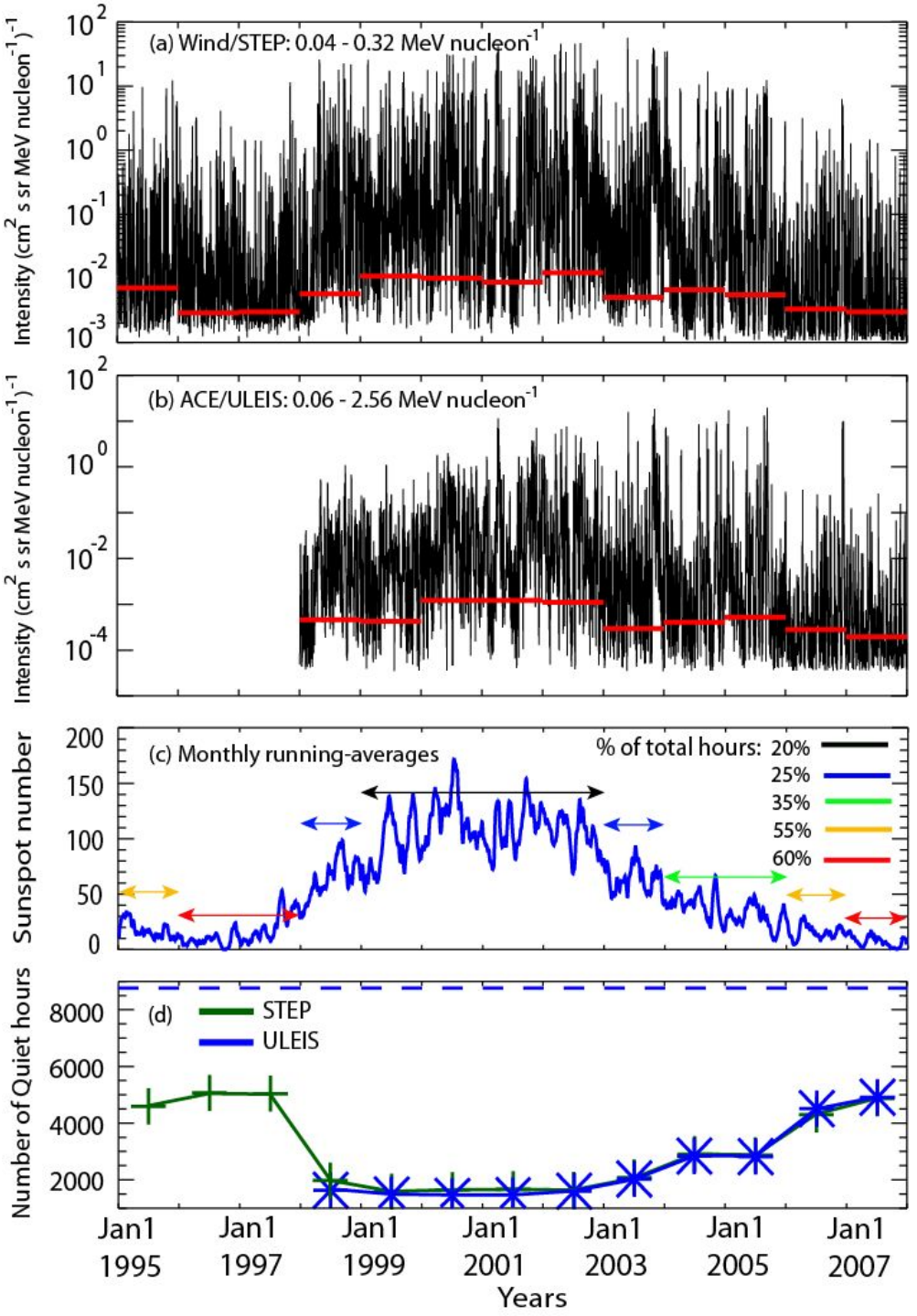
that has been transformed to the spacecraft frame, fits the data well. The frame transformation causes the spacecraft-frame spectrum at energies below ~50-100 keV to become steeper, as does the rollover that begins at ~100 keV.

Quiet Times:

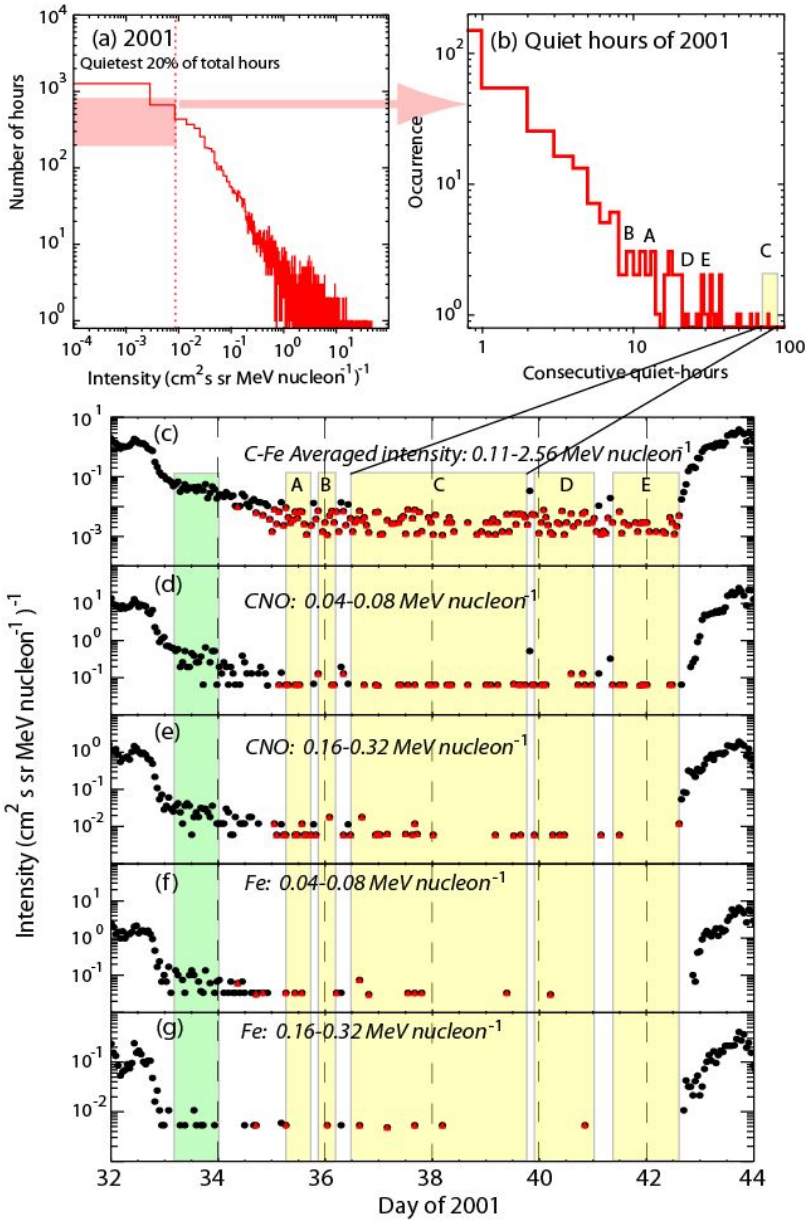
-Energy dependent

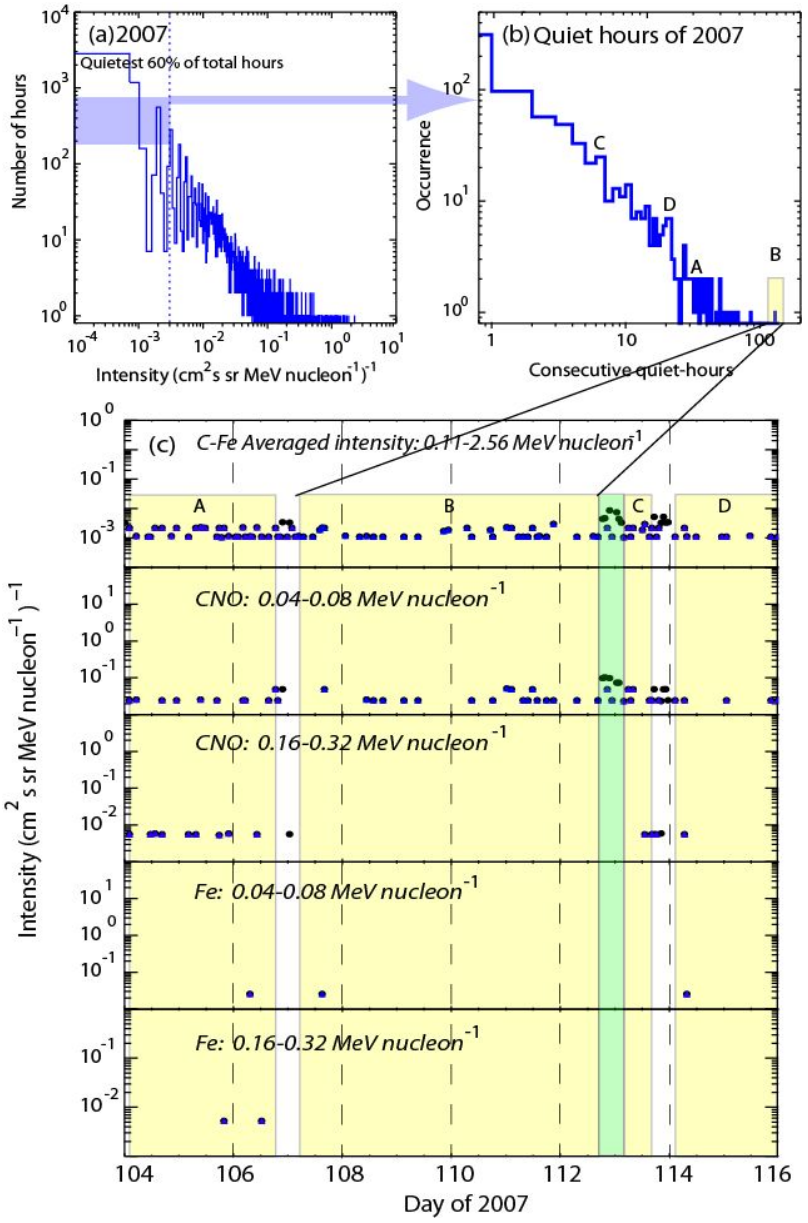
-Quiet “level” changes with solar activity

We defined the quiet-times to be a certain variable fraction (between ~20 – 60 %) of the hours that represent the lowest values of the heavy ion (C-through-Fe) intensity

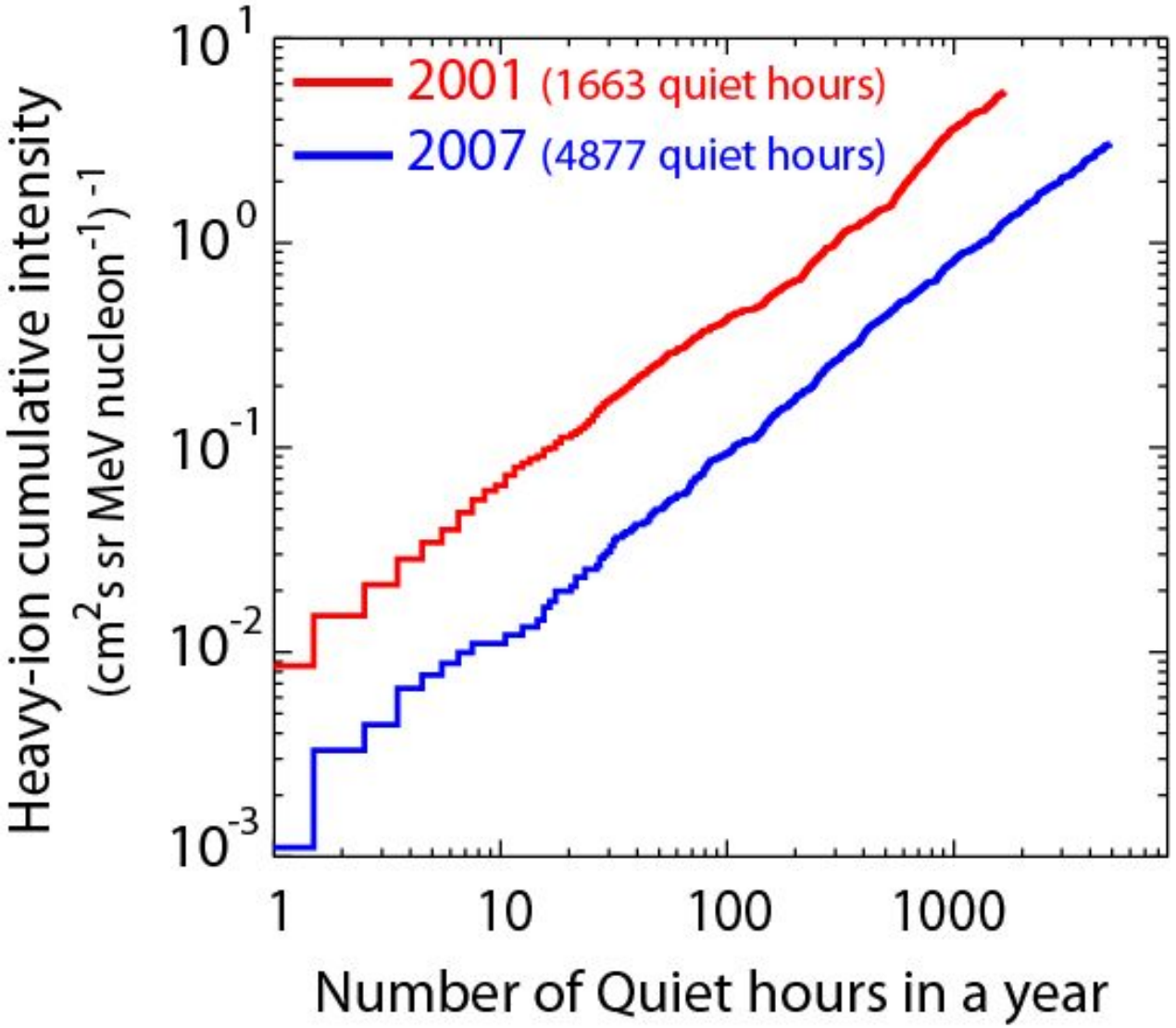


Examples of quiet times





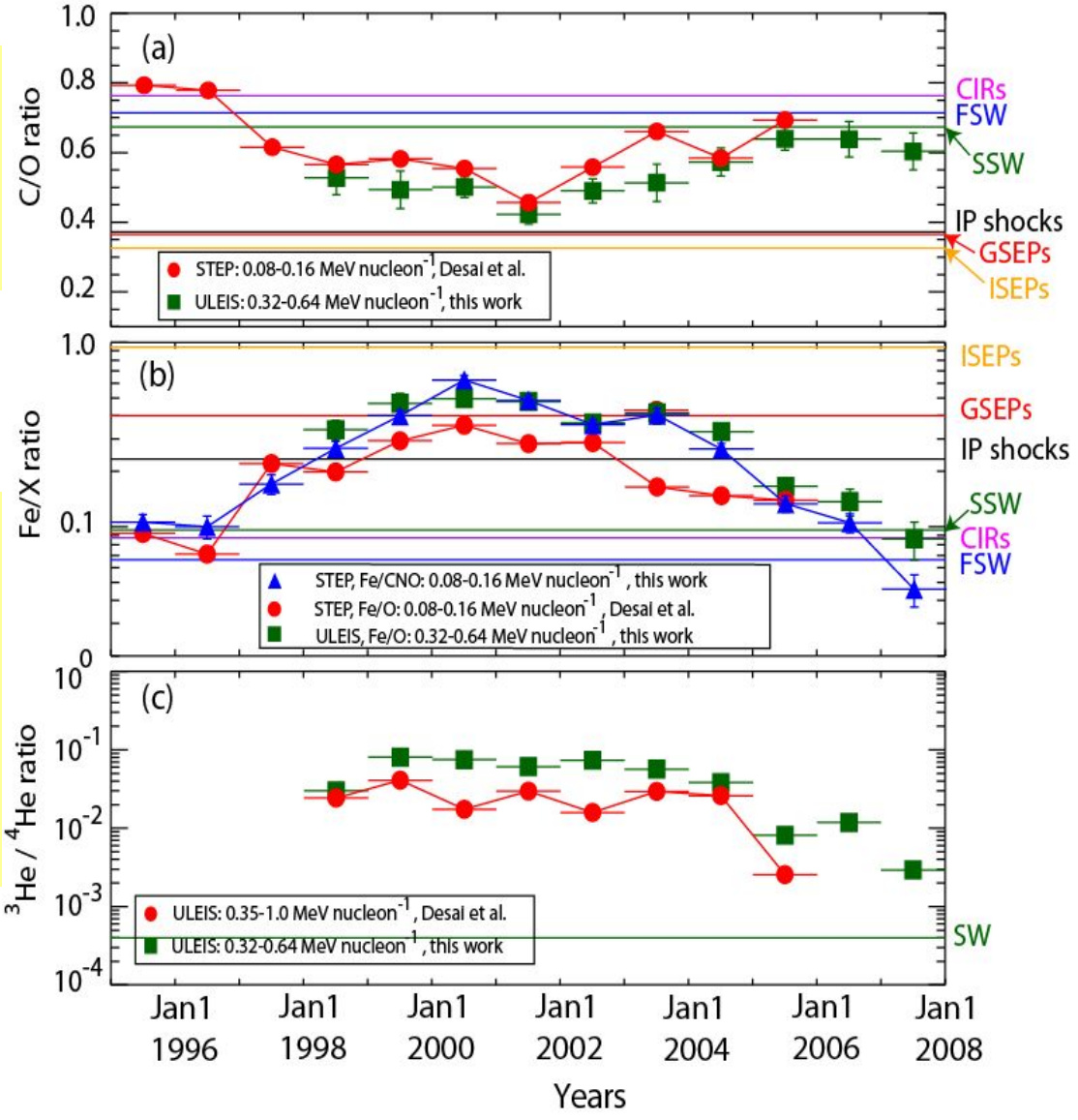
Cumulative intensity of Quiet Hours



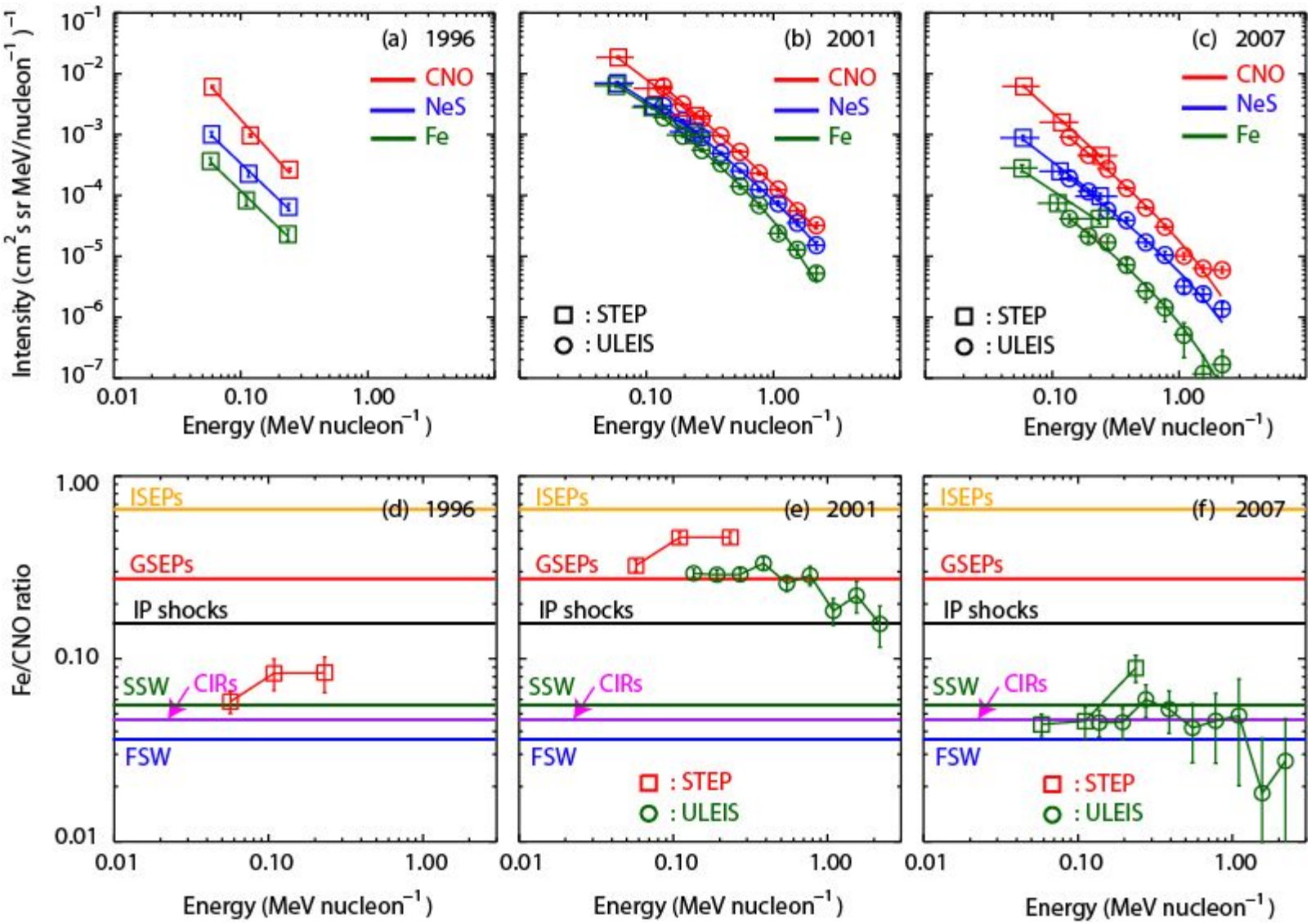
Heavy ion composition

- SW/CIR - like during solar min; SEP- like during solar max.

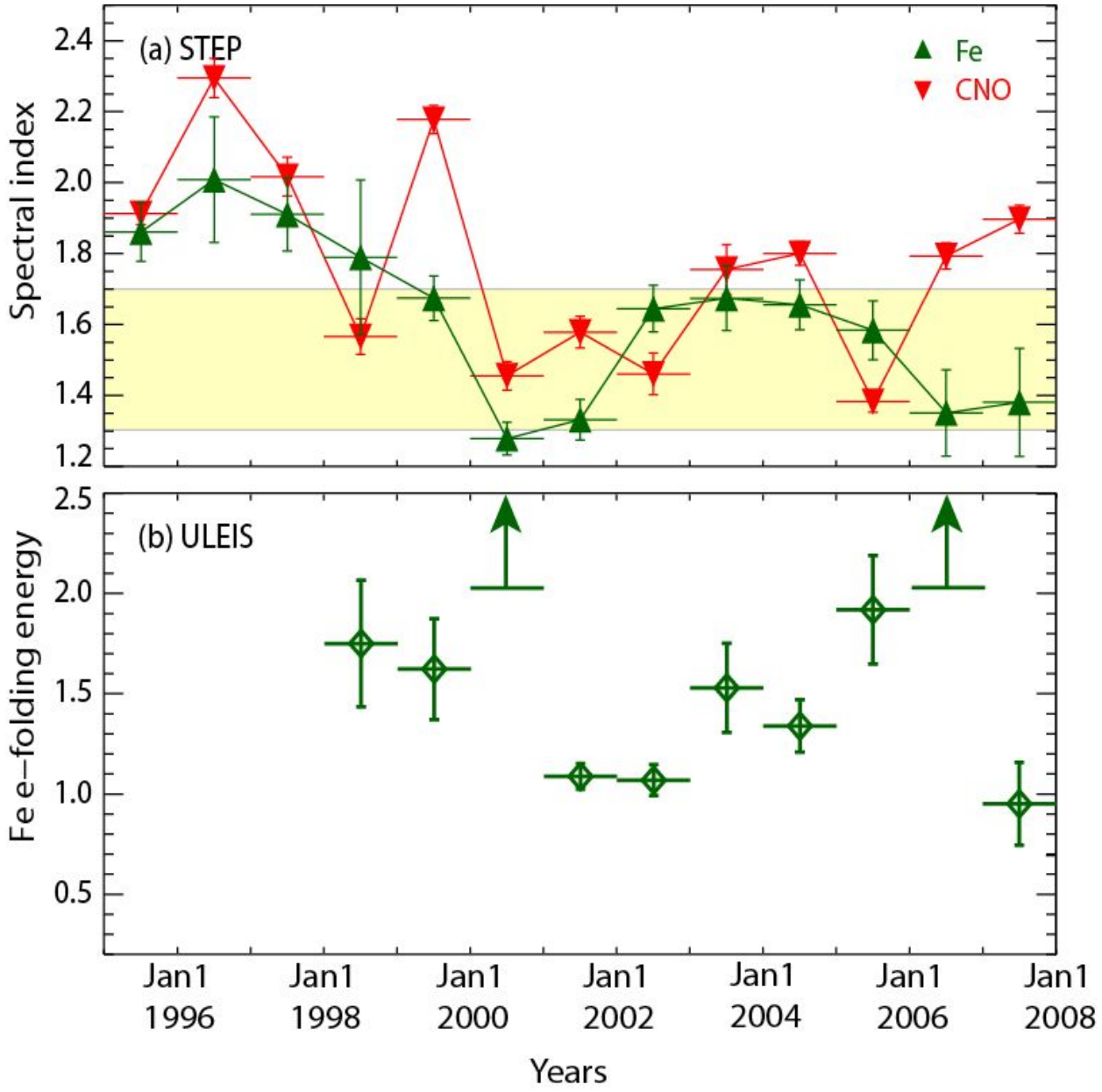
- Although it shows solar cycle dependence, $^3He/^4He$ is well-enhanced above the SW value during all years



Spectral properties



Spectral indices



Summary and Conclusions

(1) Quiet-time Fe/O and C/O abundances are correlated with solar cycle activity, similar to SEP and IP shocks during solar maximum, and SW & CIR values during solar minimum.

(2) The 3He/4He ratio lies in the 3%-8% range during the quiet times of 1998-2004 and drops to 0.3%-1.2% during 2005-2007.

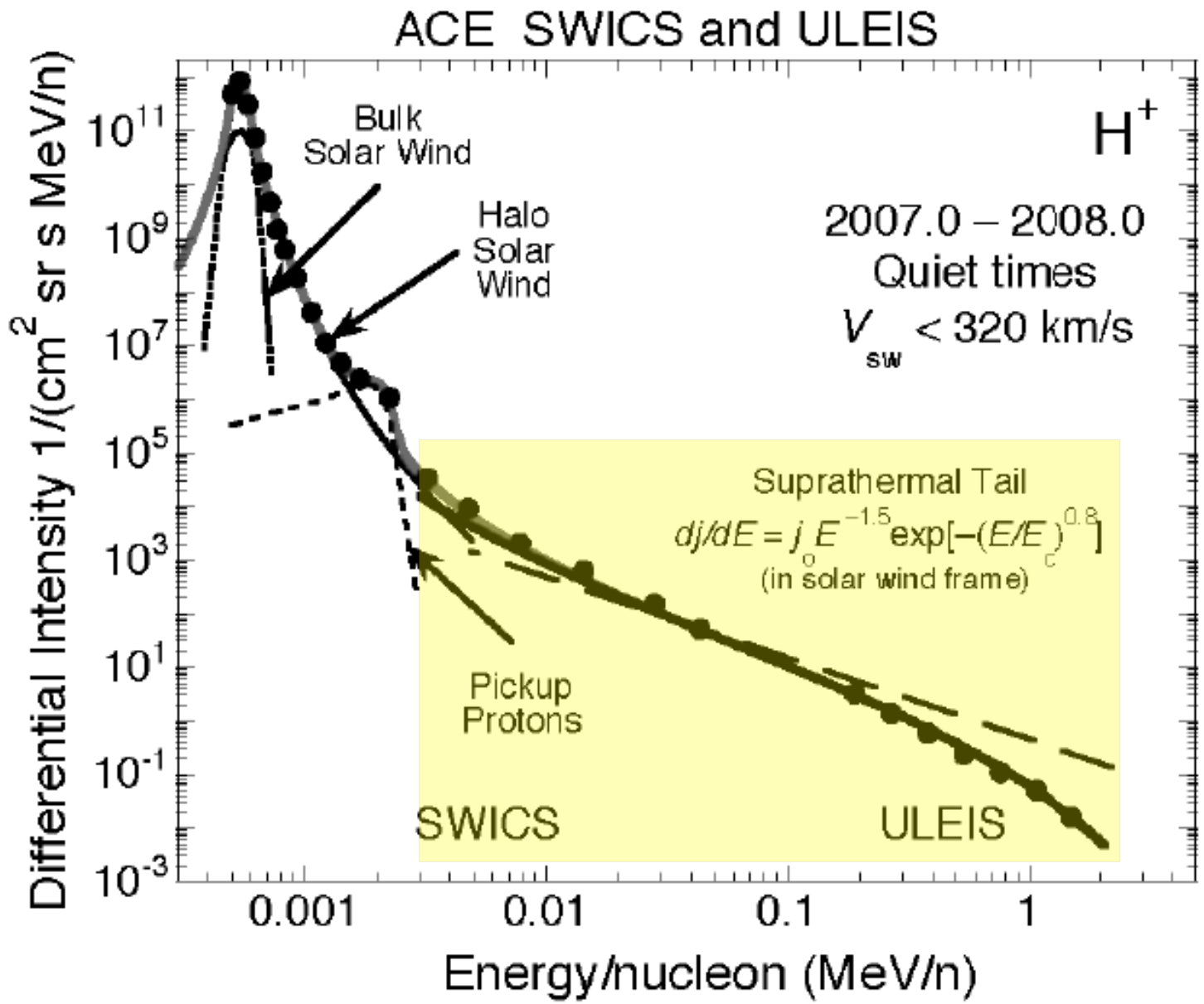
(3) During quiet times, ^{3}He is present ~27% of the time during 1998-2003, and ~5% during 2005-2007.

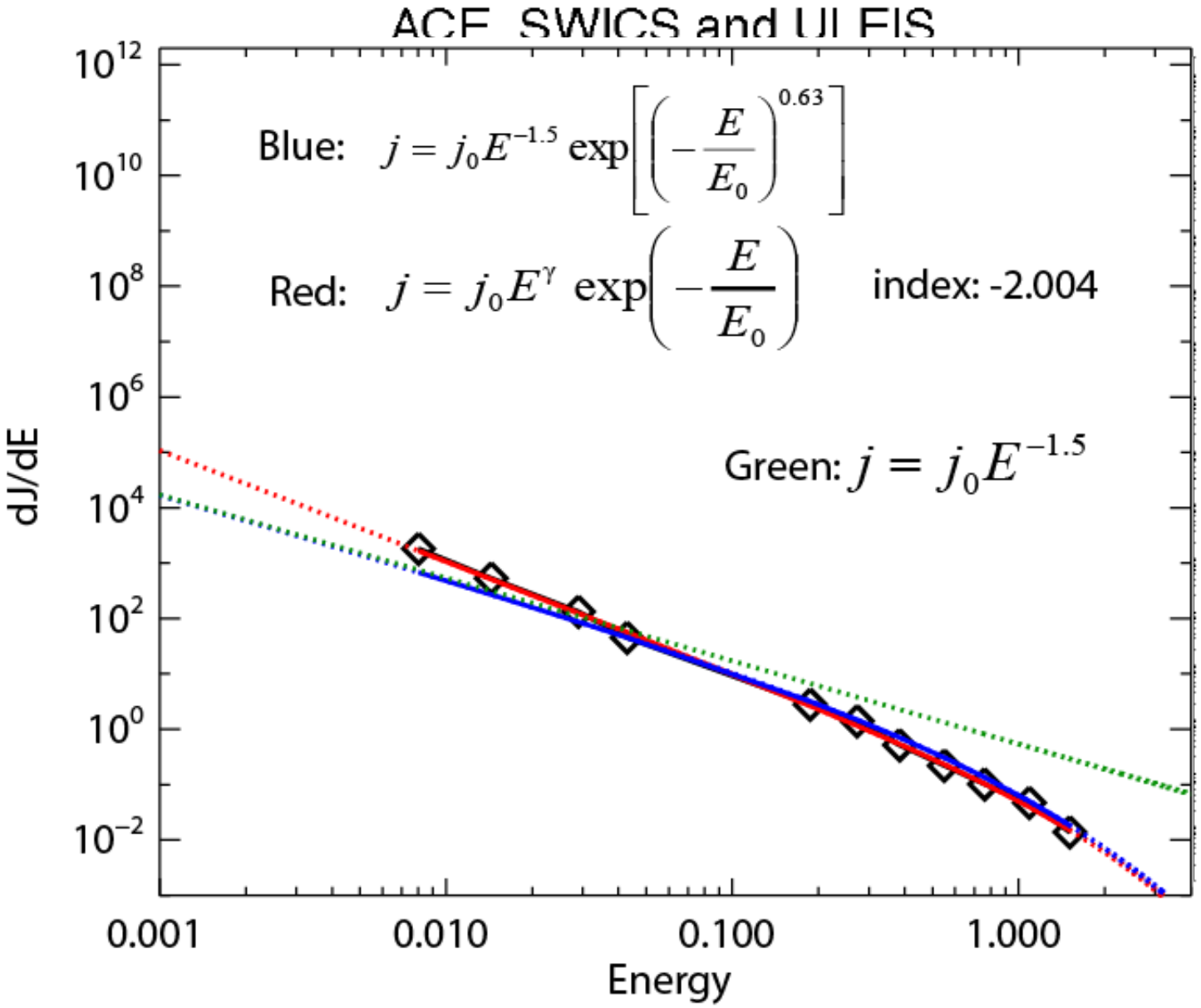
(4) All heavy ion species exhibit suprathermal tails between 0.04–0.32 MeV/n. with spectral indices ranging from ~1.27 to 2.29. These tails sometimes extend above ~2 MeV nucleon^{-1}.

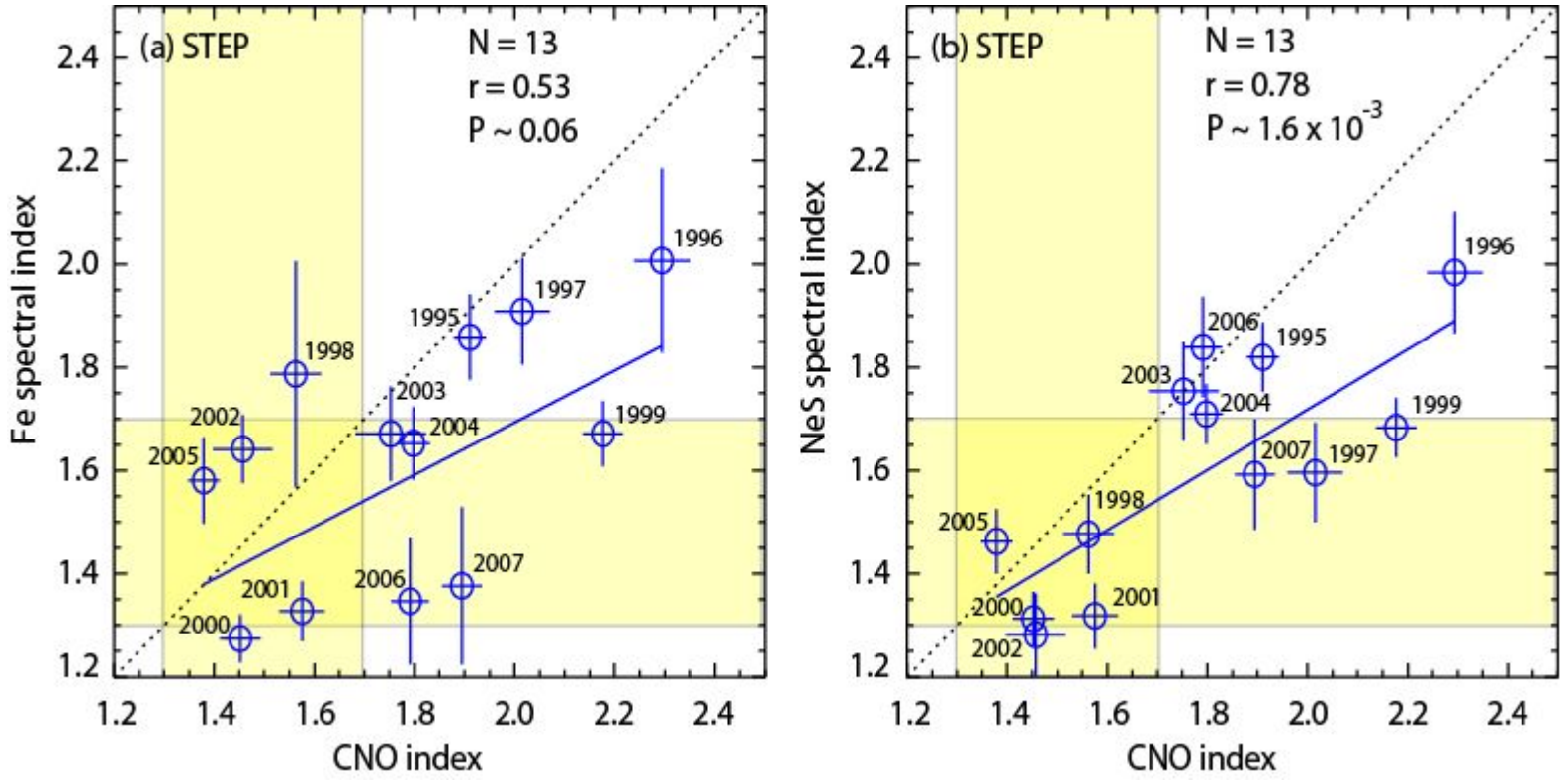
(5) For about ~50% of the time, heavy ion spectral indices deviate significantly from the 1.5 value predicted by Fisk and Gloeckler (2007).

These observations provide evidence that even during the quietest times in interplanetary space, the suprathermal population (3He and C-through-Fe) consists of ions from *different sources* whose relative contributions vary with solar activity.

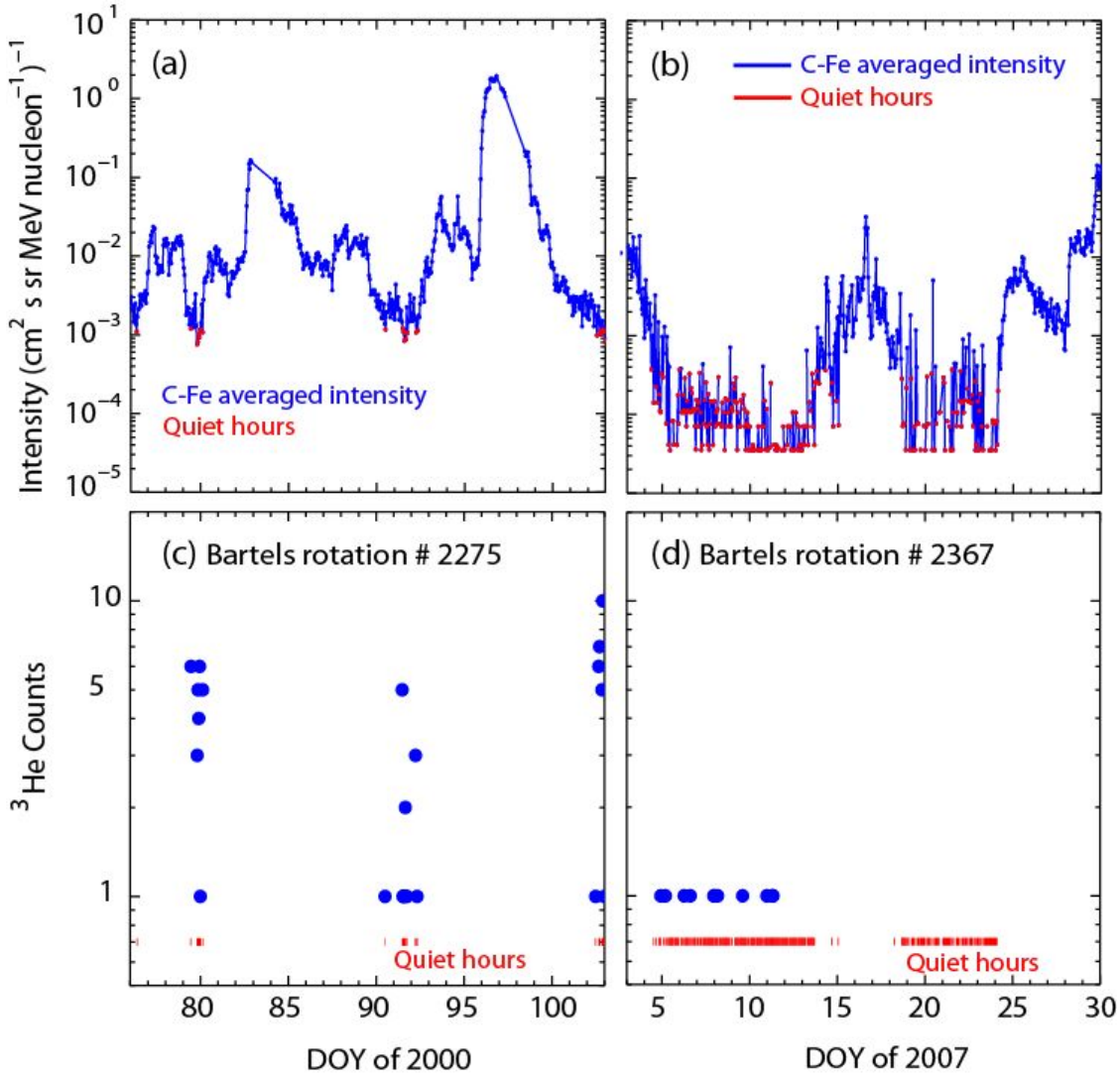
Thank you


ACE SWICS and ULEIS
Differential Intensity 1/(cm^2 sr s MeV/n)
Energy/nucleon (MeV/n)
10^{11}
10^{9}
10^{7}
10^{5}
10^{3}
10^{1}
10^{-1}
10^{-3}
0.001
0.01
0.1
1
Bulk Solar Wind
Halo Solar Wind
Pickup Protons
H$^+$
2007.0 – 2008.0
Quiet times
V_{SW} < 320 km/s
Suprathermal Tail
$dj/dE = j_o E^{-1.5} \exp[-(E/E_c)^{0.8}]$
(in solar wind frame)
SWICS
ULEIS


ACE SWICS and ULEIS
Blue: $j = j_0 E^{-1.5} \exp\left[\left(-\frac{E}{E_0}\right)^{0.63}\right]$
Red: $j = j_0 E^{\gamma} \exp\left(-\frac{E}{E_0}\right)$
index: -2.004
Green: $j = j_0 E^{-1.5}$
dJ/dE
10^{12}
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
10^{0}
10^{-2}
0.001
0.010
0.100
1.000
Energy


(a) STEP
N = 13
r = 0.53
P ~ 0.06
Fe spectral index
CNO index
1996
1997
1995
1998
2003
2004
1999
2002
2005
2001
2000
2006
2007
(b) STEP
N = 13
r = 0.78
P ~ 1.6 x 10^-3
NeS spectral index
CNO index
1996
2006
1995
2003
2004
1999
2007
1997
1998
2005
2000
2001
2002

^{3}He composition



^{3}He composition