

In-situ Observations of CIRs on STEREO and ACE during 2007-2009

G. M. Mason, JHU/APL

Mihir Desai, SWRI

Urs Mall and Radoslav Bucik, MPS, Lindau

Kristin Simunac, Univ. New Hampshire

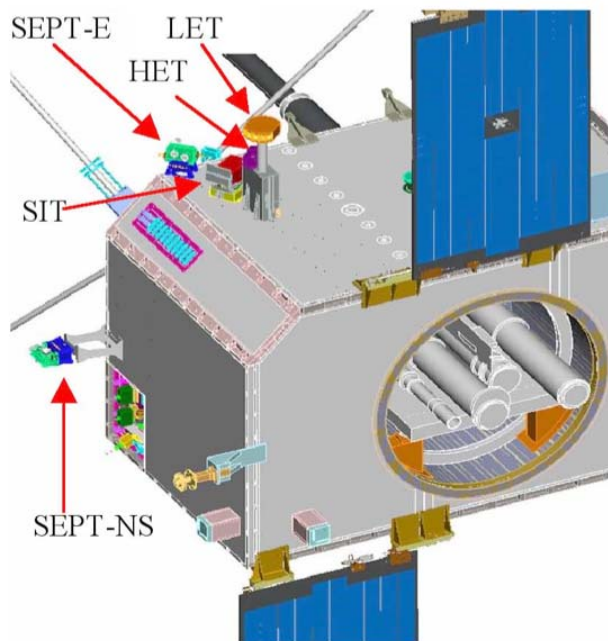
Rick Leske, Caltech

STEREO Science Working Group - 20

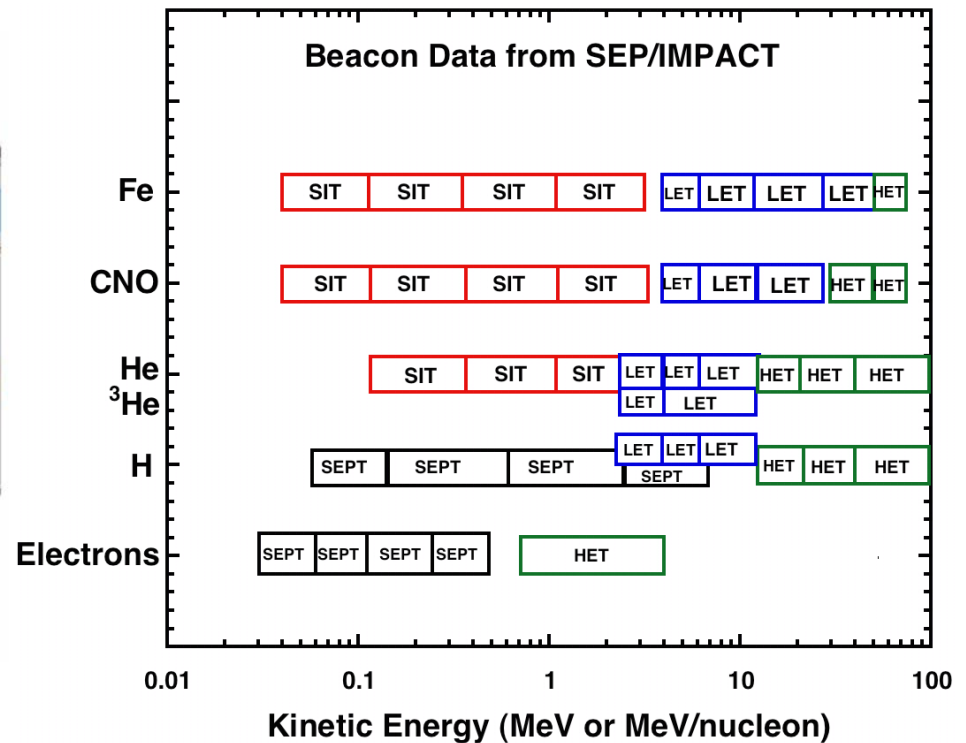
Meredith, NH Oct. 27-29, 2009

Solar Enegetic Particle (SEP) package -

(Part of the IMPACT suite, J. Luhmann, PI)

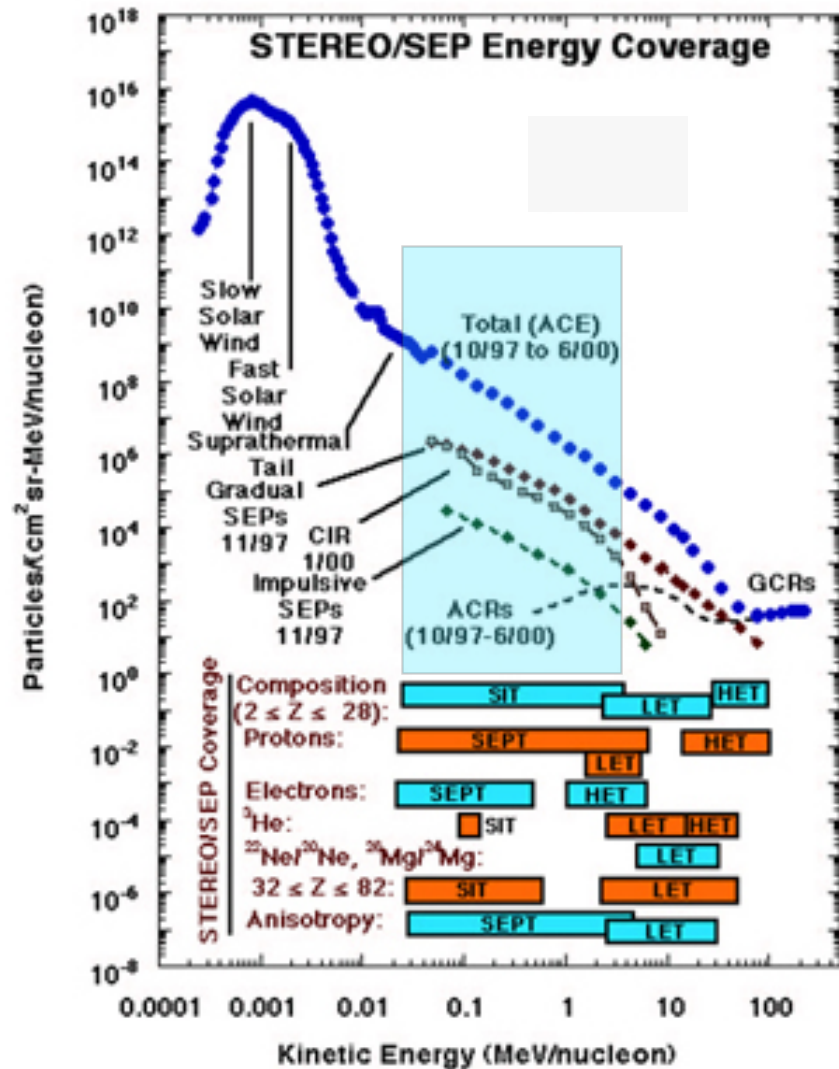
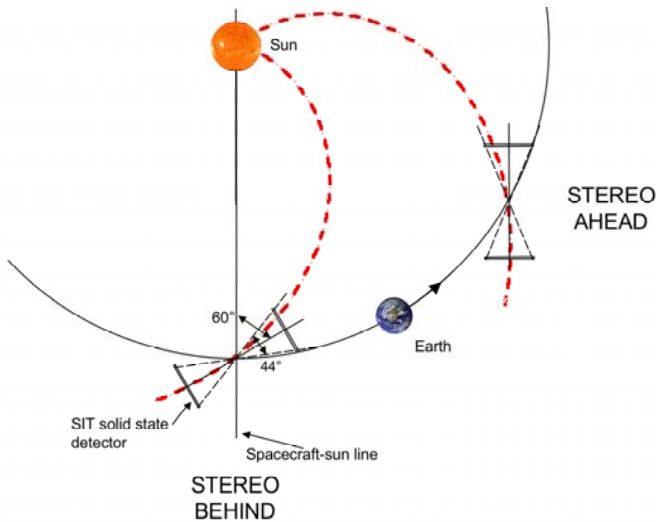
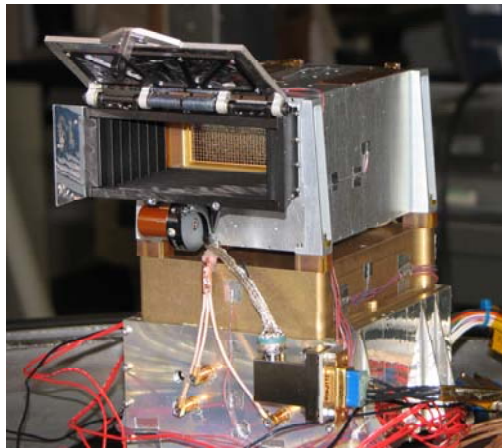


(SEP package on STEREO-A)

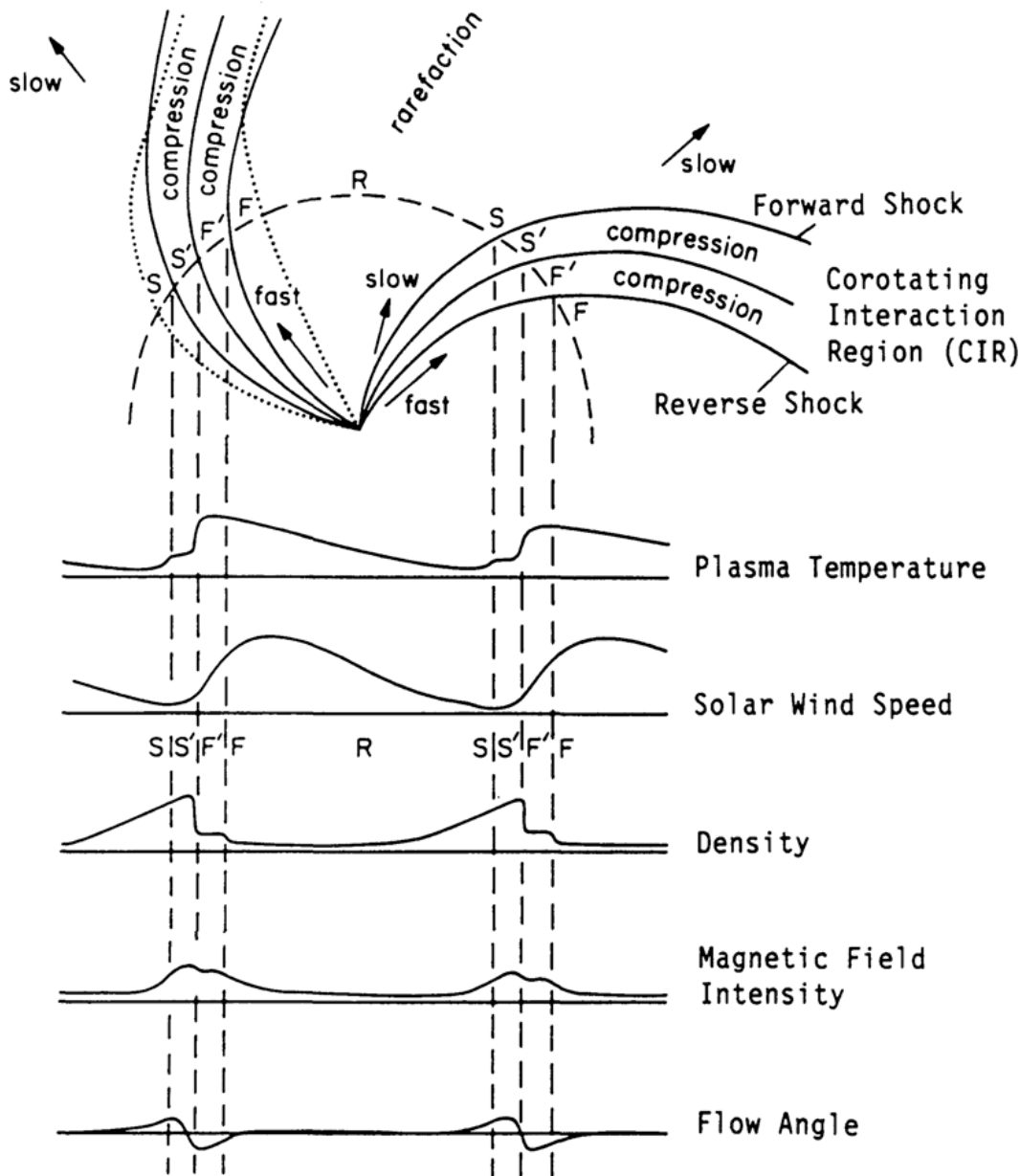


figures from Mewaldt et al., SSR, 136, 285, 2008

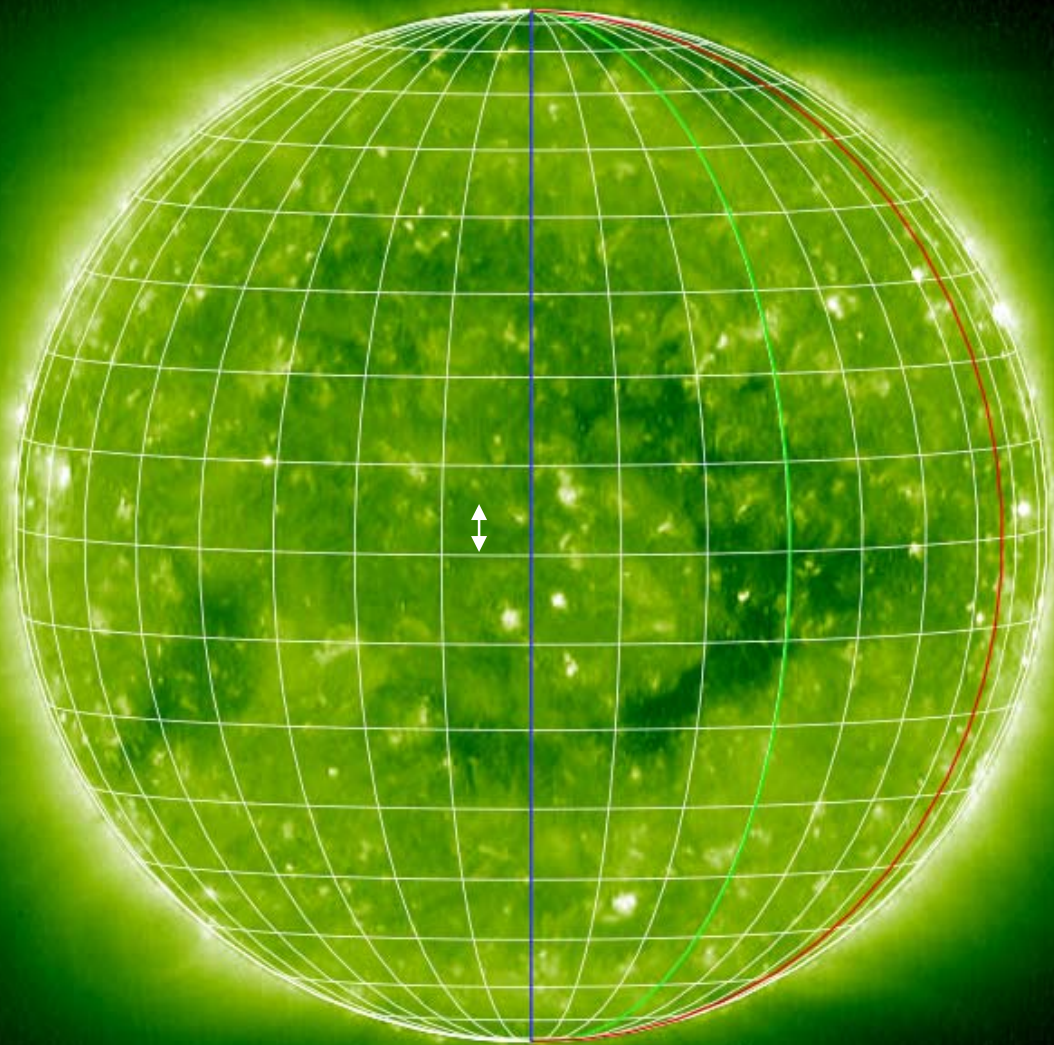
Suprathermal Ion Telescope - SIT:



instrument description: Mason et al., SSR, 136, 257, 2008.



Solar wind and magnetic field signatures of CIRs



Stereo-B SECCHI
19.5nm image

Aug 7, 2007
00:06:32

(day 220)

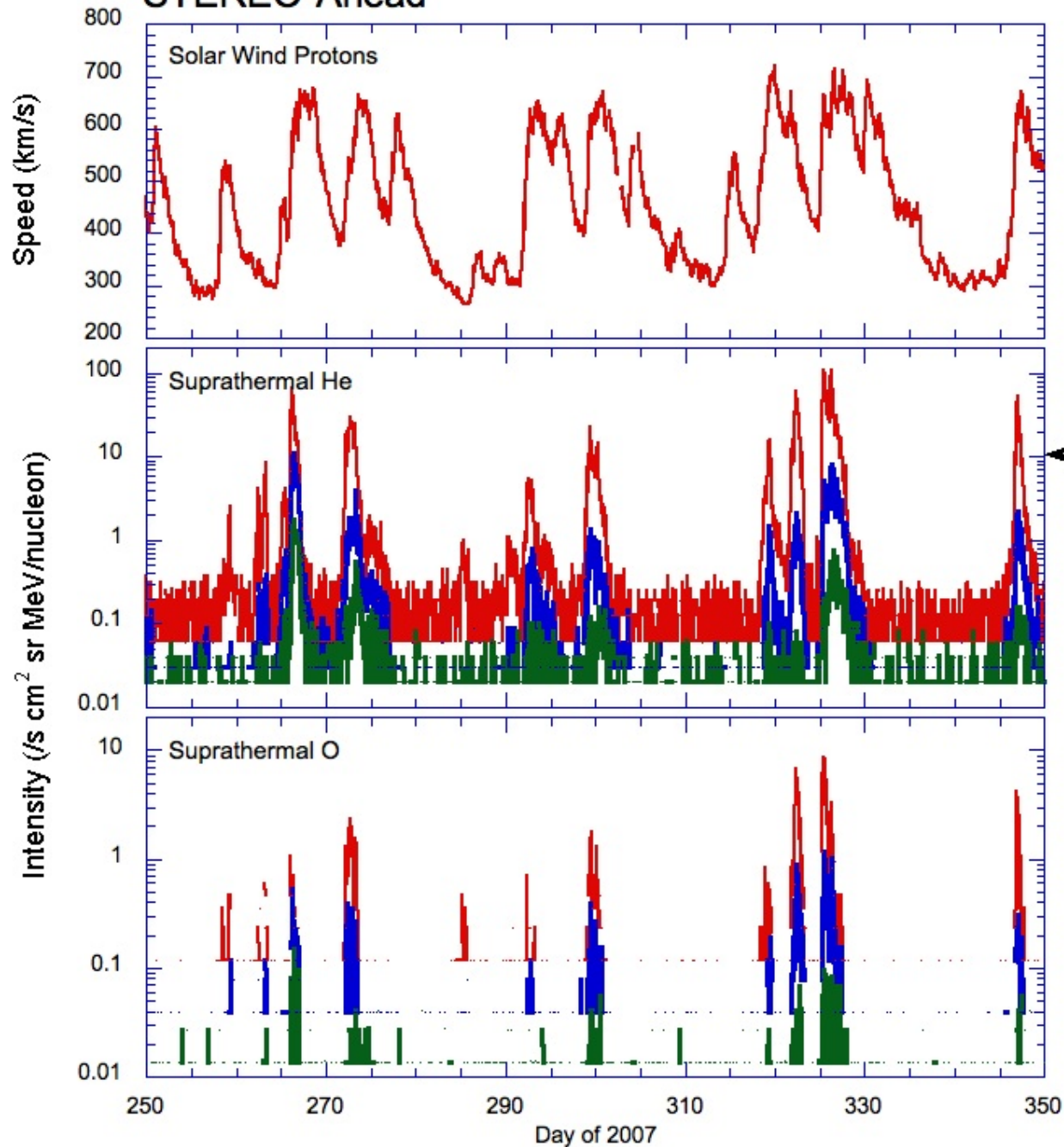
10 degree heliographic
grid overlay as seen
from STEREO-B

Central meridian seen
from STEREO-B is in
blue; green as seen
from Earth; red as seen
from STEREO-A

Solar Weather Browser
image

Stereo A is at 8.98°
latitude; B at 3.78° ; so
the 5.2° difference is
about one-half of a grid
spacings. The hole at
about E45 is probably
the one seen by
STEREO-B on day 224-
26, and was probably
missed by STEREO-A
since it's trace is about
 5° , north of B, a size
shown by the double
headed arrow at E5

STEREO-Ahead



top panel: plastic sw proton speed

middle panel: SIT He, for 189, 384, and 787 keV/nucleon

arrow marks selection threshold

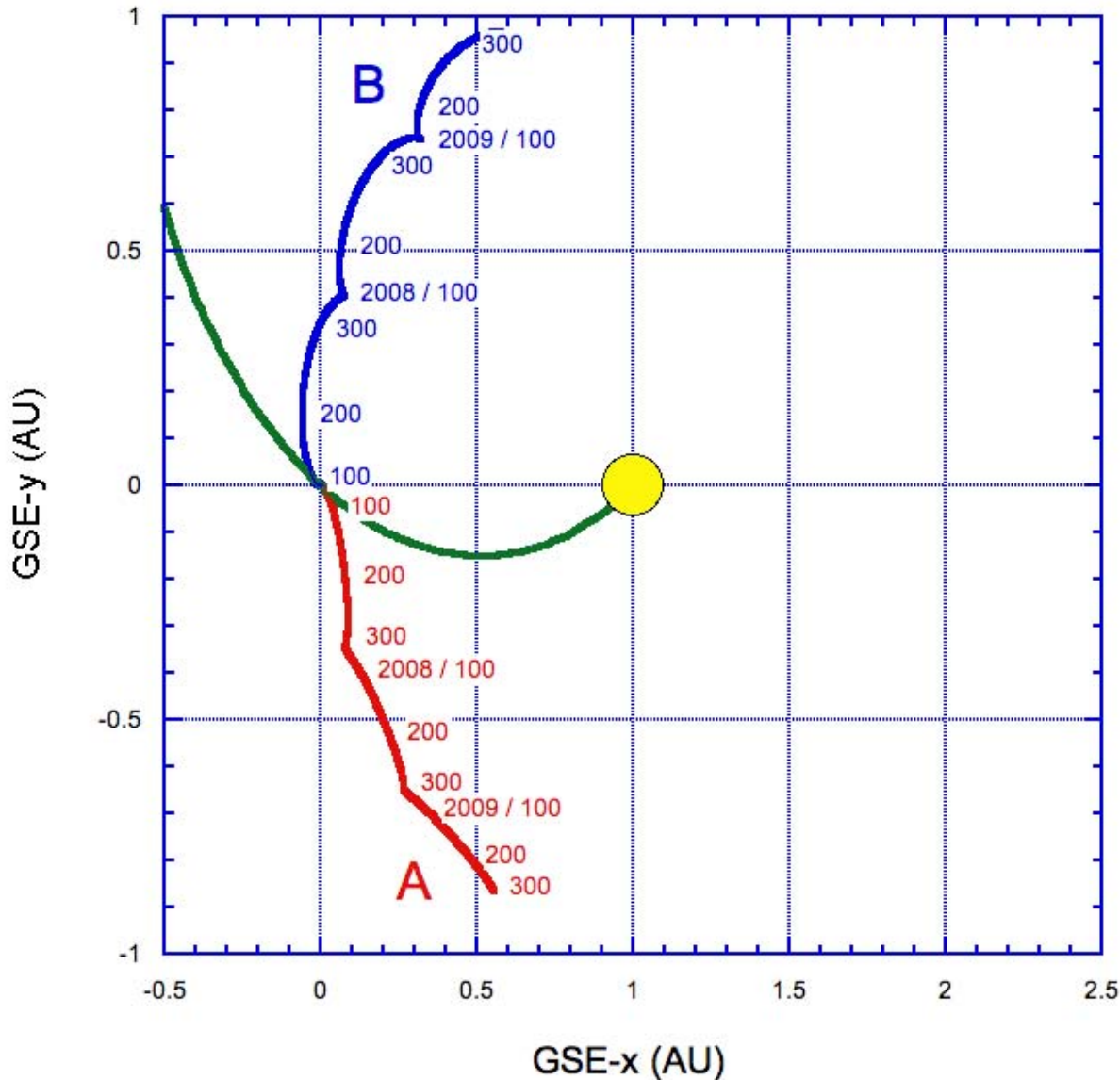
figure shows events 15-21 in Table 1. Note increases starting on days 258, 261, 284 and 291 are below the selection threshold and so are not in the table

bottom panel: SIT O for 67, 136, and 266 keV/nucleon

note high speed streams with no suprathermals around day 305, 315, and 330



STEREO positions through 2009/354 with 650 km/s spiral field line



STEREO position
angles 11/1/09:

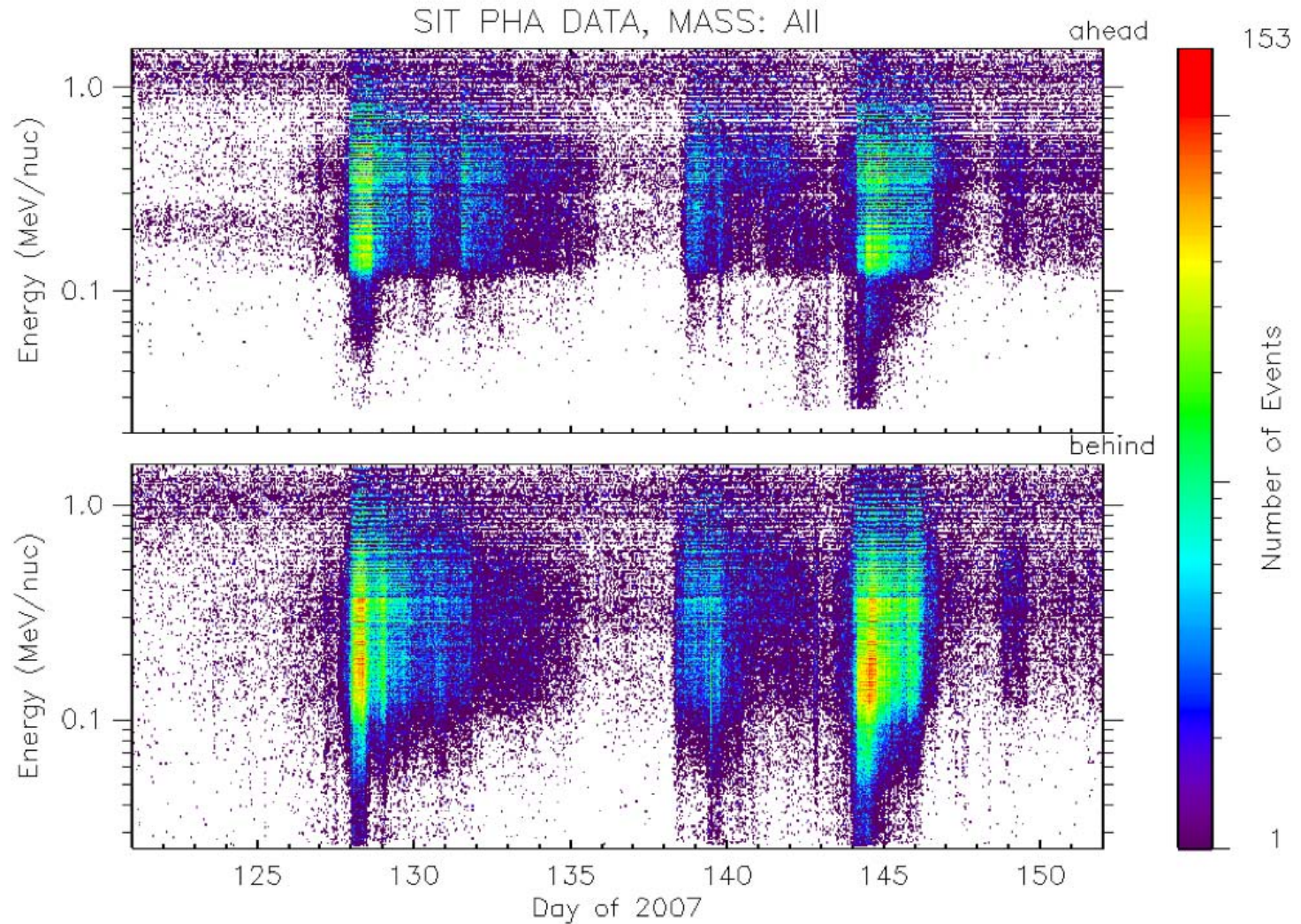
B to earth: 61.0°

A to earth: 62.7°

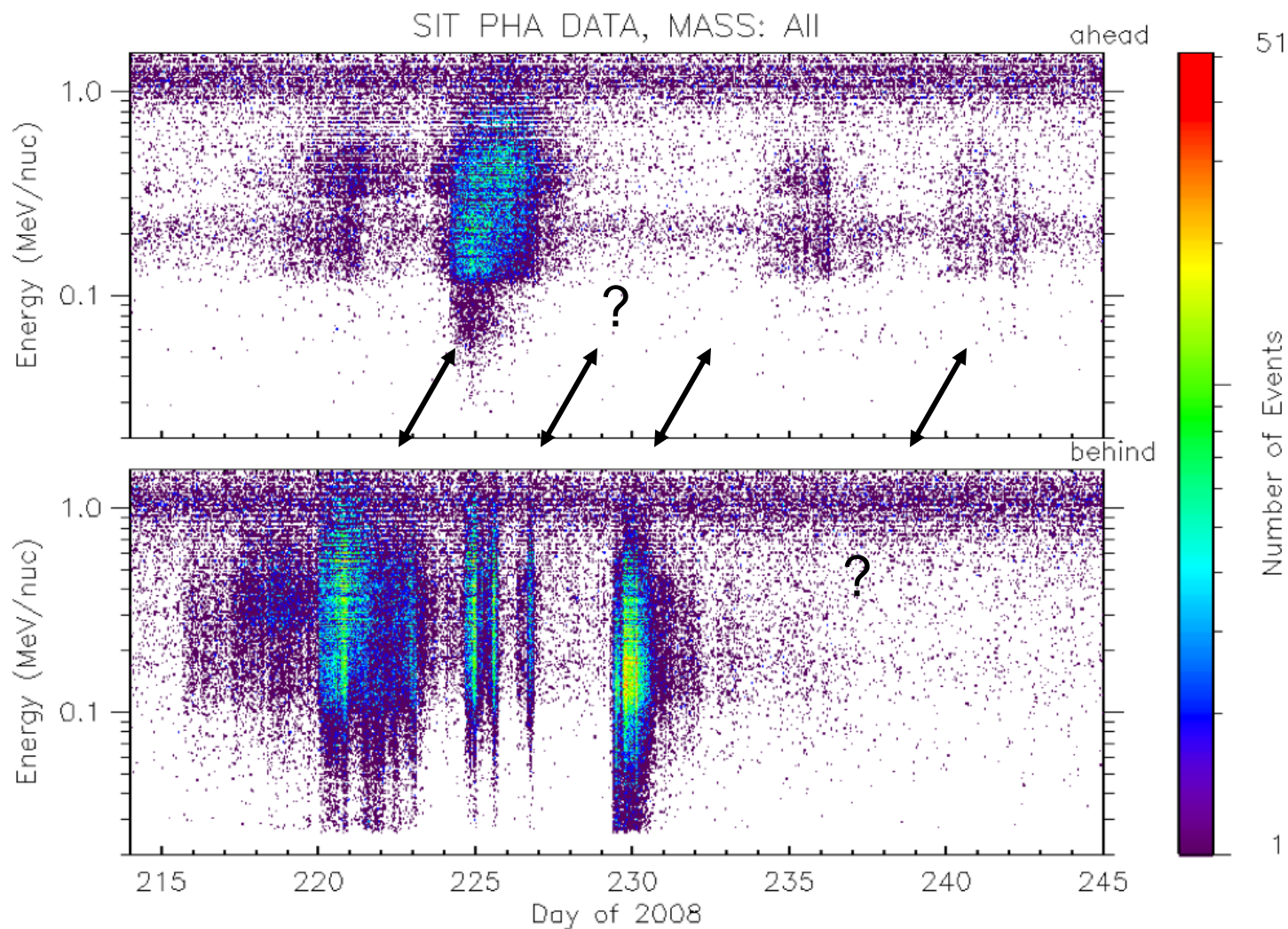
B to A: 123.7°

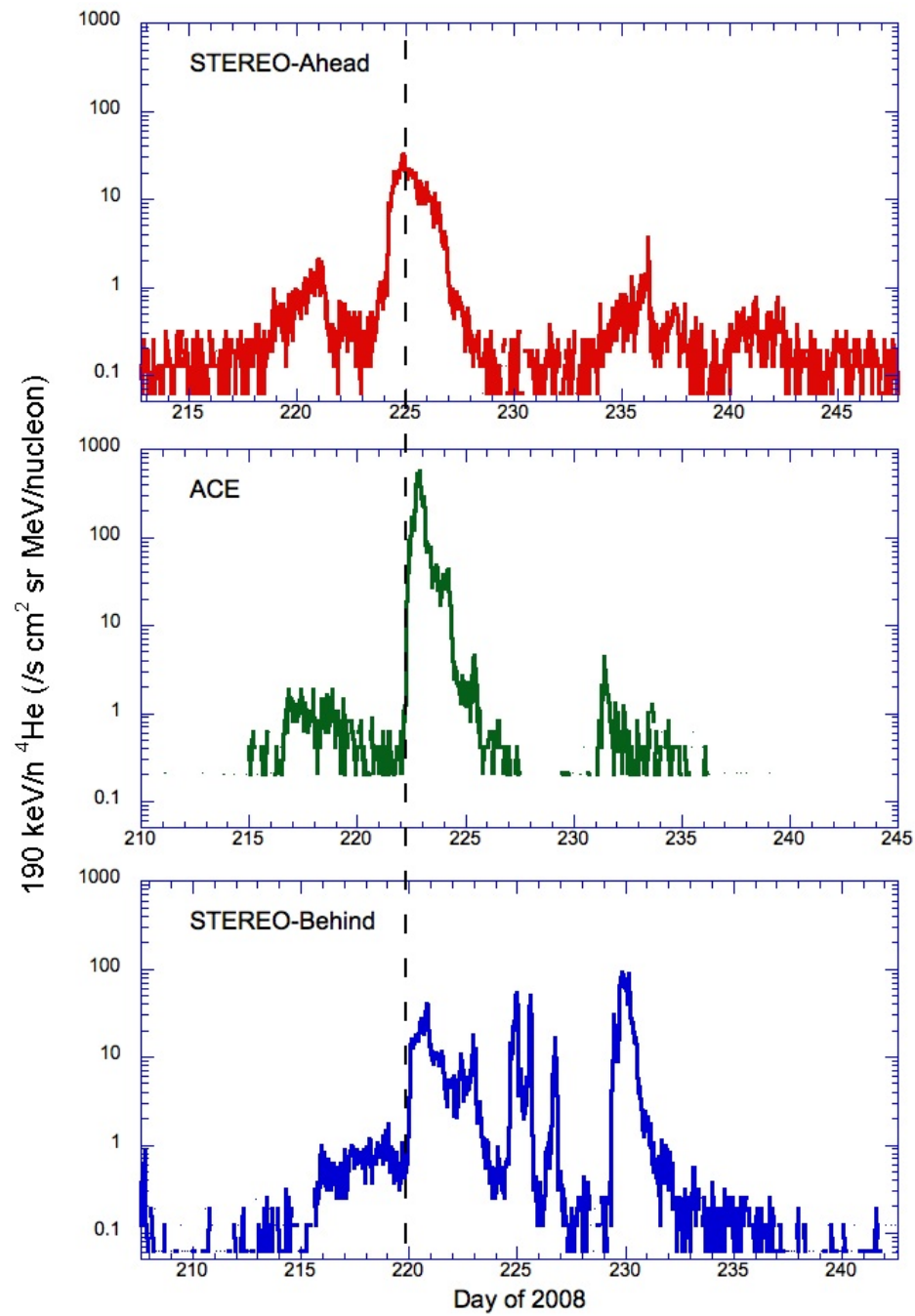
(~9.3 days
corotation
difference)

Spectrograms from -A and -B in spring 2007...quite similar



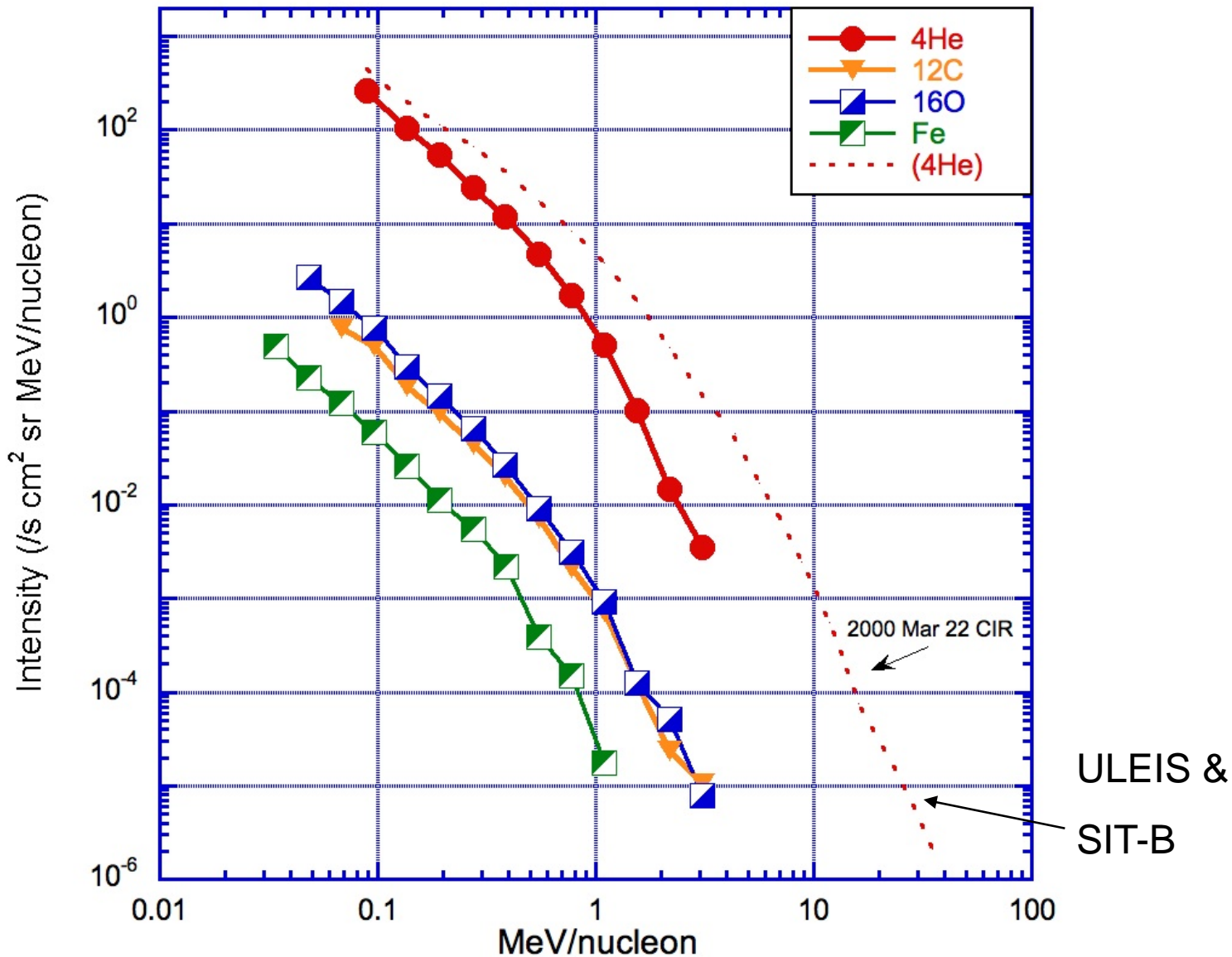
Aug. 2008 spectograms (~5 days corotation) ... some features shifted as expected, others not seen on both S/C

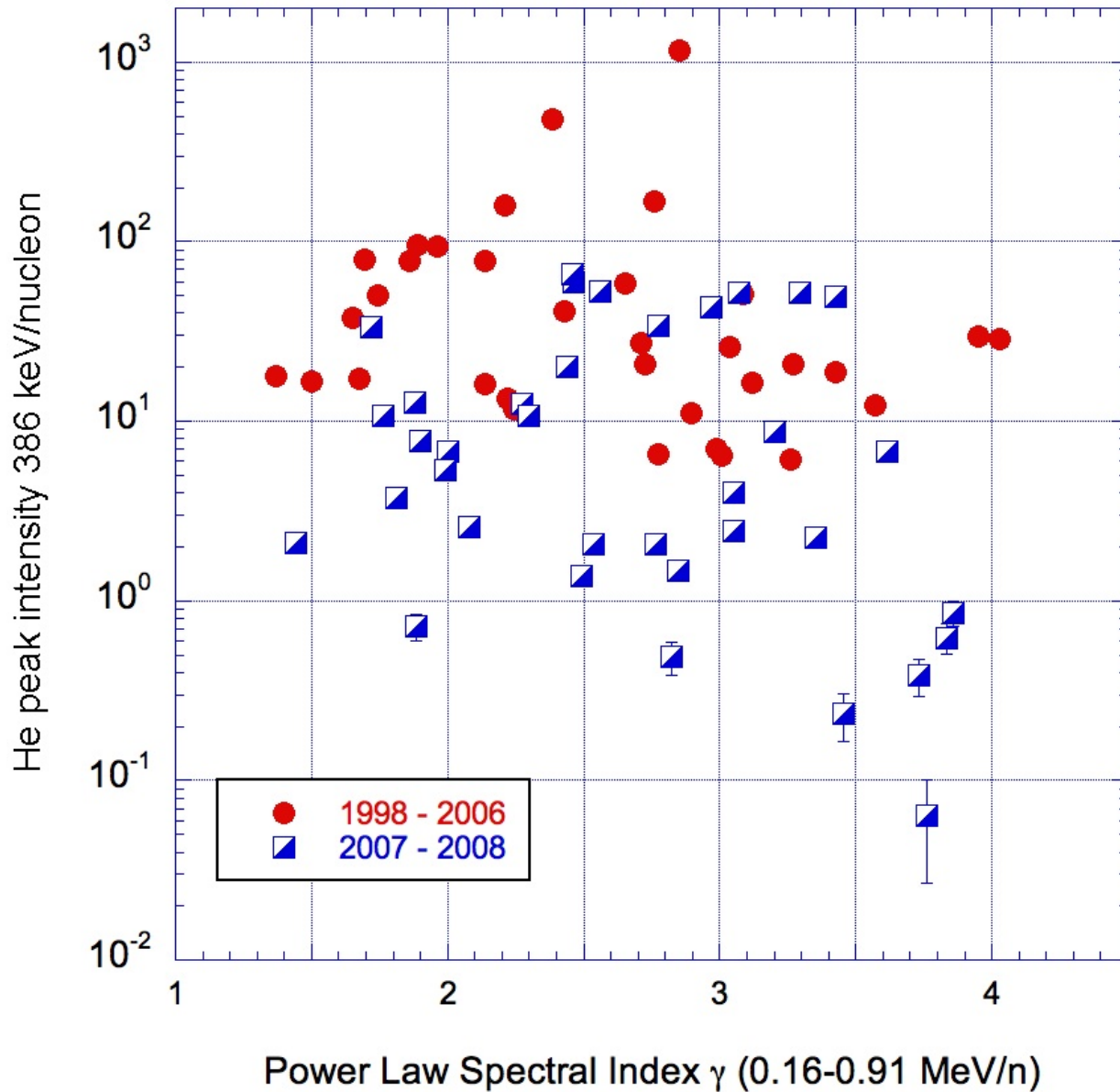




Spectral forms: broken power law--

2008 Feb 10 CIR

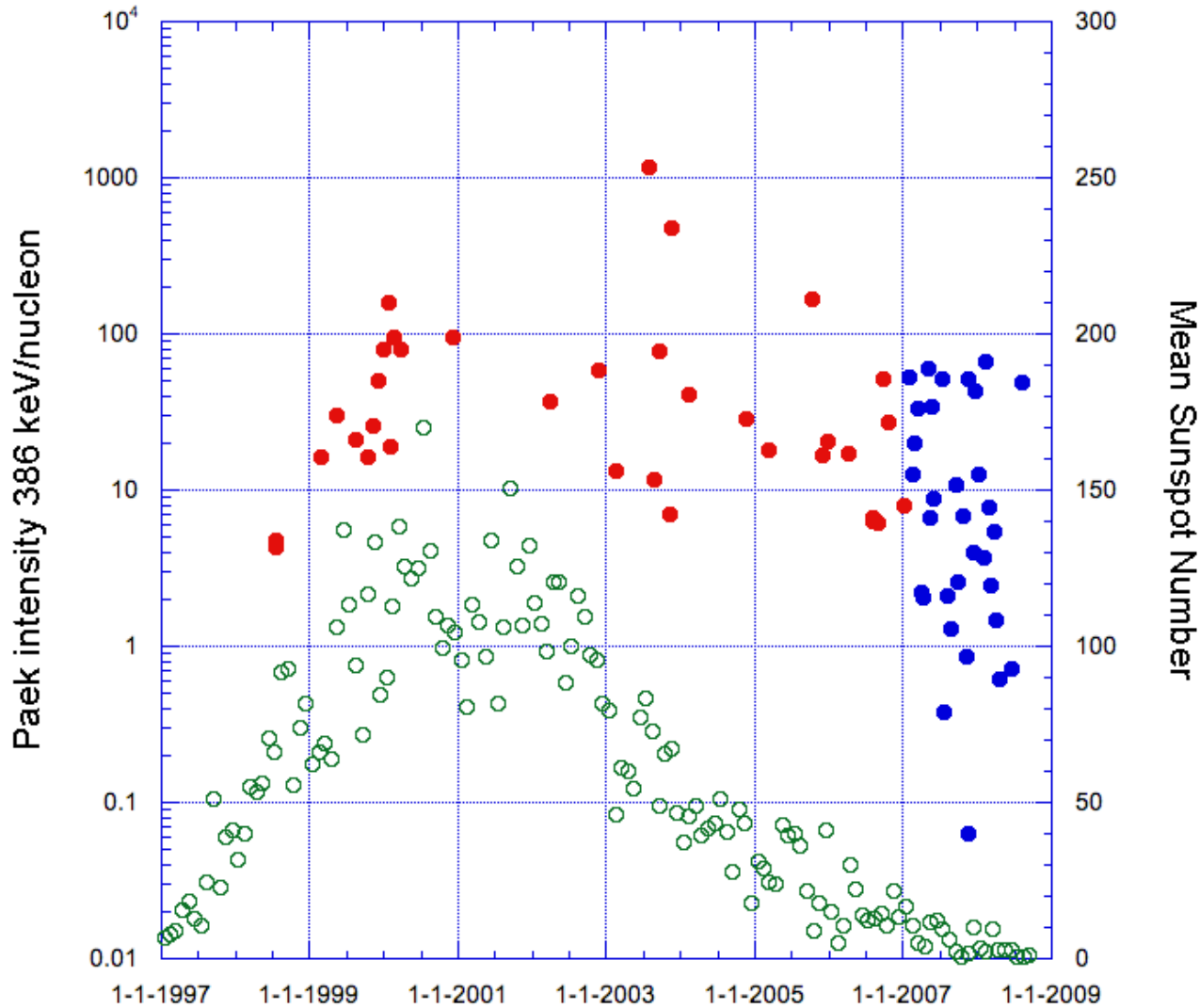




Peak intensity:

- *during ACE survey over recent solar maximum, peak He intensities (386 keV/n) did not correlate with the 160-910 keV/n spectral index*

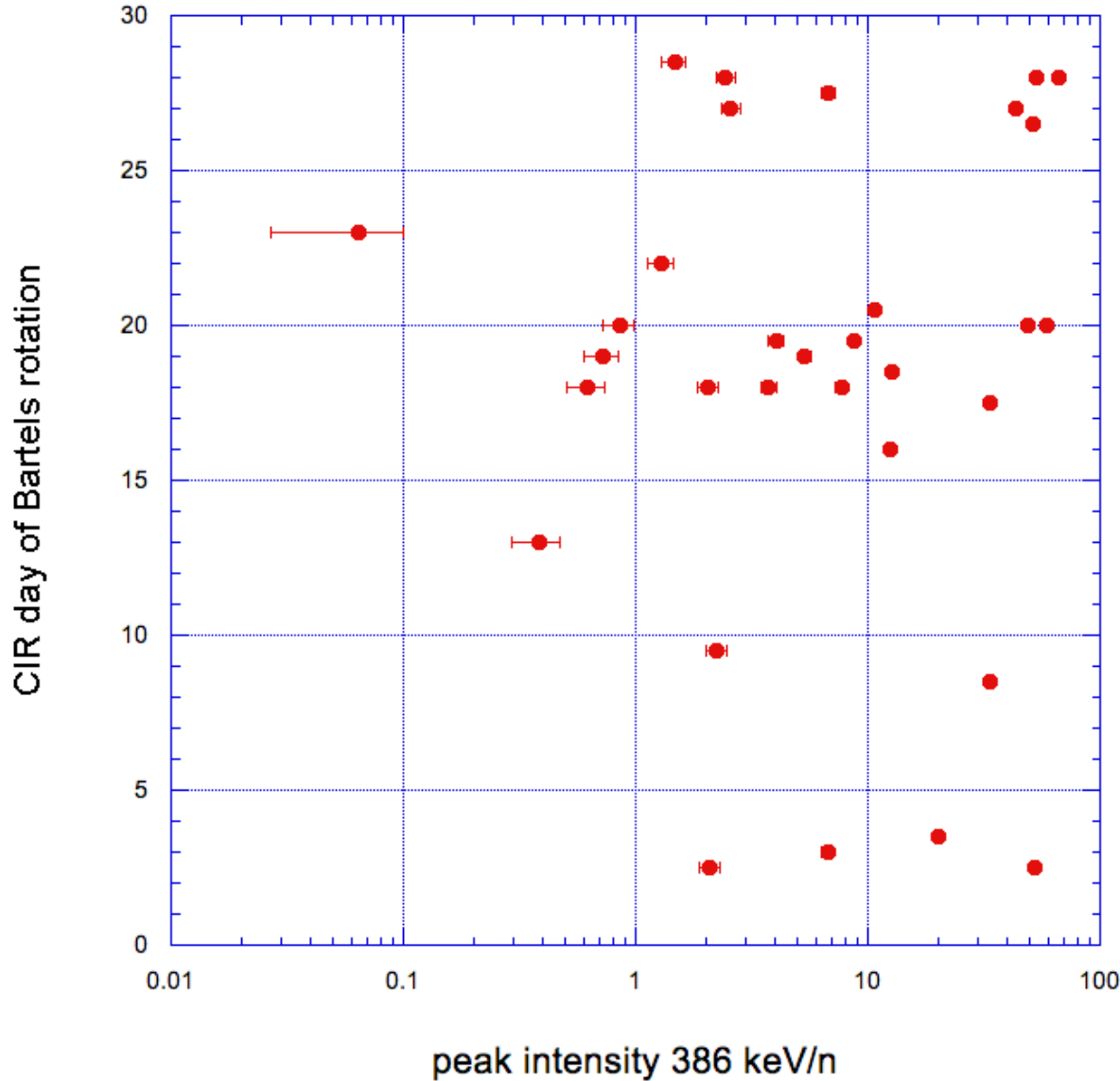
CIR peak intensities



Event sizes:

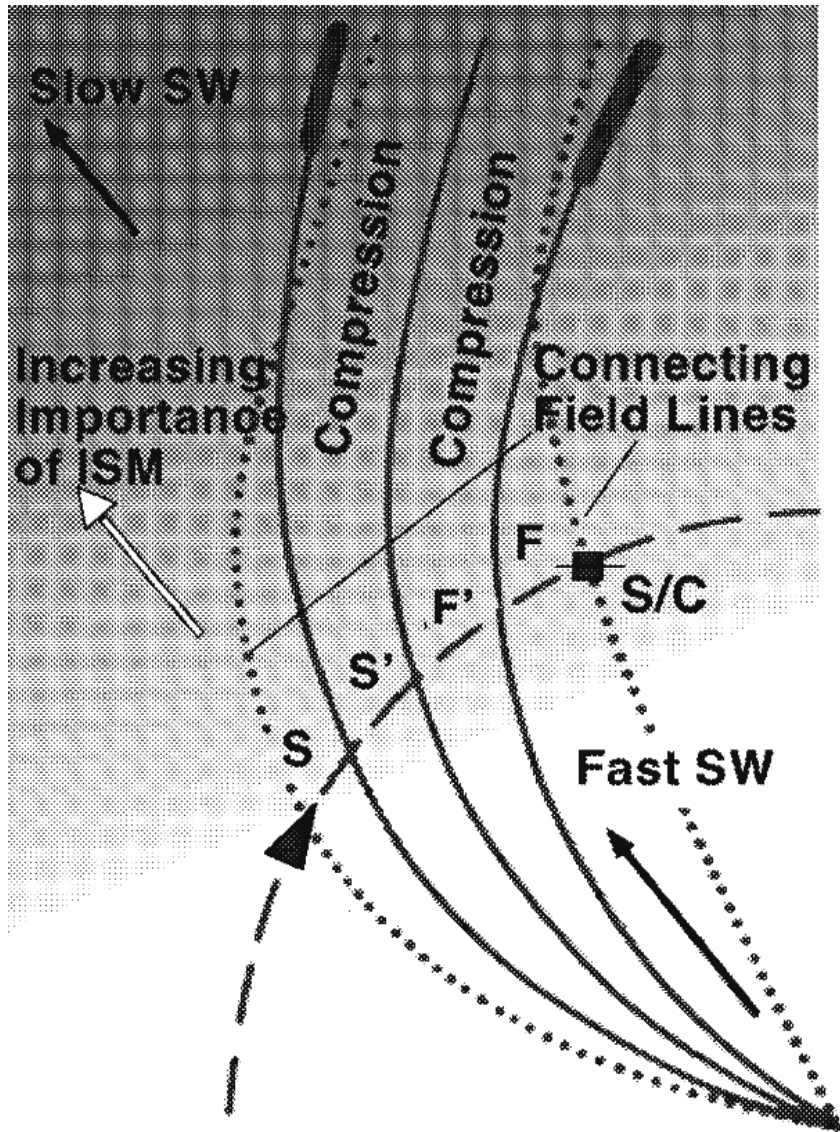
- *largest ones during 2007-08 as large as all but a few during recent solar activity maximum*
- *smaller events included in present survey might not have been seen earlier due to other activity*

SIT_cir_table



Peak intensity:

- *for 2007-2008 period the peak intensity does not depend on the solar longitude of the source regions -- see widely different intensities from each region*
- *suggests that connection details are important even if the regions are fairly stable in production of energetic particles*

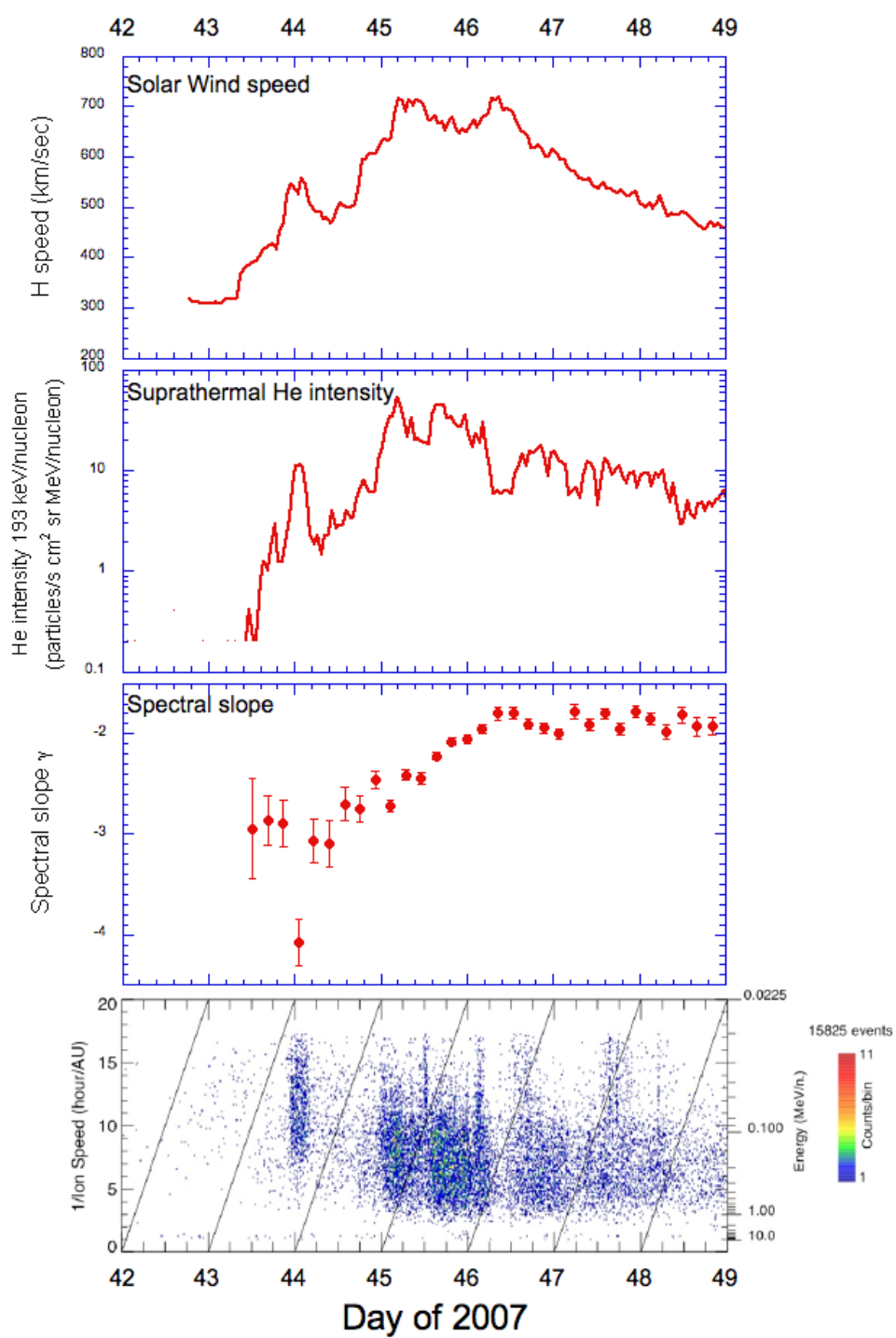


Connection to CIRs:

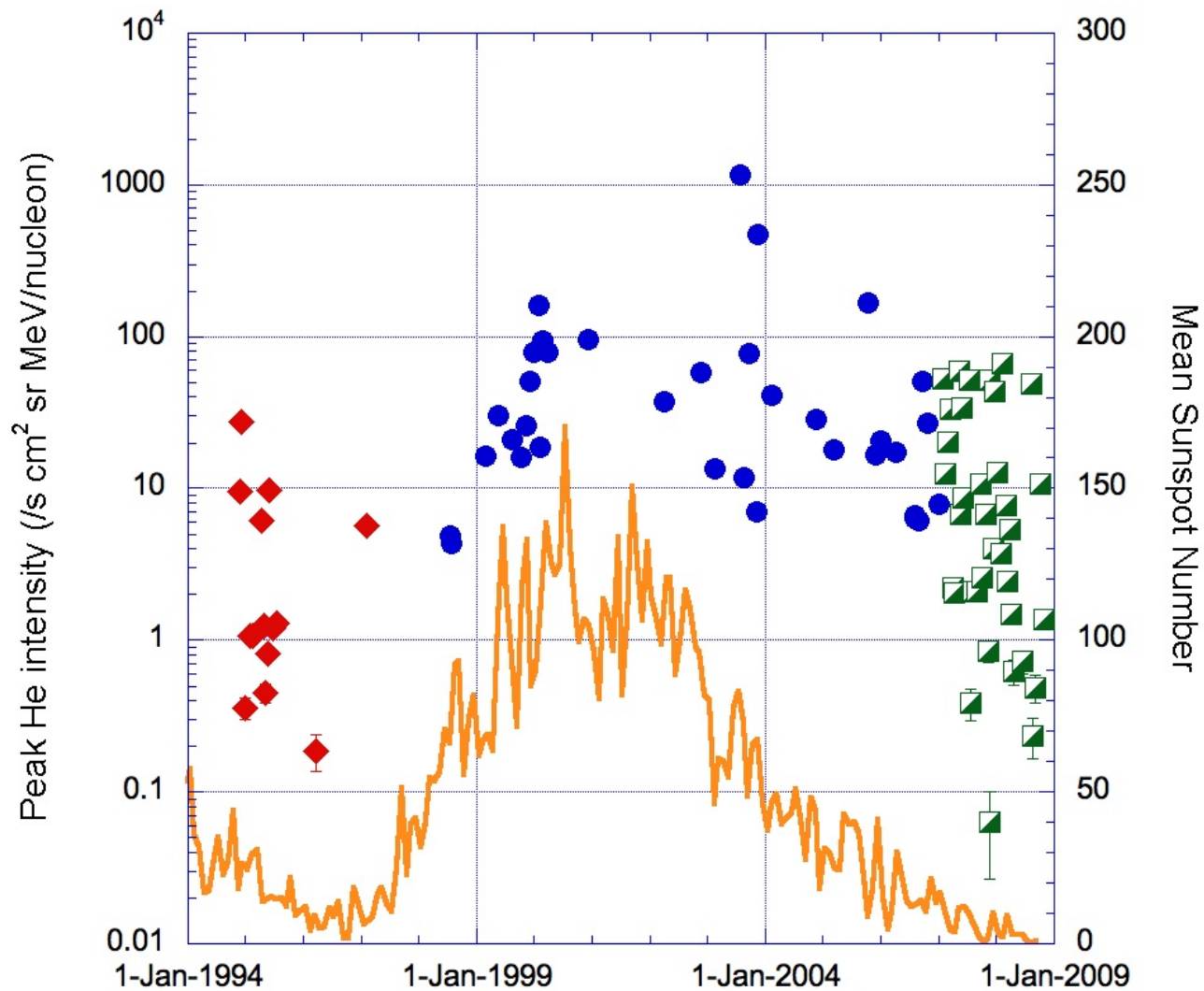
- *with source of particles beyond 1 AU, region of connection of spacecraft to outer region depends on solar wind speed*
- *simple corotating picture sometimes works, but often is more complex*

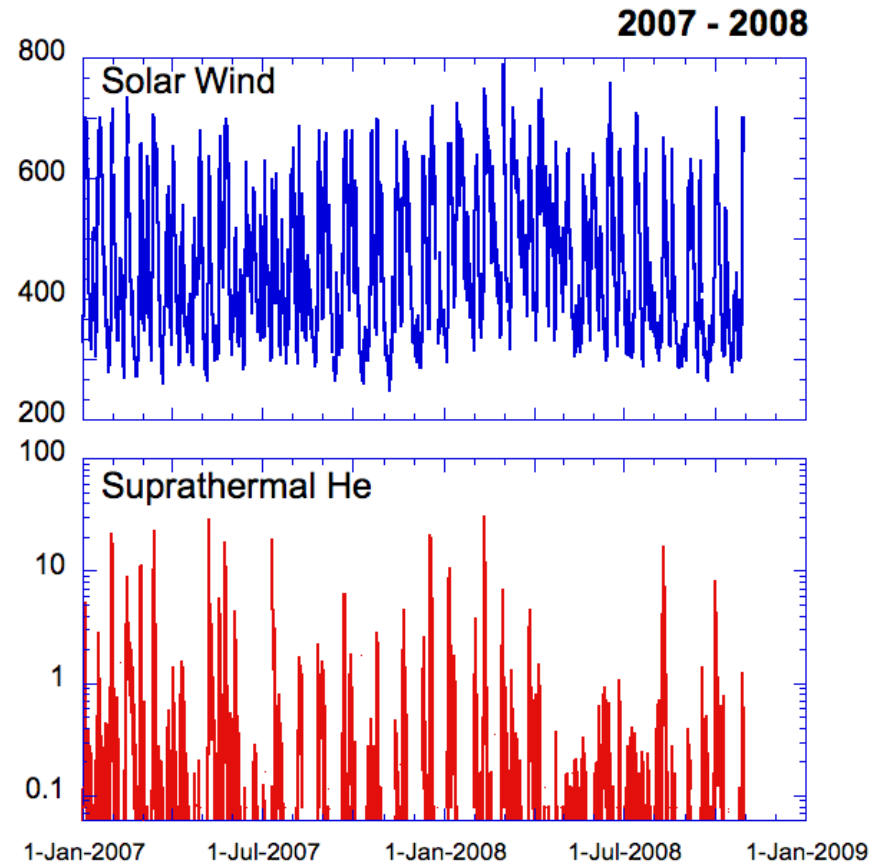
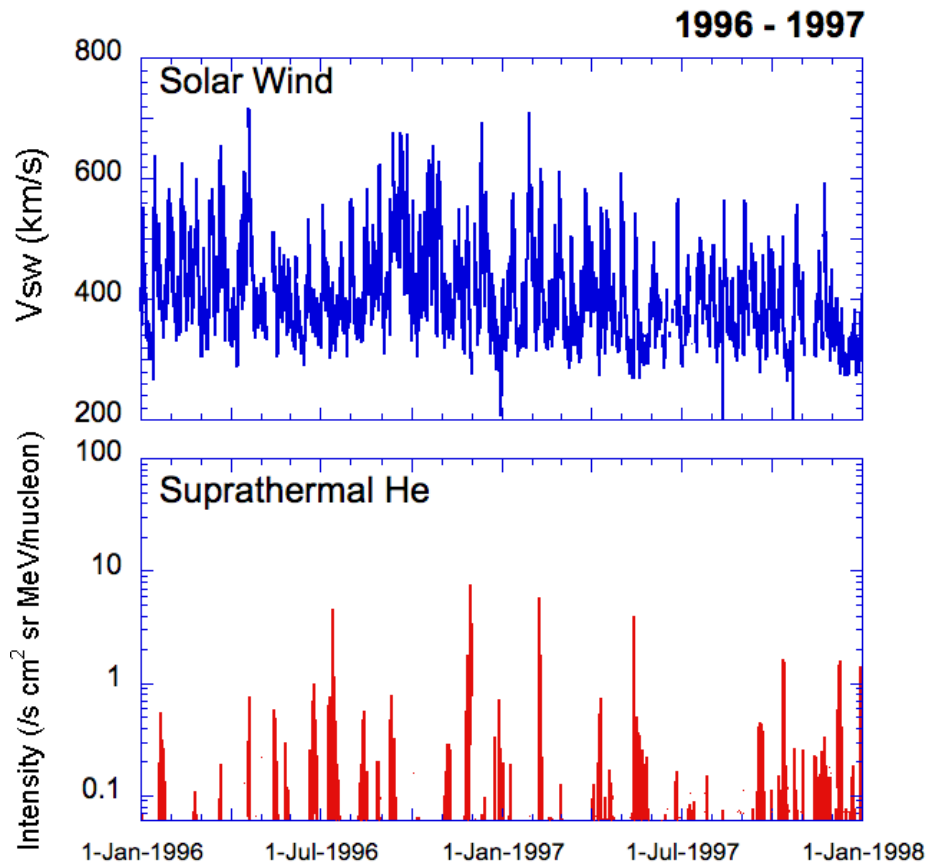
“Dropout events” --

- in several CIRs, particle intensity increases show a decrease at all energies, followed by a recovery that is also independent of energy*
- these decreases correlate reasonably well with changes in solar wind speed*
- particle energy spectra are similar before and after the dropout, although intensities may change*
- these features suggest that connection to the acceleration region beyond 1 AU is responsible for the dropouts -- not temporal changes in the CIRs*



*Comparison of 2007-2008 with
1996-1997 solar minimum
period*





Wind SWE proton speed (blue) from kp data; STEP He5/1.6 -- division by 1.6 to adjust energy window to correpond approximately (20%) to ACE 386 keV/n channel;
 Wind data blanked out for $R < 25R_e$; for solar activity days 1997/308.0-318.0, and for interplanetary shock event on 1997/326 (ACE disturbance list)

Summary --

- many fast solar wind streams and CIRs observed in 2007-2008, but not all streams produced CIRs*
- spectral forms similar to earlier surveys; much lower intensities at ~few MeV/n compared to active period*
- CIRs observed sequentially from -B to -A, but not always seen; energetic particle intensity pattern did not corotate rigidly, probably due to magnetic connection effects to the CIR beyond 1 AU*
- for 1994-2008 the most intense CIRs were during solar active periods, but cannot pinpoint simple cause for this*

- *2007-2008 period had much better defined high speed solar wind streams than prior solar minimum in 1996-1997, and many more CIRs*
- *size distribution of CIRs shows a much sharper cutoff than 10 MeV SEP protons from GOES*
- *about 25% of CIRs show “dropouts” for a day or so apparently when connection to acceleration region beyond 1 AU changes*
- *some of the complex features of the CIRs appear to be due to relatively small coronal hole solar sources, wherein the different heliolatitude traces of STEREO-B, -A, and ACE played a significant role*

published in STEREO Science Results at Solar Minimum

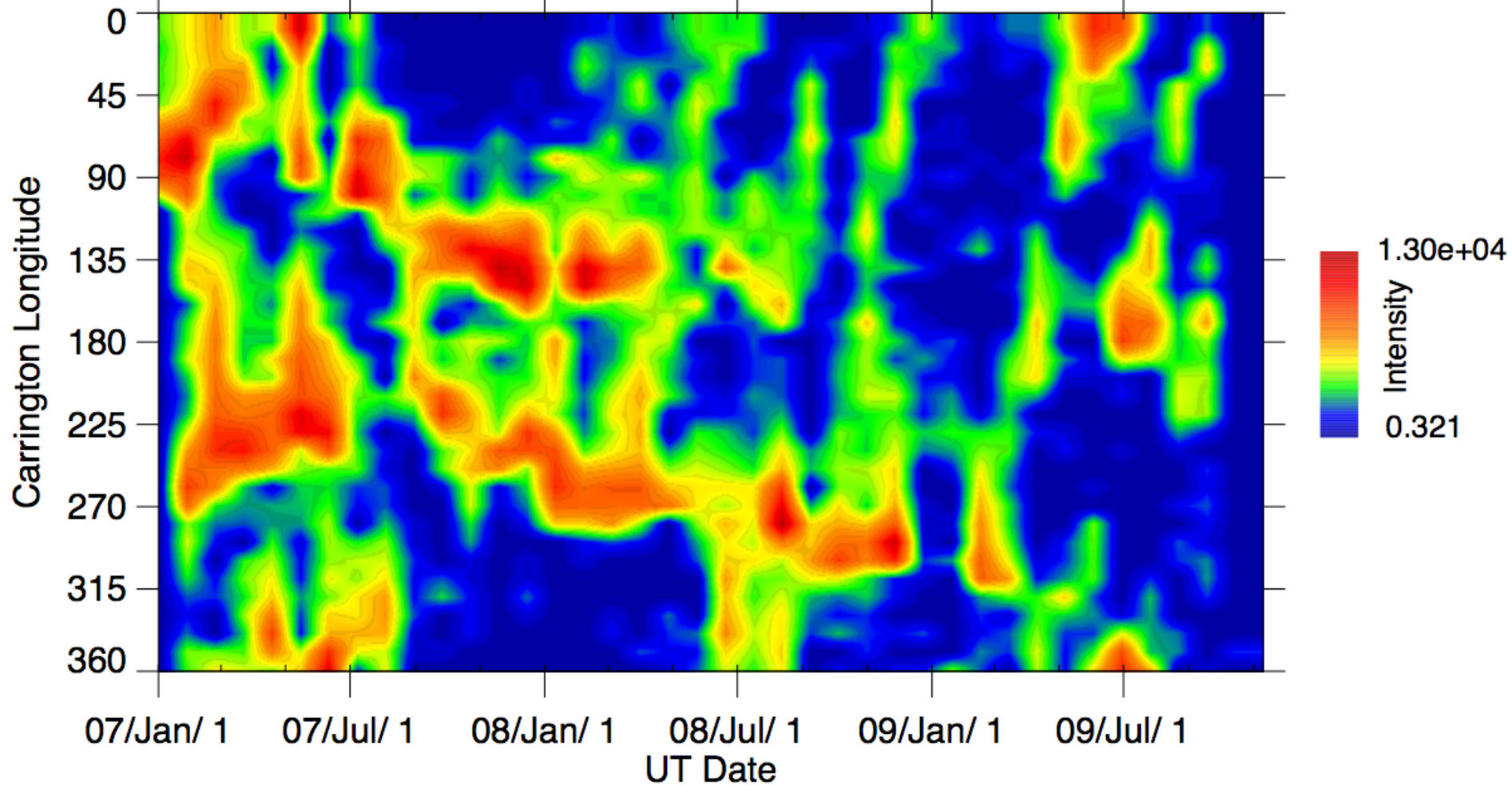
Mason et al. Solar Phys (2009) 256: 393-408 DOI 10.1007/s11207-009-9367-0

CIR activity overview

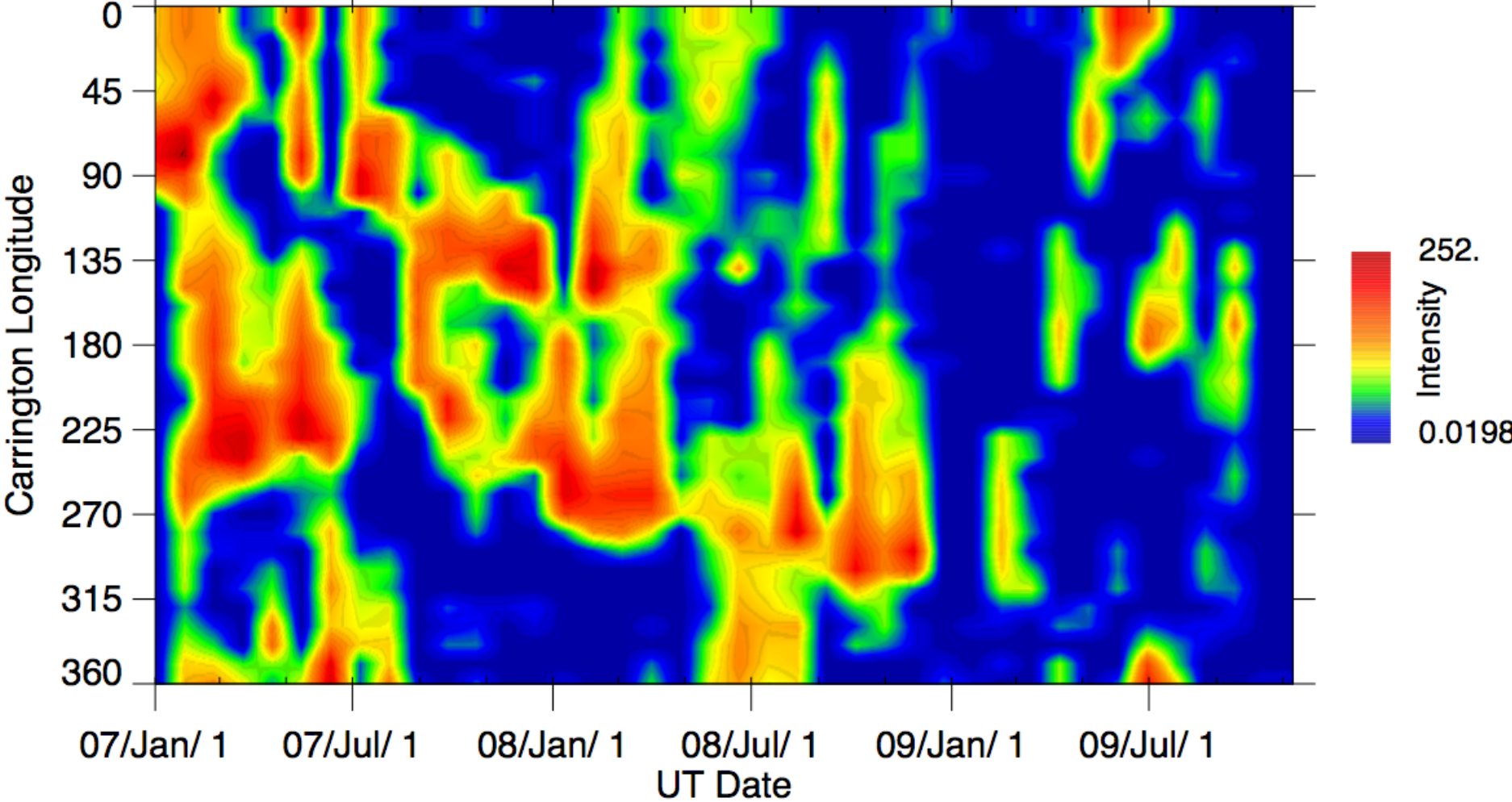
2007 - 2009

Created—Thu Oct 22 13:11:09 2009

ACE/ULEIS 0.14 MeV/n 4He

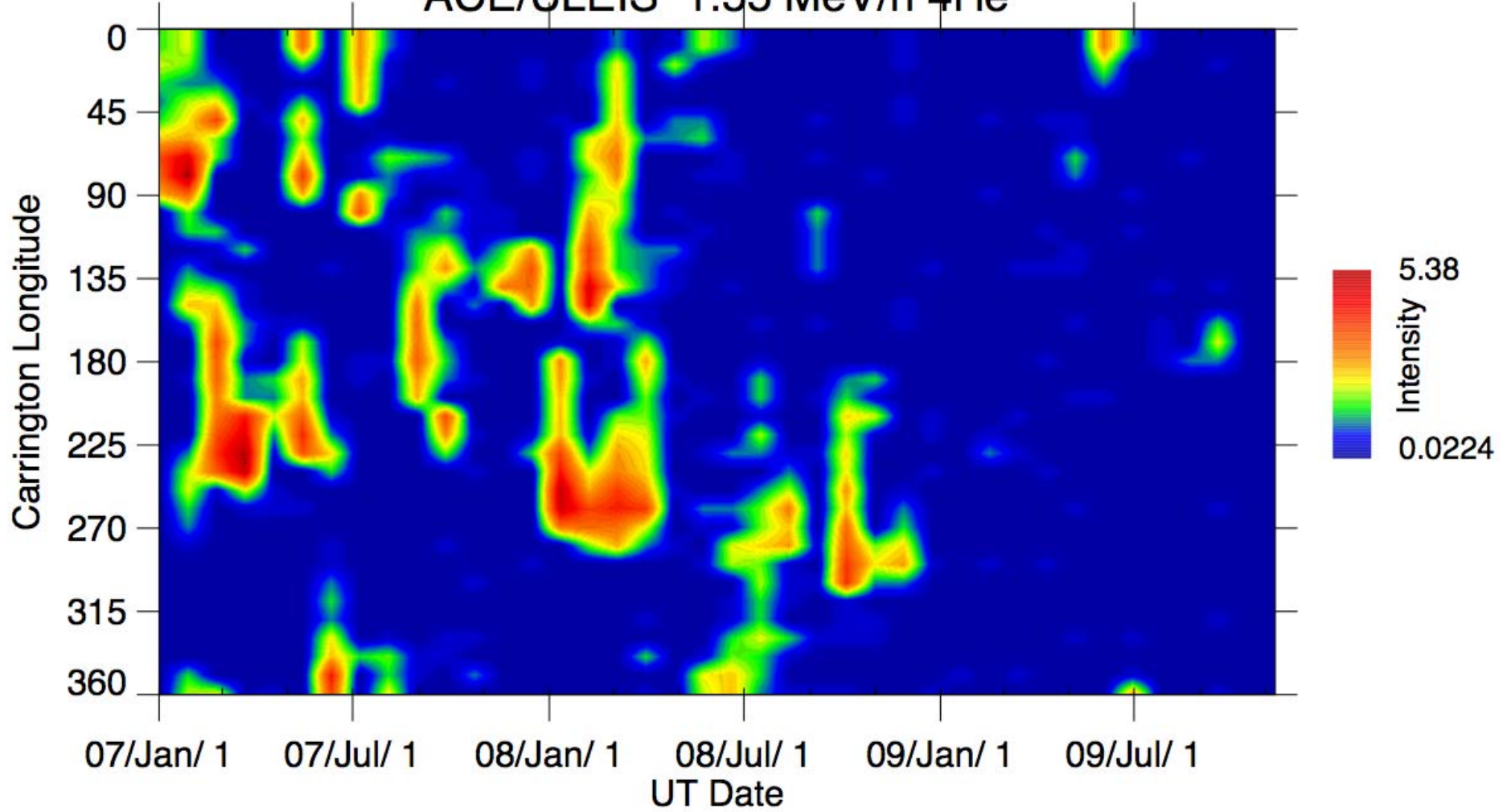


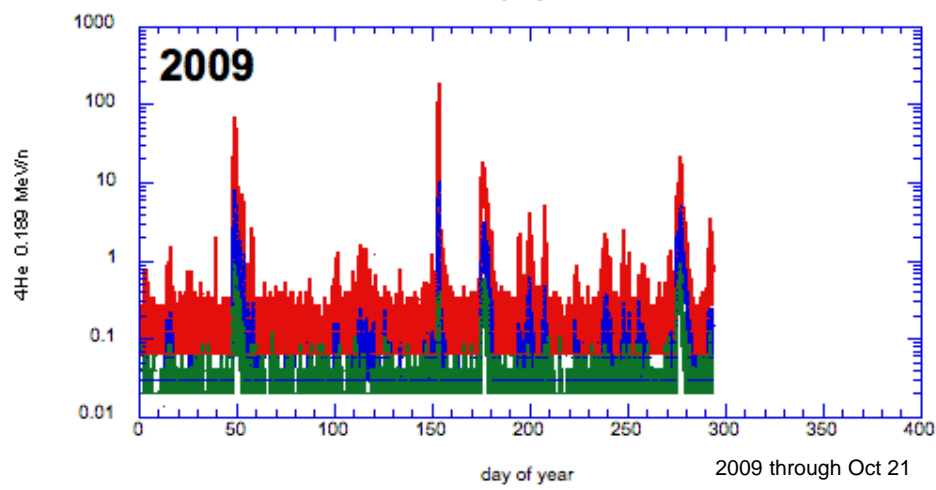
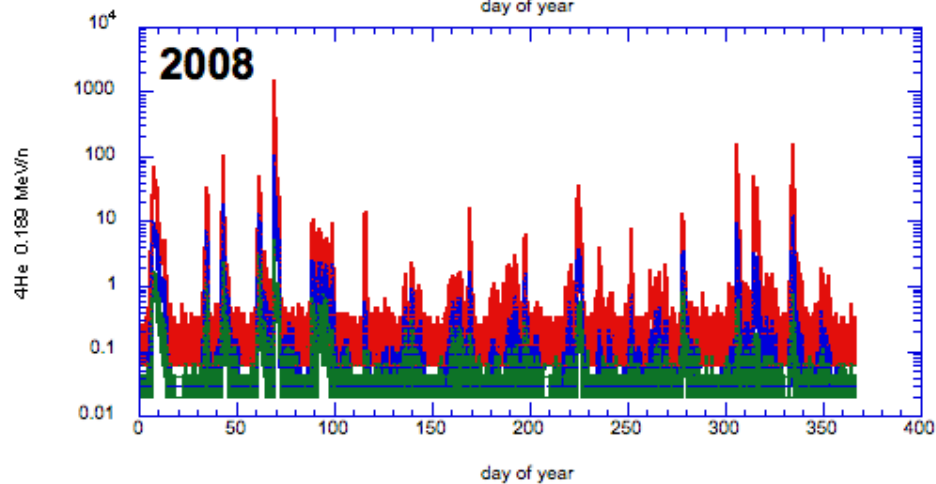
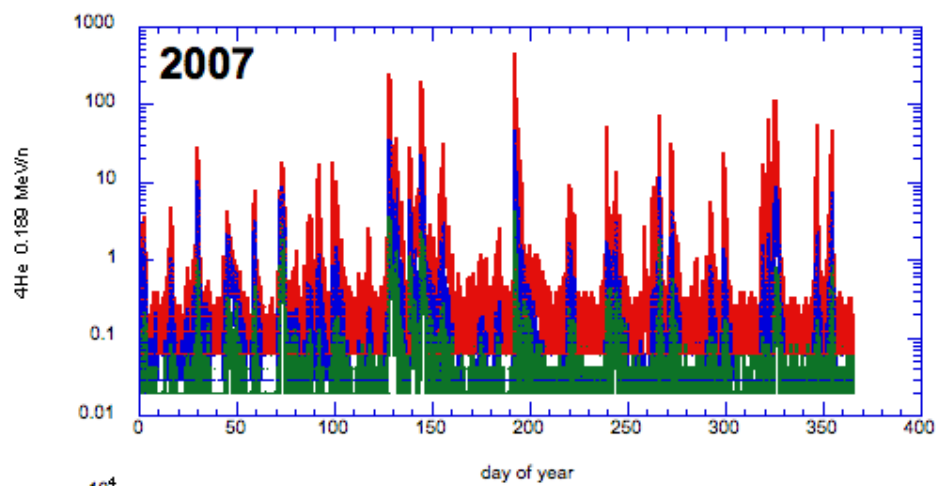
ACE/ULEIS 0.55 MeV/n 4He



Created—Thu Oct 22 13:14:10 2009

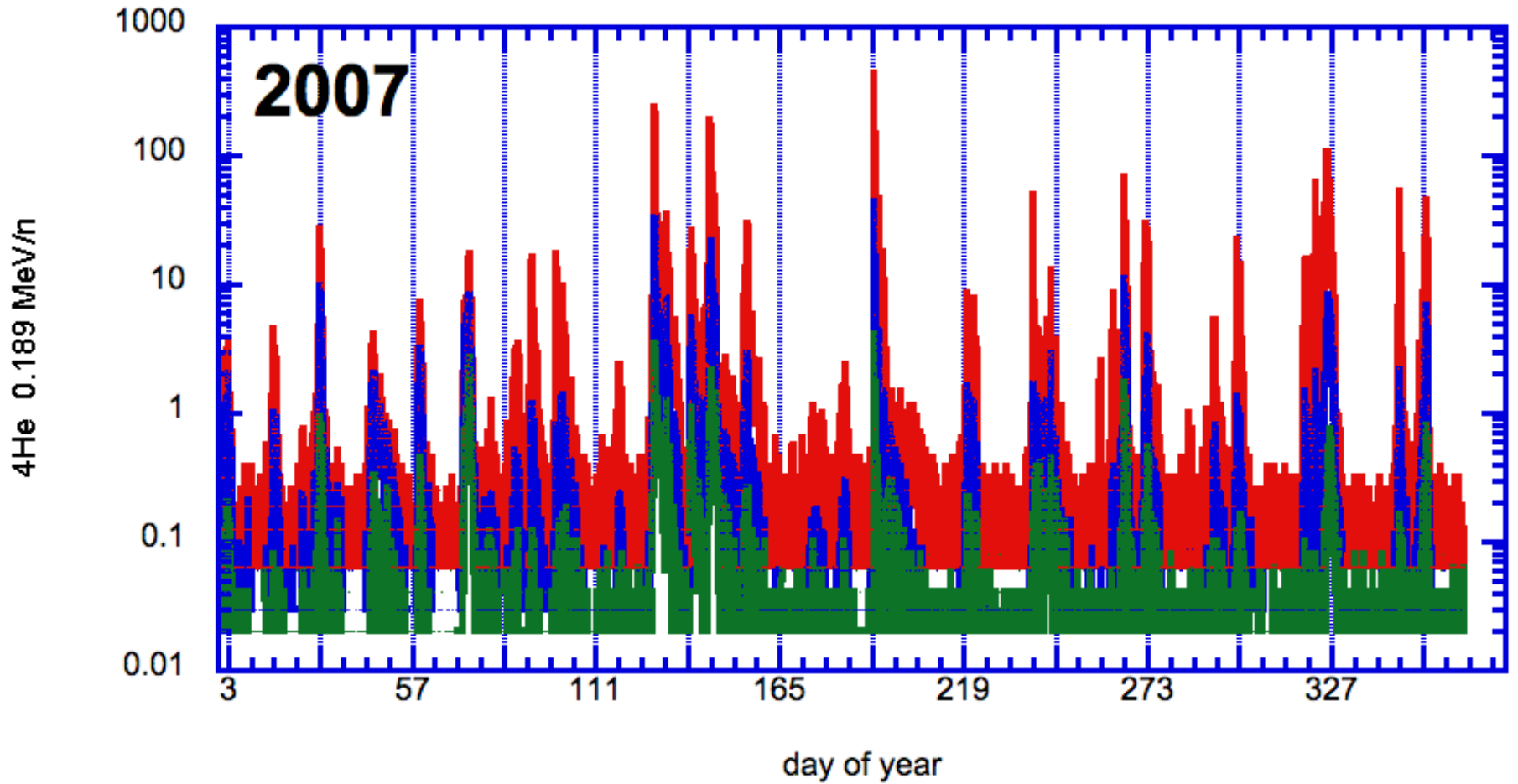
ACE/ULEIS 1.55 MeV/n 4He



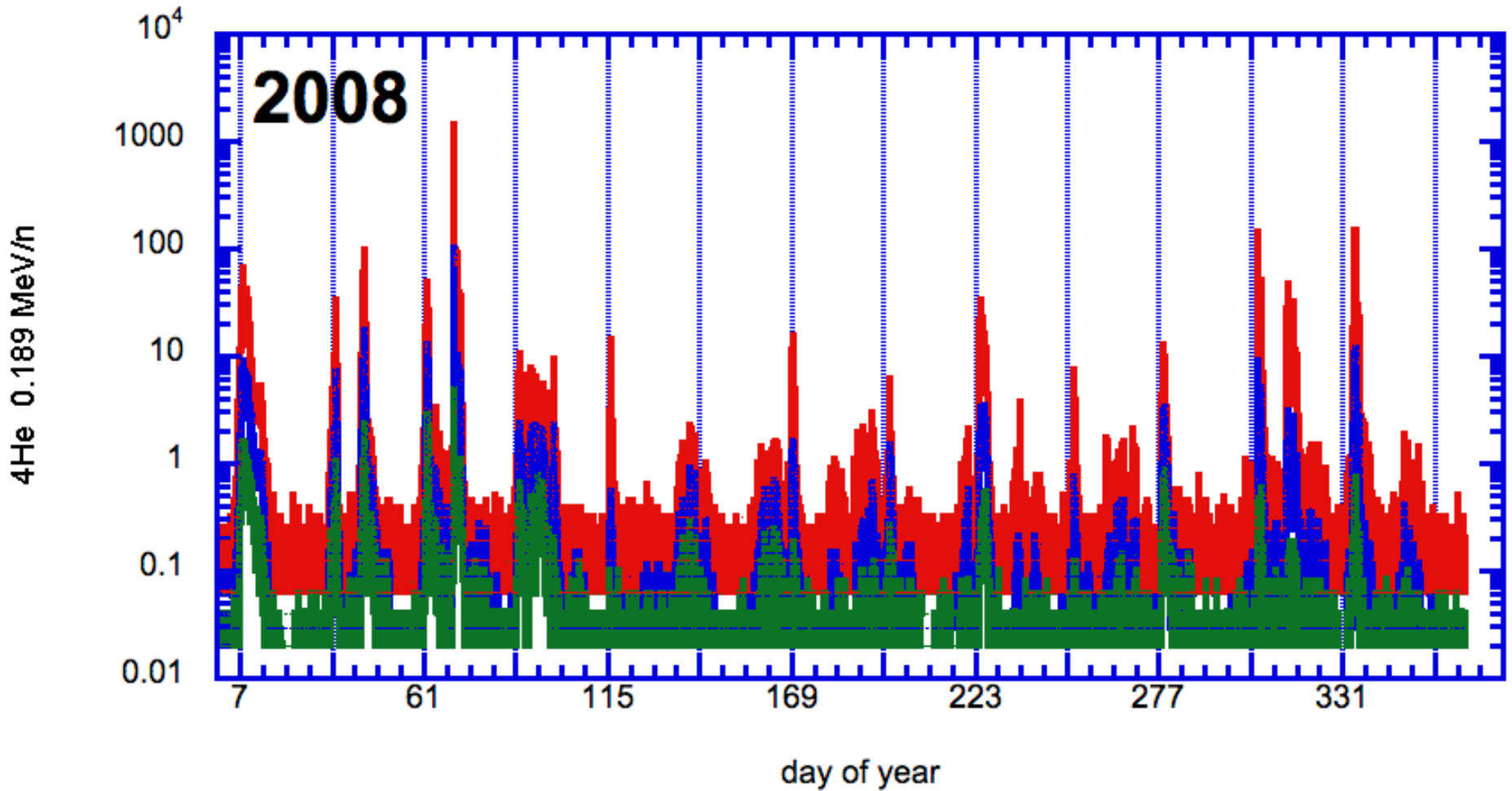


STEREO-A/SIT

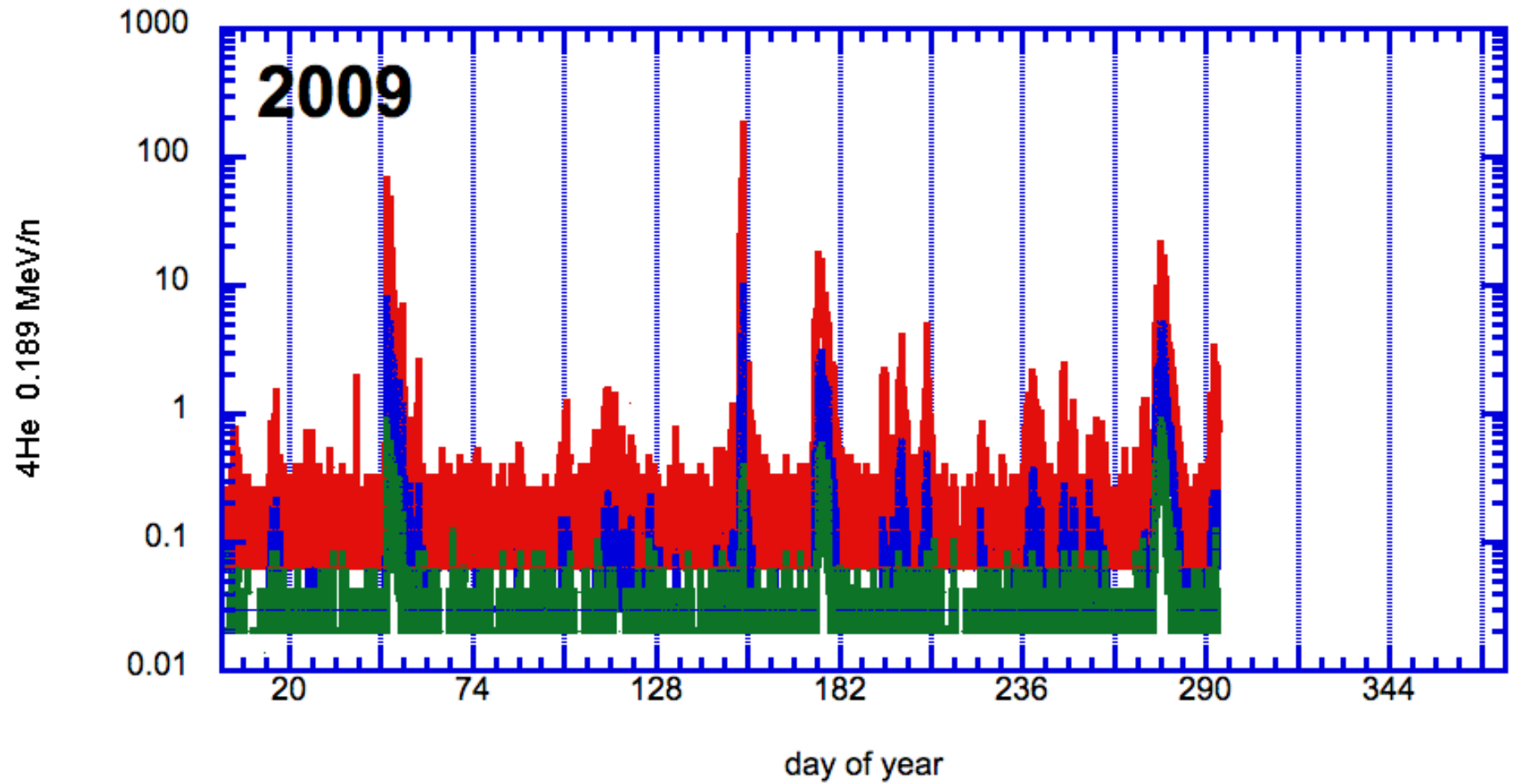
He: 189, 384, 787
keV/n



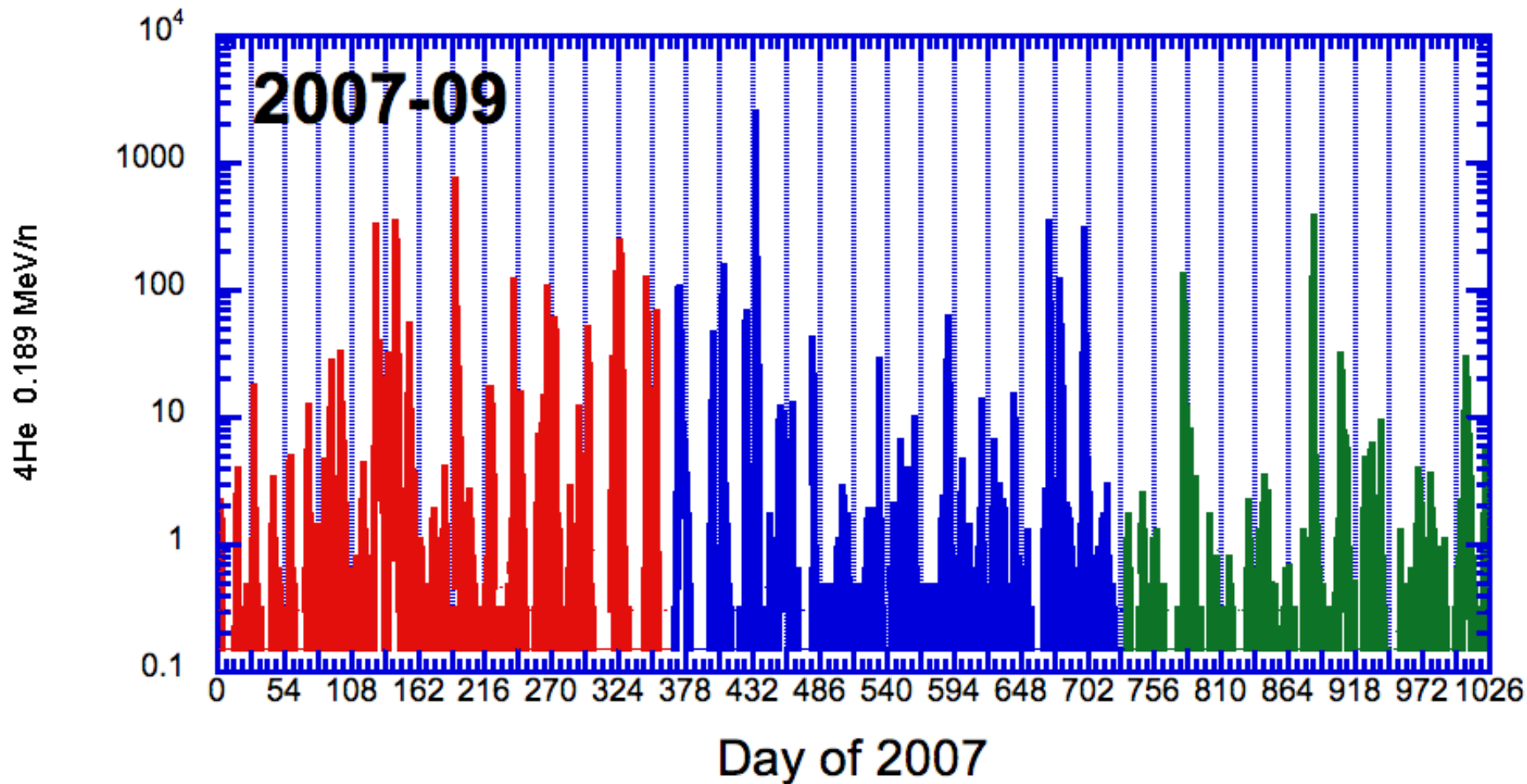
27 day tics show ~steady features



27 day tics show ~steady features

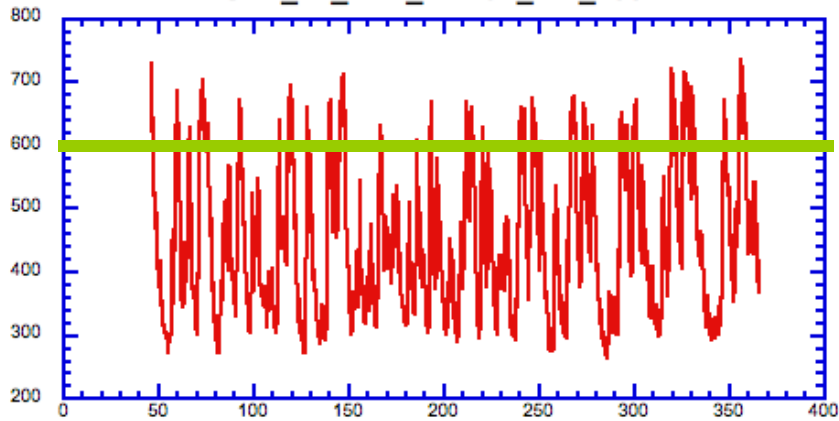


27 day tics show ~steady features



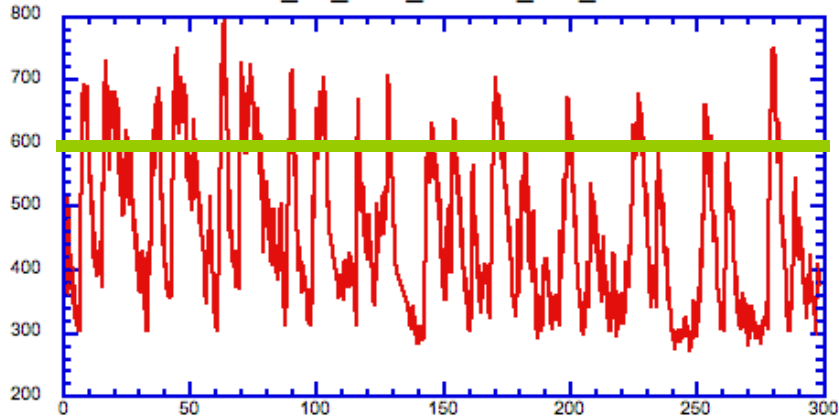
27 day tics show ~steady features

STA_L2_PLA_1DMax_1hr_2007



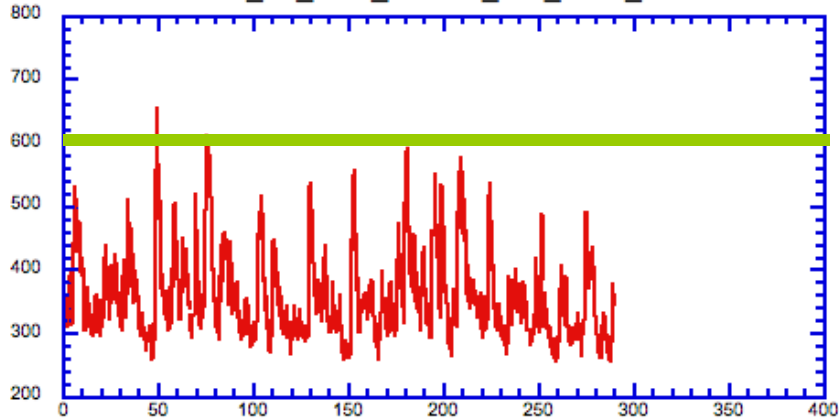
2007

STA_L2_PLA_1DMax_1hr_2008



2008

STA_L2_PLA_1DMax_1hr_2009_V04



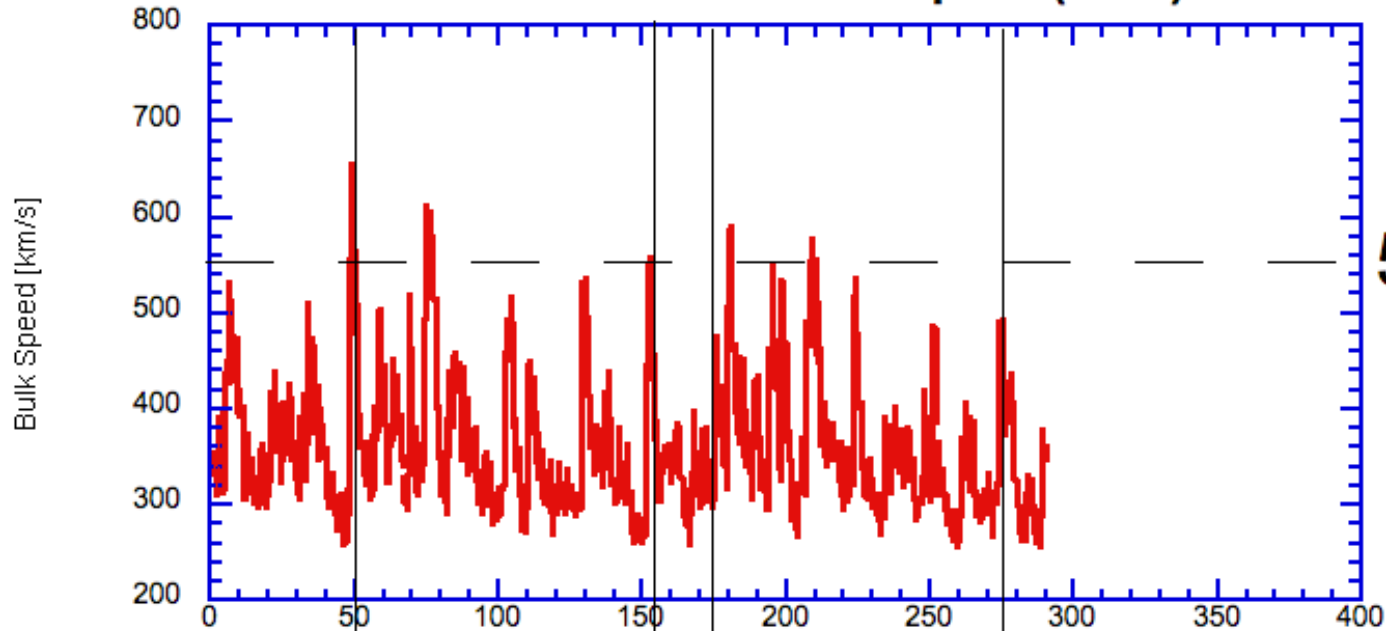
2009

Plastic-A

Solar Wind
Speed:

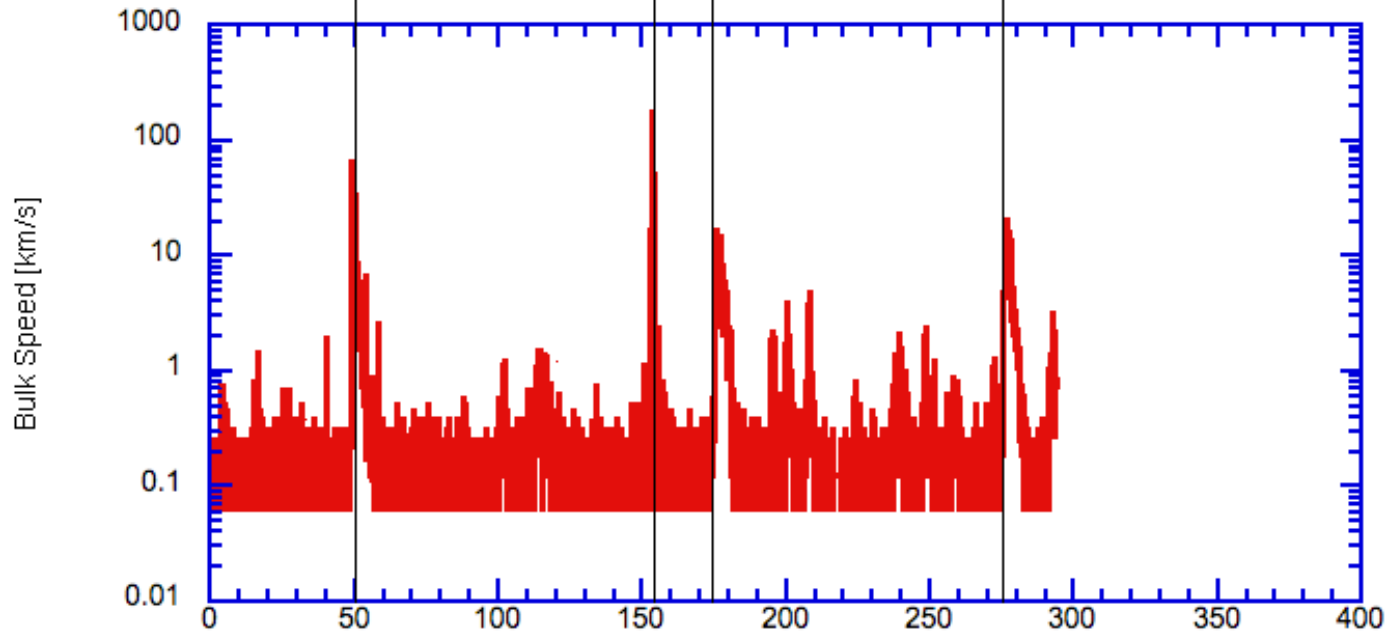
much less
time above
600 km/s in
2009

PLASTIC-A Solar Wind Speed (km/s)



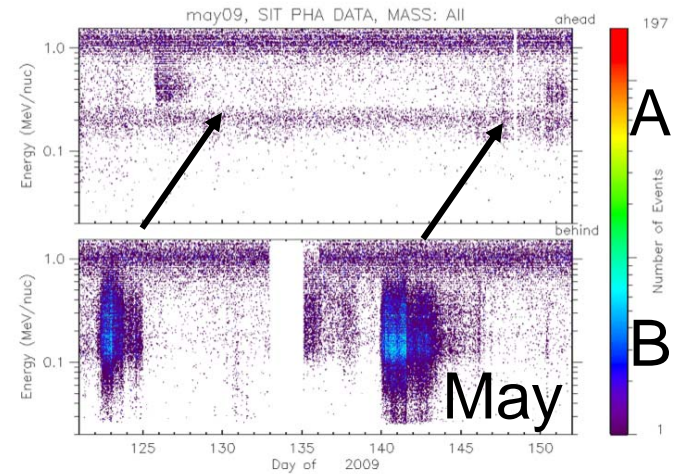
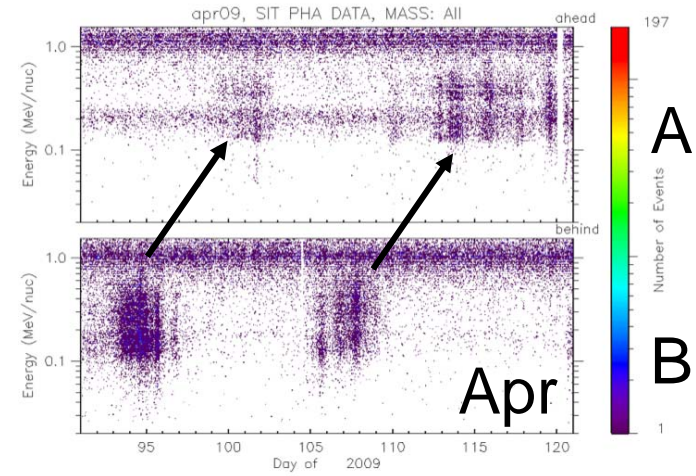
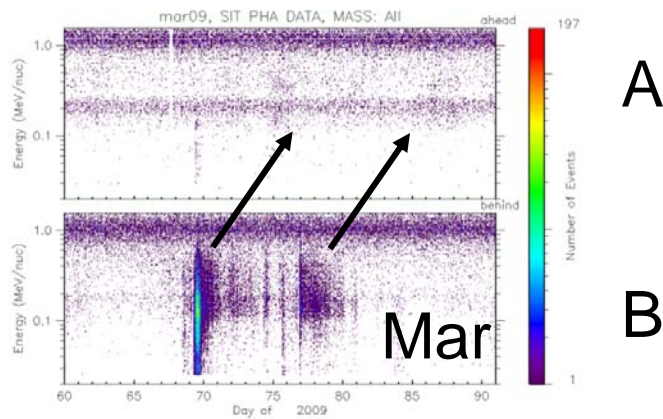
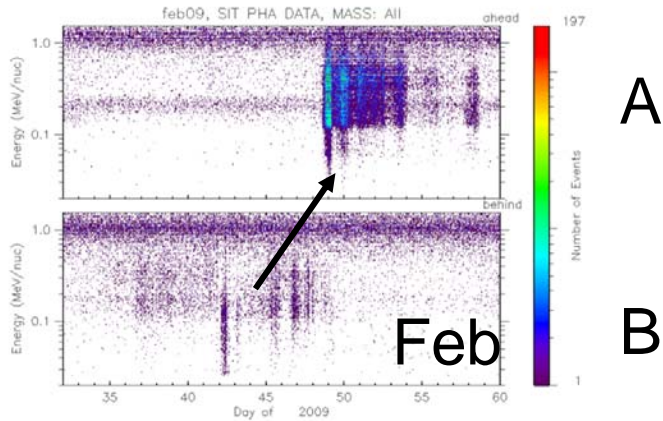
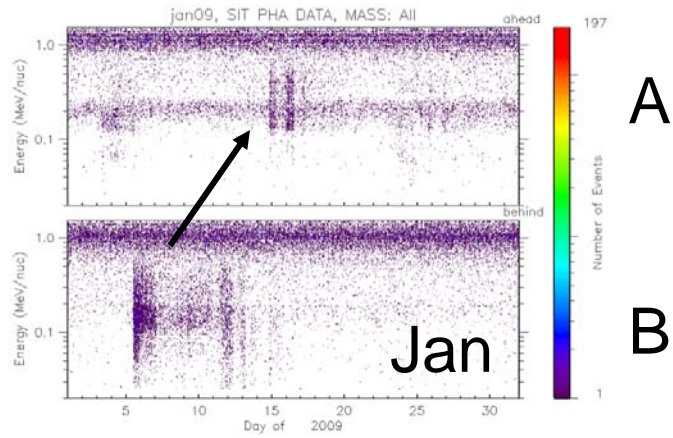
550 km/s

SIT-A 189 keV/n Helium

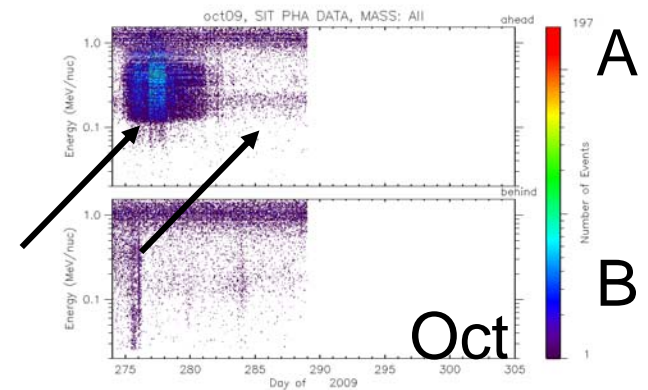
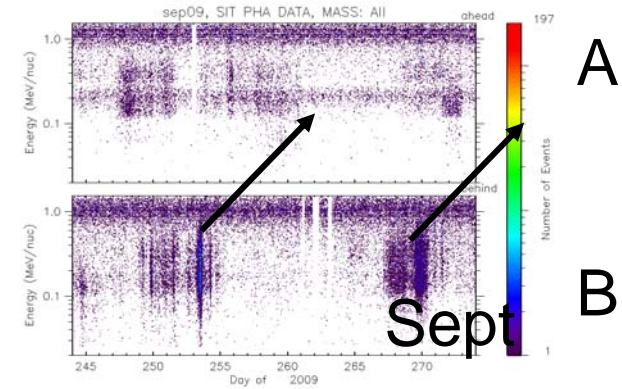
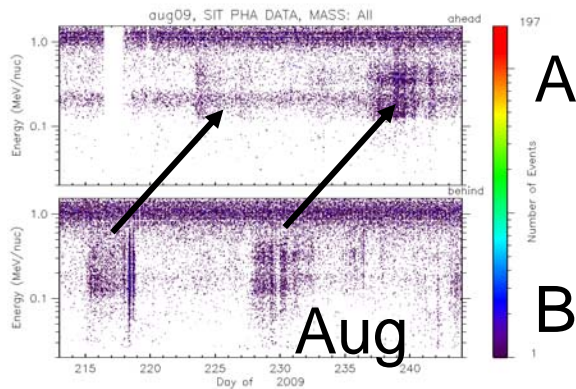
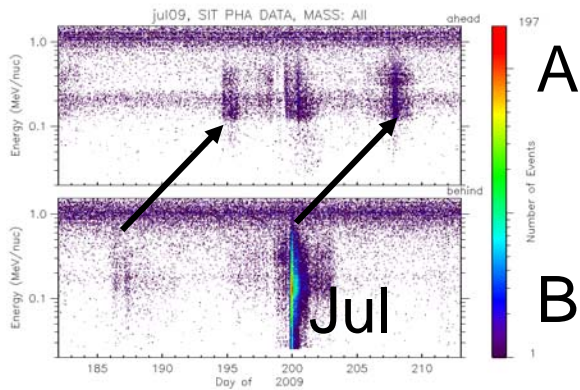
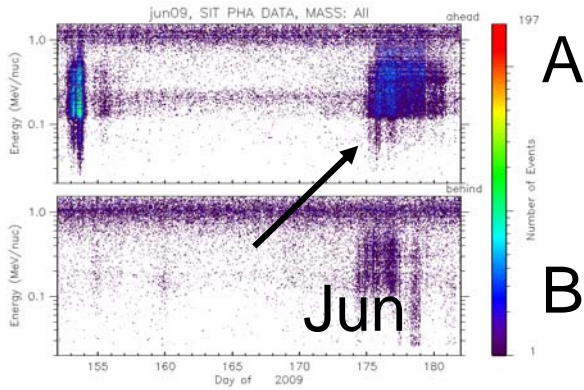


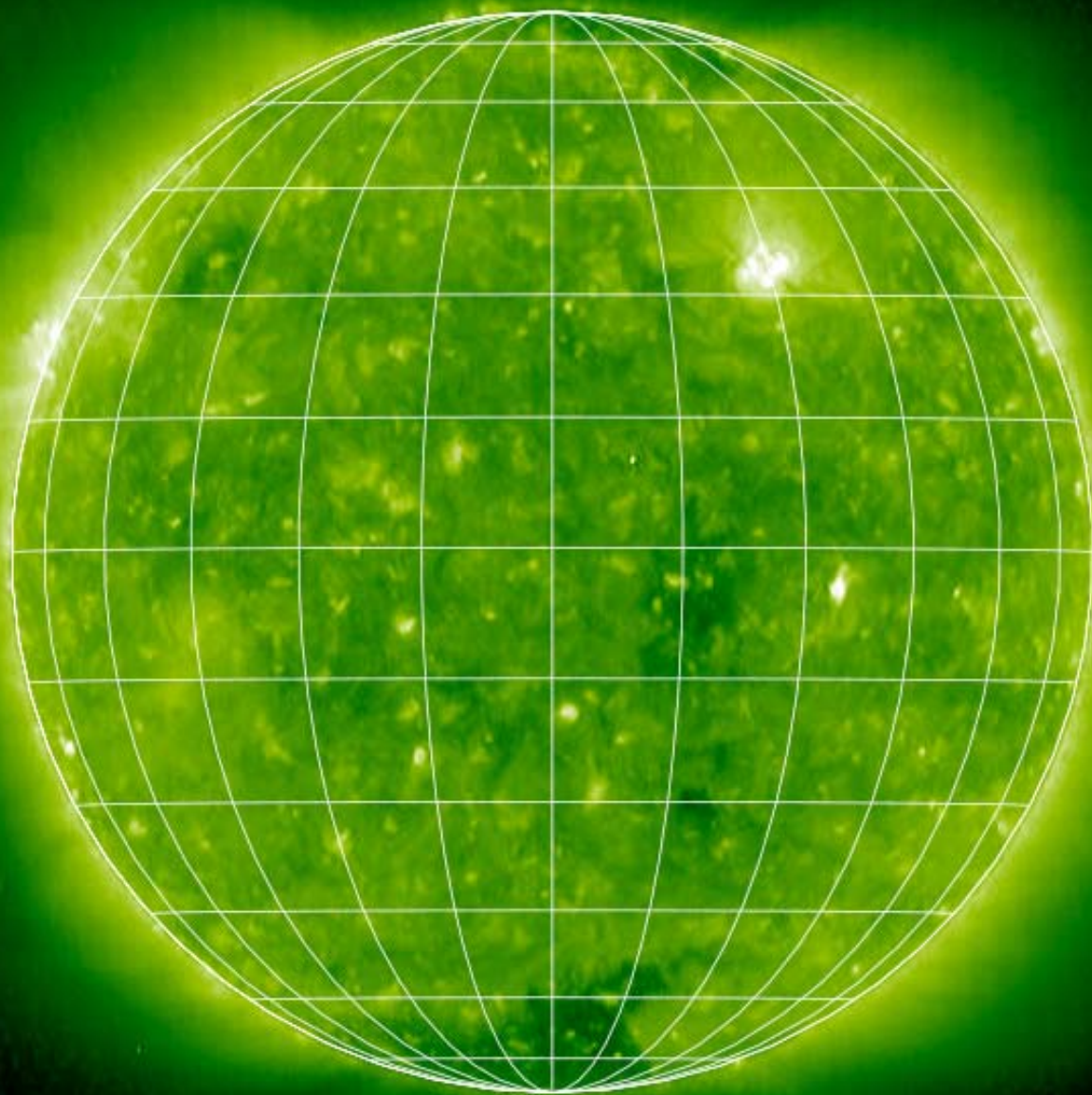
2009: see CIRs often when $V_{sw} > 500$ km/s but very wide range of energetic particle intensities

SIT STEREO A,B spectograms Jan-May 2009



SIT STEREO A,B spectograms Jul-Oct 2009

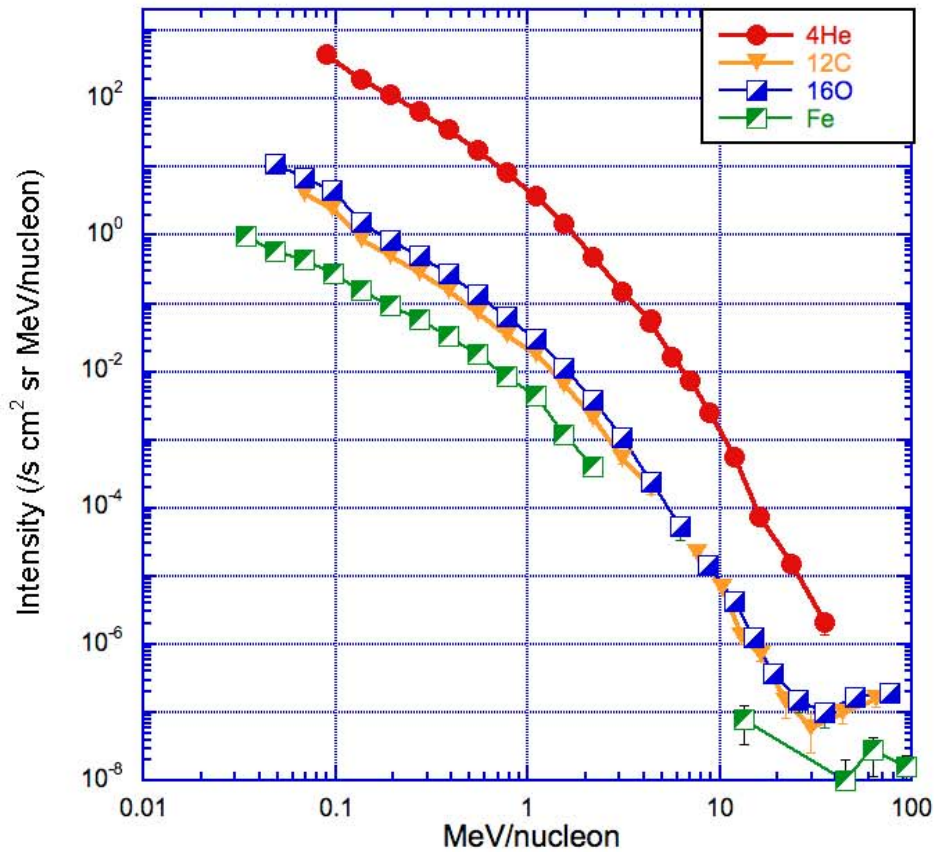




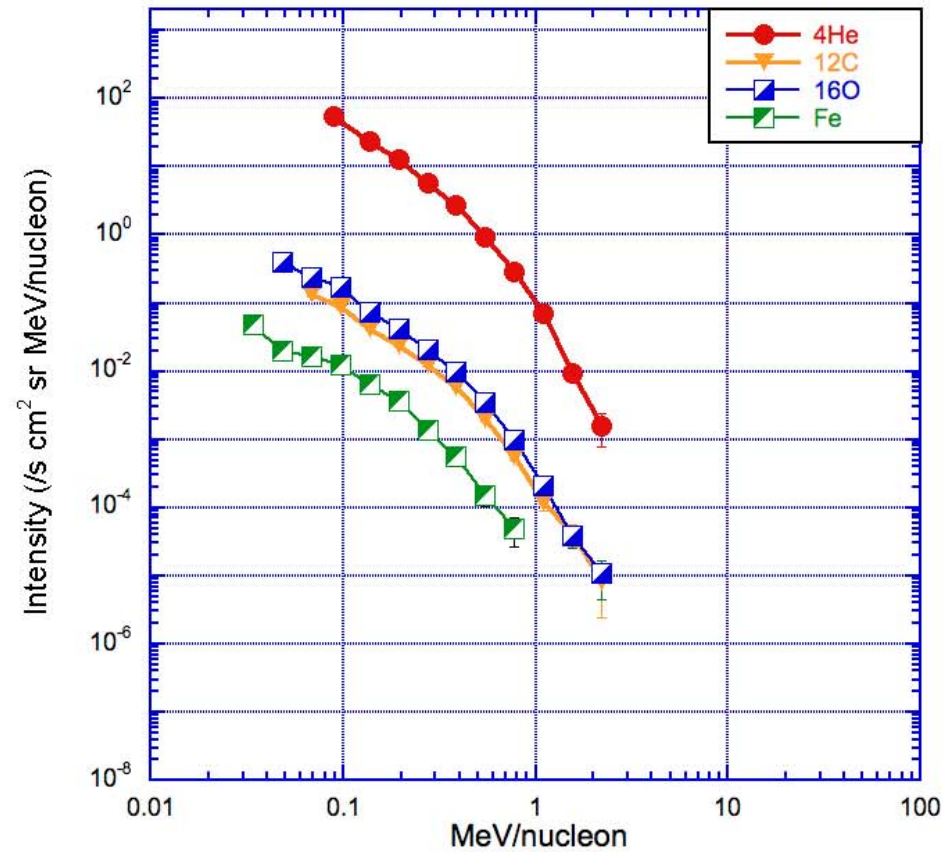
SECCHI-A
195Å view
June 2, 2009
during most
intense CIR
seen on SIT-A
during 2009

14° grid

2000 March 22 CIR

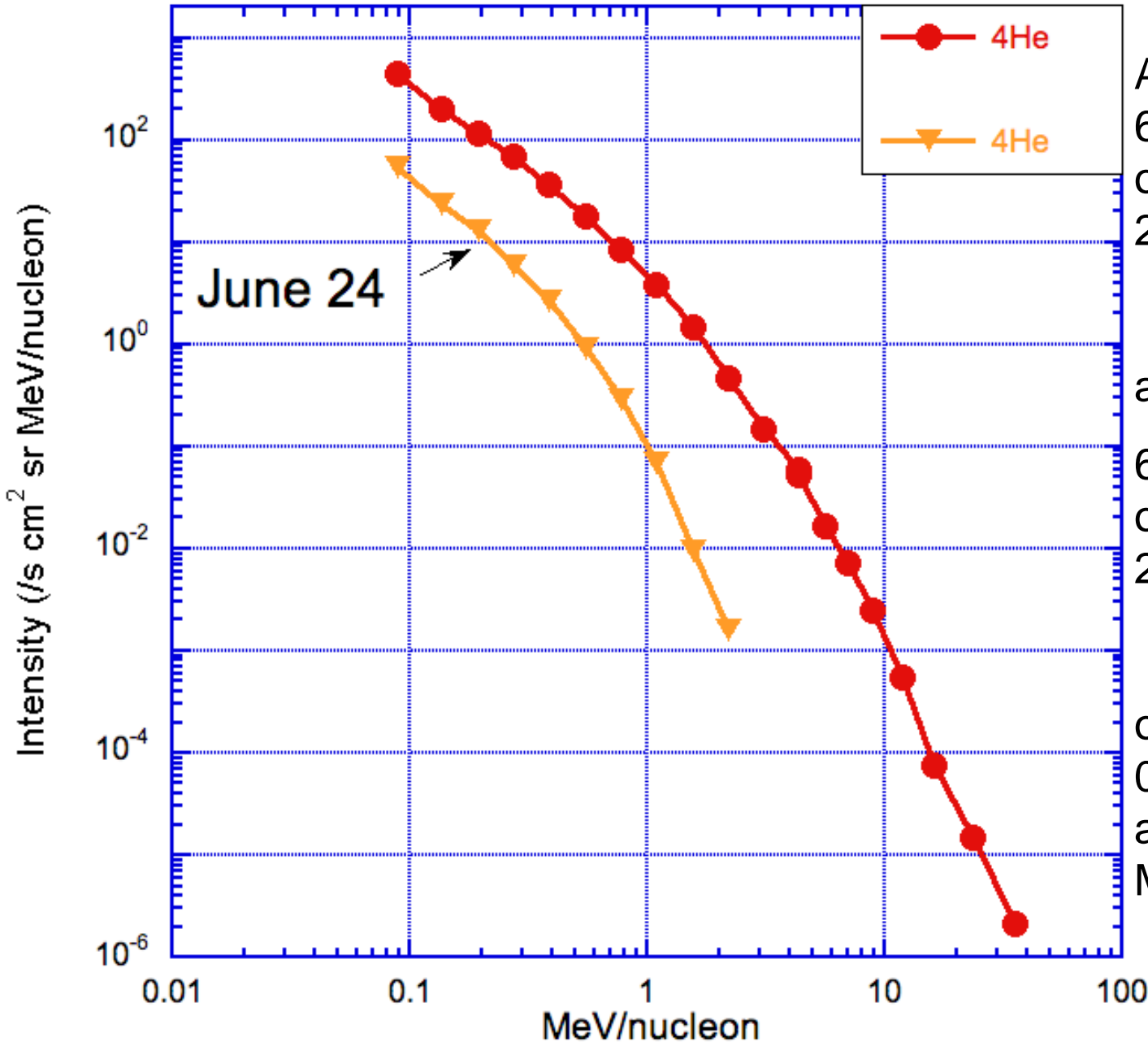


2009 June 24 CIR



“large” June 2009 CIR has typical composition spectra comparable below 1 MeV/n but much steeper above that for 2009 case

He spectra 2000 March 22 CIR vs 2009 June 24



At 100 keV/n
6/24/09 CIR is factor
of ~9 lower than
2000 March 22

at 1 MeV/n
6/24/09 CIR is factor
of ~50 lower than
2000 March 22

other CIRs in 2008-
09 producing hardly
any He above 1
MeV/n

Helium in CIRs in 2009:

- *activity lower than 2007 and early 2008, slow decline*
- *solar wind streams still present, though highest speed streams less than 2007*
- *a couple of reasonably sized CIRs through mid 2009 at low energies ($\sim < 1$ MeV/n) but very little particle acceleration above that*