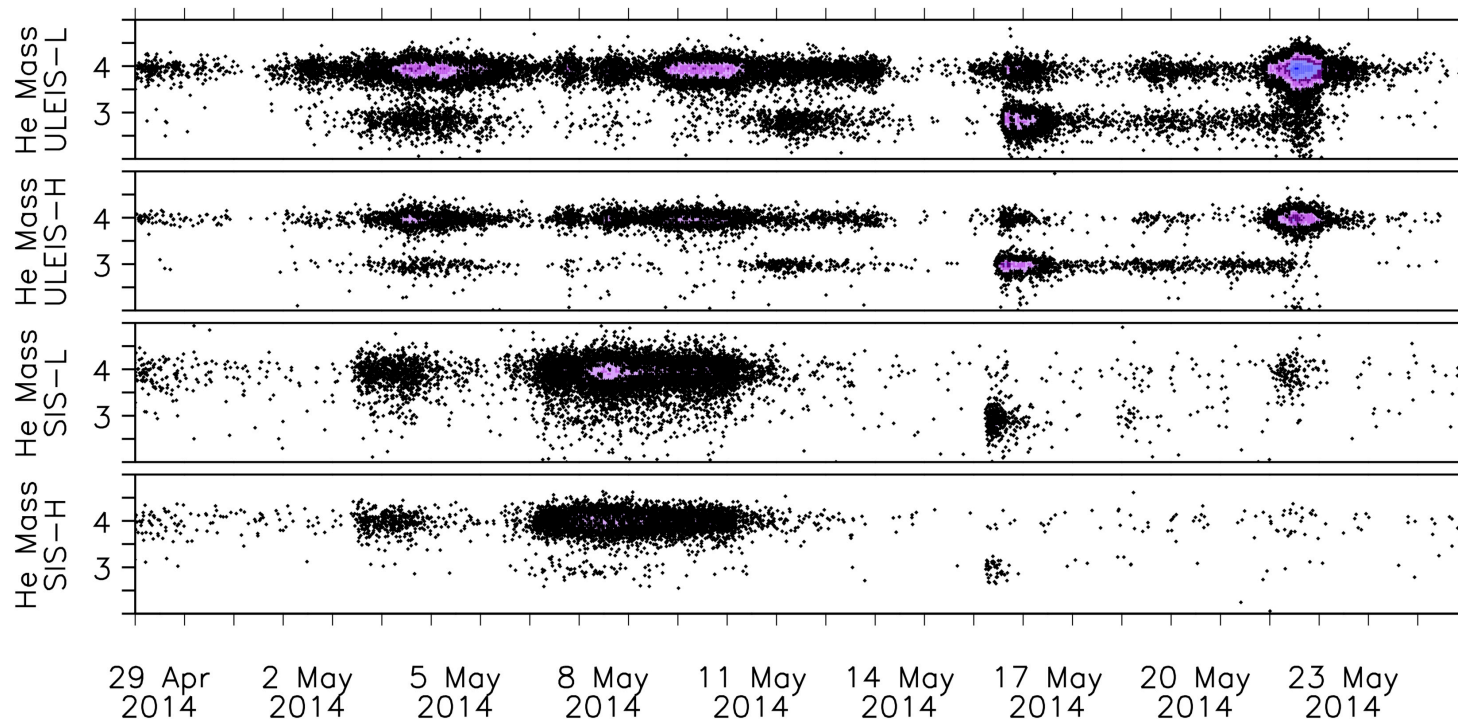


**Occurrence of
 ^3He -rich Solar Energetic Particles
near Earth and Closer to the Sun
for the
Advanced Composition Explorer
ULEIS and SIS Teams
and the
Parker Solar Probe IS \odot IS Team**

Use He Mass Spectrograms to Identify Time Periods when SEP 3He is Present

- data from ACE/ULEIS and ACE/SIS
- four energy intervals between 0.2 and 16 MeV/nuc, two from each instrument
- plot data for each 27-day Bartels rotation
- each black dot represents one detected He
- switch to color scale when dots are too dense to distinguish



next slide shows this 0.4 to 1 MeV/nuc interval from ULEIS for all Bartels rotations since the 1997 launch of ACE

Overview of ACE He Isotope Observations 1997 – 2019

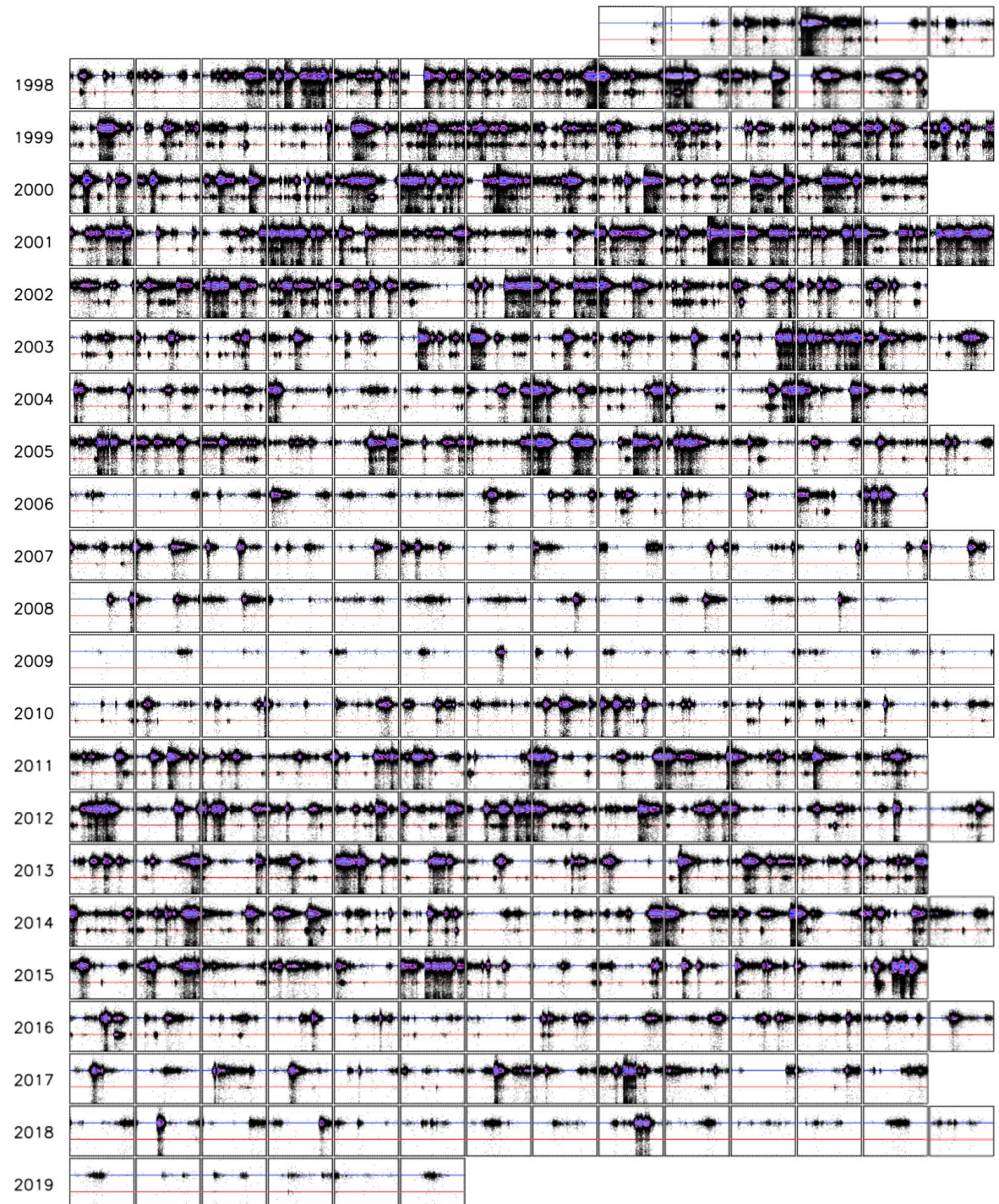
- each postage-stamp panel represents one 27-day Bartels rotation
- 0.4 to 1.0 MeV/nuc He isotopes from ULEIS
- blue line indicates nominal 4He mass, red indicates 3He
- dark vertical bands are mainly 4He spillover from large, gradual events
- during solar minimum, most of the He is from CIR events

cycle 23
maximum

solar
minimum

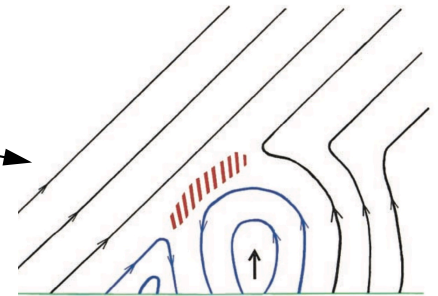
cycle 24
maximum

solar
minimum

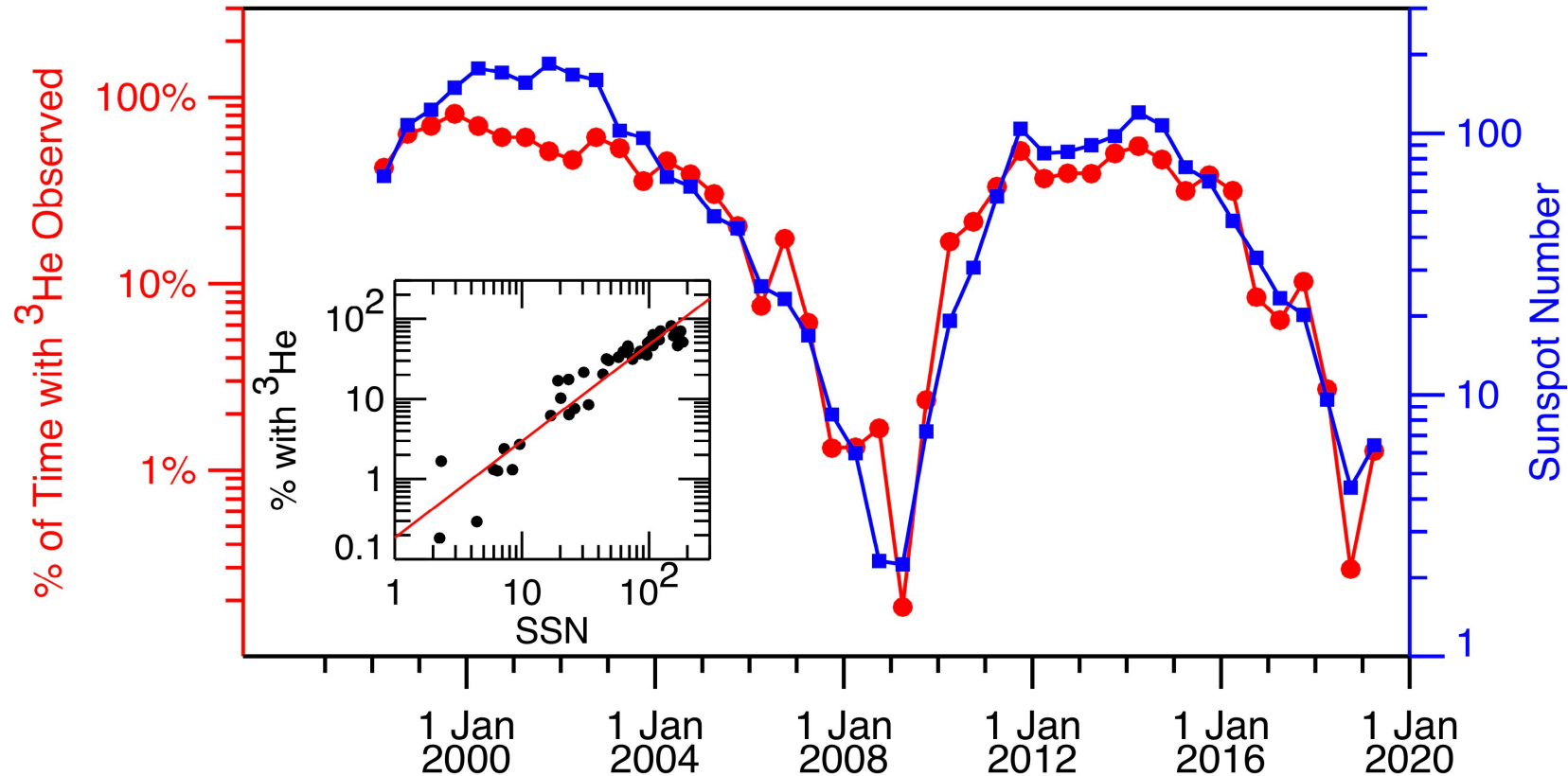


^3He and sunspots: variations over solar cycles 23 and 24

- Variation in the fraction of time that ACE has observed SEP ^3He has been well correlated with sunspot number for nearly two full solar cycles.
- Correlation is probably due to the fact that ^3He -rich events often arise from reconnection between open and closed fields at the boundaries of active regions.
- Correlation can be used to predict how often ^3He can be observed over the next several years based on predicted sunspot numbers.

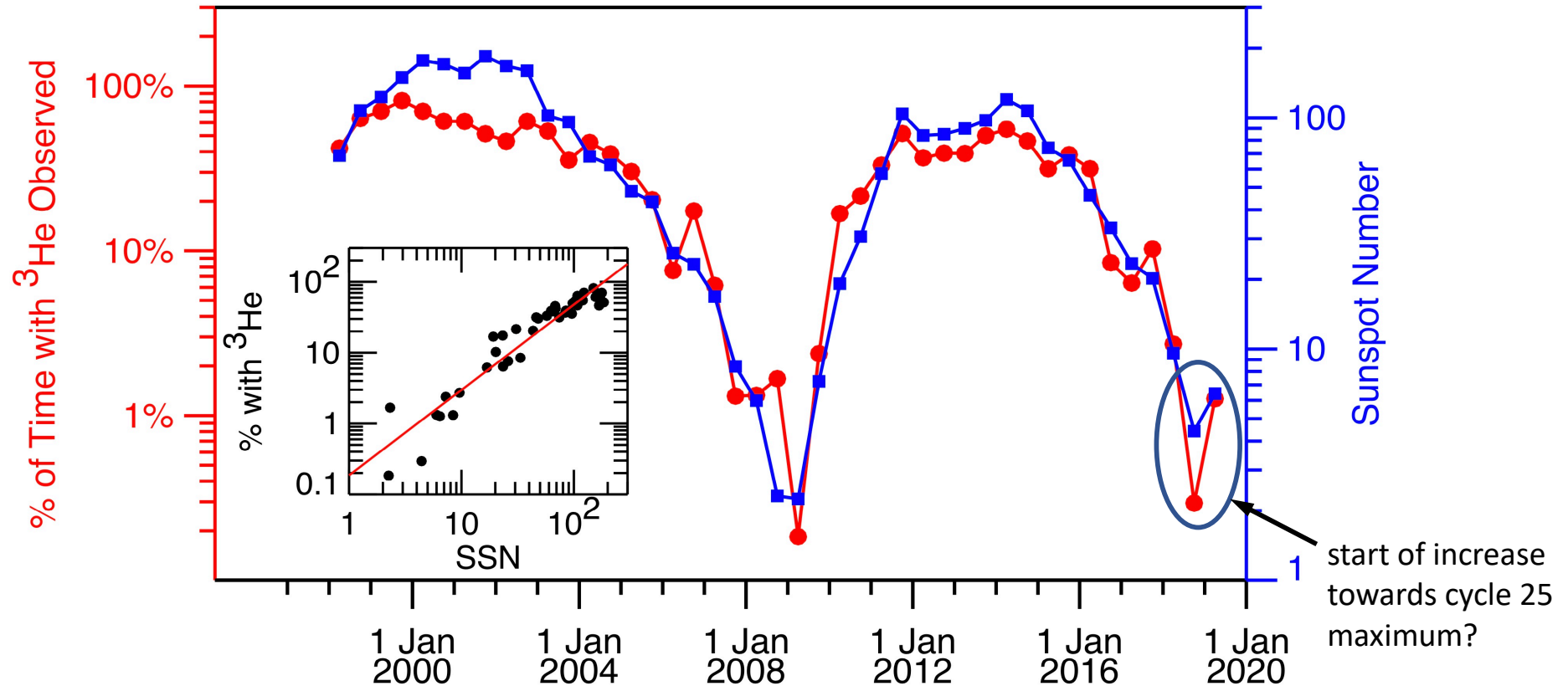


Reames, ApJL 571, L63, 2002



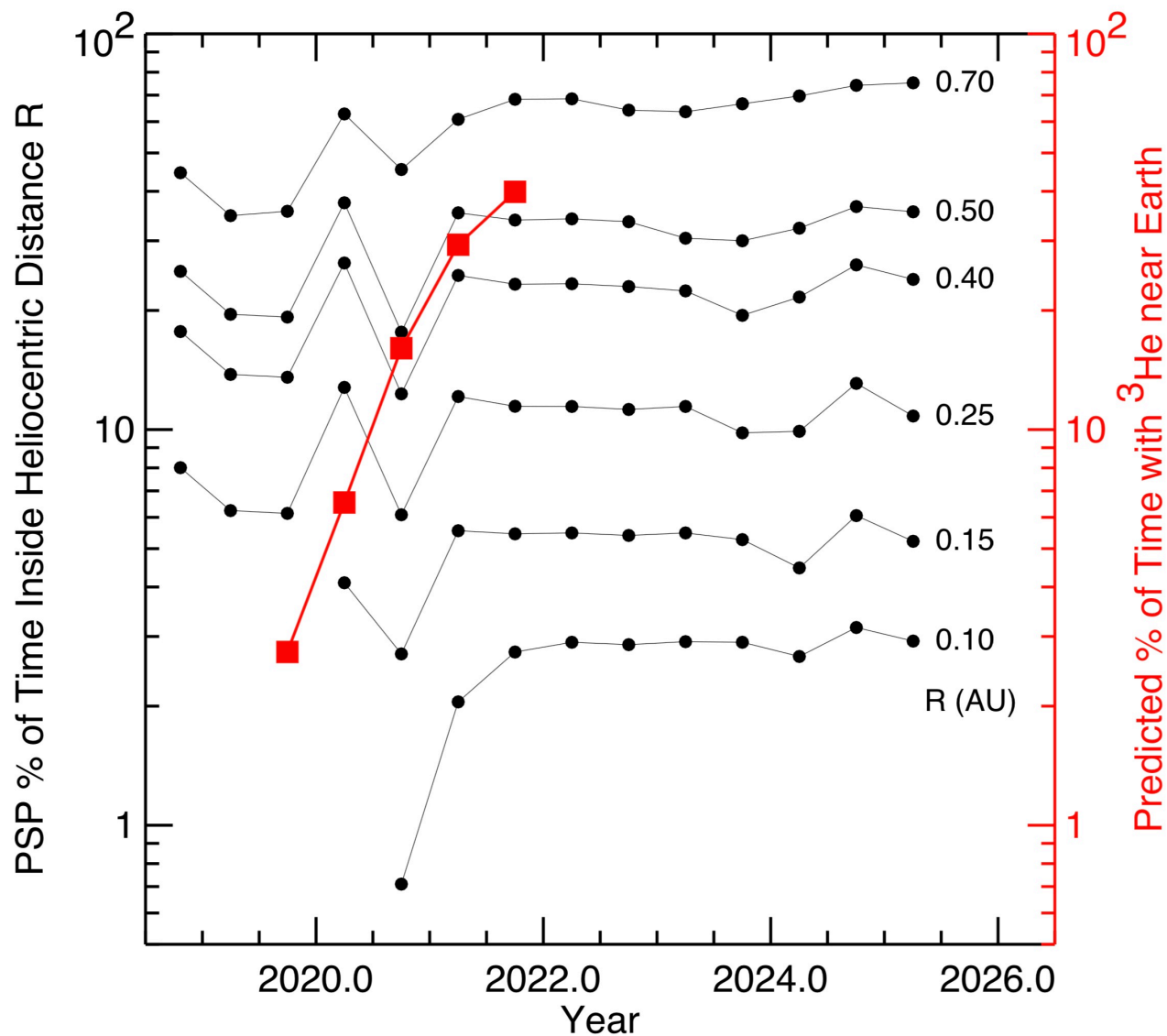
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Expectations for the next few years:

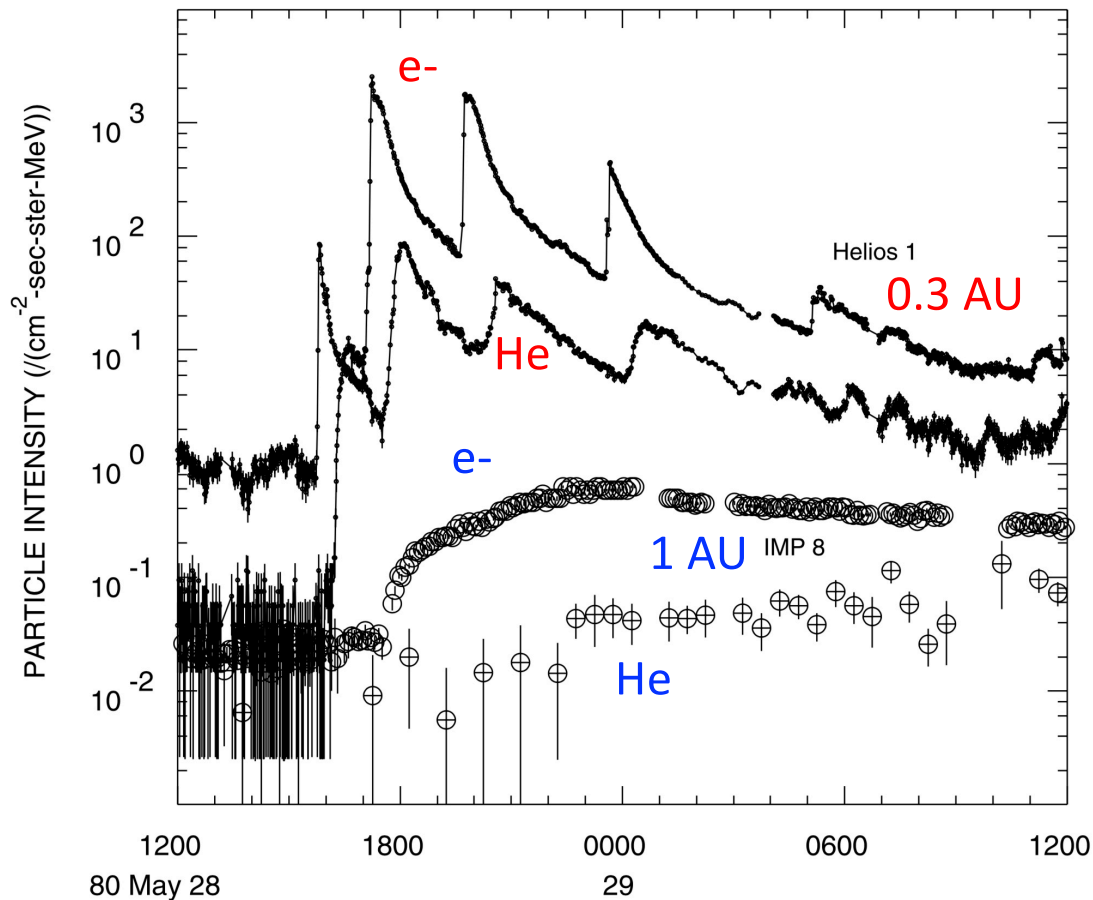
- Parker Solar Probe spending more time closer to the Sun (black)
- solar activity steadily increasing (red)



Lesson from the Helios mission:

Impulsive SEP events can look very different at different heliocentric radii

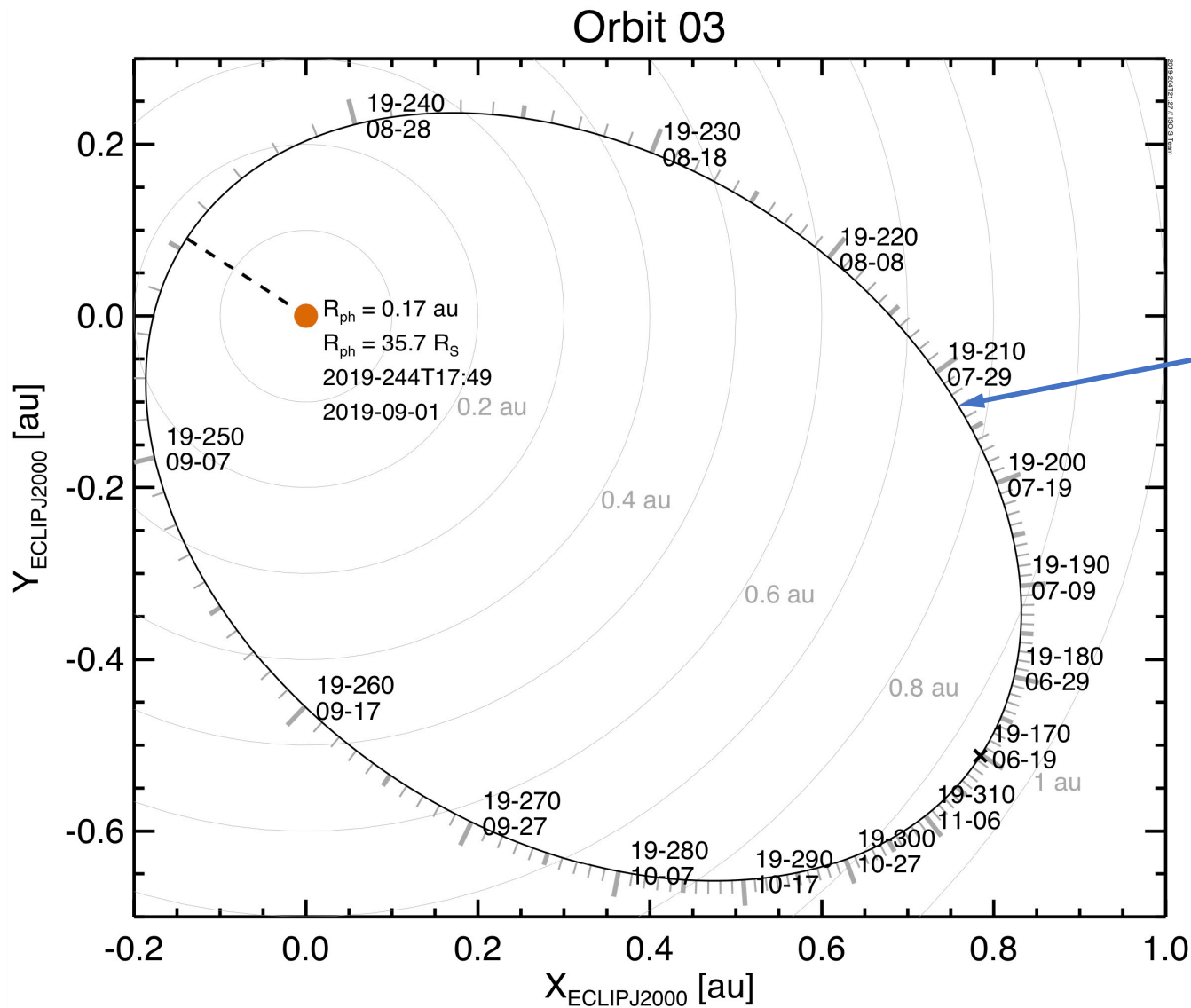
Close to the Sun, particles are more concentrated in both space and time.



- PSP perihelion distance is 0.16 AU during first three orbits—almost a factor of 2 closer than Helios came
- PSP may be able to observe 3He-rich SEP events that are too small to be detected near Earth
- over the next several years, PSP will be coming progressively closer to the Sun and solar activity will be increasing

Wibberenz & Cane, ApJ 650, 1199, 2006
see also: Mason et al., ApJ 339, 529, 1989

Parker Solar Probe Today (26 July 2019)



perihelion #3:

1 September 2019

next Venus gravity assist:

26 December 2019

present
location

perihelion heliocentric distances

orbits 1 - 3:	0.166 AU (35.7 R_s)
orbits 4 - 5:	0.130 AU (27.9 R_s)
orbits 6 - 7:	0.095 AU (20.4 R_s)
orbits 8 - 9:	0.074 AU (16.0 R_s)
orbits 10 -16:	0.062 AU (13.3 R_s)
orbits 17 -21:	0.053 AU (11.4 R_s)
orbits 22 -24:	0.046 AU (9.9 R_s)

Summary

- at solar maximum, SEP ^3He is present most of the time near Earth
- at solar minimum, the fraction of time with ^3He present drops to $<2\%$
- the fraction of time with ^3He present is well correlated with sunspot number
- solar activity, including ^3He -rich SEP events, should soon be starting to increase toward solar maximum values
- Parker Solar Probe has begun exploring the energetic particle environment closer to the Sun and should be able to determine whether there exists a large population of ^3He -rich events that are too small to be detected at 1 AU

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1. ACE / ULEIS
2. ACE / SIS
3. PSP / ISOIS