2050 CENTENARIAN RETROSPECTIVE ON SPACE ENVIRONMENT INTERACTIONS AND PROCESSES OF THE SATURN RING AND MOON SYSTEM. J. F. Cooper[1,2], [1]Heliospheric Physics Laboratory, Code 672, Heliophysics Science Division, NASA Goddard Space Flight Center, Greenbelt, MD 20771 (John.F.Cooper@nasa.gov), [2]Society of Ancient Cosmos Mariners, Clarke Geosynchronous Habitat, Earth.

Introduction: One hundred years ago in the year of my birth, 1950, we were still seven years away from the first artificial satellite, Sputnik, and had twenty-nine years remaining before Pioneer 11 first explored the Saturn system and I then entered into the exciting field of planetary science. As a surviving centenarian of this present year, 2050, I look back on the remarkable progress made in understanding the interactions between Saturn's ring system, plasma magnetosphere, neutral atmosphere, and energetic particle radiation belts.

Although my personal memories of the events contributing to this progress have long begun to fade, I am aided in recollections by my earlier account [1] and many by others and myself since then. For the 2017 account I am eternally grateful to my co-authors of that time (Peter Kollmann, Edward C. Sittler, Jr., Robert E. Johnson, Elias Roussos), and looking forward to seeing them again soon at the Solar System Geophysics Union (SSGU) Meeting at Shackleton Base on the Moon.

I have for these many years reflected on fond memories of the late Professor John A. Simpson, my "doctor father" at the University of Chicago for the Saturn work, and one of the four energetic particle instrument investigators on Pioneer 11. I also fondly recall being initiated into the "Cosmic Ray Albedo Neutron Decay (CRAND) Fraternity" by the late Professor James A. Van Allen, who discovered the Earth's radiation belts and later made key measurements and models of such belts at Saturn along with Simpson and others. He and another Pioneer 11 investigator, Walker Fillius, led the first modeling efforts from their measurements to understand the impact of neutrons from galactic cosmic ray (GCR) interactions on population of Saturn's inner radiation belts via decay of the neutrons into protons and electrons. It was by their efforts, and later by many others including myself, that we learned about this unique relationship of the Saturn system to the cosmos.

The Last 100 Years at Saturn: At largest scale in space and time this system of planet, rings, moons, and and magnetosphere is driven by four major space environment inputs. (1) Solar ultraviolet radiation sputters oxygen and other molecules off the ring and moon surfaces. (2) GCRs bombard these surfaces (mainly the A-B-C rings) to produce secondary radiation including neutrons, gamma rays, and charged particles. (3) interplanetary solar wind magnetic field and plasma interactions perturb the global magnetosphere and drive the radial transport and energization of radiation belt particles that subsequently interact with surfaces. (4) High-velocity meteroids impact the rings and moons, vaporizing surface materials and ejecting sprays of icy grains at nanometer to millimeter sizes into Saturn's space environment. Over the centenarian time scale the first three inputs have varied with the nine solar cycles of activity since 1950. During tthis time there have been seven seasonal equinoxes, when the Sun crossed the ring plane, and seven solstices at each pole of Saturn.

Our greatest challenge and success has been in understanding how all these time-modulated inputs act to drive the physical and chemical evolution of the space environment in the Saturn system and to drive the interactions between the moon and ring elements of that system. Most challenging of all was that we could only make measurements during the occasional flyby and orbital missions at Saturn. Like for the Jupiter system, it was recognized that all spacecraft visitor and permanent residents at Saturn *must* make environmental measurements to follow the long-term and short-term trends of variation. It was, for example, the 2004 – 2017 orbiter mission at Saturn that first revealed the seasonal variation of the magnetospheric ion densities and the solar cycle variation of the low-energy and high-energy proton radiation belts from CRAND.

Without the many following ancillary measurements of space environment parameters from Saturn Probe, Saturn Ring Observer, and what followed, it would have been difficult if not impossible to disentangle cyclic contributions from differently modulated inputs. Among many such measurements it may have been the discovery of the previously undetectable cloud of nanometer dust that most changed our perception of radiation belt source, transport, and loss processes, providing the necessary missing link between the plasma and energetic trapped ion populations and the meteoroid impact source in the main rings. Addition of neutron and gamma-ray imaging spectrometers to the post-Cassini missions provided direct data on internal composition and structure of the rings, thereby allowing *very suprising* conclusions to be drawn on the ring origin and evolution. These results were key to motivation to the ring sample return mission, which has just now concluded with delivery to lunar laboratories.

References: [1] Cooper J. F. et al. (2017) in *Planetary Ring Systems*, Chapter 15, Cambridge Univ. Press.