HRC Update

Almus Kenter and Ralph Kraft

Status of Instrument

The most significant news for the HRC community of the past year is the passing of Dr. Michael Juda. A more detailed article on Mike is contained on page xvii, but the HRC IPI team would like to acknowledge his tremendous contribution to the long-term health and safety and success of the High Resolution Camera. Among other key *Chandra* tasks, he was the HRC Instrument Scientist from 1993 until his passing in Dec, 2016. As such, he had primary responsibility for the safe and efficient operation of the flight instrument. He also contributed to a wide range of instrument investigations to improve the instrument performance and track down some anomalies, particularly early in the mission. He was a smart, patient, no-nonsense scientist who dedicated his professional life to *Chandra*, and he will be missed. Dr. Daniel Patnaude is now the HRC Instrument Scientist for the CXC, and the IPI team is pleased to work with Dan to maintain the health and safety of the instrument.

The HRC continues to work well with no anomalies or unusual events. In the previous newsletter we presented results from in-orbit calibration data of changes in the gain of the HRC-S. The lifetime of a Microchannel Plate detector is typically measured in terms of extracted charge. In early 2012, it was decided that HRC-S gain had decreased to the point that for some observations, the Quantum Efficiency was being affected, particularly for "soft" (LETG) observations, so the HRC-S high voltage (HV) was increased by one step per plate. Subsequent to this increase in HV, the gain initially recovered. However the gain has since decreased at a much more rapid pace (see Figure 1). It is estimated that the total charge extracted from either detector due to cosmic rays (the dominant source of extracted charge) is only ~5×10^{-4} C cm^{-2}. The amount of extracted charge is roughly two orders of magnitude below where we should expect to see significant gain effects. Nevertheless, the HRC gain has been dropping on both the HRC-I and S detectors since the beginning of the mission.

At first this was puzzling, but now it is understood. So little charge has been extracted from the HRC that the plates are still in their infancy. Early in the HRC program there were several competing thoughts on how to prep the microchannel plates before incorporating them into the instrument. One group (Leicester UK) was of the mind that the plates should undergo a process of stabilization by extracting a certain amount of charge—a process often called "scrubbing". The other group (Cambridge MA) insisted that in single photon counting mode, charge extraction would be so modest that there would never be a need to worry about MCP "lifetime". No scrubbing of HRC MCPs was ever performed. The bottom line for the *Chandra* scientific community is that beyond future high voltages increases (which the HRC was designed for), charge extraction from the HRC MCPs will only be an operational concern on a timescale of centuries.

A Selected HRC Science Observation

SAO's own Brad Wargelin (et.al.) have used the HRC in combination with other observatories to observe Proxima Cen to confirm evidence of a stellar cycle; something that was not initially expected. The observational program was motivated by the discovery that this M5.5 star, which is fully convective, has a multi-year stellar cycle like the Sun's even though it's not supposed to. For more details please see the press release of October 2016 (*https://www.cfa.harvard.edu/news/2016-25*) that was generated in concert with the publication of the associated paper: (*http://hea-www.cfa.harvard.edu/~bradw/cv/papers/Prox-Cycle.pdf*).

For the HRC-I Proxima observations, the instrument was used in an unconventional "commensalistic" mode: while the ACIS was collecting undercover background measurement data and well out of the focal plane, the HRC-I can be still used even though it is at a relatively large off-axis angle (roughly 10 to 26 arcmin) and must operated in NIL (Next in Line) mode. HRC NIL mode is telemetry limited to only ~3.5-ct/s which was adequate for the expected flux for these observations.

Based on fifteen years of optical monitoring, 4 years of *Swift* X-ray/UV data, and 2 HRC observations Wargelin et al find evidence for a 7-yr stellar cycle in Proxima Cen (dMe5.5), a fully convective star. A stellar cycle is very exciting because most models of stellar magnetic activity

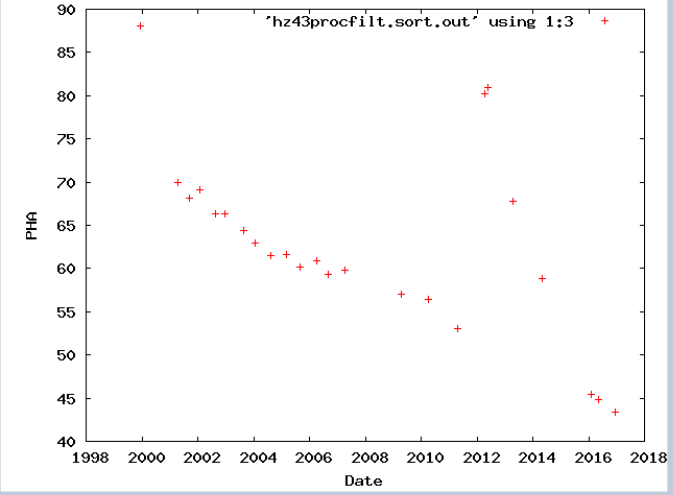

Figure 1: HRC-S gain as a function of time from HZ 43 in-flight calibration observations. Note the change in slope after the HV increase in early 2012. The voltage was increased by one step (~20V) per plate.

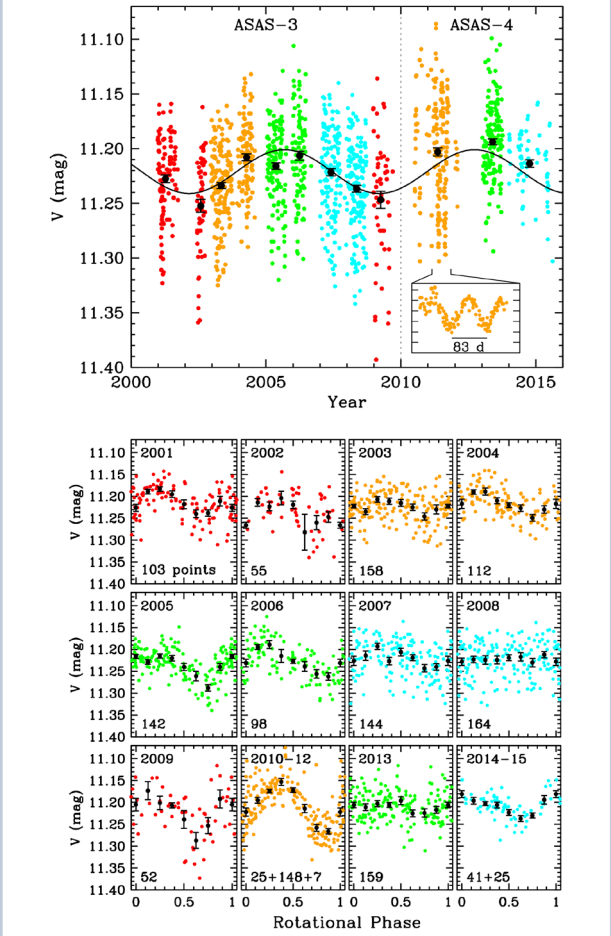

Figure 2. Brad Wargelin (et.al.) have used the HRC-I in combination with other observatories to observe Proxima Cen to confirm evidence of a stellar cycle; something that was not initially expected.

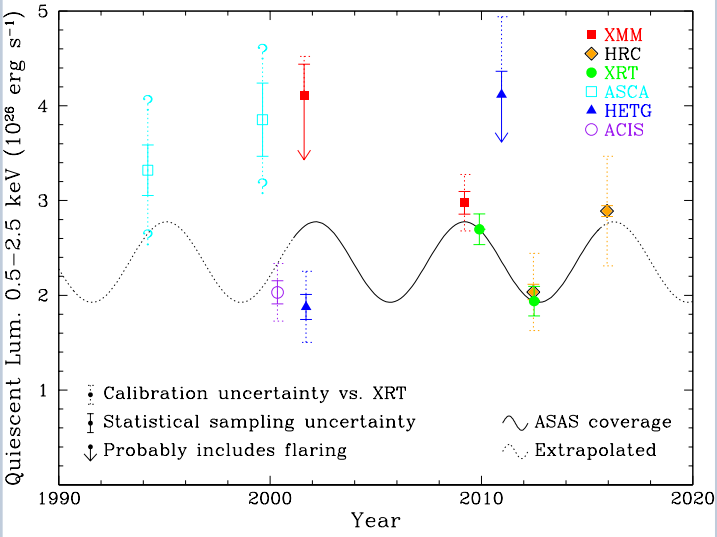

Figure 3. Corresponding optical data for Proxima observations. For details and further context please see referenced paper and press release.

predict such stars cannot support solar-like cycles. Understanding the structure and evolution of Proxima's magnetic field is also important because that's what drives X-ray/UV emission and the stellar wind, which are important factors in modeling the atmosphere (atmospheric stripping) and habitability of its newly discovered exoplanet. And as noted by the discovery announcement, "The robust detection of Proxima b has only been possible after reaching a detailed understanding of how the star changes on timescales from minutes to a decade." Further X-ray measurements are required now, while the cycle appears to be at a maximum, for confirmation and to better characterize Proxima's activity over time. ▪