HRC Update

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The High Resolution Camera (HRC) approaches its twentieth year of flight as healthy and productive as ever. From the shining poles of Jupiter to black holes in the distant Universe, *Chandra*'s sharpest eye continues to enable world-class science across the breadth of astrophysics.

Among the many exciting HRC results from the past year is a discovery found in the relativistic jet launched by a supermassive black hole. Peering into the heart of M87—the enormous central galaxy of the Virgo cluster—Snios et al. (2019) report results from two HRC-I observations spanning 5 years (2012–2017) in search of proper motions and brightness changes in X-ray emission along M87's jet. While proper motions have long been observed in radio and optical jets for a number of nearby active galaxies, Snios et al. have detected them in X-rays for the very first time, with superluminal motions up to 6.3 ± 0.4c (or 24.1 ± 1.6 mas yr^{-1}) observed parallel to the X-ray jet axis. Proper motion estimates are found for the two innermost knots, *HST*-1 and Knot D, while upper limits are placed on the remaining jet features.

Snios et al. compare these new X-ray results with previous measurements from optical and radio bands, and excellent agreement is observed both in spatial positions and proper motion speeds. It is therefore highly probable that the X-ray emission regions are co-moving with the emission regions observed in UV, optical, and radio. Brightness variations up to 53% are detected for the X-ray knots. By modeling the knots, synchrotron cooling is found to be the most probable source of the observed fading. Using the synchrotron cooling models, lower limits on magnetic field strengths of 700 μG and 150 μG were found for Knots *HST*-1 and A, respectively.

This remarkable result is thanks to the HRC's exquisite angular resolution. Offering the best point spread function available on *Chandra*, the HRC is capable of measuring proper motions on scales of better than 0.125″, thanks to the sharpness (and stability) of its imaging capability. In fact, the Snios et al. limit on Knot D's proper motion is only 50 mas (0.05″)—a spatial scale one order of magnitude finer than the PSF delivered by the High Resolution Mirror Assembly (HRMA). This is, therefore, one of the highest spatial resolution X-ray results ever obtained.

Meanwhile, the HRC remains stable and healthy, and the Instrument P.I. and Calibration teams have made substantial progress in optimizing the performance of the instrument. Even as we approach the twentieth launch anniversary of *Chandra*, the teams have managed to improve the background rejection algorithm employed in the data reduction pipeline over the past two decades. They are now testing the algorithm across the entire HRC database to quantify the percent improvement users might expect to see should they opt-in to a possible public release of this modified algo-

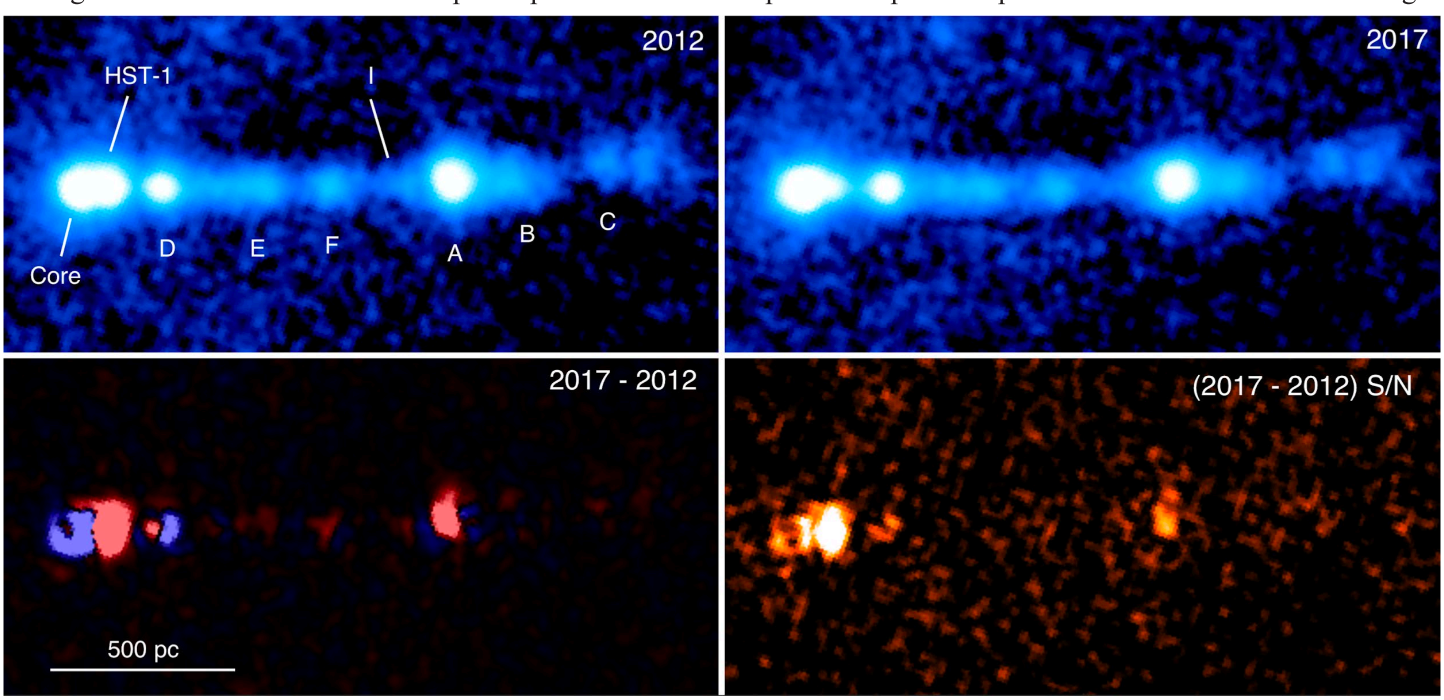

Figure 1: The HRC has recently observed proper motions of X-ray knots in M87's famous jet. Shown here are 0.1–10 keV HRC-I images (upper panels), a difference map (lower left panel), and a signal-to-noise map (lower right panel) of the M87 jet, showing clearly detected proper motion in its various knots across the five years spanning 2012–2017. Figure from Snios et al. 2019 (in prep).

rithm. Early results show that the new algorithm's 10–20% improvement in signal-to-noise could aid those in search of faint lines in their gratings spectra, or low surface brightness extended features in imaging data. The HRC IPI and Calibration teams look forward to updating the community on our progress and recommendations later this year.

Finally, a decision has been reached regarding management of the HRC gain sag effect, a long-known and well-characterized decline of detector gain that has persisted since the start of the mission. This gain sag can slowly decrease quantum efficiency (QE) and increase spatial variations within the detector. In an attempt to mitigate this sensitivity loss, the operating voltage of both HRC-S microchannel plates was increased in March of 2012, nearly restoring the instrument's sensitivity to what it had been at launch. The gain resumed dropping immediately following the voltage change, however, this time with a steeper decay rate. The gain sag has therefore "caught up", and is now roughly where it was just prior to the intervention in 2012. Nevertheless, our understanding of the issue has since increased, and the gain decline continues in a well-characterized and expected manner. As the associated QE drop is very small and entirely accounted for in calibration, no increase in the plate voltage is expected within the next year. The teams will keep the community apprised should these plans change, and look forward to many more exciting years of nominal HRC operations.