Probing the Physics of Particle Acceleration at ICM Shocks

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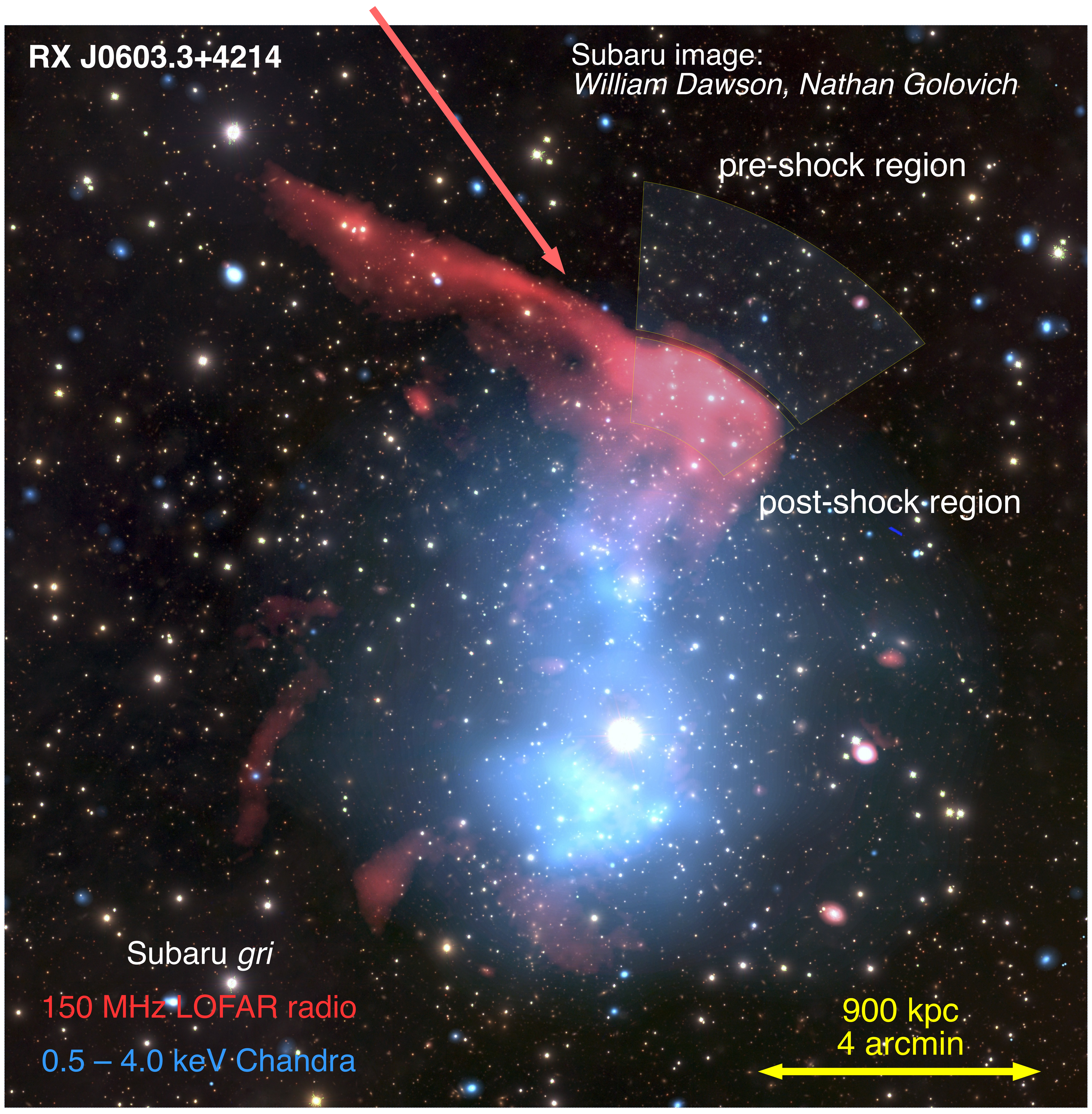
1. Radio relics

Relics are elongated Mpc-size radio sources located in the outskirts of merging galaxy clusters. These radio relics trace merger shocks where particles are accelerated to relativistic energies, causing them to emit at radio wavelengths. It is still being debated by which physical mechanism these particles are accelerated.

2. Shock Mach number

Particle acceleration models make predictions about the relation between shock Mach number and the observed radio spectral index. However, existing X-ray observations lack the sensitivity to measure the Mach numbers at large cluster centric radii with high-accuracy to test these models.

Radio Relic



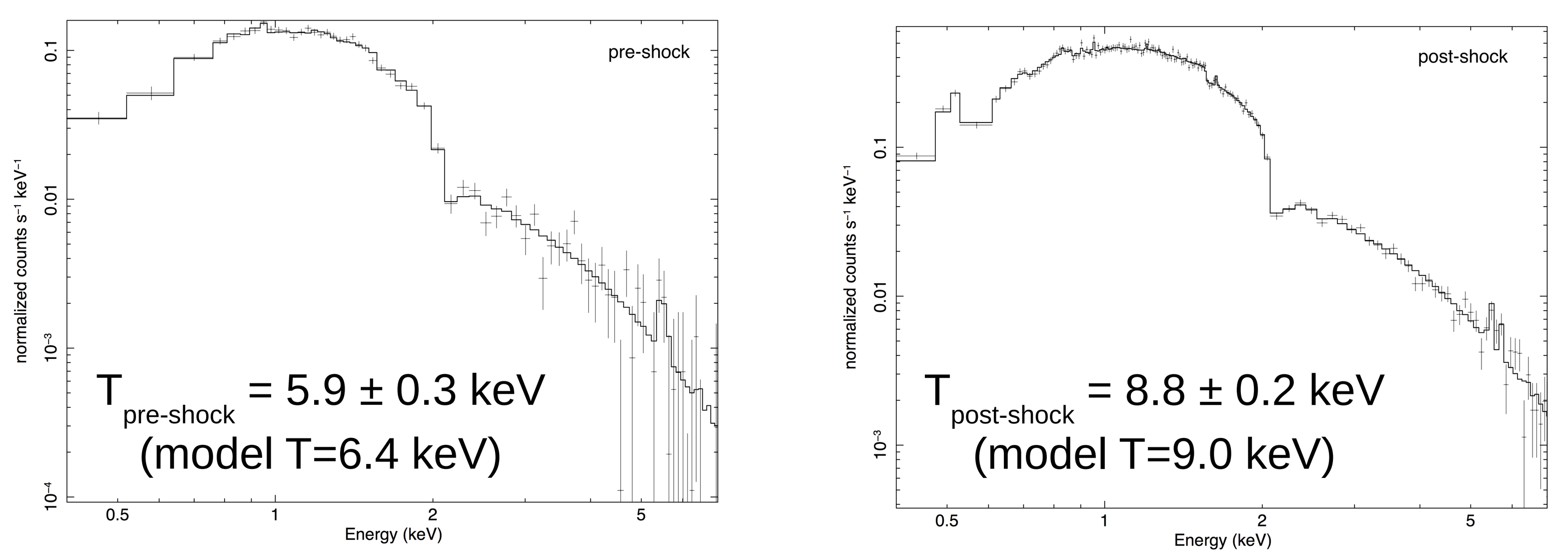
3. A case study

A textbook example of a radio relic is the one in the cluster RXJ0603.3+4214 ($z=0.225$). In a 240 ks Chandra observation a hint of a weak M~1.4 shock is found at the location of the relic, by measuring the X-ray surface brightness jump. No useful constraint could be obtained on the pre-shock temperature.

4. X-ray Surveyor simulations

Based on the Chandra count rate and measured ICM properties, we simulated an X-ray Surveyor observation of a Mach = 1.4 shock with, a post-shock temperature of 9 keV. We determine the shock Mach number from the surface brightness profile and via measurements of the pre- and post-shock temperatures.

X-ray Surveyor simulated pre- and post-shock spectra (calorimeter, 100ks)

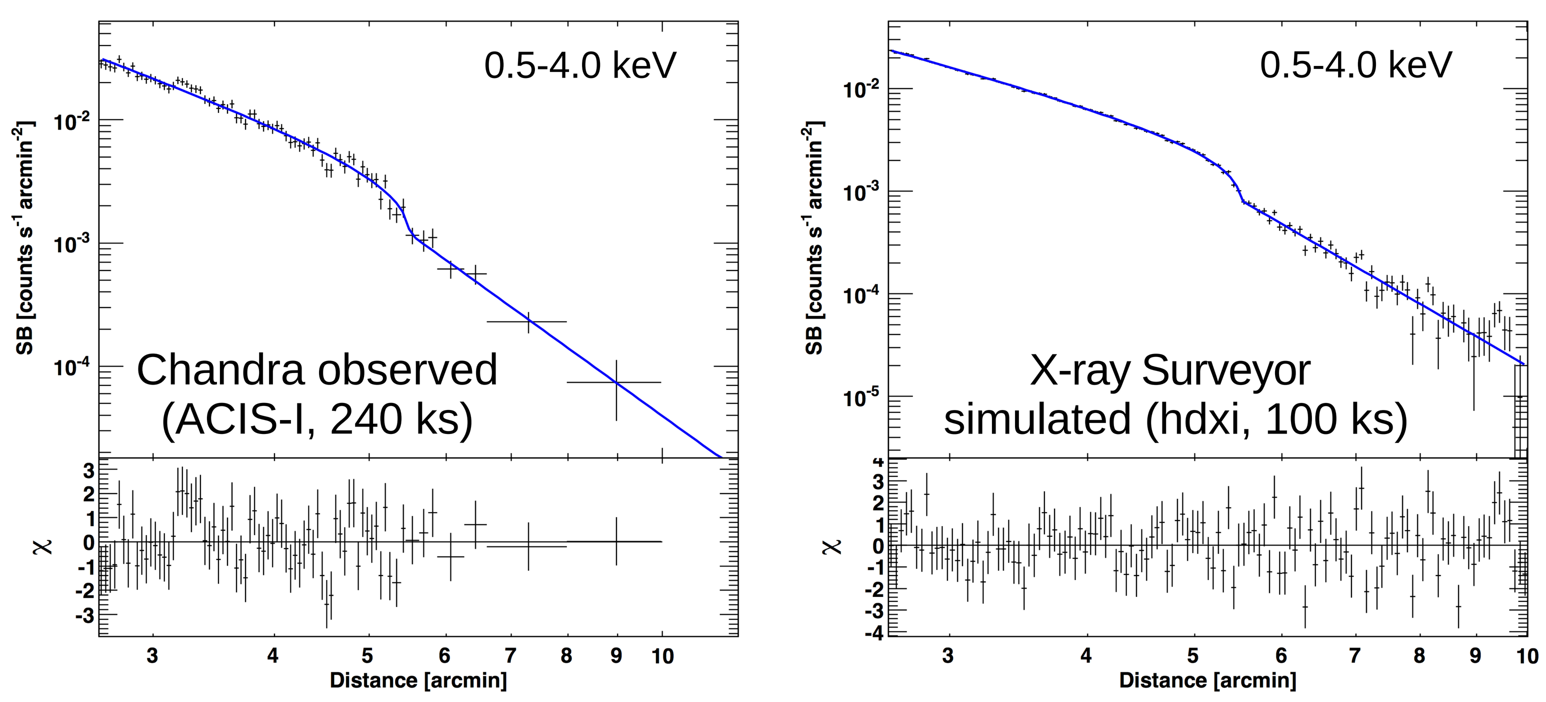


Redshift (0.225) and Abundance (0.25) were frozen in the fit, n_H was left as a free parameter.

Mach number = 1.5 ± 0.1
(model M=1.4)

Observed and simulated surface brightness profiles across the relic

Double power-law projected density profile fit with a jump



Mach number = 1.4 ± 0.3
(observed)

Mach number = 1.38 ± 0.03
(model M=1.4)

5. Conclusion

X-ray Surveyor observations will enable precise measurements of low-Mach number shocks in cluster outskirts both via the density and temperature jump, crucial for testing particle acceleration models.

References: van Weeren et al. (2010, Science, 330, 337); van Weeren et al. 2012 (A&A, 546, 124); van Weeren et al. 2015 (ApJ, submitted); Dawson et al. (in prep); Eckert et al. (2011, A&A, 526, 79); Ogrean et al. (2013, MNRAS, 433, 812)