- Interactions between radio jets and their hot atmospheres
- Constraints on possible heating mechanisms

In our sample, the archetype of extremely powerful AGN outbursts and transitional radio galaxies is represented by Hercules A – currently the second most powerful AGN outburst known ($E_{\rm tot} > 10^{61}$ erg). The spectacular and complex interaction between the large-scale X-ray environment of Hercules A and the AGN outflow are shown in Figure **??**. Using ~ 100 ks of *Chandra* data, the studies of Nulsen et al. 2005, 2011 present analyses of the ICM cavities and spherical, Mach ~ 1.6 shock surrounding the cavities. The studies showed that the shock forms a continuous cocoon around the cavities/radio lobes, and possesses $100\times$ the power radiated by gas within the cluster cooling radius. The energetic demands of the outburst are such that the accretion of hot or cold gas to fuel the AGN are strained to near maximal efficiencies. This distinguishes Hercules A from not just the other objects in our sample, but from radio galaxies in general, and gives us the opportunity to better understand the extreme end of the AGN feedback process. The Hercules A shock is more energetic than any of the shocks in our other targets, and is younger than those in Cygnus A and Hydra A, but older than the shock in Virgo A. Within the context of our sample, Hercules A's unique location in the age-energy plane highlights its value as a probe for investigating (blah...)

- Jet particle content and entrainment
- Nonthermal Xray emission from radio source
- Mixing and turbulence (jet decollimation, entrainment)
- Complete cavity census

The synchrotron power output of Hercules A between 10–10,000 MHz ($P_{\rm radio} \approx 4 \times 10^{44}$ erg s^{-1}) is on-par with Cygnus A, and is distinctly that of the FR-II class of radio galaxies. However, similar to the lower-power FR-I class, the radio morphology is jet-dominated and there are no detected hotspots. The western jet-lobe structure contains ring-like features, which it has been argued is strong evidence of intermittent nuclear activity that has culimnated in the full-source having an immense projected size of ~ 500 kpc across and ~ 300 kpc at its widest. Further, the eastern jet is X-ray bright, but the western jet is not, and there are clear signs of both jets decollimating at ≈ 50 kpc from the nucleus. The radio properties of Hercules A are unique in general and particularly among our sample. As such, an X-ray study of Hercules A at unprecedented resolution and depth will give the astrophysics community the opportunity to (blah...)

- AGN fueling energetics and SMBH growth
- Constrain the presence (or absence) of multiphase gas
- Metal enriched outflows

At the heart of Hercules A is a compact (~ 10 kpc), resolved thermal source which does not host a point source but does host the fuel powering the AGN outburst. HST observations revealed that the optical core is composed of the cD AGN host galaxy and a small merger companion. At the very center of the cD, VIMOS IFU Hα+N[II] observations indicate the presence of a structured, rotating gas disk which is oriented orthogonal to the jet axis. The optical complexity of the Hercules A nucleus is difficult to understand in relation to the hot, X-ray component given the limitations of the existing data. In order to piece together the link between the nuclear hot and cold gas phases, understand how the AGN is fueled and powered, and investigate the redistribution of metal-enriched gas on scales the size of the cD halo, we must have high-SN data in bins the size of individual ACIS pixels. Data of this quality will allow us to study (blah...)