Simulating *Astro-H* Observations of Galaxy Cluster Gas Motions

J. ZuHone (MIT), E. Miller (MIT), A. Simionescu (ISAS/JAXA),
M. Bautz (MIT), M. Markevitch (NASA/GSFC), I. Zhuravleva (Stanford)

Mapping the Gas Turbulence in the Coma Cluster (arXiv:1505.07848)

- Measuring the second-order structure function (SF) from spatial differences of the line shift constrains the velocity power spectrum (PS).
- The SF can be computed using spatial configurations of individual 3′x3′ *Astro-H* pointings at ~1.5′ resolution (Figure 1).
- Using models of turbulent velocity fields in a Coma-like cluster with varying parameters, we compute the SF of the line shift, accounting for cosmic variance and measurement errors (Figure 2).
- We find that *Astro-H* will be able to constrain the injection scale of the turbulent motions, using a pointing configuration with large baselines (Figure 3).

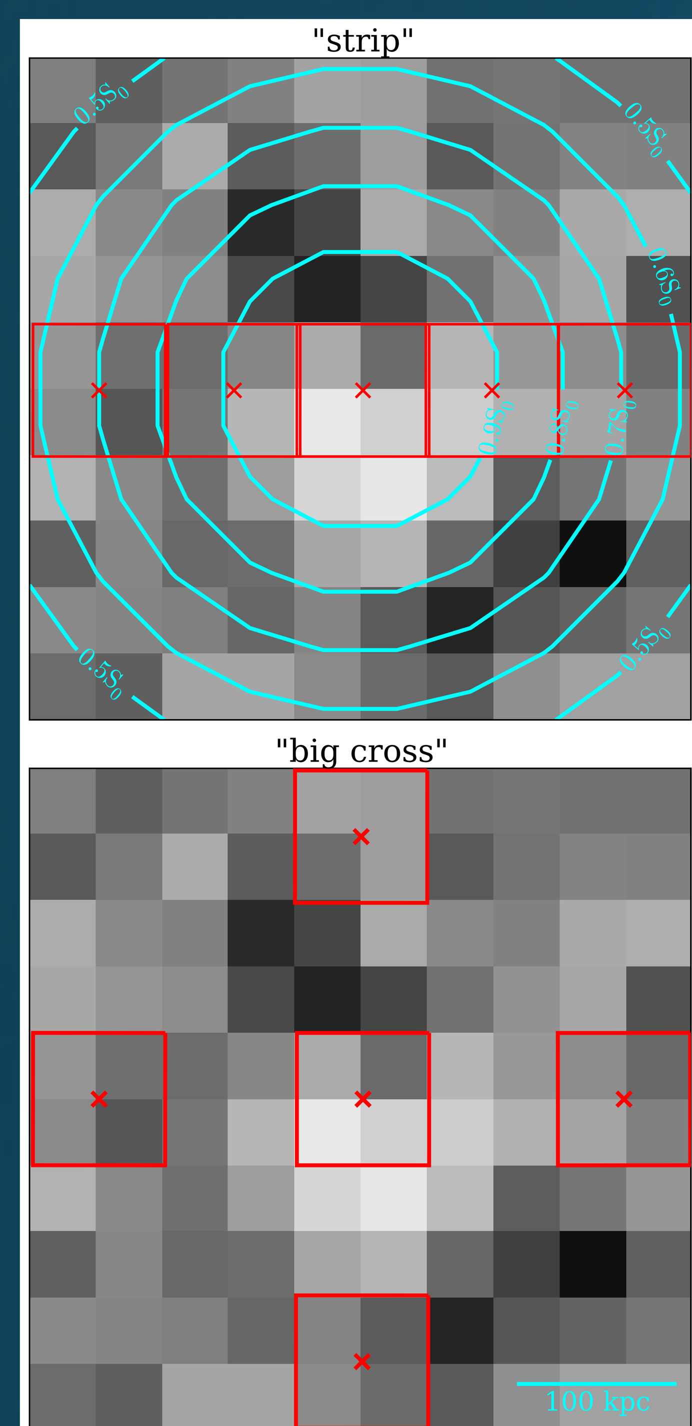

Figure 1: Example pointing configurations for calculating the structure function.

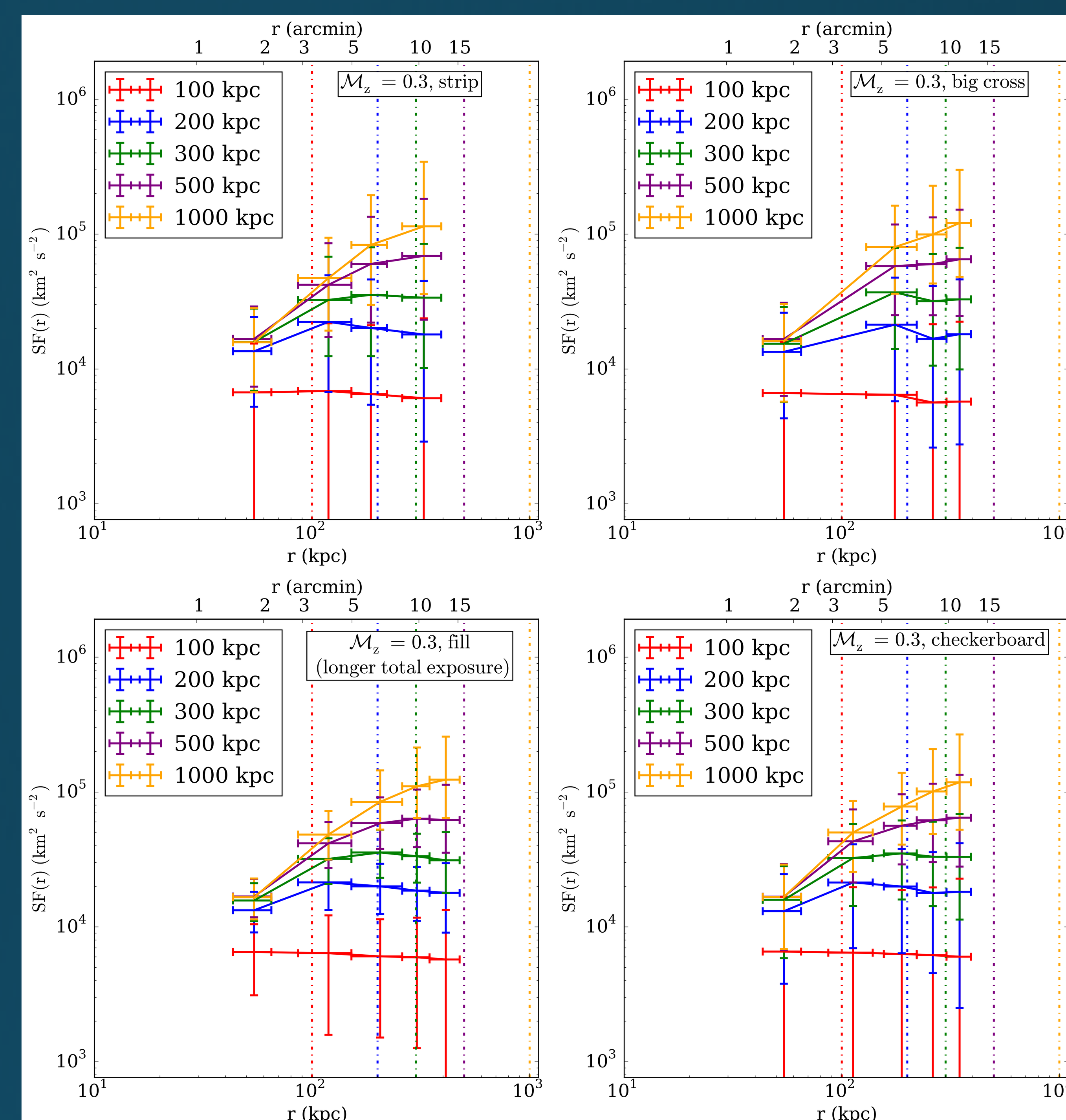

Figure 2: Second-order structure functions for varying injection scale of turbulence and different pointing configurations.

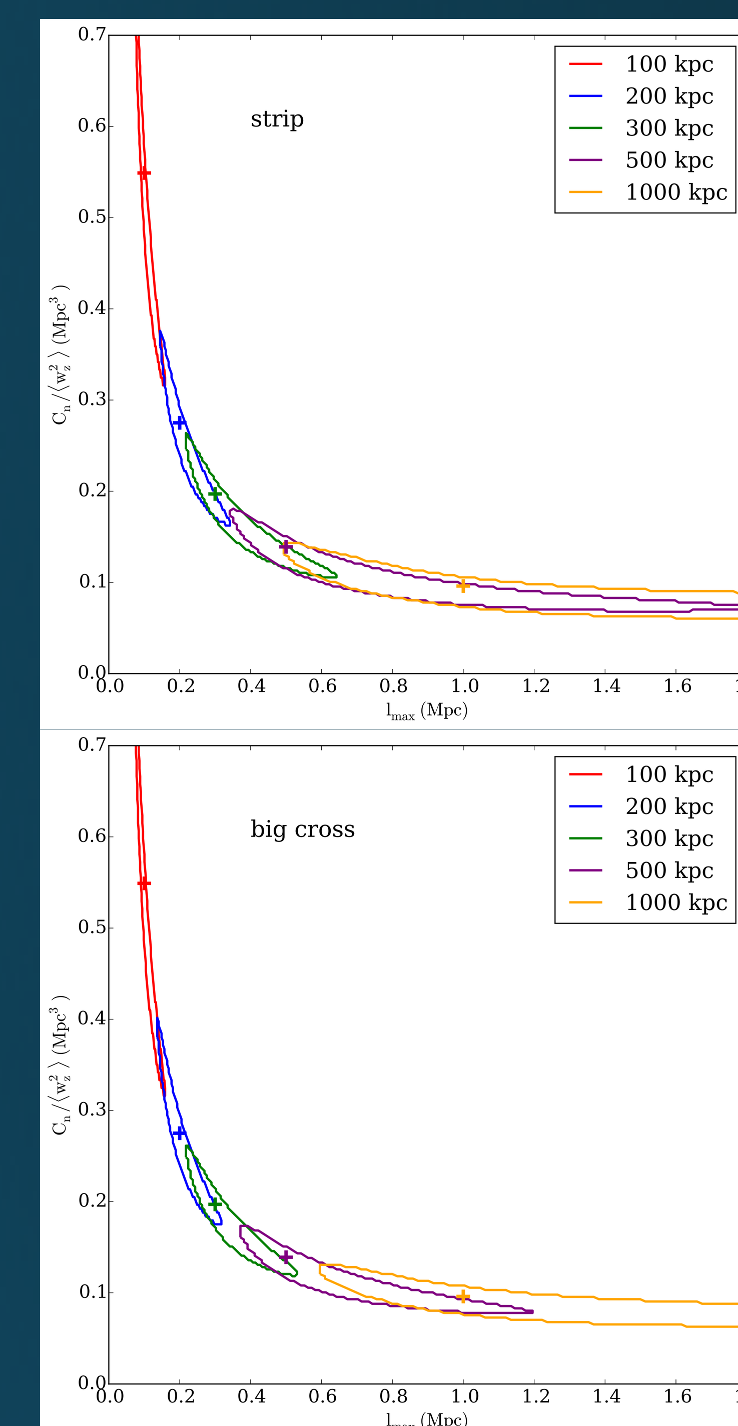

Figure 3: 68% confidence regions for PS normalization and injection scale.

Detecting Bulk Motions in Cluster Cool Cores

- The "cold fronts" seen in *Chandra* images of cool-core clusters are associated with subsonic tangential "sloshing" motions.
- We examine hydrodynamic simulations of sloshing with varying levels of viscosity to show that these motions produce shifting and broadening that *Astro-H* will be able to observe in nearby systems (Figures 4 and 5).
- The line broadening associated with cold fronts is dominated by the large scale motion, not small-scale turbulence or instabilities, so constraints on viscosity are limited (Figure 6).
- We use synthetic *Astro-H* spectra to constrain various spectral models (Figure 7), and we find that models that do not incorporate velocity broadening can be ruled out.
- We also find that it will be essential to account for the effects of PSF scattering (~1′) from the bright core for accurate determinations of the velocity shift, width, and gas temperature.

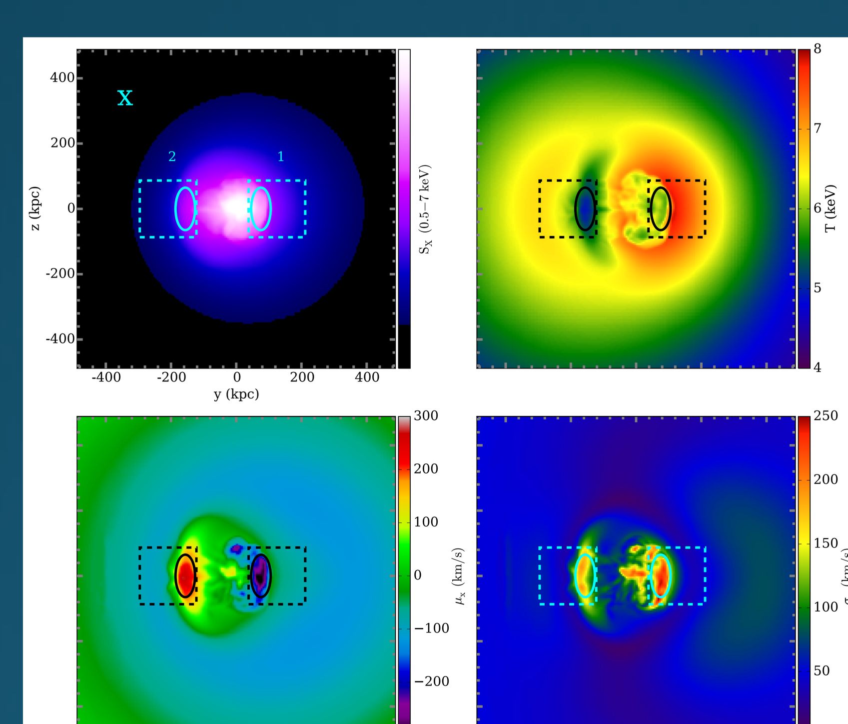

Figure 4: Projections of quantities along the simulation x-axis with spectral extraction regions indicated.

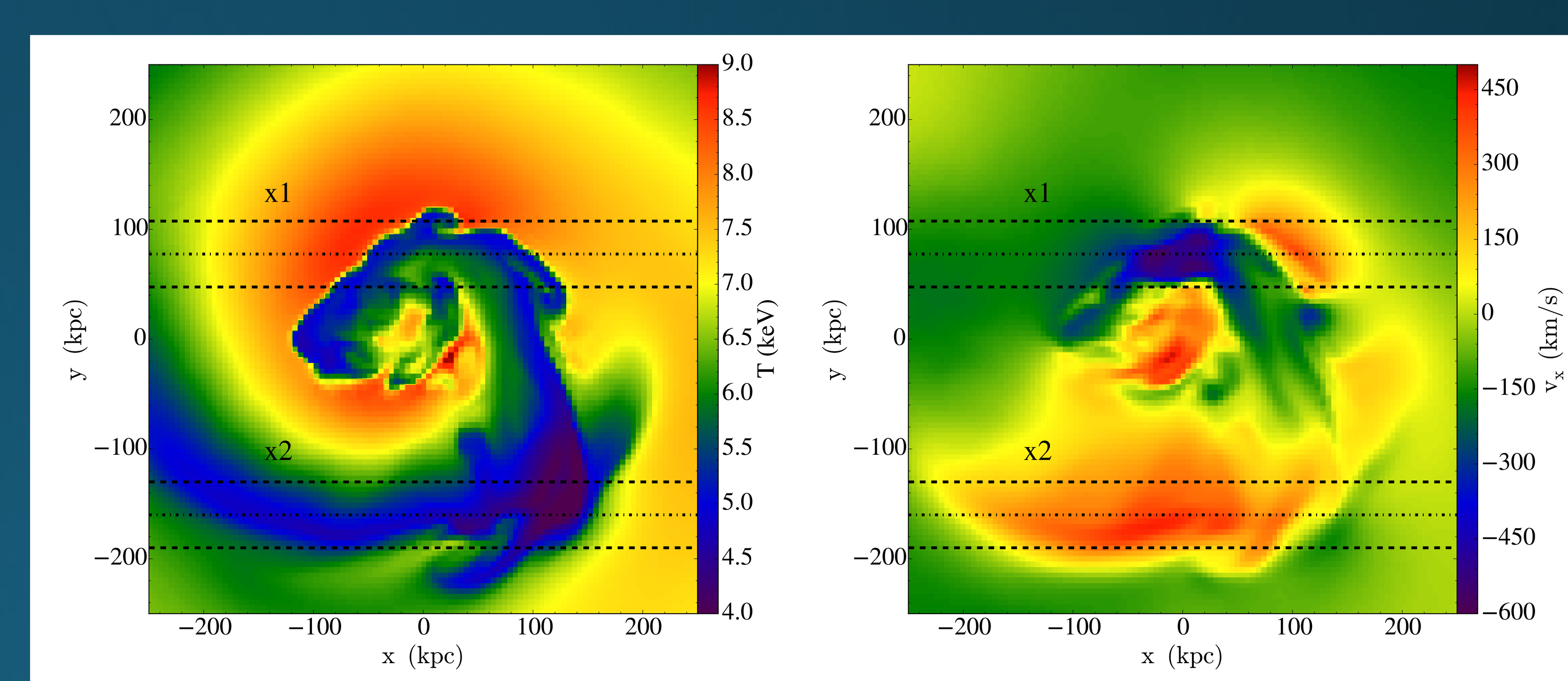

Figure 5: Slices through temperature and the x-component of velocity, with regions selected for spectral extraction marked as cylinders along the line of sight in the x-direction.

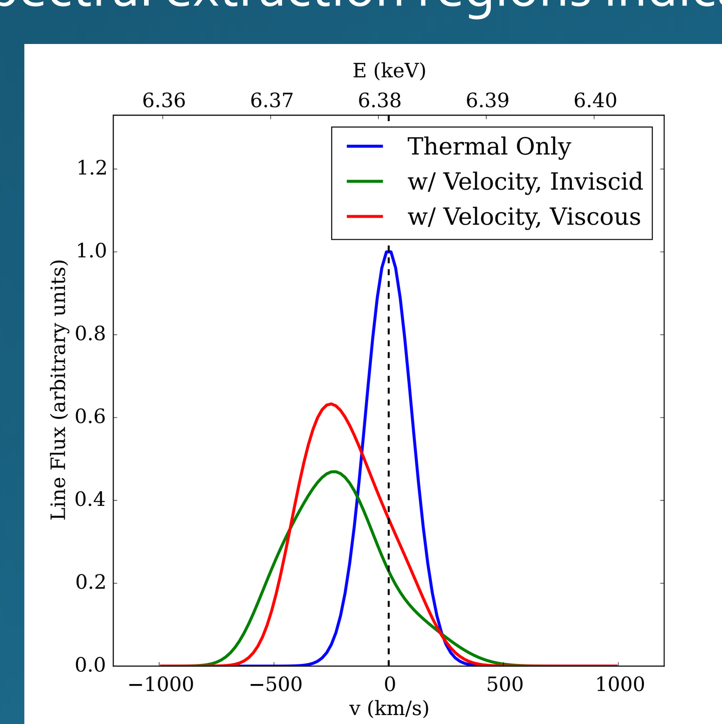

Figure 6: Effect of velocity broadening on a "toy" iron line, from region "x1".

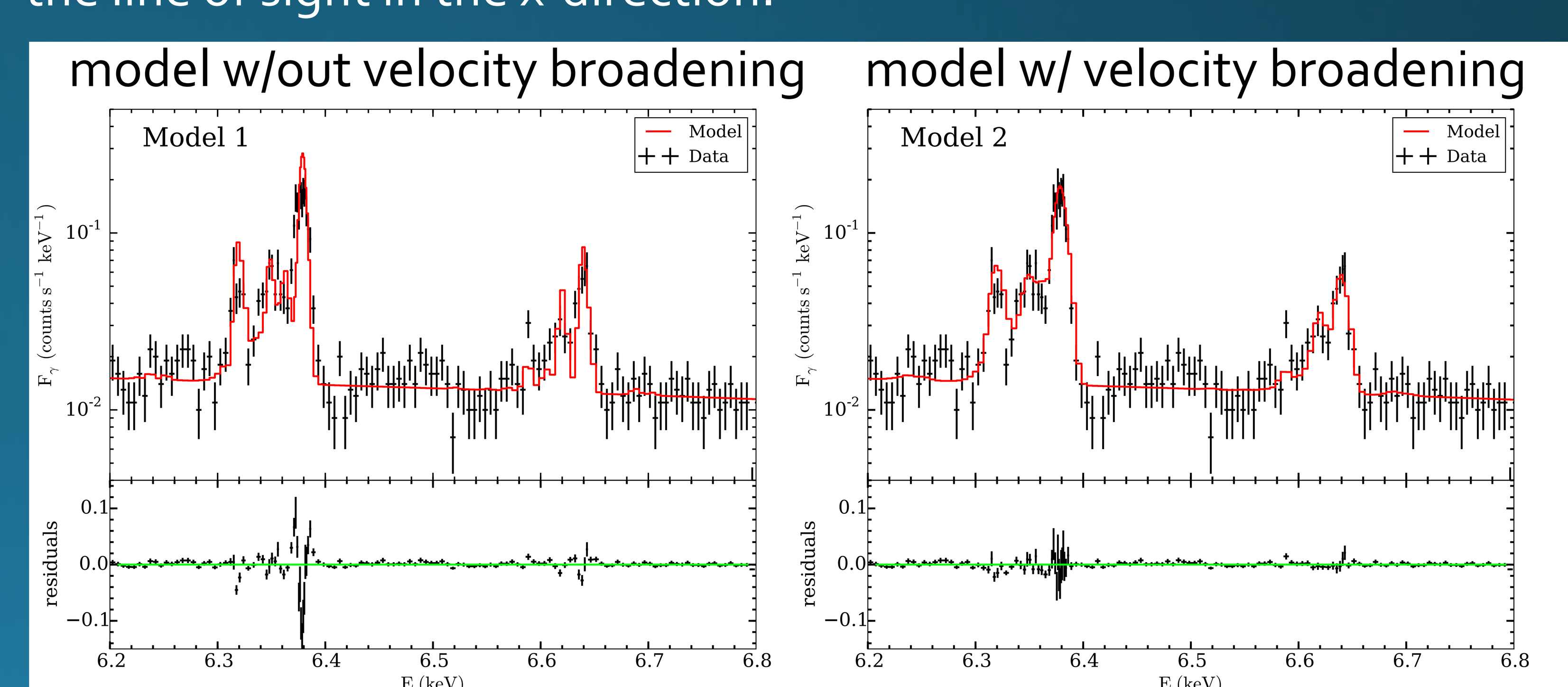

Figure 7: Synthetic *Astro-H* spectra and fitted models for region "x1", around the Fe-K lines.

email: jzuhone@mit.edu