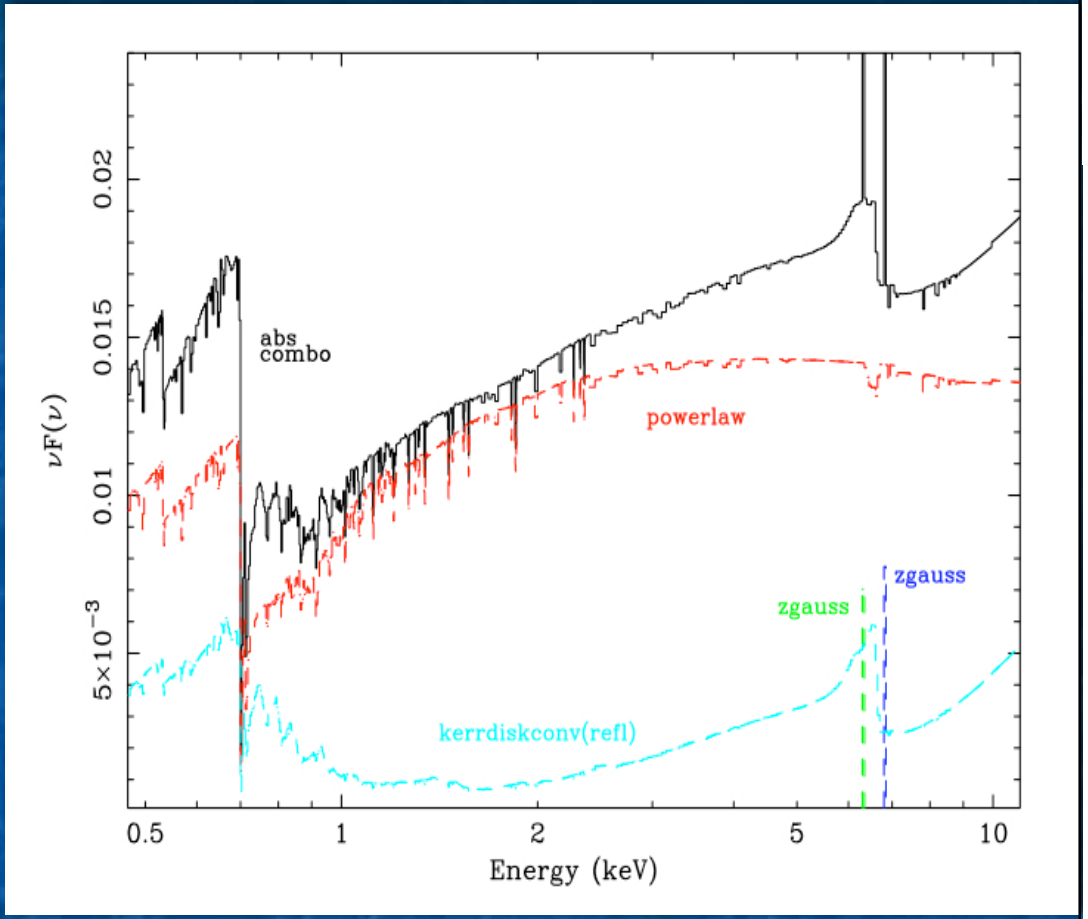
Astro-H studies of AGN and clusters of galaxies

Chris Reynolds
(U.Maryland)

I : Unraveling the physics of AGN

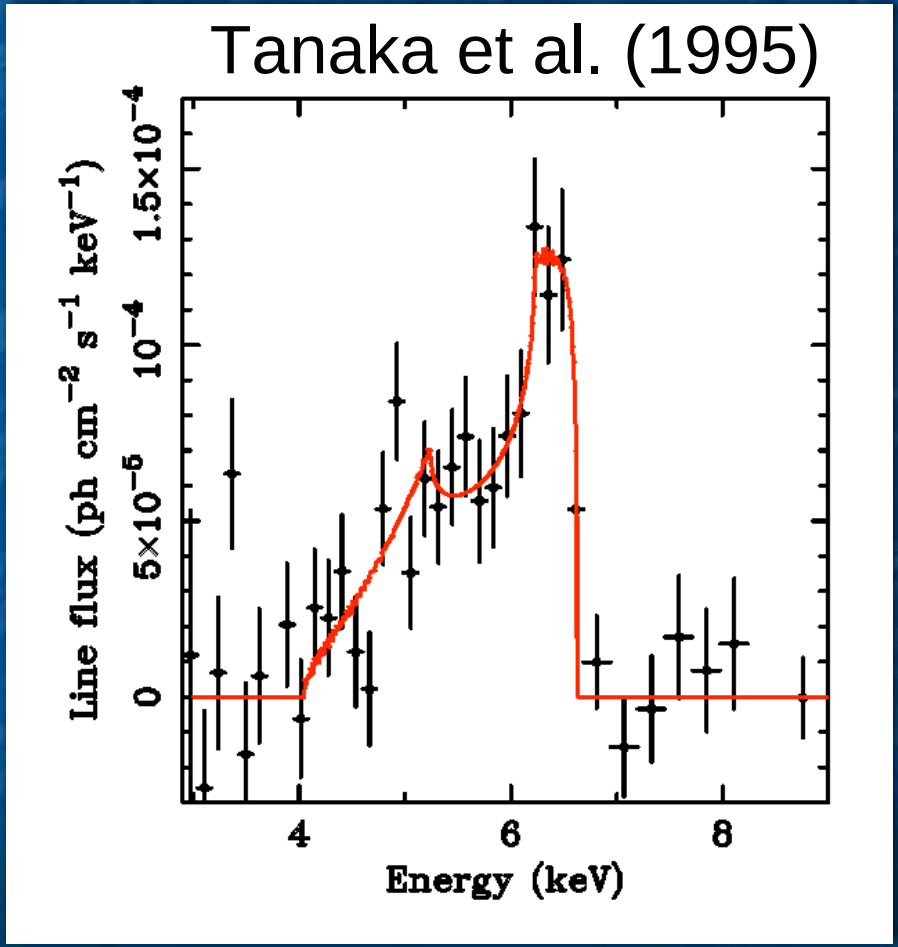
- AGN spectra are complicated …
  - Photoionized absorption
  - Reflection from distance material
  - Reflection from relativistic accretion disk
  - Possibility of multiple continuum components
- Need to decompose spectra into these components… can be ambiguous unless we have
  - High spectral resolution (to characterize absorption)
  - Large energy band

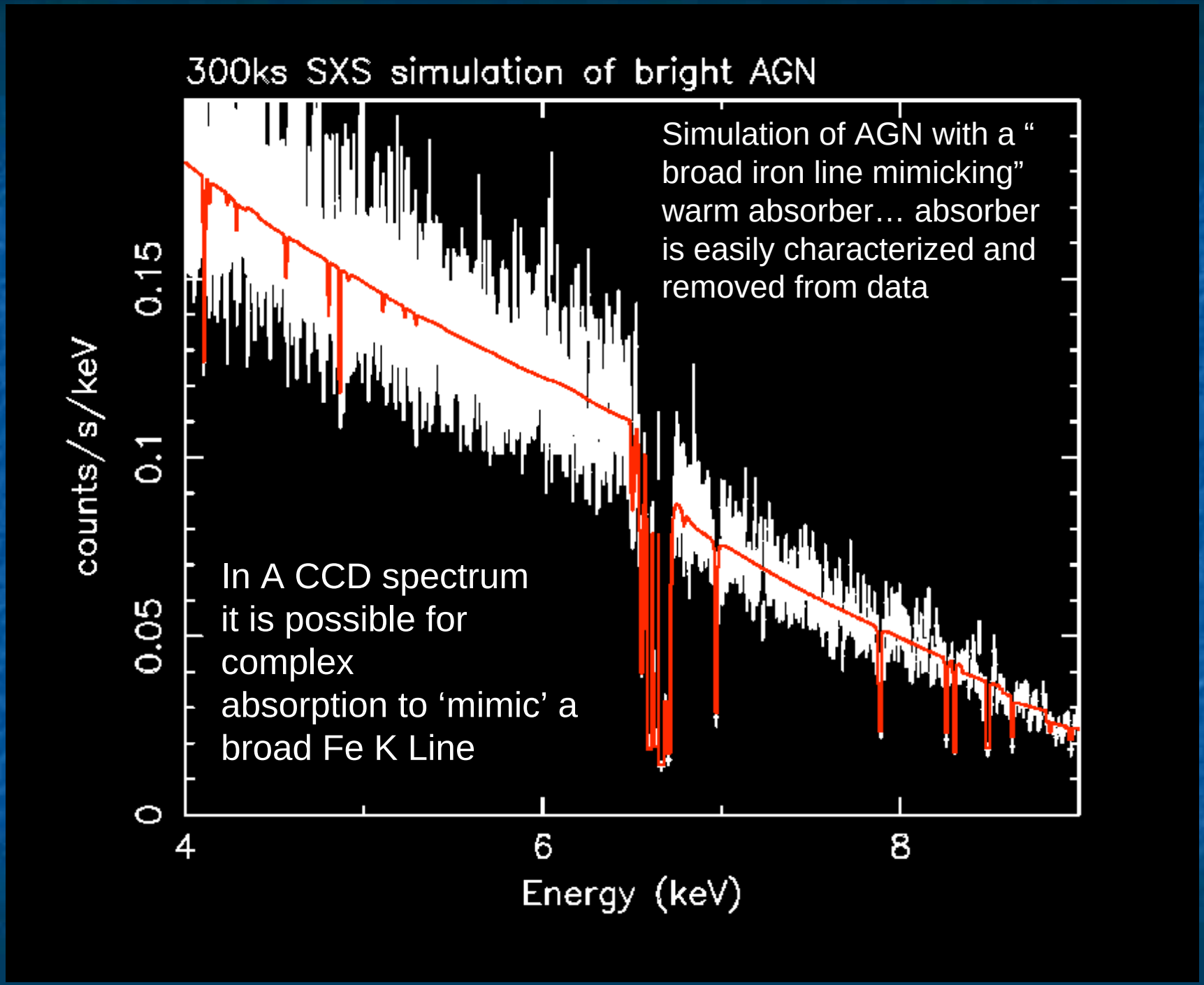


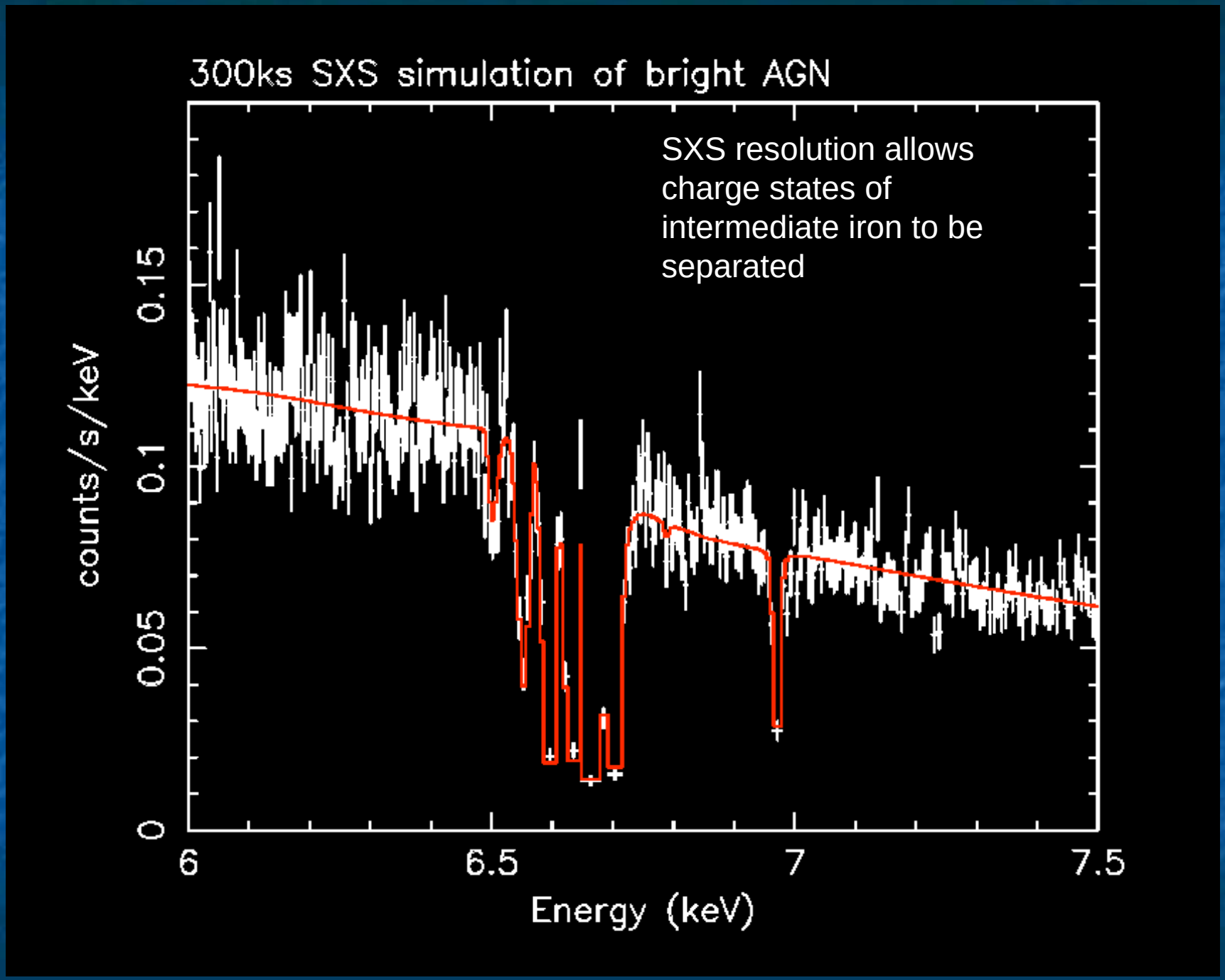
Spectral complexity in MCG-6-30-15 (Brenneman & CSR 2006)

‘Use’ of Broad Fe K Line

- Important goal of AGN research is to study extreme physics close to black holes
  - Best tool to date is the broad iron line first found by ASCA (Tanaka et al. 1995)
- Promise of the future:
  - The demographics of black hole spin
  - Testing details of relativistic accretion disk theory
  - Probing the jet-disk connection



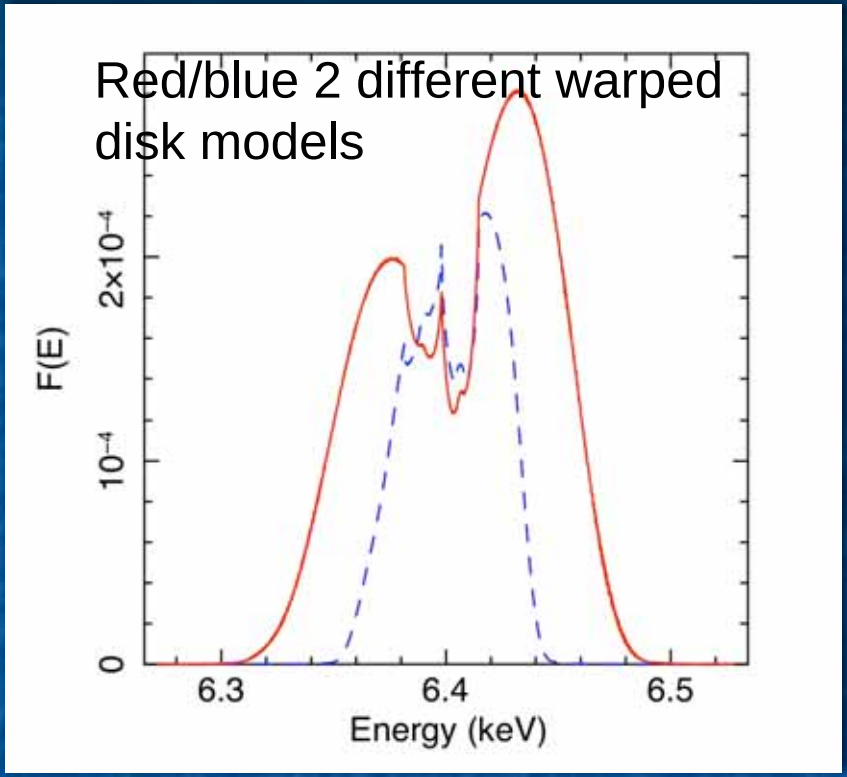

300ks SXS simulation of bright AGN
Simulation of AGN with a " broad iron line mimicking" warm absorber… absorber is easily characterized and removed from data
In A CCD spectrum it is possible for complex absorption to 'mimic' a broad Fe K Line
counts/s/keV
0
0.05
0.1
0.15
4
6
8
Energy (keV)


300ks SXS simulation of bright AGN
SXS resolution allows charge states of intermediate iron to be separated
counts/s/keV
0
0.05
0.1
0.15
6
6.5
7
7.5
Energy (keV)

Large-scale warped disks in AGN

- Importance of warped disks:
  - Could be large scale manifestation of BH spin
  - May provide the obscuring matter in many type-2 AGN
- NGC4258 (M106) is a fantastic laboratory for AGN physics…
  - Suzaku sees narrow iron line… has all of the properties expected if it arises from the surface of a Bardeen-Peterson warped disk
  - **Astro-H can look for line profile predicted by this model**

Predicted iron line profile from large-scale warped disk in NGC4258 (Reynolds et al. 2009)



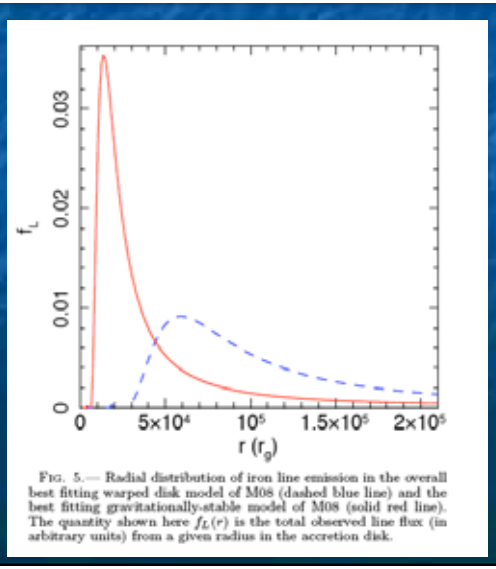
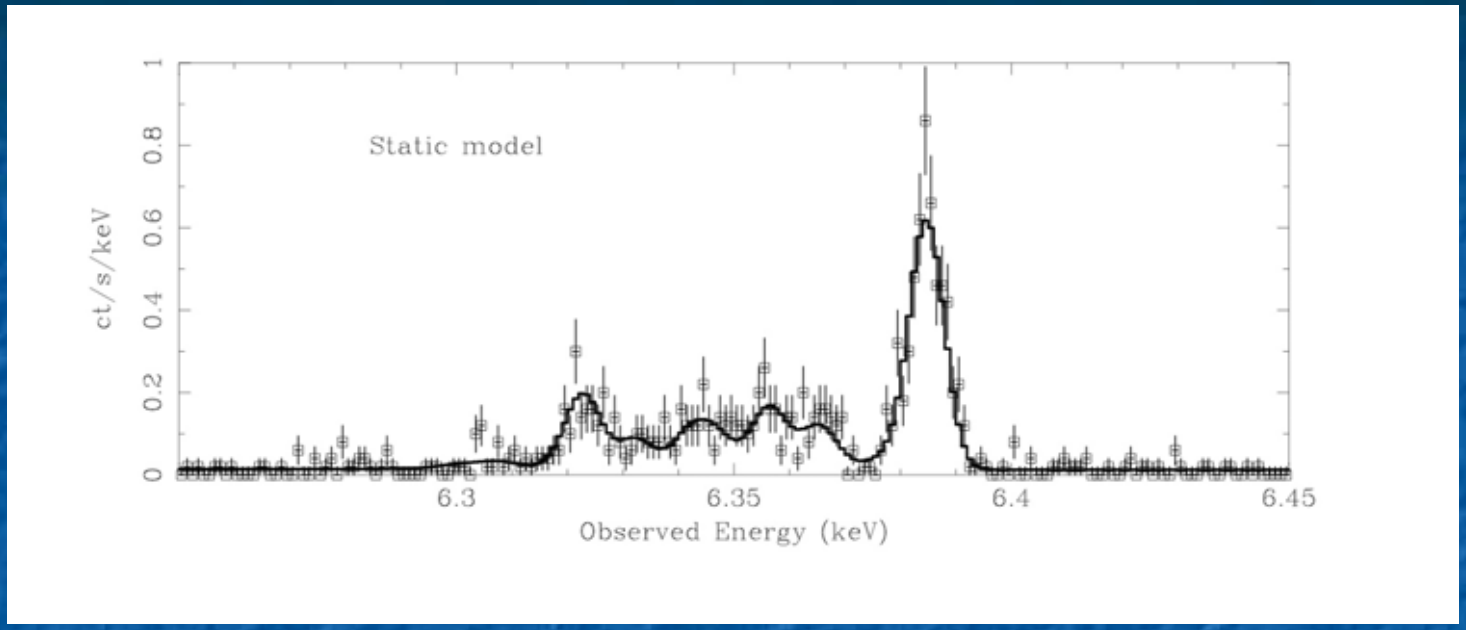


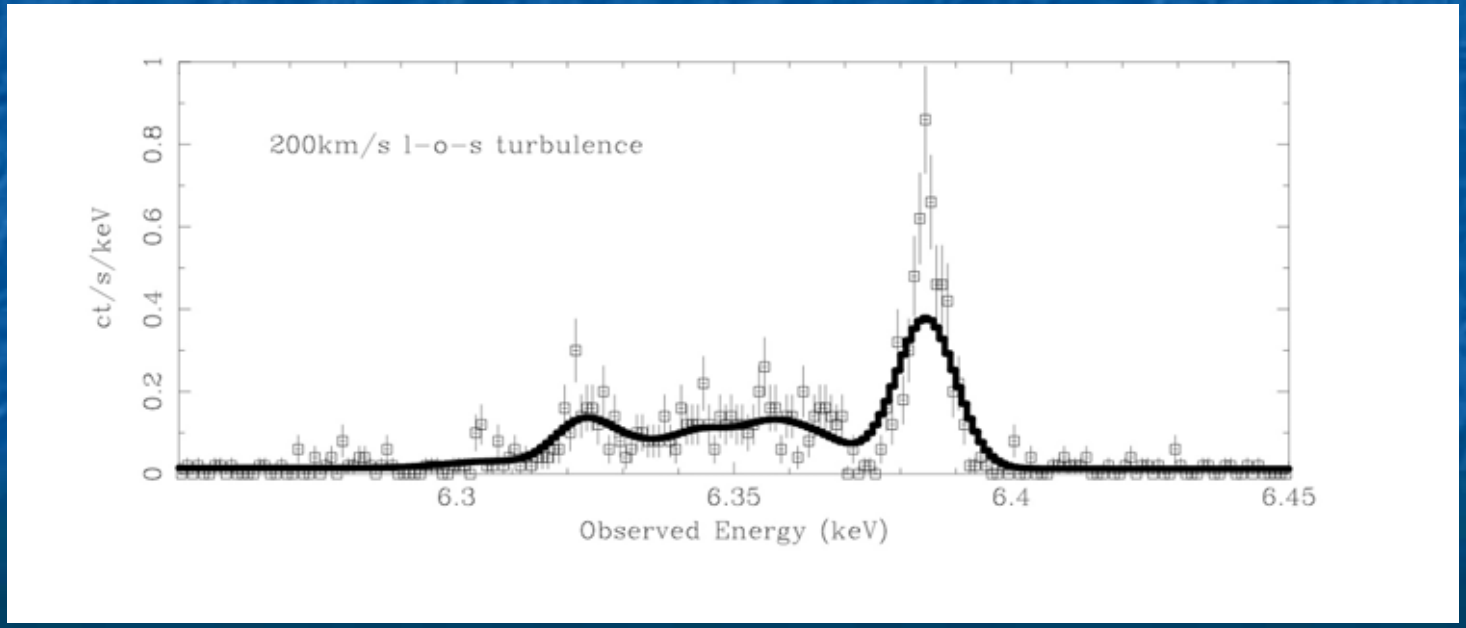
FIG. 5.— Radial distribution of iron line emission in the overall best fitting warped disk model of M08 (dashed blue line) and the best fitting gravitationally-stable model of M08 (solid red line). The quantity shown here $f_L(r)$ is the total observed line flux (in arbitrary units) from a given radius in the accretion disk.

II : Dynamics of intracluster medium

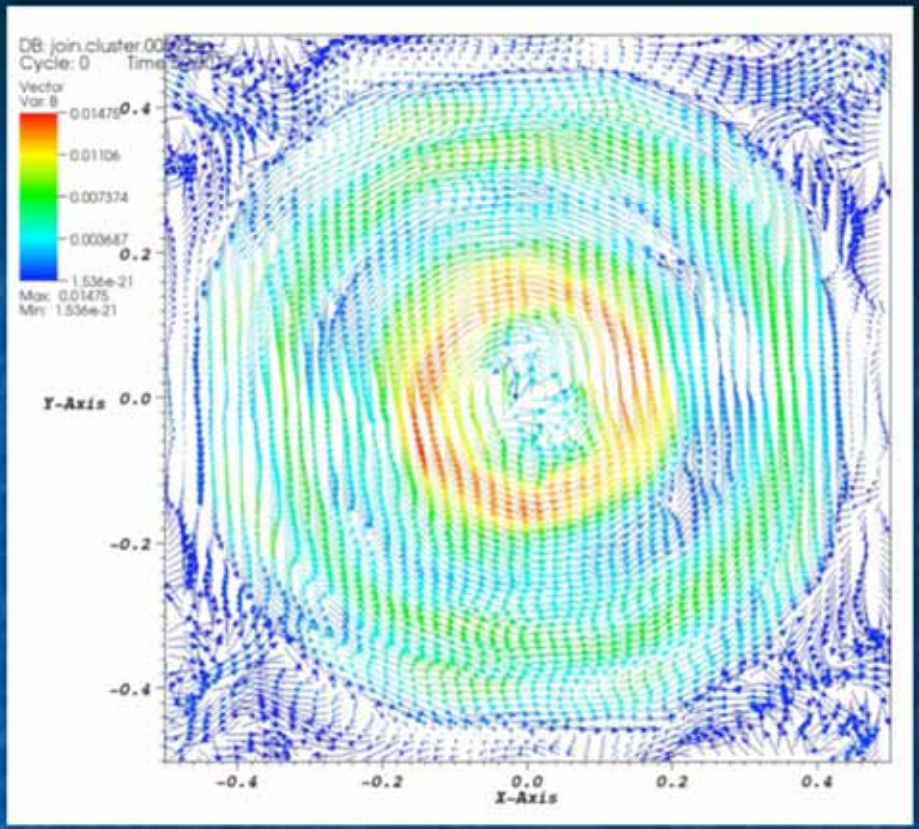
- Major advance is Astro-H's ability to study dynamics in the ICM
- Fundamental theoretical aspects of the ICM are unclear…
  - Recently discovered MHD and plasma instabilities have profound effect on ICM
  - Connection between ICM and AGN is crucial for preventing cooling but still not understood
- So, what kind of ICM motions are expected?
- *My principal role in this regards is as a theorist…*

Astro-E2 XRS simulation of turbulence in Abell 4059





- On-going program to simulate the dynamics of ICM cores including…
  - 3-dimensional MHD
  - Anisotropic transport processes
- We study non-linear behavior of conduction-driven MHD instabilities… leads to turbulence
- Eventually…
  - Can predict spatial distribution and magnitude of turbulence
  - Understand interaction of these MHD effects with AGN feedback
- Crucial background theory for Astro-H studies of clusters



Courtesy of Tamara Bogdanovic (UMd)

The arrows show magnetic fields (with color denoting field strength).
magnetic field has been "wrapped up" onto shells by the MHD instabilities

Will choke off thermal conduction
On route to this stage, the ICM is driven into a state of turbulence…