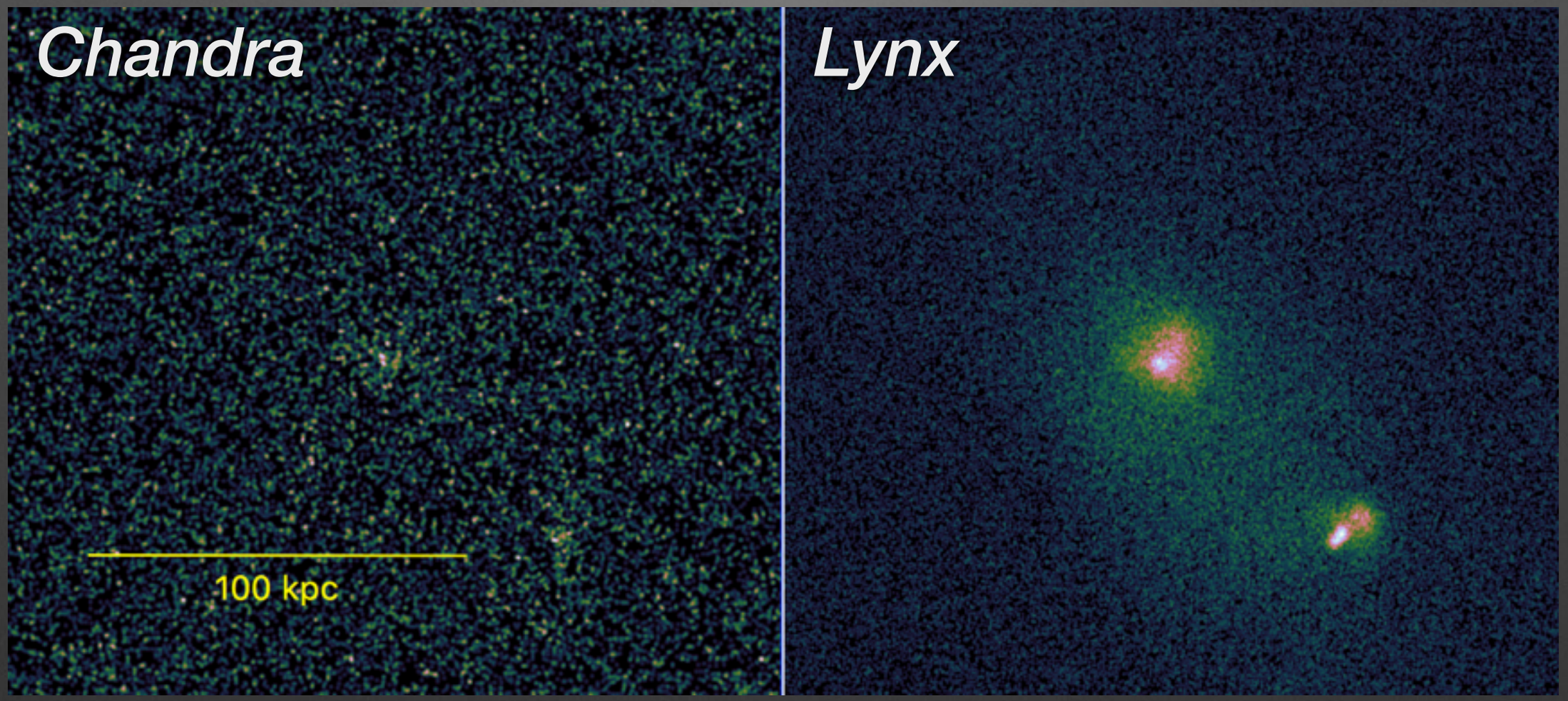
Probing the Detailed Physics of Hot Baryons with Lynx: Predictions from Mock Observations

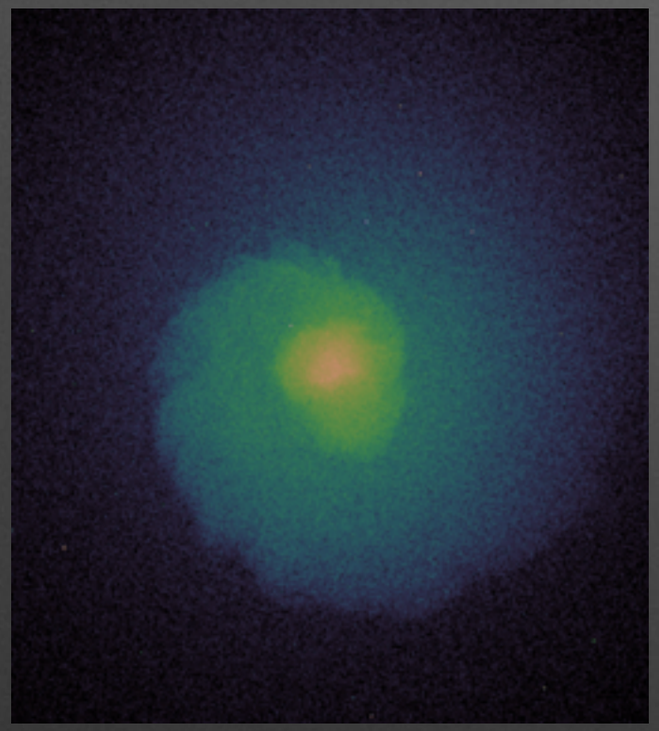


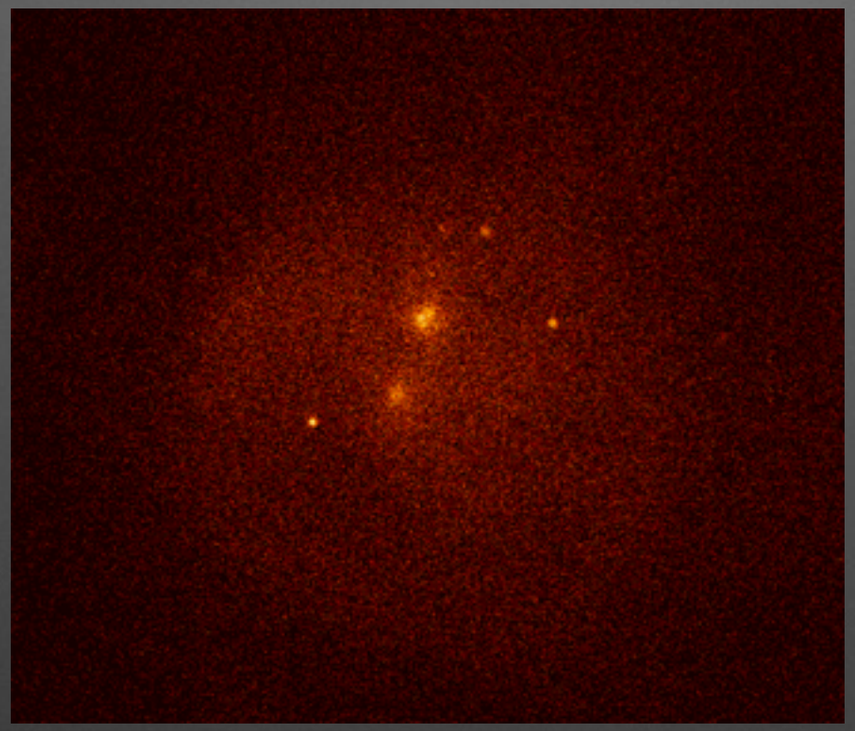
John ZuHone

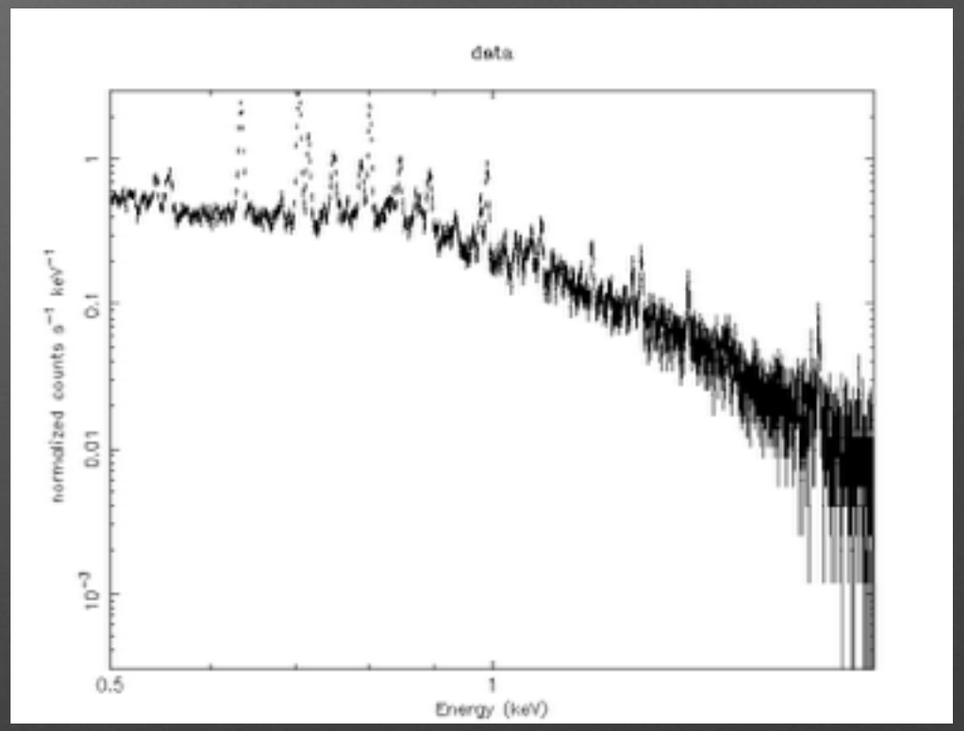
Probing the Physics of Hot Baryons

- We need all three of *Lynx*'s killer features for this science
  - High angular resolution for mapping the gas structure at small scales
  - Large effective area for increased S/N
  - High spectral resolution for detailed analysis of multiphase gas and for velocity measurements

Mock Observation Tools

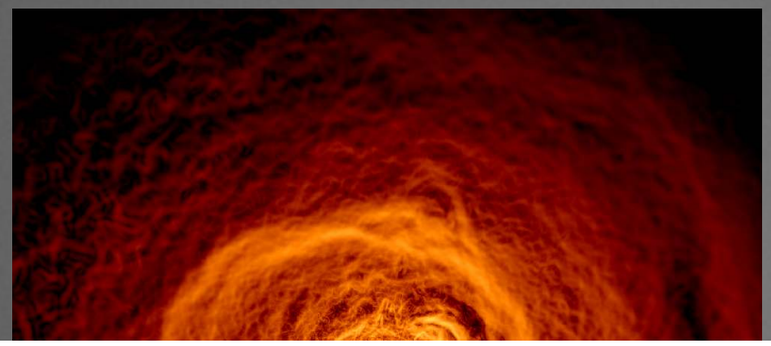


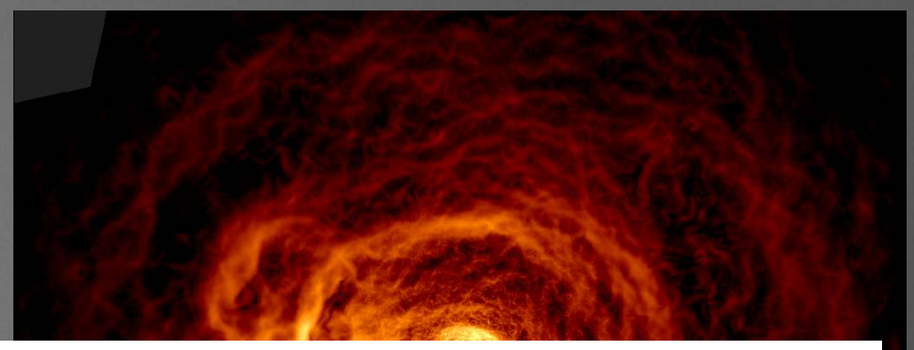




SOXS: http://hea-www.cfa.harvard.edu/~jzuhone/soxs

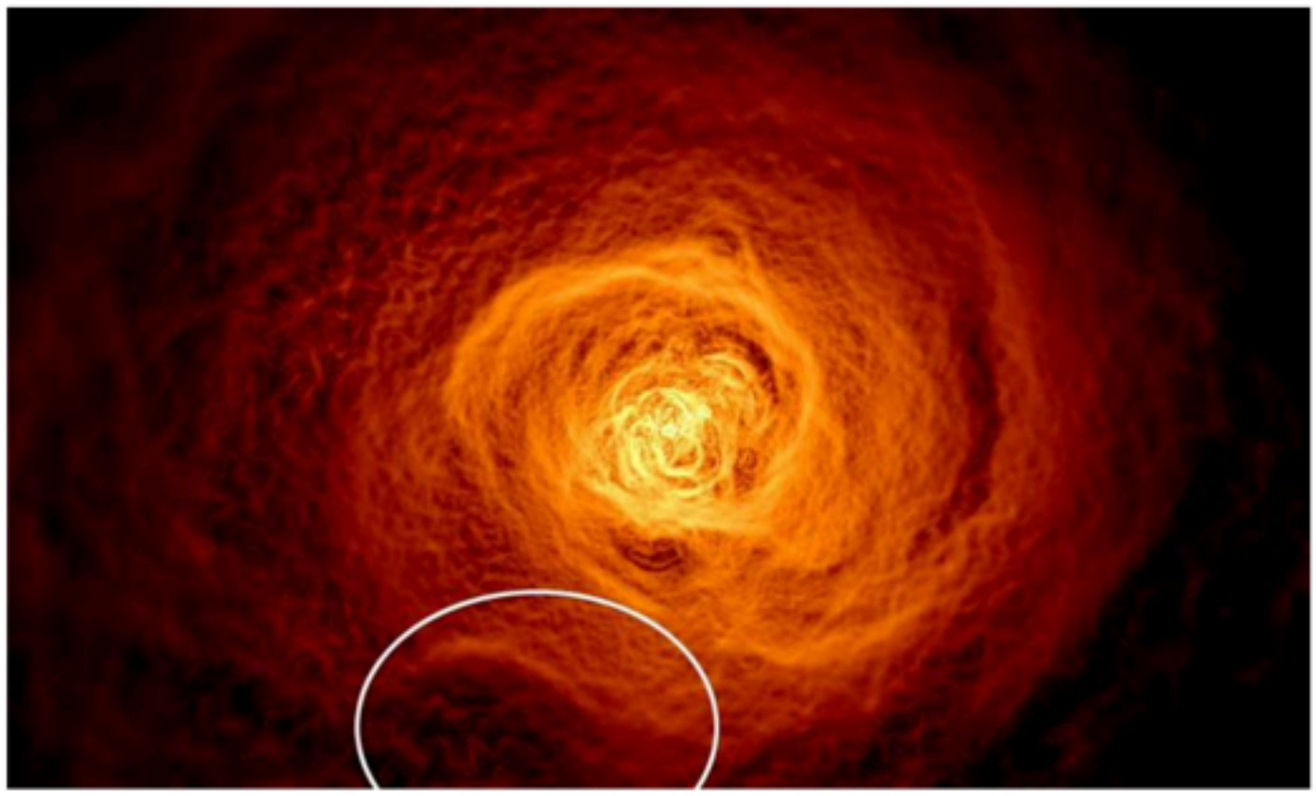
pyXSIM: http://hea-www.cfa.harvard.edu/~jzuhone/pyxsim





Scientists find giant wave rolling through the Perseus galaxy cluster

May 2, 2017 by Francis Reddy



This X-ray image of the hot gas in the Perseus galaxy cluster was made from 16 days of Chandra observations. Researchers then filtered the data in a way that brightened the contrast of edges in order to make subtle details more obvious. An … more

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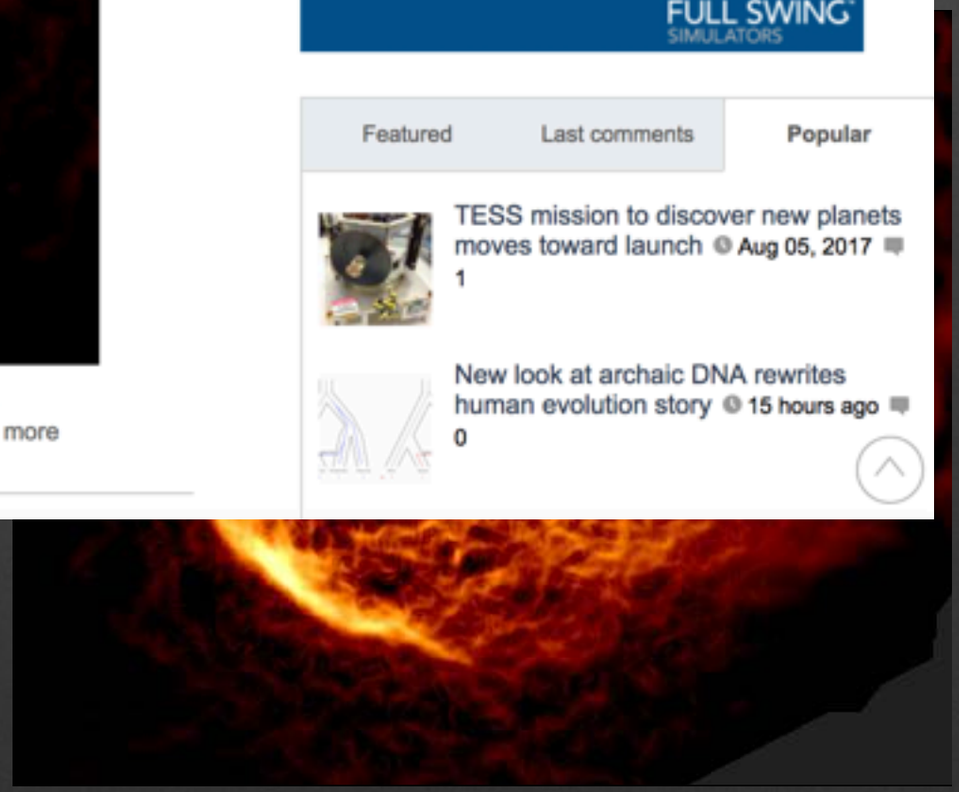
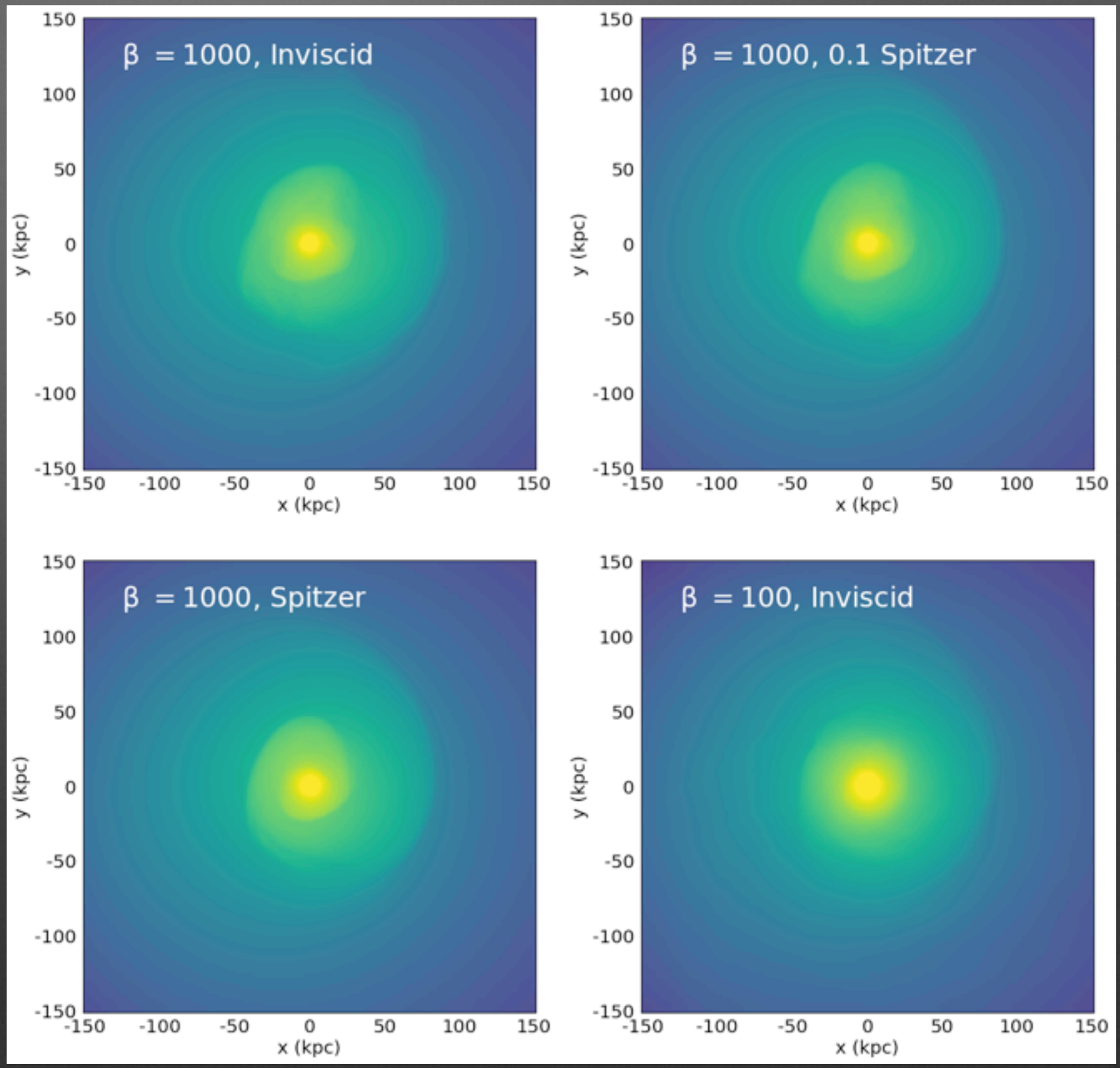


see Stephen Walker's poster!

A3667

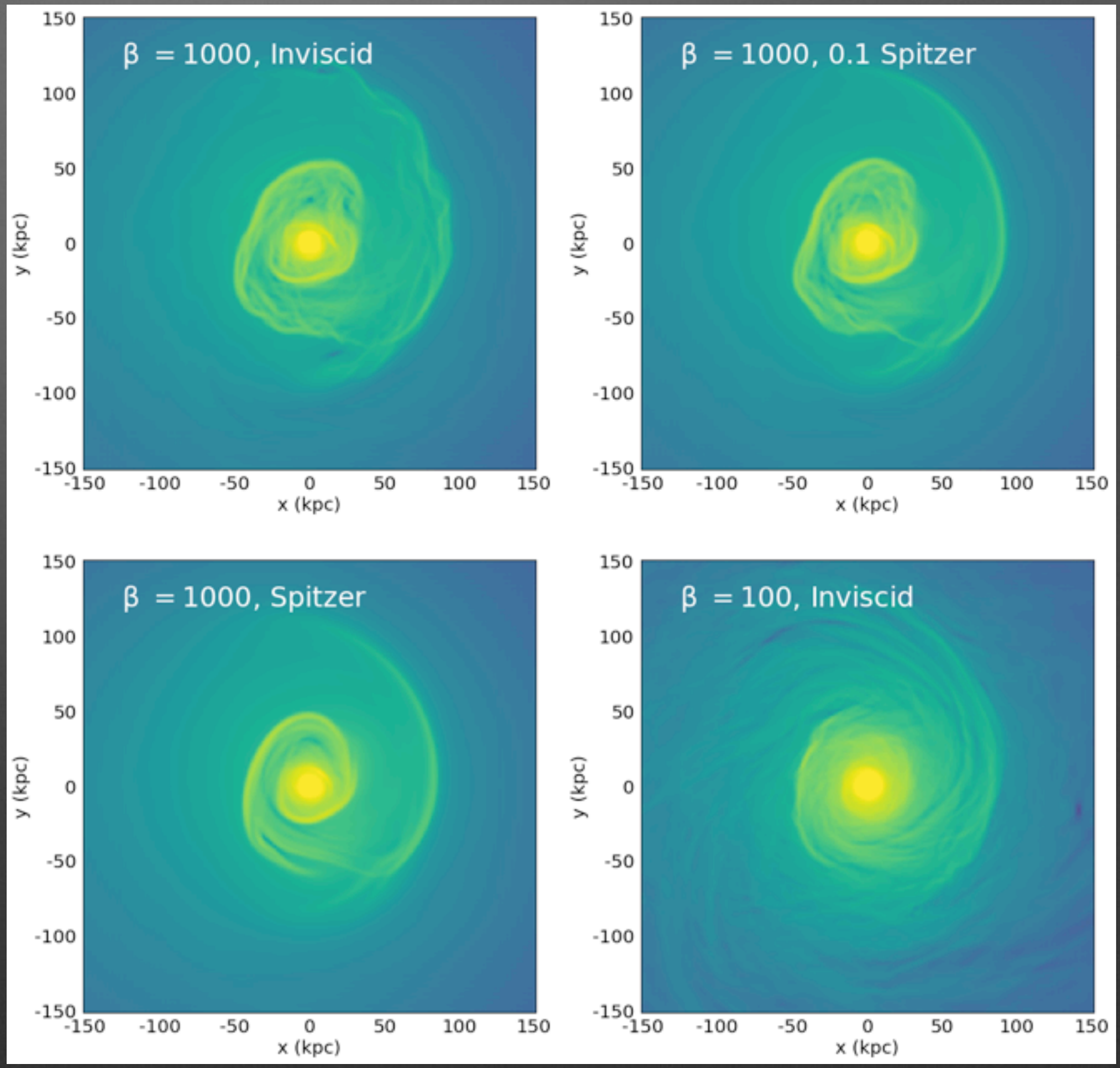
Surface Brightness

GGM Filtering: Varying Physics



Bellomi et al., in prep

Surface Brightness Gradient



GGM Filtering: Varying Physics

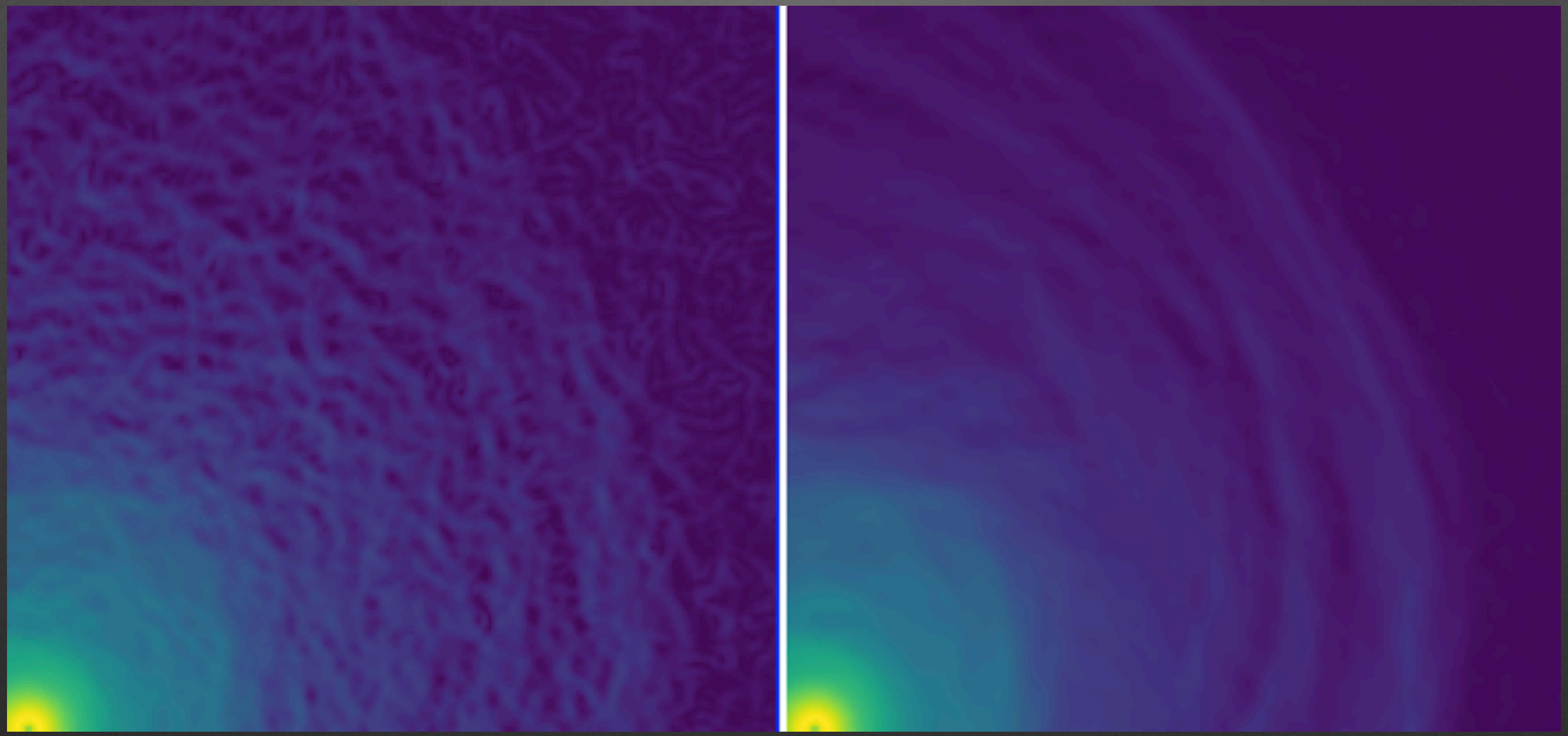
Bellomi et al., in prep

Edge Analysis: *Chandra* vs. *Lynx*

Nearby cluster with exposure of 500 ks

Chandra ACIS-I (Launch)

Lynx HDXI

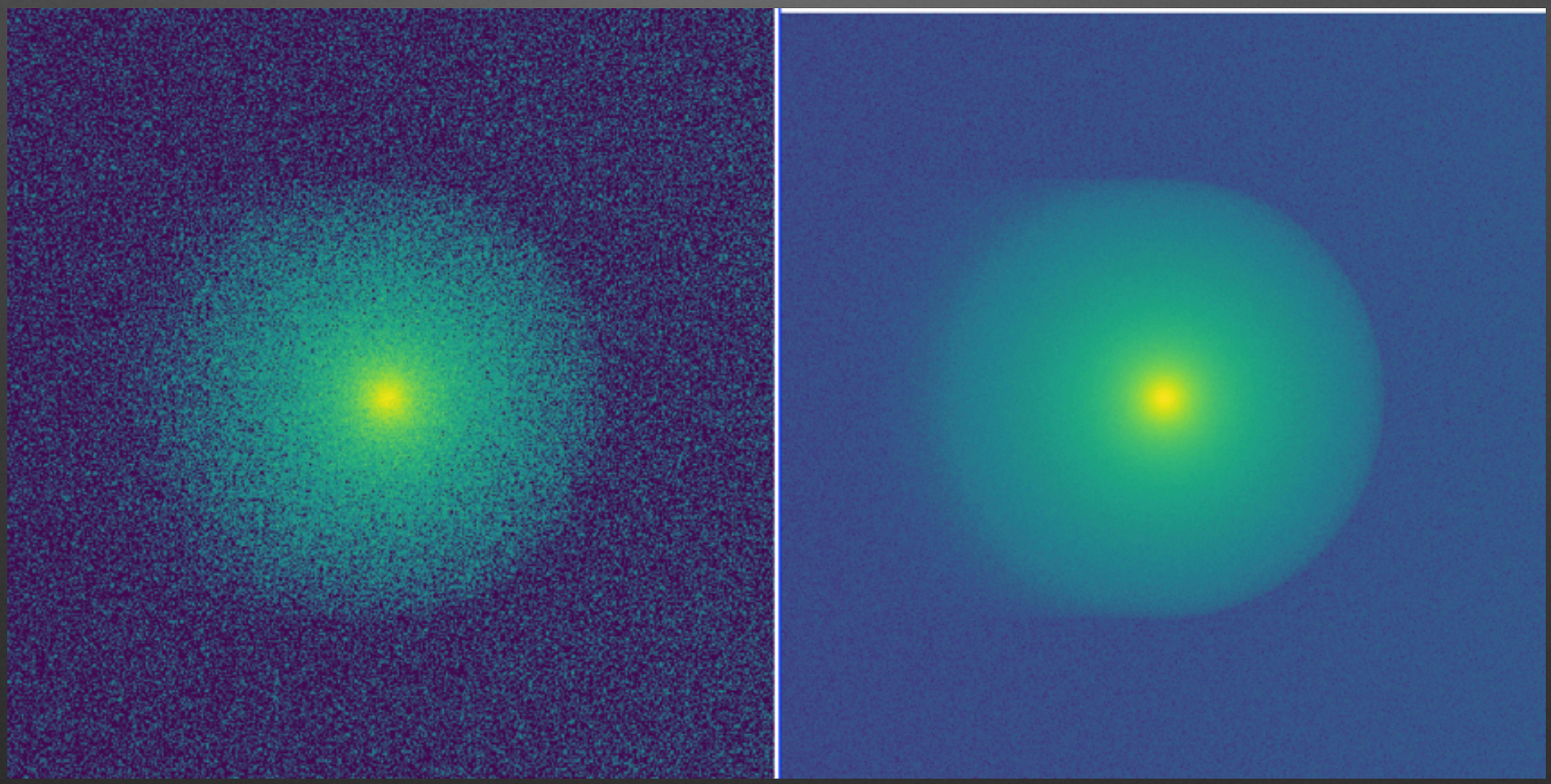


Magnetic Draping Layers: *Chandra* vs. *Lynx*

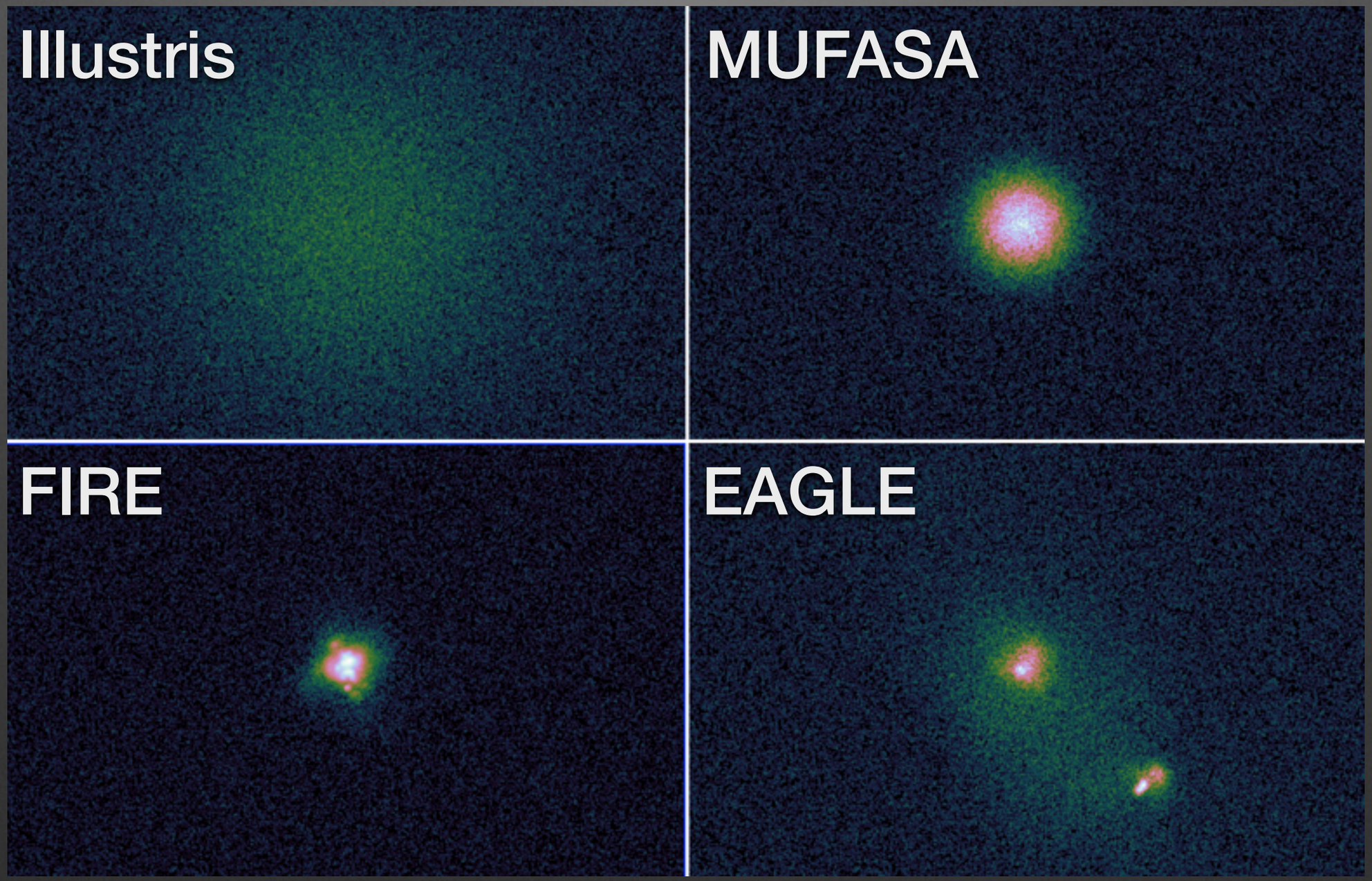
Toy model of NGC 1404, 500 ks exposure (see Yuanyuan Su's poster)

Chandra ACIS-I (Launch)

Lynx HDXI



New Views of Hot Baryons in Galaxies

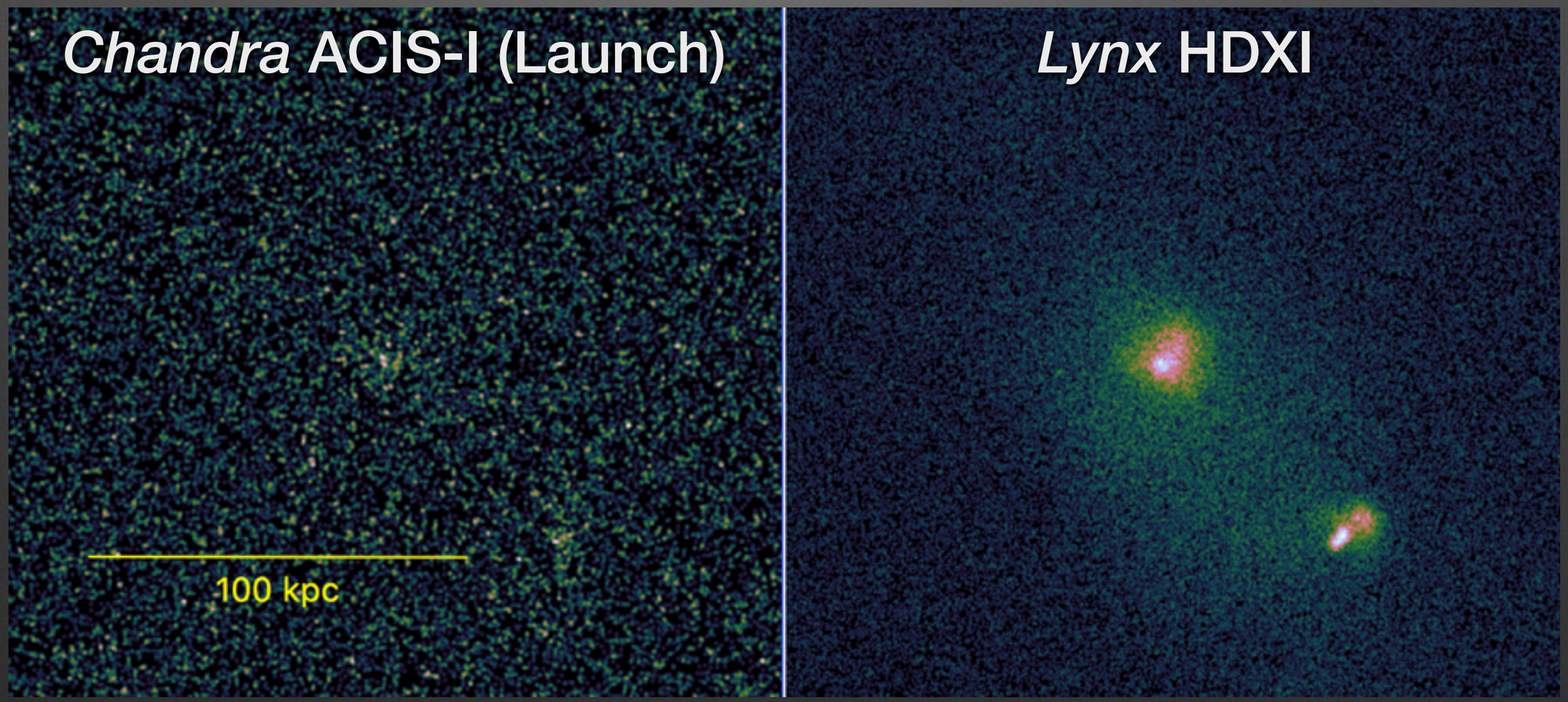


xrs-baryons WG: Andrey Kravtsov, Clarke Esmerian, Romeel Davé, Ben Oppenheimer, Susan Nulsen, Ralph Kraft, Akos Bogdan…

New Views of Hot Baryons in Galaxies

Susan Nulsen
Ralph Kraft
Akos Bogdan

$M \sim 3 \times 10^{12}\ M_{\odot}$ halo from the EAGLE simulations (courtesy Ben Oppenheimer)

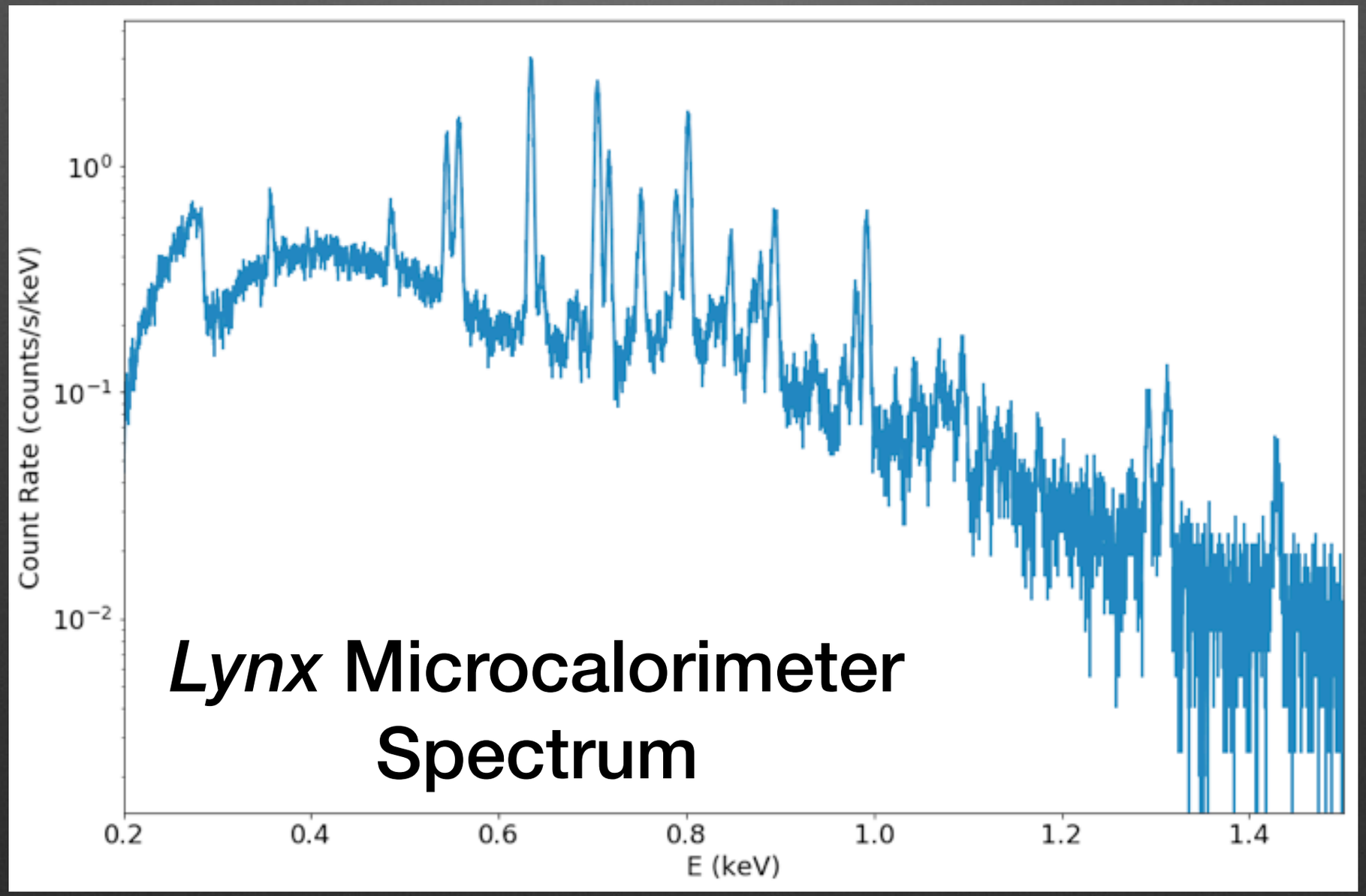


Low energy response of HDXI is important here!

New Views of Hot Baryons in Galaxies

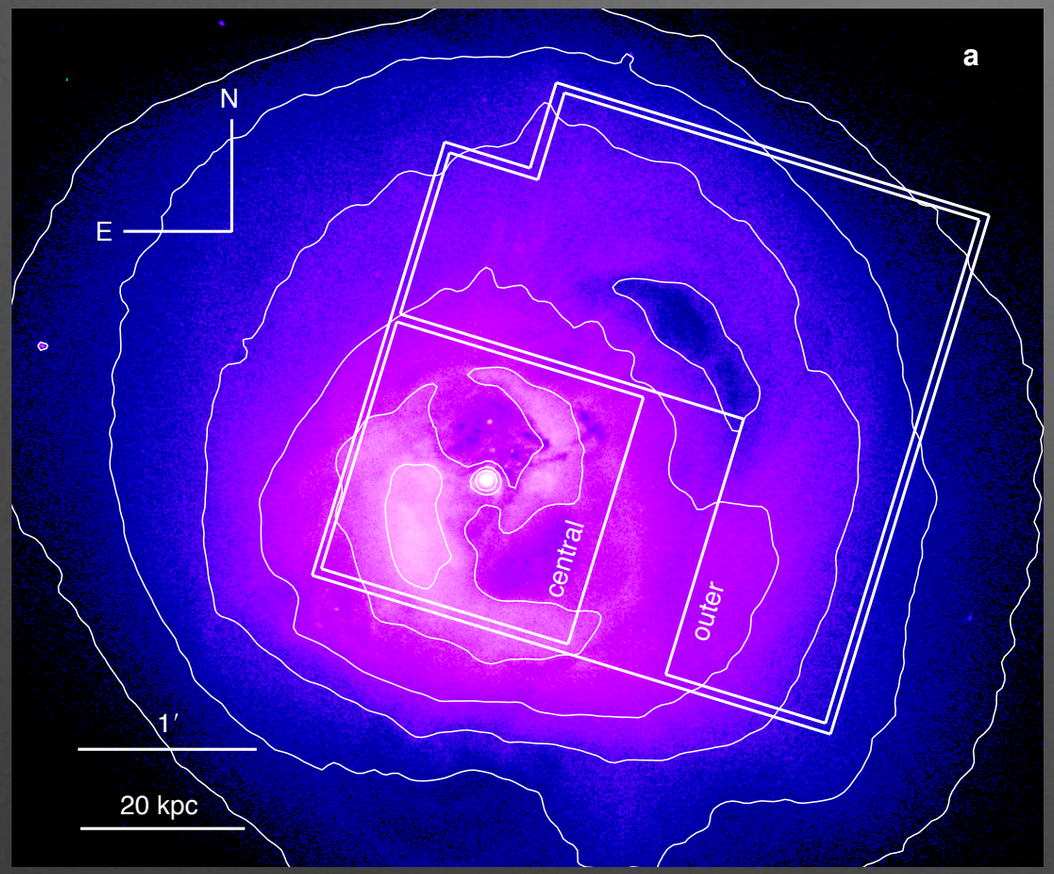
Susan Nulsen
Ralph Kraft
Akos Bogdan

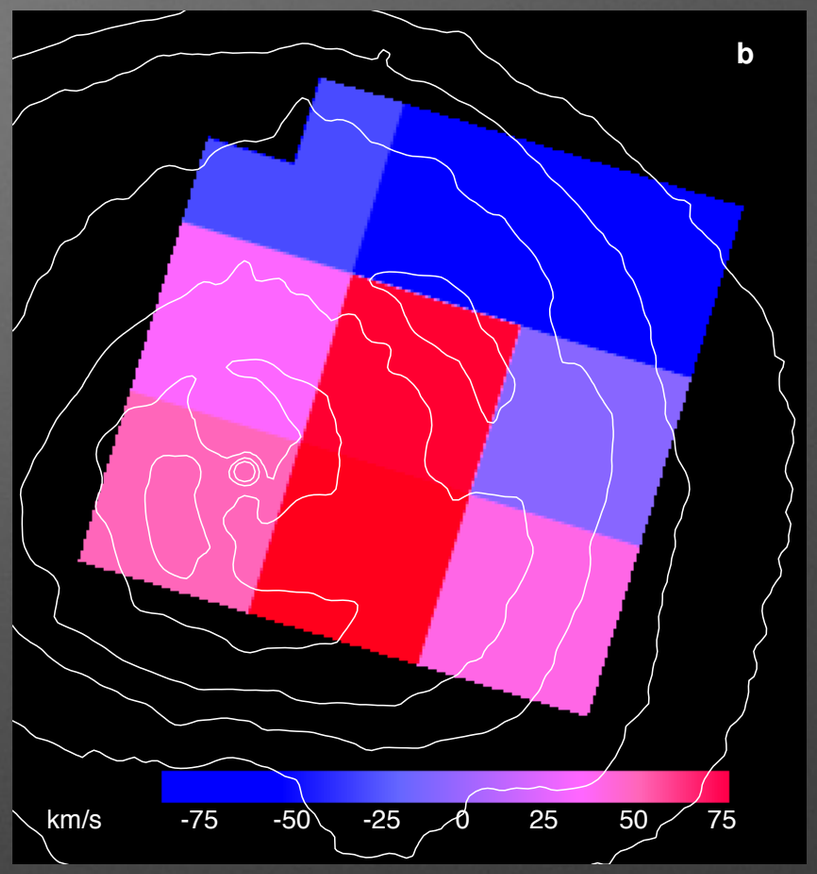
$M \sim 3 \times 10^{12}\, M_\odot$ halo from the EAGLE simulations (courtesy Ben Oppenheimer)



Lynx Microcalorimeter Spectrum

Hitomi Observations of Perseus

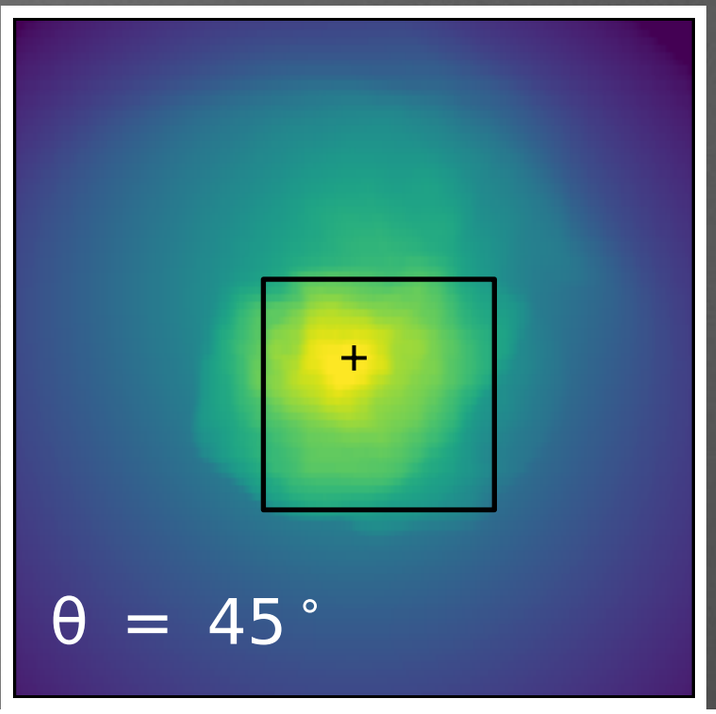


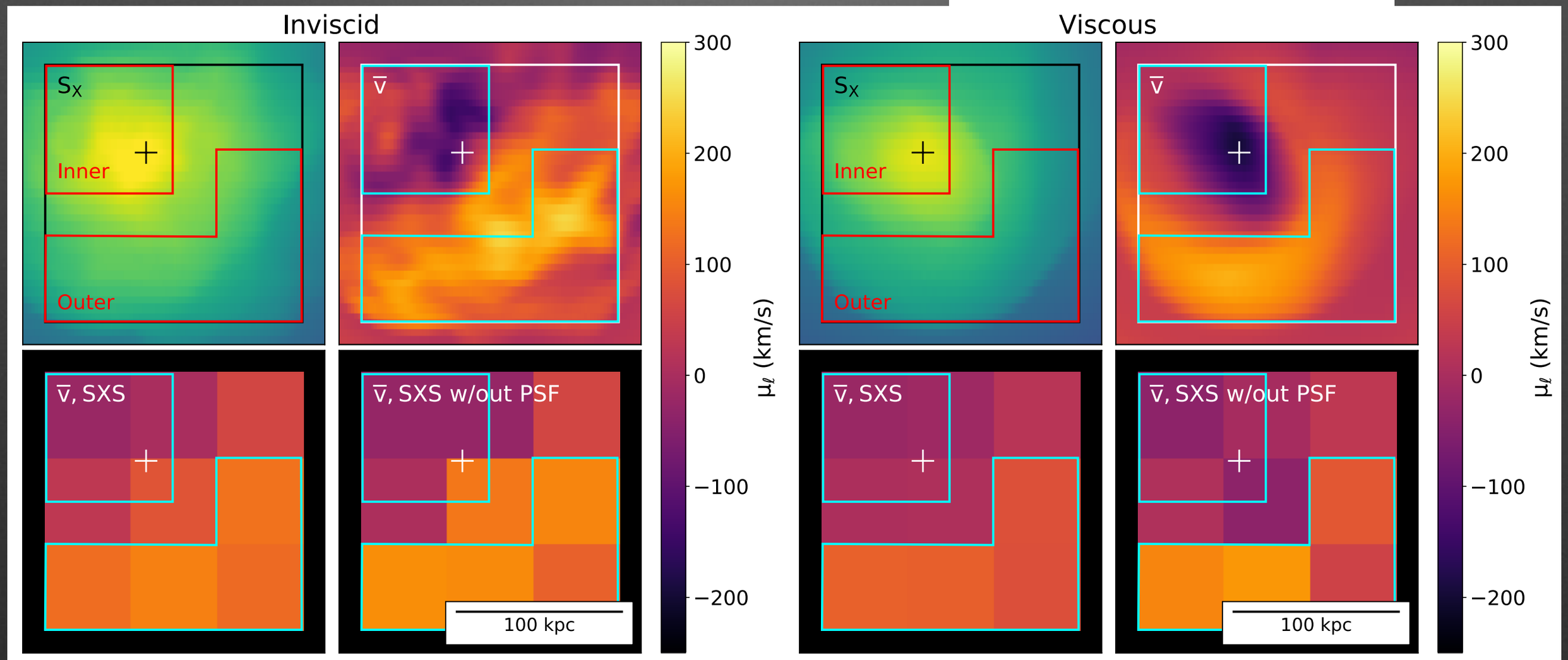


- $\Delta v \sim 150 \pm 70$ km/s (line shift gradient)
- $\sigma \sim 164 \pm 10$ km/s (velocity dispersion)
- $P_{turb}/P_{th} < 10\%$ quiescent

Hitomi Collaboration et al. 2016

Mock *Hitomi* Velocity Maps

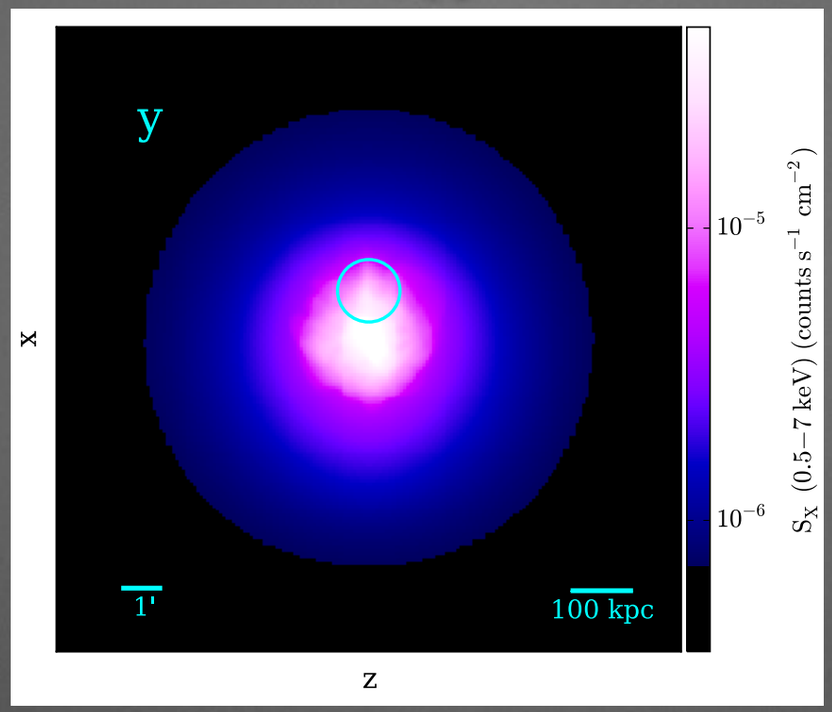




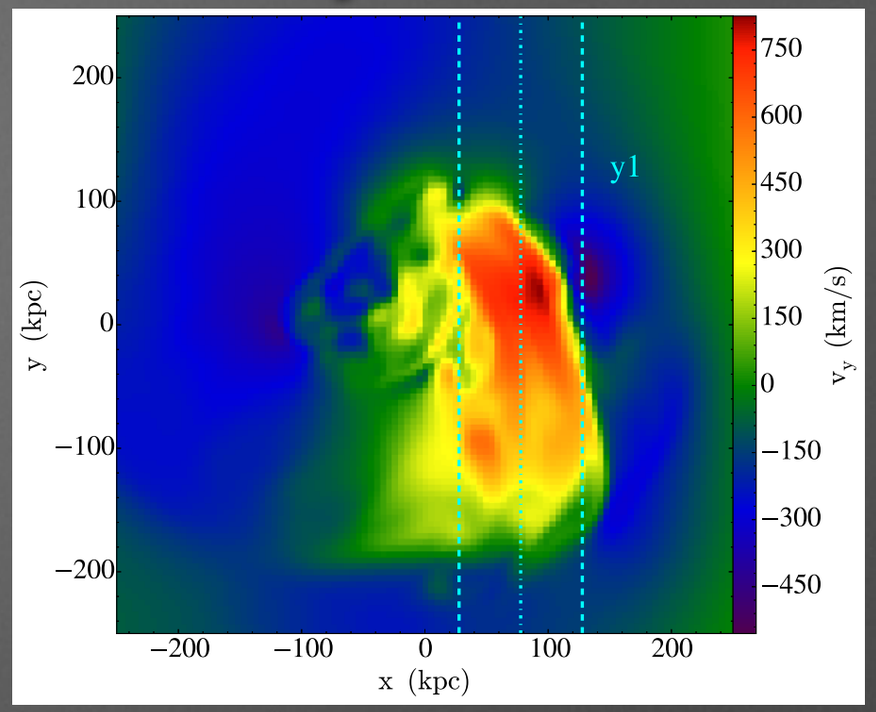
ZuHone et al. 2017, in prep

Non-gaussian line shapes from LOS and sky plane variations (ZuHone et al. 2016)

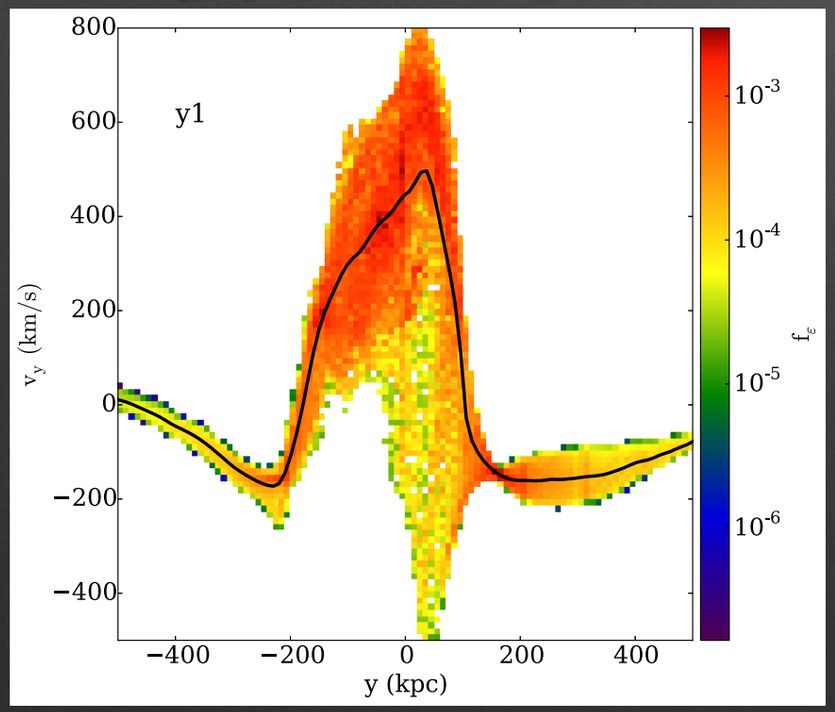
S_X



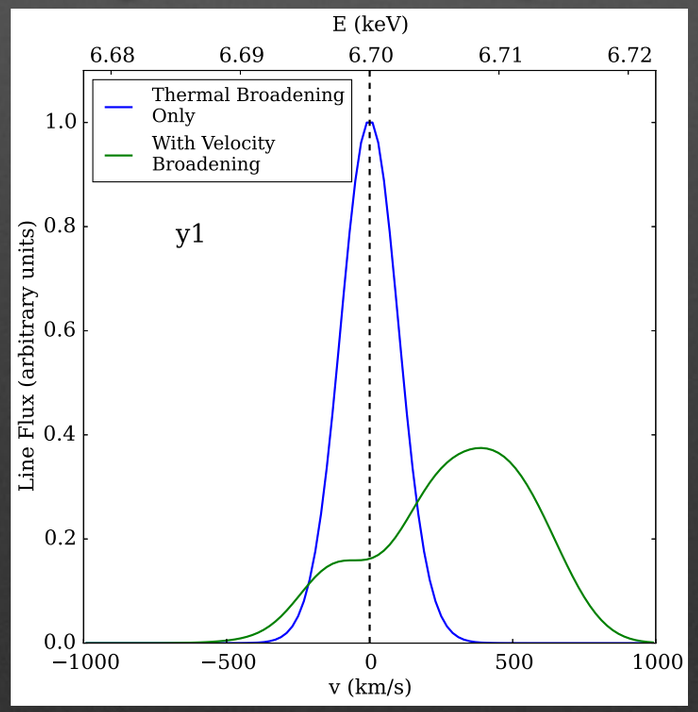
v_y slice



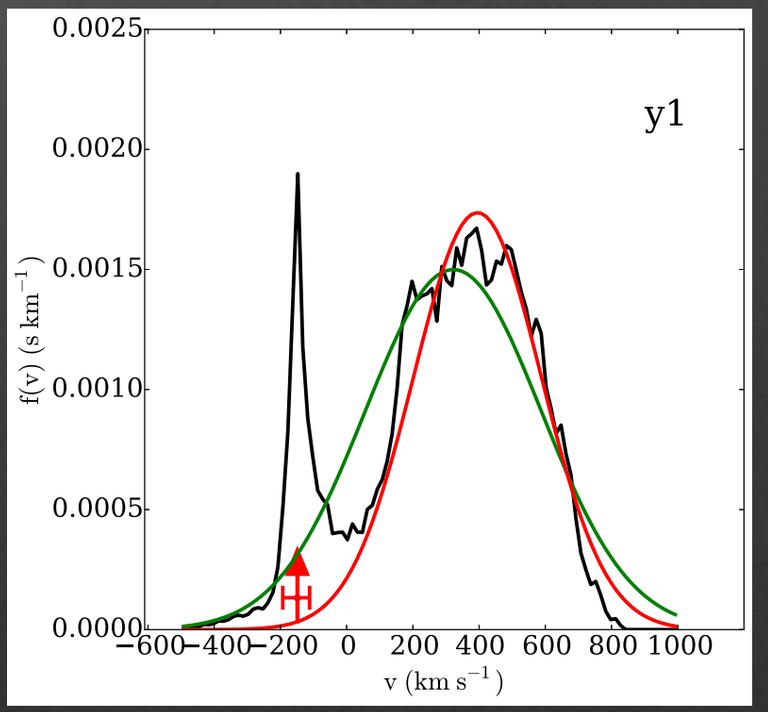
v_y phase plot



v_y line shape



$f(v_y)$



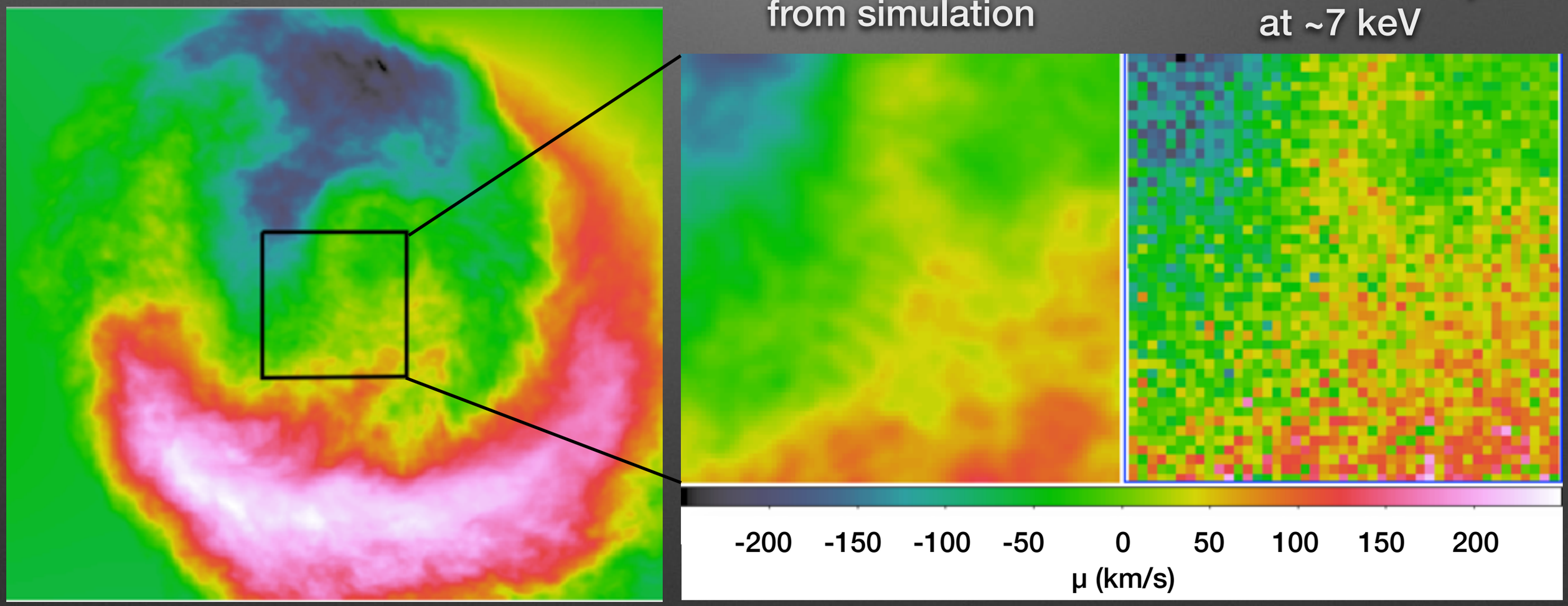
(also see poster by Erwin Lau)

Mock *Lynx* Line Shift Map

VERY PRELIMINARY WORK

from simulation

from fits to Fe complex at ~7 keV



500 ks microcalorimeter observation of simulated cluster at z = 0.025

Summary

- *Lynx* will provide a unique window into the properties of hot galaxy, group, and cluster plasmas, thanks to the combination of high angular resolution, large effective area, and high spectral resolution

- High angular resolution and large effective area will provide an unprecedented window onto the properties of surface brightness fluctuations, and potentially provide an indirect measurement of the magnetic field in clusters and help constrain the plasma microphysics

- High angular resolution and large effective area will reveal the hot-gas halos of galaxies in previously unseen detail; enabling measurements out to larger radii, detecting multi-phase gas, and distinguishing between different feedback models

- We need all three killer features to place real constraints on the kinematical properties of the ICM down to small length scales via direct measurements of gas motions