OBSERVING SIMULATED GALAXY CLUSTERS: THE PROSPECTS OF VELOCITY DIAGNOSTICS

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“Galaxy clusters as giant cosmic laboratories”

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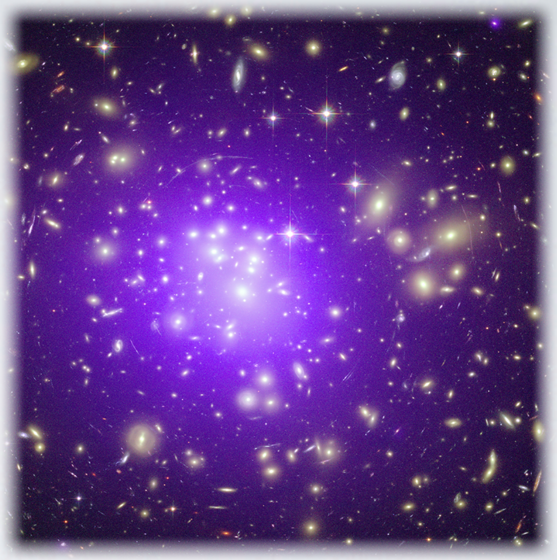
OUTLINE

- Motivation
- Phox: structure of the code
- Application, perspectives
- Summary

CLUSTERS OF GALAXIES:
AT THE TOP OF THE COSMIC HIERARCHY



- Crossroads of cosmology and astrophysics

  → total gravitating mass

- Hot diffuse plasma (**ICM**), $T \sim 10^7$-10^8 K: **X-rays**

- Use X-ray observations of the ICM to trace intrinsic structure & total mass

Hydrostatic Equilibrium

$$\frac{1}{\rho}\frac{dP}{dr} = -\frac{GM}{r^2}$$

+

- Spherical symmetry
- Gas pressure support only due to thermal motions

X-RAY MASS:

$$\mathbf{M}(<\mathbf{r}) = -\frac{\mathbf{k_B T_{gas}}}{\mathbf{G}\mu\mathbf{m_p}}\mathbf{r}\left(\frac{\mathbf{d}\ln\rho_{\mathbf{gas}}}{\mathbf{d}\ln\mathbf{r}} + \frac{\mathbf{d}\ln\mathbf{T_{gas}}}{\mathbf{d}\ln\mathbf{r}}\right)$$

Reliable?
Valid assumptions?
What about non-thermal motions?

HE: $$\frac{1}{\rho}\frac{dP}{dr} = -\frac{GM}{r^2}$$

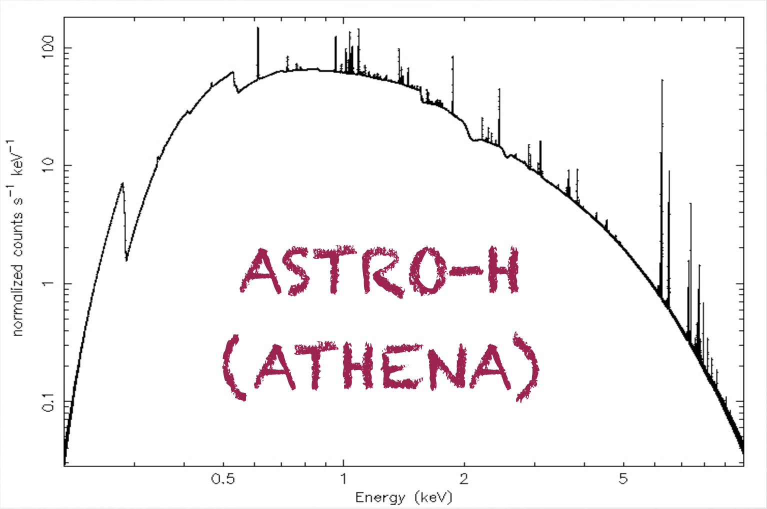
e.g. turbulence, bulk motions (straming, rotation)
[Fang et al. 09; Lau et al. 09; Zhuravleva et al. 10;
Biffi, Dolag, Böhringer 2011]

where

$$P = P_{thermal} + P_{non-thermal}$$

✓ possible to constrain <u>directly</u> with hydro-simulations!

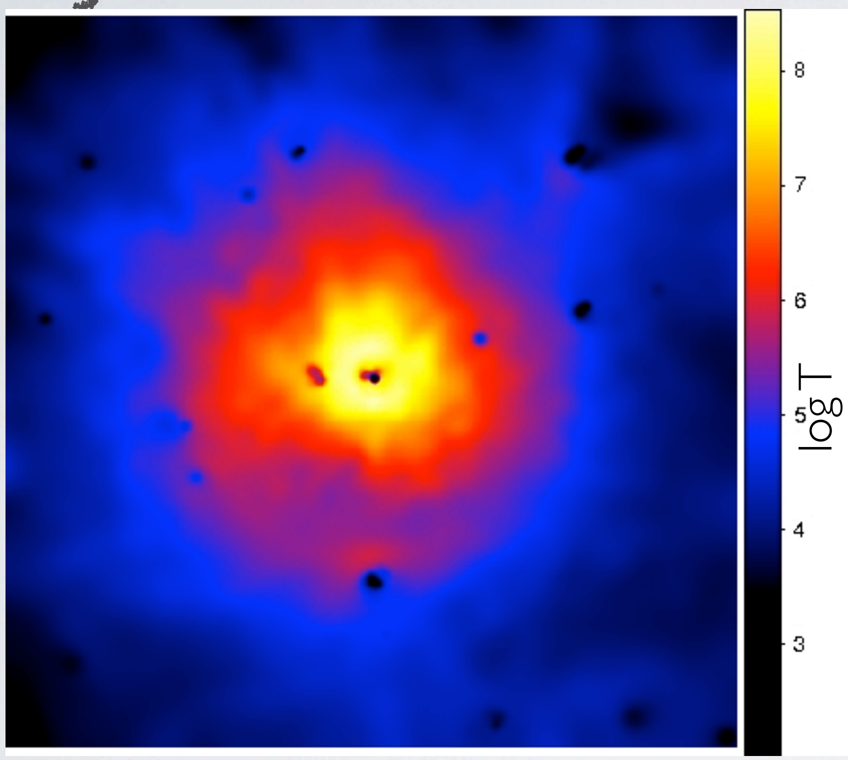
(possibly) detectable spectral signatures:
velocity broadening of emission lines



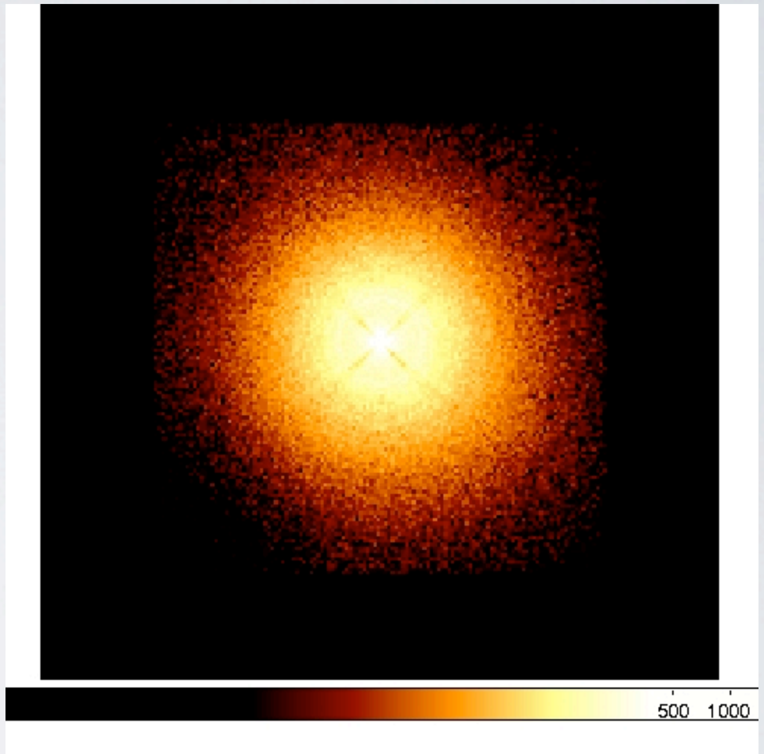
Required faithful comparison between hydro-simulations and X-ray observations

A NEW X-RAY PHOTON SIMULATOR

hydro-simulation



mock observation

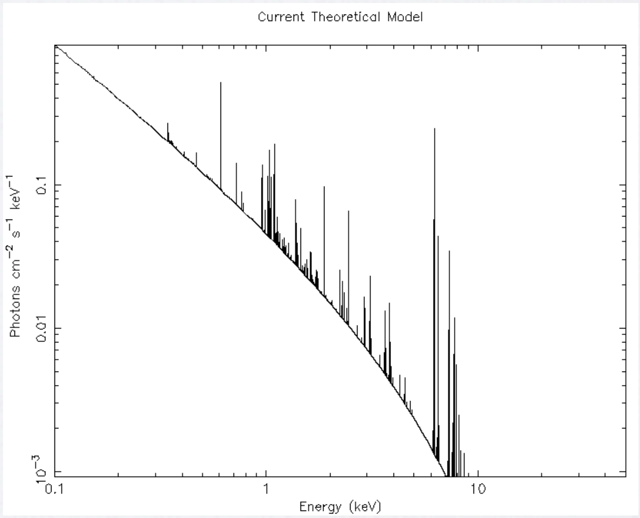


Gas element ~ single-temperature emitting plasma

Emission in the X rays: spectrum → photons

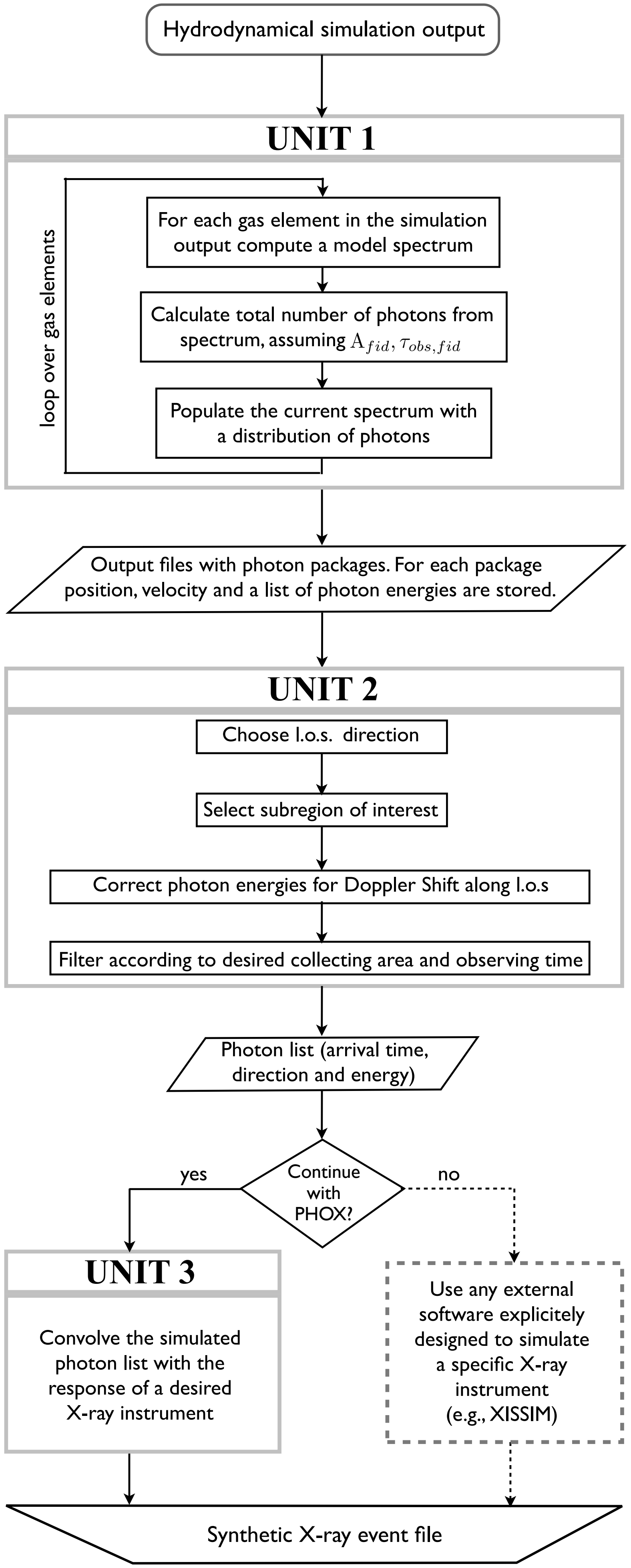
$(\mathbf{x},\mathbf{v})_i$

$(n,T,Z)_i$



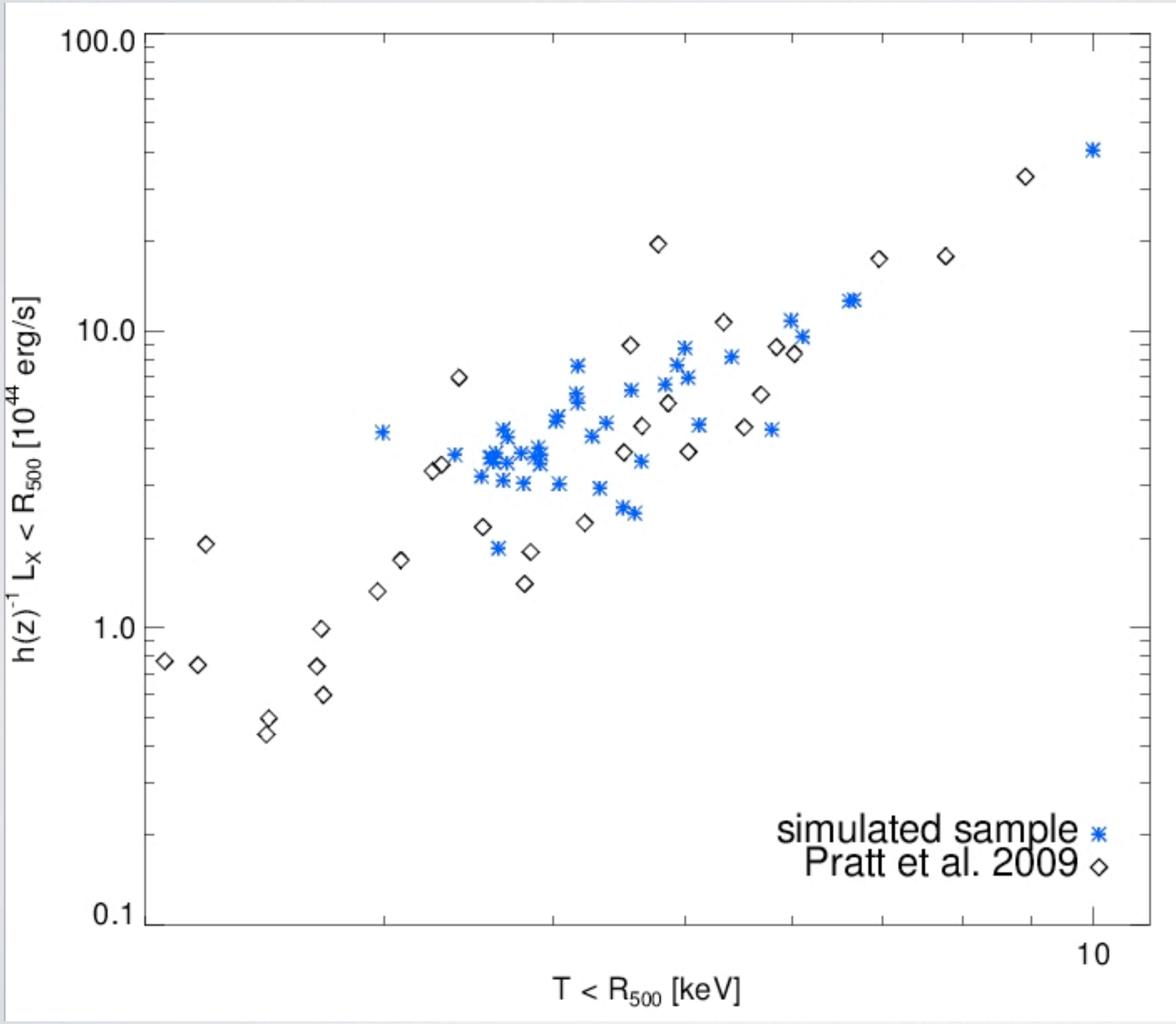
Biffi, Dolag, Böhringer, Lemson 2012, MNRAS

PHOX



- **UNIT 1:** generation of the ideal virtual cube of photons
- **UNIT 2:** geometrical selection and projection along l.o.s.
- **UNIT 3:** convolution with a real instrumental response

RECONSTRUCTING GLOBAL PROPERTIES: THE L_X-T RELATION



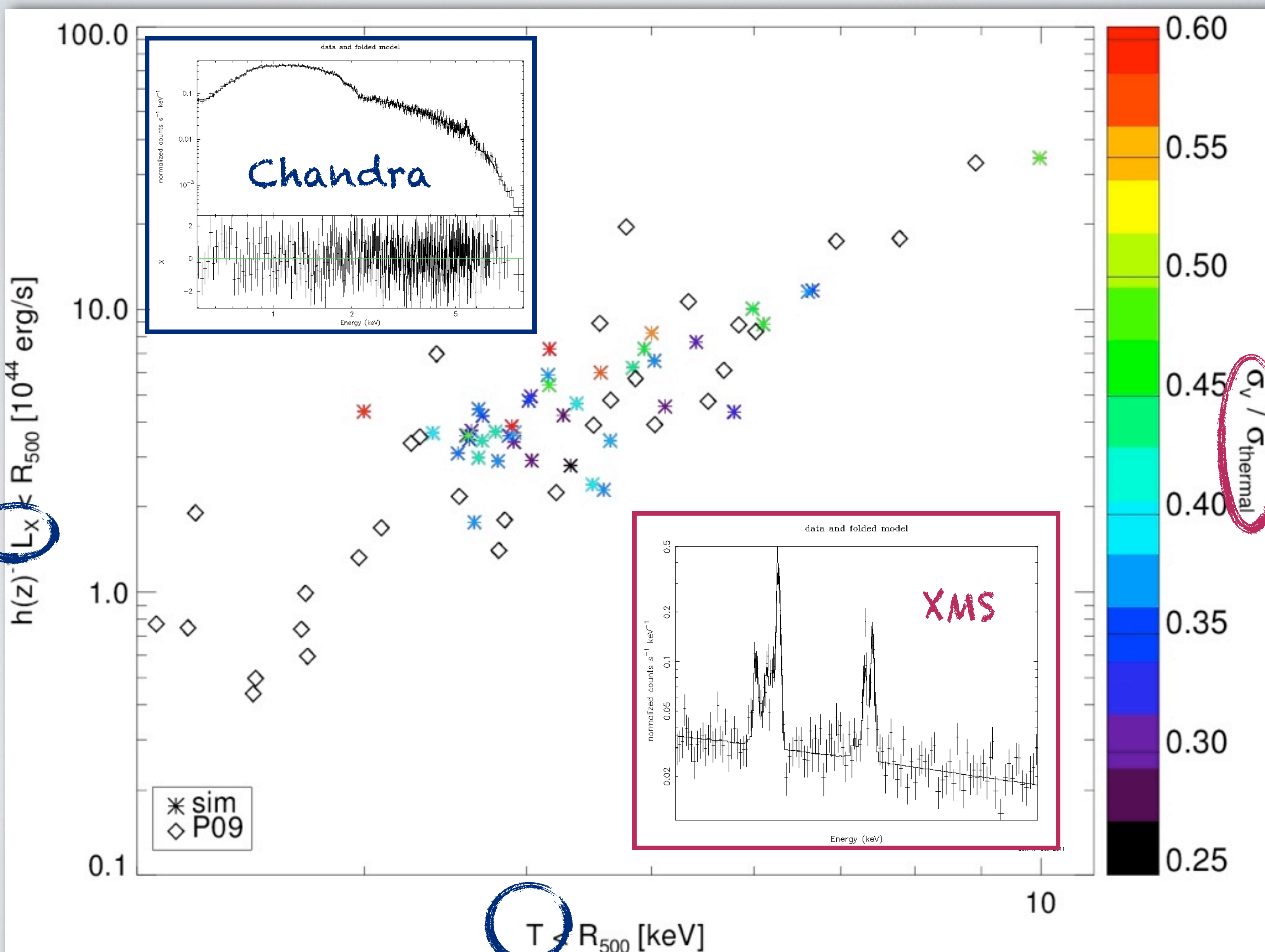
"MAGNETICUM" hydro-simulation:

- box size of 352 Mpc/h
- ~4 x 10^8 particles
- z(snap) = 0.2

➡ sample of simulated clusters: **43 halos**

✓ mock Chandra observations obtained with PHOX

ICM VELOCITY DIAGNOSTICS: L_X-T RELATION

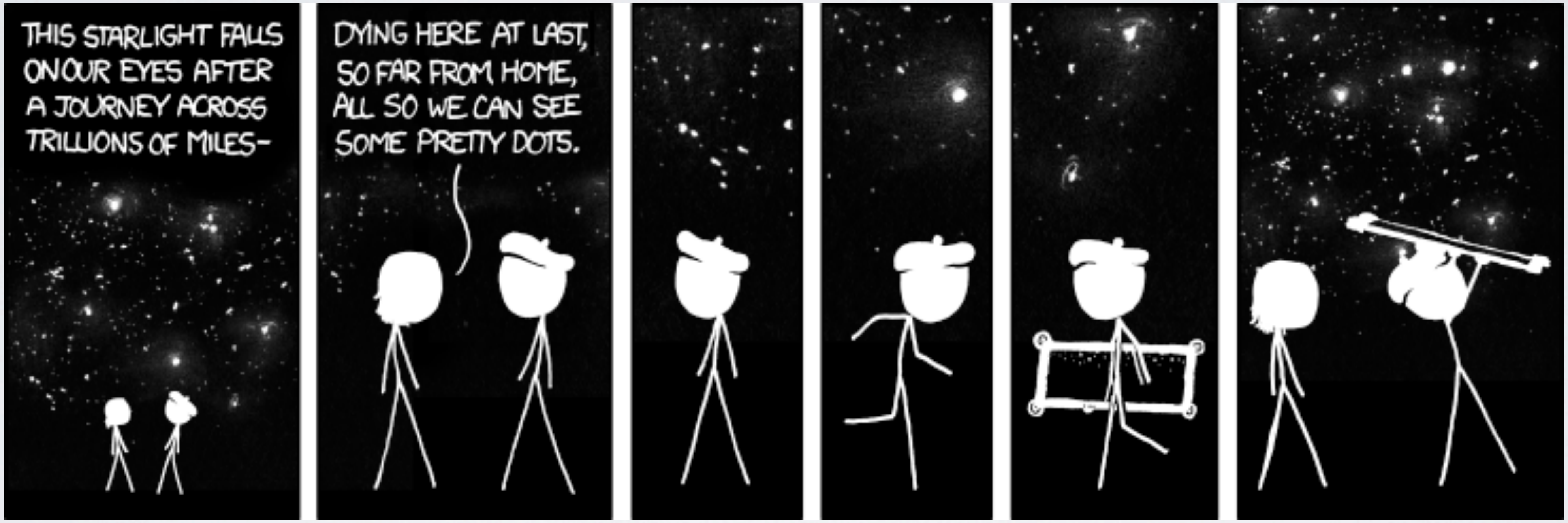


Biffi, Dolag, Böhringer 2012, *to be submitted*

PHOX: ADVANTAGES & PERSPECTIVES

- preserve **high spatial and energy resolution**:
  predict X-ray observational results achievable with upcoming instruments,
  study of gas non-thermal velocity field from high-precision spectroscopic data;
  effect of velocity field on mass determination and scaling relations;
- perform very efficiently mock X-ray observations of large cosmic volumes;
- process <u>very efficiently</u> **large catalogues of clusters**, from a single photon cube for a given simulation output;

THANKS!



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