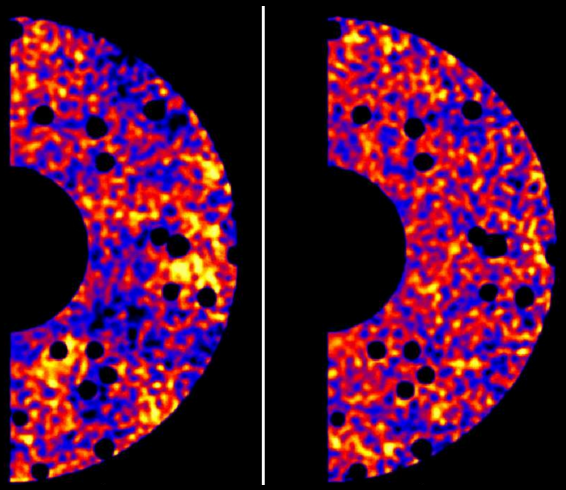
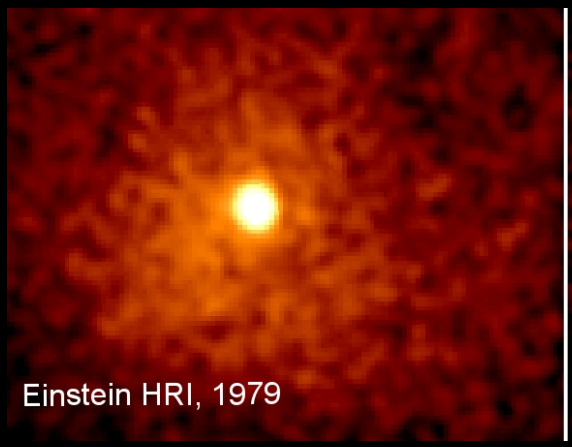
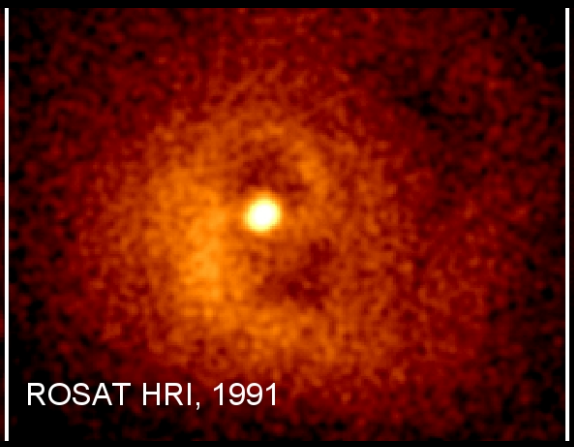
Constraining gas motions in galaxy clusters, and more

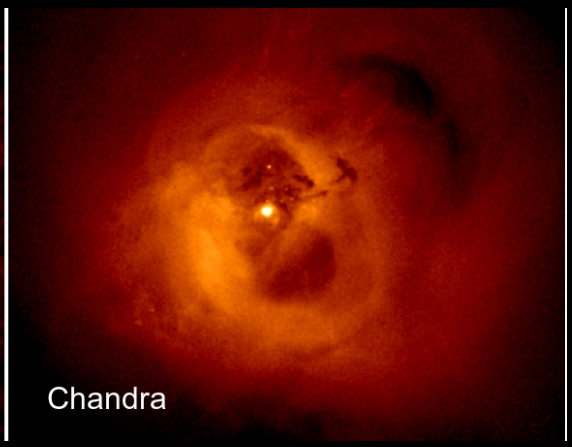


Stephen Walker

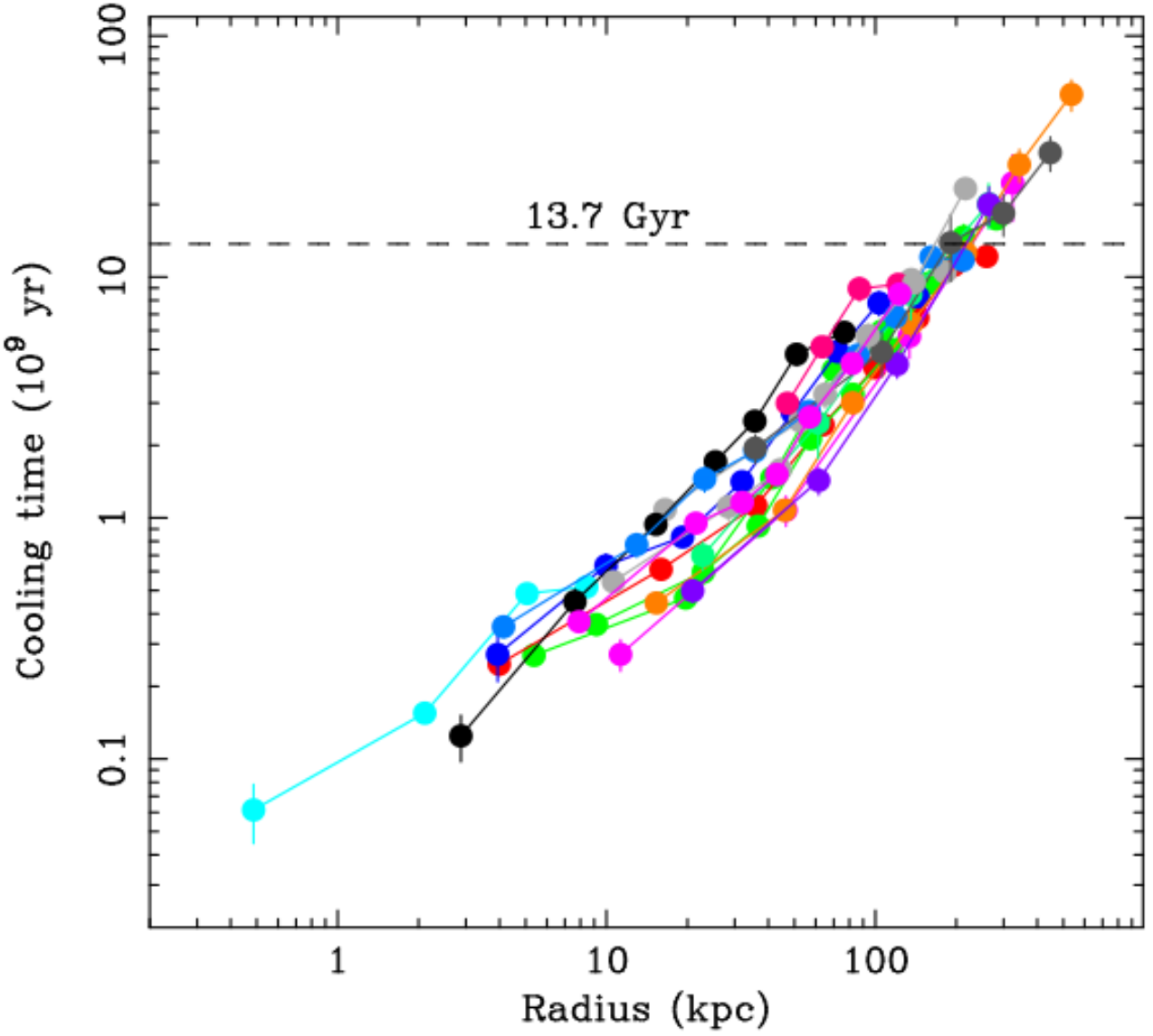
UNIVERSITY OF CAMBRIDGE



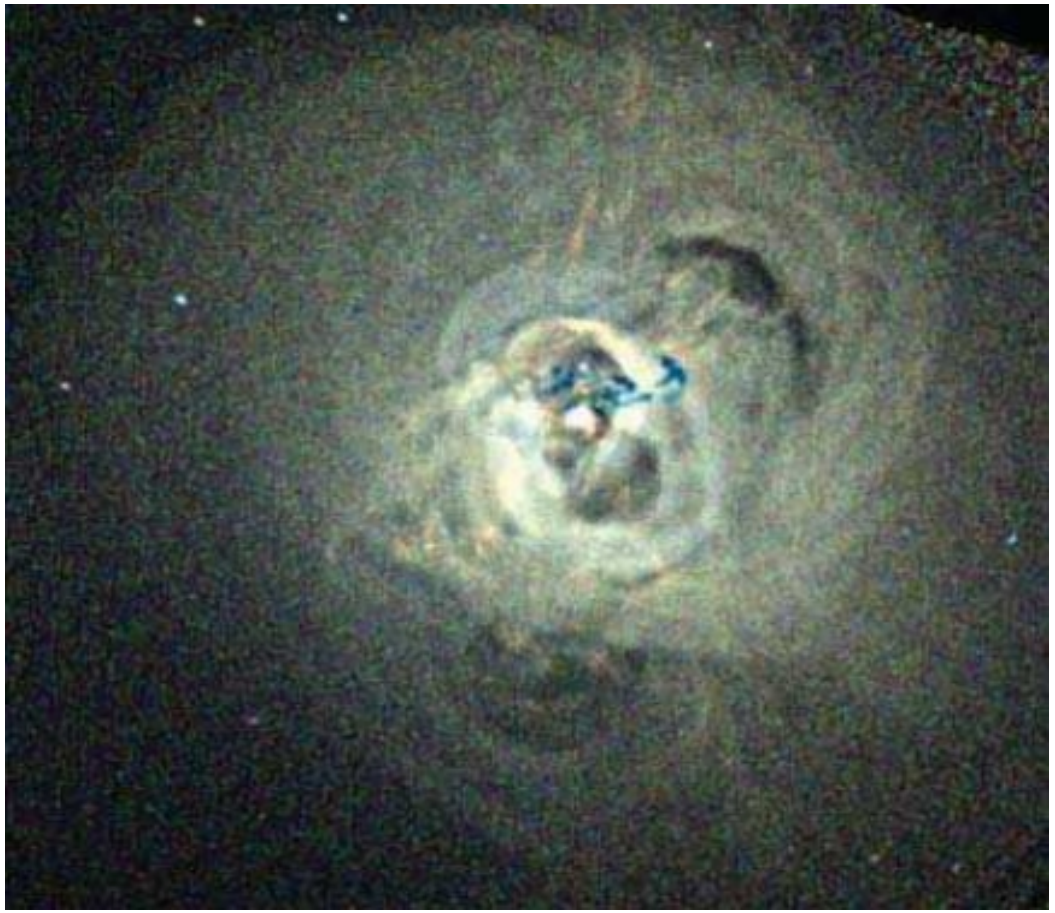




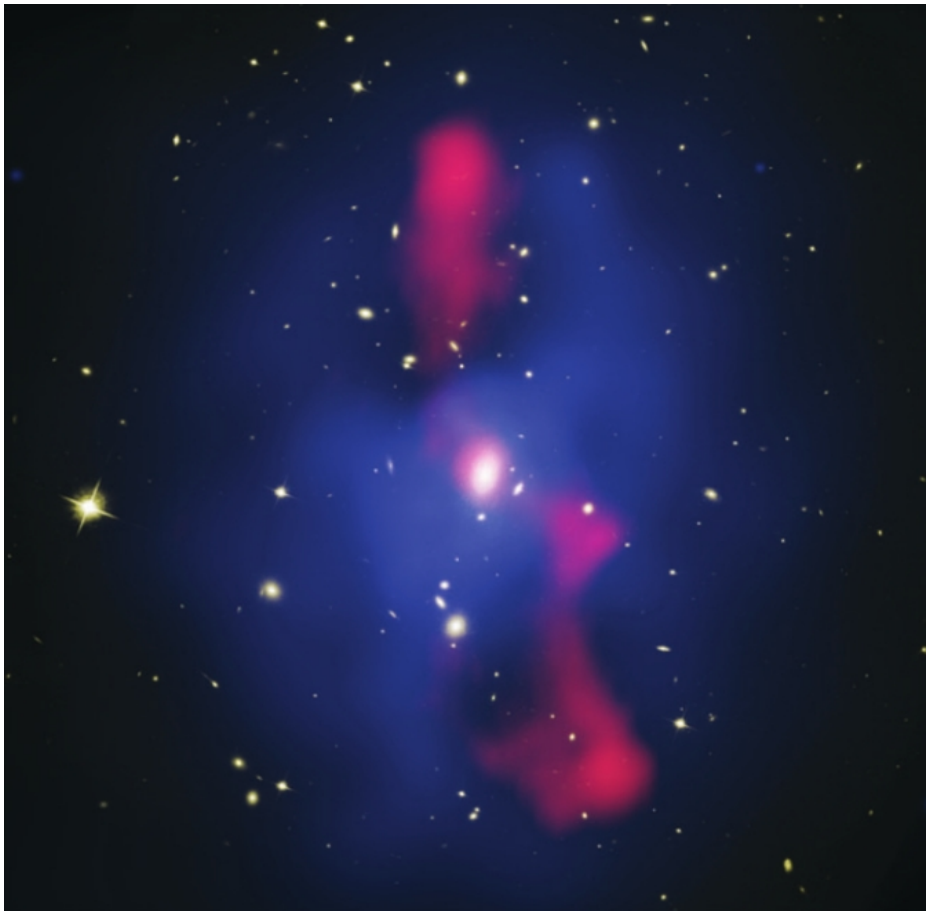
Jeremy Sanders, Andy Fabian



Voigt & Fabian (2004)

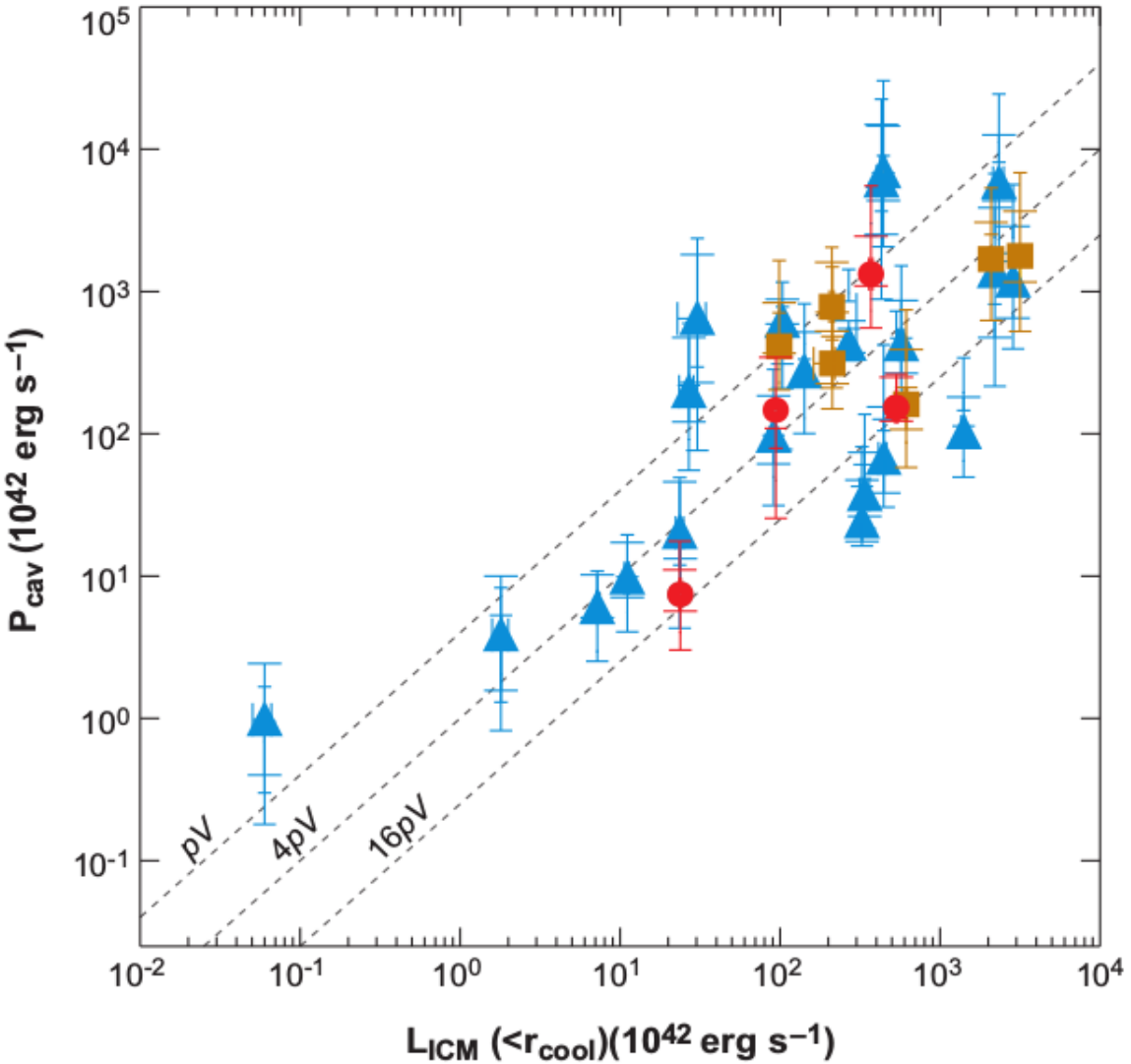


Perseus cluster



MS0735.6+7421

- Cavities in ICM can be used as calorimeters



Rafferty et al. (2006)

- How is this feedback energy dissipated into the ICM?

- How is this feedback energy dissipated into the ICM?
- How can we observe this with existing instruments?

- An historical aside ...

Effects of the variability of the nucleus of NGC1275 on X-ray observations of the surrounding intracluster medium

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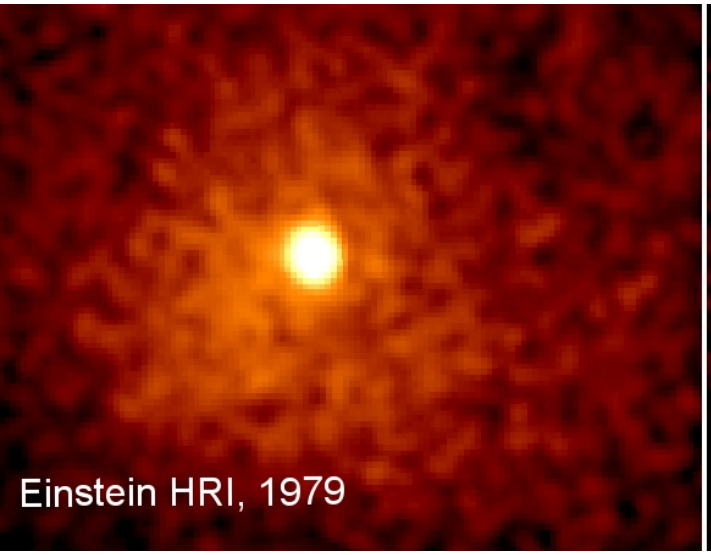
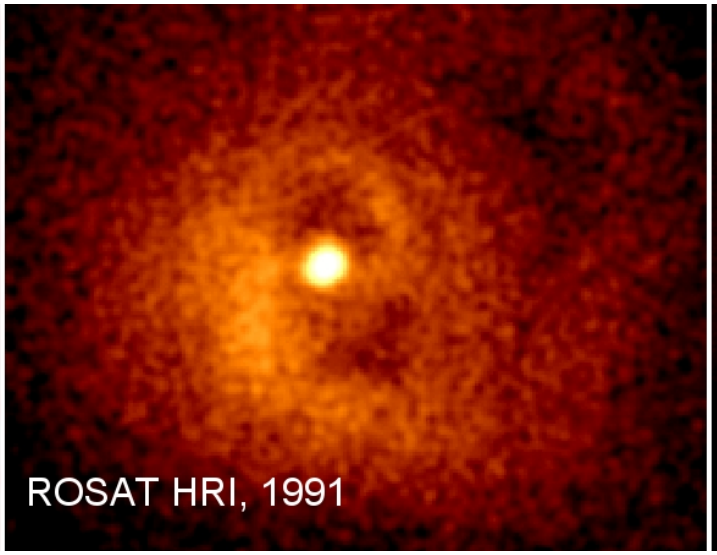
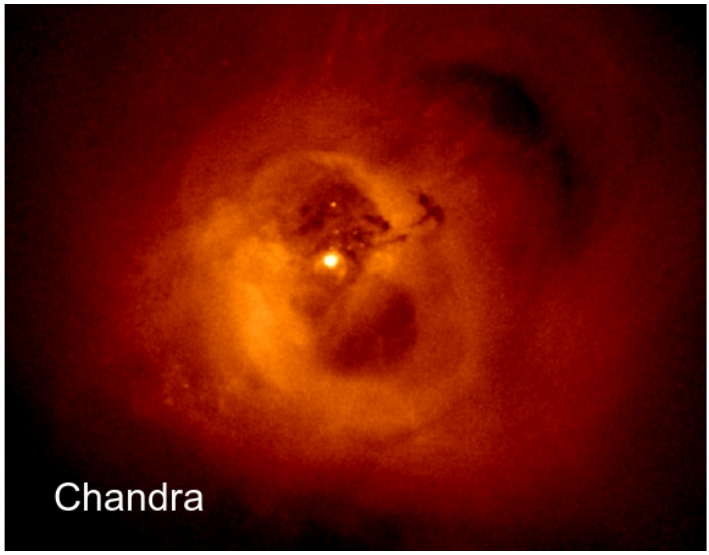
15 April 2015

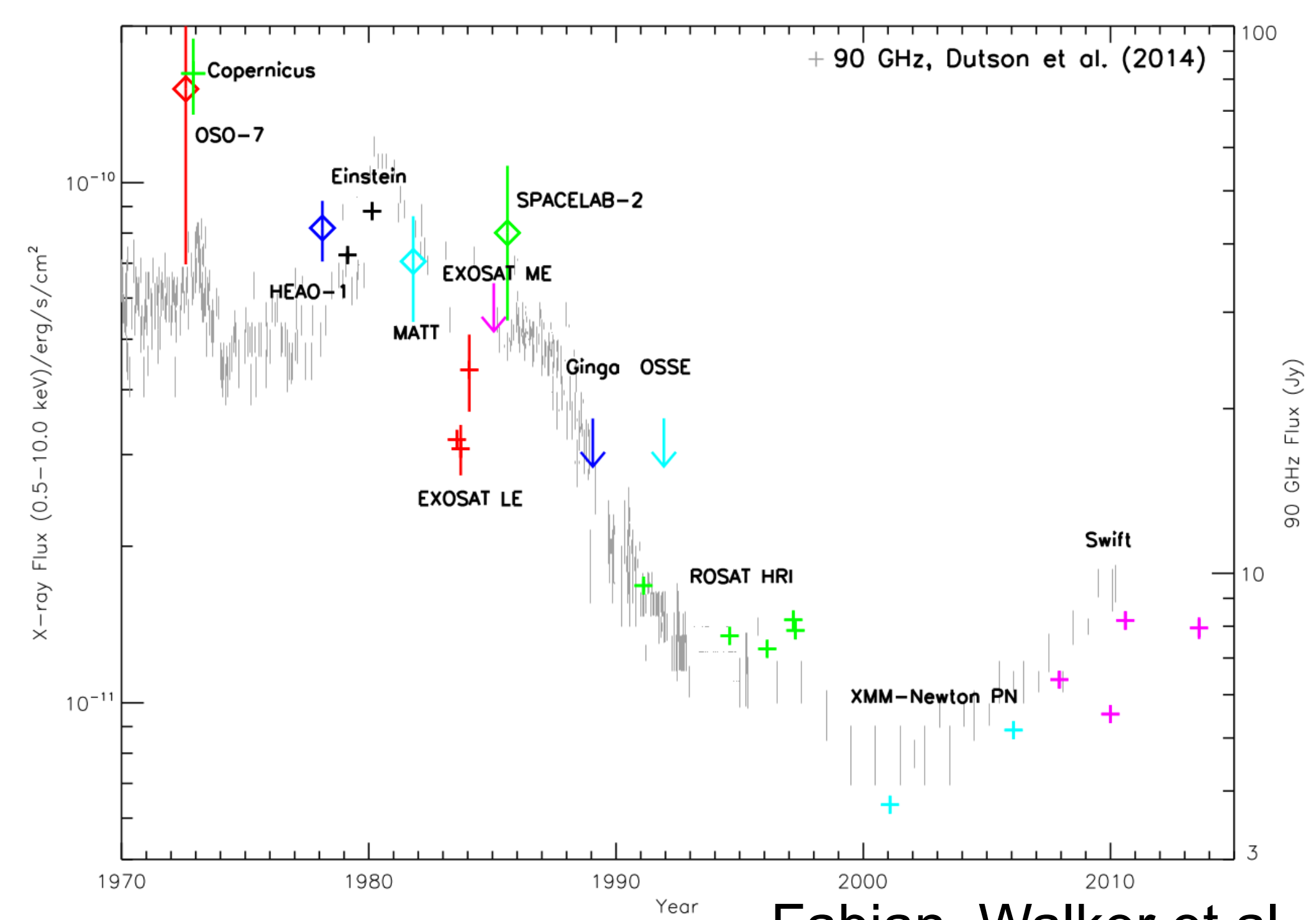
ABSTRACT
The active galaxy NGC1275 lies at the centre of the Perseus cluster of galaxies, which is the X-ray brightest cluster in the Sky. The nucleus shows large variability over the past few







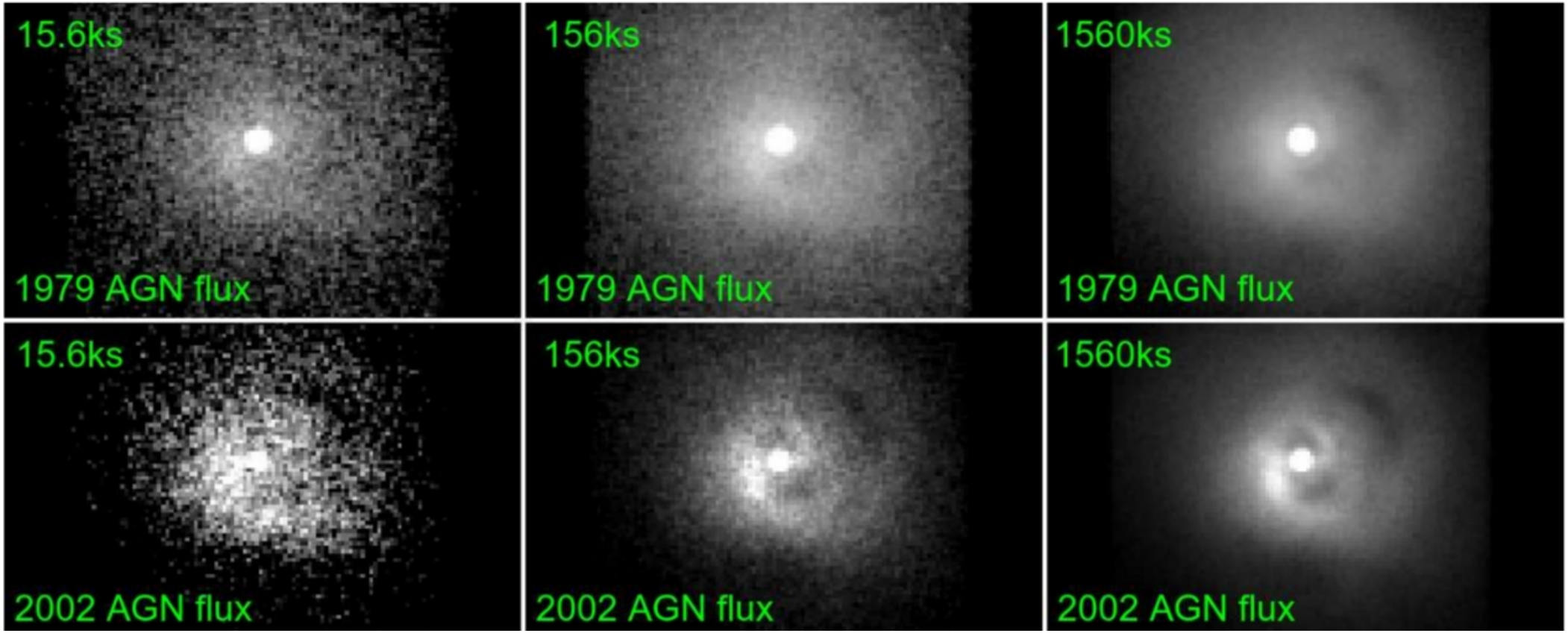
Fabian, Walker et al. 2015



Fabian, Walker et al. 2015

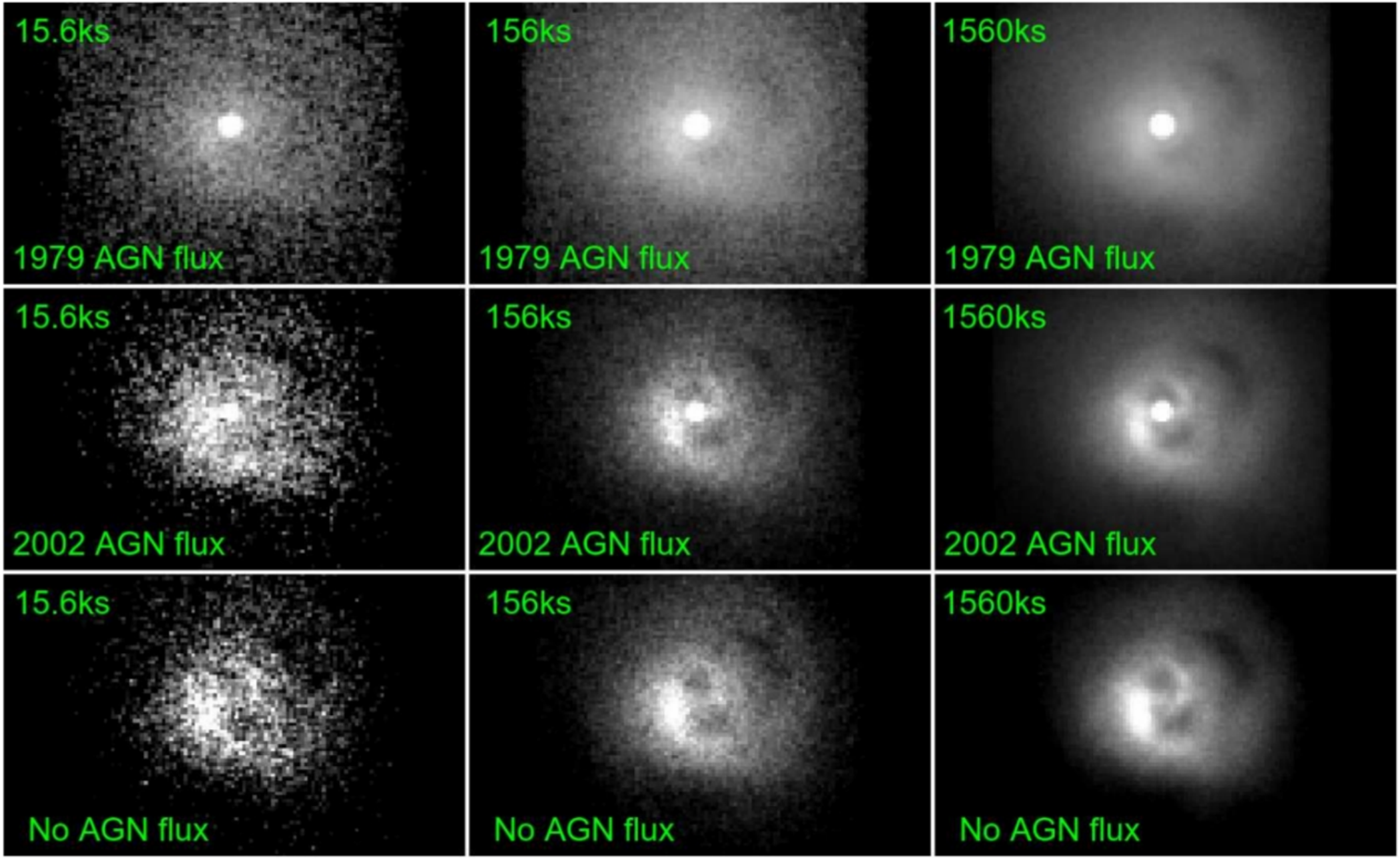
SimX simulations

Fabian, Walker et al. 2015



SimX simulations

Fabian, Walker et al. 2015



Fabian, Walker et al. 2015

- How is this feedback energy dissipated into the ICM?
- How can we observe this with existing instruments?

Constraining gas motions in the Centaurus cluster using X-ray surface brightness fluctuations and metal diffusion

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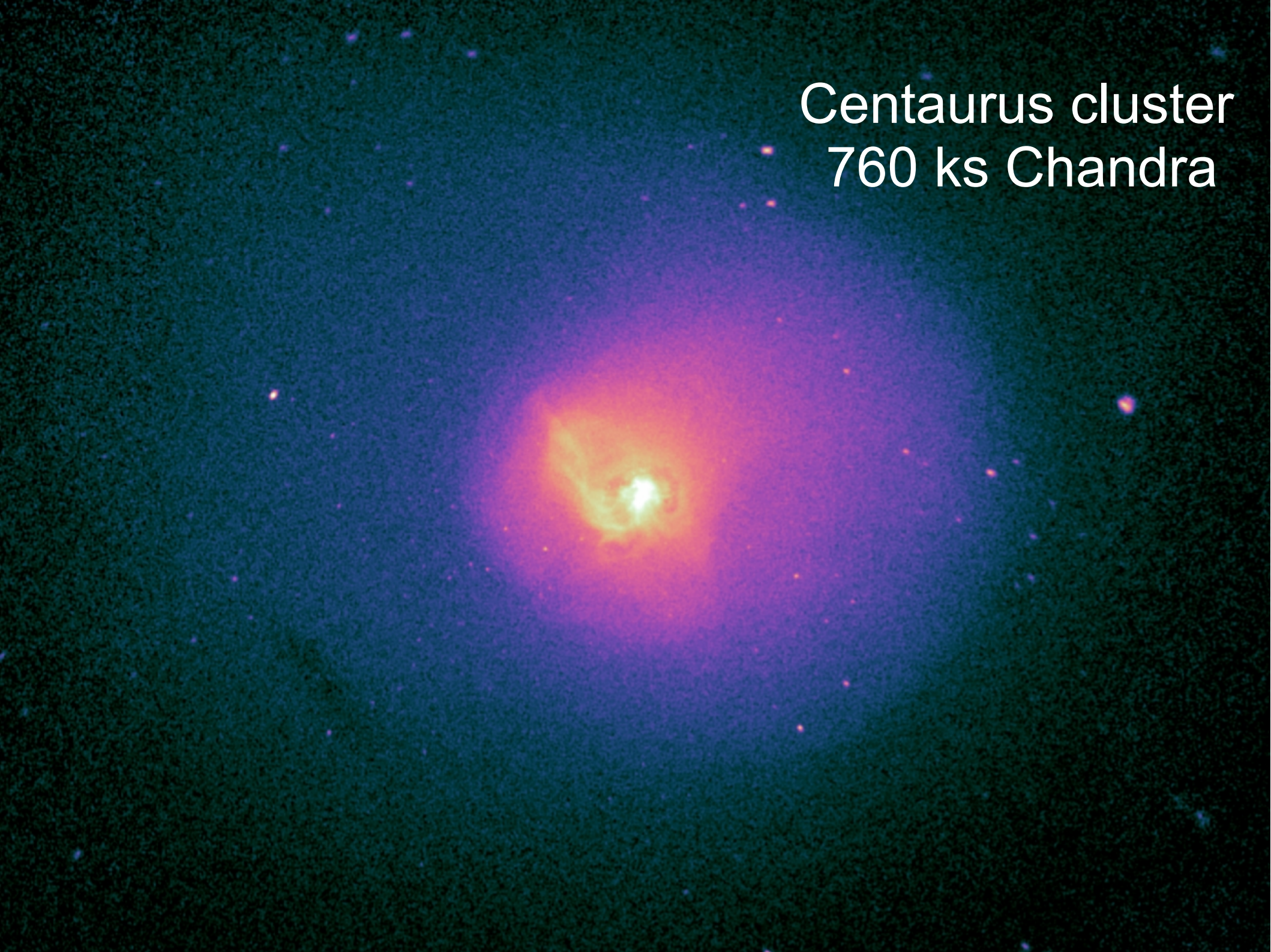
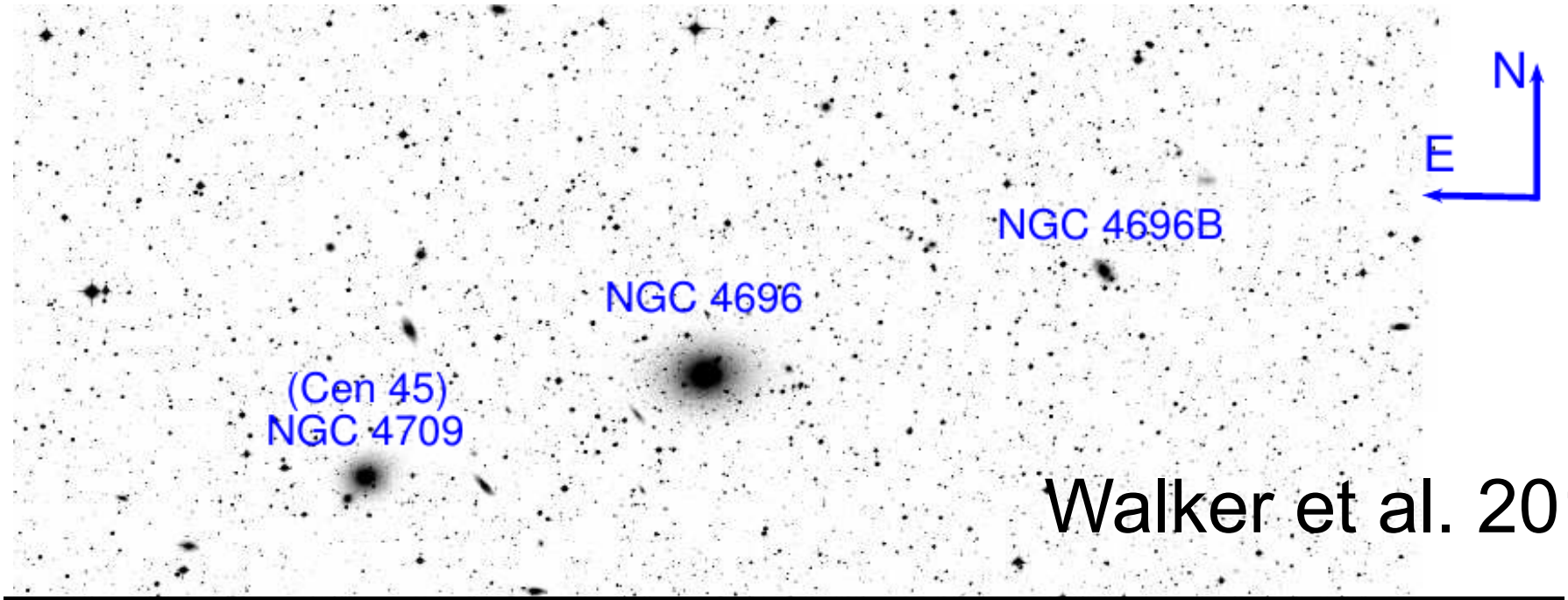
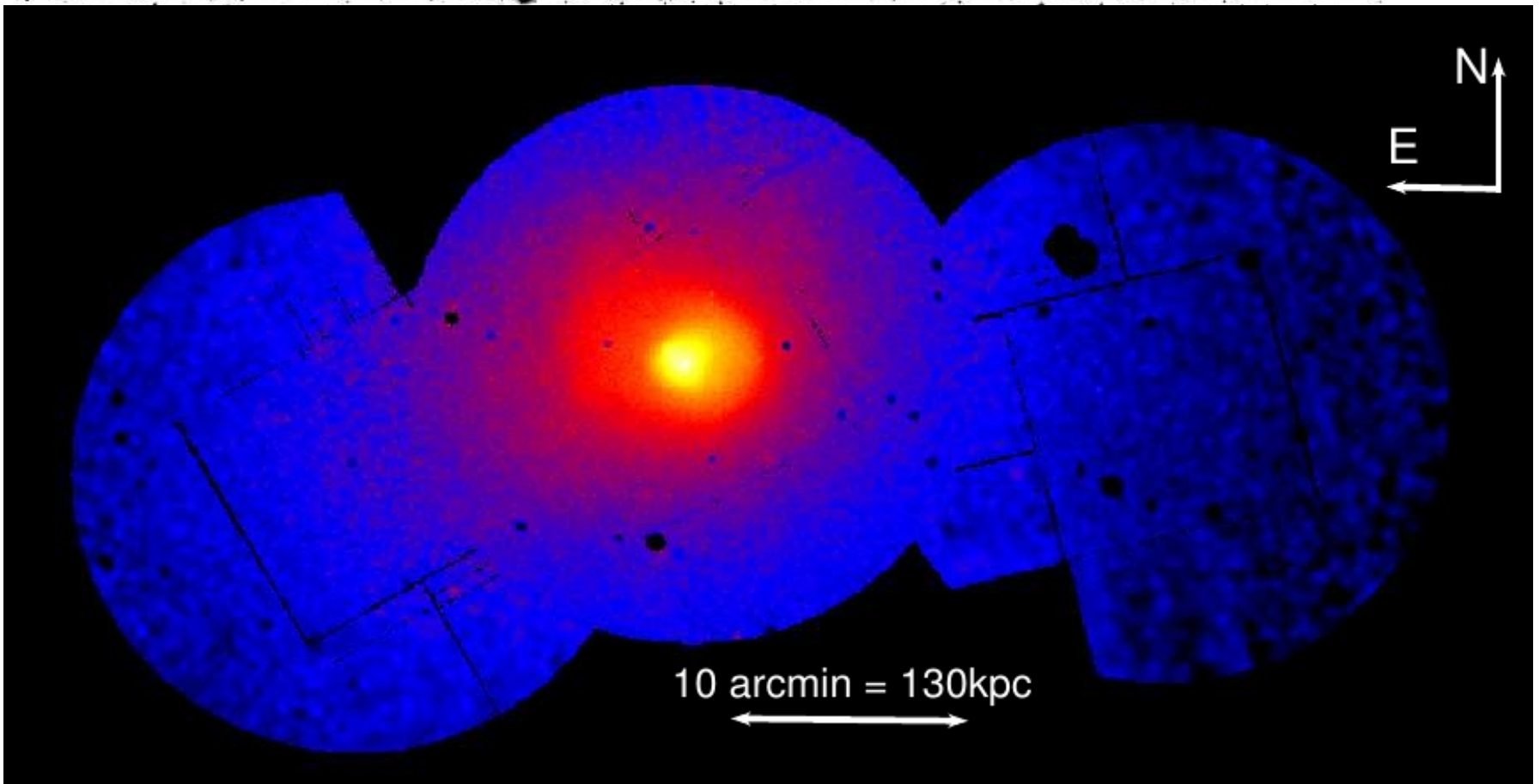
[1]*Institute of Astronomy, Madingley Road, Cambridge CB3 0HA*
[2]*Max-Planck-Institute fur extraterrestrische Physik, 85748 Garching, Germany*

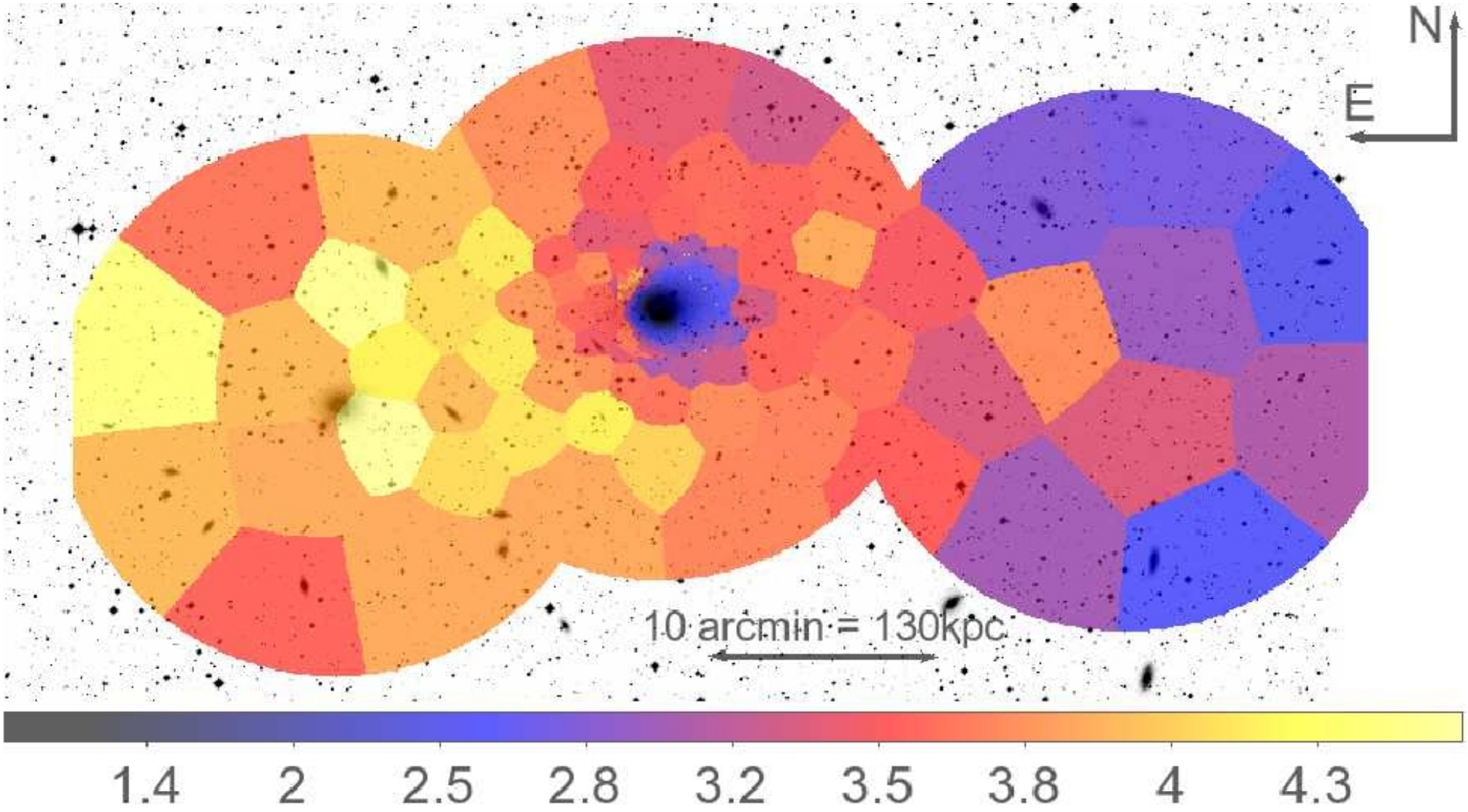

Centaurus cluster
760 ks Chandra



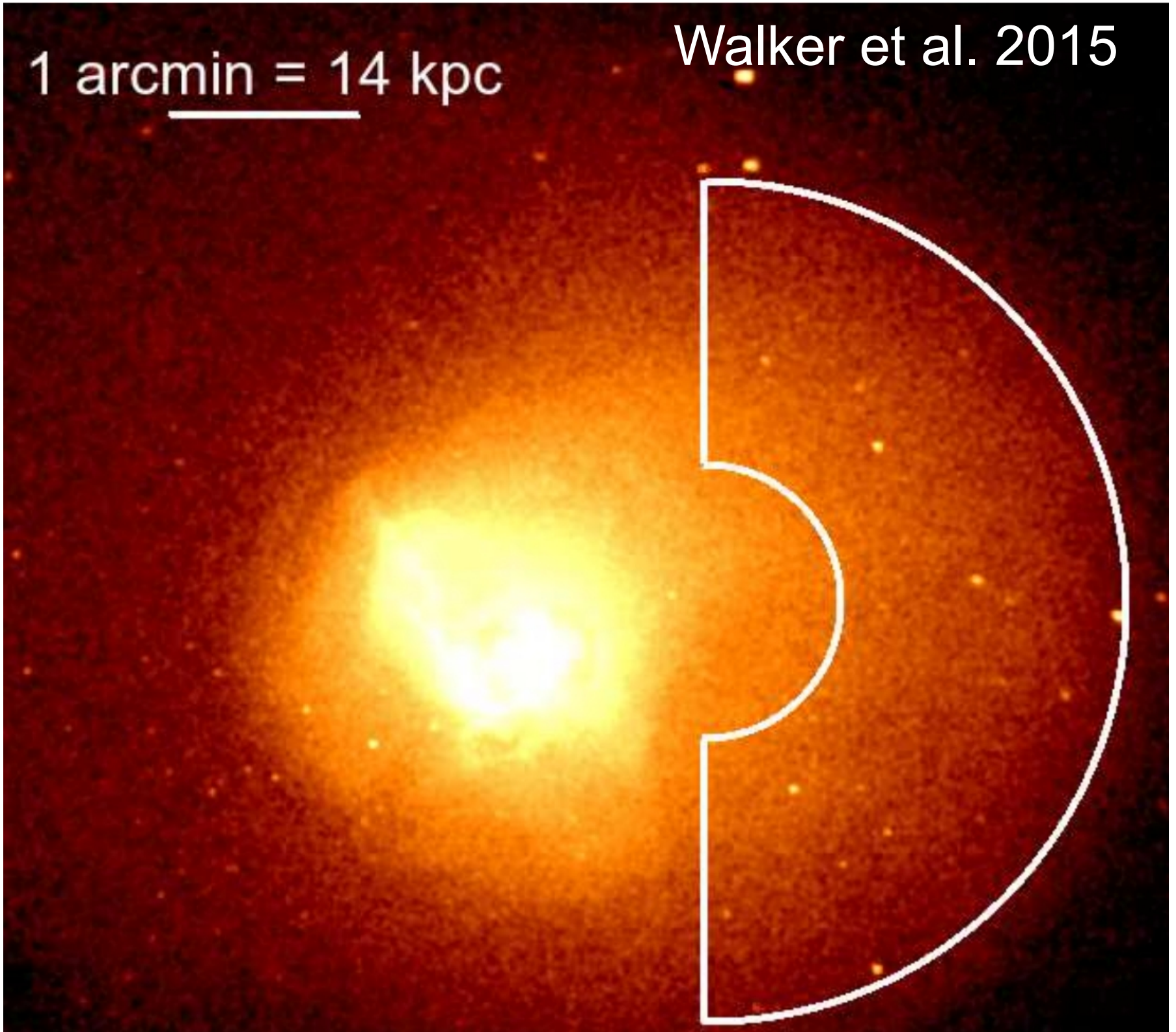
Walker et al. 2013b

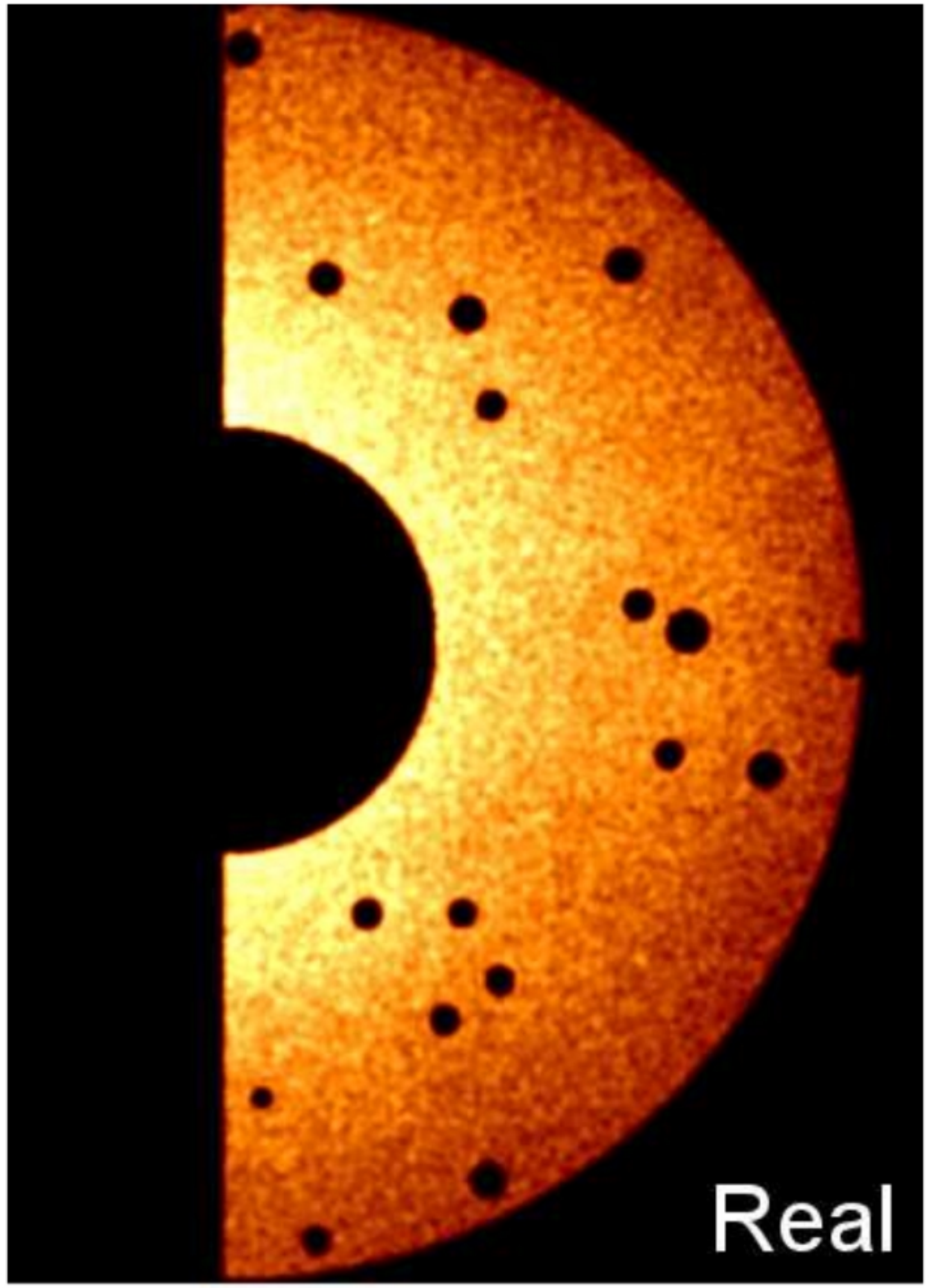


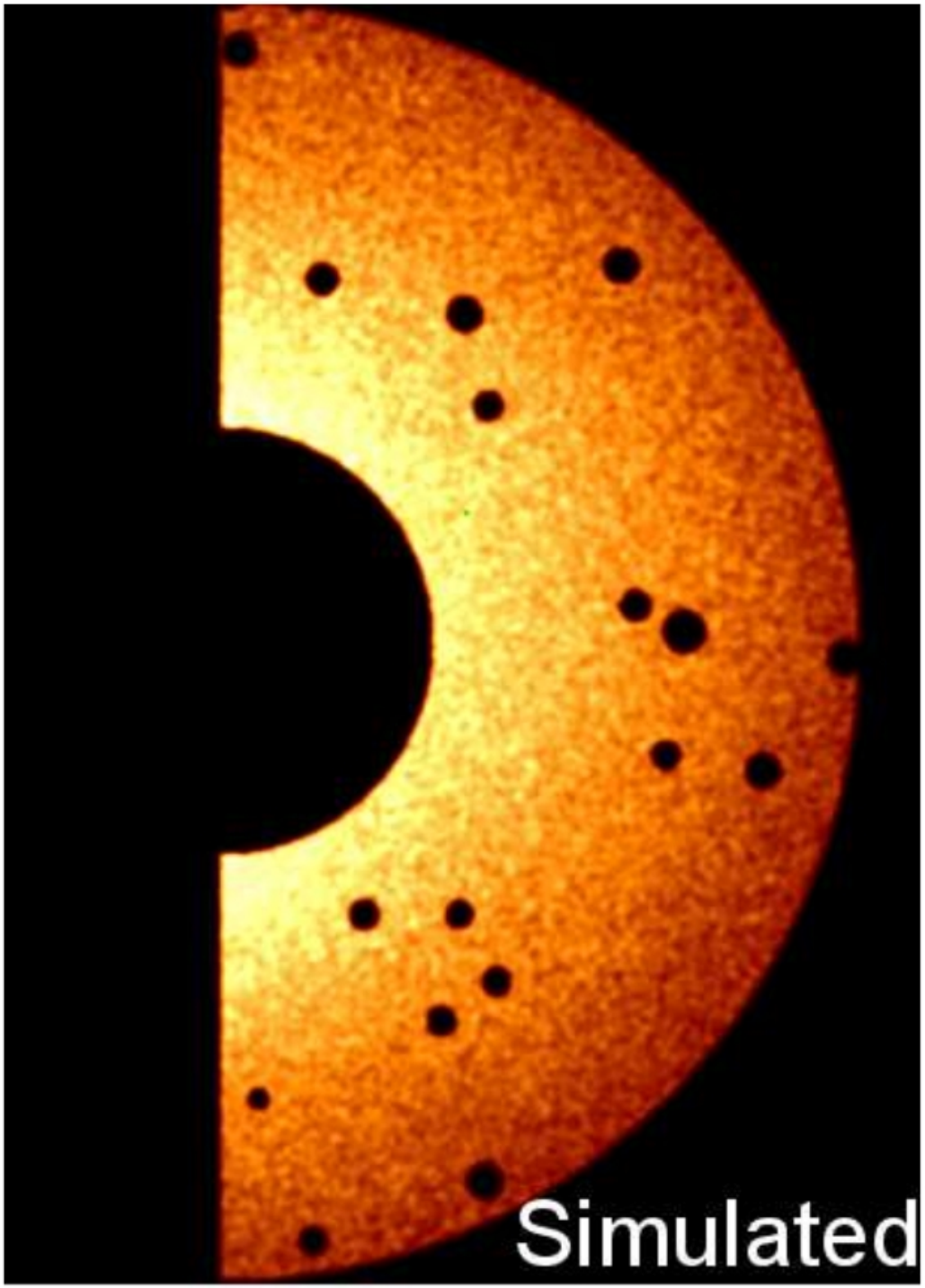
Temperature map



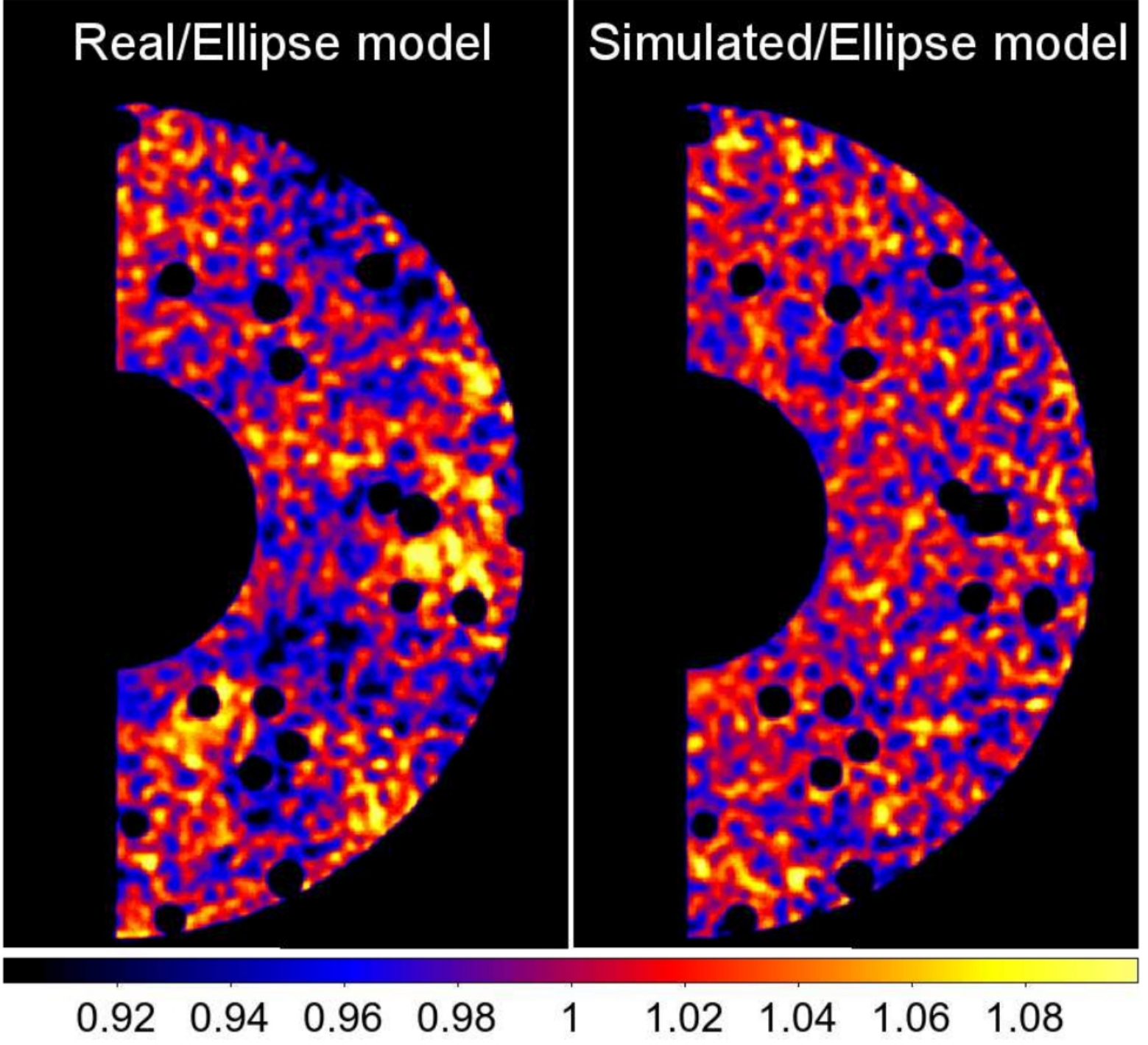
Walker et al. 2013b


1 arcmin = 14 kpc
Walker et al. 2015

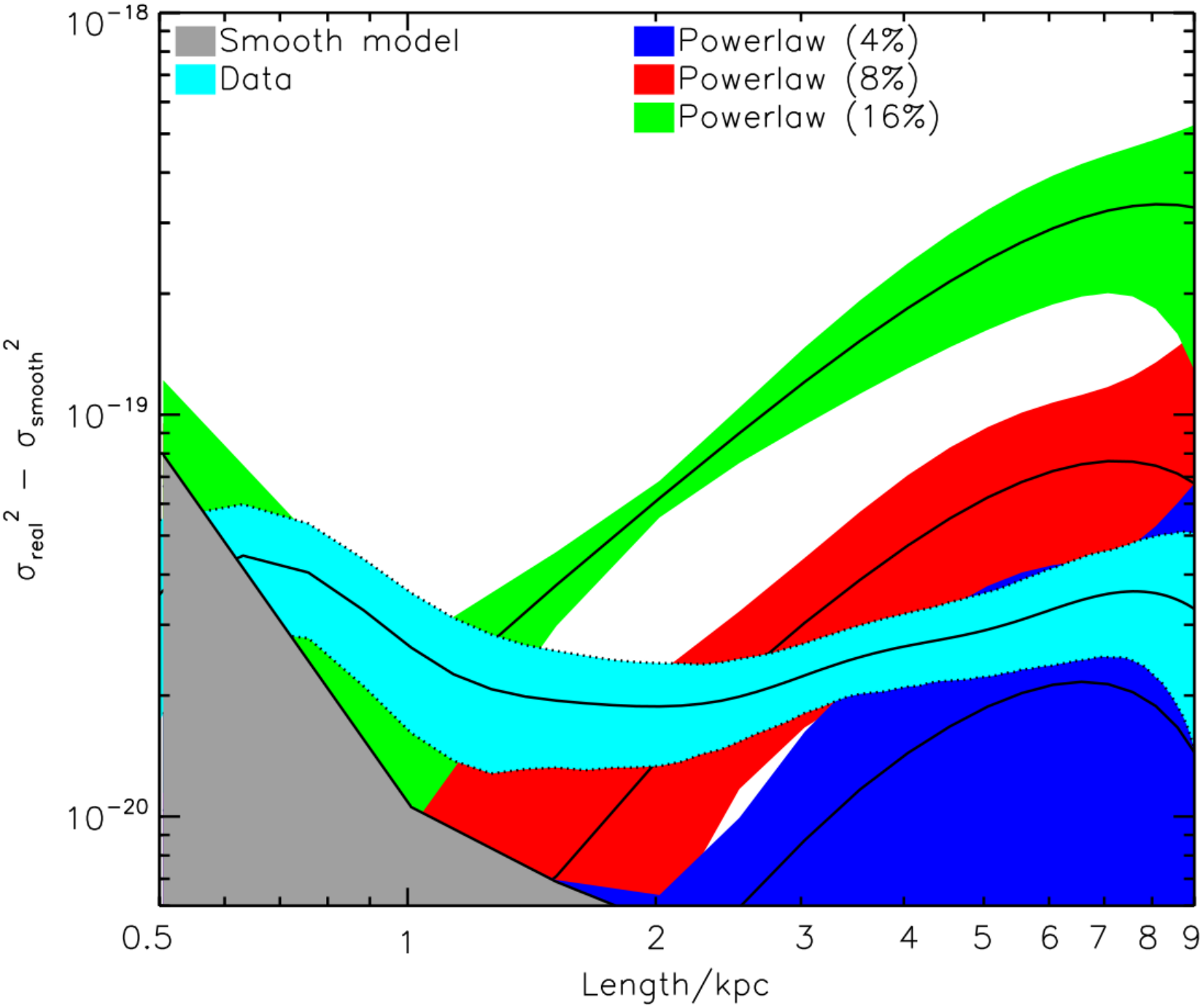




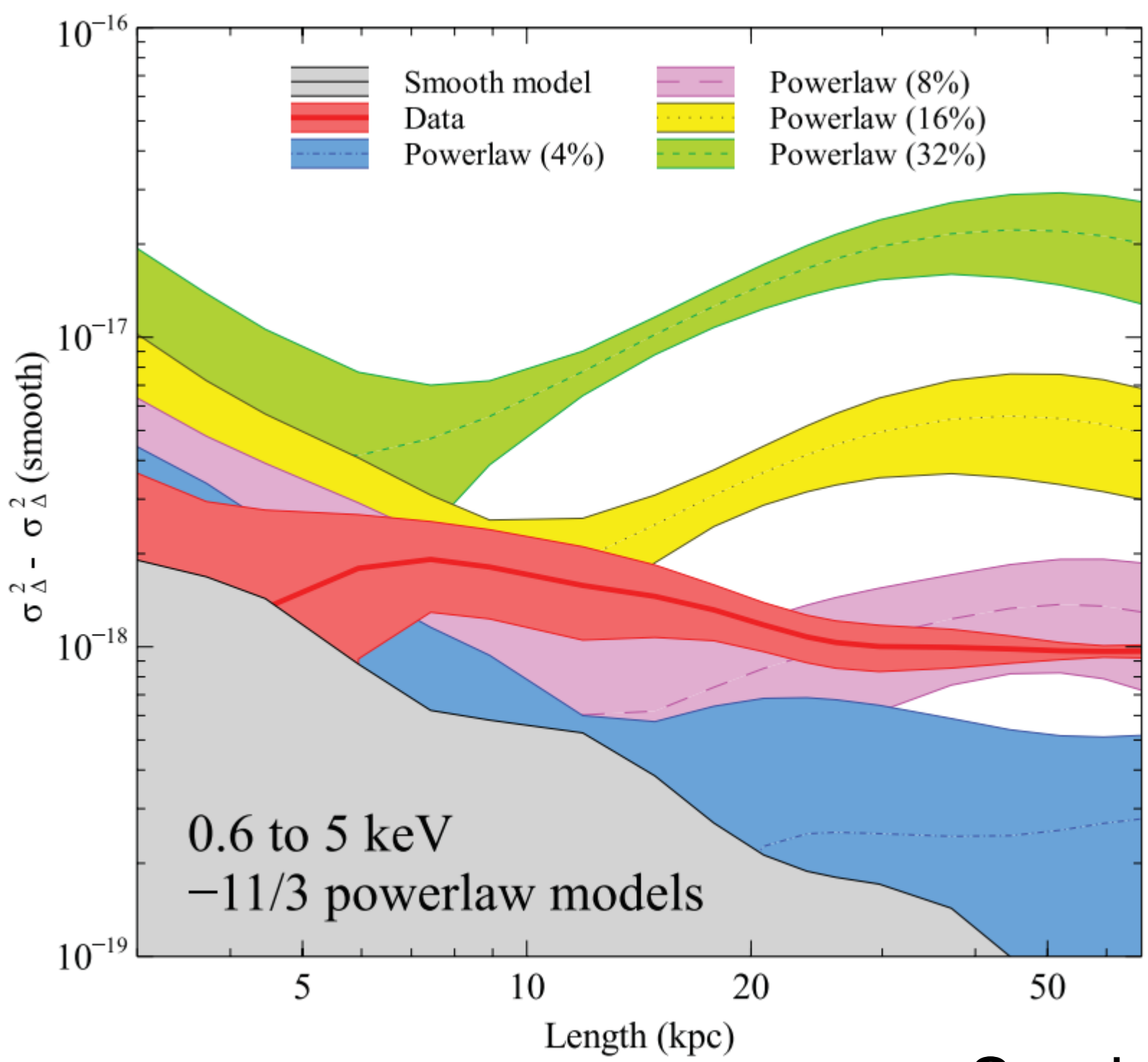
Walker et al. 2015



Walker et al. 2015

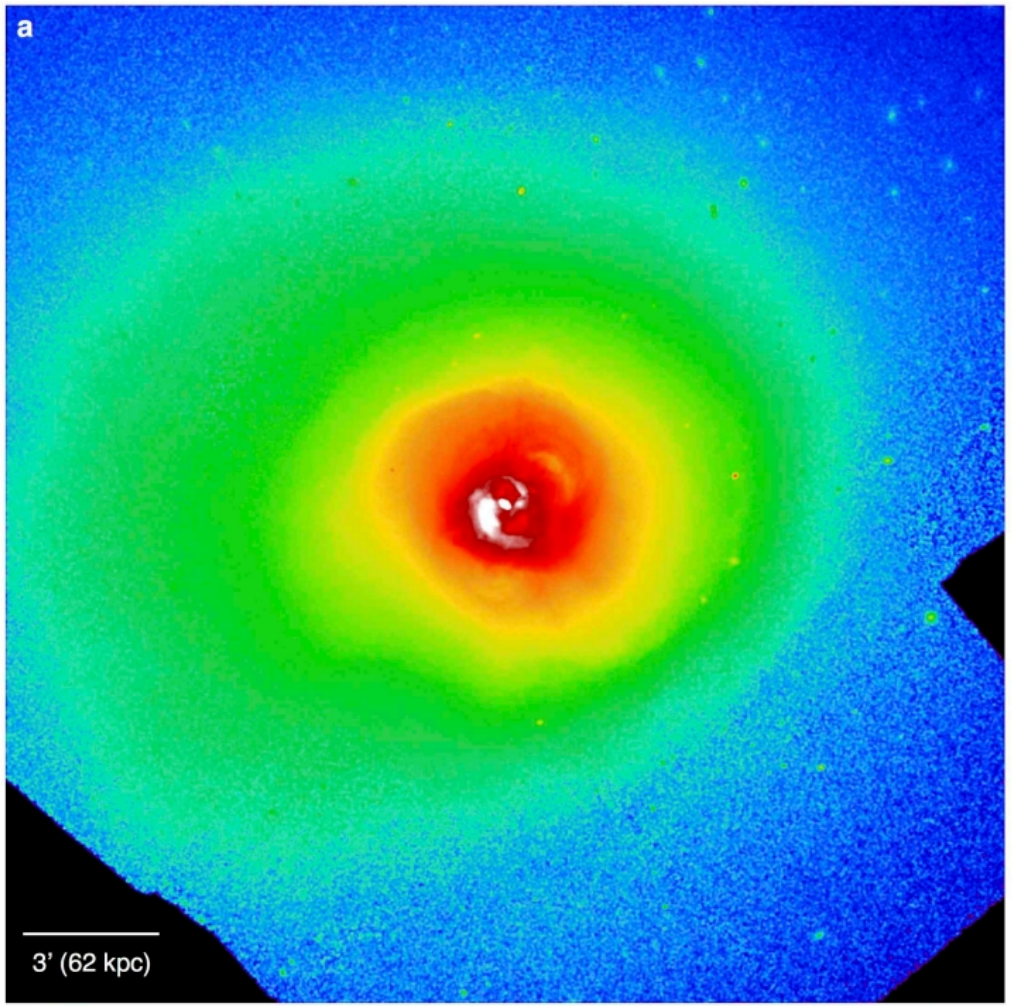


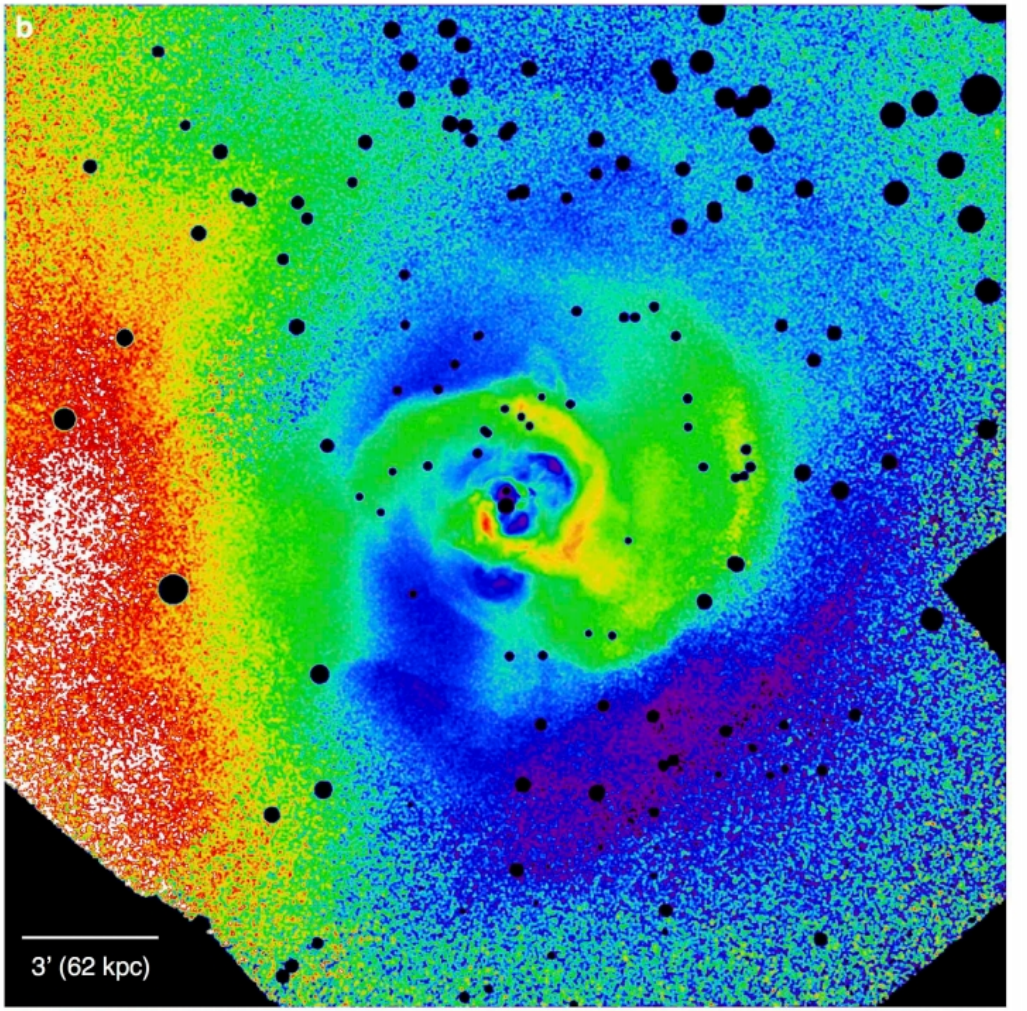
Walker et al. 2015



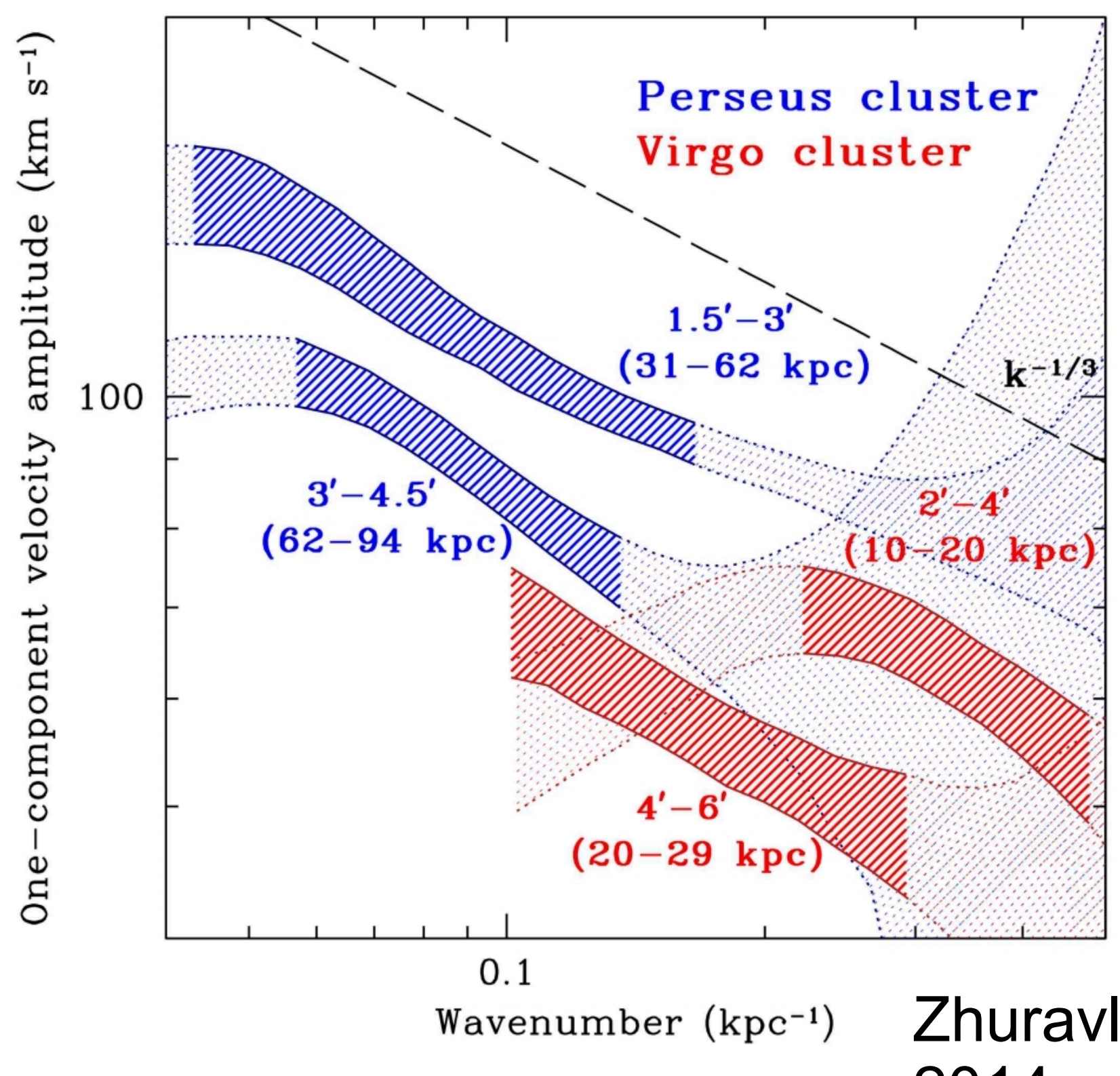
AWM7

Sanders & Fabian

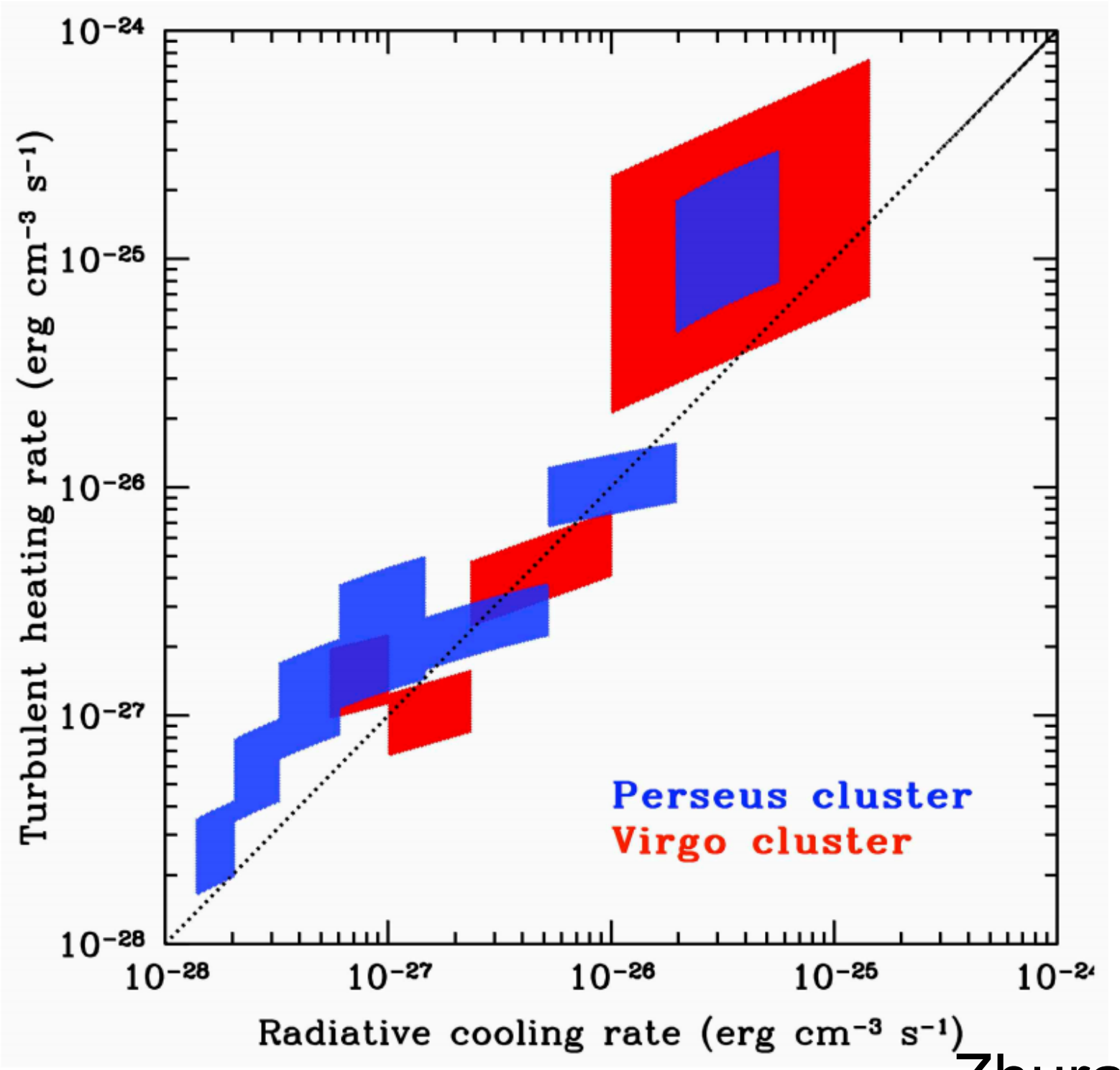




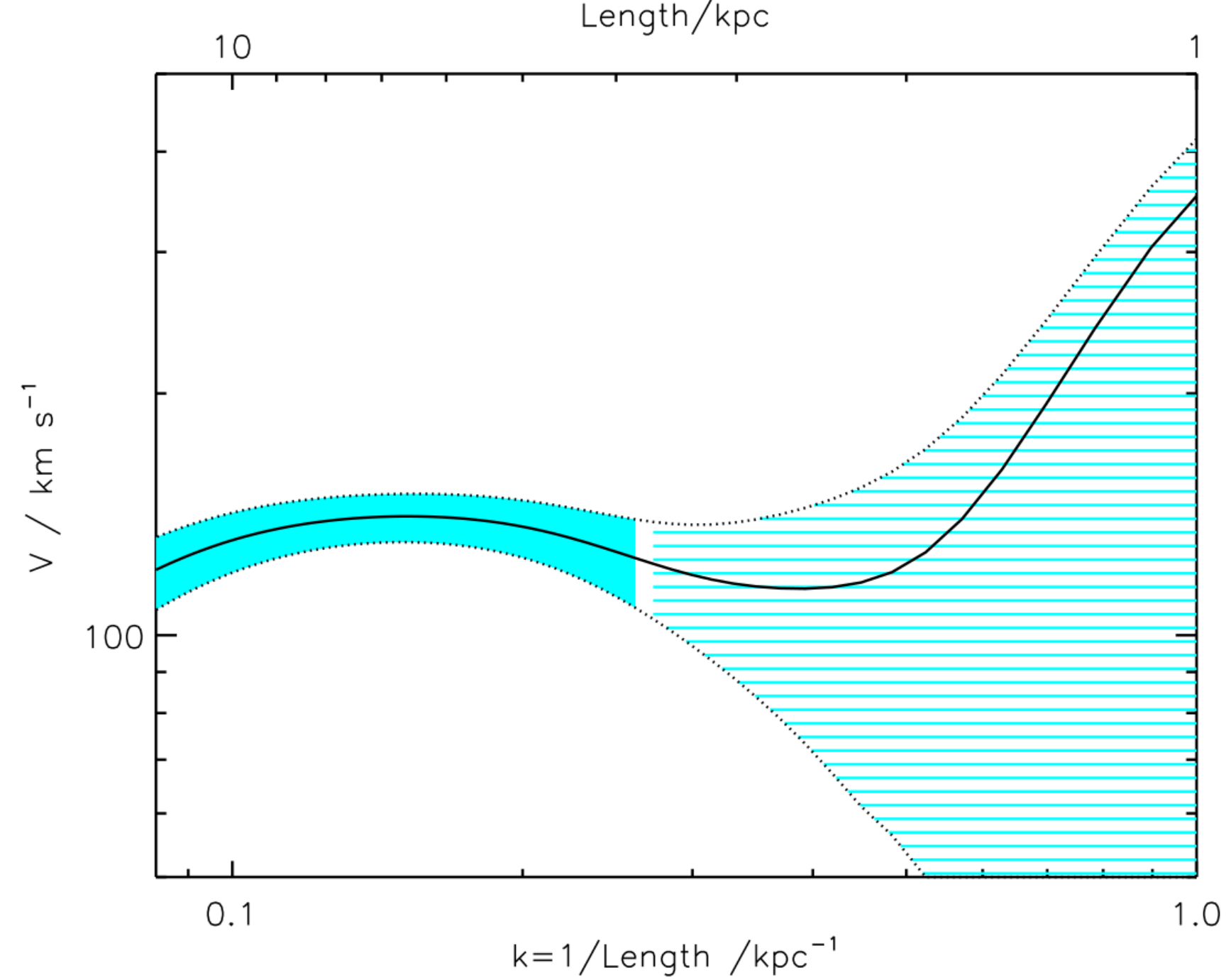
Zhuravleva et al. 2014



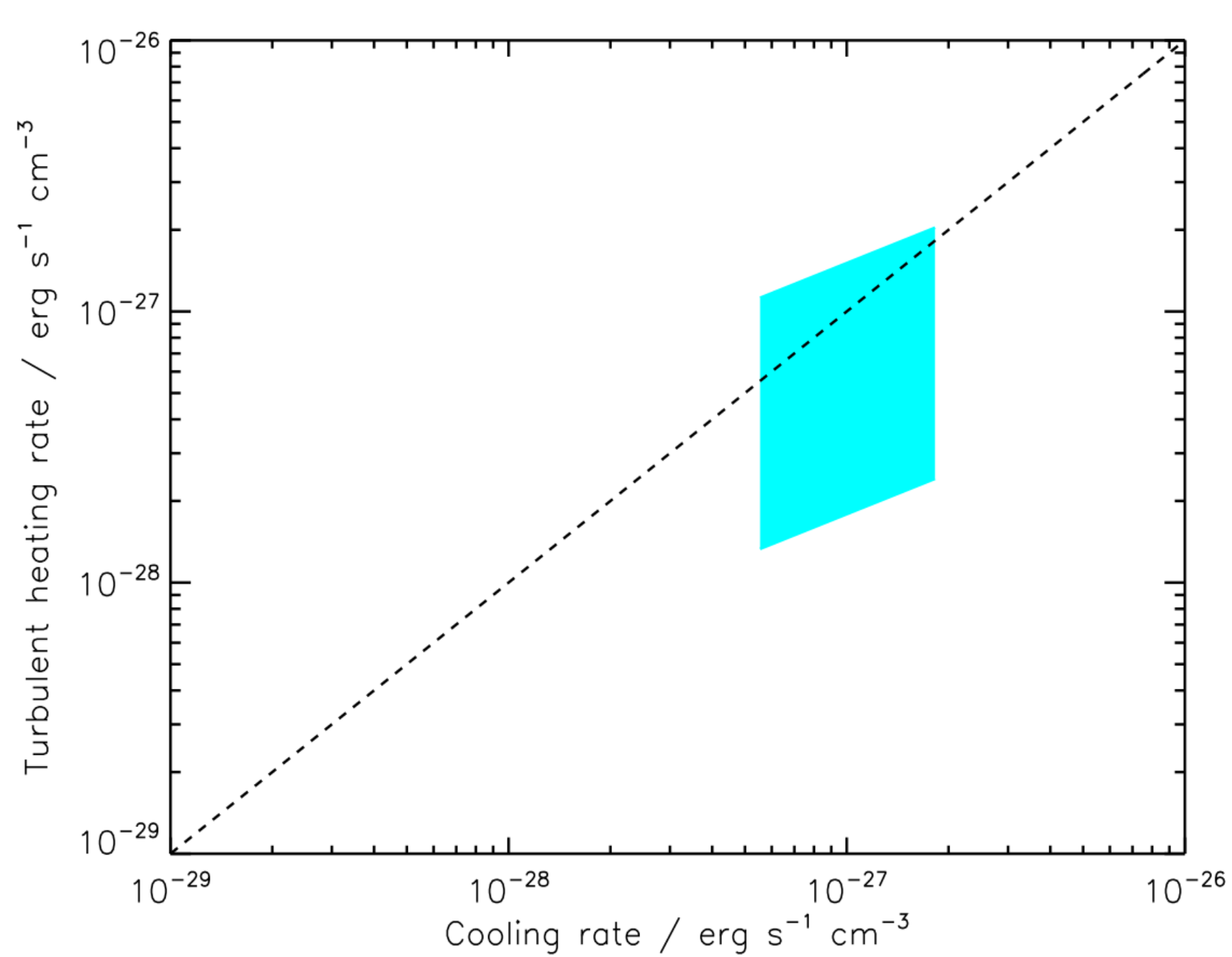
Zhuravleva et al. 2014



Zhuravleva et al.

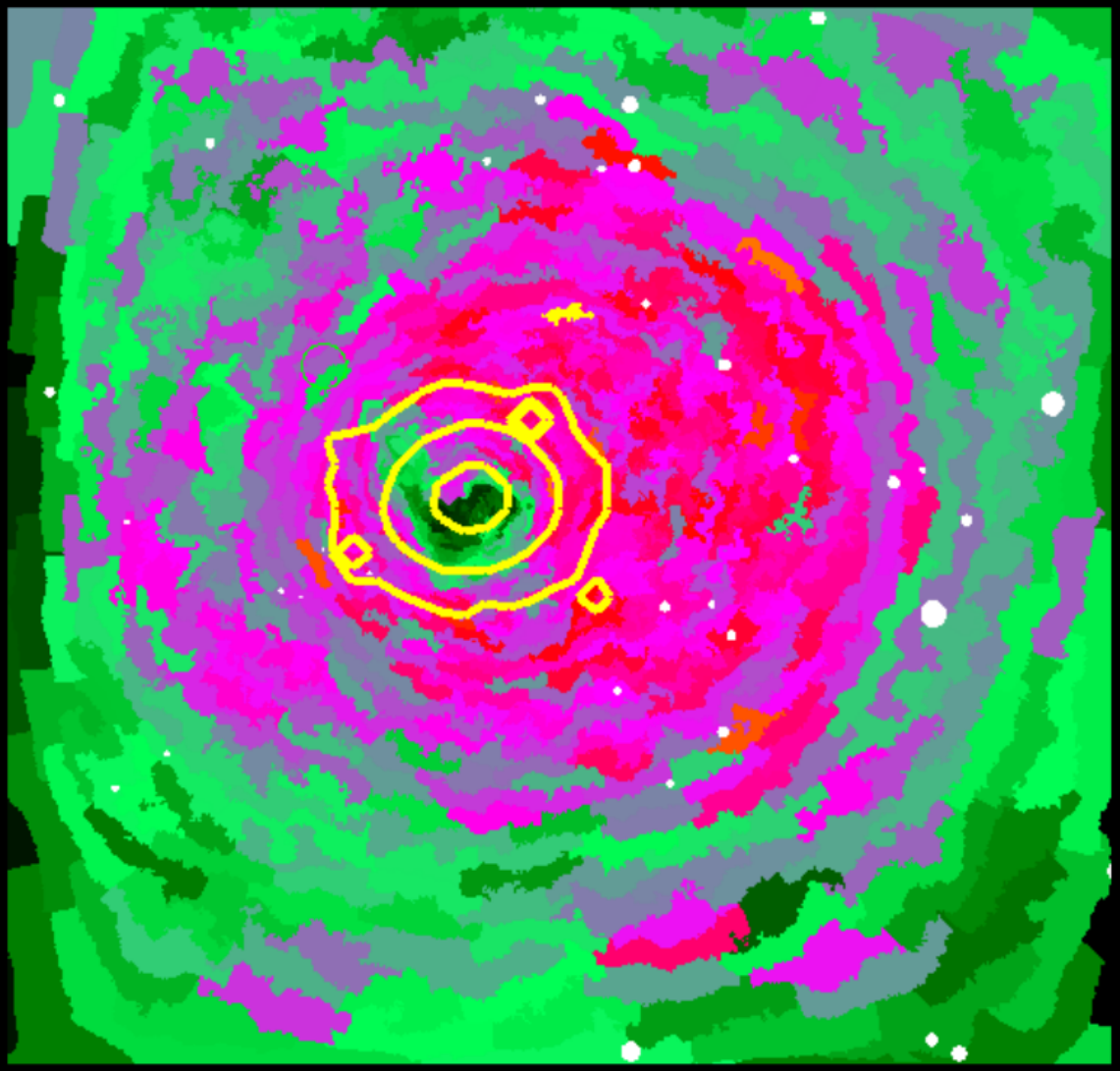


Walker et al. 2015



Walker et al. 2015

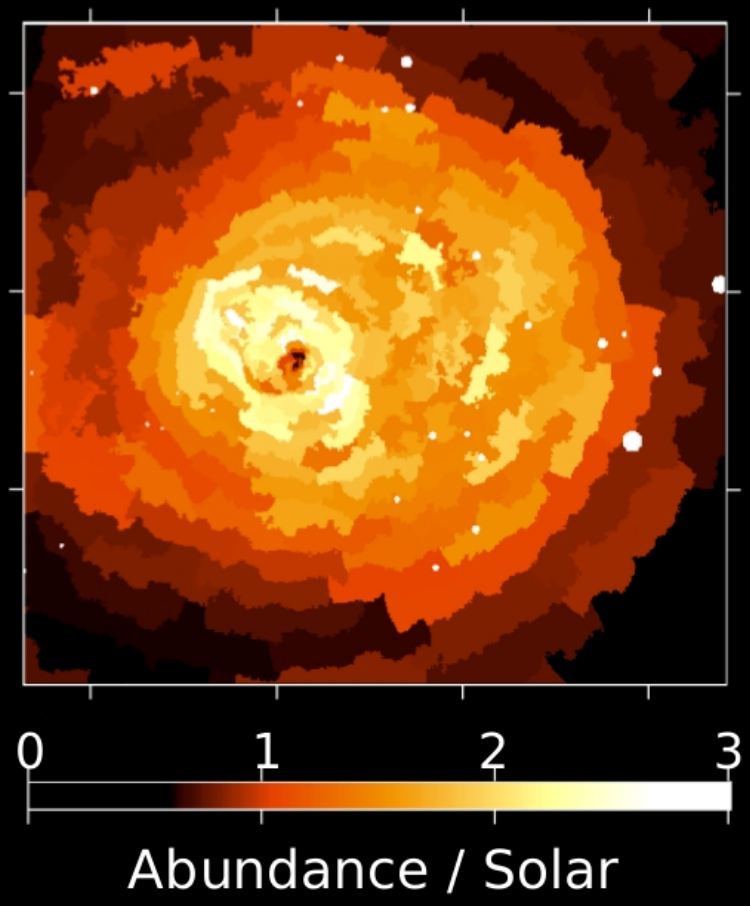
Tracing Gas Motions

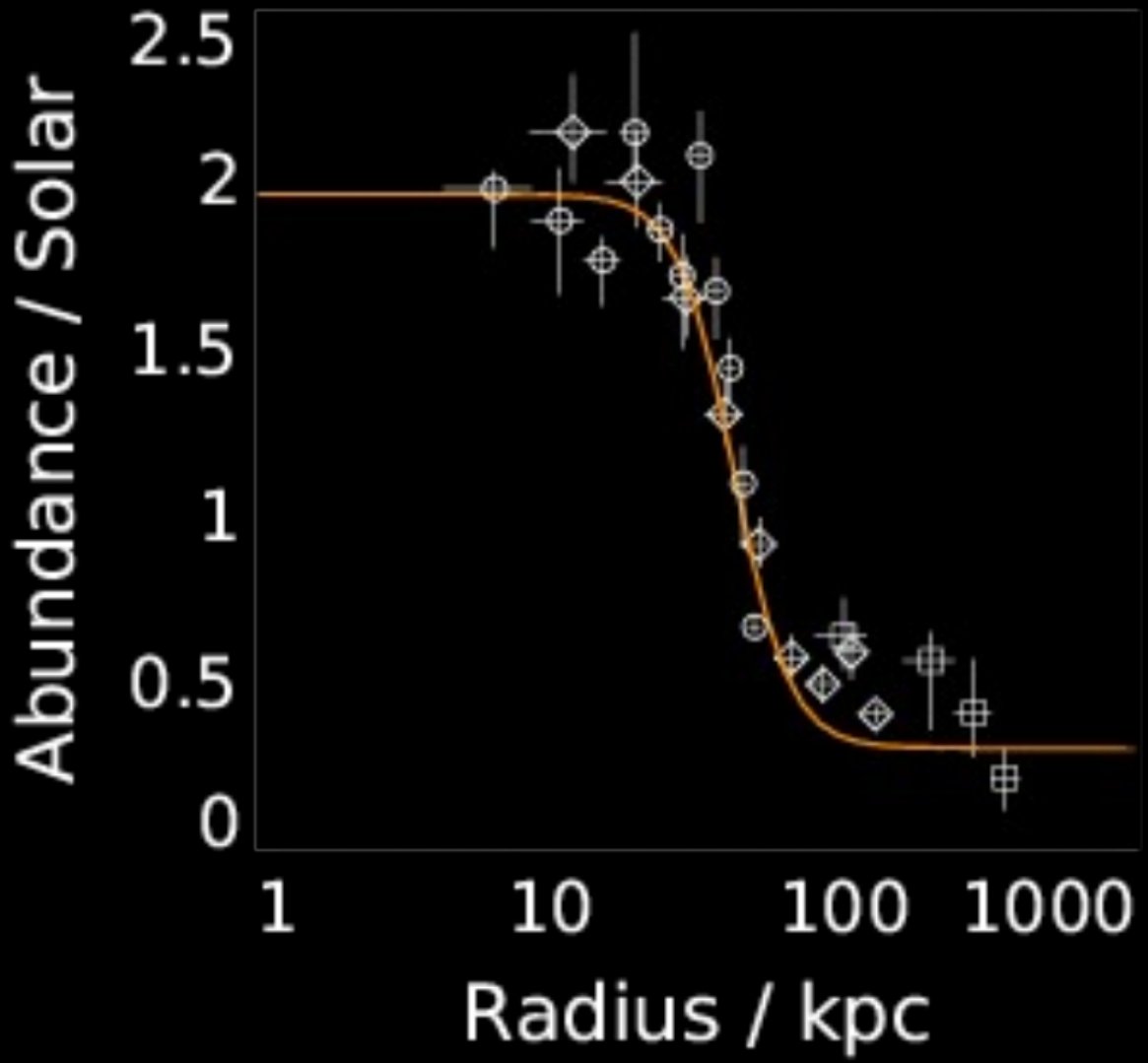


- The central iron abundance peak is much broader than the galaxy light profile
- This allows the iron distribution to be used as a tracer for the underlying gas motions

Graham et al.

Abundance Profile





Graham et al.

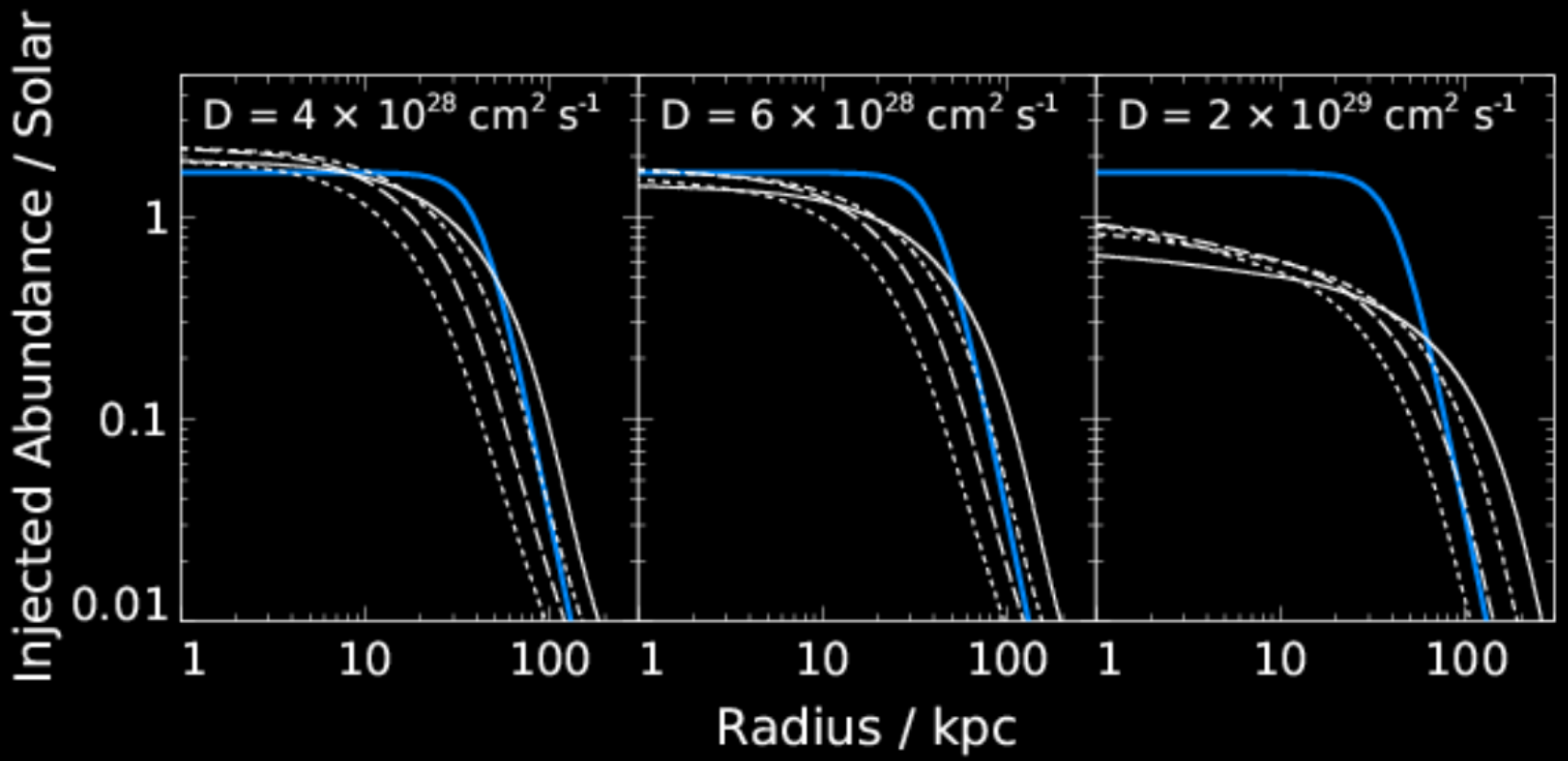
Modelling iron motion

- Following the work of Rebusco et. al. (2005) on the Perseus cluster
- Treat the movement of iron as a diffusion process:

$$\frac{\partial na}{\partial t} = \nabla \cdot (Dn \nabla (a)) + S$$

n – Hydrogen density
a – Iron abundance
D – diffusion constant
S – Iron sources

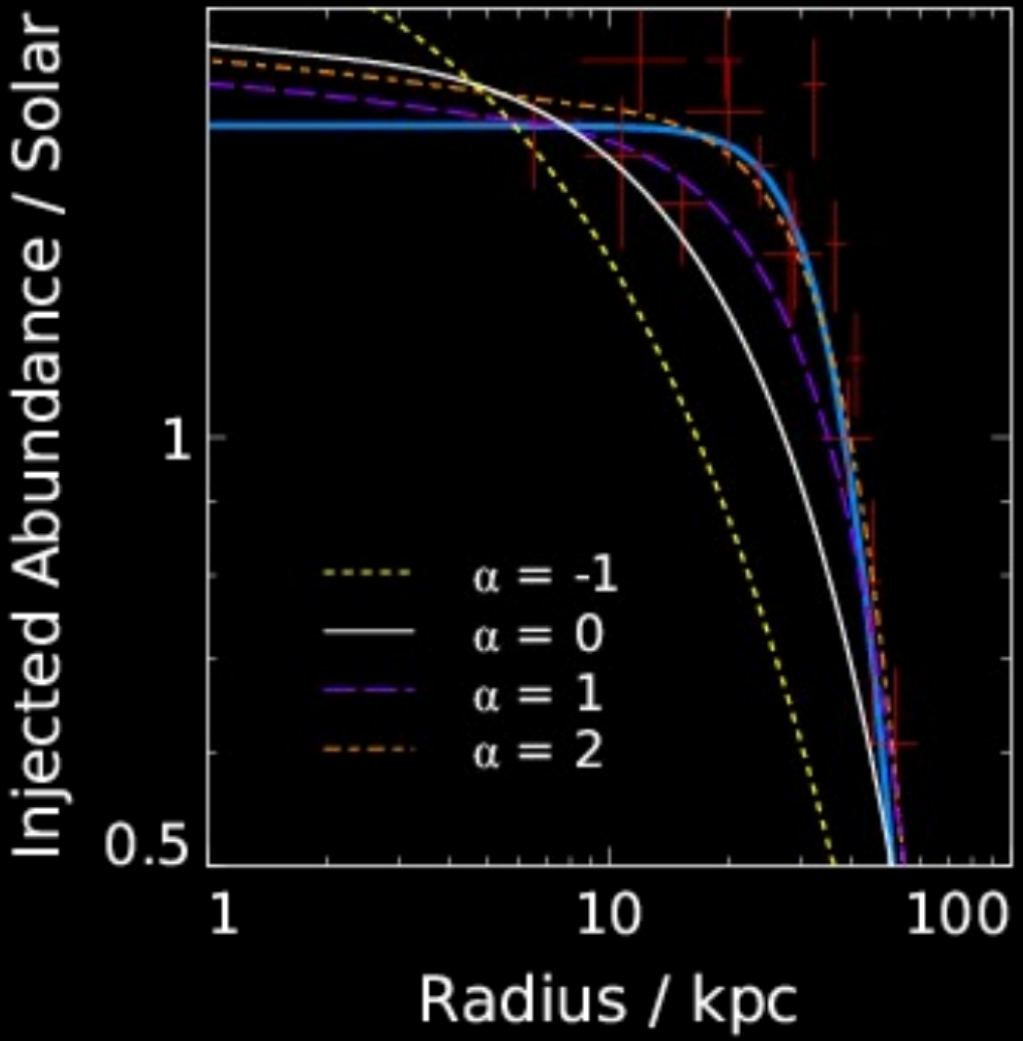
Uniform Diffusion Coefficient



- Best fit is between 4x10^{28} cm^2 s^{-1} and 6x10^{28} cm^2 s^{-1} compared to 2x10^{29} cm^2 s^{-1} for Perseus

$$D \approx 4 \times 10^{28} \left[\frac{n_H(r)}{n_H(r_0)} \right]^2 \mathrm{cm}^2 \mathrm{s}^{-1}$$

Variable Diffusion Coefficient



- Models where the diffusion coefficient decreases with radius are a better fit

$$D \approx 4 \times 10^{28} \left[\frac{n_H(r)}{n_H(r_0)} \right]^2 \mathrm{cm}^2 \mathrm{s}^{-1}$$

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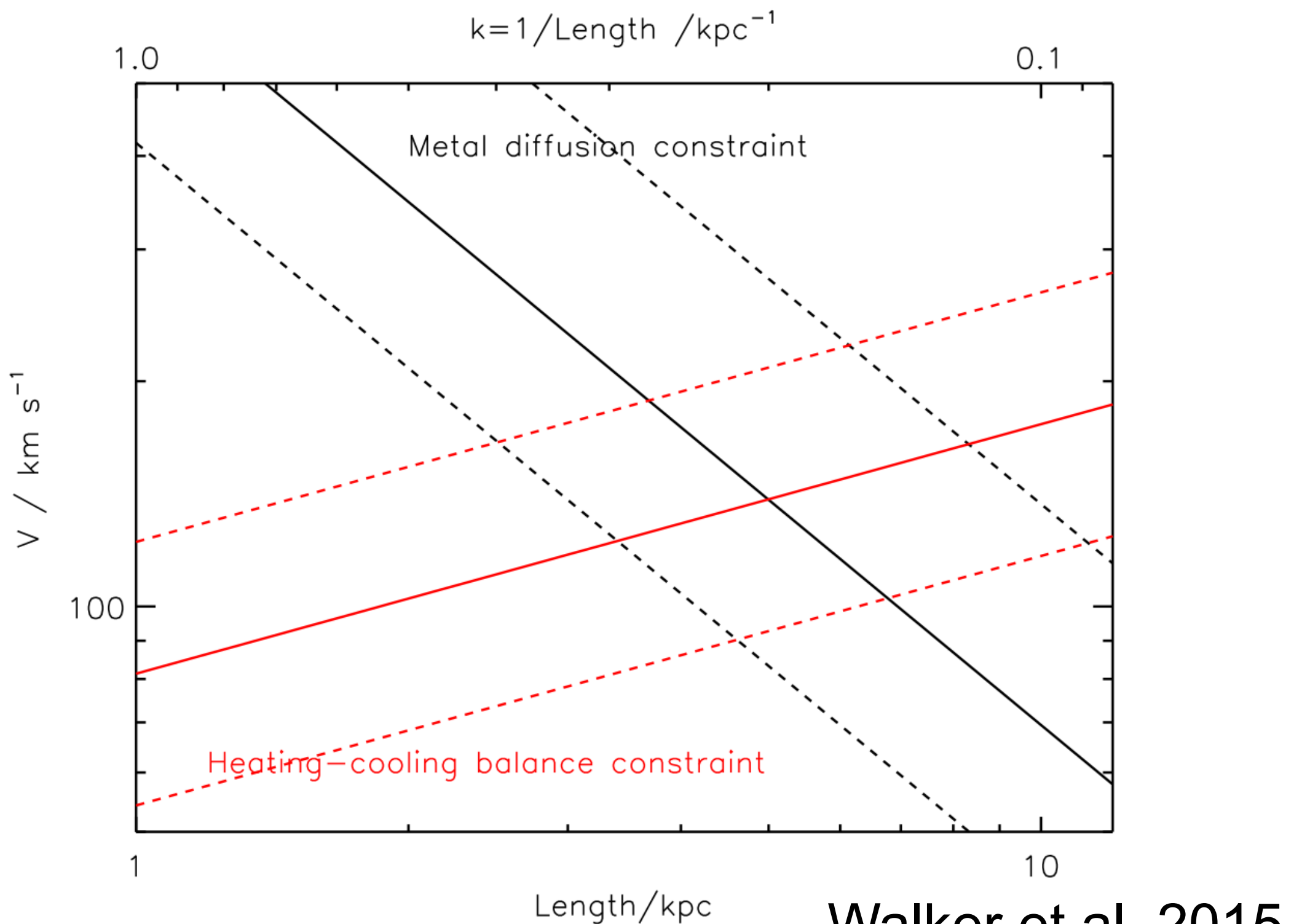
$$D \sim 0.11 v l$$



Walker et al. 2015

$$\Gamma_{diss} \sim 0.4 \rho v^3 / l$$

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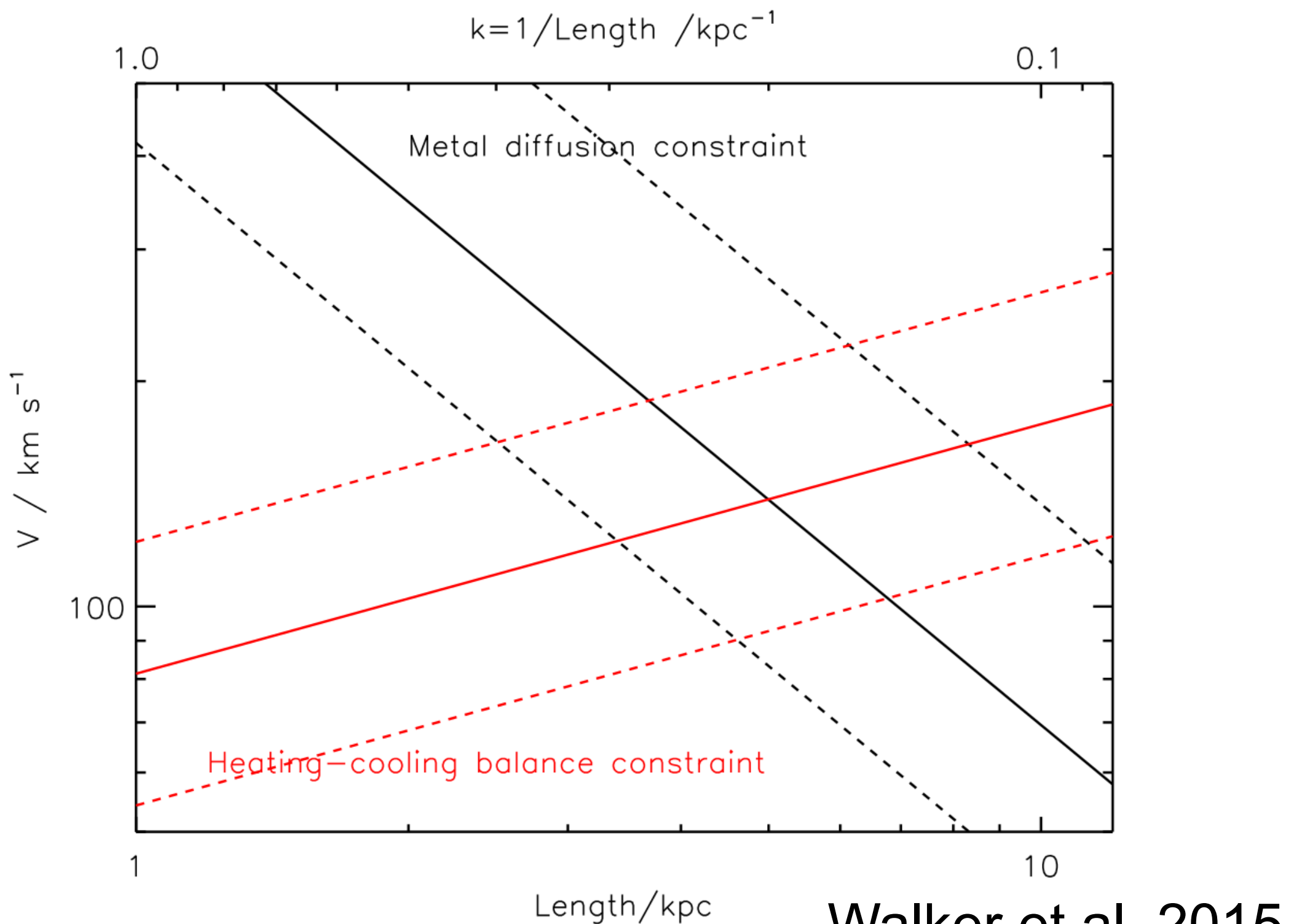
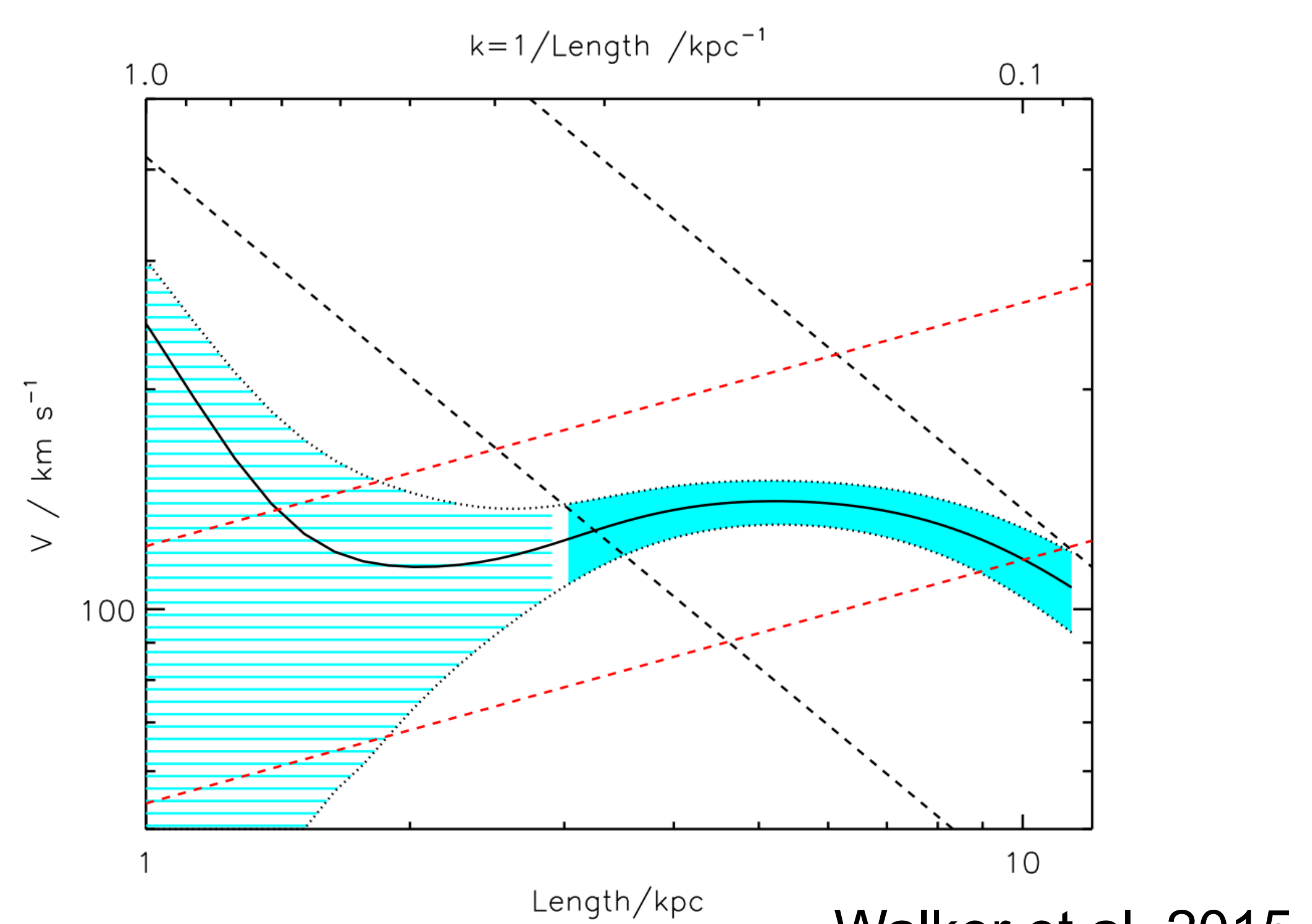
$$n(r)^2 \Lambda(T(r), A(r)) \sim 0.4 \rho v^3 / l$$



Walker et al. 2015



Walker et al. 2015

- Excess surface brightness fluctuations ~ 8% on 2kpc scales
- Gas motions of 100-150km/s
- Turbulent heating rate could balance cooling
- Independent constraints from metal diffusion consistent with surface brightness flucuations

Thank
you