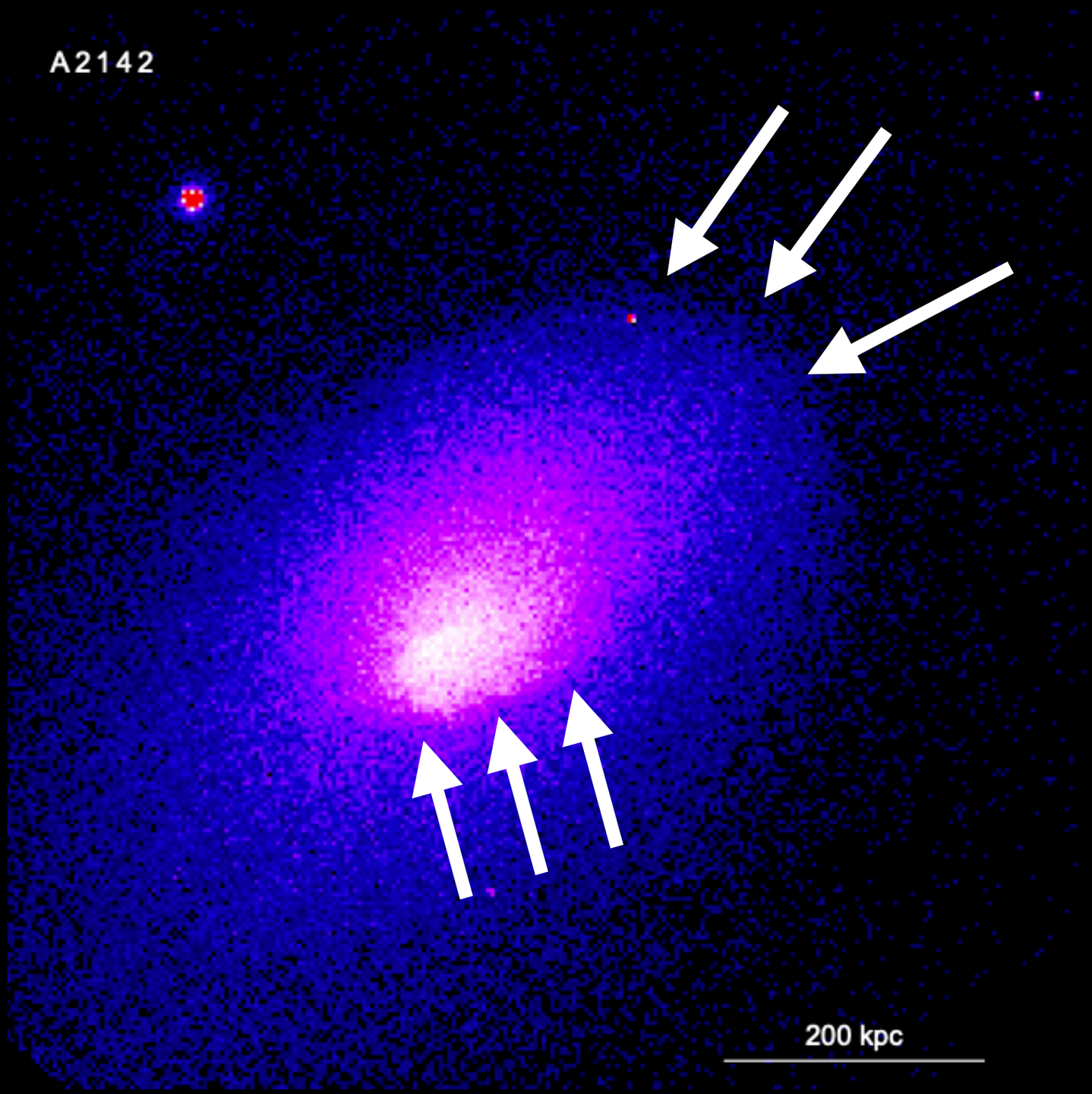
Unravelling the physics of the ICM with cold fronts

Stephen Walker

University of Alabama in Huntsville

J. ZuHone
A. C. Fabian
J. S. Sanders
J. Hlavacek-Larrondo
M. Gendron-Marsolais
H. Intema
J. T. Bamford

Early Chandra observations of galaxy clusters



Found strange edges in X-ray surface brightness

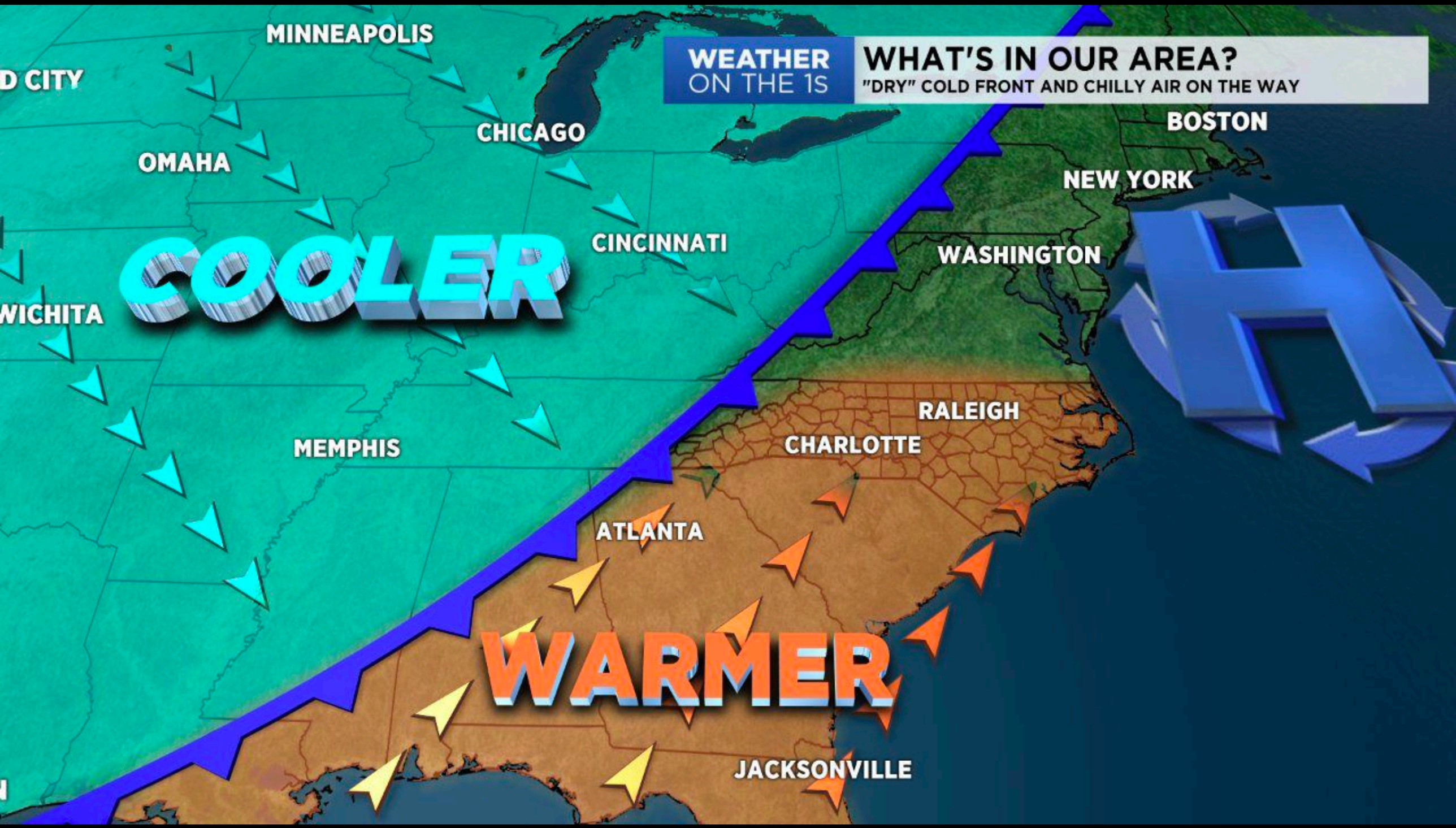
Temperature lower on more dense side - the opposite of a shock!

Incredibly sharp edges - something must support them against instabilities

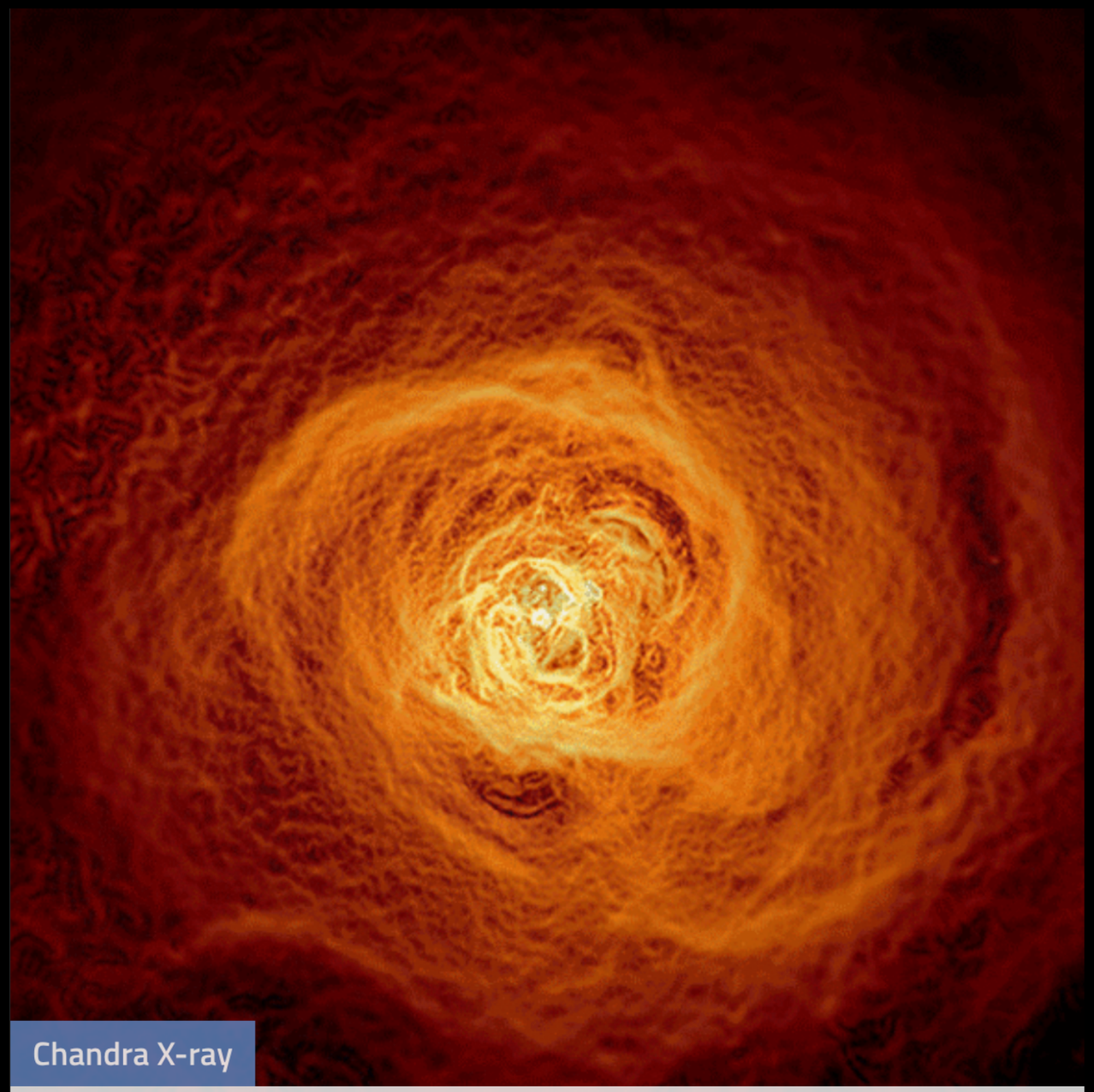
How can they survive?

Markevitch+2000

Named ‘cold front’ after the (very annoying) weather phenomenon



Caused by ‘sloshing’ of the cool core of the cluster in reponse to minor merging.



Chandra X-ray

Scientists Find Giant Wave Rolling Through the Perseus Galaxy Cluster

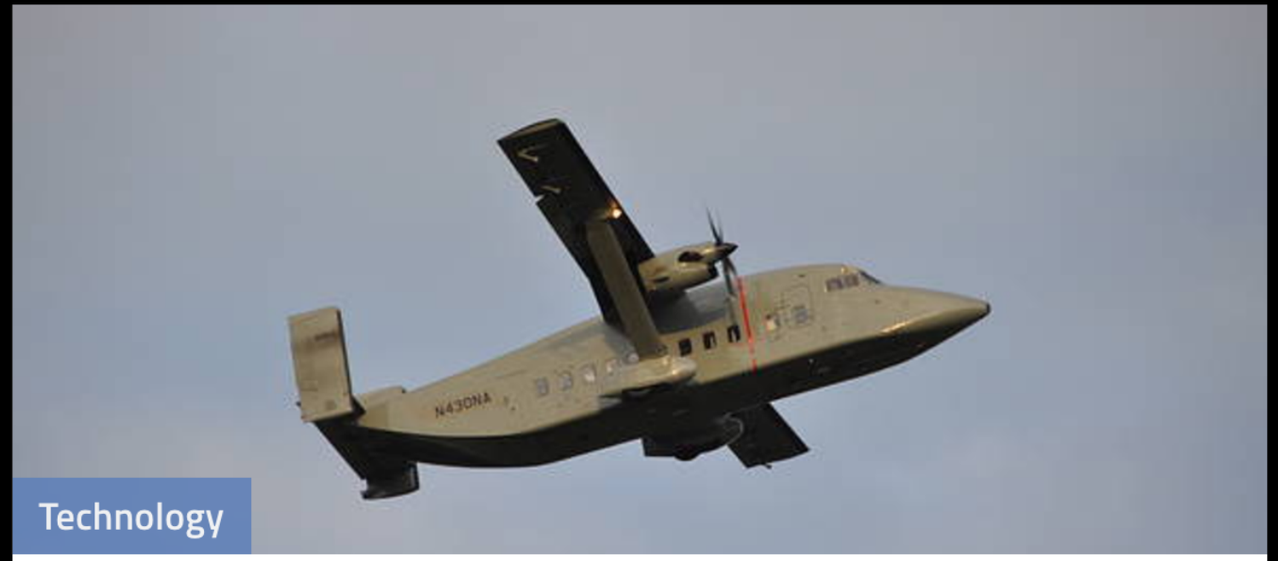
SOFIA

SOFIA Confirms Nearby Planetary System is Similar to Our Own

NASA Events

Friday, May 12: Expedition 51 Spacewalk

Calendar | Launches and Landings



Technology

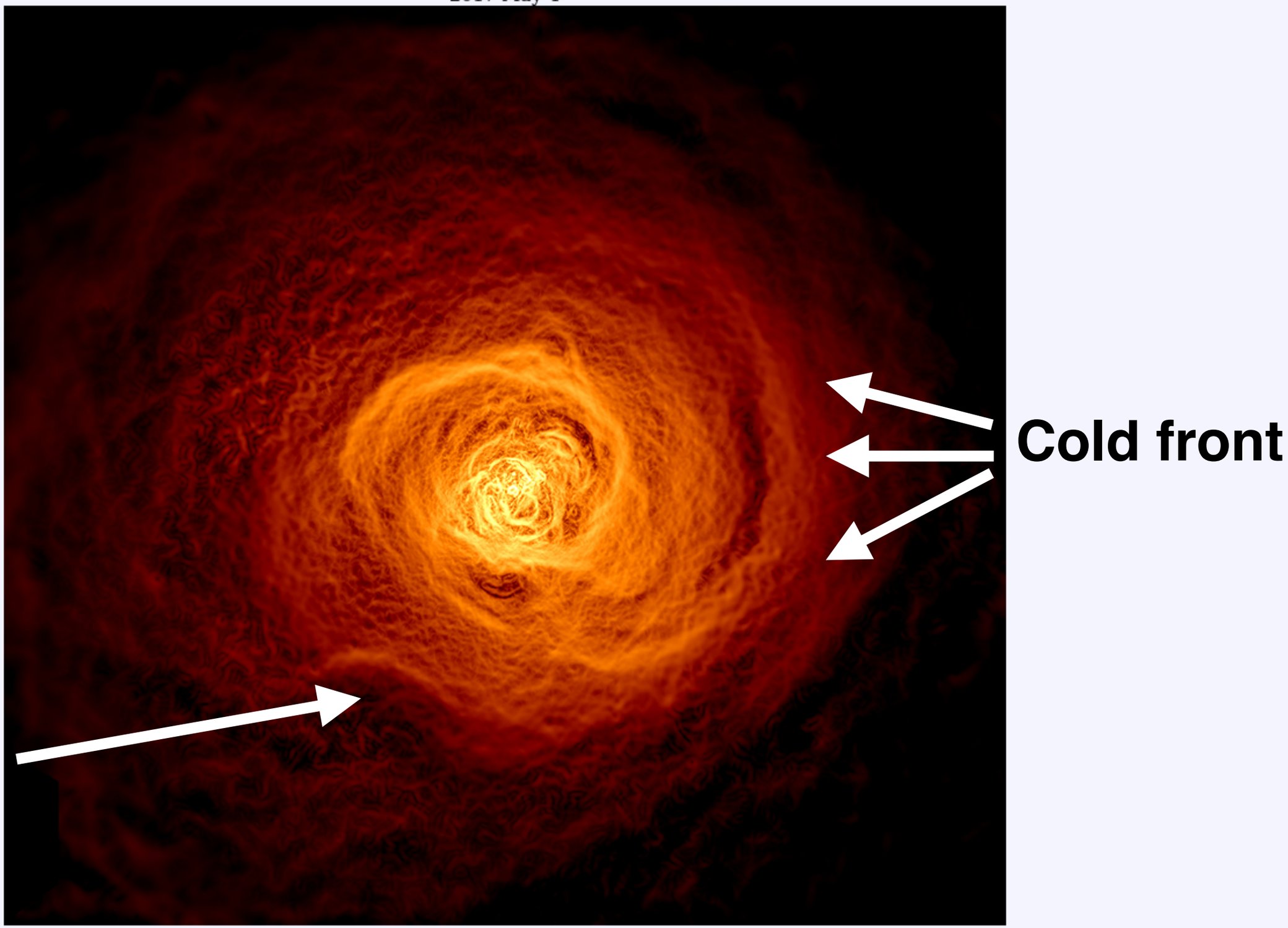
NASA to Measure Greenhouse Gases Over the Mid-Atlantic Region in May

Walker et al. 2017, MNRAS 468, 2506, arXiv:1705.00011

Astronomy Picture of the Day

scover the cosmos! Each day a different image or photograph of our fascinating universe is featured, along with a brief explanation written by a professional astronomer.

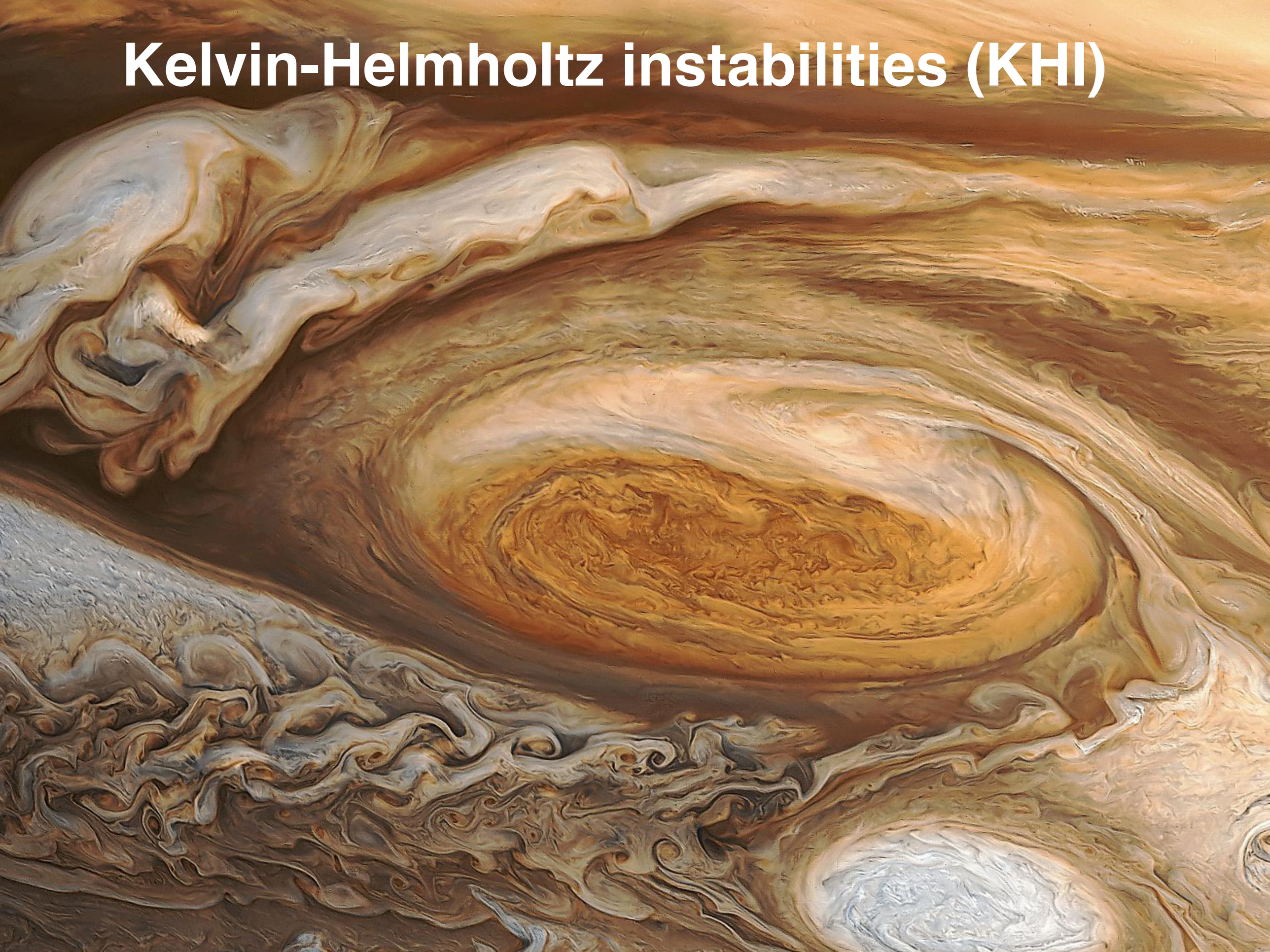
2017 May 4



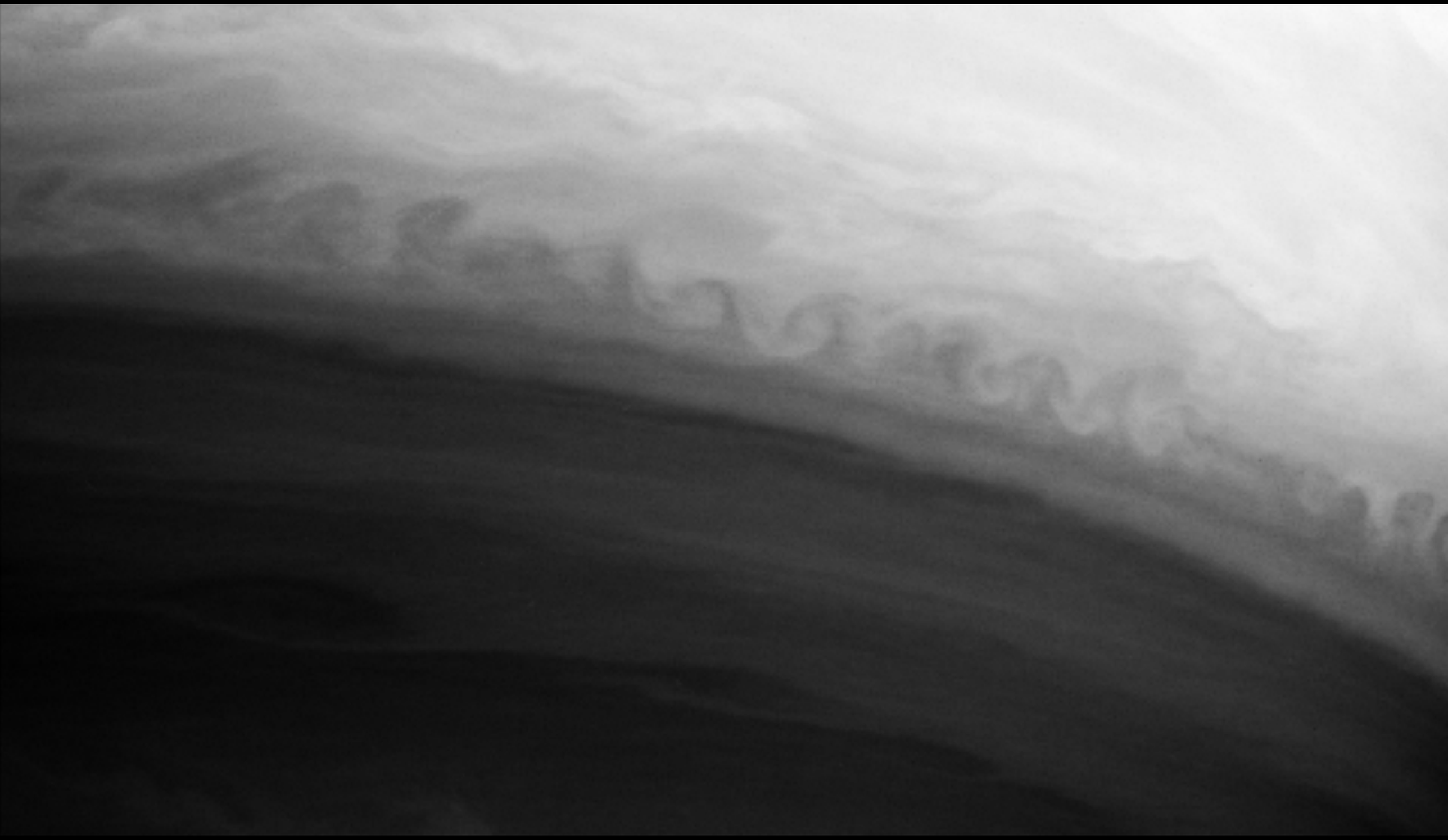
The Perseus Cluster Waves
Image Credit: NASA, CXC, GSFC, Stephen Walker, et al.

Kelvin-Helmholtz instabilities (KHI)

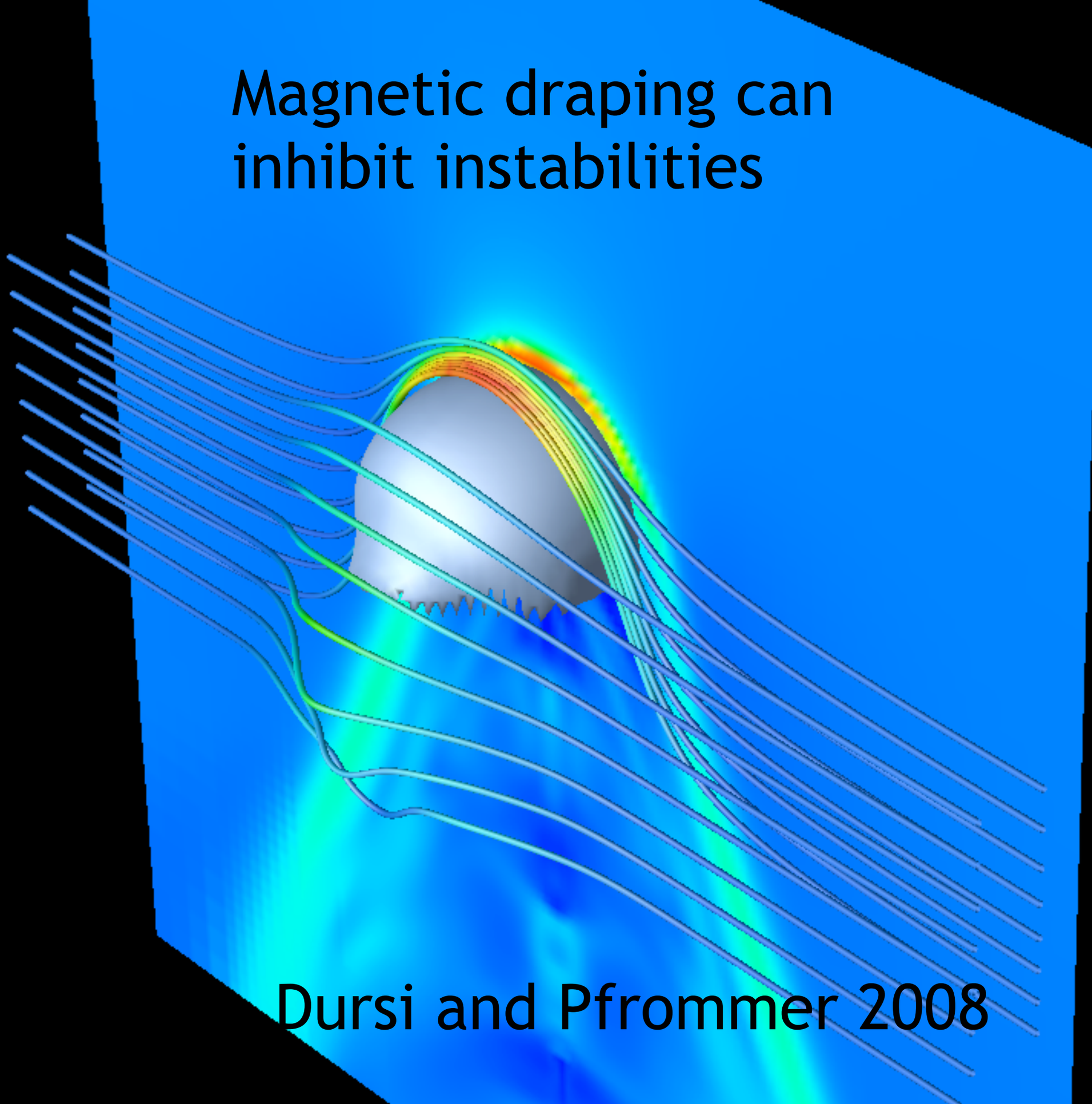
Kelvin-Helmholtz instabilities (KHI)



Kelvin-Helmholtz instabilities (KHI)

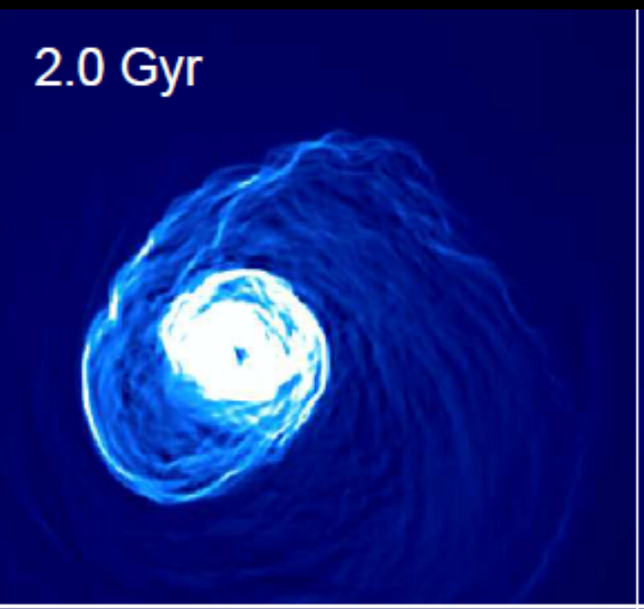


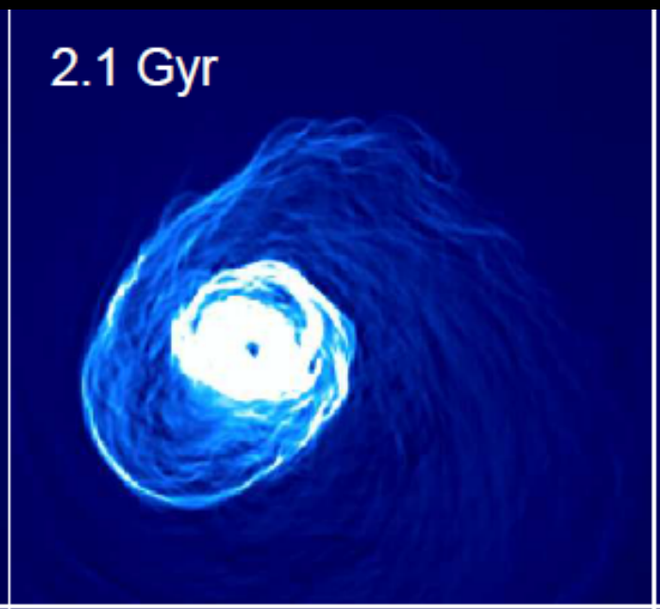
Magnetic draping can inhibit instabilities

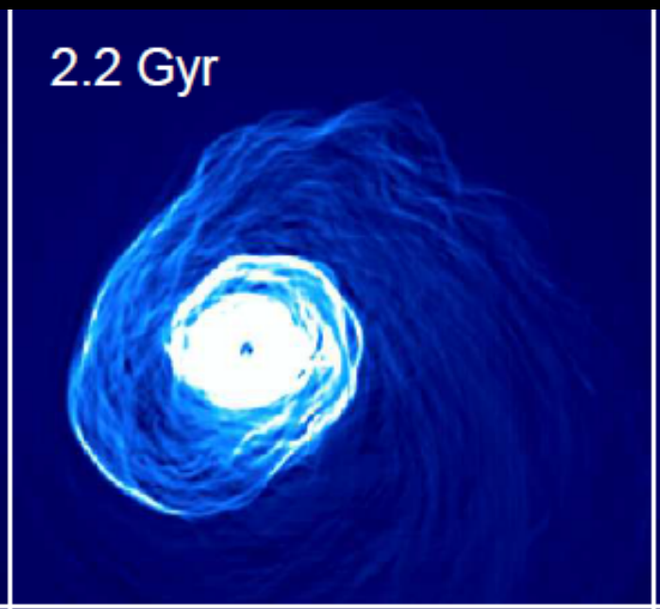


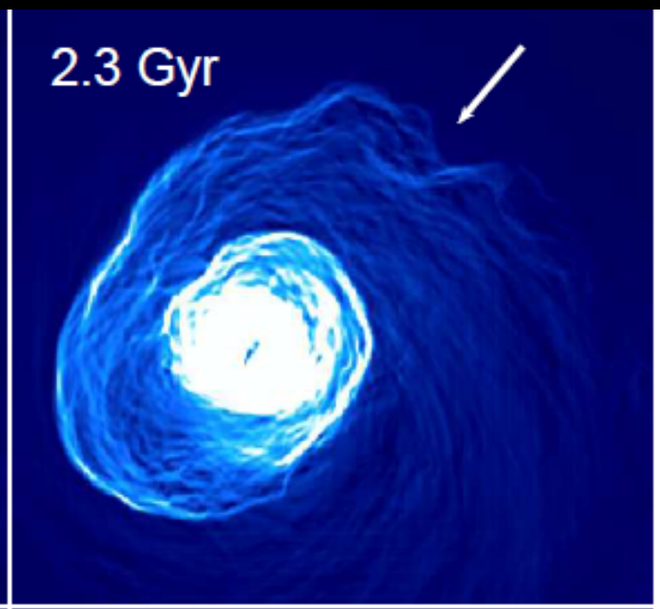
Dursi and Pfrommer 2008

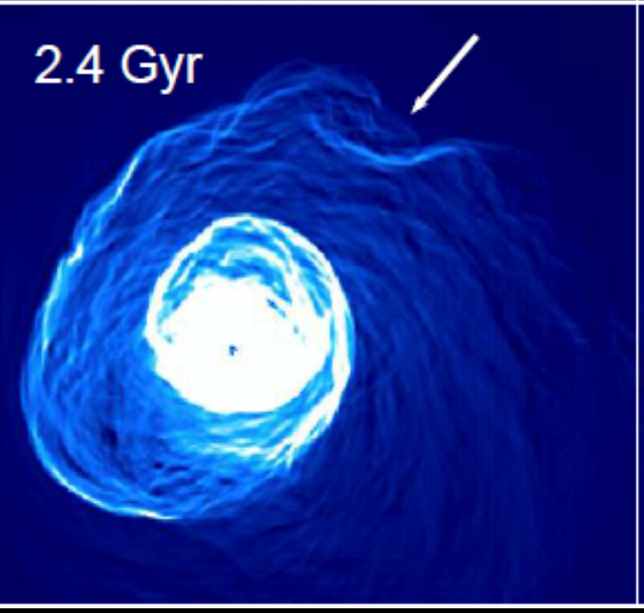
Comparing to simulations

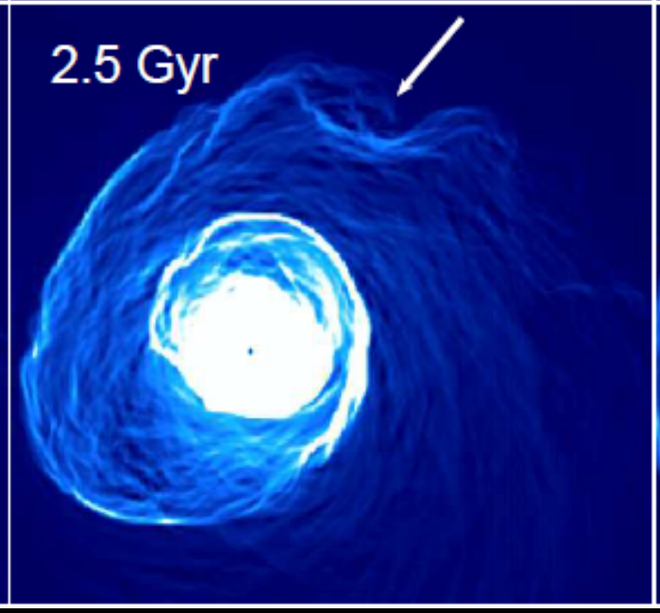


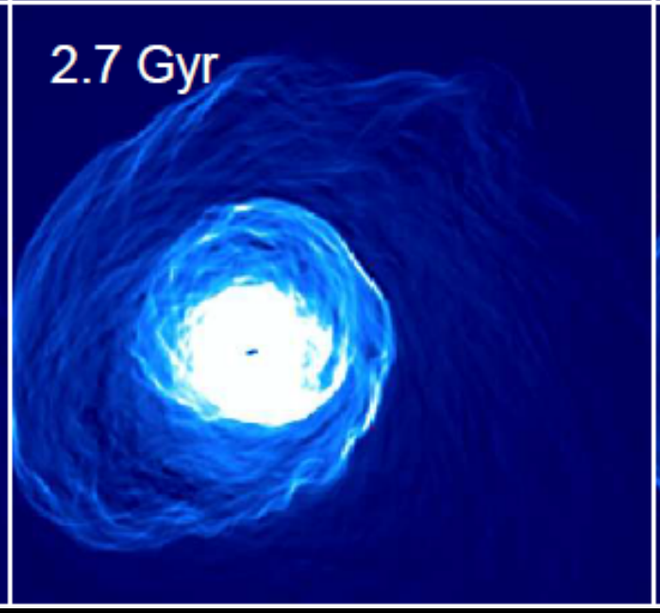


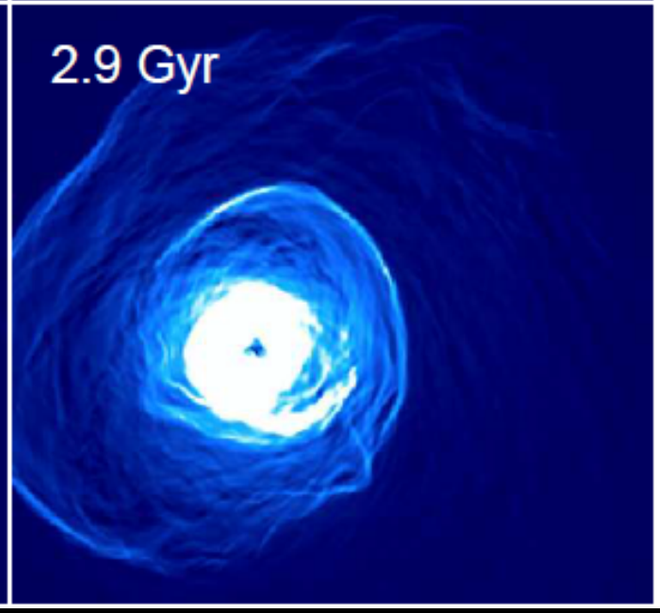












Walker+17

Perseus, Chandra

150kpc

50kpc

Bay

Oute

Sloshing simulation reproduces mysterious ‘bay’ very well as a KHI

X-ray emissivity, simulation, beta=200

145kpc

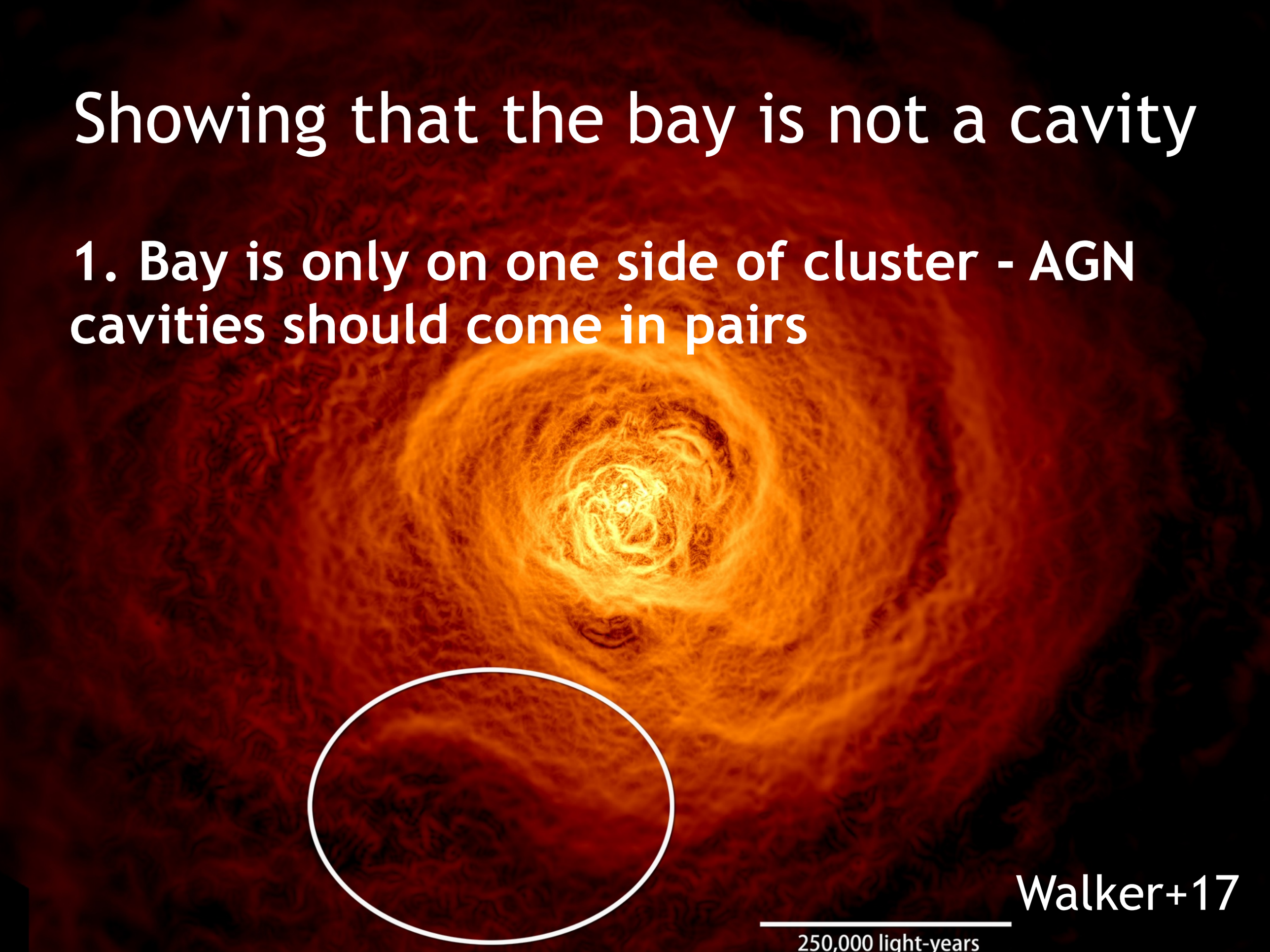
50 kpc

Outer cold front

Walker+17

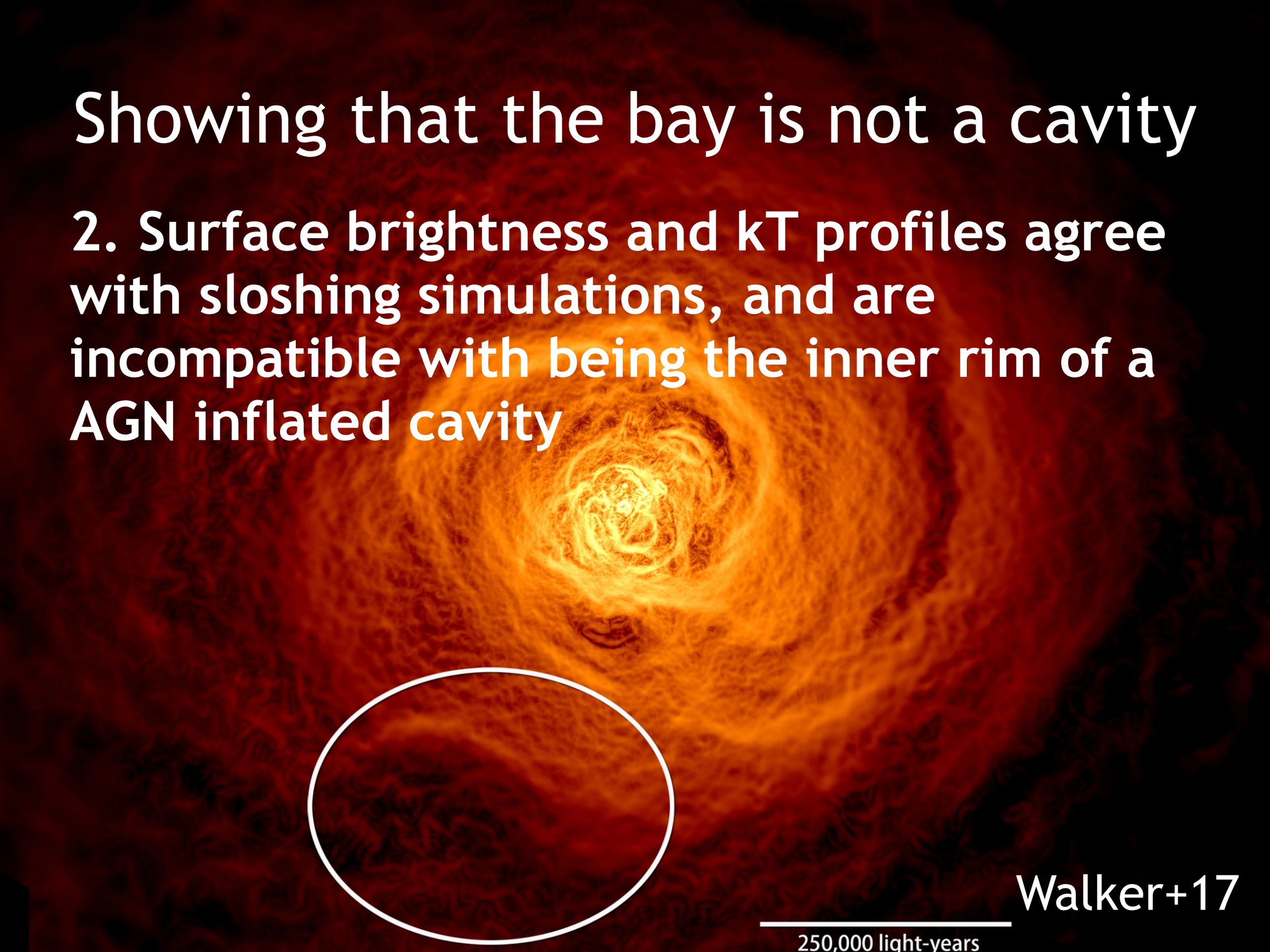
Showing that the bay is not a cavity

1. Bay is only on one side of cluster - AGN cavities should come in pairs



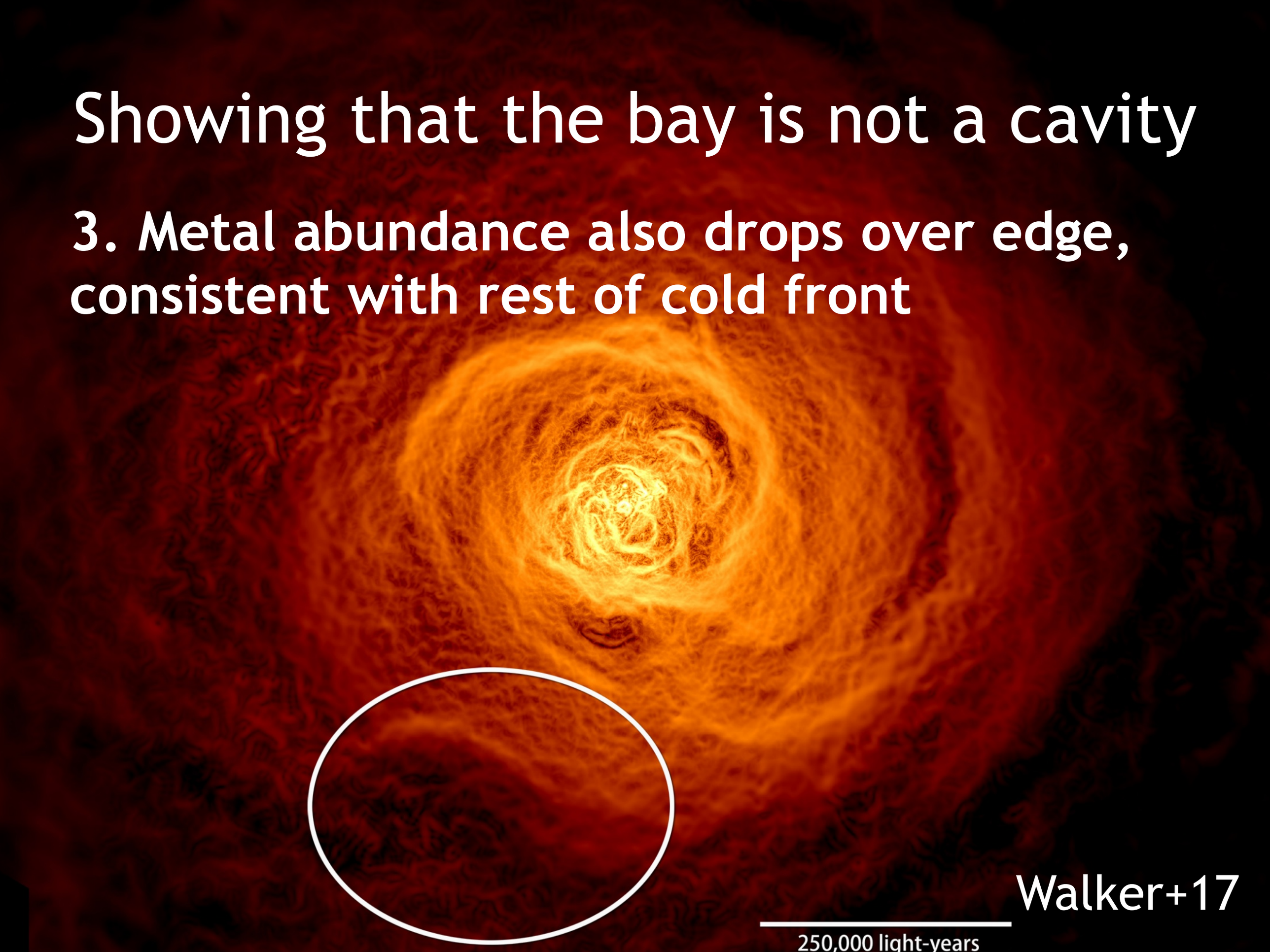
Showing that the bay is not a cavity

2. Surface brightness and kT profiles agree with sloshing simulations, and are incompatible with being the inner rim of a AGN inflated cavity

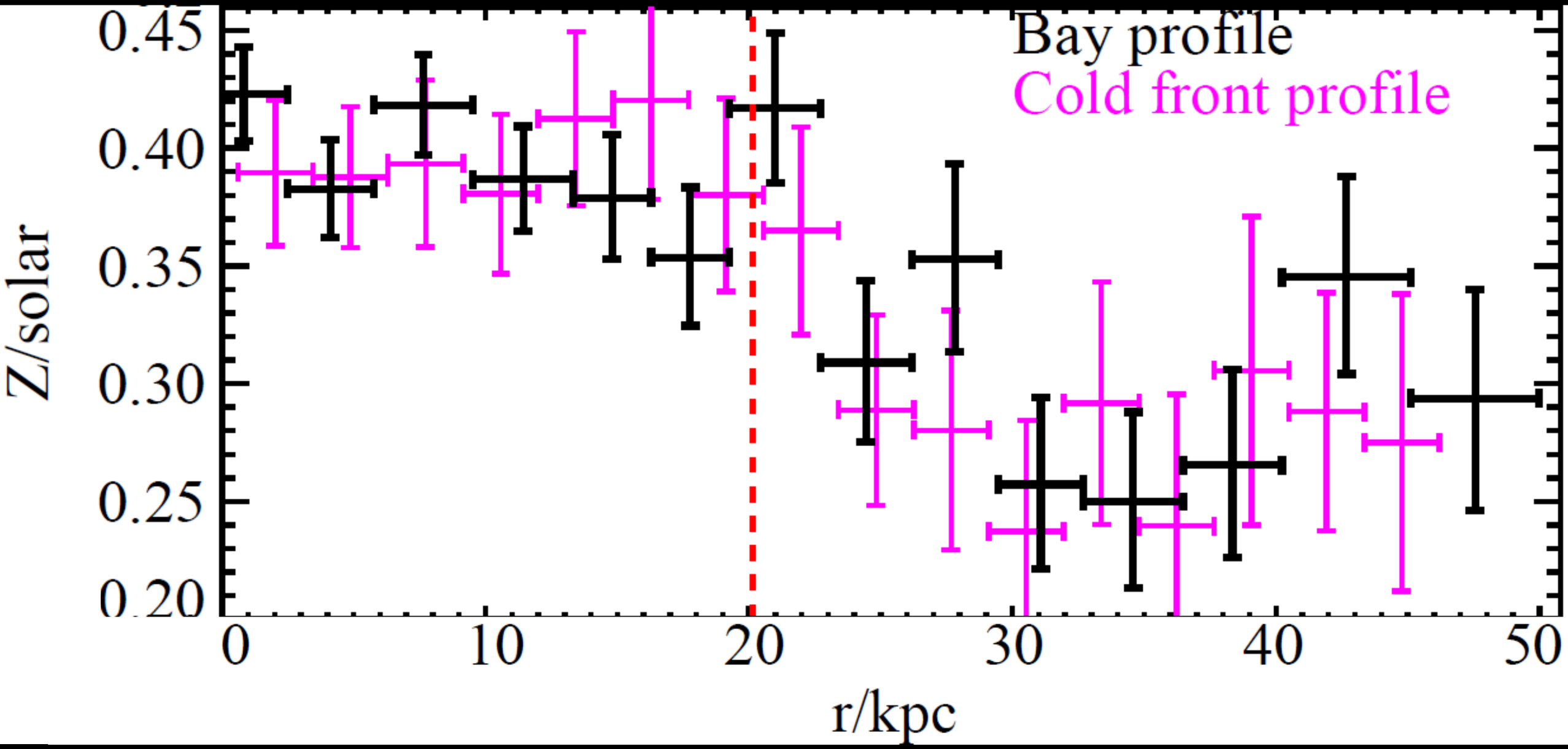


Showing that the bay is not a cavity

3. Metal abundance also drops over edge, consistent with rest of cold front



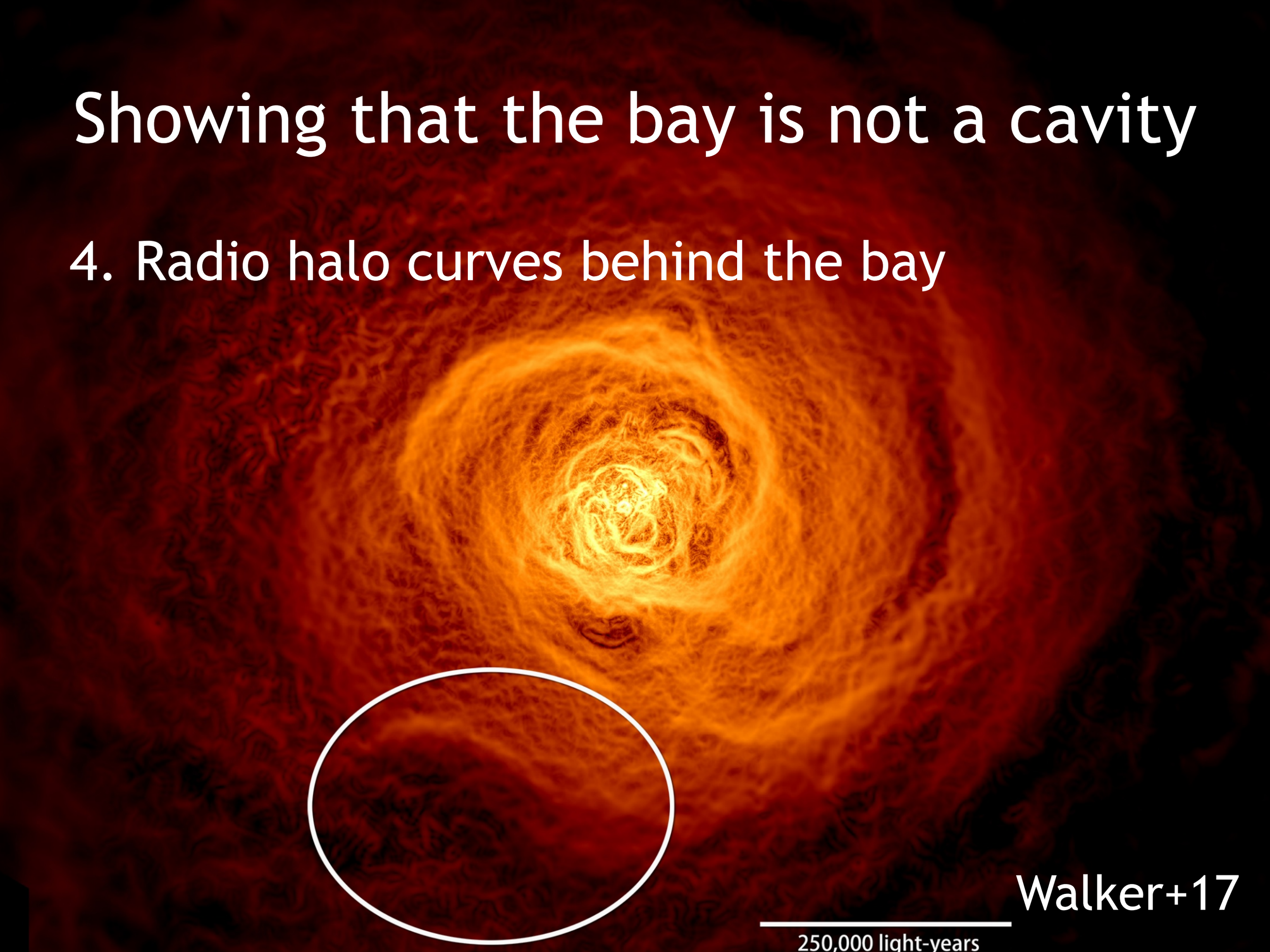
Metallicity profiles



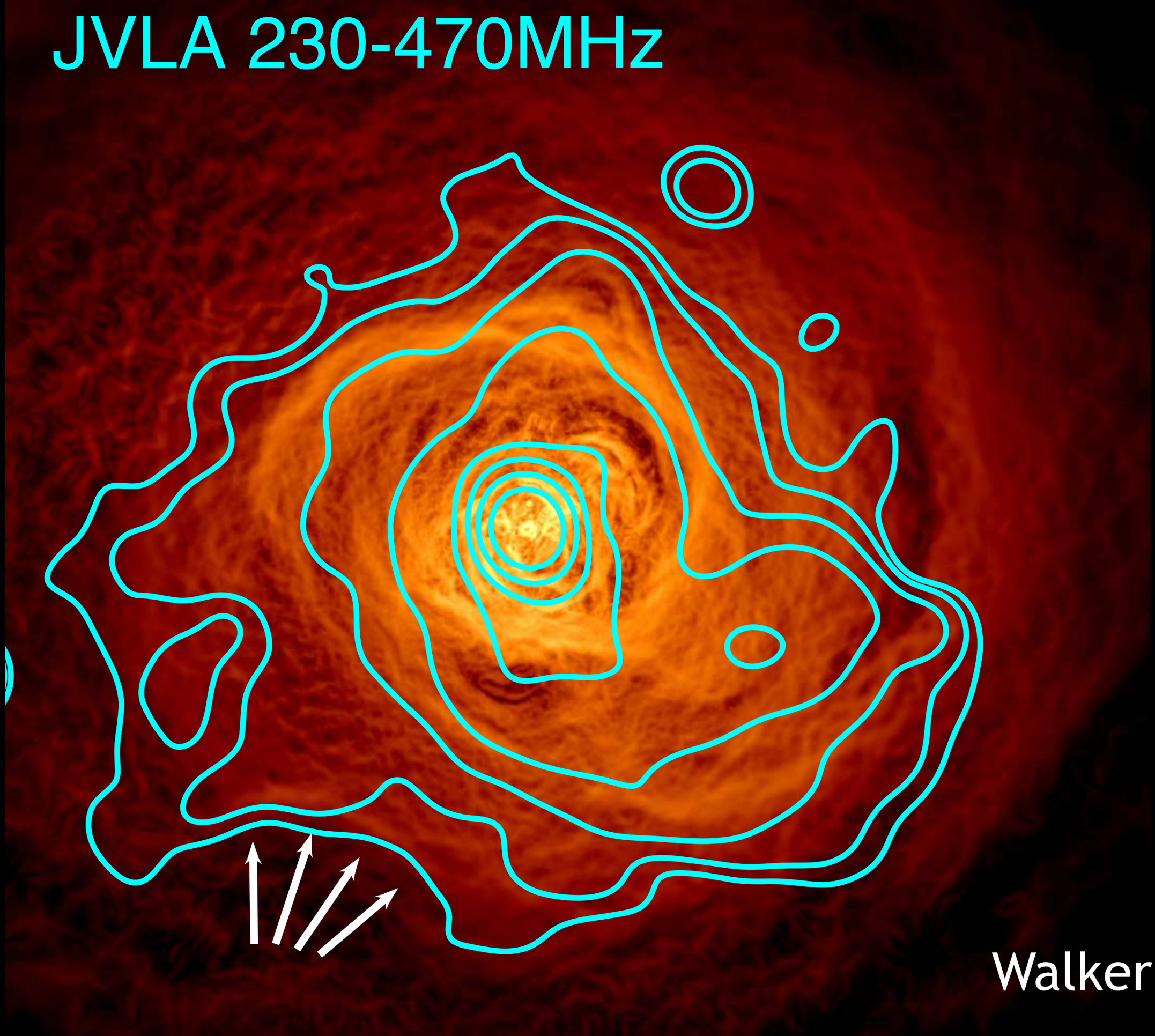
Walker+17

Showing that the bay is not a cavity

4. Radio halo curves behind the bay

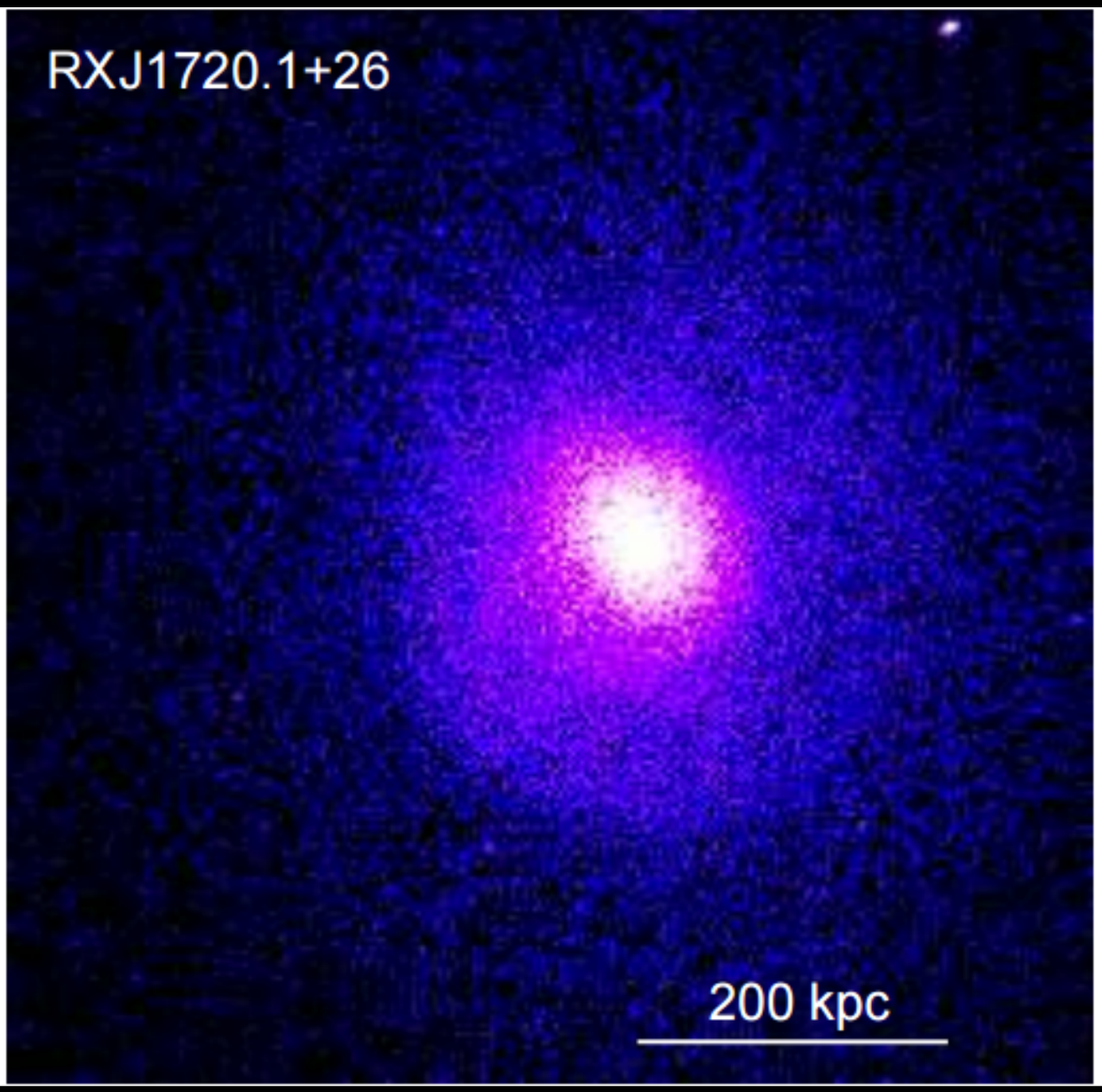


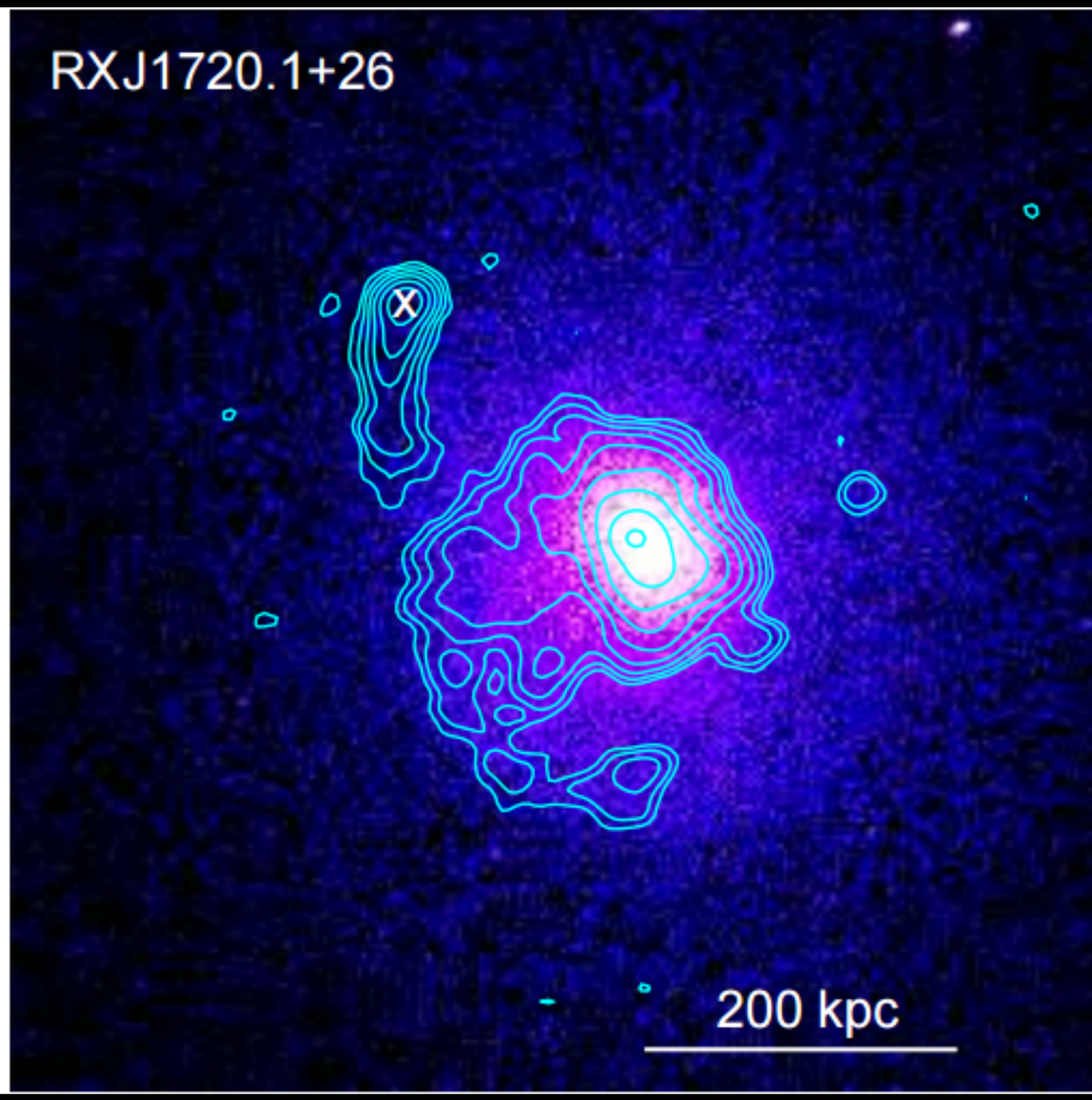
JVLA 230-470MHz



Walker+17

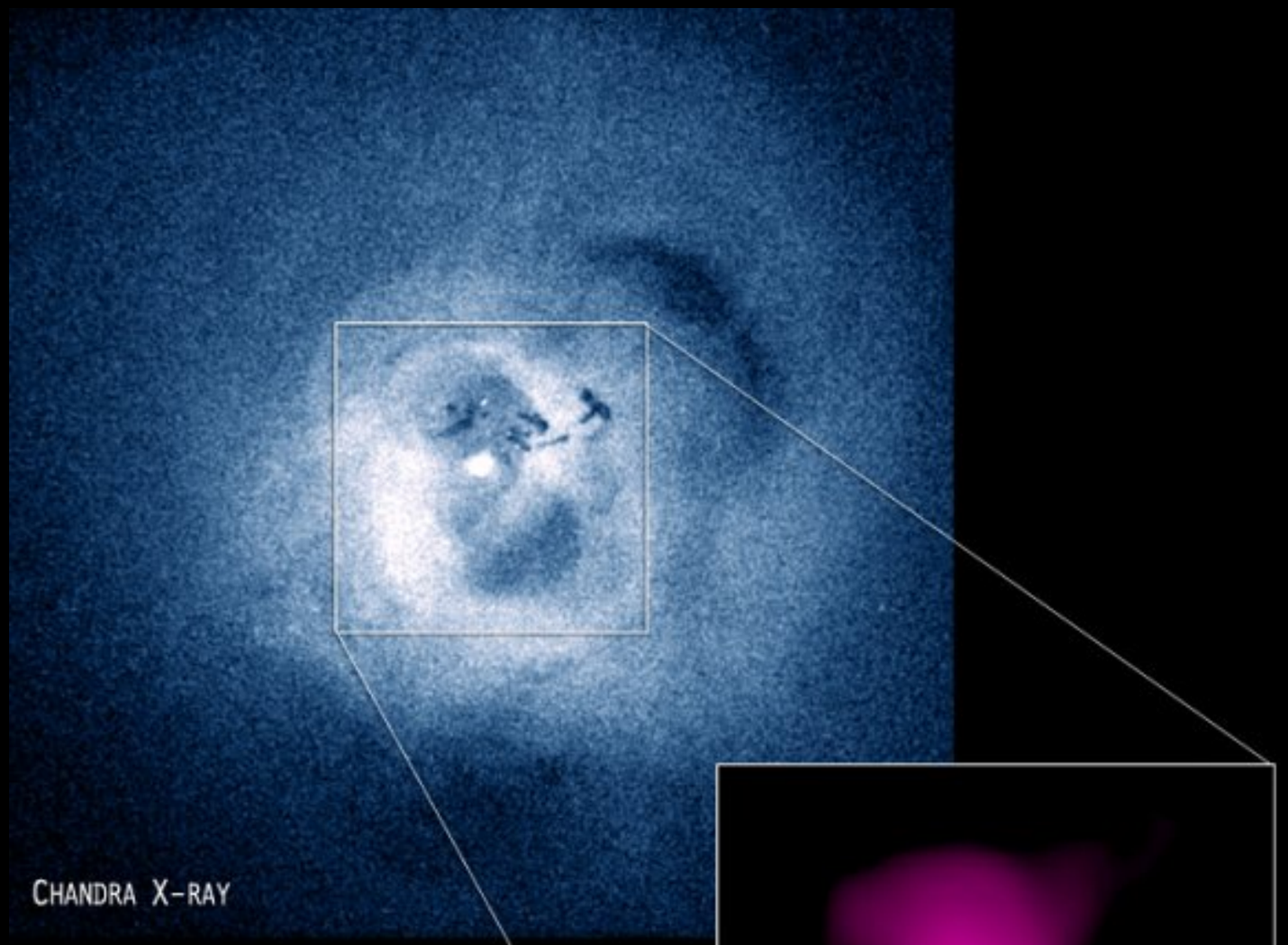
Just like in cold fronts, which constrain radio haloes behind them



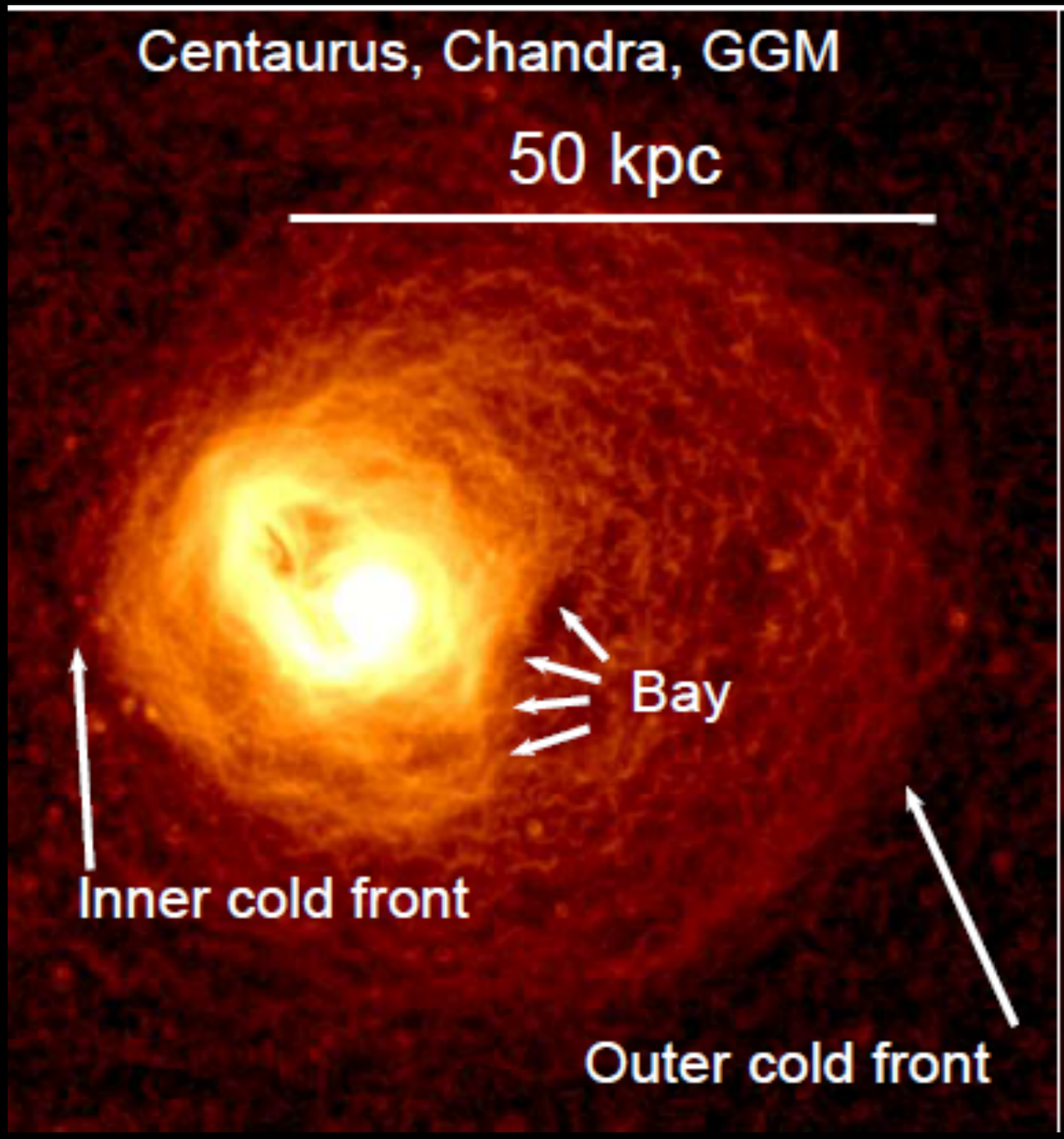


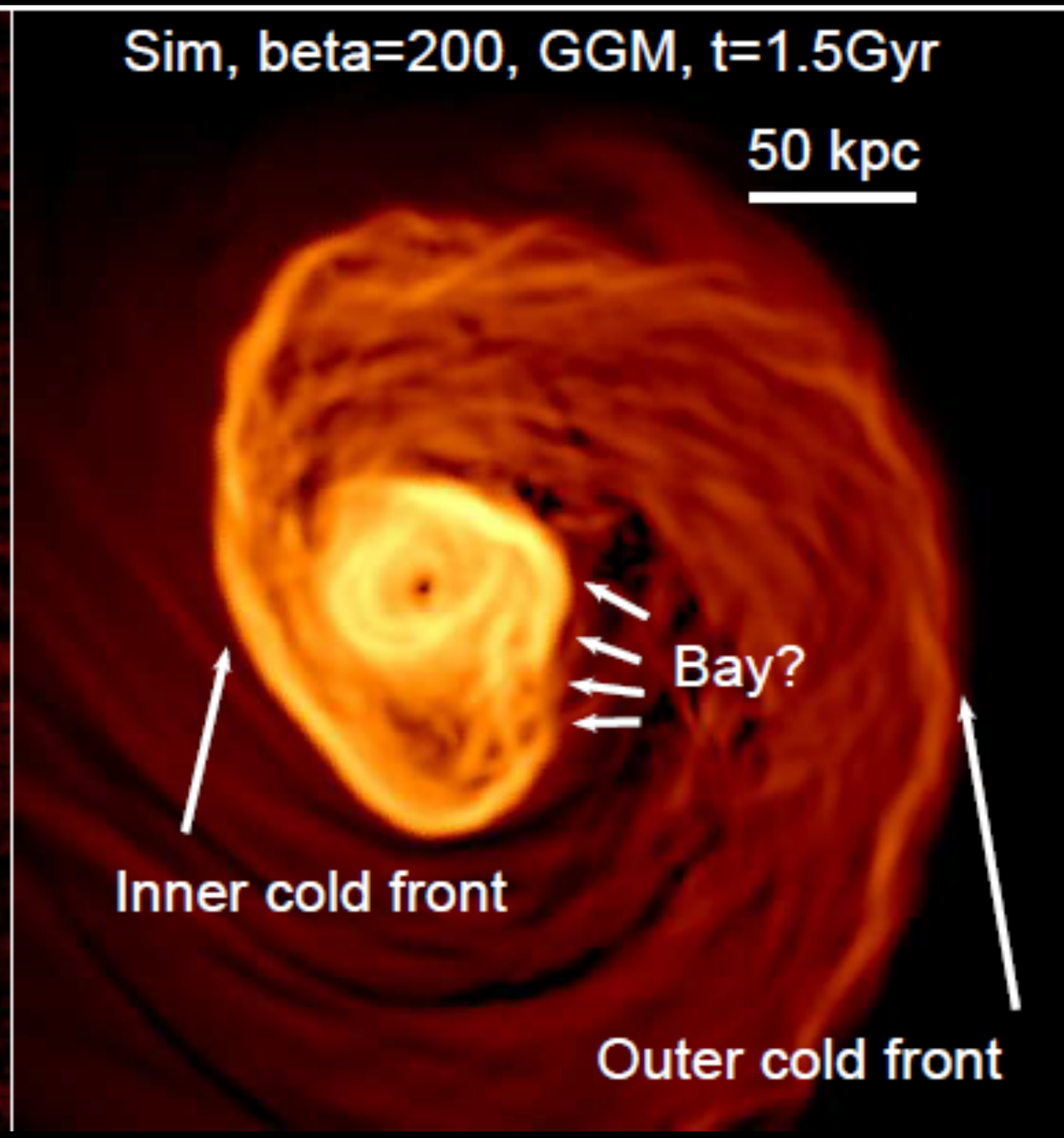
ZuHone et al. 2013

Whereas AGN cavities are *filled* by radio emission



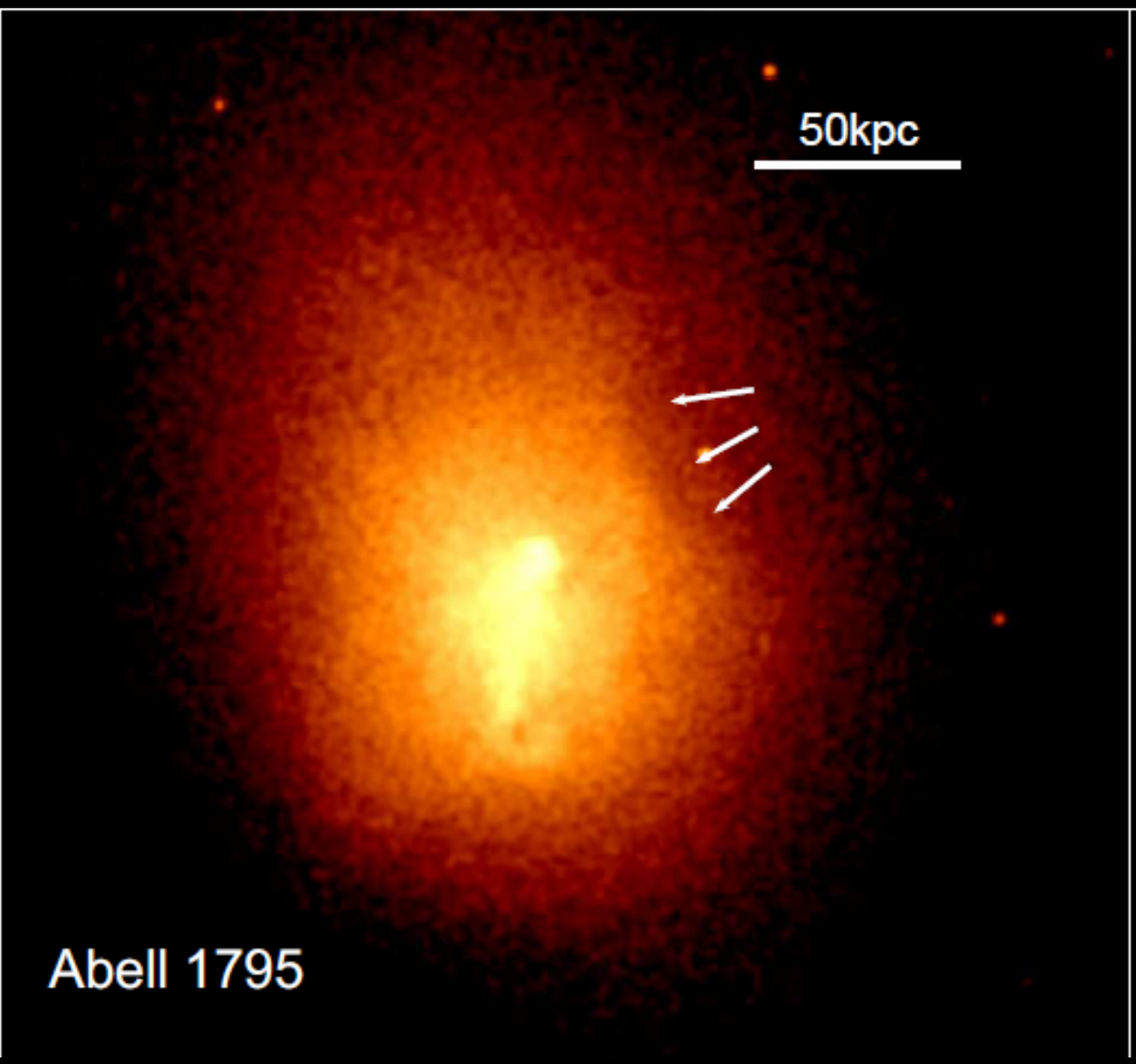
Similar ‘bay’ in Centaurus

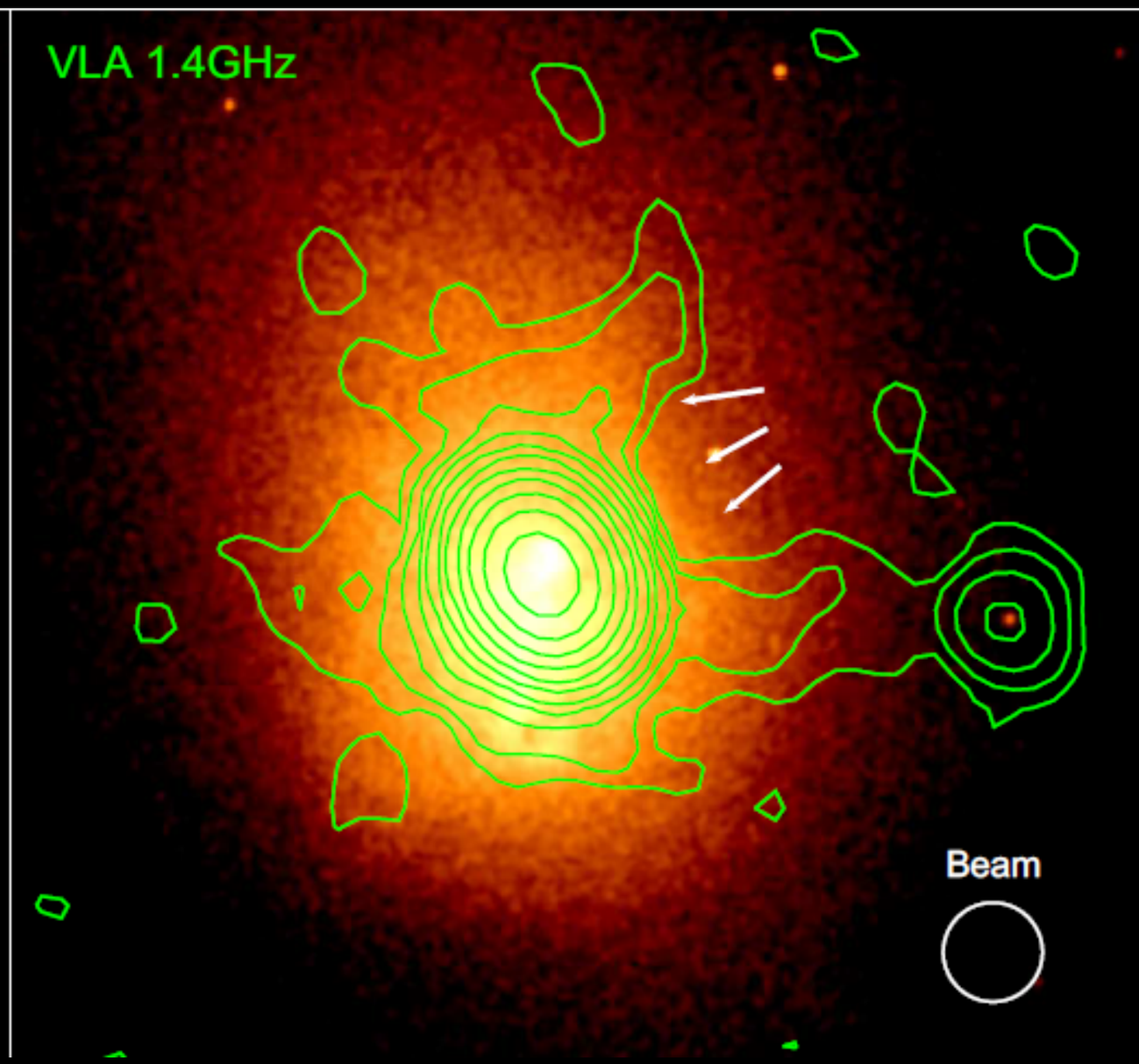




Walker+17

And in Abell 1795 (harder to see)





Walker+17

And finally….

We now know that cold fronts can grow to enormous sizes over billions of years!

One in Perseus reaches out to 700 kpc (nearly half the viral radius)

MENU

nature astronomy

Letter

The split in the ancient cold front in the Perseus cluster

Stephen A. Walker ✉, John ZuHone, Andy Fabian & Jeremy Sanders

Nature Astronomy (2018)

doi:10.1038/s41550-018-0401-8

Download Citation

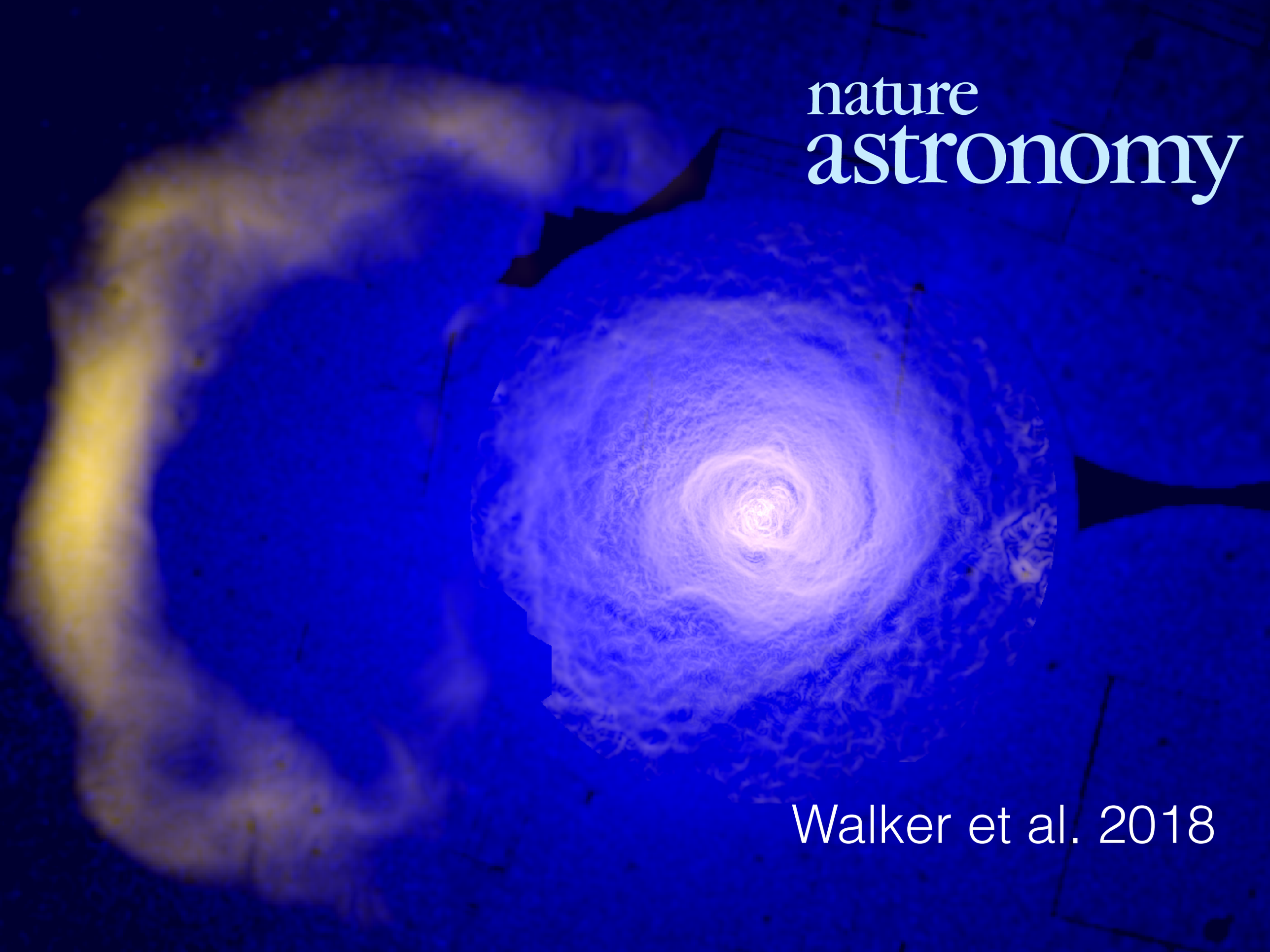
Galaxies and clusters

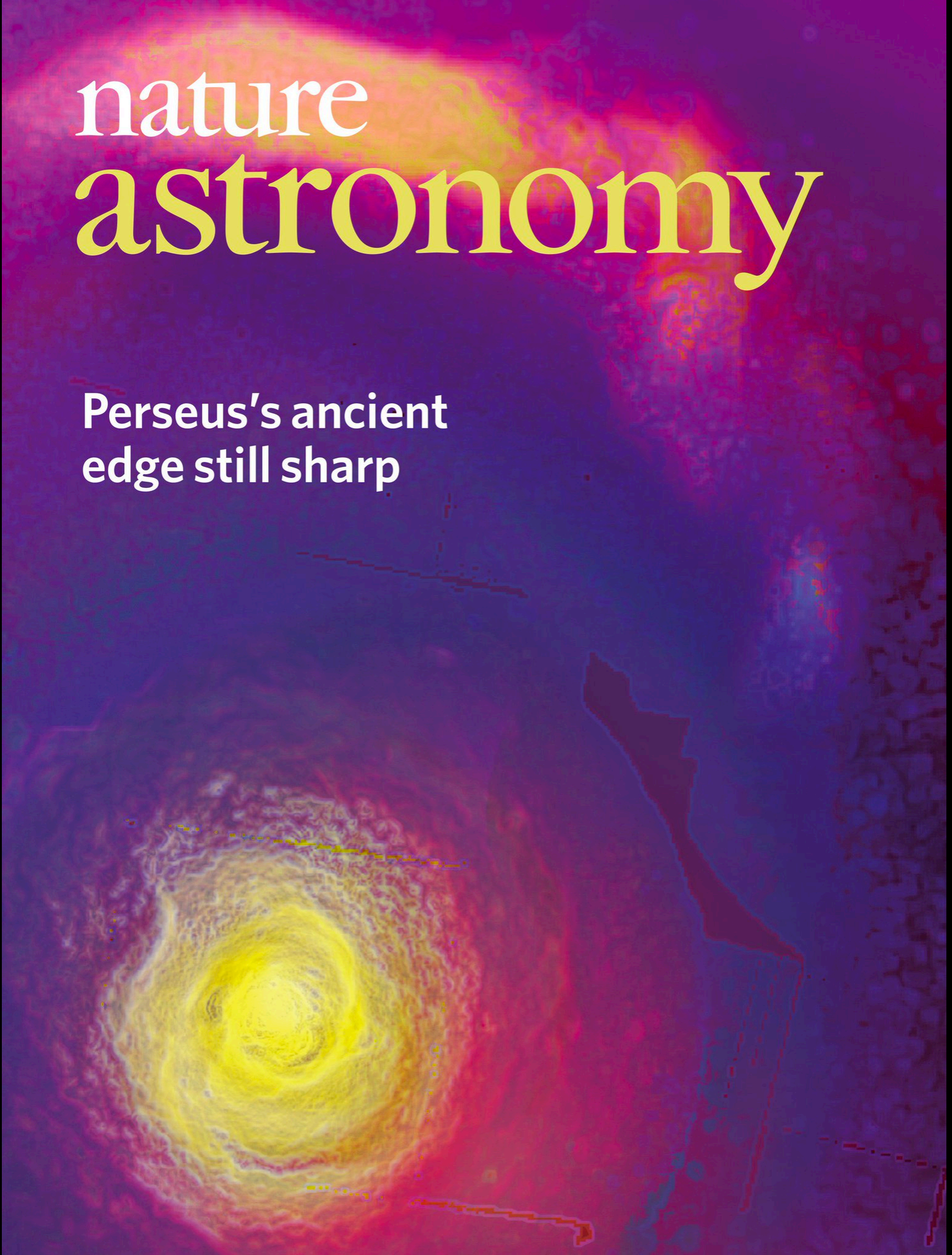
High-energy astrophysics

Received: 12 October 2017

Accepted: 26 January 2018

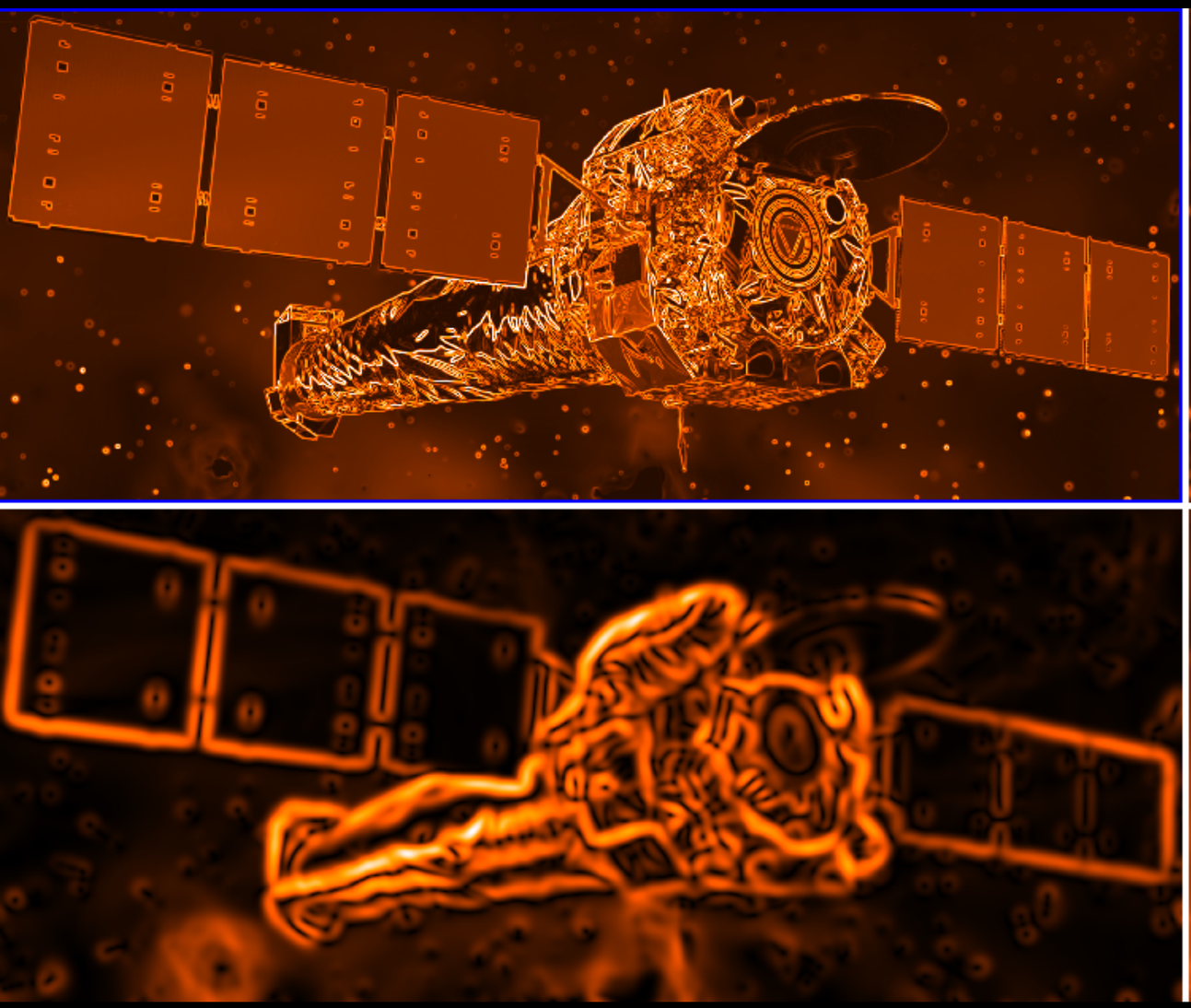
Published online: 26 February 2018

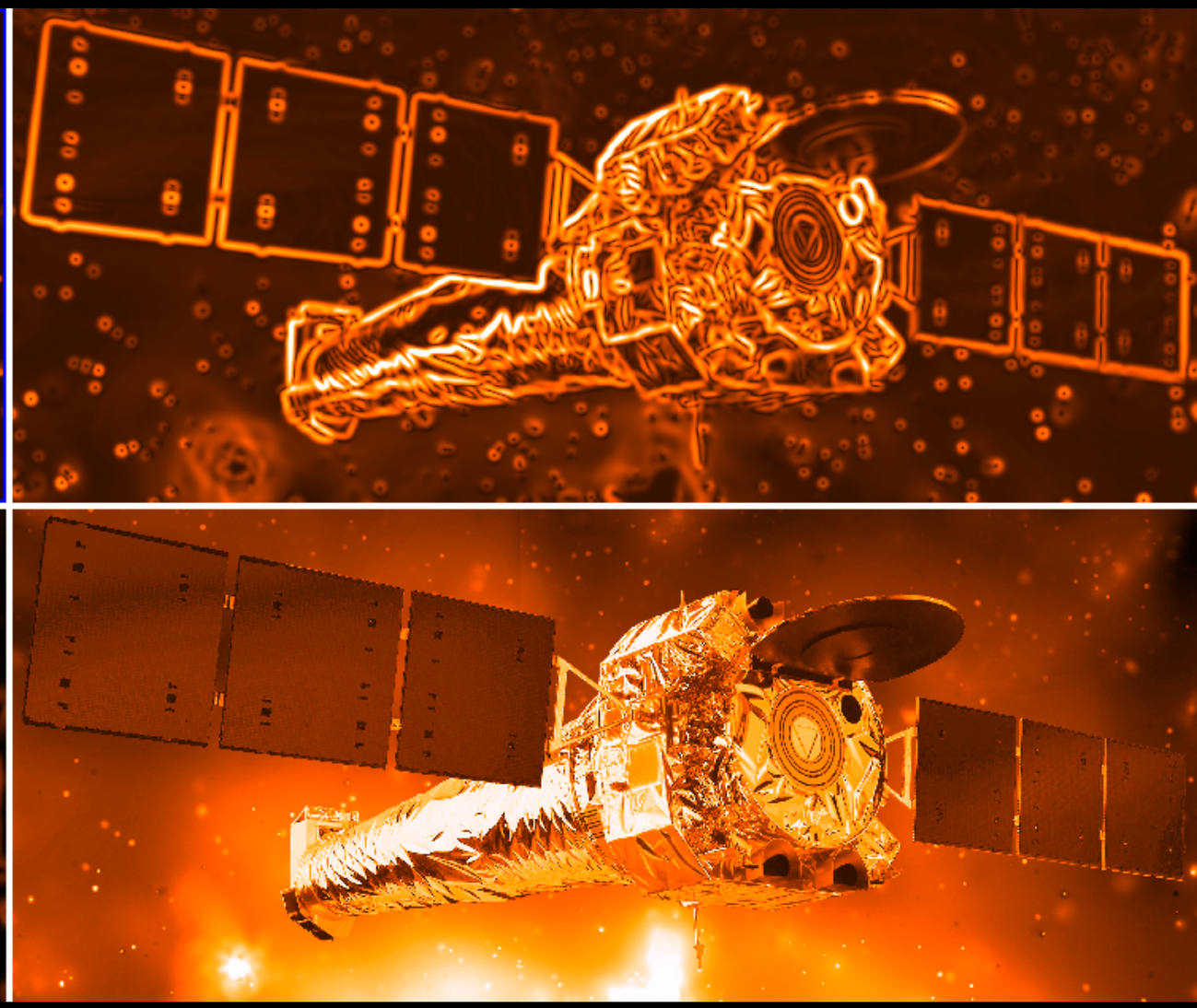

nature
astronomy
Walker et al. 2018



Walker et al. 2018

Thank you Chandra!!!





Any questions, please email
stephen.walker@uah.edu