

Welcome!

PROMOTING
INTERACTIONS
AROUND INTERACTING

**GALAXY
CLUSTERS**



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA



A few (new) local tips

A few (new) local tips:

“Beyond the wave”



Exhibition of paintings by Hokusai Hiroshige
Archeological Museum (centre)
12Oct-3March
closes at 19.30

<http://www.oltrelanda.it>



A few (new) local tips:

“FICO”



“Largest food park in the world”

reachable in 20 min by bus
from Bologna city center (~5E)

<https://www.eatalyworld.it/en/>



A few (new) local tips:

“The time machine”



3D virtual tour on medieval Bologna
~25 minutes , ~20Euro, open 10-19
via Zamboni 7 (~5 minutes from here)



<http://www.lamacchinadeltempo.eu/home>

Program/format



Wednesday

10 OCTOBER

chair: H. Akamatsu

- 9:30 F. VAZZA welcome and intro
- 10:00 S. ETTORI: "X-ray Galaxy Clusters: open problems on the mass distribution"
- 10:30 P. MAZZOTTA "Cosmic SZ background and the quest for faint features in Planck observations"
- 11:00 break
- 11:30 S. PLANELLES "Multi-wavelength mock observations of simulated galaxy clusters"
- 12:00 R. VAN WEEREN "A search for the radio cosmic web: cross-correlating LOFAR images with LSS tracers"

lunch

chair: S. Planelles

- 14:00 K. DOLAG "Something from Simulations" [sic]
- 14:30 K. RAJPUROHIT "Large scale structure at cluster outskirts: polarization aspects"
- 15:00 A. DE GRAAF "A search for warm-hot baryons in the cosmic web through the SZ effect"
- 15:30 break
- 16:00 V. GHIRARDINI "The joint effort of Planck and XMM in the X-COP cluster sample"
- 16:30 F. DE GASPERIN "Observing pre-mergers at ultra-low radio frequencies"
- 17:00 H. AKAMATSU "X-ray properties of large-scale filaments between clusters pairs"
- 17:30 OPEN DISCUSSION Promoters: M. Bruggen+ S. Planelles



Thursday

11 OCTOBER

chair: F. Degasperin

- 9:30 D. DALLACASA "Electrons and magnetic field from galaxies in clusters"
- 10:00 N. AGHANIM "Recent analysis of SZ signal in the largest cosmic structures to search for the hidden baryons"
- 10:30 A. SIMIONESCU "Metallicity constraints in the clusters outskirts obtained from X-ray observations"
- 11:00 break
- 11:30 A. BONAFEDE "The interacting system MACSJ0717+3745: magnetic field and cosmic ray electrons"
- 12:00 D. WITTOR "A numerical view on the "observed" emission from radio relic"

lunch

chair: A. Simionescu

- 14:00 A. BOTTEON "Particle acceleration in pre-merging galaxy clusters: the LOFAR view"
- 14:30 H. BOURDIN "Detecting SZ substructures in the cluster peripheries"
- 15:00 P. DOMINGUEZ-FERNANDEZ "Time evolution of the magnetic spectrum in the ICM"
- 15:30 break
- 16:00 C. STUARDI "Magnetic field amplification in merging galaxy clusters: the case of RXCJ1314"
- 16:30 N. LOCATELLI "Tracing the cosmic web around A2744"
- 17:00 V. BIFFI "The ICM metal enrichment in cluster outskirts and its origin"
- 17:30 OPEN DISCUSSION Promoters: A. Simionescu+F. Degasperin



Friday

12 OCTOBER

chair: F. Vazza

- 9:30 M. HOEFT "Filamentary radio emission in cluster outskirts"
- 10:00 G. BRUNETTI "Particle acceleration in galaxy clusters and beyond"
- 10:30 J. DONNERT "Early cluster interaction in the Cygnus system - shock or no shock"
- 11:00 break
- 11:30 S. DE GRANDI "Study of Galaxy Clusters growth with the XCOP sample"
- 12:00 G. BERNARDI "The pursuit of large scale structure radio features: A399-A401, A781 and the Shapley concentration"

lunch

- 14:00 FINAL DISCUSSION Promoters: D. Eckert+ H. Akamatsu

Program/format

- a) things we think we know
- b) things we thought we knew but are actually turning out to be puzzling
- c) things we hope we will understand in the next ~ 10 years (how?)

#InteractingClusters2018

Let's respect presenters who will show work in progress and preliminary/speculative results:

ask for permission to tweets of sensible slides!

Speakers, please make it clear if you don't want to be tweeted.

If you want to share your presentation (or parts of it) in the program page: send it to franco.vazza2@unibo.it or hand me a PDF

Others

I assume you adhere to the code of conduct visible at the bottom of the website.

Reimbursement forms: you have to hand or scan them back to Alma Mater Foundation (a.vriz@fondazionealmamater.it) including all is needed in original (yes, you may have to send stuff back via regular mail, sorry for this).

**Now,
science...**

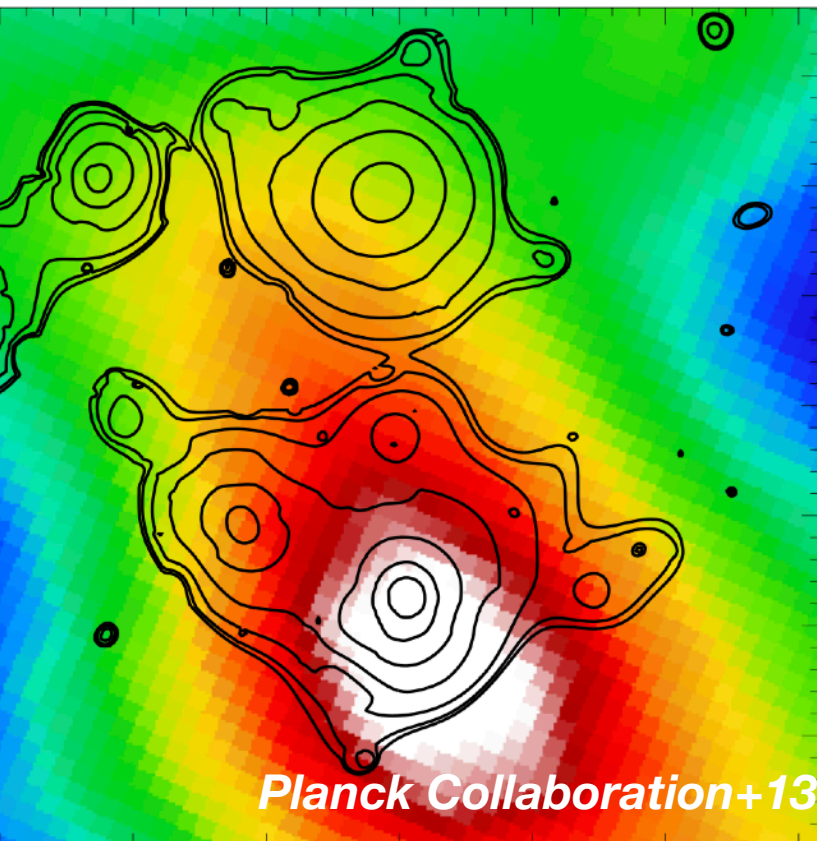
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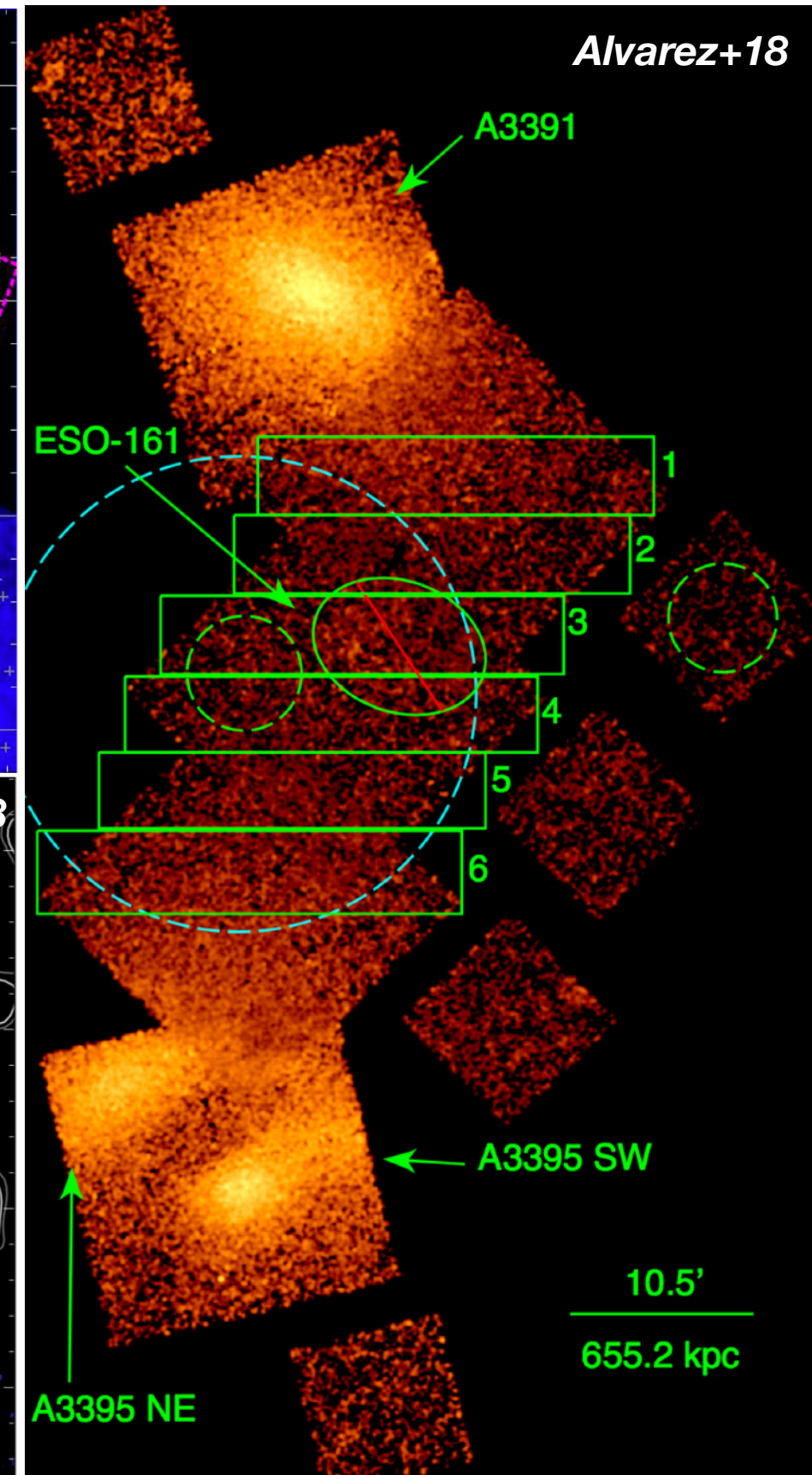
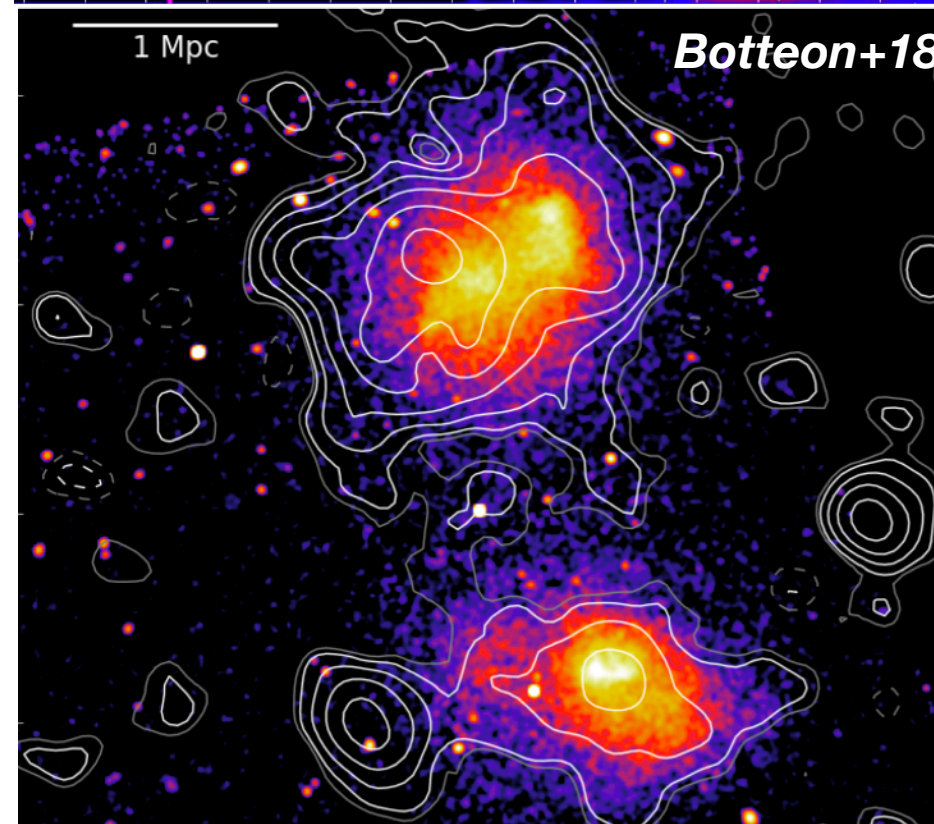
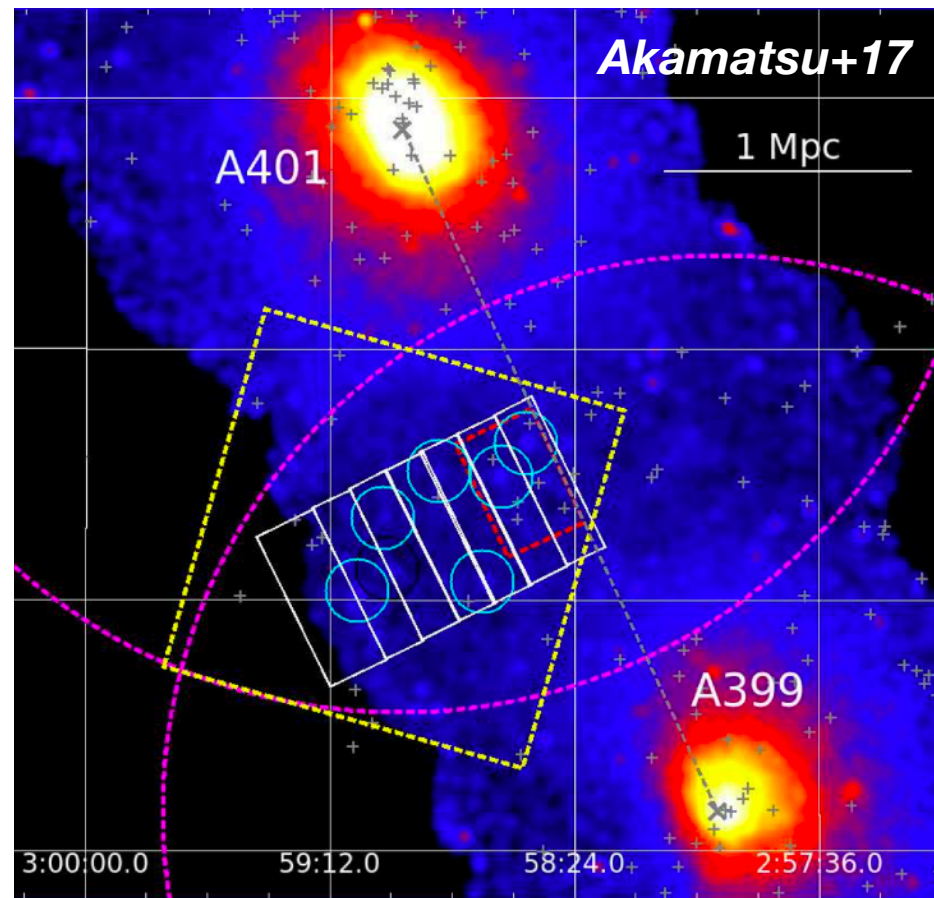


Why caring about early interacting clusters?

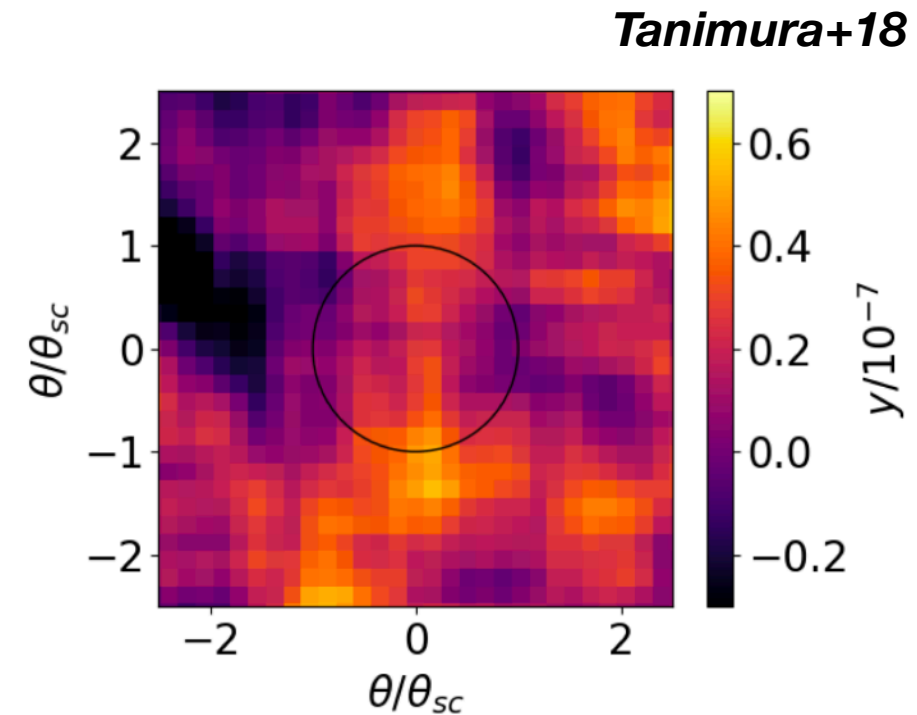
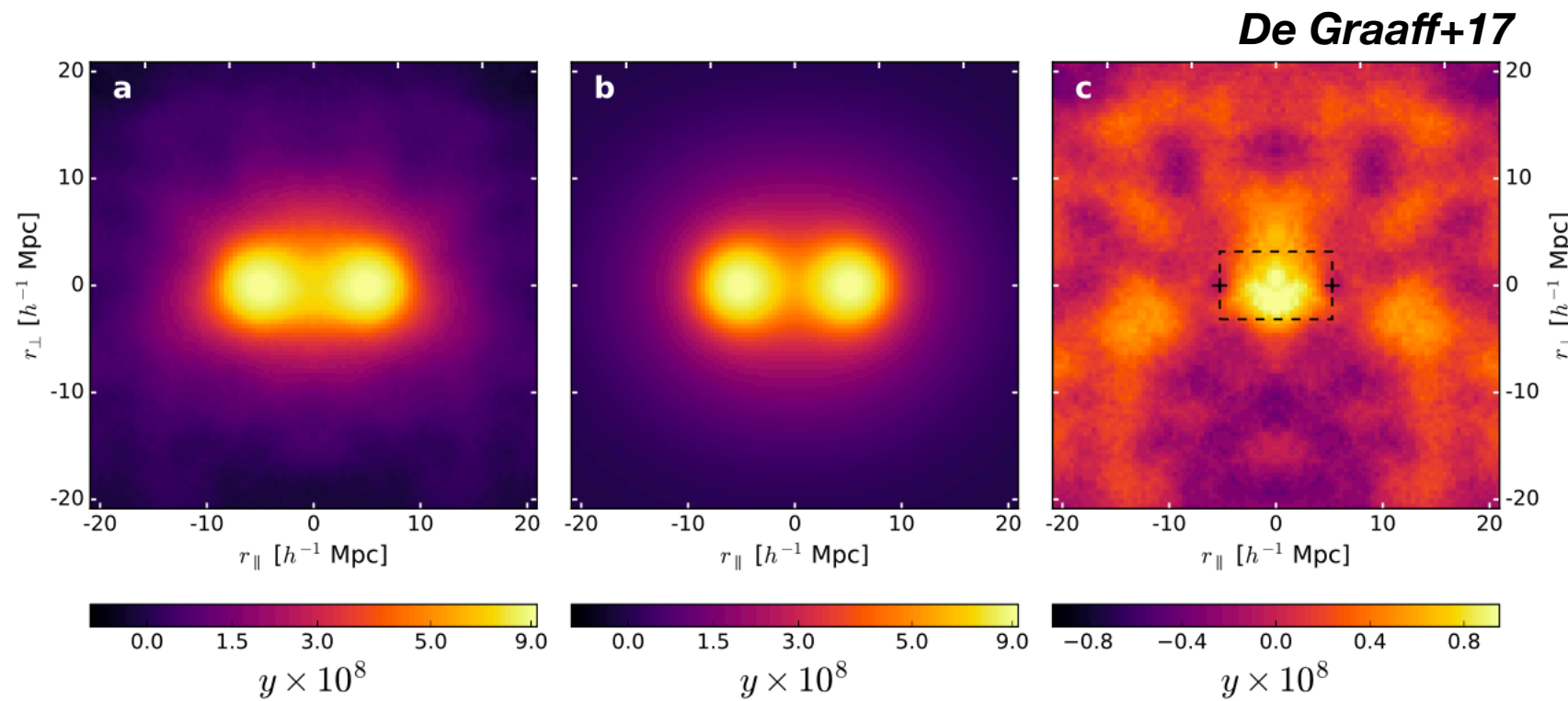


They are
observed (in X-ray,
SZ, radio)

Their number will
likely increase in
incoming surveys.

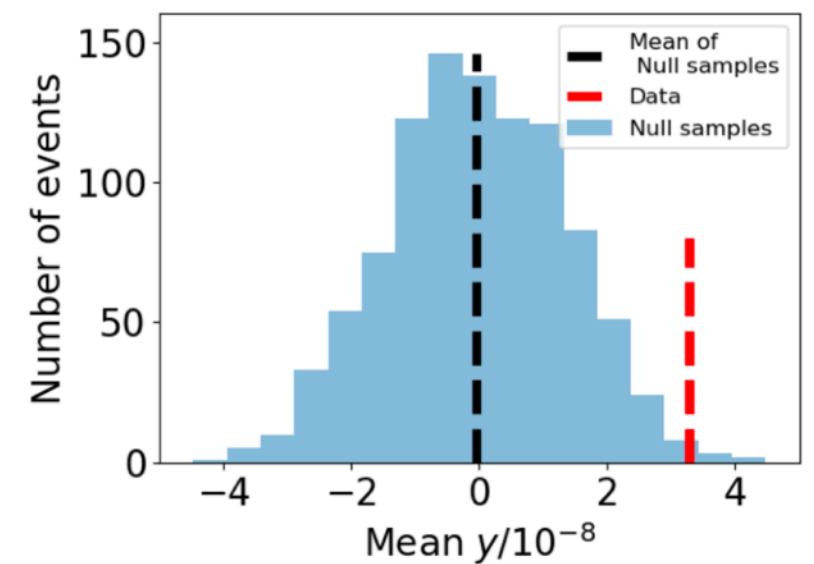


Do we get a complementary view via stacking of pairs?

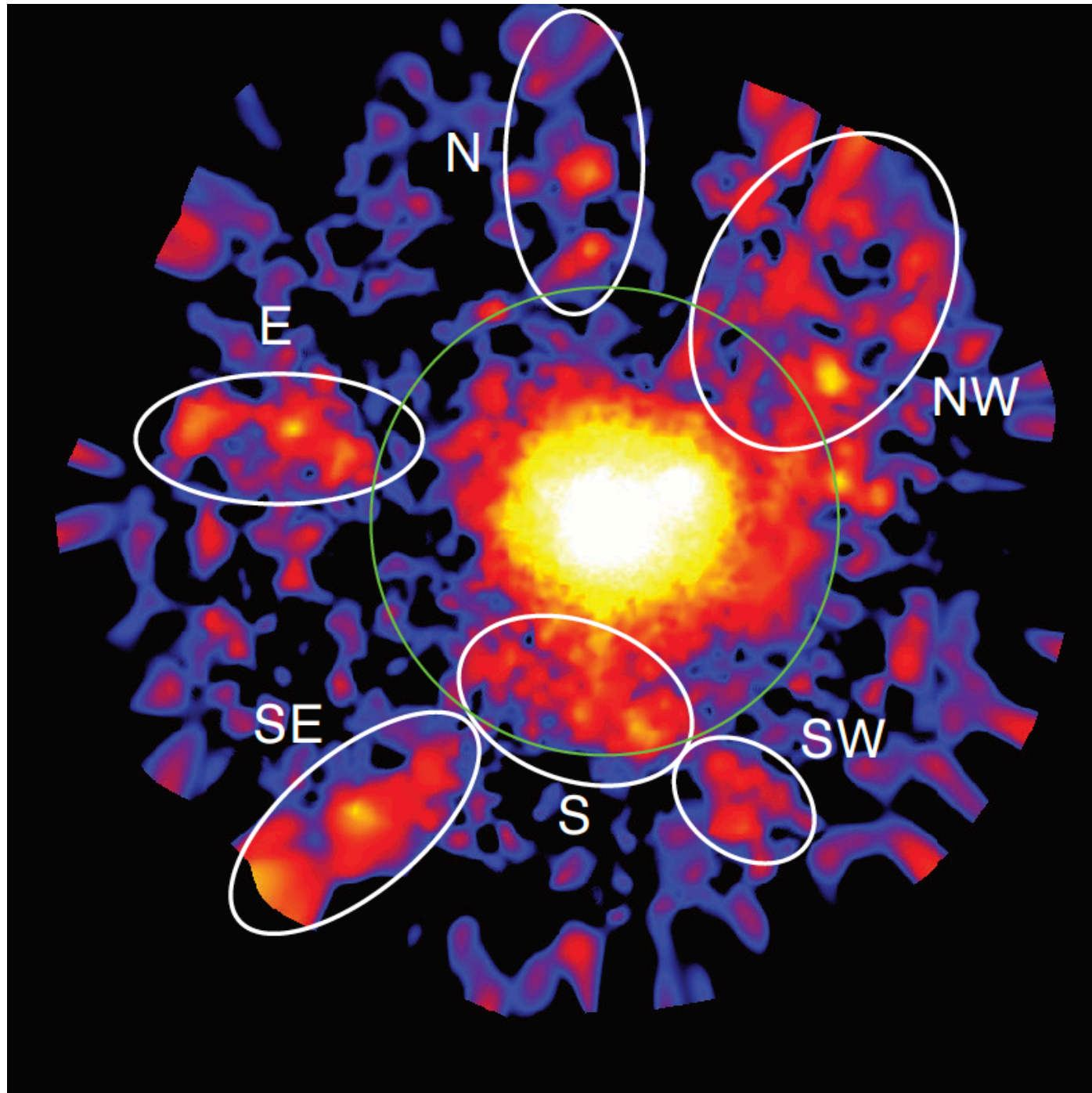


Stacking of galaxy halos / clusters
probed gas bridges between pairs.

Should become possible also in X-ray
and radio in the next ~ 10 years.



Are bridges = intracluster filaments?



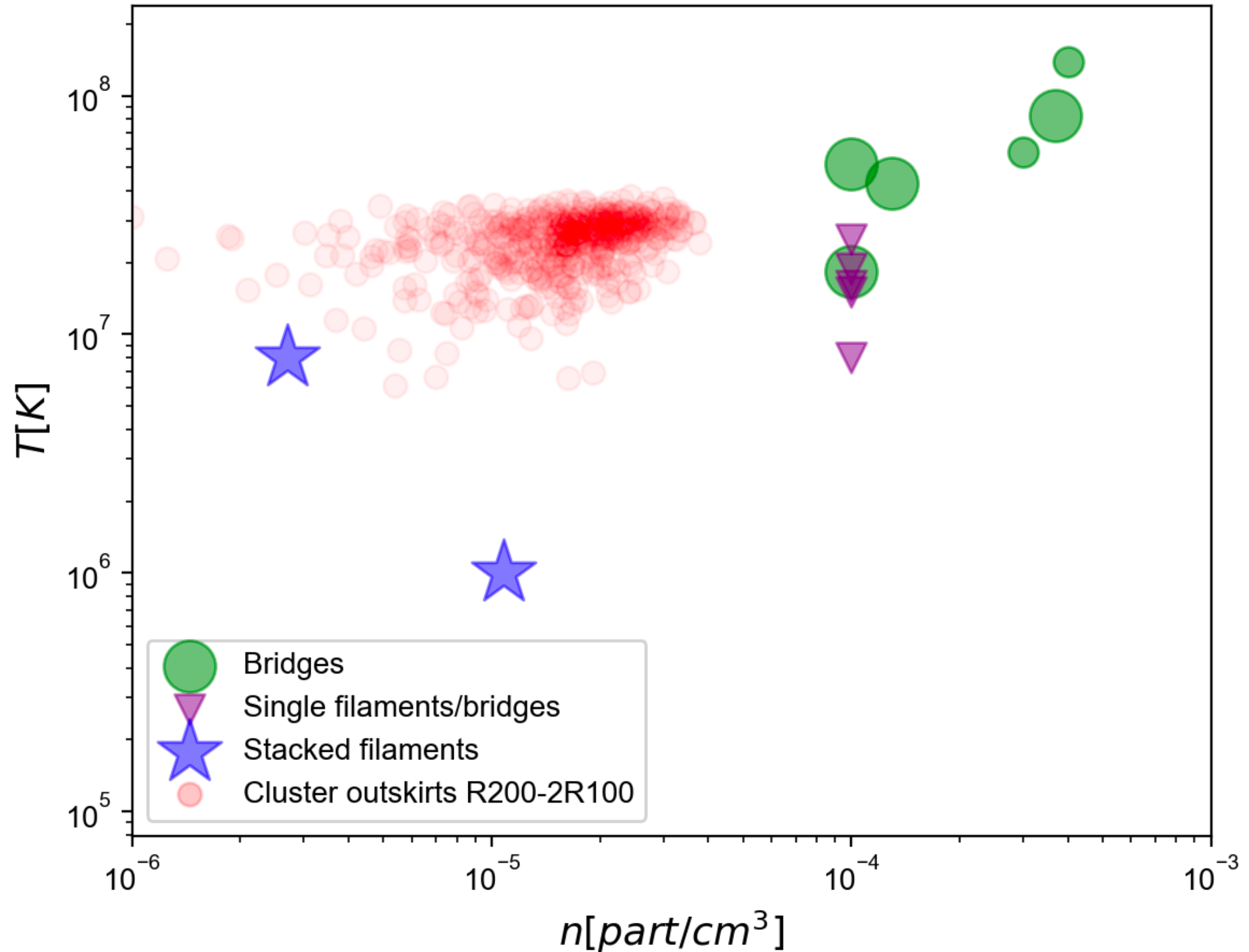
Eckert+15

Some recent genuine detection of filaments in X-ray (XMM).

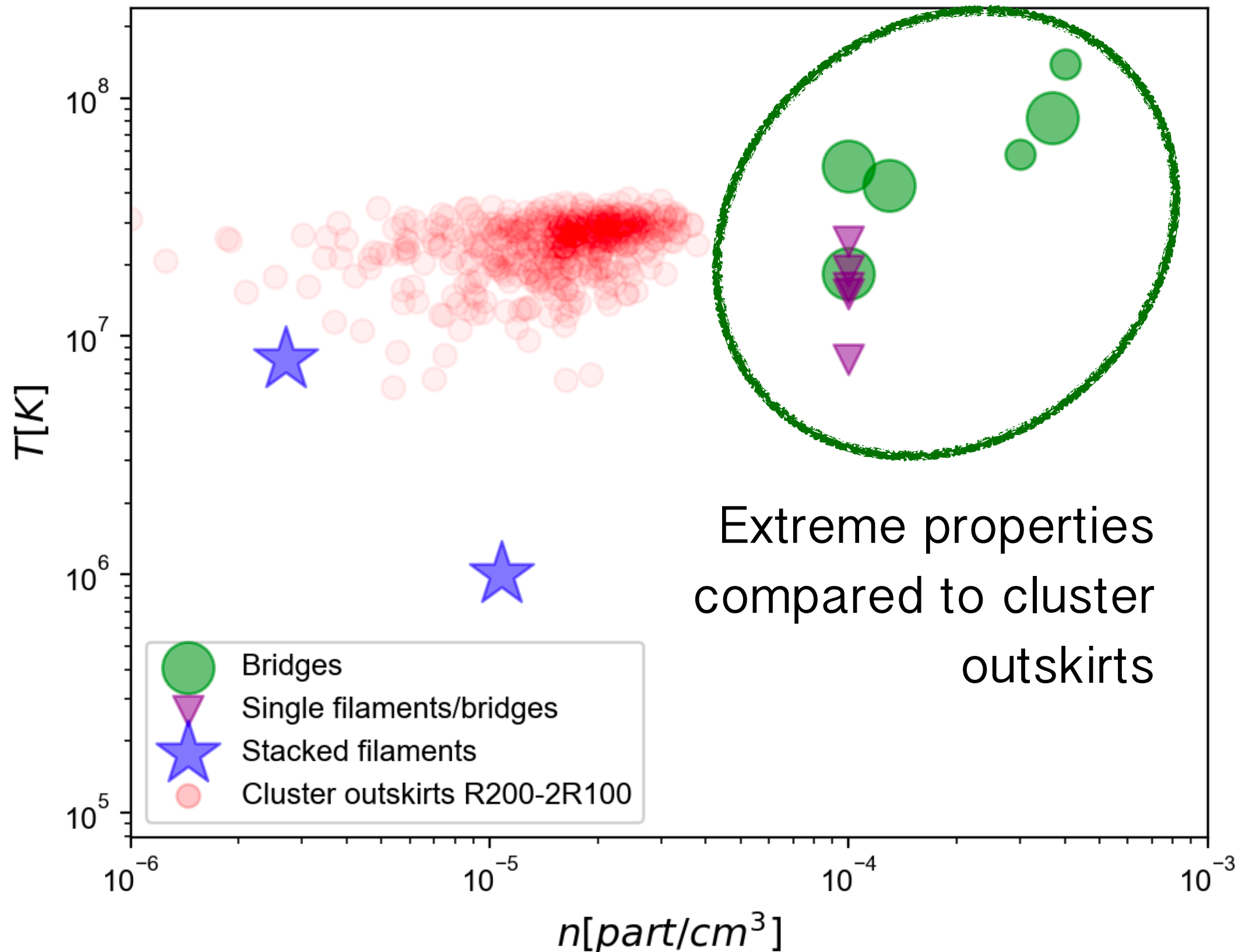
Are bridges between cluster pairs filaments?

Are they filled with WHIM?
ICM? Or else?

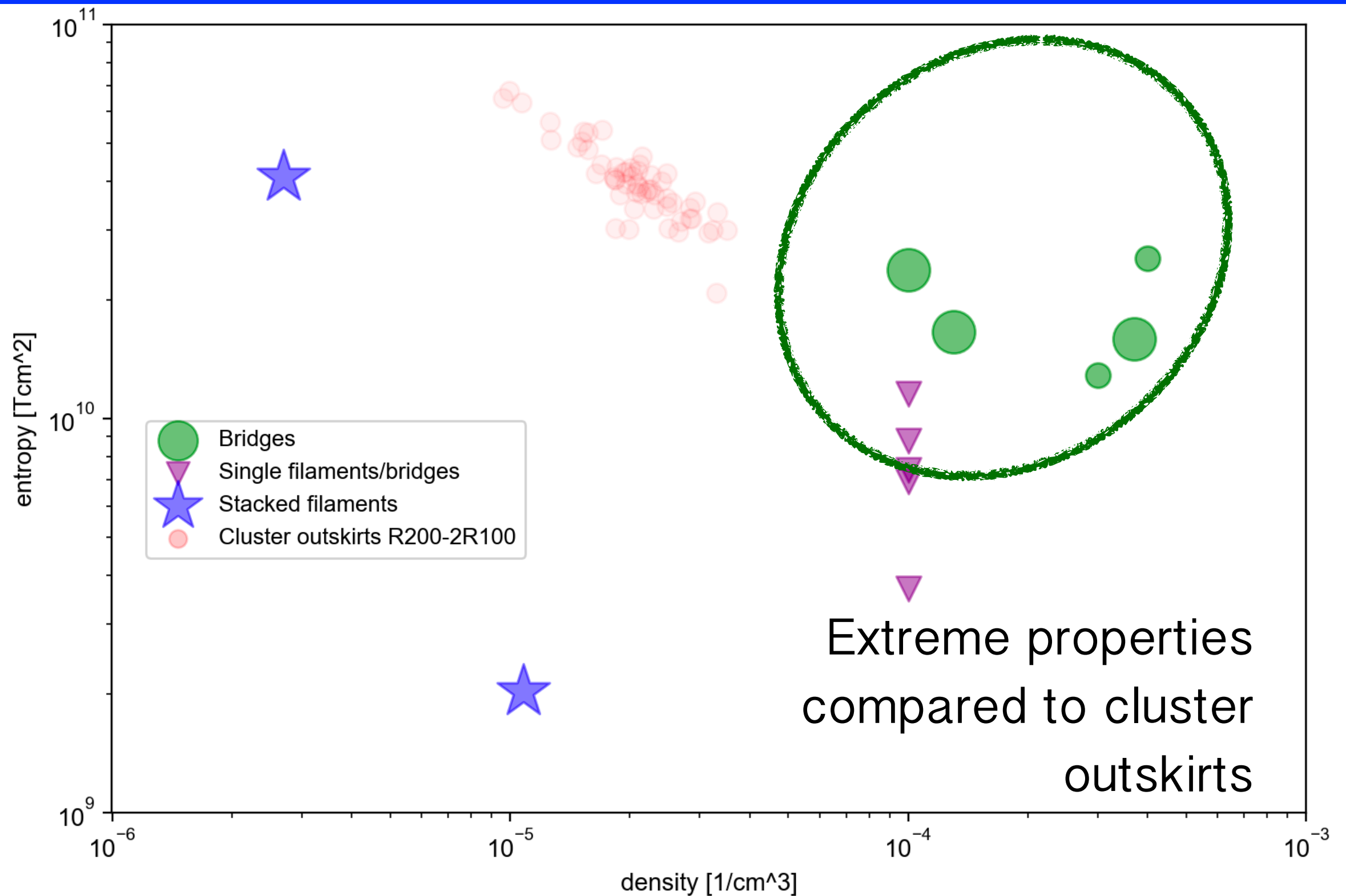
What are the gas properties inferred so far for bridges and filaments?



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What has been detected in single bridges/filaments gives:

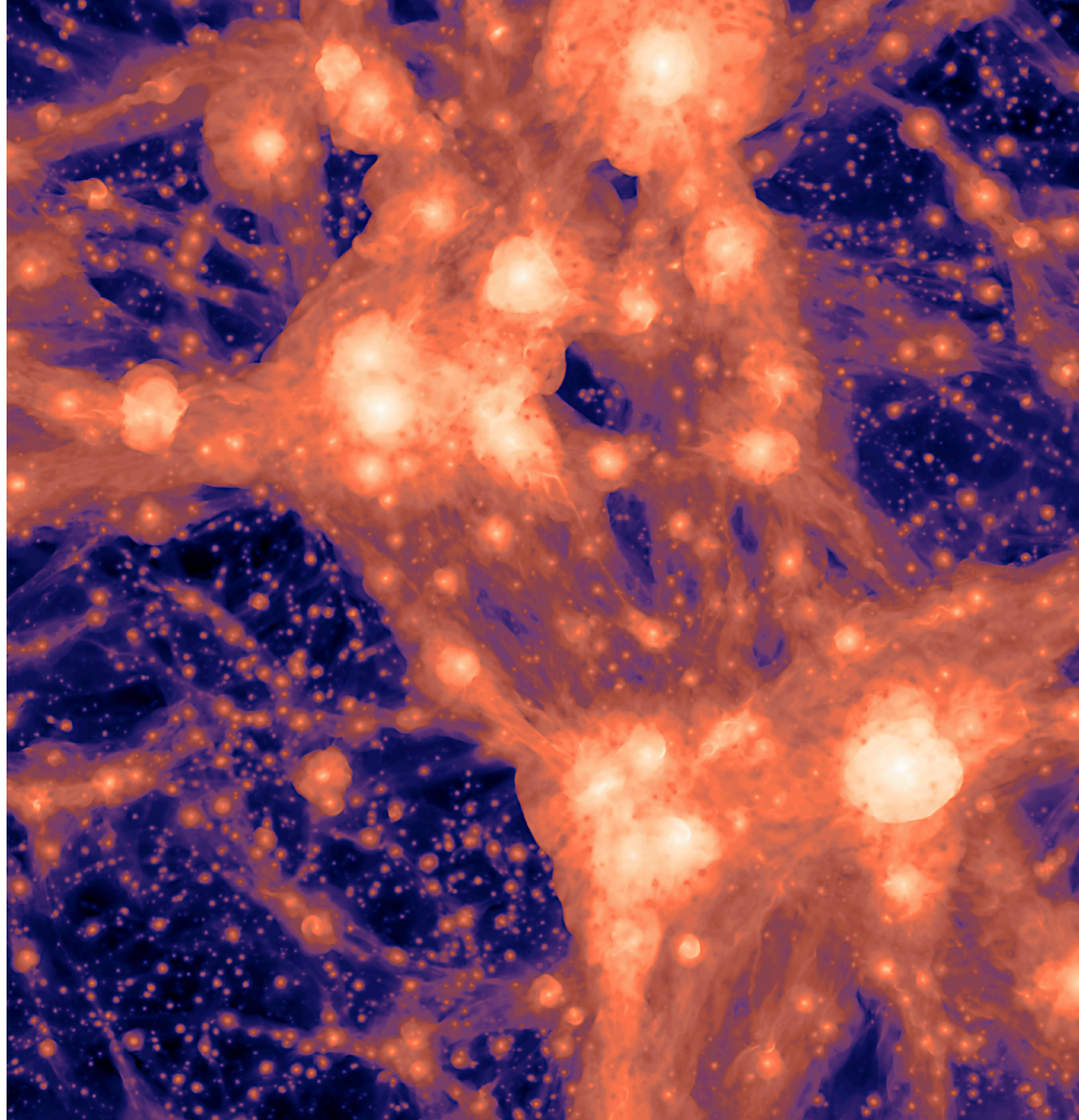
$$n_{fila} \sim 1 - 5 \times 10^{-4} \text{part/cm}^3 \qquad T_{fila} \sim 1 - 5 \times 10^7 - 10^8 \text{ K}$$

Compared to stacking detections, this is

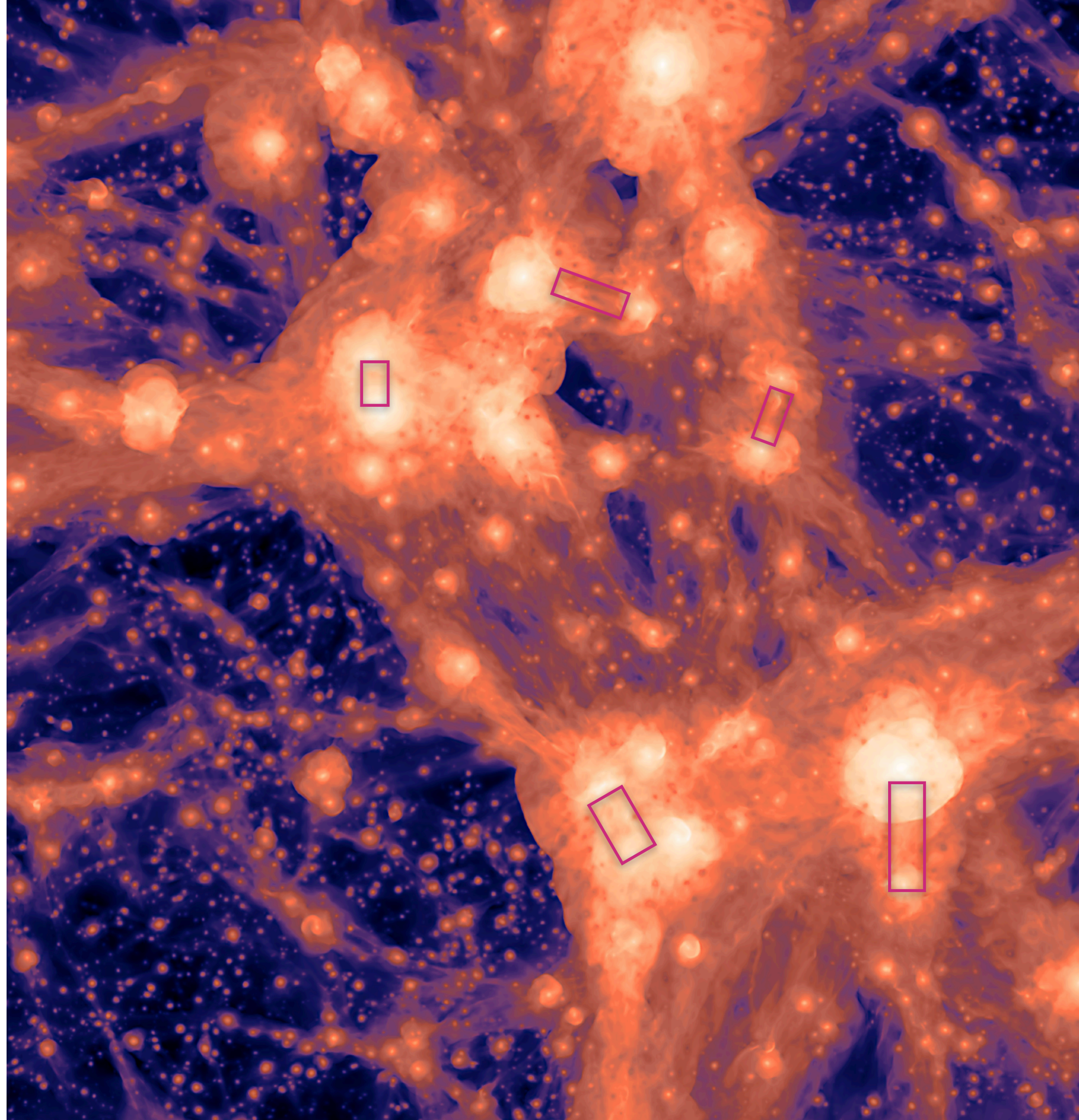
$$n_{fila} \sim 10 - 10^2 n_{stack} \qquad T_{fila} \sim 10 - 10^2 T_{stack}$$

Which is more representative of missing baryons?

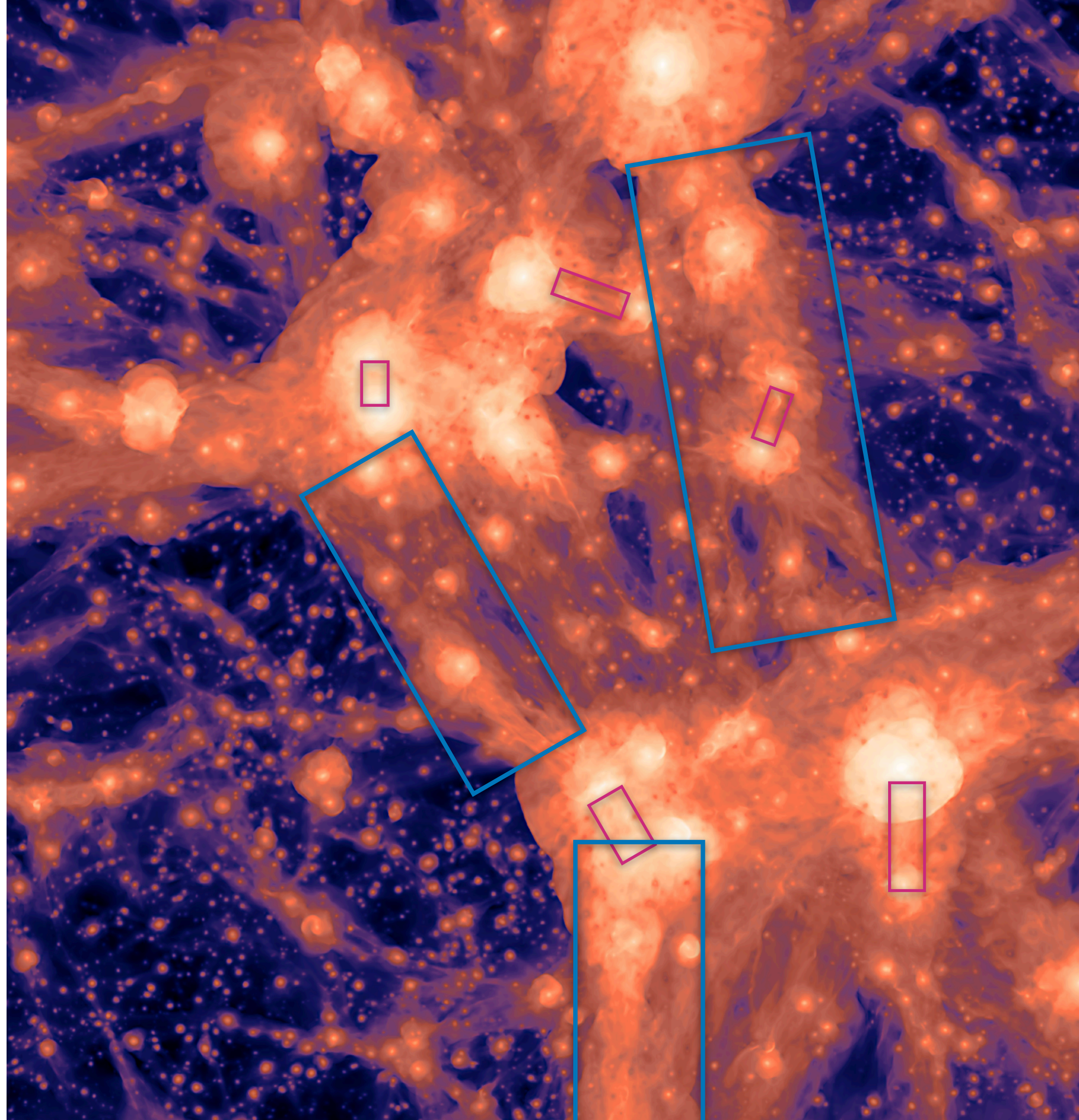
- At least in simulations,
bridges
≠
filaments



- At least in simulations,
bridges
≠
filaments



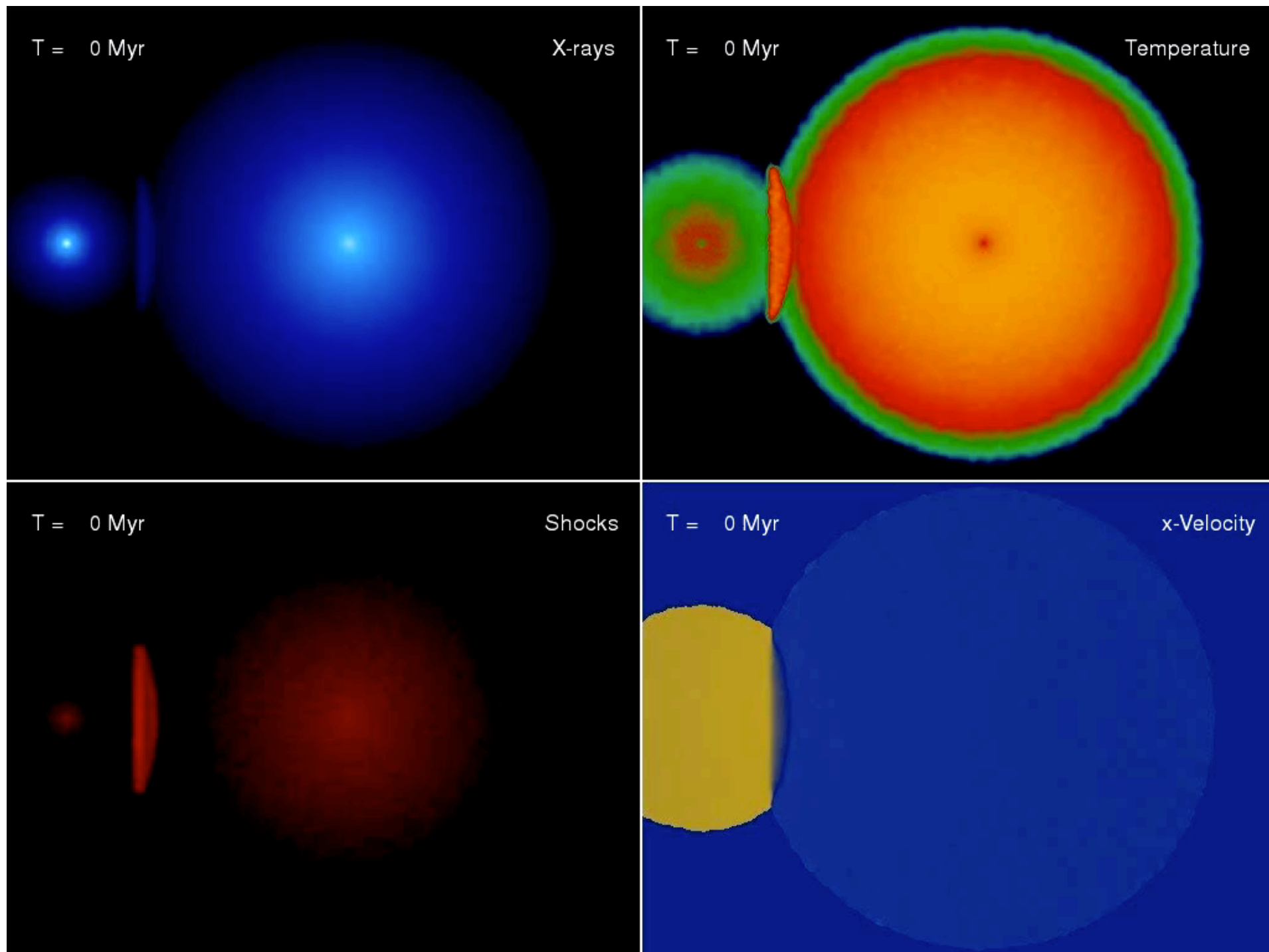
- At least in simulations,
bridges
≠
filaments



Dynamical activity in interacting clusters: how much? where?

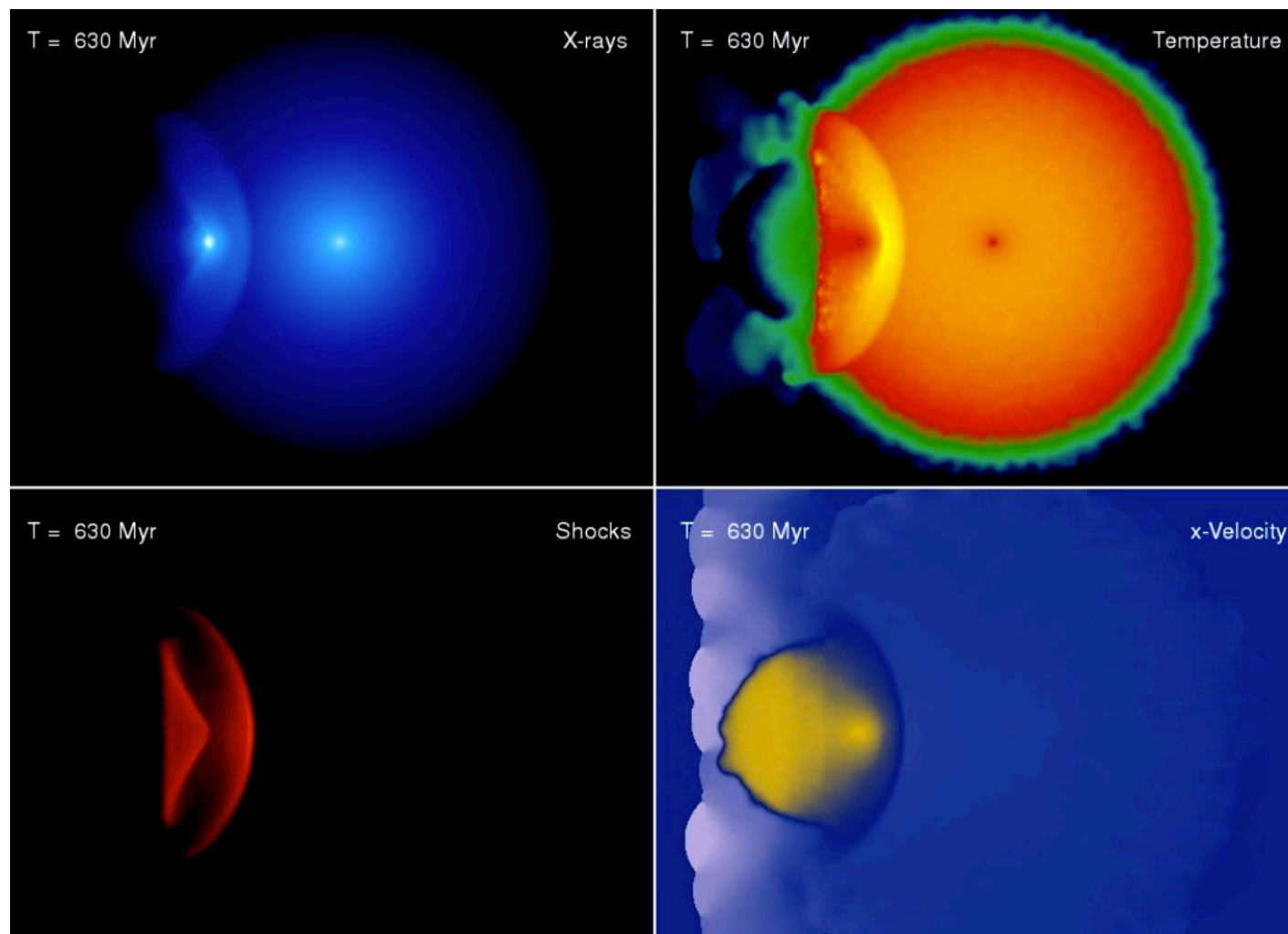
- Level of shocks and turbulence in bridges unclear.
- Stationary vs transient dynamical features.
- Fundamental to predict/understand radio observations.

Early cluster interactions in simulations: I) “binary models”



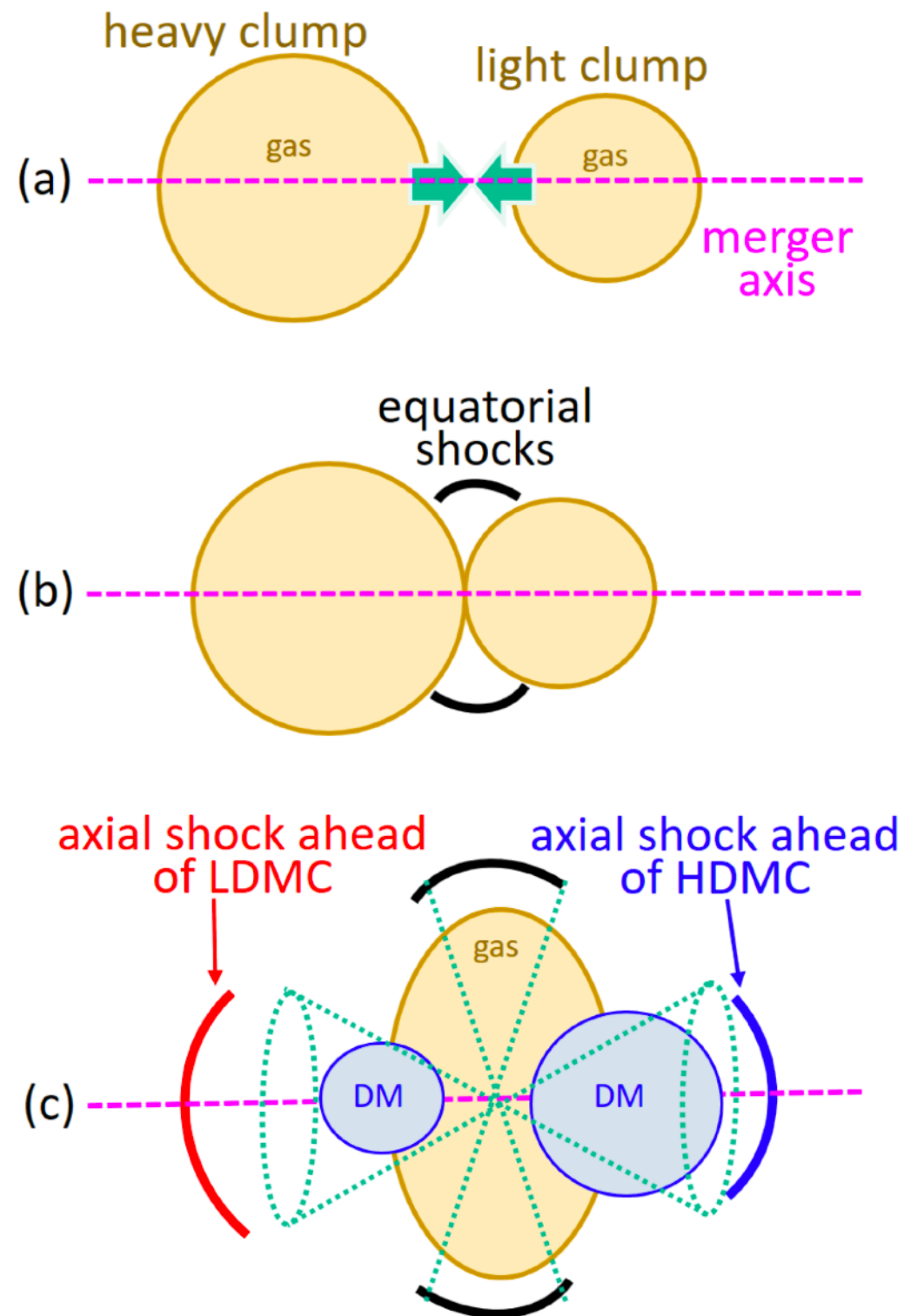
Springel+, Gadget2

Early cluster interactions in simulations: I) “binary models”



- M~2 shocks before the merger on ~Mpc scales
- Little turbulence between the two cores
- hot/high entropy gas between the cores

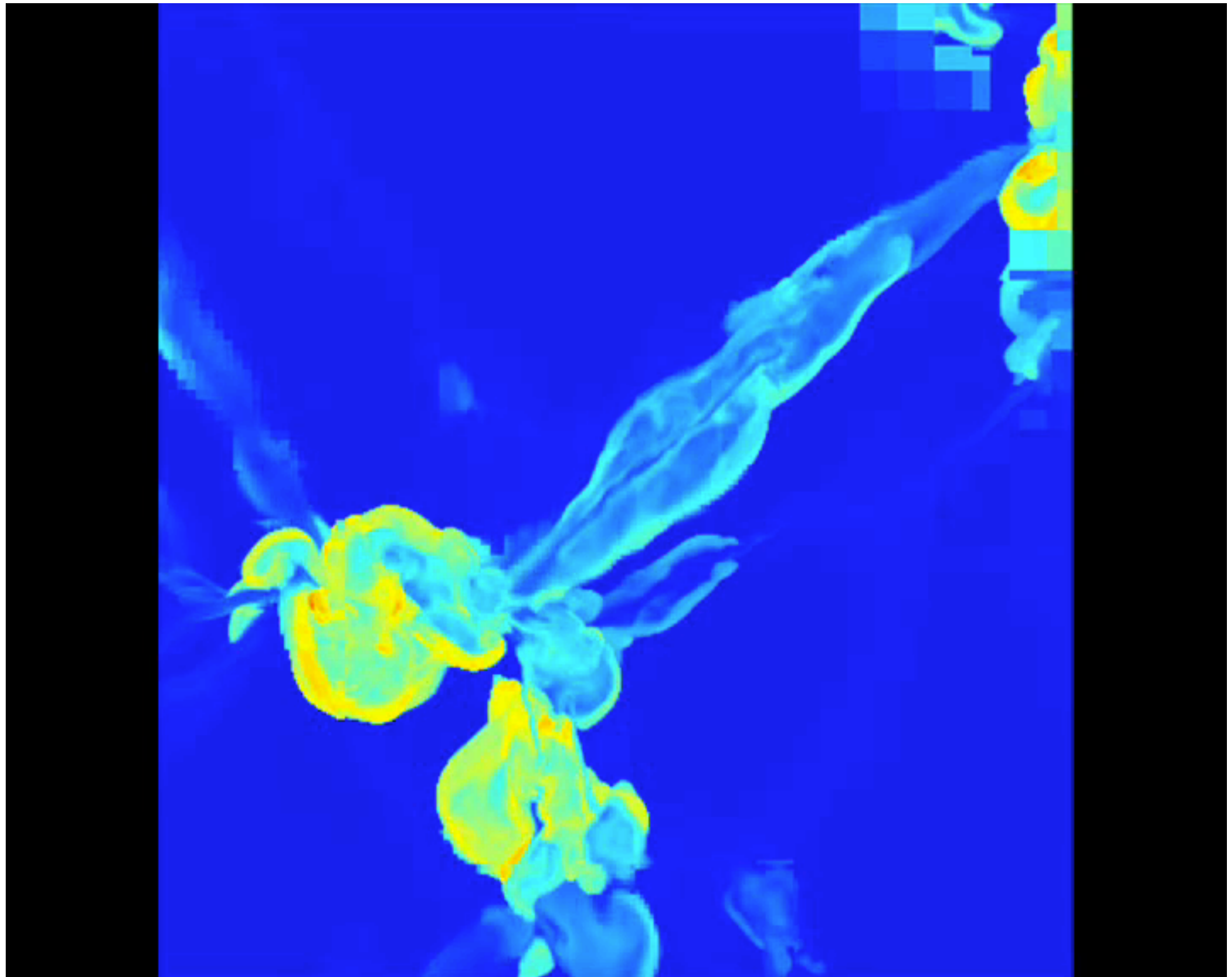
Early cluster interactions in simulations: II) cosmological simulations



- almost no shocks in between cores
- shocks are launched *perpendicular* to merger axis

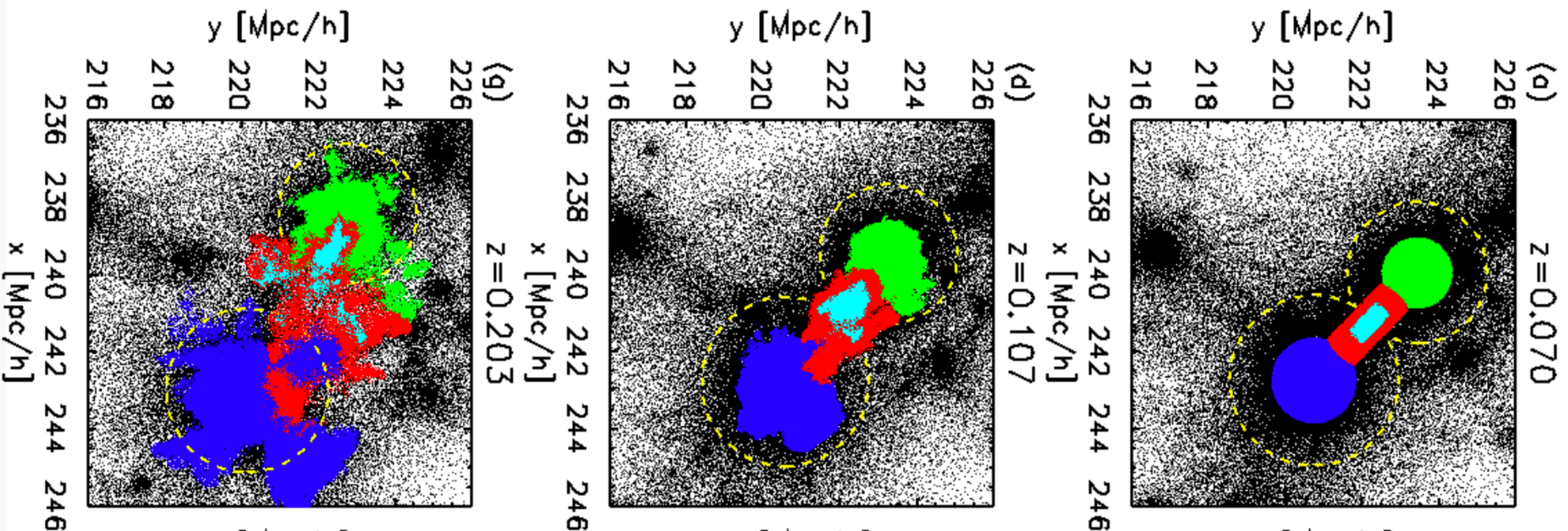
How complex is gas dynamics in bridges?

Gas temperature (slice)



Enzo simulations (~2010)

Numerical simulations: where does the gas come from?



- ~50% of gas particles in the bridge come from $>R_{\text{vir}}$

How complex is gas dynamics in bridges?

Gas density

Enzo simulations (2016)

How complex is gas dynamics in bridges?

Gas entropy

Enzo simulations (2016)

How complex is gas dynamics in bridges?

Gas temperature + magnetic fields (projection)

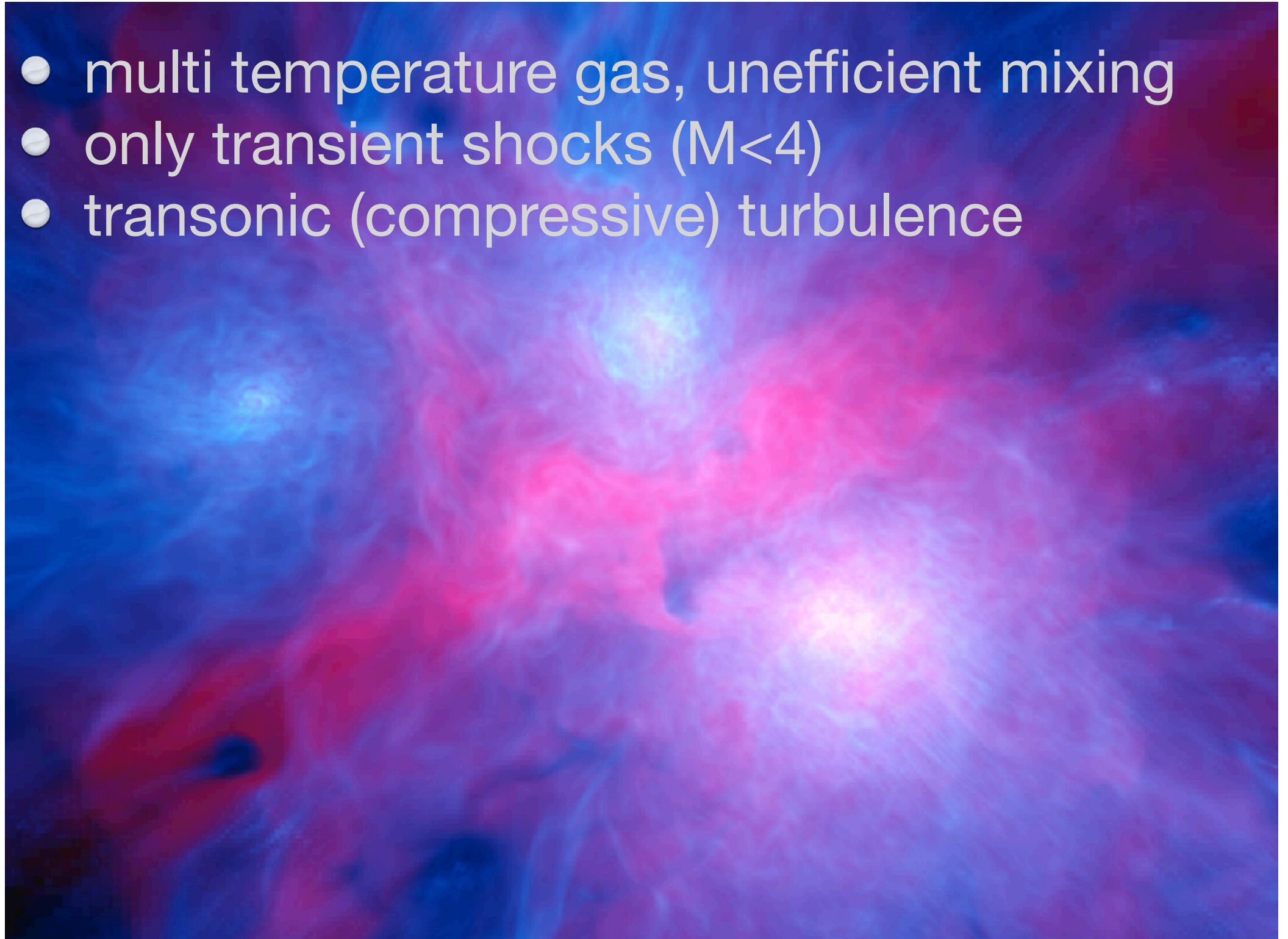


Enzo simulations (~2018)

How complex is gas dynamics in bridges?

Gas temperature + magnetic fields (projection)

- multi temperature gas, unefficient mixing
- only transient shocks ($M < 4$)
- transonic (compressive) turbulence

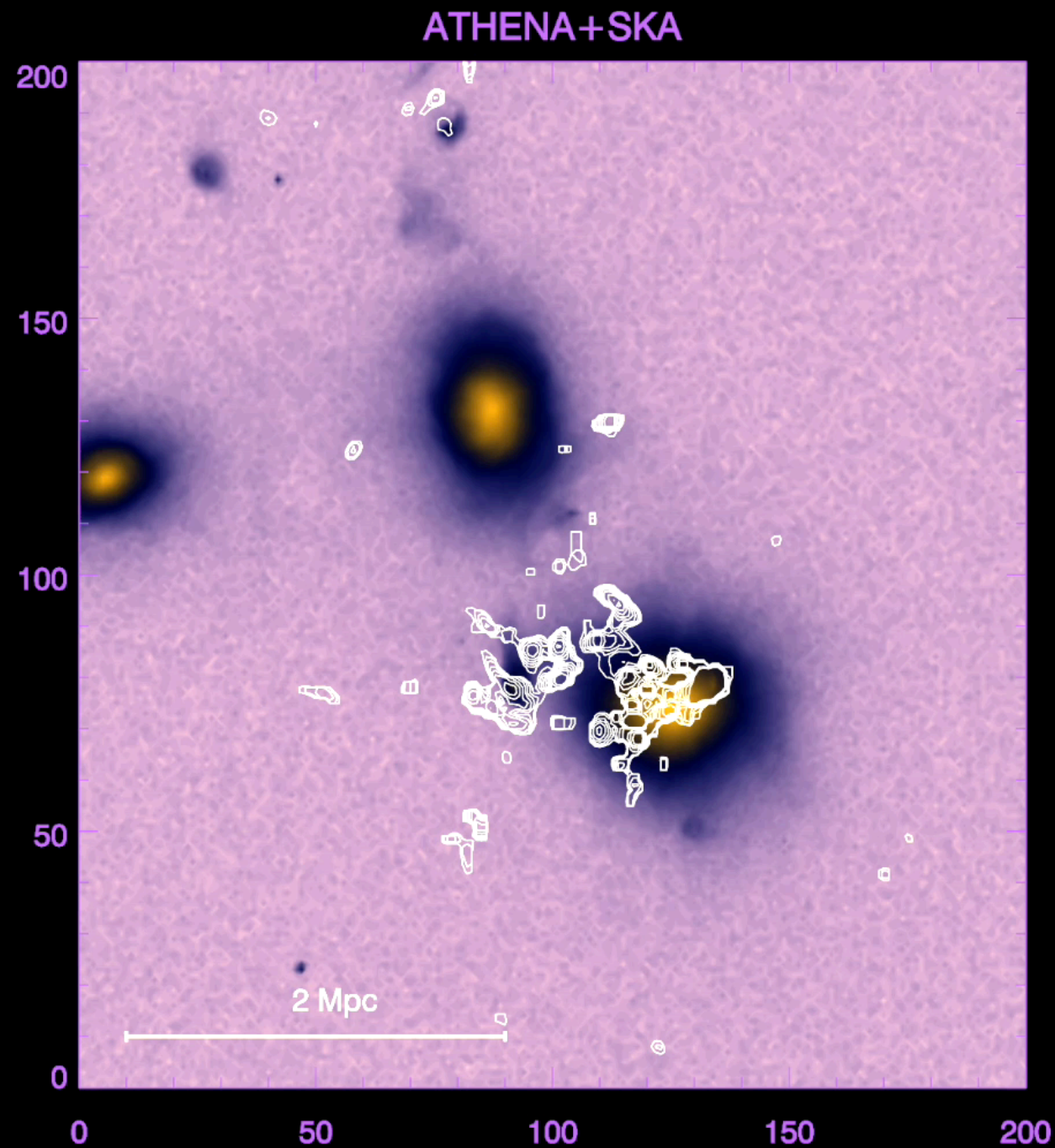


Enzo simulations (~2018)

Non thermal emission from in interacting pairs:
magnetic fields? cosmic rays?

- Amount of seed relativistic electrons to accelerated unclear. Depends on star formation history and stripping efficiency.
- Metallicity measurements may help there.
- Whether a small-scale dynamo is expected there also unclear. ICM-like evolution or filament-like?

How complex is gas dynamics in bridges?

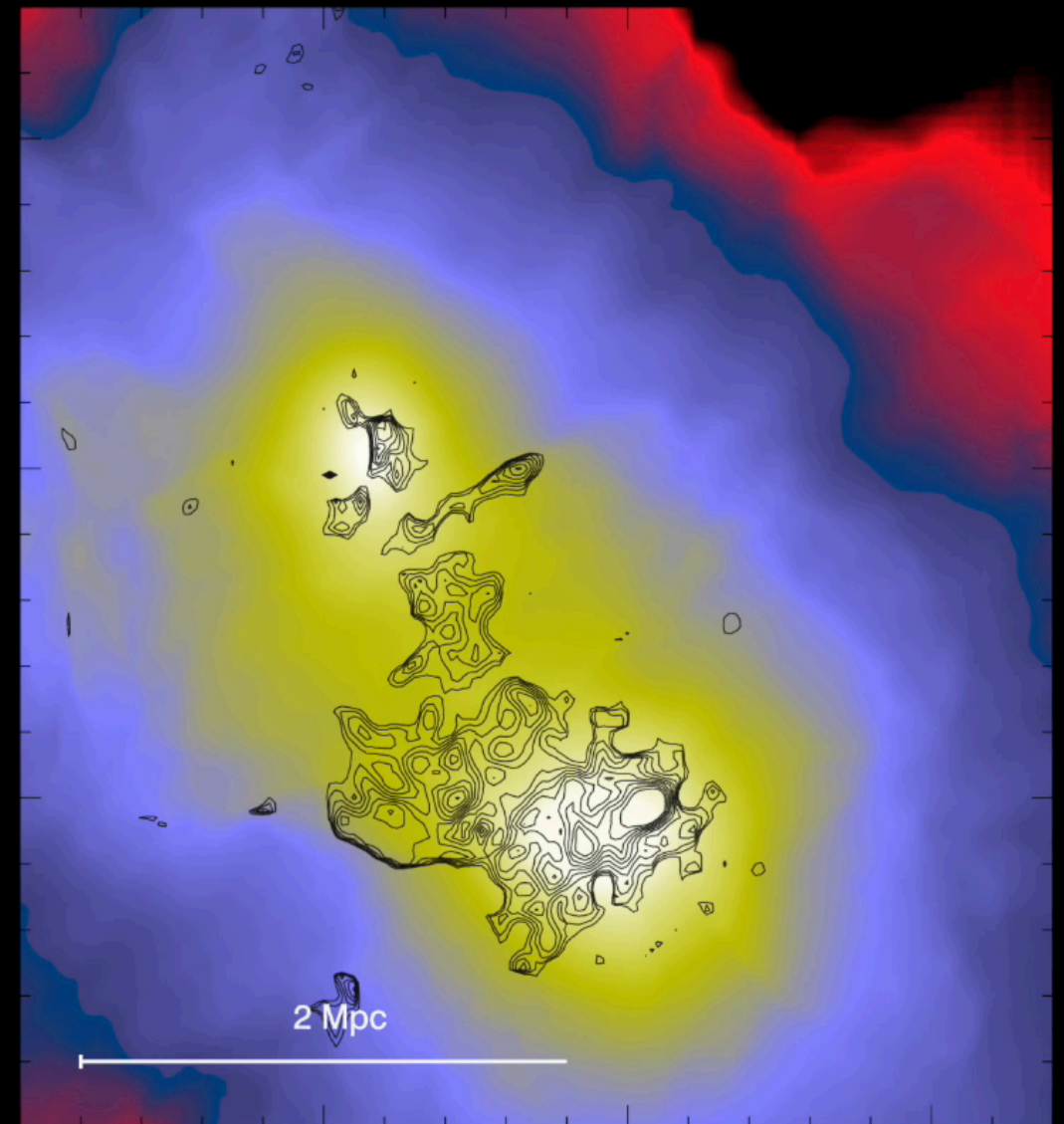
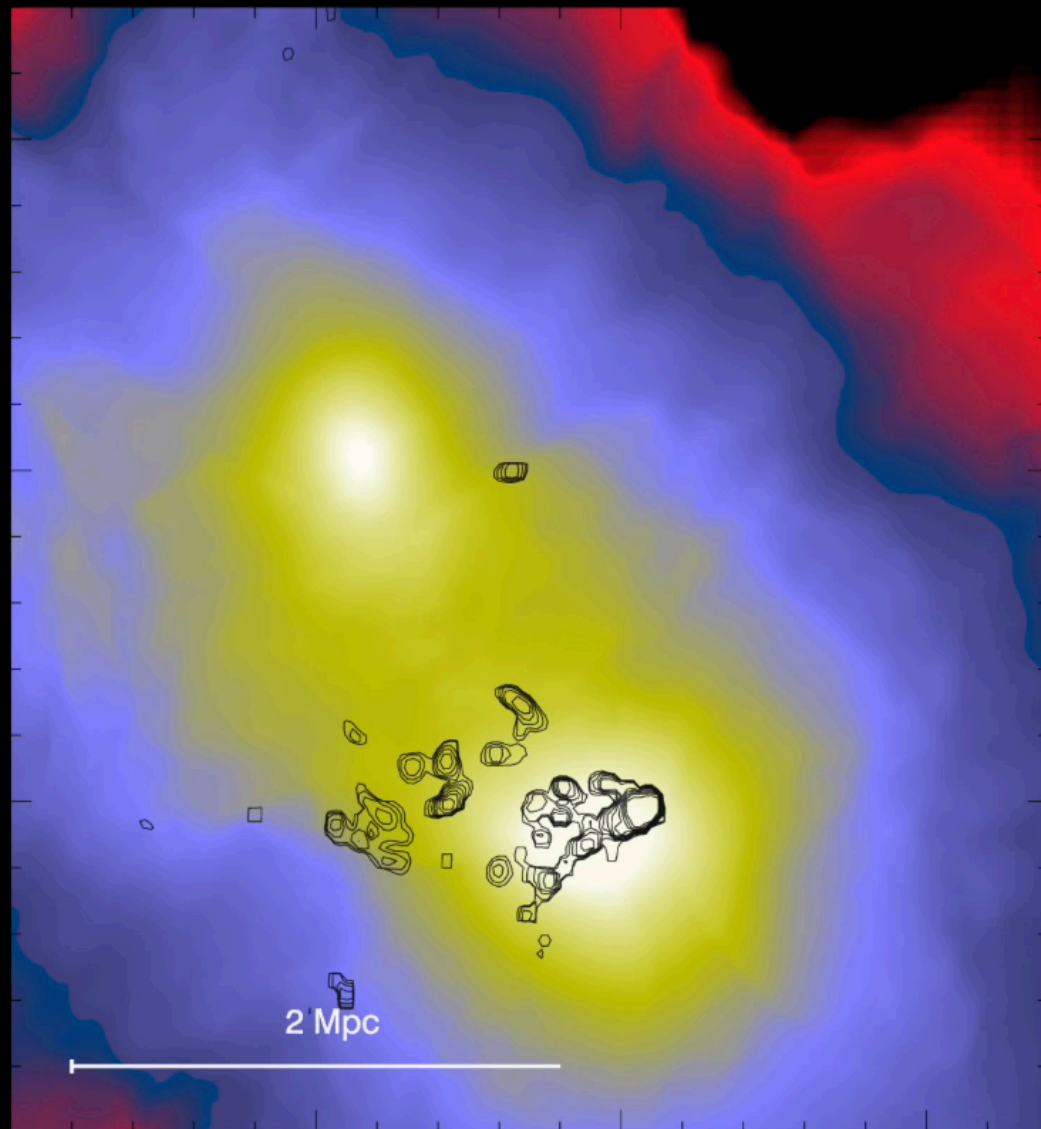


Vazza, Ettori+ in prep

What is the evolution of relativistic particles in bridges?

- Uncertainty in shock and turbulent history
- Are pre-core collision conditions in bridges more or less suitable for particle acceleration than typical cluster outskirts?

How complex is gas dynamics in bridges?



Enzo simulations (~2018)

**Thanks for
answering all
the above
questions
during the rest
of the week!**

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