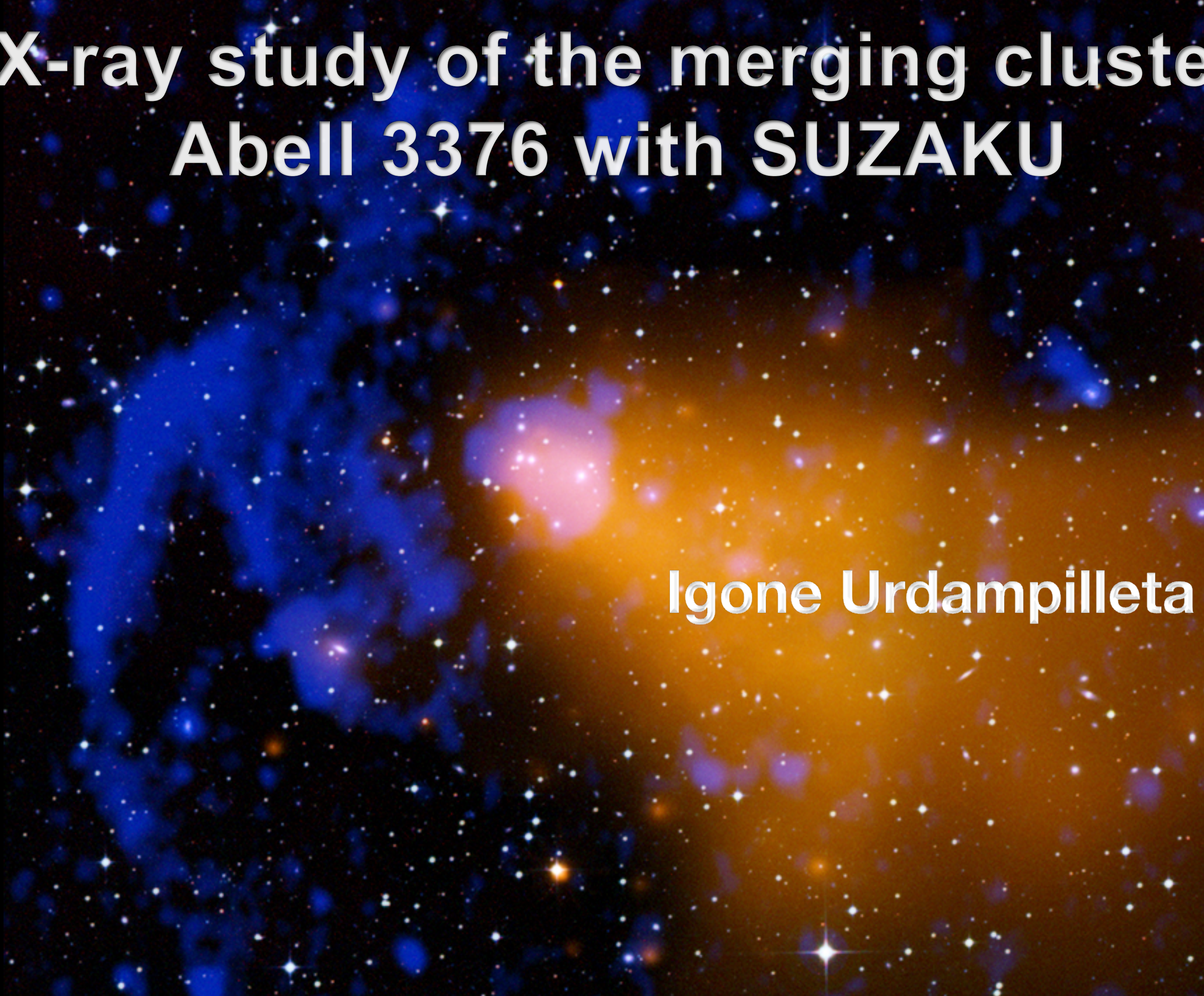
X-ray study of the merging cluster Abell 3376 with SUZAKU



Igone Urdampilleta

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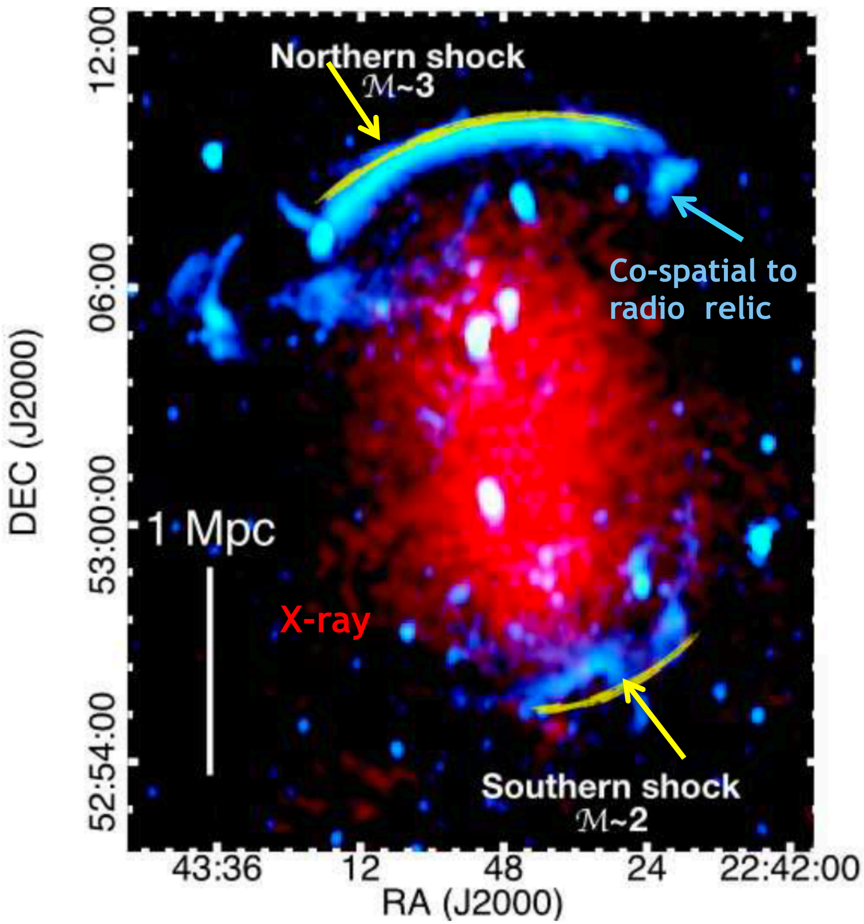
SRON
Netherlands Institute for Space Research

Sterrewacht Leiden

Merging Galaxy Clusters

CIZA J2242.8+5301 "Sausage"

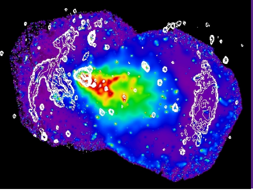


Akamatsu et al. 2015

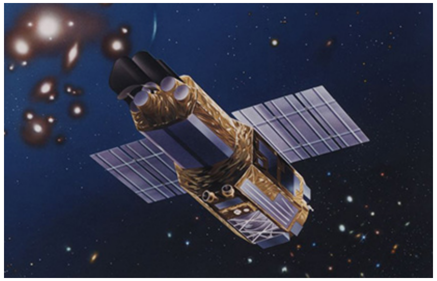
Cluster mergers produce large-scale X-ray shocks

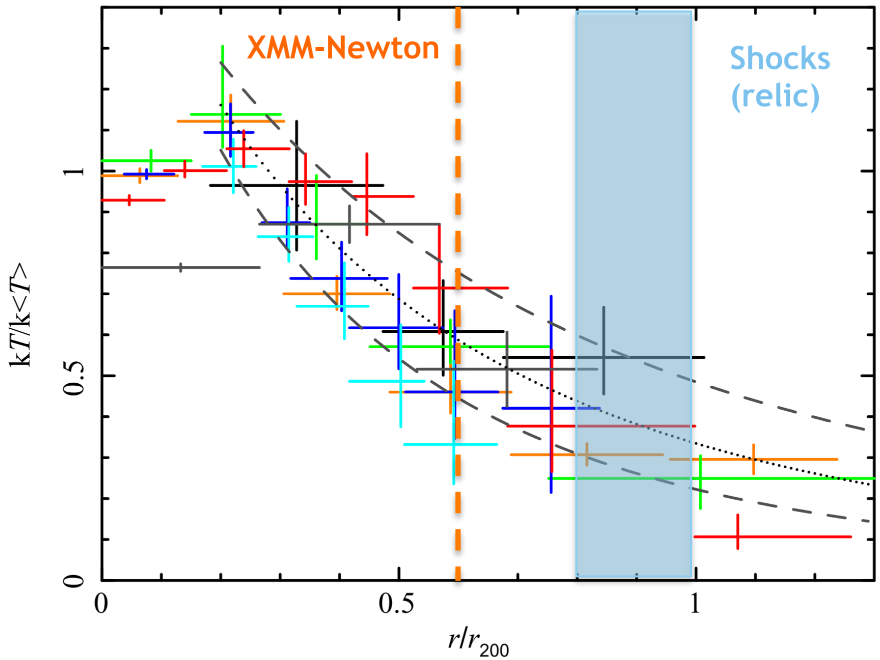
Radio relics are good tracers of X-ray shocks

How can low-M shocks accelerate e^- ?



Why Suzaku?



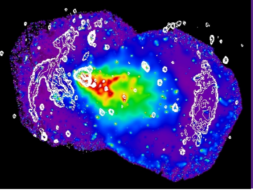


Akamatsu et al. 2011

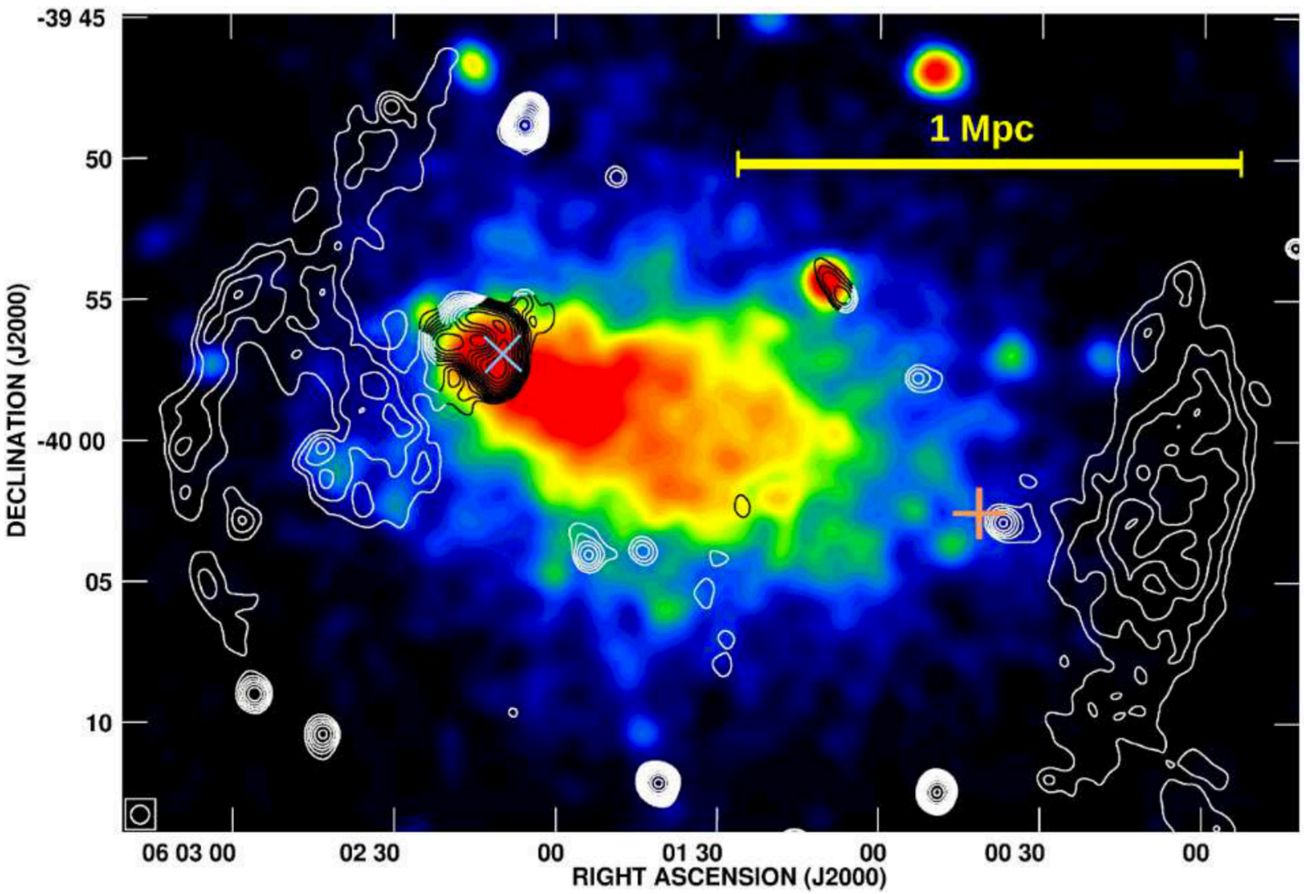
Hoshino et al. 2010, George et al. 2008, Tamura et al. 2008, Reiprich et al. 2009, Bautz et al. 2009, Kawaharada et al. 2010

XIS good performance allows the **low surface brightness** outskirt to be detected:

- ✓ Low and stable detector background



Abell 3376



X-ray (ROSAT)

Radio (GMRT)

Kale et al. 2011

z = 0.046

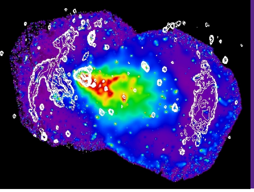
M ~ 4x10^{14} M$_\odot$

(Monteiro-Oliveira et al. 2017)

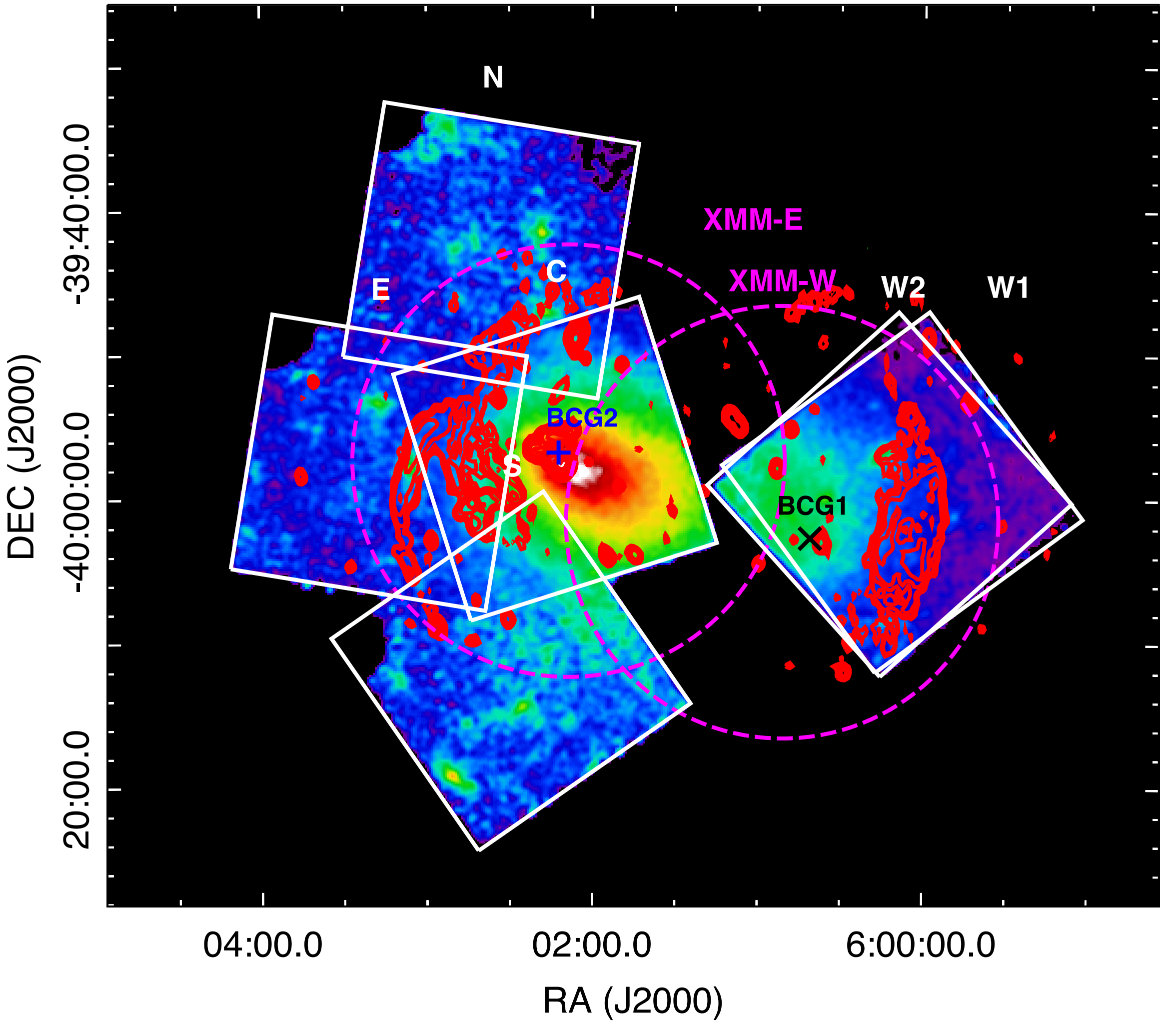
<kT> ~ 4 keV

Two giant arc-like (~2 x 1.6 Mpc) radio relics

Discovered by Bagchi et al. 2006



Suzaku XIS Abell 3376

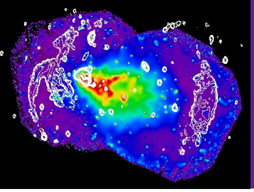


Radio (VLA)

(Kale, R.)

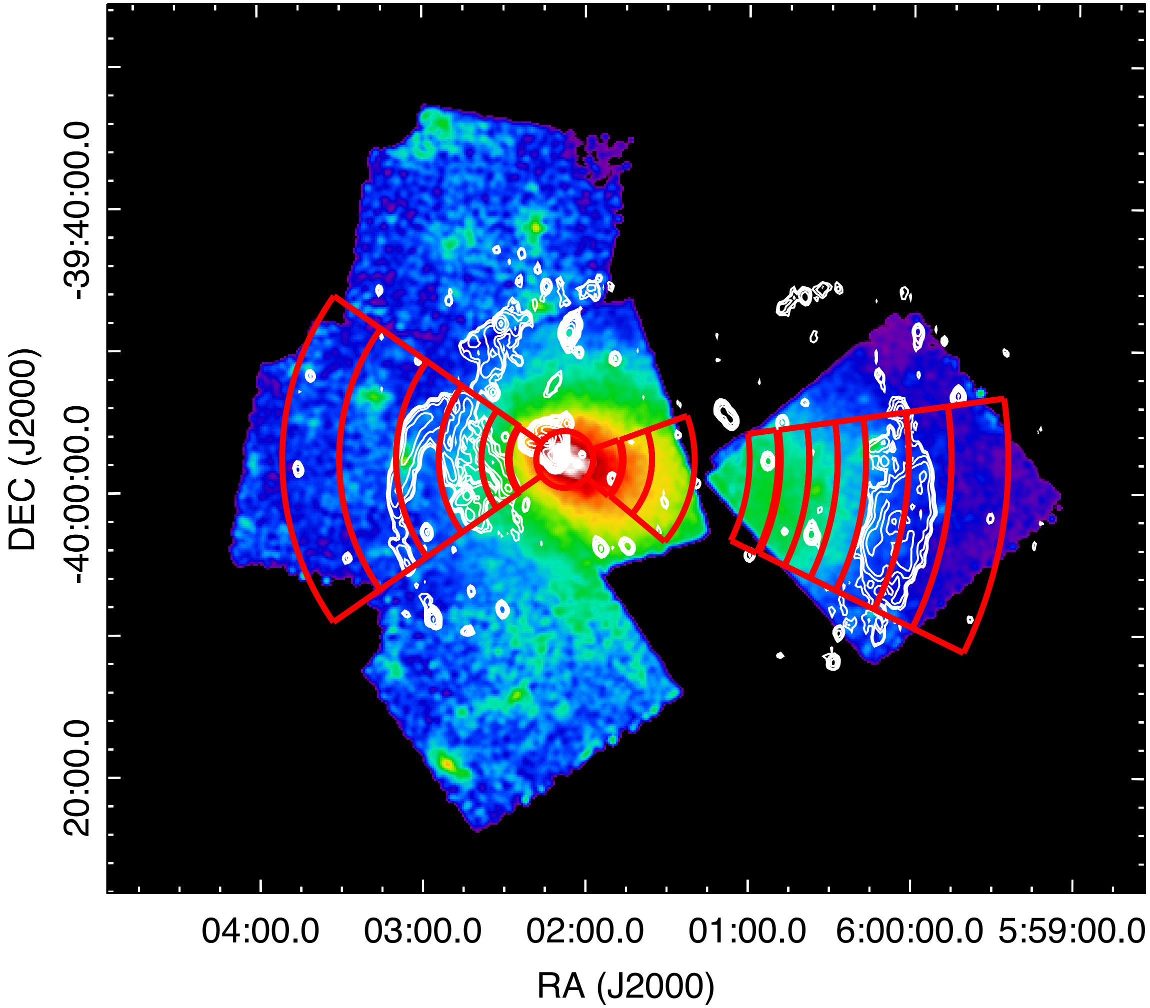
Eastern relic:
N, E, S

Western relic:
W1 & W2

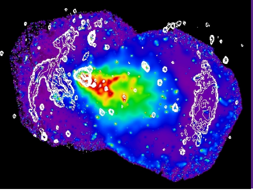


E & W Regions

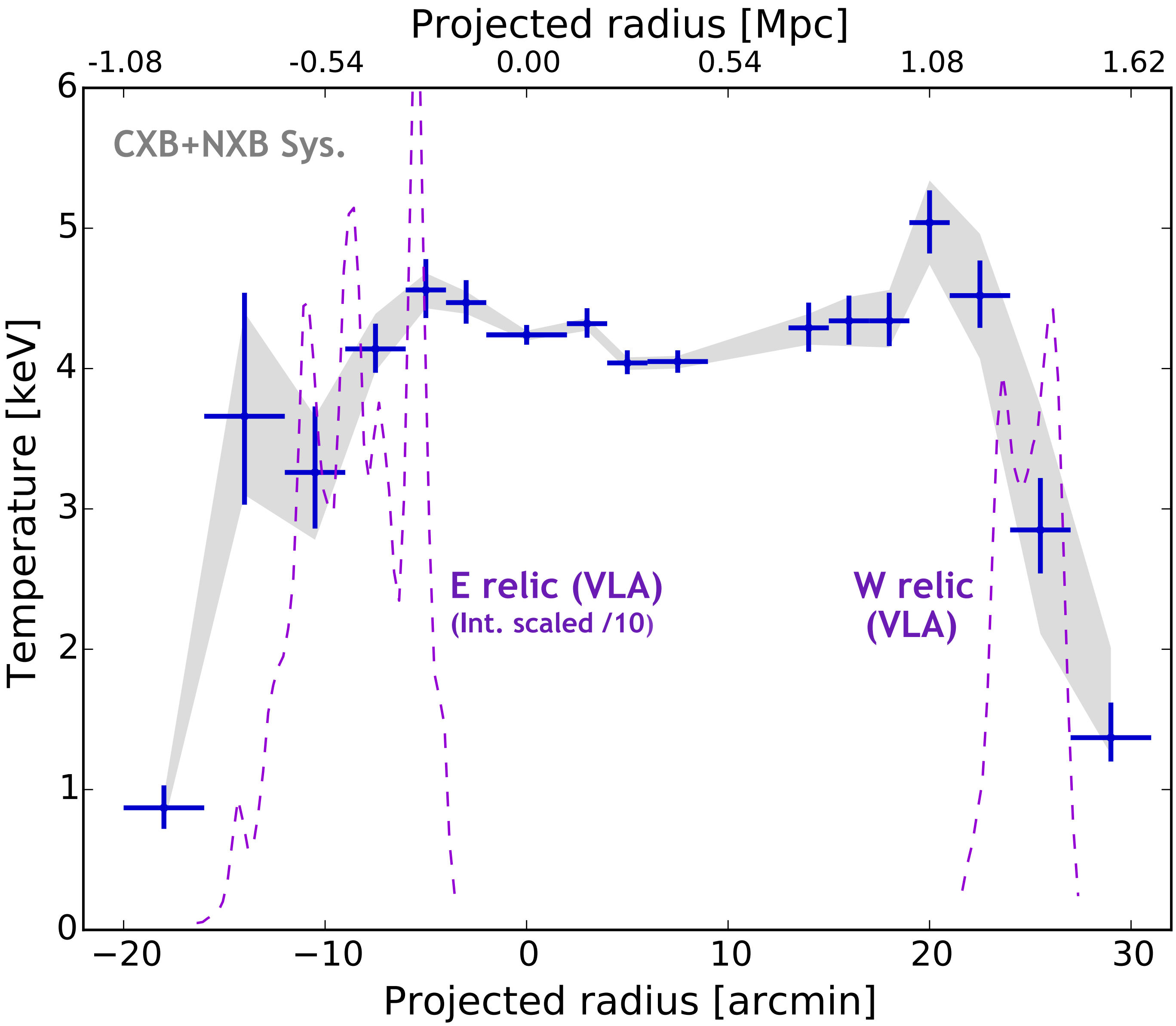
Eastern relic

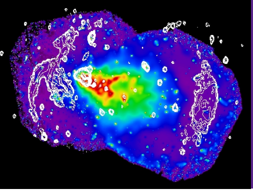


Western relic



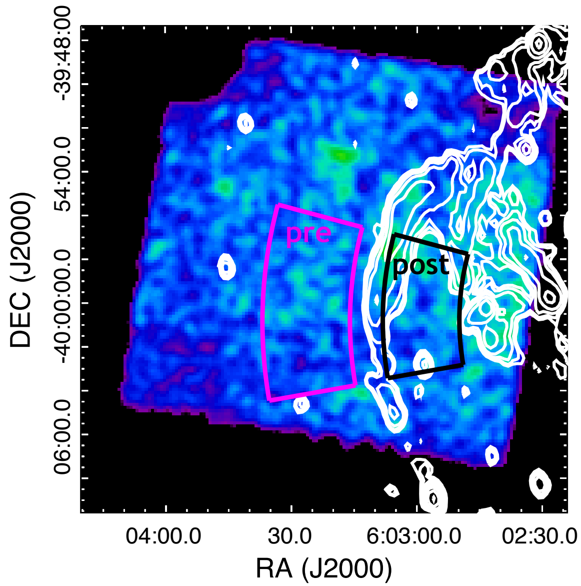
E & W T radial profile



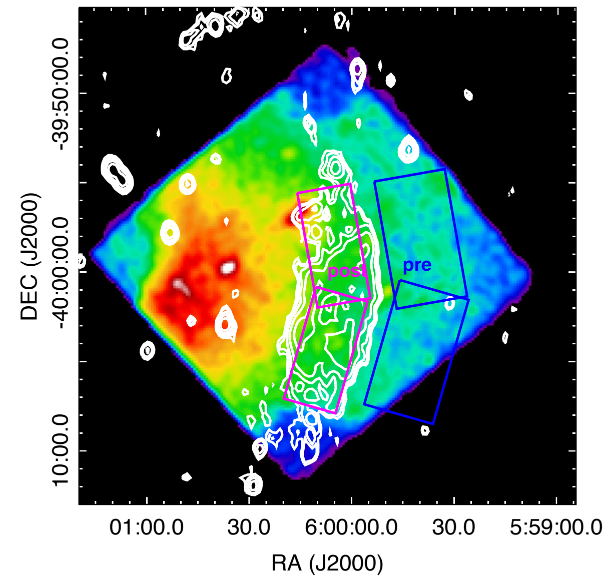


Pre and Post-shock regions

Eastern



Western



	kT (keV)
Post	$3.34^{+0.58}_{-0.47}$
Pre	$0.91^{+0.22}_{-0.17}$

$$\frac{T_{post}}{T_{pre}} = \frac{5\,M^4 + 14\,M^2 - 3}{16\,M^2}$$

	kT (keV)
Post	$4.22^{+0.29}_{-0.23}$
Pre	$1.27^{+0.36}_{-0.21}$

M_E ~ 3.00 ± 0.28

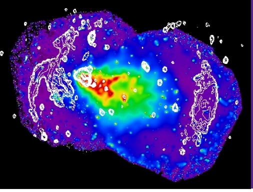
v_{sE} ~1416 ± 90 km

t_{core} ~ 0.6 Gyr

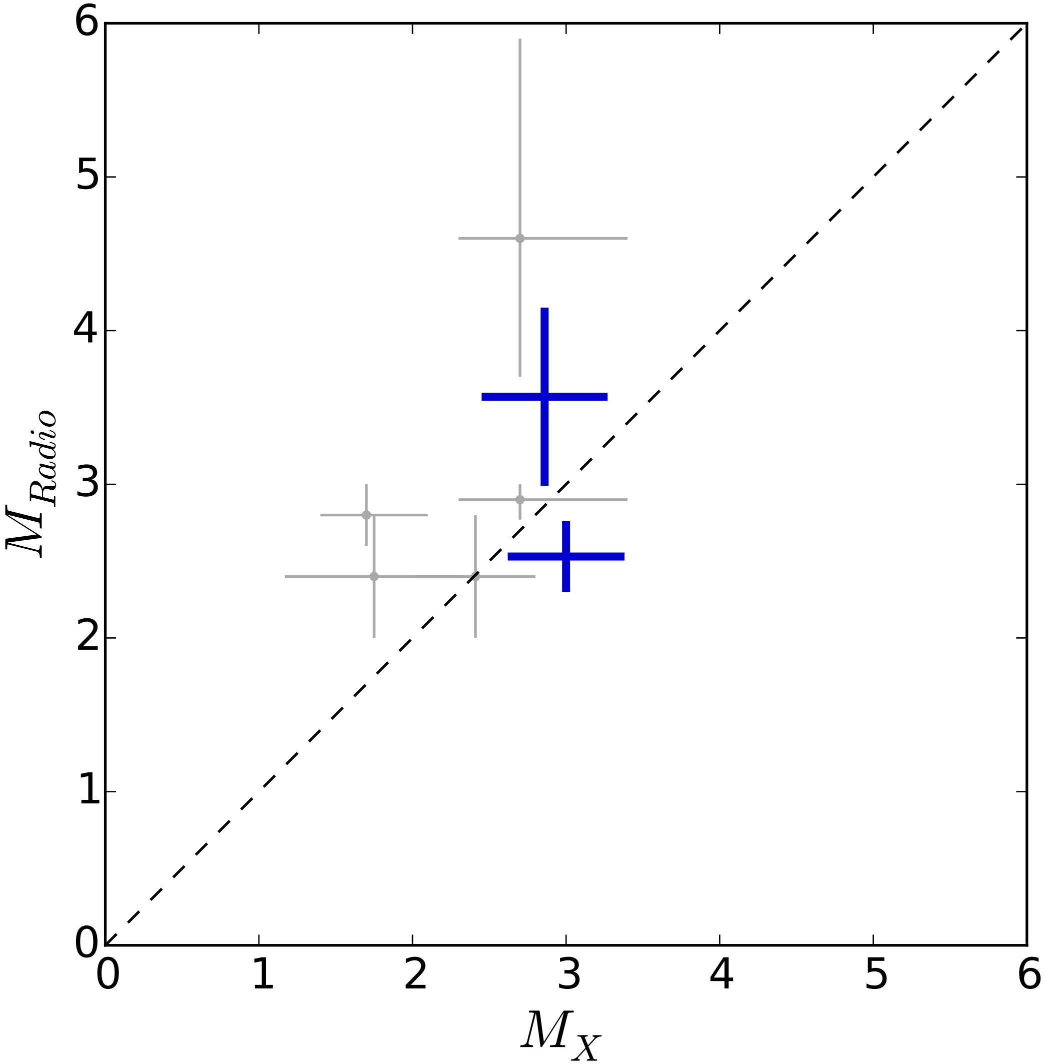
M_W ~ 2.86 ± 0.41

v_{sW} ~1827 ± 170 km

t_{core} ~ 0.6 Gyr



M from X-ray and radio

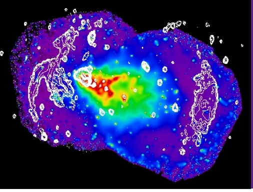


Reasons for M discrepancies:

1. **Clumpiness in ICM**
   (Nagai & Lau 2011; Simionescu et al. 2011)
2. **Projection effects**
   (Skillman et al.2013; Hong et al. 2015)
3. **Re-acceleration pre-existing e⁻**
   (Markevitch et al. 2005; van Weeren et al. 2017)

$$M_{radio} = \frac{2\alpha + 3}{2\alpha + 1}$$

Kale et al. 2012/This work
Akamatsu et al. 2015



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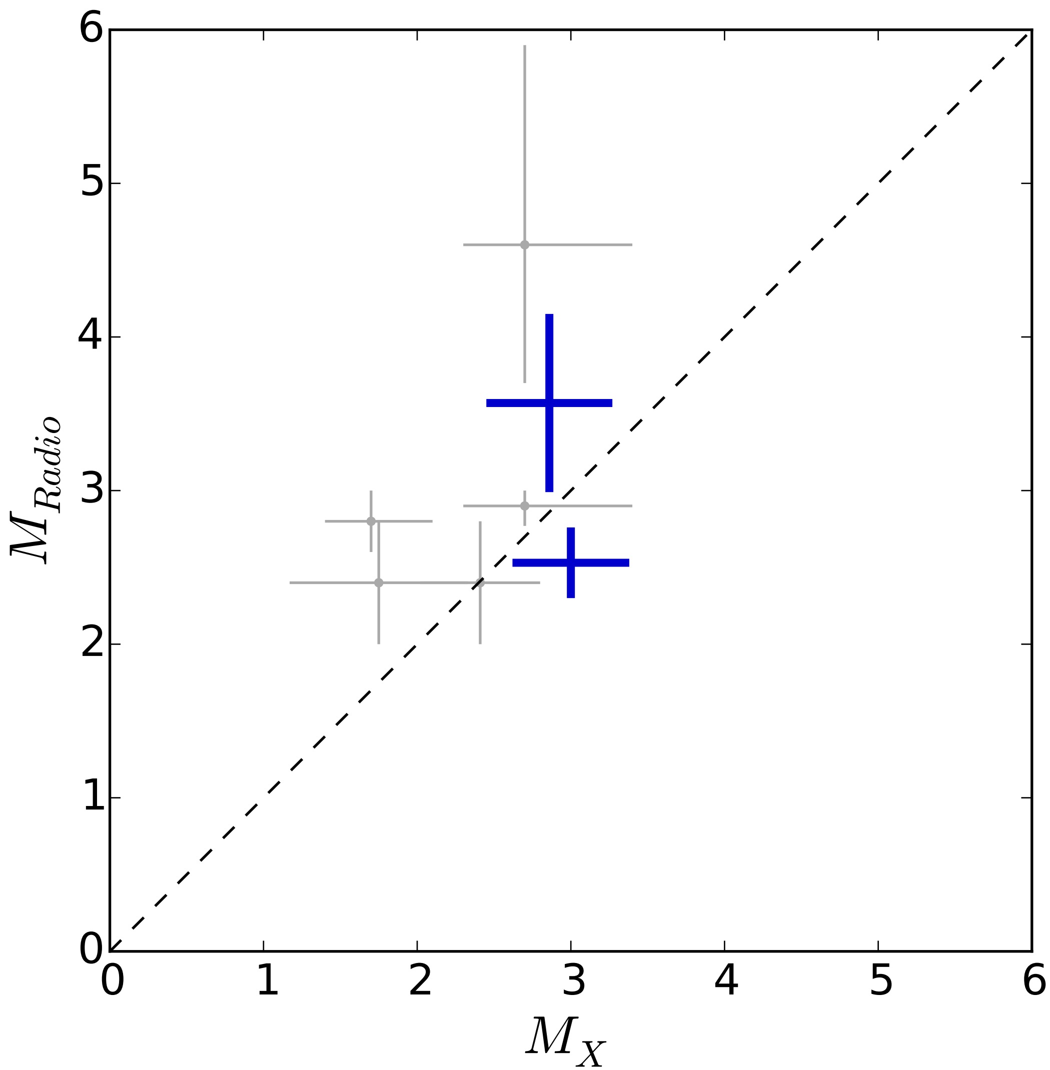

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Low-fr. and high-resolution radio observations needed

Kale et al. 2012/This work
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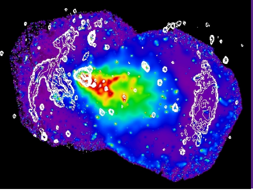

Summary

- X-ray shock front confirmed at Western and preliminary evidences at Eastern relic with a M~3.

- Shocks velocities are ~2000 km/s for W and ~1500 km/s for E and t_{core}~ 0.6 Gyr.

- Low-frequency and high-resolution LOFAR radio observations needed.