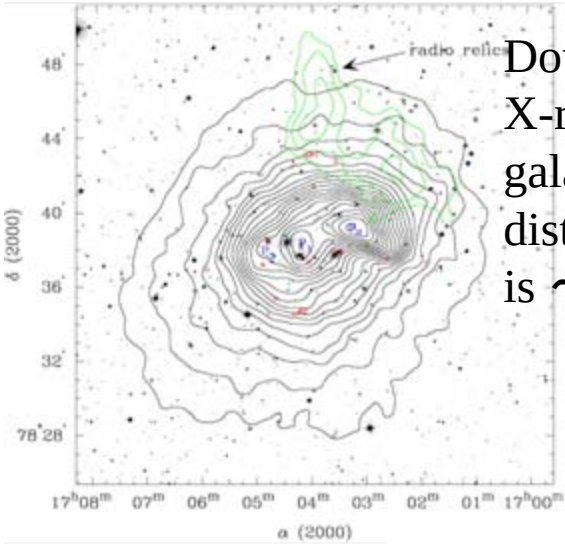
Suzaku Measurements of Gas Bulk Motions in a Galaxy Cluster

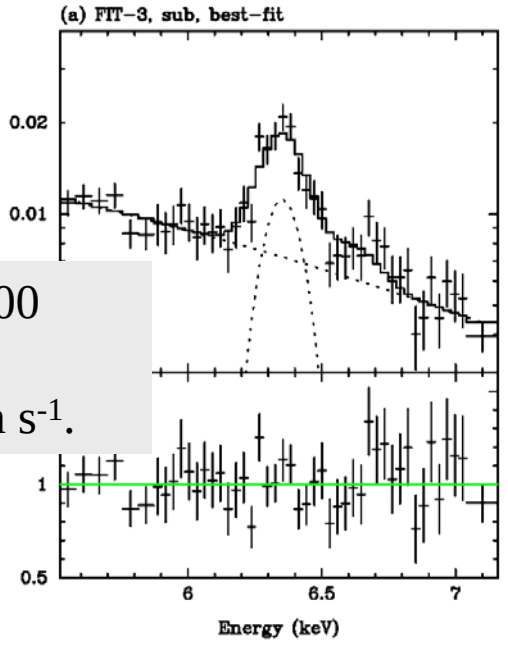
Takayuki Tamura
(ISAS/JAXA)
In collaboration with
K. Hayashida,
S. Ueda, and M. Nagai
(Osaka)

Summary

- X-ray Doppler mapping of the ICM is a next major step to study the cluster dynamics.
- Suzaku observation of the merging system A2256 demonstrated this.
- A significant shift of the redshift of the sub component was detected. The gas moves is pair with galaxies.
- Bulk motions and turbulences will be measured by the ASTRO-H (SXS). IXO should go distant universe to catch the evolution of cluster formation.



Double peaked in X-ray image and galaxy velocity distribution Δv is $\sim$ 2000 km s^{-1}.



X-ray: Δv=1500 $\pm$300(sta.) $\pm$300(sys.) km s^{-1}.

A simulation of the Bullet cluster

Simulation by John Wise of the Kavli Institute for Particle Astrophysics and Cosmology.

dark matter (blue)

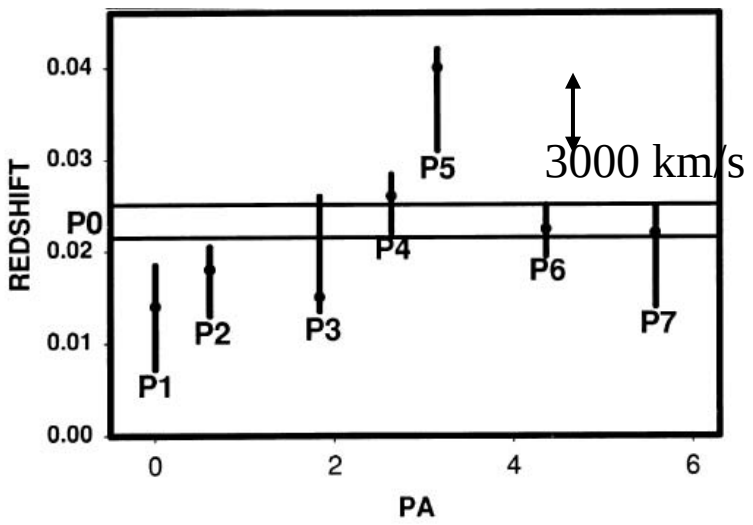
luminous matter (red)

Dynamical motion of the ICM

- X-ray imaging have shown cluster dynamics in the plane of the sky.
- No direct measurement of the gas motion.

Credit: X-ray: NASA/CXC/CfA/M.Markevitch et al.; Optical: NASA/STScI; Magellan/U.Arizona/D.Clowe et al.; Lensing Map: NASA/STScI; ESO WFI; Magellan/U.Arizona/D.Clowe et al.

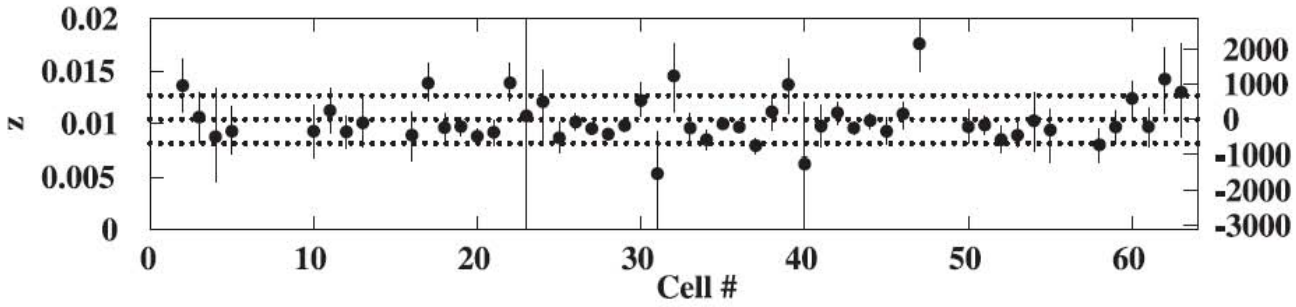
Previous Attempts

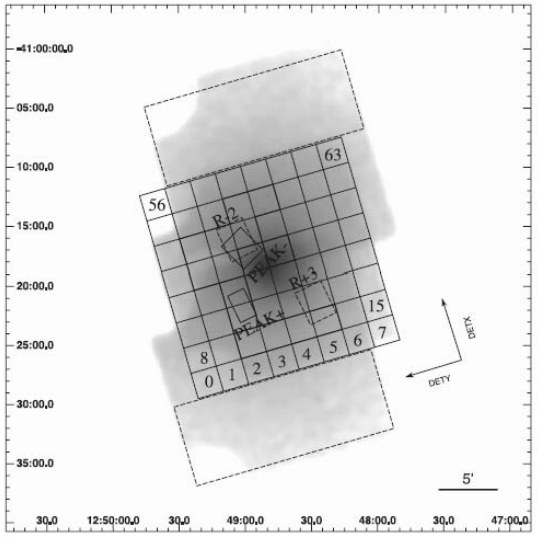


ASCA

Perseus: Dupke and Bregman (2001) claimed 4100 (+2200, -3100) km/s, but not confirmed by later study (Ezawa et al. 2001)

Centaurs: Dupke and Bregman (2001) claimed 1600 ± 320 km/s, but not confirmed by Suzaku

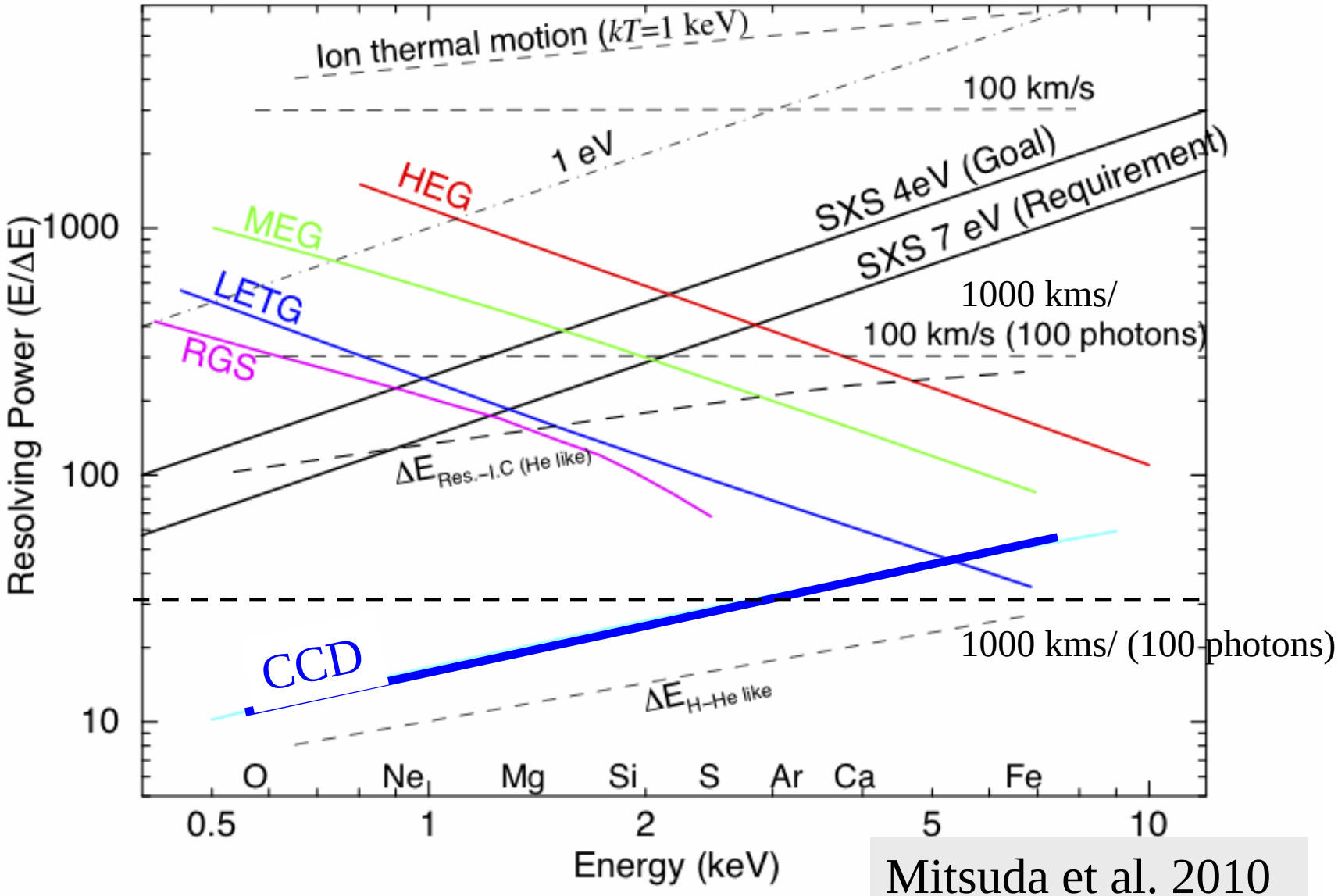




Suzaku Limits

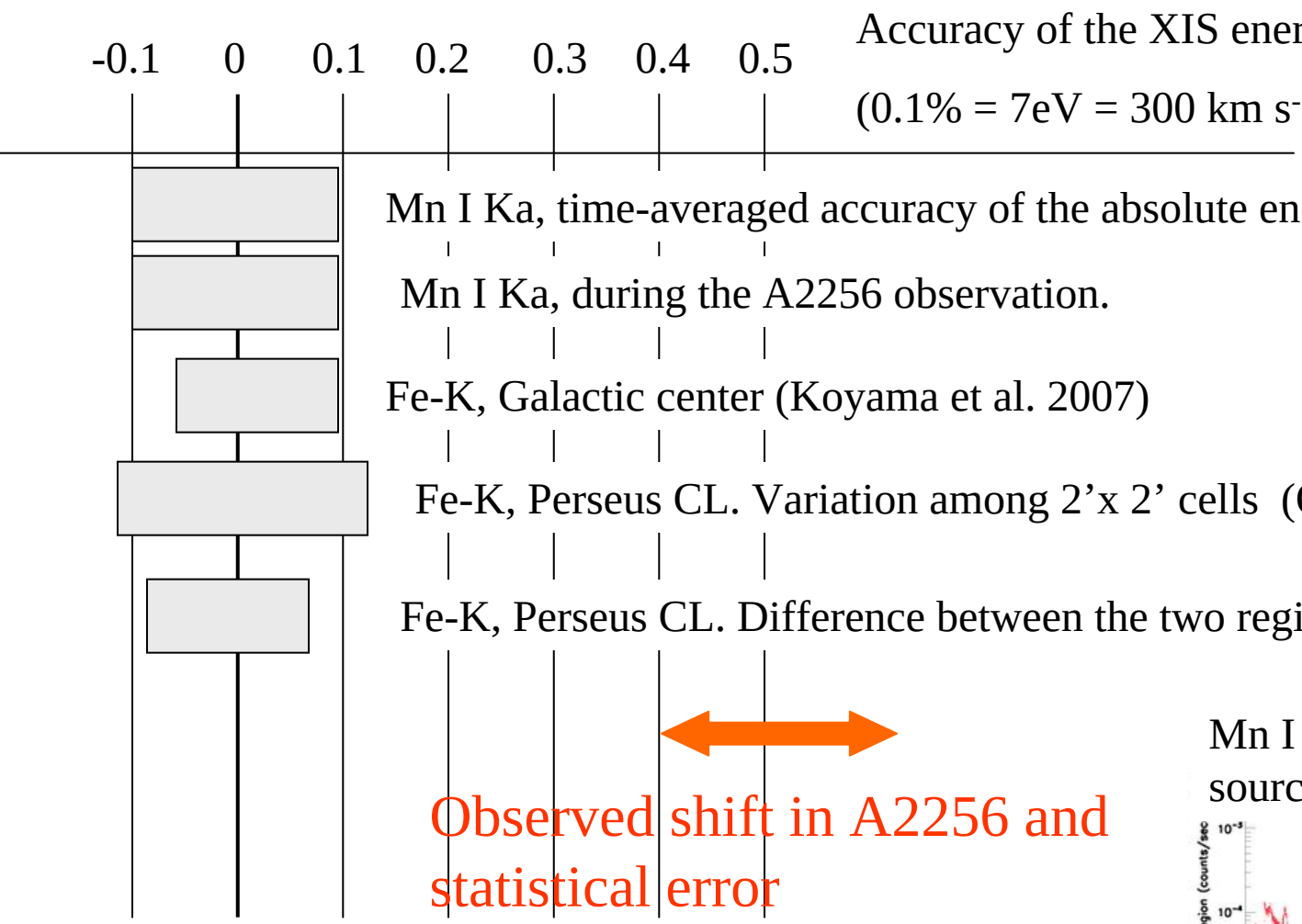
- Centaurus: $\Delta v < 1400$ km/s (Ota et al. 2007)

Spectral Resolution and Features

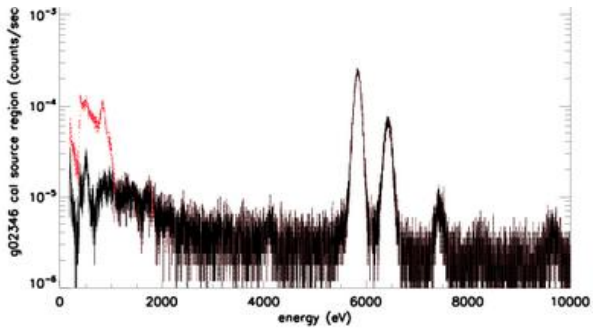


Mitsuda et al. 2010

Suzaku XIS energy gain calibration

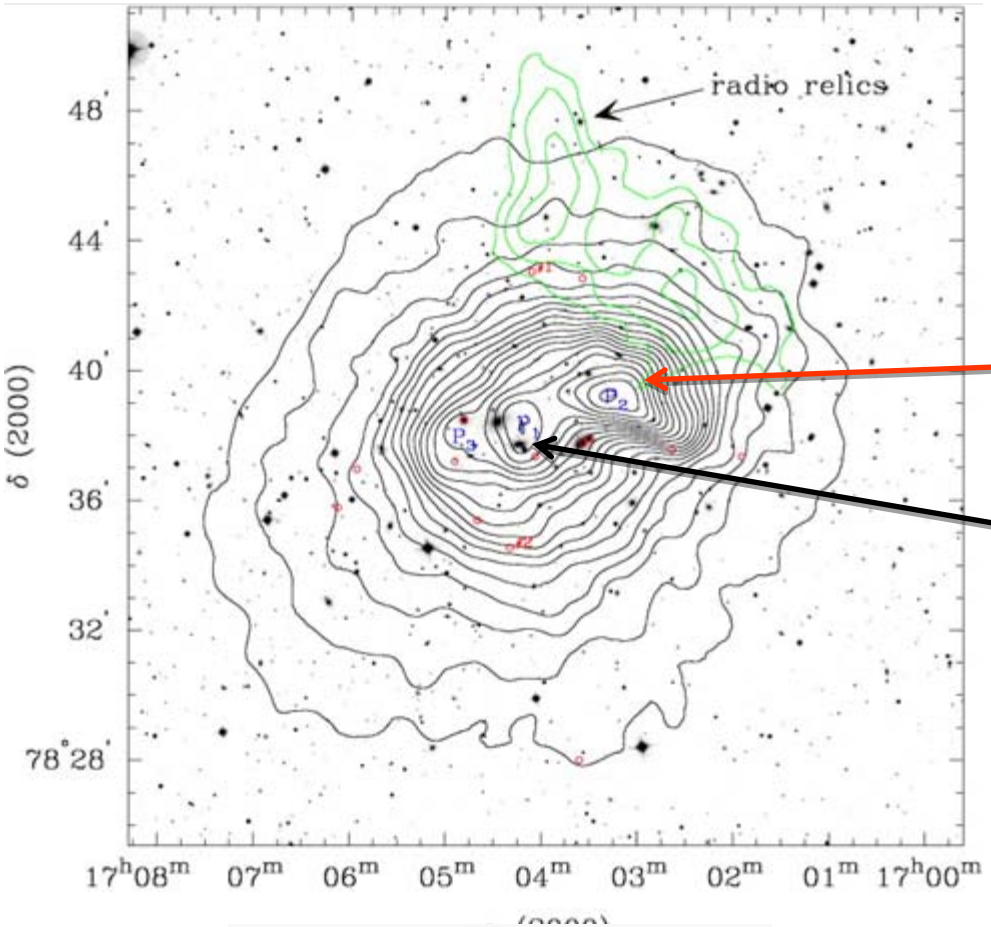


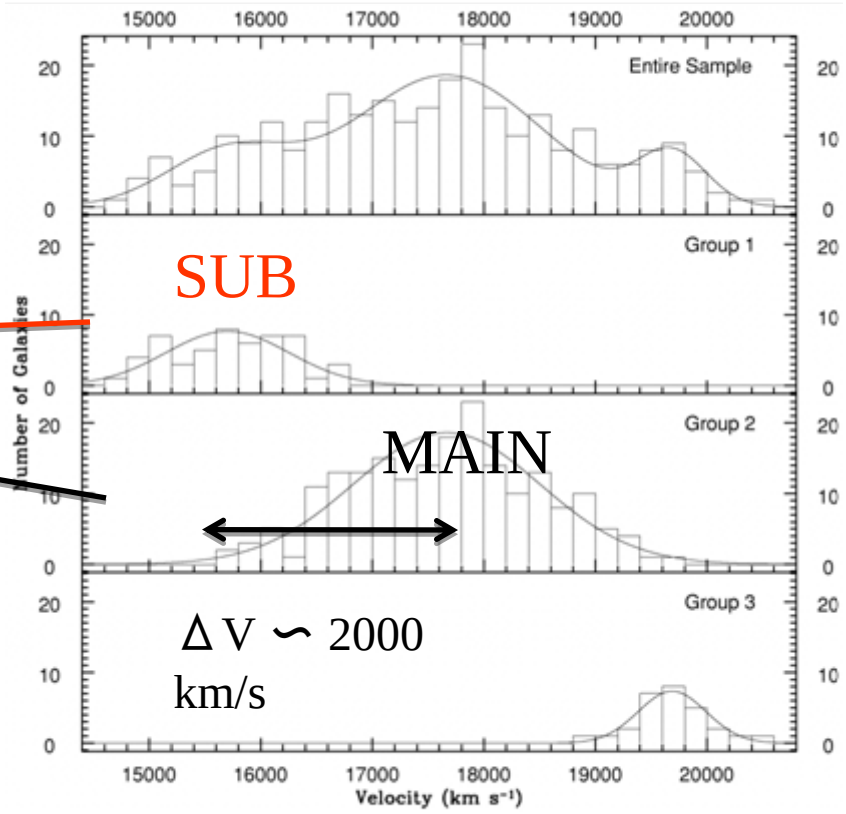
Mn I K lines from the Cal. source



Good calibration is a key

A2256, X-ray bright, double peaked merging cluster





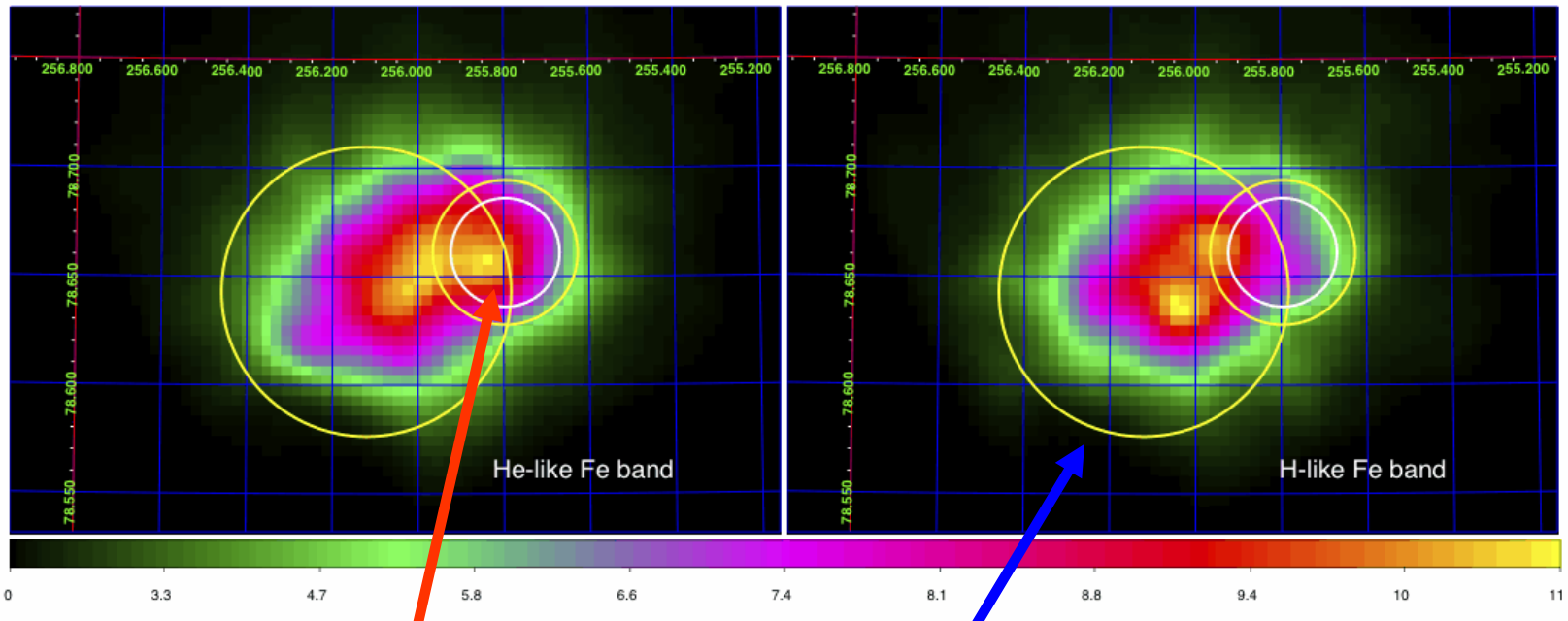
Sun et al. 2002 (Chandra)

Berrington et al. 2002 (galaxy radial velocities)

Suzaku Fe-line Image of A2256 (1)

He-like Fe band

H-like Fe band

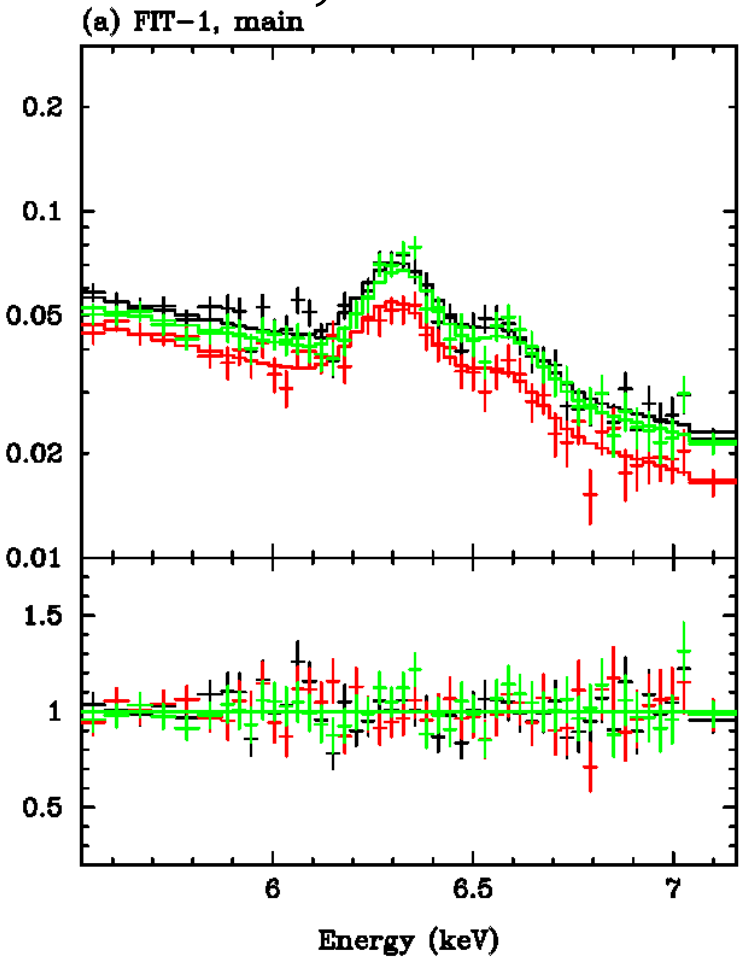


Sub, cooler

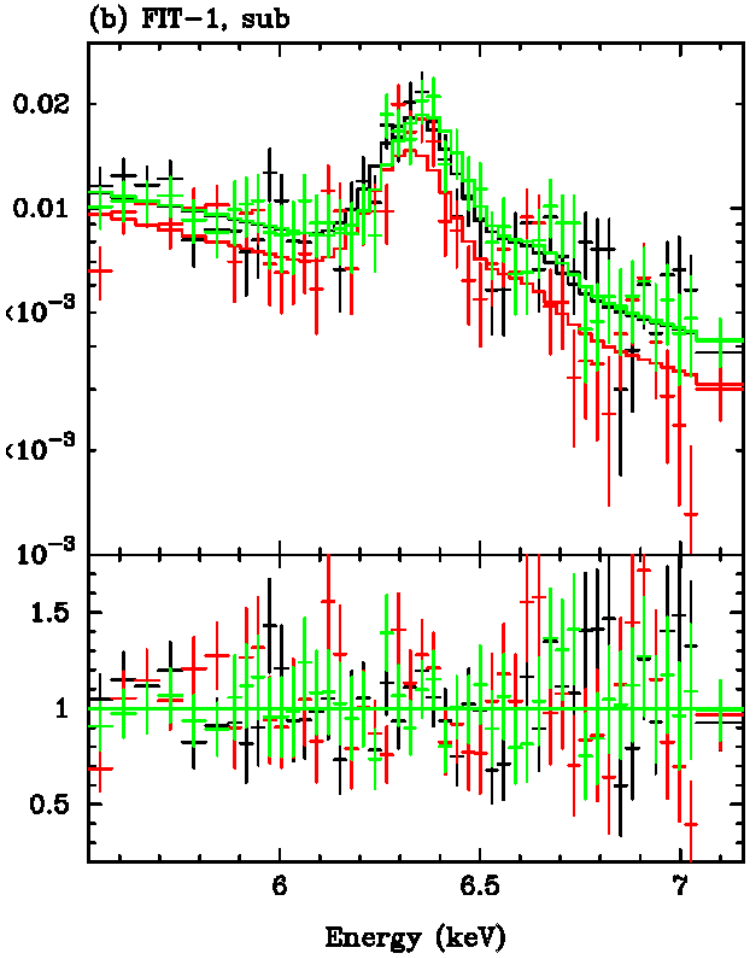
Main

Suzaku Results on A2256 (2)

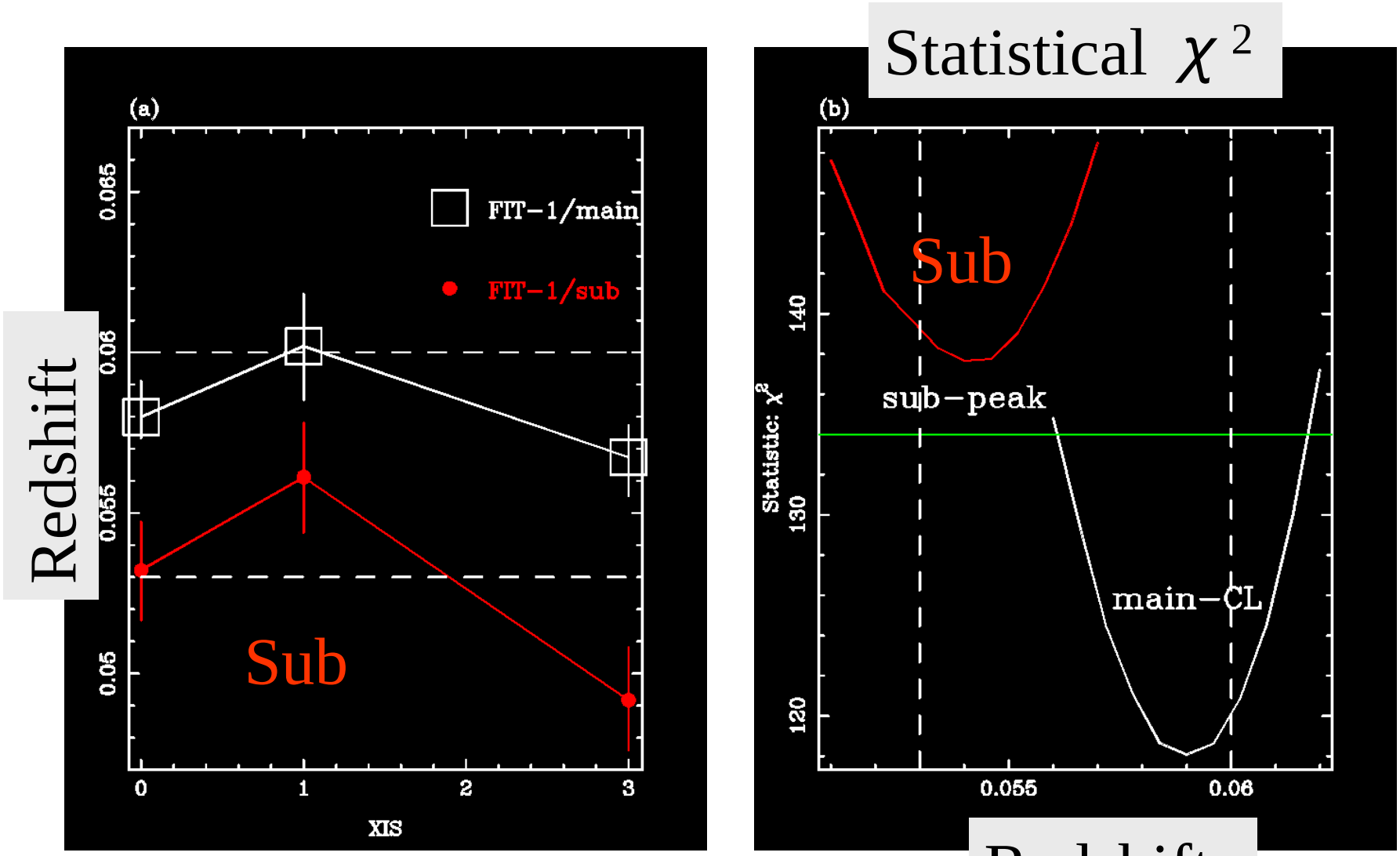
Main, 7.1 keV



Sub, 5.0 keV



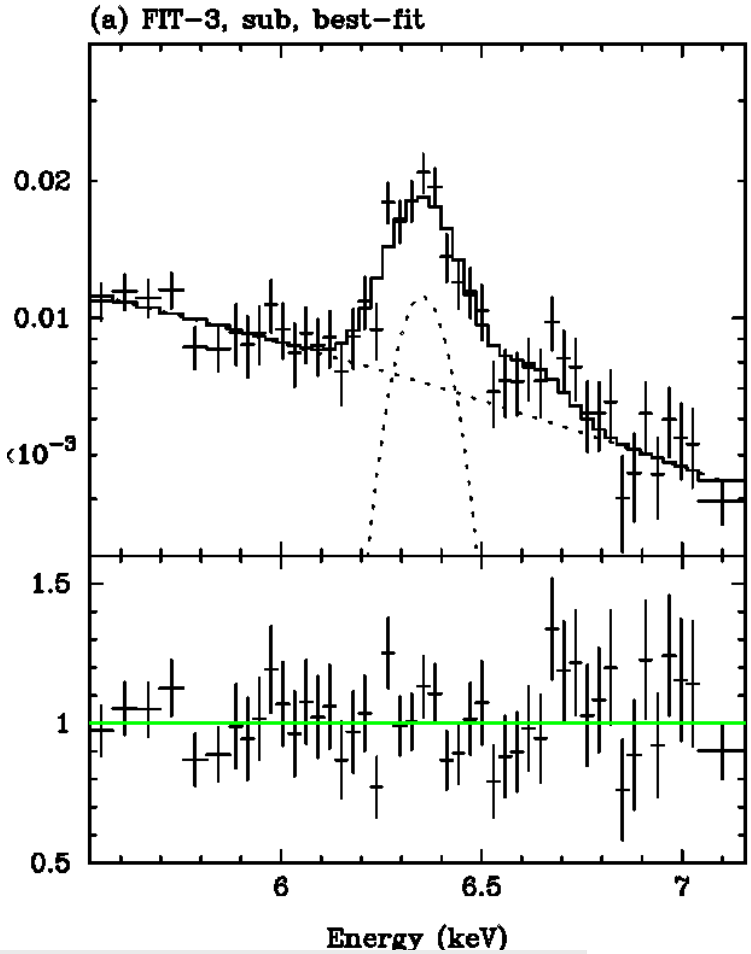
Redshifts from X-ray and Optical

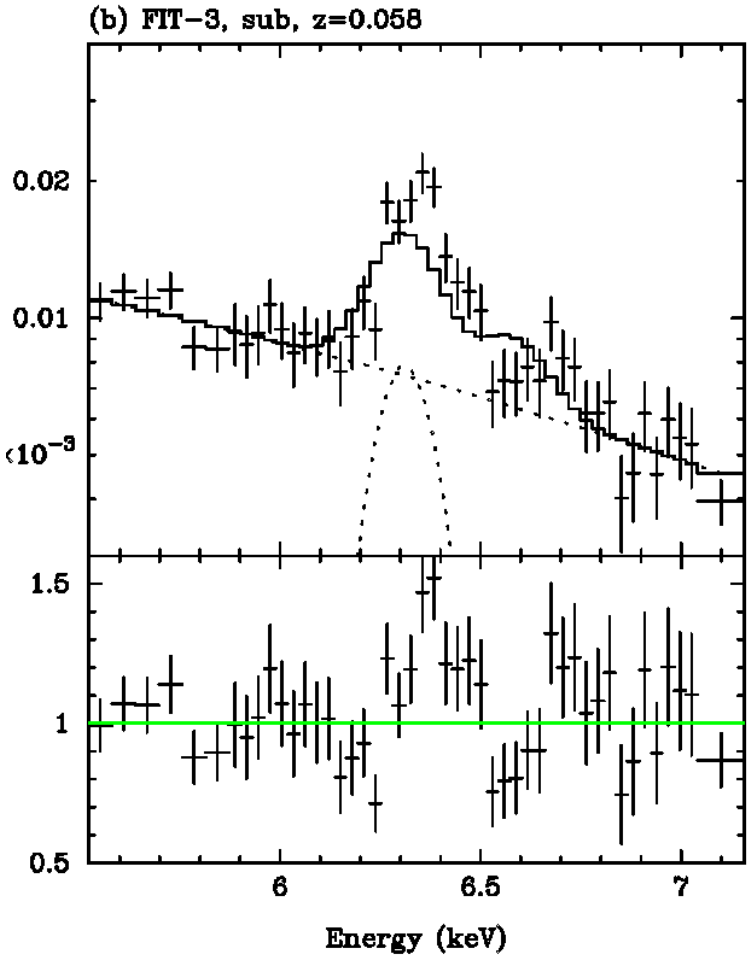


Sub Region Spectra

Best fit redshit

Δv fixed to 0





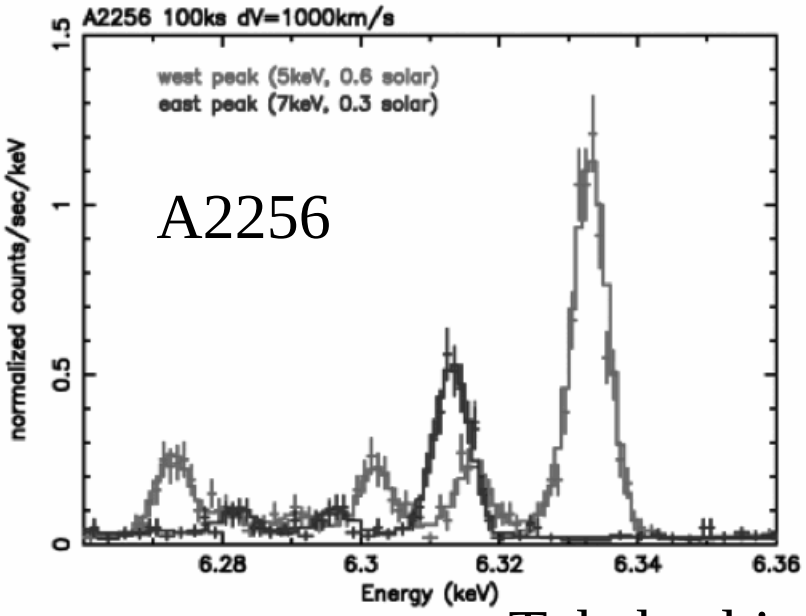
χ^2/dof = 40.4/42

χ^2/dof = 80.8/43

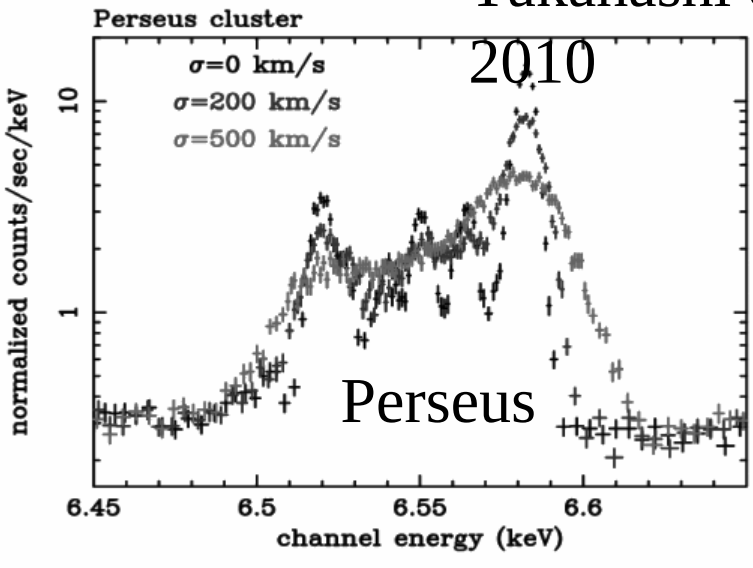
Suzaku, ASTRO-H, and IXO Spectrometers

		Suzaku XIS	ASTRO-H SXS (best estimate)	IXO XMS
Effective Area	cm^2 @ 7 keV	460	220	6000
FOV		18’ x 18’	3’ x 3’	5’ x 5 ’
Spatial Resolution,	HPD	120”	90”	5”
Energy Resolution	$E/\Delta E$ @ 7 keV	50	1000	3000

ASTRO-H (Soft X-ray Spectrometer)



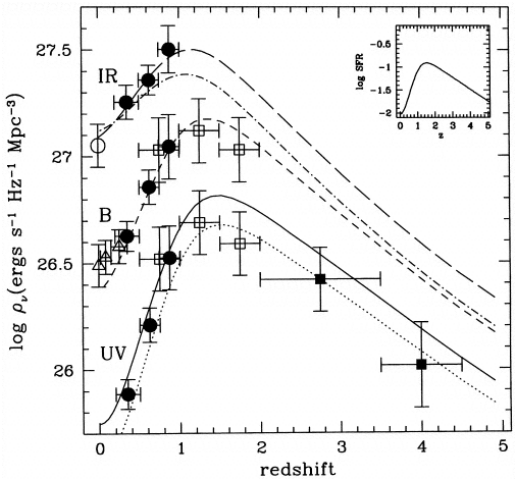
Takahashi et al. 2010

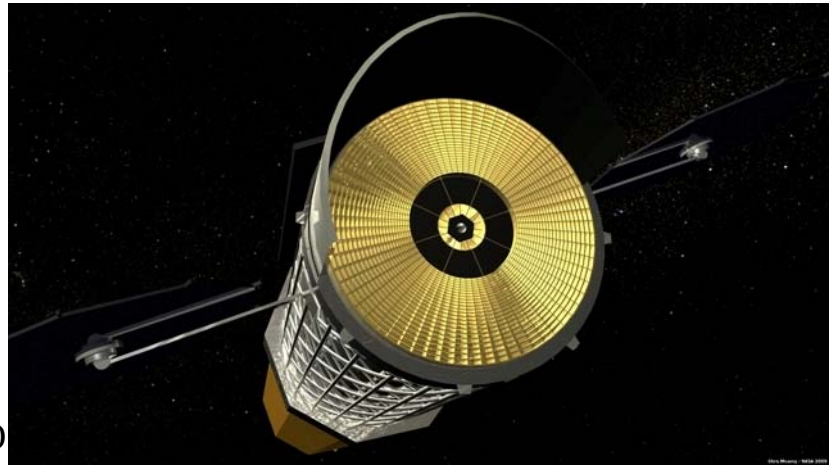


- Systematic measurements of the bulk motions in nearby clusters.
- Detect and locate the gas turbulence.
- Combined with hard X-ray imaging, gas dynamics, particle acceleration, shocks and non-thermal processes will be investigated.

IXO

- Separation of ion temperature from the gas motion in the line profile.
- Detailed velocity fields in nearby clusters.
- Go distant universe (z ∼ 2) and constrain evolution of the gas dynamics and study history of complex interplay among gas, galaxies, and dark matter.





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