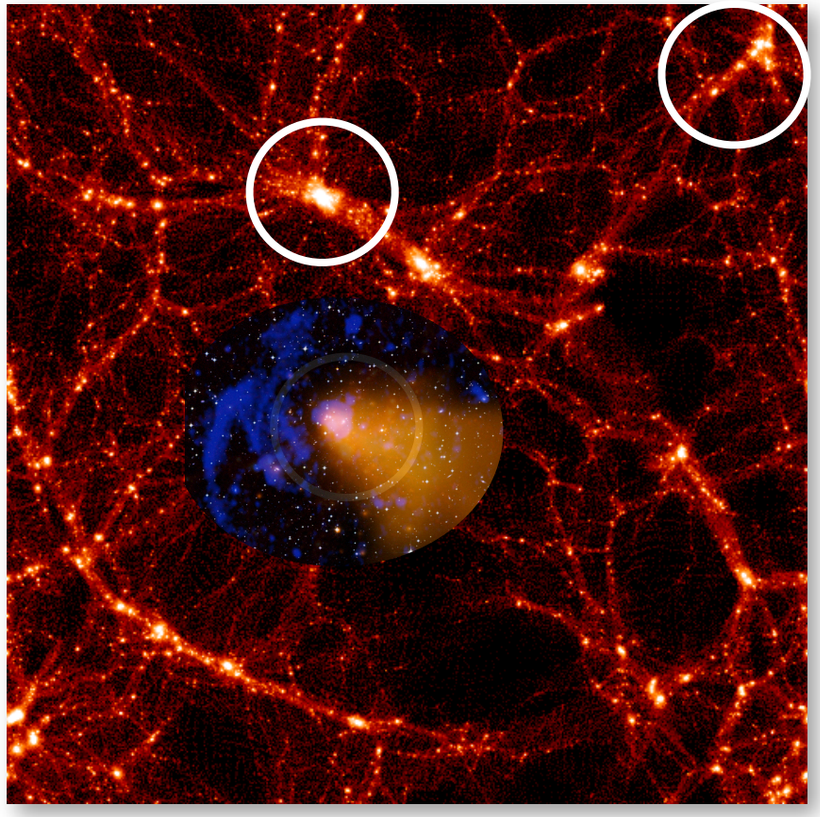
Diffuse radio sources in galaxy clusters



Chiara Ferrari

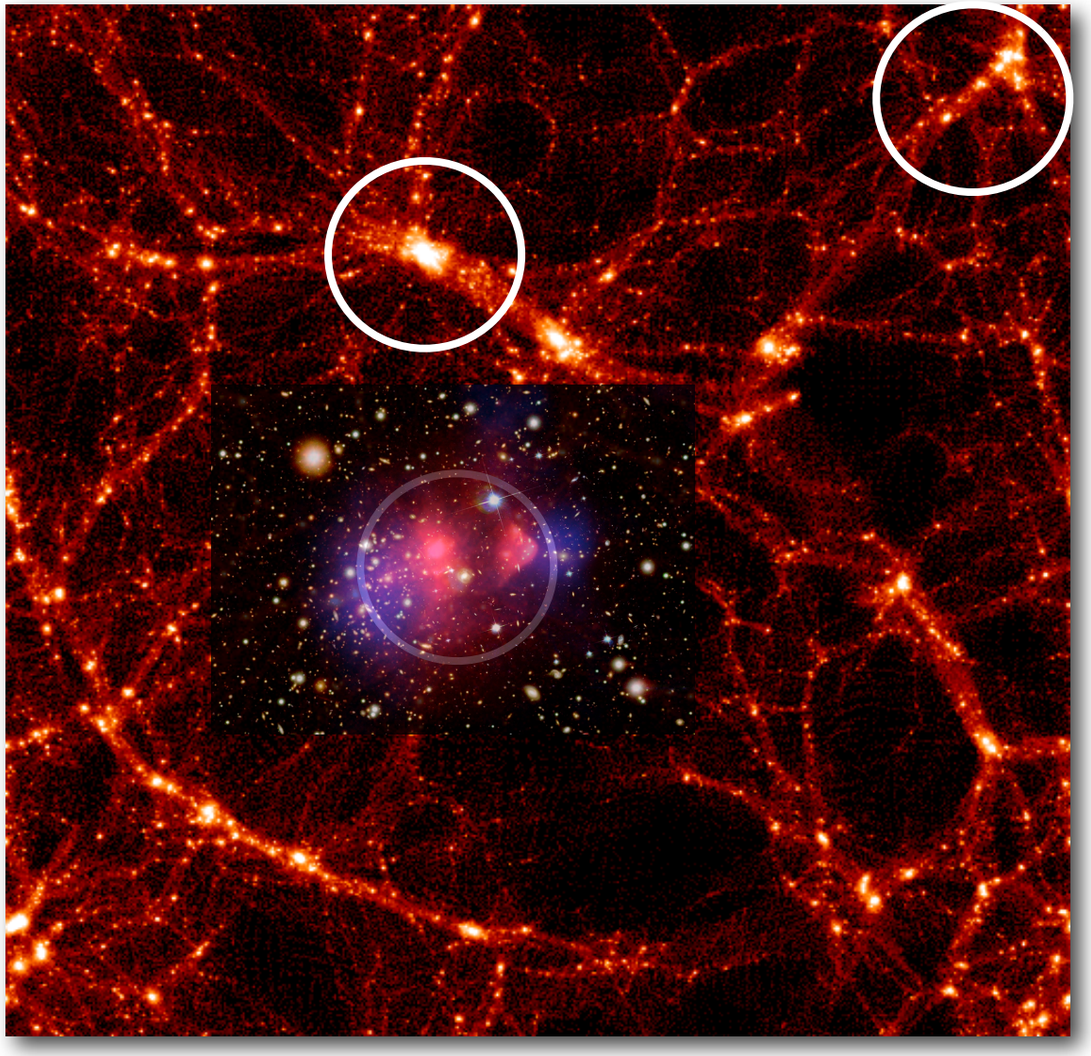
LAGRANGE

Observatoire de la CÔTE d'AZUR

Université Nice Sophia Antipolis

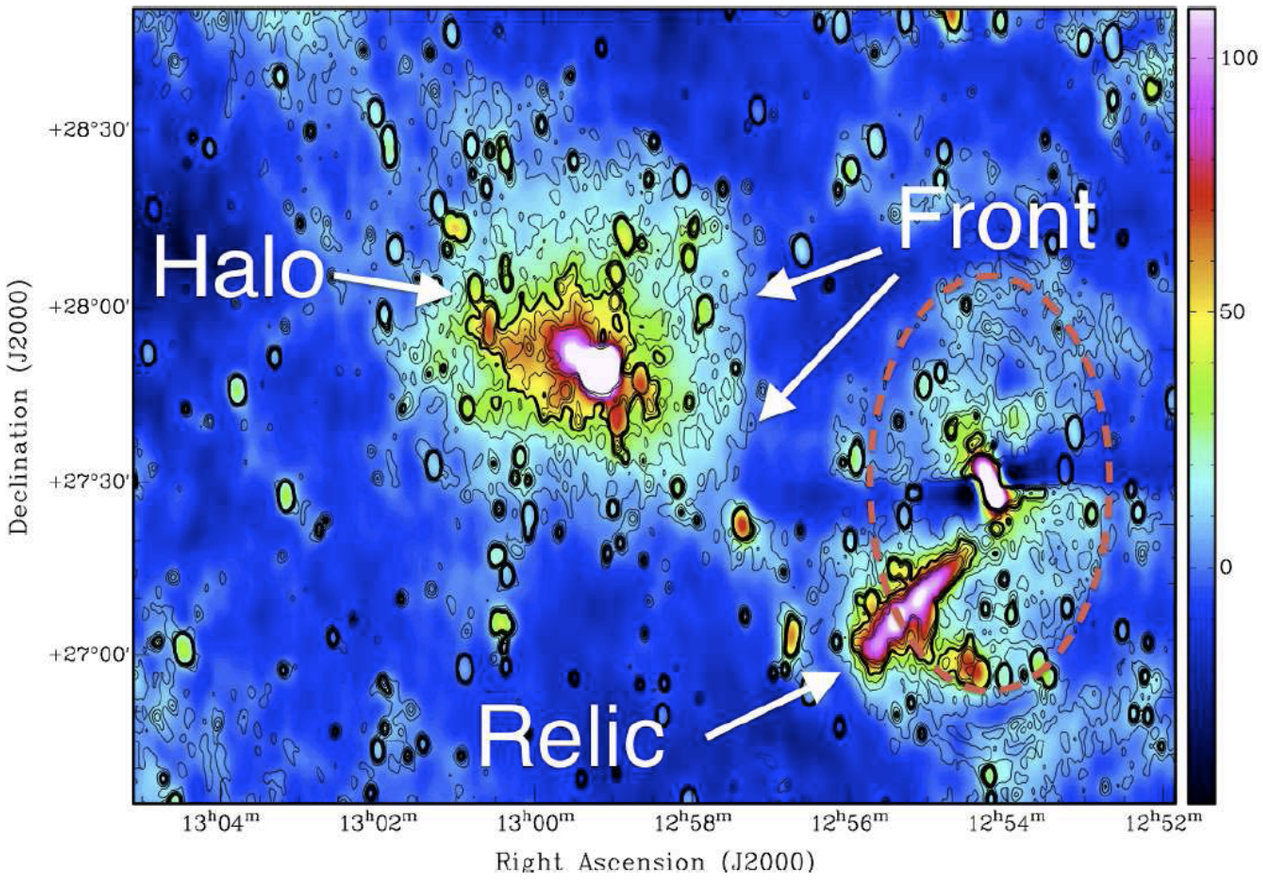
Scaling relations:
from observable to cluster mass

$$
\begin{aligned}
M_{cluster} \quad &\propto \boxed{M_{gas}} \\
&\propto \boxed{T^{3/2}} \quad \textbf{X-rays} \\
&\propto \boxed{L_X^{3/4}} \\
&\propto \boxed{L_{optical}} \\
&\propto \boxed{\sigma^2_{v,gal}} \quad \textbf{Optical} \\
&\propto \boxed{Y^{3/5}_{SZE}} \quad \textbf{Sub-mm}
\end{aligned}
$$



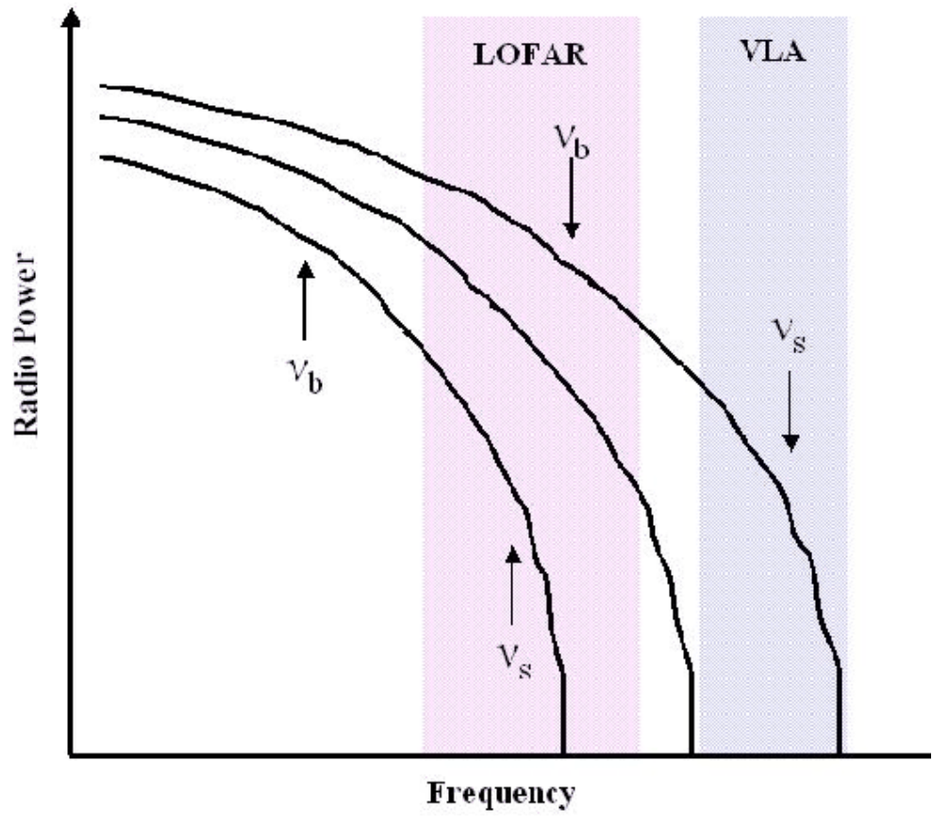
Observables → Galaxy cluster physics comprehension → Mass

Galaxy cluster physics &
Importance of non-thermal studies



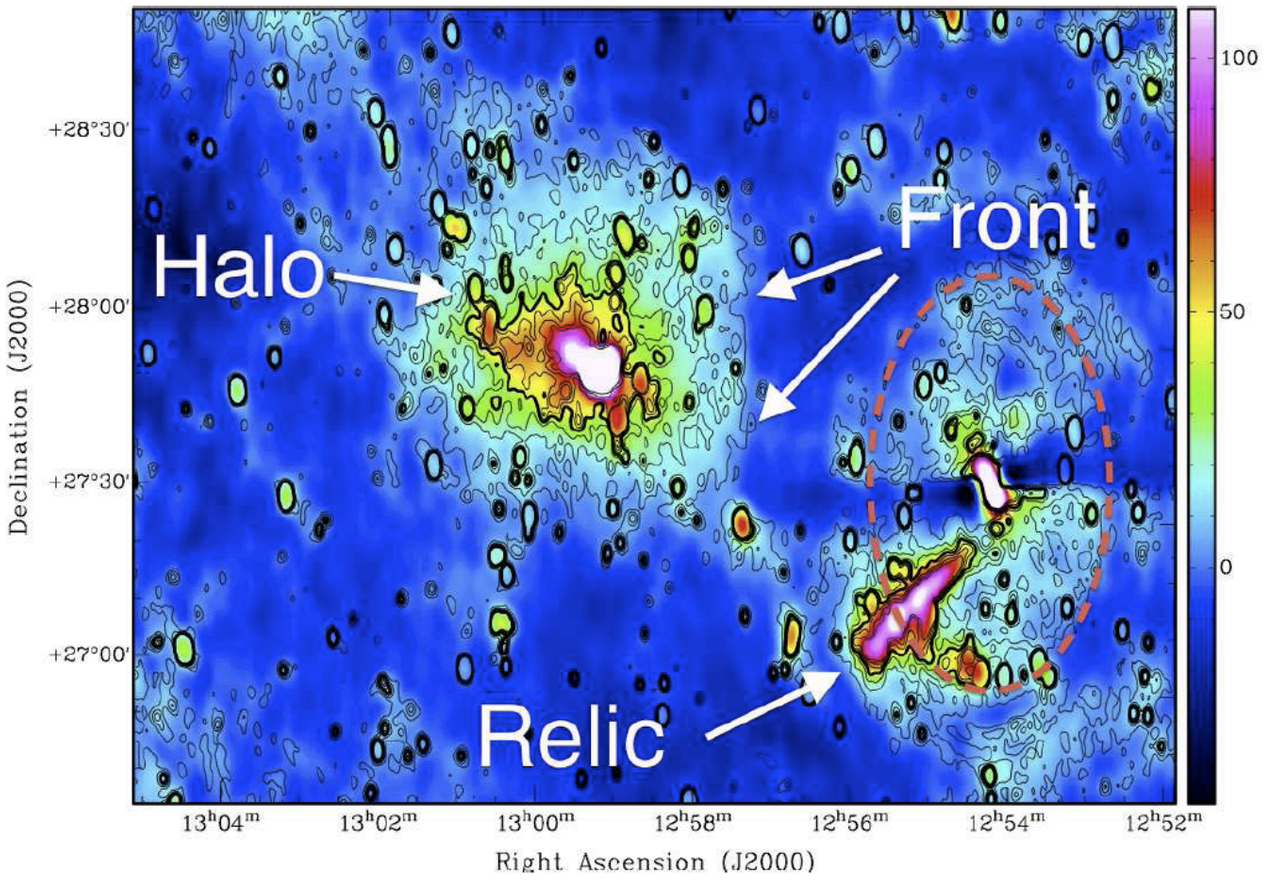
The Coma cluster observed at 352 MHz with WSRT (resolution: 135" x 68")

Brown & Rudnick+ 11



Cassano+ 11

Galaxy cluster physics & Importance of non-thermal studies



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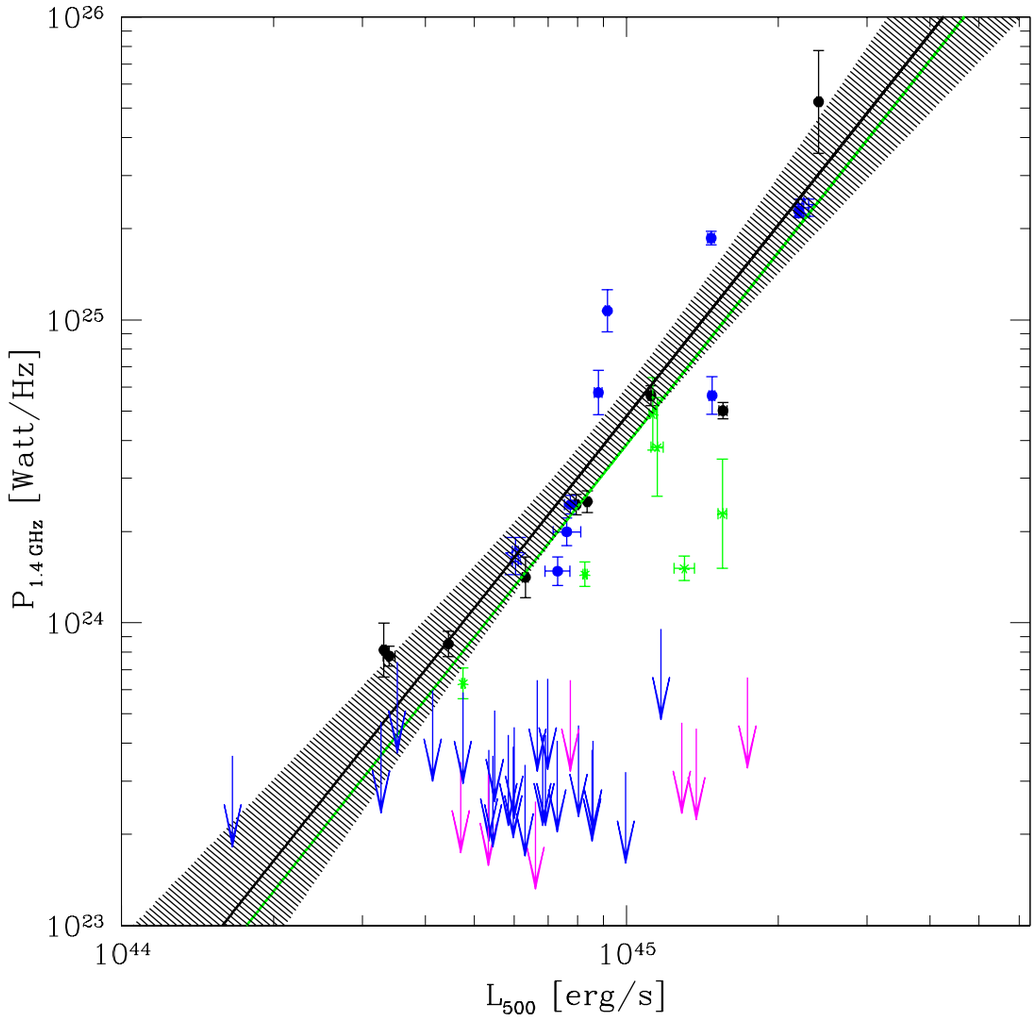
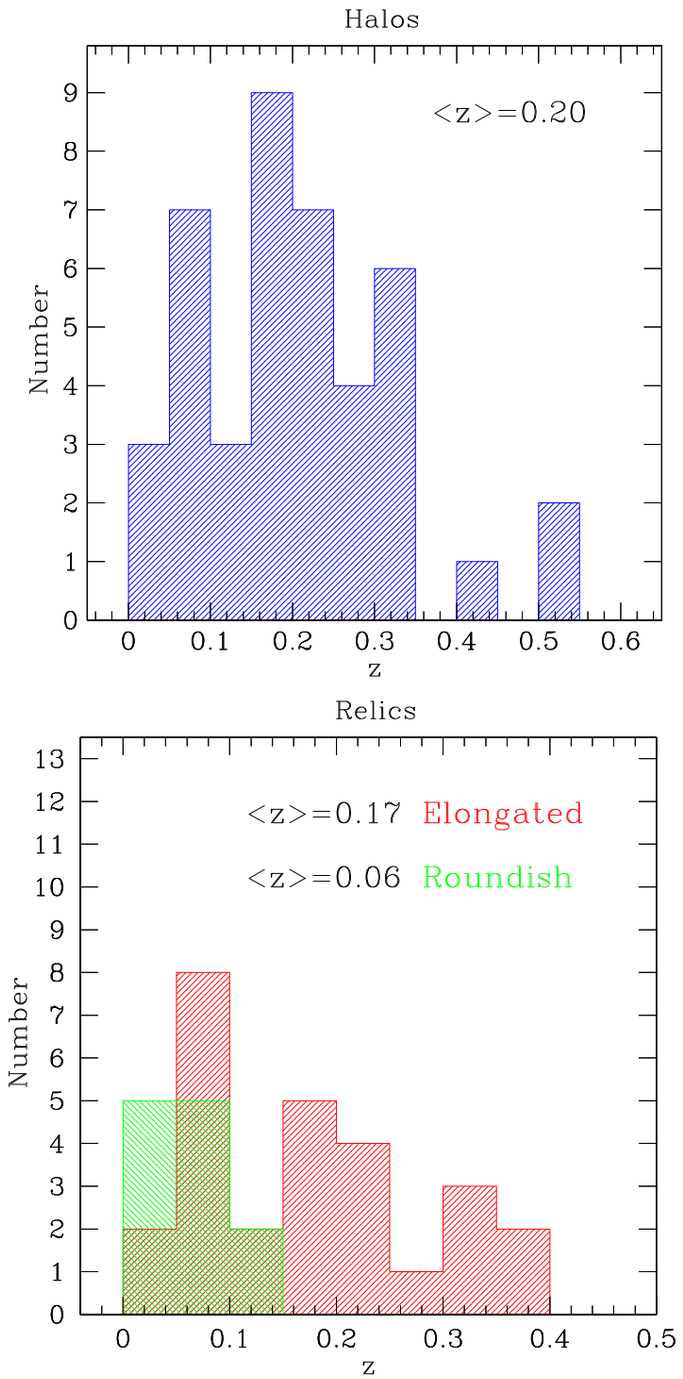
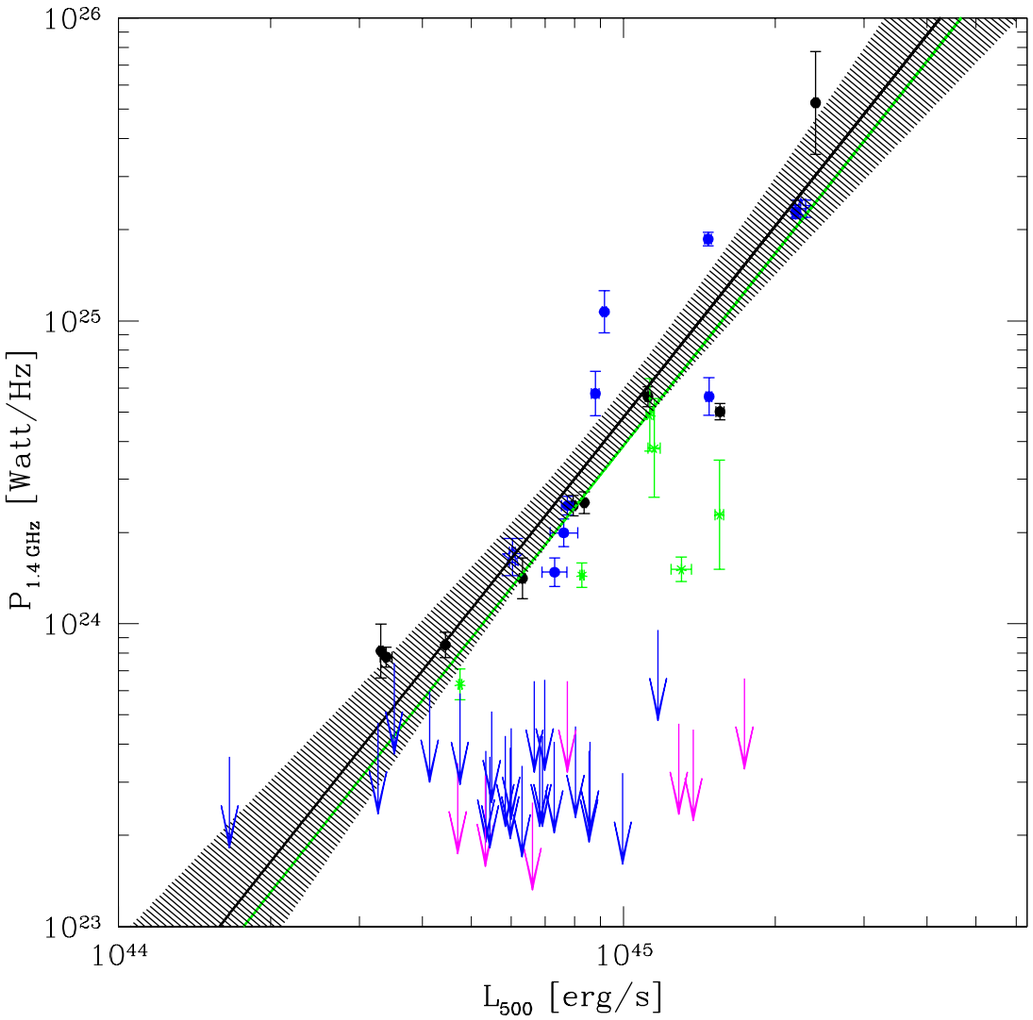


Cassano+ 13

Galaxy cluster physics & Importance of non-thermal studies

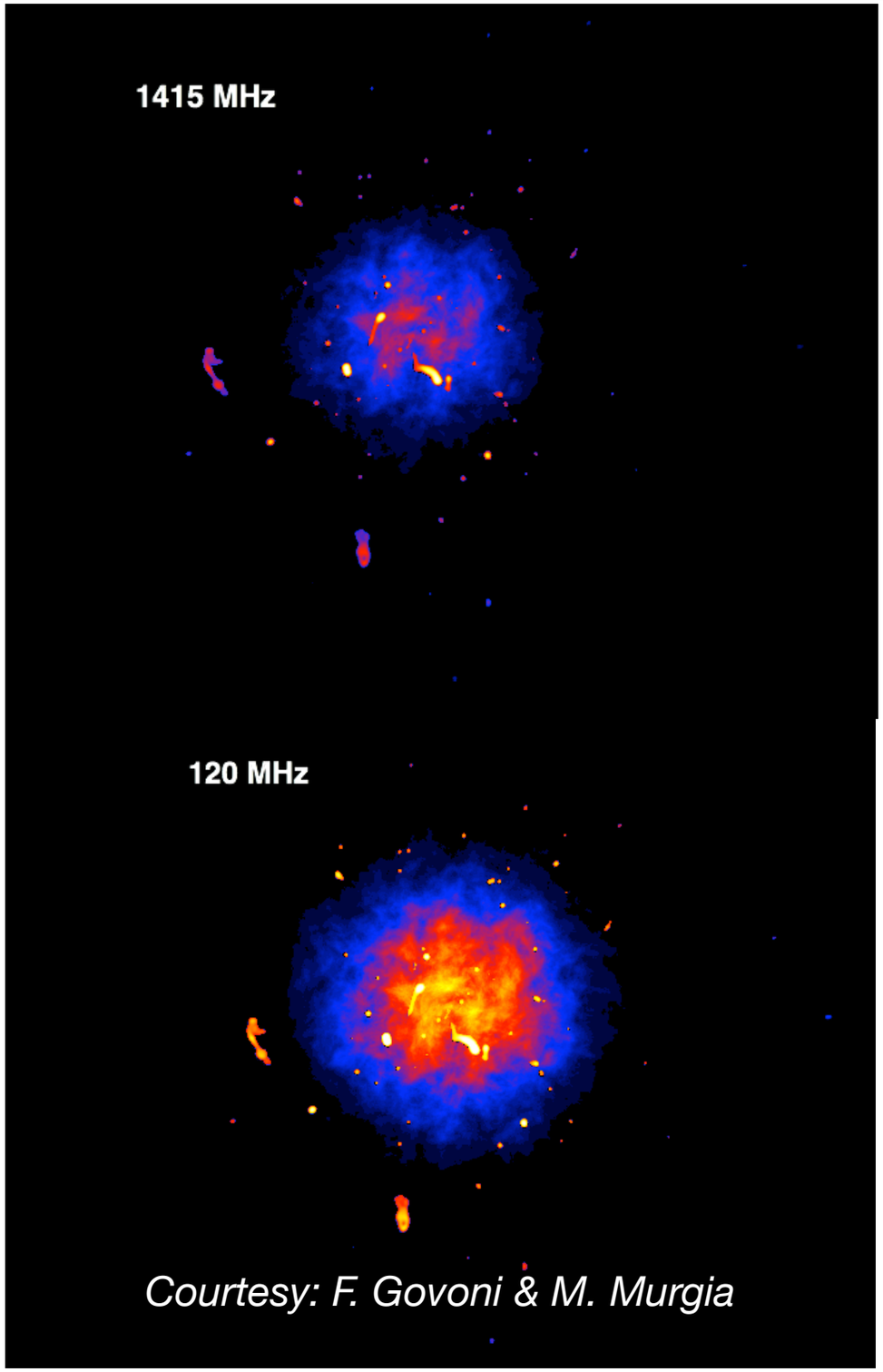


Feretti+ 12



Cassano+ 13

Modeling diffuse radio sources in clusters



Courtesy: F. Govoni & M. Murgia

Relativistic electron population

(γ_{min}, γ_{max}, $\alpha_{injection}$)

Magnetic field model

($<\mathbf{B}>_0$, $<\mathbf{B}>(r)$, $|B_k|^2 \propto k^{-n}$, Λ_{min} & Λ_{max} with $\Lambda \propto 1/k$)

Equipartition → Emissivity → Brightness

↓

2.4×10^{25} W/Hz @ 1400 MHz

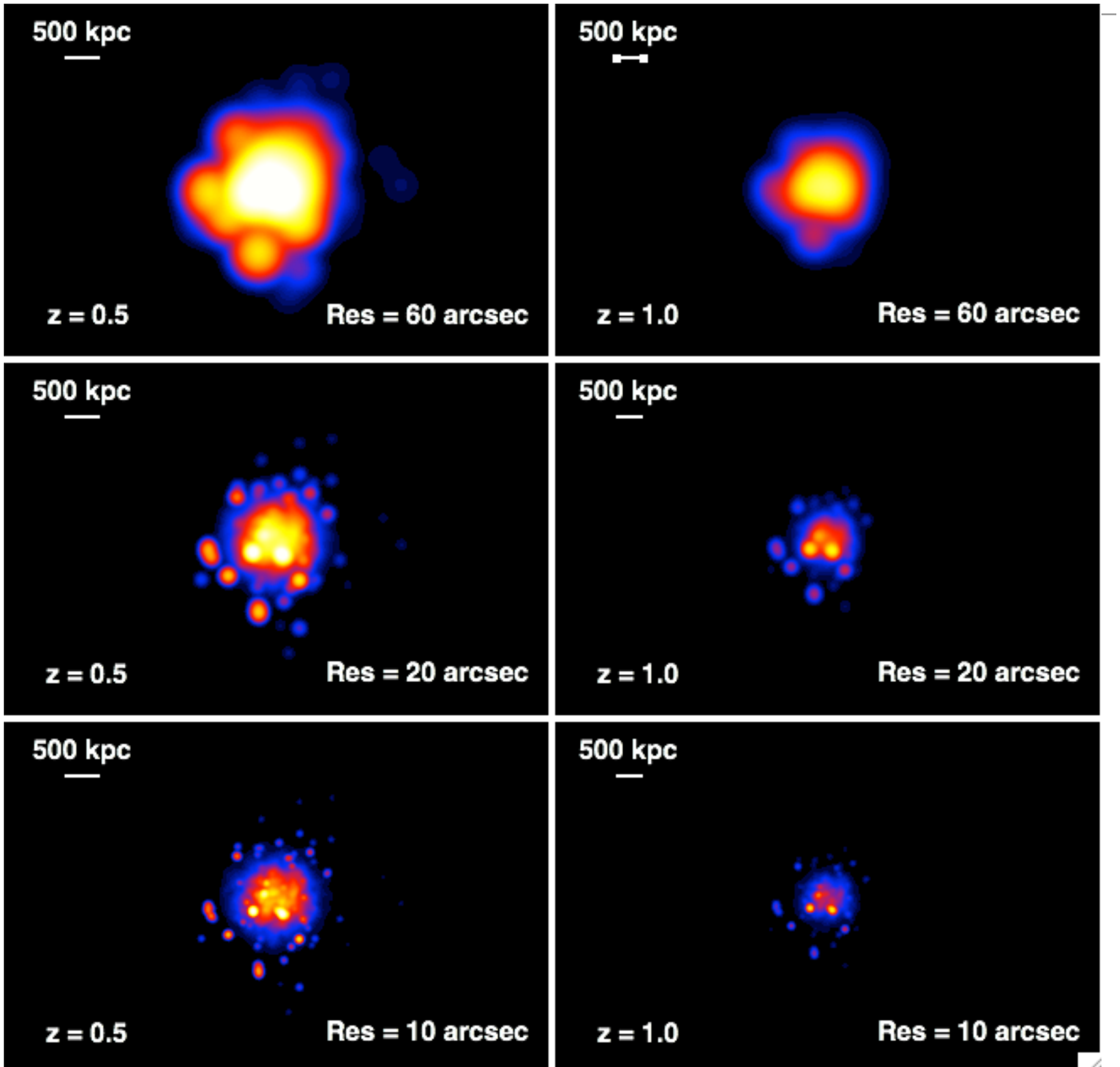
3.2×10^{26} W/Hz @120 MHz

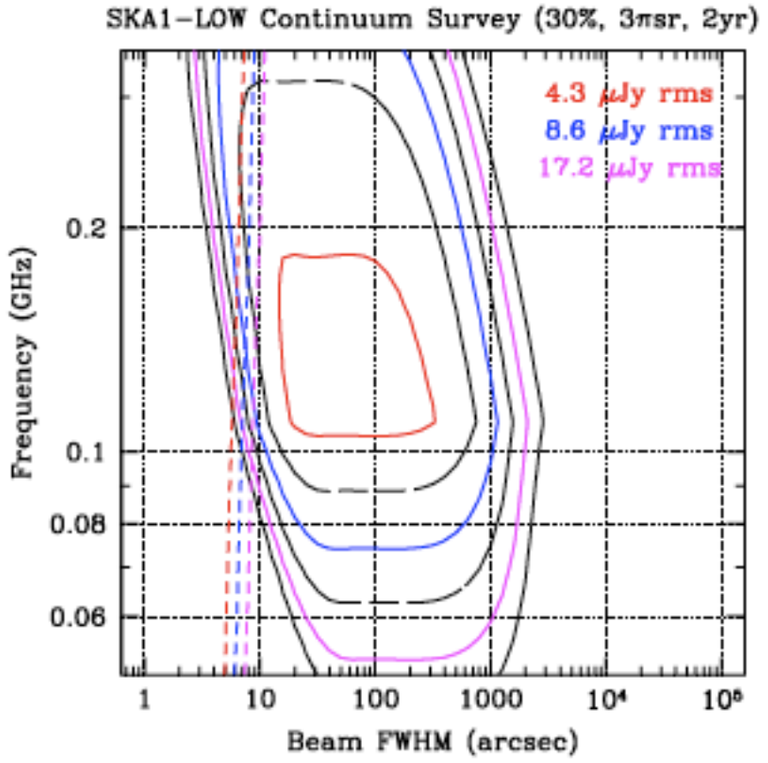
1.3×10^{27} W/Hz @ 30 MHz

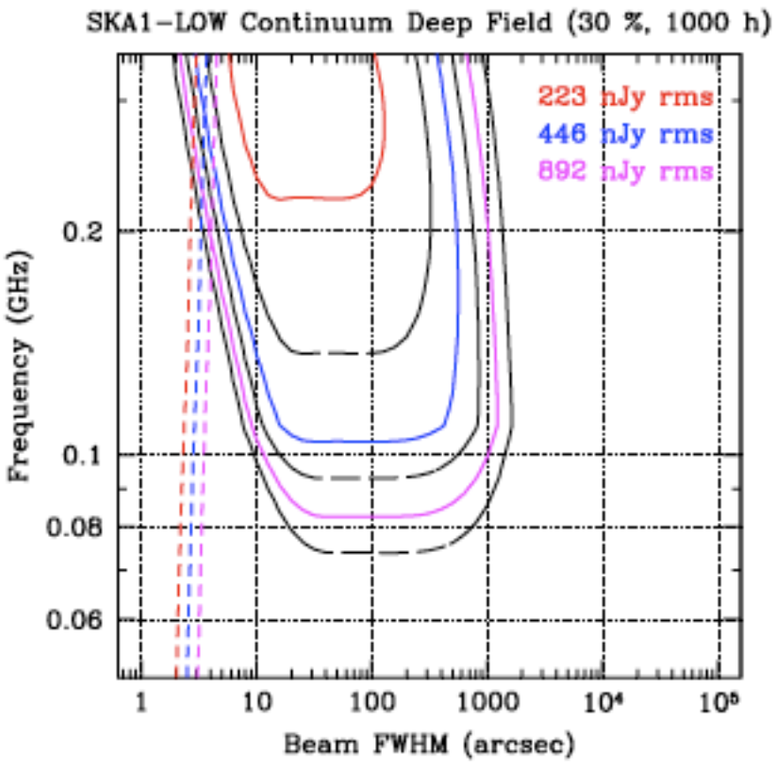
Faraday tool

(Murgia+ 04)

Importance of joint high-resolution & high-sensitivity observations







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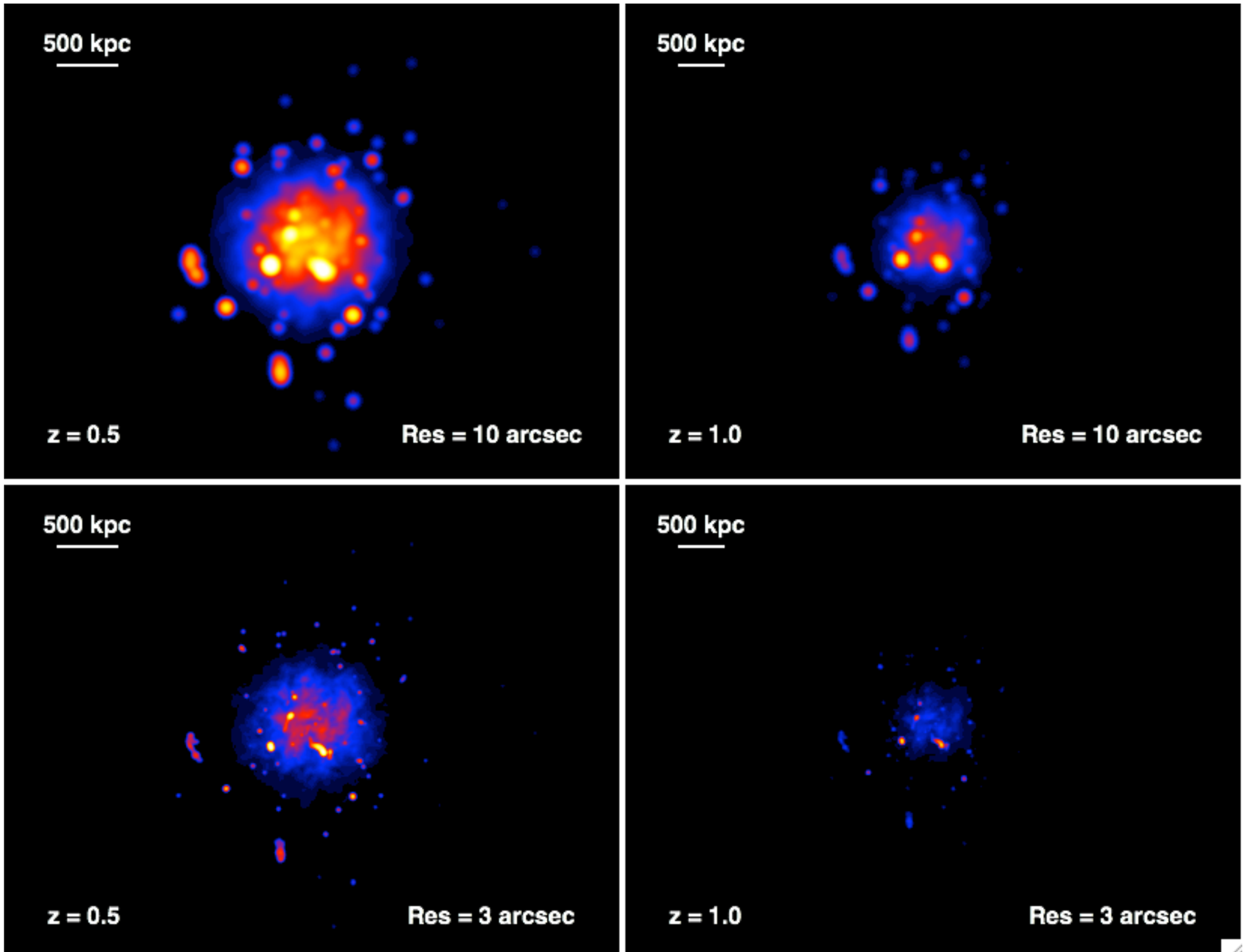
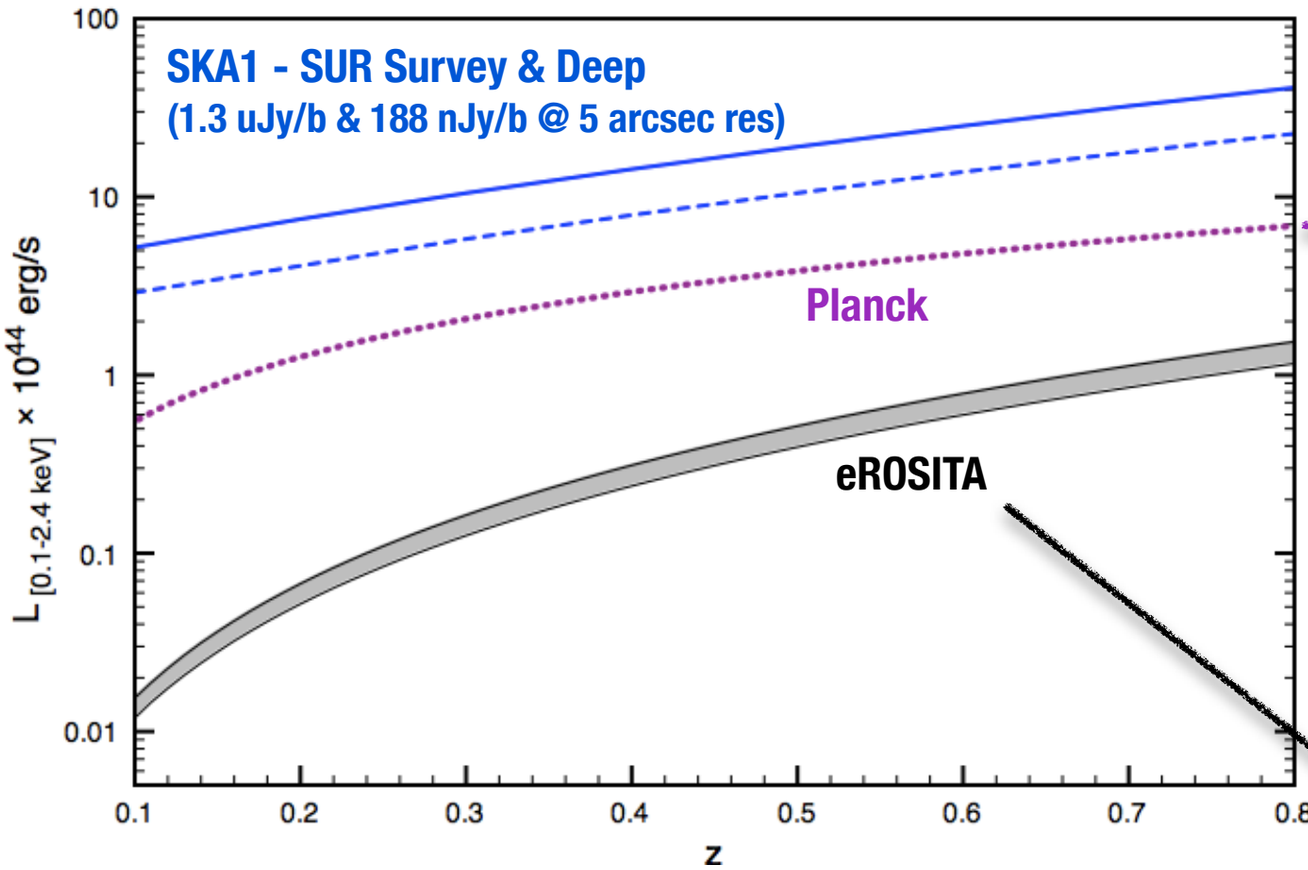
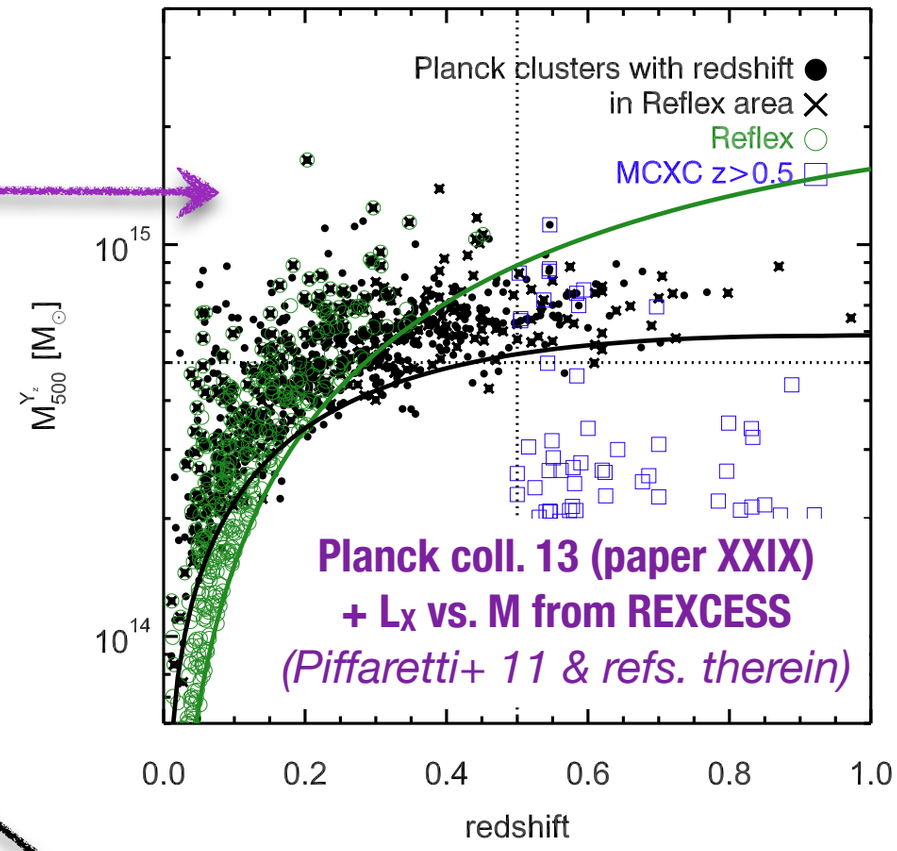
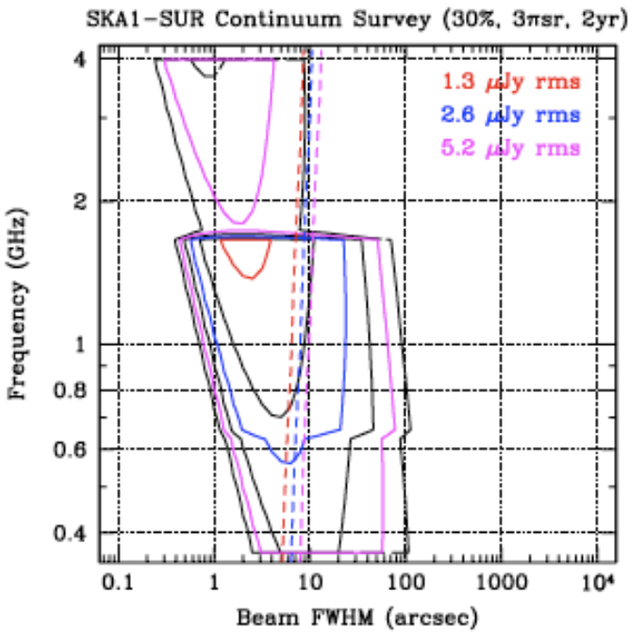
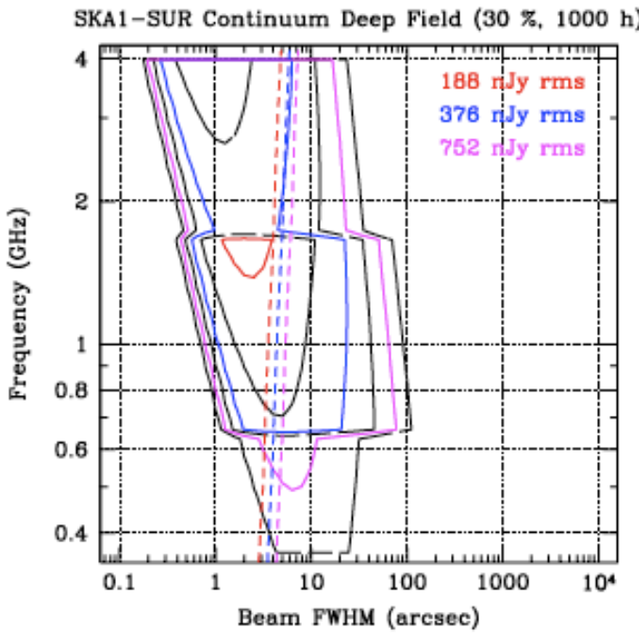


Some estimates of what we can get









eROSITA all-sky survey detection limit for ~4 keV clusters
(courtesy: T. Reiprich)

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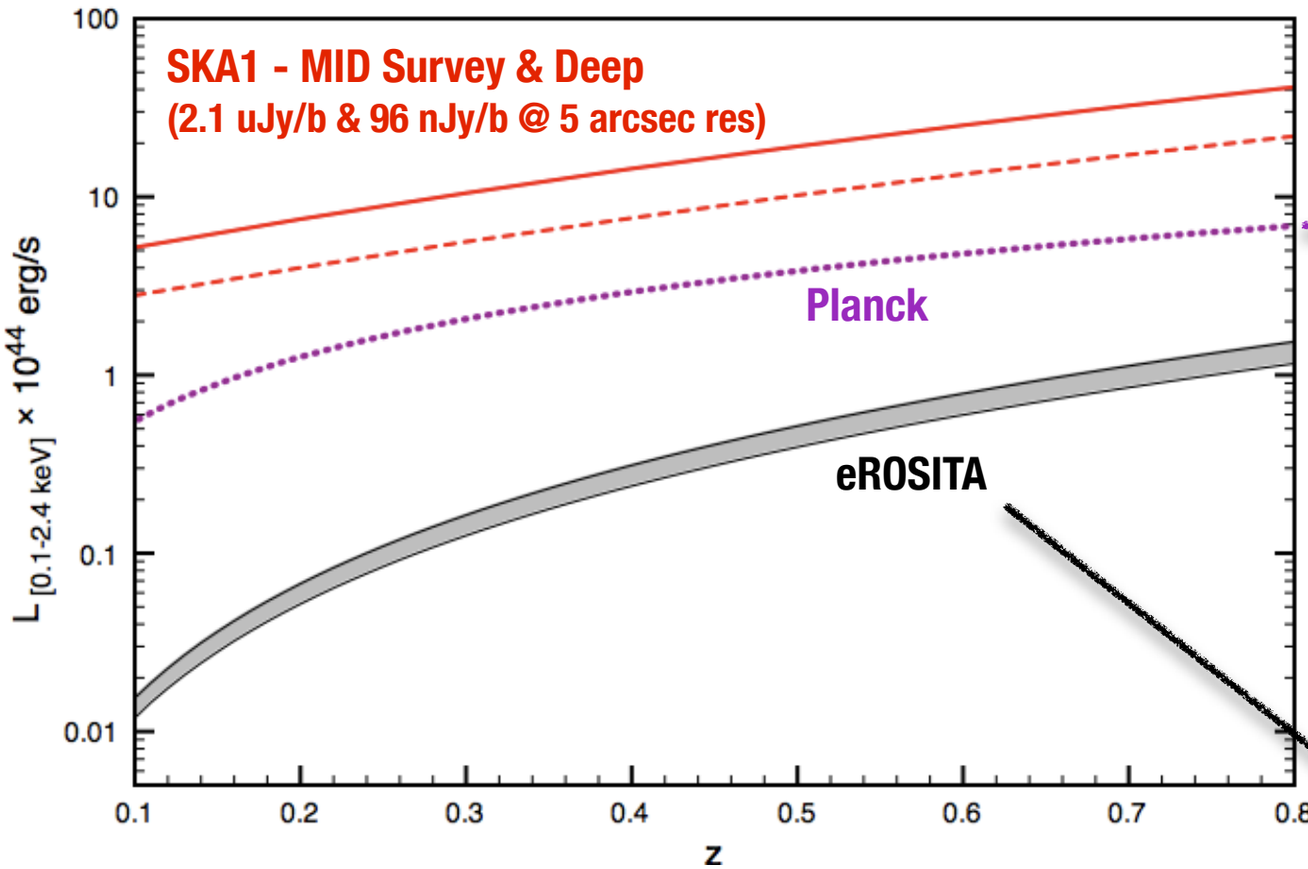

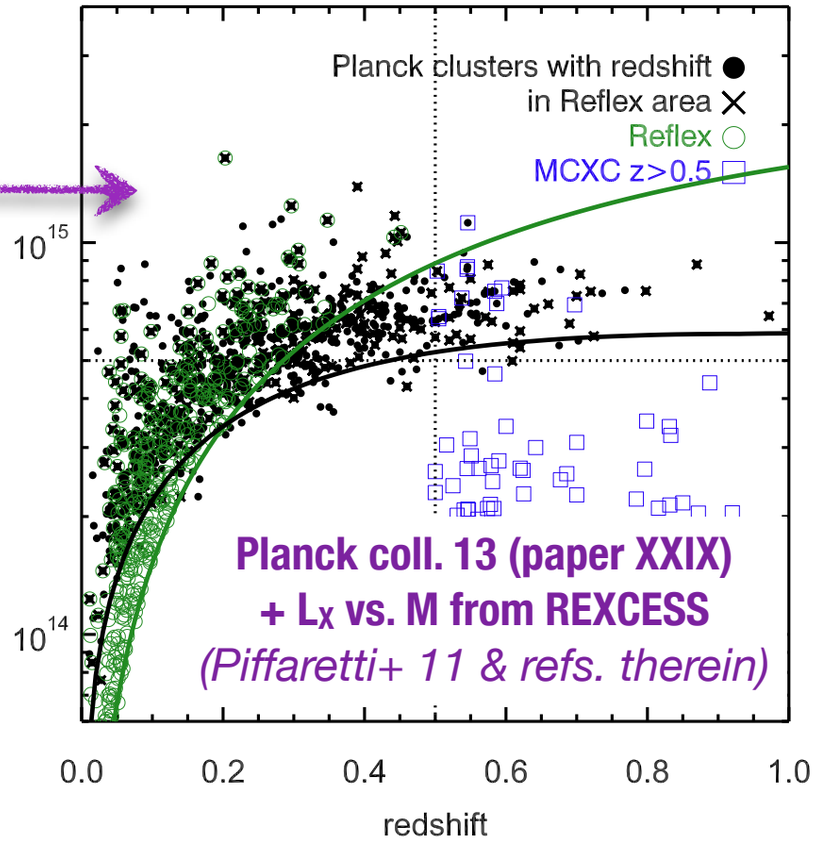

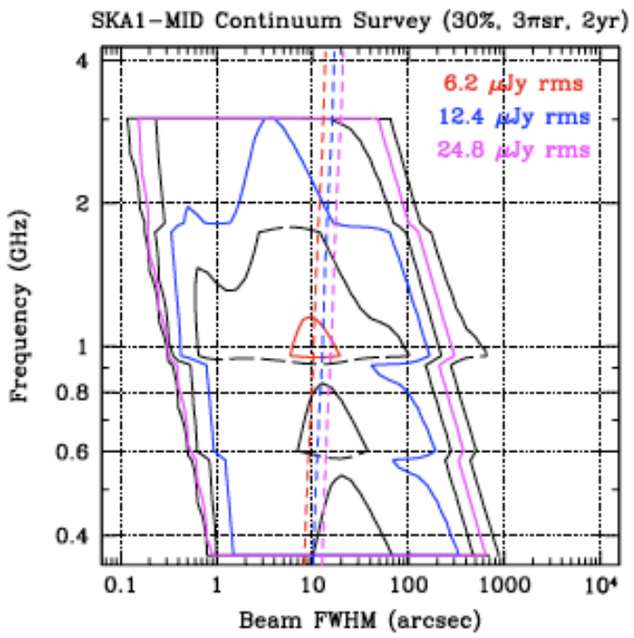

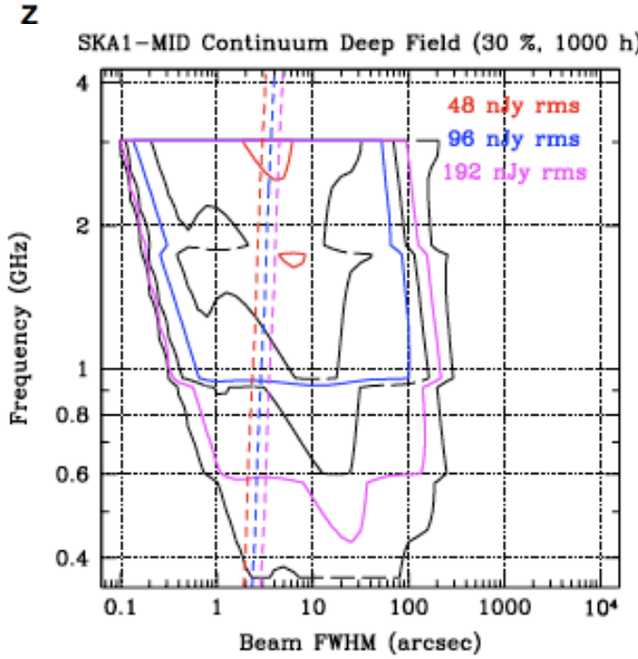

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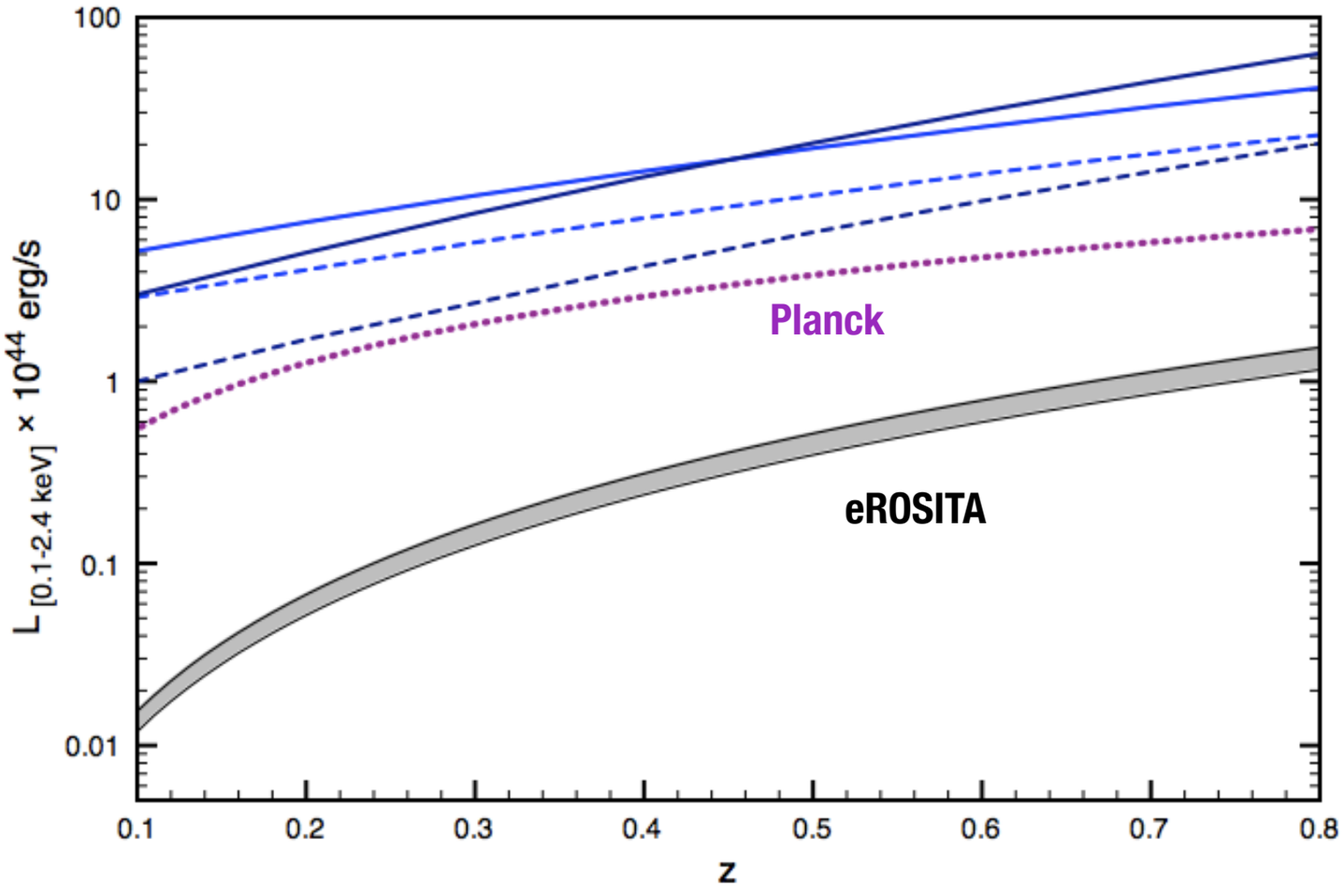


SKA1 - SUR Survey & Deep
(1.3 uJy/b & 188 nJy/b @ 5 arcsec res)

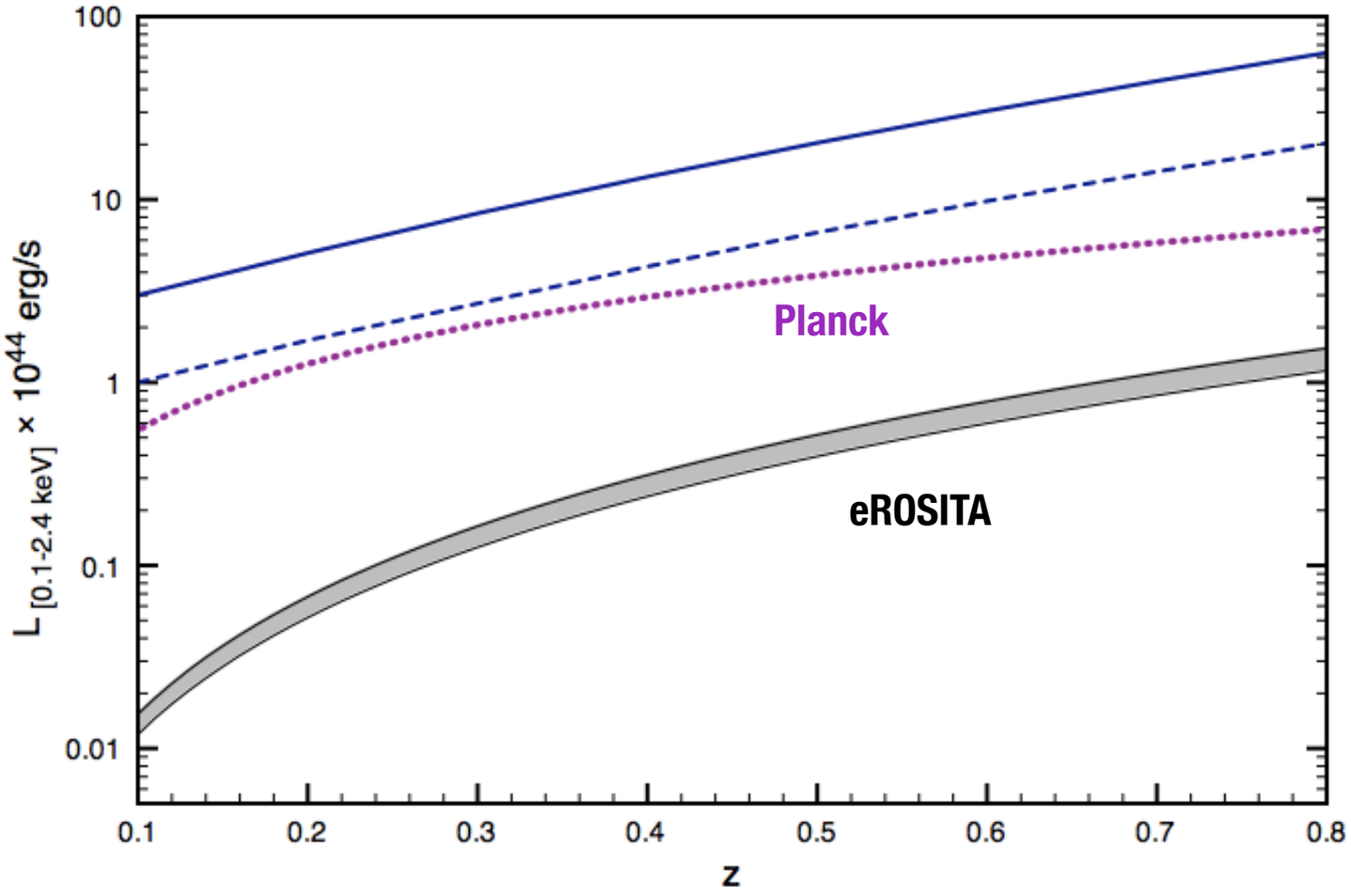
Halos with R = 0.5 Mpc

Halos with R(L_X) (Cassano+ 06)

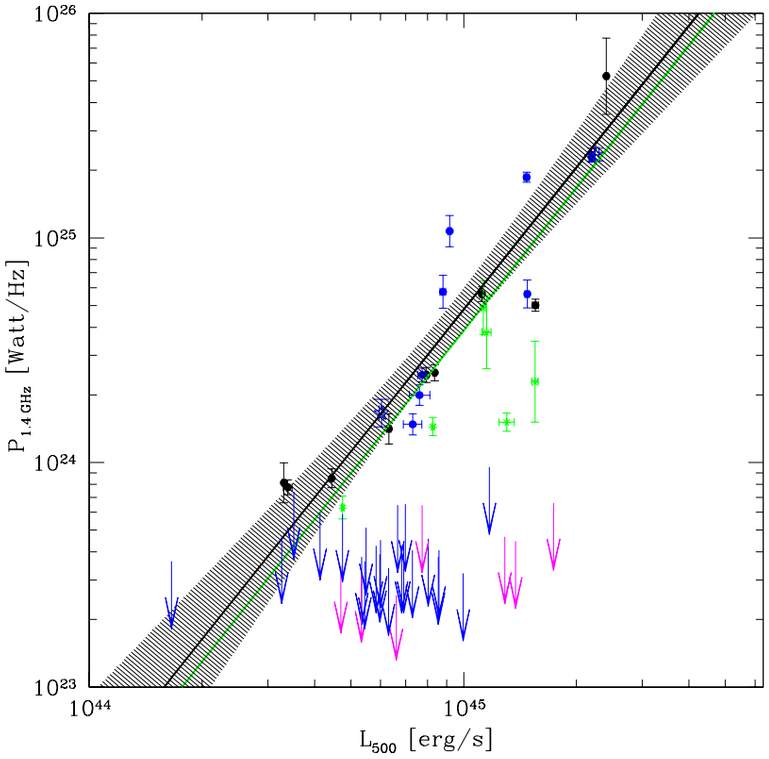
$$B_\nu(\eta \mathrm{R}_h) = \xi \frac{\mathrm{L}_{1.4GHz}(1400/\nu)^\alpha (1+z)^{-(3+\alpha)}}{1.5 \times 10^{31} (\eta \mathrm{R}_h)^2}$$

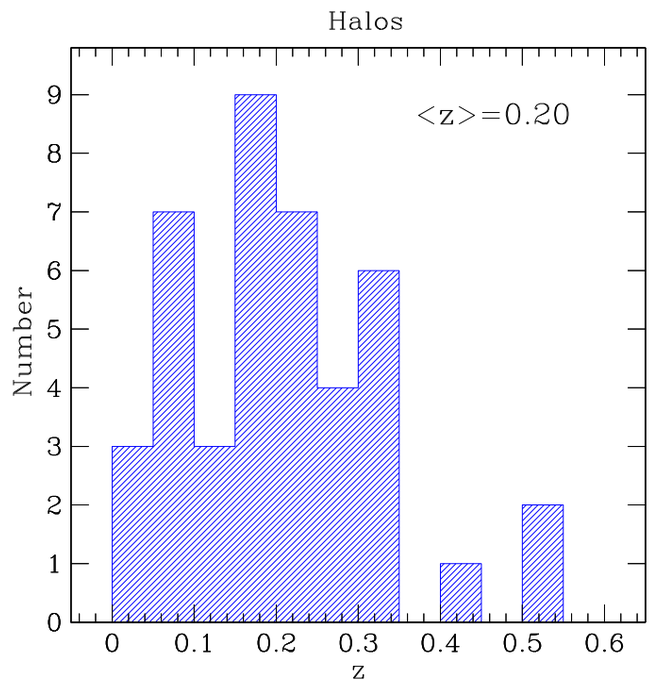
Taking into account $(1+z)^{-4}$ factor for IC energy losses

Some estimates of what we can get

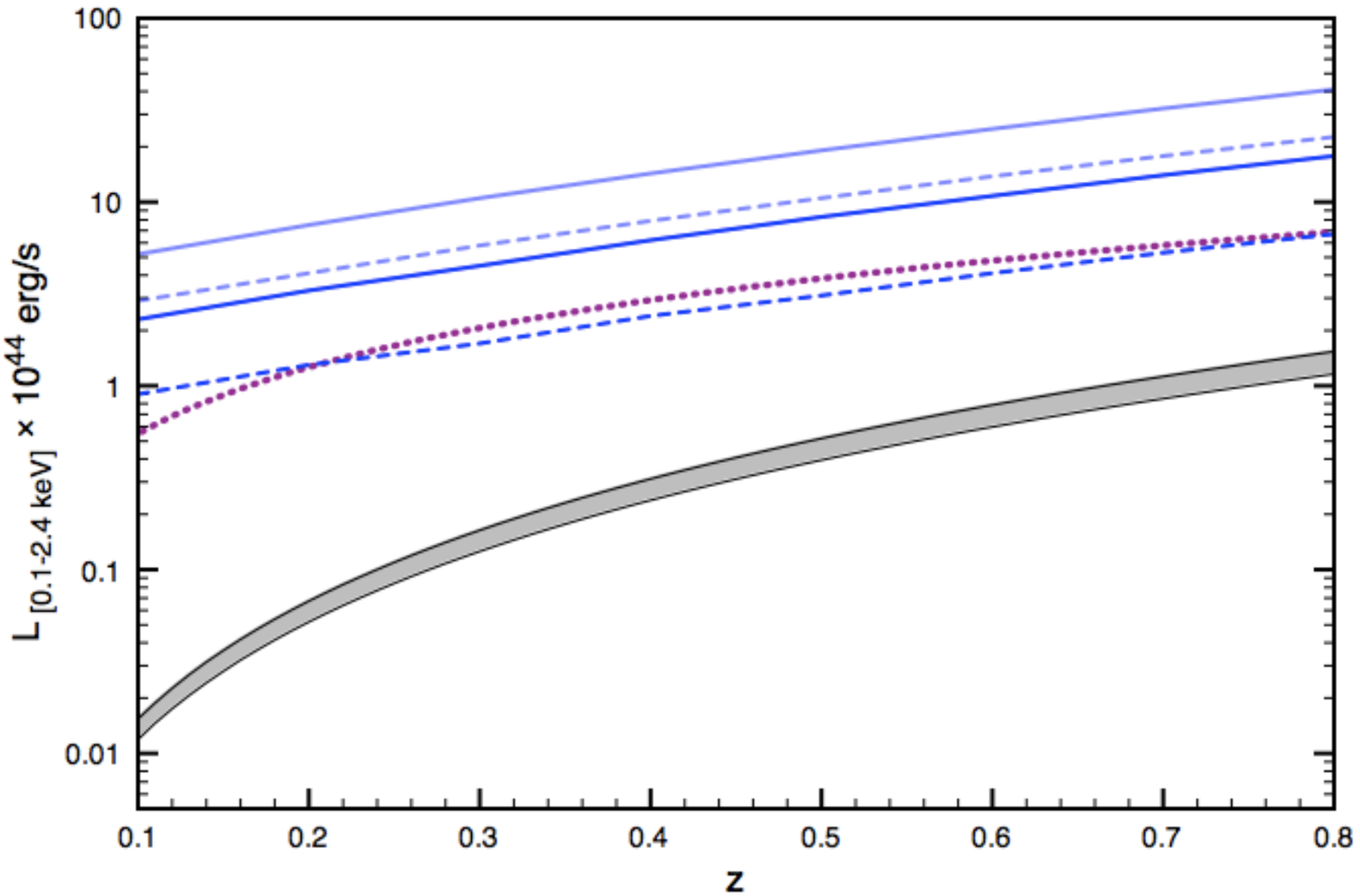


SKA1 - SUR Survey & Deep & $R_{halo}(L_X)$
(1.3 uJy/b & 188 nJy/b @ 5 arcsec res)





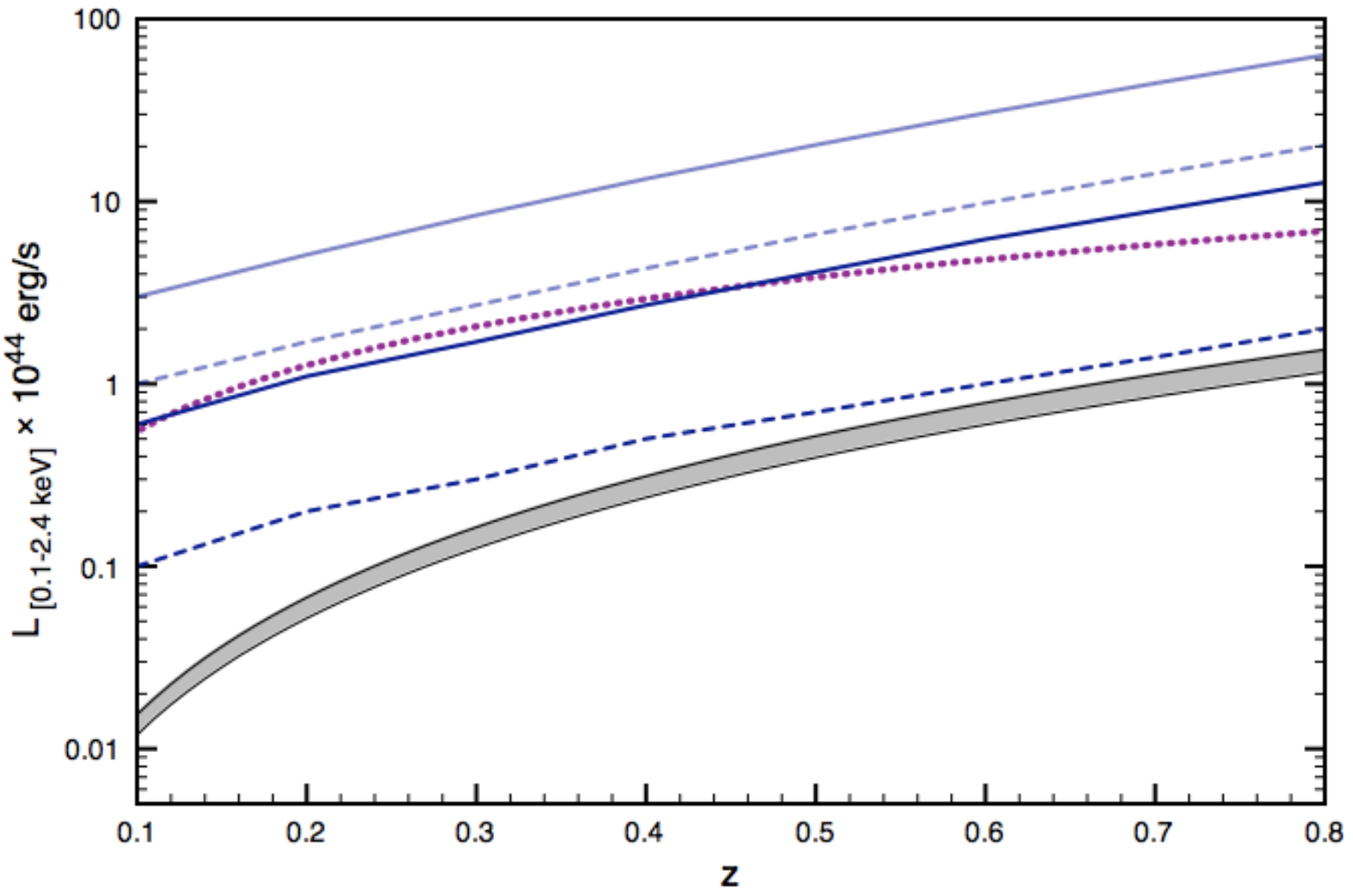
Some estimates of what we can get



SKA1 - SUR Survey & Deep & R=0.5 Mpc

(1.3 uJy/b & 188 nJy/b @ 5 arcsec & 15 arcsec res)

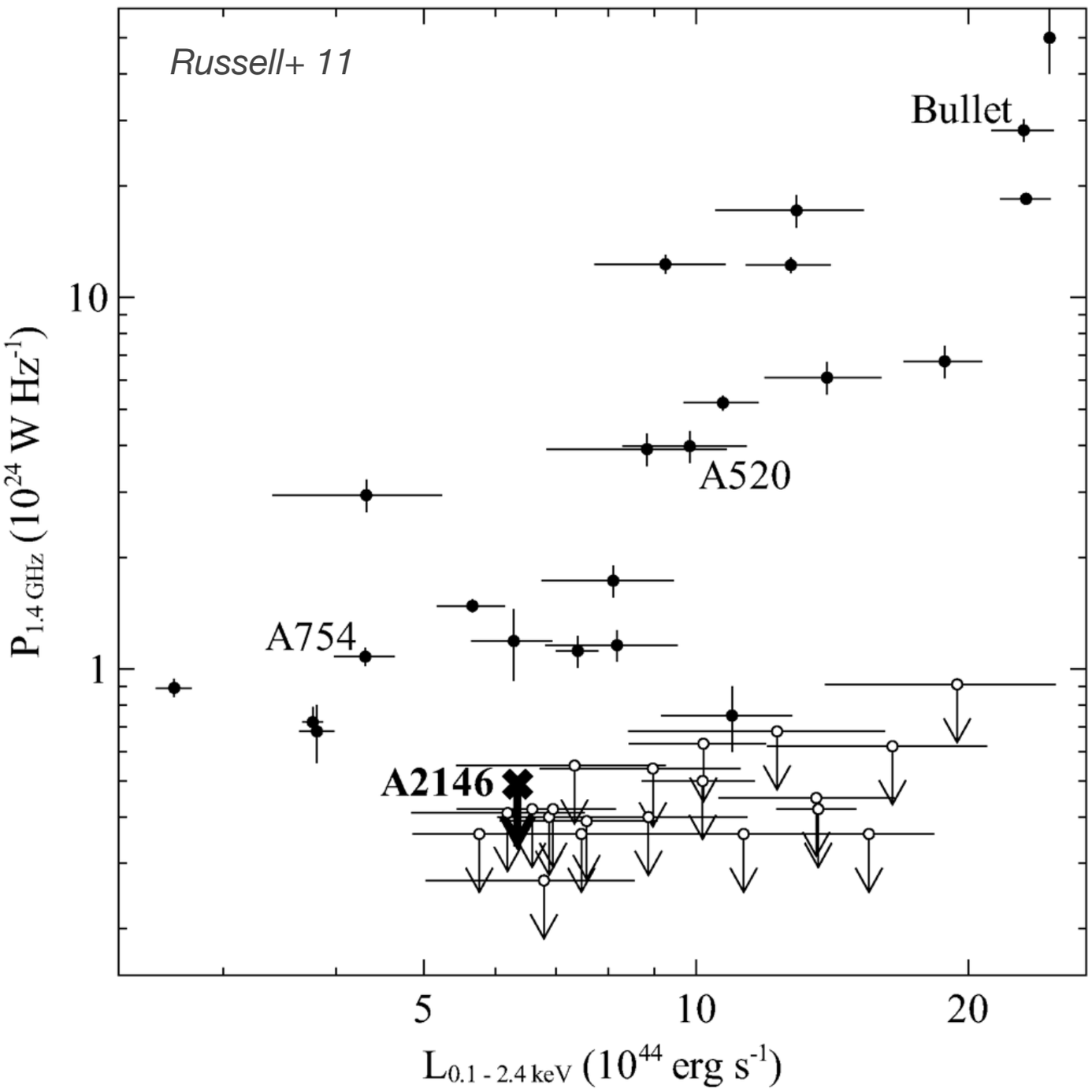
Some estimates of what we can get



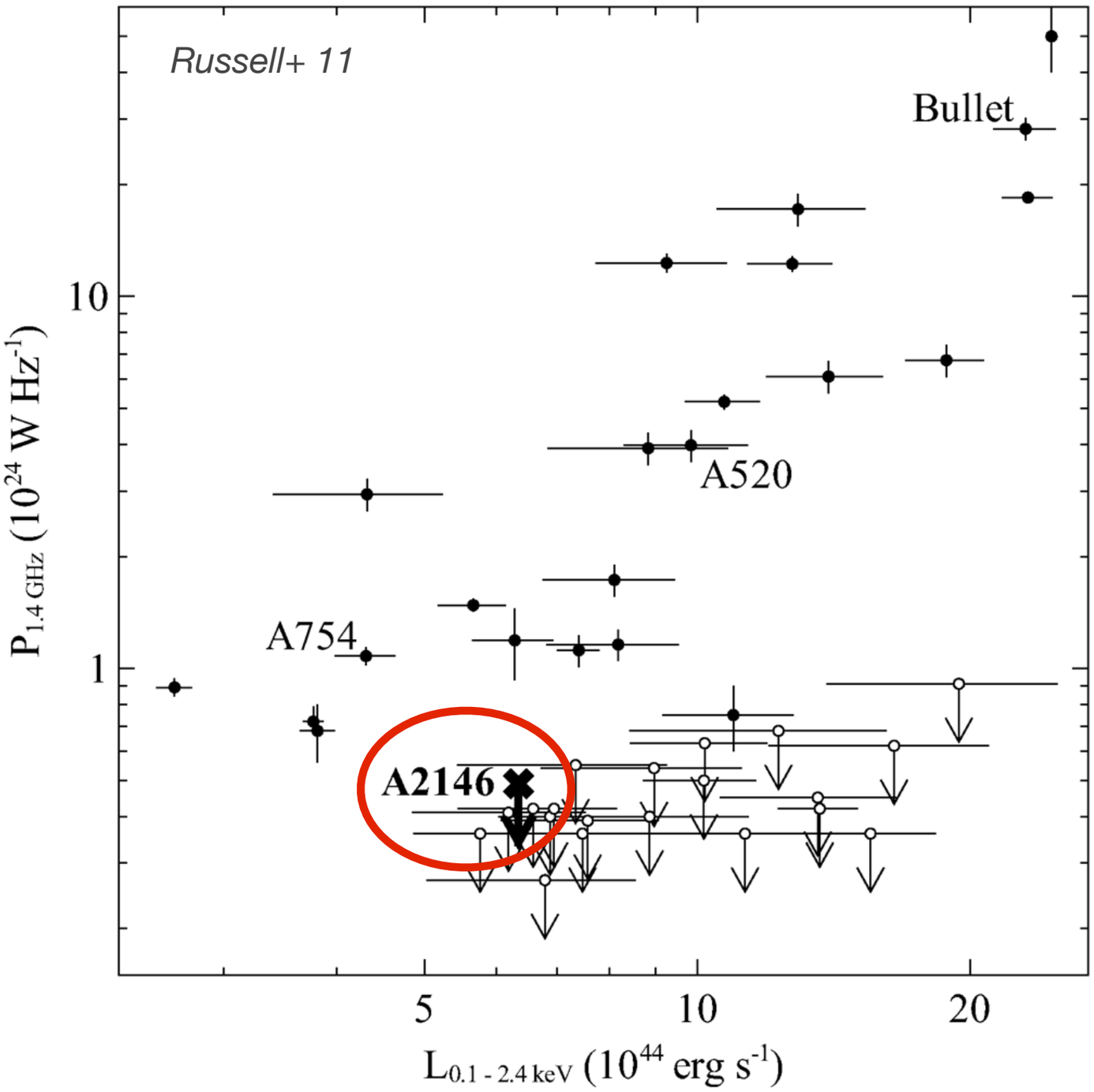
SKA1 - SUR Survey & Deep & R=0.5 Mpc

(1.3 uJy/b & 188 nJy/b @ 5 arcsec & 15 arcsec res)

Which clusters host Mpc-scale radio sources?



Which clusters host Mpc-scale radio sources?



Importance of a Southern survey: follow-up with ESO facilities

- Sub-structures in the X-ray and optical surface densities

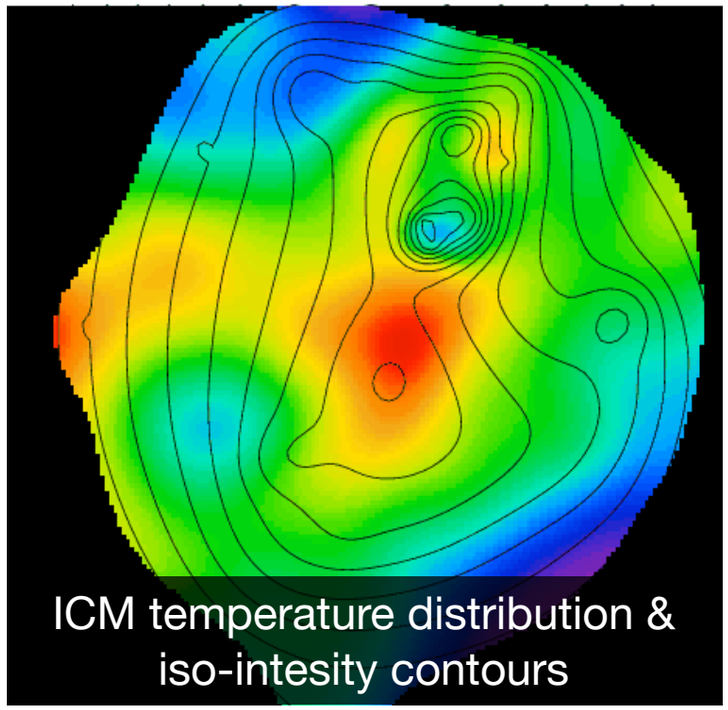
  (Ferrari+ 05; Ferrari+ 06)

- Non-gaussian radial velocity distribution of cluster galaxies

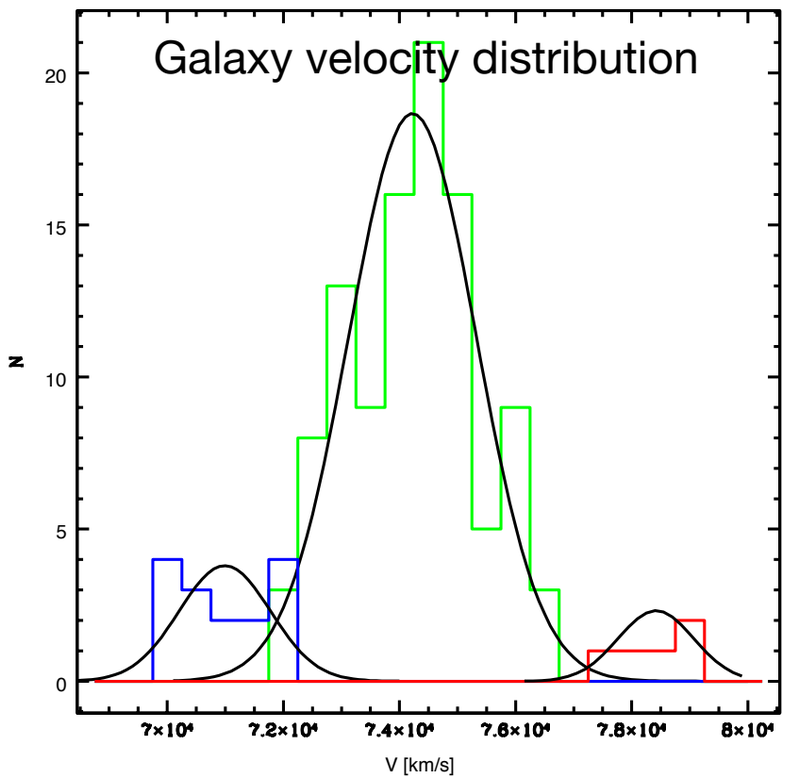
  (e.g. Ferrari+ 03)

- Patchy ICM temperature, pressure and metallicity maps

  (e.g. Kapferer, Ferrari+ 06)



ICM temperature distribution & iso-intesity contours



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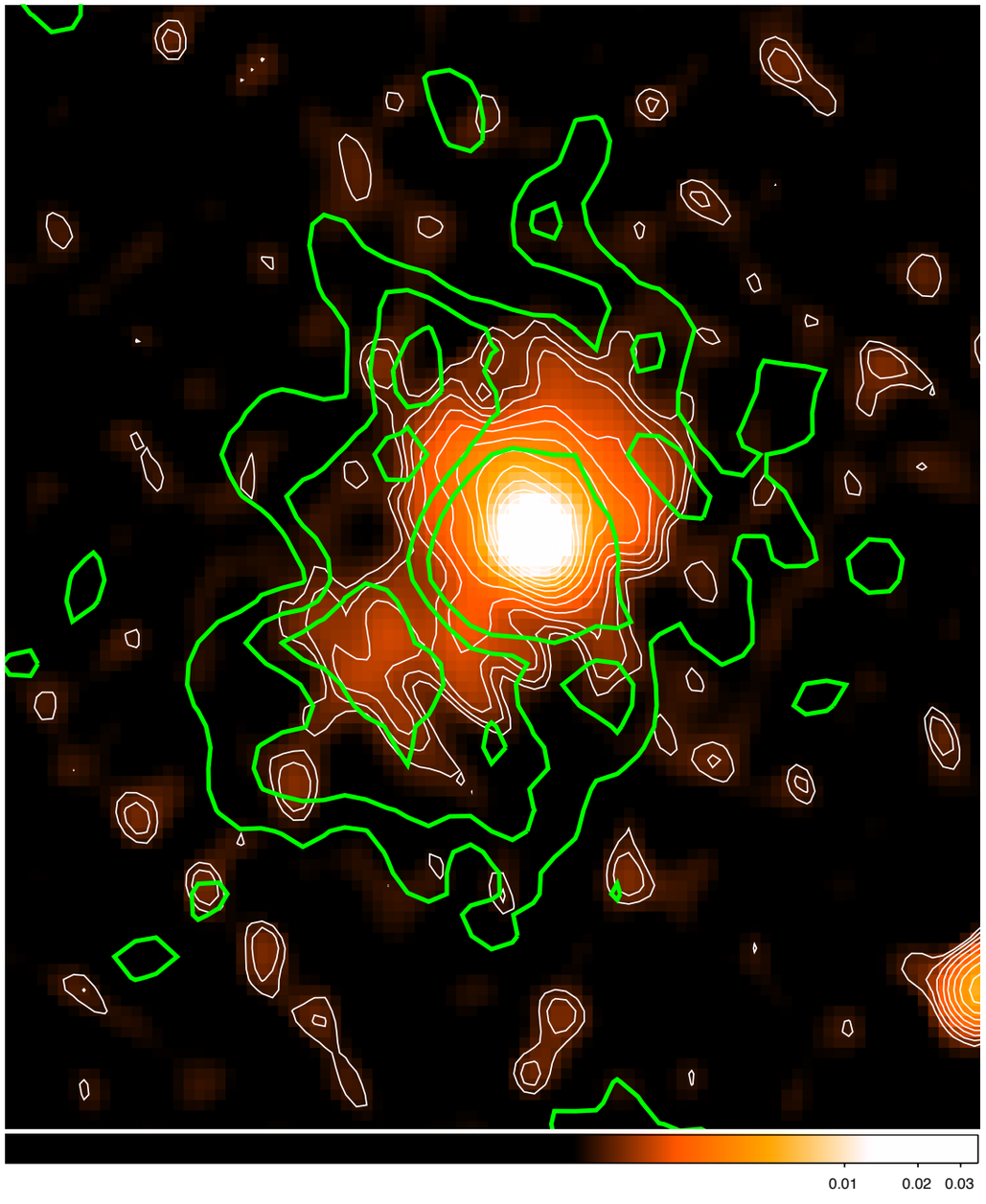
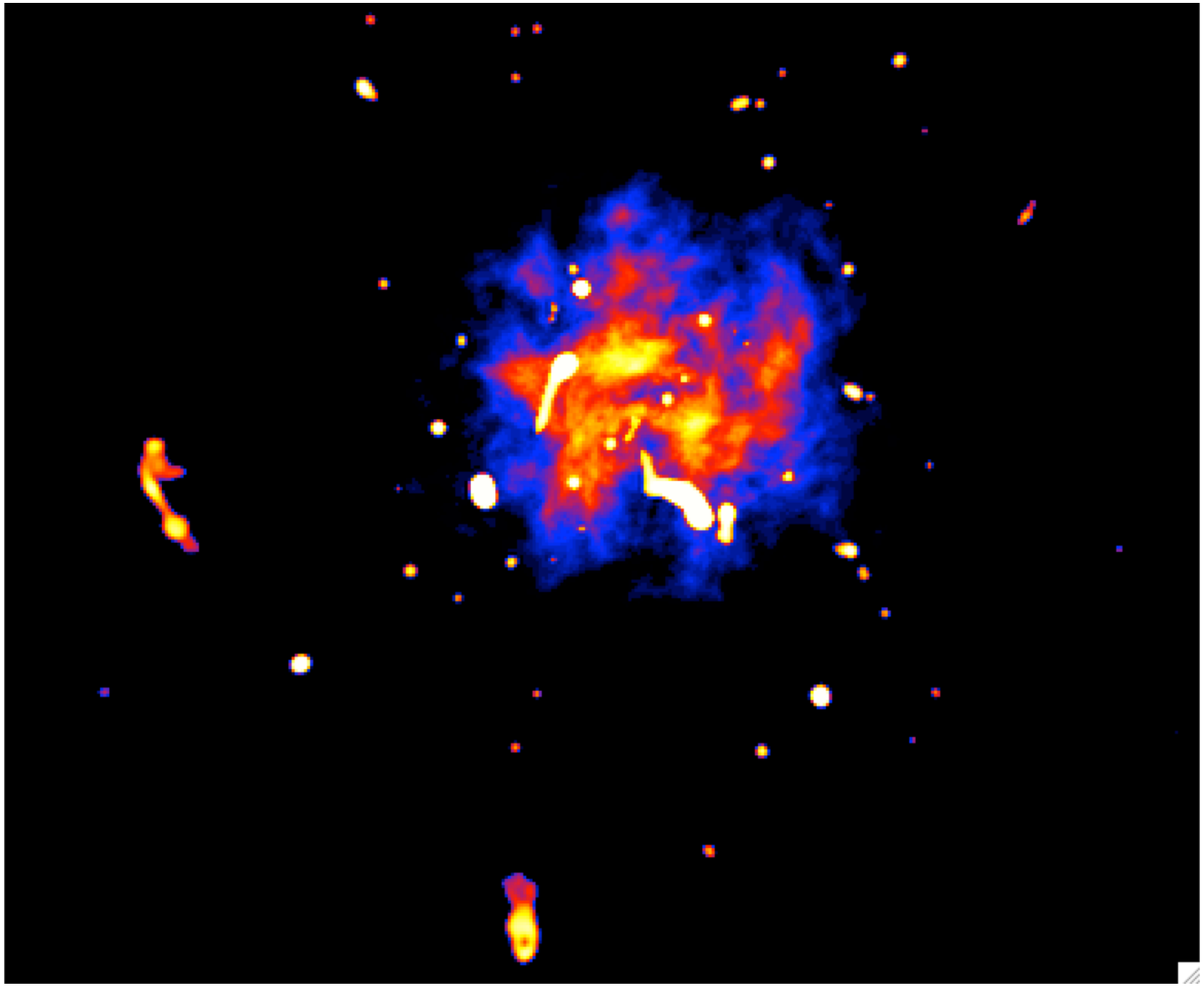


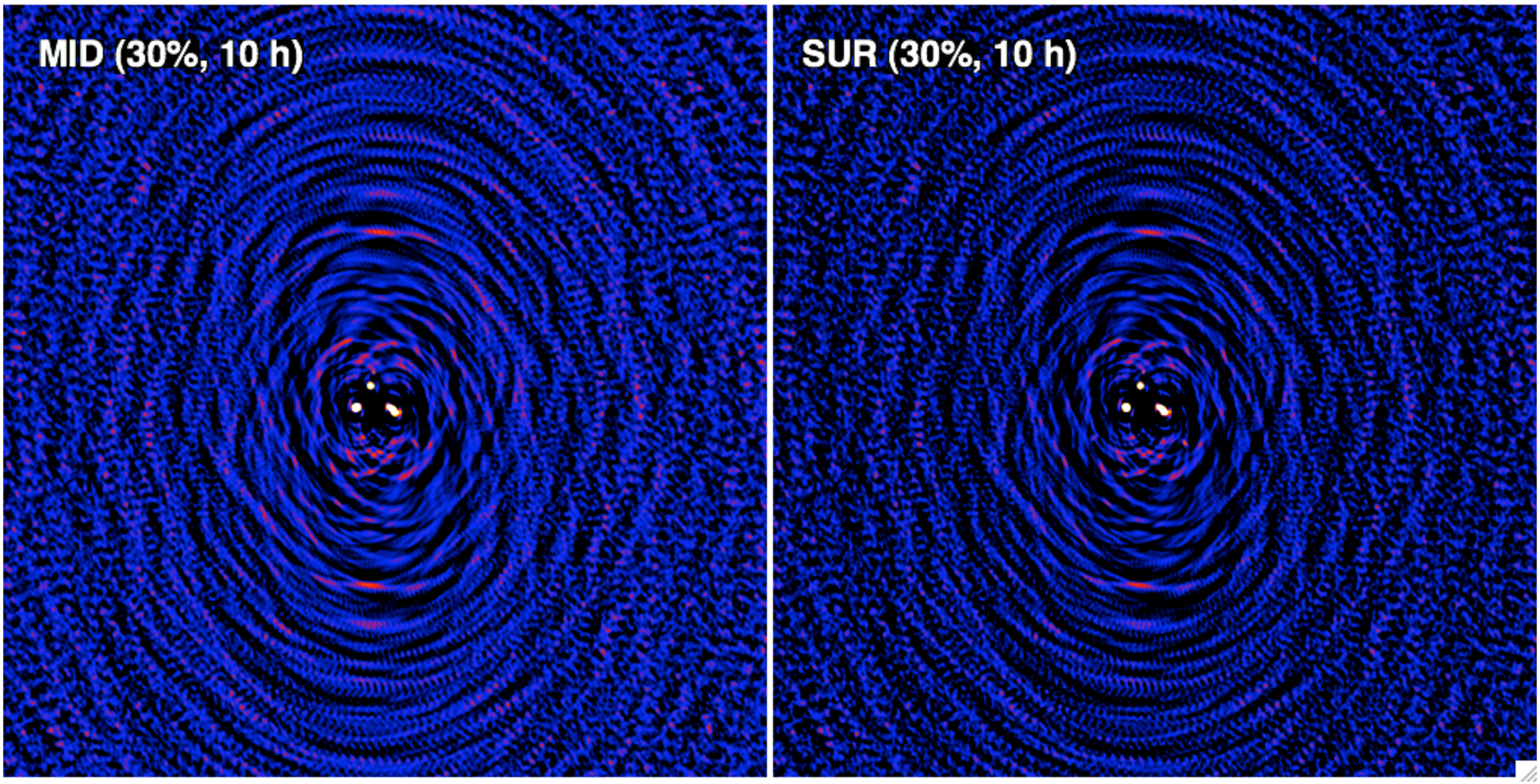
Ferrari+ 11

614 MHz map & contours (GMRT)
SZE contours (MUSTANG - Mason+ 10)

SKA observation simulations ?



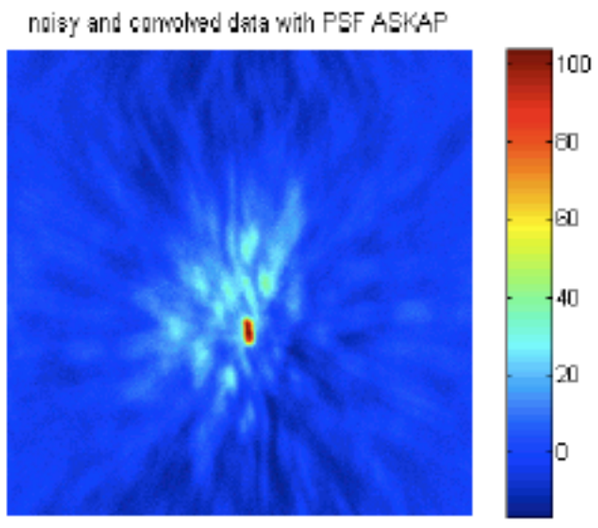
OSKAR2 simulations:
need of good deconvolution algorithms !

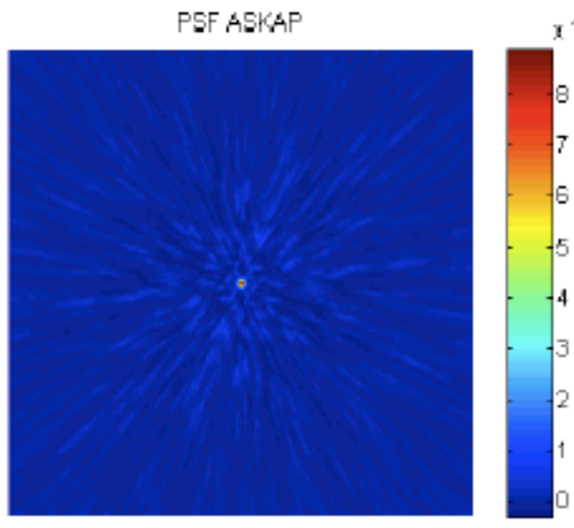


Courtesy: A. Gauci & K. Zarb Adami

Deconvolution methods

Tests are done on a simulated image, with two bright compact components and a faint smooth diffuse component.
The original image is convolved with the PSF of ASKAP





See also, e.g., Wiaux+ 09; Li+ 2011; Carrillo+ 12, 13

Courtesy: A. Dabbech
ASKAP PSF - Courtesy: M. Whiting

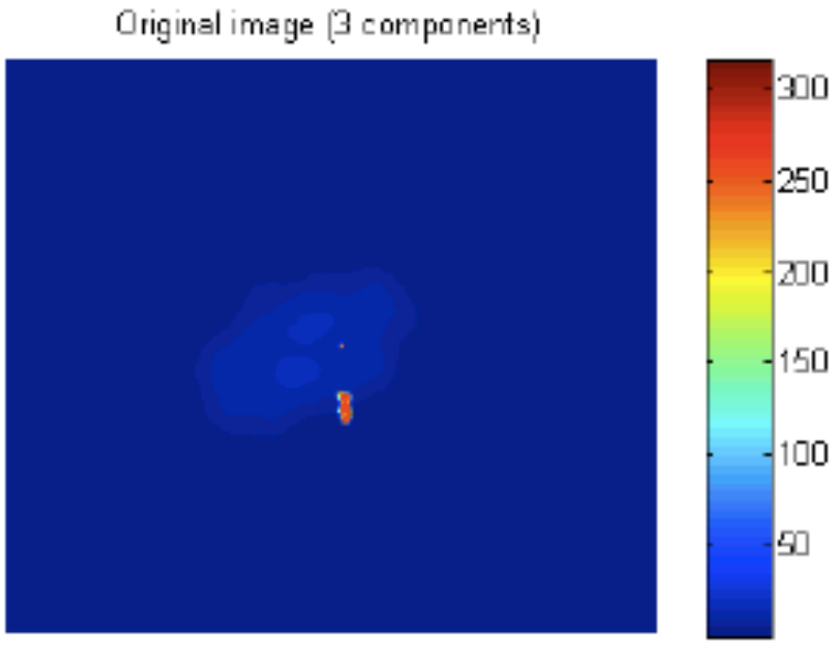
Conclusions

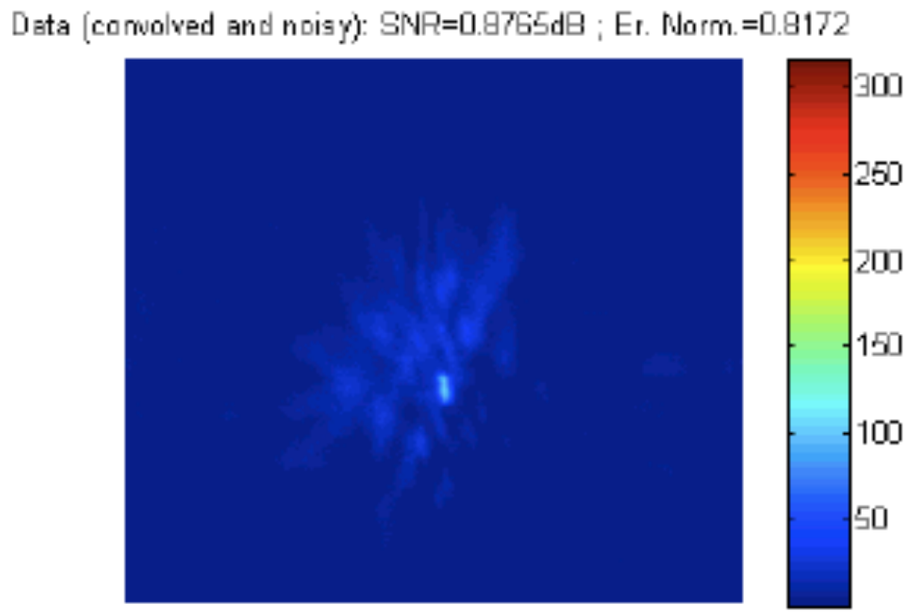
- what kind of survey parameters would be needed to search for extended emission from halos and relics, i.e. depth, area, resolution/sensitivity to extended structure ?
- would you prefer a blind or targetted survey ?
- do you have a preference between SKA1_MID or SKA1_SUR ?

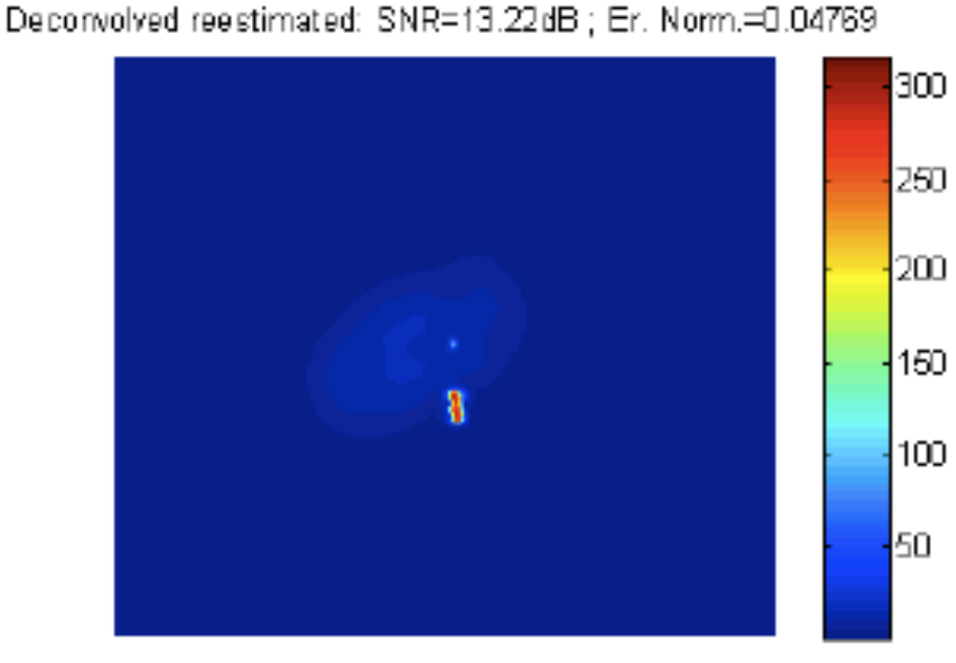
Notes:

- B_{min} ~ 30 m → we won't be able to detect halos/relics @z<0.05
- interesting on-going EMU-POSSUM discussion about how we will measure spectral indexes across wide bands (in particular for extended sources)

Good recovery of the faint and extended component !







Courtesy: A. Dabbech
ASKAP PSF - Courtesy: M. Whiting