Using Extended Sources to Probe cluster magnetic fields: BT galaxies

Melanie Johnston-Hollitt

Victoria University of Wellington

Cluster Magnetic Fields

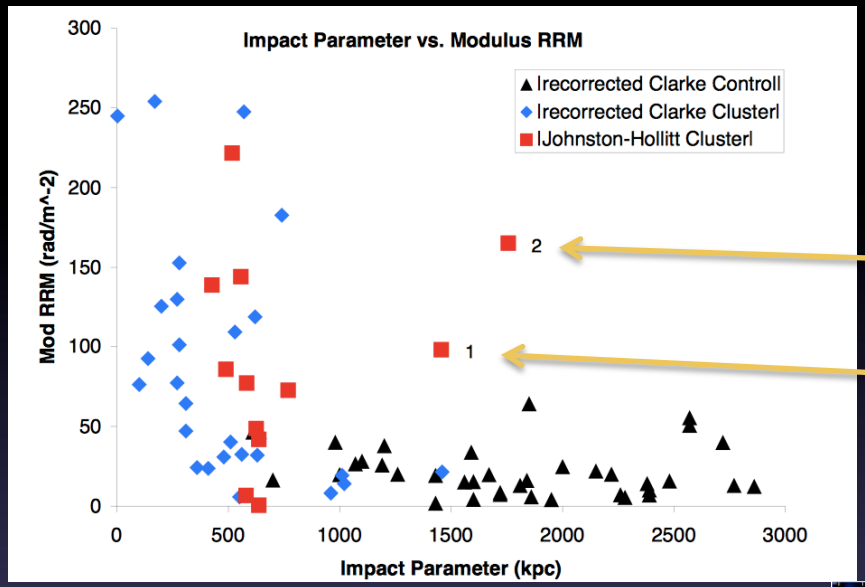
- We know galaxy clusters have magnetic fields at microGauss levels.
- We don't know their extent, filling factors, or relationship to and influence on the dynamical state of clusters.

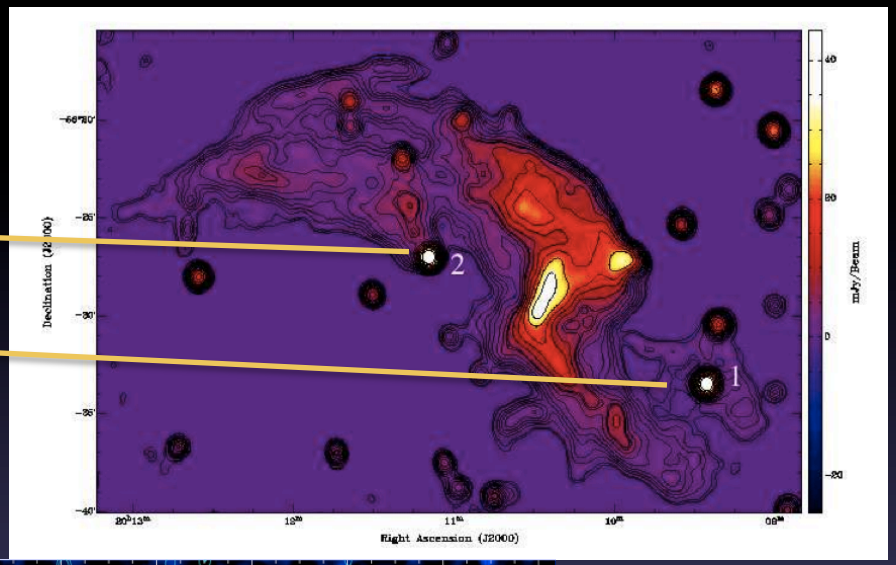
Statistical RM studies of clusters

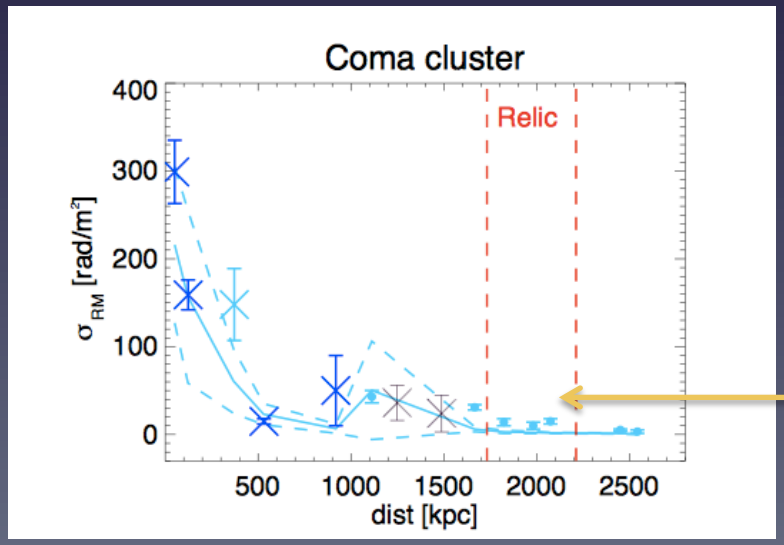
- Statistical studies of RMs through clusters have been undertaken since the late 80s (Hennesey et al 1989, Kim et al 1999, Clarke et al 2001, Johnston-Hollitt et al 2004… Bonafede et al., 2013)
- Results have been statistical and hampered by:
  - Contributions from foregrounds (intrinsic and extrinsic)
  - Poor sampling (source counts and across cluster)
  - Poor polarisation data
- A decade ago it was proposed that SKA would address many of these issues (Ferretti & Johnston-Hollitt 2004)

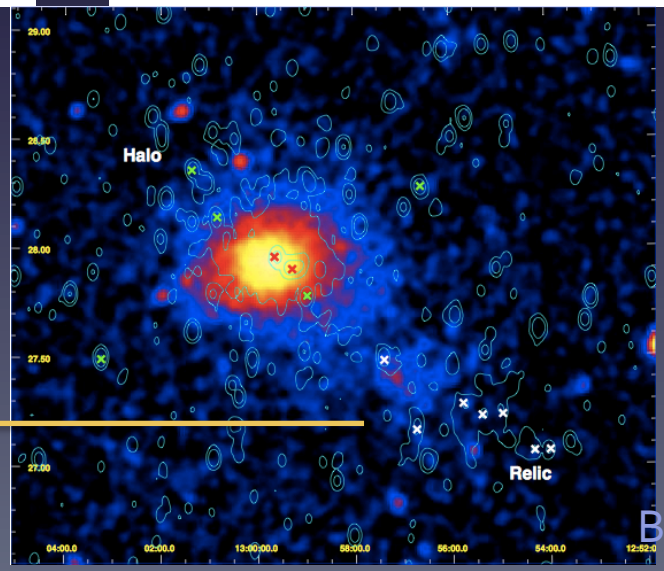
RMs through relics

Johnston-Hollitt 2004









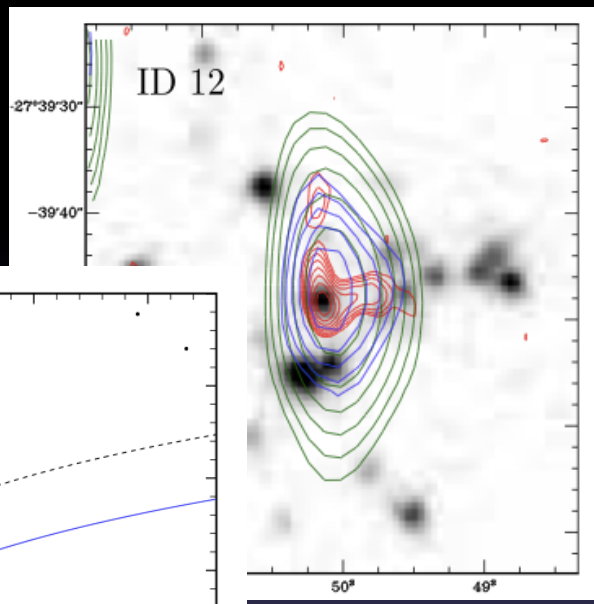
Bonafede et al. 2013

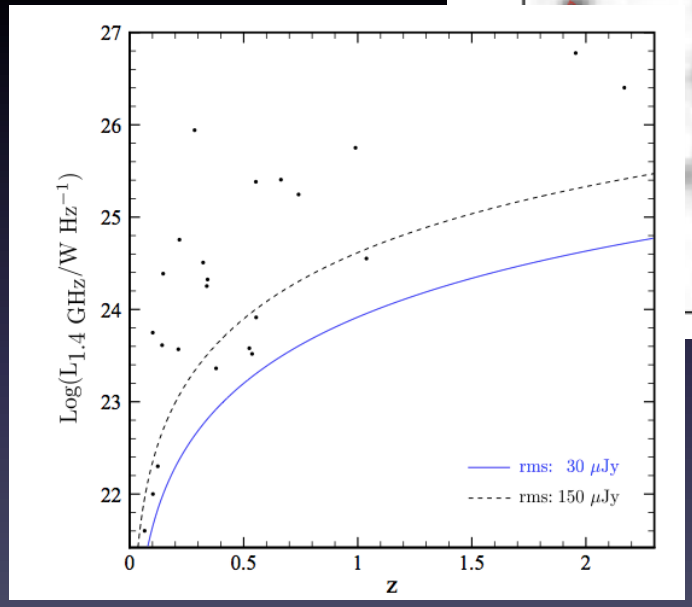
RMs Through Clusters

- We are clearly seeing an increase in both the number of sources to use as probes through clusters and SKA will increase this.
- In addition to the number of sources we will also get an increase in the resolution of sources and it's this I'd like to consider now…

HTs and BTs are probes

- Bent-tailed sources are known to be found in clusters environments at a rate of 1-2 in the locate Universe (z < 0.1) at the resolution and sensitivity of current surveys.
- Resolution limits of sources such as the NVSS or FIRST limit these sources to upwards of 200 kpc
- Recent deep surveys at 1.4 GHz with 2" find BTs as small as 30 kpc across and probe to deeper redshifts (now up to z=2)



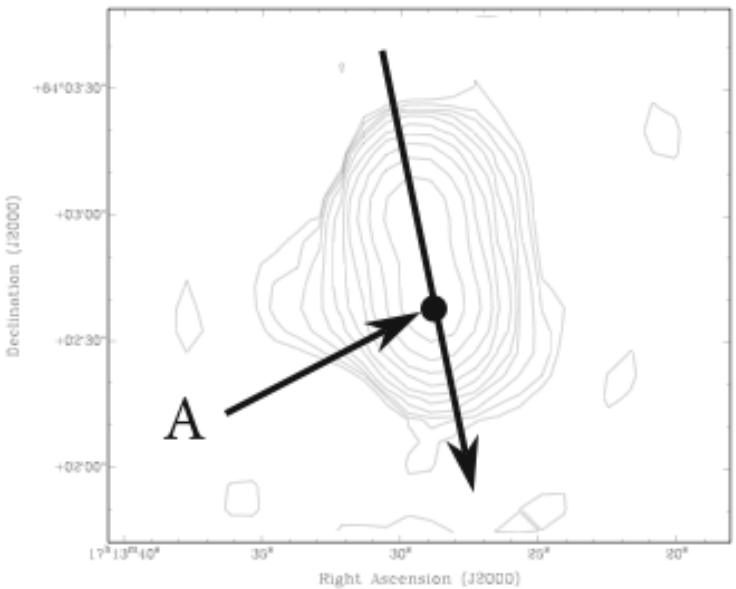


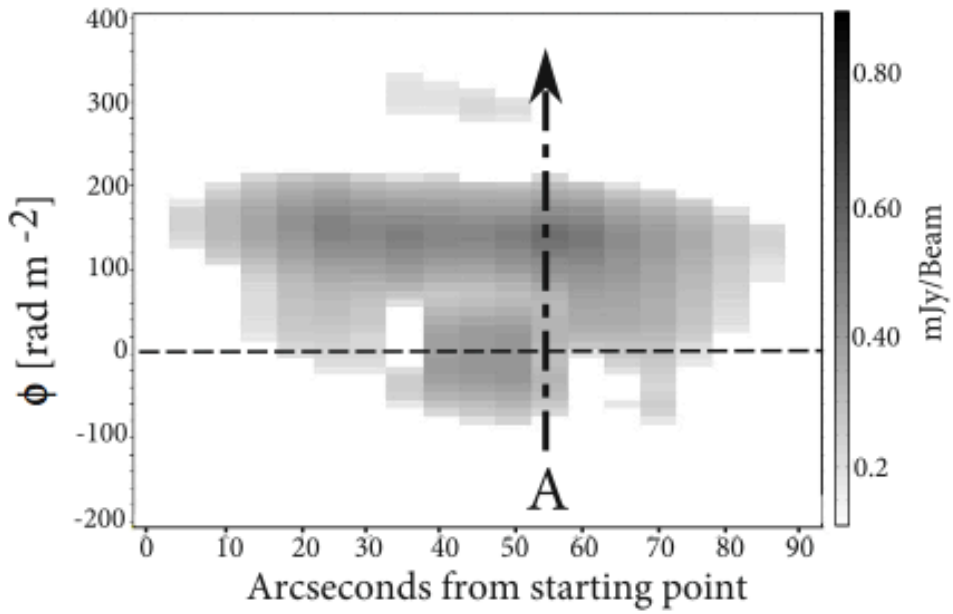
Green ATLAS data 3rd release, Blue, 1st data release, red VLA. Dehghan (2014 – phd thesis), Dehghan et al (2014 – to be submitted today)

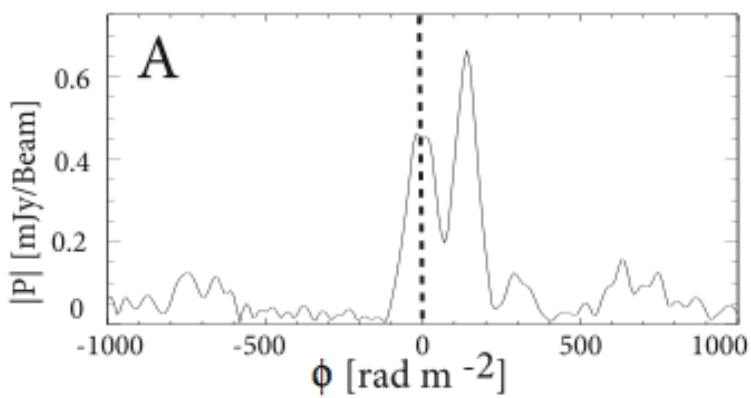
BTs as B probes

- A number of papers have used the resolved tailed galaxies to examine cluster magnetic fields (Owen & Eilek 2002, Vogt & Ensslin 2008, Govoni et al 2006, Guidetti et al., 2008 & 2010, Pizzo et al. 2011, Pratley et al. 2013 – RM Synthesis).
- As the tails have nice ordered internal fields they can be used as resolved screens to probe the RMs changes caused by clusters in which they are embedded.

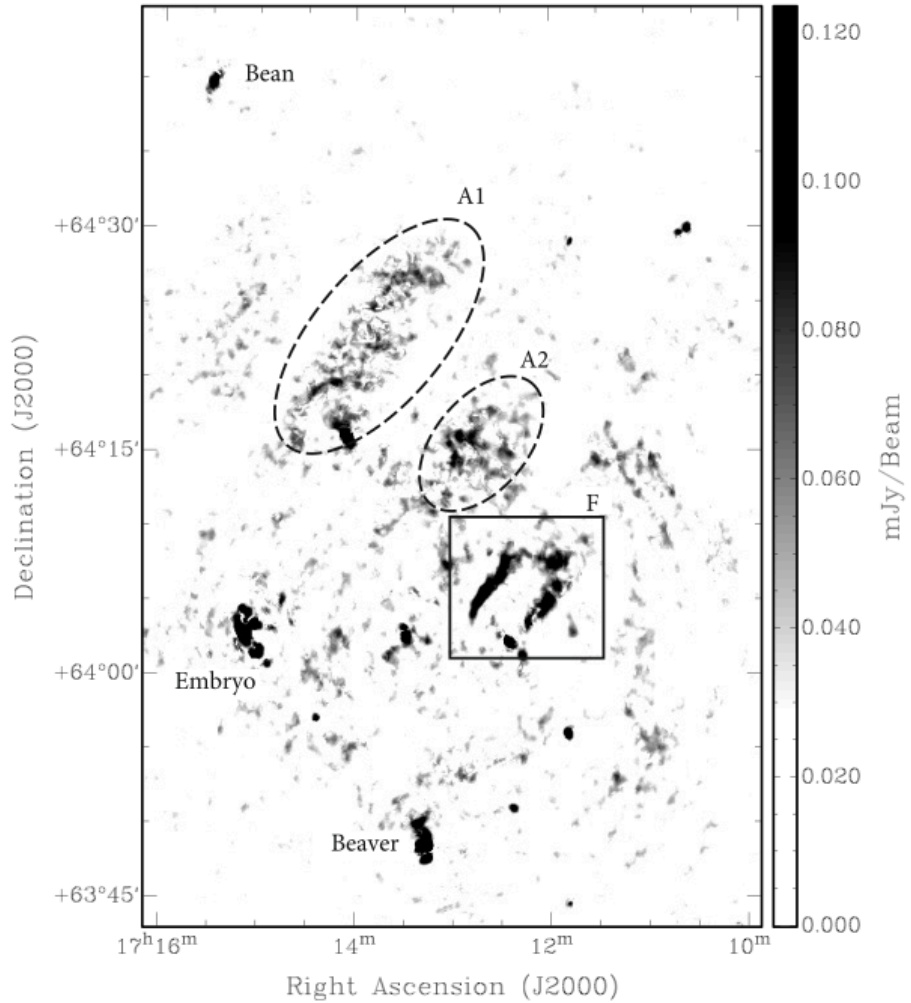
DOUBLE

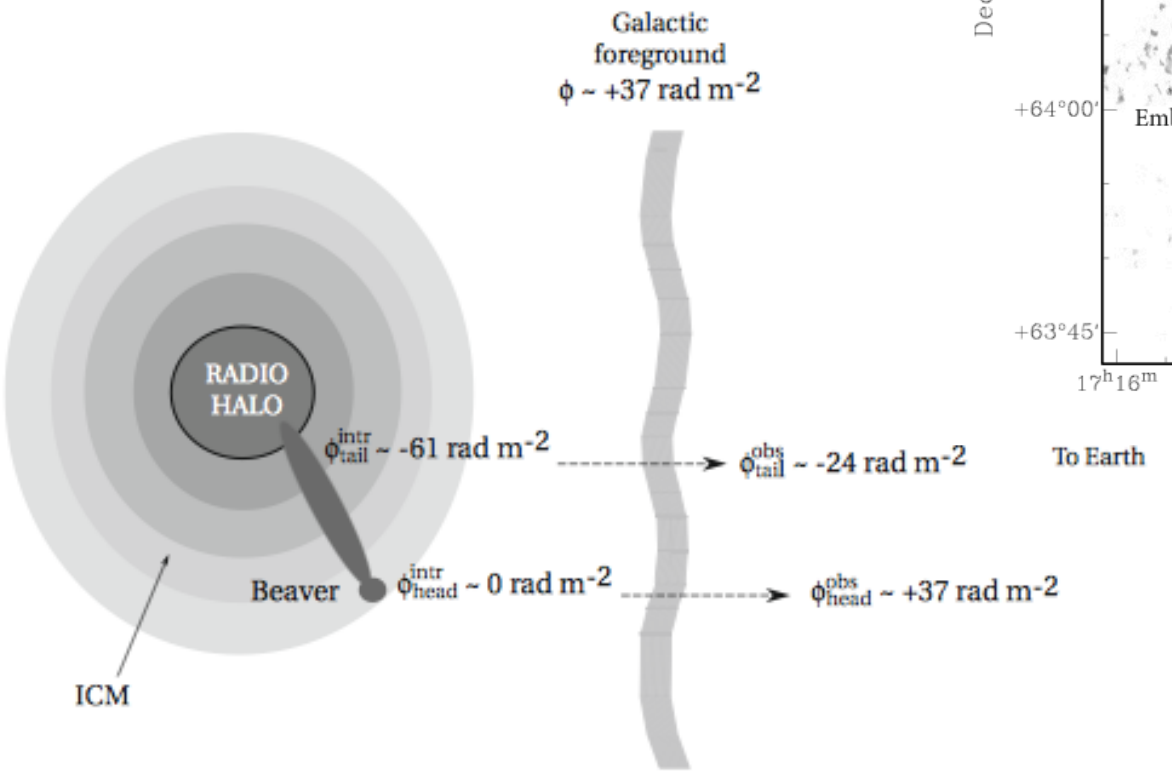






A2255: Pizzo et al. 2011





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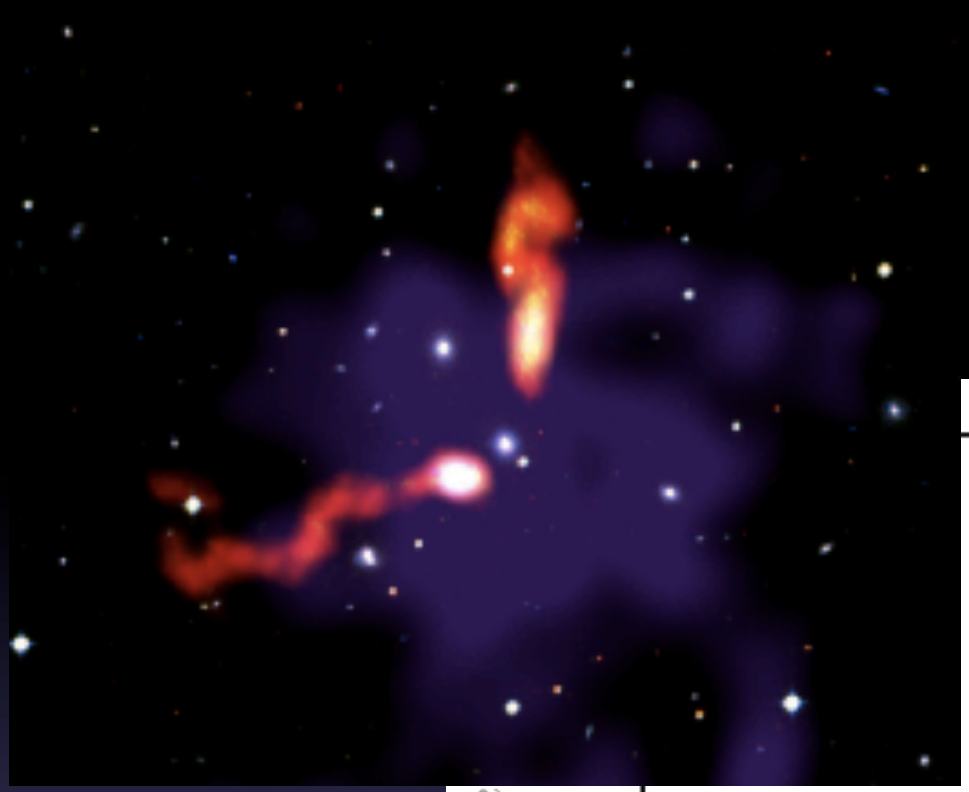
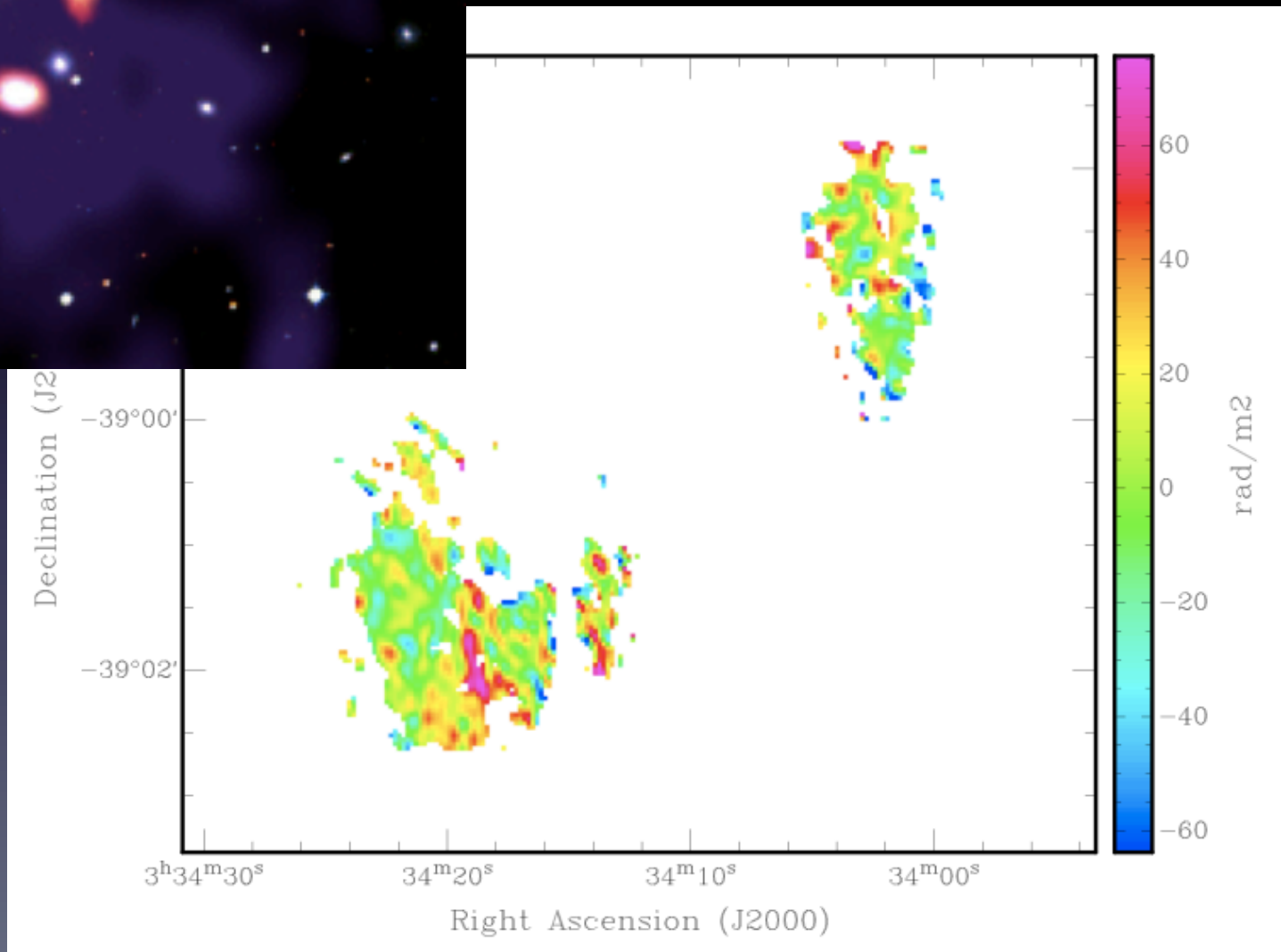
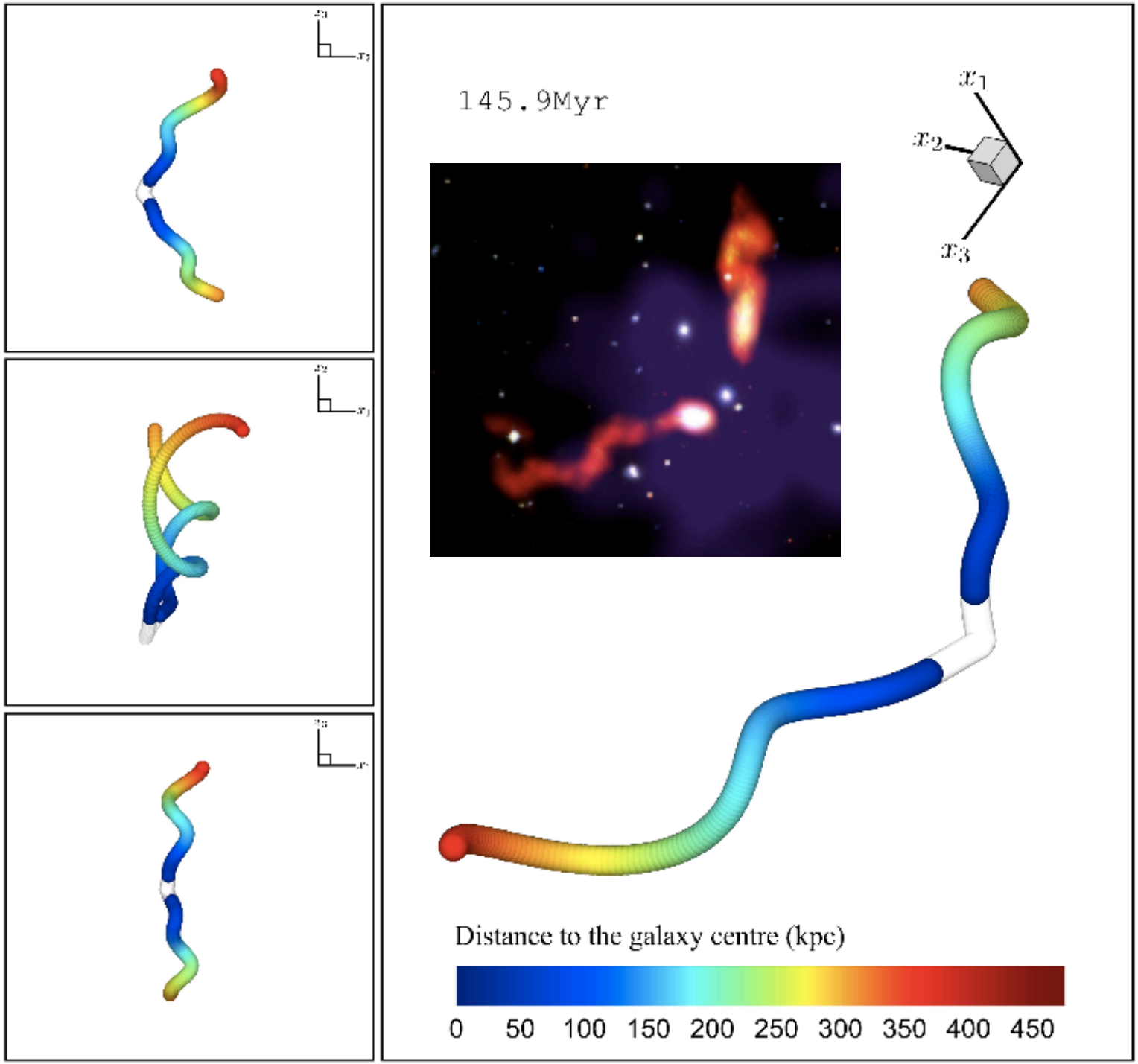


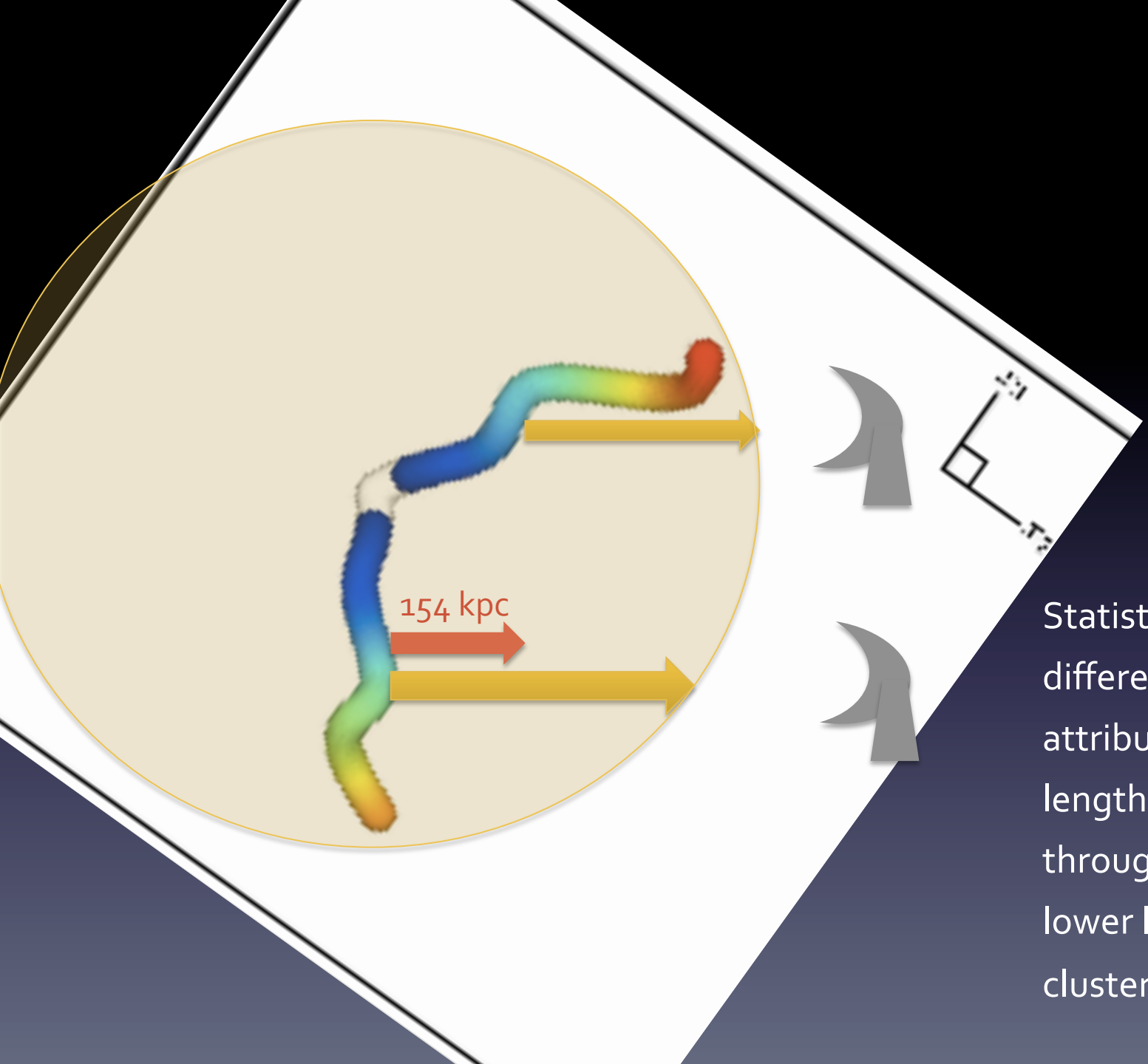


A3135: Map of the RM Synthesis fit pixel. Allows you to look at the turbulence scale in clusters.

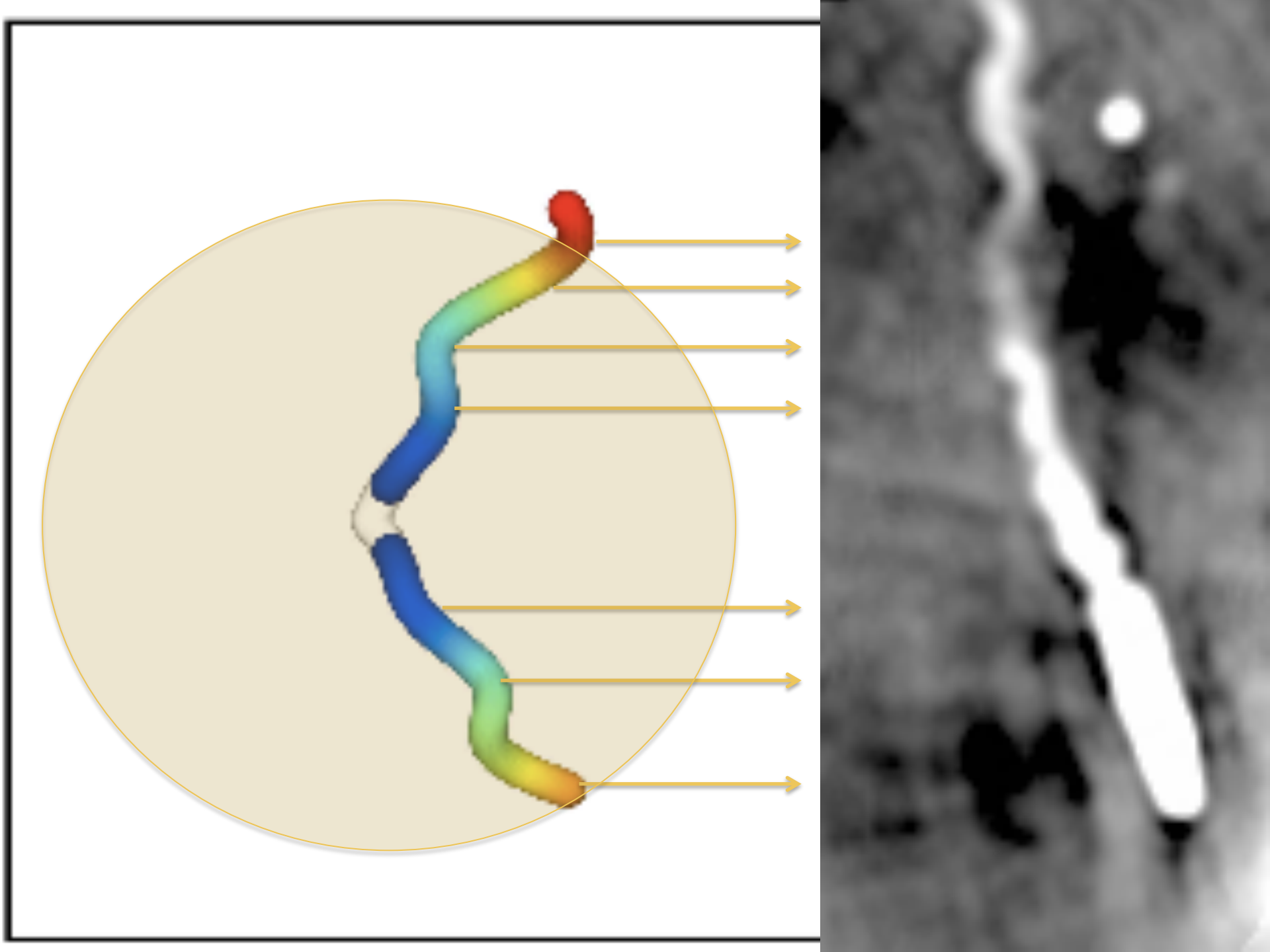
Pratley et al. (2013)

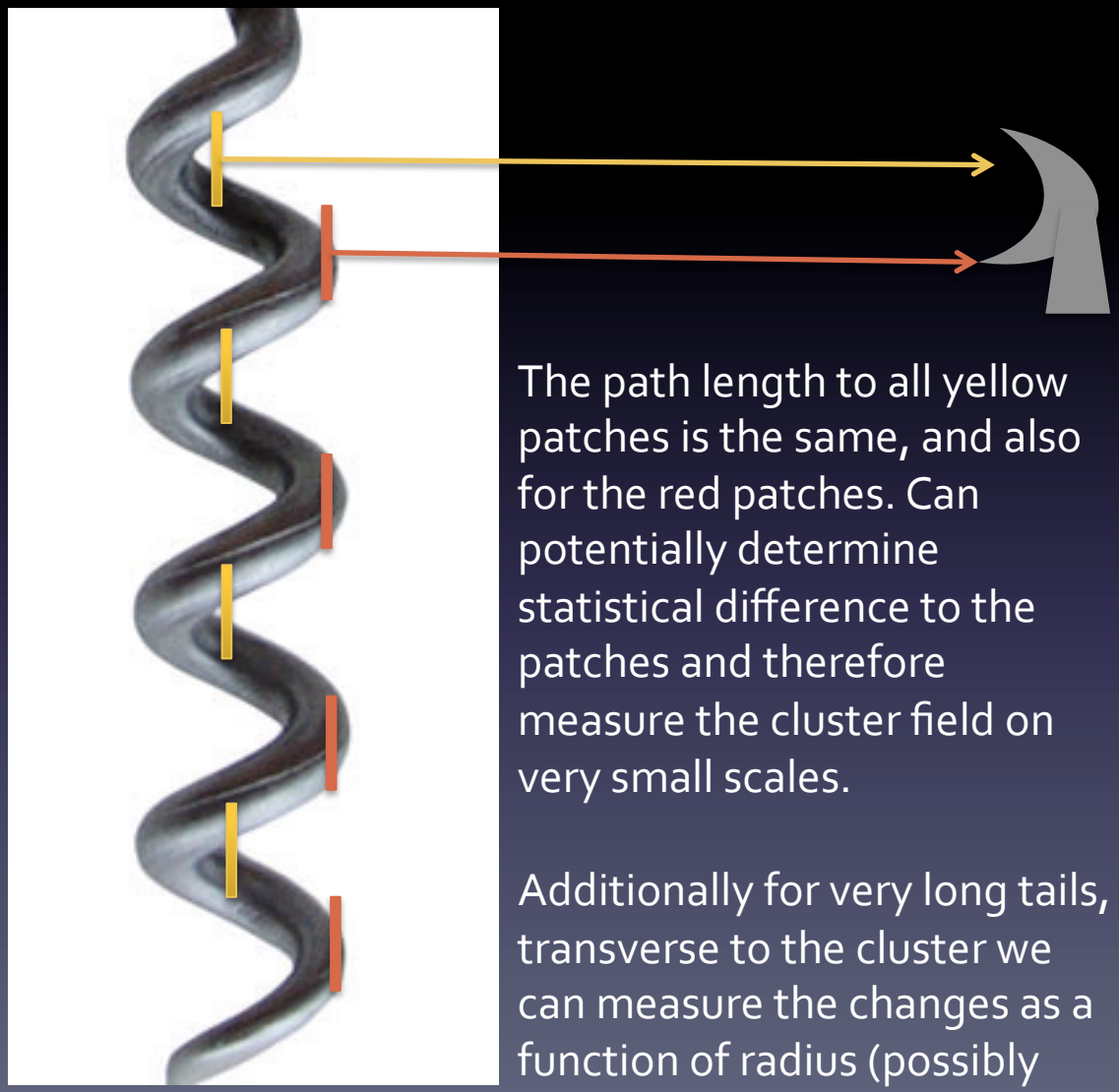
Model of the HT
Pratley et al. (2013), Dehghan (2014)





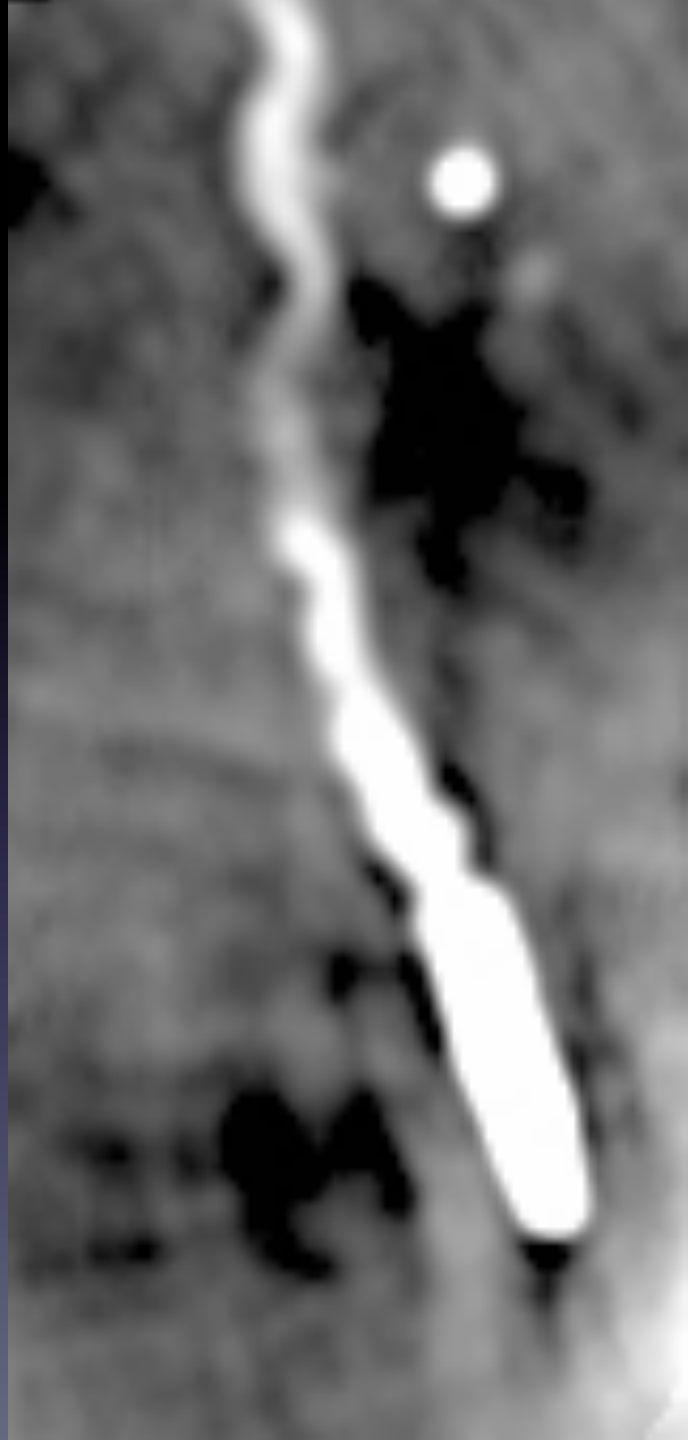
Statistical difference in RM attributed to path length difference through ICM -> lower limit on cluster B field





The path length to all yellow patches is the same, and also for the red patches. Can potentially determine statistical difference to the patches and therefore measure the cluster field on very small scales.

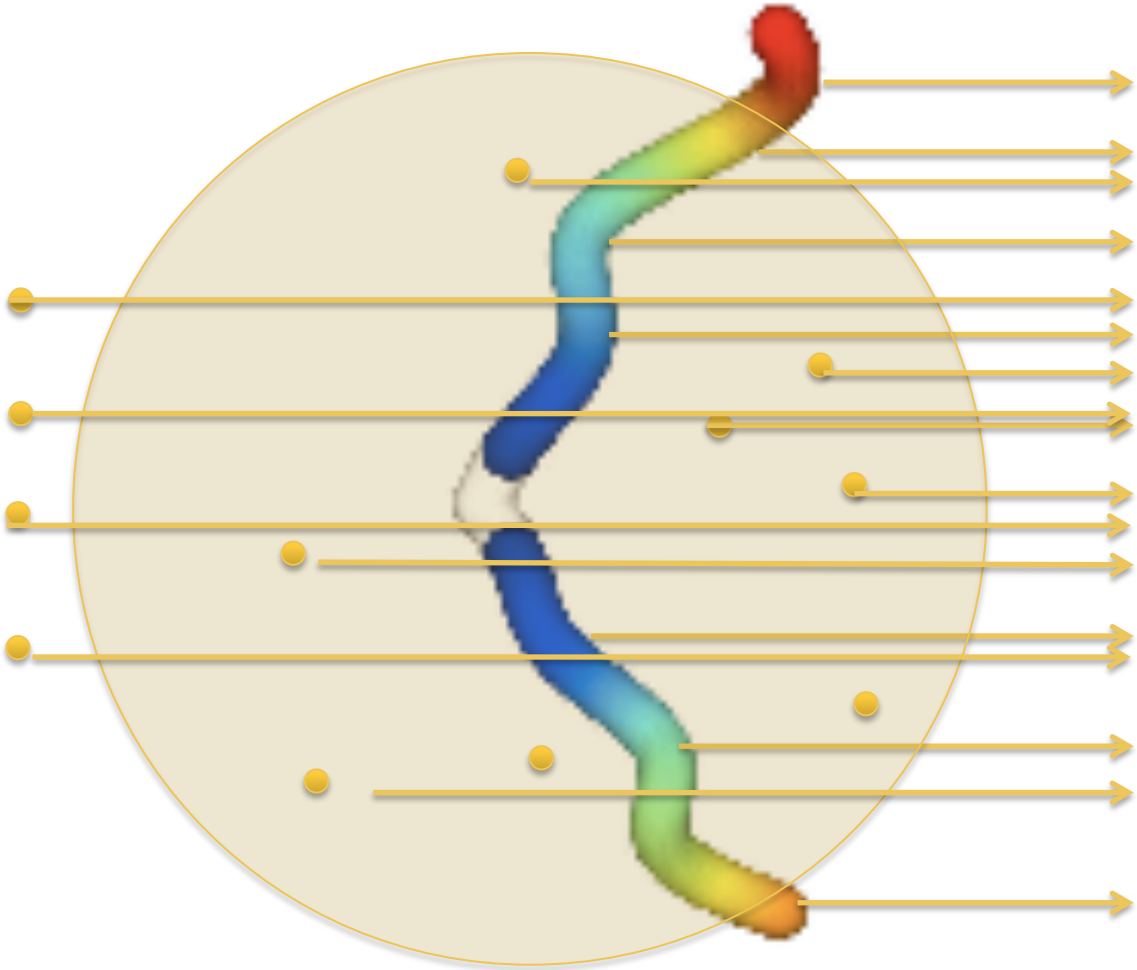
Additionally for very long tails, transverse to the cluster we can measure the changes as a function of radius (possibly with a running mean)



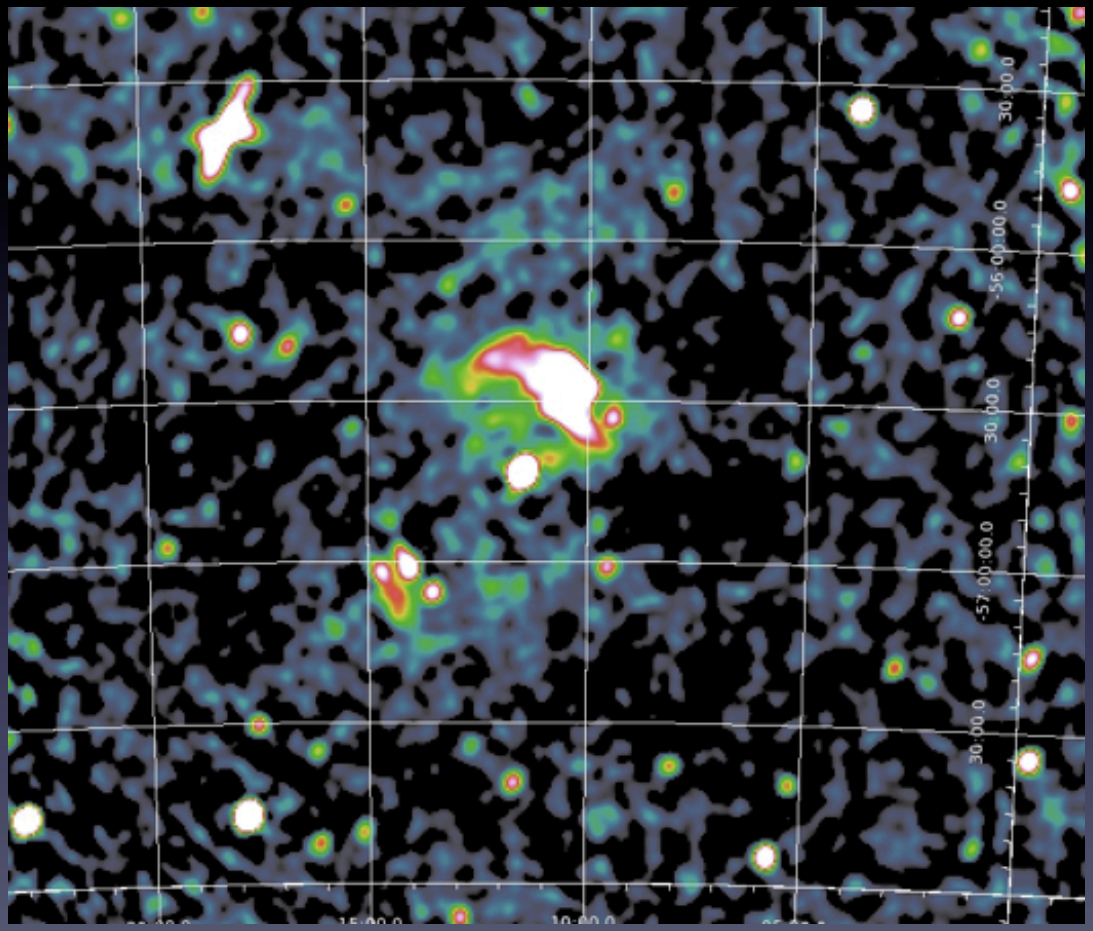
Corkscrew HTs

- With 2″ resolution there should be 500,000 BTs,
- With 0.5″ resolution there should be 2 million.
- Meaning for SKA-mid we should detect ~ 5,000 to 20,000 corkscrew HTs
- Tightness of the spiral gives scales over which you can limit the cluster turbulence.

RM Grid + BTs



Diffuse Sources in Clusters



- A3667 at 165 MHz with the MWA. Diffuse emission is larger that previously seen but no evidence of a bridge. Hindson, Johnston-Hollitt et al (in prep).
- Should get thousands of background RMs through A3667.

Diffuse Sources in Clusters: A3266

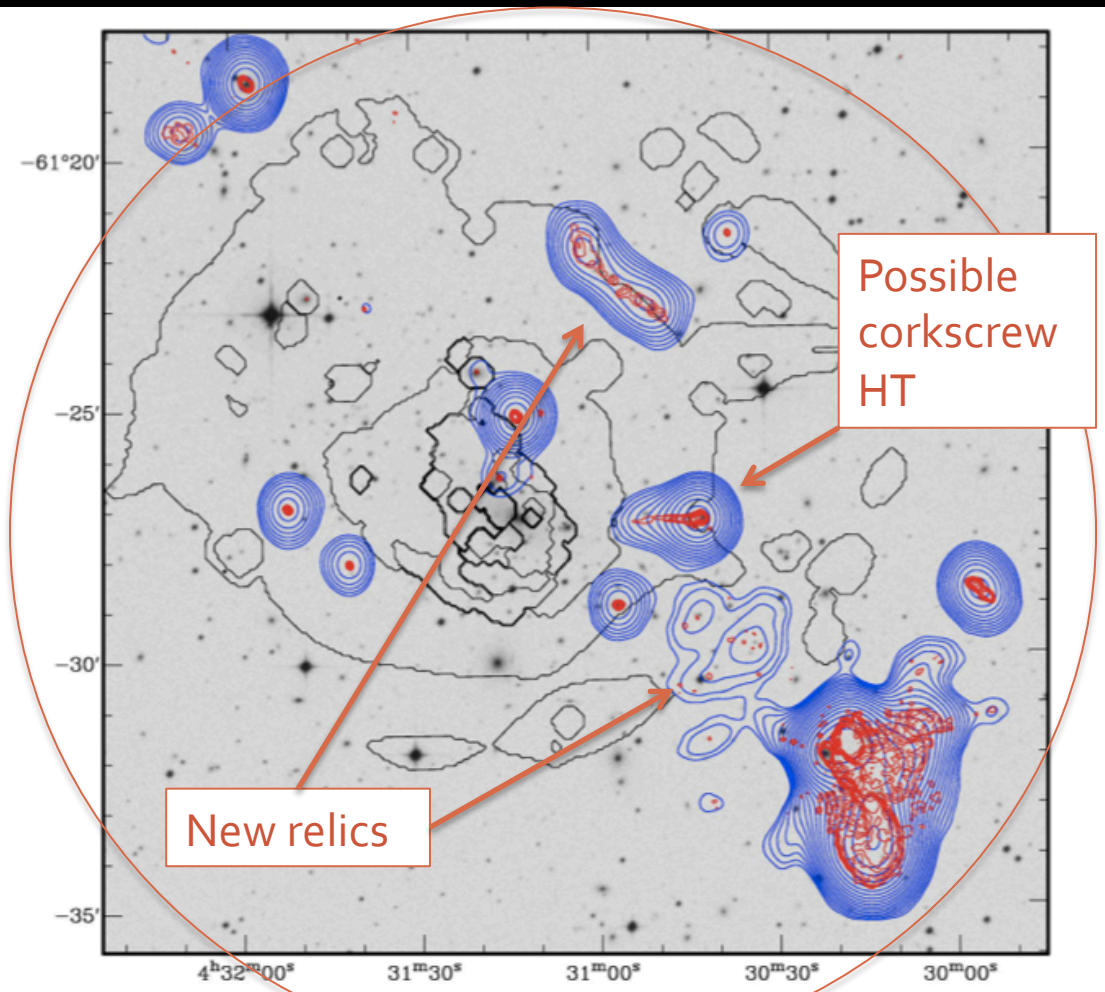
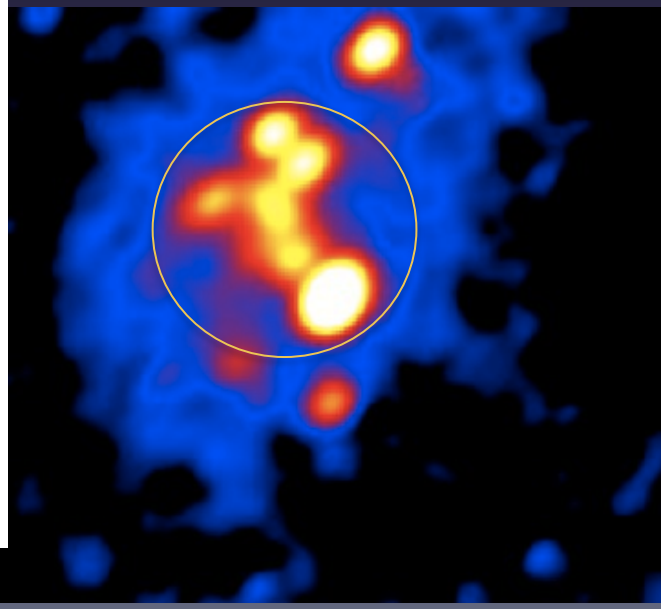


Figure 13. DSS optical image of A3266. Black contours indicate XMM electron density (Finoguenov et al. 2006), blue and red contours correspond to high- and low-sensitivity 1.4GHz radio, respectively.

A3266 at 180 MHz with the MWA. Diffuse emission filling entire cluster. Extending two recently detected relics (Rowan Miller Honours Thesis & Miller et al (in prep)), Johnston-Hollitt, Hurley-Walker et al. 2014)



What do we need?

- For BTs as probes, we need resolution at least 2" but higher would be better for corkscrew galaxies (cf comments about sweet spot though) high sensitivity with good polarisation purity and understanding off-axis effects. Good science case for SKA-Mid and SKA-Survey.
- For BTs with complex morphology might also need redshifts to determine companion to model the correct orientation – only good on a case by case basis.

Strategy

- Use of the RM Grid for cluster magnetic fields requires selection of parameters for maximum sources/area (see Larry's talk). This might not be optical for using things like corkscrew BTs which will likely need higher resolution.
- Probably best to stick to RM grid specs but then follow up individual BT and corkscrew sources at higher resolution with greater sensitivity.

Final Comment…

- What do we need as data products for polarisation science?
- Where is the line between what the SKA project delivers and what is processed by external research teams?