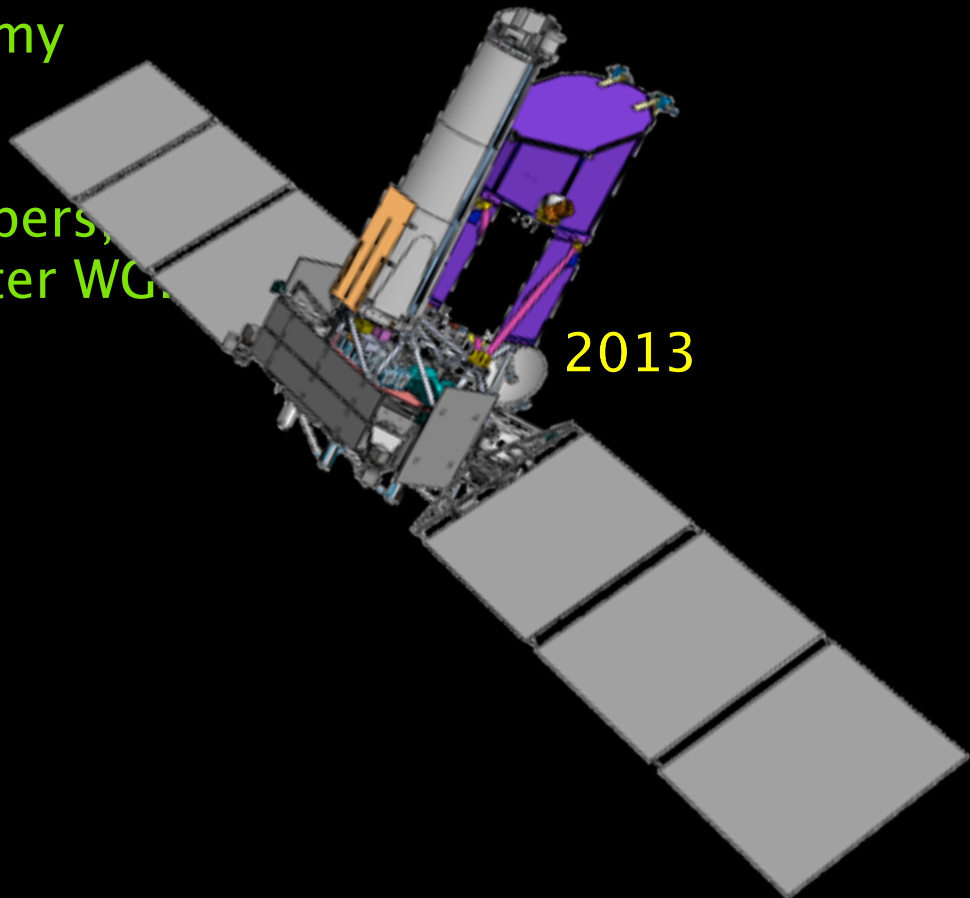
ASKAP/EMU – eROSITA Complementarity and Synergy for Galaxy Cluster Science (Cosmology)

Thomas Reiprich
Argelander Institute for Astronomy
Bonn University
http://dark-energy.net
With input from EMU team members, especially R. Norris and the cluster WG.

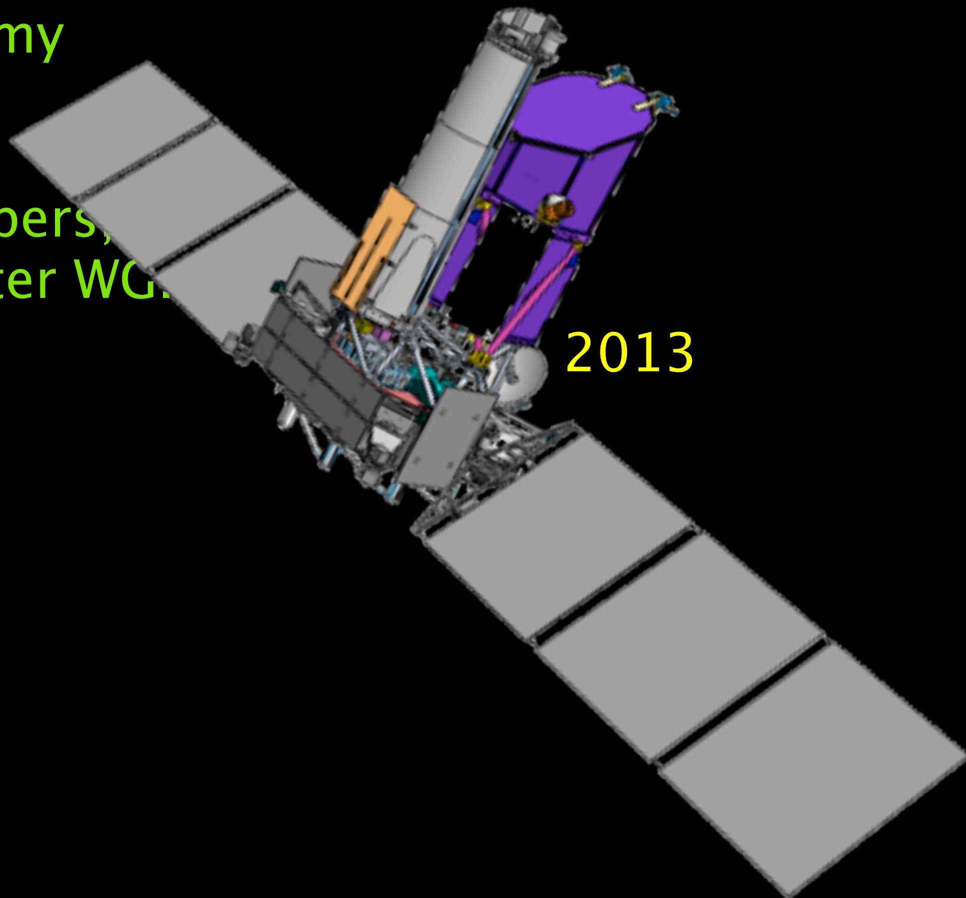


2013

ASKAP/EMU – eROSITA Complementarity and Synergy for Galaxy Cluster Science (Cosmology)

Thomas Reiprich
Argelander Institute for Astronomy
Bonn University
http://dark-energy.net

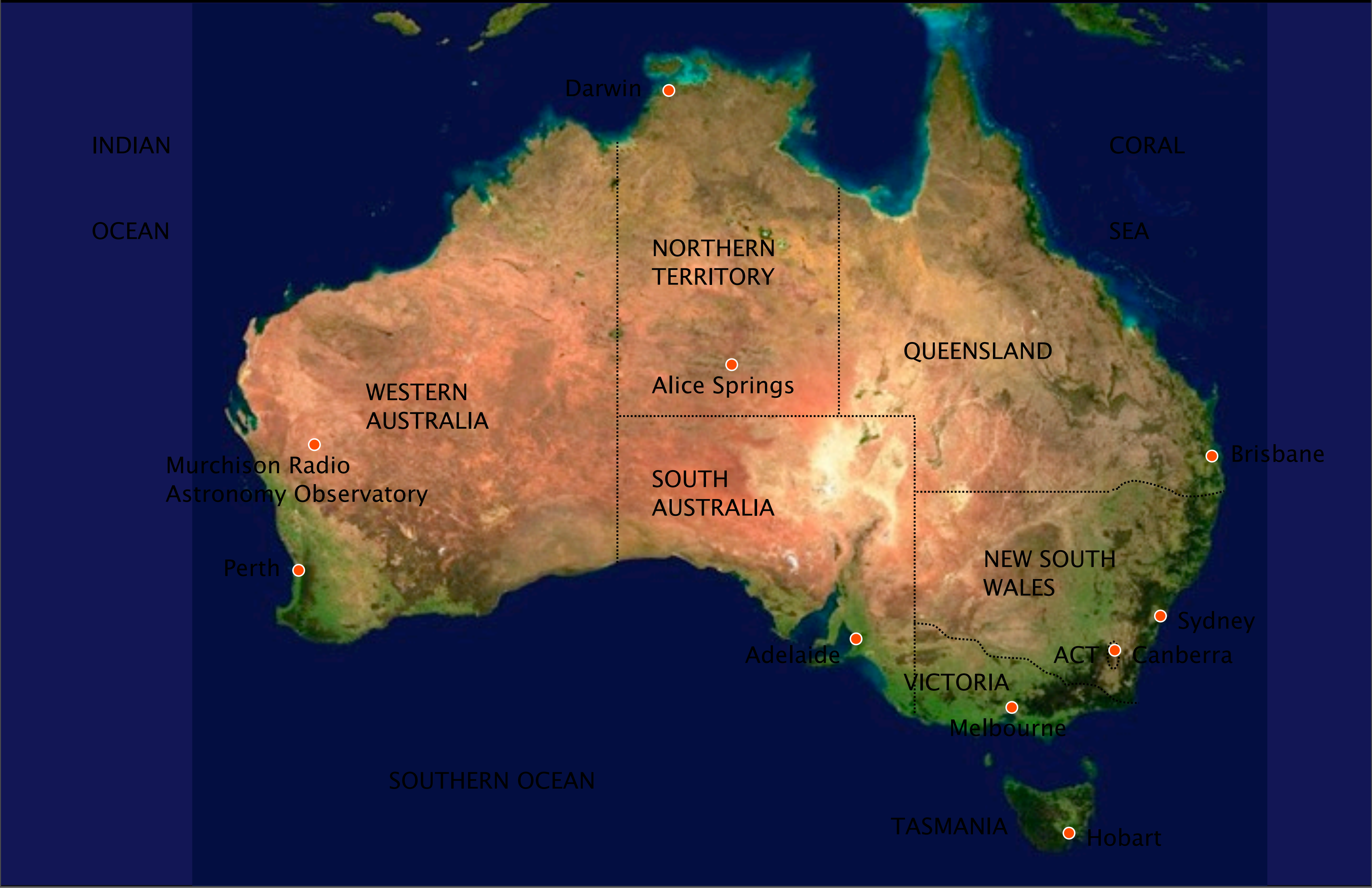
With input from EMU team members,
especially R. Norris and the cluster WG.



2013

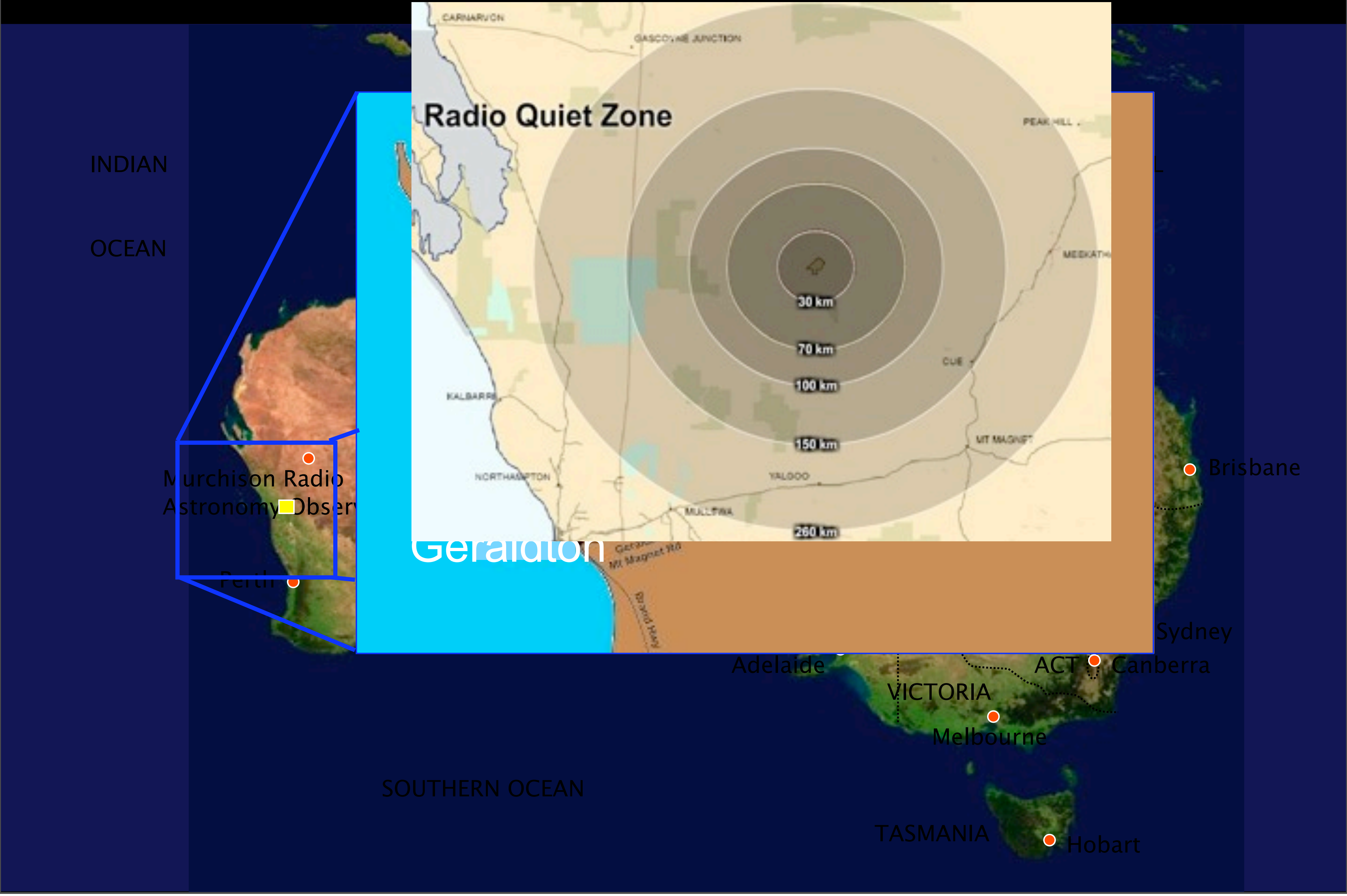
What is ASKAP?
Australian SKA Pathfinder

- A$170M (=€120M) project now under construction in Western Australia.
- Completion early 2013.
- 36*12m antennas.
- Antennas have a 92-pixel phased array feed (PAF).
- 30 sq. deg FOV!


Darwin
INDIAN
OCEAN
CORAL
SEA
NORTHERN
TERRITORY
QUEENSLAND
Alice Springs
WESTERN
AUSTRALIA
Murchison Radio
Astronomy Observatory
SOUTH
AUSTRALIA
Brisbane
Perth
NEW SOUTH
WALES
Sydney
ACT
Canberra
Adelaide
VICTORIA
Melbourne
SOUTHERN OCEAN
TASMANIA
Hobart

Australia – WA – Midwest –

Australia – WA – Midwest –



Australia – WA – Midwest –

Murchison


INDIAN
OCEAN
SOUTHERN OCEAN
Brisbane
Sydney
ACT
Canberra
Adelaide
VICTORIA
Melbourne
TASMANIA
Hobart
Geraldton
BOOLARDY STATION
Entry to MRO Site
MURCHISON
BOOLARDY
30km
YALGOO
PINDAR
MULLEWA
98km
NW Coastal Hwy
Mullewa Carnarvon Rd
Brand Hwy

Murchison

INDIAN
OCEAN
Murchison Radio
Astronomy Observ
Perth
Shire of Murchison
Geraldton
MULLEWA
PINDAR
YALGOO
Brisbane
Sydney
ACT
Canberra
Adelaide
VICTORIA
Melbourne
SOUTHERN OCEAN
TASMANIA
Hobart

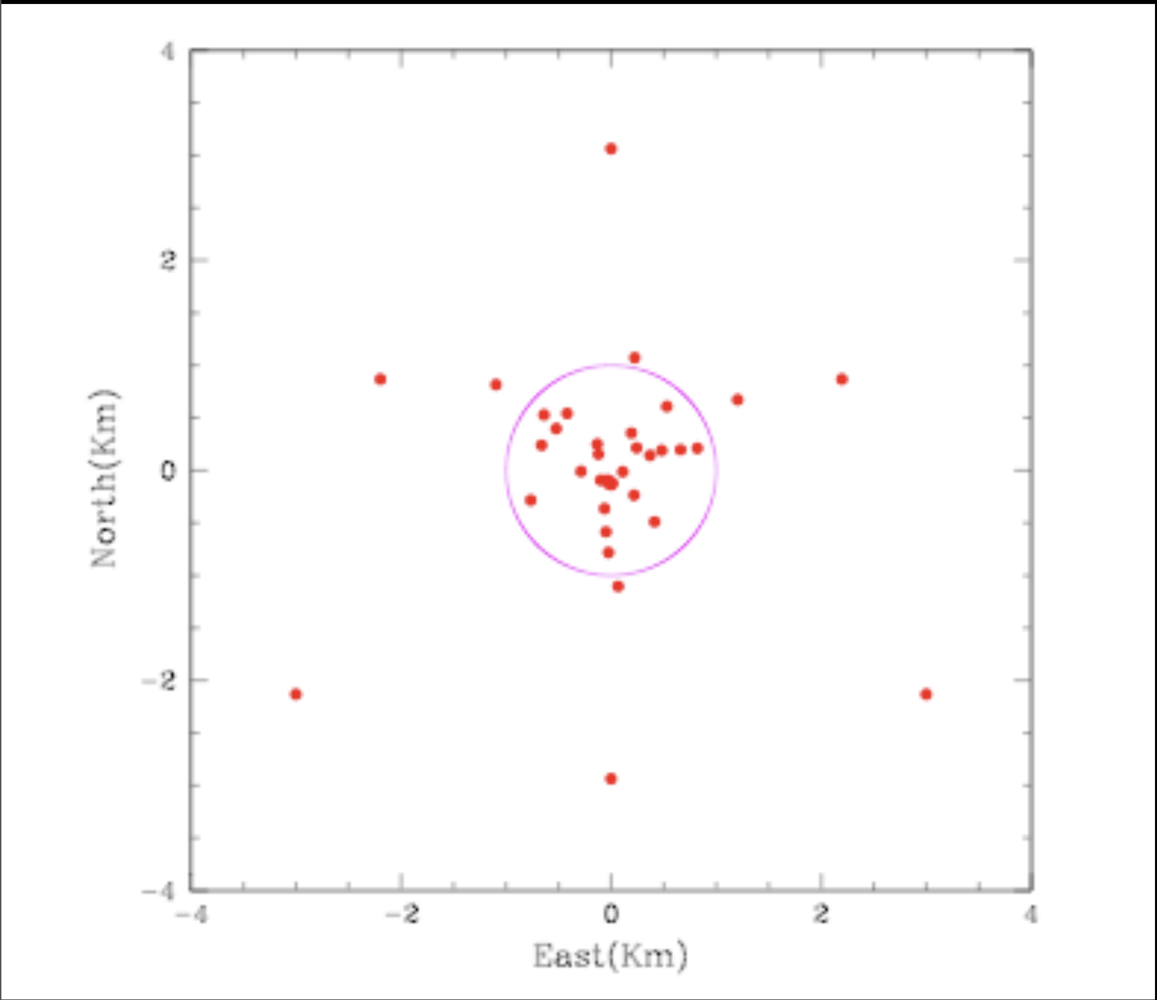
Murchison

INDIAN
OCEAN
Shire of Murchison
MULLEWA
YALGOO
PINDAR
Geraldton
gazetted towns: 0
population: “up to 160”
Brisbane
Sydney
Adelaide
ACT
Canberra
VICTORIA
Melbourne
SOUTHERN OCEAN
TASMANIA
Hobart

Murchison


INDIAN
OCEAN
Murchison Radio
Astronomy Observ
Perth
Shire of Murchison
Netherlands
YALGOO
PINDAR
MULLEWA
Geraldton
gazetted towns: 0
population: "up to 160"
Brisbane
Sydney
Adelaide
ACT
Canberra
VICTORIA
Melbourne
SOUTHERN OCEAN
TASMANIA
Hobart

36 Antenna Array Configuration



Natural weighting:
resolution 20 arcsec

Continuum:
uniform weighting:
resolution 10 arcsec

Spectral Line:
Inner 30 dishes only,
resolution 30 arcsec

(all at 1.4 GHz)

Gupta et al. 2008, ATNF ASKAP Memo 21

What is EMU?

Evolutionary Map of the Universe

38 proposals submitted to ASKAP
(including one EMU cluster piggy-bag from H. Andernach)

2 selected as being highest priority

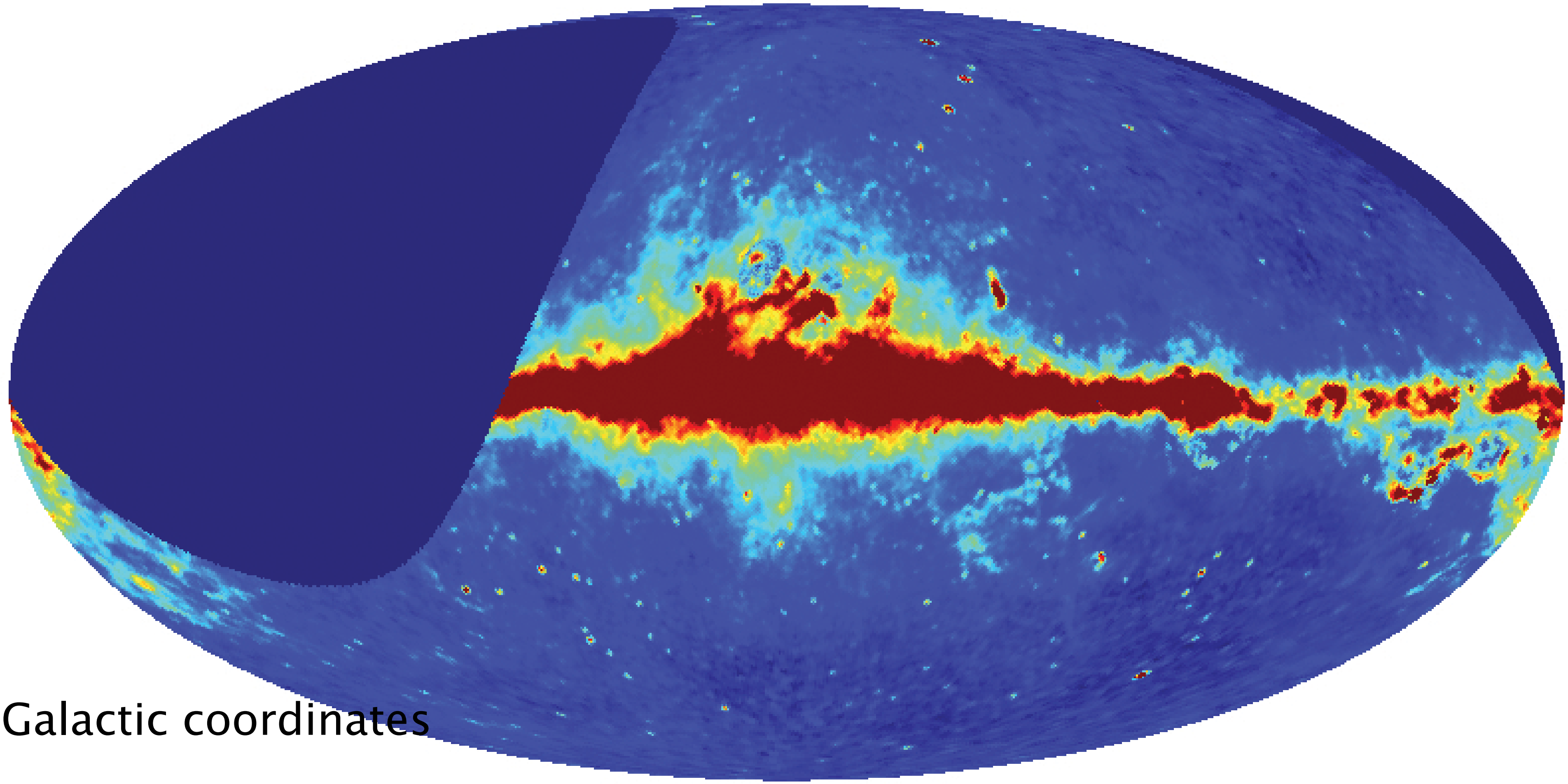
- EMU all-sky continuum (PI Norris)
- WALLABY all-sky HI (PI Koribalski & Staveley-Smith)

8 others also supported

- COAST pulsars etc
- CRAFT fast variability
- DINGO deep HI
- FLASH HI absorption
- GASKAP Galactic
- POSSUM polarisation
- VAST slow variability
- VLBI

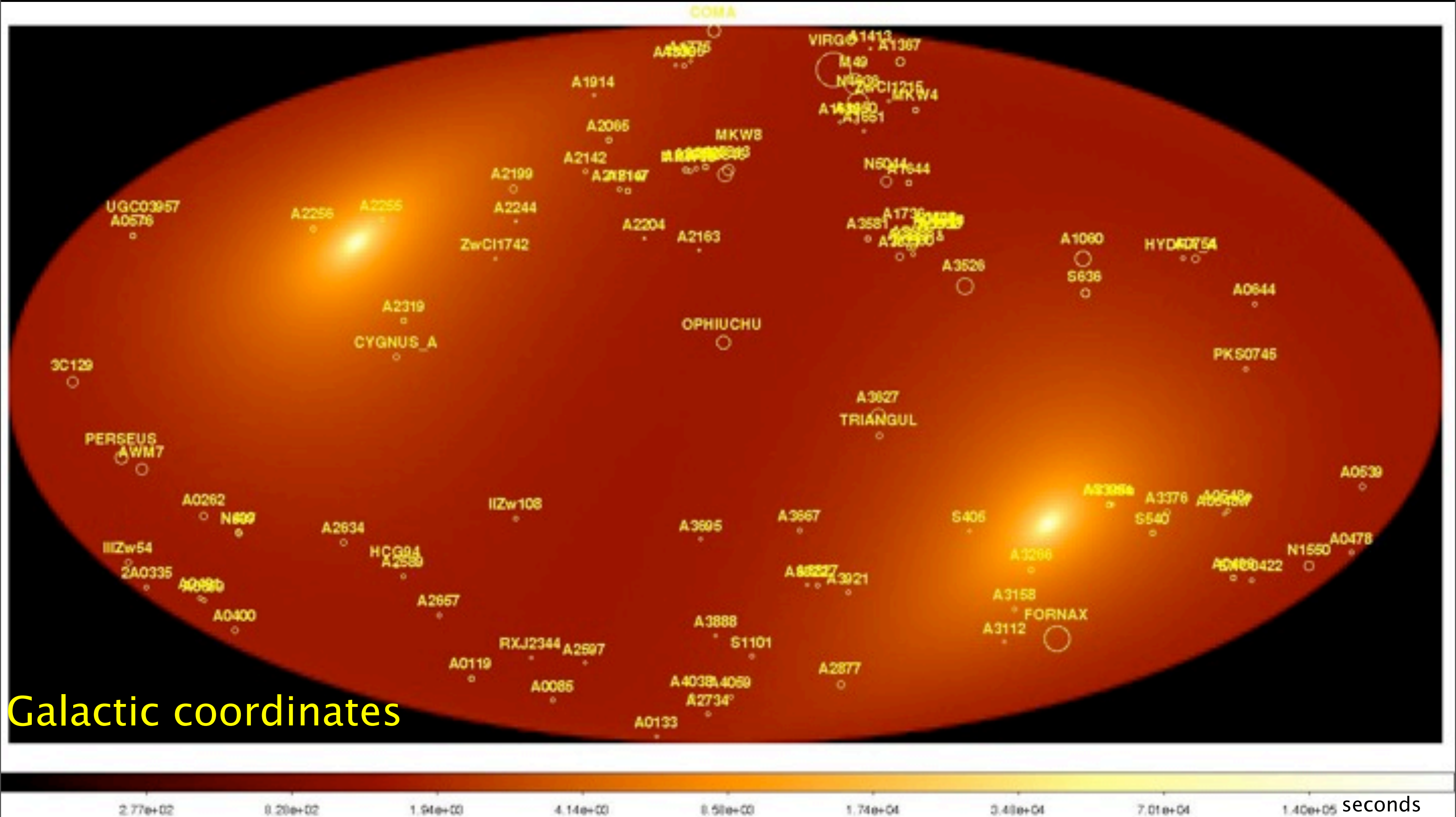
- Deep radio image of 75% of the sky (to declination +30°).
- Frequency range: 1100-1400 MHz.
- 40 x deeper than NVSS.
  - 10 μJy rms across the sky.
- 5 x better resolution than NVSS (10 arcsec).
- Better sensitivity to extended structures than NVSS.
- Will detect and image ~70 million SF galaxies and AGN at 20cm (S. Croom's talk).
- Images, catalogues, cross-IDs, to be placed in public domain (~12 hours after data taking).
- Survey starts 2013.
- Total integration time: ~1.5 years (as long as it takes!)?

EMU Sky Coverage



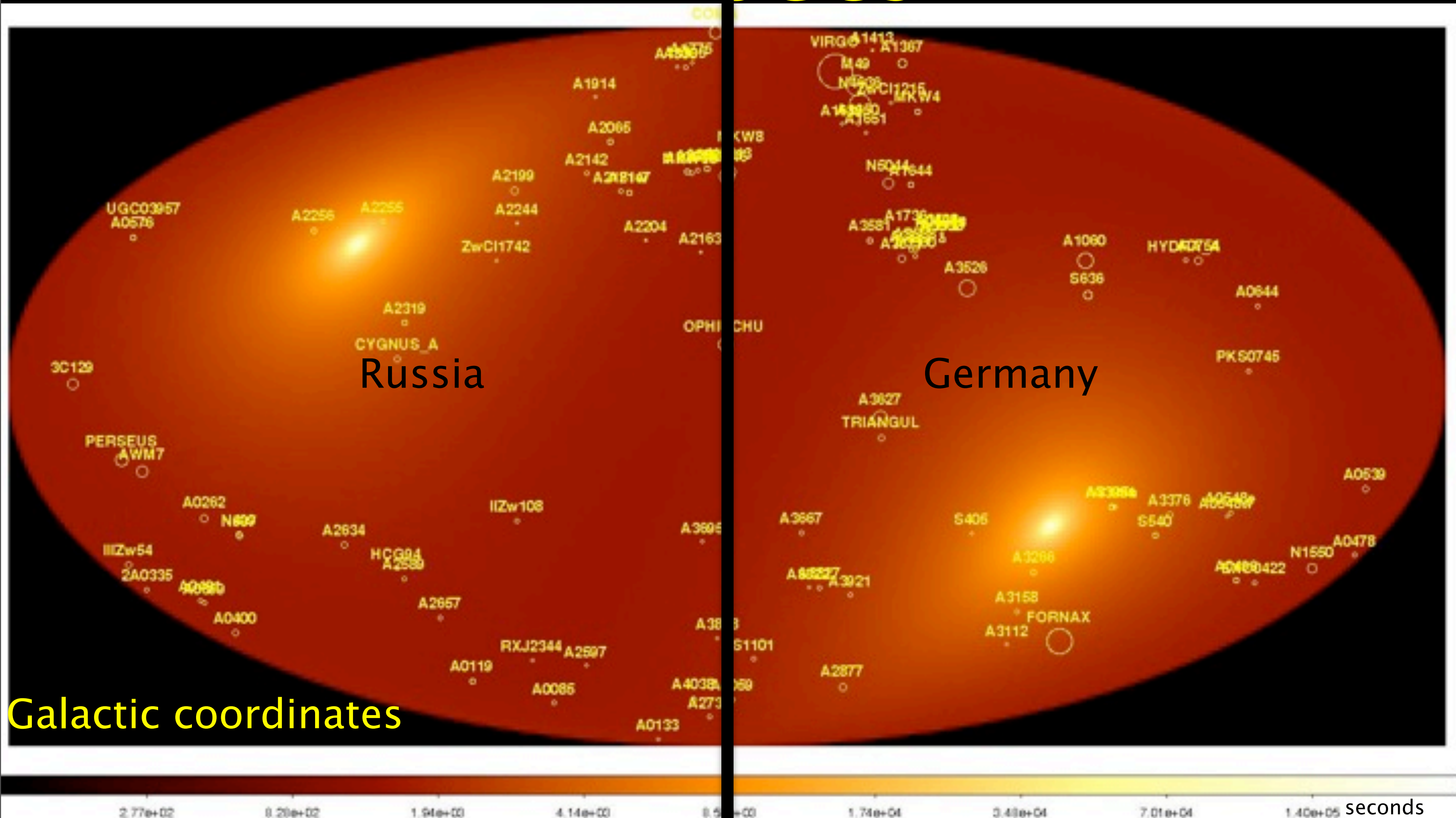
Norris et al. (2011)

The Brightest Local Clusters: HIFLUGCS



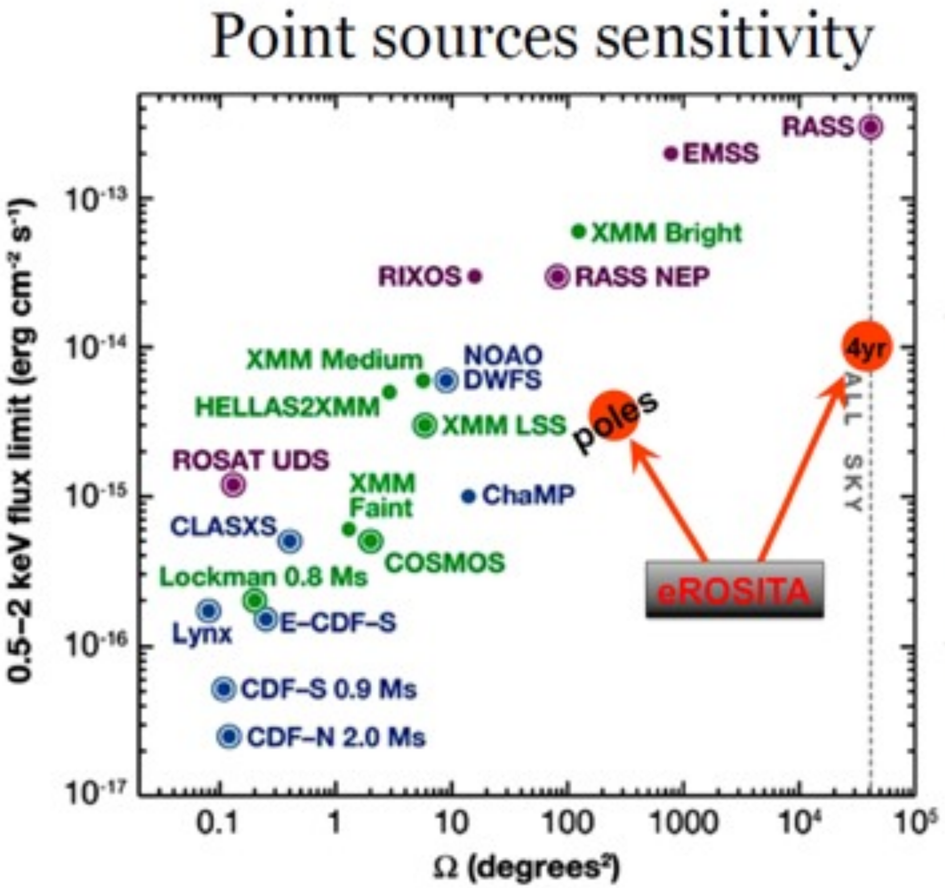
eROSITA exposure map provided by J. Robrade.

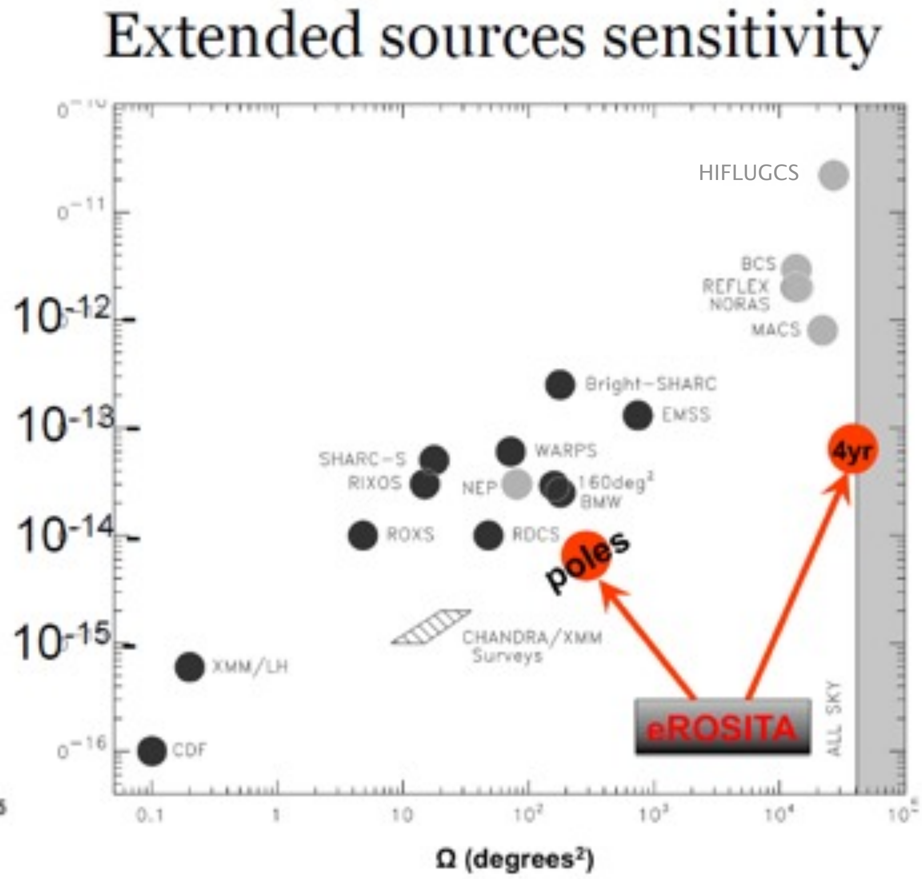
The Brightest Local Clusters: HIFLUGCS



eROSITA exposure map provided by J. Robrade.

Comparison with other Surveys

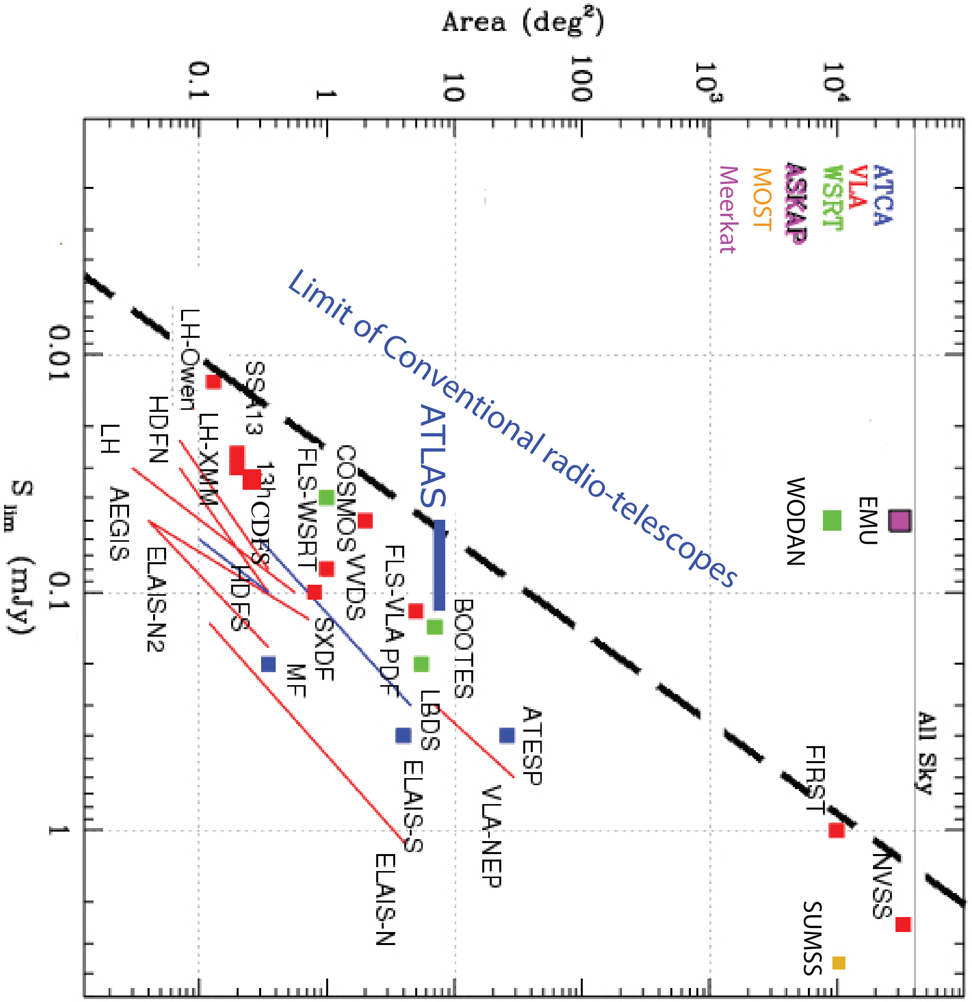


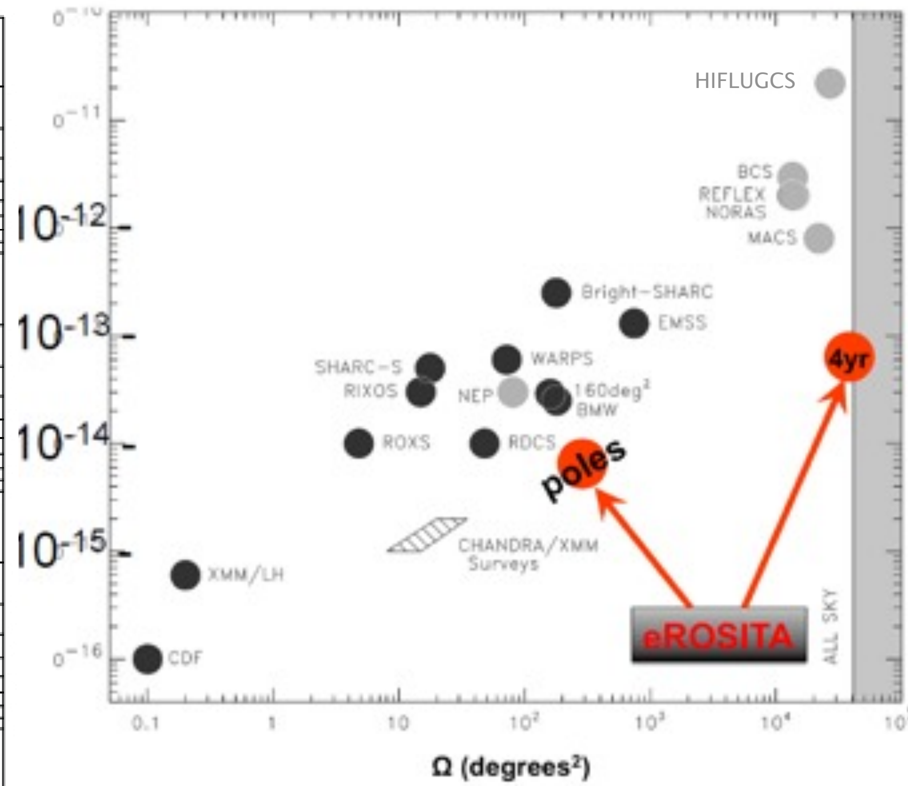


All sky: 10^{-14} (0.5-2 keV)
2×10^{-13} (2-10 keV) [erg/cm²/s]

Provided by P. Predehl

Comparison with other Surveys





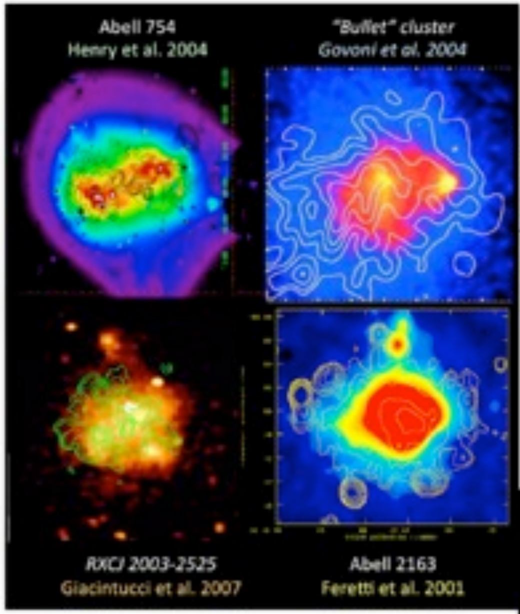
Provided by P. Predehl

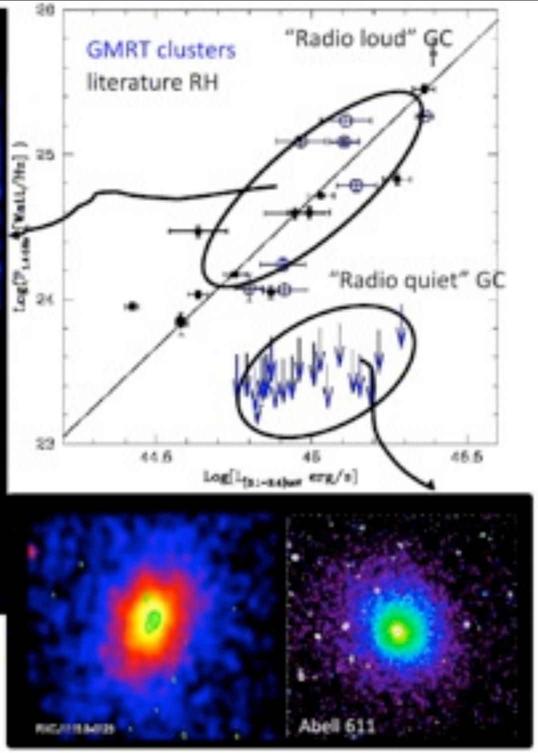
Norris et al. (2011)

What Kind of Cluster Radio Sources will EMU Detect?

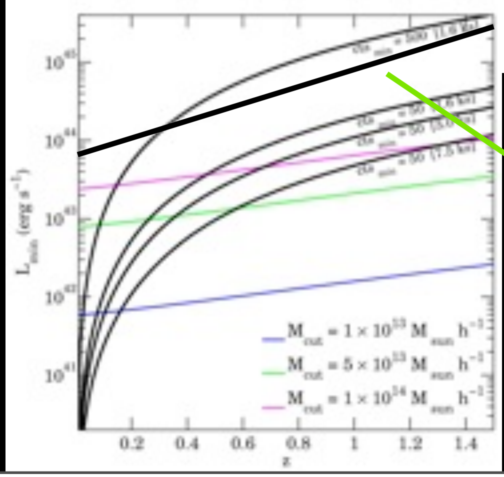
- Radio (mini-) halos.
- Radio relics.
- Tailed radio galaxies.
- (Central) radio galaxies.

Radio Halos + Radio Relics: ≤1,000

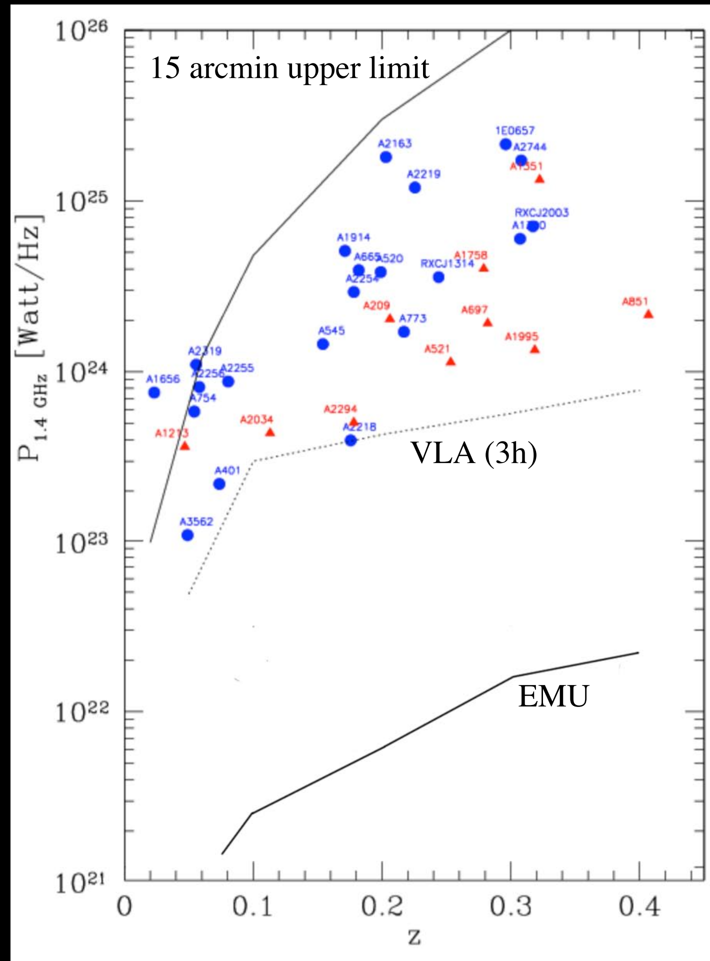




Cassano (2011)



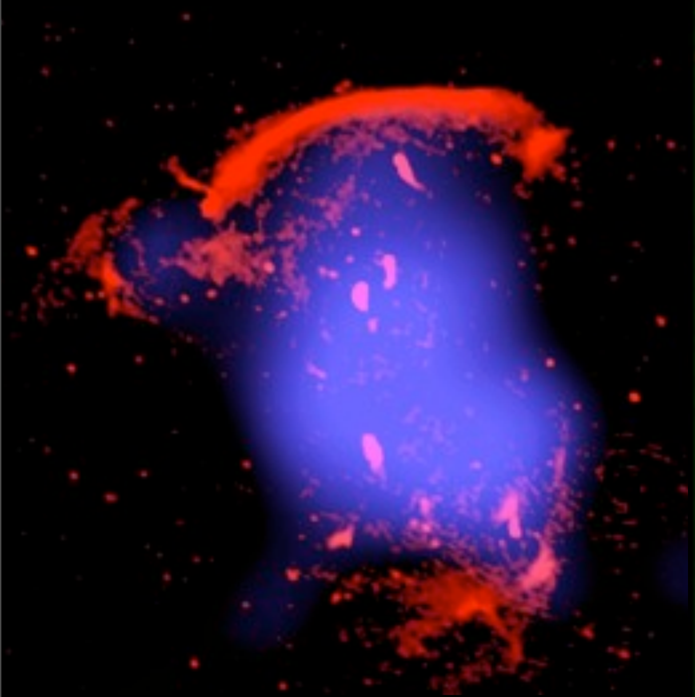
~EMU-Wide,
C. Ferrari



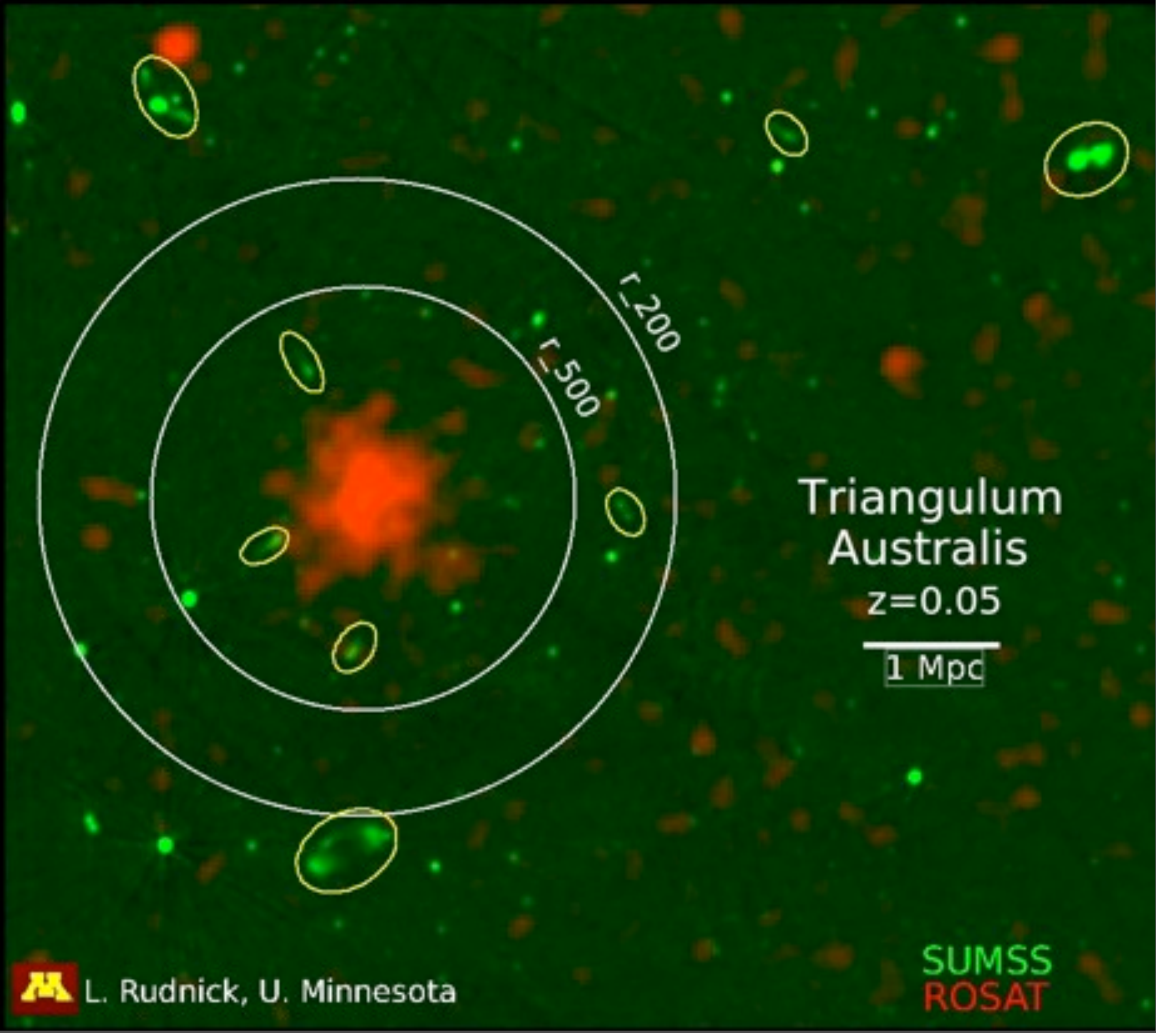
~1 Mpc halo; Norris et al. (2011)

(Talks by H. Roettgering and M. Hoeft.)

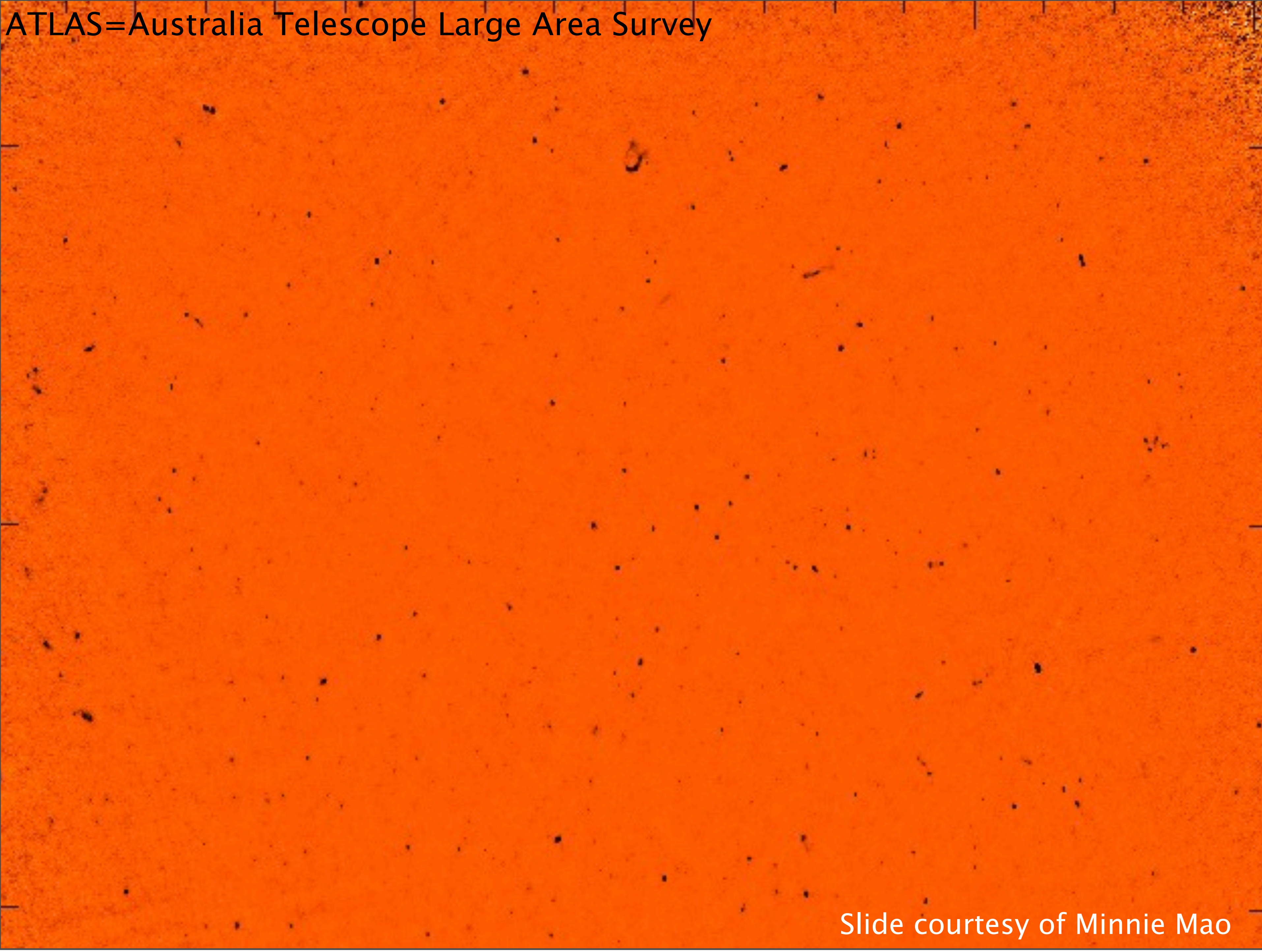
Tailed Radio Galaxies: ≥10,000 Clusters



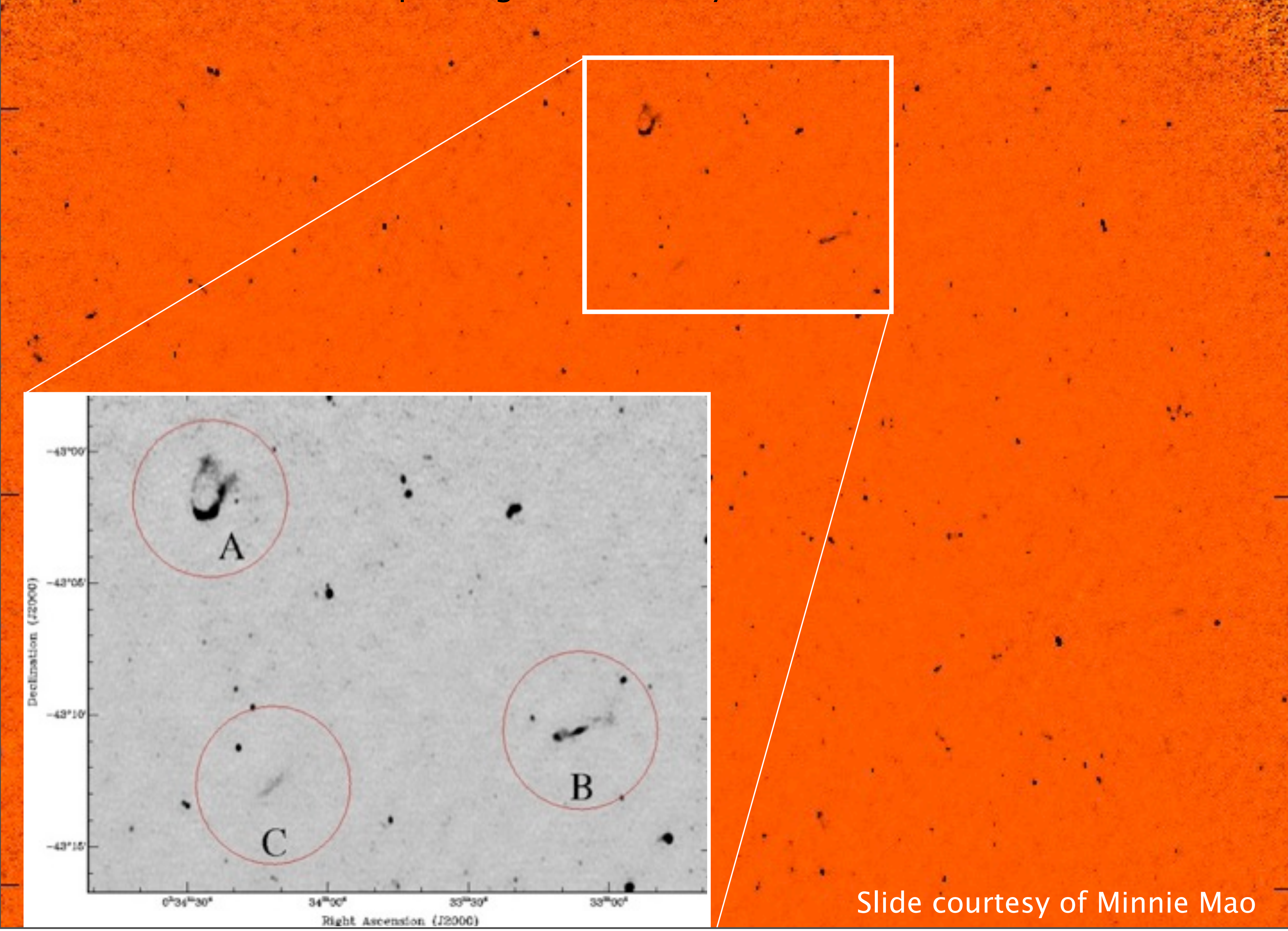
van Weeren et al. (2010)



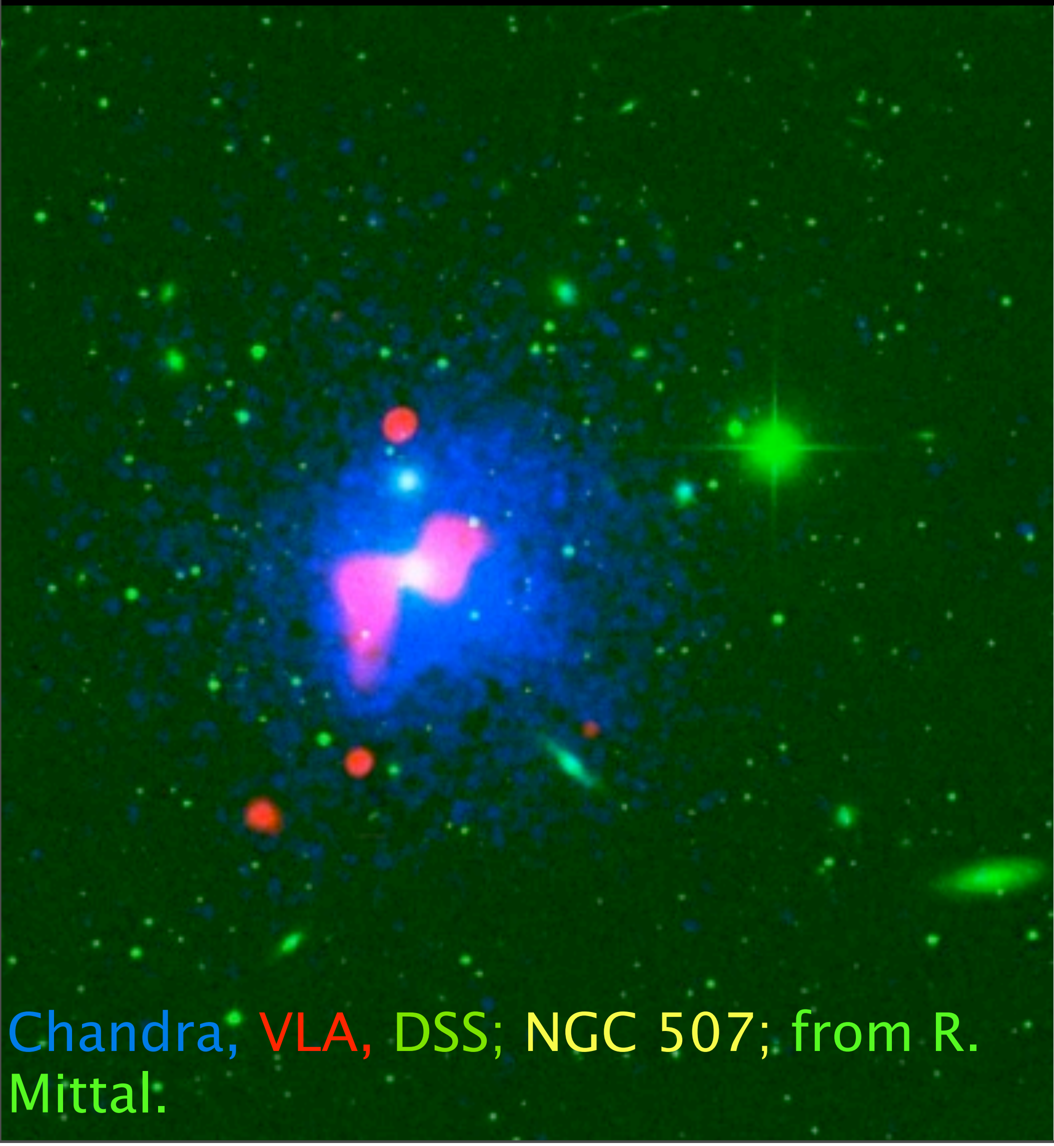
ATLAS=Australia Telescope Large Area Survey



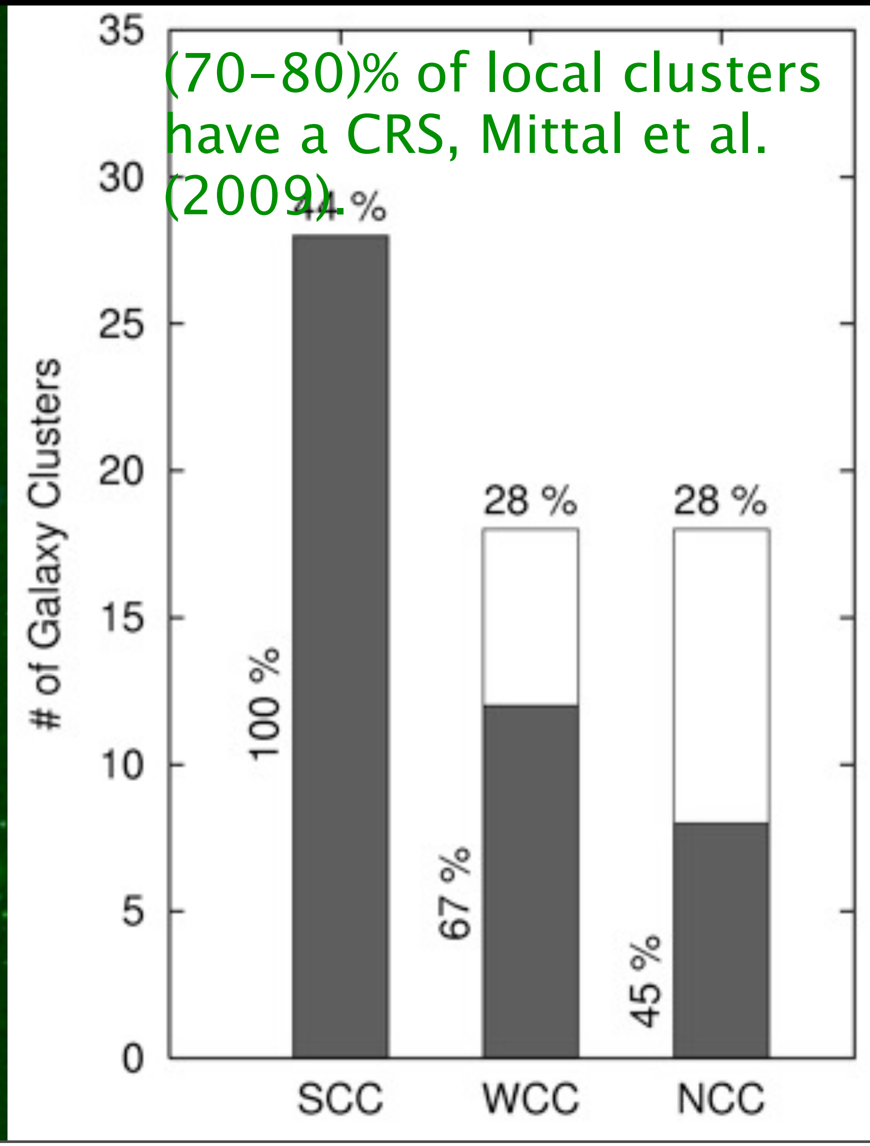
ATLAS=Australia Telescope Large Area Survey



(Central) Radio Galaxies for ≥Half of All eROSITA Clusters



Chandra, VLA, DSS; NGC 507; from R. Mittal.

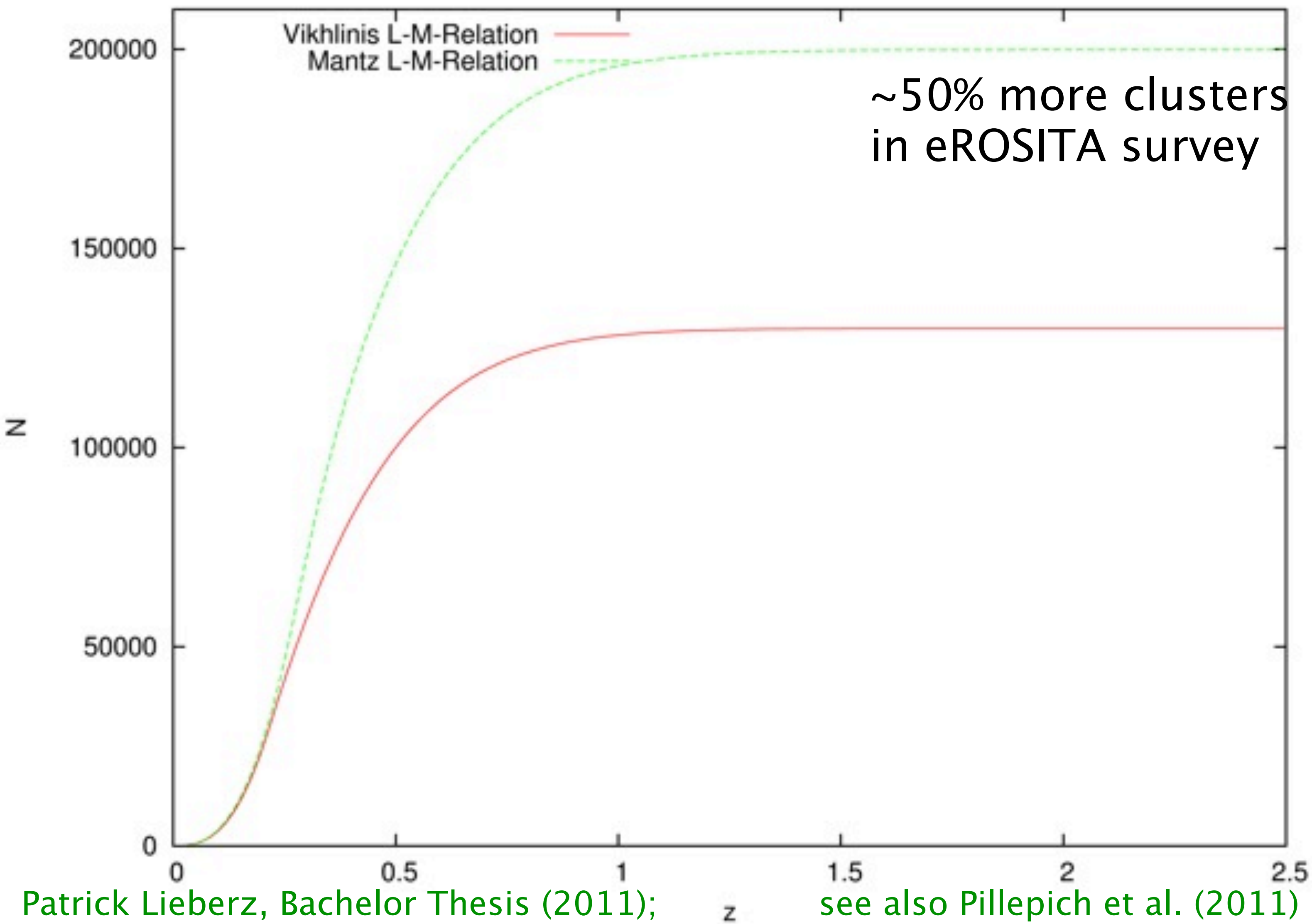


(70-80)% of local clusters have a CRS, Mittal et al. (2009).

Possible Role of EMU

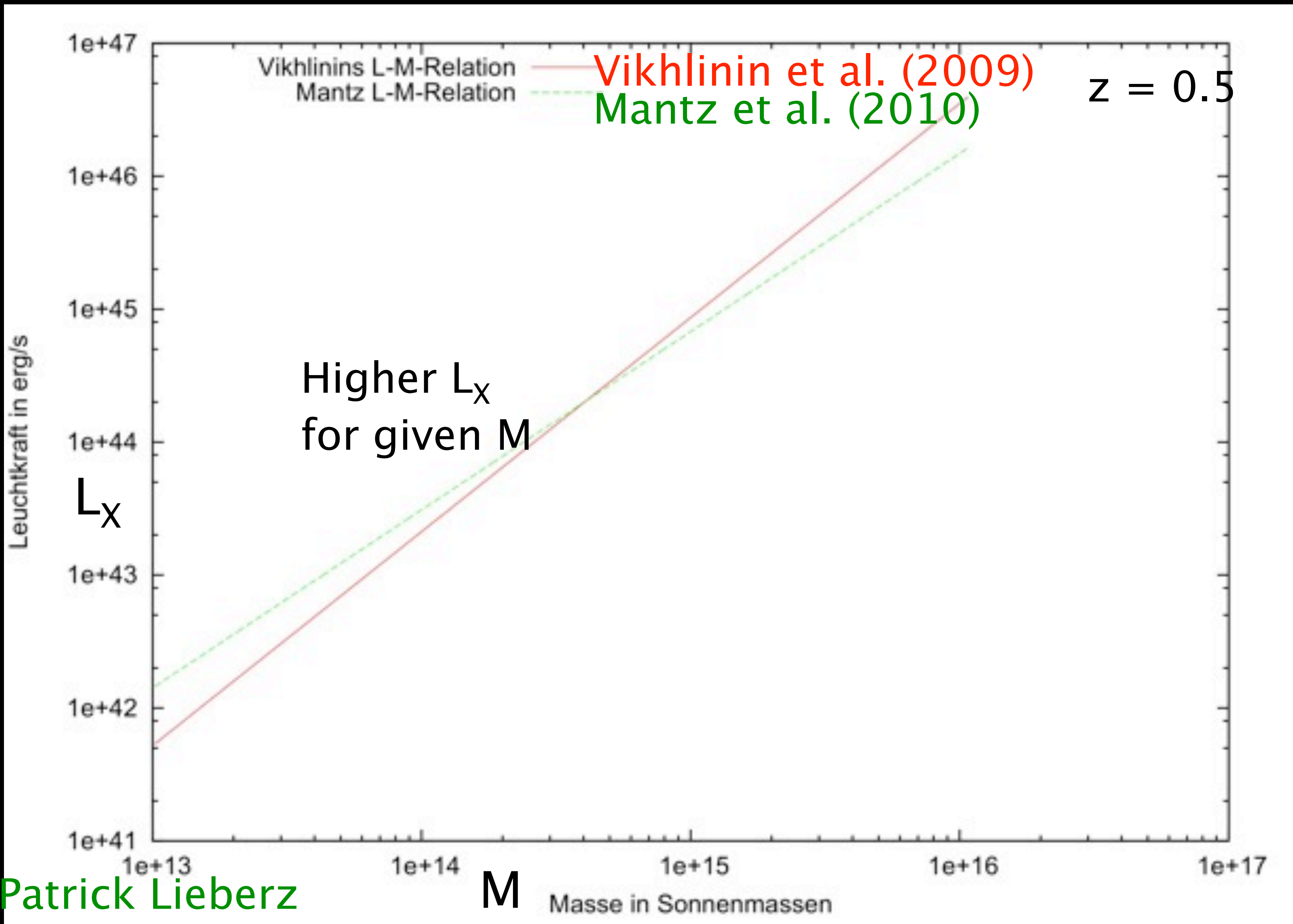
- EMU will likely detect ≥10,000 clusters (Norris et al. 2011). Combination with eROSITA data will allow us to study cluster physics in detail and with great statistics (see also talks by M. Hoeft and H. Roettgering). But how can EMU be useful for eROSITA cluster cosmology?

Dependence of Total Number of Detected Clusters on L_X–M Relation



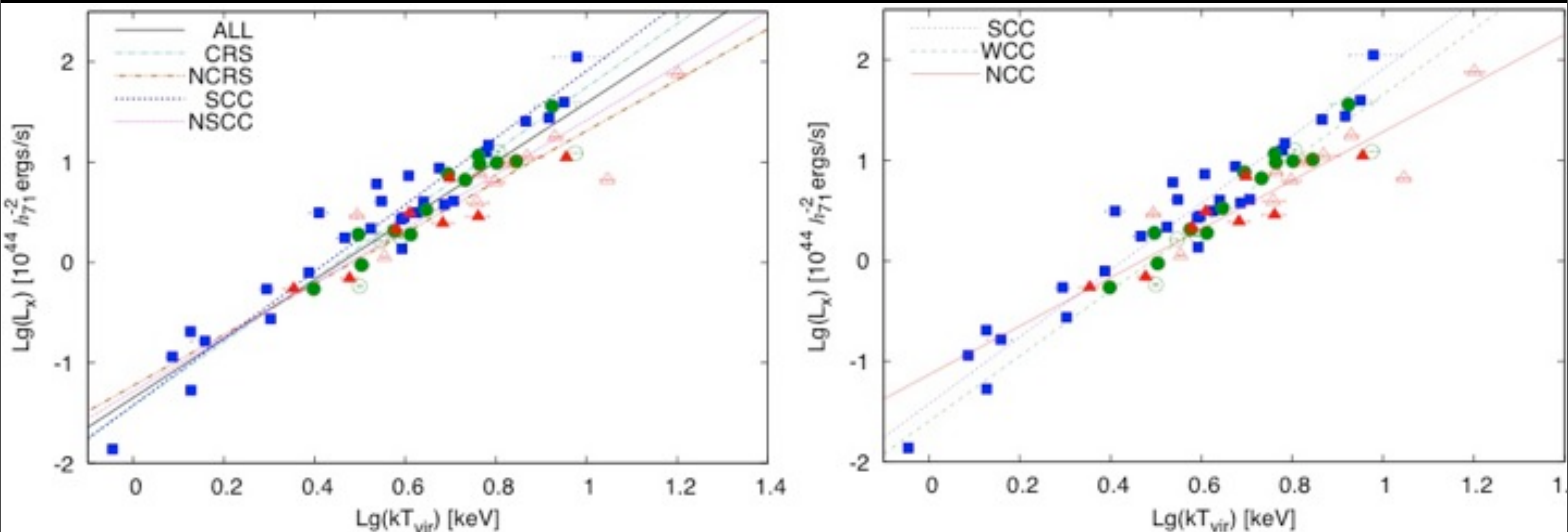
Patrick Lieberz, Bachelor Thesis (2011); see also Pillepich et al. (2011)

L_X–M Relations



Patrick Lieberz

Dependence of L_X–T Relation on Presence of Central Radio Source (CRS) and on Dynamical State



CRS slope = 3.2
NCRS slope = 2.5

SCC (proxy for relaxed) slope = 3.3
NCC (proxy for merger) slope = 2.4

Mittal et al. (2011), based on complete HIFLUGCS sample, selection effectscorrected individually for different subsamples.

Possible Role of EMU

- Classifying into CRS and NCRS clusters will be useful for a better differentiation of applicable scaling relations, resulting in more robust cosmological constraints. EMU will be able to detect CRS for many eROSITA clusters.

- Same applies for relaxed and disturbed clusters. Radio halos, typical radio relics, and NATs reside almost exclusively in disturbed clusters, and EMU will find a significant fraction of them.

Summary

- The ASKAP/EMU sky coverage and sensitivity are perfect matches to eROSITA (not only for clusters).
- Multiwavelength follow-up efforts could benefit from each other.
- eROSITA will be very helpful to identify relic (and halo) candidates (from EMU, WODAN, LOFAR) with clusters.
- The upcoming radio plus X-ray information will allow us to study cluster physics systematically with great statistics.
- Cross-correlating the ≥10,000 EMU clusters (e.g., from tailed radio galaxies) with the ~100,000 eROSITA clusters will enable observational checks of the eROSITA selection.
- Radio information will allow us to better disentangle cosmology and scaling relation details, ultimately resulting in more robust cosmological constraints.
- To do: e.g., how to optimally combine the radio and X-ray info for the different purposes.