High Frequency Radio Properties of Central AGNs in Cluster Environments

Junhyun Baek[1], Aeree Chung[1], Evangelia Tremou[2],
Bongwon Sohn[3], Taehyun Jung[3]

1 Yonsei University, Korea
2 Michigan State University, USA
3 KASI, Korea

credit : chandra photo album

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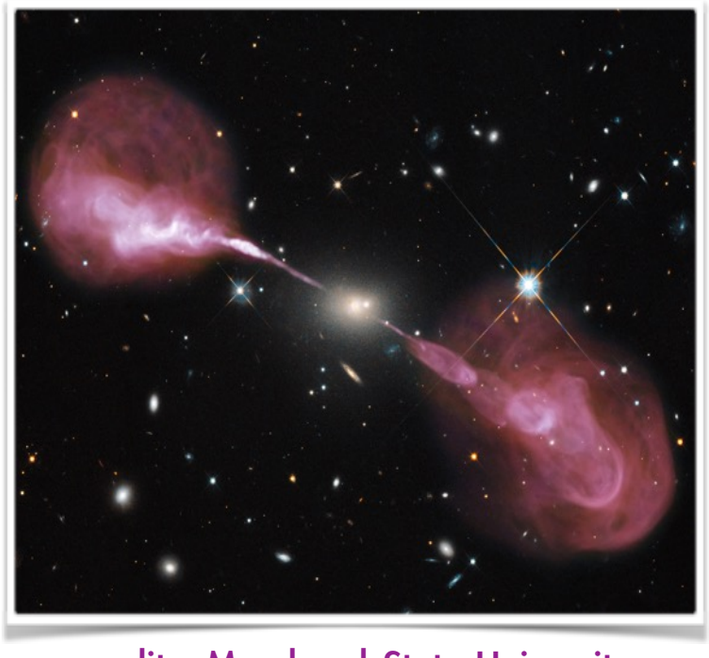
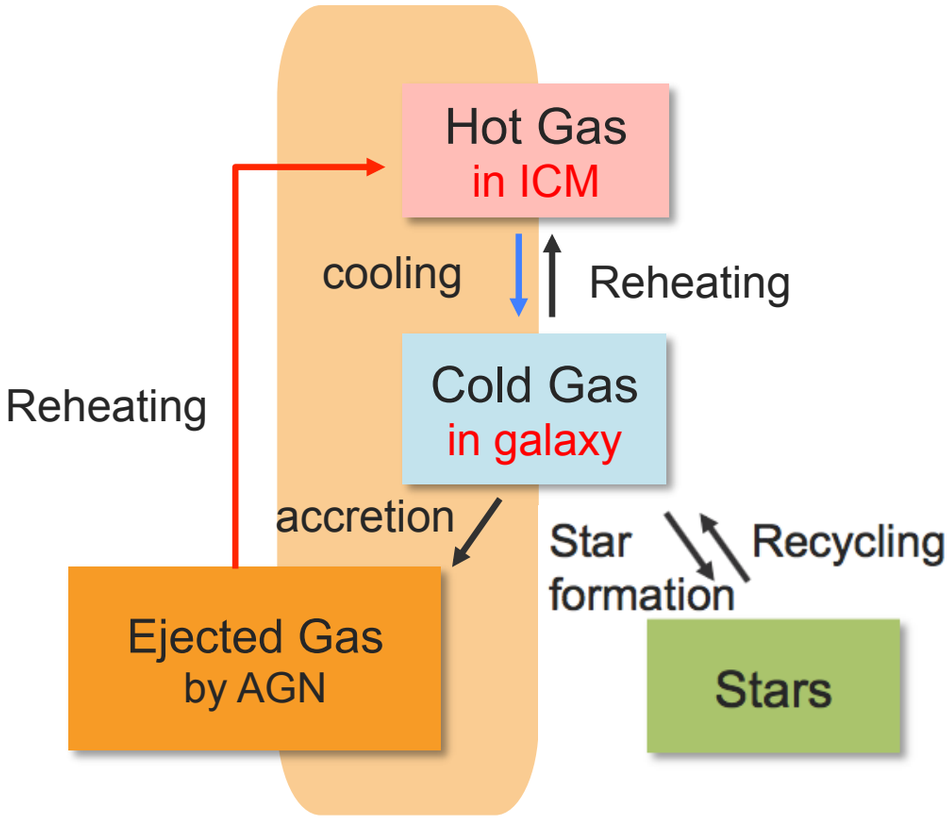
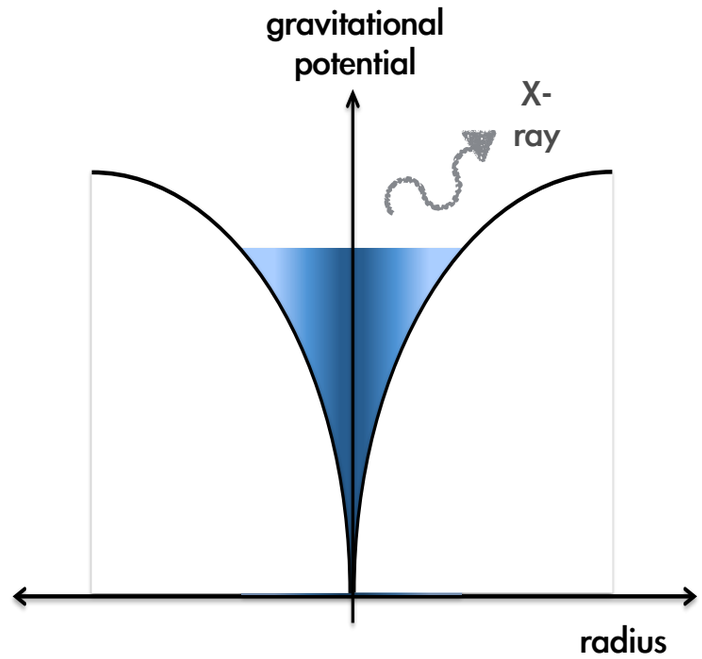


credit : Morehead State University

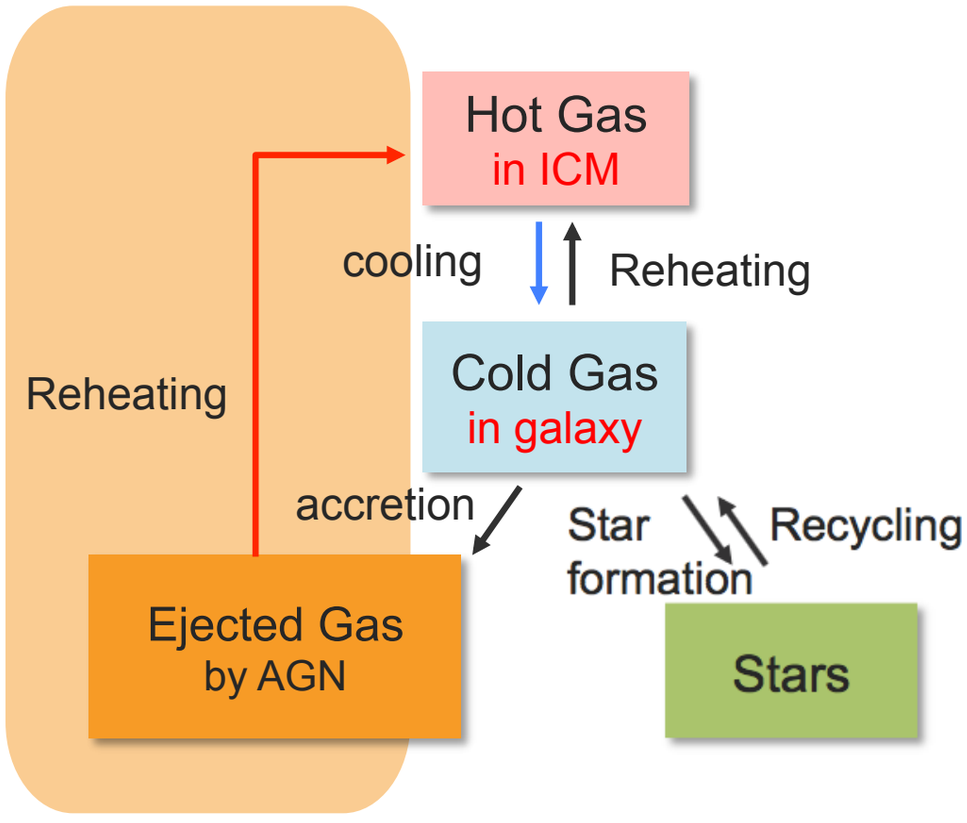
An AGN feedback in galaxy clusters

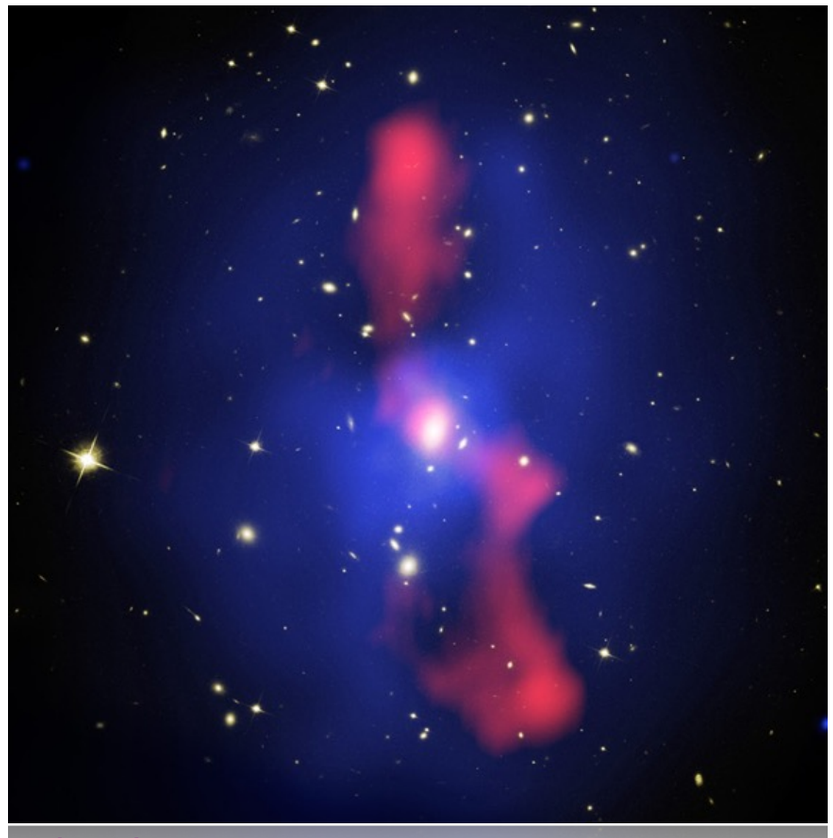




- The cooling flow can accelerate the nuclear activity of central galaxy.

An AGN feedback in galaxy clusters





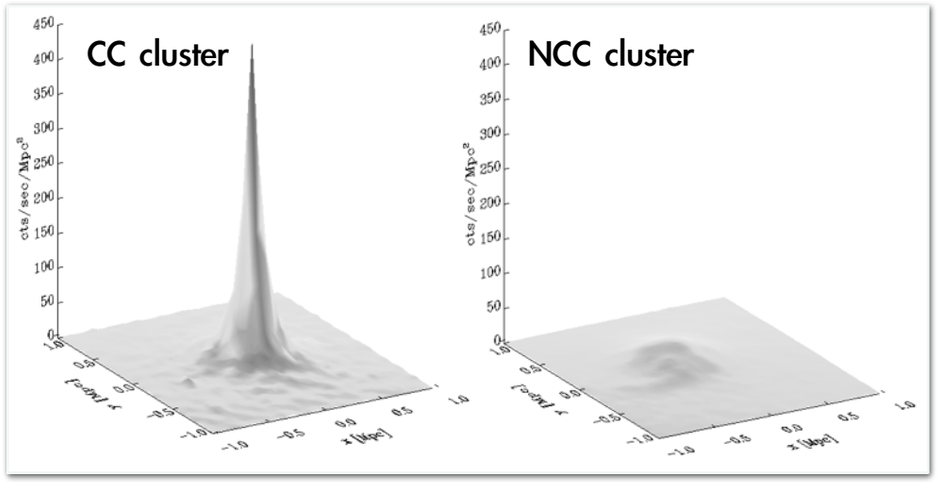
Galaxy cluster MS0735.6+7421
blue(X-ray) + yellow(optical) + red(radio) image
(credit : chandra photo album)

- The presence of central AGN may prevent further cooling of gas in the cluster core region.
  => Detailed feedback mechanism should be studied.

Classification of galaxy cluster in X-ray

Cool core / Non-cool core

- Criteria : how much the sharpness of X-ray distribution at the center

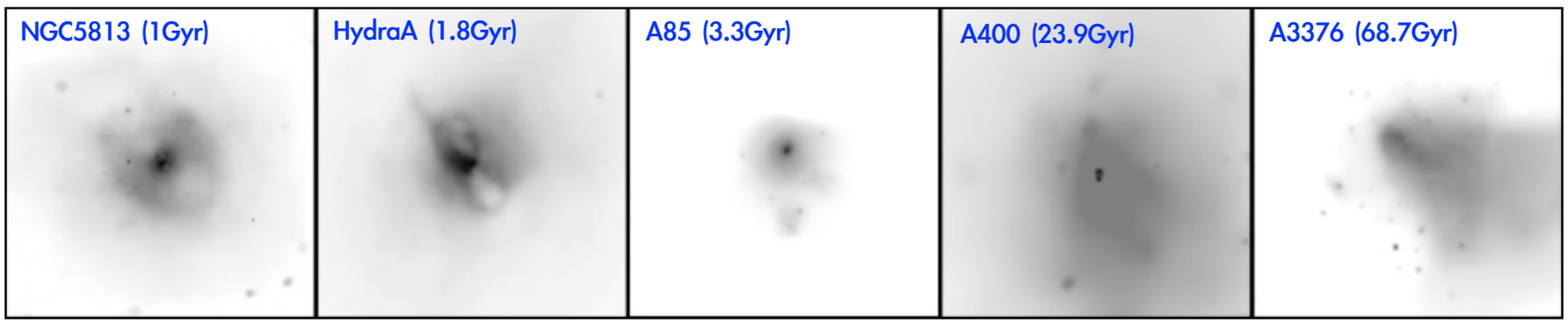


Fabian & Sanders (2009)

Cooling time

: remaining time until ICM is totally concentrated in cluster

: classify the cool core and non-cool core clusters



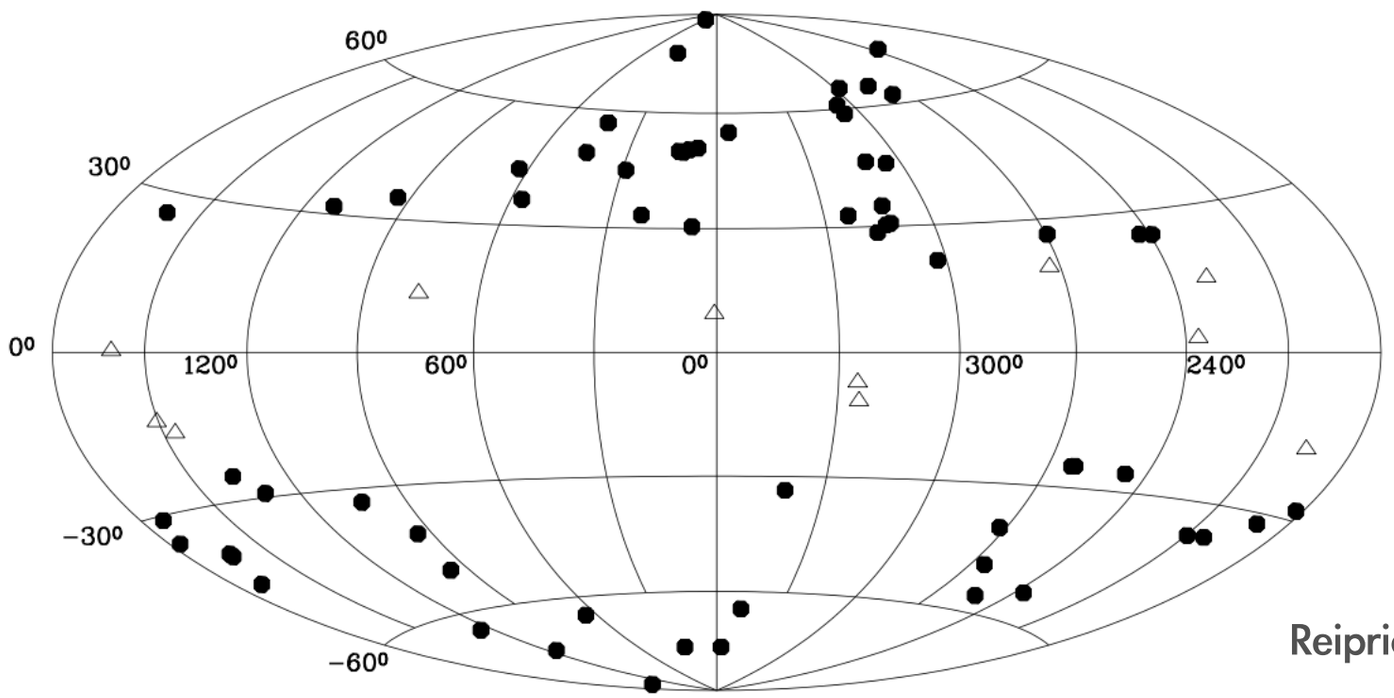
Credit : Chandra photo album

The extended HIFLUGCS catalog

- The extended HIghest X-ray FLUx Galaxy Cluster Sample (eHIFLUGCS) (Reiprich & Böhringer 2002)

- Comprised with 106 galaxy clusters and group from ROSAT all sky survey data (redshift < 0.2)

- Flux limited sample : $f_x(0.1\text{-}2.4\ keV) > 2.0 \times 10^{-11}$ ergs/s/cm^2



Reiprich & Bohringer (2002)

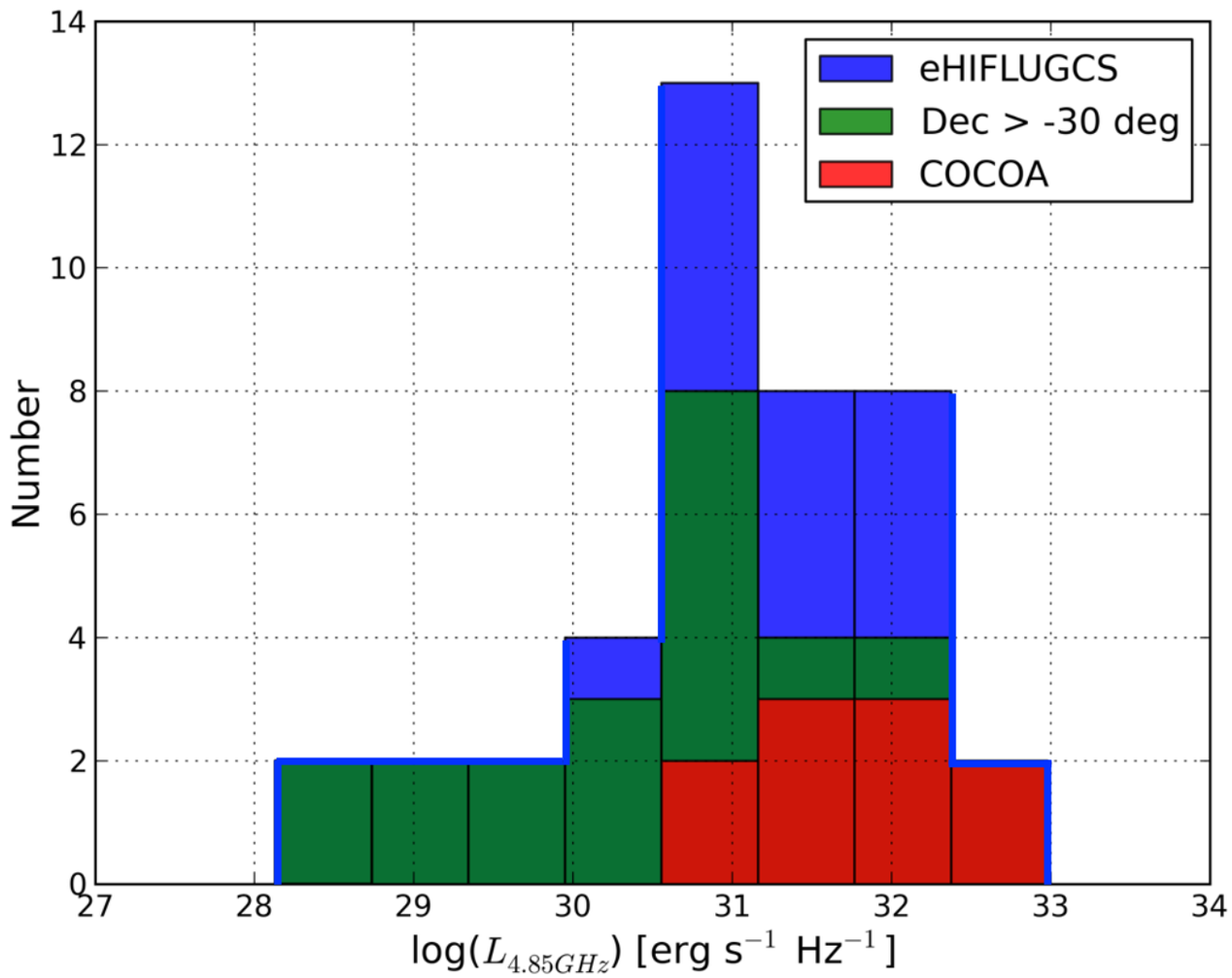
Our sample

- 10 clusters with radio-bright cD galaxies selected among the eHIFLUGCS catalog (redshift : 0.02 ~ 0.10)

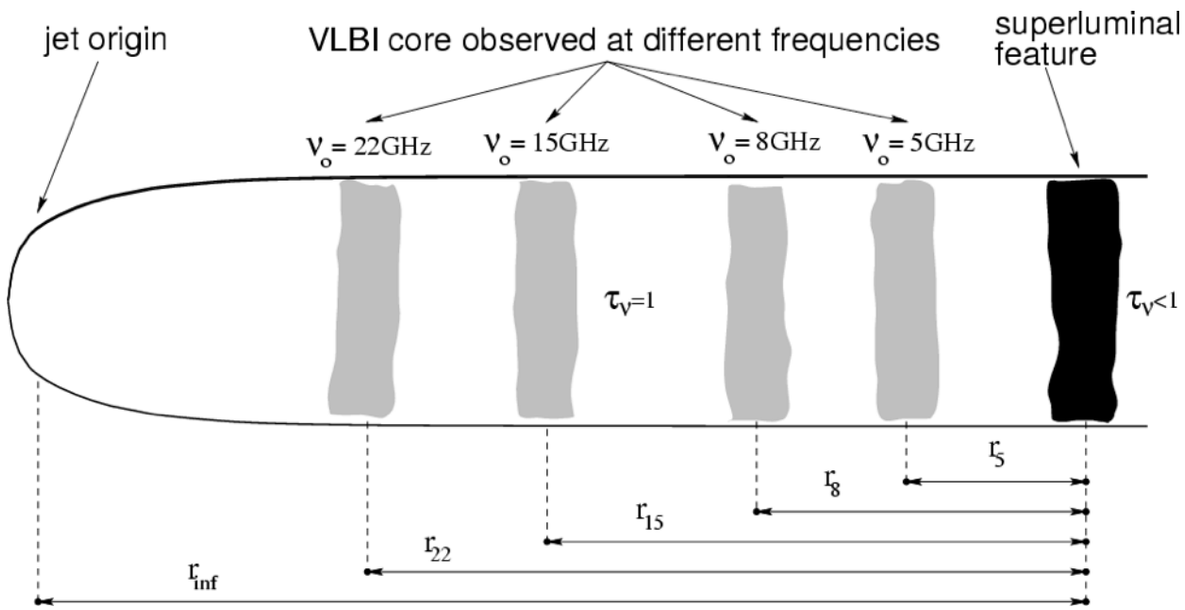
- $S_{4.85\,GHz}$ > 400 mJy from GB6 / PMN survey

- Biased to radio bright objects

- Cover a broad range of cooling timescale : 1 - 30 Gyr



Observed region at each frequency



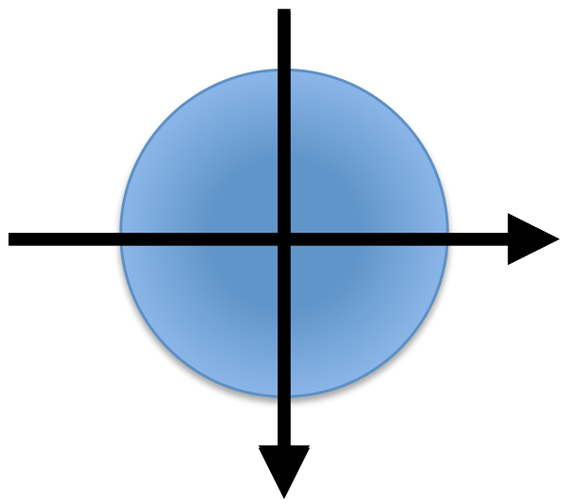
Kovalev et al. (2008)

- Optically thin regions are different at each frequency
- High radio frequency observation can see the inner part of the core
- Advantages of high frequency observation
  - Measure the intrinsic power of AGN
  - Study the starting region of AGN activity

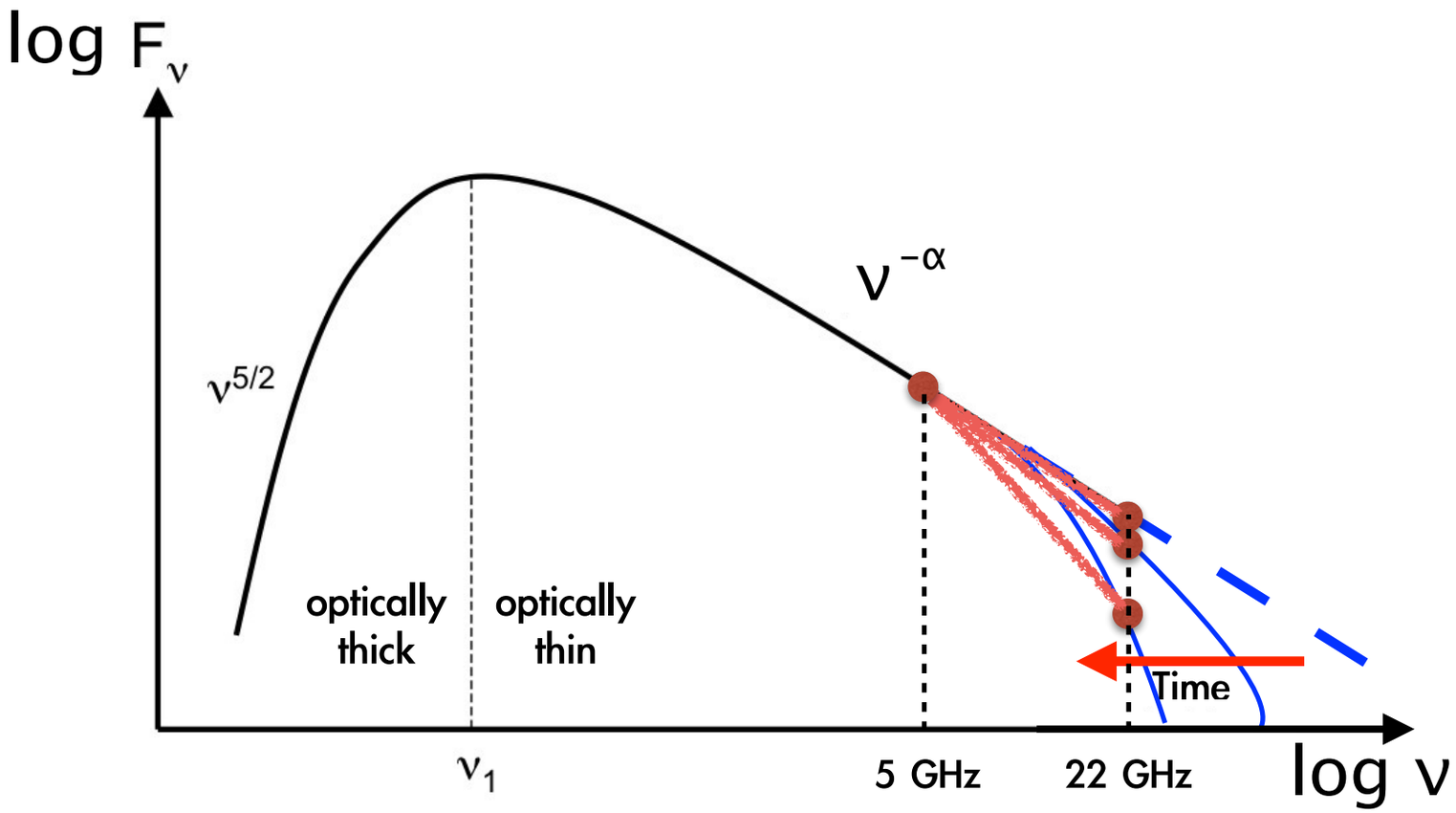
KVN single dish observation

- Purpose : measure the 22 GHz flux of central AGNs
- Date : 2013 June - October
- Telescope : KVN Yonsei
- Cross-scan method
- Observe 10 sample
  and detect 9 objects
- Data reduction : CLASS package

Cross-scan method

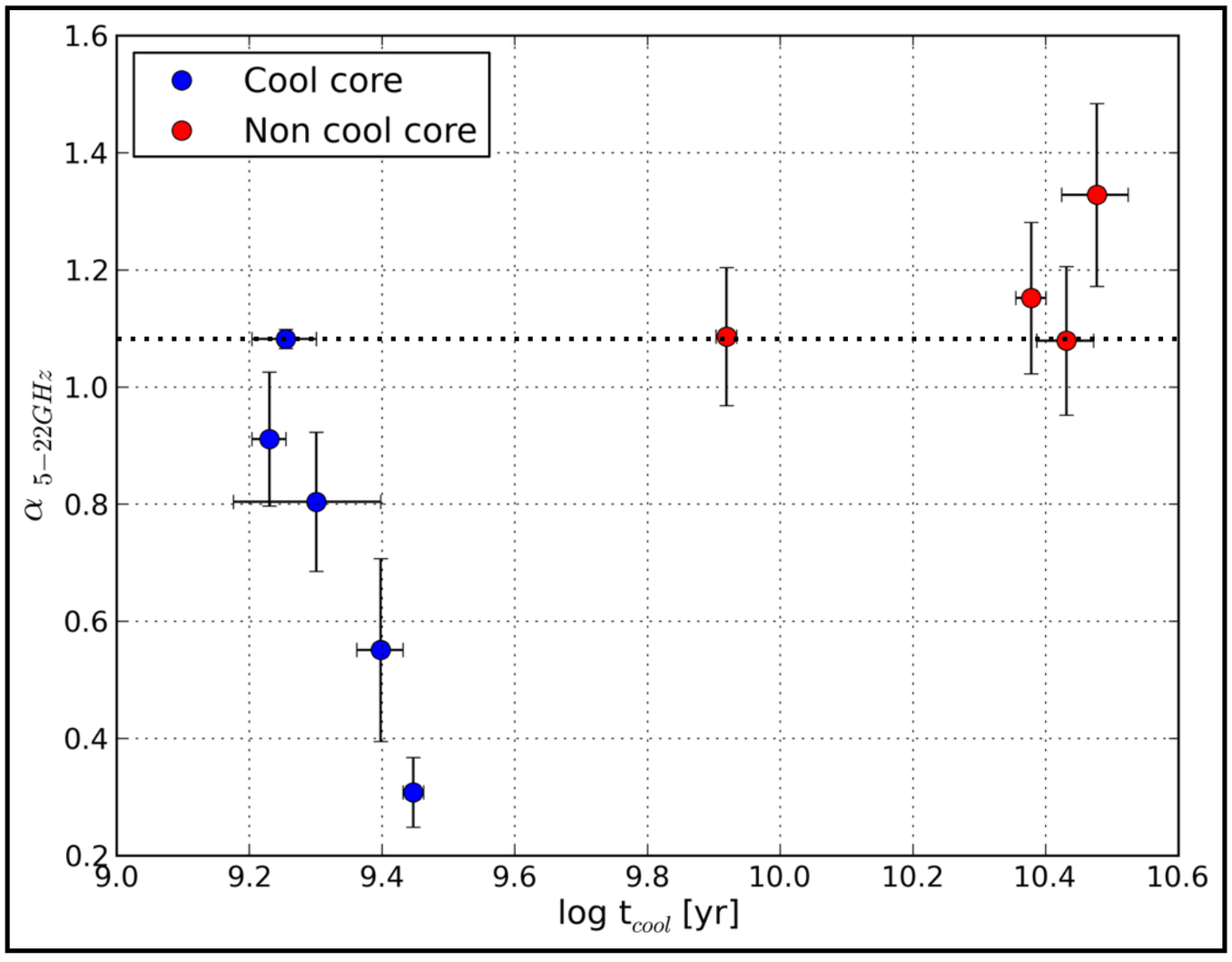


Results - Synchrotron age from spectral index



- High energy particles lose their energy earlier in synchrotron radiation
- Long time radiated AGN has steep spectral index at high frequency

Results - Cooling time vs. spectral index



- Spectral index : 4.85 GHz to 22 GHz
- 4.85 GHz flux from GB6 / PMN survey
- 22 GHz flux from our KVN single dish observation
- The spectral indices of CC AGNs are smaller, implying younger synchrotron age

KVN VLBI observation

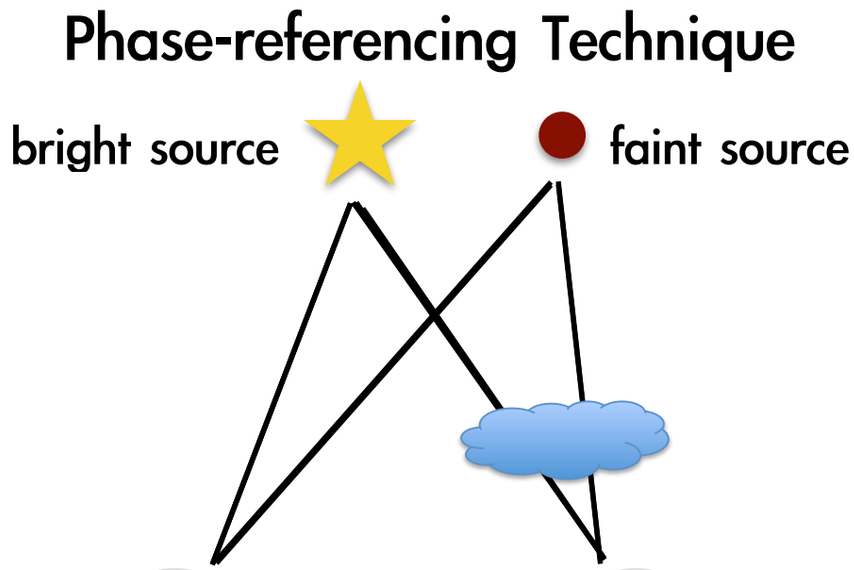
- Purpose : measure the parsec scale core morphology of central AGNs

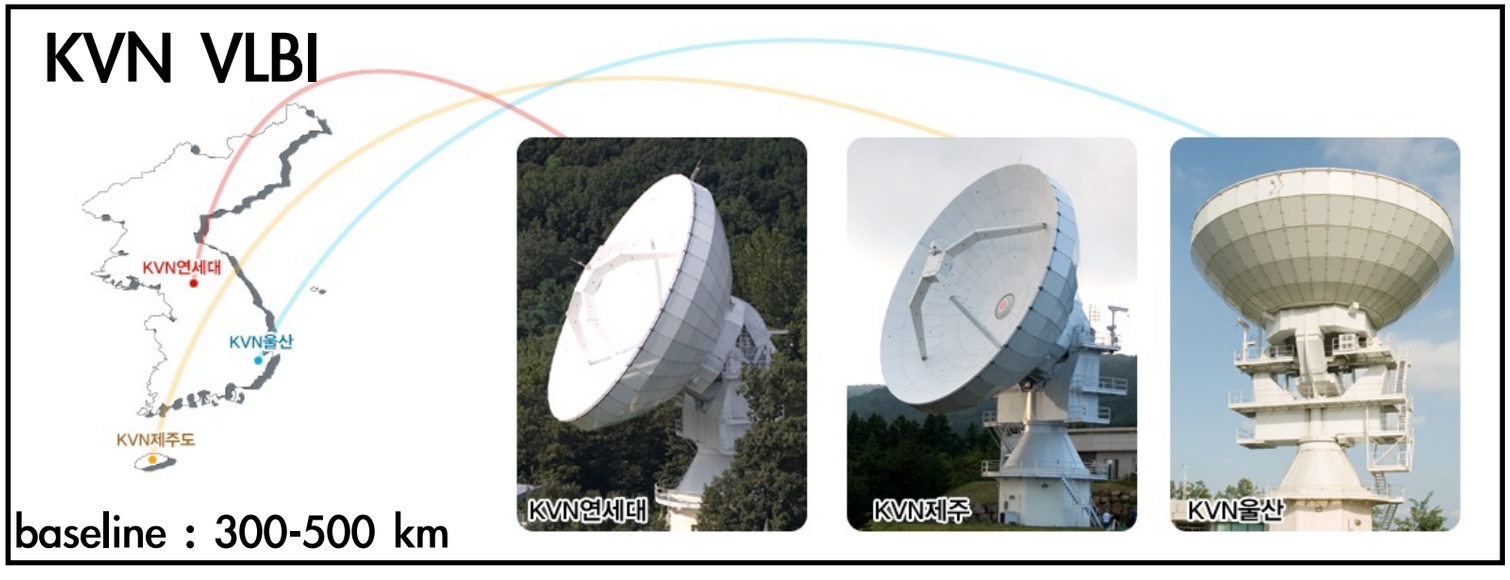
- Date : 2013 October - November

- Phase referencing technique

- Observe 9 sample and detect 7 objects

- Data reduction : AIPS + DIFMAP



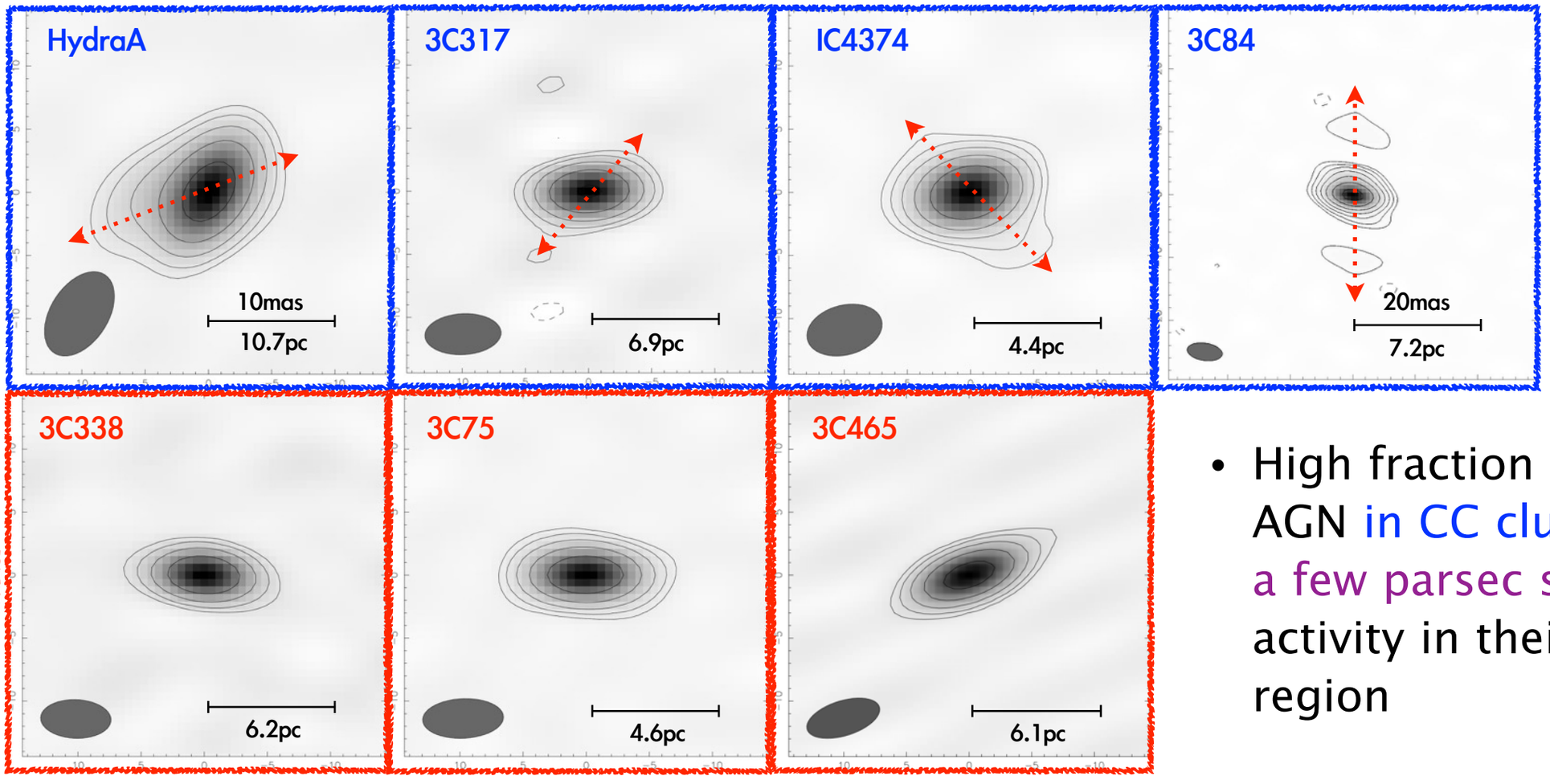


Results - radio morphologies at inner part

From KVN VLBI observation at 22 GHz (mili-arcsec resolution)

Cool core

Non cool core



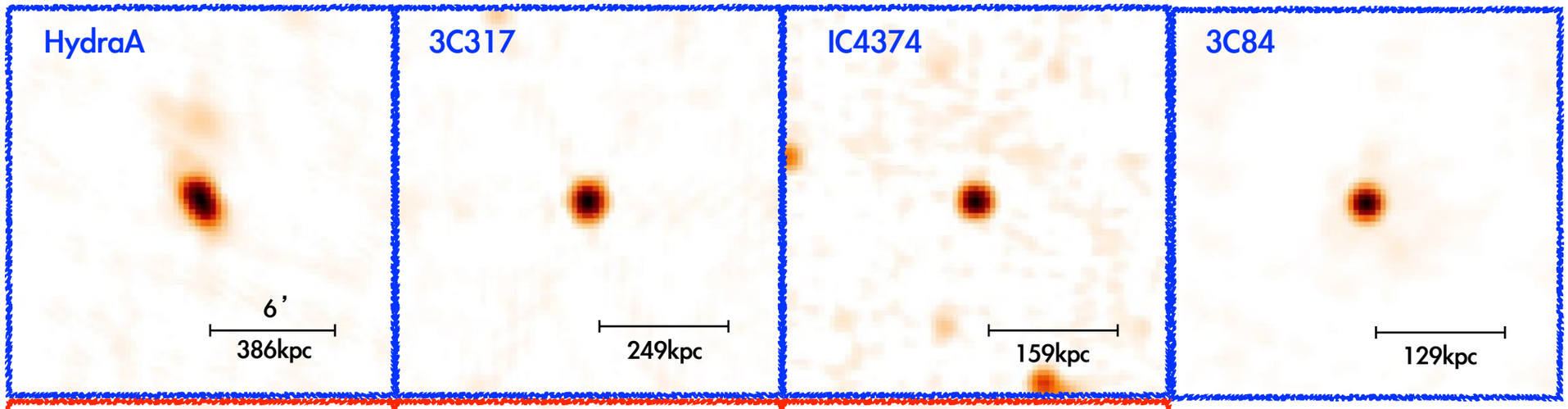
- High fraction of central AGN in CC clusters has a few parsec scale jet activity in their core region

- CC AGNs have been more recently powered and are currently more active.

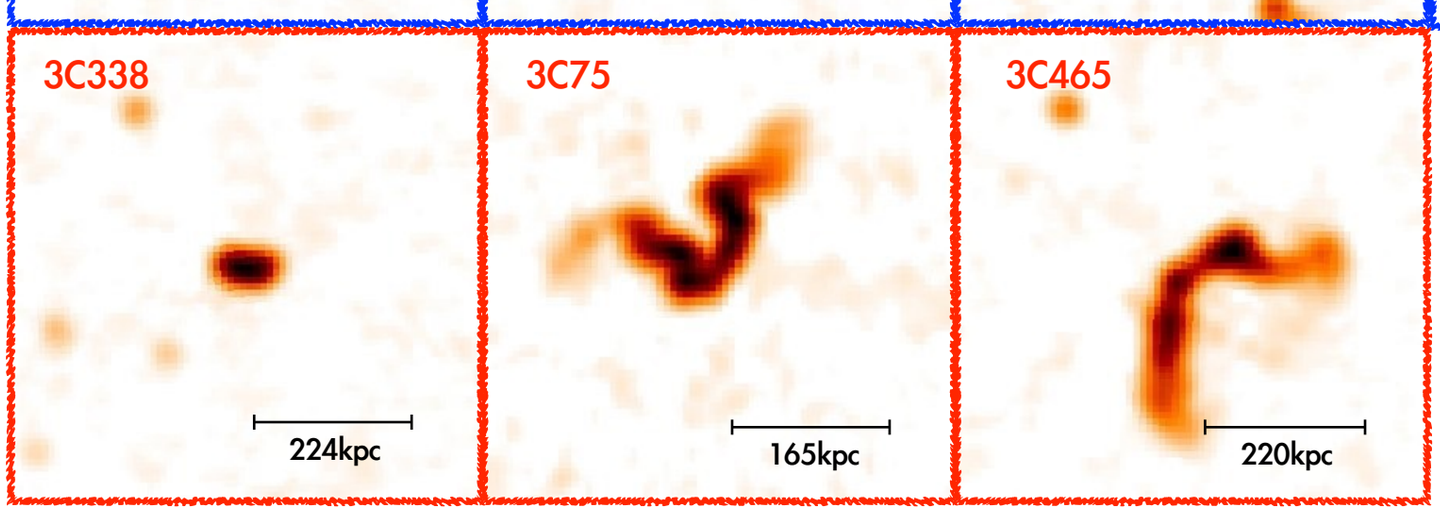
Results - radio morphologies at outer part

From NRAO VLA sky survey (NVSS) at 1.4 GHz (arcsec resolution)

Cool core



Non cool core

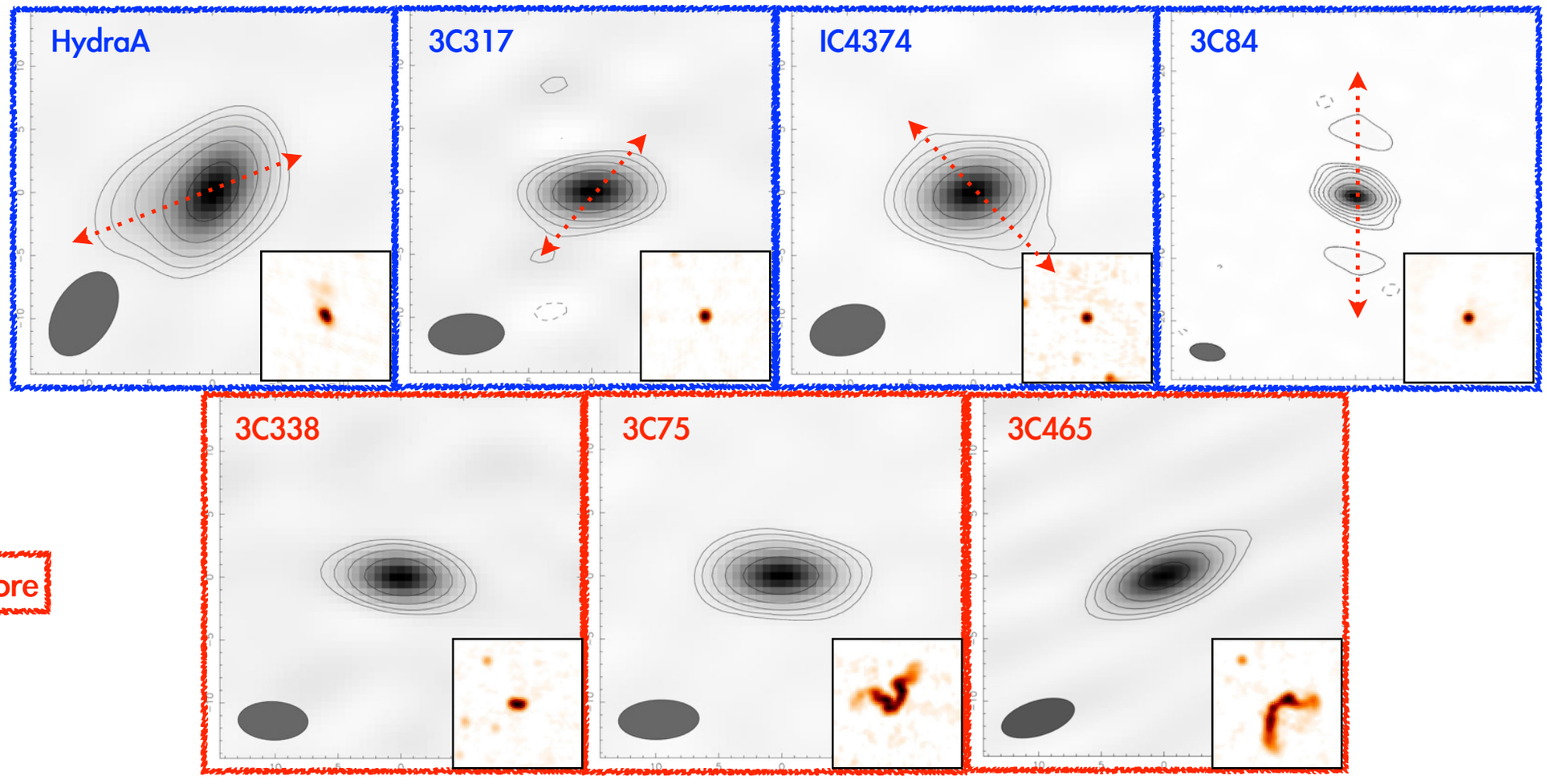


- Central AGN in NCC clusters has a few hundred kilo-parsec scale jet activity in their extended region

Results - radio morphologies

Cool core

Non cool core



- Jet morphologies of core & extended part show opposite features in CC clusters & NCC clusters

- CC AGNs have been more recently (re)activated
  -> Could be young radio source!

Conclusions

- CC AGNs tend to have younger synchrotron age & extended pc-scale structures / compact kpc-scale structures.

- NCC AGNs tend to have older synchrotron age & compact pc-scale structures / extended kpc-scale structures.

- Considering the formation process of central galaxies, wet mergers between sizable galaxies are less likely to be the mechanism for activating an AGN in the cluster center.

- Our results strongly suggest that a flow of cooling gas in the cluster center can make the central AGNs more recently (re)activated.

Thank you :)