MeerKAT HI Study of High-powered AGN: a PILOT SURVEY (MHISHAPS)

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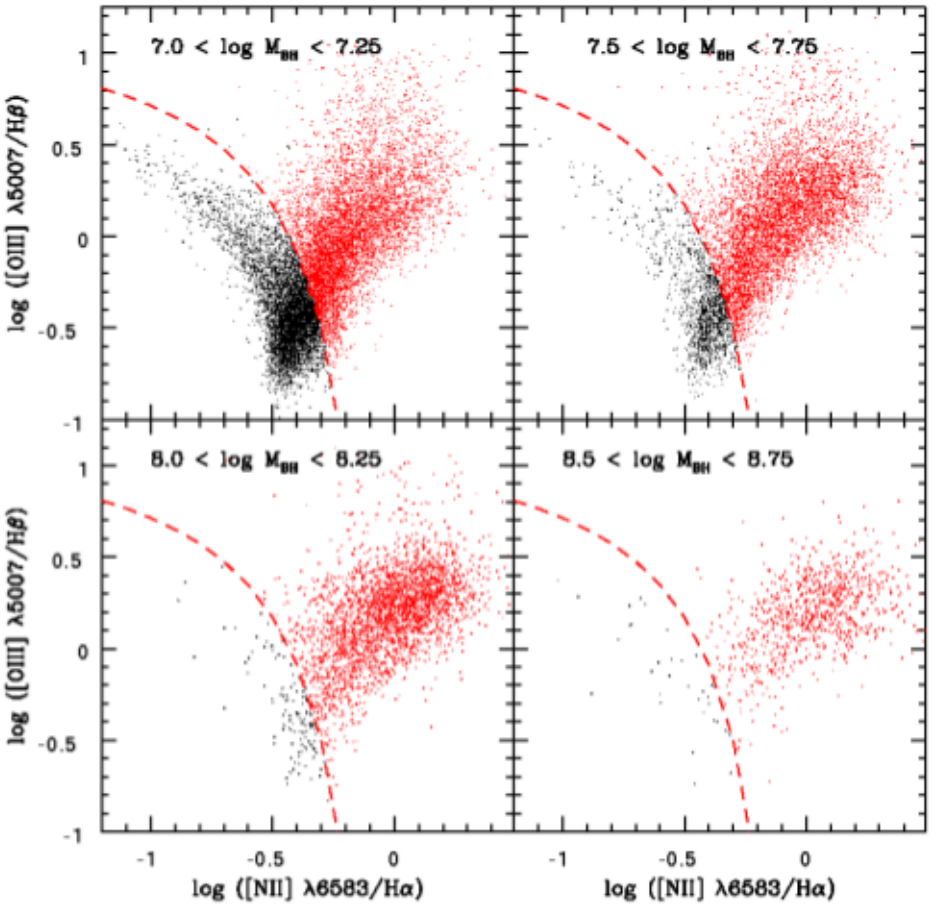
AIMS

- To use the early science MeerKAT to observe HI absorption in radio galaxies with known redshift up to z=0.58.
- Measure the equivalent width against the background radio source and infer HI column densities and masses for the detected gas.
- Infer the line-of-sight gas kinematics, and where possible use the resolved source structure to constrain the geometry of the system
- Compare our detections against the radio power, luminosities and accretion states of the AGN
- Compare our results with recent surveys of nearby radio galaxies using WSRT

Host Galaxies

- There is a co-evolving relationship between supermassive black holes (SMBHs) and their host galaxies
- Stellar mass and SMBH growth in galaxies supply of cold (T < 10,000K) gas

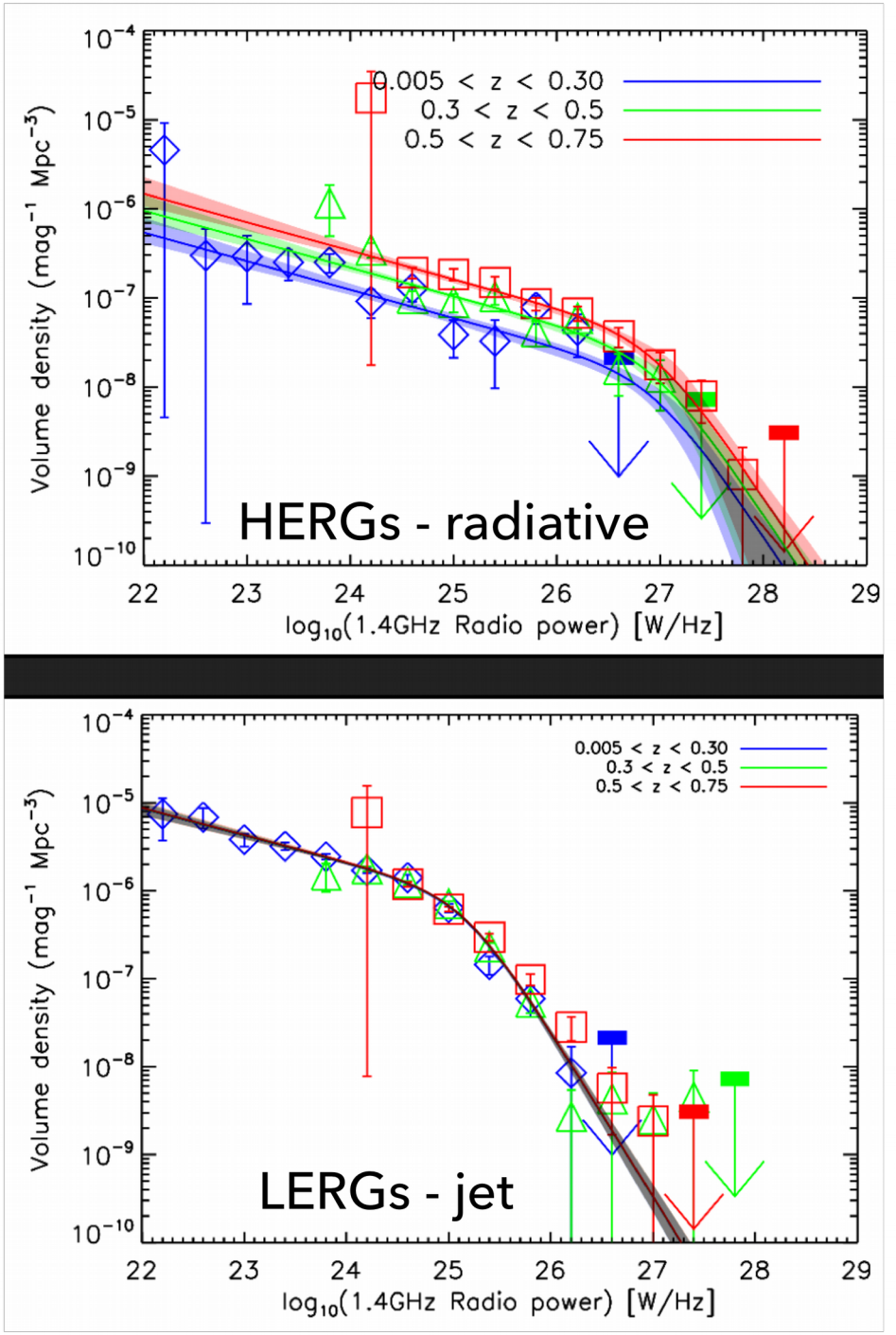


AGNs red points and star-forming galaxies black points. (Kauffmann & Heckman 2009)

Host galaxies

- HERGs are radio-loud members of the radiative-mode AGN population
  - Strong $(1+z)^3$ evolution of radiative mode AGN traces star formation and cold gas supply
  - AGN with greater than 1% Eddington are hosted by star-forming galaxies

- LERGs typically in massive early type host and radiatively inefficient accretion
  - AGN with much less than 1% Eddington are hosted by higher mass passive galaxies that are globally poor in HI gas

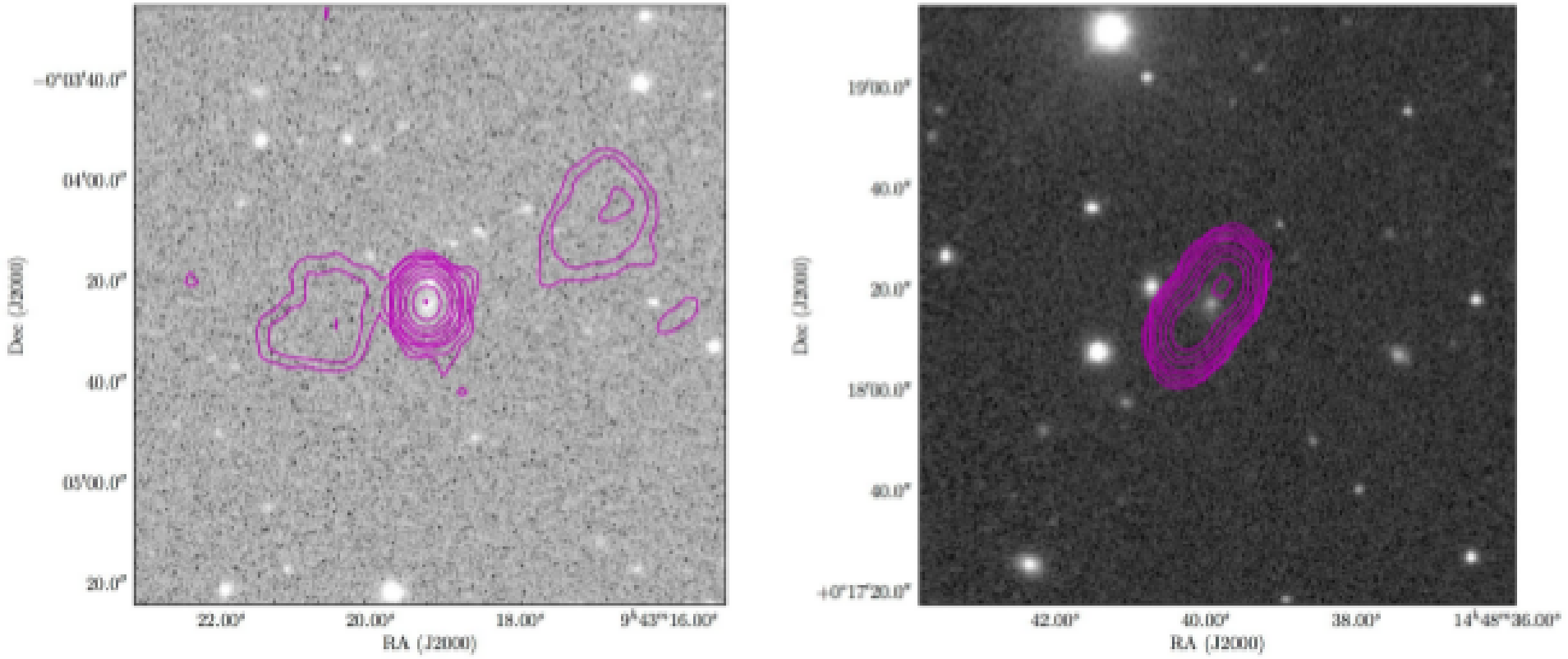


Sample Selection

- Our targets are from the Large Area Radio Galaxy Evolution Spectroscopic Survey. Ching et.al 2017
- 19,179 radio sources
- 10,856 have reliable redshifts and 85% are radio AGN
- We selected 15 radio AGN with:
  - A total flux density in FIRST greater than 500mJy
  - A reliable spectroscopic redshift between z = 0.1 and 0.58.
  - Avoided the known RFI-afflicted regions of the MeerKAT L-band

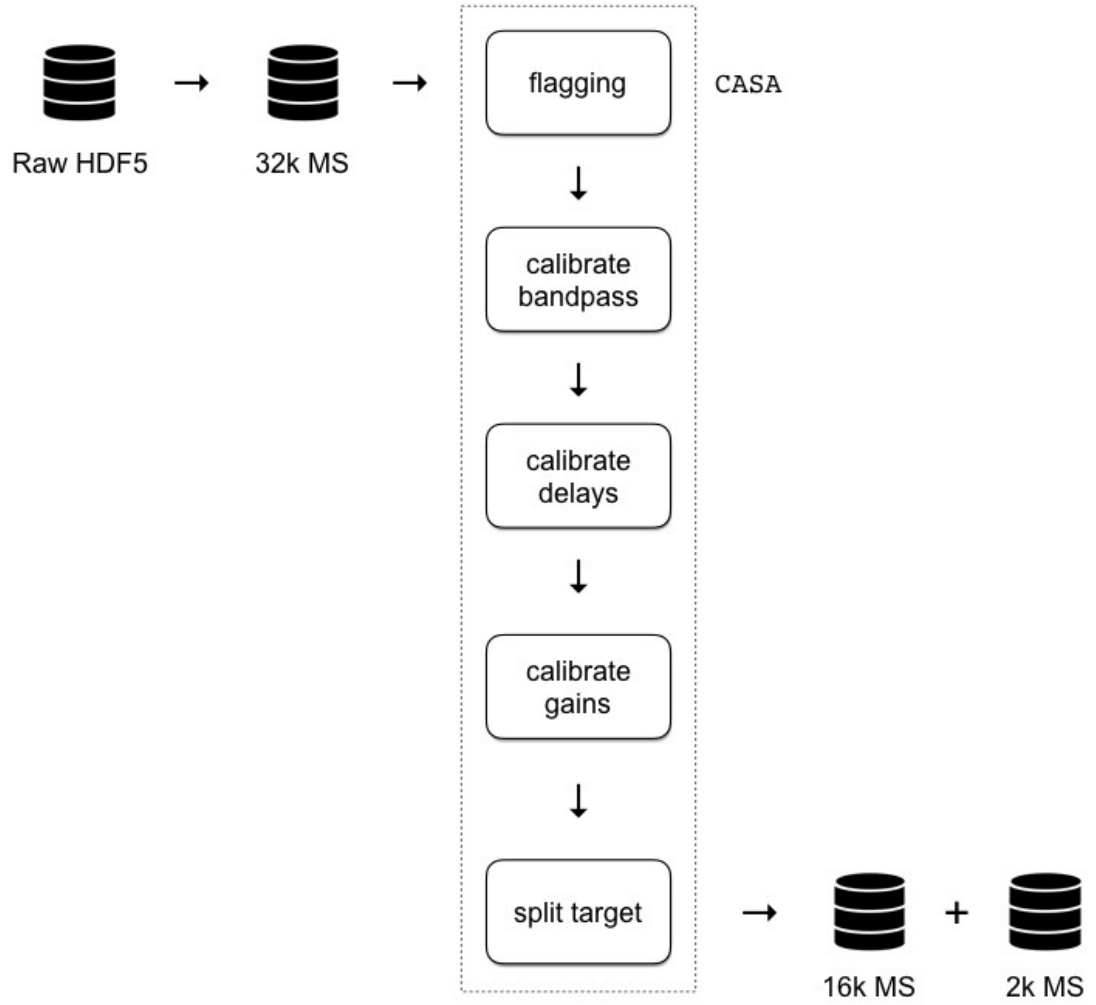
Sample Selection

- Of these, 11 sources have a peak FIRST flux density greater than 100 mJy within a 10 kpc radius of the host galaxy
- We selected 9 targets that were visible at night with MeerKAT during March/April 2018
- Our targets are split roughly equally between high-excitation (>1% Eddington) and low-excitation (<1% Eddington) radio galaxies
- All have radio powers greater than $L_{1.4} = 10^{26}$ WHz^{-1}

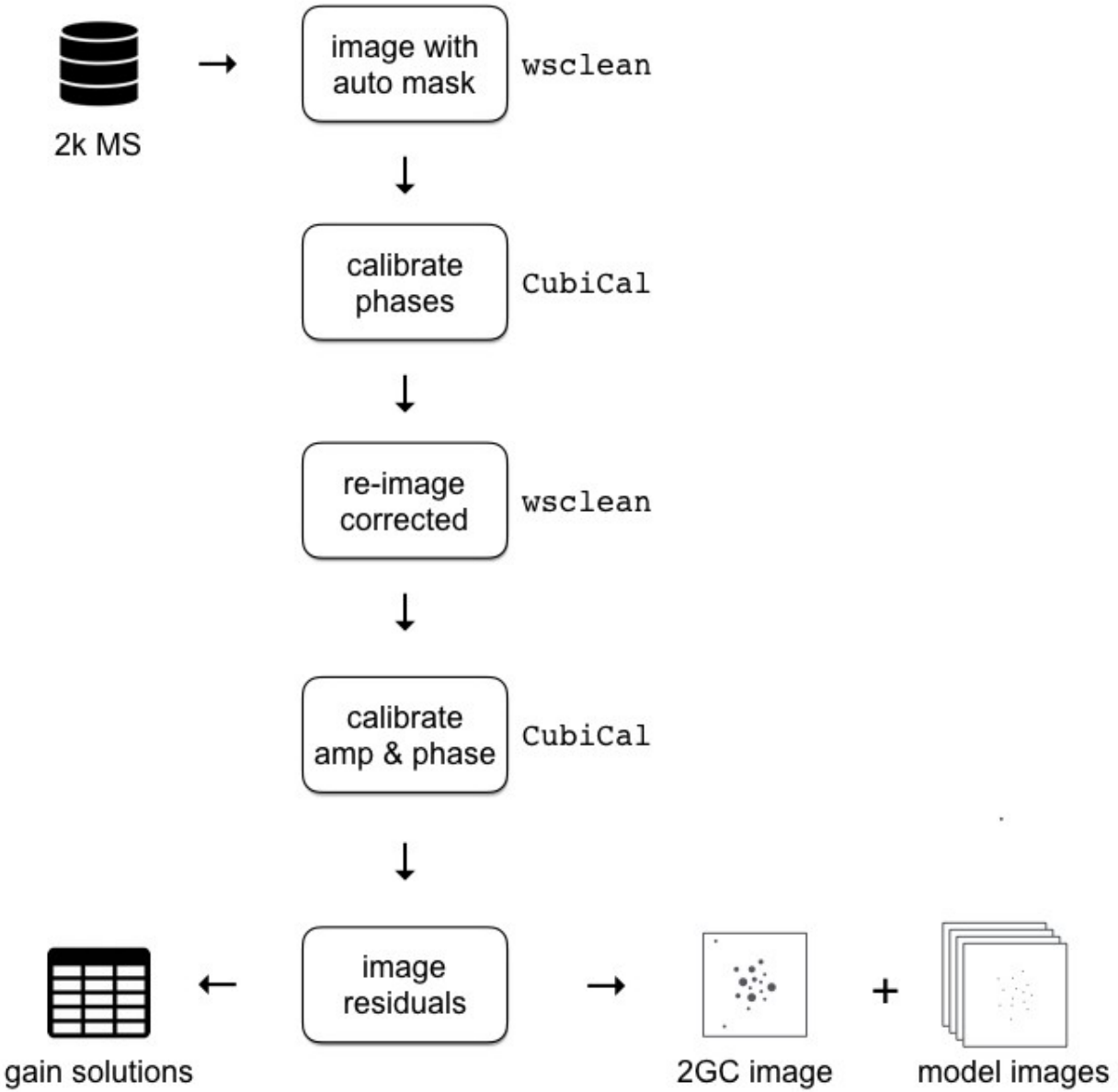


J094319.23-000424.8 (HERG; z =0.4642) and J144839.94+001816.7 (LERG; z = 0.4378). Shown are the SDSS i-band grey-scale image and FIRST contours. Contour levels are given at 1, 2, 5, 10, 20, 50, 100, 200, and 500 mJy per beam.

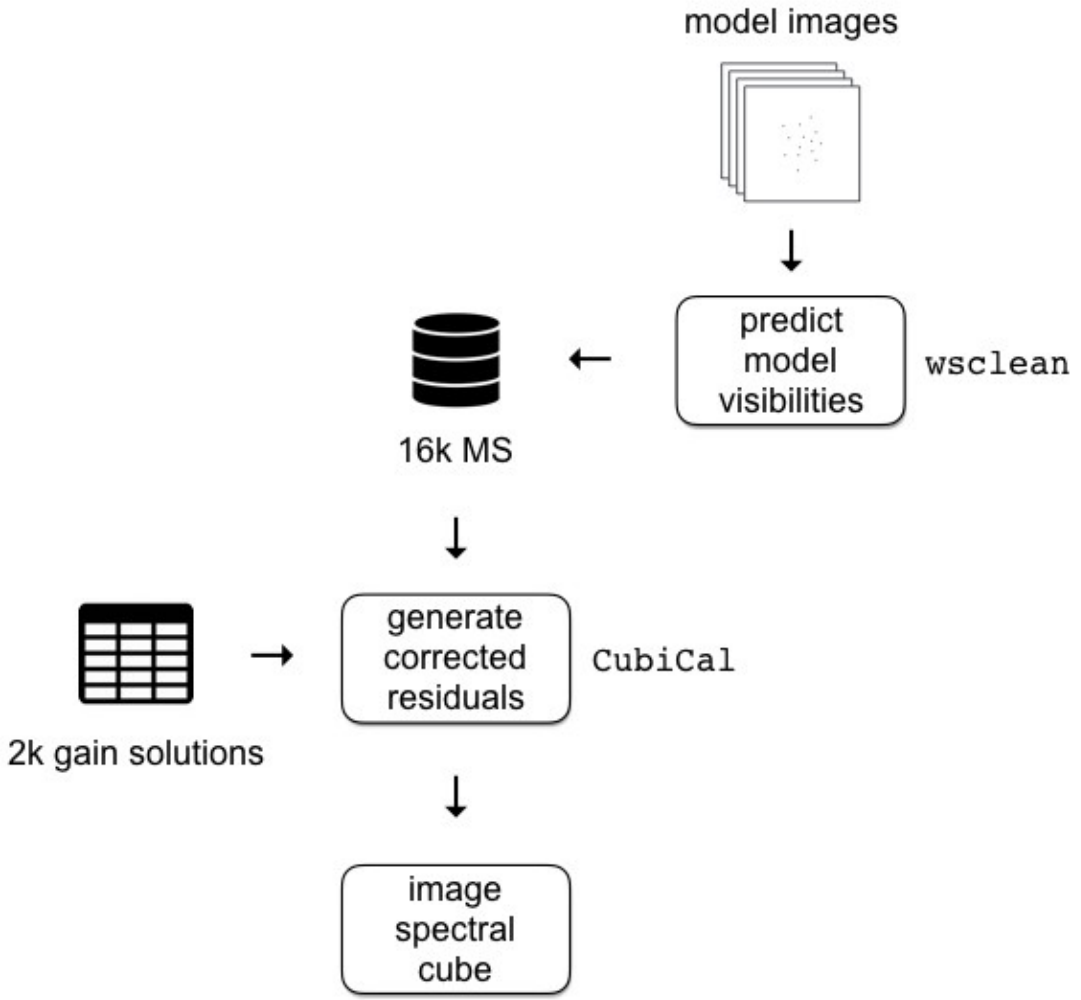
Initial processing (flagging, reference cal, averaging)



Self-calibration on 2k channel MS



Calibration and continuum subtraction, 16k channel MS



Parallel to this work

- We constructed a new sample of distant radio galaxies with redshifts and stellar masses
- This sample will be useful for MeerKAT observations of HI absorption to understand the fueling and feedback from such sources
- We use the Likelihood Ratio technique to cross-match the Sydney University Molonglo Sky Survey (SUMSS) radio catalog at 843MHz with the VISTA Hemisphere survey (VHS) near-infrared catalog
- We use the Dark Energy Survey to obtain photometric redshifts of the radio sources

Radio data

- SUMSS survey on MOST (Australia) at 843 MHz
- Sky area 3,500 sq deg
- Resolution of 45”cosec|δ|x45”

Optical/NIR Data

NIR – VHS (Chile) on VISTA survey:

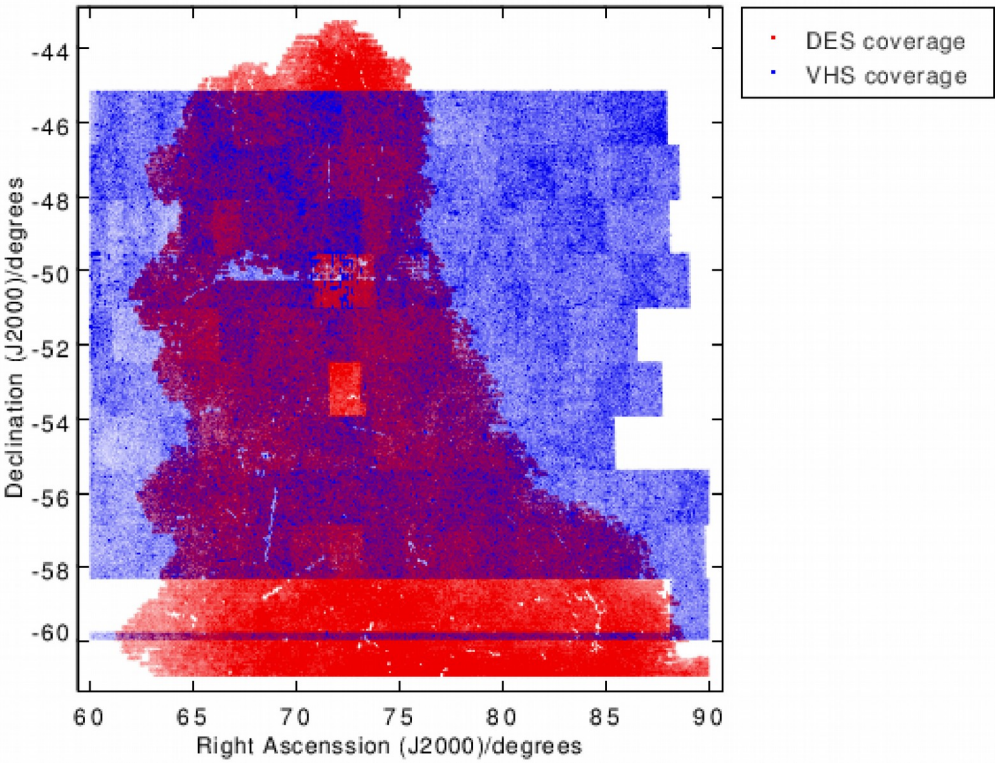
- Sky area 18,000 sq deg
- YJHK bands

Photometric redshift - DES survey on Blanco (Chile):

- Sky area 5,000 sq deg
- griz

Cross-matching

- Data from SUMSS and VHS online
- Sources are brighter than 12mJy/beam
- Region: $-60^{O} < Des < -45^{O}$ and $60^{O} < RA < 90^{O}$
- SUMSS 2,700 sq deg
- VHS 2,300 sq deg
- DES 1,300 sq deg



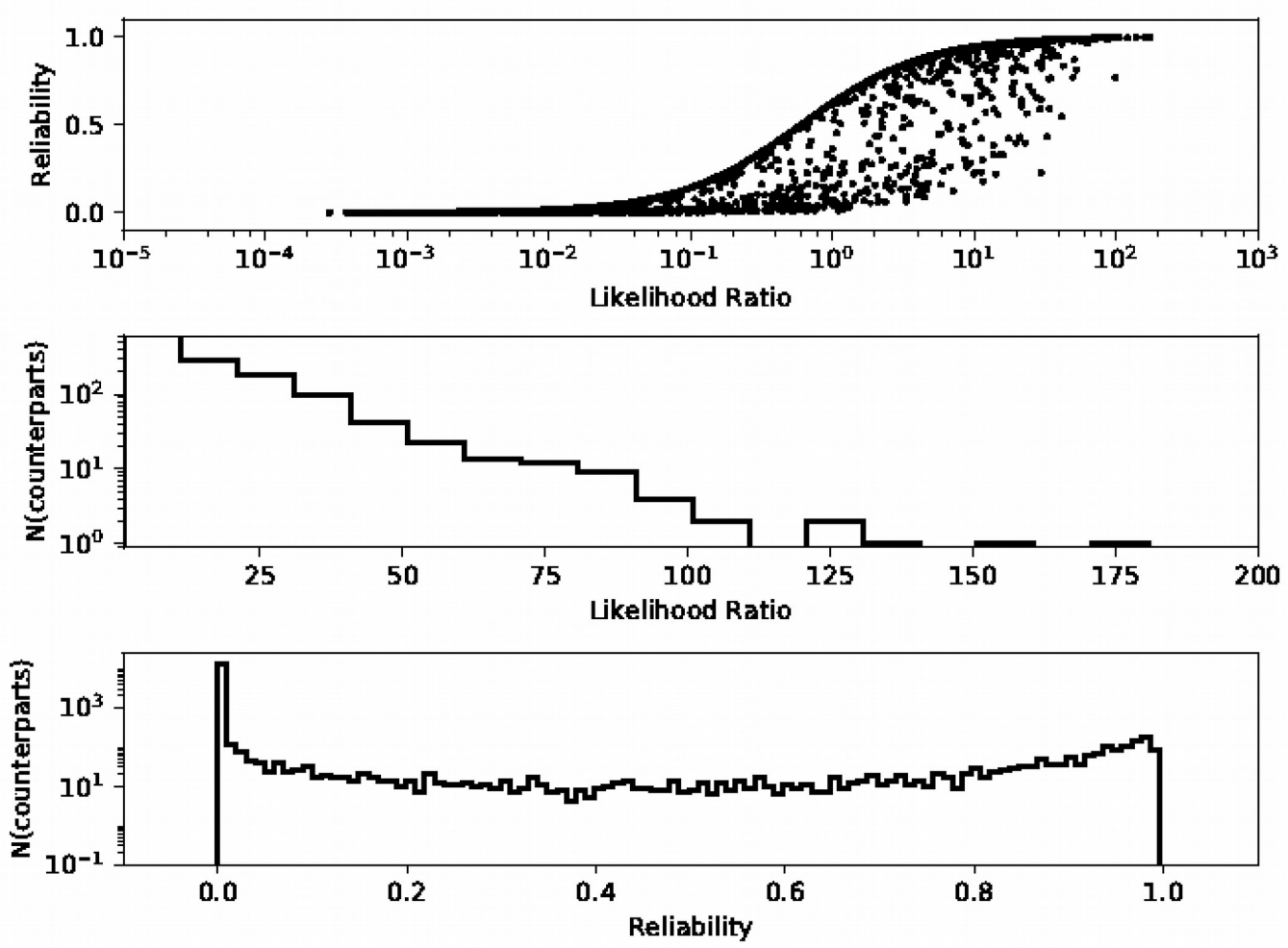
- We found 1,195 VHS sources with counterparts.
- 81 of these sources were false identified.
- The crucial advantage of the LR technique:
  - Does not only use the positional information
  - Includes brightness information, flux and source density to identify the most reliable counterparts

Reliability

$$Rel_i = \frac{LR_i}{\sum_j LR_j + (1 - Q_0)}$$

Q_0 Fraction of true counterparts above the VHS magnitude limit.

$$N_{cont} = \sum_{R \geq 0.8} (1 - R)$$



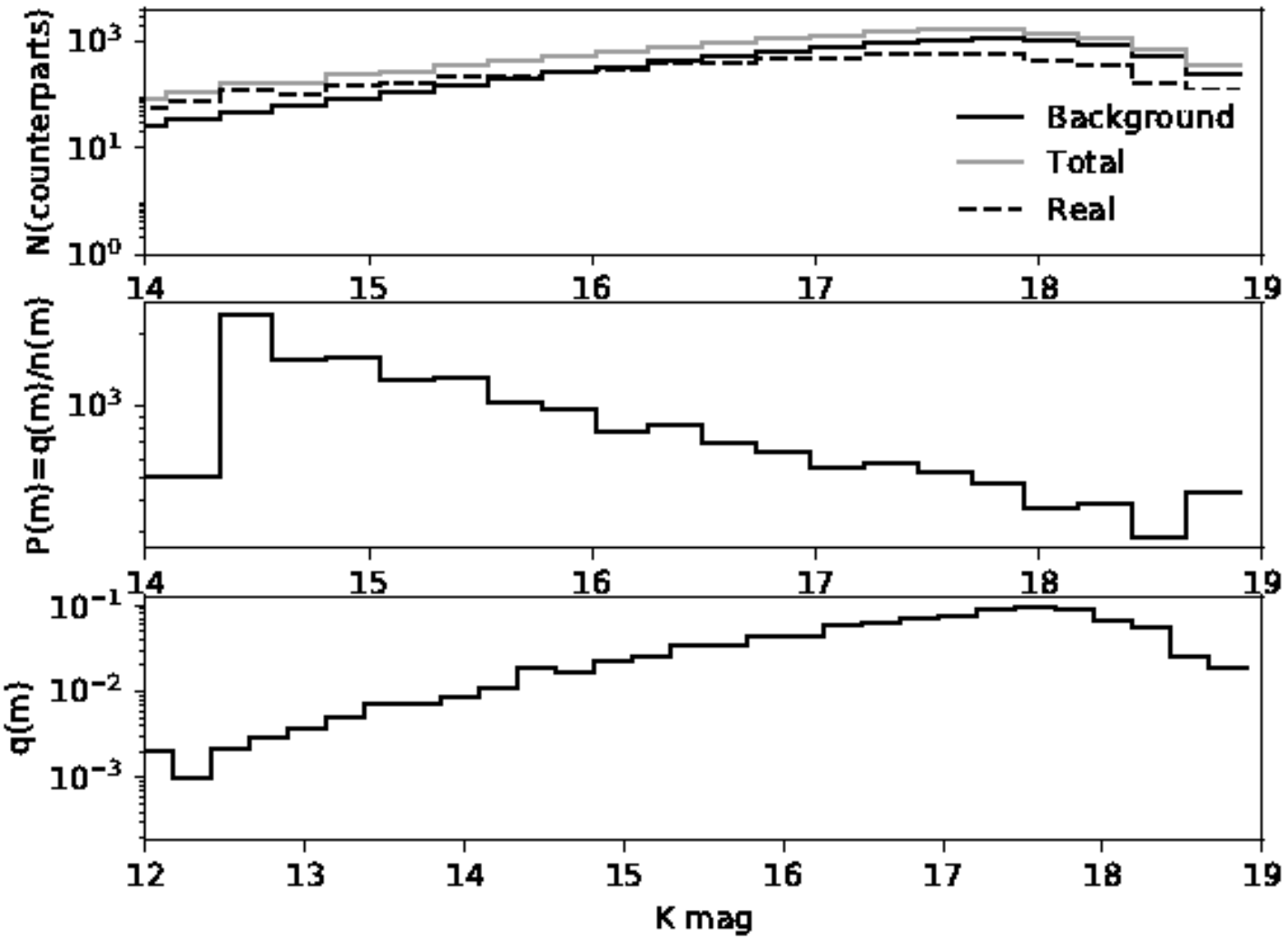
Magnitude dependence

Real counterparts =

Total(m) – Background

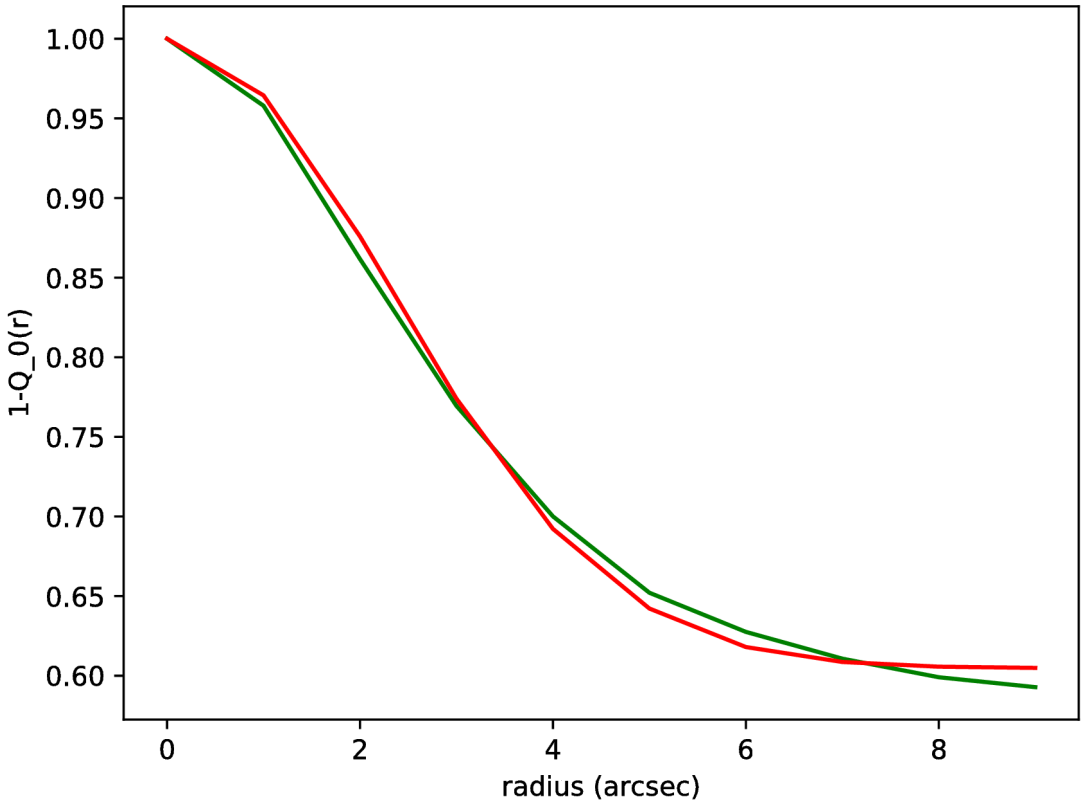
Subtract background

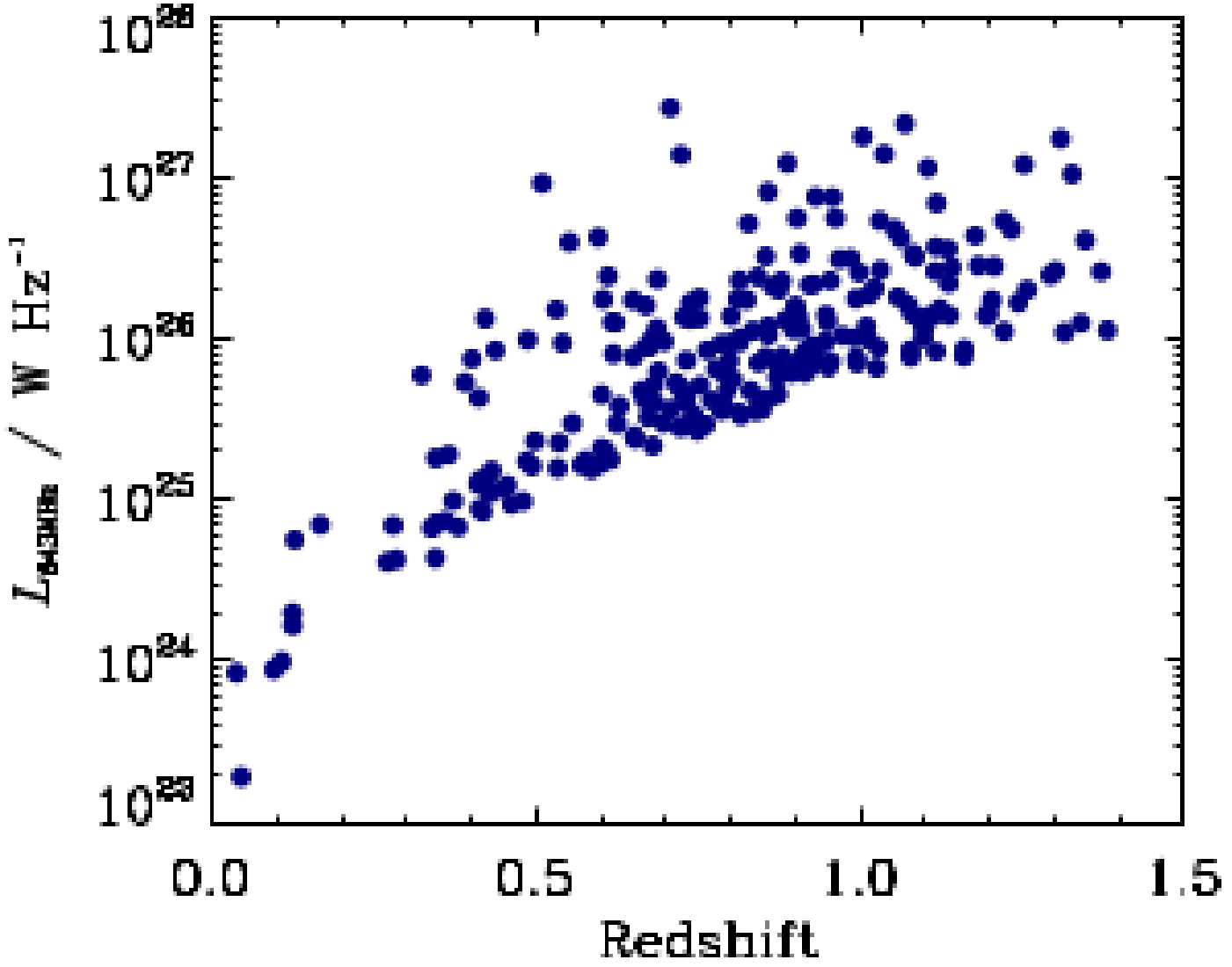
$$q(m) = \frac{real(m)}{\sum real(m)} * Q_0$$



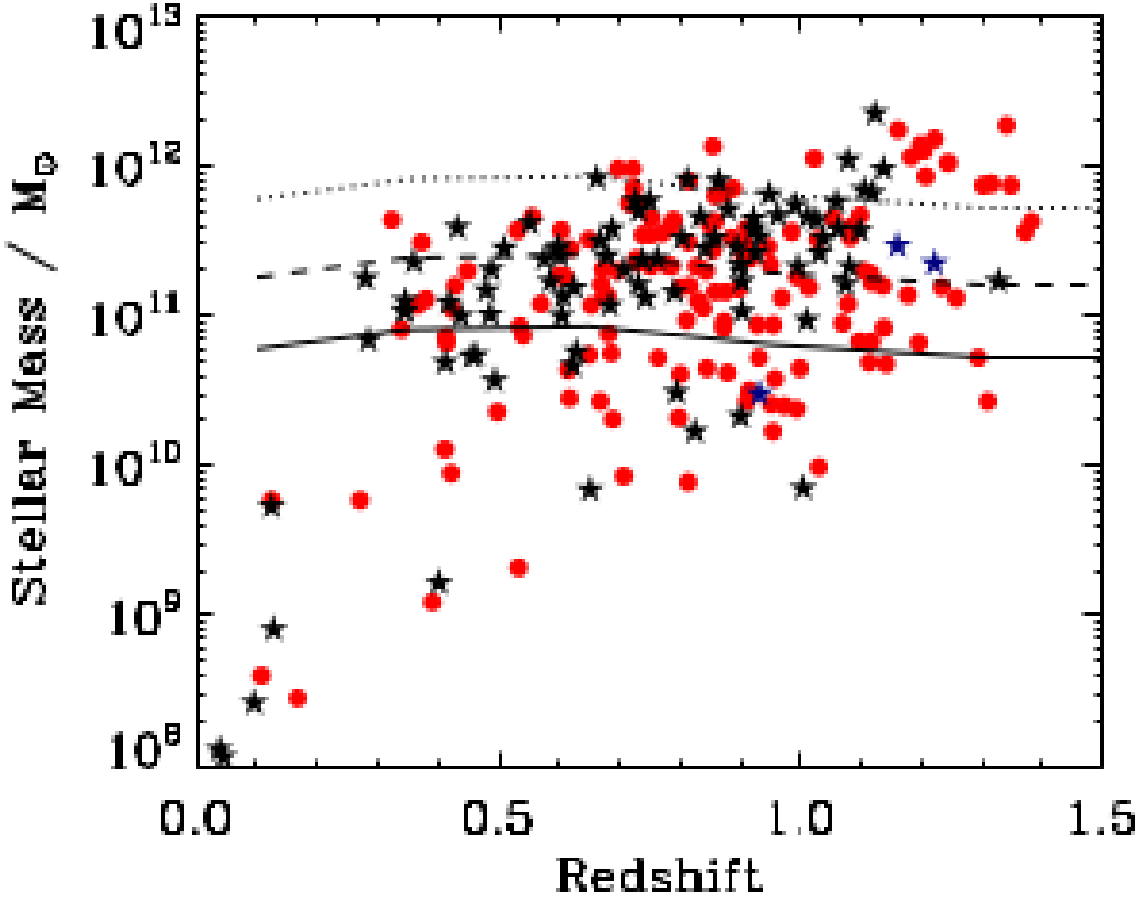
Q_0 estimation

$$\frac{U_{obs}(r)}{U_{random}(r)} = 1 - Q_0 F(r)$$

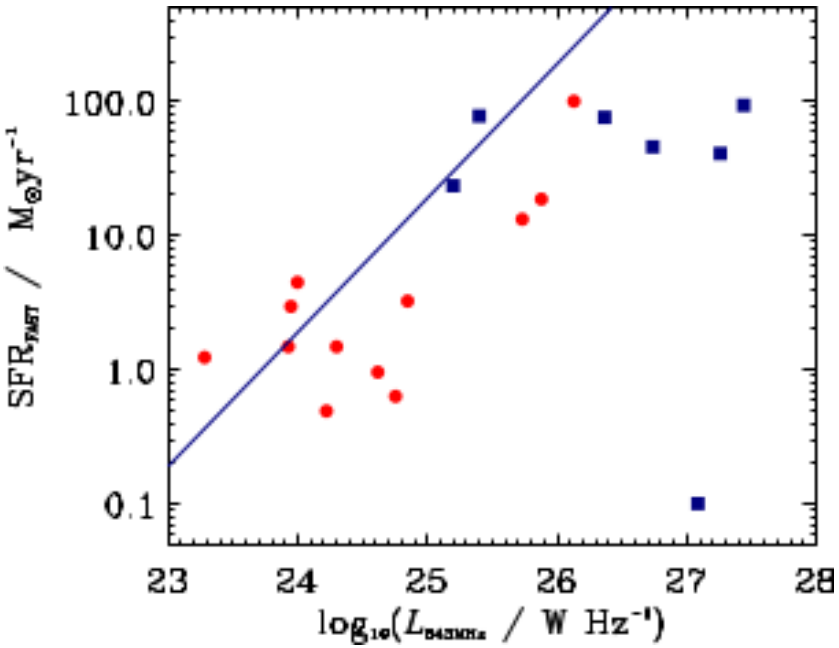




843 MHz radio luminosity versus redshift for radio galaxies samples from our SUMSS+DES+VHS sample. (Marubini et.al in prerparation)



The solid line represents Model from Wright et al. (2017) at z < 0.1 and Ilbert et al. (2013) at z > 0.1. The dashed line correspond to 5M and the dotted line to 10M



Marubini et.al in preparation

Summary and future work

- We obtained 1,195 sources with Reliabilty above 0.8
- Reliability above this value ensures that the contamination rate is low.
- Reliability in the K-band source dominates the NIR.
- We found 81 sources to have false identification, i.e. contamination of 6.8%.
- For radio galaxies we estimate Q_0 = 0.395
- After matching the SUMSS/VHS sources with DES, we found 249 sources with photometric redshift.
- One of the first large samples of powerful AGN for MeerKAT
- HI absorption line follow up to investigate the fuelling and outflows from powerful AGN.