THE EVOLUTION OF THE 98 GHZ SOURCE POPULATION SINCE Z = 4.5

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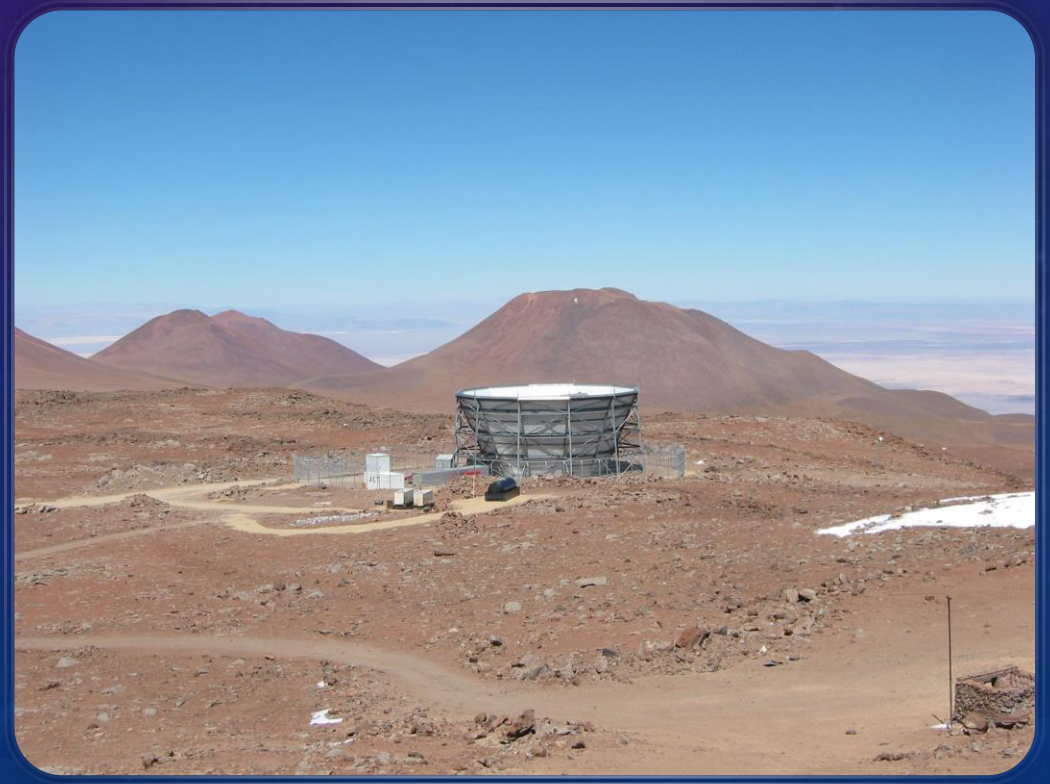

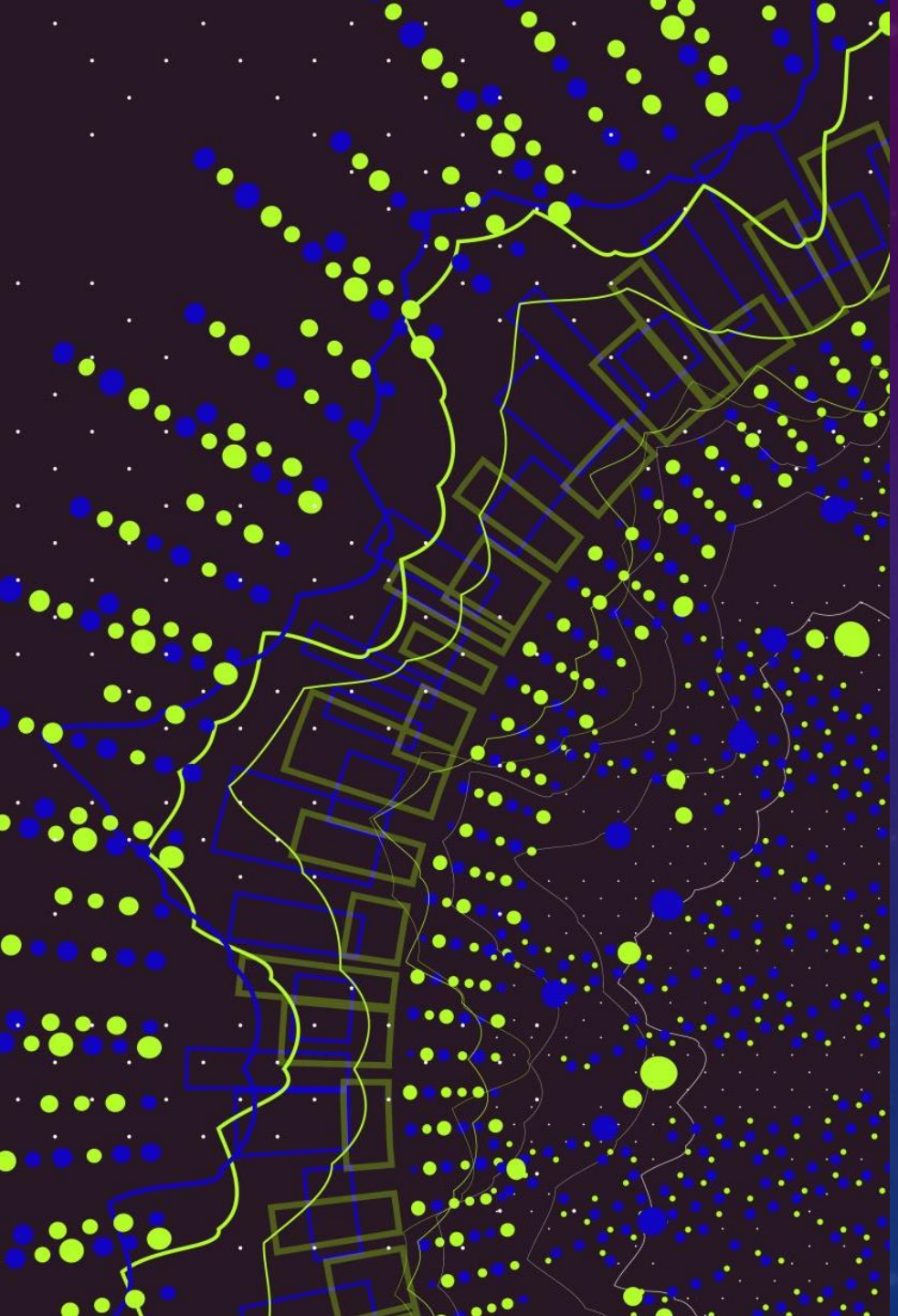

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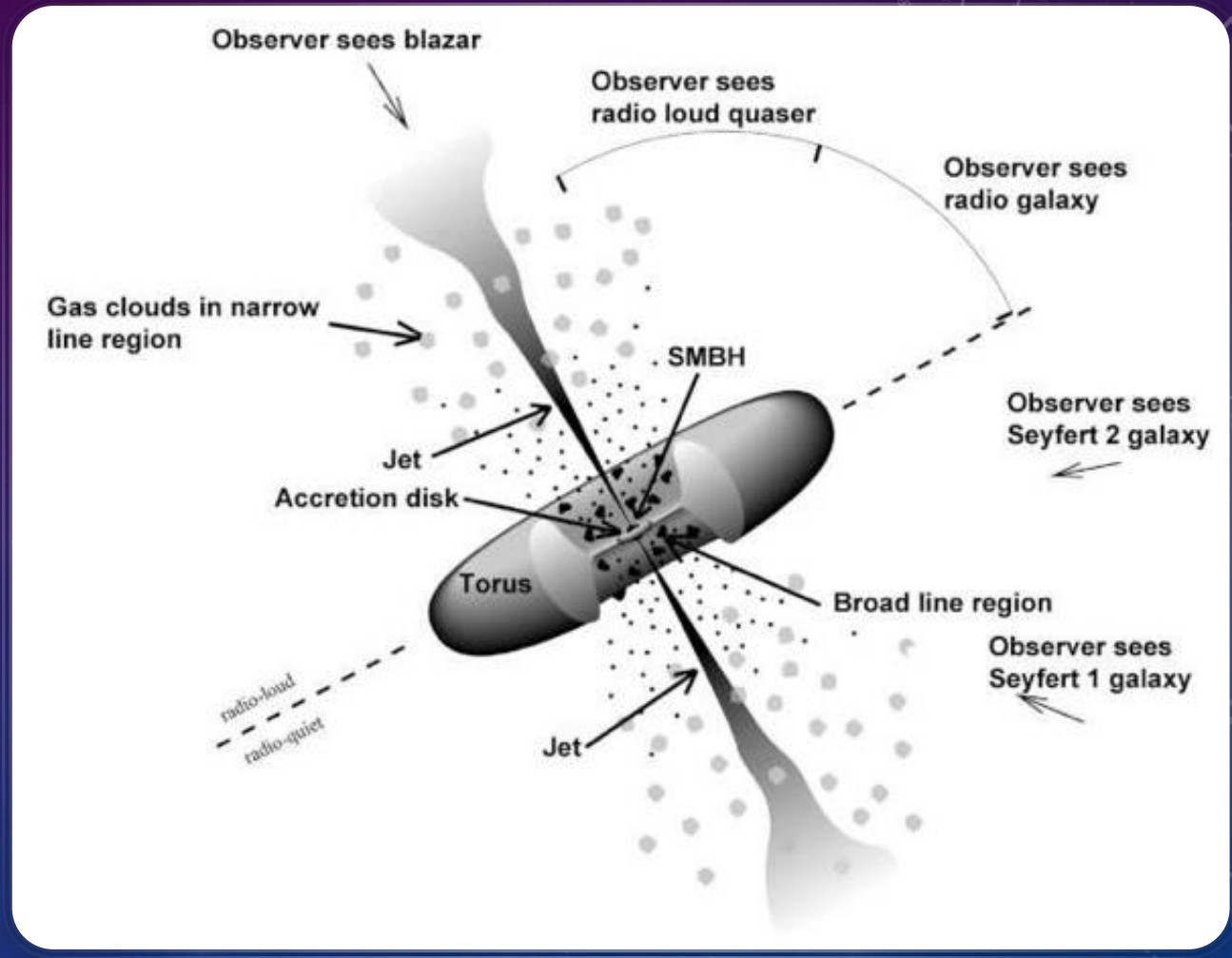
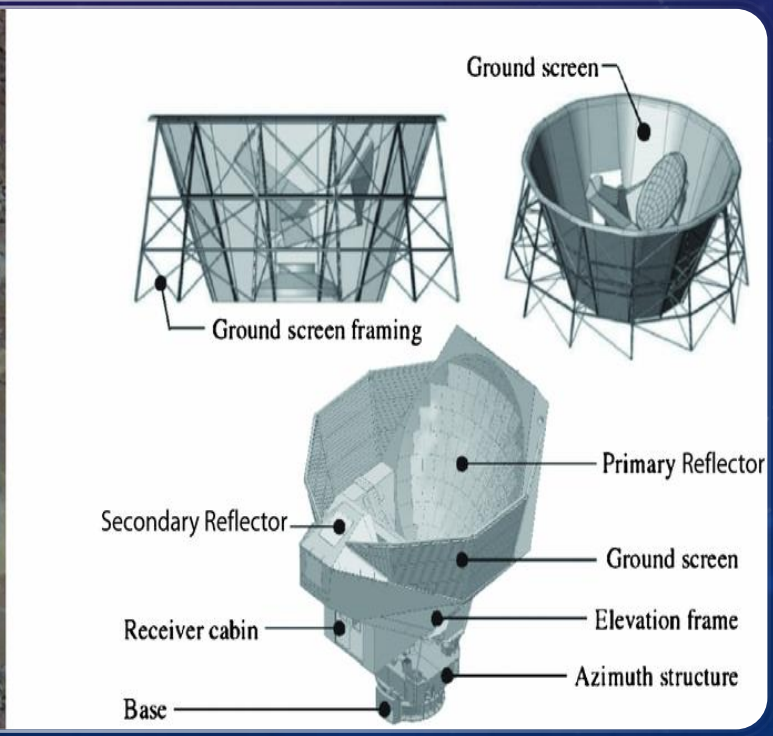
ACTIVE GALACTIC NUCLEI

- Active Galactic Nuclei are Supermassive Black Holes at the center of host galaxies known for emitting bright jets and winds
- The bright luminosity observed is due to non-stellar radiation as the black hole accretes matter into the galaxy's center.
- There are different types of AGNs, such as blazars, quasars, or Seyfert galaxies.



ATACAMA COSMOLOGY TELESCOPE (ACT)

- The Atacama Cosmology Telescope [Swetz et al., 2011] was a millimeter-wave telescope in the Atacama Desert on Cerro Toco, North of Chile.
- It had arcminute resolution, and high sensitivity, and performed microwave-wavelength sky surveys that are used for studying the Cosmic Microwave Background (CMB) radiation and the radiation left after the Big Bang.

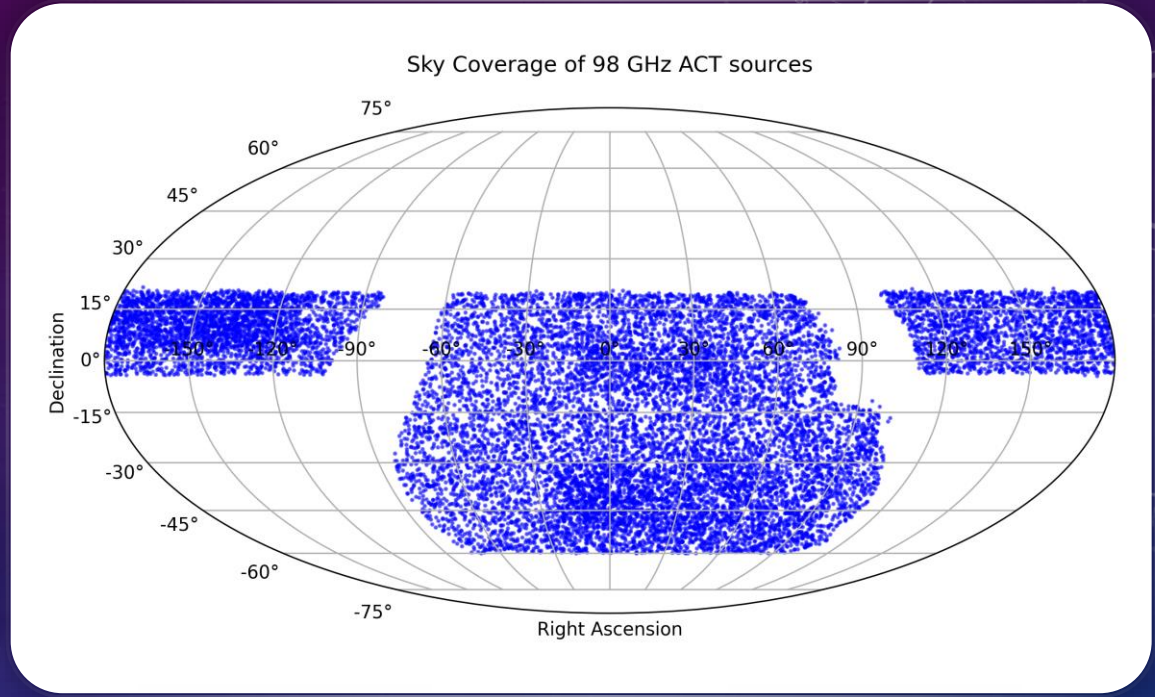


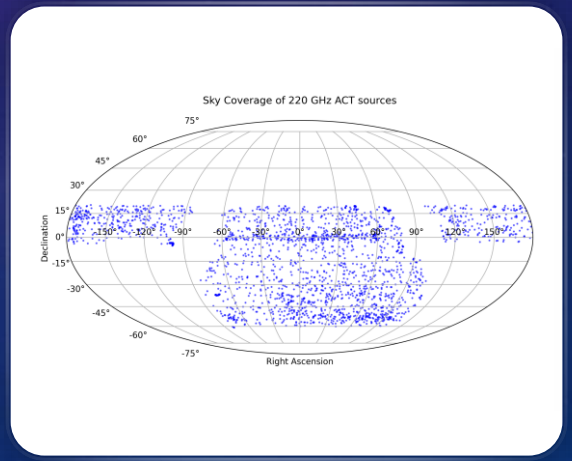
ATACAMA COSMOLOGY TELESCOPE (ACT)

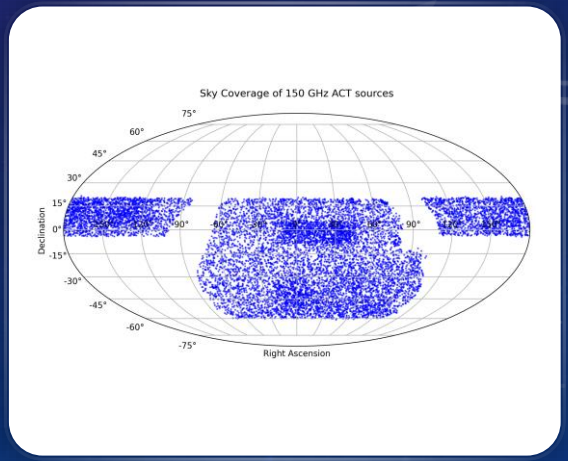
- ACT first saw light in October 2007, having a Millimeter Bolometer Array Camera (MBAC) as its first receiver.
- Since then, the telescope has received two major receiver updates, the first one is for polarization-sensitive observations (ACTPol)[2013-2016] [Niemack et al., 2010] and the second one is the Advanced ACT [AdvACT] (2017-2022) [Henderson et al., 2016].
- The ACT project focused on many things, mainly the CMB. Projects like using ACT DR4 maps and cosmological parameters to produce arcminute-resolution maps of the CMB's polarization anisotropy and temperature at 98 and 150 GHz [Aiola et al., 2020].

ACT SKY COVERAGE (DATA RELEASE 5)

- In our case, we will be using the data collected at millimeter wavelengths using the ACT [Swetz et al., 2011], which has surveyed most of the southern sky with arcminute resolutions.
- The most recent data release is ACT DR5 [Naess et al., 2020] covering a sky area of approximately 18 000 deg^2, collected at 98, 150, and 220 GHz.
- This data has the deepest large area collected at the mentioned frequencies and this allows us to search for never-seen-before objects in extremely large surveys.







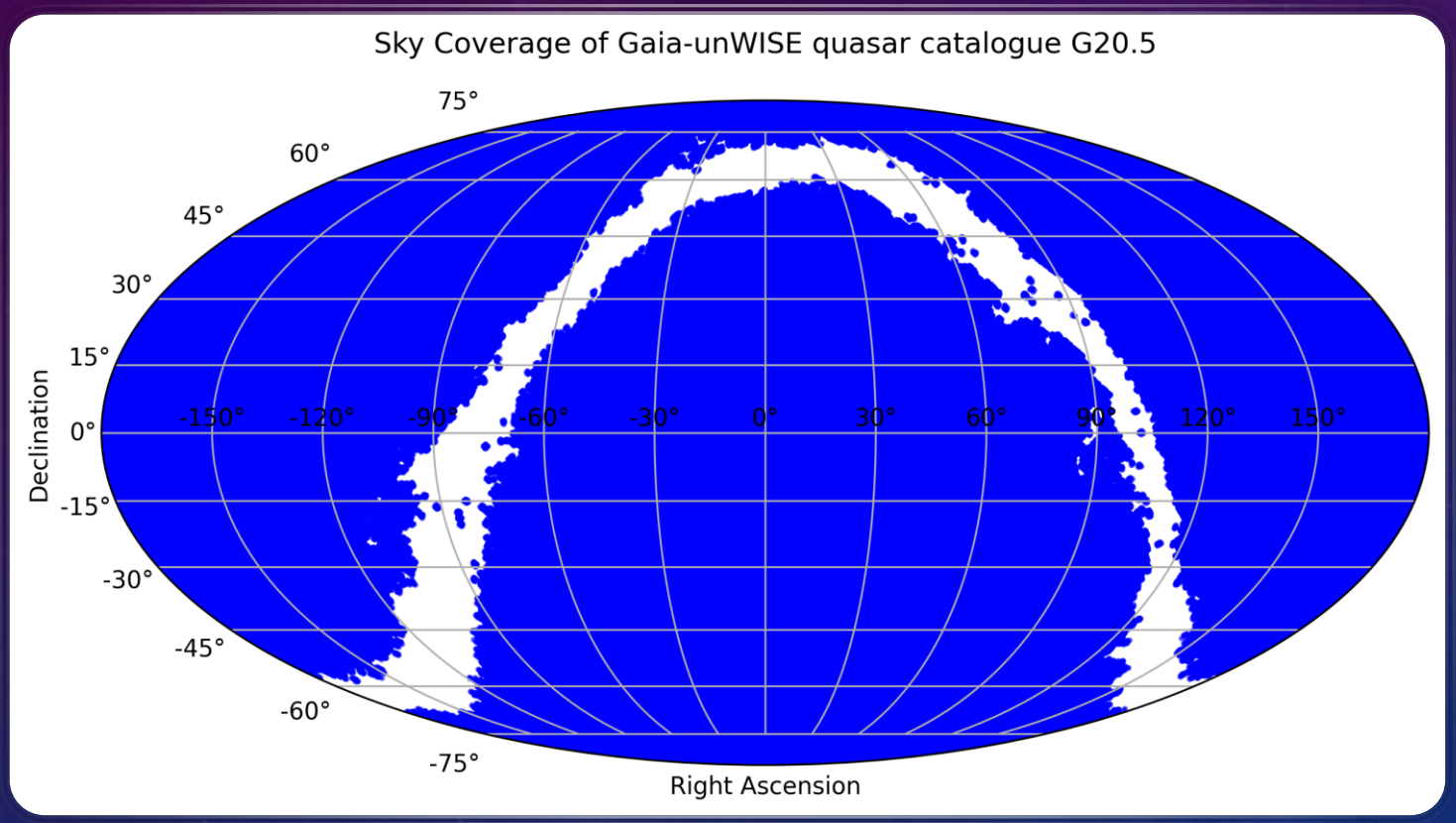
USING ACT DR5 FOR AGN INVESTIGATION

- What many researchers did with the 98 GHz ACT sources was to do the number counting and calculate the spectral indices of these sources, which helped identify that most of these sources are AGNs.
- In our case, we will look at the redshifts of these AGNs to see how their environments have evolved.
- Previous studies showed the kind of sources that can be observed at 150 and 220 GHz due to the ACT observations between 2008-2010 [Vargas et al., 2023], which were mostly synchrotron radiating sources and Dusty-Star-Forming Galaxies.
- [Gralla et al., 2020], used source catalogues from the MBAC-based equatorial survey at frequencies of 148 and 218 GHz from observations during the 2009 and 2010 seasons, including 227 GHz data observed in the 2010 season. 797 total detections were made, as 510 sources were radio-loud AGNs, and 287 were Dusty star-forming galaxies (according to the resulting spectral indices calculated).

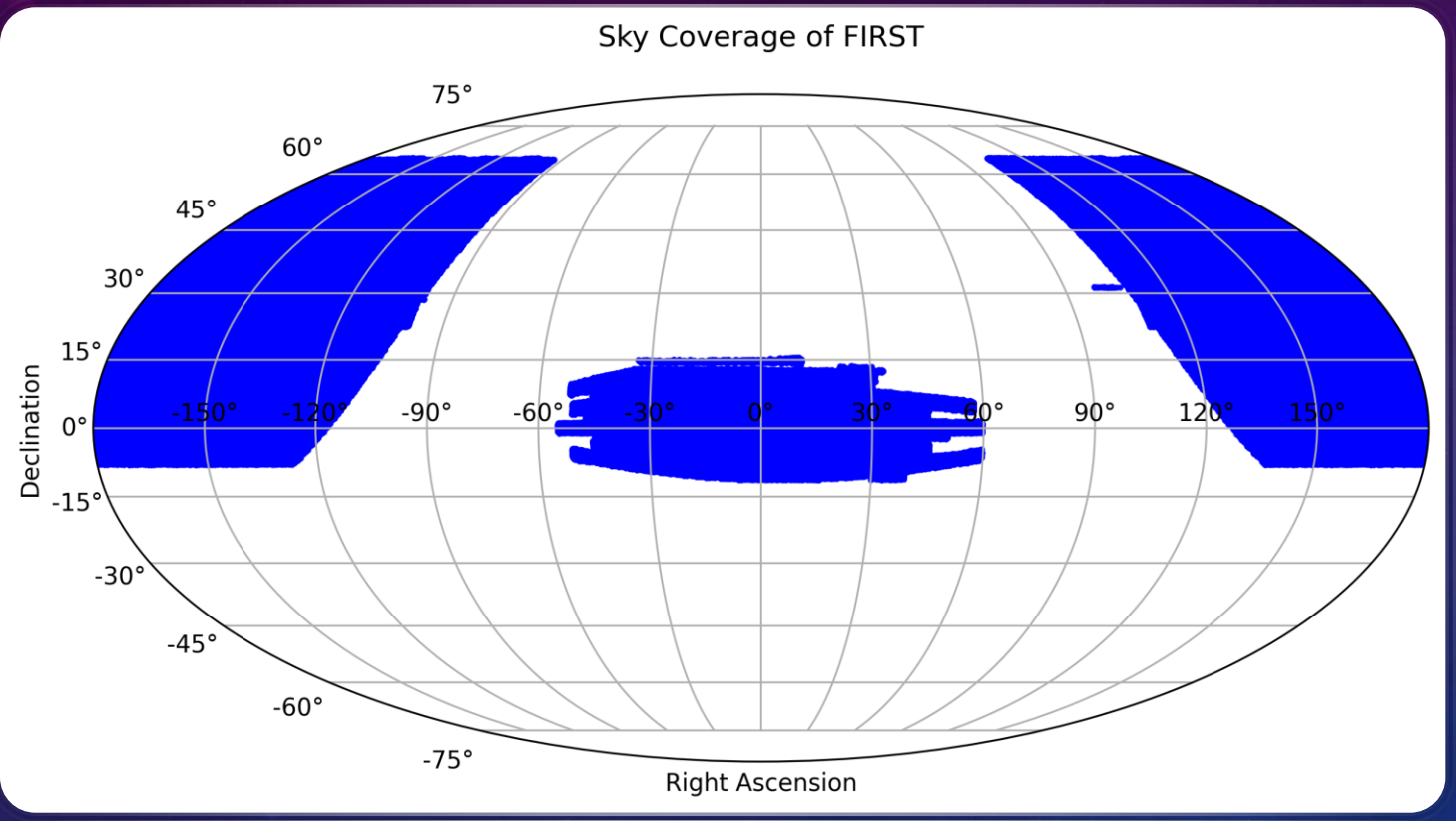
GAIA –UNWISE QUASAR CATALOGUE

- Gaia, a space satellite constructed by the European Space Agency, was sent to space in 2013 and it is expected to end with its observations when 2025 ends.
- The launch of the satellite was on 19 December 2013 and, it arrived at the L2 Lagrange point on 8 January 2014, which is 1.5 million kilometers from Earth.
- We are using redshift data collected by Gaia (Gaia-unWISE Quasar catalogue) [Storey-Fisher et al., 2024], which has two different versions namely Gaia Quaia G20.0 (G-band magnitude < 20) & Gaia Quaia G20.5(G-band magnitude < 20.5).
- The Quaia G20.0 has 775,850 quasar candidates and Quaia G20.5 has 1,295,502 quasar candidates.

UNWISE QUASAR CATALOGUE COVERAGE



- The two catalogues draw on 6,649,162 quasar candidates and their redshift estimates were obtained from the BP/RP spectra. The Blue photometer operates at wavelengths of 330-680 nm, while the operation wavelengths of 640-1050 nm are for the Red Photometer [Hodgkin et al., 2013].
- These are essential in determining the properties of stars like the age, mass, temperature, and which elements are they made out of [Eyer et al., 2013].
- The Catalog uses both the photometric and spectroscopic redshifts (collectively known as spectrophotometric redshifts), where the spectrometric redshifts used are from the observations done by the Sloan Digital Sky Survey and the quasar sample is called SDSS DR16 and the photometric redshifts are from the unWISE quasar sample.

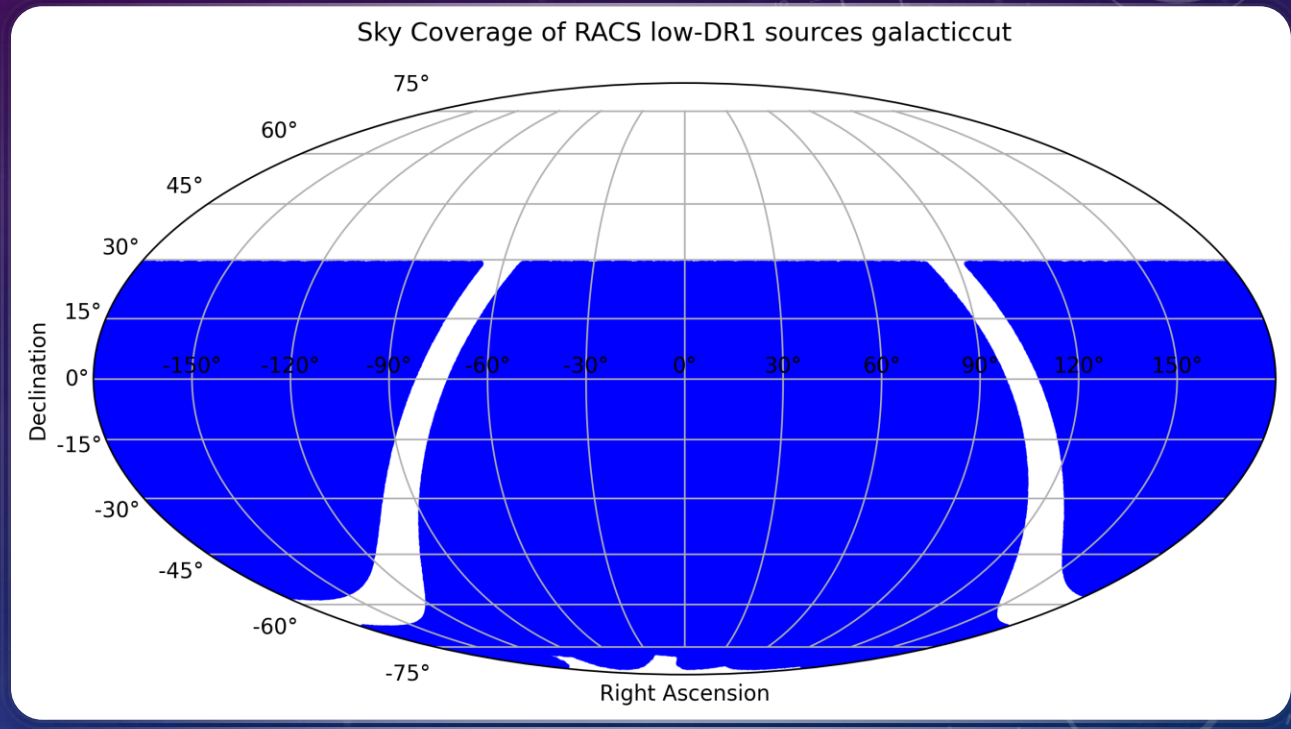


OTHER RADIO SURVEYS USED.

- The FIRST (Faint Images of the Radio Sky at Twenty-Centimeters) survey covered an area of $\sim$ 10575 deg^2, which is composed of 8444 deg^2covered in the north and 2131 deg^2covered in the south Galactic caps, which is 25% of the entire sky [Sasmal et al., 2022].
- The catalogue released on 17 December 2014,consists of 946 432 radio sources collected from observations from 1993 until 2011 at 1.4 GHz using the NRAO VLA B-configuration.
- The FIRST survey has high sensitivity and better resolution, so it will enable us to study a high numberof faint radio galaxies and morphologies.

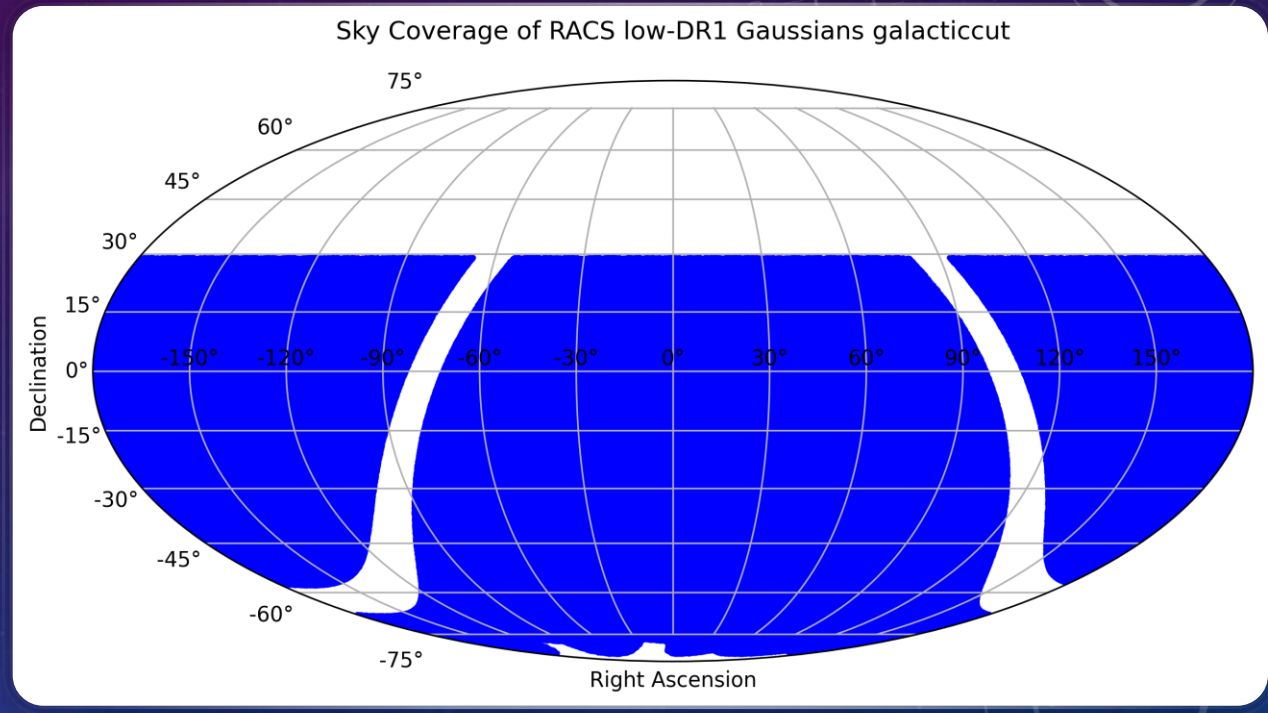
RACS - THE RAPID ASKAP CONTINUUM SURVEY

- RACS is the very first survey covering a large area to be conducted using 36 antennas of the ASKAP(Australian Square Kilometre Array Pathfinder), making deep surveys [McConnell et al., 2020]
- It is used to image the entire sky that is south of the declination $\delta = +51^{\circ}$ at a frequency range of 700 -1800 MHz (in our case, we use 887.5 MHz).
- It is located in Western Australia at the Murchison Radio-astronomy Observatory and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) operates it.



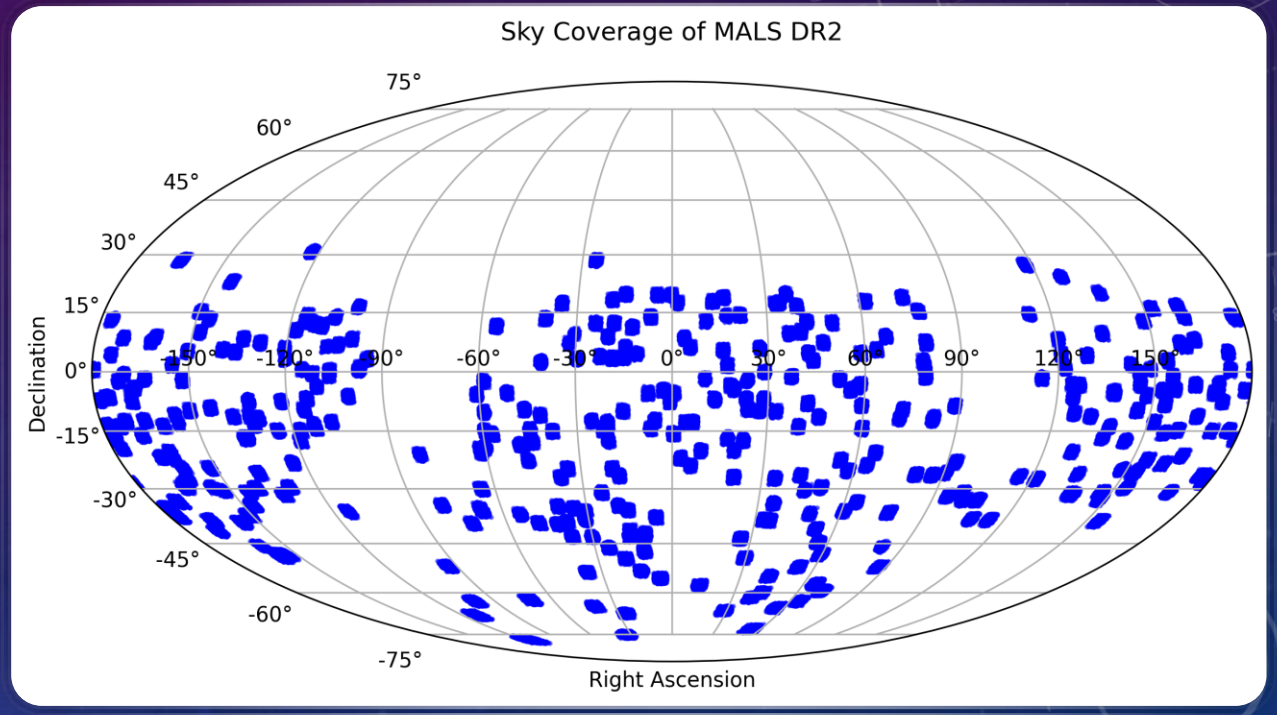
RACS - THE RAPID ASKAP CONTINUUM SURVEY

- Using RACS at a frequency of 887.5 MHz we will observe radio emission sources that are mostly dominated by synchrotron emission.
- We are using two types of RACS catalogues, named the Gaussian Component and the Source catalogues.
- The Gaussian Component catalogue can be used to deblend the emission from close neighbouring sources that are not associated with each other.
- The source catalogue is useful for providing information on multicomponent sources.



MALS – MEERKAT ABSORPTION LINE SURVEY

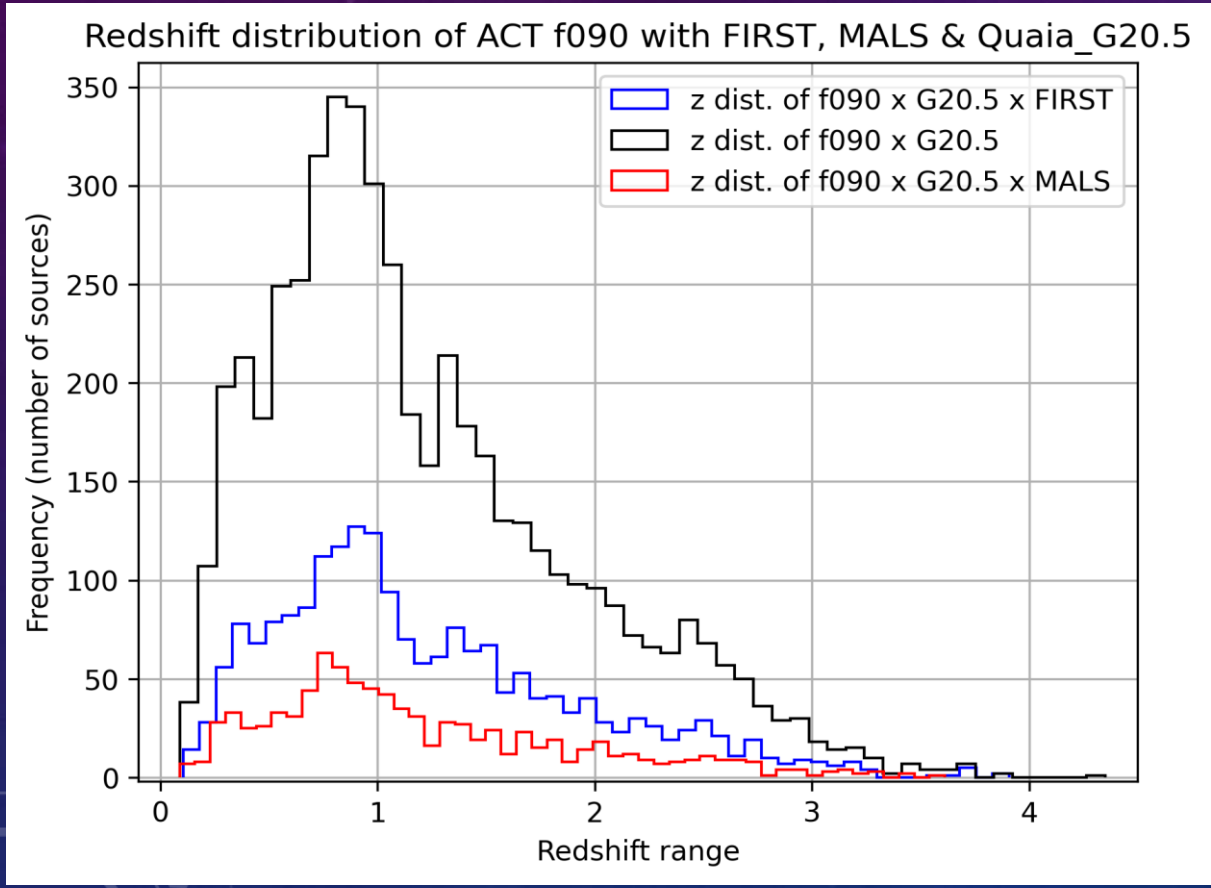
- The MeerKat Absorption Line Survey started on 14 June 2020, and the observations are using the frequency range (580 - 1015 MHz) for the UHF-band & (900 - 1670 MHz) for the L-band.
- We will use the MALS DR2v1 and the survey covers an area of 4344 deg^2, observing 971 980 radio sources collected by 391 pointings at a frequency of 1270 MHz.

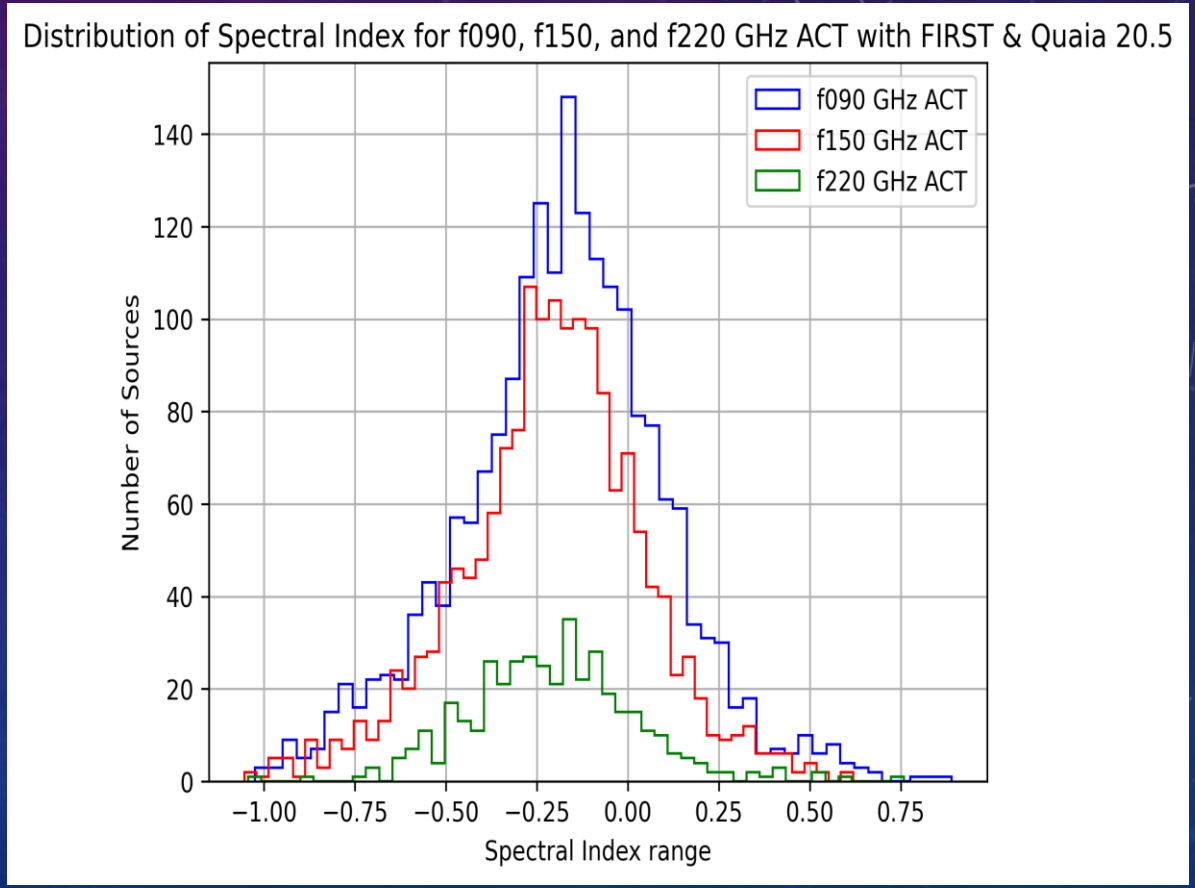


OUR SEARCH FOR ACTIVE GALACTIC NUCLEI

- The ACT DR5 98 GHz catalogue has > 15 000 sources which is a larger catalogue compared to the 695 used in [Vargas et al., 2023] and 191 used in [Marsden et al., 2014], and it is mostly made up of AGNs.
- we start with cross-matching
- The ACT-98 GHz data is cross-matched with the data AGNs are already found like the Quasar catalogue made using observations by the Gaia satellite.
- From literature, AGNs are associated with spectral indices of $\alpha \leq 1$, so we use other radio surveys that are cross-matched with the 98 GHz ACT sources and the quasar catalogue to calculate them.
- For the redshift of our sources, we use redshifts from Gaia-Quasar catalogue

REDSHIFT AND SPECTRAL INDEX DISTRIBUTIONS





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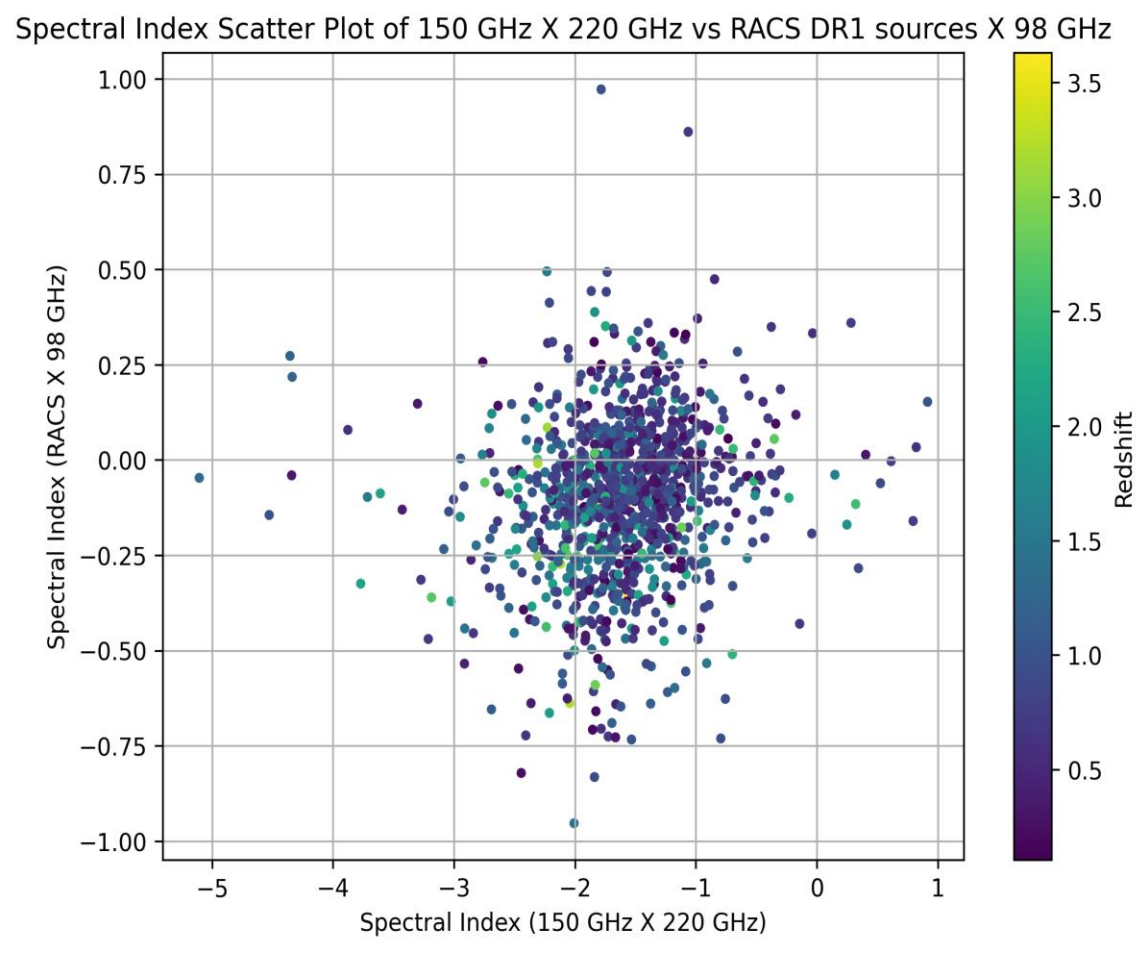
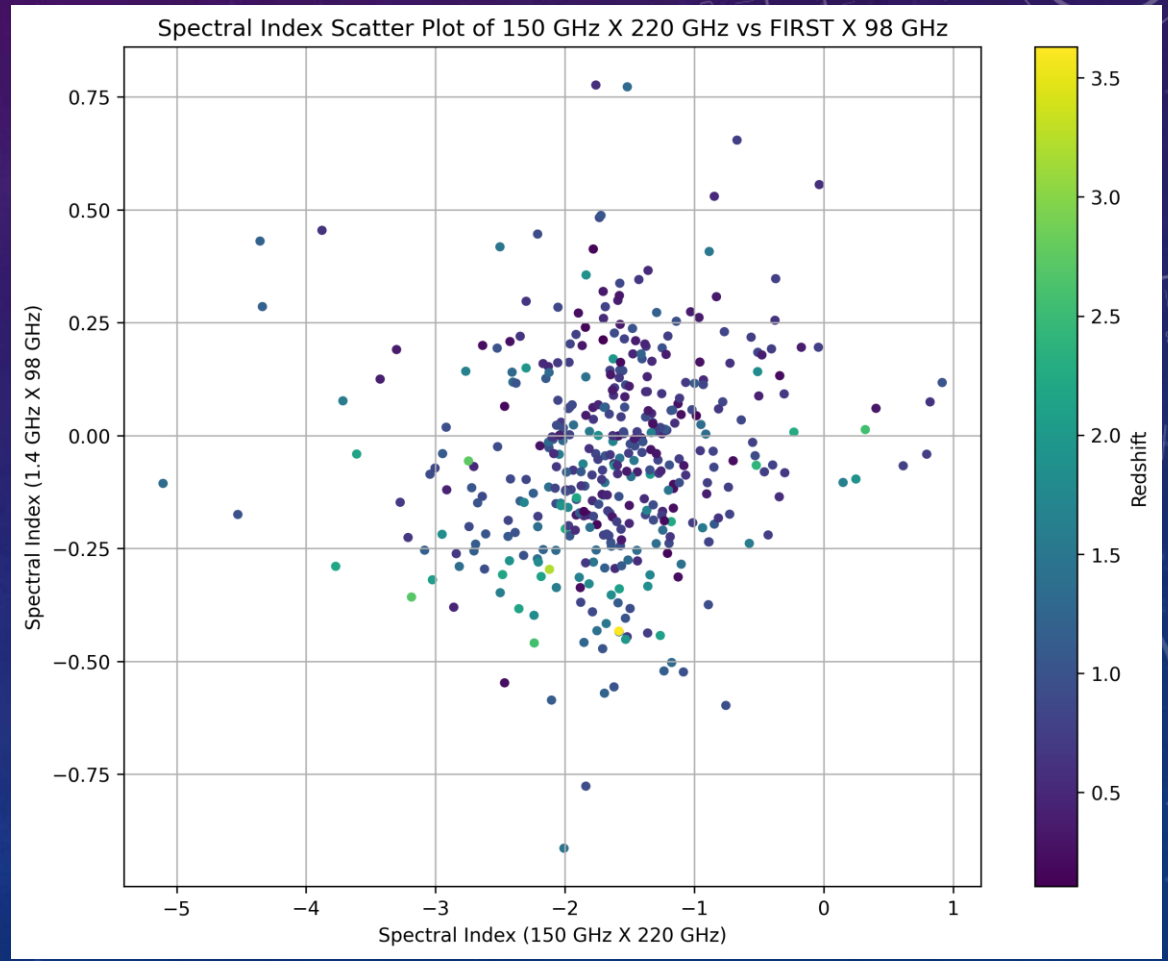
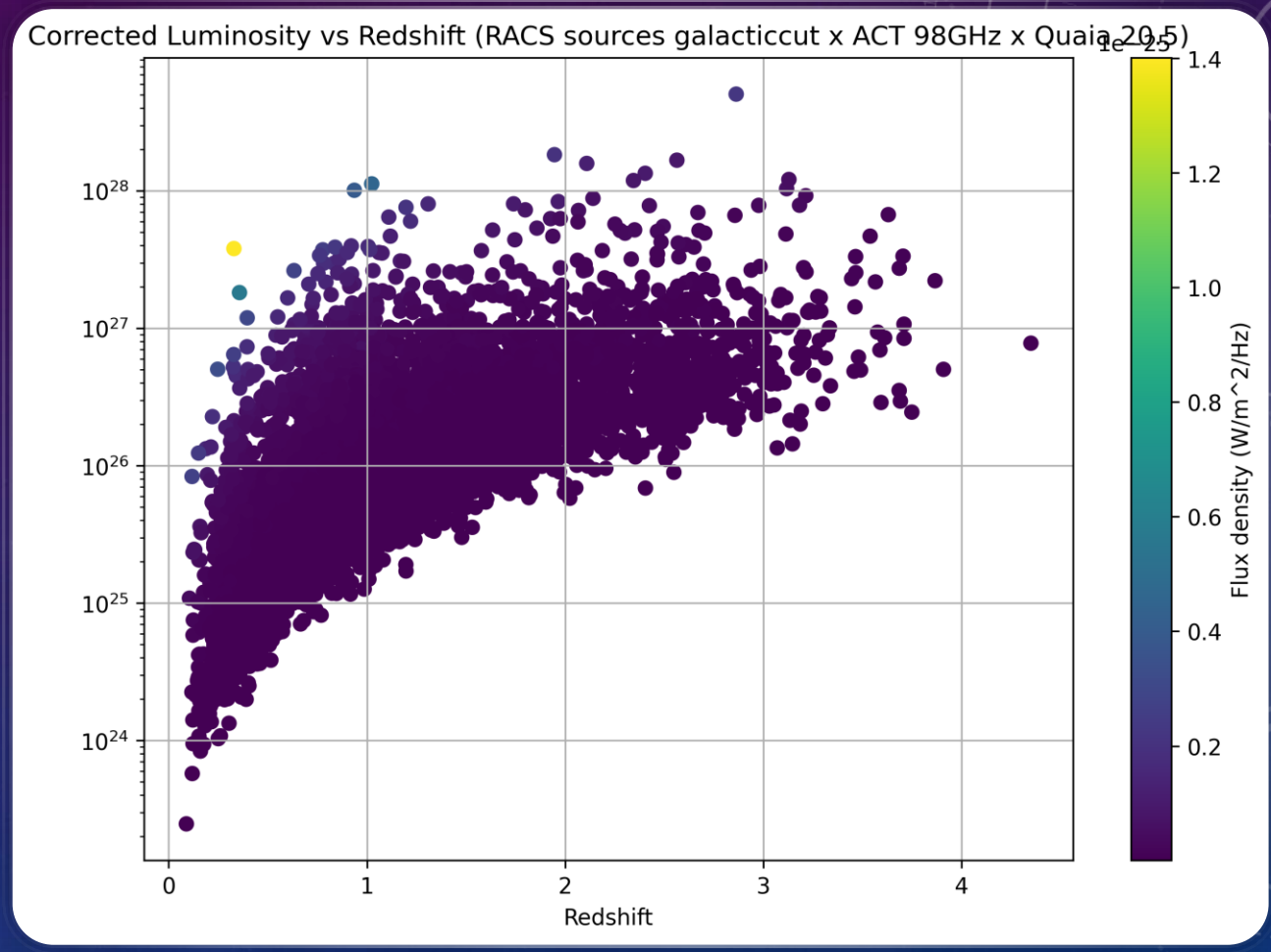




LUMINOSITY VS REDSHIFT PLOTS

- Only in the RACS source catalogues, do we have a source that has a redshift z > 4



FIRST Image

Area not covered by FIRST survey

VLASS 3.1

VLASS Pilot

VLASS 1.1v2

VLASS 1.2v2

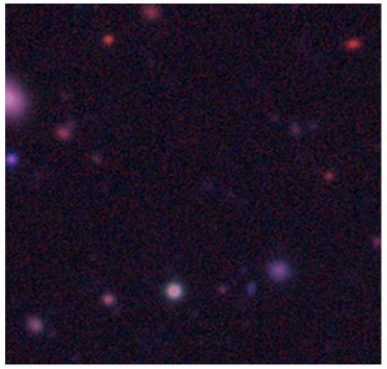
VLASS 2.1

VLASS 2.2

XMM-Newton Image

RACS Image

Optical Legacy Survey Image

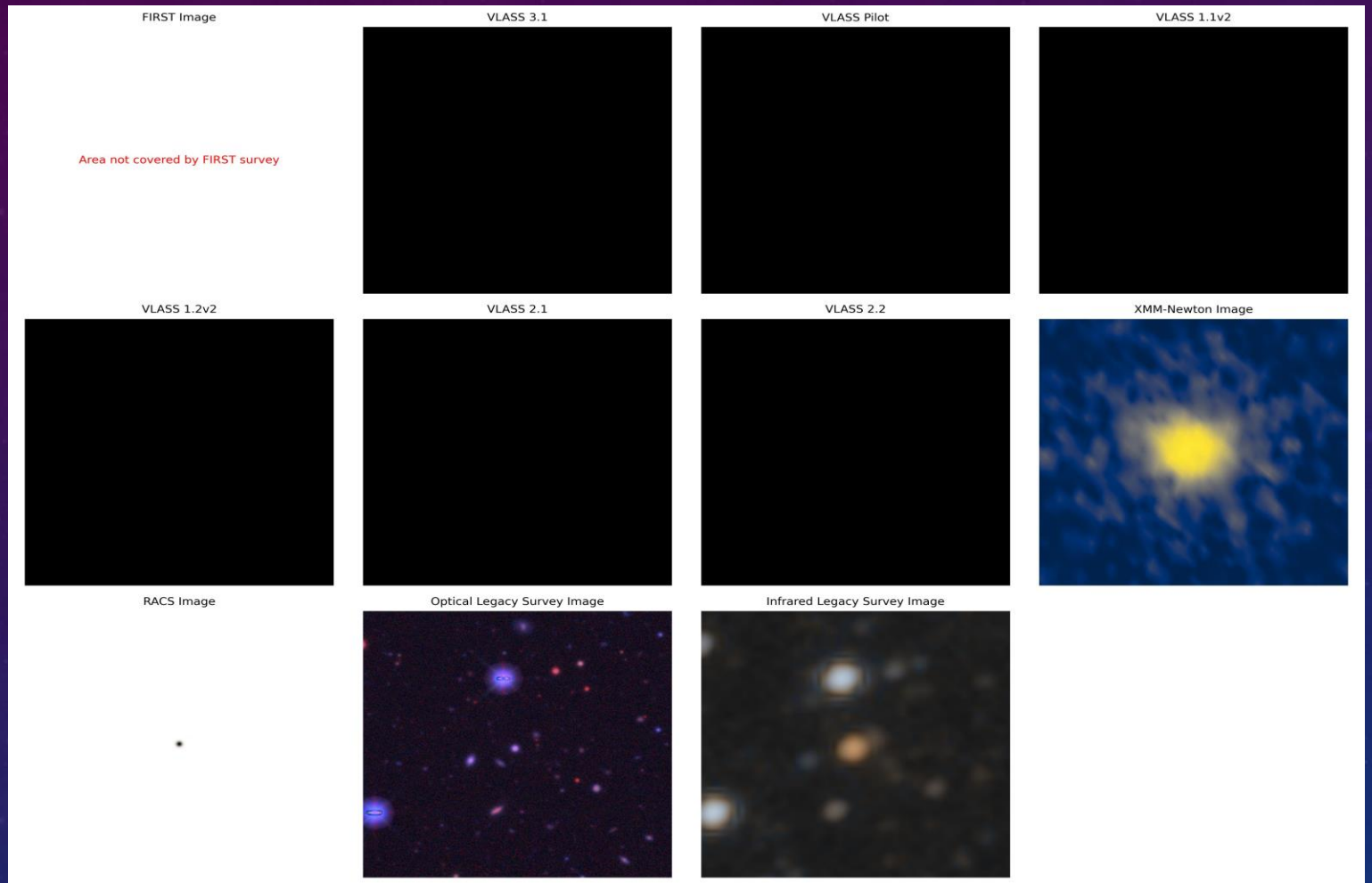


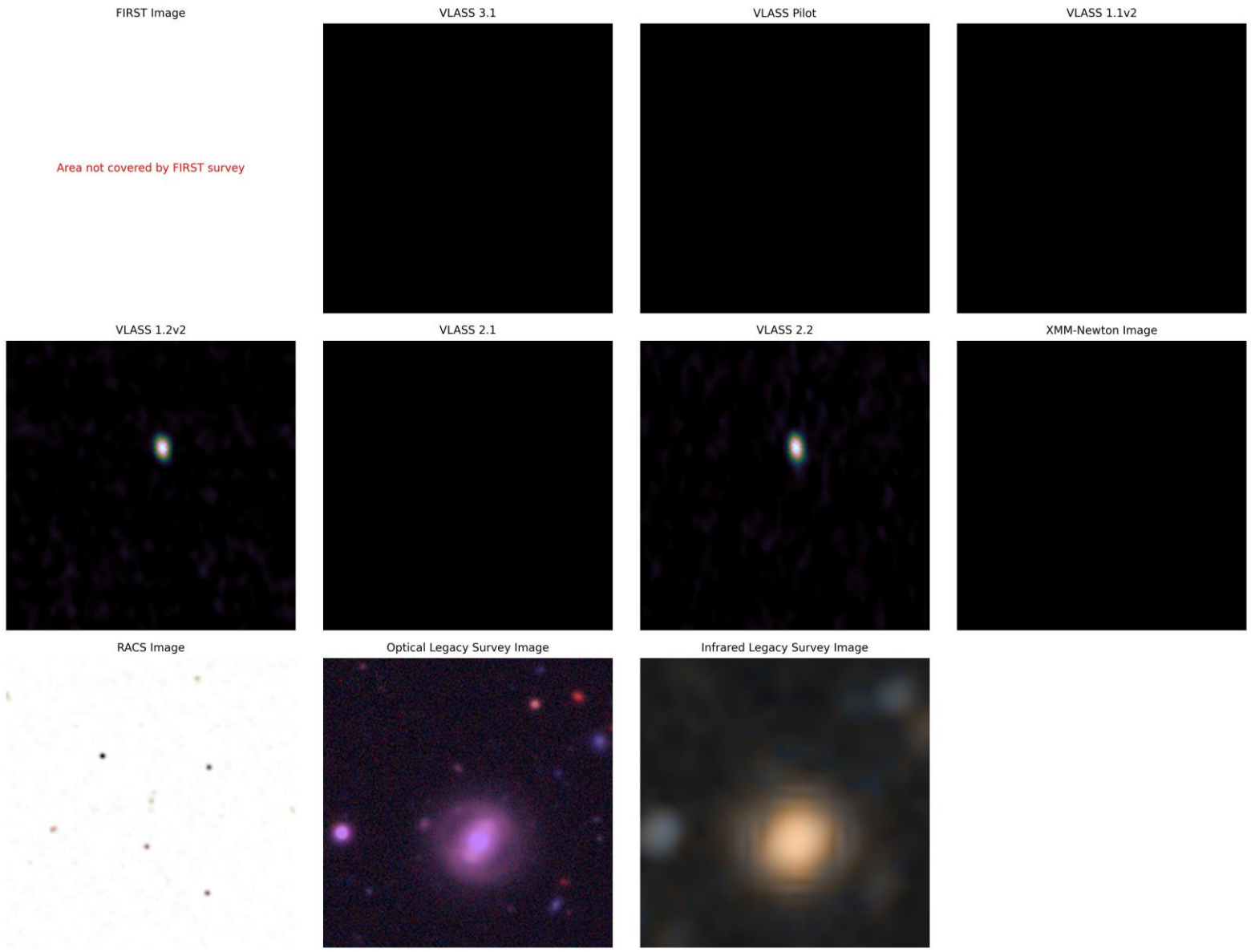
Infrared Legacy Survey Image

IMAGES OF SOURCES AT DIFFERENT WAVELENGTHS

- ACT-S J002.7-4815 (z = 4.35)

HIGHEST LUMINOSITY SOURCE (ACT-S J0440.2-4333) (Z = 2.86)





ACT-0354.5-1339

- Low redshift and low luminosity (z = 0.09)

CURRENT WORK

- Using volume-limited samples on luminosity vs redshift plots to determine the luminosity function of sources of different surveys