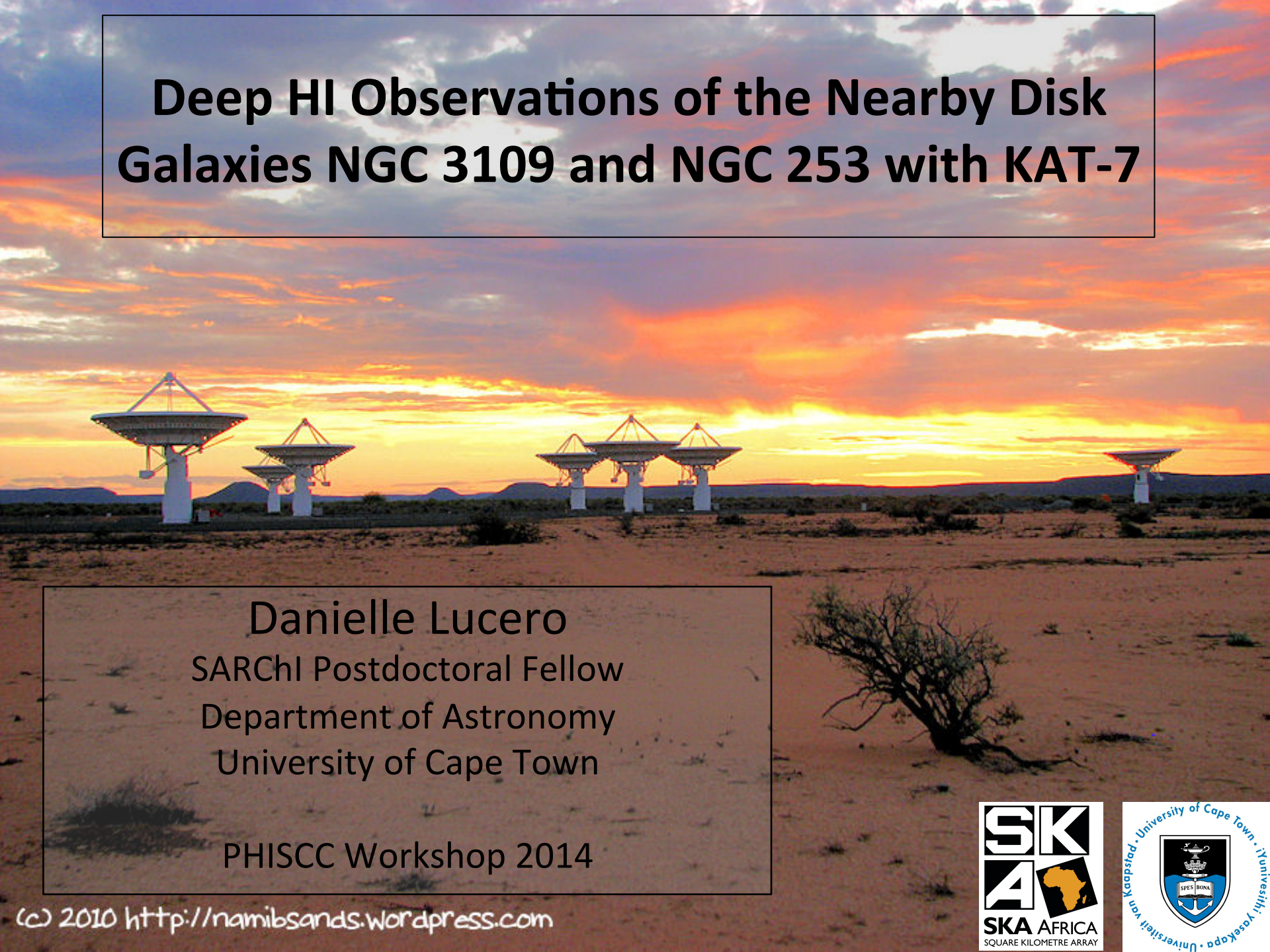
Deep HI Observations of the Nearby Disk Galaxies NGC 3109 and NGC 253 with KAT-7



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PHISCC Workshop 2014

SKA AFRICA
SQUARE KILOMETRE ARRAY

University of Cape Town • iYunivesithi yaseKapa • Universiteit van Kaapstad

KAT-7 Specifications

Key performance parameters of KAT-7:

Parameter	*Value*
Number of Antennas	7
Dish Diameter	12m
Baselines	26 m to 185 m (see here)
Frequency Range	1200 MHz - 1950 MHz
Instantaneous Bandwidth	256 MHz
Polarisation	Linear (H + V)
Tsys	< 35 K across the entire frequency band (~30 K average) for all elevation angles > 30 deg

Correlator Modes:

Mode	*# Bands*	*Band Bandwidth*	*Channel Bandwidth*	*Available*
Wideband	1	256 MHz	390.625 kHz *	Yes
8k Wideband	1	256 MHz	48.8 kHz **	Yes, but unsupported
HI Galaxy Clusters	1	400/16 = 25 MHz	25/4096 = 6.1 kHz	Yes
HI Galaxies / Maser Search	1	400/64 = 6.25 MHz ***	6.25/4096 = 1.525879 kHz	Yes
Maser monitoring	1	400/256 = 1.5625 MHz ***	1.5625/4096 = 381.4697 Hz	Yes

* The channel bandwidth is obtained by dividing the IF bandwidth (400 MHz) by the total number of channels (1024). Note that only 256 MHz of the IF bandwidth is useable.

** The IF bandwidth (400 MHz) is divided by 8192 channels.

*** The useable Band Bandwidth will be slightly less, and will be determined as part of the acceptance testing.

Advantages of KAT-7 for HI

- Short baselines and low system temperature.
  - KAT-7 is sensitive to large scale low surface brightness emission.
- Galaxies correlator mode: 25Mhz bandwidth, 1 km/s channels.
  - Allows sensitive observations at high spectral resolution.
- Currently in science commissioning phase.
  - Gobs of time available for simultaneous science and commissioning.

HI Science Verification Projets

- NGC 3109 (Claude Carignan, Brad Frank, Kelley Hess, Danielle Lucero, Toky Randriamampandry, Sharmila Goedhart, Sean Passmoor)
- NGC 253 (Danielle Lucero, Claude Carignan, Tom Oosterloo)
- M83 (George Heald, Erwin de Blok, Danielle Lucero)
- Virgo Cluster HI (Amidou Sorgho, Kelley Hess, Claude Carignan, Jacqueline van Gorkom)
- Antlia Cluster (Kelley Hess, Tom Jarret)
- NGC 5044 Group (Danielle Lucero; Claude Carignan)

KAT-7 HI Science: NGC 3109

KAT-7 Science Verification: Using HI Observations of NGC 3109 to Understand its Kinematics and Mass Distribution

C. Carignan[1], B. S. Frank, K. M. Hess, D. M. Lucero and T. H. Randriamampandry
Department of Astronomy, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa
and

S. Goedhart and S. S. Passmoor
SKA South Africa, The Park, Park Road, Pinelands, 7405, South Africa
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ABS

HI observations of the Magellanic-type sp
Array Telescope (KAT–7), are used to analy
to what is obtained using VLA data. KAT–7
which is under construction. The short base
make it sensitive to large scale low surface bri
7 allow the measurement of the rotation cu
extent of existing measurements. A total H
what was detected by the VLA observations
The observationally motivated pseudo-iso
very well the observed rotation curve but th
a much poorer fit to the data. While having
discrepancy between the observed RC and th
this is done at the expense of having to use
and/or very large values for the MOND *univ*
cannot reconcile MOND with the observed k
quantities. As for many slowly rotating gas-
NGC 3109 continues to pose a serious challe

Subject headings: techniques: interferometric –
and dynamics – galaxies: haloes – cosmology: d

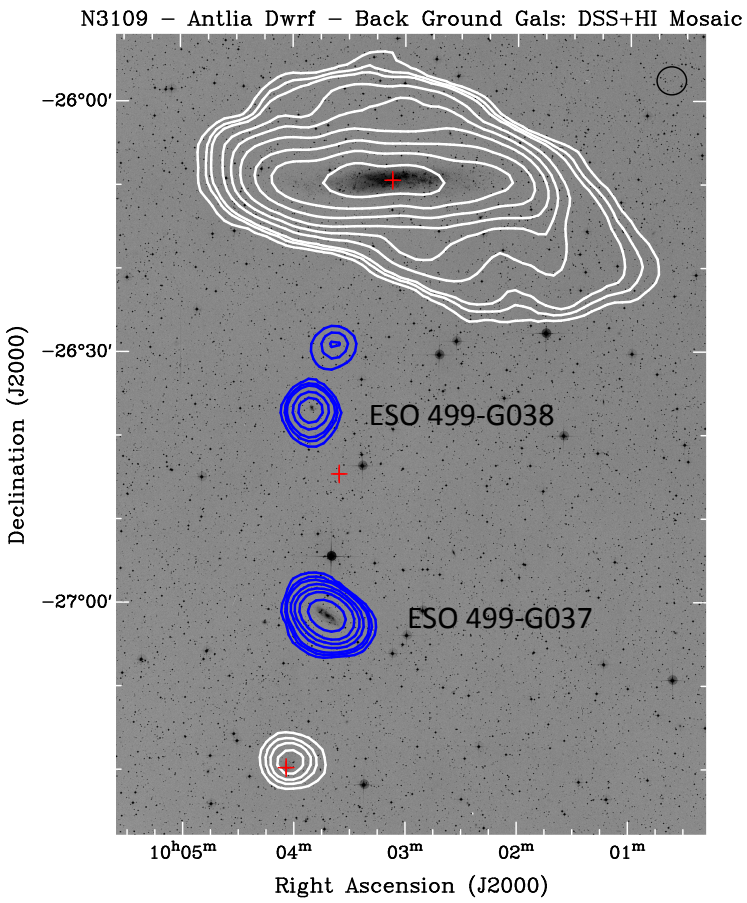
KAT-7 HI Science: NGC 3109

- Magallenic type dwarf spiral galaxy
- Dynamical study

- Why is NGC 3109 interesting?
  - Previous dynamical studies indicate that mass models composed of a luminous disk and a Isothermal dark matter halo produce good fits to the observed rotation curve (Hα, VLA HI).
  - A Modified Newtonian Dynamics Model (MOND) cannot reproduce the observed rotation curve (Randriamampandry 2013).
  - Parks HI data indicates that the warp observed in the HI disk could be due to a dynamical encounter with the Antlia dwarf.

✧ Deeper HI observations allow us to measure the RC farther out as well as look for indications of tidal interactions.

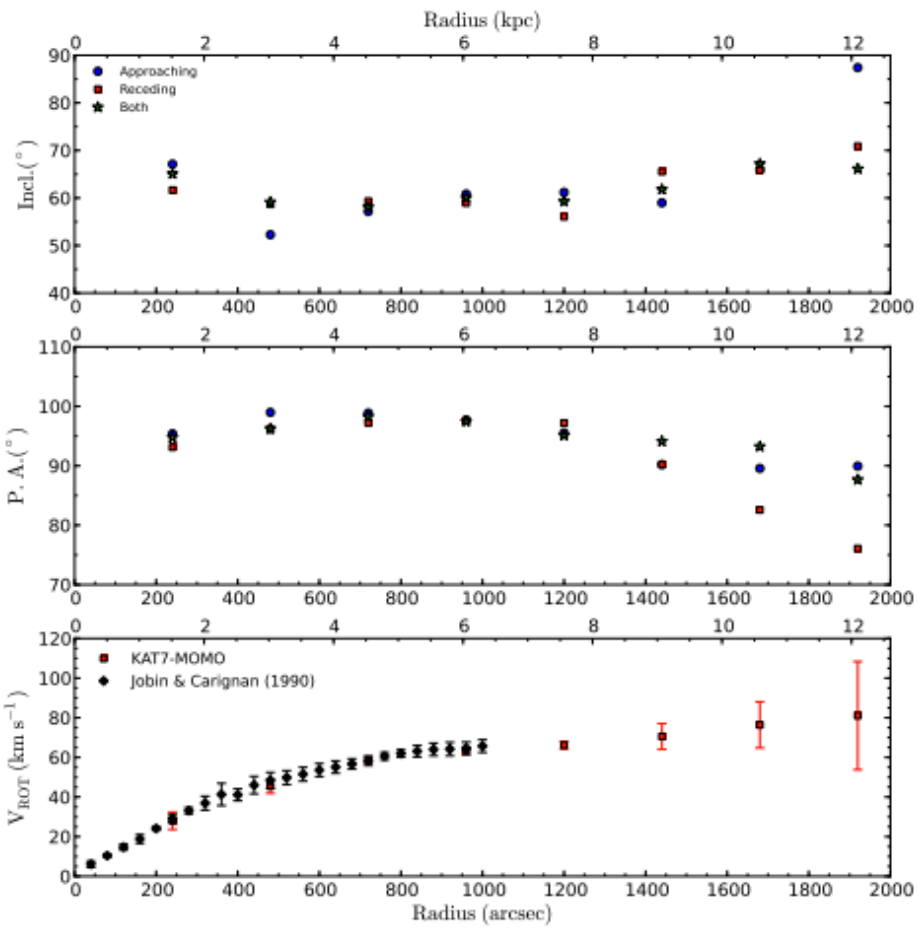
KAT-7 HI Science: NGC 3109



Carignan et al. 2013

- Three pointing mosaic. 25 hours per pointing.
- 3.7 mJy/beam in one 1.3 km/s channel. Reached surface densities of ~1x10^{19} atoms cm^{-2}
- 40% larger HI mass than that measured by the VLA.
- Lopsided HI distribution.
- Increased sensitivity allows us to derive a RC out to 32’ (~12 kpc), 14’ farther than the VLA ANGST data.
- Allows us to re-test DM and MOND mass models.

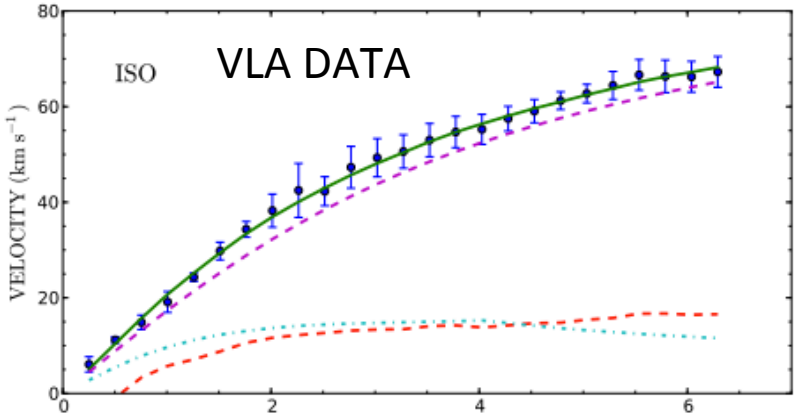
KAT-7 HI Science: NGC 3109

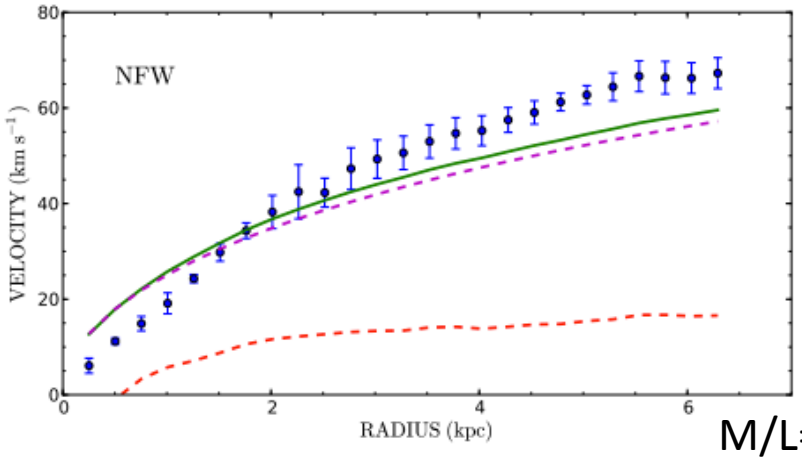


- RC derived using GIPSY task ROTCUR on the moment 1 maps.
- HI warp more prominent on the approaching side.
- RC agrees well with VLA data in the inner parts.

KAT-7 HI Science: NGC 3109

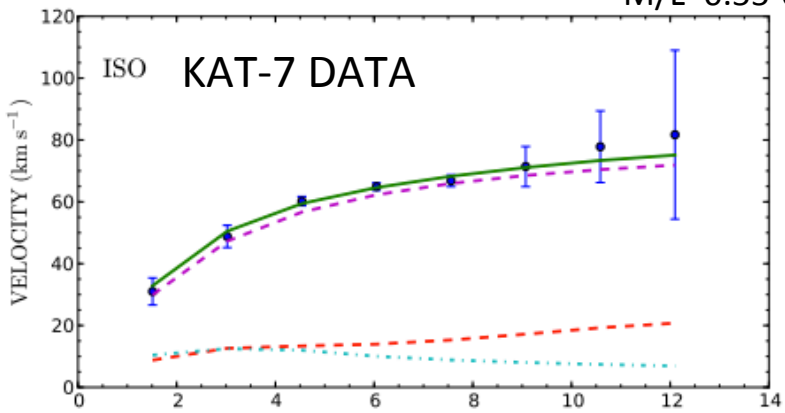
- **ISO and NFW mass models**. Blue points: observed HI velocities; dash purple: DM Halo; dash red: HI disk; dash dot teal: Stellar disk; Solid Green: quadratic sum of components

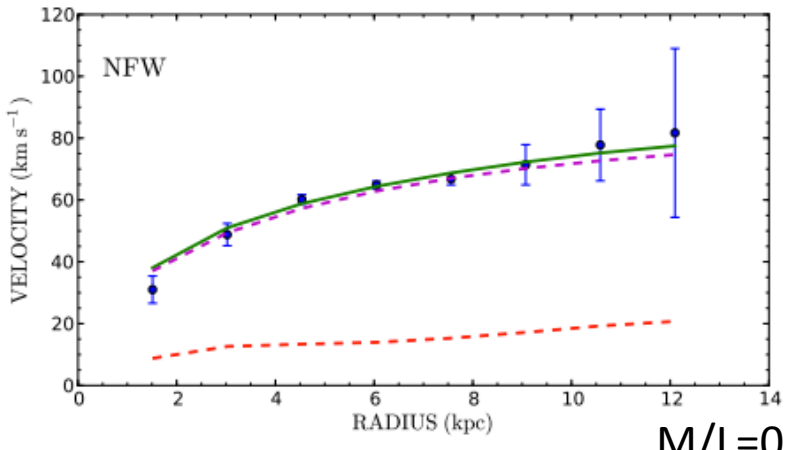




M/L=0

M/L=0.55-0.76



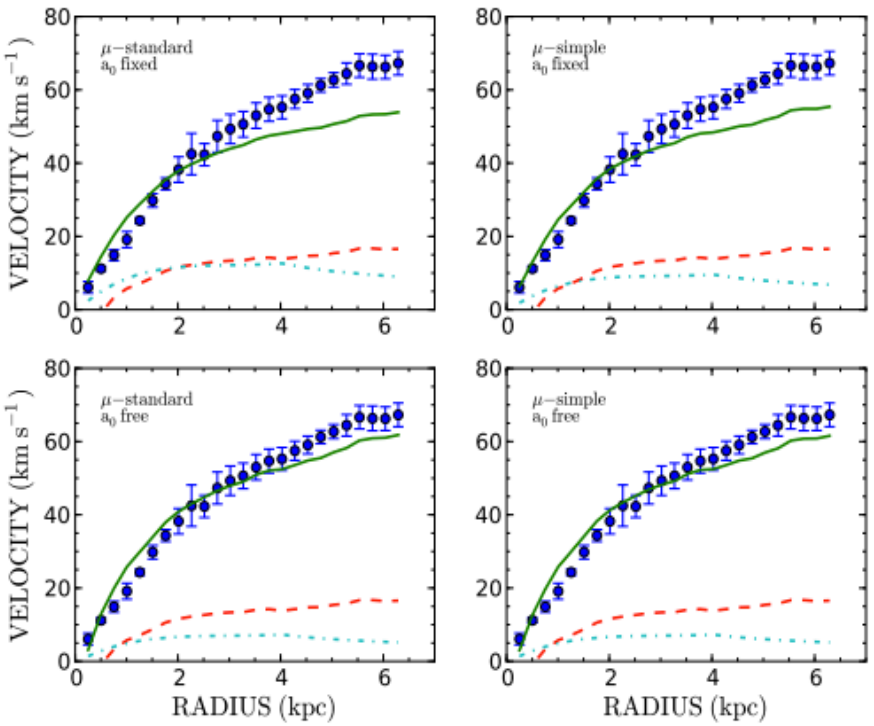


M/L=0

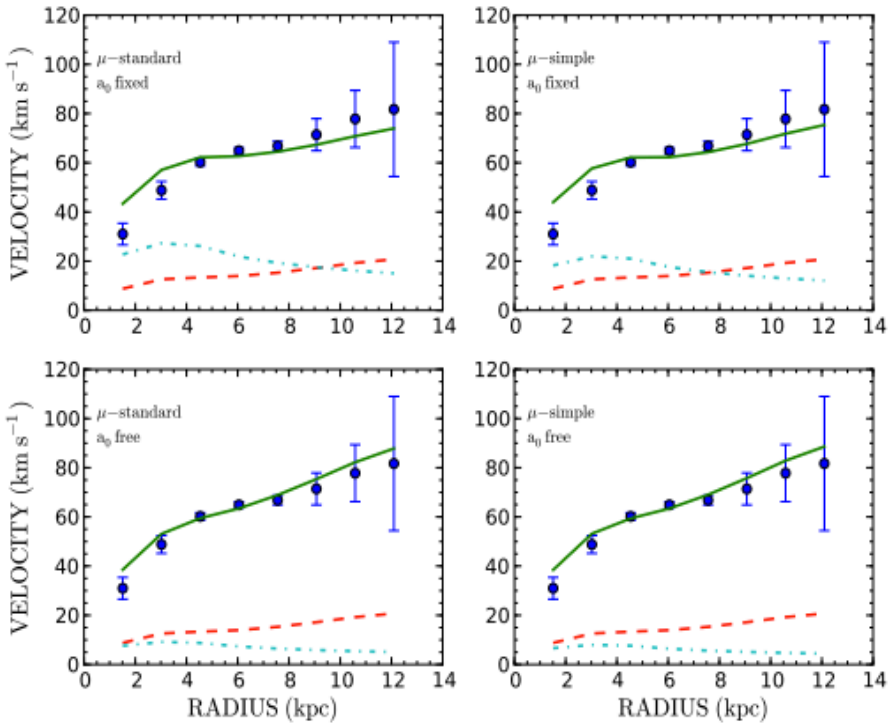
KAT-7 HI Science: NGC 3109

- **MOND Mass Models**: blue points: observed velocities; dash purple: DM Halo; dash red: HI disk; dash dot teal: Stellar disk; Solid Green: quadratic sum of components

VLA DATA



KAT-7 DATA



Produces large reduced Chi squared.

Produces large a_0 values and a M/L much to small.

KAT-7 HI Science: NGC 3109

Summary:

- Observationally motivated DM ISO model reproduces observed rotations curves. While the cosmologically motivated NFW models give a much poorer fit.
  - NGC 3109 has a **cored** and not a cuspy DM Halo.

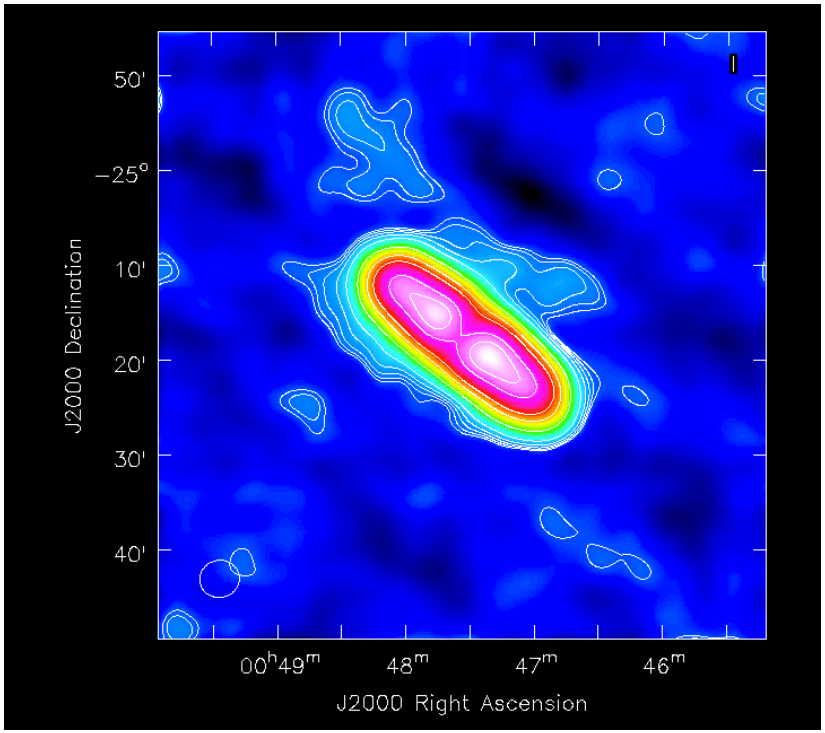
- MOND models produce unreasonable M/L ratios and large values of a_0.
  - Strong evidence against MOND (other cases see Sanchez-Salcedo et al. 2013)

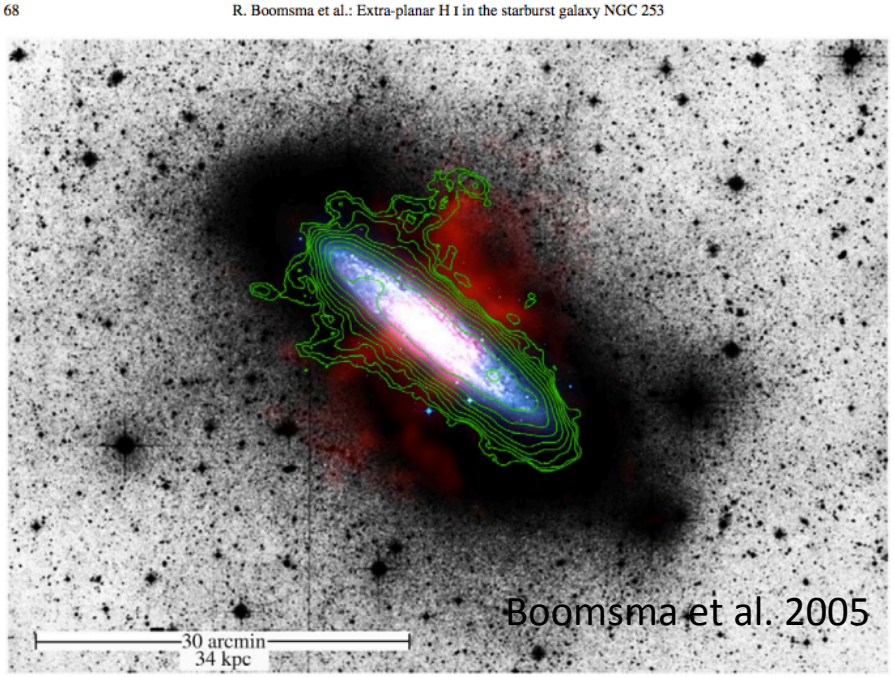
- Besides some elongation of the outer isophotes, no further evidence is found for a past encounter and/or interaction between NGC 3109 and the dSph/Irr Antlia. We are still exploring this possibility.

➢ Despite its small collecting area, KAT-7 has a niche for detecting large scale low level emission in nearby very extended galaxies!

KAT-7 HI Science: NGC 253

- Observation Goals: Look for extra planar HI. Eventual kinematic analysis.
- 120 hours in one pointing using the 25MHz spectral line mode.
- ~2.2 mJy/beam in one 1.3 km/s channel.
- Produce similar sensitivity to the ATCA observations (~1x10^{19} atoms cm^{-2}).





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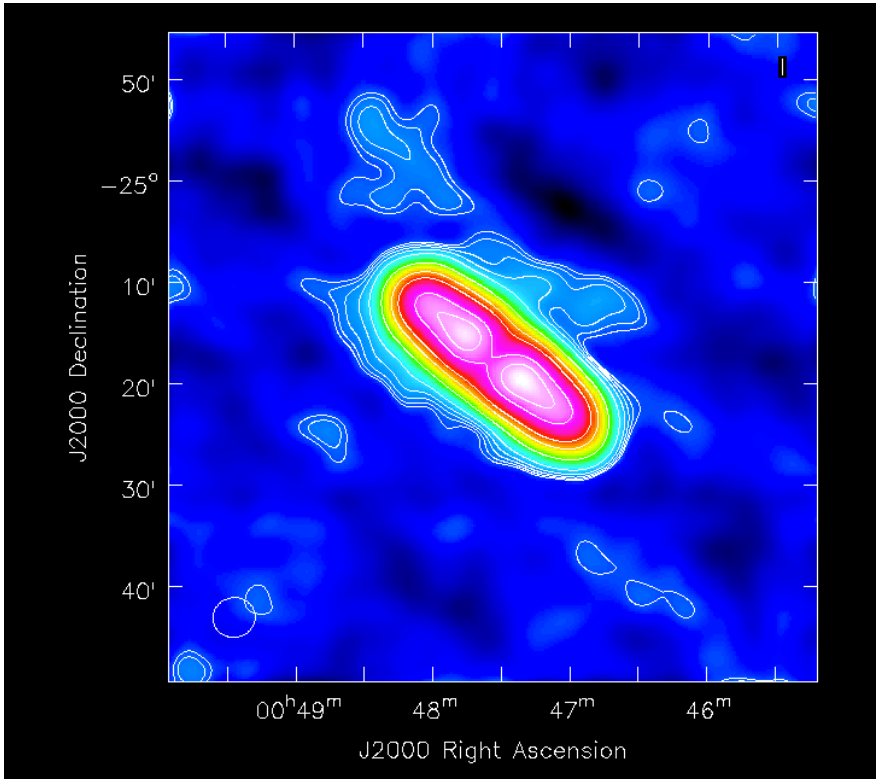
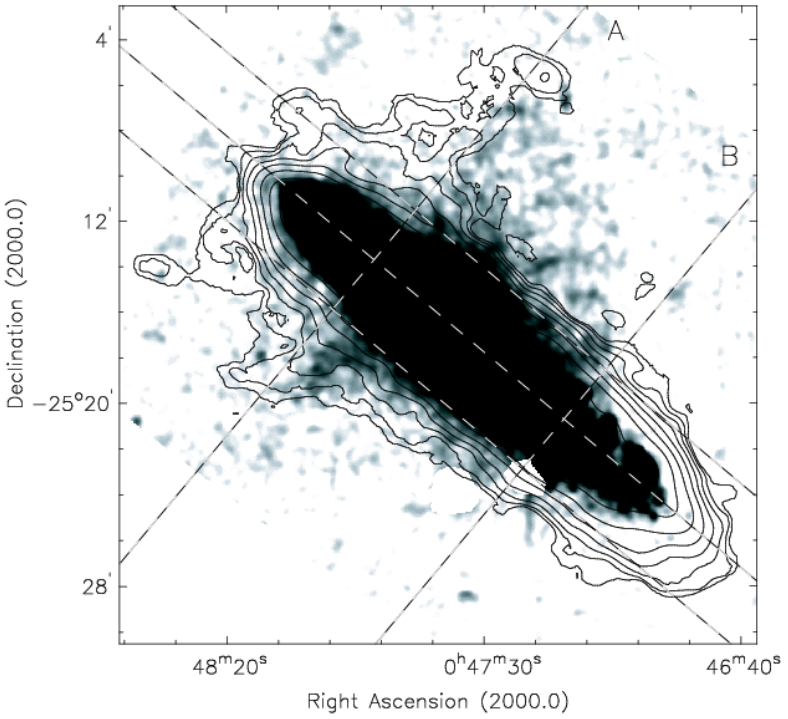
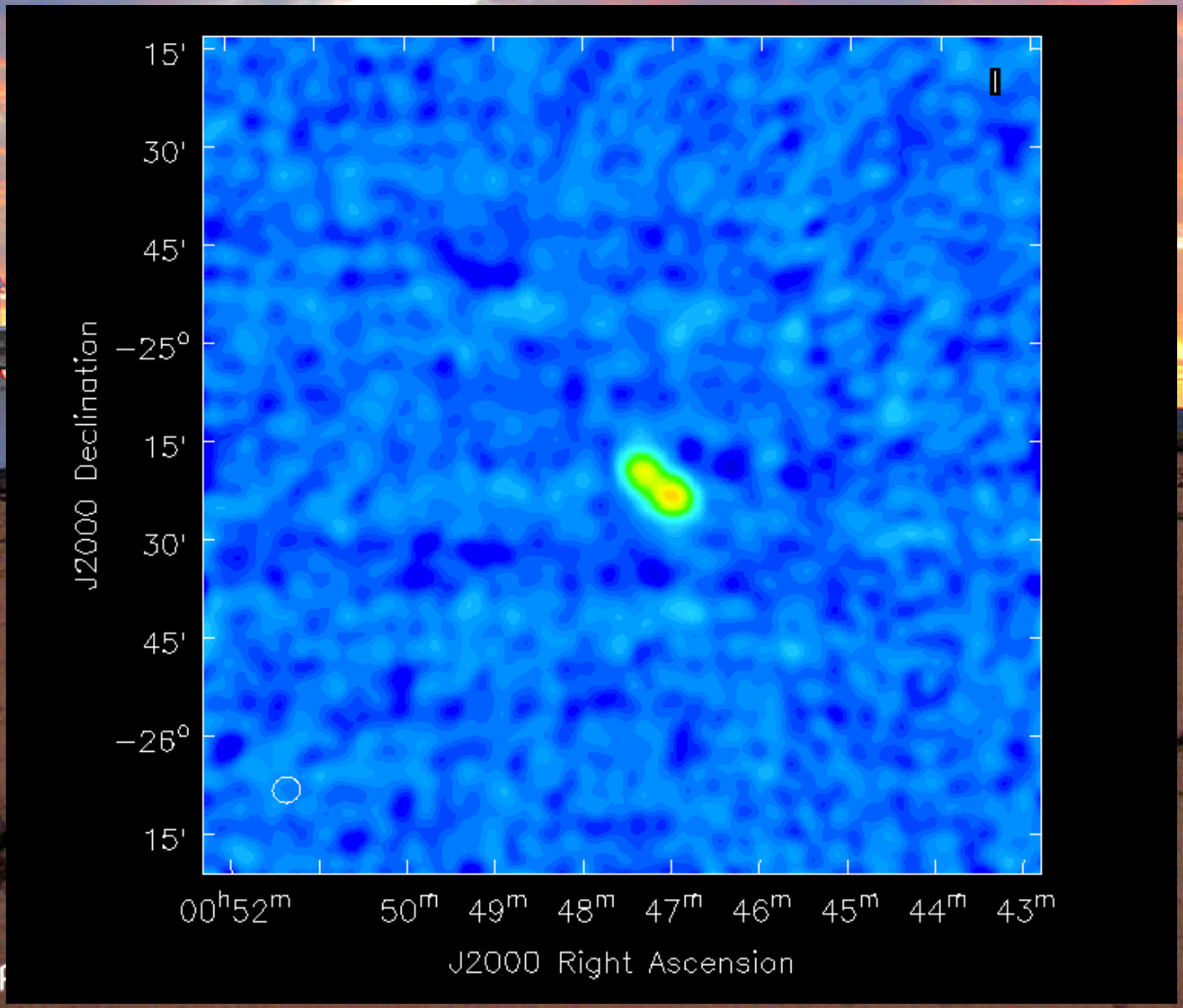


Boomsma et al. 2005: lowest contour 1.8x10^{19} cm^{-2}



KAT-7 HI Science: NGC 253



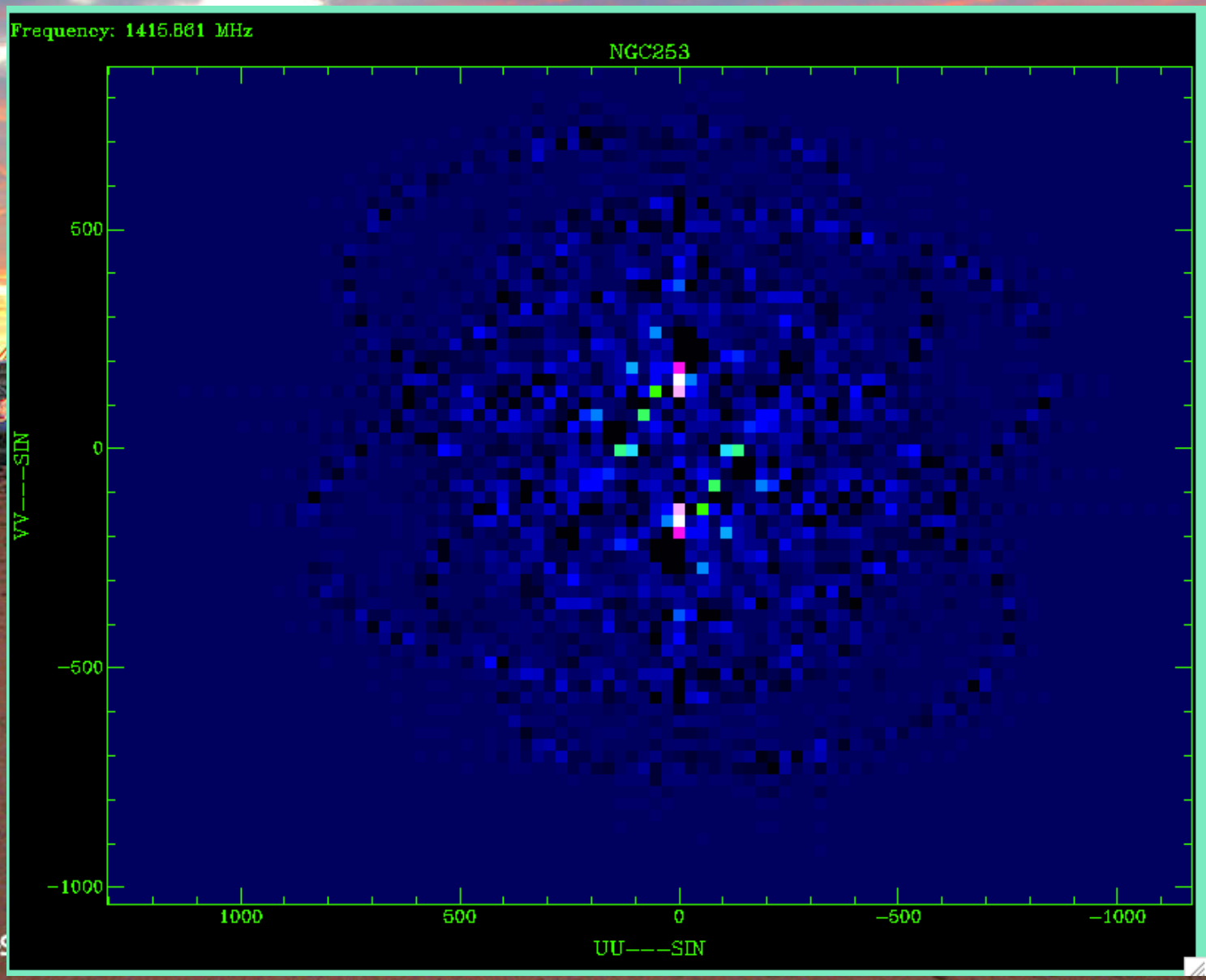
KAT-7 HI Science: NGC 253

FFT(Miriad) of dirty cube reveals U=0 RFI

AIPS task: UVNOU

No task available in CASA.

Remove data in PLOTMS



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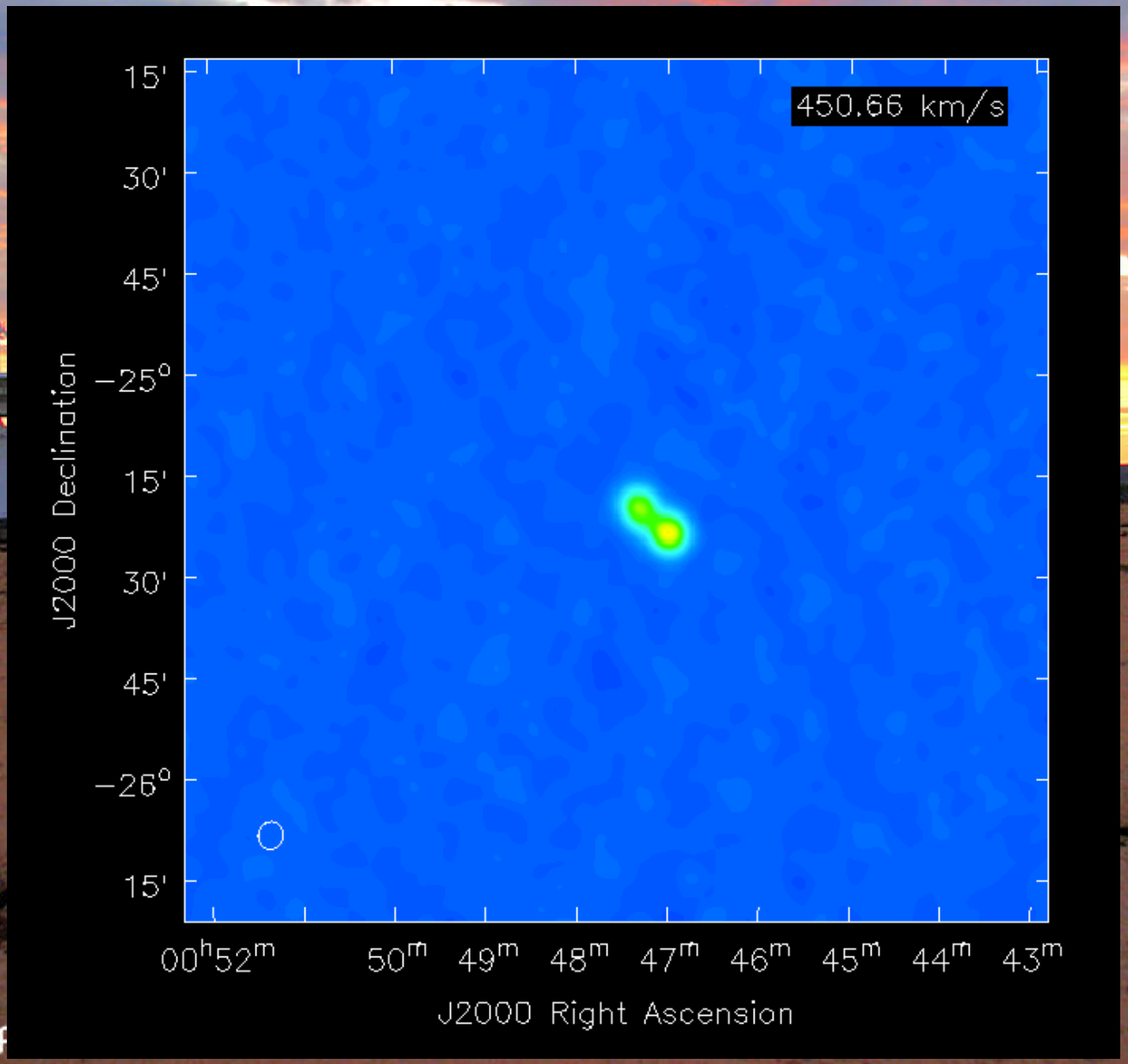

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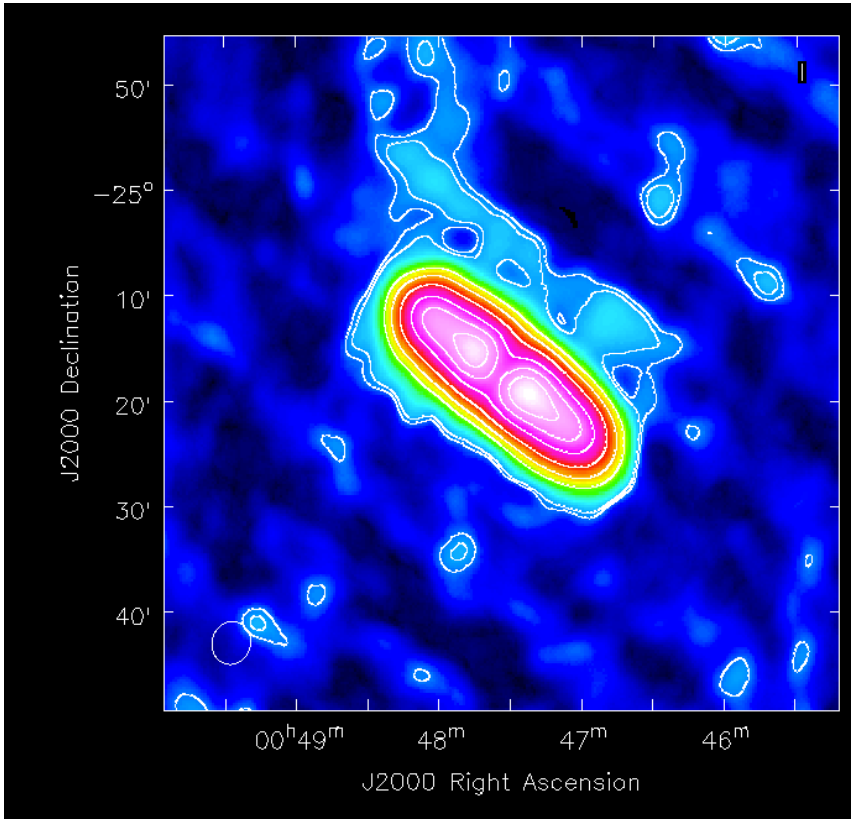
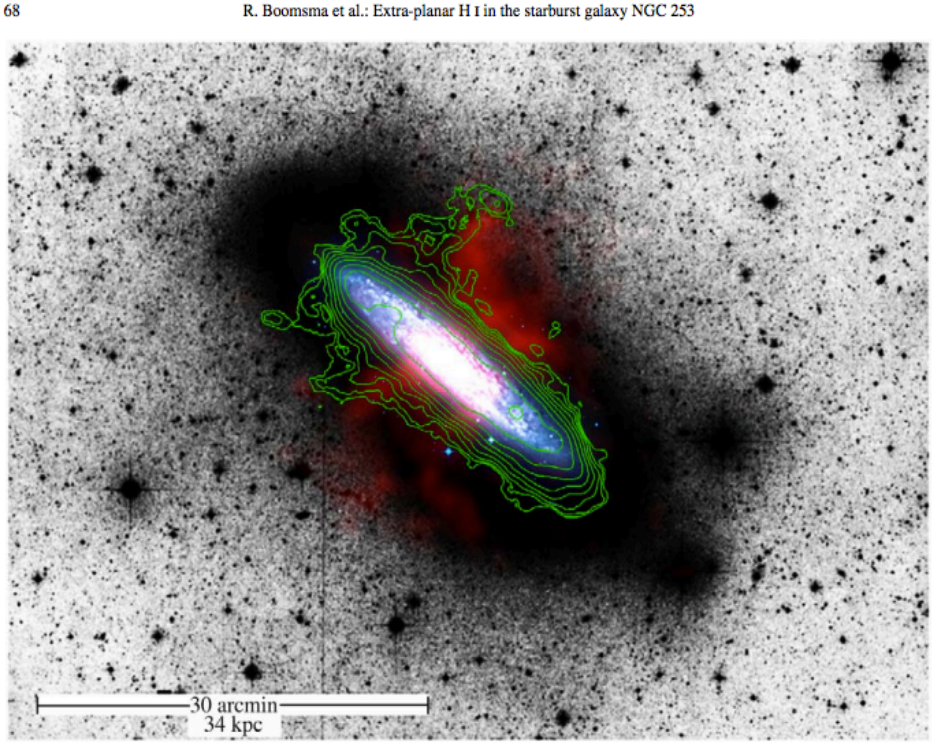
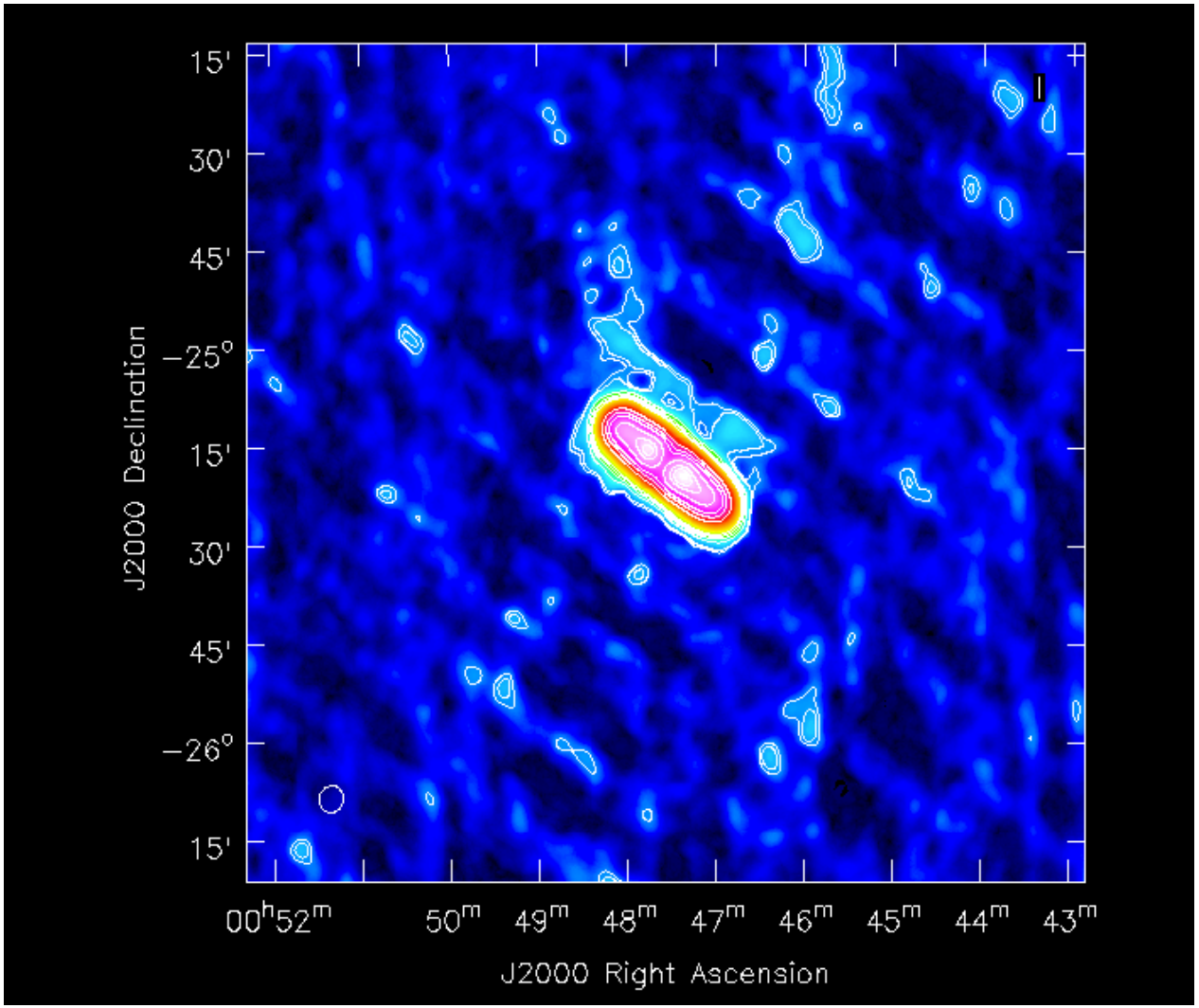




Boomsma et al. 2005

13 km/s res – N_{HI}~ few x10^{18} cm^{-2}

KAT-7 HI Science: NGC 253



- Yucky Diagonal Stripes!
- Likely a dynamic range issue due to errors in the bandpass calibration.
- More work to be done!
- Stay Tuned!

CONCLUSIONS

- KAT-7 is a niche instrument well suited to search for low surface brightness HI in nearby galaxies or extended complexes (e.g. nearby groups).
- HI Science is being produced in conjunction with commissioning of the HI modes!
- Helping to highlight issues that MeerKAT and the SKA may face.


Thank You!
We say:
ENOUGH!
STOP THE
KILLING!
#WeSayEnough

KAT-7 HI Science: M83

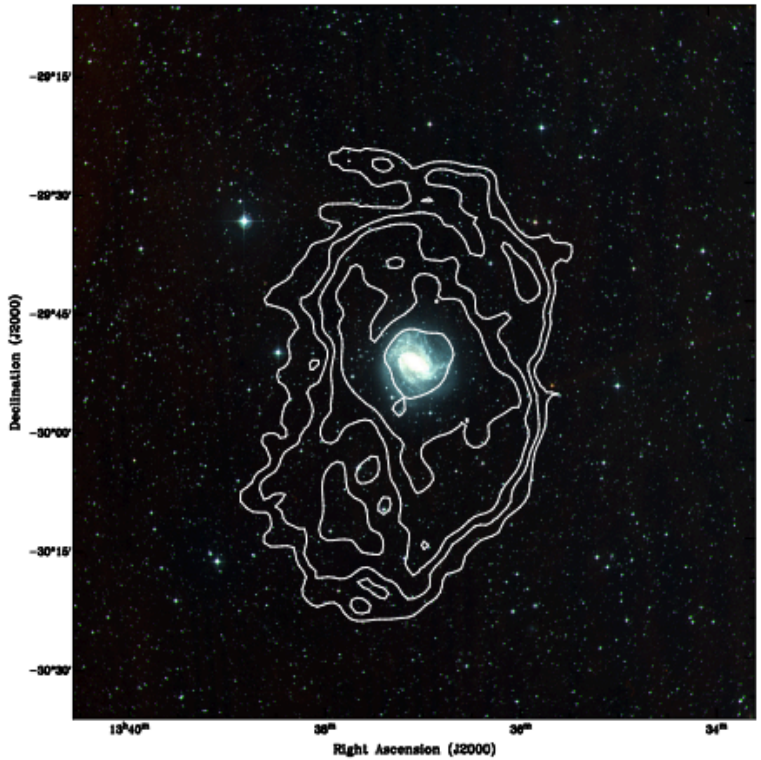
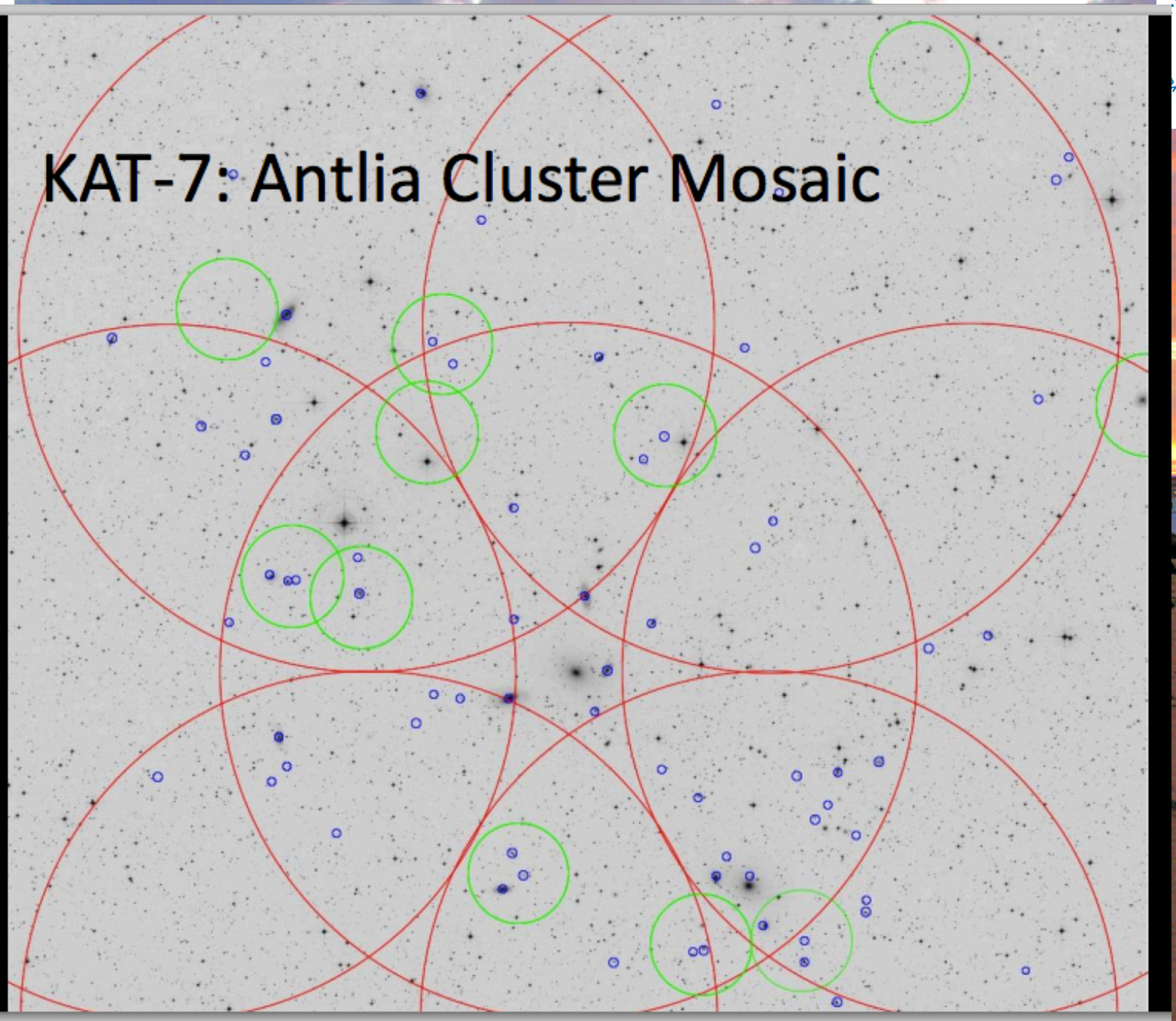


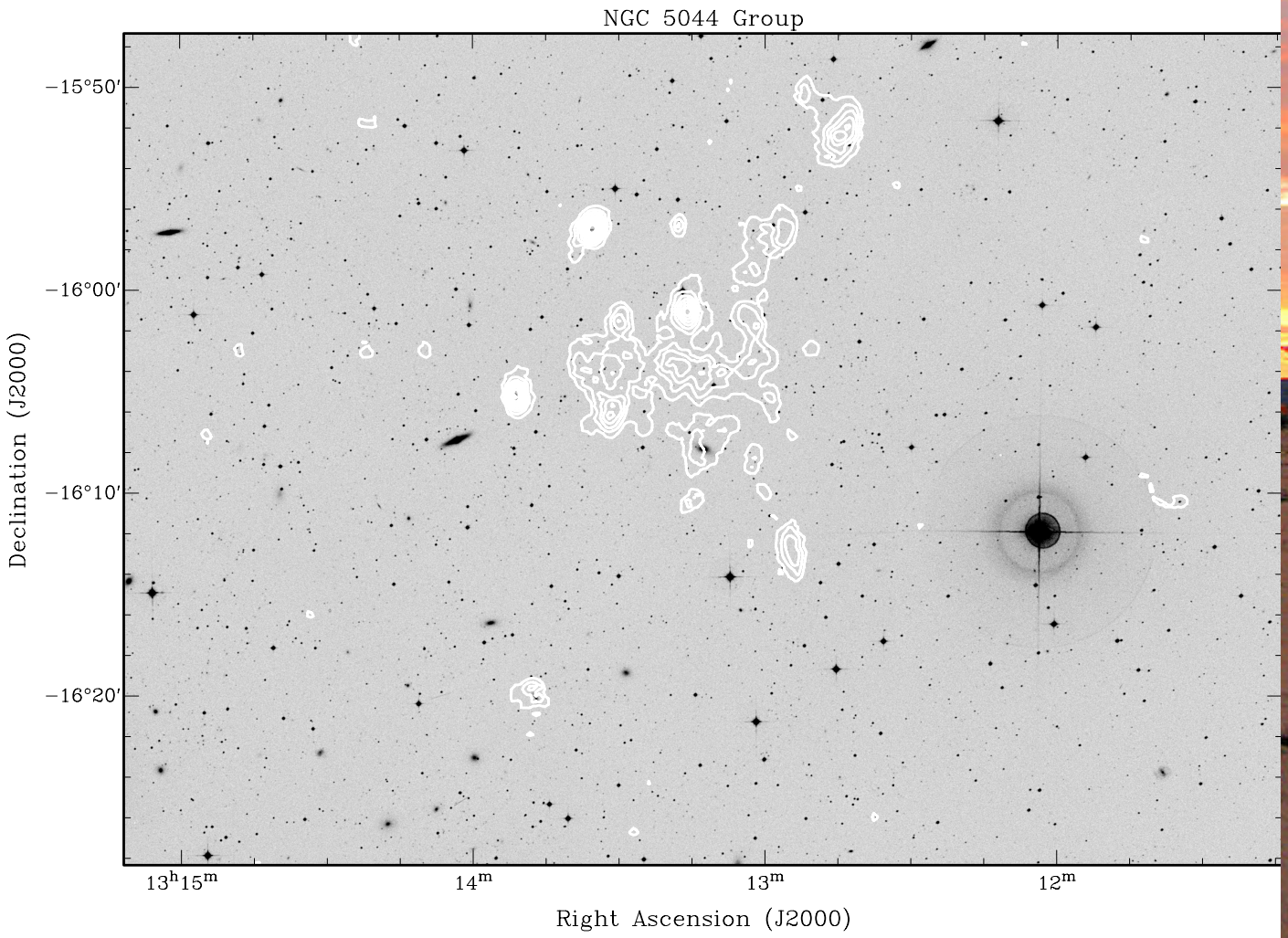
*Figure 6. Total intensity (moment-0) HI image from the M83 dataset overlaid on the DSS image. Contours start at 2 Jy/beam*km/s and increase by powers of 2. At this resolution (197x166 arcsec) the first contour corresponds to $N_{HI} = 6.8 \times 10^{19}$ cm^{-2}.*

- PIs Nadeem Oozeer; George Heald
- Observation Goals: (1) Make scientifically competitive HI map. (2) Test polarization calibration.
- 12 hour track in the 256MHz continuum mode (84 km/s channels).
- Produced HI map with sensitivity ~6x10^{19} atoms cm^{-2}.

KAT-7: Antlia Cluster Mosaic



KAT-7 HI Science: NGC 5044 Group



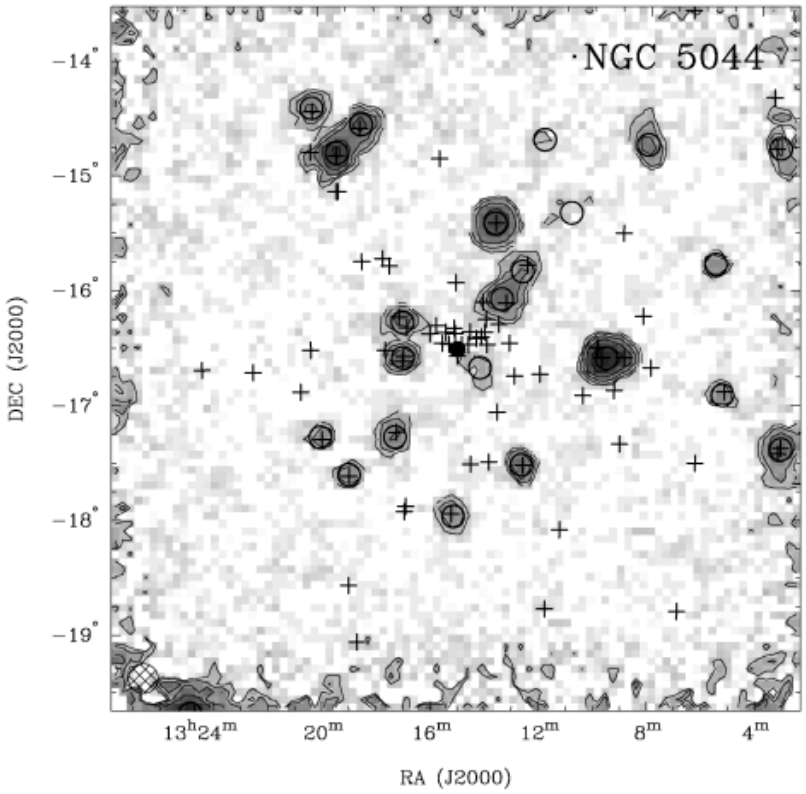
Lucero, Nyland, & Young in prep. 0.3 mJ/bm in 43 km/s chans. Lowest contour is ~1x10^{19} cm^{-2}

KAT-7 HI Science: NGC 5044 Group

- NGC 5044 is a poor group. Interesting as an evolutionary stage in mass assembly towards richer clusters.
- At a Redshift of 0.00928 (29 Mpc), it has an angular scale well suited for studies of the structure in its intra-group medium with KAT-7 (several degrees).
- Brightest X-Ray Group in the Sky.
- Deep Chandra images show the presence of several small IGM cavities in the group core, indicative of recent AGN outbursts
- HI observations with Parkes show the presence of a significant amount of HI near and around the group center.

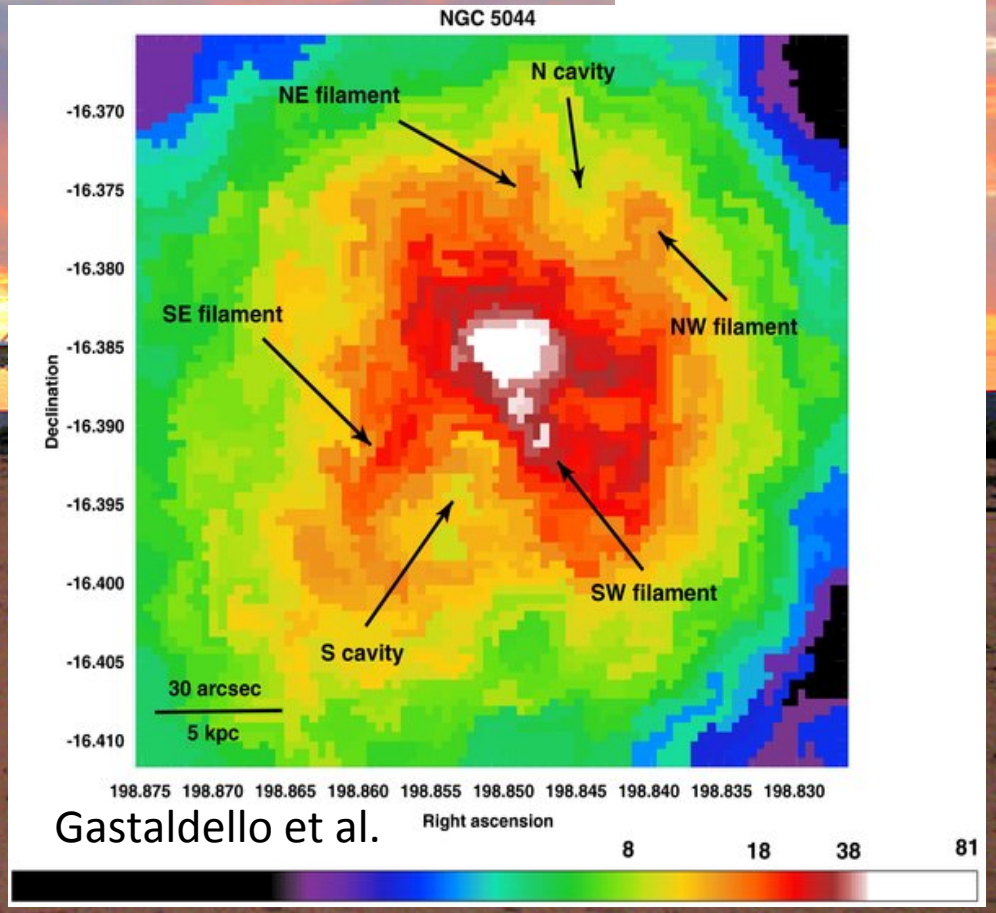
KAT-7 HI Science: NGC 5044 Group

PARKES DATA (Kilborn et al. 2009)



15.5’ beam, 13.5 km/s channels, 20 hours basket weave pattern. ~1x10^{19} cm^{-2}

Chandra DATA



Gastaldello et al.

KAT-7 HI Science: NGC 5044 Group

Project Aims:

- Make a deep HI image (120 hours) centered on the EVLA Field with KAT-7 looking for low surface density large scale HI emission.
- Commissioning: Combine EVLA field with KAT-7 data. Should produce a very sensitive HI image of the region.
- We hope to use the HI morphologies and kinematics to determine:
  - How are the group members losing their HI: tidal interactions or ram-pressure stripping?
  - What effect if any has the recent AGN outbursts had on the HI content of the group members near the group core.