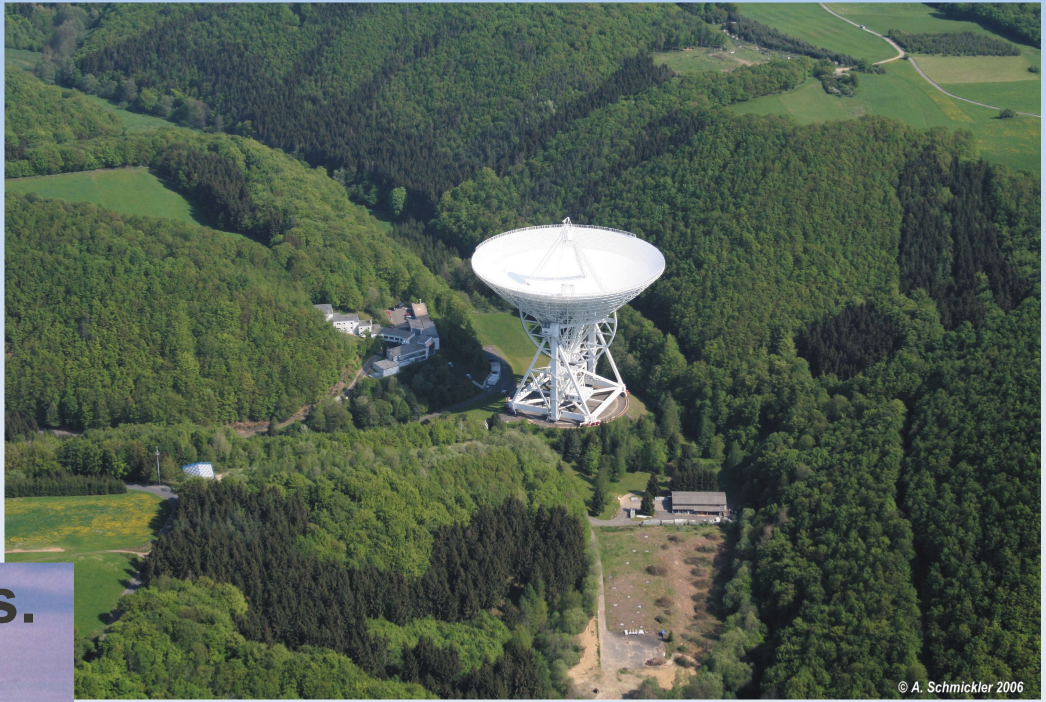
HI-mass comparison of nearby galaxies

Effelsberg 100-m radio telescope



vs.

Very Large Array

Outline

1) Motivation
   i. Short-spacing
2) Data
   i. The HI Nearby Galaxy Survey (THINGS)
   ii. Effelsberg Bonn HI Survey (EBHIS)
3) Data-reduction
4) Analysis
   i. Flux-comparison
5) Conclusion

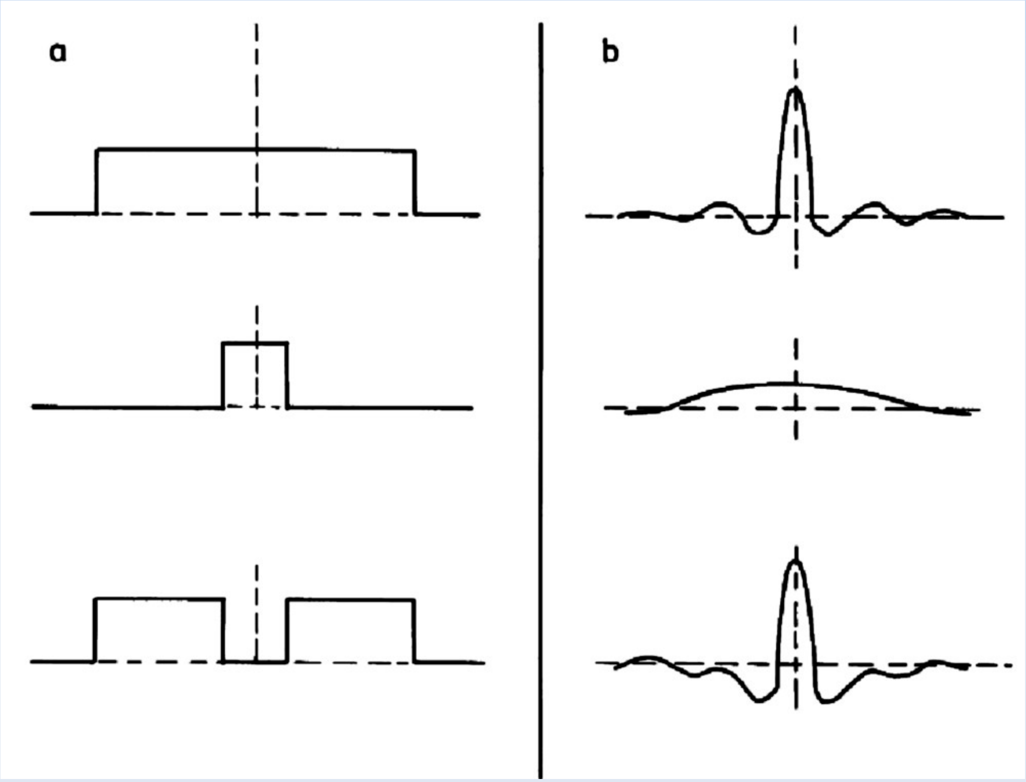
Motivation

- Interferometer
- Very Large Array
  a) Large separation between individual antennas
  b) Missing flux due to missing spacings
  c) Studying small-scale structure

- Single-dish
- Effelsberg 100-m radio telescope
  a) Limited dish size because of technical restrictions
  b) Measures the total flux
  c) Studying diffuse gas large-scale structure

Motivation
Short-spacing

- Bijective transformation between Fourier- (u, v) and spatial-domain (l, m)
- Large spatial frequencies correspond to small structures
- Limitation on the smallest separation between telescopes
  - ➔ Missing short spacings
  - ➔ Missing zero spatial-frequency
  - ➔ Missing flux



a) Spatial-frequency-domain

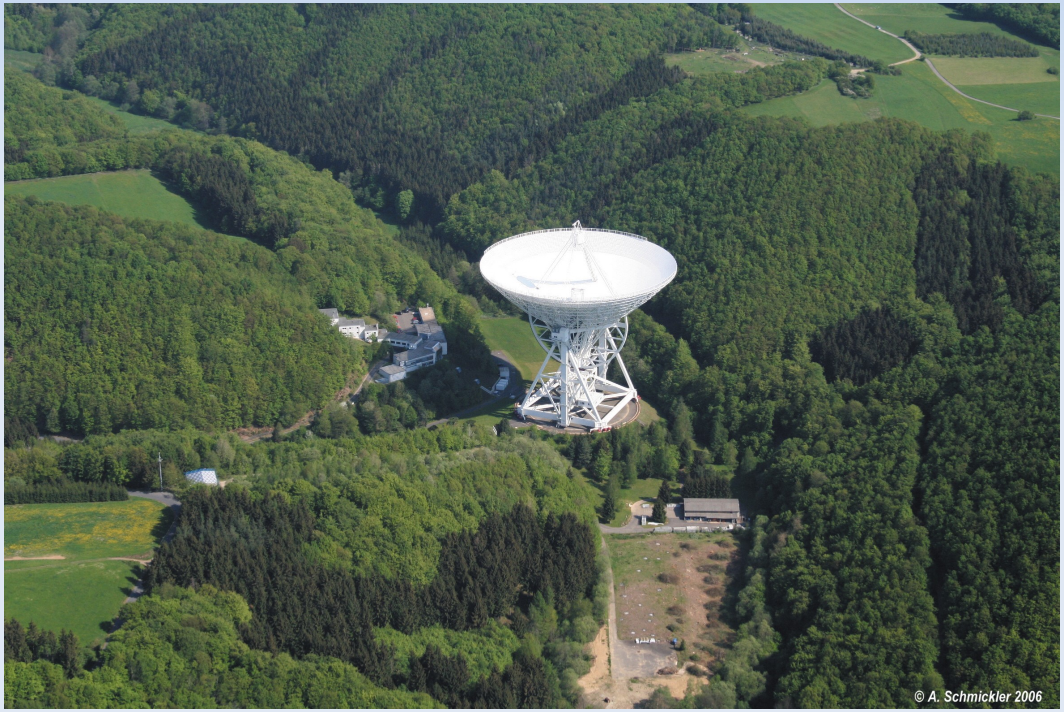
b) Spatial-domain

Data

”The HI Nearby Galaxy Survey (THINGS)”

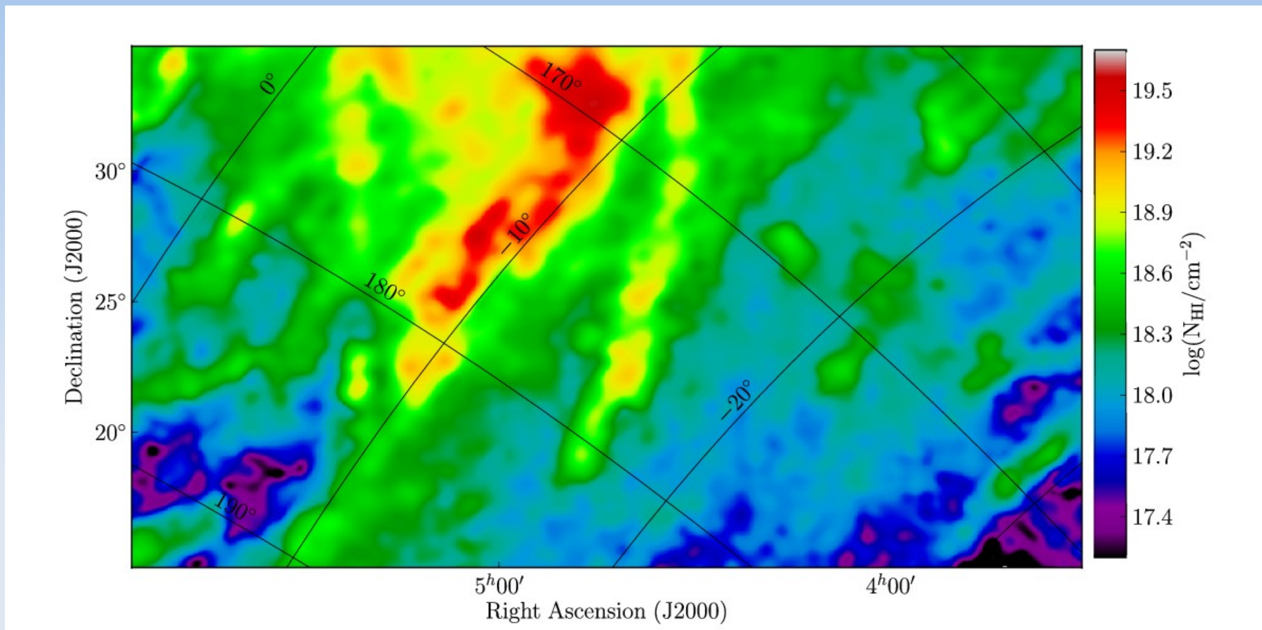
- Walter et. al (2008)
- Performed with the VLA
- Observing 34 nearby (2-15 Mpc) galaxies
- Resolution of 6'' (500 pc) and 5.2 km s^{-1} respectively
- Combining data from B-,C- and D-configurations, 11h in total per source
- Publications on rotation curves (de Blok et al. 2008), star-formation (Leroy et al. 2008) and non-circular motions (Trachternach et al. 2008)

Data
”Effelsberg Bonn HI Survey (EBHIS)”

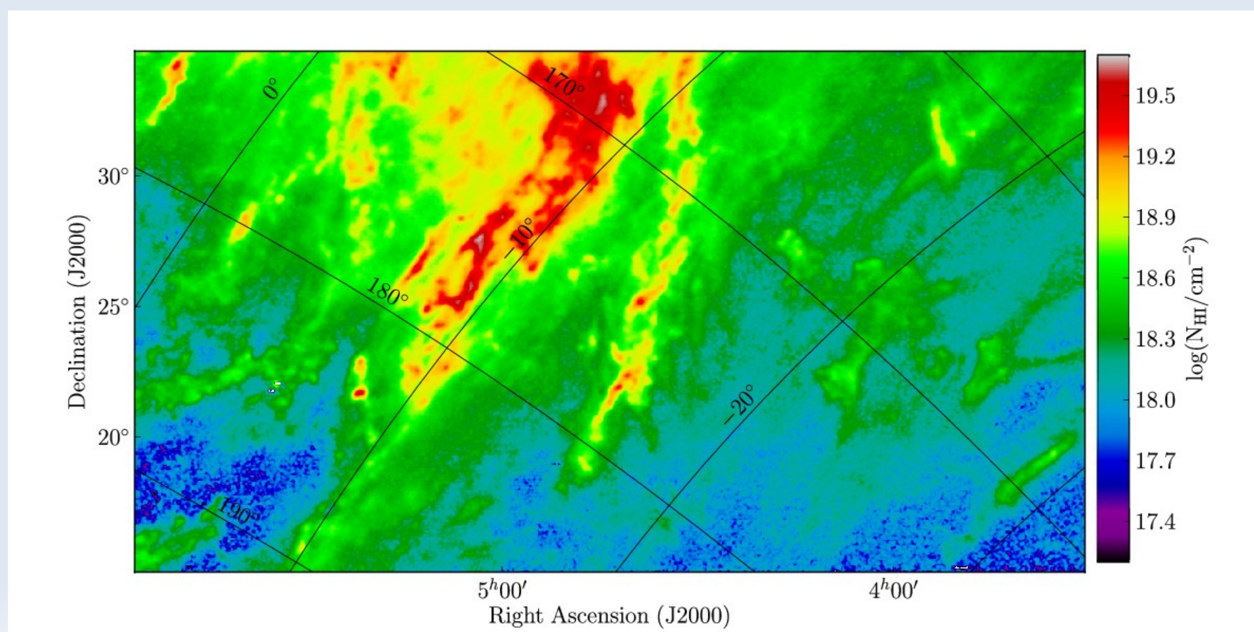


- Full-sky survey of the northern hemisphere (> -5˚)
- Covers the Milky Way HI gas and in parallel the extragalactic sky out to a distance of 270 Mpc (z = 0.07)
- Resolution of 10.5' and 2.1 km s^{-1} respectively
- 15 out of the 34 THINGS galaxies have been observed so far

Data
EBHIS/LAB



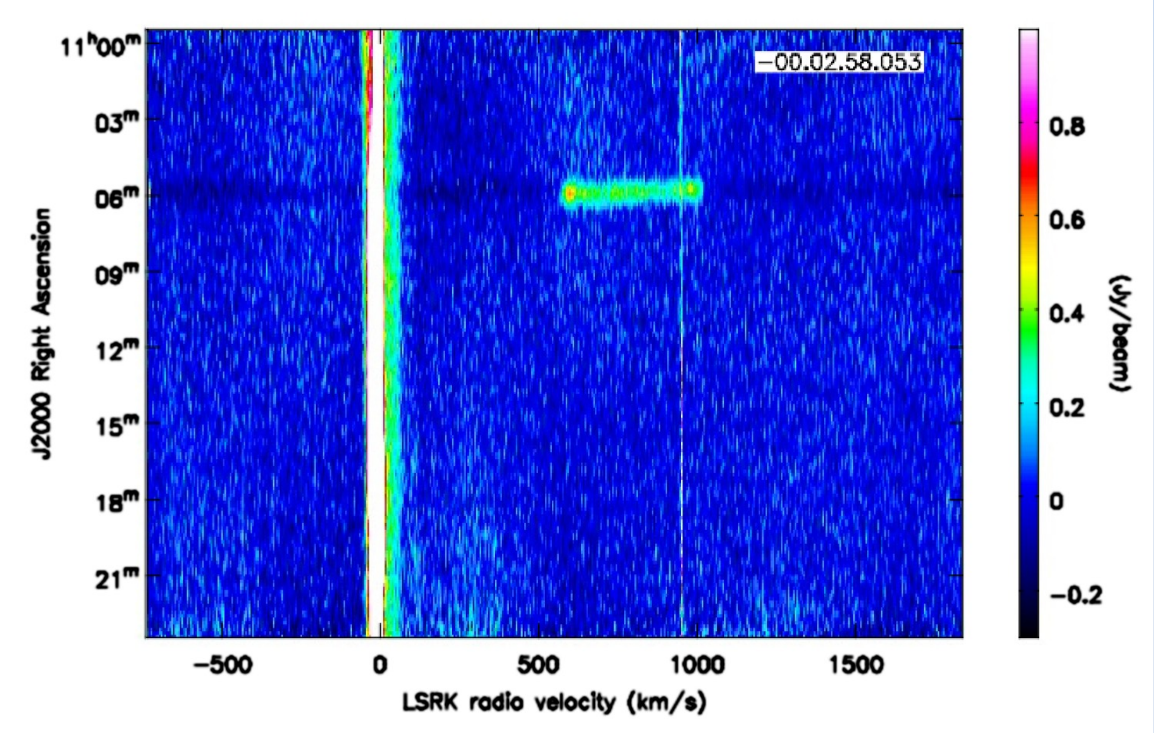
Leiden/Argentine/Bonn (LAB) HI Survey
Spatial res.: 30′



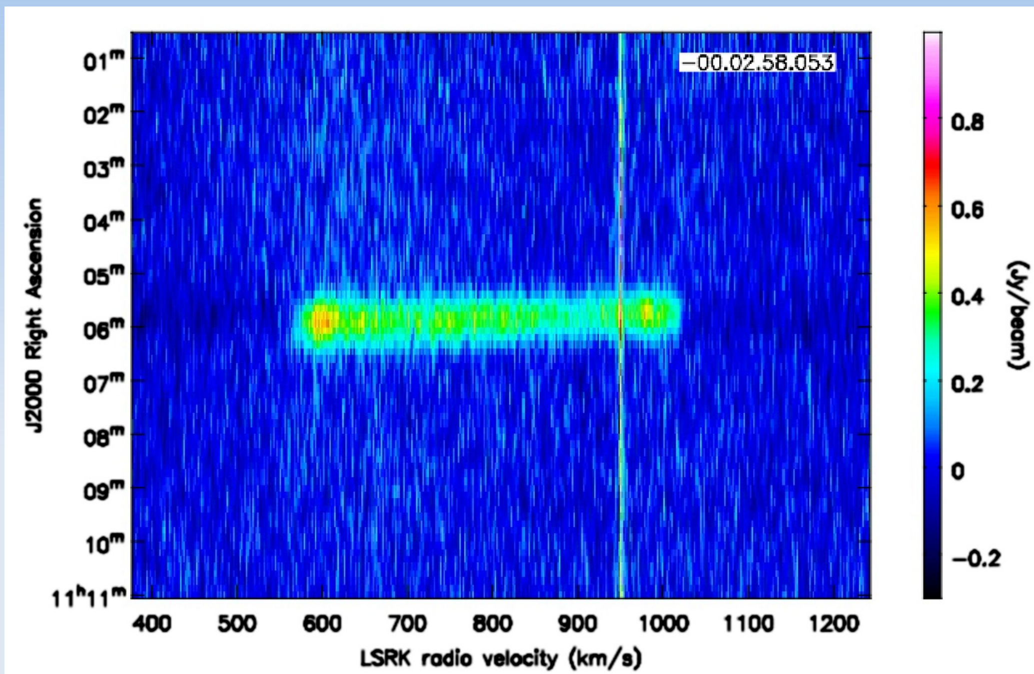
Effelsberg Bonn HI Survey (EBHIS)
Spatial res.: 10.5′

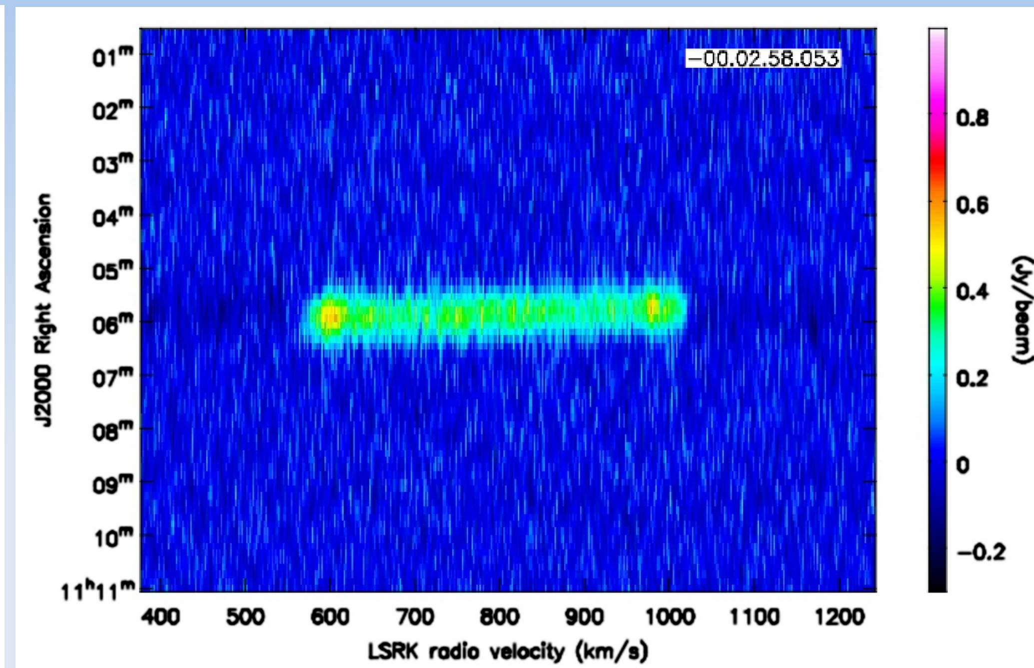
Data reduction
Entire cube

- 5° x 5°-map as produced by standard-EBHIS data reduction
- Different systematics that require further work with the data
  i. MW-emission
  ii. Narrowband-RFI
  iii. Missing flux in spectral direction due to standing wave-correction
  iv. Sinusodial-pattern in RA-direction because of standing waves, varying in phase



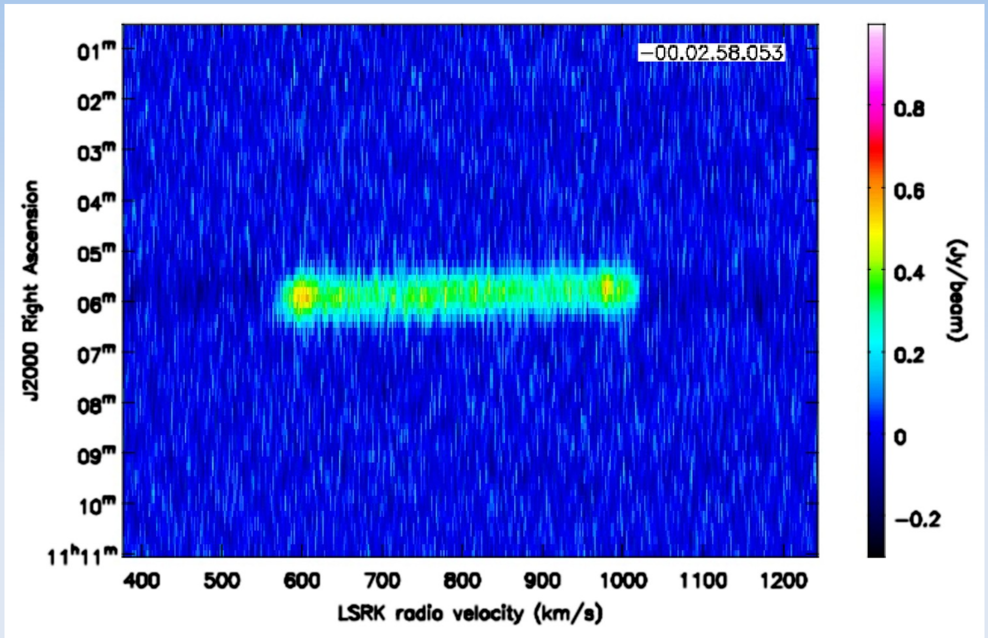
Data reduction
Position fit

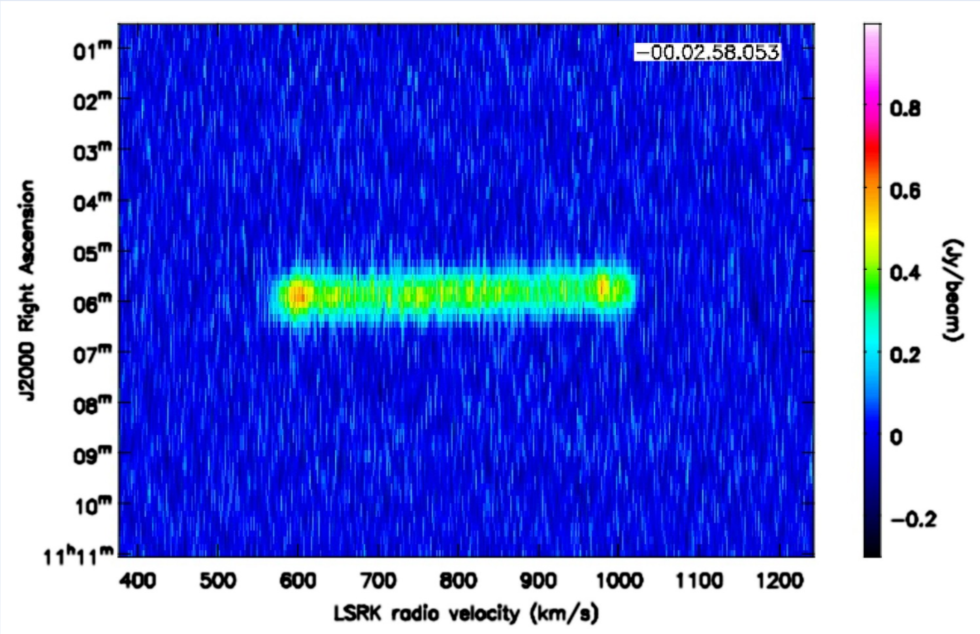




- Applying 2nd order polynomial in RA-direction to remove RFI and standing waves
- Exclude source, MW-emission and other physical objects

Data reduction
Spectral fit

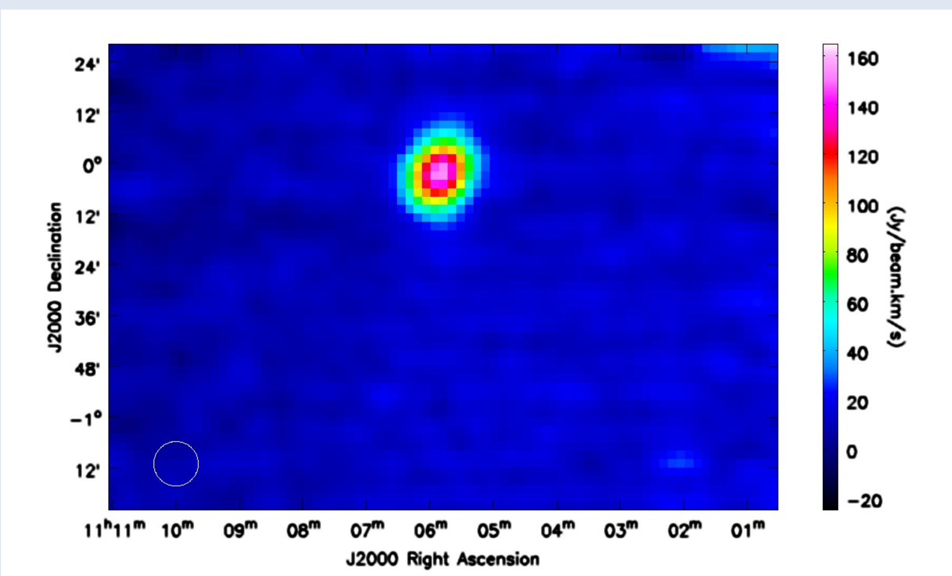


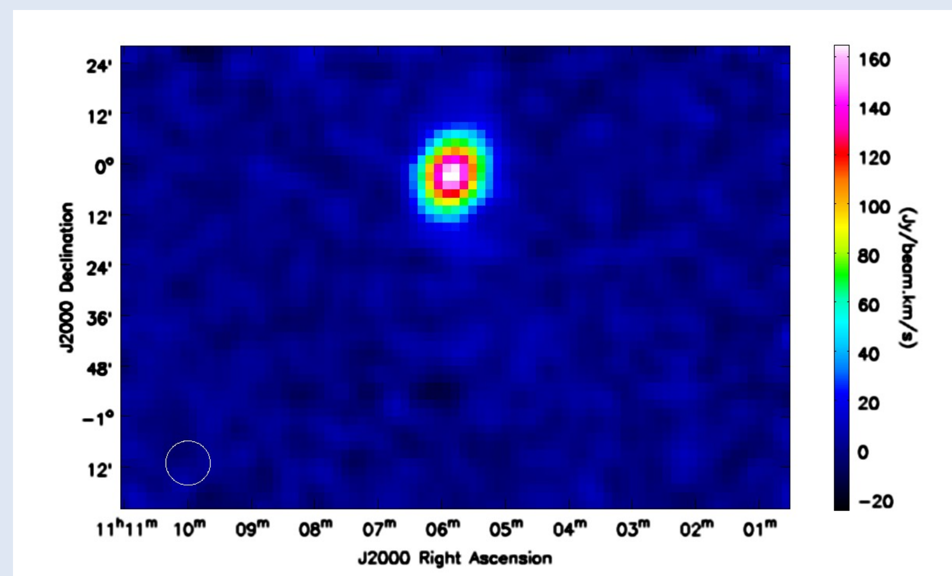


- Fitting 1st order polynomial in spectral direction
- Accurate continuum modelling

Data reduction
Moment-0-map / Flux determination

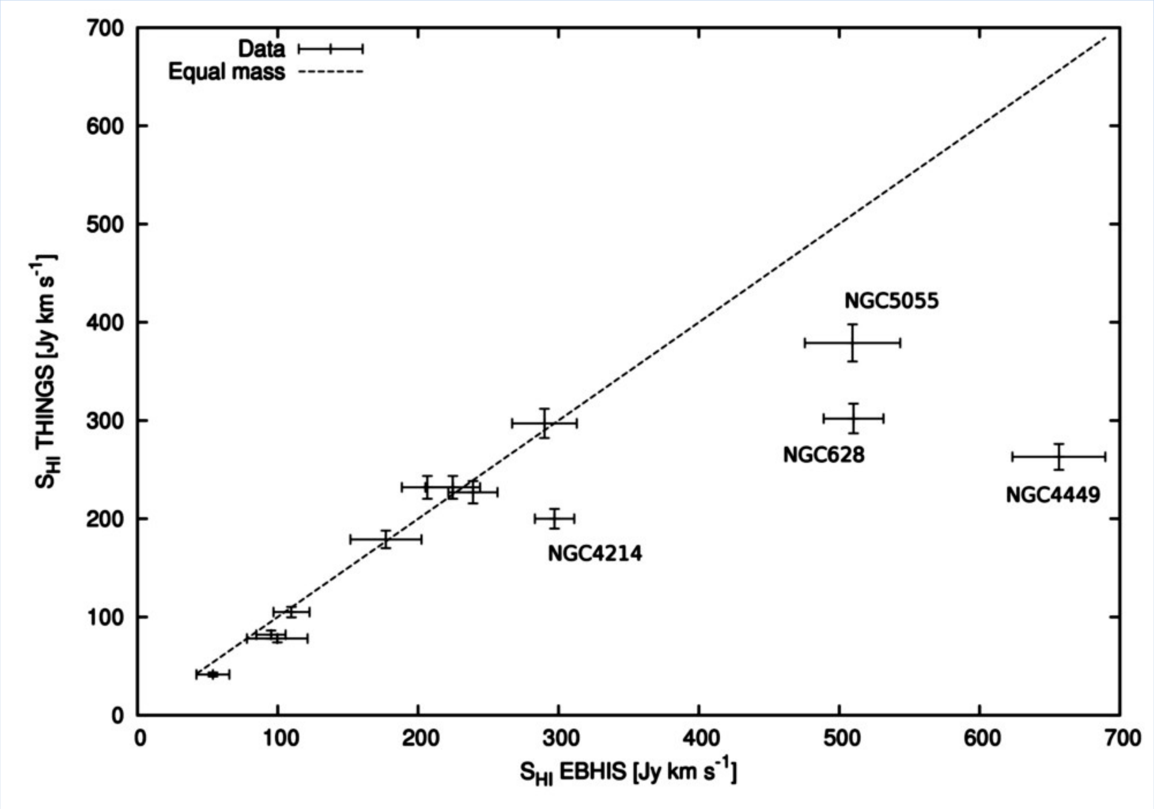
- Summarizing over velocity channels
- Major quality increase
- Very homogenous noise
- Flux-gain about 10% - 30%
- Flux determination on basis of moment-0-maps



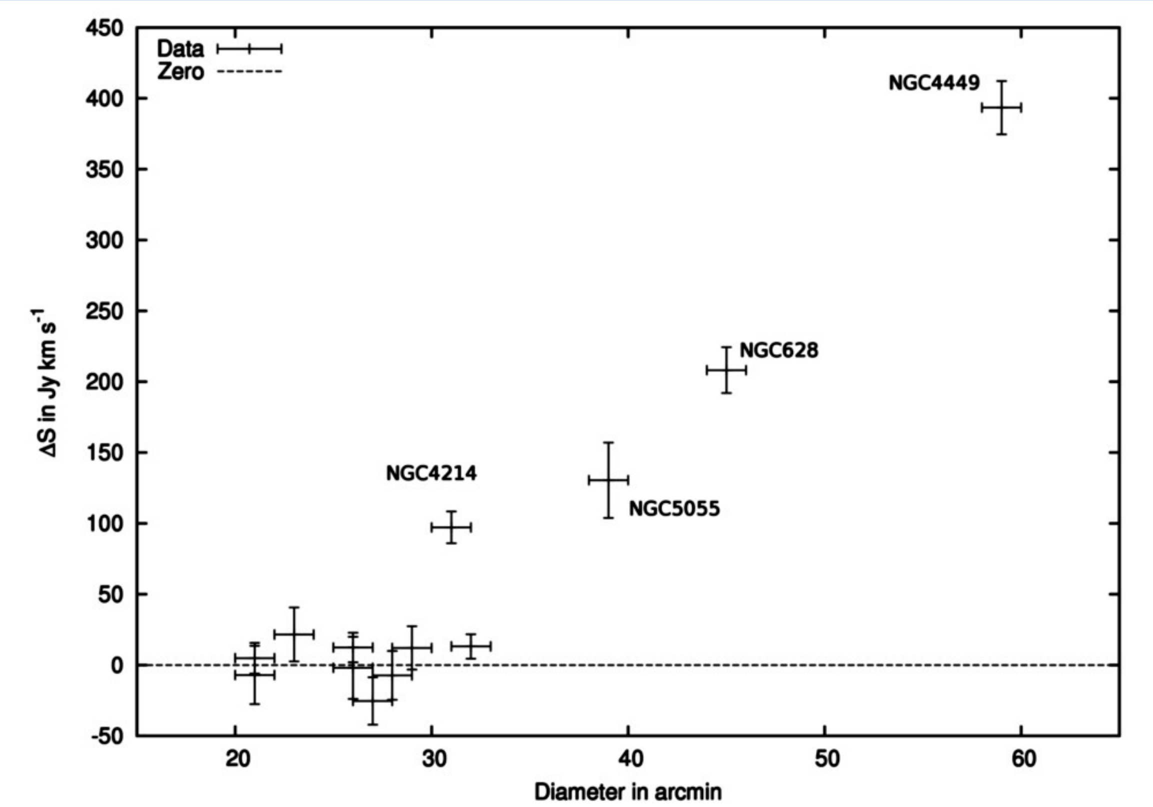


Analysis
Flux comparison EBHIS/THINGS

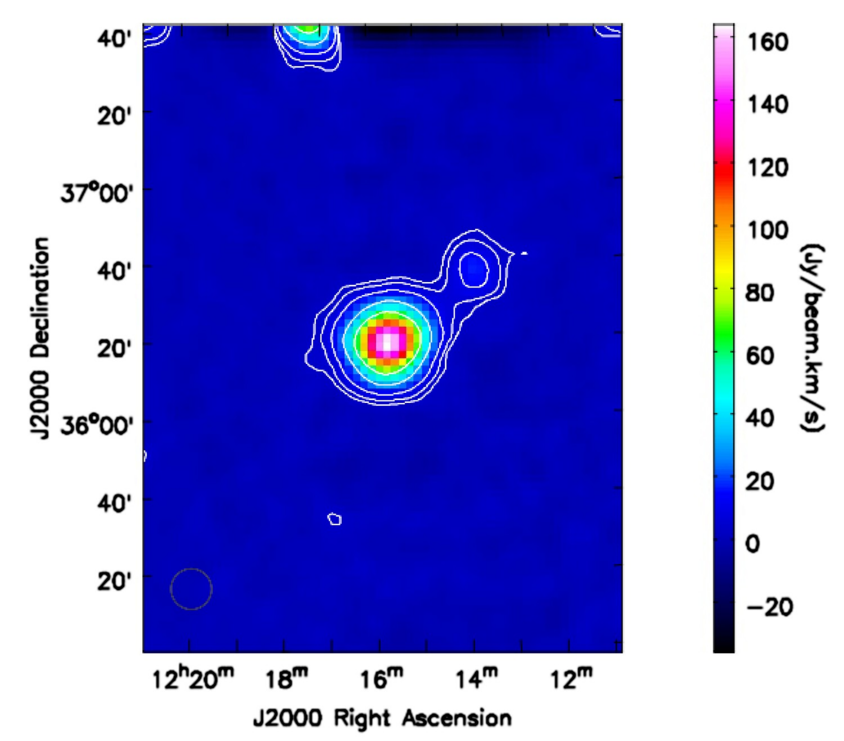
- 1:1-correlation for most of the sources
- Deviations towards brighter, more extended sources
- Partially more extended than VLA-beam (30'), but this effect does not contribute more than a few percent



Analysis
Flux vs. diameter



- Dependence on diameter clearly visible
- NGC4214 lies fully within the VLA beam, but reveals significantly higher flux in single-dish observations



Conclusion

- Investigations necessary due to missing short-spacing flux
- Data reduction on top of the standard-EBHIS-data-reduction offers access to high-quality moment-0-maps
- Flux can be reproduced and deviations towards brighter and more extended sources can be explained with missing short-spacings

Appendix
Outlook

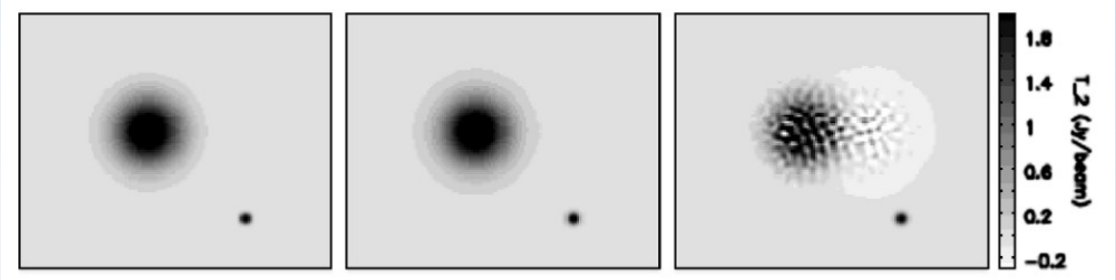
- Another 16 sources will be observed within EBHIS, offering better statistics and more information on short-spacing
- Using a Monte-Carlo approach to investigate systematic errors
- Combining single-dish and interferometer-data in order to produce high-quality data (e.g. with the WSRT)

Appendix
Uncertainties

- Statistical
  - Using number of pixels and noise to determine the statistical fluctuations
- Systematical
  - Observational (e.g. standing waves)
  - Data reduction (e.g. incorrect fitting due to strong continuum emission)
  - Dependence on choice of the polygon
  - Calibration (~3%)

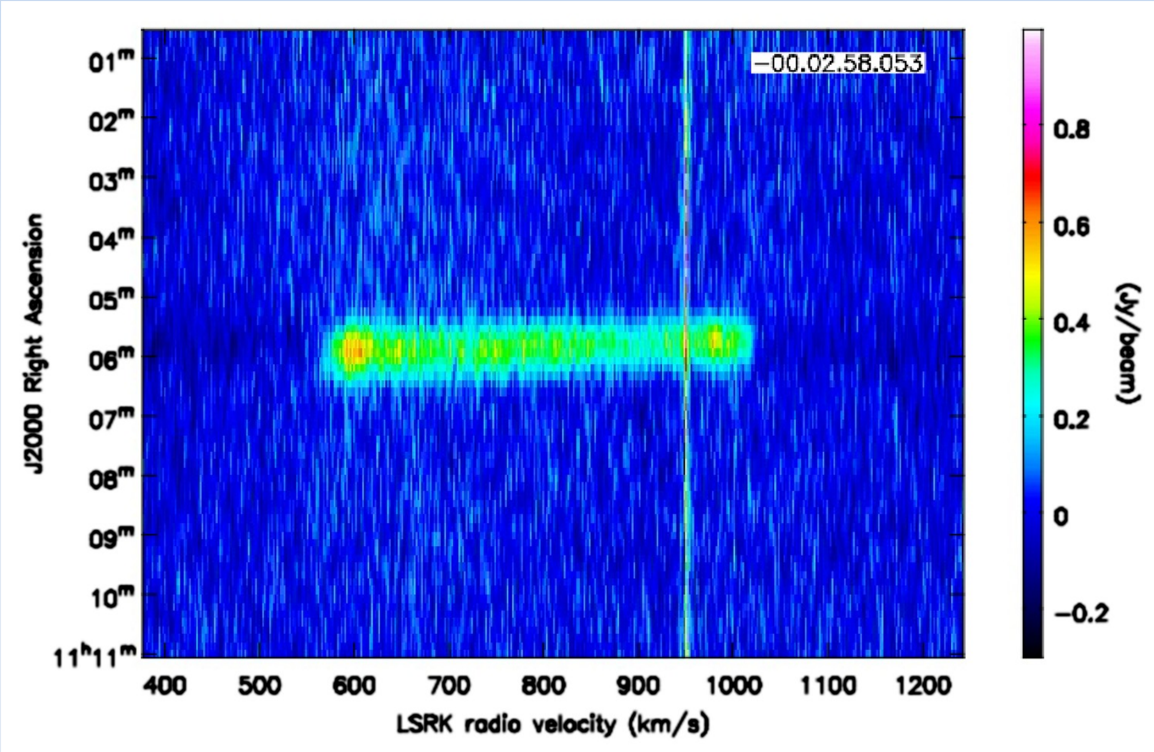
Appendix
Cleaning

- THINGS uses classic AIPS algorithm
- Improvements to this algorithm have been suggested by Rich et al. (2008) (multi-scale cleaning) and by Rau & Cornwell (2011) (multi-scale multi-frequency cleaning)
- No information on cleaning-errors given in the THINGS publications
- Papers by Rich et al. and Rau & Cornwell indicate atleast the same order of magnitude as the calibration error (5%)



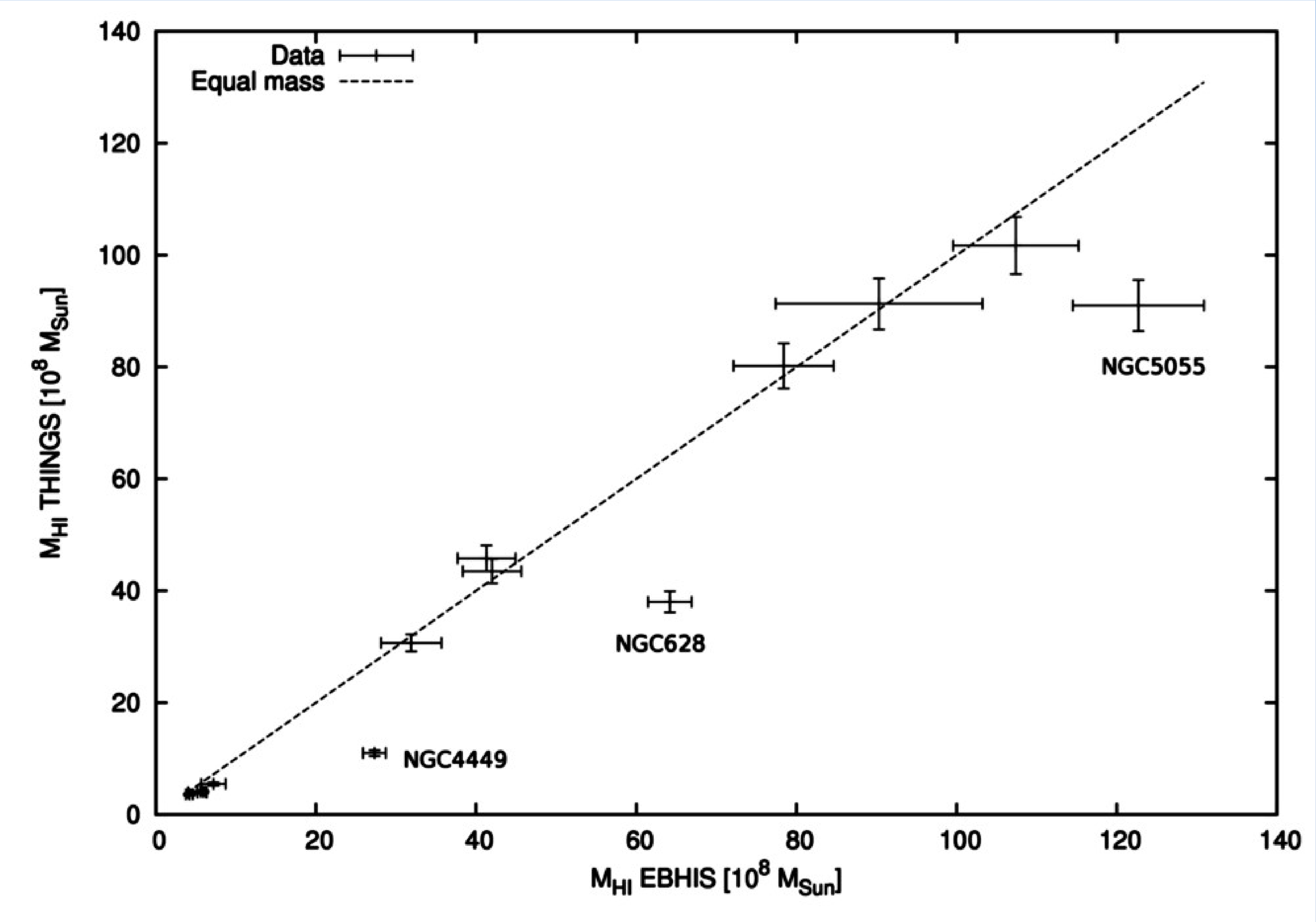
True image | Multi-scale clean | Classic clean

Appendix
Subcube



- Subcube for easier and faster data reduction
- Reduces most systematics to linear scales

Appendix
Mass comparison



Appendix

Results

Galaxie	S_{THINGS} in Jy km s^{-1}	S_{EBHIS} in Jy km s^{-1}	$S_{\text{Fisher\&Tully}}$ in Jy km s^{-1}	M_{THINGS} in $10^8 M_\odot$	M_{EBHIS} in $10^8 M_\odot$	Abstand D in Mpc	Durchmesser in Bogenmin.
DDO154	82,1	$95,2 \pm 7,6$	$74,1 \pm 4,7$	3,6	$4,2 \pm 0,3$	4,3	32 / 3,0
NGC2903	232	225 ± 13	186 ± 10	43,5	$42,0 \pm 2,4$	8,9	28 / 12,6
NGC3184	105	110 ± 10	126 ± 6	30,7	$31,9 \pm 2,8$	11,1	21 / 7,4
NGC3198	227	239 ± 10	206 ± 12	102	107 ± 5	13,8	29 / 8,5
NGC3351*	50,1	$63,7 \pm 12,8$	–	11,9	$15,3 \pm 3,1$	10,1	16 / 3,1
NGC3521	297	290 ± 14	281 ± 40	80,2	$78,4 \pm 3,9$	10,7	21 / 11
NGC3627*	40,6	$27,4 \pm 17,5$	$60,6 \pm 5,1$	8,2	$5,6 \pm 3,6$	9,3	9 / 9,1
NGC4214	200	297 ± 5	–	4,1	$5,9 \pm 0,1$	2,9	31 / 8,5
NGC4449+	263	656 ± 14	–	11,0	$27,3 \pm 0,6$	4,2	59 / 6,2
NGC4736	78,1	$99,7 \pm 18,7$	$59,9 \pm 7,0$	4,0	$5,2 \pm 1,0$	4,7	23 / 11,2
NGC4826	41,5	$53,8 \pm 10,1$	$56,3 \pm 15$	5,5	$7,2 \pm 1,3$	7,5	26 / 10,0
NGC5055+	379	510 ± 19	372 ± 18	91,0	123 ± 5	10,1	39 / 12,6
NGC628+	302	510 ± 6	381 ± 17	38,0	$64,2 \pm 0,8$	7,3	45 / 10,5
NGC7331	179	177 ± 20	218 ± 27	91,3	$90,3 \pm 10,2$	14,7	26 / 10,5
NGC925	232	207 ± 12	301 ± 14	45,8	$41,3 \pm 2,4$	9,2	27 / 10,5