

Mid-Frequency SKA: Proposed Implementation Roadmap, Pt I

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Implementation of SKA-mid: the road to 10^9 HI galaxies

- A Key Science Project for full SKA: a billion HI galaxies to $z=1.5$ (and beyond)
- How do we get from "here" to "there"?
- Where is "here"?
- What would be scientifically useful, and fundable, steps between "here" and "there"? Timescale?

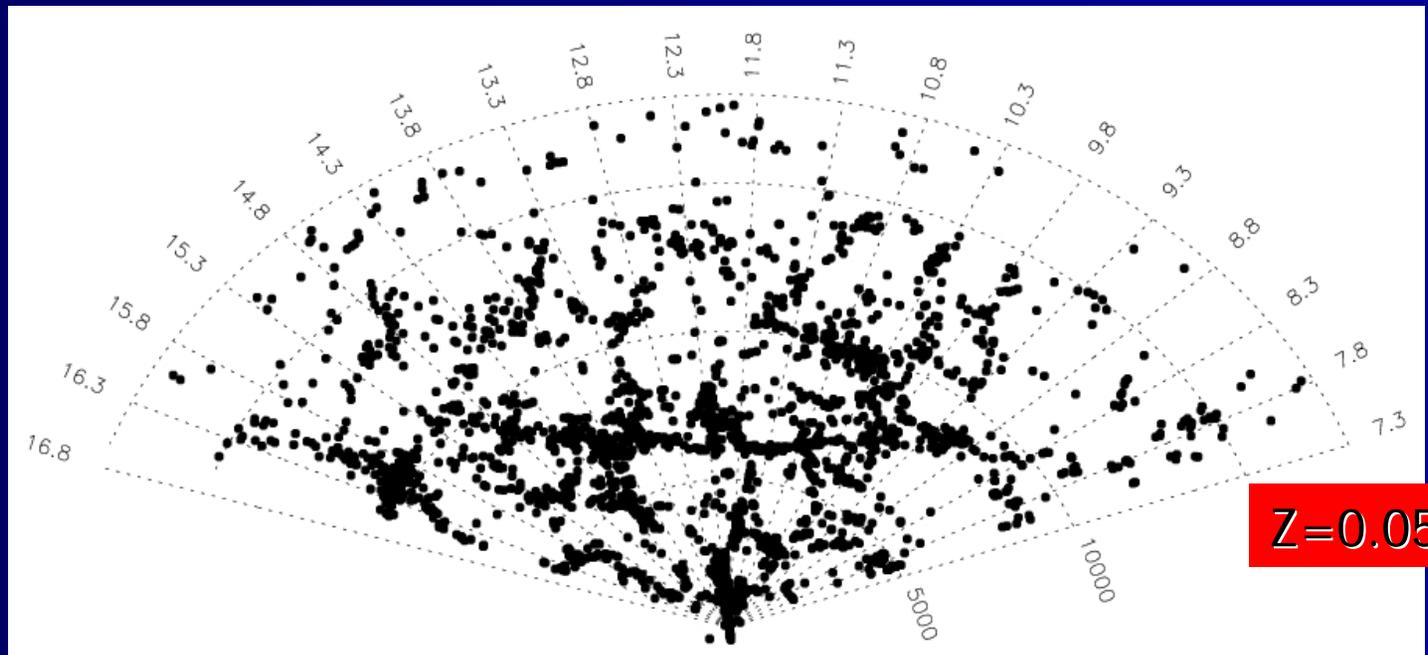
HI surveys – the past

- HI Parkes All Sky Survey - HIPASS
(2004; Meyer, Zwaan et al.)
 - All southern hemisphere, plus northern extension to Dec = +25 deg
 - 5300 galaxies over 70% of sky
 - sensitivity 13 mJy per 15 arcmin beam, at 18 km/s velocity resolution
 - 64 MHz BW, -1280 – 12,700 km/s
 - 280 galaxies with $\log M_{\text{HI}} < 8.5$ in south

HI surveys – the present

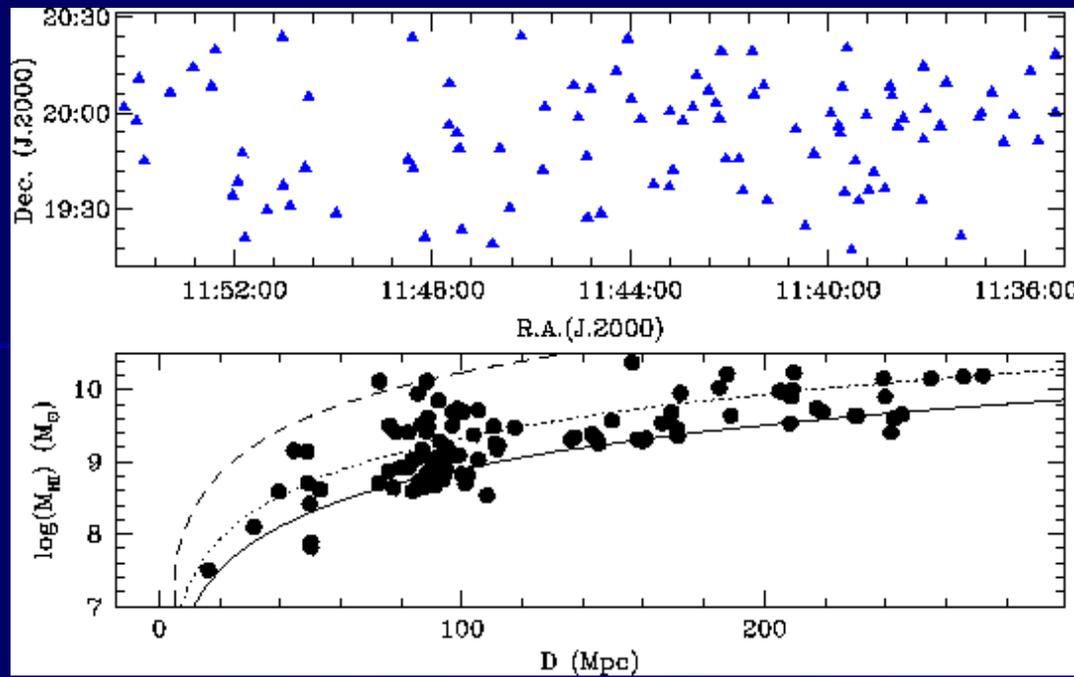
- Arecibo Legacy Fast ALFA Survey - ALFALFA (Giovanelli et al.)
 - Ongoing, planned 7000 deg² of high-galactic latitude Arecibo sky
 - ~2.2 mJy per 3.5 arcmin beam, at 10 km/s velocity resolution
 - 100 MHz BW, -1600 – 18,000 km/s (+ new broad-band spectrometer?)
 - 25,000 expected detections in ~6 years, to $z=0.06$, hundreds with $\log M_{\text{HI}} < 7.5$.

Wedge plot of 2700 HI sources detected with ALFALFA (with 7.5% of survey)



HI surveys – the present (cont.)

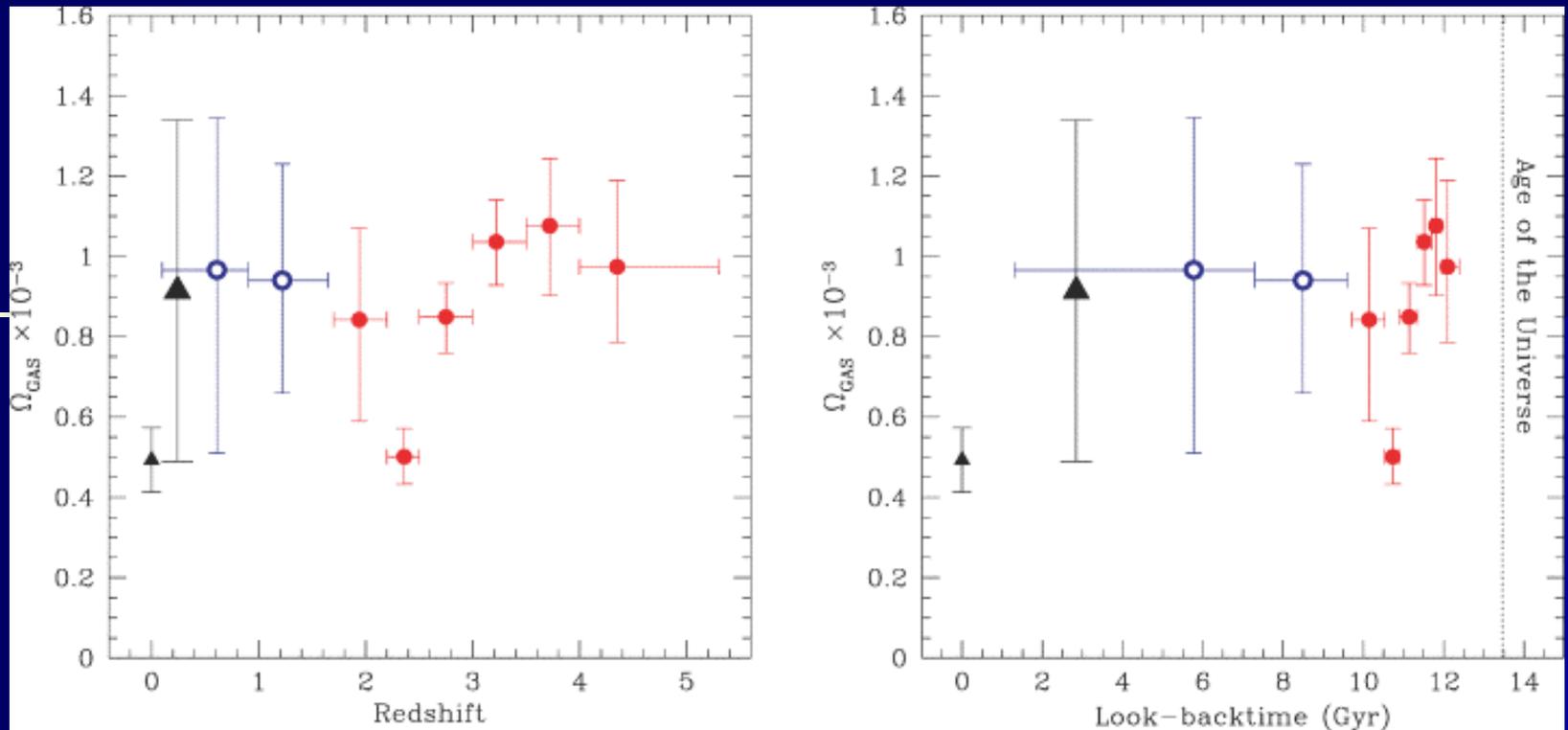
- Arecibo Galaxies Environment Survey - AGES (Davies et al.)
 - Ongoing, planned 200 deg² total on 13 selected areas (Virgo, groups, individual gals, filaments, Local Void)
 - ~0.8 mJy per 3.5 arcmin beam (300 vs. 40 sec per beam), at 10 km/s velocity resolution
 - Will find low-mass galaxies to larger distances, but not as large-angle survey



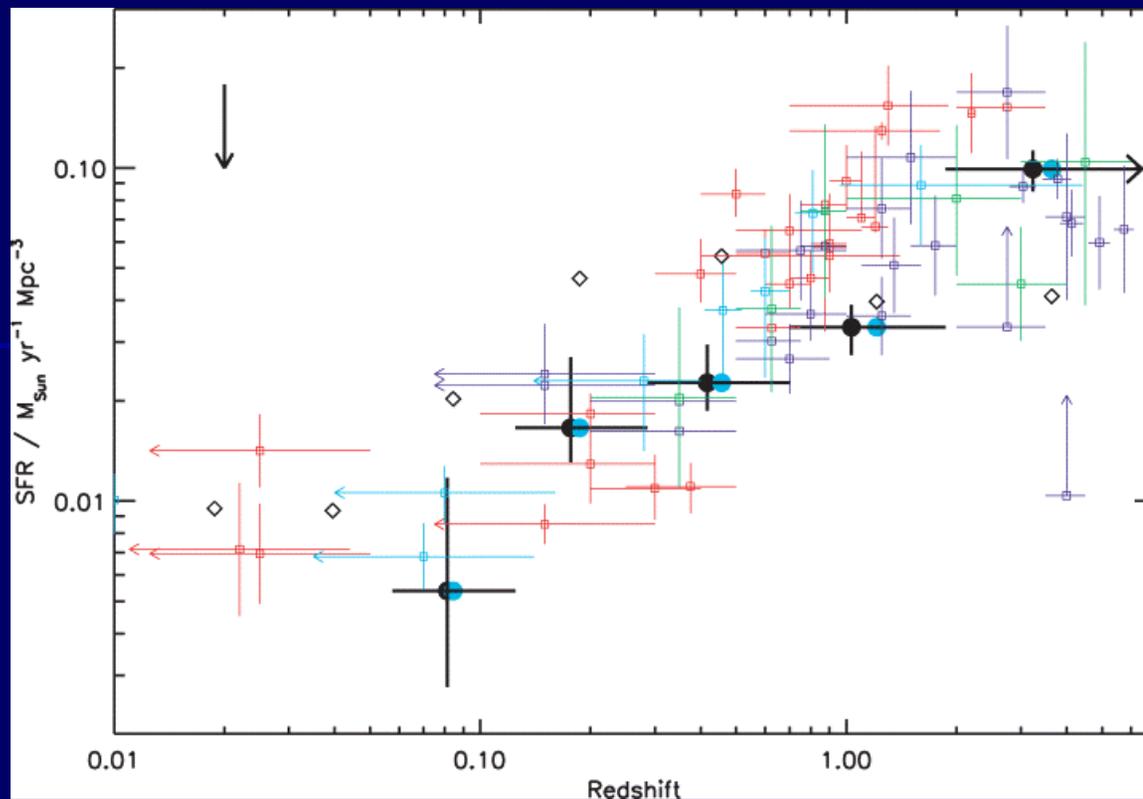
- Sky dist. and HI mass vs. distance for 100 HI sources in AGES Abell 1367 region sample (Cortese et al.). Solid line detection limit $S/N=6.5$, $W=200$ km/s, dotted line same for ALFALFA, dashed HIPASS
- Similar depth survey to be conducted at low-Galactic latitudes, starting with 450 deg² inner Galaxy ALFA ZOA (Henning et al.) commensal with ALFA Pulsar and ALFA RRL

The next step

- Current generation ALFA surveys will yield ~several $\times 10^4$ galaxies to $z \sim 0.1$, will characterize the local HI mass function very well. (Arecibo capable of going deeper, but confusion issues for high z , especially for blind surveys)
- HI detection beyond $z = 0.1$ has been achieved, though currently rare - $z=0.28$ with AO (Catinella et al.) also $z=0.2$ WSRT (Verheijen et al.) and $z=0.24$ in aggregate sense with GMRT (Lah et al.)



- Neutral gas density in Universe (from Lah et al. 2007). $z=0$ triangle is from HIPASS, large triangle is new GMRT measurement. High redshift points come from damped Ly- α measurements. Note large uncertainty in redshift range $z = 0.1 - 1.5$, corresponding to 2/3 age of Universe.

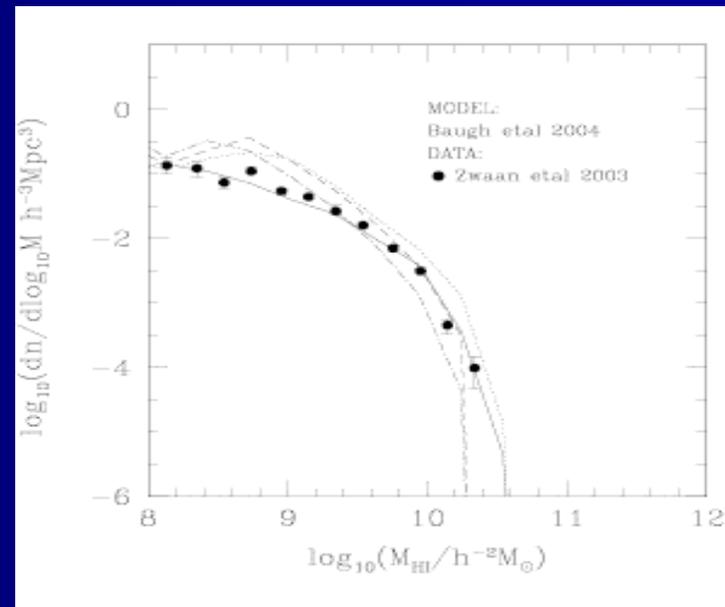


- Cosmic star formation history (Panter et al. 2007)
- Want record of HI over redshift with large evolution in SFR – where, how, is gas going to stars?

The next step (cont.)

- A Goal: Evolution of HIMF. Most of the action should be between $z=0-1$, $M_{\text{HI}} = (0.4 - 4) \times 10^9 M_{\text{sun}}$ (vd Hulst et al. 2004)

Predicted evolution of HIMF in hierarchical picture (Baugh et al. 2004). Dots are measured $z=0$ (Zwaan 03). Lines are predictions: solid $z=0$, dotted $z=1$, dashed $z=3$, dot-dashed $z=4$



The 1% solution: SKA pathfinders

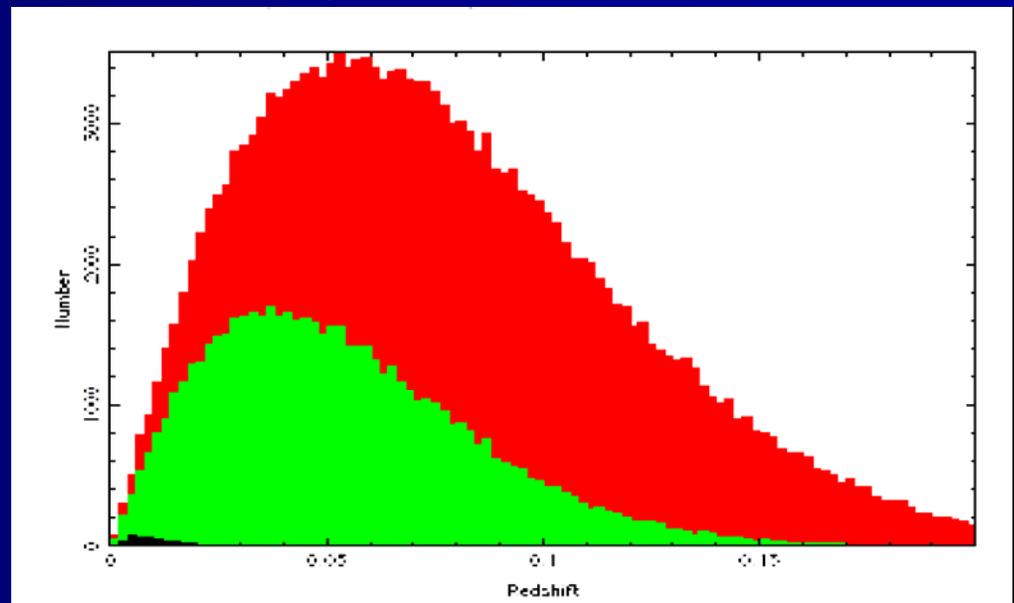
- E.g. ASKAP, 700-1800 MHz, with strawman 30 12m dishes with PAF, upgrade/expansion to 45.

5-sigma detections
for all southern-
hemisphere, "shallow"
(1 yr) survey
strawman, expansion
FOV 30 deg² – depends
on success of PAF
technology -
N=600,000

Z=0.05



Johnston et al. 2007

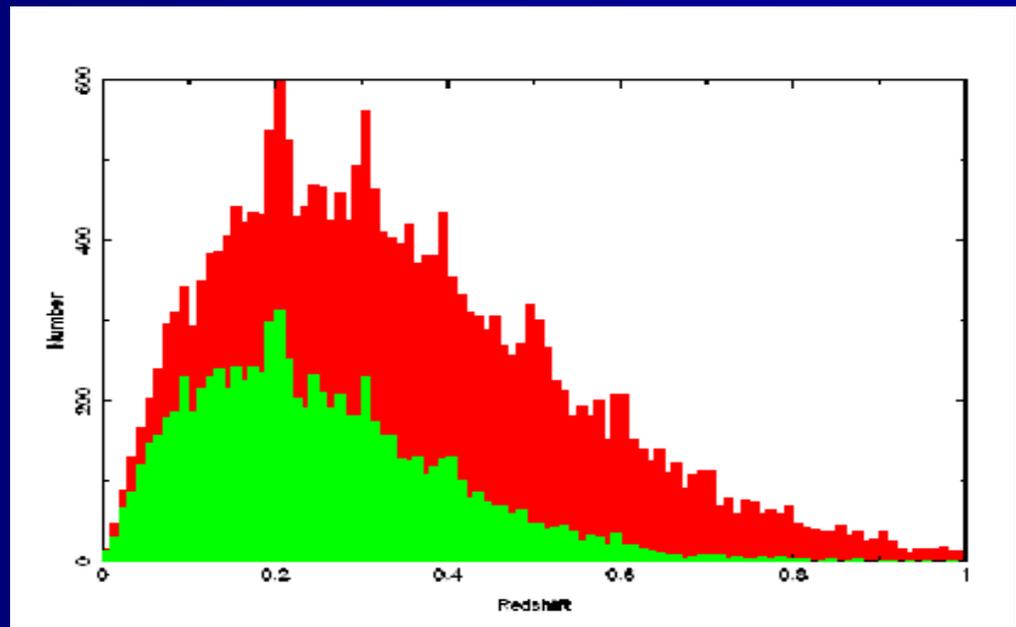


ASKAP (cont.)

Similar simulation
for a deep (1 yr)
single pointing,
 $N = 100,000$

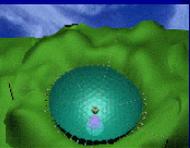
$Z=0.2$
↓

Johnston et al. 2007



New pathfinders include

- ATA – currently ATA-42, 6m dishes, FoV 2.45 deg at 21cm. Full array could do deep HI
- MeerKAT – design decisions ongoing, aim 80 12m dishes, single pixel feeds
- FAST – 500m dish, significant funding, design developing



What's next?

- Next science step must be significant, or not worth funding
- The big step forward could be HIMF to $z=1$
- Want SB sensitivity, but also want resolution to assign proper HI mass (e.g. at $z=1$, $20'' = 160$ kpc)

SKA Phase I – the 10% solution

- At $z=1$, reach $3.6 \times 10^9 M_{\text{sun}}$ in 360 hours, $2.1 \times 10^9 M_{\text{sun}}$ in 1000 hours (Draft Phase I science case)
- To reach $5 \times 10^8 M_{\text{sun}} \sim 750$ day survey with 10% SKA. Long time, but worthwhile
- If few pointings, long time, then prefer large FoV

Timescales

- ALFA surveys complete ~5+ years, new pathfinders underway.
- Connection to multi- λ : large optical/IR surveys (e.g. LSST) going concerns in the 2010's, time will be ripe for deep HI surveys
- SKA proceeds – when/how do we best join forces with international community given US funding realities?
- Also depend on other SKA-mid science/tech issues (Myers, Cordes)

Last thoughts

- Is the US really interested in SKA-mid?
- Are we on board with SKA project? What funding should we push for? Timeline? How to influence?
- Even in a technologically connected world, there's nothing like people working together – *in the same place* - toward a common goal. If we seriously want US stake in SKA-mid, with possibility of effort being led elsewhere, we need funded people on the ground where design is occurring.