High-*z* HI requirements for spatial resolution

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Trying to anticipate 2020+ science

Explicit goal of SKA baseline design: “ensure that astronomical performance will be a major step [forward] over currently available telescopes” (p 19) implies new scientific parameter space.

Distinct science needed to justify investment in facility and grant support for science team members from respective national agencies.

Three kinds of high-*z* HI science

I. spatially unresolved and spectrally unresolved

– total M_{HI} as a function of galaxy type

– M_{HI} term in baryonic Tully-Fisher relation

II. spatially unresolved and spectrally resolved

– velocity profile asymmetry vs. galaxy type

III. spatially resolved and spectrally resolved

– full HI-based Tully-Fisher relation

– detection of tidal tails, post-merger debris, etc.

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sensitivity (*A*/*T*, Δ*t*) ↕

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↕ **configuration; use of “superresolution” (?)**

III. spatially resolved and spectrally resolved

Superresolution: maybe not...

Basic idea (e.g., Scoville et al. 1997): you can recover information about source structure on size scales Δr that are smaller than your synthesized beam if

- + observations have high velocity resolution Δv
- + source has strong velocity gradients (dv/dr)
- + source kinematics allow simple parametric models

Equivalently: we can centroid individual channel maps to better than nominal resolution.

For HI, dv/dr small at large galactocentric radii

$\Rightarrow$ don't expect huge payoff from this technique.

Three pre-2020 "high-z" surveys

CHILES (VLA, PI van Gorkom):

one (COSMOS) field, 1000 hr, to $z_{HI} = 0.45$

Ultra-deep tier of DINGO (ASKAP, PI Meyer):

two (GAMA?) fields, 2500 hr each, to $z_{HI} = 0.43$

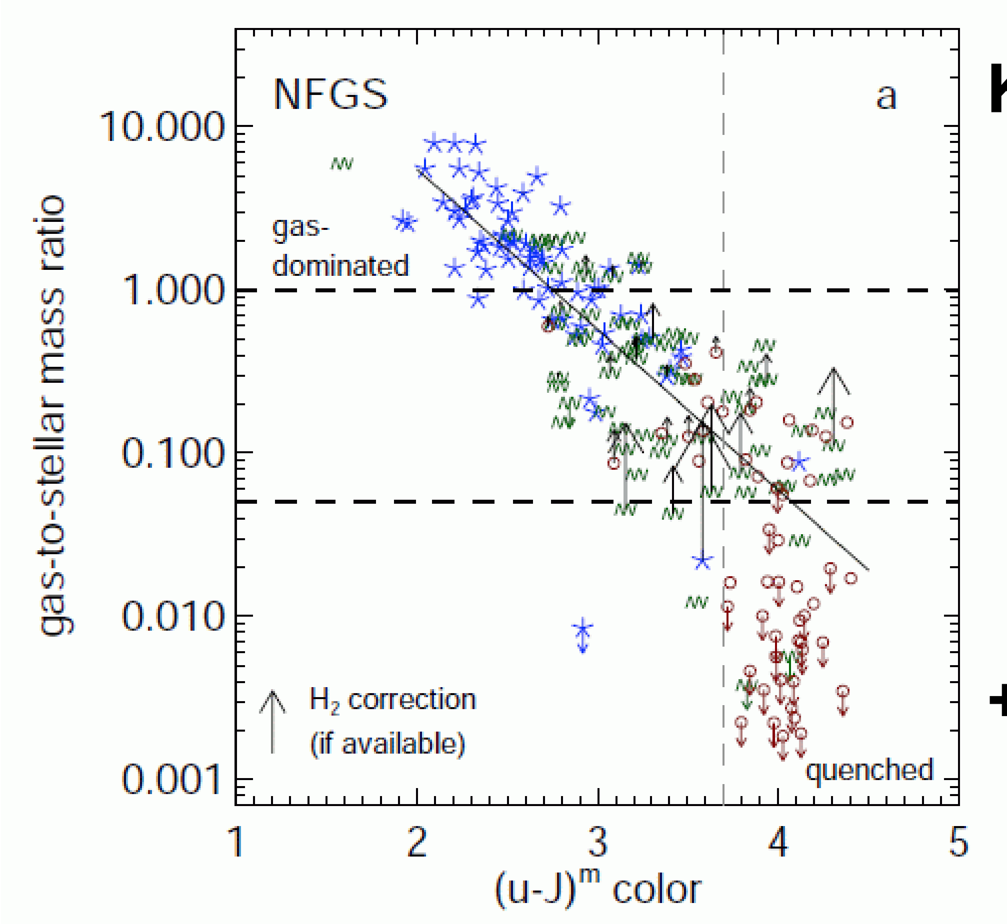
LADUMA (MeerKAT, PIs Blyth, Holwerda, & Baker):

one (ECDFS) field, 5000 hr (split), to $z_{HI} = 0.58$ ($\rightarrow$ 1.45)

Expectation: at "high" redshift, LADUMA will mostly be doing "type I" (global M_{HI}) science.

Open question # 1

Will LADUMA et al. validate predictions of empirical optical "photometric gas mass" estimators?

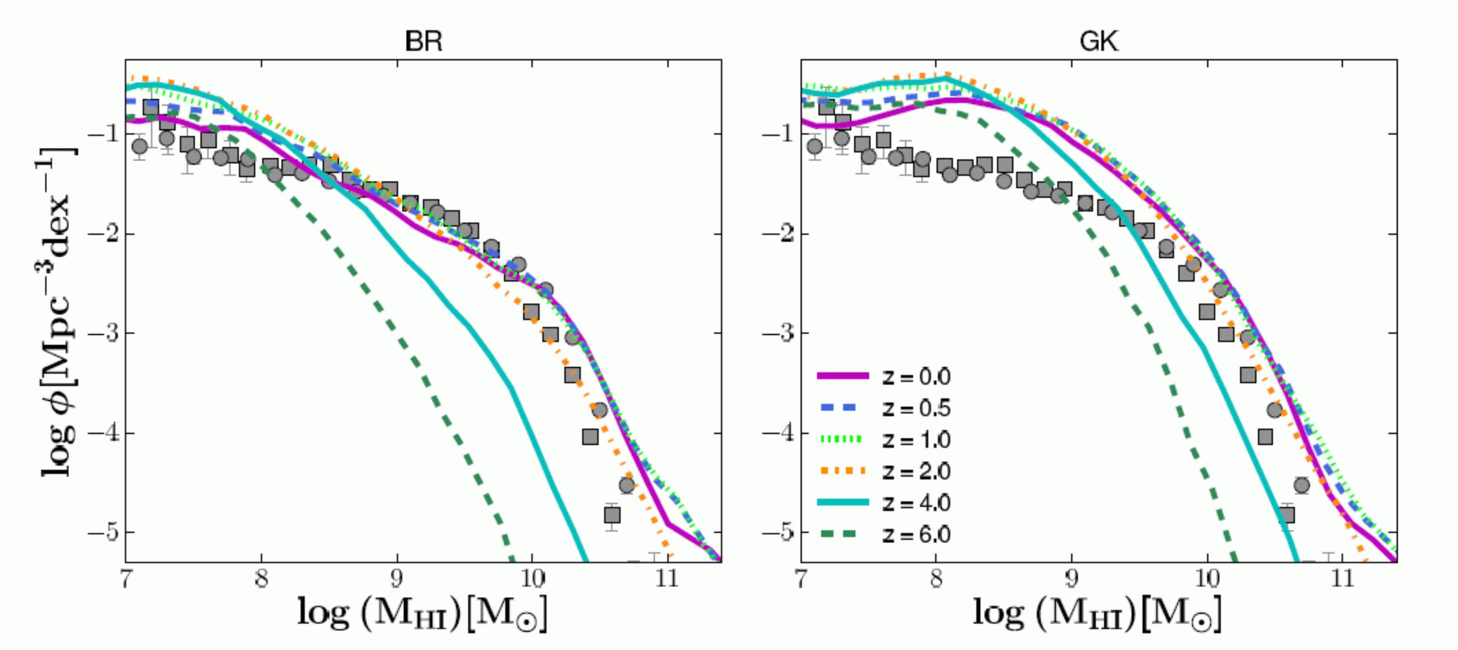


Kannappan et al. (2013, ApJ, in press; arXiv:1308.3292): 0.36 dex rms scatter in M_{gas}/M_{star} vs. U–NIR color

+ see Zhang et al. (2009) and Catinella et al. (2010)

Open question # 2

Will LADUMA et al. validate predictions of increasingly sophisticated semi-analytic models?

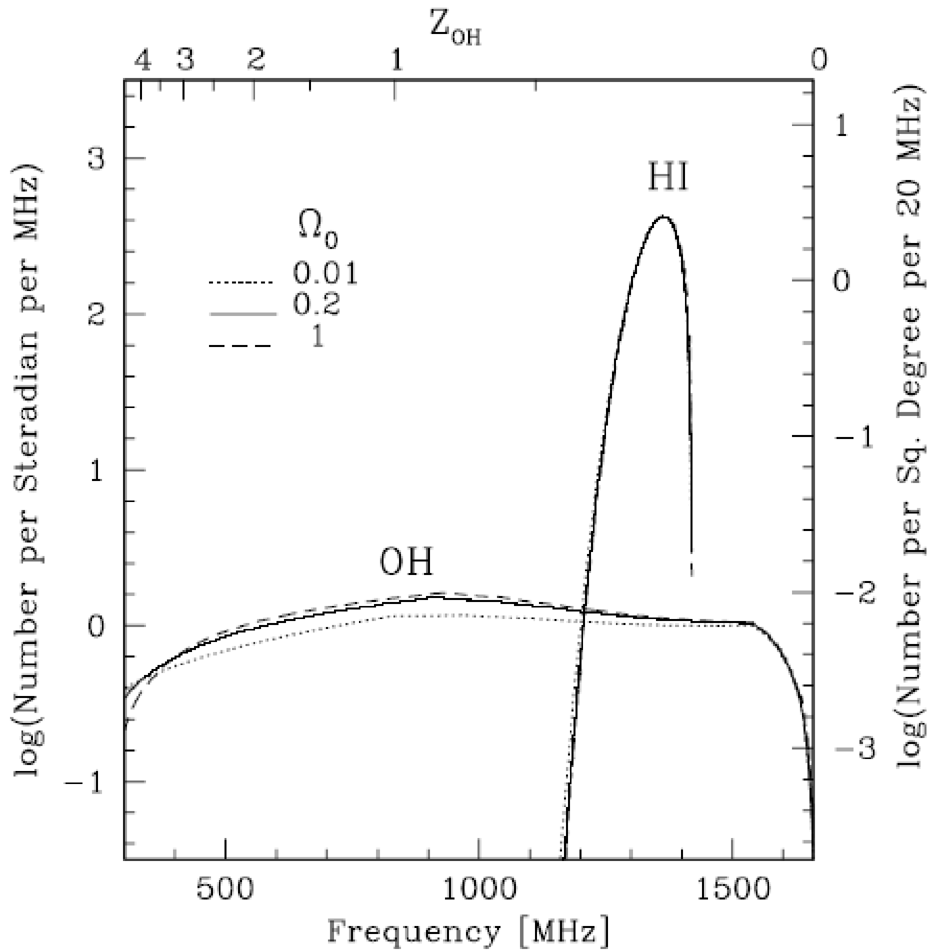


Popping et al. (2013, MNRAS, submitted; arXiv:1308.6764): two recipes for HI/H_2 partition; HIMF same for all $z < 2$

Open question # 3

Will LADUMA et al. source counts be dominated by OH megamasers rather than HI emitters at high *z*?

Briggs et al. (1998): for non-evolving HIMF and plausible model of cosmic merger history, $\Sigma_{OH} > \Sigma_{HI}$ for all $z_{HI} > 0.18$.



Bottom line

If...

+ photometric gas mass estimators get global M_{HI} right out to $z_{HI} \sim 1.45$,

+ semi-analytic models get global M_{HI} right out to $z_{HI} \sim 1.45$, and

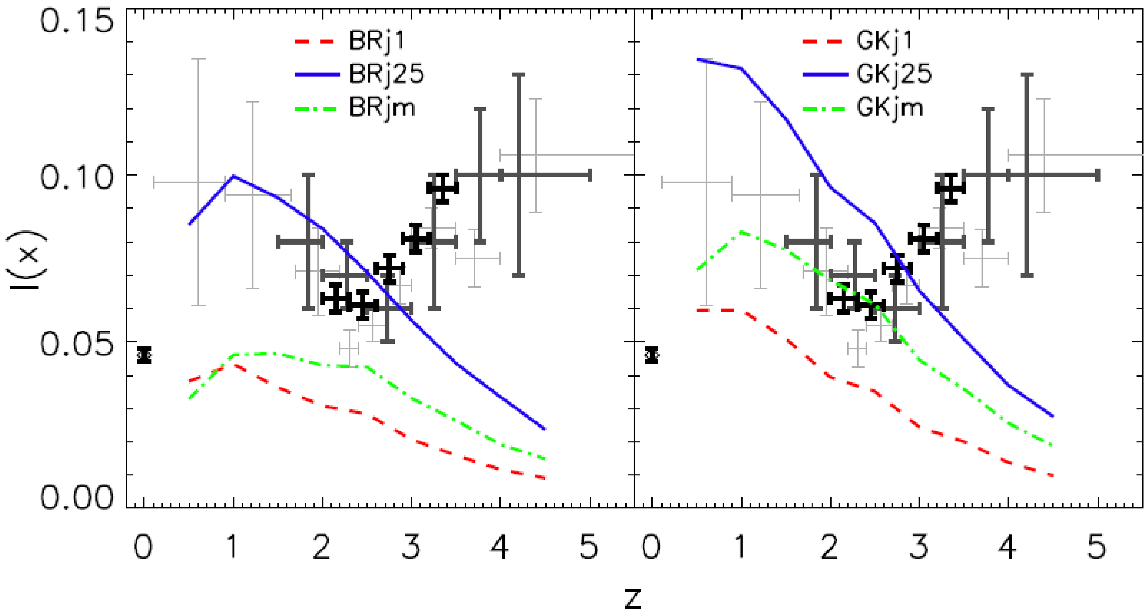
+ better-than-VLA/ASKAP/MeerKAT depth will net far more new OH than HI sources at $z_{HI} > 0.2$,

...then doing "type I" science out to $z_{HI} \sim 2$–3 with SKA1-mid may not be too compelling by 2020.

If LADUMA et al. don't happen, open questions will still be open for SKA1-mid... but hope to avoid this.

Where can resolution help? (i)

Better recipe for HIMF, per Popping et al. (2013)! →



Berry et al. (2013, MNRAS, submitted; arXiv:1308.2598):

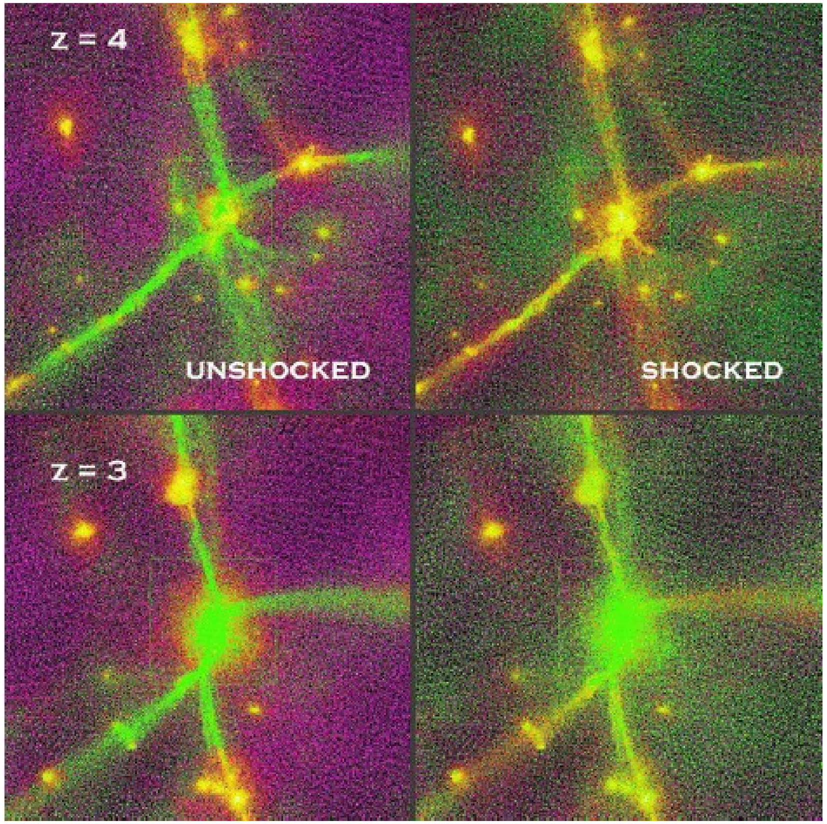
Popping et al. (2013) models require correction factor

f_j = ratio of gas:halo specific angular momentum = 2.5

(perhaps varying with merger history) to get close to damped Lyα absorber (DLA) N_{HI} distribution.

Gas in disks has "special" *J*? DLAs not due to disks?

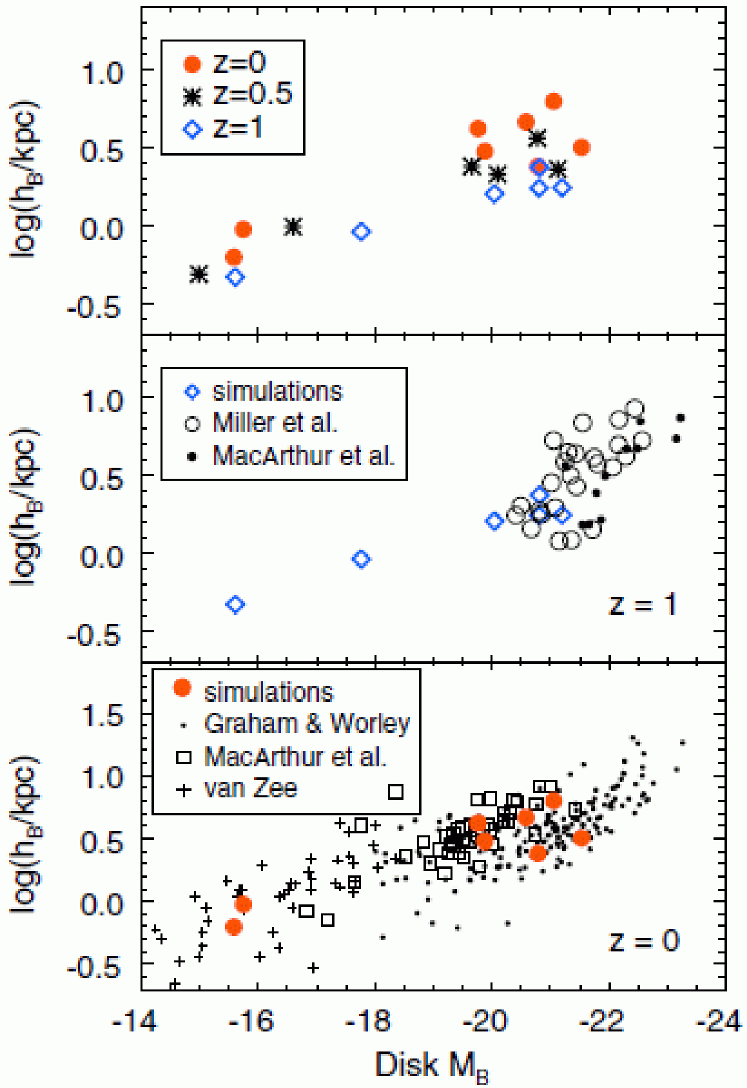
Where can resolution help? (ii)



Brooks et al. (2009): cold flows deliver gas with high specific angular momentum, thereby building disks early.

We'd like to look for imprints of this process in *J* distributions of HI disks as functions of *M*, *z* (on which cold accretion may depend).

How high resolution is needed?



Brooks et al. (2011)

Disks become more compact at high *z* (at fixed magnitude).

At *z* ~ 1, 1" ~ 8 kpc.

Largest nearby galaxies (e.g., in THINGS) show HI profiles flat to *r* ~ 20 kpc, for which ~2.5" resolution would give 2 beams per diameter at *z* ~ 1.