All you would like to do with the SKA on neutral hydrogen

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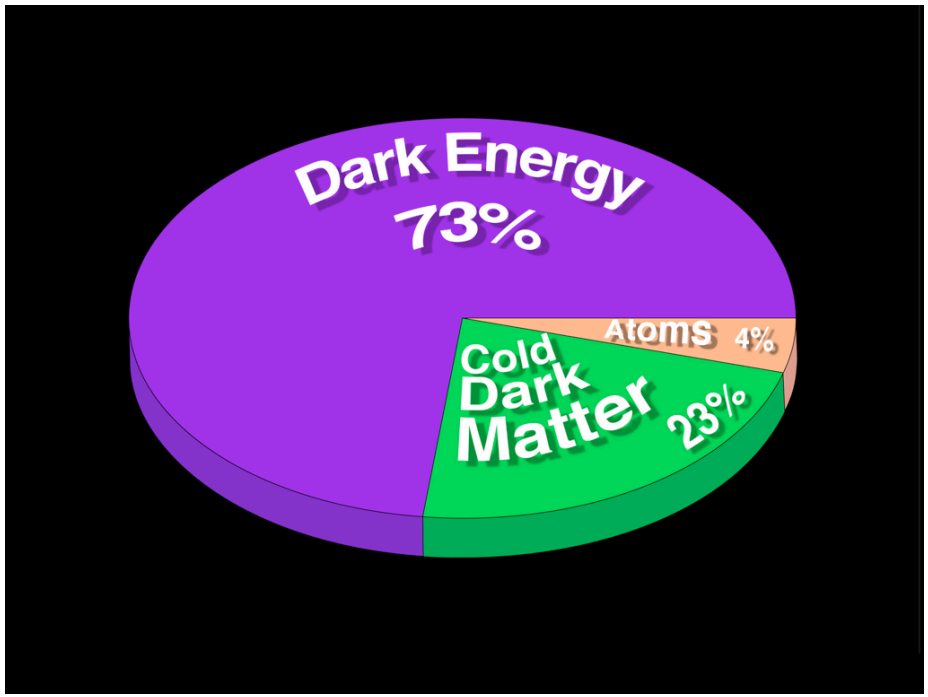
Who cares about neutral gas?

Cold gas takes up only 1% of baryon mass

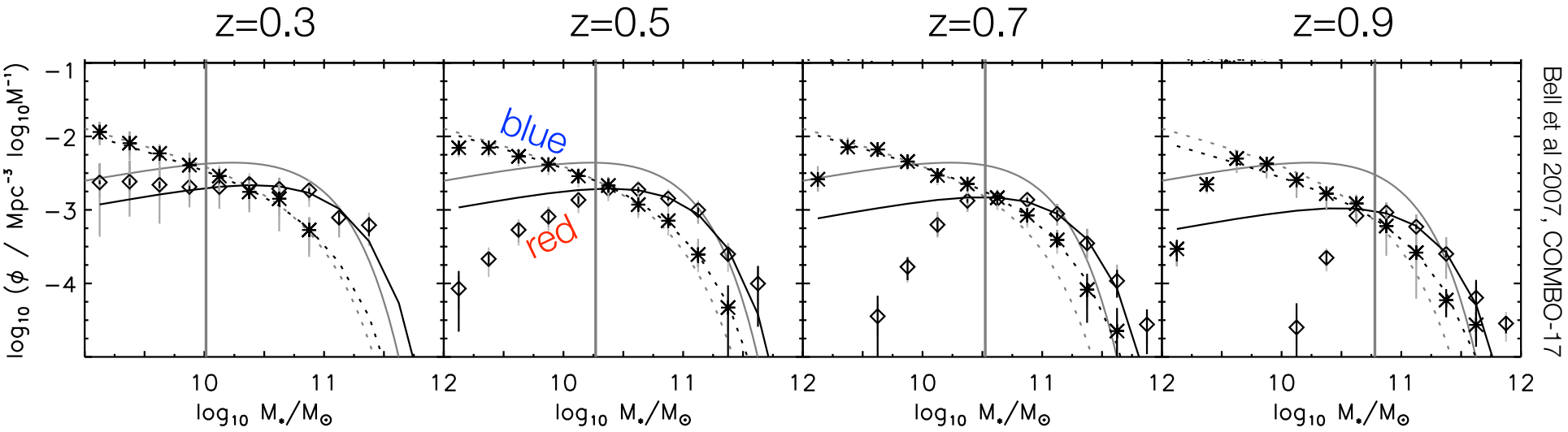
but:

- H is the most **abundant** element...
- **Fuel** for star formation (via H_2 ...)
- **Tracer** of galaxy dynamics
- **Search tool** for missing satellites
- **Indicator** of galaxy interactions

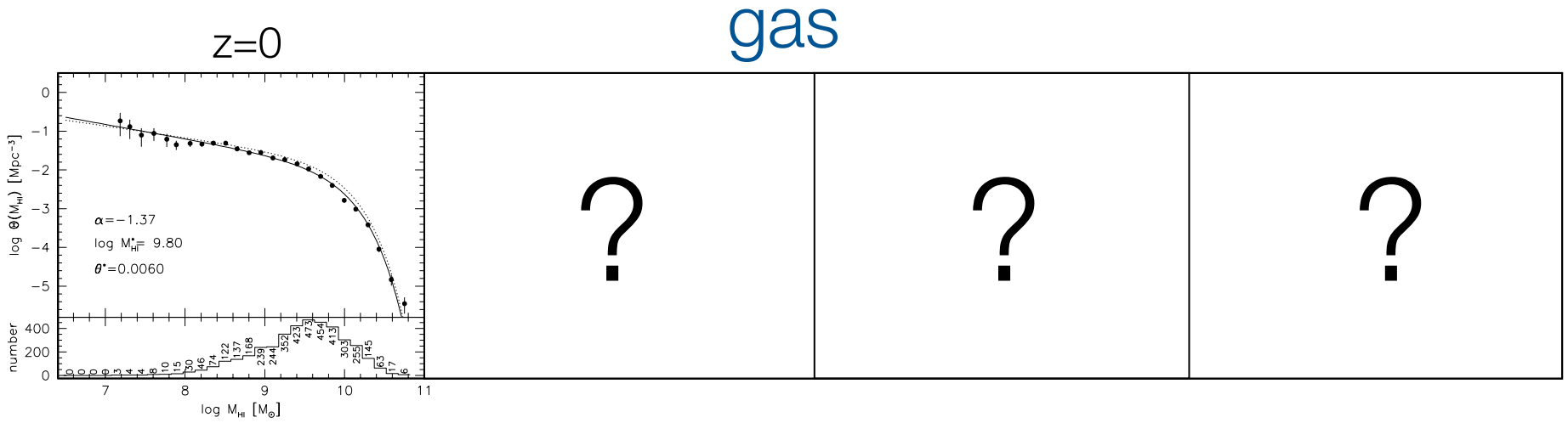


Evolution of **stellar mass** and **cold gas mass**

stars

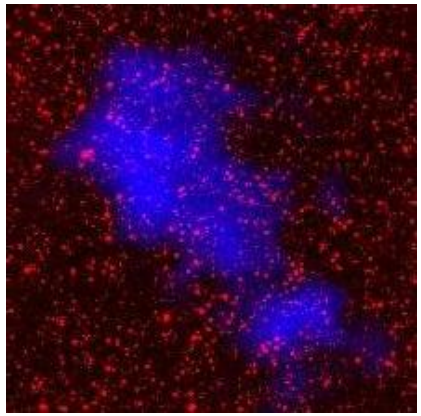


gas

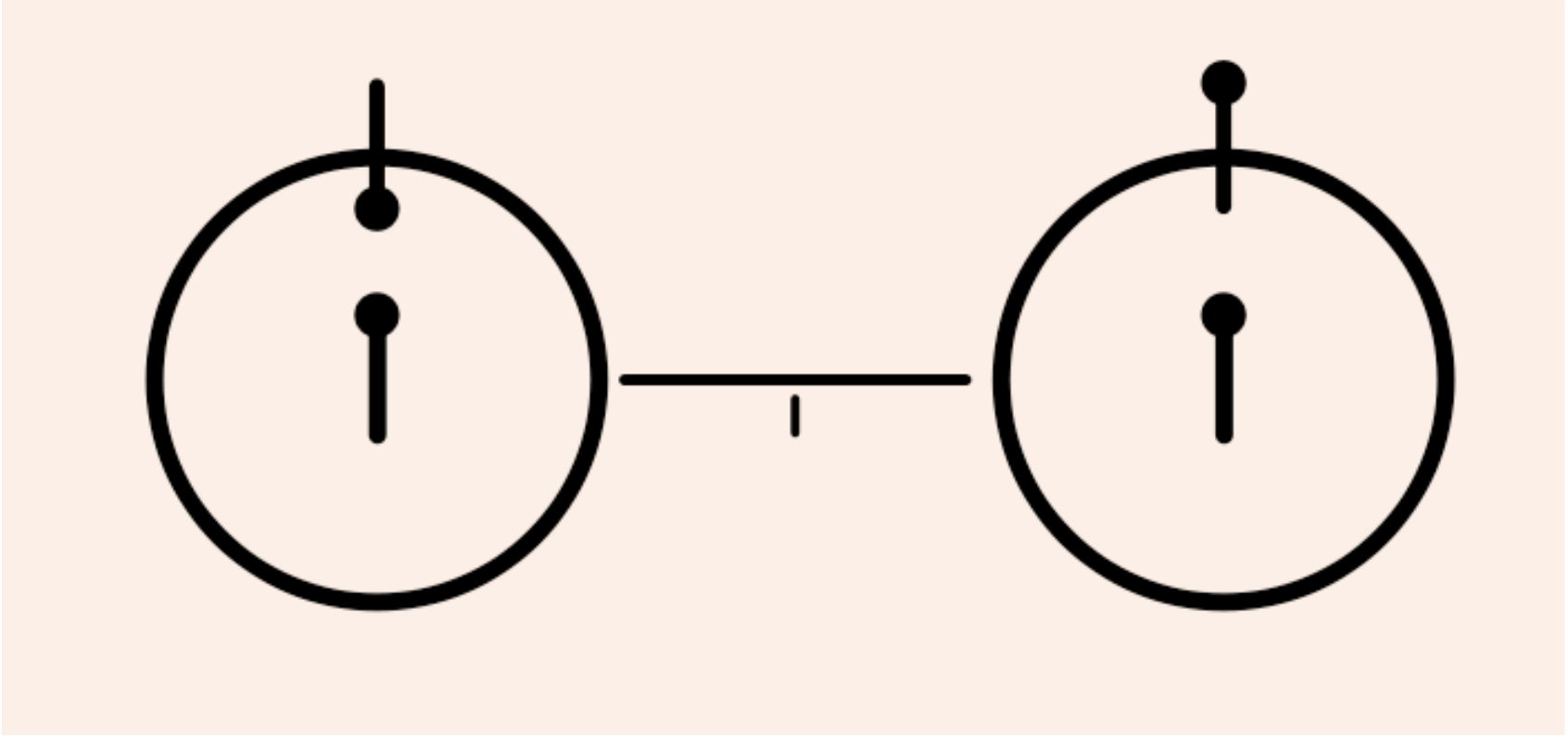


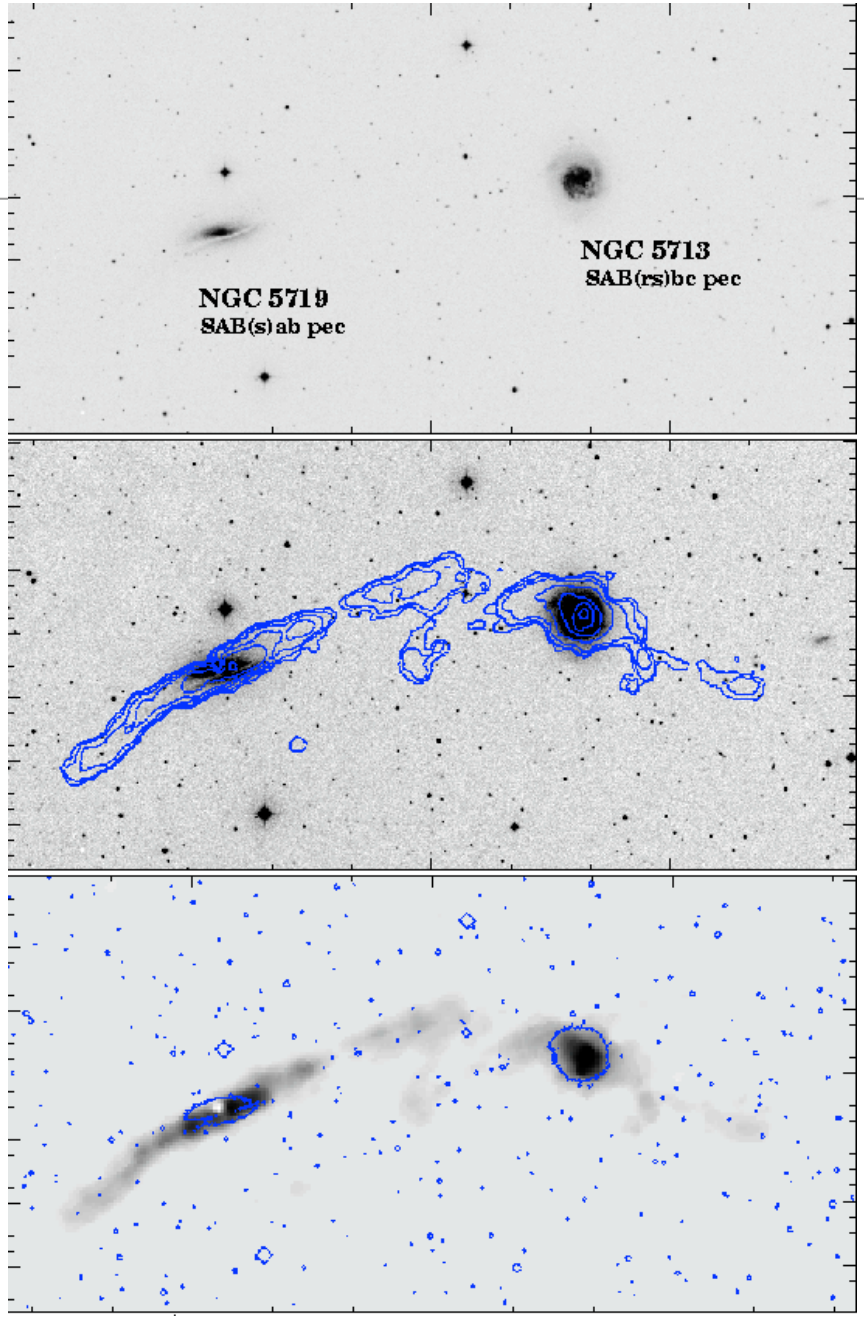
Need to know the **cold gas** as function of z

HI → H_2 → stars



HI is simple

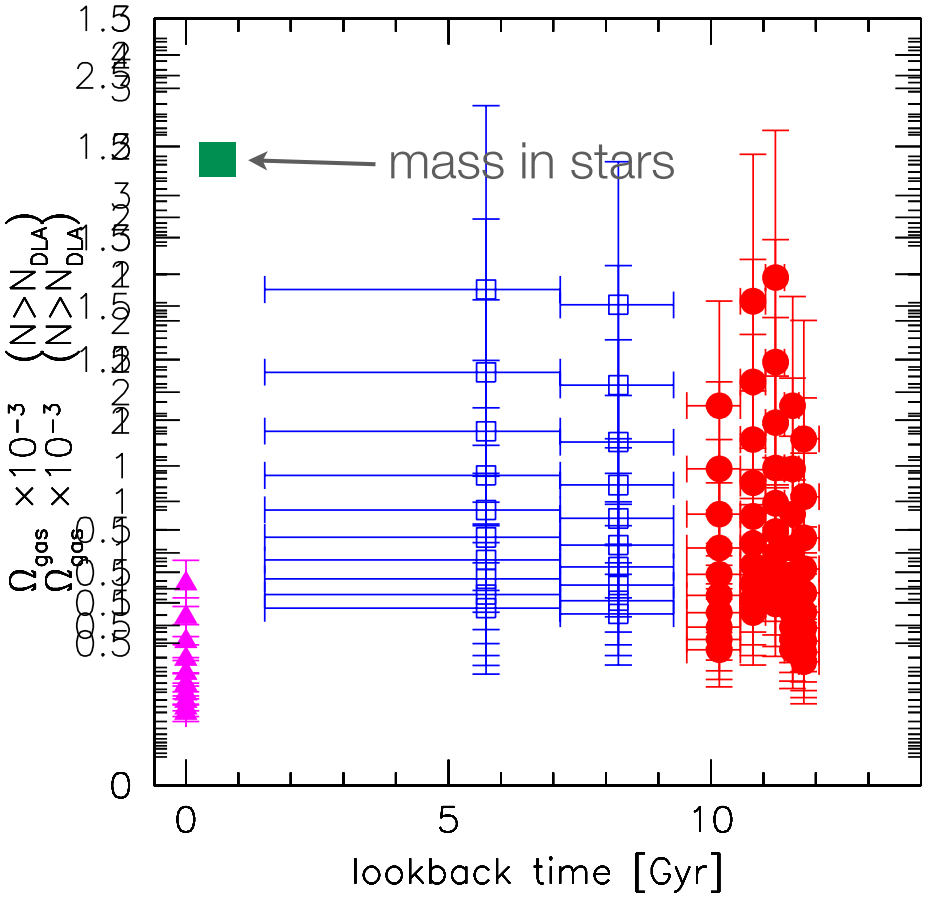




NGC 5713/5719 System

HI rogues gallery (Hibbard)

The **evolution** of the cosmic **HI mass density**



HI is a phase,
not a reservoir

Future challenges for HI surveys

Missing satellites

low mass end

deep & wide

Environmental effects on gas properties

Evolution of cosmic gas mass

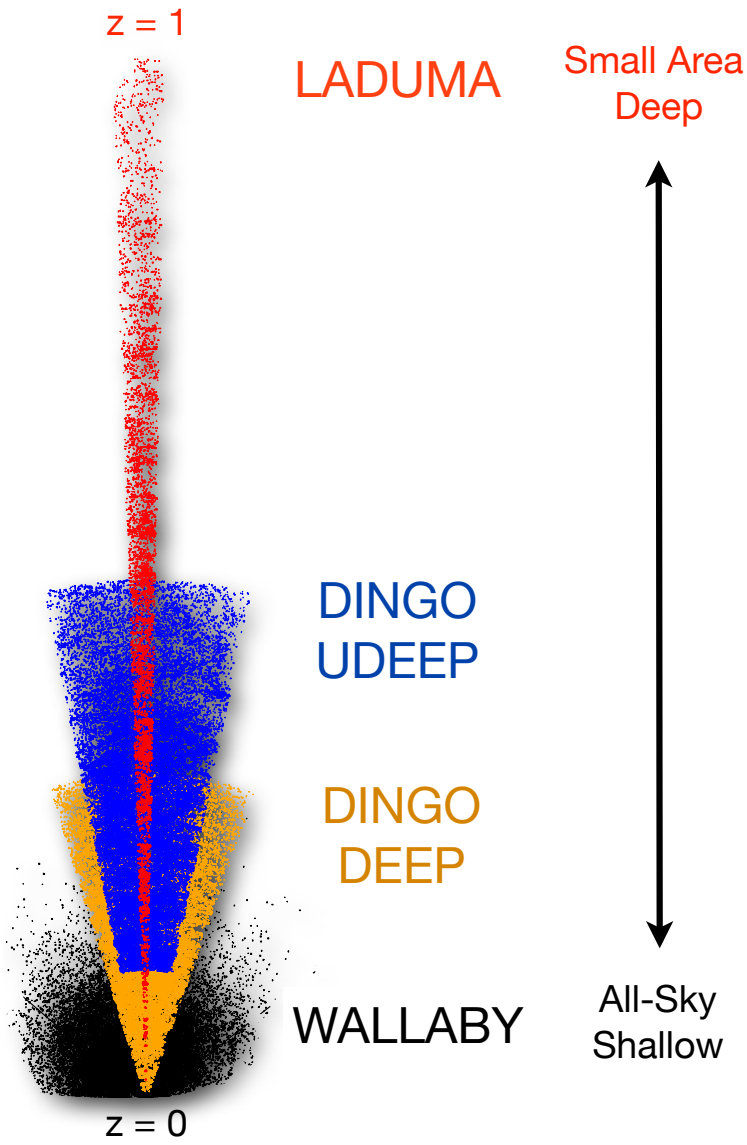
environment

really wide

evolution

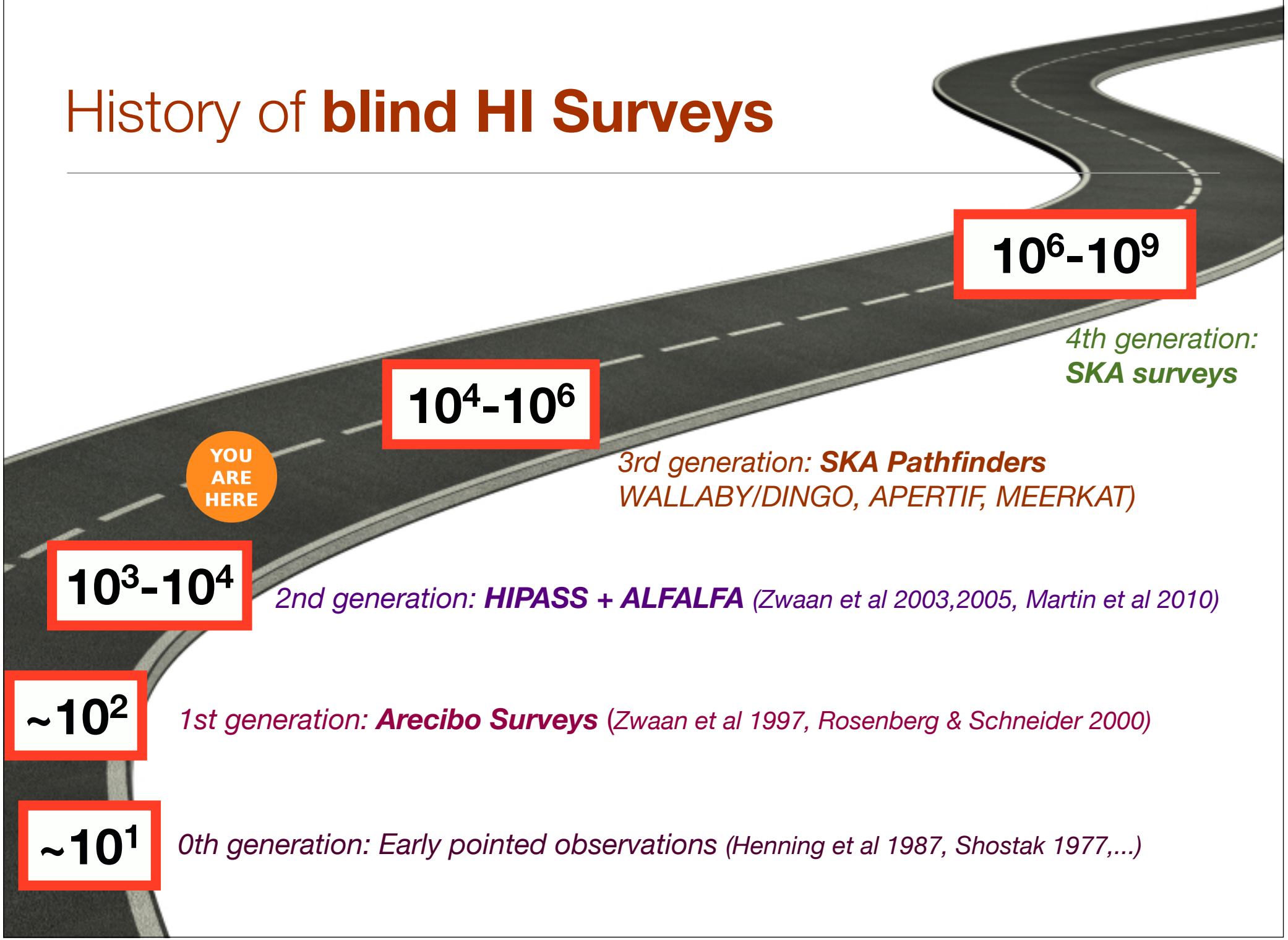
deep

Upcoming surveys with SKA Pathfinders **will cover all of this**…



From Meyer 2011

History of **blind HI Surveys**



10^6-10^9

4th generation:
SKA surveys

10^4-10^6

YOU ARE HERE

3rd generation: ***SKA Pathfinders***
WALLABY/DINGO, APERTIF, MEERKAT)

10^3-10^4

2nd generation: ***HIPASS + ALFALFA*** *(Zwaan et al 2003,2005, Martin et al 2010)*

~10^2

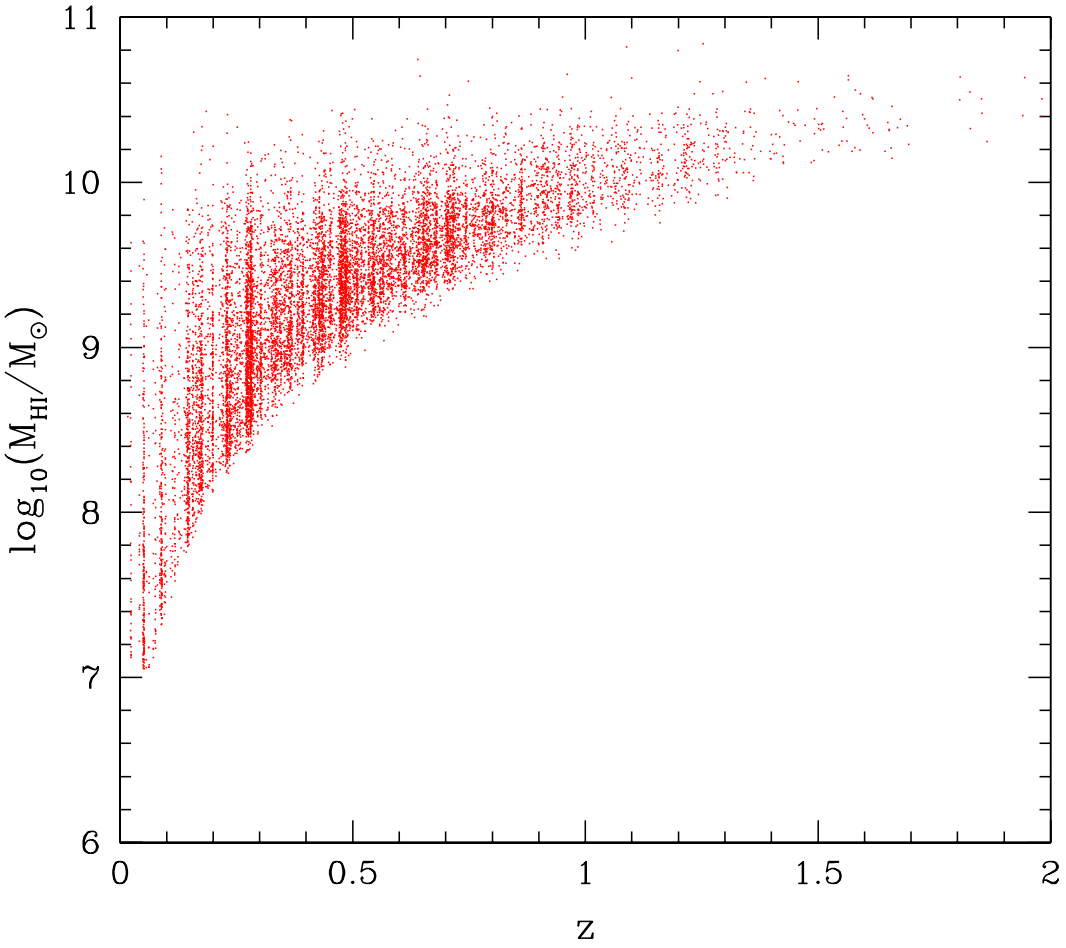
1st generation: ***Arecibo Surveys*** *(Zwaan et al 1997, Rosenberg & Schneider 2000)*

~10^1

0th generation: Early pointed observations (Henning et al 1987, Shostak 1977,...)

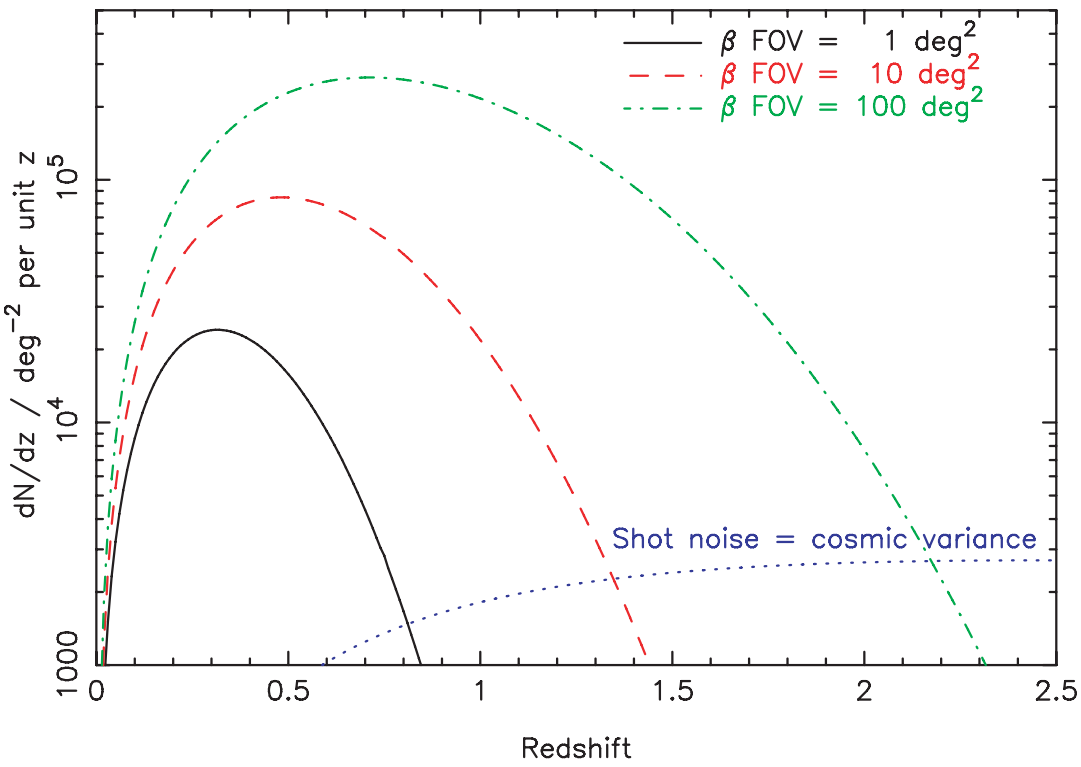
Example: **deep field** HI survey with **SKA$_1$**

- Single field, 1000 hours
- Frequency range 450-1430 MHz
- Angular resolution: 4”, better if possible
- Spectral resolution: 18.3 kHz (4 km/s at z=0)
- Field size: 0.7 deg^2 at z=0 increasing to 6 deg^2 at z=2



Example: **Wide field z<2** HI survey with **SKA_2**

- a full SKA_2, mid frequencies
- cover one hemisphere
- one year duration
- measure HI mass function and HI mass density out to z=1.5
- excellent measurement of galaxy power spectrum out to z=1.5



Abdalla et al 2010

Example: **z=3 deep** HI survey with **SKA_2**

- one year integration with a full SKA_2, low frequencies
- Observing frequency ~350 MHz
- Field of view ~400 deg^2
- ~10^6 galaxies at z=3

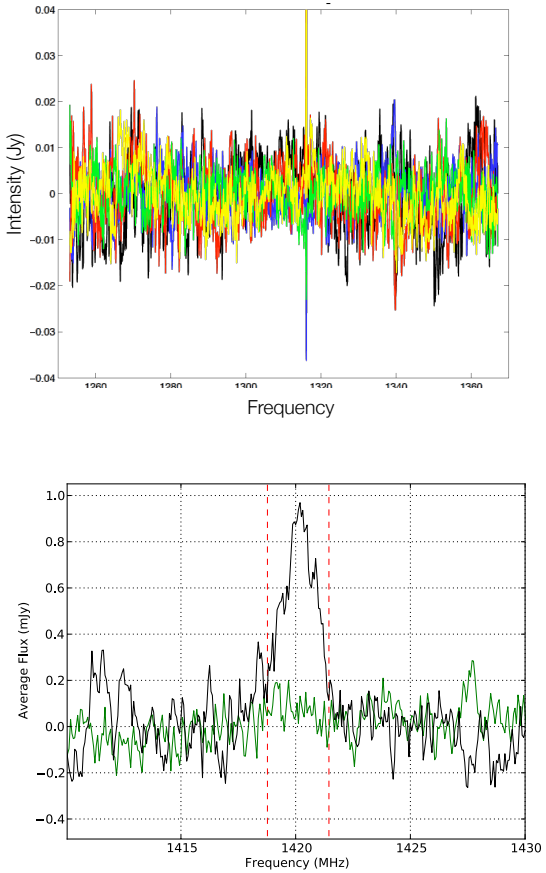
Emission line (1)	Telescope and band (2)	$dN/(dz\,dA)$ in 24 h 3-σ (22)	10-σ (23)	Nb. of detections in 1 yr 3-σ (24)	10-σ (25)	Nb. of stacked galaxies (26)	Signal-to-noise n of a 24 h stacking (27)
HI	SKA_1-LF	–/–	–/–	$51 / 1.2 \cdot 10^4$	–/340	$1.1 \cdot 10^4$	1/5
HI	SKA_2-LF	–/51	–/–	$1.2 \cdot 10^5 / 3.4 \cdot 10^6$	$3.4 \cdot 10^3 / 3.6 \cdot 10^5$	$1.1 \cdot 10^5$	15/77
CO(1–0)	SKA_1-HF	$1.1 \cdot 10^4$	$1.5 \cdot 10^3$	740	100	1	2
CO(1–0)	SKA_2-HF	$1.4 \cdot 10^5$	$4.1 \cdot 10^4$	$9.1 \cdot 10^3$	$2.8 \cdot 10^3$	1	21
CO(3–2)	ALMA-3	$5.2 \cdot 10^4$	$1.4 \cdot 10^4$	610	160	1	9
CO(4–3)	ALMA-3	$3.8 \cdot 10^4$	$1.0 \cdot 10^4$	250	69	1	8
CO(5–4)	ALMA-4	$4.2 \cdot 10^4$	$1.4 \cdot 10^4$	180	58	1	12
CO(6–5)	ALMA-5	$1.7 \cdot 10^4$	$7.6 \cdot 10^3$	50	22	1	6
CO(7–6)	ALMA-5	$1.0 \cdot 10^4$	$5.7 \cdot 10^3$	22	12	1	3
CO(8–7)	ALMA-6	$6.5 \cdot 10^3$	$3.3 \cdot 10^3$	11	5.4	1	0.9
CO(9–8)	ALMA-6	$4.0 \cdot 10^3$	$1.7 \cdot 10^3$	5.2	2.3	1	0.2
CO(10–9)	ALMA-7	$1.5 \cdot 10^3$	500	1.6	$5.3 \cdot 10^{-1}$	1	0.03

Obreschkow et al 2011

HI Stacking

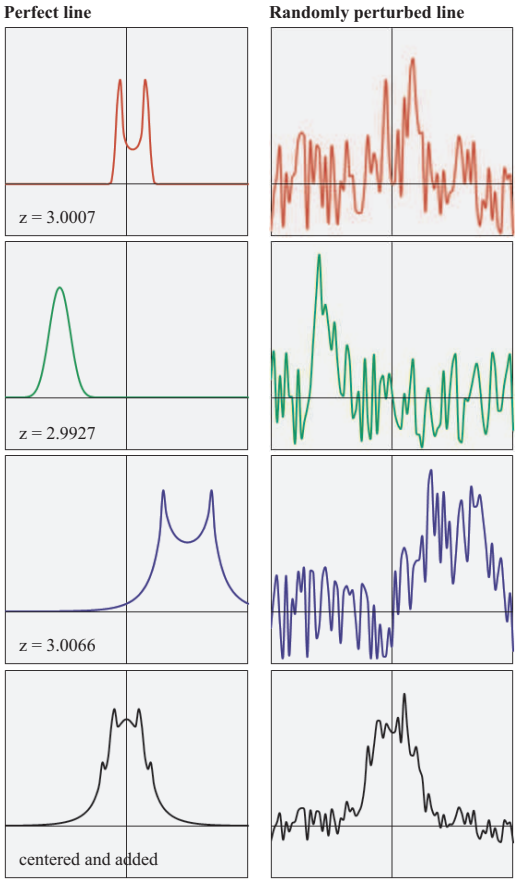
- Measure statistical properties of galaxies beyond where individual detection can be made

Measured at z~0



Delhaize et al in prep

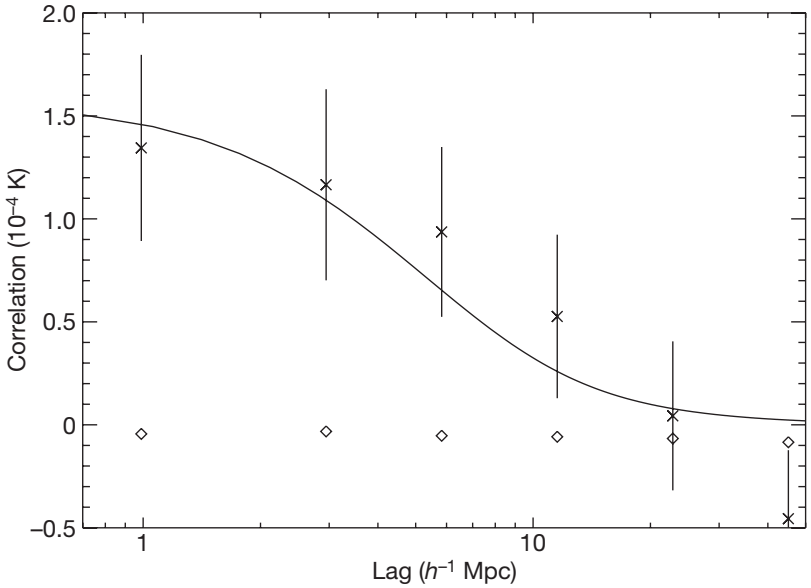
Simulated at z=3



Obreschkow et al 2011

21cm intensity mapping

- Measure cumulative HI 21-cm signal from galaxies
- auto-correlation: challenging measurement
- cross-correlation with optical galaxies:
  - Chang et al (2010) detected this signal with the GBT in the DEEP2 field at z=0.8
- with SKA the HI power spectrum and the cosmic mass density of neutral hydrogen can be measured



Chang et al 2010

HI with the SKA

- **Role of gas in galaxy evolution**
- **Cosmology**
- **Test CDM predictions**
- **Tully-Fisher**
- **Detailed morphology and kinematics**
- **Low column density and connection to intervening absorbers**
- **HI 21-cm absorbers**