The nature of GRB hosts from their HI 21 cm emission
- a question only SKA can answer

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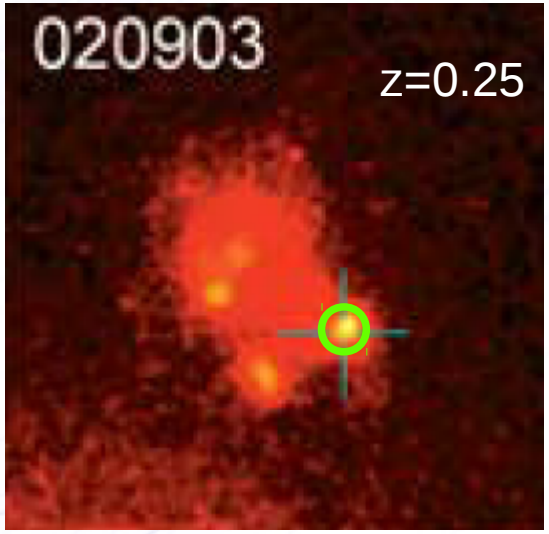
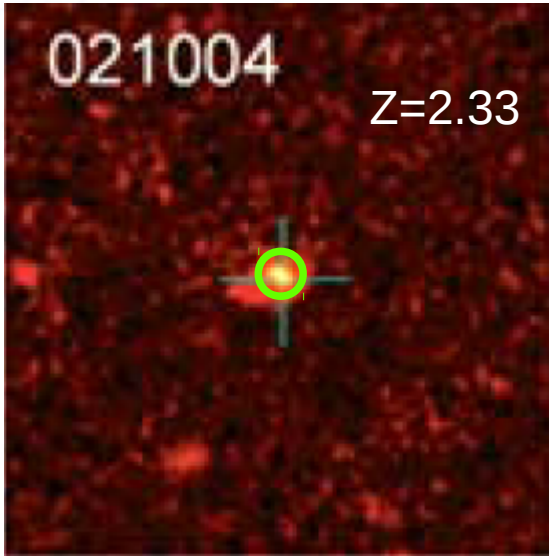
Gamma Ray Bursts

- GRBs
  - Extremely bright flashes of gamma ray with a tail in x-ray
  - Detectable upto the highest redshifts
- ☆ Highest spectroscopically confirmed redshift is 8.23 (Tanvir+ 2009)
- Duration of bursts has bimodal distribution
  - <2 sec: short
  - >2 sec: long
- These two sets are fundamentally different
- Here we will focus only on Long GRBs

Long GRBs

- Most believed model
  - Collapse of a very massive star
- Beacons of star forming galaxies
- Observationally confirmed
  - Not only from star forming galaxies
  - But also the bluest, most star forming regions of those galaxies (Fruchter+ 2006, Le Floch+ 2003)





GRBs: afterglow

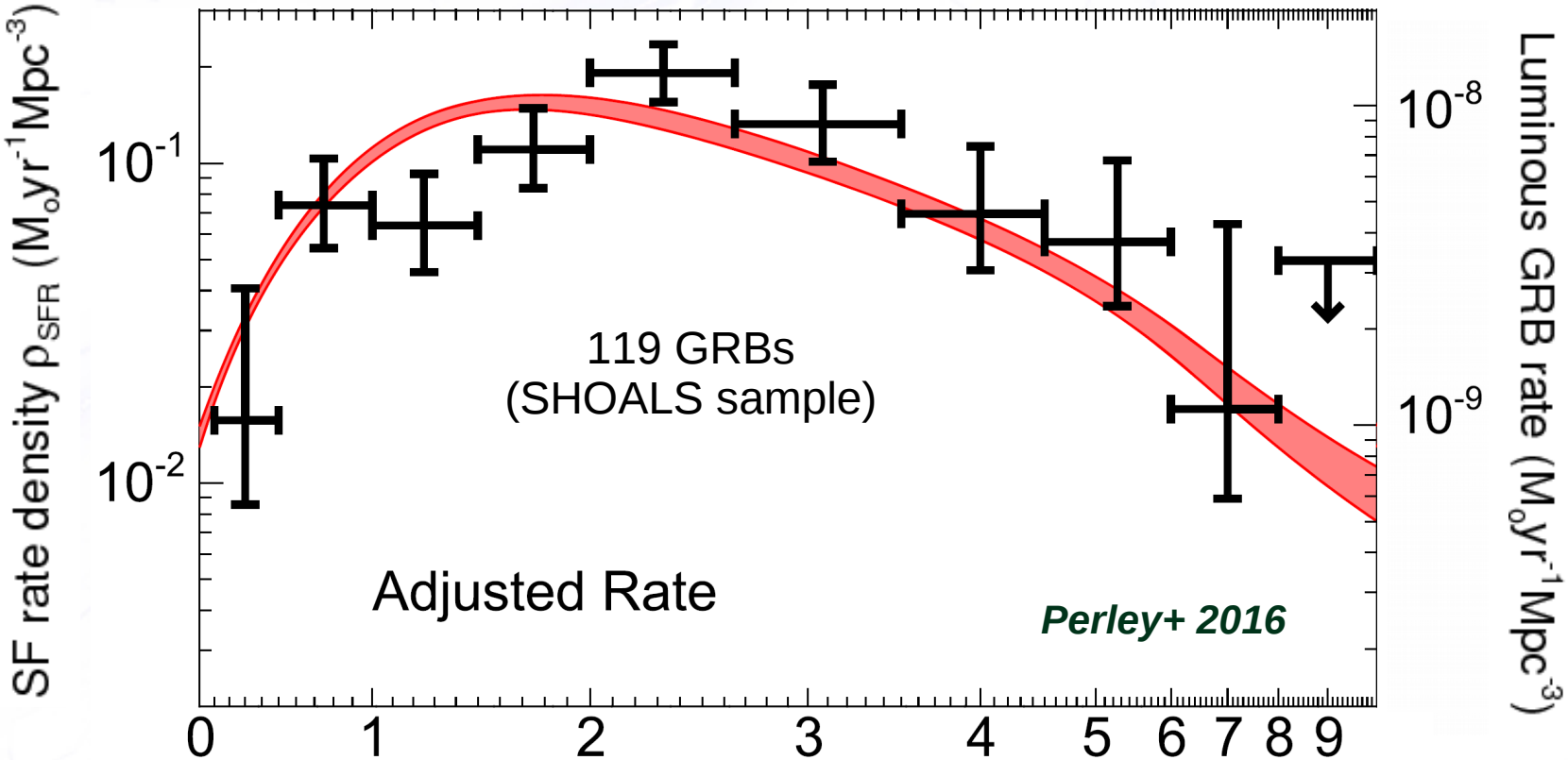
- GRBs followed by afterglow emission ranging from x-ray to radio
- Optical afterglow
  - spectra used to detect ISM in absorption
    - absorption lines: used to get redshifts, accurate abundances and metallicities, kinematics, dust properties
  - localization to arcsec accuracy

- Optical afterglow fades away in a day
- Though it is challenging to observe afterglow
  - can now observe host galaxy in emission

☆*GRB detectability unrelated to host's luminosity or dust content*

GRB host galaxies

- Extensively studied over last decade
- At low redshifts (z<2):
  - low mass and metallicity, higher than normal SFR surface densities
- At z>2: sample the general population of star forming galaxies

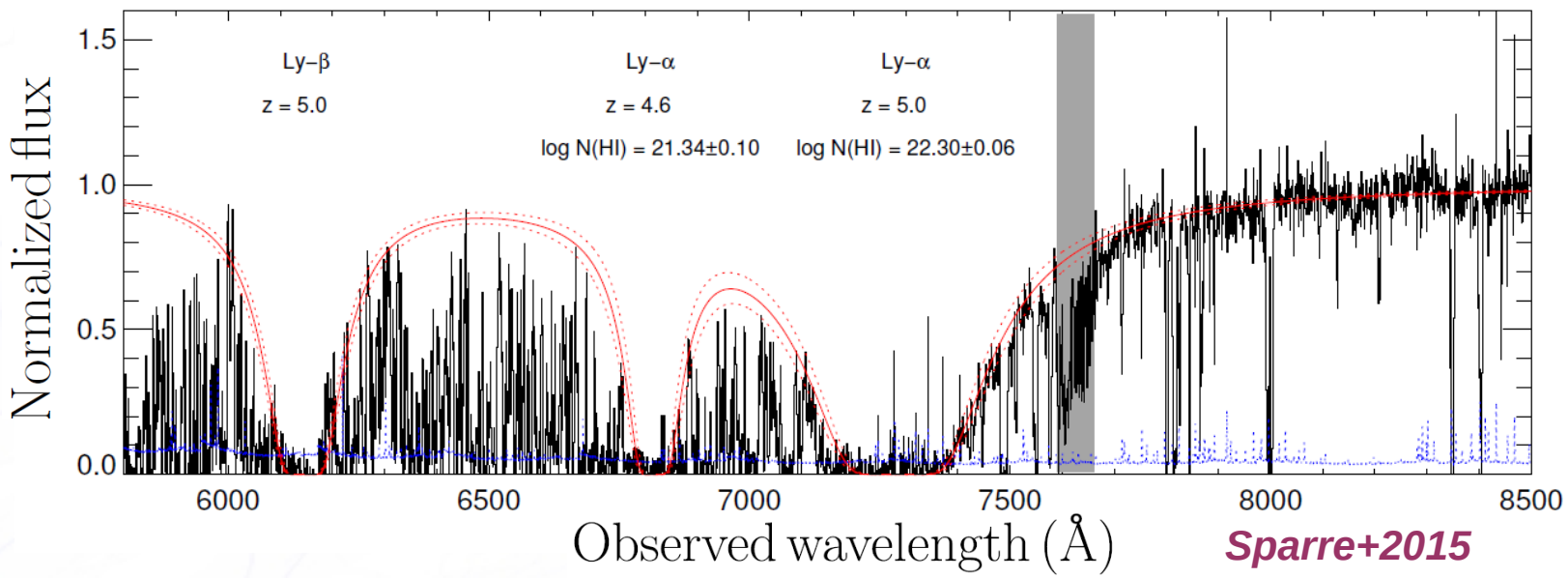


Gas in GRB hosts

- Neutral gas detected through Lyman alpha **absorption**

Gas in GRB hosts

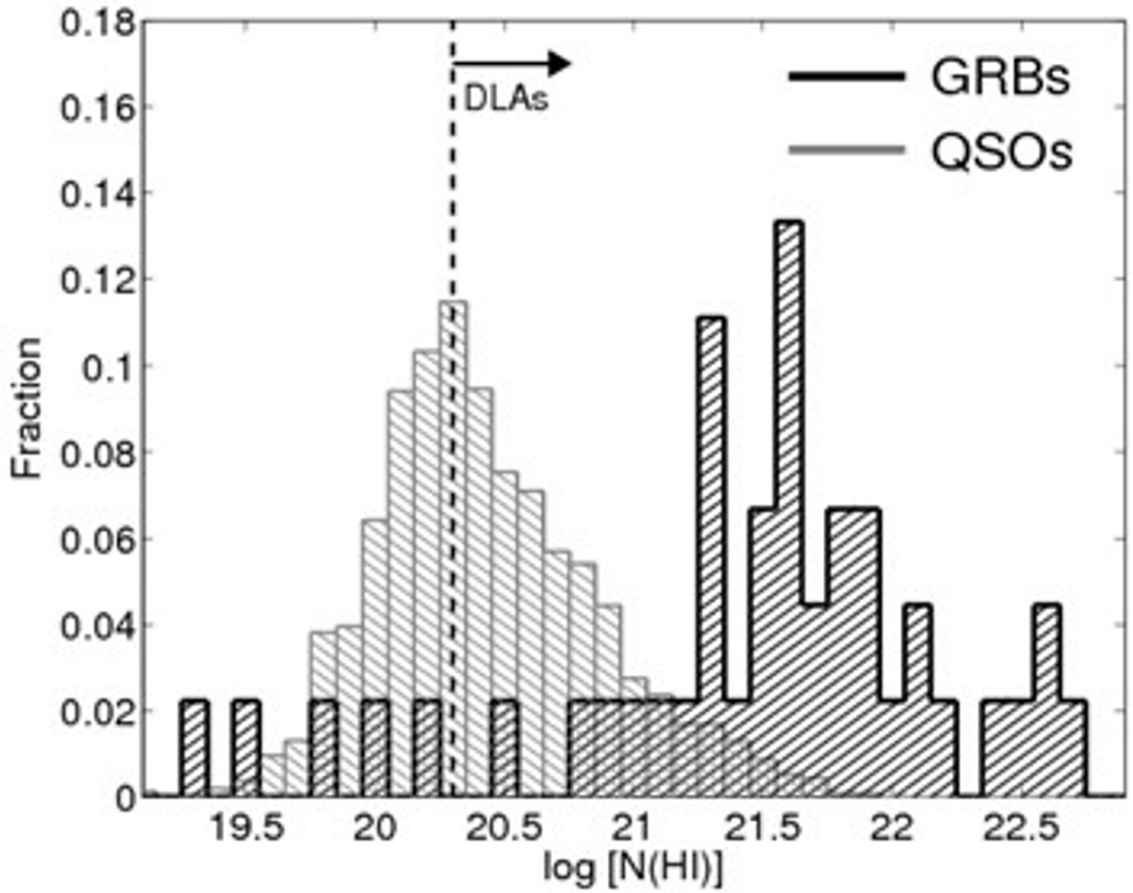
GRB 111008A, z = 5.0



Sparre+2015

High column density Gas in GRB hosts

- Only 5 of 1200 QSO DLAs, the reservoirs of HI, have $N_{HI} > 10^{22}$ cm^{-2}
  - Common for GRBs

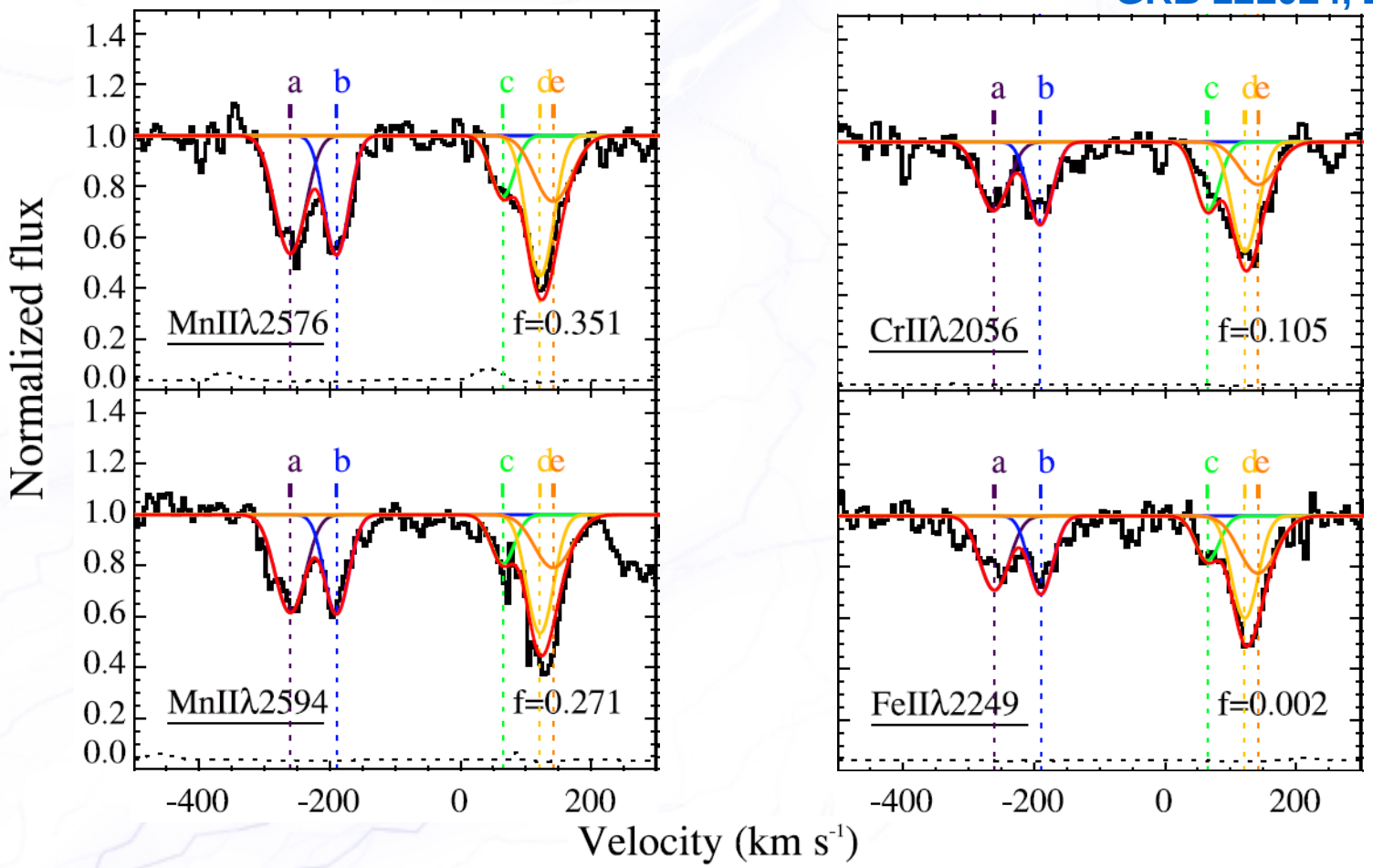


http://slideplayer.com/slide/6856733/ by Edo Berger

Atomic gas in GRBs

- High column density systems → low ion lines trace the atomic gas
- Interestingly they have very large velocity widths
- Common to see distinct components separated by hundreds of km/s

GRB 121024, z = 2.3



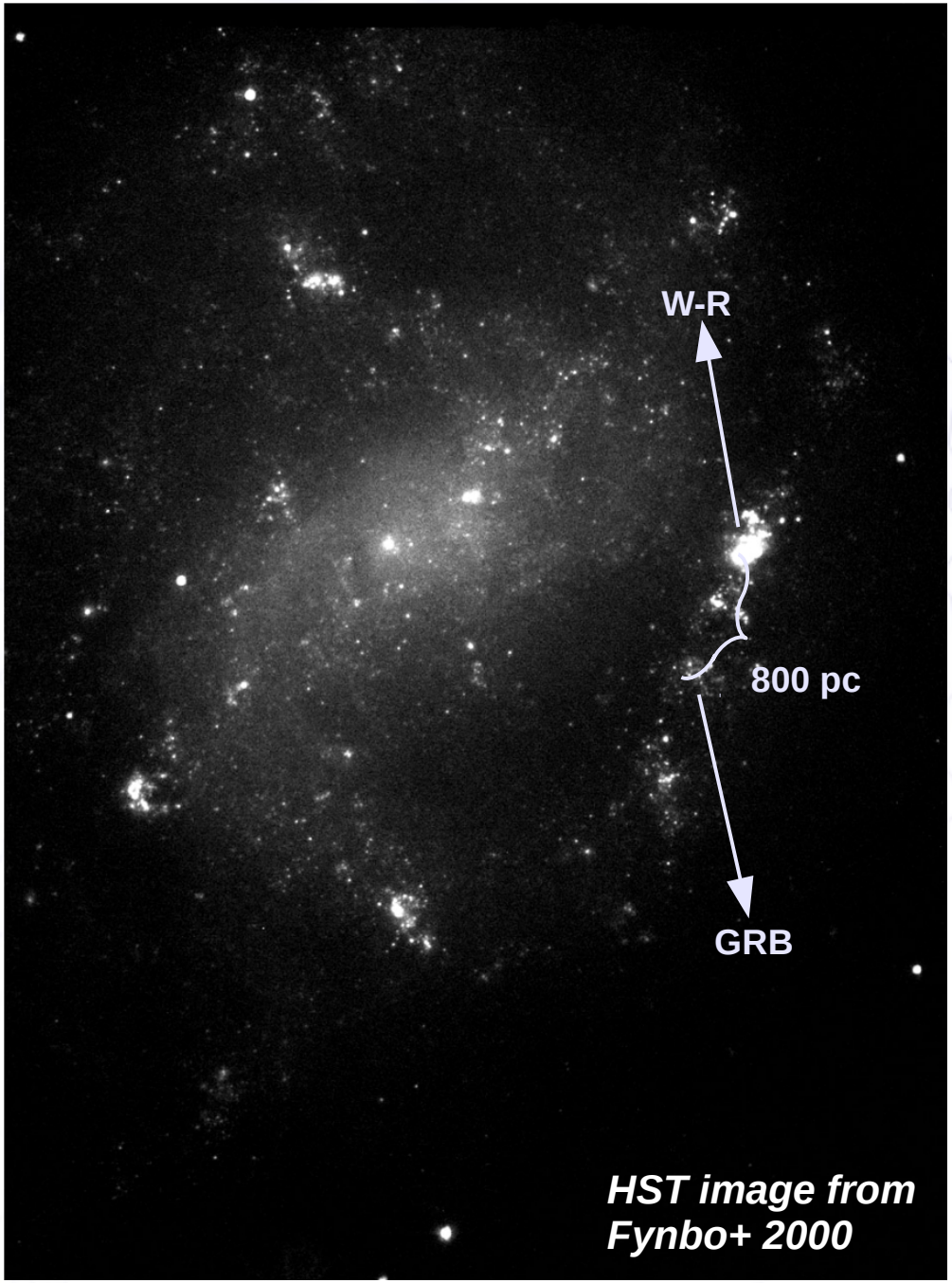
Friis+2015

HI emission survey of GRB hosts

GRB	Redshift	$\log(M_*/M_\odot)$	Observatories used
980425	0.0087	8.7	GMRT
060218	0.0334	7.72	Arecibo
100316	0.0591	8.93	archival ATCA
060505	0.0889	9.76	GMRT, JVLA D
080517	0.089	9.6	JVLA C, GMRT
031203	0.1055	9.72	GMRT

Closest Known GRB Host, ESO 184-G82

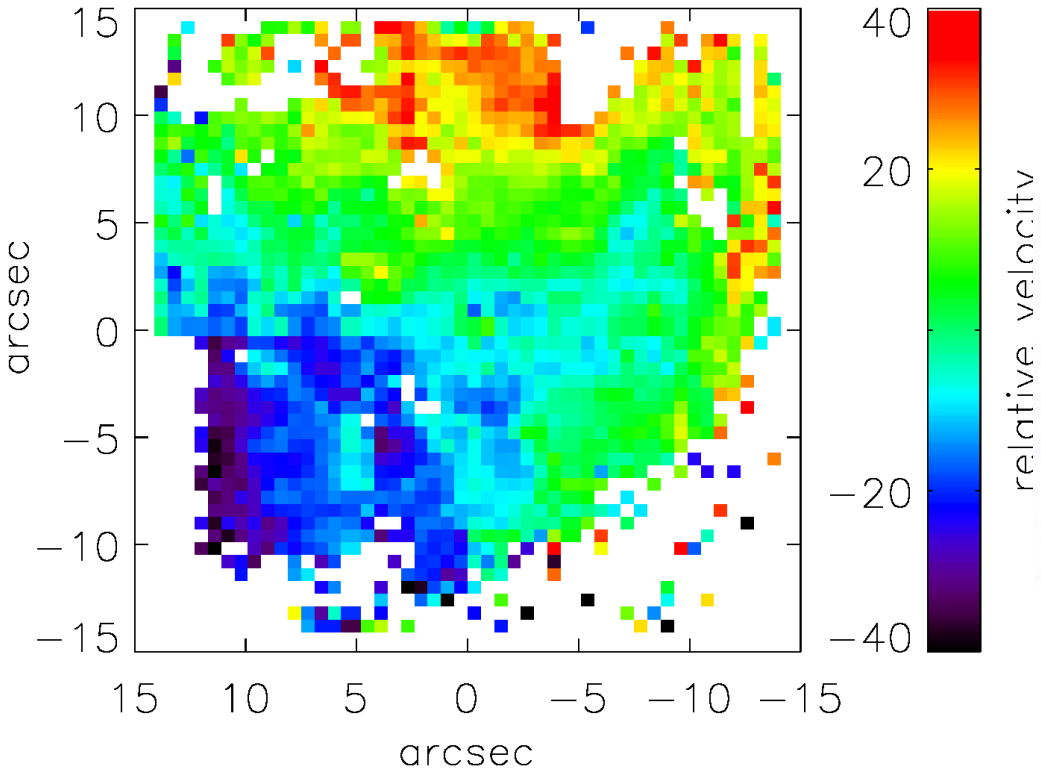
- GRB 980425 / SN 1998bw
  - at z = 0.0087
    - $M_* \sim 5 \times 10^8 M_\odot$
- Wolf-Rayet Region
  - One of the brightest HII regions
  - Dominates the host's emission at FIR, mm, radio
  - One of the highest star formation rate densities in the local universe
    - $sSFR_{W\text{-}R} > 10 \times sSFR_{galaxy}$



HST image from Fynbo+ 2000

Why the extreme SF properties?

- Spectroscopic studies showed no interaction with the 6 galaxies in the field (Foley+ 2006)



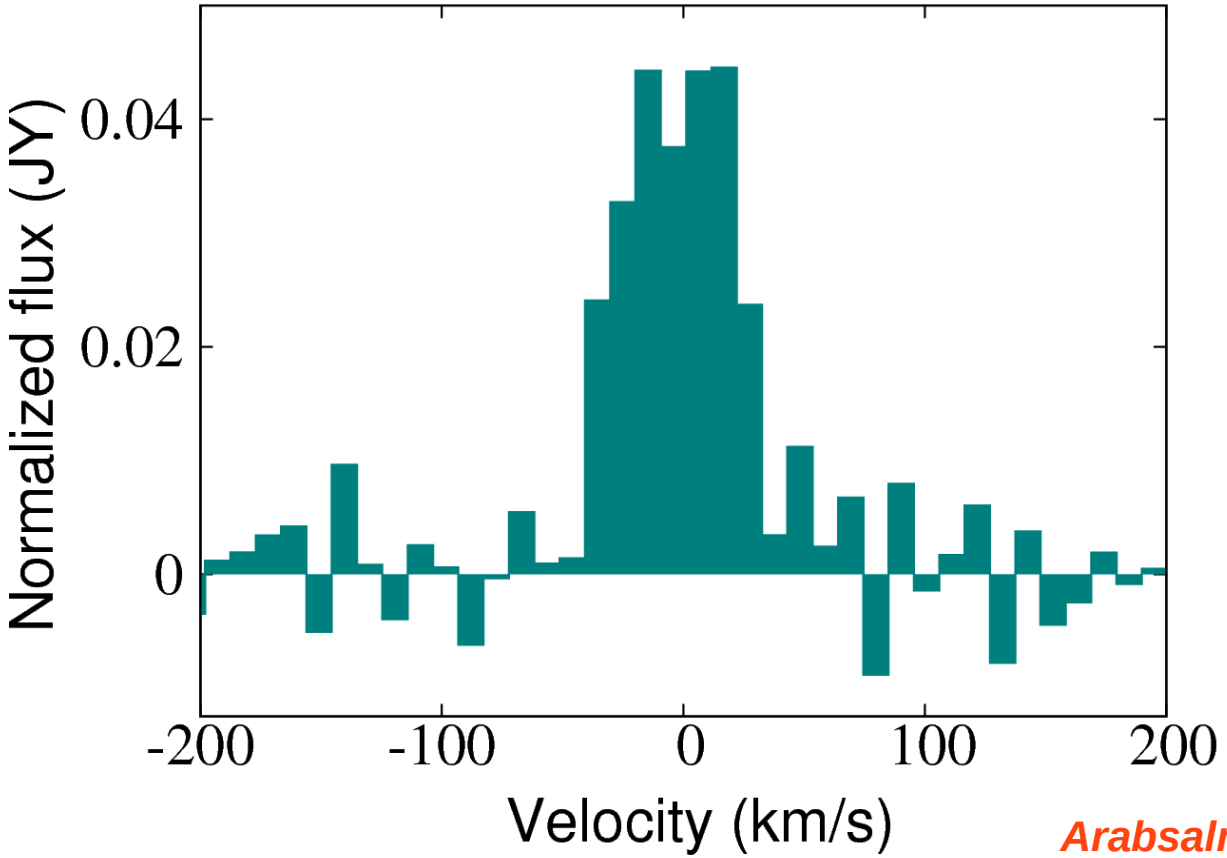
Velocity field from Hα observations

Christensen+ 2008

- ***GMRT HI 21 cm observations*** (-53 deg. declination!)
  - Initially 2.5 hours on source, followed by 10 hours on source

The HI 21 cm emission spectrum

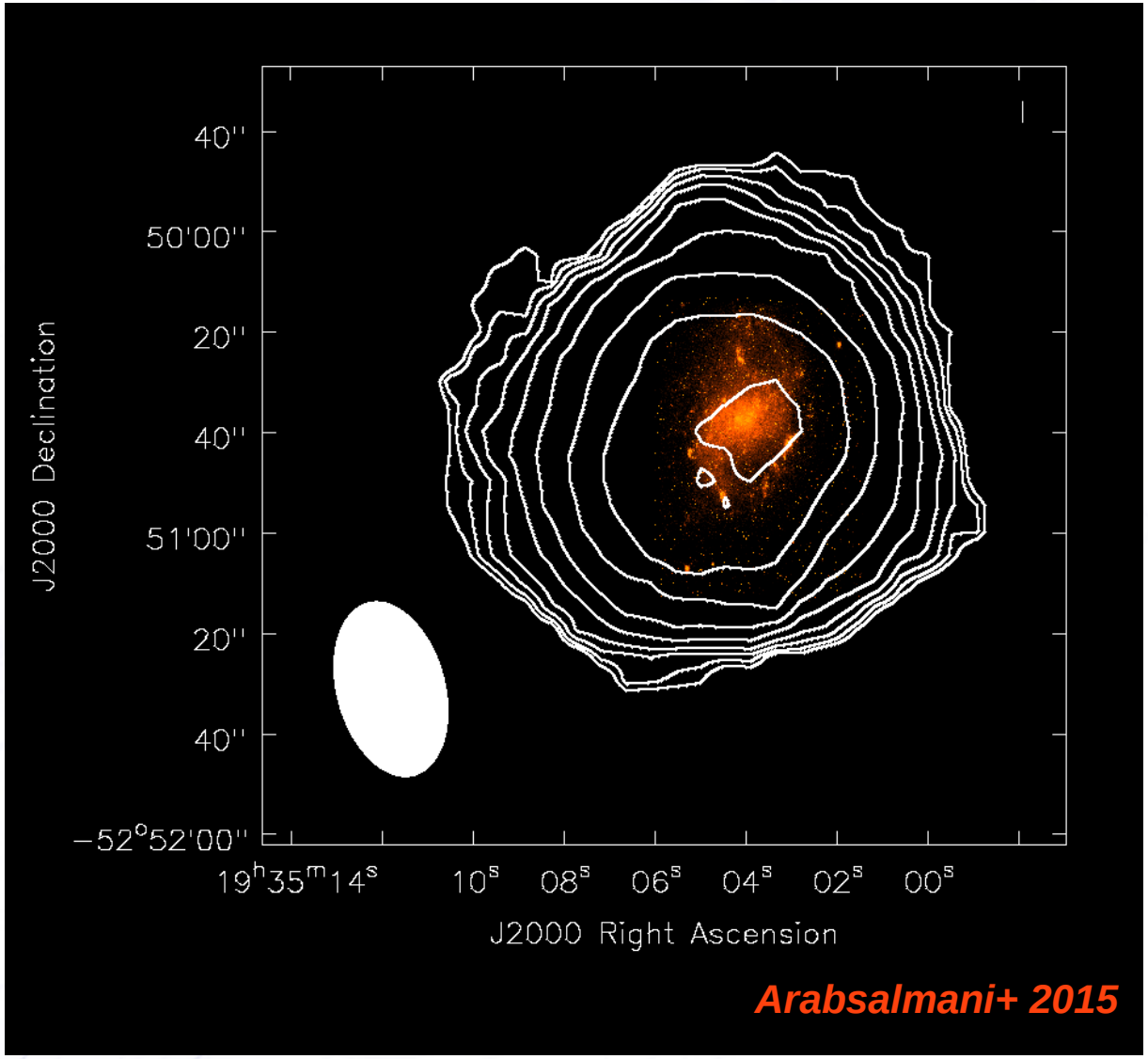
$M_{HI} = 10^9 M_\odot \sim 2 \times M_*$



Arabsalmani+ 2015

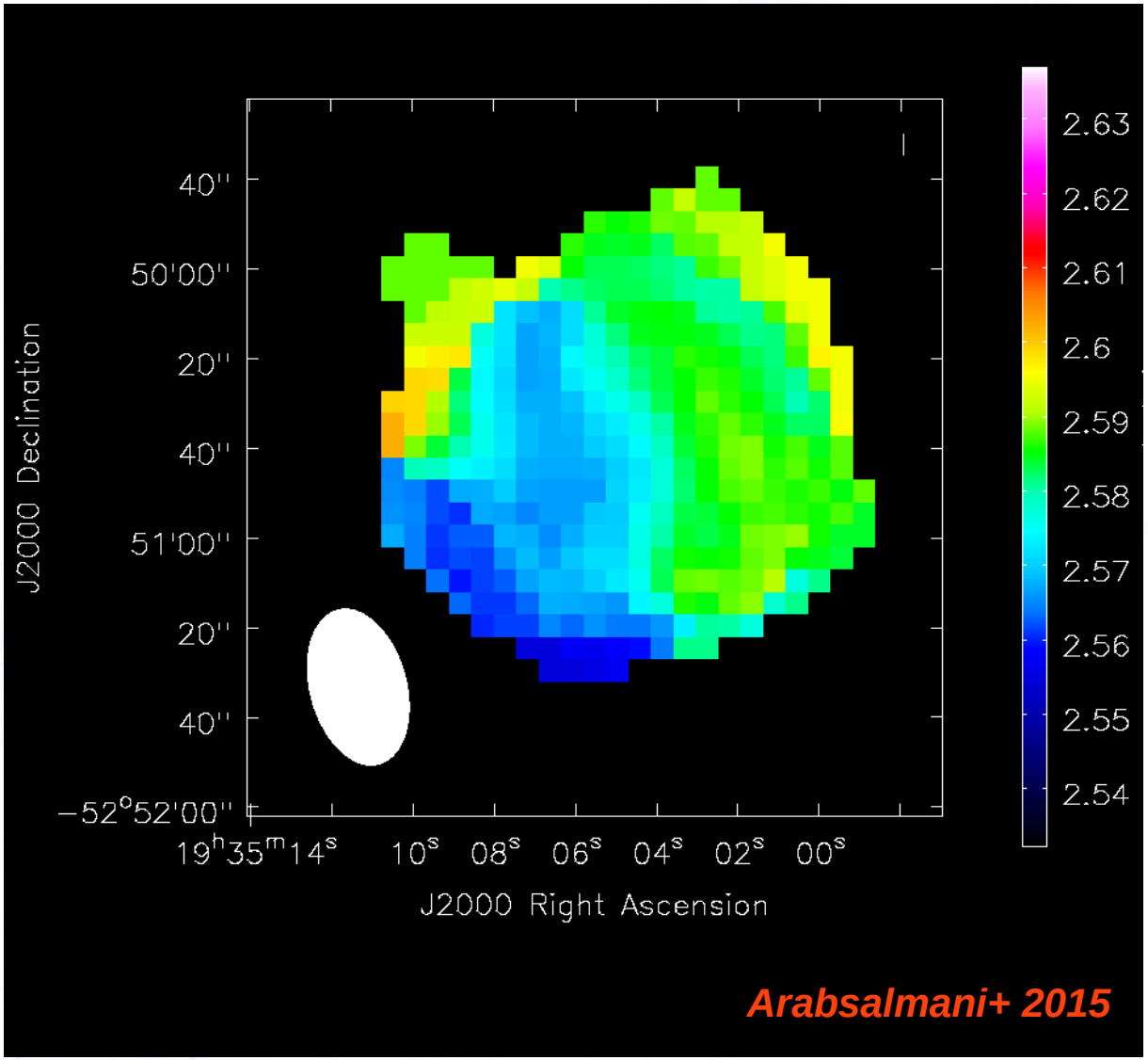
Total intensity map

Coarse Resolution, sensitive to the extended emission



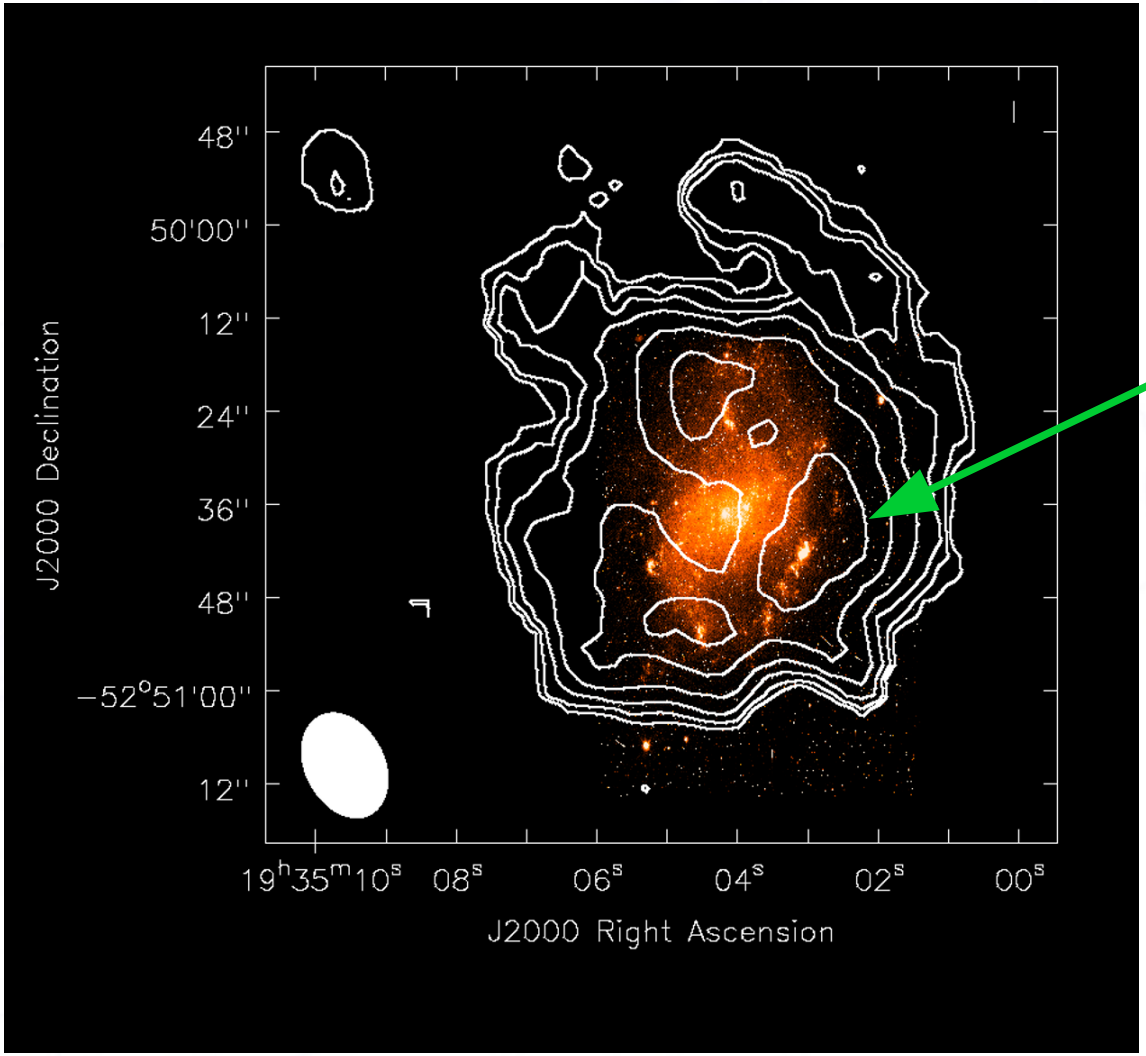
Velocity field

Coarse spatial resolution, Unit: 10^3 km/s



Total intensity map

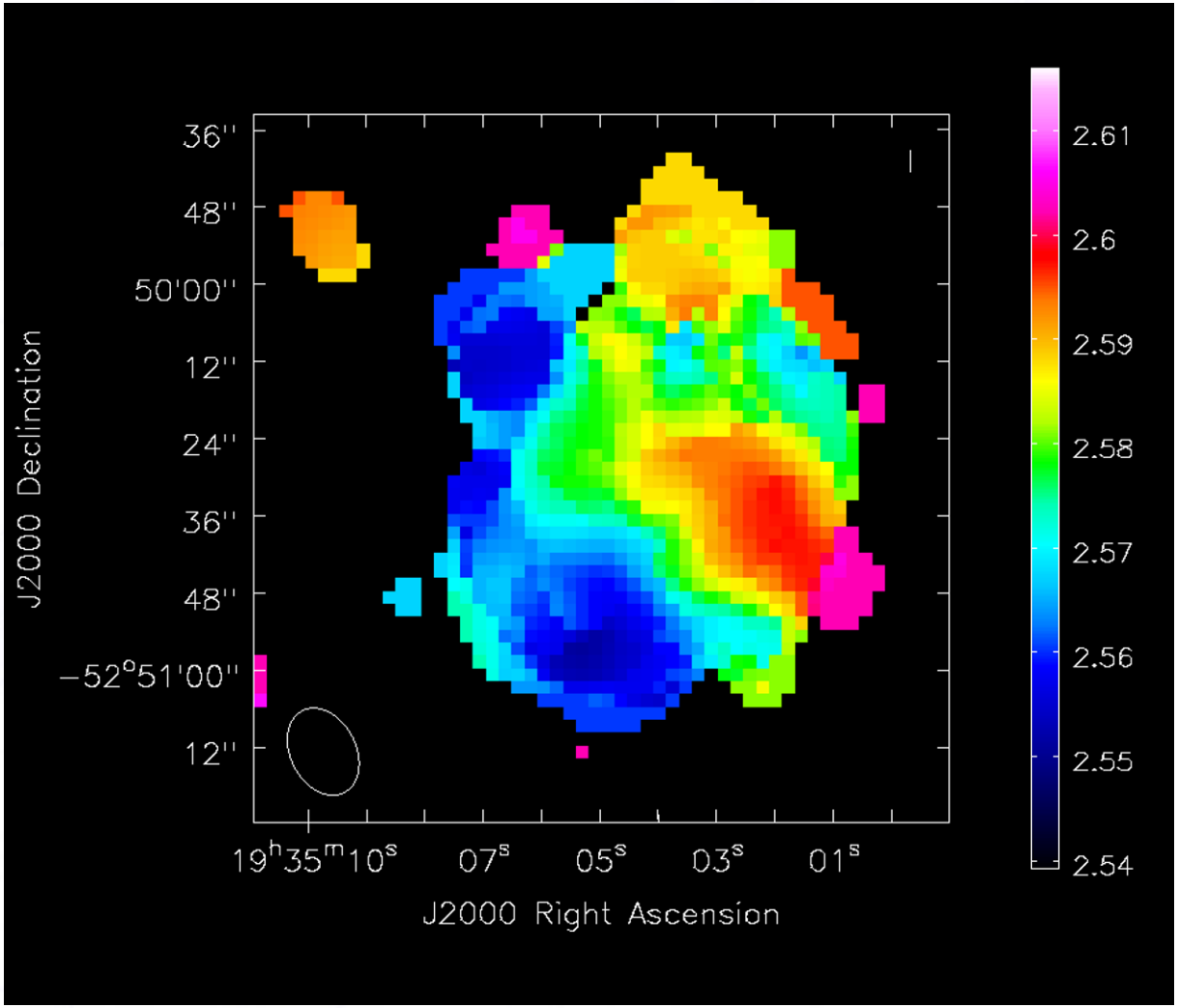
Medium Resolution, the actual extent of the gas disk seen



N(HI) = 10^{21} cm^{-2}

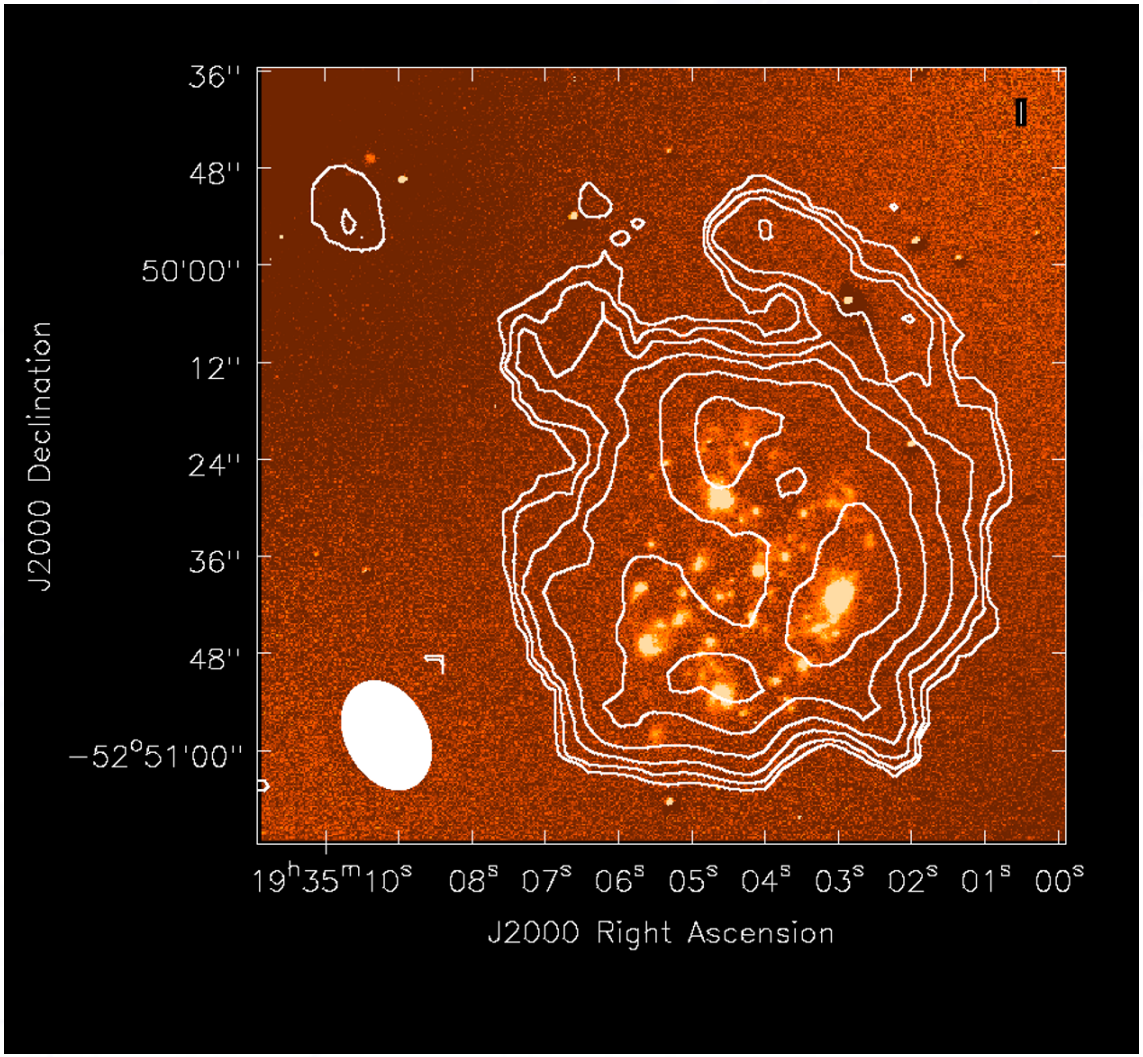
Velocity field

Medium spatial resolution, Unit: 10^3 km/s



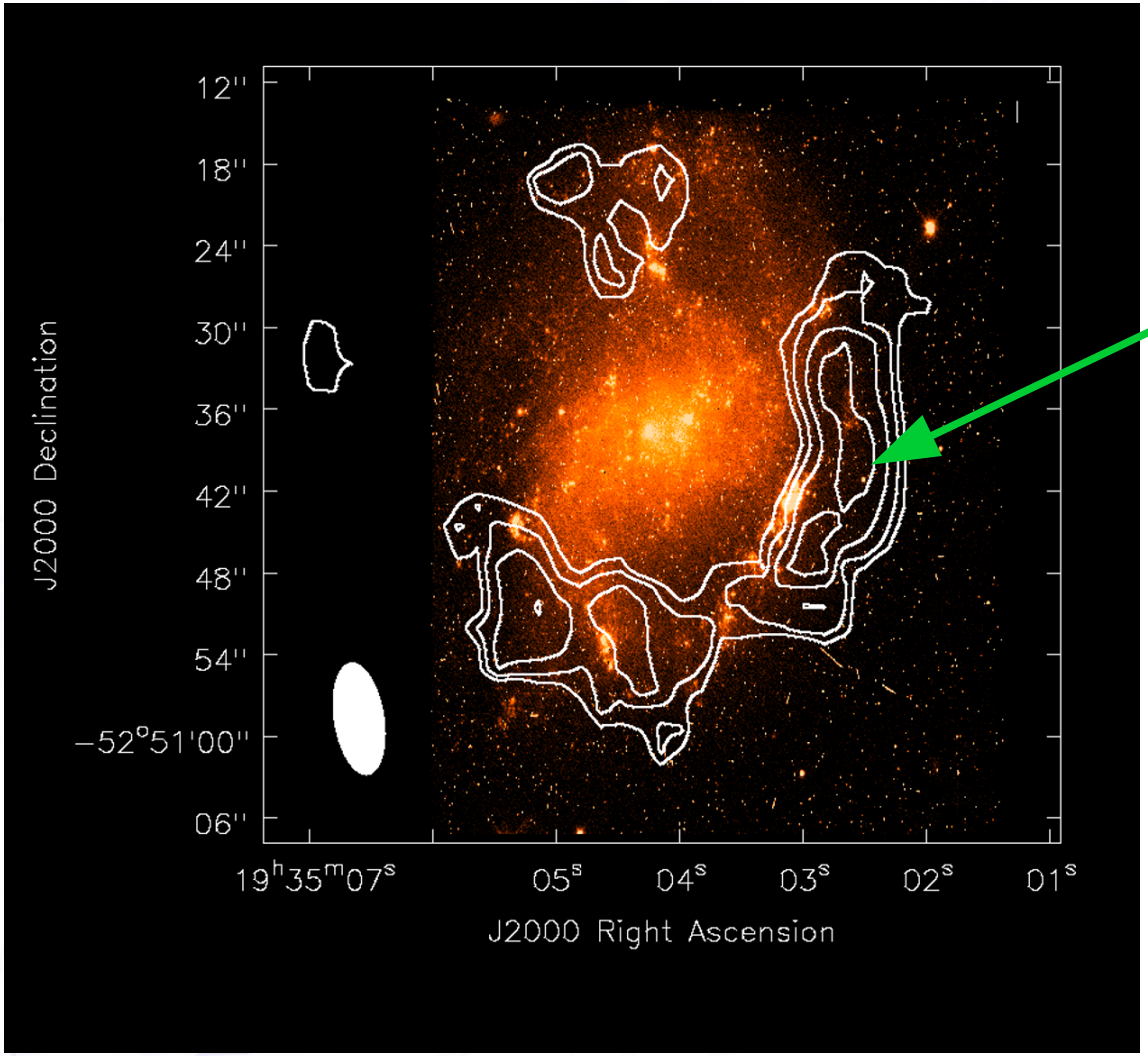
Total intensity map

Medium Resolution, overlayed on Hα image



Total intensity map

High Resolution map, sensitive to the highest N(HI)

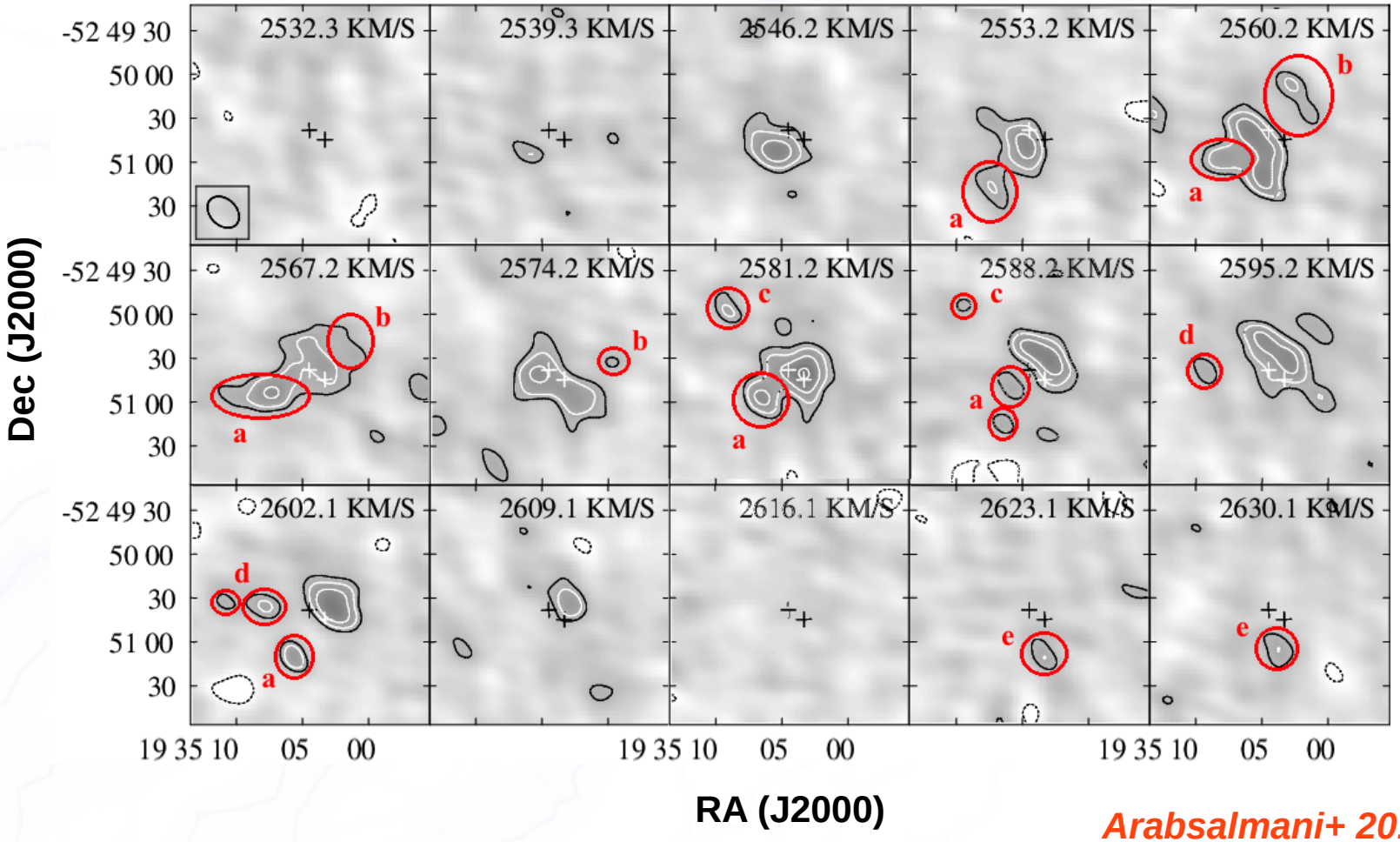


N(HI) = $10^{21.2}$ cm^{-2}

Velocity channel maps

Disturbed gas, with more than 23% of HI offset in velocity

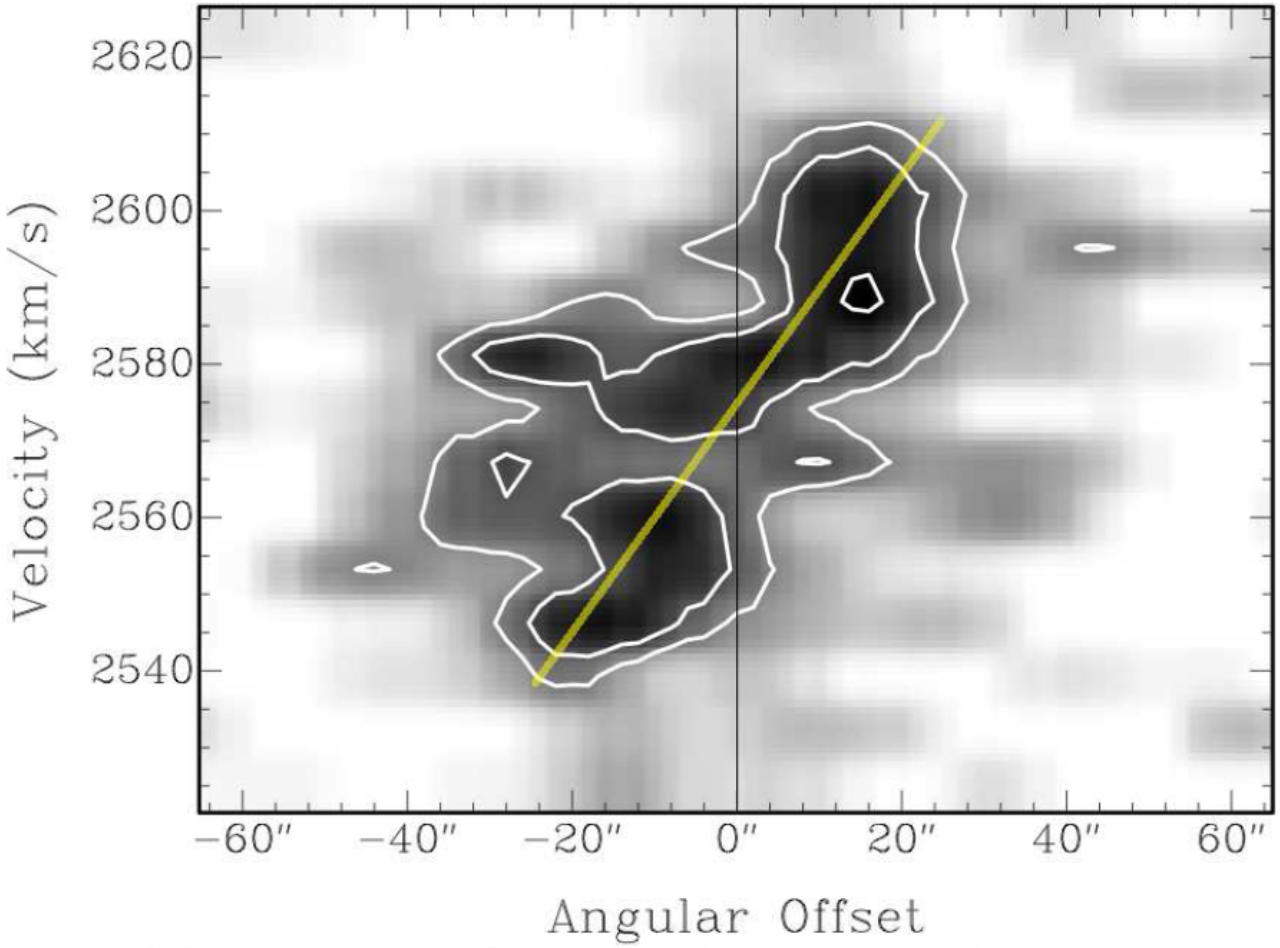
Minor merger caused enhanced star formation



Arabsalmani+ 2015

Position-velocity diagram

Cut along major kinematic axis.



Arabsalmani+ 2015

HI content of nearby GRB hosts

- Other than for the nearest, all we have are limits
  - A difficult task for the present generation of radio observatories

GRB	Redshift	$\log(M_*/M_\odot)$	$\log(M_{HI}/M_\odot)$	Best observation using
980425	0.0087	8.7	9.0	GMRT
060218	0.0334	7.72	<7.8	Arecibo
100316	0.0591	8.93	<9.7	ATCA (Michalowski+ 15)
060505	0.0889	9.76	<9.2	GMRT, JVLA D
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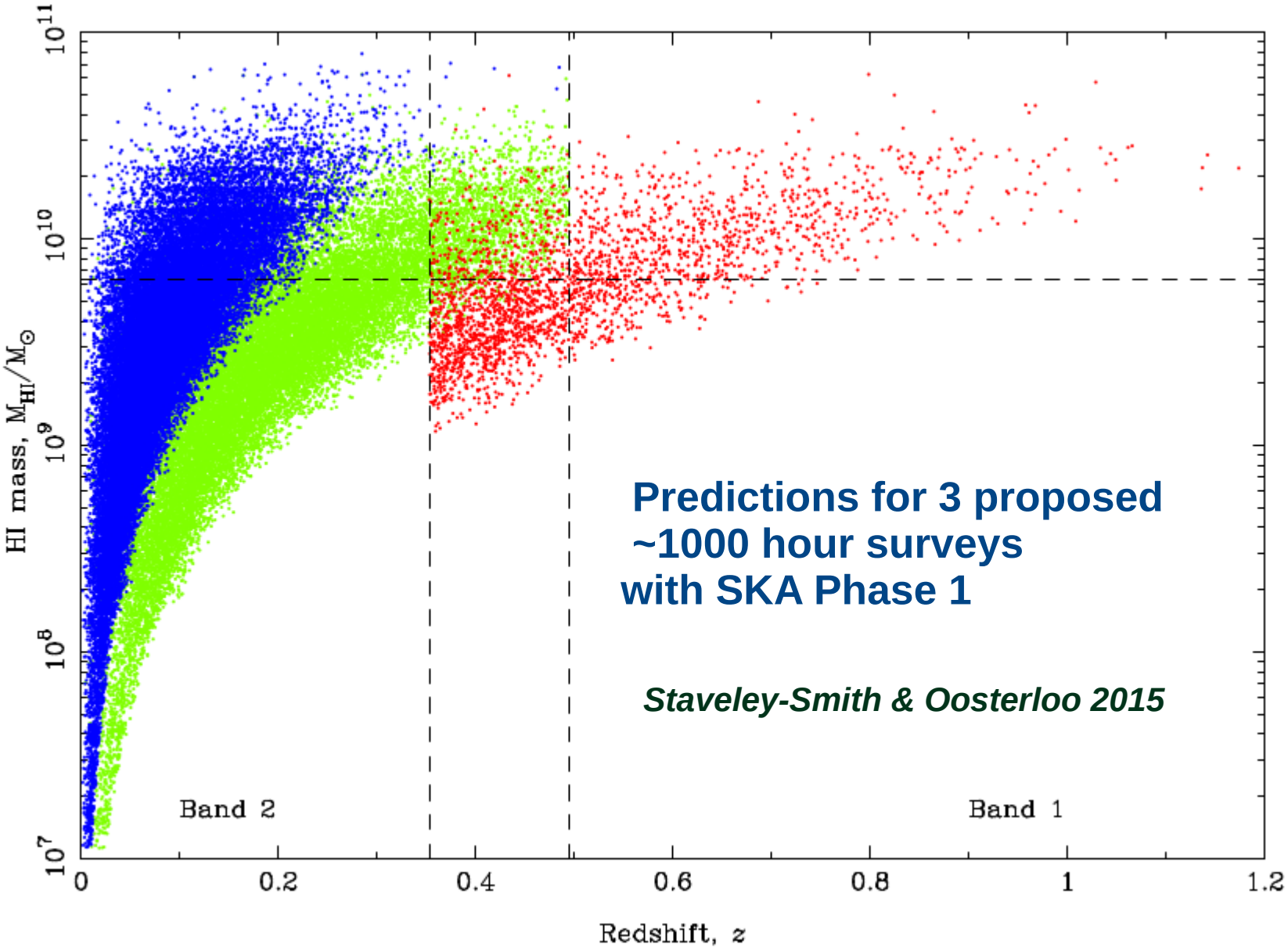
Arabsalmani, Roychowdhury+ in preparation

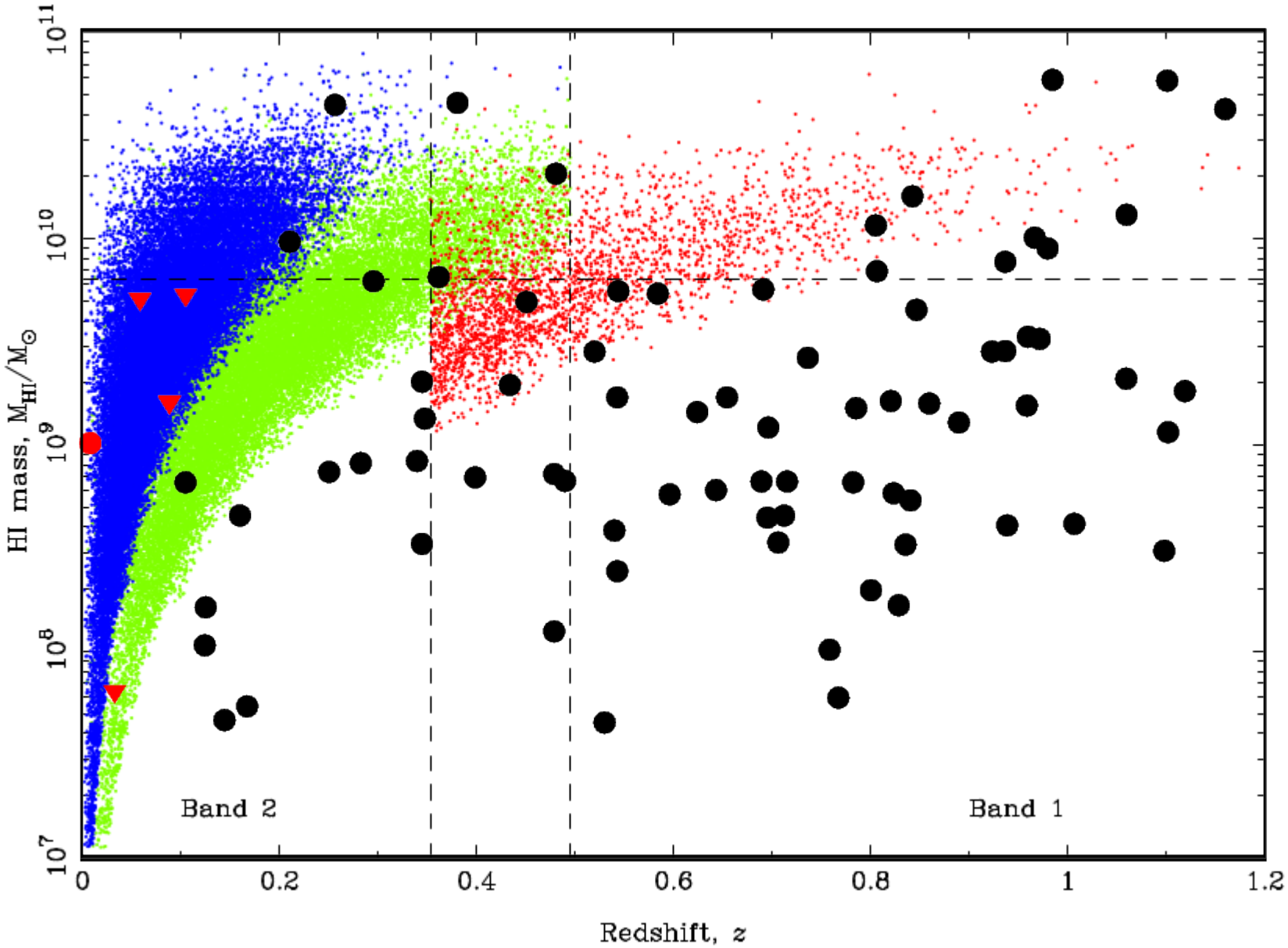
SKA to the rescue?



Predictions for 3 proposed ~1000 hour surveys with SKA Phase 1

Staveley-Smith & Oosterloo 2015

SKA necessary to create sample



Summary

- GRBs: beacons of star forming galaxies upto the highest redshifts
- GRB hosts display very high N(HI) in absorption
- Their atomic gas show complex kinematics in absorption

- Gas content and distribution unknown
- We carried out a HI 21 cm emission survey of nearby GRB hosts
- Closest known GRB host → minor merger behind GRB formation
- Non-detection of HI in emission from other hosts
- SKA absolutely necessary to map the atomic gas in GRB hosts and establish the real nature of GRB hosts