The structure of the Zone of Avoidance by high enough(?) resolution – foreground of GRBs

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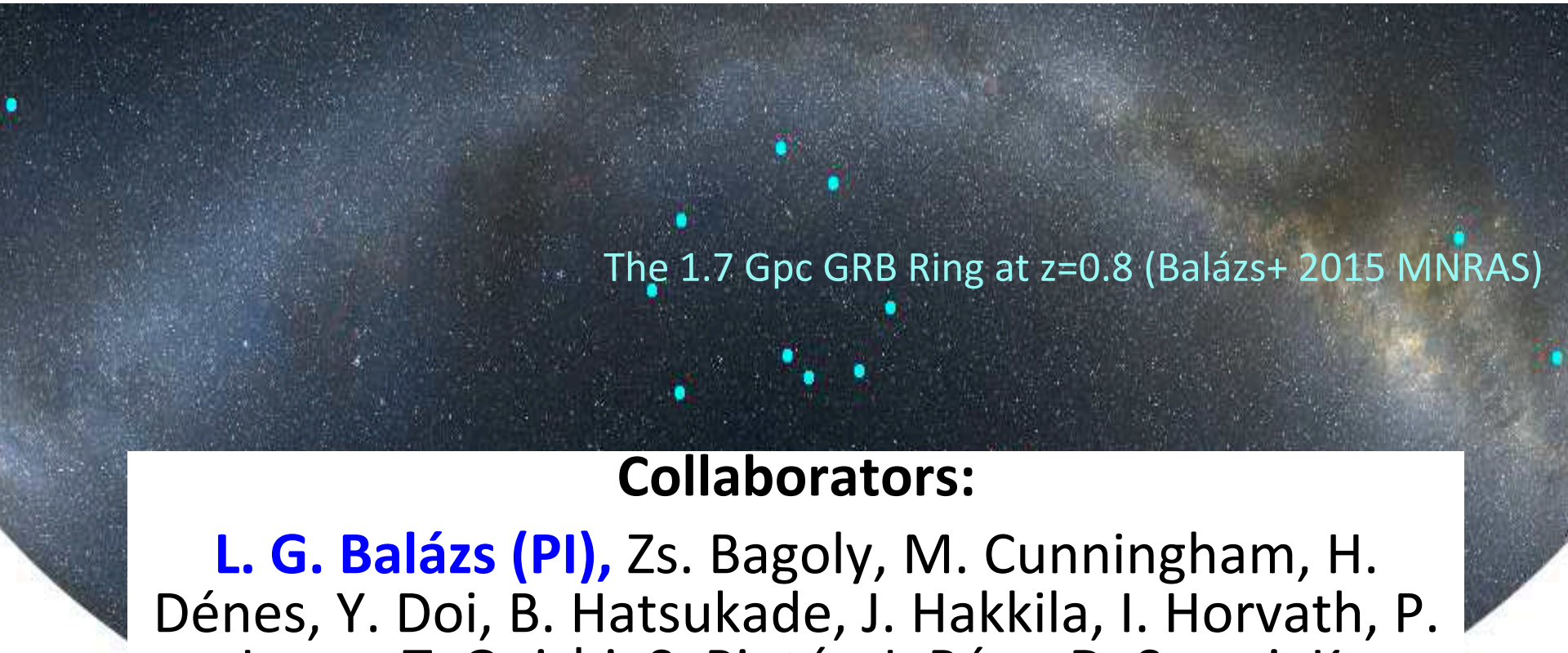


Collaborators:

L. G. Balázs (PI), Zs. Bagoly, M. Cunningham, H. Dénes, Y. Doi, B. Hatsukade, J. Hakkila, I. Horvath, P. Jones, T. Onishi, S. Pintér, I. Rácz, D. Szecsi, K. Tachihara, P. Veres, S. Zahorecz

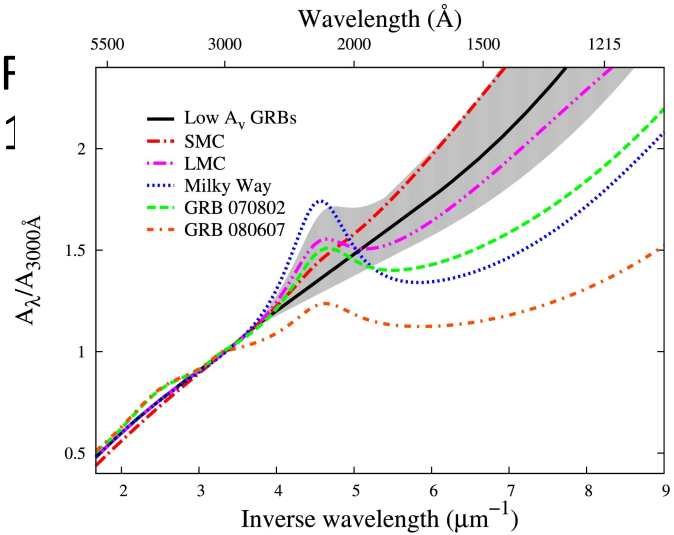
Long or “classical” GRBs (Mészáros 2006)

- associated with explosions of massive stars (Stanek+ 2003)
- expected to trace ongoing star-formation up to z = 9.4
- Prompt γ emission (0.1-2 MeV) – internal shock
  - Thermal emission from the photosphere
  - Non-thermal emission, produced in the jet
  - by reverse shock propagating back into the ejecta
  - Note: Less likely from magnetic reconnection or dissipation processes, if the ejecta is highly magnetized
- Afterglow – external shock
  - fireball advancing into an approximately smooth external environment (wind blown stellar or ISM)
  - GRB jet impacts the surrounding medium → afterglow (e.g. Mészáros + Rees 1992; Sari+1998)

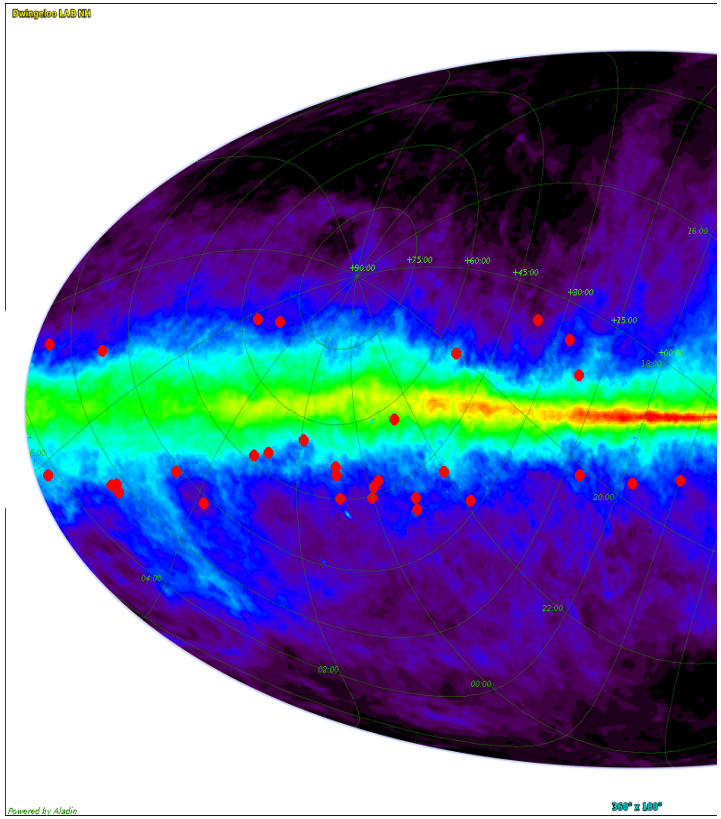
Intrinsic ISM parameters (density, metallicity, …) at the GRB jet (< 200 pc)?

- What are the parameters there around the GRB?
- Afterglow: continuum radiation in all wavelengths
- Afterglow X-ray spectrum – bright and "simple"
  - Approximated as power-law continuum modulated by absorption (Behar+2011; Schady+2011; Zafar+2011; Campana +2012 …)
  - Iron emission line
- Rest frame optical and UV abs. lines (eg. F Elíasdóttir+2009 dust; Perley+2011, Schady+2011
  - Metallicity and extiction peculiarities
- Absorption: intrinsic, CGM, IGM, MW

(eg. Schady 2015 JHEA)



Estimating the Galactic foreground 1. input data



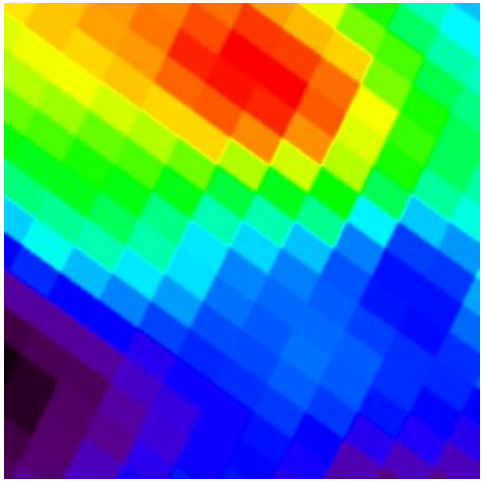
Swift GRBs at low B with known ***z*** overlaid on HI 21cm map

- **Spectroscopy**
- **HI surveys**
  - **LAB 36’** (Leiden Argentine Bonn Survey, Bajaja+1985; Kalberla+2005)
  - **EBHIS 10.8’** (Effelsberg-Bonn HI Survey of Milky Way gas Winkel+2015)
  - **HI4PI 16.2’** (EBHIS+GASS, HI4PI collaboration 2016)
- **IRAS products 5’ - 6’**
  - **SFD** (IRAS recalibrated, Schlegel+1998)
  - **SFD recalibrated** (SDSS, Schlafly+2011)

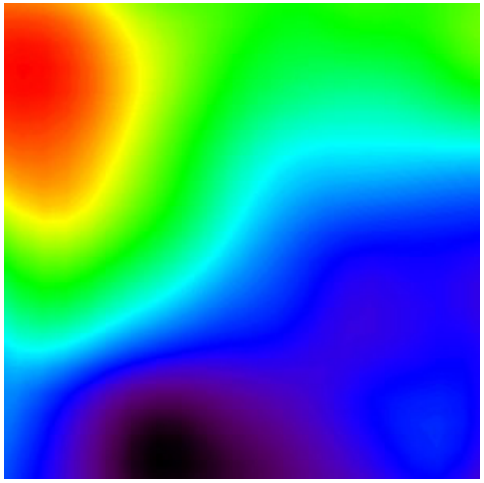
New:

- **pan-STARRS1 E(B-V) 7’-14’** (d < 4.5 kpc stellar photometry, Schlafly+2014, Green+2015)
- **AKARI FIS 2’** (Doi +2015)
- **Planck PR2 A_V 5’** (Planck Collaboration 2016)
- ATCA HI 21cm (this study)

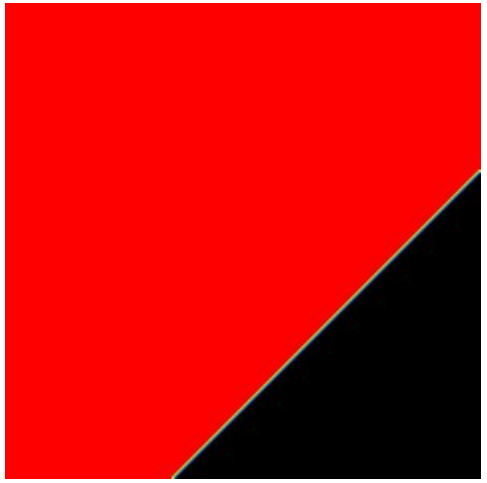
IRAS based N(H)
Schlegel et al. 1998



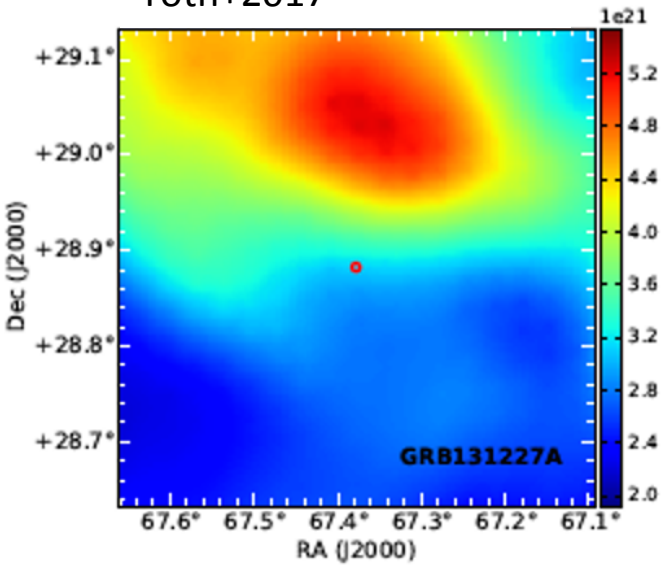
HI 21cm line intensity
Winkel et al. 2016



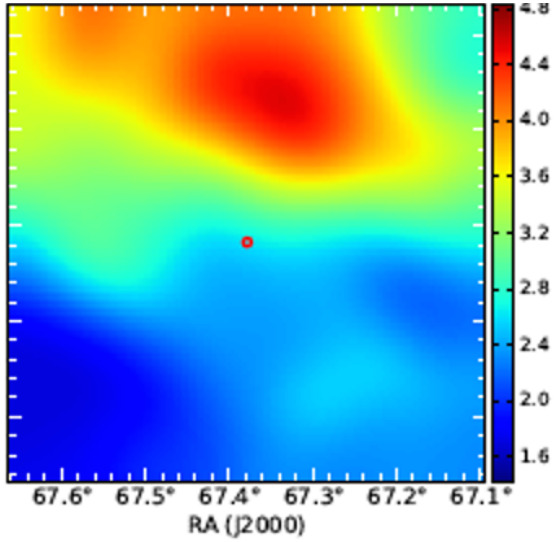
HI 21cm line intensity
Dickey & Lockmann 1990



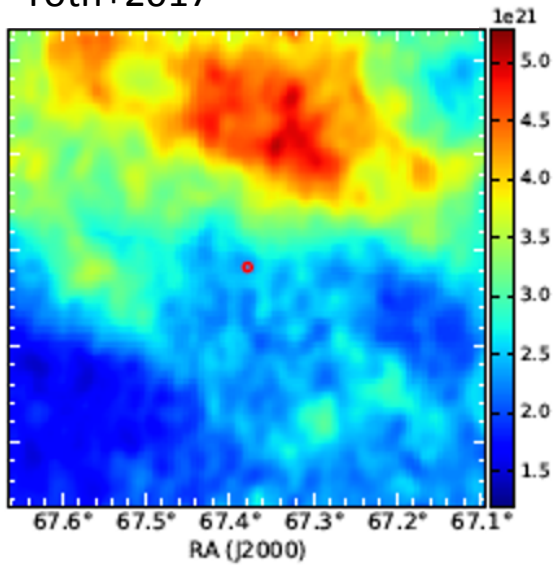
Planck based N(H)
Tóth+2017



AKARI based smothed N(H)
Tóth+2017



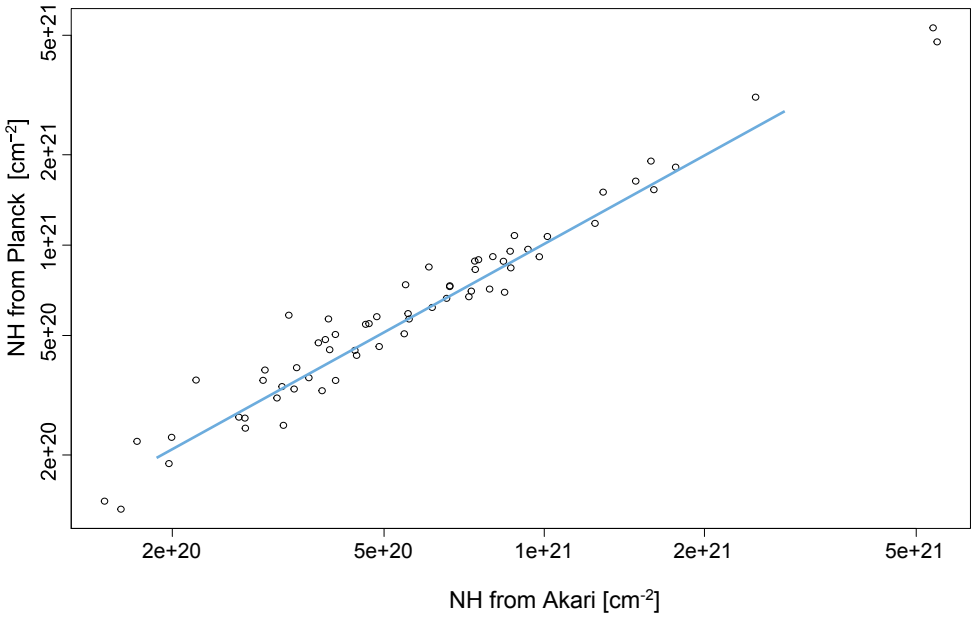
AKARI based N(H)
Tóth+2017



GRB 131227A, z=5.3; N(H) down 20%

Estimating the Galactic foreground 2. data proc.

Correlation of Planck & AKARI based N(H)



Planck A_V PR2

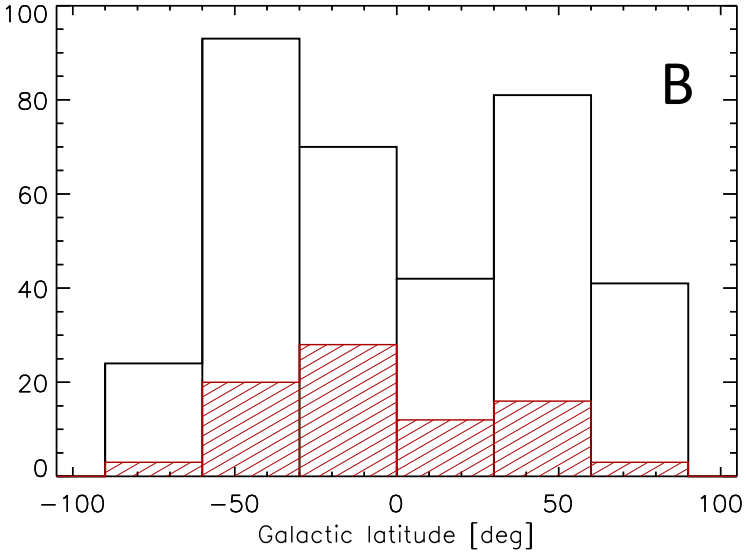
- based on WISE 12µm; IRAS 60µm & 100µm; Planck 857GHz; 545GHz; 353GHz PR2
- Dust model (Drain+Li 2007) renormalized to SDSS QSO

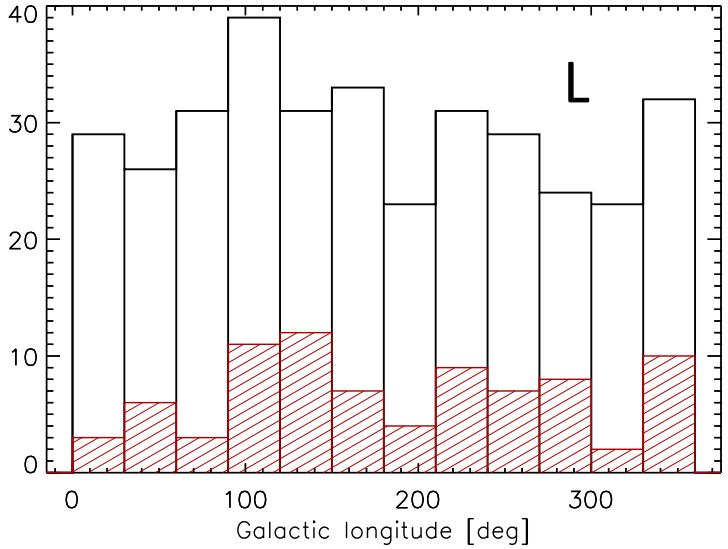
AKARI FIS based N(H)

- AKARI Far Infrared Surveyor (FIS, Kawada+2007)
- All sky images 65, 90, 140, 160µm (Doi+2015)
- Zodi subtraction (Ootsubo+2016)
- T_dust → radiance → N(H)
- Smoothed to 5' & correlated with Planck A_V
- 30' x 30' fields selected (GRBs)
- Renormalized to Planck

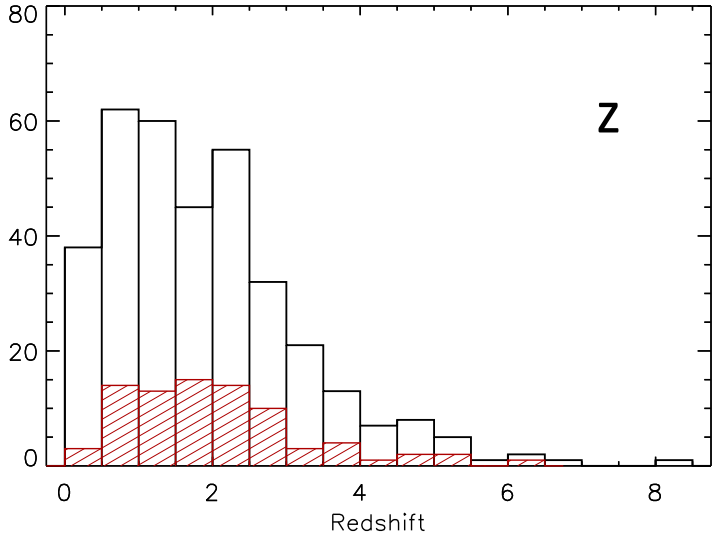
Planck maps: http://pla.esac.esa.int/pla/#maps

Selected GRB directions (depending on the available AKARI image quality)



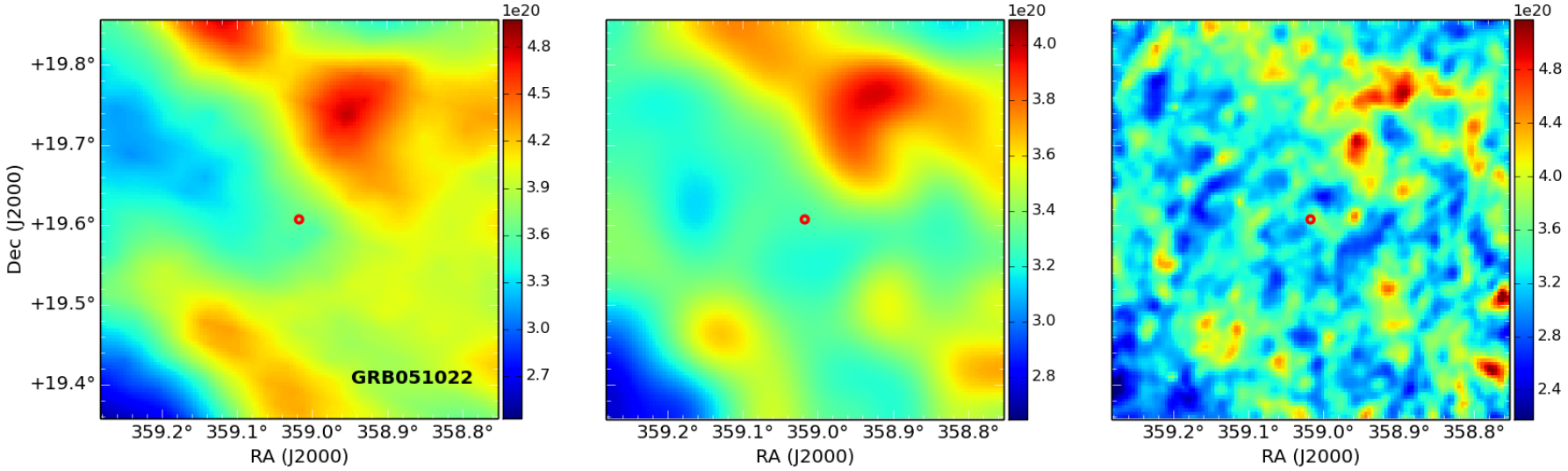


- Low and intermediate galactic latitudes are over-represented



GRB 051022A – LGRB in the GRB Ring

- Well known dark LGRB, (no optical afterglow / $A_{V,Int}$)
- Host galaxy
  - SFR = 271 $M_{\odot} yr^{-1}$ (from [OII] line flux); stellar mass: $logM_{*} = 10.42 \pm 0.05\ M_{\odot}$ (Levesque+2014); detected in CO 4-3 (ALMA, Hatsukade+2014)
- HI foreground EBHIS: $N(H)_{Gal} = 3.9E+20\ cm^{-2}$

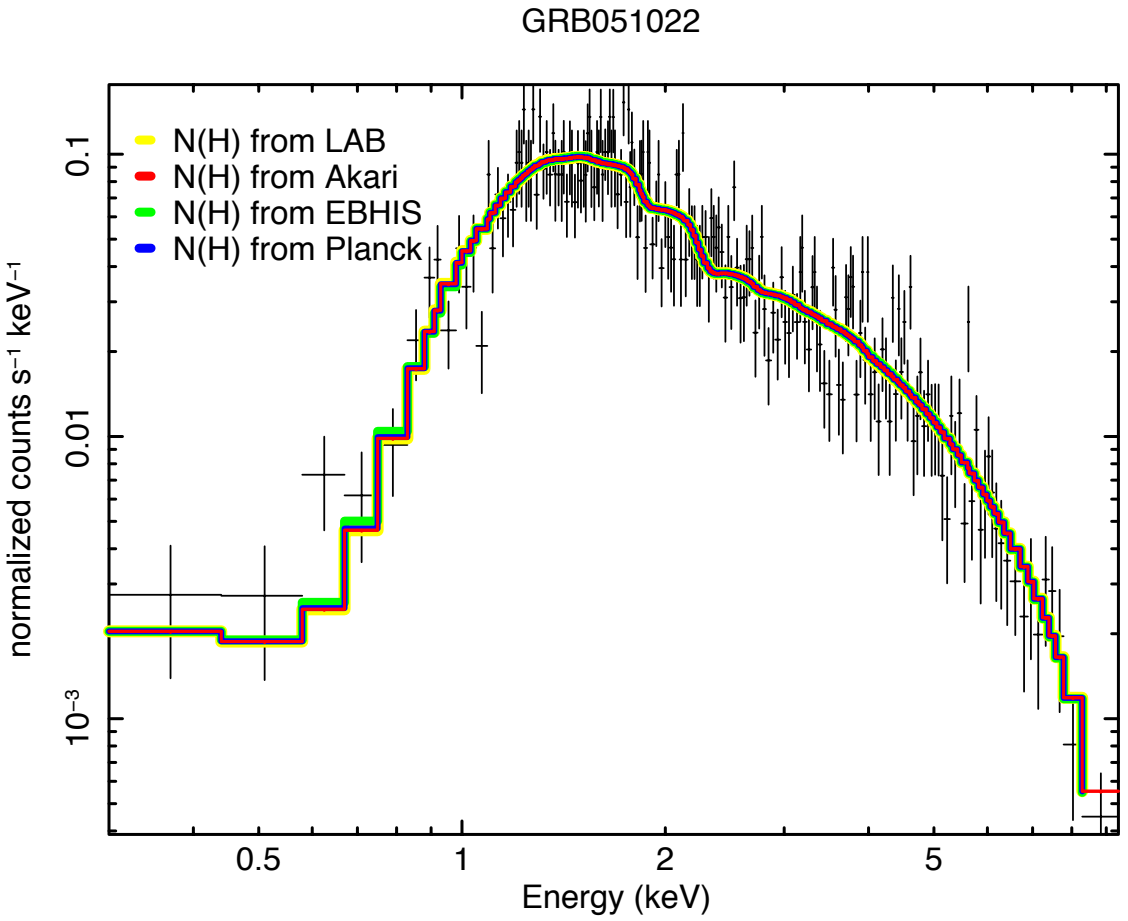


Planck smoothed AKARI FIS AKARI FIS

AKARI: $N(H)_{Gal} = 3.3E+20\ cm^{-2}$ (Tóth+ 2017)

X-ray spectrum of GRB 051022A re-fitted

- Swift-XRT GRB Catalogue (Evans+ 2009)
- analyzed with Xspec (Arnaud 1996)
- same model as in the automatic analysis of the UKSSDC (Evans+ 2009)
- with refined AKARI based foreground $N(H)_{Gal}$
- $N(H)_{Int}$ at host galaxy: 5% higher



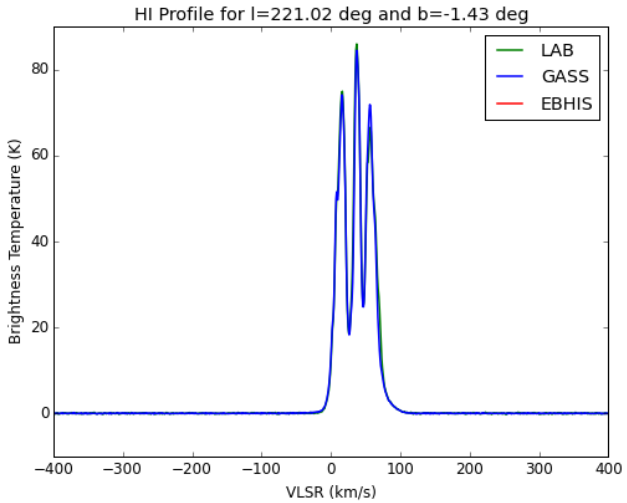
See also:
http://www.swift.ac.uk/xrt_spectra/docs.php
http://www.swift.ac.uk/xrt_spectra/algorithm.php

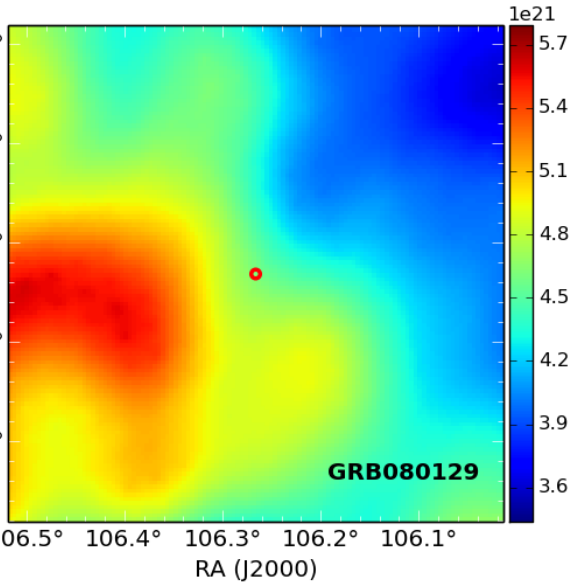
Rácz+ 2017

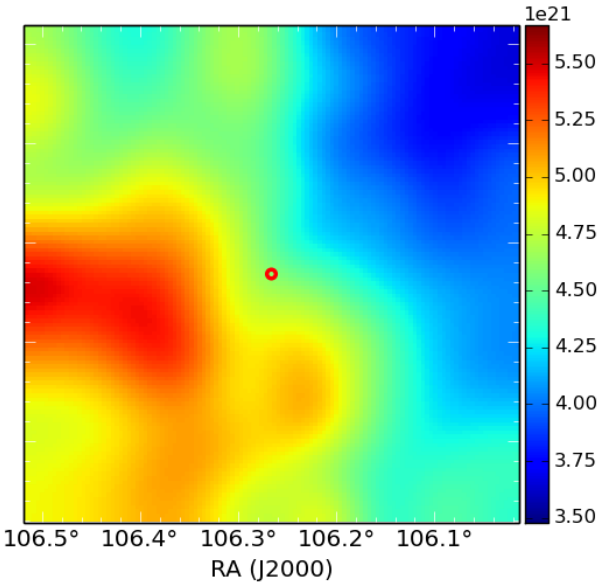
Galactic foreground of GRB 080129

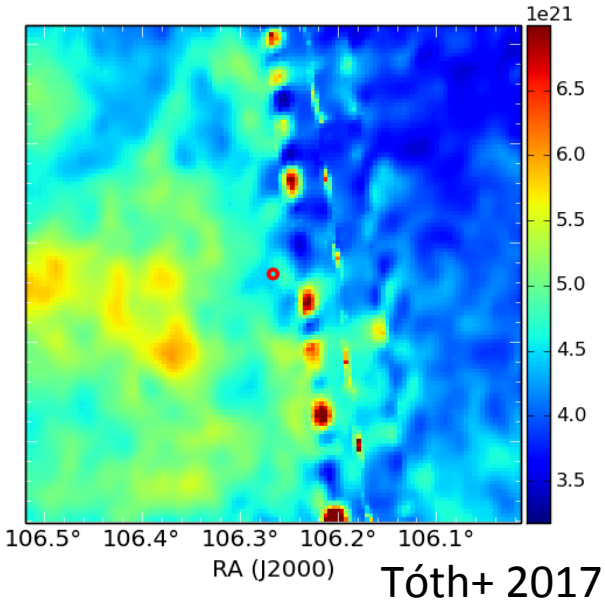
$N(H)_{GASS}$=6.3E+20 cm^{-2} from the GASSIII HI Survey (Kalberla +2015)

$N(H)_{AKARI}$=4.5E+20 cm^{-2} (artifacts!)





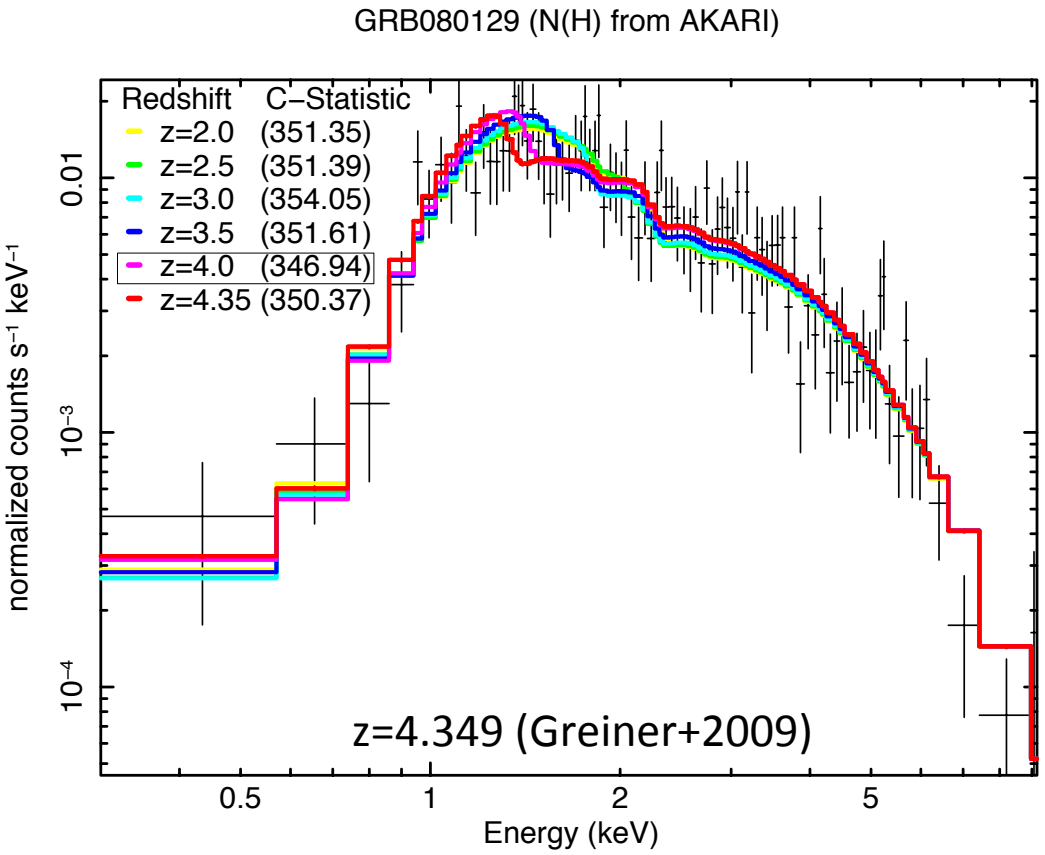




Tóth+ 2017

X-ray spectrum of GRB 080129 re-fitted

- Swift-XRT GRB Catalogue (Evans+ 2009)
- analyzed with Xspec (Arnaud 1996)
- same model as in the automatic analysis of the UKSSDC (Evans+ 2009)
- with refined AKARI based foreground $N(H)_{Gal}$
- $2< z < 4.35$ variation with fixed $N(H)_{Int}$



See also the poster by I. Rácz

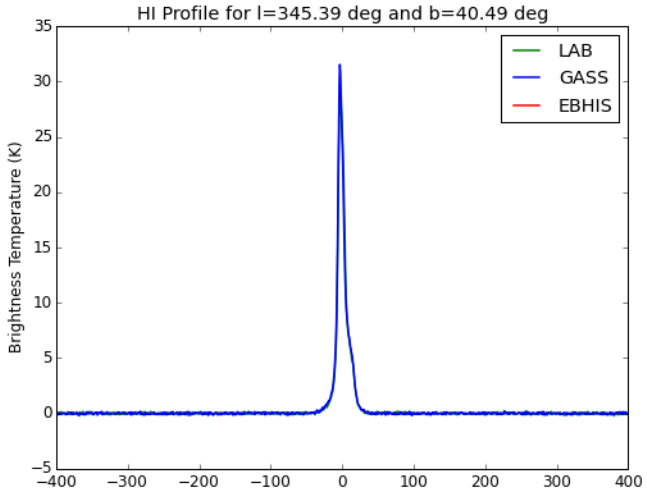
Tóth+ 2017

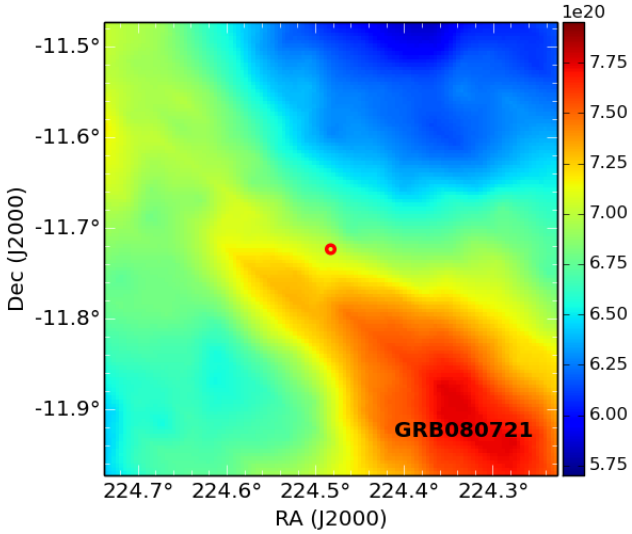
The Galactic foreground towards GRB 080721

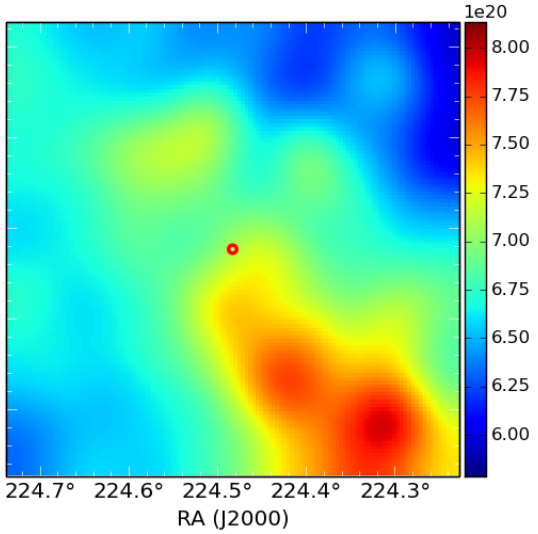
$N(H)_{GASS\ III} = 7.51E+20\ cm^{-2}$ (Kalberla +2015)

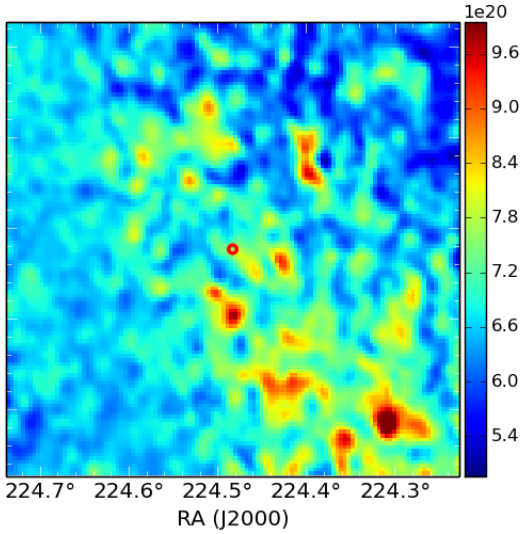
$N(H)_{LAB} = 6.9E+20\ cm^{-2}$ (Campana+2012)

$N(H)_{AKARI} = 6.8E+20\ cm^{-2}$



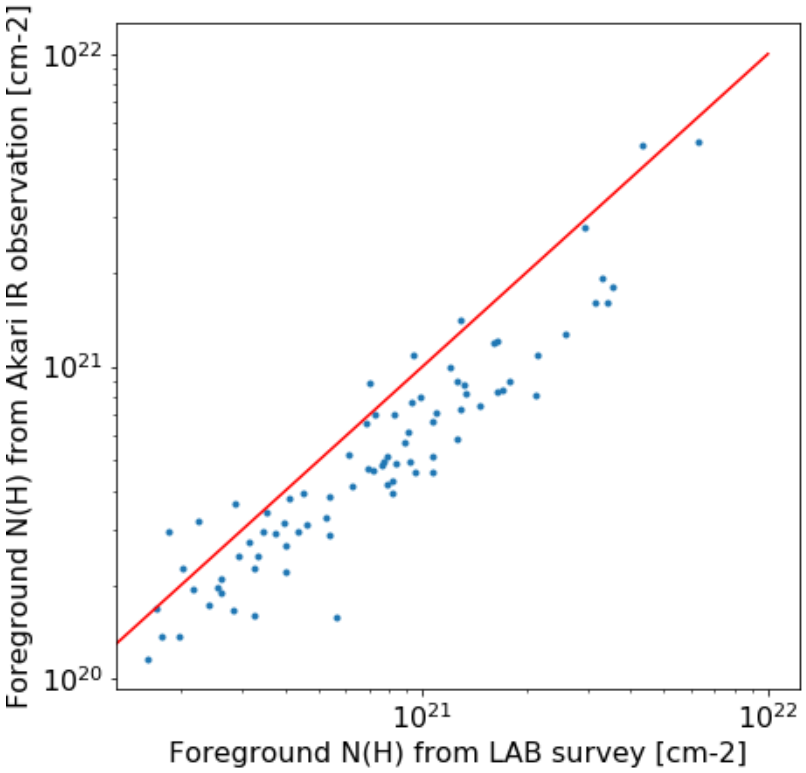




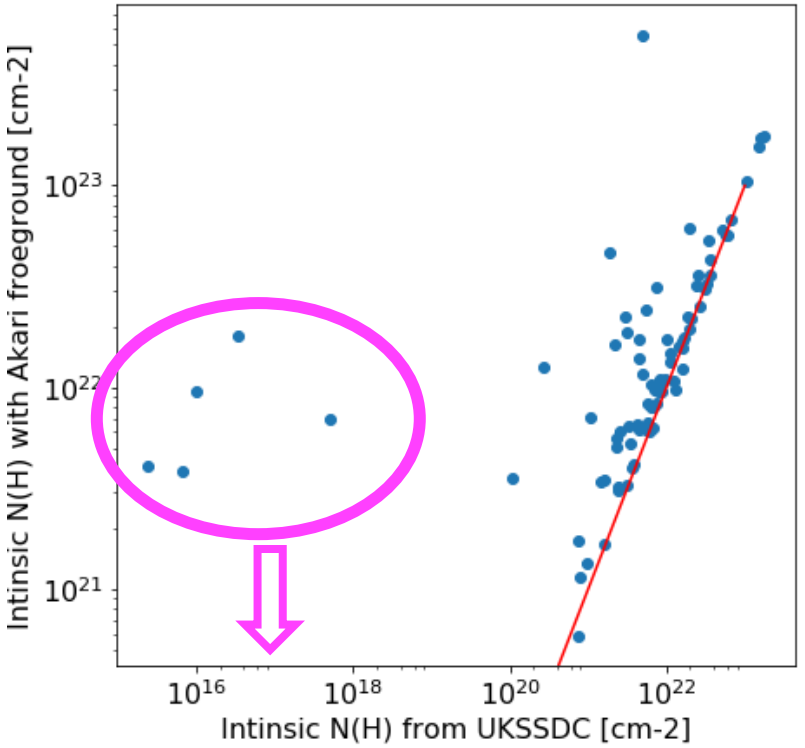


Effect of foreground (MW) correction on the intrinsic (host galaxy) hydrogen column density

Galactic foreground (MW)



Intrinsic N(H) (host galaxy)



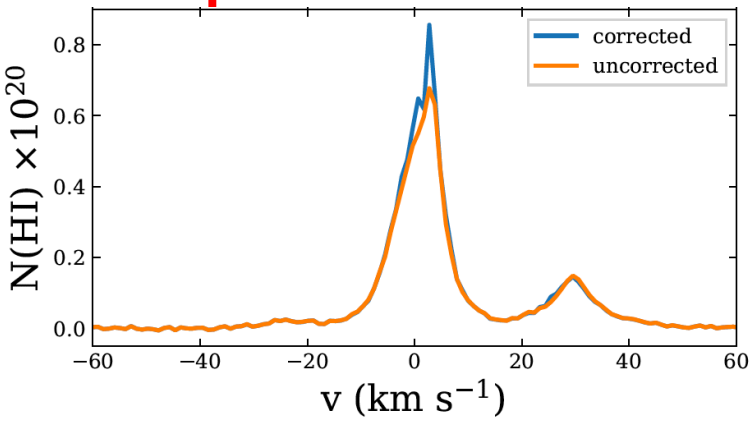
Tóth+ 2017

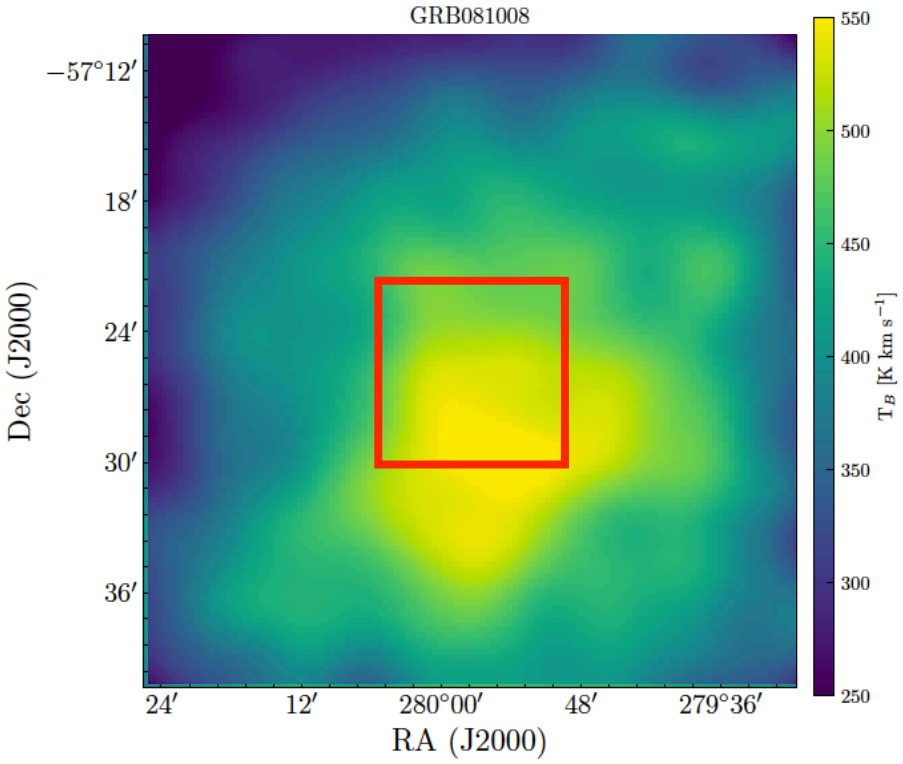
ATCA 21cm with continuum point sources

- Spatial resolution: 2.75'x2.12'
- velocity resolution: 0.103 kms^{-1}
- one phase ISM

$$N(HI)_{corrected} = C_0 \int_{\Delta V} T_B(v) \frac{\tau}{1 - e^{-\tau}} dv$$

- i.e. the measured T_B was corrected with the optical depth from HI absorption towards a continuum source near GRB 081008 (our target)

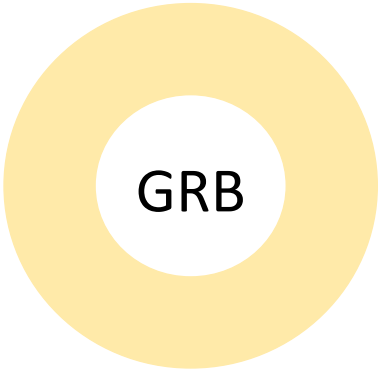




Dénes, Jones, Tóth+ in prep.

Summary

- Galactic foreground revealed by its IR emission
  - AKARI FIS
  - Herschel mapping: still more structure
    - see posters by Pintér, S. & Perger K.
- $N(H)_{MW}$ typically slightly lower than LAB estimates
  - Clumpy ISM on all the full column density ranges
  - Filling factor of dense ISM is low
- Resolution matters (a bit)
- **Slightly higher intrinsic N(H)**
- Need for further high resolution N(H)
  - using eg. ATCA, …



What will you take home after eating the cookies?

"cold material occupy only 1%" (Marc-Antoine)

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