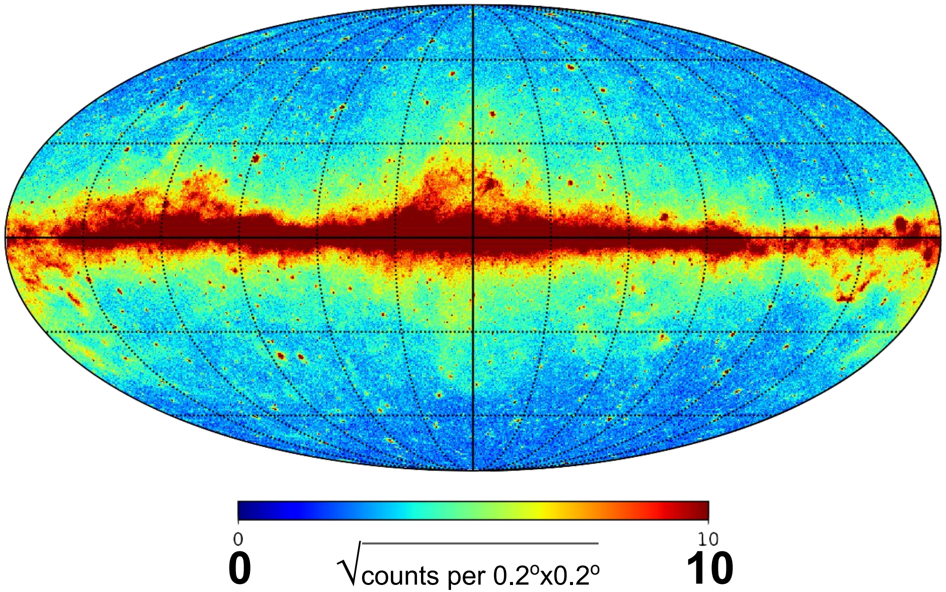
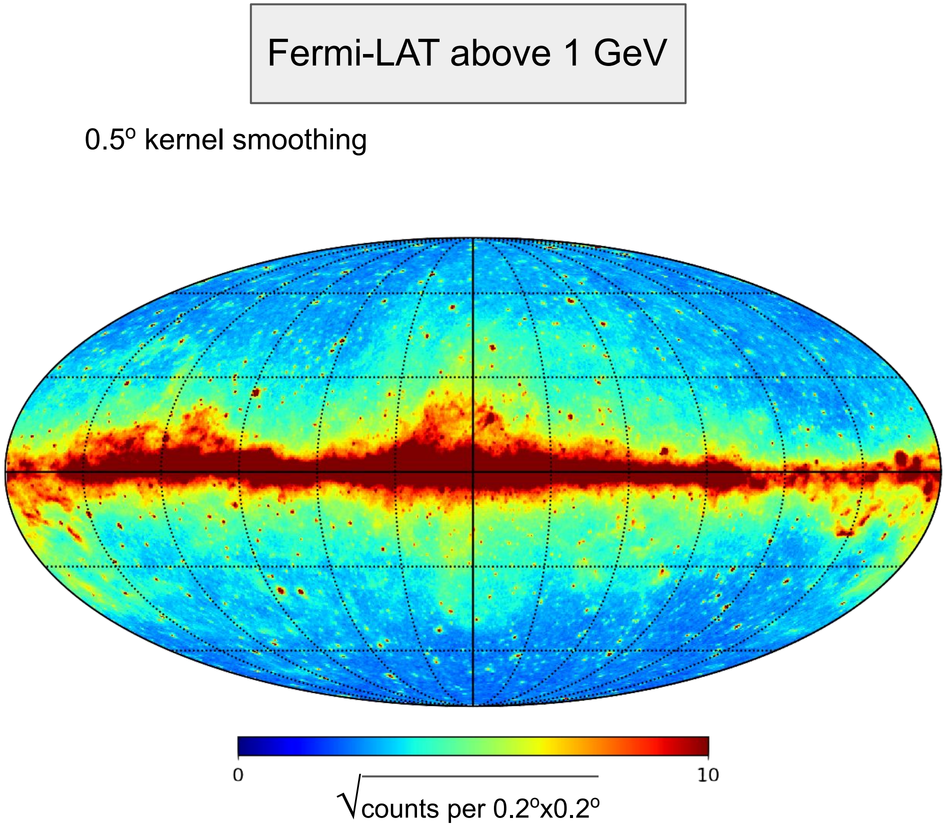
The Other Planck Constant :
Unseen dust emission at low NHI

Jean-Marc Casandjian
DAp, CEA - Saclay, France

- foreword: γ-ray with Fermi-LAT
- dust and HI column density
- UV

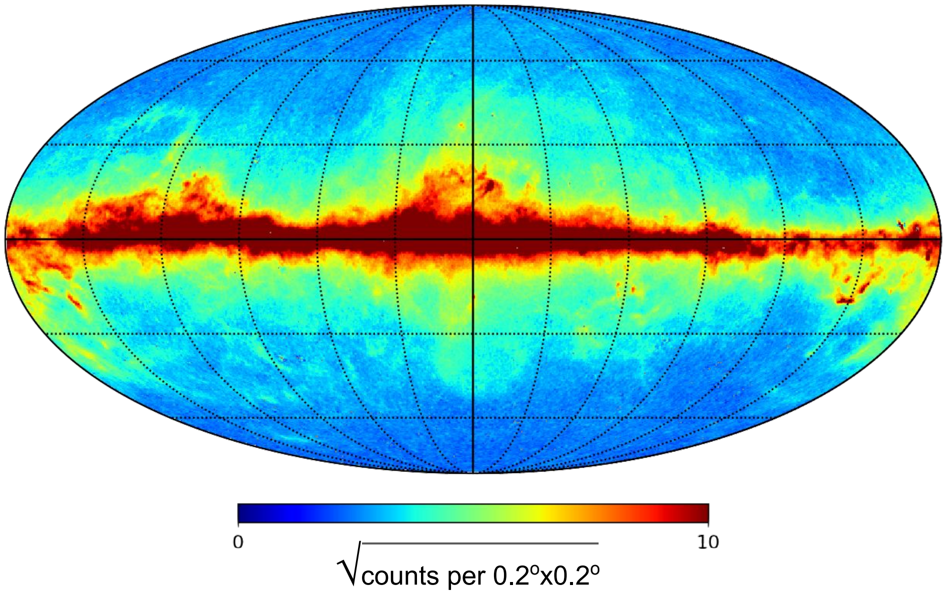
Fermi-LAT above 1 GeV




Fermi-LAT above 1 GeV
0.5° kernel smoothing
0
10
√counts per 0.2°x0.2°

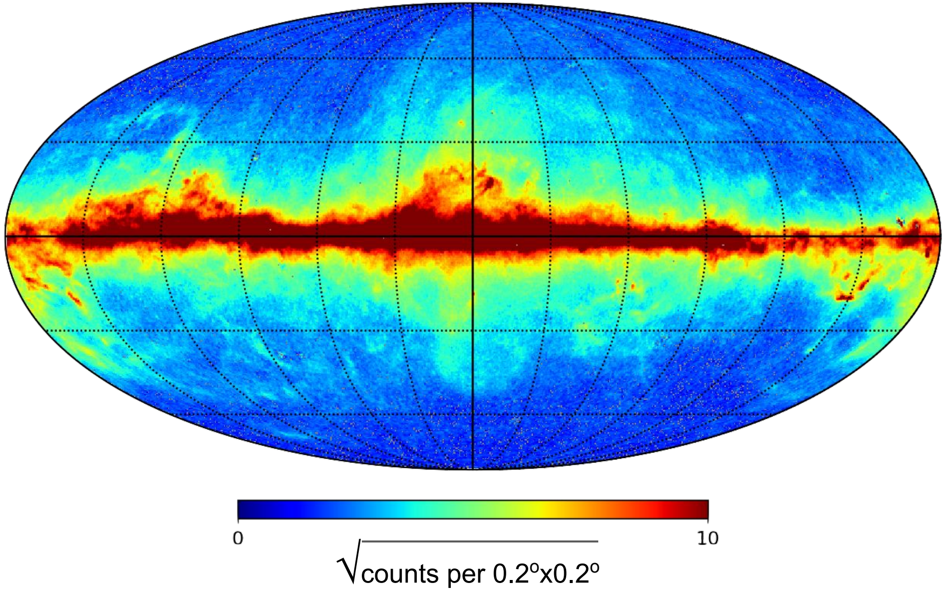
Fermi-LAT above 1 GeV

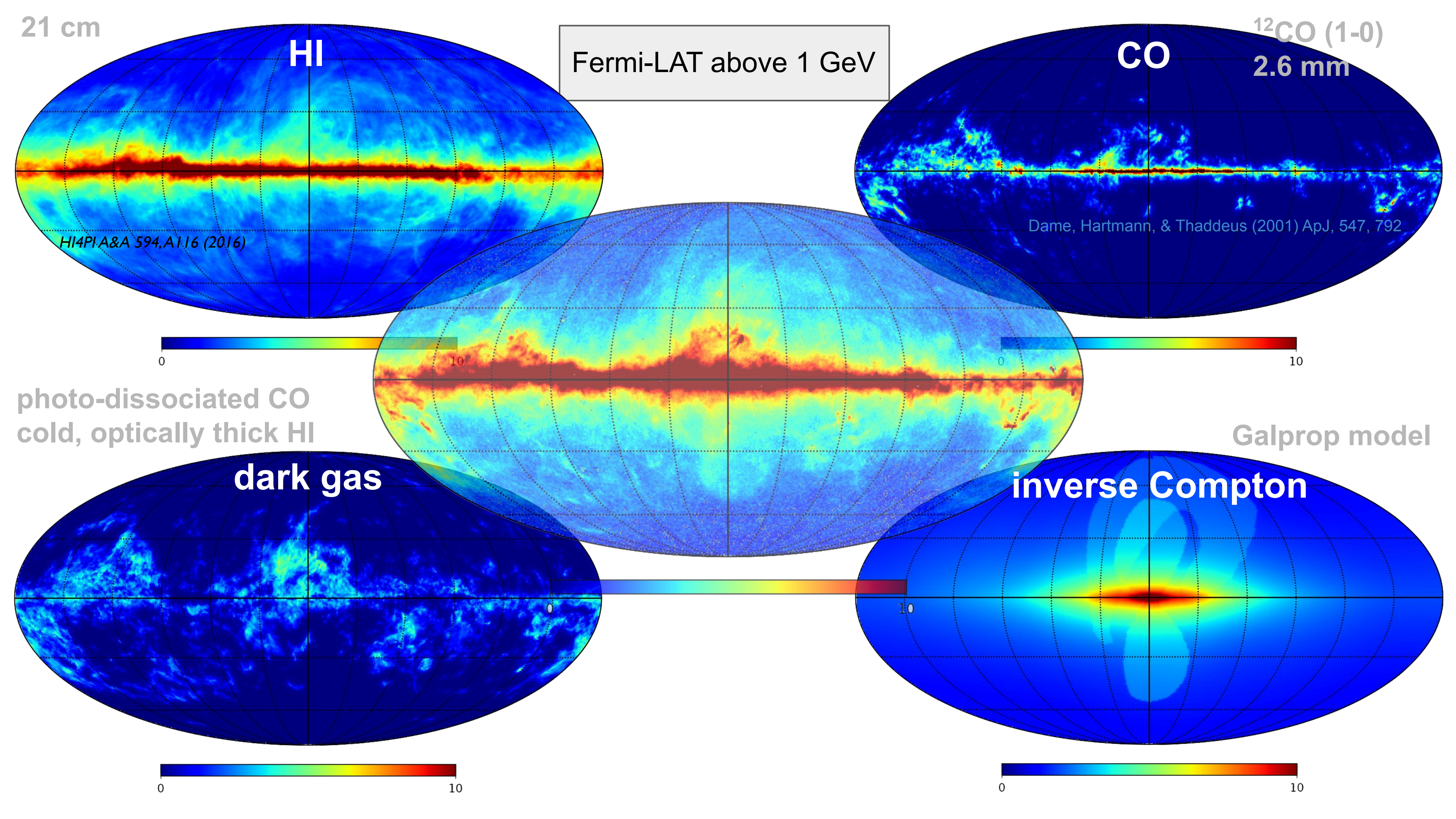
0.5° kernel smoothing
point and extended sources subtracted



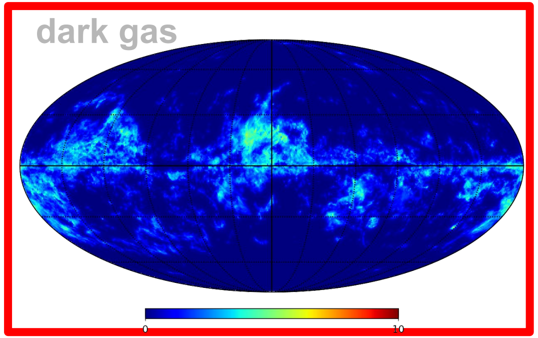
Fermi-LAT above 1 GeV

0.5° kernel smoothing
point and extended sources subtracted
isotropic emission subtracted





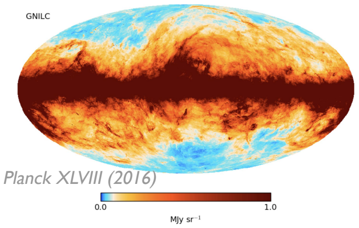
Fermi-LAT above 1 GeV
21 cm
HI
HI4PI A&A 594, A116 (2016)
^{12}CO (1-0)
2.6 mm
CO
Dame, Hartmann, & Thaddeus (2001) ApJ, 547, 792
photo-dissociated CO
cold, optically thick HI
dark gas
Galprop model
inverse Compton
0
10


dark gas
0
10

dark gaz = τ_{353}/σ - (NHI+2X_{CO}WCO)

optical depth at 353 GHz

opacity



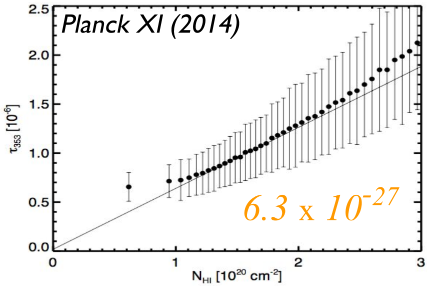
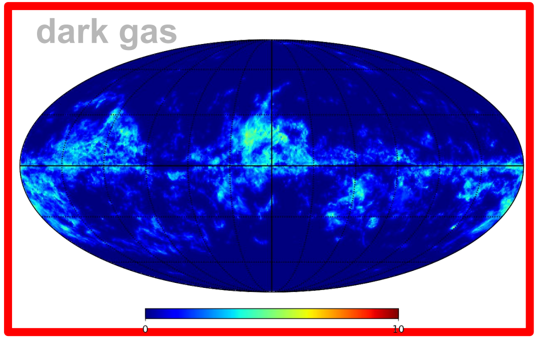


Fig. 21. τ_{353} as a function of $N_{\rm H\,I}$ estimated at 30′ resolution. Each point and its associated bar is the mean and standard deviation of τ_{353} in bins of $N_{\rm H\,I}$. The solid line is the linear regression fit using pixels for which $1.2 < N_{\rm HI} < 2.5 \times 10^{20}\,{\rm cm}^{-2}$. Its parametrization is $\tau_{353} = 6.3 \pm 0.1 \times 10^{-27}\,N_{\rm H\,I} - 0.02 \times 10^{-6}$.



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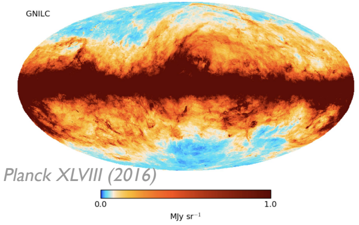


Planck XLVIII (2016)

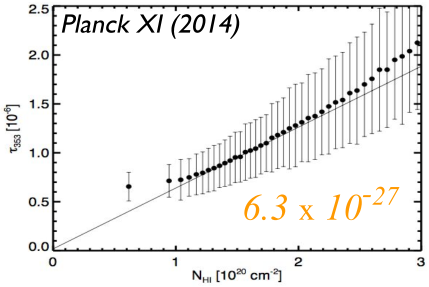
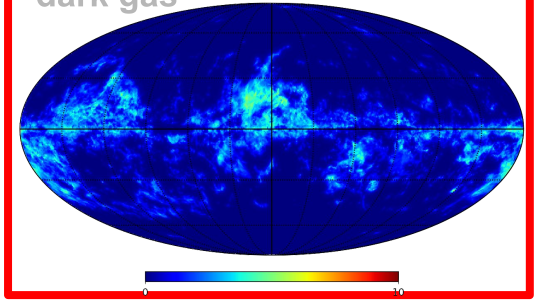


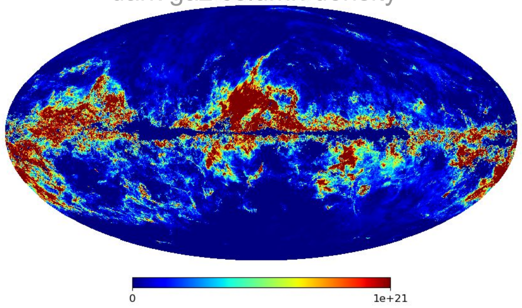
Fig. 21. τ_{353} as a function of $N_{\rm HI}$ estimated at 30′ resolution. Each point and its associated bar is the mean and standard deviation of τ_{353} in bins of $N_{\rm HI}$. The solid line is the linear regression fit using pixels for which $1.2 < N_{\rm HI} < 2.5 \times 10^{20}\,{\rm cm}^{-2}$. Its parametrization is $\tau_{353} = 6.3 \pm 0.1 \times 10^{-27}\,N_{\rm HI} - 0.02 \times 10^{-6}$.

dark gas



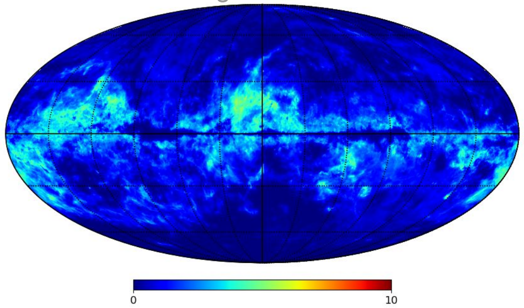
$\sigma = 6.3 \times 10^{-27}$

dark gaz column density



exposure convolution

dark gaz counts



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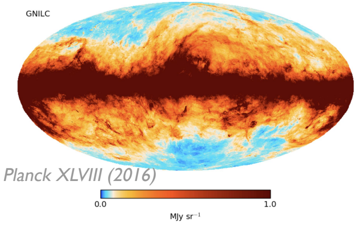
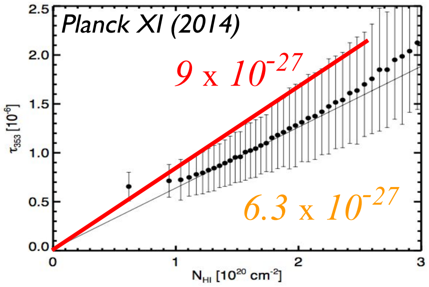
optical depth at 353 GHz

opacity





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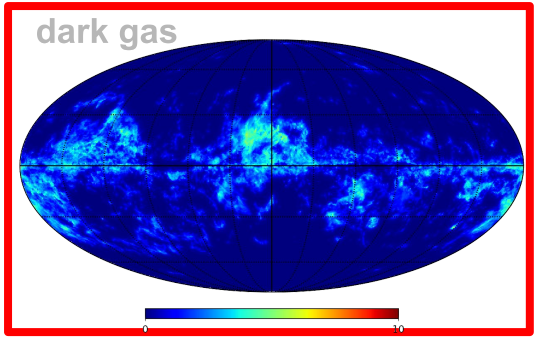

dark gaz column density

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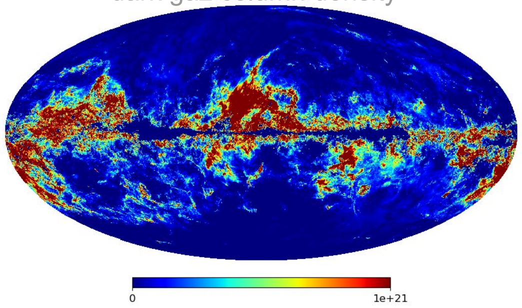
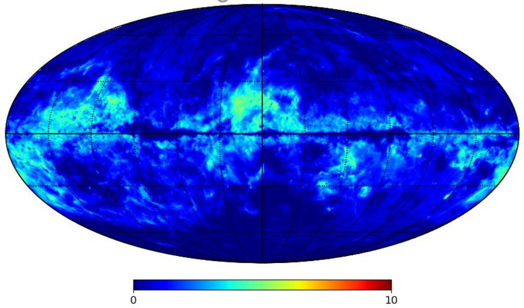
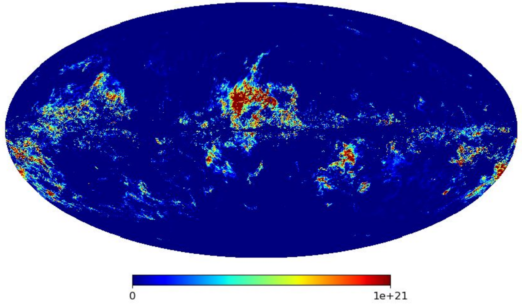


exposure convolution



$\sigma = 9 \times 10^{-27}$



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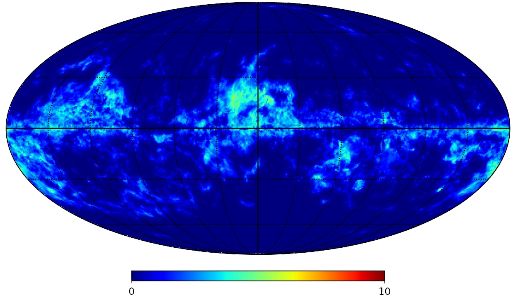
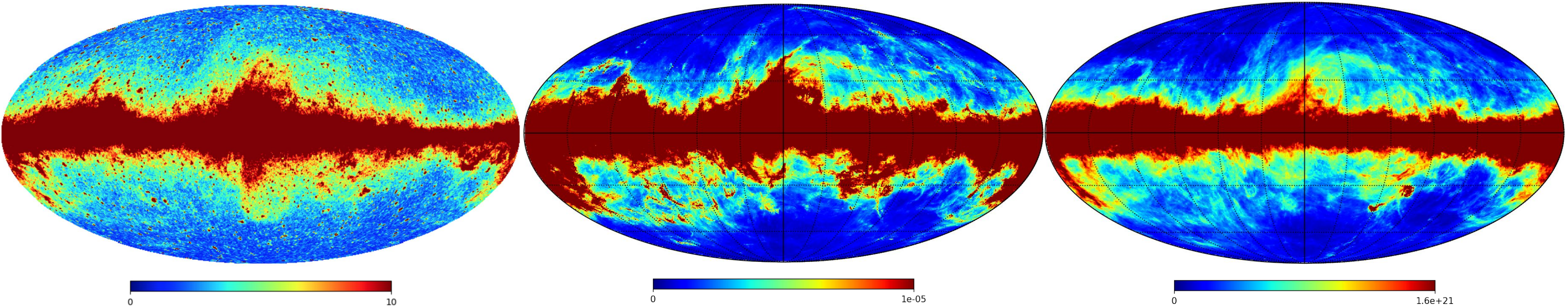


Fermi, Planck and gas radio surveys are not compatible !

γ-ray | optical depth τ_{353} from FIR | HI 21 cm



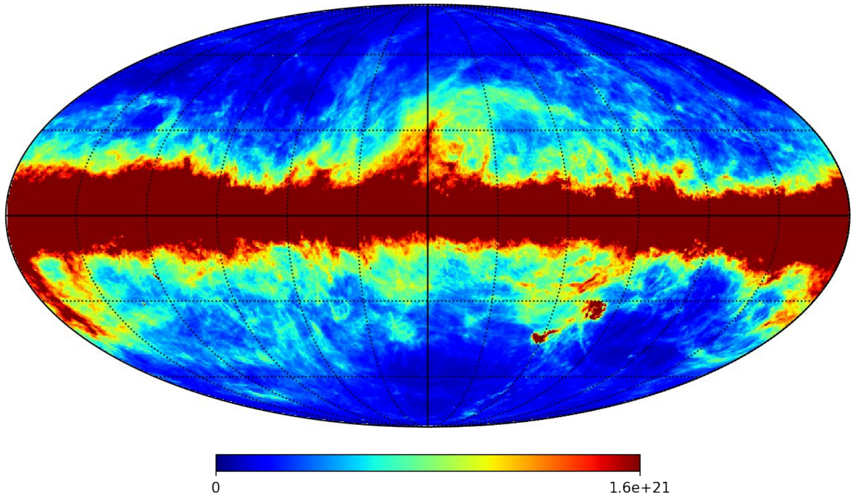
0 *Fermi 12 years* **10**

0 **1E-5**
Planck XLVIII (2016)

0 **1.6E20**
HI4PI A&A 594,A116 (2016)

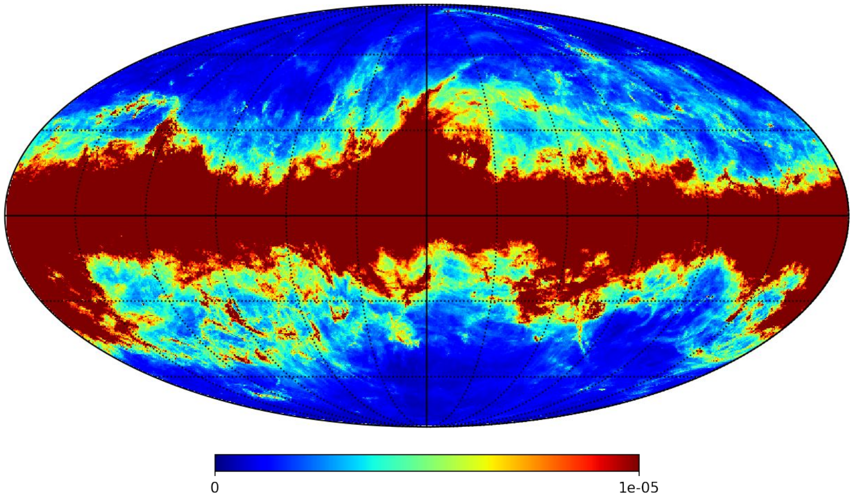
Simplest comparison between NHI and τ

HI 21 cm



0 1.6E21

optical depth τ_{353} from FIR



0 1E-5

=1.6E21 x 6.3E-27

=1.6E21 x σ

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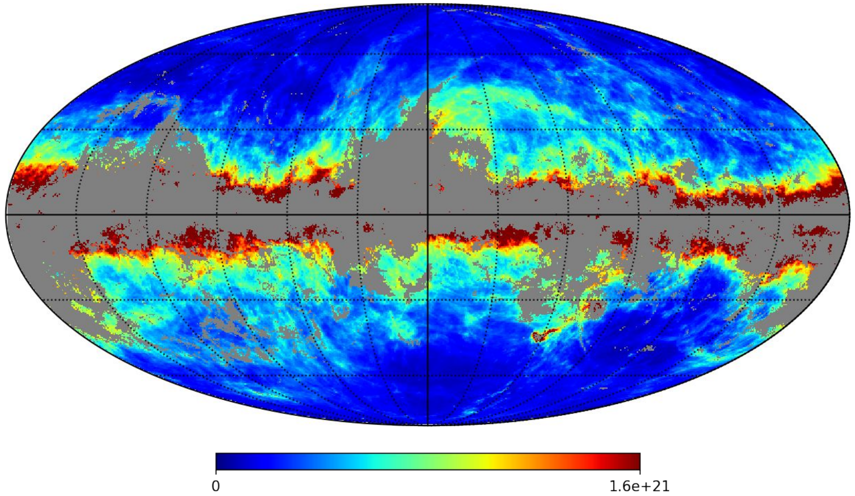
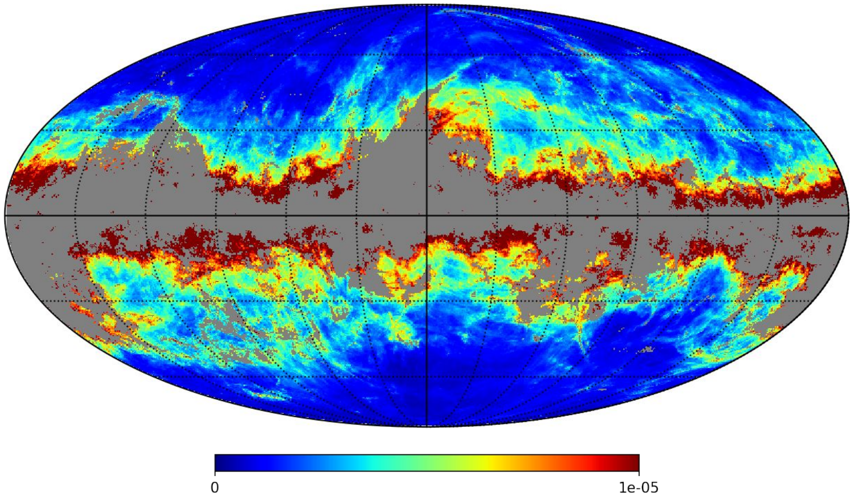


0 **1.6E21**

optical depth τ_{353} from FIR



0 **1E-5**

=1.6E21 x 6.3E-27

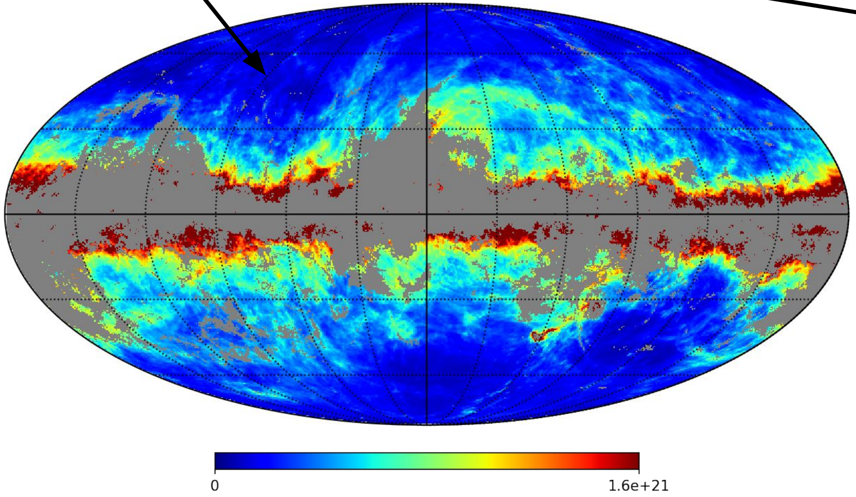
=1.6E21 x σ

We mask LOS with high NH where dust is not a good tracor for HI (H2, DNM, dust over-emissivity)

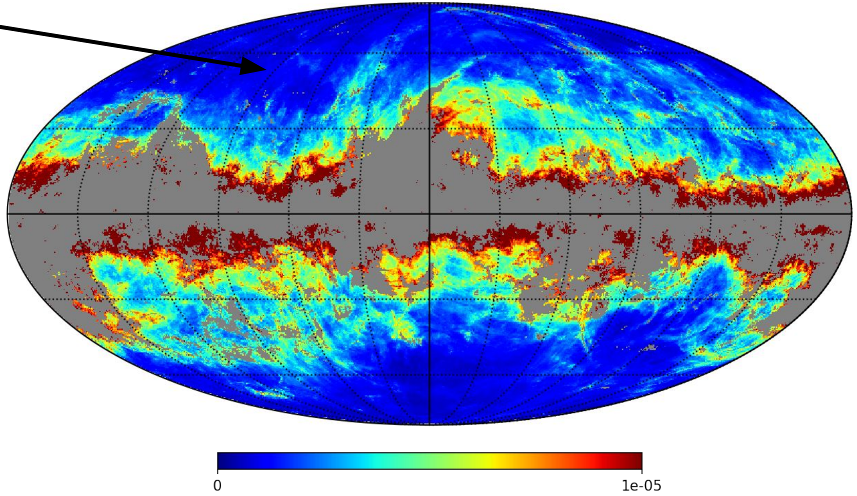
Simplest comparison between NHI and τ

agreement at low NHI

HI 21 cm



optical depth τ_{353} from FIR



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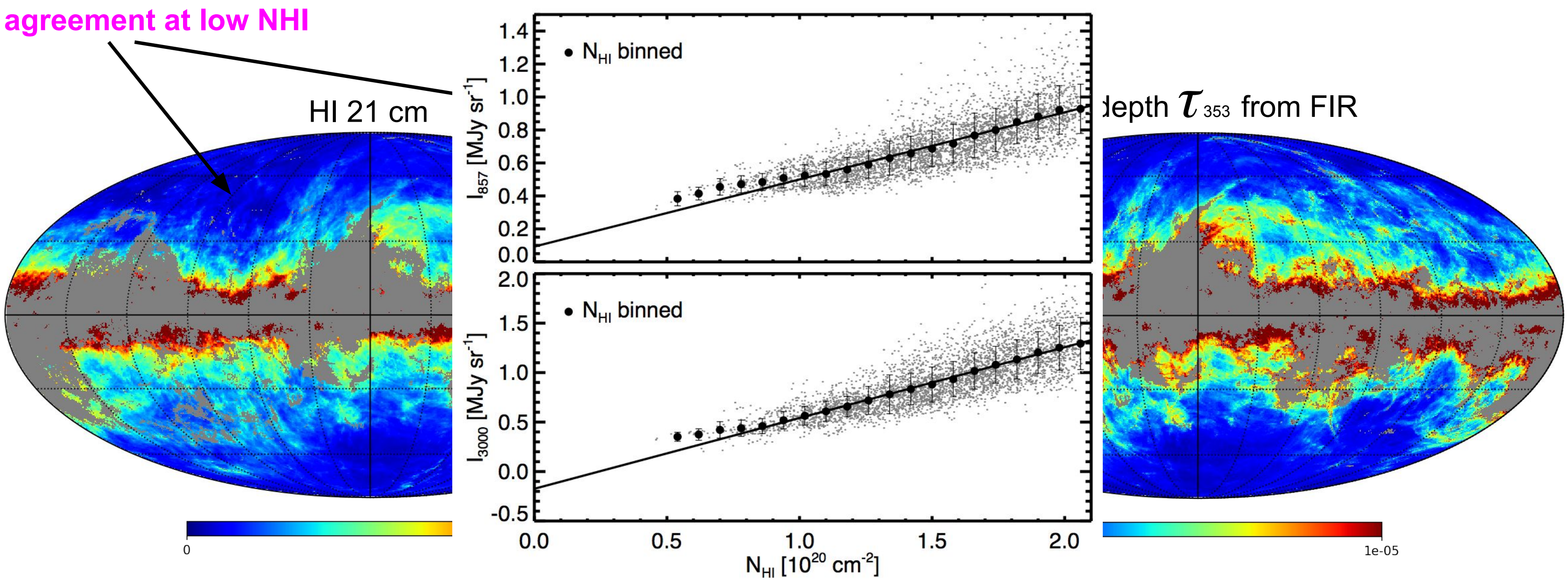
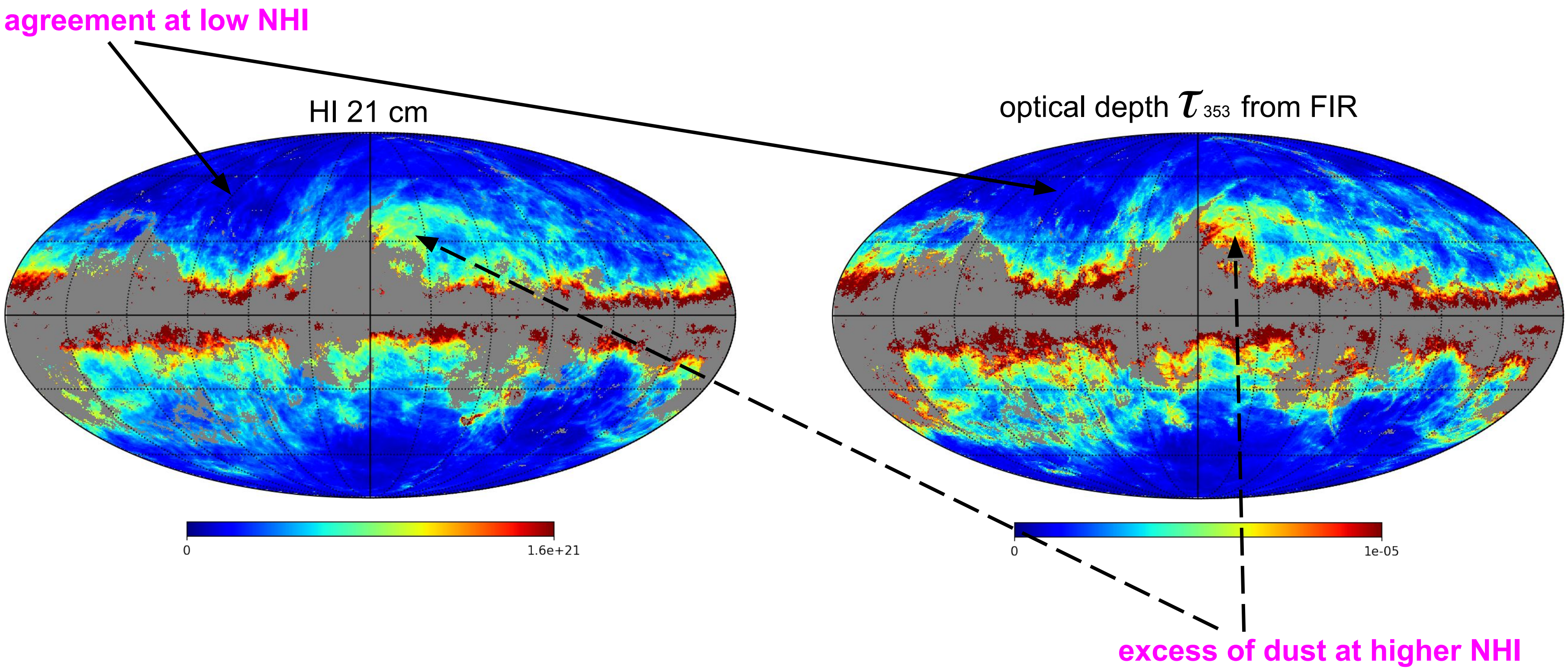
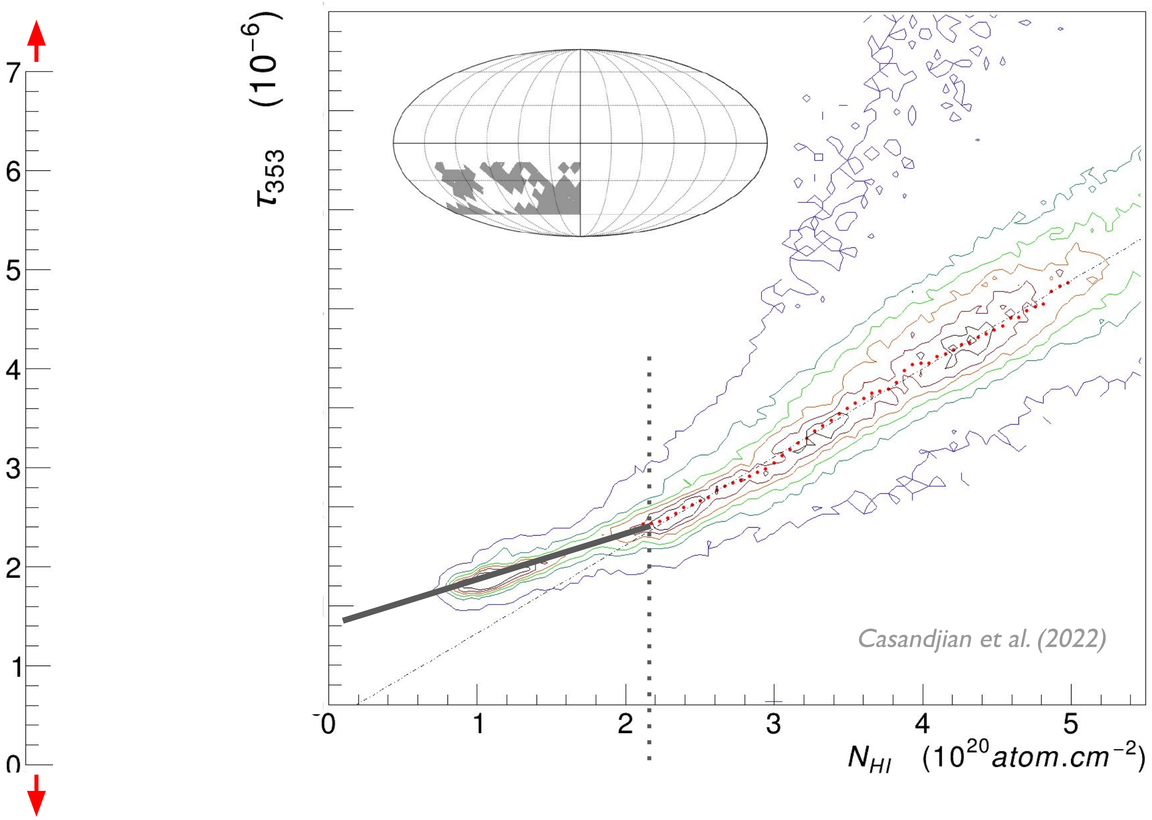


Planck: differential measure, instrument offsets not known !

Simplest comparison between NHI and τ



Why is there an excess of dust compared to NHI predictions at intermediate NHI ?



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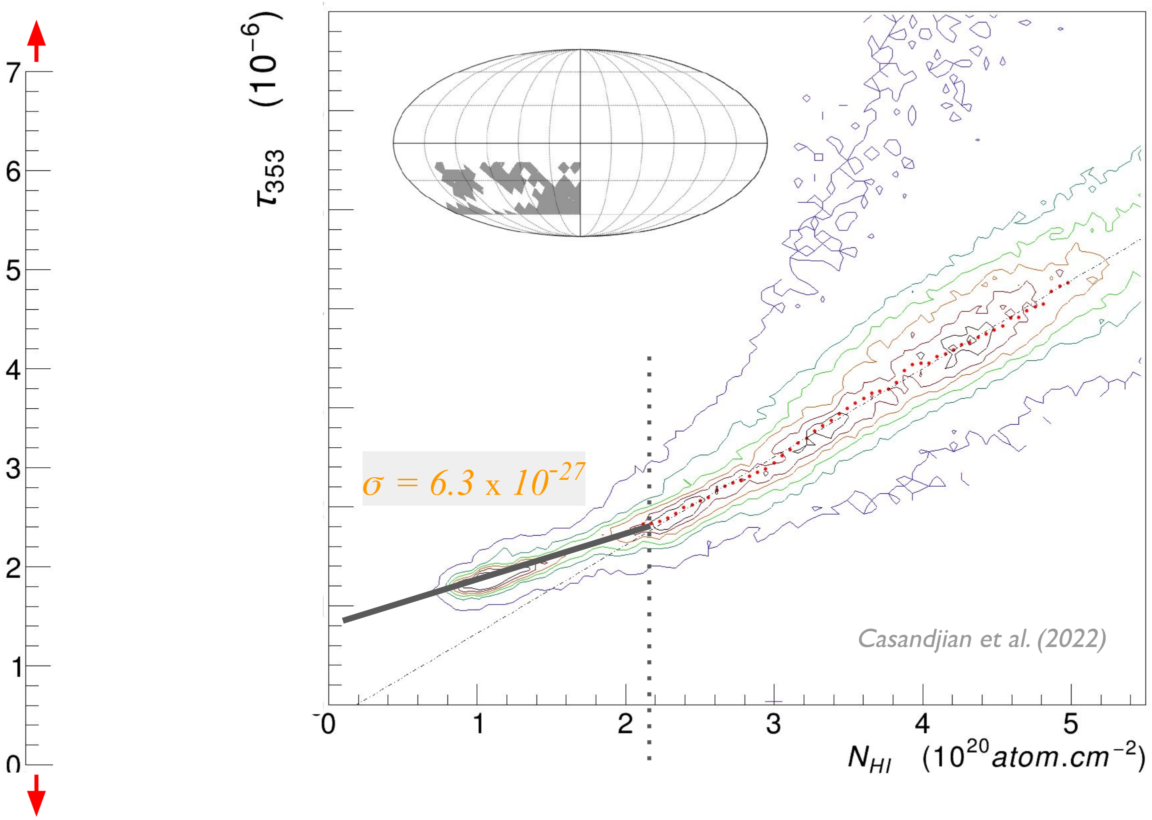

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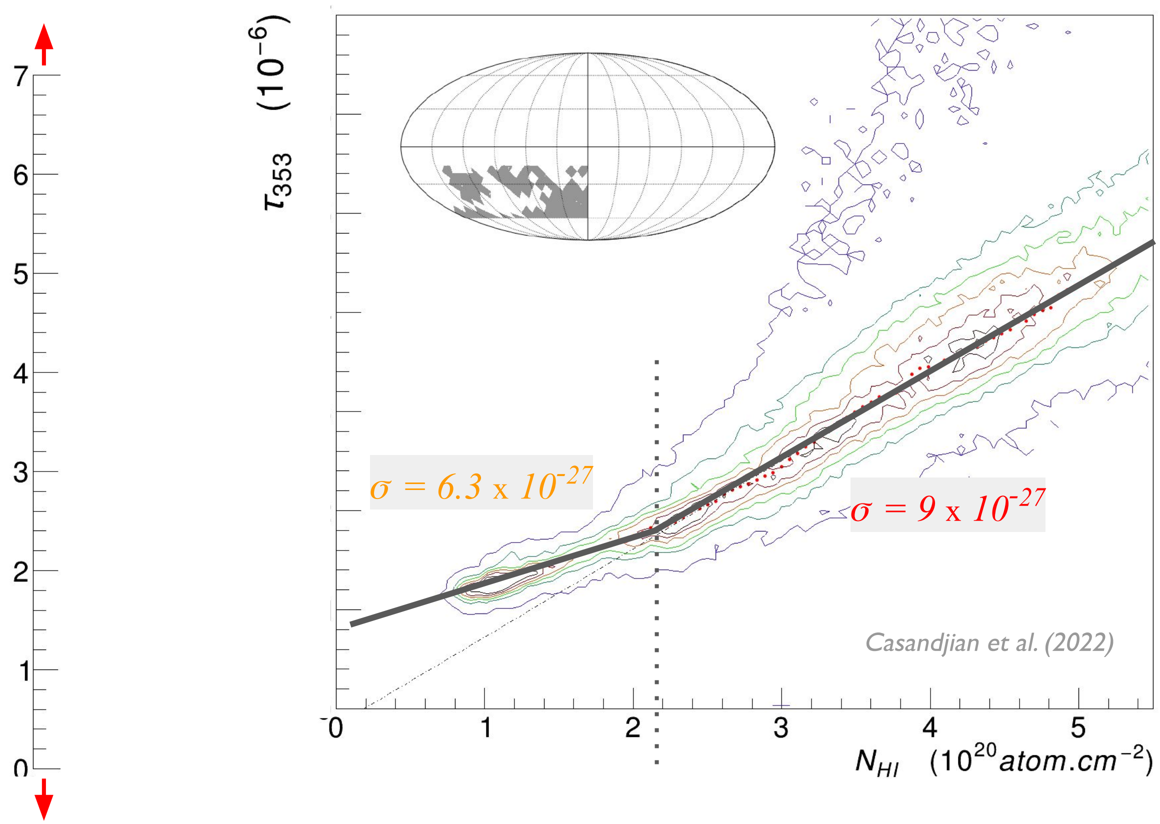

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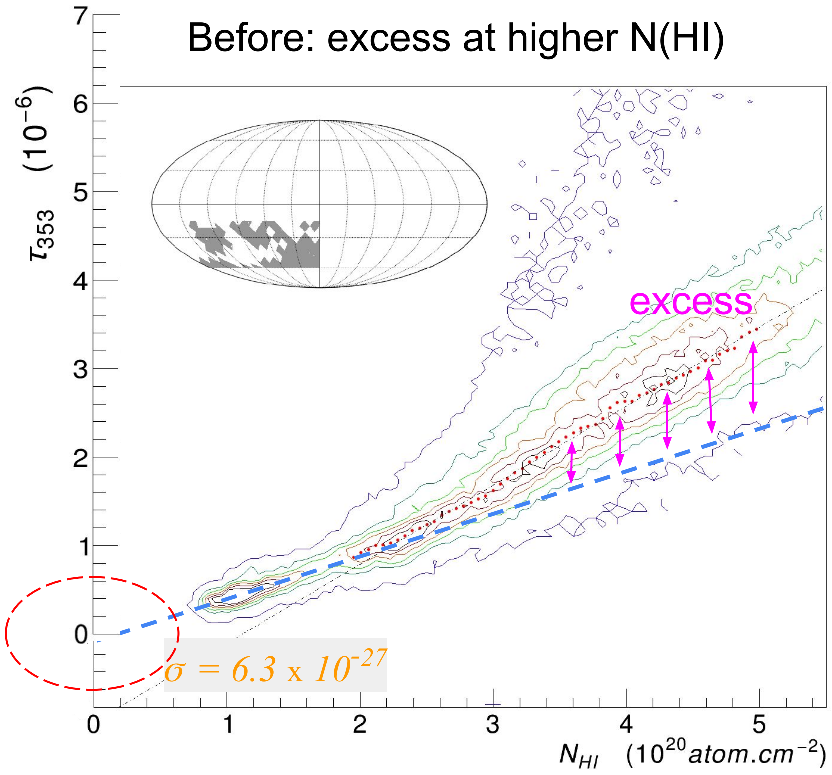

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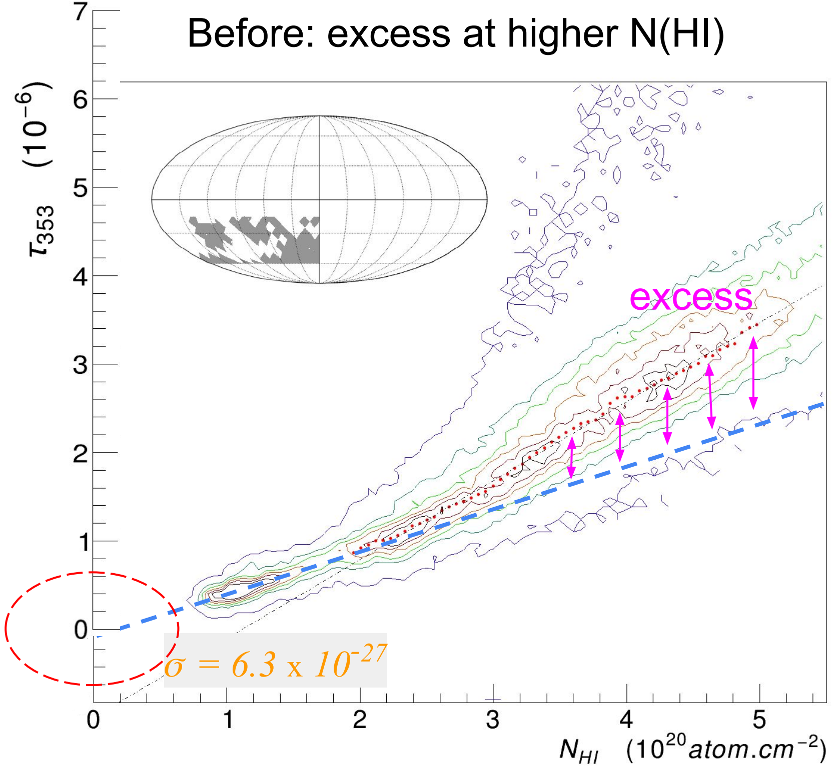

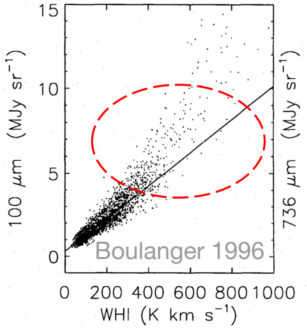

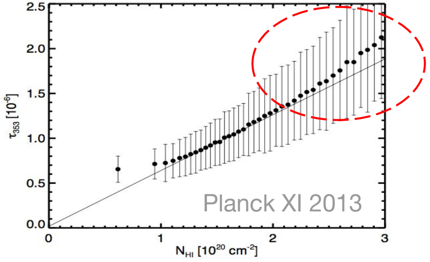

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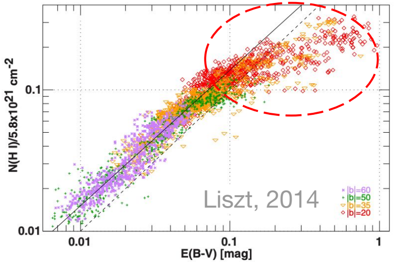

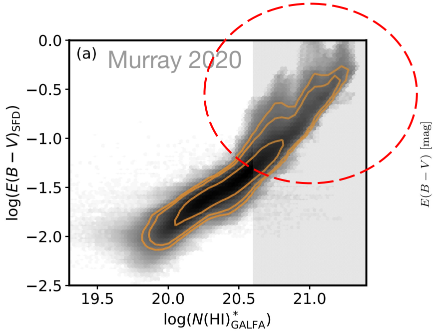

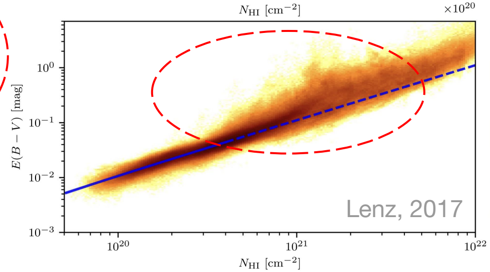

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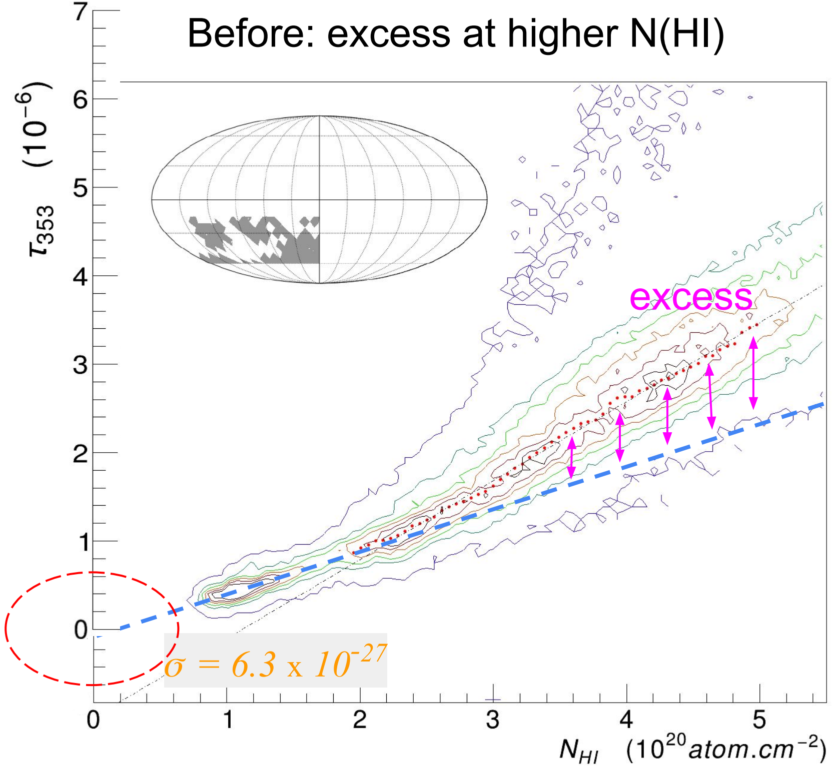

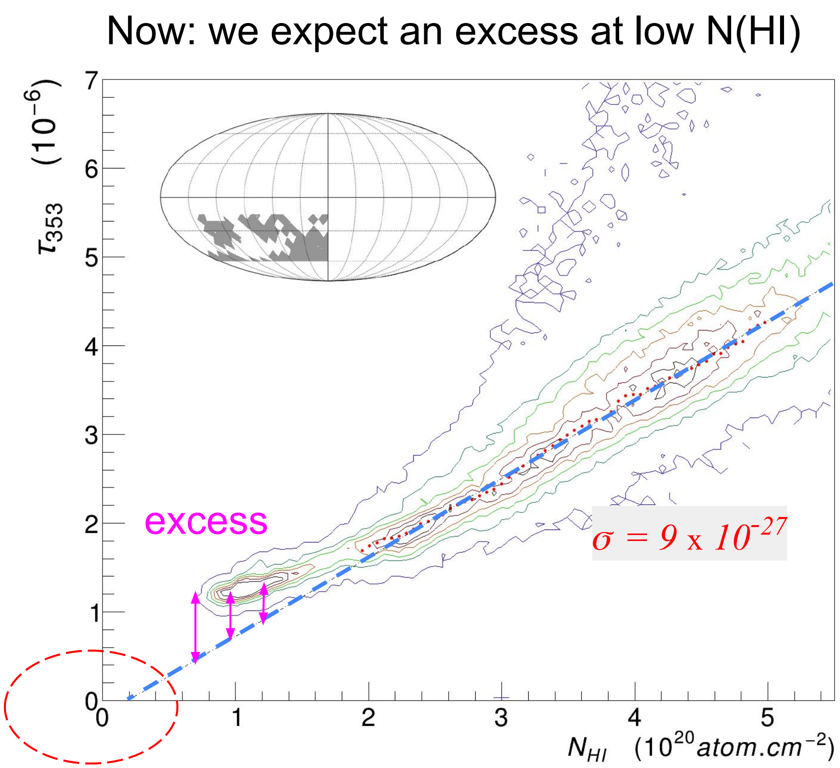

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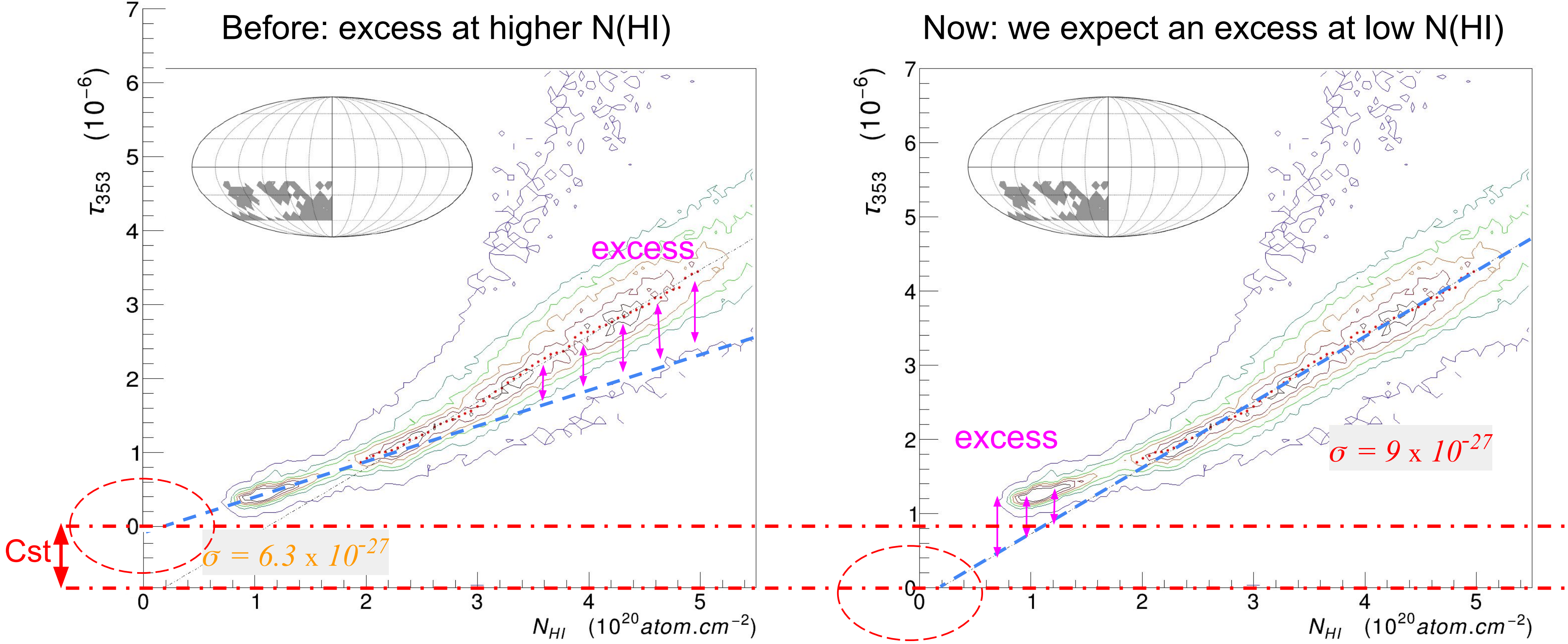
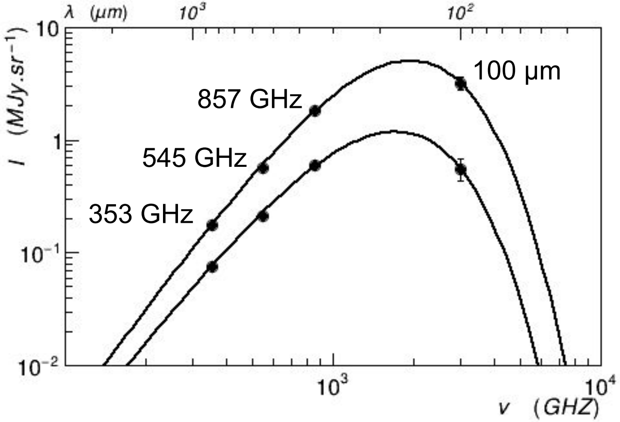


MBB fit

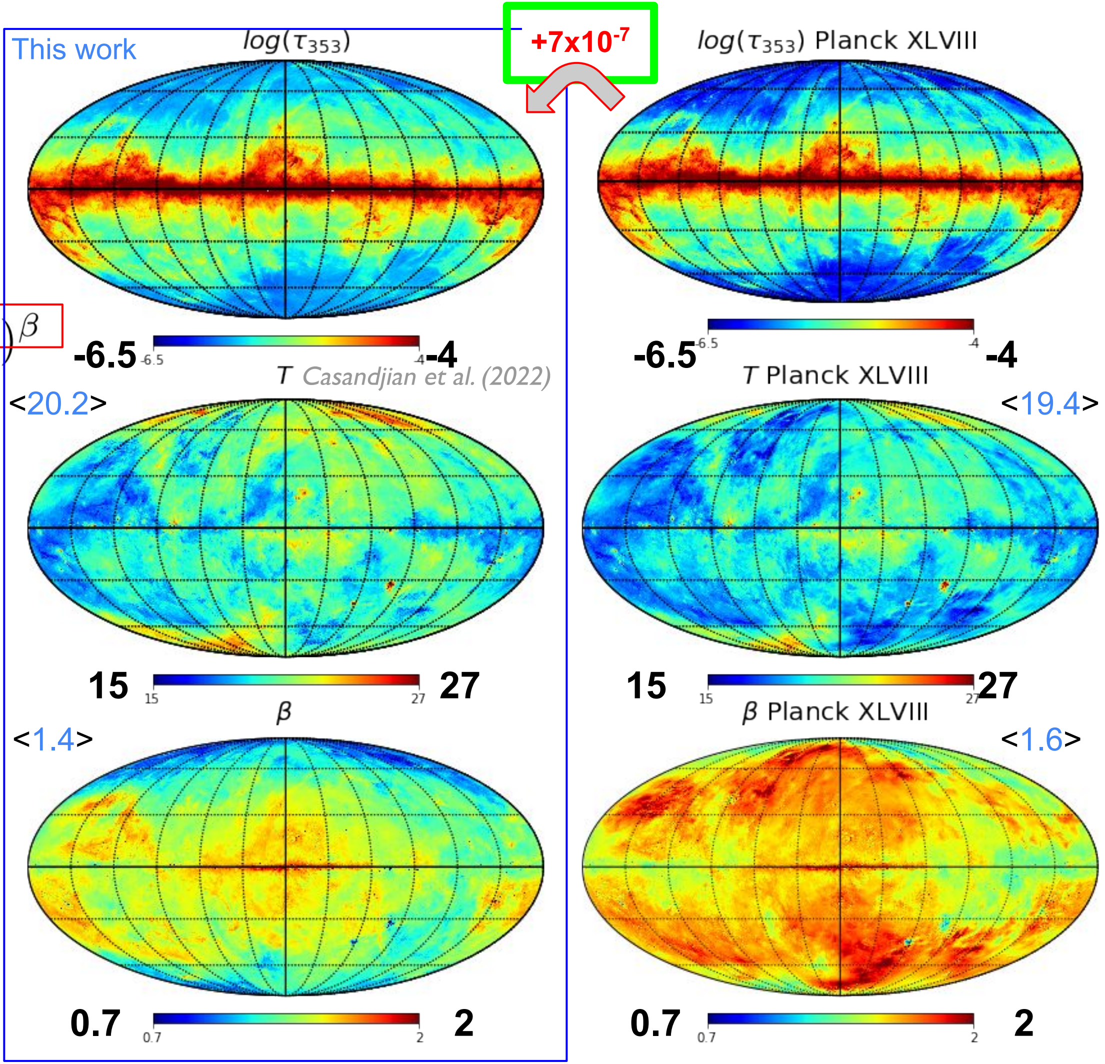
$$I_\nu(\tau_{353}, T, \beta) = \tau_{353} B_\nu(T)(\nu/353\,\mathrm{GHz})^\beta$$



We repeated :

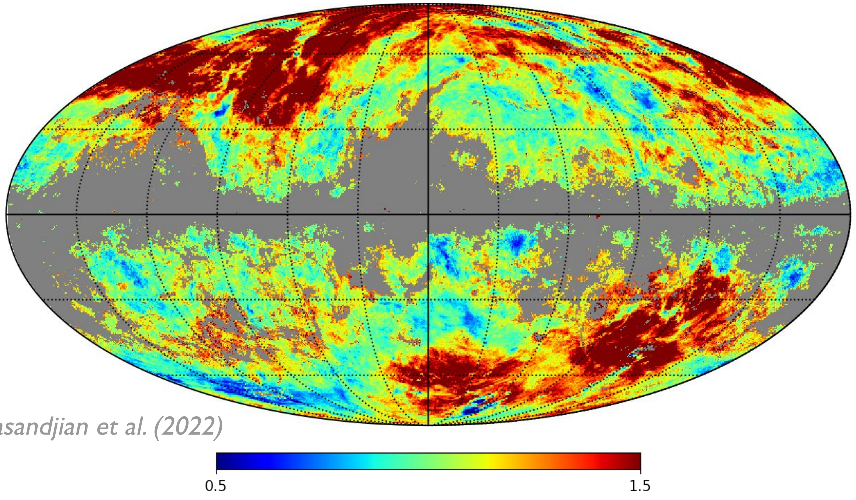
Planck XI (2014)

Planck XLVIII (2016)



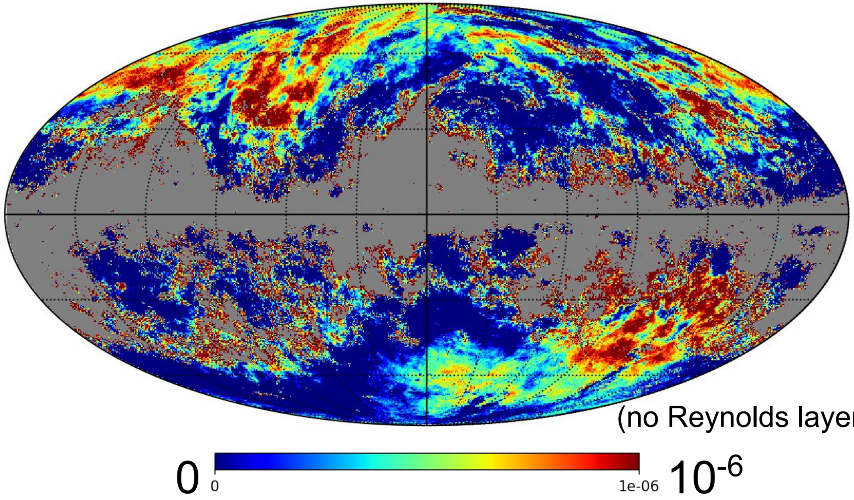
Comparison with N(HI)

τ_{353} / N(HI) /9x10^{-27}



Casandjian et al. (2022)

τ_{353} - N(HI) x 9 10^{-27}



(no Reynolds layer)

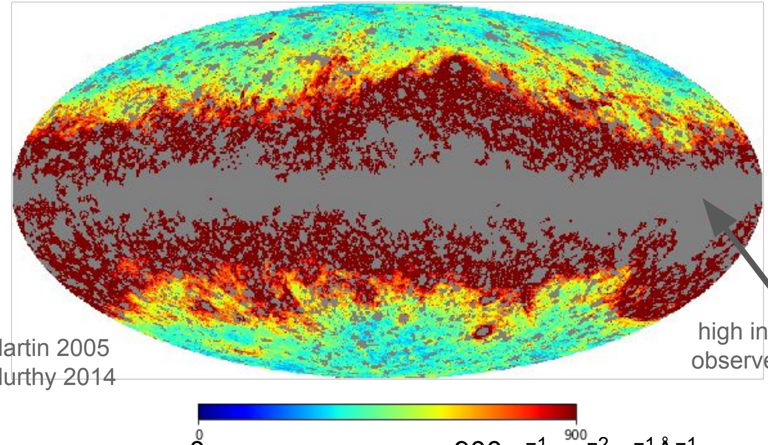
0 ... 10^{-6}

We observe an excess of dust at low N(HI) (compared to N(HI) prediction)

- Excess in UV
- Excess of γ-ray if gas associated to dust
- Excess in Optical (COB) ?

GALEX

FUV (1350-1750 Å)

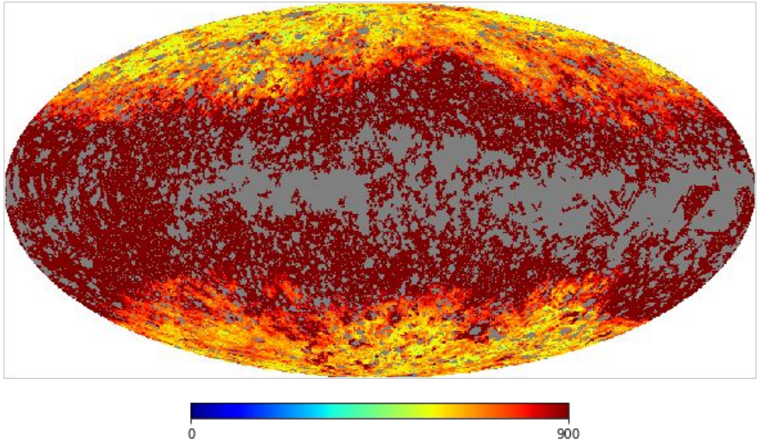


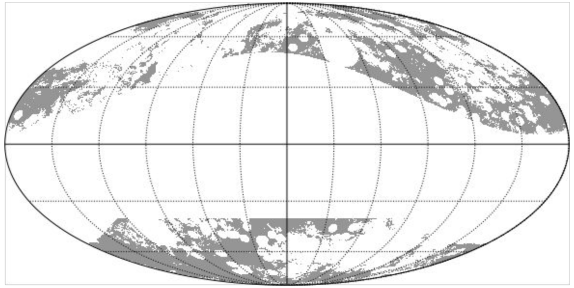
Martin 2005
Murthy 2014

high intensity regions not observed

0 900 $s^{-1}cm^{-2}sr^{-1}Å^{-1}$

NUV (1750-2850 Å)



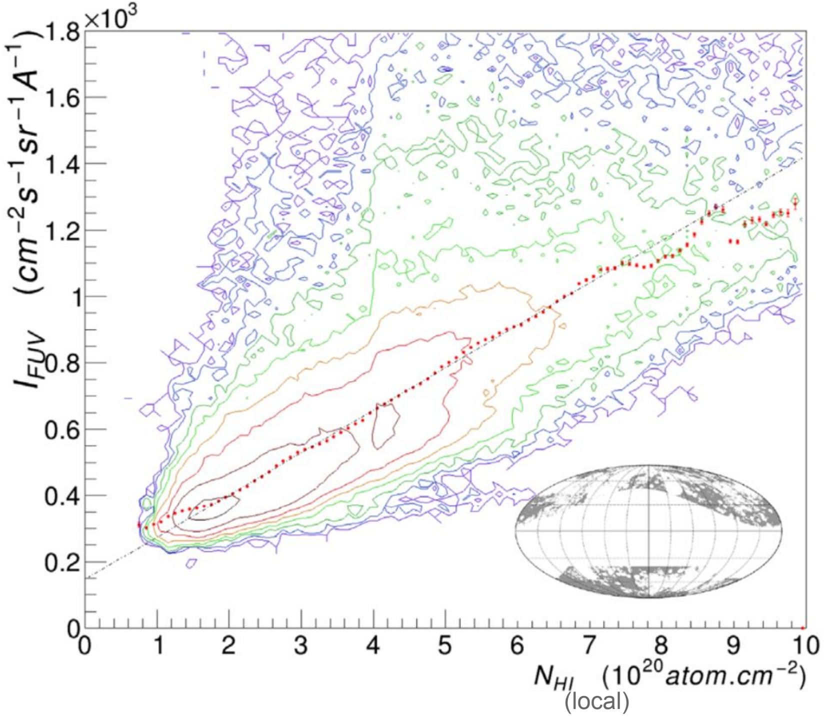


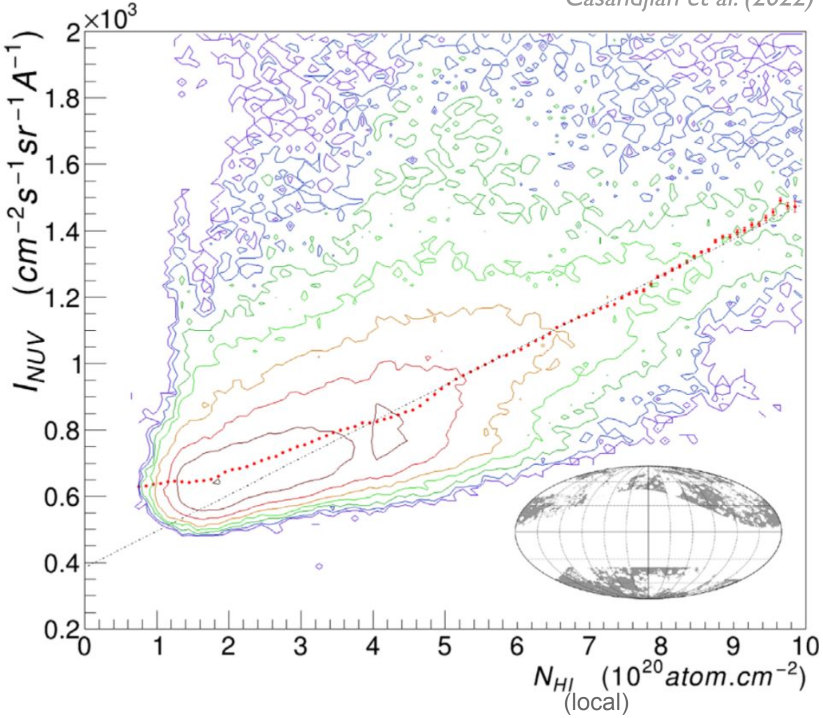
mask:

- 40° of the Gould Belt
- b = -40°- 0°
- 10° from 6 bright star with halo
- 2.5° from TD1 bright UV stars catalog
- where is have dark gas
- at the excess location

$$I_{uv} = \sigma \times NHI + I_o$$

Casandjian et al. (2022)





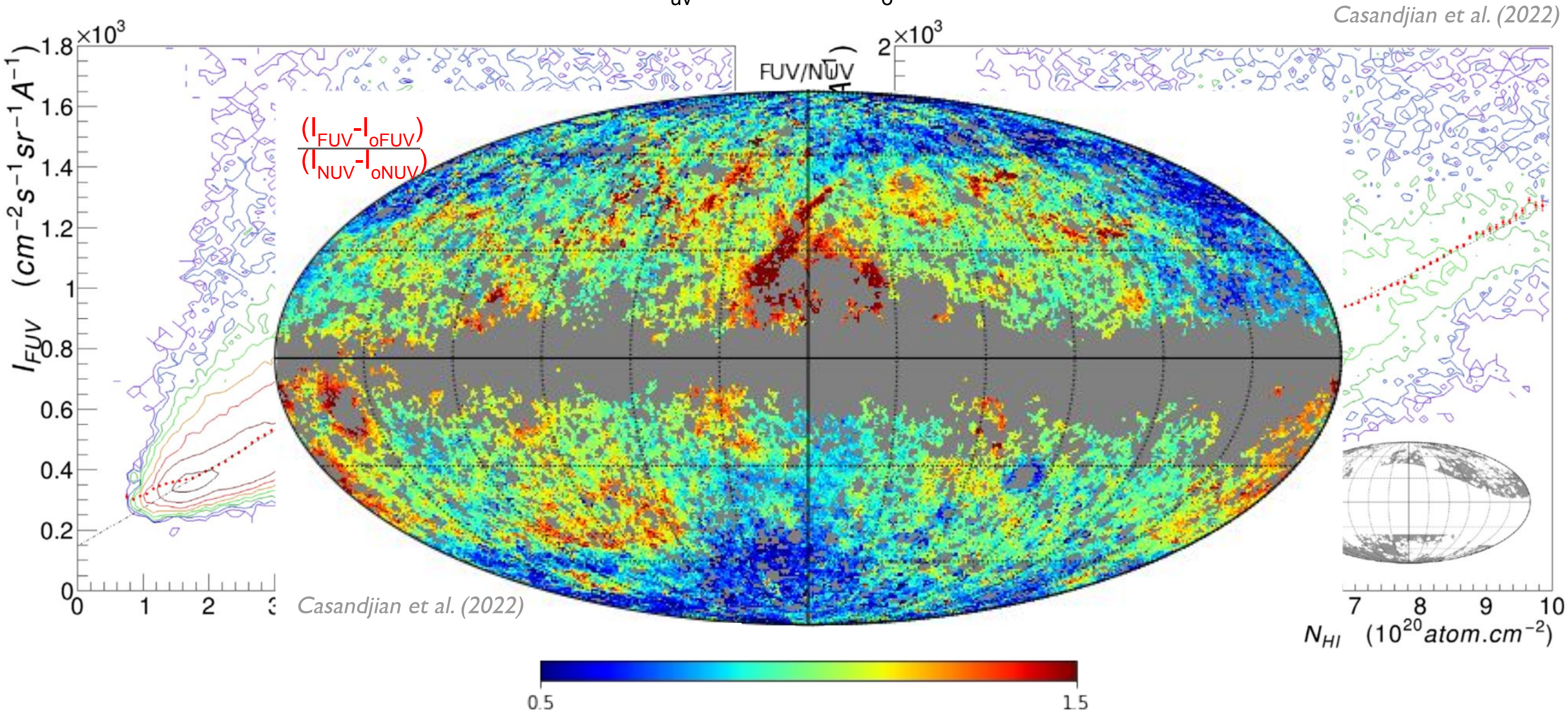
$\sigma_{FUV} = (130 \pm 4) \times 10^{-20}$ photons s^{-1} cm^{-2} sr^{-1} $\check{A}^{-1}$ cm^2

$I_{0(FUV)} = 137 \pm 15$ photons s^{-1} cm^{-2} sr^{-1} $\check{A}^{-1}$

$\sigma_{NUV} = (111 \pm 6) \times 10^{-20}$ photons s^{-1} cm^{-2} sr^{-1} $\mathring{A}^{-1}$ cm^2

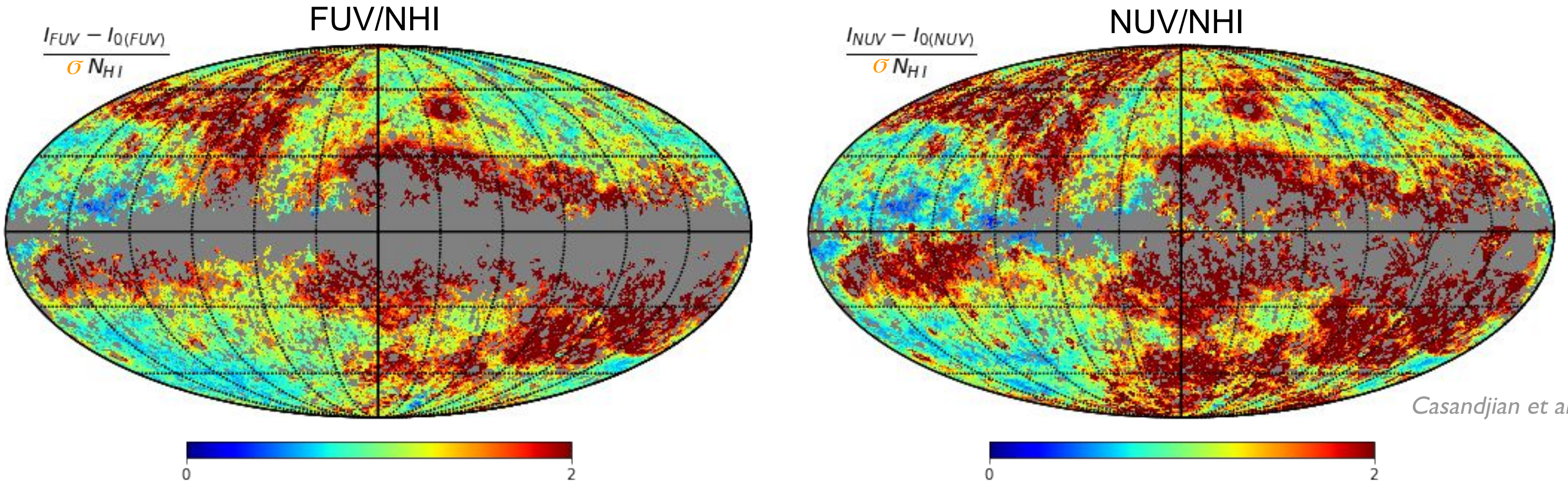
$I_{0(NUV)} = 378 \pm 45$ photons s^{-1} cm^{-2} sr^{-1} $\mathring{A}^{-1}$

$$I_{uv} = \sigma \times NHI + I_o$$



$I_{0(FUV)} = 137 \pm 15$ photons s^{-1} cm^{-2} sr^{-1} $\check{A}^{-1}$

$I_{0(NUV)} = 378 \pm 45$ photons s^{-1} cm^{-2} sr^{-1} $Å^{-1}$



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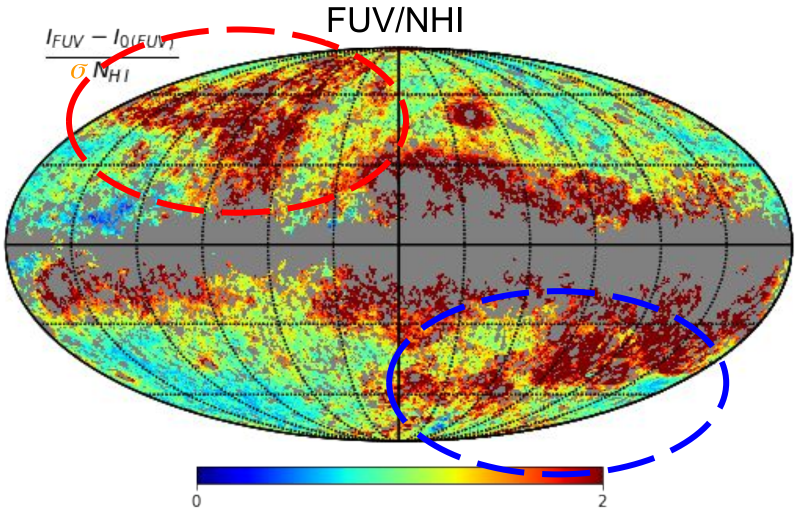
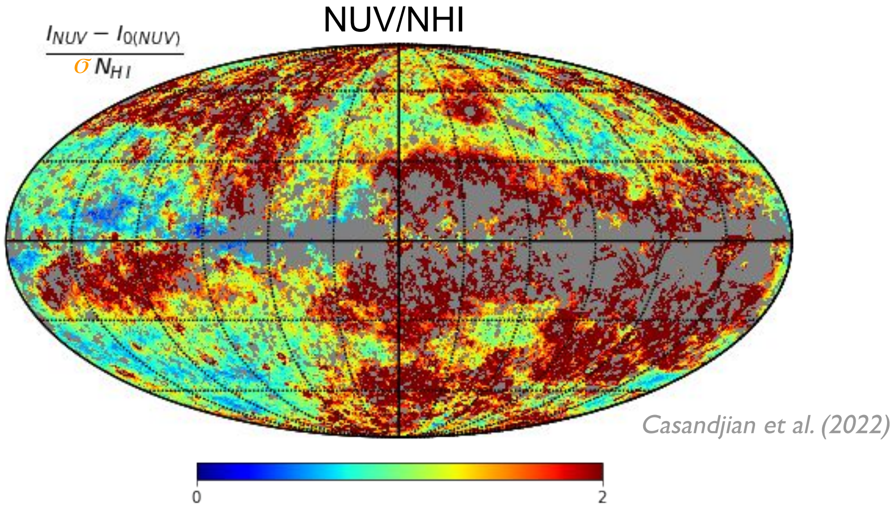
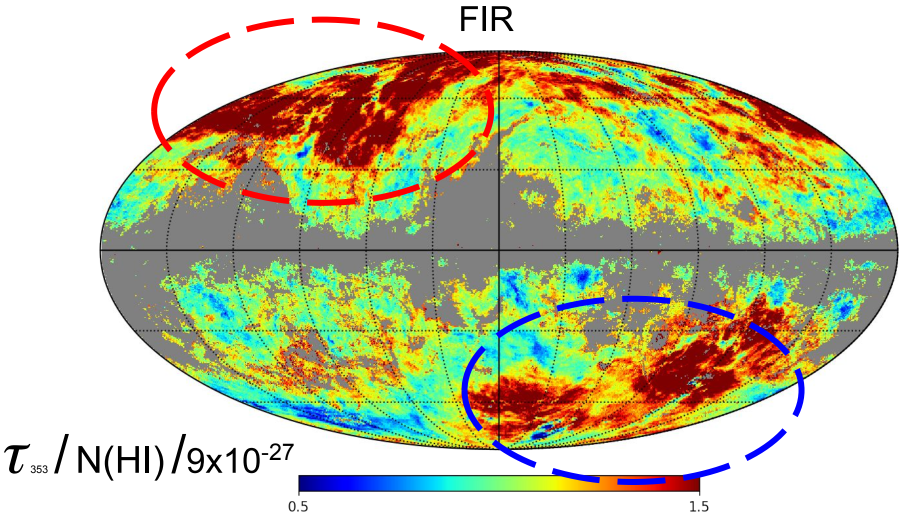
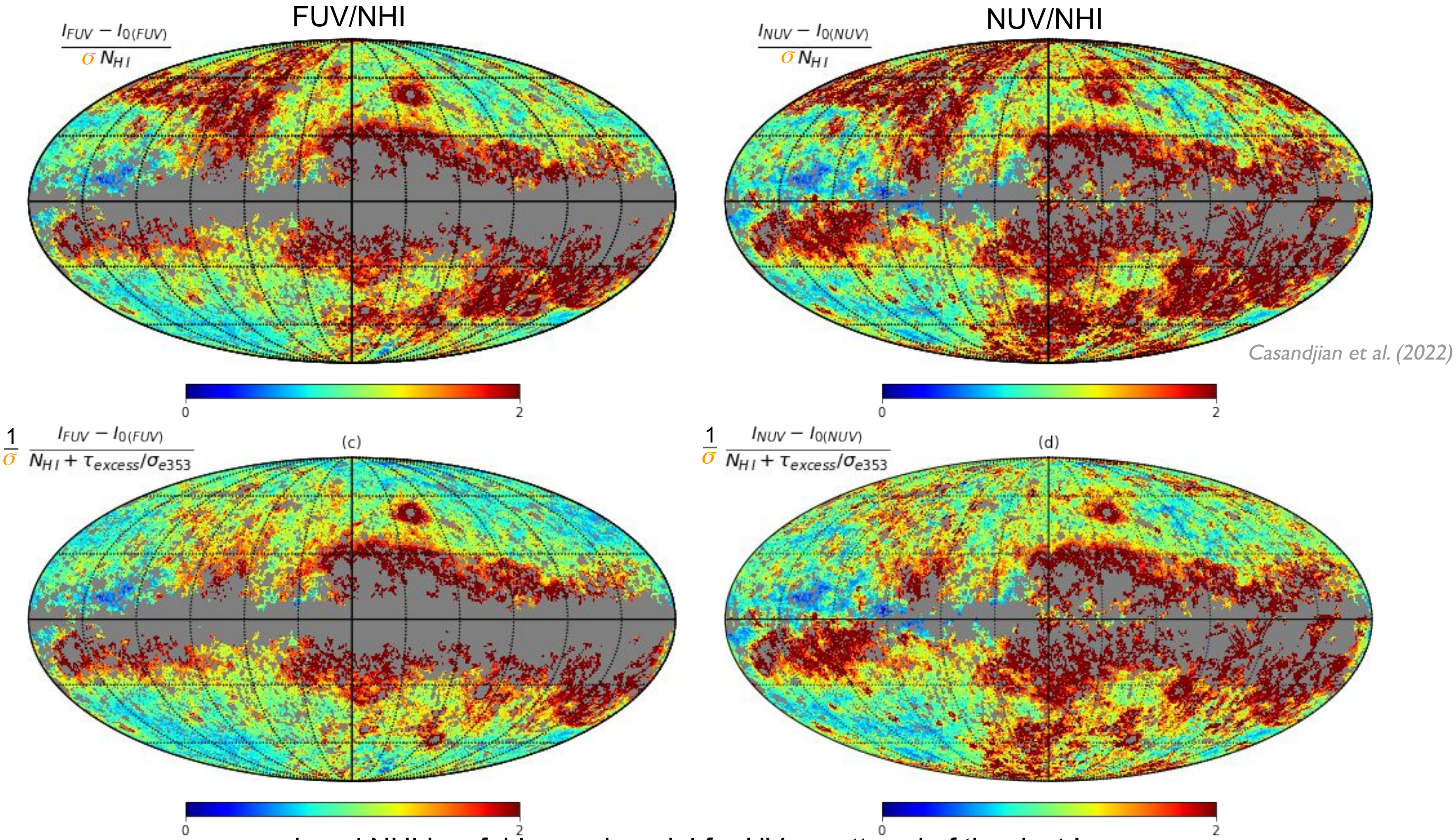




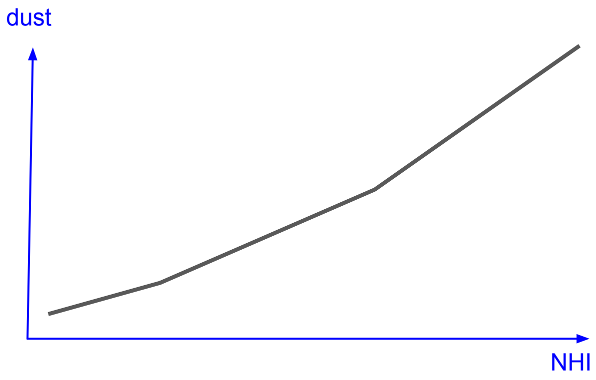


Same spatial distribution for dust excess as in FIR

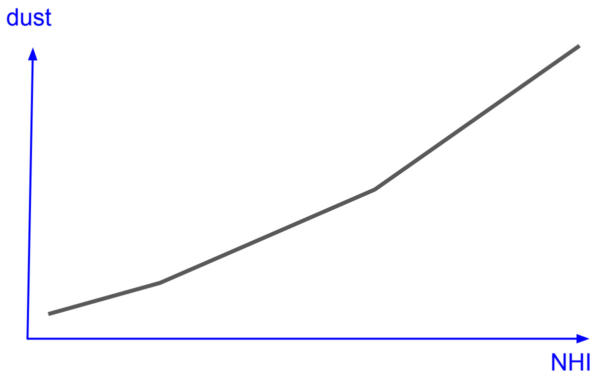


Local NHI is a fairly good model for UVs scattered of the dust !

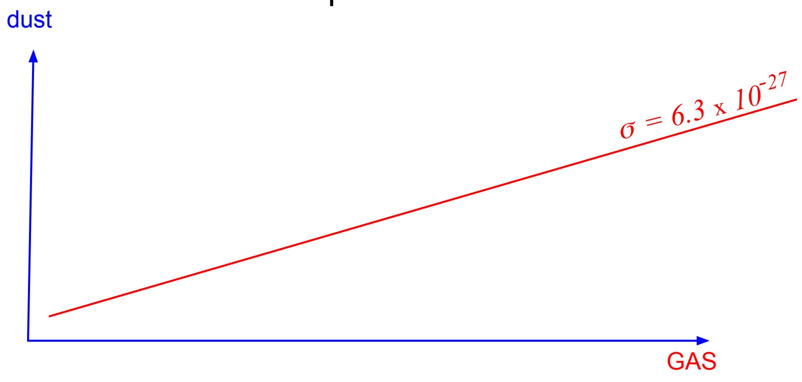
CONCLUSION



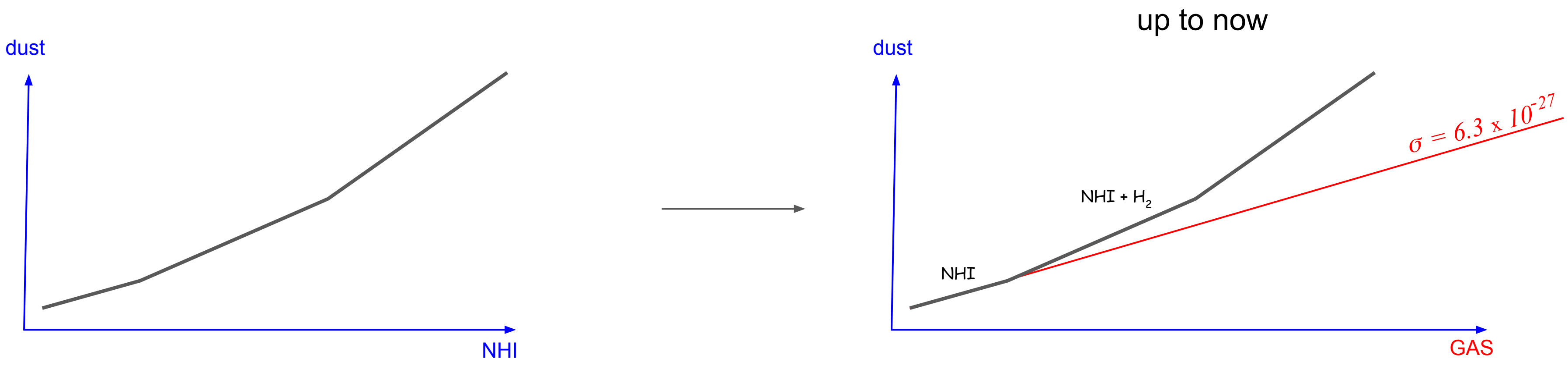
CONCLUSION



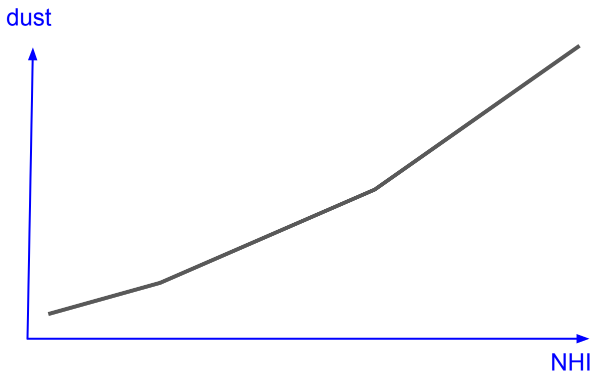
up to now

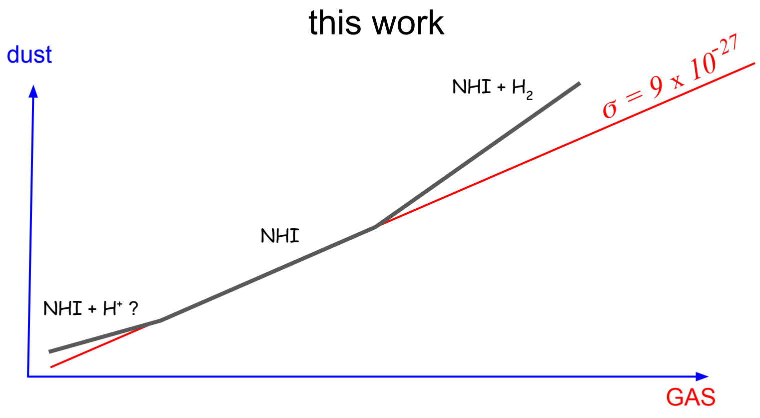


CONCLUSION

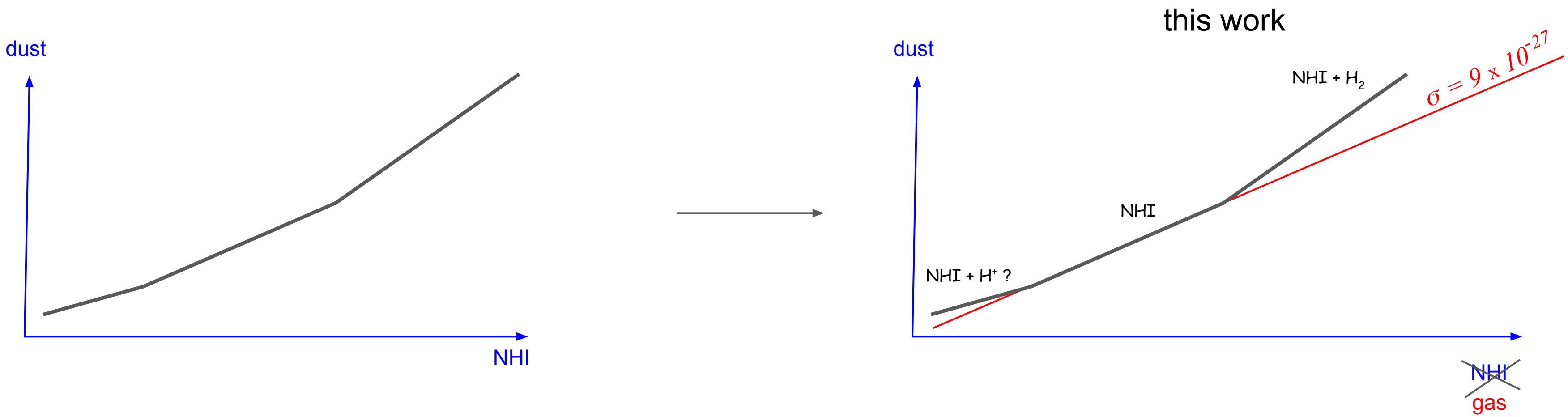


CONCLUSION





CONCLUSION



- Planck-HFI offsets were incorrectly measured, assuming that the hydrogen is only atomic at low column density.
- We corrected the Planck-HFI offsets and fitted a MBB to Planck intensities.
- We observed that the dust opacity has risen by 40%, and that dust optical depth has increased by a constant of $7x10^{-7}$.
- The leads to unseen excesses of dust at low NHI.
- This excess is also observed at FUV and NUV wavelengths, could it partially account for the COB excess ?
- Local NHI can be used to model UVs scattered of the dust.