Fermi-LAT study of the ISM in Chamaeleon region using the *Planck* thermal dust optical depth

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on behalf of the *Fermi*-LAT collaboration

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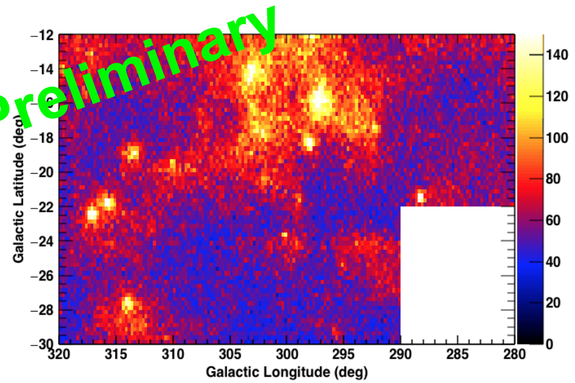
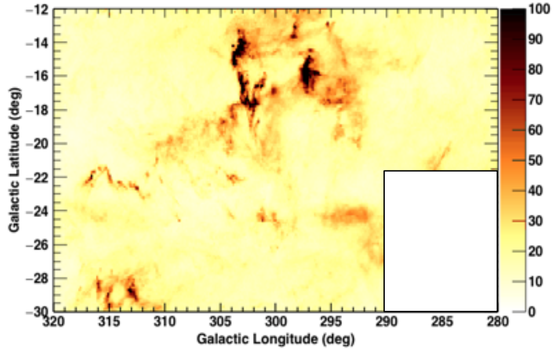


γ-ray data



$\tau_{353} \propto N_H^{1.3}$ model

We report a γ-ray study of the ISM for the Chamaeleon molecular-cloud complex using a total column density (N_H) model based on the dust optical depth (τ_{353}) from the *Planck* thermal emission model. We found that the $\tau_{353} \propto N_H^{1.3}$ model provides the best fit to the γ-ray data, which may suggest dust grain evolution in the molecular cloud complex.

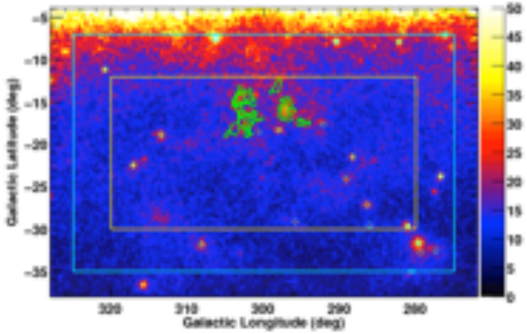
Study of γ rays from Molecular Cloud Regions

γ rays ∼ CRs x ISM (or ISRF)

Diffuse GeV γ rays are powerful probe to study the ISM

- **γ-ray production does not depend on the chemical and thermodynamic state of the ISM**
- **A good tracer of the total gas column density**

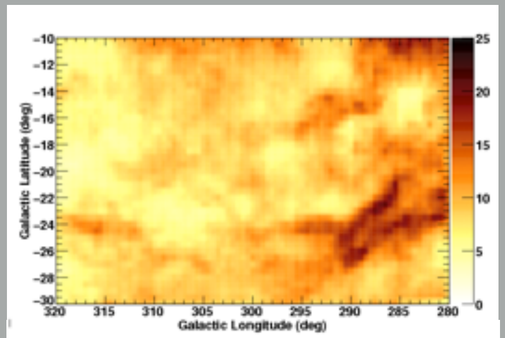
γ ray (*l*,*b*,*E*)



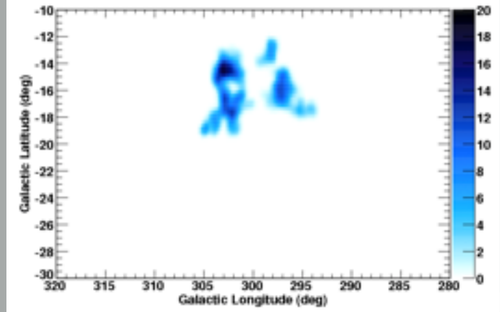
=

(Ackermann+12)

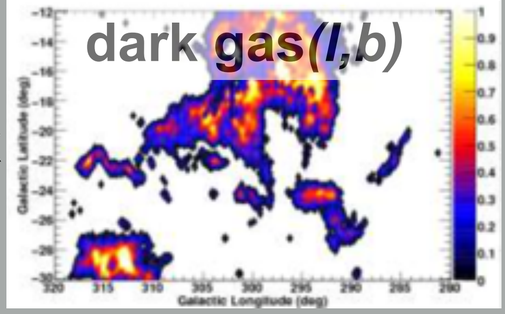
$q_{HI}(E)$ x



+ $q_{CO}(E)$ x



+ $q_{dark}(E)$ x



+ background emission (IC, Isotropic and point sources)

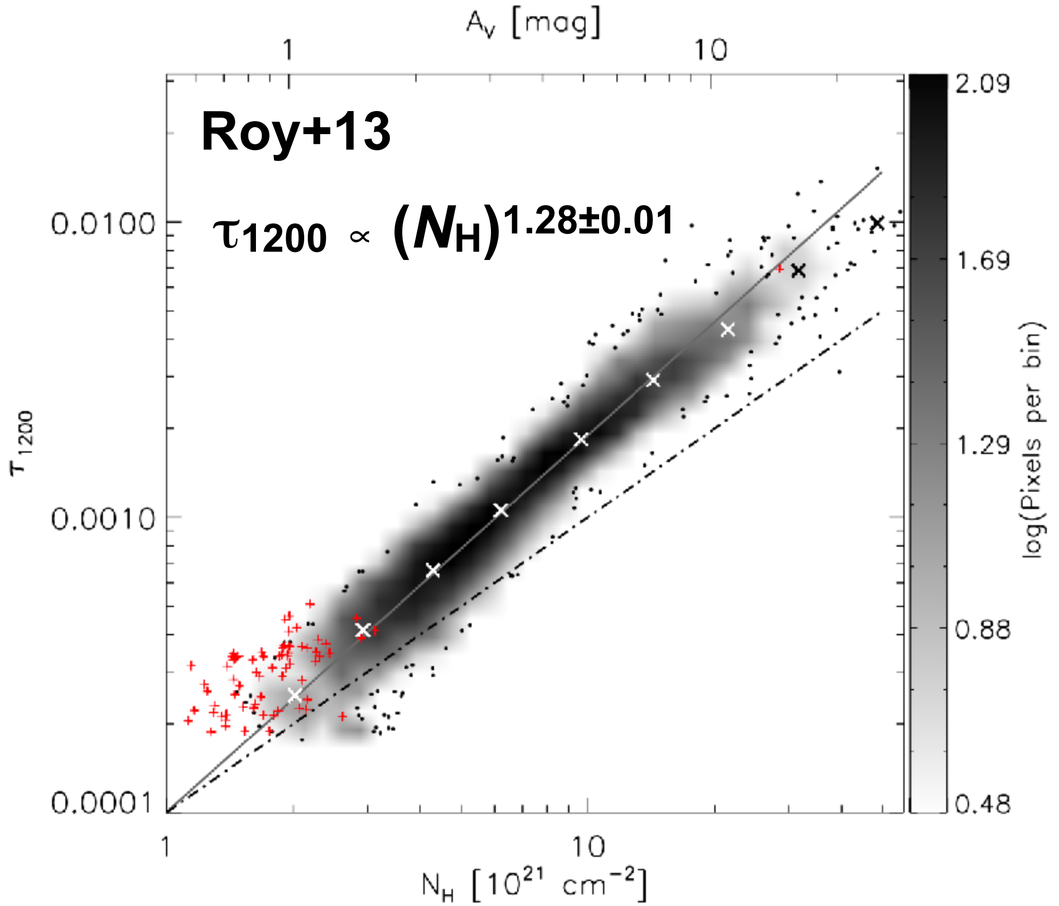
"Conventional γ-ray analysis" (e.g., Ackermann+12)

- **Fit γ-ray data with linear combination of three gas maps under the assumption that CRs uniformly thread the ISM**
- **"dark gas" (gas not traced by standard HI and CO observations) map is inferred by dust extinction map**

N_H Model and γ-ray Analysis

- **Fukui+15 suggested N_H model based on linear function of the thermal dust optical depth τ_{353}**
- **Roy+13/Okamoto+17 found <u>nonlinear relation</u> in Orion/Perseus molecular clouds**

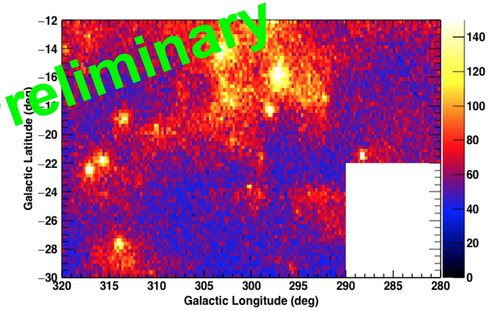
- **We examined several N_H models as function of <u>τ_{353} with linear/nonlinear relations</u> by fitting them to γ-ray data in the Chamaeleon region**



(Reddening data obtained with 2MASS)

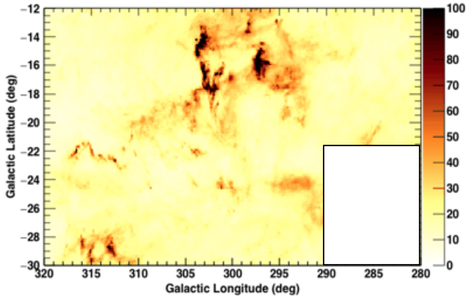
$$\frac{N_{\rm H}(l,b)}{N_{\rm H,ref}} = \left(\frac{\tau_{353}(l,b)}{\tau_{353,\rm ref}}\right)^{1/\alpha}$$

γ ray (*l*,*b*,*E*)



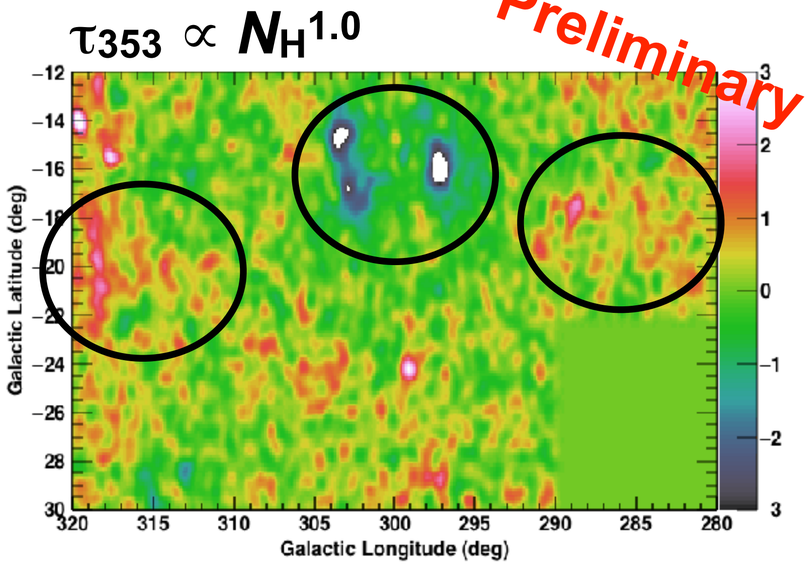
Preliminary

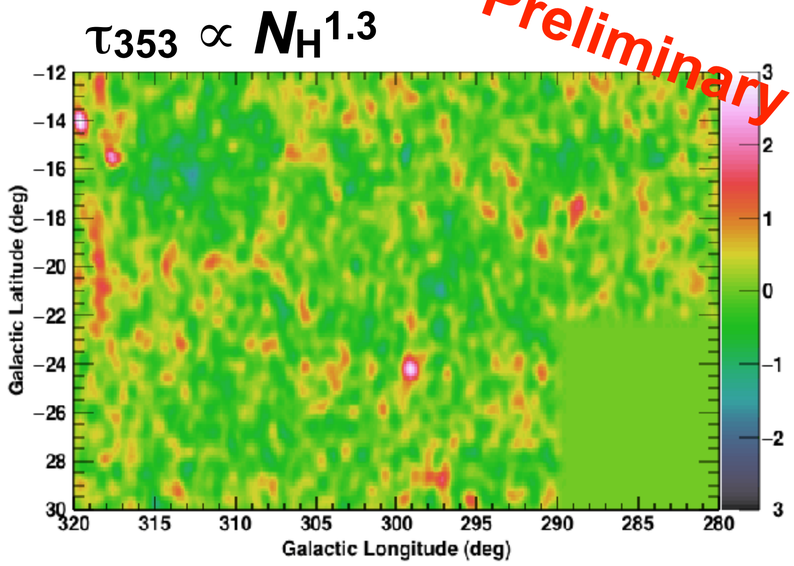
= $q_H(E)$ x

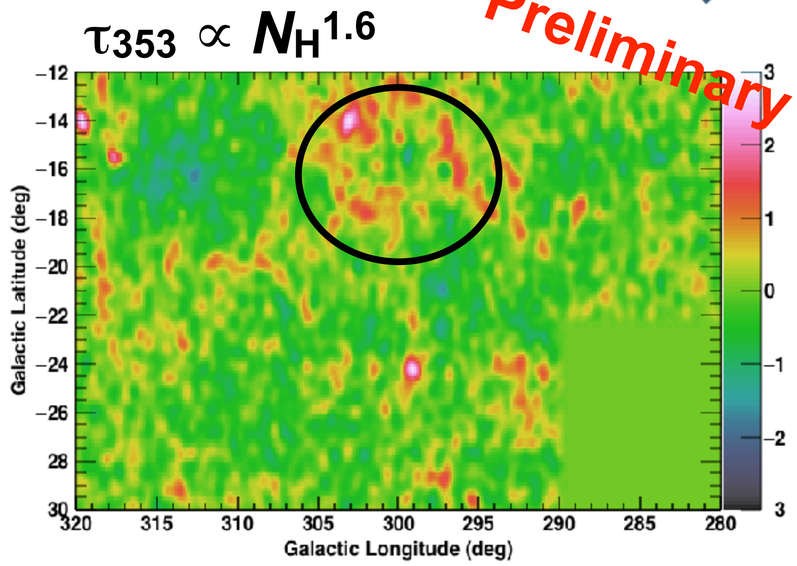


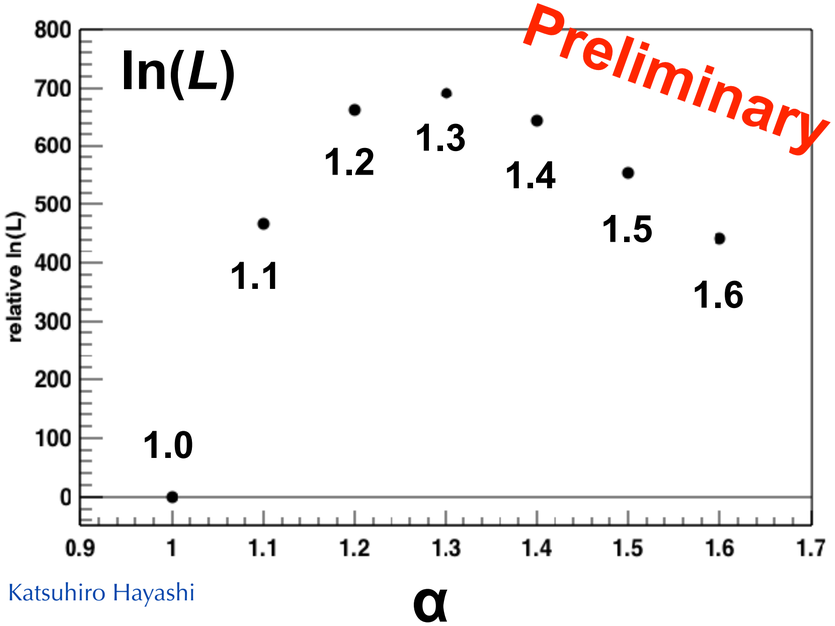
$$+ I_{\rm IC}(l,b,E) + I_{\rm iso}(E) + \sum_j {\rm PS}_j(l,b,E)$$

Results (Residual Maps)









- Residuals in standard deviation (σ)
- Significant positive and negative residuals are seen in the models of $\tau_{353} \propto N_H^{1.0}$ and $\propto N_H^{1.6}$
- $\tau_{353} \propto N_H^{1.3}$ model provides the best fit to γ-ray data; lower residuals and the highest ln(*L*)
- The nonlinearity may suggest grain evolution in the molecular cloud complex

References: Ackermann et al. 2012, ApJ, 755, 22
Okamoto et al. 2017, ApJ, 838, 13
Fukui et al. 2015, ApJ, 798,6
Roy et al. 2013, ApJ, 765, 55