A Case Against PAHs as the Carrier of the AME

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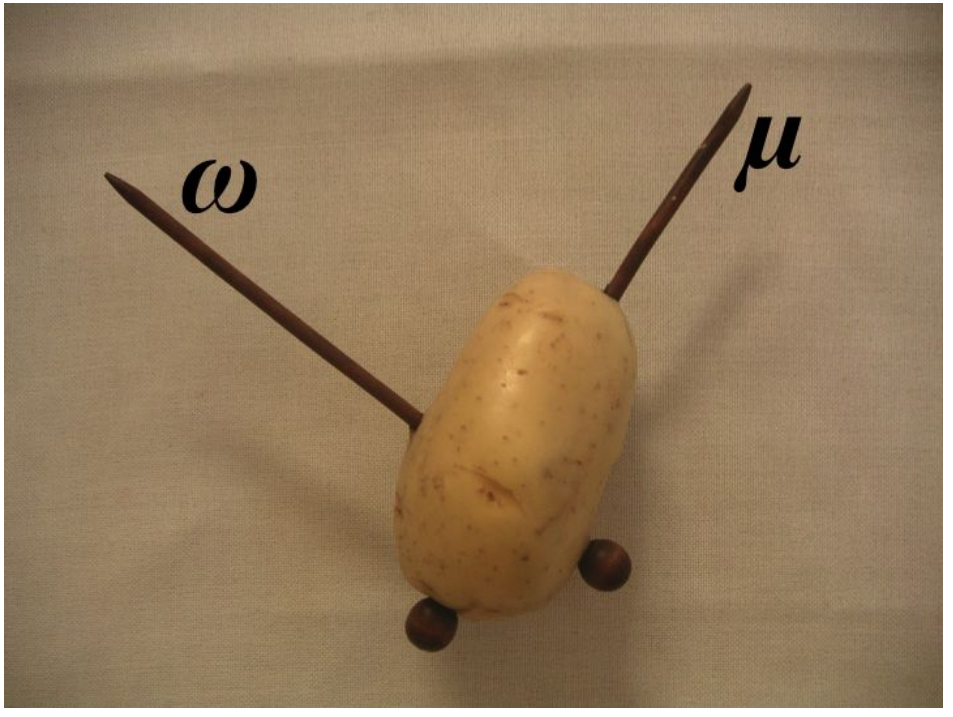
Spinning Dust Physics

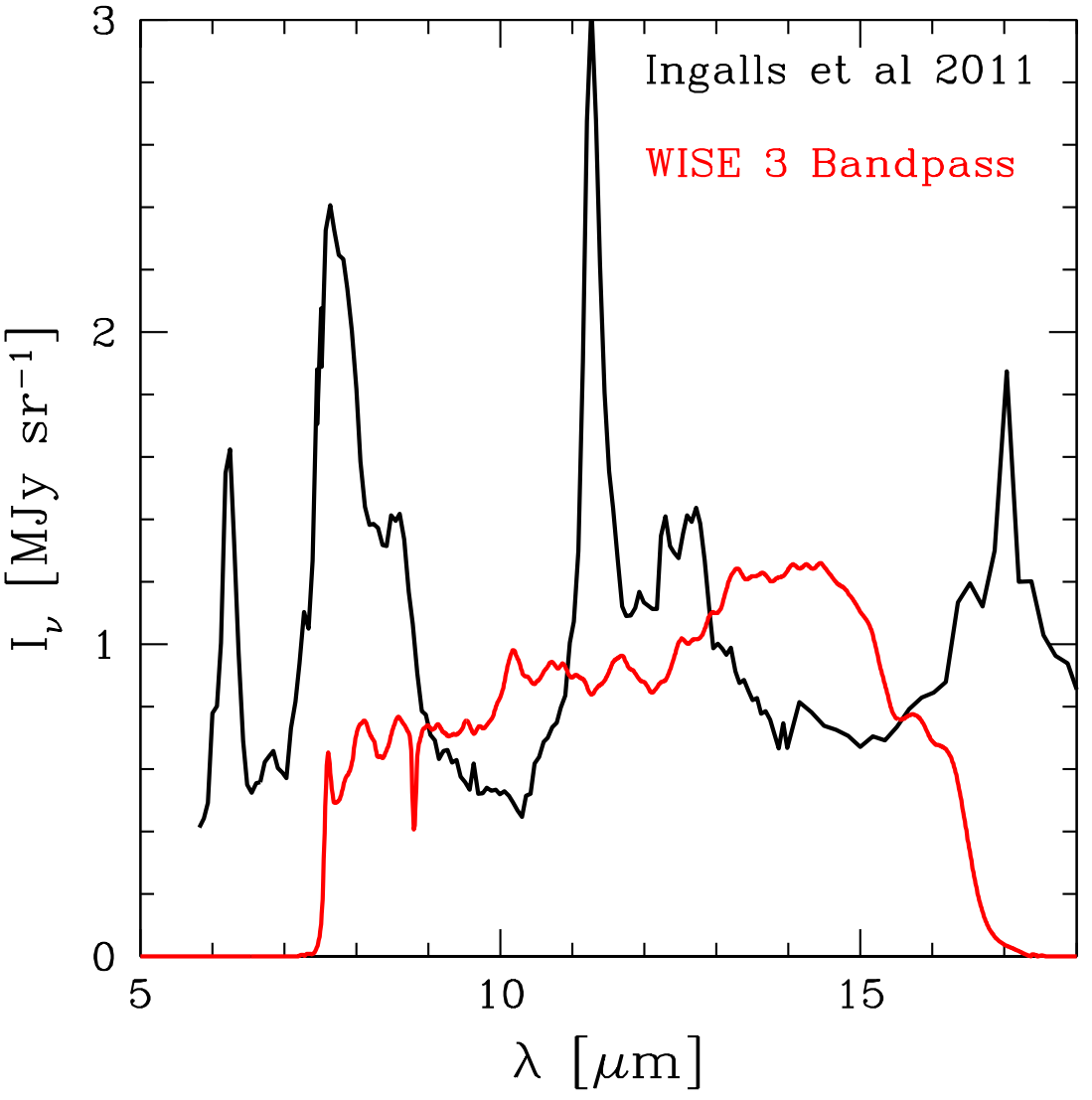
- AME can be explained by spinning dust grains (Draine & Lazarian 1998ab)
- Very small grains (e.g. PAHs) can get spun up by gas collisions, radiative torques, and other processes
- If grains have a dipole moment, this rotation causes them to radiate



Credit: Yacine Ali-Haïmoud

PAHs

- Attractive AME carrier because they are small and ubiquitous
- Abundance traced by IR emission features at 8 and 12 μm



Spinning Dust Emissivity

Galactic spinning dust emissivity

$$j_{\nu,\ 30\ \mathrm{GHz}}/n_H = 3 \times 10^{-18}\ \mathrm{Jy\ cm^2\ sr^{-1}\ H^{-1}}$$

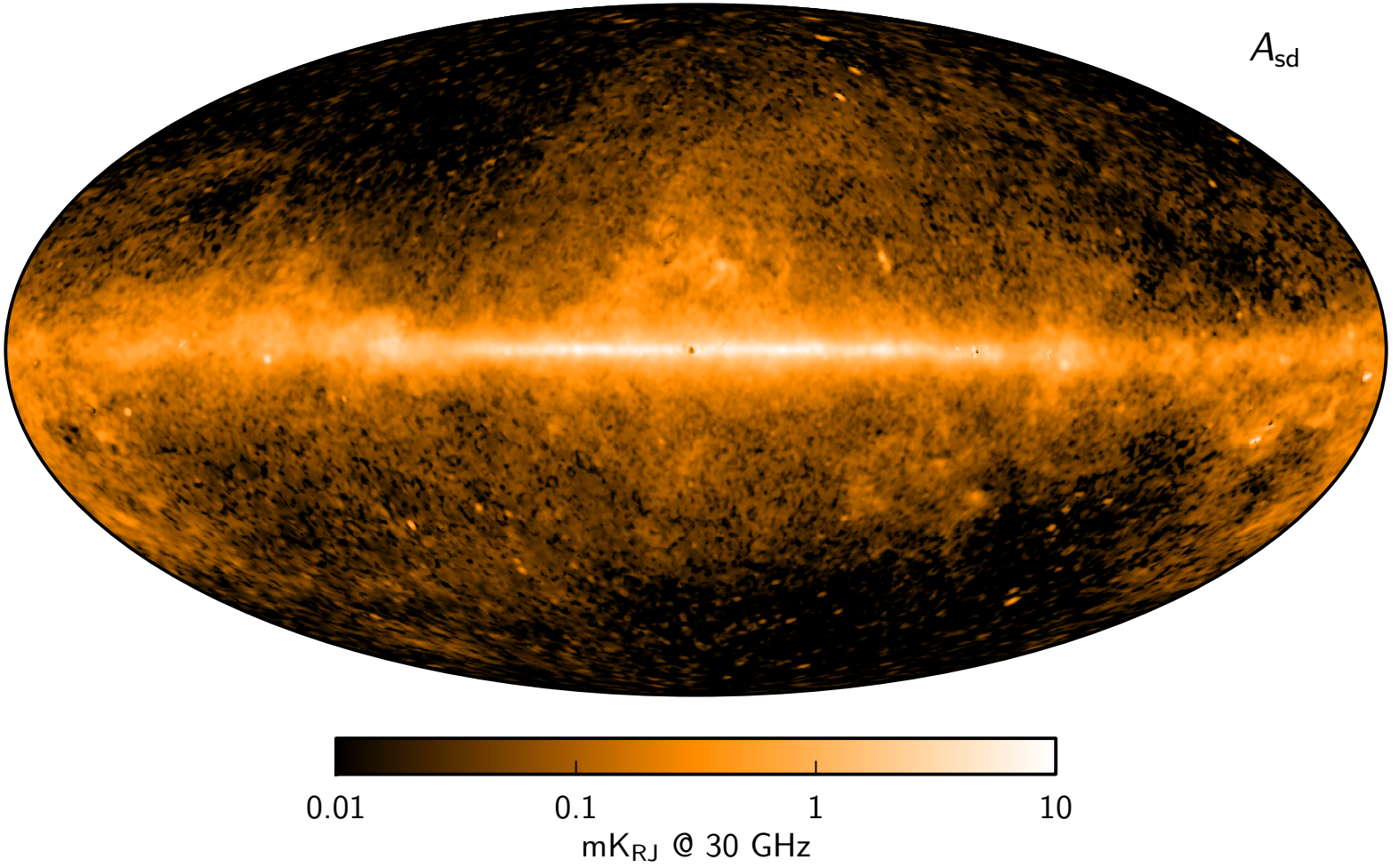
Emissivity per PAH fairly robust to environmental conditions, so assume a linear scaling with Σ_{PAH}

$$\boxed{I^{\mathrm{AME}}_{\nu,\ 30\ \mathrm{GHz}} = 1.0 \left(\frac{\Sigma_{\mathrm{PAH}}}{M_\odot\ \mathrm{kpc}^{-2}} \right)\ \mathrm{Jy\ sr^{-1}}}$$

Full-Sky Test of the Spinning PAH Hypothesis

Full-sky maps of the AME derived from component separation of the microwave sky by *Planck* let us test the AME-PAH connection in detail.

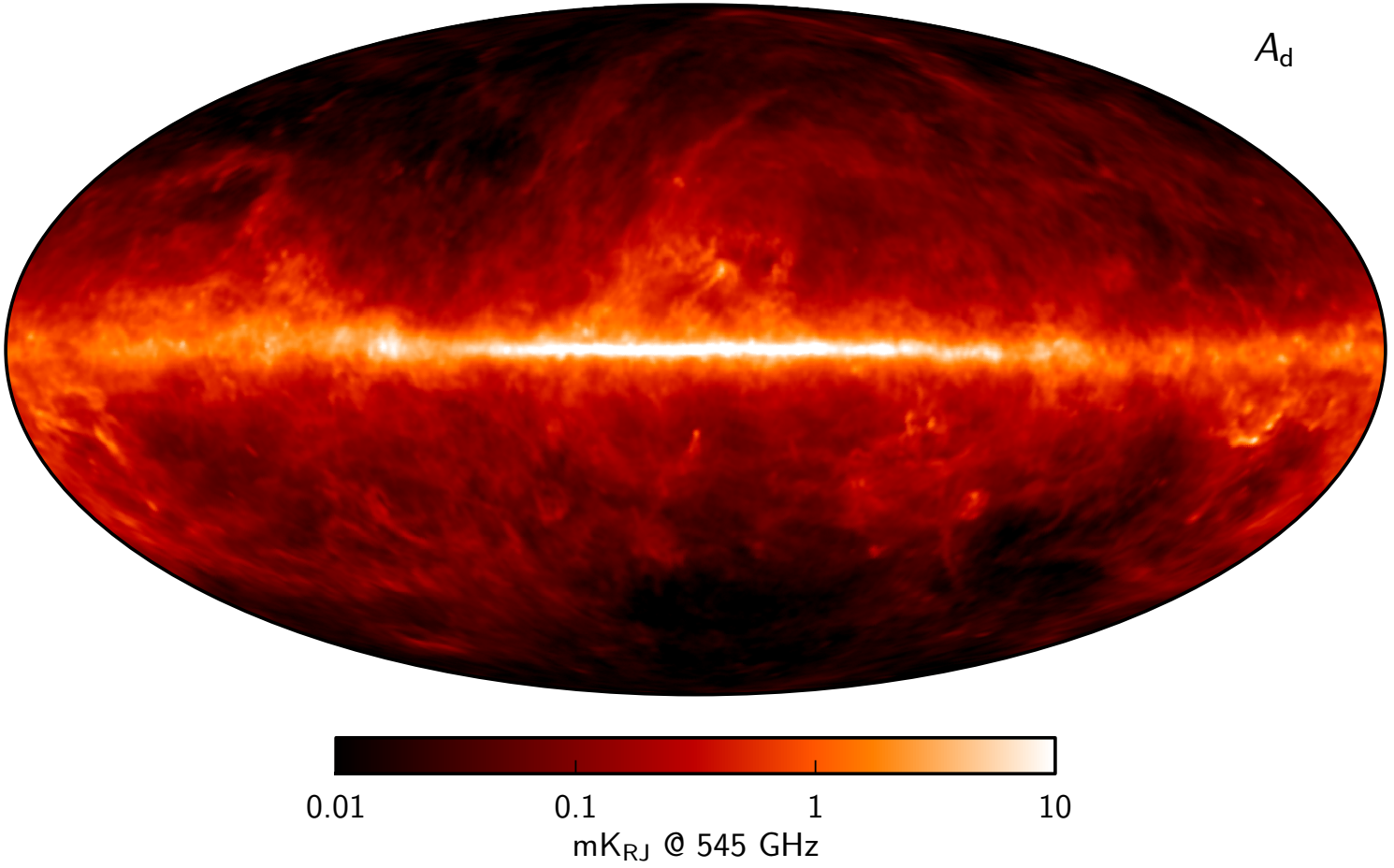
I_ν^{AME}



Planck 2015 X

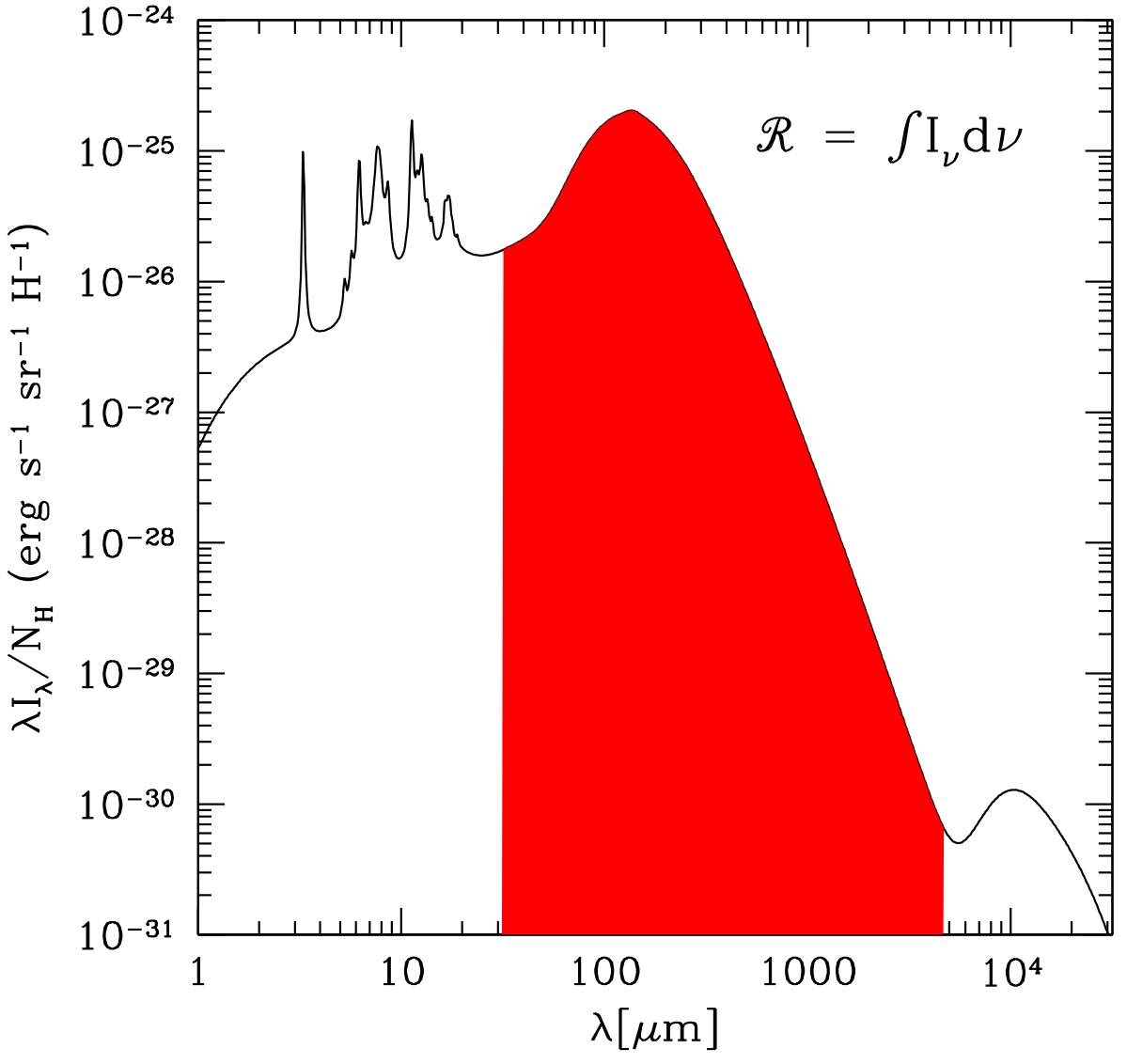
τ_{353}

$$I_\nu = \tau_\nu B_\nu (T_d)$$
$$\tau_\nu = \kappa_\nu M_d$$

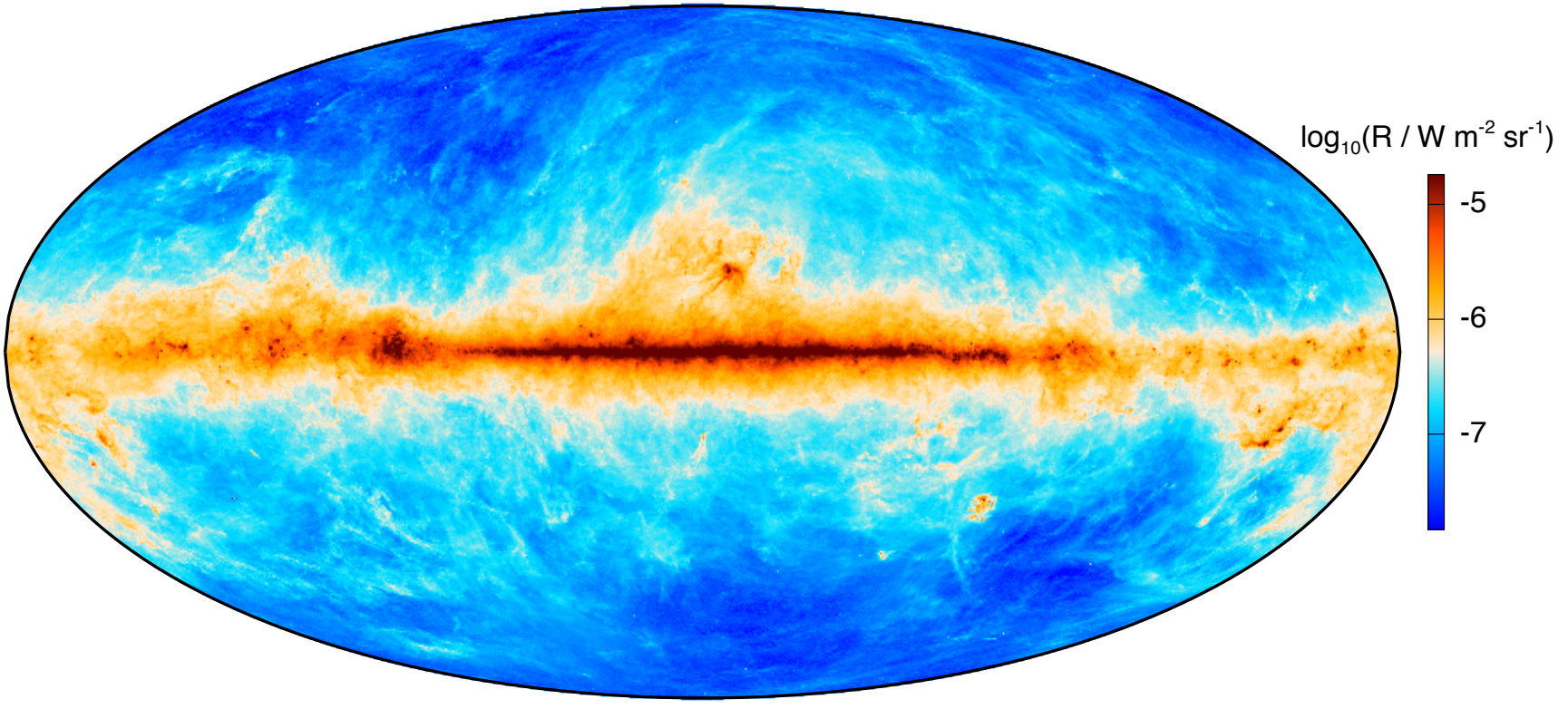


Planck 2015 X

$\mathcal{R}$

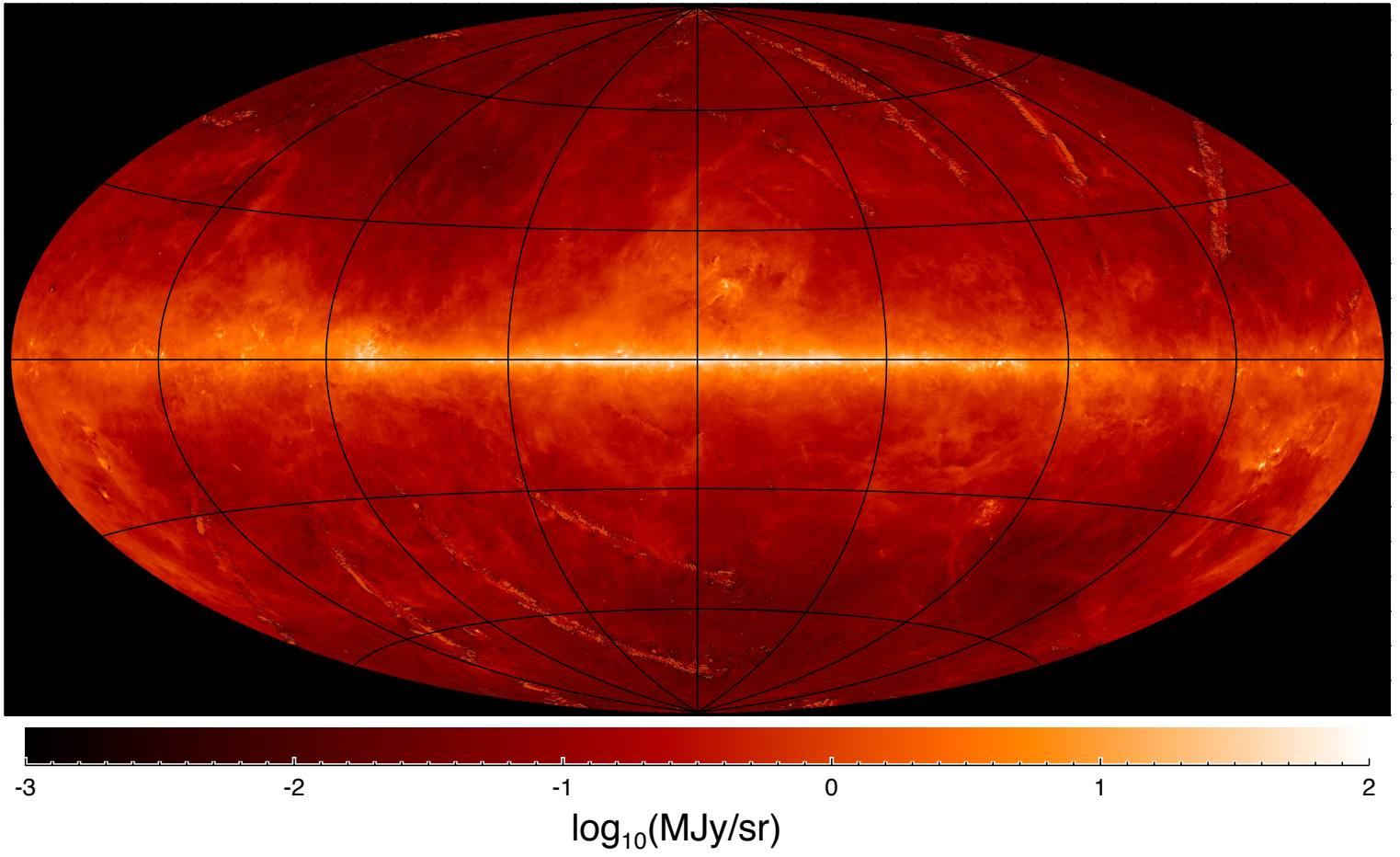

$\mathcal{R} = \int I_\nu d\nu$
$\lambda I_\lambda / N_H$ (erg s^{-1} sr^{-1} H^{-1})
10^{-24}
10^{-25}
10^{-26}
10^{-27}
10^{-28}
10^{-29}
10^{-30}
10^{-31}
1
10
100
1000
10^4
$\lambda[\mu m]$

$\mathcal{R}$



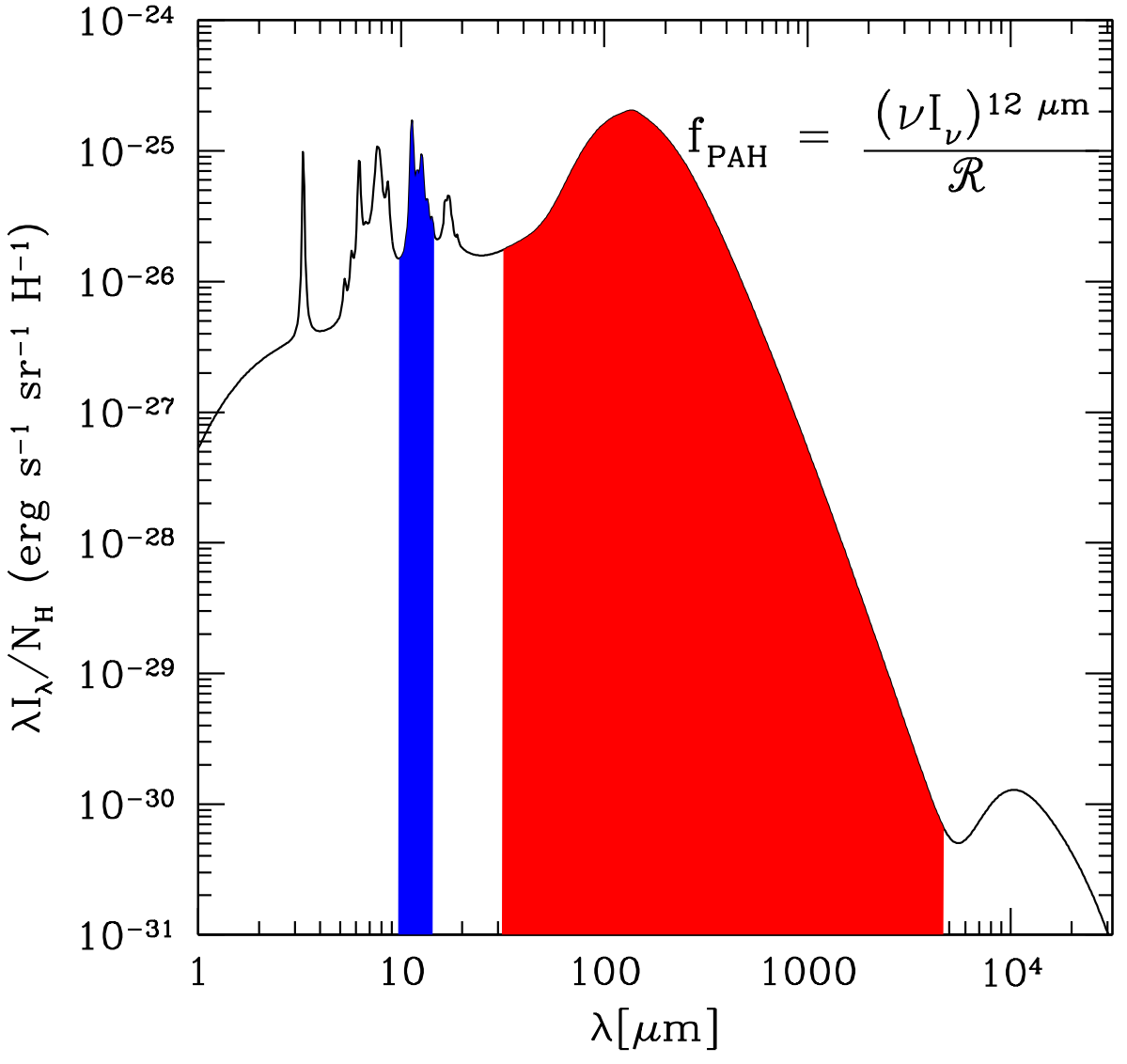
Planck 2013 XI

$I_\nu^{12\,\mu\mathrm{m}}$

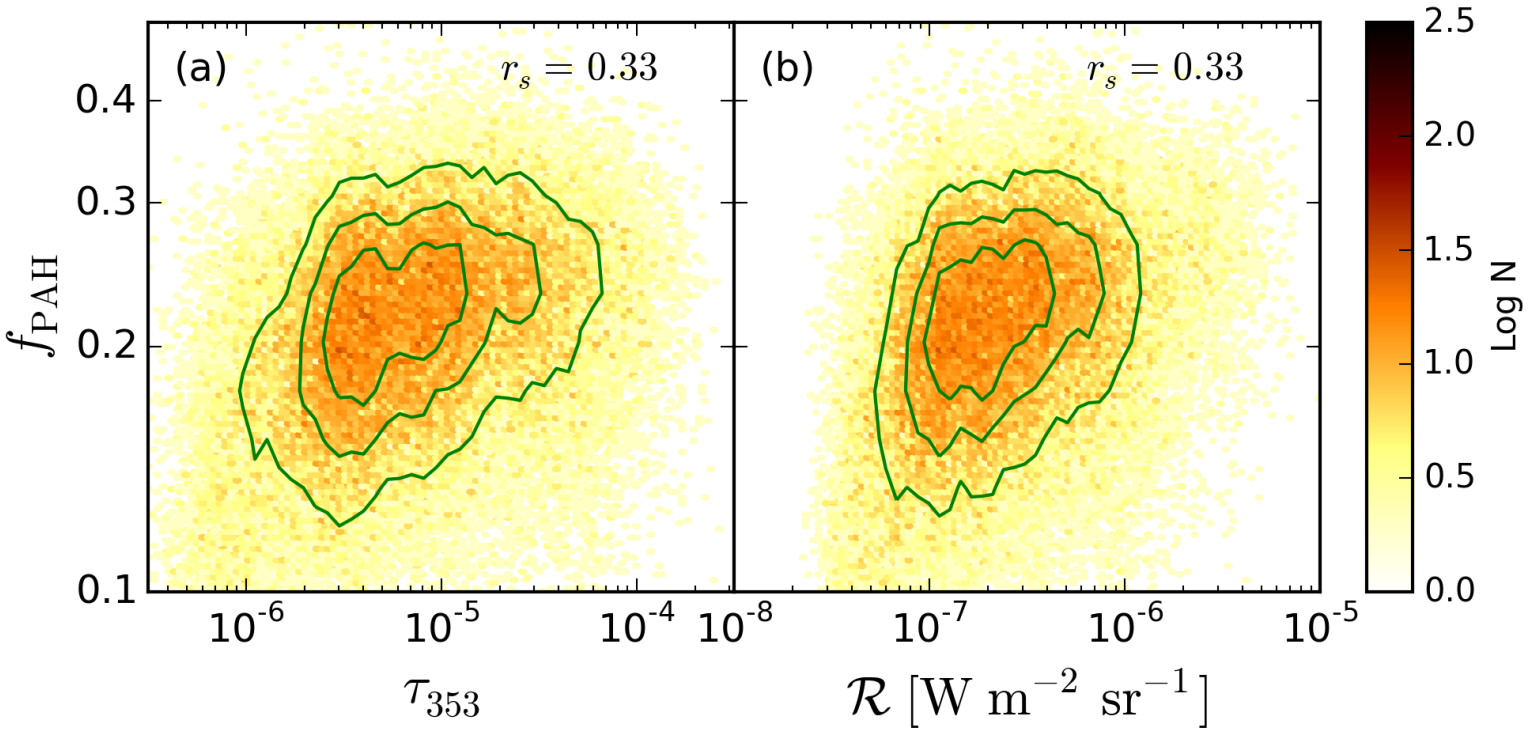


Meisner & Finkbeiner 2014

$f_{\rm PAH}$


$f_{\rm PAH} = \frac{(\nu I_\nu)^{12\ \mu m}}{\mathcal{R}}$
$\lambda I_\lambda / N_H$ (erg s^{-1} sr^{-1} H^{-1})
10^{-24}
10^{-25}
10^{-26}
10^{-27}
10^{-28}
10^{-29}
10^{-30}
10^{-31}
1
10
100
1000
10^4
$\lambda[\mu m]$

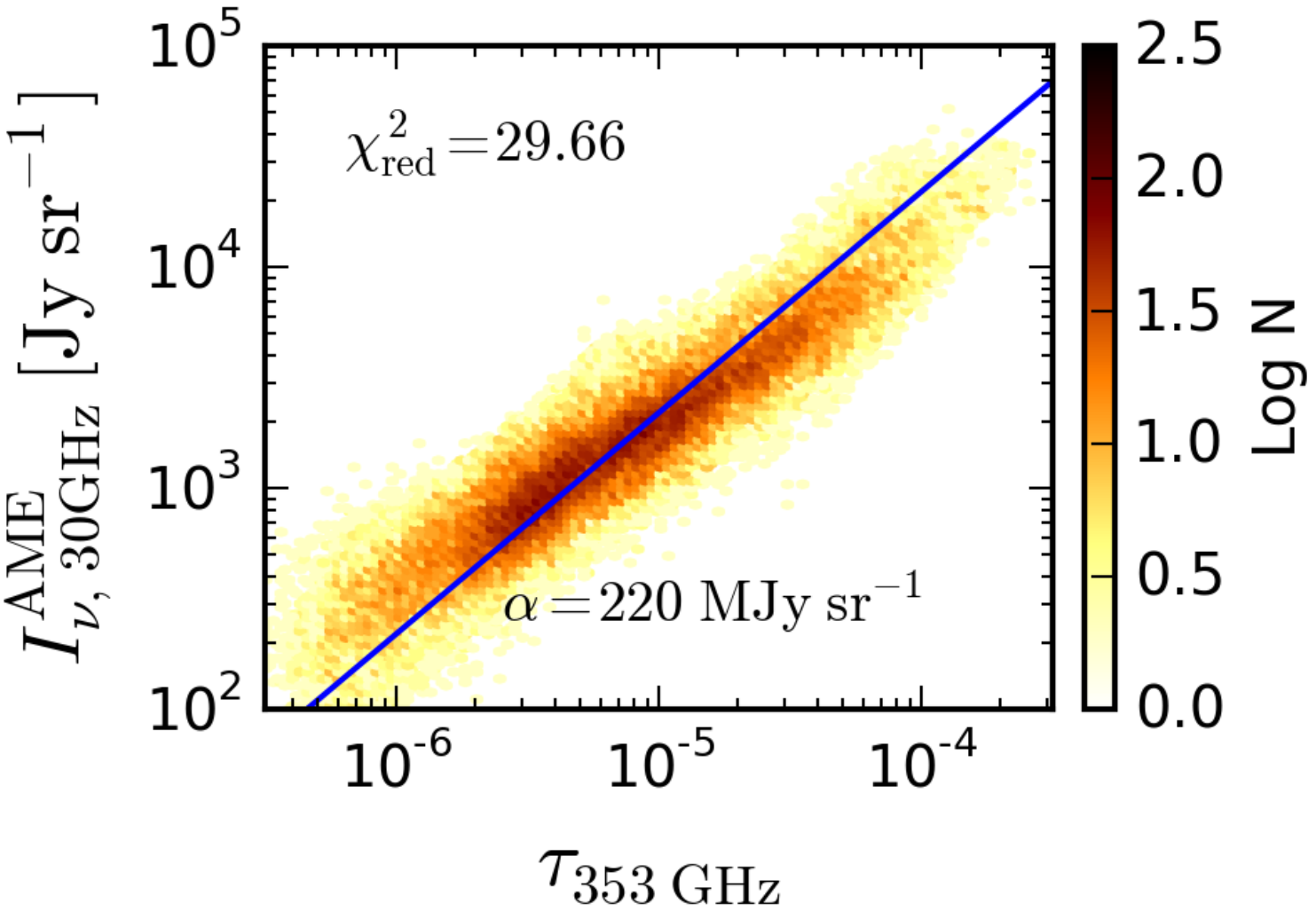
PAH Destruction



Model Predictions

1. Linear correlation with τ_{353}
2. Even tighter correlation with $f_{\mathrm{PAH}}\tau_{353}$
3. No strong correlation with radiation field

Correlation with τ_{353}



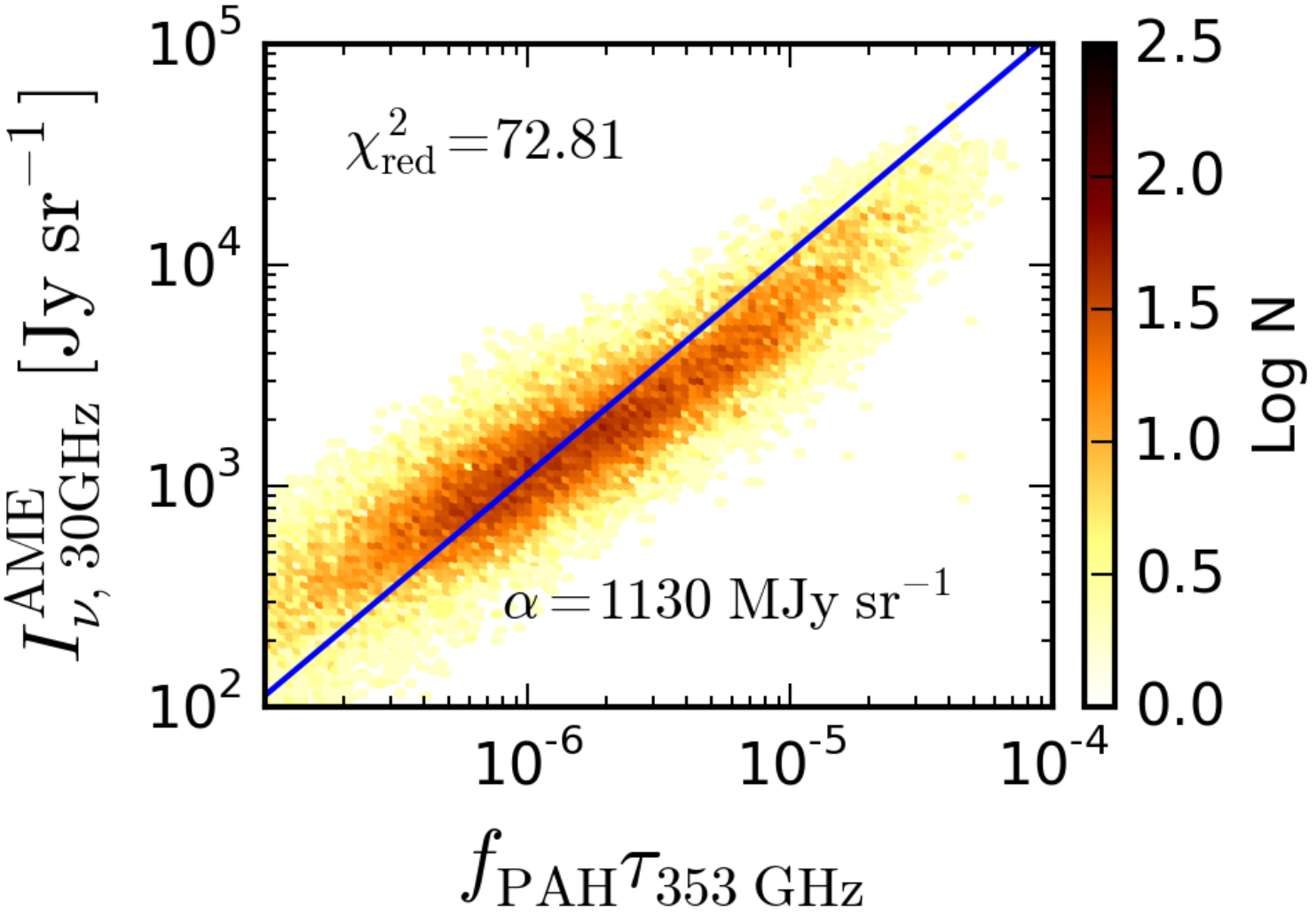
Model Predictions

✓ Linear correlation with τ_{353}

2 Even tighter correlation with $f_{\mathrm{PAH}}\tau_{353}$

3 No strong correlation with radiation field

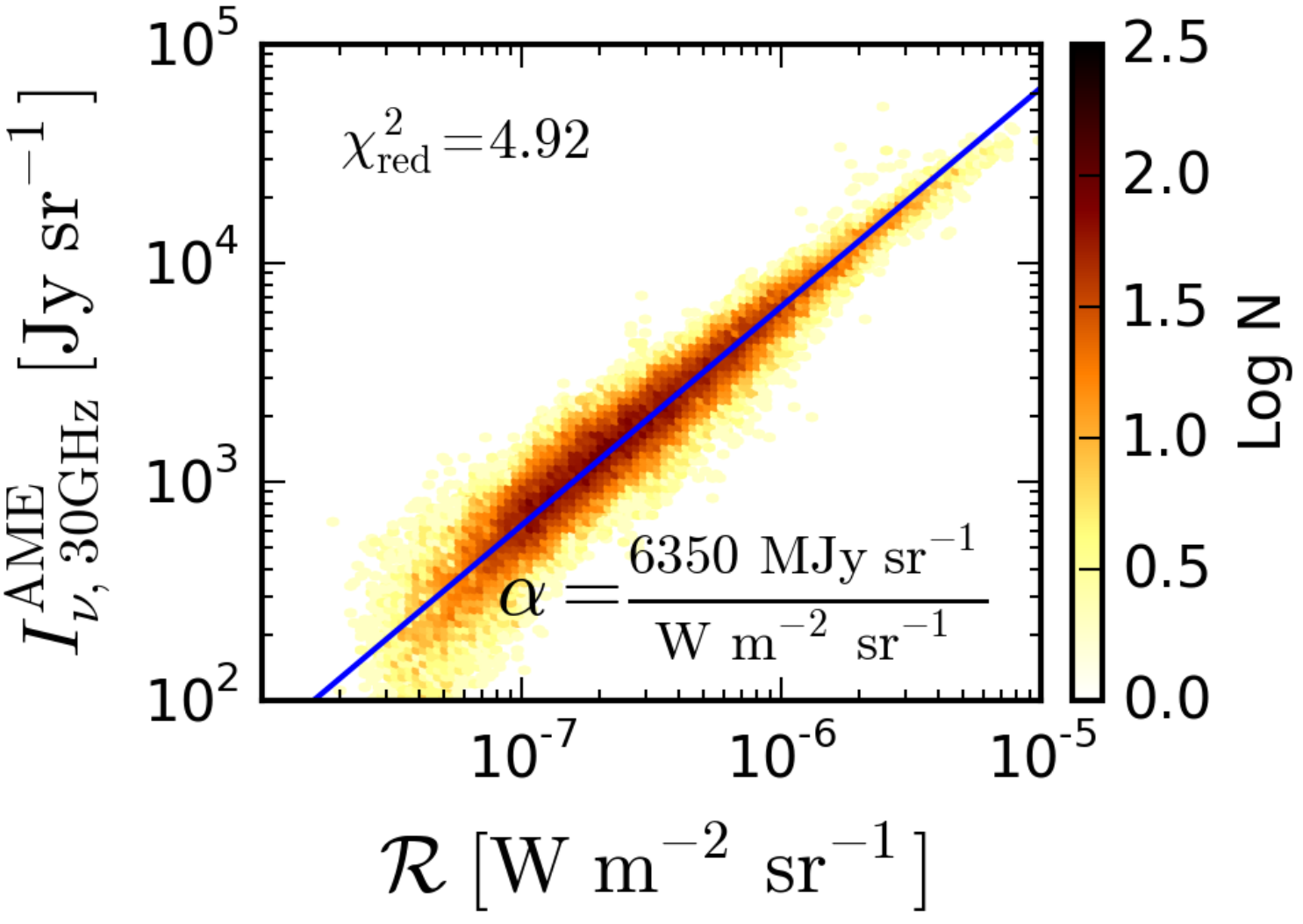
Correlation with $f_{\mathrm{PAH}}\tau_{353}$



Model Predictions

- ✓ Linear correlation with τ_{353}
- X Even tighter correlation with $f_{\mathrm{PAH}}\tau_{353}$
- 3 No strong correlation with radiation field

Correlation with $\mathcal{R}$



Model Predictions

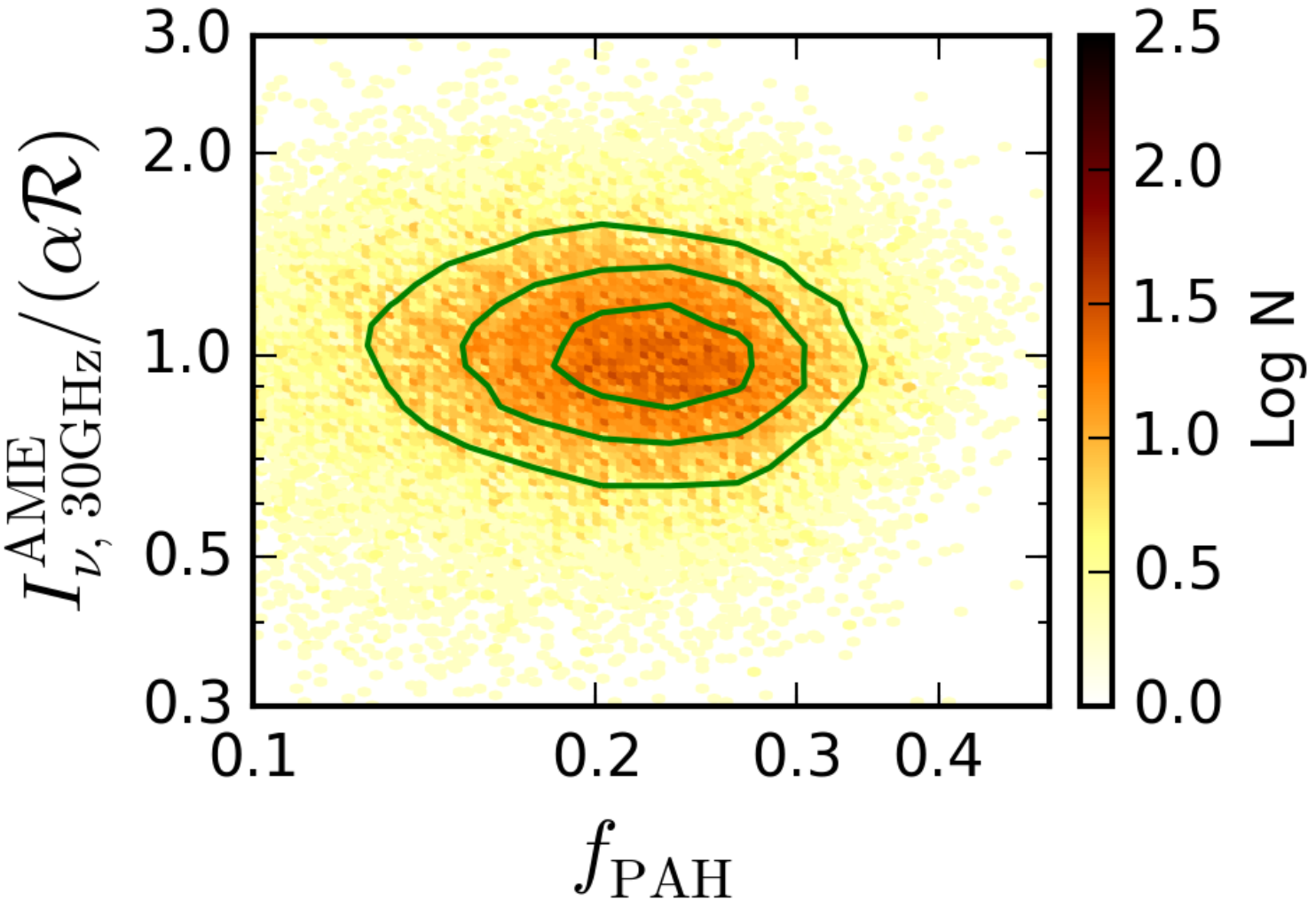
- ✓ Linear correlation with τ_{353}
- X Even tighter correlation with $f_{\mathrm{PAH}}\tau_{353}$
- X No strong correlation with radiation field

A Further Test

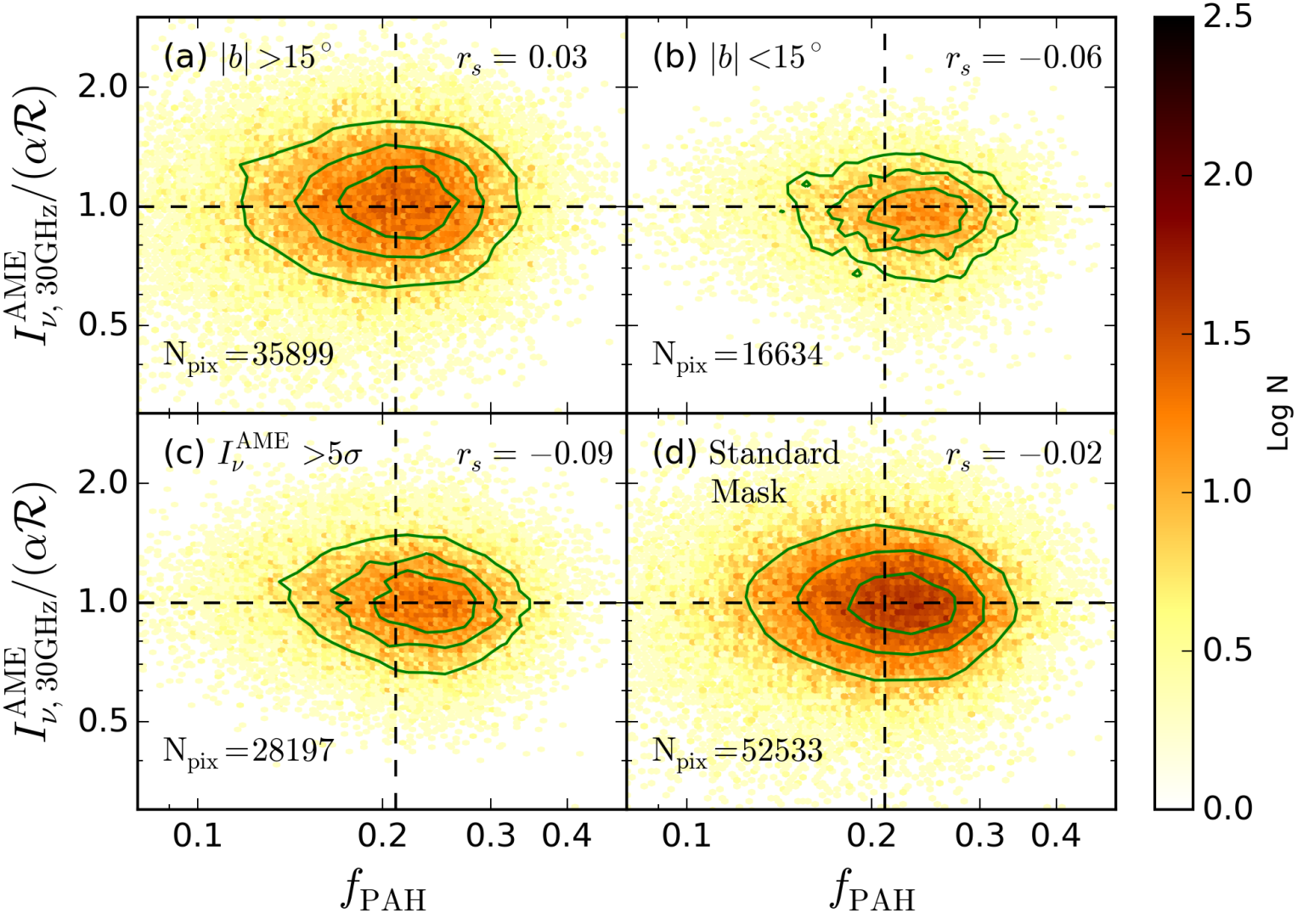
- Does PAH abundance explain fluctuations in AME/$\mathcal{R}$?

Correlation with $f_{\rm PAH}\mathcal{R}$

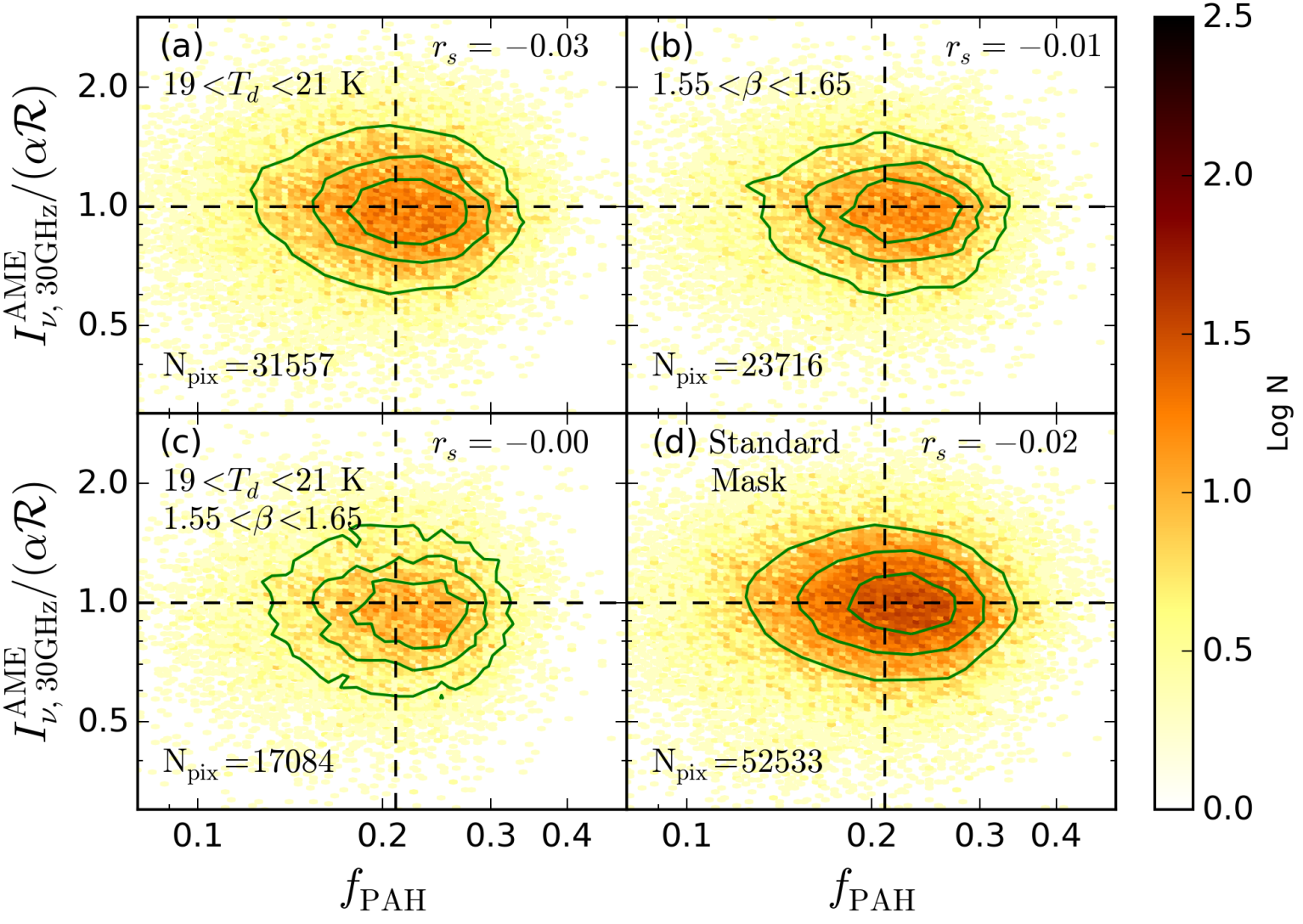
- $f_{\rm PAH}$ does **NOT** improve the correlation with $\mathcal{R}$



No Dependence on Galactic Latitude



No Dependence on Environment

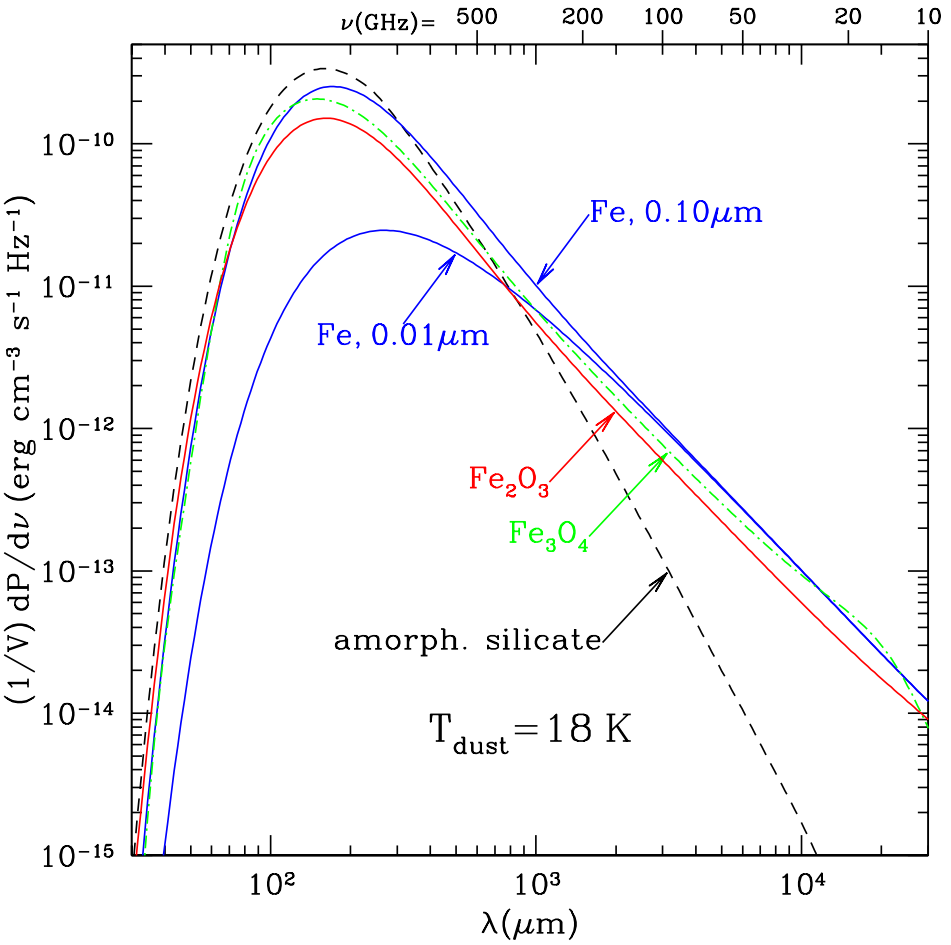


Alternate Models

- What are our next-best theories?

Magnetic Nanoparticles

- **Emissivity per unit volume** of 0.01μm grains heated to 18K
- Emissivity in mm and sub-mm much stronger than amorphous silicate grains



Draine and Hensley 2013

Some Problems...

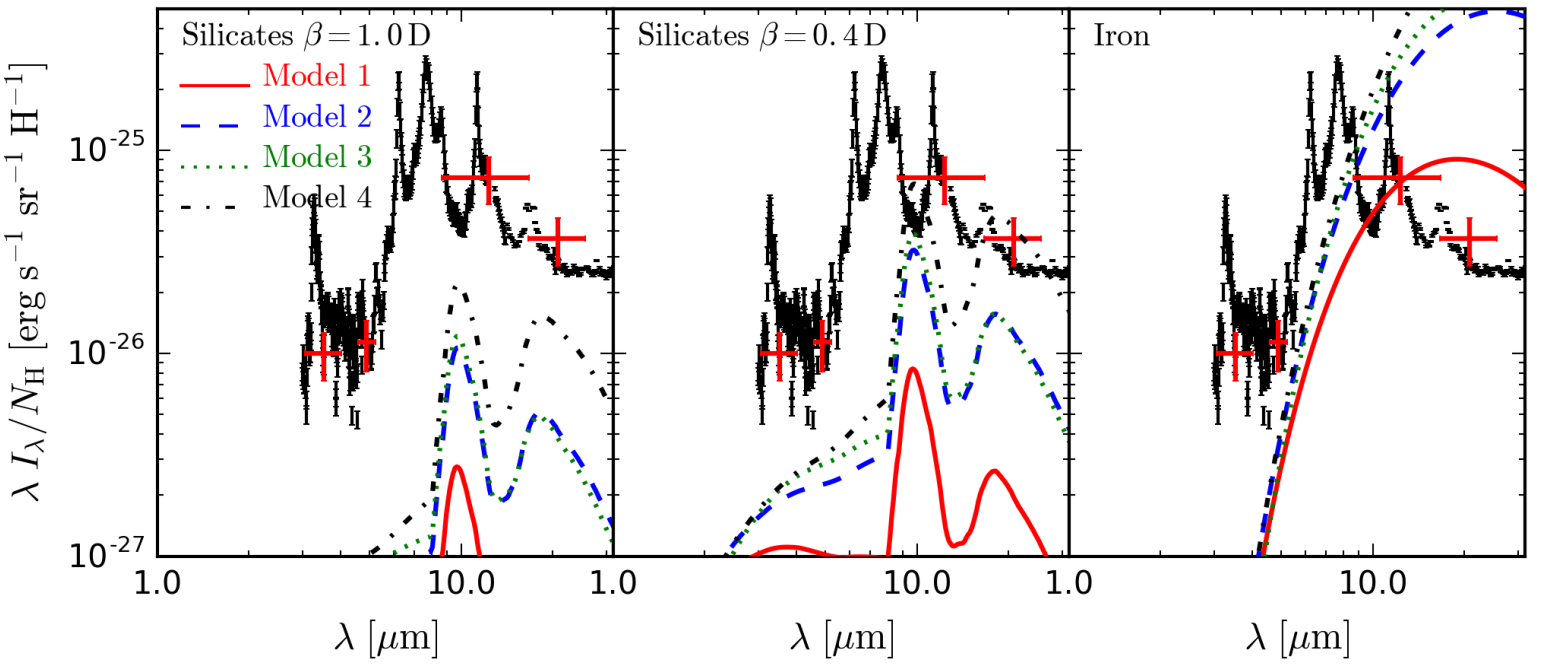
- Not great at reproducing the shape of the SED
- Emission would likely be strongly polarized, in conflict with observations
- Could still be *part* of the AME

Spinning Non-PAHs

- Still spinning dust, just not PAHs – see Thiem's talk
- Not clear whether including a sufficient number of ultrasmall grains of a different type (e.g. silicates) would violate other constraints (e.g. UV extinction)

Spinning Non-PAHs

Preliminary!



No Spinning PAH Emission?

- Invoking alternate explanation still requires asking why the PAHs *aren't* producing significant spinning dust emission
- Electric dipole moments overestimated?

Conclusions

- No apparent link between AME and PAHs, other carriers and other mechanisms should be (re)considered
- New data is needed to better separate AME from other emission