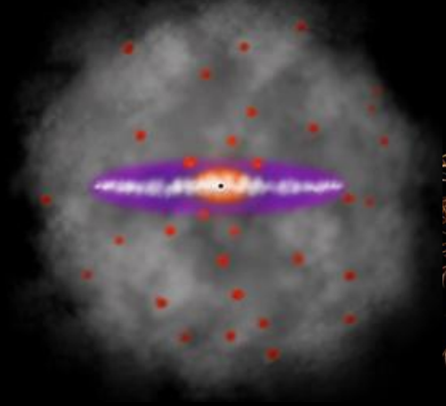

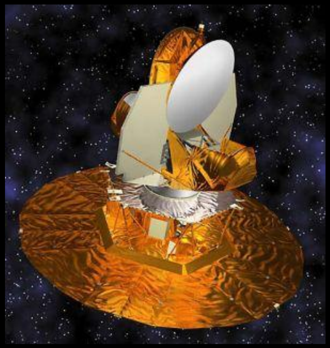

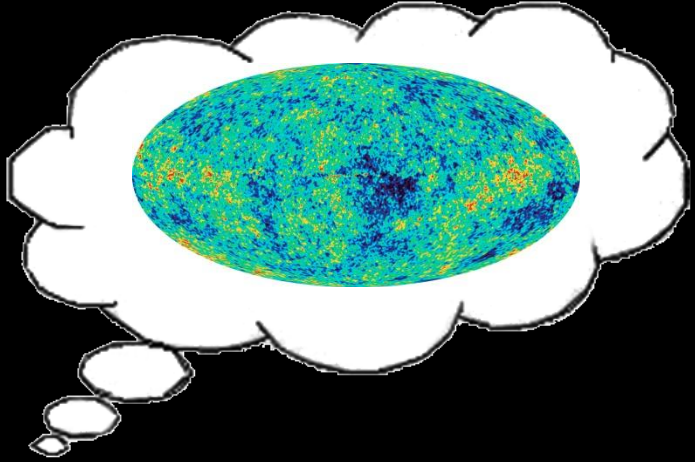

Evaluating the Dark Matter Contribution to Galactic Synchrotron Radiation

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with Stefano Profumo[1] and Brandon Anderson[1]

[1] University of California – Santa Cruz

Identification of Dark Matter   Montpellier, France   July 26, 2010

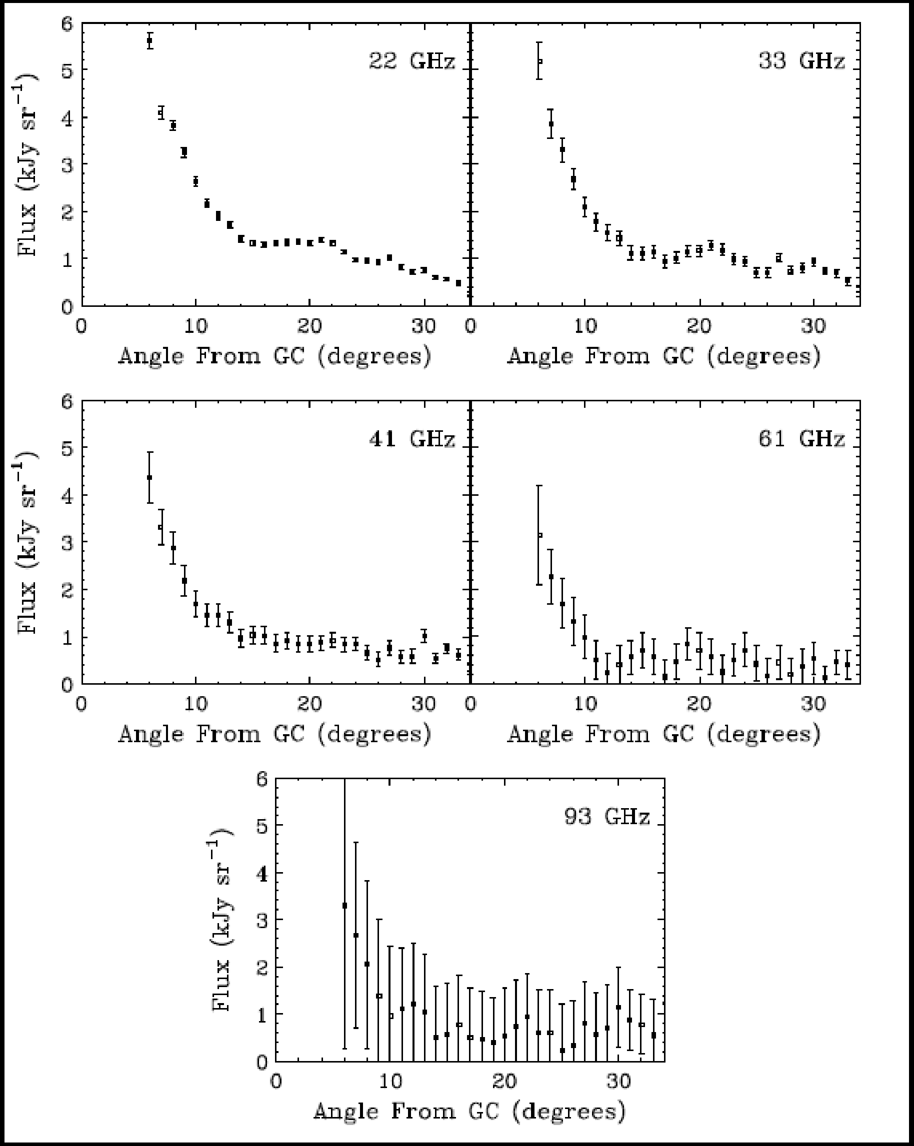
Outline

- Does dark matter naturally explain the observed WMAP haze?
- Does the parameter space of cosmic ray propagation allow a dark matter model of the WMAP haze?
- What would a dark matter model for the WMAP haze look like at higher energies?

The WMAP Haze

- Finkbeiner (2004) pointed out an unexplained residual in the WMAP dataset

- The existence of this residual is controversial, and is not detected by the WMAP team (Gold et al. 2010)

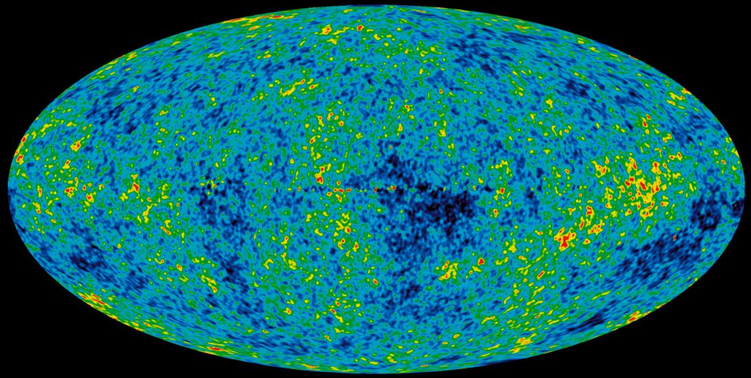


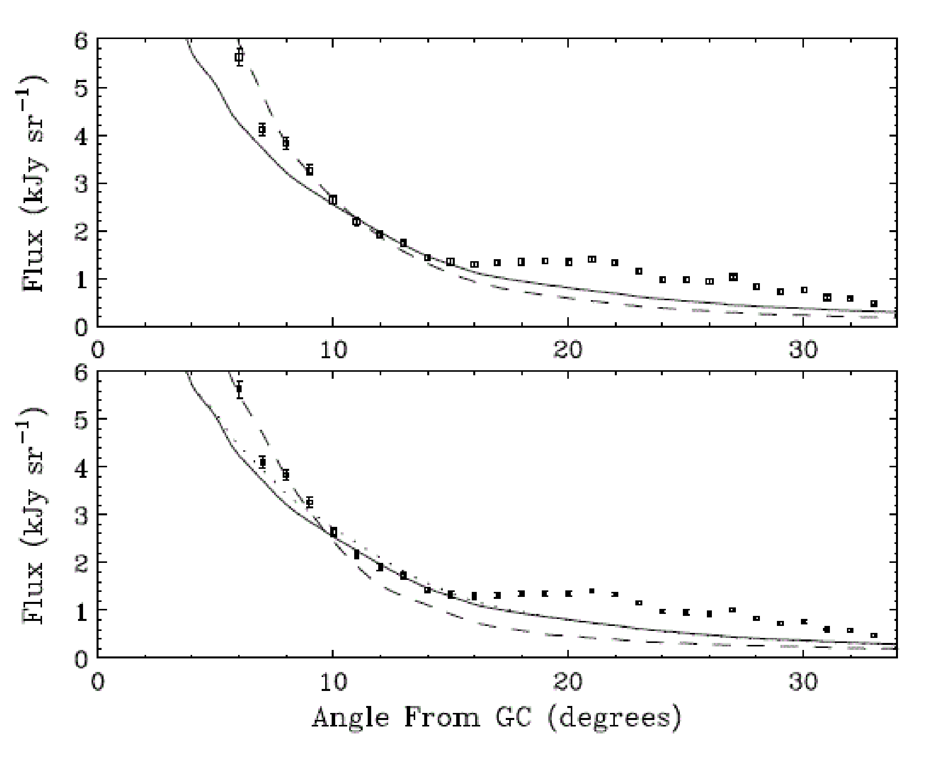
Hooper et al. (2007) (0705.3655)

The WMAP Haze

- Hooper et al. (2007) explained the WMAP haze as the result of dark matter annihilation

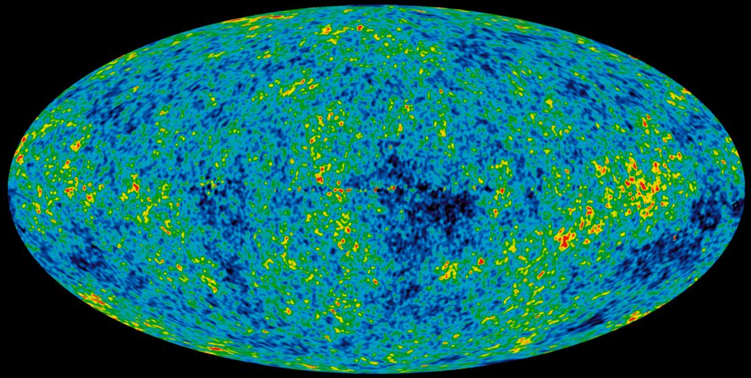
- Also explained by pulsars (Kaplinghat et al. 2009)





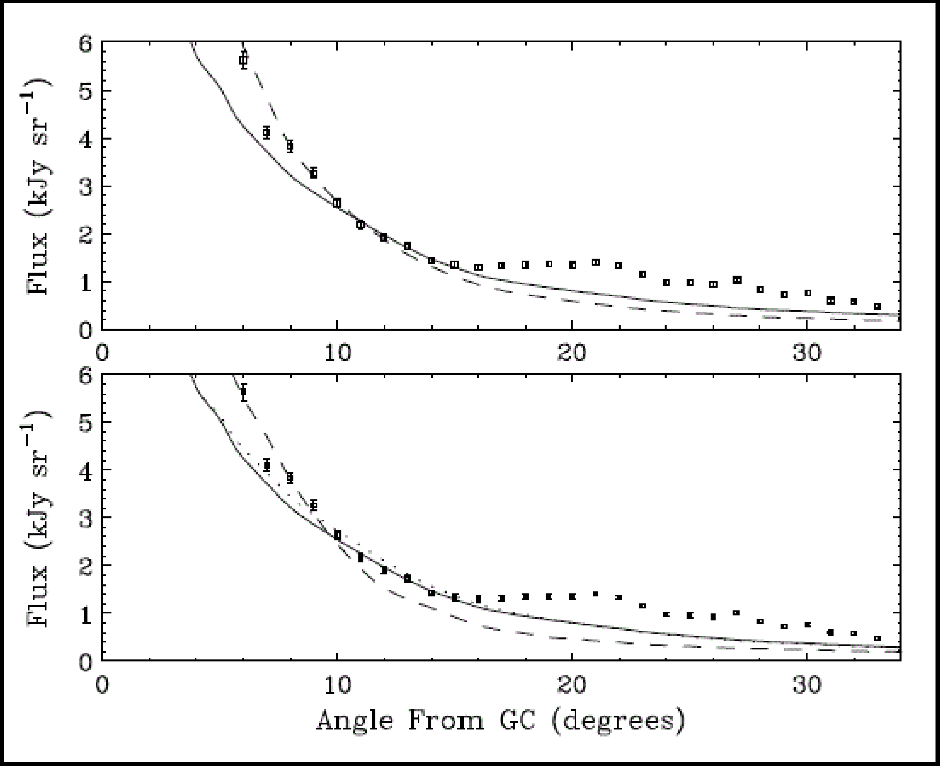
Hooper et al. (2007) (0705.3655)

The WMAP Haze



- The dark matter matches to this haze employed non-standard diffusion parameters

- M_X = 100 GeV
- B = 10 μG
- XX → e^+e^-
- NFW Profile
- $D_0 = 1.58\times10^{28}$ cm^{2}s^{-1} (4 GeV)



Hooper et al. (2007) (0705.3655)

Our modeling codes

- Use DarkSUSY to calculate the primary e^+e^- spectrum for a range of well motivated DM models
- Use Galprop to determine the synchrotron emission and nuclear abundances in each propagation model
- Isolate the simulated DM haze by subtracting the synchrotron component from the corresponding simulation with DM disabled.

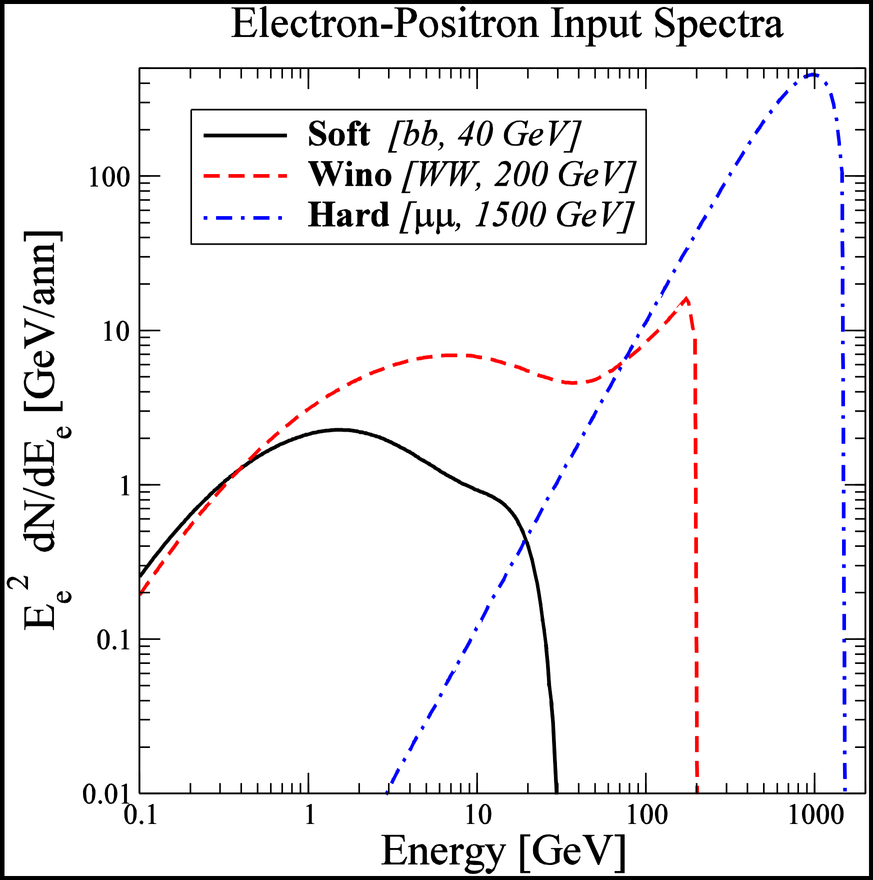
Dark Matter Models

- We test three DM annihilation channels which span a range of motivated WIMP decay models

Soft (40 GeV XX → b b-bar)

Wino (200 GeV XX → W^+W^-)

Hard (1500 GeV XX → $\mu^+\mu^-$)



Galprop Models

- Employing the public version of Galprop, we use the following parameters in our default setup:
  - $D_0 = 5.0 \times 10^{28}\ cm^2\ s^{-1}$
  - Simulation Height = 4 kpc
  - $V_{alfven} = 25\ km\ s^{-1}$
  - Convection = Disabled
  - $B = 11.6 \exp(-r / 10kpc - z / 2kpc)\ \mu G$

Boost Factors

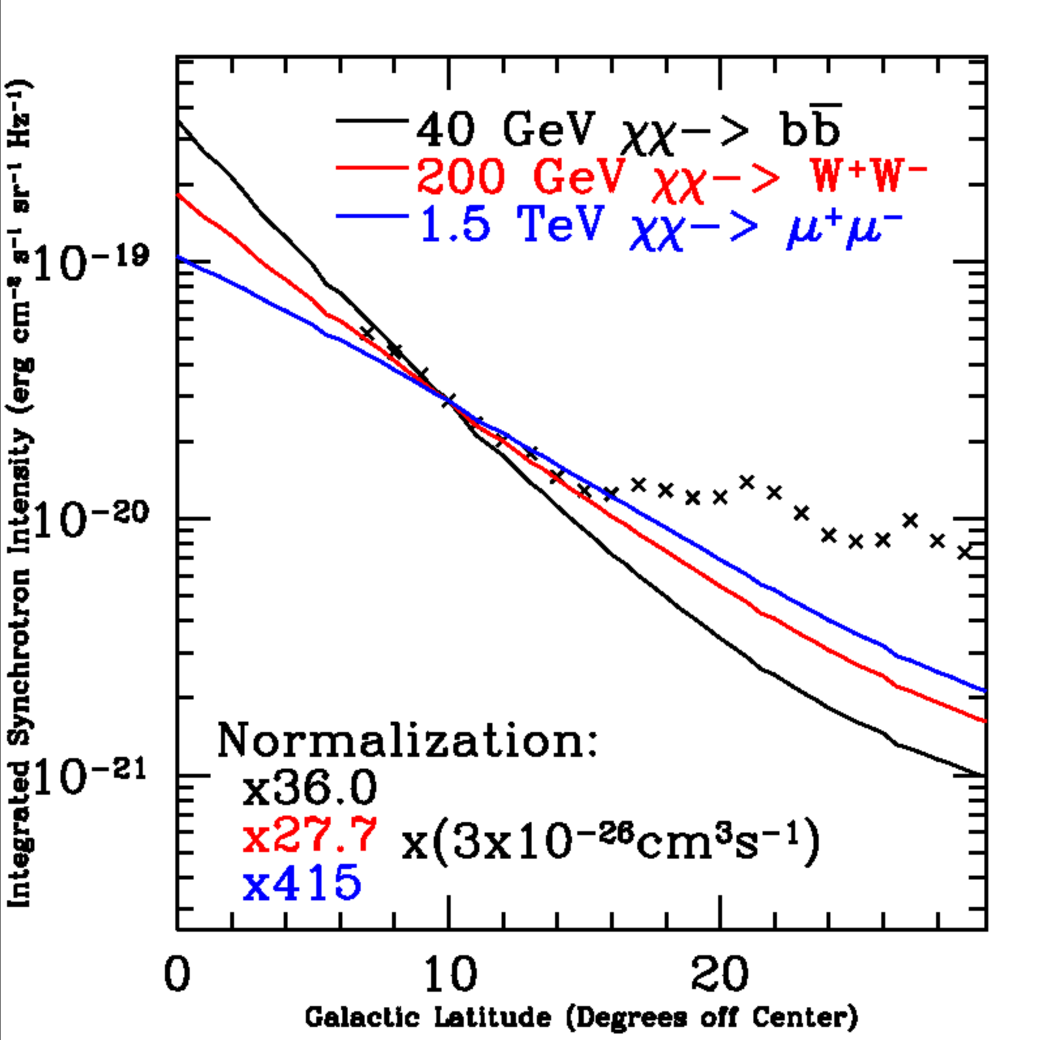
- We multiply the simulated haze by a universal constant to match the observed WMAP haze at 10 degrees latitude and 23 Ghz.

$\Phi = \rho^2(x)/M_{DM}^2 \ \langle\sigma v\rangle$ $\qquad \langle\sigma v\rangle \sim 3 \times 10^{-26}\ cm^2 s^{-1}$

- Changes in $\langle\sigma v\rangle$
- Density fluctuations in DM substructure
- Sommerfield enhancements

Default Model Predictions

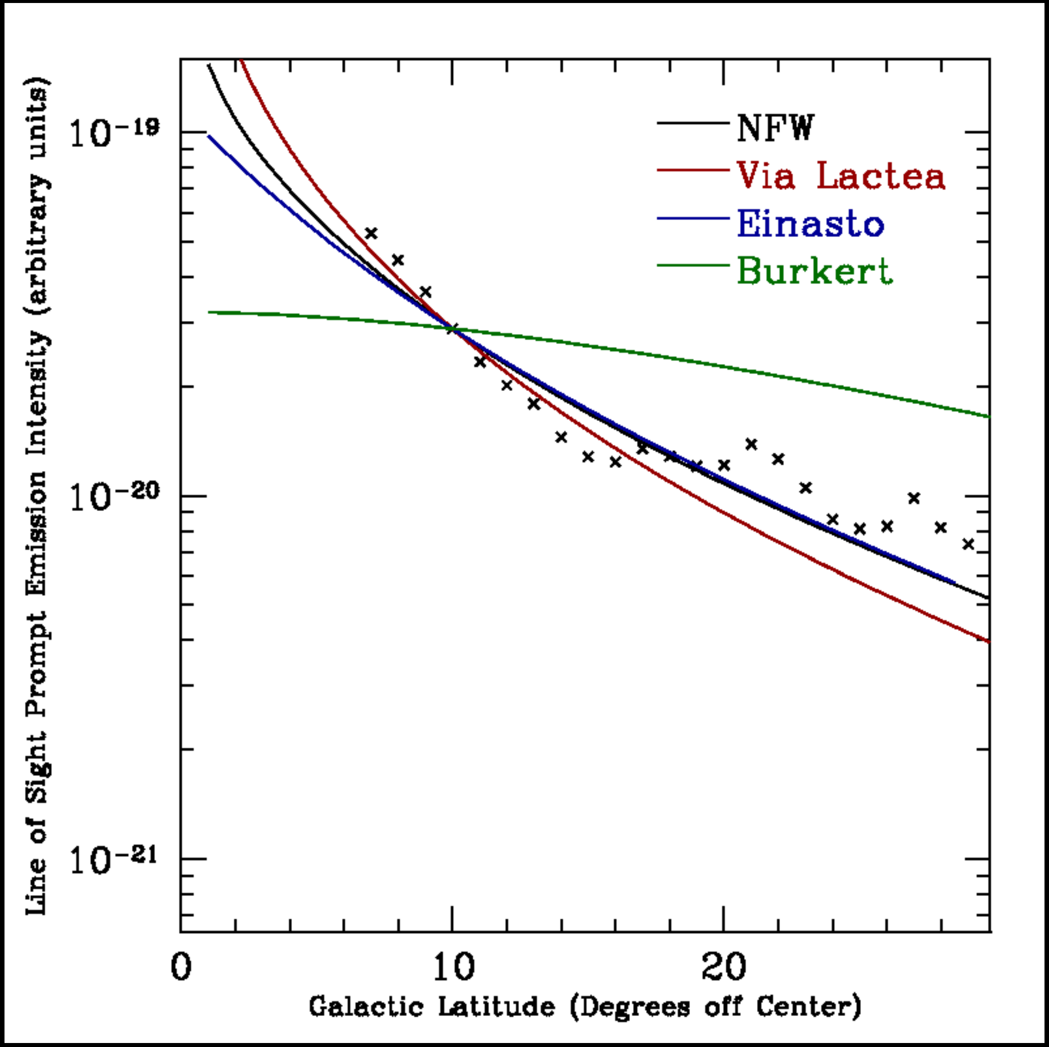
- Our default model shows a morphology which falls off much faster as a function of latitude than the observed haze
- The WMAP haze requires large boost factors



Role of Diffusion

- Without diffusion, the DM profiles actually suggest a much flatter distribution

- Diffusion plays <u>counterintuitive</u> role of increasing the falloff in emission at high latitudes



Role of Diffusion

- We test four diffusion parameters:
  - Diffusion Constant (D_0)
    - Ability of charged particles to move through galaxy
    - Can be thought of as the "thickness" of the soup the particles move through
  - Simulation height (z)
  - Alfvén Velocity (v_α)
  - Convection Velocity

Role of Diffusion

- We test four diffusion parameters:
  - Diffusion Constant (D_0)
  - Simulation height (z)
    - Height of zone which particles move through before they exit the "soup" of the galaxy
  - Alfvén Velocity (v_α)
  - Convection Velocity

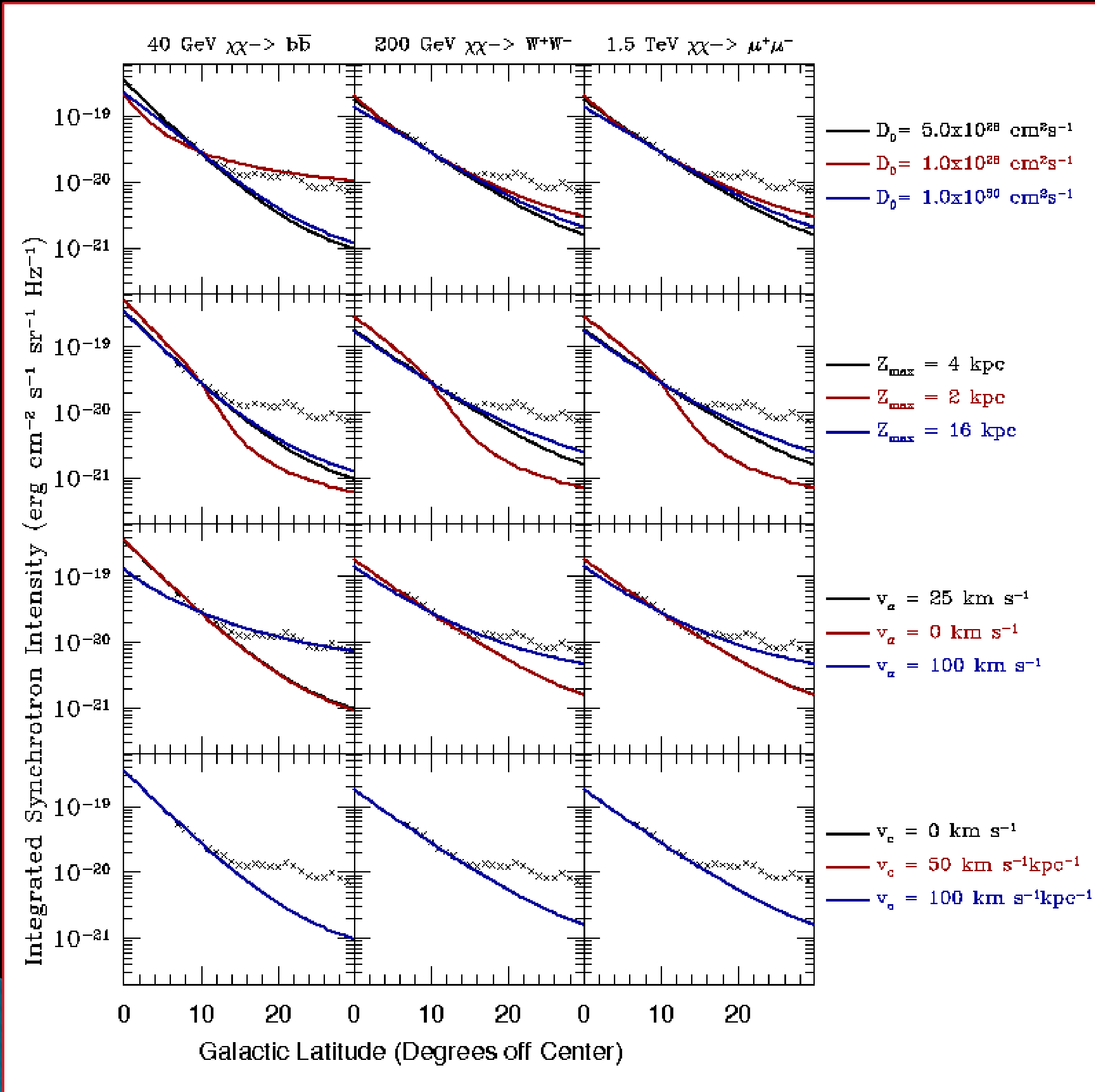
Role of Diffusion

- We test four diffusion parameters:
  - Diffusion Constant (D_0)
  - Simulation height (z)
  - Alfvén Velocity (v_α)
    - Diffusion of particles through momentum space
    - Reacceleration of particles
  - Convection Velocity

Role of Diffusion

- We test four diffusion parameters:
  - Diffusion Constant (D_0)
  - Simulation height (z)
  - Alfvén Velocity (v_α)
  - Convection Velocity
    - Cosmic "wind" pushing particles out of the galaxy

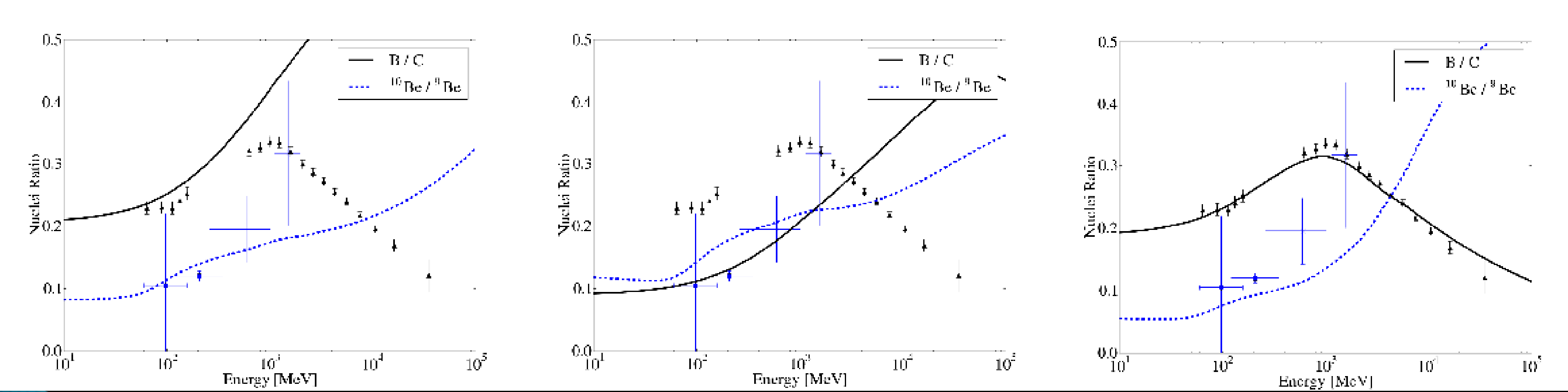
Role of Diffusion



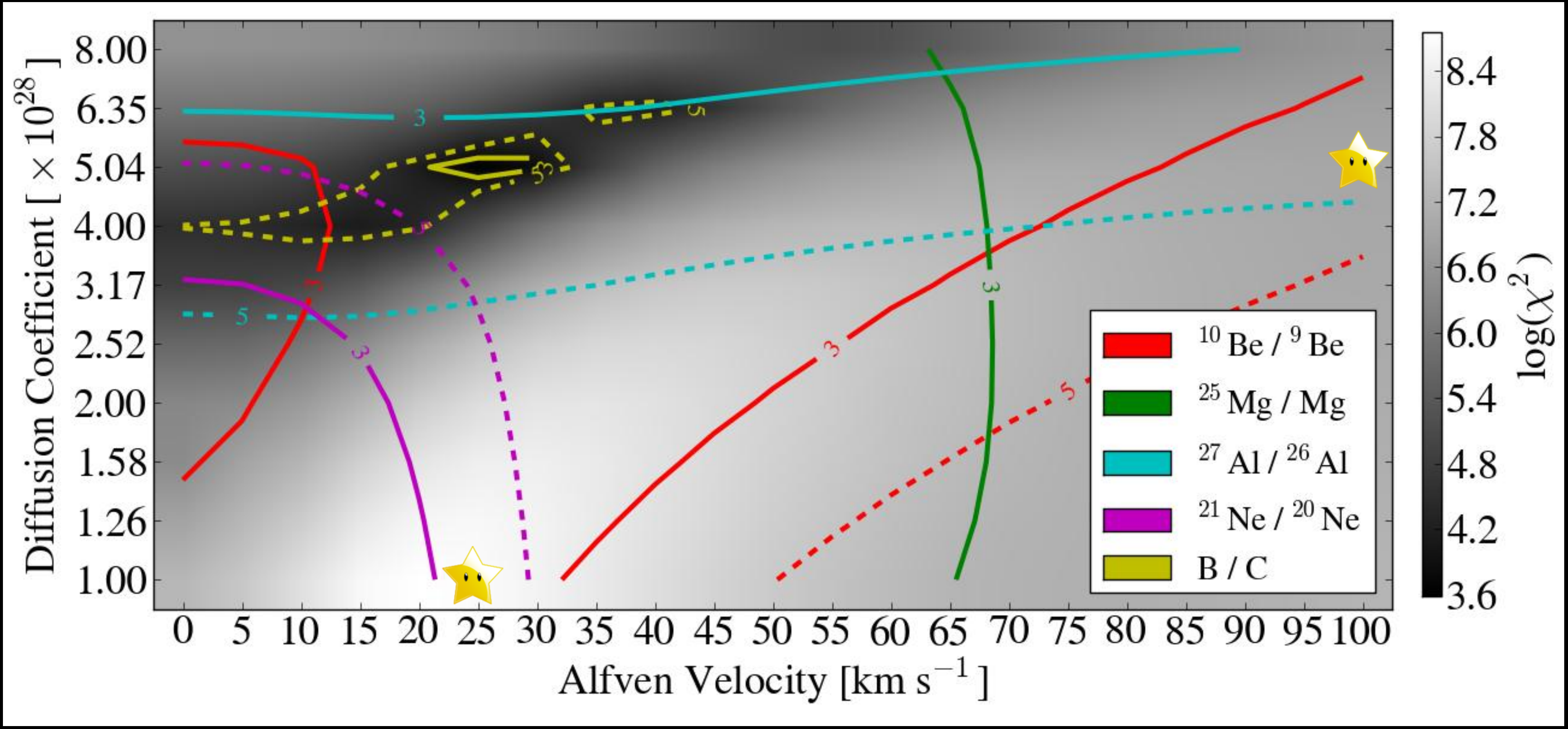
- The diffusion constant and Alfvén velocity greatly affect the Haze morphology

Constraints on Diffusion

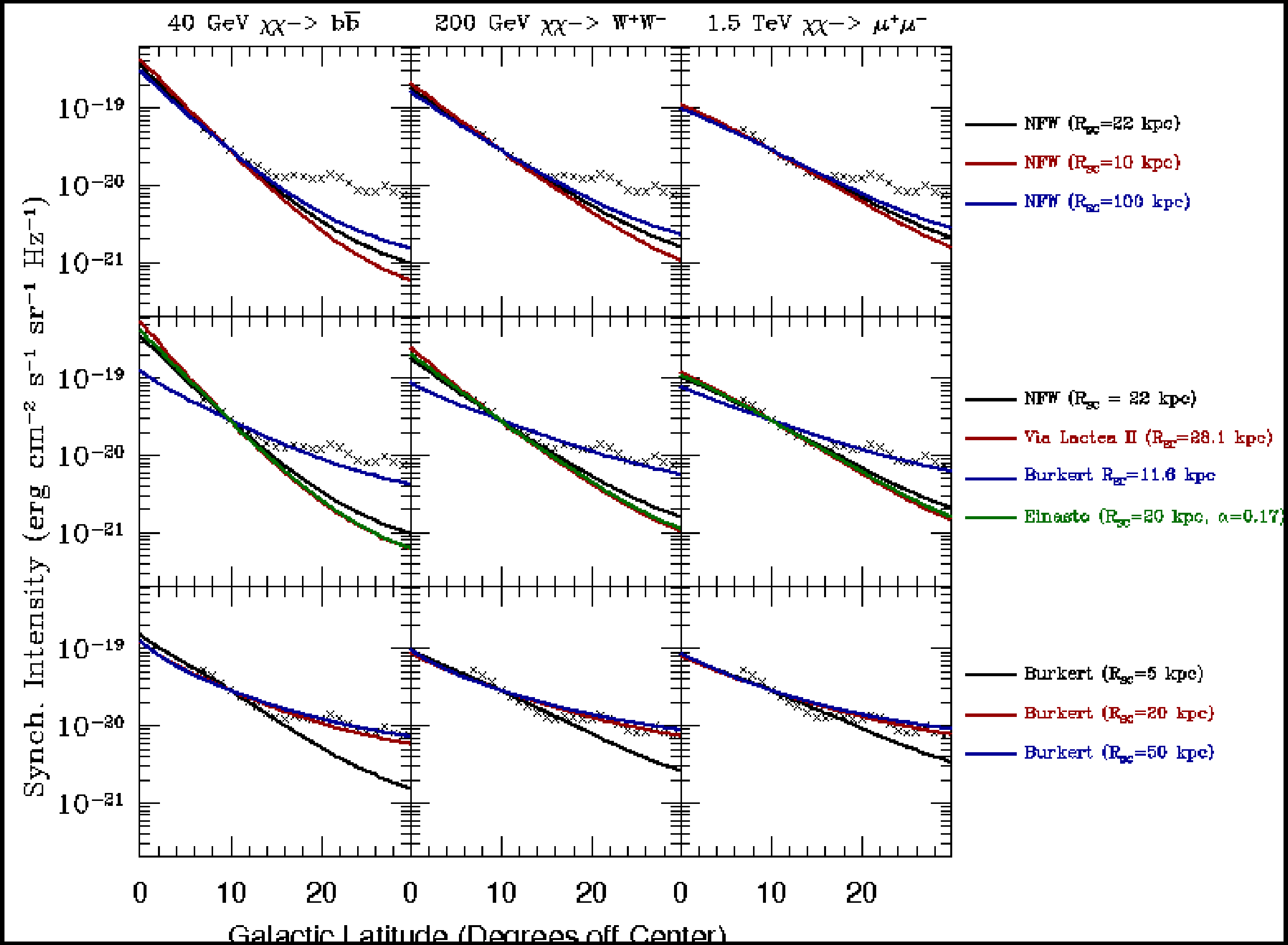
- Changes in the diffusion setup will affect the ratio of cosmic ray primary to secondary species
- This allows changes in the diffusion setup to be constrained by local cosmic ray observations



Constraints on Diffusion



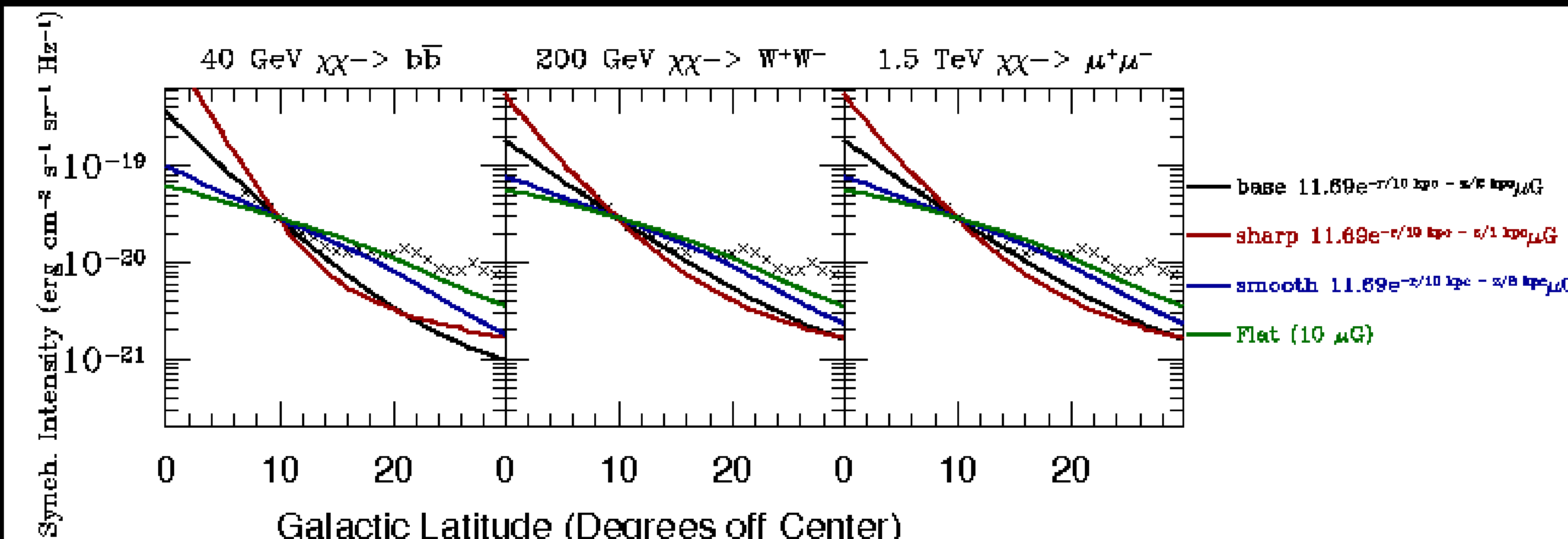
DM Profiles



Only profile which brings a reasonable match to the WMAP haze is a Burkert profile

- Profiles with dense galactic centers are unable to recreate the haze

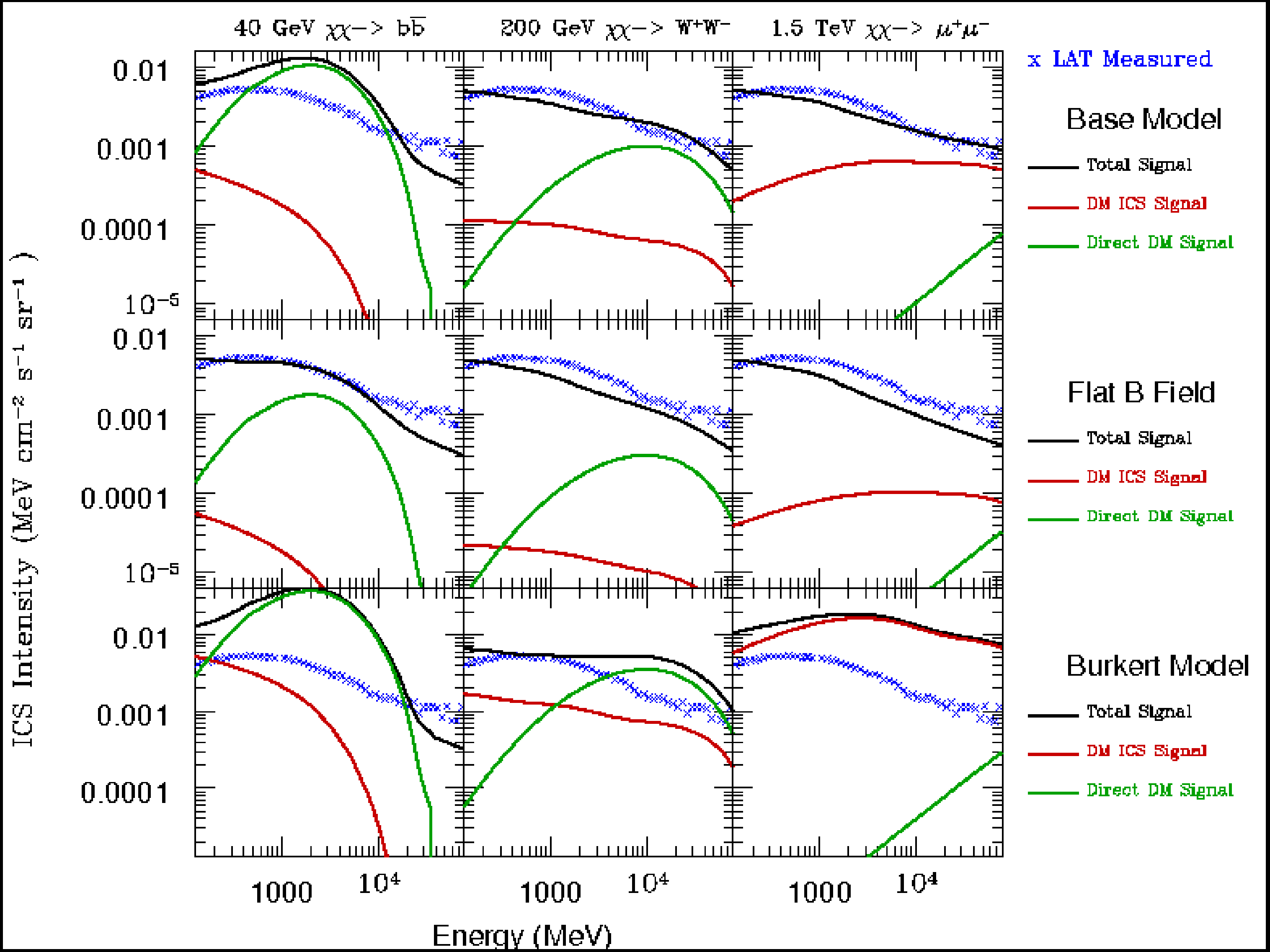
Magnetic Field Models



- Magnetic fields are an important uncertainty in our models

WMAP Matches?

- We have two possible matches to the morphology of the WMAP haze:
  - Changes in the magnetic field distribution (Flat magnetic field)
  - Changes in the DM density distribution (Burkert profile)
- Changes in the diffusion parameters have been ruled out by cosmic ray constraints



ICS

- Expected Fermi signals from our "matching" profiles

Conclusions

- Standard Dark Matter/Diffusion setups do not provide a reasonable match to the WMAP haze
- Diffusion setups that would match the WMAP haze are well constrained by cosmic ray observations
- DM profiles which would move annihilations to higher latitudes are well constrained by Fermi observations

arXiv: 1004.3998

Future Prospects

- New models of lepton diffusion are thus necessary if dark matter models are to reproduce the synchrotron haze
  - Non-isotropic diffusion setups
  - New magnetic field distributions

Extra Slides

Extra Slides