Kinetic Theory and Fast Wind Observations of the Electron Strahl

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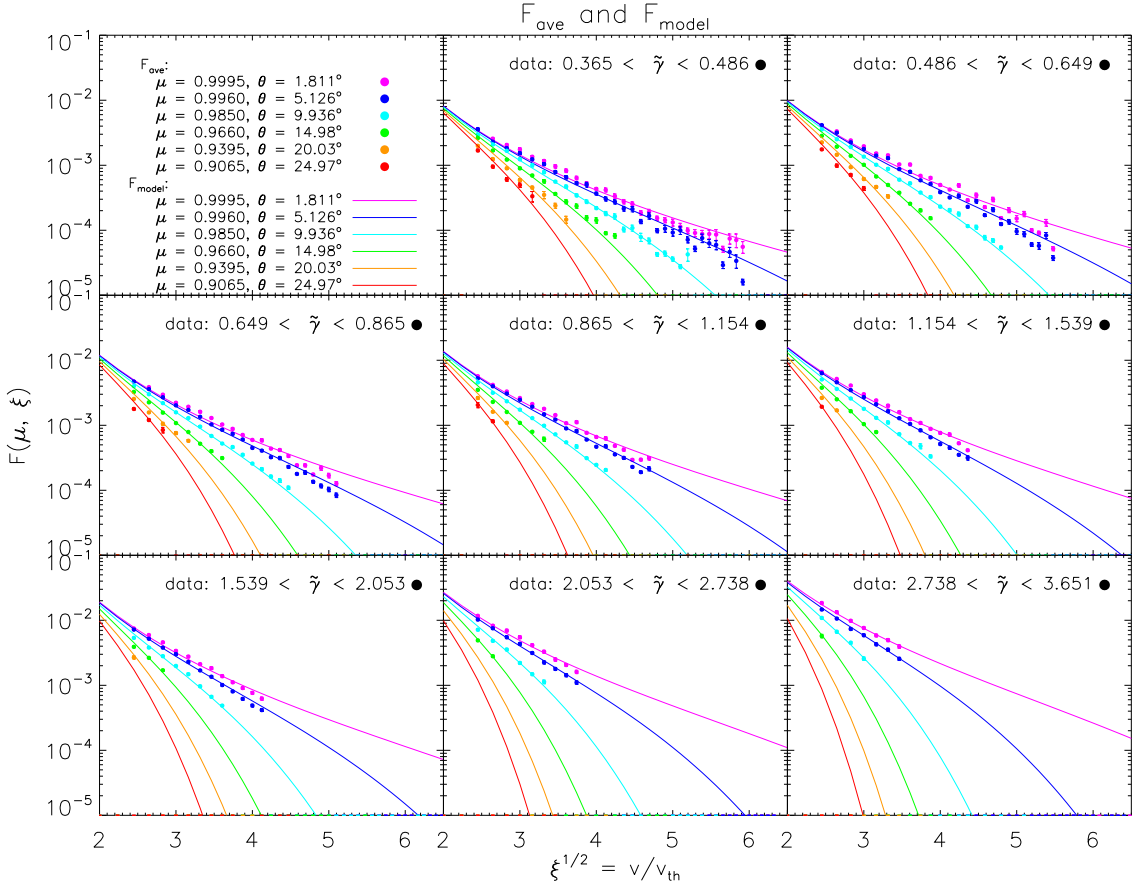
Asymptotic solution (Horaites et al., 2017)

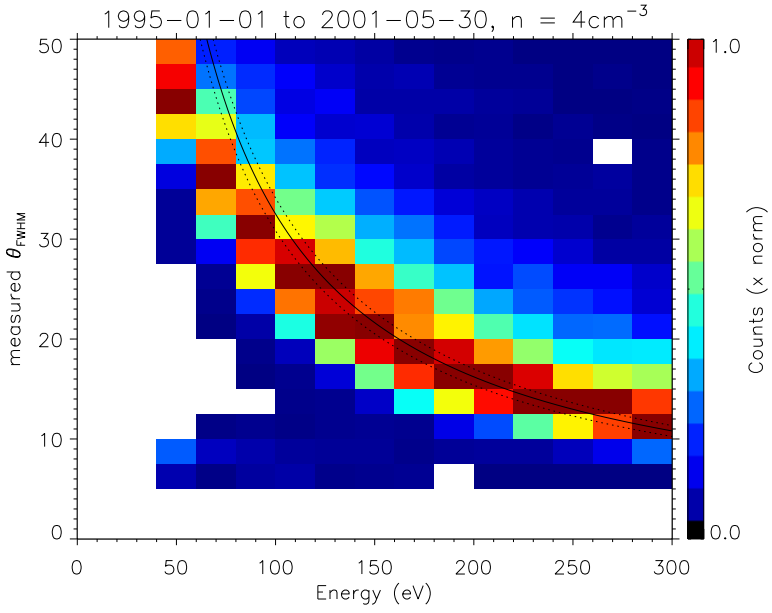


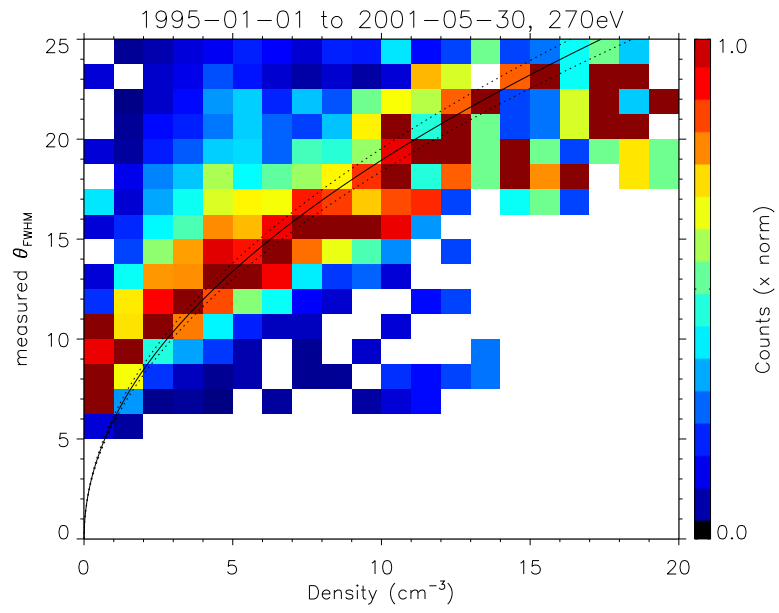
$$F(x,\xi,\mu) \sim (x/x_0)^{\alpha_s}\xi^{\epsilon}\exp\left\{\tilde{\gamma}(x)\Omega\xi^2(1-\mu)\right\}$$

$$f(\mathbf{v},x) = \frac{NF(\mathbf{v}/v_{th}(x),x)}{T(x)^{\alpha}}, \qquad \mu \equiv \mathbf{v}\cdot\hat{x}/v, \qquad \xi \equiv \left(\frac{v}{v_{th}}\right)^2$$

Scaling relations

$$\theta_{FWHM} \approx 951 \sqrt{\frac{nx}{|\Omega|\mathcal{E}^2}} deg. \quad (1)$$





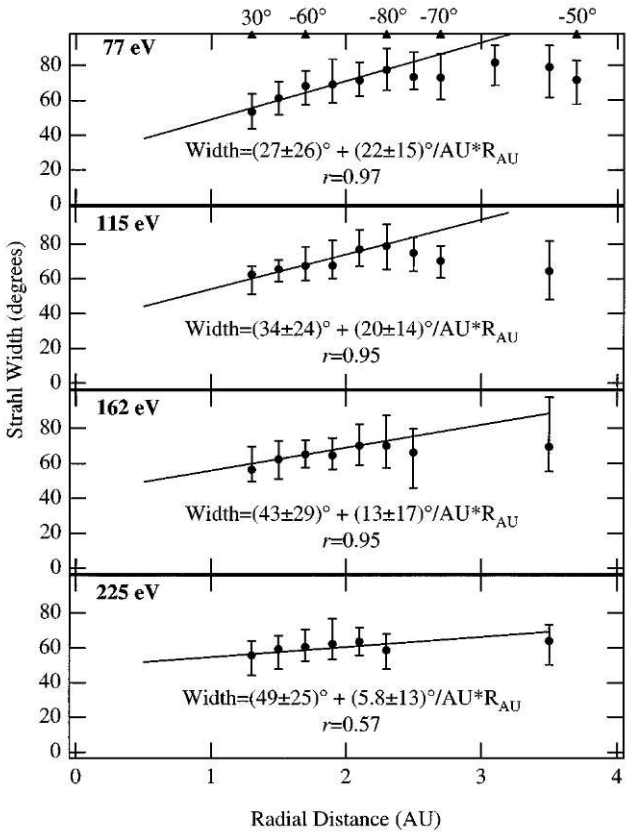
For given n, $\theta_{FWHM} \propto \mathcal{E}^{-1}$

For given $\mathcal{E}$, $\theta_{FWHM} \propto \sqrt{n}$

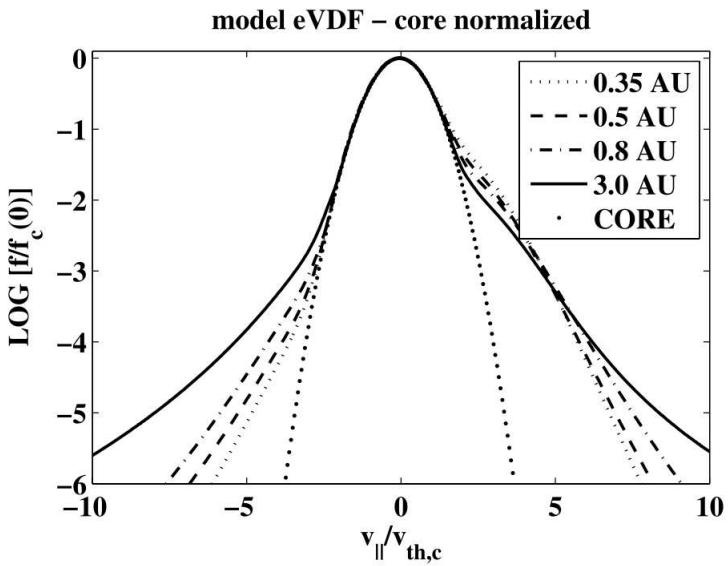
Scaling with distance

Assuming Ω =const., $n(x) \propto x^{-2}$, our theory predicts:

- $\theta_{FWHM} \propto x^{-1/2}$ (fixed $\mathcal{E}$)
- strahl amplitude $\propto x^{\alpha_s}$ ($\alpha_s > 0$!)



Hammond et al., 1996



Stverak et al., 2009

Conclusions

- Asymptotic solution to self-similar kinetic equation can effectively model the strahl distribution.
- Model correctly predicts how θ_{FWHM} depends on density and energy.
- Model appears to contradict measurements of how strahl amplitude and θ_{FWHM} vary with distance.
- Model may need to be improved by accounting for other physical effects, such as wave-particle interactions.