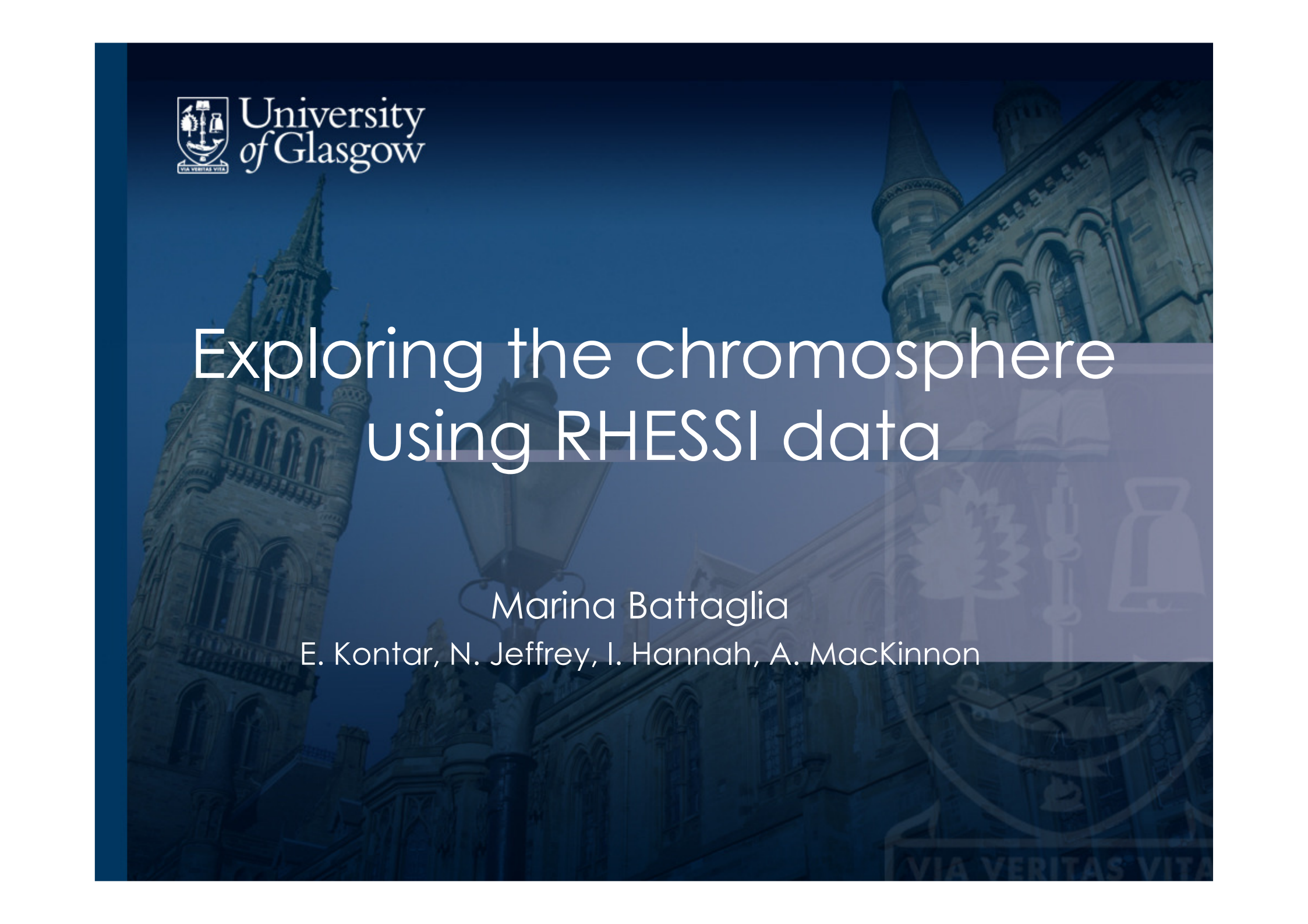


Exploring the chromosphere using RHESSI data

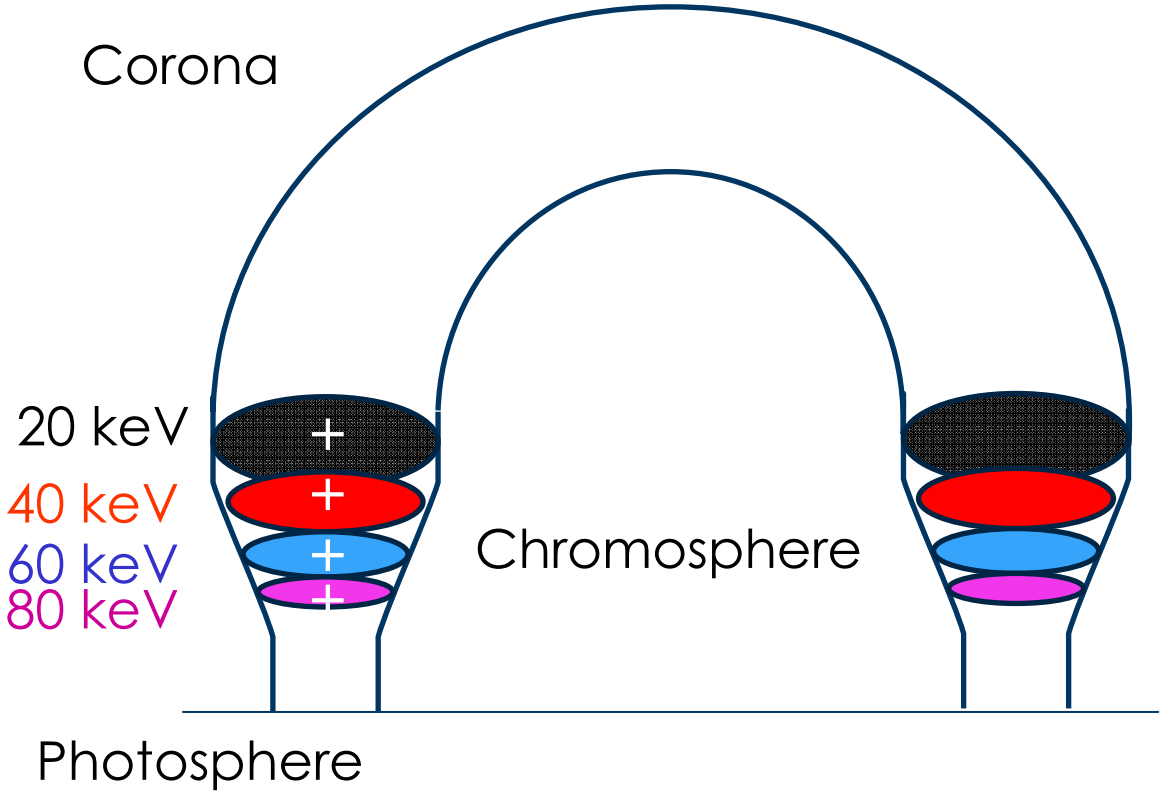
Marina Battaglia
E. Kontar, N. Jeffrey, I. Hannah, A. MacKinnon

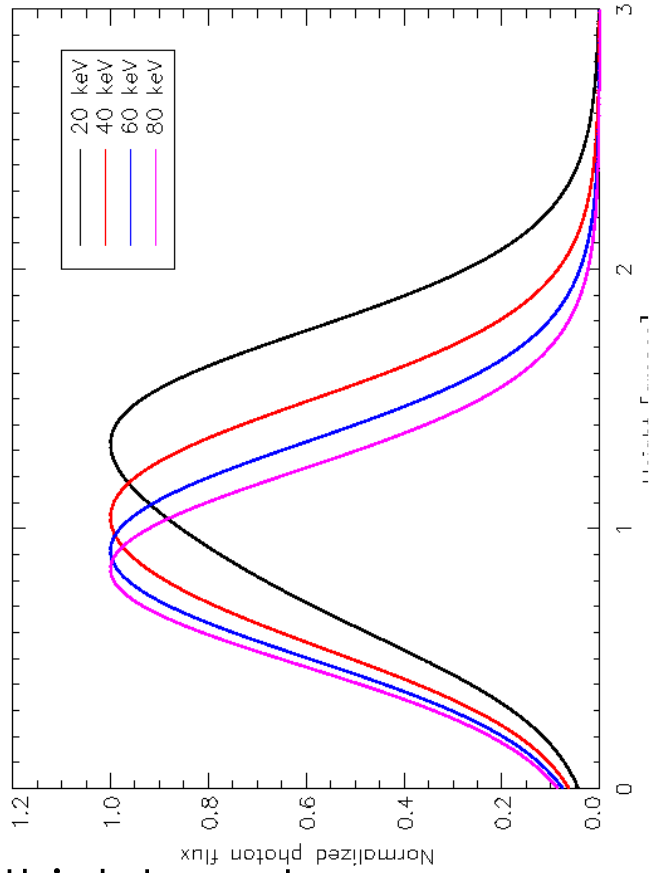
University of Glasgow

Motivation

Use measurements of the position and size of hard X-ray footpoint sources to investigate the chromospheric density, magnetic field and the physics of electron transport in the chromosphere.

Simple thick target model: Position

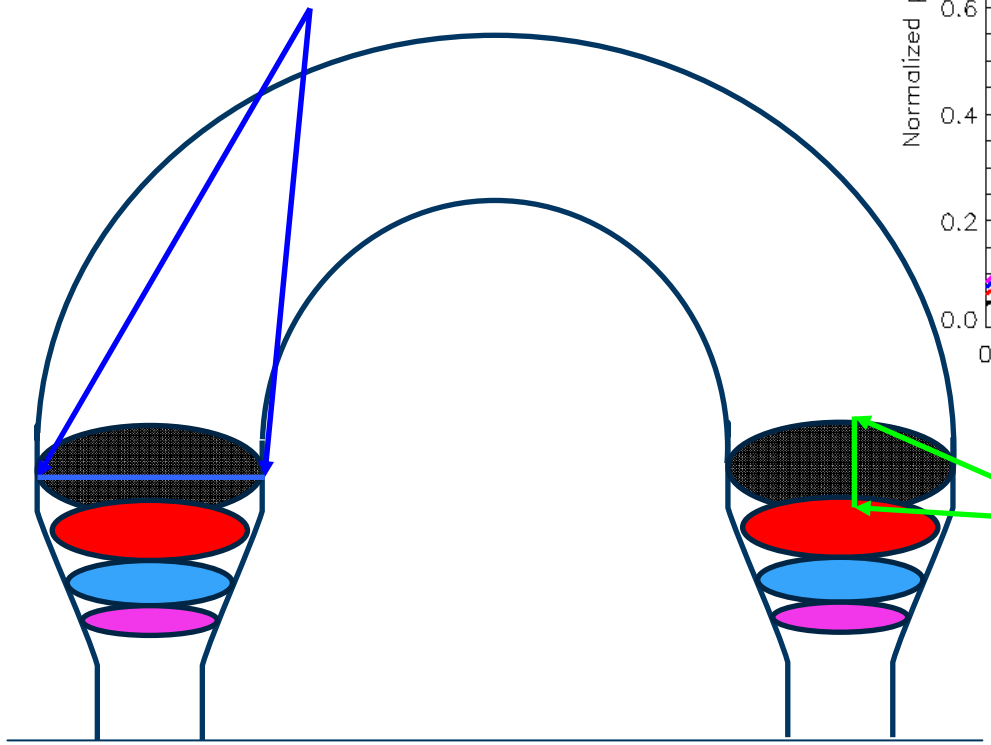


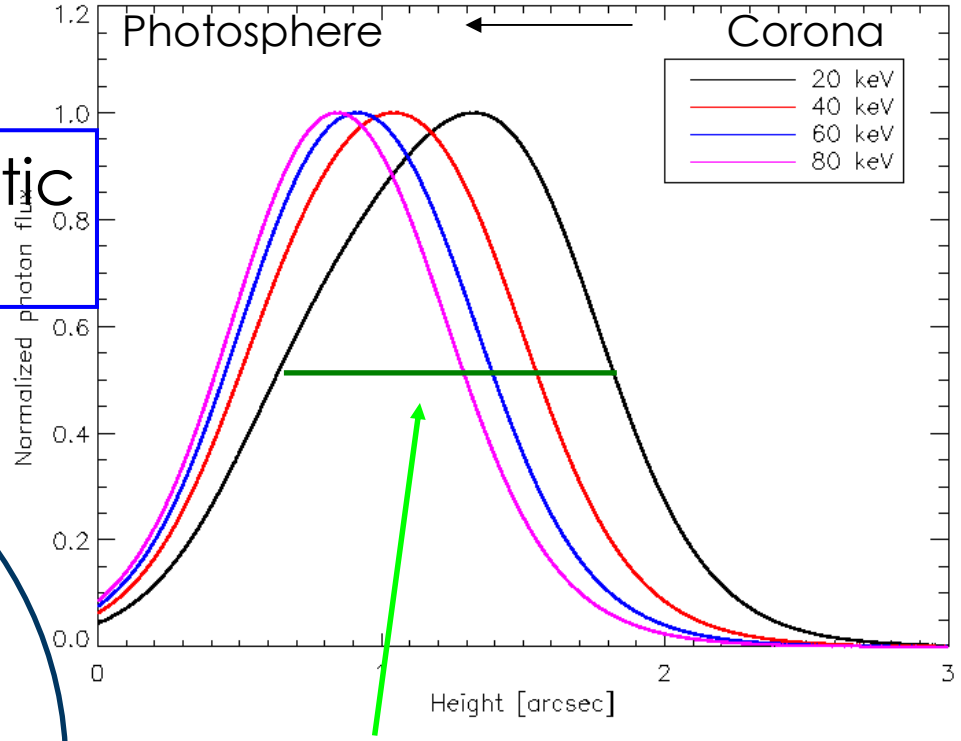


Energy dependent position of footpoints in thick target

Simple thick target model: Source size

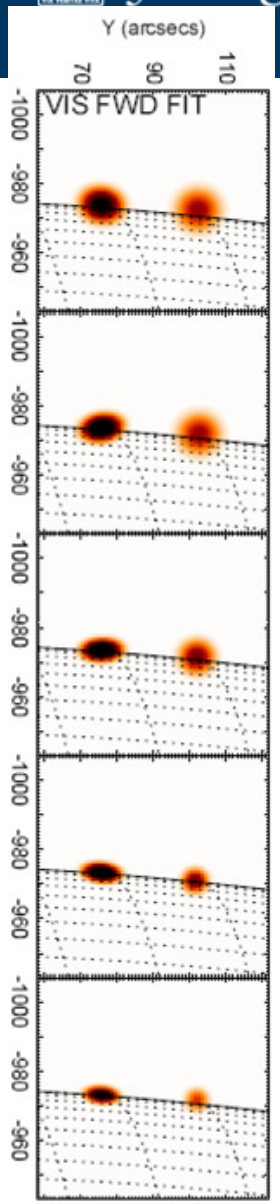
Horizontal extent → magnetic field convergence





Vertical extent → Physics of electron transport

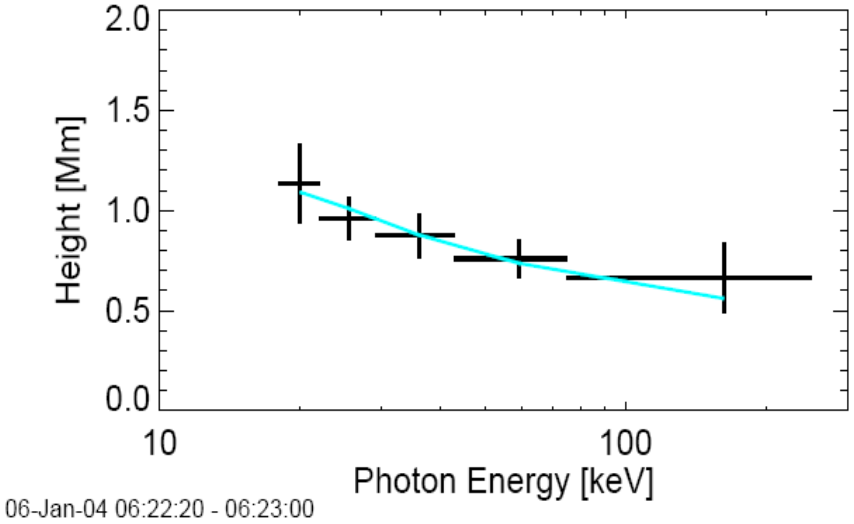
Position: January 6th 2004



Kontar et al. 2010

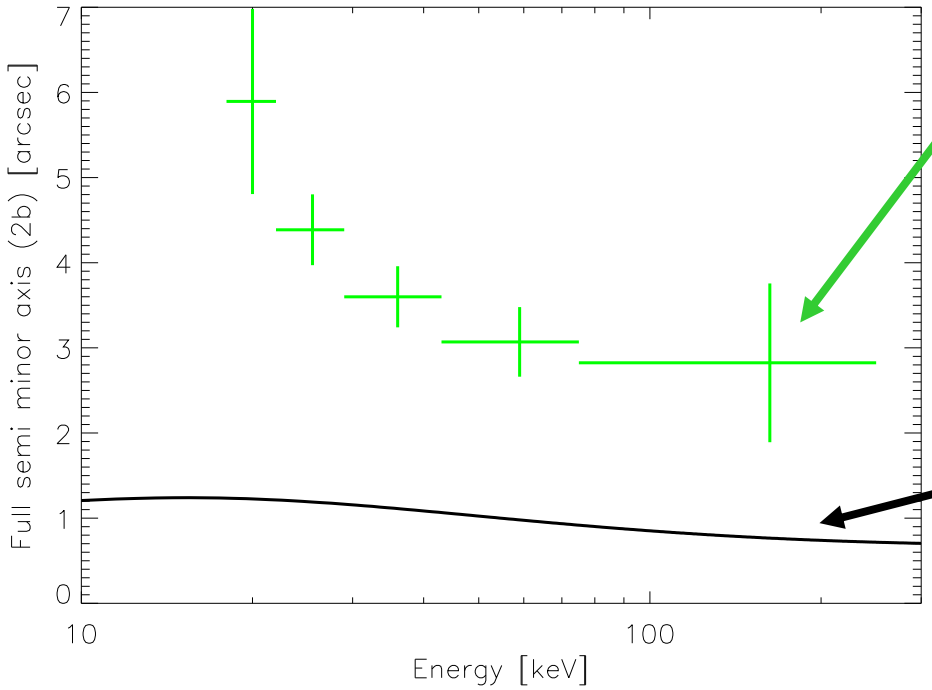
$$n(h = r - r_0) = n_0 \exp\left(\frac{-(r - r_0)}{h_0}\right),$$

Fixed at photospheric density



Density scale height h_0~150 km

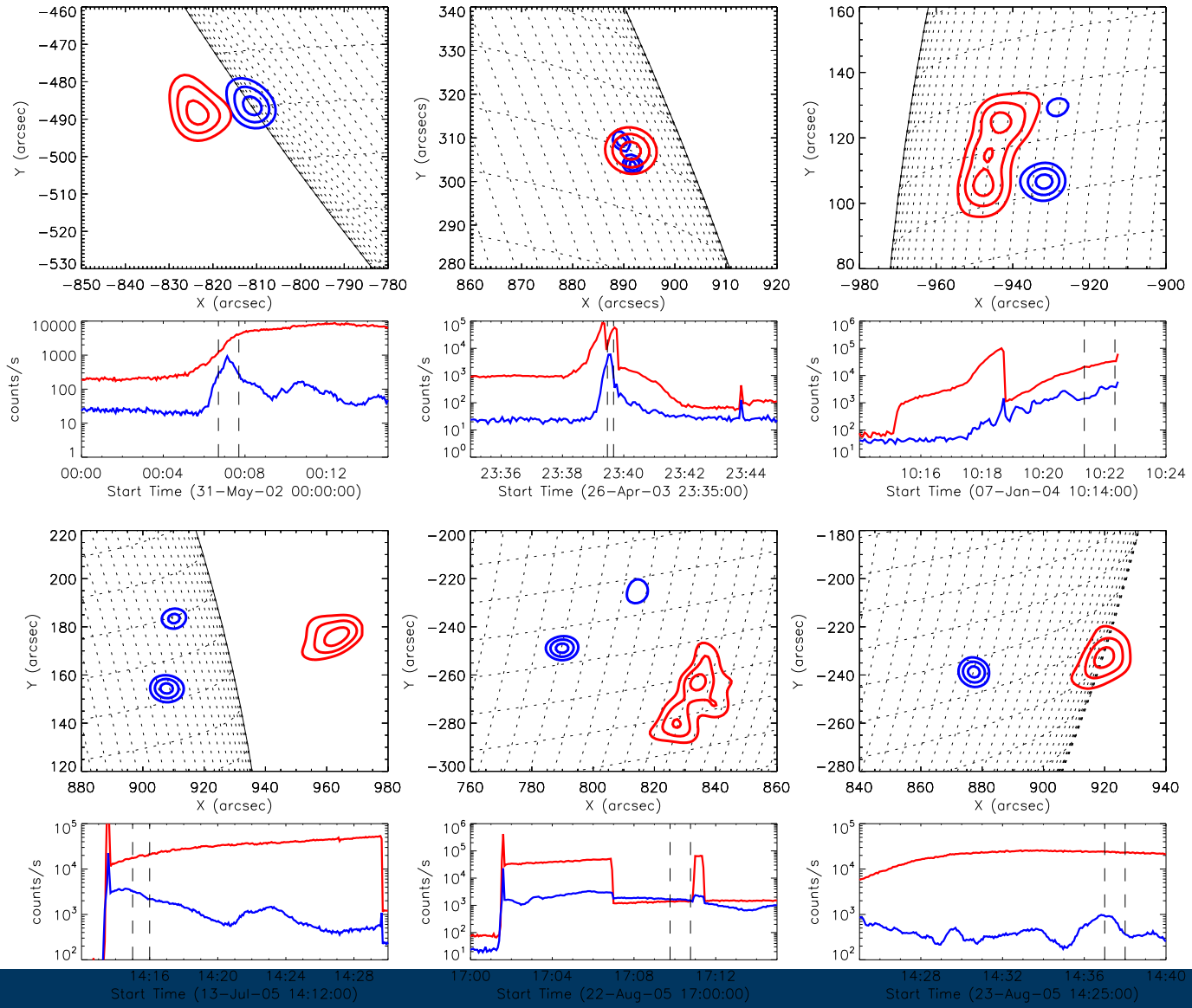
Size: January 6th 2004



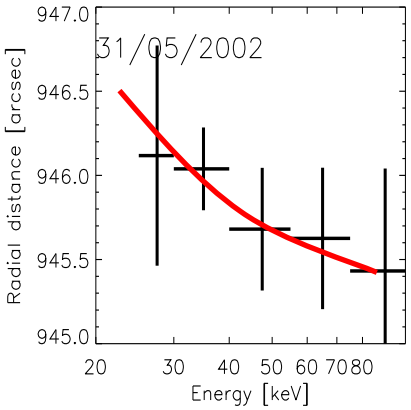
Vertical size of the footpoint measured in 6th January event

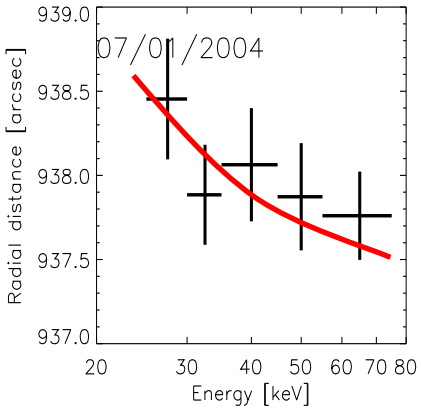
Vertical size of the footpoint, expected from collisional transport

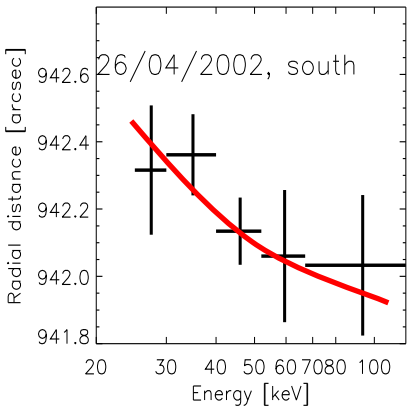
One very nice event – how about others?

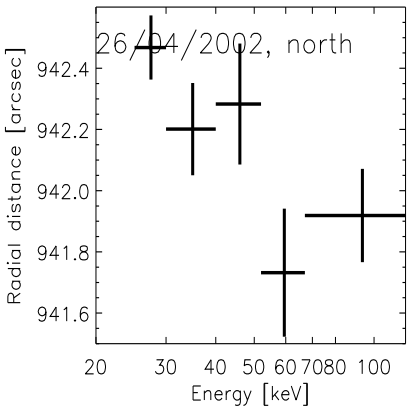


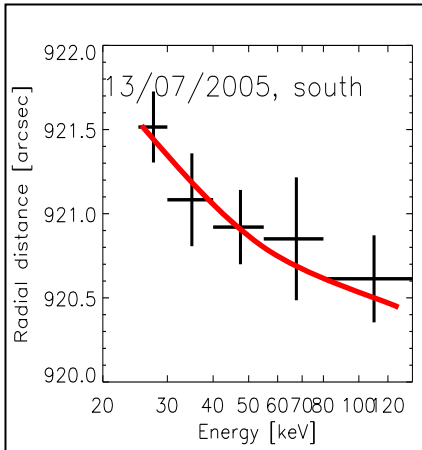
Radial positions

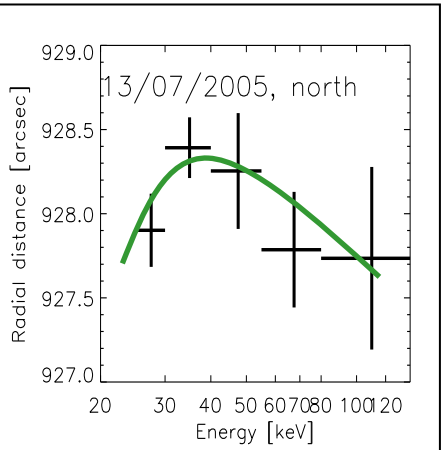


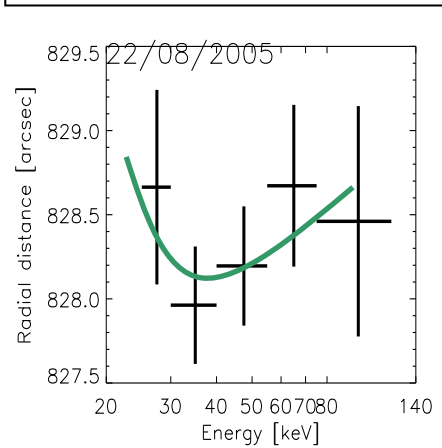


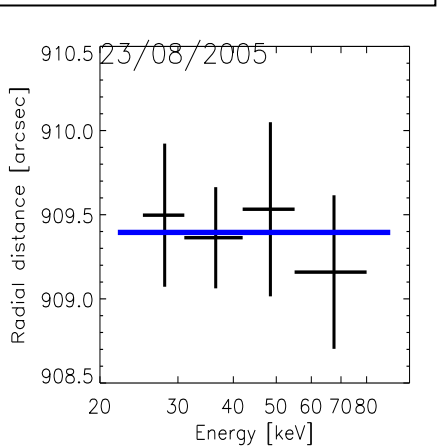




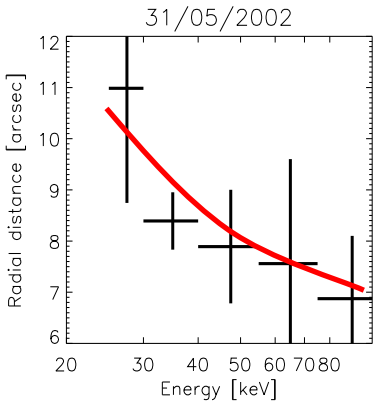


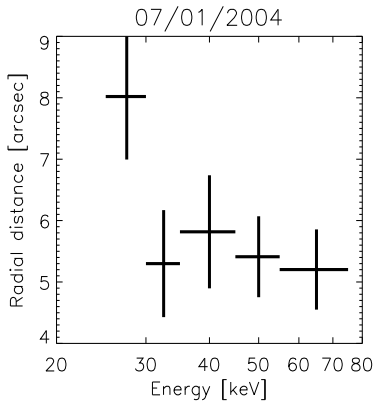


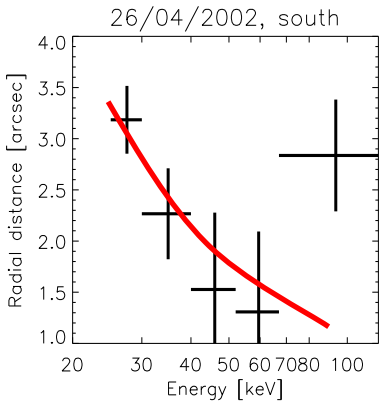


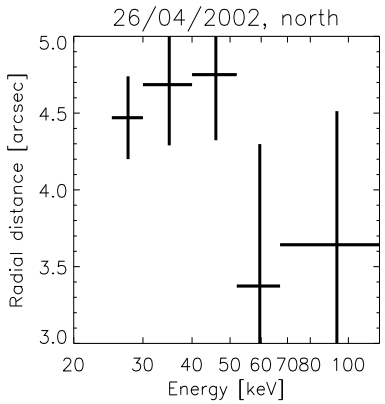


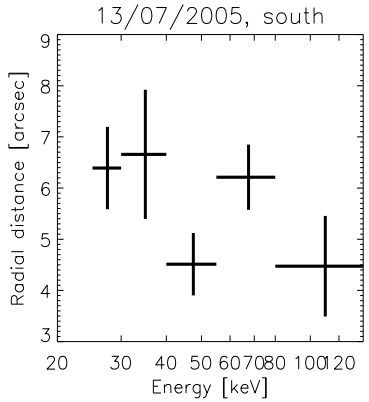
Full width half maximum

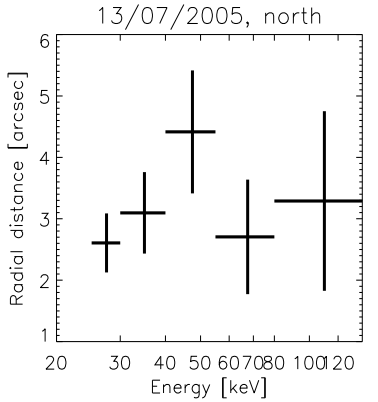


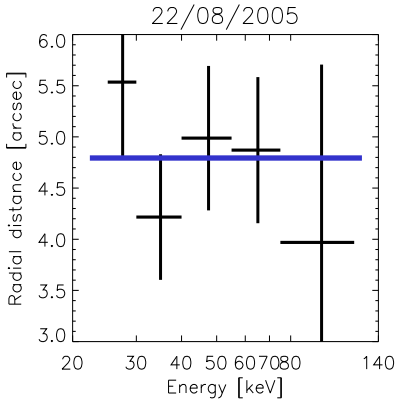


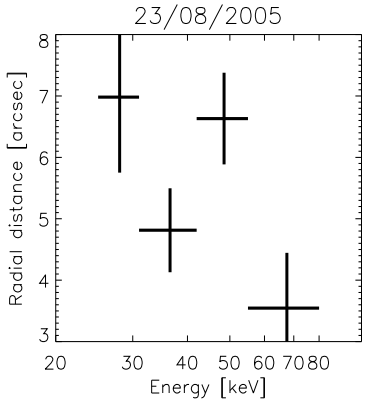












Theory of electron transport

Leach & Petrosion 1981

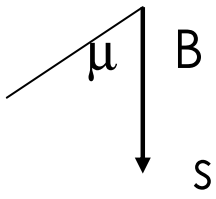
Time independent Fokker-Planck equation

Change of electron flux with distance along field lines

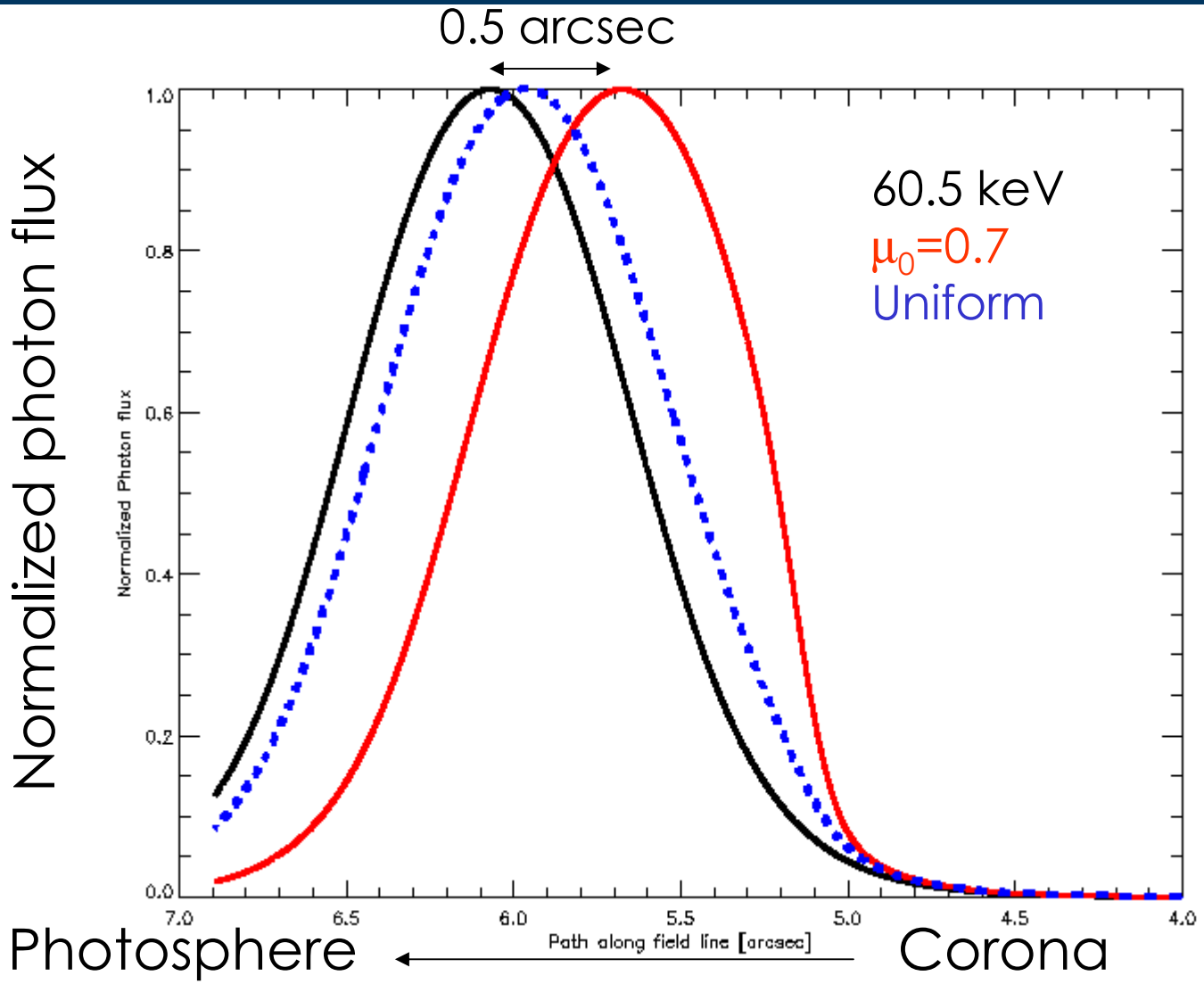
$$\frac{\partial F}{\partial s} - \frac{(1-\mu^2)}{2\mu}\frac{d\ln B}{ds}\frac{\partial F}{\partial \mu} - \frac{C_1 n(s)}{\mu E}\frac{\partial F}{\partial F} - \frac{C_2}{\mu}\frac{\partial}{\partial \mu}\left[(1-\mu^2)\frac{\partial F}{\partial \mu}\right] = -\frac{C_1 n(s)}{\mu E^2}F$$

Collisional energy loss Collisional pitch angle scattering

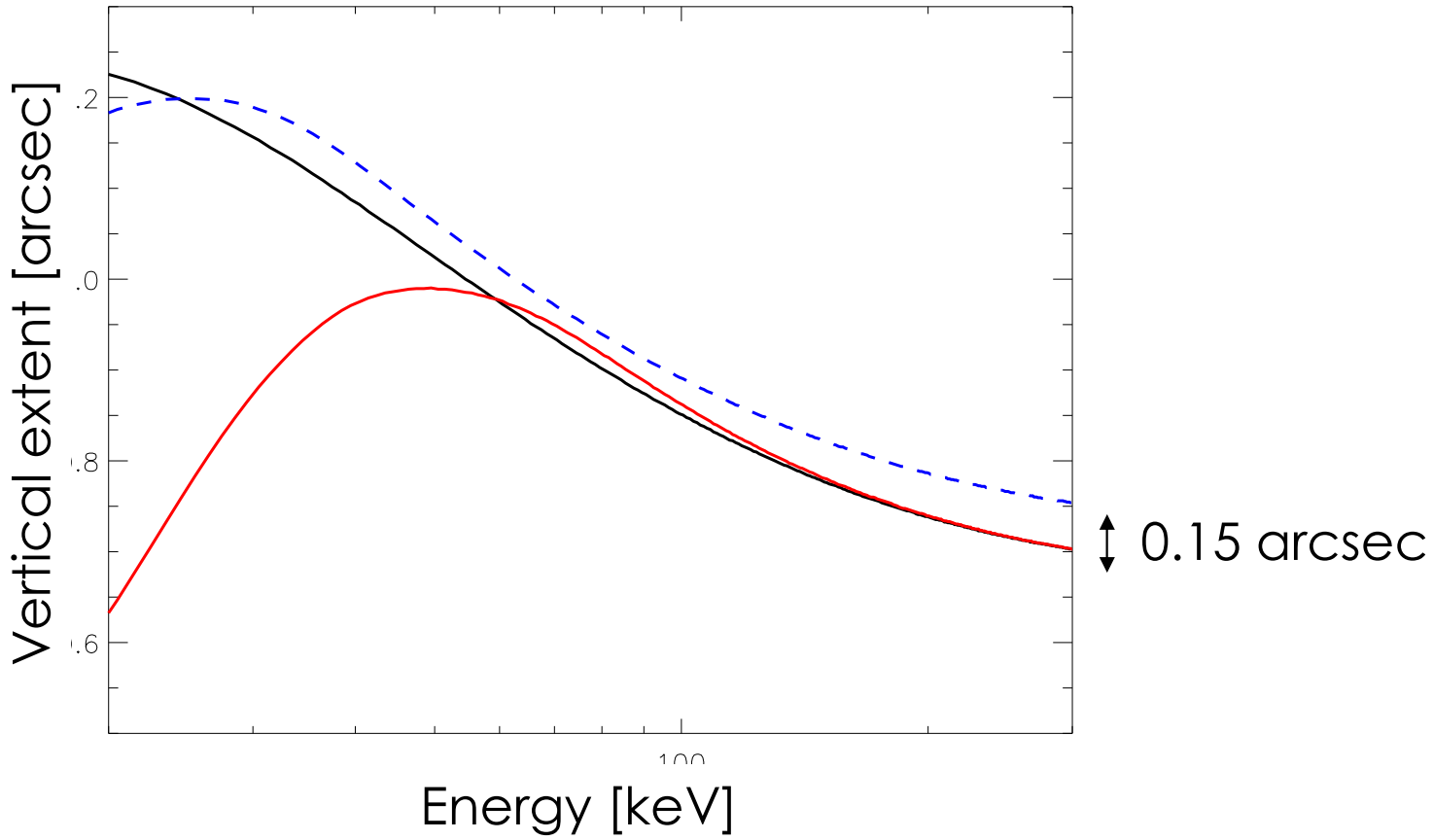
Magnetic field pitch angle change



Analytic treatment of magnetic field convergence



Change in vertical extent when including magnetic field



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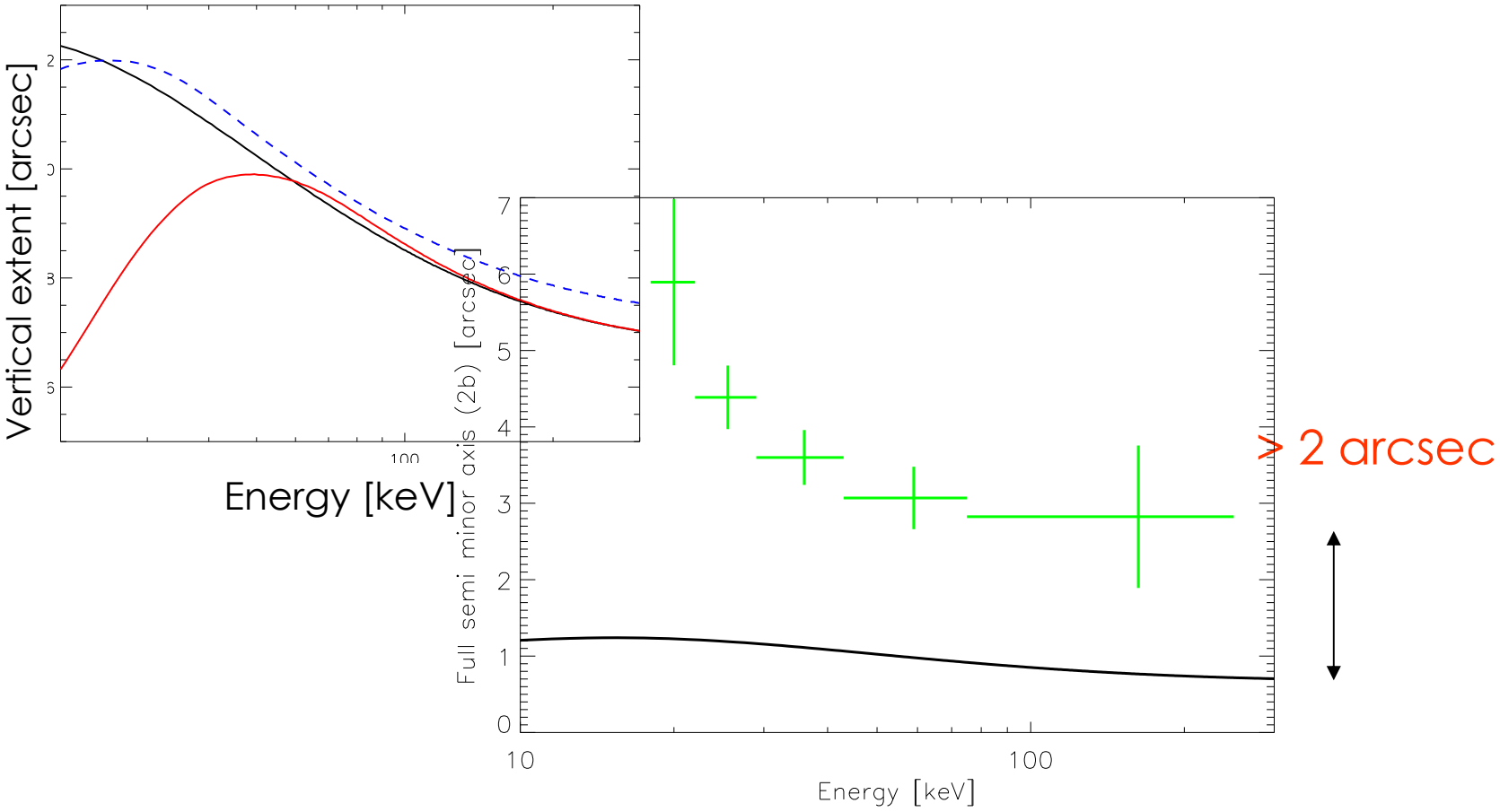

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Numerical simulations

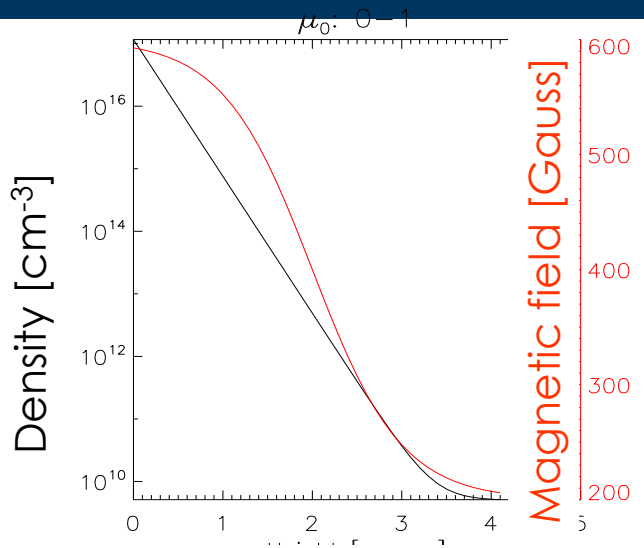
- Take

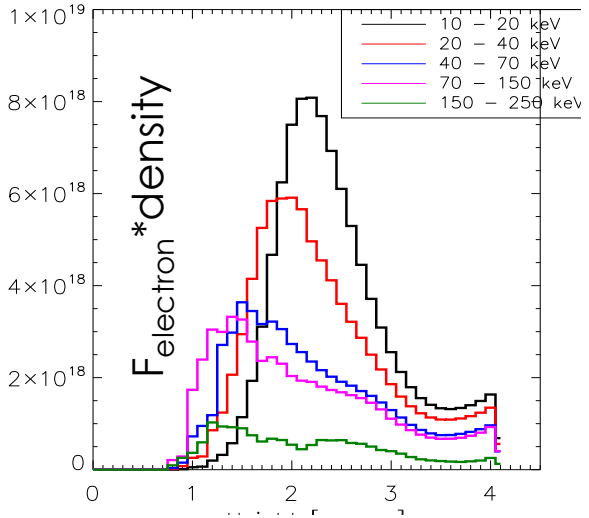
$$\frac{\partial F}{\partial s} - \frac{(1-\mu^2)}{2\mu}\frac{d\ln B}{ds}\frac{\partial F}{\partial \mu} - \frac{C_1 n(s)}{\mu E}\frac{\partial F}{\partial F} - \frac{C_2}{\mu}\frac{\partial}{\partial \mu}\left[(1-\mu^2)\frac{\partial F}{\partial \mu}\right] = -\frac{C_1 n(s)}{\mu E^2}F$$

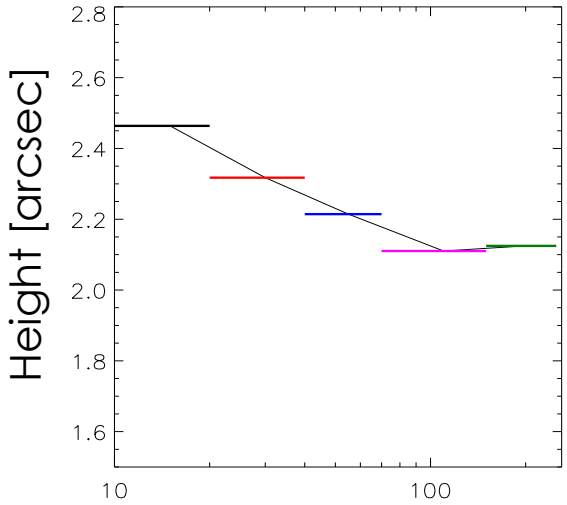
and implement it as test particle simulation

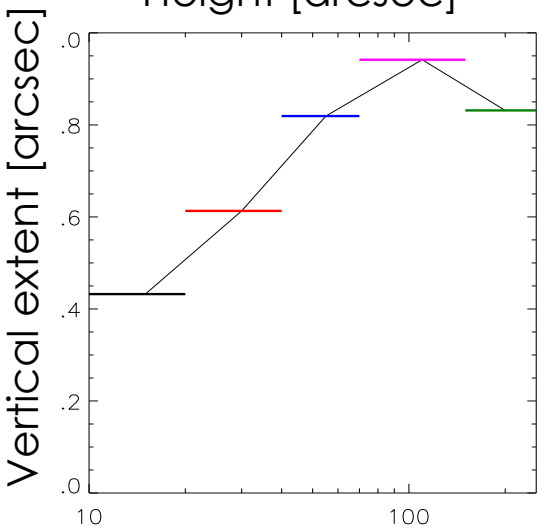
→ Can treat magnetic mirroring
→ Collisional pitch angle scattering
→ Add additional terms for pitch-angle diffusion

Preliminary results: Mirroring









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Conclusions

- Observations of energy dependent position and sizes of footpoints can be used to investigate the chromospheric density, magnetic field and the physics of electron transport
- Observations suggest that the simple thick target model is inaccurate in many cases
- Numerical simulations will be used to evaluate effects such as magnetic mirroring and collisional pitch angle scattering and the effect they have on the observed position and size of X-ray sources