The hard X-ray limb of the Sun

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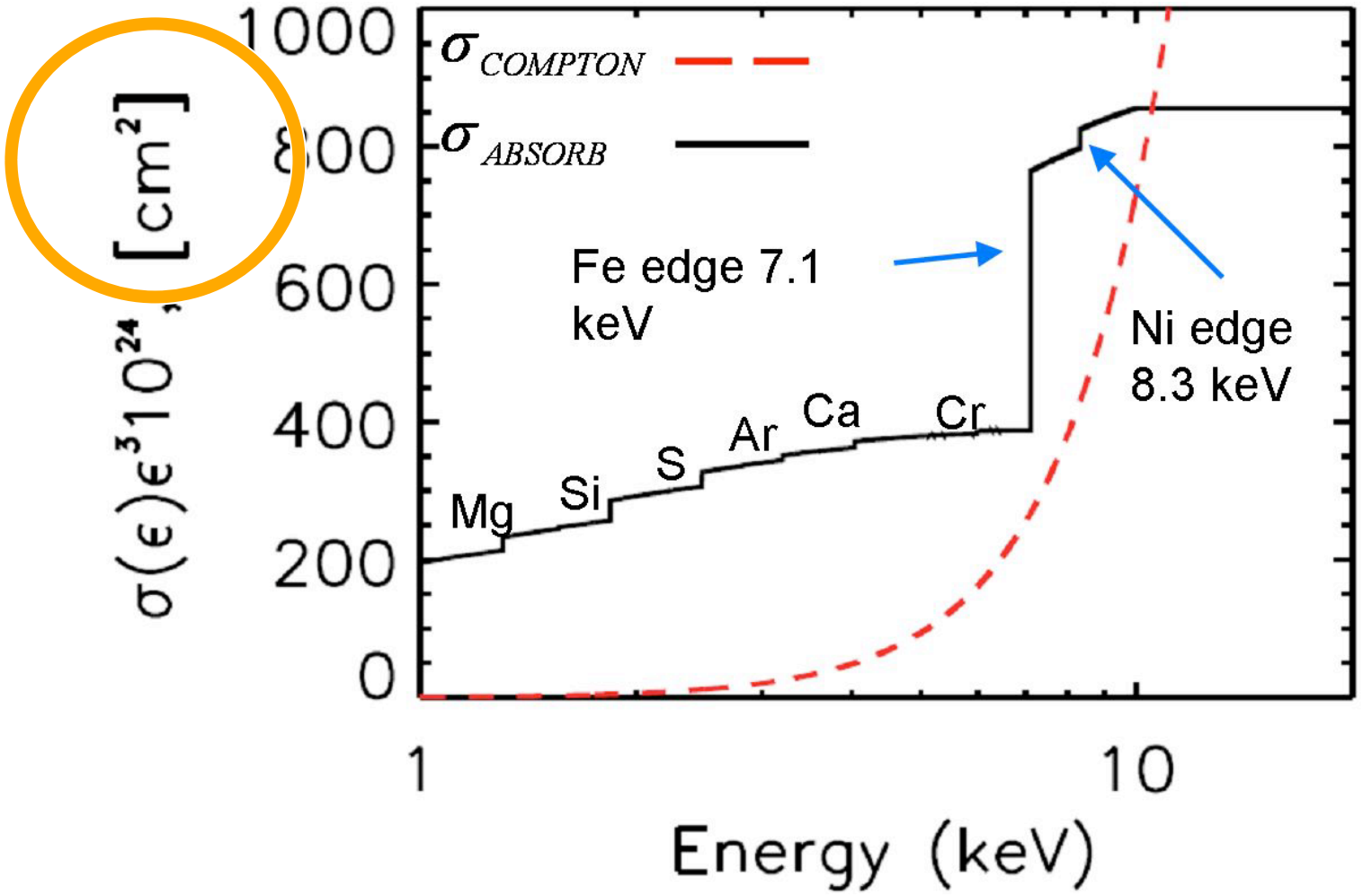
Basic factors

- Gravity makes the limb round to about 10 ppm
- Gravity also makes it smooth: the maximum small-scale roughness (the Wilson depression) is of order 0.1%
- Above the photosphere the rough structure rapidly increases in amplitude because of dynamics created by convection and oscillations in the interior

How do we sense the limb?

- The radius of the Sun is defined at $\tau_{5000} = 1$ (ie, unit opacity at 5000 Å at disk center
- At the limb, the altitude of $\tau_{5000} = 1$ increases, depending upon the details of the opacity around 5000 Å
- For Thomson opacity, ie that applicable to hard X-rays for which $h\nu << m_e c^2$ but above the photoeffect range, the limb is at 649 km above the radius.

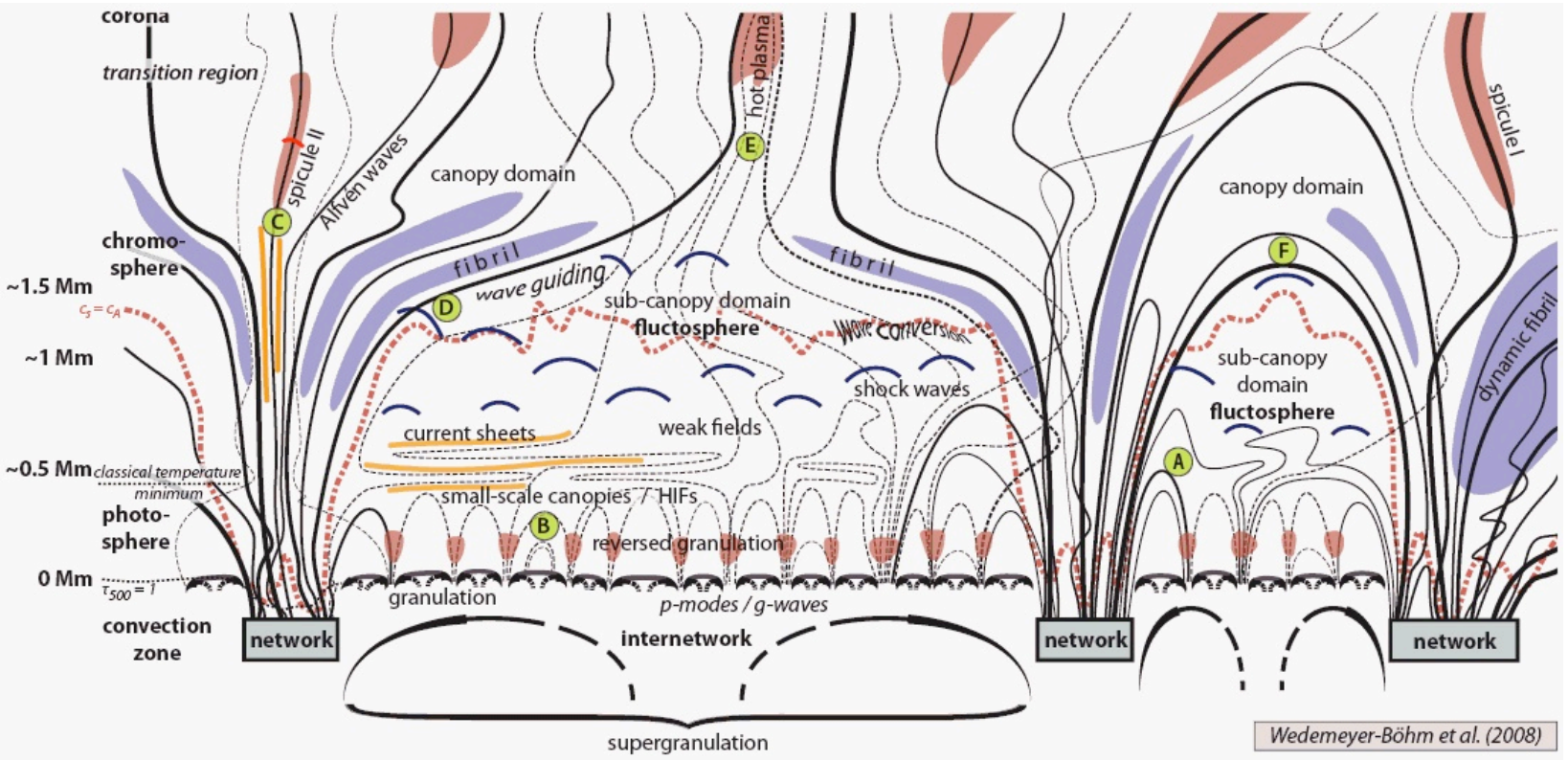
Kontar-Jeffrey opacities



Can RHESSI measure the structure of the limb usefully?

- Traditional models (the “semi-empirical” approach of VAL-C) are 1D and have no direct height scale
- Modern knowledge of the structure of the chromosphere depends on complex models that treat radiative transfer and dynamics simultaneously
- X-ray opacity is relatively simple (very simple in the Thomson-scattering energy range)

Modern models

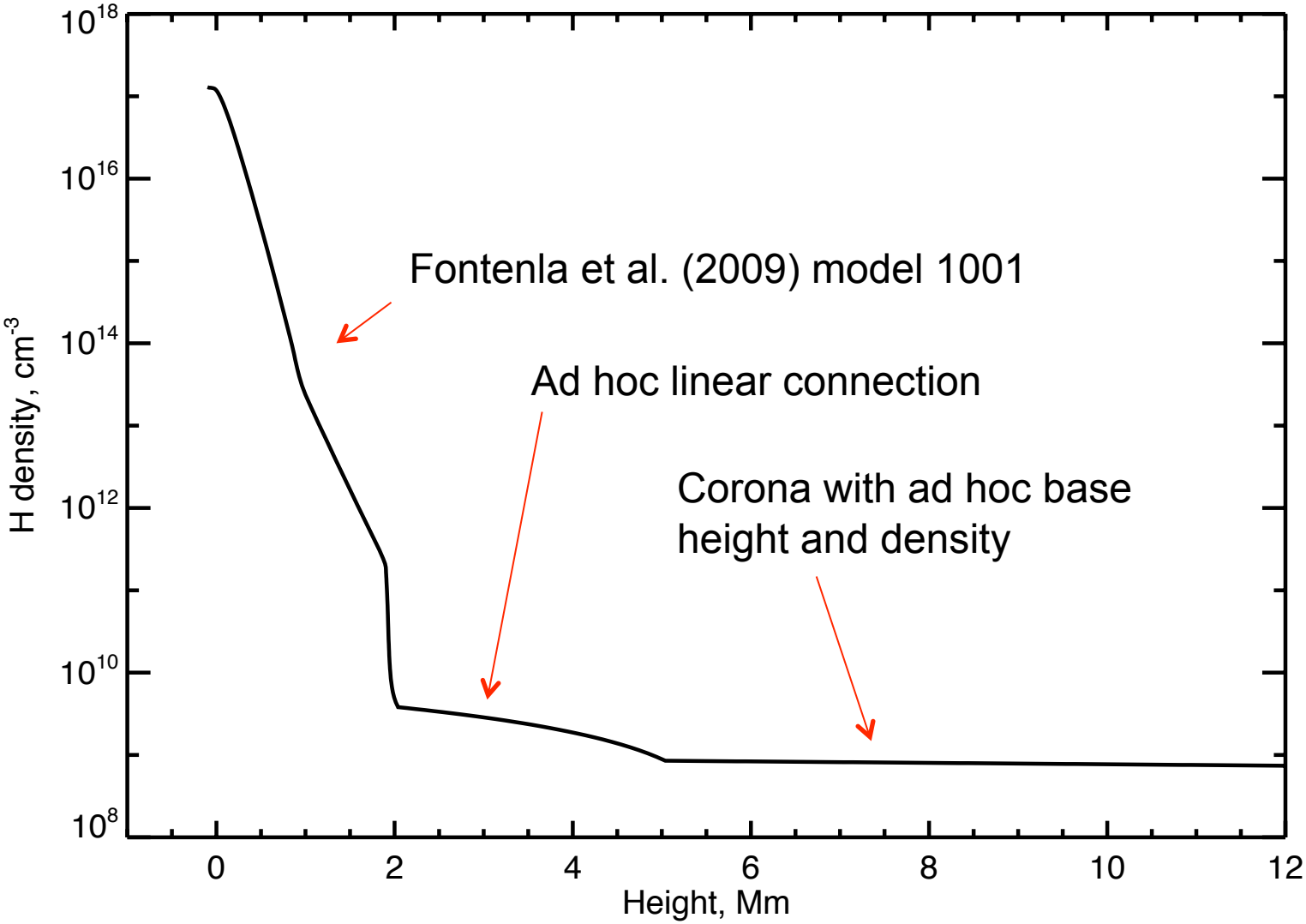


From Wedemeyer-Bohm in the Cartoon Archive.
The lower version is a more realistic scaling.

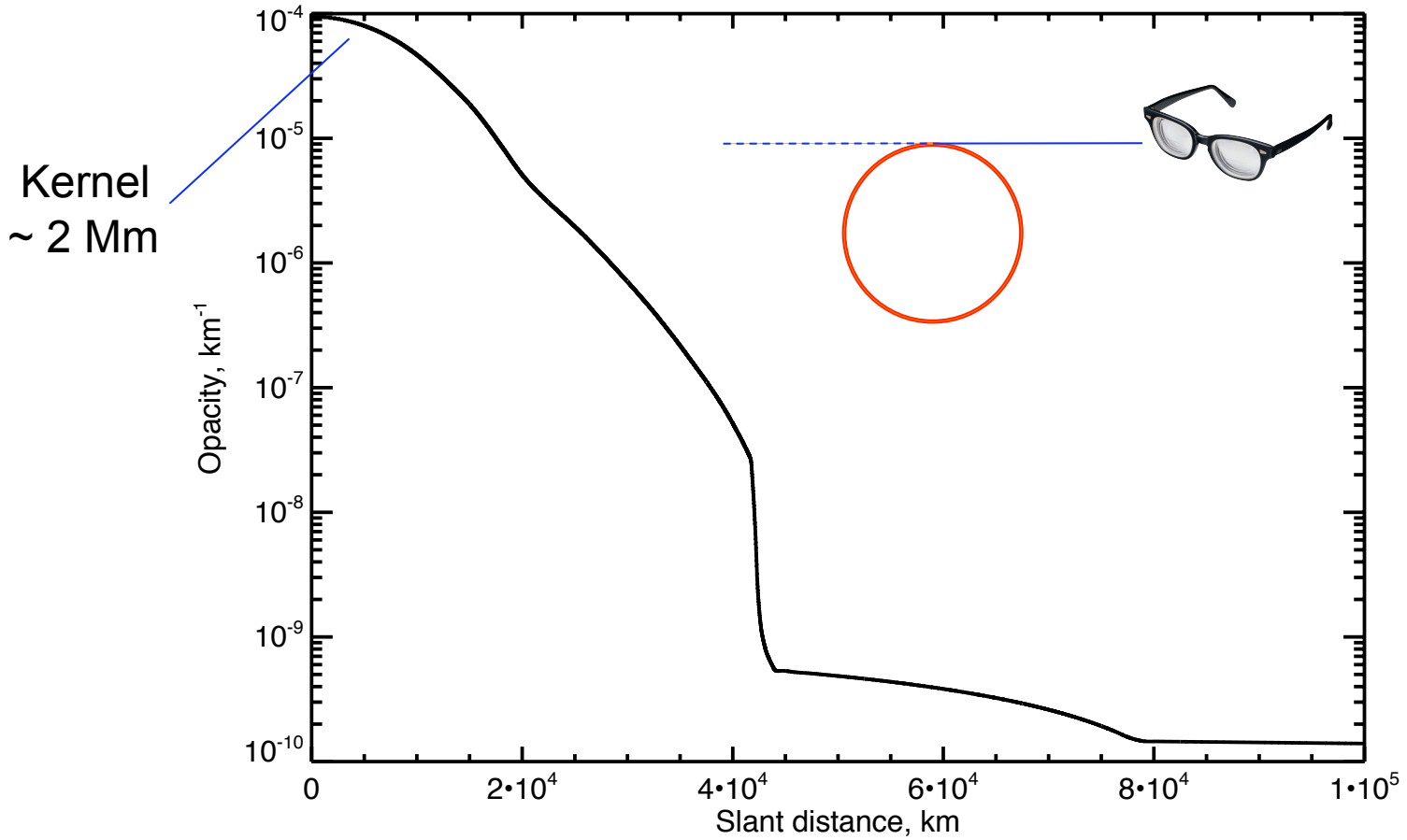
What could RHESSI learn?

- The actual height distribution of mass in the quiet solar atmosphere is known only anecdotally at present. This is because of the dynamics and the uncertainties of radiative transfer, I think
- The height jump at the Fe K edge would determine the iron abundance in a straightforward way

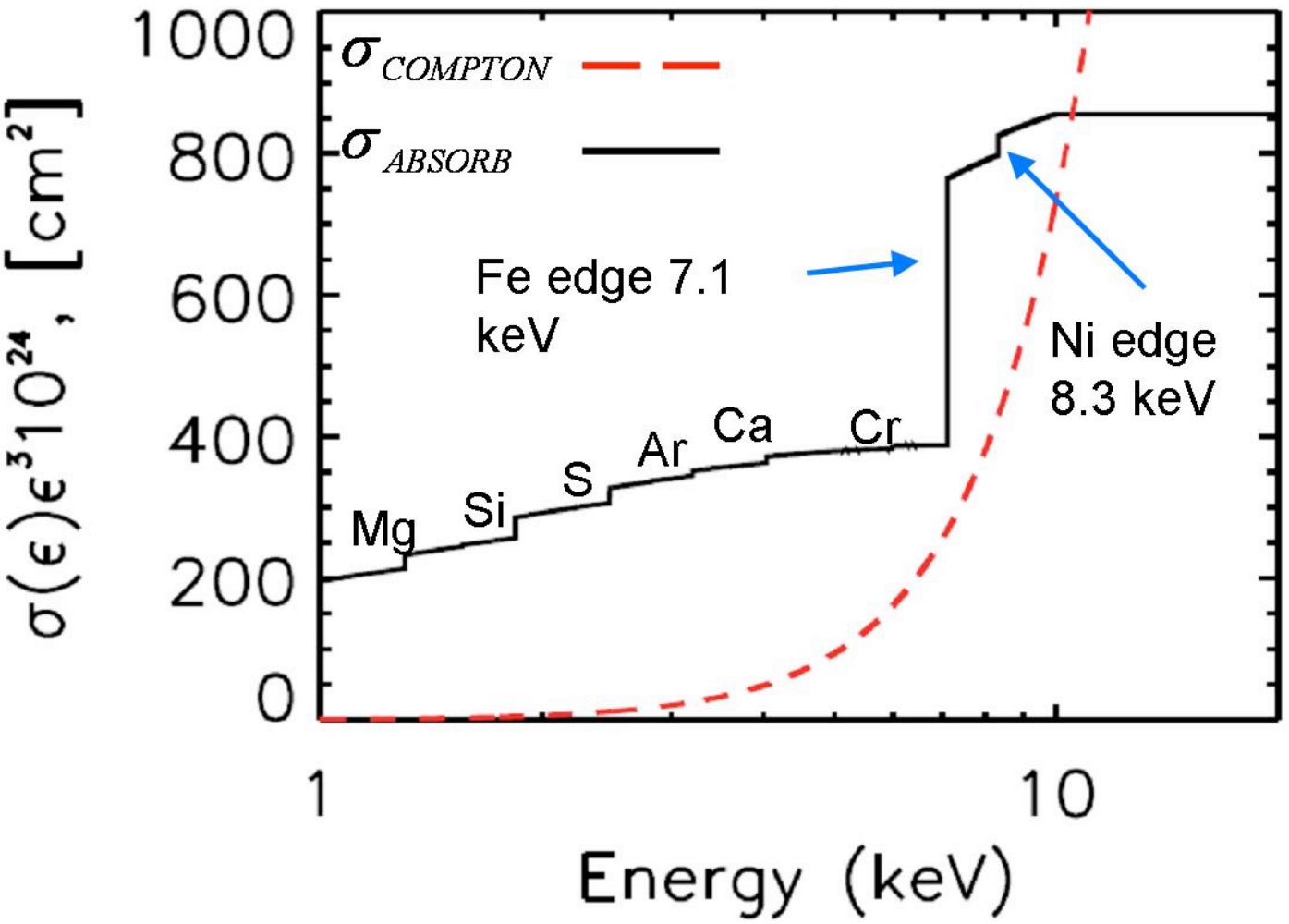
Based on models, what can we expect?



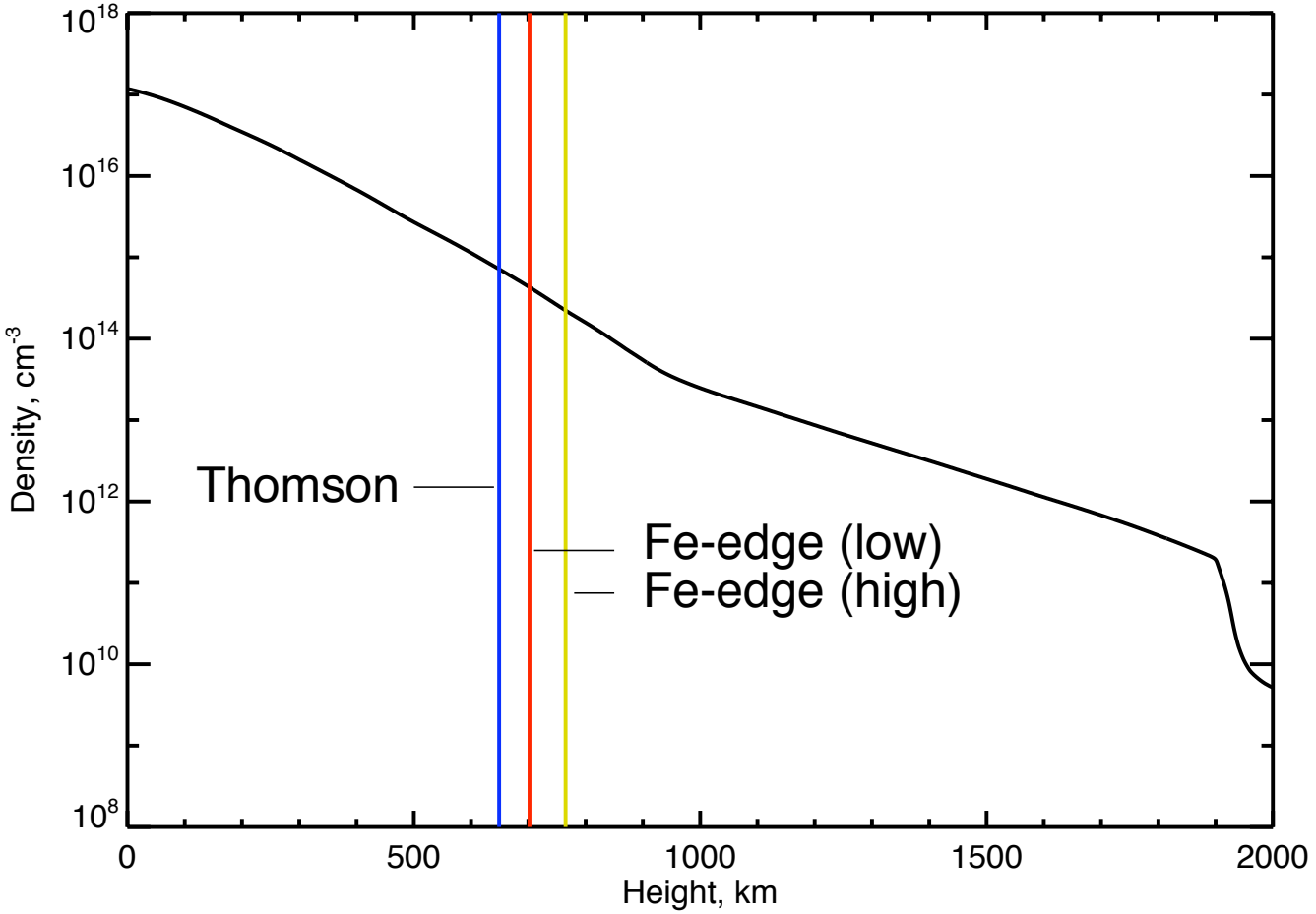
The Thomson opacity integrated along the tangent to the X-ray limb (649 km)



Kontar-Jeffrey opacities



Limb heights



What could RHESSI learn?

- Three photon energies: 7.1^{-} kev, 7.1^{+} keV, and ~15 keV (Thomson range)
- The height differences of the limb are discouragingly small: 0.086 arc sec to determine the Fe abundance;
- 0.16 arc sec to determine if there is any Fe at all
- RHESSI limb observations will be **very informative** for various reasons, even if the Fe abundance is a bit of a stretch

Practical matters

- Flare source from behind the limb

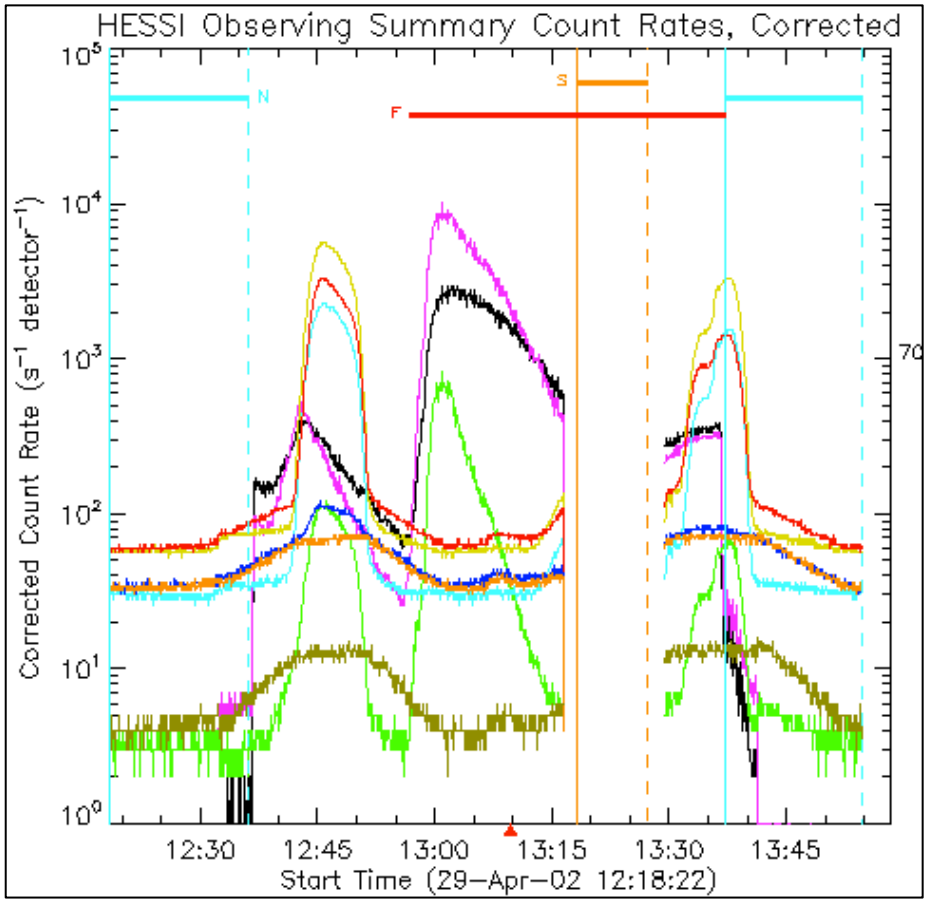
  - need to know location (STEREO)

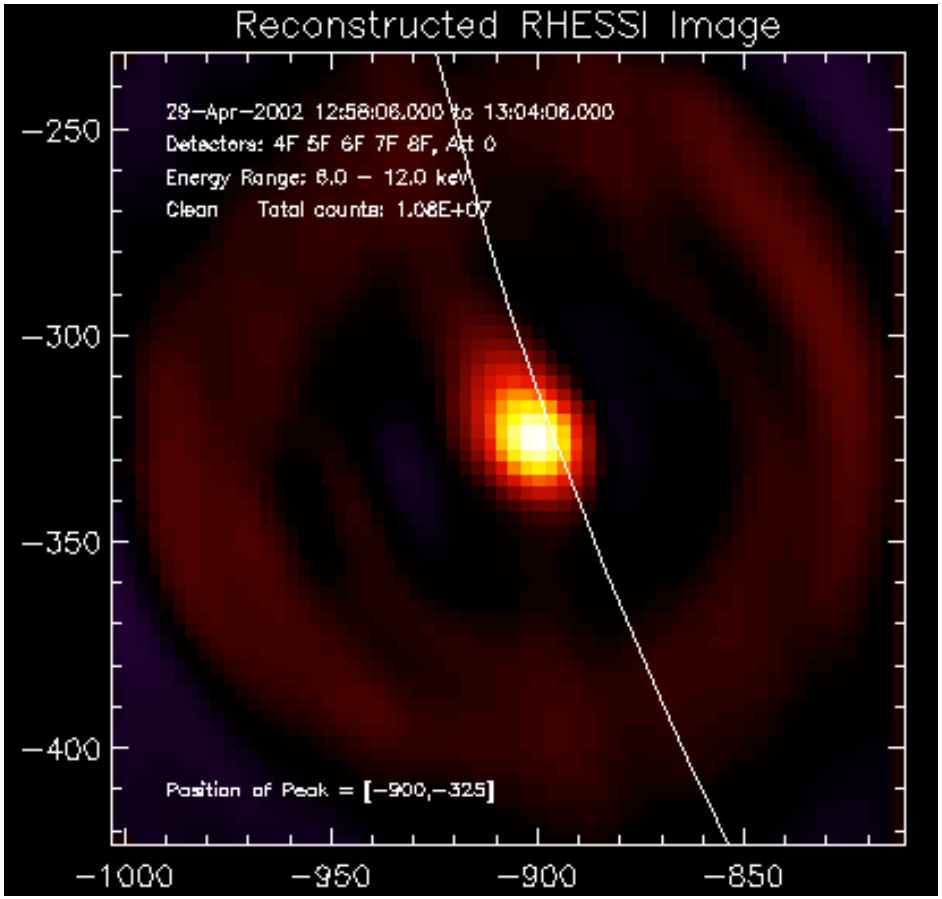
  - ideal spectrum is featureless time-stationary continuum
- We (Hurford) know how to use visibility phases for measuring limb structure
- We (Glesener, Krucker) have found a candidate source for practice
- We (Battaglia) have found that footpoint sources occur (in the TTM) above the limb; hence we may have useable continuum background sources

Practice flare

- SOL2002-04-29T13:03 C2.2 AR9934
- http://sprg.ssl.berkeley.edu/~tohban/browser/?show=grth+qlpcr+qli02+grwa&date=20020429&time=130147

Practice flare





Longitude -101.2 +- 1.3? Source height > 10^4 km?