So just what is a Thick Target?

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When is a target “thick”?

- ***When the particles lose (or gain) a substantial amount of energy in the target***

so that

- ***the emitting particle spectrum (that inferred from radiation diagnostics) is substantially different than the injected spectrum***

Example – Coulomb Collisions

- $dE/dN = - K/E = - (K/E^2)\ E$
- Infinitely thick target:

  $F(E)\ \Delta N = (E/K) \int_E^{\infty} F_0 (E_0)\ dE_0$;

  $F_0 = -d/dE\ (K\ \Delta N\ F(E)/E)\ |_{E=E0}$
- $F \sim E^{-\delta} \rightarrow F_0 \sim E_0^{-\delta-2} = E_0^{-\delta_0}$
- $\delta = \delta_0 - 2$; emitting spectrum *two powers harder* than injected spectrum (spectral flattening by collisions)

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- $I(\varepsilon) \sim \varepsilon^{-\gamma}$ $\delta = \gamma-1$(thin), but $\boldsymbol{\delta_0 = \gamma+1}$ **(thick)**

“Partially thick” targets

- Note that for an energy *loss* scenario (e.g. collisions), *an infinitely thick model is the most efficient radiator for a given injected flux*

“Partially thick” targets

- The emitting electron spectrum lies between the injected spectrum and that corresponding to an infinitely thick target
  - Low energies ($E^2 << K\Delta N$)
    - thick target form $\delta = \delta_0 - 2$
  - High energies ($E^2 >> K\Delta N$)
    - thin target form $\delta = \delta_0$

$\rightarrow$ Spectral steepening at high energies

$\rightarrow$ “Knee energy” gives information on ΔN

Can a (collisional) target be thick enough to produce spectral modification but thin enough to emit negligible radiation (e.g., below the limit set by the RHESSI dynamic range)?

- NO!
- Substantial spectral modification $\Delta E \sim \beta E$

- This requires a column depth ΔN such that

  $\Delta E \sim K\, \Delta N/E \sim \beta E \rightarrow \Delta N \sim \beta E^2/K$

- Fraction of emission $\sim \Delta N/N_{stop}$

  $= \Delta N \,/\, (E^2/2K) \sim \beta$

[cf. St-Hilaire et al. [2009] critique of Emslie et al. (2003) explanation for difference in footpoint spectral indices]

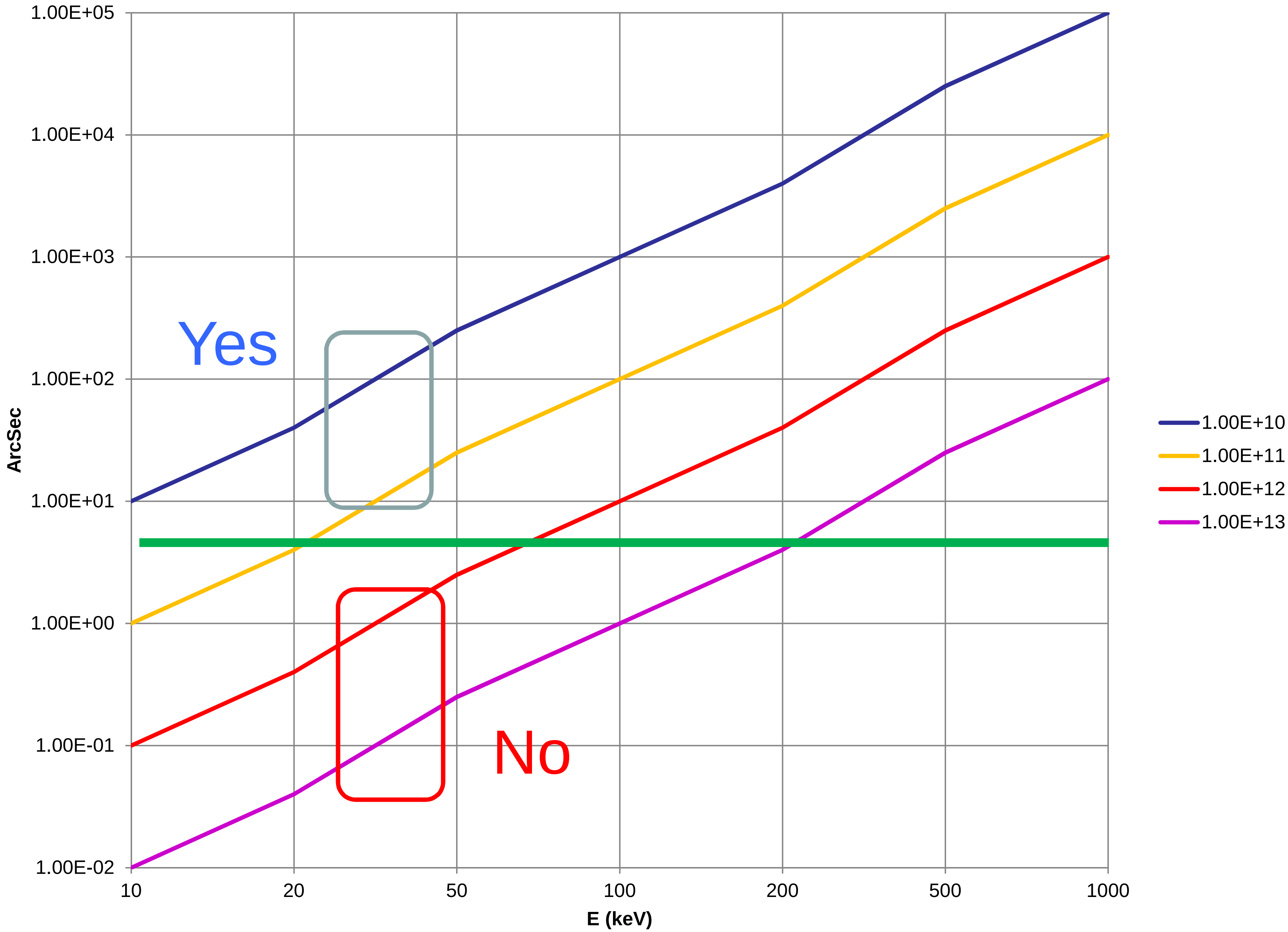
How thin do the observed "slices" of a thick target have to be before they are each effectively thin?

- Column density (cm^{-2}) ~ $E^2/2K$ ~ 10^{17} E^2

- Thickness (cm) ~ 10^{17} E^2 / n(cm^{-3})

- Angular size (arcseconds) ~

206265 ×10^{17} E^2 / n R(cm) ~ $[E(keV)]^2$ / $[n_9(cm^{-3})]$



1.00E+05
1.00E+04
1.00E+03
1.00E+02
1.00E+01
1.00E+00
1.00E-01
1.00E-02
ArcSec
10
20
50
100
200
500
1000
E (keV)
Yes
No
1.00E+10
1.00E+11
1.00E+12
1.00E+13

Can the acceleration region be “thick”?

- Yes! (cf. JCB remarks)
- ***<u>In this case the “injected” spectrum is not a well defined quantity</u>***