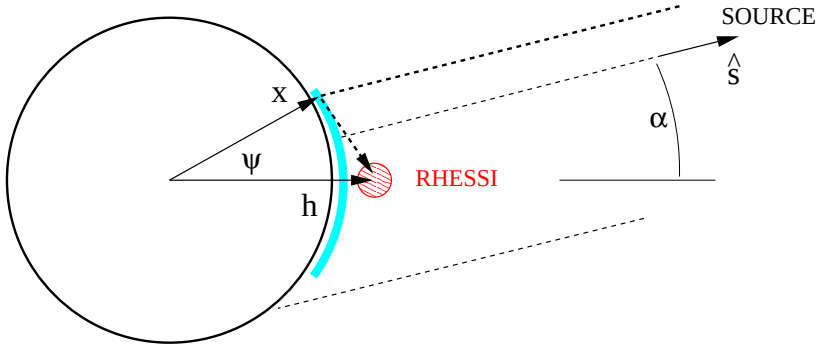
Earth Albedo: Simple Model with Single Compton Scattering + Absorption, Barometric Atmosphere



RHESSI count/s/keV:

$$
\begin{aligned}
J_{\rm direct}(\mathbf{h},E) &= A_{\rm det}\, S(E)\, e^{-\int_{\mathcal{D}} n\kappa\, dl} \\
J_{\rm scatt}(\mathbf{h},E) &= \int d\mathbf{x}\, n(\mathbf{x})\, \sigma\Big(\hat{\mathbf{s}}\cdot\frac{\mathbf{x}-\mathbf{h}}{|\mathbf{x}-\mathbf{h}|},E\Big)\, \underbrace{\frac{A_{\rm det}}{A_{\rm det}+|\mathbf{x}-\mathbf{h}|^2}}_{\approx\Omega}\, S(E_0)\, e^{-\int_{\mathcal{S}}\kappa n\, dl}
\end{aligned}
$$

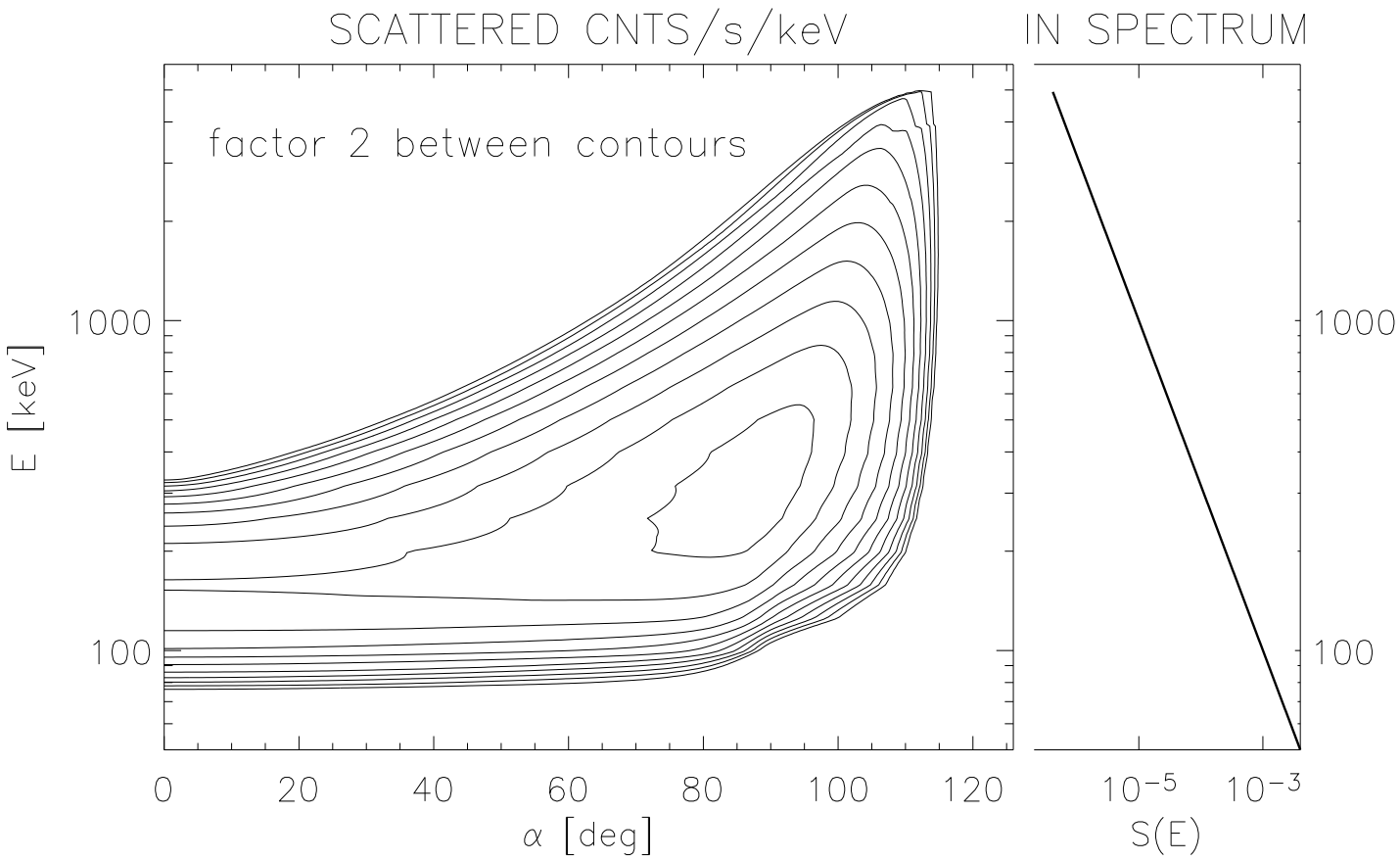
where

E	.....	observed (scattered) energy
$\mathbf{h}$	.....	RHESSI position, $\lvert\mathbf{h}\rvert = r_E$ + 600 km
$\mathbf{x}$	.....	scatterer position
$\hat{\mathbf{s}}$	.....	source direction
$\mathcal{D},\mathcal{S}$	.....	paths ($\mathbf{h}$ to source), ($\mathbf{h}$ to $\mathbf{x}$ to source)
$n(\mathbf{x})$	.....	atmospheric density, $n_0 e^{-(\lvert\mathbf{x}\rvert-r_E)/H}$
$\sigma\,(\cos\theta, E)$	.....	$= \frac{r_0^2}{2}\left(\frac{E}{E_0}\right)^2\left(\frac{E}{E_0}+\frac{E_0}{E}-2(1-\cos^2\theta)\cos^2\phi\right)$
$\frac{E_0}{E}$	.....	$= 1+\frac{E_0}{m_e c^2}(1-\cos\theta)$
ϕ	.....	infall polarisation
κ	.....	HXR absorption (photoeffect, E-dependent)
S	.....	infall spectrum, ct/s/cm^2/keV
$A_{\rm det}$	.....	detector cross section

- Considered volume: $r_E < |\mathbf{x}| < r_{max} \doteq r_E + 20H$ and $r_{max}/r_H < \cos\psi < 1$
- Averaging $\langle\cos^2\phi\rangle = 1/2$ for simplicity
- $\Rightarrow J(\mathbf{h},E)$ depends on α and E only

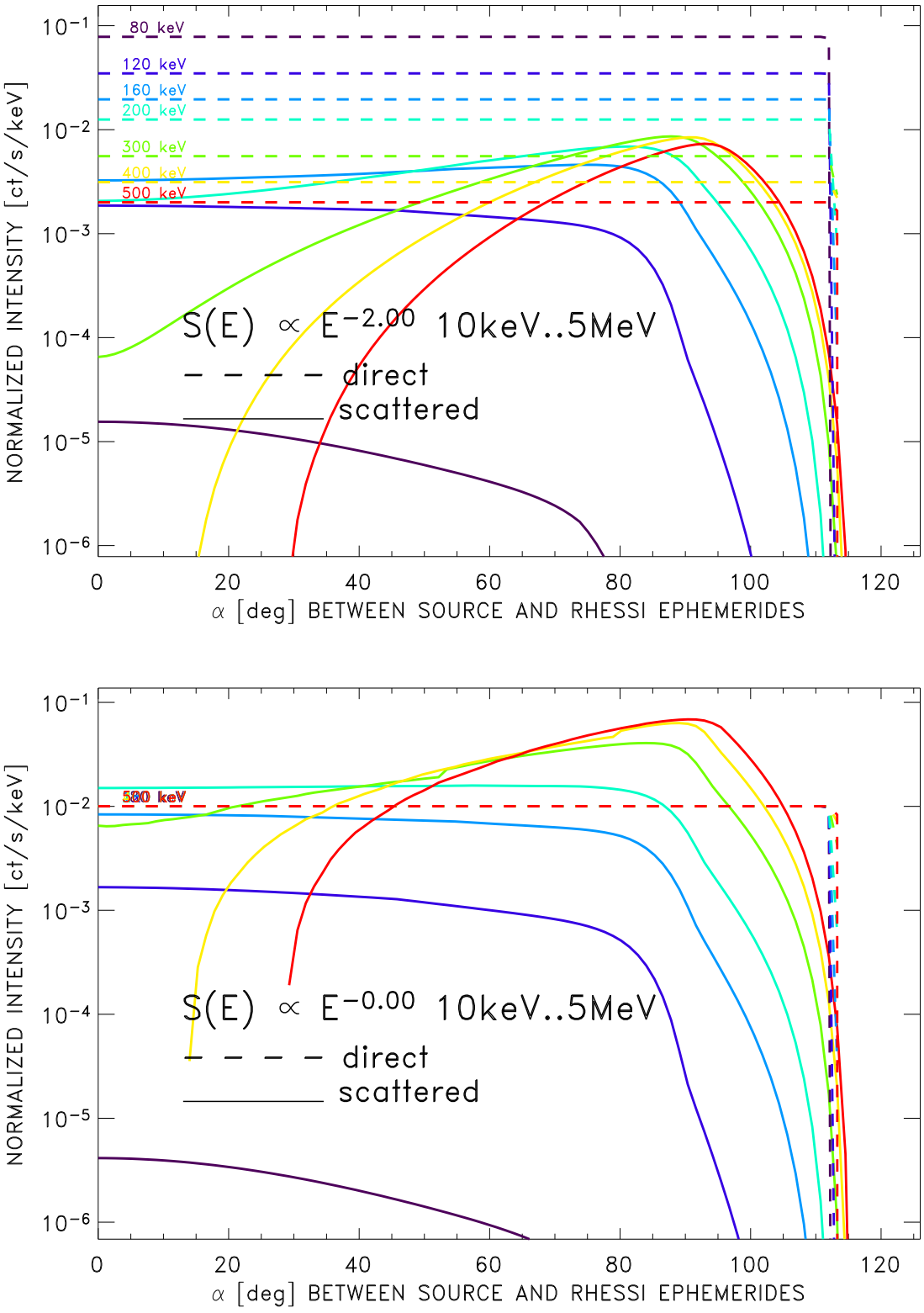
NB: split $Sn\sigma d\mathbf{x}$ into $S\,dA$ (photons entering $d\mathbf{x}$) and $n\sigma dl$ (scattering prob in $d\mathbf{x}$), with $d\mathbf{x} = dA\, dl$.

Results (1)



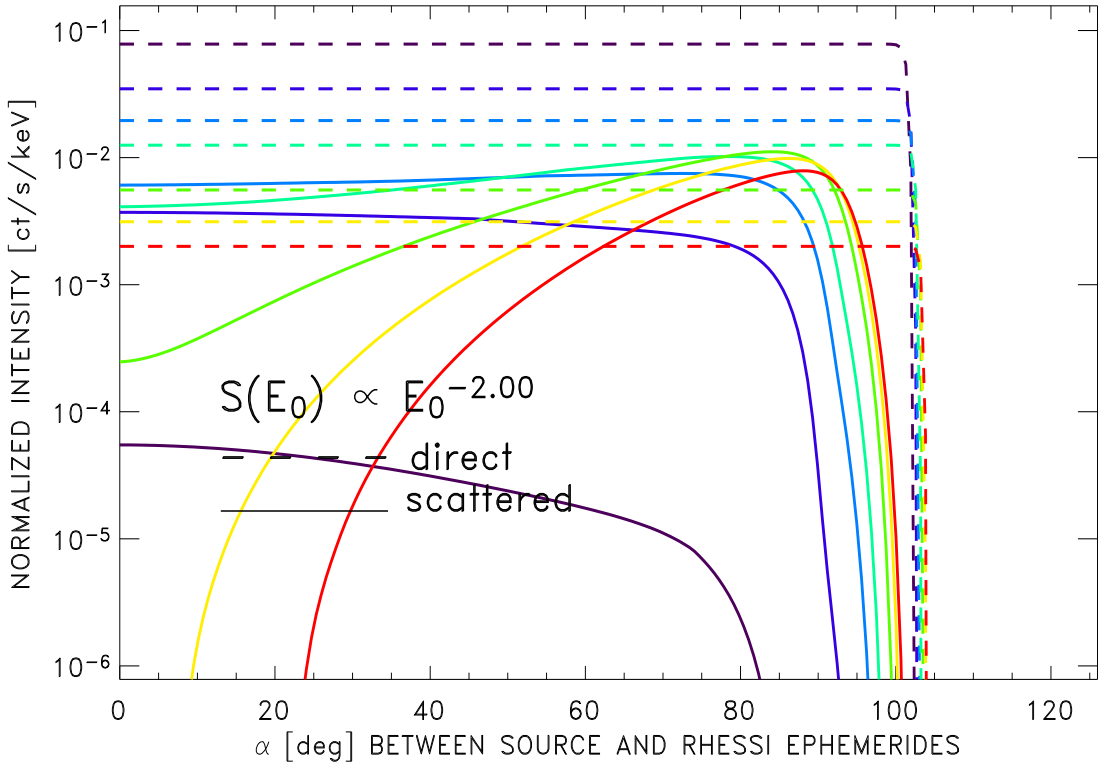
- Assumption: $S(E) \propto E^{-2}$, with 10 keV $< E <$ 5 MeV
- Maximum at $\alpha = 88.6^o$ and $E = 315$ keV
- Earth shadow is entered at $\alpha \sim 110^o$ (orbit at 600 km)
- Energy and momentum conservation require $\frac{E}{m_e c^2}(1 - \cos\theta) < 1$, which suppresses $J_{\rm scatt}(\alpha, E)$ at small α and at large E. (θ=180^o backscattered photons have $E \leq$ 255.5 keV.)
- High energies mostly forward scattered in limb-sounding configuration
- Parameters used: $R_H =$ 6978 km; $R_E =$ 6378 km; $H =$ 8km; $n_0 = 2.6810^{19}{\rm cm}^{-3}$.

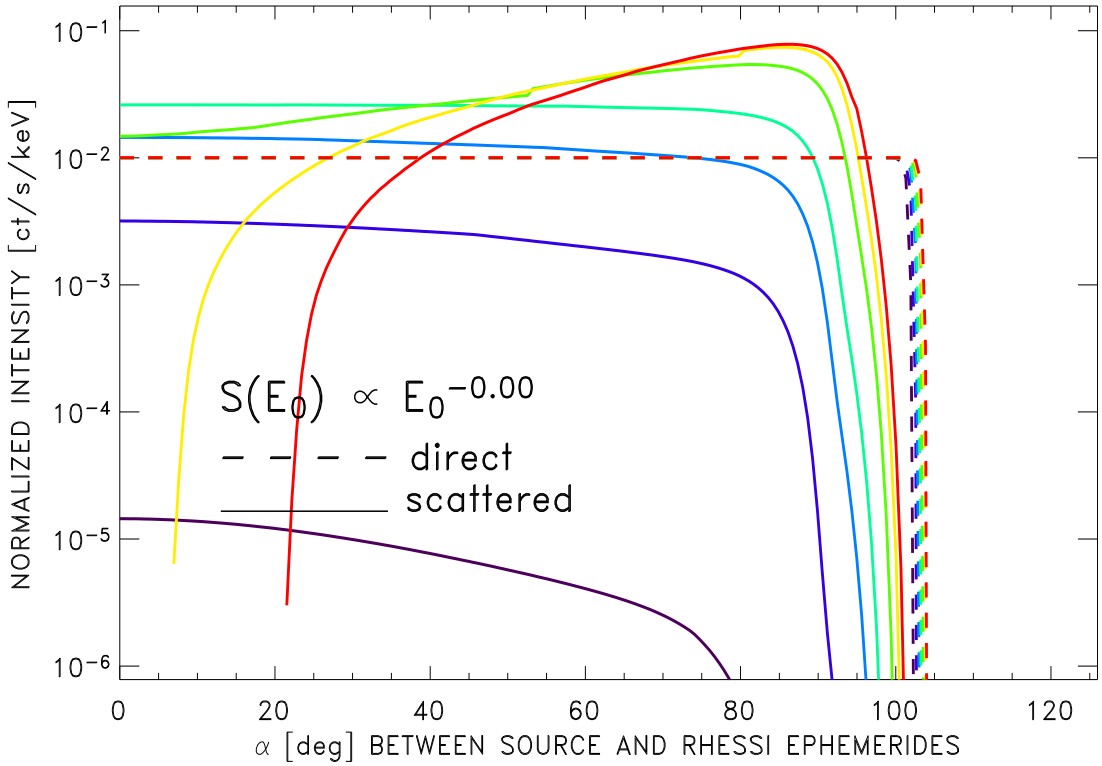
Results (2)



For realistically hard spectrum (top), the scattered count rate exceeds the direct one only above $\sim$ 250 keV. Bottom: flat spectrum up to 5MeV.

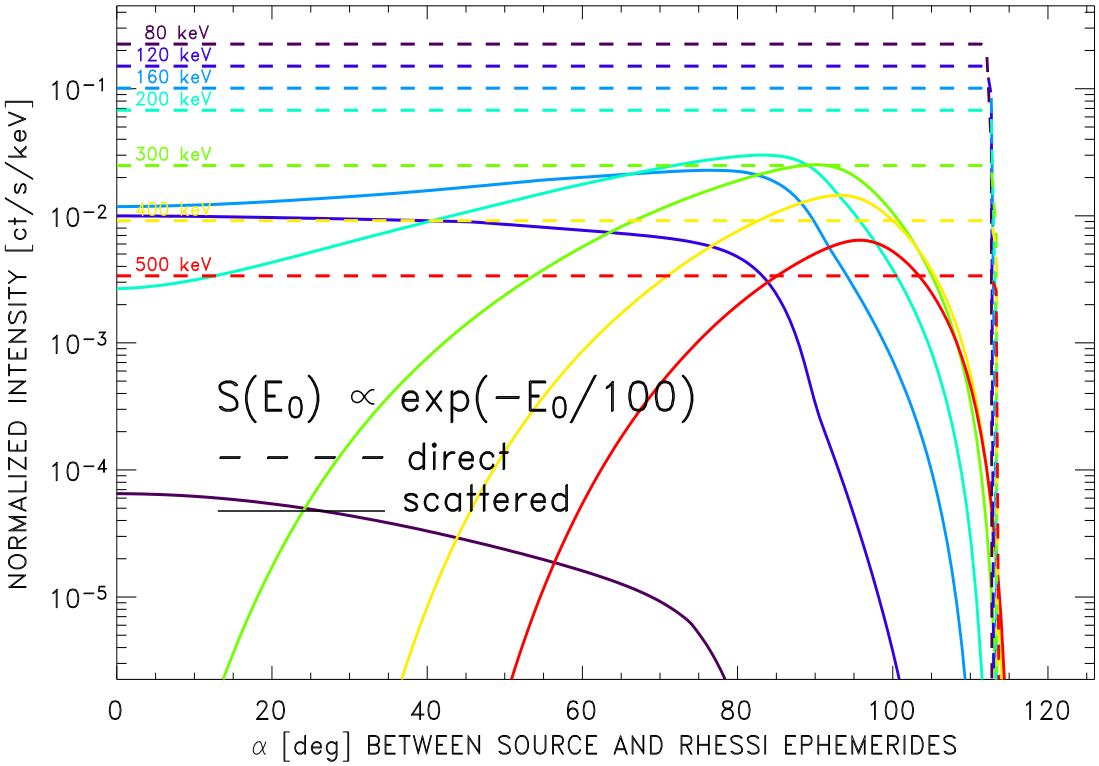
... similar, with RHESSI orbit at 200 km:





Earth shadow entered at $\alpha \sim 104^o$

... similar, with thermal infall spectrum:



Similar behaviour as for power law spectra; high energies of the scattered counts decay together with the infall spectrum.