Ion energies Relevant to Nuclear Emission Processes

γ-ray deexcitation lines

$\left.\begin{matrix} p \\ \alpha \end{matrix}\right\} + {}^{12}C \longrightarrow {}^{12}C^{*4.439}$

$\left.\begin{matrix} p \\ \alpha \end{matrix}\right\} + {}^{16}O \longrightarrow {}^{12}C^{*4.439} + \ldots$

$\alpha + {}^{4}He \longrightarrow {}^{7}Li^{*0.478}$

$\alpha + {}^{4}He \longrightarrow {}^{7}Be^{*0.429}$

neutrons

$p + {}^{4}He \longrightarrow n + \ldots$

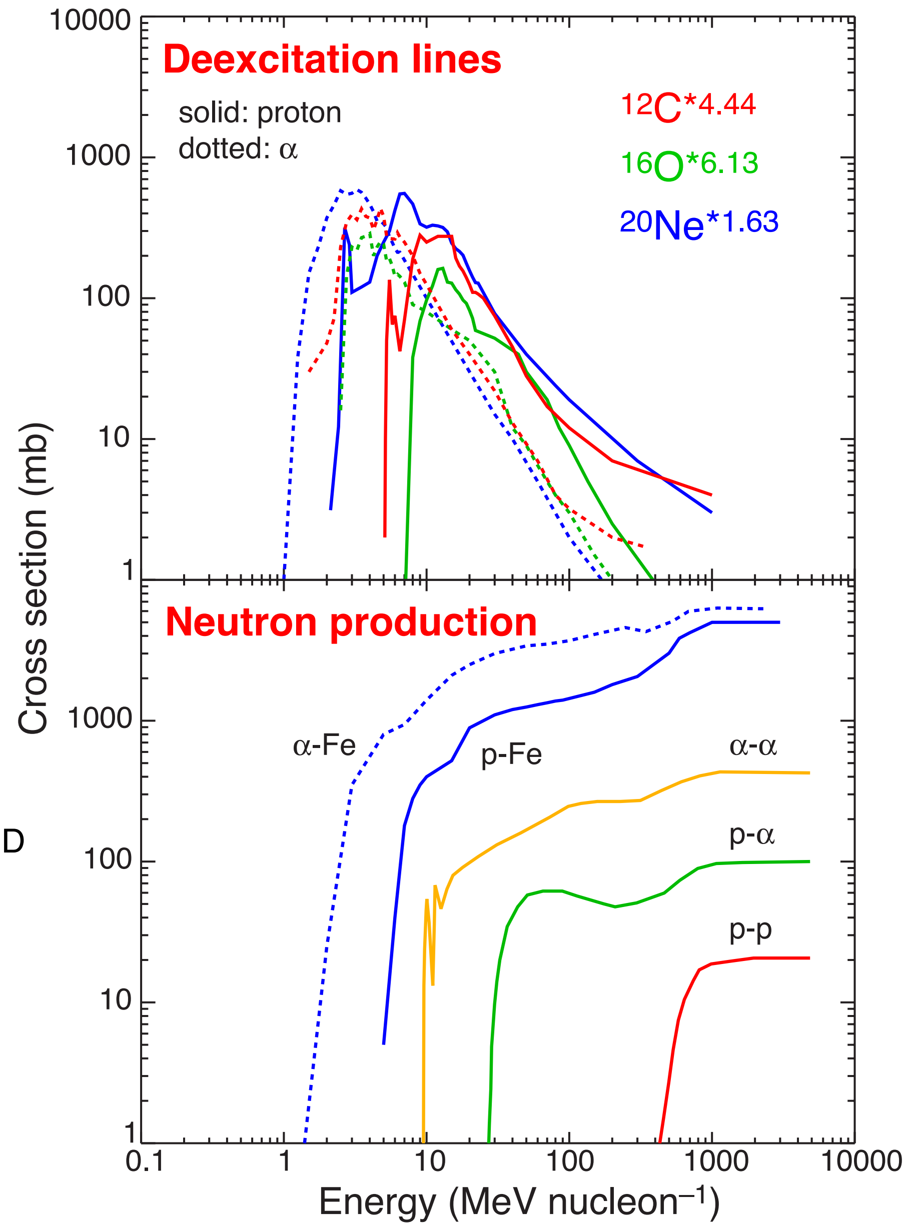
$\alpha + \alpha \longrightarrow n + \ldots$

$\left.\begin{matrix} p \\ \alpha \end{matrix}\right\} + {}^{12}C \longrightarrow n + \ldots$

} escape to space

capture on photospheric H $\longrightarrow$ D

2.223 MeV n-capture line



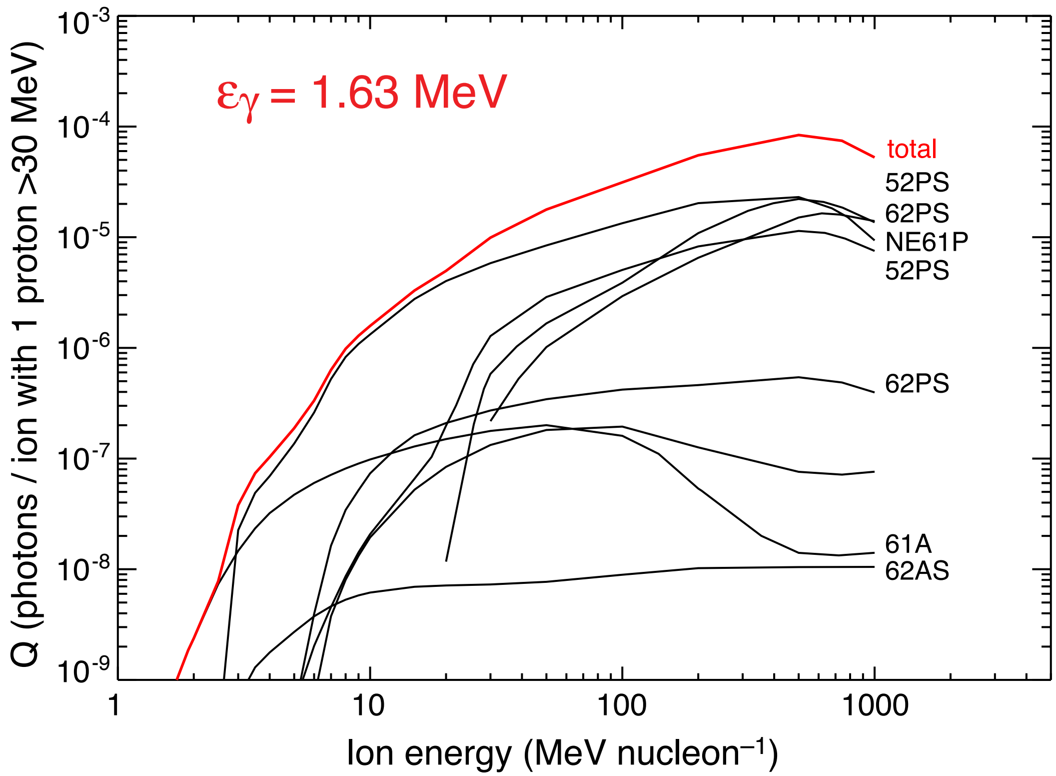
Yield calculation

Thick target yield from ions with energy E_0 MeV nucleon^{-1}:

$$Q(E_0) = n\int_0^{E_0} dE \frac{\sigma(E)}{dE/dl(E)} P(E_0, E)$$

$$P(E_0, E) = exp\left[-n\int_E^{E_0} \frac{\sigma_N(E')}{dE/dl(E')} dE'\right]$$

yields calculated for ions with impulsive flare abundances, $\alpha/p = 0.1$ and normalized to 1 proton >30 MeV

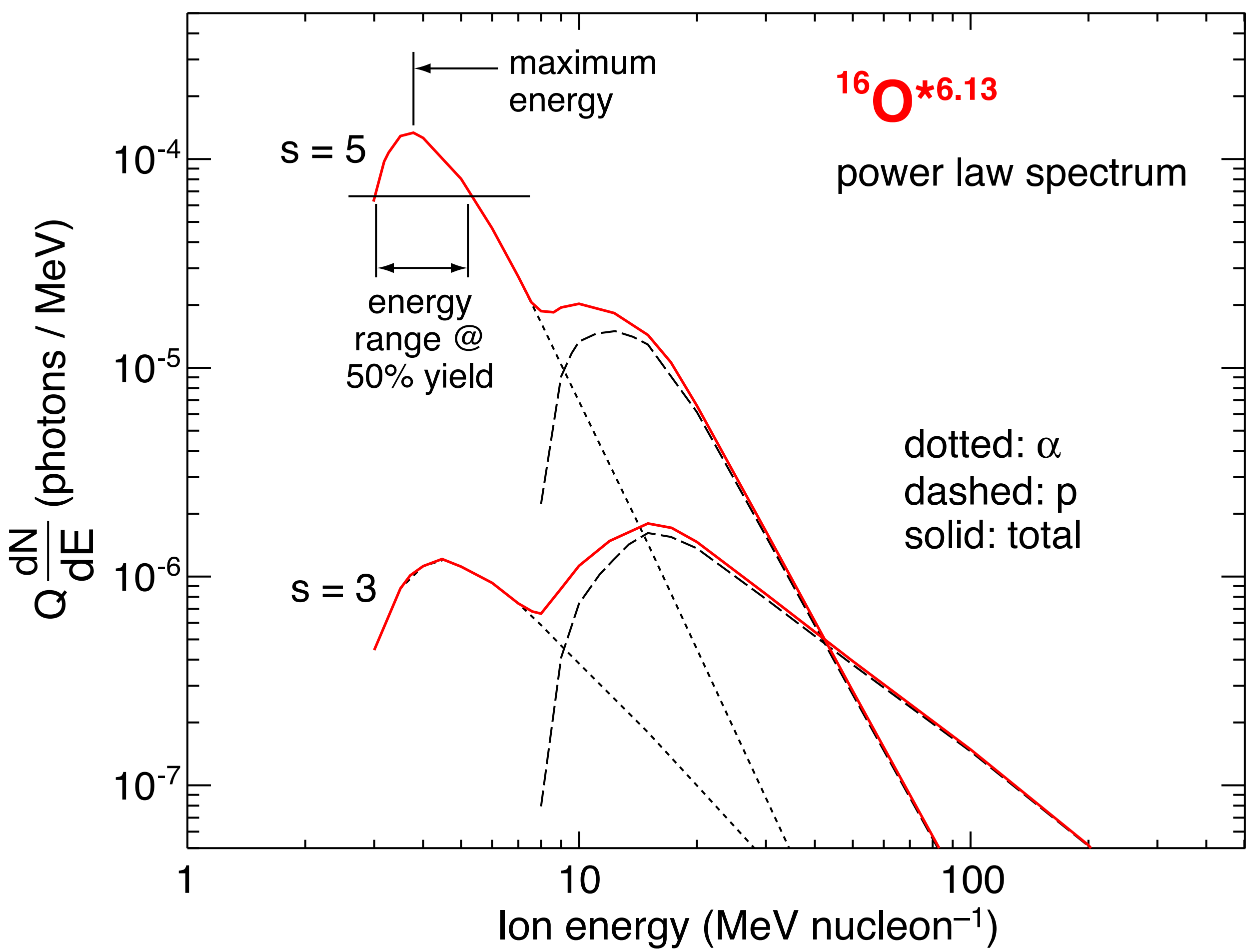


Yields for Power Law Spectra

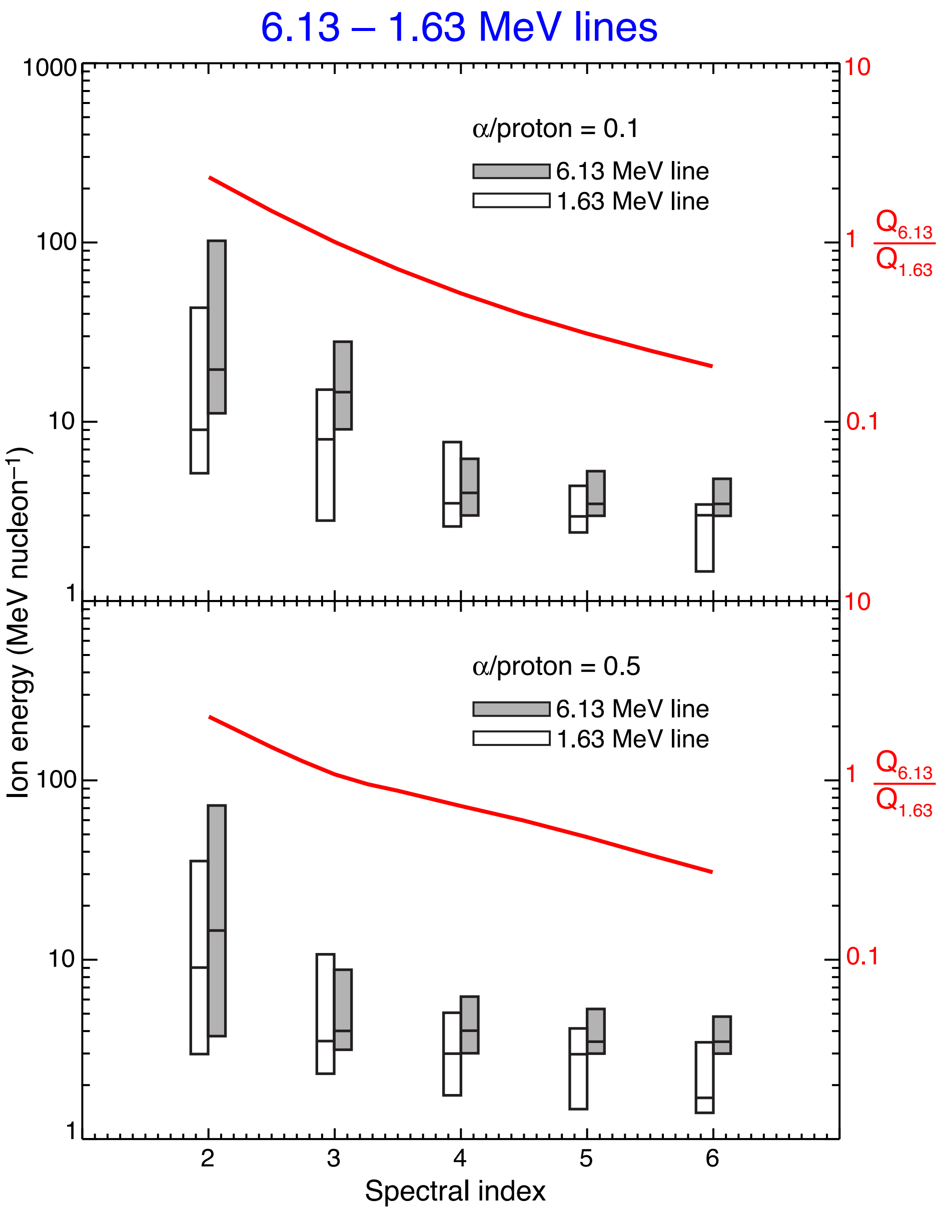
Weight with spectrum:

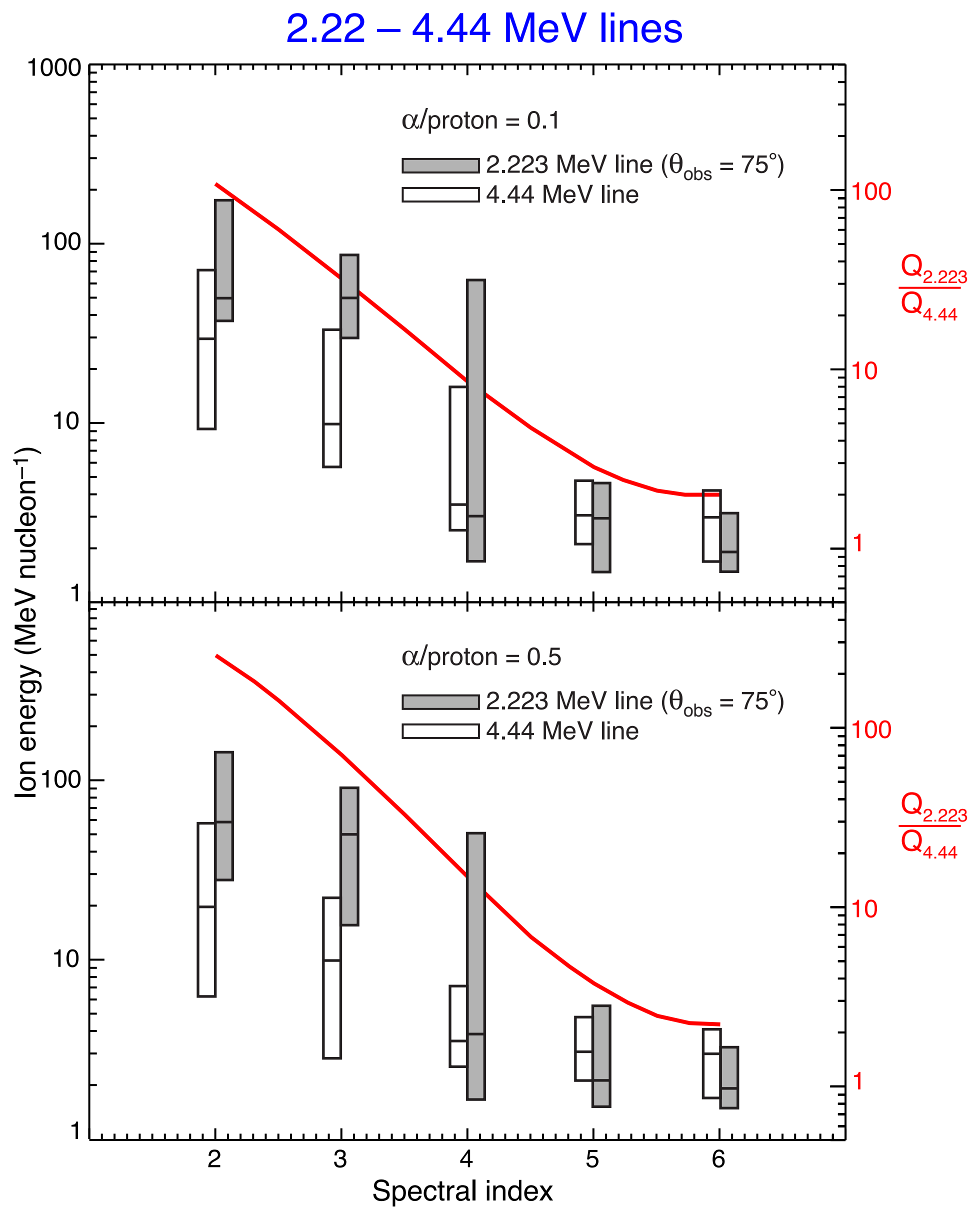
$$Q(E_0)\,\frac{dN}{dE}(E_0)$$

yields calculated for ions with impulsive flare abundances, $\alpha/p = 0.1$ and normalized to 1 proton >30 MeV

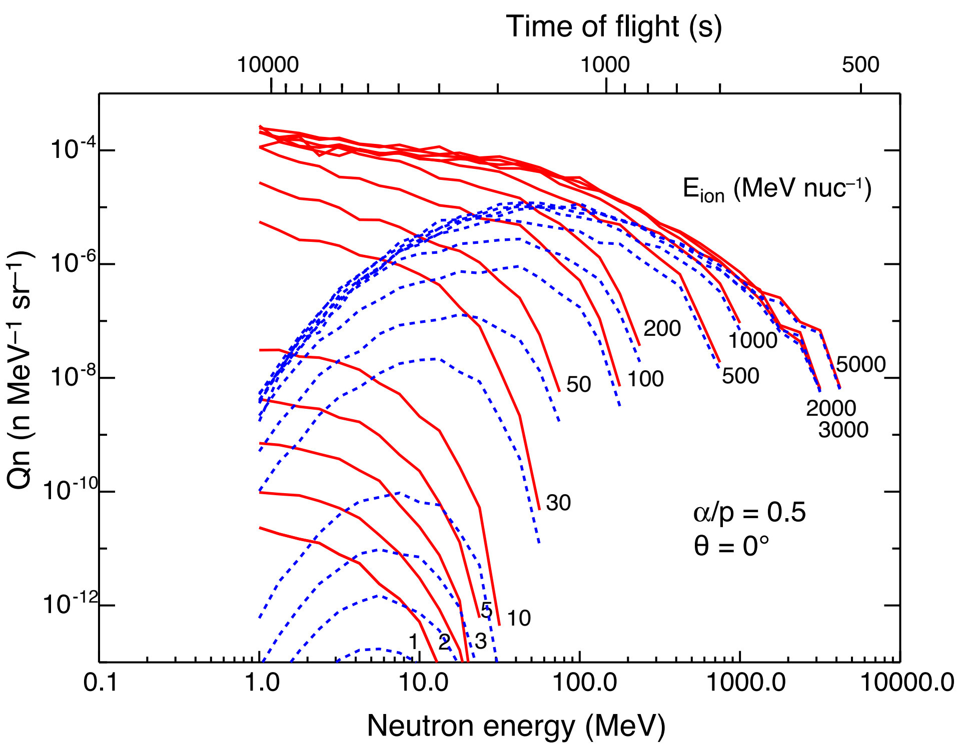


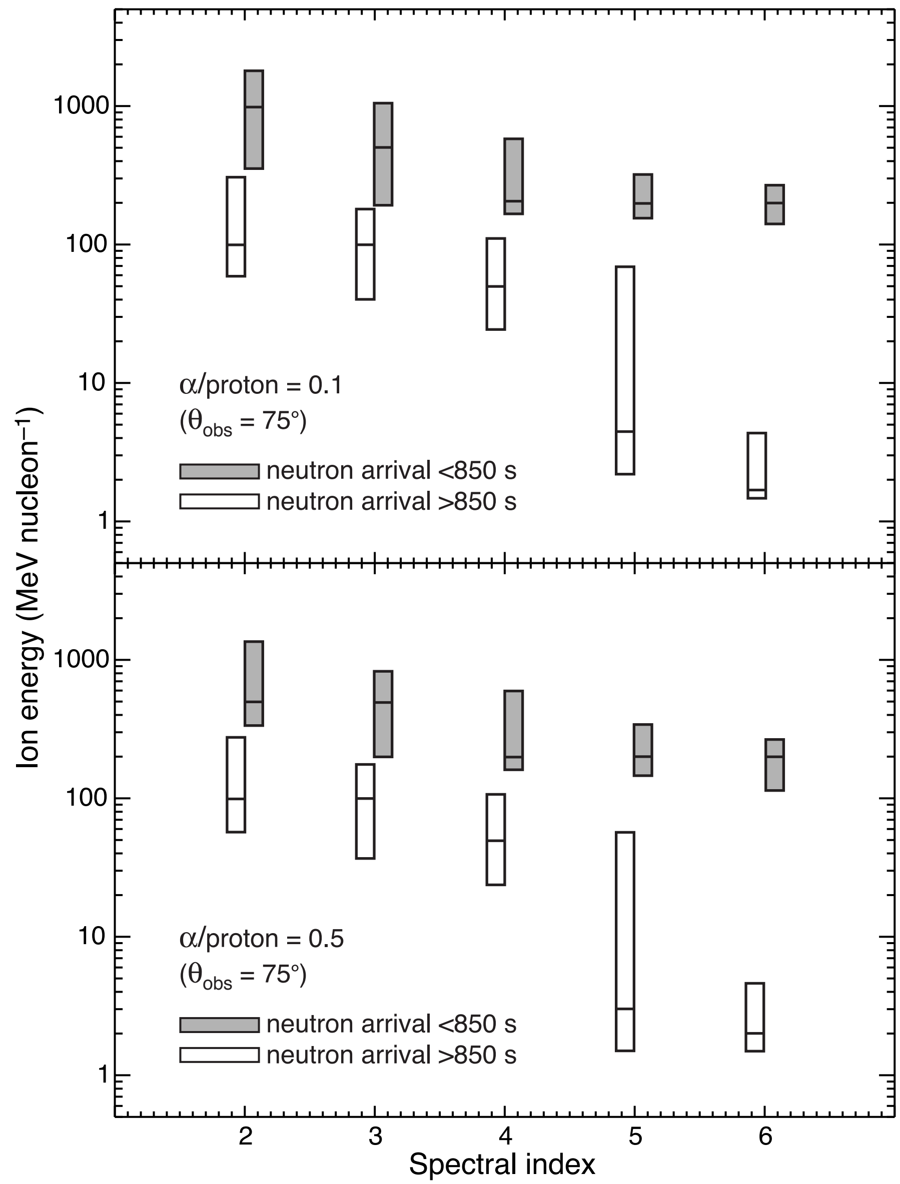
Ion Energy Ranges (50%) for Line Ratios Assuming Power Law Spectra





Ion Energy Ranges (50%) for Neutrons Arriving at Earth Assuming Power Law Spectra





Application to the OSSE Observations of the 1991 June 4 Flare

obtained a consistent index of ~4 from both the 6.1/1.6 MeV and 2.22/4.44 MeV line ratios

but an unbroken PL with s = 4 over-produced the arriving neutrons early in the observation

introducing a cut-off in the ion spectrum at 150 MeV nucleon^{-1} provided an improved fit which did not affect the predicted yields for the lines