# X-Ray Attenuation through the Upper Atmosphere

## The Fundamentals and Intuition Behind Detecting a Nuclear Explosion from Space

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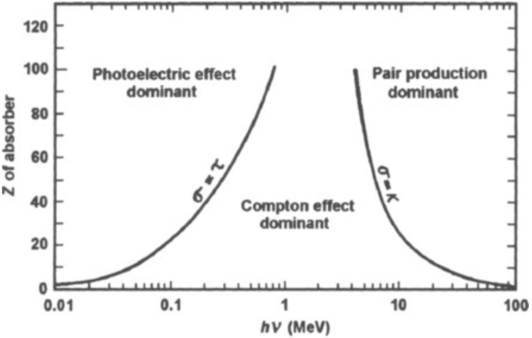
August 4, 2020

# X-Ray Production

- 35-45% Energy released as thermal radiation
- Produces fireball with extremely high temperatures (100 million C)
- Fireball acts as a blackbody and radiates in the x-ray spectrum

# X-Ray Attenuation

- Compton-effect
- Photoelectric-effect
- Pair-production




- Together, these form the attenuation coefficient for a particular medium

# X-Ray Attenuation Coefficient

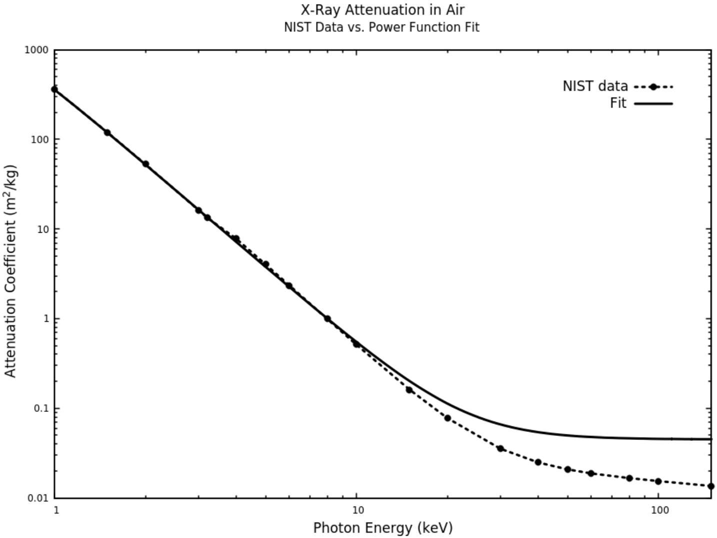



Figure: X-Ray Attenuation Coefficient Fit

# Attenuation Equation

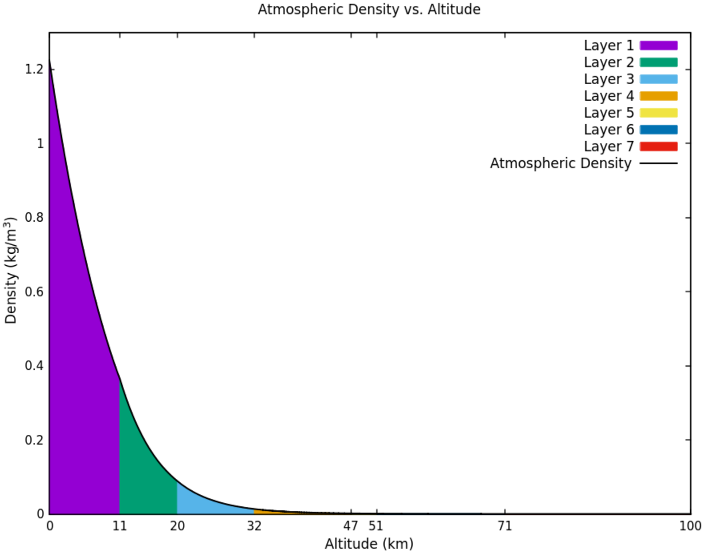
Attenuation follows the form:

$$e^{-\sigma \rho x}$$

Where:

- $\sigma$ = Attenuation coefficient
- $\rho$ = Density of medium
- $x$ = Distance traveled through medium

# Atmospheric Density



# Barometric Formulas

Equation 1:

- $\rho = \rho_b \cdot \left[\dfrac{T_b}{T_b + L_b \cdot (h - h_b)}\right]^{\left(1+\frac{g_0 \cdot M}{R^* \cdot L_b}\right)}$

Equation 2:

- $\rho = \rho_b \cdot \exp\left[\frac{-g_0 \cdot M \cdot (h - h_b)}{R^* \cdot T_b}\right]$

# Calculating Attenuation

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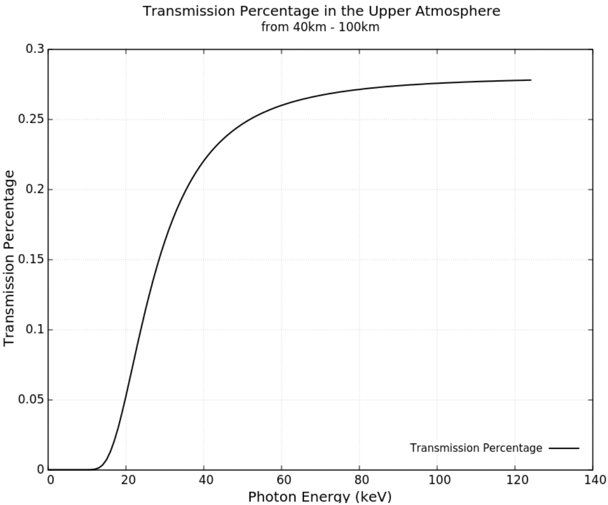
- $e^{-\sigma\int_a^b \rho(h)dh}$

This allows for calculation of attenuation over an interval while incorporating a variable density

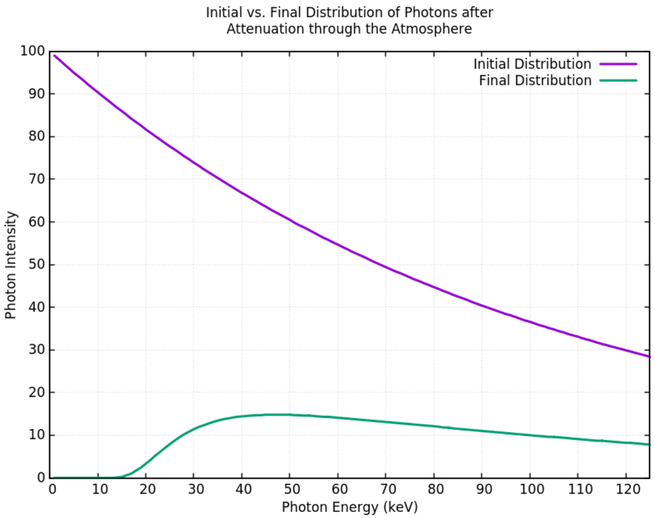
# Photon Distribution

- Create bins of photons with different energy
- Fill bins according to some photons distribution such as an exponential decay function
- Multiply bin intensity buy transmission percentage for the particular interval

# Transmission Percentage



# Distribution Evolution



# Distribution Surface Evolution