FLUKA Simulation Updates 15/10/20

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Topics

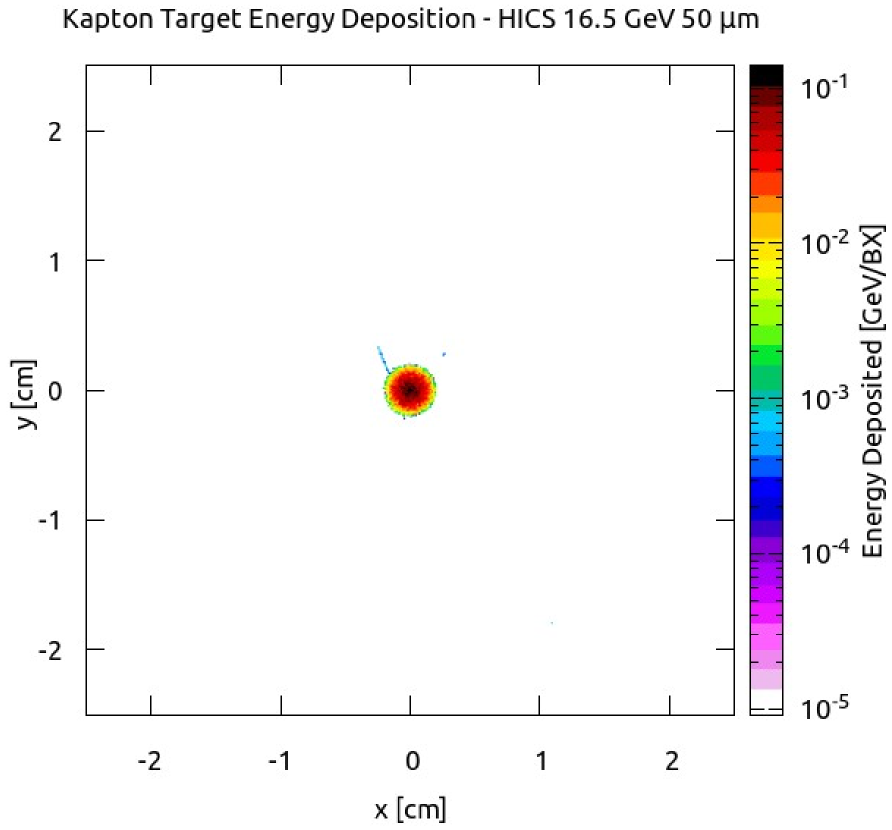
- Thermal degradation of Kapton target
- Deconvolution of electron signal

Thermal Degradation of Kapton

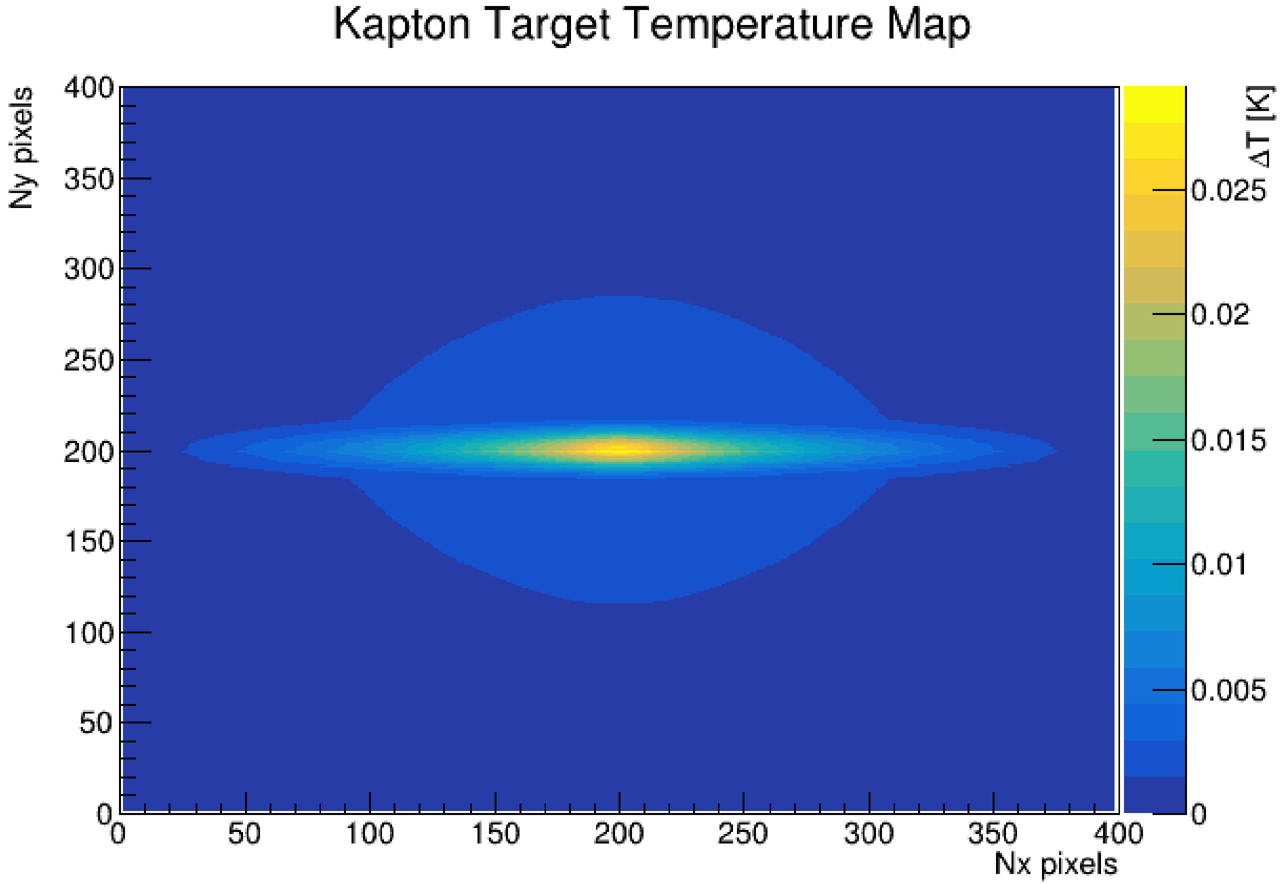
- Pressure gradient at spectrometer target

  ~ 10 -100 MPa
- Energy deposition at centre of photon beam ~0.1 GeV/BX
- After 2 hrs, change in core temperature 0.03 K

Energy Deposition on Target



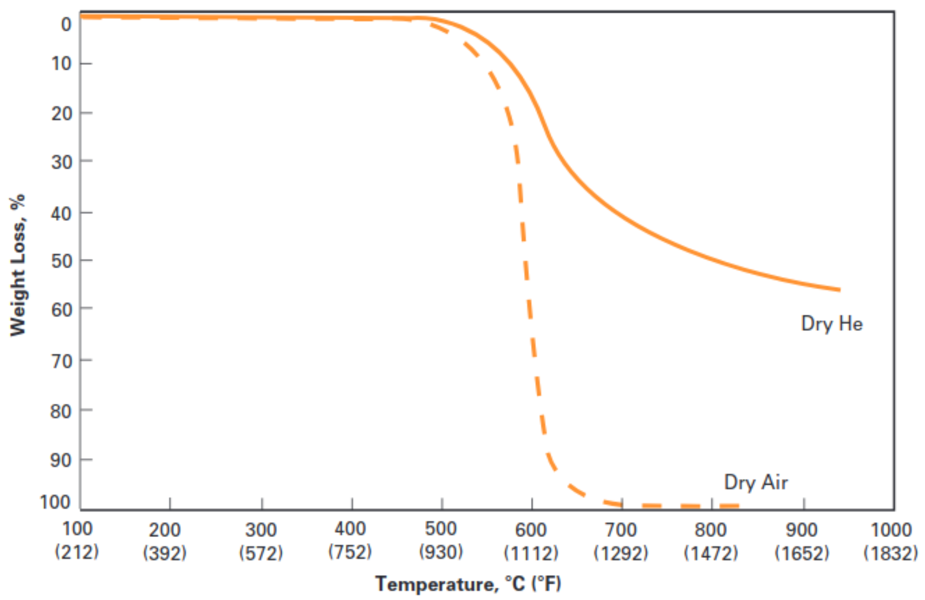
Temperature Map of Target



Thermal Degradation

- Taken from DuPont website – Kapton physical specifications document
- Thermal degradation occurs for changes of temperature ~600 K
- From before 0.03 K/ 2hrs → 20000 *2 hrs = 4.5 years

Figure 9. Weight Loss, Type HN Film, 25 µm (1 mil)*



Deconvolution Process I

- Bethe-Heitler differential cross section

$$\frac{d\sigma}{dx} = \frac{A}{X_0 N_A}\left[1 - \frac{4}{3}x(1-x)\right]$$

- X = E/k; fractional energy of photon given to electron
- The emitted electron spectrum after passing through a target can be expressed as

$$\frac{dN_e}{dE} = \frac{\rho \Delta z}{X_0}\int dk\, \Phi(E,k)\frac{dN_\gamma}{dk}$$

Deconvolution Process II

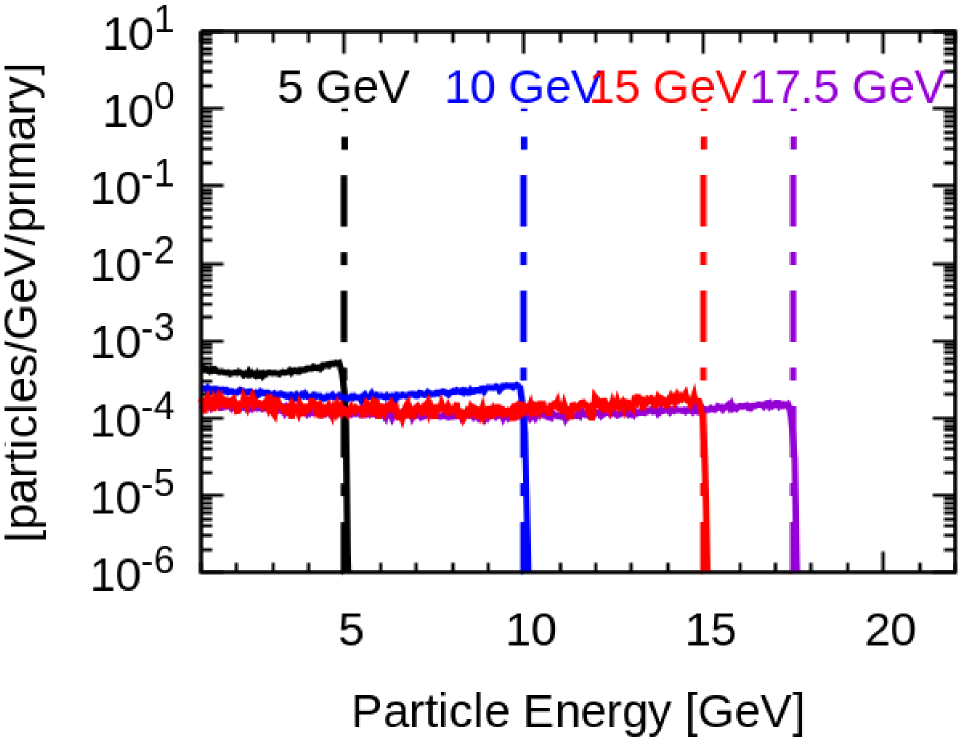
- For a monoenergetic photon spectrum

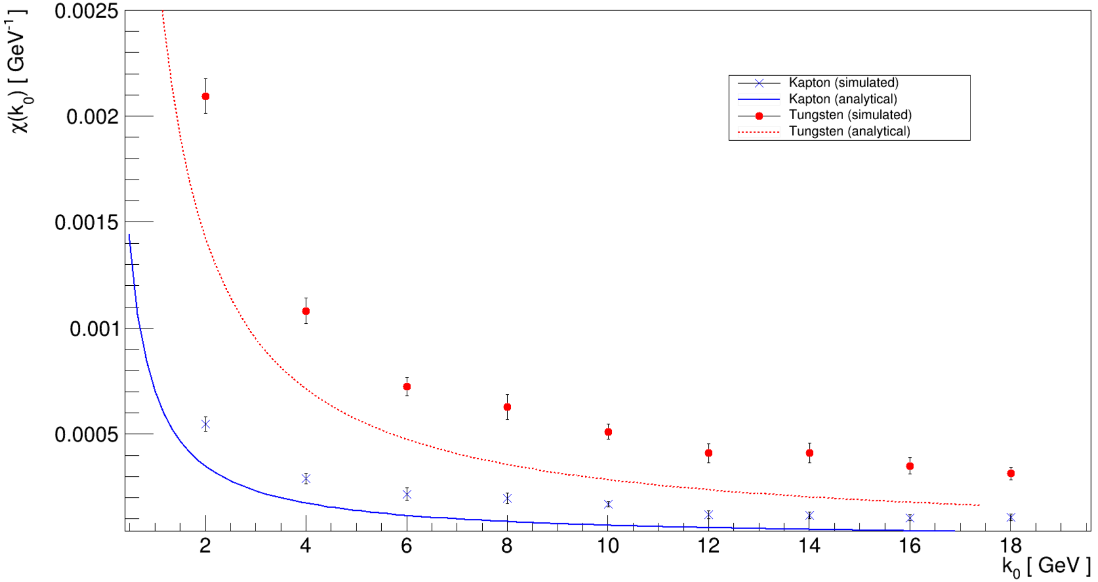
$$\frac{dN_\gamma}{dk} = N_0\delta(k - k_0)$$

- The midpoint between the maximum and minimum spectrum value is given by

$$\chi(k_0) = \frac{5N_0K}{6k_0}$$

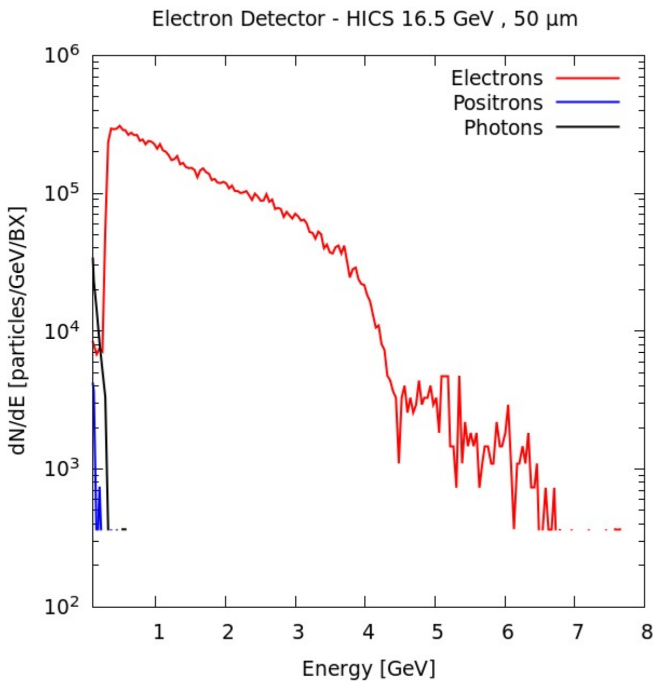
Deconvolution - Calibration



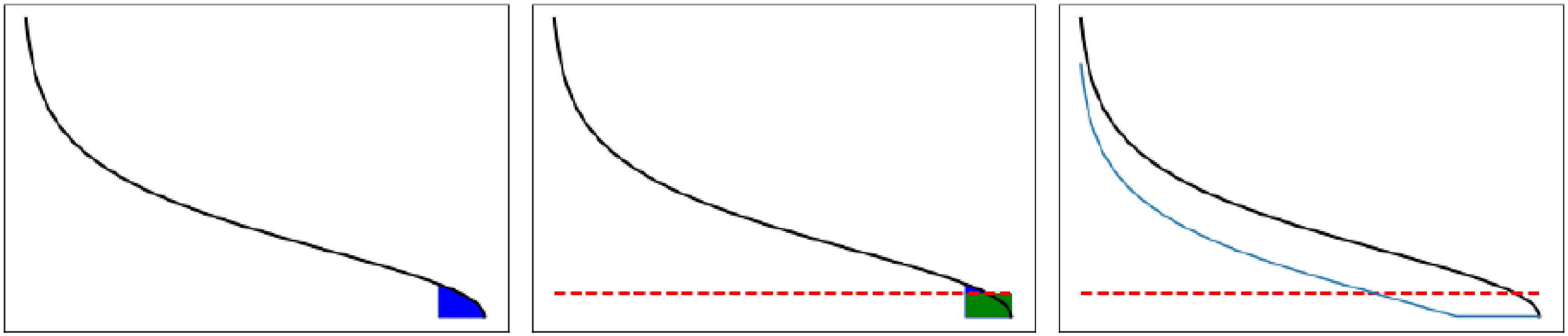


Deconvolution Algorithm

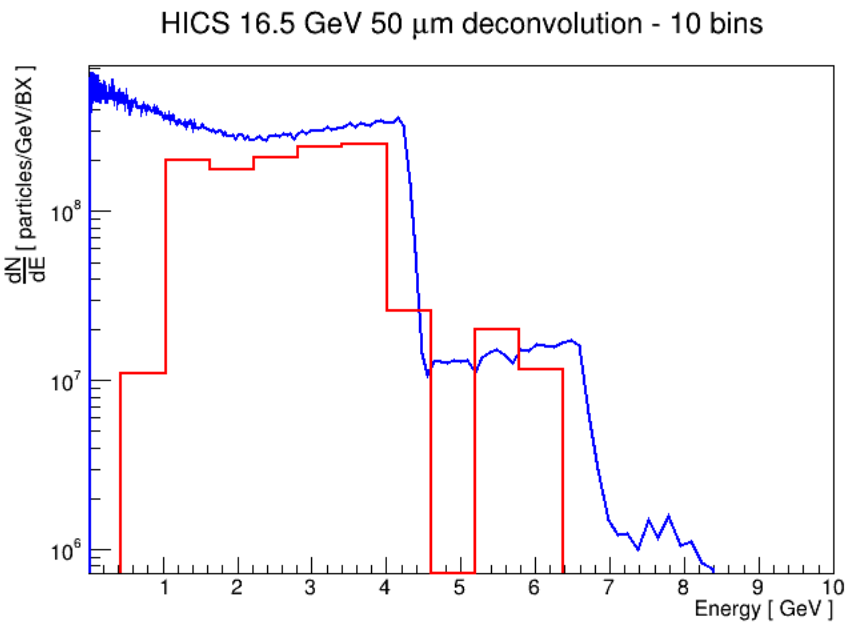
- Electrons with highest energy produced by photons with highest energy
- Calculate contribution to number of photons in energy bin from these high energy photons → requires response function
- Ratio of electron number in spectrum to contribution is the magnitude of the photon spectrum at this energy
- Subtract all energy contribution from electron spectrum
- Iterate this process in decreasing energy



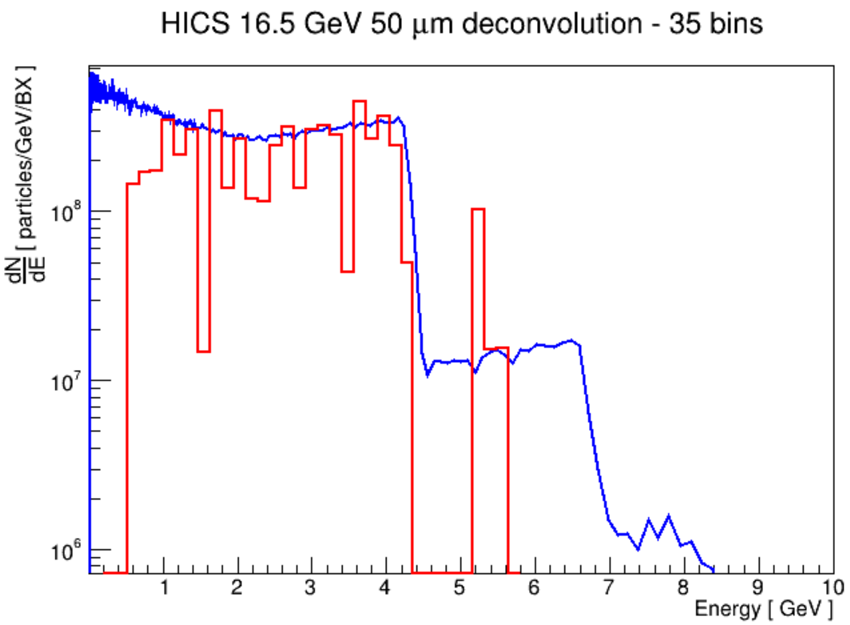
Deconvolution Algorithm - Diagram



Deconvolution Results



First Compton edge – 4.2 +/- 0.33 GeV



First Compton edge – 4.2 +/- 0.08 GeV

Deconvolution – Theoretical Methods

- Problem of deconvolution is essentially solving a Fredholm integral equation of first kind
- Using numerical quadrature, approximate integral equation as

$$f(E_i) \approx \sum_{j=1}^{m} \omega_j \phi(E_i, k_j) g(k_j) \;\Rightarrow\; \mathbf{f} = \mathbf{K}\mathbf{g}$$

- Reconstruction of photon spectrum boils down to matrix inversion – sensitive to uncertainities in the electron spectrum
- May provide a more robust way of determining uncertainties in the deconvolved results and also allow for calculating the available accuracy from knowledge of experimental precision