Forward Spectrometer Update

Kyle Fleck and Dr. Gianluca Sarri

Deconvolution of Electron Signal

- Previously, factor of 5000 between deconvolved (photon) spectrum and the actual input signal for both peak ξ values of 0.3 and 3.1
- Updated algorithm to include the effect of 'first order' pair production in air from unconverted photons after target
- This improves accuracy but still a factor of ≤ 100 off
- Possible cause is 'second order' effect in air - converted electrons/positrons emit bremsstrahlung which in turn pair produces in the air

$\xi = 0.3$ Results

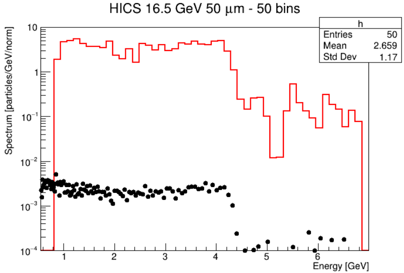

Figure: Deconvolved spectrum before direct pair production in air included

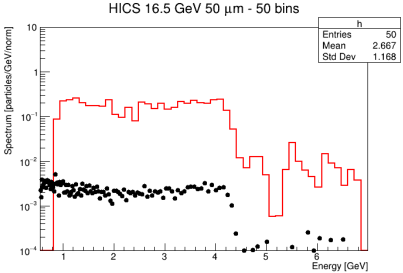

Figure: Deconvolved spectrum with direct pair production in air included

$\xi = 3.1$ Results

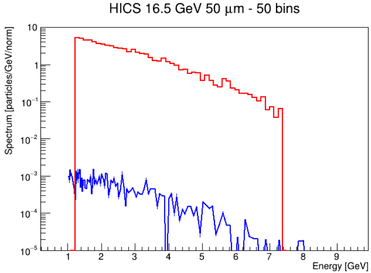

Figure: Deconvolved spectrum before direct pair production in air included

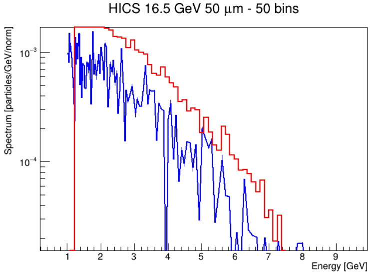

Figure: Deconvolved spectrum with direct pair production in air included

Bremsstrahlung-Pair Production Effect

- Implementation based off similar method to the Bethe-Heitler response of the target
- Using the energy spectrum for the **converted** electrons/positrons (symmetric) $\frac{dN}{d\epsilon}$
- The spectrum of emitted bremsstrahlung is related via

$$\frac{dN_\gamma}{dk} = \frac{\rho N_A L}{A} \int d\epsilon \, \frac{d\sigma_B}{dk} \frac{dN_e}{d\epsilon}$$

- This can be used in turn to generate the bremsstrahlung-pair produced (BPP) electron/positron spectrum

$$\frac{d\mathcal{N}}{dE} = \frac{\rho N_A L}{A} \int dk \, \frac{d\sigma_{pp}}{dE} \frac{dN_\gamma}{dk}$$

BPP continued

- These can be combined to give the result

$$\frac{d\mathcal{N}}{dE} = \left(\frac{\rho N_A L}{A}\right)^2 \int dk\, d\epsilon\, \frac{d\sigma_{pp}}{dE} \frac{d\sigma_B}{dk} \frac{dN}{d\epsilon}$$

- There is a subtlety in the choice of integration limits
- The bremsstrahlung spectrum is given by the formula (from PDG - Passage of Particles through Matter)

$$\frac{d\sigma_B}{dk} = \frac{1}{k}\left\{\frac{A}{X_0 N_A}\left(\frac{4}{3} - \frac{4}{3}y + y^2\right) + \frac{4\alpha r_e^2}{9}(1-y)(Z^2+Z)\right\}$$

- $y = k/E$ is the fractional energy of the electron/positron given to the emitted photon

BPP - Limits of Integration

- $\frac{d\mathcal{N}}{dE}$ is a function of E and so is only evaluated at a particular value each time
- For a BPP electron of energy E, only a photon of energy $k \geq E$ could produce it
- Likewise, a bremsstrahlung photon of energy k could only be produced by a traversing electron of energy $\epsilon \geq k$
- Therefore, the correct limits of integration are

$$\int_{E}^{E_{max}} dk \int_{k}^{E_{max}} d\epsilon$$

Summary

- Deconvolution algorithm now include direct pair production of unconverted photons in the air
- Still a relative factor of ≤ 100 between reconstructed and actual photon spectrum
- Shape is preserved despite this - critical for edge finding
- Possible reconciliation by including the secondary BPP effect - still in process of being implemented
- Other news - new method implemented for electron spectrum construction which seems to be more effective so far