Low Energy EMC Response using
\[ \Sigma_0 \rightarrow \Lambda \gamma \]

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The Concept

For 2 body decays such as, $\Sigma_0 \rightarrow \Lambda \gamma$, photon kinematics are easily determined:

$$E_{\gamma}^{calc} = \frac{M_{\Sigma_0} - M_{\Lambda}}{2(E_{\Lambda} - p_{\Lambda} \cos \theta_{\Lambda \gamma})}$$

It is possible to compare the measured photon energy to the calculated value to study the energy resolution.
Analysis Method

Compare reconstructed photon energy (ecalEnergy()) to calculated value:

\[
\frac{E_{\gamma}^{\text{meas}} - E_{\gamma}^{\text{calc}}}{E_{\gamma}^{\text{calc}}}
\]

Peaks fit with Novosibirsk and Background with a Quadratic. Determine peak and energy resolution (FWHM/2.355) in 50 MeV bins of $E_{\gamma}^{\text{calc}}$.

Cuts Optimized (from MC) in the lowest energy bin.
A Fit

\[
\frac{(E_{\gamma}^{\text{meas}} - E_{\gamma}^{\text{calc}})}{E_{\gamma}^{\text{calc}}}, \ 175 > E_{\gamma} > 200 \text{ MeV}
\]
Ecalt Smearing

- Smearing of Ecalt estimated using MC:
- Fit w/ Triple Gaussian

\[
\frac{E_{\text{calc}} - E_{\text{true}}}{E_{\text{true}}}, \quad 175 > E_\gamma > 200 \text{ MeV}
\]
Method: Toy MC

- Generate Random Numbers, R, based on Triple Gaussian Fit to
  \[ \frac{E_{\text{calc}} - E_{\text{true}}}{E_{\text{true}}} \]

- Generate Random Numbers, R', based on Hypothesized Novosibirsk
  \[ \frac{E_{\text{meas}} - E_{\text{true}}}{E_{\text{true}}} \]

[Graphs and tables showing statistical data and distributions]
Kolmogorov

\[
\frac{E_{\text{meas}} - E_{\text{calc}}}{E_{\text{calc}}} \quad \frac{E_{\text{calc}} - E_{\text{true}}}{E_{\text{true}}}
\]

- Now We have which we generated using Toy MC from the triple Gaussian fit to \(E_{\text{true}}\) and a hypothesized Novosibirsk function for \(E_{\text{meas}} - E_{\text{true}}\).

- From The actual Novosibirsk fit to data, we can generate a toy MC of:

\[
\frac{E_{\text{meas}} - E_{\text{calc}}}{E_{\text{calc}}}
\]

- Perform Kolmogorov histogram comparison of our smeared distribution to the Toy data set generated from Novosibirsk fit to data
Some Results

• The Blue Histogram is generated from the Novosibirsk fit to data.

• The Red Histogram is from the method in which a hypothesized Novosibirsk function is smeared with a Triple Gaussian from.

• The Black histogram is from the hypothesized Novosibirsk function.

• The red and blue histograms are compared using the Kolmogorov Test
Oversmearing Sigma

Oversmeared - large sigma

Undersmeared - small sigma

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Oversmearing Peak

Oversmeared - large peak

Undersmeared - small peak
Oversmearing Tail

Oversmeared - large tail

Undersmeared - small tail
A good smearing

• In order to produce a good smearing, the initial Novosibirsk parameters from the fit to data are passed to our ‘hypothesized’ Novosibirsk function which describes $E_{m}-E_{true}/E_{true}$.

• The three important parameters (sigma, tail, and peak) are varied separately:
  – Sigma is varied first: we loop through sigmas to find the one that gives the best Kolmogorov probability.
  – The tail is varied next (w/ sigma = best sigma from above) to find the one that gives the best Kolmogorov probability.
  – Now the tail and sigma are set to their ‘best’ values and the peak is varied.
  – Since the parameters are correlated, we then set the tail and peak to their best values and vary sigma once again to determine how much it has changed
A good smearing

A Kolmogorov comparison yields a 96% probability that the red and blue histogram come from the same parent distribution.
A good smearing

A Novosibirsk Fit to the red histo on the previous page - my smeared distribution

A Novosibirsk Fit to the blue histo on the previous page - distribution from data
Fluctuations in Kolmogorov Probabilities

- If we now study how the Kolmogorov Probability changes depending on what value of sigma (or tail, peak) we feed to our hypothesized Novosibirsk, we see chaotic fluctuations.
  - See next 3 pages for plots

- What does this imply???
Kolmogorov Prob Vs. Tail

![Graphs showing Kolmogorov Prob Vs. Tail]
Kolmogorov Prob Vs. Peak

Zoomed
Kolmogorov Prob Vs. Sigma
Summary

• So, the method does appear to give reasonable results. Comparing the two fits on slide 14, we see relatively good agreement between the parameters of the two fits - taking into account, of course, that the errors from the fit are not an accurate measure of the true errors on the parameters.

• I will try to have an update for next weeks meeting.