0.1 LednickyFitter

The code developed to fit the data is called "LednickyFitter", and utilizes the ROOT TMinuit implementation of the MINUIT fitting package. In short, given a function with a number of parameters, the fitter explores the parameter space searching for the minimum of the function. In this implementation, the function to be minimized should represent the difference between the measured and theoretical correlation functions. However, a simple χ^2 test is inappropriate for fitting correlation functions, as the ratio of two Poisson distributions does not result in a Poisson distribution. Instead, a log-likelihood fit function of the following form is used [**?**]:

$$\chi^2_{PML} = -2\left[A\ln\left(\frac{C(A+B)}{A(C+1)}\right) + B\ln\left(\frac{A+B}{B(C+1)}\right)\right] \tag{1}$$

where A is the experimental signal distribution (numerator), B is the experimental background distribution (denominator), and C is the theoretical fit correlation function.

The LednickyFitter uses Equations **??** – **??** to build the theoretical fit, and Equation 1 as the statistic quantifying the quality of the fit. The parameters to be varied by MINUIT are: λ, R, f_0 ($\mathbb{R}f_0$ and $\mathbb{I}f_0$ separately), d_0, and normalization N. The fitter currently includes methods to correct for momentum resolution and a non-flat background. These corrections are applied to the fit function, the data is never touched. The fitter is able to share parameters between different analyses and fit all simultaneously.

In a typical fit, a given pair is fit with its conjugate (ex. $\Lambda\mathrm{K}^+$ with $\bar{\Lambda}\mathrm{K}^-$) across all centralities (0-10%, 10-30%, 30-50%), for a total of 6 simultaneous analyses. Each analysis has a unique λ and normalization parameter. The radii are shared between analyses of like centrality, as these should have similar source sizes. The scattering parameters ($\mathbb{R}f_0$, $\mathbb{I}f_0$, d_0) are shared amongst all.

Initially, we left open the possibility for the $\Lambda\mathrm{K}^+(\bar{\Lambda}\mathrm{K}^-)$ and $\Lambda\mathrm{K}^-(\bar{\Lambda}\mathrm{K}^+)$ systems to have different source radii. After always finding these two be consistent, we decided to join the radii parameters between these systems. So, now, in a typical fit of our $\Lambda\mathrm{K}^\pm$ data, all $\Lambda\mathrm{K}^\pm$ analyses ($\Lambda\mathrm{K}^+$, $\bar{\Lambda}\mathrm{K}^-$, $\Lambda\mathrm{K}^-$, $\bar{\Lambda}\mathrm{K}^+$) are fit simultaneously across all centralities. Scattering parameters are shared between pair-conjugate systems (i.e. a parameter set describing the $\Lambda\mathrm{K}^+$ & $\bar{\Lambda}\mathrm{K}^-$ system, and a separate set describing the $\Lambda\mathrm{K}^-$ & $\bar{\Lambda}\mathrm{K}^+$ system). For each centrality, a radius and λ parameters are shared amongst all pairs. Each analysis has a unique normalization parameter.

In the case of fitting with residuals, the λ_{Fit} parameter serves as an overall normalization shared by all contributors, such that Eqn **??** becomes:

$$\begin{aligned} C_{measured}(k^*_{\Lambda K}) &= 1 + \sum_i \lambda'_i [C_i(k^*_{\Lambda K}) - 1] \\ \lambda'_i &= \lambda_{Fit}\lambda_i \\ \sum_i \lambda'_i &= \lambda_{Fit}\sum_i \lambda_i = \lambda_{Fit} \end{aligned} \tag{2}$$

where λ_i is obtained from THERMINATOR, as explained in Section **??**, and whose values are presented in Table **??**. For Coulomb-neutral pairs, such as $\Lambda\mathrm{K}$, $\Sigma^0\mathrm{K}$, and $\Xi^0\mathrm{K}$, $C_i(k^*_{\Lambda K})$ is calculated from Eqn. **??**, with the help of Eqn. **??**. For those residual pairs which include a Coulomb interaction, $C_i(k^*_{\Lambda K})$ is either calculated using the CoulombFitter method (Sections **??** and **??**) with no strong interaction, or by using the $\Xi^{\mathrm{ch}}\mathrm{K}^{\mathrm{ch}}$ data directly. Unless otherwise stated, the $\Xi^{\mathrm{ch}}\mathrm{K}^{\mathrm{ch}}$ residual contribution is modeled using the experimental $\Xi^{\mathrm{ch}}\mathrm{K}^{\mathrm{ch}}$ data, and all other charged contributors (ex. $\Sigma^{*\mathrm{ch}}\mathrm{K}^{\mathrm{ch}}$) are modeled using the CoulombFitter technique with no strong interaction contribution.

To summarize, the complete fit function is constructed as follows:

1. The uncorrected, primary, correlation function, $C_{\Lambda K}(k^*_{\rm True})$, is constructed using Eq. 2 (with the help of Eqns. **??** and **??**)

2. If residuals are included:

   - the parent correlation functions are obtained using:
     - Eq. 2 (with the help of Eqns. **??** and **??**) for the case of Coulomb-neutral pairs
     - $\Xi^-\mathrm{K}^\pm$ experimental data for $\Xi^-\mathrm{K}^\pm$ contributions
     - a Coulomb-only curve, with the help of Secs. **??** and **??**, for pairs including the Coulomb interaction
   - the contribution to the ΛK correlation function is found by running the parent correlation function through the appropriate transform, via Eq.**??**

3. The primary and residual correlations are combined, via Eq.**??**, to form $C'_{Fit}(k^*_{\rm True})$

   - in the case of no residual contributions included in the fit, $\lambda_i = \lambda_{\Lambda\mathrm{K}}$ in Eq. 2 is set equal to 1. Then, the extracted λ_{Fit} parameter should be roughly equal to the pair purity
   - when residuals are included, the λ_i values are presented in Table **??**

4. The correlation function is corrected to account for momentum resolution effects using Eq. **??**

   - $C'_{fit}(k^*_{Rec}) = \dfrac{\sum\limits_{k^*_{True}} M_{k^*_{Rec},k^*_{True}} C'_{fit}(k^*_{True})}{\sum\limits_{k^*_{True}} M_{k^*_{Rec},k^*_{True}}}$

5. Finally, the non-flat background correction is applied, and the final fit function is obtained

   - $C_{Fit}(k^*_{Rec}) = C'_{Fit}(k^*_{Rec}) * F_{Bgd}(k^*_{Rec})$

Figures **??**, **??**, and **??** (**??**, **??**, and **??**, or **??**, **??**, and **??**), in Section **??**, show experimental data with fits for all studied centralities for $\Lambda\mathrm{K}^0_\mathrm{S}(\bar{\Lambda}\mathrm{K}^0_\mathrm{S})$, $\Lambda\mathrm{K}^+(\bar{\Lambda}\mathrm{K}^-)$, and $\Lambda\mathrm{K}^-(\bar{\Lambda}\mathrm{K}^+)$, respectively. In the figures, the black solid line represents the "raw" fit, i.e. not corrected for momentum resolution effects nor non-flat background. The green line shows the fit to the non-flat background. The purple points show the fit after momentum resolution, non-flat background, and residual correlations (if applicable) corrections have been applied. The extracted fit values with uncertainties are also printed on the figures.