Gradient method with re-weighted events and it's implementation for Tauola to fit the three pion mode

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Outline

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Motivation

For fitting RChL hadronic currents we were looking for method satisfying our current and future needs.

Gradient method with re-weighted events:

- Can be used for fitting ***not*** unfolded data and with experimental cuts
- Can be used with multidimensional distributions.
- Can be used when fitting analytical function is impossible.

Technical aspects

What re-weighting means in our case?

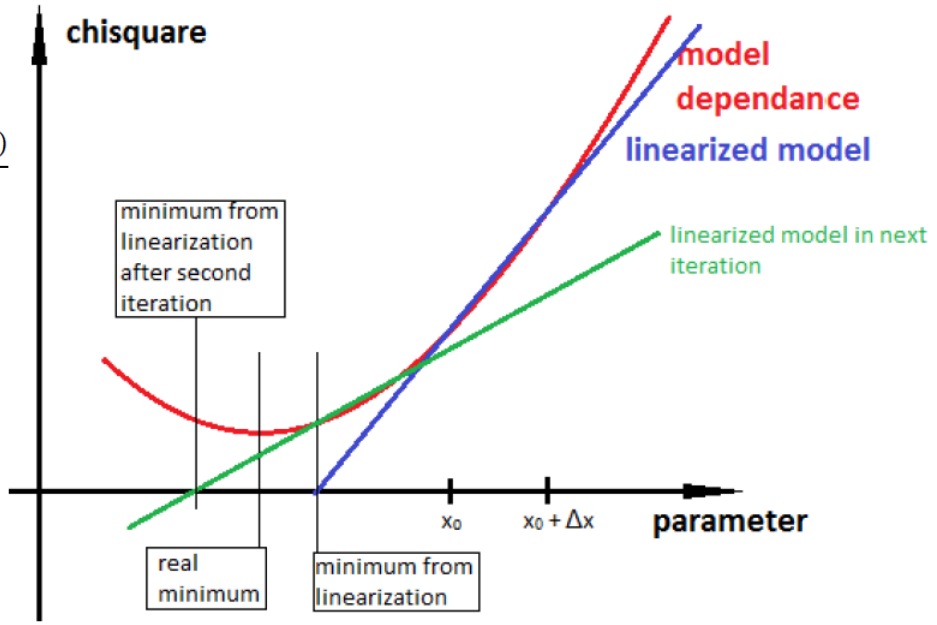
- First we generate sample of events with given set of parameters.
- Then for each event separatelly we calculate weight according to new set of parameters.
- Throught teoretical model (in our case RChL) we can calculate matrix elements for events. Weight is simply ratio of new matrix element for given event to old one.

Technical aspects

- Gradient method comes into action when we have to decide how to change parameters of model to make it more accurate.

$$\left.\frac{\partial f(a_1, a_2, a_3, \dots, a_n)}{\partial x_i}\right|_{\Delta} = \frac{f(a_1, a_2, \dots, a_i + \Delta x_i, \dots, a_n) - f(a_1, a_2, a_3, \dots, a_n)}{\Delta x_i}$$

$$f(x_1, x_2, x_3, \dots, x_n) = f(a_1, a_2, a_3, \dots, a_n) + \sum_i (x_i - a_i) \left.\frac{\partial f(a_1, a_2, a_3, \dots, a_n)}{\partial x_i}\right|_{\Delta}$$



Technical aspects

- Method's main weakness is jumping around local minima, and reweighting is time consuming. Moreover, it's sensitive to starting point.
- To minimize influence of those defects we limit range of parameters and size of iteration steps by estimation of second derivative with quadrative terms only and we don't allow it to exceed certain value (Minuit by default uses very similar algorithm).

$$f''(x)\big|_{x_0} = \frac{\frac{f(x_0+\Delta x)-f(x_0)}{\Delta x} - \frac{f(x_0)-f(x_0-\Delta x)}{\Delta x}}{\Delta x} = \frac{f(x_0+\Delta x)-2f(x_0)-f(x_0-\Delta x)}{(\Delta x)^2}$$

$$f(x) = f(x_0) + f'(x_0)\cdot(\mathrm{x}-x_0) + \frac{1}{2}f''(x_0)\cdot(\mathrm{x}-x_0)^2$$

$$f'(x_0)\cdot(\mathrm{x}-x_0) > L\cdot\frac{1}{2}f''(x_0)\cdot(\mathrm{x}-x_0)^2 \quad \rightarrow \quad (\mathrm{x}-x_0) < \frac{2\cdot f'(x_0)}{\mathrm{L}\cdot f''(x_0)}$$

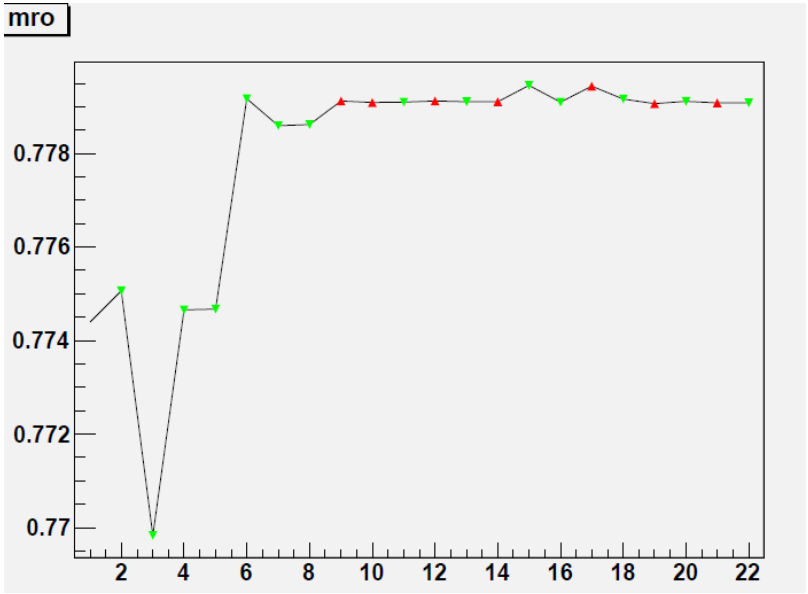
Technical aspects

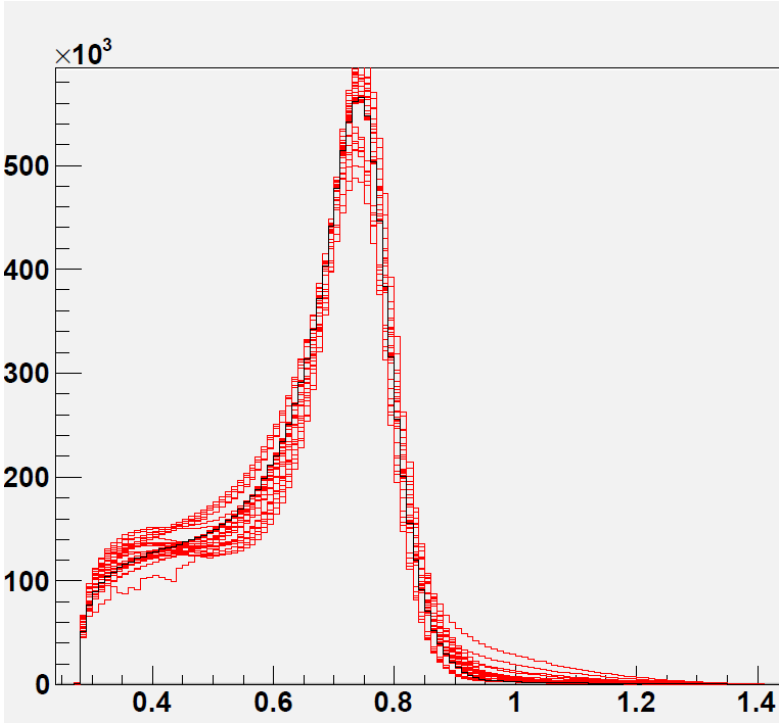
- For one step of fitting we require 2*(number of parameters)+1 processes(1 for each point) → preffered fitting on cluster.
- 1 point takes depending on CPU takes 3-7h
- Reasonable results can be achieved in ~10-20 iterations, but getting true minimum would take many more.

In this term it seem reasonable to stop further iterating by hand, when we decide that further improvement is not cruical and would cost too much time.

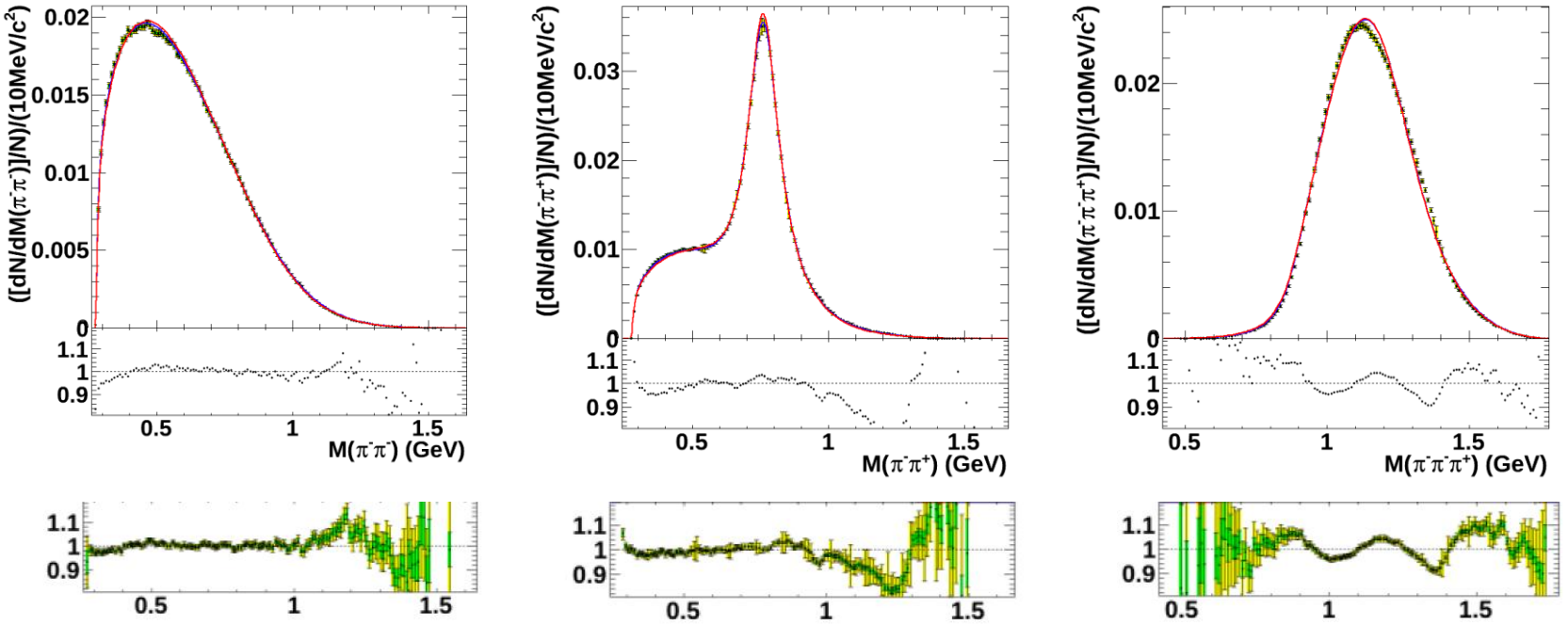
Technical aspects

In order to see better what's happening during the fitting we can make additional plots:





Some results



Comparison between fitting to 3-pion 1-D BabBar data with gradient method (red line) and fitting semi-analytical function (blue line).

Summary and plans

- Gradient method with re-weighted method was sucessfully implemented and tested. It’s limitations in terms of our model can be considered as well known.
- Method is prepered for use with other decay channels and multidimensional distributions whenever they will become available for fitting.
- Potential options for further improvement on strategy developing and fitting of RChL currents are under consideration. Work on projection operators is ongoing.