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Parallelization of Maximum Likelihood Fit Technique Using MINUIT and RooFit Packages

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MINUIT is the most common package used in high energy physics for numerical minimization of multi-dimensional functions. The major algorithm of this package, MIGRAD, searches for the minimum by using the gradient function. For each minimization iteration, MIGRAD requires the calculation of the first derivatives for each parameter of the function to be minimized.

Minimization is required for data analysis problems based on the maximum likelihood technique. Complex likelihood functions, with several free parameters, many independent variables and large data sample, can be very CPU-time consuming. For such a technique the minimization process requires the calculation of the likelihood function (and corresponding normalization integrals) several times for each minimization iteration. In this presentation we will show how MINUIT algorithm, the likelihood calculation, and the normalization integrals calculation can be easily parallelized using MPI techniques to scale over multiple nodes or multi-threads for multi-cores in a single node. We will present the speed-up improvements obtained in typical physics applications such as complex maximum likelihood fits using the RooFit package. Furthermore, we will also show results of hybrid parallelization between MPI and multi-threads, to take full advantage of multi-core architectures.

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