Research on CP Violation in B Mesons Decay and Related HTC Application

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In this article I give a brief introduction of my research on CP violation in the decay mode of charged B mesons to three charged pions. I show the method to process the huge dataset in KEK (Japan) to be a smaller one and transmit it to Virginia Tech for further analysis. In addition, future HTC application in my research has also been discussed.

I. INTRODUCTION OF THE RESEARCH

Nowadays all evidence says that the universe is made up of nuclear matter such as protons, neutrons, and electrons. In the laboratory it is possible to create antimatter which appears to be identical to matter except that in close contact with matter both can annihilatel [1]. This leads to the question that why is our universe a matter universe rather than an antimatter universe or a universe with equal amounts of each and then becomes nothing? We now know that fundamental properties of matter and antimatter determine how the universe evolves, so there must a property that causes matter to be preserved over antimatter. At the very least, there must be something we call violation of CP-symmetry. CP-symmetry is the combination of charge conjugation symmetry and parity symmetry, which states that the laws of physics should be the same if a particle were interchanged with its antiparticle (C symmetry), and left and right were swapped (P symmetry). According to our current theoretical understanding, it should occur in the decays of particles called B mesons, rarely but in many distinctive ways. Its measurement is expected to confirm or refute our interpretation of the particles and forces that we observe.

My current research concentrates on the mode that charged B mesons decay to three charged pions, which will probe the properties of the weak interaction through their dependence on the complex quark couplings in CKM matrix and direct CP asymmetry via rate difference between the decay of B mesons and corresponding anti-B mesons [2]. The B mesons I am studying are produced at the KEK laboratory in Tsukuba, Japan via the collisions of high energy electrons and positrons. These B mesons quickly decay into other particles with hundreds of decay modes. The specific decay mode I am working on will be considered to be signal, and all the other modes will be treated as background which I should suppress. Also, since the Belle detector in KEK can only probe a few certain kinds of daughter particles after the decays, a lot of analysis works such as Monte Carlo simulation and particle reconstruction are needed. Therefore, an effective computational system with optimized methodology is necessary.

II. COMPUTATIONAL ASPECT

The KEK computer system has several types of servers which consist of PowerEdge 600. The system configuration is shown in Figure 1. LGI are used when we login to KEK computer system from internet. WG are used when we do interactive processing such as editing programs, compile programs, and submit jobs. SC are used for running batch jobs. SMG serve matrix tables of Secure Matrix [3]. To login to WG, we need Secure Matrix authentication which uses image password integrating image of shape and one-time password, as shown in Figure 2. The numbers in the matrix will be changed every time. The whole password will include some characters set by a user and the certain part of the Secure Matrix whose position is chosen by a user when he initializes the password.

Type of Server		Abbreviation	Num.
Login Server		LGI	3
Work Group Server		WG	80
Calculation Server	cluster4	SC	480
DB Server		SCDB	5
Work File Server		WFS	16
Application Server		APP1	1
Application Server		APP2 (CVS)	1
SECUREMATRIX GSB Server		SMG	2

FIG. 1: The table shows the types of the servers in KEK and the number of computers in each server.

Analyzing whole dataset which has hundreds of terabyte data in KEK by individuals is inefficient since it takes much time and occupies large disk space. Therefore some datasets, in which the specific physics mode is enhanced, should be prepared for physicists before the analysis by the procedure called skim. The Figure 3 shows the idea of the skim. In this procedure, we implement rough cut conditions on the whole dataset and we have much smaller output dataset which still includes all the valuable information for our research and is much faster to analyze or transmit.

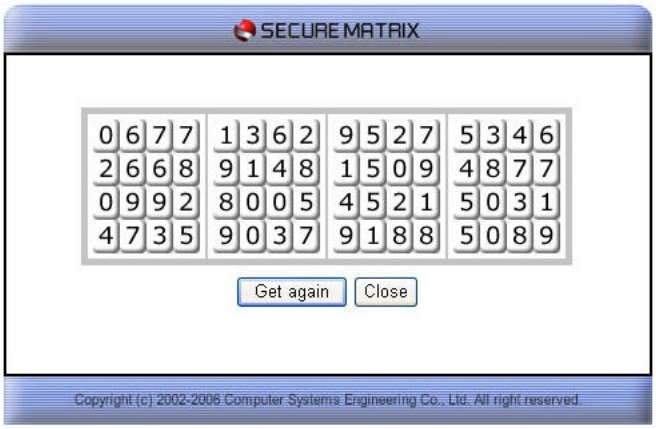

FIG. 2: The Secure Matrix includes four 4 by 4 matrices, which yield random elements every time we get token.

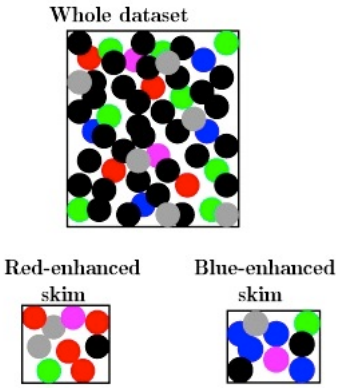

FIG. 3: The skim procedure picks the preferred events from the whole dataset by loose cut conditions.

After we have the skimmed files ready, we move them to the server in Virginia Tech for the further analysis since the disk space in KEK is limited: every user has only 250 GB quota to store the data. The skimmed data files in our case include approximate 1 TB signal data files and 4 TB Monte Carlo data files. The internet speed between KEK and Virginia Tech is about 5MB/s so it takes about 11 days to finish the transmission. The server in Physics Department of Virginia Tech has about 30 TB disk space for our group which is quite enough for our data storage and analysis. We have Condor installed in Virginia Tech campus so we can apply the HTC on our research. The whole Belle library are also pre-installed here so there is no compatible problem.

III. FUTURE PLAN

Generally, the problem in high energy physics is better suited for HPC. But since we have hundreds of computers for undergraduate lab in the Physics Department which can run Condor jobs during nights and weekends, HTC can be very useful, too. Every event for particle reconstruction or Monte Carlo simulation in the dataset is independent from each other, so the distributed jobs will be effective to process many events on many different kinds of computers in the department. After that, the results can be combined together into a small ROOT file which is about several megabytes, which stores all the physics results I needed to extract the rate difference of decay of B mesons and anti-B mesons. I will apply what I have learnt from OSG summer school on my analysis, and it will accelerate the progress of my research with no doubt.

[1] D. H. Perkins, *Introduction to High Energy Physics, 3rd Edition* (Addison-Wesley Publishing Company, Inc, 1987).
[2] S. Hashinmoto, M. Hazumi, and B. Golob, *Physics at Super B Factory* (High Energy Accelerator Research Organization, 2010).
[3] *B-factory computer system*, URL `http://bweb1.kek.jp/manuals/index-e.html`.