CERN SUMMER STUDENTS 2013 REPORT

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1. Abstract

LHC is our main research tool for now which helped us to found the Higgs boson. But after the LHC mission will ends we would like to build another acelerator to continue the researches. TLEP is one of the possible future accelerators. We don't know for now a required detectors design for that collider and we have to make a huge analysis to eliminate all uncertainties. To reach this we need a fast reconstruction and simulation tool. This project was aimed on researching the possibilities of the Particle Flow Simulation tool - the pretty fast simulation of Particle Flow. If we succeed on that we would have a very fast way to produce PF particles and then we could use them to make an analysis.

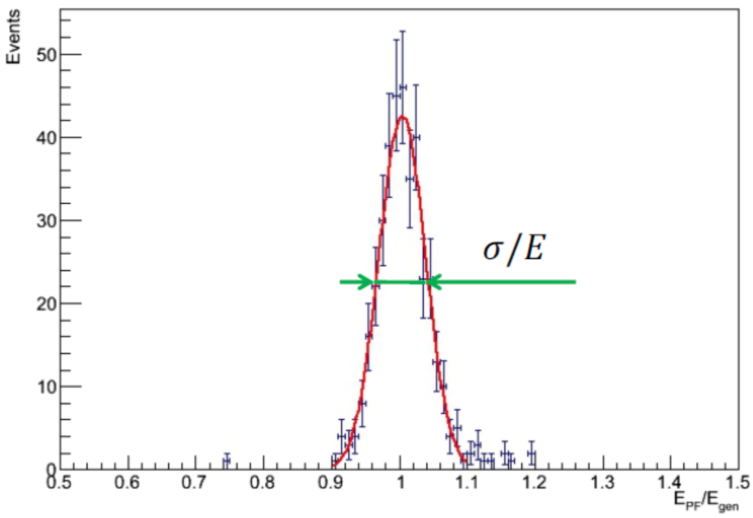
2. Introduction

TLEP is a circular electron-positron collider, it will be housed in a bigger, 80 kilometers tunnel. It can reach the center-of-mass energy up to 340 GeV. Obviously, the synchrotron radiation for the relativistic electrons is very high, but we can deal with that. Circular collider design allows to get a high luminosity and use well-known acceleration technologies. TLEP is a Higgs factory, this means that it can produce up to 40000 Higgs bosons per year. The main processes for Higgs production are $e^+e^- \to Z^* \to ZH$ and $e^+e^- \to H\nu_e\widetilde{\nu}_e$. We need a large amount of Higgs bosons to make a precise measurements of Higgs boson's widths and couplings. If difference between couplings and widths of the Standart Model from other models exists then they are very small and we need a super precise measurment tool to detect this differences. TLEP is this tool. To guide the detectors design physicists have to review the specific of electron-positron collisions and jets production. The only thing we need for that is a fast simulation of Particle Flow. Particle Flow is a tool that allows us to fully reconstruct particles' information using the data from calorimeters and tracking system. The full simulation and reconstruction of CMS is a massive thing and reconstruction takes a lot of time (something like one event per minute). PF Simulation allows us to avoid the full simulation and boost this reconstruction very well. The only thing we want to check is the agreement between CMS Fast Sim and the PF Sim. If thie agreement will be reached, CMS scientists could use the PF Sim for the TLEP analysis.

3. Content of the Project

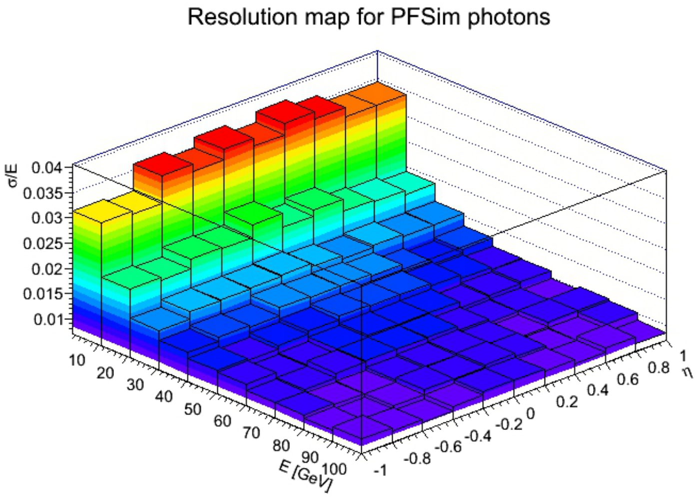
During my project I used the CMS framework (CMSSW 5.3.9), PF Sim packadge (created by my supervisor Colin Bernet), ROOT and a lot of side packages.

Because we have to check the agreement between Fast Sim and PF Sim I used the both of them to got the relative calorimeter resolution and compare them. To get this resolution the followint technice was used. First, I used the particle gun to generate particles one by one. Photons with energy from 10 GeV up to 100 GeV and the barrel part of the detector ($|\eta| < 1$) was reviewed. The main point ot the project is measuring the detector properties related to the individual properties. Let's see how in works.



Pic.1 The measurement of the ECAL's relative resolution

I had plot the $\frac{E_{PF}}{E_{gen}}$ distribution, where E_{PF} means the energy of PF particles and E_{gen} means the energy of generated particles. Obviously, the distribution has a paek around $\frac{E_{PF}}{E_{gen}} = 1$. The distribution is close to gaussian. After that I fitted it with gaussian, this fit was good. And then I've got the relative resolution of the ECAL (I've got resolution for the ECAL because I "shoot" photons). I have done the segmentation over the energy and pseudorapidity and obtained the relative resolution for each bin. If we plot that resolution as function of E and η we will get the resolution map. Resolution map is a convenient graph allows us to get the parameters we need.



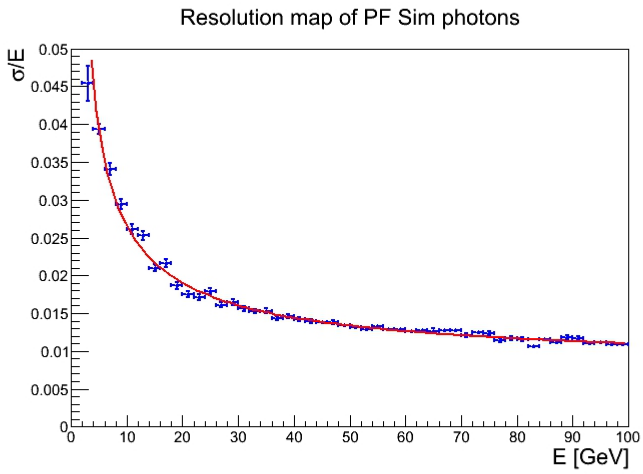
Pic.2 Resolution map for PF Sim photons.

I had reviewed the slices of the resolution map with fixed η and have got the relative resolution as function of energy. After that I fitted this function with parameterized function of ECAL's relative resolution, which has the form:

$$\frac{\sigma}{E} = \sqrt{(\frac{A}{\sqrt{E}})^2 + (\frac{B}{E})^2 + C^2}$$

The first term is a stocastic term, second one is the noise term and the third one takes into account the calibration of the crystals.

After the fit I've got the following picture.

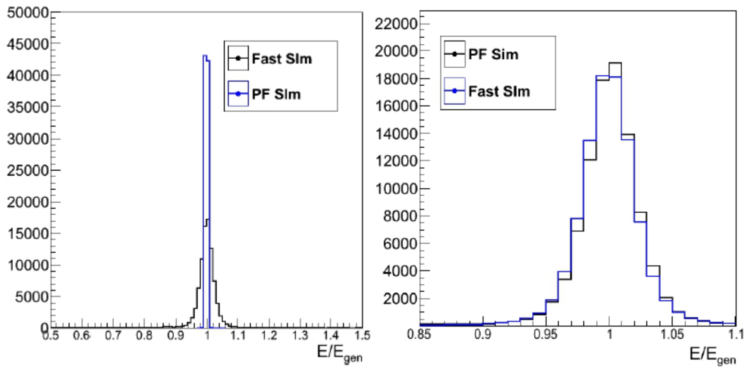


Pic.3 Fitting by ECAL's resolution function

We can obtain the parameters of the fit function and put it to the PF Sim and make a comparison.

4. Results

The main result of that project is that the agreement between PF Sim and Fast Sim in the case of photons was reached. The following pictures can illustrate this.



(a) (b)

Pic.4 Comparison of PF Sim and Fast Sim before the measurements (a) and after the measurements (b)

As we can see, after putting the fit parameters into the PF Sim, the difference between PF Sim and Fast Sim, in the case of photons, is very small. This means we could use this simulation to make a further analysis for TLEP. Moreover, the scripts and measurements methods, that were deweloped during my project, could be used with PF Sim for any other types of analysis, not only for TLEP. After reviewing other types of particles we will get the correct fast simulation of PF Sim, that could be used for e^+e^- analysis.