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Mid-year Progress Report

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Summary:

The formal title of the project is "Investigation of the e^+e^- Luminosity Spectrum", and the project outline sets three aims. The first two aims are intermediary and technical: they can be considered done. Achieving the ultimate aim is well under way, as we already understand aspects of the question, and have solved the larger technical difficulties.

The aims have been slightly extended in the range of beam pathologies to investigate, and what remains to be done now is the comparison of the true luminosity spectrum vs. the reconstructed one, and the parameterization of this spectrum. We also aim to answer the questions that were set in the project outline.

1. The Aims

The general aim of the project is to "contribute to the production of a complete simulation of the TESLA beam and its effects on the observation of the mass of the top quark and $W^{\pm}$ bosons." This breaks up into three specific aims, as detailed in the project outline.

Overall, the aims have been or are in the process of being fulfilled, and we have not significantly deviated from them. Work is now being done on aim iii), and different pathologies have already been investigated.

i. Generating beam definition files

"Develop a program that would generate beam definition files for different shape/size beams, in ASCII, in a format readable by guinea pig".

This has been done via a series of scripts written in python, which can generate several beam descriptions by varying a parameter, then run guinea-pig and the analysis. This allows us to vary beam energy for example, and visualise the influence this has on the different parameters of the collision.

ii. Interfacing with CERN root

"Learn to use the root package, interface it with the simulation and use it to analyse it."

Learning to use root has taken a fair amount of time due to the nature of the package, which is constantly in development. Concurrent versions and incomplete classes were some of the difficulties, but the critical learning face is over and in the process we have produced some root macros which automate the creation of multiple graphs, and correlation graphs, so the output from guinea-pig can be analysed in varying levels of detail: either by looking at overlaid histograms or at specific correlations.

iii. Produce simulations of different beam phenomena

This is really the heart of the project, and is still under work. In the project outline, three questions had been set. We have answered the second one: "Is there a correlation with position of event within the bunch?", as we have found a correlation that shows that events that happen later in the bunch have a lower energy on average, as the electrons have travelled through a whole bunch. This in itself is an new result for the community, and it confirms what could be expected from physical intuition.

The first question "Does correlated dispersion compensate for acollinearity?" is still being investigated, as we have extended it a little. A correlation between dispersion (Δp) and luminosity ($\sum p$) has been sought for collinear beams, but more work is needed.

The third question "Offsets and beam bending", has been partly investigated with some of the software written—we now have histograms of significant guinea-pig output such as energy of the beams, energy of collisions, location of collisions for different x and y beam offsets. However, the specific effect on luminosity spectrum has not been clearly demonstrated yet.

We expect the first and third question to be investigated properly soon, as we have set the stage to answer them as part of a wider approach of the luminosity spectrum investigation.

2. Details of Software written

i. GPAnal (C++)

This C++ program makes root objects, containing histograms, from all guinea-pig outputs. These can then be opened from root (usually via a macro) to view parameters and how they have varied.

ii. Phython scripts

These run guinea-pig and GPAnal_fz several times, while varying a parameter (energy or x-offset, etc..), while creating a file structure and output files with names that directly tell the user about the parameters that were used and varied.

iii. root macros

We have a number of different root macros, which can overlay histograms, or put useful output histograms on a single page. We have also made macros to look in detail at the correlation between dispersion (Δp) vs. luminosity ($\sum$p).

Using these macros we have generated many different graphs, allowing us to understand beam interactions better.

3. Difficulties encountered

Some technical difficulties were encountered—guinea-pig is unmaintained and until this week could not be made to work with a TESLA beam--and NLC-B beam was used instead, and some parameters such as transverse momentum components of the particles before collision could not be output until now. It also took some time to understand exactly what guinea-pig was outputting and how this could be used in our context—we had to gain an understanding of the algorithm it uses to understand the time-sequence of even-producing particles, for example.

Learning root also proved a challenge, as it is a complex and sometime unpredictable package.

4. Conclusion and future plans

It appears now that we are in good course to achieve the aims that had been set; there is a better understanding of the physical problems at hand, and the major technical difficulties have been solved: we have a working framework, and the technical knowledge to extend it.

A fair quantity of graphs describing many parameters have been produced via the root macros; only some of those graphs give us new insights, but their overall value is in checking the code written, and gaining an more complete understanding of the inter-related phenomena at hand. Notably, a correlation was found between the place of an event within the bunch and its energy—the energy is highest for the first events, as these particles have not been through the opposite bunch.

We now want to concentrate on comparing the luminosity spectrum, and comparing it with the one that can be reconstructed; quantitatively we could compare via a parameterization of the luminosity spectrum, or via its statistical moments (mean, RMS, squewedness etc.) This should be done also to compare different formulas for the reconstruction (such as Klaus' formula), and will be done for a series of beam "pathologies", namely: more than one photon radiated, dispersion in the beams, early to late electron in bunch variation, transverse disruption angles and realistic beamspreads and correlated momenta.

An parallel task is also to generate TELSA outputs using the new version of guinea-pig, to check on another accelerator than NLC.