Ludlam, Thomas W

From: Hans Bichsel [hbichsel@uw.edu]
Sent: Tuesday, August 30, 2011 9:36 PM
To: Ludlam, Thomas W
Subject: R & D for an EIC
Attachments: eicbudget.xlsx

From: hbichsel@uw.edu

Seattle 30.8.2011 Hello Tom,

This is in response to your "Call for Proposals about Generic Detector R&D for an EIC". Please consider this letter to be an expression of interest on our part. If there is also interest on yours, we will then need to submit this proposal through the University's Grants and Contracts Administration.

It is my understanding that GEANT4 is widely used for the simulation of the interaction of radiations with detectors. I have studied the GEANT4 documents about these interactions and conclude that some of the methods used are somewhat primitive and based partly on parameter fits derived from experimental data.
We have found that a reliable calculation of straggling functions can be made with convolutions [RMP = Bichsel 1988] for which the differential cross section for single collisions calculated with the Bethe-Fano (BF) method is used.

A comparison for a straggling function calculated with BF-convolutions and with GEANT4 [G4] was made for 93 GeV protons traversing 0.01 mm of Si. The most probable energy loss D_p was 18% smaller for BF than for G4, and the FWHM w was 11% smaller.
A further study is in progress. I expect the differences in D_p to get smaller with increasing thickness of the Si, but cannot guess the change for w.

It may be noted that for the 100 experimental data quoted in RMP the difference between measured and calculated D_p was less than 2% for 90 values, about 5% for 10 values. For w the difference was less than 3% for 90 values and about 10% for 10 of them.

The calculations for the collision cross sections [CCS] and straggling for P10 gas [Bichsel 2006] were made with the Fermi-Virtual-Photon [FVP, also called PAI] method CCS and the convolution method.
The errors of the total CCS [up to 12%, Bichsel 2011] were covered up by the adjustments made in the conversion of energy loss in P10 into detector signal.

We suggest for simulations with GEANT4 that single collision cross sections calculated with the BF method be introduced. In addition straggling functions can be calculated with the convolution method as outlined in Bichsel 2006 and 2011 rather than by using MC simulations.

The processes are described below.

It is important to note that the stopping power dE/dx is not useful for calculations for thin absorbers, but a calculation of dE/dx is an incidental result of straggling calculations. It is compared with existing stopping power and range tables to assess the precision of the CCS. The appropriate quantity for the calculations is the total collision cross section [or its inverse, the mean free path between collisions].

Description of PROJECT

1. Calculations of differential cross section for single collisions with the BF method. As described in Bichsel 2011 the calculations with the FVP method result in differences in the total collision cross sections exceeding 15%. It is interesting that the stopping powers for the two methods in general differ by less than 1%. The consequences for the straggling functions are complex.

   The basic input data are the cumulative integrals over the GOS [generalized oscillator strength] for the K-, L- and M-shells of the atoms used in the detectors, based on the results from Bote 2008.

2. Calculations of spectra for multiple collisions ("straggling") in a layer of detector are made with convolutions (1988, 2006, 2011), using the BF differential collision cross sections.

3. If random values of the energy loss for single ions are needed they can be derived from the cumulative integrals of the straggling functions, Bichsel 2006.

4. Tables of collision cross sections and straggling functions will be produced according to the needs for the practical applications of simulations for the detectors.

5. For detectors with multiple layers the energy loss by the particles will be simulated by MONTE CARLO calculations using the method outlined in 3 above.

6. The conversion of energy loss into the output signal of the detector must be studied (Bichsel 2006, Fisyak 2011). This is a complex problem which is still progressing for STAR and ALICE.

7. The errors of calculations with FVP may be partly disguised by the processes needed in the above conversion.

8. Programs developed for the analysis of STAR TPC data in connection with Bichsel 2006 could be modified to be included in related studies.

REFERENCES

H. Bichsel, "Straggling in thin silicon detectors,"
Rev. Mod. Phys. 60 (1988) 663.

H. Bichsel, "A method to improve tracking and particle identification in TPCs and silicon detectors", Nucl. Instr. Meth. A 562 (2006) 154-197

D. Bote and F. Salvat, "Calculation of inner-shell ionization by electron impact...", Phys. Rev. A 77 (2008) 042701.

H. Bichsel, "Interaction of radiation with matter", in Landolt- Boernstein, New Series, Group I, Vol.21, Elementary Particles, Subvolume B, Detectors for Particles and Radiation, H. Schopper and C. Fabjan Eds., Springer (2011).

Y. Fisyak, Private communication, February 2011

RESOURCES needed

The development of the program and the calculations of the BF differential collision cross sections and straggling functions will take 6-12 months.

Other studies described above and needed for the specific detectors must be explored and developed. I assume that another year would be sufficient for a basic exploration of the necessary studies.

For most of the study a PC will be sufficient. A "compute cluster" is located at CENPA and would be available for large scale calculations.

We have about 40 professional physicists at CENPA, concerned with more than a dozen major projects. At present there is no spare personnel available to work on the EIC project, so we would propose the addition of a postdoc for the study.
A spread sheet eicbudget.xlsx is attached.
I would supervise the study and would spend most of my time on the study, at no expense to EIC.

Sincerely yours

Hans Bichsel
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Ludlam, Thomas W

From: Nikolai Smirnov [smirnoff@rhig.physics.yale.edu]
Sent: Monday, November 14, 2011 6:15 PM
To: Ludlam, Thomas W
Cc: Aschenauer, Elke; Hans Bichsel
Subject: Generic Detector R&D proposal

Dear Tom,
I had a possibility to read H.Bichsel's proposal to continue his very useful and reliable efforts which allow to calculate number and position of electrons due to a charge particle ionization.
It is extremely crucial data to simulate detector response on "experimental measurement level" ("slow" simulator) with good precision, and special for high space resolution detectors (like low mass Si vertex, GEM, MicroMeGas, TPC with TIMPEX and "Si-" readout, ...) including dE/dX data.
During many years of my activities to prepare simulation results for different detector set-ups I found that the best way to use FVP-PAI model is to call Hans. And in a short time he will prepared needed for simulation tables.
So, I would like to support his "Project" and to be a "user" in a future.
Best regards, Nikolai.

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Research in Energy Loss Proposal

Period	2QFY12	3QFY12	4QFY12	1QFY13	2QFY13	3QFY13	4QFY13	1QFY14
Postdoctoral	12900	12900	12900	12900	12900	12900	12900	12900
Benefit rate	27.2%	27.2%	27.2%	27.2%	27.2%	27.2%	27.2%	27.2%
Indirect	54.0%	54.5%	54.5%	54.5%	54.5%	54.5%	54.5%	54.5%
Salary	12900	12900	12900	12900	12900	12900	12900	12900
Benefits	3509	3509	3509	3509	3509	3509	3509	3509
Travel		1000				1000		
Indirect	8861	9488	8943	8943	8943	9488	8943	8943
Total	25270	26897	25352	25352	25352	26897	25352	25352
By Fiscal year			**77518**				**102951**	**25352**