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ELEC5b-Excel: A New Tool for Radiation Budget Calculations

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ABSTRACT

The new tool for radiation budget calculations, ELEC5b-Excel has been developed by Jlab RadCon group. This paper describes it's aim, capabilities and structure. Brief instructions for running the worksheet are also included.

1. INTRODUCTION

"Radiation Budgeting" is the practice adopted at Jlab which aims to control the prompt environmental radiation produced by the operation of the experimental Halls. The environmental radiological increment of each proposed experiment is estimated in advance using the running condition parameters of the experiment such as beam energy and current, materials and geometries of the beam-line setup, and duration of the experiment. If the estimated combined dose at Jlab boundary significantly exceeds design goal (at present, 10 mrem per calendar year, or approx. 10 percent increase of natural radiation background), then a special effort must be made to improve shielding or rearrange the schedule of experiments.

Radiation Control Group continuously monitors the radiation environment on the CEBAF site and at the site boundaries and issues quarterly accounts which report and analyze the current radiation budget status.

The calculation methods for the dose estimates have been developed in the Radiation Control Group. They include the analytical approach, implemented in the computer code ELEC5b (Stapleton, 1996), which takes into account the processes of electron scattering as well as electron and photoneutron production in the experimental targets and beam-line equipment in the Hall, shielding attenuation in the roofs, and neutron skyshine radiation which is the main source of the dose at the site boundary. This method is inevitably simplistic but shows very good qualitative and reasonable quantitative (within +/-50%) agreement with the measured doses. The main advantage of this method as compared with the detailed Monte Carlo simulations of the Experimental Halls, targets and beam-line structures, is that it does not require large computational resources, but it cannot be used to model the complicated geometries that can be done by MC method. It has been implemented as a FORTRAN code and used in the dose calculations for the experiments scheduled to run in 1996 - 98.

This note describes the new implementation of the method in the form of a radiation budget calculation tool which combines the convenience of an EXCEL user interface with the programming capabilities of Visual Basic. The new program, based on the latest version of ELEC5b, takes its input parameters and places the results of the calculation into the standard EXCEL spreadsheet radiation budget form. This method eliminates extra stages of the input information transfers, is user-friendly, and therefore more reliable.

2. DESCRIPTION

The set of input parameters for each experimental setup specifies running time, electron beam energy and current, and represents the approximate structure of beam lines in the experimental Halls A or C. The beam line longitudinal structure is modeled as a series of scatterers along the beam, characterized by atomic number A and nuclear charge Z of the material, thickness in mg/cm2, and position in cm relative to the pivot point. Compounds can be represented as several "elementary" scatterers. The transverse structure of the beam line is characterized by one parameter, a "critical dumpline angle". It is assumed that electron scattering or photon production at an angle greater than critical would produce beam loss. For convenience, the critical angle is specified by two numbers: critical radius, and distance from the pivot to the critical window. All targets upstream the critical window are considered to be "scattering" targets, i.e. capable to produce beam loss via scattering processes; the targets downstream the critical window are "non-scattering", which participate only in direct production losses.

In the new ELEC5b-Excel tool the input parameters are specified in columns of a spreadsheet, one column per setup, and have the same structure as it was in ELEC5b-Fortran code (see Figure 1). There are slots available for 9 "scattering" and 2 "non-scattering" targets, and cells in the table for beam energy, current, critical radius and distance. The targets additional to the "exp't target" can be turned ON and OFF using check marks in the control panel at the top of the sheet. The target in the OFF state wouldn't appear in the table and wouldn't be used in the calculations. Any target can be turned OFF in a given setup just by deleting the material name in the corresponding cell. The information which is standard for the setups such as A and Z of the targets and critical radius and distance can be "hidden" using User/Full information switch at the control panel. Some targets have special names assigned corresponding to most frequent beam line structures: radiator target, experimental target, cryotarget window, exit window, dumpline scattering and nonscattering targets (the last three are characteristic for Hall C). Additional target slots are designated for composite targets and non-standard configurations.

Thus, the upper portion of a column contains input information necessary for ELEC5b-Excel to calculate the estimated dose rate for the setup. The calculated value will be placed in the lower portion of the table in the line "estimated fence post dose rate,

HALL C EXPERIMENT **RADIATION BUDGET FORM** **REV: B**

 # E97-002 **run dates: 1997-98** **name of liaison Oscar A.Rondon**

													totals:
	setup number		1	2	3	4	5	6	7	8	9	10	
beam	energy	GeV	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	
	current	uA(CW)	0.02	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
radiator	element		Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	
	thickness	mg/cm2	500	500	500	500	500	500	500	500	500	500	
	dist. to pivo	m	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	
	Z		29	29	29	29	29	29	29	29	29	29	
	A		64	64	64	64	64	64	64	64	64	64	
exp't target	element		H	H	D	H	D	H					
	thickness	mg/cm2	332	332	654	332	654	332					
	dist. to pivo	m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Z		1	1	1	1	1	1	0	0	0	0	
	A		1	1	2	1	2	1	0	0	0	0	
add'l target 1	element		N[15]	N[15]	N[15]	N[15]	N[15]	N	Fe	Fe	Fe	C	
	thickness	mg/cm2	1658	1658	1635	1658	1635	1547	277	554	830	2000	
	dist. to pivo	m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Z		7	7	7	7	7	7	26	26	26	6	
	A		15	15	15	15	15	14	56	56	56	12	
cryo tgt window	element		Al	Al	Al	Al	Al	Al				Al	
	thickness	mg/cm2	178	178	178	178	178	178				178	
	dist. to pivo	m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Z		13	13	13	13	13	13	0	0	0	13	
	A		27	27	27	27	27	27	0	0	0	27	
exit window	element		Be	Be	Be	Be	Be	Be	Be	Be	Be	Be	
	thickness	mg/cm2	70	70	70	70	70	70	70	70	70	70	
	dist. to pivo	m	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
	Z		4	4	4	4	4	4	4	4	4	4	
	A		9	9	9	9	9	9	9	9	9	9	
dumpline scattering	element		He	He	He	He	He	He	He	He	He	He	
	thickness	mg/cm2	212	212	212	212	212	212	212	212	212	212	
	dist. to pivo	m	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	
	Z		2	2	2	2	2	2	2	2	2	2	
	A		4	4	4	4	4	4	4	4	4	4	
nonscatt. target	element		He	He	He	He	He	He	He	He	He	He	
	thickness	mg/cm2	230	230	230	230	230	230	230	230	230	230	
	dist. to pivo	m	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Z		2	2	2	2	2	2	2	2	2	2	
	A		4	4	4	4	4	4	4	4	4	4	
dumpline nonscatt.	element		He	He	He	He	He	He	He	He	He	He	
	thickness	mg/cm2	230	230	230	230	230	230	230	230	230	230	
	dist. to pivo	m	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Z		2	2	2	2	2	2	2	2	2	2	
	A		4	4	4	4	4	4	4	4	4	4	
critical window	radius	cm	20.32	20.32	20.32	20.32	20.32	20.32	20.32	20.32	20.32	20.32	
	dist. to pivo	m	13.46	13.46	13.46	13.46	13.46	13.46	13.46	13.46	13.46	13.46	
scattering weighting factor			0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	
time	run time	hours	48	72	96	36	48	156	8	8	8	24	504
	(100% eff.)	days	2.0	3.0	4.0	1.5	2.0	6.5	0.3	0.3	0.3	1.0	21.0
	installation	hours											0
	time	days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
estimated fence post dose rate	method 1	urem/hr											
	method 2	urem/hr											
	conservative	urem/hr											
% of allowed average		%											
dose per setup		urem											
% of annual dose budget		%											

% of allowed dose for the total time:

If greater than 200% review for local shielding

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Fig. 1

method 1". The input parameter "run hours" will be used to calculate the estimated dose per setup. In this version, we have introduced an extra line of parameters in consideration of possible installation time needed by an experimental setup. Introduction of this parameter does not change the total dose produced and therefore the percentage of annual dose budget taken by the experiment. But the average dose rate during the experiment (and therefore the percentage of allowed dose for total time-our critical control parameter) will be smaller if the experiment needs noticeable installation time.

To add new setup(s) in the table one should increase the number of setups using the switch in the upper sell of the right column of the table.

The lower part of the last column is used for totals. The calculation starts upon clicking on the "calculate" button.

Figure 1 shows typical experiment input set.

3. INNER STRUCTURE

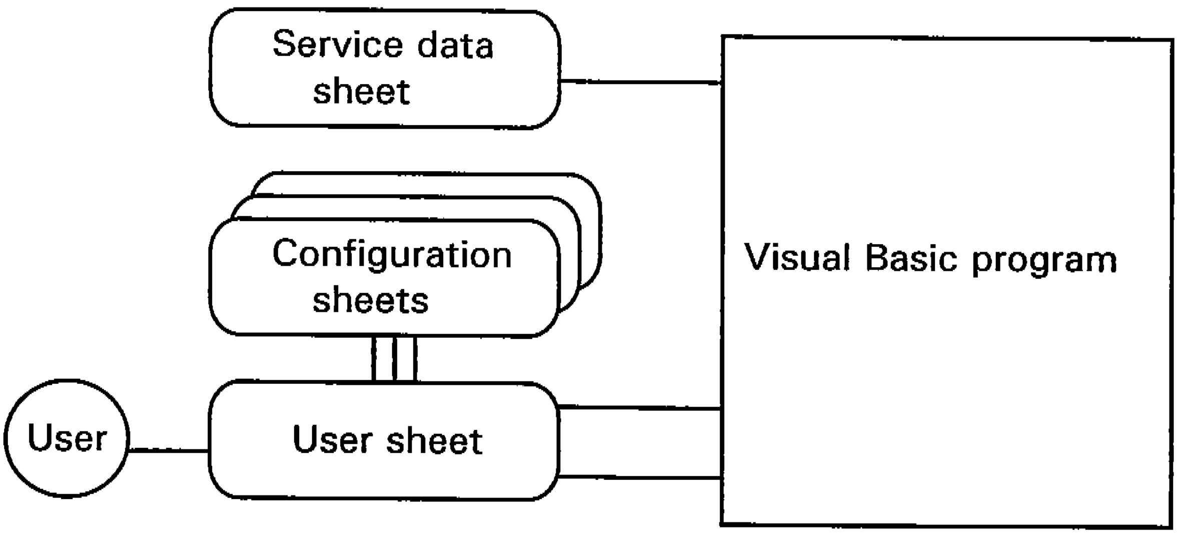

Fig. 2

A block diagram of the tool is shown in the Figure 2. The only user available structure is the "User sheet". It is an ordinary Excel sheet, and serves as an interface that simplifies work with input, and result data. It contains controls that enable one to modify "User sheet" in accordance with concerning task, to start calculations, and execute budget form printing and are controlled by Visual Basic code. "Service data sheet" stores some constants for program calculations. "Configuration sheets" store information about some default settings for halls, such as number of targets, their characteristics, used materials etc. The above sheets serve as an interface that simplifies data and program changes. Different sheets correspond to different levels of changes.

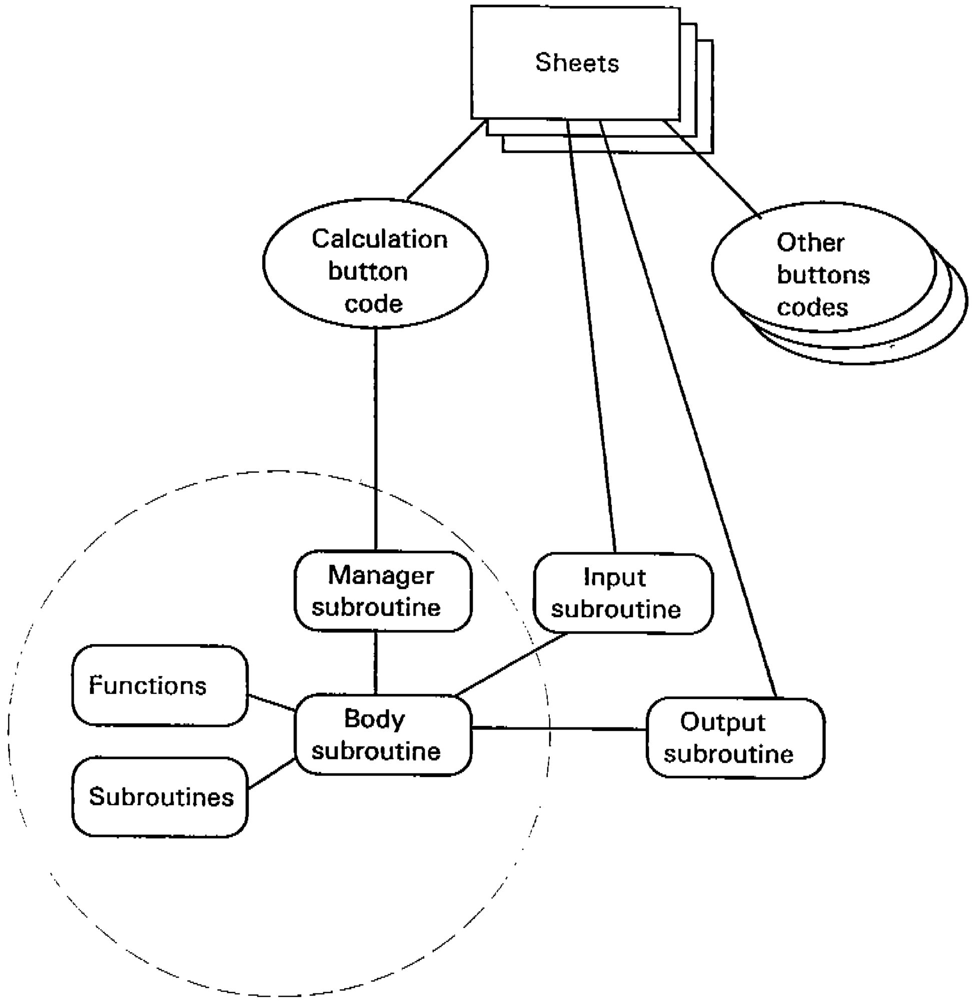

Fig. 3

Program structure is shown in figure 3. Each sheet control has its own code in Visual Basic. After the "Calculation" button has been pressed, the main program begins. "Body" subroutine treats single setup data. "Input" and "Output" subroutines are responsible for the data exchange with sheets. "Manager" subroutine makes all necessary preparations for the current setup. The part of Visual Basic program that makes calculations is written close to initial FORTRAN program (highlighted by dashed circle).

4. HOW TO USE THIS PROGRAM

The program requires Microsoft Excel 5.0/95 , 7.0/95 or 97.
1. Open file. The sheet shown in fig. 4 will appear.
2. Choose the hall letter (A or C). Default configuration and data will be installed automatically.
3. Use check boxes to add or remove targets.
4. Use option buttons (**User/Full**) to ensure or change basic data installed by default.
5. Choose the number of setups (right top cell of the table). New columns will contain the same data as previous one. The proper use of this feature will simplify your input.
6. Fill in input (highlighted by blue) cells.
7. Push "**Calculate**" button. Output results will appear in red cells.
8. Push "**Print**" button. The table will be printed out in standard format on one or several sheets. An example of output budget form is shown in figure 5.
9. You can have several different budget forms in one *Workbook*. Just copy an existing *Worksheet* with budget form (for information see any guidebook on Excel). Now they are independent.