LCE, Light Collection Efficiency simulation tool.

A.G.Shamov, A.R.Buzykaev
Budker Institute of Nuclear Physics
630090 Novosibirsk, Russian Federation

LCE code simulates all physical processes essential for light collection in Cherenkov and scintillation detectors including light scattering and re-emission of light by wave length shifters. LCE employs the Open Physics Analysis Language (OPAL) for the detector description and the simulation process control. It allows one to specify an arbitrary dependence of the optical parameters on the wave length and simulate physical processes or their modes which were not foreseen in the program initially. Currently LCE is available under VAX/VMS only.

Key words: Simulation; aerogel; WLS; Cherenkov counter.

1 Introduction

Particle identification systems based on the Aerogel Threshold Counter (ATC) were supposed to be used in all detectors designed to study B-physics in the Υ energy region. This paper describes the Monte Carlo code called LCE and employed for simulation of the ATC systems of KEDR [2,3] and Ba$\bar{\text{B}}$ardetectors [4,6,6].

2 Physical processes

LCE code simulates following physical processes:

Cherenkov light radiation,
light refraction on media boundaries,
Rayleigh scattering,
light absorbtion in radiators and light guides,
light reflection from detector walls of various types,
light absorbtion on detector walls,
light absorbtion and re-emission by Wave Length Shifters (WLS)
and photon detection.

All optical parameters involved can arbitrary depend on the light wave length. Wall absorbtion coefficients can arbitrary vary in space. A few different models are foreseen for the photon detection simulation. The main part of the physical algorithm is used since the work [1].

3 Geometry representation

Unlike to many other simulation tools, the main geometrical entity of LCE is *a wall* but not *a block*.

Walls are pieces of plains or second order surfaces. To describe a wall one must state the inequality for its surface and the set of additional inequalities (*bounds*) selecting the required piece of the surface.

A space regions limited by walls and having constant optical parameters is called *a block*. A block may have an arbitrary shape, it is not necessarily closed nor convex. A photons is located inside the block, if it crosses one of the block's walls on its way. A photon travels from block to block though windows on their walls which must be specified explicitly.

Such approach seems adequate to the nature of the problem is rather efficient and can be implemented easily.

4 Input language

The LCE is an example of the OPAL-based application. OPAL [7] is an Open Physical Analysis Language which includes the most important FORTRAN-77 operators and can be expanded with arbitrary application-specific statement. An application can define the set of objects (variables, arrays and callable procedures) which are available at OPAL level.

The LCE declares as OPAL variables the most urgent data including the photon wavelength $\%WL$, its current coordinate $\%P$ and direction of motion $\%D$, its statistical weight $\%PW$ etc..

The commands most frequently used in detector description are shown below in various possible formats:

$BLOCK[\backslash NAME = bname] -$
$[REFRACTORY\_INDEX = ri[(\%WL)]\ -$
$[ABSORBTION\_LENGTH = al[(\%WL)]]\ -$
$[SCATTERING\_LENGTH = sl[(\%WL)][\backslash LAW = slaw(\%D)]]\ -$
$[WLS\_NAMES = wlsname[, wlsname..]]$

$NESTED\ BLOCKS\ bname[...]$

$WALL[\backslash NAME = wname]\ surface\ -$
$[BOUNDS = surface[,...]]\ -$
$[REFLECTION\_TYPE = type[\backslash LAW = rlaw(\%WL)]]\ -$
$[ABSORBTION\_COEFFICIENT = abs[(\%WL)]]\quad END$

$WALL[\backslash NAME = wname]\ surface\ -$
$[BOUNDS = surface[,...]]\ -$
$[REFLECTION\_TYPE = type[\backslash LAW = rlaw(\%WL)]]\ -$
$[ABSORBTION\_COEFFICIENT = abs[(\%WL)]]$

$WINDOW\ [surface]\ TO = bname.wname$

$WINDOW\ [surface]\ -$
$TO = DETECTOR[\backslash PROCEDURE = dp[(\%WL, \%PW)]]$

END_WALL
END_BLOCK

All the command and parameter keywords can be reasonably abbreviated. The surface inequalities denoted as $surface$ can be specified as expressions containing dummy variables x, y and z. The examples are $(x-xc)**2+(y-yc)**2 < radius**2,\ x > 0$ etc. The inequality sign specifies the front side of a surface. The other way to specify surfaces is referencing of walls by their names.

The following types of reflection are foreseen: $Fresnel$, $Lambert$, $mirror$, $isotropic$ and $userdefined$. To implement its own reflection type, an user must create an OPAL procedure for the photon reflection and specify it with the $\backslash LAW$ qualifier.

The default scattering law (isotropic) and the detection procedure can be modified in the same way.

In any place were a numeric value is required, one can substitute an arbitrary expression with possible dependence on the wave length and, for some parameters, on the photon position.

The Wave Length Shifters referenced in $BLOCK$ commands can be described with the special command WLS. The use of *nested blocks* makes the detector description simpler and allows to simulate such thing as multiple bubbles of air in a scintillator.

The other LCE commands and the standard OPAL commands facilitate a detector description ($COPY$, $MOVE$, $ROTATE$, $DO-ENDDO$) allows to specify the light generation procedure, control the simulation process ($GENERATE$, $STOP$, $ACCOUNTING$), book, fill and display histograms required ($BOOK$, $FILL$,$PLOT$) etc..

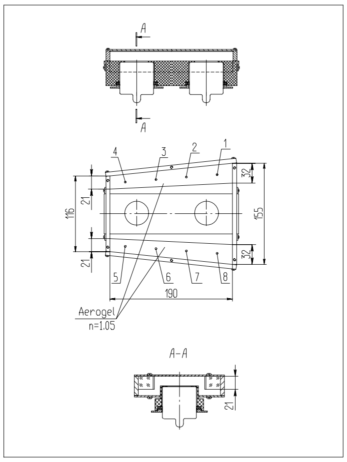

Fig. 1. One of the Ba$\bar{B}$arATC prototypes.

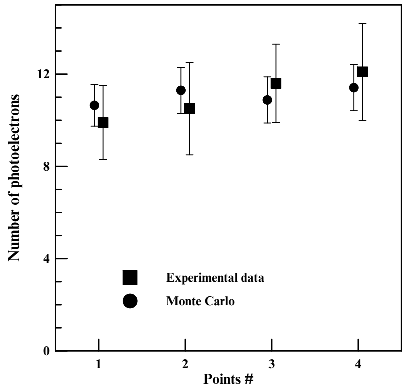

Fig. 2. LCE simulation VS beam test data.

One of the Ba$\bar{B}$arATC prototypes simulated with the LCE code is shown in fig.1, the LCE predictions are compared with the beam test data in fig. 2 (paper [6]).

5 Conclusion

After several years of intensive use, LCE can be stated as an efficient and convenient simulated tool. It was carefully tested on the configurations with known analytical solutions. Its predictions for ATC prototypes are in agreement with the experimental results.

References

[1] A. Aksenov et al., Int. Symp. on Position Detectors in High Energy Physics, Dubna, Russia, 1988. D1.13-88-172, p.313.

[2] A. Onuchin et al., 5th Int. Conf. on Instr. for Colliding Beams Physics, Novosibirsk, Russia, 1990 (World Scientific 1990), p.208.

[3] A.Buzykaev et al., Nucl. Instr. an Meth. A379 (1996) 453-456.

[4] A.Buzykaev et al., Ba$\bar{B}$arNote 170, 1996.

[5] K.Arisaka et al., Nucl. Instr. an Meth. A379 (1996) 460-464.

[6] D. Boutigny et al., Ba$\bar{B}$arNote 290, 1996.

[7] A.G.Shamov. OPAL, an Open Physics Analysis Language. These proceedings.