FLUKA+GEANT4 SIMULATION OF CALICE

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The approach to perform FLUKA simulation of the CALICE test beam prototype and first results are presented.

1 Introduction

Good detector design choices require a reliable modelling of hadronic interactions. GEANT4 [1] is the de facto standard for detector simulation but other packages such as FLUKA [2] offer very serious alterntive physics models. A well designed test beam study should discriminate between these models and the aim of this work is to enable a systematic comparison between the *physics* content of these two packages, to identify key areas for the forthcoming CALICE test beam(s). It is expected that FLUKA physics models will be availble through GEANT4 in the future, but not on the timescale required by CALICE.

The aim is to test a variety of detector models implemented in MOKKA but without having to define each geometry directly in FLUKA data cards (difficult, error prone, likely to introduce non-physics differences).

2 Method and results

Geometry and physics are decoupled in both FLUKA and GEANT4. A suite of interface routines FLUGG (FLUka with GEANT4 Geometry), wrappers for f77/C++) written [3] by P. Sala (a FLUKA author) allows use of the FLUKA physics models (object code only distributed, f77) with GEANT4 (open source, C++). User control within the simulation is available at each tracking step or energy deposition event, and can be used to write out information for subsequent analysis. It is noted that for GEANT4 replicated or parametrised volumes (correspond to FLUKA "lattice volumes"), the region index is degenerate, which presents some issue for the user analysis and which prevents boundary crossing detection. For example, in the CALICE ECAL test beam prototype, FLUKA "sees" 3×32 Si volumes, but the volume id is degenerate in z transverse to detector slabs (3 towers), in depth y (within a stack of 10 Si layers) and these correspond to the *insensitive* regions of Si. All sensitive regions of Si share a single volume id and this associating them with a particular MOKKA layer/cell hit has to be done either using a Common Geometry Application method to convert spatial coordinate to indices (to be implemented) or "by hand" in post processing with knowledge of cell structure.

The procedure to use MOKKA with FLUKA currently requires modification of the MOKKA source (changes could be implemented as material to select with cpp), as follows. (i) delete all GEANT4 classes except for those related to detector construction, detector parametrisation and magentic field construction, (ii) delete corresponding #include, variables, class definitions in .cc/.hh, (iii) code where SensitiveDetector is set, (iv) anything related to G4RunManager, DetectorMessenger, (v) code for visualisation or interactive use. There are no high level validation tools are provided with FLUGG and some difficulty has been experienced in keeping a consistent set of GEANT4 MOKKA, FLUKA, FLUGG, compilers, external packages; in part because of lack of source code availability of FLUKA and in part because both FLUGG and MOKKA require specific ranges of versions of GEANT4.

In operation, two stages are necessary. The first is a one-time initialisation in which the GEANT4 geometry and material definitions are used to write out ASCII files which define all materials/compounds/mixtures used and the material to volume assignements in the format required by FLUKA. Later runs use these cards and tracking of particles takes place within the actual GEANT4 geometry with physics processes provided within FLUKA. As usual within FLUKA, e.m. properties of materials have to be created using the PEMF processor, Sternheimer tables, etc. (well described in FLUKA documentation, but less clear for exotic materials).

Studies used beam of e^-, μ^-, π^-, p at 1 and 10 GeV, at $90^{\o}$ to ECAL front face at $(x, z) = (0.5, 0.5)$ cm. Figs. 1 and 2 show results for the ProtoEcalHcalRPC model, changing to a different model is trivial.

Future work will improve technical reliability for larger samples, review thresholds/step sizes to improve speed, study alternative HCAL technology options and compare systematically with GEANT3/4 results [4], by writing out hits directly in MOKKA format.

References

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3. M.Campanella, A.Ferarri, P.R.Sala and S.Vanini, ATLAS internal note ATL-SOFT 98-39 (1998); ibid ATL-SOFT 99-004 (1999).
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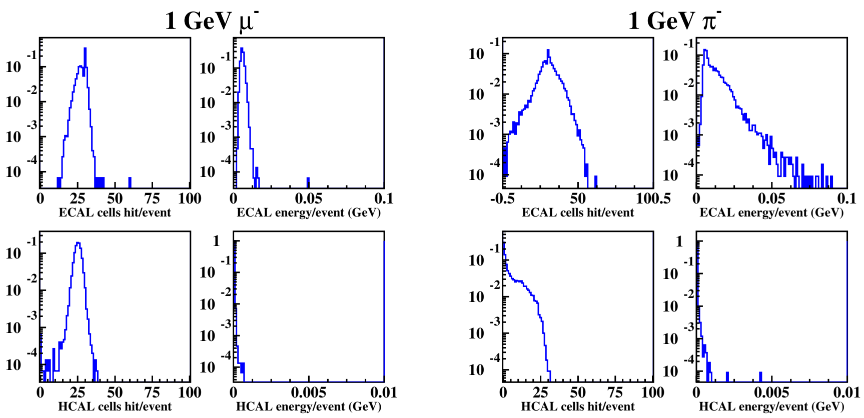

Figure 1: No. of cells hit and energy deposited per event in ECAL and HCAL by 1 GeV μ^- and π^-.

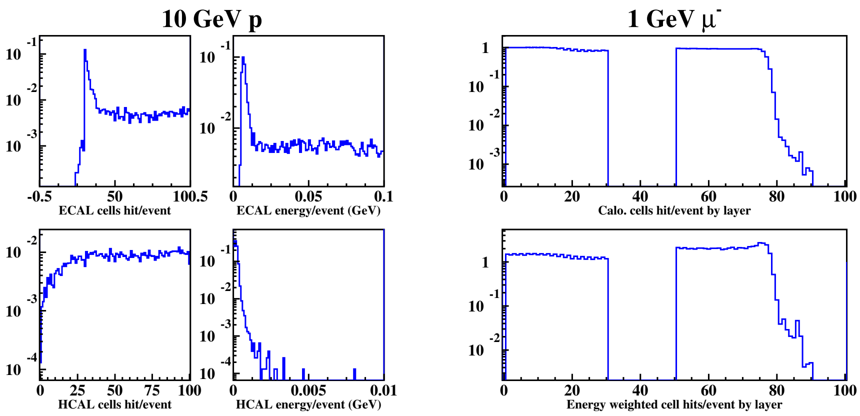

Figure 2: (l.h.s.) As per Fig. 1 but for 10 GeV p (l.h.s.), (r.h.s.) longitudinal response of ECAL (layers$<$ 30) and HCAL (layers$>$ 50) to 1GeV μ^-, as both cells hit and energy weighted hits per event. The regular structure in ECAL hits is related to the average material mixture used in MOKKA, producing higher energy tail in alternating Si layers. (This has subsequently been observed in MOKKA directly.)