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CALICE ECAL testbeam at FNAL-MBTF

(Draft proposal to CALICE Steering Board)

G. Mavromanolakis[1] *, D. Ward[1], N. Watson[2]

[1] *Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, U.K.*
[2] *CCLRC Rutherford Appleton Laboratory and University of Birmingham, U.K.*

CALICE ECAL and HCAL prototypes are under construction and first testbeams will take place in 2005. The detector technology/concept debugging is the top priority goal for this phase of testbeams. From the simulation side, studies reveal significant discrepancies among shower packages which prevent model independent predictions of calorimeter performance and reliable detector design optimization. This is illustrated in fig. 1 and 2 which depict the level of uncertainties in the electromagnetic and the hadronic sector, respectively. Thus the testbeam program is of high priority and will help to resolve the situation and reduce the current large uncertainty factors.

The Si/W ECAL prototype is at the final stage of production and a first testbeam will take place at DESY in late 2004/early 2005 with electrons up to 7 GeV. This will allow first detailed debugging studies of a full scale prototype and thorough understanding of the detector. Testbeam with electrons at FNAL will confirm results and first conclusions and especially extend the studies to higher energies. Of particular interest are studies related to saturation effects, the constant term of energy resolution etc.

Simulation studies are based on samples of 10^4 events, and differences among different available models are evident and statistically significant. Taking into account effects of beam spot size, beam momentum spread, contamination, in the real testbeam a sample size of 10^6 of events on tape should be the baseline figure. This means that with an average DAQ rate of 100 Hz it will take about 3 hours per sample. Or consequently we expect that at most 5 data samples per day can be recorded.

As an example, a simple realistic exercise of logistics: at least 1 sample per configuration, times at least 6 energy points, times 3 different angle configurations and possible position scan for some of the configurations, and for 5 data samples per day, results that minimum 10 days of testbeam time is required. This estimate excludes any startup period for setup runs to "understand" the beam and the detector. So in total a request of 2 weeks run with electrons seems very reasonable.

Of concern is the fact that the current status of electron beams at FNAL-MBTF is "problematic". This should be clarified, to establish the nature of the problem and how it can be improved.

Given the imbalance between high demand and short availability of testbeam facilities for the following years, we believe we should exploit the available beam time and the

* email: `gmavroma@hep.phy.cam.ac.uk` or `gmavroma@mail.cern.ch`

capabilities of each detector to the maximum and extract as much as possible useful information we can. One possibility is to expose the ECAL (with a block of material in front) to low energy hadrons and perform inclusive measurement of hadronic shower development. We are mainly interested in hadrons of energy less than 10 GeV.

The proposed method is depicted in fig. 3. The ECAL is exposed to a hadron beam, first without and then with one and two blocks of W, each of depth equivalent to that of ECAL ($\simeq 0.9\ \lambda_I$). The three consecutive "photos" combined reveal the inclusive profile. Discrepancies between models are significant and by comparing simulation and testbeam data some first discrimination of them may be achieved. In general, this type of studies will provide useful results complementary to further detailed studies performed by future combined runs of ECAL+HCAL.

Testbeam run with ECAL alone with pions and protons would be useful at 2-3 energy points below 10 GeV, if possible. Also runs at 45° angle configuration will be useful to extend the total depth by 40%. Although further angle and position scans are not envisaged still a requirement of 2 weeks beam time is reasonable mainly because of the fact that larger samples (2 to $5 \cdot 10^6$) may be needed to compensate for the pion/proton contamination.

We conclude with a list of questions and key issues that should be emphasized. We believe that these are of importance not only for an ECAL standalone testbeam but also for the forthcoming ECAL+HCAL combined program.

- It is obvious that in order to perform meaningful and conclusive studies by comparing testbeam data with simulation results we need to know the beam with precision i.e. transverse profile, momentum spread, particle content. Thus hodoscopes' position resolution and Cherenkov counters' separation efficiency play a crucial role in the success of the testbeam.
- Especially the Cherenkov counters' energy dependent efficiency needs to be well known as effective sample size of given species is limited by product of this with actual content, and could be problematic at high energy for pions, low energy for protons.
- What is the minimum beam energy of electrons and hadrons which the FNAL-MBTF can deliver. Also what is the maximum energy of electrons.
- For the run with electrons it will be useful to be capable to go lower than 7 GeV in order to have some overlap region with the results of the testbeam at DESY.
- For the run with hadrons what are the characteristics of the beam expected at 10 GeV. Is it possible to go lower than that or at least have some energy points close to 10 GeV.
- The proposed ECAL exposure to hadrons may give useful and complementary results to further detailed studies performed in an extensive testbeam program with ECAL+HCAL combined. Besides, the technical know-how acquired, regarding the control of the hadron beam and the full system, will facilitate the integration of the HCAL when it is complete.

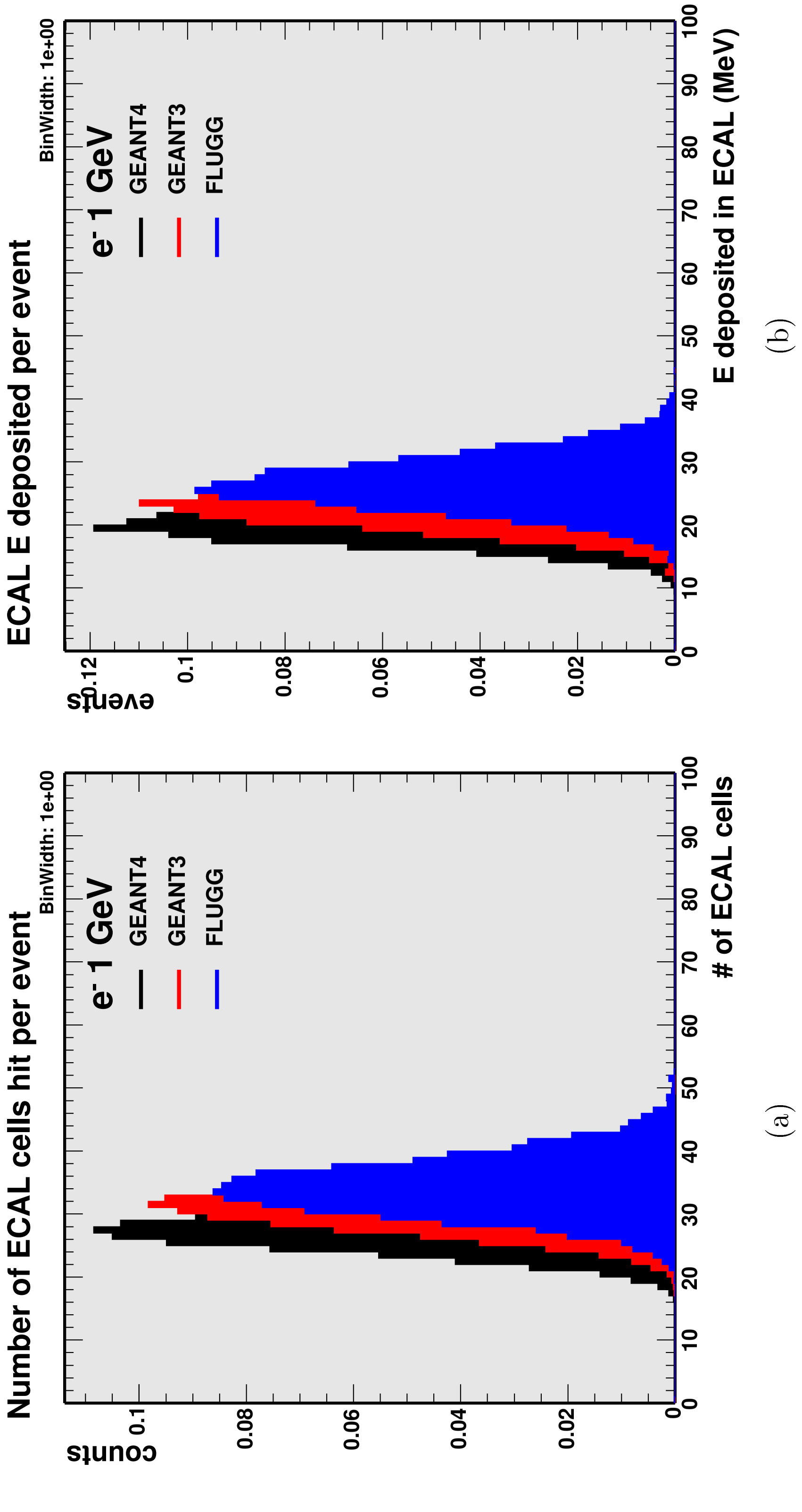
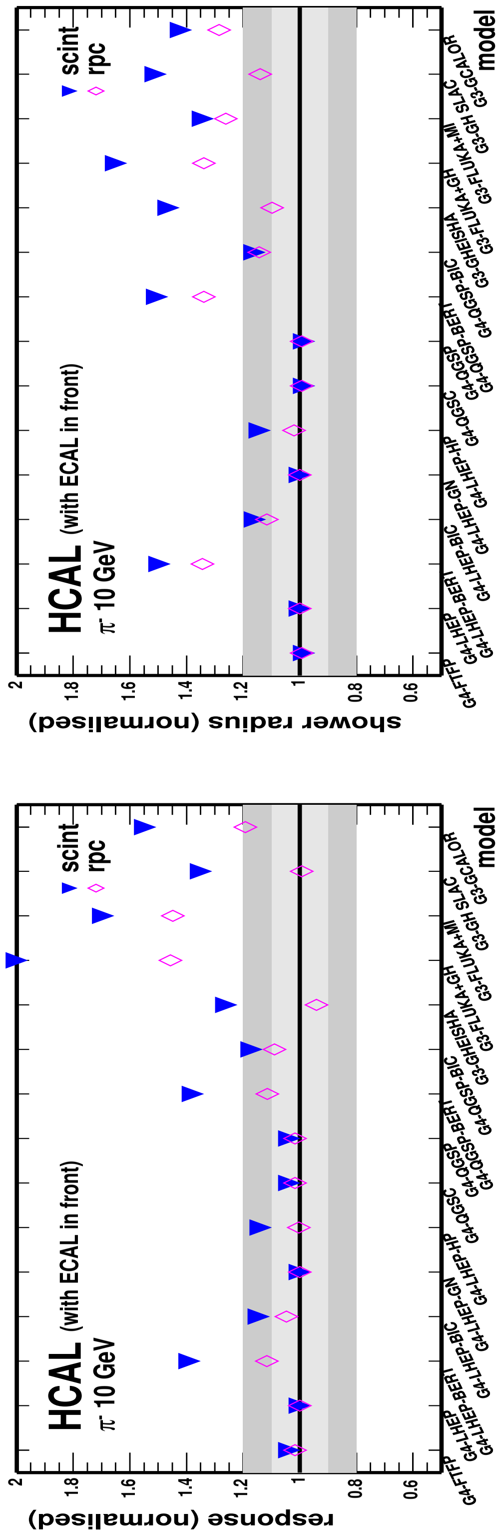
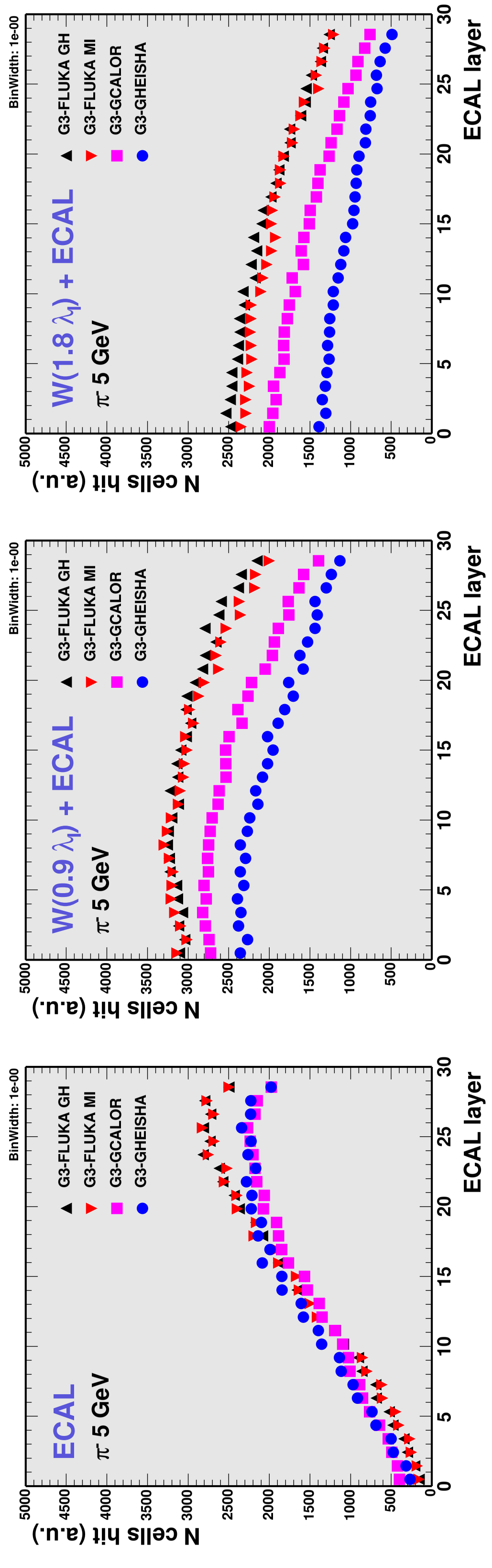


Figure 1: ECAL response to 1 GeV electrons as predicted by three commonly used simulation frameworks, (a) response in terms of total number of cells hit per event, or (b) total energy deposited per event.



(a) (b)

Figure 2: (a) hadronic calorimeter response, in terms of total number of cells hit, vs hadronic model, (b) average shower radius vs model. Results for both versions of HCAL (scintillator tiles or rpc) are shown.



(a) (b) (c)

Figure 3: inclusive longitudinal shower development of 5 GeV pion as predicted by various hadronic packages, (a) ECAL, (b) ECAL with a block of 0.9 λ_I W in front, (c) ECAL with a block of 1.8 λ_I W in front.