GEM TN-92-214

Selection of the GEM Hadronic Calorimeter Technology: Decision Memorandum

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Abstract:

The GEM Collaboration has selected a hybrid calorimeter (liquid krypton/scintillator) as the preferred technology for inclusion in the GEM Technical Design Report. This choice reflects our goal to develop a major detector for the SSC optimized for physics discovery with gamma, electron, and muon final state signatures and with important abilities for missing E_T and high luminosity. We intend to optimize the use of this dual technology calorimeter.

DECISION MEMORANDUM

SELECTION OF THE GEM

HADRONIC CALORIMETER TECHNOLOGY

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SUMMARY

The GEM Collaboration has selected a hybrid calorimeter (liquid krypton/scintillator) as the preferred technology for inclusion in the GEM Technical Design Report. This choice reflects our goal to develop a major detector for the SSC optimized for physics discovery with gamma, electron and muon final state signatures and with important abilities for missing E_t and high luminosity. We intend to optimize the use of this dual technology calorimeter.

CONTEXT OF THE DECISION

A previous memorandum (GEM-TN-92-200) describes the process and reasons for the choice of a liquid krypton sampling calorimeter as the preferred technology for our electromagnetic calorimeter. In that memo we conclude that, "the liquid krypton technology offers the best overall opportunity for GEM to construct a superior electromagnetic calorimeter". Further, we state that "integral to this decision is the assumption that vigorous development and optimization of the liquid krypton technique will continue, and that no compromises will be made in our performance goals". Finally we conclude that "our decision leaves open the single remaining system choice, namely that between an integrated liquid krypton electromagnetic and hadronic calorimeter vs. a hybrid liquid krypton electromagnetic calorimeter surrounded by a scintillating fiber hadronic module".

A study of hybrid systems was initiated in May of this year, and a number of different configurations with different LKr thickness were studied over a period of time. The

problems in accommodating the signal feedthroughs and the services and supports for cryogenic detectors inside a tightly integrated scintillation calorimeter were identified but not resolved.

Following the E-M decision we undertook a review of the options, including the Baseline integrated liquid krypton/argon solution, a reduced integrated version, using 9 interaction lengths of active calorimeter in the barrel, followed by 3 of passive absorber, and hybrid options.

In order to study the hybrid solutions, we formed a task force consisting of Bill Wisniewski (chairman), Cliff Eberle, Howard Gordon, Mike Harris, Yuri Kamyshkov, Lyle Mason, Mark Rennich, Gary Sanders, and Larry Sulak. Recognizing the problems with the hybrid designs employing three cryostats, they turned their attention to a design with two cup-shaped cryostats. The found solutions to some of the problems with that design in our earlier integration studies, such as the support and service routing for the central tracker, though these solutions lead to increase the material in front of the EM calorimeter, and the blind insertion of a rather long device. Of course the projective crack at $\eta = 0$ is a doubtful feature of this configuration.

Both the integrated calorimeter and the results of the study by the hybrid task force were presented and discussed at the Collaboration Council meeting on October 8, 1992. Following that presentation, we discussed with the GEM Executive Committee our conclusion that a hybrid calorimeter with a liquid volume substantially smaller than the full integrated liquid design offered the best potential for our experiment. They discussed this conclusion and made useful comments. For example, they commented on the radius of the transition between the two techniques. They endorsed our decision to select the version of a hybrid calorimeter best in accord with the goals of GEM, in particular the best

performance for photons and electrons.

THE ISSUES

The goals of the hadron calorimeter in GEM are two-fold: first, to provide functions necessary to enable optimum performance of the GEM electromagnetic calorimeter and muon systems; and second, to carry out important physics goals directly provided by the hadronic calorimetry, jet physics, and, in particular, missing E_t physics.

Functions crucial to goals for e's and γ's include isolation cuts, shower leakage, etc. Functions crucial for muons include muon identification by penetration and detection in the outer portion of the absorber, information on muon energy deposition in the calorimeter, and to provide a shield to ensure a quiet environment in the muon spectrometer. For missing E_t physics important considerations in the hadronic calorimetry are hermiticity, resolution and tails on the resolution function.

Engineering considerations considered in choosing the calorimeter include technical difficulty and risk, manufacturability by the GEM Collaboration (e.g., off-site and off-shore), assembly and installation, and integration issues such as detector access, backgrounds and beamline, etc. Finally, issues of cost, schedule, operation, calibration and maintenance have been considered and evaluated.

The advantage of a hybrid calorimeter which seems most clear to us is the reduced diameter of the cryostat and the reduced volume of liquid krypton. The clear problem is the necessity of obtaining access to the inner calorimeter for services, etc.

Another issue is compensation. To keep the jet response within the requirements of GEM requires a degree of compensation which can be achieved by a compensating

calorimeter following a thin liquid calorimeter, or somewhat less well, by a LKr calorimeter with a high-Z absorber.

There has been wide spread recognition that the balance between the last two factors leads to two possibly attractive hybrid calorimeter designs, with either a LKr section as thin as possible, or thick enough to shield the services, feedthroughs, supports and any other imperfection in the remaining portion of the calorimeter. The two cases correspond to a thickness about two and six interaction lengths.

We then weighed the strengths and weaknesses of both approaches on the numerous technical considerations discussed above, stressing the potential of each regarding performance for our physics goals.

THE DECISION

The decision we reached is that GEM should pursue the development of a hybrid calorimeter with a LKr scintillator transition at about six interaction lengths as it offers the best possibility of optimizing the design to a practical, manufacturable calorimeter system that can meet our ambitious design goals.

This hybrid calorimeter allows the development of the electromagnetic section, optimized toward our ambitious physics goals for gammas and electrons. The smaller cryostat than in the integrated design eases the mechanical constraints allowing possible improvements in several performance areas and insuring against compromises in the detailed design. In addition the smaller volume of liquid krypton, possibility of off-site construction, etc. are decided advantages.

The fact that the services are shielded by the liquid section means that we can be sure

that the performance remains very close to that simulated for the integrated design while detailed engineering is carried out.

Similarly, in order to retain a jet performance similar to that of the Baseline 1 LAr-Cu calorimeter, a lead absorber will be used in the first six interaction lengths.

This optimization was discussed with and received the support of the Executive Committee on November 6.