CMS Upgrade MB Response to SLHC Document:

10.02: R&D for a high η trigger and tracking detector for CMS

(Contact Person: Archana Sharma, CERN)

This proposal should be revised to include more information on performance requirements, including triggering capabilities, more R&D on detector performance and a plan for development of detector readout and trigger electronics. Please see the comments from the referees.

Specific requests for the revised proposal are:

1. Provide a plan for R&D on time resolution, efficiency in a 20 ns window, discharge probability and aging. As part of this, explain the R&D plan to optimize the detector geometry, electric field configuration, gas mixture and front-end electronics. Explain the institutional responsibilities for this R&D.

2. Provide more details on the plan to study and design the full electronic chain for trigger and readout, including the trigger algorithms. Information should be provided on multiplexing, readout rates, how the individual planes are combined, etc.

3. Provide a more detailed schedule with project reviews and milestones at appropriate points in the schedule when major design, and technology choices will be made, and showing how the results from prototype studies will be folded into the choices of the full scale detector.

4. Provide a plan for simulation studies to evaluate the detector physics and trigger performance, especially the effects of occupancy (including neutron/gamma hits), the impact of the strip pitch on the trigger and the interplay with the CSC chambers in the same region. How will the proposed system complement the existing CSC capabilities?

In addition, we request you to address the detailed comments on the proposal from the referees below.

Referee #1:

1) The R&D seems to concentrate more on mechanical aspect than on performance evaluation

I understood that GEM detector is preferred with respect to Micromegas due to high discharge probability in Micromegas.

A COMPASS like detector (where GEM were used as tracking devices) has been considered in the tests presented in the paper (standard gas misture Ar/CO2), but If the GEM detector for the CMS upgrade should serve not only as tracking but also as triggering device maybe a more LHCb like detector should be considered.

Indeed an intense R&D activity for the optimization of the time performance of GEM detectors at LHC has been performed by LHCb collaboration (where those detector are used for LV0 muon triggering) since a critical issue is the high efficiency in the bunch-crossing identification, which require a high detector time resolution (typical detector time resolution with the standard Ar/CO2 gas mixture is about 10 ns r.m.s).

As far as the rate capability is concerned the parameters that can influence the performance of the system at LHC and which will require more R&D are time resolution, efficiency in 20ns time window, discharge probability and aging effect. The above parameters depend on:

a) Detector geometry (thickness of drift, transfer and induced gaps and layout of readout pads and strips)
b) Electric fields configuration in the drift, transfer and induction gaps
c) gas mixture – CF4 based gas mixture to be considered.
d) front-end electronics

The review is lacking information about those parameters.

Before going in the modeling and definition of the full scale mock-up more R&D on the detector parameters suitable for a system which will act as trigger detector at very high rate and in hostile conditions are needed.

2) No any mention is done in table 2 about which institutions will take care of R&D for construction parameters and optimization of the performance of the system

3) Need to understand also the full electronic chain also for trigger and readout.

4) It would be important to understand the trigger algorithms and the integration with the rest of trigger system.

Referee #2:

The proposal describes a quite advanced generic R&D program for MPGDs.
As far as CMS upgrade is concerned it is clearly stated what are the intentions for the application of the detector within the CMS environment, but, concentrating mainly on mechanics dimensions, it is lacking information on several CMS related aspects.

1) Simulations within the CMS contest should be explicitly included as a task: in particular occupancies should be evaluated rather fast.
2) Ideas about triggering with a description of the trigger algorithm (patterns?) are completely missing: expected transverse momentum resolution versus detector resolution could already be estimated
3) Neutrons/gamma hits impact on trigger should be considered as a part of the program
4) Readout aspects are not at all touched while at least an assessment of the feasibility (readout rates, degree of multiplexing ...) should be an outcome of the R&D.
5) How are signals from each plane of triple GEMs combined? ORed, ANDed, any strange combination?

6) Are both types (MICROMEGAs and GEMs) still an option, or are MICROMEGAs type detectors definitely ruled out?
7) Is it possible to use Ar/CO2 85/15 % already used in the DTs? This would reduce the number of gases flowing in the detector.
8) The schedule seems unnecessarily tight: it looks like choices on full scale detector are done before having really understood the small size prototype.

Referee #3:

The proposal covers interesting detector R&D for muon detectors in high occupancy environments. It is incomplete in several aspects, however, if this is to be considered as all of the R&D necessary before proposing a major new detector system for CMS. First of all, a simulation program is necessary to justify the physics utility of an extension to the RPC muon system using MPGDs. This is considered outside the scope of this proposal, but I think it is necessary. Second of all, the upgrade is meant to be a triggering system, and yet there is no R&D mentioned that covers that aspect. This is another major deficiency.

The proponents claim that the high eta region of CMS is vacant. This is not true. Although the present RPC muon system covers only $|\eta|<1.6$, the CSC system extends to $|\eta|=2.4$ and is expected to remain viable even beyond $L=10^{34}$. Thus, while R&D on new applications of detector technologies might be useful in a general sense, to propose a new system in this region requires physics justification. What does the new system add beyond the CSC system that increases the physics output of the experiment? This requires a physics and detector simulation effort.

Since a primary purpose of a system based on one of the MPGD technologies studied here is to provide trigger capability, we should understand and prototype how that is to be done before a decision is taken on a system based on this R&D. But only the detector R&D and systems engineering is mentioned. In fact it is noted that for the MPGD prototype, "a pragmatic choice of strip widths will be made based on the number of electronic channels available." In fact, I would propose choosing the strip pitch that is necessary to meet the trigger demands, which in turn depends on simulations that show what pitch is necessary to achieve the desired performance (e.g. Pt resolution, occupancy). Only then do you start to prototype the real system including trigger electronics. Additionally, there is no mention how muon patterns, or roads, are to be identified and implemented. This is an important electronics R&D area not included.

I think we need to add these areas, and the associated milestones on when to have input delivered.

Referee #4:

0) It is very good to have this proposal written up.

1) it is practically not worth writing this proposal if the end date is March 2011... a longer time scale would allow folding new institutes into the developing R&D plan, which could be written somewhat more generally to allow that.

2) it seems to me necessary to give some idea of how this folds into an overall high-eta (non-CSC) upgrade.

3) a more mundane comment: "discharge probability" is not defined.