

CMS Upgrade MB Response to SLHC Document:

09.02: Proposal for the Hadron Forward Calorimeter HF Upgrade Phase I (Contact Person: Yaser Onel)

While the R&D in this program is important and the case for replacement of the HF PMTs is clear, the definition of the scope of work in this proposal needs clarification. There is a mixture of activities appropriate for the phase 1 upgrade and other activities that are more immediate.

There should be two separate proposals, one which details studies and activities directed at the more immediate problems faced by the HF and with R&D for the Phase 1 upgrade. An even more serious concern is the plan to make tests using the HF detector itself while operating CMS for data-taking. This is a matter for the CMS Management Board and not the Upgrade MB.

Therefore we encourage the submission of a revised proposal, which presents a clear plan for R&D not using the existing HF as much as possible and leading to the SLHC Phase 1 upgrade. It is important that this R&D program be placed in the context of the overall HCAL Upgrade plan. The HCAL Project Manager should review this. After completion of this step, the aspects of the plan impacting CMS before the Upgrade Phase 1 should be presented to the CMS MB and the specific R&D Program for SLHC Phase 1 should be resubmitted as a new proposal. Please see the comments from the referees.

Specific requests for the revised proposal are:

1. Explain which R&D activities can only be done with the existing detector and not with the test modules in a test beam and why.
2. Explain how the R&D activities with the existing operating HF detector will not cause problems for CMS data-taking.
3. Separate R&D needed for SLHC Phase 1 from that needed for data-taking before the Phase 1 upgrade.
4. Explain the R&D plan with a time-line beyond FY09, milestones including dates for key decisions (e.g. photo-detector and manufacturer decisions) and institutional responsibilities.
5. Provide a cost breakdown.
6. Explain the sharing of resources between this proposal and proposal 09.01.
7. Formulate the performance requirements for the HF at the SLHC Phase 1 more clearly based on simulation results.
8. Provide a detailed plan for simulation of the HF performance that justifies the performance requirements, particularly the energy precision and sensitivity to backgrounds. This plan should include a time-line for this program beyond FY09, milestones and institutional responsibilities.
9. Explain the relation and trade-offs between the SiPMT and the other PMTs discussed in the body of the proposal and how the R&D Program will address this. (SiPMs are only mentioned in the summary and not in the proposal main body).
10. Explain how the two energy signals in the two readouts would be distinguished so that the correct energy is chosen. (It is not clear that picking the lesser energy is always the best choice).

11. Explain whether the waveform processing will be done for the L1 trigger or only for the readout data and how the trigger will manage to function.

Referee #1:

In my view this is not a very well defined upgrade proposal.

There is mixture of upgrade and tests proposed for a detector that is supposed to take data; this in my view should not be done. Any change of a detector of the importance of HF, needs to be proven to really improve the addressed problem quantitatively.

From the number of proposed upgrades in the summary I can only support the first one, after the proponents have specified the precision of the energy calculation with the second channel, in case the first channel has to be refused. Up to now I only found vague statements as "...and use the smaller signal as at least closer to containing the correct energy information", which in my view cannot yet justify a change.

Referee #2:

The proposal appear to address the current issues encountered during operation of the HF. To my knowledge no duplication of effort.

The proposal should be endorsed, but more details are needed:

Precisions concerning schedule and resources along with milestones including key decision dates like for photodetector type and manufacturer selection should be added to the proposal. In particular I think resources shared with the R/D described in the 09.01 proposal should be explained as it is essentially the same groups involved.

Referee #3:

Proposal HF PMT Upgrade for FY09

1. Obtain candidate HF replacement PMT with the following properties:

i) $QE > 45\%$,

ii) metal or similar envelope and thin window,

iii) compatible in shape and area with 2 independent optical channels per tower. Candidates from the Hamamatsu Ultra Bialkali series PMT's and Photonis will be investigated.

2- Test the candidate tubes for radiation-induced backgrounds, energy resolution using 2 channels per tower, and standard tests to compare with the existing HF tubes.

3- Modify one HF readout box and equip 1/2 with new dual channel PMT's and re-cable to extract last dynode information for the TDC readout. This box will be installed in the HF detector before the CMS closes again.

4- Study and fabricate/obtain a minimum of timing and waveform information, such as multihit TDC with constant fraction discriminators (1/2 ns resolution), up to Wave Form Digitization, for at least 2 towers using the last dynode, and use it in test beams, and prepare to port it to the existing readout. Requires software efforts.

These are my comments/questions/requests:

- the short description of the R&D program is only based on PMT. Why in the summary there is a discussion on SiPM ? This point should be clarified: is this proposal based on PMT or not ?
- this program is missing a commitment for simulation study. Are the proponents aiming to participate to this simulation study
- this program is restricted to FY09. Can we have the program for the future ?
- there is no clear description of the responsibilities nor the FTE associated with each item in the R&D list
- how the proponents will manage to have in situ measurements without disturbing the system
- I do not understand if the proponents are aiming to have the processing of the waveform at the level of L1 trigger or in the readout

I propose to postpone the approval of this proposal until we have a clear breakdown (who is in charge of what and how many people ?).

Referee #4:

Background and Discussion

HF covers a very important eta range for new physics. The detector performance must be maintained, via an upgrade path (staged if necessary) keeping ahead of the degradation which will develop with accumulated luminosity.

The HF upgrade has two aspects:

(1) PMT replacement - for tube aging, thinner windows and higher QE (transmission loss in fibers+window). This upgrade can be staged if needed, spanning the present readout and the Phase I upgrade readout.

(2) Phase I readout upgrade using the new tubes, doubling the readout channels and adding timing information. This is part of the overall HCAL electronics upgrade.

This proposal is for R&D support for (1). While SiPM solutions have been discussed for HF, they do not look cost effective, nor can they be implemented timely enough for (a)-below, should this be necessary.

The degradation of HF with integrated luminosity, and the upgrade path is outlined here:

(a) Interactions in the borosilicate windows of the present PMTs produce fake high energy signals. These can be quite effectively filtered out offline, but will contaminate the trigger. As the luminosity increases and the physics reaches for more rare events this problem will only increase. The proposed solution is to use multi-channel tubes with two readout channels viewing the same eta tower. This will allow identification of window-generated signals (one of two readouts) from calorimeter-generated (both readouts). Candidate tubes have much reduced window thickness, so the overall rate will be lower. Further reductions may be possible using timing information. Simulation studies are underway to estimate how serious these window interactions will be for physics, but the real case will probably be made with collision data in spring 2010, with a decision to purchase new tubes by summer 2010.

(b) Light transmission in through the quartz fibers and borosilicate PMT windows will fall by around 50% by the shutdown for Phase I upgrade. This can be compensated by increasing the tube voltage/gain, but see (c) below. The candidate replacement tubes have a factor two higher quantum efficiency which will compensate for this light loss.

(c) The tube gain will fall off due to the total charge delivered by the PMTs. HF is divided into three eta rings in terms of PMT power supply system. This tube-lifetime is expected require replacement of tubes in the high eta ring before the shutdown or Phase I upgrade. The middle eta ring will probably be changed in this shutdown, and the low eta ring could perhaps last until the shutdown for Phase II. The upgrade scenario is to replace the tubes in each eta ring as needed to keep ahead of this aging. The life expectance of the new tubes must be confirmed. The inner eta ring will likely be replaced more than once.

This R&D proposal follows on from successful earlier work. It focuses on qualifying candidate multi-channel PMTs via:

(1) beam and radiation aging tests

(2) retro-fitting one HF readout box to accept a set of new tubes. This will allow a direct side-by-side comparison of the window interactions in the new and current tubes. The test can be limited in duration (swapping tubes is expected to be a one-day operation), and would have to be approved by CMS.

(3) an investigation of how improved timing information might be incorporated in the readout.

Recommendation

No cost breakdown was provided in the proposal - this information should be requested. Nevertheless the costs are not expected to be high, in which case this R&D should be supported. The work so far is very encouraging and it is important that candidate tubes be qualified so that staged replacement can be carried out early if needed.

This work is not duplicated. It is focused on the primary questions for the baseline Phase I upgrade path for HF.