

CMS Upgrade MB Response to SLHC Proposal:

08.01 R&D for Single-Sided Sensors with HPK – M. Manelli

It is our intent to approve this proposal. Please see the comments from the referees.

Specific requests before final approval are:

1. Explain the areas of work, capabilities and responsibilities of each of the participating institutes.
2. Explain how the proposal builds on the conclusions from RD50 and its relation to other approved proposals on sensor R&D.
3. Discuss the possibilities for selecting other vendors, using them in this program and the risks associated with a single vendor.
4. Explain how the choice of test structures, strip, pixel and substrate options will be done, how many sensors will be made and the work plan for the evaluation and irradiation of these sensors.
5. Comment on the technical challenges associated with fabricating detectors using oxygenated and epitaxial silicon or of thinning wafers after high temperature processing and whether HPK has experience with these challenges.
6. Comment on the needs for test beam facilities and how these will be fulfilled.
7. Explain the proposal timeline and expected rate of progress.

R&D for Thin Single-Sided Sensors with HPK

CMS ref: 08.01

Contact: M Mannelli

Ref 1

I believe the work described in this proposal is important to achieving CMS goals in the upgrade tracker and should be pursued. The proposal covered all the issues relevant for detectors operating in the high radiation environment at the SLHC, though with not much detail.

The timescales for mask design, processing and testing detectors at high radiation levels are quite long. The goal of obtaining results for all design options on each substrate material in one year is possible but ambitious, so the work should begin as soon as possible.

The resources in place are adequate and the partnering with HPK, who produce the most advanced highest-quality detectors in the world, is a good choice, especially based on past experience.

My recommendation is for approval of this proposal. However, some of the issues and questions that I think should be addressed are listed below:

1. The proposal did not lay out the areas of work and responsibilities of each of the participating institutions. This should be well defined.
2. The proposal mentions it is building on the experience of RD50 who have done quite a lot of work on detectors for high radiation, for example effects of different wafer types. The results found by RD50 were not discussed, but should be taken into account, since it should provide some guidance.
3. The choice of HPK is an obvious one; but does CMS intend to pursue studies with other manufacturers? I am not concerned with choosing only HPK, but if other manufacturers are being pursued the efforts should be coordinated so that the same tests are done and meaningful comparisons can be made.
4. The variety of test structures, strip and pixel options, and substrate options is quite large. Testing all of these devices will be a considerably large effort, so a more detailed work plan will be needed.
5. There was no discussion of the technical challenges of fabricating detectors using epitaxial silicon or of thinning wafers after high temperature processing. I expect these issues are under control but it would have been nice to see some discussion of it. Does HPK have experience with this?
6. Test beam availability for testing and irradiation were not discussed. I assume availability of these facilities is not a problem?

Ref 2

The project is certainly an important R&D for the SLHC. It has a strong point in using a well known Industrial Partner as HPK for the different type of substrate and in having an already detailed number of geometries and substrate to investigate that allow a systematic study of different parameters for different materials. The proposal need some improvements, I list in the following some recommendations:

- 1) It would be better clarify in the proposal if the availability of HPK has been verified for what concern the use of more exotic substrate other than FZ, in particular the oxygenated and the epitaxial;

- 2) It is better to specify how many sensors per type are roughly planned: this places a scale on costs and work load;
- 3) The sharing of duties among the institutes should be better specified: there should be a good balance between the need of cross-check of results, that is very important, and the varieties of different substrates each laboratory can measure. A more detailed work plan is needed;
- 4) The time scale of one year to exploit the entire program seems to be not sufficient and it is not clear if sensors will be tested first without irradiations and then at different doses. The understanding of the multitude of results that will be obtained for the different sensors geometries and substrate will require more time than proposed
- 5) a better specifications of the target irradiation / steps for the different sensors would be appreciated, for pixel and strip detectors.

Looking to the other proposals in order to check possible synergies or complementarities with this project, I noticed that the level of detail of the programs is very different, some are very detailed and it is easy to understand the plan while others have very general planning without sufficient details: this makes difficult to judge if there are unnecessary overlaps.

Ref 3

This proposal as such is an important contribution to the tracker upgrade. It addresses crucial design parameters of the sensors for a new tracker which need to be studied before a choice can be made. The proposed close collaboration with Hamamatsu will certainly be useful for the tracker. The proposed approach to look at different combinations of sensor geometry and materials has been very successful in the R&D phase for the current tracker. However, at that time the group involved in these studies was concentrated at CERN while now there are many different groups involved in this proposal. The proposal is rather vague about how the work will be organized. A related issue concerns overlaps with other R&D proposals like the one of Manfred Krammer and the one of Luukka et al. There is substantial overlap in the work plan and in the list of participants. Finally I think that the anticipated schedule is rather optimistic.

My recommendations are:

1. The proposed work should be carried out and receive the full support of the CMS tracker.
2. The authors of the proposal should supply a more detailed work plan to show how the involved institutions will work coherently towards the objectives of this proposal.
3. The authors should clarify the relations of this proposal to the other approved proposals on sensor R&D. Will the same work be part of several R&D proposals?

A more general recommendation (more to the sensor working group): one should try to include new groups into the existing R&D proposals on sensors rather than creating more proposals on the same topics. This is fairly obvious, but someone should really look after this so that we avoid a situation in which we would have to reject duplicated proposals.

Other comments:

A second supplier is probably essential for the eventual procurement of the large number of sensors which will be needed for a new Tracker. How can this be achieved or encouraged?

A one year timescale for delivery of results seems rather short and ambitious. This is encouraging but there are no details of the effort available so is difficult to judge.

The infrastructure requirements and DAQ and electronics needs are not explained. Are these all available in the participating labs?