

CMS Upgrade MB Response to SLHC Document:

08.04: Power Distribution System Studies for the CMS Tracker, Fermilab, Iowa, Mississippi (Contact Person: Simon Kwan)

It is our intent to recommend this proposal for approval. Please see the comments from the referees.

Specific requests before final approval are:

1. Explain the relative focus of the testing program on pixels vs. strips
2. Explain which of the various powering schemes mentioned will be emphasized and which will be developed vs. evaluated as part of the proposal
3. Explain how much savings in material might be realized through transmitting control signals over power lines, including the additional receiver hardware. Also explain how much effort would be involved in developing such a system.
4. Explain how the development of the simulation tool fits into the proposal goals and schedule and the division of effort between the hardware and simulation tool development.
5. Explain how the work done in this proposal will fit in with an integrated power solution for the whole pixel detector.
6. Explain the relation and opportunities for collaboration with the work being done as part of proposal 07.01 by the Aachen group and also with the R&D program funded at CERN to work on power and involving CERN, RAL, Bonn, Krakow, PSI and Aachen.
7. Explain the relation of this research program to the Fermilab CAPTAN system, the role you envision for the CAPTAN system in this R&D program, and how components would be adapted to the CAPTAN system.

Referee #1:

Discussion of content

The hardware development is centered around a flexible Data Acquisition system called CAPTAN, which has - as I understand it - been developed for pixel module tests during the tracker production phase, and is being further extended and improved. This system will be used to perform system test measurements and possibly test beam measurements with different powering distribution schemes. It is not said explicitly but I assume that the main focus of these tests will be on pixel modules. This is certainly interesting, and not yet covered by other groups in the tracker. I would like to understand better though if and to what extent such tests are planned with strip modules as well, since here other groups are already active and we should aim for coordination.

The powering schemes mentioned cover an impressively wide range: "serial powering arrangements using shunt regulation, low dropout linear regulation, switched capacitor DC-DC conversion, and PWM techniques using air core transformers in the printed circuit board traces". However, no detail is given and it is not clear to me if this is an academic list or if this is really the list of possibilities that will be evaluated. In particular it is not obvious from the proposal if the authors intend to use commercially available components, custom components from other parties or if they plan to contribute to the development of these devices themselves. Since this is the key point in a proposal on powering, in my opinion more detailed information is needed here. Since the proposal is not very clear on this point, it is hard to judge how crucial the contribution would be and if the goals are realistic and can be achieved.

One specific item mentioned is the SPi chip developed at Fermilab (Marcel Trimpl), which the authors want to evaluate. This would indeed be a very useful contribution to the project, and the Fermilab group is of course in an ideal situation to do this.

Another line of interest is the transmission of control signals over power lines. While this is conceptually interesting, I am personally somewhat skeptical; e.g. if the effort involved really pays off in terms of material budget reduction. At least in the strip tracker (I do not know for the pixels) only a few temperature and humidity lines are transmitted electrically, and while these can be spared, receiver units must be installed in the sensitive detector area to uncode these signals.

The second part is the development of a simulation tool, which implements boundary conditions such as existing cables, and can be used to investigate failure probabilities etc. It could indeed be useful to have a more "objective" way to compare e.g. the failure risk of various schemes. In the descriptive part of the proposal this part has a very prominent position. However this is not reflected in the part on goals and schedule.

Alignment with tracker upgrade objectives and other activities

It is up to the pixel community to deliver a proposal for the powering of their upgrade detector. This should be a solution supported by the whole of the pixel community, including the barrel part. If this support is granted and a certain coordination is achieved, the activity mentioned within this R&D proposal is well suited to make a significant contribution to this decision process.

People involved

I know only very few of the people involved personally. Clearly the Fermilab CMS tracker group has an excellent record. I cannot judge for Iowa and Mississippi. The number of involved people is certainly impressive, even assuming that most of them will work on this project only part-time (the fractions of time spent on this project are not indicated in the proposal). It would be interesting to know how the man power splits into the simulation part and the hardware development part.

Goals

Three goals are specified:

Goal 1: "Review the current power distribution design of the tracker", Q2-Q4 2008.

This seems to include the simulation activity. It looks realistic to me.

Goal 2: "Produce demonstration hardware...", Q2 2008 - Q2 2009. This sounds realistic as well, since the basic parts of this hardware are already existing.

Goal 3: "Measure the effects that specific details of the power distribution scheme may have on detector performance and reliability", Q1-Q4, 2009. This goal is not very precise (see my comment above). Due to this fact, it will definitely be possible to achieve it.

Conclusions

My general impression is positive. This can be very interesting. I would however appreciate to have more information on the following points:

- How much of this activity will be devoted to pixels / strips?
- Which powering schemes will be studied, e.g. which types of DC-DC converters? Is own development work planned? If yes, on what exactly? If not, what devices will be tested?
- Manpower split into simulation and hardware development, so that relative importance can better be judged?
- In view of the particular organization of the pixels project: how is this activity integrated into the overall pixels upgrade project?

Referee #2

The proposal is topical. The project as described in the introduction (section 1) is very attractive. It is good that CMS investigates diverse powering schemes and networks from a system point of view, harnessing experience from other engineering fields such as power electronics and telecommunications. It is also good that software models are developed to analyze powering network and components failure modes and reliability with a system perspective. The proposal to maintain constant links with the current CMS system is excellent as it could allow one to model the reliability of the existing system before extrapolating to a future one.

This good impression is unfortunately limited to the introduction section. When one reads the project goals (section 5), it becomes apparent that only a subset of the activities described in the introduction is actually envisaged. Some of the most interesting aspects (such as investigation of solutions used in other fields or design of software modeling tools) have disappeared and the three remaining goals do not differ much from what is proposed in 07.01 for instance. I am thus afraid we are duplicating effort unless the scope of the project is expanded to what is described in the introduction part of the proposal.

So, to be specific, how will 08.04 collaborate with 07.01 and how will it complement it? How will 08.04 liaise with ATLAS groups working on serial powering? Where is the link to other fields such as power electronics engineering? Who will develop the set of software design tools? Can FY09 be better described?

Finally, the proposal to study signaling over power lines seems to be on the edge of the project scope.

Referee #3

The problem of power consumption and distribution for a future tracker is clearly of utmost importance.

The proposal addresses several critical issues of this problem and therefore it is of great potential value for CMS. The problem of reducing power in a SLHC tracker and bring it efficiently to the front-end modules is multidimensional and it addresses a large spectrum of issues from electronics design to mechanical layout. For instance, the validation of any solution in the real environment of the CMS tracker will be absolutely necessary and can already be started with existing modules and read-out systems.

Nevertheless a very similar R&D activity has already been started in the tracker community and is currently being coordinated within CMS by the Aachen group. This Aachen group is already in active contact with some of the other key players in the community, for instance groups designing DC-DC converters, and has also developed some reference test and validation benches.

In addition, a specific R&D program has been funded at CERN and as an European collaboration to study the problem and propose solutions. This is actively being exploited today by Atlas and others (CERN, RAL, Bonn, Krakow, PSI, Aachen).

For this reason, it would seem reasonable and constructive to either join or expand the Aachen activity, as to avoid duplications of work or creation of inconsistent comparisons. In both cases, an in depth discussion with the Aachen group would probably clarify issues that may already have been addressed, and avoid repetitions of work.