Referee report on Module Production Readiness Review for the Scintillating Fibre Detector on 28.07.2016 at Heidelberg, Germany

Referees

Peter Glässel (external); Giovanni Passaleva; Christoph Rembser (external); Olaf Steinkamp; Andreas Schopper

Executive Summary:

The referees thank the LHCb SciFi group for the invitation to participate in the SciFi Module production readiness review (PRR) at Heidelberg. The review has been very well prepared by the Heidelberg team and was actively supported by many colleagues from the SciFi group.

Supporting documents and presentations are available at https://indico.cern.ch/event/549600. This includes a "LHCb SciFi Module Production Guide" that will be updated on a regular basis, as well as two detailed presentations. The first provides an overview of the module design and describes the production of the tooling and the module itself, as well as the storage modalities. The second presentation discusses the organisation and available manpower, the workshop layout and available tooling, as well as the workflow and planning. Following the presentations, the review concluded with a visit of the production and assembly sites. The tooling, the produced pre-series modules as well as the quality assurance equipment were presented in detail.

The referees were very impressed by the enormous effort, careful preparation and excellent status of the production and assembly sites in Heidelberg, including preparation of the "LHCb SciFi Module Production Guide", which will be very useful also in view of sharing experience with the second production site at NIKHEF. The production of the SciFi modules is carefully planned and the pre-series production experiences have demonstrated that the process is mature. A total of 4 modules have been produced by the time of the PRR (1 dummy, 1 for the EDR and 2 for the PRR). The available personnel and facilities are adequate. All the elements to understand and judge the production steps were clearly illustrated and shown in practice in the laboratory. In conclusion, the site is ready and well prepared to start production.

Among a few comments and recommendations that are listed in the following, there is one concern that we would like to point out, which is the mirror damage when applying the longitudinal cut to the raw mats. We recommend to study this problem in detail and to find a solution before starting mass production.

In the following we list in some more detail all comments and recommendations that have been noted throughout the review by the referees.

Comments and recommendations:

Preparation of fibre mats:

The longitudinal cut of all fibre mats is being realised at the module production centres. The parameters for cutting have been studied, however some further optimization is needed. The biggest concern is that there is evidence of damage to the glued mirror at the end of the fibre mat, leading to appreciable light loss (up to 40%) for the channels at the edge. There are several ideas on how to mitigate this problem but no convincing solution exists yet. We recommend that the longitudinal cut of the fibre mat at the mirror end is studied in detail, and that a cutting procedure is validated and documented.

Production of mechanical pieces:

There is quite a number of small and medium sized pieces to be produced for the module assembly, besides the large honeycomb panels. If produced in house, which seems the current plan, we recommend that the production of these pieces is well planned ahead and done in advance of schedule in order not to risk a stop of the module production because of material shortage.

The light injection system is made of a 1mm optical fibre that is laterally scratched by hand in order to allow for the light to escape the fibre and to illuminate the SiPMs. We recommend that this manual scratching is replaced by some automatized procedure that guaranties a uniform machining.

Module and part design:

As far as the tolerances are concerned the module "pitch" is defined as 529 mm and the width of the cold box as 528 mm, which leaves a clearance of 2 mm between two modules. This clearance has to absorb the tolerances for the machining and assembly of the side covers. Even though this looks adequate, we recommend that all tolerances should be well defined, documented, and monitored during the Quality Assurance, especially in view of the different than expected thickness of the black polyamide foil, the final position of the longitudinal cut and the tolerance of the U-shaped side covers assembly.

In addition, the interface with the cold box should be double-checked with NIKHEF, also in view of the outcome of the cold-box EDR (cold box sealing).

Module assembly:

The required number of modules, including spares, was quoted as 162 (128+24+10). This requires a total of 1296 fibre mats, which is exactly what was quoted in the fibre-mat PRRs as the number of mats to be produced. We recommend that the production yields, quality and losses are carefully monitored throughout the series production in order identify possible shortage of fibres and/or fibre mats at an early stage.

The overall assembly procedure has been very well defined and many details have been studied and optimised. It looks as if some bending of the fibre mats along their width (of up to 4 mm) can be accommodated for in the assembly procedure. Some further optimization will probably be made during the early production phase (e.g. the gluing of the U-shaped side walls), but the currently defined procedure is already very adequate.

Quality Assurance and Data Base:

Q&A tests are well defined and cover all the critical aspects of the assembly. In particular, the linearity of the alignment pins and the parallelism between mats are important parameters.

We recommend that during assembly, the samples for each batch of critical materials like glues, carbon fibre pieces, etc. are kept and that data of the batches (vendor, date of shipment, etc.) are saved in the database and attached to the corresponding module data. This may turn useful in case of problems in the future.

In the test procedures there was no mentioning to weight every module. We recommend to add this and to include the data to the documents.

We felt that the exact procedure and tolerances for final qualification and categorisation of a module need still to be established and agreed. These criteria will also be useful to select the type of module, e.g. beam-pipe modules, modules at the sides of the detector, etc.

When serial production has started and some experience has been gained, we recommend to study the possibility of repairing and recovering some modules that do not fully qualify, depending on the fault. Thus a “repair threshold” and procedure would help, especially to synchronise experience and expertise between the module production sites at NIKHEF and Heidelberg.

We recommend that a test of the deformation (bending) of a module when hanging, in particular due to the displaced centre of gravity, should be given high priority. Should this turn out to be a

problem, it might influence the design of the interface between the module and the support structure.

Infrastructure:

The lab and workshop infrastructure is fully adequate for the production. Assembly space is large enough, and there is adequate storage space.

Schedule:

Within 5 working days 2 modules can be produced in serial production at one production site. With this output of 2 modules per week from Heidelberg and another 2 modules per week from NIKHEF, all modules needed for the full detector (without spares) can be produced by January 2018, which matches very well the fibre mat and fibre delivery schedule.

Manpower:

The assembly is quite manpower intensive but the available personnel seems adequate. Manpower is shared with ALICE TPC endcap production which allows for efficient sharing of resources but might cause problems if one project runs into trouble or requires more resources than expected. We were assured however that additional manpower could be made available at Heidelberg in a situation of crisis.

Risk assessment:

In principle, if the fibre mats are handled properly, there should be no major risk in the panel assembly. As already mentioned earlier, the most critical operation is the longitudinal cut. An early estimation of the yield of good cut results is crucial, which in any case should quickly reach the (close) to 100%, to allow for the timely order of additional material (fibres), if needed.

We recommend that all elements required for performing the longitudinal cut are once more reviewed in detail to minimize any risk of damage of the mats (e.g. frequency of cutting blade exchange, alignment and protection against unwanted movements, well trained personnel over whole production period, etc.).

We also recommend to assess the risk of exchanging parts or using wrong parts during assembly. It should be checked that the various parts to be assembled are built in such a way that the assembly mistakes (like e.g. part exchange, wrong glue, misaligned mats, etc.) are minimised, and to what extent it might be possible to recover a wrongly assembled module (see also Q&A).