Reply to questions

FASER Collaboration

LHCC referees meeting

26/11/2018

l. 563: I would like to know if the 80 SCT modules you will get from ATLAS are all the available ones, or are there more spares that ATLAS will keep? Is anything known about the state of the modules, and how they have been treated since the production?

There are 196 spare barrel modules and 138 spare endcap modules at CERN. These have been stored at room temperature in B304 since passing acceptance tests, housed in special cases (aluminum for barrel and plastics for endcap). The QA tests which we are now starting are the first tests since the detector was constructed.

l. 710: how much influence has the threshold on the position resolution? Do you rely on charge sharing between strips, and does this work with this threshold?

A binary output against the threshold is obtained for each strip, which results in less information on charge sharing than for analogue readout. The SCT usually set a threshold of 1fC, and the average number of strips with a hit for a particle parallel to the lorentz angle is around 1.2, which implies that the charge sharing is not a big effect. The charge sharing effect is taken into account for Monte Carlo, but given the low number of strips per particle, not in the default ATLAS reconstruction of the space-point positions.

l. 745: what is the expected noise rate of the veto scintillators with settings that require 99% efficiency? Is 2 layers really enough, or did you consider to have 3 for better redundancy?

We have been in discussion with the scintillator experts in the CERN DT department, who tell us that given the thickness of the scintillator (2cm) a large light output for MIPs are expected and the noise rate per scintillator should be O(Hz) and therefore not an issue. Since we record the full waveform, we can in addition adjust the threshold offline and will likely be achieve higher efficiencies than 99%. In total we have four scintillators in the veto (two in front and two behind the lead block) which should provide sufficient redundancy. However, it might indeed be very well be worth constructing the support structure so that we can add a third station later.

l. 765: is it a potential problem that the trigger scintillator layer has a small dead gap exactly in the middle? Or is it planned to position the trigger layer such that the expected beam position is not hitting that gap?

The gap is in the center of the aperture and will be about 1.5mm. There is redundancy in the system since we have two trigger stations and the calorimeter. The inefficiency can also be avoided by having an offset between the scintillators and then a small overlap (increasing the material in the tracking volume) or by constructing the scintillators with matching slope in the overlap region (slight increase in construction complexity). Full simulation studies will determine the need for this.

l. 879 ff: Could you point out more clearly what are the requirements for
a) the precision with which you have to know the alignment of the components and
b) the precision of the actual alignment.
I assume that for example you can determine the position of the SCT layers later on with muon data quite well, even if they are not perfectly positioned, while the magnet positioning probably has to be very precise, and can only be determined from a survey?

We will place the magnets with respect to each other and to the LOS with ~1mm precision which is adequate for the physics. This should be fairly simple with the detector support structure and the degrees of freedom this allowed to move for the magnets. (Note that when we measure the magnetic fields on the surface we need to make sure that the magnet support pillars are oriented with respect to the bending plane precisely, such that the bending plane of all magnets will be precisely aligned).
All detector components can be placed with an alignment of a similar 1mm precision (although better should be achieved).
We would then survey the alignment of the tracking stations to know their relative alignment position (especially in the bending plane) to of order 100um. The alignment between tracking stations in the bending plane will determine the momentum resolution and a 100um level alignment corresponds to a 100% momentum uncertainty for 650 GeV particles.
The alignment between SCT modules in a tracking plane will be done to good precision using muon tracks in data, utilizing the overlap between modules in a plane. The alignment between tracking planes in a tracking station should also be possible to good precision with muon tracks in data, as these planes are close together, and one can use a straight line approximation for tracks in this region.
Note that although it is very useful/nice to have good momentum resolution at higher momenta it is not necessary for the new physics searches that we concentrate on.

l. 937: you mention only one fibre connection here both for data and DCS signals. In line 1403 there are at least 2 fibres for data and commands, but even that does not include any redundancy (as I think it is good practice to de-couple your DCS signals, that might be needed to protect you detector in critical situations, from your normal data transfer). Since usually the increase in cost is only minor if you add another cable/fibre from the beginning (at least compared to replacing a damaged one much later) I wonder if you considered to add a spare connection?

We will indeed ask for spare fibers, but we have not yet managed to discuss with the experts from the relevant CERN group (EN-EL-FC) on how many fibers they normally pull. At the moment it is not foreseen to have a separate network connection for DCS which would require two more switches and a slight more complex networking setup. After a recent discussion with a DCS expert we are considering that option.

l. 946: is this signal available already in the TI12 area, or do you need a new connection to point 1? If the second one is the case, is the cost included in the "TBD" in Table XVII?

The signal needs to be transmitted to TI12 over a new fiber connection to SR1 (surface building in point-1) where it can be connected to the signal coming from the cern control center in Prevessin. The cost for this would be included in the TBD in Table XVII, although this cost is not expected to be very high.

l. 970: If you need to use the "AND" of the two scintillators in the trigger, is the resulting efficiency high enough for your requirements?

Since the signal has a pair of particles, the scintillator efficiency should be above 99% per layer, above 98% per trigger station and above 96% if we have to do an AND between the two trigger station. Additional redundancy is provided by the calorimeter, so we don't expect a large trigger inefficiency.

l. 979: I don't understand how sampling also the LHC clock helps to overcome the intrinsic resolution of 16ns of the digitiser and improve it to better than 1 ns

The digitizer samples at 2ns while the trigger logic only provides signals in steps of 16ns. Sampling the clock with the same digitizer as the PMTs one can measure the time difference between the edge of the clock signal and the timing PMTs to at least 2ns and by waveform fits it should be possible to do better than 1ns.

I. 991: is there any documentation available for the UniGE USB3 GPIO board?

Unfortunately no formal documentation exists for the board, but the block diagram and the small description given in the TP. This is something that will be added in the near future. But what we have is the following :

- full schematics, BOM & gerber files for PCB manufacturing and components assembly;
- full functional test setup with HW adapters, FW for testing (to be downloaded into FPGA) and automated script for testing the board after assembly. This test covers 100% of the components used for the FASER requirements (except for the Ethernet but that will be added to functional test once ready);
- VHDL library and a FW skeleton as a starting point for the user of the board (FPGA I/Os, USB wrapper – and later Ethernet wrapper);
- JSON editor for the description of the HW interface connected to the FPGA : this is used by the general and versatile readout application in order to provide access to FW & HW feature of the board : as a starting point also, no SW is required to be written in order to access to slow control & readout.

l. 1113: I was a bit surprised that you mention here Cat5e specifically. Is there any reason not to use Cat6 or better?

Indeed this was a mistake Cat5e must not be used, Cat6 or Cat7 SFTP are the minimum.

fig. 42: do you have enough person power for firmware and DAQ software development available (or interested)?

We have an electronic engineer, with firmware experience from UniG who will write the firmware for the TLB and the SCT readout modules (for the later with help from Yosuke/Hide who have experience in the SCT readout in ATLAS). Yannick (who designed the board being used) will give overall guidance for both projects. Given that the actual logic in both TLB and SCT readout boards is rather small, we believe this will be sufficient.
For the DAQ software we have some expertise in the group and a few people who can contribute to this (Brian, Anna, Enrique, Eric, Dave). In addition we are looking at existing DAQ frameworks to see if there is something we can base this software on to save resources.

fig. 47 and 48: it looks to me as if the calorimeter PMTs stick out a little bit from your trench. Is that correct? If yes, is it necessary, or could you make the trench a bit longer?

Due to the slope in TI12 and the fact that the PMTs are in the centre of each calo module, they will be above the ground (before any digging), so they can stick out from the trench without problem. This has been checked by the 3D integration model of the setup. We want to minimize the digging required in order to save time in the schedule.

l. 1343: what does "No allowance made for network service diversions." mean?

Here network services refers to any needed services. For the CE works this was concerning ventilation from the EN-CV group, as when this text was written the civil engineers had not had a chance to discuss with EN-CV, and so were not aware of possible stoppages in the ventilation during LS2. They have now discussed this and there are no expected stoppages that would affect the CE works.

l. 1395: have you considered using a 32A cable instead of 16A, to have a bit more margin for some components needing more power than you expect?

The 16A power is the nearest available power to TI12. It is therefore the easiest to install for us, and it will cover our needs for FASER operation. However the temporary power for the CE works will need 63A (this is relatively new information to us), and so it maybe that installing 63A as permanent power and using that for FASER operations is easier than installing 63A temporary power, and then 16A permanent power. We will discuss that with the relevant CERN team (EN-EL).

l. 1423: why is there no surface test foreseen with the magnets installed? I don't know if you could measure cosmics like that, but even if not you can test if everything runs together smoothly and stable in the presence of the magnetic field.

This is a good point. We had originally foreseen a dedicated cosmic data taking without magnets and a dry assembly with magnets. It is true however that we should test the full system running including with the magnets installed on the surface. We should be sensitive to some level of close-to-horizontal cosmic rays although at very low rate. We have updated our planning to foresee such a test.