Comments To Phase1PaperDraft_v3

Feb 8th

General comments

• There is some inconsistency in the use of past vs present tense. Katja has already identified several instances. I noted a few more. I suggest you review the paper once more and make the text uniform. Actions that refer to the past (the detector was installed) should use past tense. Properties identified in the past but valid anytime (for example the current depends on voltage) can be described in either in past or present tense. Please choose one approach and follow it. → done.

• I would define once and forever the detector: upgraded pixel = Phase 1 pixel = detector and use one term throughout the paper
→ done on L57, changed in Section 2, 3, 5

• In various places adjectives like good, excellent, poor, ect are used. I think we should avoid this, as they don't carry any specific meaning so they don't help in describing the detector's performance quantitatively
→ ok, changed or removed where appropriate. Left in cases where the meaning is specified in the previous/next sentence.

• I think you should introduce the definition of Run2, Run3,... LS1, LS2, ... at the very beginning, with the corresponding years. If not, you end up introducing it several times in the paper in convoluted sentences. While reading the paper I didn't think of checking the glossary since Run X is not an acronym.
→ok. Done. (Run 2 removed from text)

Line by Line

• L52 add 'up to a maximum pileup'

• L56 we should introduce the concept of Run2, Run3,.... → does not seem to be necessary, since only Run 3 is used and already defined.

• This last sentence is quite convoluted. How about "In order to maintain efficient and robust tracking till the end of Run 3, the original pixel detector has been replaced by a new system referred to as Phase-1 pixel detector throughout the paper. The installation of the Phase-1 pixel detector took place during the LHC winter shutdown of 2016/2017."→ ok, changed.

• L70 Thanks for having removed this type of references (which I don't find suitable to a paper since they don't point to the proper sections). I suggest you remove this one as well. → ok, removed

• L81 "whole pseudorapidity". "Whole" with respect to? I suggest you state "over the pseudorapidity range |eta| < 2.5". → ok

• L82 but aslo --> and

• L82 drop 2014 (assuming you've introduced LS1, ..) → ok

• L83 can you specify the radius? so it is easy to compare to the radius of the pixel a few lines below → ok

• L87 I think we have already discussed this but I don't find it in your answers to older comments. I think we should use center of the detector here and not interaction point given that the interaction point changes → ok

• L90 I still think you should remove "hybrid" since modules in the later part of the paper refers to the sensor+ROC+hybrid. So what is the hybrid module? → removed.

• L96 I would remove "mechanically". → ok

• L177 Should we have the citation for the DC-DC converters here? → no, why?

• L128 please add "compared to the original pixel detector" → ok

• L129 since you talk about radius, you have to state "with respect to the beam line or z axis" (you cannot reference a radial distance to a 3D space point) → ok
• L129-135 I think this paragraph needs some rewording. Firstly, I would show the expected dose for L1 for both 300 and 500/fb in the table. Secondly, here I would write "... as shown in Table 2. The Phase-1 pixel detector is designed to cope with a maximum dose of XYZ MRad. The L1 will therefore be replaced in ...."
→ In an earlier version of the paper, we did show the fluence for L1 both at 300\inv and 500\inv. This has been changed based on request. Prefer not to change it back again. Also the text states already that the fluence for 500\inv exceeds the operational limits and that we therefore need a replacement.
• L157 this is an example of 'excellent' which is not suitable for a publication. I would replace it with "optimal", indicating that we defined a metric and modify the design to optimize it → agreed and changed.
• L159 again here, I think we should beam line? → ok
• L176 therefore less affected --> therefore are less affected → ok
• L177 higher signal charge after a high --> high signal charge even after high
• L190 covering needs an object after that. Given that including that will be complicated I suggest you drop 'covering' → ok
• L191 eventually --> that may → ok
• L205 Phosphorous, small case → ok
• L239 what is a good efficiency? please add a numerical value → prefer not to add number here, as the measured efficiency depends on luminosity. Changed to "high efficiency"
• L240 would drop 'collected in 2017 and 2018'. It is not relevant (the dependency is on the amount of luminosity and not on when it was collected) → ok
• L282 I suggest "include a larger ..." → prefer to keep as is to have nouns in the list.
• L301 This sentence may not be clear to non experts. You mention simulation and collision data. Can you try to clarify? A possibility may be "Based on the same simulated architecture, data losses in FPIX and outer BPIX layers are smaller than 2% at the expected maximum hit rate of 120 MHz/cm2 in pp collisions"
→ This is not what it means. What we meant to say is that the simulation is for proton-proton collisions and not for X-rays. Changed the sentence to: "Based on the same architecture simulation but now using simulated proton-proton collision events, the data losses in FPIX and in the outer BPIX layers are less than 2% at the expected maximum hit rate of 120MHz/cm2."
• L320 drop "in the innermost layers". By adding this you are re-defining the deployment of the chip which you nicely introduced with the table earlier on. → ok
• From here till the end of the section: There is some inconsistency in the way you present the conditions leading to loss of efficiency. In L322-323 you only mention high rates. Then on L331 you also mention that it happens at low rates. You motivate why it happens at high rate, while you explain that the issue at low rate is due to coincidence of events. The suggestions/questions are
o explain from the very beginning that issues happen at both high and low rates
o is there a 'medium' rate where the problem does not appear? If so, how can it be?
It is very hard to explain the details. It is a coincidence of two events which are likely

to happen at both, low and high data rates. Figure 7 shows very clearly that in the intermediate region the efficiency is much higher, the effect there is not very strong. We cannot explain all these details in the paper, it also would not be very useful to the readers. Every chip-designer knows that synchronization problems are nasty and must be avoided. If you really object to this paragraph we can reduce/remove it and just say that we had inefficiencies.

• L363 the sentence is a bit long. How about breaking as "stream. This is suitable ..." → ok
• L374 I know I have already commented on this but the sentence (and a similar one later on) is still not clear. How can an address set by wirebonding? I know what you mean but you have to improve the description for the paper
→ changed to: Each TBM has a 5-bit hub address. The address is defined by the voltage levels applied to the corresponding pads on the TBM. The pads are either connected through wire bonds to the HDI or to an internal pull-down resistor.

• L388 Rather than "because" you want to write "As a result of ... could be added..." → ok
• L396 "so much energy" --> significant amount of energy → ok
• L397 disturbs --> affects → ok
• L411 in LS2? Yes.
• L419 move "different mounting scheme" to end of sentence → is at the end of the sentence
• L438-439 mix of present and past tense → fixed.
• L443 what does excellent means? → removed
• L498 specify if the modules were tested while cold → clear from the previous sentence.
• L500 Semantically speaking, the procedure does not verifies, does not measures ... How about "The testing procedure includes verification of ... measurement of ...."? → ok
• L509 starting --> initial → ok
• L519 region --> range? → ok
• L519 what does safe mean? please select a different term → removed
• L524 exactly 100%? → yes
• L548 next --> following → ok
• L557 I think you should explain why you can use the values in the linear region → The decision to use 2 parameters instead of 4 was political, in went all the way to the top CMS management. The DB group objected to storing 4 parameters per pixel.
Why does not not hurt us so much. There are 2 reasons. One is that the natural Landau charge fluctuations are so big that they partly wipe out effects of imperfect calibrations. Two, the area where the charge saturates is anyway dominated by large delta-rays which spoil the resolution very much. So truncating them has actually a positive effect, and the fact that the reconstructed charge imperfect does not matter.

We have added a sentence.

• L560 'pass ..'' sounds jargon. How about "The pad and the sensors are

coupled..." → ok

• L562 "makes its way back" is also too jargonish. I suggest "The generated signal is readout by the ROC...." → ok

• L567 do you mean adopted or adapted/modified? → the latter, changed.

• L569 again, the measurement itself does not verify. It is the result of the measurement that indicates whether or not something happened. How about "The IV characteristic of the modules is determined to assess whether handling damaged the module"? → ok

• L629 I understand what you mean, but we cannot use "mechanics" as a replacement for ladder, rings, etc. Can you write exactly: ladders are ..? → changed.

• L711 excellent again :) → removed the statement.

• L753-768 shouldn't we use past tense here? → why? This is a description of the system.

• Fig 21 This figure is quite hard to interpret. I am sure we cannot re-make it, but we can try to help the reader by expanding the caption:

o Define D, epsilon,, .BG, Manual,...

o Add here too the acceptance range

o Katja's suggestion for rewording is very good → improved following Ulrich's suggestion.

• L776 I agree with Katja and I remember we've already discussed this part. We would need to know by how much the sag deviated from the specs and how we concluded that no further stiffening was required. We cannot use the argument that we have stability now to motivate a choice done in the past. If we cannot answer these questions, I would remove the statement. → removed.

• L885-888 this sentence is very long, please break it → ok

• L894 drop "inside the detector volume". The reader already understands that anything on the service cylinder is in the volume. → ok

• L917 this is not grammatically correct. I suggest, "The two-copper-layers PCBs are rigid" or you mean that the PCBs are stiffened by ...? → the former.

• Fig 27 In black and white the blocks are not visible, Maybe add an arrow? or text box? → disagree. Keep as is

• L1000 'very well' is not that meaningful. I'd remove it and leave "according to specs" → ok

• L1022 excellent → removed.

• L1139 The sentence does not flow well. I would break it after "2017". And add "The pilot system benefitted from the possibility to access the pixel detector during ..." → ok

• L1146 something is wrong. What do you mean by "offline systems"? → changed to DAQ.

• L1167 drop "signs of". This is too colloquial. You can just have "monitored for SEUs" → ok

• L1188 the issue with the address is here as well
→ sentence removed.

• L1231 use past tense → ok

• L1245 should we define P5? → removed

• L1270 drop "were found that" → ok

• L1295 I agree with Katja → changed.

• L1297-1304. I find this part quite hard to read. Can you please write shorter sentences? You could have:

o In order to minimize further potential damage, the second

half-cylinder was tested by leaving the detector on and cooled while the CO_2 system provided   coolant at an adjustable temperature. The temperature of the coolant was lowered in $5 \circ C$ steps. As a result, only 0.02% of pixels were found lost. The CO_2 system at CERN provided cool-down   rates smaller than $1 \circ C$/min and no increase in bump-bond loss after reassembly and   testing at CERN was noted.
→ ok, done

• L1309 Agree with Katja's point → see answer to Katja
• L1313 here again do you mean adopted or adapted? → adapted
• L1369 The figure does not show the tolerance. Please explain the figure and then draw conclusions. → changed "tolerance" to "space"
• Figure 40 please improve the caption. The figure does not show the tracking system, it show vertices/hits/...? → ok
• Figure 41 Please add a legend or an explanation to the caption: different curves correspond to optical links → ok
• L1415 you never use "detection threshold" before, it may be misleading. → removed.
• L1527 the 10um is on what? → wrt CMS coordinates
• L1550 I suggest "In the 2017 data taking ..." → ok
• L1555 "It was decided" is a bit too informal for a paper. How about "To avoid any damage to the DC-DC converters (see Section 10.4 for more details) power cycles were done only during the LHC non-collision periods in 2018. This was achieved by ...." → ok
• L1561 I would like to simplify this sentence as "The pixels are calibrated by ..."Also you don't need to explain again what calibration means (L1563, you have a section on that). → ok
• L1566 The cluster does not represent the charge. A cluster is a set of hits. Please improve the sentence, → changed
• L1577 what is a broken cluster? Also in Fig 44 → changed to split clusters
• Tab 5 I am wondering whether it would be worth reporting LAs for all layers? Or state at least how others behave? → after previous comments it was decided to only show the results for L1.