Type A. English/Style/Formatting (including figures)

Abstract:

L III-IV: “The design of the upgraded CMS pixel detector allows to cope with the higher instantaneaous luminosities that have been achieved by the LHC after the first long shutdown of the accelerator.” There appears to be missing word(s) in this sentence, and ‘instantaneous’ has been misspelled. → ok, rephrased. Typo fixed.

L V-VII: “The upgraded detector has higher tracking efficiency and lower masswith four barrel layers and three endcap disks to provide a hit coverage up to absolute pseudorapidities of 2.5.”It is implied by the context, but the way it is phrased, that the first clause refers to the phase-0/original pixel detector. Would suggest making it explicit as the sentence does not otherwise flow. Suggest: “Compared to the original pixel detector, the upgraded detector has a higher tracking efficiency and lower mass, and consists of four barrel layers and three endcap disks that provide a hit coverage up to absolute pseudorapidities of 2.5.” → ok

Section 1:

L79: “... readout electronics and dataacquisition system,as well as the power system and cooling.” Missing comma.--> ok

L90: "29mm, 68mm, 109mm, and 160mm" -> "29, 68, 109, and 160mm" → ok

L91: "291mm, 396mm, and 516mm" -> "291, 396, and 516mm" → ok

L106: “This scheme allowed for installingthe installation of the CMS …”Improved phrasing - clearer tense for the verb. → rephrased

L126: “In order to optimize the tracking and vertexing resolution, it is crucial …”Missing comma. → ok

L127: “Despite the additional sensor layers, the …” Missing comma. → ok

L135: “… from the beam line, the …” Missing comma. → ok

L139-140: “Therefore, a replacement …” ‘Therefore’ is usually followed by a comma when the following text is a clause. → ok

Section 2:

L118: “In particular, higher bandwidth electronics isareneeded to be able to …” Electronics is plural? → plural. Changed.

L141: “... four times less,and hence the outer layers of BPIX …” ‘Thus’ is usually followed by a comma when the following text is a clause. → ok

Line 156: “... of the silicon sensor,a high-density interconnect …”Added comma for better phrasing of the clause. → ok

Section 3:

L173: “The sensors of the BPIX and FPIX detectorswere …” Plural - two different detectors → ok

L179: “… follow the so-called n-in-in …”‘so-called’ is more formal than ‘so called’ (and is used on Lines 198 and 201 → removed “so called” following other comment.

L186: “… collect the charge, which is also of advantage as it allows to operate …” Final clause could be phrased better. Proposed rewording: “… collect the charge, which also allows the advantage of operating the sensors under-depleted.” → rephrased following another comment.

L190: “In n-in-n sensors,the …” Added comma → ok

L190: "as large area implant" -> "as a large area implant" → ok

L192: “... towards the device’sedge,a series …” Missing associative punctuation and added comma to make clauses clearer. → ok

L201: “In case of the BPIX sensors the n-side isolation …” Start of the sentence seems to be missing several words. Propose: “In thecase of the BPIX sensors,the …” → ok

L216: “Therefore,…” Comma usually follows ‘therefore’ when the following text is a clause

L218-219:Two requirements not one? Phrasing seems odd given the previous sentence (and in general). Propose: “The most critical requirements were that of a maximum current of 2 mA and a temperature of +17C at 150V reverse bias voltage.” → no, one requirement: Current less than 2mA at a bias voltage of 150V, measured at room temperature. Changed to “…, measured at a temperature…”

L220: “The FPIX sensors are usinguseopen p-stops for n-side isolation.” ‘Are using’ indicates something is happening currently, but potentially temporarily. ‘Use’ is more appropriate here. → ok

L222: “… the p-stops,electrons will accumulate …” Insertedcomma for better phrasing. → ok

L223: “The grid’sresistance depends …” Original sentence has no subject -inserted subject to avoid potential confusion. → ok

L225: “… of the p-stops,the distance …” Insertedcomma for phrasing. → ok

L232: “By design,the position …” Insertedcomma for phrasing. → ok

L237: “… magnet,the Lorentz …” Missing comma. → ok

L243 “… is,to a large extent,defined …”Whilst the sentence works without added commas, I think they improve the phrasing of the clause. → ok

L246: “After the replacement the new innermost BPIX layer…” The replacement of what? No clear subject is confusing. Propose: “After replacing the original pixel detector,the new innermost BPIX layer …” → changed to: “After the replacement of the innermost layer during LS2, the new innermost \bpix

layer must withstand a fluence that is expected to be about twice as high until the end of Run~3. In order to maintain a high enough signal charge, the pixel detector power supplies will be upgraded to deliver a maximum voltage of 800\,V."

L316: "In the PROC600,the pixels …" Insertedcomma for phrasing. → ok

L340: "… buffer is full,the double …" Inserted comma for phrasing. → ok

L341: "… column does notlongeracquire new hits …" Grammar. → rephrased based on other comment.

L350: "During operation,reset signals were sent …" Insertedcomma for phrasing. → ok

L357: Would it be better to separate the two independent clauses into two separate sentences? → ok

L396: "However,…" When 'however' is used to start a sentence, it must be followed by a comma. → ok

L407: Appears to be a missing word. Propose: "... revealed avulnerability to …" or "… revealed vulnerabilitiesto …" → ok, former.

L412: "Because of a design issue in the TBM,a single transistor …" Inserted comma → ok

L536: "At the same time,the address of …"Added comma for better phrasing. → ok

L540: "ThenThe trimming procedure was thenperformed." Instinctively 'then' should not occur at the start of the sentence starting a paragraph - having it later in a sentence improves the flow. → ok

L567: "It is sufficient to consideronly considerthe …" Swap 'consider' and 'only' – instinctively flows better. → ok

L570: Same as L540 comment. → ok

L621: "… were too highsensor leakage currentsthat were too highor …" Suggested rewording instinctively flows better. → ok

Section 4:

L638: "In both BPIX and FPIX,the sensor …"Missing comma? → ok

L717: "… process,high-precision…"Missing comma. → ok

L723: "… during production,a long term test …" Missing comma. → ok

L754: "… dummy heaters,and …" Missing comma → ok

Section 5:

L845: "… (SegmentsB+C) …" Surely plural? Unless I've missed that Segment B+C is not a combination of two segments, but actually a singular segment called B+C? → ok

L848: “For monitoring purposes,the BPIX …”Missing comma. → ok

L864: “In FPIX,most of thistheseelectronics is implemented …” Missing comma, and mix of singular pronoun with plural noun (both should be plural to be consistent). → ok

L877: “… full CMS pixel detector DAQ,together…”Missing comma. → ok

Section 6:

L888-889: “… experimental cavern,and areconnected to the …” Unnecessary Oxford comma – improved phrasing by removing comma and adding ‘are’. → ok

L892: “… cable channels.; Aand secondly, the …”Generally better to avoid sentences beginning with ‘And’ if at all possible. As this is a two point list, replace full stop with semicolon to avoid this. → ok

L896-897: “… drops along the cables.andIn particular, this ledto unacceptable Ohmic losses, which …”The sentence feels overly long. Suggest that the clauses be split into two separate sentences as indicated above. → ok

L898: “Therefore, the CMS Phase-1 pixel detector powering is thereforebased …” Original phrasing feels off. → ok

L913: “… of 1-2MHz,and in this …”Missing comma? → ok

L915: “… on pulse width modulation,and act …” Unnecessary Oxford comma. → ok

L963: “… to 2.0 and 2.3A,for DC-DC …” Comma is not necessary. → ok

L970: “… in FPIX,two DC-DC converter pairs…” Missing comma? → ok

L982: “… adaptations in orderto be compatible …”Improved sentence flow. → ok

L991: “The sensorwires however, areused to measure …” Surely ‘sensor wires; and not ;sense wires’? Changed ordering of ‘however’ and ‘are’ to improve sentence flow. → no it is “sense wire”. The wire used to sense the voltage. Order changed.

L992-993: Unnecessary comma between clauses. Also, the flow of the two clauses in this long sentence could be improved by separating them into two sentences. The latter clause could be merged with the subsequent short sentence in Line 993. Propose: “The sensor wires however, are used to measure the input voltage of the DC-DC converters. Thisinformation is used in a slow control loop, which can be enabled or disabled, to adjust the output voltage such that the voltage drop on the cables is compensated.” → ok

L999: “During LS2,the power …”Missing comma → ok

L1005: “In general,the power system …”Missing comma? → no comma

L1010+1022: Is there a prefered style to refer to the shutdown period? i.e. ‘shutdown 2017/2018’ in the text seems clunky compared to ‘2017/2018 shutdown’ → rephrase for first instance, adopted for second instance.

L1024: “In LS2,the DC-DC …” Missing comma? → ok

Section 7:

Figure 28: suggestion to split the top and bottom figure as separate figures. → Prefer to keep in one figure as the numbers in the top and bottom part belong together.

L1073: "… operation of the cooling system,even during maintenance …" Missing word and comma. → ok

L1090: "… transmitter,and a backup chiller …"Missing Oxford comma. → ok

L1092: "… pressure flowmeter,and a needle valve." Missing Oxford comma. → ok

L1097: "… phase return pipe,and vacuum …"Missing Oxford comma. → ok

L1099: "-straints,the transfer lines connecting …" Missing comma. → ok

L1112: "… accumulator,and the …" Unnecessary Oxford comma. → ok

L1116: "… in March 2017,the cooling system …" Missing comma. → ok

L1123: "… pixel detector,a …"Missing comma. → ok

L1131: "… -perature,or heat load …" Missing Oxford comma. → ok

L1135: "Based on these results,the mass flow …" Missing comma. → ok

Section 8:

L1141: Same as L1010+1020 wrt. EYTS → kept

L1158: "… TBM design,and jitter …" Unnecessary Oxford comma - list too short to require clarification. → ok

Section 9:

L1177: "In this section,the integration …" Missing comma. → ok

L1188: "… Zurich,where reception tests …"Missing comma? → ok

L1190: "… qualification results,a mounting map …"Missing comma. → ok

L1196: "In the next step,the micro-twisted-pair cables …" Missing comma. → ok

L1198: "In the final step,the four layers …"Missing comma. → ok

L1206: "… for power, cooling,and readout." Missing Oxford comma. → ok

L1208: "… motherboards,and the adapter boards …"Missing Oxford comma. → ok

L1209: "ThenThe cooling tubes were thenlaid in …" Sentence and paragraph flows better when placing 'then' later in the sentence rather than at the start of it. → ok

L1210: "The DC-DC converters were subsequentlyscrewed on top of the cooling

bridges.” Replace ‘then’ with subsequently to avoid identical sentence structure. → ok

L1223: “… trigger distribution,and to ensure …”Missing Oxford comma. → ok

L1234: “Within the transport boxes,…” Missing comma. → ok

L1238: “After the assembly,the complete …”Missing comma. → ok

L1243: “If accessible,the few …” Missing comma. → ok

L1245: "dead" -> "non-functional" (dead seems jargon, and is a little morbid) → ok

L1249: “After thetransportation, the system was tested …” Reworded so that the sentence flows better. Also added missing comma. → ok

L1252: “Anissue with some groups of modules drawing too high current was observed during the cold test.”Rearranged the sentence so that it flows better. → ok

L1253: “After detailed investigations,the issue …”Missing comma → ok

L1256: “… in the affected area,the issue was resolved …”Missing comma. → ok

L1281: “… were installed, cabled,and tested.”Missing Oxford comma. → ok

L1297 “… testing,and final …” It is unclear if there is a missing Oxford comma or not due to the previous commas. → ok

L1306-1307: “… on the top and bottom,that weredesigned to insert …” Improves the flow of the sentence and paragraph. → ok

L1308: “… 5mm,with respect to the beam pipe,is ensured …”Missing commas? → ok

L1310: “… the pixel detector,the muon detector …” Missing comma. → ok

Section 10:

L1373: “… optical fibers,and cooling lines …”Missing Oxford comma. → ok

L1376: “During the course of data-taking,the detector is …”Missing comma? → ok

L1381: “… measurements,as well as the …”Missing Oxford comma. → ok

L1386: “… the detector modules,the delays …”Missing comma. → ok

L1406-1411: Style of bullet point list is inconsistent with previous list(s) in this document. Previously, the first word of each point is not capitalised and all points, except the final one, end with a semicolon. → ok

L1419-1420: “... the more effective isthe charge sharing …” Improves flow of the sentence. → ok

L1424: “Within ROCs,pixels …” Missing comma. → ok

L1435: “… thresholds,periodic re-adjustments …” Missing comma. → ok

L1438: “… beginning of 2018,the thresholds …”Missing comma. → ok

L1441: “After optimization in 2018,the L1 thresholds …”Missing comma. → ok

L1446-1447: Either insert comma or rephrase slightly:

o“For the PSI46digROC,the time-walk effect is small, about 300 e-”

o“Thetime-walk effect is small for the PSI46digROC, about 300 e-” → ok, latter.

L1447: “Therefore,the in-time …” Missing comma – therefore should always followed by a comma when starting a sentence. → ok

L1448: “For the PROC600,the …” Missing comma. → ok

L1455: “In addition,the …”Missing comma.

L1469: “For each pixel,pulses with …” Missing comma. → ok

L1474: “Due to radiation,the optimal signal …” Missing comma. → ok

L1477-1478: “… gain variations. Therefore,for hit charge reconstruction,the …” Separated clauses into separate sentences and added commas to improve structure and flow of the text. → ok

L1479: “In the offline reconstruction,the conversion …” Missing comma. → ok

Section 11:

L1489: “However, towards the end of 2017,the fraction …” Missing comma. → ok

L1492: “… winter shutdown 2017/2018,all …” Missing comma and same query as L1010+1020 → ok for comma

L1493: “Subsequently,the …” Missing comma. → ok

L1496: “…-tem,the granularity …”Missing comma → ok

L1497: “Therefore, modules connected …”Missing comma. → ok

L1500: “InsteadThe current will insteadflow through …” Sentence flows better with relocation of ‘instead’, and avoids inserting an otherwise missing comma. → ok

L1520: “Problems have been encountered however for BPIX L1 and L2.”Rephrased for better sentence flow. Also avoids inserting otherwise missing comments. → ok

L1529: “… measurement,the actual …” Missing comma. → ok

L1542-1543: Either add missing comma, or rephrase (which improves the flow of the sentence):

*

“However, with someprobability,vital circuits will be affected …”

*

"However, With someprobability however,vital circuits will be affected …"→ ok, former

L1556-1557: Same as L1542-1543:

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"To avoid any damage to the DC-DC converters (Section 6.4),power cycles were done only during the LHC non-collision periods in 2018."

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"Power cycles were done only during the LHC non-collision periods in 2018 to avoid any damage to the DC-DC converters (Section 6.4)." → ok, former

L1571: "… efficiencies,or beam background events." Missing Oxford comma. → ok

L1571: "In addition,the cluster …" Missing comma. → ok

L1596: "… to the sensor surface in orderto …" Improves flow of sentence → ok

L1609: "Therefore,the hit …" Missing comma. → ok

L1618: "'dynamical' inefficiencythat isexplained in Section 3.2." Improves flow of sentence → ok

L1628: "At luminosities above 1.4x1034cm-2s-1,the hit efficiency …" Missing comma. Alternatively: "The hit efficiency in L1 drops at luminosities above 1.4x1034cm-2s-1, reaching …" → ok

L1629-1630: "inefficiency ... is ... lower" -> "efficiency ... is ... higher" (avoid a double negation, it requires more time to process while reading). → ok

L1634: "Together with the efficiency,the position resolution …"Missing comma. → ok

L1639: Opening quotation mark around 'triplet" method is the wrong way around. → don't know why. Latex is correct, use: ``triplet''

L1641: "Whenever possible,this third layer …" Missing comma. → ok

* General style comment: "the BPIX" or "the FPIX" vs just "BPIX" or "FPIX" are both used interchangeably in the document when either works in context. Best to stick to one style? → ok. Use "the BPIX and FPIX detectors"

Type B. Everything else (e.g. strategy, paper structure, emphasis, additions/subtractions, etc).

* General comment: Please check for all relevant plots, whether they should be labeled as “CMS”, “CMS Tracker”, or similar, according to CMS or tracker pubcom guidelines. → This is done. The rule is that all plots that have CMS collision data or simulation have a “CMS” label, all other plots do not have a label.
→ Figure 45 add label.

* General comment: several figures are taken over from other, more detailed publications. Please always make clear in the captions of those figures these come from another publication, eg. for readers to cite (also) the underlying detailed publication. Several examples are given below in the detailed comments. → citations are done when needed. Most plots have so far only been published as “preliminary”

* Abstract: “higher tracking efficiency” -> “better tracking performance” (because also fake rate is needed to compare performance) → ok

* L57: “maximum pileup” -> “maximum average pileup” (because event by event it can be higher) → ok

* L103-104: I am confused on the counting of the FPIX modules. Table 1 seems to have double the number of modules than those stated in the text. However, I think what I missed is that you count both the “forward” and “backward” FPIX in the Table. Maybe this can be clarified also in the text? → The number in the text gives the number on one half disk. The table gives the number for the two disks on both sides, which is indicated by the +- z position. The number in the table is therefore 2x(forward/backward)2(two half-disks) = 4 x the number in the text. Added parenthesis in the text.

* Figure 3: has this figure already been published elsewhere? If yes, please add citation to the caption. → no, just preliminary.

* L147:Does there exist some reference that compares performance of the Phase-0 to Phase-I detector? It would be nice if you could cite such a reference to support/quantify the “equal or better performance” claim in the text. → not yet. Performance paper is in the plans.

* L185:I am not familiar with “irradiation-induced space charge sign inversion”, but I am no expert in these technologies. If it is easy to clarify/rephrase this, it could be good for comprehensibility for the non-expert audience. On the other hand, if it is standard in this field, then you can leave it as is. → consider standard.

* L230: reading this, I realized the size of the sensors doesn’t seem to be given anywhere. Please consider adding this. → Indeed! Added at the beginning of section 3.

* L236-238: there is an implicit assumption here on the tracks’ incident angle to the sensors; probably them coming in perpendicular to a good approximation for a sufficiently high momentum. We think it may be better to explicitly mention this. → don’t think it is necessary to add definition of LA

* L280-281: “allows for three pending column drains” -> didn’t understand that. Maybe spend a half sentence explaining that. → added “…., meaning that the double columns are capable of recording new hits while still copying information from the previous hits to the buffers in the periphery.”

* L324-325: for other irradiation campaigns, you mentioned the facility used; for

consistency worth adding here as well. → it is the same as for the PSI46dig. No need to repeat it.

* Figure 7: It seems like the old PROC600 with reset (yellow) is generally a bit more efficient than the revised PROC600 with reset (green). Does this not invalidate the changes made in the revised version? → No. It is probably just a fluctuation. These are different modules tested at a different time.

* L394-396:If a functionality has not been used, perhaps it should also not be mentioned? Or is it important to document this unused functionality? → prefer to keep this, as it is an important feature that still might be used in the future.

* L400: “and avoid to lose them” -> what does “them” refer to? The data, ROCs,...? Please clarify in the text. → the data. Added.

* L432:maybe also refer again to Figure 4 where these different designs are drawn? It helps to visualize these differences once again. → ok

* L479: here you use “kapton”; in the caption of Fig 9 “polyimide”. We suggest to use one of both, for consistency. → ok, use the latter.

* L499: you speak of gluing here, but have not described the gluing procedures anywhere it seems (or we missed it). If so, this is confusing, so in that case remove the reference to gluing, or add a paragraph or so describing the gluing. → Gluing step is explained for BPIX modules on L456ff, but now added a sentence also here.

* Figure 11: What is the difference between “All” and “Detector grade”? I assume the latter means “Those pixel modules that passed the quality requirements to go into the detector”, but is that defined somewhere in the paper? Somewhere around L605 would perhaps be a good place to formally define “detector grade”. → yes, this is what it means. Added definition.

* L611: “pixel mask mechanism” comes unexpected here, because not discussed elsewhere. Please add a necessary discussion where appropriate. → indeed. Added in the ROC section

* L820: “slow control” is jargon for the non-expert reader. Please add clarification. → This is what it is called also in other publications. See for example; https://www.semanticscholar.org/paper/The-CCU-25-%3A-a-network-oriented-Communication-and-a-Paillard-Ljuslin/717fe424ed395122c41ddfe98f9caaf1ad9277e8

* L1036: since you just described the advantages of CO2 cooling before, this may be a nice place to add that the used coolant has negligible environmental impact; something more and more relevant, also for experimental high-energy physics. → ok, added.

* Figure 29: what is “design pressure” in the figure? Since the operational range is 10-70bar, it’s weird to see the design outside of the range. Maybe it’s a design maximum pressure? → yes, this is what it is. Removed figure as the important information is also given in the text.

* L1107 and 1122: we think it would be good to swap these two subsections: first the mockup, and then finish the discussion on cooling with the performance of the actual system. → ok

* Figure 31: the right-hand plot does not mirror the left-hand one. For ladder number 12, you explain the measurement is probably dodgy, but what about nr 13 and 14 being low? On L1137 you explicitly say it's critical to understand things in detail, but as is the plot does not reflect such understanding. → the two loops are not exactly symmetric, so we do not expect symmetry.

* L1299: It is not clear from this discussion why you had a 0.15% loss; because the detector was too warm? Better be explicit. → rephrased

* L1353: this leaves me wonder whether a leak can close itself, or whether the original assessment of the leak may have been a false positive. If the answer is known or suspected, it may be good to add it. → Changed to: "...nor was a leak present when the detector was re-installed in 2018 leading to the conclusion that the high pressure leak was due to a connection made
during installation rather than an issue inside the half cylinder."

* L1364: with the phrasing "follows the procedure", it seems as if you redid the work from the reference. Rather, you draw from that publication, which is perfectly fine, but it should be clear you don't repeat the measurement. → The full analysis was repeated. The reference uses 2015 data.

* Figure 40: add to the caption that these figures are taken from citation [63]. → They are not. This is were we publish them the first time.

* L1443: "are delayed" -> "may be delayed" (because it depends on the signal amplitude and the phase tuning) → ok

* L1456: isn't it contradictory to lower the thresholds below the in-time threshold, when this will induce low-charge signals to fall out of the 25ns readout window? This may be worth clarifying. → There is always a an intime-threshold which is higher of the set threshold. It is like a delta added on the top of the set threshold, one cannot just go above it.

* Figure 43: was this published elsewhere already? Then please cite in the caption. → no, preliminary version shown at conferences.

* Figure 44: was this published elsewhere already? Then please cite in the caption. → no, preliminary version shown at conferences.

* L1598-1599: you describe the FPIX method, but without results. That feels weird. Could you add a sentence explaining no public results are available for FPIX, or something like that? Or drop FPIX altogether (since I guess the LA is much less important there)? → deleted these statements.

* Figure 45: was this published elsewhere already? Then please cite in the caption. → no.

* L1654: "well understood and modeled" -> in rphi data does 22% better than simulation, which looks quite a significant discrepancy, and in the opposite direction it usually goes, with data better than simulation. If it is well understood, as you say, it is worth explaining where this non-negligible difference arises from. →

It is very difficult to make simulation agree exactly with data. The simulation does not include many details of the real sensor (e.g. no electric fields). It is adjusted by smearing of various simulation parameters (e.g. noise, signal). This adjusts the simulation to one scenario, but would be wrong for another, for example if you adjust simulations to fit data in the middle of a year,
it will not fit exactly at the beginning or end. Note that CMS does not have a time-dependent MC yet.
Replace “very close” with “close”.
Delete “well understood and”.

* L1655: this sentence begs the question of whether the position resolution changes over time, especially since at several places throughout the paper the possible effects of eg. irradiation on the position resolution is emphasized. → Yes, it does but this will be explained in the performance paper.
It is a conscious choice that we made here to just give a flavor if the detector performance without going into time/historical changes. This will be the subject of the performance paper.

* Figure 46: was this published elsewhere already? Then please cite in the caption. → no, preliminary version shown at conferences.

* Figure 47: was this published elsewhere already? Then please cite in the caption. → no, preliminary version shown at conferences.

* L1656, Summary: for such an extensive paper, the summary is very short. Since some people may not read more than the abstract and the summary, it may be useful to repeat some key design and performance facts about the phase1 pixel detector. → prefer to keep as is

* L1670, Acknowledgments: we don’t know the tracker pubcom guidelines on this, but for regular long CMS papers, a much more extended acknowledgments section is used. This may be appropriate here as well. You may in any case consider to thank the LHC, and maybe even CMS? → This is the acknowledgement that we used for several recent papers.