Reviewing the document was made more difficult due to the poor formatting of the manuscript. Therefore, some of the line numbers mentioned below might be wrong and we encourage the authors to seek a solution for the formatting problems before resubmission.

A:We are sorry that the line numbers from the lineno package get pushed into the text itself. This is an unfortunate side effect of the double column layout of the journal and we cannot see an easy way to fix it. The additional “line numbers” added on the left seem to come from Springer’s processing and we can’t seem to do anything about that - they don’t match up to the actual lines in the text.

In addition, it seems that many/most of the references (only analysing the reference names) are from within the HEP community. A broader view should be taken, i.e. references from outside the HEP community should be considered.

A: We tried our best to improve the breadth of references when possible and a significant number are non-HEP. However, as the paper addresses HEP-specific needs many of the most relevant references are internal to HEP.

Some general points were mentioned in the referee reports. These might be addressed in the Introduction and/or Conclusion (or Section 2?):

Attention must be better paid to
- Carefully take into account the consequences on the computing facilities (Tiers 0 to 1) of such or such solution that may be raised from the POW and that may lead to extra cost. For instance, HPC or GP/GPU facilities if they provide more efficient (in CPU time) ways to do specific processing are much more expensive traditional HTC farms.

- extra cost that may be generated by Hybrid Computing especially if made of commercial resources.

- not to produce solutions that may lead to the set up of dedicated hardware that then may not be mutualized with other experiments yet supported by the same funding agencies as HL-LHC.

A: We hope that we clarified in our modifications that our big motivator is cost per physics. It is discussed in particular in the introduction to the chapter on facilities (3.7) in the 6th paragraph.

- Tier 1s must be part of these works at the earliest possible stage.

Even though it is well understood that this document focuses on HEP computing challenges, the proposed program does not make any reference to the European or worldwide computing for

research context. It is mandatory that all these works take into account the evolution of the e-infrastructures they rely on . This may require some closed interactions with bodies like EGI, OSG, EUDAT, PRACE, NRENs… This « collaborative » work must be more clearly identified within the relevant POW if not within a dedicated one.

A: This is re-stressed in the third paragraph of the Conclusions.

Finally, the work package relative to Security and Authentication and Authorization Infrastructure purposes a sum-up of the most important actions expected to be achieved. As these issues are beyond the scope of the HEP community and depend on the various national security policy it is of first importance that this work package is handled at the very stage of the proposed roadmap.

A: We agree and that it is what the CWP suggests. We made made the introduction and the trust & policies section more explicit about it.

Detailed comments:

Introduction
line 141: I suggest to exchange the word "contributors" to "stakeholders" + I would suggest to start a new bullet point before "by the effective"

A: This sentence was probably misunderstood, we really speak about software code contributors (i.e., developers). The text has been clarified.

line 201: please provide a reference for the "20 million lines of code"

A: We have rephrased this to be less specific and to identify the order of magnitude that we are speaking about (10s of millions). Some references were added to support this. There are no official/blessed numbers that one can cite for all experiments.

line 296: please provide a reference for "AArch64 may achieve lower power costs..."

A: Several references were added.

line 299: please provide a reference or a more specific name/example for "More extreme is an architecture that would see specialised..."

A: Several references added.

line 377: please provide examples incl. references for "which developed novel and major new technologies..."

A: Several references added.

Section 3.2:
line 684
The first action item for detector simulation seems out of place. While it is desirable to extend the validity of the physics modeling towards the FCC, this is not really a computing issue, nor does it impact the speed of simulations that will be necessary for the HL-LHC, except if by making it more accurate the result is slower code. If I go to the section on current practices, this is a bit better targeted towards improving accuracy AND efficiency. My suggestion is to at least mention software performance as a goal in this bullet.

A: The bullet point was rephrased to emphasise the software improvements, however this is a good example of a case where physics and software improvements go hand in hand (there is no point in increasing the physics accuracy if the computing costs of the new code make it infeasible to run at the required scale). We see that in many cases re-visiting the code to improve the physics performance results also in better implementations that balance, or even reduce, the runtime and we added a reference to support that. (In particular, for the Geant4 photoelectric, bremsstrahlung and gamma-conversion processes, new models improved the sampling of final state and also obtained CPU improvements at the level of 10-30 %, when on these parts of the code.)

lines 715-727: it is striking that this section (and section 3.1) discusses human resources, while the following sections do not. It might be more impactful to isolate all human resource discussions to section 4.

A: We agree and we removed this bullet, gathering all such discussions in Section 4.

Section 3.3:
line 1103: remove the double "the"

A: Thanks for spotting it, done.

lines 1212-1219+1221: in lines 1212-1219 you speak of algorithms etc., but in 1221 you talk about educating physicists in modern coding practices - NO, these are two different things: algorithms and coding practise is like theoretical and experimental particle physics; both are connected but require different educational profiles. Concerning algorithms I advise that HEP stronger collaborates with computer science, which are experts in algorithms.

A: We rephrased this point to make the distinction clearer and also agree with the assessment that working with computer scientists is very important.

The last piece of the R&D program, l. 1320, is not very specific. It would be useful to sharpen up the deliverable here, rather than using an "e.g. charged particle tracking" and "a number of such efforts"

A: We have added a reference to the longer working group paper that contains further details.

Section 3.4:
“Scope and Challenges”: I’m sure that HEP Data Management also adheres to the FAIR principles. This is a much used buzzword, but not using it here in this context might raise the question why. Hence, you should make a conscious decision whether or not to mention these FAIR principles.

A: A sentence was added to clarify, with a forward reference to the section on data preservation.

line 1334: “quasi-real time”; perhaps better: “near real-time”

A: Done.

The first piece of the R&D "enable ... to be plugged in dynamically" could do with some more specificity. The bullet is very general. Is it in conflict with the 3rd to last about interacting and exchanging data?

A: We don’t think there is a conflict but we tried to clarify the text and added a reference.

line 1371: provide examples (incl. references) for "...emergence of new analysis tools coming from industry and open source projects..."

A: Done.

line 1386 ff.: This is also called “provenance”. You might want to use this term here.

A: We added a few words to make the connection with “provenance”.

lines 1476ff.: please provide references for each given example technology

A: References added.

line 1569: I would have expected more milestones, e.g. in the direction of uptake of the software (or at least an evaluation) mentioned above or integrating/interfacing them in existing environments

A: It is true that there are few milestones here, but this does reflect what the sub-section authors felt was realistic to add when the section was written. In data analysis the next few years (and

2020 milestones) are crucial as there are a number of prototype studies that will happen, after which subsequent development goals will become clearer and the next milestones will be better defined. So, no change made.

Section 3.5 (Machine Learning):
line 1636: “… most CPU intensive elements …”; GPUs are apparently well suited for at least some of the ML algorithms. You might want to mention them here.

A: The sentence preceding the bulleted list was altered to make this point.

line 1710: “HSF IML”; for better readability, you might want to write “HEP Software Foundation IML” here.

A: In fact, it was the next mention about HSF IML (l1710) which was wrong. Fixed.

Section 3.7:
line 2150: please provide a reference for "two orders of magnitude..."

A: Reference added.

lines 2153-2161: it would be good to have some "test projects" for SDNs in HEP, but nothing could be found later in the R&D programme from line 2242 ff.

A: Some references to ongoing projects were added, as well as a milestone which was obviously missing (it is already work in progress in fact).

lines 2238-2241: please update the numbers and the reference, which is from 2017

A: We have not been able to find another reference that gives the same overview and, through informal communication with the WLCG project leaders, there was no substantial change in the last year of LHC Run 2. So this was left unchanged.

lines 2257 + 2301: will these working groups be part of HSF or somewhere else - in any case state something

A: Clarified and references were added to already formed WGs.

Section 3.8:
line 2405: It is striking that this section adds a 2018 programme. Others only discuss 2020 and 2022. Is this an intentional difference?

A: 2020 and 2022 were the recommended milestones for the people who contributed the topical sections, but we never forbade adding others when it makes sense for that particular activity

area. So this we did not change as it reflected the particular plans of the group who worked on this topic.

Section 3.10:
lines 2746-2780: the whole Section should be improved. The challenge of R&D is not clear. Seems to be a minor activity compared to the other subsections in section 3.

A: It is true that Visualisation is not one of the most pressing problems we face. Nevertheless the interested parties here did take the time to plan their roadmap, which is an example of consolidation towards common solutions, so for that reason we considered it worthy of inclusion. The section authors presented their view and the editors don't foresee that it can be significantly rewritten at this stage.

line 2762: the text here is vague e.g. "the wg will also work towards a more convenient access... through a client-server interface", "...a service to deliver streamed event data would be designed". More details would be nice

A: A reference was added that has significantly more details.

line 2774: please provide a reference/link for the mentioned workshop

A: A reference to Workshop Appendix added, where all of the relevant events are listed.

Section 3.11:
In contrast to previous sections, this R&D section does not have dates. Just short-term and long-term

A: This has been fixed to be 2020 and 2022 goals, aligned with the rest of the paper.

line 2861: is it git or github - is there an effect of the recent purchase from Microsoft, please elaborate.

A: On Git versus GitHub/GitLab (social coding), it was discussed in the topical paper linked to the CWP on this topic, but was accidentally omitted from this paper. It has been added back in. We don't want to discuss the recent purchase of GitHub by Microsoft as the discussion is not about a specific instance of a social coding site, but rather a class of services.

Section 3.12:
line 3291 please provide examples and/or a reference for "next-generation identity federations". There are some out there, e.g. bwIDM.

A: Reference added.

Section 3.13 (Security)
Line 3171: add data privacy. Data privacy: legal questions, as in unauthorised access to personal data. Data protection: avoiding unauthorised access.

A: This topic was not discussed during the CWP process and only became more of a hot topic after CWP publication, so we don't think this can be added now.

line 3286: "… attributes published by each federation …": Federations do not provide attributes. And attributes are not necessarily linked to authentication.

A: No change. Federations publish the information of each IdP and each IdP provides/releases attributes. Thus it seems valid to speak about attributes published by each federation. This doesn't imply that they are necessarily linked to them but we don't seriously envisage to connect directly to each IdP.

line 3298: "Although federated identity provides…": X.509 is also a ferreted ID solution.

A: Clarified.

lines 3322+3333: please also give the long name for WISE and FIM4R

A: This was given at line 3344+. There are references to these acronyms but it may be that this was part of the formatting problems mentioned in the initial comments where in early version of the submitted articles, references were not properly resolved. So we hope the new version is now fine.

line 3333: CERN is not the only partner in AARC, also major Tier-1s also participate, e.g. KIT and NIKHEF. Please re-formulate/add this.

A: Thanks for spotting it, you are perfectly right. Reformulated.

Section 4:
line 3432: what does "promoting specific champions in the field" mean here in detail, please provide examples. How can they be promoted?

A: The phrasing was improved to avoid the ambiguity from the use of "promoting".

Section 4.1:
lines 3447: please provide examples (+ a reference) from science where "users express their requirements and computer specialists implement solutions", otherwise this falls from heaven and this argumentation can not be used.

A: This assertion has been removed as it is hard to justify and it is actually not a central point in the argument.

Section 4.2 and 4.3:
these are rather weak sections compared to the importance of the topic. After reading the sections 3.x I would have expected to also see a work programm and milestones, but nothing is here - a pity... You could generate ideas e.g. establish working groups on this topic, organise workshops, etc. but nothing is mentioned...not good.

A: We agree with you, in fact it was clearly identified when the CWP was finalized. But we do not want to make false promises as we are not (the CWP authors/endorsers) in a position to take concrete actions/decisions as a community and our collective experience is that making progress in this area is difficult without concrete funding support (privately, we know of a few initiatives, but none which were there in time for the CWP). This reflects a genuine weakness in this area and we hope that future work, at the national or institutional level, can progress on the implementation. We thought nevertheless that it was important that the community had a statement on how important it is to progress on these issues.