Report on the UK Future Collider Town Hall (6/7/2023)

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1 Introduction

In the 2020 update to the European Strategy for Particle Physics [1], three statements were made regarding high-priority future collider initiatives: (1) Full exploitation of the Large Hadron Collider (LHC) and its High-Luminosity upgrade (HL-LHC) remains the top priority; (2) an electron-positron "Higgs factory" is the highest priority next collider; (3) we should investigate the technical and financial feasibility of a 100 TeV hadron collider at CERN. Corresponding planning was also performed in the US — the Snowmass 2021 community planning exercise which culminated in summer 2022 [2]. Both processes highlighted the importance of engaging Early Career Researchers (ECRs) in planning for the future of the field. The increasingly long timescales associated with large-scale collider experiments make it imperative that there is both sufficient interest and expertise in the ECR community to deliver these ambitious projects.

Following the European Strategy Update, the UK particle physics community is continuing to develop its involvement in future collider research and plans in relation to these three priorities and beyond, ahead of the next European Strategy update planned for 2027. An important part of this road-map for future colliders is to inform and engage early career researchers (ECRs) in discussions, planned feasibility studies, and the future decision-making process.

This report describes the discussions and outcomes of a UK town-hall meeting on future colliders that was organised in July 2023 Agenda 06/07/2023. Following two successful UK Early Career Researcher (ECR) meetings discussing future colliders beyond the LHC in 2022 (the first in Birmingham in April Agenda 24/4/2022, the second in Cambridge in November Agenda 4/11/2022), the aim of this town-hall was to encourage everyone (both ECRs and non-ECRs) in the UK High Energy Physics community to come together and discuss the prospects and challenges associated with possible road-maps for future colliders beyond the Large Hadron Collider (LHC). This event aimed to address one of the community recommendations documented in the report produced from the November ECR event, and was planned to coincide with the Particle Physics Advisory Panel (PPAP) community meeting Agenda PPAP community meeting 06/07/2023.

The organising committee was comprised of ECRs and researchers recently engaged in organising ECR activities. The event was run in hybrid format, and was kindly sponsored by the Institute of Physics (IOP) High Energy Physics special interest group. The event was well-attended; of 63 registrants, 27 identified as "lecturers/tenured academics", 18 as "postdocs or early-career fellowship holders", 11 were PhD students and 7 filled "other" in the career stage category. There were also a number of non-ECRs who attended the town-hall discussion in person having not registered for the event due to their attendance at the PPAP community meeting, and are thus not included in this count (and due to the mail circulation would have been unlikely to fill the survey). The organisers observe that an area for improvement for future meetings could be to increase the number of ECRs attending in person (the majority of the participants that identified as ECRs were connected remotely, possibly due to their not attending the subsequent PPAP meeting).

This report will proceed as follows: section 2 will provide a brief summary of the meeting, then section 3 will discuss the participant survey which was circulated after the meeting and was filled out by 33 participants. Section 4 will provide some recommendations from these efforts then Section 5 will conclude.

2 Summary of the meeting

The event was divided in two, with the first part including short "flash talks" on topics including the physics prospects, detector and accelerator challenges, software and computing, sociological and sustainability challenges and outreach, to ensure the event was accessible to members of the community who are new to discussions on future colliders. The speakers also provided links to further resources in their backup slides, so attendees could follow up on area interest after the meeting.

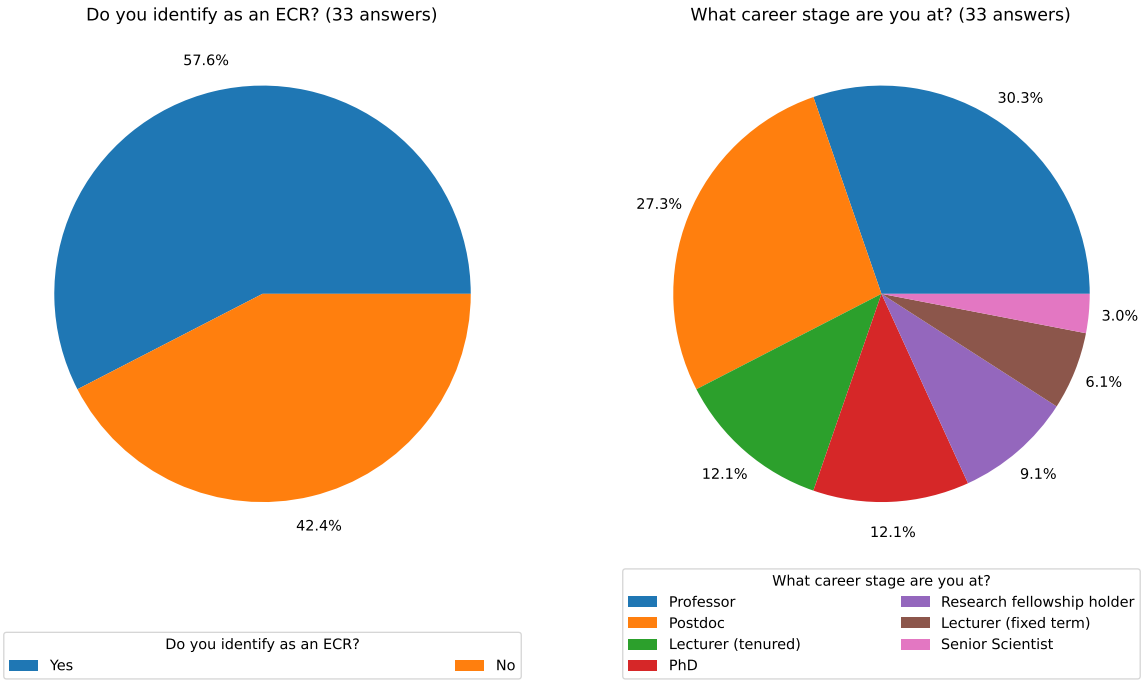
This was followed by the open "town-hall" where attendees were encouraged to have open discussions about the future road-map. A Google Doc allowed additional questions to be submitted anonymously and discussed beyond the session. The organisers note that the presence of non-ECRs helped to develop discussion and allowed different questions to be debated than in the previous ECR-only event. However, there was less direct input from ECRs in discussion, particularly more junior ones. It is unclear of the cause of this, one aspect is the relative amount of in-person attendance between groups, and another is that ECRs may have made more use of the Google Doc instead to ask questions. For future events, the organisers propose to consider alternative event formats which could provide a better balance of these components.

3 Participant survey

Out of the 63 participants registered for the event, 33 people responded to the participant survey. The following subsections will present the results of this survey according to different sections. However, the organisers would like to note the relatively small sample size, and possible selection bias associated with the results (those more engaged in discussions about future colliders would arguably be more likely to fill out the survey). For that reason a broader survey of the UK community is recommended.

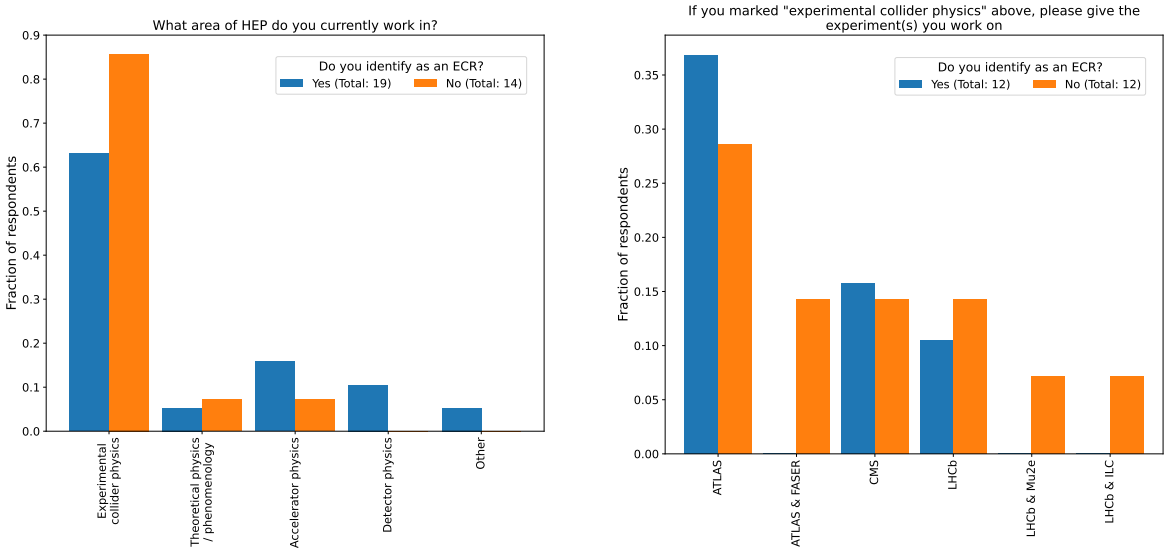
3.1 Composition of Respondents

As Figure 1 shows, 57.5% of respondents self-identify as ECRs, most of the more senior respondents are Professors, and most of the ECR respondents are post-PhD. Figure 2a demonstrates that the majority of respondents work in Experimental Collider Physics, though ECR respondents represent a wider range of areas of HEP. Focusing on respondents who work in Experimental Collider Physics, Figure 2b shows that most are part of the ATLAS collaboration, and non-ECRs are more likely to be involved in more than one experiment.



(a) (b)

Figure 1: The composition of survey respondents in terms of (a) self-identifying as an ECR and (b) career stage.



(a) (b)

Figure 2: The composition of survey respondents in terms of (a) area of HEP worked in, and (b) experiment worked on (if applicable). Answers are split by self-identification as an ECR.

3.2 Career Prospects

Focusing now on respondents' future plans, in Figure 3 it is shown that 73.7% of ECR respondents want a long-term career in HEP. Overall, only 60.6% respondents hope to stay in the UK long-term. For those that are undecided or don't want to stay in the UK, the main factor for the decision is shown in Figure 4. For both ECRs and non-ECRs the main reason is a belief that there are better opportunities elsewhere.

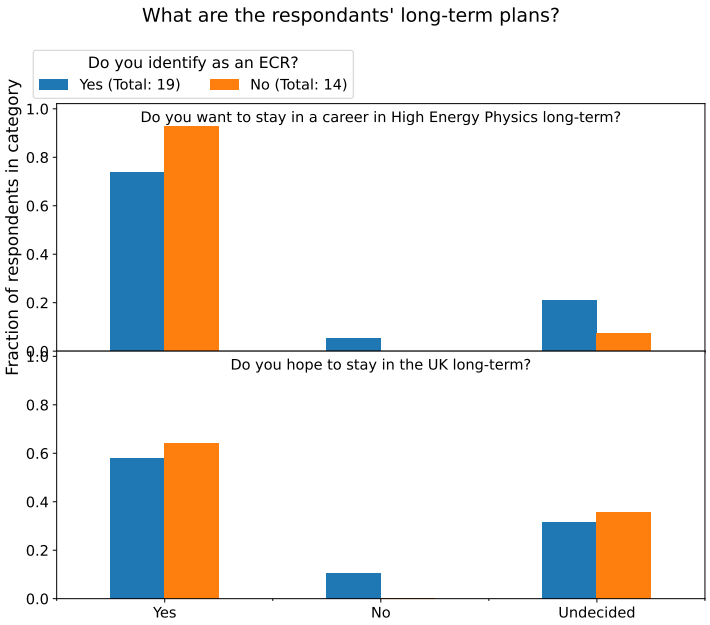


Figure 3: Respondents opinions on wanting to stay in HEP and the UK. Answers are split by self-identification as an ECR.

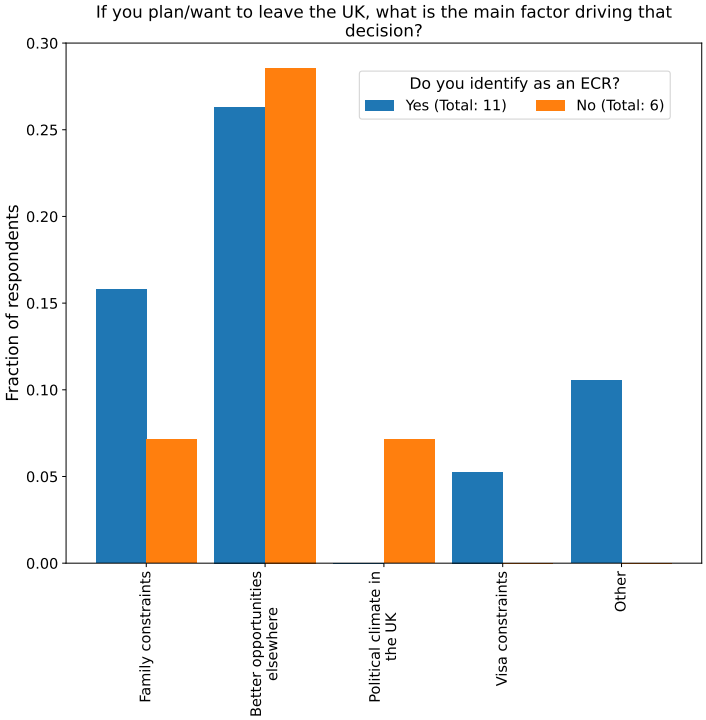


Figure 4: What the main reason is for respondents wanting to leave the UK, if applicable. Answers are split by self-identification as an ECR.

3.3 Future Colliders

To start assessing respondents views related to future colliders, Figure 5 shows the fraction of time respondents are working or want to work on future colliders, along with how much time they spend working on instrumentation and software+computing. Focusing on the top panel, 68.4% of ECR respondents are not working on future colliders at all, compared to 50% of non-ECRs, while another 43% of non-ECRs are working on this area with only up to 20% of their time. Comparing this to the second panel, which looks quite different, it is clear that most respondents (including all ECRs) would like to spend a non-zero — fraction of the their time working on Future Colliders. Dominantly, 63.2% of ECRs and 71.4% of non-ECR respondents would like to spend up to 20% of their time on future collider work. Looking at the lower two panels, ECRs are spending more of their time on average working on instrumentation and software+computing than non-ECRs.

Figure 6 shows the biggest barrier to respondents working on future colliders. For ECRs, over half of the respondents are limited by time commitments, with a further 20% limited by funding constraints. For non-ECRs the dominant barrier by far is time commitments.

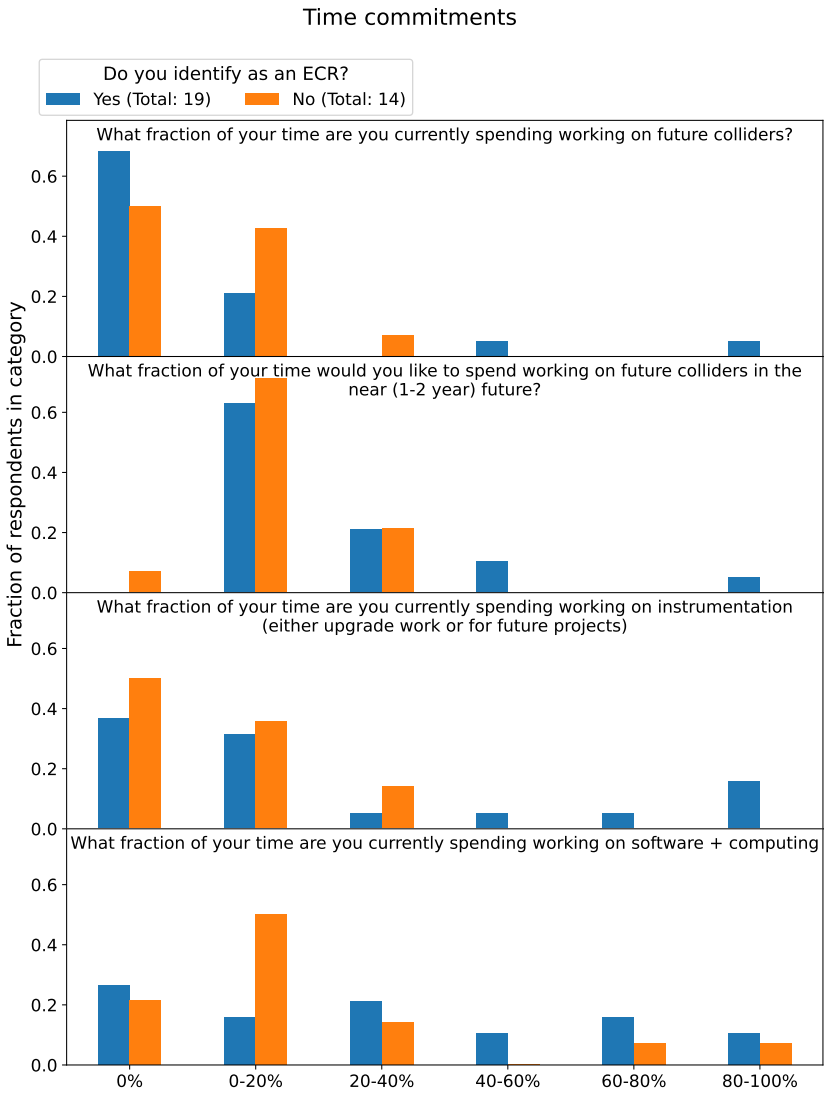


Figure 5: Amount of time that respondents are spending, or would like to spend, working on different areas. Answers are split by self-identification as an ECR.

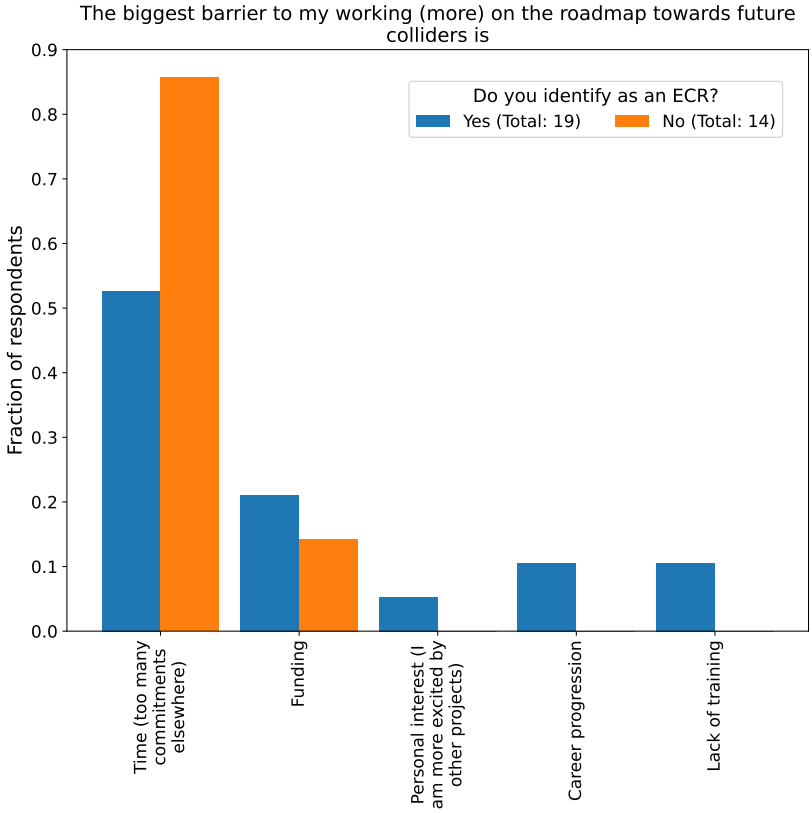


Figure 6: Respondents' main barrier to working (more) on the future collider road-map. Answers are split by self-identification as an ECR.

In Figure 7, respondents' agreement on various statements about future colliders are presented. In the top panel, it is shown that 26.4% of ECR respondents do not feel excited by the physics prospects associated with future colliders beyond the LHC, whilst 0 non-ECR respondents felt this way. In the second panel, ECR respondents show a wide spread of views on whether the decisions made about future colliders will impact their desire to stay in the field, whilst the majority of non-ECR respondents disagree that this will have an impact. In the third panel, both ECR and non-ECR respondents generally express agreement with the 3 statements make in the recent European Strategy Update. In an open box allowing further comments on this statement, the following comments were given:

- "FCC-hh does not have to be a precondition for statements 1 and 2. CERN's future programme does not need to be based on indefinite expansion to a FCC-size tunnel." (non-ECR)
- "The international community should continue to diversify the types of HEP experiments we develop and work on, potentially encouraging "big" collider experimental students to contribute to either current smaller projects concurrently or a future one." (ECR)
- "I feel full exploitation for the HL-LHC project puts future collider projects too far into the future to be enticing to ECRs. Particularly for accelerator physics there aren't many interesting challenges for us to solve on either the HL-LHC and FCC-ee. The interesting challenges involved in the FCC-hh accelerator are largely in the magnet design, which is its own field entirely." (ECR)
- "I find this hard to rectify with the growing need for sustainability worldwide. These 3 statements don't even hint at sustainability." (ECR)

In the forth panel, there is a range of levels of agreement about whether the integrated FCC programme should be build. On average the ECR respondents have a stronger level of support for the FCC than the non-ECR respondents. Finally, the bottom panel shows how respondents agree to the statement that it is **not** environmentally responsible to build another collider project. ECRs and non-ECRs on average disagree with the statement, though ECR respondents are slightly more in agreement.

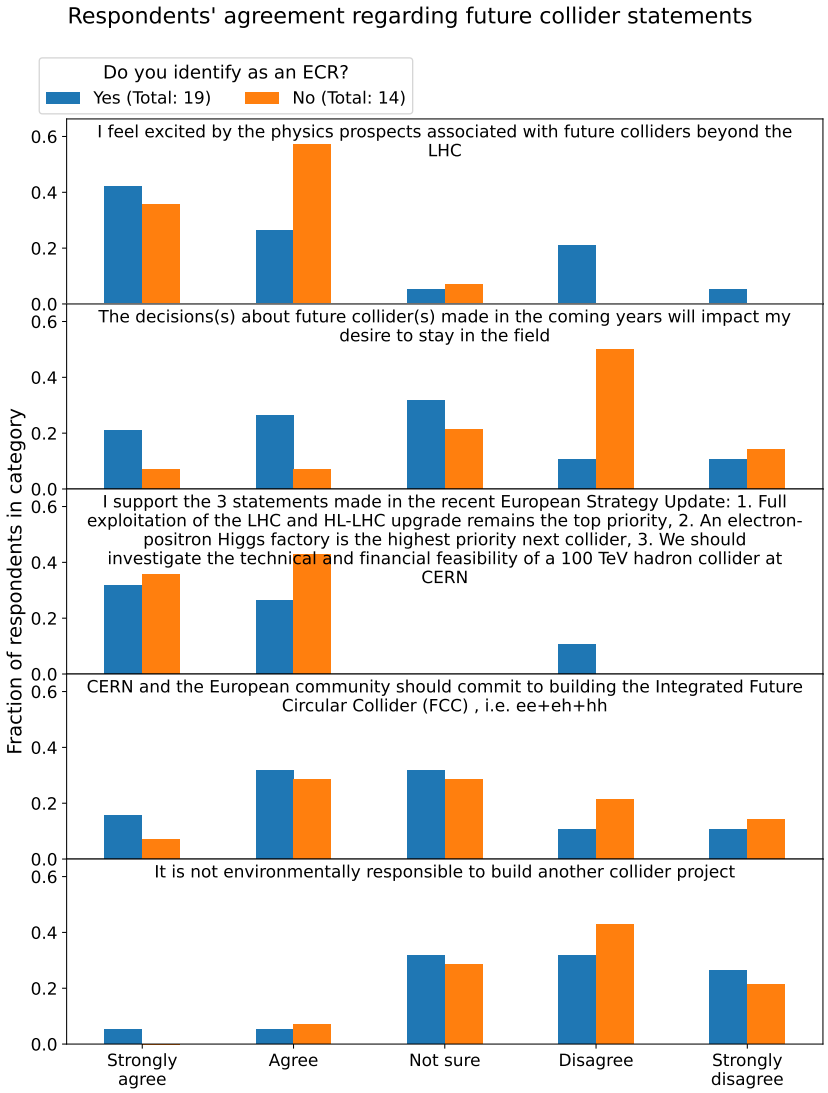


Figure 7: Respondents levels of agreement to statements about future colliders. Answers are split by self-identification as an ECR.

Respondents were also asked which, currently proposed, future collider option they would like to see build. This is shown in Figure 8, illustrating large differences between ECR and non-ECR views. For ECRs, 52.6% chose the integrated FCC programme, with the second largest group (15.8%) favouring a Muon Collider. For non-ECRs, 42.9% chose the FCC as the preferred option, with an equal 21.4% support for the ILC or 'other' as the next most popular option. For those that entered 'other', clarifications given in an open box included:

- "Not convinced that the case for a new collider at the $>$ 10B level has been made, or that such a machine will be built." (ECR)
- "CLIC and a plasma-based collider" (ECR)
- "Undecided at the moment" (non-ECR)
- "Answer depends on timescale" (non-ECR)

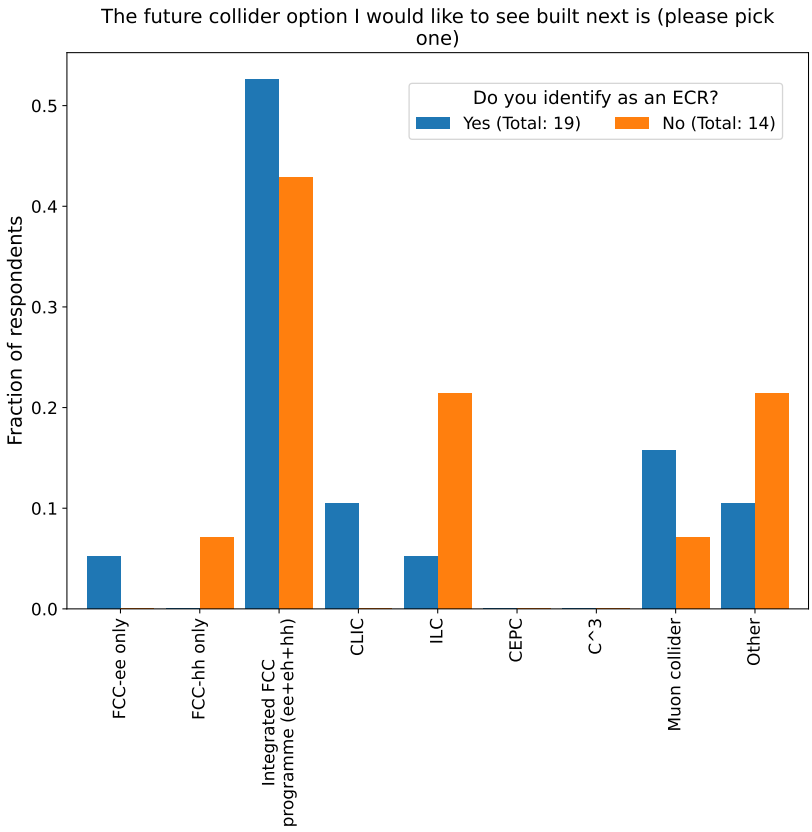


Figure 8: Which future collider option would respondents most like to see built. Answers are split by self-identification as an ECR.

3.4 Events and Knowledge

In the final part of the survey, participants were questions about their agreement with statements relating to this event and its goals. These results are summarised in Figure 9. In the top panel, respondents' agreement about how well-informed non-ECRs are about ECR concerns is shown. The distributions for ECR and non-ECR are similar, with non-ECRs agreeing slightly more about how well-informed they are. In an open box allowing further comments, the following comments were given:

- "I believe the non-ECR community underestimates the size of scepticism of the future of the field amongst ECRs in the UK, not just around the FCC, but also around the immediate viability of career paths in the field which they see as vastly underpaid compared to our colleagues in Europe and the US. They see UK salary and avenue for promotion as unreflective [sic] of the workload of the field and the culture surrounding the treatment of people in it. There is a very real possibility that all of our best ECRs in the UK will either leave for a different country to be better rewarded for their work or will leave the field all together even if they don't want to." (ECR)
- "There is a clear lack of understanding of the issues from the non-ECR community. As happened in the meeting, when ECR concerns over the nature of the future projects is mentioned it is often downplayed by non-ECR people, often claiming the field is at an 'exciting' moment." (ECR)
- "ECRs cannot work on Future Colliders in isolation. We need group support and leadership." (ECR)
- "The timescale for FCC is one of the biggest problems I can see in the field; it is not entirely excluded that public opinion will change to the point that a very, very power intensive machine will not be allowed to run, regardless of whether it is claimed that the electricity is from 'green' sources. SSC was cancelled after construction had started and public opinion can change more rapidly than direction of our field with elongated timescales for future colliders." (non-ECR)
- "I talk to local ECRs, but not necessarily the wider community." (non-ECR)

- "It may also be interesting to know opinions about whether the non-ECR HEP community is sufficiently motivated to address the concerns of the ECR community, which is a very different, but relevant, question." (ECR)

The second panel asks if the event has increased respondents' understanding of the challenges and opportunities associated with future colliders. 89.4% of ECR respondents agree that the event helped with this, in line with one goal for this event. The third panel shows that all ECR respondents and almost all of the non-ECR respondents would be interested in attending similar events to this one in the future.

Lastly, respondents were asked if they feel adequately informed about how to participate in UK discussions on future colliders. The distributions between ECR and non-ECR responses are similar here, with 72.7% of participants overall agreeing with the statement.

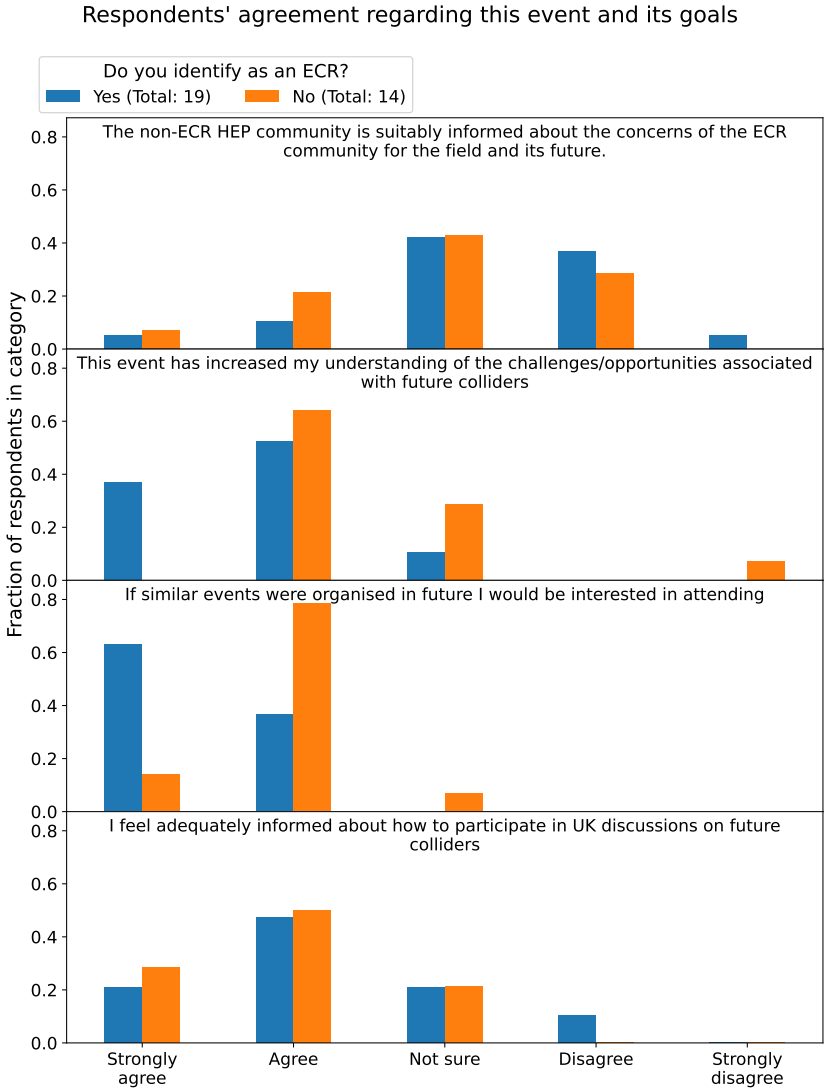


Figure 9: Respondents levels of agreement to statements about this event and its goals. Answers are split by self-identification as an ECR.

4 Summary of community recommendations

To begin, the existing recommendations based on the April 2022 meeting are reiterated. These included:

- An outreach-focused event discussing how to "sell" the future collider road-map to the public and policy makers would be welcome. This could be standalone or part of a broader event.
- A town-hall style meeting enabling further discussion between ECRs and the broader UK community should be organised. In order to share ideas and thoughts this should be open to the full community.
- The training opportunities in software and computing, and instrumentation, should be better documented and publicised amongst the HEP community, and discussions should be had on how to better encourage supervisors/PIs to support ECRs pursuing training outside their direct line of work.
- More interaction between existing future collider/R+D collaborations and ECRs providing practical information and technical support with getting involved would be beneficial.

This event addressed the second item in these recommendations. The organising committee strongly recommends that the other three items remain priorities for the future. We would also like to emphasise that the event described in the first item should be open to everyone in the community.

In addition, the following recommendations have been compiled by the organising committee based on the discussions in the meeting and results of the survey:

- Establish a sustainable plan to enable more regular discussions between the ECR and non-ECR community about the future road-map of HEP (this includes identifying who will coordinate/fund these efforts). This includes ensuring plans to involve UK ECRs in the national consensus gathering process for the next European strategy are discussed early and circulated to the community prior to the process beginning.
- More centralised community-wide surveying should be performed (or where data is available it should be shared with the community), which could include analysing reasons for PhD students leaving the field after their PhD, and whether this has changed over time.
- Many participants indicated a desire to devote a small fraction of their time to future collider efforts. As UK efforts towards future colliders gain momentum towards the next European Strategy, these should remain transparent and open to the ECR community. Mechanisms where 10% of an individuals (whether ECR or non-ECR) time could, in collaboration with others, be converted to meaningful outcomes, should be documented and available to the community.
- Identify the group(s) of people taking responsibility for carrying the recommendations forward, and ensure they receive adequate support and recognition for this work.

5 Conclusion and Outlook

This report has summarised some of the discussions and concerns raised during the UK Town Hall on future colliders, and the survey which accompanied it, which addressed one of the recommendations made after a previous UK ECR Future Collider Forum. A set of community recommendations has been produced, in addition to the previous recommendations formed.

Of these, the organising committee proposes that the highest priority item is to identify a group (or groups) of people to take the lead in ensuring the following recommendations are followed through in an appropriate order (with limited resources prioritisation will be acceptable):

- Establish a sustainable plan to enable more regular discussions between the ECR and non-ECR community about the future road-map of HEP (this includes identifying who will coordinate/fund these efforts). This includes ensuring plans to involve UK ECRs in the national consensus gathering process for the next European strategy are discussed early and circulated to the community prior to the process beginning.
- An outreach-focused event discussing how to make the case for the future collider road-map to the public and policy makers would be welcome. This could be standalone or part of a broader event.

- Mechanisms where a small fraction an individuals (whether ECR or non-ECR) time could, in collaboration with others, be converted to meaningful outcomes, should be documented and made available to the community, along with technical support for those new to these areas. This includes future feasibility studies, and the detector R+D collaborations currently being formed in response to the ECFA detector R+D roadmap.
- The training opportunities in software and computing, and instrumentation, should be better documented and publicised amongst the HEP community, and discussions should be had on how to better encourage supervisors/PIs to support ECRs pursuing training outside their direct line of work.
- More centralised community-wide surveying should be performed (or where data is available it should be shared with the community), which could include analysing reasons for PhD students leaving the field after their PhD, and whether this has changed over time.

It should be noted that the recommendations from the previous section have been rephrased and reordered but the list is not ordered by priority. These recommendations are made with the hope of further informing and engaging ECRs in the road-map toward future colliders, and to facilitate their participation in decision-making on the future of High Energy Physics within the UK.

6 Acknowledgements

The organising committee would like to thank the Institute of Physics High Energy Physics Group for sponsoring this event, and to the University of Birmingham for hosting the event.

References

[1] European Strategy Group 2020 *Update to the European Strategy for Particle Physics* (CERN Council, 2020); https://cds.cern.ch/record/2720129.

[2] Narain, M. et al. *The future of US particle physics: The Snowmass 2021 Energy Frontier Report.* Preprint at [arXiv:2211.11084,hep-ex] (2022).