

Report on ECR Future Collider Forum (4/11/2022)

Andrew Chisholm, Matthew Kenzie, Michaela Queitsch-Maitland,
Cristiano Sebastiani, Sarah Williams

November 2022

1 Introduction

This report describes discussions and outcomes from an Early Career Researcher (ECR) forum on future colliders beyond the LHC that took place on 4th November 2022 hosted by the University of Cambridge. This meeting was organised following an initial event held at the University of Birmingham in April 2022 (Agenda 24/4/2022) that was hosted by the Institute of Advanced Study (IAS) and organised to coincide with a visit by Prof Eliezer Rabinovici, chair of CERN council. Due to constraints on the time and venue this event was invite-only and limited to in-person attendance. It was agreed that the ECR-only format provided a positive and constructive environment in which to engage and inform ECRs about future collider challenges and prospects, but there was consensus that a broader meeting within the UK community would be highly beneficial, which this event aimed to deliver.

The agenda (Agenda 4/11/2022) was organised into five plenary sessions, which are given below along with the speakers.

- Physics opportunities and existing anomalies (Nicholas Wardle, Imperial College)
- Accelerator technologies (Tessa Charles, University of Liverpool)
- Detector technologies (Daniel Hynds, University of Oxford)
- Theoretical challenges and opportunities (Tevong You, Imperial College)
- Software and computing challenges and opportunities (Josh McFayden, University of Sussex)

Each session consisted of a short (15-20') talk, to prompt discussions, with the remaining time allocated for Q+A. The main future collider options discussed were the Future Circular Collider (FCC) at CERN running in either ee , eh or hh modes, linear e^+e^- colliders and muon colliders. While the accepted definitions

of an ECR are diverse and numerous, an attempt was made to approach speakers relatively early in their academic careers.

In addition to the plenary sessions, the following features were “added” relative to the initial meeting in Birmingham:

- A short participant survey was created to collect quantitative feedback from participants, and participants were encouraged to fill this out either on the day/after the event.
- There was a “break-out” session where participants were divided into smaller groups (8 people) and encouraged to discuss a set of proposed questions. The results of these discussions were then summarised in the full group.
- A panel discussion was organised at the end of the day where senior UK academics joined through zoom to enable a Q+A on questions/issues raised during the day on future colliders.

This report has been compiled by the organising committee of the ECR forum and aims to provide a brief summary, and set of community recommendations for moving forwards. It is structured as follows: Section 2 will provide a summary of the plenary discussions in the meeting, and Sections 3 and 4 will discuss the break-out session and panel discussion respectively. Section 5 will summarise the results of the participant survey, which was completed by 28 participants. Section 6 will provide a concise set of community recommendations for next steps, then Section 7 will conclude and look ahead.

2 Summary of the meeting

There were 55 participants registered for the meeting, which was run in a hybrid format. A collage showing some pictures from the day and portraits submitted by some of the online pictures is given in Figure 1.

Whilst detailed minutes were taken throughout the meeting, this section will not duplicate the material presented in the talks, and will instead briefly comment on key points arising from the discussions that feed into the recommendations presented at the end of the report.

- There was a lot of discussion on if/how we can sell e^+e^- as discovery machines as well as motivating the importance of precision measurements and selling the programme to the public. This included discussions of what we could learn from other areas of physics, for example the James Webb Space Telescope in astrophysics.
- For the accelerator technologies, there was discussion about how best to quantify the energy footprint of future colliders (luminosity per unit energy/ energy per higgs, or otherwise), and questions on whether it is efficient for accelerator physicists to spread across multiple projects, and when the decision on the next machine will be taken.



Figure 1: Collage containing photos from the ECR forum and portraits submitted from remote participants.

- On the detector side, questions included whether we can use synergies with industry to rebuild expertise in the UK (to which it was noted that person-power is needed to develop and maintain these links), and how/whether it is feasible for PhD students to get involved in detector R+D.
- In the theory discussion, there was further discussion about the need to “sell” the future roadmap to the public and the importance of discussing the strategy for outreach to the public/media within the community, and a note that exploiting future colliders will rely on significant advances in theoretical calculations (which the community also needs to support and deliver).
- When discussing software, it was noted that the lack of funding/personpower for software and computing work was noted in the US snowmass process so isn’t just a UK/European problem. Unlike on the detector side (where numbers were lower), around 30% of the room raised their hand when asked whether they work on software > 50% of their time (excluding analysis code).
- In response to a question of whether there was a software-equivalent of the UK Advanced Instrumentation School, it was noted that there are re-

sources available through SWIFT-HEP and that for PhD students training is available through RAL.

3 Breakout discussions

The breakout sessions aimed to provide a platform for more informal discussion and networking amongst participants. Whilst details/minutes of these discussions are not provided in this report, for completeness, the questions used for discussion in the breakout session are listed below.

- From a technology readiness perspective, what is your impression on what extent could a detector for ILC/FCC-ee/FCC-hh could be build “tomorrow” if the accelerators were spontaneously delivered?
- If all existing “anomalies” (e.g. lepton universality in B decays, W mass, muon g-2) were resolved by measurements / theory developments, is there still a compelling case for a new collider beyond the HL-LHC?
- Is there a case to skip a future lepton collider if a machine like FCC-hh could be built significantly earlier (e.g. by 20 years)?
- Do you agree with the current baseline strategy (2020 European Strategy document) i.e. focus should be a “e+e- Higgs factory”
- Is the vision for a 100km accelerator environmentally responsible?
- Can a case for public funding of a new accelerator be made against a backdrop of the challenges brought by a war in europe, a cost of living / energy crisis and accelerating climate change?
- If the funding case for the LHC had to be made today, would it have been built?
- Is there an optimal way for today’s ECRs to begin to invest some of their time to contribute to the realisation of a future collider, while making significant contributions to the LHC programme?

4 Panel discussion

After the break-out sessions, a 45 minute panel discussion was held aiming to provide a Q+A-style interaction between the ECRs at the event and senior academics in the UK community. The panellists were:

- Matthew Needham (University of Edinburgh, chair of Particle Physics Advisory Panel for STFC)
- Guy Wilinson (University of Oxford, FCC-ee-UK coordinator)
- Andy Pilkington (University of Manchester, FCC-hh-UK coordinator)

- Monica D’Onofrio (University of Liverpool, BSM panel member for European Strategy Update and member of STFC strategic review of particle physics panel)
- Sinead Farrington (University of Edinburgh, UK Plenary ECFA delegate and member of STFC strategic review of particle physics panel)
- Michael Spannowsky (University of Durham, director of the Institute for Particle Physics Phenomenology, IPPP)

Questions were submitted using the slido platform, which allows anonymous questions but also enables participants to “like” questions, which then enabled the chair of the session to select questions that had been echoed by the largest numbers of participants. When going through the discussion, questions were asked to selected panellists (to avoid duplication) but others were encouraged to join in if they had additional points to raise. Participants in the room were also encouraged to ask questions if they wished. The questions raised included:

- When/what timescale do we need to make a decision on the future collider?
- Who, in the UKRI/ national government, decides which (if any) collider gets built?
- Is there anything we need to ensure that we do so that the UK is involved in whatever decision is made? Are there any risks of the UK being “left behind”?
- Is there a strong theoretical or experiment basis for FCC-eh (e.g. PDF studies, magnet prototyping etc)?
- Do you have any views on what we can do to strengthen the link between theory and experimental community in the UK?
- What would be the UK’s contribution to FCC if detector R& D in the UK is limited?
- Are there any members of the panel who have a future collider scenario other than FCCee \rightarrow hh?
- Do you have any suggestions how to facilitate/encourage ECRs to commit to spending more time working on future colliders?

Whilst this provided an effective format to involve the broader community whilst retaining the ECR-only format of the meeting, it was noted that 45 minutes was too short to cover all of the questions submitted in detail, and having a format where all of the panel were connected remotely with most participants in the room could have made two-way interactions harder. The large number of questions submitted again highlights the desire for more interaction between the ECR community and those involved in planning and decision making in the roadmap towards future colliders. This will be revisited in the community recommendations.

5 Participant survey

28 participants responded to the survey out of 55 registered for the event. Of these respondents:

- 15 were postdocs, 2 held independent fellowships (FLF/ERF/URF), 2 were tenured staff or lecturers and 1 was a fixed-term lecturer.
- 24 (86%) are pursuing (or interested in pursuing) a long-term career in HEP, with the remaining 4 undecided (no respondents said “no”, so this should be seen as a selection bias effect).
- 24 (86%) work in experimental collider physics, 3 in theory and 1 from accelerator physics. Of the experimental collider physicists, 17 were affiliated with ATLAS, 3 CMS and 4 LHCb (3 of the ATLAS respondents also noted involvement in FASER/future colliders).
- 21 (75%) said they are not currently working on future colliders, 6 are but with 0-20% of their time and only 1 with 20-40%.
- 18 (64%) are not working in instrumentation, 3 are spending 0-20% of their time, 1 20-40%, 1 40-60%, 3 60-80% and 2 80-100%

The survey then contained questions aimed at understanding the opinions and concerns of the participants related to future colliders. Figure 2 shows the responses given to the question of what participants felt their biggest barrier to my working (more) on the roadmap towards future colliders is. There was also a note here that technical support getting started with future collider work would be beneficial.

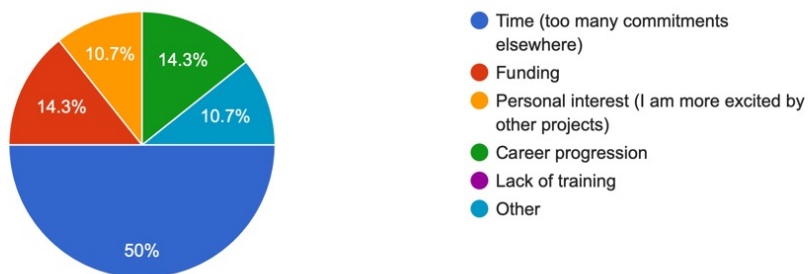


Figure 2: Responses given by participants when asked about the biggest barrier to their working (more) on the roadmap towards future colliders.

A subset of the questions asked candidates to indicate their level agreement with statements on a 5-level scale including strongly agree, agree, not sure, disagree to strongly disagree. The responses were as follows:

¹(1) Full exploitation of the LHC and HL-LHC upgrade 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.

Statement	Strongly agree	Agree	Not sure/ neutral	Disagree	Strongly disagree
I feel excited by the physics prospects associated with future colliders beyond the LHC	12	12	2	1	1
I support the 3 “headline” statements made in the recent European Strategy Update ¹	15	10	1	2	–
I would like to spend more of my research time working on the roadmap towards future colliders	5	17	5	1	–
CERN and the European community should commit to building the Future Circular Collider (FCC)	11	8	5	2	2
This event has increased my understanding of the challenges/opportunities associated with future colliders	9	15	2	1	1
If similar events were organised in future I would be interested in attending	18	9	1	–	–
I feel adequately informed about how to participate in UK discussions on future colliders	4	14	6	4	–

Table 1: Summary of responses to questions asking participants level of agreement with a set of statements. The numbers in the column are the number of respondents (out of 28)

The survey also allowed an opportunity for participants to provide additional comments/feedback to the panel. Detailed analysis of these comments is beyond the scope of this report but will provide key input to future discussions and planning. A few points are noted here as they feed into the community recommendations below:

- More time/opportunity for audience participation in the panel discussion would have been welcome. The panel discussion was only scheduled for 45 minutes and in that time it wasn't possible to get through all of the questions raised on slido. A larger event to provide more interaction and discussion between communities would be beneficial.
- It was noted that more information on the existing future collider collaborations (and how to get involved in R+D) would be beneficial to ECRs.
- Case studies or advice/discussion on career progression for ECRs working on future colliders would be beneficial.

6 Summary of community recommendations

These recommendations have been compiled by the organising committee based on the discussions in the meeting and results of the survey.

1. An outreach-focussed event discussing how to “sell” the future collider roadmap to the public and policy makers would be welcome. This could be standalone or part of a broader event.
2. 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.
3. 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.
4. More interaction between existing future collider/R+D collaborations and ECRs providing practical information and technical support with getting involved would be beneficial.

7 Conclusion and Outlook

This report has summarised some of the discussions and concerns raised during the ECR future collider forum and provided some community recommendations for next steps to further inform and engage ECRs in the roadmap towards future colliders. There is also a hope that these events will provide a platform for ECR

involvement and participation in decision making on the future of High Energy Physics in the UK community.

8 Acknowledgements

The organising committee would like to thank the Particle Physics Department (PPD) at STFC, and the Institute for Particle Physics and Phenomenology (IPPP) for their willingness to support this event, the participants of the panel discussion (Monica D’Onofrio, Sinead Farrington, Matthew Needham, Andy Pilkington, Guy Wilkinson and Michael Spannowsky) for their time and engagement, and to the Cavendish Laboratory at the University of Cambridge, and the West Hub, for hosting the event.