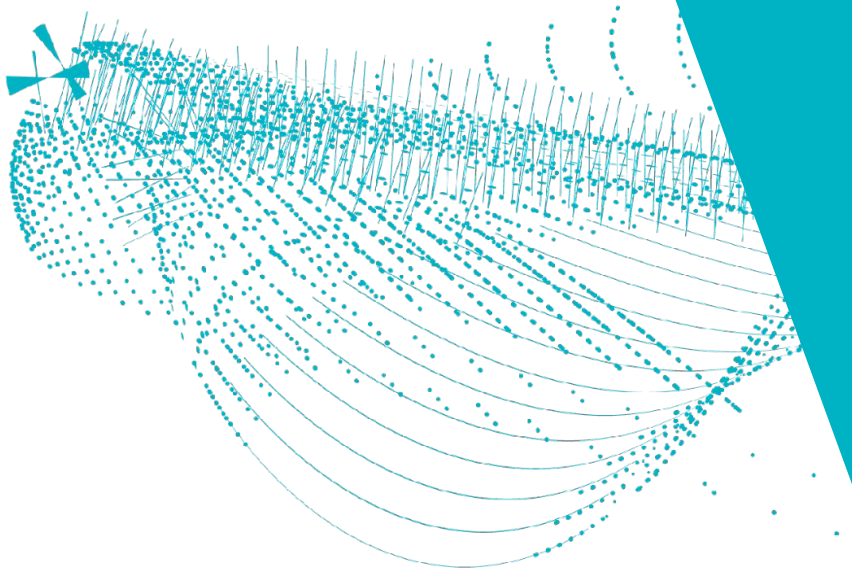
Nikhef



The ECFA Early-Career Researchers Panel

Lydia Brenner
On behalf of the
ECFA Early-Career Researchers Panel

ECFA ECR Panel composition and activities

Members are, in general, ***PhD students and postdocs, either with a non-permanent contract or with up to eight years after obtaining the PhD****. Up to* ***three members*** *(+1 for countries with LDG lab), among them at least one PhD student and one postdoc, can be nominated* ***by each ECFA country*** *represented in ECFA for a* ***mandate of two years****,* ***extendable for another two years****. Nominations are to be endorsed by Plenary ECFA. Members act as individuals, but should be able to represent the views of early-career researchers in particle physics in the nominating country.*

➔ Diversity in cultural background, career and research, try to represent the community
- From PhD students to young assistant professors
- Theoreticians, phenomenologists, experimentalists, …

3-4 panel meetings per year, handled by *Organization Committee*

Jan-Hendrik Arling, Holly Ann Pacey, Marko Pesut, Valentina Zaccolo

5 ECR delegates in Plenary ECFA

Lydia Brenner, Armin Ing, outgoing: Henning Kirschenmann, Eleonora Diociaiuti

Incoming: Andrea García Alonso, Holly Ann Pacey, Patrick Dougan (starting in 2024)

1 delegate in Restricted ECFA: Lydia Brenner

Activities in 2023

First large overhaul of members in 2023 (end of first two year term)
See arXiv:2212.11238 for a complete summary of 2021-2022 activities

Actual work is done in **working groups** that are flexible

Future Colliders WG

Will focus on this
since this is most relevant for this meeting

Future colliders WG

Goal: Inform ECRs about future collider options and development, enabling them to shape their own vision on future colliders

Indico: ***Future colliders for early-career researchers*** 27th of September 2023

Short presentations on prospects, lots of time for discussions. Can serve as reference information for ECRs.

➔ Almost one hundred in-person participants, > 100 on Zoom

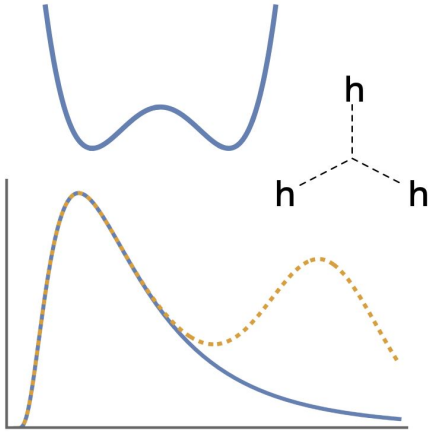
Key message 1: Communicating need for future colliders

Summary

Exciting times ahead if a future collider is built!

- Guaranteed deliverables:
  - Precision measurements
  - Higgs self-coupling
- Potential direct discoveries

Anke Biekoetter



There are guaranteed discoveries!

- Learn how to communicate importance of precision

Future colliders are worth it

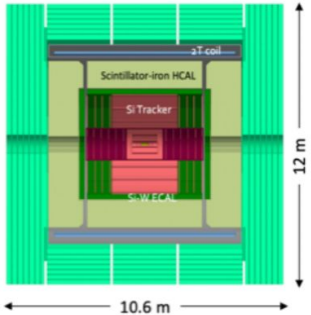
- For science and society

See sustainability not as a concern but as a challenge

- To develop technologies relevant for society

Key message 2: Knowledge transfer and collaboration

CLD



https://arxiv.org/abs/1911.12230 and FCC CDS vol. 2

Well established design
- ILC -> CLIC detector -> CLD

Full Si vtx + tracker; CALICE-like calorimetry; large coil, muon system

Engineering and R&D needed for
- reduction of tracker material budget
- operation with continous beam (no power pulsing: cooling of Si sensors for tracking + calorimetry)

Possible detector optimizations
- Improved σ_p/p, σ_E/E
- PID: timing and/or RICH?

- Had participants from all future collider communities at our workshop
  - Open and creative exchange of ideas beyond various borders
- Future collider R&D is highly transferable from one collider proposal to another (and beyond)
  - Good ideas will survive a collider or two…

Good reasons for everyone to work on future colliders!

And muon colliders too

Nikhef

Key message 3: Enabling careers on future colliders

It's a long time until any future collider is operational

- Take future collider decision as early as possible
  - To give ECRs a concrete goal and timeline
  - To ease applying for grants
- Long-term R&D projects and support for careers in instrumentation
  - DRD Collaborations look very promising!
- Important for ECRs to broaden their horizon
  - Projects such as ECN3 very attractive to complement future collider work

What are the considerations for choosing the next step

What do **WE** (the ECR community) find most important in the considerations for a next collider

- What are the physics questions we want answered?
- How can we make sure that the probable physics is diverse enough?
  - Are several smaller colliders preferable over one large collider for the diversity of the achieved physics program?
- What are the upgrade possibilities of proposed projects?
- How precise can we get, taking realistic improvements in theory predictions into account?
- How can we make sure the collaboration with other energy range experiment is ensured?
- **Is the future collider programme compatible with ECR careers considering possible large time gaps after HL-LHC runtime?**
  - Would/could muon colliders make it in time to follow the HL-LHC?
- **Can we bridge the gap between HL-LHC and a large future collider with enough attractive projects?**
- How can we make a next collider is sustainable in terms of energy use?
- **At what time-scale should the ECR community dedicate itself to one particular proposal?**
- **How can ECRs make the impact they desire on the decision making process?**

What's next?

- Short arXiv paper about the event in preparation

From ECFA to the national communities

- Goal is to follow-up the ECFA-wide event with national, in-person events on future colliders, directing discussions into the ECFA countries as some issues are country dependent

First report from the UK on town hall style follow up event;
https://conference.ippp.dur.ac.uk/event/1201/sessions/1509/attachments/4963/6722/TownHall_July2023_Report.pdf

Career Prospects and Diversity in Physics programme WGs

Career Prospects and Diversity in Physics Programme WGs

Designed a survey to collect information on

- What is the impact of the collaboration size on ECRs?
- Assess the career prospects of ECRs, how can our panel help, what are the main problems?
- What do ECRs think is needed for a successful career versus what is actually needed?

Circulated to ECR community (760 responses!)
Analysed all questions [pdf], correlation studies still ongoing.

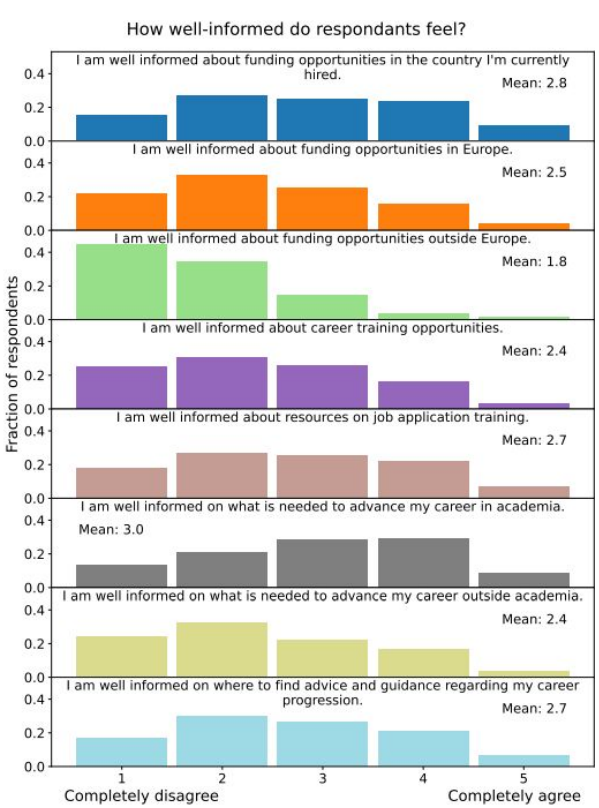
Structure of the survey

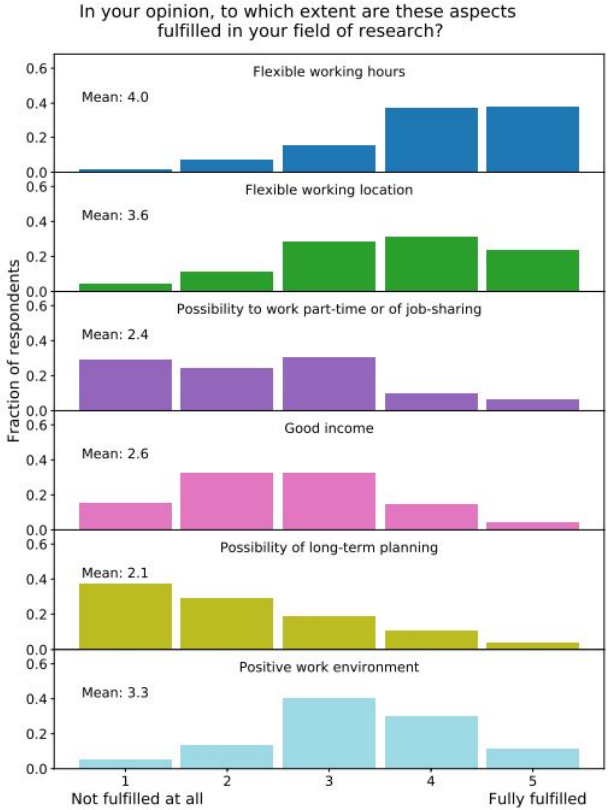
- ❏ Personal data
- ❏ Field of work
- ❏ Collaboration and working group
- ❏ Diversity of Physics
- ❏ Career perspective and planning
- ❏ Work-life balance
- ❏ Leaving academia
- ❏ Recognition and visibility
- ❏ Final questions, feedback and remarks

Status update (J. Allen, A. Lelek, H. Pacey, G. Pietrzyk, G. Räuber)

First result

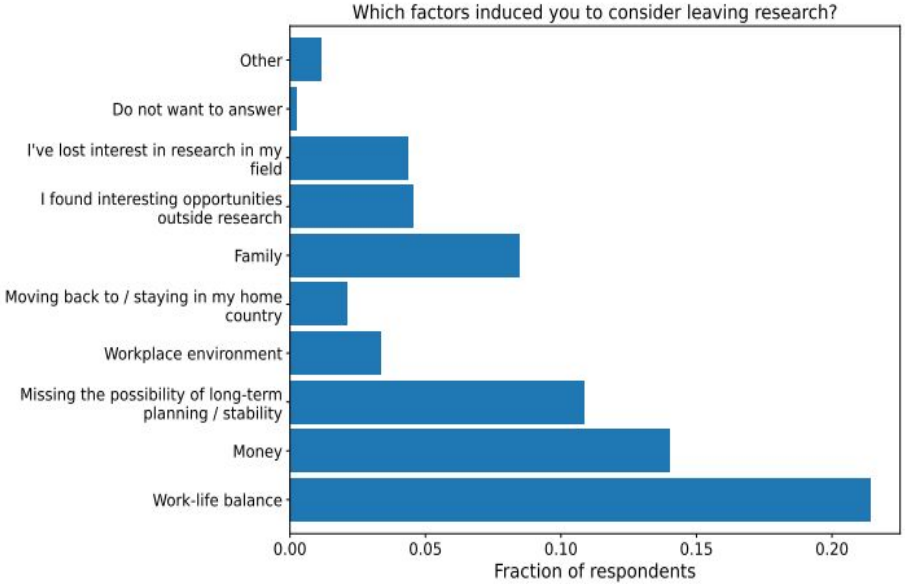
- ECRs not as well-informed about training / opportunities as they could be.
- ECRs feel some aspects important to work-life balance are unfulfilled.

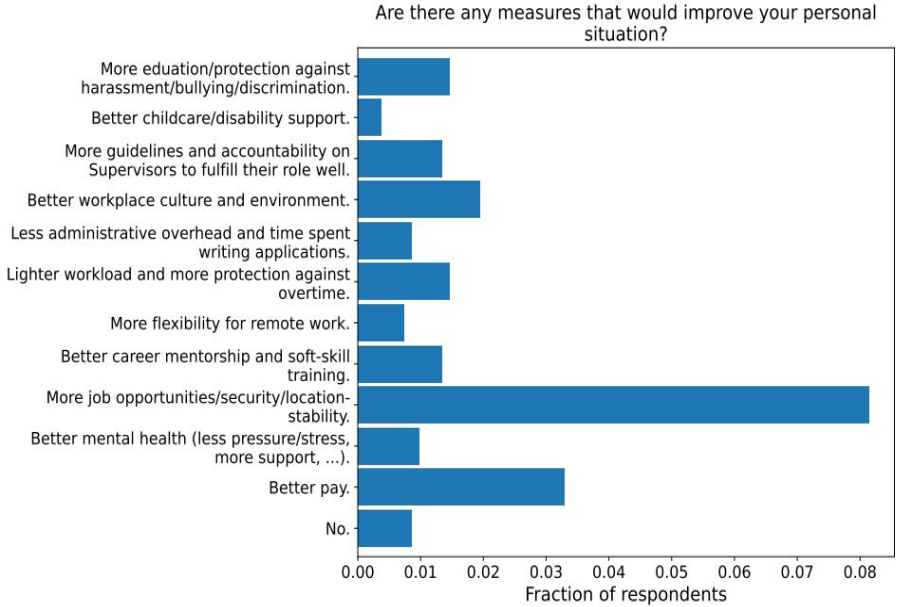




First result

Consistent conclusion that lack of job stability and poor work-life balance are the biggest challenge for ECRs and the main cause of them considering leaving research.





14

Software and Machine Learning for Instrumentation

Main goals of the group

- Analyse problems and challenges faced by early career researcher (connected to their software and machine learning work)
- Provide mechanisms to create a more friendly environment in which scientists receive substantive support in their self-development

To get to know the community better and its current problems, a survey is being prepared

16

Long-term goal of the group

- Organise school/workshop dedicated in software training/development for instrumentation work. The program would focus on:
  - Training in Open Source Software, Data Acquisition Systems, Detector Control Systems
  - Presentation of currently working groups related to software for future colliders

The program would be selected according to the survey results

Final thoughts, summary and conclusions

- Just had our first large member renewal
- Future colliders event was great!
  - Follow up needed
- Active working groups
- Summary of 2023 activities in an arXiv paper and ECFA newsletter.

Keep in touch with us

- Our webpage to find your country ECR representative
- ecfa-ecr-organisers@cern.ch
- Subscribe to ecfa-ecr-announcements e-group to get notified about our activities!

Back up

Back to the future

Jorgen d'Hondt (experimental view): *The Future doesn't exist yet*
Federico Buccioni (theory view): T*omorrow is today!*

Let's instead write: *The future is ours!*
(Prof. Rabinovici)

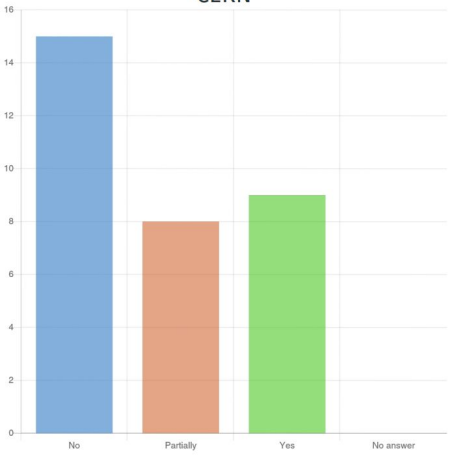
So which future collider do we want?

20

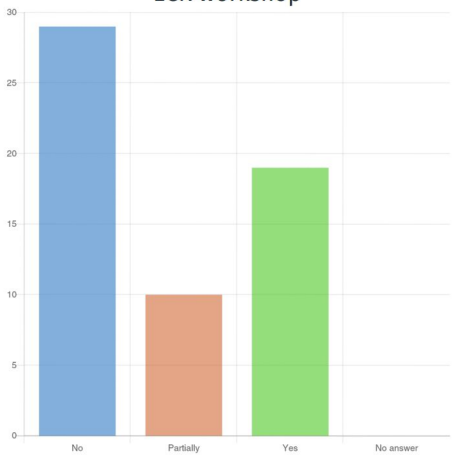
CERN and ECR Workshop survey (full presentation here)

- Are you currently working on projects connected to future colliders?

CERN



ECR workshop

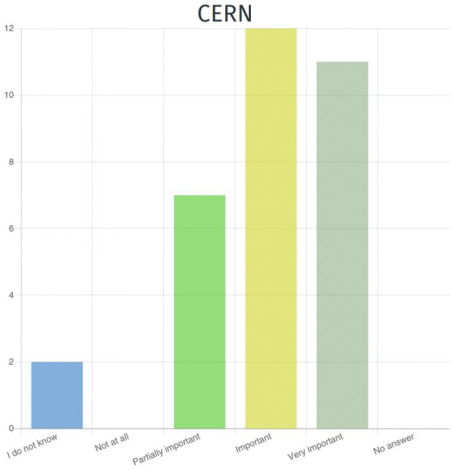


- Majority already working (partially or fully) on future collider projects

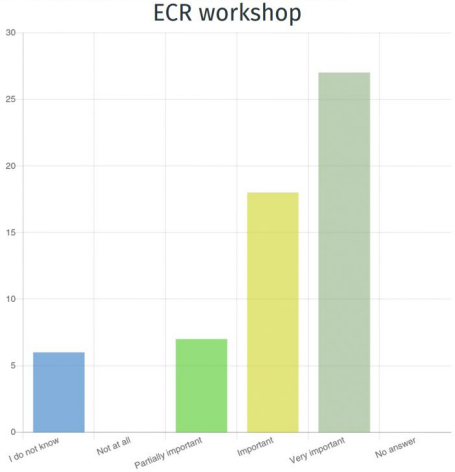
- Majority already working (partially or fully) on future collider projects

- How important is the future collider programme for your career?

CERN



ECR workshop



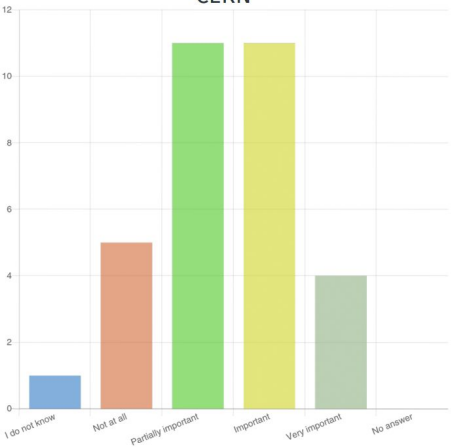
- A future collider program is considered important by (almostt) everyone

- A future collider program is considered important by (almost) everyone

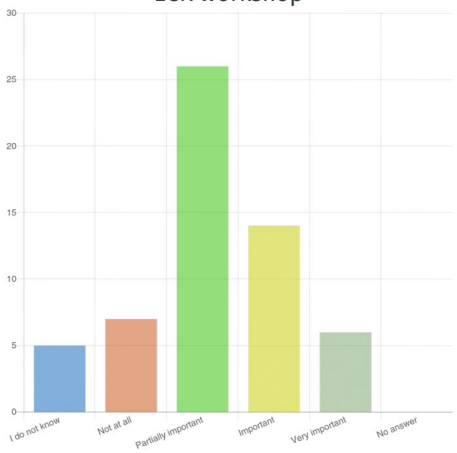
CERN and ECR Workshop survey (full presentation here)

- Is the choice of a specific future collider over another important for your career?

CERN



ECR workshop

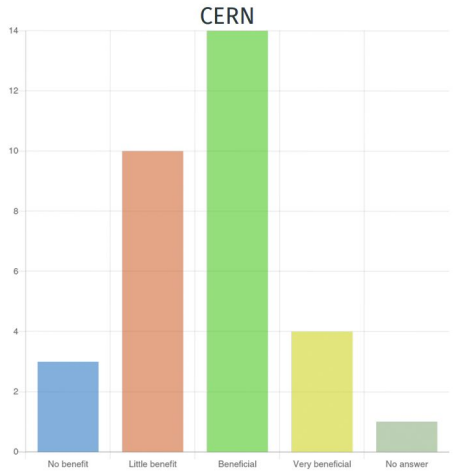


- The choice of the collider seems to matter, in part or completely

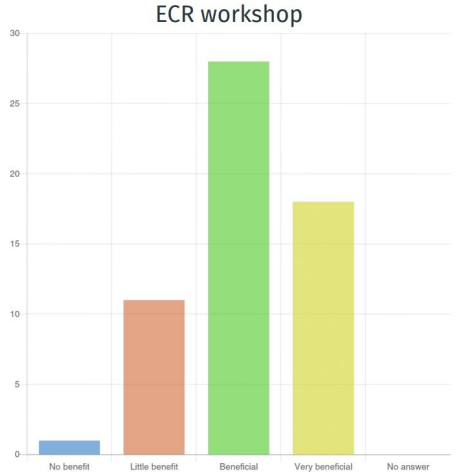
- The choice of the collider seems to matter, in part or completely

- Do you consider including future-collider related projects in your activities as beneficial to your career?

CERN



ECR workshop

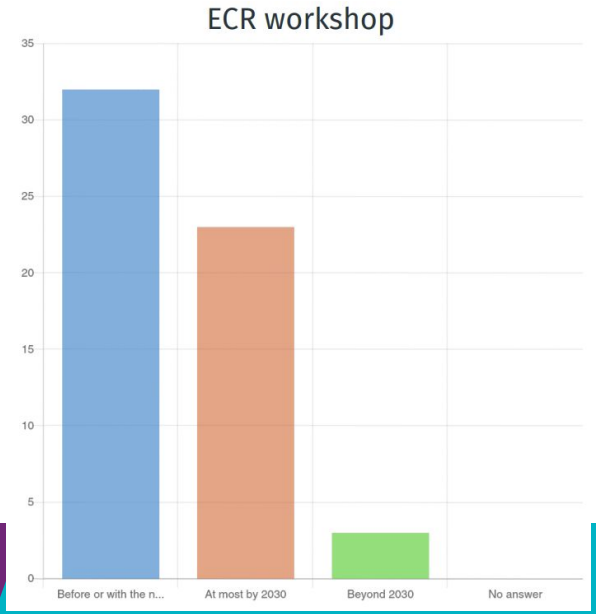


- Sizable 'little benefit' choice

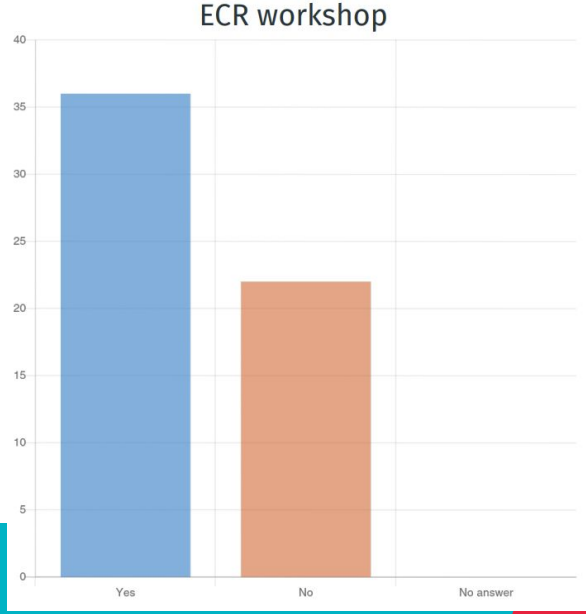
- More positive outlook

CERN and ECR Workshop survey (full presentation here)

In light of your career prospects, how long do you think it is acceptable to wait before the decision of which machine to build is made



Would you accept to work nearly full time on a project connected to a future collider, while the decision on the next machine is still pending? If yes, under which conditions



Requirements for the next HEP machine

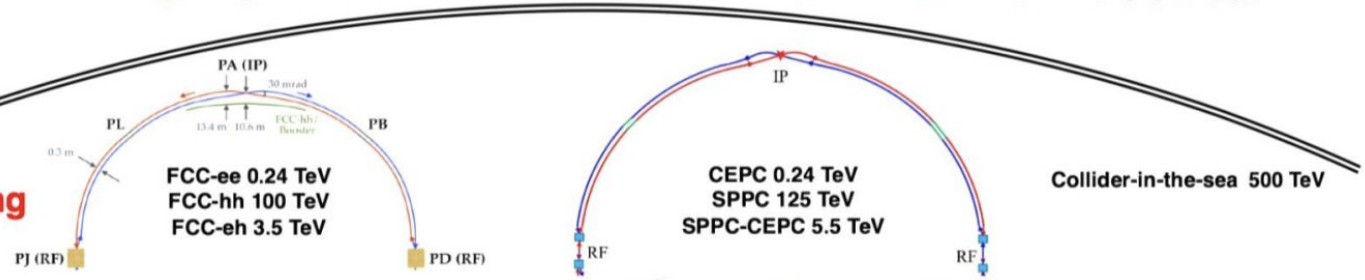
- From pure physics
  - Capable of H and t physics complementary to/beyond LHC and HL-LHC
  - Capable of Z and W physics beyond currently known
    ⇒an e^+e^- collider covering a region of 90-350 GeV centre of mass energy (cme)
- Somewhat physics related issues
  - It is good to start data taking with some overlap with the HL-LHC operation since the results might influence each other's scientific programme.
    ⇒A machine which can be built within the next 10~15 years.
  - Can be upgraded to probe higher energy scales if physics result motivates.
  - Should not damage the diversity of particle physics activities.
    ⇒A machine with a reasonable cost
- HEP sociology
  - Continuity in the HEP programme to sustain the community
- Other issues have become increasingly important
  - Environmental impact, energy consumption, resource availability, attractivity in technology, impact on industries, spinoffs, …

Tatsuya Nakada

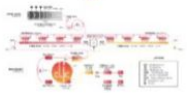
24

Future collider proposals: 0.125 – 500 TeV; e+e-, hh, eh, μμ, γγ, …

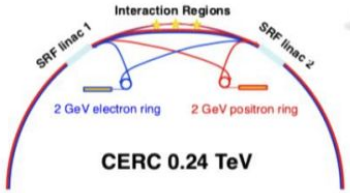
- **Storage ring colliders**
- **Linear colliders**
- **ERL colliders**
- **Muon collider**
- **Wakefield colliders**




ILC 0.25 TeV

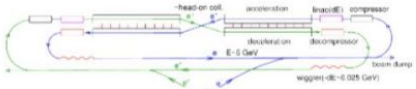

CLIC 0.24 TeV

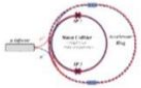

CCC 0.25 TeV



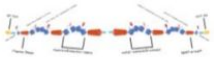
CERC 0.24 TeV


ReLiC 0.24 TeV


ERLC 0.24 TeV


MC 10 TeV

10 km

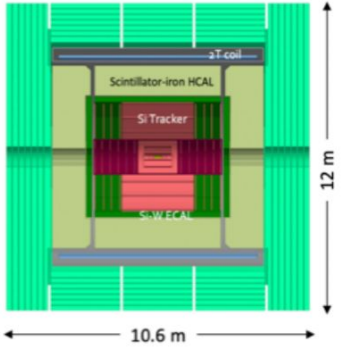

PWFA 15 TeV


LWFA 15 TeV


SWFA 3 TeV

CLD

https://arxiv.org/abs/1911.12230 and FCC CDS vol. 2



Well established design
- ILC -> CLIC detector -> CLD

Full Si vtx + tracker; CALICE-like calorimetry; large coil, muon system

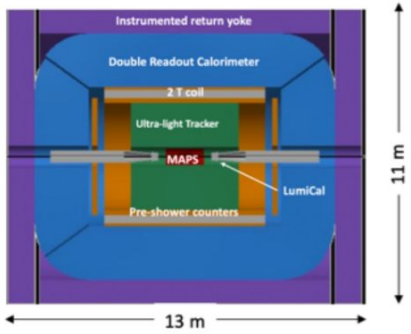
Engineering and R&D needed for
- reduction of tracker material budget
- operation with continous beam (no power pulsing: cooling of Si sensors for tracking + calorimetry)

Possible detector optimizations
- Improved σ_p/p, σ_E/E
- PID: timing and/or RICH?

CDR

IDEA

FCC CDR vol. 2



- Less established design
  - But still ~15y history: ILC 4th Concept
- Si vtx detector; ultra light drift chamber w powerfull PID; compact, light coil; monolitic dual readout fibre calorimeter; muon system
  - Possibly augmented by crystal ECAL
- Active community
  - Prototype designs, test beam campains, …

Allegro

M.Aleksa @ FCC Week, 2022

new

- A design in its infancy
- High granularity Noble Liquid ECAL is core
  - Pb+LAr (or denser W+LCr)
- Drift chamber; CALICE-like HCAL; muon system.
- Coil inside same cryostat as LAr, possibly outside ECAL
- Active Noble Liquid R&D team
  - Readout electrodes, feed-throughs, electronics, light cryostat, …
  - Software & performance studies

And even muon collider now!

Precision measurements at FCC-ee

Baseline FCC-ee operation model (+ potential resonant Higgs for electron Yukawa)

Working point	Z, years 1-2	Z, later	WW	HZ	tt		(s-channel H)
$\sqrt{s}$ (GeV)	88, 91, 94		157, 163	240	340-350	365	m_H
Lumi/IP ($10^{34}\,cm^{-2}s^{-1}$)	115	230	28	8.5	0.95	1.55	(30)
Lumi/year (ab^{-1}, 2 IP)	24	48	6	1.7	0.2	0.34	(7)
Physics Goal (ab^{-1})	150		10	5	0.2	1.5	(20)
Run time (year)	2	2	2	3	1	4	(3)
Number of events	5×10^{12} Z		10^8 WW	10^6 HZ + 25k WW → H	$10^6 t\bar{t}$ +200k HZ +50k WW → H		(6000)

Physics at the Z-pole, W^+W^-@threshold ~ m_W, Higgs factory, tt@threshold ~ m_t

great opportunities for precision QCD: a_s, jets, hadronization models...

The foreseen precision is staggering:

this poses astounding but also attractive challenges on theory predictions

- calculations within the SM of equivalent accuracy needed to exploit full discovery/exclusion power
- theory will serve as an input in many measurements, e.g. electroweak pseudo observables (EWPOs)

[Blondel, Janot 2106.13885]

Observable	present value ± error	FCC-ee Stat.	FCC-ee Syst.	Comment and leading exp. error
m_Z (keV)	91186700 ± 2200	**4**	100	From Z line shape scan Beam energy calibration
Γ_Z (keV)	2495200 ± 2300	**4**	25	From Z line shape scan Beam energy calibration
$\sin^2\theta_W^{\rm eff}(\times 10^6)$	231480 ± 160	**2**	2.4	from $A_{FB}^{\mu\mu}$ at Z peak Beam energy calibration
$1/\alpha_{QED}(m_Z^2)(\times 10^3)$	128952 ± 14	**3**	small	from $A_{FB}^{\mu\mu}$ off peak QED&EW errors dominate
R_ℓ^Z $(\times 10^3)$	20767 ± 25	**0.06**	0.2-1	ratio of hadrons to leptons **acceptance for leptons**
$\alpha_s(m_Z^2)$ $(\times 10^4)$	1196 ± 30	**0.1**	0.4-1.6	from R_ℓ^Z above
σ_{had}^0 $(\times 10^3)$ (nb)	41541 ± 37	**0.1**	4	peak hadronic cross section luminosity measurement
$N_\nu(\times 10^3)$	2996 ± 7	**0.005**	1	Z peak cross sections Luminosity measurement
R_b $(\times 10^6)$	216290 ± 660	**0.3**	< 60	ratio of bb̄ to hadrons stat. extrapol. from SLD
$A_{FB}^{b,0}$ $(\times 10^4)$	992 ± 16	**0.02**	1-3	b-quark asymmetry at Z pole from jet charge
$A_{FB}^{pol,\tau}$ $(\times 10^4)$	1498 ± 49	**0.15**	<2	τ polarization asymmetry τ decay physics
τ lifetime (fs)	290.3 ± 0.5	**0.001**	0.04	radial alignment
τ mass (MeV)	1776.86 ± 0.12	**0.004**	0.04	momentum scale
τ leptonic ($\mu\nu_\mu\nu_\tau$) B.R. (%)	17.38 ± 0.04	**0.0001**	0.003	e/μ/hadron separation
m_W (MeV)	80350 ± 15	**0.25**	0.3	From WW threshold scan
Γ_W (MeV)	2085 ± 42	**1.2**	0.3	From WW threshold scan Beam energy calibration
$N_\nu(\times 10^3)$	2920 ± 50	**0.8**	small	ratio of invis. to leptonic in radiative Z returns
m_{top} (MeV/c^2)	172740 ± 500	**17**	small	From tt̄ threshold scan QCD errors dominate
Γ_{top} (MeV/c^2)	1410 ± 190	**45**	small	From tt̄ threshold scan QCD errors dominate
$\lambda_{top}/\lambda_{top}^{SM}$	1.2 ± 0.3	**0.10**	small	From tt̄ threshold scan QCD errors dominate
ttZ couplings	± 30%	**0.5 − 1.5 %**	small	From $\sqrt{s} = 365$ GeV run

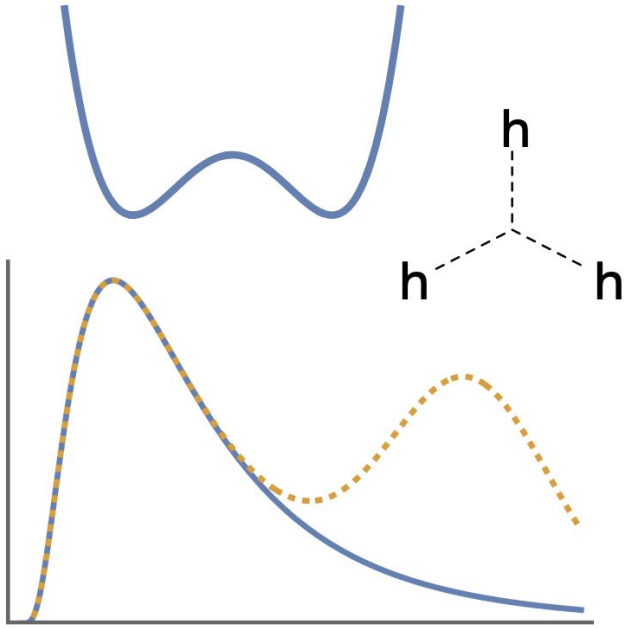
Federico Buccioni

Summary

Exciting times ahead if a future collider is built!

- Guaranteed deliverables:
  - Precision measurements
  - Higgs self-coupling

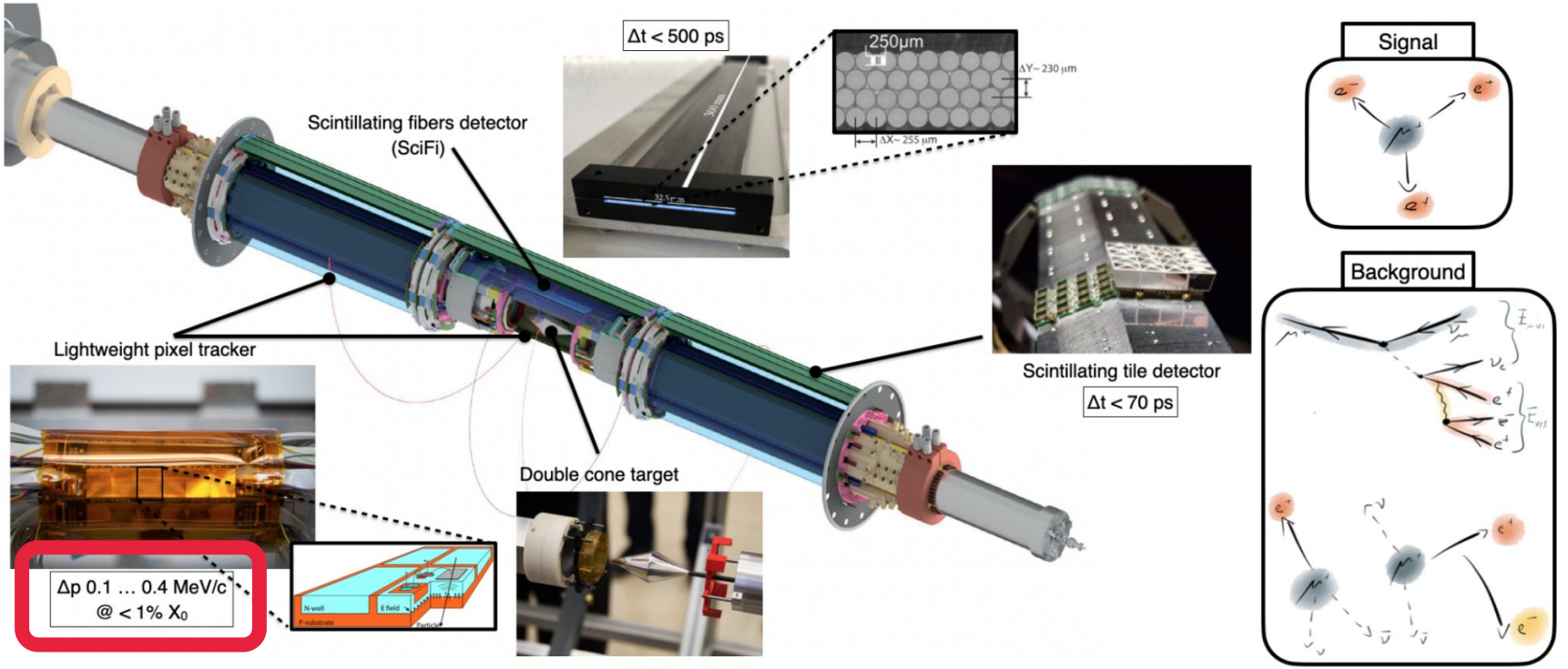
- Potential direct discoveries



Anke Biekoetter

Mu3e detector

The aim is to improve the current limit of $\mathcal{B}(\mu \to eee) < 1.0 \times 10^{-12}$ (90 % C.L.) to S.E.S. $< 10^{-16}$[2].

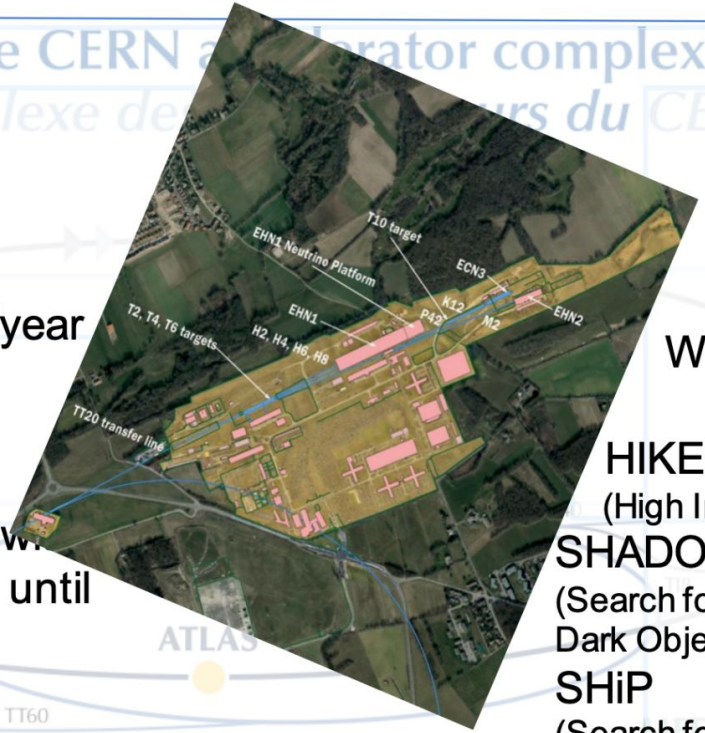


29

- ECN3 - part of the SPS NA
- 400 GeV
- high intensity up to 10^{19} pot/year
- high duty cycle

Currently :

the NA62 experiment w
an approved program until
LS3.



What is after LS3?

HIKE
(High Intensity Kaon Experiment)
SHADOW
(Search for Hidden And
Dark Objects With the SPS)
SHiP
(Search for Hidden Particles)

Iaroslava Bezshyiko

What cool things can we do with ATLAS/CMS/LHCb/ALICE leftovers after HL-LHC?
Using waste particles: Beam dumps at future colliders?

30

Conclusions

(Ultra-relativistic) heavy-ion collisions: unique tool to study QCD matter under extreme conditions

Next decades will be crucial to shape the post-LHC future of heavy-ion field!

- Whole new opportunities for heavy-ion studies with colliders like FCC
- EIC will *complement* these future heavy-ion studies by exploring cold QCD
- New (and unconventional) ideas are welcome!

Future colliders need you 👊
Thank you for your attention!

Ivan Vorobyev

Reflections

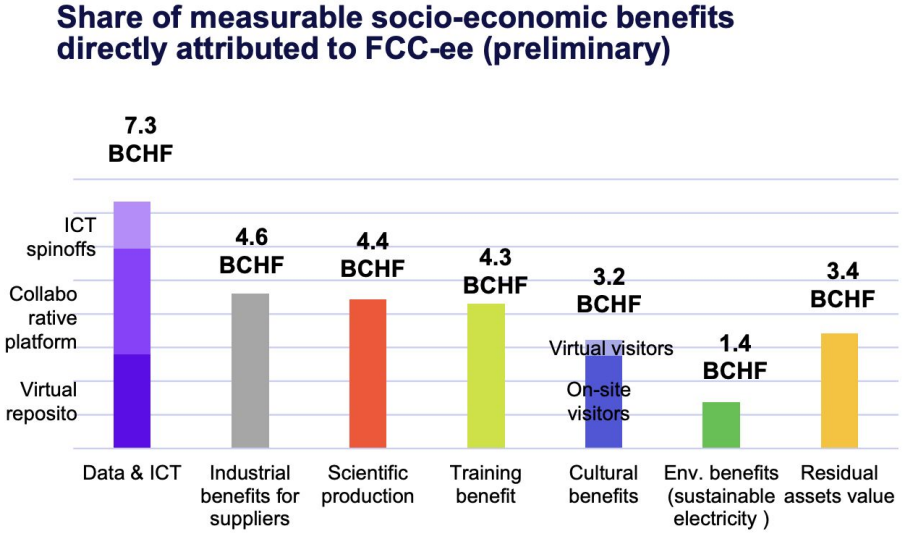
- ECRs need to be involved in future projects – it is **your** future
  - In the early stages, these projects are driven by experienced senior colleagues
    - They have the luxury/duty of preparing the future, but todays ECRs will benefit from this and actually carry out the science – get involved, you can make a difference ...
- Participating in running experiments gives invaluable experience
  - Real data is not simulation, but ATLAS SCT works a lot better than the testbeam
  - Experience the full chain from detector operations to paper acceptance
  - A different experience of collaboration, analysis WGs/hierarchies, getting results
    - Some colleagues worked only on LHC expts. from 1990 until now – I'm glad I did not
- Expertise is transferrable between experiments / projects
  - Figure out what you are interested in and good at – look for synergies
    - I have worked on tracking/b-tagging & precision measurements at OPAL and ATLAS
- Say yes to leadership opportunities even if it upsets your plans
  - Explore different areas, learn new skills, broaden your horizons
    - Less-attractive tasks are still vital, people appreciate that you take them on
- Be prepared for setbacks, surprises and successes – good luck !

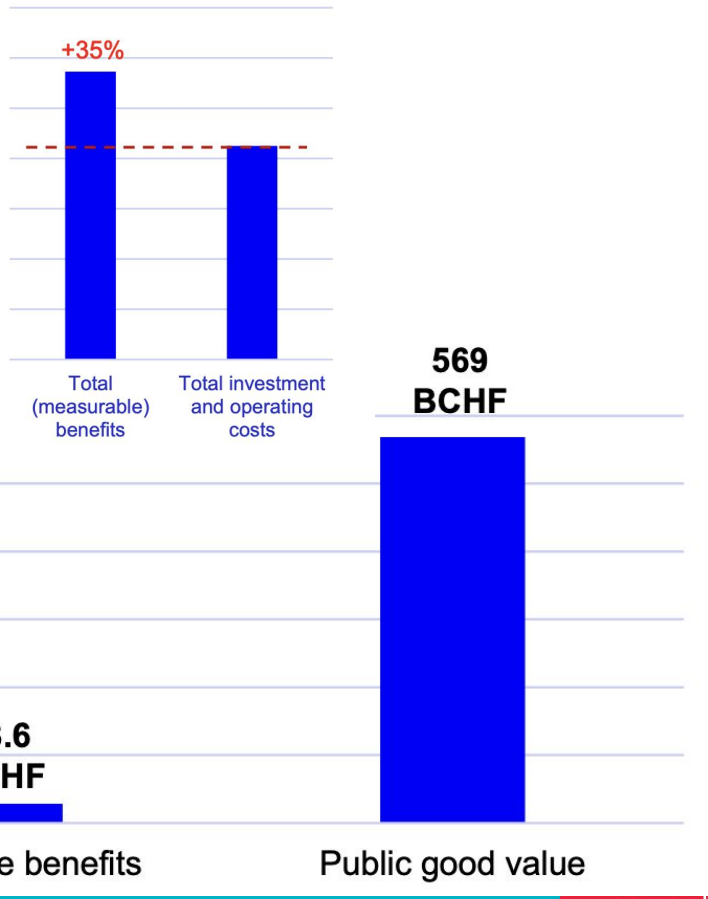
32

ECRs: This is YOUR TIME, YOUR FUTURE

- BIRMINGHAM ONE FULL DAY, PARIS TWO HOURS, CAMBRIDGE, LONDON TWO HOURS, UK ECR+, GENEVA ONE FULL DAY.
- COUNCIL VIEW INFORMED ACTION
- ECR INFORMED ACTION

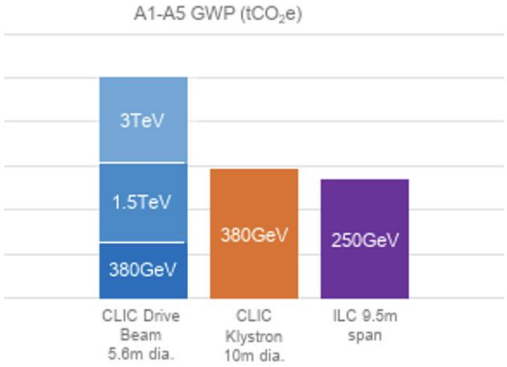
Eliezer Rabinovici





Future colliders are *worth it*!

LifeCycle Assessment: CLIC & ILC



UN Breakthrough Outcomes for 2030

For the built environment sector, the UN breakthrough outcomes for 2030 detail that 100% of projects due to be completed in 2030 or after are net zero carbon in operation, with at least 40% less embodied carbon compared to current practice. This has been set to make sure the sector is on track for 100% projects to be net zero carbon across the whole life cycle by 2050.

https://climatechampions.unfccc.int/system/breakthroughs/

- **We need to consider how to get to net zero carbon operation and 40% less impacting construction for our future projects….**

Roberto Losito

35