Activities of the ECFA ECR Panel

Emanuele Bagnaschi (INFN LNF/CERN)
on behalf of the ECR session organizing committee

12 October 2023

Second ECFA workshop on e+e- Higgs/EW/Top factories

`Paestum, Italy`

The ECFA and the ECR Panel

ECFA

- ECFA -- European Committee for Future Accelerators
- All countries (+CERN) elect representatives to sit in the "plenary" ECFA
- One representative per country in the "restricted" ECFA
- Since 2020 an Early Career Researcher (ECR) Panel exists. It has representative both in PECFA and RECFA.
- https://ecfa.web.cern.ch/

The ECFA and the ECR Panel

ECR Panel

The objective of the ECFA Early-Career Researchers (ECR) Panel is for its members to discuss all aspects that contribute in a broad sense to the future of the research field of particle physics. In its advisory role to ECFA, the panel reports to ECFA on a regular basis. An annual report of the ECFA ECR Panel is added as a standing item to the agenda of Plenary ECFA meetings.

Role

- ECR community link to the update of the European Strategy via the ECFA
- Activity divided in various working groups. For a full overview, see https://arxiv.org/abs/2212.11238
- You should get involved!

Composition

- 3 representatives for each ECFA country, +1 for the major laboratorities
- Composed of researchers going from PhD to assistant professors
- Theorists/phenomenologists and experimentalists work together with the aim of representing the diverse viewpoints of the community
- 3-4 panel meetings per year, handled by Organization Committee (3 members)
- 5 ECR delegates in Plenary ECFA, 1 delegate in Restricted ECFA

The ECFA ECR workshop at CERN

Day agenda

- Held at CERN on the 27th of September
- Topical presentations with ample discussion time
- Four main sessions: overview; challenges; different viewpoints; people and money
- Slides and recordings are available on `INDICO`

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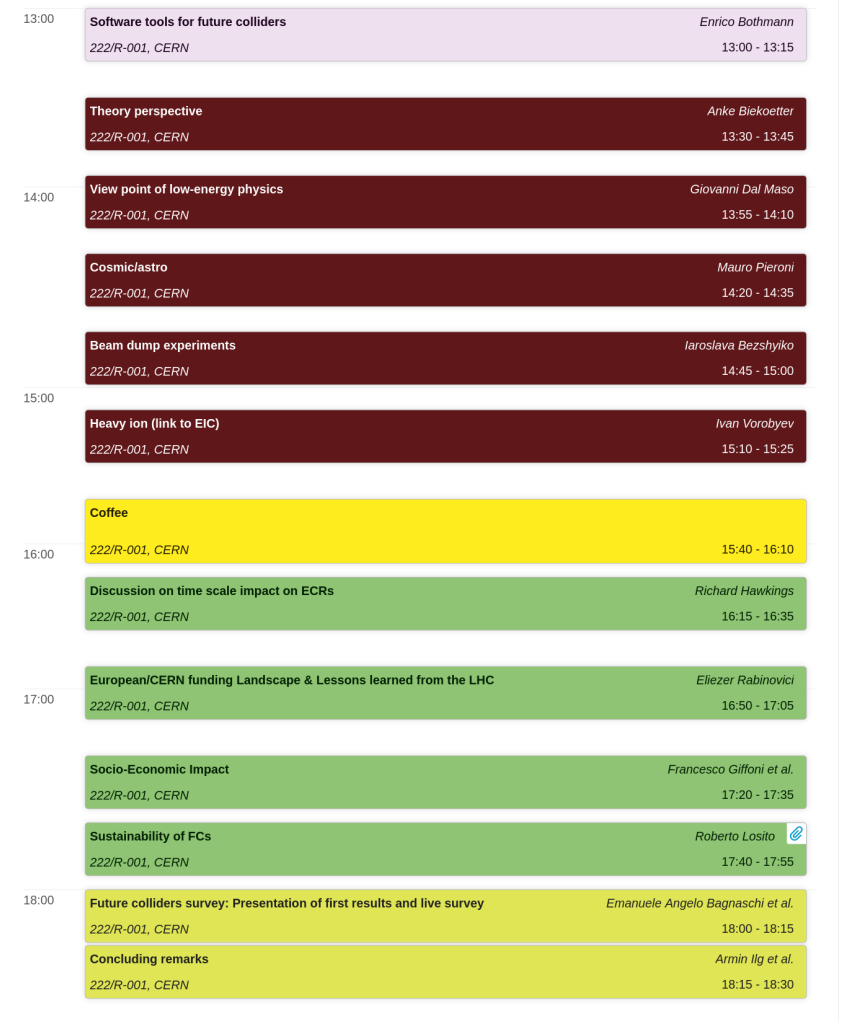
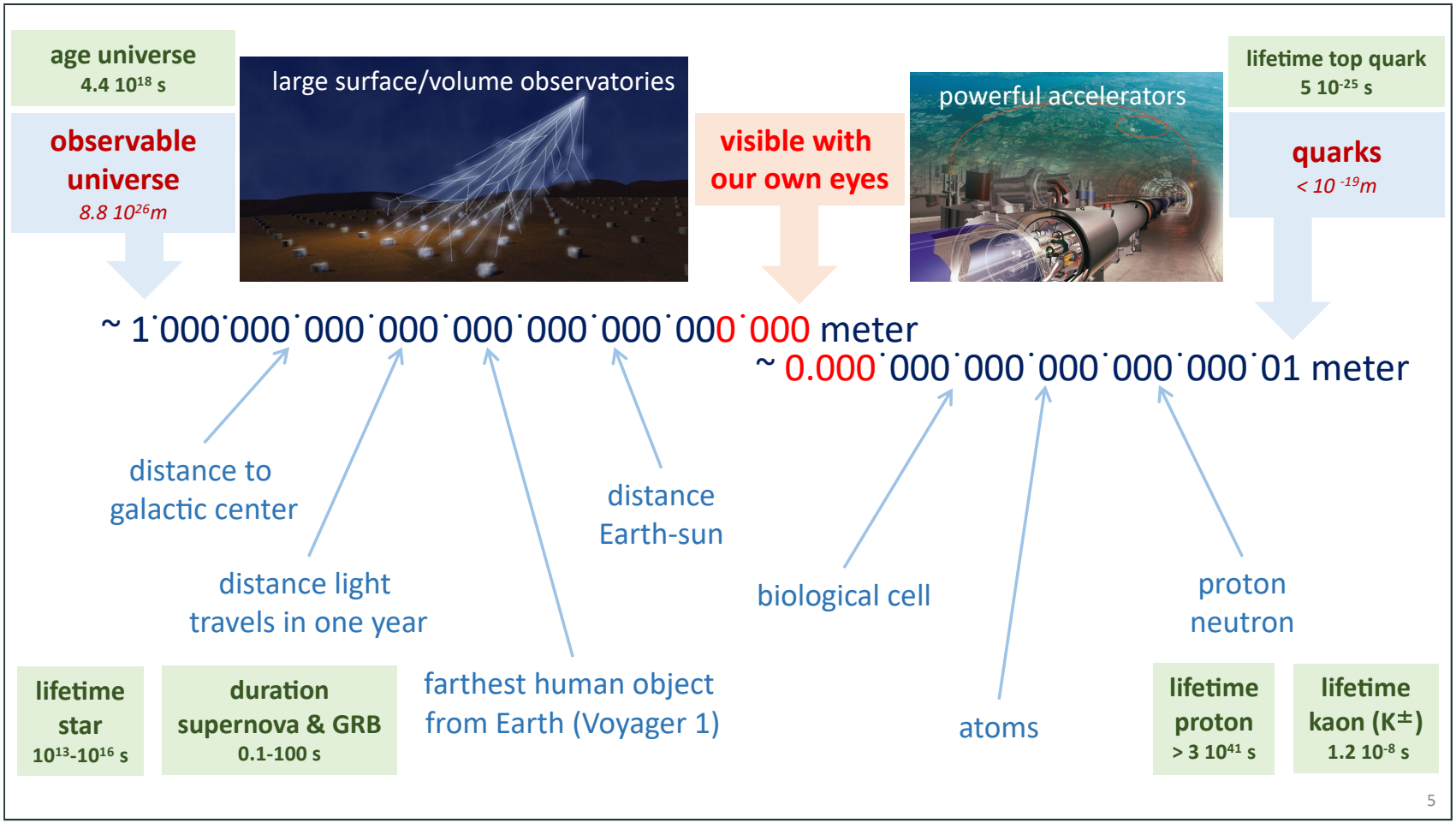




[Jorgen D'Hondt, *Towards the future of particle physics*]
[slides, recording]

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, …

27/09/2023 T. Nakada Landscape for the future colliders 9

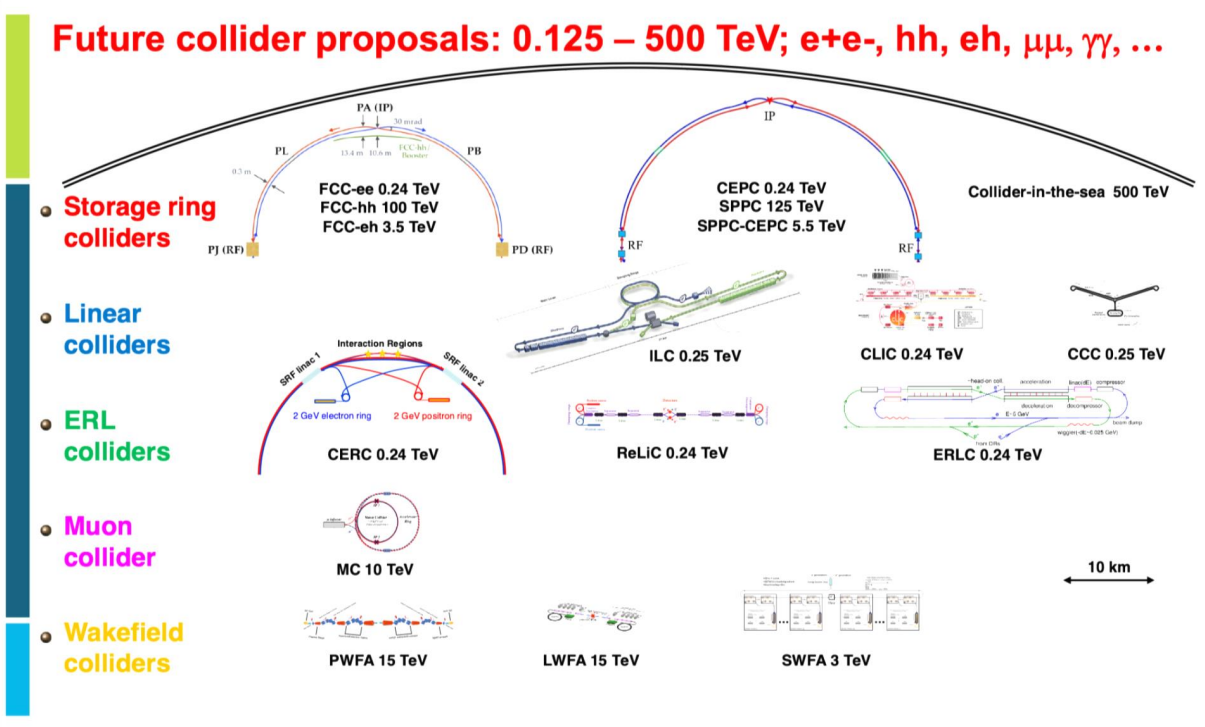
[Tatsuya Nakada, *The future collider landscape*]
[slides, recording]

Collider Proposals at Snowmass

Implementation Task Force (ITF) looked at many different proposals

Cannot cover them all

Select according to European view



[Daniel Schulte & Tatiana Pieloni, *Input from accelerator physicists*]
[slides]

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	$t\bar{t}$		(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
$\sin^2\theta^{\rm eff}_W(\times 10^6)$	231480 ± 160	**2**	2.4	from $A^{\mu\mu}_{FB}$ at Z peak Beam energy calibration
$1/\alpha_{QED}(m_Z^2)(\times 10^3)$	128952 ± 14	**3**	small	from $A^{\mu\mu}_{FB}$ off peak QED&EW errors dominate
R^Z_ℓ $(\times 10^3)$	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^Z_ℓ above
σ^0_{had} $(\times 10^3)$ (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 $b\bar{b}$ to hadrons stat. extrapol. from SLD
$A^{b,0}_{FB}$ $(\times 10^4)$	992 ± 16	**0.02**	1-3	b-quark asymmetry at Z pole from jet charge
$A^{pol,\tau}_{FB}$ $(\times 10^4)$	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 Beam energy calibration
Γ_W (MeV)	2085 ± 42	**1.2**	0.3	From WW threshold scan Beam energy calibration
$\alpha_s(m_W^2)(\times 10^4)$	1170 ± 420	**3**	small	from R^W_ℓ
$N_\nu(\times 10^3)$	2920 ± 50	**0.8**	small	ratio of invis. to leptonic in radiative Z returns
m_{top} (MeV/c^2)	172740 ± 500	**17**	small	From $t\bar{t}$ threshold scan QCD errors dominate
Γ_{top} (MeV/c^2)	1410 ± 190	**45**	small	From $t\bar{t}$ threshold scan QCD errors dominate
$\lambda_{top}/\lambda^{SM}_{top}$	1.2 ± 0.3	**0.10**	small	From $t\bar{t}$ threshold scan QCD errors dominate
ttZ couplings	± 30%	**0.5 − 1.5 %**	small	From $\sqrt{s} = 365$ GeV run

[Federico Buccioni, *Theory challenges: precision calculations*]
[slides, recording]

QED initial-state radiation

Careful treatment of QED-ISR is fundamental for FCC-ee phenomenology (precision observables)

Two main approaches: Collinear factorization vs YFS

soft-photons resummed to all-orders

well established framework

implemented already in several MC generators

priority to soft logarithms

Great recent progress on formulation of coll. factorisation beyond LL [Frixione 1909.03886, 2105.06688; Bertone et al 1911.12040, 2207.03265]

lepton PDFs with with coll. logarithms resummed to NLL accuracy

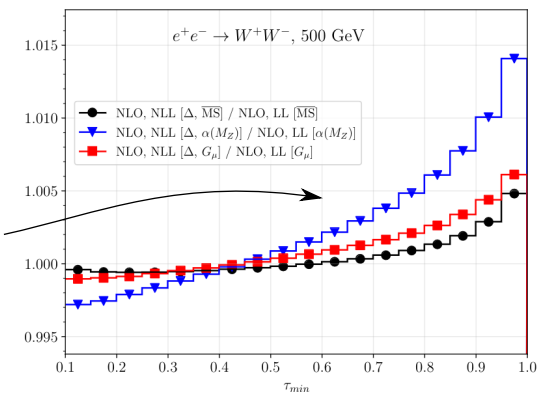
$$d\sigma_{e^+e^-} = \sum_{ij} \int dz_+ dz_- \, \Gamma_{i/e^+}(z_+, \mu^2, m_e^2)\, \Gamma_{j/e^-}(z_-, \mu^2, m_e^2)\, d\hat{\sigma}_{ij}(z_+ p_{e^+}, z_- p_{e^-}, \mu^2) + \mathcal{O}(m_e^2/Q^2)$$

NLL resummation is absolutely necessary for target precision:

Future avenues:

- Reaching NNLL would be ideal (hard but within timeline)
- Thinking of simultaneous resummation of soft and collinear emissions

~1% level effect

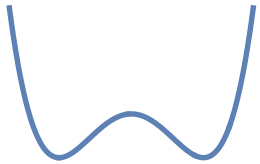


(NLO_EW + NLL_PDFs)/(NLO_EW + LL_PDFs)

[Federico Buccioni, *Theory challenges: precision calculations*]
[slides, recording]

Higgs physics

What we know



$$V = -\mu^2 |\phi|^2 + \lambda |\phi|^4$$

Anke Biekötter - JGU Mainz 3

[Anke Biekötter, *Theory perspective*]
[slides, recording]

Higgs physics

What we actually know

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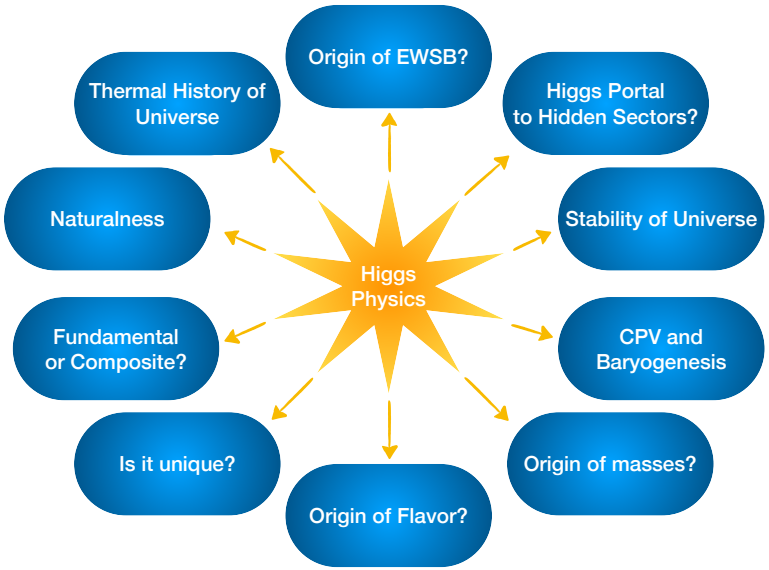
[Anke Biekötter, *Theory perspective*]
[slides, recording]

Higgs physics

What we actually know

$$V = -\mu^2 |\phi|^2 + \lambda |\phi|^4$$

Good reasons to believe that the Higgs is related to BSM physics



[Dawson et al. (2209.07510)]

[Anke Biekötter, *Theory perspective*]
[slides, recording]

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 !

[Richard Hawkings, *Discussion on time scale impact on ECRs*]
[slides, recording]

COMMON: MAINTAIN A LEADERSHIP VIA A VISION

CERN TO PROVIDE THE BEST SCIENCE AND TECHNOLOGY ARENA.

- **WHAT VISION? CONSIDERATIONS AND CONCERNS**

- **Scientific (Higgs and?)**
- **Technological (HL and High Field Magnets)- RECFA MAP**
- **New Detectors – NEW "ALICE", "ATLAS", "CMS", "LHCb", NEW!-RECFA MAP**
- **Construction: Geology , Environment**
- **Financial**
- **ECRs**
- **Politics and overlap issue.**

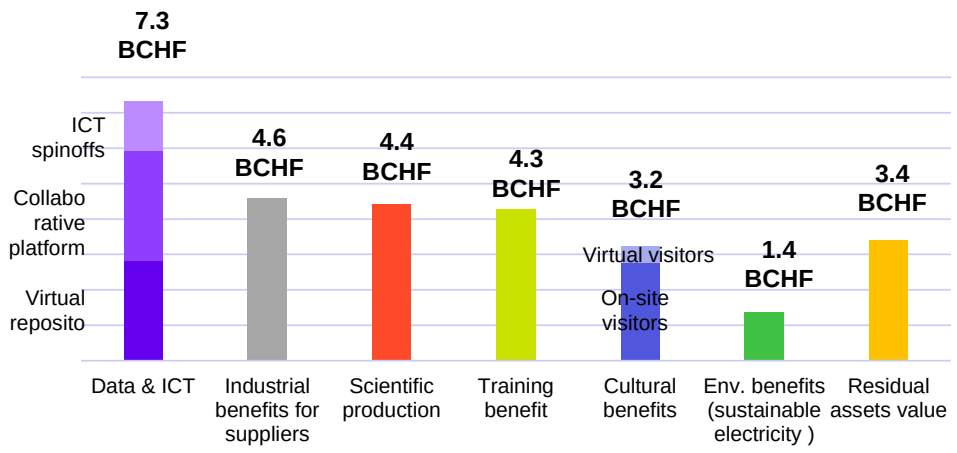
THE FUTURE REQUIRES SCIENTIFIC AND TECHNOLOGICAL VISION.

EXCELLENCE IS EXTREMELY HARD TO ACHIEVE AND SO EASY TO LOOSE.

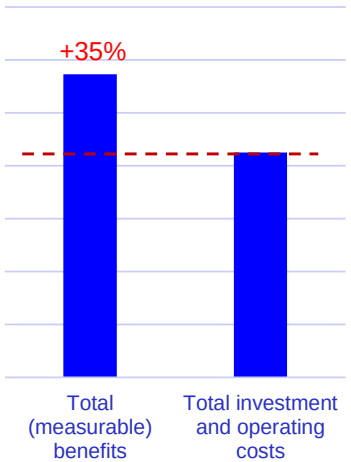
[Eliezer Rabinovici, *The view from the CERN council and ECRs*]
[slides, recording]

A preview of results of the quantitative model

Share of measurable socio-economic benefits directly attributed to FCC-ee (preliminary)



Benefit vs costs (preliminary)

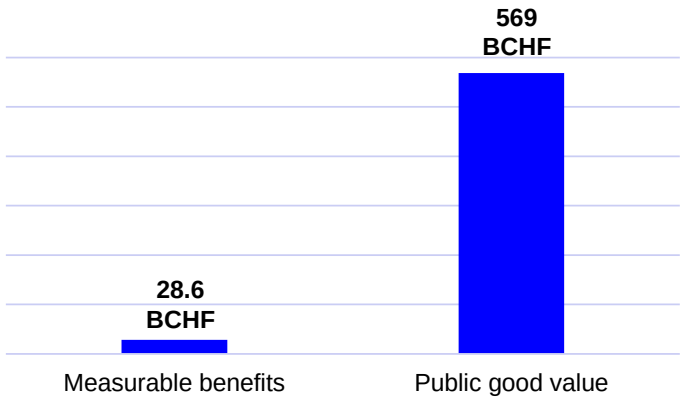


Benefits and costs are discounted at a Social Discount Rate of 2%.

[Francesco Giffoni & Massimo Florio, *Socio-economic impact*]
[slides, recording]

Measurable benefits vs the total public good value

- **On-line surveys** to representative samples of population in France, Switzerland, Germany, Israel, Italy, Japan, Poland, UK, USA: **10,448 total respondents.**
- **Estimation of their willingness to financially support FCC-ee, because of its perceived utility for humankind.**
- **Extrapolation of estimates** to other potential FCC-ee contributing countries.



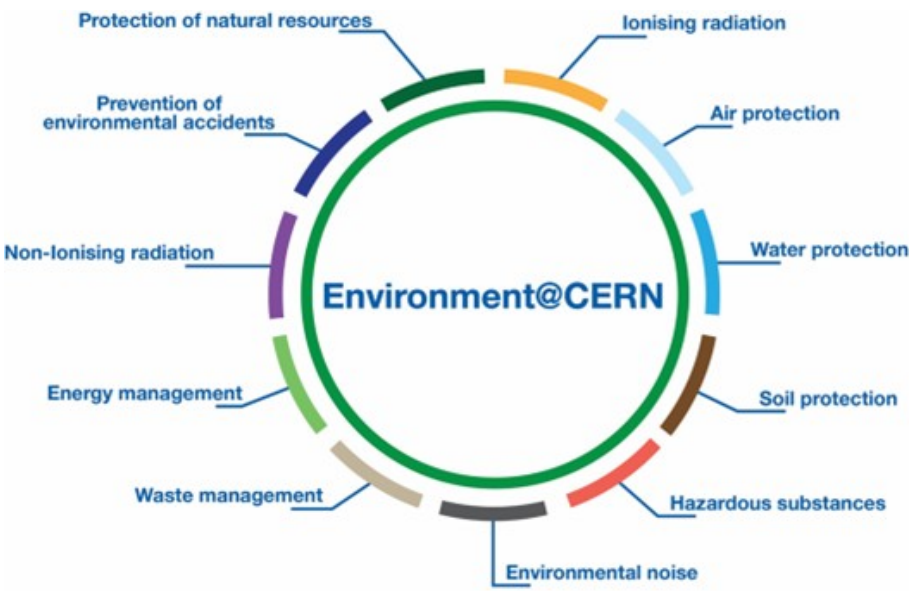
The values are discounted at a Social Discount Rate of 2%.

Secci, L., Giffoni, F., and Delugas, E. (2023). The value of particle physics research at CERN as public good (1.0). Zenodo. https://doi.org/10.5281/zenodo.7766949

[Francesco Giffoni & Massimo Florio, *Socio-economic impact*]
[slides, recording]

CERN Environmental Protection Steering Board

- **Main body for prioritization and implementation of environmental objectives**
- **Created in 2017, involves members of the ED, line management and units for management of energy and environmental footprint.**
- **Steers projects for about 40 MCHF**
  - Retention basins and new STEP to control effluents
  - Cooling towers upgrades
  - Dismissal of oil-based transformers
  - Replacement of GHG in detectors
  - Inventory of Scope 1, 2, 3 emissions, biodiversity, Noise & waste managements….
- **Coordinates the editing of the CERN Environmental report**



[Roberto Losito, *Sustainability of FCs*]
[slides, recording]

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

We will not pick the next collider today, but we ask the questions that need answering

- 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?

Additional questions; please email them to; ecfa-ecr-future-colliders@cern.ch

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[Lydia Brenner, *Final remarks*]
[slides]

Future activities of the ECFA ECR panel

Outlook

- Follow-up events at the national level, organized by local committees of the ECFA countries
- Goal: discuss country-dependent issues/aspects (e.g. funding sources, role of the national agencies etc.)
- Goal: help the formation of a cohese ECR community at the national level
- Organization in progress, send an email to ecfa-ecr-future-colliders@cern.ch to participate!

ECR session organizers

Organizing committee

- Emanuele Bagnaschi (CERN/INFN)
- Antimo Cagnotta (U. Napoli)
- Uli Einhaus (DESY)
- Adrian Irles (IFIC CSIC/UV)
- Dolores Garcia (CERN)

And now the panel discussion!