CERN and the Environment Town Hall meeting

Sustainability in future accelerators

Roberto Losito

8 November 2024

CEPS
CERN Environmental Protection Steering Board

Sustainability in a nutshell

- **Defined in 1987 by the UN Bruntland Commission on Environment and Development:**

*"Sustainable development is development that **meets the needs of present without compromising** the ability of future generations to meet their own needs"*

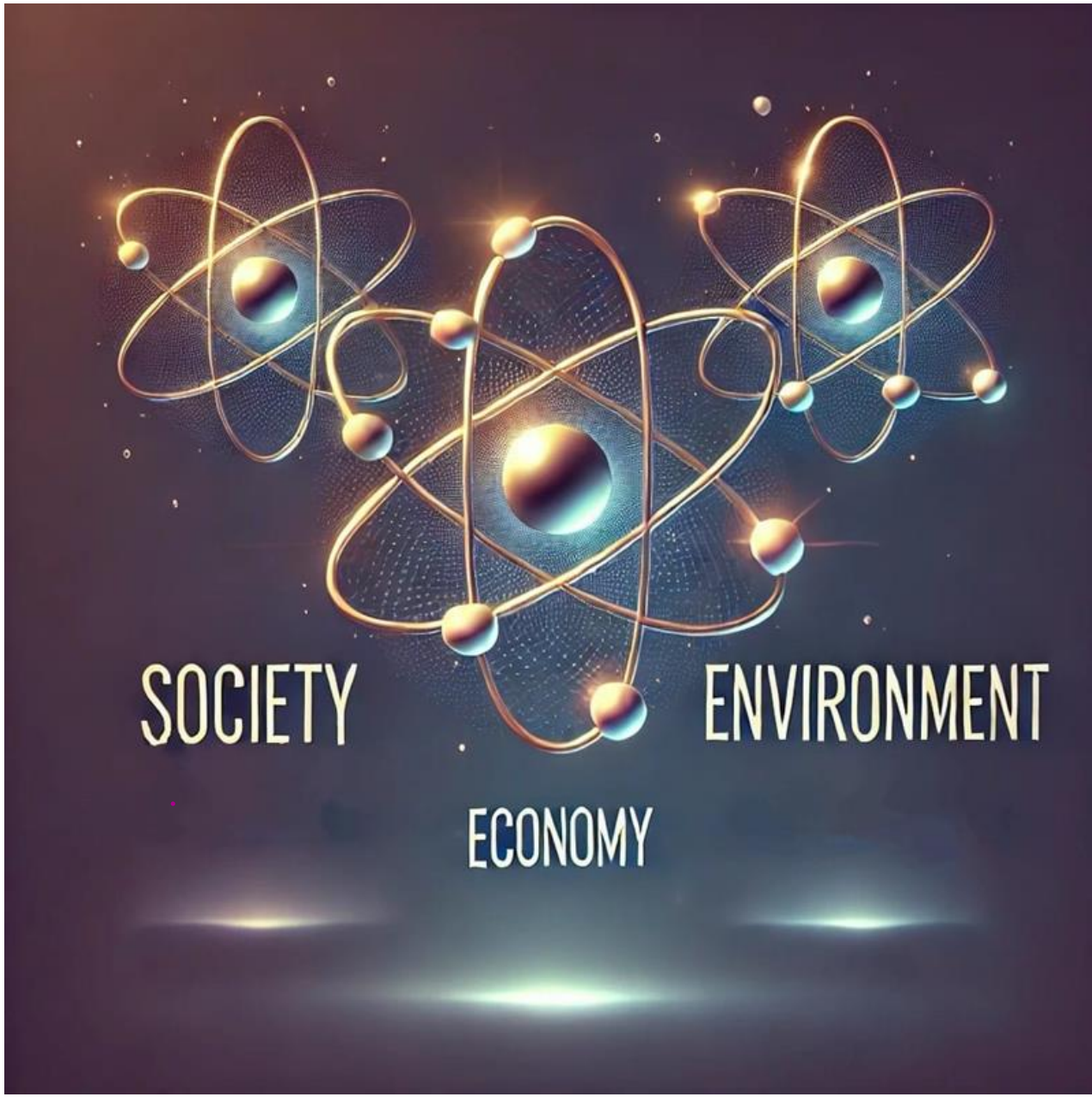
→ Supports the **aspirations** of the present generation to sustain innovation and development, but also their (our!) **responsibility** towards future generations!

Sustainability in a nutshell

- Every human activity has an impact on…

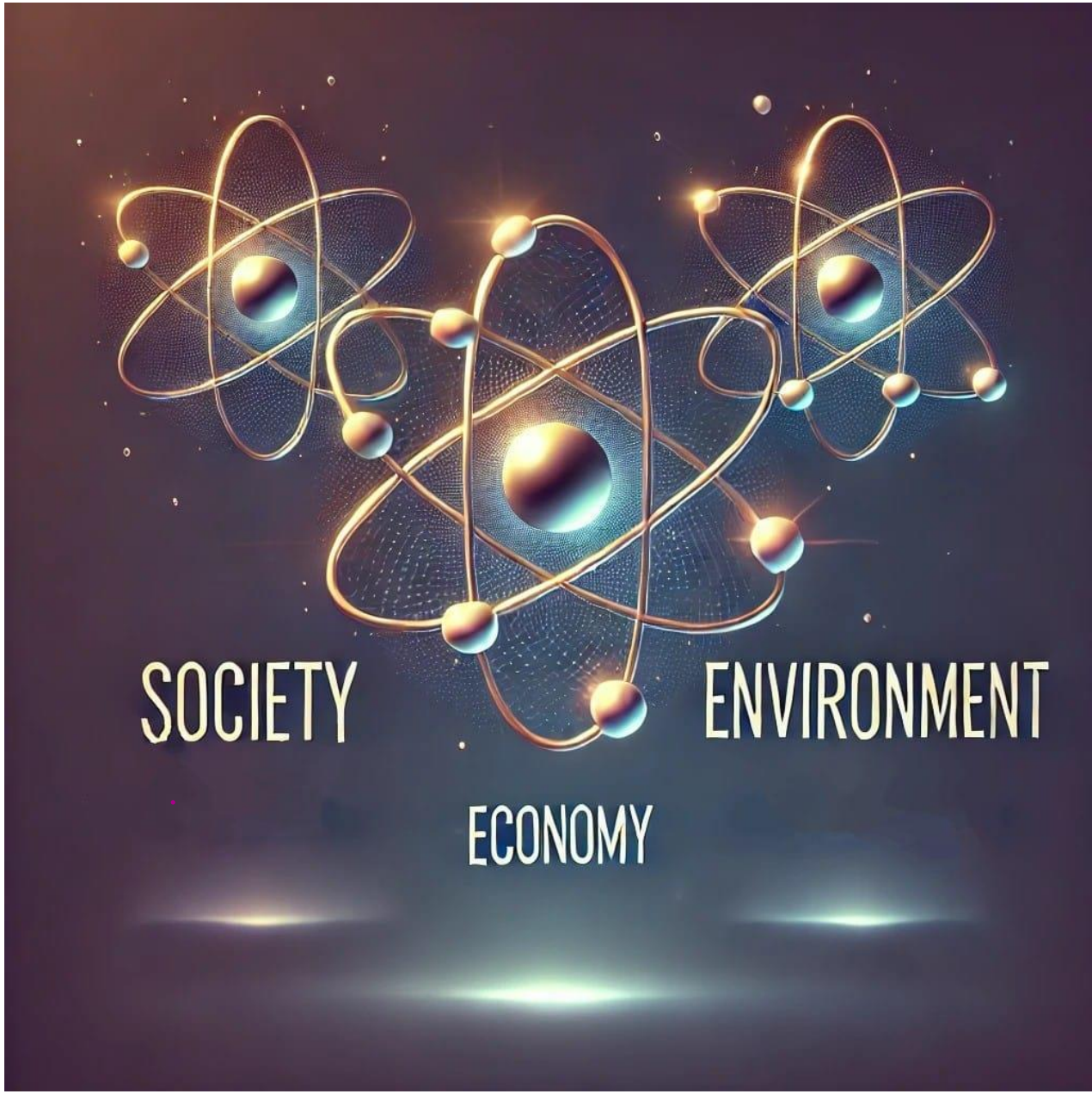
- **Society**:
  - Scientific output
  - Realisation of a dream!
  - Training of researchers, engineers, technicians…
  - Creation of a hub (CERN) where different cultures, sensibilities and brains can meet and establish cross-border, long term relationships based on a shared passion for knowledge

- **Economy:**
  - Innovation
  - Transfer of Technology to industry
  - Training of researchers, engineers, technicians…



Sustainability in a nutshell

- Every human activity implies pros and cons…
- **Environment**
  - Impact on air, water, soil, natural resources (cons)
  - … but we also learn to from those issues, seeking solutions to reduce this impact, transferring what we learn to society…

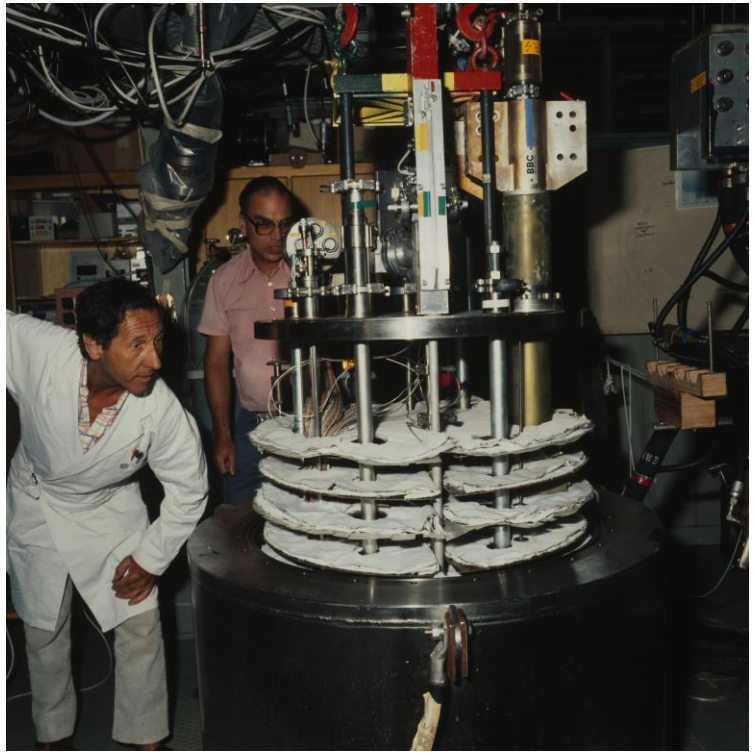


International Context

- Following the **2020 EUSPP**, with clear recommendation to study and minimise the Environmental impact of high energy physics activities, to pay attention to their Socioeconomic Impact, and in particular to promote actions to increase it, several panels have been implemented by the global community at various levels:
  - **ICFA** revived a **Panel on Sustainable Accelerators and Colliders**, to exchange information and create momentum for global activities in the field
  - The **Laboratory Directors' Group** established a **Working Group** to define a methodology to assess future projects in terms of sustainability, with the goal of understanding the main drivers of environmental impact of future colliders and promote optimisation measures
  - **CERN** established a **Sustainable Accelerators Panel**, to promote best practices, share experience, identify innovations that help to reduce the impact of CERN accelerators.

CERN and Sustainability

In order to make LEP and LHC possible, CERN developed many innovative technologies to reduce consumption of electricity, water and resources



CERN and Sustainability

In order to make LEP and LHC possible, CERN developed many innovative technologies to reduce consumption of electricity, water and resources

Environmental considerations have evolved in line with the establishment of the UN Sustainable Development Goals and Host State legislation

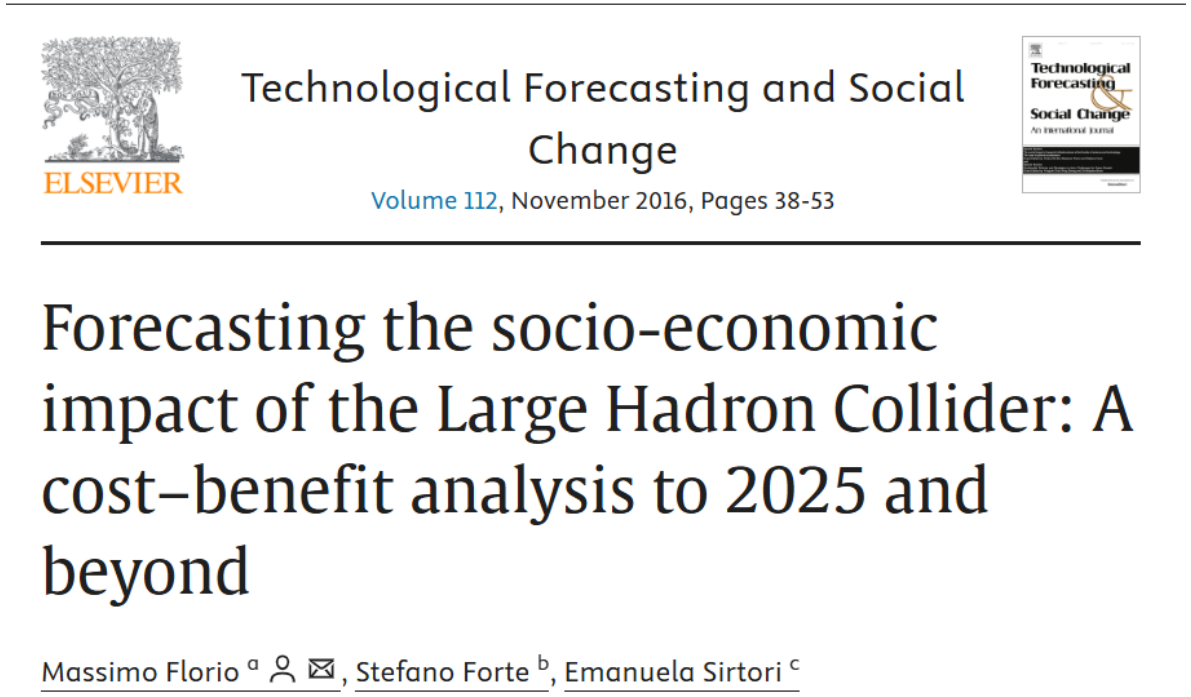
Since the mid 2010s, EU and other funding agencies introduced the evaluation of the Socioeconomic impact of large Research Infrastructures as part of the approval process

Other funding agencies are also requesting socioeconomic reports to provide funding

CERN therefore decided to start doing socioeconomic impact studies based on a scientific and professional approach: first exercise starting with HL-LHC in collaboration with the University of Milano

Socioeconomic impact studies in HL-LHC

- The study identified and measured KPIs to quantify the return to society
  - Scientific papers and citations
  - Increased turnover of industries involved in HL-LHC
  - Positive impact of discoveries (through new technologies, patents, training of scientists, etc.)


ELSEVIER

Technological Forecasting and Social Change

Volume 112, November 2016, Pages 38-53

Forecasting the socio-economic impact of the Large Hadron Collider: A cost–benefit analysis to 2025 and beyond

Massimo Florio [a], Stefano Forte [b], Emanuela Sirtori [c]

https://doi.org/10.1093/icc/dty029

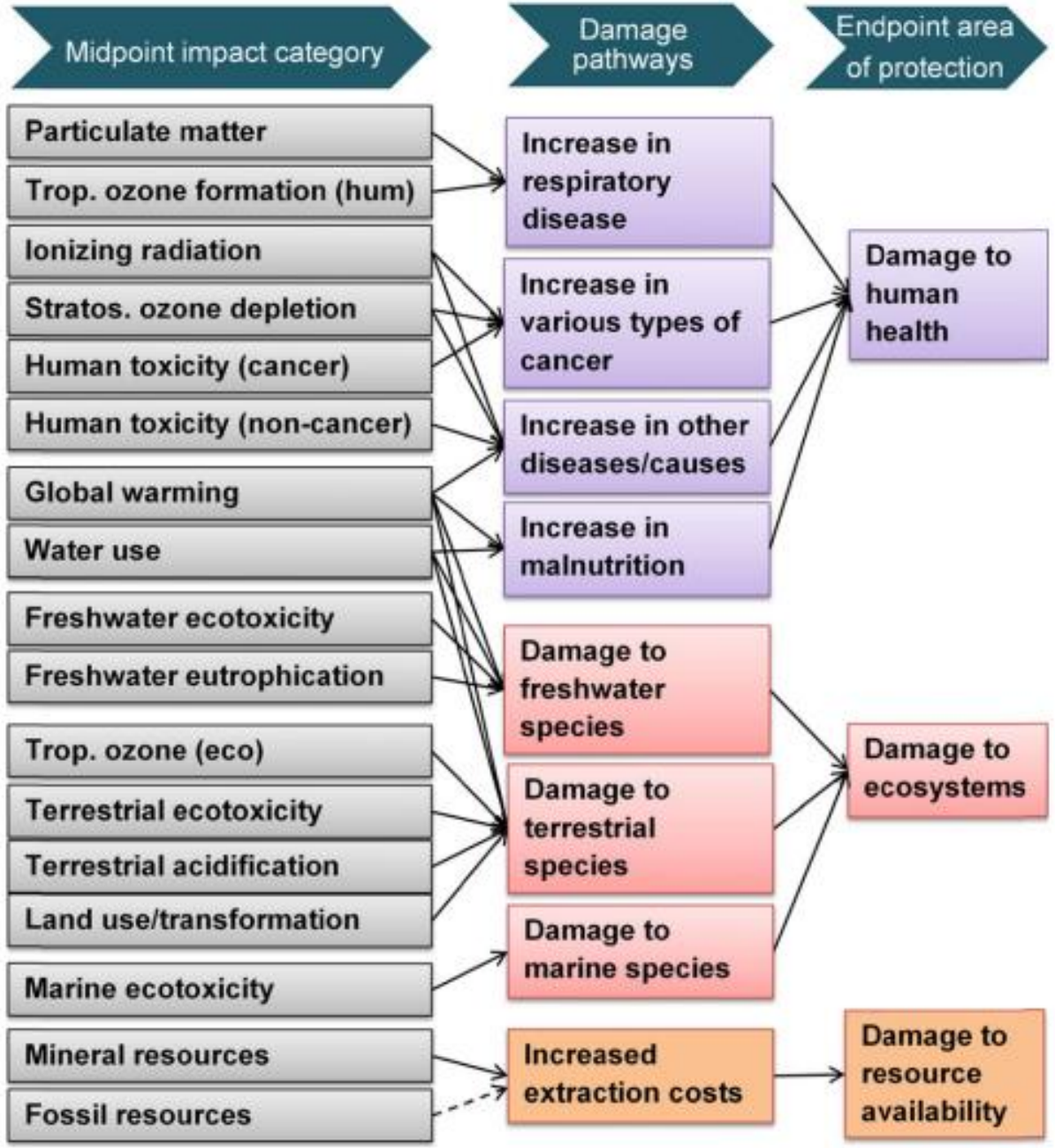
https://arxiv.org/pdf/1603.03654

CERN and Sustainability of future accelerators

- Every study for future large colliders is now due to produce a **Socioeconomic impact assessment** study.
  - We now have a certain experience and collaborations with international partners to help us perform such studies
- **We started to perform LifeCycle Assessment (LCA) of CERN activities and of future projects, to understand where to act to reduce our impact**
- **In the current CERN environment strategy, we focus on the most relevant domains that we know we can control and reduce if necessary**
  - Emissions to atmosphere (tCO_2 eq)
  - Energy Consumption
  - Water and Effluents
  - Radioactive and conventional waste….

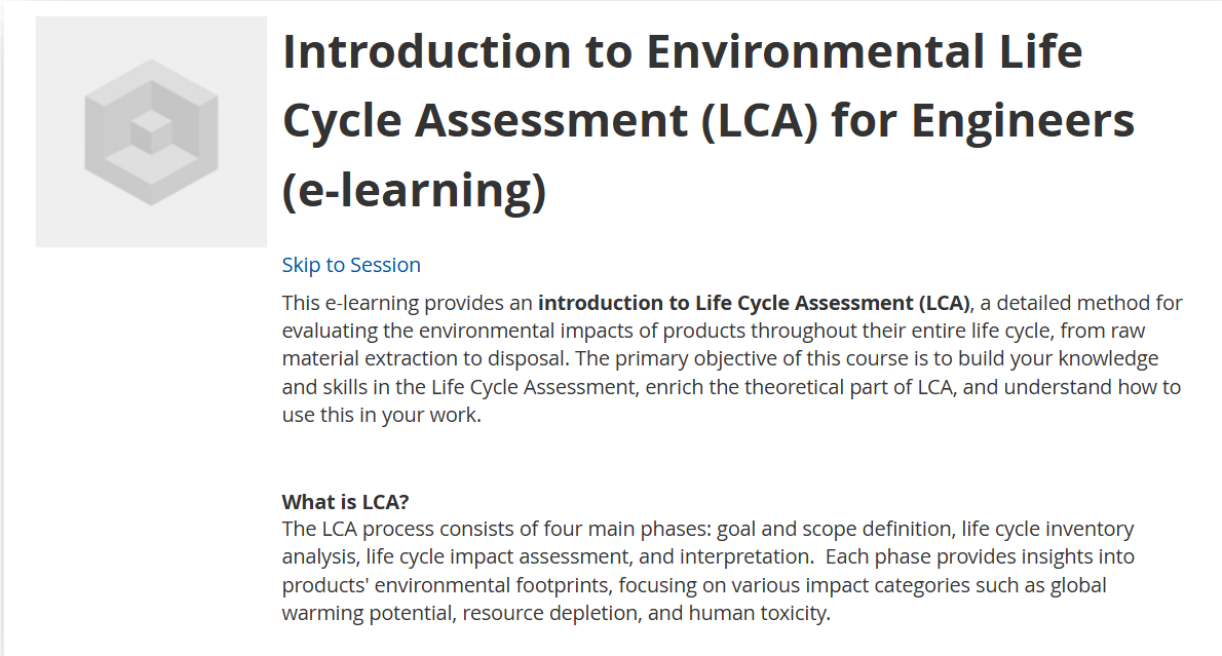
Lifecycle assessment

- **Process to evaluate the impact of a human activity**
- **Long term (~5 - 10 years) vision: every component designed at CERN should integrate LCA from the start of the design process and be optimised**
- **See Int J Life Cycle Assess (2017) 22:138–147) for the ReCiPe Methodology (2016) ---** https://doi.org/10.1007/s11367-016-1246-y



Lifecycle assessment

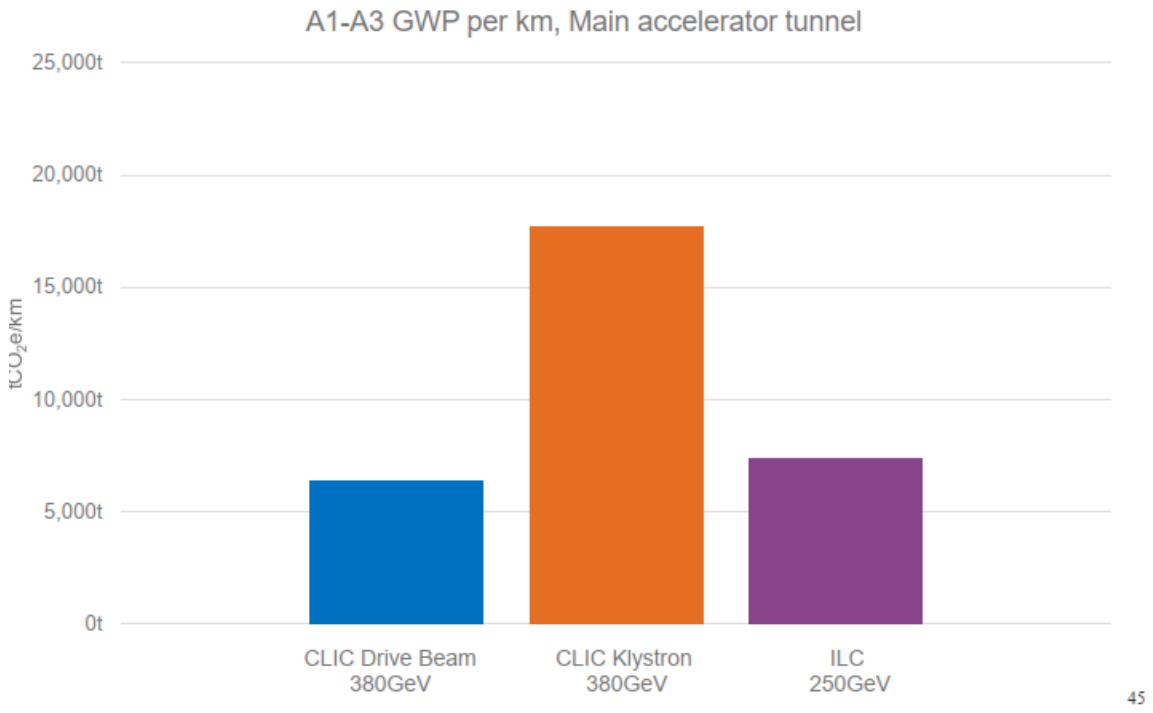
- **Lifecycle Assessment training**
- Available on our learning hub for free! (need a CERN account): link available here
- We are evaluating LCA software packages and have the intention to provide a common platform, ideally in collaboration also with other laboratories worldwide, to allow anybody to perform (simple) LCA from the beginning of a new project
- We still advise, for large projects, to seek expert advice.
- *Remember that all those numbers are taken very seriously by the public: publish only when you are sure they are correct!*



Examples: CLIC, ILC and FCC tunnels

CLIC & ILC

EDMS 2917948



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FCC

Link to report

1.3 RÉSULTATS

L'analyse a fourni une ventilation détaillée des émissions de GES selon les différentes phases du cycle de vie et les matériaux. Les **principales sources d'émissions** identifiées **sont l'acier armé (14 %), le béton préfabriqué (49 %) et le béton (23 %)**. Cette analyse met en évidence les **possibilités de réduction des émissions grâce à la nécessité d'établir des exigences techniques** pour les infrastructures qui permettent de concevoir l'infrastructure en tenant compte de la réduction des émissions de carbone, de **sélectionner soigneusement les matériaux** en accord avec les exigences établies, d'**optimiser les processus de construction** et d'**améliorer l'efficacité énergétique**. L'impact total sur les émissions de gaz à effet de serre du cas initial et du cas de référence est indiqué dans le Tableau 1.1.

Tableau 1.1 Synthèse du calcul initial et du scénario de référence pour le budget carbone du FCC.

Empreinte CO_2	Calcul initial	Scénario de référence	Réduction
Souterrain (Stage A1-A5)	999 780 tCO2(eq)	**477 390 tCO2(eq)**	52%
Site technique x4 (Stage A - C)	63 832 tCO2(eq)	**17 546 tCO2(eq)**	73%
Site expérimental x4 (Stage A - C)	119 990 tCO2(eq)	**31 735 tCO2(eq)**	74%
Total	1 183 602 tCO2(eq)	**526 671 tCO2(eq)**	56%

CERN and Sustainability – Responsible Procurement

- What we do today impacts what we will do tomorrow!
- Procured materials, components and services are a substantial part of CERN's CO_2 footprint
- In order to minimise indirect (Scope 3) CO_2 emissions generated by CERN activities, the ED approved in July 2023 a **Responsible Procurement Policy**
  - The implementation is being prepared in line with the provisions of ISO 20400:2017 – Sustainable Procurement
- **Key factors will be:**
  - Adjudication based on Total Cost of Ownership: CAPEX+OPEX
  - Engagement with suppliers
  - Alignment of CERN specifications with International environmental standards (e.g. for new buildings)

CERN Environmentally Responsible Procurement Policy

The objective of the CERN Environmentally Responsible Procurement Policy is to minimize the environmental impact throughout the lifecycle of the goods or services that are purchased by the Organization.

CERN shall define and implement its Environmentally Responsible Procurement Policy by embedding environmental considerations as standard in its procurement activities.

This Policy is aligned, and designed to work in conjunction, with the CERN Procurement Rules. It constitutes an integral part of CERN's endeavour to achieve identified objectives in relation to the environment and sustainability.

This Policy commits CERN to environmentally responsible procurement and to achieving sustainable results both internally and throughout its supply chains.

The Organization undertakes to:

- integrate environmentally responsible procurement practices into current and future supply chains;
- measure the impact of environmentally responsible procurement;
- communicate with, and give guidance to, the CERN community on implementing, monitoring and reporting on environmentally responsible procurement;
- demonstrate and share, where appropriate, best practice for environmentally responsible procurement with its Member States and other organisations, particularly other research laboratories.

CERN will embed environmental responsibility where appropriate throughout all phases of the procurement process, including at the design phase. Careful and reasoned attention will be given to the need for the procurement, the specificities of the goods or services being procured, the choice of the supplier, the terms of procurement and the principle of continuous improvement.

The Director-General assigns responsibility for the implementation of the Environmentally Responsible Procurement Policy to the following parties:

CERN and Sustainability - End of Life

- **Components that cannot be free-released at the end of their lifetime because of activation will increase the impact of future accelerators at CERN**

- **We have efficient tools today to anticipate the level of activation in components based on operational scenarios:**

- FLUKA.CERN is the Radiation physics code used to evaluate activation of materials, ambient dose, emission to atmosphere etc.

- Is used in all our communication with Radioprotection authorities in the two Host States, including for the characterisation of radioactive waste

- We will have to pay attention to the choice of materials and operational modes so as to minimise as much as possible the activation of future accelerators

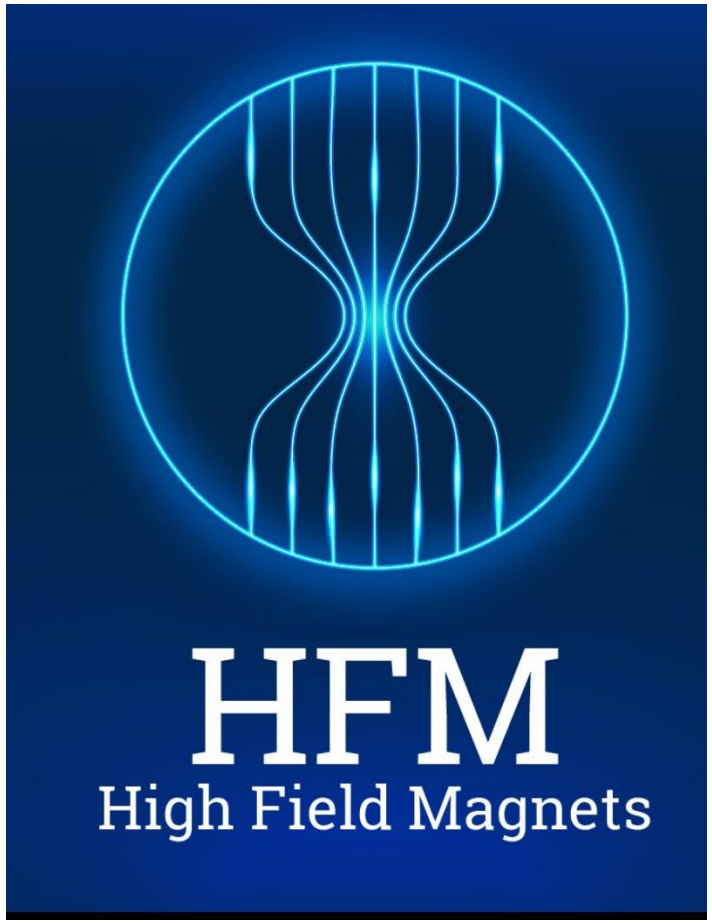
CERN and Sustainability - End of Life

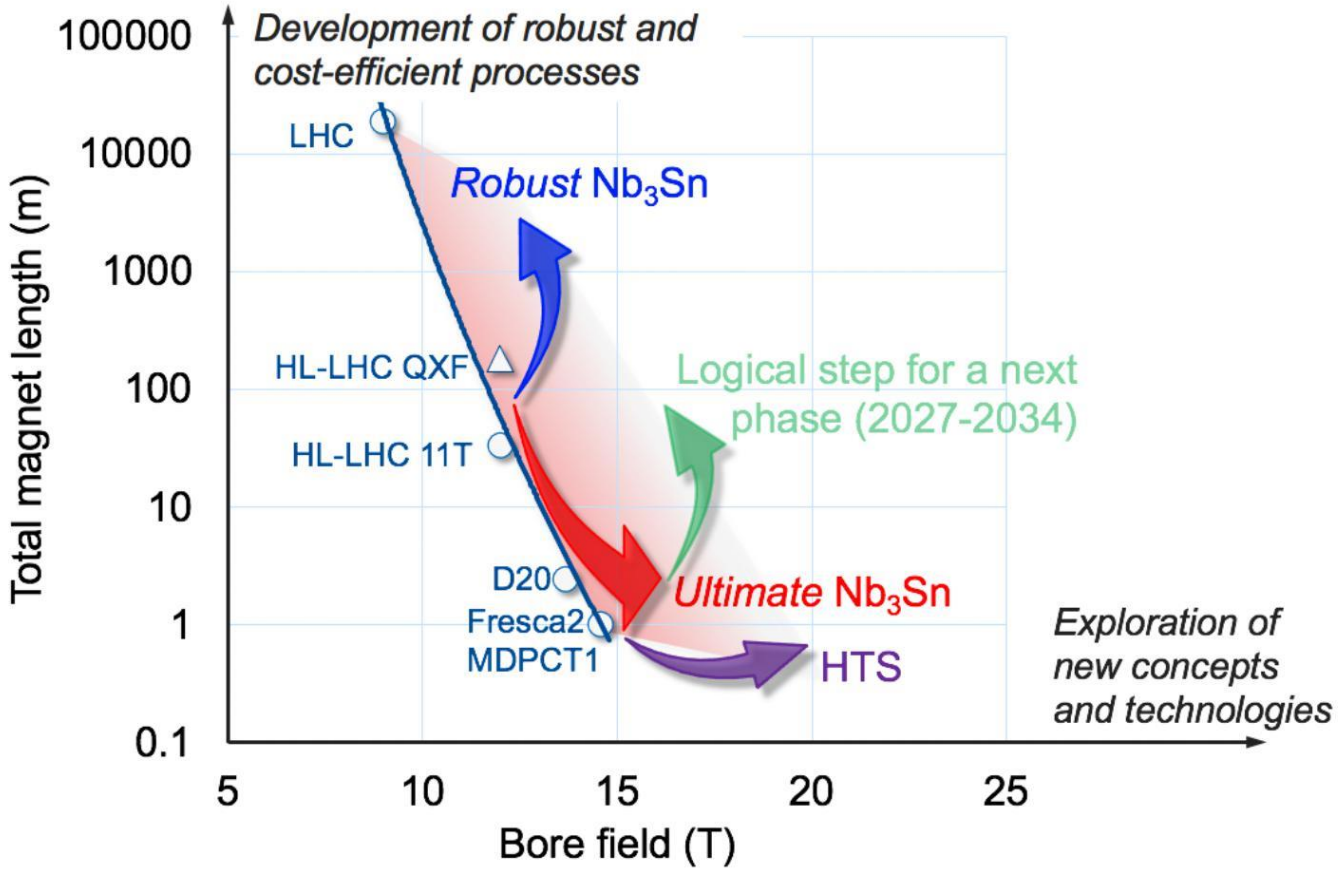
- Actiwiz is an in-house development based on CERN FLUKA
- Within seconds it calculates radionuclide inventories and associated hazards for arbitrary materials and radiation fields
- Comes with 80 built-in radiation scenarios specific to CERN's accelerators

  Main uses:
  - Radiologically optimised material selection
  - Radiological characterisation of radioactive waste

Safety benefit	Operational benefit	End of life-cycle benefit
• Lower dose rates and committed doses	• Reduced downtime due to faster access • Less restrictions for manipulation & access	• Smaller amount and less critical radioactive waste • Smaller financial burden

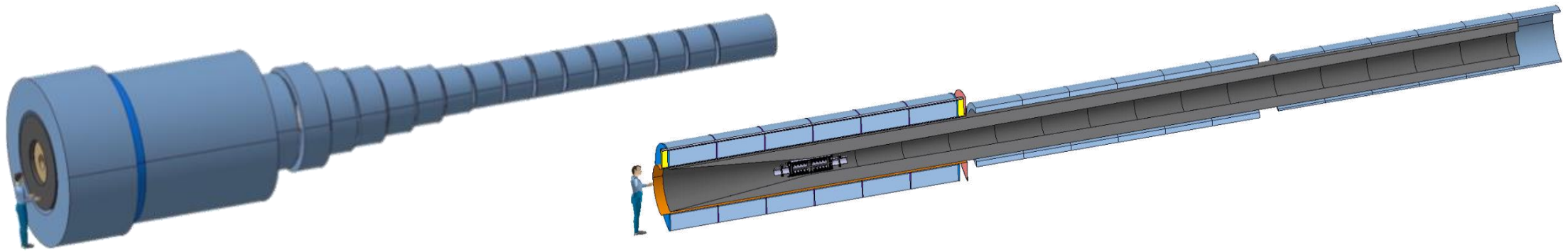
Future accelerator technologies?
Superconductivity: High Field Magnets





Future accelerator technologies?
High Temperature Superconductors

Target & Capture Solenoids for the Muon Collider



US-MAP Proposal (<2016)

E_M = 2.9 GJ
T_{op} = 4.2 K
M_{coils} = 200 tons
M_{shield} = 300 tons
P = 12 MW

EM = 1 GJ
Top = 10…20 K
Mcoils = 110 tons
Mshield = 196 tons
P = 1 MW

IMCC Proposal (2023)

Future accelerator technologies? Metamaterials

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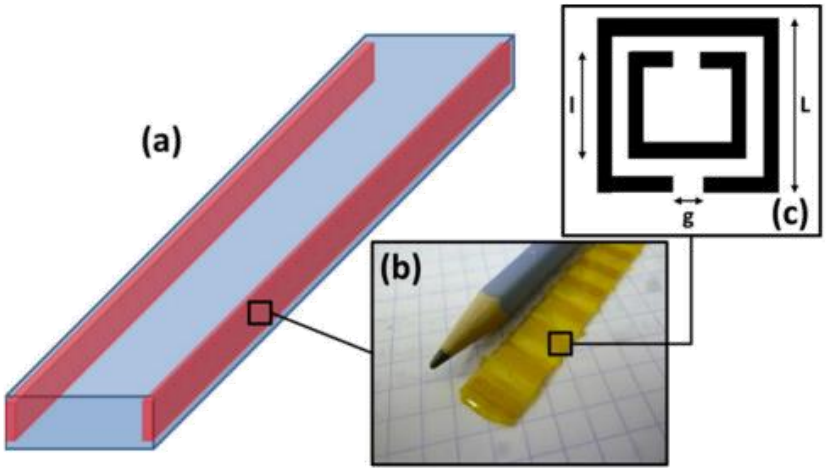
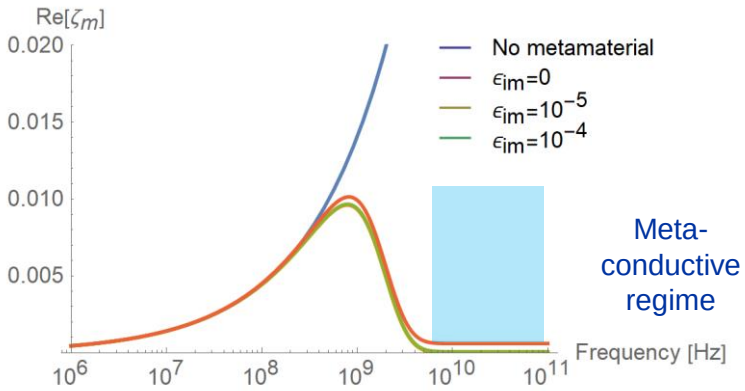
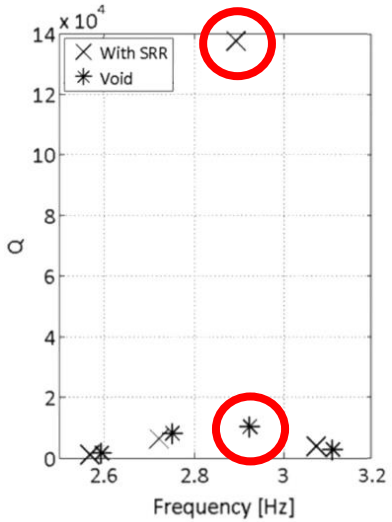
Source of the picture





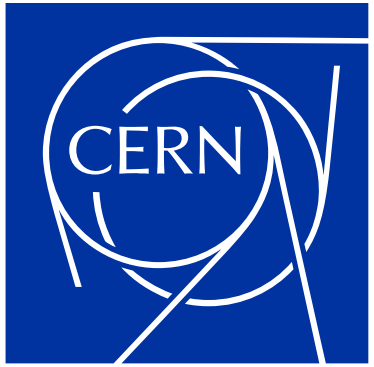
Meta-conductive regime

Courtesy C. Zannini



Conclusions

- **CERN has always taken the optimisation of its environmental and societal impact very seriously**
- **In the last few years we studied and developed our future project proposals in full coherence in respect of the UN SDGs, the sustainability requirements of funding agencies and of our host states**
- **CERN is a major actor in the International context of Large Research Infrastructures, and we develop practices and technologies that are transferred to other laboratories, and to society**
- **We can all make an impact: start by taking the training on Lifecycle assessment!**



home.cern