# Sustainability in HEP

and what can we do to help?

**Juliette Alimena**, Ben Brueers, Nils Gillwald, Eleanor Jones for the **DESY FH Sustainability Forum**
German Belle II Environmental Sustainability Kickoff Meeting
December 19, 2023

# What is sustainability and sustainable development?

**"meeting the needs of the present without compromising the ability of future generations to meet their own needs"**

From the <u>Report of the World Commission on Environment and Development: Our Common Future, 1987</u>

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"how we must live today if we want a better tomorrow"

From the UN Sustainable Development Goals

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# What is sustainability and sustainable development?

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They can be divided into three categories:

➔ Economic growth
➔ Social inclusion
➔ **Environmental protection**

# What is sustainability and sustainable development?


**13 CLIMATE ACTION**

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Goal of the month for November 2023

**Goal 13:** Take urgent action to combat climate change and its impacts
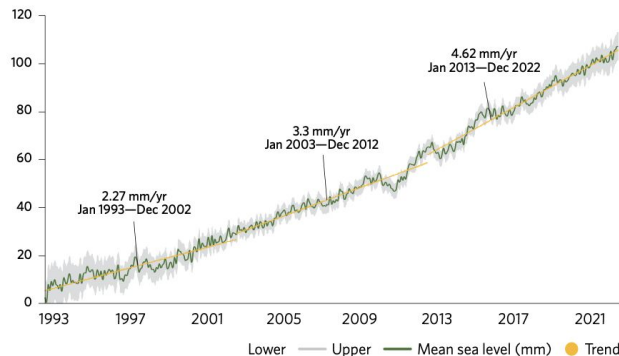
# Climate change in numbers

- ❏ At the current rate, the world temperature will **increase by 1.5 ℃ by 2035** and faces a **2.5 ℃ warming by 2100**.
- ❏ The **rate of sea-level rise has doubled** in the last decade.
- ❏ Global emissions must be halved by 2030, on the way to net-zero by 2050, but on current national plans, **emissions are set to rise by 10%**.

**Global annual mean temperature relative to pre-industrial levels (1850–1900 average), 1850–2022 (degrees Celsius)**
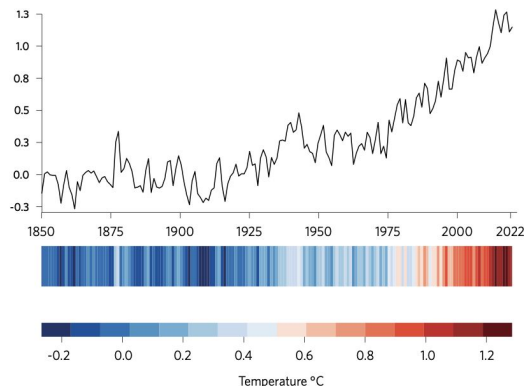
Source: The figure and climate stripes are drawn from the World Meteorological Organization's State of the Global Climate 2022 report, which combines six international data sets for temperature: HadCRUT.5.0.1.0 (UK Met Office), NOAAGlobalTemp v5 (USA), NASA GISTEMP v4 (USA), Berkeley Earth (USA), ERA5 (ECMWF), and JRA-55 (Japan).
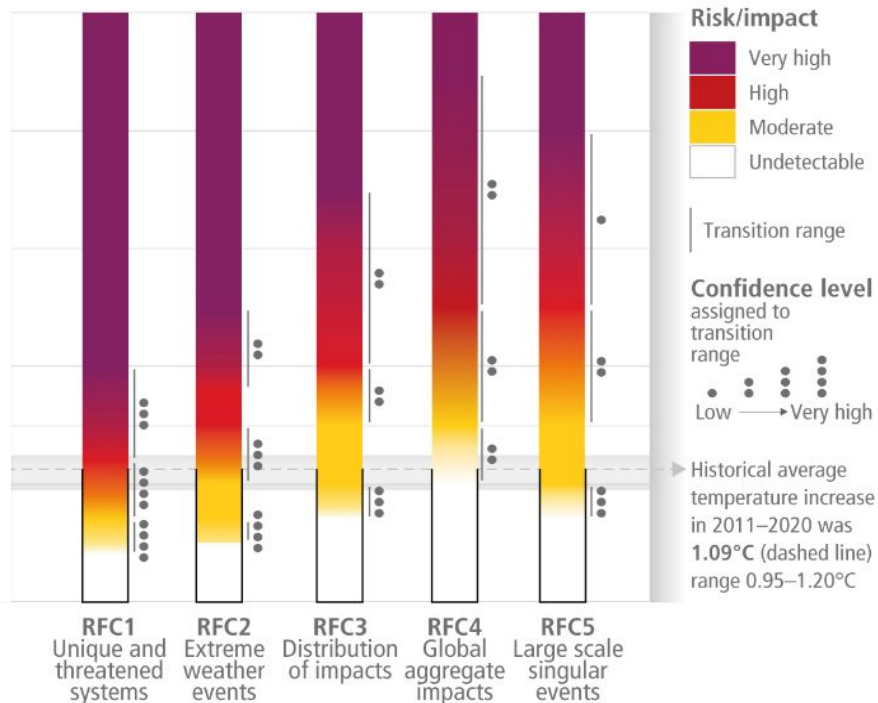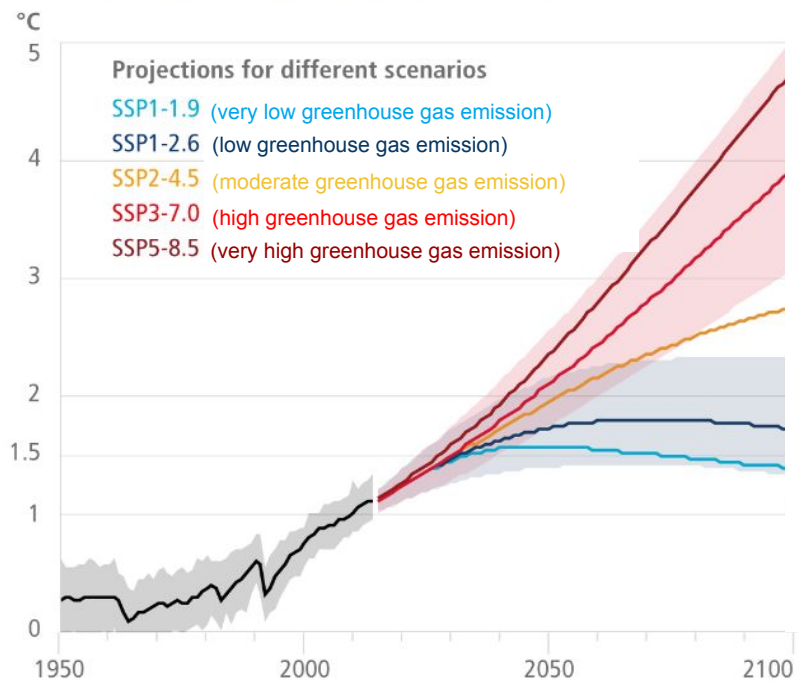
**Global mean sea level, 1993–2022 (millimetres)**

4.62 mm/yr
Jan 2013—Dec 2022

3.3 mm/yr
Jan 2003—Dec 2012

2.27 mm/yr
Jan 1993—Dec 2002

Lower — Upper — Mean sea level (mm) — Trend

Note: Based on satellite measurements.

Source: Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS); data from AVISO altimetry (www.aviso. altimetry.fr). Taken from the World Meteorological Organization's State of the Global Climate 2022 report.
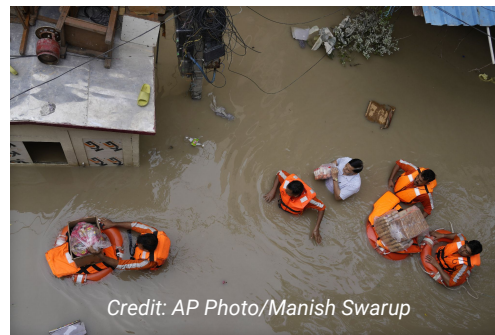
# How bad could it get?
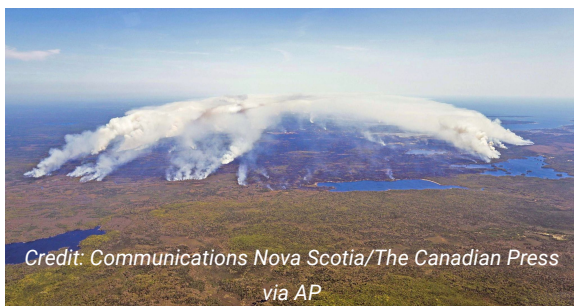
# Effects of climate change

Flooding in Italy, May 2023



Credit: AFP via Getty Images

Floods in India, July 2023



Credit: AP Photo/Manish Swarup

Wildfires in Canada, May 2023



Credit: Communications Nova Scotia/The Canadian Press via AP

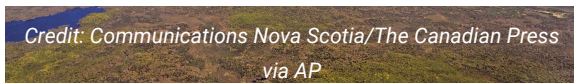Wildfires in Greece, July 2023



Credit: Reuters

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# Effects of climate change

Flooding in Italy, May 2023

Floods in India, July 2023

**We all have a responsibility to reduce greenhouse gas emissions and to limit global warming, individually and as a community in HEP**

*Credit: Communications Nova Scotia/The Canadian Press via AP*

*Credit: Reuters*

# What is the FH Sustainability Forum?

**SUBSCRIBE**

fh-forum-sustainability@desy.de

…a platform to discuss, to improve & to change for sustainable high energy physics within DESY FH!

❏ Talks & discussions on different sustainability topics: identify unsustainable practices – discuss, share, and implement sustainable solutions – networking
❏ Establish innovative and support existing projects working towards a sustainable HEP
❏ Monthly meetings: usually one Monday per month at 16h
❏ Regular sustainable computing workshop for DESY users

❏ DESY, in collaboration with German universities, will deliver one endcap for the future trackers of CMS and ATLAS

  ❏ Requires Detector Assembly Facilities (DAFs), which are clean-rooms that use Fan Filter Units (FFUs)
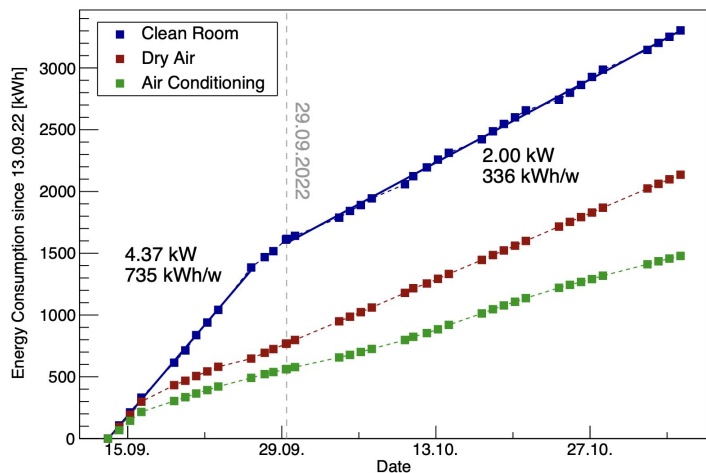


❏ Early in 2023, a study to optimise the clean room energy consumption was launched

❏ Aim of the optimisation was to reduce energy consumption without degrading air quality

  ❏ Reduced the energy consumption of the FFUs by over 50%

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# DESY FH examples: MC generation techniques

❏ Event weights can be negative but this leads to slow statistical convergence

    ❏ The higher the fraction event weights, the higher the required number of events that needs to be produced
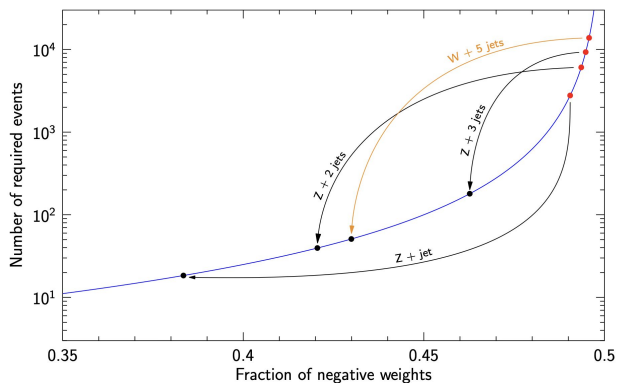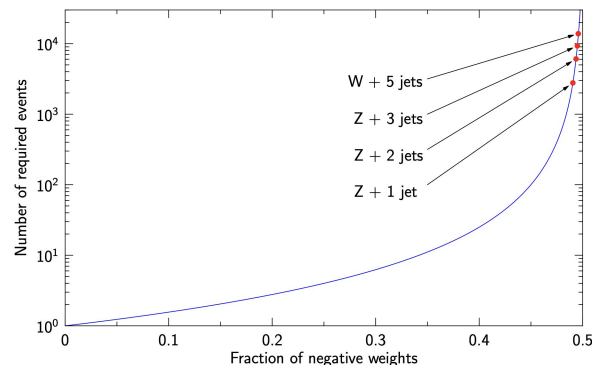


❏ Cell resampling drastically reduces the number of required events

    ❏ The idea is to remove negative weights by smearing over small phase space regions

    ❏ Has been demonstrated to preserve predictions in an ATLAS analysis, Eur. Phys. J. C77 (2017) 361

    ❏ Computationally efficient

# DESY FH examples: computing



- ❏ Held **1-day workshop** (September 8, 2023) on **Sustainable Computing**, hosted by the FH Sustainability Forum and FH IT experts
  - ❏ https://indico.desy.de/event/40426/
- ❏ Participants learned about:
  - ❏ Writing efficient code
  - ❏ Using batch computing in a sustainable way
  - ❏ Maximizing resources and minimize waste
- ❏ Examples demonstrated with local computing clusters and tailored to the needs of the FH division
- ❏ **Next workshop, tailored to beginners will be January 17 and 18, 2024. https://indico.desy.de/event/42345/** Please register, 25 spots in total!

# Other HEP examples: RPC leaks

- ❏ Almost 50% of ATLAS $CO_2$e emissions originates from gases with high GWP
  - ❏ In particular, from leaks in the RPCs where 1000 L / h == 5.8 Tons $CO_2$ / h

- ❏ 2 mitigation strategies:
  1. Fix the gas leaks. But:
     - ❏ Difficult to access and takes a long time
  2. Using special foam (applicable to ~50% gas inlets) But:
     - ❏ Cannot be applied if there is a complete crack

- ❏ Recuperation system for R134A under investigation
  - ❏ First results are promising
  - ❏ CMS is saving 10% of fresh gas

- ❏ Dilution of gas mixture
  - ❏ Addition of $CO_2$ gives 15% reduction in combined GWP

| Gas | GWP |
|-----|-----|
| $CO_2$ (Carbon dioxide) | 1 |
| R134A (Tetrafluoro-ethane) | **1430** |
| $SF_6$ (Sulfur hexafluoride) | **22800** |
| $C_3F_8$ (Octafluoropropane) | 8830 |
| $C_6F_{14}$ (Perfluorohexane) | 9300 |

# Other HEP examples: CMS remote operations

- **DESY remote operations → travelling saved**
- Large number of DQM shifts at the CMS Center at DESY:

  - 35 shift blocks for Tracker DQM Shifter and Tracker DQM Shift Leader

  - 34 shift blocks for online DQM

- **Saved ~69 round trips to CERN**

  - With one round trip by plane corresponding to 450 kg $CO_2$*, one round trip by train to 61 kg $CO_2$*



**Up to 31 tons of $CO_2$ saved!!**

*greentripper.org

# Other HEP examples: future colliders

❑ A **lifecycle approach** needs to be considered for all future projects to achieve the target energy and luminosity whilst also conserving resources
- ❑ Consider the entire lifecycle of a project, from construction through to end-of-life
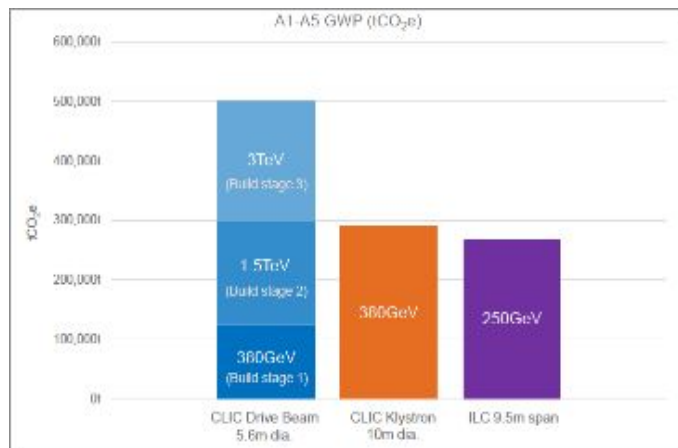




❑ CERN have already started to engage in this
- ❑ First comprehensive study commissioned for the impact of civil engineering work CLIC and ILC
- ❑ Sets a new standard for lifecycle studies for future colliders

# Other examples: Einstein Telescope travel footprint

❏ The Einstein Telescope collaboration had a whole workshop devoted to sustainability
❏ For the workshop, they estimated their travel carbon footprint

We have estimated the carbon footprint associated to travels for this ET collaboration meeting

Participants have provided the carbon footprint of their travel when they registered



Travel distance
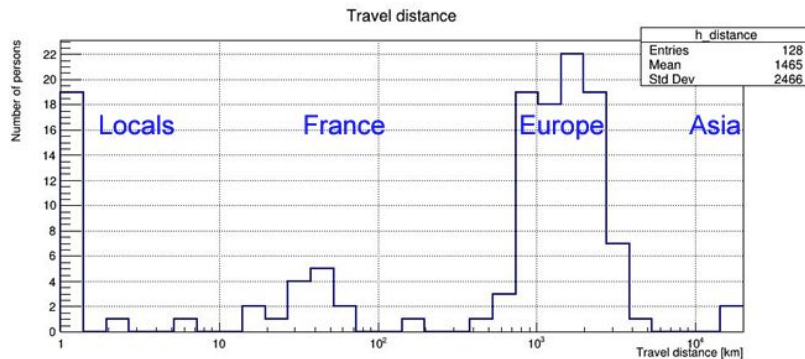
146 participants
18 persons did not provide information about their trip
$CO_2$ emission w/o contrails = 17717 kg → 19901 kg (extrapolating missing info)
$CO_2$ emission w/ contrails = 31480 kg → 35361 kg (extrapolating missing info)
$CO_2$ emission per person = 30000 kg / 146 = 205 kg for 4 days of meeting

In average a French person emits  ~10 t / year of $CO_2$      (2050 target: 2 t / year)
                                 ~ 27 kg / day             (2050 target: 5 kg / day)

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# Final remarks

Next forum meeting:

"Evaluating the environmental impact of the ISIS-II neutron and muon source" Hannah Wakeling

Monday 22nd January 16:00

**"Unless we act now, the 2030 Agenda will become an epitaph for a world that might have been."**

António Guterres, Secretary-General of the United Nations

in The Sustainable Development Goals Report 2023

fh-forum-sustainability-organisers@desy.de
Any interest from Belle II members to help organize?