Labos 1point5

Reducing the environmental footprint of our research activities

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1st Belle II Sustainability Meeting
13 May 2024

cnrs NUCLÉAIRE & PARTICULES

Labos 1point5

LPC Particules pLasmas Univers applicationS
Laboratoire de Physique de Clermont

What is Labos 1point5 ?

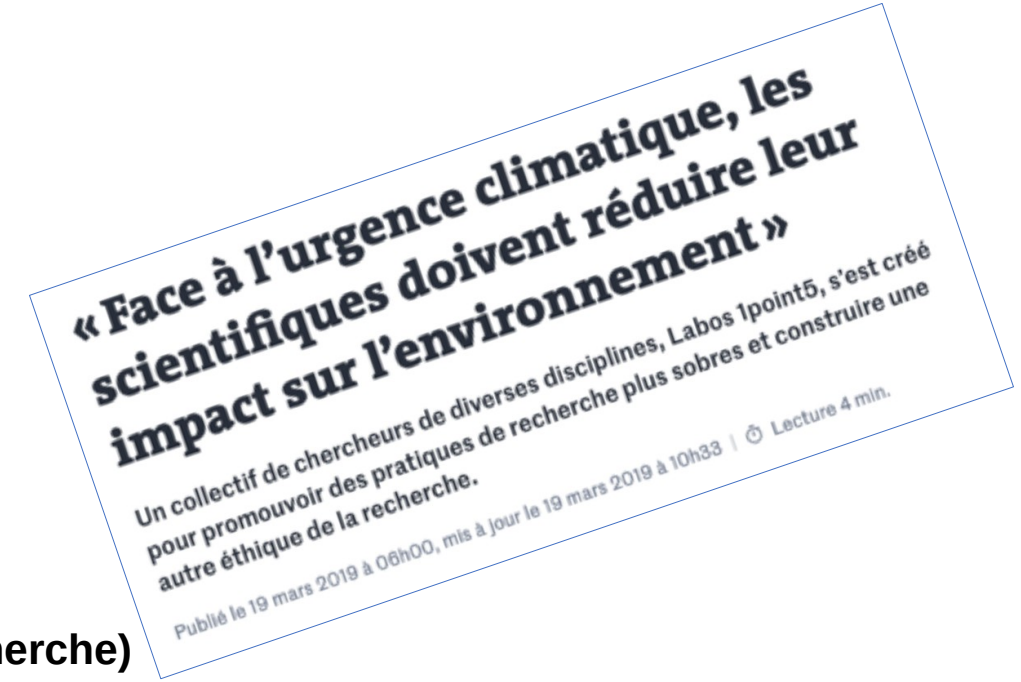
1. A grassroot collective action « to understand and reduce the environmental footprint of research » :

- Created in March 2019

(op-ed in French leading newspaper *Le Monde* & website with call for participation)

- Networks of people, labs and initiatives

~4000 following our work



« Face à l'urgence climatique, les scientifiques doivent réduire leur impact sur l'environnement »

Un collectif de chercheurs de diverses disciplines, Labos 1point5, s'est créé pour promouvoir des pratiques de recherche plus sobres et construire une autre éthique de la recherche.

Publié le 19 mars 2019 à 06h00, mis à jour le 19 mars 2019 à 10h33 | Lecture 4 min.

2. A research project called GdR (Groupement de Recherche)

- Created in November 2021 by CNRS, IRAE, ADEME, Sorbonne Université
- ~250 participating in research activities (all gender, discipline, age)
- Develops tools to help the labs to change their practrice
- Scientific publications on the evaluation and analysis of research carbon footprint

The « principles » of Labos 1point5

- Essential to quantify and understand the carbon footprint of research, its determinants, uncertainties and heterogeneity
- Implementing locally designed and deliberated solutions in research laboratories, to re-appropriate our laboratories as decision-making places

GdR

- Organize reflexive work on the coherence, responsibility and ethics of research in relation to the low-carbon transformation of our societies (carbon emissions main but not only focus)

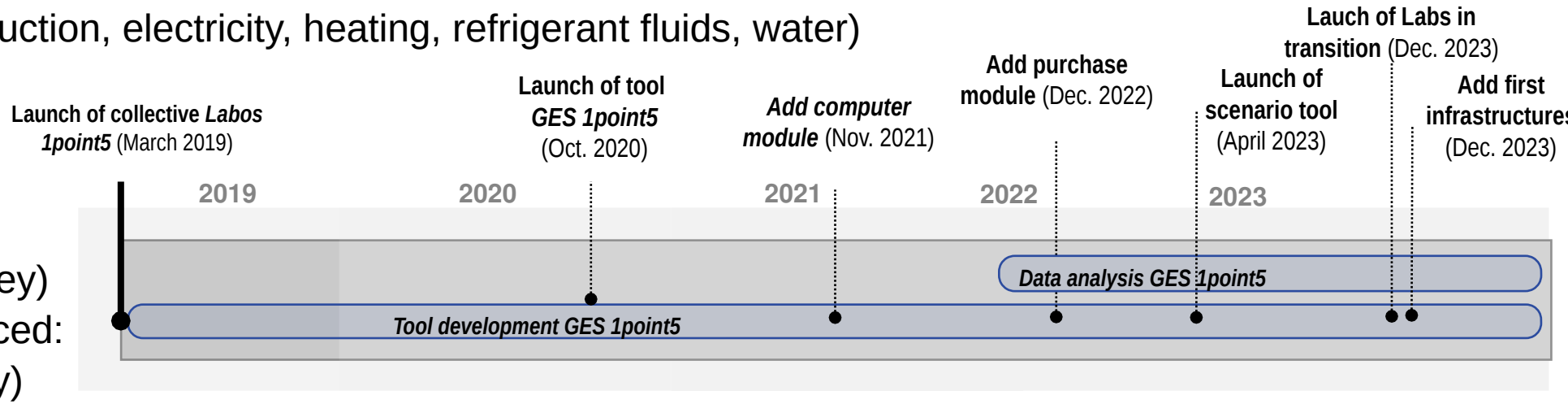
→ **Reinventing a way of doing research compatible with planetary boundaries**

(keeping in mind that fundamental/physics research may not be considered essential to a society in crisis...)

GES 1point5: a tool to measure the carbon footprint of laboratories

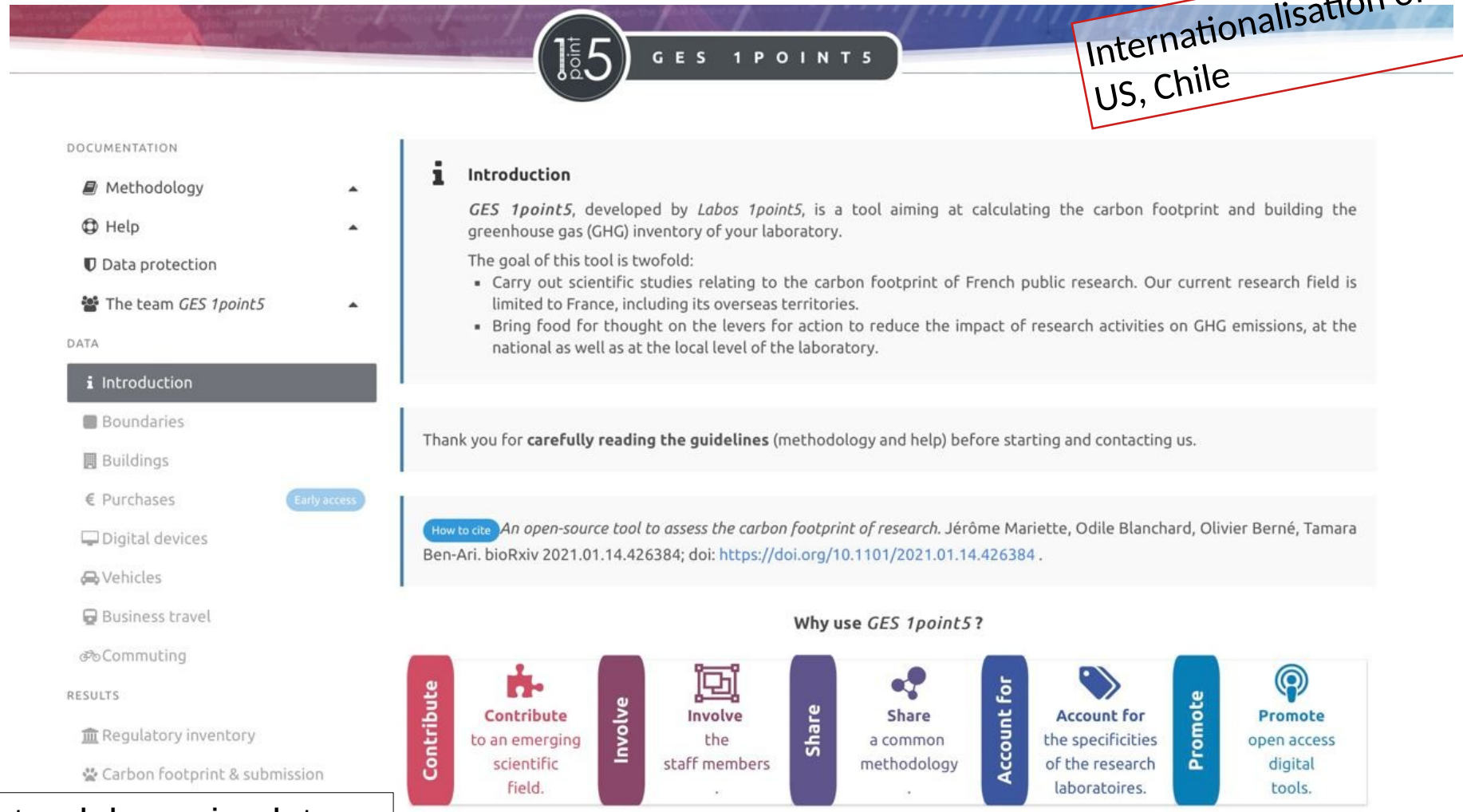
- GES 1point5:
  - 1 free & online tool to carry out GHG inventory of laboratories
  - 1 methodology
  - 1 GHG inventory = 1 year & 1 laboratory
  - Recommended by

- Emissions categories:
  - Buildings (construction, electricity, heating, refrigerant fluids, water)
  - Purchases
  - Digital devices
  - Lab vehicles
  - Business travels
  - Commutes (survey)
  - Recently introduced:
    - Food (survey)
    - Research infrastructures (CERN, GENCI [HPC], astronomical observatories)
    - Farming activities (fertilisers, livestock)
    - More to come soon (WLCG?)



GES 1point5: a free and online tool

Internationalisation of tools:
US, Chile



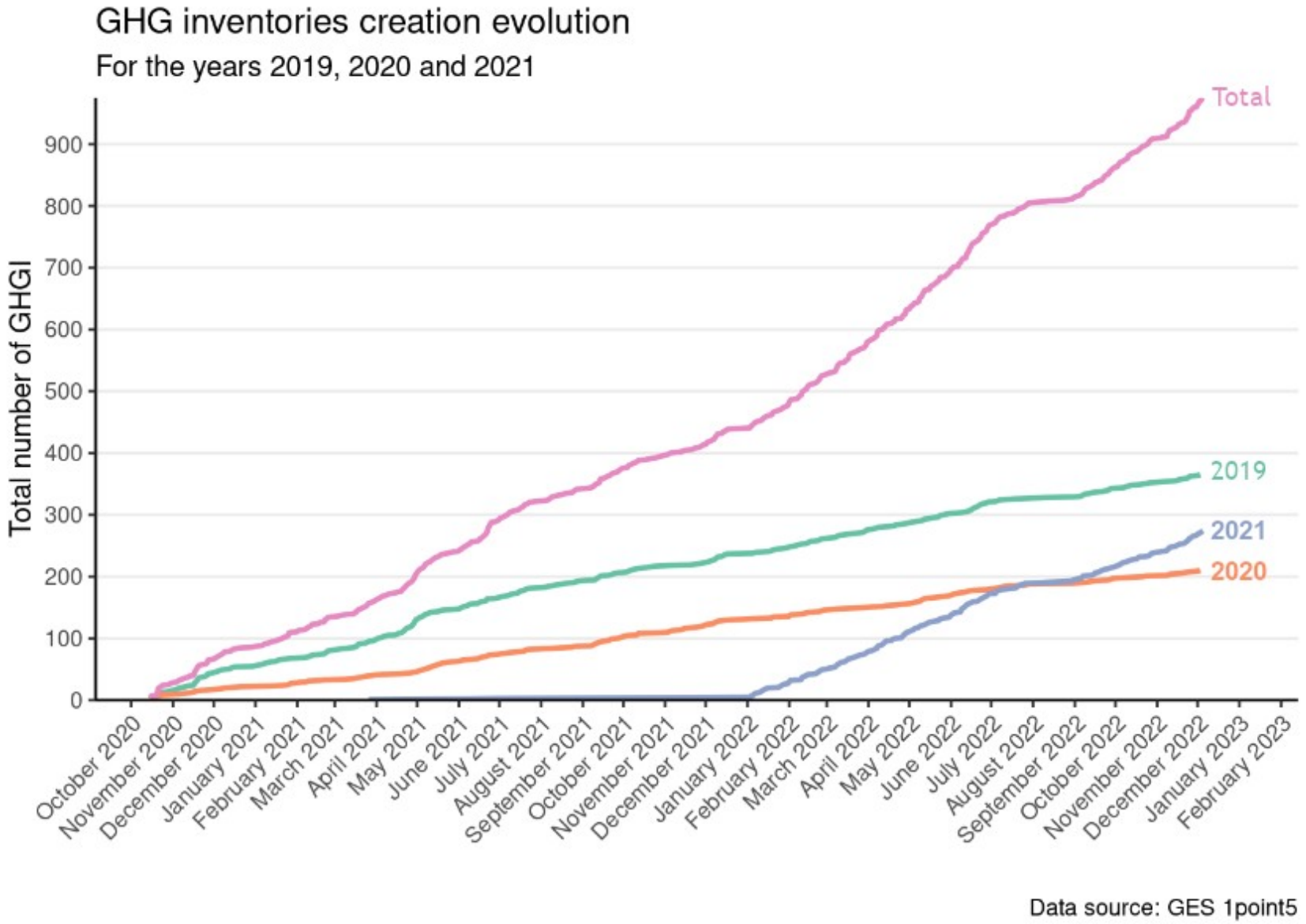
J. Mariette et al 2022
An open-source tool to assess the carbon footprint of research
Environ. Res.: Infrastruct. Sustain. 2 035008

GitLab source code:
https://framagit.org/labos1point5/l1p5-vuejs

Available standalone simulators:
- commute
- travels
- food

https://apps.labos1point5.org/ges-1point5

Footprint: GES 1point5 as a GHG common base

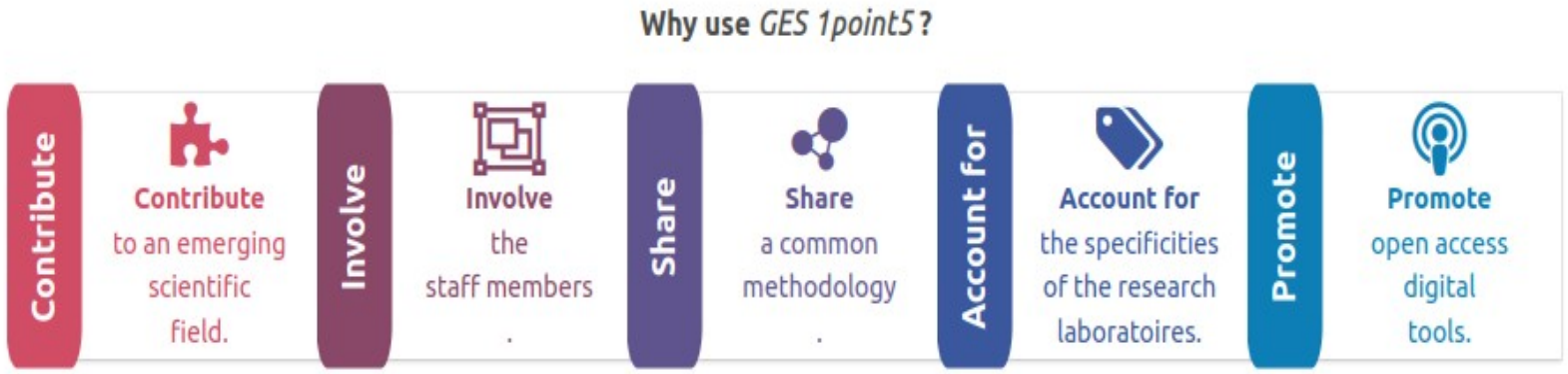


- High adoption rate and increasing
- Already >1100 labs

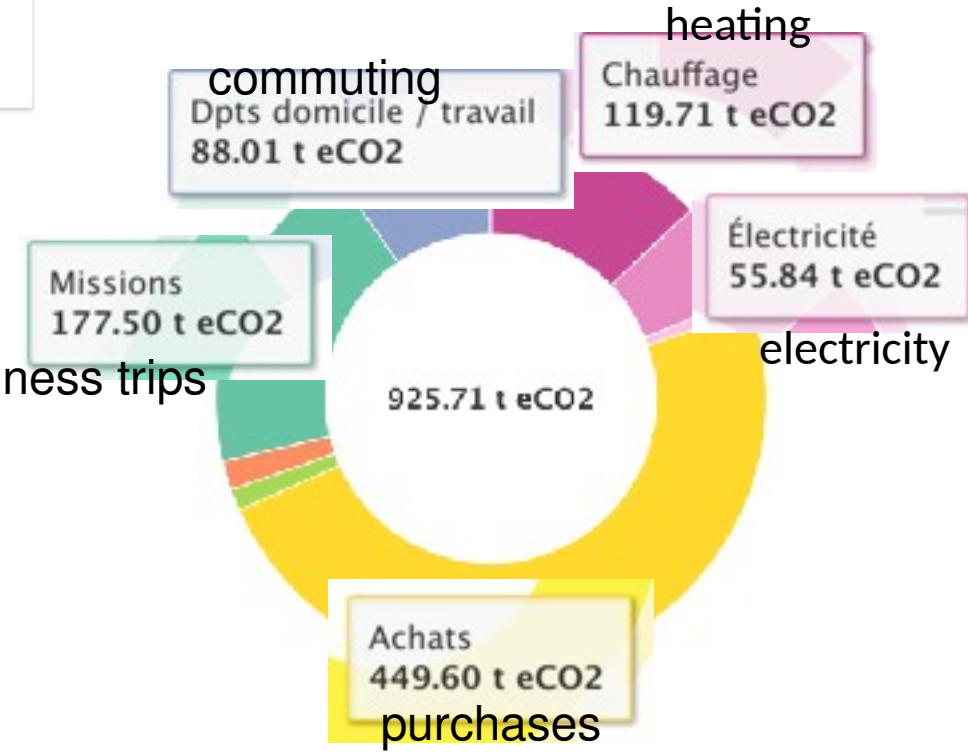
(out of ~ 2000 labs/UMR) and >2400 GHG inventories

[J. Mariette et al (2022)]

GES 1point5, a tool for GHG assessment and analysis



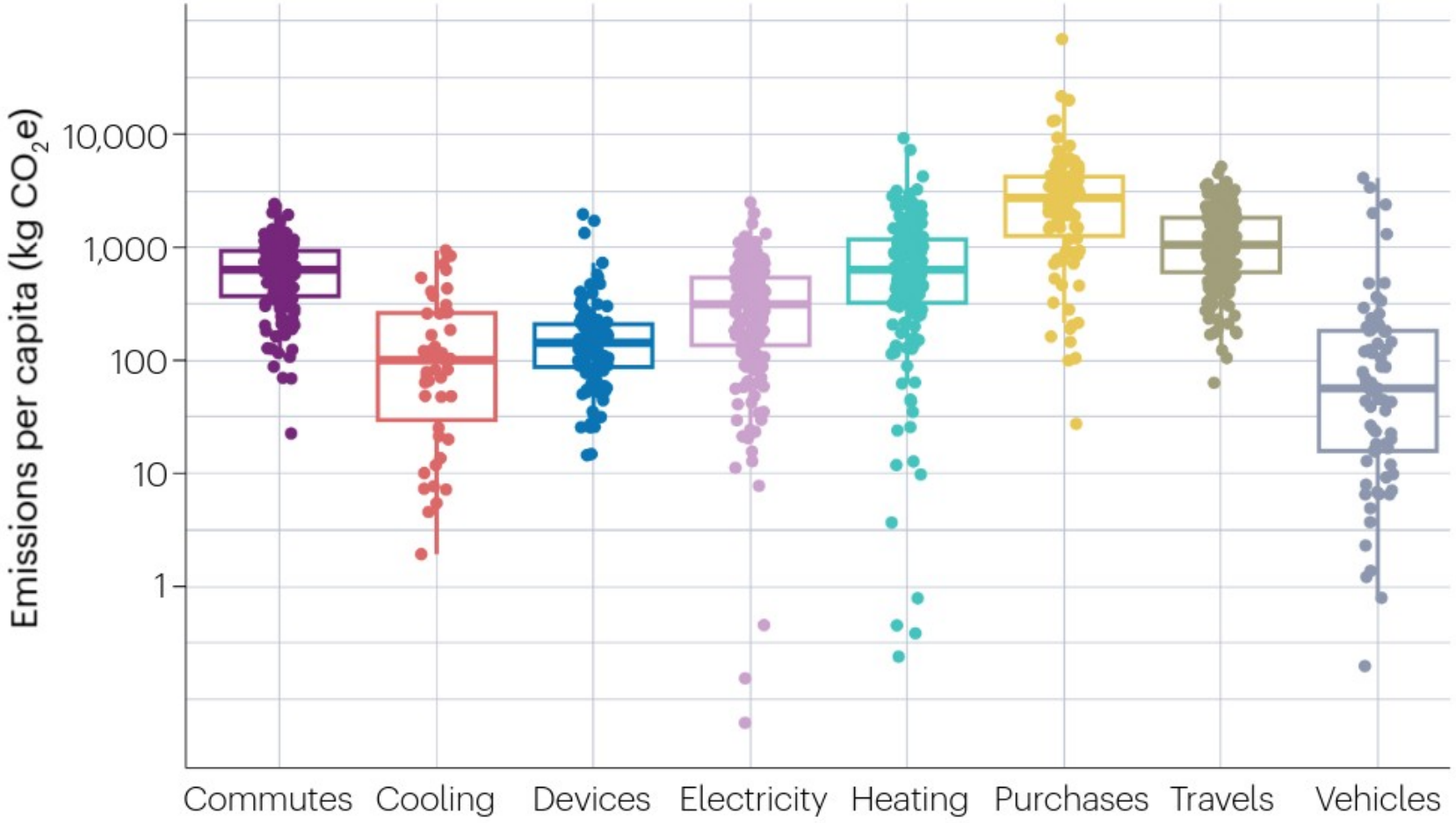
Estimation of the annual carbon footprint of a fictive laboratory



- Several papers out already [list], e.g.:
  - Travels: *Flight quotas outperform focused mitigation strategies in reducing the carbon footprint of academic travel*
    [Tamara Ben-Ari et al 2024 Environ. Res. Lett. 19 054008]
    [EarthArXiv]
  - Procurement: *Purchases dominate the carbon footprint of research laboratories* [bioArXiv]

https://apps.labos1point5.org/ges-1point5

Distribution of the carbon footprint of laboratories (no infrastructure yet)



- Year 2019 (~150 labs)
- Validated reports
- Heterogeneity between laboratories
  - But labs from IN2P3 are rather homogeneous
- Purchases (40%) and travels (25%) dominate the laboratories footprint

~1000 t CO2e / year per lab
~7,3 t CO2e/year per capita
~1 250 000 t for the total sector

[T. Ben-Ari, *How research can steer academia towards a low-carbon future,* Nat Rev Phys 5, 551–552 (2023)]

Including the research infrastructures...

- Suspecting they could have a not negligible impact

- Huge diversity !
  - Delicate work to define the right metric to share the footprint

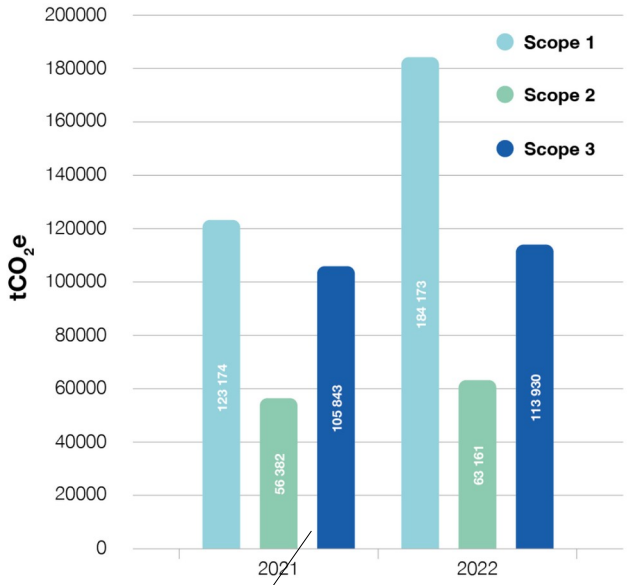
- Implemented (early ‘24) in a first “batch” (more to come)
  - CERN
  - GENCI (national computing center)
  - Astronomical observatories
  - Fertilizer usage
  - Livestock

CERN : Splitting the impact among users

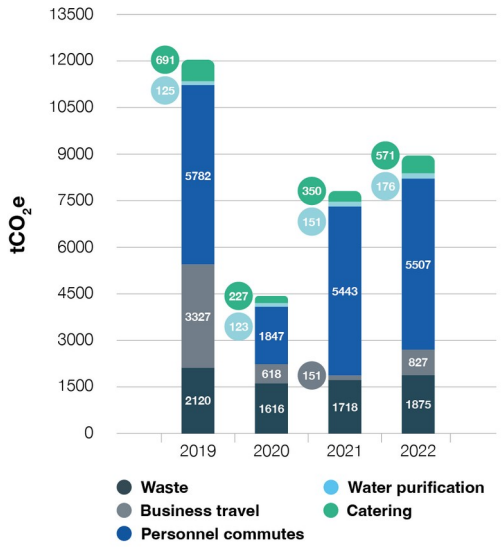
- Non trivial given the available inputs
  - Share of accelerators?
    - No accelerator = no physics in detectors
  - Fair share of LHC emissions:
    - ¼ per experiment?
    - By number of physicists?
    - By integrated luminosity?
    - By construction cost?
  - Scope 3 not available with experiment split → how to share?
- Account for LHC construction?
- Account for tunnel construction?
- Average over data-taking and Long Shutdown years or accept yearly variations?
- Count only physicists, or also technicians, engineers, etc?
- In the end, keep it simple for GES 1point5 users

Inputs, last CERN environmental report

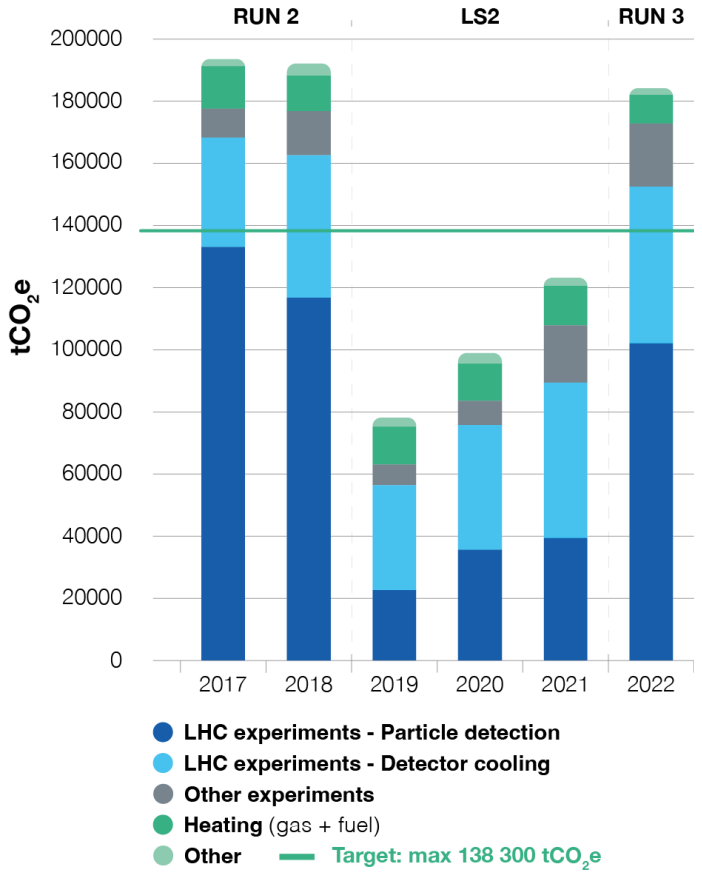
- https://hse.cern/environment-report-2021-2022/emissions



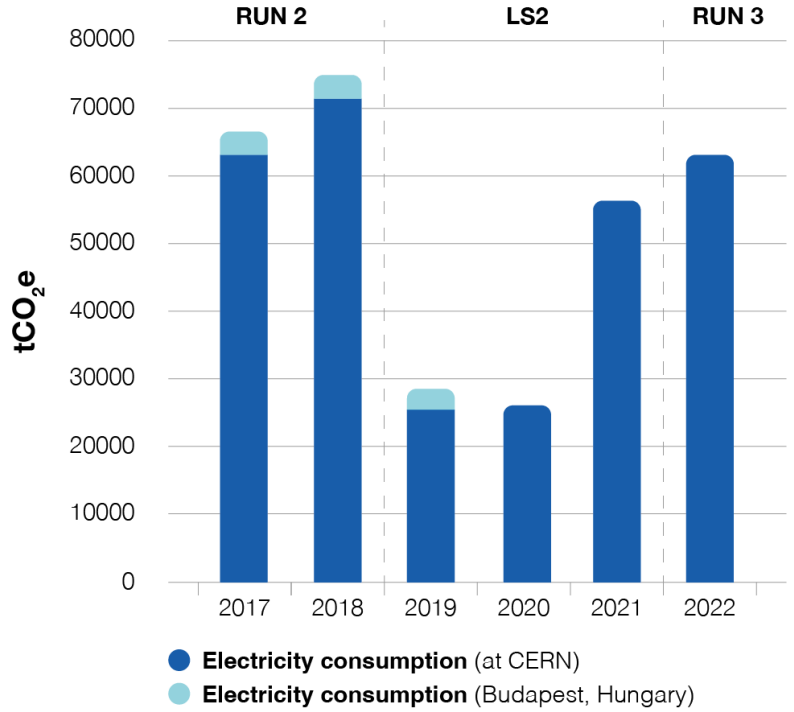
Scope 3 includes procurement for past two years



Scope 3 (excluding procurement)



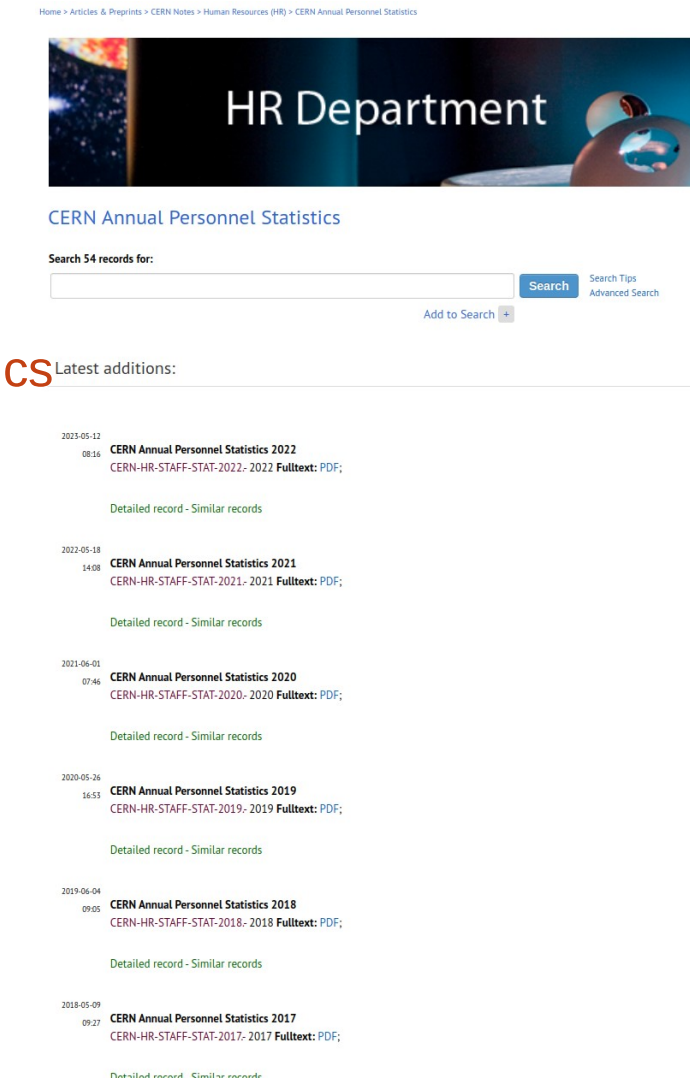
Scope 1



Scope 2 (previous years recomputed)

Personnel statistics

- How to distribute the footprint?
  - Share it among the physicists using CERN
    - CERN's goal is to provide them data
    - Well known numbers, by CERN and labs
    - PhD student, post-doc, staff on 31st Dec
  - https://cds.cern.ch/collection/CERN%20Annual%20Personnel%20Statistics



		2017	2018	2019	2020	2021	2022
2	**Runs**	Run 2	Run 2	LS2	LS2	LS2	Run 3
3	**Users CERN (31-déc.)**	**12236**	**12569**	**12428**	**11399**	**11175**	**11860**
4	Atlas	3912	3971	3983	3699	3517	3580
5	CMS	3076	3092	3055	2862	2749	2940
6	Alice	1314	1320	1329	1180	1159	1208
7	LHCb	870	913	946	887	910	959
8	**->Exp LHC**	**9172**	**9296**	**9313**	**8628**	**8335**	**8687**
9		74,96%	73,96%	74,94%	75,69%	74,59%	73,25%
10	LHC	78					
11	SPS	733	745	718	676	695	711
12	PS	219	229	204	179	177	221
13	**-> Acc**	1030	974	922	855	872	932
14		8,42%	7,75%	7,42%	7,50%	7,80%	7,86%
15	**--> Autres Expe**	**2034**	**2299**	**2193**	**1916**	**1968**	**2241**

LHC experiment users

Accelerator sector
→ added to "other experiments"

Other-experiment users

Scope 1

1		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
2	**Runs**	Run 2	Run 2	LS2	LS2	LS2	Run 3	Run 3	Run 3	Run 3	LS3
18	**Emissions (tCO2eq)**	373,542	380,366	220,270	231,057	285399	361264				
19	scope 1	193600	192100	78169	98997	123174	184173				
20	*Exp-Detec LHC*	*133029*	*116690*	*22597*	*35537*	39355	101850				LHC
21	*Exp-Refr LHC*	*35312*	*46122*	*33665*	*40383*	50171	50475				LHC
22	*Other Exp*	*9132*	*14068*	*6918*	*7846*	18325	20430				nonLHC
23	*Heating*	*13700*	*11300*	*12221*	*12000*	12618	9012				any
24	*others*	*2130*	*3921*	*2768*	*3231*	2704	2403				any
25	->LHC	168341	162812	56262	75920	89526	152325				
26	-> non LHC	9132	14068	6918	7846	18325	20430				
27	-> anyexp	15830	15221	14989	15231	15322	11415				

18.35t/phys (for LHC experiment users)

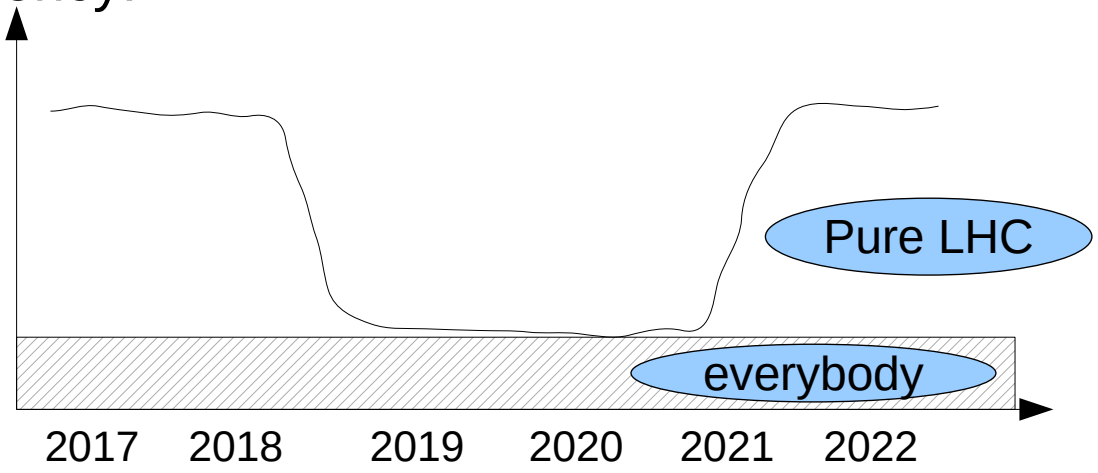
38	scope 1 LHC/user	18.35	17.51	6.04	8.80	10.74	17.53
39	scope 1 nonLHC/user	2.98	4.30	2.22	2.83	6.45	6.44
40	scope 1 any	1.29	1.21	1.21	1.34	1.37	0.96

2.98t/phys (for non-LHC experiment users)

+ 1.29t/phys (LHC or non-LHC)

Scope 2 (mostly electricity)

- Global tendency:



Numbers retroactively increased (2017-2020) in latest report 2021-2022

Hypothesis: during shutdown electric consumption per physicist for LHC experiments is similar to non-LHC physicist consumption

Cooling!
→ LS with high consumption

1		2017	2018	2019	2020	2021	2022	2023	
2	**Runs**	Run 2	Run 2	LS2	LS2	LS2	Run 3	Run 3	
30	scope 2	66589	74913	28554	26127	56382	63161		
31	scope 2 (any)	27340,5	27340,5	28554	26127	27340,5	27340,5	Ave (19',20	27340,5
32	scope 2 (LHC)	39248,5	47572,5	0	0	29041,5	35820,5		

Scope 2 (mostly electricity) - **Uncertainties**

- Evaluate with another sharing:
  - LHC data production: largest part of scope 2 → give it all to LHC users

1		2017	2018	2019	2020	2021	2022
2	**Runs**	Run 2	Run 2	LS2	LS2	LS2	Run 3
41	scope 2 for LHC	7.26	8.06	3.07	3.03	6.76	7.27
42	scope 2 (any)	2.23	2.18	2.30	2.29	2.45	2.31
43	scope 2 (LHC)	4.28	5.12	0.00	0.00	3.48	4.12

  - Comparing the two methods:
    - LHC: [15, 27%] → 30%
    - Non-LHC : [10,16%] → 20%

Scope 3

Some assumptions for early periods

	Run 2	Run 2	LS2	LS2	LS2	Run 3		
	2017	2018	2019	2020	2021	2022		
Waste	1875	1875	2120	1616	1718	1875	2017/8: use running condition (2022)	
Business travel	3327	3327	3327	618	151	827	2017/8: use pre-covid condition (2019)	
Commute	5782	5782	5782	1847	5443	5507	2017/8: use pre-covid condition (2019)	
Water	176	176	125	123	151	176	2017/8: use running condition (2022)	
Catering	691	691	691	227	350	571	2017/8: use pre-covid condition (2019)	
Sub-total	11851	11851	12045	4431	7813	8956		
procurement	101502	101502	101502	101502	98030	104974	<2021: Average(21', 22')	101502
Total	113353	113353	113547	105933	105843	113930		

Adding **procurement**, from recent years
(not available in reports before 2021)

Construction of LHC

- Not clear how to handle it
  - Tunnel already existing (LEP)
  - Amortization period (how long?) or single shot at construction time?
  - How to take into account the upgrades ?

- Order of magnitude

12	cost:	4.50E+09	euros	LHC+4 experiments (CHF=euros)	
13	years:	2008	2040	32	years
14				1.41E+08	euros/year
15	EF:	0.3	kg/euros		
16	Co2eq:	4.22E+04	tonnes		
17	physicists:	8600			
18		4.91	t/phys		

→ Much smaller than yearly usage → choice to **ignore** it

  - Philosophically not crazy: what matters today is new emissions
  - But important to keep it in mind for future infrastructures

Results & Uncertainties

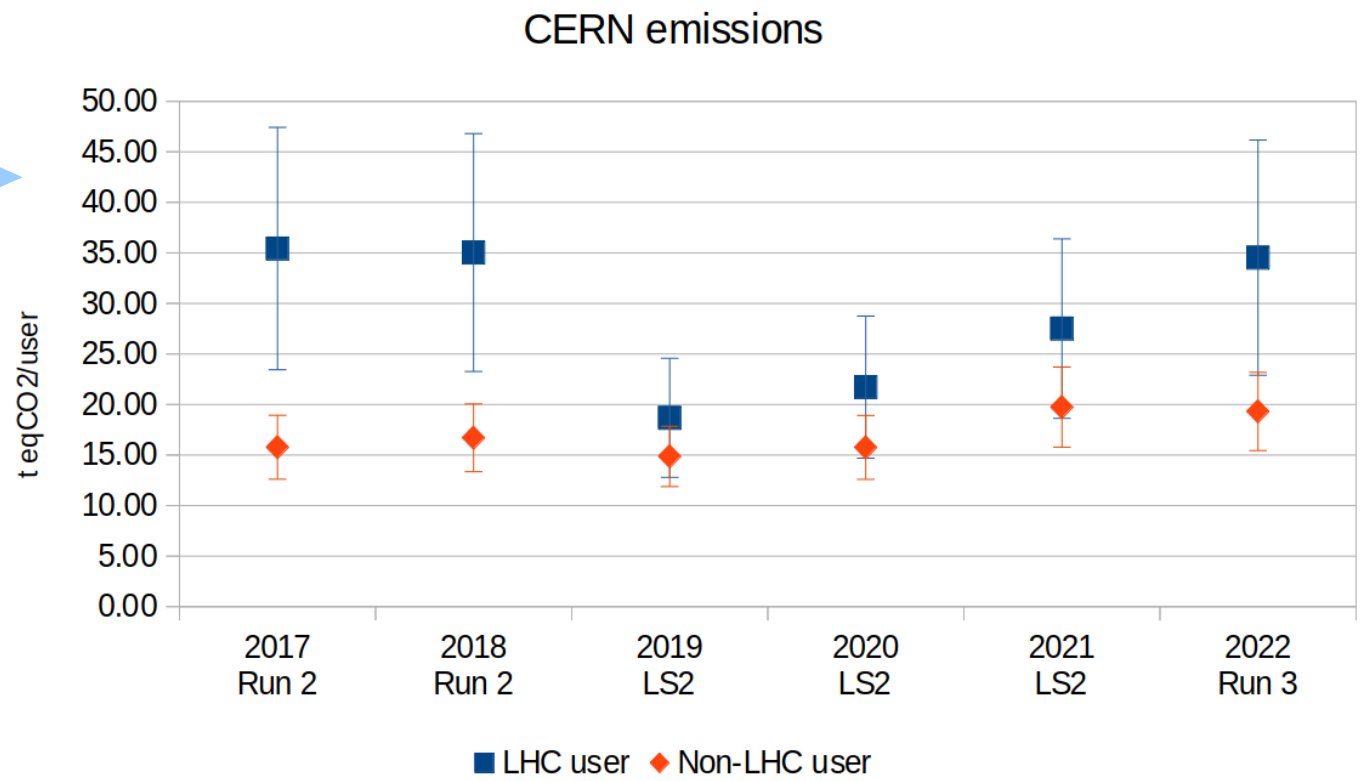
- Uncertainties
  - Methodology:

    Comparaison btw 2 methods:

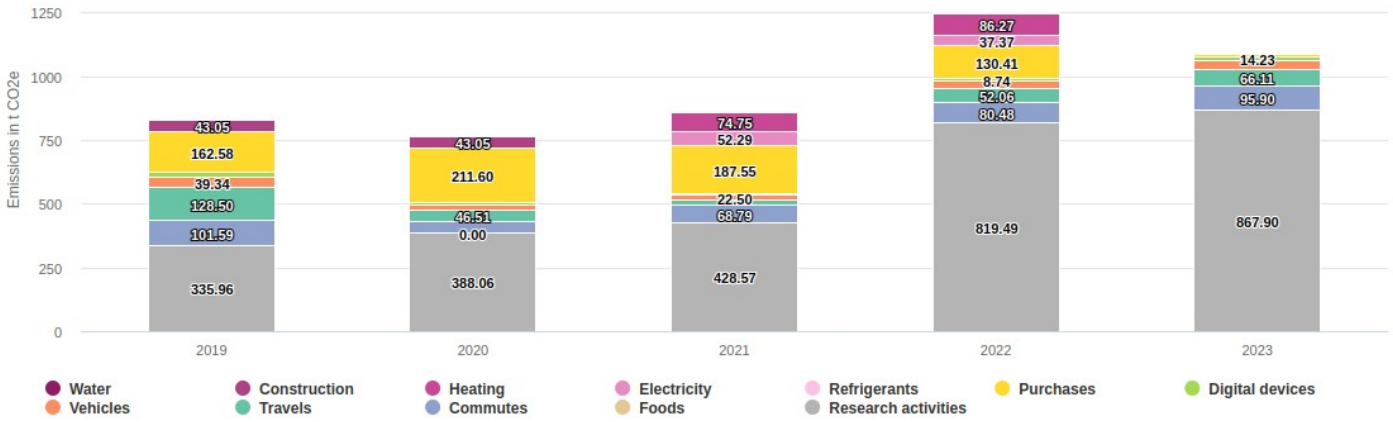
    LHC: [15, 27%] → 30%

    non-LHC : [10,16] → 20%
  - Emission factors: (from GES1point5)
    - Gases : 30%
    - Electricity (FR): 10%
- Results:
  (computing still to be included...)

		2017	2018	2019	2020	2021	2022	2023
2	Runs	Run 2	Run 2	LS2	LS2	LS2	Run 3	Run 3
52	FE t/user (LHC)	-0,15	-0,17	-0,27	-0,23	-0,24	-0,20	-> 30%
53	FE t/user (CERNuser)	0,16	0,15	0,09	0,10	0,10	0,14	->20%



Results for LPCA



Just a single number to be provided:

- Number of LHC users that year

Category	Type	Sub-type	Amount	Unit
Research facilities	CERN	LHC experiment	32	User(s)
Research facilities	Astronomy	STEREO, TESS, GAIA, GALEX, WISE...		Utilisation
Research facilities	Astronomy	STEREO	0.1	% facility usage
Research facilities	Astronomy	TESS	0.01	% facility usage
Research facilities	Astronomy	GAIA	0.01	% facility usage
Research facilities	Astronomy	GALEX	0.02	% facility usage
Research facilities	Astronomy	WISE	0.01	% facility usage
Research facilities	Astronomy	HST	0.01	% facility usage
Research facilities	Astronomy	SWIFT	0.01	% facility usage
Research facilities	Astronomy	Fermi	0.04	% facility usage
Research facilities	Astronomy	Pic-du-Midi Observatory	2.74	% facility usage
Research facilities	Astronomy	Anglo-Australian Telescope	0.06	% facility usage
Research facilities	Astronomy	VLT (Paranal)	0.01	% facility usage
Research facilities	Astronomy	GTC	0.09	% facility usage
Research facilities	Astronomy	TAROT	2	% facility usage
Research facilities	Astronomy	VLA	0.01	% facility usage

10 persons

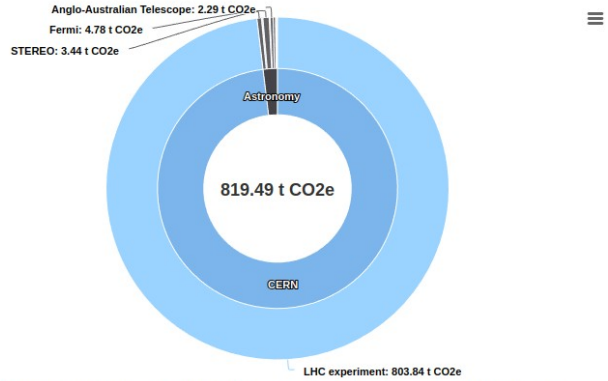


Figure : *Carbon footprint of laboratory research activities separated by their types.*

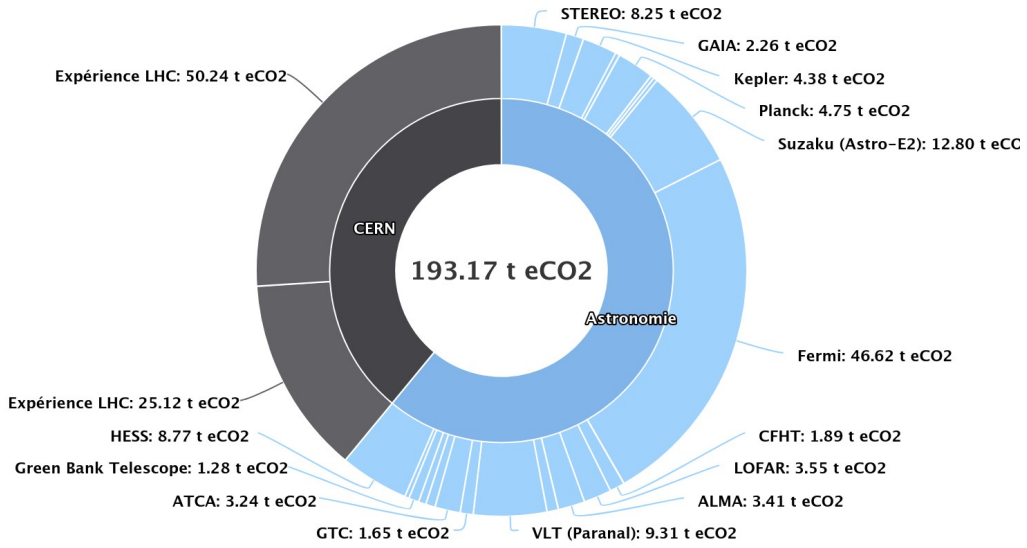
Type of research activity	Emissions (t CO2e)	Share of the research activity footprint
CERN	803.84 ± 297.42	98 %
Astronomy	15.64 ± 12.52	2 %

Astronomy

- Takes into account telescopes (in space and on Earth) used in laboratory's publications
- Easy to use: just provide lab's name
- Emissions attributed with ratio of *lab authors who published articles citing infrastructure* and *all authors in the world who published articles citing the same infrastructure*
- Amortisation : 38 years for telescopes and 18 years for satellites
- Bibliometric data extracted from ADS
- Does not include yet recent infrastructures like Euclid, CTA, LSST, etc.
- Ref : arXiv: 2201.08748 [astro-ph.IM]

$$EC_{\text{infra}} = \frac{GES_{\text{construction}}}{\text{amortissement}} + GES_{\text{opérations}}$$

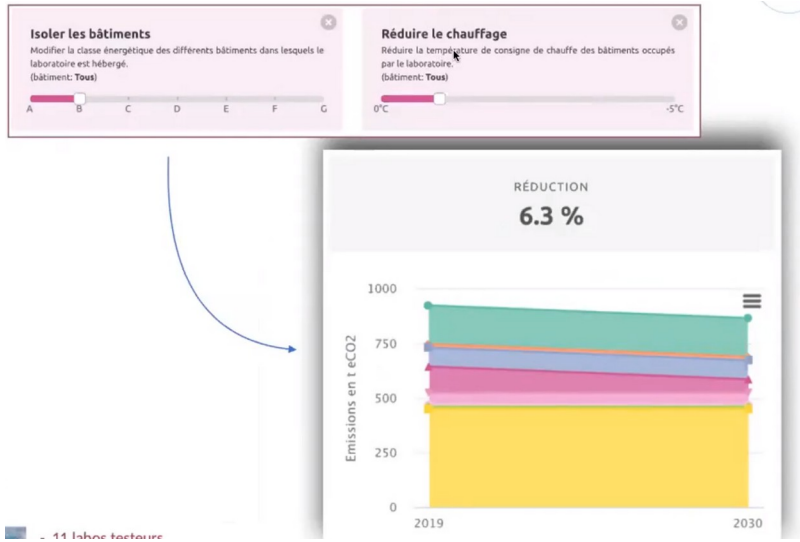
$$EC_{\text{labo}} = \sum_i \left(EC_{\text{infra}_i} \times \%\text{utilisation}^{\text{labo}}_{\text{infra}_i} \right)$$



CPPM (fake LHC to see astro)

Implementing CERN reduction in Scenario1point5

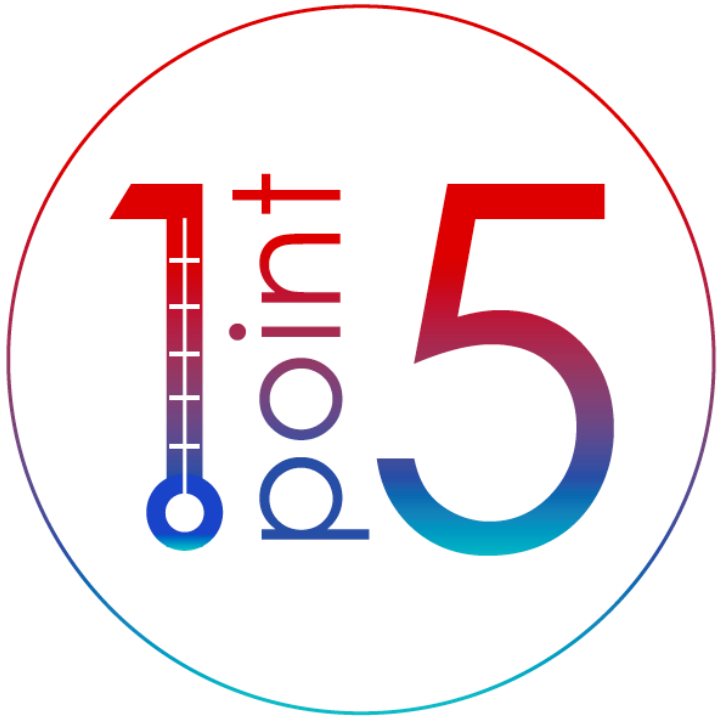
- That will ...
  - Answer to
    “our biggest GHG emission source is CERN,
    and they're going to cut back on gas,
    so we don't have much left to do for our 50% reduction?”
  - Raise awareness of the long-term consequences of our technological choices
    (especially as the FCC proto-collab will be launched next year).



- So … What will the CERN footprint be in 2030?
  - CERN plans to reduce Scope 1 by 28% (wrt/ 2018) by 2025
    → Scope 1(2018) *28% / nb of phys = -5.8t
  - To be applied only if the reference year is not a LS

Conclusion

- French research community got together in Labos 1point5 to tackle climate change:
  - All research areas involved
  - Started as grassroot initiative, now supported officially and encouraged by funding agencies
  - Provides tools, methods, webinars, scientific papers, etc
- First step: standardised GHG emissions for all labs with single tool: GES 1point5
- Large database to analyse structure of research emissions:
  - Importance of purchases
  - Impact of various scenarios on travel emissions
  - Large impact of big research infrastructures
    - Includes already astronomy, CERN, computing center, …
- From this knowledge, call for action
  - Labs designing GHG emission reduction plans (goal: -50% by 2030), simulating impact with Scenario 1point5
  - Sharing experience with Transition 1point5



https://labos1point5.org/

Backup

- Numbers from slide 22

			2017	2018	2019	2020	2021	2022		
55										
56			Run 2	Run 2	LS2	LS2	LS2	Run 3		
57	**FE t/user (LHC)**		**35.43**	**35.04**	**18.68**	**21.72**	**27.51**	**34.53**	divide all 3 scopes	
58		30%	10.63	10.51	5.60	6.52	8.25	10.36	methodology	
59		30%	5.51	5.25	1.81	2.64	3.22	5.26	gases	
60		10%	0.65	0.73	0.23	0.23	0.59	0.64	electricity	
61	**total uncertainty**		**11.99**	**11.77**	**5.89**	**7.03**	**8.88**	**11.64**		
62										
63	**FE t/user (exp non-LHC)**		**15.77**	**16.70**	**14.86**	**15.75**	**19.74**	**19.31**		
64		20%	3.15	3.34	2.97	3.15	3.95	3.86	methodology	
65		10%	0.22	0.22	0.23	0.23	0.24	0.23	electricity	
66	**total uncertainty**		**3.16**	**3.35**	**2.98**	**3.16**	**3.96**	**3.87**		

Travels

Flight quotas outperform focused mitigation strategies in reducing the carbon footprint of academic travel
[T. Ben-Ari et al 2024 Environ. Res. Lett. 19 054008]

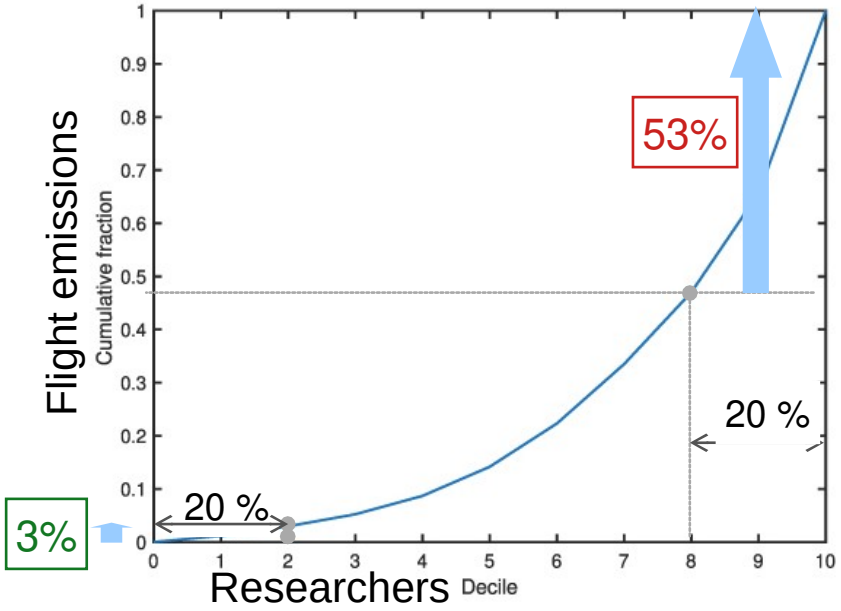
- 137k travels
- Planes ~95% of emissions
- Evaluate replacement of air travel by train
- -50% by 2030

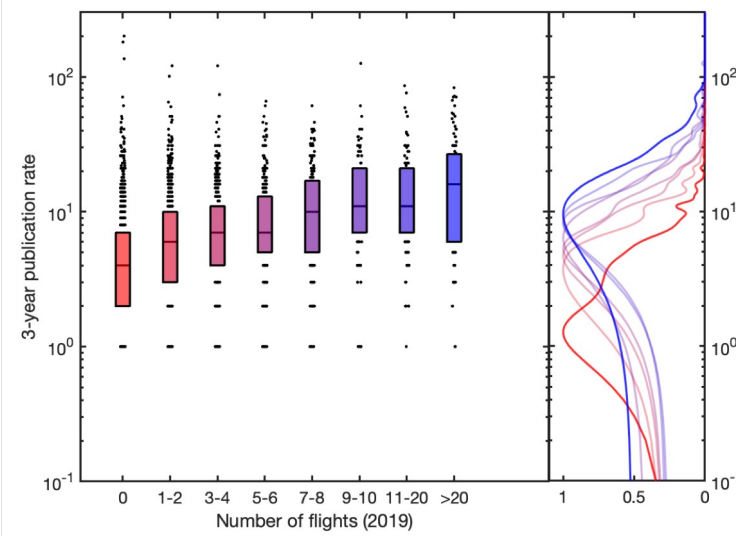
Current ministerial guideline

Minimum Allowable Distance (in distance or approximate duration) for Air Travel Clearance

Air Mileage Moderation in Quantity or Distance		No modal shift policy	375km (~2h30)	600km (~4h)	In mainland France	900km (~6h)	1000km (~6h40)	1200km (~8h)	1500km (~10h)
No moderation policy		0	0.3	3	8	12	15	18	21
Reduce air travel number for conferences	20% fewer trips	8	8	10	13	17	20	23*	26*
	50% fewer trips	19	19	21	24	27	30	32	34
	1 r. trip/3 years	14	13	14	17	18*	19*	21**	22**
	1 r. trip/4 years	18	18	19	22	22	23*	24*	23**
Reduce long–haul air travel number	20% fewer trips	13**	14**	16**	21**	26**	28**	32**	35**
	50% fewer trips	32**	33**	35**	40**	44**	47**	51**	53**
	1 r. trip/4 years	28**	28**	31**	35**	40**	43**	46**	49**
	1 r. trip/6 years	37**	38**	40**	45**	50**	52**	56**	59**
Reduce air travel mileage	20% decrease	20***	20***	22***	26***	30***	32***	34***	37***
	50% decrease	48***	49***	50***	52***	54***	56***	57***	59***
	5800km/year	38***	38***	39***	41***	42***	44***	45***	46***
	4500km/year	47***	47***	48***	50***	51***	52***	52***	53***
Reduce air travel number	20% fewer trips	19	20*	22*	25*	29*	31*	34*	36**
	50% fewer trips	48	48	49	52	54	55	57*	58*
	1 r. trip/year	36*	36*	33	32*	29*	28**	27**	27***
	1 r. trip/2 years	61	61	58	57	51*	50*	46*	44**

The carbon footprint of scientific visibility
[O. Berné et al 2022 Environ. Res. Lett. 17 124008]

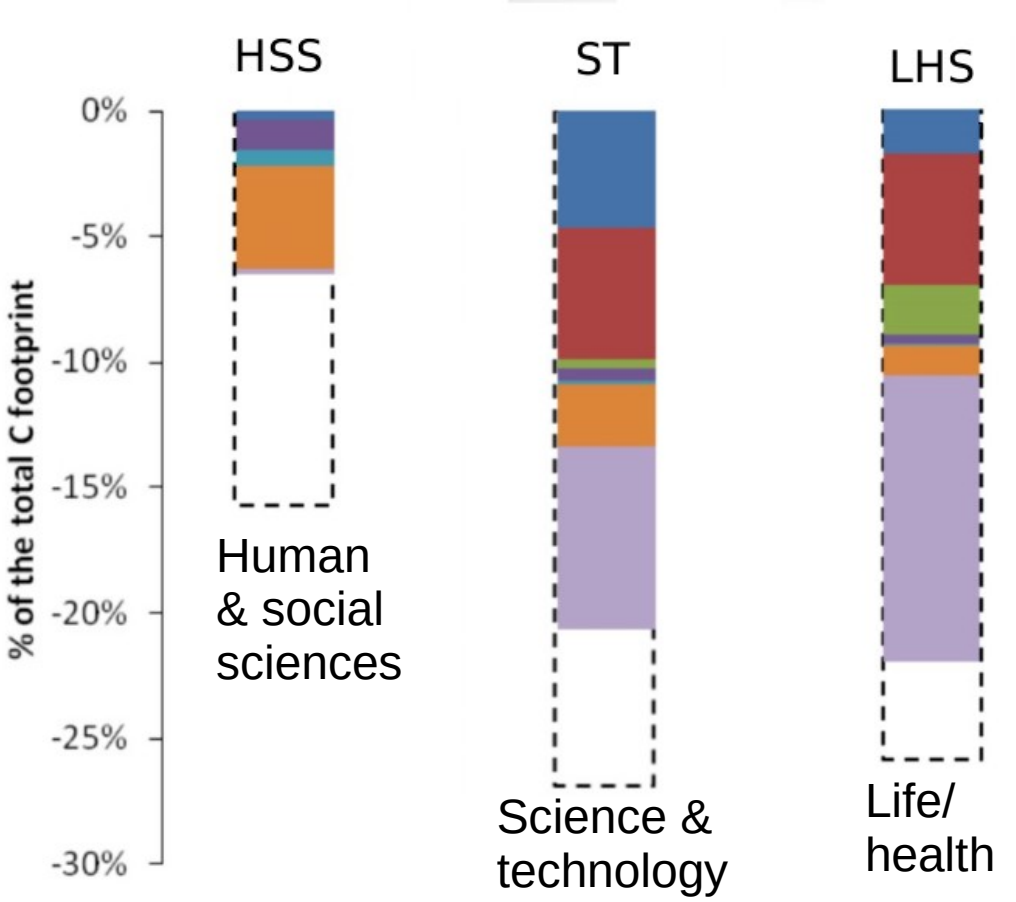




Procurement

- Difficult to quantify properly
- Using monetary emission factors:
  - Good for large-scale orders of magnitude
  - Tricky at smaller scales
  - Large uncertainties

- Relies on French procurement system with ~250 categories (Nacres)
  - Single EF per category
- Serious limitation
  - "good" practice costs more → "more" emissions



MS1	+ 50% of equipment time
MS2	50% pooling equipment
MS3	Replace 80% of plastic by glass
MS4	75% vegetarian catering
MS5	- 50% in furniture
MS6	- 50% in computing purchases
MS7	- 50% in consumable purchases

Purchases dominate the carbon footprint of research laboratories [bioArXiv]

Demand-based strategies can achieve a 20% reduction in the total footprint (-40% in the purchasing footprint).

Research and environmental footprint

A very present topic (I kept the quotes in French) **:**

Recommendation of the CNRS biology Scientific Council: November 2021 [here]

« La recherche ne peut s'affranchir de la prise de conscience de son impact environnemental »

Tribune Labos1point5

« Notre objectif est d'imaginer un nouvel horizon pour le monde académique, qui s'affranchisse d'une compétition frénétique reposant sur l'illusion d'une énergie abondante et sans limites. »

Recherche : pour une éthique environnementale, Le Monde, 15 mars 2022 (https://labos1point5.org/reflexion/RechercheEthiqueEnvironnementale)

COMETS advice (CNRS ethics committee): December 2022 [here]

« Integrating environmental issues into research practices – An ethical responsibility »

MESR [French ministry of higher education and research] Climate and biodiversity plan : November 2022

HCERES [French research evaluation committee] adds questions on environmental issues in institution evaluation : October 2023

And laboratories are moving forward

(often faster than institutions)