CLIC INDUSTRY AND STUDENTS OVERVIEW

in the framework of Societal Impact Assessment Study

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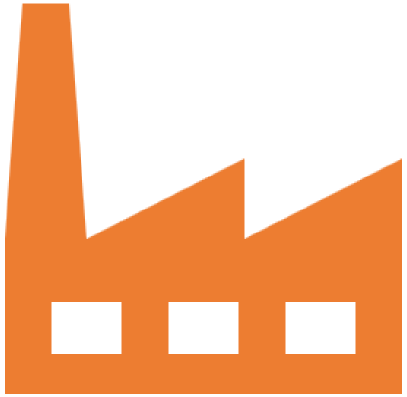
For CLIC Project meeting 39

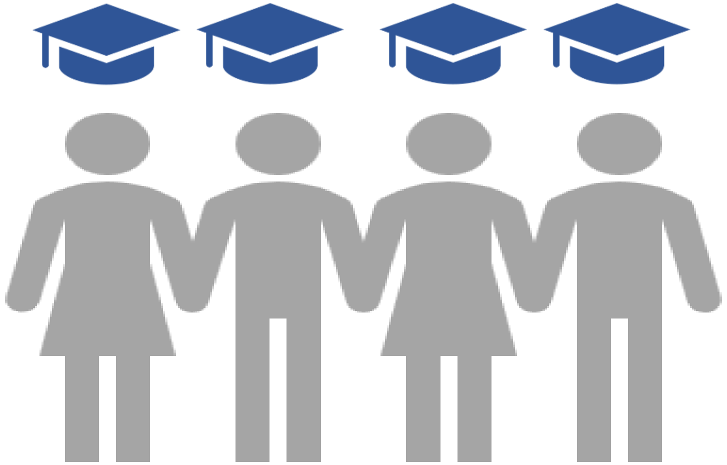
15.06. 2021

Outline



Industrialization

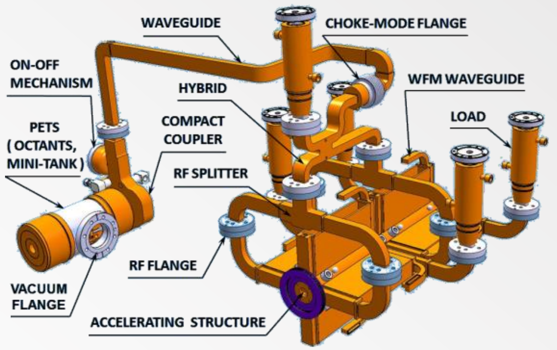
Students (Human capital)



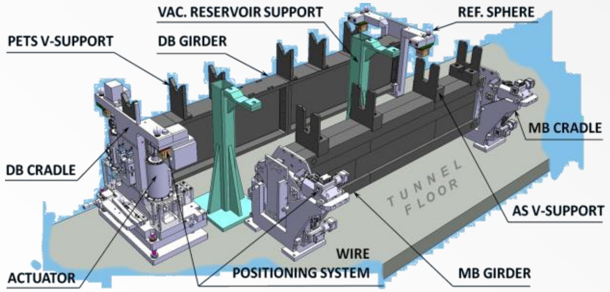
Societal Impact Assessment

CLIC

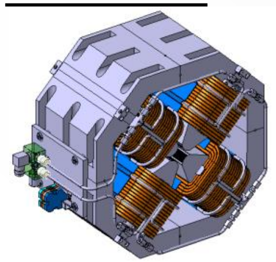
RF SYTEM

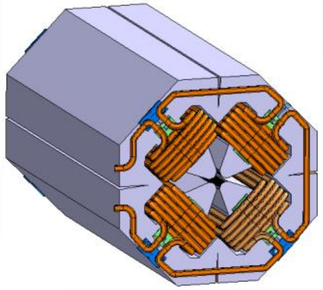


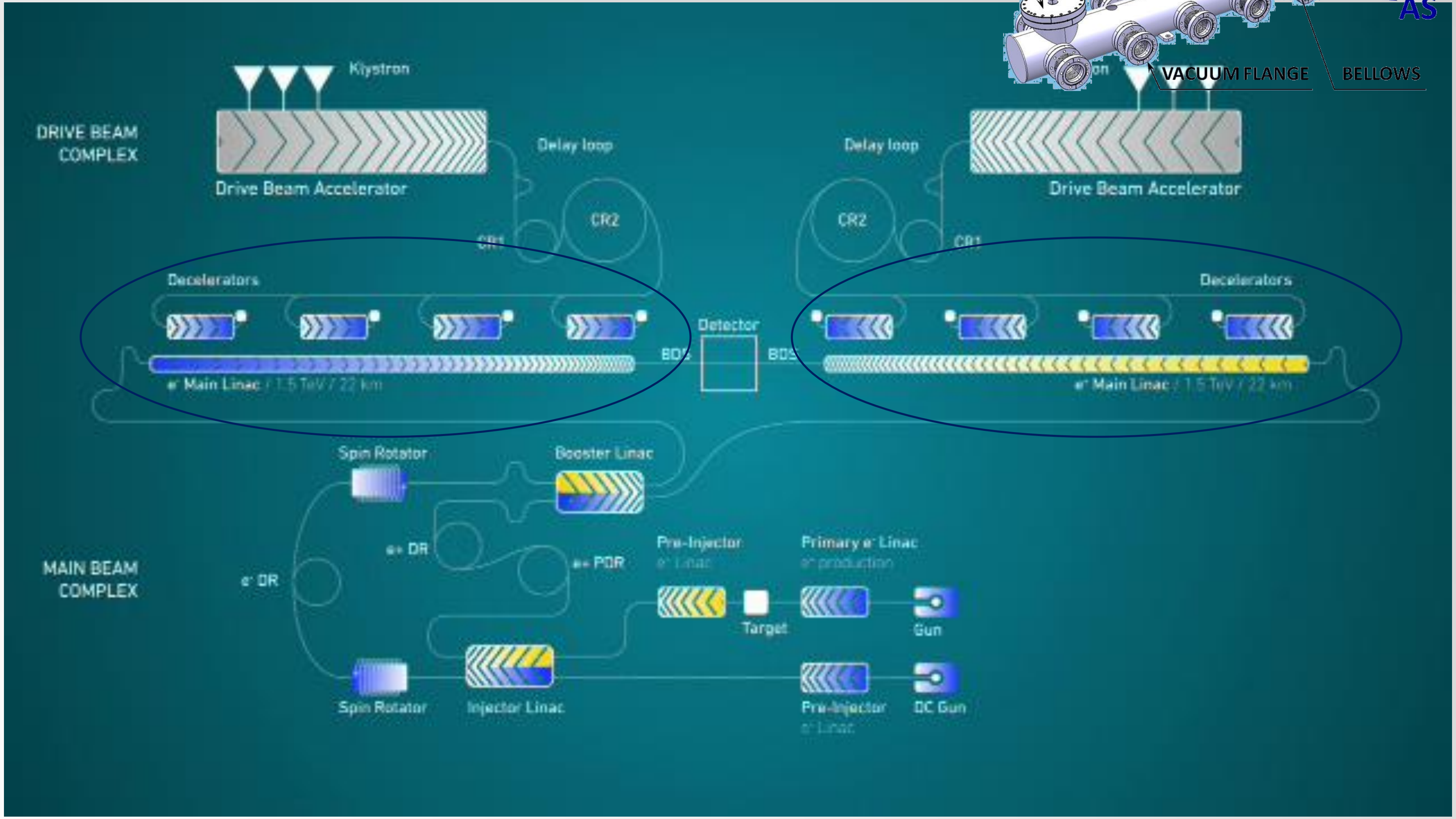
ALIGNEMENT, STABILISATION and SUPPORT SYSTEMS



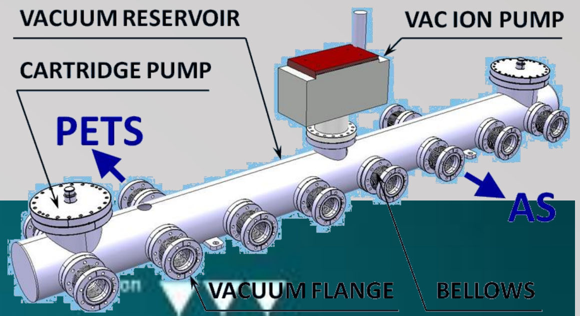
MAGNETS







VACUUM SYTEM

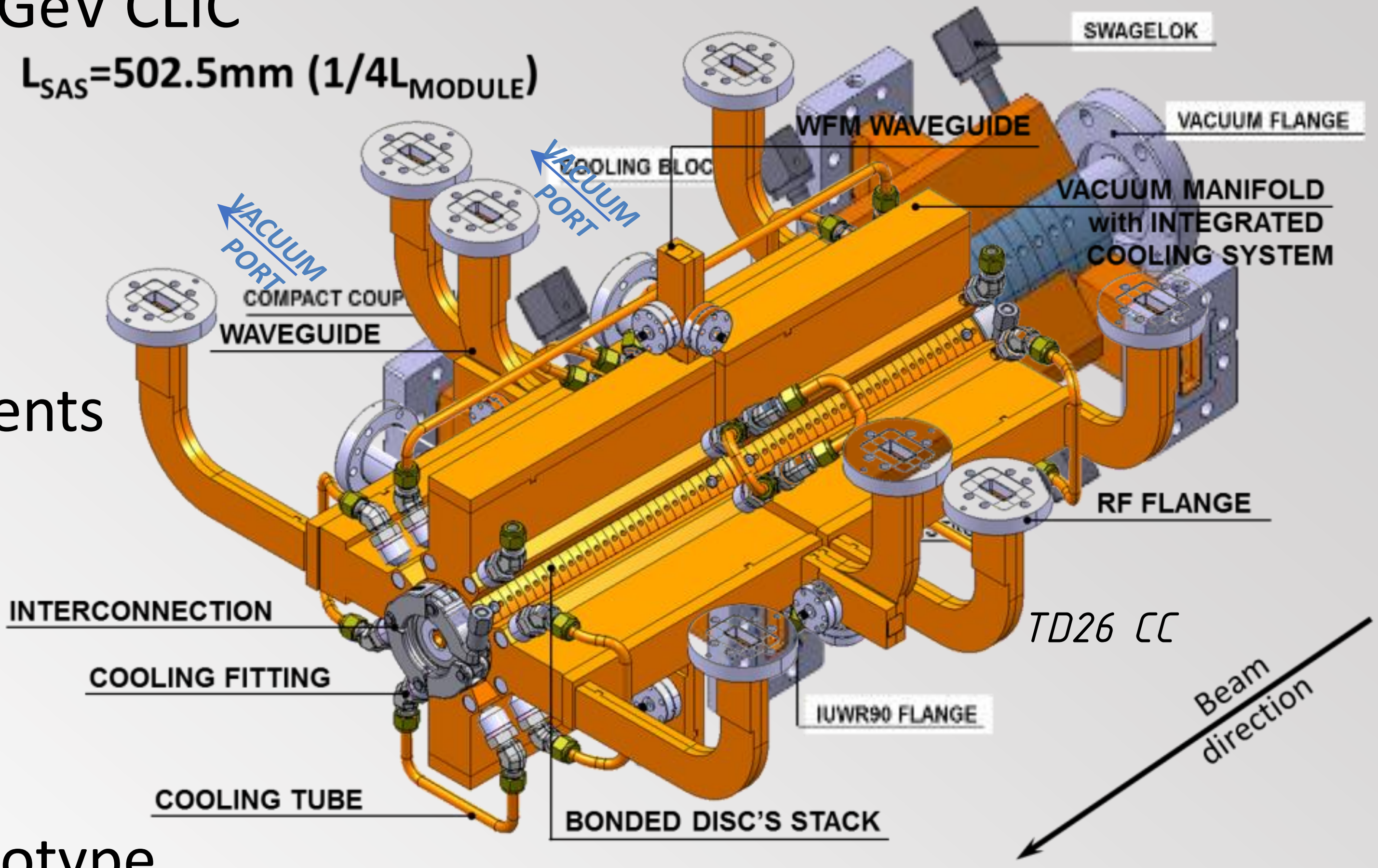


Accelerating structures

- About 8% of the total cost of 380 GeV CLIC
- Involved emerging technologies
- Extreme tolerances for
  - Machining;
  - Assembly.
- Tolerances driven by RF requirements
- Limited number of suppliers

TD26 CC

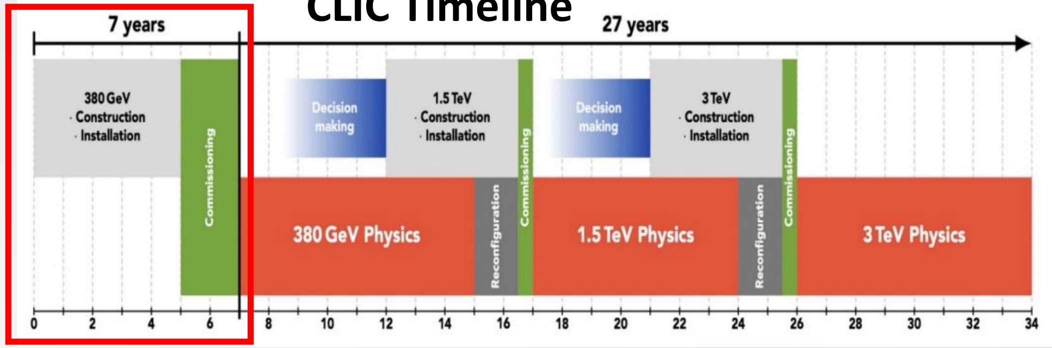
- Demonstrated performance
- Established fabrication procedure
- Easy to scale to the final CLIC prototype



From prototype to mass production

- CLIC 380 GeV → 21 630 accelerating structures → 627 270 discs
- The construction and installation time estimated to 5 years

CLIC Timeline



- 6 months machining of 120 discs → 1 discs/day to 501.82 discs/day
- 0.1 assembled cavities to 17.3 cavities/day

Fraction of total no of structures	Discs (type A)	Full assembly (disc version) Optional	Production period (year)	Production rate (discs/day) at 250 work-days/yr	Production rate (cavities/day) at 250 work-days/yr
100%	627 270	21 630	5	501.82	17.3
50%	313 635	10 815	5	250.91	8.65

CLIC Industrialization study

12 COMPANIES → **EUROPE AND JAPAN (through KEK collaboration)** → **VISITS + MEETINGS + PAPER TECHNICAL QUESTIONNAIRE**

- **8 UP MACHINING**
- **3 HEAT TREATMENT (HT)**
- **1 UP + HT**

- **7 EUROPEAN**
- **5 ASIAN**

TECHNICAL SURVEY INDUSTRIALIZATION OF 12 GHZ ACCELERATING STRUCTURES (AS)

- PREPARATION FOR MASS PRODUCTION

DO WE HAVE ENOUGH QUALIFIED SUPPLIERS?

HOW SHOULD WE ORGANISE THE SUPPLY OF AS AMONG DIFFERENT COMPANIES?

WHAT IS THE MOST EFFICIENT PRODUCTION PROCESS?

WHAT KIND OF INVESTMENT WILL BE NEEDED AND HOW THIS WILL AFFECT COST?

WHAT WILL BE THE RAMP-UP AND RAMP-DOWN PRODUCTION TIME?

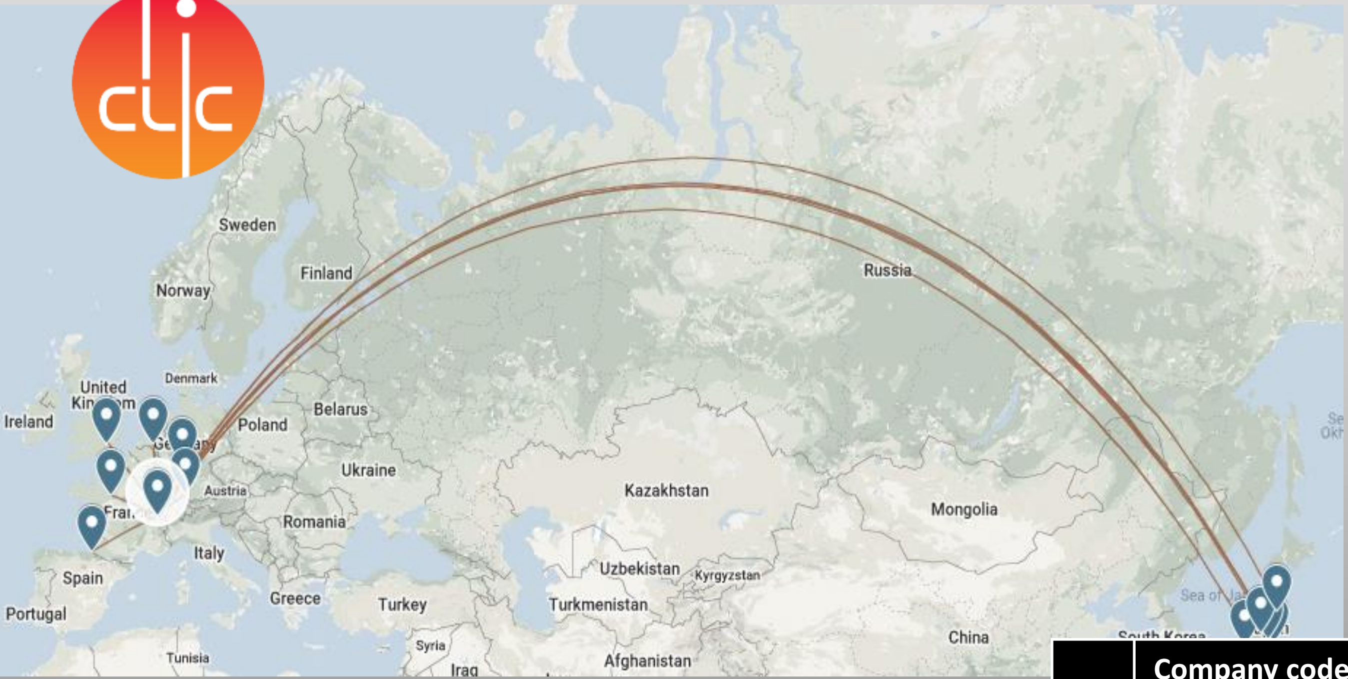
WHAT ARE THE MAIN RISKS?

WHAT QUALITY ASSURANCE NEEDS TO BE PUT IN PLACE? HOW DOES IT AFFECT THE COST?

WHAT YIELD SHOULD WE EXPECT?

For CLIC

For companies



TECHNICAL SURVEY

92%

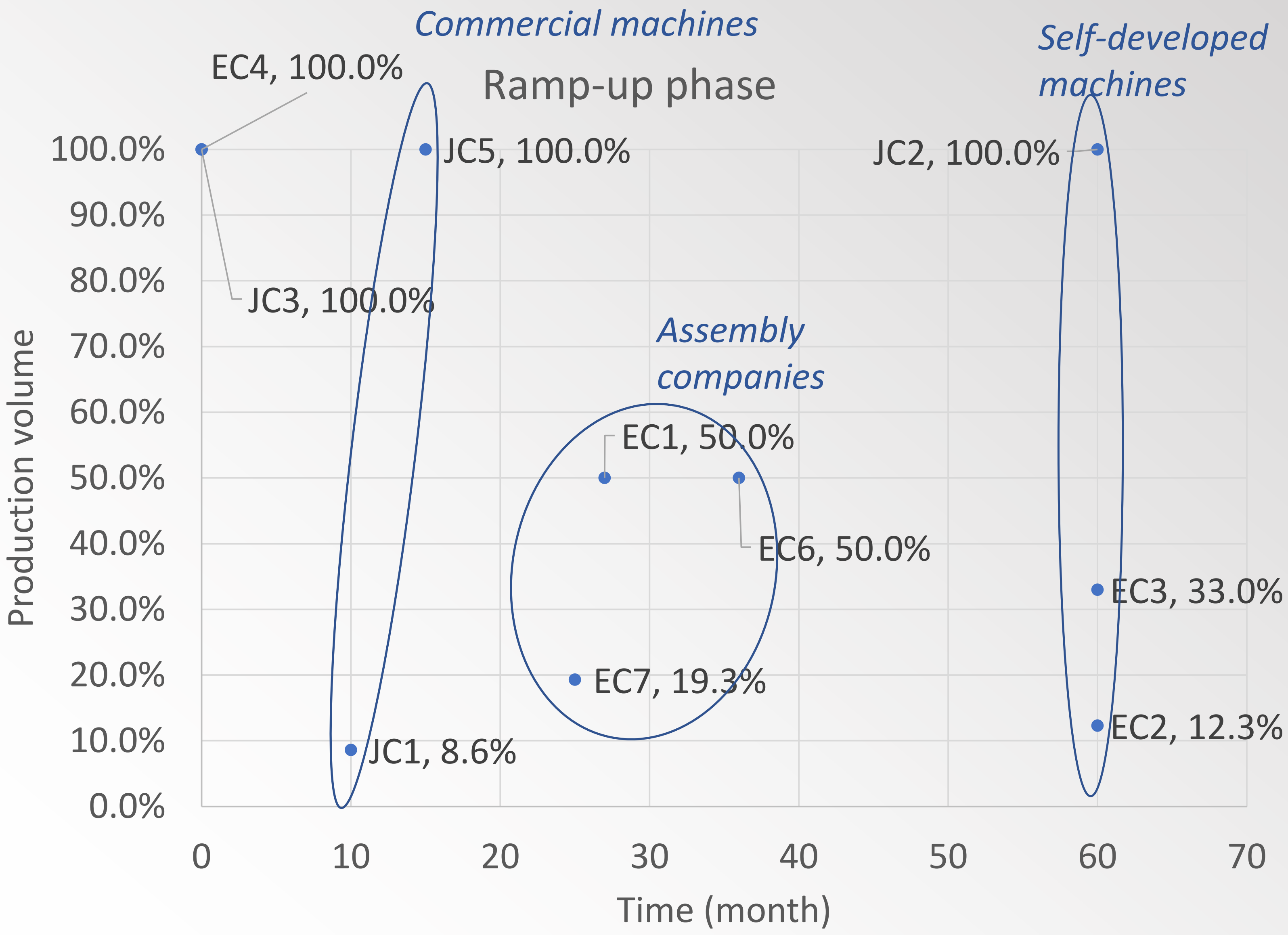
- 12 COMPANIES CONTACTED
- RECEIVED FEEDBACK FROM 6 EUROPEAN AND 5 ASIAN COMPANIES

For the further study we use the data from 10 suppliers

- 12 companies:
  - 5 Japanese
  - 7 European
- 11 feedback → 10 used

	Company code	Operational Field	Experience	Desirable volume
1	JC 1	**UP machining**	One structure	8.6%
2	JC 2	**UP machining**	With a collaborator	100%
3	JC 3	**UP machining**	With a collaborator	100%
4	JC 4 Poor data provided	**achining**	Qualification part	ND
5	JC 5	Assembly	With a collaborator	100%
6	EC 1	Assembly	One structure	50%
7	EC 2	**UP machining**	Structures	12.3%
8	EC 3	**UP machining**	Structures	30%
9	EC 4	**UP machining**	With a collaborator	100%
10	EC 5 No reply	**UP machining**	Structures	0%
11	EC 6	Assembly	Structures	100%
12	EC 7	Assembly	One structure	19.3%

Production volume vs ramp-up

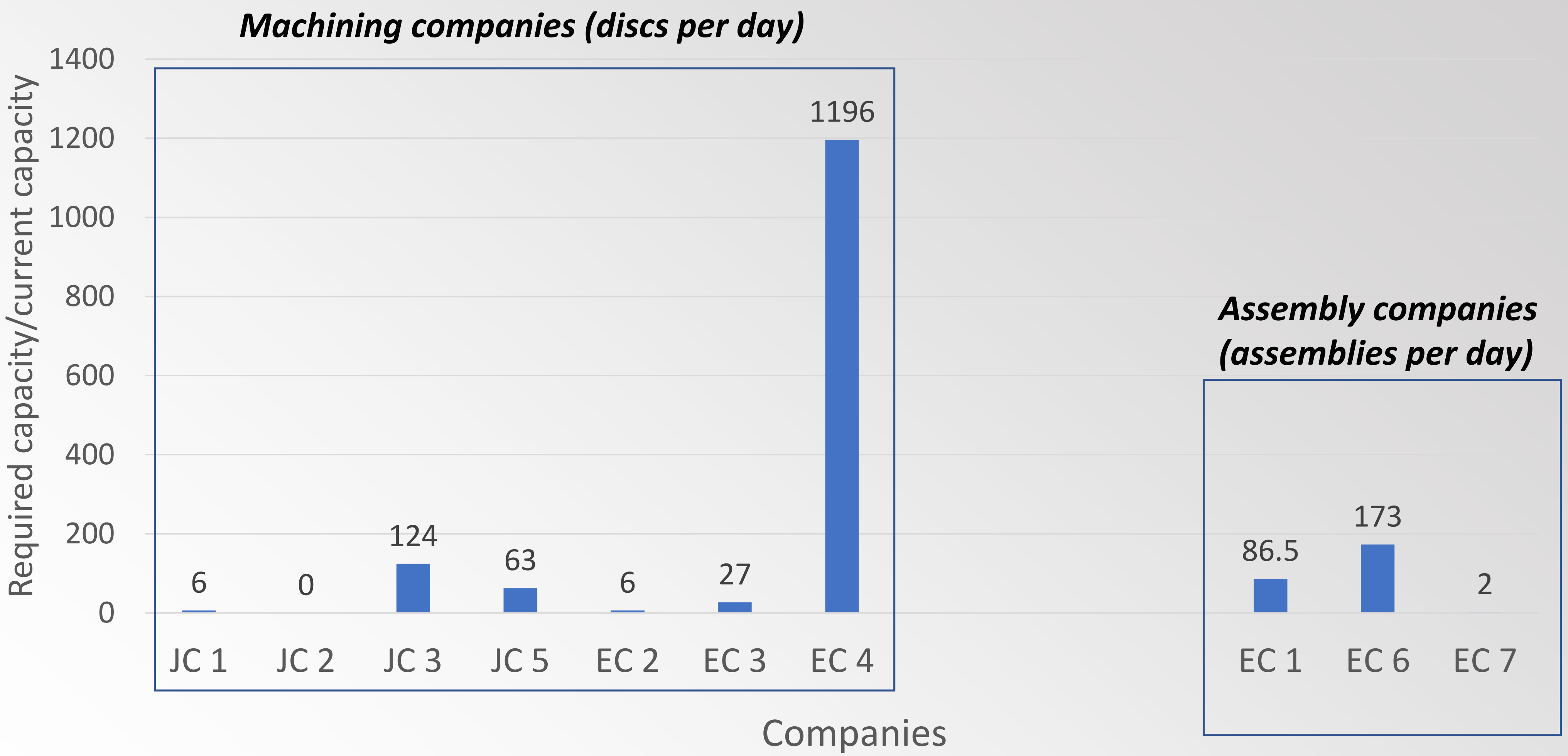


Ramp-up: *time to scale up to the stable manufacturing phase*

5 years – UP companies
Between **2 and 3 years** – HT companies

- Difference in ramp-up because of different machining strategies:
  Customised, commercial or self-developed machines.
- Less preparation time for companies who supposed to use commercial machines.
- We can consider that the assembly premises will need less preparation time.
- The full production period including the ramp-up phase is varied **from 6.5 to 10 years** for machining companies, and **from 5 to 6.5 years** for HT companies.

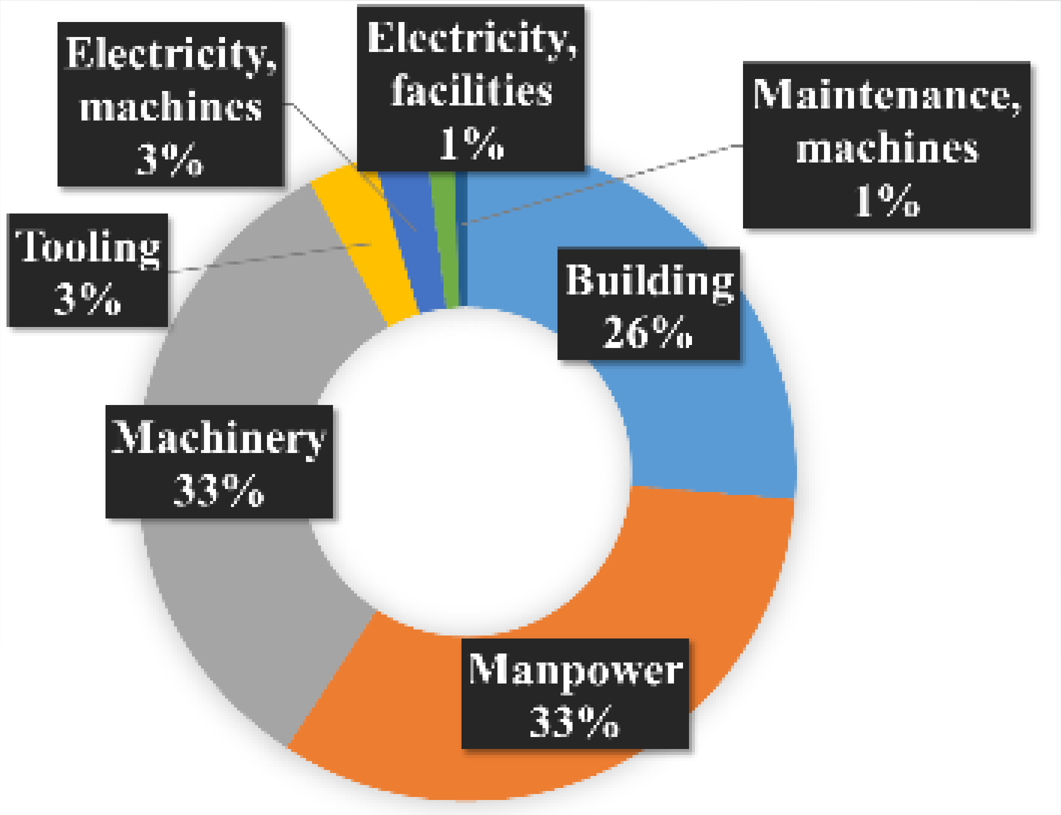
Scaling coefficient for production



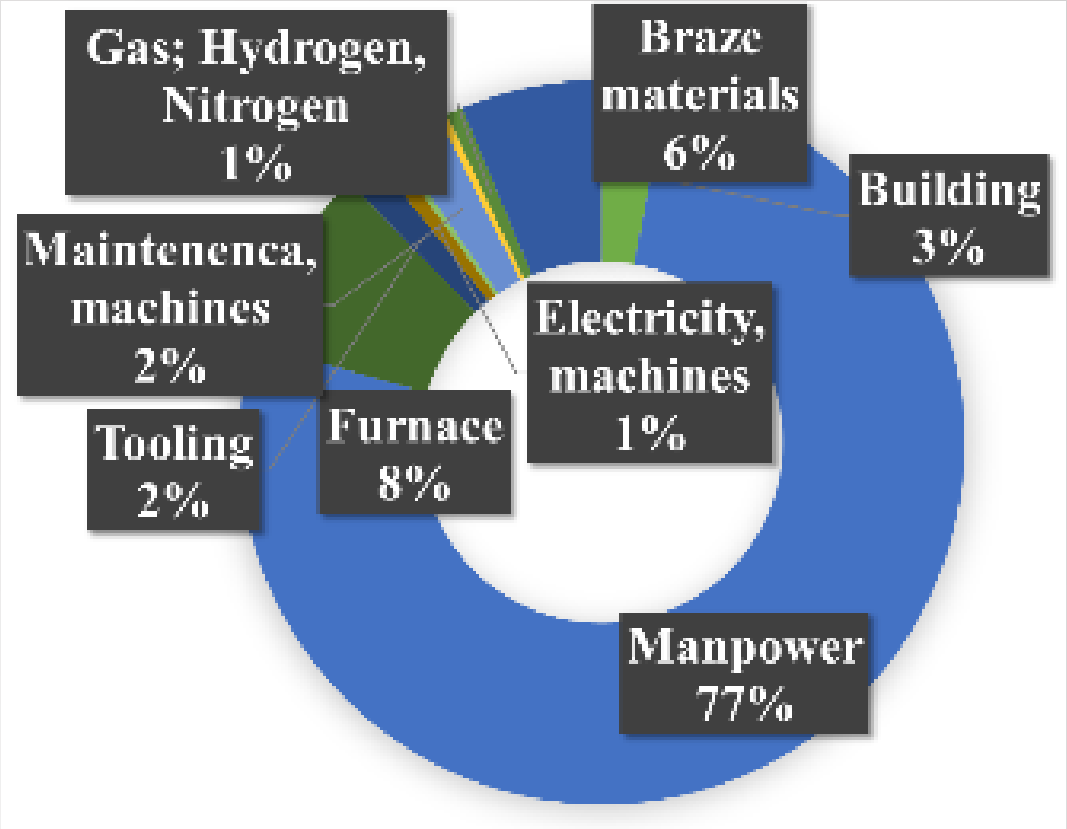
Summary table

Code	Technology for CLIC	%	Scale coef.	Ramp (months)	
				up	down
EC 2	UP machining	12.3	6	60	2
EC 4	UP machining	100	1196	ND	ND
JC 1	UP machining	8.6	6	10	6
JC 2	UP machining	100	ND	60	ND
JC 3	UP machining	100	124	ND	ND
EC 1	HT operations	50	86.5	27	10
EC 6	HT operations	100	173	36	ND
EC 7	HT operations	19.3	2	25	ND
JC 5	Full supply	100	63	15	3
EC 3	Full supply	30	27	60	ND

Cost breakdown



UP machining disc



HT operations

Cost reduction factor

Code	%	Technology for CLIC	Mass production (cost reduction factor)	
			UP	HT
EC2	12.3	UP machining	1.5	
EC4	100	UP machining	1.2	
JC1	8.6	UP machining	1.1	
JC2	100	UP machining	4	
JC3	100	UP machining	ND	
EC1	50	Assembly		4.1
EC6	100	Assembly		4.1
EC7	19.3	Assembly		7.5
JC5	100	Full supply	ND	ND
EC3	30	Full supply	1.8	2.5

Summary

Enough suppliers

For 21630 AS

Ready to build consortiums

Cost reduction

Factor
Discs: 1.1 – 4
HT assembly: 2.5 – 7.5

Timeline

Ramp up
Discs: ~5 years
HT: 2-3 years
Ramp down
2 – 10 months
Full production
Discs: 6.5 – 10 years
HT: 5-6.5 years

Magazinik, A., Mäkinen, S., Catalan Lasheras N., Sauza Bedolla J., (proceeding for IPAC 2021), 'Industrialization study of the accelerating structures for 380 GeV Compact Linear Collider.

Societal Impact Assessment (SIA)

…started in the beginning of 2018

Voir en français

May 2019

In Granada, the European particle physics community prepares decisions for the future of the field

The European particle physics community is meeting this week in Granada, Spain, to discuss the roadmap for the future of the discipline

13 MAY, 2019

LC NEWSLINE

THE NEWSLETTER OF THE LINEAR COLLIDER COMMUNITY

CURRENT ISSUE
10 MAY 2019

A common scientific, technical and strategic vision

Download the current issue as a full .pdf

PREPRINTS

ARXIV PREPRINTS

1905.00220
Complementarity between ILC250 and ILC-GigaZ

1904.10156
Gauge-Higgs unification at e+e− linear colliders

1904.07407
Minimal Dirac Neutrino Mass Models from U(1)R Gauge Symmetry and Left-Right Asymmetry at Collider

1903.12327

MEXT outreach SCRF SLAC TDR
Technical Design Report United

FEATURE

Executive Summary of the Science Council of Japan's Report

21 December 2018

This is the executive summary of the Science Council of Japan (SCJ)'s report on the International Linear Collider, released on 19 December 2018. This is an unofficial translation by KEK from the original Japanese.

BACKGROUND

The International Linear Collider (ILC) is an international project in the field of elementary particle physics to construct a straight accelerator (linear accelerator) to perform high-energy electron-positron collision experiments, and thereby advance research on the Higgs particle.

In response to the receipt of "Regarding Deliberations on International Linear Collider (Requests)" by the President of the Science Council of Japan from the Ministry of Education, Culture, Sports, Science and Technology on July 20, 2018, the "Review Committee on the Revised Version of the International Linear Collider Project" and "Technical Verification Subcommittee" were established. Since the ILC is a major international project requiring huge long-term investment and international cooperation, the committees deliberated on the project itself, including its academic ... status of ... systems at ... oad, and for

... ion of the ILC

... yond the ... celerator- and ... ergy particle ... iggs couplings ... ocate

... ow been ... riod of 30 ... fore proposing ... nd support ... perspective, ... es.

... apan ... n the sense of ... er spread out ... ng hard and

On the other hand, with regard to the technical and economic ripple effects other than its pure academic significance, the effects of the ILC are unclear at the moment and are considered to be limited. More in-depth dialogue with the

- **On the significance to the public and society of implementing the ILC project (revised plan) in Japan**
  As with much other purely academic research, the ILC project arouses the public's intellectual interest in the sense of knowledge exploration. In addition, if it develops into a hub at which advanced researchers, who will later spread out across the world, develop in an environment where top-class scientists from around the world are working hard and competing, then the project's significance is substantial.
  On the other hand, with regard to the technical and economic ripple effects other than its pure academic significance, the effects of the ILC are unclear at the moment and are considered to be limited. More in-depth dialogue with the general public, and residents in the vicinity of the potential site in particular, is needed to communicate not only the scientific significance of the ILC project but also its potential merits, advertised in the context of regional development, and potential environmental impacts from civil construction and the production of radioactive material, based on accurate information provided by the scientific community.

Use SOCIETY, SOCIETAL *4* times

European Strategy Update

June 2020

Following almost two years of discussion and deliberation, the CERN Council today ann

To highlight the impacts of particle physics

he future of particle physics in Europe within the global particle-physics landscape. Presented during the open part of the Council's meeting, held remotely due to the ongoing COVID-19 pandemic, **the recommendations highlight the scientific impact of particle physics, as well as its technological, societal and human capital.**

"This is a very ambitious strategy, which outlines a bright fu

To invest in strong cooperative programmes

ise approach. We will continue to invest in strong cooperative programmes **between CERN and other research institutes** in CERN's Member States and beyond," declares CERN Director-General Fabiola Gianotti. **"These collaborations are key to sustained scientific and technological progress and bring many societal benefits."**

Beyond the immediate scientific return, major research infrastructures such as CERN have vast societal impact, thanks to their technological, economic and human capital. Advances in accelerators, detecto

Partnerships with large RI help drive innovation in industry

ct on areas li

aerospace applications, cultural heritage, artificial intelligence, energy, big data and robotics. **Partnerships with large research infrastructures help drive**

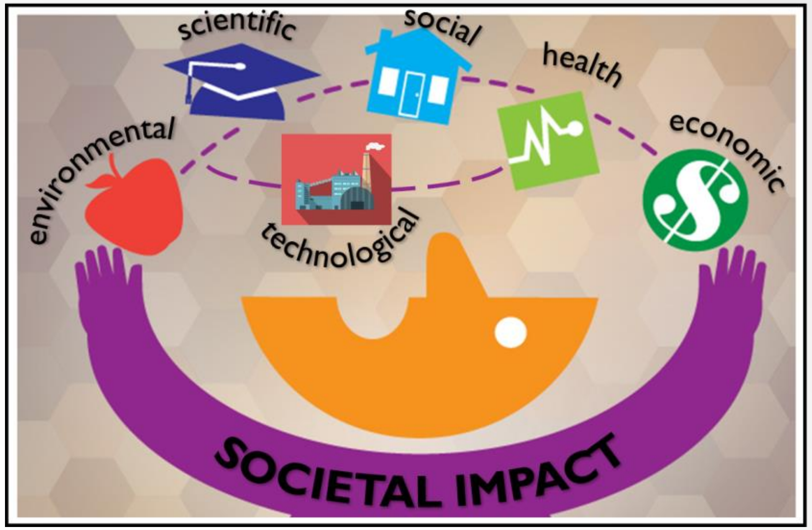
The successful completion of the High-Luminosity LHC in the coming decade, for which upgrade work is currently in progress at CERN, should remain the

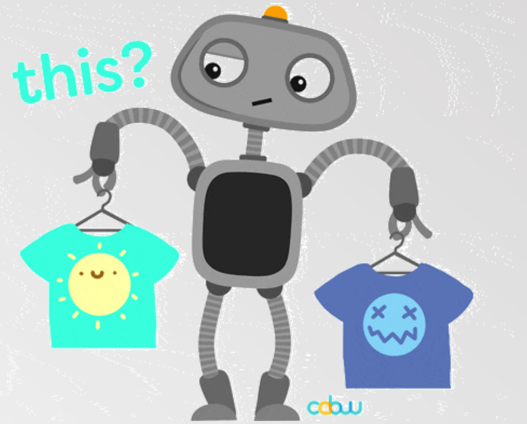
To ramp up focused and transformational R&D

strategy emphasises the importance of ramping up research and development (R&D) for advanced accelerator, detector and computing technologies, as a necessary prerequisite for all future projects. **Delivering the near and long-term future research programme envisaged in this Strategy update requires both focused and transformational R&D, which also has many potential benefits to society.**

SIA Highlights

- The source of economic value generation is public investment in fundamental research.
- How to assess that society **will be better with a project** or worse?
- It is important to identify the **value for society and economy,** how it can be measured and where it comes from.

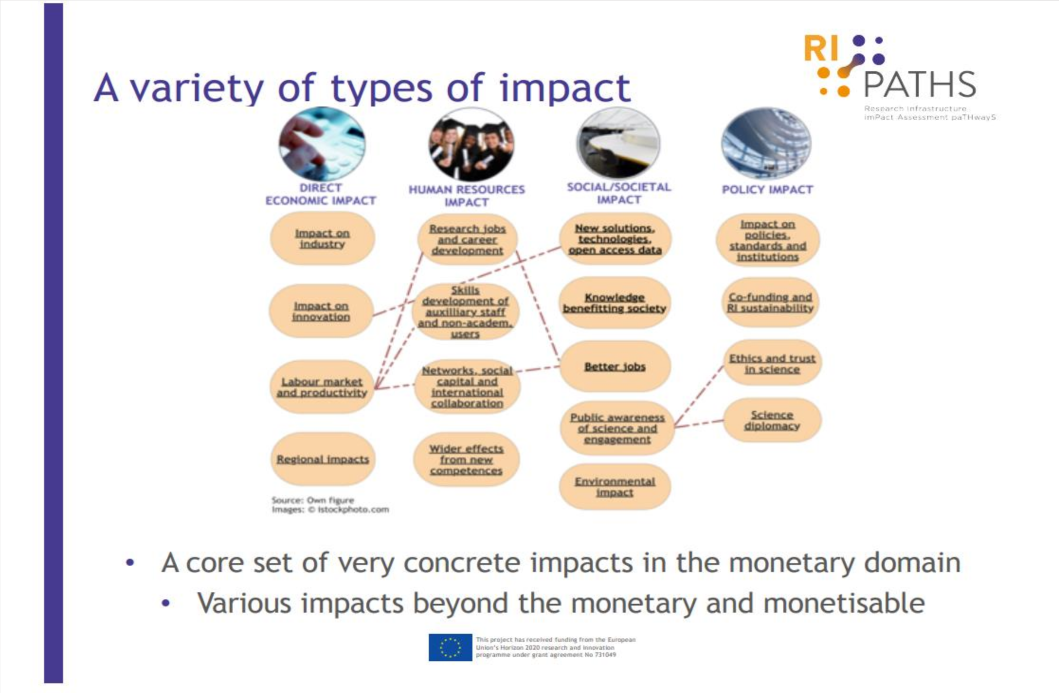


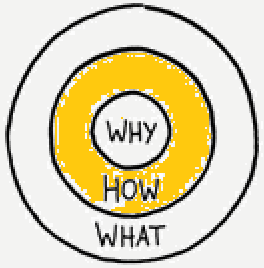


Others

- The community of assessing societal impact of research infrastructures is growing, many institutes, laboratories are involved around the World.
- There are several European projects aimed to build a comprehensive assessment model, such as the RI-PATHS project.

- Several RI involved
  - ALBA
  - DESY
  - CERN
  - ELIXIR
  - EATRIS
  - CESSDA





(VALUE FOR "NON-USERS")

NON-USE

COST-BENEFIT ANALYSIS

WEIGHT UP PROJECT COSTS AGAINST BENEFITS

NET USE

(VALUE FOR USERS OF AN INFRASTRUCTURE)

The model is built by identifying the ***benefits*** *of an action as well as the associated* ***costs****, and subtracting the* ***costs*** *from* ***benefits****.*

Fundamental vs applied RI: two case studies

LHC (The Large Hadron Collider)

Project time scale: 32 years

The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator. It first started up on 10 September 2008, and remains the latest addition to CERN's accelerator complex. The LHC consists of a 27-kilometre ring of superconducting magnets with a number of accelerating structures to boost the energy of the particles along the way.

Florio, M., Forte, S. and Sirtori, E. (2016) 'Forecasting the socio-economic impact of the Large Hadron Collider: A cost–benefit analysis to 2025 and beyond', *Technological Forecasting and Social Change*, 112, pp. 38–53. doi: 10.1016/j.techfore.2016.03.007.

CNAO (The National Hadrontherapy Centre for Cancer Treatment)

fondazione CNAO
National Center of Oncological Hadrontherapy for the treatment of tumours

Project timescale: 30 years

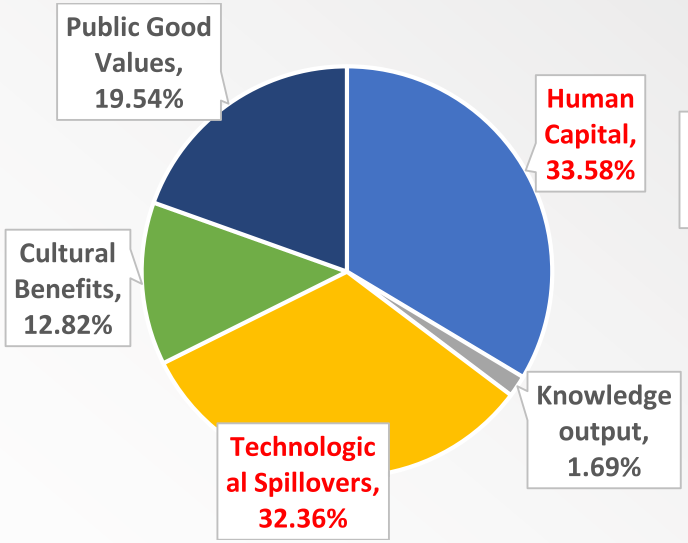
The National Centre of Oncological Hadrontherapy (CNAO) in Pavia is a non-profit Foundation established by the Health Minister for the cure of radio-resistant or inoperable tumors making use of carbon ions and protons (hadrontherapy).
Hadrontherapy hits the tumour with the highest precision and spare

THE SOCIO-ECONOMIC IMPACT OF THE NATIONAL HADRONTHERAPY CENTRE FOR CANCER TREATMENT (CNAO): APPLYING A CBA ANALYTICAL FRAMEWORK CHIARA PANCOTTI GIUSEPPE BATTISTONI MARIO GENCO MARIA VITTORIA LIVRAGA PAOLA MELLA SANDRO ROSSI SILVIA VIGNETTI The C Chiara (no date). Available at: http://www.economia.unimi.it (Accessed: 12 December 2018).

Social discount rate (recommended by EU Guide) 3%

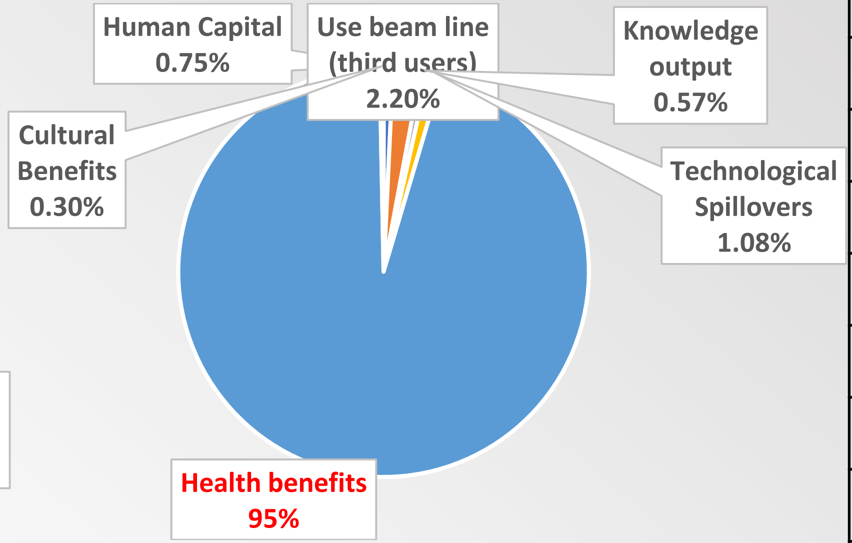
Results

LHC Benefits



B/C ratio = 1.2
Cost = 13.5 billion €
NPV=3.1 billion €

CNAO Benefits



B/C ratio = 4.4
Cost = 0.466 billion €
NPV=1.65 billion €

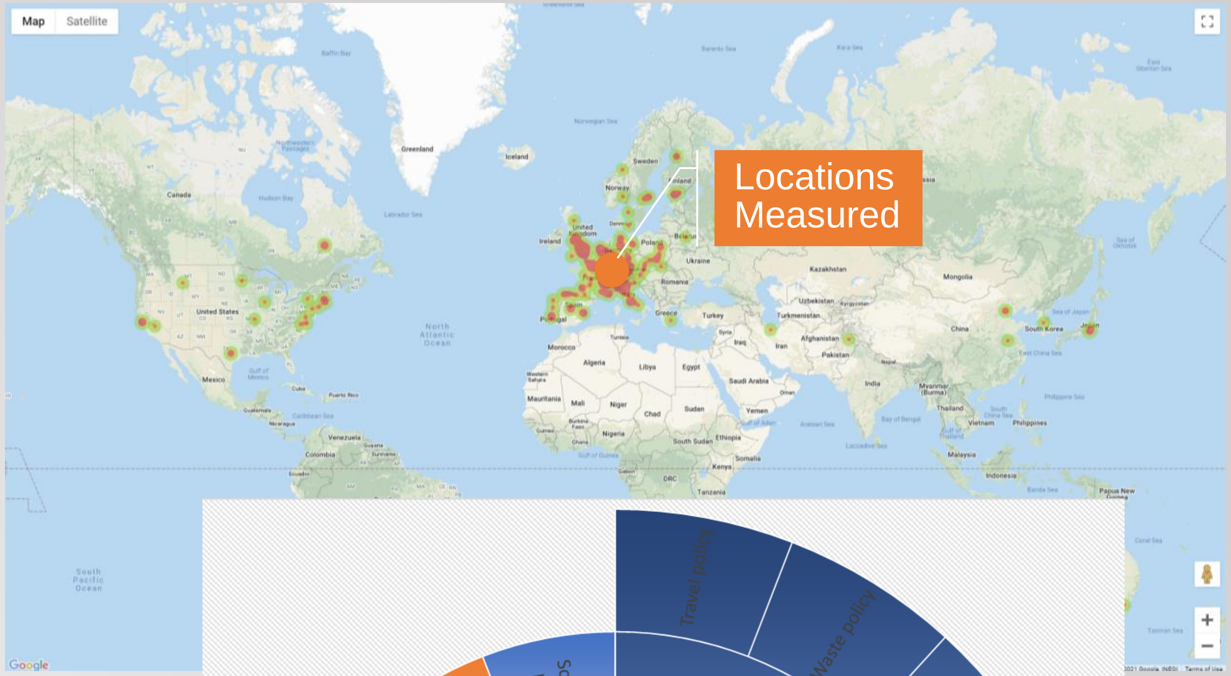
Benefit categories	Impact	
	LHC[a]	*CNAO*[b]
Total Benefit	100%	100%
Human Capital (H)	33.58%	0.75%
Knowledge output (S)	1.69%	0.57%
Technological Spillovers (T)	32.36%	1.08%
Health Benefits (A)	-	95%
Use beam line (third users)	-	2.20%
Cultural Benefits (C)	12.82%	0.30%
Public Good Value (B_n)	19.54%	-
Benefit/Cost ratio	1.2	4.42

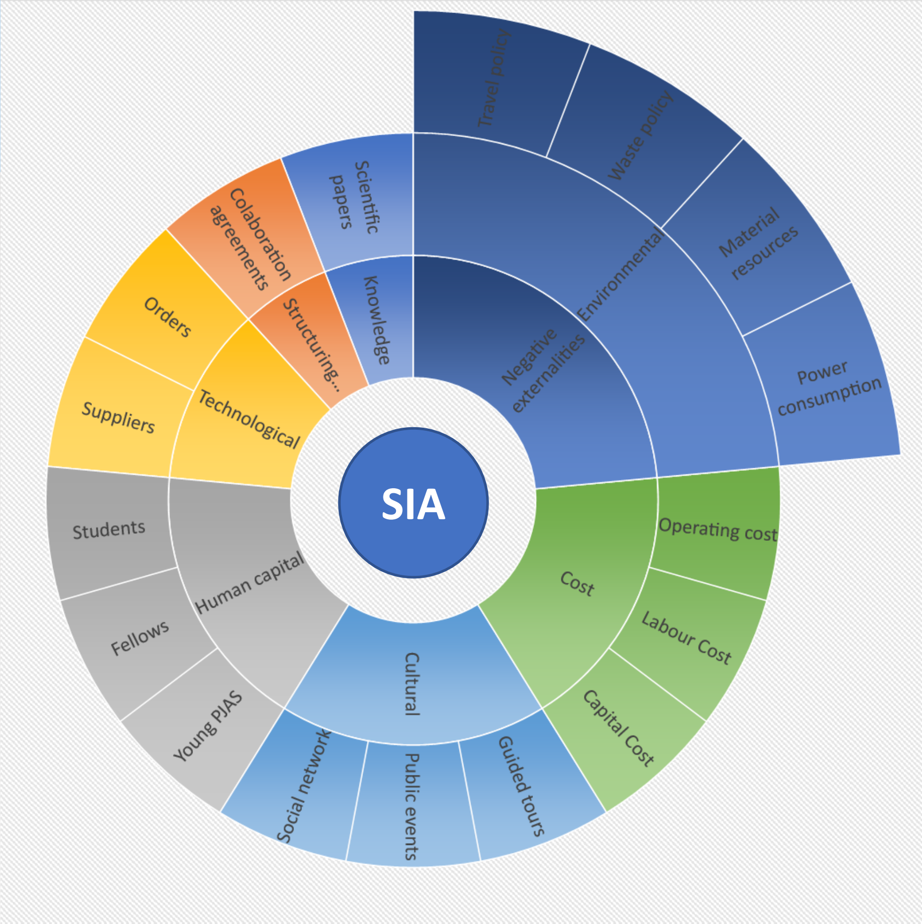
a. The percentage is calculated based on the numbers from Florio, M., Forte, S., Siirtori, E., 2016

b. The percentage is calculated based on the numbers from Battistoni, G., Genco, M., Marsilio, M., Pancotti, C., Rossi, S., Vignetti, S., 2016

Back to CLIC

- To assess societal impact of CLIC:
  - To evaluate all impacts of the study;
  - To highlight the positive impacts for society, industry etc.
  - To reinforce significance of the study in the decision-making process.
- Opposite to many other studies, an assessment aims to be done before starting the construction.





CBA for CLIC

$$ENPV_{FRI} = [S + T + H + Str + C] - [K + L_S + L_O + O + E] + B_n$$

- The methodology framework from LHC
- The assessment at the early phase of the project
- The early study on EIA was done in 2011. Hence the negative effects can be minimised by correcting actions (Waaijer, C. S. (2011), *CERN-GS department, GUIDELINES AND CRITERIA FOR AN ENVIRONMENTAL IMPACT ASSESSMENT FOR A LINEAR COLLIDER PROJECT, GS-Note-2011).*
- Data collection:
  - from 2009
  - For the moment focused on the CLIC Accelerator
  - Further work has to be done for CLICdp (detectors and physics collaboration)
- The most difficulty lays in converting benefits to money.

Assessment fields

Knowledge output (S)*:* the data collection from internal CERN Document Server, Inspire, Collaboration institutes sources

Technological spillovers (T)*:* orders from the CERN procurement database and industrial survey on the spread of CLIC technologies and other clients;

Human capital (H)*:* CERN human resource, technical and doctoral students, fellows and other young researchers;

Cultural effect (C): general cultural activities, such as conferences, events and visits of the facility;

Collaborative network formation (Str);

$\boldsymbol{B_n}$ is a non-use value of scientific discover.

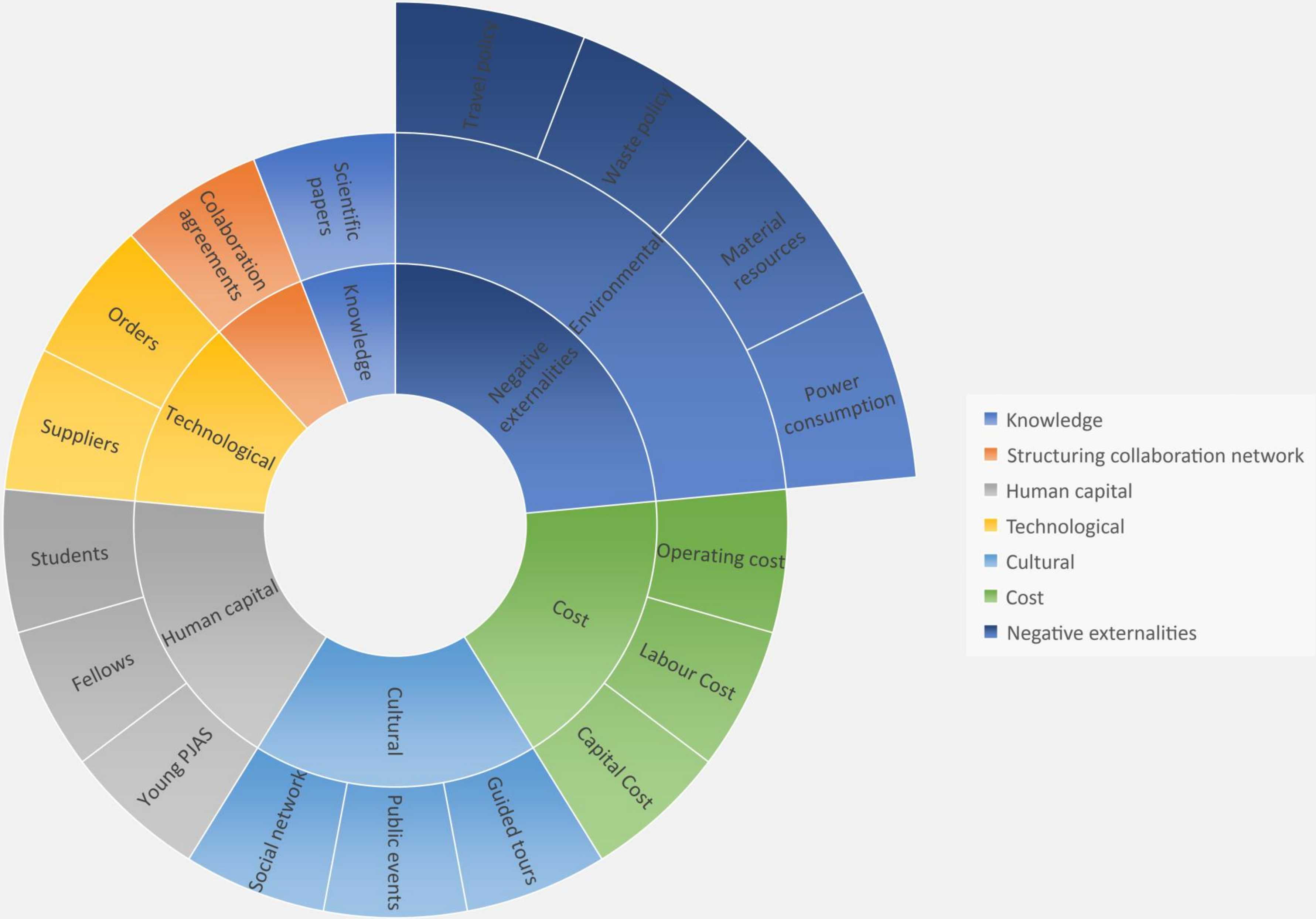
The cost estimation is presented in the CLIC PiP:

Capital cost (K): *differs for the considered stage of the project.*

Labour cost: *7000 FTE-years for a material cost 3690 MCHF ⇒ 1.9FTE-year/MCHF (based on LHC results) 40% of scientific and engineering personal(L_S) and 60% other staff (L_O);*

Operating cost (O): 116 MCHF.

Negative externalities (E): *from EIA*


Travel policy
Waste policy
Material resources
Power consumption
Environmental
Negative externalities
Scientific papers
Knowledge
Colaboration agreements
Orders
Suppliers
Technological
Students
Fellows
Young PJAS
Human capital
Social network
Public events
Guided tours
Cultural
Operating cost
Labour Cost
Capital Cost
Cost
Knowledge
Structuring collaboration network
Human capital
Technological
Cultural
Cost
Negative externalities

Assessment model boundaries and sets

- Timeframe: 2009 – 2019
  - Active development phase
  - Earlier data is more difficult to collect
- The main assessment categories:
  - Knowledge via publications,
  - Human capital via young researchers,
  - Cultural,
  - Negative externalities via environmental impact,
  - Technological (industrial) via industries,
  - Structuring via collaboration network formation
- The main social groups concerned:
  - Scientists,
  - Students and young researchers,
  - Firms in the procurement chains and other organizations,
  - Institutions,
  - General public, including onsite and website visitors and other media users

CLIC Societal Impact

DATA MODEL

13000 Procurement Orders

180 Collaborations

930 Suppliers

296 Students

130 Collaboration contracts

54 Countries

1800 Publications

CLIC accelerator

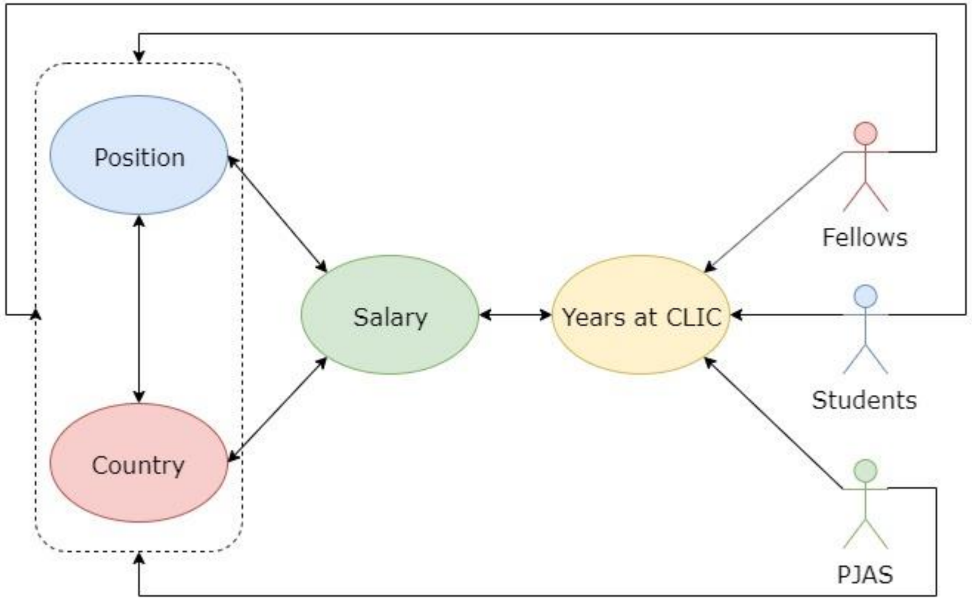
Data from 2009 to 2019

Human capital

Students

- ***Human capital (H)*:** salary earned over the entire work career after leaving the project and taking into account 40 years career length.
- Four categories of early-career researchers (ECR): technical, doctoral student, fellows and PJAS (young age);
- DATA from: CERN PD, EDMS, Research gate, LinkedIn, CDS.
- Check their carriers,
- About incremental salary based on the statisti
    - Glaasdoor.com
    - Payscale.com
    - CERN.ch

PJAS	60
TECH	67
DOC	106
FEL	63
	296



Students

- Can result in:
  - Social benefits (renting and leaving in the area) * ~ 1000 CHF/per person and per month;
  - Training cost – receiving grants for studies;
  - **Human capital - salary increase – premium because of getting experience and skills.**

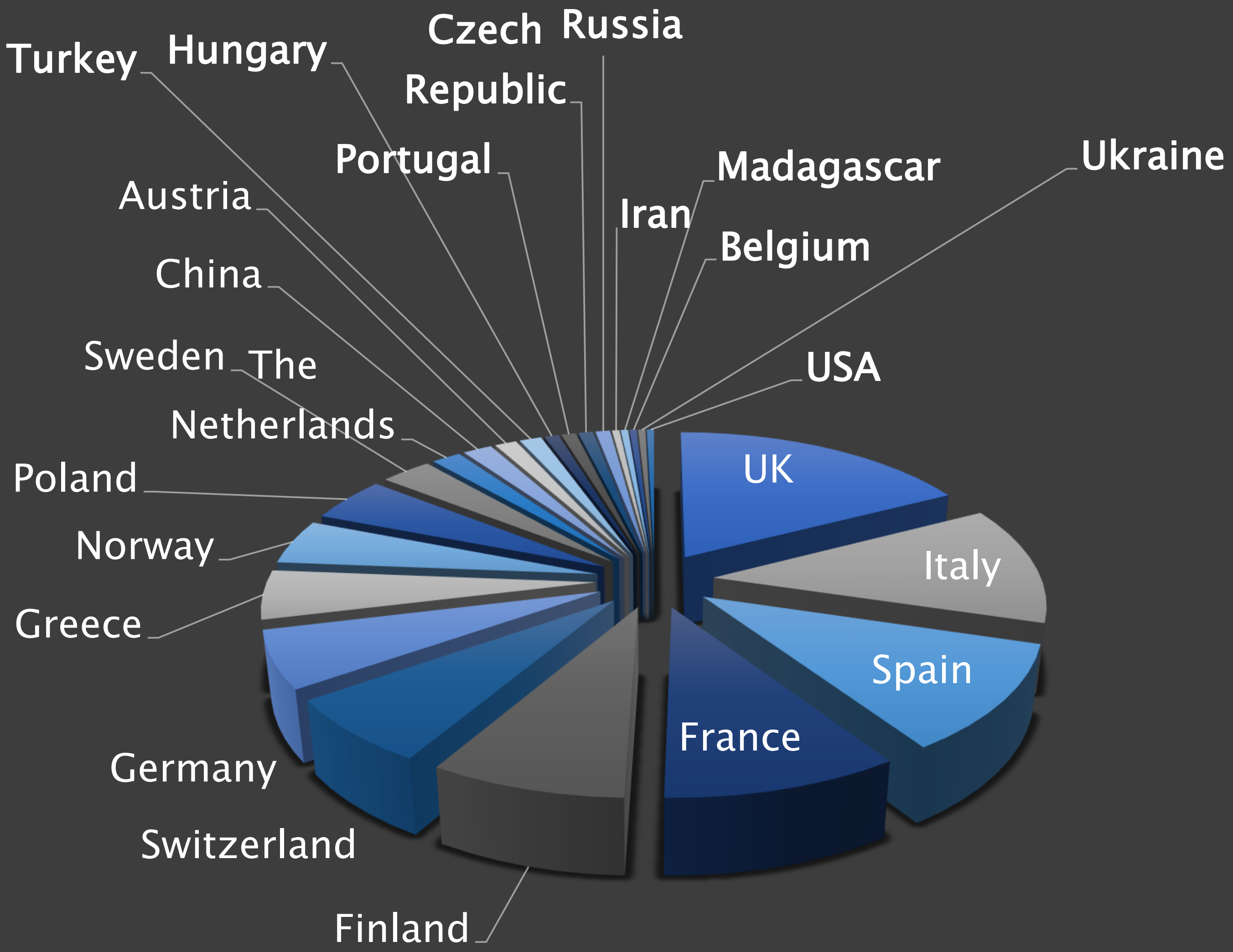
The extra training in RI increases salaries between 3% for a student and 7% for an employee) for LHC is worth about 5% excess salary.
Ref: Camporesi, T. *et al.* (2017) 'Experiential learning in high energy physics: A survey of students at the LHC', *European Journal of Physics*. Institute of Physics Publishing, p. 025703. doi: 10.1088/1361-6404/aa5121.
https://iopscience.iop.org/article/10.1088/1361-6404/aa5121/pdf

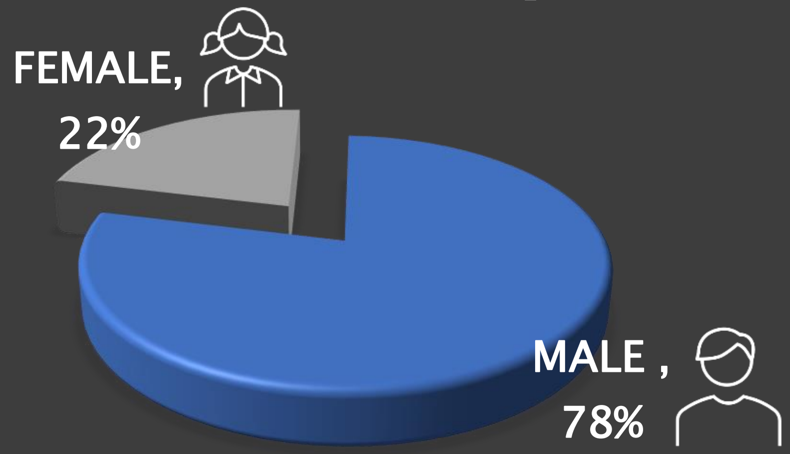
The human capital is … of the total benefits of the project
For LHC **33%** (1993-2025)
For HL-LHC is **40%** (1993-2038)**.**

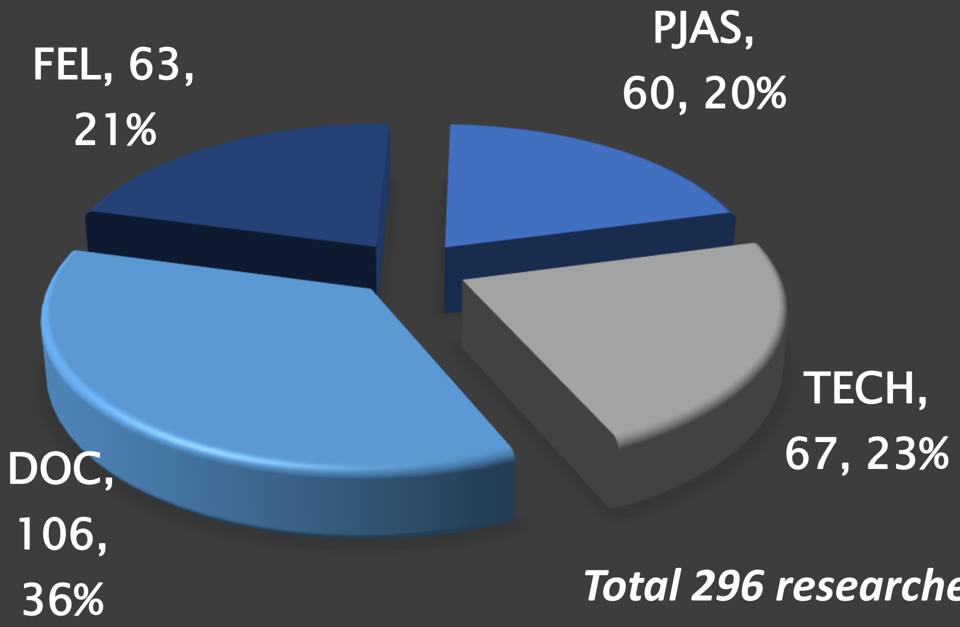
Bastianin, A. (2018) 'Social Cost Benefit Analysis of HL-LHC CERN HL-LHC and FCC', (May).

Descriptive statistics

Early carrier researchers: Human Capital

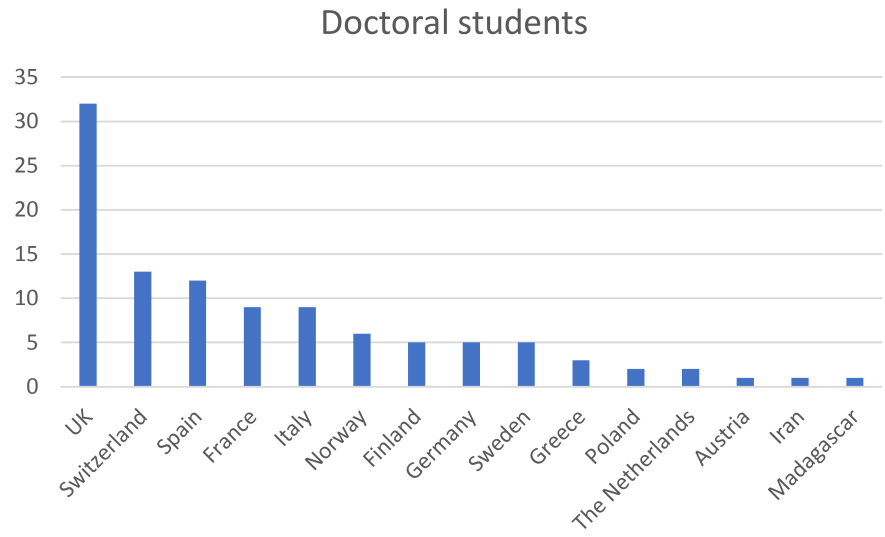


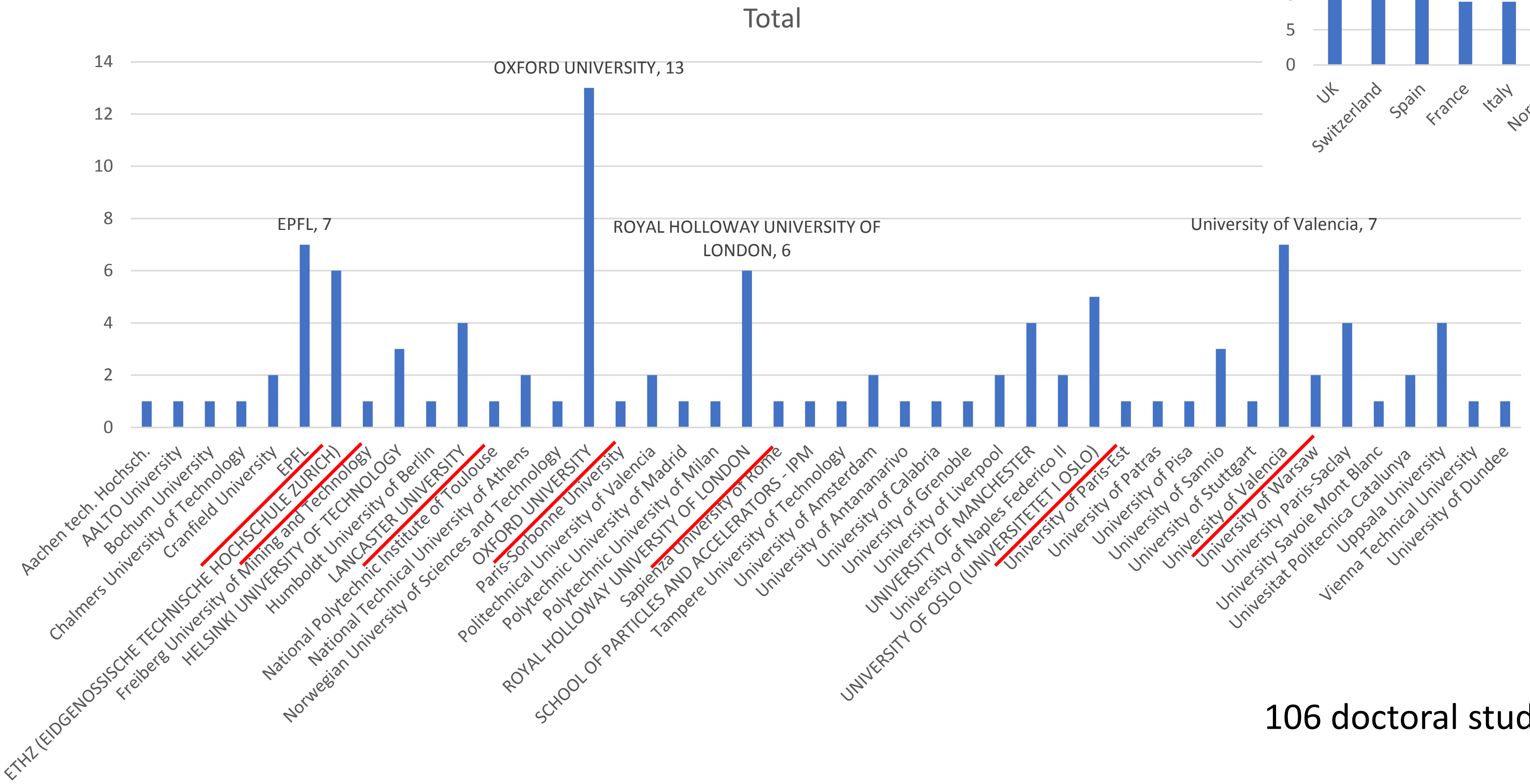




Total 296 researchers

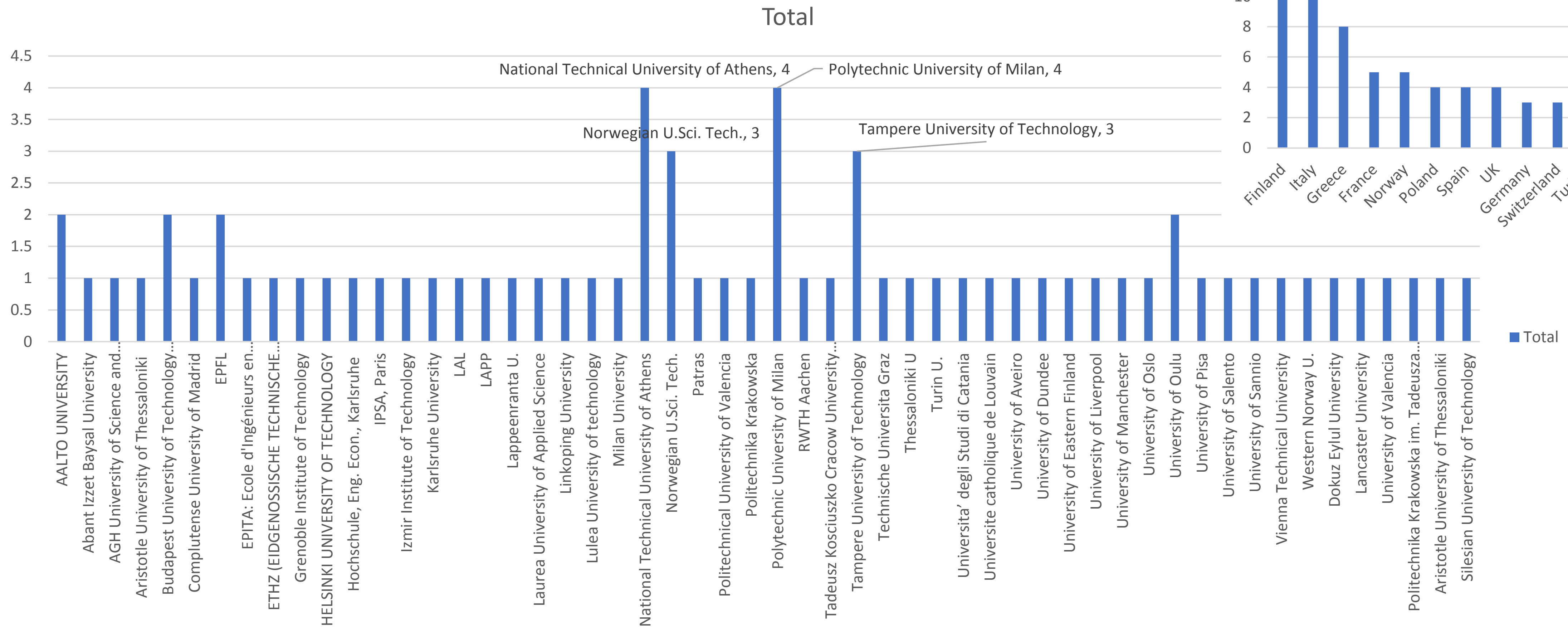
Doctoral students' university

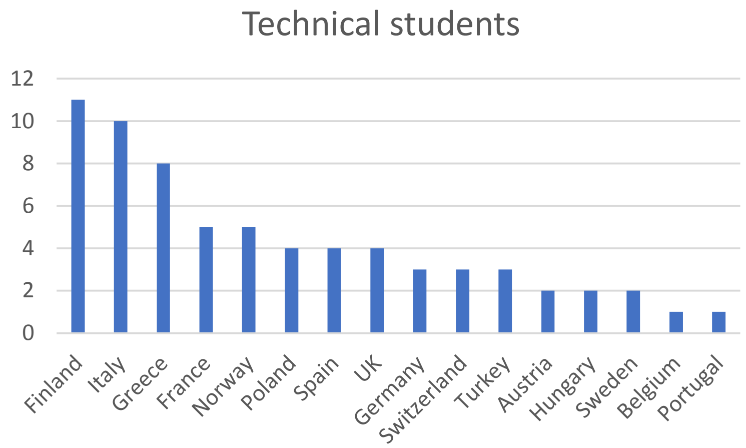




106 doctoral students from 44 universities

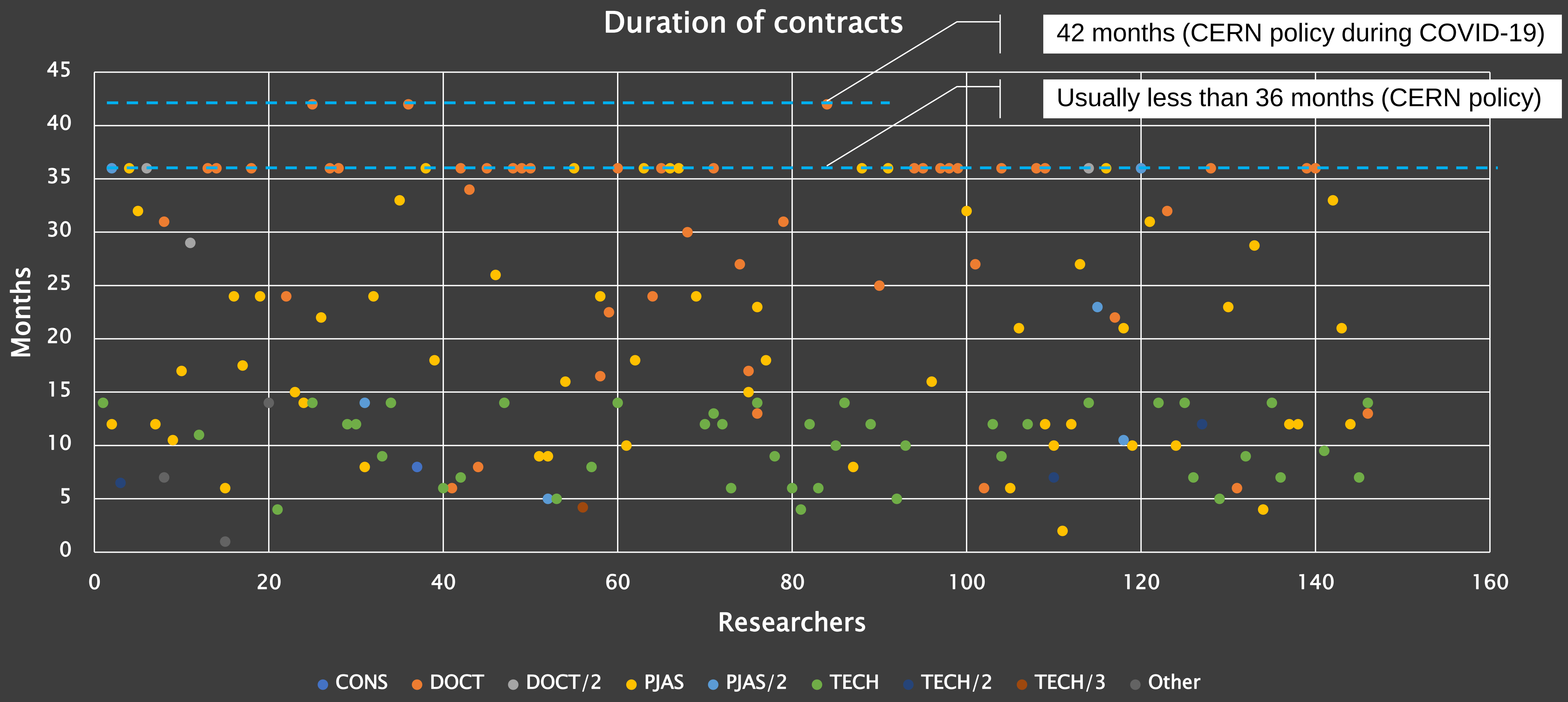
Technical students' university



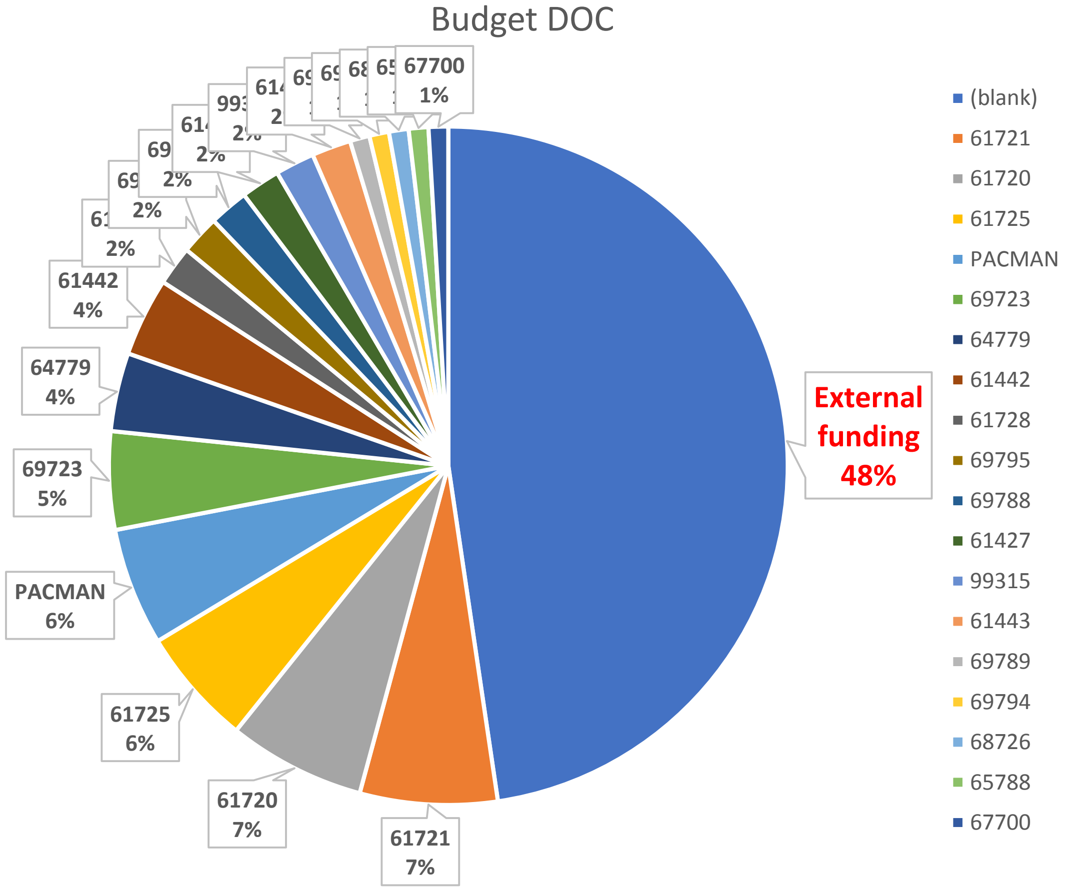


68 technical students from 54 universities

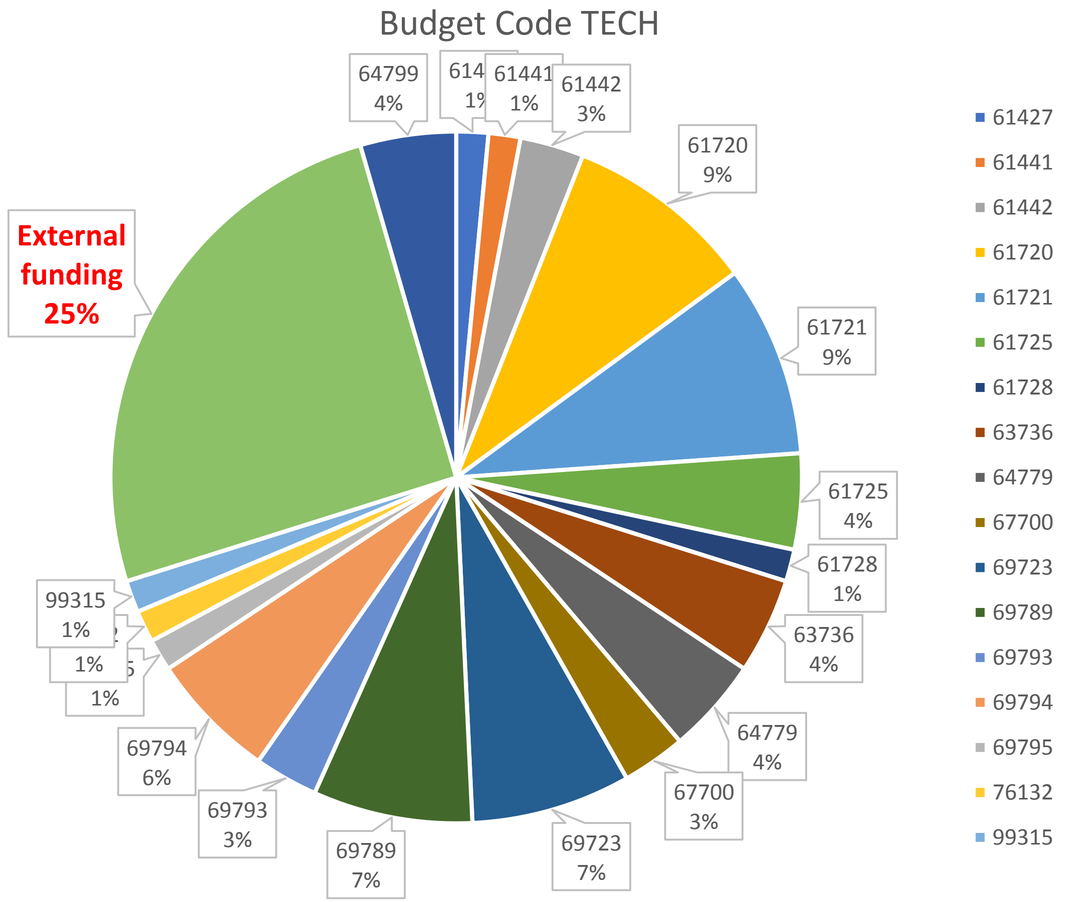
Experience duration



Budget



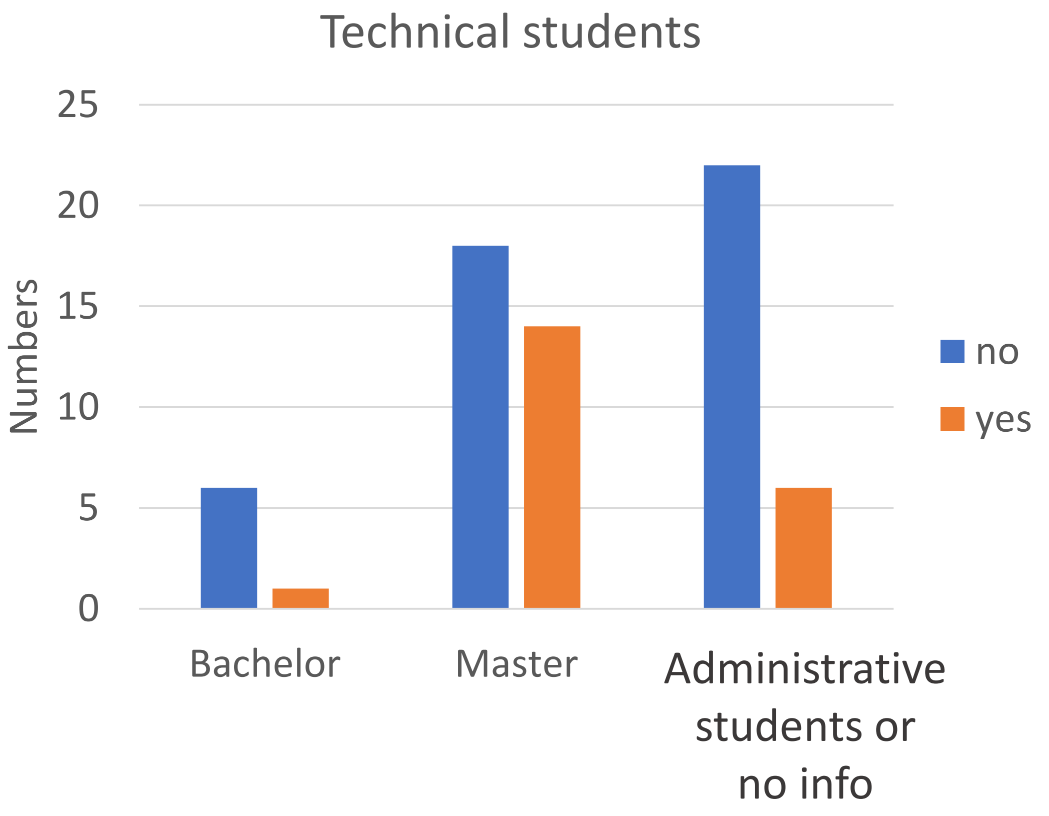
Budget DOC
External funding 48%
61721 7%
61720 7%
61725 6%
PACMAN 6%
69723 5%
64779 4%
61442 4%
67700 1%
(blank)
61721
61720
61725
PACMAN
69723
64779
61442
61728
69795
69788
61427
99315
61443
69789
69794
68726
65788
67700

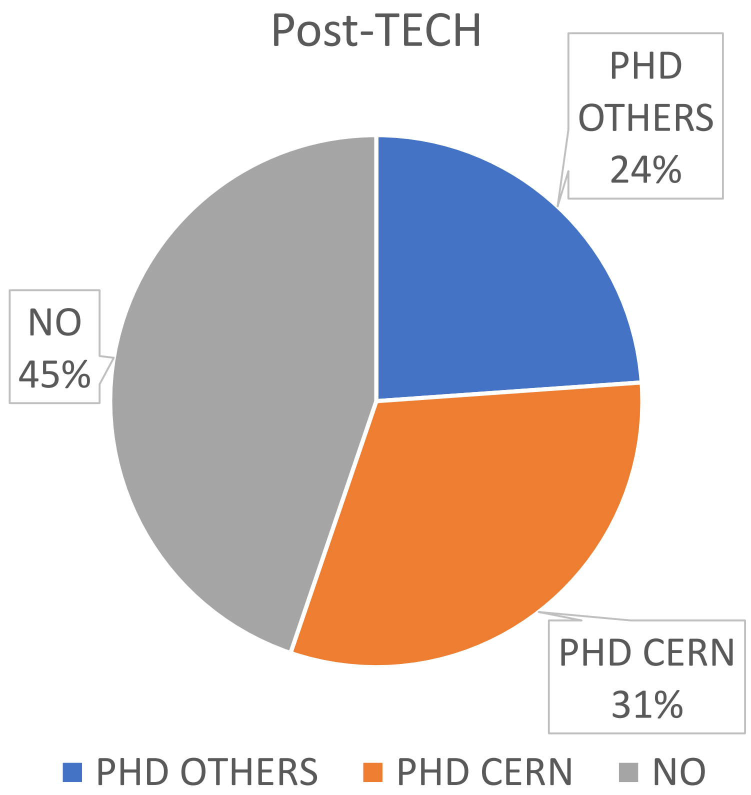


Budget Code TECH
External funding 25%
64799 4%
61441 1%
61442 3%
61720 9%
61721 9%
61725 4%
61728 1%
63736 4%
64779 4%
67700 3%
69723 7%
69789 7%
69793 3%
69794 6%
99315 1%
61427
61441
61442
61720
61721
61725
61728
63736
64779
67700
69723
69789
69793
69794
69795
76132
99315

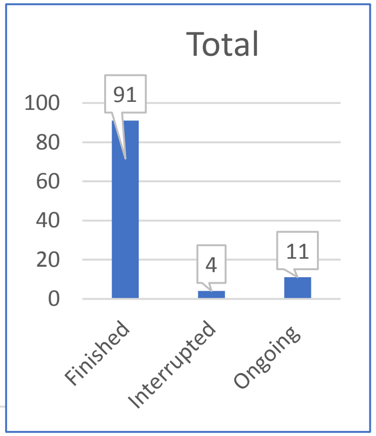
… do a PhD?

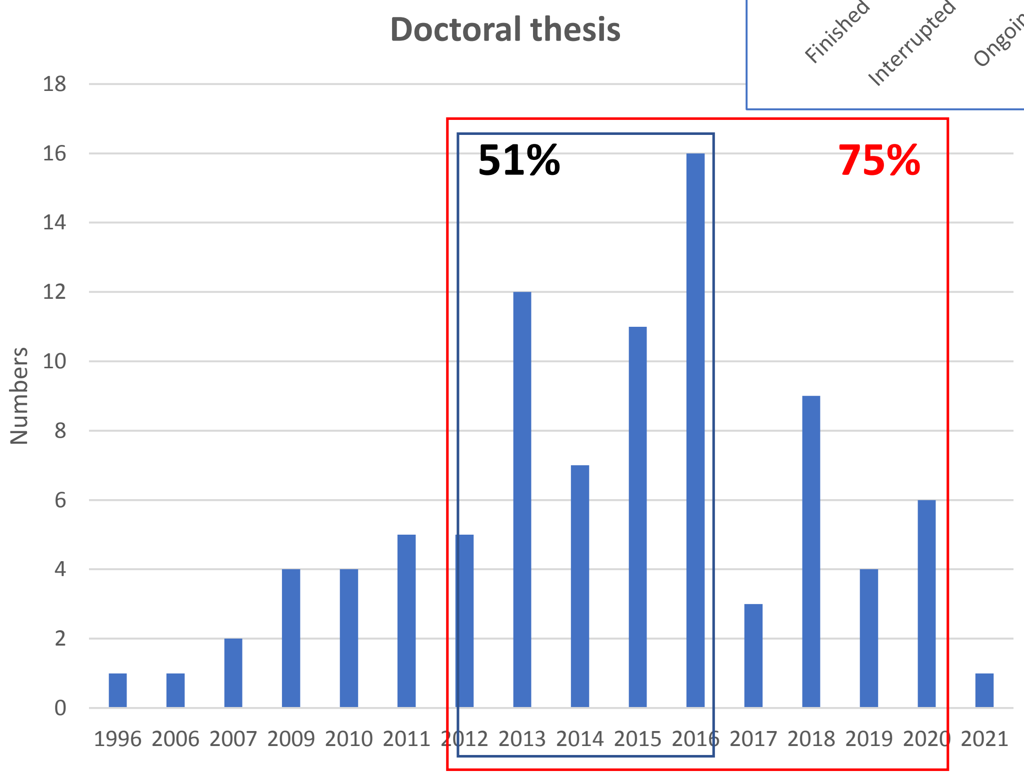
About 55% of technical students embark in a PhD program after CERN, 31% stay to do PhD at CERN

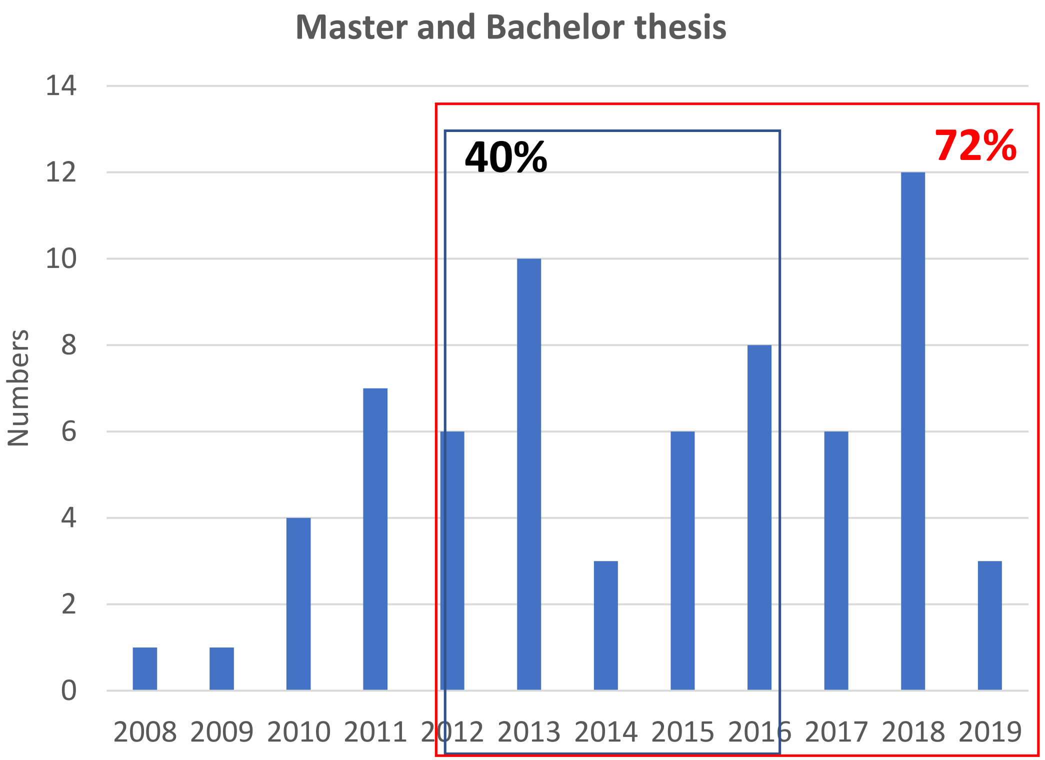




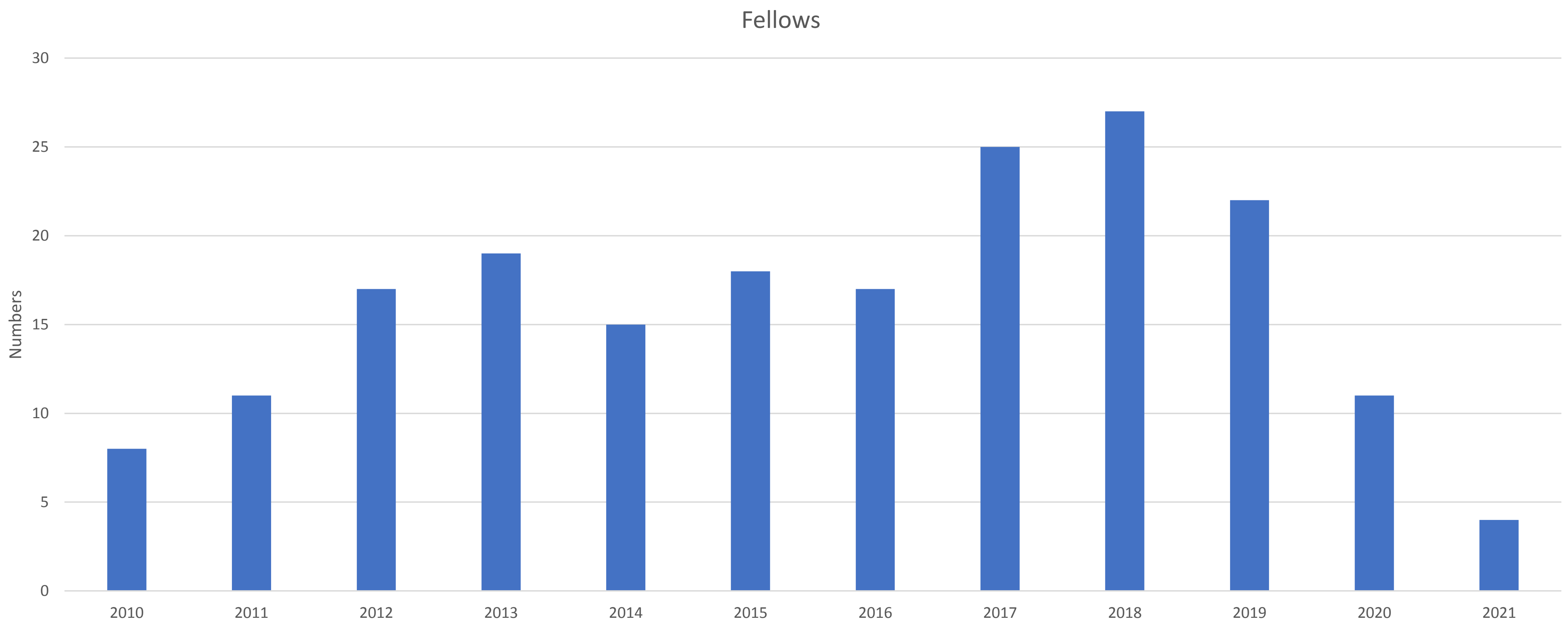
DOCTORAL and TECHNICAL students



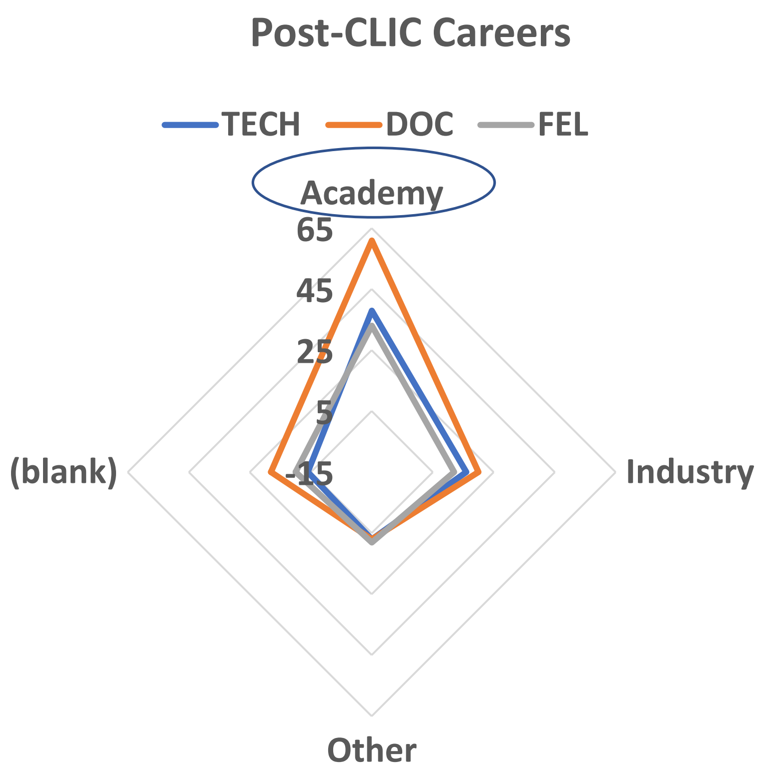


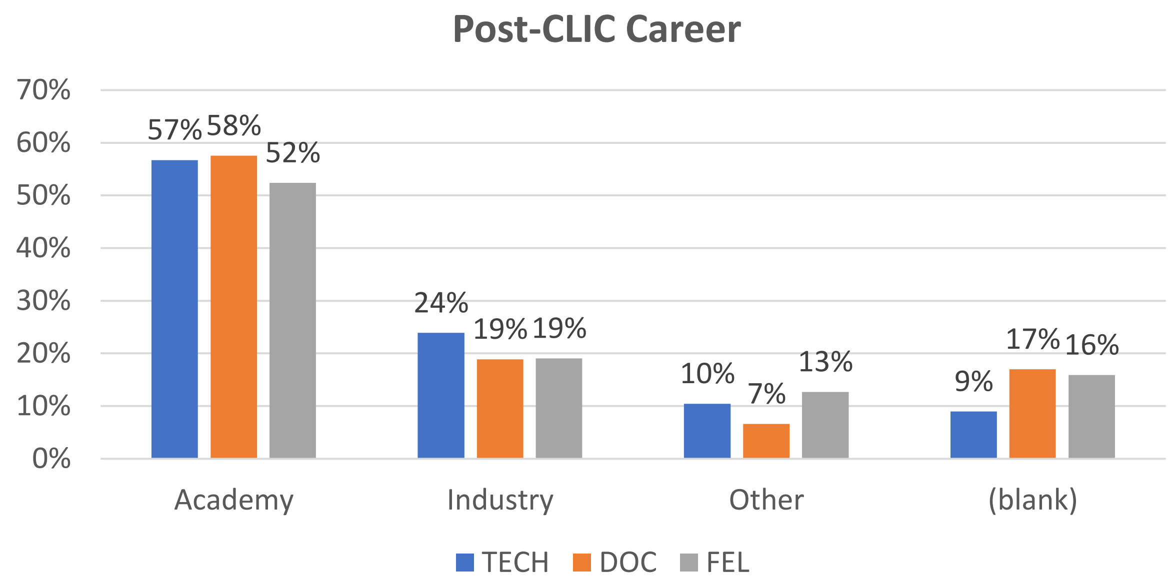


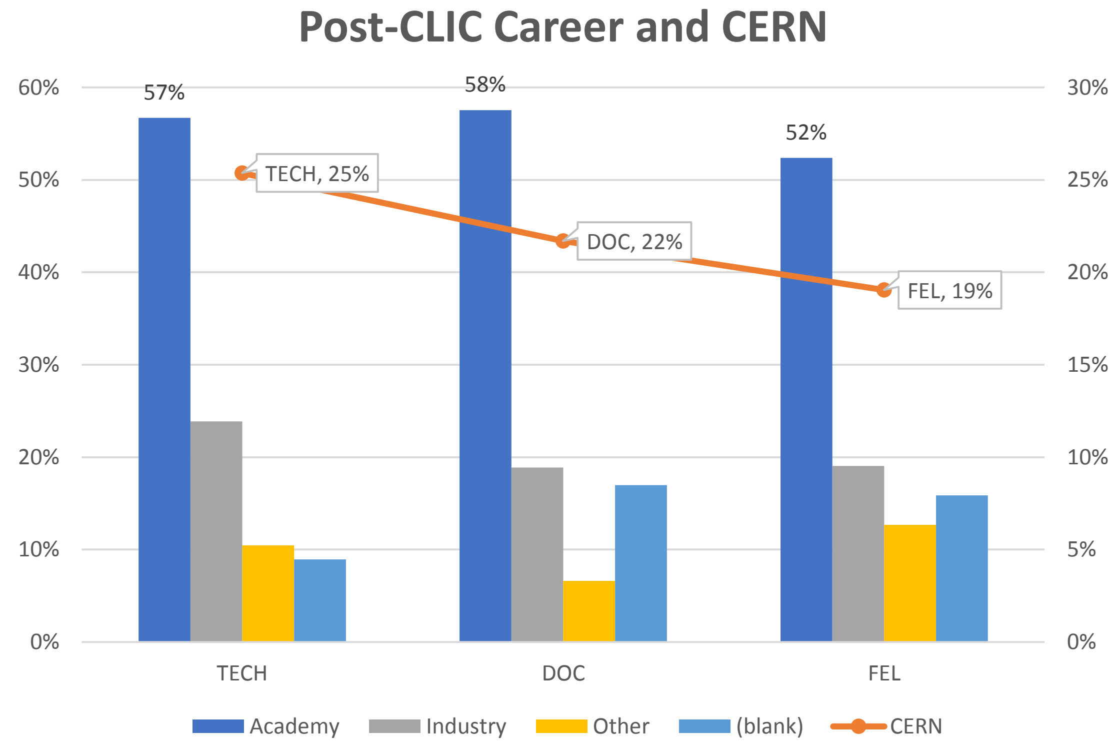
Fellows


Fellows
30
25
20
15
10
5
0
Numbers
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

Careers







CLIC

More than 50% in Academy and Research centers, ~ 20% in Industry, and ~10% in Other fields.

LHC data

Technical students: 10% research or academy, 45% industry and 45% others.

Other students 60% academy and 20%+20% industry + others.

Benefits

- Three different sources:
  - $\Delta\ salary_i$ from payscale.com (using skilled and average salaries per profession: engineers, researchers and managers).
  - $\Delta\ salary_i$ from glassdoor.com (using an average salary per a company)
  - Percentage premium from LHC study – 11.8%.
- We calculated NPV (Net Present Value), taking into account the discount rate 3%, recommended by *EU (2014) Guide to Cost-benefit Analysis of Investment Projects: Economic appraisal tool for Cohesion Policy 2014-2020, Publications Office of the European Union. DOI: 10.2776/97516.*

$$\sum \binom{Number\ of\ students}{N_i} \times \binom{Incremental\ salary}{Salary_i} \times \begin{matrix} Discounting\ effect \\ over\ 40\ years \end{matrix} = \begin{matrix} Social\ value\ of\ human \\ capital\ formation \end{matrix}$$

$$\Delta = \ Salary_{skilled\ specialist} - Salary_{ECR}$$

Florio, M. et al. (2016) 'Exploring Cost-Benefit Analysis of Research, Development and Innovation Infrastructures : an Evaluation Framework', pp. 1–86. doi: 10.1080/13545700022000077962.

Salary premium *(per person)*

Category	Source	Not discounted CERN salary premium (CHF)	Discounted salary CERN premium (CHF)	Cost/Benefit ratio
Technical students	Payscale.com	Over 40 years: 245975 Per year: 6149	Over 40 years:142141 Per year: 3554	6.3
	11.8% *	Over 40 years: 388706 Per year: 9718	Over 40 years: 224621 Per year: 5615	10
Doctoral students	Payscale.com	Over 40 years: 386292 Per year: 9657	Over 40 years: 223227 Per year: 5580	4.3
	11.8% *	Over 40 years: 388706 Per year: 9718	Over 40 years: 224621 Per year: 5615	4.3
Fellows	Payscale.com	Over 40 years: 308353 Per year: 7709	Over 40 years: 178187 Per year: 4455	1
	Glassdoor.com	Over 40 years: 919366 Per year: 22984	Over 40 years: 531274 Per year: 13282	2.3
	11.8% *	Over 40 years: 388706 Per year: 9718	Over 40 years: 224621 Per year: 5615	1.2

* Florio, M., Forte, S. and Sirtori, E. (2016) ‘Forecasting the socio-economic impact of the Large Hadron Collider: A cost–benefit analysis to 2025 and beyond’, *Technological Forecasting and Social Change*, 112, pp. 38–53. doi: 10.1016/j.techfore.2016.03.007.

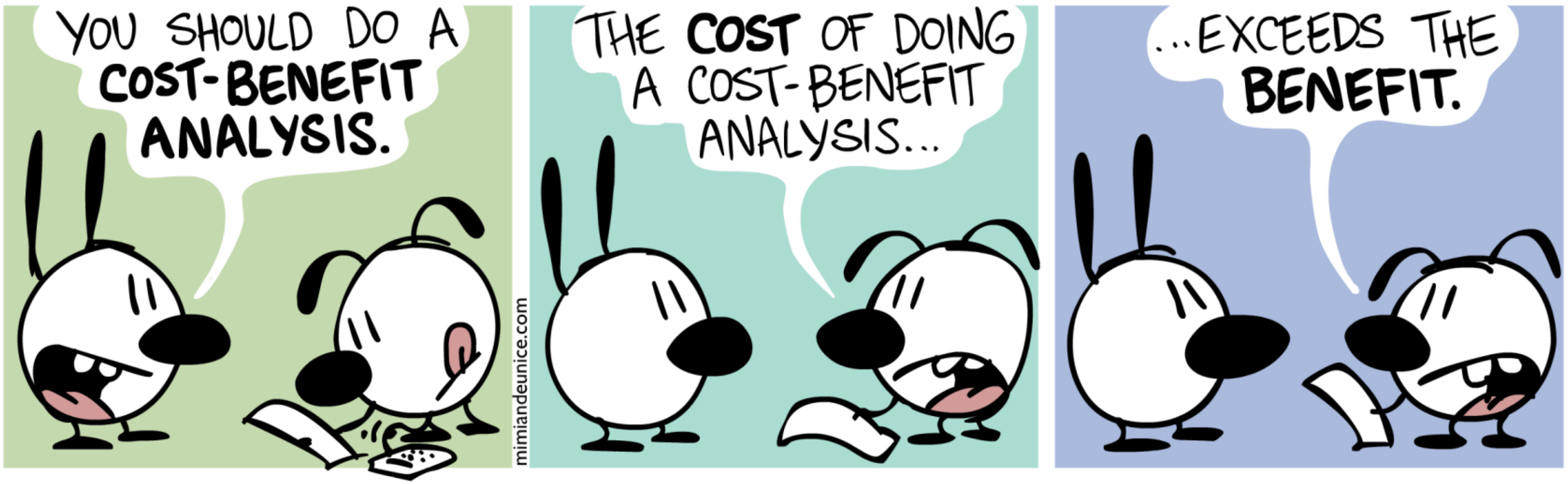
Summary

- Industrialization study is done
  - The corresponding CLIC-Note is in progress;
  - The results is presented in the proceeding for IPAC 2021.
- Societal Impact Assessment
  - One part of the SIA was presented as a NPV calculation of Early-career researchers,
  - The value calculated based on different sources,
  - The ration Cost\Benefit is between 4.3 to 10 for students, and 1 to 2.3 for fellows

What is next?

…continue with other assessment categories

- Evaluation and NPV calculation of Knowledge benefits (using Publications)
- Evaluation and NPV calculation of Technological benefits (using CERN procurement orders)



Thanks

EXTRA

Fundamental vs applied RI: two case studies

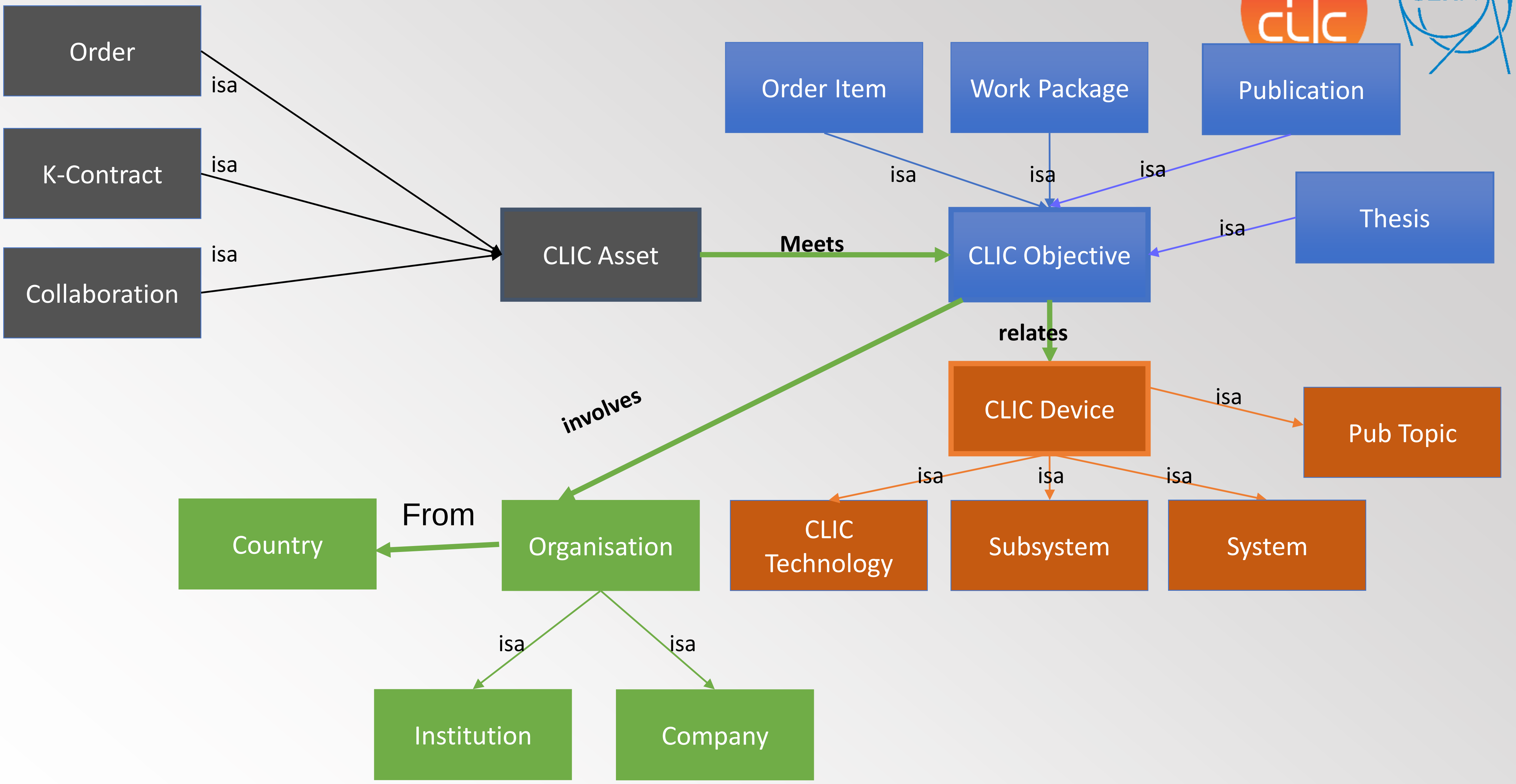
LHC (The Large Hadron Collider)

The main goal is to study the precise nature of the forces that govern fundamental interactions, which requires colliding particles to hit each other at the highest possible energy.

CNAO (The National Hadrontherapy Centre for Cancer Treatment)

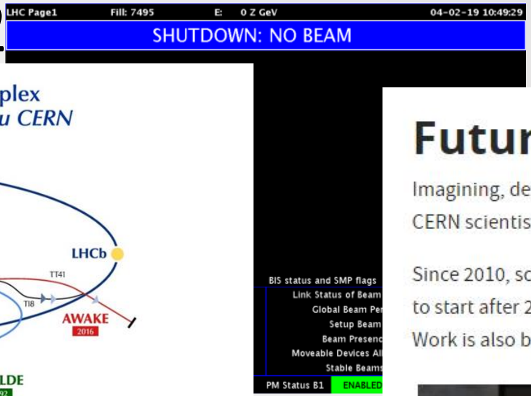
The main goals is treating patients by using hadron particles accelerated by synchrotron and it aims at providing hadrontherapy advanced research in clinical, radiobiological and domestic matters.

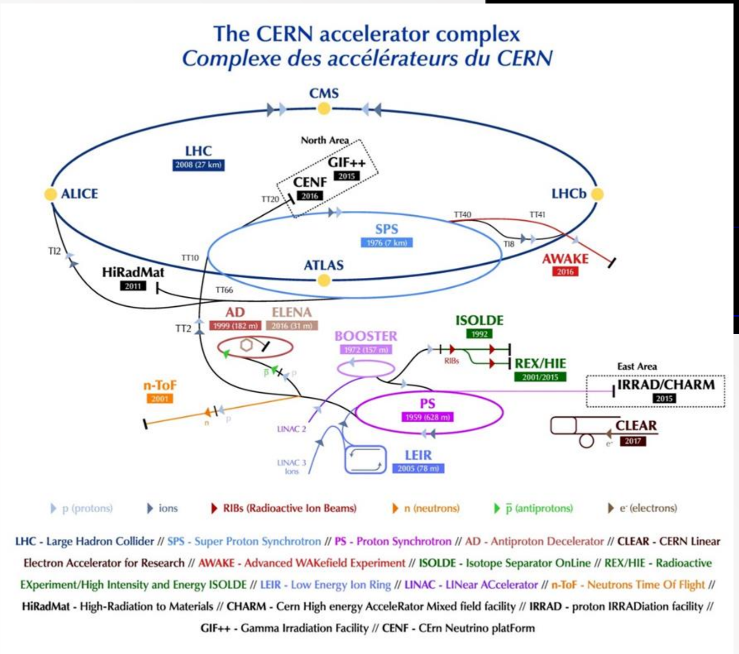
CLIC DATA MODEL

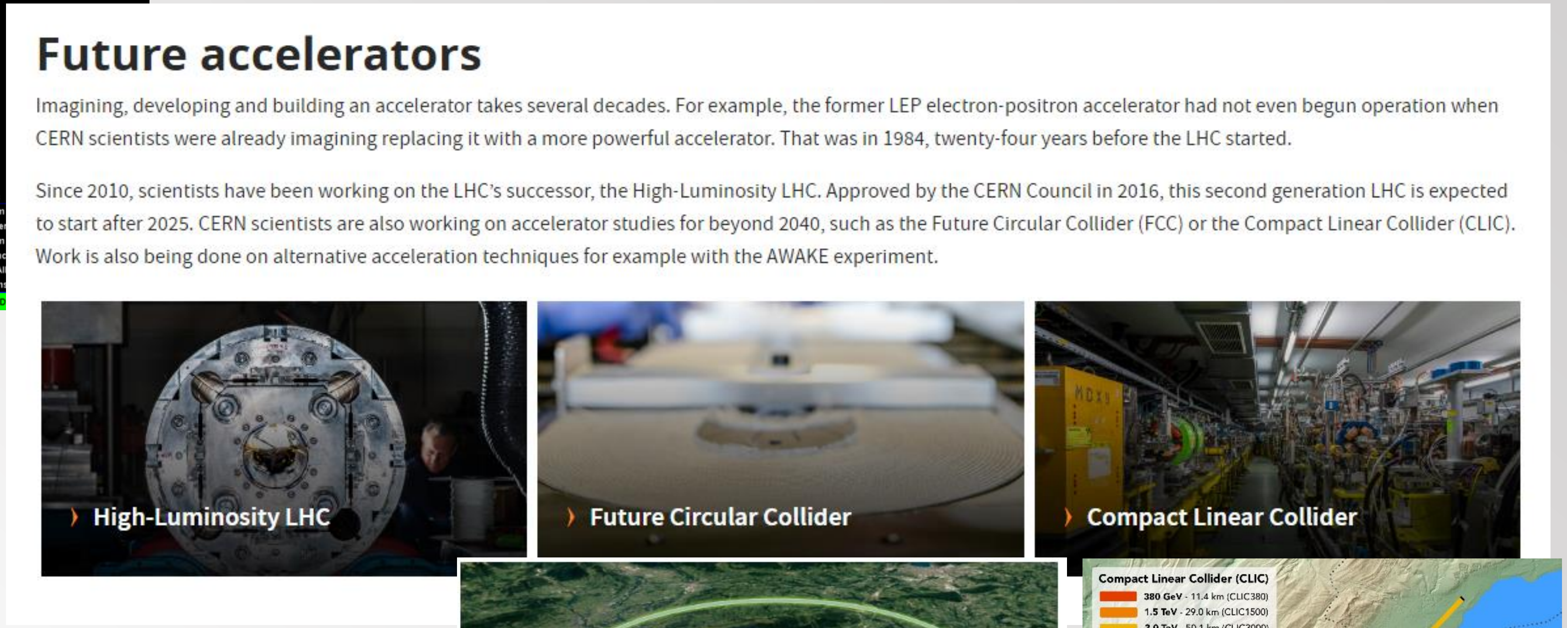


Accelerators ~~only~~ at CERN

- LHC is the world's largest and most powerful particle accelerator (27 km ring) successfully operated for the first run 2009-2013 and for the second run 2015-2







Future accelerators

Imagining, developing and building an accelerator takes several decades. For example, the former LEP electron-positron accelerator had not even begun operation when CERN scientists were already imagining replacing it with a more powerful accelerator. That was in 1984, twenty-four years before the LHC started.

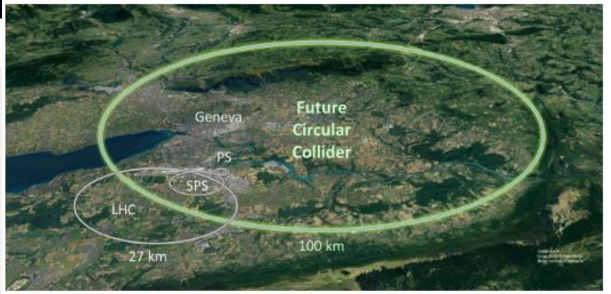
Since 2010, scientists have been working on the LHC's successor, the High-Luminosity LHC. Approved by the CERN Council in 2016, this second generation LHC is expected to start after 2025. CERN scientists are also working on accelerator studies for beyond 2040, such as the Future Circular Collider (FCC) or the Compact Linear Collider (CLIC). Work is also being done on alternative acceleration techniques for example with the AWAKE experiment.

› High-Luminosity LHC

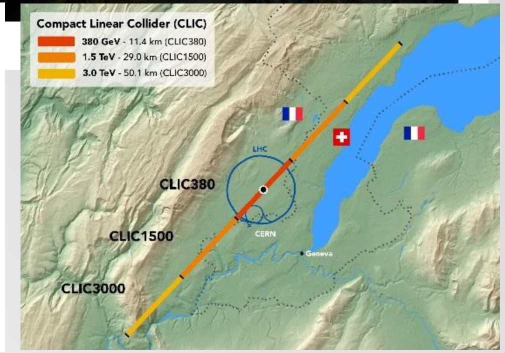
› Future Circular Collider

› Compact Linear Collider

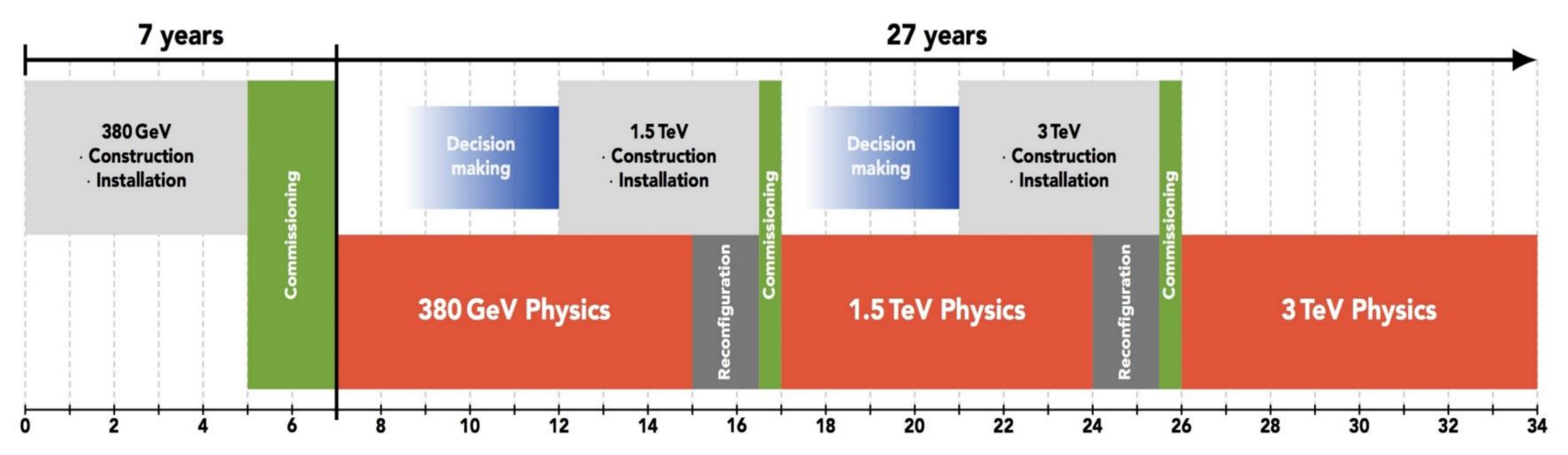
- Stopped for two years for major upgrade and renovation works, restart in 2021.
- From 2025 The High-Luminosity LHC (HL-LHC) increase luminosity by a factor 10 beyond LHC design value.

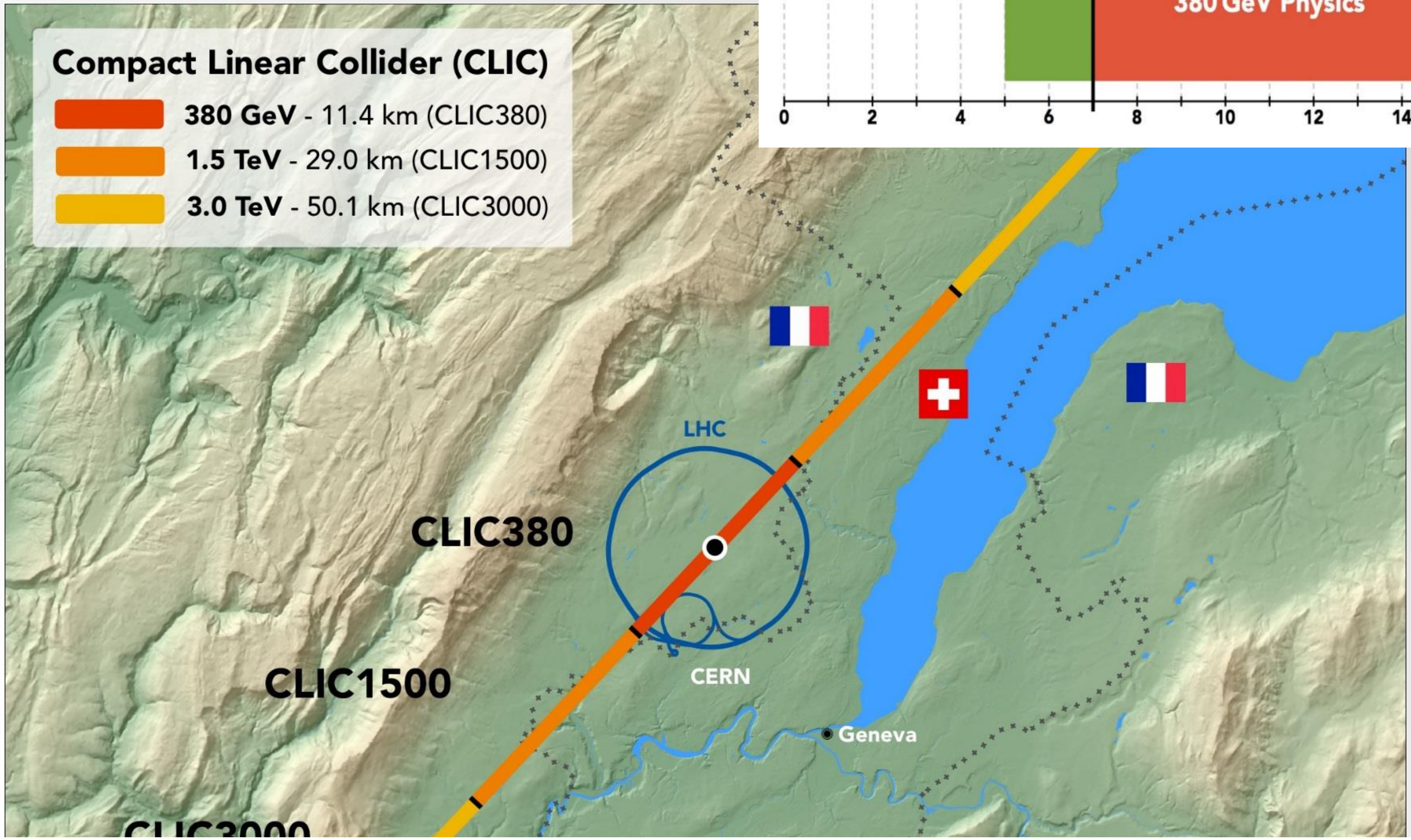


A schematic map showing where the Future Circular Collider tunnel is proposed to be located (Image: CERN)



CLIC





Construction and operation of the machine for all three stages ~ 34 years

Collaborations with ~ 50 institutes

CLIC (Compact Linear Collider) study on future **electron-positron collider.** TeV-scale high-luminosity linear particle collider that aims to explore the next energy frontier.

Main categories. How to calculate?

Knowledge output (S) (from CNAO)*:* number of papers and its citations, taking into account their production time and time to understand in case of citations. unit production cost/value of L0 (“insiders” scientists) and L1 (other scientist and citing L0) papers 275 and 265 EUR. L2 and further has not been estimated. 1h is needed to decide of a citation.

Technological spillovers (T)*:* procurement orders – incremental profits gained through additional sales to third parties, after the procurement contract with CERN, thanks to technology transfer and knowledge acquired “for free”. Turnover for the suppliers through estimates of economic utility/sales ratio (categorized according to technological intensity codes (order value and quantity)).

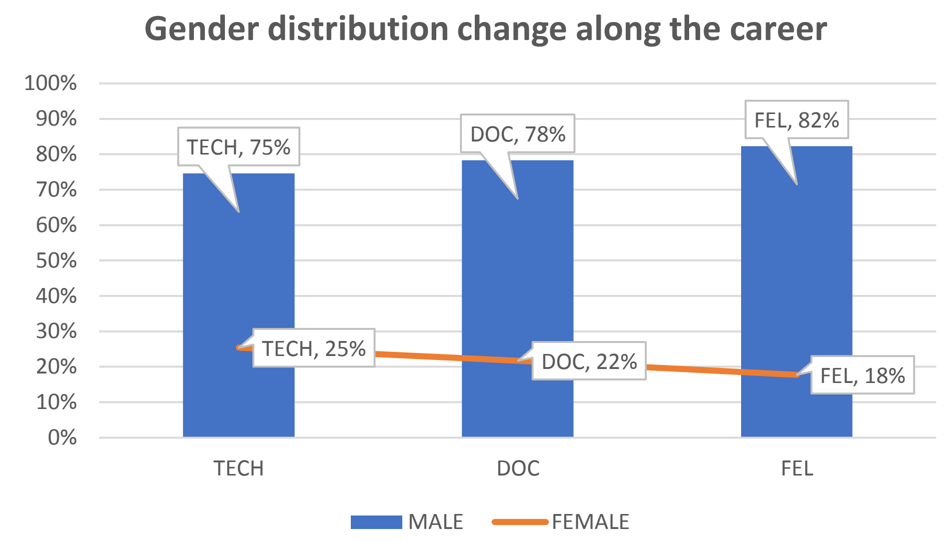
Human capital (H)*:* salary earned over the entire work career after leaving the project and taking into account 40 years career length.

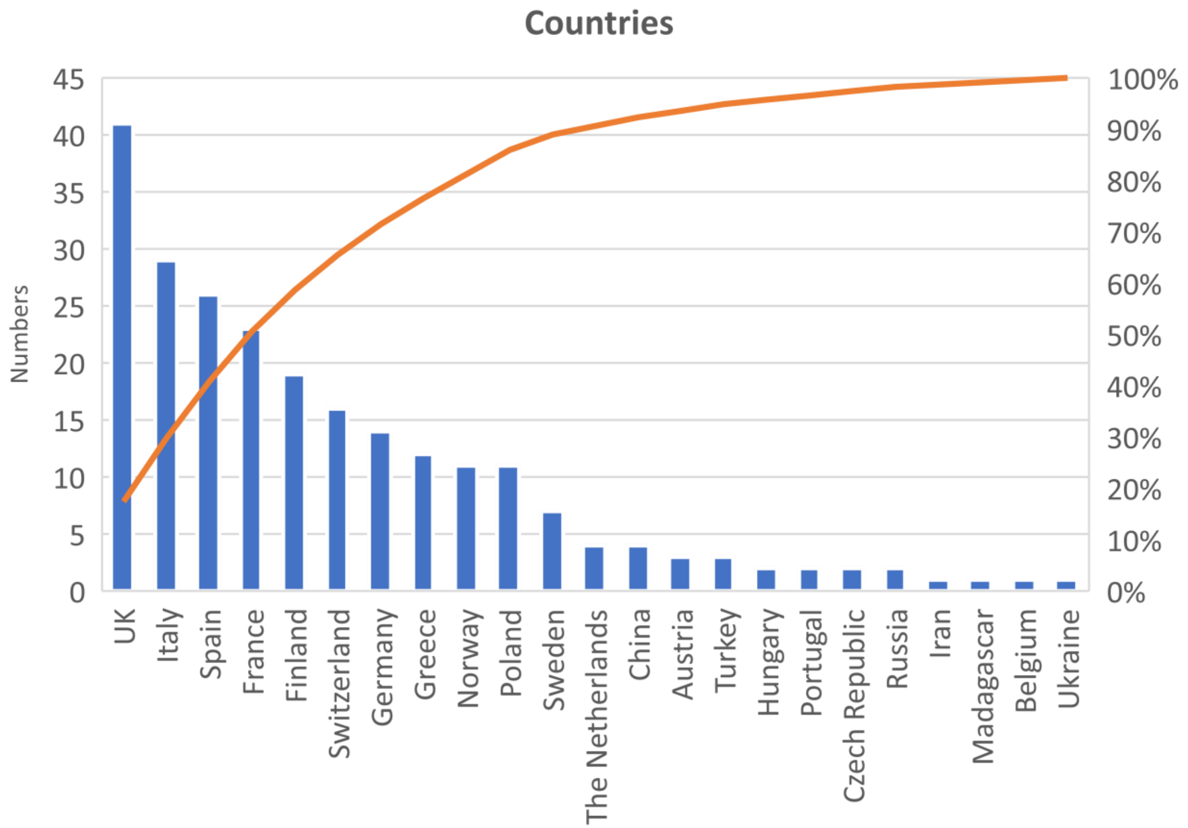
Cultural effect (C): general cultural activities, such as conferences, events and visits of the facility, based on the time spent in travelling, travel cost, length of stay, means of transport, areas of origin etc. number of website visitors on the basis of historical data (time spent).

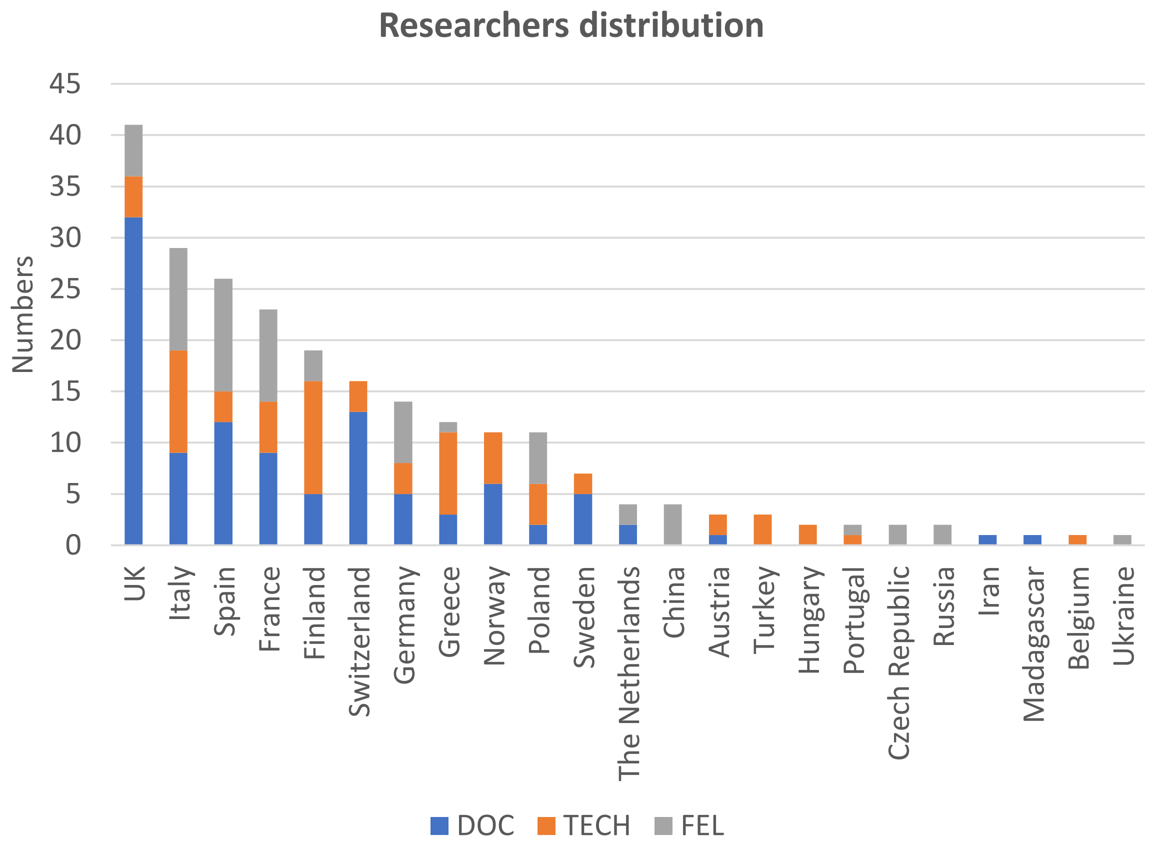
$\boldsymbol{B_n}$ *(LHC)* is a non-use value of scientific discover., scientific knowledge as a public good, based on the questionnaire around university students as representative of future taxpayers, including a question WTP for LHC research activities (a fixed lump-sum).

CLIC data:
- 1996-2021
- 78% male
- 24 counties
- 296 ECR

LHC data:
- 1995-2013
- 75% male
- 52 counties
- 384 interviewed







Industry

DATA from CERN PD, the industrial survey

1. Benefits associated with procurement activities

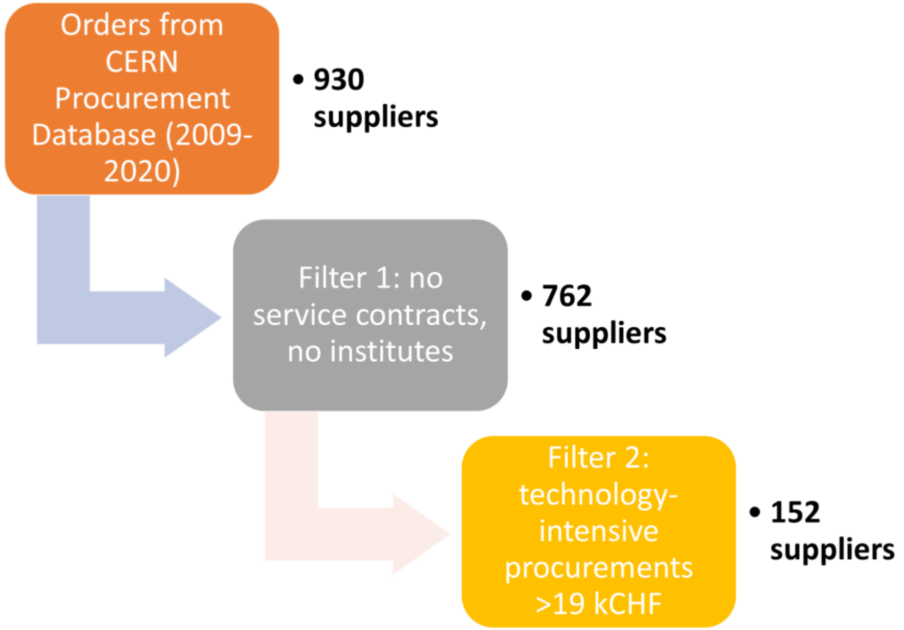
Regression analysis on the possible benefits: marketing image, expansion, learning outcome, R&D, innovation.

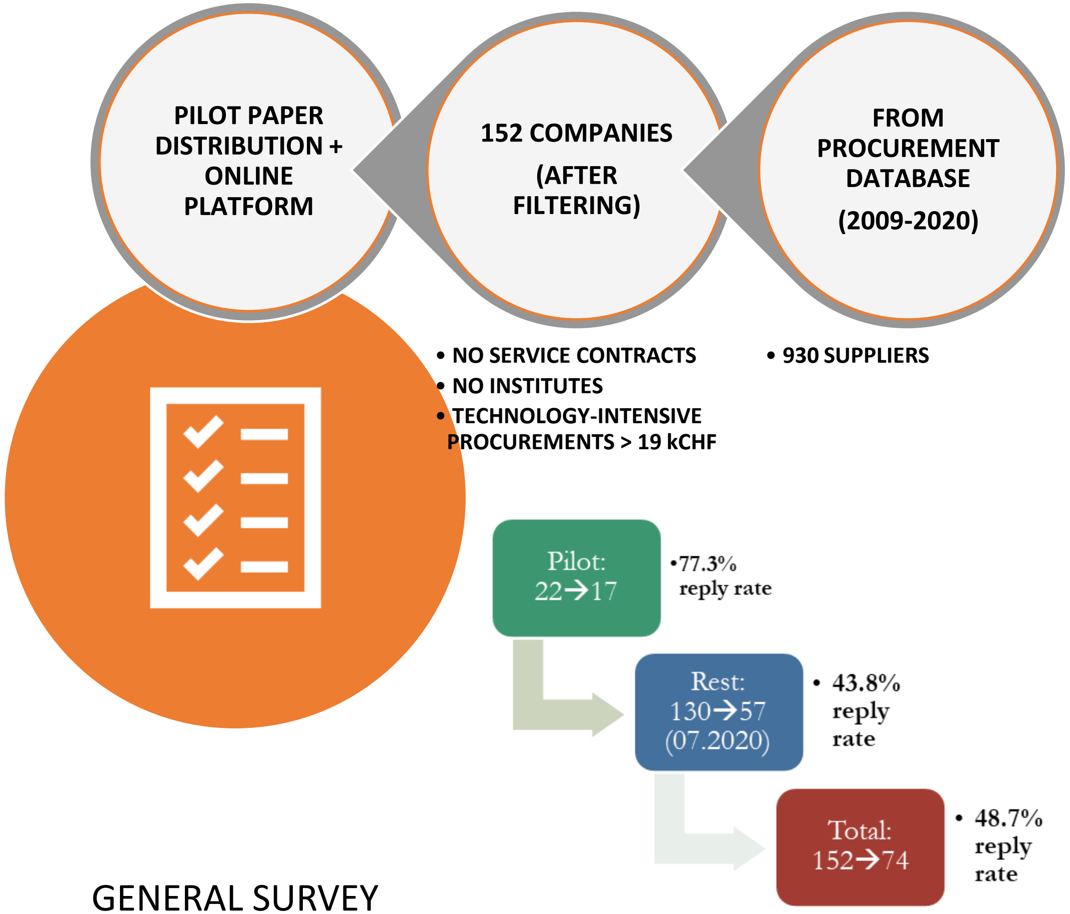
Key influence: size, age, scientific events, relationship with CERN, CLIC and other RI, CHF per order.

2. Benefits associated with economic utility

- Increased Turnover
- Cost saving: Value of the Open Hardware → to save resources on R&D in a company.

Industrial survey





GENERAL SURVEY

- *TECHNOLOGICAL SPILLOVERS ASSESSMENT*

Benefits (statistical analysis)

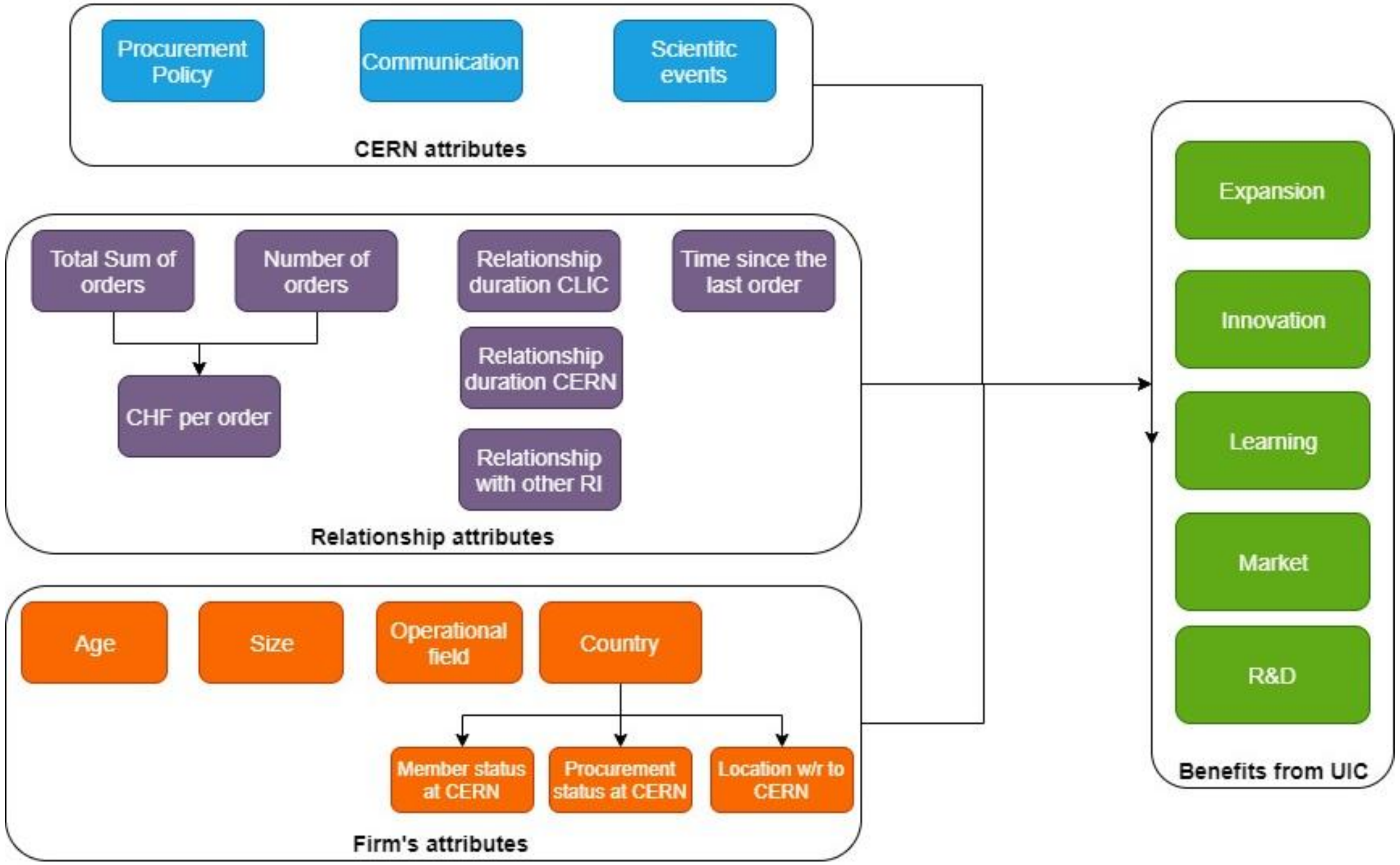
1. We distinguish the following outcomes for industries from CLIC collaboration:

- Innovation,
- Process, service improvement,
- Marketing image,
- Market expansion,
- R&D improvement.

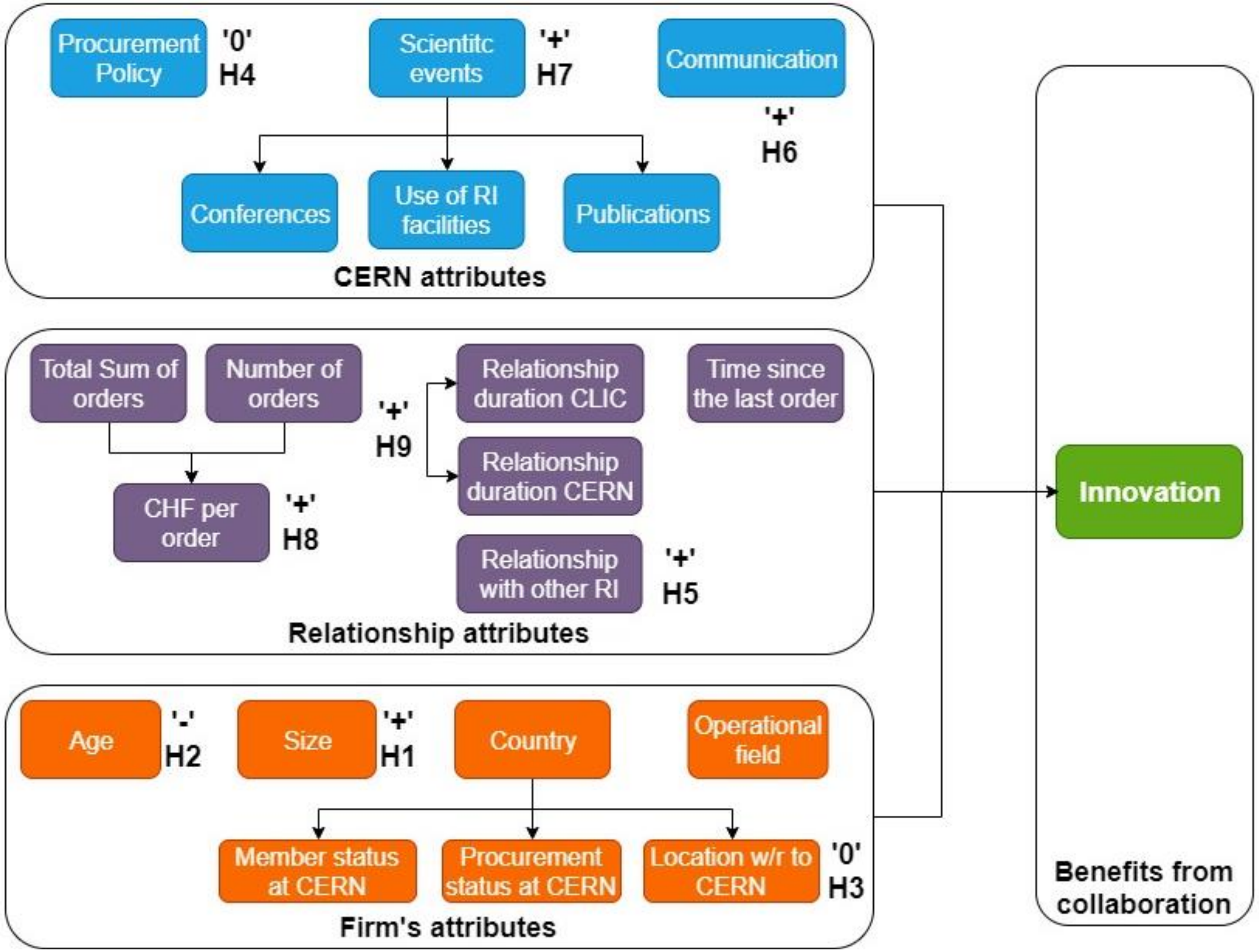
2. We distinguish the key influencing factors, grouped by:

- CERN attributes,
- Relationship attributes,
- Firm's attributes.

3. Repeat the regression analysis for each outcome (see next slide).

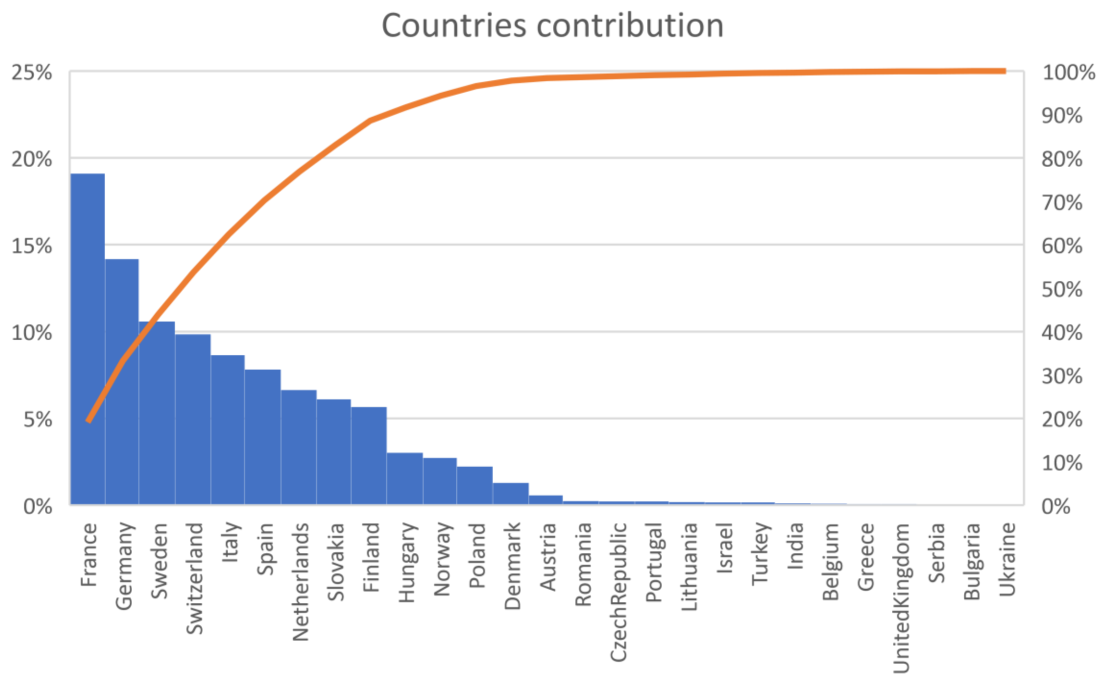


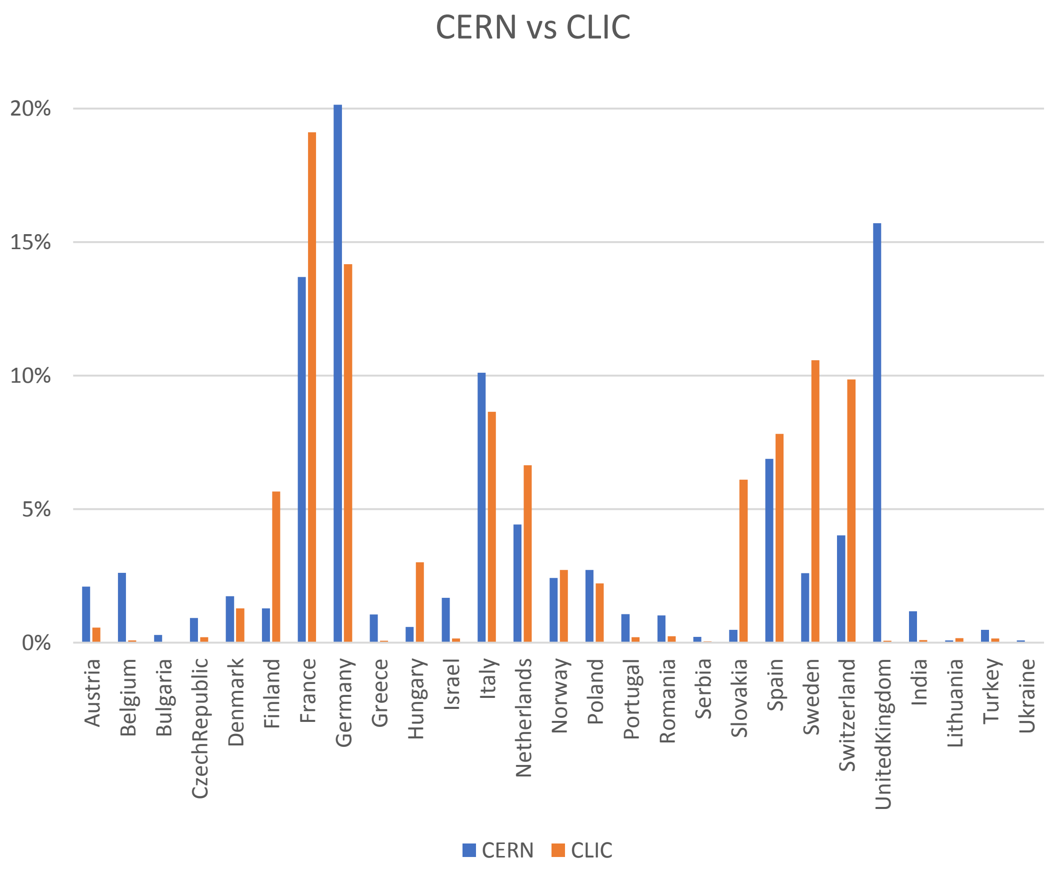
Conceptual framework (innovation)

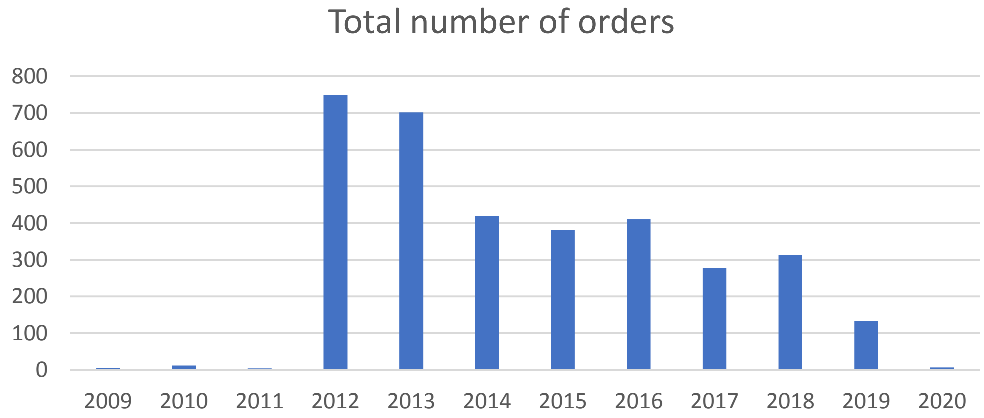


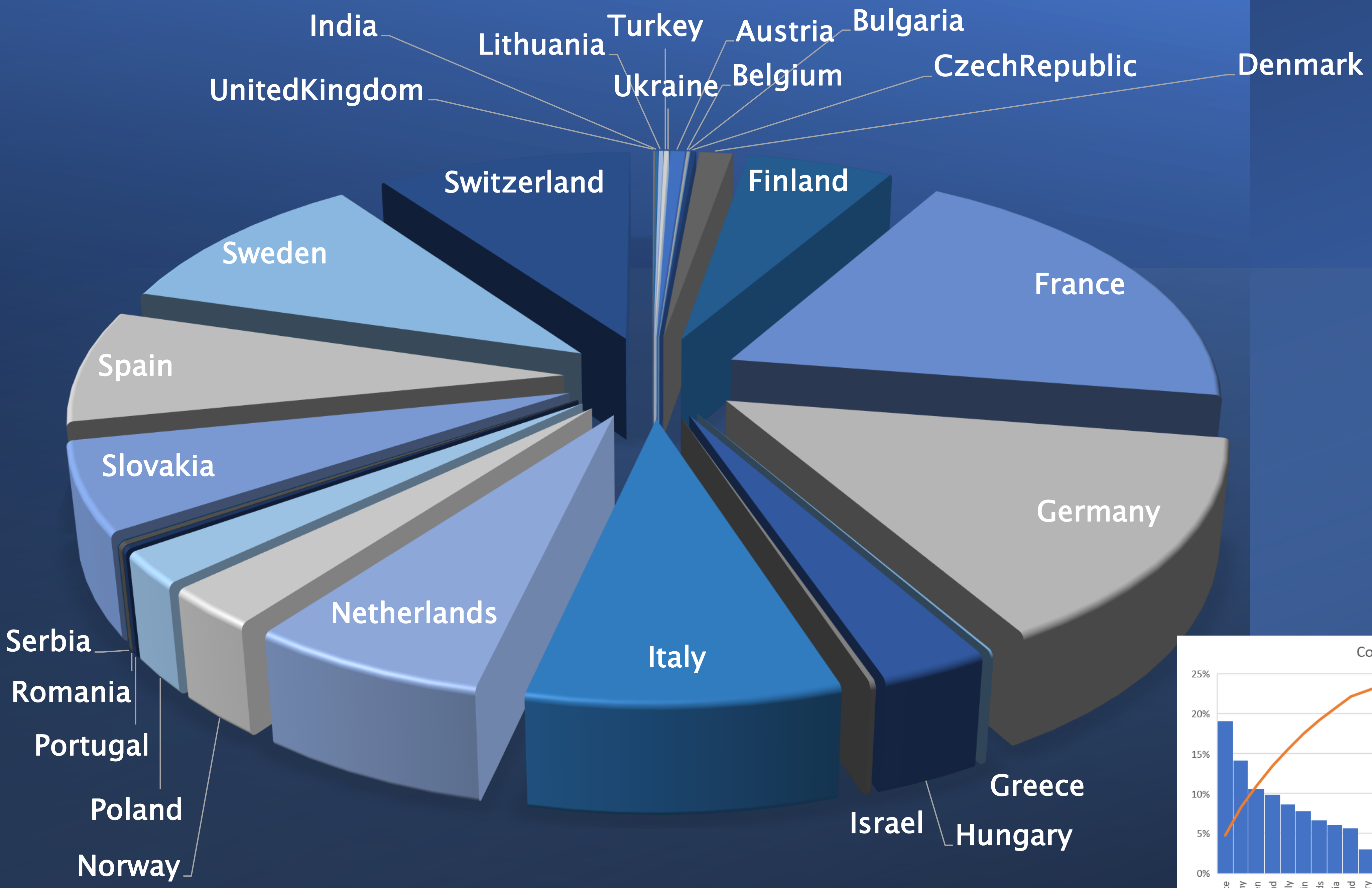
Magazinik, A., Catalan Lasheras, N., Mäkinen, S., Sauza Bedolla, J., (not published yet) 'Industry Collaboration with Large Research Infrastructures : What factors influence knowledge benefits for companies ?', proceeding for ICE 2021.

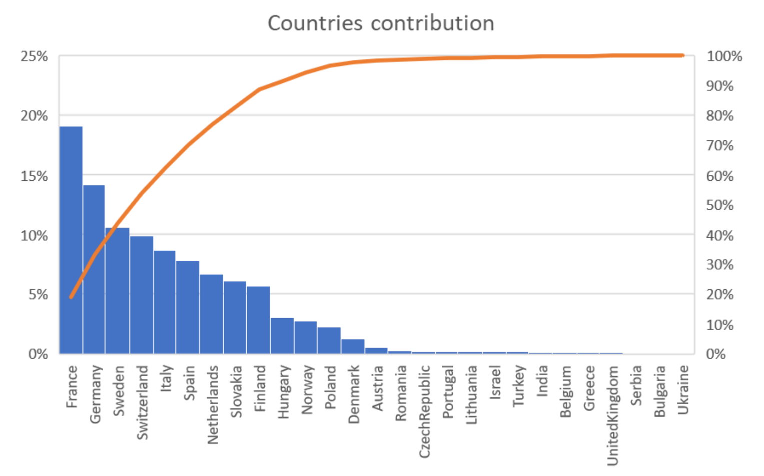
Descriptive statistics







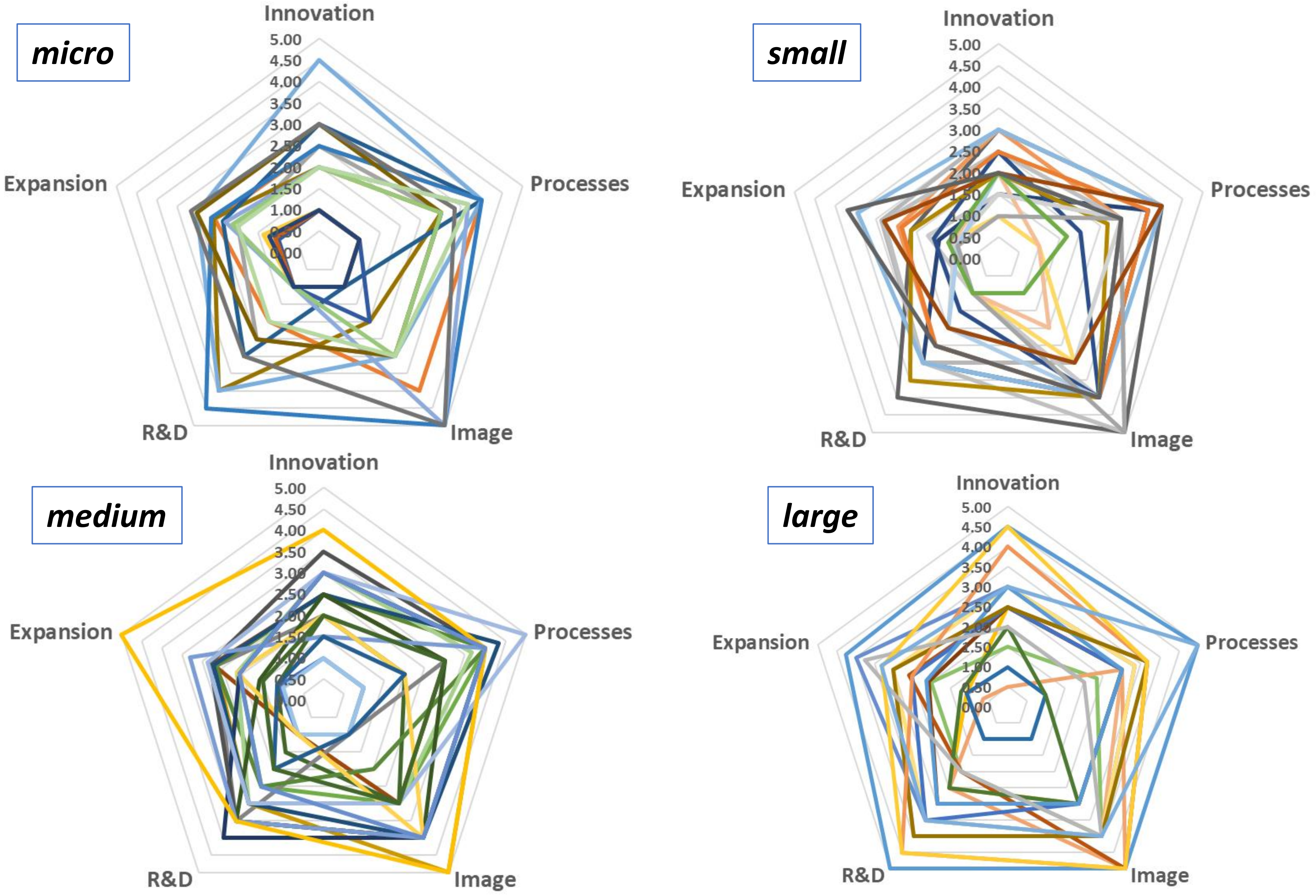

India
Lithuania
Turkey
Austria
Bulgaria
UnitedKingdom
Ukraine
Belgium
CzechRepublic
Denmark
Switzerland
Finland
Sweden
France
Spain
Slovakia
Germany
Netherlands
Italy
Serbia
Romania
Portugal
Poland
Norway
Israel
Greece
Hungary


Countries contribution
25%
20%
15%
10%
5%
0%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
France
Germany
Sweden
Switzerland
Italy
Spain
Netherlands
Slovakia
Finland
Hungary
Norway
Poland
Denmark
Austria
Romania
CzechRepublic
Portugal
Lithuania
Israel
Turkey
India
Belgium
Greece
UnitedKingdom
Serbia
Bulgaria
Ukraine

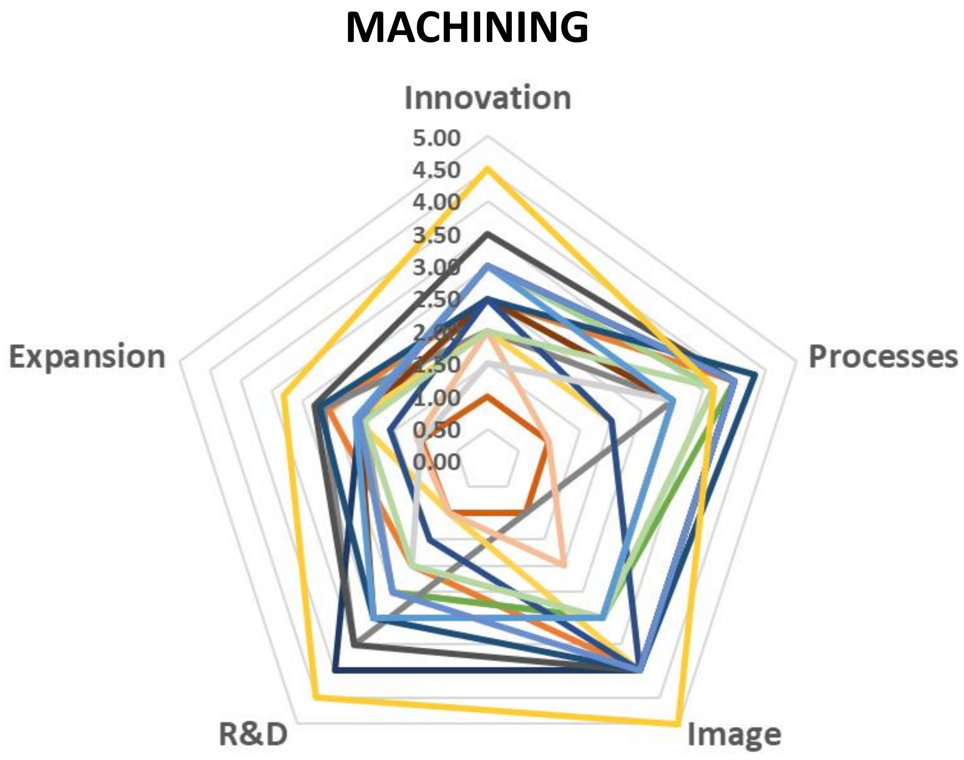
Radar graphs (different firm sizes)

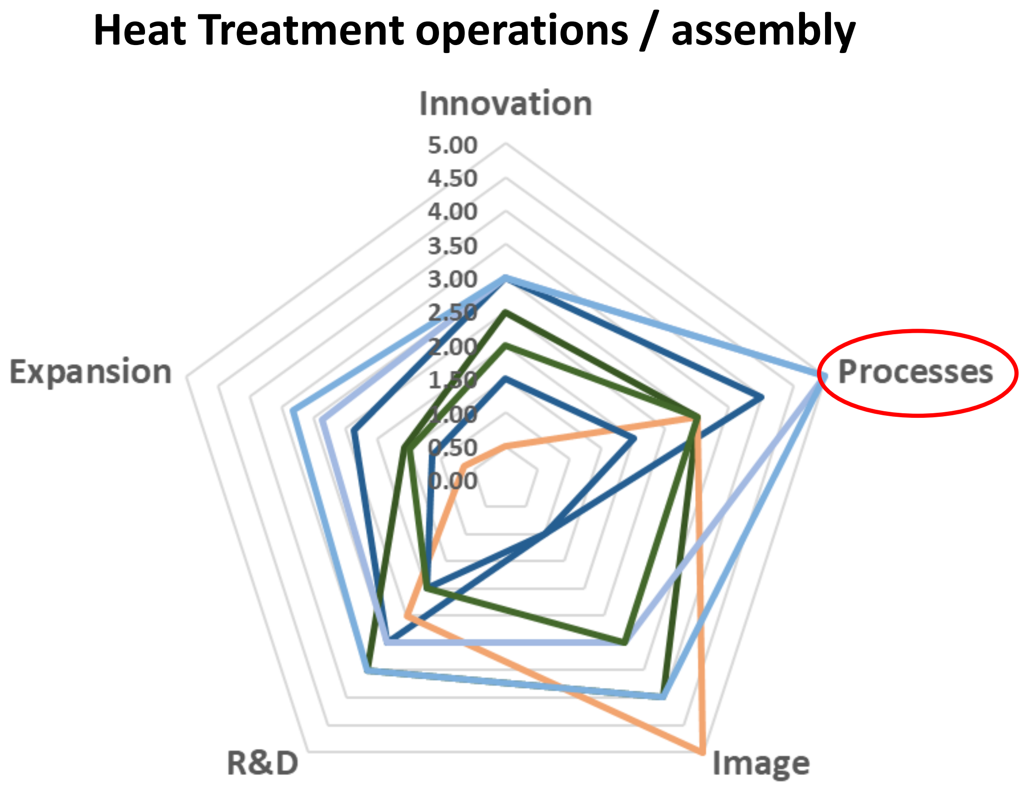
The bias to one of the benefits depending on the company sizes:

- micro, and small size companies show a bias to **<u>image lifting</u>** because of the collaboration with RI,
- medium size companies additionally signalise benefits towards **<u>the learning in terms of the improving the process, product and logistic,</u>**
- large size companies distribute more homogeneously benefits between all five outcome fields.



Radar graphs (technology)

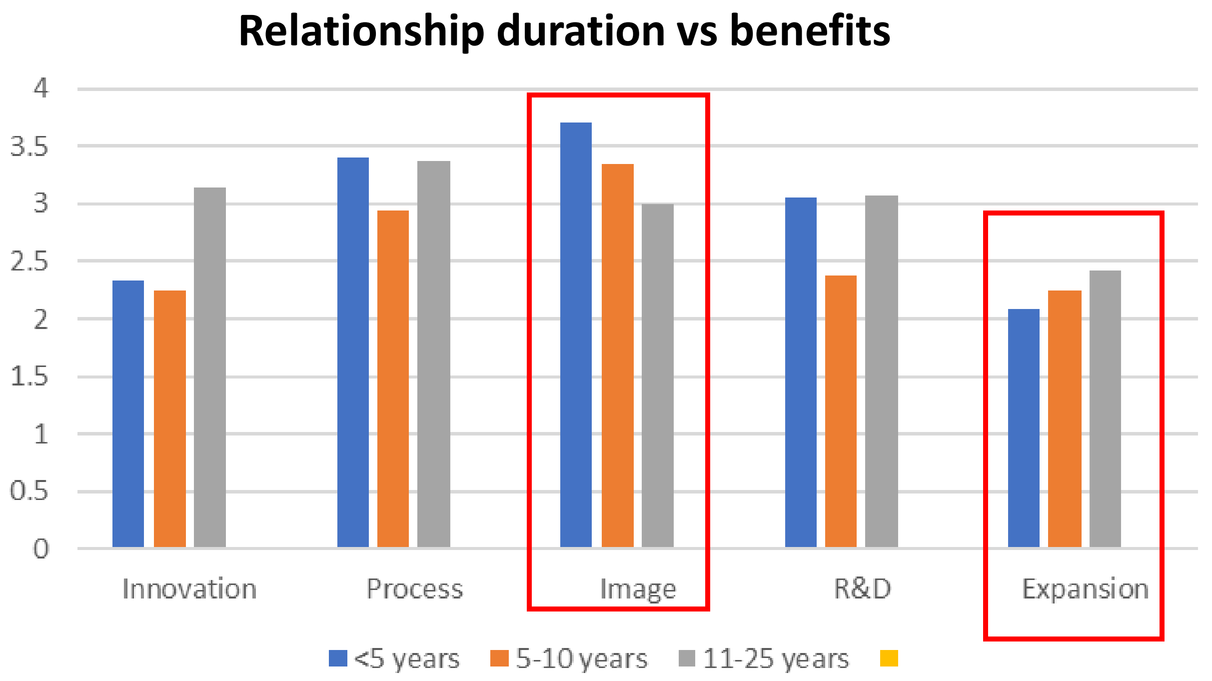


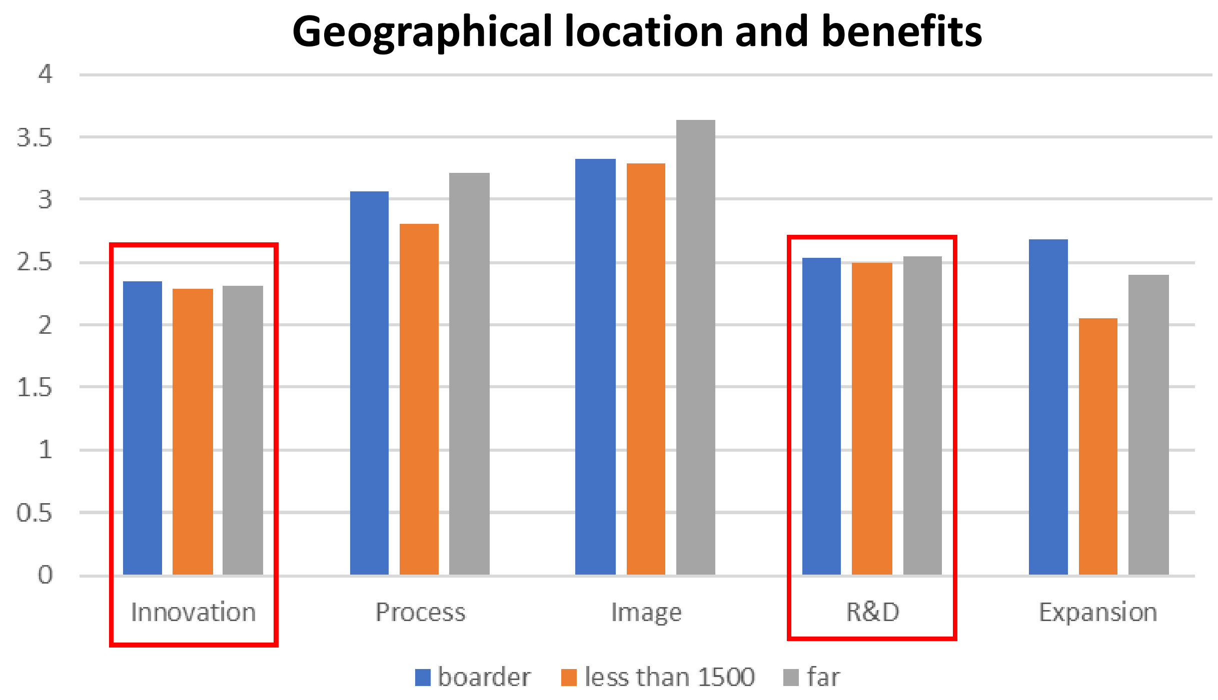


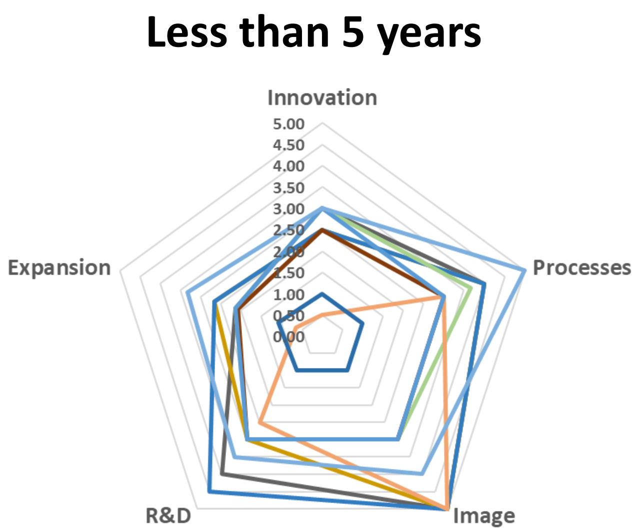
Process improvement, because of TT to companies (visits, procedures, present expert at site during operations and assembling prototypes)

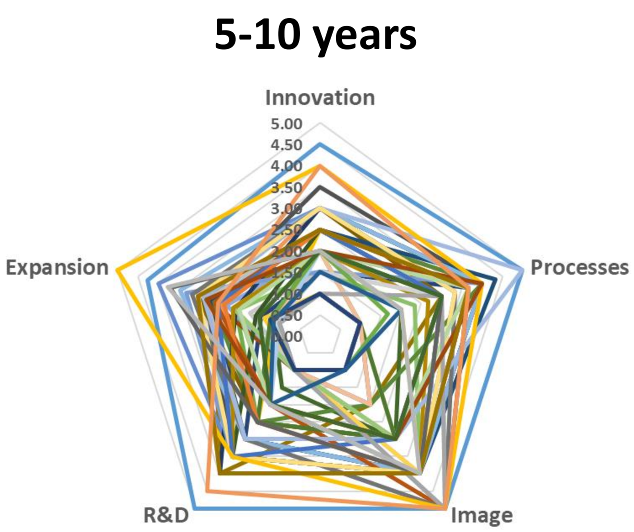
Other observations

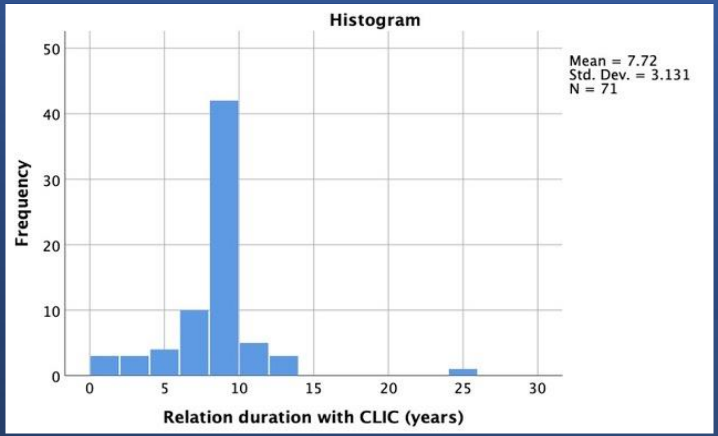
- Benefits can change among the relationship time,
- Marketing image benefit is higher in the beginning of relationship and expansion higher for longer relationship,
- Location does not affect innovation and R&D benefits.

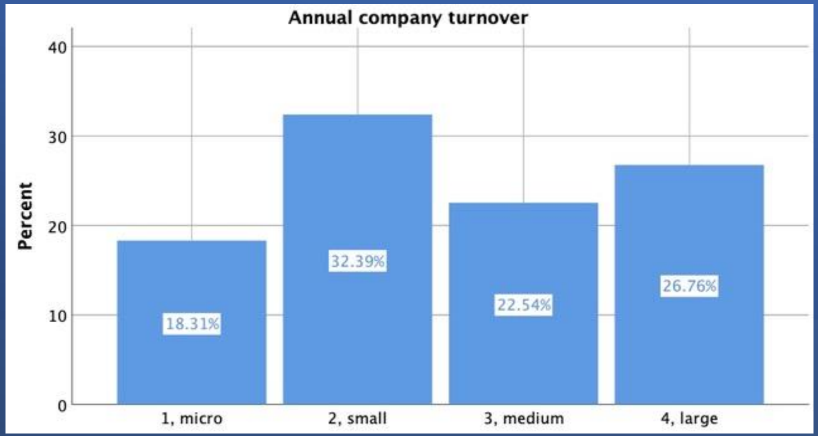


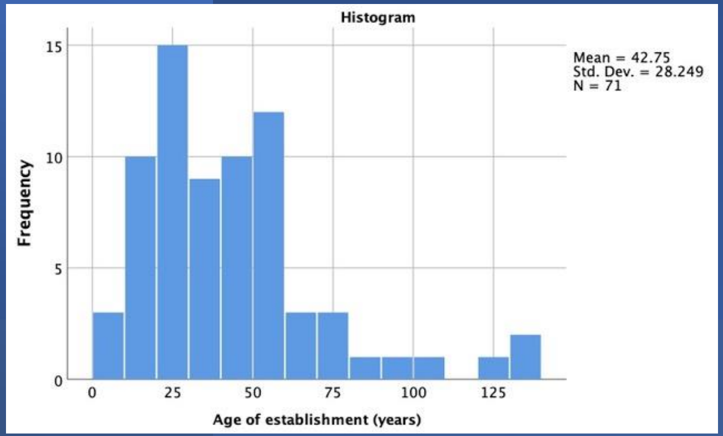


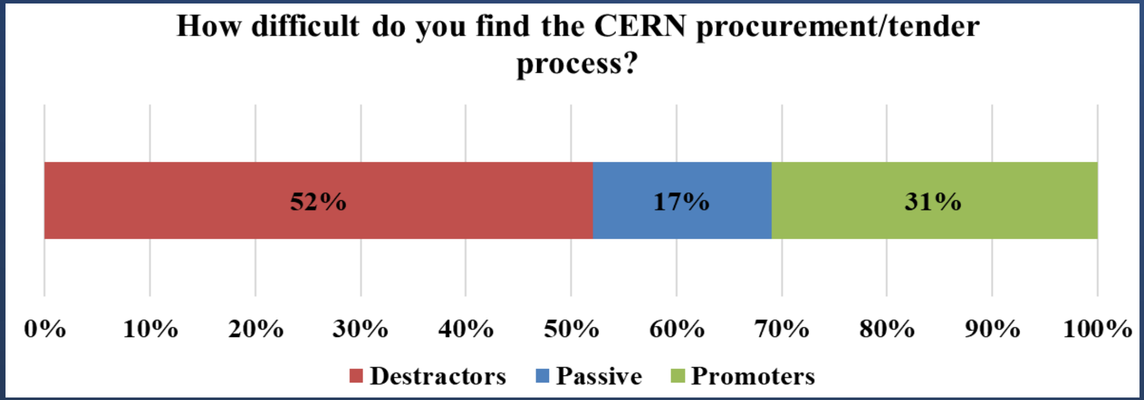


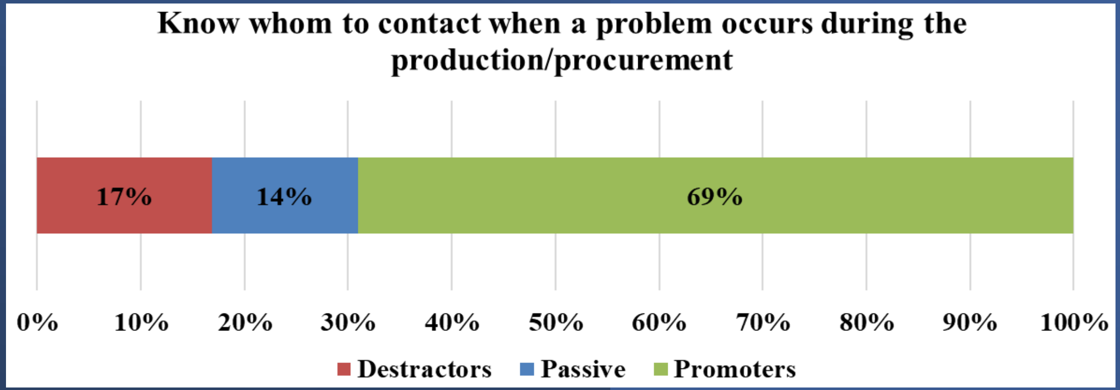


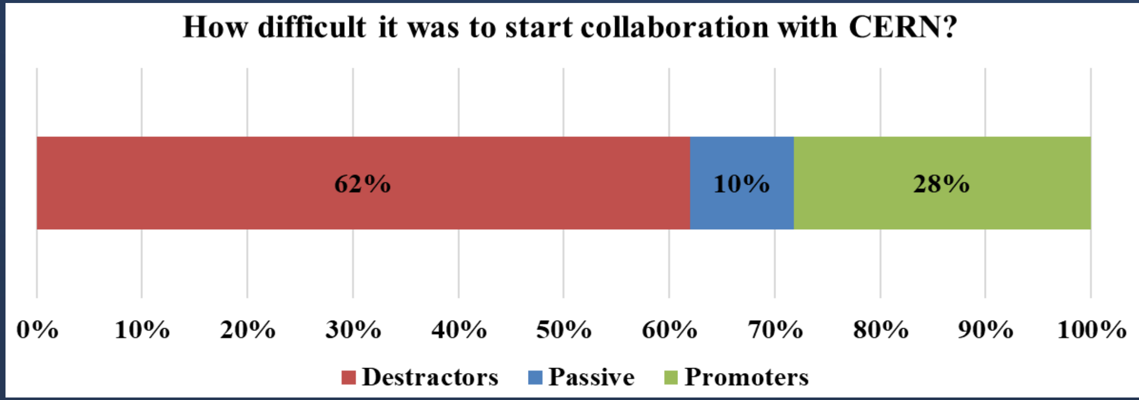

Histogram
Mean = 7.72
Std. Dev. = 3.131
N = 71
Frequency
0
10
20
30
40
50
0
5
10
15
20
25
30
Relation duration with CLIC (years)


Annual company turnover
Percent
0
10
20
30
40
18.31%
32.39%
22.54%
26.76%
1, micro
2, small
3, medium
4, large


Histogram
Mean = 42.75
Std. Dev. = 28.249
N = 71
Frequency
0
5
10
15
0
25
50
75
100
125
Age of establishment (years)


How difficult do you find the CERN procurement/tender process?
52%
17%
31%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Destractors
Passive
Promoters


Know whom to contact when a problem occurs during the production/procurement
17%
14%
69%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Destractors
Passive
Promoters


How difficult it was to start collaboration with CERN?
62%
10%
28%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Destractors
Passive
Promoters

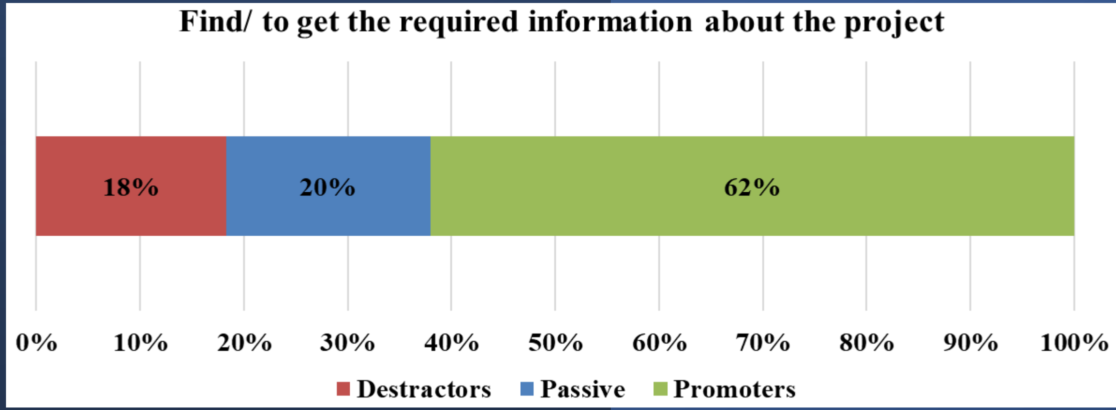

Find/ to get the required information about the project
18%
20%
62%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Destractors
Passive
Promoters

TABLE 3. LINEAR REGRESSION ANALYSIS

Dependent variable: Technical knowledge gained from CERN related technologies or services are used in other business lines								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Size	0.229 (0.156)*	0.225 (0.158)*	0.205 (0.159)	0.235 (0.155)*	0.231 (0.155)*	0.187 (0.153)	0.225 (0.153)*	0.221 (0.153)*
Age of the company	-0.199 (0.006)	-0.213(0.006)*	-0.172 (0.006)	-0.15 (0.006)	-0.170 (0.006)	-0.098 (0.007)	-0.103 (0.006)	-0.119 (0.006)
Country code 3 (Location)	-0.006 (0.214)	0.019 (0.224)	0.018 (0.227)	0.103 (0.044)	0.077 (0.232)	0.017 (0.285)	0.070 (0.286)	0.036 (0.292)
Technology	0.006 (0.042)	0.015 (0.043)	0.031 (0.043)	-0.045 (0.044)	-0.052 (0.044)	-0.006 (0.045)	-0.012 (0.044)	-0.018 (0.044)
Procurement Policy								
How difficult it was to start collaboration with CERN?		-0.040 (0.063)	-0.069 (0.066)	0.013 (0.064)	0.052 (0.066)	0.078 (0.064)	0.052 (0.064)	0.055 (0.064)
How difficult do you find the CERN procurement/tender process?		-0.074 (0.065)	-0.022 (0.066)	-0.067 (0.065)	-0.094 (0.066)	-0.005 (0.073)	-0.024 (0.072)	-0.052 (0.073)
Communication								
Know whom to contact when a problem occurs during the production/procurement			0.128 (0.239)	0.143 (0.224)	0.132 (0.224)	0.009 (0.227)	0.037 (0.224)	0.064 (0.226)
Find/ to get the required information about the project			0.068 (0.266)	-0.102 (0.261)	-0.083 (0.261)	0.045 (0.263)	-0.01 (0.262)	-0.023 (0.262)
Scientific events								
The company participates in scientific conferences, workshops, fairs etc.				0.288 (0.136)*	0.302 (0.136)**	0.262 (0.142)*	0.224 (0.141)	0.232 (0.142)
The company will appreciate a possibility to use CERN Infrastructure for their current or future needs				0.295 (0.131)**	0.284 (0.131)*	0.289 (0.135)*	0.240 (0.135)	0.239 (0.135)
The company produced publications due to business with CERN				-0.045 (0.188)	-0.034 (0.187)	-0.01 (0.199)	-0.016 (0.196)	-0.031 (0.197)
CHF per order					-0.138 (0.0)	-0.157 (0.0)	-0.215 (0.0)*	-0.202 (0.0)
RI relationship with CERN								
Relation duration with CLIC						0.283 (0.061)**	0.286 (0.06)**	0.252 (0.061)*
Relation duration with CLIC (with end date)						0.039 (0.095)	-0.038 (0.097)	0.013 (0.102)
Relation duration with CERN						-0.141 (0.017)	-0.189 (0.017)	-0.172 (0.017)
Relationship with other RI								
Do you have collaboration/business with other Research Institutes (number)?							0.25 (0.039)*	0.215 (0.040)
Time since last order								0.124 (0.09)
R	0.274	0.290	0.340	0.513	0.529	0.592	0.620	0.629
R square	0.075	0.084	0.116	0.263	0.280	0.351	0.384	0.396

Note: Robust standard errors in parenthesis. ***, **, * denote significance at the 1%, 5% and 10% level respectively.

Findings from regression

- Companies benefit from collaboration already at the early stage of an international study,
- Correlation between suppliers’ innovation benefit and taking place scientific events (participation in conferences, workshops, having a possibility to use RI facilities by industries).
- Moreover, the findings present significant effect of having collaboration with other RI coming along with the CLIC – supplier relationship duration. It is important for companies to understand this effect which is explained by sharing a list of qualified companies between collaborative institutes.
- No influence from CERN procurement policy neither from CERN communication on getting innovation benefits.

TECHNOLOGICAL IMPACT

- use existing CERN developments,
- Reduce the production price

Economic Benefits = Incremental Turnover + Cost Saving

Utility/sales ratio = 3

Incremental Turnover = EBITDA×Sales×3× $EBITDA$

Sales = Sum of CERN orders,
Utility = Sales×3
Incremental turnover = Utility×EBITDA

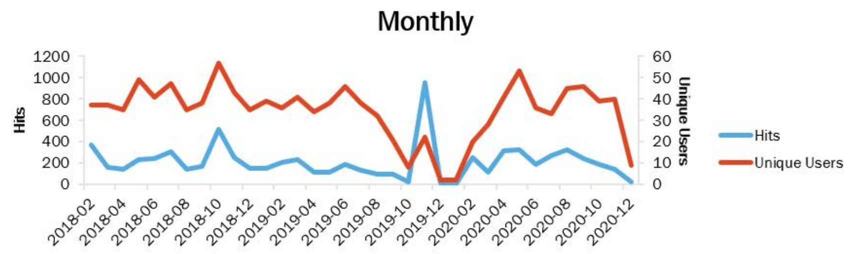
EBITDA margin measures a company's Earnings Before Interest, Taxes, Depreciation, and Amortization as a percentage of the company's total revenue.
The EBITDA is extracted from ORBIS.com

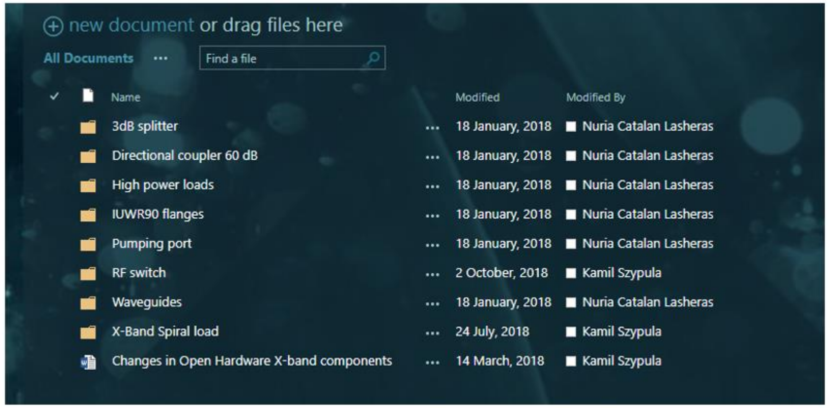
Reference: (Bianchi-Streit, M. et al. (1984) 'Economic utility resulting from CERN contracts (second study)'. CERN. doi: 10.5170/CERN-1984-014.)

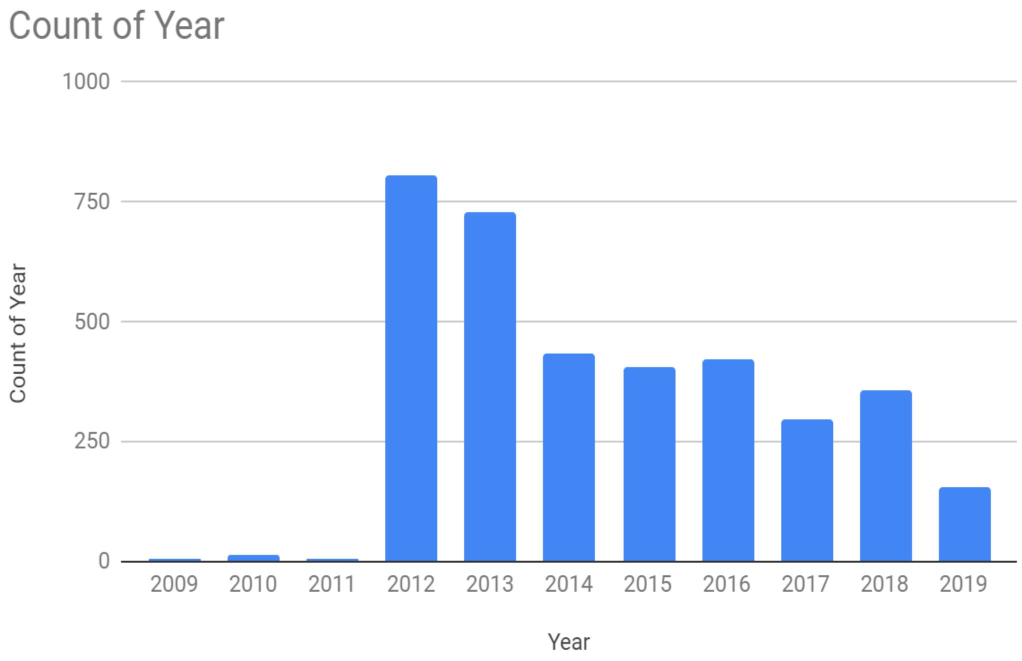
OPEN HARDWARE

- 39 users from around 18 laboratories and companies

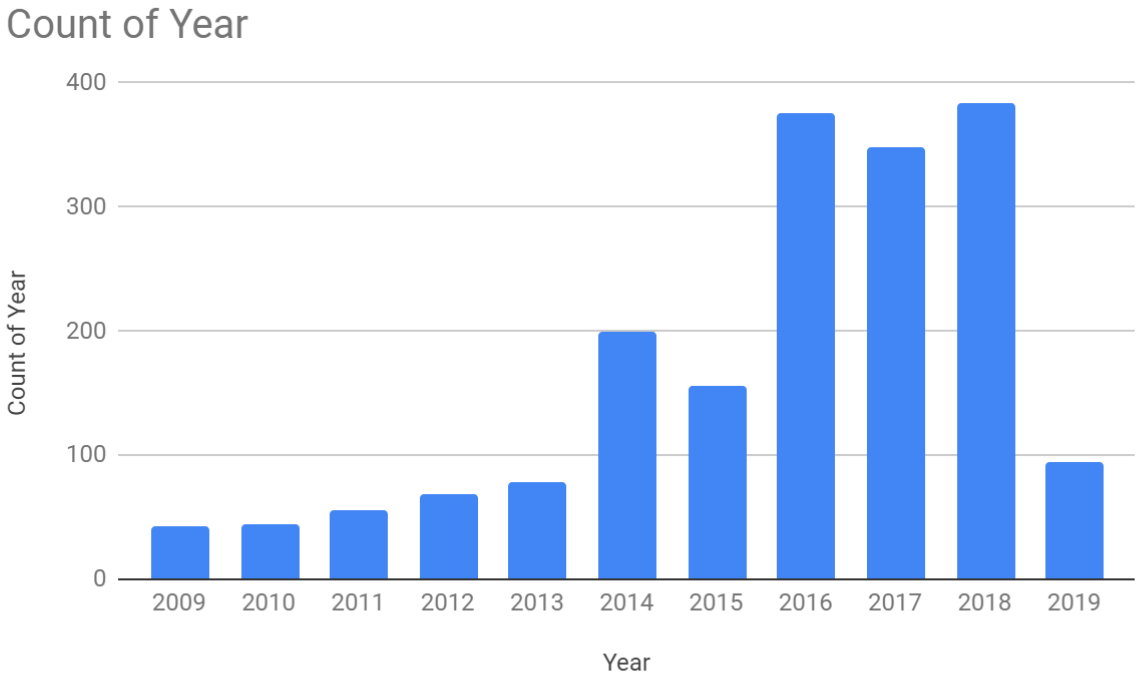
N. Catalan Lasheras, CLIC project meeting 38, 10.12.2020





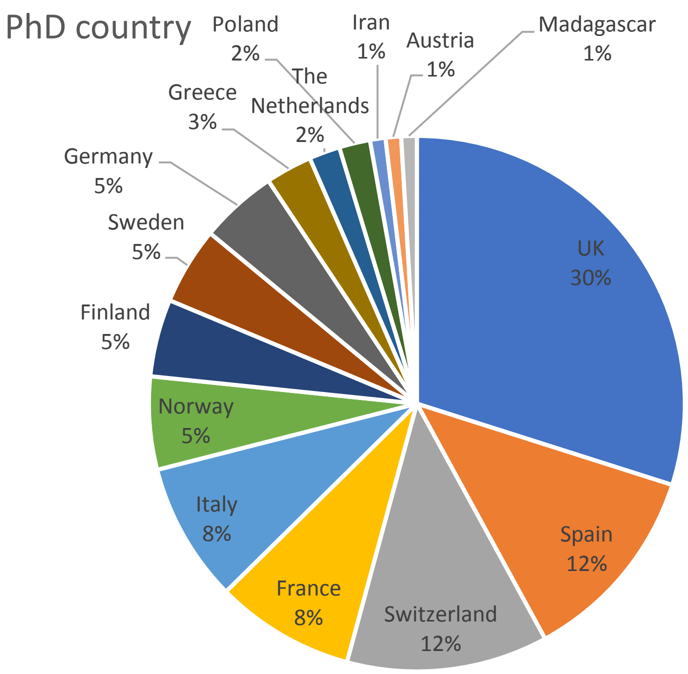


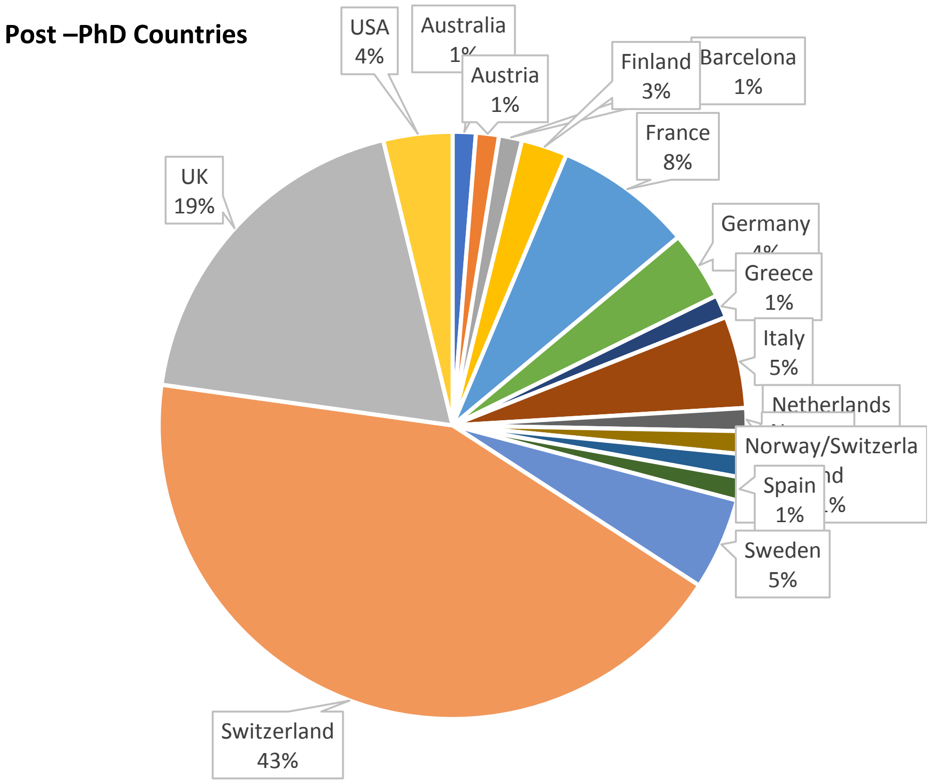
Procurement orders

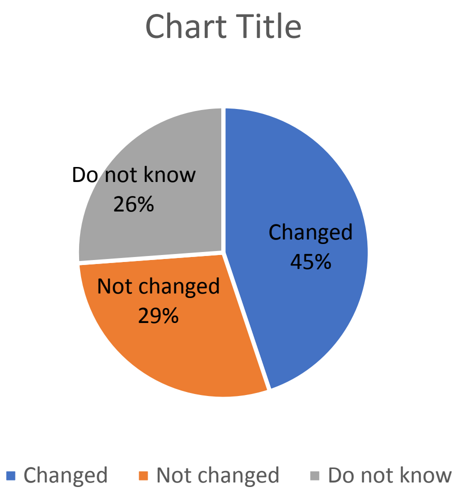


Publications

Doctoral

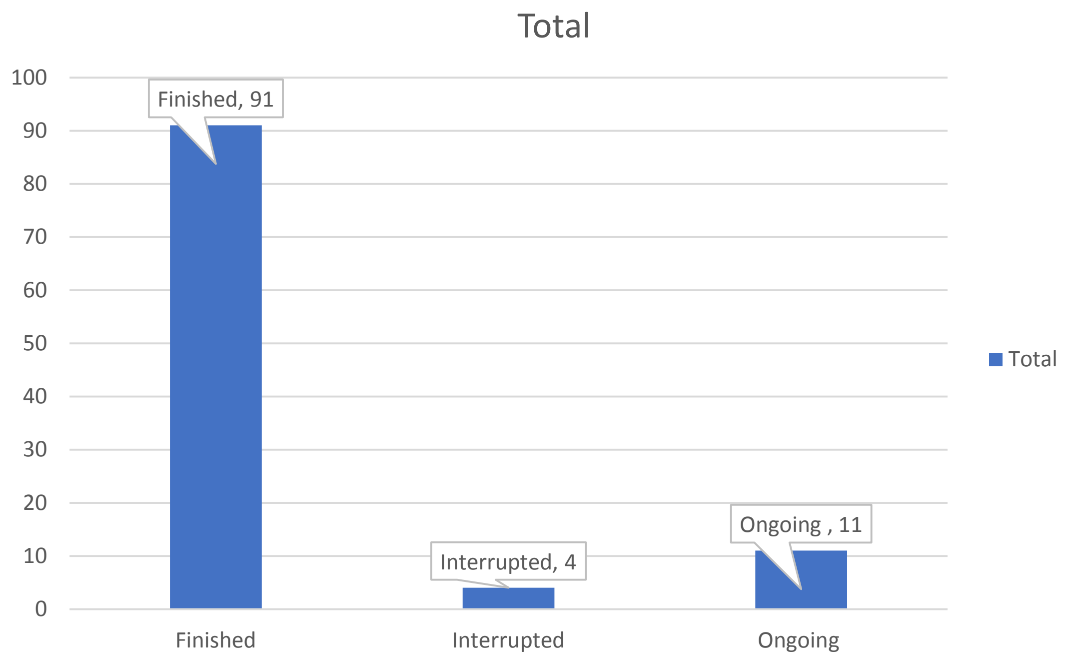


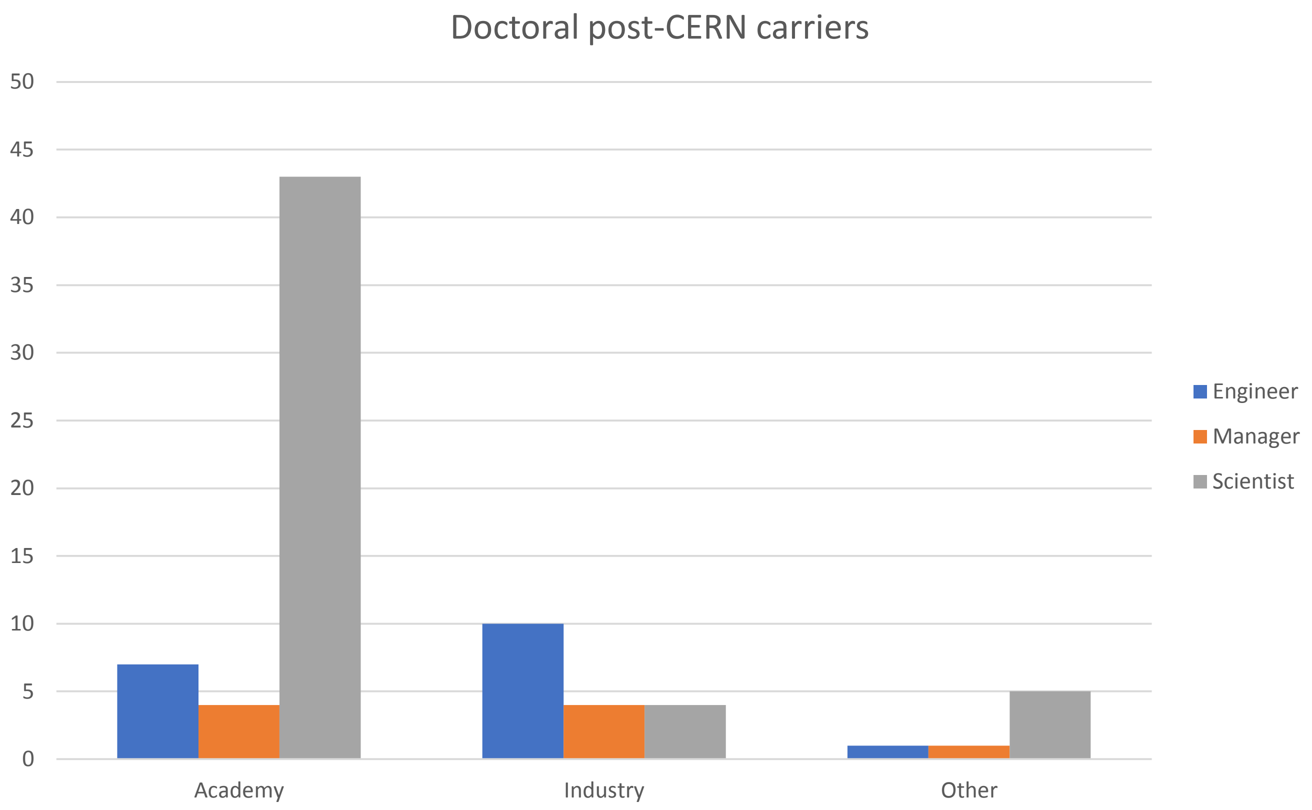


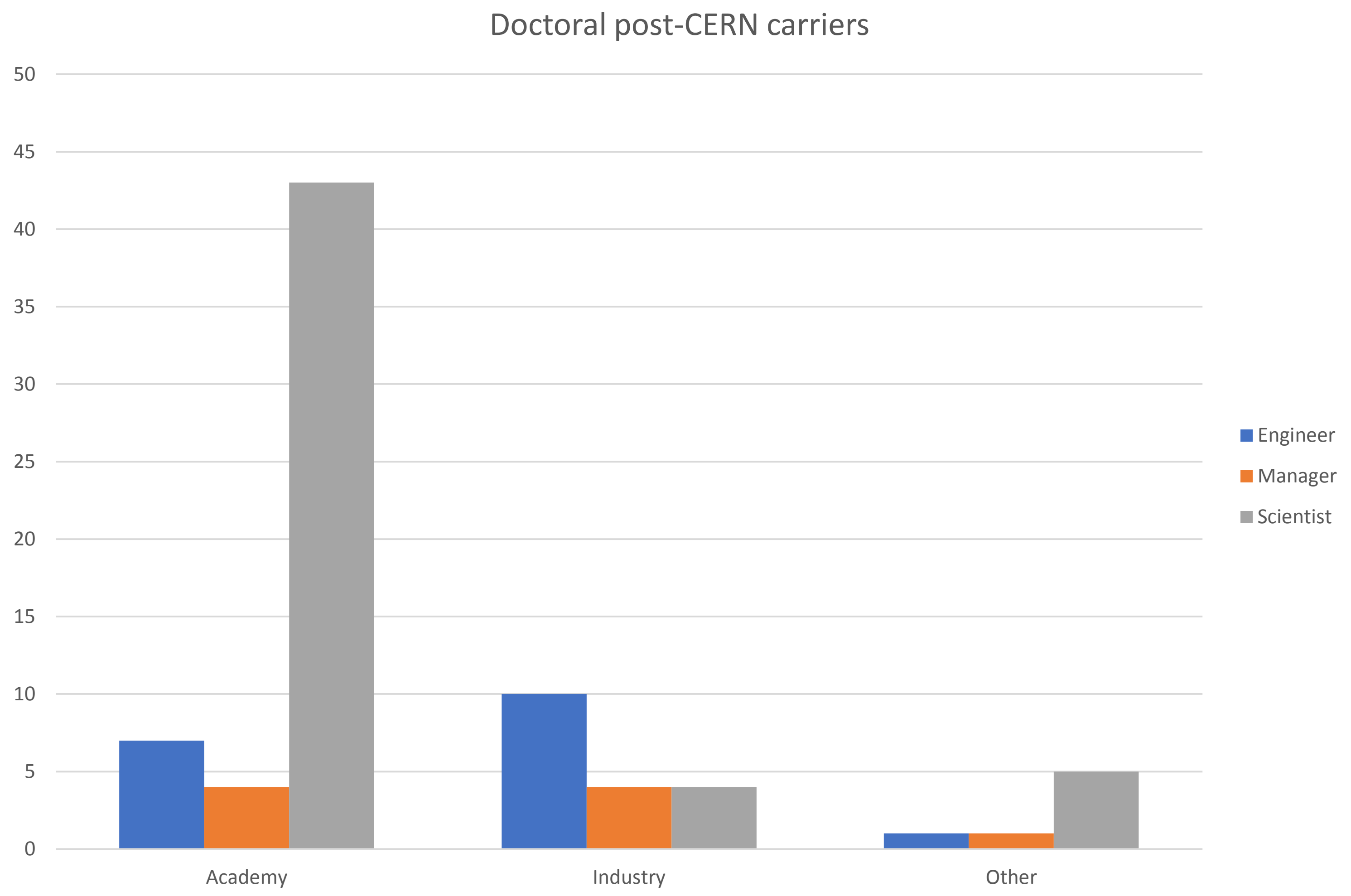


France, Finland, Switzerland and UK have less tendency to change their countries

Doctoral status






Doctoral post-CERN carriers
50
45
40
35
30
25
20
15
10
5
0
Academy
Industry
Other
Engineer
Manager
Scientist