EPFL CMi - Center of MicroNanoTechnology

Philippe Flückiger

2 May 2023

École polytechnique fédérale de Lausanne

EPFL
CMi

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EPFL MicroNanoFabrication Annual Review Meeting

Philippe Flückiger, EPFL, May 2nd, 2023

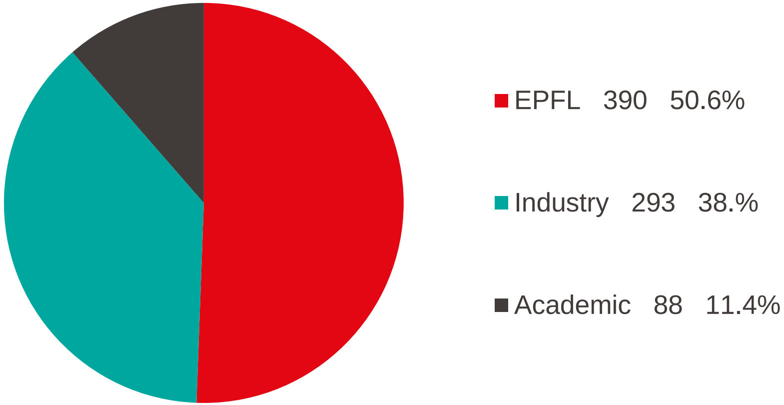
Next editions :

- 14.05.2024 – 23rd edition
- 13.05.2025 – 24th edition
- 12.05.2026 – 25th edition

Welcome & thanks

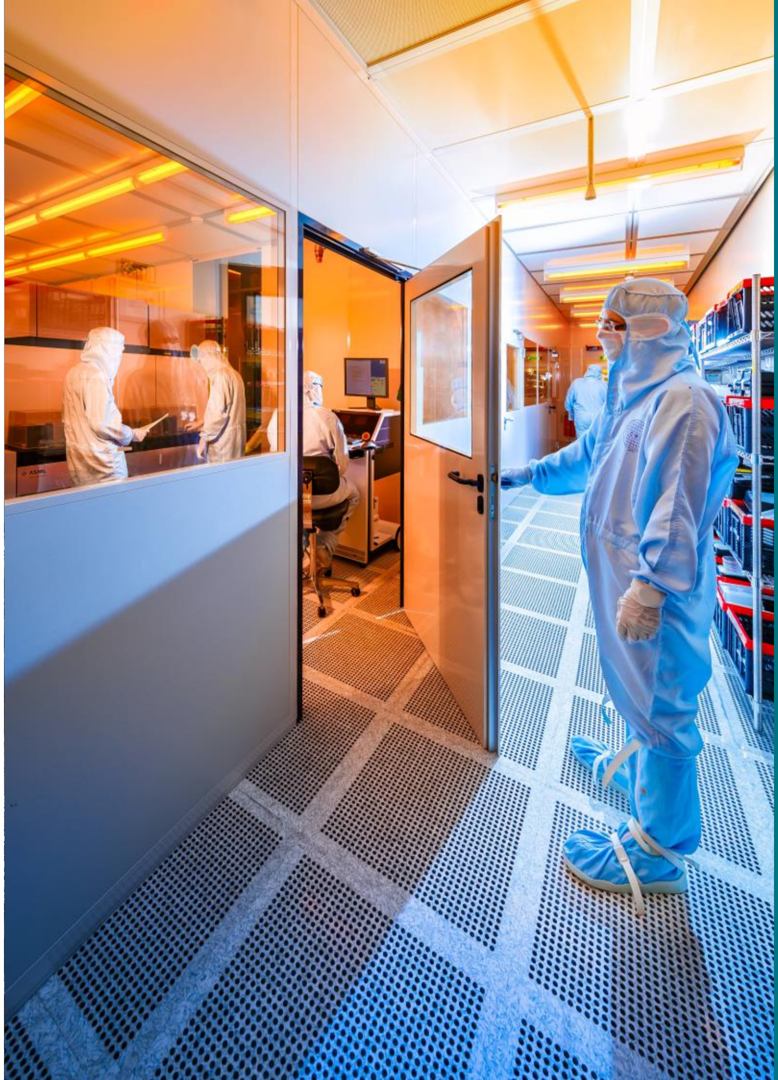
- Welcome to the 22nd edition of the CMi MicroNanoFabrication Annual Review Meeting
- 786 participants registered (with 40% from industry, with 50% from outside EPFL)
- Many thanks for your participation

- Global companies
- Local industry
- Startups
- Suppliers
- Government Agencies
- Researchers
- Faculty members
- Students
- Colleagues from other academic cleanrooms



List of participants available at :

- -> Traveling from 18 different countries
- -> Networking



CMi at glance

Users
Finances
Governance
Staff
Tools
Cleanroom
Projects

Users in 2022

Engineering Sc.		Basic Sc.	Life Sc., Civil Eng.,	Ext. Acad.		Companies		
STI-IBI-BIOS	STI-IEM-POWERLAB	SB-IPHYS-CRP	SV-BMI-UPMCCABE	AMI_FR_BioPhysics	UCLouvain	ActLight	Kistler	Sensirion
STI-IBI-CLSE	STI-IEM-PV-LAB	SB-IPHYS-GR-GA	SV-BMI-UPRAMDYA	CERN_2	UCLouvain_IMMC	Adaptyv_Biosystem	Ligentec	Sigatec
STI-IBI-LBEN	STI-IGM-EMSI	SB-IPHYS-HQC	SV-GHI-UPPERSAT	CERN_EP_dept	UNI-SUSSEX-PH-IQT	Adept_Neuro	Lionix_Intl	Silicon_Austria_7
STI-IBI-LBMM	STI-IGM-LMTS	SB-IPHYS-LASPE	SV-IBI-UPDEPLA	CHUV		Advanced_Fiber_Re	LSPR	Silicon_Austria_9
STI-IBI-LBNC	STI-IGM-LNET	SB-IPHYS-LBEM	SV-IBI-UPLUT	CSEM_E1		Aleva	Lumiphase	SilMach
STI-IBI-LBNI	STI-IGM-LRESE	SB-IPHYS-LEB	SV-IBI-UPNAE	CSEM_T1		Alpes_Lasers	Lunaphore	SoHHytec
STI-IBI-LHTC	STI-IGM-MICROBS	SB-IPHYS-LMSC2	SV-ISREC-UPBRI	CSEM_T4		AMS_Intl_AG	Mackinac	Sunbioscience
STI-IBI-LNE	STI-IGM-NEMS	SB-IPHYS-LPBS	SV-PTECH-PTBET	CSEM-Muttenz_Cent		Annaida	MCH-processing	SwissflexMicro
STI-IEL-GR-SCI	STI-IMX-FIMAP	SB-IPHYS-LPQM1	SV_SSV-TP1	EMPA_Dubendorf		ArcoScreen	Melexis	SYANDSE
STI-IEM-AQUA	STI-IMX-INE	SB-IPHYS-LQM		ETHZ_D-ITET_IEF		Asulab	MicroR_Systems	TrueDyne_Sensors
STI-IEM-GALATEA	STI-IMX-LMGN	SB-IPHYS-LQP		ETHZ_D-MAVT_MNS		Axetris	Miraex	XRnanotech
STI-IEM-GR-QUA	STI-IMX-LMOM	SB-IPHYS-LUMES		ETHZ_D-MAVT_Nanop		Bloesch	Mistic	Xsensio
STI-IEM-HYLAB	STI-IMX-LMSC	SB-ISIC-LAS		ETHZ_D-PHYS_LFKP		Bright-Sensors	Morphotonix	
STI-IEM-ICLAB	STI-IMX-LP	SB-ISIC-LPDC		HES-SO-GE_inSTI		Bruker	Nanoga	
STI-IEM-LAFT	STI-IMX-LPAC	SB-ISIC-LPI		HES-SO-GE_inSTI_2		Colibrys	Nanosurf	
STI-IEM-LAI	STI-IMX-QMAT	SB-SCI-RH		Metas		Corintis	Nanoworld	
STI-IEM-LANES	STI-IMX-SMAL	SB-SPC-BPP		PSI_LNB		Creal	Novagan	
STI-IEM-LMIS1	STI-IMX-SUNMIL	SB-SPC-II		PSI_LNQ		Deeplight	Optotune	
STI-IEM-LMIS2	STI-INX-LSBI	SB_SPH_TP1	ENAC-IIC-LESO-PB	PSI_LSB		Enlightra	Oxford_Ionics	
STI-IEM-LMIS4	STI-SCI-AXS			PSI_LXN		EXALOS	Pi_Imaging	
STI-IEM-LO	STI-SCI-DD			PSI_PSD-LMN		FEMTOprint	Piemacs	
STI-IEM-LPMAT	STI-SCI-MM			UNIBAS		Freshape_ex-H_Gla	Preciflex	
STI-IEM-LPQM2	STI_SEL			UNIFR_Chemistry		Gersteltec	Q_Ant	
STI-IEM-LWE	STI_SMT-TP1			UNIGE_DPNC		Hexisense	Roche-ITB	
STI-IEM-NAM	STI_SMT-TP2			UNIGE_GAP		ID_Quantique	Rolex	
STI-IEM-NANOLAB				UNIGE_Physique		Infrascreen	SEED	
STI-IEM-PHOSL				UNISANTE		KEP_Innov	Senbiosys	
52 (369)		19 (93)	10 (25)	30 (47)		66 (126)		

# of laboratories

# of users

- Total: 177 labs & companies (employing 577 users)

Users in 2022

Engineering Sc.		Basic Sc.	Life Sc., Civil Eng.,	Ext. Acad.		Companies		
STI-IBI-BIOS	STI-IEM-POWERLAB	SB-IPHYS-CRP	SV-B MCCABE	AMI_FR_BioPhysics	UCLouvain	ActLight	Kistler	Sensirion
STI-IBI-CLSE	STI-IEM-PV-LAB	SB-IPHYS-GR-GA	SV- OYA	CERN_2	UCLouvain_IMMC	Adaptyv_Biosystem	Ligentec	Sigatec
ST REN	ST EMSI	SB- HQC	SV-	CERN_EP_dept	UNI-SUSSEX-PH-IQT	Adept_Neuro	Lionix_Intl	Silicon_Austria_7
S	S	SB	SV-	CHUV		Advanced_Fiber_Re	LSPR	Silicon_Austria_9
S	S	SB	SV-	CSEM_E1		Aleva	Lumiphase	SilMach
S	S	SB	SV- BI-UPNA	CSEM_T1		Alpes_Lasers	Lunaphore	SoHHytec
S	S	SB	SV- BRI	CSEM_T4		AMS_Intl_AG	Mackinac	Sunbioscience
STI-IBI-LN	STI-IGM-N	SB-IPHYS-L	SV-	CSEM-Muttenz_Cent		Annaida	MCH-processing	SwissflexMicro
STI-IEL-GR-SCI	STI-IMX-FIMAP	SB-IPHYS-LPQM1	SV_	EMPA_Dubendorf		ArcoScreen	Melexis	SYANDSE
STI-IEM-AQUA	STI-IMX-INE	SB-IPHYS-LQM		ETHZ_D-ITET_IEE		Asulab	MicroR_Systems	TrueDyne_Sensors
STI-IEM-GALATEA	S GN	SB-IPHYS-LQP		ETHZ_D-MAV		Axetris	M	XRnanotech
STI-IEM-GR-QUA	S	SB-IPHYS-LUMES		ETHZ_D-MAV		Bloesch	M	Xsensio
STI-IEM-HYLAB	S	SB		ETHZ_D-PHY		Bright-Sensors	M	
STI-IEM-ICLAB	S	SB		HES-SO-GE_		Bruker	N	
STI-IEM-LAFT	S IMX	SB		HES-SO-GE_ STI_		Colibrys	N nosu	
STI EM-LAI	STI-IMX-QMA	SB		Metas		Corintis	Nanoworld	
S ES	STI-IMX-SMAL	SB		PSI_LNB		Creal	Novagan	
S	STI-IMX-SUNMIL	SB-SPC-II		PSI_LNQ		Deeplight	Optotune	
S	STI-INX-LSBI	SB_SPH_TP1	ENA	PSI_LSB		Enlightra	Oxford_Ionics	
S	STI-SCI-AXS			PSI_LXN		EXALOS	Pi_Imaging	
STI-IEM-L	STI-SCI-DD			PSI_PSD-LMN		FEMTOprint	Piemacs	
STI-IEM-LPMAT	STI-SCI-MM			UNIBAS		Freshape_ex-H_Gla	Preciflex	
STI-IEM-LPQM2	STI_SEL			UNIFR_Chemistry		Gersteltec	Q_Ant	
STI-IEM-LWE	STI_SMT-TP1			UNIGE_DPNC		Hexisense	Roche-ITB	
STI-IEM-NAM	STI_SMT-TP2			UNIGE_GAP		ID_Quantique	Rolex	
STI-IEM-NANOLAB				UNIGE_Physique		Infrascreen	SEED	
STI-IEM-PHOSL				UNISANTE		KEP_Innov	Senbiosys	
52 (369)		19 (93)	10 (25)	30 (47)		66 (126)		

Bio Engineering

Mechanical Engineering

Physics

Global Health

Swiss Inst. for experimental cancer research

Materials

Chemical Sciences and Engineering

CERN CSEM PSI EMPA ETHZ Universities

Startups SMEs Big companies

Electrical and Micro Engineering

Civil Engineering

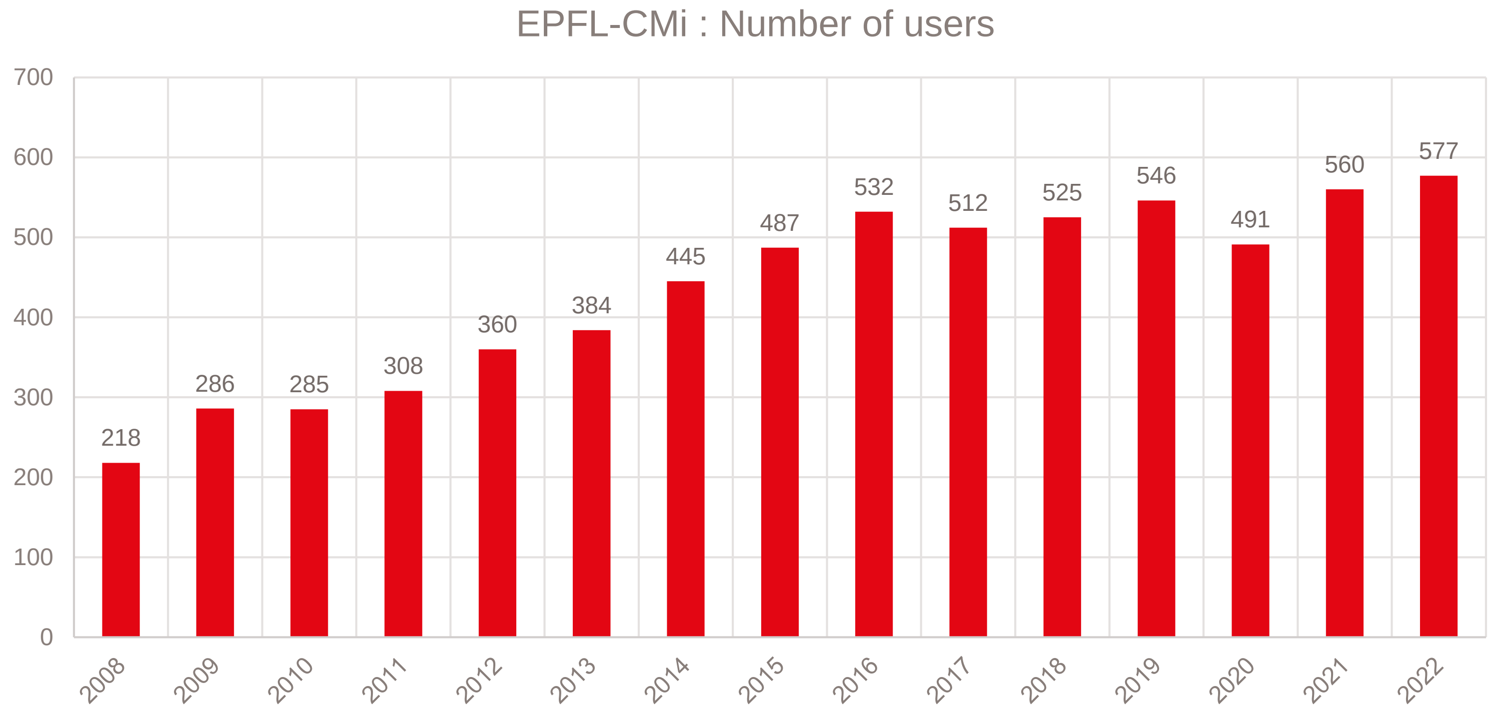
# of laboratories

# of users

- Total: 177 labs & companies (employing 577 users)

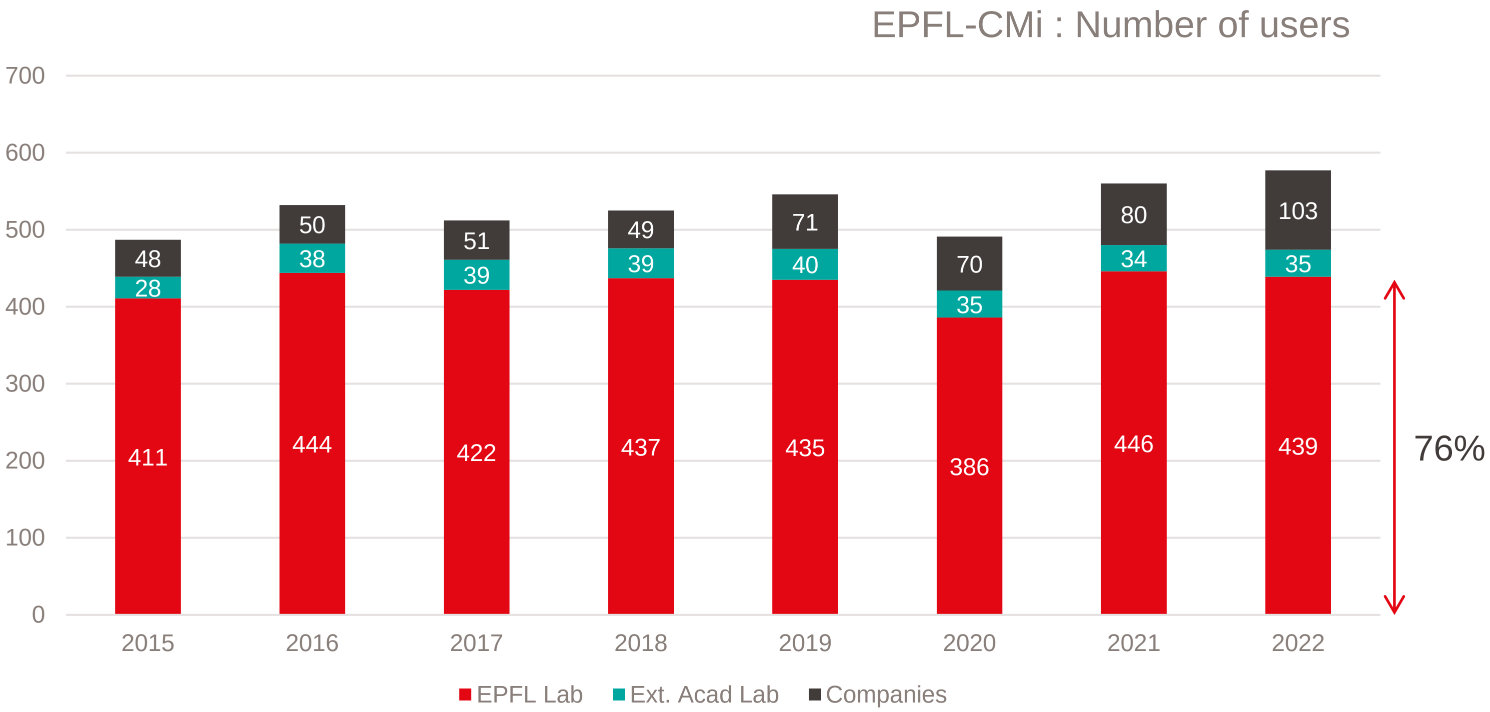
EPFL CMi

Users in 2022



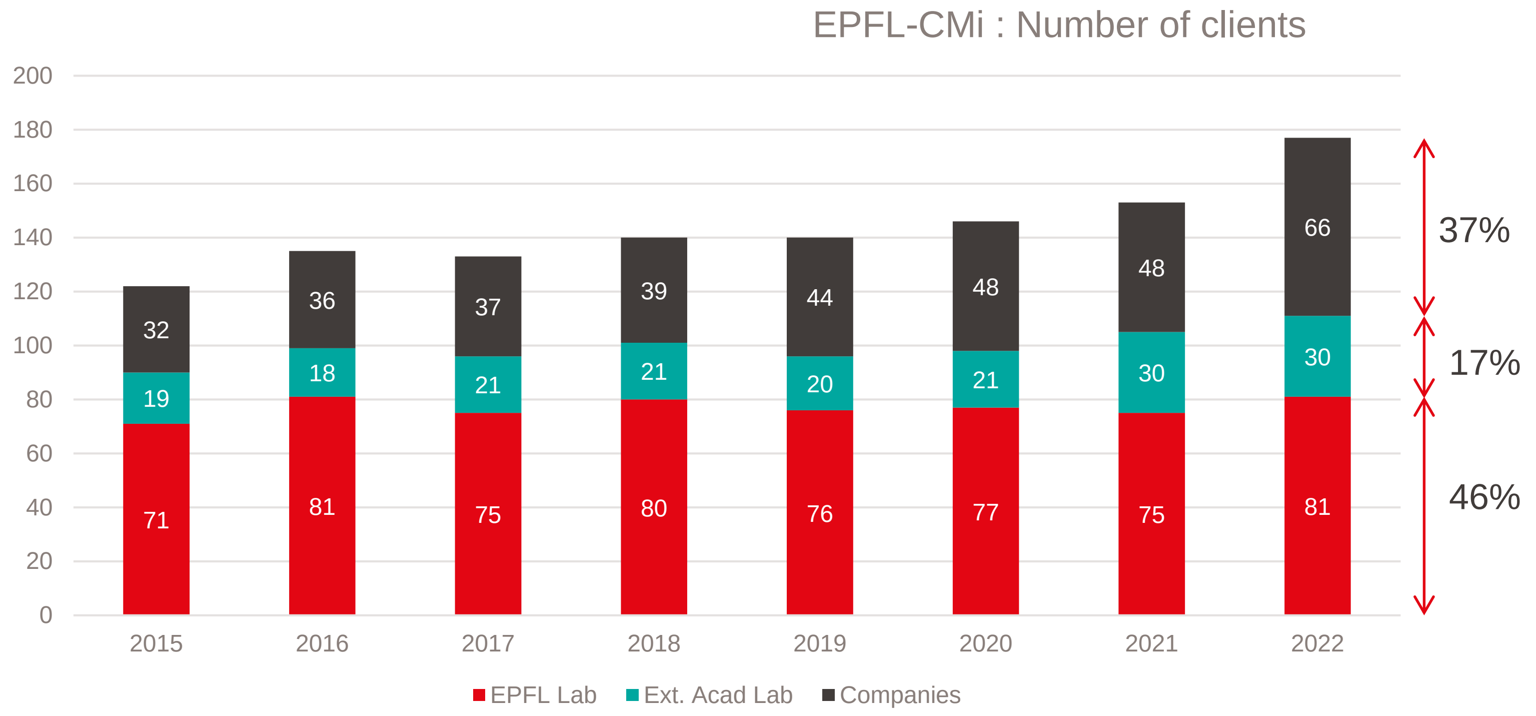
- Substantial increase of the number of users over the years
- User = Person who has made at least one transaction during the year

Users in 2022



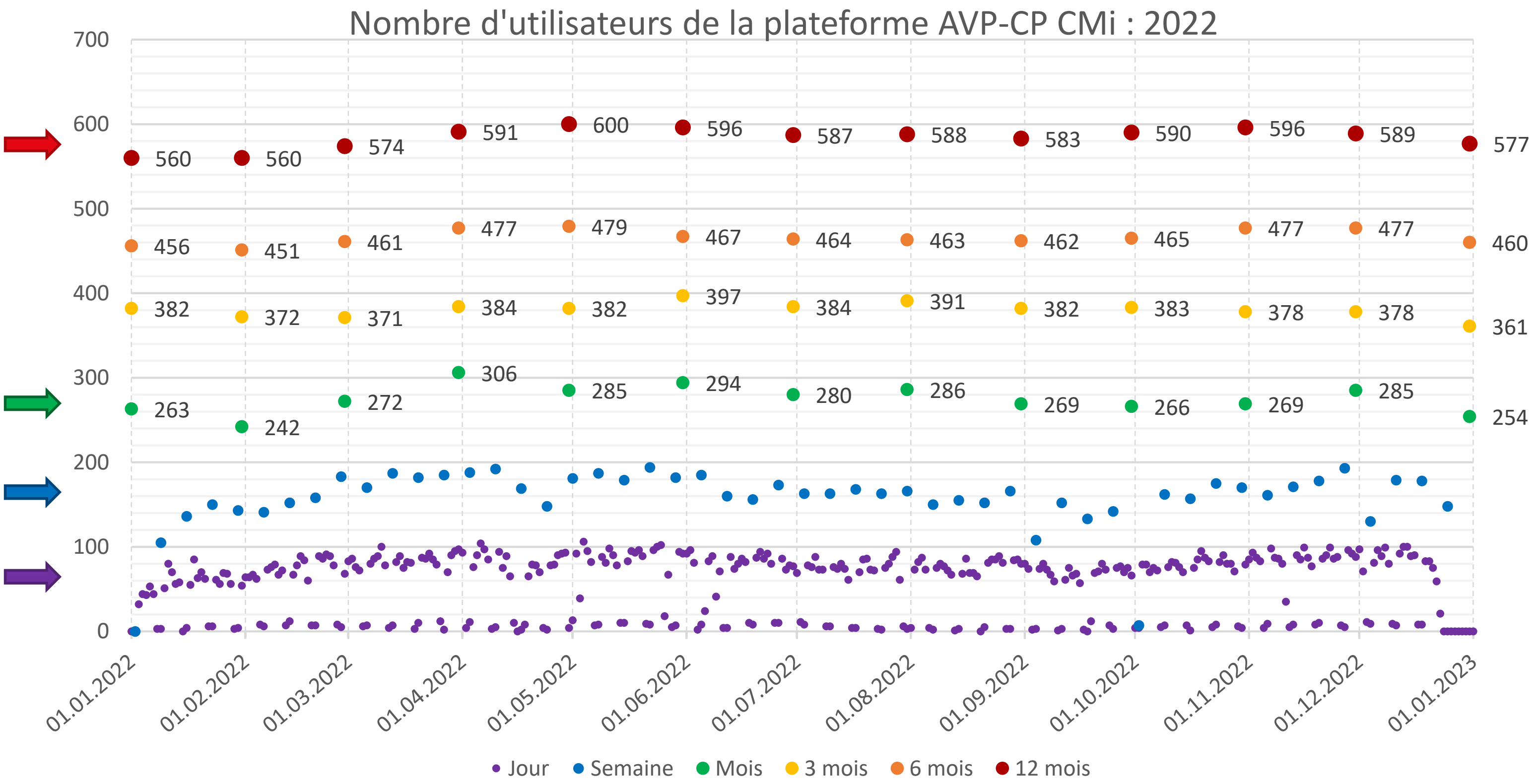
- 577 users in 2022
- EPFL : 76% Ext. Acad. : 6% Companies : 18%

Clients in 2022



- 177 clients in 2022 : Namely 81 EPFL Lab, 30 Ext Lab and 66 companies
- Client = EPFL Labs, External Academic Labs and Companies

Users in 2022



600 / 12 months

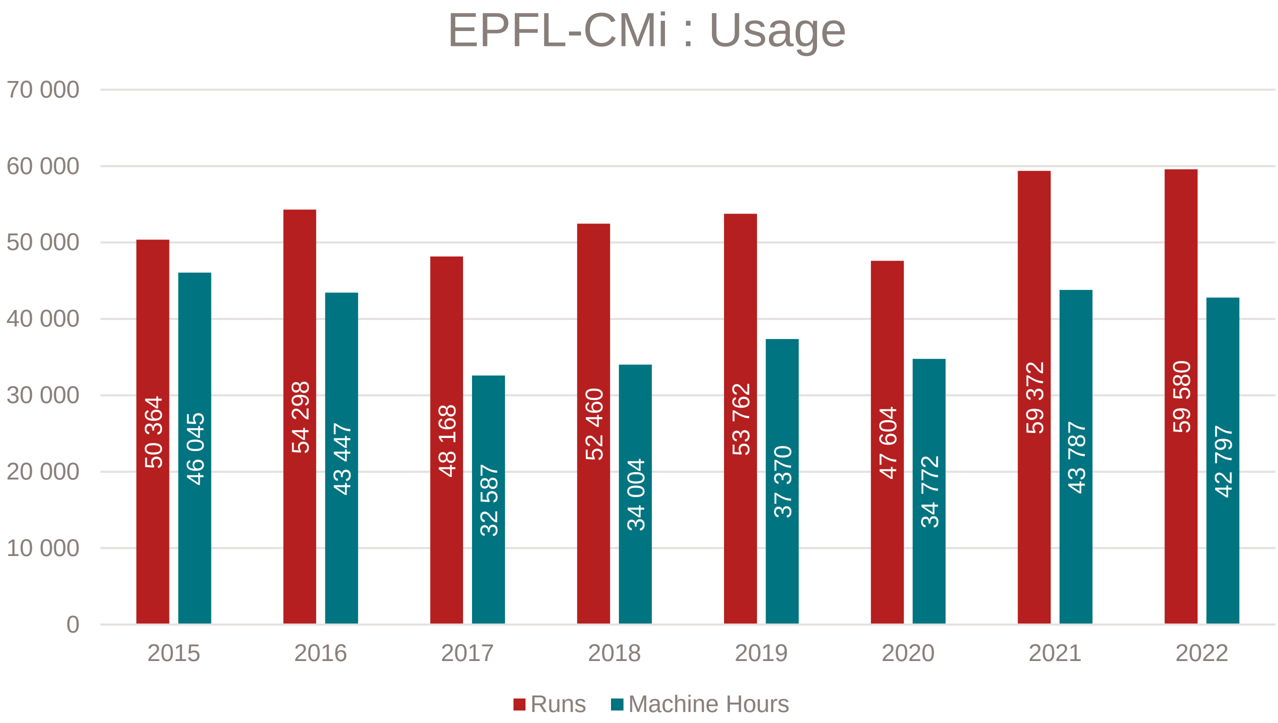
300 / month

200 / week

100 / day

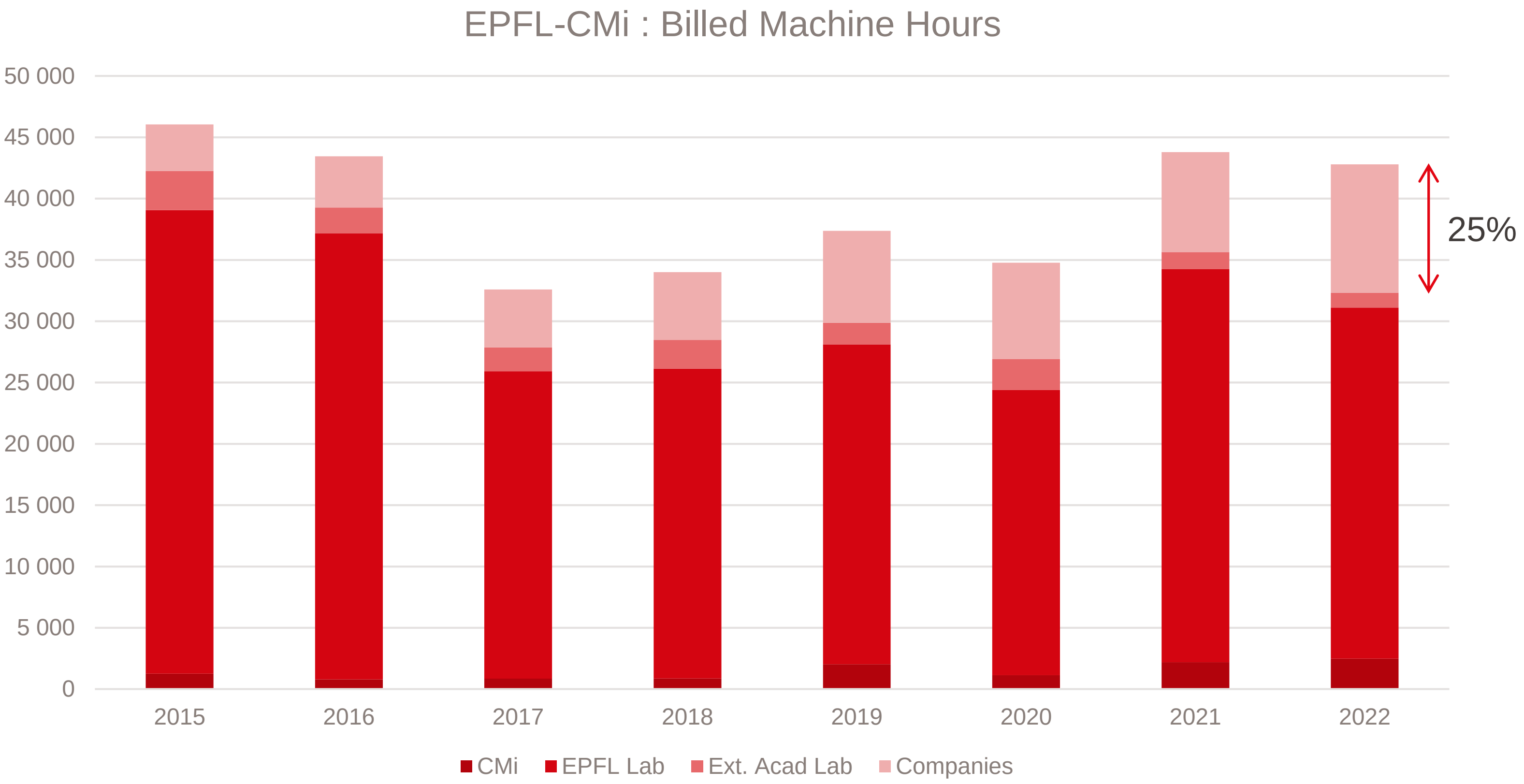
- Around 100 users per day, 200 per week, 300 per month and 600 per year.
- User = Person who has made at least one transaction during the year

Usage in 2022



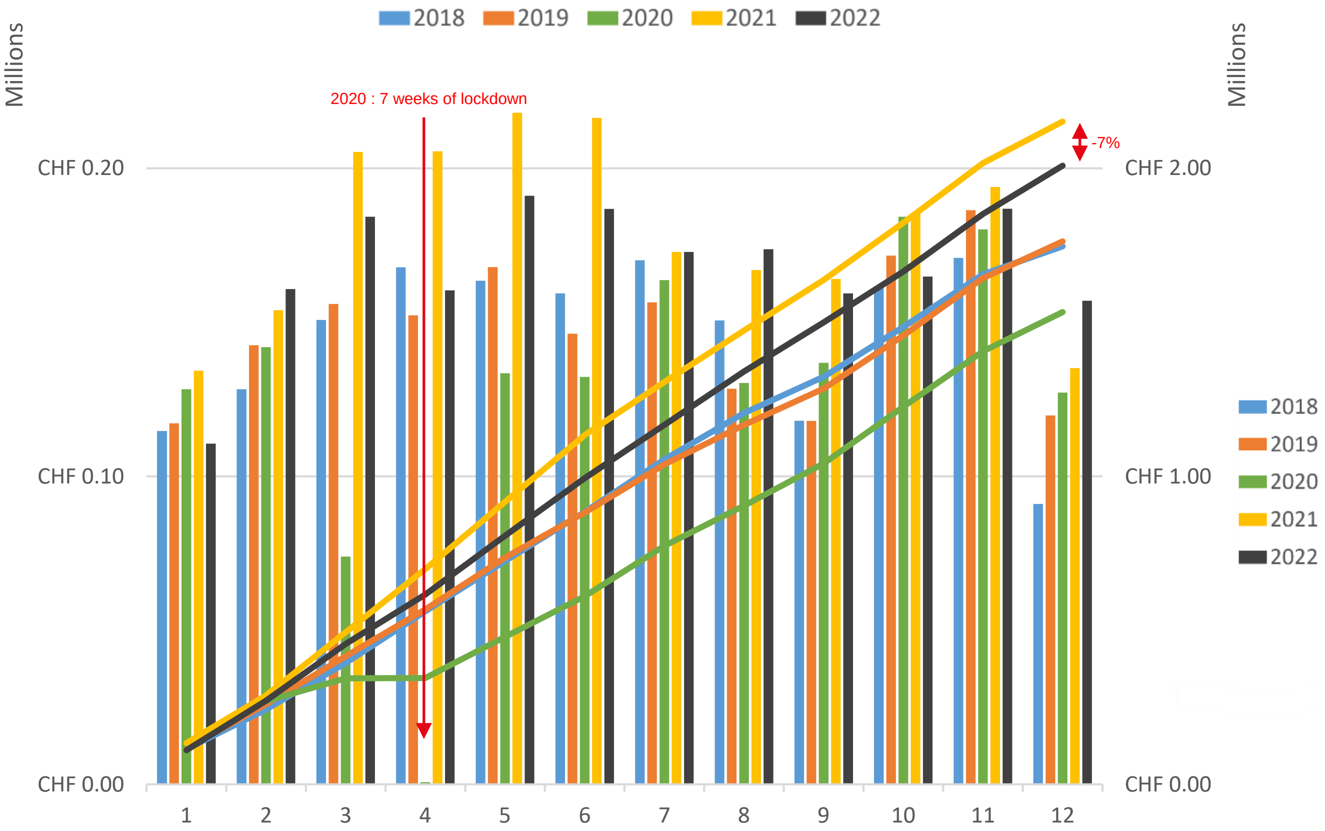
- The users generated 59’580 runs / 42’797 machine hours in 2022

Usage in 2022



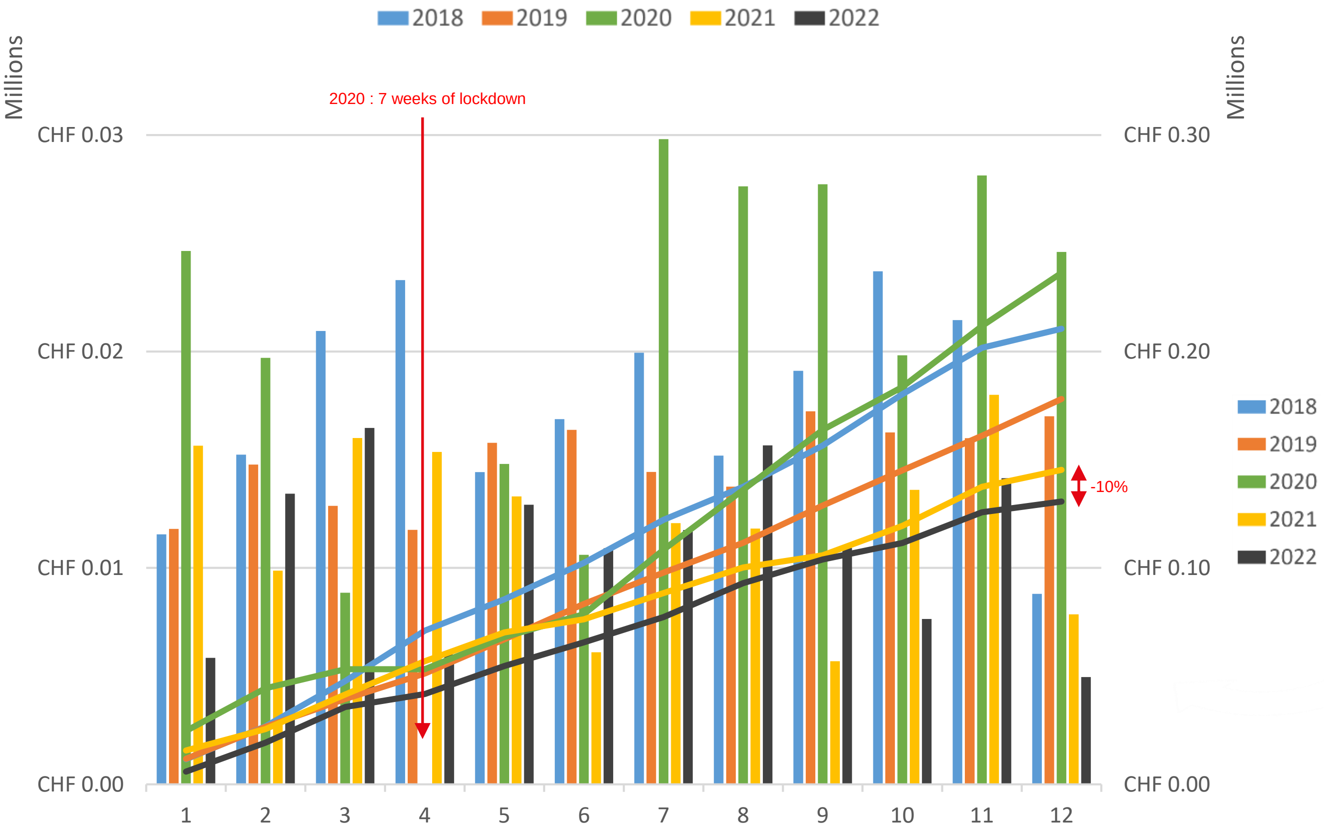
- Billed Machine Hours per client class
- 25% of the machine hours were billed to companies.

Invoicing to internal EPFL Users



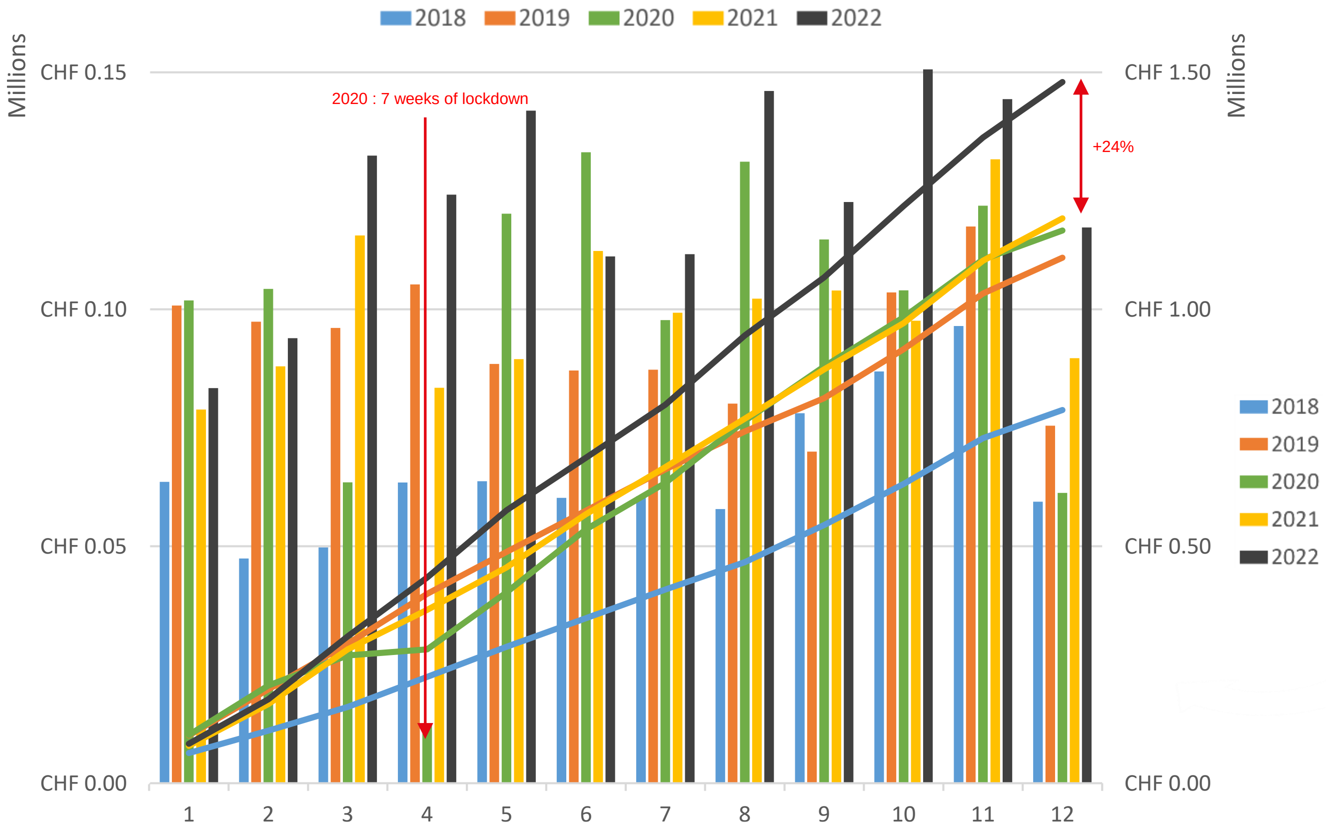
- Monthly invoicing to the users for the usage of the tools
- 2.01MCHF invoiced in 2022 to our internal EPFL users (56% of the total)

Invoicing to external academic Users



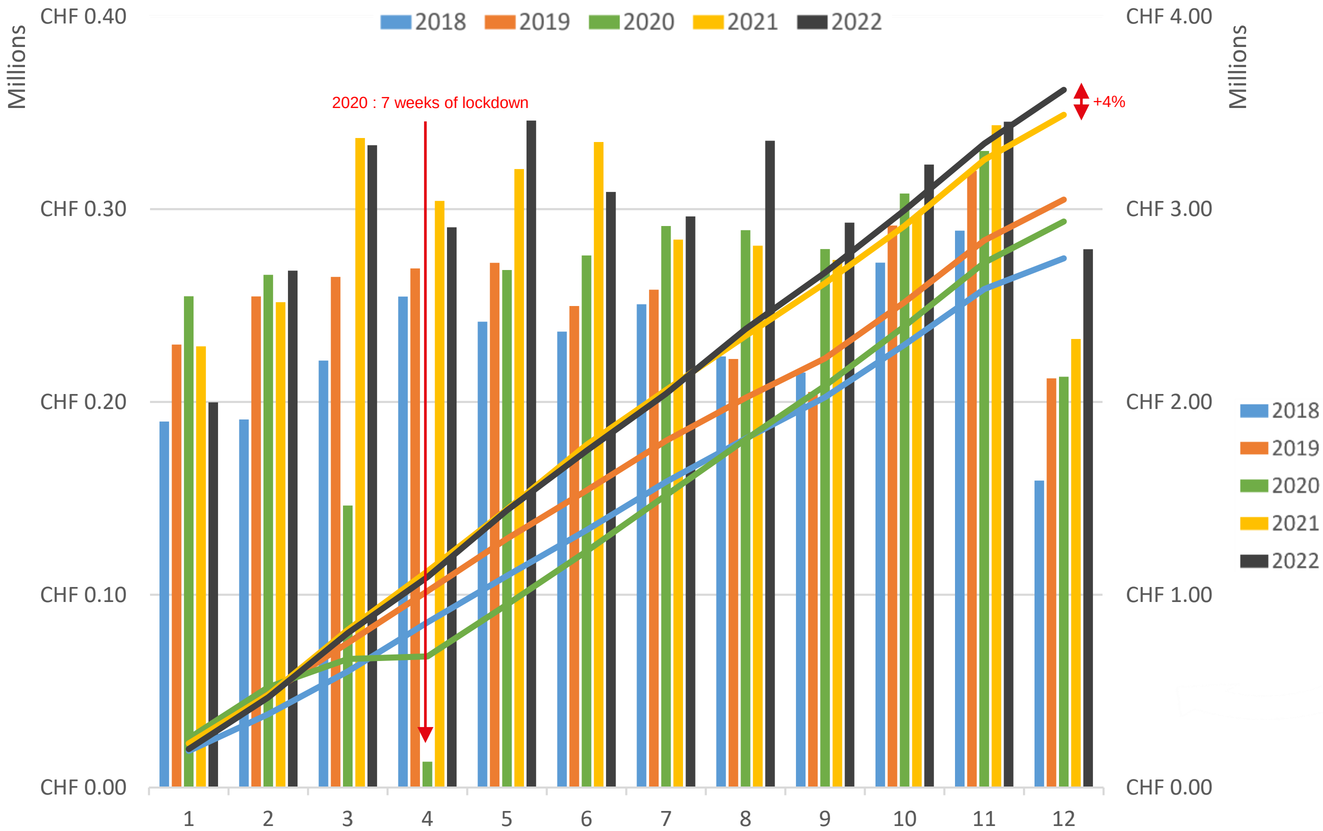
- 0.13MCHF invoiced in 2022 to our external academic users (4% of the total)

Invoicing to companies



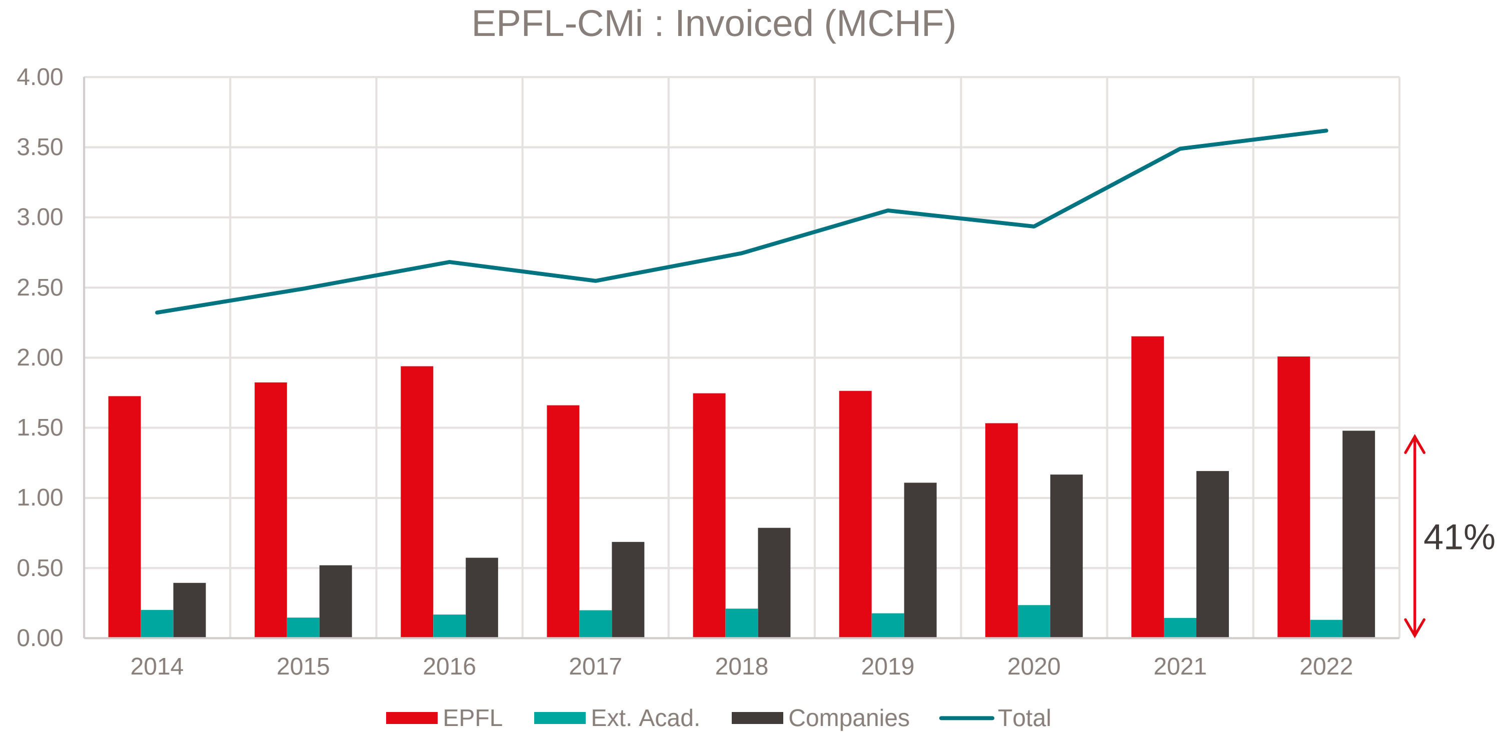
- 1.48MCHF invoiced in 2022 to our industrial users (41% of the total)

Total invoicing to all users



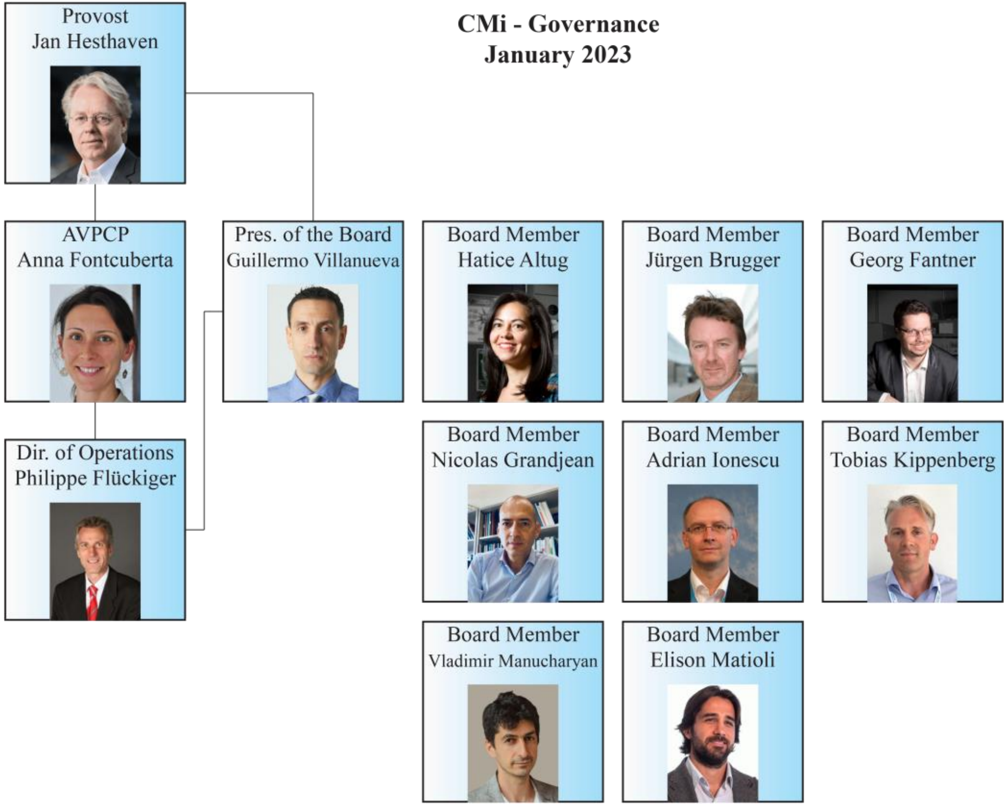
- 3.62MCHF invoiced in 2022 in total (+4% compared to 2021)

Invoicing in 2022



- Amount billed per client classes over the years
- Among the 3.62 MCHF invoiced in 2022, 41% were invoiced to companies

Governance



CMi - Governance
January 2023

Provost
Jan Hesthaven

AVPCP
Anna Fontcuberta

Dir. of Operations
Philippe Flückiger

Pres. of the Board
Guillermo Villanueva

Board Member
Hatice Altug

Board Member
Jürgen Brugger

Board Member
Georg Fantner

Board Member
Nicolas Grandjean

Board Member
Adrian Ionescu

Board Member
Tobias Kippenberg

Board Member
Vladimir Manucharyan

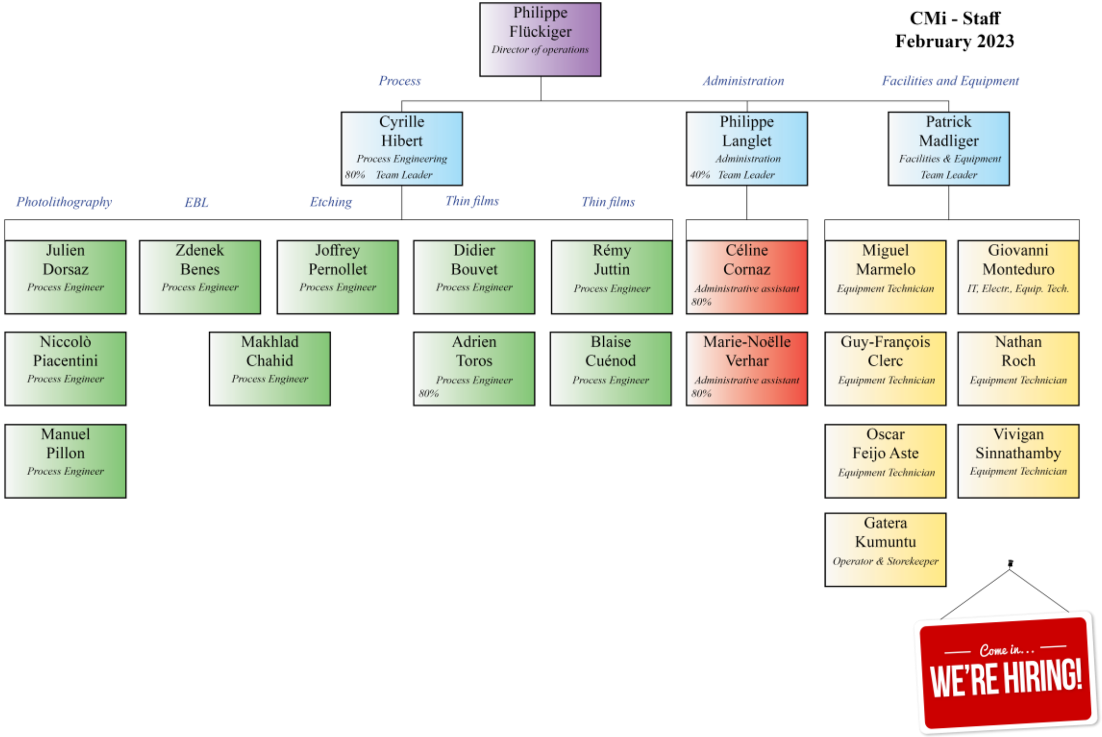
Board Member
Elison Matioli

Governance

- Since January 2021 the CMi reports to the Associate Vice President for Centers and Platforms and to the Vice-President for Academic Affairs.
- Our executive board is composed of 9 Professors including our president
- Members nominated for a period of 4 years from
  01.11.2018 until 31.10.2022
  01.11.2022 until 31.10.2026

- New Member : Prof. Vladimir Manucharyan
- New President of the board : Prof. Guillermo Villanuava

Staff



CMi - Staff
February 2023

Philippe Flückiger — *Director of operations*

Process

Cyrille Hibert — *Process Engineering* — *80% Team Leader*

Photolithography
- **Julien Dorsaz** — *Process Engineer*
- **Niccolò Piacentini** — *Process Engineer*
- **Manuel Pillon** — *Process Engineer*

EBL
- **Zdenek Benes** — *Process Engineer*

Etching
- **Joffrey Pernollet** — *Process Engineer*
- **Makhlad Chahid** — *Process Engineer*

Thin films
- **Didier Bouvet** — *Process Engineer*
- **Adrien Toros** — *Process Engineer* — *80%*

Thin films
- **Rémy Juttin** — *Process Engineer*
- **Blaise Cuénod** — *Process Engineer*

Administration

Philippe Langlet — *Administration* — *40% Team Leader*
- **Céline Cornaz** — *Administrative assistant* — *80%*
- **Marie-Noëlle Verhar** — *Administrative assistant* — *80%*

Facilities and Equipment

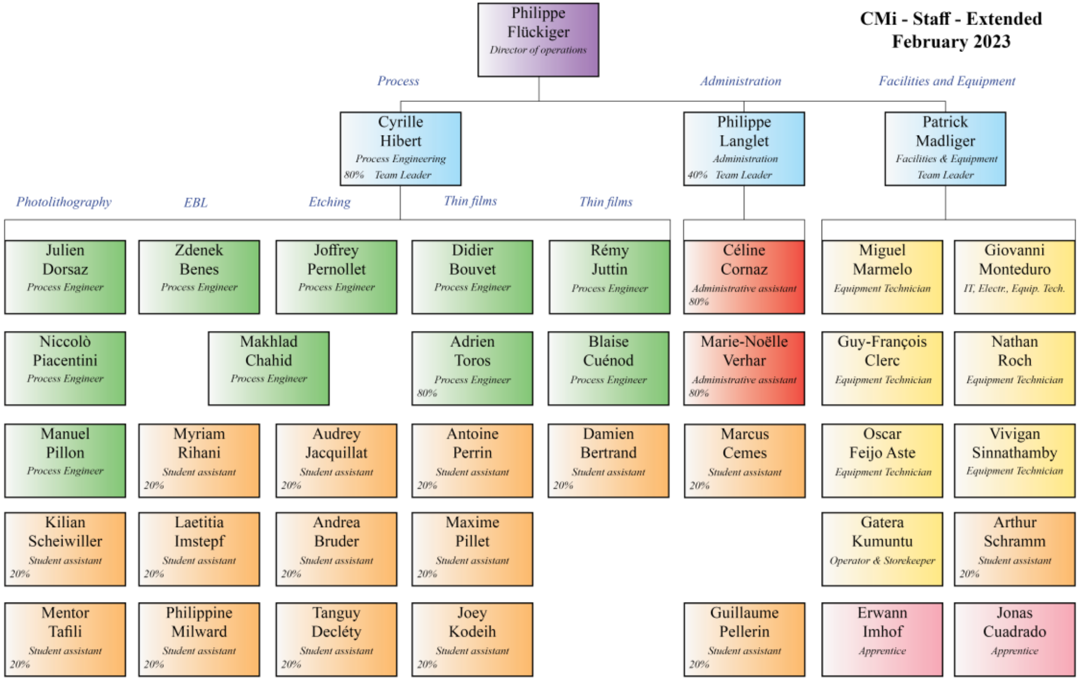
Patrick Madliger — *Facilities & Equipment* — *Team Leader*
- **Miguel Marmelo** — *Equipment Technician*
- **Giovanni Monteduro** — *IT, Electr., Equip. Tech.*
- **Guy-François Clerc** — *Equipment Technician*
- **Nathan Roch** — *Equipment Technician*
- **Oscar Feijo Aste** — *Equipment Technician*
- **Vivigan Sinnathamby** — *Equipment Technician*
- **Gatera Kumuntu** — *Operator & Storekeeper*

Staff

- Staff composed of 21.6 FTE employees
- We have plans to increase to 23.6 FTE employees by 2024 with 2 equipment engineers
- 5 employees are currently still under non-permanent positions
- Employ 14 student assistants (part time)
- Train 2 apprentices

- Our staff is specialized in Process / Administration / Facilities and Equipment

Staff



CMi - Staff - Extended
February 2023

Philippe Flückiger
Director of operations

Process
- **Cyrille Hibert**, *Process Engineering*, 80% Team Leader
  - *Photolithography*
    - Julien Dorsaz, *Process Engineer*
    - Niccolò Piacentini, *Process Engineer*
    - Manuel Pillon, *Process Engineer*
    - Kilian Scheiwiller, *Student assistant* 20%
    - Mentor Tafili, *Student assistant* 20%
  - *EBL*
    - Zdenek Benes, *Process Engineer*
    - Makhlad Chahid, *Process Engineer*
    - Myriam Rihani, *Student assistant* 20%
    - Laetitia Imstepf, *Student assistant* 20%
    - Philippine Milward, *Student assistant* 20%
  - *Etching*
    - Joffrey Pernollet, *Process Engineer*
    - Audrey Jacquillat, *Student assistant* 20%
    - Andrea Bruder, *Student assistant* 20%
    - Tanguy Decléty, *Student assistant* 20%
  - *Thin films*
    - Didier Bouvet, *Process Engineer*
    - Adrien Toros, *Process Engineer* 80%
    - Antoine Perrin, *Student assistant* 20%
    - Maxime Pillet, *Student assistant* 20%
    - Joey Kodeih, *Student assistant* 20%
  - *Thin films*
    - Rémy Juttin, *Process Engineer*
    - Blaise Cuénod, *Process Engineer*
    - Damien Bertrand, *Student assistant* 20%

Administration
- **Philippe Langlet**, *Administration*, 40% Team Leader
  - Céline Cornaz, *Administrative assistant* 80%
  - Marie-Noëlle Verhar, *Administrative assistant* 80%
  - Marcus Cemes, *Student assistant* 20%
  - Guillaume Pellerin, *Student assistant* 20%

Facilities and Equipment
- **Patrick Madliger**, *Facilities & Equipment*, Team Leader
  - Miguel Marmelo, *Equipment Technician*
  - Guy-François Clerc, *Equipment Technician*
  - Oscar Feijo Aste, *Equipment Technician*
  - Gatera Kumuntu, *Operator & Storekeeper*
  - Erwann Imhof, *Apprentice*
  - Giovanni Monteduro, *IT, Electr., Equip. Tech.*
  - Nathan Roch, *Equipment Technician*
  - Vivigan Sinnathamby, *Equipment Technician*
  - Arthur Schramm, *Student assistant* 20%
  - Jonas Cuadrado, *Apprentice*

Staff

- Staff composed of 21.6 FTE employees
- We have plans to increase to 23.6 FTE employees by 2024 with 2 equipment engineers
- 5 employees are currently still under non-permanent positions
- Employ 14 student assistants (part time)
- Train 2 apprentices

- The 14 student assistants play an important role in the daily operations
- They provide services and they perform training for the new users

New Tools

	Delivery	
1	2019	Spectro reflectometer Filmetrics
2	2019	Microscopes optiques Leica (7x)
3	2019	Upgrade IBE Veeco
4	2019	Système de mesure EM & vibrations
5	2019	DUV stepper ASML
6	2020	Post CMP cleaner GnP
7	2020	Critical Point dryer Tousimis
8	2021	Silicon etcher SPTS Rapier
9	2021	Profilomètre optique Contour-X 200 Bruker
10	2021	Coater/developer TEL ACT-8 cleantrack
11	2021	Système d'alignement Athena ASML
12	2021	Déménagement stepper ASML
13	2021	Prober MTI TS150
14	2021	Manual spin coater LSM150 Z13 Sawatec
15	2021	Rénovation SRD (4x) Peritest
16	2021	Polisseuse CMP2 Alpsitec
17	2021	UHV evaporator Plassys
18	2021	XeF2 Vapor etcher SPTS Xactix X4
19	2021	Automatic wire bonder F&S Bondtec
20	2022	Hottes solvants Herren
21	2022	Fours LPCVD Centrotherm
22	2022	Flash annealing system Rovak
23	2022	HMDS YES
24	2022	Spectro reflectometer Filmetrics
25	2022	Resistivity measurements Filmetrics
26	2022	ICP-PECVD Oxford
27	2022	PECVD Corial/Plasmatherm D250L
28	2022	PR stripper ESI
29	2022	PVD Cluster Alliance Concept
30	2022	Direct Writer MLA150
31	2022	Ellipsometer Woollam RC2
32	2022	Graveur metal Oxford PlasmaPro 100 Cobra
33	2022	Wafer Bonder EVG
34	2022	SEM Zeiss Merlin
35	2022	CVD diamant IPLAS
36	2022	FIB Zeiss Crossbeam
41	2022	SIMS IBE
42	2023	Profilomètre mécanique KLA P-17
43	2023	Coucheuse manuelle Sawatec 150 & 200
39	2023	Récupération sécurisée des solvants
46	2023	Dielectric etcher KLA SPTS Omega Synapse
37	2024	EBL2 Raith EBPG5200 Plus
38	2024	EBL1 Raith Upgrade of EBPG5000 PLus
40	2024	Evaporateur Joule Alliance Concept EVA 451
44	2024	Evaporateur Lift-off Bühler SYRUSpro 700 LT
45	2024	Coucheuse automatique EVG150

Electron beam lithography

- Second EBL tool is purchased
- Delivery in 2024
- EBPG5200 Plus
- advanced fracturing modes for lowest line-edge roughness
- 10-holder airlock
- with full 200-mm writing capability
- 200MHz when available
- + upgrade of EBL1, pattern generator 125MHz, 20 bit upgrade

- During these 6 years we are installing 45 new pieces of equipment !
- Not going through the whole list but focus on significant examples

New Tools

	Delivery	
1	2019	Spectro reflectometer Filmetrics
2	2019	Microscopes optiques Leica (7x)
3	2019	Upgrade IBE Veeco
4	2019	Système de mesure EM & vibrations
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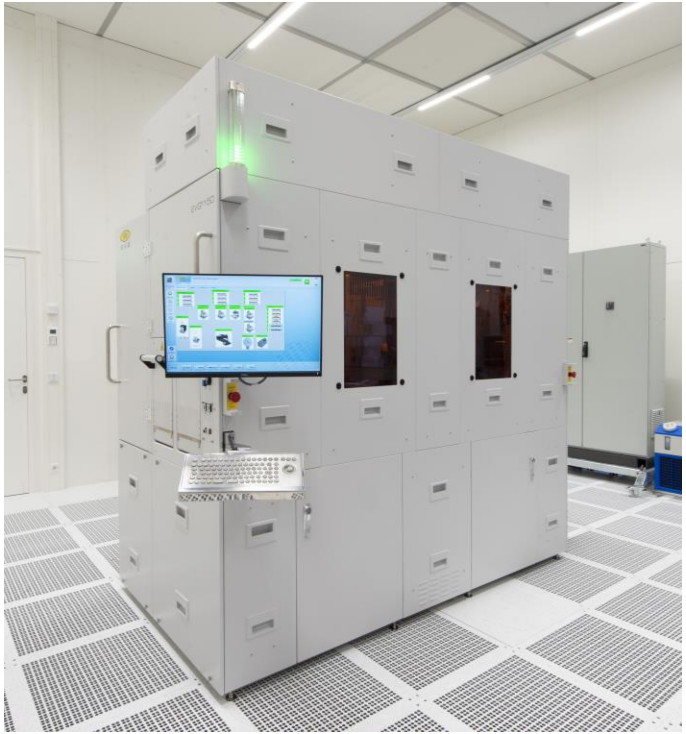
15	2021	Rénovation SRD (4x) Peritest
16	2021	Polisseuse CMP2 Alpsitec
17	2021	UHV evaporator Plassys
18	2021	XeF2 Vapor etcher SPTS Xactix X4
19	2021	Automatic wire bonder F&S Bondtec
20	2022	Hottes solvants Herren
21	2022	Fours LPCVD Centrotherm
22	2022	Flash annealing system Rovak
23	2022	HMDS YES
24	2022	Spectro reflectometer Filmetrics
25	2022	Resistivity measurements Filmetrics
26	2022	ICP-PECVD Oxford
27	2022	PECVD Corial/Plasmatherm D250L
28	2022	PR stripper ESI
29	2022	PVD Cluster Alliance Concept
30	2022	Direct Writer MLA150
31	2022	Ellipsometer Woollam RC2
32	2022	Graveur metal Oxford PlasmaPro 100 Cobra
33	2022	Wafer Bonder EVG
34	2022	SEM Zeiss Merlin
35	2022	CVD diamant IPLAS
36	2022	FIB Zeiss Crossbeam
41	2022	SIMS IBE
42	2023	Profilomètre mécanique KLA P-17
43	2023	Coucheuse manuelle Sawatec 150 & 200
39	2023	Récupération sécurisée des solvants
46	2023	Dielectric etcher KLA SPTS Omega Synapse
37	2024	EBL2 Raith EBPG5200 Plus
38	2024	EBL1 Raith Upgrade of EBPG5000 PLus
40	2024	Evaporateur Joule Alliance Concept EVA 451
44	2024	Evaporateur Lift-off Bühler SYRUSpro 700 LT
45	2024	Coucheuse automatique EVG150



Coater Developer

- EVG 150
- Tooled for 100mm and 150mm
- 3 coating modules
- 4 low viscosity lines
- 4 medium/high viscosity lines
- 4 lift-off underlayer lines
- 8 hotplates
- 3 chill plates
- 1 HMDS
- 1 developer station with 3 lines

- A new coater developer is purchased for photolithography
- To be delivered in Q1 2024

New Tools

	Delivery	
1	2019	Spectro reflectometer Filmetrics
2	2019	Microscopes optiques Leica (7x)
3	2019	Upgrade IBE Veeco
4	2019	Système de mesure EM & vibrations
5	2019	DUV stepper ASML
6	2020	Post CMP cleaner GnP
7	2020	Critical Point dryer Tousimis
8	2021	Silicon etcher SPTS Rapier
9	2021	Profilomètre optique Contour-X 200 Bruker
10	2021	Coater/developer TEL ACT-8 cleantrack
11	2021	Système d'alignement Athena ASML
12	2021	Déménagement stepper ASML
13	2021	Prober MTI TS150
14	2021	Manual spin coater LSM150 Z13 Sawatec
15	2021	Rénovation SRD (4x) Peritest
16	2021	Polisseuse CMP2 Alpsitec
17	2021	UHV evaporator Plassys
18	2021	XeF2 Vapor etcher SPTS Xactix X4
19	2021	Automatic wire bonder F&S Bondtec
20	2022	Hottes solvants Herren
21	2022	Fours LPCVD Centrotherm
22	2022	Flash annealing system Rovak
23	2022	HMDS YES
24	2022	Spectro reflectometer Filmetrics
25	2022	Resistivity measurements Filmetrics
26	2022	ICP-PECVD Oxford
27	2022	PECVD Corial/Plasmatherm D250L
28	2022	PR stripper ESI
29	2022	PVD Cluster Alliance Concept
30	2022	Direct Writer MLA150
31	2022	Ellipsometer Woollam RC2
32	2022	Graveur metal Oxford PlasmaPro 100 Cobra
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45	2024	Coucheuse automatique EVG150

PVD Lift-off evaporator

- Bühler SYRUSpro 700 LT
- source to substrate distance is 1330mm
- Chamber inner dimensions: 700mm x 700mm
- Chamber inner height: Approximately 1550 mm
- RF 80 ion source

- EVA 760 : 450 350 250 mm
- LAB 600H : 1010 630 mm

- A new lift-off evaporator is purchased
- To be delivered in Q1 2024

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PVD Thermal Evaporator

- Alliance Concept EVA 451
- with load lock
- 4 sources
- cryogenic pump

- A new thermal evaporator is purchased. To be delivered in Q1 2024.
- Appropriate to deposit conductive layers for eliminating charges during EBL

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Dry etching of dielectrics

- SPTS Synapse
- O2, SF6, Ar, N2, C4F8, He, CHF3 and H2 or CH4

- New dielectric etcher is purchased. To be delivered end of 2023.
- To separate metal free dielectric etching and to offer more capacity

New Tools

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Dry etching of metal

- Oxford PlasmaPro 100 Cobra
- BCl3 (heated), HBr, Cl2, CF4, O2, O2 Ar, SF6
- To replace our >25 old etcher

- Dry etching of metal was delivered on 16 March 2023

New Tools

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45	2024	Coucheuse automatique EVG150

PECVD thin films

- Corial D-250L
- SiOx, SiN, SiC, aSi and aC films

- PECVD thin films deposition delivered on 31 March 2023

New Tools

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1	2019	Spectro reflectometer Filmetrics
2	2019	Microscopes optiques Leica (7x)
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45	2024	Coucheuse automatique EVG150

Wafer Bonder

- EVG 810/301/610/510
- 1x plasma activation
- 1x single wafer cleaning
- 1x optical alignment
- 1x bonding

- A set of 4 tools dedicated to wafer bonding to be delivered on May 4th 2023

New Tools

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1	2019	Spectro reflectometer Filmetrics
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Mechanical Profiler

- KLA Tencor-P17
- Stylus profiler

- Mechanical profiler delivered on 30 March 2023

New Tools

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2	2019	Microscopes optiques Leica (7x)
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CVD diamond

- 100mm wafers
- Upgrade ongoing for safety
- H2, B2H6, PH3
- Acceptance in discussion

- CVD diamond was delivered in October 2022

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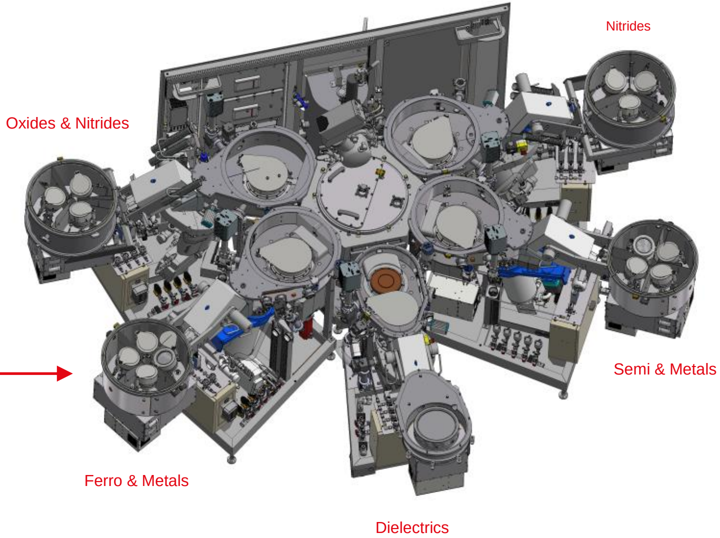

PVD Cluster Tool

- Alliance Concept CT-200
- 5 chambers
- Oxides & nitrides (3x100mm)
- Ferro & metals (4x100mm)
- Dielectrics (1x250mm)
- Nitrides (3x100mm)
- Semi & metals (4x100mm)

- A new PVD Cluster Tool with 5 chambers delivered 23 September 2022

New Tools

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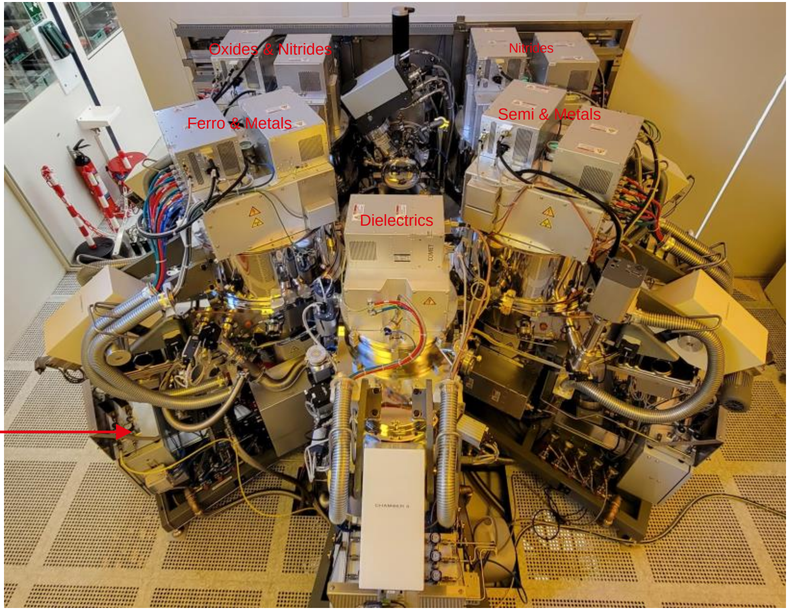
26	2022	ICP-PECVD Oxford
27	2022	PECVD Corial/Plasmatherm D250L
28	2022	PR stripper ESI
29	2022	PVD Cluster Alliance Concept
30	2022	Direct Writer MLA150
31	2022	Ellipsometer Woollam RC2
32	2022	Graveur metal Oxford PlasmaPro 100 Cobra
33	2022	Wafer Bonder EVG
34	2022	SEM Zeiss Merlin
35	2022	CVD diamant IPLAS
36	2022	FIB Zeiss Crossbeam
41	2022	SIMS IBE
42	2023	Profilomètre mécanique KLA P-17
43	2023	Coucheuse manuelle Sawatec 150 & 200
39	2023	Récupération sécurisée des solvants
46	2023	Dielectric etcher KLA SPTS Omega Synapse
37	2024	EBL2 Raith EBPG5200 Plus
38	2024	EBL1 Raith Upgrade of EBPG5000 PLus
40	2024	Evaporateur Joule Alliance Concept EVA 451
44	2024	Evaporateur Lift-off Bühler SYRUSpro 700 LT
45	2024	Coucheuse automatique EVG150



PVD Cluster Tool

- Alliance Concept CT-200
- 5 chambers
- Oxides & nitrides (3x100mm)
- Ferro & metals (4x100mm)
- Dielectrics (1x250mm)
- Nitrides (3x100mm)
- Semi & metals (4x100mm)

- A new PVD Cluster Tool with 5 chambers is currently under acceptance tests

New Tools

	Delivery	
1	2019	Spectro reflectometer Filmetrics
2	2019	Microscopes optiques Leica (7x)
3	2019	Upgrade IBE Veeco
4	2019	Système de mesure EM & vibrations
5	2019	DUV stepper ASML
6	2020	Post CMP cleaner GnP
7	2020	Critical Point dryer Tousimis
8	2021	Silicon etcher SPTS Rapier
9	2021	Profilomètre optique Contour-X 200 Bruker
10	2021	Coater/developer TEL ACT-8 cleantrack
11	2021	Système d'alignement Athena ASML
12	2021	Déménagement stepper ASML
13	2021	Prober MTI TS150
14	2021	Manual spin coater LSM150 Z13 Sawatec
15	2021	Rénovation SRD (4x) Peritest
16	2021	Polisseuse CMP2 Alpsitec
17	2021	UHV evaporator Plassys
18	2021	XeF2 Vapor etcher SPTS Xactix X4
19	2021	Automatic wire bonder F&S Bondtec
20	2022	Hottes solvants Herren
21	2022	Fours LPCVD Centrotherm
22	2022	Flash annealing system Rovak
23	2022	HMDS YES
24	2022	Spectro reflectometer Filmetrics
25	2022	Resistivity measurements Filmetrics
26	2022	ICP-PECVD Oxford
27	2022	PECVD Corial/Plasmatherm D250L
28	2022	PR stripper ESI
29	2022	PVD Cluster Alliance Concept
30	2022	Direct Writer MLA150
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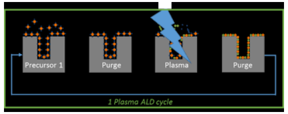
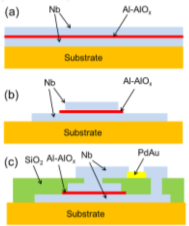
45	2024	Coucheuse automatique EVG150
46	2024	ALD for SC nitrides NbN NbTiN
47	2024	UHV Sputter Nb/Al-AlOx/Nb
48	2024	UHV evaporation chamber for SC
49	2024	Chip to wafer bonder
50	2024	Nanoimprint (thermal and uv) tool
51	2024	Etcher 1 for quantum materials
52	2024	Etcher 2 for quantum materials





Schematic overview of the JJ fabrication process.

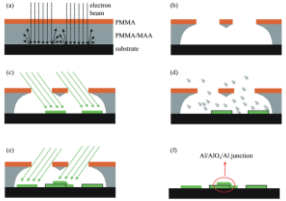


Fig. 2. (color online) Schematics of Al/AlO$_x$/Al junction Dolan bridge shadow evaporation fabrication process. (a) Electron beam writing, (b) development, (c) first aluminum layer evaporation, (d) oxidation, (e) second aluminum layer evaporation, (f) liftoff.

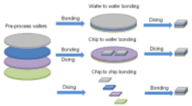
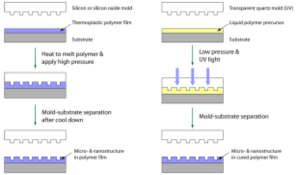


Figure 3. Different bonding technologies for 3D Integration circuit according to fabrication approach.

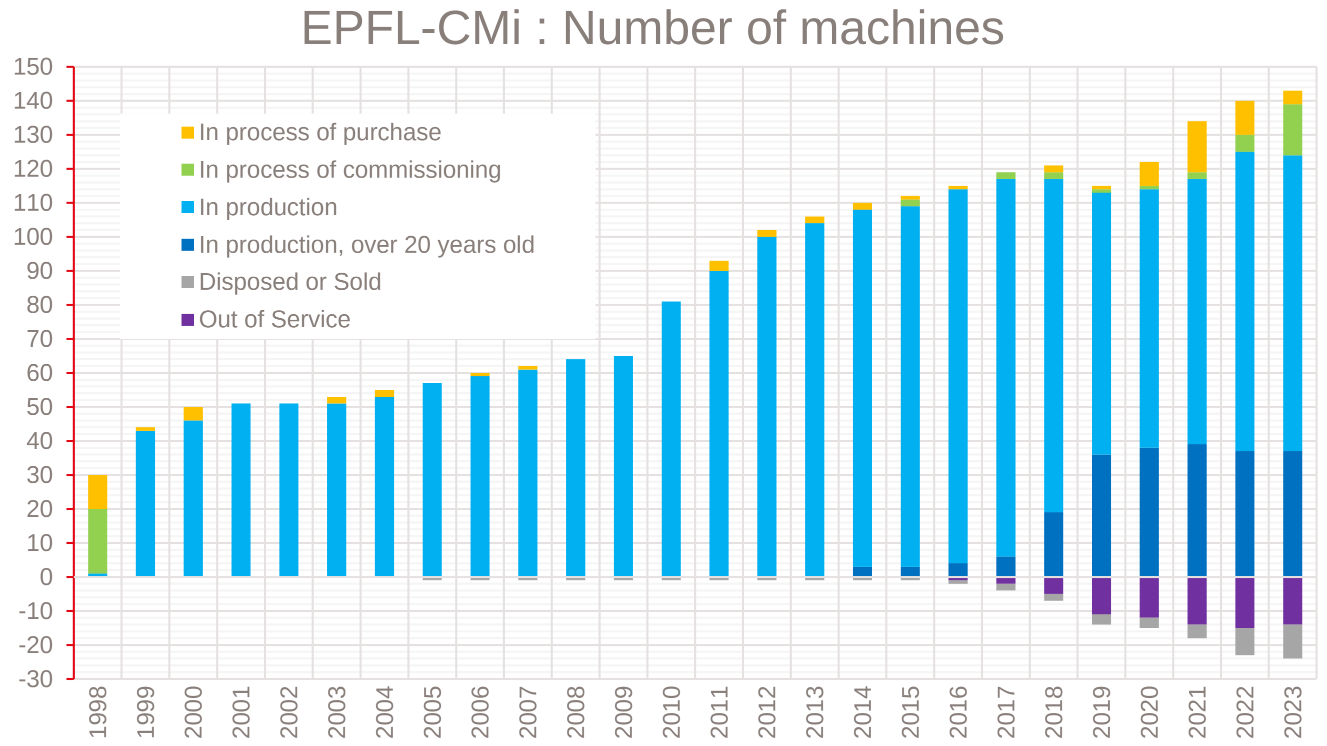


- 7 new projects are initiated in 2023

New projects

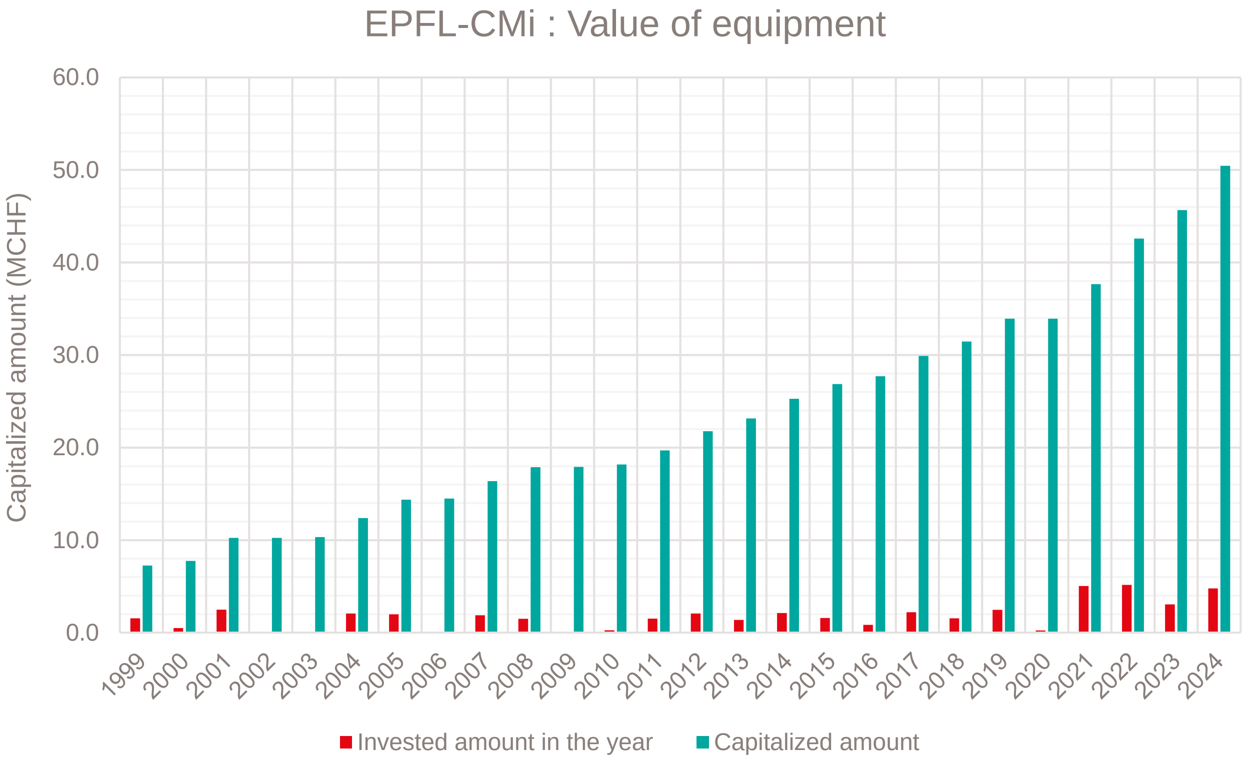
- ALD for SC nitrides NbN NbTiN
- UHV Sputter for Nb/Al-AlOx/Nb
- UHV evaporator for Al/Al2Ox/Al (our second tool of this kind)
- Chip to wafer bonder
- Thermal and uv Nanoimprint tool
- 2x RIE etchers for quantum mat.

New Tools



- 125 machines in production in 2022
- 19 machines in process of commissioning or purchase in the beginning of 2023

New Tools

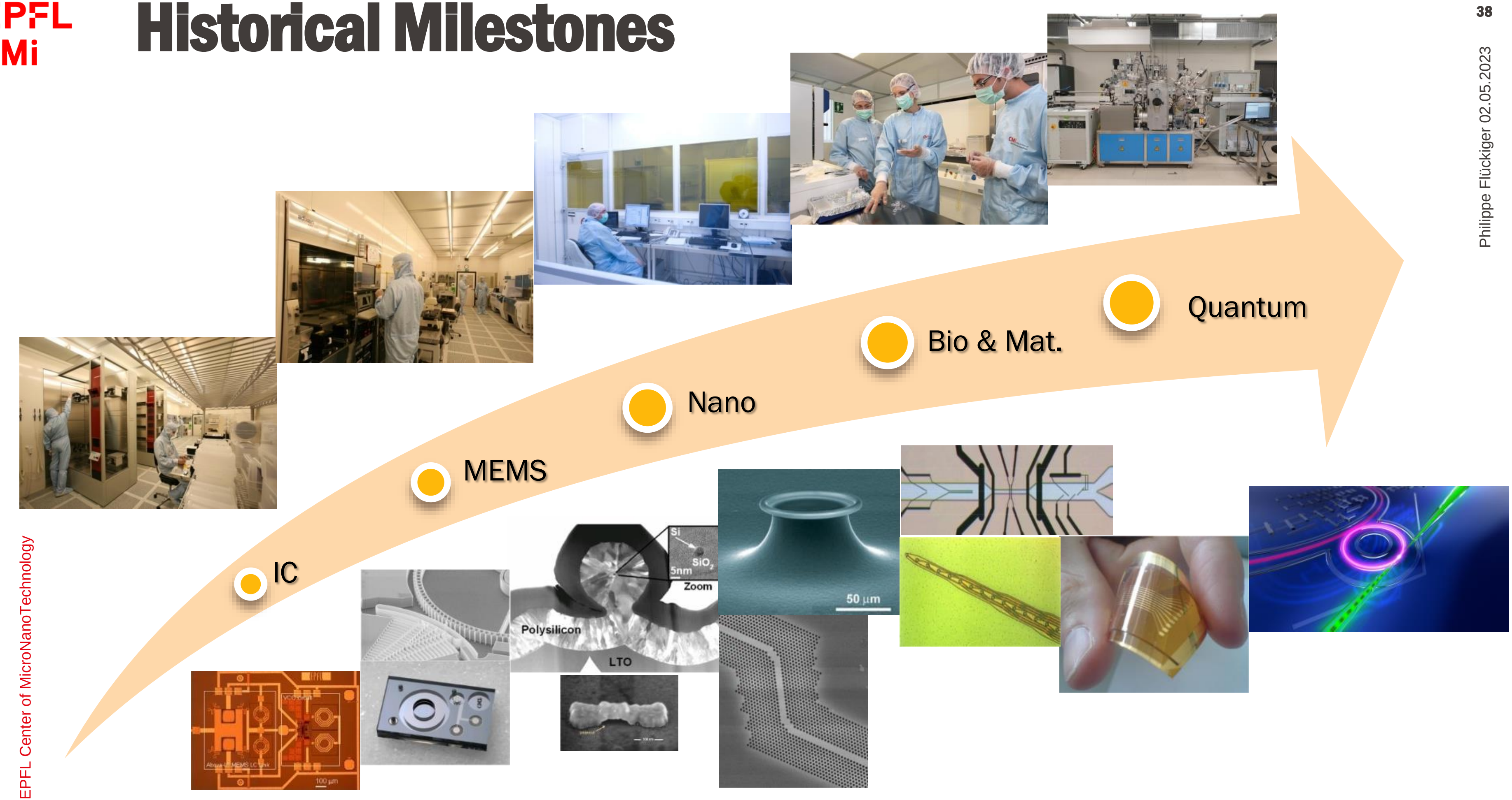


- The value of the equipment reaches 50.4MCHF (purchase price)
- 18.7 MCHF were granted over the last 4 years (2020-2023)

Historical Milestones

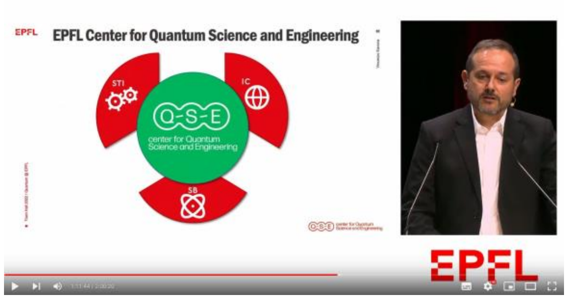
Microelectronics & MEMS 1998	• CMi created in 1998 & Cleanroom opened in March 1999 • Basic Microelectronics processes • MEMS processes like **Deep silicon etching**, **SU-8**
Nano 2005	• **Electron Beam Lithography** ordered in december in 2005 • Focused Ion Beam ordered in september 2003 • Atomic Layer Deposition in 2011
Cleanroom extension 24/7 2010	• Cleanroom extension opened in 2010 for **more flexibility** and cheaper access • **Operated now in 24/7 mode** since 2012 • **PDMS**, SU-8, Chemistry, Metrology, Non-conventional processes
Materials Diversity 2013	• **Ion Beam Etching**, PVD, ALD, PLD, Dry Etching • Chemistry • Photolithography: Mask Fabrication, Coater & Developer, Mask Aligner
DUV Stepper lithography 2019	• **DUV stepper** • Renewal of aging tools & Adding new capabilities • Envision the acquisition of a second EBEAM at the horizon of 2022
Renewal & Broadening 2019	• Deep Si etcher - XeF2 etcher - CMP - Post CMP Cleaner - Super Critical Dryer - Metal etcher • **PVD Cluster** - LPCVD furnaces - PECVD - Flash Lamp Annealing - Direct Writer • **Wafer bonding** - CVD diamond - Optical Profiler - SEM - Ellipsometer
Quantum Science & Engineering 2022	• UHV evaporator (2x) for **Josephson Junctions** - UHV sputter for **Josephson Junctions** - ALD for SC • Second electron beam lithography system

Historical Milestones

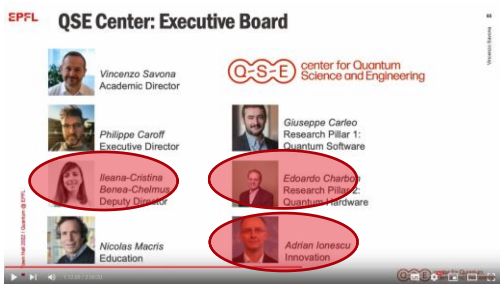


- Broadening the CMi offer and the CMi users base along the time by incorporating

Historical Milestones



EPFL Center for Quantum Science and Engineering



QSE Center: Executive Board

Vincenzo Savona
Academic Director

Philippe Caroff
Executive Director

Ileana-Cristina Benea-Chelmus
Deputy Director

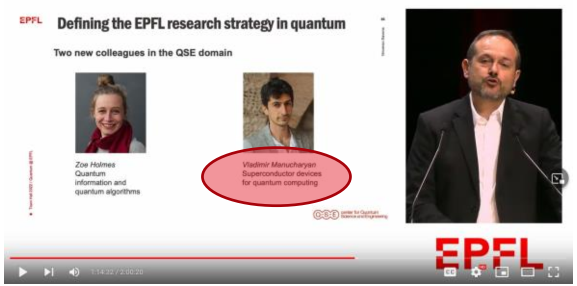
Nicolas Macris
Education

Q-S-E center for Quantum Science and Engineering

Giuseppe Carleo
Research Pillar 1: Quantum Software

Edoardo Charbon
Research Pillar 2: Quantum Hardware

Adrian Ionescu
Innovation

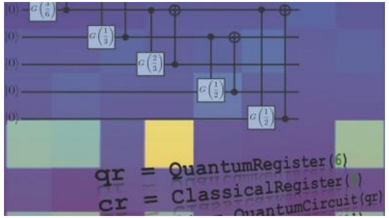


Defining the EPFL research strategy in quantum

Two new colleagues in the QSE domain

Zoe Holmes
Quantum information and quantum algorithms

Vladimir Manucharyan
Superconductor devices for quantum computing



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cr = ClassicalRegister(
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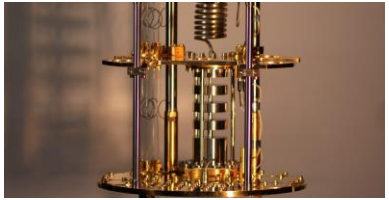
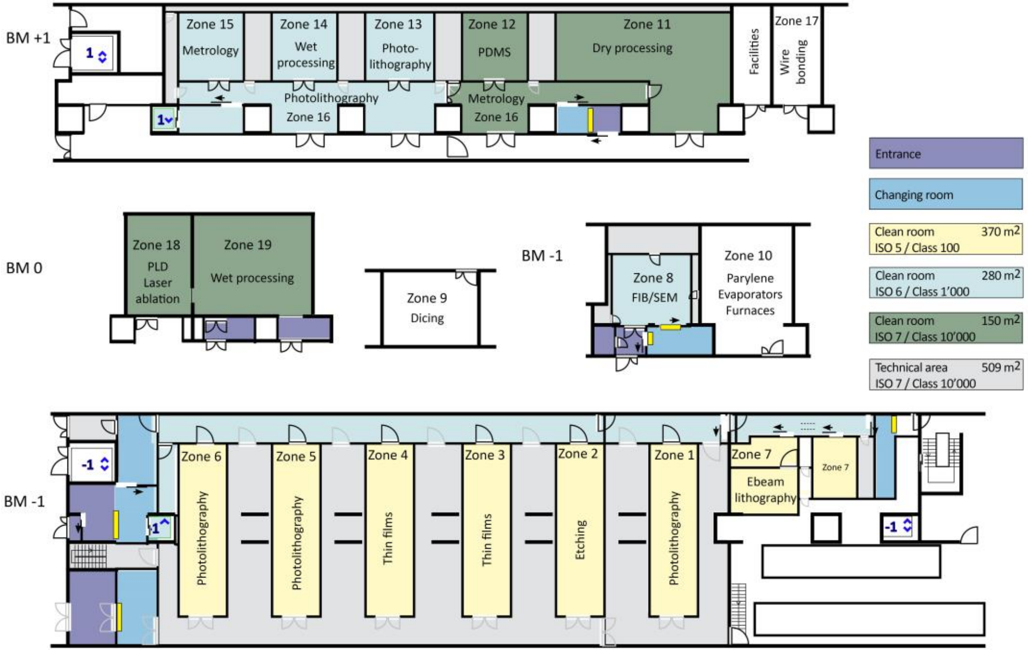


QSE at EPFL

- Created in 2022
- Two research pillars :
- Research Pillar I: Applied quantum algorithms and data science
- Research Pillar II: Quantum hardware materials and systems
- Pillar 2 will be leveraging the advanced nanofabrication facilities present on campus

- EPFL Center for quantum Science and Engineering created in 2022
- An important axis of development for CMi

Cleanroom

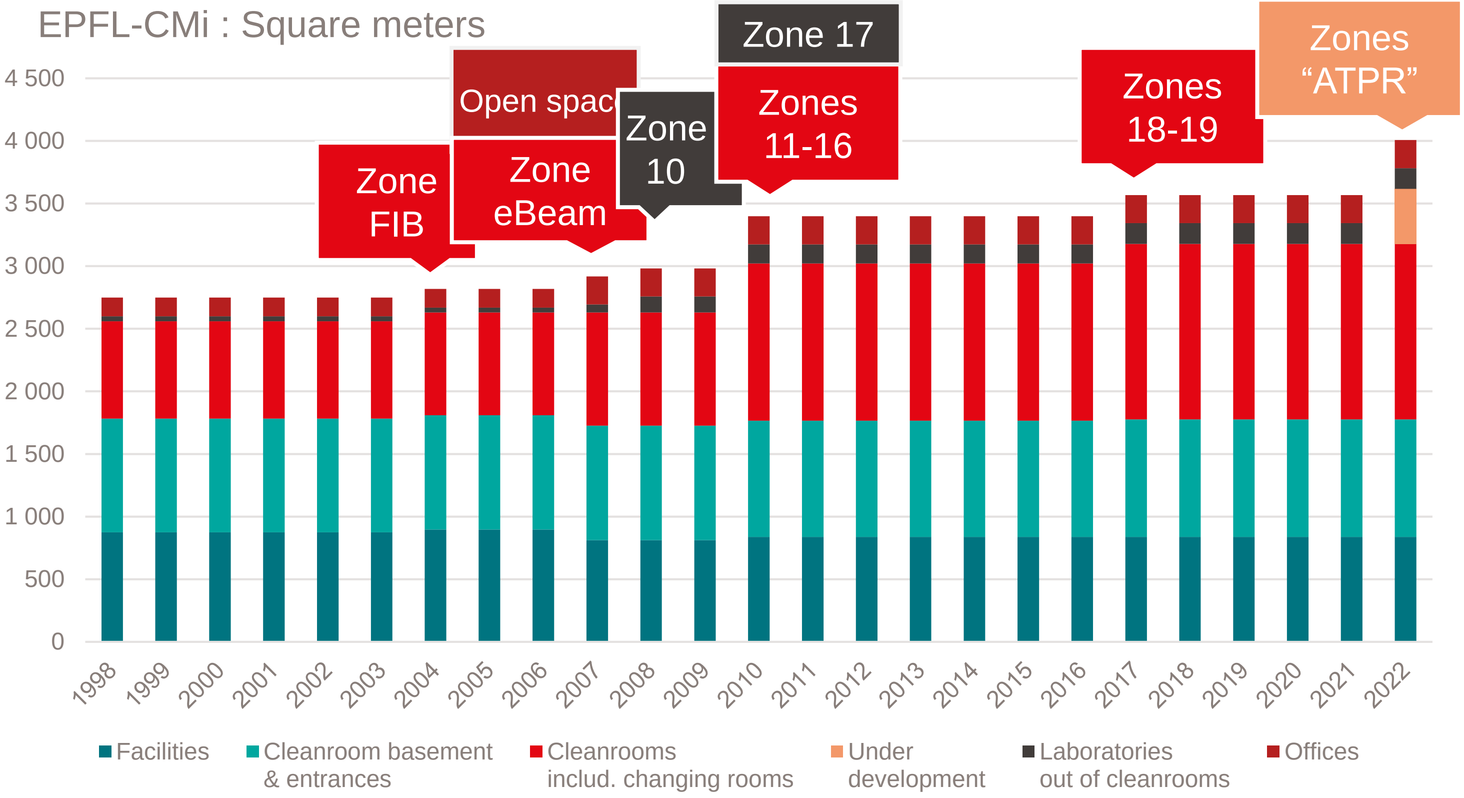


Initial surface BM-1 (1998)	900m^2
Extension BM+1 (2010)	350m^2
Extension BM0 (2017)	150m^2
Extension BM0 (2024)	440m^2
Total Surface	1840m^2

- Space is a concern
- 2023: Transform the space received from the STI at level BM0 into a cleanroom

Cleanroom

4'010 m²

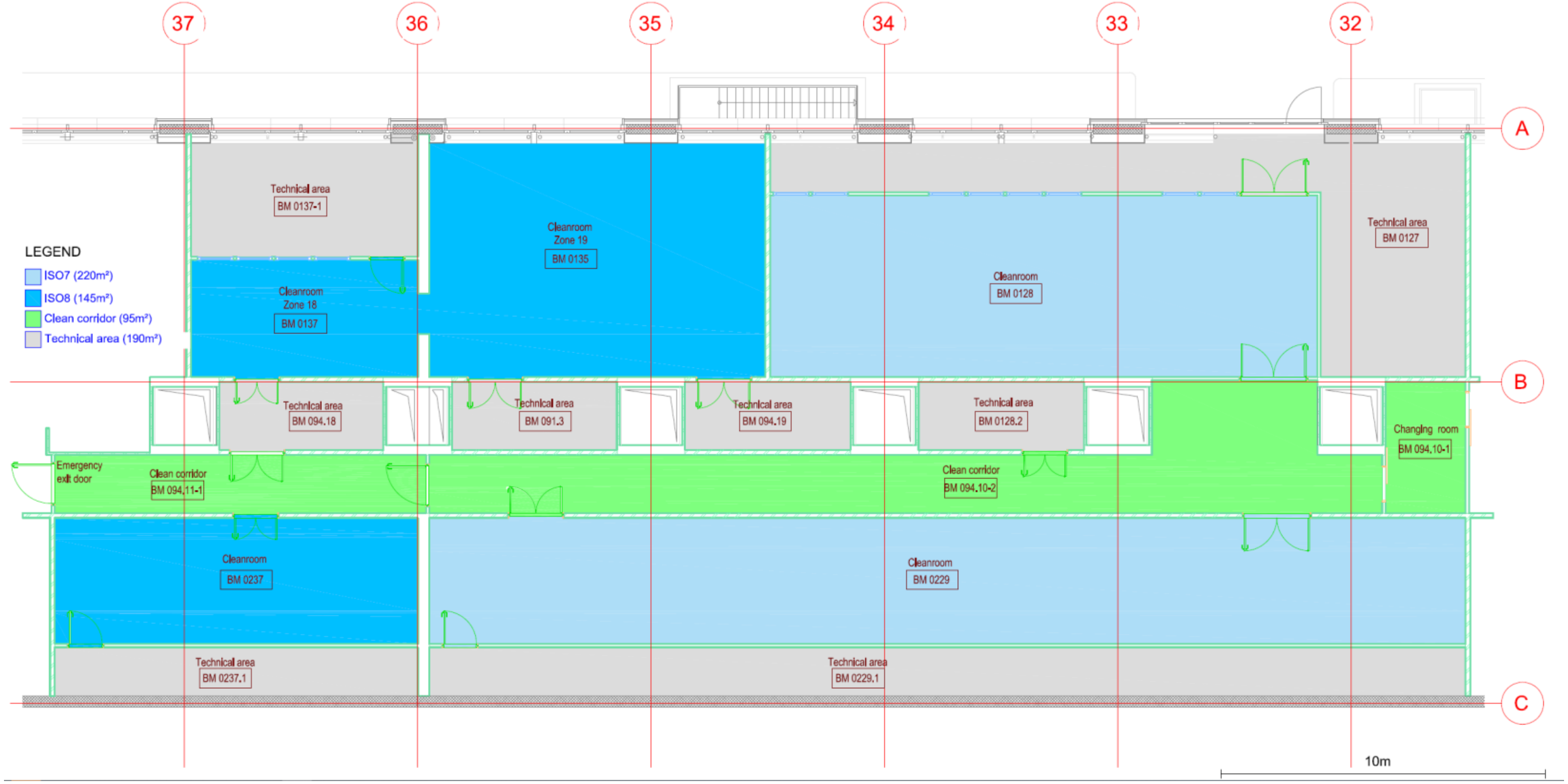


- 1'400 m2 of CR + 440 m2 under development + 165 m2 of standard labs
- 1'780 m2 of facilities, basement & entrances + 225 m2 of offices

Cleanroom

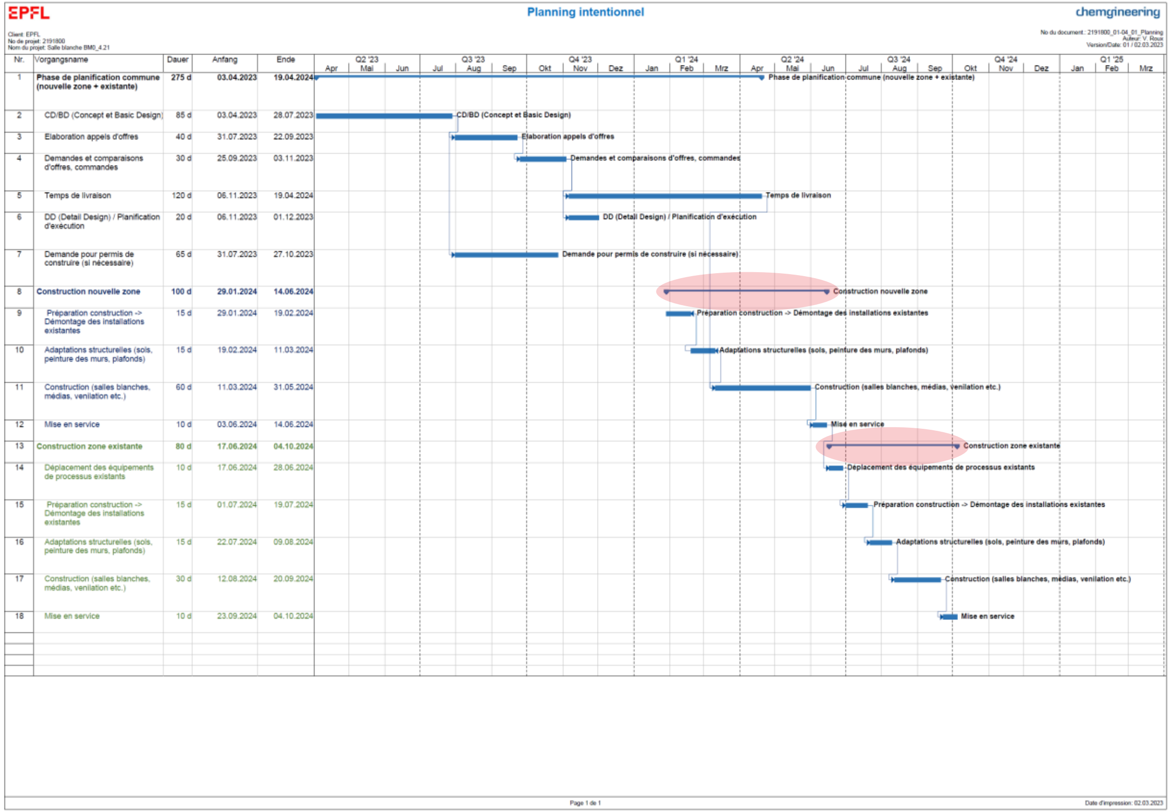
- Transform this 700m^2 space into a cleanroom space

Cleanroom



- We plan to build cleanrooms accessible by a central clean corridor
- 365m^2 of cleanroom

Cleanroom



EPFL

Planning intentionnel

chemgineering

Client: EPFL
No de projet: 2191800
Nom du projet: Salle blanche BM0_4.21

No du document.: 2191800_01-04_01_Planning
Auteur: V. Roux
Version/Date: 01 / 02.03.2023

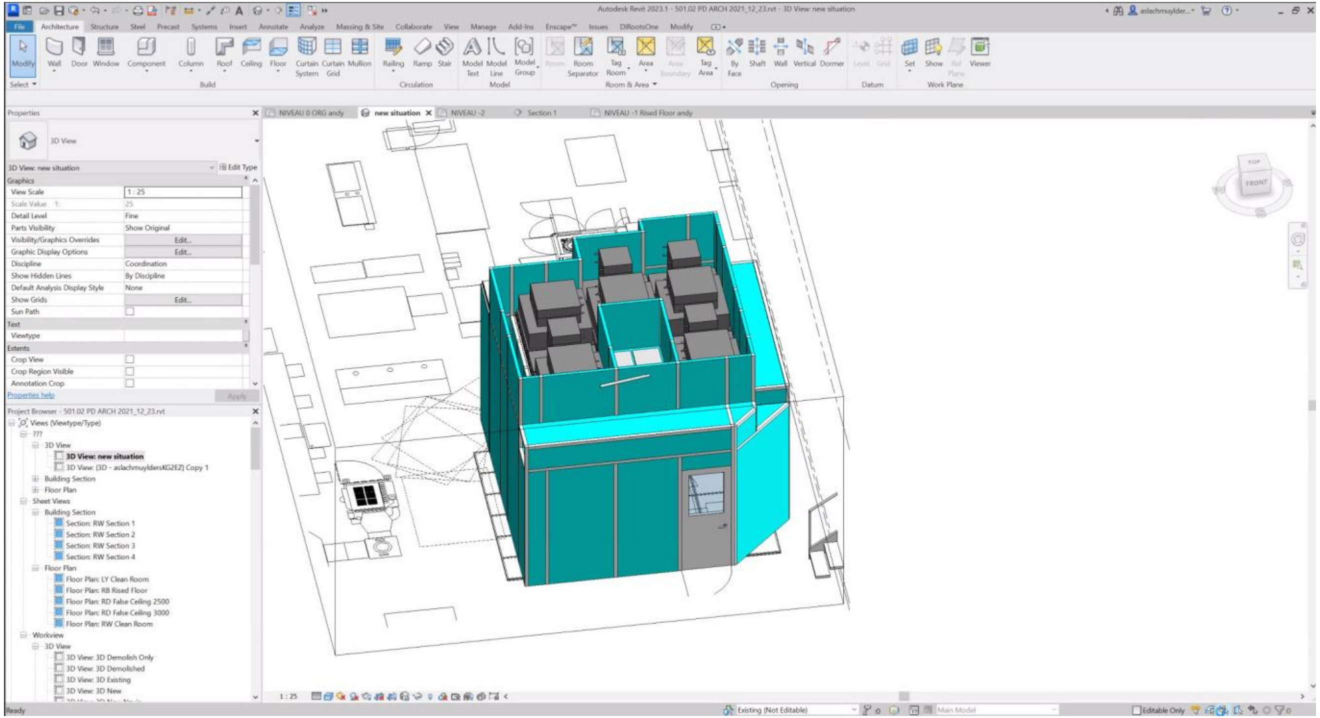
Nr.	Vorgangsname	Dauer	Anfang	Ende
1	**Phase de planification commune (nouvelle zone + existante)**	**275 d**	**03.04.2023**	**19.04.2024**
2	CD/BD (Concept et Basic Design)	85 d	03.04.2023	28.07.2023
3	Elaboration appels d'offres	40 d	31.07.2023	22.09.2023
4	Demandes et comparaisons d'offres, commandes	30 d	25.09.2023	03.11.2023
5	Temps de livraison	120 d	06.11.2023	19.04.2024
6	DD (Detail Design) / Planification d'exécution	20 d	06.11.2023	01.12.2023
7	Demande pour permis de construire (si nécessaire)	65 d	31.07.2023	27.10.2023
8	**Construction nouvelle zone**	**100 d**	**29.01.2024**	**14.06.2024**
9	Préparation construction -> Démontage des installations existantes	15 d	29.01.2024	19.02.2024
10	Adaptations structurelles (sols, peinture des murs, plafonds)	15 d	19.02.2024	11.03.2024
11	Construction (salles blanches, médias, venilation etc.)	60 d	11.03.2024	31.05.2024
12	Mise en service	10 d	03.06.2024	14.06.2024
13	**Construction zone existante**	**80 d**	**17.06.2024**	**04.10.2024**
14	Déplacement des équipements de processus existants	10 d	17.06.2024	28.06.2024
15	Préparation construction -> Démontage des installations existantes	15 d	01.07.2024	19.07.2024
16	Adaptations structurelles (sols, peinture des murs, plafonds)	15 d	22.07.2024	09.08.2024
17	Construction (salles blanches, médias, venilation etc.)	30 d	12.08.2024	20.09.2024
18	Mise en service	10 d	23.09.2024	04.10.2024

Page 1 de 1

Date d'impression: 02.03.2023

- The whole project will take around 2 years
- Actually we expect another 6 months delay

Cleanroom



Properties

3D View

3D View: new situation | Edit Type

Graphics	
View Scale	1 : 25
Scale Value 1:	25
Detail Level	Fine
Parts Visibility	Show Original
Visibility/Graphics Overrides	Edit...
Graphic Display Options	Edit...
Discipline	Coordination
Show Hidden Lines	By Discipline
Default Analysis Display Style	None
Show Grids	Edit...
Sun Path	☐
Text	
Viewtype	
Extents	
Crop View	☐
Crop Region Visible	☐
Annotation Crop	☐

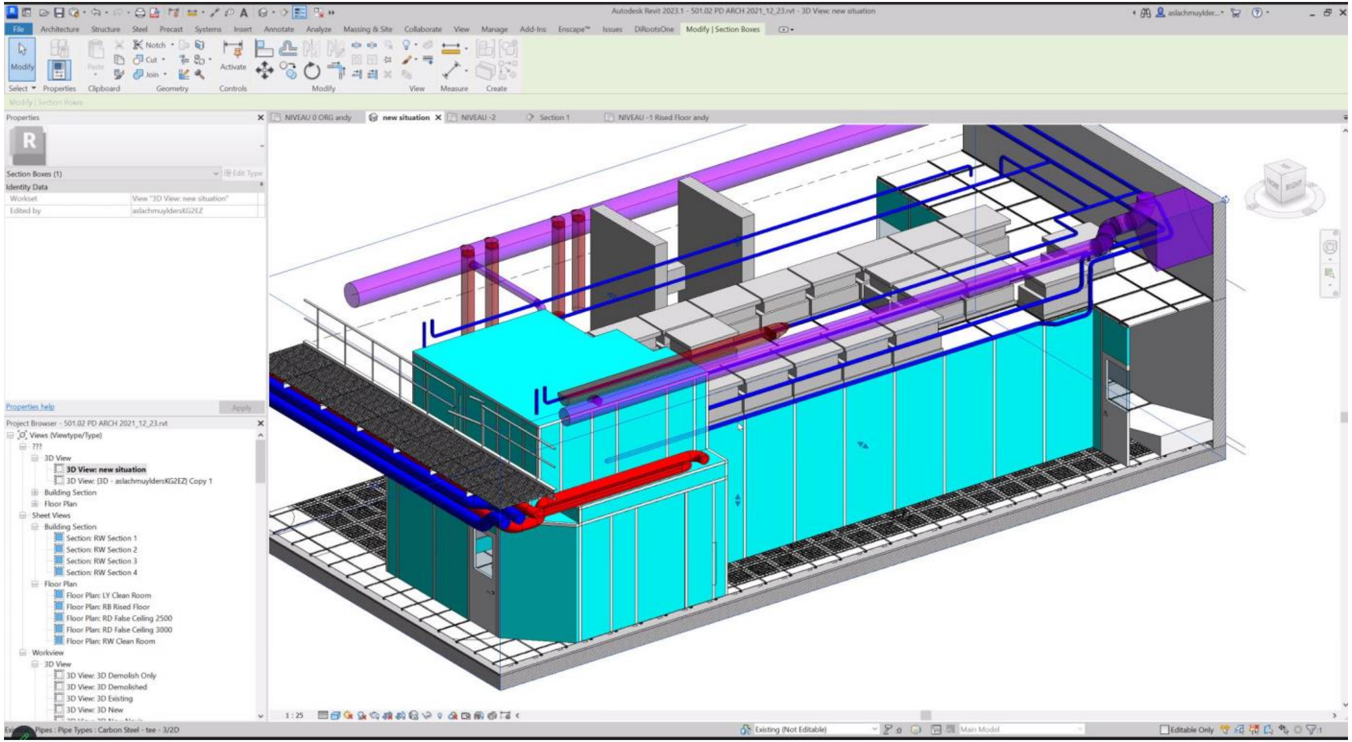
Properties help | Apply

Project Browser - 501.02 PD ARCH 2021_12_23.rvt

- Views (Viewtype/Type)
  - ???
    - 3D View
      - **3D View: new situation**
      - 3D View: (3D - aslachmuyldersKG2EZ) Copy 1
    - Building Section
    - Floor Plan
  - Sheet Views
    - Building Section
      - Section: RW Section 1
      - Section: RW Section 2
      - Section: RW Section 3
      - Section: RW Section 4
    - Floor Plan
      - Floor Plan: LY Clean Room
      - Floor Plan: RB Rised Floor
      - Floor Plan: RD False Ceiling 2500
      - Floor Plan: RD False Ceiling 3000
      - Floor Plan: RW Clean Room
  - Workview
    - 3D View
      - 3D View: 3D Demolish Only
      - 3D View: 3D Demolished
      - 3D View: 3D Existing
      - 3D View: 3D New

- We will transform the extremity of zone 1 to accommodate EBL2
- We need tight control of temperature, EM noise and the acoustic noise

Cleanroom



- A view of the future zone 1 with EBL2 at the extremity

Capital Investment

- Processing Equipment

Scientific Equipment Levels -1 / 0 / +1	40 MCHF
Total	**50 MCHF**

- Cleanroom Infrastructures

Cleanroom Infrastructures Level -1	12 MCHF
Cleanroom Infrastructures Level +1	7 MCHF
Cleanroom Infrastructures Level 0 (1)	2 MCHF (2017)
Cleanroom Infrastructures Level 0 (2)	TBD
Total	**21 MCHF**

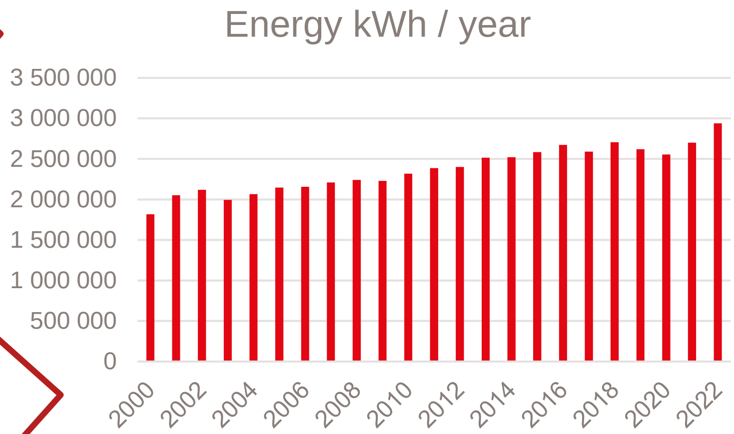
- Total 71MCHF

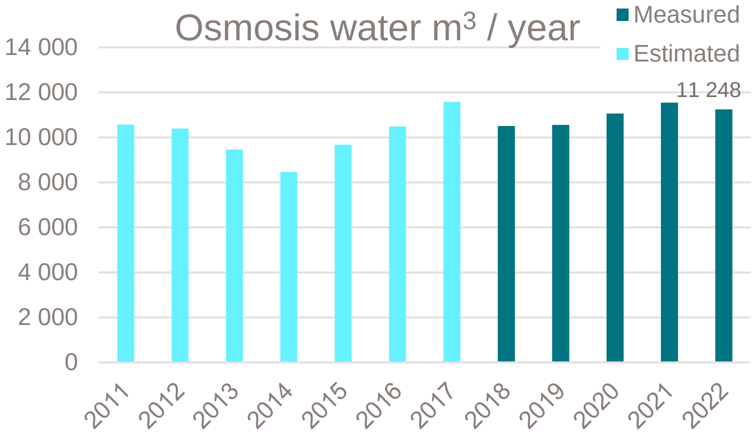
Energy & Fluids

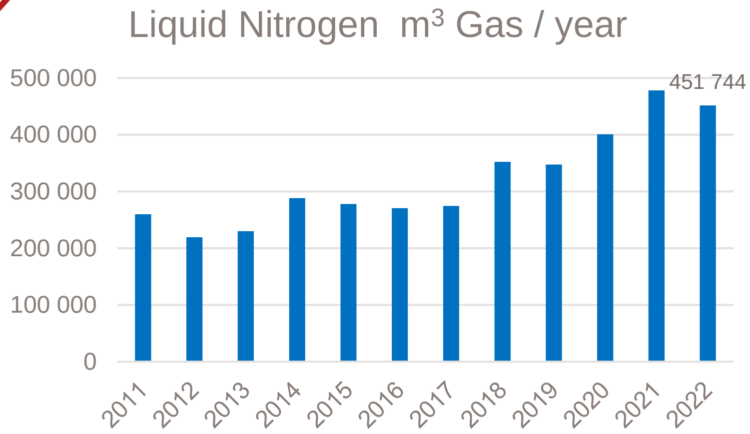
CMi
2.9 GWh

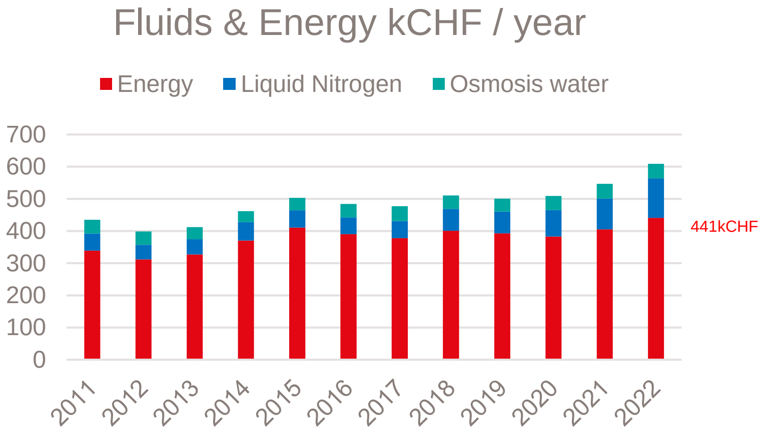
CMi : 6% of EPFL

EPFL-Ecublens
48 GWh

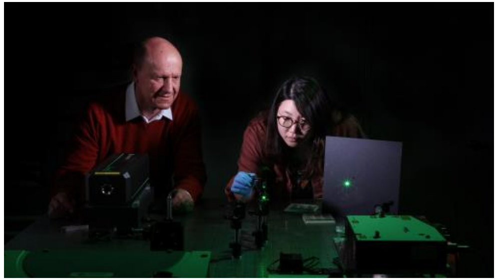
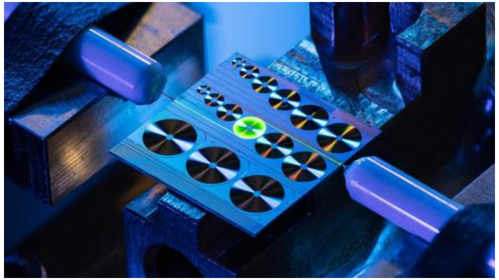
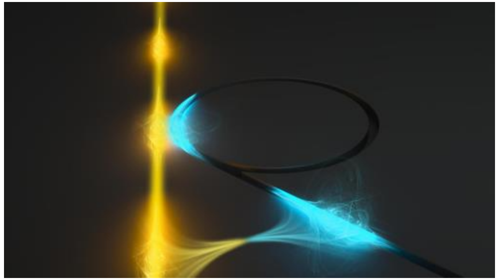

Energy kWh / year


Osmosis water m³ / year


Liquid Nitrogen m³ Gas / year

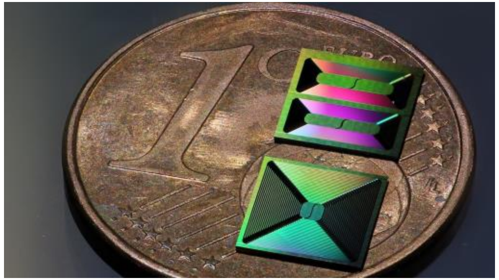
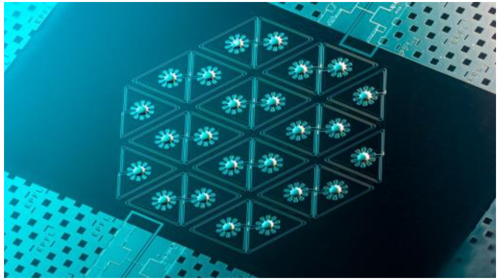
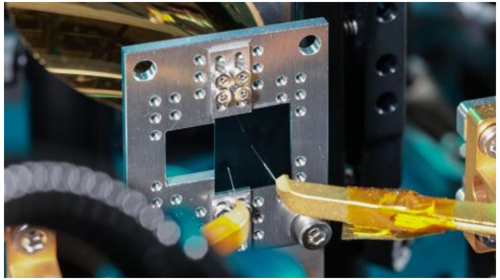
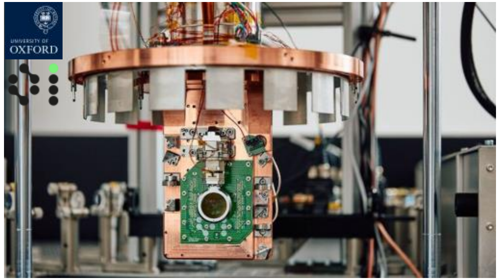
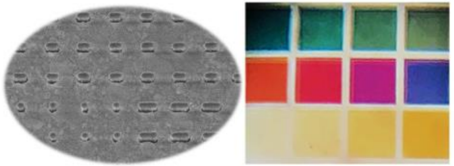

Fluids & Energy kCHF / year

CMi inside

Martin (PLASMONIC) Advanced Materials https://doi.org/10.1002/adma.202108225 March 2022	Grandjean (QUANTUM DOTS) Light: Science & Applications (http://www.nature.com/lsa) https://doi.org/10.1038/s41377-022-00799-4 April 2022	Kippenberg (PHOTONIC INTEGRATED CIRCUIT) Science https://doi.org/10.1126/science.abo2631 Juin 2022
		
Matioli (ELECTRONICS) Nature Electronics https://doi.org/10.1038/s41928-022-00812-z August 2022	Kippenberg (NANOPHOTONICS) Science https://doi.org/10.1126/science.abo5037 August 2022	Ramdya (NEURAL RECORDING) Nature Communications https://doi.org/10.1038/s41467-022-32571-y August 2022
		

- A selection of publications which attracted special interest (last 12 months)
- Relayed onto the EPFL home page

CMi inside

Kippenberg (PHOTONIC INTEGRATED CIRCUIT) Nature https://doi.org/10.1038/s41586-022-05329-1 September 2022	Kippenberg (SUPERCONDUCTING OPTOMECHANICS) Nature https://doi.org/10.1038/s41586-022-05367-9 December 2022	Benea (PHOTONIC INTEGRATED CIRCUIT) Nature Communications https://doi.org/10.1038/s41467-022-35517-6 January 2023
		
Oxford Ionics (QUANTUM COMPUTING) £30 million funding https://www.physics.ox.ac.uk/news January 2023	Martin (PLASMONIC) Advanced Optical Materials https://doi.org/10.1002/adom.202202165 January 2023	Matioli (ELECTRONICS) Nature https://doi.org/10.1038/s41586-022-05595-z February 2023
		

- A selection of publications which attracted special interest (last 12 months)
- Relayed onto the EPFL home page

CMi inside

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<td>Zbinden (PHOTON DETECTORS)
Nature Photonics
https://doi.org/10.1038/s41566-023-01168-2
March 2023</td>
<td>Kippenberg (INTEGRATED PHOTONICS)
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March 2023</td>
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Nature Communications
https://www.nature.com/articles/s41467-023-37078-8
March 2023</td>
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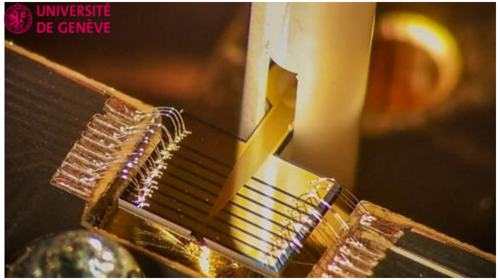
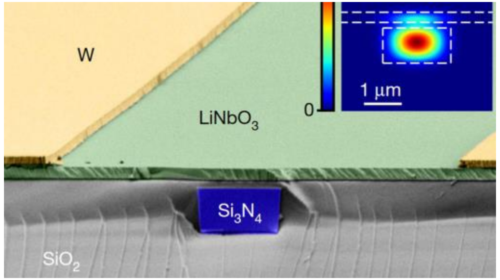
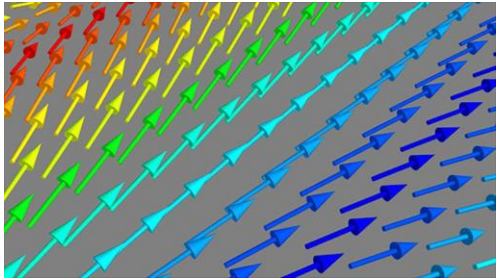
<td> </td>
<td> </td>
<td></td>
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<tr>
<td>Altug (NANOPLASMONIC)
Nature Biomedical Engineering
https://doi.org/10.1038/s41551-023-01017-1
April 2023</td>
<td>Auteur (TITRE)
Journal
https://doi.org/
2023</td>
<td>Auteur (TITRE)
Journal
https://doi.org/
2023</td>
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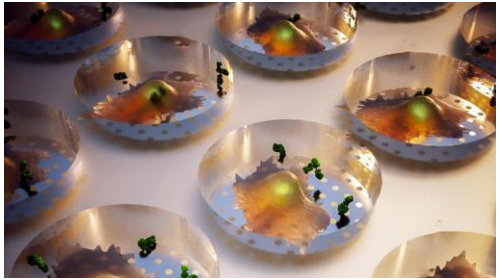
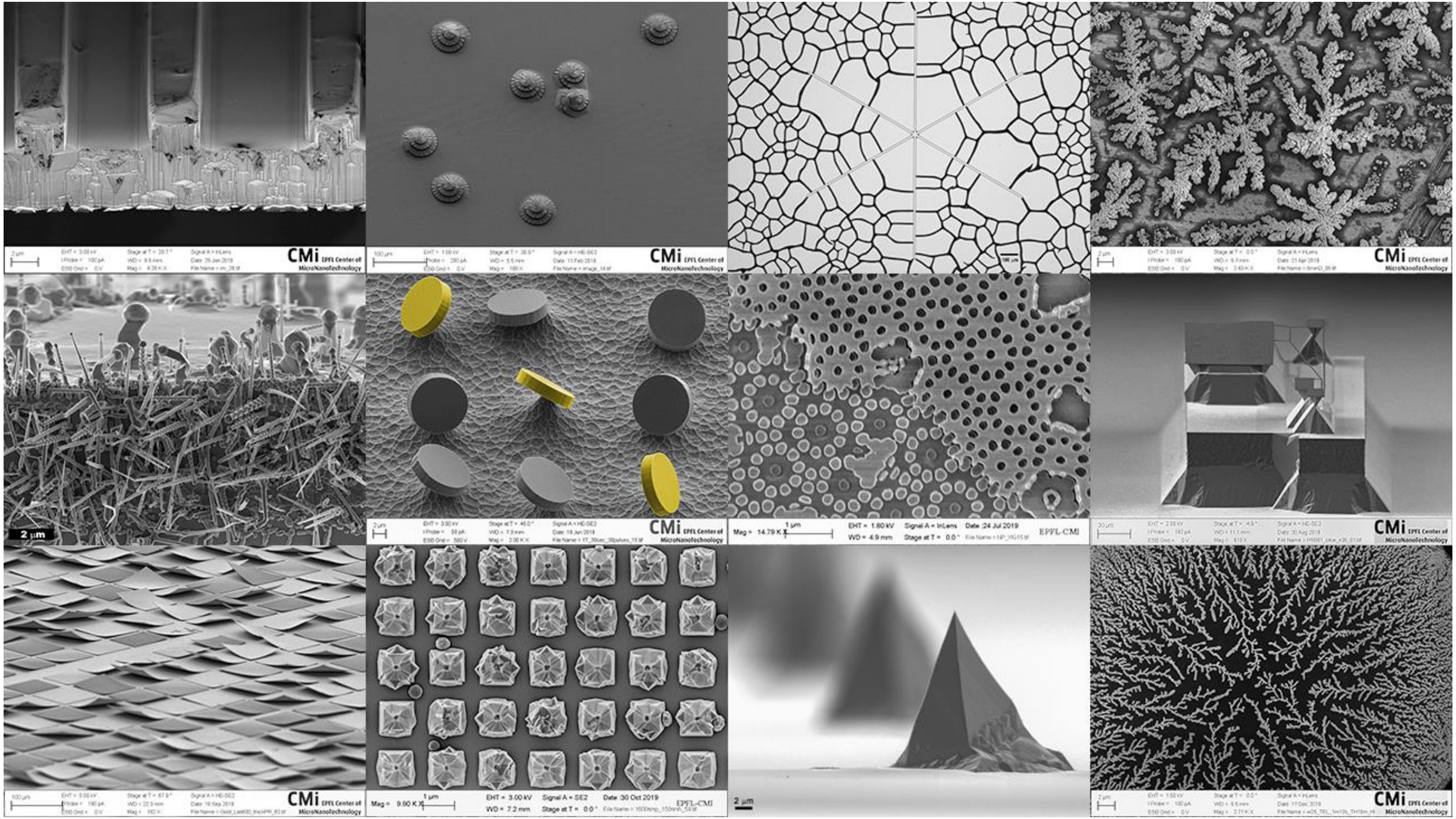
<td></td>
<td>Prof. Kippenberg :
3 publications in Nature + 2 publications in Science in 12 months with Cmi inside

University of Oxford & Oxford Ionics :
Press release - University of Oxford - 10.01.2023
Startup from the University of Oxford raised 30M£ with CMi inside

UNIGE & ID Quantique :
Communiqué de presse - UNIGE - 13.03.2023
CMi inside</td>
<td></td>
</tr>
</table>

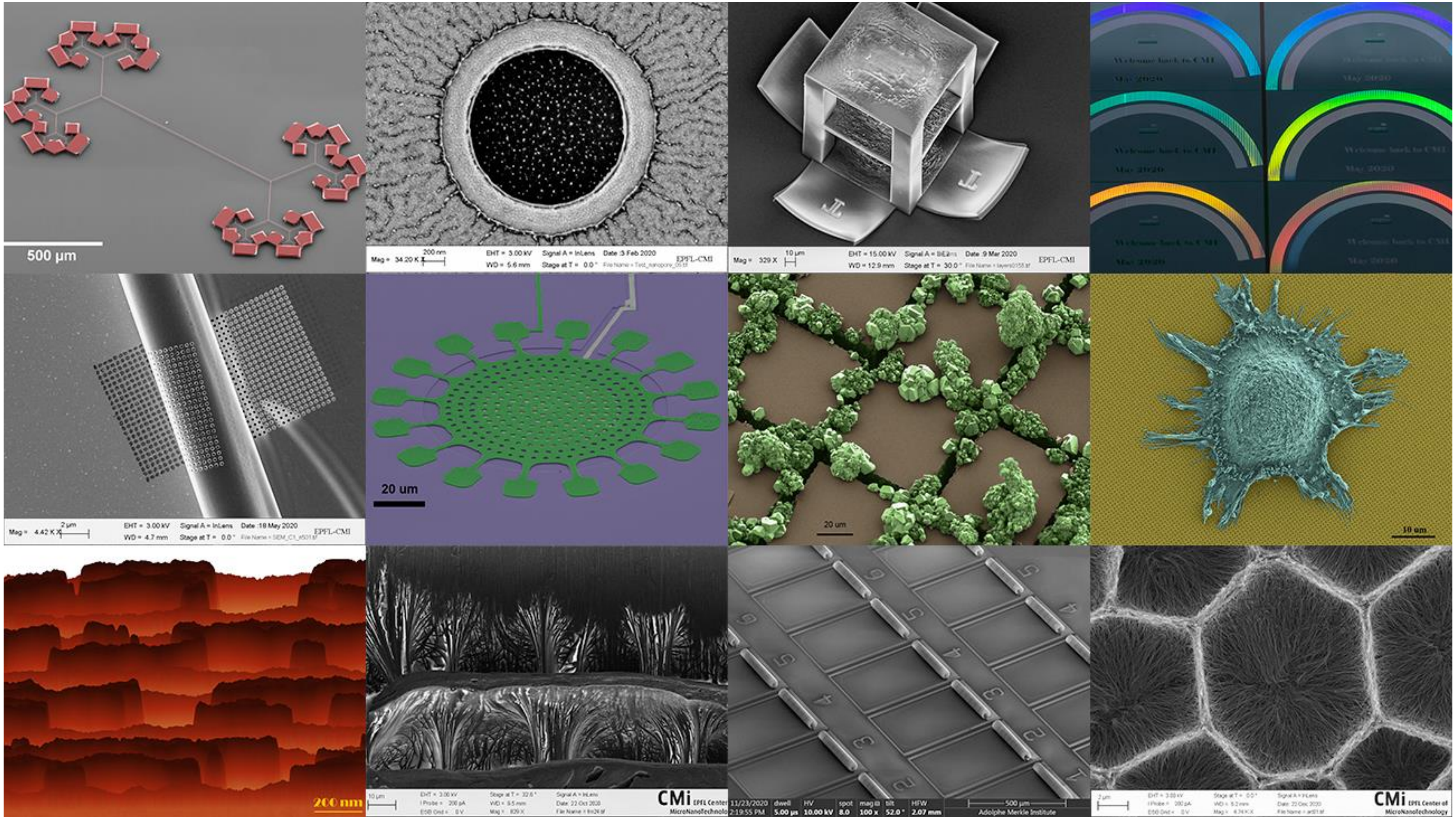
- A selection of publications which attracted special interest (last 12 months)
- Relayed onto the EPFL home page

Picture of the month 2019

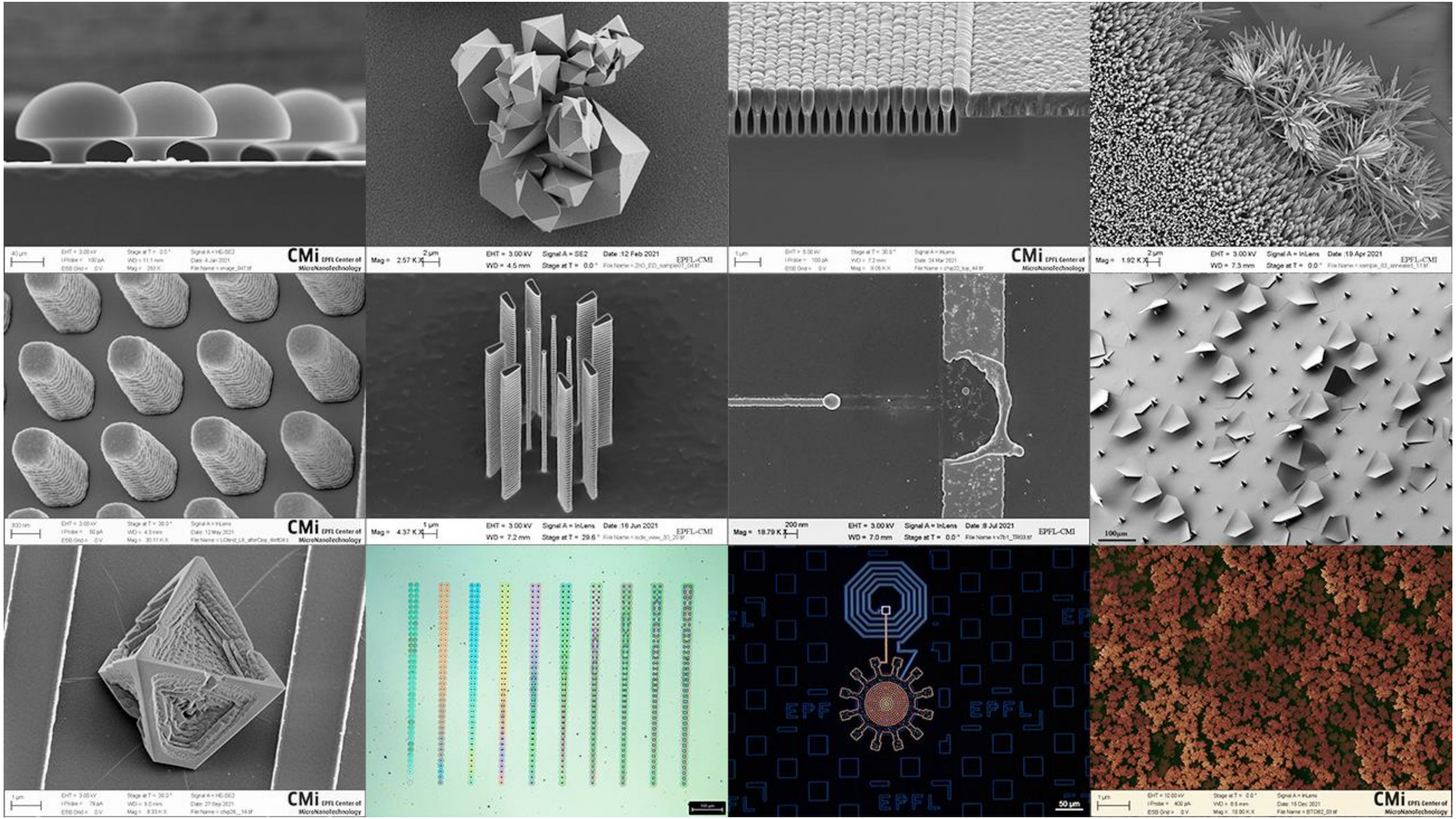


For the pleasure of the eyes : the official winners of the monthly picture contest

Picture of the month 2020

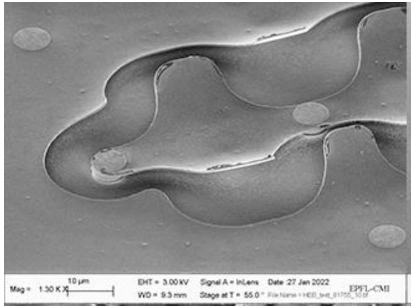


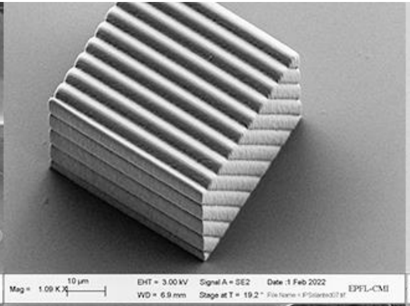
Picture of the month 2021

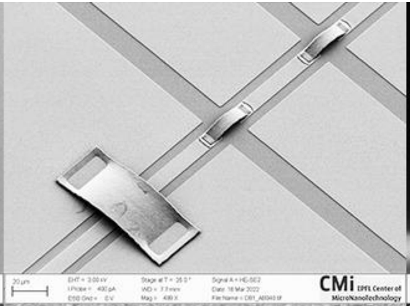


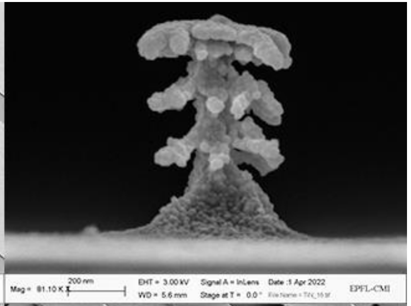
Philippe Flückiger 02.05.2023

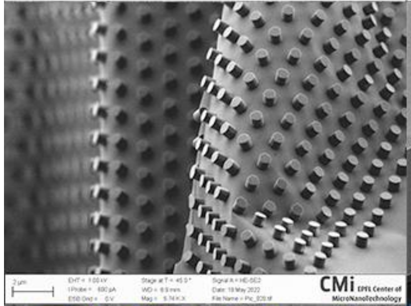
Picture of the month 2022

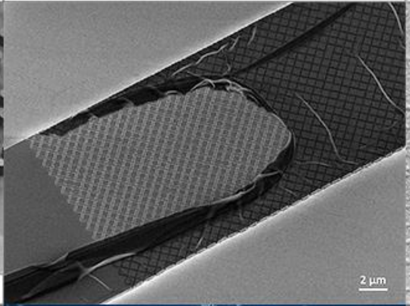


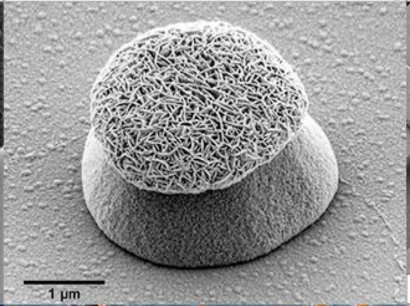


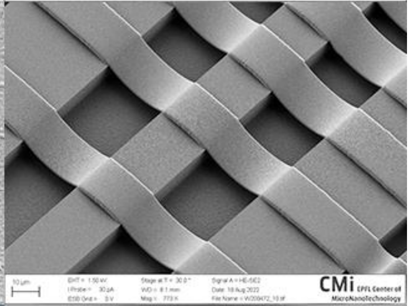


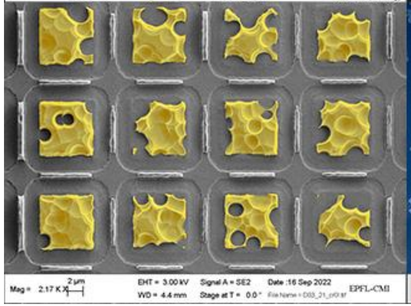


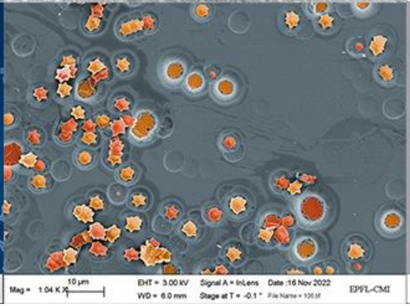


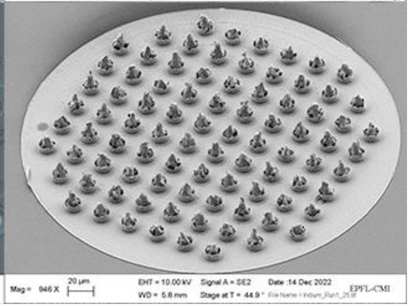












Program

CMi EPFL Center of MicroNanoTechnology

Projects at the EPFL Center of MicroNanoTechnology

MAY 2023

cmi.epfl.ch

EPFL

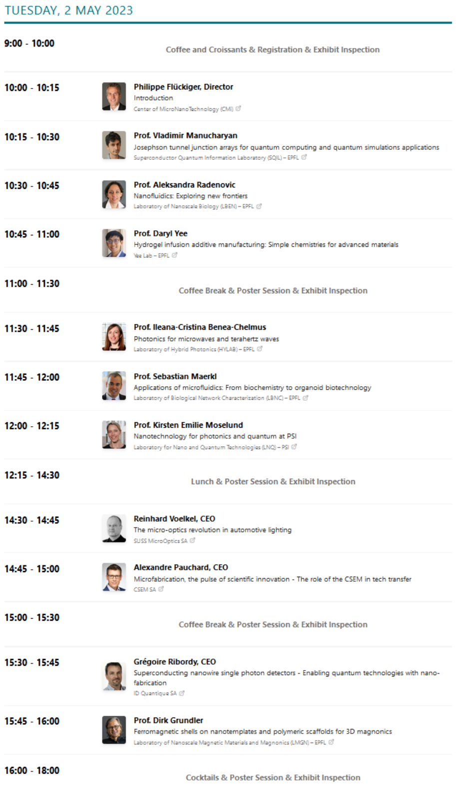
List of posters

- The 184 posters presented today are available online
- Password is available on request
- A few paper brochures are available

https://cmiaccess.epfl.ch/projects/

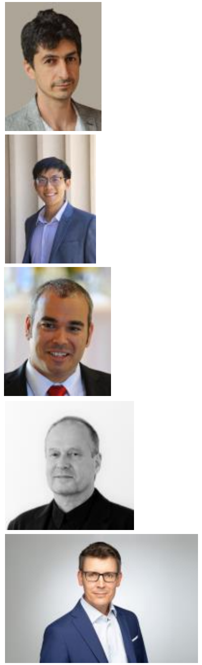
Front page: SEM image of our microns size colleague written with Nanoscribe

Program



TUESDAY, 2 MAY 2023

9:00 - 10:00	Coffee and Croissants & Registration & Exhibit Inspection
10:00 - 10:15	**Philippe Flückiger, Director** Introduction Center of MicroNanoTechnology (CMi)
10:15 - 10:30	**Prof. Vladimir Manucharyan** Josephson tunnel junction arrays for quantum computing and quantum simulations applications Superconductor Quantum Information Laboratory (SQIL) – EPFL
10:30 - 10:45	**Prof. Aleksandra Radenovic** Nanofluidics: Exploring new frontiers Laboratory of Nanoscale Biology (LBEN) – EPFL
10:45 - 11:00	**Prof. Daryl Yee** Hydrogel infusion additive manufacturing: Simple chemistries for advanced materials Yee Lab – EPFL
11:00 - 11:30	Coffee Break & Poster Session & Exhibit Inspection
11:30 - 11:45	**Prof. Ileana-Cristina Benea-Chelmus** Photonics for microwaves and terahertz waves Laboratory of Hybrid Photonics (HYLAB) – EPFL
11:45 - 12:00	**Prof. Sebastian Maerkl** Applications of microfluidics: From biochemistry to organoid biotechnology Laboratory of Biological Network Characterization (LBNC) – EPFL
12:00 - 12:15	**Prof. Kirsten Emilie Moselund** Nanotechnology for photonics and quantum at PSI Laboratory for Nano and Quantum Technologies (LNQ) – PSI
12:15 - 14:30	Lunch & Poster Session & Exhibit Inspection
14:30 - 14:45	**Reinhard Voelkel, CEO** The micro-optics revolution in automotive lighting SUSS MicroOptics SA
14:45 - 15:00	**Alexandre Pauchard, CEO** Microfabrication, the pulse of scientific innovation - The role of the CSEM in tech transfer CSEM SA
15:00 - 15:30	Coffee Break & Poster Session & Exhibit Inspection
15:30 - 15:45	**Grégoire Ribordy, CEO** Superconducting nanowire single photon detectors - Enabling quantum technologies with nano-fabrication ID Quantique SA
15:45 - 16:00	**Prof. Dirk Grundler** Ferromagnetic shells on nanotemplates and polymeric scaffolds for 3D magnonics Laboratory of Nanoscale Magnetic Materials and Magnonics (LMGN) – EPFL
16:00 - 18:00	Cocktails & Poster Session & Exhibit Inspection



Program

- Very exciting program
- 10 presentations
- Spanning an exceptionally broad range
- Try to be different every year
- Not always invite our heavy users
- Emphasize on the new Professors @ EPFL
- Sometimes also some exotic users
- One common point:
- MicroNanoFabrication

Program

3DAG	allianceconcept	BECKHOFF	BOVARD	BRUKER	BÜHLER	COMSOL	confovis
EUMETRYS	evatec process systems	EVG	EVIDENT OLYMPUS	FEMTOPRINT	HEIDELBERG INSTRUMENTS	Hilpert electronics	HYBRID SA
idonus	IMT PRECISION ON GLASS	KEYENCE	KLA INSTRUMENTS	LIGENTEC	lyncée tec	microqubic	MICROTEST
muRata INNOVATOR IN ELECTRONICS	nanosurf	NANO WORLD INNOVATIVE TECHNOLOGIES	neyco VACUUM & MATERIALS	NIL TECHNOLOGY	obducat	Park SYSTEMS	PFEIFFER VACUUM
Plasmadiam EDWARDS	Plasma Therm	PLASSYS	Quantum Design EUROPE	RAITH NANOFABRICATION	schaefer	SAL SILICON AUSTRIA LABS	SQC
SUSS MicroOptics	swiss mnt network micro & nanotechnology	SWISS VACUUM	vistec Electron Beam	Zurich Instruments			

Exhibitors

- 45 companies
- Thank you to all of them

- Thank you to all our exhibitors

EPFL
CMi

“Alone we can do so little, together we can do so much.”

École polytechnique fédérale de Lausanne

EPFL
CMi

Merci

Enjoy the conference
Thank you for your attention

Philippe Flückiger

École
polytechnique
fédérale
de Lausanne

Merci

Enjoy the conference
Thank you for your attention

Philippe Flückiger

École
polytechnique
fédérale
de Lausanne

EPFL at glance

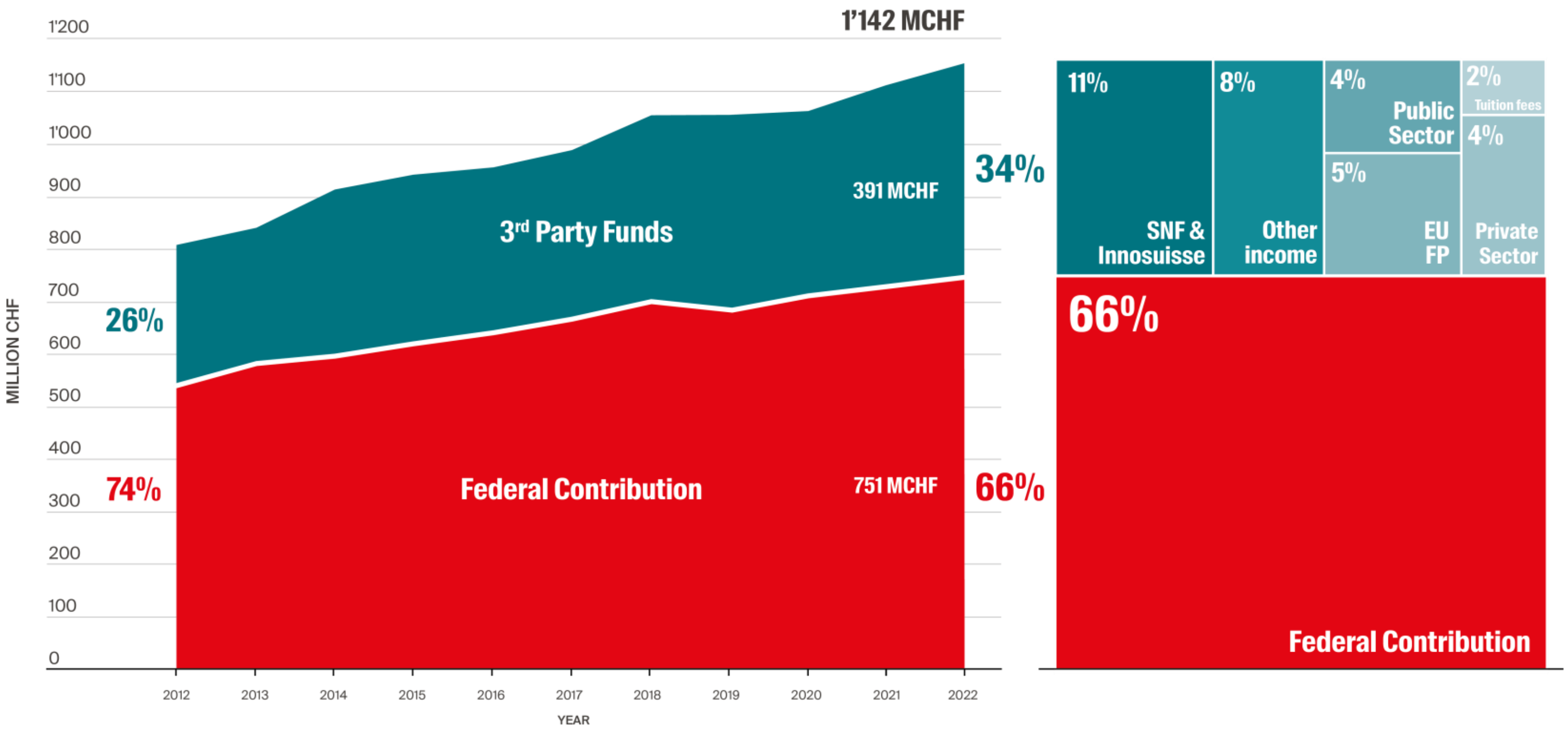
12’576
Students

366
Professors

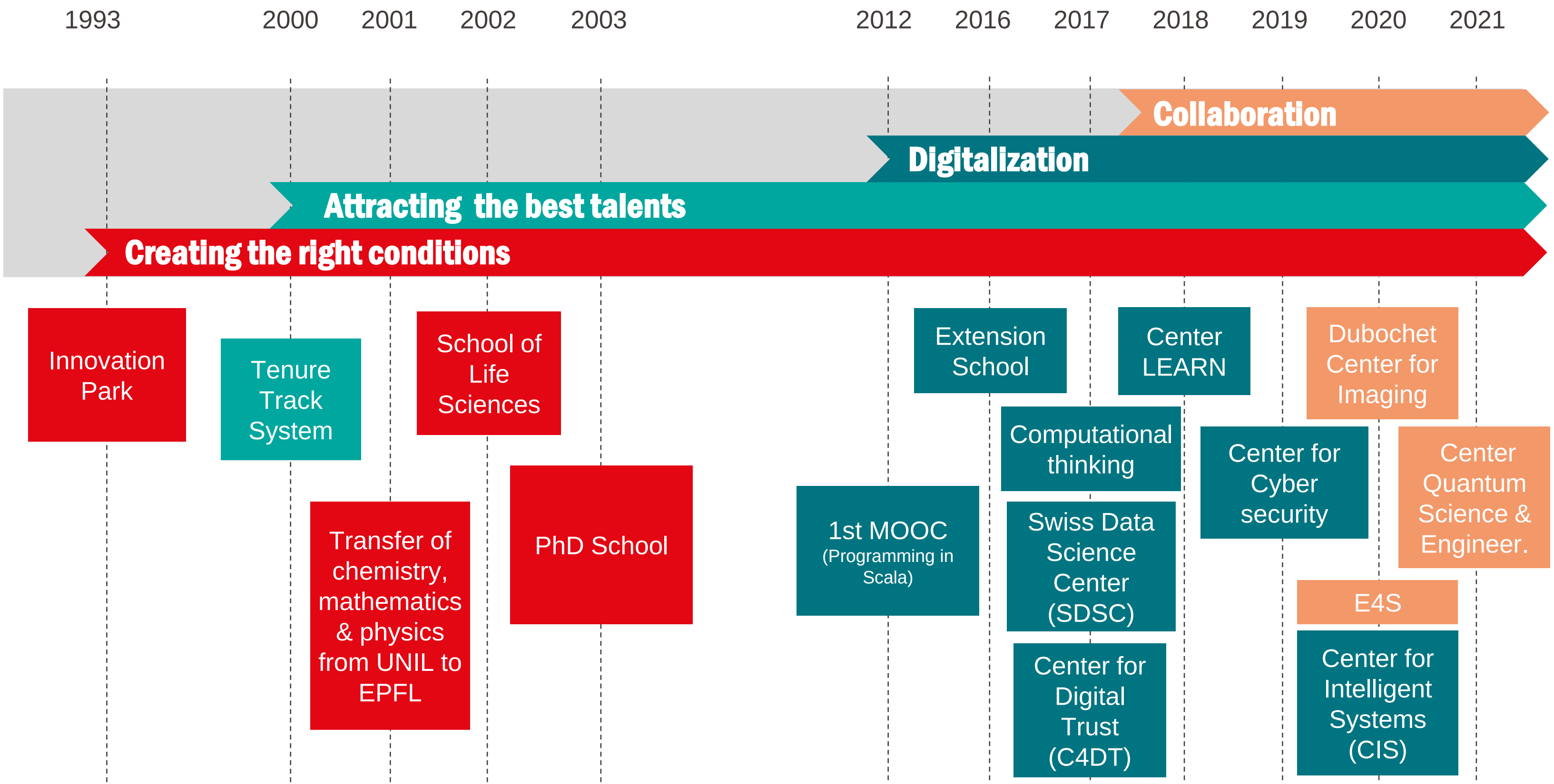
+6’400
Employees (incl. Phd)

+130
Nationalities

Funding 2022



Establishing EPFL as a leading school in the 21st century



1993 2000 2001 2002 2003 2012 2016 2017 2018 2019 2020 2021

Collaboration

Digitalization

Attracting the best talents

Creating the right conditions

Innovation Park

Tenure Track System

Transfer of chemistry, mathematics & physics from UNIL to EPFL

School of Life Sciences

PhD School

1st MOOC (Programming in Scala)

Extension School

Computational thinking

Swiss Data Science Center (SDSC)

Center for Digital Trust (C4DT)

Center LEARN

Center for Cyber security

Dubochet Center for Imaging

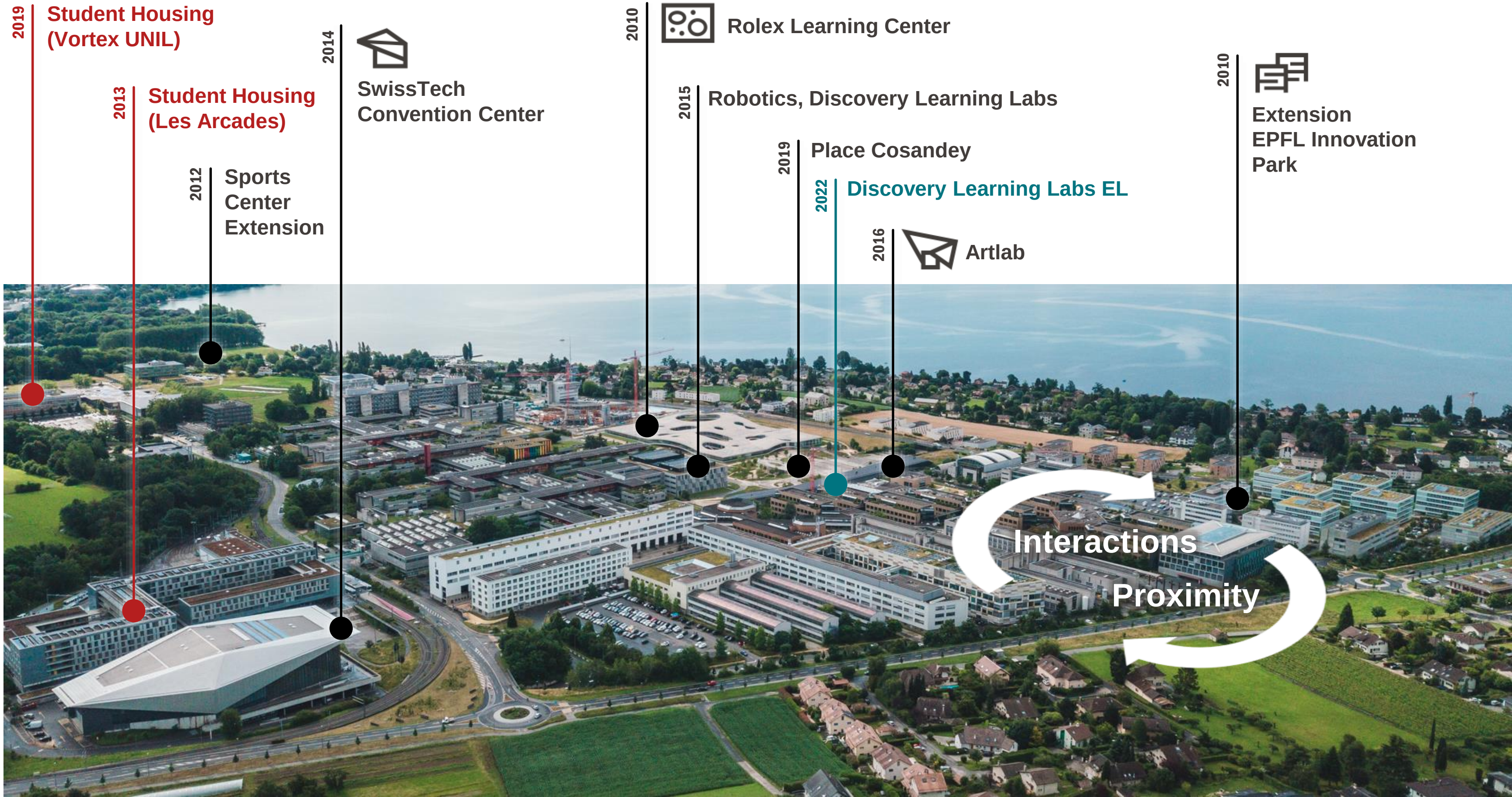
E4S

Center for Intelligent Systems (CIS)

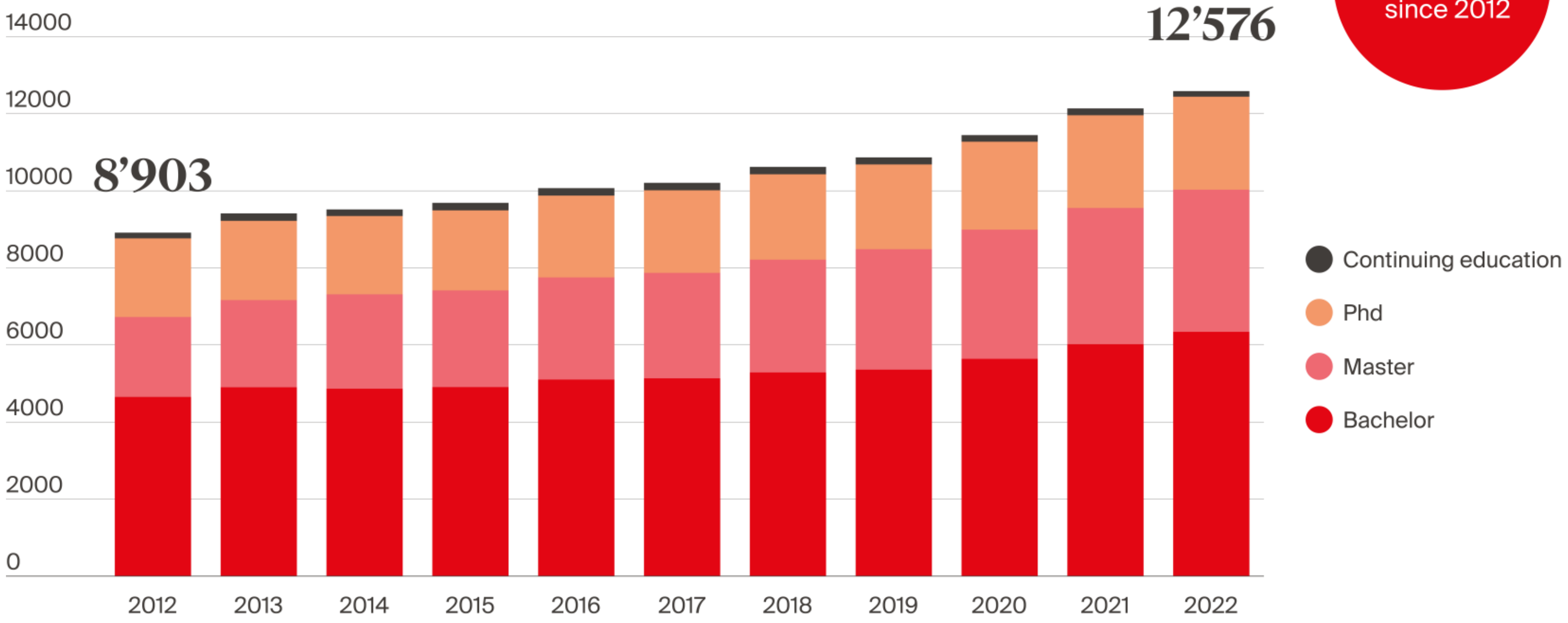
Center Quantum Science & Engineer.

EPFL CMi

EPFL Campus



Number of students

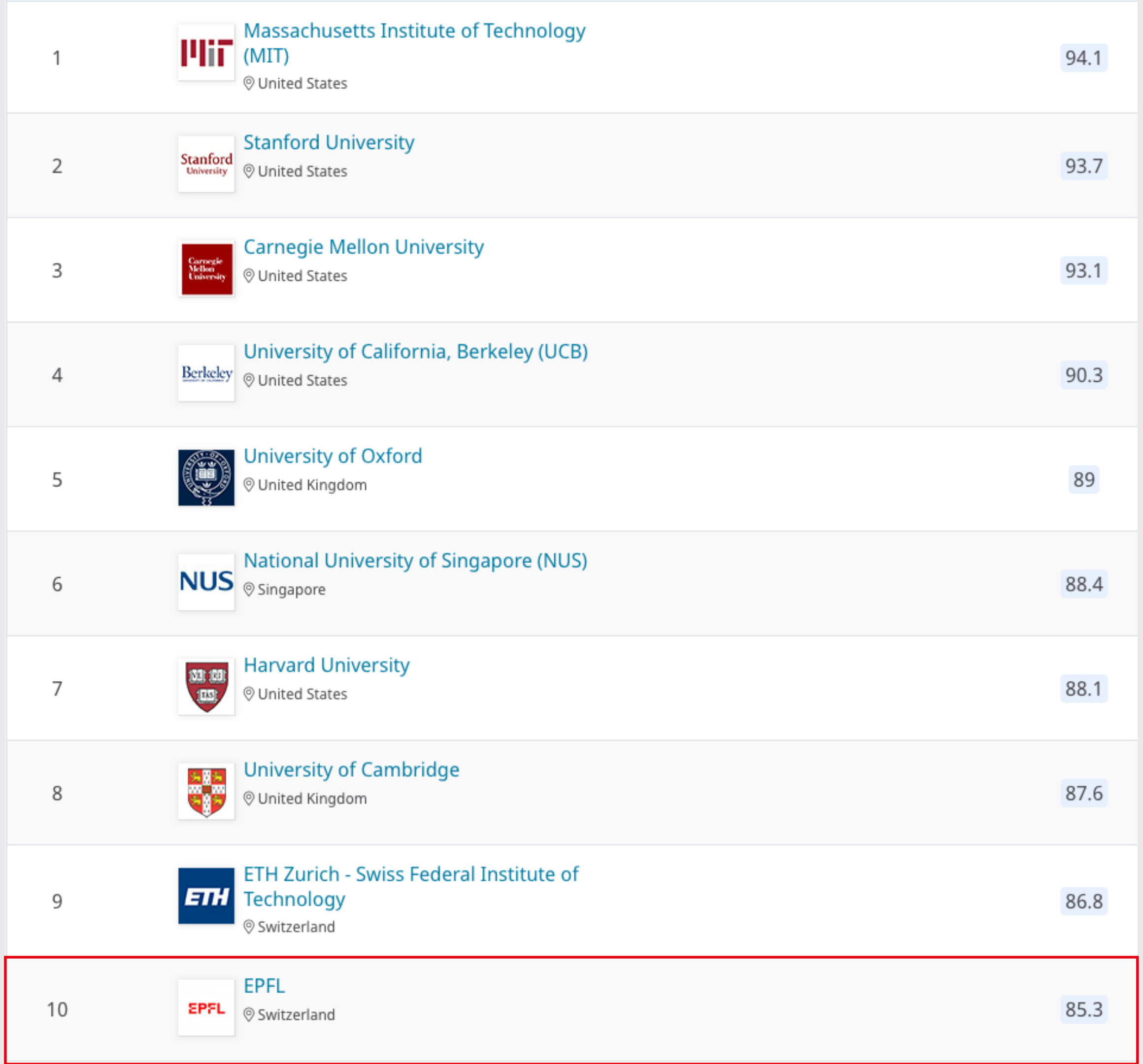


+41% since 2012

Speaker

Education

QS World University Rankings 2022 in computer science & information systems

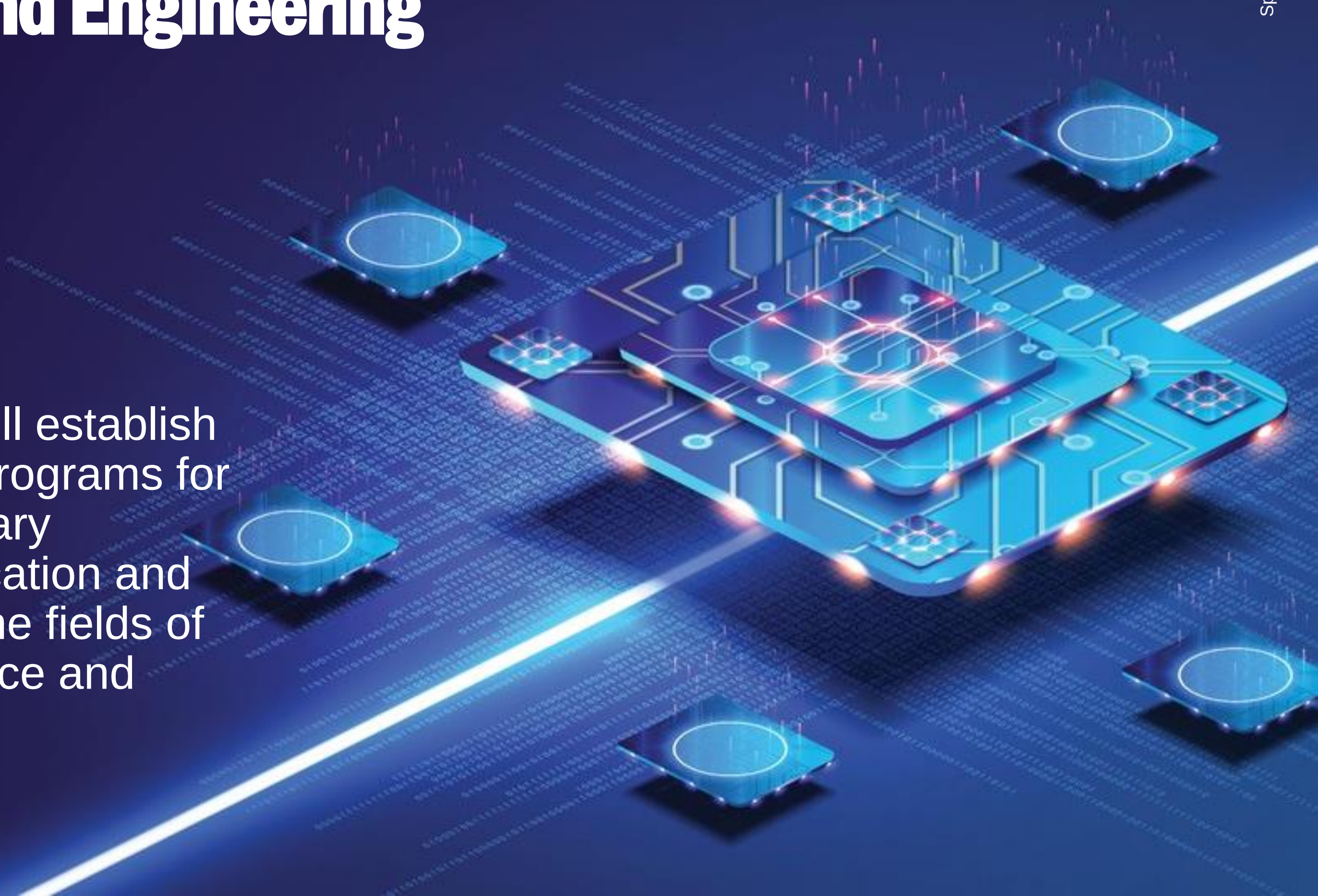


1	Massachusetts Institute of Technology (MIT)	United States	94.1
2	Stanford University	United States	93.7
3	Carnegie Mellon University	United States	93.1
4	University of California, Berkeley (UCB)	United States	90.3
5	University of Oxford	United Kingdom	89
6	National University of Singapore (NUS)	Singapore	88.4
7	Harvard University	United States	88.1
8	University of Cambridge	United Kingdom	87.6
9	ETH Zurich - Swiss Federal Institute of Technology	Switzerland	86.8
10	EPFL	Switzerland	85.3

QS WORLD UNIVERSITY RANKINGS®

Source: *www.topuniversities.com*

New Center for Quantum Science and Engineering



QSE Center will establish and promote programs for cross-disciplinary research, education and innovation in the fields of quantum science and engineering.