

LHCP2020

May 25-30, 2020

Online

The Eighth
Annual Conference
on Large Hadron
Collider Physics



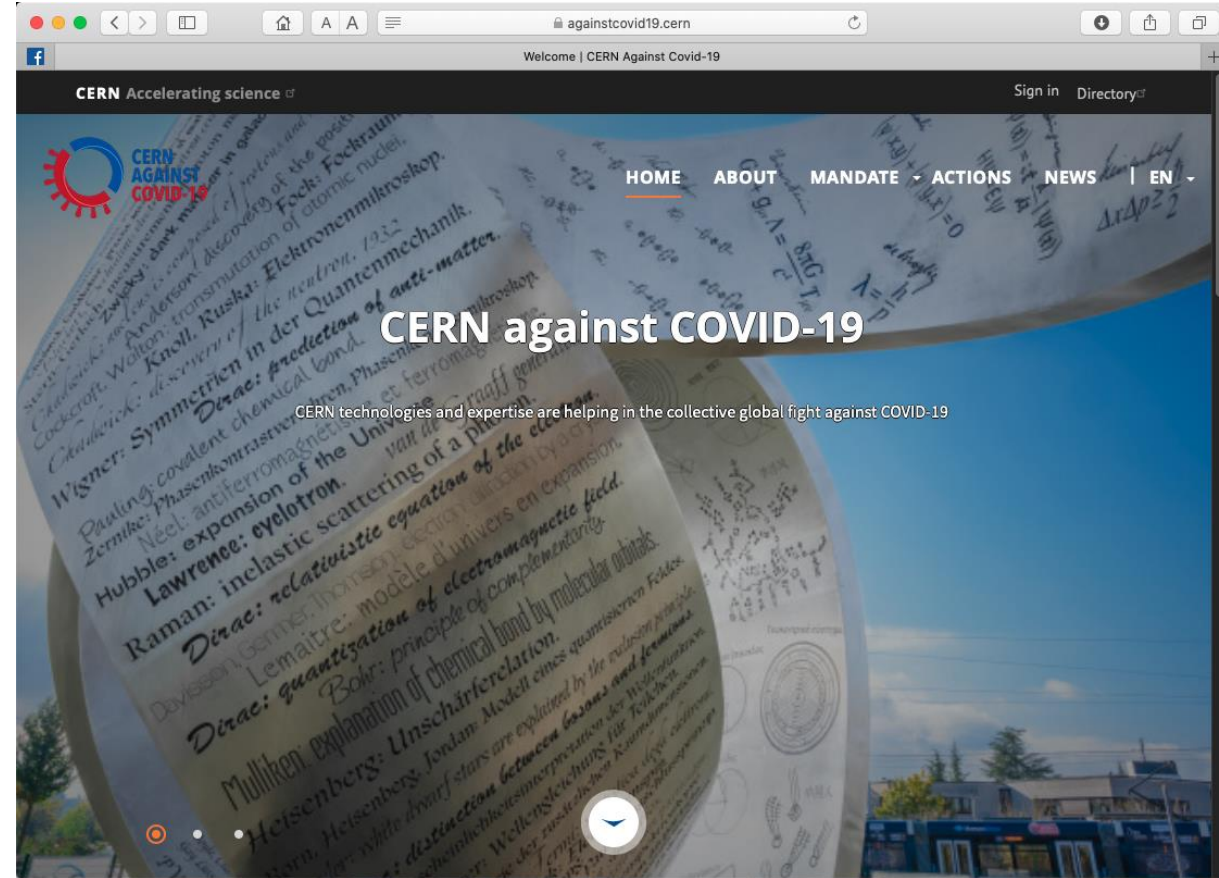
CERN against Covid-19

Beniamino Di Girolamo (CERN)

LHCP2020 Conference - 30 May 2020

Background

- **Task force established by the CERN DG on 26 March**
- **Mandate:**
“to collect and coordinate potential ideas and contributions from CERN’s scientific community of over 17 000 people worldwide to the societal fight against COVID-19. These initiatives will draw on technical and scientific expertise and facilities at CERN, in the Member State countries and beyond and will be carried out in collaboration with that community.”
- **Main message:** CERN is present to help society and researchers in other fields at this difficult time



<https://againstcovid19.cern/>

The Task Force



Beniamino Di Girolamo (CERN, ATS-DO, Chair), Bettina Hamoudi (CERN, IPT-KT, Secretary) Giovanni Anelli (CERN, IPT-KT), Gianluigi Arduini (CERN, BE-ABP), Kirsten Baxter (DG-LS), Ian Bird (CERN, IT-SC), Themis Bowcock (University of Liverpool, LHCb), David Chaloin (SMB-SC), Paolo Chiggiato (CERN, TE-VSC), Manuela Cirilli (IPT-KT), Alberto Di Meglio (CERN, IT-DI), Friedemann Eder (IR-REL), Cédric Garino (CERN, SMB-SC), James Gillies (CERN, IR-SPE), Massimo Giovannozzi (BE-ABP), Angela Goehring-Crinon (HSE-DI) Beate Heinemann (DESY, ATLAS), André Henriques (CERN, HSE-OHS), David Lange (Princeton University, CMS), Diego Perini (CERN, EN-MME), Lucie Pocha (DG-LS), Marco Van Leeuwen (NIKHEF, ALICE), Tim Smith (IT-CDA) and Maarten Wilbers (DG-LS).

The Task Force

- **The multidisciplinary composition of the task force is a key element enabling it to be receptive to all possible ideas and contributions from researchers and the general public**
 - Several colleagues not officially in the task force are extremely active and complement the work
- **The work of the task force has allowed the acceleration of initiatives, finding short routes to results, and making known and available resources that are part of CERN's normal life and now deployed to provide help in this emergency**
- **In addition, some initiatives have been proposed and initiated in previously unexplored territories, such as ventilators**
- **Today, the aim is to describe most of the initiatives that it has been possible to take onboard, and to have a first look at the legacy of this work**

Categories of work

Medical Applications

- Ventilators
- Coatings

Help to Society

- Shields
- Visors
- Masks
- Support to emergency services
- Sanitizing gel
- Logistical support
- UV boxes

Computing and Data Analysis

- Zenodo
- folding@home

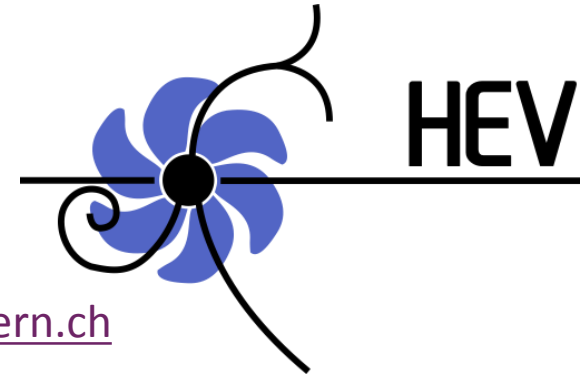




Buytaert, J., et al. "The HEV ventilator proposal." *arXiv preprint arXiv:2004.00534* (2020). <https://arxiv.org/abs/2004.00534>

HEV - A versatile, low-cost high-quality ventilator

<http://hev.web.cern.ch>



HEV is a fully specified ventilator system suitable for hospital use

- COVID-19 guidelines from the MHRA, WHO and AAMI and with clinical guidance
- both in and out of intensive care units (ICU),
- for both intubated and mask/non-invasive cases

patient comfort and safety first

many pressure control modes, pressure support and CPAP provided as standard.

- capable of supported patient controlled or machined controlled breathing

HEV is based on inexpensive and readily available components

see **EP Seminar- 19th May** J. Buytaert

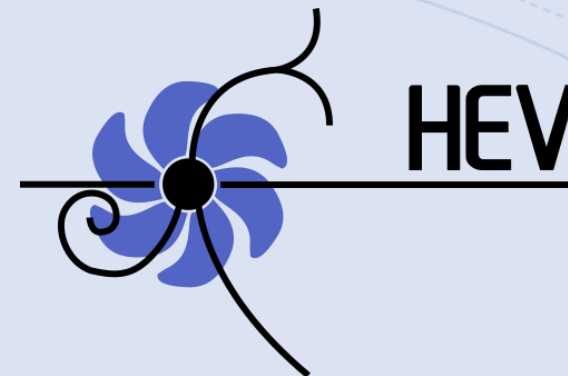
- <https://indico.cern.ch/event/918802/>

CERN, University of Liverpool, EPFL (Lausanne), UFRJ (Rio de Janeiro), IGFAE/USC (Santiago de Compostela), Nikhef (Amsterdam), University of Manchester, University of Nis, CUT (Cracow), University of Applied Sciences (Offenberg), Riga Technical University





3 Prototypes built



HEV



Prototypes for fast parallel development

- Pneumatics
- embedded control
- testing on a lung simulator

Buffer

- precise pressure control more readily accessible
- natural way to mix the gases (no need to use separate mixer)



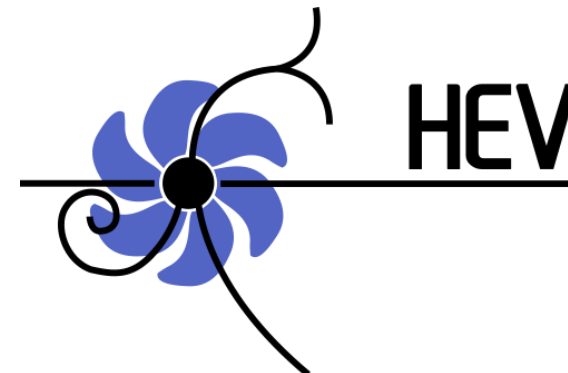
Simple to use HEV touchscreen (multilanguage)
Powered by μ computer
Ergonomic design and μ controller





HEV Timeline

Review Panel
Phil Allport,
Giovanni Anelli,
Phillip Rostalski,
Laurence Vignaux



March 27

April 3

April 10

April 17

April 23

April 30

May 7

Project start: 12 pm Friday March 27

Pneumatic Principle Demonstrated



MHRA
+ Clinical advice group

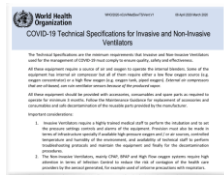
Demonstrator constructed



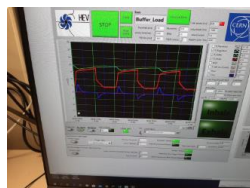
Labview controls



+ ISO
+ Medical + Engineering Advice Group



+ WHO guidelines
Demonstrator working with silicone lungs



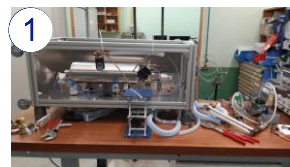
Full control panel



+ FDA guidelines
Prototype GUI



3 prototypes constructed; testing with lung simulator

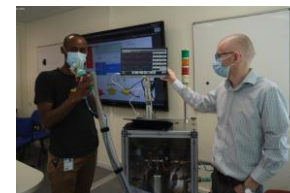


+ FMEA and Alarms tables



UI + real data

Full functional unit with user interface



minor upgrades to finalise prototype.





<https://arxiv.org/abs/2003.10405>

Mechanical Ventilator Milano

The MVM Collaboration grew from an initiative within The Global Argon Dark Matter Collaboration (GADMC)

- 160 collaborators (60 institutes, 9 companies)

designed for the treatment and weaning of acute respiratory distress syndrome in COVID19 patients

MVM obtained Emergency Use Authorization from U.S. Food and Drug Administration on May 1, 2020

CE mark, FDA Permanent Use Authorization, +Health Canada authorization being sought at this time

CERN support for software organisation and liaison with WHO



<https://mvm.care/>





MVM Timeline



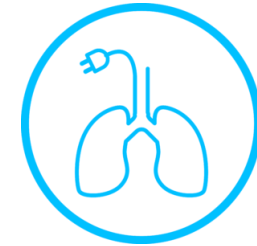
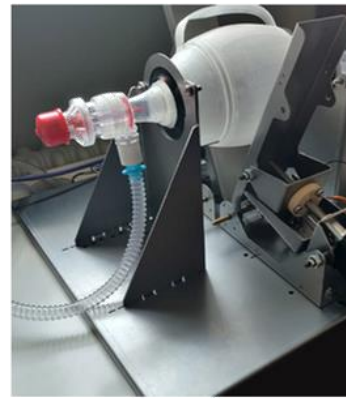
- **March 19: project conception**
- March 20: first experiments at SAPIO Life in Vaprio d'Adda (BG)
- March 21: engagement of GADMC collaborators, drafting of first paper
- March 22: engagement of EMD builder Elemaster in Lomagna (LC)
- **March 23: first submission of arxiv paper**
- **March 29: first test at San Gerardo hospital in Monza**
- March 31: second revised submission of arxiv paper
- April 10: third revised submission of arxiv paper
- April 23: submission to FDA of ISO 80601-2-80 report
- **May 1: FDA EUA authorization granted**





<https://www.ohwr.org/openbreath/lungventilator/wikis/home>

Openbreath



OPENBREATH

<https://www.openbreath.it/en/>

**construction simplicity and speed of realization
using bag valve mask**

Adopted the CERN Open Hardware License

Extremely low cost

PEEP, SIMV, CPAP modes

**CERN support for mechanical design and advice
towards incubators**

20 scientists/engineers

- International support



ZENTI

DASSAULT
S4SYSTEMES

RENISHAW
apply innovation™

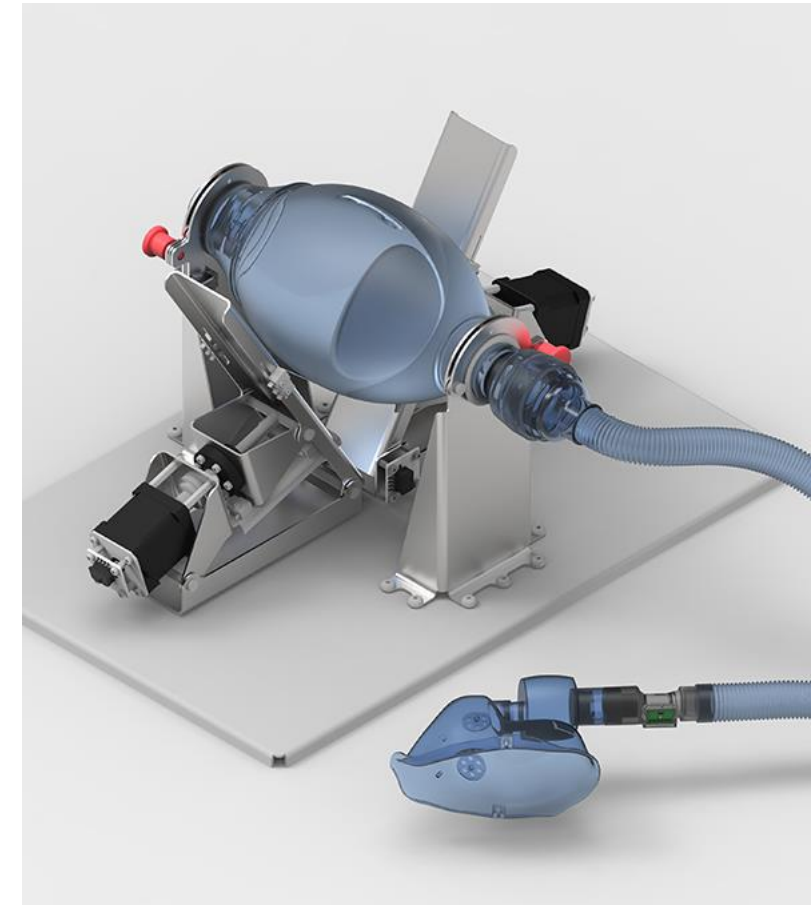
ZORTRAX

CTL

CATIA

acal^{bfi}

UPO
SIMNOVA



UV disinfection

“UVC light has been used extensively for more than 40 years in disinfecting drinking water, waste water, air, pharmaceutical products, and surfaces against a whole suite of human pathogens”

Germicidal range 200-280nm (4 to 12 eV)

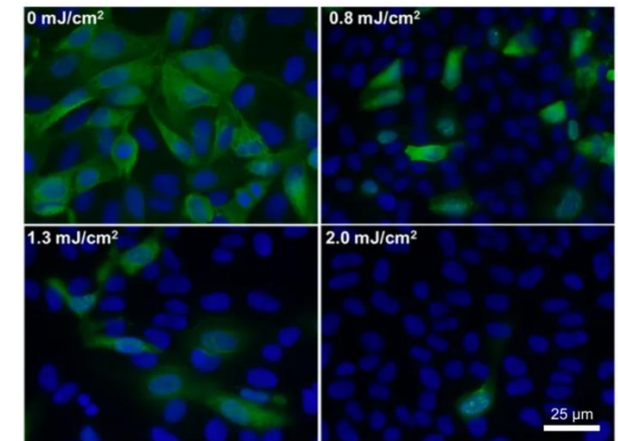
<https://www.nist.gov/news-events/events/2020/01/workshop-ultraviolet-disinfection-technologies-healthcare-associated>

No natural UVC radiation reaches the surface of the earth.

UVC can damage eyes and cause burns

UVC photons create defects including pyrimidine dimers.

- These dimers can prevent replication/prevent the expression of necessary proteins
- 2 to 8 mW s/cm² kills 90% virus ~ 10²⁰ photons /m²
- Cross-section of virus O(10⁻¹⁴m²)

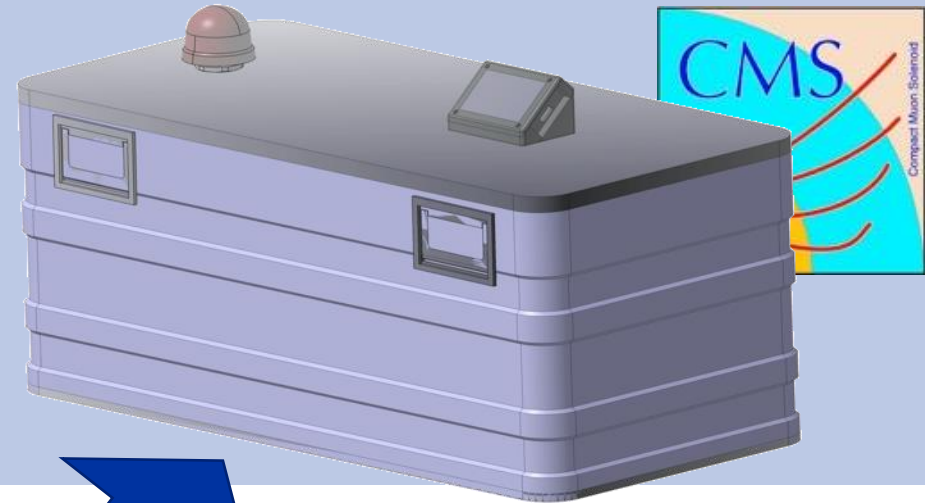


N1H1 virus Blue fluorescence:
number of sterilized *Sci Rep* 8, 2752
(2018).





A bus is disinfected using UVC in Shanghai, China (Credit: Getty Images)



UVC source: 8 x Mercury vapour based CFL

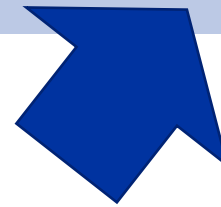
Mirrored Inner Surface / Uniform Illumination

Time based dose regulation

Dose, temperature and humidity monitoring

Console for local or remote (wifi) control

Interlock system for radiation and high voltage safety

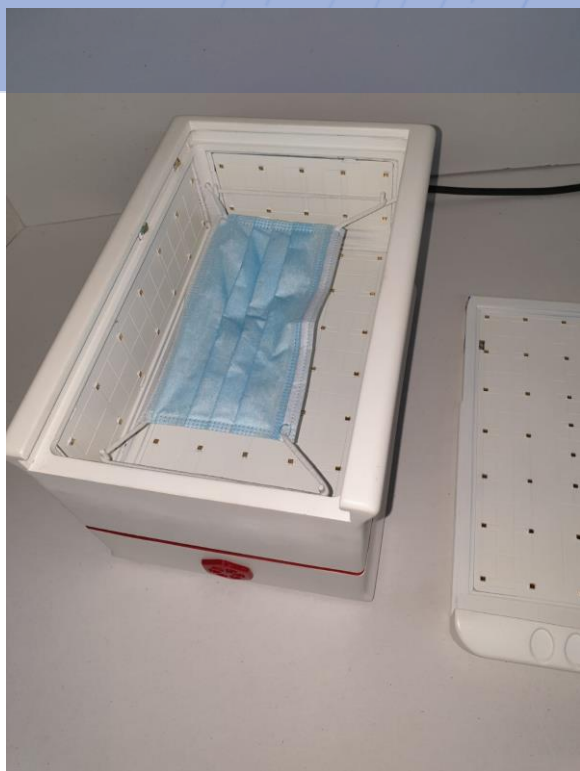


- Produce several V1 disinfection boxes at 904 in the CMS laboratory
- Evaluate electrical and radiation safety
- Biological test - SARS-CoV-2 virus
- Mask Filtering tests after UVC disinfection treatment





UVC LED Disinfection Box



- First working prototype designed and manufactured by I.M.E. firm in Italy
- Being delivered next WEEK
 - Box includes 120 x 0.5 W UV-C LED
 - **Biological tests planned**
- UCSB is working on the development of UV-LED to sanitise surfaces, and possibly, air and water

https://www.novuslight.com/developing-uv-leds-to-decontaminate-surfaces-of-covid-19_N10313.html

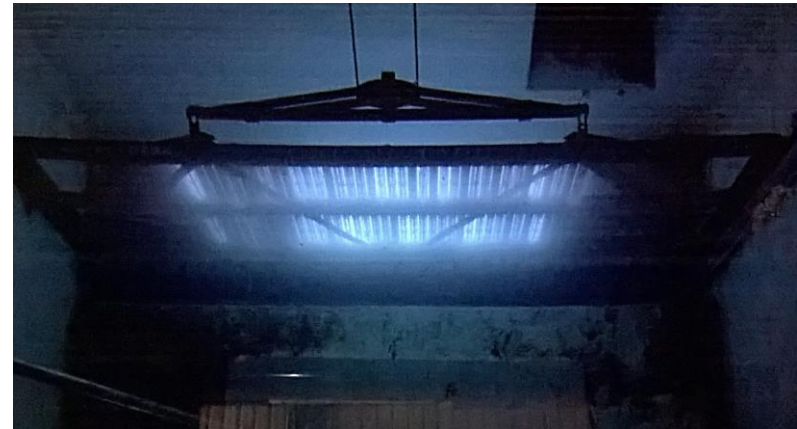




STAR DOME IRRADIATION WITH Co-60 STERILIZATION WITH ELECTRON BEAMS

Microbiological analysis of PPE pre-irradiation

- Irradiation at different doses
- Microbiological analysis post-irradiation
- Verification of mechanical and filtration integrity of PPE

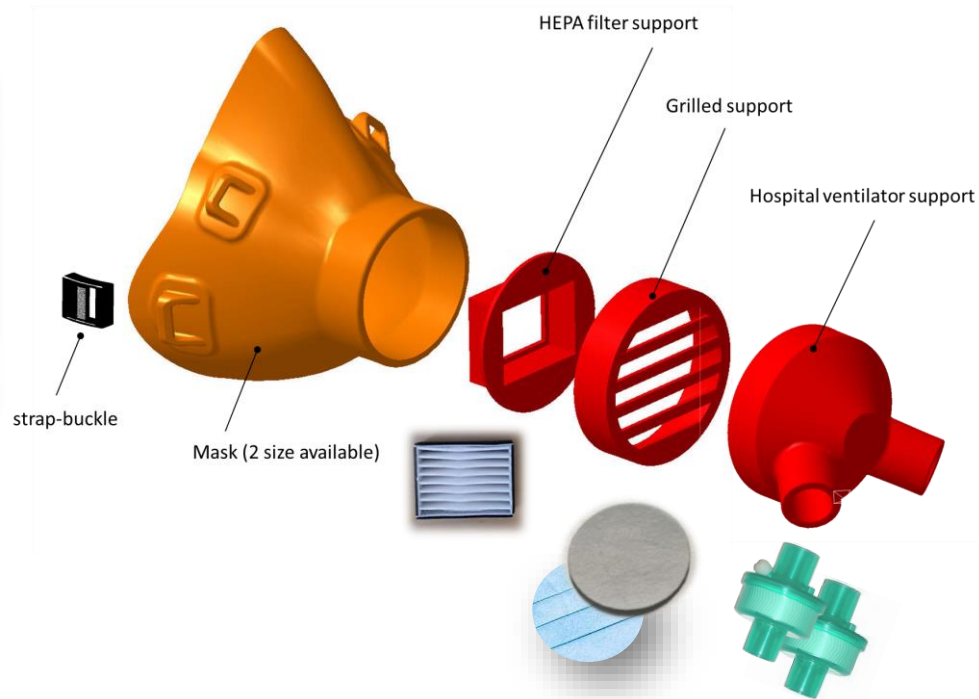


CERN Linear Electron Accelerator for Research

With STAR DOME we already have the embryo of a larger consortium in which CERN can be full partner



Washable 3D-Printed masks



Test results (Certified lab) "Grilled support"

- Filtration: $\geq 97\%$
- Breathability: $< 40\text{ Pa}$
- Temp. resistance: $-30\text{ to }70^\circ\text{C}$
- Usability: Very good

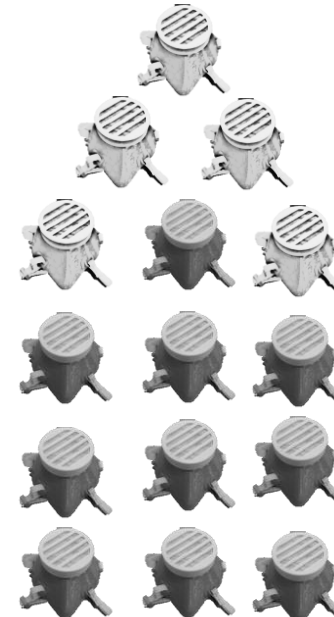
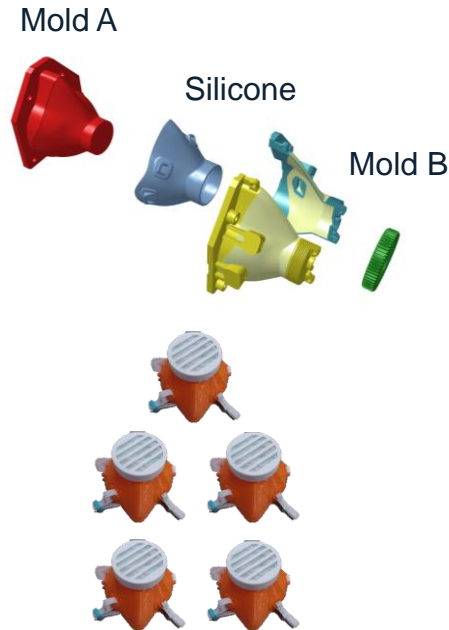
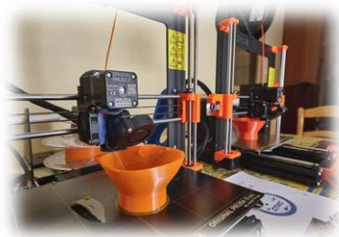


- PPE: **Respiratory protective face mask**
- Characteristics: **Re-usable**, ergonomic, **flexibility** with different filter options (i.e. change filtration %)
- Design based on applicable EN standards
- Equivalent Performance: at least **FFP2** (EN 149)



Washable 3D-Printed masks

Production rate



3D printing
(2 / day / printer)

Silicone with 3D
printed mold
(1 / h / mold)

Injection molding
(?)
In contact with possible partners



Re-useable concept:
Reduce waste / impact to
the Environment

**Washable and
biodegradable filter** under
development - CERN Baltic
Group (via *KUT, Lithuania*)

➤ In close contact with interested partners: local companies, ICRC, NGOs, *Regione Piemonte* (IT)
Release under CERN Open Hardware Licence (COHL) v2 under preparation



Coating used by ICARUS: Liquid Glass Nanopool GmbH [http//nanopool.eu](http://nanopool.eu)

A very thin coating of glass applied via aerosol/spray/dip to almost any surface

Renders it hydrophobic and easier to clean

- Fabrics(masks, gowns, surface)

Possible addition of antiviral agents in matrix

CERN's role to make connections for testing on COVID-19.

Other functionally similar activities brought to our attention include

- <https://heiq.com/technologies/heiq-viroblock/>
- These will also be investigated

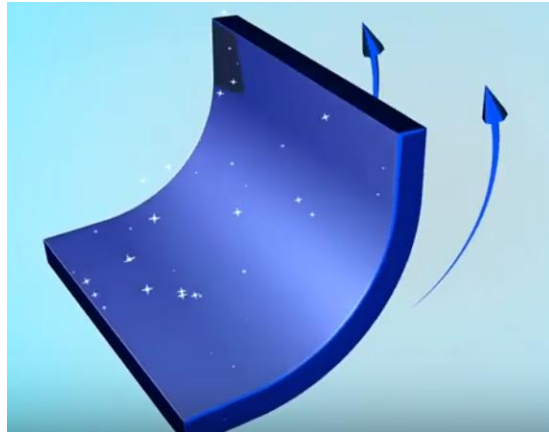




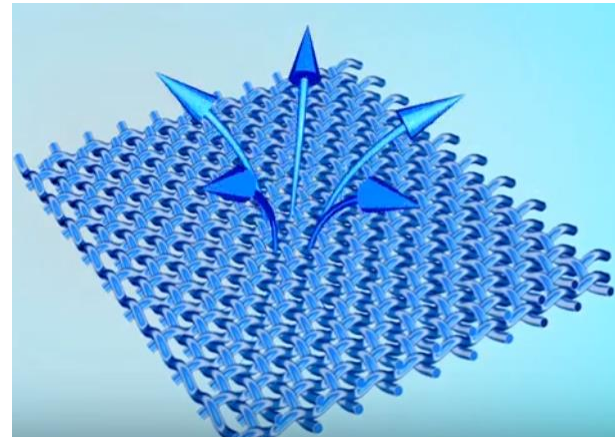
<https://www.youtube.com/watch?v=eARwlCYAwd0&feature=youtu.be>



Glass layer $O(500\text{nm})$



flexible

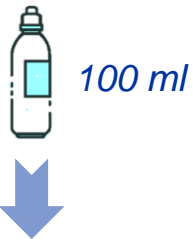
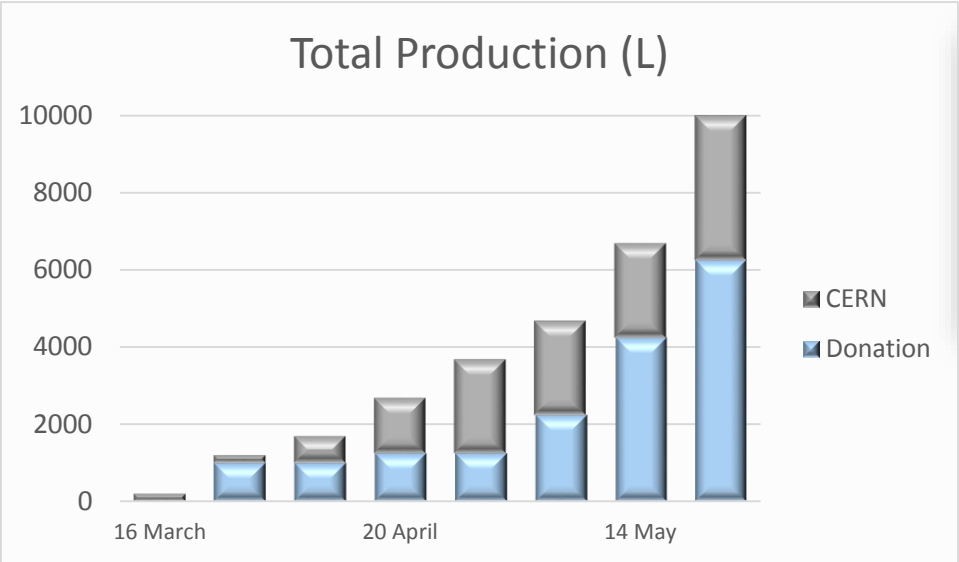


breathable



Hydro-alcoholic Hand Sanitiser

- COVID-19-specific hand sanitizer
- Initiated and produced by the **TE-VSC Chemical Lab**
- Characteristics: WHO 'recipe', labeled according to EU requirements



10 000 liters produced
(+ 6000 donated to local community)

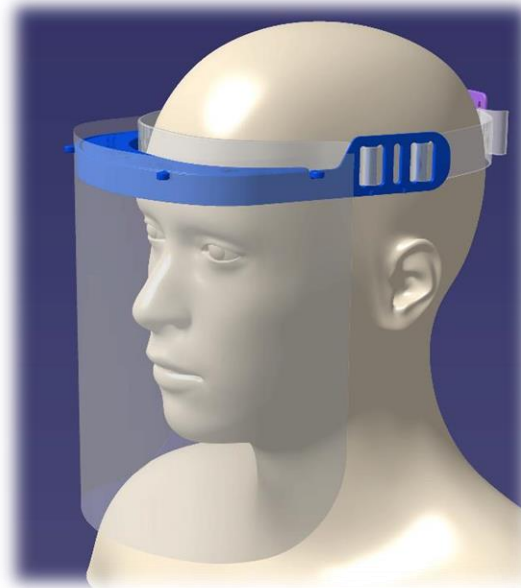
eq. 100 000 bottles !!



Face shields



Face shield - *type-1*



Face shield - *type-2*



Face shield - *type-3*

Raw material Donations:



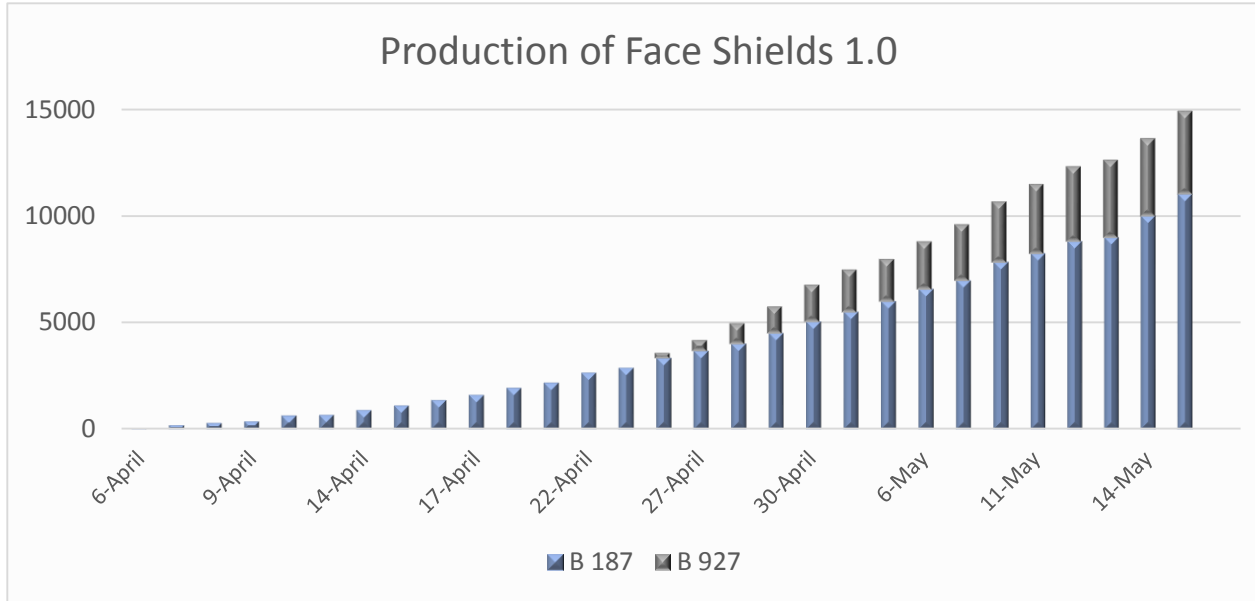
COVID-19-specific PPE: Protection against droplets and splashes of liquid *only*

Design based on applicable EN standards

Characteristics: Light, ergonomic, easy to put on, compatible with safety helmet

Release under CERN Open Hardware Licence (COHL) v2 under preparation

Face shield *type-1* 'Factory'



50 / day

900 - 1000 / day

15 000 shields produced
 +10 000 shields delivered (Donation / CERN use)
 SCEM: 50.43.30.299.0

Meyrin
Production line
(6th April)



Prevessin
Production line
(24th April)



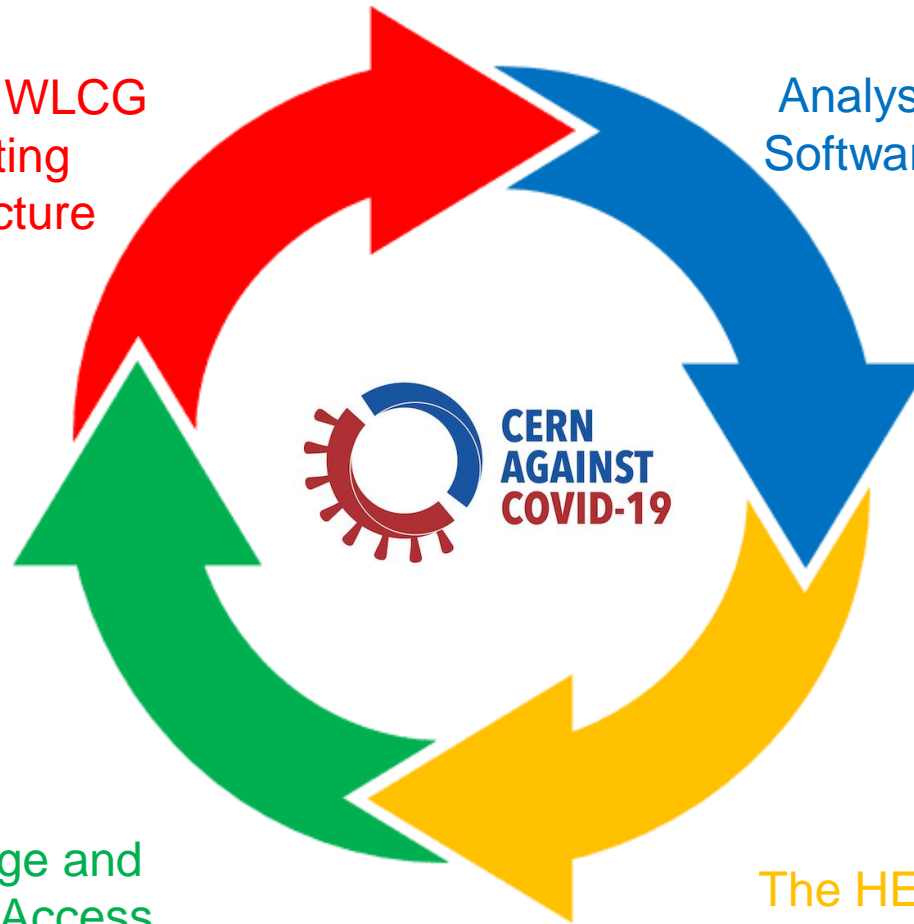
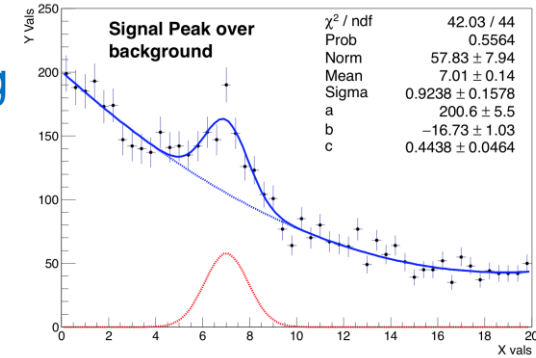
- Visits by:
- Director-General
 - Director for A&T
 - Sous Préfet de Gex
 - Ambassador of France to the UN in Geneva

Areas of Computing Initiatives



CERN and WLCG
Computing
Infrastructure

Analysis, Simulation
Software Engineering



Data Storage and
Open Data Access

The HEP Community
Skills and Creativity



CERN and WLCG Contributions

- CERN was already contributing to Folding@Home before March as a general support for scientific initiatives
- In March CERN and WLCG (initially mainly from ATLAS) have started a **community effort** to support F@H, which has **rapidly rallied resources** from **all the LHC experiments**. Today CMS and ATLAS are the largest resource providers (Top10 in May worldwide)
- In just two months the community has collectively provided around **1M computing cores** running **millions of jobs per day** from more than **220** volunteer sites and individuals

Donors: CMS and ATLAS
Top10 in May out of more than 1.5M donors

Team:
31st contributor overall
5th in May
out of more than 250k teams worldwide

Rank Project

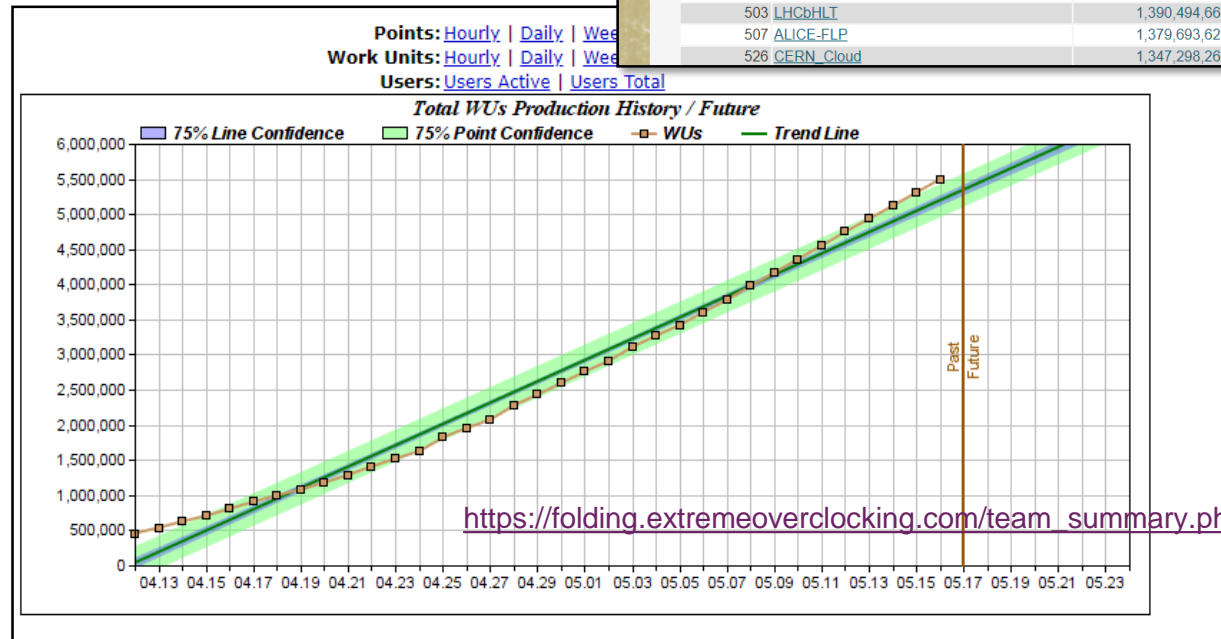
1	Anonymous
2	raqlab
3	NVIDIA_Saturn_V
4	CMS-Experiment
5	ANX_Developers
6	ATLAS_CPU
7	CRT-DC_and_Frontier_Labs
8	sdumont.petrobras
9	Arbutus

Team: CERN & LHC Comput...

Date of last work unit: 2020-05-19 18:56:42
 Active CPUs within 50 days: 1,018,282
 Team Id: 38188
 Grand Score: 20,696,258,327
 Work Units: 5,952,658
 31 of 253417
<http://public.web.cern.ch/public/>
<https://apps.foldingathome.org/teamstats/team38188.html>

Team members

Rank	Name	Credit	WUs
53	CMS-Experiment	8,275,282,617	1,711,582
77	ATLAS_CPU	6,579,078,398	1,680,295
503	LHCbHLT	1,390,494,664	236,949
507	ALICE-FLP	1,379,693,629	123,035
526	CERN_Cloud	1,347,298,262	625,625



Data Management Contributions to F@H

- A major consequence of the rapid increase in volunteer resources worldwide was the **need to scale the distribution infrastructure**
- CERN (IT and EP Dep.) **teamed up** with the Bowman Labs (home of F@H), GridPP, STFC and the Hartree HPC centre in the UK, FNAL and UChicago in US and others to **expand the F@H data infrastructure**
- HEP framework and tools such as **RUCIO** and **FTS** (used by the LHC experiments to transfer and manage data worldwide) are being deployed to expand the existing F@H services

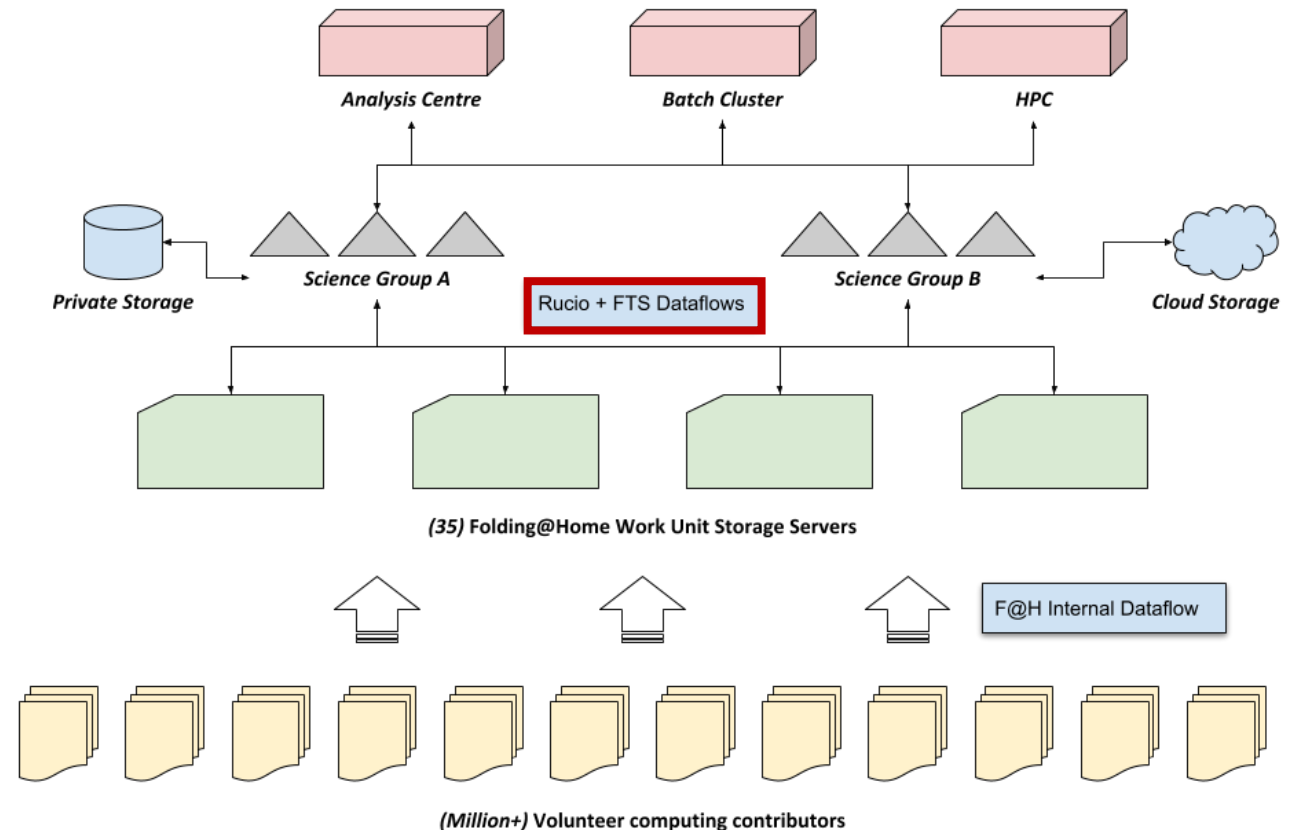
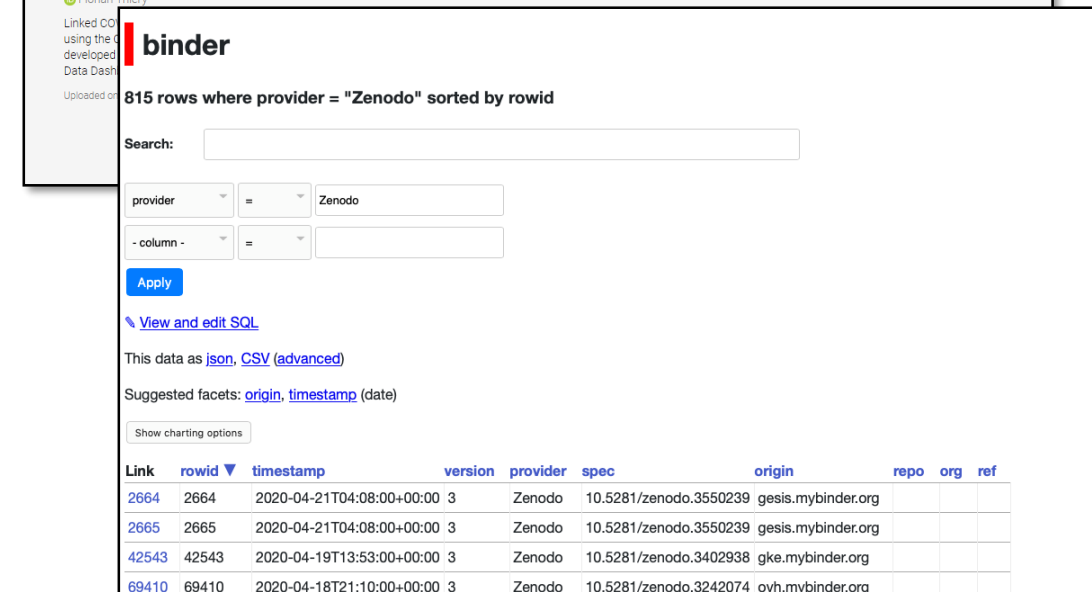
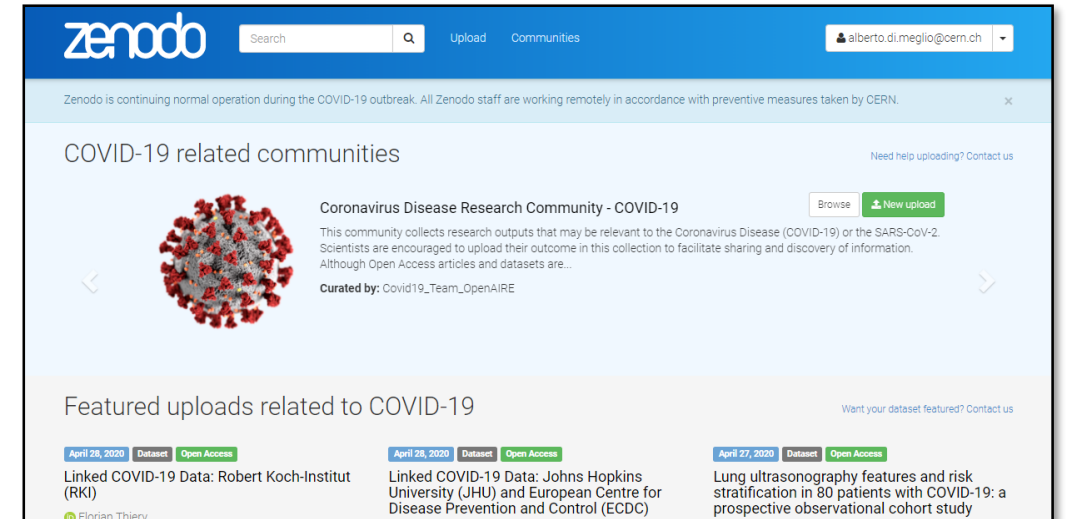


Diagram courtesy of Mario Lassnig

Open Data & Digital Assets Storage

- The worldwide research efforts against COVID-19 have brought to many more people's attention the role of **open data repositories** to support **reproducible, collaborative research**
- CERN was already very active in this area before the current situation with tools like **Zenodo** (<https://zenodo.org>) and the **CERN Open Data portal** (<http://opendata.cern.ch/>)
- Terms of Use for Zenodo have been revised in anticipation of an **increase in requests** to store open access medical research data
- **Integration of Zenodo** within the data flows of many initiatives, e.g. Binder (a popular Notebook execution framework, <https://mybinder.org>) shows **815** different Zenodo-based flows



Examples of Datasets in Zenodo

COVID-19 CT Lung and Infection Segmentation Dataset

April 20, 2020

4,486 views | 6,920 downloads

Indexed in **OpenAIRE**

Medical

Raw diffraction data for structure of SARS-CoV-2 main protease with Z1271660837 (ID: mpro-x1226 / PDB: 5RFB)

March 30, 2020

257 views | 23 downloads

Indexed in **OpenAIRE**

Biological

Linked COVID-19 Data: Johns Hopkins University (JHU) and European Centre for Disease Prevention and Control (ECDC)

May 18, 2020

3,178 views | 645 downloads

Indexed in **OpenAIRE**

Standardization

Crowdsourced air traffic data from The OpenSky Network 2020

May 1, 2020

939 views | 179 downloads

Indexed in **OpenAIRE**

Transportations

Open Access Data Initiatives

Circular Health

An initiative by the One Health Centre of Excellence at UFlorida to support the creation of a large-scale federation of open access data repositories for global health research

CERN contributions: creation of a **Zenodo** community and a **GitHub** repository, support for data collection and aggregation, workflows automation (**REANA**)

EMBL-EBI Data Portal (<https://www.ebi.ac.uk/covid-19>)

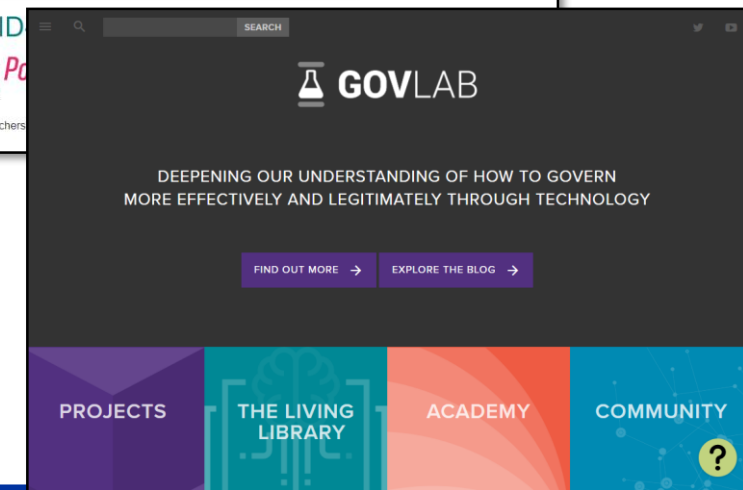
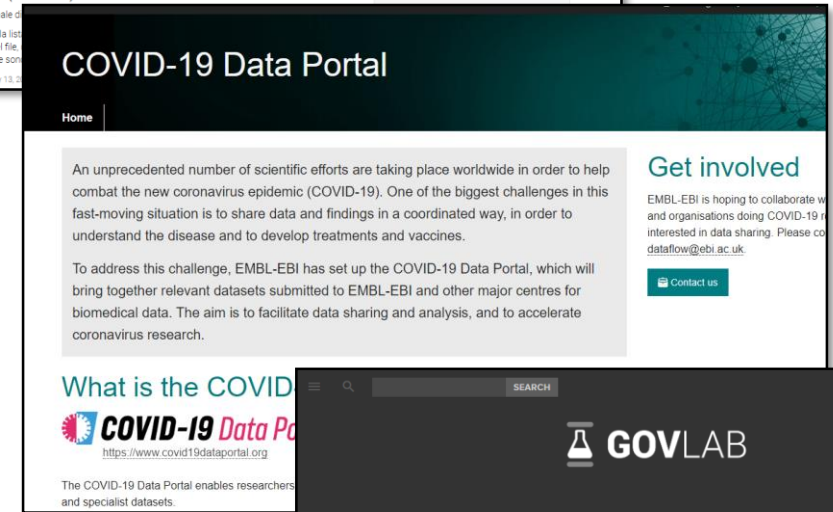
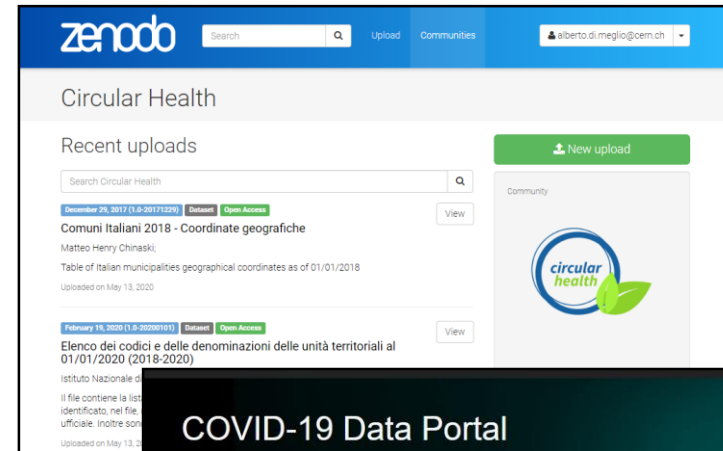
A portal to bring together relevant datasets submitted to EMBL-EBI and other major centres for biomedical data with the aim to facilitate data sharing and analysis, and to accelerate coronavirus research.

CERN contributions: agreements to direct certain types of data to Zenodo, establishment of contacts between the respective data curator teams

The Governance Lab (GovLab, <https://www.thegovlab.org/>)

International initiative to “strengthen the ability of institutions and people to work more openly, collaboratively, effectively and legitimately to make better decisions and solve public problems”

CERN contributions: Initial discussions to share ideas around effective use of open access data and policies



Data Analysis, Simulation, Software Engineering



Health Emergency and Disaster Risk Management

Implementation of the WHO emergency and disaster risk management framework, support for policies, planning, knowledge management

CERN contribution (BE, IT, KT)

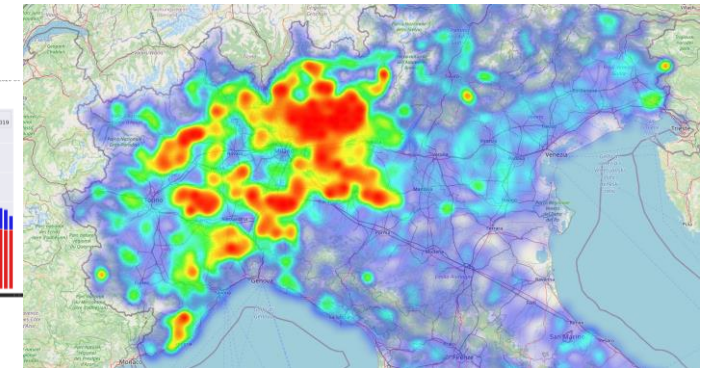
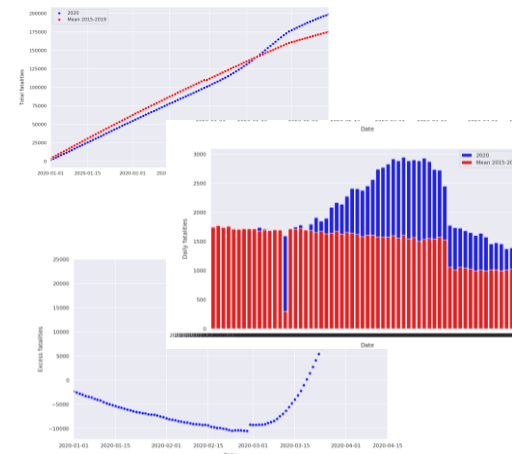
- Collaboration on data architectures optimization of risk analysis and supply chain management
- Possibly part of broader regional initiatives to integrate medical, industrial and governance data systems



Analysis of COVID-19 impact and correlations with health and social factors (co-morbidities, demographics, environmental conditions)

CERN contribution (ATS, IT)

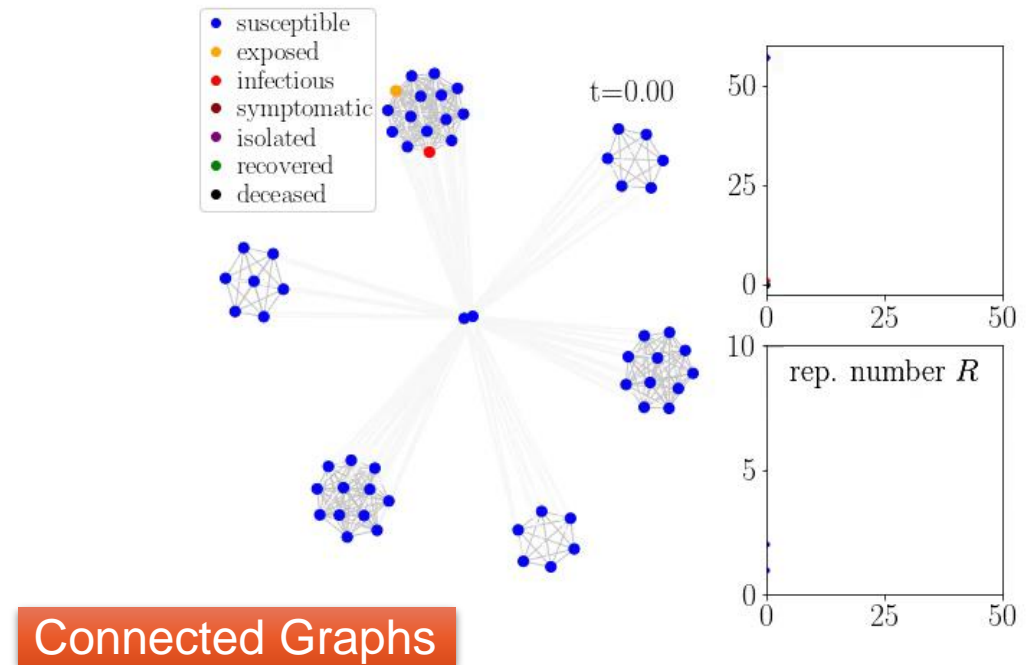
- Implementation with Zenodo, REANA, SWAN as part of Circular Health
- Data aggregation, analysis, visualization of public access statistical and demographical data



<https://github.com/CERN/CircularHealth>

Examples of Epidemiological Simulations

Simulations of virus propagation based on models of infection and recovery rates



Lukas Breitwieser - Ahmad Hesam - Fons Rademakers (IT Dep.)

Simulating the Spread of Viruses inside an Organization

Joachim Kopp (CERN TH Dep. & Uni Mainz)

Long-Term Impact

- **The relations built with organizations, international initiatives and people have strengthen even more our community**
- **Ways of supporting the initiatives beyond the current emergency are being discussed, for example via project proposals for European and national funds**
 - The collaboration on epidemiologic simulation between CERN and UNIGE in BioDynaMo has just received funds from the EOSC COVID-19 Fast-Track programme to continue the research for the next 9 months
- **Lessons learned are being shared with other organizations**
 - Many of the current activities will be provided as input for the development of services for the European Open Science Cloud (EOSC) and the Health Research & Innovation Cloud (HRIC)
 - Collaborations with other organizations such as WHO or EMBL will continue through existing or new collaboration agreements

Beyond the emergency

- **The Task Force allows CERN to provide help in this emergency**
- **This model of working, and the tools developed, will remain part of CERN's culture: we can learn from what has happened and be prepared to respond in future to any similar situation**
- **The landscape is already changing: enormous worldwide response to the first outstanding healthcare and medical research challenges (ventilators, masks, sanitisers, computing/data storage).**

Conclusions

- **CERN responded to the emergency with this Task Force joining the worldwide effort of the scientific community**
- **We are sure that this experience will not be forgotten and reused if the need arises again**
- **Both the number and quality of ideas received is very high**
 - We implemented many, we will not forget the ones we didn't have possibility yet to explore
- **This emergency has increased the contacts of CERN with society and research in other fields than High Energy Physics**
- **My deep gratitude goes to the members of the task force, to the colleagues helping and to all people that contacted us proposing initiatives or asking help**
 - **We did our best and we will continue!**



*Happiness:
the science behind a smile*



Credits

- **Invaluable help with material from:**
 - Themis Bowcock
 - Alberto Di Meglio
 - André Henriques
 - HEV collaboration
 - MVM collaboration
 - OpenBreath
 - Nanopool and VetroLiquido
 - The whole task force

