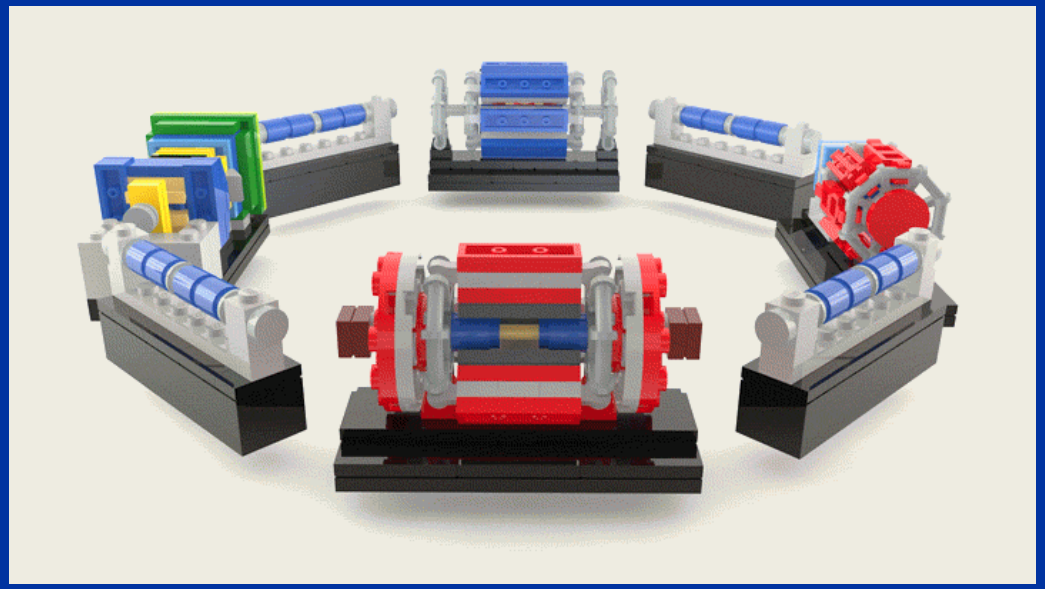


ATS New Year Webcast 2023

Mike, Malika, Katy, Brennan, Miguel, Rhodri

12th January 2023

Big thanks to Alessia Valenza and the Audio-visual team for the organisation of today's Webinar!

STAY STRATEGIC
THINK COMMUNICATIONS
PLAN FOR NEXT STEPS

Preparation and Prevention during the *Visite d'inspection commune* (VIC)

Thank you: EN-ACE-OSA, EN-ACE-OSS, HSE-OHS, HSE-RP

Ana-Paula Bernardes and Thomas Otto

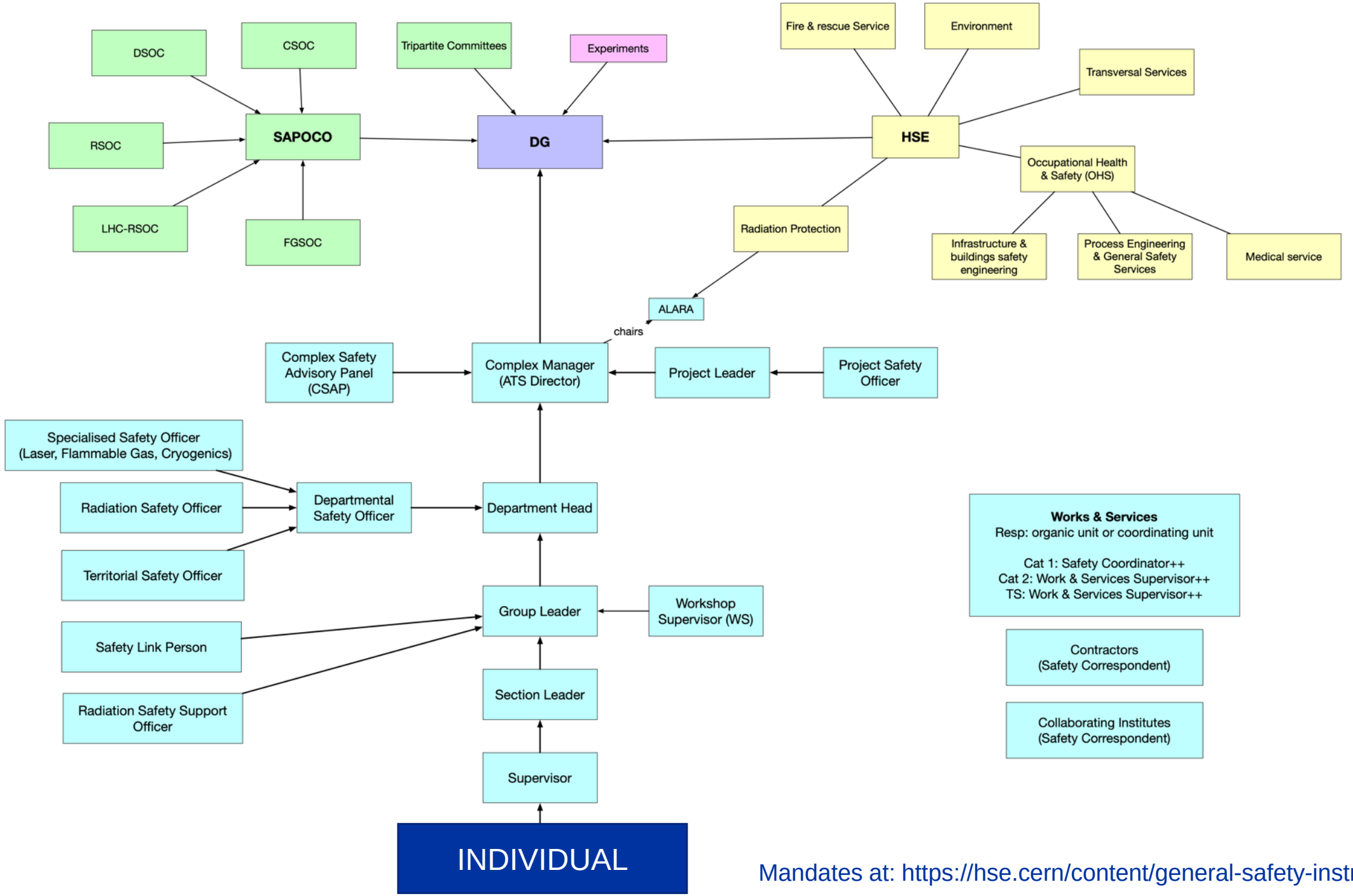
SAFETY!

Safety is the responsibility of all of us, and our safety culture is ultimately reflected in the way safety is addressed in our workplaces.

We should continue to work to ensure:

- Good **awareness** of risks across the workforce
- Clear **communication** of processes, rules, and procedures
- Clear well-defined **lines of responsibility**
- **Realistic and flexible practices** for handing both well-defined and ill-defined risks
- Appropriate **training** across the board
- To **continually learn from experience**, via monitoring, reporting and feedback.

We share responsibilities with the employers regarding contractors' personnel and must work with them to ensure full and proper safety on site in sometimes unfamiliar and complex infrastructure.



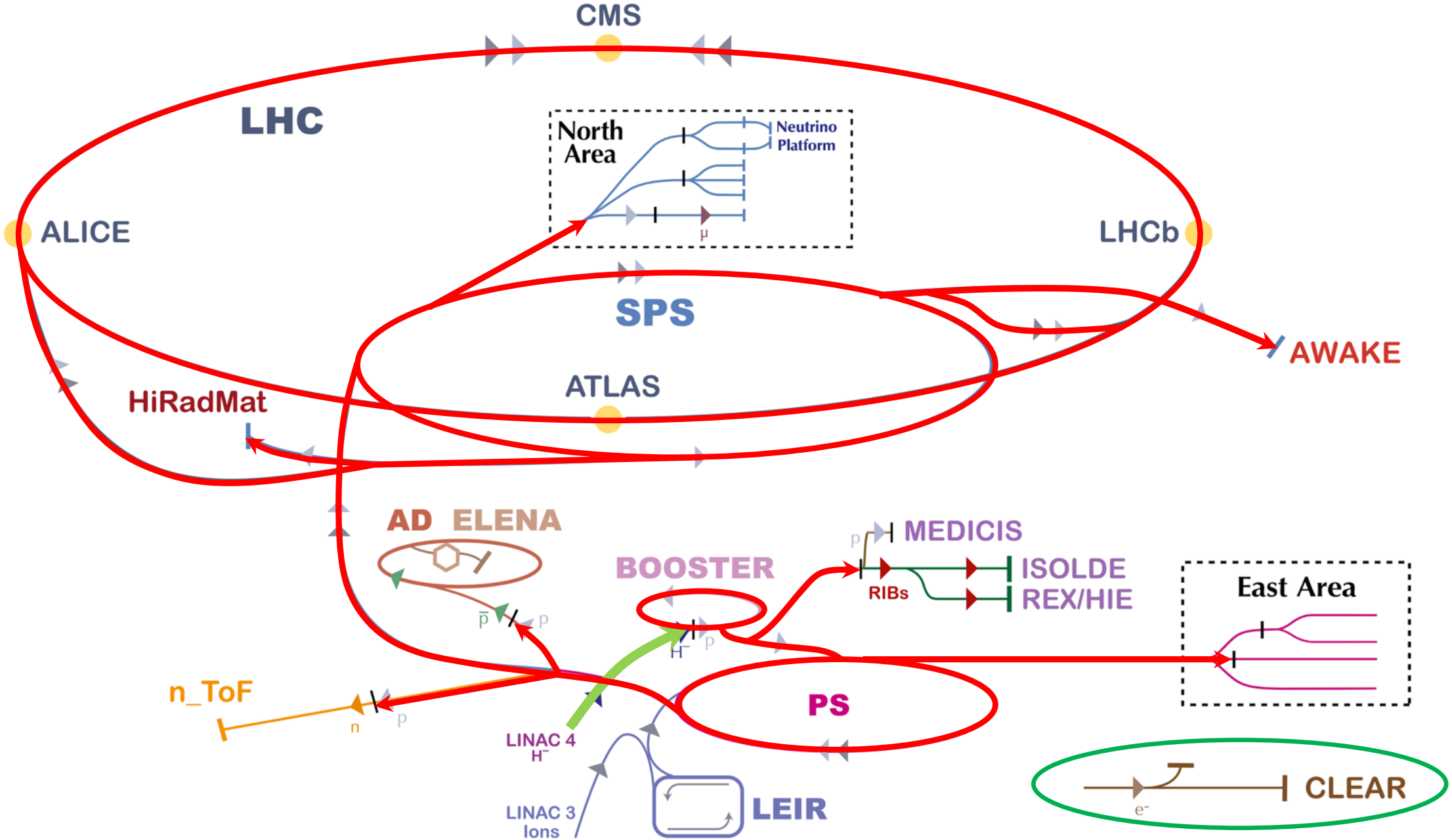
Mandates at: https://hse.cern/content/general-safety-instructions-gsi

Huge thanks

- **Safety Officers**
  - DSO, DDSO, ADSO, RSO, SSO, RSSO, TSO, FGSO, LSO, CSO
- **Roles**
  - SLP, DH, GL, SL, Supervisors, Individuals!
- **Committees and Panels**
  - SAPACO, PSO, DSOC, CSOC, RSOC, LHC-RSOC, FGSO, ALARA
  - PS-CSAP, SPS-CSAP, LHC-CSAP
- **Work Site**
  - SC, WSS, EROS

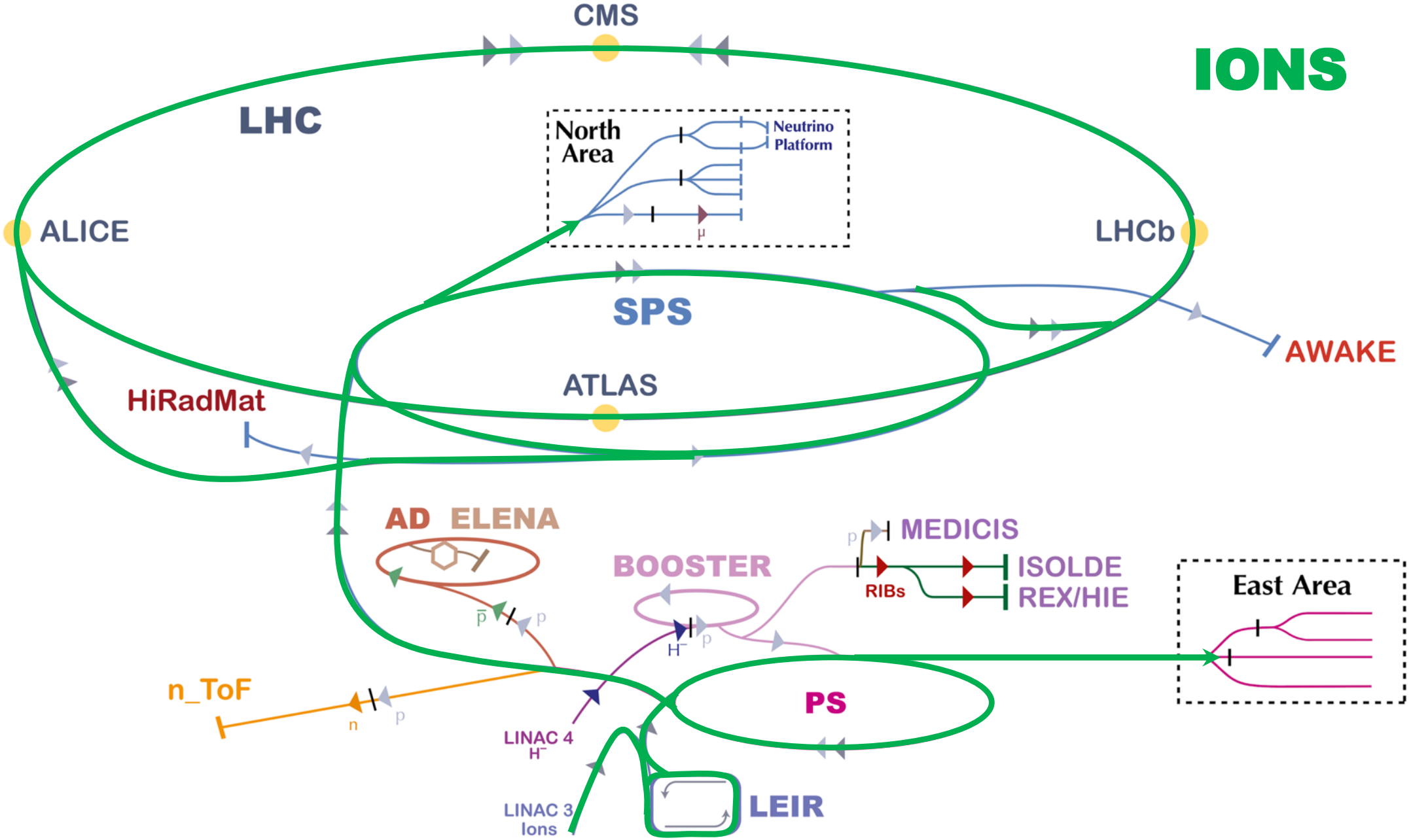
Individual responsibility

Each person participating in the activities of the Organization or present on its site shall actively contribute to the implementation of the CERN Safety Policy through exemplary conduct and, in particular, compliance with the CERN Safety Rules



H⁻ (hydrogen anion) p (protons) ions RIBs (Radioactive Ion Beams) n (neutrons) $\bar{p}$ (antiprotons) e⁻ (electrons)

IONS



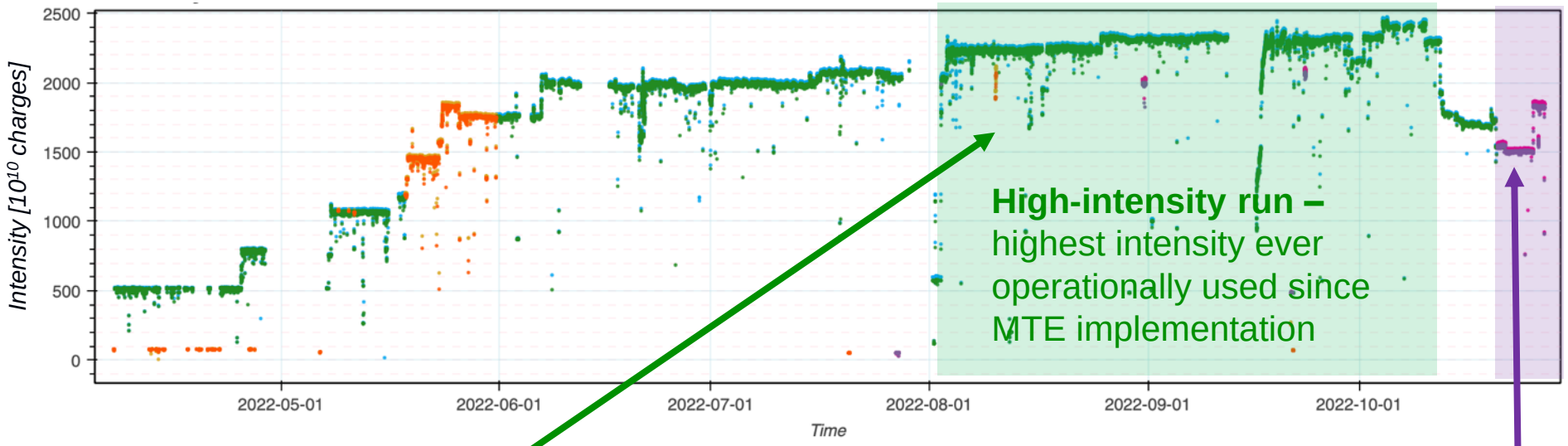
H⁻ (hydrogen anion) p (protons) ions RIBs (Radioactive Ion Beams) n (neutrons) p̄ (antiprotons) e⁻ (electrons)

Availability Overview LHC Injector Chain

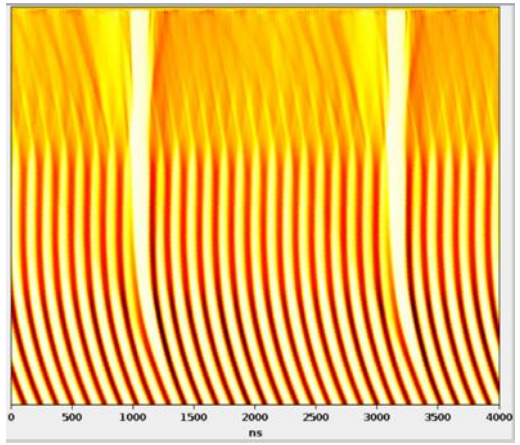
Facility	Destination	Expected 2022 Total [%]	Achieved 2022 Total [%]	Period
LINAC4	-	**95**	**97.1**	28.03.2022 – 21.11.2022
PSB	PS	**90**	**95.5**	28.03.2022 – 21.11.2022
	ISOLDE		**95.5**	
PS	SPS	**87**	**89.6**	28.03.2022 – 21.11.2022
	nTOF		**90.0**	
	AD		**90.6**	
	East Area		**91.6**	
SPS	LHC	**84**	**89.9**	25.04.2022 – 21.11.2022
	North Area		**73.2**	
	AWAKE		**92.3**	
	HiRadMat		**93.6**	

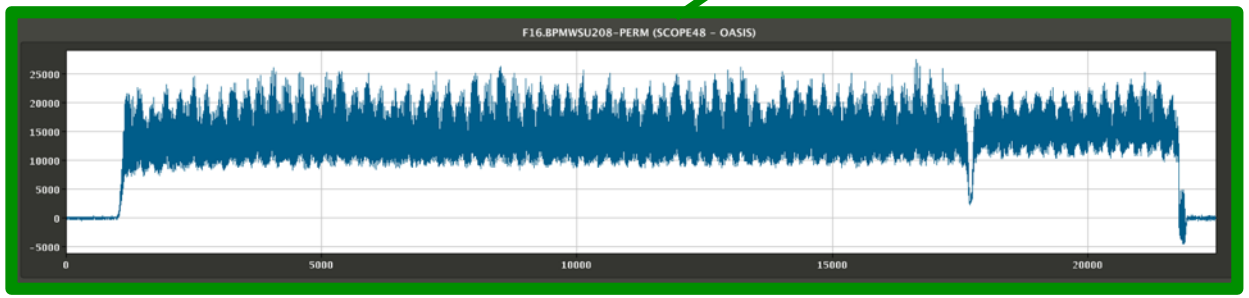
PS Highlights – MTE Beam for North Area

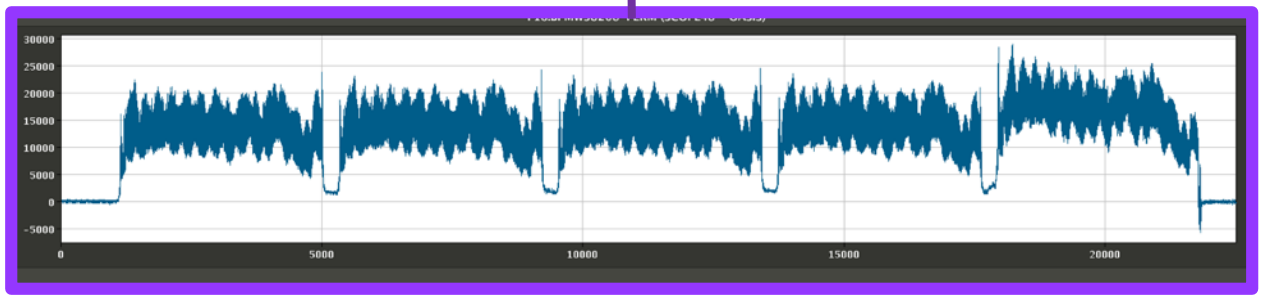
CERN PS MULTI TURN EXTRACTION



High-intensity run – highest intensity ever operationally used since MTE implementation

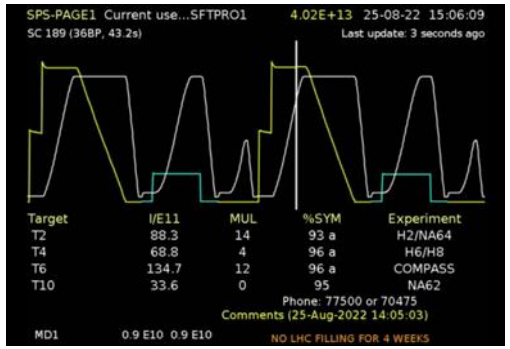




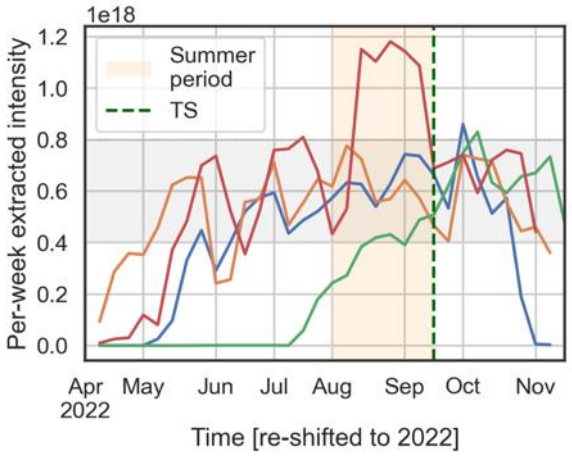


Barrier bucket beam production scheme for PS extraction loss reduction

Timeline & Milestones (mainly SPS)

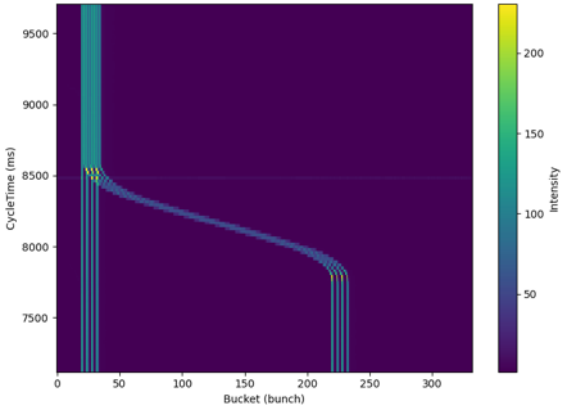


Start physics



Hot summer - record extraction rates

HiRadMat SMAUG record intensities



Ion commissioning with new system

April | May | June | July | August | September | October | November | December

TCSC

Water leak at first TCSC (TT20) Affecting North Area

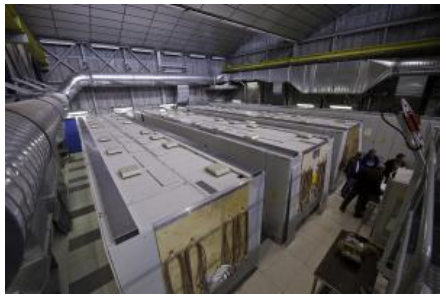
ZS

ZS sparking - required long cool-down prior to cleaning & consolidating HT connectors

TBIU

Vacuum TBIU (TCC2) Affecting North Area

POPS

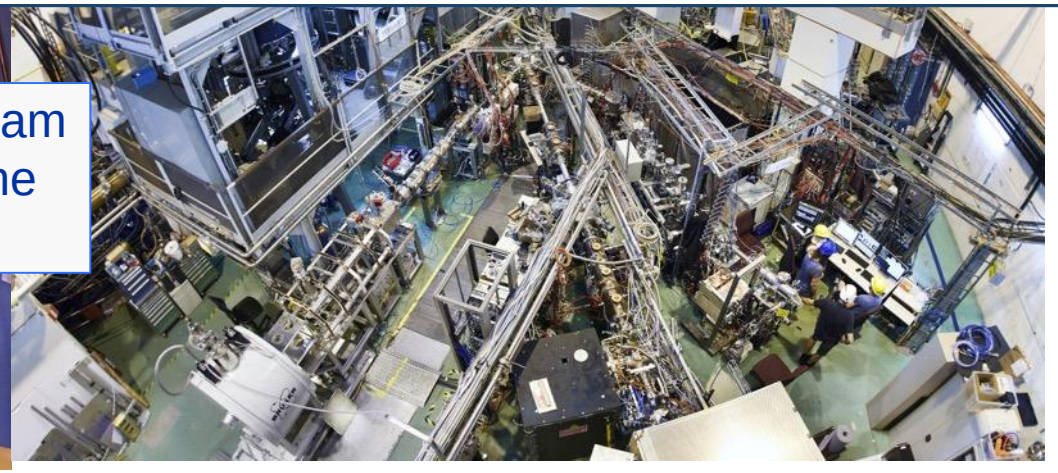


AD-ELENA

Stability, reliability and reproducibility of the ELENA beam is excellent, congratulations and a big thank you to the awesome AD team and CERN!

ISOLDE

Challenging run but very successful overall run: several problems encountered but solved thanks to the effort and commitment of all teams supporting the facility



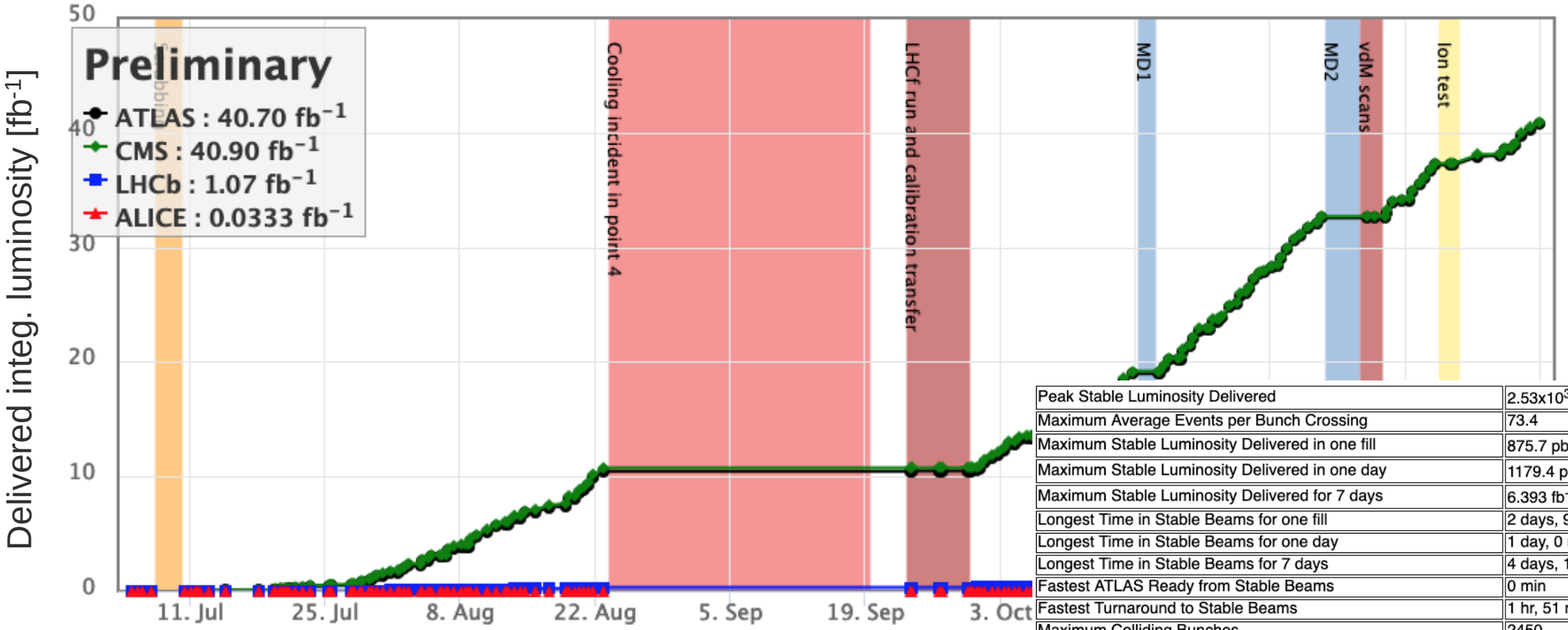
n_TOF

- **The n_TOF target works nicely and smoothly. We can even go from 165E10pps to 220E10 pps (many thanks to SY-STI group!)**
- **The delivered protons are following our expectations (many thanks to PS teams!)**

East Area

The renovation of the East Area has greatly increased the performance of all beamlines including their availability and stability. Overall, very happy users and a productive year

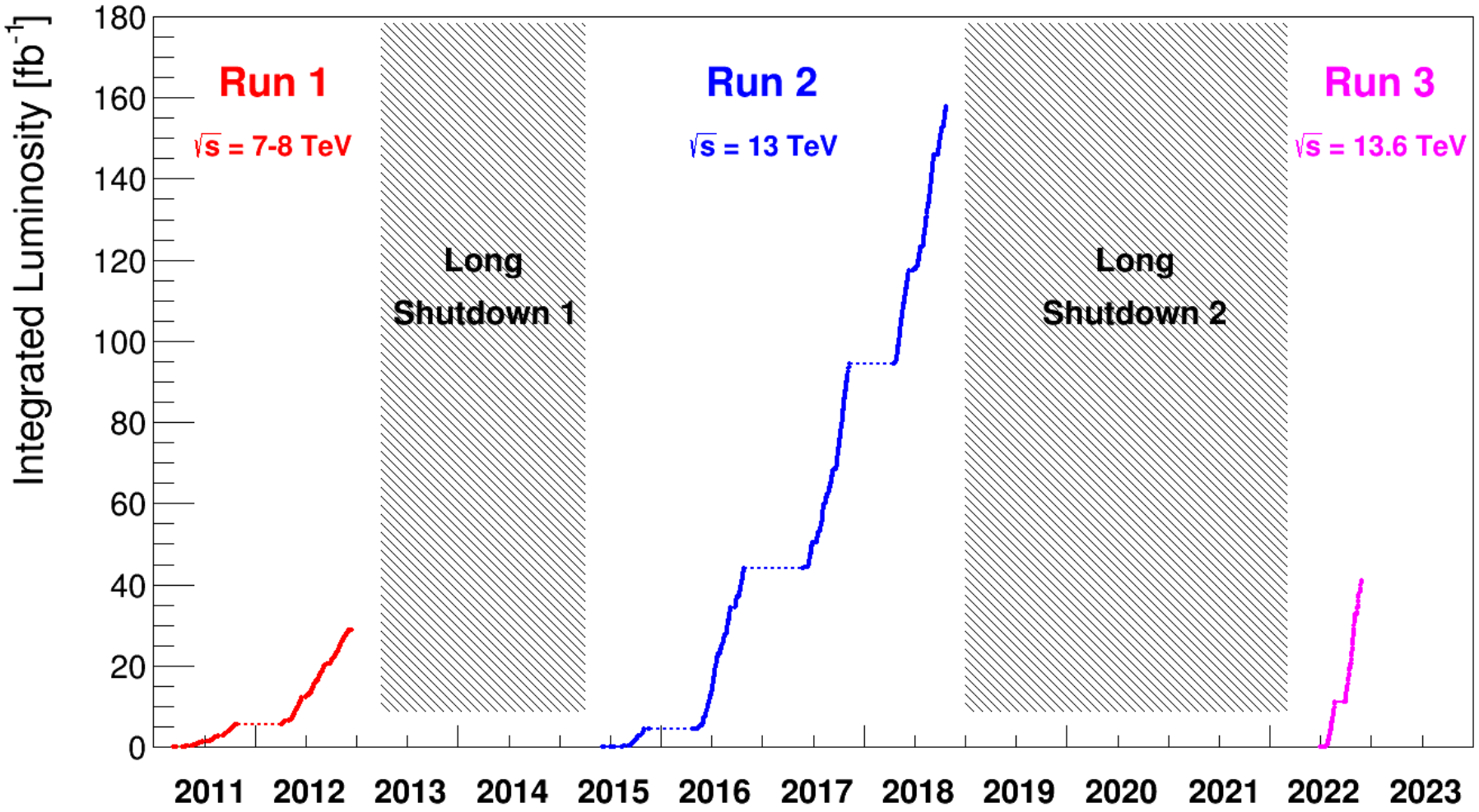
Delivered luminosity 2022



Peak Stable Luminosity Delivered	2.53×10^{34} cm^{-2}s^{-1}
Maximum Average Events per Bunch Crossing	73.4
Maximum Stable Luminosity Delivered in one fill	875.7 pb^{-1}
Maximum Stable Luminosity Delivered in one day	1179.4 pb^{-1}
Maximum Stable Luminosity Delivered for 7 days	6.393 fb^{-1}
Longest Time in Stable Beams for one fill	2 days, 9 hrs, 23 min
Longest Time in Stable Beams for one day	1 day, 0 min
Longest Time in Stable Beams for 7 days	4 days, 18 hrs, 48 min
Fastest ATLAS Ready from Stable Beams	0 min
Fastest Turnaround to Stable Beams	1 hr, 51 min
Maximum Colliding Bunches	2450
Maximum Charge per Bunch Colliding	1.48×10^{11}
Maximum Charge per Beam Colliding	3.63×10^{14}

Some stunning record-breaking performance!

Integrated luminosity over the year years

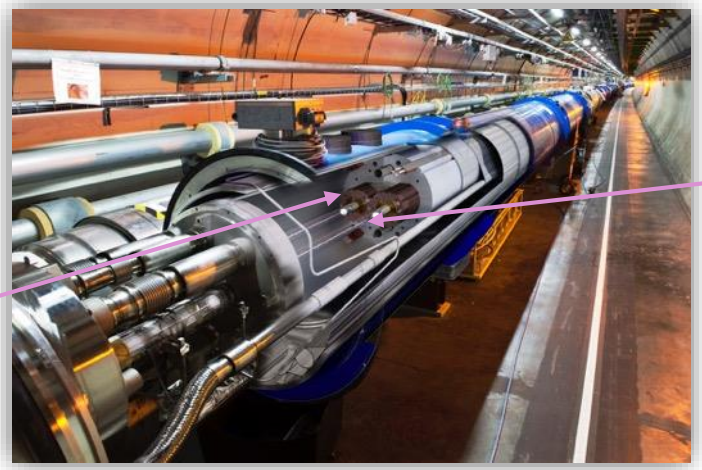


LHC Physics Production

Quench limit

15-50 mJ/cm³

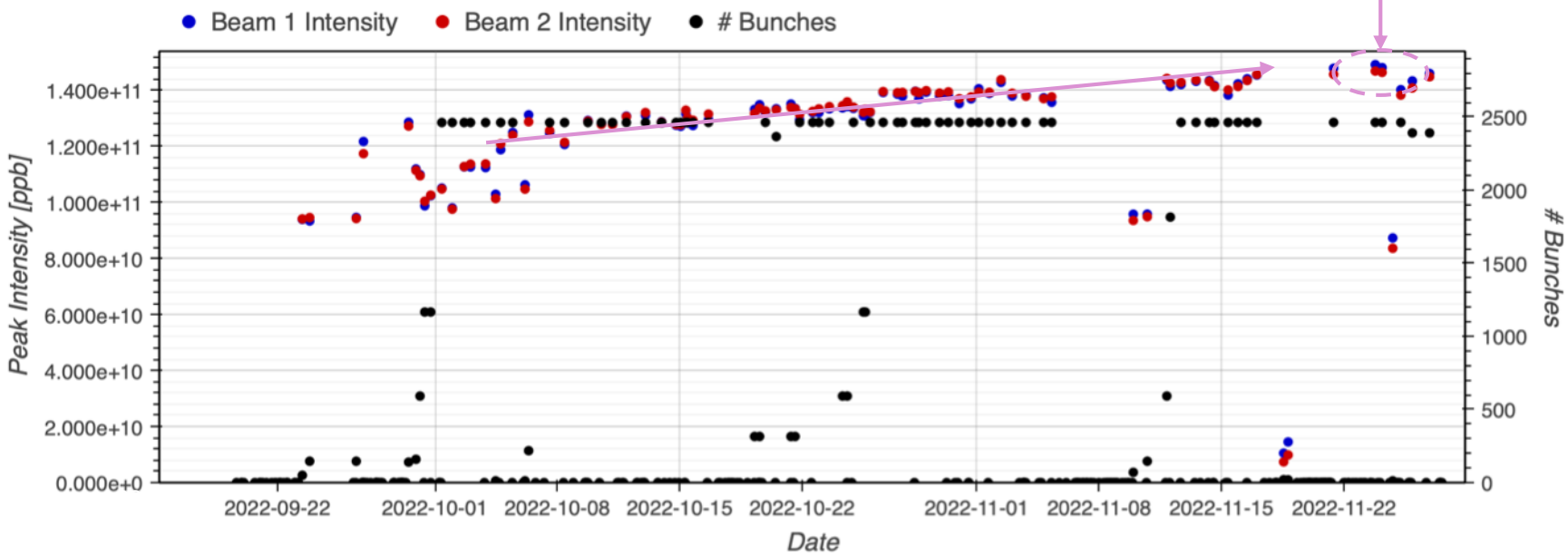
Ladybird at 10 km/h



Stored energy

Reached ~400 MJ!

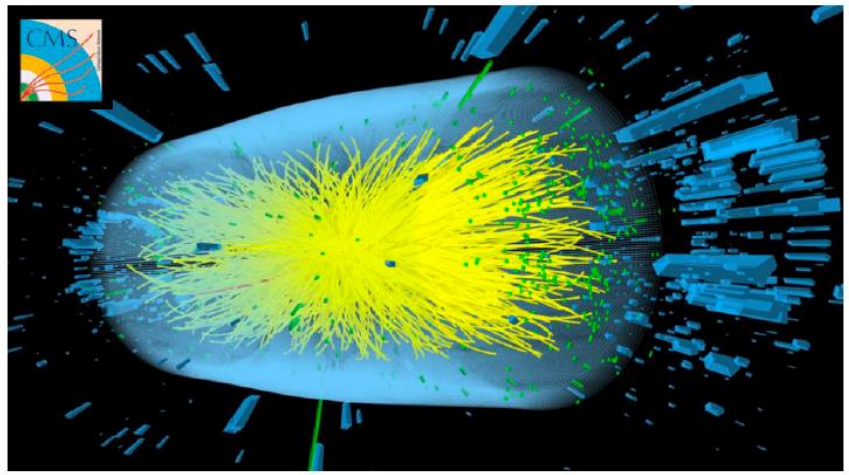
TGV at ~165 km/h



instantaneous luminosity: why level IP1 & 5?

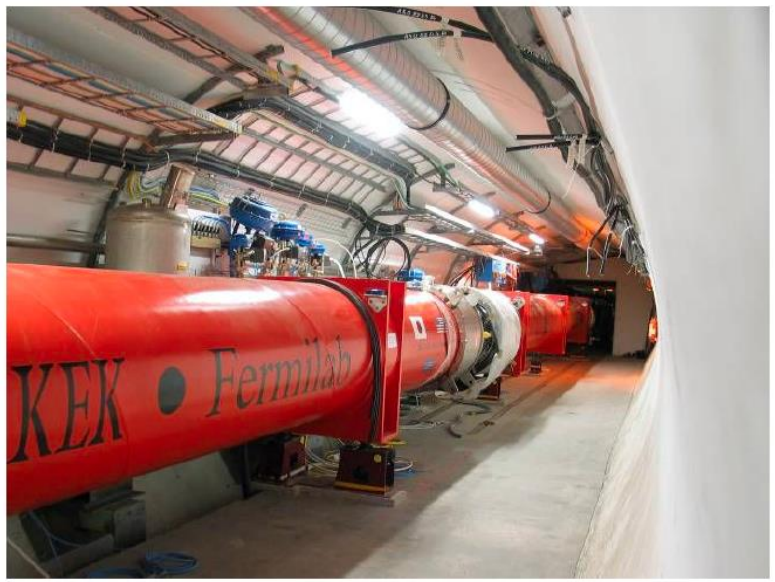
- **ATLAS and CMS pile-up**
  - processing power for event reconstruction
  - data taking efficiency & dead-time
  - limit on the average pile-up

    ➜ single-bunch instantaneous luminosity limit



- **IR1 & 5 inner triplet cooling**
  - heating due to luminosity debris
  - cooling capacity different per triplet-side
    - risk of losing cryo conditions (helium overflow)
    - slow processes: ~15 minutes "inertia"
  - limit on the total triplet heat load

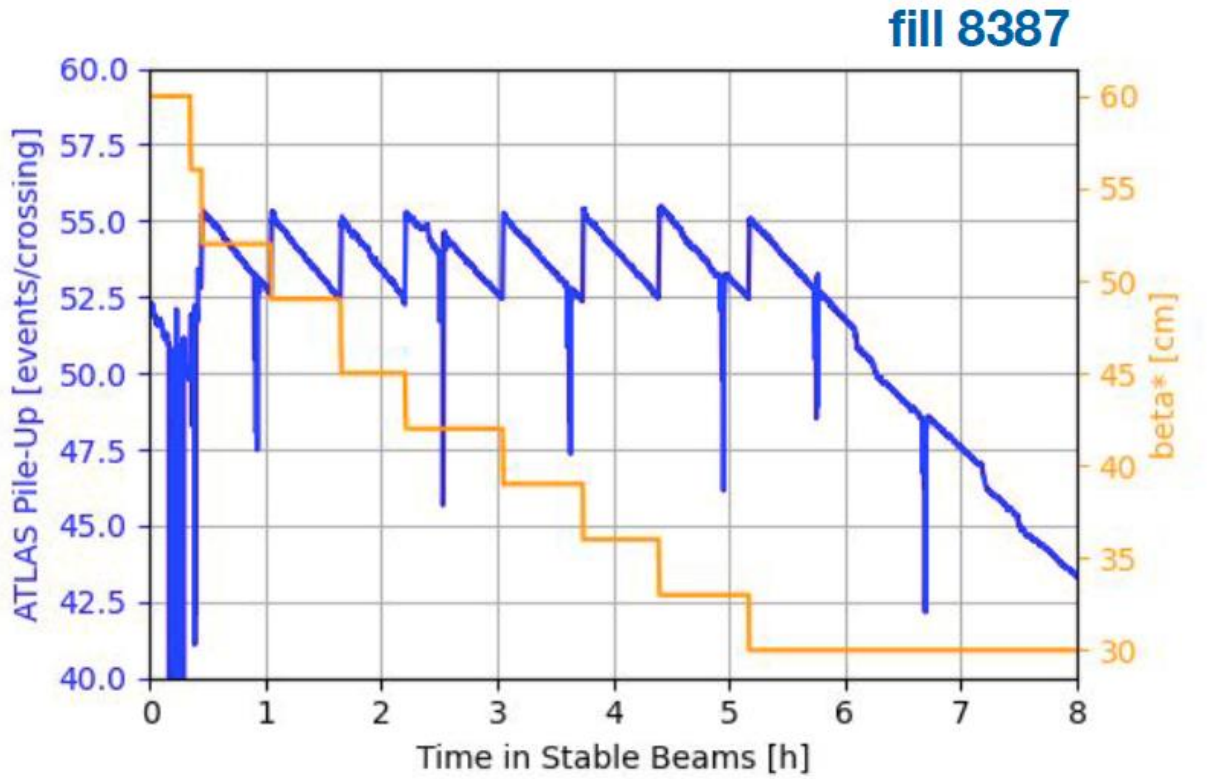
    ➜ total instantaneous luminosity limit

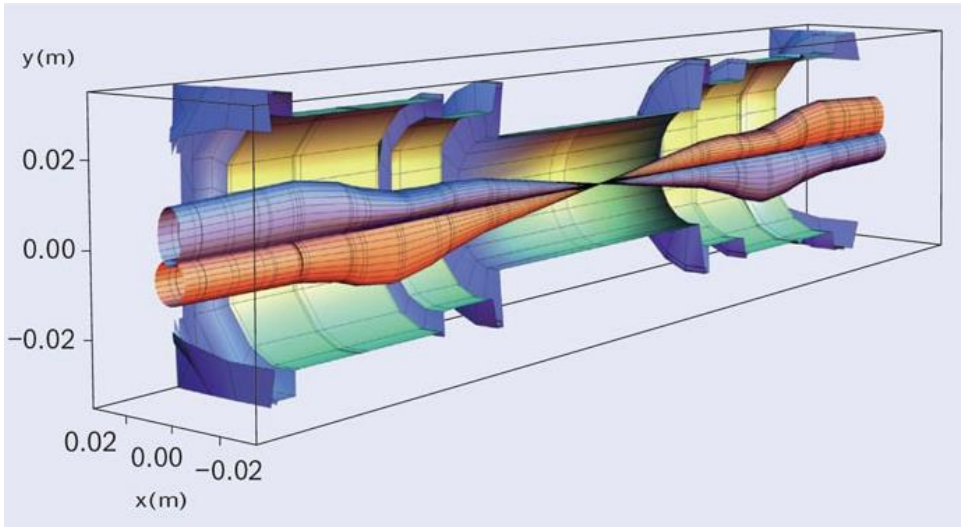


Beta* levelling

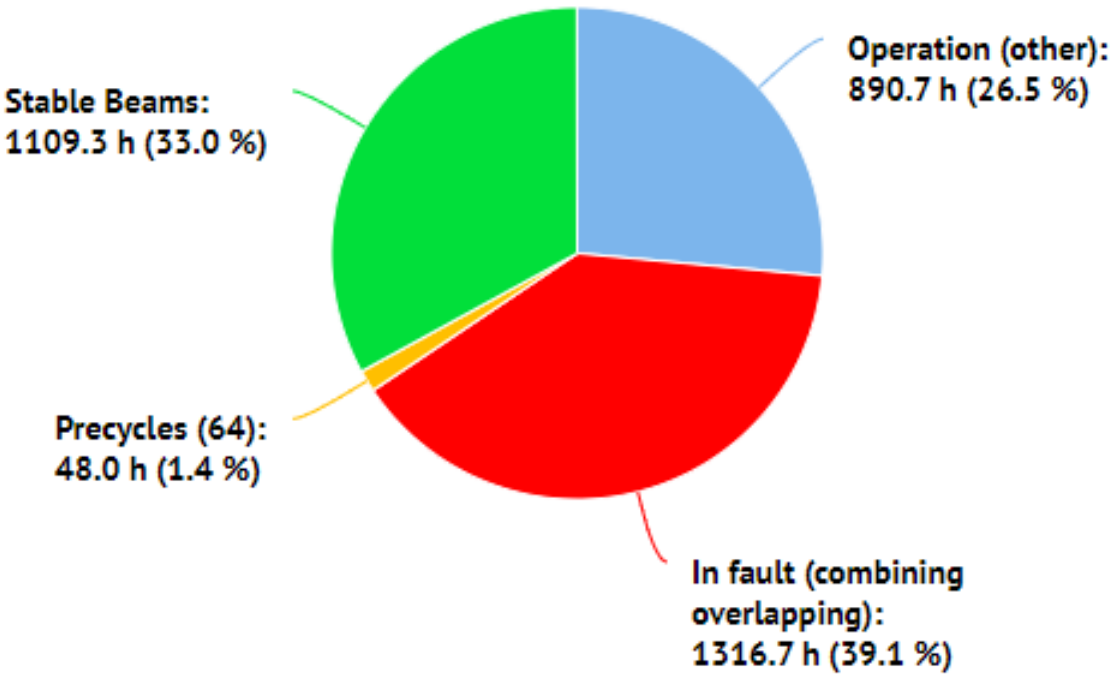
level on experiment pile-up

- limiting factor for 2022
- target: **μ = 54 ± 2.5%**

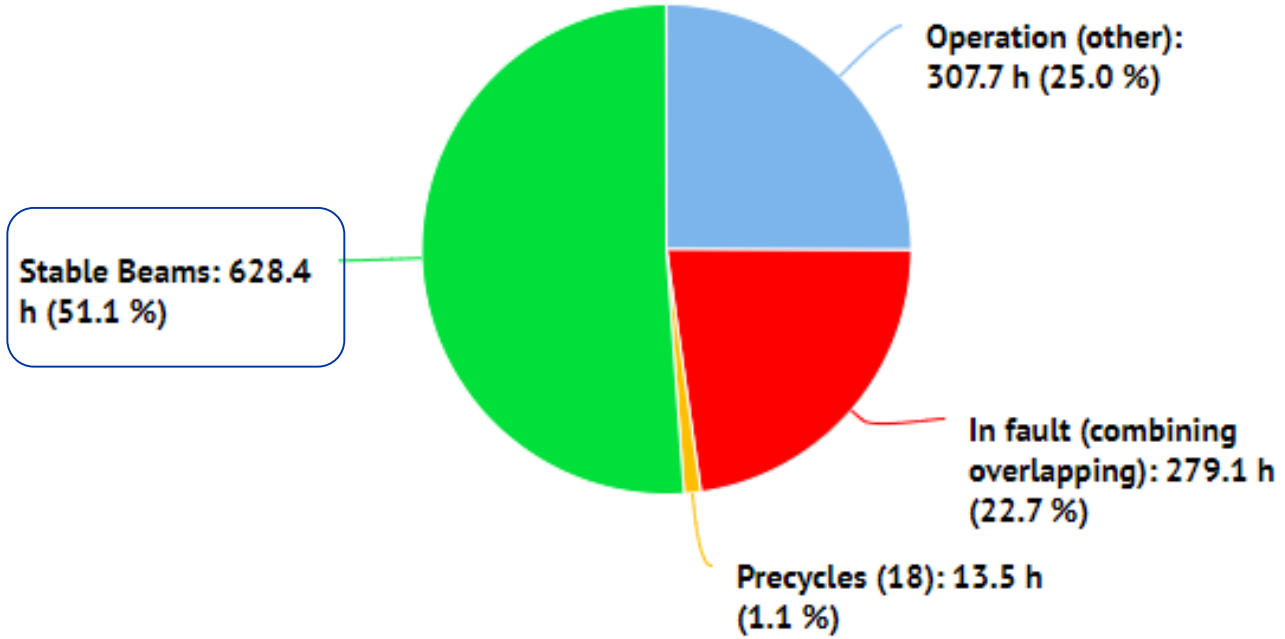




LHC Stable Beams in 2022



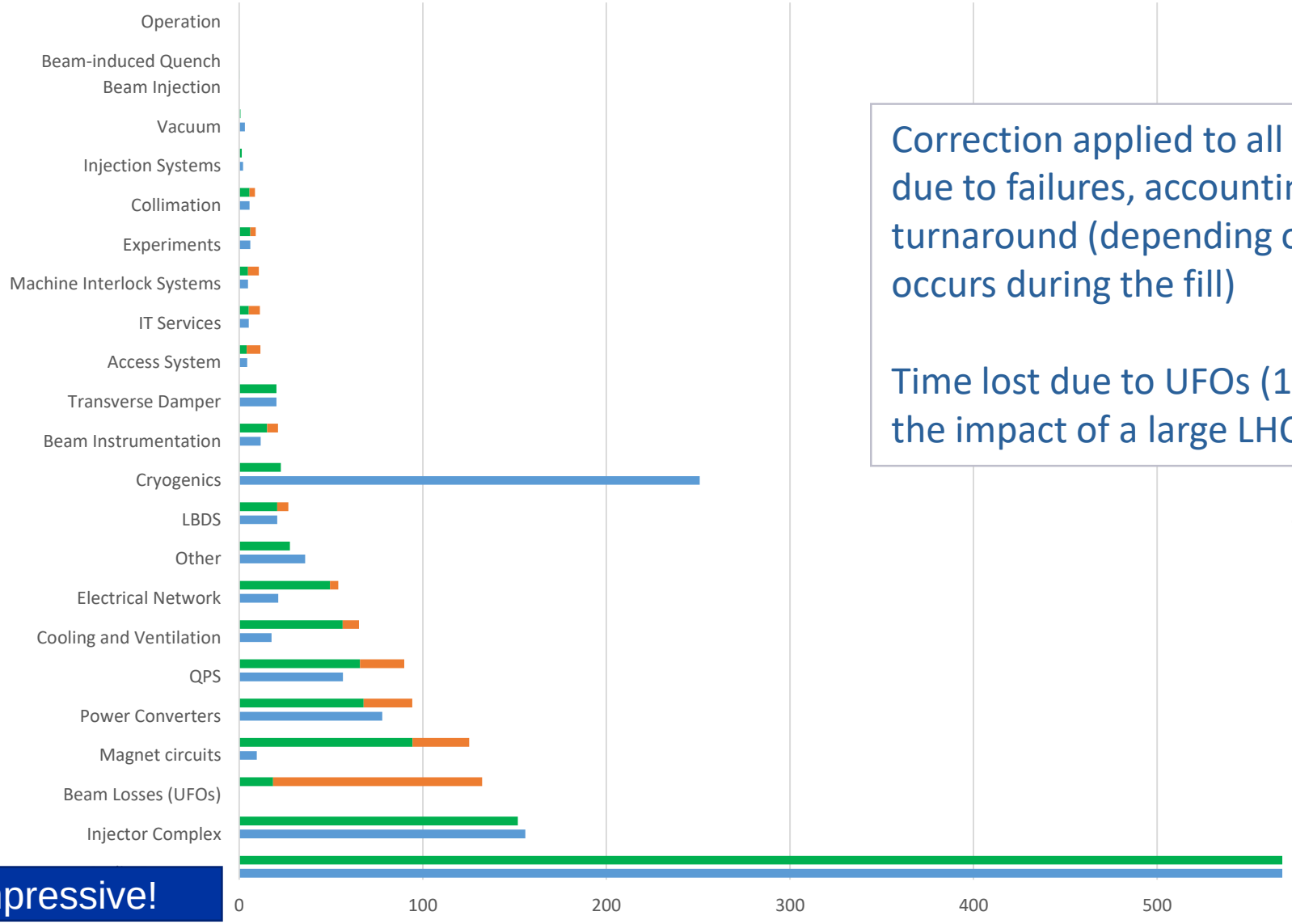
Excluding TSs, MDs



Excluding TSs, MDs, After RF stop (from Oct. 1st)

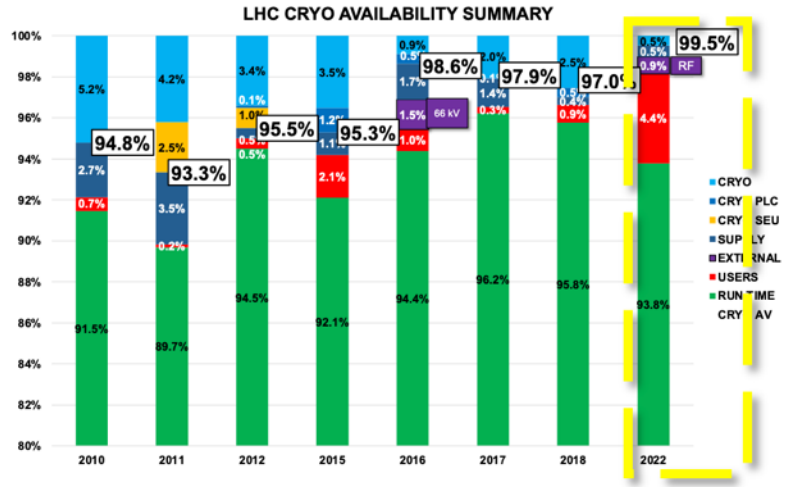
Lukas Felsberger, Jan Uythoven, Daniel Wollmann

LHC Downtime in 2022 (Turnaround Penalty)



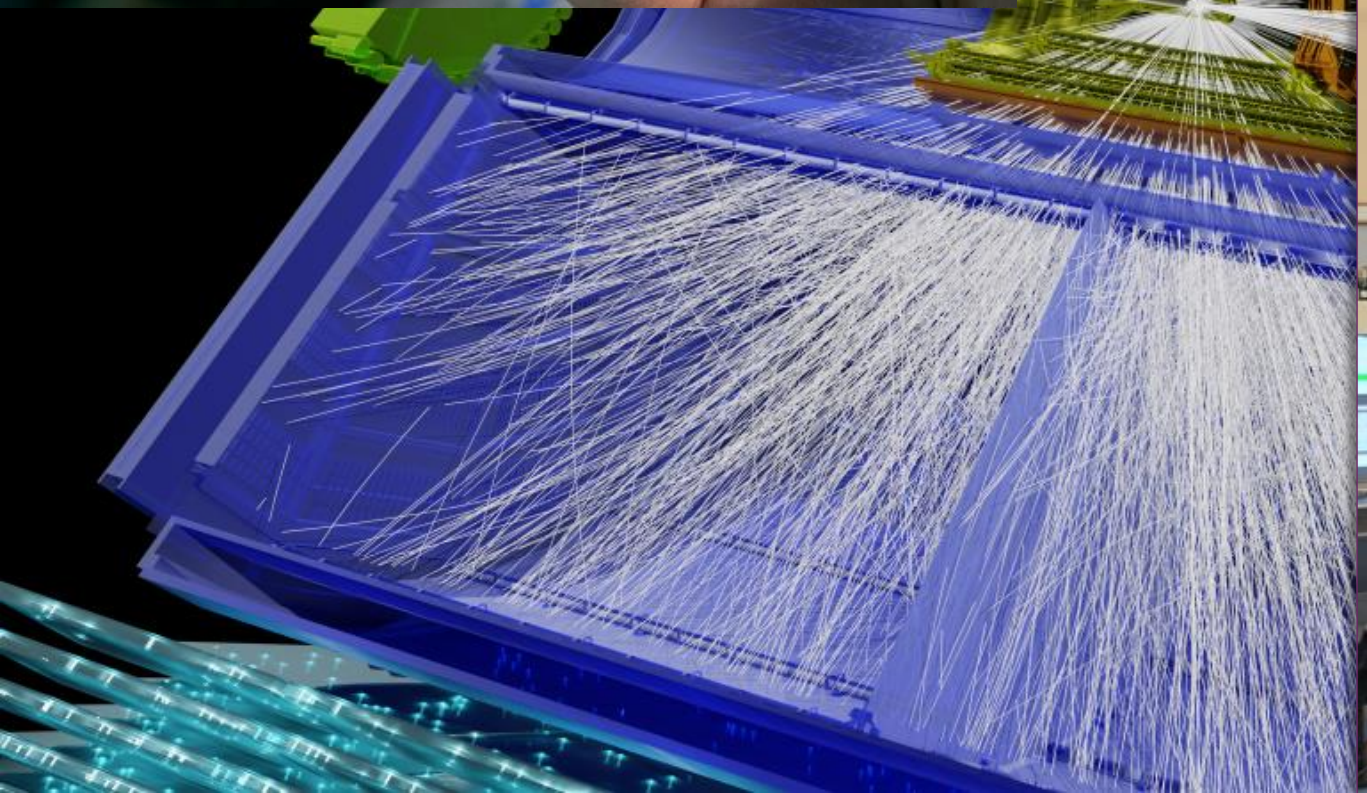
Correction applied to all top-energy dumps due to failures, accounting for up to 3h turnaround (depending on when the fault occurs during the fill)

Time lost due to UFOs (117h) comparable to the impact of a large LHC technical system



Highest cryo availability since LHC start !

Impressive!



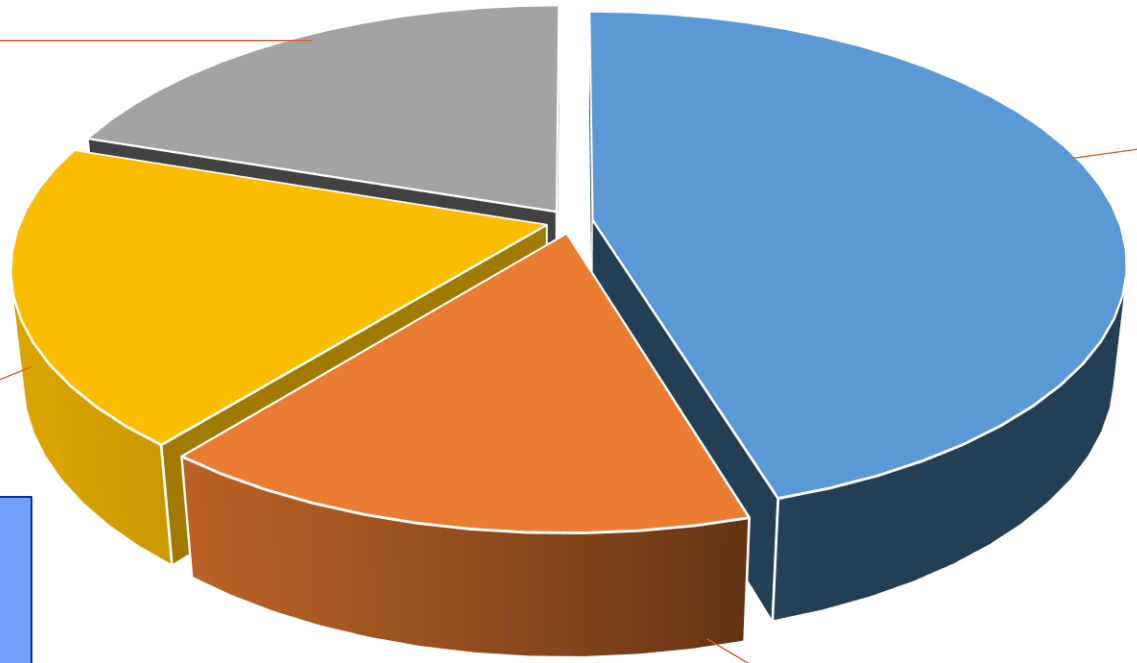

CERN

Accelerator programme: 2022 Budget (M + P expenses)

291 M (21.2% of CERN revenues)

The Accelerator Programme is the core priority of the ATS groups.

Accelerator support
~ 58 M (20%)
Engineering, controls, general services, special technologies



LHC machine
~ 132 M (45%)
Operation LHC & experimental areas
Spares & consolidation

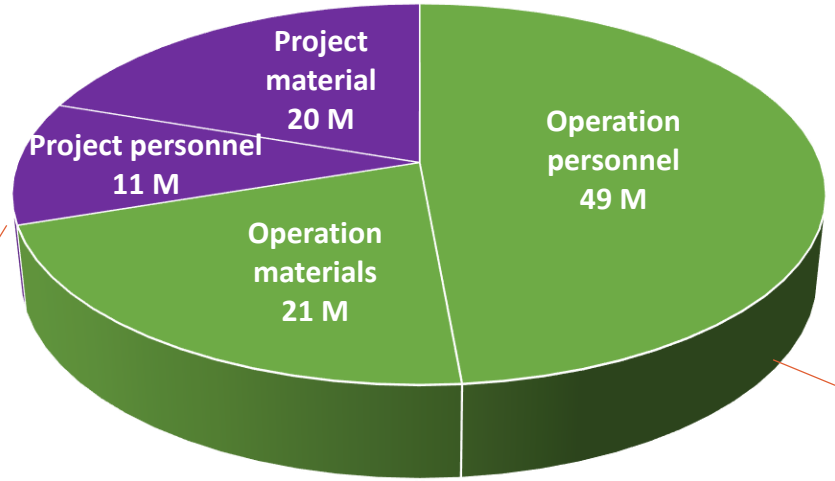
PS complex
~ 56 M (20%)
Operation: sources, Linacs, LEIR, PS, PSB, AD-ELENA, ISOLDE, n-TOF, East Area
Consolidation

SPS complex
~ 45 M (15%)
Operation SPS & North Area
Consolidation

Injectors
~ 101 M (35%)

Accelerator programme: 2022 budget Injectors (M + P)

Total injectors ~ 101 M



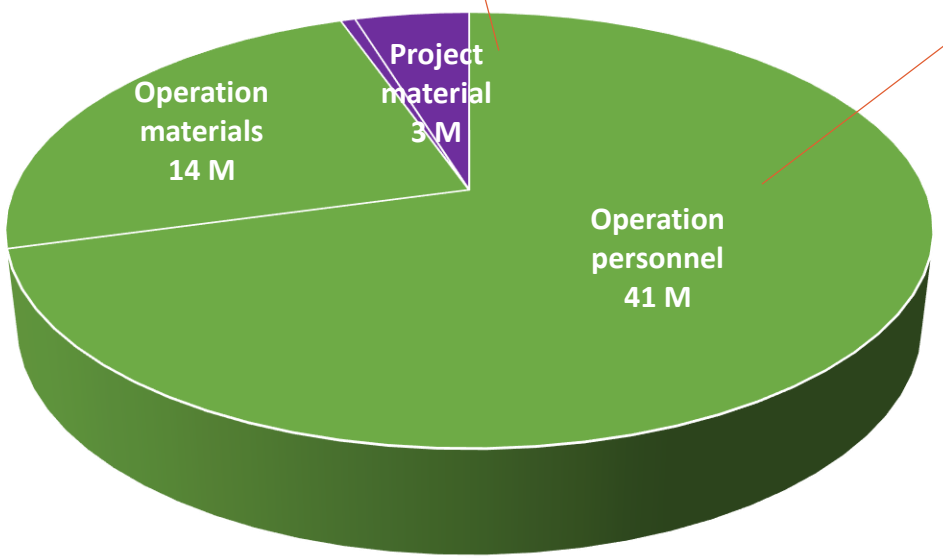
Projects~ 30 M (30%)
Accelerator consolidation 13 M
North area consolidation 9 M
Linac4 RFQ spare 3 M
PS & SPS spares 2 M
AD consolidation 2 M
Electrical network consolidation 1 M

Operation ~ 71 M (70%)
RF power and cavities 11 M
Beam operation teams 9 M
Magnets including transfer lines 7 M
Controls software and hardware 6 M
Beam instrumentation 6 M
Beam intercepting devices, Isolde and n-TOF operation 5 M
Accelerator and beam physics studies, source development 5 M
Power converters 5 M
Cooling and ventilation 4 M
Radioprotection 3 M
Coordination including experimental areas 3 M
Vacuum 2 M
Access systems 2 M
Lifting and handling equipment 1 M
Electrical network 1 M
Others 1 M

2022 budget Accelerator Support (M + P)

Total accelerator support ~ 58 M

Project ~ 3 M (5%)
General accelerator developments 2 M
Others 1 M



Operation ~ 55 M (95%)
Magnets general operation including laboratories, magnetic measurements 7 M
Vacuum special technologies including thin film coating and controls 6 M
Front-end software and hardware controls 6 M
Management and safety 5 M
Administration 5 M
Coordination machines and experimental areas, quality support 5 M
Power converter software and controls 4 M
Cryolab operation and helium 3 M
Interlock and protection systems 2 M
Beam operation software 2 M
Survey personnel 2 M
FLUKA developments 2 M
Accelerator and beam physics studies 1 M
RF and impedance measurement 1 M
Beam instrumentation 1 M
Information management 1 M
Others 2 M

Energy 2022 - background

A plethora of cyclical, structural and geopolitical developments coalesced into a perfect storm in Europe with a record-breaking surge in energy prices.

Russia's invasion of Ukraine has triggered the worst global energy crisis since the oil embargo of the 1970s, during a period of structural changes in the energy matrix as countries have been diversifying away from fossil fuels by increasing the share of renewable electricity generation to mitigate climate change

European power markets are in the midst of unprecedented changes, with a tightening supply-and-demand balance.

- Wholesale electricity prices in Europe increased by more than 400 percent from an average of €35 per megawatt-hour (MWh) in 2020 to almost €250 per MWh in December 2021 even before the war in Ukraine, which pushed the average wholesale price of electricity above €500 per MWh in March 2022.
- Under the marginal pricing method underlying wholesale electricity prices in Europe, the most expensive technology needed to meet demand within a given period sets the final price of electricity
- So, even as the levelized cost per unit of electricity from new utility-scale renewable power plants has dropped precipitously, the recent spike in wholesale electricity has broadly been driven by the cost of production at natural-gas power plants.

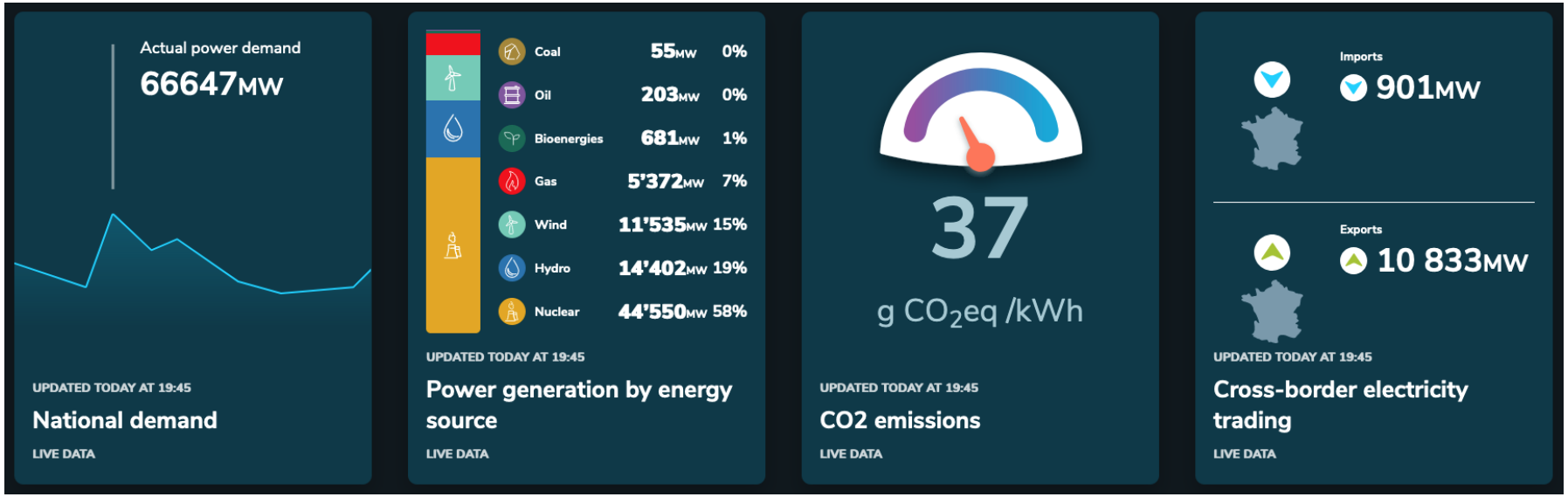
French electricity

2022 was a difficult year due to both the high price of gas and the state of France's Nuclear fleet which is slowing recovering from COVID driven maintenance delays and a stress corrosion cracks issue in the auxiliary circuits of some reactors.

France, which was a power exporter, switched to importer, intensifying the squeeze on energy supplies in the European continent that was already grappling with low supplies from Russia.

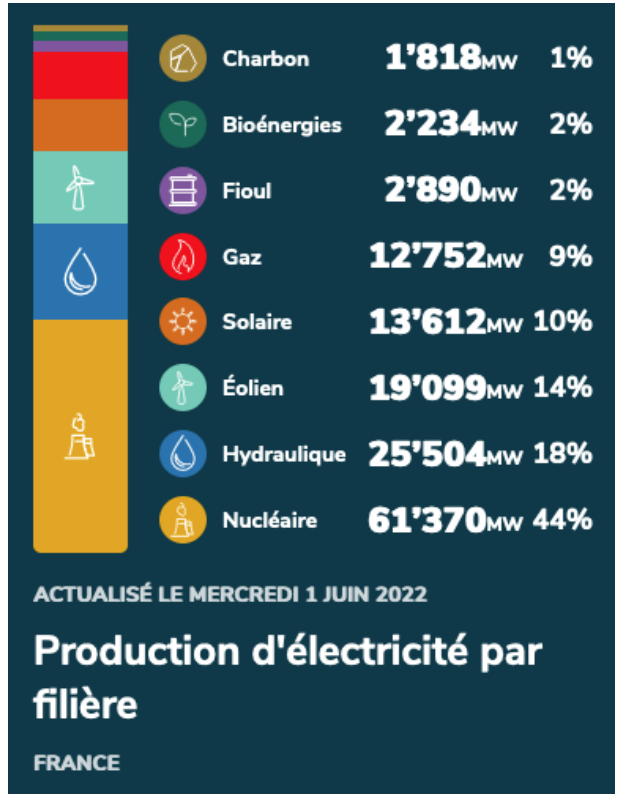
Things are getting better!

French electricity



Production - live

Low CO_2!



Maximum volumes

https://www.rte-france.com/en/eco2mix

https://app.electricitymaps.com/map

Electricity at CERN

At present CERN purchases around 70% of our electricity at a regulated tariff under the ARENH (Accès Régulé à l'Electricité Nucléaire Historique) scheme

- 42 €/MWh in 2022
- The remaining ~30% is purchased at market prices, typically a year ahead.
- 2023's supply is now full secured, but we did take a hit given the high 2023 prices (~115 €/MWh average)

CERN is protected to a significant extent by access to the ARENH mechanism, but the 2022 situation was serious enough to impact 2023's budget

ARENH scheme terminates end 2025, and from 2026 onwards, CERN electricity procurement will be fully exposed to any market volatility unless:

- Similar mechanisms are established; discussions have started with the EC and French Authorities
- Adapt our long-term sourcing and purchasing strategy – work in progress

EEX FRENCH POWER FUTURES

2023-01-11 Year Quarter Month Week Weekend Day

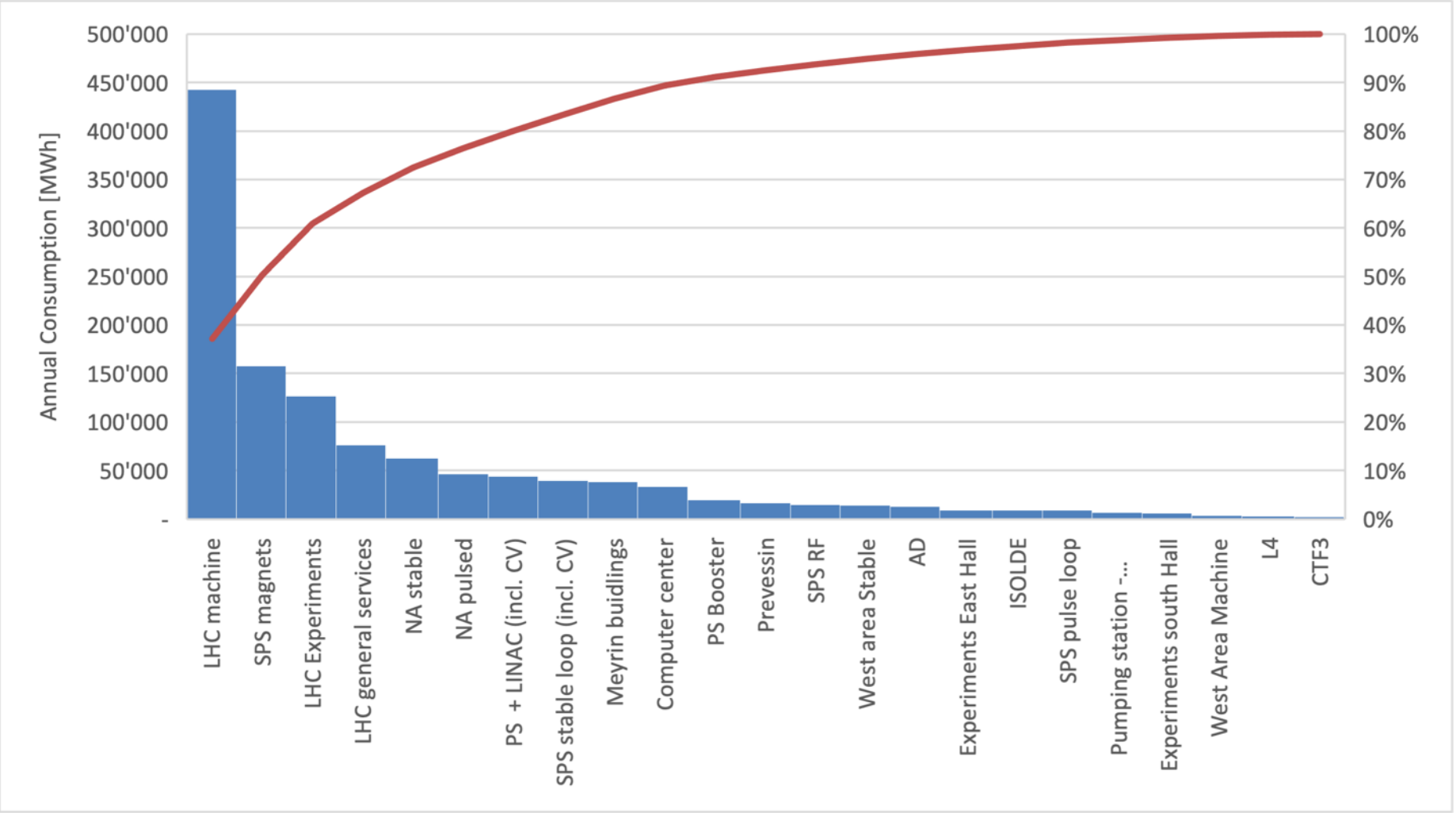
Base

Future	Last Price	Last Volume	Settlement Price	Volume Exchange	Volume Trade Registration	Open Interest
Cal-24	188.50	8'784	191.92	79'056	281'088	3'453

Cal-25	141.75	8'760	146.36	8'760	78'840	583
Cal-26	-	-	120.00	-	70'080	80
Cal-27	-	-	114.00	-	-	23
Cal-28	-	-	105.00	-	-	19

Annual consumption during a Run

Annual total ~1.3 TWh

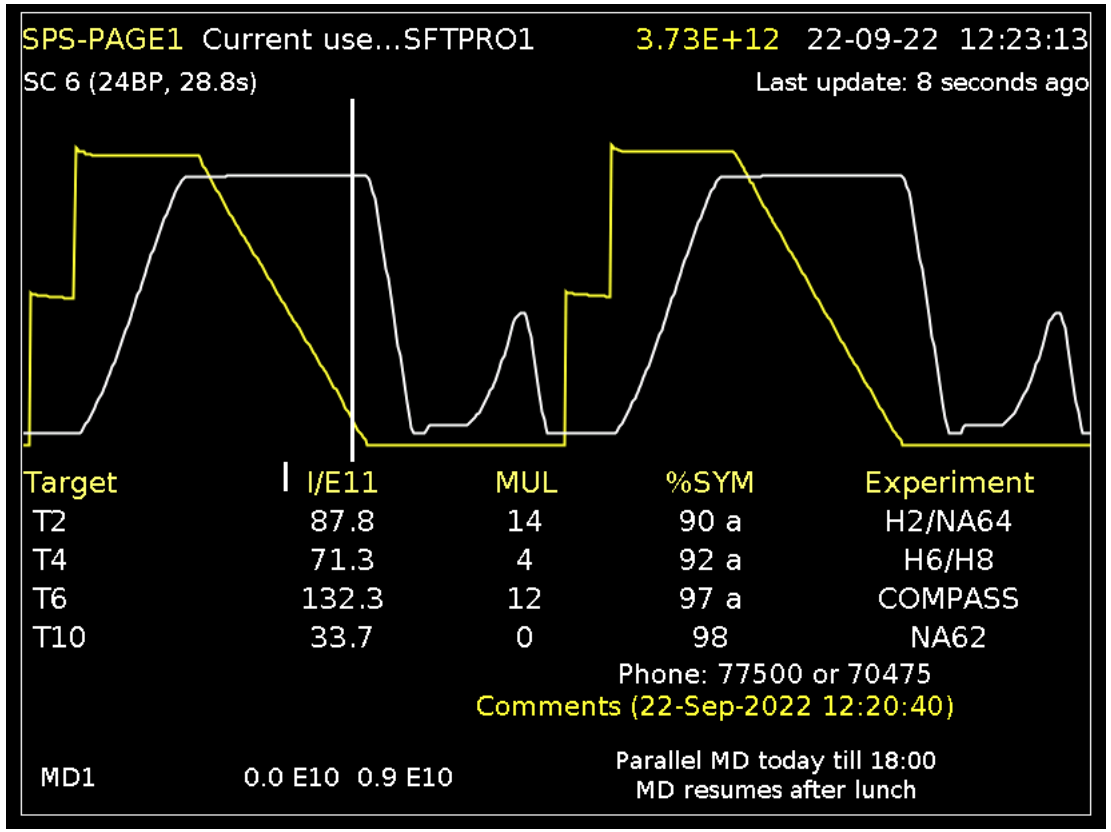


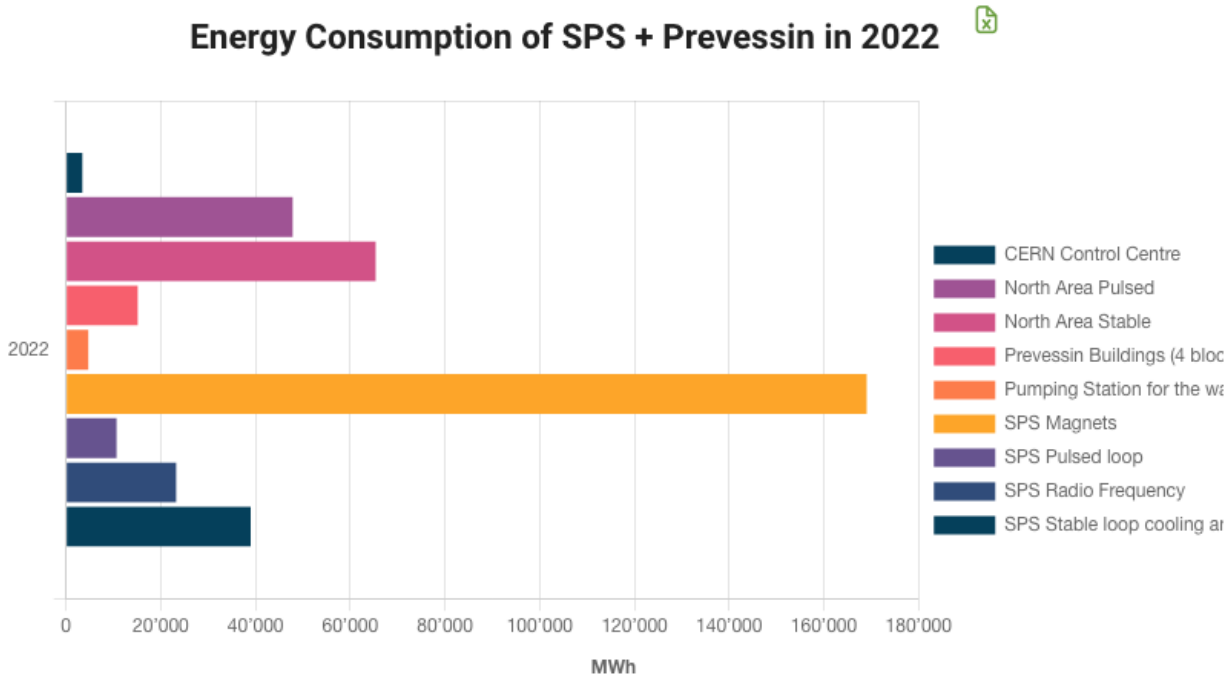
Average (17,18) [MWh]

SPS – North Area

Web Energy by EN/EL

https://energy.app.cern.ch/charts

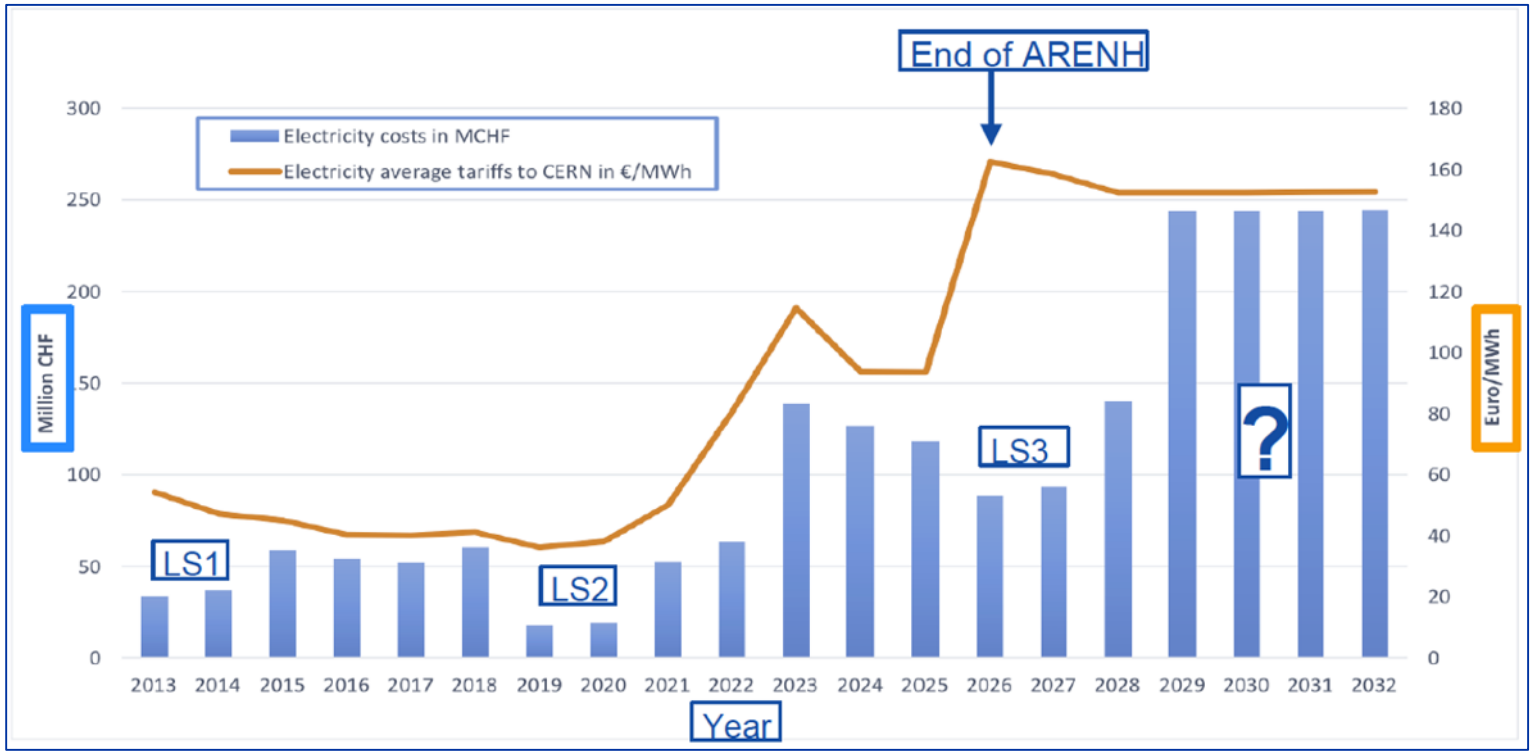




- 378 GWh out of 1245 GWh total (30%)
- SPS magnets 169 GWh (14%)

The problem…

Extrapolating out to 2032 assuming: No ARENH and ”high” future electricity prices



140 €/MWh and a full operational year in, say, 2029 gives an annual electricity bill of ~240 MCHF

Today’s prices 192 €/MWh in 2024 and 146 €/MWh in 2025

Measures

Council have requested that we draw up a set of measures to address the long-term risk should it be necessary

- **Multi-pronged package of posssible measures developed, upon request by the Council**, **as risk mitigation strategy**.
  Presented to the Council in December → very well received.

- **Two measures will be implemented in 2023 to cope with high-inflation**:
  - **reduction of the accelerator operation by 20%**
  - **2.5% "crisis levy" on staff basic salaries, as proposed by and discussed with the Staff Association** → THANK YOU!!

- **The other measures** (for 2024 and beyond) **will be implemented only if and when needed**, based on the evolution of the financial situation and CERN's priorities and needs with time, **with decision taken annually in the context of the Medium-Term Plan**.

- **Additional contributions from Member and Associate Member States being considered by the Council**
  → discussion will continue in March

2023

Work ongoing during a very full year-end-technical-stop (YETS) across the complex

Will restart machines as planned

Full programme but a shortened run (-6 weeks in 2023 with a 19 (15 + 4) week YETS 23/24)

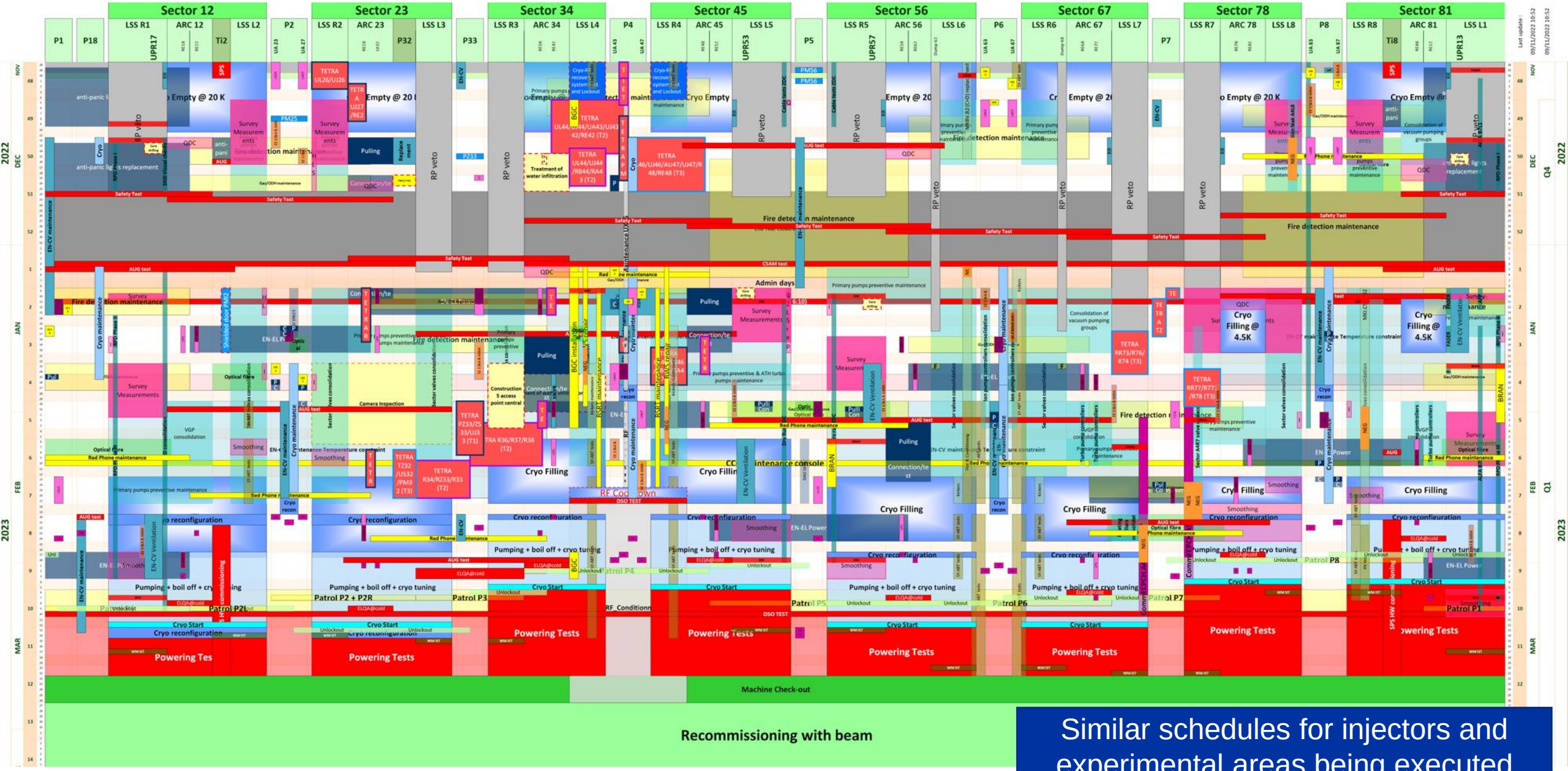
Most facility time allocation done at ~80% pro-rata based on the original non-shortened 2023 schedule…

Experimental facility	Start Physics	End Physics	Duration 2023 [days] Ver. 0.6	Duration 2023 [days]* Normal YETS	Ratio [%]
ISOLDE	10.04.2023	30.10.2023	**203**	231	83
n_TOF	10.04.2023	30.10.2023	**203**	231	83
PS East Area	17.04.2023	30.10.2023	**182**	210	81
SPS North Area p^+	01.05.2023	28.09.2023	**150**	192	78
ELENA (AD)	11.05.2023	30.10.2023	**172**	214	80
SPS North area Pb ions	02.10.2023	30.10.2023	**28**	28	100
PS East area Pb ions	16.10.2023	30.10.2023	**14**	14	100
AWAKE	01.05.2023	22.10.2022	**67**	84	80
HiRadMat	29.05.2023	10.09.2023	**15 (+13 reserve)**	20 (+8 reserve)	75 (163%)

LHC - Multi-year Overview

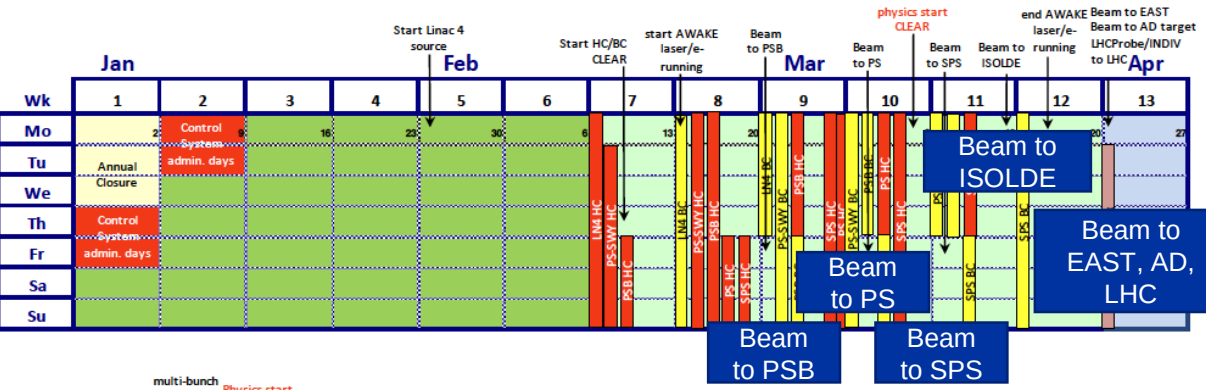
	Proton run [days]	Special runs [days]	Pb ion run (incl. p-p ref) [days]	Total physics Time [days]	MD time [days]
2016	139	10	10	159	21 (13%)
2017	127	18	10	145	18 (12%)
2018	130	14	24	168	24 (14%)*
2022	70.5	7	2	77.5	9.5 (12%)
2023	97	7	32	136	16 (12%)

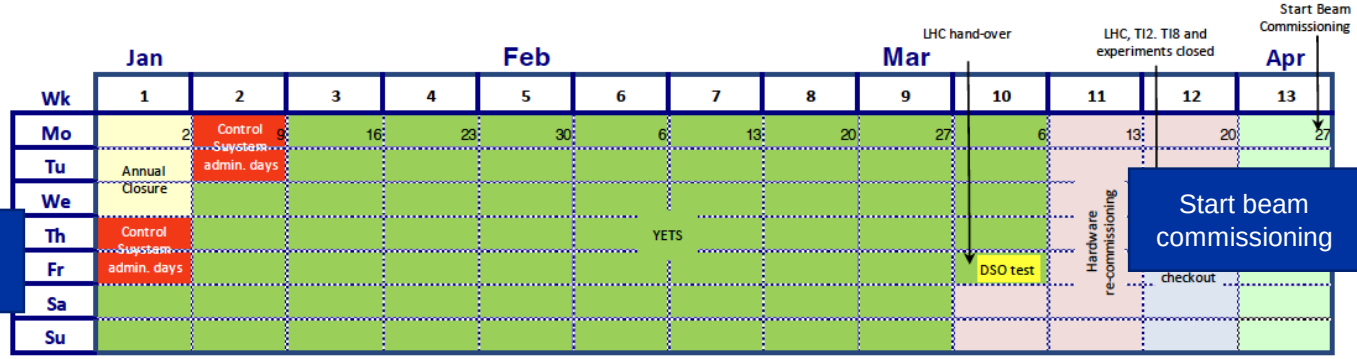
YETS 2022-23 LHC Global Schedule

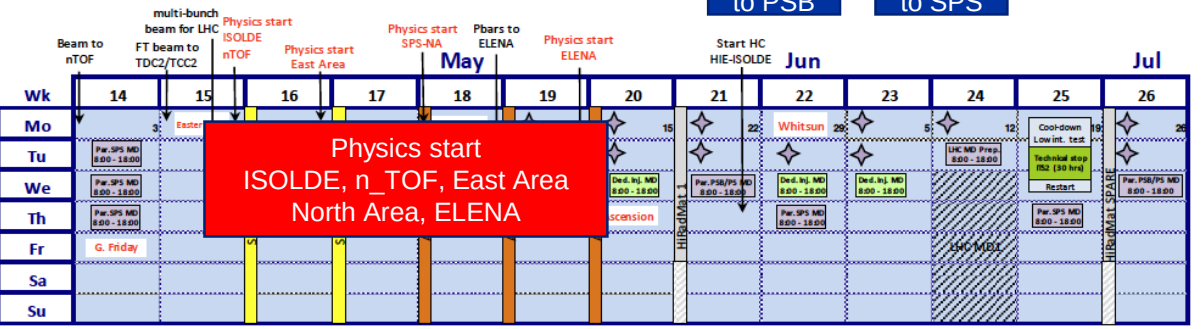


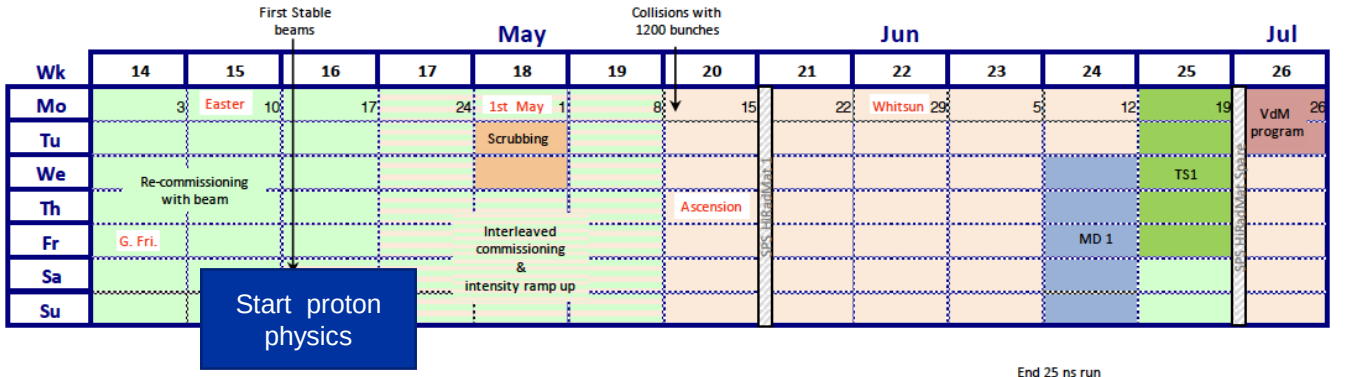
End of Year CERN closure Activities

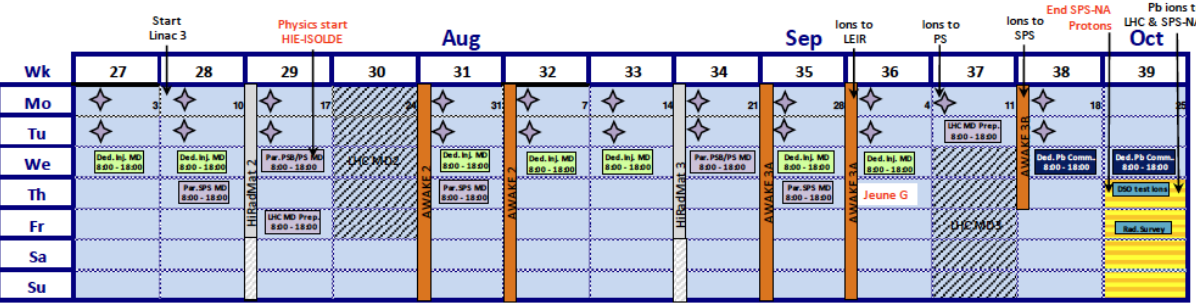
- **Safety Test (EN-AA) (IMAPCT P1 199390, P2 199392 , P3 199397, P4 199399, P5 199400 , P6 199402, P7 199403 & P8 199404)**
- **CSAM test (EN-AA) (IMPACT 199406)**
- **Firefighter exercises (IMPACT 200291) and topographic recognitions (IMPACT 200290)**
- **CV maintenance (surface) P1 (ATLAS) and P5 (CMS)**
- **SY-ABT : Supervision HV test MKI P8**

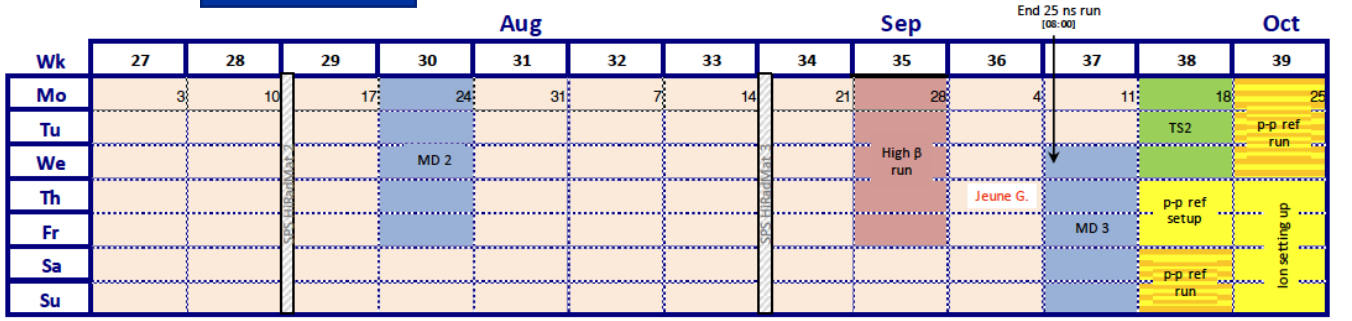

Jan
Feb
Mar
Apr
Start Linac 4 source
Start HC/BC CLEAR
start AWAKE laser/e-running
Beam to PSB
Beam to PS
physics start CLEAR
Beam to SPS
Beam to ISOLDE
end AWAKE laser/e-running
Beam to EAST
Beam to AD target
LHCProbe/INDIV to LHC
Annual Closure
Control System admin. days
Beam to ISOLDE
Beam to EAST, AD, LHC
Beam to PS
Beam to PSB
Beam to SPS

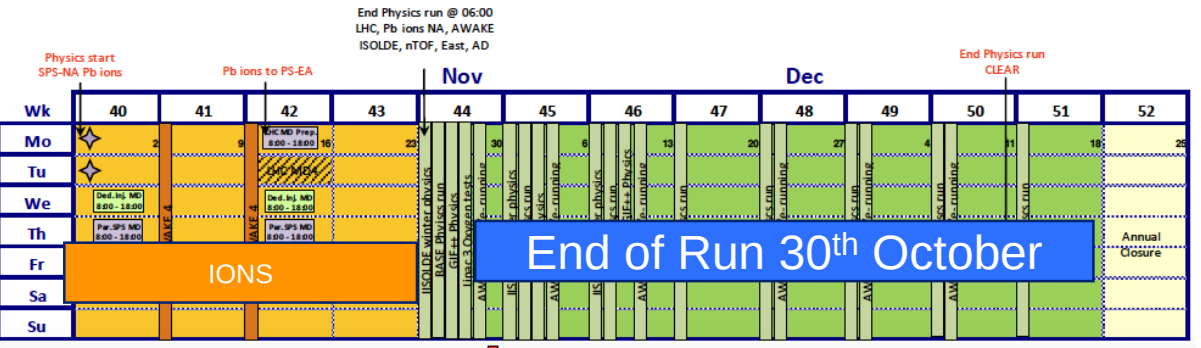

Jan
Feb
Mar
Apr
LHC hand-over
LHC, TI2. TI8 and experiments closed
Start Beam Commissioning
Annual Closure
Control System admin. days
YETS
DSO test
Hardware re-commissioning
checkout
Start beam commissioning

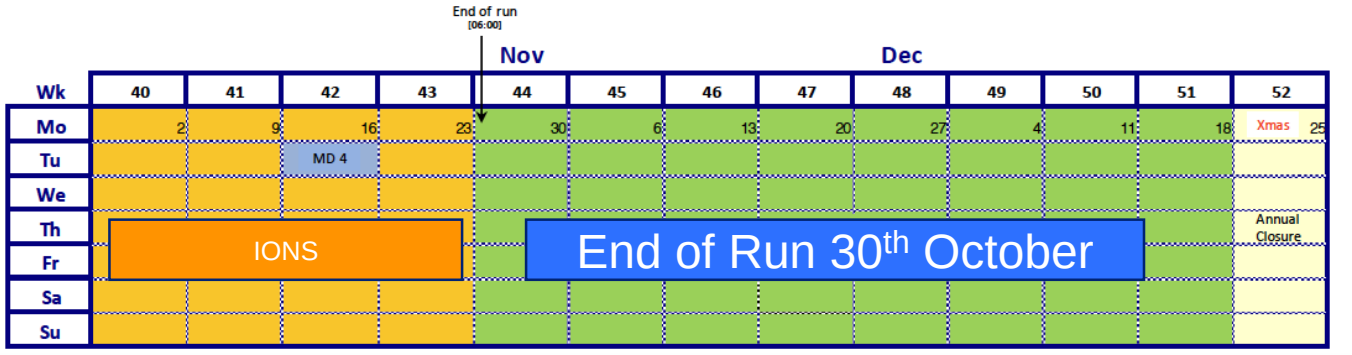

May
Jun
Jul
Beam to nTOF
multi-bunch beam for LHC
FT beam to TDC2/TCC2
Physics start ISOLDE
nTOF
Physics start East Area
Physics start SPS-NA
Pbars to ELENA
Physics start ELENA
Start HC HIE-ISOLDE
Physics start ISOLDE, n_TOF, East Area North Area, ELENA

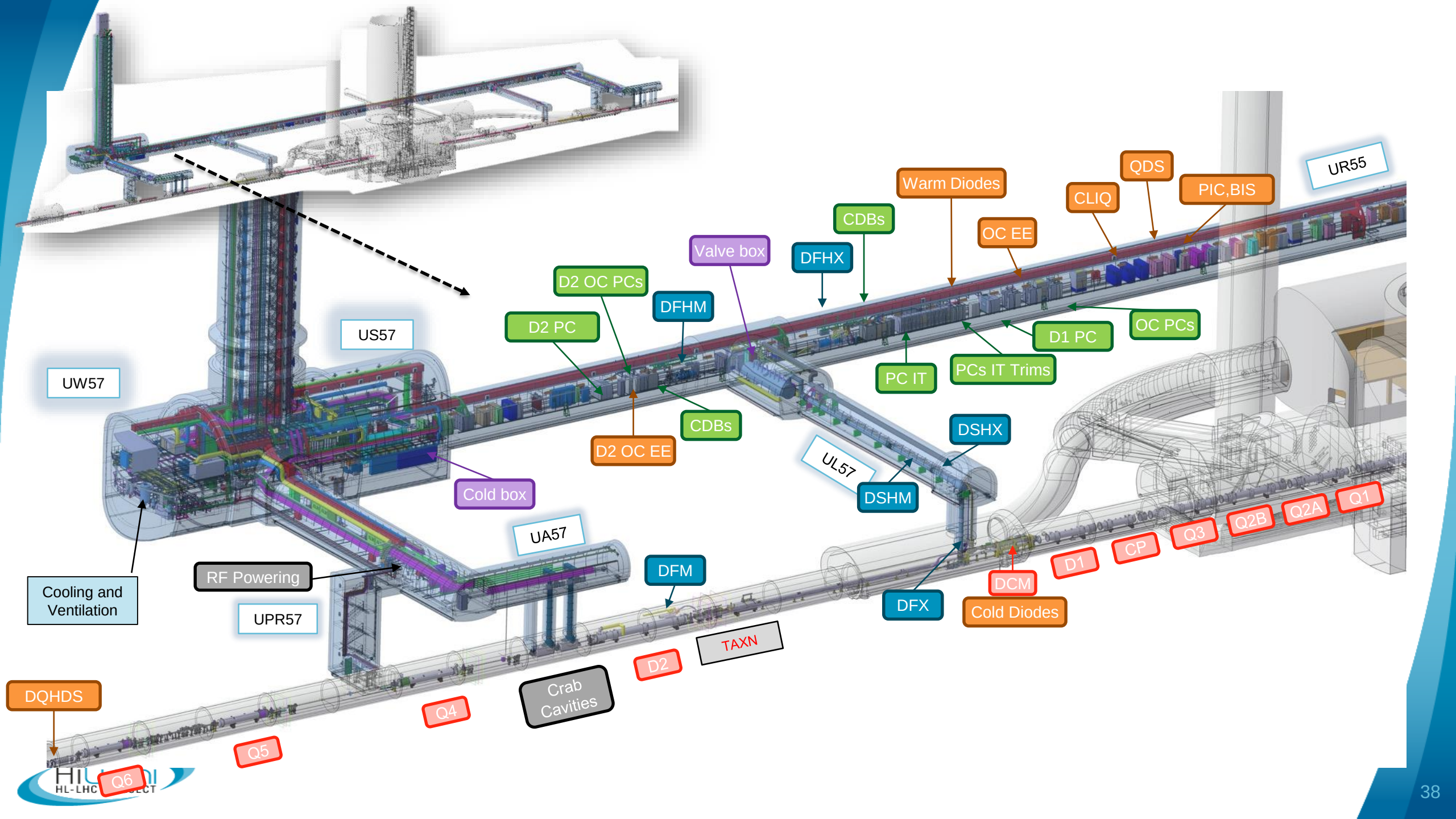

May
Jun
Jul
First Stable beams
Collisions with 1200 bunches
Re-commissioning with beam
Scrubbing
Interleaved commissioning & intensity ramp up
Start proton physics
TS1
MD 1
VdM program


Aug
Sep
Oct
Start Linac 3
Physics start HIE-ISOLDE
Ions to LEIR
Ions to PS
Ions to SPS
End SPS-NA Protons
Pb ions t LHC & SPS-NA


Aug
Sep
Oct
End 25 ns run
MD 2
High β run
Jeune G.
MD 3
TS2
p-p ref run
p-p ref setup
Ion setting up


Nov
Dec
Physics start SPS-NA Pb ions
Pb ions to PS-EA
End Physics run @ 06:00 LHC, Pb ions NA, AWAKE ISOLDE, nTOF, East, AD
End Physics run CLEAR
IONS
End of Run 30th October
Annual Closure


Nov
Dec
End of run
MD 4
IONS
End of Run 30th October
Annual Closure
Xmas


UR55
QDS
PIC,BIS
CLIQ
Warm Diodes
OC EE
CDBs
DFHX
Valve box
D2 OC PCs
DFHM
D2 PC
US57
UW57
OC PCs
D1 PC
PCs IT Trims
PC IT
CDBs
D2 OC EE
DSHX
UL57
DSHM
Cold box
UA57
Q1
Q2A
Q2B
Q3
CP
D1
DCM
Cold Diodes
DFX
DFM
RF Powering
Cooling and Ventilation
UPR57
TAXN
D2
Crab Cavities
Q4
Q5
Q6
DQHDS

Cost and Schedule Review - Executive Summary

November 2022

⊕ The **excellent performance of the upgraded injector chain** was again demonstrated with the 2022 startup and is still improved.

The project team is congratulated for excellent progress in many areas despite of challenging circumstances:

⊕ The **civil construction project** is nearing completion and is practically **on time and on budget**, even though there were major uncertainties at times.

⊕ The **MQX magnet development made significant progress** w.r.t. understanding of limiting issues, a successful endurance test of MQXFA and several magnets meeting the specifications.

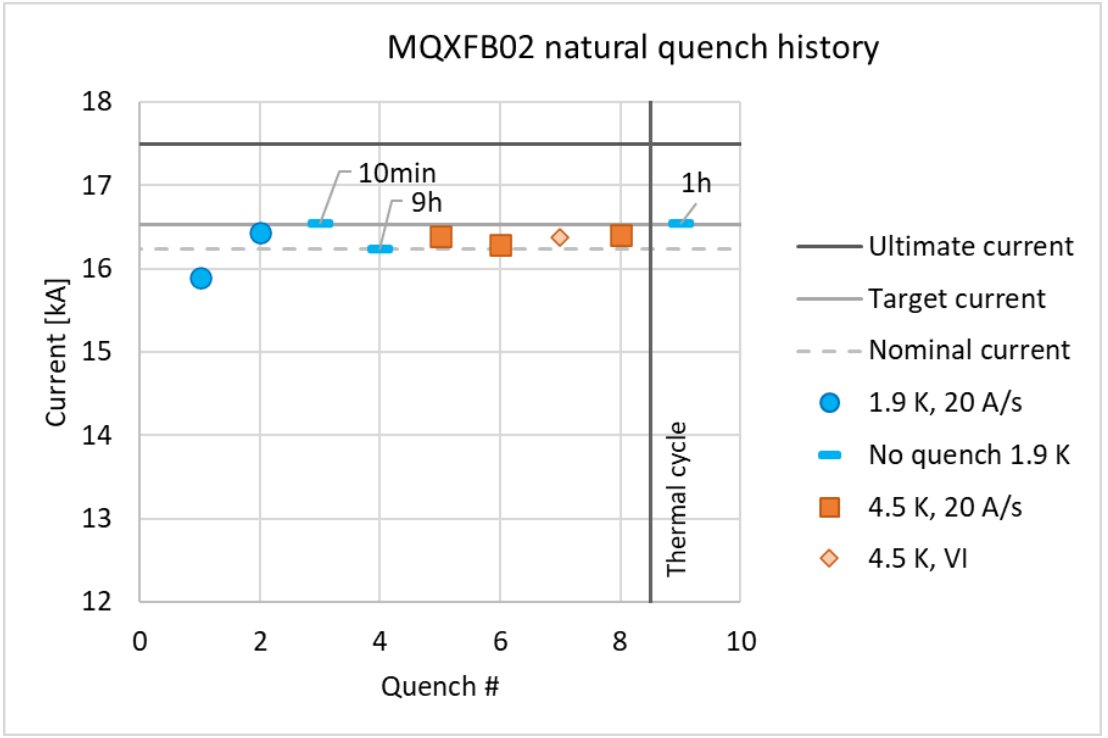
⊕ The **project reacted quickly and flexibly to the loss of the Russian contributions**. The committee welcomes that the replacement of all contributions either by in-sourcing or by de-scoping has been clearly clarified.

⊕ The **international partners are working hard** on making the project a success.

Main Quadrupole Magnets – Q2

- August 2022: Successful test of MQXFBP3 test @ SM18
- November-December 2022: tests of MQXFB02

- **New Welding/Fixed Point Procedures**
- **New Loading Procedure**
- **Coils produced before process optimization**



Congratulations to the TE & MSC teams for these results – still a long way to go but very encouraging

Acronyms!

Naming convention: the first letter indicates the system to which the equipment belongs and must be chosen from to the list of systems.

A	Acceleration, Radio Frequency
B	Beam Instrumentation
C	Controls
D	DC Electrical Distribution
M	Magnetic Elements
R	Power Converters
Q	Cryogenic Equipment
T	Targets, Dumps and Collimators
V	Vacuum

TCTPXH: Collimator Tertiary Pickup Interaction Region (X) Horizontal
MKI: Kicker Injection
DFX: Distribution Feedbox (for Triplets (X))
DQWCC: Double Quarter Wave Crab Cavity


12th annual HL-LHC Collaboration Meeting

European Strategy for Particle Physics 2020 Update

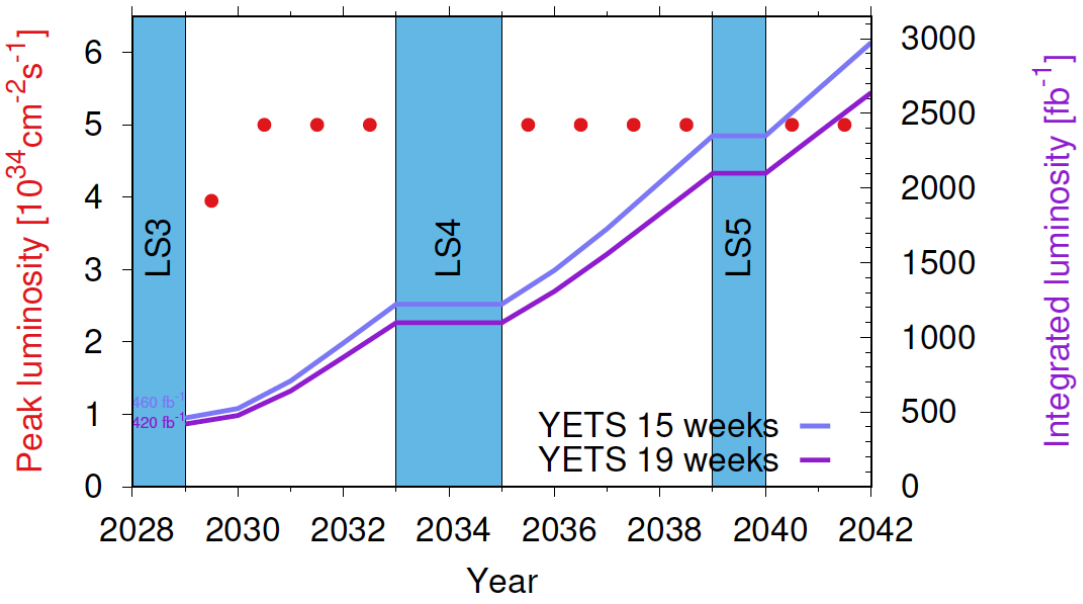
The successful completion of the high-luminosity upgrade of the machine and detectors should remain the focal point of European particle physics, together with continued innovation in experimental techniques.

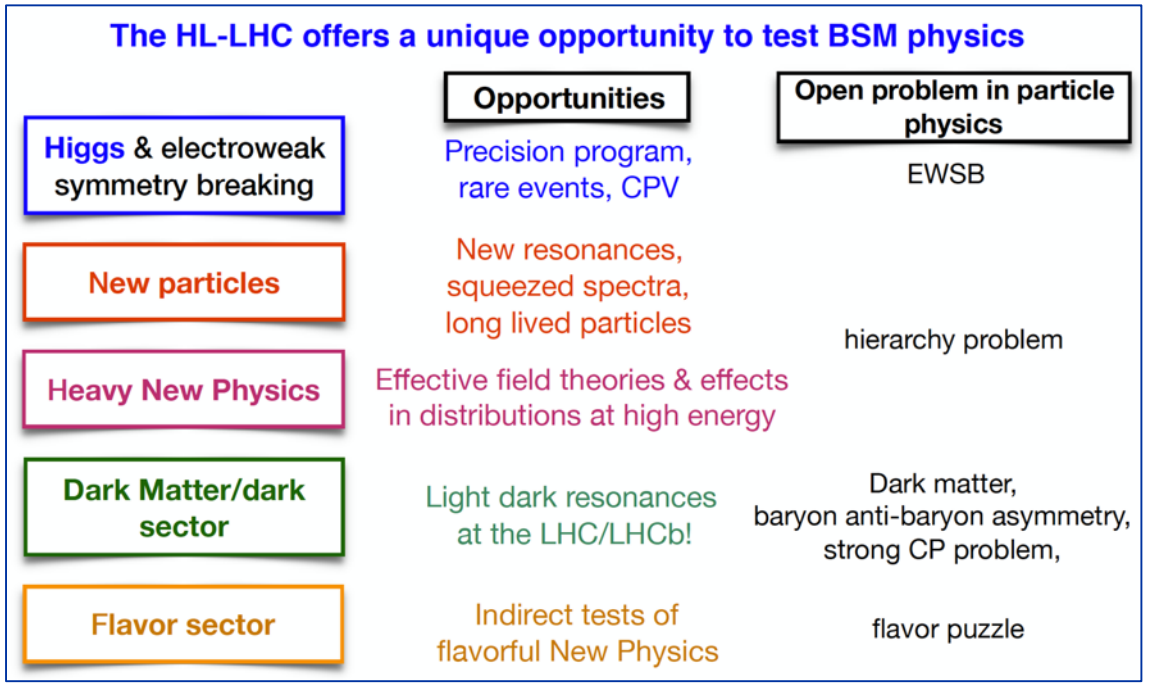
The full physics potential of the LHC and the HL-LHC, including the study of flavour physics and the quark-gluon plasma, should be exploited.

2022 Snowmass Energy Frontier Summary

Our highest immediate priority accelerator and project is the HL-LHC, the successful completion of the detector upgrades, operations of the detectors at the HL-LHC, data taking and analysis, including the construction of auxiliary experiments that extend the reach of HL-LHC in kinematic regions uncovered by the detector upgrades.

HL-LHC: rich and diverse physics programme

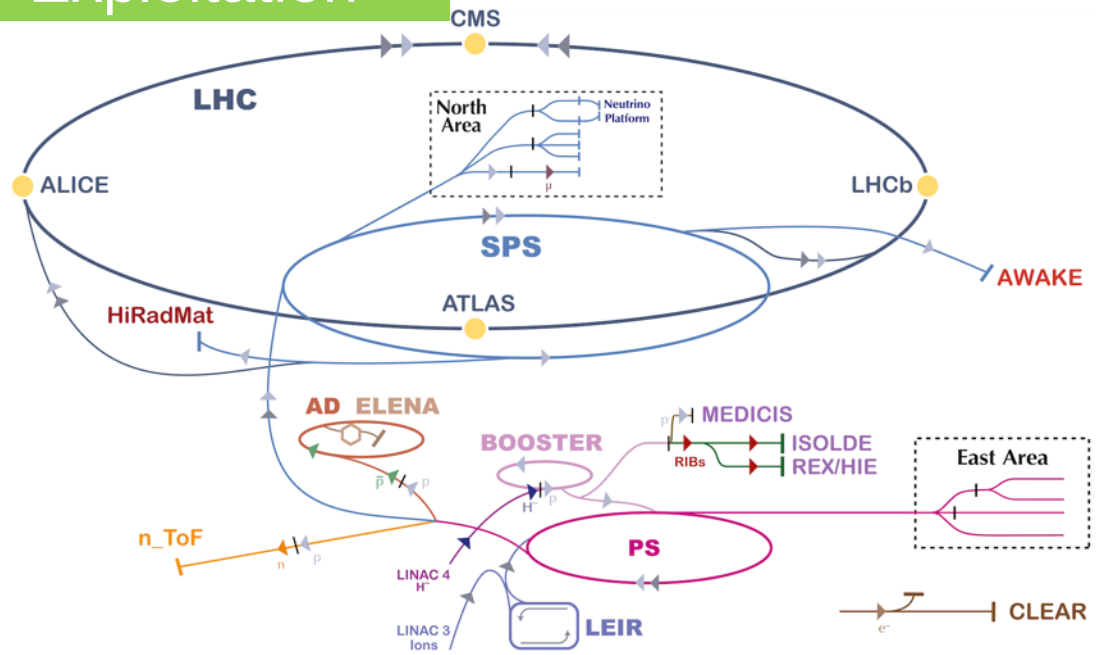




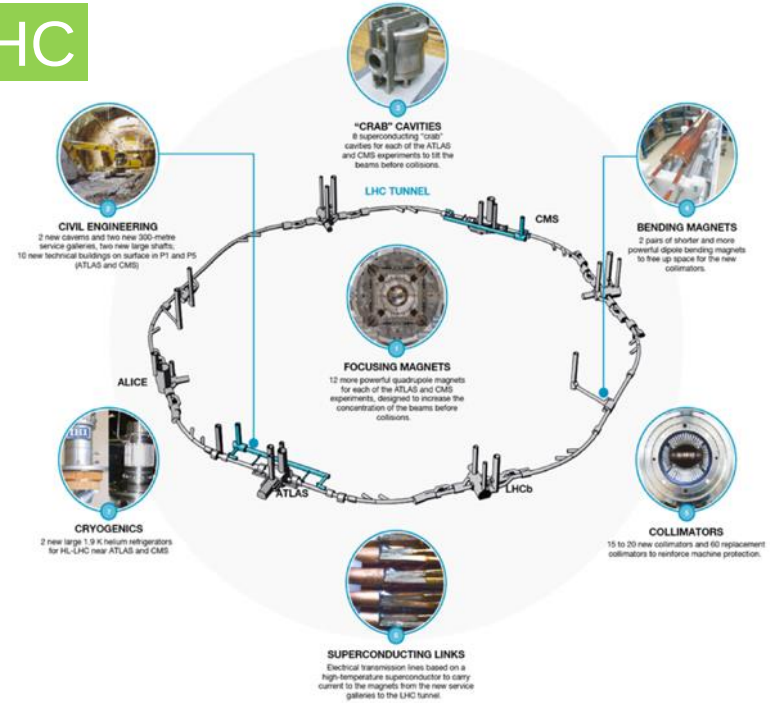
Headline deliverable is 3 ab^{-1} p-p but the physics programme promises to be impressively diverse…

Ions (ALICE 3 proposed for LS4)
b-physics (LHCb upgrade proposed for LS4)
Forward physics
Neutrinos (SND, FASERnu, **FPF**)
Long Lived Particles (GPDs, FASER, MoEDAL, *CODEX-b, milliQan, MATHUSLA, ANIBUS,* **FPF***)*
Fixed target (SMOG-2, Crystal-FT)

Exploitation

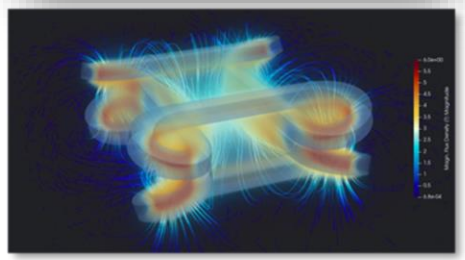


HL-LHC

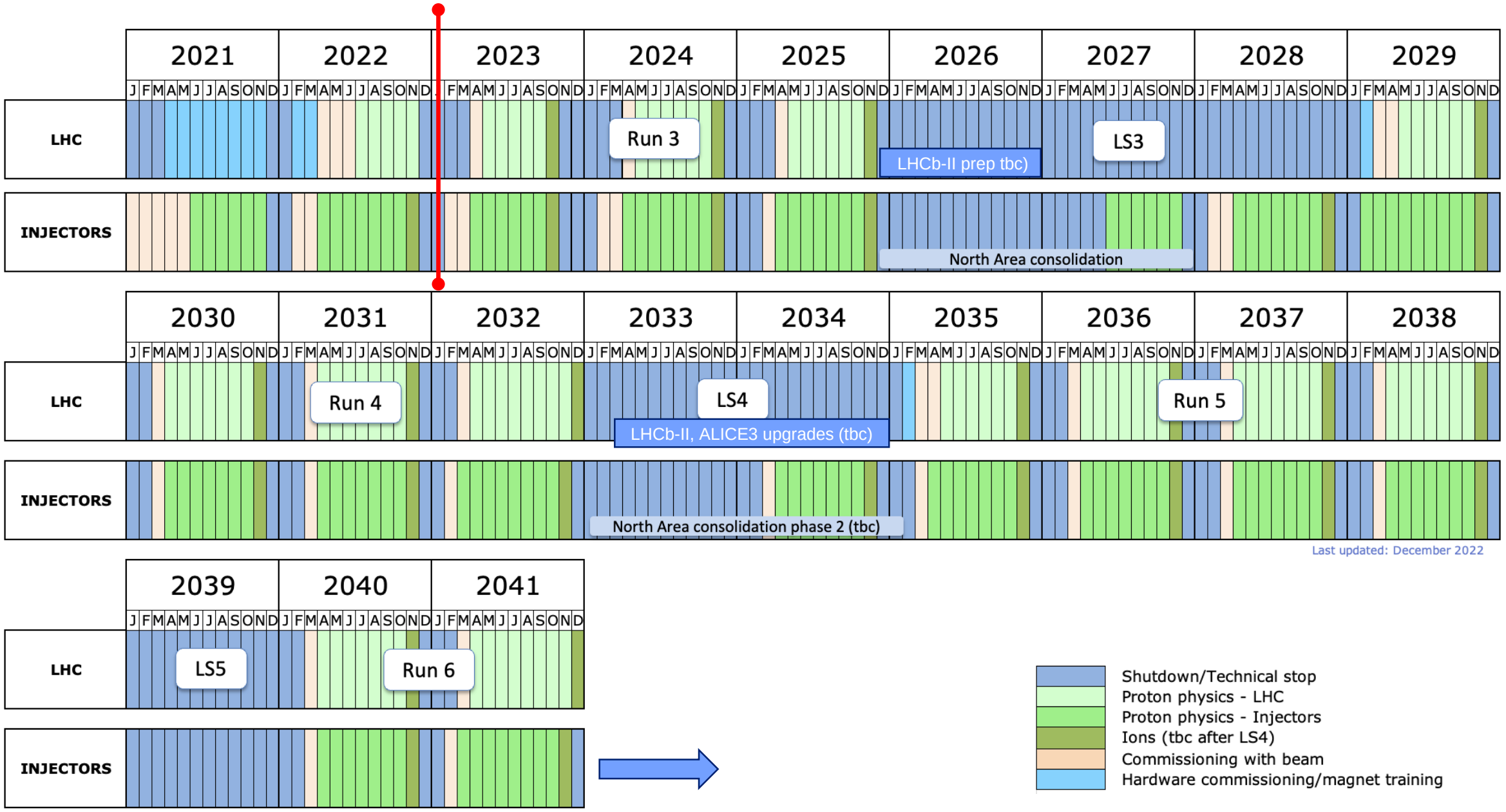


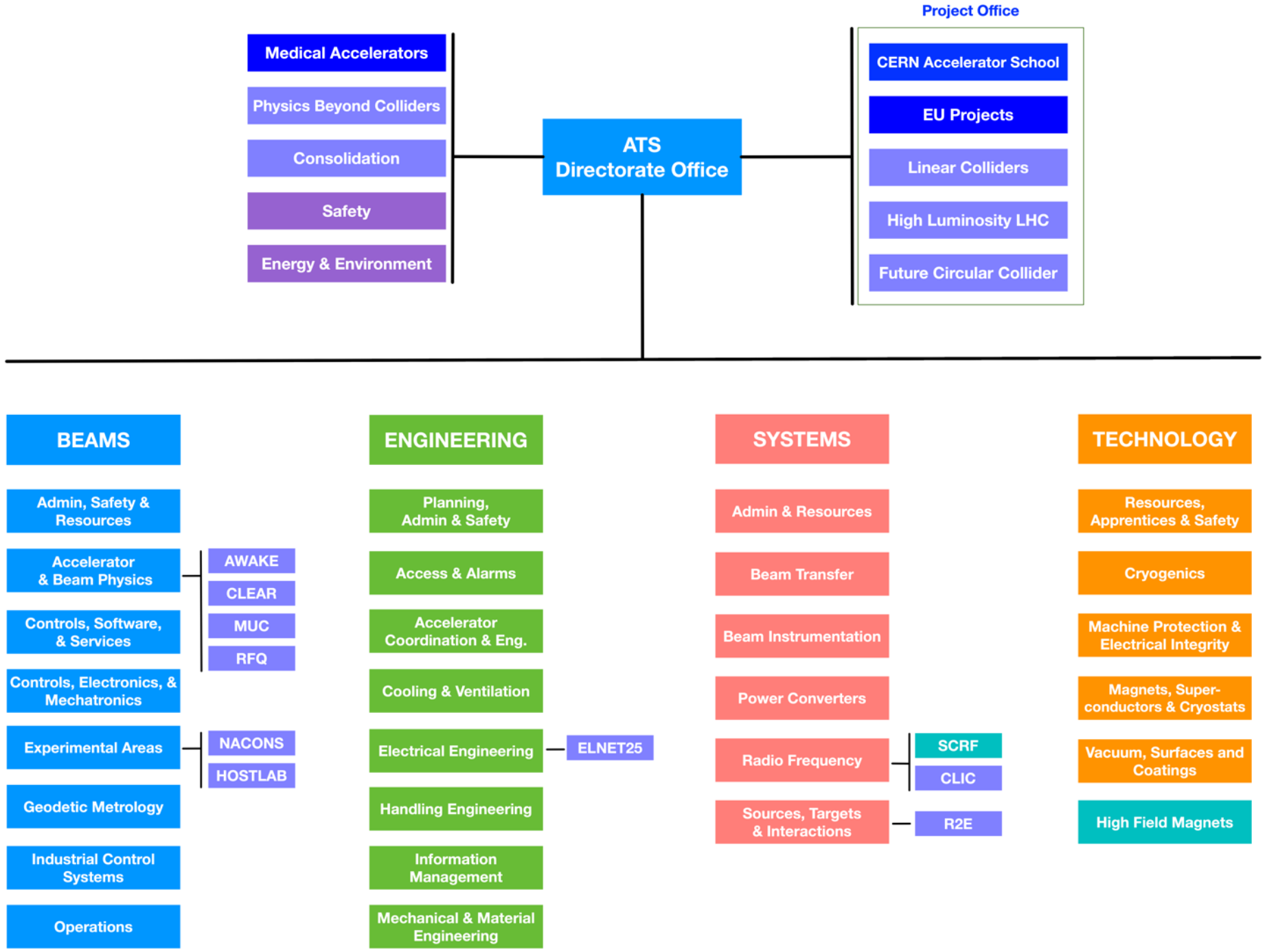
Future Options

Technology/Engineering



Indicative timeline - full and diverse physics programme




Project Office
Medical Accelerators
Physics Beyond Colliders
Consolidation
Safety
Energy & Environment
ATS
Directorate Office
CERN Accelerator School
EU Projects
Linear Colliders
High Luminosity LHC
Future Circular Collider
BEAMS
Admin, Safety & Resources
Accelerator & Beam Physics
AWAKE
CLEAR
MUC
RFQ
Controls, Software, & Services
Controls, Electronics, & Mechatronics
Experimental Areas
NACONS
HOSTLAB
Geodetic Metrology
Industrial Control Systems
Operations
ENGINEERING
Planning, Admin & Safety
Access & Alarms
Accelerator Coordination & Eng.
Cooling & Ventilation
Electrical Engineering
ELNET25
Handling Engineering
Information Management
Mechanical & Material Engineering
SYSTEMS
Admin & Resources
Beam Transfer
Beam Instrumentation
Power Converters
Radio Frequency
SCRF
CLIC
Sources, Targets & Interactions
R2E
TECHNOLOGY
Resources, Apprentices & Safety
Cryogenics
Machine Protection & Electrical Integrity
Magnets, Super-conductors & Cryostats
Vacuum, Surfaces and Coatings
High Field Magnets

People

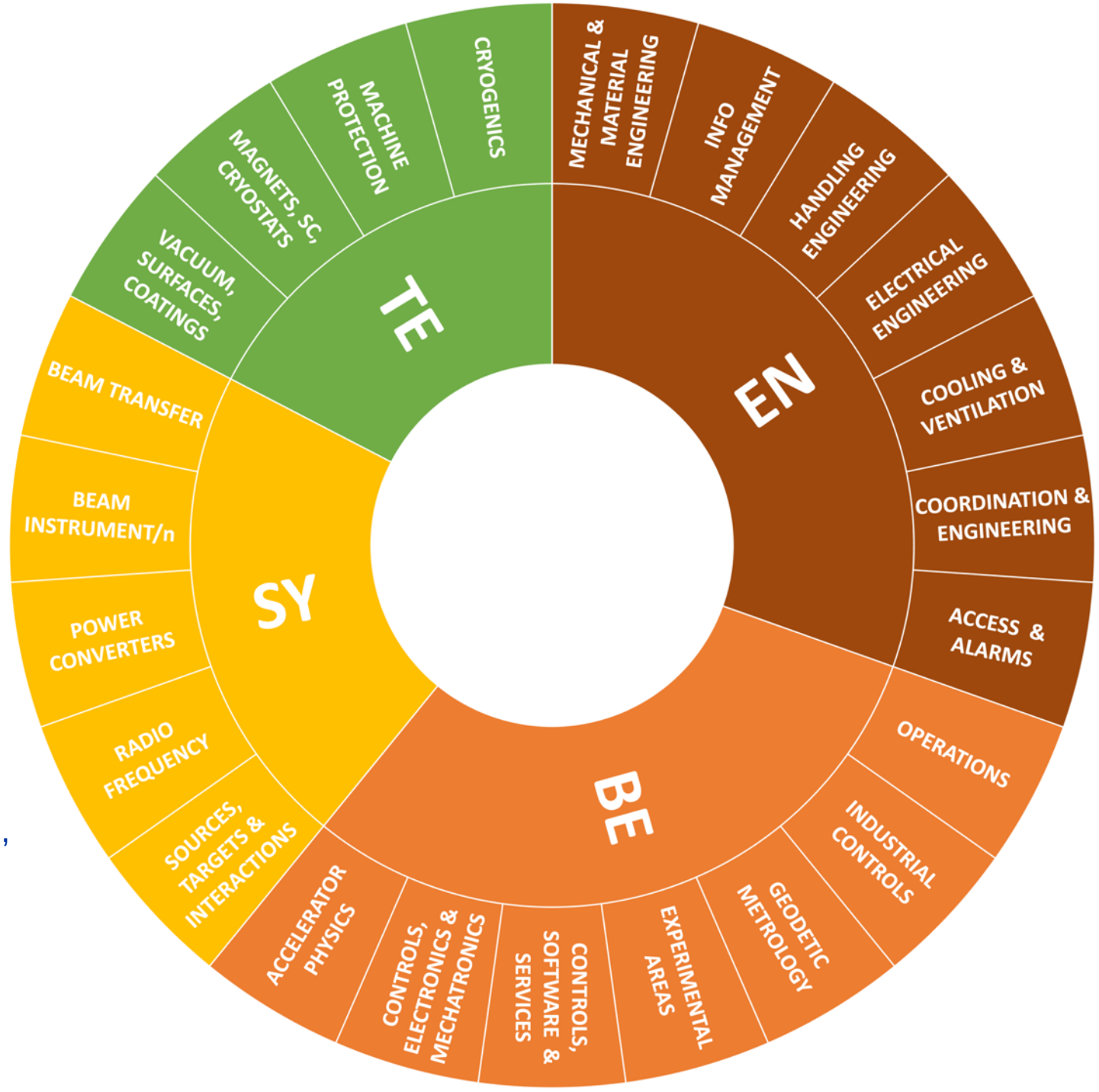
A legacy second to none

Wide-ranging and profound technological expertise and experience, proven capability to deliver on a large scale

World class facilities and labs

World class engineering capabilities coupled with processes and tools.

Well proven exploitation capabilities - Coordination, Operations…



Huge, aging, complex

Huge user base

For each domain, wide range/scale of demands, systems, legacy, hardware – much of it critical

Big technical stacks

Balance between:
M&O
Consolidation
Upgrades
Projects
R&D
++

Resource limitations

World leading present and future

Full, safe, exploitation of the remarkable potential of the complex

- Due regard to longevity & facility upgrades.
- Backed by a profound technology base and excellent support facilities.

HL-LHC - flagship machine at the energy frontier out to end ~2041

Complementary scientific diversity programme exploiting complex and facilities via Physics Beyond Colliders (e.g. ECN3, FPF…). Enthusiastic and ambitious user communities

Execution of a European Accelerator R&D Roadmap (High Field Magnets, RF, Muon Collider, Plasma Wakefield Acceleration, (Energy Recovery Linacs))

- secure the technology for next generation of machines

Sustainability and Societal impact, Outreach and Education as part of our mission

Beyond the end of HL-LHC?

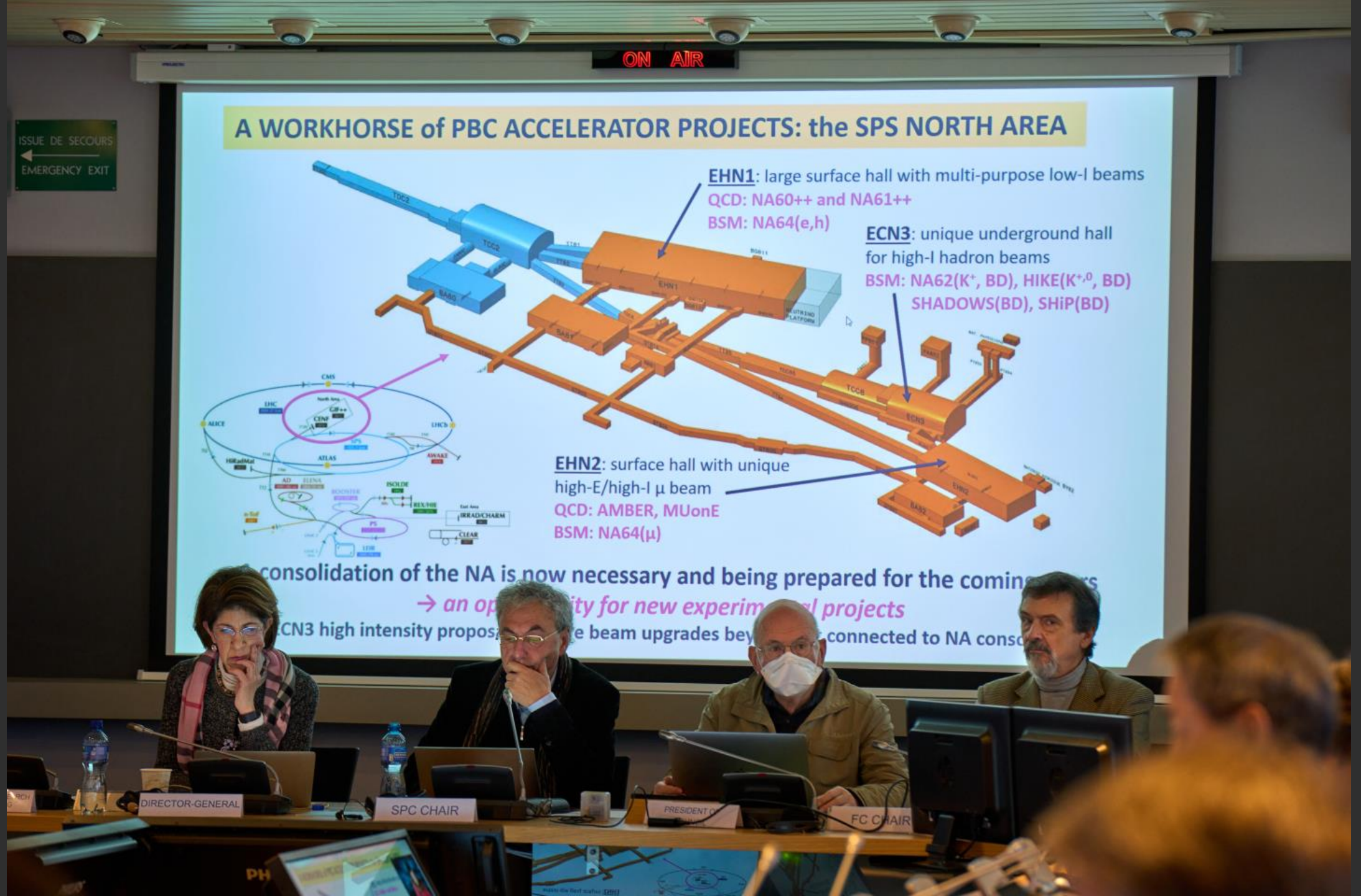
The vision is for another major project commensurate with the laboratory's capabilities, communities, and resources to assure the future of CERN for the next 50+ years

- Engine for continued investment, innovation, R&D and scientific engagement
- CERN remains a world leading Research Infrastructure
- CERN remains a prestigious symbol of worldwide collaboration, scientific excellence at the leading edge
- Geopolitical implications

The preferred direction for a future collider at CERN is the FCC

- As mandated by the European Strategy for Particle Physics
- Feasibility study to be delivered end 2025 – expect full and detailed scrutiny
- This a big, hairy, audacious goal – but then so was LEP, so was the LHC

Alternatives to be pursued as plan B (CLIC, ILC, Muon Collider)


ON AIR
ISSUE DE SECOURS
EMERGENCY EXIT
A WORKHORSE of PBC ACCELERATOR PROJECTS: the SPS NORTH AREA
EHN1: large surface hall with multi-purpose low-I beams
QCD: NA60++ and NA61++
BSM: NA64(e,h)
ECN3: unique underground hall
for high-I hadron beams
BSM: NA62(K+, BD), HIKE(K+,0, BD)
SHADOWS(BD), SHiP(BD)
EHN2: surface hall with unique
high-E/high-I μ beam
QCD: AMBER, MUonE
BSM: NA64(μ)
consolidation of the NA is now necessary and being prepared for the comin
→ an op ity for new experim l projects
CN3 high intensity propos e beam upgrades bey connected to NA cons
DIRECTOR-GENERAL
SPC CHAIR
FC CHAIR

Future Collider options

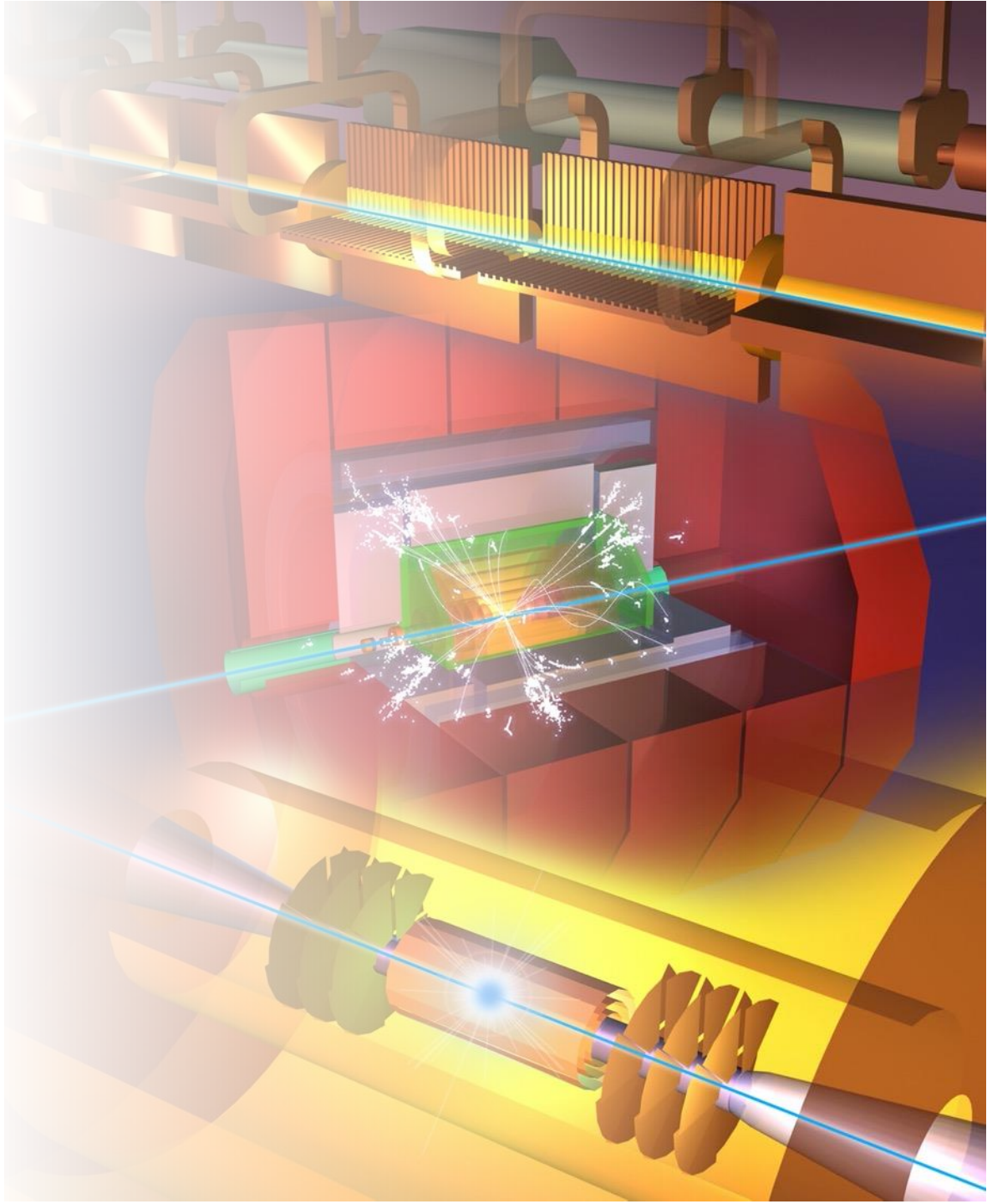
Higgs factory

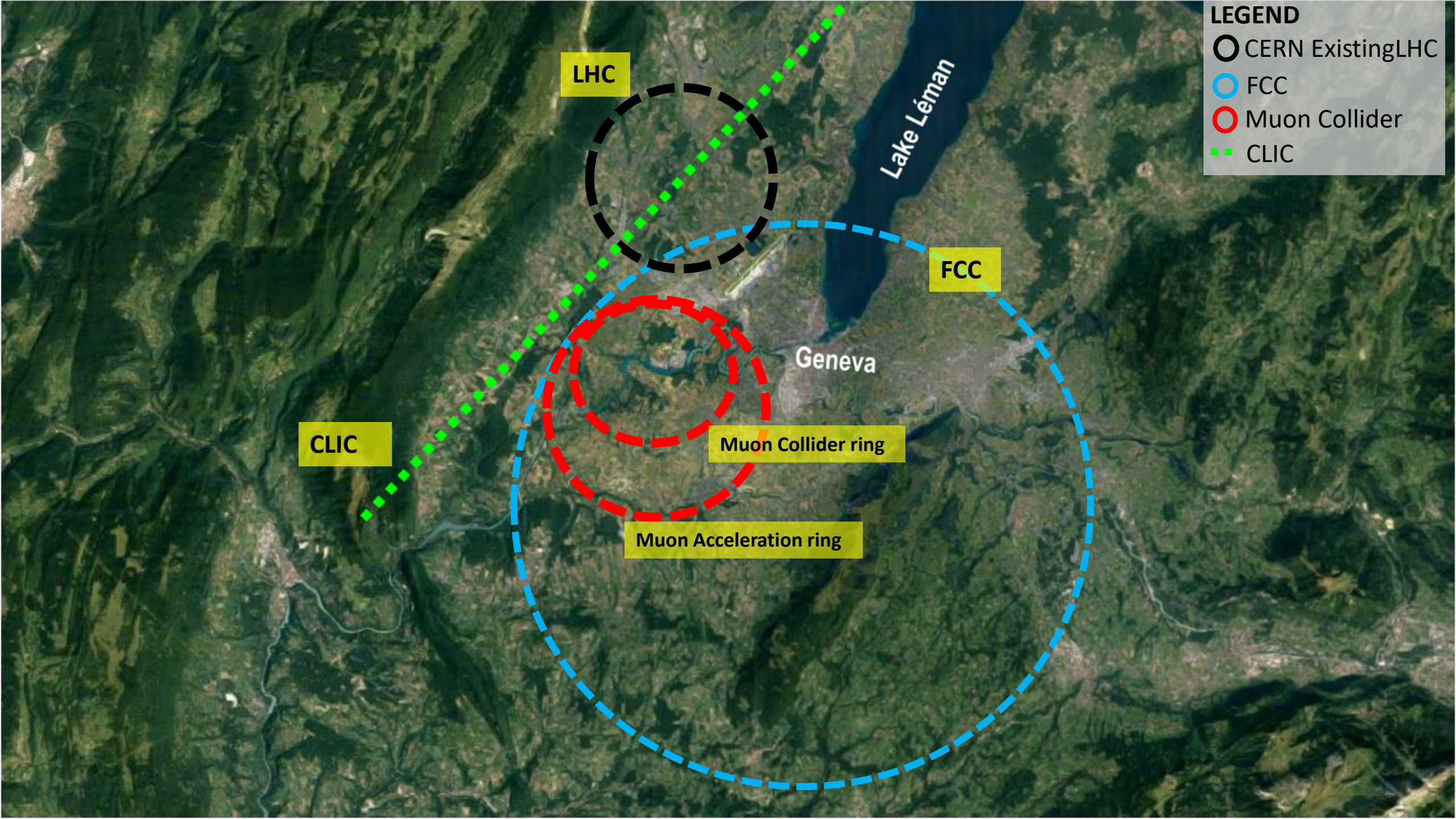
- Plan A1: **FCC-ee**
- Plan A2: **ILC**
- Plan B: **CLIC**
- Plan C: CepC, C^3

Multi-TeV

- e+e- : **CLIC**, C^3
- muons: **Muon Collider**
- protons: **FCC-hh**, SppC

Options under consideration at CERN given by European Strategy for Particle Physics Update 2020



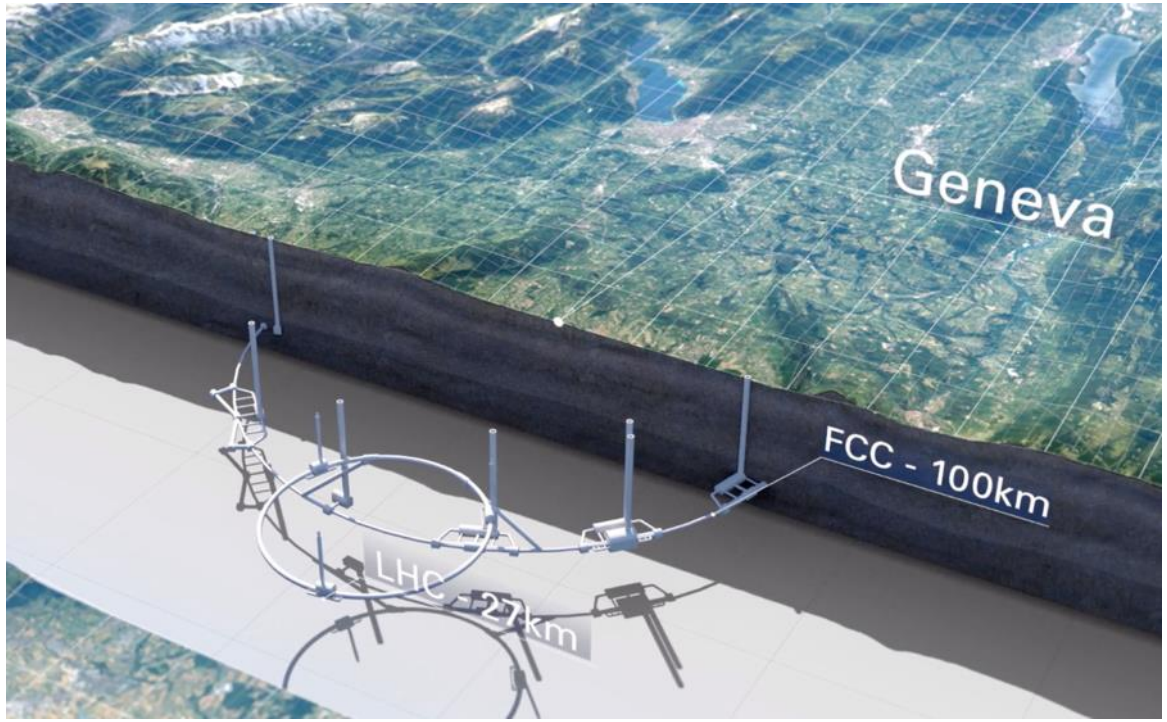

LEGEND
CERN ExistingLHC
FCC
Muon Collider
CLIC
LHC
Lake Léman
FCC
Geneva
CLIC
Muon Collider ring
Muon Acceleration ring

Which collider after the LHC?

For the longer-term : the European particle physics community has recommended to assess the technical and financial feasibility of the FCC (Future Circular Collider)

FCC: Future Circular Collider: ~91 km ring

- Technologically very ambitious → innovation driver
- Cost: ~11 BCHF for first stage
  (LHC: ~5 BCHF - tunnel was already there)
- Tentative timescale: project approval **~2028**, first-stage operation ~**2045-2060**, second-stage operation ~**2070-2090++**
- Strong support from the US (historical partnership of reciprocal contributions)
- Competition with China, which is considering a similar project



In brief…

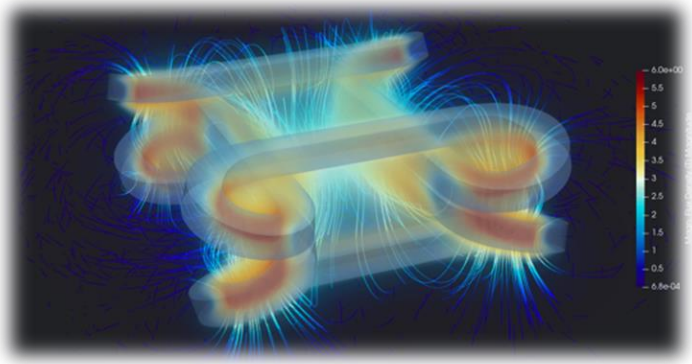
Option	Status
FCC feasibility study	Good progress – delivery of study foreseen end 2025 Serious mid–term review – Q4 2023
Linear collider - ILC	Mature design, slow progress in Japan moving to Pre-lab phase Targeted R&D phase as a bridge (funding tbc)
Linear collider - CLIC	Mature design, X-band, luminosity optimization, sustainability studies Project Readiness Report as a step toward a TDR for next ESPPU
Muon collider	International Study established, collaboration up and running Successful INFRA-DEV bid (on-hold)
Physics Beyond Colliders	Numerous smaller scale initiatives, medium scale projects under active consideration (ECN3 options, Forward Physics Facility)

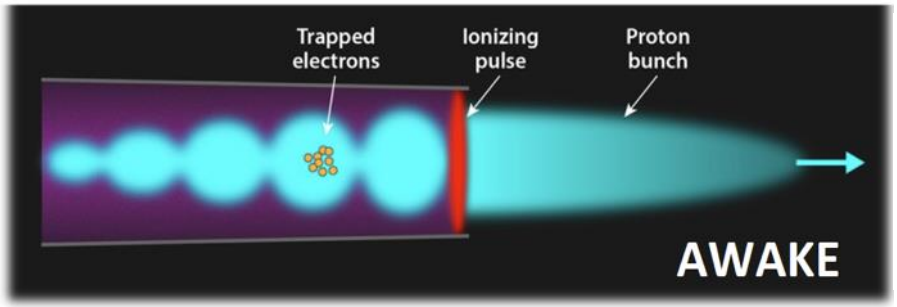
- Snowmass/P5 ongoing
- Next ESPP Update around 2026 - 2027

Accelerator R&D

MTP2023

Accelerator technologies and R&D	Total 2022-2027 Material [MCHF]	Total 2022-2027 M+P [MCHF]
RF technologies R&D	13.8	19.4
High-field superconducting accelerator magnets R&D	99.0	124.9
Proton-driven plasma wakefield acceleration (AWAKE)	22.3	35.0
CERN Linear Electron Accelerator for Research (CLEAR)	4.3	8.9
Other accelerator R&D	8.4	18.7





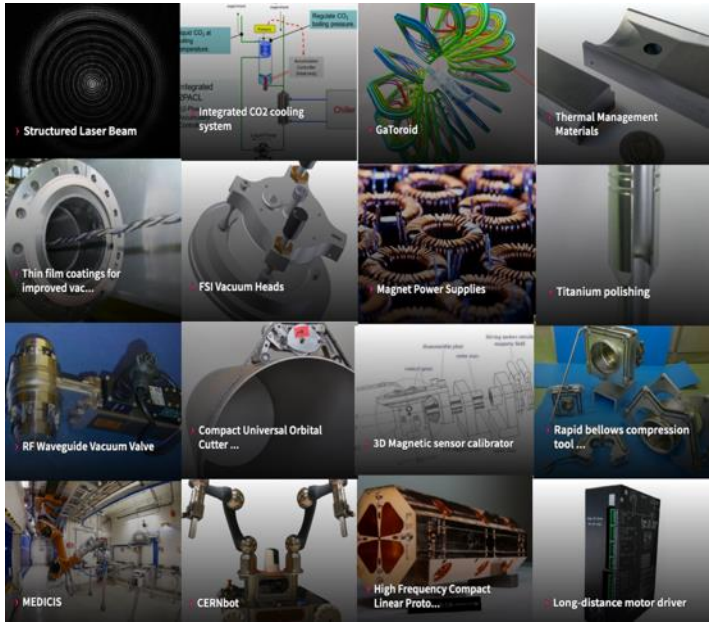
APS/Alan Stonebraker

Final 2023 budget

Programme	2023 Material & Personnel [MCHF]
Accelerator Programme	284.9
Energy, water, helium, nitrogen	169.8
HL-LHC	150.7
Physics Beyond Colliders	4.3
FCC	21.1
Linear Colliders	4.6
Muon Collider	2.7
Accelerator technologies and R&D	31.5

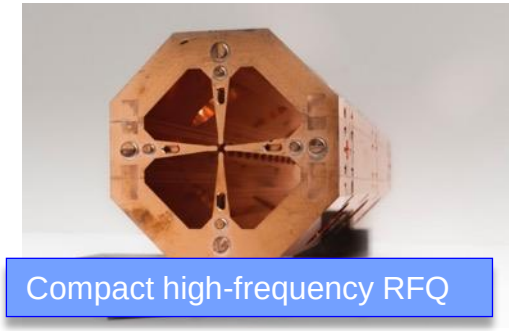
We are giving the FCC our best shot, while keeping Plan B options open and continuing to invest in PBC

Knowledge Transfer

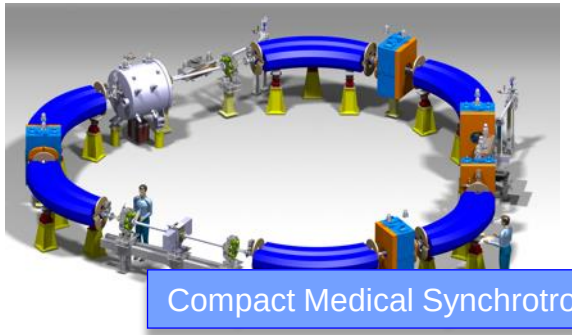


Sustainability

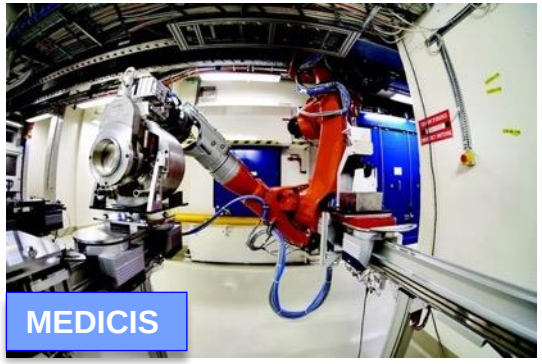
Medical Applications



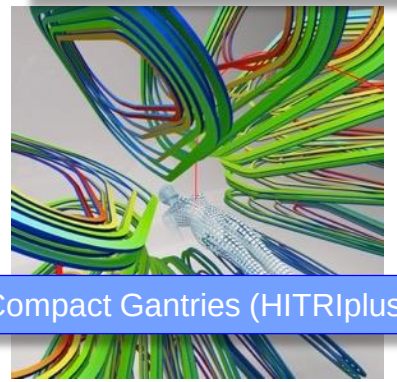
Compact high-frequency RFQ



Compact Medical Synchrotron



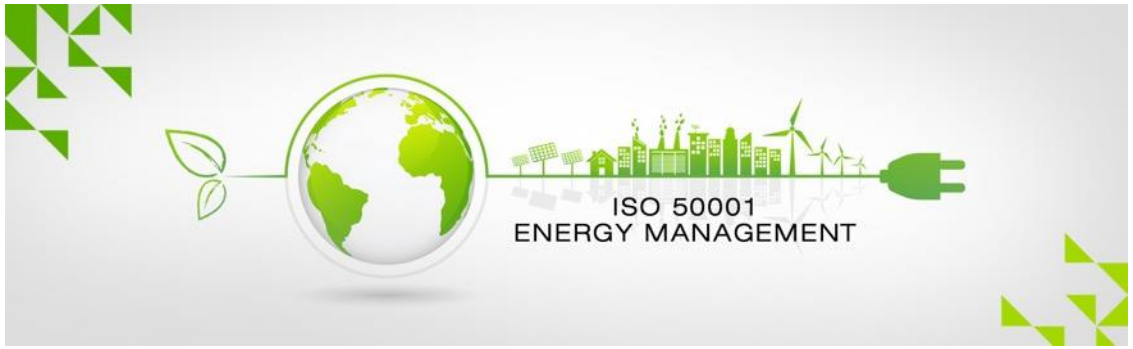
MEDICIS



Compact Gantries (HITRIplus, SIGRUM)

Horizon

I.FAST	Fostering Innovation in Accelerator Science and Technology
RADNEXT	Radiation facility network
PRISMAP	European Medical Isotope programme
HITRIplus	Heavy Ion Therapy Research Integration
FCC-IS	FCC Innovation Study
EURO-LABS	European Labs for Accelerator Based Sciences



provides a framework for organizations

- Develop a policy for more efficient use of energy
- Fix targets and objectives to meet the policy
- Use data to better understand and make decisions about energy use
- Measure the results
- Review how well the policy works
- Continually improve energy management

- **Based on solid foundations already established by CERN's Energy Management Panel (chair Serge Claudet)**

- Decision to seek certification taken Q4 2021
- Energy coordinator appointed (Nicolas Bellegarde)
- Framework and processes established in 2022
- Cross Organization buy-in assured
- Management reviews, internal audit, documentation…
- **Energy Performance Plan** developed

Certification audit took place 30 November to 2 December, **with the resultant recommendation that CERN is granted ISO 50001 certification**

Entitles CERN to 3 MCHF per annum rebate from RTE (gestionnaire du réseau de transport d'électricité français)

Research Infrastructures

RIs harness scientific expertise that drives discoveries and creation of knowledge and offer access to researchers from Europe and beyond to state-of-the art facilities.

They enable integration of research communities from all over Europe, including the less developed regions, and are the ideal place to perform multidisciplinary research.

RIs are also drivers of innovation as they develop advanced instruments and various cutting-edge technologies, in order to stay at the forefront of their research domains. These developments are often done in close collaboration with European industry, and lead to both incremental and breakthrough innovation.

RIs provide numerous benefits to European society and economy, either directly, through addressing societal challenges or industrial needs, or indirectly through training and education, as well as knowledge and technology transfer

Social Cost-Benefit Analysis of LHC and HL-LHC
Massimo Florio with Andreas Bastianin CERN Council 11 December 2020

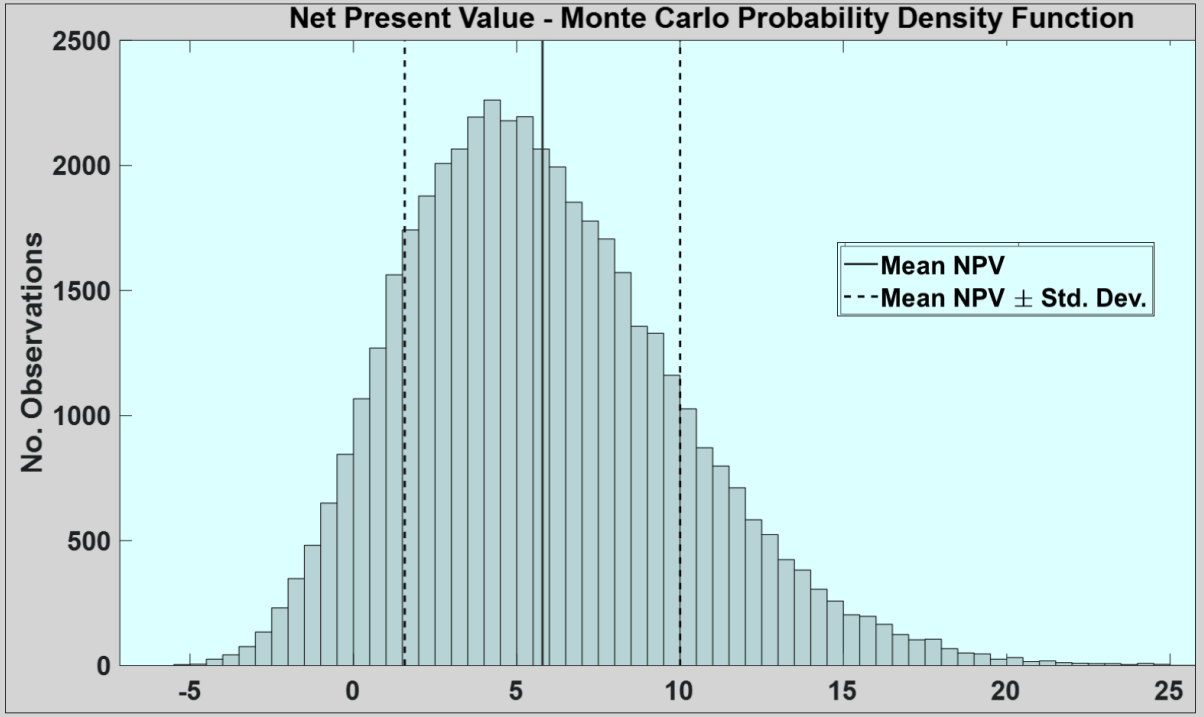
SUMMING UP: BENEFITS AND COSTS

STOCHASTIC NET PRESENT VALUE OF LHC + HIGH LUMINOSITY LHC

Benefits baseline	**25.7**
Scientific publications	0.6
Human capital	8.5
Technological spillovers	10.2
Cultural benefits	3.3
Public good value	3.1
Costs baseline	**22.3**
Net Present Value	**3.4**

Source: Bastianin, Florio (2018)

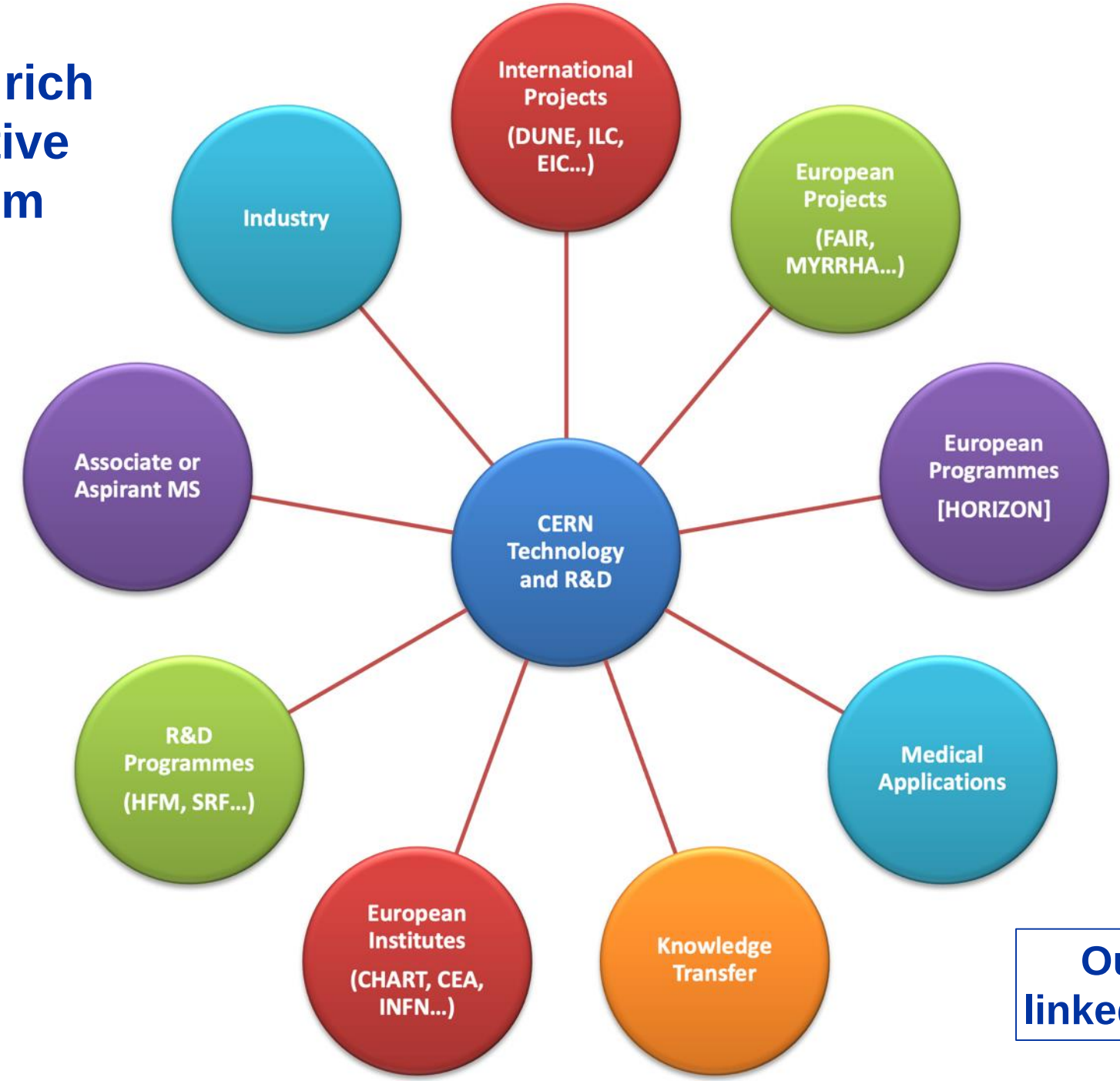
Billion CHF 2016



$$NPV = \left(PV_{B_u} + PV_{B_n}\right) - PV_c$$

"The surprising finding is that a machine as costly as the LHC, entirely devoted to describe things for which we currently have no use, passes a cost-benefit test."

Nexus of a rich collaborative ecosystem



Our future is intimately linked to our success as a RI

Staff - Survey Scope

- **Objectives of the survey** : “It's almost two years since the ATS restructuring was deployed, and we'd like to hear back from you and get your input on the new structure, the collaborative spirit, and the challenges ahead. It's a short survey and we'd appreciate it if you would answer six questions on the ATS sector.

- **6 Questions (2 open ones) :**

ATS	From set
I feel that the result of the restructuring of the A&T sector has been a success*	
What possibilities do you see to further improve the structure?*	
I feel that collaboration between ATS Groups and Departments has improved as a result of the restructuring*	
The main objectives of the sector for the coming years are clearly communicated to me*	
Aspects to address	**From set**
What for you are the three most important aspects to address by the ATS Sector in the coming years?	
Please give a short description of what we should focus on concerning these topics	

- **41.9%** response rate (i.e. 537/1282) : thanks!

+ 252 answers to open questions

Many thanks to Anne Laure Tantot and Aurelie Choy

Staff Survey - preamble

Many thanks for the responses

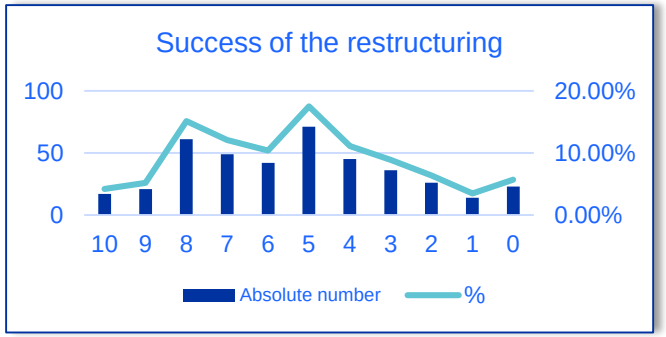
- In the open questions, there were many well-articulated comments across a wide range of topics and some pertinent suggestions
- There is lot in there to digest!

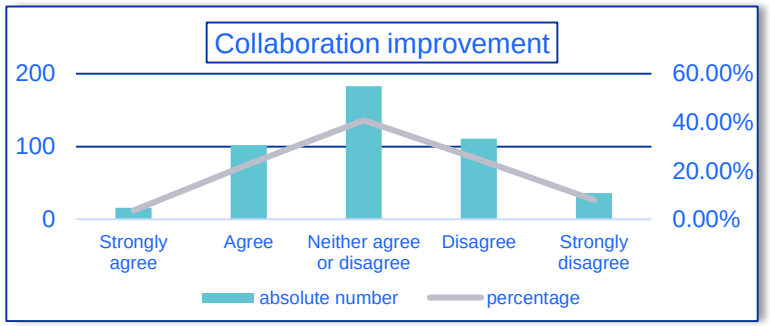
We’re in still in the early stage of analysis so only a concise overview today

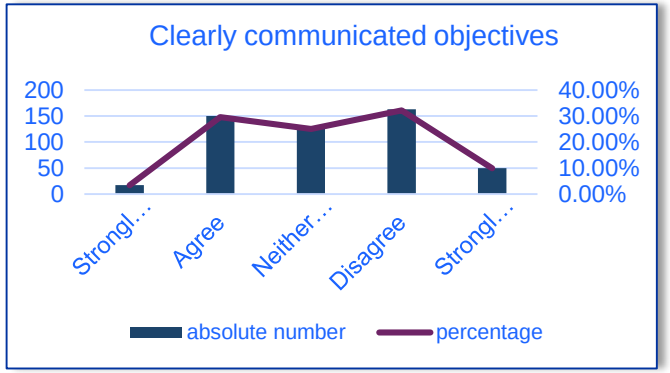
Results can be seen from the ATS, Department, or Group level and the results will be considered at each level

ATS outline view presented here today

Results







Aspects to address (top 4)!

Key points

Work Environment

- Resources, resources, resources
- Retention of expertise
- State of offices and catering facilities

Vision

- Need to think about tailoring communications to reach all personnel!
- Uncertainty about post HL-LHC era
- Resource prioritization

Development Opportunities

- Career development
- Internal mobility
- Training

Next steps

Still digesting… and a breakdown to the group level is required

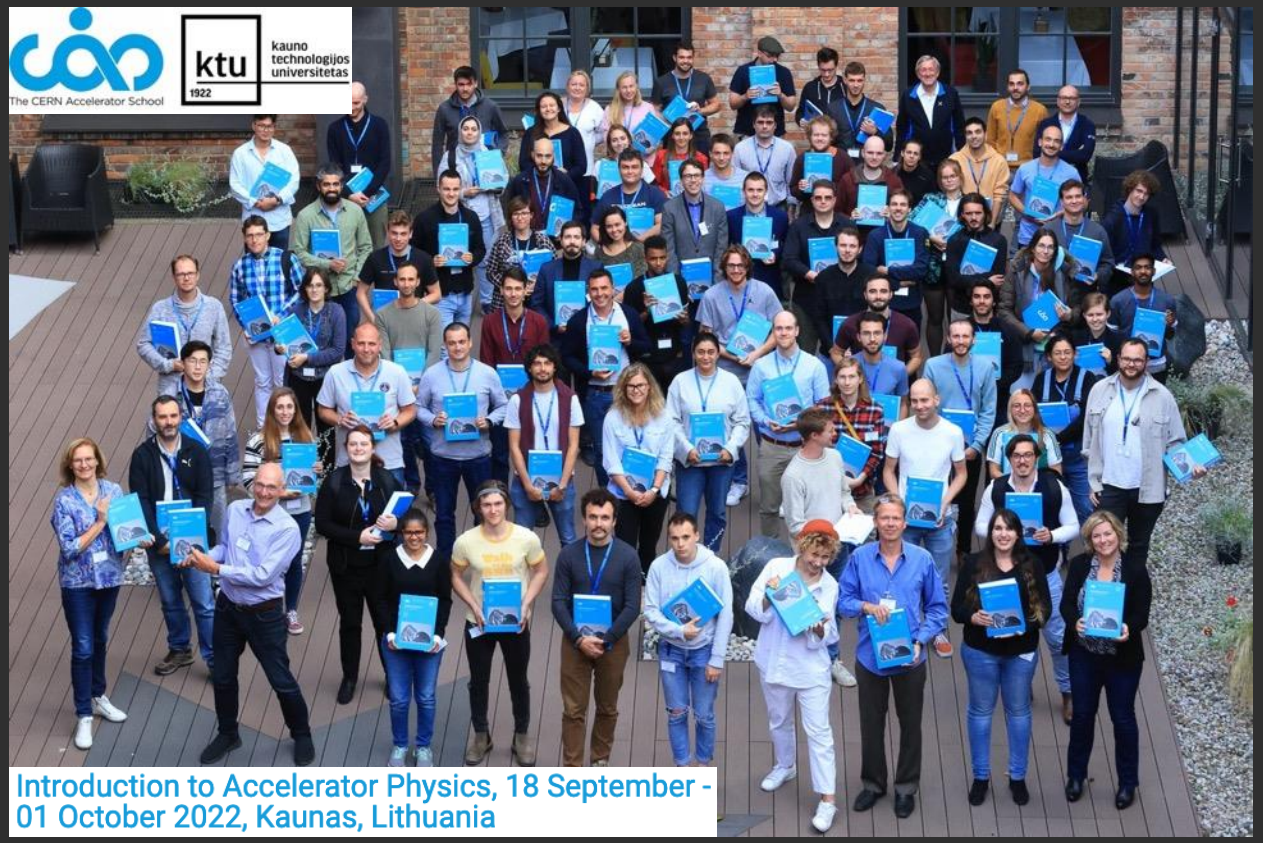
But it is clear we have some issues – we will address them

Some things we can start on now

- Communication plan (message well received)
- Mobility improvement (e.g. mobility pool within sector)
- Pass the message to SCE about offices and catering facilities (trying to be specific)
- Resources – caught between squeeze and demand – going to have to work on this going into the next MTP

An action plan will be drawn up, again across the different levels

We'll report back before the summer break



Introduction to Accelerator Physics, 18 September - 01 October 2022, Kaunas, Lithuania

UPCOMING SCHOOLS

RF for Accelerators	Introduction to Accelerator Physics	Normal and Superconducting Magnets
18 June - 1 July 2023	25 September - 8 October 2023	19 November - 1 December 2023
Berlin, Germany	Santa Susanna, Spain	Saint Pölten, Austria
Registration is open till 01 May 2023	Registration is open till 11 August 2023	Registration is open till 06 October 2023

CERN Accelerator School "Advanced Accelerator Physics" course, Sevrier, France

Thanks!

Despite COVID, Russian invasion of Ukraine, energy crisis, supply chain issues, inflation, a curtailed schedule... overall, a great year for the full accelerator complex and the experimental community.

HL-LHC - encouraging progress across the board

Good progress on Future Colliders, Physics Beyond Colliders, Accelerator R&D, Sustainability, Medical Applications, Knowledge Transfer, many, many collaborations and a lot more besides!

Looking forward, we have a full, meaningful programme ahead with numerous challenges and great opportunities.

The coming years will be decisive for the future of CERN and particle physics in Europe: we will have to deliver on the current programme and lay the foundations for the future of the field.

Acknowledgements and thanks to everyone in ATS and our colleagues from across the organization and around the world.