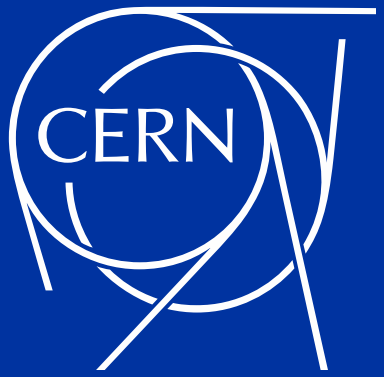


Welcome to the new-look BEAMS (BE) Department

Rhodri Jones

Gianluigi Arduini, Ronny Billen, Markus Brugger, Hélène Mainaud Durand, Alessandro Masi, Yannis Papaphilippou, Chris Roderick, Peter Sollander, Rende Steerenberg

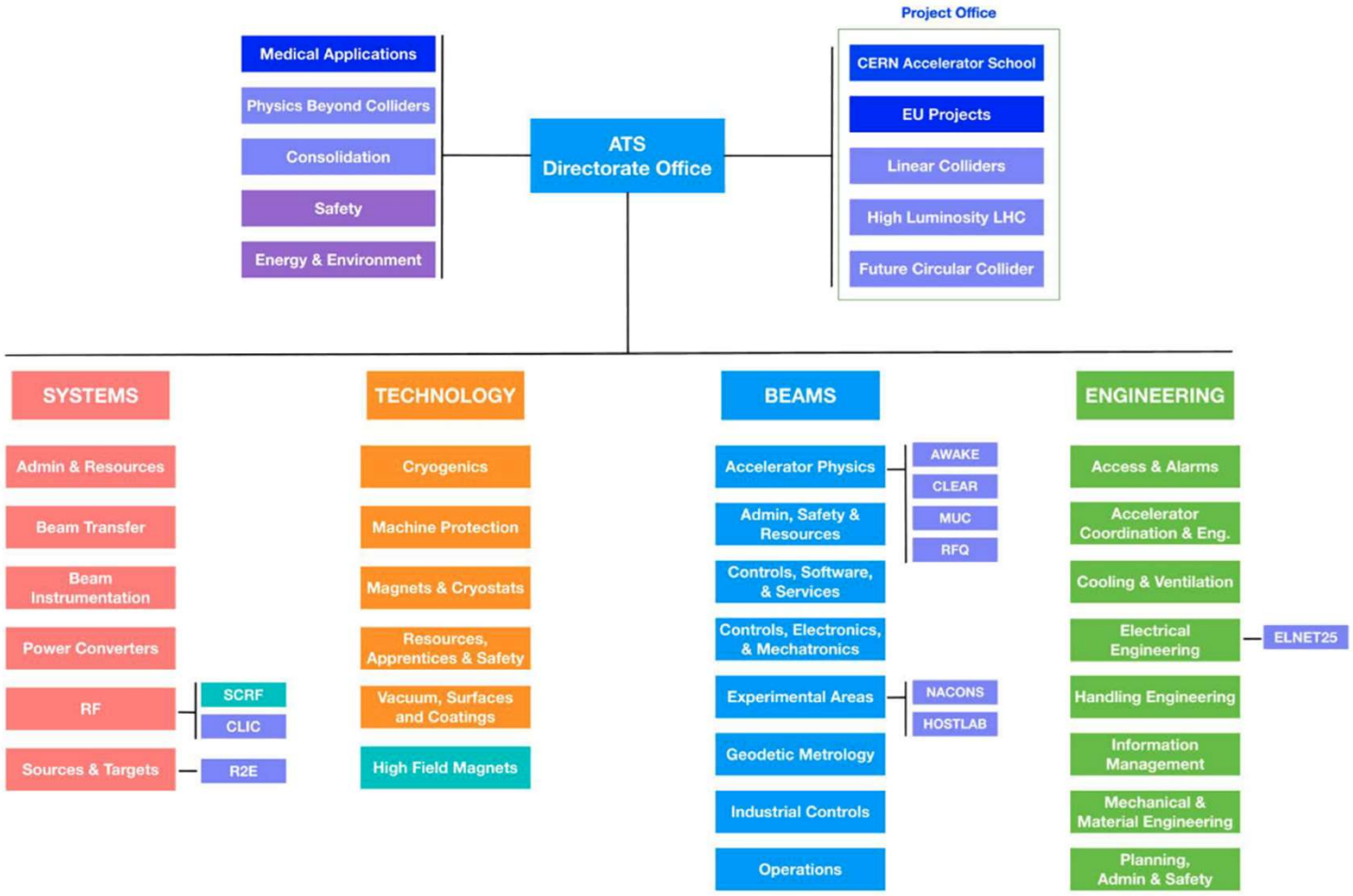
21st January 2021

BEAMS (BE) & the Motivation for Reorganisation

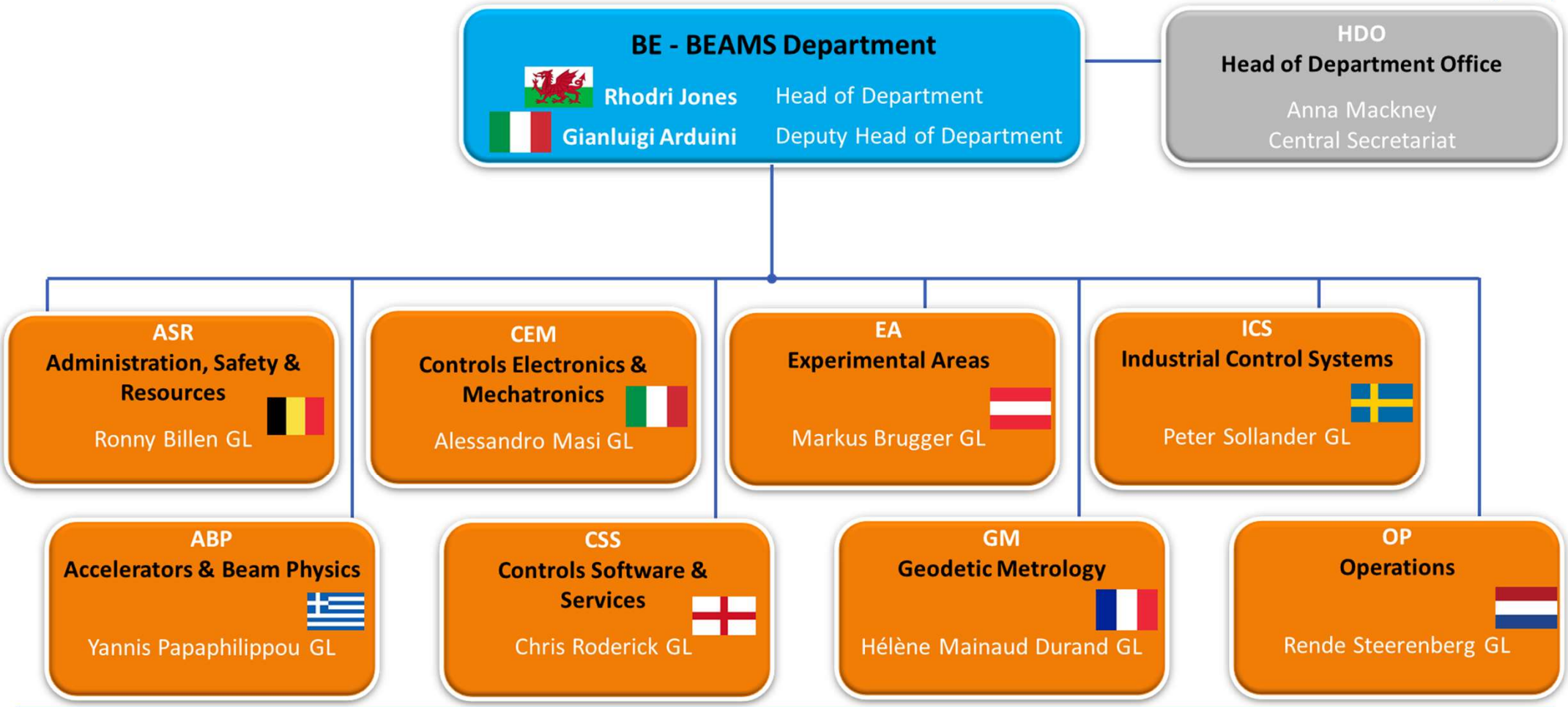
- **A constructive evolution of a structure that has clearly delivered impressive results over the last 11 years with new objectives**
  - the commissioning and exploitation of post-LIU injector complex
  - the shift from the LHC commissioning period to more regular LHC operation
  - the critical construction period of HL-LHC and need to already start planning for LS3
  - major new strategic initiatives following the European Strategy for Particle Physics (ESPP)

- **Departmental Focus**
  - Exploit sector wide synergies via grouping of functions and expertise
  - Exposure of functions and enhanced communication with the teams involved
  - More manageable department size
  - Ease administrative burden at departmental level

BEAMS (BE) at the Heart of the A&T Sector



The BEAMS (BE) Department



BEAMS (BE) – Our Mandate

The Beams Department (BE) provides CERN with the specific competencies required for:

the conception, design, survey, alignment, control and operation of accelerators, accelerator test facilities, secondary beam lines and experimental areas.

It also invests heavily in training new generations of physicists, engineers and technicians in related fields.

The BEAMS Department in Numbers

BEAMS DEPARTMENT (BE)
Head of Department: **Rhodri Jones**
Deputy Head of Department: **Gianluigi Arduini**

- **ABP** – **Accelerators & Beam Physics** – GL: Y. Papaphilippou
- **ASR** – **Administration, Safety & Resources** – GL: R. Billen
- **CEM** – **Controls Electronics & Mechatronics** – GL: A. Masi
- **CSS** – **Controls Software & Services** – GL: C. Roderick
- **EA** – **Experimental Areas** – GL: M. Brugger
- **GM** – **Geodetic Metrology** – GL: H. Mainaud Durand
- **ICS** – **Industrial Control Systems** – GL: P. Sollander
- **OP** – **Operations** – GL: R. Steerenberg

MPE / MPA									CONTRACTORS	
STAF	FELL	DOCT	TECH	TRNE	ADMI	PJAS	COAS	VISC	ENTC	TEMC
300	69	42	29	22	2	33	17	45	277	6
559									283	

STAFF			TOTAL
Indefinite	Limited duration	IC ratio	
205	95	68%	300

	FSU Contracts		TOTAL
	S144	S146	
FTE	43	7	50
kCHF (2020)	3,959	644	4,603

- **Annual operation budget ~15.2 MCHF**
- **Handling the service contracts for Gas, Scaffolding, Shielding, Cleaning & Dismantling, Survey and Alignment,…**

	BE MANAGED PROJECT BUDGETS (2021-2025)					
	AWAKE	HOSTLAB	MUON Collider	NA-CONS	Spare L4 RFQ	SPS-FIRE
Overall Budget (MCHF)	10.1	53.3	4.1	29.0	5.5	2.2
Main Contributors	SY	EN / EP		SY / EN	SY / EN	EN
TOTAL (MCHF)	104.3					

HDO – Head of Department Office

Central Administration

Anaïs Vandekerchove and Cassandra Heighton

Look after the general administration of the Department and related procedures

Strong Link with the Group Administrative Assistants

Contact: BE.central.secretariat@cern.ch

Contracts all status, arrivals/departures, special leaves, subsistence, overtime, collaboration agreements, personal schedules etc…..

Safety in the BEAMS (BE) Department

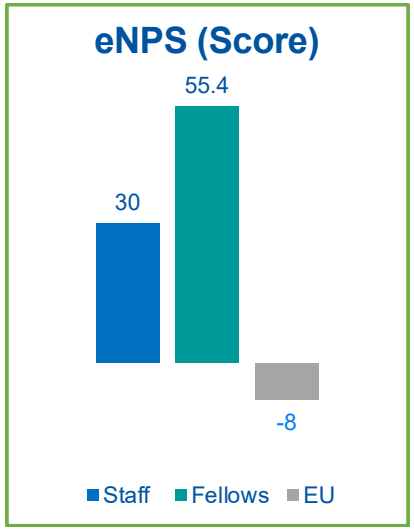
- **Individual responsibility**
  - Each person participating in the activities of the Organization or present on its site shall actively contribute to the implementation of the CERN Safety Policy through exemplary conduct and, in particular, compliance with the CERN Safety Rules
- **To help you with this we have dedicated Safety Officers**

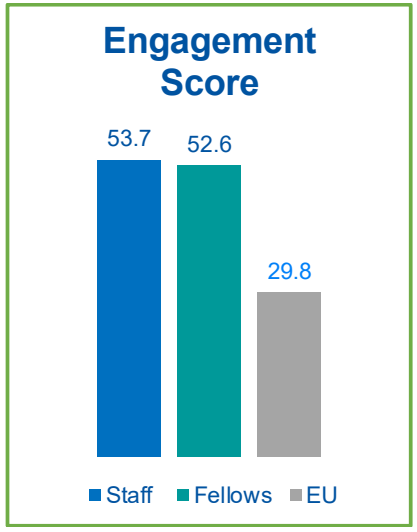
Departmental Safety Officer DSO	Deputy Dept. Safety Officer DDSO	Radiation Safety Officer RSO	Deputy Radiation Safety Officer DRSO	Territorial Safety Officer TSO
				
Christelle Gaignant	Mark Tavlet	Kurt Weiss	Andreas Herty	One for each building

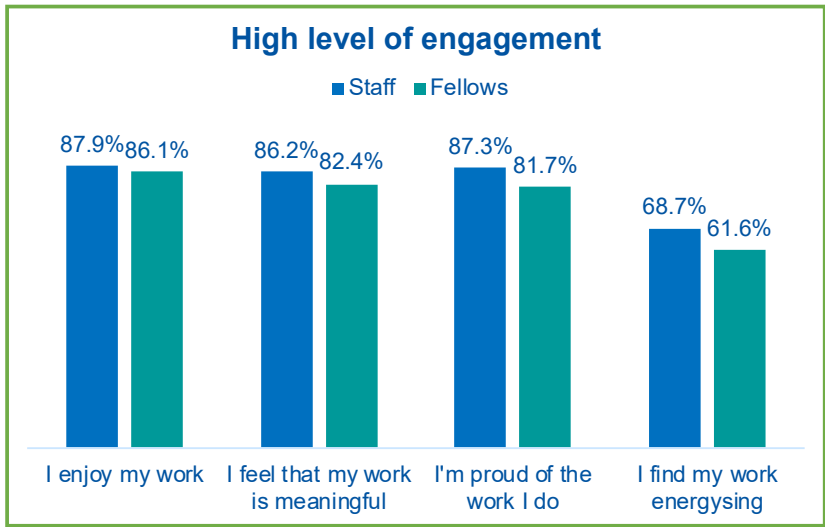
- **With linkpersons and support officers present in all groups**
  - Make sure you know who they are!

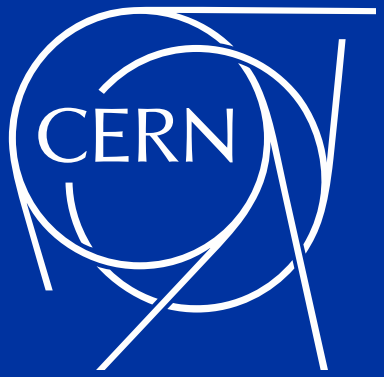
HR Support

- **Aurélie Choy – the BEAMS Human Resource Adviser (HRA)**
  - Now the single point of contact for all staff, fellows and students
- **Staff and Fellows Survey**
  - Carried out in 2019 with generally very positive feedback
  - Will continue to work with HR to address the global and more specific things identified in the survey









BE-ASR
Administration, Safety & Resources

Ronny Billen

ASR – Administration, Safety & Resources

Group Leader: Ronny Billen

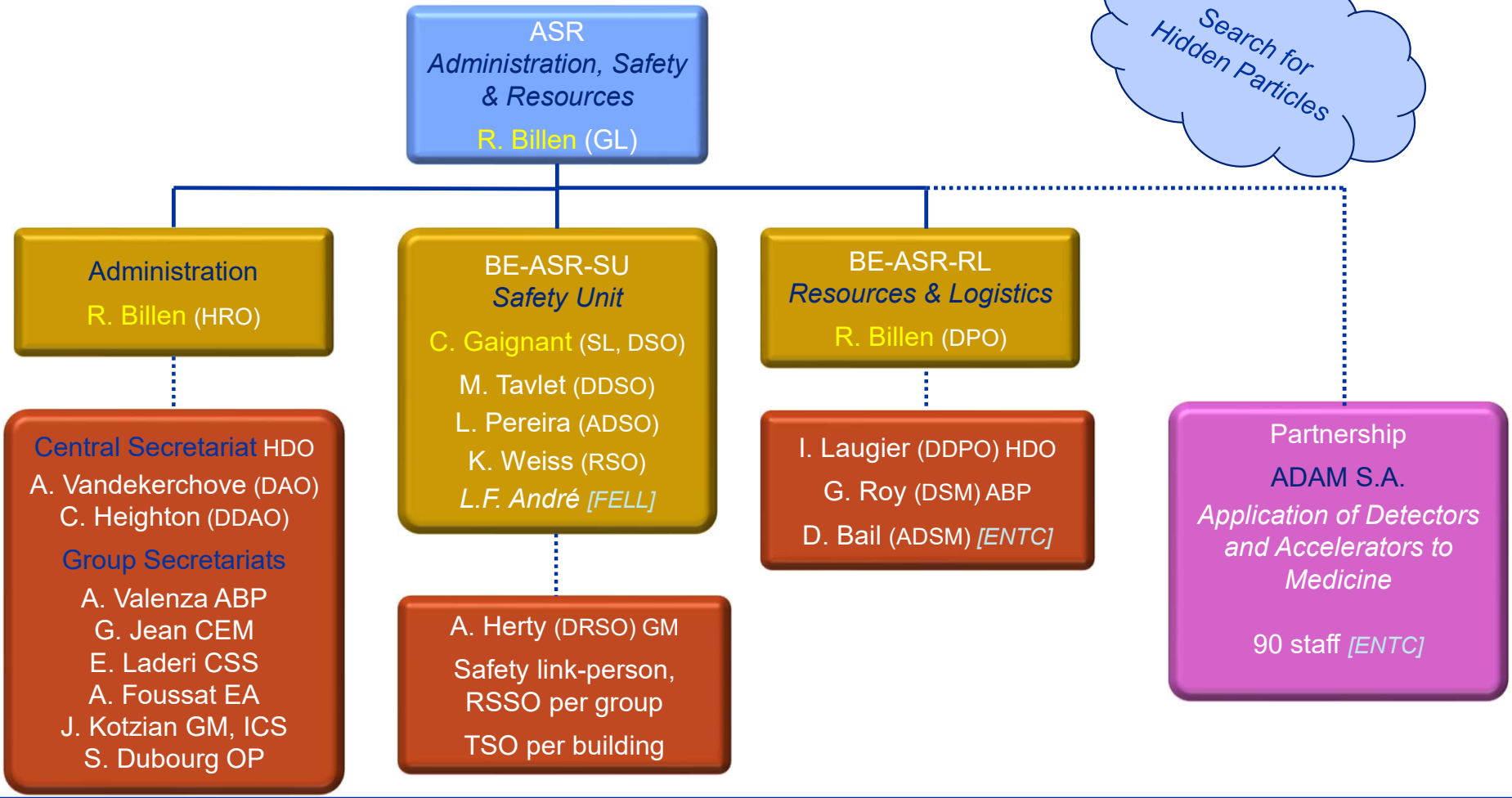
BE-ASR is a service group to the Beams Department

The group is mandated to provide overall assistance to the department head, to each individual group and to each member of personnel in BE

The scope of services concerns:

- **Planning and control of departmental human, financial and material resources**
- **Operational support to ensure the safety of all beam facilities and the safety of departmental personnel**
- **Coordination of the administration (contracts, career, special authorizations,…) related to all personnel of the department, for which the supporting staff is distributed across the department**
- **Provision of the necessary logistics and other resources necessary for the departmental staff (space management, vehicles, printing devices, drinking water,…)**

Organigram and staffing



Safety Unit

Departmental Safety :

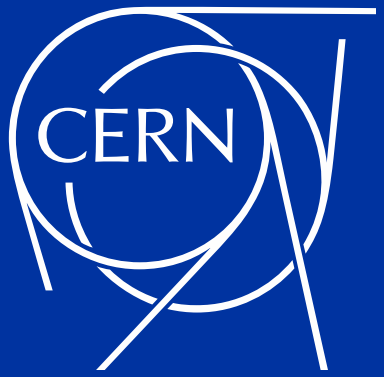
- Ensure that the safety structure is in place:
  - Safety Officers, safety link persons, workshop supervisors, emergency guides, first aiders
  - Safety training for all personnel with a safety role
- Be aware of new activities and related risks; provide support to the groups with respect to:
  - Conformity and safe operation of facilities, equipment, workshops and machine-tools
  - Annual review of prevention plans
  - Territorial safety

• Beam Safety – Particular to the BEAMS Department

- Overseeing matters of safety related to beam operation for the entire accelerator complex
- Conducting DSO tests for safe restart of accelerators, in particular the LHC and experimental zones in 2021

• Communication

- Website: https://be-safety.web.cern.ch/
- Generic e-mail: be.dso@cern.ch

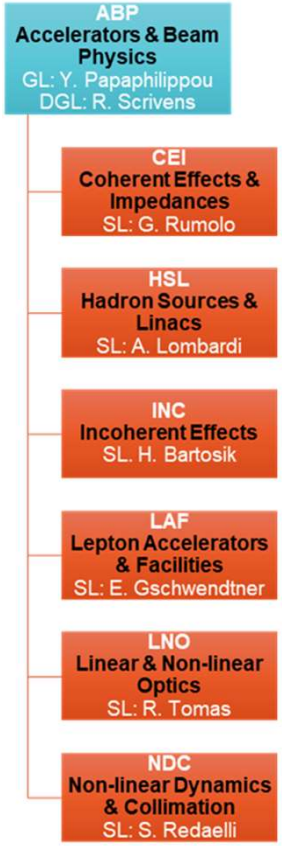


BE-ABP
Accelerators & Beam Physics

Yannis Papaphilippou

ABP – Accelerators & Beam Physics

Group Leader: Yannis Papaphilippou



The Mandate in Brief

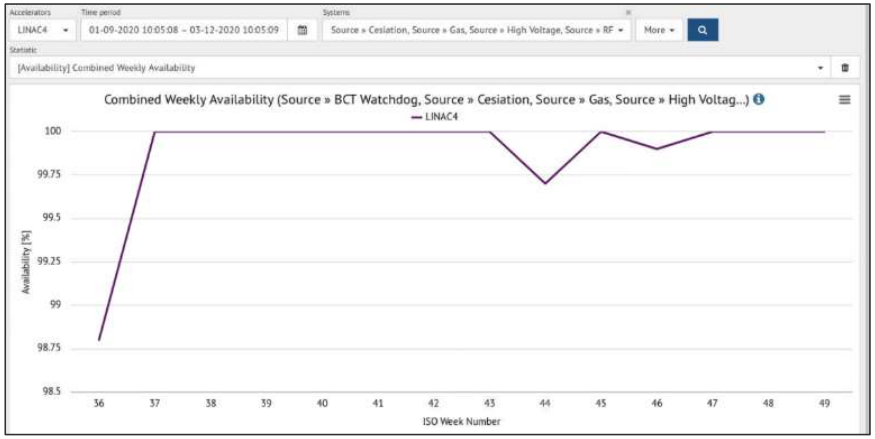
- Provides expertise for studying and understanding **beam physics** requirements throughout entire **CERN Accelerator Complex** and for future **upgrades** or new **projects**, achieved through theoretical, numerical and experimental studies covering **linear** and **nonlinear optics** and **beam dynamics**, **halo generation** and **collimation**, **cooling**, **coherent** and **incoherent collective effects**.
- It is responsible for:
  - design, construction, maintenance and operation of **hadron sources**
  - support to accelerator **operations**
  - devising ways to optimise accelerator **performance** & maintaining **optics repositories** and **models**
  - studying **new concepts** and **acceleration techniques**
  - coordinating and supporting operation of **AWAKE** and **CLEAR accelerator test facilities**
  - development, deployment, maintenance & exploitation of **accelerator physics computer codes**

Also strongly involved in teaching activities

ABP-Computing Panel
Chair: G. Iadarola

ABP Activities – Linac 4 Source Performance

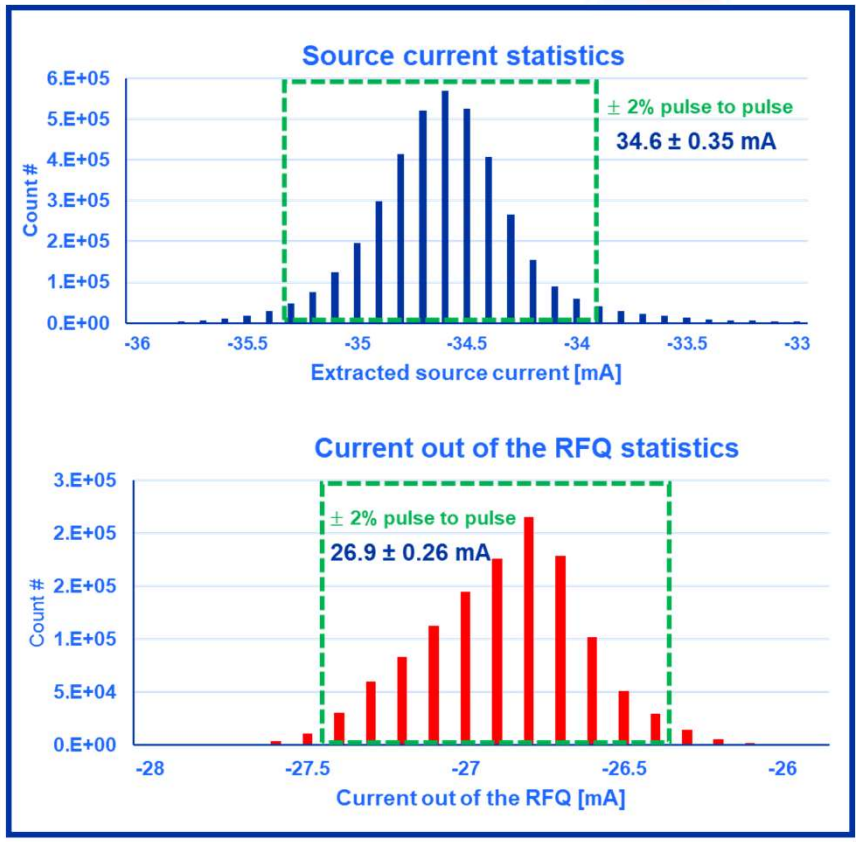
Transmission along Linac4 & transfer-line to PSB



Linac4 source weekly availability: Sep. 1st – Nov. 29th

Source extraction

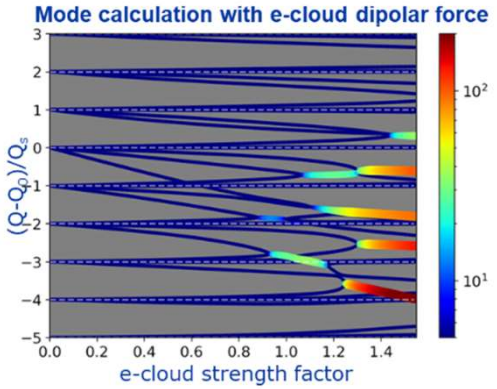
Source back

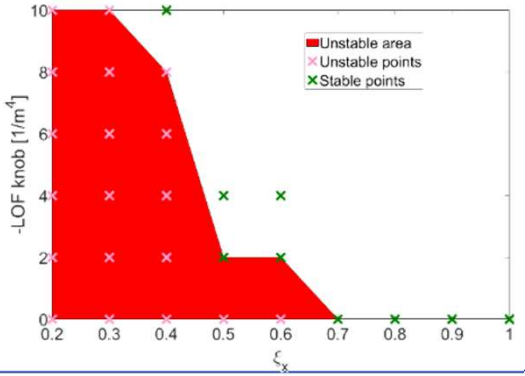


Operational beam current stats:
Oct. 1st – Dec. 1st

ABP Activities – Incoherent collective effects & noise

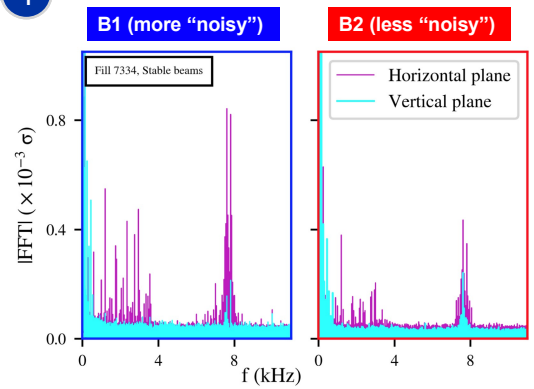
- **DELPHI Vlasov solver extension**
  - **consistent** with simulations





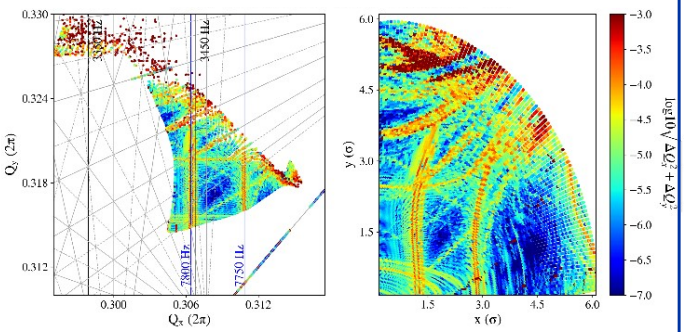
Can "noisy oscillations" of 10^{-3} σ impact the beam lifetime? **Yes.**

1



LHC "noise campaign"
in close collaboration between BE-EN-TE

2



Understanding the **interplay of noise and the machine non-linearities** from **long-term tracking…**

Important macroscopic effect shown in simulations!

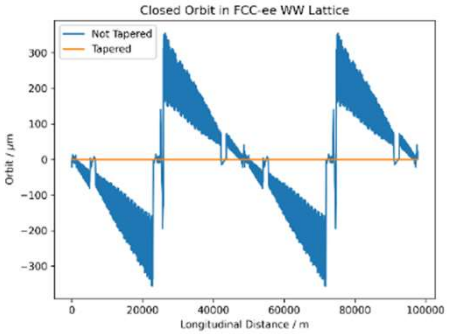
B1 (more "noisy") → **~22 hours of lifetime**

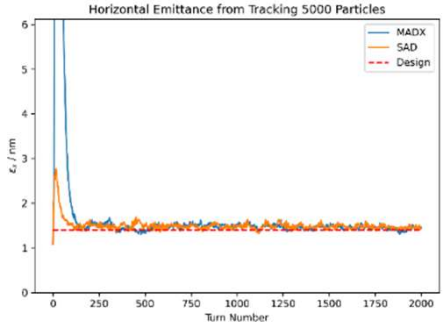
B2 (less "noisy") → **~27 hours of lifetime**

- **SPS horizontal instabilities in the LIU range of parameters**
  - Model validation by reproducing all 2018 instability observations
  - Region of stable operational settings determined for LIU beams

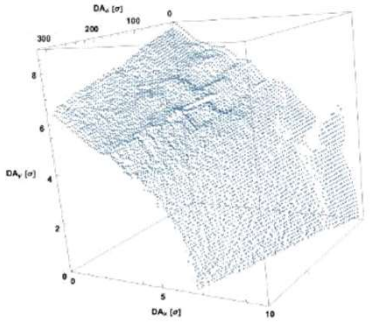
ABP Activities – Optics, non-linear dynamics, collimation

- **Tapering** in **FCCee**: compensate local beam energy variation by adjusting magnet strengths

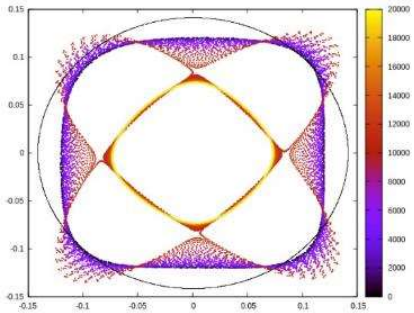




- **Non-linear dynamics studies** for estimating 3D dynamic aperture and evolution of cooled annular beams

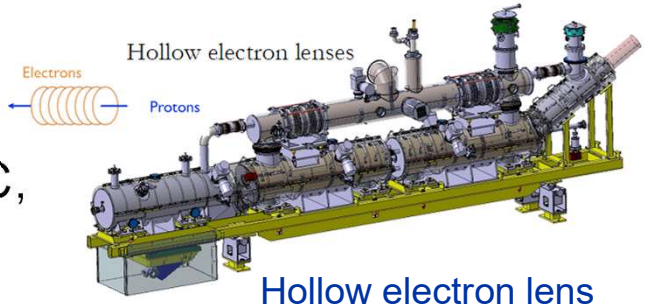


3D Dynamic Aperture

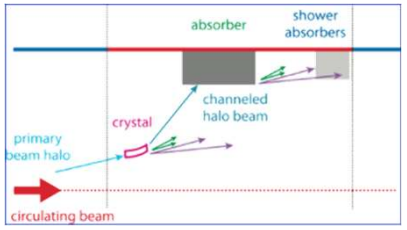


Cooled Annular Beams

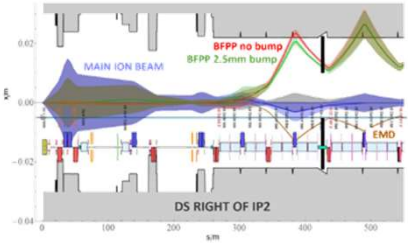
- Studies and **implementation of collimation systems** for protons and ions for (HL-)LHC, PBC, FCC,…



Hollow electron lens



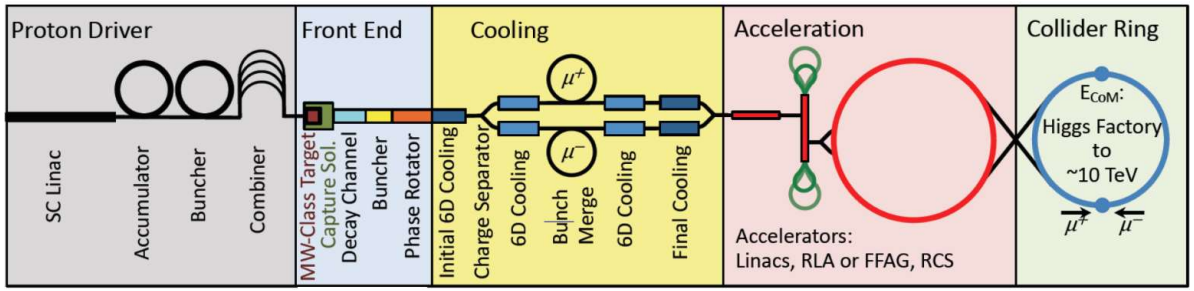
Crystal Collimation



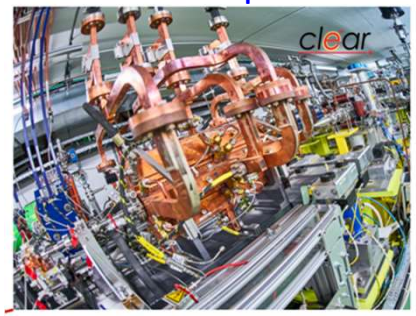
Ion Collimation

ABP Activities – Future collider studies and beyond

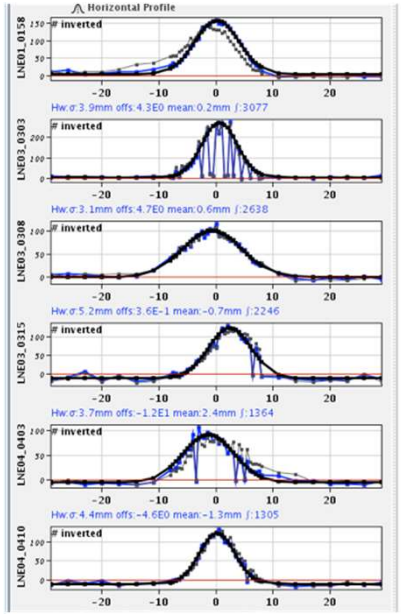
International Muon Collider Study hosted at CERN,
recommended by European Strategy, activities have started



CLEAR:
32 weeks of operation



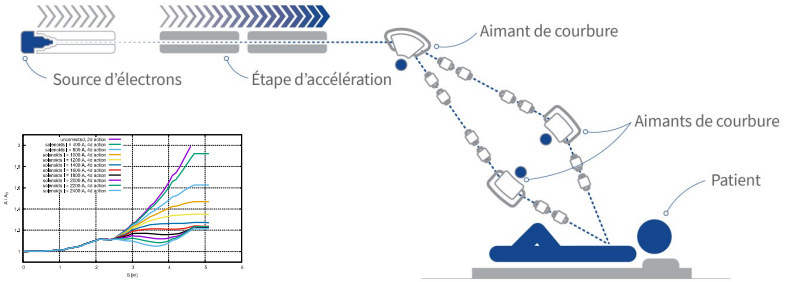
ELENA Transfer Line commissioning with H^--beam in full swing



Beam profiles on successive monitors in TL from ELENA to GBAR

CHUV-FLASH CDR: beam-dynamics-driven design

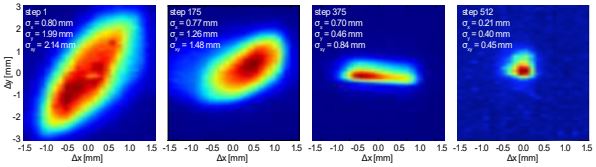
Integrated optimization of nontrivial beam parameters from cathode to patient



AWAKE: Running the facility during LS2

Controllable and reproducible electron beam for Run 2a and test-bed for Machine Learning methods, now applied to other CERN beams.

Optimization of the electron bunch size



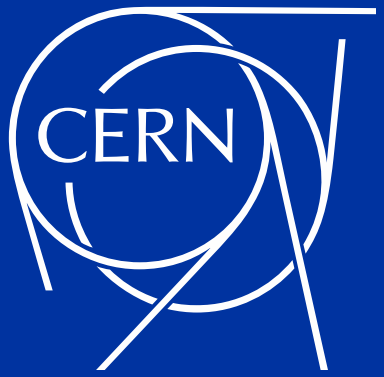
Front-to-end simulations of the LHeC energy recovery linac

eSPS CDR

FCC collider studies

ABP – Accelerators & Beam Physics Challenges

- **LIU beam implementation for protons and ions**
  - From the sources to SPS extraction addressing any intensity-brightness limitations
  - Exploring new territory with MDs (very challenging with present sanitary measures)
- **LHC Run 3 - Pave the path towards HL-LHC with LIU beams**
- **HL-LHC**
  - Consolidate the nominal operational scenario
  - Study/implement new collimation baseline concepts
- **Strengthen/integrate beam physics contributions in AWAKE, FCC, Muon, CLEAR**
- **Explore options for Physics Beyond Collider and medical accelerators**
- **Develop theoretical models and concepts with associated computing tools and potential experimental demonstration (benchmarking) in test facilities**
- **Identify set of strategic computing tools exploiting "modern" hardware (HPC cluster, GPUs) as well as traditional (CPU)**
- **Continue to investigate how machine learning techniques can benefit ABP activities**

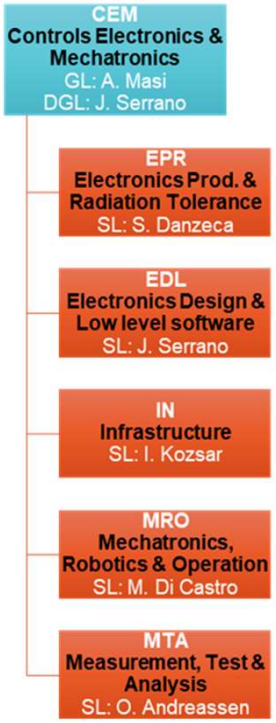


BE-CEM
Controls Electronics & Mechatronics

Alessandro Masi

CEM – Controls Electronics & Mechatronics

Group Leader: Alessandro Masi



The CEM group develops and maintains a centralised competence in controls hardware custom design, low-level software & infrastructure support, electronic development/production & radiation tolerance, mechatronics & robotics, tests and measurement systems.

CEM – Controls Electronics & Mechatronics

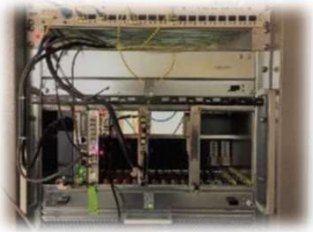
CEM
Controls Electronics & Mechatronics
GL: A. Masi
DGL: J. Serrano

- **EPR** Electronics Prod. & Radiation Tolerance — SL: S. Danzeca
- **EDL** Electronics Design & Low level software — SL: J. Serrano
- **IN** Infrastructure — SL: I. Kozsar
- **MRO** Mechatronics, Robotics & Operation — SL: M. Di Castro
- **MTA** Measurement, Test & Analysis — SL: O. Andreassen

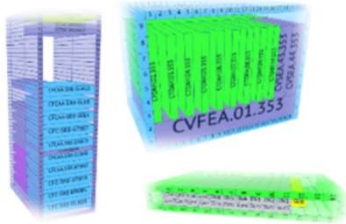
Responsible for the specification, design, procurement, integration, installation, commissioning and operation of low-level controls infrastructure: field buses, timing, embedded system, commercial and custom control modules for all CERN Accelerators, their transfer lines and the Experimental Areas.

Field buses: WorldFIP, MIL-1553

Timing distribution: GMT, White Rabbit



Front Ends: VME, cPCI and PICMG1.3, mTCA, PXIe form factors



Infrastructure Asset Management and Diagnostics

CEM – Controls Electronics & Mechatronics

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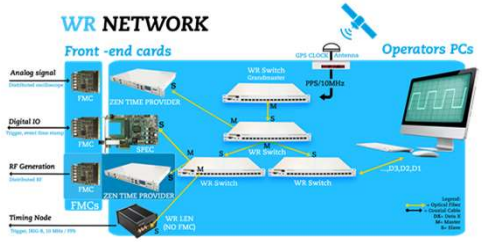
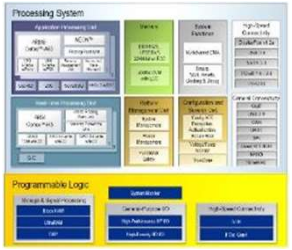
Responsible for the development, production and support of most of the generic custom electronic modules for controls, data acquisition and motion control including Linux device drivers, C/C++ libraries and associated test programs.

FMC Kit and front ends boards: Ex. Sensors Acquisition & Motion Control (SAMbuCa) ecosystem (https://ohwr.org)

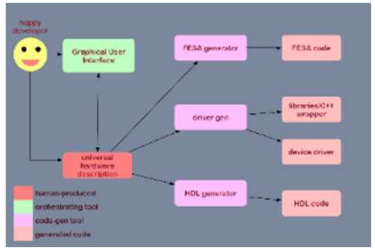


Accelerators timing solutions: GMT and White Rabbit (https://ohwr.org/project/white-rabbit/wikis/home)

DI/OT ecosystem (https://ohwr.org/project/diot/wikis)



SoC and Front-ends Linux standardisation



HDL and drivers generator

CEM – Controls Electronics & Mechatronics

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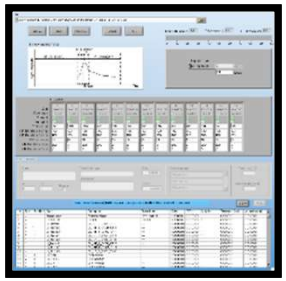
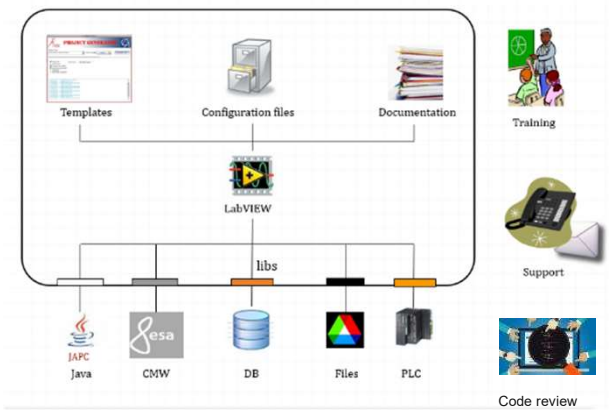
- **MRO** – Mechatronics, Robotics & Operation – SL: M. Di Castro
- **MTA** – Measurement, Test & Analysis – SL: O. Andreassen



SM18 superconducting magnet test stands

Responsible for the CERN-wide support for all tests & measurement systems based on LabVIEW and a selected set of commercial off-the-shelf products.



CERN LabVIEW support

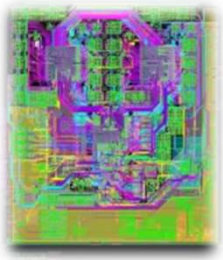
Oscilloperturbography (EN-EL)

CEM – Controls Electronics & Mechatronics

CEM
Controls Electronics & Mechatronics
GL: A. Masi
DGL: J. Serrano

- **EPR** Electronics Prod. & Radiation Tolerance — SL: S. Danzeca
- **EDL** Electronics Design & Low level software — SL: J. Serrano
- **IN** Infrastructure — SL: I. Kozsar
- **MRO** Mechatronics, Robotics & Operation — SL: M. Di Castro
- **MTA** Measurement, Test & Analysis — SL: O. Andreassen

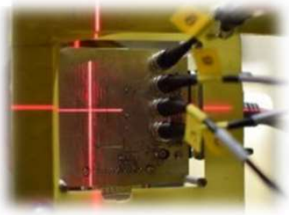
Altium Designer. cadence KiCad



PCB Layout design, production and assembly for boards and crates

Repair and rework of almost any type of components

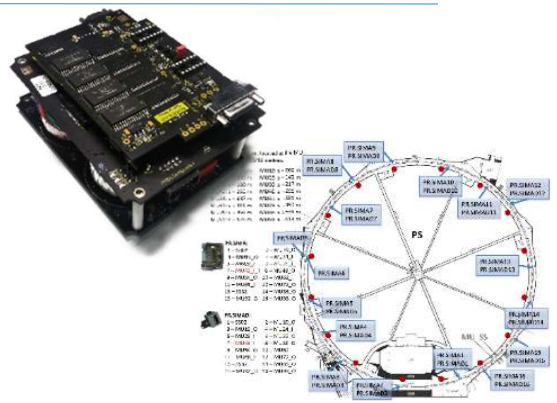
CERN central service for the layout, industrialisation and production of electronic modules based either on industrial standards or detector-specific technologies. CERN-wide support on radiation-tolerant electronics, radiation tests and radiation monitoring for evaluating the dose to electronics installed in radiation areas.



CHARM

CC60

Radiation tests Service for COTS and systems qualification



500 RadMon devices installed in the accelerator complex

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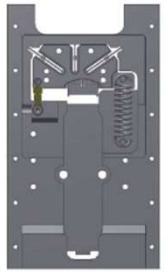
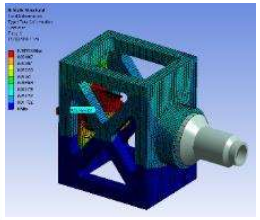
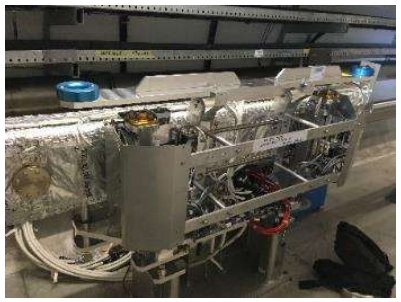
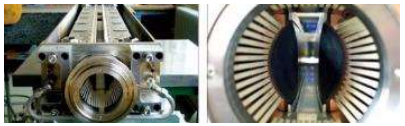
- **MTA** Measurement, Test & Analysis — SL: O. Andreassen

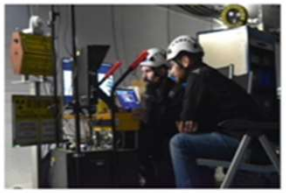
Responsible for mechatronic systems and controls design, production, installation and operational support for the LHC Collimators and the Beam Intercepting devices in the CERN accelerator complex. Robotics developments and interventions for remote inspection and maintenance in radioactive areas.

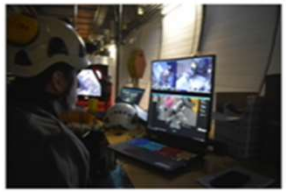




Actuators & position sensors R&D

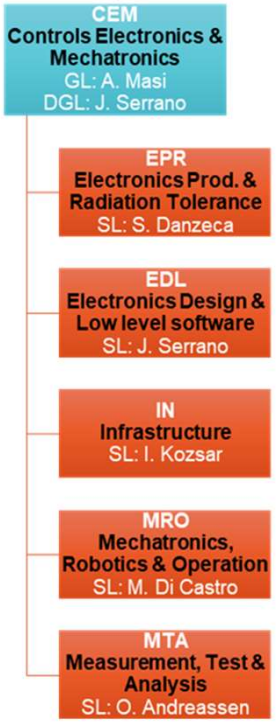

LHC Collimators low level control

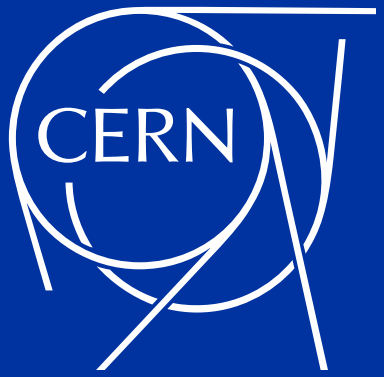
Robotics service

CEM – Controls Electronics & Mechatronics



Main Technical challenges for the coming years:

- ❑ **Generic hardware platforms - SAMbuCa, DI/OT ecosystem**
  - ✓ **LHC Collimators low-level controls**
  - ✓ **Mechatronic low-level controls for the Fully Remote Alignment System for HL-LHC (including string test)**
  - ✓ **Machine Timing consolidation – move to "White Rabbit"**
- ❑ **New robotics challenge: ATLAS shielding doors modification**
- ❑ **New Linux Image for Front-ends and System on Chip support**



BE-CSS
Controls Software & Services

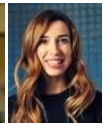
Chris Roderick

CSS – Controls Software & Services

Group Leader: Chris Roderick

CSS
Controls Software & Services
GL: C. Roderick
DGL: M. Vanden Eynden





Provides solutions for the control & monitoring of all CERN particle accelerators, their transfer lines, associated experimental areas and various supporting technical infrastructure services

FST
Front-end Software & Timing
SL: S. Deghaye

Collection of **software frameworks, libraries & tools** for **real-time control** & **data acquisition**; **central timing** system for the **sequencing & synchronization of the accelerator complex**

CSA
Configuration, Settings & Automation
SL: L. Burdzanowski

Systems to manage **physical & logical configurations**; **operational settings**; **control experimental areas**; to **automate operational procedures** and **synchronise configuration changes** across the control system

CPA
Communication, Processing & Archival
SL: V. Baggiolini

Communication between control system elements; **processing of acquired data**; **archiving data** to support diagnostics and analysis of beam and equipment performance and behaviour

GTA
GUI Technologies & Applications
SL: M. Braeger

Defining and steering the ATS GUI strategy; leading development of **GUIs to interface with core CSS systems**; providing **numerous standalone applications** & **ATS-wide services**

ISA
Infrastructure & System Administration
SL: M. Vanden Eynden

Computing infrastructure platforms to run the controls software (including CCC, CCR, Technical Consoles); **administration and monitoring** of both **back- & front-end systems**

SET
Software Engineering Technologies
SL: Stephen Page

Support, guidance and consulting, towards the ATS software developer community, for **Java & Python**, together with **tools & technologies** needed throughout the software engineering lifecycle

EXP
Exploitation Manager
M. Gourber-Pace

Engage with ATS Accelerator Controls community to **follow operational issues** & ensure **optimal Controls utilisation**

CSS – Structure

Avoid functional overlaps
or competition across sections

Re-enforce technical expertise
and **promote common approaches**

Develop synergies between related elements of the CSS portfolio, aiming to:

- **Improve integration** between sub-systems
- **Simplify** as much as possible
- **Improve the end-user experience** as a result

Work together
to *deliver complete solutions*
for our user communities

Partnerships

CEM: *together* we **provide *complete, end-to-end,* accelerator controls solutions**

ICS: CSS is now an **essential service provider**

→ Synchronised cross-group planning & developments to fulfil ATS controls needs

IT: CSS **relying on IT** services & platforms

Stakeholders

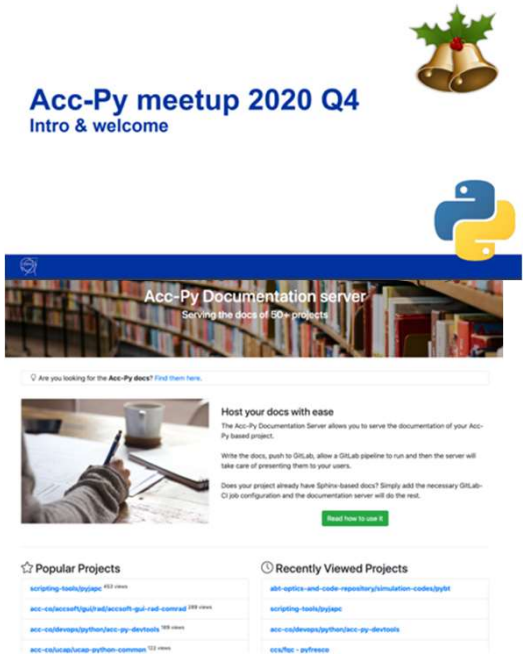
ATS Equipment, Coordination & Information Management groups

Operations (Accelerator & Technical infrastructure)

Experimental Areas & **Experiments**

Almost all **BE groups**

CSS – What we do – *Some* 2020 Highlights



Python (distribution, libraries (e.g. PyRBAC, PyRDA), docs, tools) and **user community engagement**

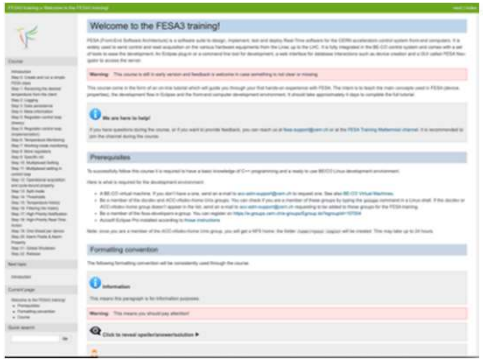
NXCALS (data migrated, WinCCOA & TIM data sources, Backport API, PyTIMBER, TIMBER & Config web apps, etc.)

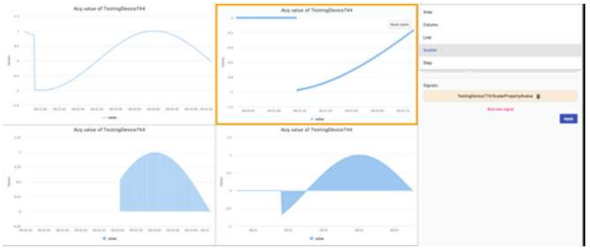
On-Line **FESA Training**

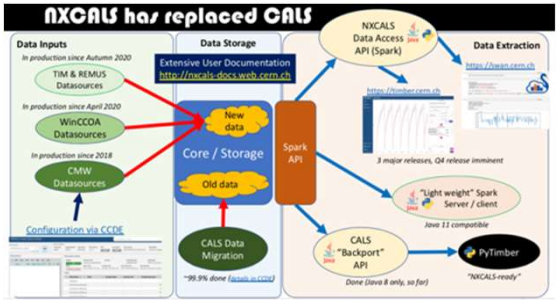
Consolidating the **GUI Strategy** (inventory, in-depth analysis, Controls Dashboards, ComRAD, acc-py-widgets)

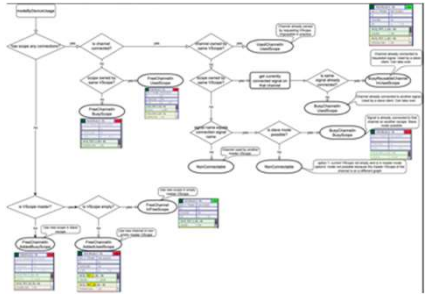
LINAC4 / PSB Sequencer application (automating the steps to help *protect the RFQ*)

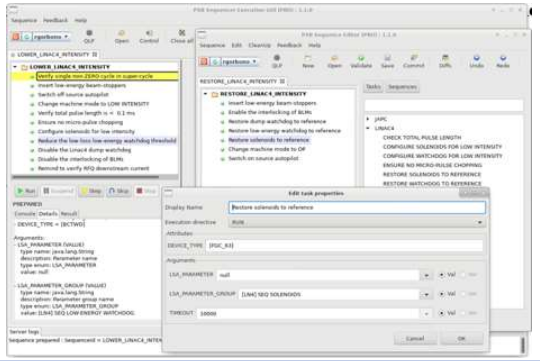
OASIS technical review, consolidation, preparation for White Rabbit trigger distribution



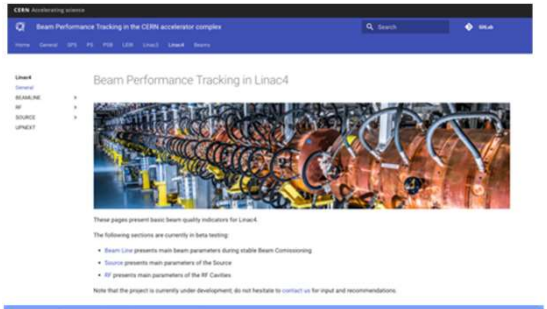


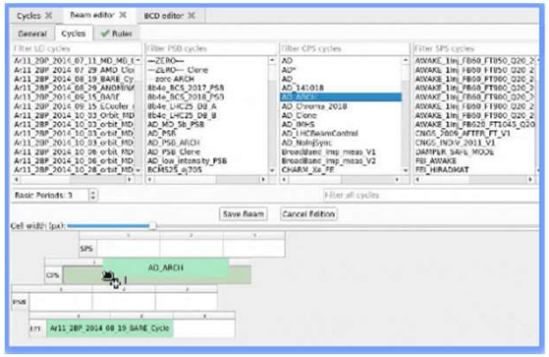


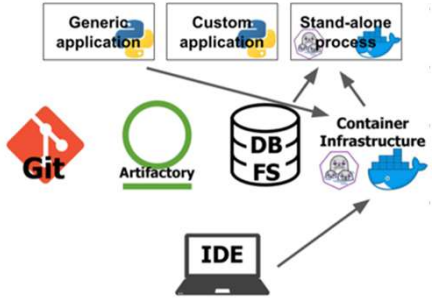




CSS – What we do – *Some* 2020 Highlights







UCAP (python support, NXCALS integration, tools, monitoring, training, increasing user-adoption)

New **HelpAlarm** application (replacing Phoenix)

Moving people to **Java 11** (big step!), significant **development tool consolidation**

New **generation of MAD Sequence inputs** from **Layout** (covering entire complex)

Beam Performance Tracking phase 1 – complete (*successful cross-group collaboration*)

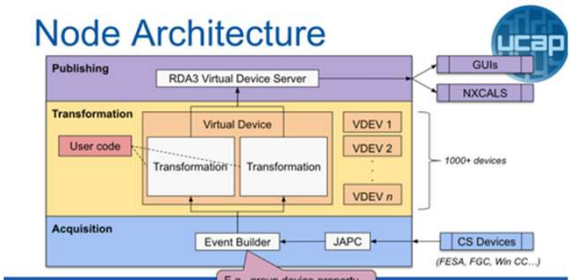
New **Timing Application Suite**

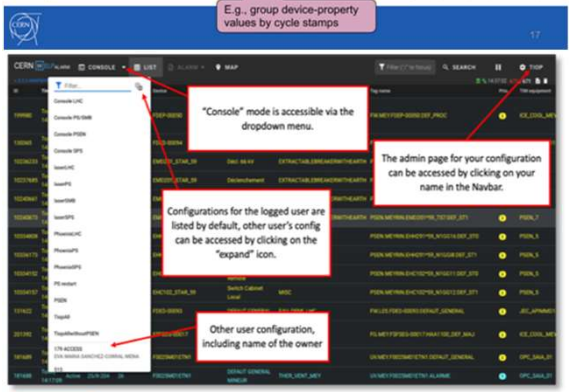
Machine Learning Platform – Model Storage

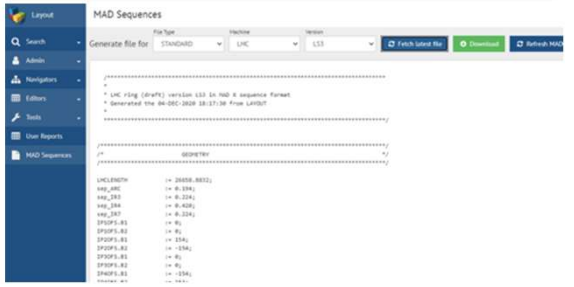
Progress on the **Containerisation project**

CCC Consoles renovation

New **LUMENS system** (Linux process management)







CSS – Main Challenges

Adapting to the **new Organisation**

- Sharing **technical & domain knowledge**, embracing **new user communities**, removing **single points of failure**
- **Technical consolidation** (whilst ensuring **service continuity** & responding to **emerging requirements**)
- Further developing the **partnership with IT**

Following the **necessary Technology Evolutions**

- Establishing the **Linux platform** for LS3 onwards
- Transitioning from "bare metal" to an **orchestrated containerized data centre**
- Adapting OASIS & GMT to use **White Rabbit**
- Reviewing and **consolidating CESAR** (EA Controls)
- Further developing **GUI strategy**
- Establishing & accommodating the emerging **Machine Learning platform** needs

….

How can we help you?

We are **service provider.**

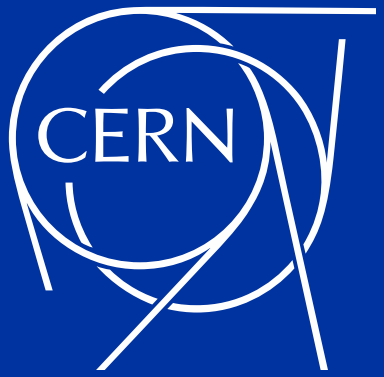
We **would like to help you.**

We **welcome feedback & discussions!**

Improving the **User Experience**

- Further **integrating Controls sub-systems** (e.g. UCAP & Fixed Displays inetgrated to CCDB)
- Improving **NXCALS performance**, adding new functionality, leveraging new techniques
- Providing an **integrated Controls Application GUI Platform**

….



BE-EA
Experimental Areas

Markus Brugger

EA – Experimental Areas – Enabling Physics

Group Leader: Markus Brugger

EA
Experimental Areas
GL: M. Brugger
DGL: F. Formenti

- AS — Associated Technical Services — SL: G. Canale
- DC — Design & Coordination — SL: M. Lazzaroni
- LE — Liaison with Experiments — SL: J. Bernhard
- EC — Engineering & Configuration — SL: F. Sanchez Galan
- PR — Projects — SL: M. Brugger

Areas & Machines, Experiments, Users

Fixed Target Experiments

LHC Experiments & Forward Detectors

~80
Group Members
Staff, Fellows, Associates, Students, Contractors
1/3 – 1/3 – 1/3

~8km
10 Beamlines
~30 Experimental Areas
100-150 User Teams
linking to equipment and service groups

~20 / 2000
Experiments & Facilities / Users
Design, Operation, Coordination, Support

Liaison **Running Beamlines** **Support & Coordination**

EA – Experimental Areas – Diversity

East Area, North Area, AD , HiRadMat
(+ support to nToF/ISOLDE)

TCC2/TDC2, H2, H4, H6, H8, F61, T8, T9, T10, T11, K12, M2

~8km Beamlines
~100-150 Teams
~1500 Users

SHINE, NA62, NA64(e&μ), COMPASS/AMBER, CLOUD, DsTau, NA63, MuonE
AD [BASE, ALPHA< AeGIS, ASACUSA, GBAR, ATRAP],
GIF++, CHARM/IRRAD, HiRadMat

15 Experiments, 4 facilities,
~500+ Users -> CERN Diversity

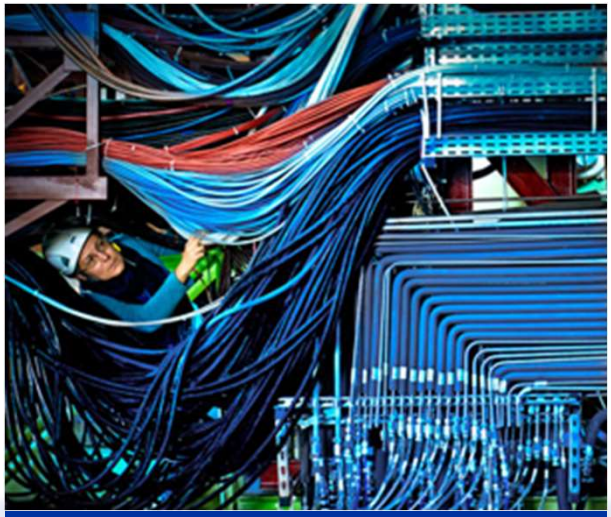
Safety/Coordination/Planning (TSO, Super-Intendents, WSS)
Cabling, Mechanical Support, Integration & Design, Gas Supply/Operation/Construction, Vacuum, Scaffolding, Shielding, Cleaning & Dismantling

Collimators, Beam Instrumentation, Vacuum, Supports, Shielding >300 devices

ELENA, AD-CONS, EAR, HL-LHC WP8, Software Migration, AWAKE

NA-CONS, PBC, K12 Intensity Increase, Shadows, RF-Separated Beams, Hostlab Phase-I & II

EA – Experimental Areas – Three Pillars

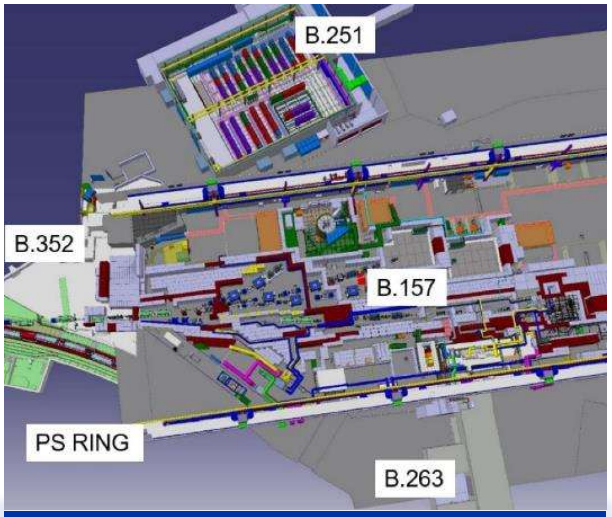


Key Services

Integration, Cabling, Total Gas Management, Vacuum & Mechanical WS, Shielding, Scaffolding, Cleaning & Dismantling

Developing niches and being referent:

Small teams often relying on single experts
CERN critical long-term expertise
Focus on user/experiment needs

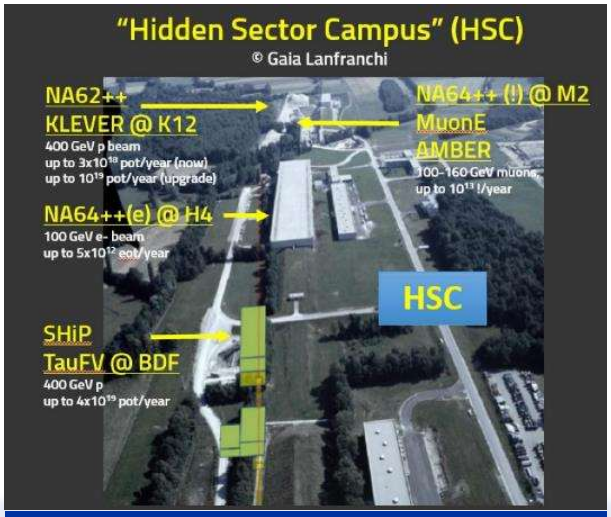


Projects

EAR, AD/ELENA, NA-CONS
HL-LHC WP8, PBC, Hostlab Phase-I & II

Legacy infrastructure & paving the way to future experiments:

Staged implementation with flexible choices to maximize compatibility with available resources and strategy decisions



Strategy

Team & PBC, Hostlab (LS3 and beyond)

PBC & European Strategy:

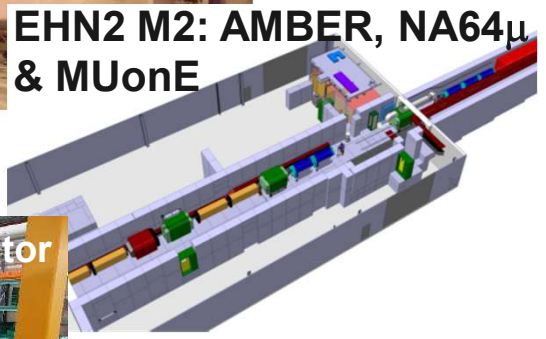
Conventional beams working group & project studies together with experiments

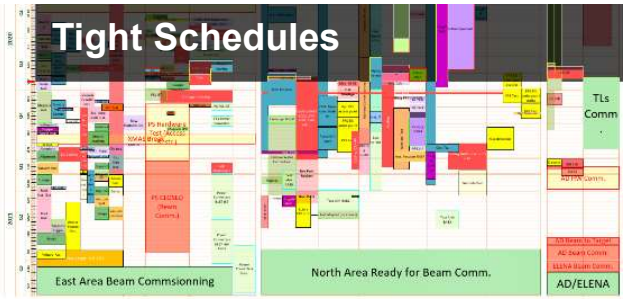
Group Structure:

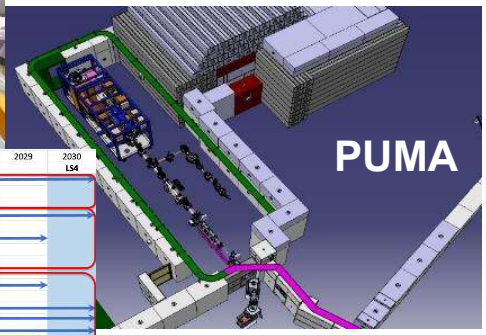
transverse project interleaved structure *services, services, coordination, engineering and physics*

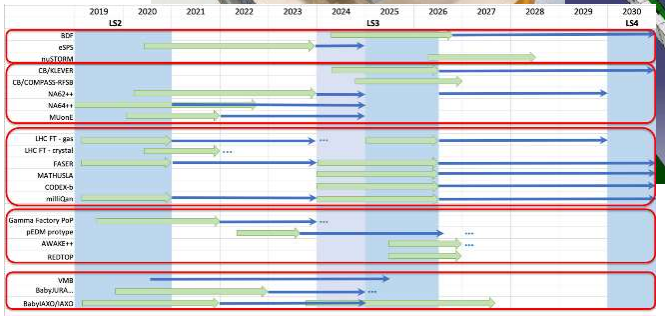
EA – Experimental Areas – LS2/Run-3/LS3/ESPP

- **Run-3 Operation (2021-2024) & LS3 Preparation**
  - 2021 Physics Readiness -> Experiments / Facilities / Users
  - HL-LHC, Hostlab & LHC Experiments
  - Required key equipment, services and technical expertise
- **Consolidation:**
  - East Area
  - Antiproton Decelerator
  - North Area
- **CERN Future & ESPP**
  - PBC & Related Projects/Experiments
  - FCC Machine Detector Interface & Experiments

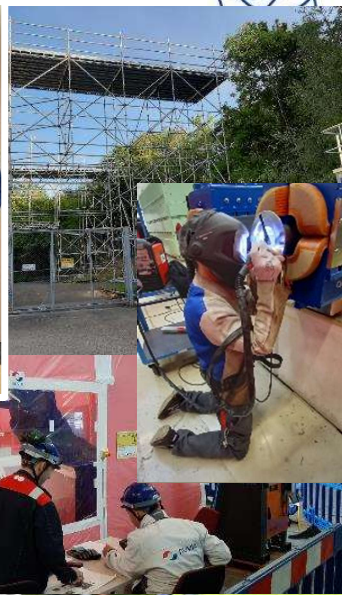




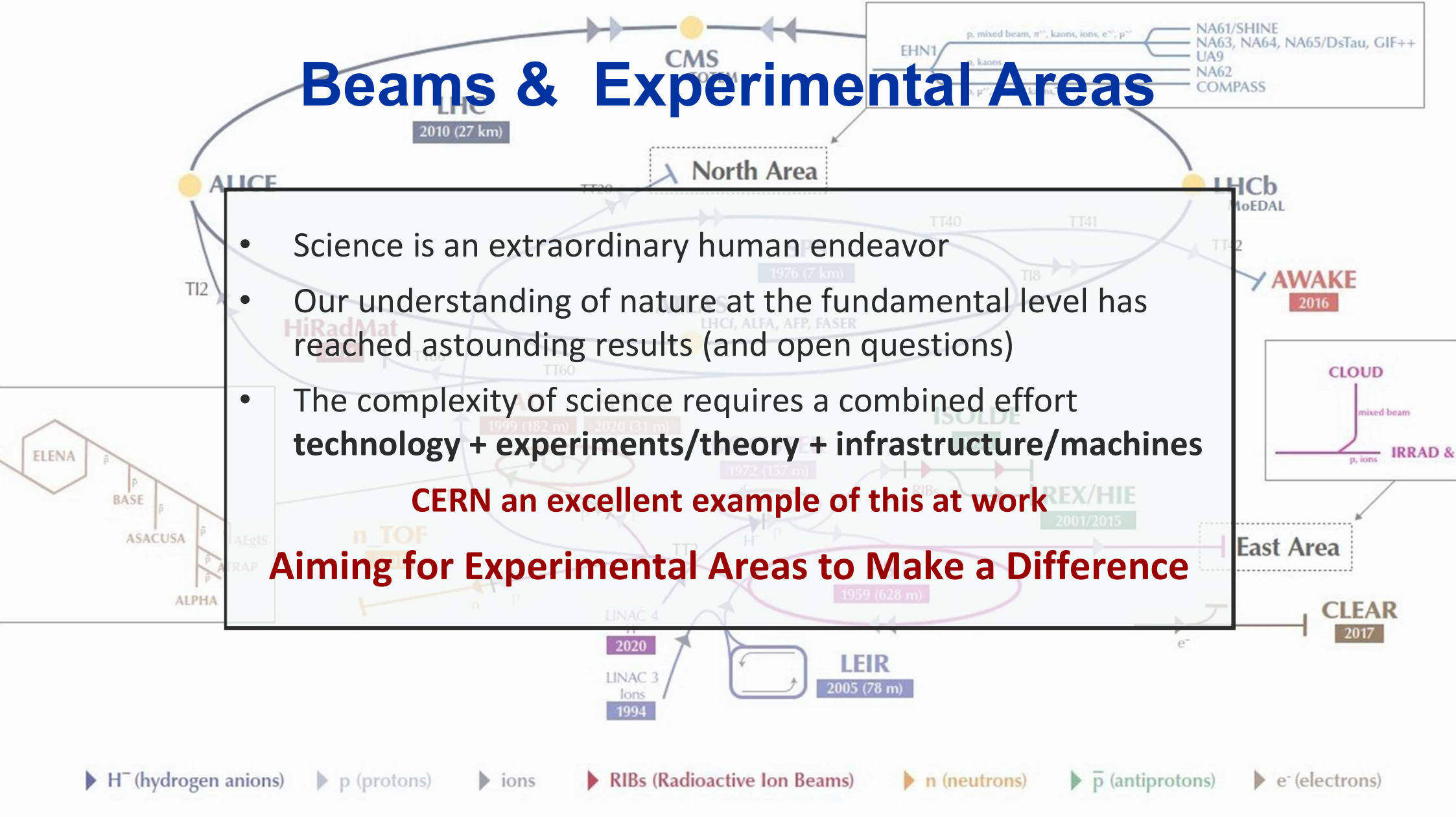




EA – Experimental Areas – TheTeam!



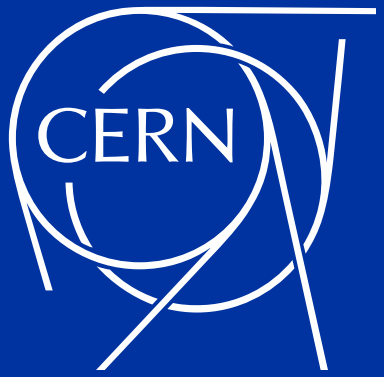
Beams & Experimental Areas



- Science is an extraordinary human endeavor
- Our understanding of nature at the fundamental level has reached astounding results (and open questions)
- The complexity of science requires a combined effort **technology + experiments/theory + infrastructure/machines**

CERN an excellent example of this at work

Aiming for Experimental Areas to Make a Difference



BE-GM
Geodetic Metrology

Hélène Mainaud Durand

GM – Geodetic Metrology -- Our Mandate --

Group Leader: Hélène Mainaud Durand

- **GM** Geodetic Metrology — GL: H. Mainaud Durand, DGL: J-C. Gayde
  - **ASG** Accelerator Survey & Geodetic measurements — SL: J-F. Fuchs
  - **ESA** Experimental Survey & Alignment — SL: J-C. Gayde
  - **HPA** High Precision Alignment Technol. — SL: M. Sosin
  - **APC** Acquisition Processing & Data Control Software — SL: F. Klumb

We provide metrology and alignment for components installed in the accelerators, their beam transfer lines and physics experiments throughout the CERN.

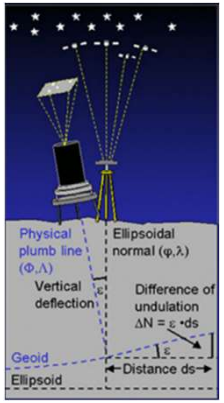
Nearly 60 km of beam lines!

~ 7500 accelerator components

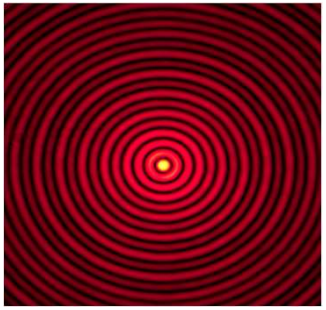
20 experiments

Thousands of sub-detectors!

Permanent monitoring

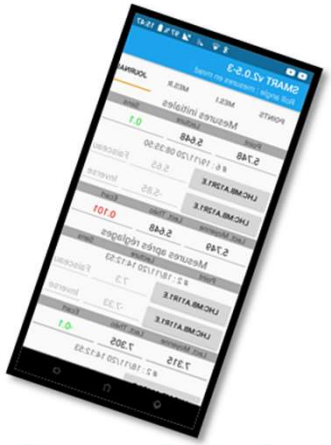


Geodetic aspects



R&D

Georeferenced scans

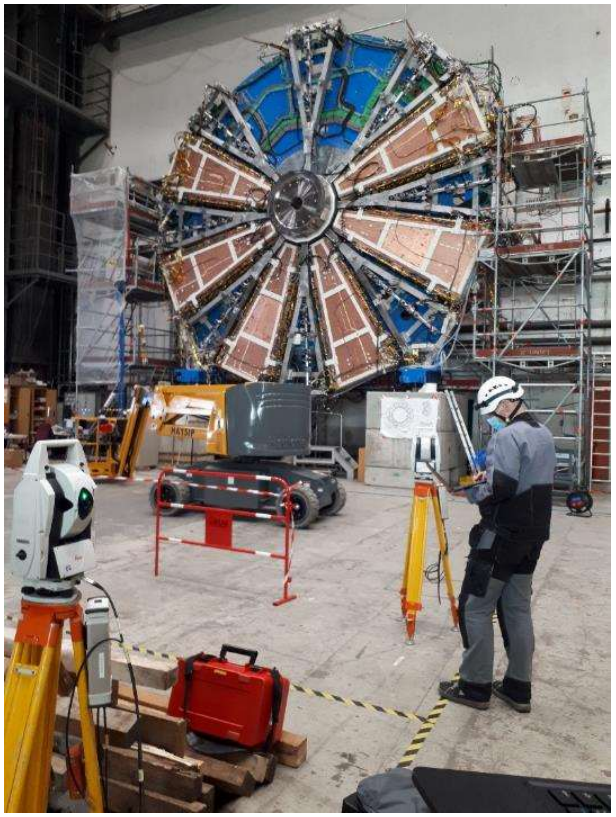


Associated software

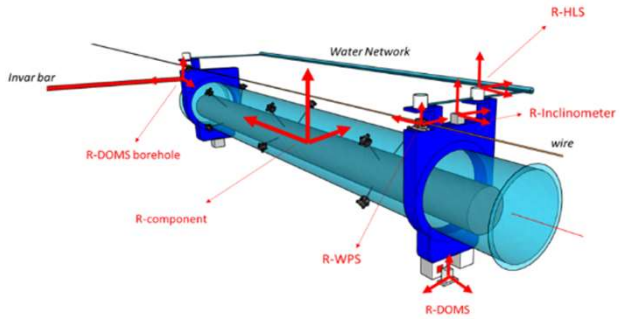
GM – Geodetic Metrology -- A few 2020 achievements --

GM
Geodetic Metrology
GL: H. Mainaud Durand
DGL: J-C. Gayde

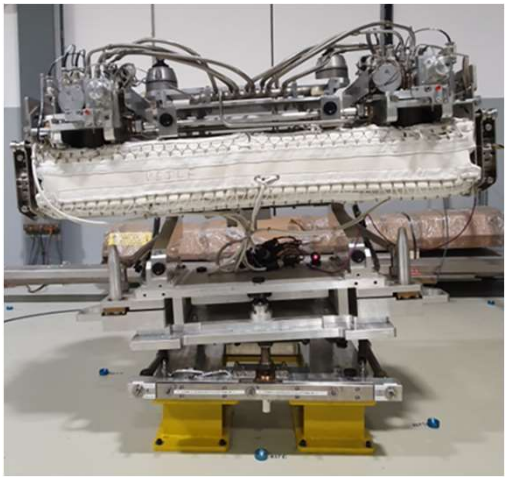
- **ASG** — Accelerator Survey & Geodetic measurements — SL: J-F. Fuchs
- **ESA** — Experimental Survey & Alignment — SL: J-C. Gayde
- **HPA** — High Precision Alignment Technol. — SL: M. Sosin
- **APC** — Acquisition Processing & Data Control Software — SL: F. Klumb



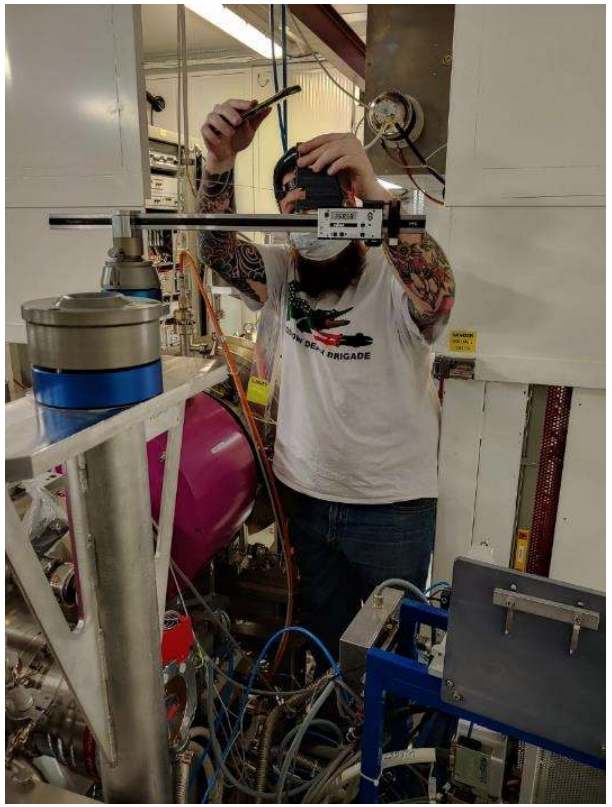
New small wheel construction



Implementation of new 3D calculation methods



Universal adjustment platform



Component alignment

GM – Geodetic Metrology -- Our day to day challenges --

GM
Geodetic Metrology
GL: H. Mainaud Durand
DGL: J-C. Gayde

- **ASG** — Accelerator Survey & Geodetic measurements — SL: J-F. Fuchs
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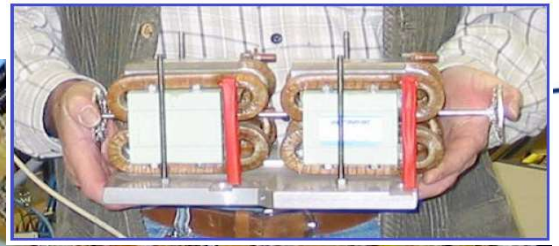
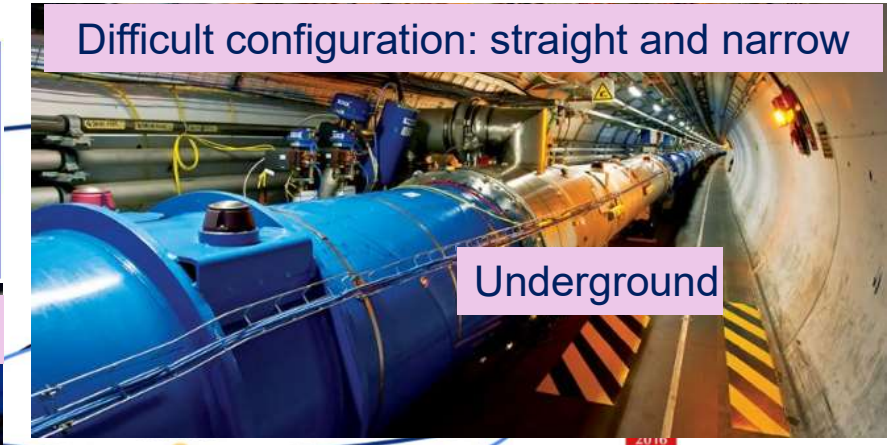


Size of the components

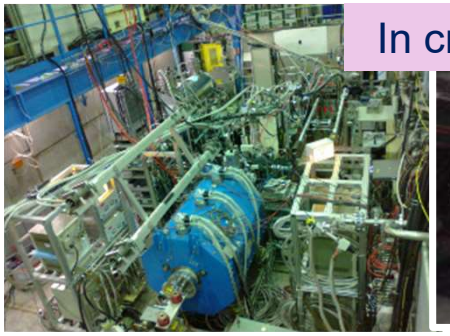
Difficult configuration: straight and narrow



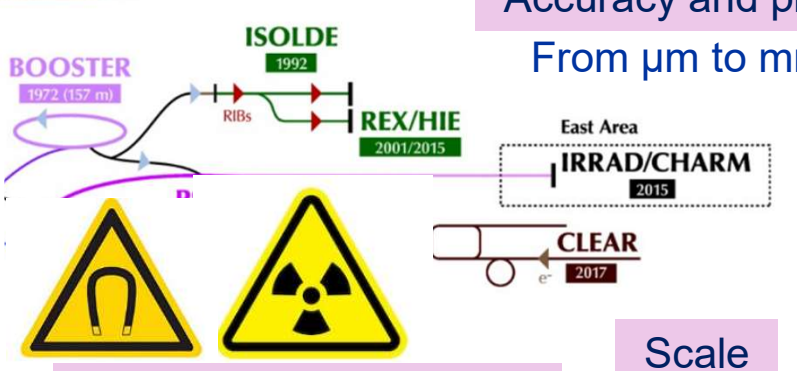
Underground

Accuracy and precision

From µm to mm…



In crowded area



Severe environment…

Scale

GM – Geodetic Metrology -- More information -

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Geodetic Metrology
GL: H. Mainaud Durand
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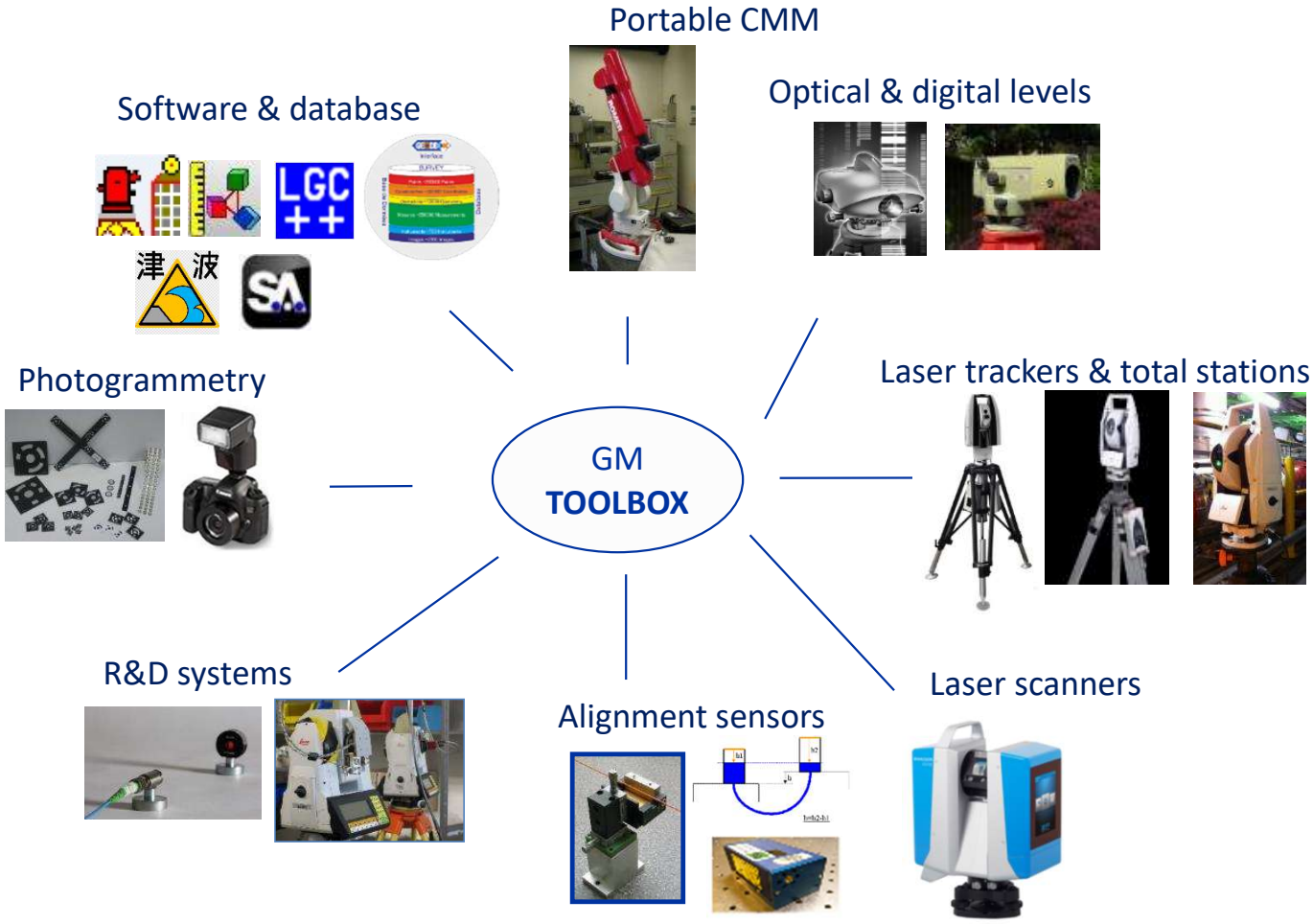
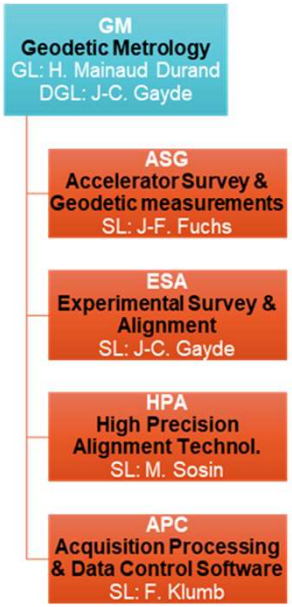


Adjustment solutions dev.

Expertise & consultancy

Knowledge Transfer

GM – Geodetic Metrology -- Our future challenges --



Time line

Explain our GM requirements to other groups

Develop & strengthen collaborations on Geodetic Metrology

Finalize LS2 the best as possible & conclude (REX) for LS3

Prepare instruments, methods & associated analyses for LS3

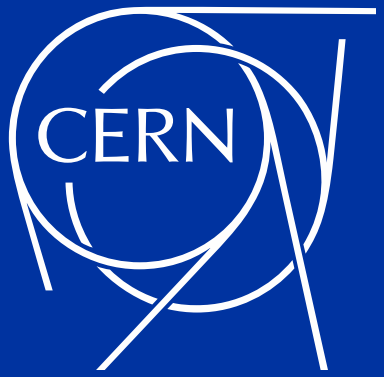
Make HL-LHC Full Remote Alignment System (FRAS) a success

Develop the potential of the Structured Laser Beam (SLB)

Consolidate GM software & dB

Develop «train-based» alignment solutions

Develop alignment solutions for the next colliders

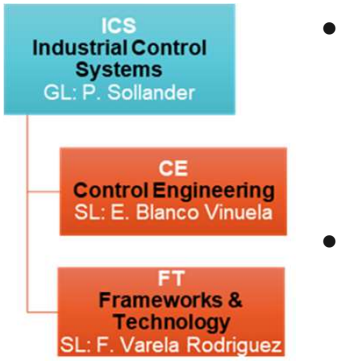


BE-ICS
Industrial Control Systems

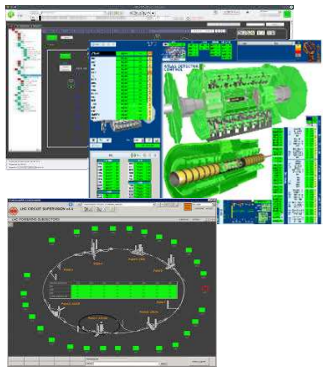
Peter Sollander

ICS – Industrial Control Systems

Group Leader: Peter Sollander



- **Mission**
  - provide the technology, frameworks, engineering and CERN-wide support for systems and projects in all domains using standard industrial control solutions
- **Responsible for:**
  - Selecting industrial controls technologies and associated communication protocols for CERN needs.
  - design, implementation and support of a set of common frameworks and tools to standardize the development of complete industrial control system solutions
  - design, development, deployment and maintenance of complete control systems for the CERN technical infrastructure, experiments and accelerator systems
  - CERN-wide support in industrial controls technologies, frameworks and control system engineering including product purchasing, licensing and distribution, consultancy, engineering, product evolution, preventive and corrective maintenance



ICS – Industrial Control Systems

ICS
Industrial Control Systems
GL: P. Sollander

CE
Control Engineering
SL: E. Blanco Vinuela

FT
Frameworks & Technology
SL: F. Varela Rodriguez

RESEARCH

Automation

Functional Safety

QA: Formal methods

Advanced Control

TECH. SUPPORT

- PLCs
- Fieldbuses
- SCADA
- Comms
- Engineering
- Consultancy

Process Control

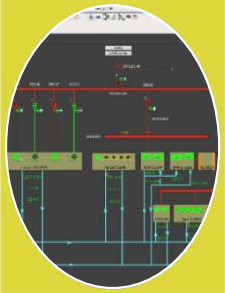
Cryogenics
Cooling
Ventilation
Gas
….

Control Systems

QPS
SURVEY
CIET

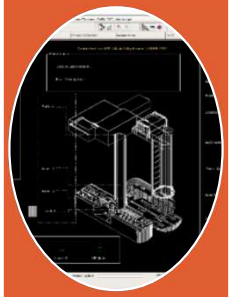
Safety Instrumented Systems

AWAKE
Primary Gas
SM18



Supervisory Control

PSEN
TIP

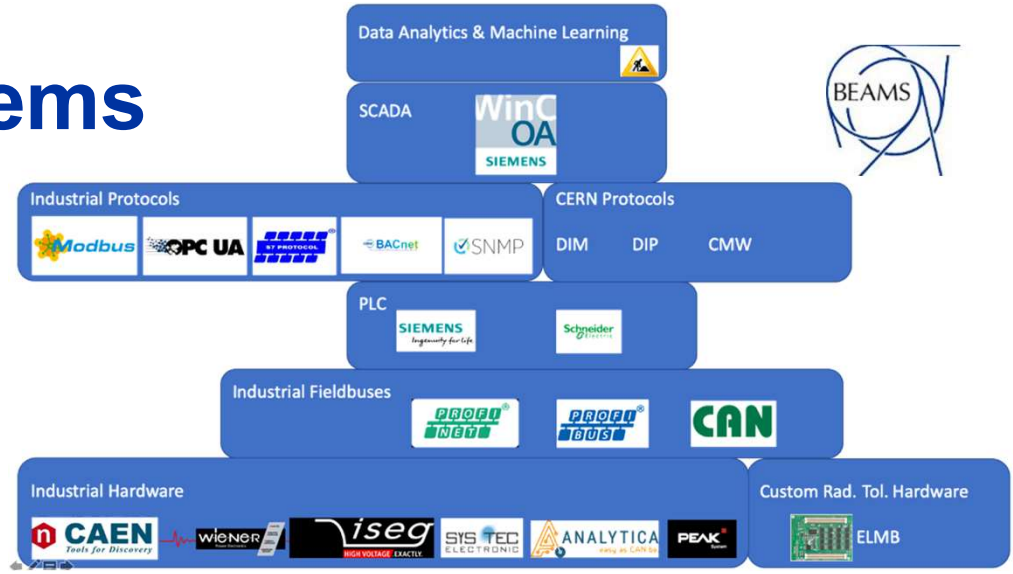


Monitoring
Technical Infrastructure

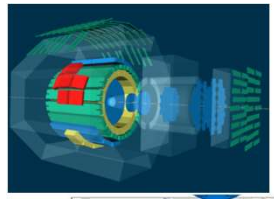
MOON
Temp IT buildings

DEVELOPMENT

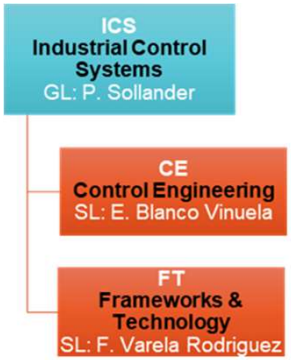
ICS – Industrial Control Systems



- **Frameworks & Technology**
  - Industrial Controls Technology stack
    - Maintenance, Support, R&D
    - Including also development tools
    - CERN-wide support
  - Industrial Controls Frameworks (JCOP & UNICOS)
    - Build on top of this technology stack to provide generic and reusable components for the implementation of control systems
    - Encapsulate the knowledge required by these technologies and protect end-users from changes the underlying stack
    - >800 Control systems in the experiments, accelerator and technical infrastructure built with the frameworks
      - Reduction of resources and, implementation and maintenance efforts
      - Centralized support

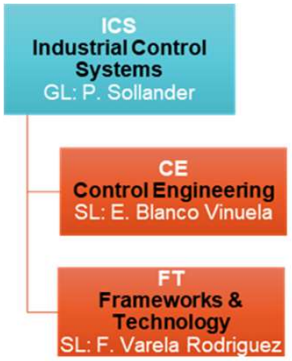


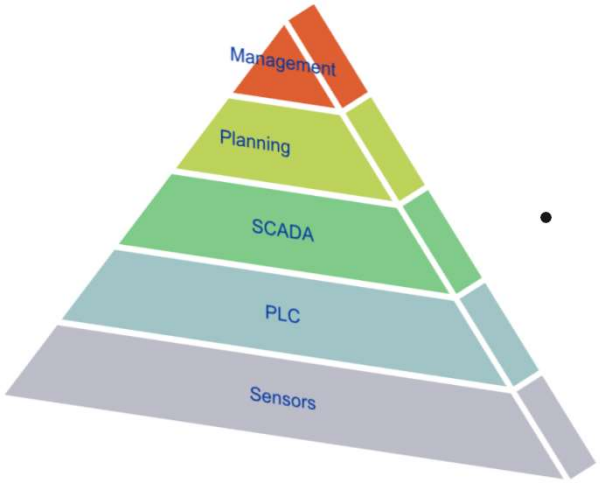
ICS – Industrial Control Systems



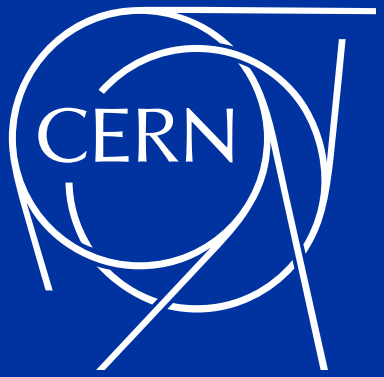
- **Main technical Challenges Short Term**
  - Schneider M580 reliability
  - WinCC OA licensing process and export control, upgrade to future version 3.18
  - Stable Linux operating system replacing CentOS7
  - Consolidation and Redesign of the UNICOS and JCOP Frameworks while keeping backwards compatibility
  - Ensure successful transition of services managed by the former BE-ICS-TI section to CSS and effective coordination of project engineering between the three controls groups
  - Optimisation and advanced control of process plants (e.g. CV electrical consumption)
  - Quality assurance: formal methods to test controller code, reinforce CI/CD and automated testing
  - Functional safety: Unify criteria on risk analysis and bringing functional safety to critical plants (SM18, Primary gas…)

ICS – Industrial Control Systems





- **Main technical Challenges for the Medium term**
  - Replacement of obsolete Siemens S7300 hardware in LS3 (PIC, WIC, DSS)
  - LS3 LHC experiment and accelerator controls upgrades
  - Evaluation and possible usage of Python as scripting language for WinCC OA
- Align and prepare for the future
  - Improve and homogenise asset management for industrial control system equipment
  - Integrate new approaches for control engineering complementing classic feedback control with Artificial Intelligence techniques
  - Evaluation of future Industrial Control System components
- **Towards *Industry4.0***
  - **Optimised operation, just in time maintenance, minimised downtime**
  - Connecting everything, leveraging machine learning and other AI technologies and being ready for what the future will bring
- A vision for the group, department, sector and beyond



BE-OP Operations

Rende Steerenberg

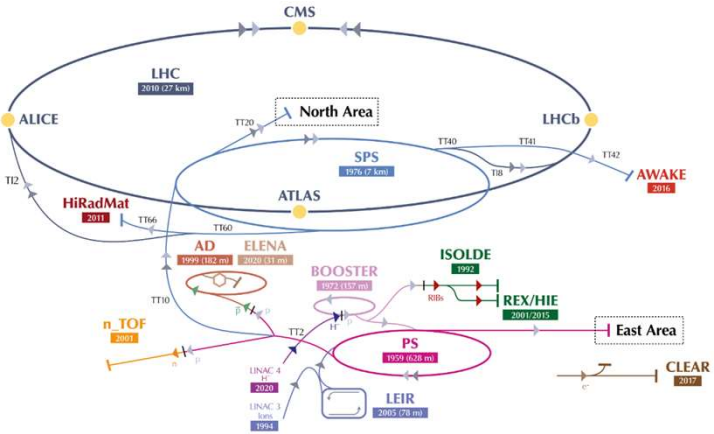
OP – Operations

Group Leader: Rende Steerenberg

OP
Operations
GL: R. Steerenberg
DGL: J. Wenninger

- **AD** — AD & ELENA Operation — SL: L. Ponce
- **ISO** — ISOLDE Operation — SL: J. Rodriguez Rodriguez
- **LHC** — LHC Operation — SL: J. Wenninger
- **PS** — PS Operation — SL: K. Hanke
- **PSB** — PSB Operation — SL: B. Mikulec
- **SPS** — SPS Operation — SL: V. Kain
- **TI** — Technical Infrastructure Operation — SL: J. Nielsen

The Operations Group has the honour to run the CERN Accelerator Complex and its Technical Infrastructure



OP – Operations

The Operations Group Mandate – responsibility for:

- the **operation**, including hardware and beam **commissioning**, of all CERN present and future **accelerators**, and the beam lines towards their associated experimental areas
- the **monitoring** of the overall **technical infrastructure** at CERN
- **Safety and access** during periods of operation in the installations
- **Supervising and co-ordinating interventions** on the CERN-wide technical infrastructure
- Operational **machine configuration** and the associated **settings management**
- **Development of methods** and dedicated **tools** required to operate the accelerator complex and technical infrastructure
- Preparation and participation in **machine studies**
- Establishing and maintaining accelerator **operation schedules**
- Preparing operational procedures and providing beam statistics

OP – Operations

OP
Operations
GL: R. Steerenberg
DGL: J. Wenninger

- AD
  AD & ELENA Operation
  SL: L. Ponce
- ISO
  ISOLDE Operation
  SL: J. Rodriguez Rodriguez
- LHC
  LHC Operation
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- PS
  PS Operation
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- PSB
  PSB Operation
  SL: B. Mikulec
- SPS
  SPS Operation
  SL: V. Kain
- TI
  Technical Infrastructure Operation
  SL: J. Nielsen

BE-OP a very welcoming and social group:

Besides working 365/24/7 we also celebrate successes together with our colleagues from departments and experiments

OP – Operations

Short-term challenges (2021):

- Re-commissioning the injector complex with upgraded and consolidated machines
- LHC Hardware commissioning, 7 TeV magnet training and beam test in Autumn
- Re-establish pre-LS2 beam performance in the injectors
- Deliver Beams for the Fixed Target physics experiments

Medium-term challenges (Run 3):

- Re-commission the LHC and establish collisions at 7 TeV
- Ramp-up LHC beam performance to LIU specifications in the injectors
- Run LHC at 7 TeV to reach at least 160 fb-1 and exploit LIU performance
- Run the beams for the rich Fixed Target physics program

Long-term challenges:

- Ensure readiness of the BE-OP group for the HL-LHC era.
- Setup and produce new beams perhaps for new experiments? (e.g. PBC, …)

OP – Operations

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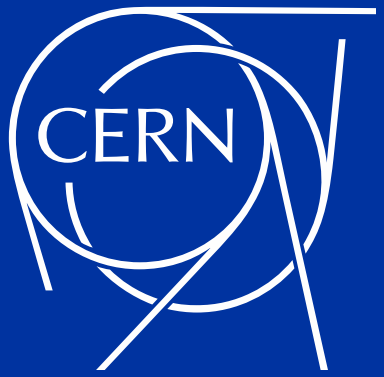
- **SPS** — **SPS Operation** — SL: V. Kain
- **TI** — **Technical Infrastructure Operation** — SL: J. Nielsen

Although we run the accelerators and facilities from our control rooms, it would not work without the valuable contributions and support from many other groups from within and outside the department

A Big Thanks to All!



The BEAMS Department and the main CERN Projects

Gianluigi Arduini

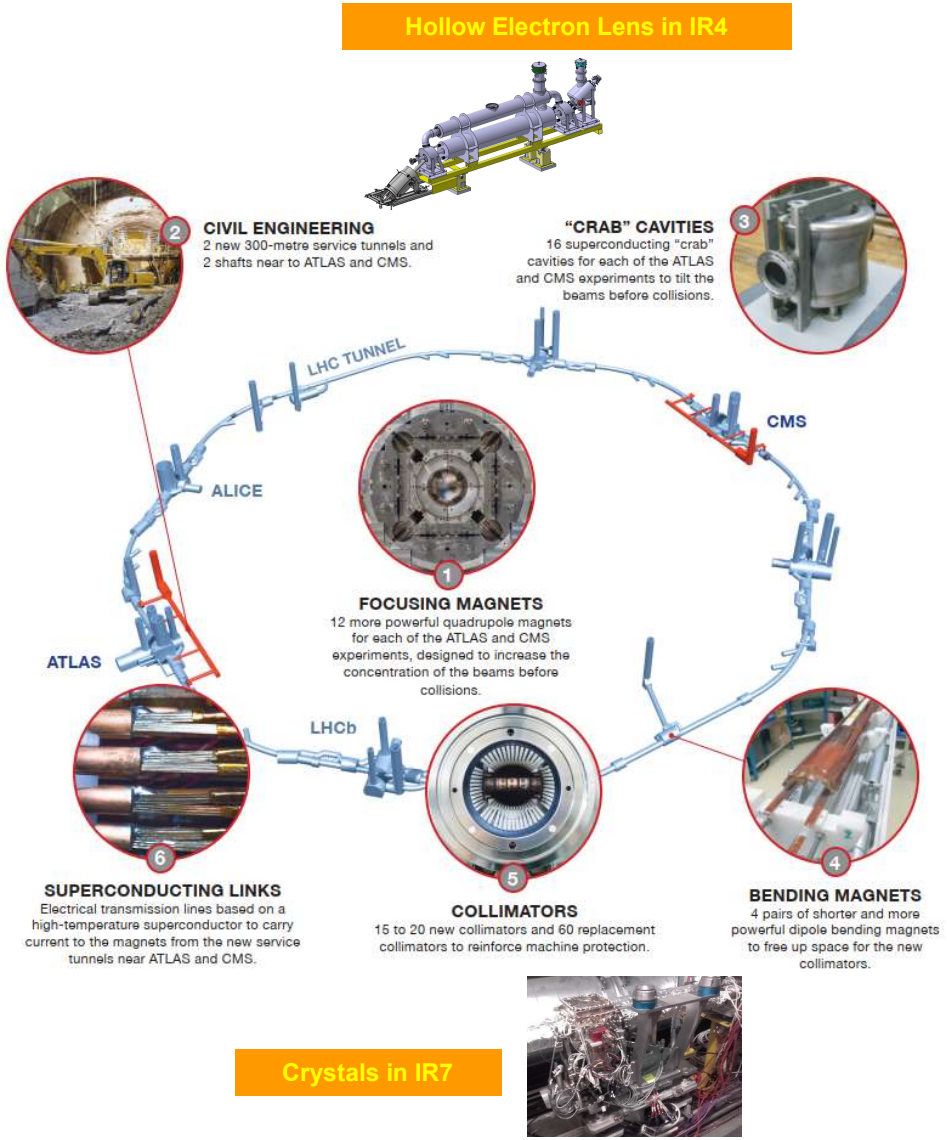
European Strategy for Particle Physics (ESPP) Update and its implementation

- Full exploitation of the LHC and its High Luminosity Upgrade is a MUST towards a future collider
- Strong support for a e+/e- Higgs factory as next step but no consensus on the type (linear/circular) and where (Japan? CERN?) ➔ FCC-ee / CLIC
- O(100 TeV) hadron collider is needed on a longer term ➔ FCC-hh
- Need to maintain a high-impact scientific diversity programme (high energy frontier exploration with colliders but also rare processes to discover deviations form the standard model, searches for feebly interacting particles to explore the “dark sector” ➔ Physics Beyond Colliders (PBC)
- At the same time continue to engage with the society: applications of accelerators and associated technologies, knowledge transfer

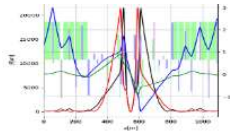
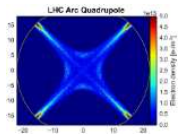
High Luminosity LHC
HL-LHC

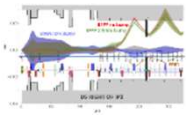
- Major Upgrade of the LHC (already started and to be concluded during LS3)

- Doubling of beam intensity/brightness
- 2-3 times higher luminosity
- 10-fold increase in integrated luminosity



High Luminosity LHC

WP1 Project Management

WP2 Accelerator Physics & Performance

WP3 IR Magnets

WP4 Crab Cavities & RF

WP5 Collimation

WP6A Cold Powering

WP6B Warm Powering

WP7 Machine Protection

WP8 Collider-Experiment Interface

WP9 Cryogenics

HiLumi HL-LHC PROJECT

WP10 Energy Deposition & R2E

WP11 11 T Dipole

WP12 Vacuum & Beam Screen

WP13 Beam Instrumentation

WP14 Beam Transfer & Kickers

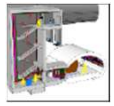
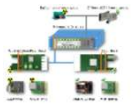
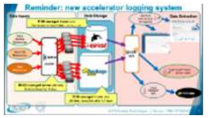
WP15 Integration & (De-)Installation

WP16 IT String & Commissioning

WP17 Infrastructure, Logistics & Civil Engineering

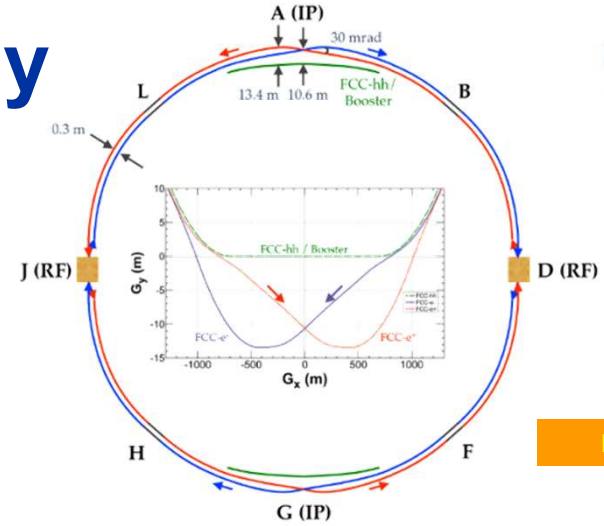
WP18 Controls Technologies



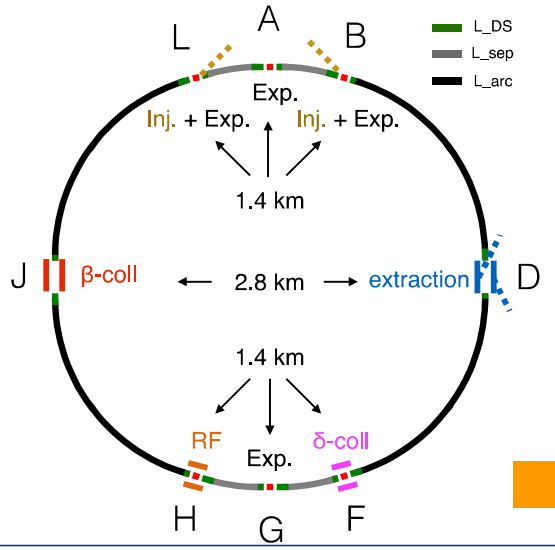




Future Circular Collider (FCC)Study

- Stage 1: FCC-ee (Z, W, H, $t\bar{t}$) as Higgs factory, electroweak & and top factory at highest luminosities
- Stage 2: FCC-hh (~100 TeV) as natural continuation at energy frontier, with ion and electron-hadron options
- Common civil engineering and technical infrastructure challenges
- FCC-ee design very challenging and needs further study:
  - Optics and collective effects
  - Machine detector interface
- FCC-hh has impressive beam (and magnet) stored energy:
  - Challenging collimation and machine protection systems
- The two layouts need to remain compatible

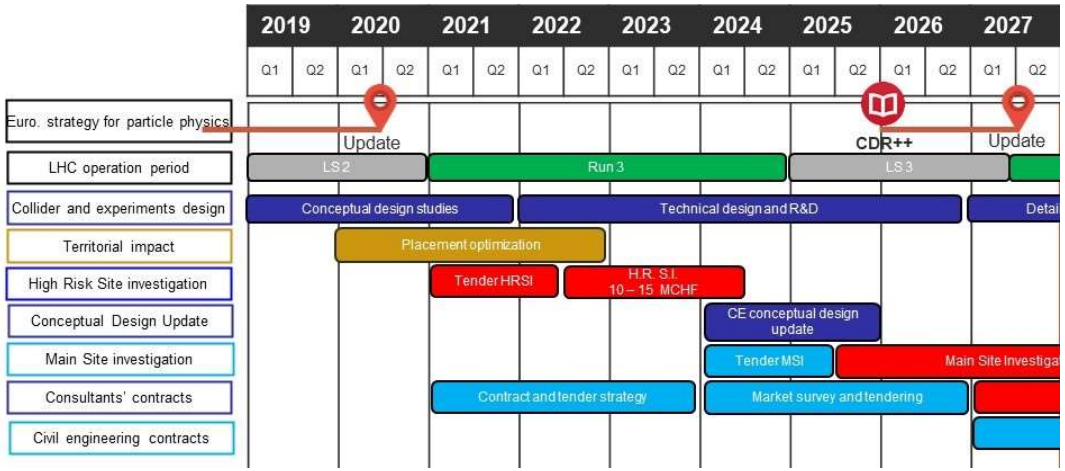


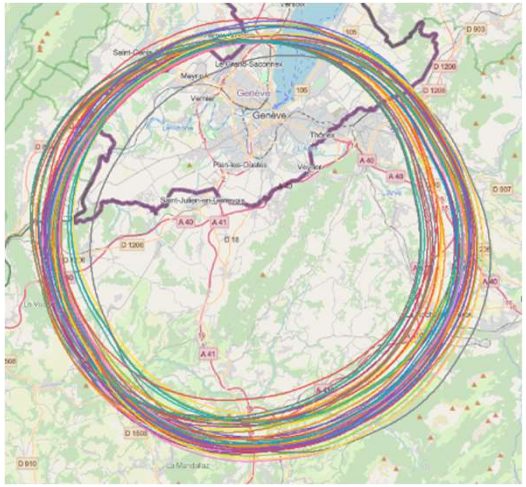
FCC-ee



FCC-hh

FCC Study Timeline and BE Contributions





Focus in the coming years: feasibility of the infrastructure and colliders

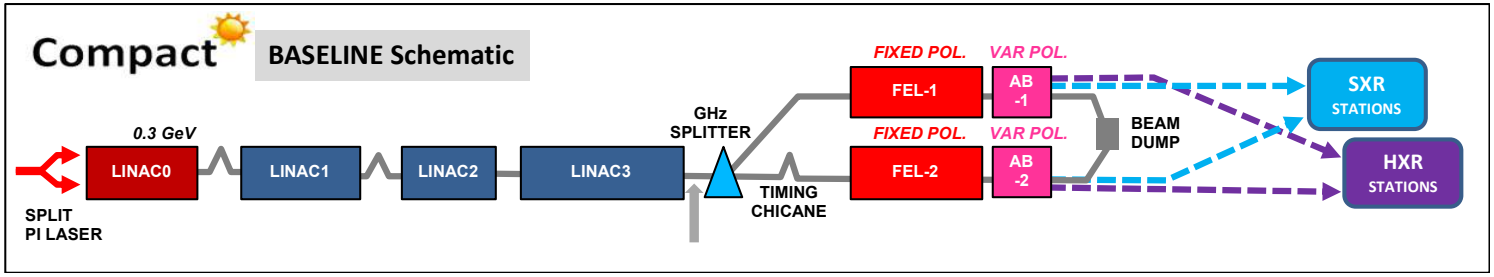
Very challenging schedule for the definition of the layout and tunnel location.

Studies in BE involving (not exhaustive):

- Accelerator physics
- Geodetic Metrology
- Machine Detector interface

Linear Collider Study
Compact Linear Collider Option (CLIC)

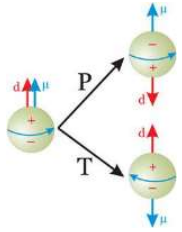
- Maintain CLIC as option for a Higgs/top “factory” for CERN:
  - High gradient studies using the CLEAR facility
  - Maintaining capabilities for start-to-end beam dynamics simulations, R&D on positron sources, extremely precise alignment/stabilization and associated cutting-edge mechatronics
  - Apply these tools for societal applications (e.g. compact Free Electron Laser based on X-band technology – Compact light)

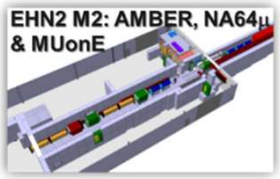


  - Critical to maintain/strengthen expertise in lepton accelerators design and associated technologies ➔ need to strengthen synergies between AWAKE/CLIC/FCC-ee/Muon Collider

Physics Beyond Colliders (PBC)

- Exploiting the unique capabilities of CERN accelerator complex and infrastructure to enrich and diversify CERN's future scientific programme





BSM physics working group

QCD physics working group

BDF working group

PBC-AF committee

EDM working group

Conventional beam working group

Technology working group

LHC FT working group

FASER study

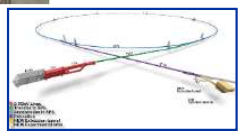
eSPS study

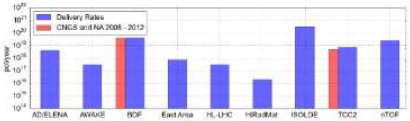
Proton production study

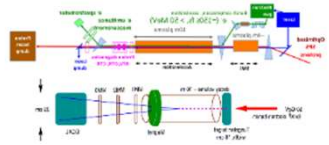
NuSTORM study

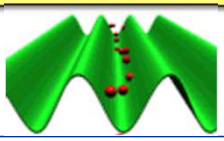
AWAKE++ study

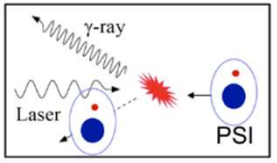
Gamma Factory study











Physics Beyond Colliders: Beam Dump Facility

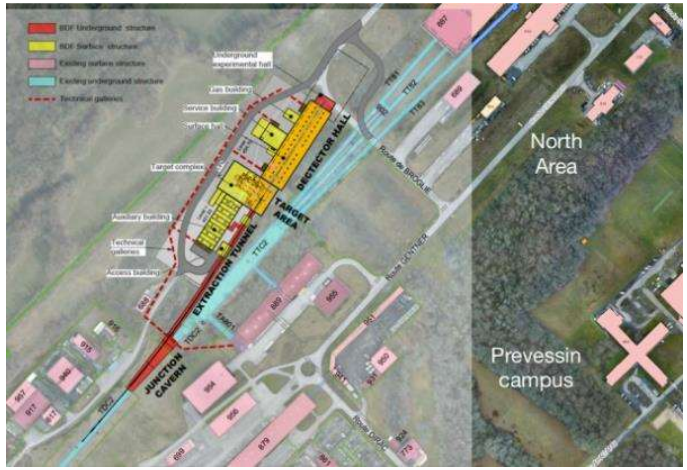
General Purpose Fixed-Target facility at the SPS that could be initially devoted to the search of Hidden Particles (could be the constituents of Dark Matter).

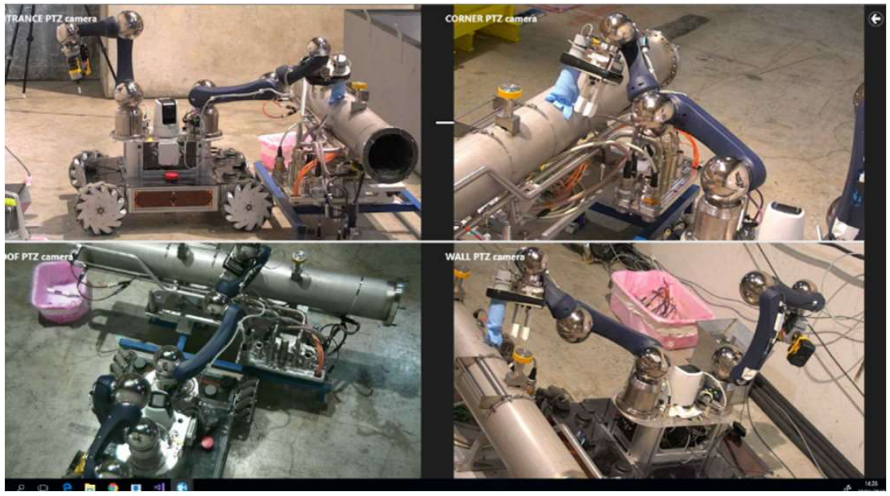
Target containing primary beam and its cascade

R&D in preparation of next ESPP

Challenges:

- Acceleration of high intensity beams (CNGS-like)
- Low loss slow extraction and target design
- High radiation environment for the target and nearby components ➔ robotic manipulations
- Design of a new dedicated experimental area

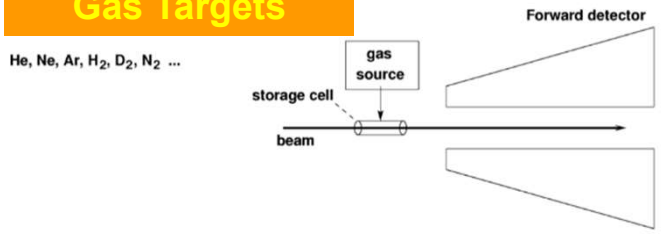


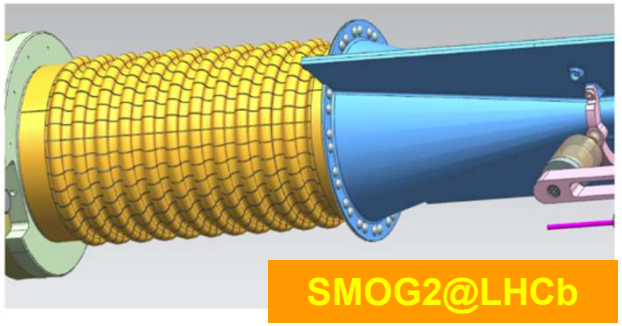


Robotic dismantling and inspection of prototype BDF target

Physics Beyond Colliders: Fixed Target @ LHC

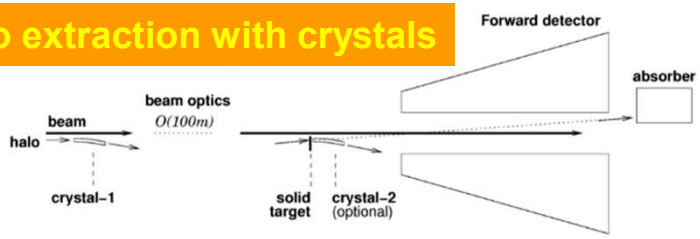
Gas Targets

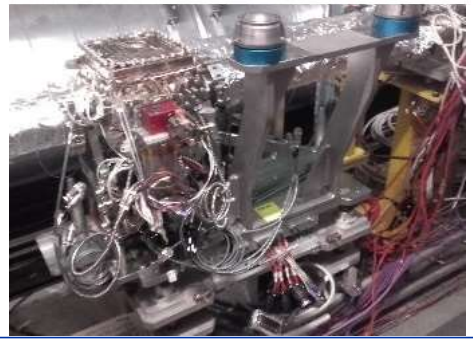


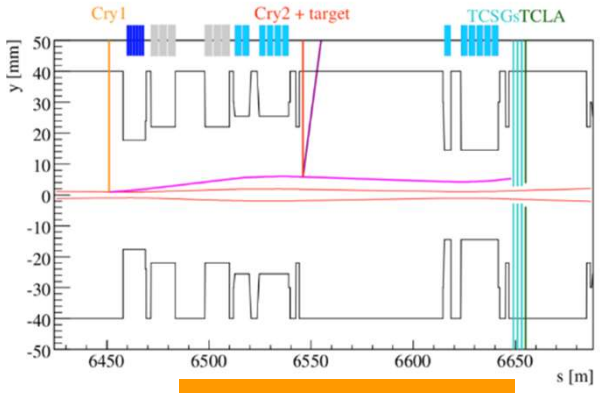


SMOG2@LHCb

Halo extraction with crystals







LHC IR3 - layout

- Beam dynamics simulations
- Validation of the design (aperture, impedance, etc.)
- Integration in the experimental area
- Characterization of extraction crystals with X-rays
- Precise remote control of the crystal position/orientation

Crystal characterization

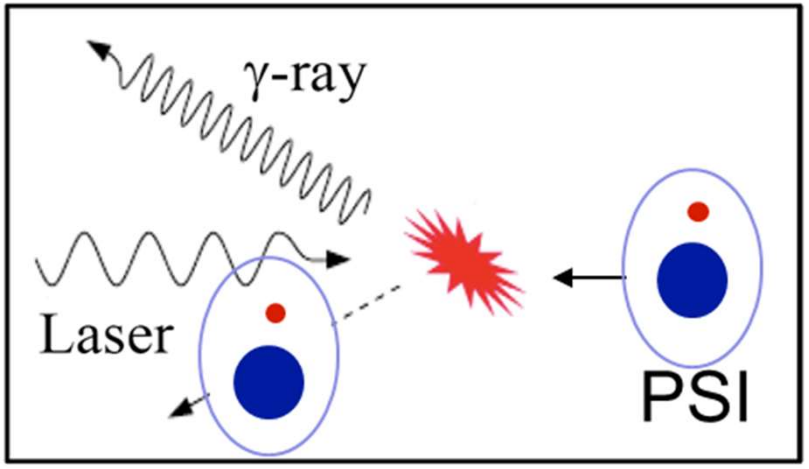
Physics Beyond Colliders: Gamma Factory

Bright, high-energy, photon source

- Huge variety of applications: Atomic, Nuclear, High energy physics, Accelerator physics

Using high-energy, partially stripped ion beams (SPS, LHC) to amplify photon energy of impinging laser beam

Aim for proof of principle test in the SPS



Contributions from BE on:

- Beam dynamics of partially stripped beams, applications for the production of high brightness positron and muon beams
- Production and operation with the partially stripped ions in the injector chain

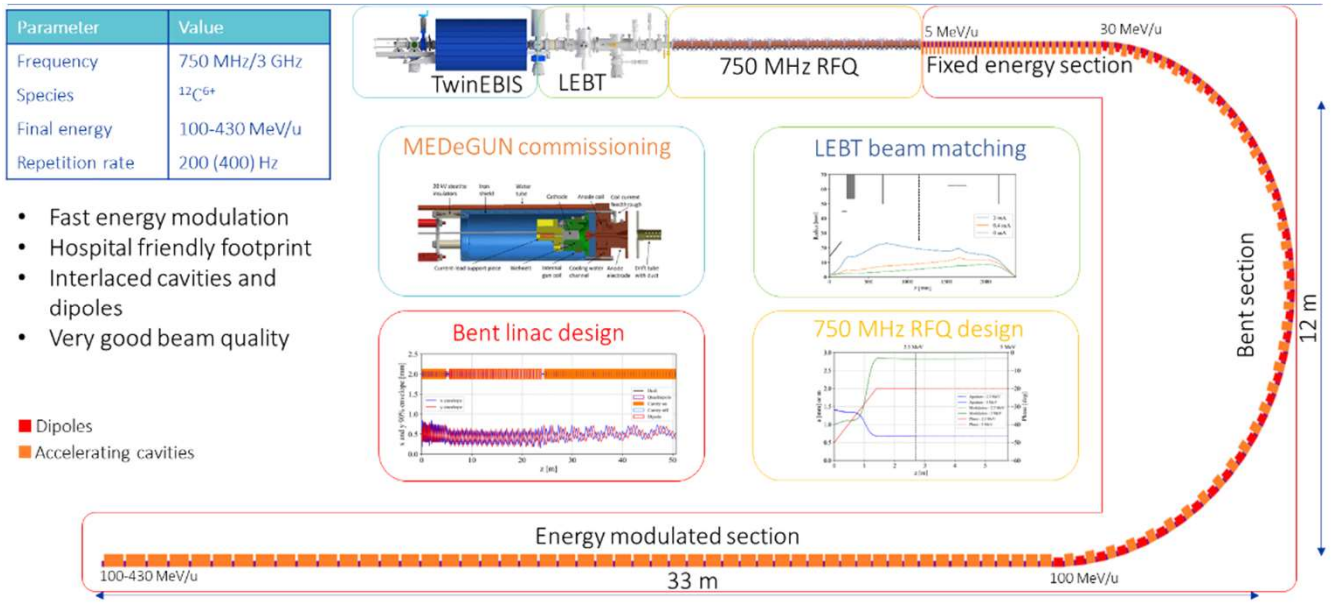
Medical Applications

Compact & hospital friendly Carbon Ion Linac:

- Design of innovative high frequency linacs (RFQ, bent linac)
- Design and test of Carbon Ion source producing high current fully stripped ions and its LEBT
- Collaboration with CIEMAT and industry

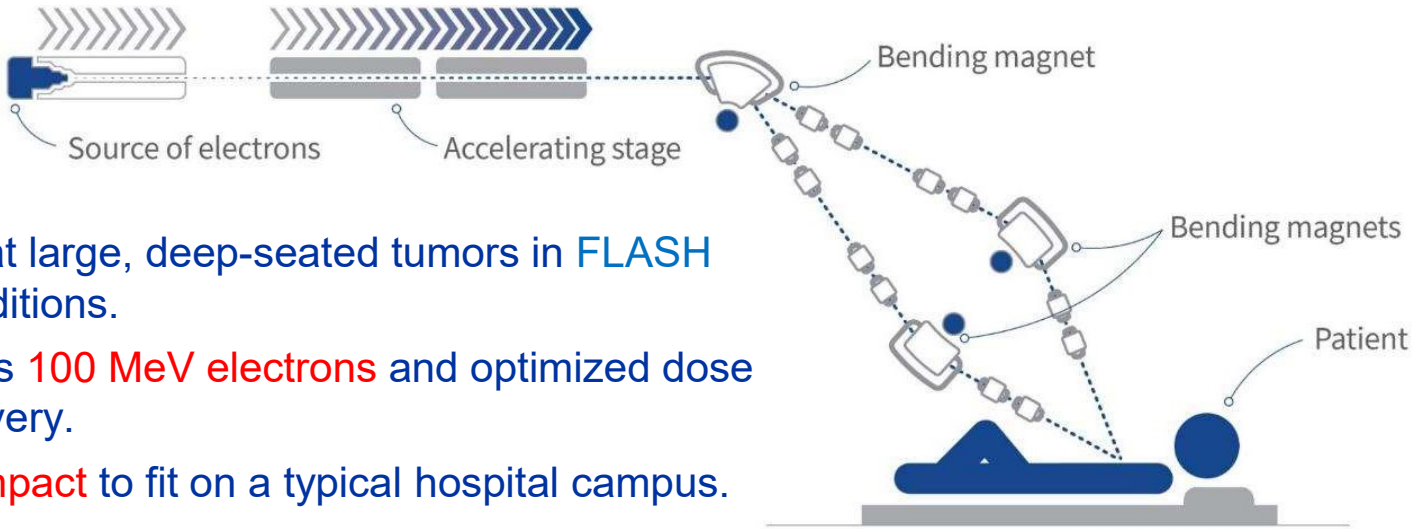
Parameter	Value
Frequency	750 MHz/3 GHz
Species	$^{12}C^{6+}$
Final energy	100-430 MeV/u
Repetition rate	200 (400) Hz

- Fast energy modulation
- Hospital friendly footprint
- Interlaced cavities and dipoles
- Very good beam quality



Medical Applications

FLASH therapy facility being designed in collaboration with CHUV ➔ using CLIC technology



Treat large, deep-seated tumors in FLASH conditions.

Uses 100 MeV electrons and optimized dose delivery.

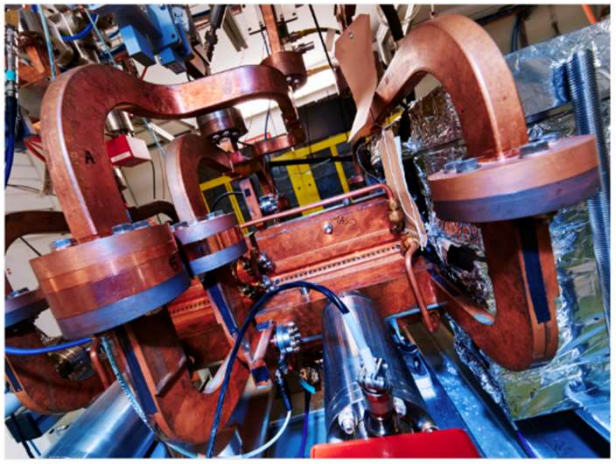
Compact to fit on a typical hospital campus.

BE contribution:
Linac & transport beam dynamics
Beam physics – commissioning and operation planning

CERN and Lausanne University Hospital collaborate on a pioneering new cancer radiotherapy facility

CERN and the Lausanne University Hospital (CHUV) are collaborating to develop the conceptual design of an innovative radiotherapy facility, used for cancer treatment

15 SEPTEMBER, 2020



Close-up of the Compact Linear Collider prototype, on which the electron FLASH design is based (Image: CERN)

https://home.cern/news/news/knowledge-sharing/cern-and-lausanne-university-hospital-collaborate-pioneering-new-cancer

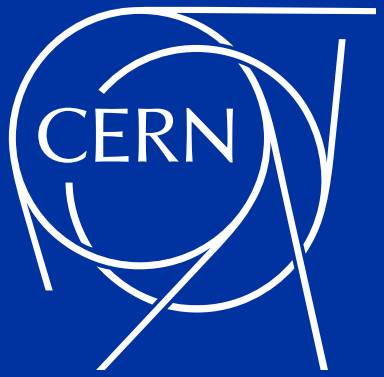
BEAMS impact on Projects/Studies is/can be HUGE!

We need to be creative to:

- Best profit from existing infrastructure to increase CERN discovery potential
- Reduce size, cost and environmental impact of present and new accelerators/experiments

BEAMS has an enormous potential to help with:

- Operational experience and profound knowledge of the infrastructure
- Cutting-edge competence and tools in accelerator and experimental area design, applied high perf. computing
- Unique experience in metrology for large infrastructures
- State-of-the-art controls technology for complex systems



Projects Hosted by the BEAMS Department

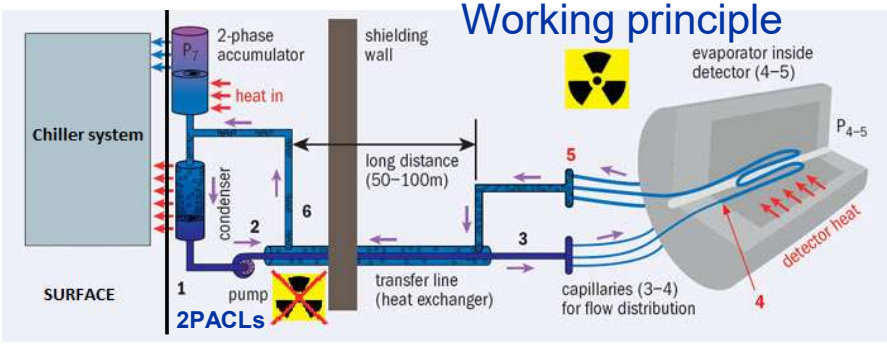
Rhodri Jones

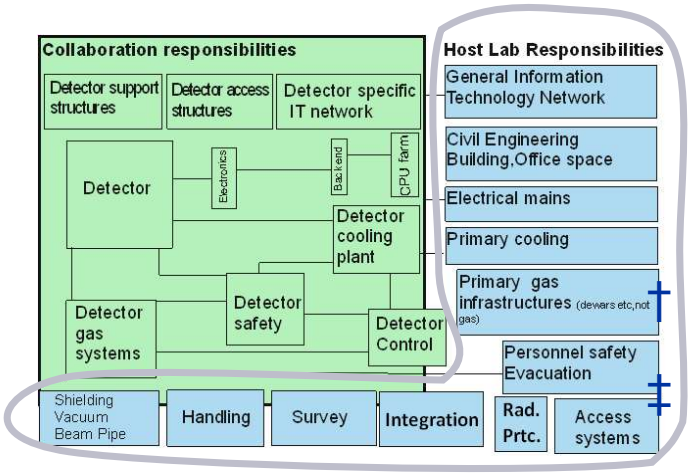
Hostlab – Phase-II Upgrades

Project Leader: Fabio Formenti

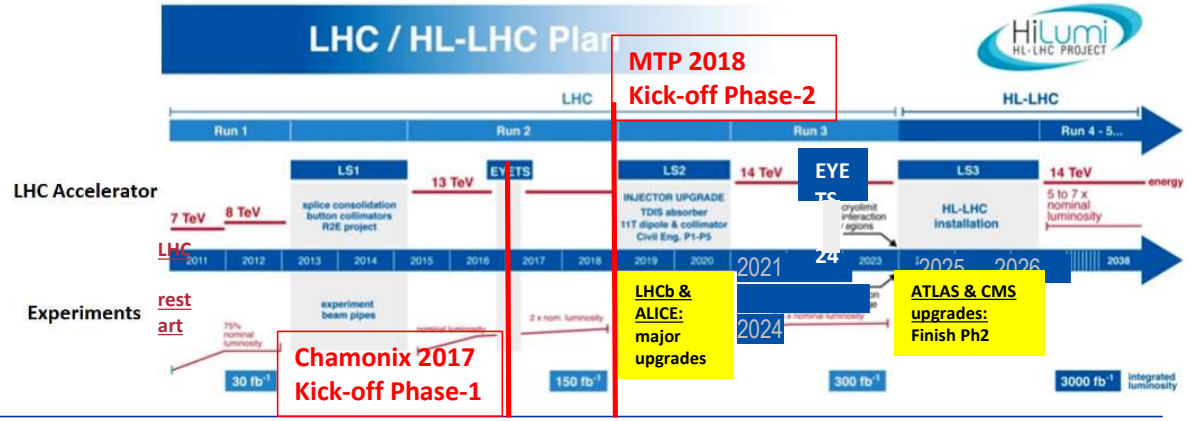
- **Hostlab Phase-II Project reached approval in 2020**
- **Addressing key projects over the years 2021-2027**
- **Counting on key technical ATS services**

e.g. CO2 Cooling Project





(Experiments to get prepared for EYETS and LSs)

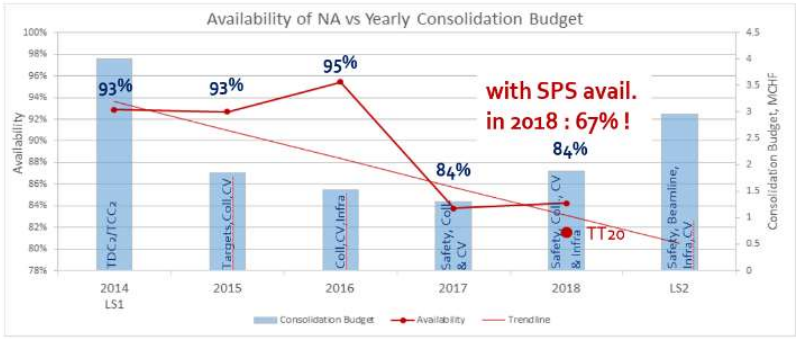


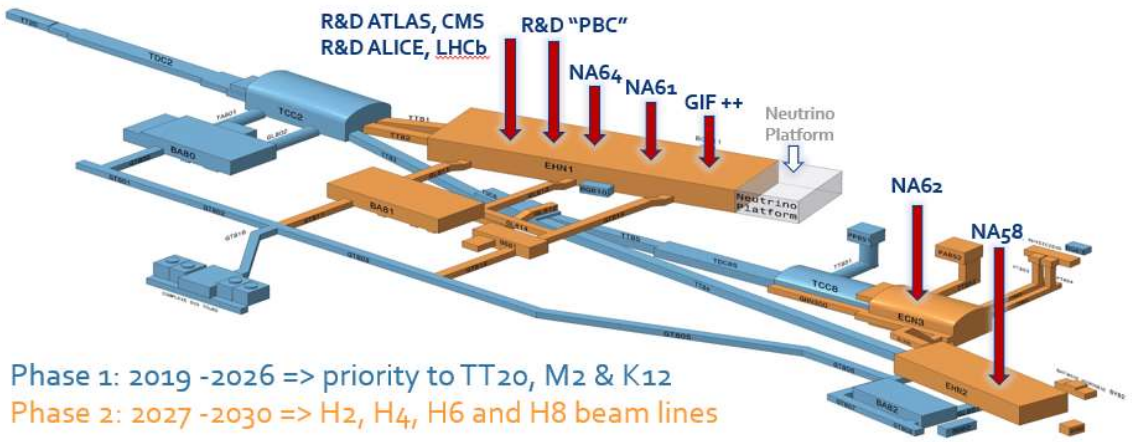
NA-CONS – Ready For Consolidation

Study Leader: Yacine Kadi

- **Initial implementation work focusing on urgent and safety related activities**
- **Detailed studies for mid/long-term options studied under ACC-CONS**

2021-2030: Consolidation Strategy:
Proposal in View of
Operation, Flexibility, Physics

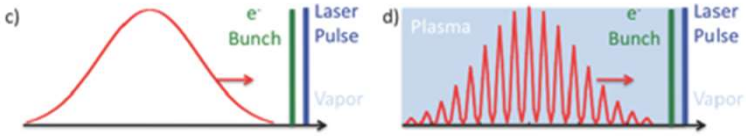




AWAKE - RUN 2

Project Leader: Edda Gschwendtner

- **Goal**
  - Accelerate electron beam to high energy (gradient of 0.5-1GV/m) while preserving the electron beam quality. demonstrate scalability of the plasma source



➔AWAKE Run 2a: ~7.5 weeks SPS beam time during 2021

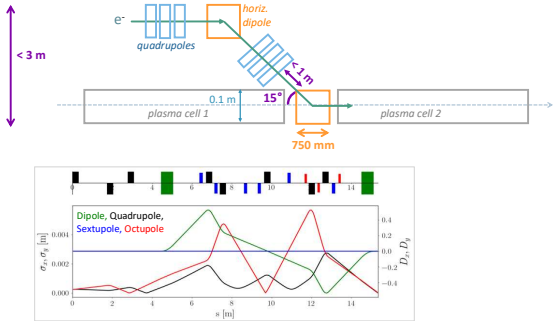
- Demonstrate seeding of the proton bunch with the electron beam.

➔Design and prototyping of AWAKE Run 2 for different phases:

New electron source

→ based on X-band
→ Well advanced design
→ Prototyping together with CLEAR

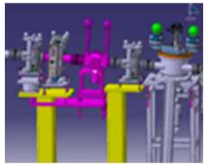
Electron line design for Run 2c



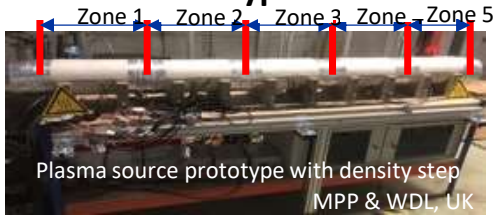
optimised to meet matching condition at plasma merge-point: $\sigma = \sqrt{4.87\ \mathrm{mm} \times \epsilon}$

Beam diagnostics

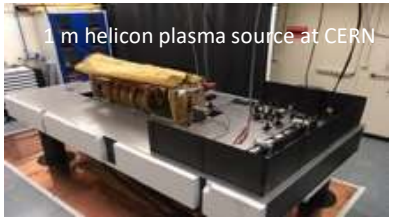
EOS, ChDR BPMs,…
→ Tests in CLEAR



Plasma Source Prototype for Run 2b in EHN1

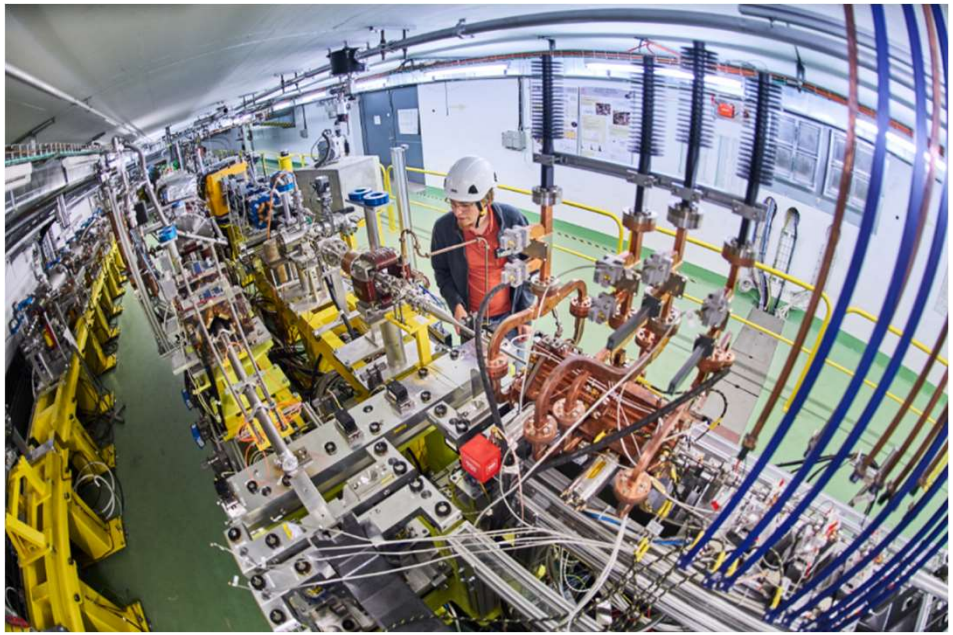


Scalable Plasma Source Prototype for Run 2d



CLEAR Test Facility

Project Leader: Roberto Corsini



Start with beam August 2017

30 to 40 weeks of operation/year from 2018 to 2020

About 20 experiments/year, CERN + external users

CLEAR is a versatile 200 MeV electron linac + experimental beamline, operated at CERN as a multi-purpose user facility

Scientific and strategic goals:

- R&D on accelerator components, including beam instrumentation & high gradient RF technology
- Irradiation studies with high-energy electrons, e.g. for testing electronic components – in collaboration with ESA – or for medical purposes(VHEE/FLASH)
- R&D on novel accelerating techniques – electron driven plasma and THz acceleration

- Maintaining CERN and European expertise for electron linacs linked to future collider studies
- Using CLEAR as a training infrastructure for the next generation of accelerator scientists and engineers.

Muon Collider Study

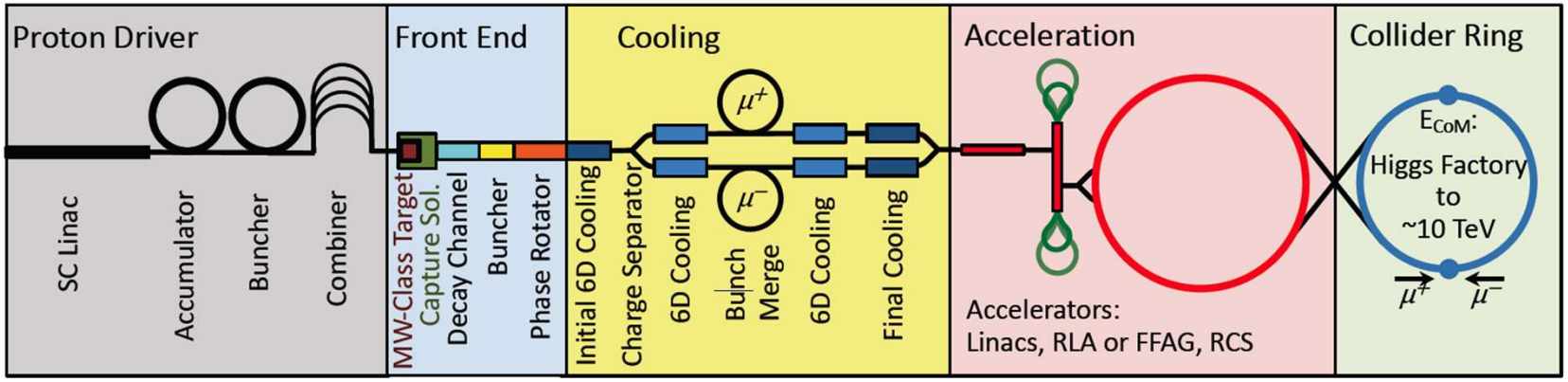
Study Leader: Daniel Schulte

Can reach high energy and luminosity

⇒ Large discovery and precision physics potential

Muons are not stable (lifetime 2.2 µs at rest)

⇒ Have to be really quick

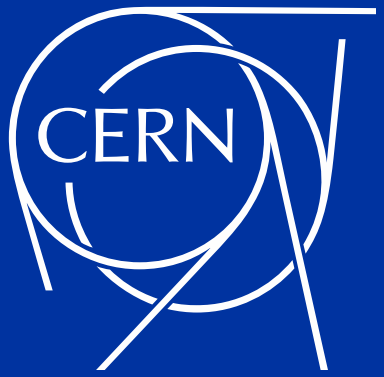


Goal:

- For next European Strategy Update evaluate if investment into Conceptual Design Review and test facility is scientifically justified

BE contribution

- Study Leadership
- Overall collider design
- Proton complex
- Muon cooling
- Collider ring
- Front-to-end integration of collider



A Few Last Words

Rhodri Jones

Main BE Objectives for the Coming Years

- **Operation - LIU Beam Commissioning & LHC Run 3**
  - Post LS2 recommissioning of the accelerator complex
  - Performance ramp-up addressing any intensity-brightness limitations encountered
  - Maintaining a happy user community for fixed target experiments
- **Consolidation**
  - Implementation of the staged consolidation of the North Experimental Area
  - Accelerator timing - moving to White Rabbit
  - Establishing the Linux platform for LS3 onwards including system on chip support
  - Consolidation & redesign of the UNICOS and JCOP Frameworks while keeping backwards compatibility
- **HL-LHC - Successful completion of the departmental led work-packages**
  - Accelerator Physics, Collimation, Machine Detector Interface, Alignment, and Controls
- **ESPP - Integrating contributions to future projects and new concepts**
  - AWAKE: Successful Run 2 & strengthening of the know-how for plasma acceleration
  - FCC: Accelerator Physics (FCC-ee in particular); Geodesy & Alignment ; Machine Detector Interface
  - Muon Collider: Accelerator Physics; Machine Detector Interface

Main BE Short & Medium-Term Challenges

- **Building a collaborative controls structure**
  - Providing an improved, reactive and coherent service to the ATS and experiments
  - Consolidating existing technologies with a push for standardisation where possible
  - Providing a strategy for future controls technologies & further developing the partnership with IT
- **Preparation for LS3**
  - With LS2 barely finished many groups already looking towards the huge amount of work coming for LS3
  - Support to experiments and machines for alignment, technical services and industrial controls
  - Completing HL-LHC contributions
- **Resource optimisation**
  - Prioritisation of work while addressing the main objectives with limited resources
  - Agreeing clear deliverables with required budget and manpower with all projects
  - Balancing level of supervision with staff manpower – either direct or through collaborations

BEAMS (BE) Working Practices

- **Continuing to manage the COVID constraints while looking forward to the future**

- **Your ideas on how to build on our collective “Esprit de Corps” welcome!**

In summary… we've got a lot do! Mike Lamont understatement! – ATS webinar 2021

Exploitation	• Safe, effective and full exploitation of the complex in Run 3 • LHC, Injectors, Experimental facilities
Projects	• Full realization of HL-LHC goals, LIU in action, CLIC
Future Options	• FCC feasibility study, Muon Collider Study, Plasma Wakefield Acceleration, Physics Beyond Colliders
Technology	• Maintain world class expertise while keeping focus on key objectives • Support facilities: maintain, consolidate labs, workshops and on-site capabilities.
R&D	• Develop and execute designated R&D programmes: HFM, SCRF… • R&D in support of ATS technical domains…
Engagement	• EU programmes, Non-member state, International labs… • Continued (managed) engagement with our partners around the world
Societal	• Energy and Environment, Knowledge Transfer, Medical Accelerators • Outreach, education

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