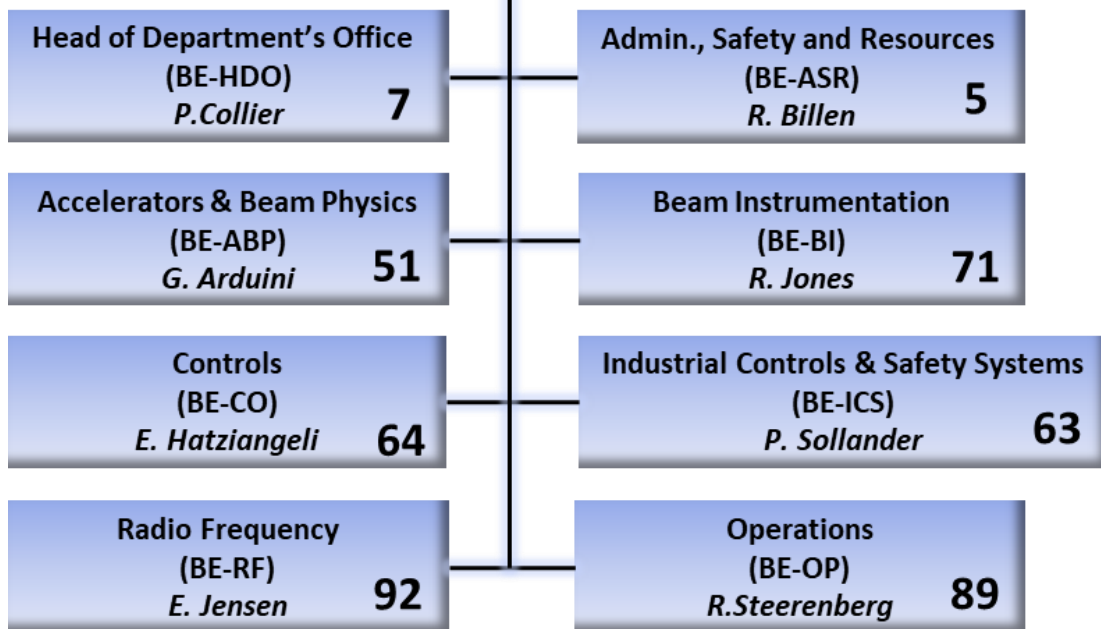




Introducing the **BEAMS DEPARTMENT**

Rhodri Jones, Head of the Beam Instrumentation Group
3rd September 2019

Department Head: P. Collier
Deputy: M. Lamont



DAO : J. Kotzian
DPO : R. Billen
DSO : M. Tavlet
DTO : E. Montesinos
RSO : F. Pirotte
HRA : S. Bott (HR)

443 Staff
(31 December 2018)

Activities

Operation/Exploitation:

- Machines,
- Technical Infrastructure including access and safety systems
- Experimental Areas

Projects:

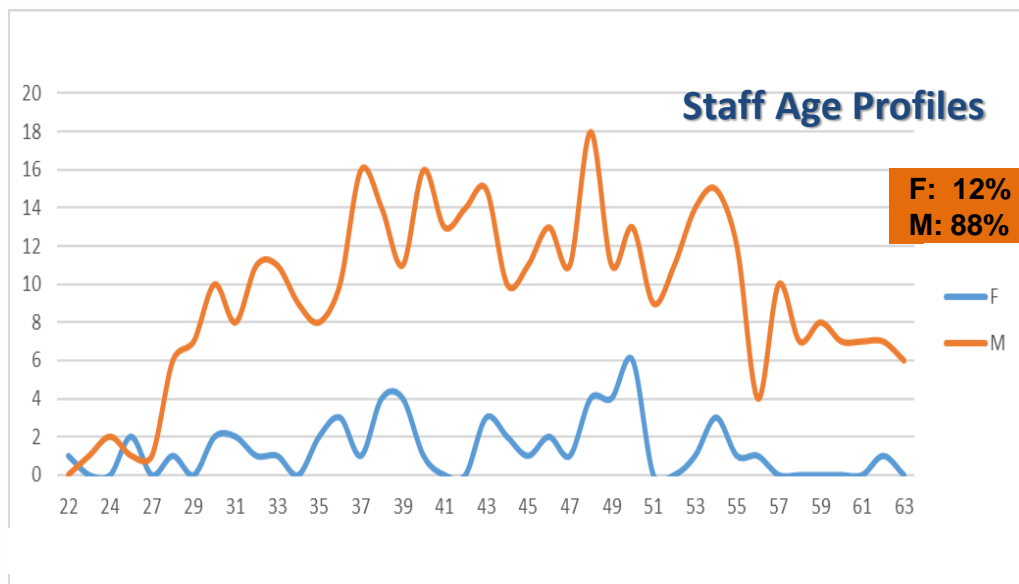
- Consolidation
- Upgrades
- Approved Projects

Studies:

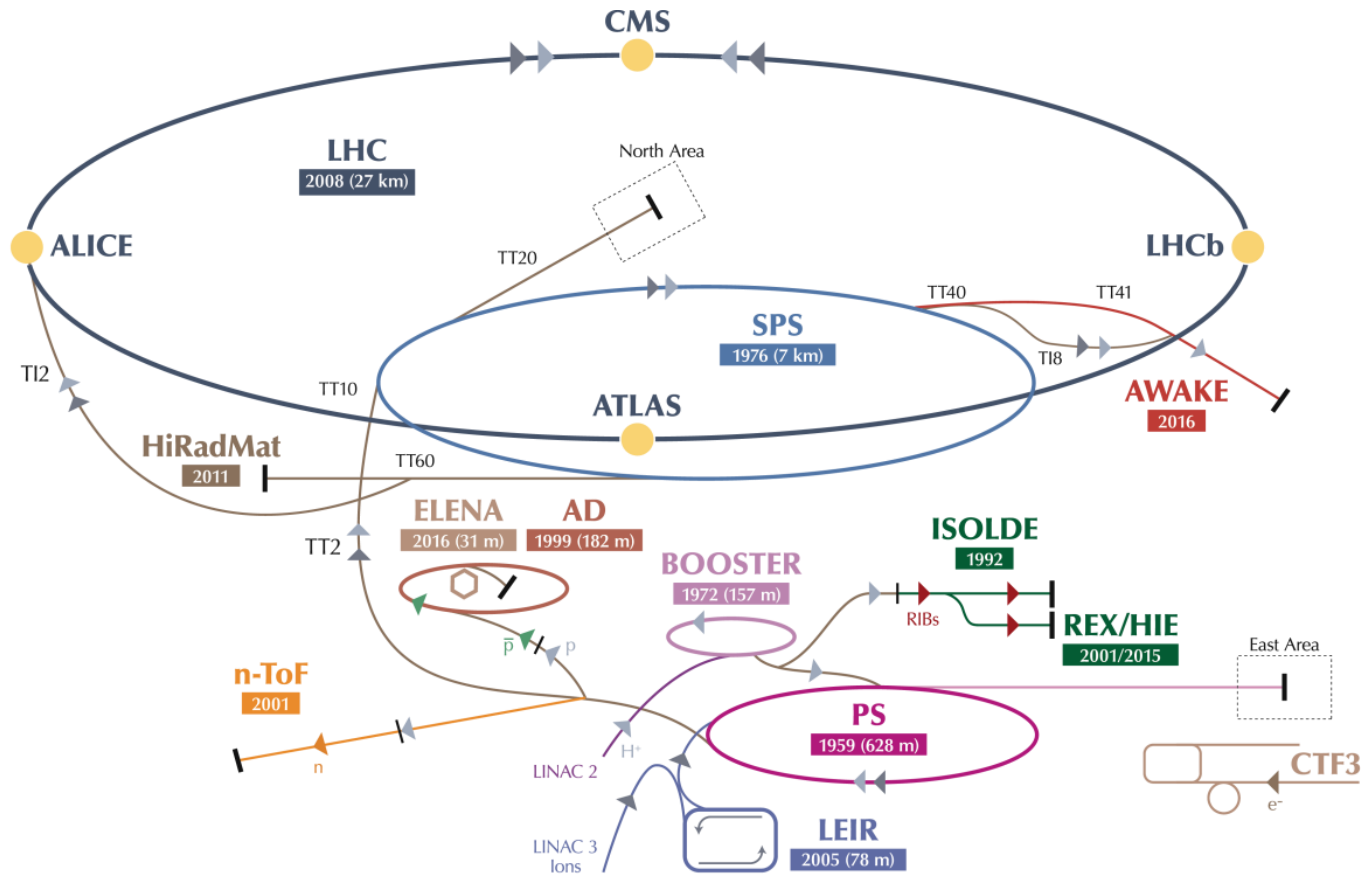
- New Facilities and machines

| 1 st December 2018 | Staff | % |
|-------------------------------------|------------|------------|
| Scientific and Engineering | 250 | 56 |
| Technical and Technical Engineering | 181 | 41 |
| Office and Admin | 12 | 3 |
| Total | 443 | 100 |

| | | % |
|---|------------|------------|
| Staff | 443 | 50 |
| Fellows | 116 | 13 |
| Doctoral Students | 58 | 7 |
| Technical Students | 40 | 5 |
| Project Associates | 41 | 5 |
| Other Associates | 174 | 20 |
| Grand Total | 872 | 100 |
| + 336 colleagues in Industrial support contracts | | |



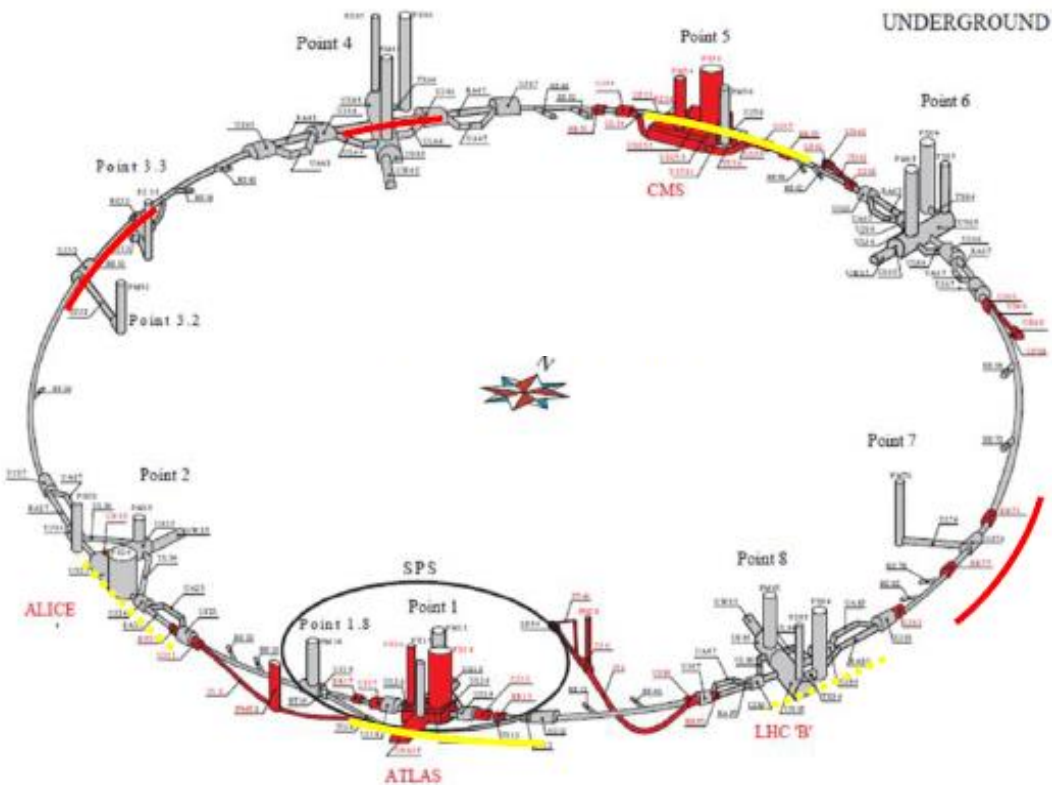
Also plenty of Diversity in Nationality with (at present) 51 Nationalities represented in the Department



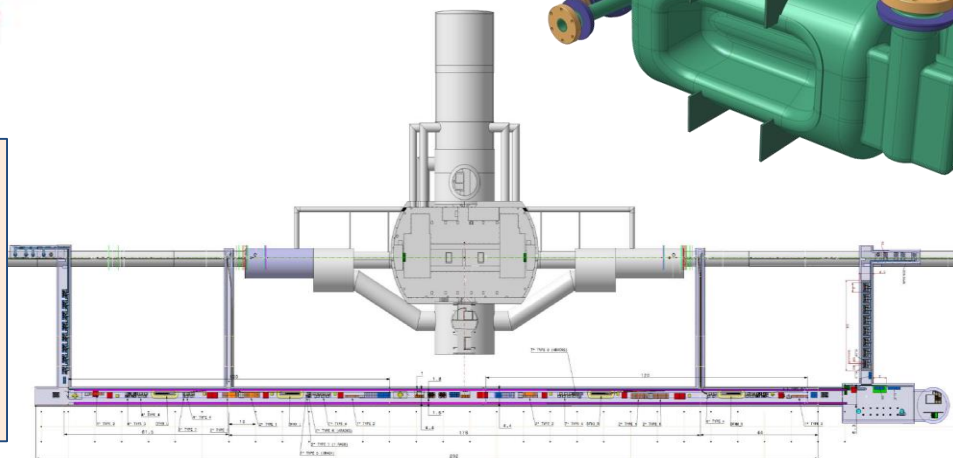
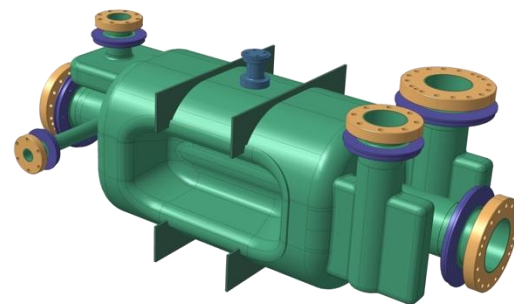
▶ p (protons) ▶ ions ▶ RIBs (Radioactive Ion Beams) ▶ n (neutrons) ▶ \bar{p} (antiprotons) ▶ e^- (electrons) \leftrightarrow proton/antiproton conversion \rightarrow proton/RIB conversion

LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron AD Antiproton Decelerator CTF3 Clic Test Facility
 AWAKE Advanced WAKEfield Experiment ISOLDE Isotope Separator OnLine REX/HIE Radioactive EXperiment/High Intensity and Energy ISOLDE
 LEIR Low Energy Ion Ring LINAC LINear ACcelerator n-ToF Neutrons Time Of Flight HiRadMat High-Radiation to Materials

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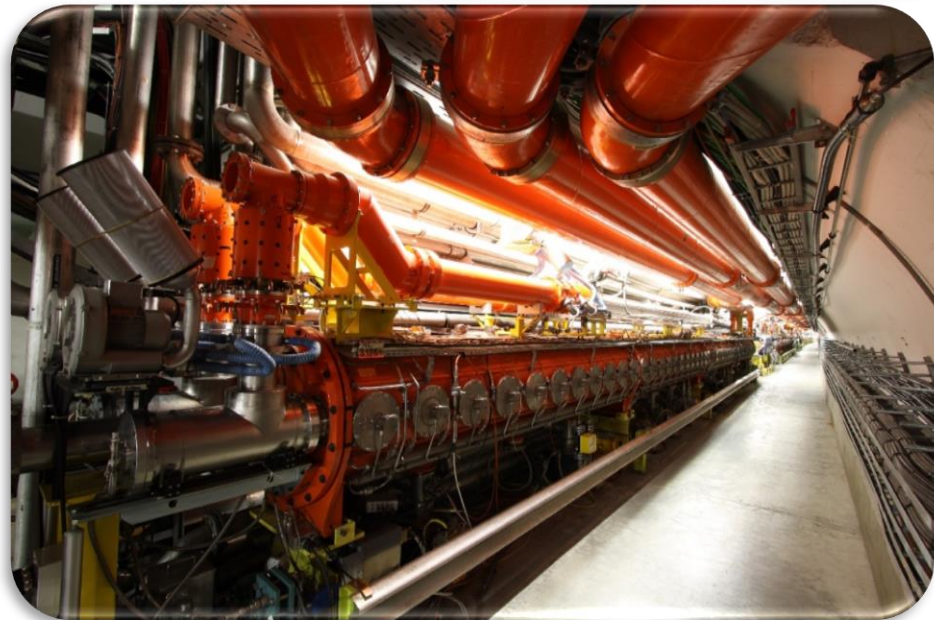
- New IR-quads Nb₃Sn (inner triplets)
- New 11 T Nb₃Sn (short) dipoles
- Collimation upgrade
- Cryogenics upgrade
- Crab Cavities
- Cold powering
- Machine protection
- Beam Instrumentation
- Controls



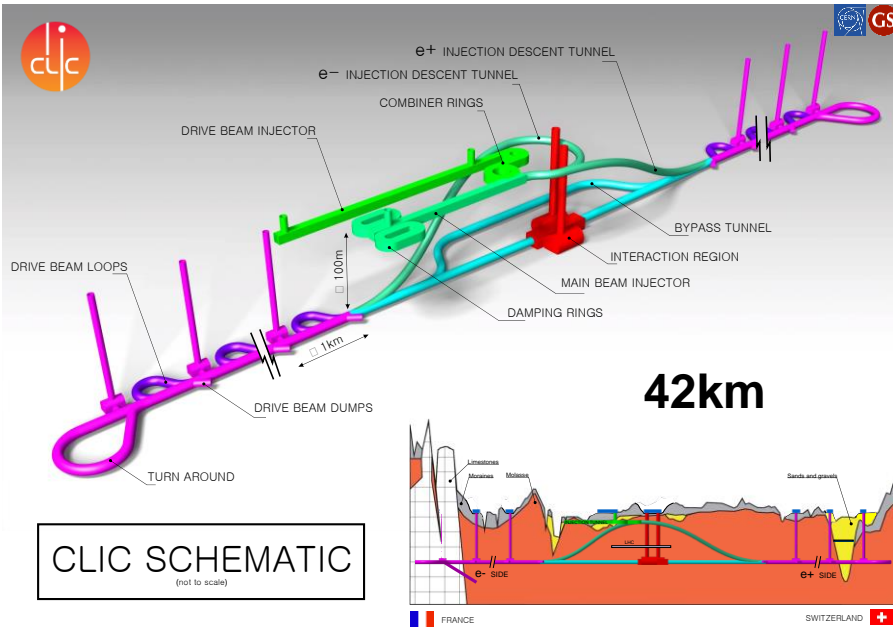
Aim to deliver 10x the LHC design
 – 3000 fb⁻¹
 Total cost ~950MCHF

- Linac4** : Injection of H^- at 160 MeV into PSB
- PSB** : Increased Extraction energy from 1.4 to 2 GeV
- PS** : Higher Injection Energy
- SPS** : RF System Upgrade

Instrumentation and Infrastructure Upgrade throughout the Injector Chain



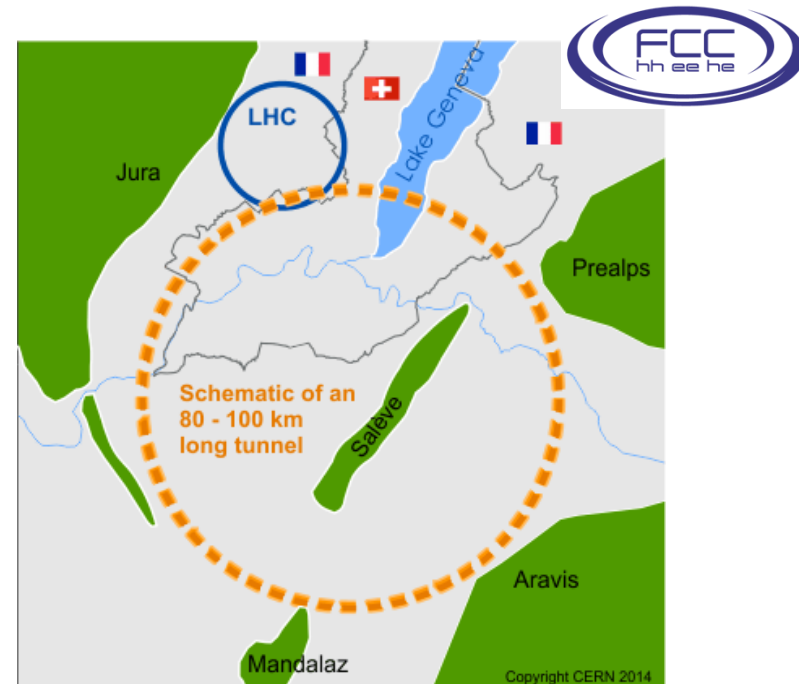
Aim to double the intensity per bunch delivered to the LHC



- Compact Linear Collider (CLIC)
- Energy up to 3 TeV – ‘discovery’ machine
- Based on Room Temperature RF Technology producing 100MV/m
- Uses a novel ‘twin-beam’ system
- International collaboration on R&D and Studies
- Very challenging technologies

CLIC SCHEMATIC
(not to scale)

- Future Circular Collider (FCC)
- 100 km tunnel infrastructure in Geneva area
- Design driven by hadron-hadron collider
 - 100 TeV centre of mass collisions
 - 7× higher than LHC
 - 16 Tesla Nb₃Sn magnets
- Could also initially house e+ e- collider
 - Precision physics at energies up to 400GeV





Introducing the GROUPS of the BEAMS DEPARTMENT

- The ASR group is responsible for:
 - Overall management and planning of Departmental Resources
 - Beams Department safety & safety during operation of all beam facilities at CERN
 - SPS fire safety project (~14 MCHF)
 - Fire brigade equipment & fire-retardant doors
 - Sprinkler system & pipework
 - Fire detection, protection & evacuation systems

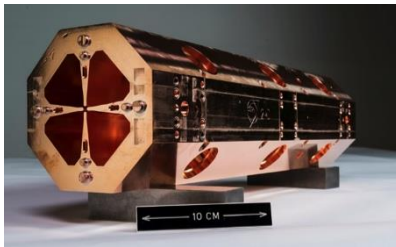


Group Leader
Ronny Billen



Portuguese Industry

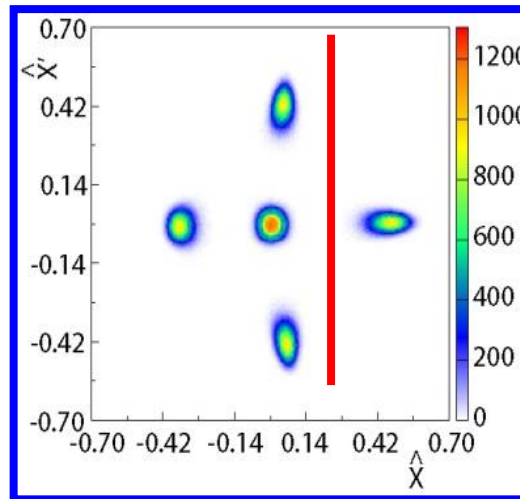
- Accelerator Physics & beam dynamics studies for complete CERN accelerator complex
- Beam & machine parameters & beam dynamics studies for HL-LHC & Injector Upgrades
- Operation, maintenance and development of hadron sources and Linacs
- Knowledge transfer to industry
 - e.g. for design of compact medical accelerators
- Development and maintenance of accelerator physics computer codes
- Studies for future accelerators, New Acceleration Techniques and Medical Accelerators



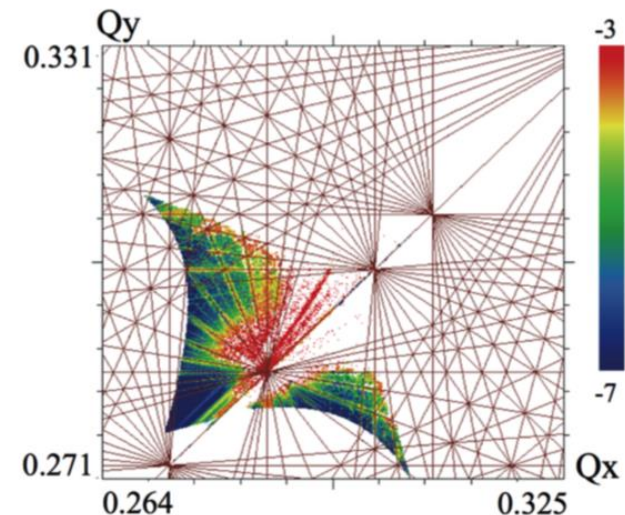
750 MHz RFQ



Group Leader
Gianluigi Arduini



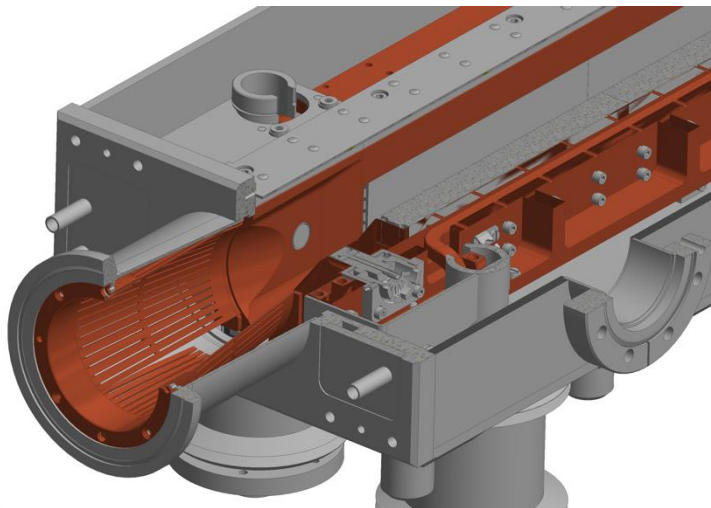
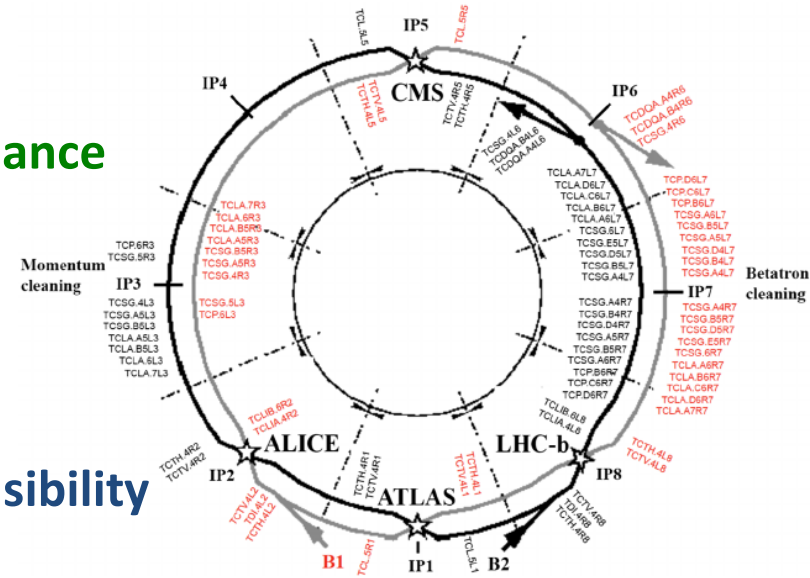
PS Multi-turn Extraction Scheme



Uncompensated Beam-Beam Footprint in HL-LHC

Leadership of the HL-(LHC) Collimation Task

- Definition of the requirements and performance
- Specification of the elements (100+)
- High level software
- Operation of the whole system
- (Most of) The hardware is under the responsibility of the EN department



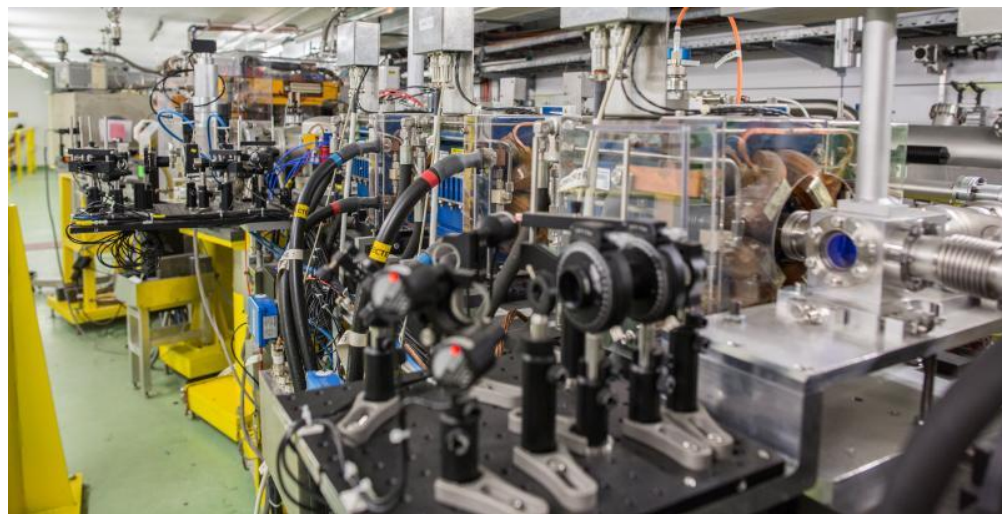
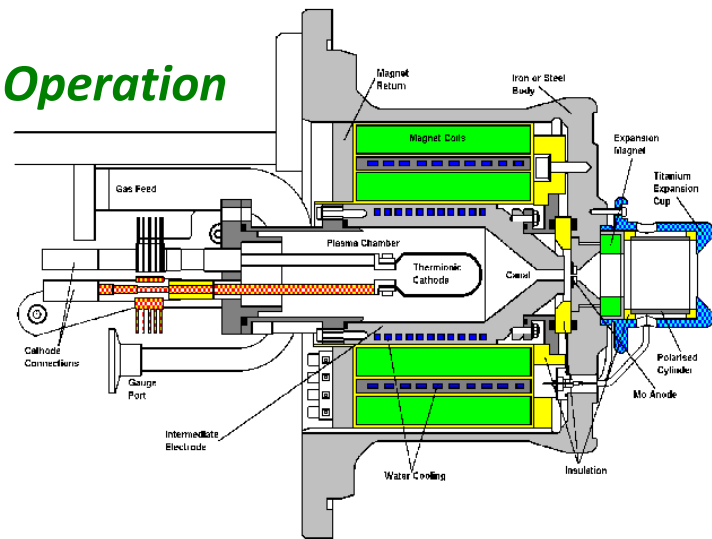
Development, Construction and Operation of all particle sources at CERN



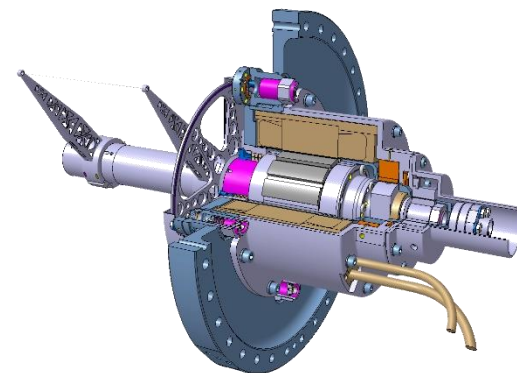
EBIS Charge Breeder at Isolde

Construction and Operation of the low-energy electron test beam facility (CLEAR)

Mainly small orders



- Responsible for building instruments that allow measurement of particle beams
- R&D to improve detection techniques & explore new avenues for future accelerators
- Activities include:
 - Accelerator physics
 - Detector technology (gaseous/optical/silicon/electro-magnetic)
 - Custom built electronics
 - Mechanical and vacuum engineering
 - Software engineering



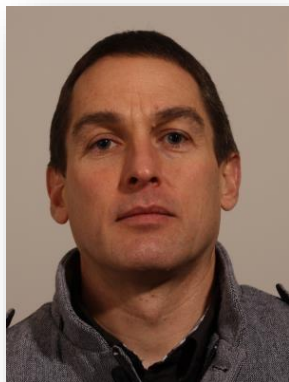
New Fast Wirescanner



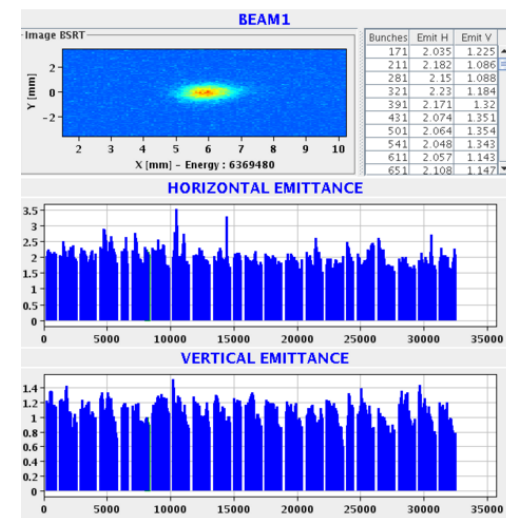
HIE-ISOLDE Diagnostic Box



AD Cryogenic Current Comparator



**Group Leader
Rhodri Jones**



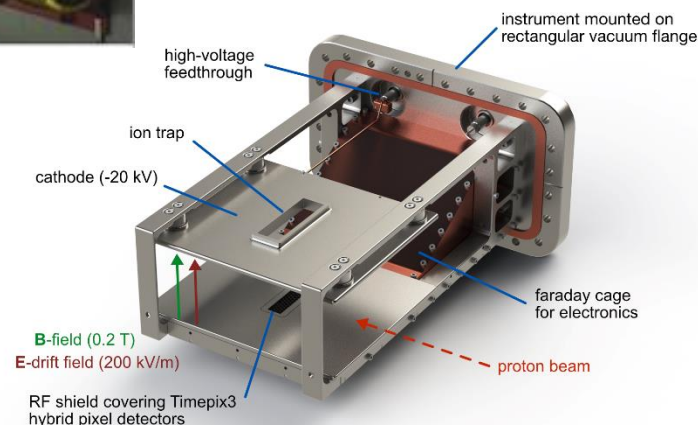
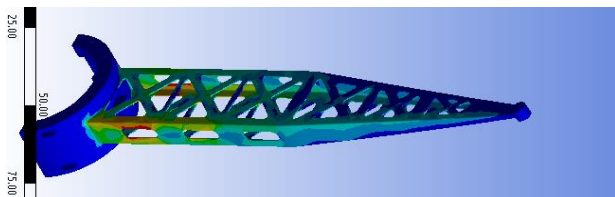
Data Acquisition & Display

Many different systems using a variety of techniques and technology spread around all of the CERN accelerators and Experimental areas:

Beam Position, Beam Profile, Beam Intensity, Beam Structure, Beam Loss

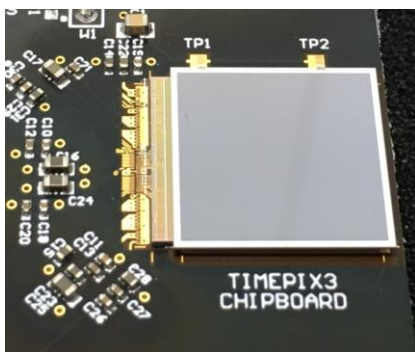
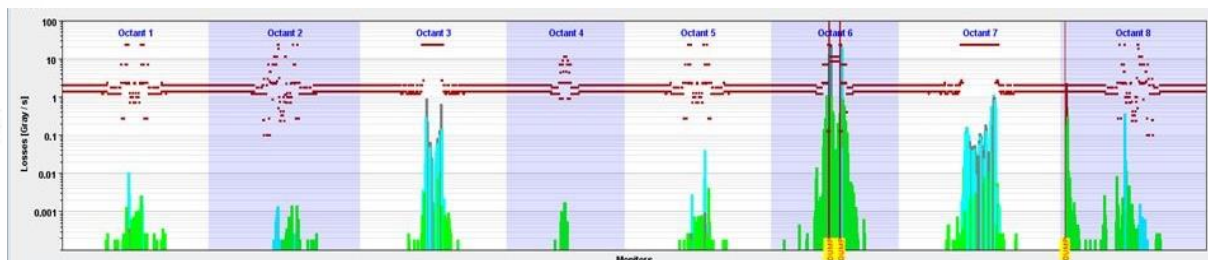
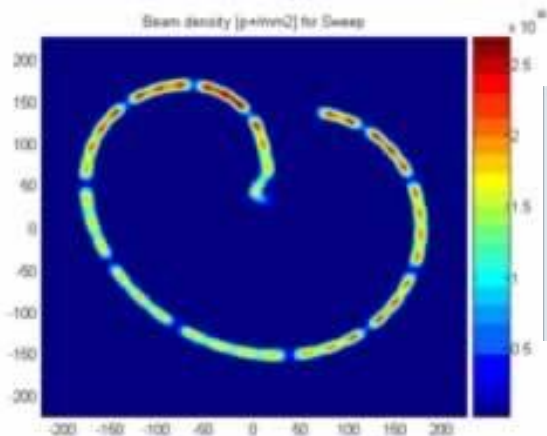
Common requirements:

Mechanics, UHV, Motorization, High Voltage, Optics, Special Materials, Specialized detectors



Combination of specialized electronics designs and some off the shelf systems – for example:

- High speed acquisition, signal treatment and transmission
- (Rad-Hard) Camera systems with digitizers
- Significant processing and concentration often needed



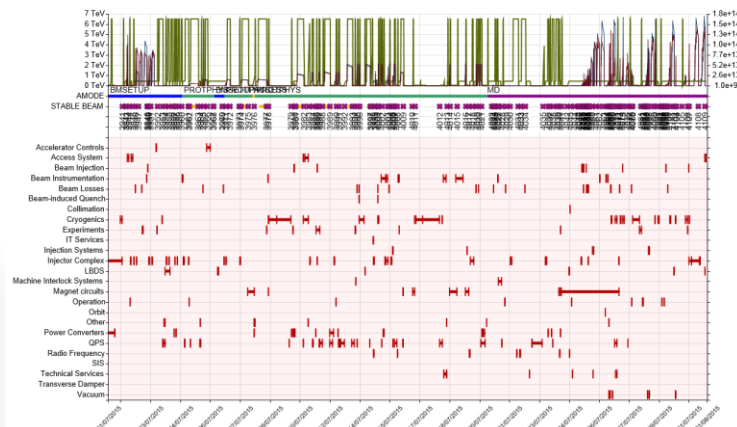
| LIU | 2018 |
|--|--|
| Mechanics production and installation for operational BWS (16 devices) | MME vac tank order Various small orders |
| Acquisition electronics and cables for wire-scanners | Small orders |
| Control electronics for wire-scanners | Production in 2 nd half of 2018 |
| Mechanical commercial components for BWS | |
| New SEM Grid (transfer line PSB-PS) | Small orders |
| Upgrade SPS Orbit Acquisition Electronics | Part of a large order for LHC |
| Provide fibre optic infrastructure LS2 | |
| LEIR Instrumentation Injection Line BPM | Small orders |

| Consolidation | 2018 |
|--|----------------------------------|
| AD beam instrumentation | Spare FMC for VXS BPM system |
| AD Cryogenic Current Comparator | |
| LHC BLM rad hard electronics | ASIC development in LS2 |
| LHC Consolidation of WS Electronics | Orders as part of LIU WS project |
| Consolidation of standard LHC BPM system | Small orders |
| Consolidation of standard LHC BLM system | Large order |
| Interlock BPM system | Small orders |
| Mechanical Spares for Critical LHC systems | New BSRT windows being finalised |

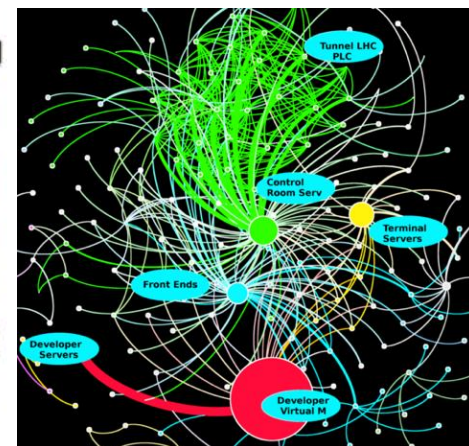
- Responsible for controls infrastructure of all the CERN accelerator complex
 - Covers the embedded front end controllers up to the application software
 - Provides standardised hardware & software services & frameworks for
 - Timing distribution, signal observation, alarms, surveillance, logging and data management



Open Hardware



Accelerator Fault Tracking

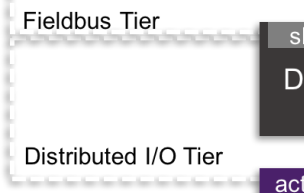
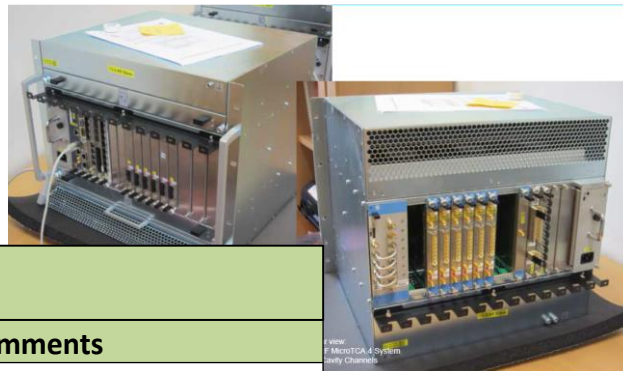


TN-GPN network traffic & dependencies



Group Leader
Eugenia Hatziangeli

Both COTS and 'in-house' card development using the Open Hardware repository and license framework



| Typical Orders | |
|--------------------------|---------------------------------|
| 2018 Order | Comments |
| White Rabbit Switches | Will split between 2 companies |
| VME modules | Likely to be 5 different orders |
| VME Crates | contract over 5 years |
| MENA25 CPU platform | contract over 2 years |
| Various Electronic cards | 8 separate orders |
| Back End Servers | Part of the general IT contract |

ME and now
easingly μ TCA

Stand

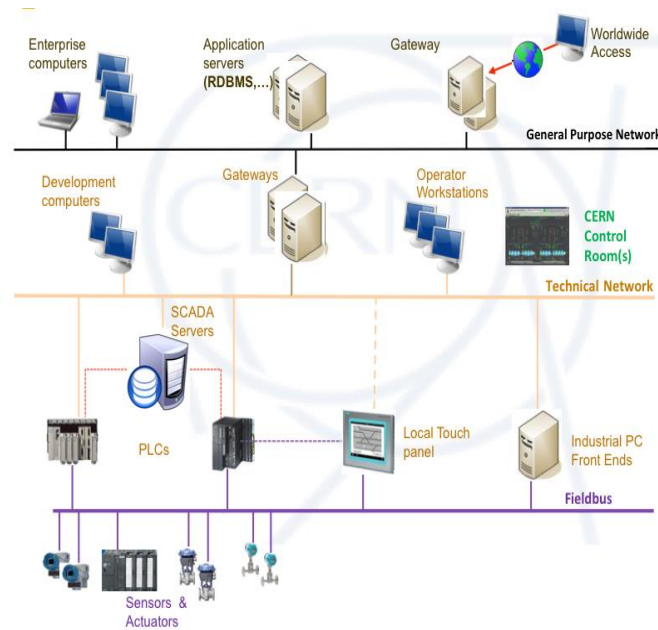
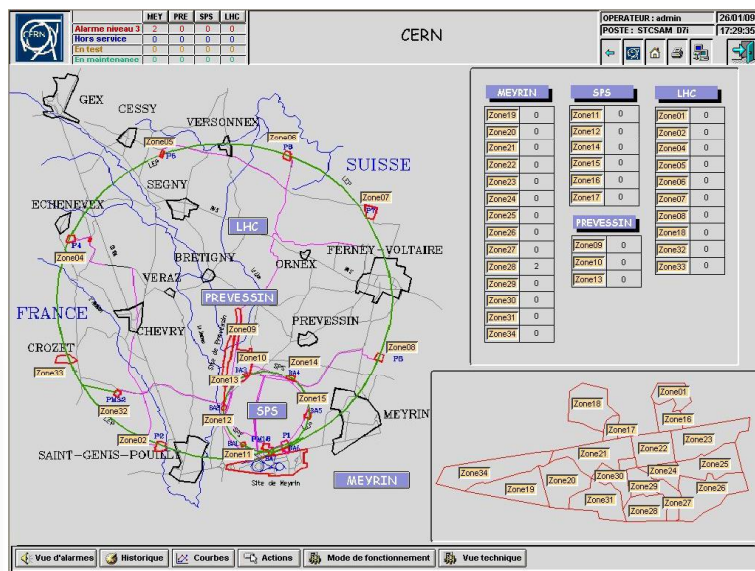


Servers now
part of the IT
contract



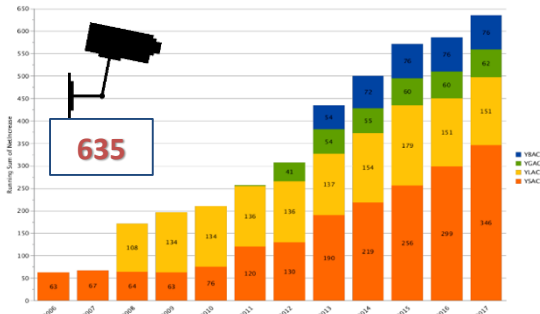
+ Custom cards for specific needs

- Design, implement, install, maintain and support CERN's safety and access control systems (site and machines)
- Industrial control systems for experiments, technical infrastructure, accelerator interlocks and other equipment
- Evaluate, select and support related tools and technologies
- Provide the necessary tools, frameworks and interfaces to integrate these systems in the CERN environment

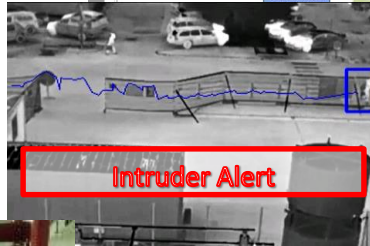
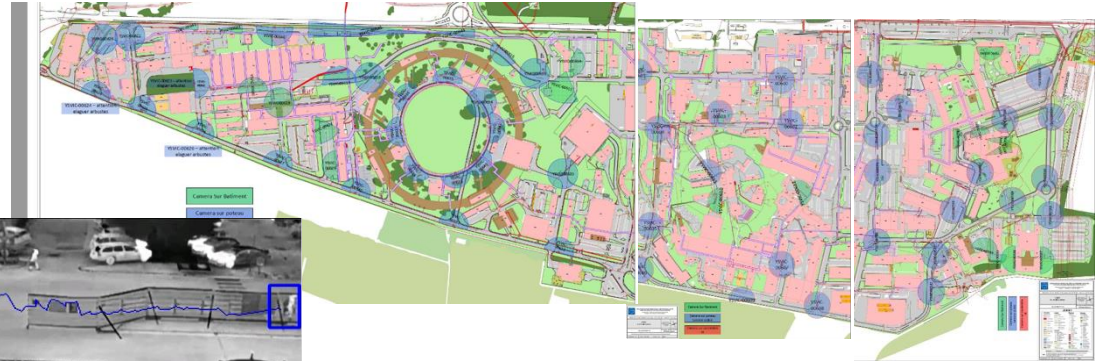
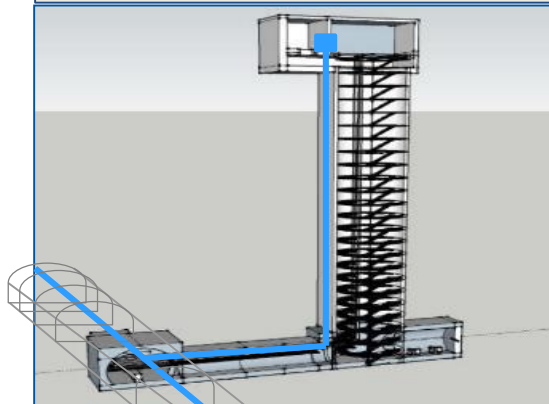


**Group Leader
Peter Sollander**

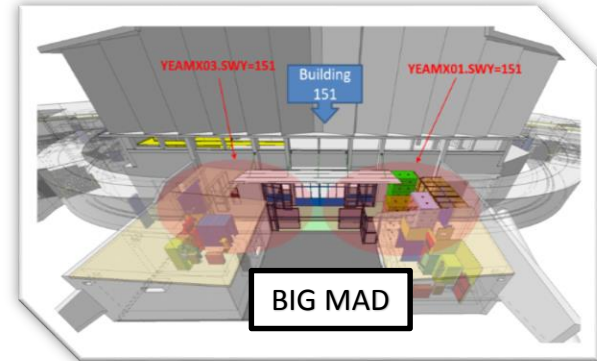
AC-YSAC-006C: Inventaire Cameras



SPS Ring line

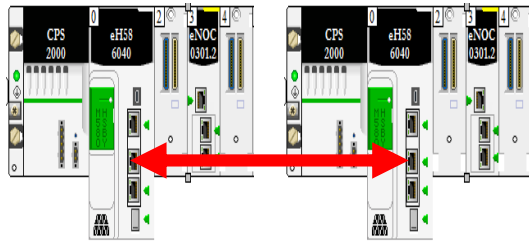


Several large contracts recently adjudicated
More to come ...

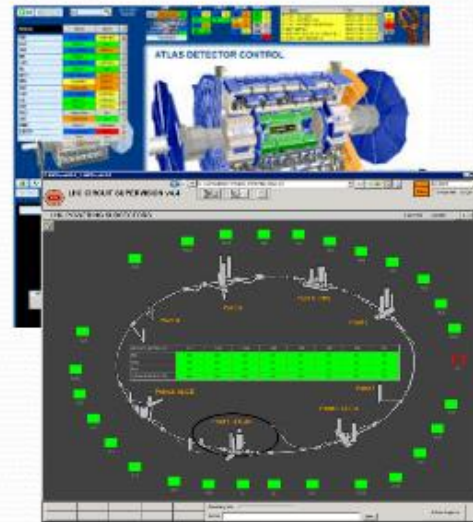
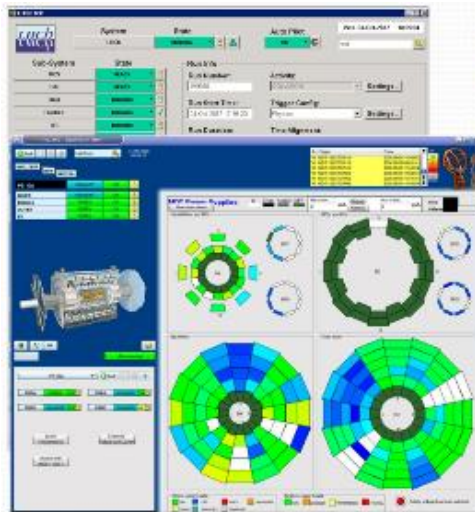
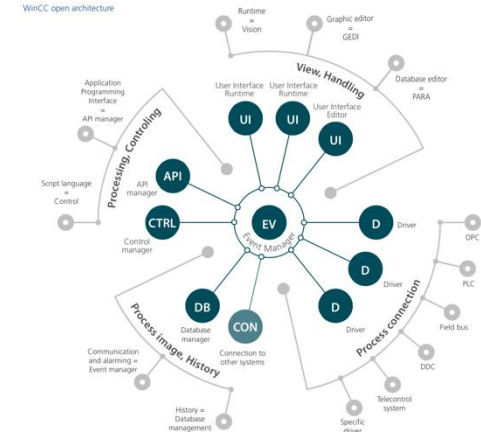


New interface LACS

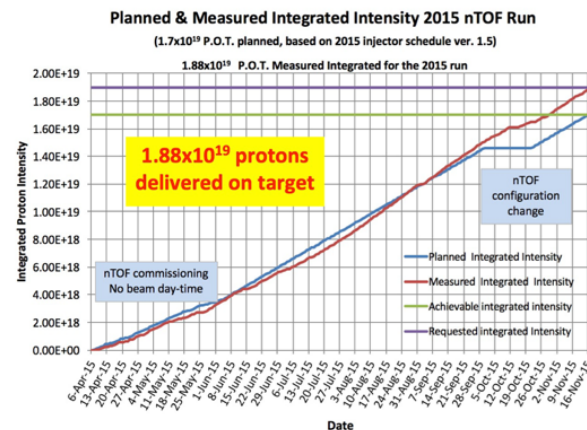
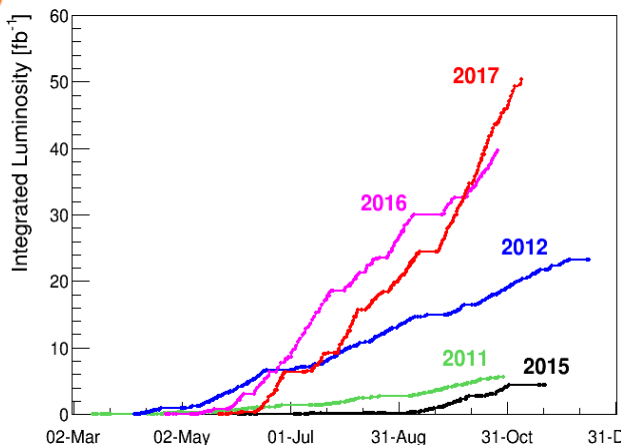
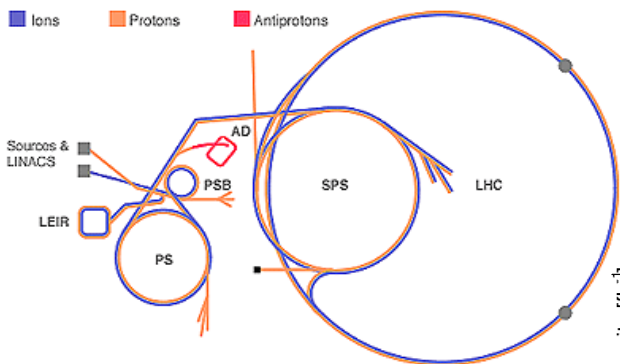
Provides facilities, hardware, frameworks and support across CERN – machines and Experiments



Blanket contracts for PLC's
Large development infrastructure
Strong links with OpenLab



- Responsible for the operation of the CERN accelerator complex
- Monitoring of the technical infrastructure for the whole CERN site
- Wide range of additional activities including
 - machine optimisation, application software, operational procedures & statistics



Group Leader
Rende Steerenberg

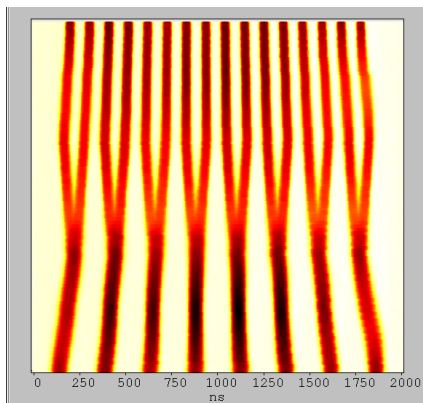
SPS-PAGE1 Current user: SFTPRO1 30-11-14 12:45:27
SC 81 (308P, 36.0s) Last update: 9 seconds ago

| Target | I/E11 | MUL | %SYM | Experiment |
|--------|-------|-----|------|------------|
| T2 | 30.7 | 14 | 87 a | NA61/H4 |
| T4 | 30.1 | 7 | 70 a | H6/H8 |
| T6 | 99.9 | 19 | 77 a | COMPASS |
| T10 | 1.9 | 0 | 57 | NA62 |

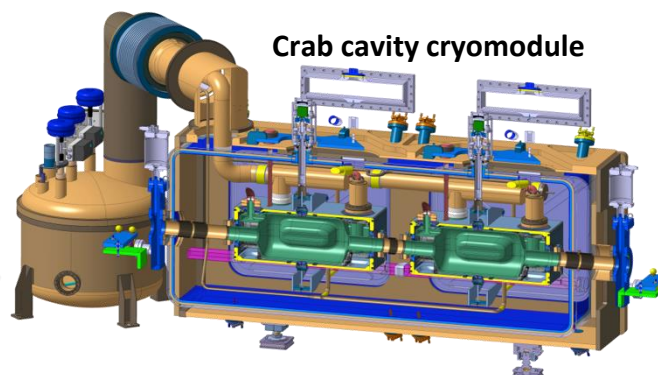
Phone: 77500 or 70475
Comments (30-Nov-2014 10:58:42)

MD1 0.0 E10 0.0 E10

- Responsible for accelerating & damping systems for all accelerators at CERN
 - Operation, maintenance & upgrades of these systems in all existing machines
- Design & construction for new approved machines
- R&D and design studies for future machines
 - Investigation of new technologies



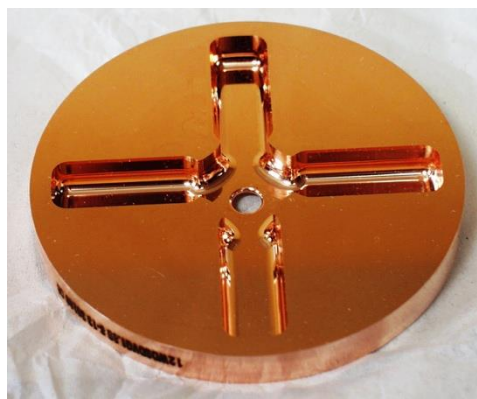
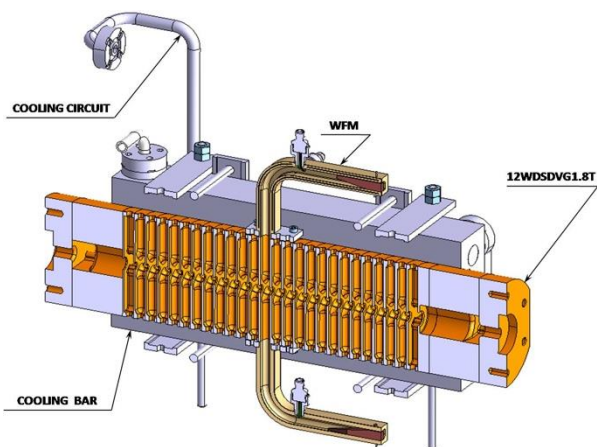
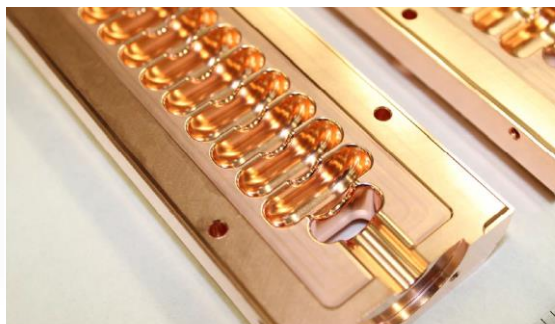
Group Leader
Erk Jensen



HIE-Isolde Cryomodule

Precision Mechanical Engineering

- Specialized materials and treatments
- Both SC-RF and Warm Structures
- Frequency range from few MHz to 12 GHz



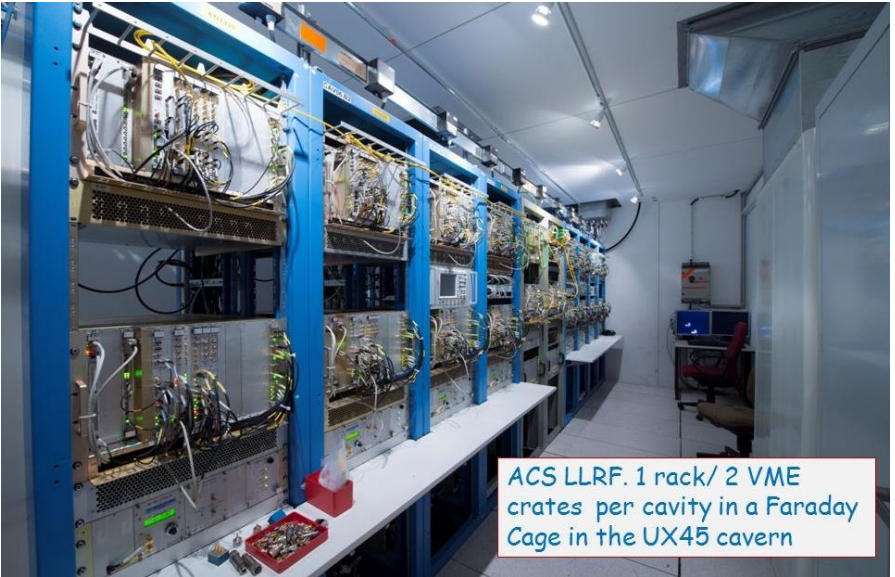
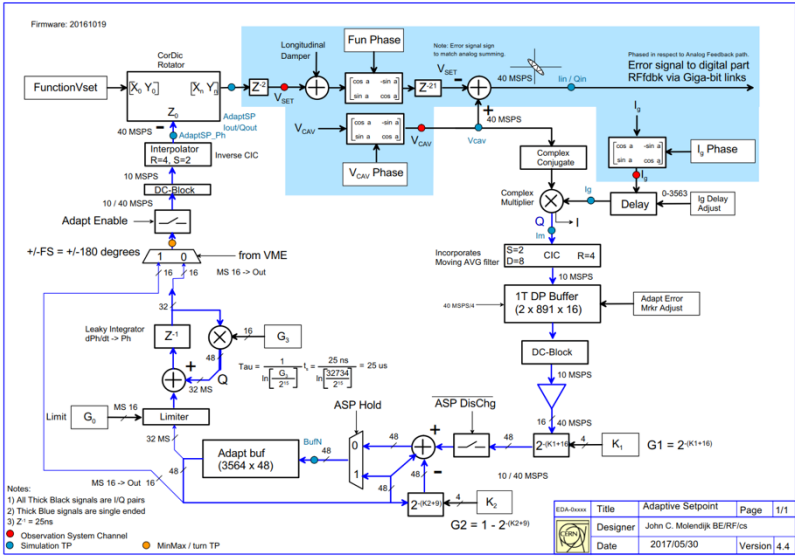
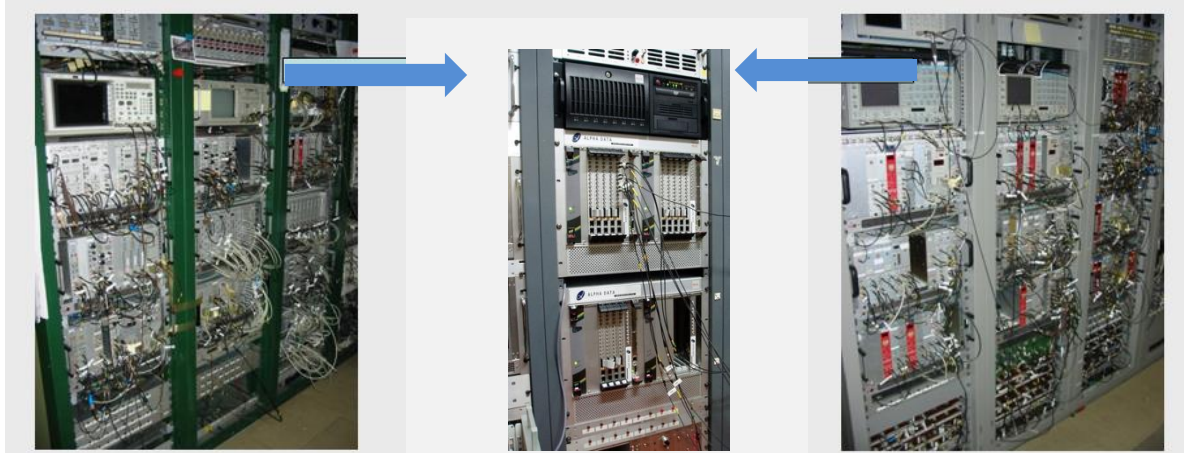


Based on:
Tetrodes, IoT, Klystron, Solid State
Several big supply/maintenance contracts



Traditionally Analog, now progressively digitized

- FPGA Programming
- Many Specialized cards
- But a lot of COTS too
- Moving from VME to μ TCA



ACS LLRF. 1 rack/ 2 VME crates per cavity in a Faraday Cage in the UX45 cavern

RF :

- Cavity tuning machine
- Solid state amplifiers for LINAC3
- Cleanroom upgrade
- Hybrid power combiners for SPS

BI:

- 4 channel 500MHz ADC FMC mezzanine
- 370 UHV RF feedthroughs for HL-LHC
- 250 semi-rigid, RF coaxial cables for HL-LHC
- Superconducting solenoid for electron beam test stand

CO:

- Supply of CPU Servers for Physics Data Processing as part of IT tender
- Frame contract for the procurement of VME64x crates

BE Covers a lot of technologies and works a lot with industrial and institute partners

- **Design of accelerators and operation**
- **Specialized electronics design & series manufacturing (few units to >1000)**
- **COTS systems including VME and μ TCA based front end computers**
- **Centralized controls infrastructure – generally COTS**
- **Mechanical Engineering – precision and UHV manufacturing**
- **Industrial Control Systems**
- **Safety infrastructure (fire detection, oxygen deficiency etc.)**
- **Site Surveillance and access control including video surveillance**
- **Controlled areas access control including individual recognition systems**



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