CERN Technology Department
“Running the Present... preparing the Future!”
Power of…

RUN 2 & LS2

CERN Road map

Resources & Infrastructures

Perspectives
Power of...
The most important TE asset is... YOU!

"you are helping CERN to preserve its competitive advantage!"
## Statistics for 2018

### All accidents

<table>
<thead>
<tr>
<th></th>
<th>CERN</th>
<th>Number</th>
<th>Days Absence</th>
<th>TE Personnel</th>
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### Bicycle Accidents

<table>
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Safety Officers & Counsellors

Thomas Otto
DSO, Deputy RSO
160648

Juan Garcia Perez
Deputy DSO
164436

Alexis Vidal
Radiation SO
164502

Olivier Pirotte
Cryogenic SO
163270

David Jaillet (Dept. EN)
Flammable Gas SO
167151

Bruce Marsh (Dept. EN)
Laser SO
162552

Leonel Antunes
Chemical SO
163612

Delphine Letant-Delrieux
Executive Counsellor
162473

Germana Riddone
Executive Counsellor
163005

"Running the Present... preparing the Future!"
### Group’s Safety Link Persons

<table>
<thead>
<tr>
<th>Name</th>
<th>Group</th>
<th>ID</th>
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<tbody>
<tr>
<td>Francesco Castronuovo</td>
<td>ABT</td>
<td>164735</td>
</tr>
<tr>
<td>Torsten Koettig</td>
<td>CRG</td>
<td>168530</td>
</tr>
<tr>
<td>Valérie Montabonnet</td>
<td>EPC</td>
<td>164432</td>
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<tr>
<td>Daniel Calcoen</td>
<td>MPE</td>
<td>163704</td>
</tr>
<tr>
<td>Juan Garcia Perez</td>
<td>MSC</td>
<td>164436</td>
</tr>
<tr>
<td>Bernard Henrist</td>
<td>VSC</td>
<td>163633</td>
</tr>
</tbody>
</table>
Radiation Support Safety Officers

**ABT**
- Cédric Baud
- Luis Miguel Coralejo Feliciano

**CRG**
- Steffen Junker

**MSC**
- Aniello Russo
- Delphine Gérard

**VSC**
- Anthony Harrison
- Jérôme Gilles Chaure
- Julien Finelle
- Paul Richard Demarest
- Alexis Vidal
- Jan Helge Hansen
- Ludovic Mourier
- Antonio Mongelluzzo
And very committed TSOs!
Thanks to **HR and Ombuds for their support**

**HRA for TE**
Valeria Perez Reale
HR Frontline

**Recruiter for TE**
Rocio Alot Barajas
HR Talent Acquisition

---

**RECURRING PROCESSES**

- MARS & Promotions
- CCRB Indefinite Recruitment
- Staff LD Recruitment

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**FIXED MEETINGS WITH STAFF**

- **ARRIVAL**
  - welcome meetings
  - induction program
  - welcome coffee
- **PROBATION**
  - Mid & End probation meetings
- **JOB CHANGE**
  - Mobility discussions
- **DEPARTURE**
  - LD-end meetings
  - Career transition advice
  - Exit interviews
  - Retirement

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**Pierre Gildemyn**
is CERN’s Ombudsperson

You can contact him:
By email: Ombuds@cern.ch
By phone: +41 (0) 22 76 73566
Portable: +41 (0) 75 411 24 96
In person: Office 500-1-004

▶ the quicker an issue is addressed, the easier it is to resolve
Thank you to CERN Departments for their support
Thank you to our Industrial Support

S144 : Actemium / Bruun & Sørensen
S145 : Serco / INEO
S146 : Soteb / Altead
S197: GE/Alstom
S175: Air Liquide/ 40-30
S176/TE - SERCAL
RUN 2 & LS2
"Running the Present... preparing the Future!"

- **Ending LS1**
  - 2014

- **Resuming after LS1**
  - 2015

- **Adjusting parameters**
  - 2016

- **Luminosity Production (I)**
  - 2017

- **Luminosity Production (II)**
  - 2018
2015 hints

- UFOs: BLM adjusted, compromise availability vs quench protection

- ULO: orbit bumped by +1mm in V and -3mm in H @15R8

- CMS Cold Box oil contamination: 73%

- Heat load evolution: scrubbing observed with physics fills at 6.5 TeV

- LHC is operational:

- LHC Integrated Luminosity: achieved ~4.3 fb⁻¹
2016 hints

- UFOs: **conditioning effect** observed!
- Heat load evolution: **scrubbing still observed** with physics fills @ 6.5 TeV
- Magnet training: **slow** and with **risks of short-to-ground**
- Peak Luminosity: 1.4 x 10^{34} cm^{-2}s^{-1}
- Integrated Luminosity: 25 fb^{-1} in both ATLAS & CMS
- Excellent availability: 40 fb^{-1} accumulated in total!
2017 hints

- 16L2 air inlet: clever response ➤ BCMS vs 8b4e
- Machine availability: 86.6%!
- Optics tricks: luminosity levelling
- Separation
- Luminosity levelling & anti-levelling
### LHC performance in 2018

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2018</th>
<th>Design</th>
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<tbody>
<tr>
<td><strong>Energy</strong> [TeV]</td>
<td>6.5</td>
<td>7.0</td>
</tr>
<tr>
<td><strong>No. of bunches</strong></td>
<td>2556</td>
<td>2808</td>
</tr>
<tr>
<td><strong>Max. stored energy</strong> per beam (MJ)</td>
<td>312</td>
<td>362</td>
</tr>
<tr>
<td><strong>β</strong> [cm]</td>
<td>30→25</td>
<td>55</td>
</tr>
<tr>
<td><strong>p/bunch</strong> (typical value) [10^{11}]</td>
<td>1.1</td>
<td>1.15</td>
</tr>
<tr>
<td><strong>Typical normalized emittance</strong> [μm]</td>
<td>~1.8</td>
<td>3.75</td>
</tr>
<tr>
<td><strong>Peak luminosity</strong> [10^{34} cm^{-2}s^{-1}]</td>
<td>2.1</td>
<td>1.0</td>
</tr>
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</table>
LHC performance in 2018

2018 hints

"Running the Present... preparing the Future!"

LHCb: 2.46 fb⁻¹

66 fb⁻¹

150 fb⁻¹ Run 2

150 fb⁻¹ Run 1 + Run 2

Integrated Luminosity (fb⁻¹)

Integrated Luminosity LHCb (fb⁻¹)
RUN 1 + RUN 2

Yes we did it!

Run 1
\[ \sqrt{s} = 7-8 \text{ TeV} \]

Run 2
\[ \sqrt{s} = 13 \text{ TeV} \]

Period | Integrated Luminosity [fb⁻¹]
--- | ---
Run 1 | 29.2
Run 2: 2015 | 4.2
Run 2: 2016 | 39.7
Run 2: 2017 | 50.2
Run 2: 2018 | 66.0
Run 1 + Run 2 | 189.3

Run 2 at 13 TeV
160.1 fb⁻¹
LHC powering test before LS2 (1 week)

2018 hints

Quadrupole training is "faster" relatively rapidly the current corresponding to 7 TeV

 Sector 12 training (end 2018)
  • Series 1000: 8 quenches
  • Series 2000: 2 quenches
  • Series 3000: 5 quenches

Surprising! Predicting a faster sector training
No limits to 7 TeV, but longer training campaign
Yes we did it!

Availability Working Group: Coordination of fault tracking for LHC and Injectors

Machine Availability and Reliability Panel: Coordination R&A activities in ATS sector
"Running the Present... preparing the Future!"

Yes we did it!

RUN 1 + RUN 2
"Running the Present... preparing the Future!"

Yes we did it!

- Start operation with physics in 2018
- Operational days: 287
- Power converters: 1371
- Interventions: 324

**Injectors**
- Linac 2&3, Leir, Booster, PS + TT2/F16 + TT10, SPS + Ti2 + Ti8 + TT40 + TT60

<table>
<thead>
<tr>
<th>Calls</th>
<th>2017</th>
<th>2018</th>
<th>Ratio 2017 / 2018</th>
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<tr>
<td>Exploitation days</td>
<td>248</td>
<td>287</td>
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<tr>
<td>During working Hours</td>
<td>153</td>
<td>183</td>
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<tr>
<td>Total</td>
<td>220</td>
<td>324</td>
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</table>
Just 1 direct faults inducing an interlock -> 1h of downtime

5 indirect faults for a total of 2.3h of downtime

Yes we did it!
## Injectors availability

<table>
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<tr>
<td>LINAC2</td>
<td>97.3%</td>
<td>99.1%</td>
<td></td>
<td>99%</td>
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<tr>
<td>LINAC3</td>
<td>99.8%</td>
<td></td>
<td></td>
<td>95.1%</td>
</tr>
<tr>
<td>PSB</td>
<td>94.3%</td>
<td>94.0%</td>
<td>97.0%</td>
<td>95.0%</td>
</tr>
<tr>
<td>PS</td>
<td>93.2%</td>
<td>90.4%</td>
<td>93.4%</td>
<td>90.2%</td>
</tr>
<tr>
<td>SPS</td>
<td>87.3%</td>
<td>76.2%</td>
<td>91.0%</td>
<td>80.4%</td>
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<tr>
<td>AD</td>
<td>90.0%</td>
<td>&gt;95%</td>
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<td>64.4%</td>
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Goodbye LINAC 2… Welcome LINAC 4!
28th December 2018

"Running the Present... preparing the Future!"

LHC
LS2 objectives

Increase **Intensity** & **Brightness** in the injectors to match HL-LHC requirements

- **LIU Project**

Increase injector **Reliability** and **Availability** to cover HL-LHC run

- **Consolidation Project**

Anticipate **Civil Engineering** works and **beam equipment**

- **HL-LHC Project**

Perform major **Maintenance & Infrastructure** Consolidations

- **M&O activities**

**Safety**  **Quality**  **Schedule**
LS2 master schedule

Edms: 1687788 v.1.2

<table>
<thead>
<tr>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
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<td>Q4</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
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<tr>
<td></td>
<td>Linac 3 &amp; LEIR</td>
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<tr>
<td></td>
<td>L4 connection</td>
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<tr>
<td>PSB</td>
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<tr>
<td>PS</td>
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<td>Switchyard</td>
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<td>SPS</td>
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<tr>
<td>LHC</td>
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</table>

RP cooldown | Powering tests | Shutdown | Individual System Tests | Cold check-out | Beam commissioning

Dec'18
LS2 schedule of the LHC

EDMS 1817804
Proton Synchrotron Booster (1972)

LIU PSB Magnets for injection and extraction

LIU PSB recombination kicker

Dec’18
LIU SPS: High voltage switch and Pulse Forming Network

LIU SPS: Vertical beam dump kicker

SPS Dump Upgrade
- 190m of SPS beamline upgraded
- Strong collaboration between BE, EN, HSE, SMB & TE
- Excellent support within TE from ABT, EPC, MPE, MSC and VSC
**Power Converters consolidations**

**TT2**
- Replacement of all power converters dated 1969
- Renew of all services

**EAST area**
- Replacement of all power converters from 1968
- Renew of all services

**MPS Booster**
- Switched ON in 1998, switched off on 12 November 2018
- Replace by POPS

**MPS PS**
- Switched ON in 1968, definitely switched off on 03 December 2018
- No more spare for POPS
4-6-8kA R2E Production

2752 Output filters
2752 HF Transformers

342 Input Modules
684 Output Modules
**East Area renovation**

- **Q74 L (CERN-Antec)**
  - Yokes under construction at CERN
  - Pre-series coil by mid January 2019

- **Q120 C (SEF)**
  - 8 coils ready for impregnation
  - Tooling and parts available
  - First assembly expected by January 2019

- **CR200 – MDX L (CNE)**
  - CR200 pre-series expected by January 2019
  - MDX L pre-series expected by January 2019

- **Q100 L – Q200 L (Tesla)**
  - Electrical steel and SS ordered
  - Receptions by end 2018
  - Pre-series coils by January 2019

- **M100 L – M200 L (Tesla-NM)**
  - Pre-series coils ongoing
  - First M100 L yoke ongoing
  - Both expected by January 2019

- **Magnet refurbishment (CERN)**
  - 9/9 QFS – 4/4 QFL – 3/5 QDS – 2/8 MCB
Magnet maintenance & consolidation

LS2 Coordination

**Maintenance**

**DISMAC** (Diode Insulation and Superconducting Magnets Consolidation)

- 22 cryo-magnets exchanged
  - 19 dipoles
  - 3 SSS

**DISMAC**

All dipoles diodes (1232) will be inspected, cleaned and consolidated. *Advanced opening* in Feb 2019. Train departure in Apr 2019, arrival in Jun 2020
- Development of the new measurement system for the follow-up of DISMAC activities
- Finalisation of an upgrade of all standard ELQA systems for LS2
- Training of HNINP teams
Revision and overhaul of all 256 circuit breakers in 32 systems of 13kA Energy Extraction

- Resolving the arcing contact issue
- Thorough inspection and maintenance of the driving mechanisms and revamp of switch status indicators
CERN road map

- **Run 2**
  - LS2:
    - Injector upgrade
    - Cryo RF P4
    - P7 11 T dip. coll.
    - Civil Eng. P1-P5
  - EYETS
    - 13 TeV

- **Run 3**
  - LS2
    - 14 TeV
  - ATLAS - CMS upgrade phase 1
  - ALICE - LHCb upgrade
  - cryo limit interaction regions
  - 2 x nom. luminosity
  - 2.5 x nominal luminosity

- **Run 4 - 5...**
  - LS3
    - HL-LHC installation
    - Cryo RF P4
    - P7 11 T dip. coll.
    - Civil Eng. P1-P5
    - 5 to 7 x nominal luminosity
    - 2 x nom. luminosity

- Integrated luminosity:
  - 30 fb⁻¹
  - 150 fb⁻¹
  - 300 fb⁻¹
  - 3000 fb⁻¹

Dec'18
CERN road map
Medium term plan guiding principle

- **Driven by Science** and aiming at implementation of European Strategy for Particle Physics.

- Takes into account **technical feasibility and financial affordability**.

- Ensure **adequate resources for maintenance and consolidation** of scientific and general infrastructure, and for **compliance with Safety requirements**.

- Next 10 years dominated by construction of **High Luminosity LHC project** (HL-LHC) ~950 MCHF.
CERN road map

Three main scientific pillars

- **Full exploitation of the LHC:**
  - successful Run 2, LS2, and Run 3 start-up.
  - Upgrade of LHC Injectors; on-track construction of HL-LHC.

- **Scientific diversity programme** serving a broad community:
  - ongoing experiments and facilities at Booster, PS, SPS and their upgrades.
  - participation in accelerator-based neutrino through CERN Neutrino Platform.

- **Preparation of CERN future:**
  - vibrant accelerator R&D programme exploiting CERN strengths and uniqueness.
  - design studies for future accelerators: CLIC, FCC (includes HE-LHC).
  - future opportunities of diversity programme: “Physics Beyond Colliders”.

2019-2020: update of the European Strategy for Particle Physics (ESPP)
Futures Accelerators: 3 vectors of R&D!

CERN responds to the European Strategy

High Luminosity
HL-LHC

High Energy
FCC and HE-LHC

High Energy and Precision Physics
CLIC

Legend:
- CERN existing LHC
- Potential underground siting:
  - CLIC 500 GeV
  - CLIC 1.5 TeV
  - CLIC 3 TeV

Schematic of an 80 - 100 km long tunnel
CERN road map - High Energy and Precision Physics
Compact Linear Collider (CLIC) Study

from 380 GeV up to 3 TeV
**2013 – 2019**
Design phase
Planed to be made in phases; R&D, technical designs with Industry, demonstrators

**2020-2025**
Preparatory phase
Procurement preparation with Industry; Final technical proposal; Authorisations

**2026 – 2034**
Construction phase
Construction, installation and commissioning of accelerator and detector(s)

---

**2019 – 2020 Decisions**
Design Phase
Update of the European Strategy

**2025 Start of Construction**

**2035 First beams**
Ready to take data; LHC program is completed
CERN road map - Full exploitation of the LHC
High-Luminosity project (HL-LHC)

10 times more luminosity
- Beam brightness…
- Proton density…
- Crossing angle…

Technology demonstrator
- High Field >11 T
- High current ~100 kA
- Mitigation of beam effects
- New collimators

Worldwide approach
- CERN Member States and International Collaborations
CERN road map – High Energy Frontier
FCC and HE-LHC as Technology demonstrator

LHC
27 km, 8.33 T
14 TeV (c.o.m.)
1300 tons NbTi

HE-LHC baseline
27 km, 16 T
26 TeV (c.o.m.)
2500 tons Nb₃Sn

FCC-hh baseline
100 km, 16 T
100 TeV (c.o.m.)
10000 tons Nb₃Sn

FCC-hh baseline
80 km, 20 T
2000 tons HTS
8000 tons LTS
High Energy Frontier

*Held by a wire?*
High Energy Frontier

Certainly challenging!
Resources & Infrastructures
Human Resources & Training (MPP)

Arrivals in TE Department in 2018

261 departures
290 arrivals!

TE Members of Personnel as at 9.12.2018

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<tbody>
<tr>
<td>Employed Personnel</td>
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<td>Staff</td>
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<tr>
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<td>130</td>
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<td>53</td>
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<td>Project Associates</td>
<td>26</td>
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<tr>
<td>Total</td>
<td>92</td>
<td>90</td>
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<tr>
<td>Exchange of Scientists</td>
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<tr>
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<td>Training programs</td>
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<tr>
<td>Students (Doct, Tech Admin)</td>
<td>74</td>
<td>74</td>
<td>59</td>
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<tr>
<td>Apprentices</td>
<td>0</td>
<td>19</td>
<td>18</td>
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<tr>
<td>Trainees</td>
<td>40</td>
<td>31</td>
<td>32</td>
</tr>
<tr>
<td>Total</td>
<td>114</td>
<td>124</td>
<td>109</td>
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<tr>
<td>Grand Total</td>
<td>793</td>
<td>802</td>
<td>831</td>
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</tbody>
</table>

Data hrt as at 9.12.2018

Increase for LS2
Human Resources & Training (MPP)

Staff Members by Age

Staff Members by Grade and Contract Type

Data hrt as at 9.12.2018
### Human Resources & Training (MPP)

*Activities of our fellows, students and associates*

![Pie chart showing various categories and their proportions.]

<table>
<thead>
<tr>
<th>Group</th>
<th>Staff cat 2</th>
<th>FELL</th>
<th>TRNE</th>
<th>DOCT</th>
<th>TECH</th>
<th>Total in ac. training</th>
<th>Ratio ac. Training / cat 2 staff</th>
<th>PJAS</th>
<th>Ratio ac. Training + PJAS / cat 2 staff</th>
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<tbody>
<tr>
<td>ABT</td>
<td>23</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>20</td>
<td>0.87</td>
<td>1</td>
<td>0.91</td>
</tr>
<tr>
<td>CRG</td>
<td>28</td>
<td>14</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>21</td>
<td>0.75</td>
<td>4</td>
<td>0.89</td>
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<td>10</td>
<td>3</td>
<td>3</td>
<td>34</td>
<td>0.89</td>
<td>4</td>
<td>1.00</td>
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<td>16</td>
<td>6</td>
<td>5</td>
<td>10</td>
<td>37</td>
<td>1.37</td>
<td>8</td>
<td>1.67</td>
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<tr>
<td>MSC</td>
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<td>11</td>
<td>8</td>
<td>60</td>
<td>1.46</td>
<td>20</td>
<td>1.95</td>
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<tr>
<td>PPR/HDO</td>
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<td>0</td>
<td>3</td>
<td>0.50</td>
<td>0</td>
<td>0.50</td>
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<tr>
<td>VSC</td>
<td>27</td>
<td>20</td>
<td>3</td>
<td>4</td>
<td>9</td>
<td>36</td>
<td>1.33</td>
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<td>1.70</td>
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<td>190</td>
<td>106</td>
<td>41</td>
<td>28</td>
<td>36</td>
<td>211</td>
<td>1.11</td>
<td>47</td>
<td>1.36</td>
</tr>
</tbody>
</table>

Data hrt as at 9.12.2018
Human Resources & Training (MTP / MPP)

Special action towards reinforcement of Cat 3 in workshops

Data hrt as at 9.12.2018
Human Resources & Training

1558 participants - Department training budget 237 kCHF fully committed

Approx. Number of Participants by Category

- Language
- Communication
- Technical
- Leadership
- Safety
- Technical Management

Approx. Internal Training Days by Group

- ABT
- CRG
- EPC
- MPE
- MSC
- TE + PPR
- VSC

Data Learning Hub 1.12.2017 – 30.11.2018
A dynamic program... part of CERN tradition

- **19** in Electronics / Physics CFC dual (15-26 y old)
- **60%** combined with a «Maturité Pro»
- **4** completed the 4-y and **4** hired in 2018
- **Award** of the 2018 UIG Union Industrielle Genevoise

Towards promising Future... new initiatives

- Exchanges with external apprentices
- Participation in events
- Collaboration with Women in Science (WINS)

An evolving program... key for success

- Continuous update to best match Industry
- Exploring domains of opportunities @ CERN
- Continuity with major partners: HUG, CFPT HEPIA, LEM, CEP

Upgrading the Apprentice Centre (B.304)

- Up-to-date mechanical workshop*
  multipurpose room for test preparation, study and work in groups
- Complementary training/practice equipment

*Antonio Mongelluzzo (TE-VSC)
More than a film stage, a reinforced continuity in TE strategy!
Vacuum activities concentrated in b. SMA18, 101, 113, 30
B. 169: from 2017, only storage area
B. 867: only for radioactive components;
Coating: 101, 252, 181
Surface treatments and chemical analysis: 102, 118, 673, 10, 867
TE actions towards Environment Protection

Vigorous campaign in TE Powering areas

Chemical hazards

- Breath-holding chemical contamination
- Gas release and potential poisoning
- Acid-alkaline exhalation
- Toxic and carcinogenic...
TE actions towards Environment Protection

Vigorous campaign in TE Powering areas. Thanks to BEQ1, BB3 & MPS PS
TE actions towards Environment Protection

6 oil-filled transformers ready to be replaced by cast-resin technology
TE actions towards Environment Protection

Strategic support from the Chemistry Lab

Pb presence in workshops and offices

XRF (X-Ray Fluorescence)

Evaluation of Life-time Prediction Kinetic Model

$OIT_t = OIT_0 \cdot e^{-kt}$
A Future driven by worldwide forefront infrastructures!

The best infrastructures for chemical surface finishing

B.107
A Future driven by worldwide forefront infrastructures!

*New polymer Lab*

Oct 2018: move from B101  
Nov 2018: 50% connected equipment  
Dec 2018: ready for CERN-wide service with B771&B927 polylab facilities
A Future driven by worldwide forefront infrastructures!

FRESCA2 - Facility for the REception of Superconducting CAbles

B.163

Contract for cryogenic distribution system in B163 in preparation (AS Scientific UK)
Contract for 13 kA energy extraction in preparation (Secheron CH)
FRESCA 2 ready for operation: Q1/2020
A Future driven by worldwide forefront infrastructures!

Unique infrastructure complex for Superconducting magnets
A Future driven by worldwide forefront infrastructures!

Unique infrastructure complex for Superconducting magnets
A Future driven by worldwide forefront infrastructures!

Unique infrastructure complex for Superconducting magnets

Running the Present... preparing the Future!
A Future driven by worldwide forefront infrastructures!

Unique infrastructure complex for normal conducting magnets

"Running the Present... preparing the Future!"
A Future driven by worldwide forefront infrastructures!

Consolidating the Power Converter Lab & frontline tools
A Future driven by worldwide forefront infrastructures!

Unique MPE testing benches

B.272

Full operational software stack
- Validation of operational tools
- Consolidation of quench detection
- Magnet and Beam Interlock systems consolidation

"Running the Present... preparing the Future!"
A Future driven by worldwide forefront infrastructures!

One of the reference for accelerator beam vacuum
A Future driven by worldwide forefront infrastructures!

Leadership for coating technologies and associated R&D
A Future driven by worldwide forefront infrastructures!

LAr Cryoplant for Neutrino factory

600 m$^3$ LAr
7’500 tons of Lar
180 tons warm gas filtered
P < 50 ppt O$_2$ eq. ($50/10^{12}$)
A Future driven by worldwide forefront infrastructures!

Unique testing platform of SC RF cavities with beams

Helium gas storage  Liquid Nitrogen

Compressor  GHe Pumps

LN2 Phase separator

Coldbox  VB1

Flexible line between fixed box and moveable table

80m cryogenic line, EYETS

7 industrial contracts complemented with local piping, cabling, controls, installed, commissioned and operated in 2018 in the difficult and under access constraint in SPS environment
TE Perspectives
High Luminosity LHC
Review of TE contributions

"Running the Present… preparing the Future!"

High Luminosity LHC Review of TE contributions

WP Support

WP1 Project Management
WP2 Accelerator Physics & Performance
WP3 IT Magnets
WP4 Crab Cavities & RF
WP5 Cabling
WP6A Cold Powering
WP6B Warm Powering
WP7 Machine Protection
WP8 Collider-Experiment Interface
WP9 Commissions
WP10 Energy Deposition & IRE
WP11 IT I Date
WP12 Vacuum & Beam Screen
WP13 Beam Instrumentation
WP14 Beam Transfer & Kilovolts
WP15 Integration & IBE-Installation
WP16 IT String & Commissioning
WP17 Infrastructure, Logistics & Civil Engineering
WP18 Controls Technologies
WPL WP Support
High Luminosity LHC
WP6a – Superconducting links & Current leads

Industrial cabling on large-size machine

18 kA MgB₂ cable

20 kA at 18 K
High Luminosity LHC

WP6a – Superconducting links & Current leads

Precision machined heat exchanger

HTS cable connection

Warm end
High Luminosity LHC

WP3 – Short model to ultimate!

Training of QXF model MQXFS4
High Luminosity LHC
WP3 – Preparing production…

Al alloy shells

coil winding

coil pack assembly

prototype structure
High Luminosity LHC
WP11 - MBHSP107 and MBHSP109

Model MBHSP107 implements all findings and improvements from about one year of work of the 11T Task Force, and

Model MBHSP109 uses graded shims to cope with coil size and module variation

MBHSP107 and MBHSP109
• 4 to 5 quenches to nominal!
• Stable at ultimate!
High Luminosity LHC

WP11 – 11 T prototype, A race against LS2 and SM-18 shutdown!
High Luminosity LHC

WP12 - Vacuum

Thermal mechanical validation of the shielded beam screens

Prototyping and mechanical and RF tests of the deformable RF bridge
High Luminosity LHC
WP12 - Vacuum

"Running the Present… preparing the Future!"

Lower SEY results from the electronic properties of C (orbital hybridization sp²)

Lower SEY is a morphological effect
High Luminosity LHC
WP7 – Machine Protection / Energy Extraction

EE systems based on IGBTs
- Two prototype switch modules for 1kA tested
- 2kA bipolar prototype under construction

EE systems based on vacuum switches
- 2kA EE system prototype fully tested
- Type tests for 600A systems ongoing

1kA modules

Vacuum switch

2x600A system

"Running the Present... preparing the Future!"
High Luminosity LHC

WP7 – Machine Protection / Quench Detection & Protection

Universal Quench Detection System (UQDS)
Versatile system easily adaptable to various tasks reaching from sophisticated quench detection systems to high performance DAQ

Conceptual design of Coupling Loss Induced Quench protection units (CLIQ) (machine version)

First successful measurements with 11 T MBH prototype in SM18
High Luminosity LHC
Support to other WPs

ALICE LS2 Upgrade preparation – central chamber
- In-process surface treatment of Al components for final chamber
- NEG acceptance test for qualification chamber – passed.

- TCDIL collimator jaws
- TCLD jaw

Temperature: 10 K – 250 K
Measurements: SEY, ESD, TDS
High Luminosity LHC

Support to other WPs

- Skimmer shape impact on a gas jet
- BEAM GAS CURTAIN DETECTOR
- normal skimmer 3
- flat skimmer 3
- inverse skimmer 3
Think the future now
Future Circular Collider Study
Future Circular Collider
Review of TE contributions

„IO“ contributed ca. 170 pages to the 3 concise accelerator volumes FCC-ee, FCC-hh and HE-LHC.

CDR volumes

1 - PHYSICS

2 Hadron Collider Summary

3 - Hadron Collider Comprehensive

4 Lepton Collider Summary

5 - Lepton Collider Comprehensive

6 High Energy LHC Summary

7 - High Energy LHC Comprehensive

Ref to FCC-hh, HL-LHC, LHeC

Concise description of main concepts and key points

- Documents the performed studies
- Material to support the baseline concepts
- A basis for the next phase
- Highlights remaining work
- Lists alternatives

FCC Special Technologies

Beam vacuum
Magnet Cold Bone
(Eurockyl WP4)

Manufacturing Technologies

CryoPlants

Induced dynamic effects

(cryo MCPs)

Architecture for magnets & machine protection

Robotics

Beam vacuum
induced dynamic effects

Normal conducting magnets

Transverse feedback

Surface-Vacuum parameters for beam-induced effects

Beam transfer devices

Beam dumps

Beam instrumentation

High Field Magnet program

2017-2021 (signed)

2016-2019 (signed)

2018-2022 (in signature)
Future Circular Collider
Review of TE contributions

Comprising a wide range of topics ...
- Geology & civil engineering
- Integration
- Electricity distribution
- Cryogenics
- Cooling & ventilation
- Transport & handling
- Installation
- Planning & coordination
- Geodesy, survey & alignment
- Controls
- Computing
- Communications & networks
- General safety
- Access control
- Radiation protection
- Environmental protection
- Power/energy consumption
- Energy efficiency
- Operation & maintenance concepts
- Availability & reliability
- ...

FCC-hh beam screen design
Stress profile during a quench

Third beam screen prototype, tested at ANKA

Quadrupole outer chamber
Dipole inner chamber
Creating vision beyond Projects & Studies

\(a-C\) coatings as mitigation of beam-induced effects in beampipes
R&D on Technologies

Driving lines

"Running the Present… preparing the Future!"
Future Circular Collider
High Field Magnets - HTS
Future Circular Collider
SEPTA as a pillar for the future

EDM electrostatic main dipole concept.

Superconducting septa developments for the FCC: Truncated Cosine Theta (TCT, left, middle) and Super conducting Shield (SuShi, right) topologies.

Diffuser successfully installed and tested at SPS LSS2 by TE/ABT in collaboration with Wigner Institute.
Future Circular Collider

Shape Memory Alloys: from feasibility study to implementation

SMA ring coupler

- Soft/hard materials + temperature control

Integrated heating/cooling collars (remote clamping/unclamping)

- Cooling/dismounting

SMA vacuum set-ups in TDC2 (SPS North Area)

- Heating/mounting

- Thin cylindrical gasket (or copper coating)

- Martensitic enlarged cold shape

- Austenitic contracted hot shape

- N2 Gas (from Tank/Dewar)

- SMA connector

- Integrated heating/cooling collars (remote clamping/unclamping)

- SMA vacuum set-ups in TDC2 (SPS North Area)
Future Circular Collider

SC RF Cavities with coatings: Niobium IEDF in HiPIMS with +50 V positive pulse

Without positive pulse

With +50 V positive pulse

Film gets densified!
Future Circular Collider
Small beampipes and SC RF cavities by electroforming

Can we use the technology of reverse NEG chambers to manufacture a cavity?

- Surface state controlled by mandrel
- No e-beam welding required

Small Beampipe SR Facilities
Closing remarks

- Detailed evaluation of resources needs in all areas; they are allocated and getting trained
  - Unique infrastructures available and upgraded
  - TE deliverables & milestones are well defined

- Readiness for LS2, including LIU & Consolidations
  - HL-LHC contributions through WPs are on the right track

- Vigorous R&D has been launched
  - In the framework of Projects & Studies
  - And beyond, opening the path to breakthrough technologies

- Ready for Physics & looking forward to the post-LHC projects proposed by ESPP
Thanks for this amazing year…
These successes and results are YOURS, there are the fruits of your engagement, pugnacity and creativity…
BE PROUD OF THEM!

Wish you the best for the coming months.

Bonnes Fêtes!

Accelerating Science and Innovation