SPS Beam Dump Overall

Etienne Carlier on behalf of LIU-SPS Dump Upgrade Working Group

Outline

- Objectives
- Planning
- Critical Systems Status
- Individual System Test
- Documentation
- Summary
Dump Relocation Objectives

- Robust and reliable dump block for LIU beams and high-power FT beams in SPS
- Reduce ambient dose around the dump assembly and to other downstream elements
- Reduction of airborne radioactivity production
- Improve ALARA during interventions on dump system and surrounding equipment
- Decouple dump from LSS1 critical system (MKP injection kicker)
- Reduction of residual dose rate in critical LSS1 areas

The future SPS internal dump will be located in LSS5
### Dump Operational Conditions

<table>
<thead>
<tr>
<th>Beam Type</th>
<th>$E_{\text{Max}}$ [GeV]</th>
<th>Bunch Intensity [$p^+ / \text{bunch}$]</th>
<th># of bunches</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIU-SPS 80b</td>
<td>450</td>
<td>$2.43 \times 10^{11}$</td>
<td>320</td>
</tr>
<tr>
<td>HL-LHC Standard</td>
<td>450</td>
<td>$2.43 \times 10^{11}$</td>
<td>288</td>
</tr>
<tr>
<td>HL-LHC BCMS</td>
<td>450</td>
<td>$2.43 \times 10^{11}$</td>
<td>288</td>
</tr>
<tr>
<td>SPS-FT North</td>
<td>400</td>
<td>$1.40 \times 10^{10}$</td>
<td>4200</td>
</tr>
<tr>
<td>SPS-FT SHiP</td>
<td>400</td>
<td>$1.07 \times 10^{10}$</td>
<td>4200</td>
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</tbody>
</table>

### SPS super-cycles

#### FT Production (18BP - 30BP)

<table>
<thead>
<tr>
<th></th>
<th>SPS-FT</th>
<th>MD</th>
<th>SPS-FT</th>
<th>MD</th>
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</thead>
<tbody>
<tr>
<td>SHiP-6BP North-12BP</td>
<td>3BP</td>
<td></td>
<td>SHiP-6BP North-12BP</td>
<td>3BP</td>
</tr>
</tbody>
</table>

#### LHC Filling (30BP-42BP)

<table>
<thead>
<tr>
<th></th>
<th>SPS-FT</th>
<th>MD</th>
<th>HL-LHC</th>
<th>MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHiP-6BP North-12BP</td>
<td>3BP</td>
<td></td>
<td>Standard-18BP 80b-18BP BCMS-24BP</td>
<td>3BP</td>
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</tbody>
</table>

#### Most demanding super-cycle (18 BP = 21.6 s)

- SPS-FT SHiP pulse period: 7.2 s
- MD period: 3.6 s
- SPS-FT SHiP pulse period: 7.2 s
- MD period: 3.6 s

**22.1 μs, SPS-FT SHiP beam dumping**

Total average beam power in the most demanding super-cycle

\[ \sim 266 \text{ kW} \]
Internal Beam Dump - Implementation

- Single dump for all energies and beam types
- 3 vertical kickers (MKDV)
  - One upstream the QD.517 and two after
  - Fully redundant system
  - Dynamic range of 32
- 3 horizontal dilution kickers (MKDH)
  - As today
- Enlarged QFA.518 quadrupole
  - Vertical dog-leg (QD.516, QF.518, QD.519)
- Optimised MKDH & V tracking functions
  - Better use SPS apertures (QFA.518)
- Reversion of MKDH polarity
  - Improve SE beam transmission through QFA.518
  - Compatible with UA9 instrumentation in dump region

Schematic view of LSS5 with LIU-SBDS – V plane

Dump of SFTPRO on resonance QFA.518 cross section

Dump of LHC beam with 2 or 3 MKDVs
SPS Beam Dump – Integration in SPS Point 5

QD.517
QFA.518
QF.519

Dump Abutment
Dump
Dump Cooling

Vertical Kickers MKDV
Horizontal Dilution Kickers MKDH
Instrumentation BTV
Secondary Masks
Transport & Beamline Bridges
Tunnel Enlargement

LIU Workshop, 13-15 February 2019
SPS Beam Dump Overall - Etienne Carlier
• 21 months duration
• 626 tasks identified and scheduled (SBDS + others)
• Covers both LSS1 (dump removal) and LSS5 (dump installation)
• No contingency
Master Plan – Key Dates

• 1st Phase: LSS5 preparation  Deadline 31-03-2019
  • Beamline removal (half-periods 516, 517, 518 & 519)
  • De-cabling campaign (LSS5-, ECX5, LSS5+ and Tunnel eye)
  • Kicker transmission lines cabling campaign (ECA5 - LSS5-)

• 2nd Phase: Civil engineering (ECX5)  Deadline 31-12-2019
  • Removal metallic structure
  • Tunnel enlargement
  • Dump abutment
  • Transport and machine bridges

• 3rd Phase: LSS5 beamline re-installation  Deadline 07-08-2020
  • Cabling campaign
  • Hardware installation (kickers, instrumentation, dump, UA9 experiment...)
  • Vacuum closure (bake-out)
  • Dump replacement rehearsal

• 4th Phase: Individual System Tests  Deadline 20-09-2020
  • Kickers, cooling & ventilation, converters, instrumentation
## Work Packages

<table>
<thead>
<tr>
<th>No.</th>
<th>Task</th>
<th>Contact Person</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Dump, shielding and mask</td>
<td><a href="mailto:antonio.perillo-marcone@cern.ch">antonio.perillo-marcone@cern.ch</a></td>
</tr>
<tr>
<td>2</td>
<td>Civil Engineering</td>
<td><a href="mailto:stewart.mcilwraith@cern.ch">stewart.mcilwraith@cern.ch</a></td>
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<tr>
<td>3</td>
<td>Instrumentation</td>
<td><a href="mailto:lars.jensen@cern.ch">lars.jensen@cern.ch</a></td>
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<tr>
<td>4</td>
<td>Cooling and ventilation</td>
<td><a href="mailto:willy.vandenbroucke@cern.ch">willy.vandenbroucke@cern.ch</a></td>
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<tr>
<td>5</td>
<td>Power distribution</td>
<td><a href="mailto:marcin.szewczyk@cern.ch">marcin.szewczyk@cern.ch</a></td>
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<tr>
<td>6</td>
<td>Cabling</td>
<td><a href="mailto:daniel.ricci@cern.ch">daniel.ricci@cern.ch</a></td>
</tr>
<tr>
<td>7</td>
<td>Handling &amp; Transport</td>
<td><a href="mailto:jeann-louis.grenard@cern.ch">jeann-louis.grenard@cern.ch</a></td>
</tr>
<tr>
<td>8</td>
<td>Integration</td>
<td><a href="mailto:yvon.muttoni@cern.ch">yvon.muttoni@cern.ch</a></td>
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<tr>
<td>9</td>
<td>Alignment</td>
<td><a href="mailto:patrick.bestman@cern.ch">patrick.bestman@cern.ch</a></td>
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<tr>
<td>10</td>
<td>Radiation protection</td>
<td><a href="mailto:helmut.vincke@cern.ch">helmut.vincke@cern.ch</a></td>
</tr>
<tr>
<td>11</td>
<td>Fast pulsed magnets (power)</td>
<td><a href="mailto:laurent.ducimetre@cern.ch">laurent.ducimetre@cern.ch</a></td>
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<tr>
<td>12</td>
<td>Fast pulsed magnets (controls)</td>
<td><a href="mailto:pieter.van.trappen@cern.ch">pieter.van.trappen@cern.ch</a></td>
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<tr>
<td>13</td>
<td>Power converter</td>
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<tr>
<td>14</td>
<td>Machine protection</td>
<td><a href="mailto:jan.uythoven@cern.ch">jan.uythoven@cern.ch</a></td>
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<tr>
<td>15</td>
<td>Magnets</td>
<td><a href="mailto:jeremie.bauche@cern.ch">jeremie.bauche@cern.ch</a></td>
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<tr>
<td>16</td>
<td>Vacuum</td>
<td><a href="mailto:ja.ferreira@cern.ch">ja.ferreira@cern.ch</a></td>
</tr>
<tr>
<td>17</td>
<td>Experiment (UA9)</td>
<td><a href="mailto:francesca.galluccio@cern.ch">francesca.galluccio@cern.ch</a></td>
</tr>
</tbody>
</table>
Kickers: Magnets / Pulse Forming Networks

- Design done
- Prototype under test
- Last drawings almost finished
- Procurement ongoing and series assembly started

- Magnets finished, UHV accepted (1002), ready for HV tested
- Entry box components ready for assembly
- Upgrade terminating resistors: DO ready to be launched
Kickers: Transmission lines

MKDV: CLP50 coaxial cable, used in other kicker systems

MKDH: custom multi-coax 4 x 7.0L/10.4

→ Both type of cable and all connector parts delivered
→ 20 MKDV cables already installed (YETS-2018)
→ Cable trays installed in ECA5, ECX5 and LSS5-
→ 58 MKDV & 15 MKDH cables to be completed before end of March 2019
Kickers: Solid State Switch

Production

12-GTO redundant solid state switches for MKDV kicker. Mandatory to cover the required dynamic range of 32

→ 2 switches built; HV tests ongoing
→ Series components in production.
→ Series assembly not yet started

Test

1 switch tested DC at 40kV (nominal = 38 kV)
2 switches in redundant operation tested up to 26 kV (nominal = 36 kV)

→ Low voltage performance validated (rising edge at injection)
→ Few problems identified from 25 kV
No blocking issues identified.

Solution identified for the three identified failure modes

Full risk analysis ongoing (no backup solution based on existing hardware)

Reliability run will be restarted W9-2019 and completed before end of May 2019 (Deadline is LSS1 dump decommissioning)
Kickers: Integration & Controls

- Kicker platform installed in ECA5 (acceptance test completed)
- 1t crane operational (acceptance test completed)
- All infrastructure specified and installation dates defined
- Cable trays installed
- Installation started (racks, oil retention trays...)
- Fire protection implementation in ECA5 kicker platform still to be frozen (03/2019)
- Material transfer across ECA5 still to be defined (platform to elevator)

- Test of critical control components in parallel with operational system in 2018 successfully completed (Trigger synchronization, Fast Interlocking...)
- Study of SBDS arming sequence (TSU & BETS) and machine protection integration (injection inhibition) in progress
Dump Core
Single 5.0 m long absorber block for complete SPS energy range (14 - 450 GeV);

<table>
<thead>
<tr>
<th>N.</th>
<th>Material</th>
<th>Length [cm]</th>
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<tbody>
<tr>
<td>#1</td>
<td>Graphite R7550</td>
<td>440 cm</td>
</tr>
<tr>
<td>#2</td>
<td>TZM (Titanium Zirconium Moly)</td>
<td>20 cm</td>
</tr>
<tr>
<td>#3</td>
<td>Pure Tungsten</td>
<td>39 cm</td>
</tr>
<tr>
<td>#4</td>
<td>CuCr1Zr</td>
<td>1 cm</td>
</tr>
</tbody>
</table>

Survival probability factor $S$: $1.69e-07$
“$S$”: the probability that a 450 GeV proton escapes the 5.0 m absorbing blocks.

Shielding
- Innermost layer (concrete) $\rightarrow$ 50 cm;
- Second layer (cast-iron) $\rightarrow$ 1 m;
- Outermost layer (Concrete and marble) $\rightarrow$ 40/50 cm.
Multi-material external shielding:
- Cast-iron → 520 tons
- Concrete → 90 tons
- Marble → 48 tons

Cast iron first shielding ~16 tons
Dump core and vacuum chamber ~2 tons

~ mass 676 tons

Average beam power absorbed by the dump in the most demanding super-cycle

<table>
<thead>
<tr>
<th>Dump components</th>
<th>Power absorbed [kW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphite absorbing blocks</td>
<td>97</td>
</tr>
<tr>
<td>TZM blocks</td>
<td>5</td>
</tr>
<tr>
<td>Tungsten block</td>
<td>1</td>
</tr>
<tr>
<td>Copper core</td>
<td>84</td>
</tr>
<tr>
<td>Seamless vacuum tube</td>
<td>8</td>
</tr>
<tr>
<td>First shielding</td>
<td>28</td>
</tr>
<tr>
<td><strong>Absorbed power</strong></td>
<td><strong>223</strong></td>
</tr>
</tbody>
</table>
Dump, Shielding & Mask - Status

- **Production**
  - Dump core
  - Vacuum chamber and upstream & downstream chambers
  - Shielding (First and external)

- **Milestones up to installation**
  - Dump core
  - Shielding
  - Masks

- **Test and prototyping**
  - Hot Isostatic Pressing (HIP) prototypes
  - Cooling plate test bench
  - Mock-up

- **Risk analysis and mitigation measure**

→ Francois-Xavier
**Instrumentation**

Dumped 14 GeV SFTPRO beam (left).

The region to be instrumented is shaded grey

Example of an image of a beam dilution as expected to be captured by the BTV system

Instrumentation must be able to acquire dumped beam profile:

- Anytime
- Over the complete SPS energy range
- Resolution <200um both plan

→ **BTV type instrumentation**

- Scintillation Al2O3:CrO2 screen (very good sensitivity)
- Optical line + Digital camera + Shielding

- Max number of particles per dump up to 8E13p
- Number of particles seen per year up 5.88E18p

- Heat load:
  - Intensity limit of Al2O3:CrO2 → 1E13p/mm²
  - Worst case is MKD failure → 6.5E12p/mm²
Instrumentation – Vacuum Chamber

**Mechanics**
- Fixed screen
- Easy/fast replacement (screen failure case)
- Pre-alignment performed in lab

**Impedance**
- IWG meeting #22 (23-Aug-2018, indico 751383)
- The design is **supported by the IWG**.

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**Side view of the BTV chamber**

**3D view of the BTV chamber**

**Evolution of the impedance performance**

- First design
- Diameter 219mm with RF finger
- Straight closure
Instrumentation: Integration

- >17m long optical line
- Without ‘active’ optical element - only mirrors
- Camera BASLER 2448 x 2048 pixels

- Radiation limits for BASLER digital camera
  - TID < 10Gy/yr
  - Fluence < $3 \times 10^7$ cm$^{-2}$
Instrumentation - Deliverable

- Vacuum parts
  - Design: 100%
  - Fabrication: End 2019
  - Still to order: Viewports (DN250)

- Optical line
  - Mirrors: Received
  - Mechanics (supports, covers, etc...): Q2-2020

- Shielding
  - Blocks: Q2-2019
  - Assembly test in lab: 2019

- Electronics & Controls
  - Hardware: Q1-2020
  - Software – FESA: Q3-2019
  - Software – Expert: Q1-2020

- Installation: 06/2020
Vacuum - Status

- **LSS5 layout**
  - No further modifications expected (SPSLNINS0143)
  - Optimisation of vacuum sector in half-period 517 & 518 vacuum ongoing to integrate properly vertical dog-leg between QD.517 and QD.519
  - Final update of the drawing with correct grounding and vacuum flange insulation schematics ongoing
  - ECRs for post LS2 LSS1 & LSS5 layout ready for approval
  - Any modification that could rise, from now on, will have an impact on the readiness date.

- **Design**
  - Due to the latest layout modification, the last items to be designed will be completed by **June 2019**, without compromising the readiness date for production
  - All jobs needed are agreed upon and opened with EN-MME.

- **Production**
  - Drift production ongoing
  - aC coating of 15 chambers already completed
  - No showstoppers for the **December 2019** readiness date.

- **Procurement**
  - DN250 valve procurement ongoing, delivery expected in **March 2019**
  - Support under production.
Vacuum – Acceptance test

- **Acceptance tests**
  - MKDV : **February 2019** (ongoing)
  - BTV : **April/May 2020**
  - TIDVG#5 : **January 2020** (Tests will follow the same procedure as for the TIDVG#4)

- **TIDVG Bake-Out:** with core in first shielding (water for cast iron (52°C) and hot air for copper core (200°C))
  - BB5 (mock-up) : 04/2020
  - in-situ : 24/07 – 06/08/2020 (10 days)

---

<table>
<thead>
<tr>
<th>Final installation</th>
<th>22d</th>
<th>24/06/2020</th>
<th>23/07/2020</th>
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</thead>
<tbody>
<tr>
<td>Beam dump installation</td>
<td>10d</td>
<td>24/06/2020</td>
<td>07/07/2020</td>
</tr>
<tr>
<td>Close vacuum sector 533 + pumping</td>
<td>10d</td>
<td>08/07/2020</td>
<td>21/07/2020</td>
</tr>
<tr>
<td>Alignment of Beam dump</td>
<td>2d</td>
<td>22/07/2020</td>
<td>23/07/2020</td>
</tr>
<tr>
<td>Beam dump bake-out (60cm perimeter + Flashlights)</td>
<td>10d</td>
<td>24/07/2020</td>
<td>06/08/2020</td>
</tr>
<tr>
<td>Re-alignment after bake-out</td>
<td>2d</td>
<td>07/08/2020</td>
<td>10/08/2020</td>
</tr>
</tbody>
</table>
Parameters specification
- Cooling and ventilation circuits defined.
- Optimisation completed after modification of the dump vacuum chamber for air cooling instead of water cooling.
- Pending final validation.

Integration
- Location of shielded de-ionisation cartridge filter in ECX5 defined.
- Routing of ventilation ducts (ECX5 – BA5) defined
- Position of control cubicle in BB5 defined
- Actuators and sensors type and position in cooling skid defined. R2E issues solved.
- Skid integration in ECX5 in progress. Metallic support structure still to be designed.

Readiness
- Procurement process launched
- Installation dates defined (deadline in-situ dump bake-out (July 2020))
  - Cooling: March-June 2020 (On track)
  - Ventilation: April-May 2020 (On track)
Civil Engineering - Activities

Metallic structures dismantling

Dump support (2\textsuperscript{nd} phase)

Metallic structures installation (transport & beamline bridges)

Tunnel eye widening
Civil Engineering – Critical Path

Preparation

- Registration (and training) of contractor and consultant personnel ongoing
- Activity follow-up strategy defined. First technical coordination meeting 20/02
- Submission of method statement for dismantling 28/02
- First VIC mid-March
- Work to start on the 1st of April

All works are on the critical path (9 months period without contingency)
Civil Engineering - Risks

• Safety risk
  • Lead paint (presence confirmed)
  • Asbestos (low probability, testing planned)
  • Hydrocarbons (presence confirmed)
  • Radiation (pre-testing carried out, low probability)
  • Lack of firewater during dismantling phase (during 2 weeks)

• Technical risks
  • Tunnel collapse
  • Damage to concrete abutment blocks
  • Existing / new tunnel interface
  • Dust propagation
  • Late modification (downstream shielding, optical camera maintenance platform...)

• Planning risks
  • Coordination
  • Machine breakdown
  • Crane breakdown
  • Access problem
  • Slow advancement rate

Full risk analysis performed

→ Mitigation measures defined for each identified risk
Mainly driven by kicker pulsed test. Others systems in the shadow.

- Expected duration 20 weeks in total (6 phases)
- External conditions required for each phase defined

<table>
<thead>
<tr>
<th>Phase</th>
<th>Duration</th>
<th>Goal</th>
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<tbody>
<tr>
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<td>DC magnet conditioning</td>
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<td>HV circuit closure</td>
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<td>Slow interlock test</td>
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<td>6</td>
<td>Low voltage pulse test</td>
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<td>Fast interlock test</td>
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<td>Voltage increase</td>
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<td>Local Reliability Run</td>
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<td>4</td>
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<td>Remote Reliability Run</td>
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<tr>
<td>5</td>
<td>2</td>
<td>Dry Run</td>
<td>W45-2020</td>
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Summary & Outlook

- Project on tracks, but…
  - No contingency in the installation planning…
- Small technical issues still to be closed
  - Kicker Solid State Switch performance at 36 kV still to be confirmed
  - Dump cooling and ventilation functional specification to be released
- Major risk identified and mitigation measures defined
- No non-conformity identified
  - Installation of dump upstream mask planned for post LS2
- Next key-dates are the 1st of April
  - 1st of April: Start of Civil Engineering activities in ECX5
  - 1st of June: Start de-commissioning of LSS1 beam dump
- Full documentation available at https://espace.cern.ch/te-project-SBDS5-LIU-SPS-BeamDumpUpgrade
Internal Beam Dumping - Principle

- Reuse existing SBDS#1 concept
- Keep system simple and reliable
- Only two major components required (kickers & dump)
## Civil Engineering - Procurement

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<th>Status</th>
<th>Delay</th>
<th>Comments</th>
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<tbody>
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<td>Contractors personnel training</td>
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<td>All contractors personnel to complete CERN training by 19/02/19</td>
</tr>
<tr>
<td>Consultants personnel training</td>
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<td>All consultants personnel to complete CERN training by 04/04/19</td>
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<td>All material specifications, PHS received. Method statements to follow.</td>
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<td>Works to begin on 01/04/19 as previewed</td>
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### Activity Status Delay Comments

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<td>Previewed</td>
<td>No</td>
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# Civil Engineering – Safety Risks

<table>
<thead>
<tr>
<th>Subject</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lead paint</strong> (presence confirmed)</td>
<td>Modifications to steel structure paint requires:  &lt;br&gt;- PPE: Protective mask, gloves &amp; clothing  &lt;br&gt;- CPE: Dust suction at point of modification, water applied to paint  &lt;br&gt;- Environmental: Tracking of discharge</td>
</tr>
<tr>
<td><strong>Asbestos</strong> (low probability, testing planned)</td>
<td>Demolition of tunnel waterproofing would require:  &lt;br&gt;- PPE: Full body suit  &lt;br&gt;- CPE: Depressurised work zone / specific ventilation, multi-zone SAS shower installation  &lt;br&gt;- Environmental: Closed packaging &amp; tracking of discharge</td>
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<tr>
<td><strong>Hydrocarbons</strong> (presence confirmed)</td>
<td>Tunnel demolition requires:  &lt;br&gt;- PPE: protective clothing, mask, gloves, personal gas detectors  &lt;br&gt;- CPE: Zone gas detectors, extinguishers, specific ventilation  &lt;br&gt;- Environmental: Spoil tracking procedure</td>
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<td><strong>Radiation</strong> (pre-testing carried out, low probability)</td>
<td>Removal of elements from work zone:  &lt;br&gt;- 1st scan on site  &lt;br&gt;- 2nd scan in base of ECA5  &lt;br&gt;- 3rd scan passage via truck portal in Meyrin prior to discharge</td>
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<tr>
<td><strong>Lack of firewater during dismantling phase (during 2 weeks)</strong></td>
<td>Dismantling methods:  &lt;br&gt;- Plan A: Without flame or sparks  &lt;br&gt;- Plan B: With protective cell surrounding flame or sparks, extinguishers present, local water source provided</td>
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<td>Subject</td>
<td>Mitigation</td>
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<tr>
<td>Tunnel collapse</td>
<td>- Tunnel demolition previewed in multiple non-adjacent phases&lt;br&gt;- Thorough geotechnical analyses carried out prior to works to identify ground layers and risks</td>
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<tr>
<td>Damage to concrete abutment blocks</td>
<td>- Contractor mechanic to be on-call, CERN training to be completed with other Grisoni employees&lt;br&gt;- Machine inspections prior to beginning of works&lt;br&gt;- Machine specifications and service records submitted</td>
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<tr>
<td>Existing / new tunnel interface</td>
<td>- External test of waterproofing adhesion&lt;br&gt;- Stop point prior to beginning of connection works</td>
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<td>Dust protection</td>
<td>- Airtight work zone to be isolated on both sides of works</td>
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<tr>
<td>CERN modifications (downstream shielding, optical camera maintenance platform, OTHERS…???)</td>
<td>- Downstream shielding agreed by all project actors and integration model. ECR under preparation and modification to be presented to engineer / contractor.&lt;br&gt;- Modification to design of concrete blocks for dump abutment and connection to tunnel floor. No major impact for Works.&lt;br&gt;- Optical beamline maintenance platform not considered in IT documents. Cost of design and construction as yet unknown. Time for construction also unknown.</td>
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</tbody>
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## Civil Engineering – Planning Risks

<table>
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<tr>
<th>Subject</th>
<th>Mitigation</th>
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</table>
| Interface coordination           | - EN-HE contractors dedicated to CE works 100% of time  
- CE works at exactly same time as EN-HE contractor hours  
- Daily RP scanning time agreed between Grisoni and RP representatives  
- Coordinates (telephone, email) of stakeholders representing EN-HE (staff + Altéad) and SMB-SE (Staff, Grisoni, Atkins, Dekra) made available to all parties |
| Machine breakdown                | - Contractor mechanic to be on-call, CERN training to be completed with other Grisoni employees  
- Machine inspections prior to beginning of works  
- Machine specifications and service records submitted |
| Crane breakdown (ECA5 / ECX5)    | - EN-HE presence 100% of time                                                                                                                                                                             |
| Access problems through ECA5 PAD | - Mitigation measures not yet discussed                                                                                                                                                                 |
| Slow advancement rate            | - Possibility to superpose multiple activities (not preferred solution due to increased safety risks). Extra VIC to be previewed where required                                                        |
Keywords

- Review readiness prospects and critical subsystems for selected highest risk/impact systems
- Preparation planning with present status (delivery, assembly, vacuum acceptance tests, pre-tests, etc… up to readiness for installation)
- Specify IST periods and dependencies on other groups/support
- Identification of specific technical an schedule risks and mitigations