TCLMs Material and Design Options

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Introduction

Aim:
1. Reviewing of the TCLM technical requirements in order to update the functional specification EDMS 2276600
2. Design/engineering studies ongoing (Work Mandate to MME in EDMS 2681235) to optimize:
   - RP ALARA (quick plug-in, fast-connection flanges) → not discussed here
   - Costs (material/tolerances)
   - Feasibility

Could some requirements be reviewed in order to simplify the fabrication/reduce the cost?
Current design

4xTCLM5,6

LHCTCLM_0001

copper

4xTCLM4

LHCTCLM_0002

tungsten
Actual design

4xTCLM5,6

1. LHCTCLM_0001

4xTCLM4

1. LHCTCLM_0002

- Copper
- Tungsten
Motivation to trigger new studies (materials/design)

1. TCLM4,5,6: Technical/practical challenges in the Cu-SS brazing
2. TCLM4: Strict tolerances on Cu/W
3. TCLM4: High cost of W
Motivation to trigger new studies (materials/design)

1. TCLM4,5,6: Technical/practical difficulties in the Cu-SS brazing

Unconventional manufacturing-looking for design simplification, if possible:
- Two advanced techniques required to a company (EBW + brazing)
- Procedure validated at CERN requires a specific cleaning process before brazing (see EDMS 1394105)
- Attention to internal leaks and leak tightness

Possible alternatives:
- SS+Cu coating: excluded if the required thickness is above ~10μm (internal stresses)
- SS+Cu plating: not indicated in case of welding (infiltration of chemical products, acid,.. Long term potential issue)
- Explosion bonding SS-Cu (not-conventional)
- SS chamber (ok for WP10) ➔ evaluate the impact on impedance (1007mm long chamber)

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Motivation to trigger new studies (materials/design)

2. TCLM4: Strict tolerances on Cu pipe (to match the magnet aperture) and on W → difficult to achieve/expensive

- ~340kEUR for W, half of the price for machining

Proposed solution:
- Reduce the beam aperture (50.6→49mm, 60.2→58.6mm) to relax the tolerances (ok for WP10)
- Positive impact on the peak dose on the first MCBY(from 17 to 2MGy)
- evaluate the compatibility with beam size
Motivation to trigger new studies (materials/design)

3. TCLM4: High cost of W

Proposed solution:
• Decrease the outer diameter of W
  → peak losses on the first MCBY below reference case with the smaller aperture
  → Total power on the cryogenic system lower with respect to the reference case (but with smaller aperture)
• W is needed only on the outgoing beam from the IR

<table>
<thead>
<tr>
<th></th>
<th>Total power [W]</th>
</tr>
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<tbody>
<tr>
<td>REF Rout=7cm</td>
<td>31/1.2</td>
</tr>
<tr>
<td>TCLM4 B1/B2 Rout=5cm</td>
<td>38/1.4</td>
</tr>
<tr>
<td>MCBYs*</td>
<td>4.1</td>
</tr>
<tr>
<td>Q4*</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
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</tbody>
</table>

*Cold mass+beam screen

Courtesy of M. Sabate
Other ongoing studies

- Cu-W gap not compatible in terms of peak dose on the magnet
  - Studies ongoing to find a compatible solution (e.g. gap in different azimuthal position)
Conclusions

- Studies are proposed to reduce the TCLM cost and fabrication challenges:
  - Evaluate the impact of reducing the beam aperture to decrease the tolerances to make easier/less expensive manufacturing
  - Evaluate the effect of having SS beam pipe to make easier/less expensive manufacturing
  - Reduce the external diameter of W to reduce the material cost
- Some optimization has been already validated:
  - Replacing W with Cu on the incoming beam of TCLM4
Possible complication (integration P.O.V)

- Q4: WPS
- Q5: WPS + SCLink (1st picture below)
- Q6: SCLink
- SC link are not an issue if only the mask (not the support is dismount).
<table>
<thead>
<tr>
<th></th>
<th>B2 horizontal full opening</th>
<th>B2 vertical full opening</th>
<th>B1 horizontal full opening</th>
<th>B1 vertical full opening</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TCLM4</strong></td>
<td>60.2 mm</td>
<td>50.6 mm</td>
<td>50.6 mm</td>
<td>60.2 mm</td>
</tr>
<tr>
<td><strong>TCLM5/6</strong></td>
<td>46.5 mm</td>
<td>36.9 mm</td>
<td>36.9 mm</td>
<td>46.5 mm</td>
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