R2E Annual Meeting 2018

Results of Functional Radiation Tests of QPS Equipment (to be installed during LS2) at CHARM

Surbhi Mundra
On behalf of TE-MPE-EP
Contents

• QPSs for LS2
• DQLPUBv2
  • About, test setup, results, summary
• uQDS
  • About, test setup, results, summary
• Conclusions
Quench Protection Systems to be installed in LS2

<table>
<thead>
<tr>
<th>Location</th>
<th>DYPQ rack</th>
<th>RR73/RR77</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protection of</td>
<td>Main quadrupole</td>
<td>11T magnets</td>
</tr>
<tr>
<td>No. of Units</td>
<td>392 (+48)</td>
<td>4</td>
</tr>
<tr>
<td>Expected dose rate</td>
<td>&lt;1 Gy/y .. 10+ Gy/y</td>
<td>~1 Gy/y</td>
</tr>
<tr>
<td>Expected Dose</td>
<td>200 Gy</td>
<td>30 Gy</td>
</tr>
<tr>
<td>Components</td>
<td>Commercial out of the shelf (COTS),tested in PSI</td>
<td>Commercial out of the shelf (COTS), tested in PSI</td>
</tr>
</tbody>
</table>
About DQLPUBv2

Located under “A” or “C” dipoles in LHC tunnel

Expected annual dose: <1 Gy/y .. 10+ Gy/y
Target lifetime dose: 200Gy
About DQLPUBv2
DQLUBv2: Test Setup

Control room
- Swiss plug F3
- Keysight 33500B
- Ethernet
- Loop monitoring
- Interlock IN
- Interlock OUT
- HDS Control
- Labview
- NI USO6353
- DC supply HMP4040

Test room
- Swiss plug F4
- Vtap 6x2
- NE12

DUT
- VDE
- DQLIM
- DQLPUB
- Interlock IN
- Interlock OUT
- nQPS trigger
- HDS Control
- WorldFIP

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Position</th>
<th>Target Inside</th>
<th>Target Outside</th>
<th>Dose [Gy]</th>
<th>Total POT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run 1</td>
<td>“CuOOOOO”</td>
<td>10</td>
<td>2018-06-13</td>
<td>218.69</td>
<td>1.27E+16</td>
</tr>
<tr>
<td>Run 2</td>
<td>“CuOOOOO”</td>
<td>10</td>
<td>2018-06-20</td>
<td>229.25</td>
<td>1.64E+16</td>
</tr>
<tr>
<td>Run 3</td>
<td>“CuOOOOO”</td>
<td>10</td>
<td>2018-09-05</td>
<td>156.5</td>
<td>1.78E+16</td>
</tr>
<tr>
<td>Run 4</td>
<td>“CuOOOOO”</td>
<td>10</td>
<td>2018-09-12</td>
<td>197.22</td>
<td>1.47E+16</td>
</tr>
</tbody>
</table>
DQLPUBv2: Supply Monitors

Run 1 & Run 2: June’2018

- **UHDS** shows drastic change with dose over 70Gy → change of mezzanine board → small deviation in Run2
- **UPS** voltage shows constant decay through both runs
DQLPUBv2: Events Observed

Run 1 & Run 2: June’2018

1. System reset → DQAMC resets DQQDL → DQAMC resets itself → DQAMC resets DQQDL → double pulse
2. Voltage difference between Vtaps > 100mV → interlock loop opening, heater firing
3. Loss of communication detected by DQAMC → single pulse
4. Loss of communication detected by DQAMC → single pulse
5. Variation of reference voltage with radiation → change in bridge voltage → **Automatic loop opening and heater firing**
DQLPUBv2: Supply Monitors

Run 3 & Run 4: Sep’2018

- **UHDS** showed gradual degradation and stayed close to 900V (±20V) till 240 Gy
- **UPS** voltage shows slow decay through both runs
- The breaks in the data are due to unavailability of WorldFIP data.
- The pulses in the data correspond to power cycles.
DQLPUBv2: Interlock and Heater Status

Run 3 & Run 4: Sep’2018

Interlock and heater trigger status

- Open
- Close
- Fired
- Not fired

Absolute Time

00:00:00 00:00:00 00:00:00 00:00:00 00:00:00 00:00:00 00:00:00 00:00:00

Dose (Gy)

0 50 100 150 200 250 300 350 400

Interlock 1
Heater 1
Heater 2
DQLPUBv2: Test Flow

Run 1
- Variation in UHDS
- Variation in IHDS
- Single pulses
- Double pulses

Run 2
- Variation in IHDS
- Single pulses
- Double pulses

Run 3
- Variation in IHDS
- DQQDLB failure due to isolator

Run 4
- Variation in IHDS
- DQQDLB failure due to op-amp

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Position</th>
<th>Target Inside</th>
<th>Target Outside</th>
<th>Dose [Gy]</th>
<th>Total POT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run 1</td>
<td>“CuOOOO”</td>
<td>10</td>
<td>2018-06-13</td>
<td>218.69</td>
<td>1.27E+16</td>
</tr>
<tr>
<td>Run 2</td>
<td>“CuOOOO”</td>
<td>10</td>
<td>2018-06-20</td>
<td>229.25</td>
<td>1.64E+16</td>
</tr>
<tr>
<td>Run 3</td>
<td>“CuOOOO”</td>
<td>10</td>
<td>2018-09-05</td>
<td>156.5</td>
<td>1.78E+16</td>
</tr>
<tr>
<td>Run 4</td>
<td>“CuOOOO”</td>
<td>10</td>
<td>2018-09-12</td>
<td>197.22</td>
<td>1.47E+16</td>
</tr>
</tbody>
</table>
**DQLPUBv2: Summary of Performance**

- **DQAMC** survives for 100 Gy on average, then it fails due to the microFIP IC.
- **DQCSU** works at least up to 241 Gy.
- **DQQDL** performs well up to 330 Gy.
- For Run 3 and Run 4, failure of DQQD LB was attributed to failure of one digital isolator and one op-amp respectively. However,
  - 20 digital isolators used in DQLPU B unit, 1 failed out of 47 tested within Run 1-4;
  - 58 operational amplifier used in DQLPU B unit, 1 failed out of 140 tested within Run 1-4.
About UQDS

Located at RR73 / RR77

Expected annual dose: ~1 Gy/y
Target lifetime dose: 30Gy
UQDS: Test Setup

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Position</th>
<th>Target Inside</th>
<th>Target Outside</th>
<th>Dose [Gy]</th>
<th>Total POT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run 1</td>
<td>“CuOOOO”</td>
<td>10</td>
<td>2018-09-26</td>
<td>2018-10-01</td>
<td>247.7</td>
</tr>
</tbody>
</table>
UQDS: Results

Interlock and heater status

Interlocks' and heaters' status on quench
UQDS: Summary of Performance

- WorldFIP interface card stopped working at 60 Gy
- At ~100 Gy Interlock loop opened and could not be closed
- Analog channels worked well (at least) up to 130 Gy (RS485 reading was stopped at 130 Gy, unable to resume at 250 Gy)
- Power supply survived 250 Gy!

<table>
<thead>
<tr>
<th></th>
<th>26-Sep</th>
<th>27-Sep</th>
<th>28-Sep</th>
<th>29-Sep</th>
<th>30-Sep</th>
<th>01-Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>DQAMU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital Platform</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Channels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power supply 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power supply 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

- 392 DQLPUBv2 units and 4 UQDS units to be deployed in LS2
- CHARM provides radiation environment similar to LHC but at higher rate
- DQLPUBv2
  - Expected total dose is 200 Gy
  - 4 weeks of irradiation campaigns, @1.5 Gy/hr
  - Survives > 300 Gy with change of DQAMC
- UQDS
  - Expected total dose is 30 Gy
  - 1 weeks of irradiation campaigns, @1.5 Gy/hr
  - Survives > 100 Gy with change of DQAMU
  - More research on photoMOS required
Thank you!