FLASH Accelerator Studies: High Gradient, Cryo and Irradiation Measurements
## FLASH operation

685 Mev / 13.5 nm 5 Hz operation (july 2006)

<table>
<thead>
<tr>
<th>module</th>
<th>cavity</th>
<th>$E_{acq}$ [MV/m]</th>
<th>attenuator [dB]</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACC1</td>
<td>1, 2, 3, 4</td>
<td>13</td>
<td>—</td>
<td>capture section, lower gradient</td>
</tr>
<tr>
<td></td>
<td>5, 6, 8</td>
<td>20</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>14</td>
<td>3</td>
<td>too high FE</td>
</tr>
<tr>
<td>ACC2</td>
<td>3, 4, 5, 7, 8</td>
<td>19</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>quench</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>13</td>
<td>3</td>
<td>quench</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>15</td>
<td>2</td>
<td>quench</td>
</tr>
<tr>
<td>ACC3</td>
<td>1, 2, 3, 5, 8</td>
<td>18.5</td>
<td>—</td>
<td>cavity tuner problem / OFF</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>12</td>
<td>3</td>
<td>quench</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0</td>
<td></td>
<td>very high FE / OFF</td>
</tr>
<tr>
<td>ACC4</td>
<td>1 ... 8</td>
<td>20</td>
<td>—</td>
<td>limited at 23.5 MV/m</td>
</tr>
<tr>
<td>ACC5</td>
<td>1 ... 8</td>
<td>21</td>
<td>—</td>
<td>limited at 25 MV/m</td>
</tr>
</tbody>
</table>
FLASH operation

685 Mev / 13.5 nm 5 Hz operation (july 2006)
Cavities @ ACC4

Module 4

Cavity tests:
- Vertical (CW)
- Horizontal (10Hz)
- Module 4 (1Hz)
- Module 4 (5Hz)

Cavity

- 1 - C48
- 2 - S34
- 3 - AC57
- 4 - AC56
- 5 - AC55
- 6 - AC59
- 7 - Z52
- 8 - AC64

E_{ACC} [MV/m]

D.Kostin, R.Lange, B.Mukherjee, DESY.  
FLASH Seminar, October 17th, 2006
Cavities @ ACC5

Module 5

Cavity 6 is a source of a dark current of 200 nA (peak) at 25 MV/m. Radiation level measured at 1 m distance from module 5 dump side: 18 µSv/min.
$Q_0$ Measurements

new measurement august 2006
(RF calibration done)

$Q_0$ Measurements

![Graph showing $Q_0$ vs. $E_{ACC}$]
RF Coupler in the Module

- warm window
- cold window
- cavity
- module
- 70K shield
- 4K shield
RF Coupler windows temperatures

Accelerating module ACC5 high gradient test:

24 hr. at 280 kW pro coupler : 28 MV/m, 10 Hz rep.rate (cavities 6 and 8 slightly detuned)

\[ \Delta T_{70K} = 60K \text{ (from 80K to 140K) no problem for the cryo system} \]

\[ \Delta T_{300K} = 27K \text{ (from 297K to 324K) warm window cooling with dry N}_2\text{ gas must be used above 28MV/m at 10Hz rep.rate} \]
Radiation measurements

Operation mode:
1. ACC4/5 at 22.5 MV/m
2. ACC4/5 at 14/30 MV/m
rep. rate: 10 Hz.

TLD cells gamma dose measurements

Bubble detectors neutron dose measurements

Bhaskar Mukherjee, DESY
Radiation measurements

GAF chromic films gamma dose measurements

Bhaskar Mukherjee, DESY

D.Kostin, R.Lange, B.Mukherjee, DESY.  FLASH Seminar, October 17th, 2006
Conclusions

★ The last two modules, 4 and 5, fulfill the TESLA500 specifications.

★ ACC5 / module 5, tested at the repetition rate of 5 Hz was operating at the accelerating gradient of 25.5 MV/m, 500 + 800 µs full length flat-top pulse and quality factor of $1 \times 10^{10}$.

★ ACC5 10 Hz operation was done at 23 MV/m, $Q_0$ vs $E_{acc}$ curve measured with a new RF calibration and cavities 6 and 8 not completely detuned (so they contribute to the cryo losses), at 28 MV/m measured $Q_0=6.4 \times 10^9$.

★ All modules have functioned continuously during certain periods of time.

★ The beam operation done with all modules, 700 MeV was reached.

★ Irradiation measurements show the increase of the gamma dose near the dump end of the module 5 (ACC5) up to 0.3–0.5 mGy/min with accelerating gradient near and above 25 MV/m with almost no neutrons. Previous module studies showed, that cavity 6, ACC5, is a source of a dark current (field emission).