X-Band Traveling Wave Deflecting Mode Cavity

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• Motivation
• Fabrication and Testing
• Experimental Plans
Motivation

- A precise longitudinal shaping of the relativistic electron bunches is a critical requirement for the on-going and future experiments and devices:
  - FELs (the gain length exponential dependency on peak current)
  - Advanced acceleration schemes (injection into the laser and plasma acceleration devices)
  - Thomson sources (short X-ray pulse production requires longitudinal beam shaping)
  - NLC (luminosity at the interaction point is a function of peak currents)
  - X-band deflecting cavity offers unique resolution capabilities
Motivation

- **Important features:**
  - directly map the electron beam longitudinal phase-space (including sliced measurements)
  - single-shot measurements
  - can be used to calibrate non-expensive and less destructive devices
  - does not rely on any pre-assumptions about the beam current profile
  - excellent temporal resolution
Experimental Layout

- Original plan was to install XTD at ATF in sequence with “silencer” cavity.
Design Parameters

- 3-D model was developed and optimized numerically:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sqrt{Z=E_0/P^{1/2}}$</td>
<td>8.48</td>
<td>kV/mW$^{1/2}$</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.660</td>
<td>m$^{-1}$</td>
</tr>
<tr>
<td>$\nu_s/c$</td>
<td>0.0267</td>
<td>-</td>
</tr>
<tr>
<td>$E_{\text{max}}/P^{1/2}$</td>
<td>20.57</td>
<td>kV/mW$^{1/2}$</td>
</tr>
<tr>
<td>$L_{\text{TOT}}$</td>
<td>0.46</td>
<td>m</td>
</tr>
<tr>
<td>$E_{\text{max}}/P^{1/2}$</td>
<td>92</td>
<td>kV/mW$^{1/2}$</td>
</tr>
<tr>
<td>$\tau_F$</td>
<td>57</td>
<td>ns</td>
</tr>
<tr>
<td>$N_c$</td>
<td>53</td>
<td>-</td>
</tr>
<tr>
<td>$P_{\text{out}}/P_{\text{in}}$</td>
<td>0.55</td>
<td>-</td>
</tr>
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</table>
The deflector resolution was simulated to be 4 fs RMS, which is perfect for ATF compressor (~70 fs beam):

$$\Delta x_d = \omega_{RF} \Delta t \sqrt{\beta_d \beta_f} \left( \frac{e V_0}{E} \right) \sin(\Delta \psi)$$
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Manufacturing Process
Timeline

- 1st prototype built in late 2007; after QA decided to built in house;
- 2008-2009: in house manufacturing, CNC upgrade to improve surface finish, project runs out of funds;
- 2010: 2nd prototype tests, bead pull, 15 MHz red shift, debugging
- Installation at ATF – early 2011 (transfer to UCLA).

From ATF Users meeting in 2007:
- Initial design and cold test were performed during Phase I (in 2006)
- 3-D RF design of the structure is finalized
  - single cell design;
  - couplers;
  - polarization control;
  - analysis of tolerances;
  - tuning requirements.
- Engineering design is nearly complete
  - 3-D CAD drawing;
  - cooling channels design;
  - waiting for a feedback from the vendors.
- Manufacturing
  - test of the geometry distortion due to brazing is on the way;
- Installation at ATF - end of 2007
Present Manufacturing Capabilities

<table>
<thead>
<tr>
<th></th>
<th>Specified tolerances</th>
<th>Achieved Tolerances*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell diameter</td>
<td>+/- 0.0005</td>
<td>+/- 0.0002</td>
</tr>
<tr>
<td>Cell Length</td>
<td>+/- 0.0005</td>
<td>+/- 0.0002</td>
</tr>
<tr>
<td>Iris Diameter</td>
<td>+/- 0.0005</td>
<td>+/- 0.0005</td>
</tr>
<tr>
<td>Flatness</td>
<td>0.0005 inch</td>
<td>0.0002 inch</td>
</tr>
<tr>
<td>Surface Finish</td>
<td>8 micro-inch</td>
<td>4-6 micro-inch</td>
</tr>
</tbody>
</table>
RF Testing

- RF Cell Stack testing at RadiaBeam
- 2\textsuperscript{nd} prototype has been bead pull tested at SLAC
RF Test Results

- Good news after bead pull: couplers are close to perfect.
- Bad news – consistent red shift of 15-20 MHz throughout all of the RF measurements.
- Contributing factors:
  - NO filler 1.5 MHz down
  - Vacuum 1-2 MHz down
  - Humidity 1-2 MHz down
  - Mode holes shape is slightly different in the model (10 MHz)
- Compensated with 20 µm change in cells diameter, new cells are in fabrication.
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Experimental program

- Deflection cavity cross-calibration with other diagnostics:

momentum-phase mapping with the linac

CTR autocorrelation
Experimental program

- Measuring CSR effect on the longitudinal phase space of the compressed beam:
Conclusions

- RadiaBeam is developing an X-band deflecting cavity.
- Target longitudinal resolution at ATF is in femtosecond range
- Present status: in fabrication
- Commissioning will be performed by UCLA
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