Max IV Project Status Report

Pedro F. Tavares, on behalf of the Max IV Project Team
MAX IV

Short Pulse Facility

Injector LINAC

3 GeV Ring

1.5 GeV Ring

FEL (Phase II)
Facility Lay-Out

Injector LINAC

1.5 GeV Ring

3 GeV Ring
Conceptual Basis of the Max IV Design

- Scientific Case calls for high brightness radiation over a wide spectral and time range: IR to Hard R-rays, Short X-Ray Pulses.
- Need for high brightness: low emittance and optimized insertion devices.
- This is hard to achieve in a single machine:
  - higher electron beam energy → harder photons
  - lower electron beam energy → softer photons

Need to Compromise
Different machines for different uses:

- A high energy ring with ultra-low emittance for hard X-ray users.
- A low emittance low energy ring for soft radiation users.
- A LINAC based source for generating short pulses and allowing for future development of FEL source.
An integrated Solution

- Compact Magnet Design. High precision, low price. High vibration frequencies
- Full Energy Injector LINAC: Short Pulses
- Large Number of Magnets
- Small Magnet Apertures
- Wake-Fields
- Ultra Low Emittance Robust Lattice Design. High Stability. Large Momentum Aperture Low Cost
- Low RF frequency, Long Bunches
- Multi-purpose Strong Magnets
- Narrow vacuum Chambers Low Vacuum Conductance: NEG Coating
- Low Vacuum Conductance: NEG Coating
- Landau Cavities
- IBS
### Storage Rings Parameters

<table>
<thead>
<tr>
<th></th>
<th>High Energy</th>
<th>Low Energy</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>3</td>
<td>1.5</td>
<td>GeV</td>
</tr>
<tr>
<td>Average Current</td>
<td>500</td>
<td>500</td>
<td>mA</td>
</tr>
<tr>
<td>Circumference</td>
<td>528</td>
<td>96</td>
<td>m</td>
</tr>
<tr>
<td>Horizontal Emittance</td>
<td>0.23 - 0.37</td>
<td>6</td>
<td>nm rad</td>
</tr>
<tr>
<td># Straight Sections</td>
<td>20</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Length of Straight Section</td>
<td>4.8</td>
<td>3.5</td>
<td>m</td>
</tr>
<tr>
<td>Hor Beam Size</td>
<td>45</td>
<td>184</td>
<td>µm</td>
</tr>
<tr>
<td>Vert Beam Size</td>
<td>2</td>
<td>13</td>
<td>µm</td>
</tr>
<tr>
<td>Beam Lifetime</td>
<td>10</td>
<td>10</td>
<td>hours</td>
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</table>
16 Quadrupoles.
18 Sextupoles.
6 Octupoles.

5 Gradient Dipoles
2 Soft-End Dipoles (Matching Cells)
Magnets for the Max IV Rings

- Magnet Design for 3 GeV ring is completed.
- Supplier for 304 tons of ARMCO steel for all magnets in MAX IV selected.
- Call for tender for Magnet manufacturing.
- Prototype Magnet Block built and undergoing tests since June 2010.
Concrete girder, $f_{\text{res}} > 100$ Hz (elevated floor)
Integrated quad + sext + oct + graded dipole
Integrated design incl pre-wiring, water manifolds etc
MAX IV 3 GeV End Cell

Diagram showing various components such as Sext, BPM, Corr, Dip, QD, QF, Oct, Soft End, and Corr.
## Prototype 3 GeV Ring Magnet Block

Several Magnets Machined out of a Single Solid Iron Block

<table>
<thead>
<tr>
<th>Field</th>
<th>0.52</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradient</td>
<td>8.6</td>
<td>T/m</td>
</tr>
<tr>
<td>Gap (pole center)</td>
<td>28</td>
<td>mm</td>
</tr>
<tr>
<td>Good Field Region</td>
<td>-12.5 to +15</td>
<td>mm</td>
</tr>
<tr>
<td>Number</td>
<td>100 + 40</td>
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</table>
Vacuum Systems

- Copper chambers, extensive use of NEG coating
- Detailed Design in Progress at ALBA.
- Procurement for chambers: early 2011
3 GeV Ring RF System

- Cavity specs finalized. Procurement started.
- Low Level RF System Design done at ALBA
- Prototype Work on Landau Cavity started
Hardware Subsystems

✓ Digital Commercial Board: cPCI with 8ADCs, 8DACs and FPGA for Loops and 16 ADCs and FPGA for Diagnostics.
✓ Analog Front End for Upconversion (DC to RF)
✓ Local Timing System: 75MHz digital clock synchronized with General Timing System (10MHz)
Vibration Studies on Max IV site

XVIII ESLS, Trieste Nov. 2010..
• Top-up shots into both rings every few minutes, for a few seconds @ 10 Hz.
• In between top-ups, deliver beam to Short Pulse Facility at 100 Hz.
• Low Level RF must provide the flexibility for fast mode changes
• Significant RF power redundancy (max on crest Energy is 3.7 GeV)–high reliability.

MAX IV Injector LINAC Parameters

<table>
<thead>
<tr>
<th></th>
<th>Injection into HE Ring</th>
<th>Injection Low Energy Ring</th>
<th>Short Pulse Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy</strong></td>
<td>3</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td><strong>Charge per Pulse</strong></td>
<td>300</td>
<td>300</td>
<td>100</td>
</tr>
<tr>
<td><strong>Time Structure</strong></td>
<td>3 S Band Bunches @ 10 Hz</td>
<td>3 S Band Bunches @ 10 Hz</td>
<td>1 S Band Bunch @ 100 Hz</td>
</tr>
<tr>
<td><strong>Normalized Emittance</strong></td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td><strong>Pulse Length</strong></td>
<td>660</td>
<td>660</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Structures</strong></td>
<td>Sband, Travelling Wave, Warm</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Electron Source</strong></td>
<td>Photo Cathode RF Gun</td>
<td></td>
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</tr>
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</table>
Modular RF System

Linac Module (18 of them)

1 35 MW klystron
1 Pair of SLED cavities
2 pcs 5 m linac structures

20 MV/m max gradient
Max dutyfactor 0.001
Solid state modulators
=> variable pulse length
Recent LINAC events

- Detailed Optics design review in collaboration with Daresbury Lab.
- Accelerating Structures Contract Signed Oct. 2010
- Supplier for RF Units (Modulator + Klystrons) defined. Contract to be signed soon.
- Gun Test Stand under construction
- Gun Sled Cavity and Solenoid Delivered.
- Gun Laser Contracted signed – delivery in 2011.
Recent Events

• Detailed Design Report Completed and Presented at the First Machine Advisory Committee Meeting (September 2010)

• Committee Members: (L. Rivkin (PSI), P. Kuske (BESSY), K. Balewsky (DESY), S. P. Møller (ISA), M. Cornacchia (SLAC)

• Committee considered MAX IV an innovative and daring project and concluded that

  ..DDR has addressed all the issues relevant to achieving the performance goals...tolerance requirements...are demanding but not beyond what is reachable...
Recent Events (cont.)

- March 2010: Building Contract Signed
- September 2010: Swedish Research Council approves release of 1 BSEK for the machine construction + 25 years operational budget.
- September 2010: Four proposals for the building design have been presented by competing companies.
- October 2010: Wallenberg foundation announced 450 MSEK for funding of beamlines.
- November 22, 2010: Groundbreaking ceremony.
C Recommendations: Machine Design

- Further studies on collective effects.
- Further studies on effects of insertion devices.
- Further investigations on diagnostic needs.
- Implications of Max III experience for the Max IV design concerning the quality of the magnets.

- Detailed Design Report continues to be updated.
- Detailed Engineering Design of Components is under way.
- Prototype Work is on-going.