Upgrade of the CSC Endcap Muon Port Card with Spartan-6 FPGA

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- Track Finder crate in the counting room
- Peripheral crate on iron disk (one out of 60)
- FED crate in the counting room (one out of 4)

- TTC Optical Fibers
- Four LVDS links to Global Muon Trigger
- Trigger optical links (3 out of 180)
- DAQ optical link (one out of 468)

- Skewclear copper cables to peripheral crates (10 or 12 per chamber)

- Cathode Strip Chamber (one out of 468)

- LVDB ALCT

- SLINK64 to CMS DAQ
MPC Upgrade Requirements

- Be able to deliver all 18 trigger primitives from the EMU peripheral crate to the upgraded Sector Processor (currently, only 3 LCTs out of 18 are delivered)
- Preserve sorting capabilities of the Muon Port Card
- Preserve 3 “old” 1.6Gbps optical links to the present CSC Track Finder
Upgrade Developments

- Use existing Muon Port Card main board
  - TMB interface remains unchanged
     (2 LCTs per TMB @ 80MHz)
  - 3 “old” optical links are still available
- First prototype (2010-2011) was based on Virtex-5 FPGA
  - Expensive FPGA ($1610)
  - 12 external TLK2501 serializers
  - High power consumption
  - 2.4Gbps/channel data rate
  - one SNAP12 optical transmitter
- Second prototype (2012) is based on Spartan-6 FPGA
  - Inexpensive FPGA ($280)
  - 8 embedded GTP serializers
  - 3.2Gbps/channel data rate
  - Modest power consumption
  - one SNAP12 optical transmitter
Spartan-6 Mezzanine
Old And New Mezzanines Installed

Three Spartan-6 mezzanines are installed on a spare production MPC boards; two of them are equipped with optical transmitter.

Ran PRBS and FPGA-to-FPGA data transmission tests with SP10 VME Receiver at the University of Florida in April.

Board 1:
- 2 channels out of 8 failed… soldering issue… fixed later.
- On remaining 6 channels:
  - PRBS test OK, BER < $10^{-13}$ per channel (>100 m fiber).
  - Random data patterns from FPGA to FPGA: ~66K iterations, 510 words each; no errors.

Board 2:
- All 8 channels OK.
  - PRBS transmission OK.
  - Random data patterns from FPGA to FPGA: 1K iterations, 510 words each; no errors.

Tested with 9 TMBs in the peripheral crate; same “safe window” as production board.
Latency Measurements

■ Present MPC-to-SP system at CMS: 580 ns
  - TLK2501 Transmitter (1.6Gbps - 80MHz)
    ~23 ns
  - 100 m optical MMF fiber
    ~500 ns
  - TLK2501 Receiver (1.6Gbps - 80MHz)
    ~57 ns

■ New system (prototypes): 589 ns
  - Spartan-6 GTP Transmitter (3.2Gbps – 160MHz)
    ~20 ns (without Tx buffer, measured)
  - 100 m optical MMF fiber
    ~500 ns
  - Virtex-6 GTX receiver (3.2Gbps – 160MHz)
    ~69 ns (without Rx buffer, estimate)
Other Measurements

<table>
<thead>
<tr>
<th>Clock source</th>
<th>Compression</th>
<th>Configuration time, milliseconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPGA internal 26MHz</td>
<td>No</td>
<td>153 ms (worst case 163 ms)</td>
</tr>
<tr>
<td>FPGA internal 26MHz</td>
<td>Yes</td>
<td>115 (worst case 163 ms)</td>
</tr>
<tr>
<td>External USERCLK 32MHz</td>
<td>Yes</td>
<td>100 (worst case 132 ms)</td>
</tr>
<tr>
<td>External USERCLK 40MHz</td>
<td>Yes</td>
<td>80 (worst case 106 ns)</td>
</tr>
</tbody>
</table>

- **Power consumption:**
  - Spartan-6 FPGA
    - ~1A Vccint (1.2V)
    - ~0.15A Vccaux+Vcco (3.3V)
    - ~0.8A GTPs (1.2V)
  - MPC (main board + Spartan-6 mezzanine)
    - <4A @ 3.3V
Irradiation Test of Spartan-6 FPGA

- Planned for summer 2012
### Production Cost Estimate

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spartan-6 Mezzanine</td>
<td>$280</td>
</tr>
<tr>
<td>FPGA</td>
<td>$280</td>
</tr>
<tr>
<td>SNAP12 Transmitter</td>
<td>$500</td>
</tr>
<tr>
<td>Other components</td>
<td>$300</td>
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<tr>
<td>Fabrication and Assembly</td>
<td>$400</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1,480</strong></td>
</tr>
</tbody>
</table>

- Optical cable with 12 fibers, 100 m - $429
- Will need 80 mezzanines and 120 optical cables (including one spare per peripheral crate)
MPC Upgrade Plans

- Continue testing of the existing Spartan-6 and SP10 prototypes
  - test stands at Rice and UF for firmware and hardware developments
  - have 2 Muon Port Cards with new Spartan-6 mezzanines and one SP10 board with Virtex-6 receiver
  - continue data transmission tests at UF in April-May
- Proceed with the Spartan-6 pre-production prototype design
  - replace connector to optical plug-in card with more reliable
  - minor schematic and layout fixes
  - complete schematic in September-October
  - produce and test 3 prototypes by December 2012
- Production and Installation
  - integration tests with the new uTCA SP board in the 1st half of 2013
  - fabrication and tests of 80 mezzanine boards – 2nd half of 2013
  - equip all MPC boards with new mezzanines, re-work front panels, re-test boards – end 2013 - early 2014
  - install at CMS – spring 2014