Trigger and Readout System for Straw Tubes Detectors

Grzegorz Korczył (grzegorz.korczył@gmail.com)
International PhD Studies in Applied Nuclear Physics and Innovative Technologies UJ, Kraków
Plan

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2. Simplified readout setup
3. Triggering HPTDC
4. Data structure
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6. HLD files
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Full Readout Setup

- Expandable up to 16 data sources
- GbE (50MBps) uplink to Event Build

TRBv2
- 4 HPTDC x 32 channels
- 2Gbps optical link

Triggering controlled by CTS Addon
- Triggered from external source
- Multiple trigger inputs gating
- Self trigger at specified rate

Rates in idle state (1x TRB, 1xTDC):
- Trigger: 135kHz
- Uplink: 25MBps
Simplified Readout Setup

- 4 HPTDC x 32 channels
- FE (8MBps) uplink to Event Builder

- Needs external trigger source

- Rates
  - Trigger: 160kHz (theoretical)
  - Uplink: 8MBps
Triggering HPTDC

- External trigger input on TRBv2
- Signal connected to each TDC on 32nd channel and treated as reference time
- TDC triggered with a configurable delay (0xc0 [31;24])
- File configurable parameters

- Asynchronous trigger

- „Triggerless”
Data Structure

- **“Full” setup**
  - Collects and encapsulates data on several levels
  - Addressing needed
  - Deeper unpacking needed
  - Larger overhead:
    - Minimal empty event:
      - 40B Queue headers
      - 16B Subevent headers
      - 12B HUB headers
      - 8B + 4 (8B + n*8B) TDC headers + data (single)
      - 8B + 4 (8B + n*4B) TDC headers + data (pairing mode)
      - = 108B
    - Addition from CTS ~20B

- **“Simplified” setup**
  - Data comes from only one source
  - Smaller overhead:
    - Minimal empty event:
      - 8B Endpoint headers
      - 8B + 4 (8B + n*8B) TDC headers + data (single edge)
      - 8B + 4 (8B + n*4B) TDC headers + data (pairing mode)
      - = 48B
TRBv3

Key features:
- 4x Lattice ECP3 70
- 1x Lattice ECP3 150
- 4x SFP
  - 2x GbE duplex links
  - 2x TrbNet links
- 4x 156 pin connectors with power supp
  - Input lines for TDC-in-FPGA
  - Connectors to small Addon Boards
- 1x regular Addon connector

TDC in FPGA
- ~ 6ps time resolution
- 17ps in Hi-Res mode by HPTDC

- Configurable number of TDC channels
- Extendable number of data transmitters
HLD File

- Binary file with saved events
- Subevents structure
- Tools:
  - Daq_anal – decodes data to ASCII
  - HYDRA – heavyweight framework for full unpacking
  - Unpackers – lightweight ROOT library unpacker

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Unpacker

- Independent C++ software
  - Few source files and MakeFile needed to compile
- Designed as ROOT library to be loaded at startup
- Creates ROOT structures from HLD files

Current limitations (but not hard to solve!):
- Decodes only TDC data from TRBv2 subevents
- Can decode data from one endpoint at a time
Unpacker Structure

- **Unpacker**
  - Prepares ROOT tree
  - Iterates through all events in the file
  - Creates and executes HLDEvents
  - Fills the tree with decoded events

- **HLDEvent**
  - Contains
    - Information about event
    - List of Hits
  - Filters out event from specified endpoint
  - Decodes TDS data
  - Creates Hit objects

- **Hit**
  - Contains:
    - TDC number
    - Channel
    - Leading time
    - Trailing time / Width (mode dependent)
Running the Unpacker

- **Compilation:**
  - Simply make
  - No other dependencies
  - Creates `libunpacker.so`

- **Load library to ROOT:**
  - Start ROOT from a directory with `rootlogon.c` file
  - `gSystem->Load("path/to/unpacker/libunpacker.so");`

- **Call the Unpacker:**
  - Create an instance of Unpacker
  - `Unpacker(const char* hld, Int_t nEvt, Int_t subEvtId, Int_t refChannel)`
Running the unpacker

[Image of a ROOT Object Browser window showing the contents of a ROOT file]

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Running the Unpacker
Running the unpacker

```
<table>
<thead>
<tr>
<th>event.Hits.channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>95</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>105</td>
</tr>
<tr>
<td>110</td>
</tr>
<tr>
<td>115</td>
</tr>
<tr>
<td>120</td>
</tr>
<tr>
<td>125</td>
</tr>
</tbody>
</table>
```

<table>
<thead>
<tr>
<th>htemp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entries</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>RMS</td>
</tr>
<tr>
<td>128363</td>
</tr>
<tr>
<td>110.8</td>
</tr>
<tr>
<td>11.85</td>
</tr>
</tbody>
</table>