R&D for PID front-end electronics

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Agenda

• R&D for PID testbed:
  – Fast focusing DIRC (~450 channels)
• Waveform sampling:
  – BLAB2 ASIC
• Fiber-optic DAQ
  – Initially cPCI
• Feature extraction
  – DSP prototype plans

Orsay SuperB Meeting 16-FEB-09
Focusing DIRC Prototype (T-492)

Beam spot: $\sigma < 1\text{mm}$

Lead glass:
- Correction off: $\sigma = 10.4\text{mrad}$
- Correction on: $\sigma = 6.9\text{mrad}$

Local START time: $\sigma \sim 36\text{ps}$

Scintillator counter (MCP-PMT)
- Quartz counter (MCP-PMT)
- Hodoscope (scint. fibers)

10 GeV electrons

Beam Pipe

Hodoscope (scint. fibers)
Test results: timing slot 7, pad 15 to Philips slot 1&6 for run 27, pos 1, direct photons

\( \sigma \approx 170 \text{ps} \) (close neighbor in hit plane)

\( \sigma \approx 240 \text{ps} \) (symmetry partner in hit plane)

\( \sigma \approx 275 \text{ps} \)

Decided to upgrade all channels to new BLAB electronics
Fast Focusing DIRC $\rightarrow$ to Bldg. 121

- **LCLS Operations**
  - Parasitic running possible, but
  - Rad safety system in ESA

- **Move to nice cosmic stand**
  - 1 mrad resolution
  - Precision timing and further studies w/ new electronics

1.6GeV/c $P_{\text{min}}$ through range stack
Instrument with BLAB ASICs

- Comparable performance to best CFD + HPTDC
- MUCH lower power, no need for huge cable plant!
- Using full samples significantly reduces the impact of noise
- Photodetector limited

BLAB1 -- NIM A591 (2008) 534

6.4 ps RMS (4.5ps single)

Accepted NIM, arXiv:0805.2225
Highly Integrated Readout

- Buffered LABRADOR

**TABLE II: BLAB2 ASIC Specifications.**

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photodetector Input Channels</td>
<td>16</td>
</tr>
<tr>
<td>Linear sampling arrays/channel</td>
<td>6</td>
</tr>
<tr>
<td>Storage cells/linear array</td>
<td>512</td>
</tr>
<tr>
<td>Sampling speed (Giga-samples/s)</td>
<td>2.0 - 10.0</td>
</tr>
<tr>
<td>Outputs (Wilkinson)</td>
<td>32</td>
</tr>
</tbody>
</table>

HPK H-8500 Readout basis for this next step
Original (just amps [custom CFD]+CAMAC ADC/TDC)

Different size PMTs placed up against window (will replace g-10 with 7 H-8500 size cut-outs)
PID Readout Testbed: waveform sampler → cPCI
The building blocks
Readout System Components

- Up to 8x64 channels per cPCI card
- Very portable DAQ
- Up to 3,584 channels/cPCI crate

Very cost effective, probably ATCA used in actual SuperB (?)
New readout system

128 Channels readout

All fibers routed for 7x 64 channels (448 total)

Black cables for only 16 channels old amplifiers
New CAMAC Readout Working, BLABs Undergoing timing Calibration

Complete Installation [Mar 22]

Experience with running 448 channels of readout

Single p.e. signal
Fast Feature Extraction

Assume:
100kHz singles per pixel

150kHz trigger rate
200ns trigger window (2% occup.)
Each 64-chan PMT has ~200k hits/s
Each hit = 32 samples * 12bits = 384bits
⇒ ~77Mbits/s
(link is 2.5Gb/s ~ x10 margin)
[perhaps 2x PMT/link]

BlackFin DSP
• Pedestal subtract
• Feature extract → T, Q
(tentatively allow up to 8x hits in 200ns)
• Time = 2Bytes, Q = 2Bytes

1k PMT * 1.28 hit typ * 4By = 5.12kB/event

Estimate 1.5us/hit processing time,
To be evaluated
Prototype Data feature extraction card

- 4x fiber pairs/FINESSE
- 2x dual Shark DSP/FINESSE
- Equivalent of PMC slot for ATCA?
- 64k total system channels
- ~32 9U sized cards?

FPGA
2x BlackFin DSP
RAM (cal consts.)

Fiber Tx/Rx
Summary

• 448 channel BLAB2-based readout system being commissioned for fast focusing DIRC test stand

• BLAB3 (improved amp, deeper buffering) ASIC under design

• Lessons from current operation already valuable

• Demonstrate fast feature extraction

• Benchmark performance for TDR
Back-up slides
Focusing DIRC Prototype Optics

- **Radiator:**
  - 1.7 cm thick, 3.5 cm wide, 3.7 m long fused silica bar (spares from BABAR DIRC).
- **Optical expansion region:**
  - filled with a mineral oil to match the fused silica refraction index (KamLand oil).
  - include optical fiber for the electronics calibration (PiLas laser diode).
- **Focusing optics:**
  - a spherical mirror with 49cm focal length focuses photons onto a detector plane.
Test setup in the cosmic ray telescope