Setting up SCT Links

- Data Links
- TTC Links
- Timing in detector
- Monitoring bit errors
Data Links

• Can adjust
  – VCSEL current,
  – Receiver threshold (this is a DC coupled link)
  – Timing wrt receiver electronics (ie phase of local copy of 40 MHz clock).

• In practice set VCSEL current to 10 mA and only change if required (radiation damage).
RX threshold/Phase

- 2D scan using clock/2 mode of FE module ie i/p 40 MHz clock ➔ o/p 20

- Green 50% “1” ➔ good region

- Set delay to be away from black strip ie edge

Injection Delay

RX Threshold divided by 10

0 5 10 15 20

ST_RX_DELAY

0 5 10 15 20

Clock Delay

RX Threshold divided by 10

0 5 10 15 20

ST_RX_DELAY

0 5 10 15 20

St. 20951491.0.20220170200123_2i

Triggers

1220951491.0.20220170200123_2ii

Toi

1220951491.0.20220170200123_2iii

4000

3500

3000

2500

2000

1500

1000

500

0

1220951491.0.20220170200123_2iv
RX Threshold

- Still need separate RX threshold scan using burst data because of non-balanced code

Send burst of fixed data pattern

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RX threshold

- Slow-turn on channels

Small effect of slow turn-on

Very bad channel

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TX Links

• Uses BiPhase Mark (BPM) encoding → balanced code.
• To set-up links only parameter to adjust is VCSEL current (pin bias set to 6V don’t adjust until needed by radiation damage).
  – Just set to default 10 mA and leave it until required (radiation damage for p-i-n diodes).
  – Check that p-i-n current I_{pin} is reasonable.
• Links with balanced codes much easier to set-up and operate!
Mark: Space Ratio Adjustment

- Non 50:50 MSR $\rightarrow$ jitter in recovered 40 MHz clock $\rightarrow$ Need to adjust MSR.

Both edges used to recover 40 MHz clock
MSR Optimisation

- Use modules in clock/2 mode, look at returned data.
  - Use chains of inverters to stretch pulse. MSR register settable from s/w.
  - Set MSR value
  - Scan receiver phase ➔ measure duty cycle of received clock.
  - Flip phase of BPM signal (send data “1”) and repeat scan.
MSR Scans

Use clock delay scan to measure duty cycle before and after flip

Plot asymmetry vs MSR

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ATLAS/CMS Opto wg September '08
MSR Summary

• Scans work:
  – 2 links see same BPM signal agree on optimal MSR register value.

• Still need more work to optimise this scan
  – Finer steps in MSR values
  – Finer scan of phase using 40 ps steps instead of 1ns steps.

• BPM ok for SCT operation (RMS jitter < 1 ns) but difficult to achieve a very low jitter recovered clock ➔ eg don’t use 160 MHz BPM signal ➔ 3.2 Gbits/s clock.
Timing Adjustment

• Need to trigger on correct BC!
• Need to set clock delay accurately to optimise detector efficiency.
• Can adjust
  – L1 trigger signal in units of 25 ns
  – BC clock fine delay in units of 0.35 ns
• Set-up timing with dead reckoning and verify/scan with beam.
Dead Reckoning

• Measure propagation delays in cables/chips from trigger o/p to o/p of BPM-12 chip.
• Measure propagation times in fibre cables.
  – Very simple system used: send pulse down one fibre in a ribbon and connect a “reflector ribbon” at the other end to send the light back. Used optical probe/digital scope to measure propagation delay.
• Calculate propagation times for short lengths of on-detector fibres.
• Correct for time of flight for particles from vertex to detector modules.
Trigger Timing with Cosmics

Look at number of coincidences between chip hits from two sides of modules

Vary time delay, find maximum coincidences

Dead reckoning was correct!

SR1 Cosmics

Peak at 0

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ATL
M6 timing in for pit cosmics

- Scintillator trigger
- Threshold: 1.2 fC
- Cosmics mode: 3 BC + level hit
- Each ROS samples 1/4 barrel
- Pause/resume to change BOC delay
- Plot # coincidence hits vs event

run 42135 (initial delay 22)
  pause at event 450
  delay += 3 (25)
  pause at event 860
  delay -= 6 (19)
  pause at event 1300
  delay -= 3 (16)
  pause at 1680
  delay += 4 (20)
  pause at 2370
  delay += 1 (21)
stop run 42135 after ~ 2675 trigs
conclude that 20 is the optimal offset
Timing from 1 event: beam splash

- Coincident hits from single beam splash event (10/9/08)
- Time bits → adjust by 2 clock cycles
- Coarse timing can (almost) be set with only 1 event!

Most hits are 001
Should be mix of 010 and 011

Time bin bits
Cosmic Fine Delay Scans

- SR1 Cosmic scans
- Used trigger scintillator ➔ timing
- Measure module hit efficiency versus trigger time.
- Readout if hit in 3 time bins but record bit time pattern.
Fine Delay With Beam

- Set fine-delays to calculated values.
- Scan fine delay and measure module hit efficiencies.
- Make adjustments in groups of 12 modules as we use 12 way ribbons.
- Needs 5000 tracks $\Rightarrow$ 17000 min bias events $\Rightarrow$ $\sim$ 2 hours to perform scan.
- Should be very stable?
Monitoring Link Errors

• Data pattern has some fixed bits (preamble, part of header and trailer).
• Send 8 LSBs of L1 and 4 of BC to module, compare with full L1 and BC in ROD.
• See few modules with L1 and BC errors but not fixed run to run…under investigation.
• Can monitor BER in-situ.
Summary

• Can set up data and TTC links but DC coupled links much more difficult than
  Can optimise MSR for BPM signals to get low enough clock jitter but small jitter will remain.
  • Timing adjustments ok.
  • BER can be monitored in-situ.