Trigger/Timing Logic Unit (TLU) and EUTelescope
Outline

• Rolling Shutter Sensors and Triggered Readout
  – Why?
  – How?

• EUDET TLU Hardware

• Triggering Modes
  – Trigger/Busy
  – Trigger/Busy/Data

• Software (EUDAQ)
  – TLUProducer
  – TLUControl
Rolling Shutter Sensors

- MIMOSAxx MAPS, used in EUDET and AIDA pixel beam-telescope
- Not really triggered.....
- Continuously sensitive
- Read-out continuously from one side of sensor to other
Rolling Shutter with Trigger

• Rolling-shutter sensors aren't triggered.
• EUDET/AIDA telescope has a trigger.
• Why?
• Telescope operates with other devices.
  – Often these do require a trigger to sample data (e.g. LHC sensors)
  – Will (almost) always have different clock-rate/frame rate. Need to correlate data.
Rolling Shutter with Trigger

• Produce a trigger from scintillation detectors in beam
• Know that a particle has passed through telescope, but not which side of rolling shutter.
• ... so read out two frames for each trigger.
• Use the (simplest) approach of one trigger = one event = one pair of frames.
Rolling Shutter with Trigger

- For example, assume a particle passes through the sensor when frame-\(N\) is being read out.
- If in position “A” will be in frame \(N\)
- If in position “B” will be in frame \(N+1\)
To enforce only one trigger per frame, readout sets veto until a pair of frames has been read out:
EUDET JRA1 TLU Hardware

• Designed to give a simple but flexible interface to trigger/timing signals at EUDET JRA1 beam-telescope

• Produces triggers from beam scintillators.

• EUDET-Memo-2009-4
EUDET JRA1 TLU Hardware

- FPGA configuration is loaded every time TLU starts
- Outgoing trigger has fixed latency w.r.t. Scintillator triggers
- Can provide clock, but usually asynchronous trigger/busy handshake
EUDET TLU Hardware Signals

- **TLU 0.2c** has six DUT interfaces.
  - Four can be switched between RJ45 and LEMO (two with TTL, two with NIM levels). Two RJ45 only.

- **RJ45 connectors have four signals**
  - Trigger (TLU->DUT)
  - Busy (DUT->TLU)
  - DUT-Clock (DUT->TLU)
  - Reset (TLU->DUT. Not normally used)
JRA1 TLU Interface

• Different triggering modes:
  – Trigger-Busy handshake
    
    \[\text{Trigger} \quad \text{Busy} \quad \text{Trigger–Clock}\]
  
  – Trigger Data handshake
    
    \[\text{D0} \quad \text{D1} \quad \text{D2} \quad \ldots \quad \text{Dn} \quad \text{Trigger} \quad \text{Busy} \quad \text{Trigger–Clock}\]
JRA1 TLU Interface

- Trigger-Busy+Data handshake protects against telescope and device-under-test becoming de-synchronized.
- Trigger number can be read out for each event.
- N.B. The DUT controls if trigger-number is read out.
JRA1 TLU Interface

- Triggers can be vetoed by DUT raising TRIGGER_CLOCK line.
  - Can be combined with simple trigger/busy handshake for “dead-time free” readouts that send a continuous stream of data.
  - Send “buffer almost full” signal.

- Time-stamp stored for each trigger.
EUDET TLU Hardware Signals

• For RJ45 connections, use screened (e.g. Cat-6) cables.
  – Signals not “DC-balanced”, so unlike Ethernet can't use magnetic/capacitive rejection of common mode signals.
TLU Readout Software

- EUDET TLU communicates to host-PC using USB 2.0
- Records a time-stamp for each trigger issued.
- TLUProducer.exe runs with EUDAQ and controls TLU (loading firmware, trigger configuration, starts triggers, stops triggers, controls internal triggers)
- To run TLU stand-alone use TLUControl.exe (no interface to EUDAQ)