

1. Front-End-Electronics

1.1 Overview

The SciFi Front-End-Electronics (FE) sub-system is part of the SciFi DAQ system. It is interconnected to the SciFi back-end system (BE, aka TELL40). The DAQ system is split into two geographical partitions: DAQ_A and DAQ_C, hence sub-divided into FE_A and FE_C as shown in figure 1. The FE is mounted on the frame and connected by flex cables to the silicon photo multiplier's (SiPM). This basic unit, known as Read Out Box (ROB), is the connecting point between detector and outside world and consists of two ½ROBs.

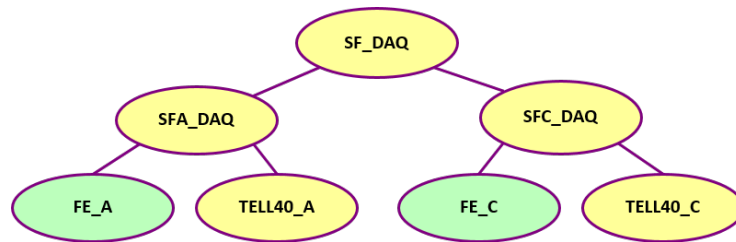


Figure 1: SciFi DAQ layout

A ½ROB is the final part of the FE-chain to be controlled, hence it acts as the Device Unit (DU) of the FE sub-system. It contains a Master-board, 4 Cluster-boards and 4 PACIFIC-boards. The Master GBTX chip of the Master-board is connected by a fiber, known as the *control link* (blue), to a SOL40 board in order to provide a bi-directional connection to control and monitor the ½ROB. Figure 2 shows the connection diagram, including the 8 unidirectional *data link* fibers (red) to the TELL40, which are used for the physics data.

A dedicated PCI Express board is developed called the **PCIe40**. Its functionality is defined by the firmware of the FPGA mounted on it. It will be either a SOL40 for the controls of the FE or a TELL40 for the back-end data acquisition. Each PCIe40 board has 48 optical link connectors, which implies that it can either control and monitor 48 ½ROBs or readout the data of (48/8) 6 ½ROBs.

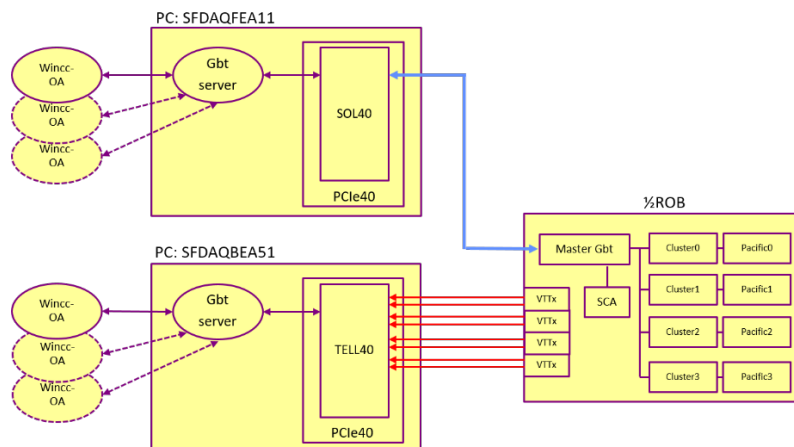


Figure 2: Control flow of a ½ROB

It is foreseen that only **one** PCIe40 board will be installed on a (Linux) PC. For the connection to the PCIe40 board (either SOL40 or TELL40) a Gbt-server is adapted. It provides connectivity, using DIM, between a client (for the FE one or more WinCC-OA projects) and in case of FE to the SOL40 and further on to the ½ROB and its hardware consisting of numerous GBTX chips, SCA chips and FPGA's mounted on the Master, Cluster and PACIFIC-boards.

1.2 Layout

The layout of the SciFi sub-detector is shown in figure 3. Based on this scheme the following numbers and naming scheme are envisaged:

- T = Station [1,2,3]¹
- L = Layer [0-3]
- Q = Quadrant [0-3]
- M = Module, T_{1,2}[0-4], T₃[0-5]

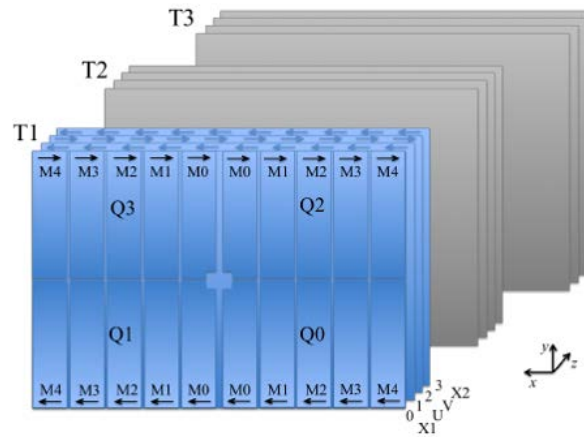


Figure 3: Layout of the SciFi detector

Station 1 and 2 have 5 modules per layer, while station 3 has 6. For the total amount of modules the following calculation is applied:

$$T_1 = 4(L) * 4(Q) * 5(M) = 80$$

$$T_2 = 4(L) * 4(Q) * 5(M) = 80$$

$$T_3 = 4(L) * 4(Q) * 6(M) = 96$$

The SciFi FE sub-system consists of 256 modules (or ROBs). As mentioned before each module consists of 2 ½ ROBS (or DU and known as H₀ and H₁), which brings the total amount of device units to 512. The SciFi detector is split into an A and C side, which for the DAQ and DCS is determined by the quadrant number:

Side A: Q1, Q3

Side C: Q0, Q2.

1.3 FSM integration

Figure 4 partially shows the FSM tree for the FE side A (side C looks similar). The 2 top nodes of the sub-detector have the following domain names: SFA_DAQ_FE and SFC_DAQ_FE. They will be implemented as Control Units (CU). Between the 2 CU's and the 512 DU's 4 intermediate layers, all implemented as Control Units, can be distinguished. From top to bottom: T-layer, L-layer, Q-layer and M-layer. Following the LHCb ECS Integration Guidelines, they could have for instance the following names:

¹ For unknown reasons the station numbering starts at 1 instead of 0.

- Station: **SFA_DAQ_FE_T1**
- Layer: **SFA_DAQ_FE_T1L0**
- Quadrant: **SFA_DAQ_FE_T1L0Q1**
- Module: **SFA_DAQ_FE_T1L0Q1M0**
- ½ROB: **SFA_DAQ_FE_T1L0Q1M0H0**

The total amount for this configuration of Control Units (CU) is 321 and Device Units (DU) 512.

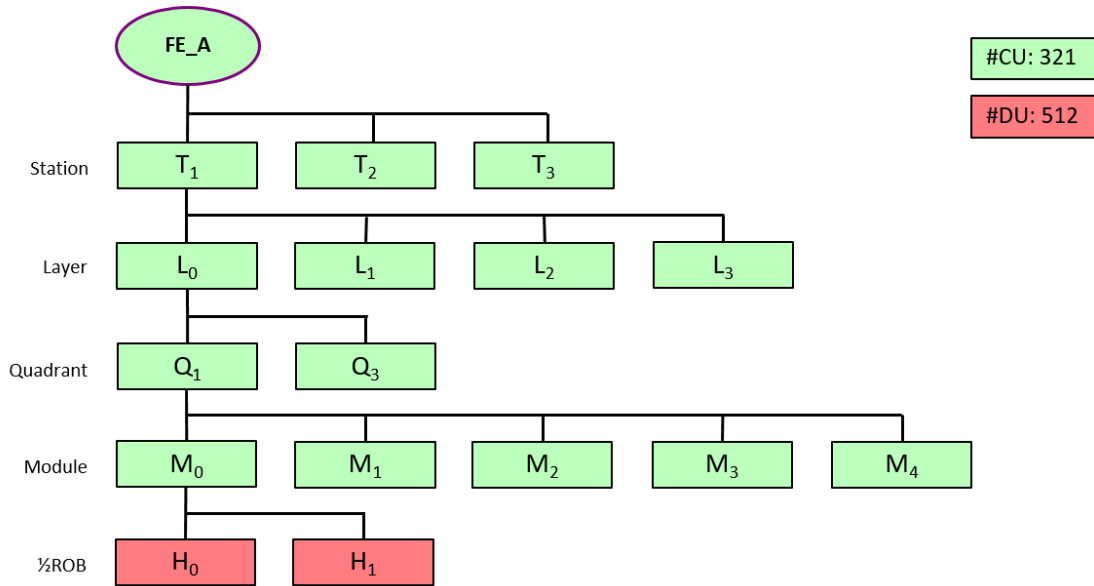


Figure 4: FSM-tree

The operation domain of the DU (and for the CU's as well), is shown in figure 5.

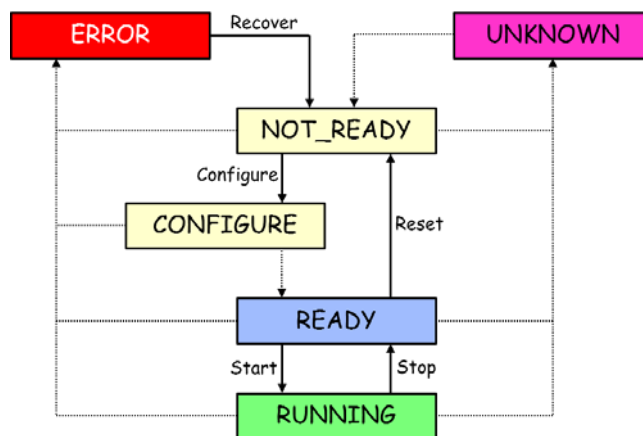


Figure 5: ½ROB state diagram

1.4 Controls

Concerning the fan-out of the PCIe40 board and the proposed FSM hierarchy, the following list (see table 1) of FE-PCs will be applied. Each PC controls a whole quadrant of a station (1/12 of the detector).

no.	FE- PC	FSM-domains	½ROBS
1	SFDAQFEA11	SFA_DAQ_FE_T1LxQ1	40
2	SFDAQFEA13	SFA_DAQ_FE_T1LxQ3	40
3	SFDAQFEA21	SFA_DAQ_FE_T2LxQ1	40
4	SFDAQFEA23	SFA_DAQ_FE_T2LxQ3	40
5	SFDAQFEA31	SFA_DAQ_FE_T3LxQ1	48
6	SFDAQFEA33	SFA_DAQ_FE_T3LxQ3	48
7	SFDAQFEC10	SFC_DAQ_FE_T1LxQ0	40
8	SFDAQFEC12	SFC_DAQ_FE_T1LxQ2	40
9	SFDAQFEC20	SFC_DAQ_FE_T2LxQ0	40
10	SFDAQFEC22	SFC_DAQ_FE_T2LxQ2	40
11	SFDAQFEC30	SFC_DAQ_FE_T3LxQ0	48
12	SFDAQFEC32	SFC_DAQ_FE_T3LxQ2	48

Table 1: PCs for the FE

A PC controls 4 FSM-domains: $0 \leq x \leq 3$. The name of the PC conforms with the LHCb ECS Guidelines and the sub-system part (last 3 letters or digits) is made out of <A|C><Station><Quadrant>.

WinCC-OA will be utilized as SCADA system for the control and monitoring of the FE sub-system. For each ½ROB at least 9 data-points exist: 1 for the Master-board, 4 for the Cluster-boards and 4 for the PACIFIC-boards. Efforts to combine these into a single data-point failed, due to the size of the separate data-point element (dpe) types. In particular the PACIFIC-board type is very large: 8871 dpe's. The Master-board type is 1090 dpe's big and the Cluster-board 1910 dpe's. In total 44214 dpe's are needed to control a single ½ROB.

The Gbt-server has to connect almost all these data-points to the SOL40 by means of DIM-services and DIM-commands. For a single ½ROB in total 14714 DIM-services and 7357 DIM-commands are maintained. Again most of them are used by the PACIFIC-boards (80%).

Each WinCC-OA project for the FE shall have at least 2 control managers for the monitoring of the FE sub-system.

1. **Watchdog-State:** control manager to maintain the actual state (as shown in figure 5) of each ½ROB. These states are input for the DU's and propagated upwards to the CU's.
2. **Watchdog-Environment:** control manager to keep track of the temperature sensors, voltages, currents and single event upsets (SEU). It raises alarms and alerts if necessary. It may even switch off the LV in case of imminent danger.

The DU of the ½ROB should be able to execute the possible commands as shown in figure 5: RECOVER, CONFIGURE, RESET, START and STOP. These commands are implemented as WINCC-OA scripts. The CONFIGURE command requires access to the database containing the settings of the numerous registers and calibration data of the PACIFIC chips.