# Requirements for the CSC New ROD Complex

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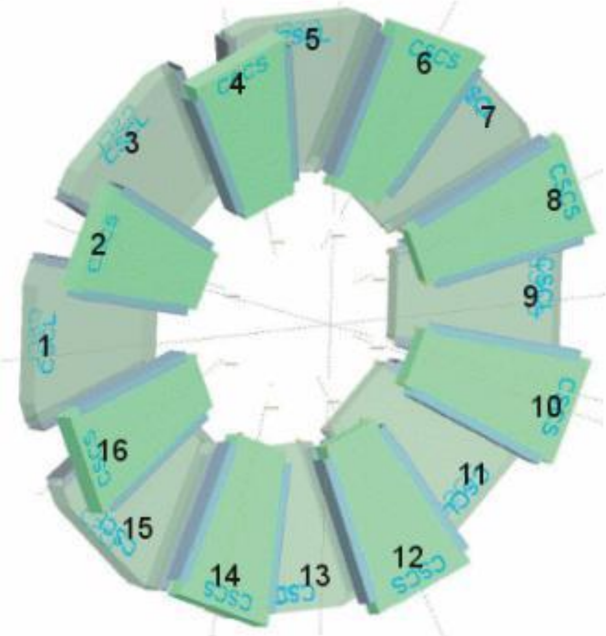
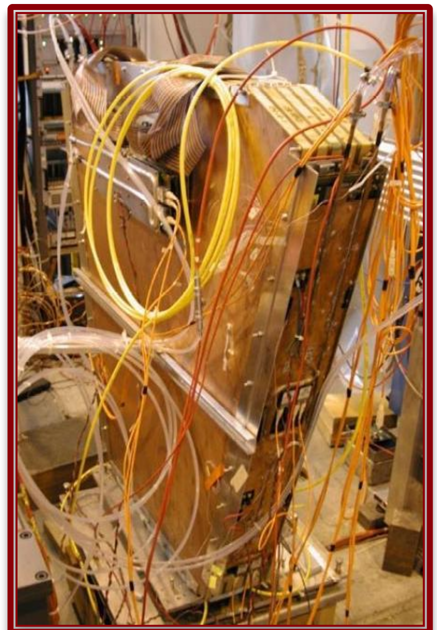
# CSC Detector





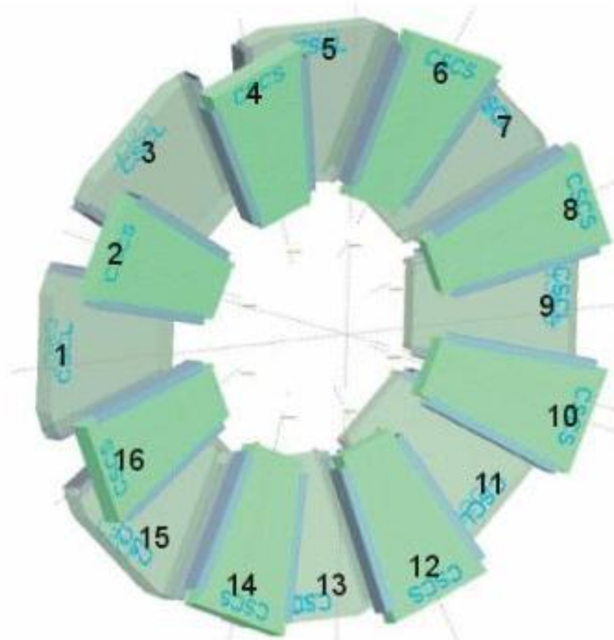

## CSC detector

- Two end-caps
- Thirty-two chambers



## Each chamber

- Four precision layers.
- Four transverse layers.
- Each precision layer: 192 channels.
- Each transverse layer: 48 channels.
- Total: 960 channels

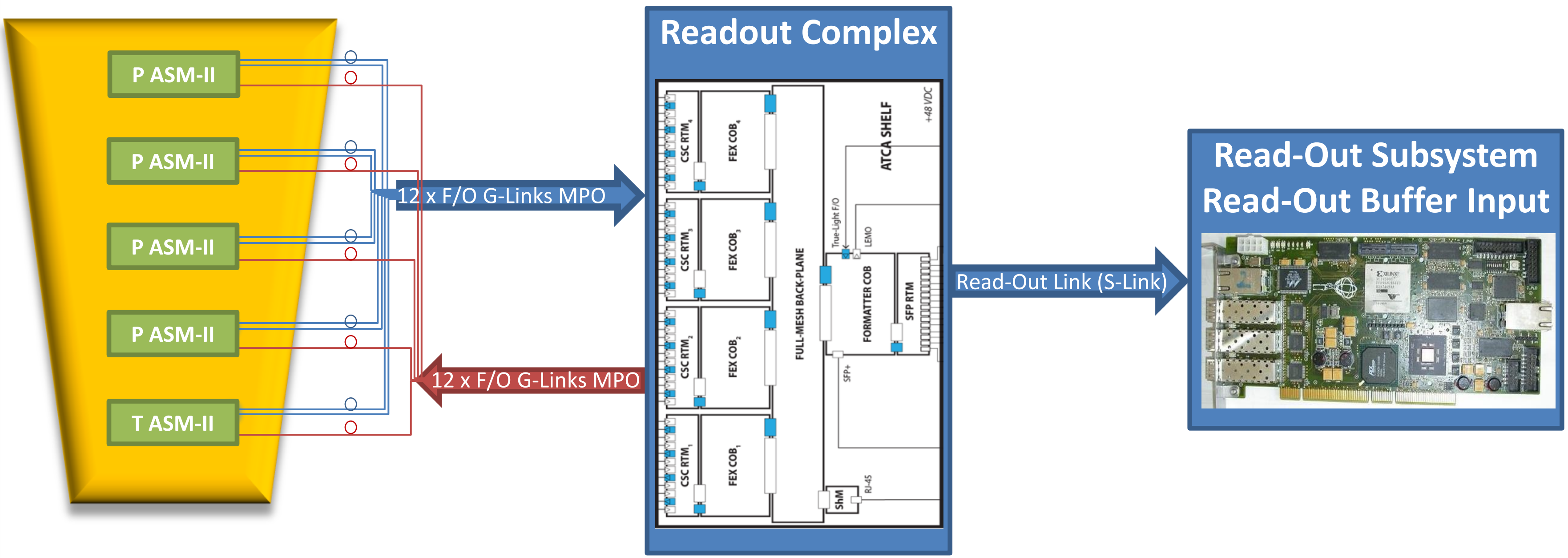


# One Requirement



## General Requirement

*Upon receipt of a Level 1 Accept, the ROD Complex must retrieve the corresponding CSC chamber data and send the resulting feature extracted and formatted event to the Trigger and Data Acquisition (TDAQ) system.*



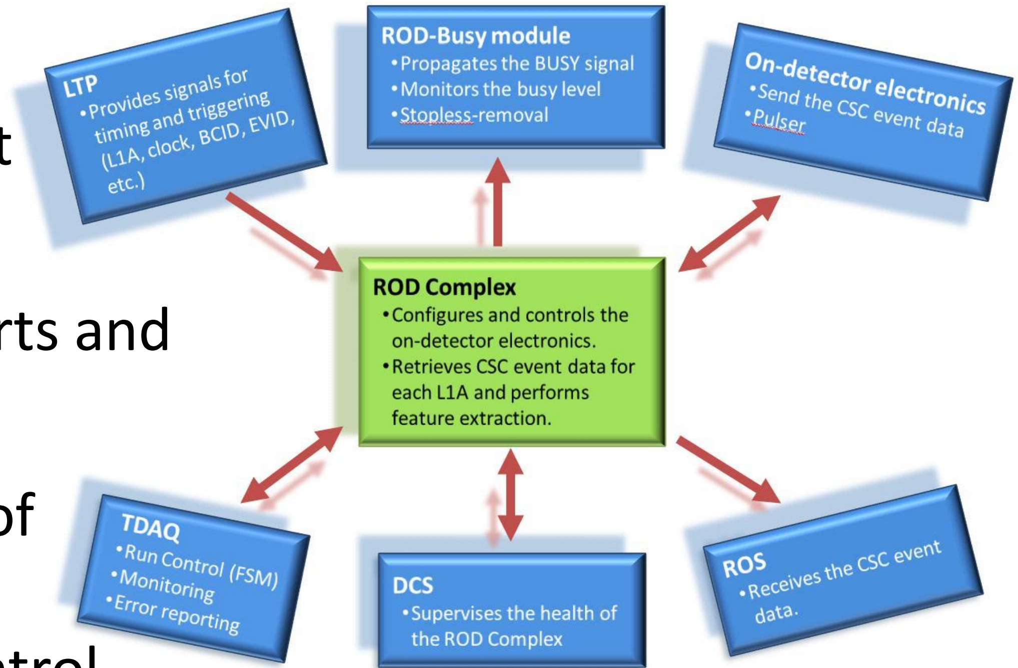
# Interfaces



**On-detector electronics**: CSC chamber data and Pulser.

**Local Trigger Processor**: Signals for timing and triggering.

**Read-Out Subsystem**: Destination of the CSC event data.



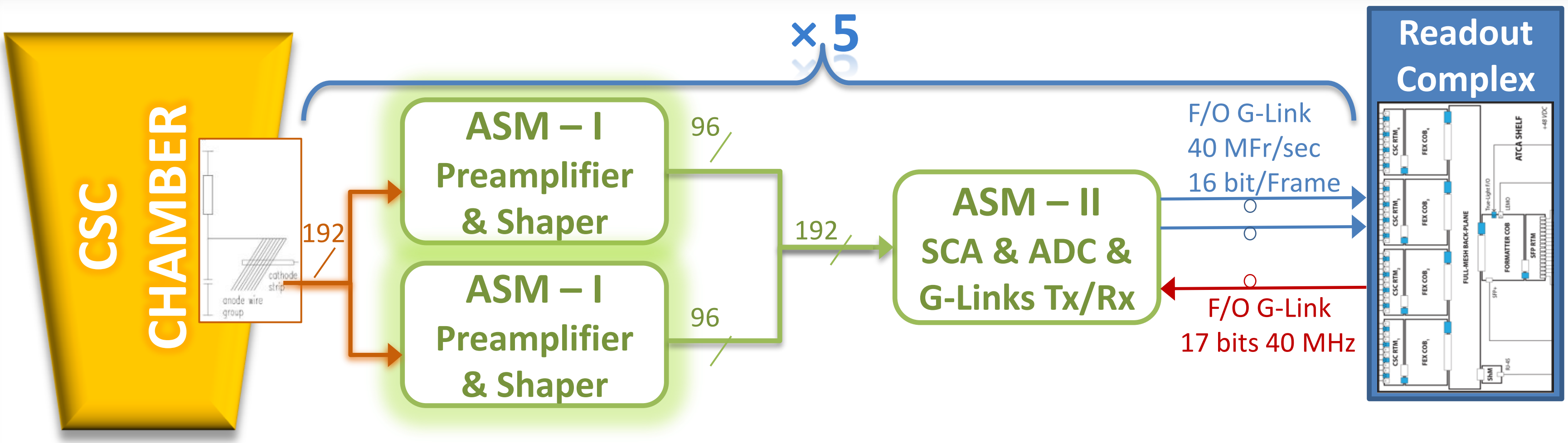

**ROD-Busy module**: Transports and monitors the BUSY signal.

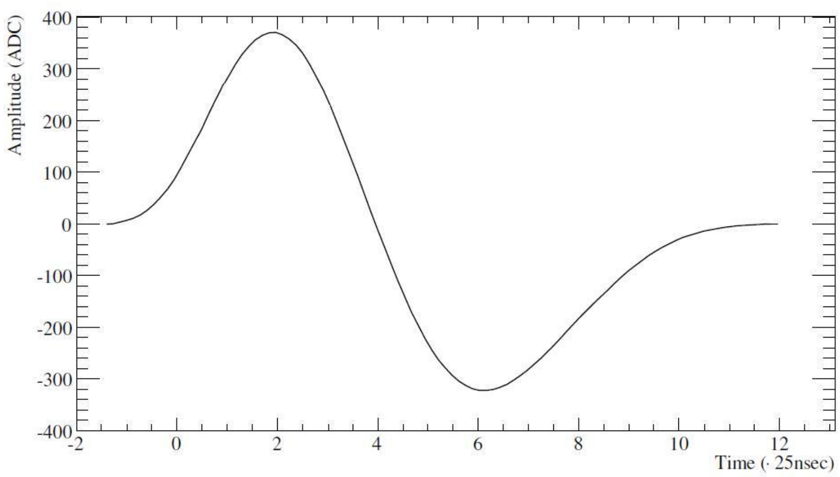
**TDAQ online system**: A set of software interfaces with functionality for the RunControl, monitoring, error reporting, etc.

**Detector Control System**: Safe operation of the detector.

# On-detector Electronics: ASM-I





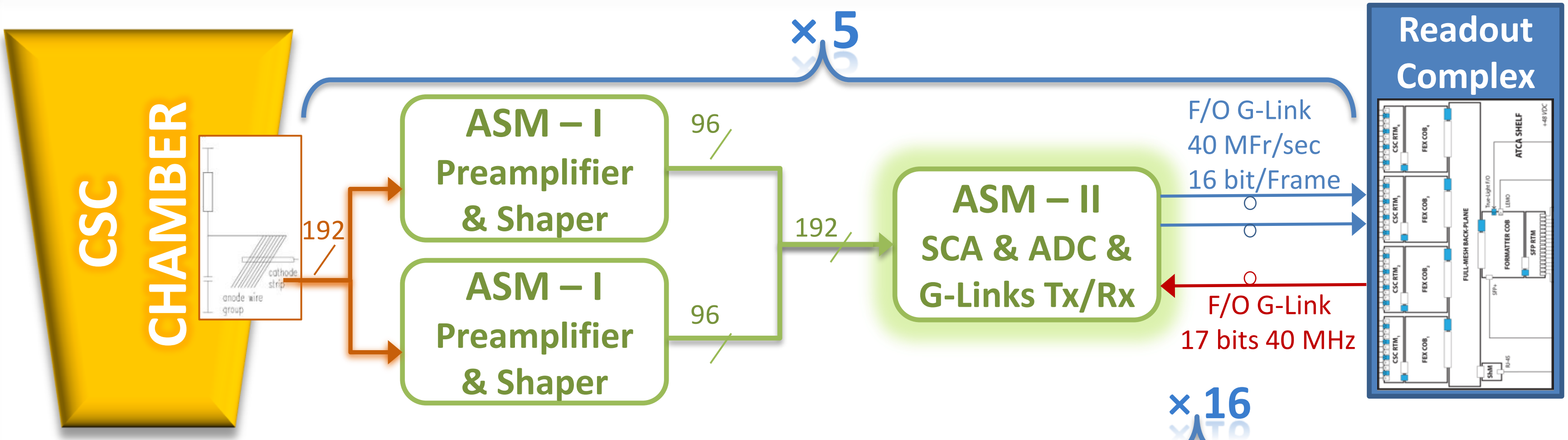




## Chamber

- Precision layers: 768 strips.
- Transverse layers: 192 strips.
- 10 ASM-I and 5 ASM-II.
- P/S forms a bipolar pulse with 140 ns shaping time.
- The shaped pulses are sampled every 50 ns.

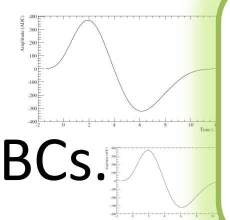
# On-detector Electronics : ASM-II






**SCA**

- 12 channels per SCA.
- 144 cells per channel.
- Worst case latency: 188 BCs.
- Write: 20 / 40 MHz

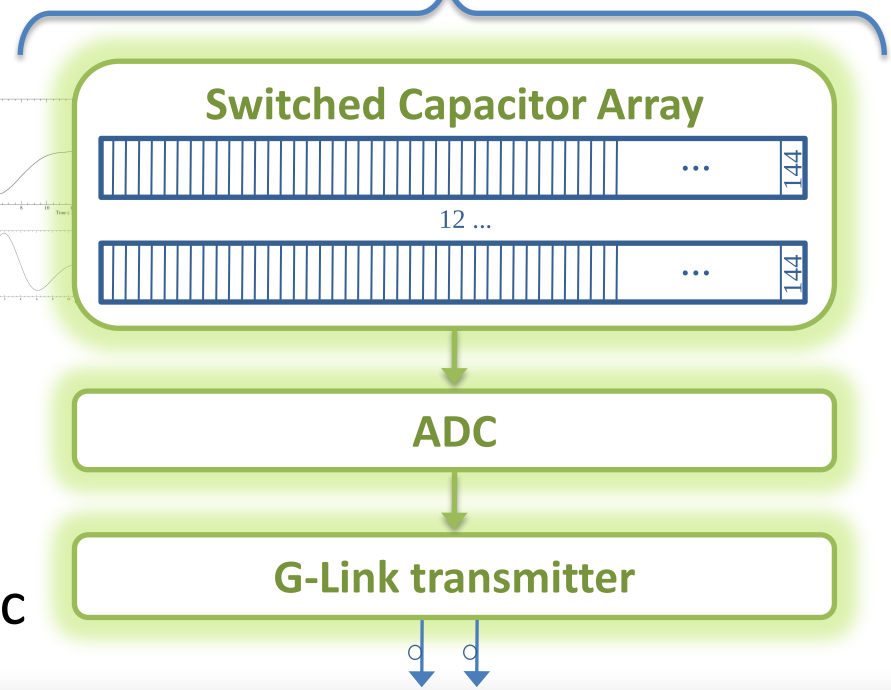


**ADC**

- Read: 6.7 MHz

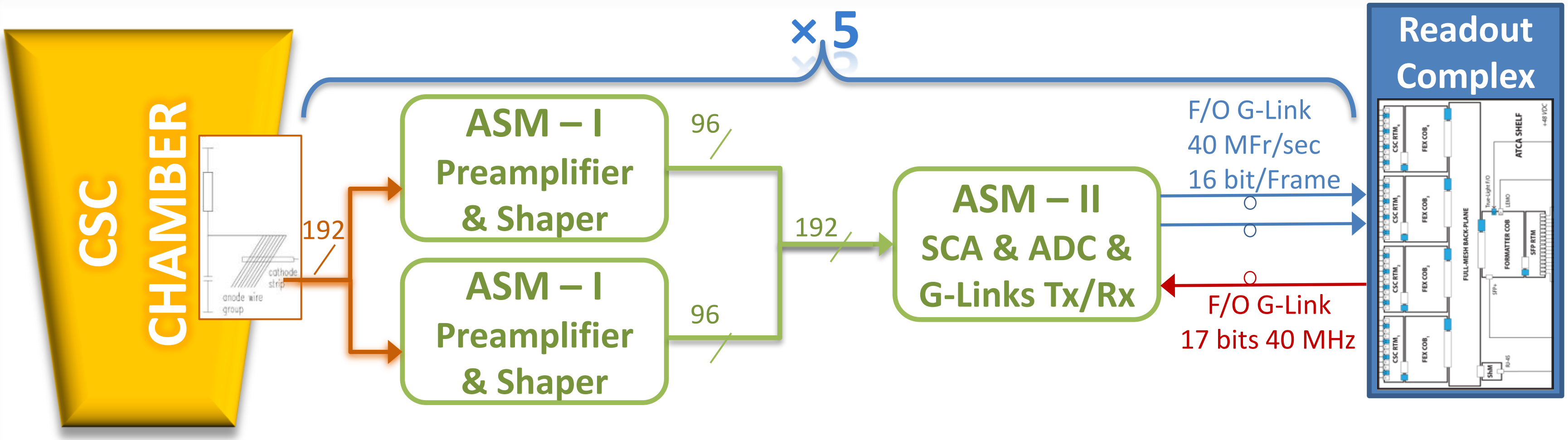
**G-Link**

- 40 MHz 16 bits/frame
- 640 Mbits/sec – 1.28 Gbits/sec



# On-detector Electronics: Requirements






**UR101**: The ROD Complex must implement the G-Link protocol.

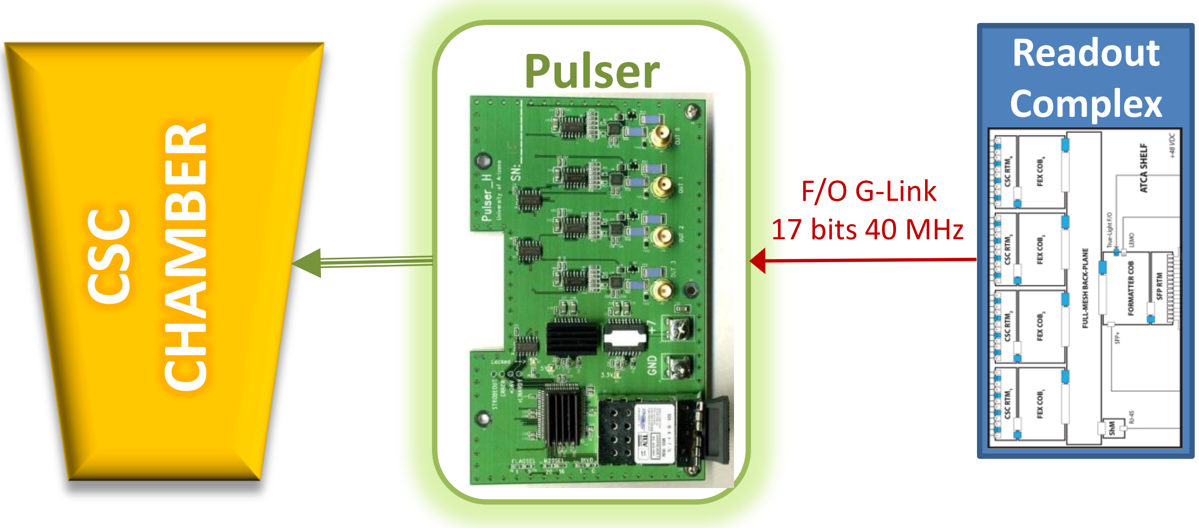
**UR102**: The ROD Complex must lock all fibers with the same phase in order to provide constant timing.

**UR103**: The ROD Complex must control the ASM-II.

**UR104**: The number of samples and sampling frequency (20 or 40 MHz) must be configurable and the latency must be adjustable.

# On-detector Electronics: Pulser



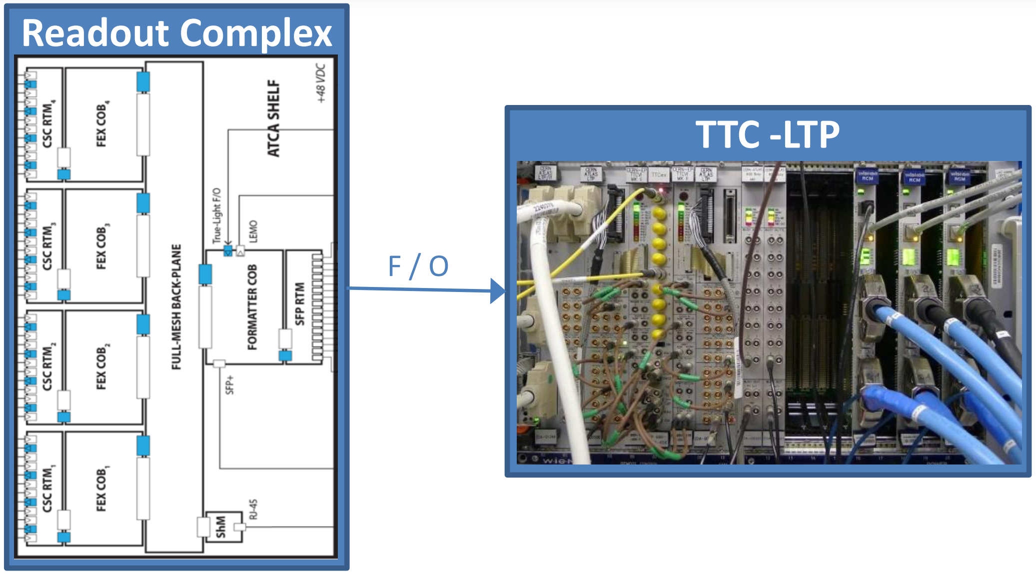



The Pulser provides a fast voltage step to the calibration planes of the on-detector electronics channels simulating a particle interacting with the Cathode Strips of the CSC. Control is externally delivered via the fiber optic link.

**UR105**: The ROD Complex must control the on-detector Pulser.

# TTC - LTP






The **TTC-LTP** provides the ROD Complex with all the trigger and timing signals originated from the CTP (BC clock, L1A, BCID, EVID, reset, trigger type, etc.).

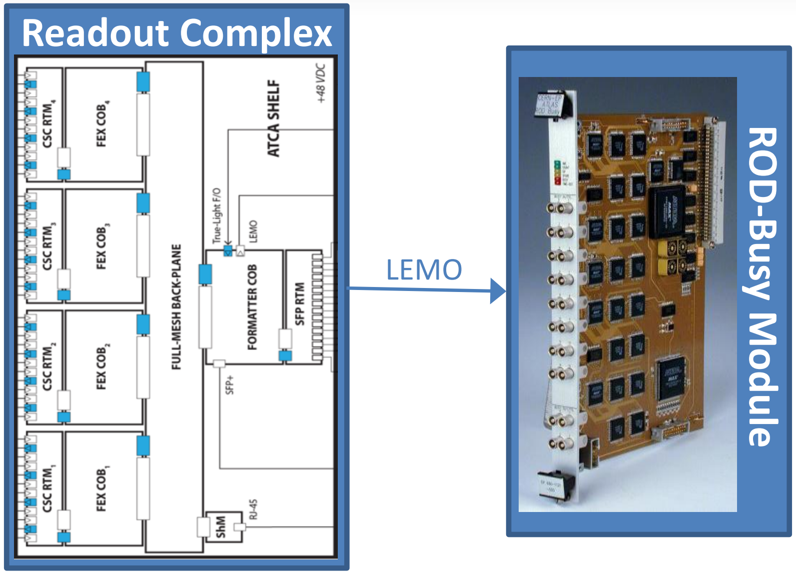
**UR201**: The ROD Complex must receive and process the Trigger, Timing and Control (TTC) signals.

**UR202**: The ROD Complex must be able to re-synchronize with ATLAS when needed (TTC restart and stopless recovery).

**UR203**: Upon receipt of a L1A, the ROD Complex must retrieve the chamber data, perform feature extraction if need be, and output the resulting formatted event to the ROL.

# ROD-Busy Module



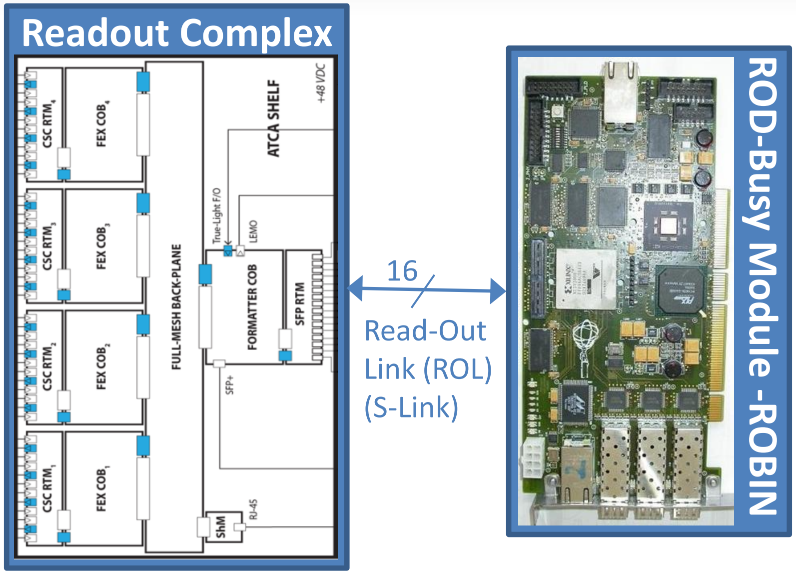



The **ROD-Busy Module** receives the BUSY signal from the detector and relays it to the CTP, thus inhibiting and throttling the L1A rate. This module also monitors and controls the busy levels during the run (stop-less removal).

**UR301**: The ROD Complex must provide a BUSY signal to the ROD-Busy module and assert it only when necessary (internal buffer nearly full) and under the constraints of UR001.

# Read-Out Subsystem



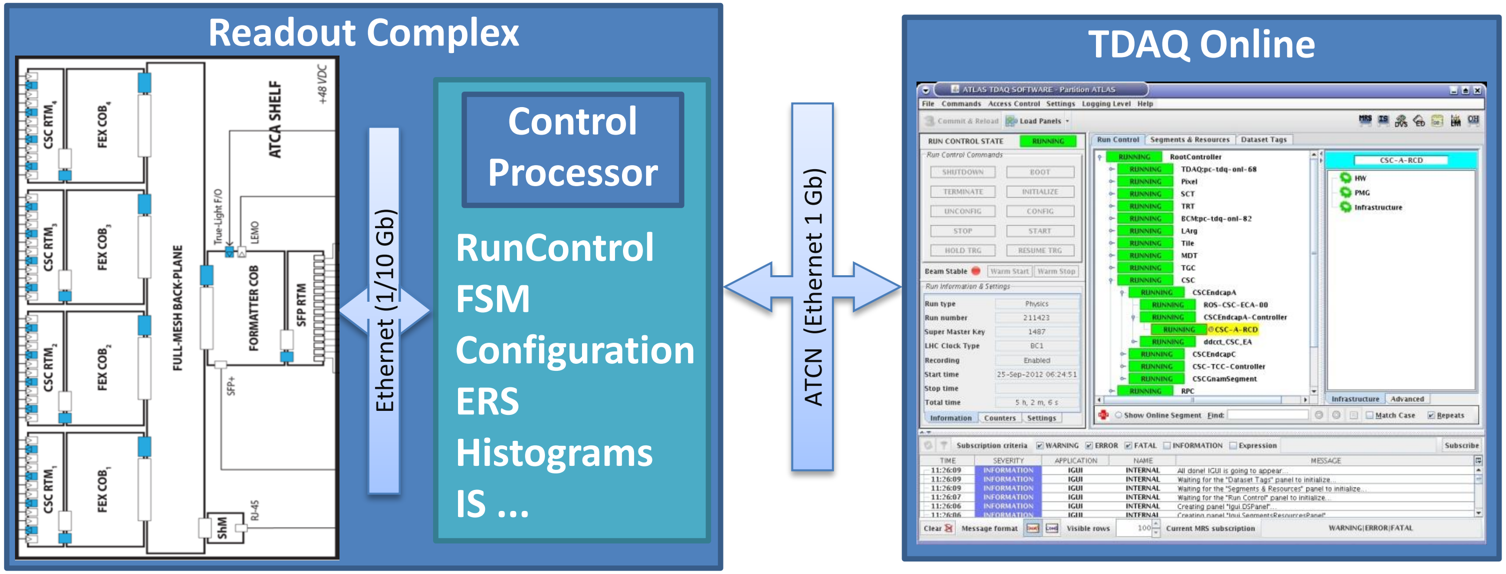



A **Read-Out Subsystem** has as many as 12 Read-Out Links (ROL), implemented as a Simple Link (S-Link). Each link's bandwidth is 160 MBytes/second. Includes XON/XOFF as the data flow control mechanism. The CSC event data is transmitted over 16 ROLs.

**UR401**: The ROD Complex must output the event data resulting from a L1A to the S-link interface.

# TDAQ Online System

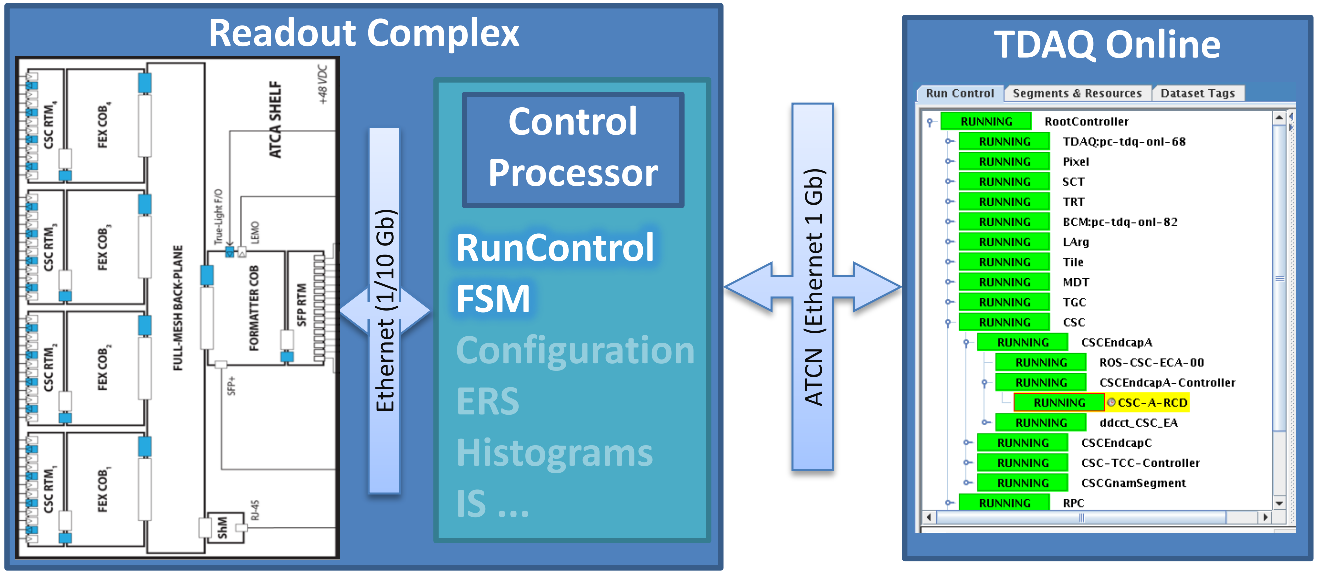





Some of the TDAQ software packages are essential to integrate the CSC with the TDAQ infrastructure. For example a RunControl application will be present to control and configure the ROD Complex. Other packages are required for monitoring purposes. The TDAQ release is installed in the network file system in P1.

# TDAQ Online System



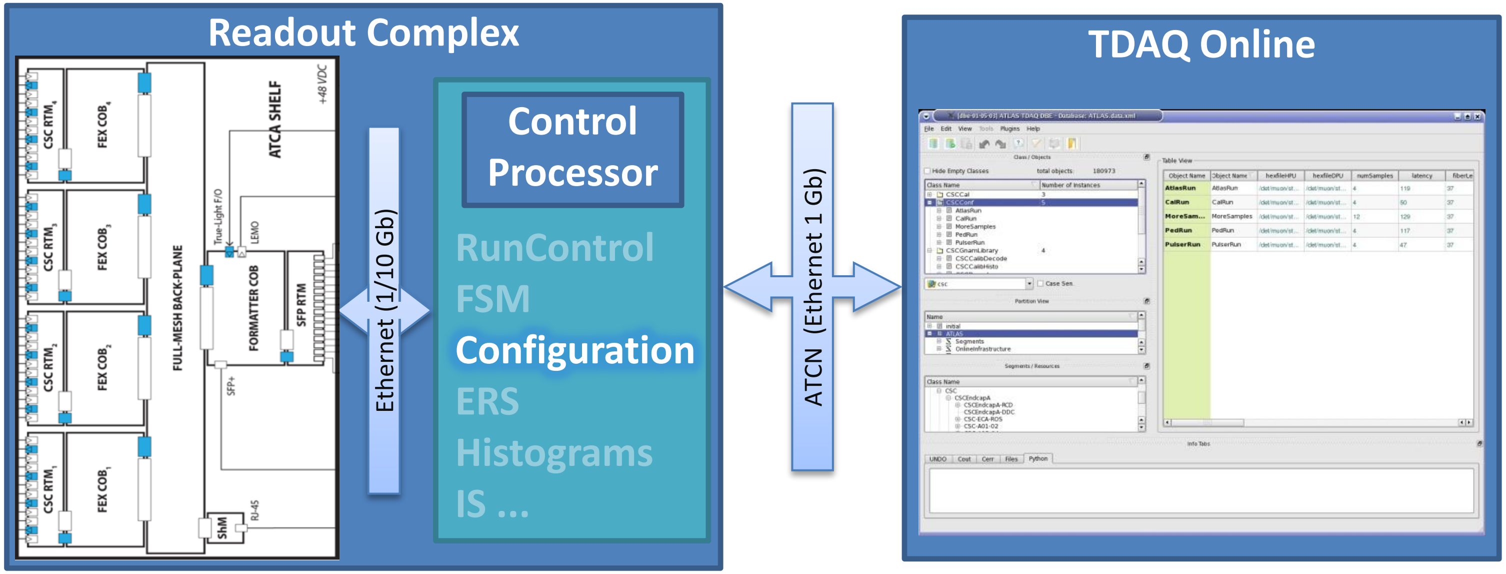



**UR601**: The ROD Complex must follow the TDAQ Finite State Model (FSM) and respond to state transitions.

The RunControl application responds to transition commands typically triggered by the Run Control shifter. Also commands like RESYNC (TTC Restart, Stopless recovery) are handled here.

# TDAQ Online System



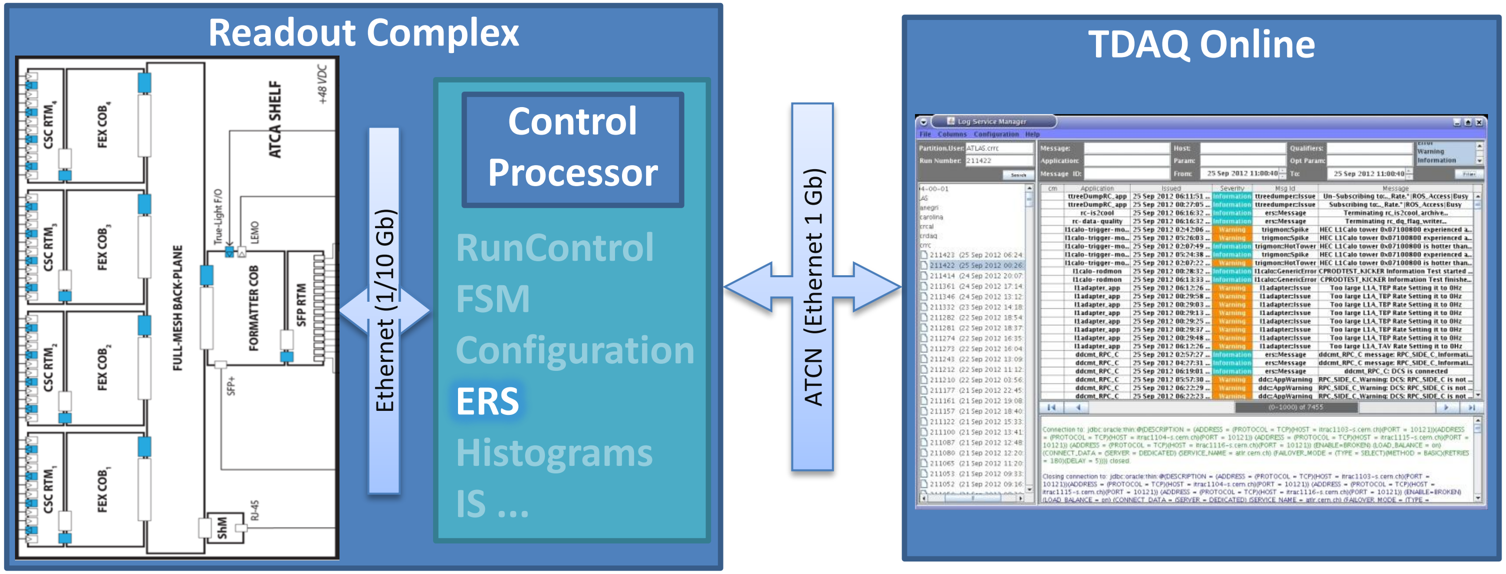



**UR602**: Variables that parameterize the behaviour of the ROD Complex must be stored and retrieved from the TDAQ configuration database.

This configuration is stored in a relational database and can be retrieved for any given run.

# TDAQ Online System



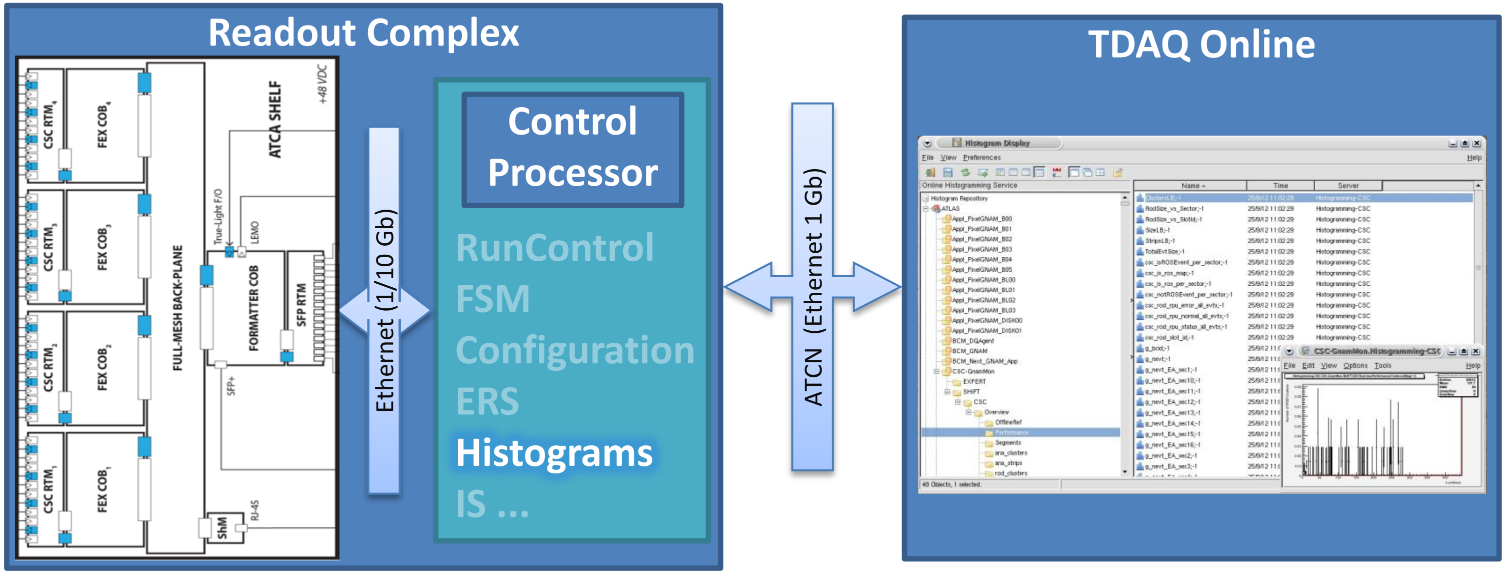



**UR603**: Errors that require an action from the shifter must be made public to the TDAQ Error Reporting Service (ERS).

The messages are stored in a relational database and be browsed using the Log Manager.

# TDAQ Online System



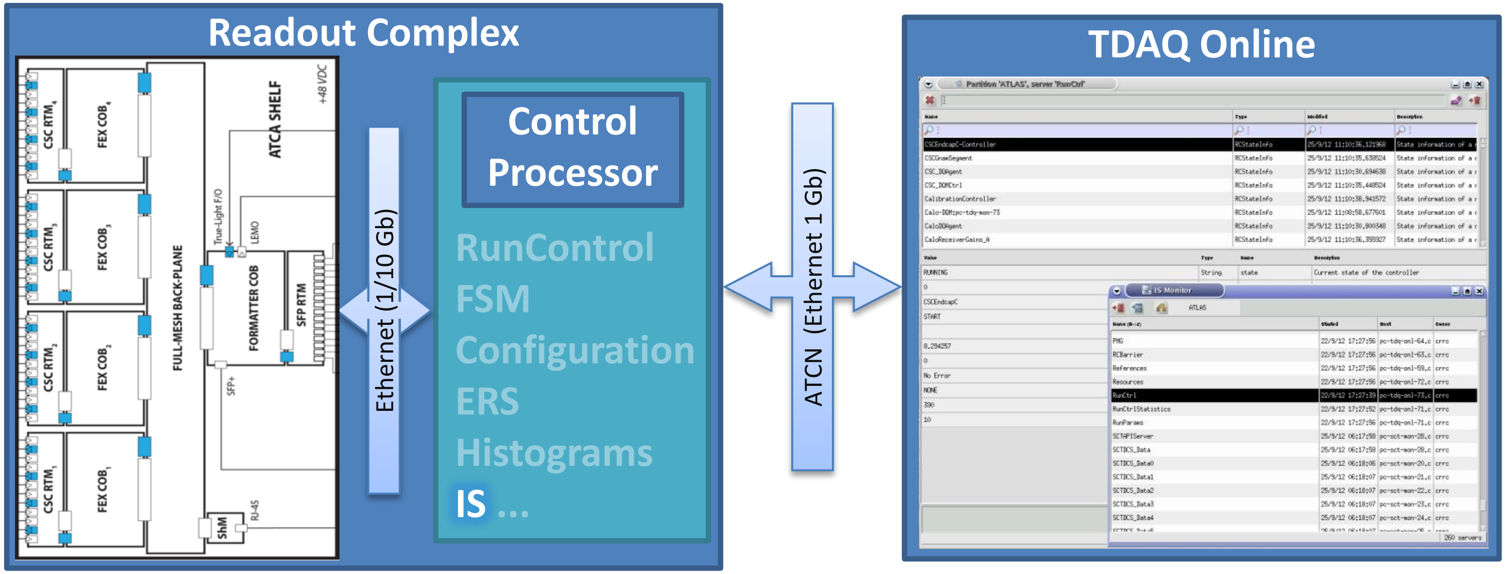



**UR604**: When histograms need to be made public, the Online Histogram Service (OHS) must be used.

Histograms are permanently stored and can be viewed using the Online Histogram Presenter

# TDAQ Online System



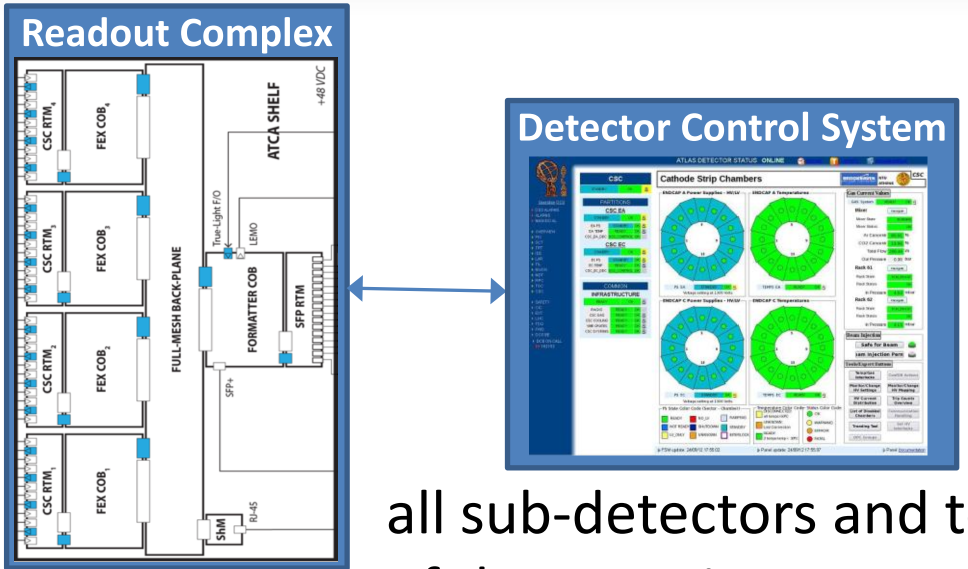



**UR605**: When information needs to be made public, the Information Service (IS) must be used.

IS information is updated on-the-fly and is useful for 'real-time' monitoring.

# Detector Control System





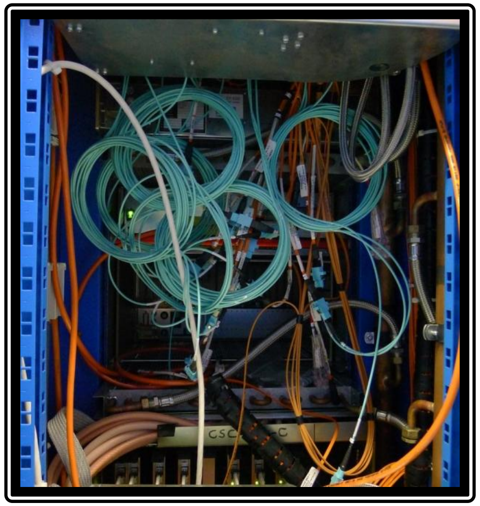

The principal task of the **Detector Control System** is to enable the coherent and safe operation of the detector and to serve as a homogeneous interface to all sub-detectors and to the technical infrastructure of the experiment.

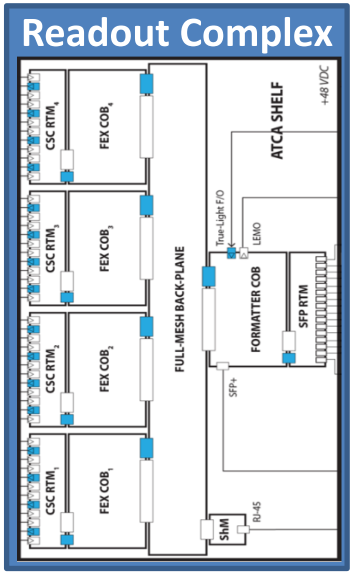
**UR701**: It must be possible to remotely power on/off the ROD Complex via the DCS interface.

**UR702**: To further satisfy UR701, it must be possible to remotely monitor the ROD Complex, (voltage, current, and temperature) via the DCS interface.

# Installation








**UR801**: The ROD Complex must adhere to the ATLAS-wide rack specifications in terms of crate mounting, power consumption, power dissipation, airflow direction, etc.

**UR802**: The ROD Complex must adhere to the ATLAS Technical and Control Network (ATCN) specifications in terms of cabling, ports, bandwidth allocation, etc.

# Data Processing



**UR501**: The ROD Complex must ensure the validity of the chamber data in each stage of the data flow.

**UR502**: It must be possible to mask out specific layers for a given chamber.

**UR503**: The ROD Complex must be capable of processing data differently depending on the purpose of the run (**UR504**, **UR505**, **UR506**).

**UR507**: The CSC event data must conform to the ATLAS and CSC format.

# Performance



**UR001**: The ROD Complex must handle average L1A rates of up to 100 KHz at the required data occupancy (UR002) without imposing a dead-time of more than 1%. A safety margin of 20% (120 KHz) would be desirable to accommodate new requirements in ATLAS.

The ROD Complex must also be able to handle a L1A trigger burst as constrained by the simple dead-time (4 BCs) and the complex dead-time (8 L1As in 80 µs.).

**UR002**: The ROD Complex must handle the expected data volume for the required trigger rate (UR001).

The estimated average CSC event size for a µ = 80 is ~19 KBytes or ~0.6 KBytes per chamber.

**UR003**: The ROD Complex must operate robustly regardless of the inputs from external systems: L1A rate, data occupancy, corrupted data, TDAQ commands, etc.

# Backup Slides



Backup Slides

# Backup: Data Processing



**UR504**: The ROD Complex must be capable of feature extracting the raw data received during physics runs. Broadly speaking, the feature extraction algorithm consists of two steps: threshold comparison and wrong-time rejection (around a ~75 ns window).

**UR505**: The ROD Complex must be capable of processing event data for calibration and pedestal runs with at least 8 samples and trigger rates that provide sufficient calibration data during the available ATLAS calibration periods.

**UR506**: The ROD Complex must be capable of processing data from runs dedicated to the study of the bipolar pulse generated by the pre-amplifier and shaper circuitry. Data must be sparsified as described in UR504 but with a configurable number of samples of at least 30 and trigger rates that provide sufficient data during the available ATLAS calibration periods.

# Backup: Feature Extraction



**Feature extraction**:

When a particle passes through the chamber and generates a signal, a cluster is formed, which a group of neighboring channels that show a response to the particle. Each channel in the cluster is a hit, and ideally only the hits from the clusters that occurred in a chosen time window for the trigger are to be kept.

At a L1A rate of 100 KHz and 4 12-bit ADC samples per channel, ~500 MBytes/sec of data per chamber are produced. Data for two chambers (~1 GBytes/sec) are directed to one ROL (160 MBytes/sec). Only event data with potential hits should be sent.

A threshold cut is used to eliminate channels that are not hit, and a time cut (75 ns window) is used to eliminate clusters that are out-of-time.

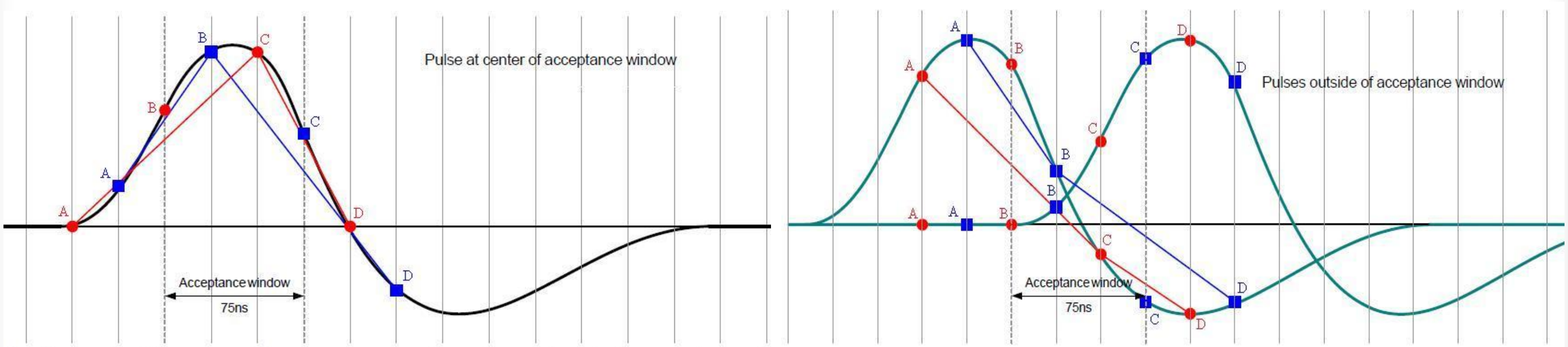
# Backup: Feature Extraction



## Feature extraction: threshold cut

Each individual channel is associated with a unique threshold value. The sample is only accepted if it is larger than the corresponding threshold.

## Feature extraction: time cut



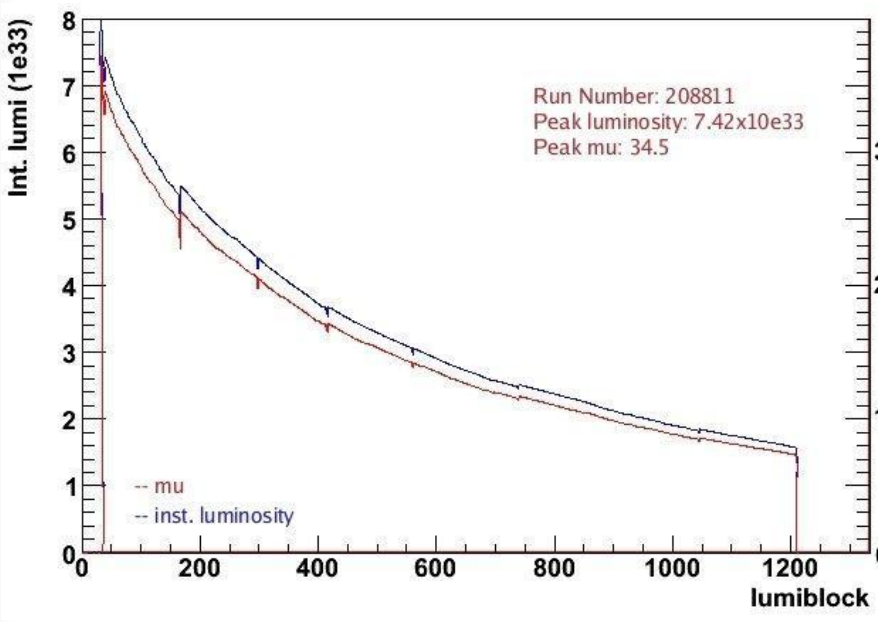

In-time pulse (lines every 25 ns, squares are phase B samples, circles are phase C) Out-of-time pulses (lines every 25 ns, squares are phase B samples, circles are phase C)

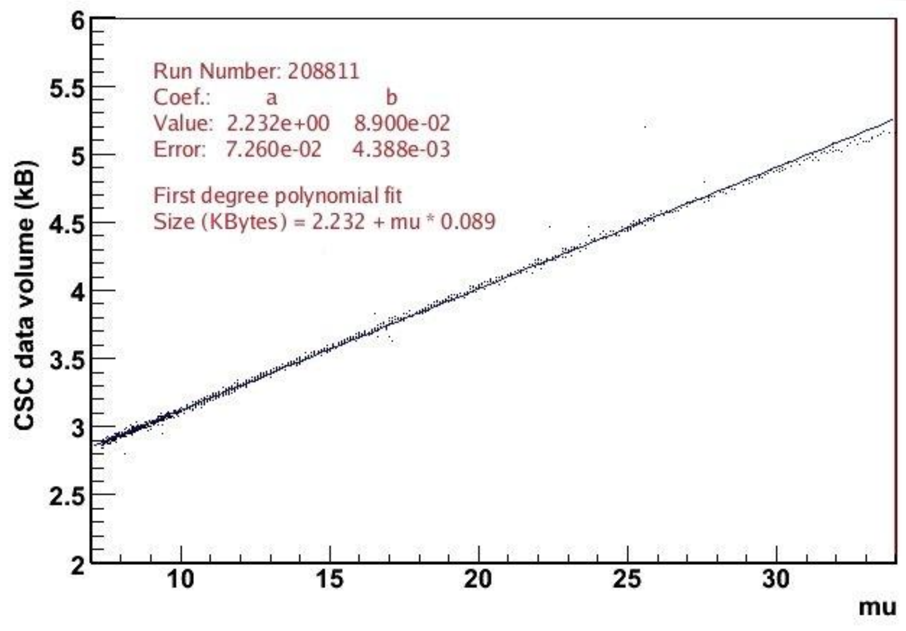
The sampling is adjusted so that the nominal peaking time for in-time hits falls halfway between the B sample of the later sampling and the C sample of the earlier sampling. The nominally largest sample (B or C) must be larger than samples A and D.

# Backup: Performance



## Relationship between CSC event size and pile-up (μ):




But currently, the CSC sends 2 samples not 4. Apply a factor of 2.
First degree polynomial fit:

$$CSC\ Event\ Size\ (KBytes) = 2 * (\mu * 0.089 + 2.232)$$

# Backup: Performance



Phase 0: L = $1 \times 10^{34}$ $cm^{-2}$ $s^{-1}$, 14 TeV, 25 ns → $\mu$ = 27.

However: These nominal values might easily be exceeded.

Bunch spacing = 25 ns.? If so ...

The data volume estimation might be affected by switching from a bunch spacing of 50 ns to 25 ns.

Be safe: to have enough margin design for Phase 1.

Phase 1: L = $3 \times 10^{34}$ $cm^{-2}$ $s^{-1}$, 14 TeV, 25 ns → $\mu$ = 80.

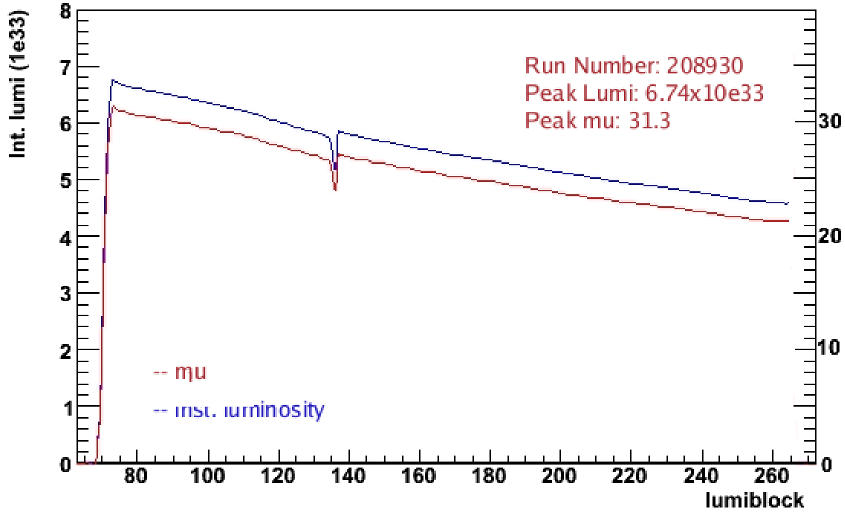
*CSC Event Size (KBytes) = 2 * (80*0.089 + 2.232)*

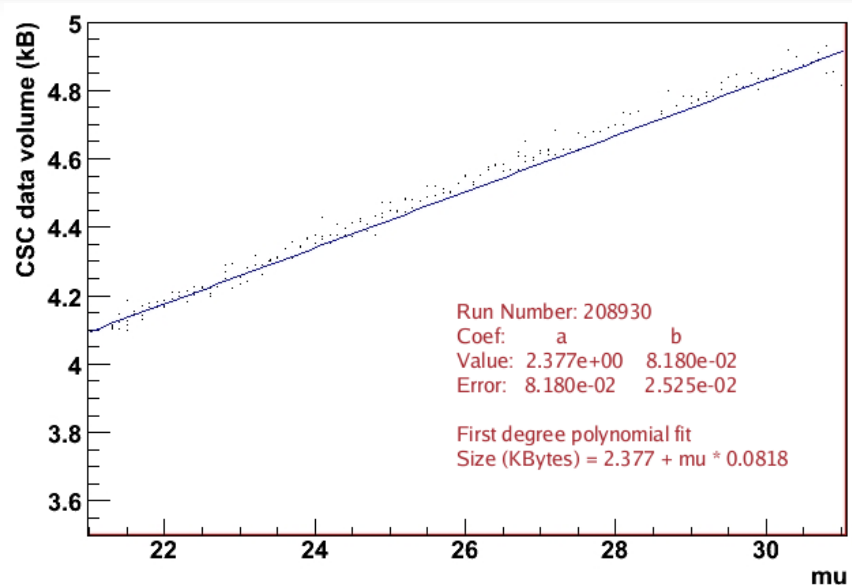
*CSC Event Size (KBytes) =* ~19 KBytes

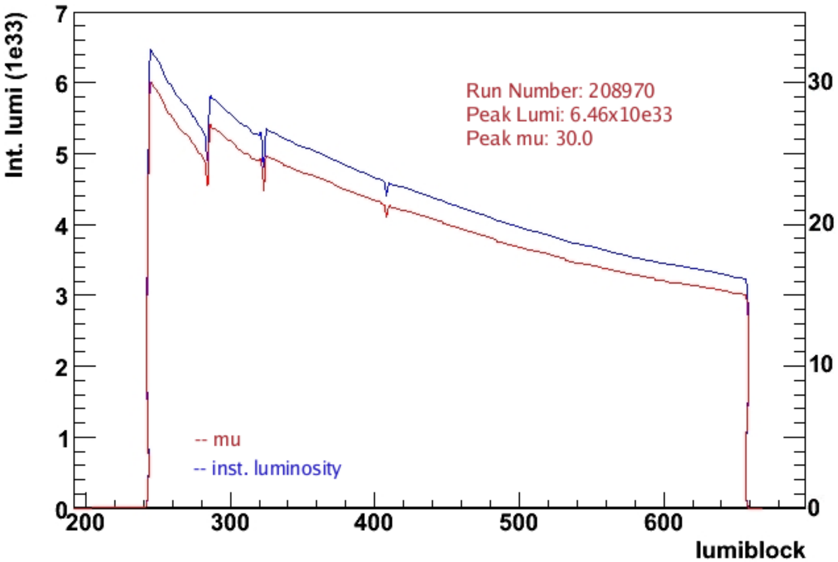
*CSC Chamber Size (KBytes) =* ~0.6 KBytes

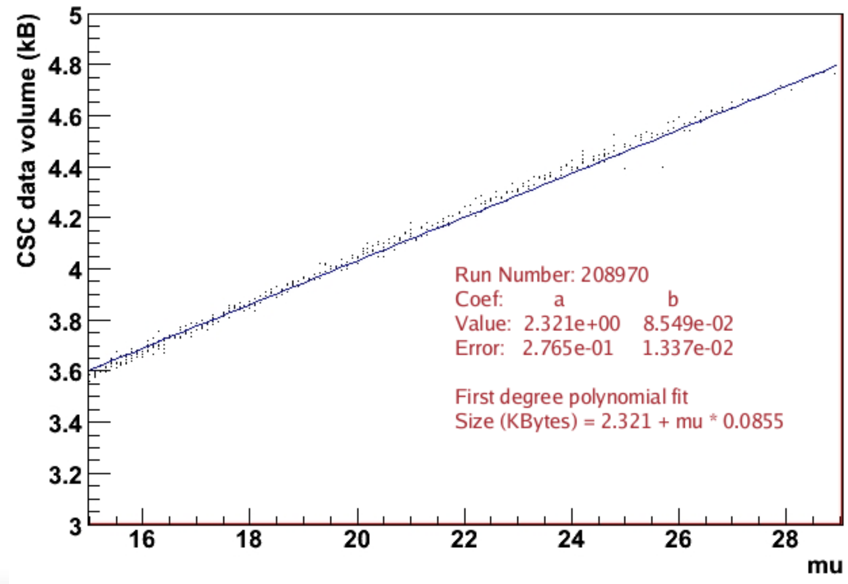
# Backup: Performance





# Backup: Rack



## On rack requirements:

Private discussion with Martin Jaekel on-going:

- He is not aware of any ATLAS official document on the subject.
- Rack power, cooling, etc., was always discussed individually for each rack in a 'Rack Review'.
- Standard racks are supplied with 10 KW, and cooling depends on the number of heat exchanger, each taking up to 3.x KW.
- If this was not sufficient for the detector needs, it is possible to deliver 20 KW or even 50 KW.

# Backup: Dead-time



## Complex dead-time:

Thilo Pauly, *Complex Deadtime Considerations for Phase-0 upgrade*.

https://indico.cern.ch/getFile.py/access?contribId=8&resId=1&materialId=slides&confId=161188