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Level-1 Calorimeter Trigger RODs

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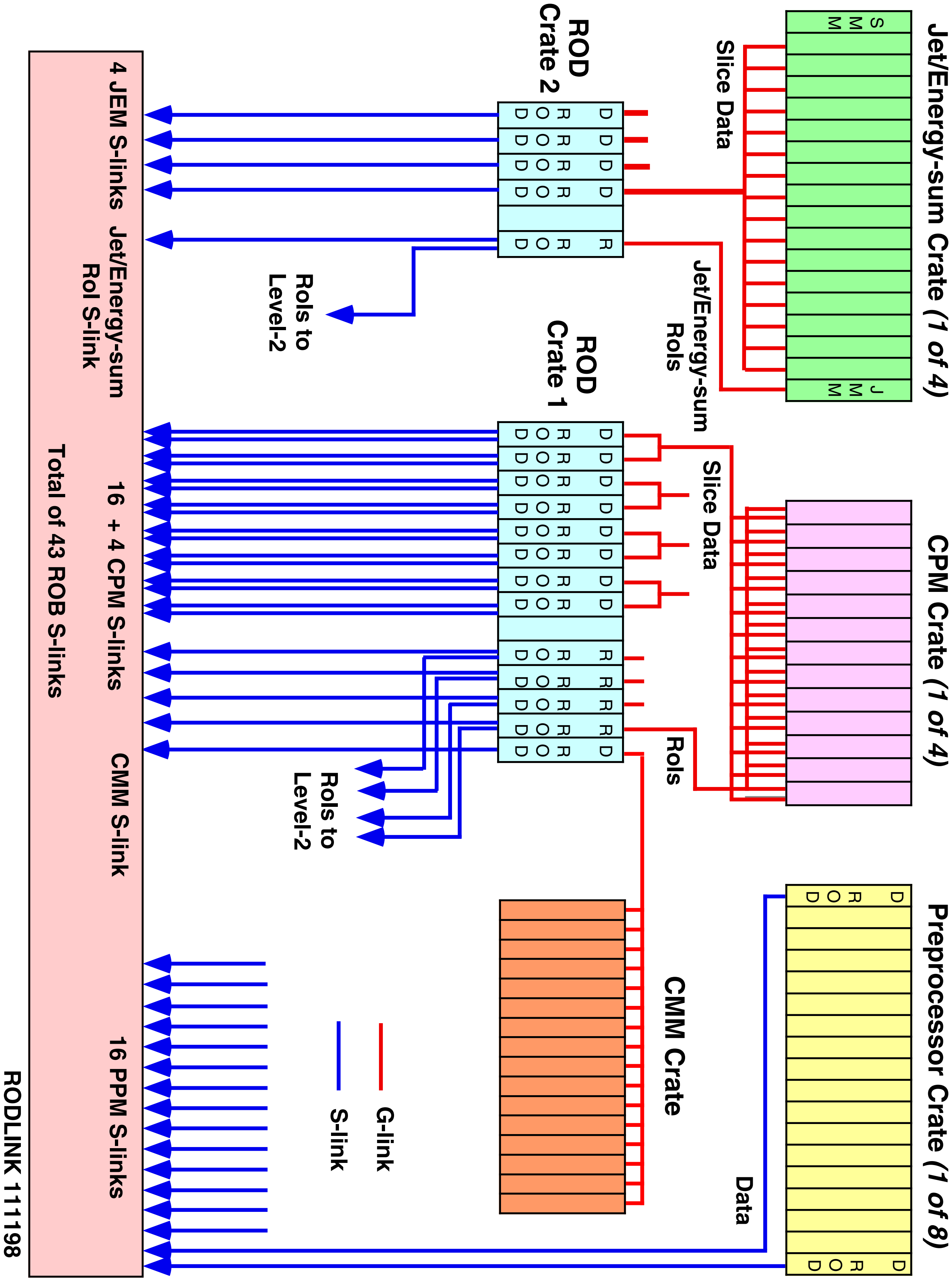
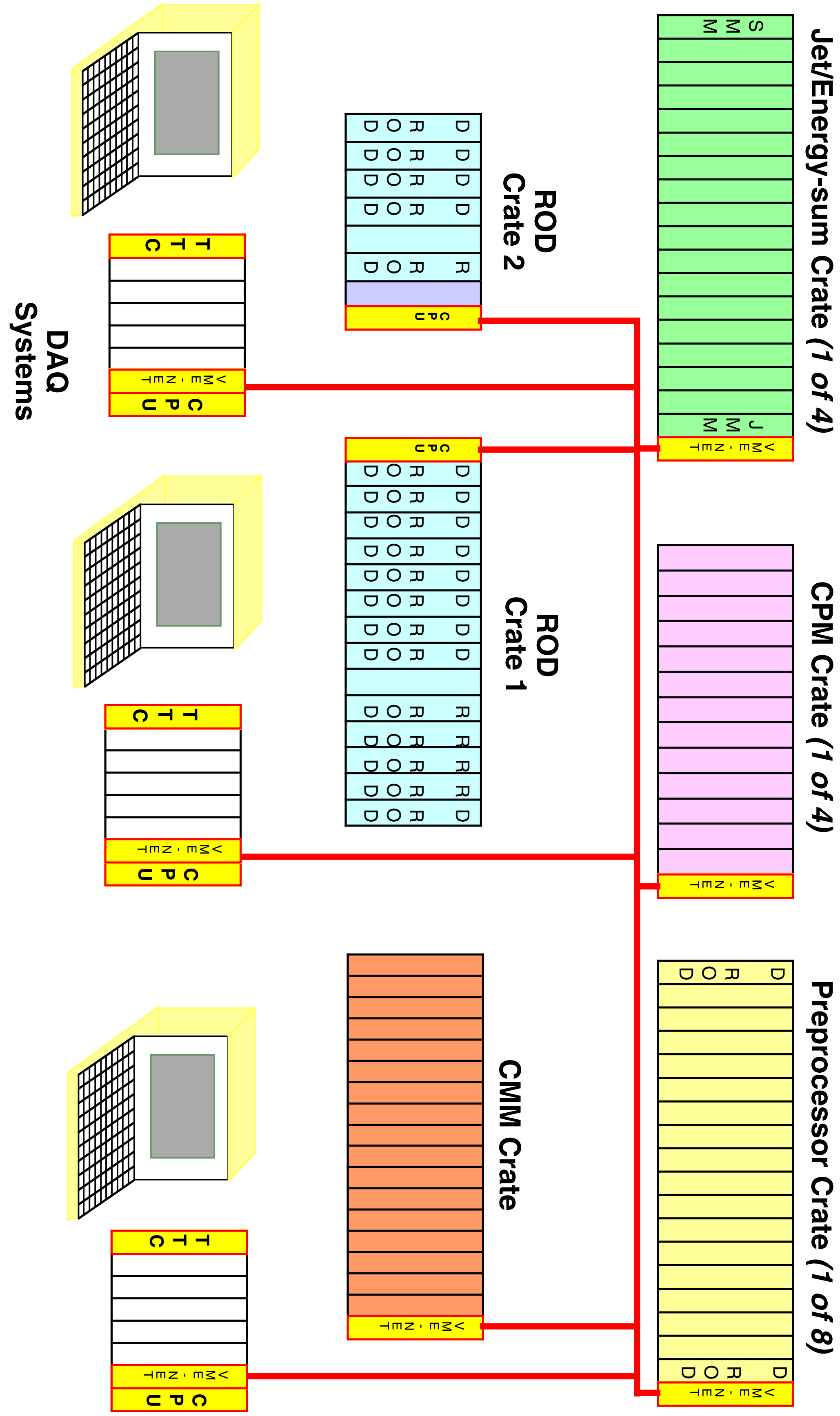
Overview

- **Overview of ROD connections**
- **Data Routes into RODs**
- **Data volumes, latency and dead time**
- **Tasks performed in the ROD**
- **Technology Issues**
- **Monitoring and Control**

ROD Overview



Level-1 ROD Overview

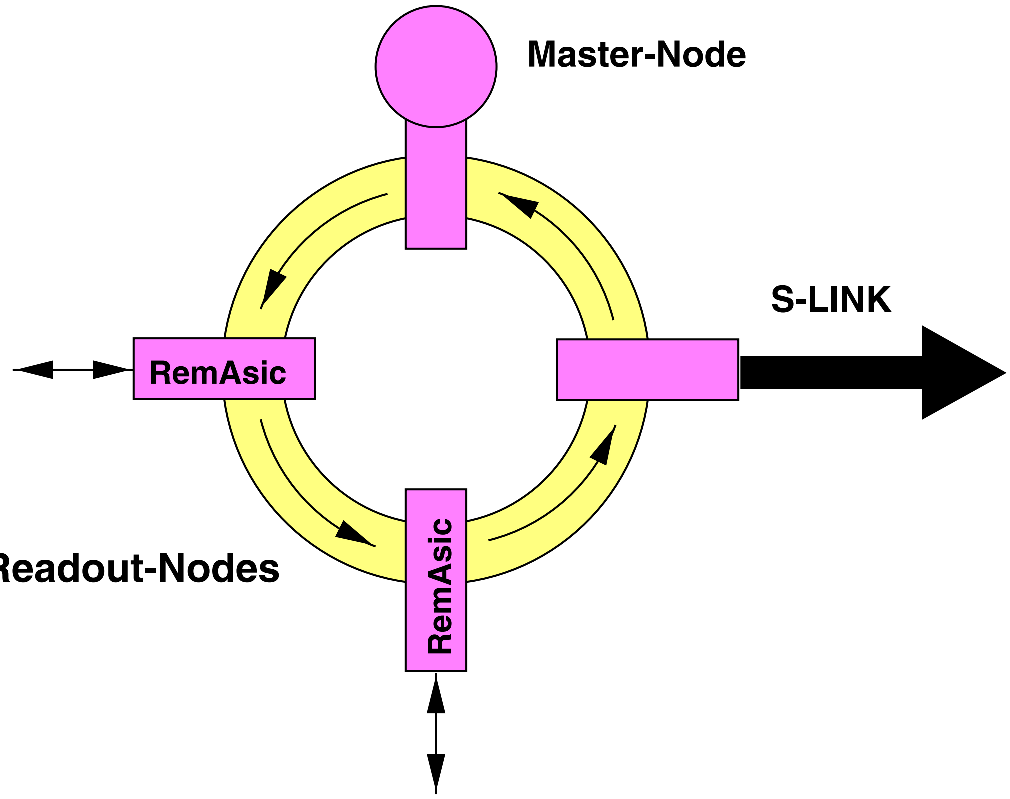


DAQ Infrastructure for Control, Monitoring, Diagnostics & Installation

ROIDAQ 101198

Data routes into ROD - PreProcessor

PipelineBus



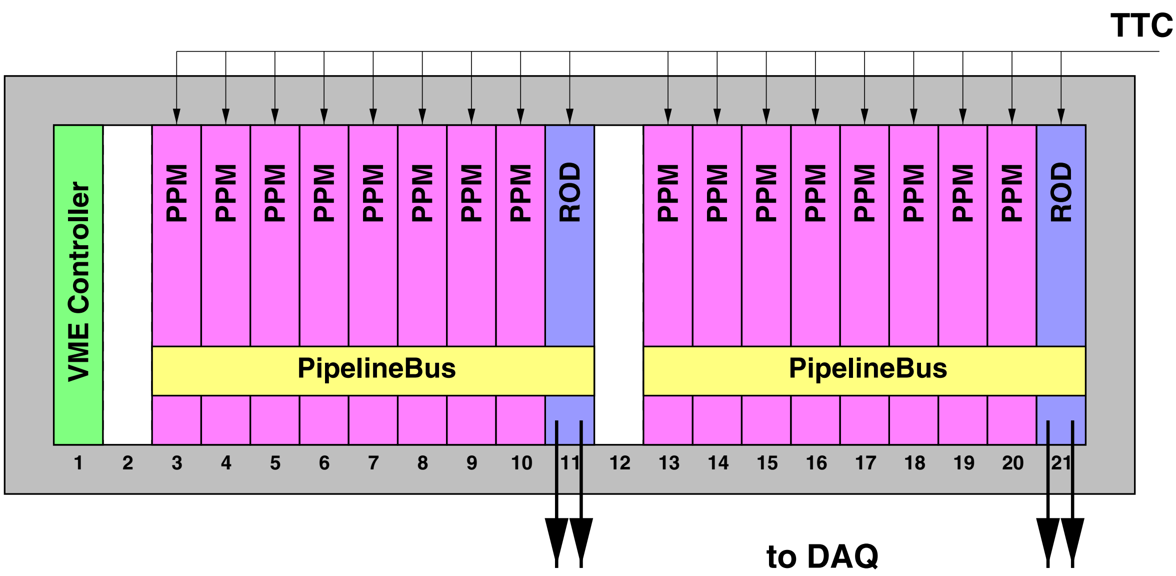
- Parallel shift register with ring-like topology forms pipeline
- Synchronous shifting of words through pipeline
- Data is injected into slots of the data stream running through the pipeline, which are marked as empty
- Commands issued by a master node control the bus

- Bus extension to the S-Link
- Bandwidth: 32 Bit @ 40 MHz -> 152.6 MByte/s
- Serial configuration possible (fewer wires, lower bandwidth)

- Demonstrator system under construction
  - General purpose VME motherboard
  - Specific function on mezzanine cards
  - also used for demonstrator MCM

Data routes into ROD - PreProcessor

Pre-Processor - Readout Configuration



Readout configuration of crates:

- **1 crate: 16 modules, 2 Readout Driver, 4 Readout Links**
- **Whole system: 8 crates -> 32 Readout Links**

Bandwidth numbers:

- **Readout Link: 100 MByte/s**
- **Protocol overhead of standard ATLAS readout format @ 100 kHz: 5 MByte/s @ 100 kHz (for each Readout Link)**
- **1 status bit per trigger tower @ 100 kHz: 6 MByte/s for 8 PPMs**

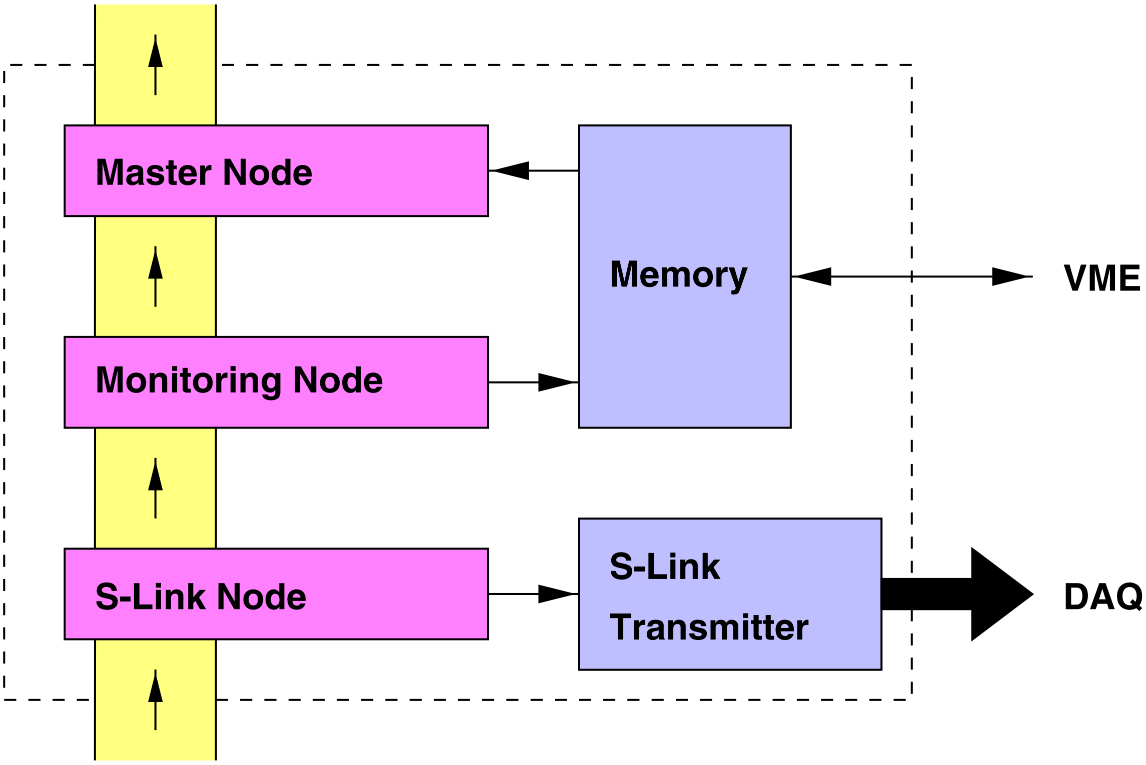
Readout performance:

- **Assuming data compression with a factor of 2.5**
- **Assuming PipelineBus bandwidth not being the limiting factor**
- **Taking into account protocol overhead and 2 status bits per channel**

-> Readout is possible for 6 words of 10 bits width
(e.g. 5 bunch crossings raw data and corresponding BCID result)

Data routes into ROD - PreProcessor

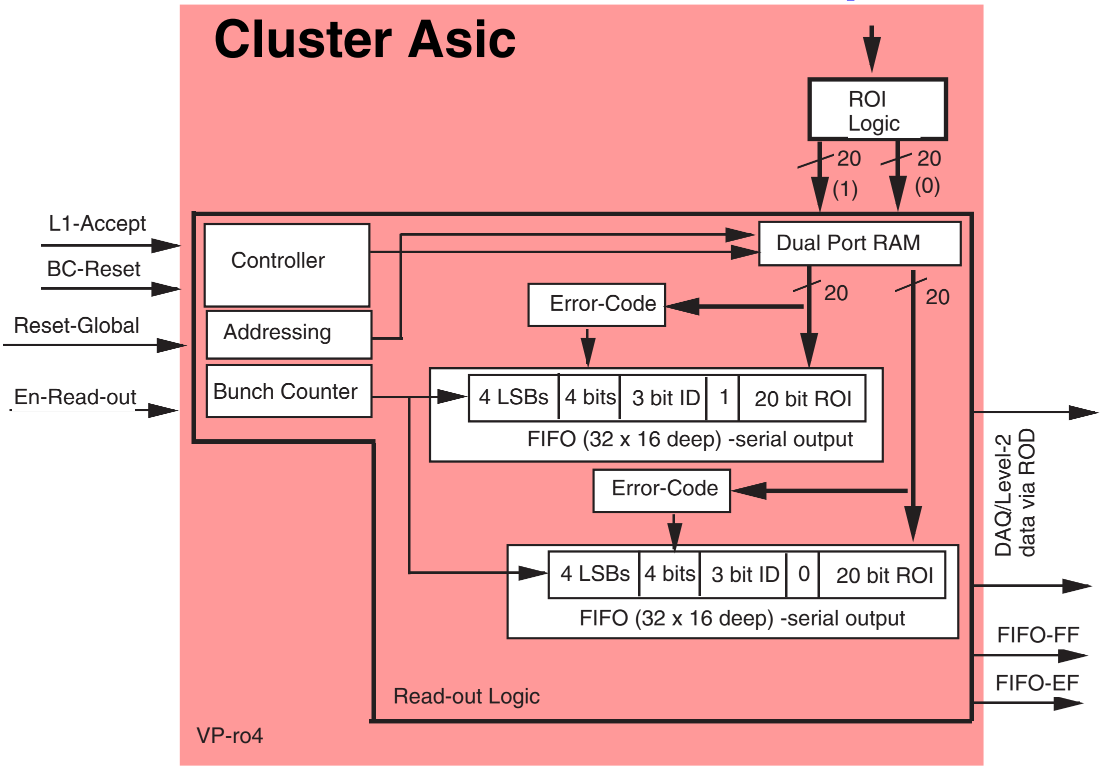
Readout Driver Module (ROD)

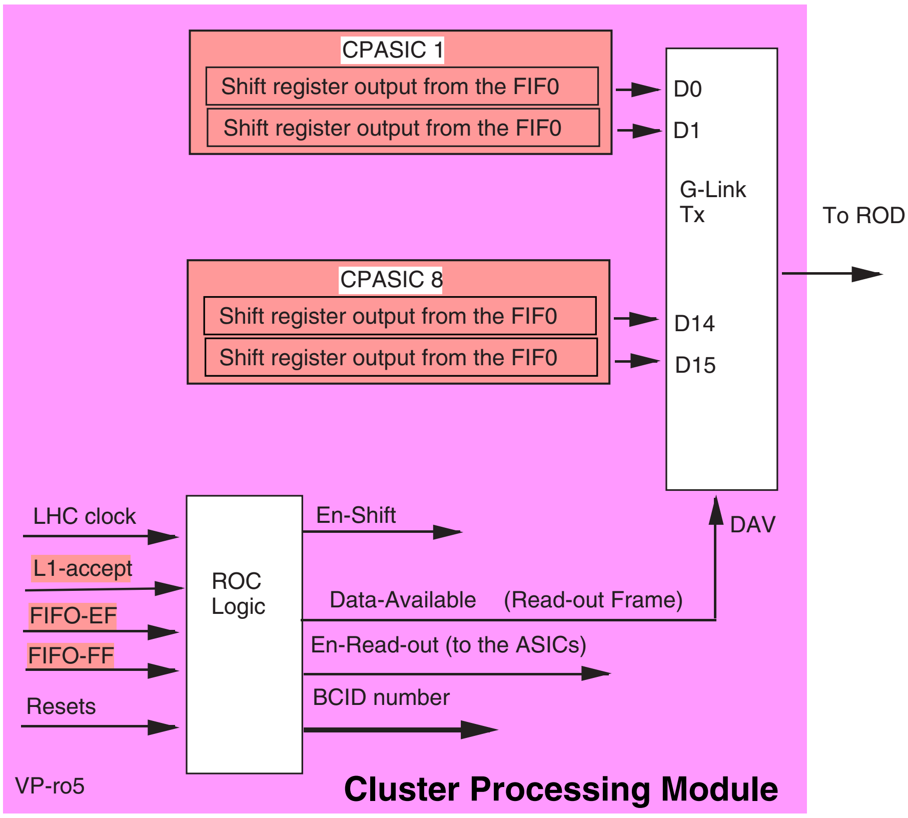


- Master Node:
    - Control of PipelineBus
    - Injection of configuration data into pipeline
- Monitoring Node:
    - Storing and/or processing of read out data for diagnostics
- S-Link Node:
    - Construction of event blocks (ATLAS standard format)
    - Expansion of event number and bunch crossing number
    - Transmission of data to DAQ
    - Checking for errors in synchronisation

Data routes into ROD – e/γ and Jet/energy

Both transfer data via G-Link. An example…





Tasks performed in the RODs

**We have two types of ROD hardware - Pre-processor and common Jet and e/γ RODs.
All RODs have an interface to the dedicated level-1 computer system.**

Pre-processor RODs

- **Control and arbitrate the PPr crate Pipeline bus**

At configuration time:
- **Accept configuration data and download into pre-processor modules.**

When running:
- **Receive pre-processor time slices over PipelineBus;**
- **Format into standard event fragments;**
- **Transmit over S-link to ROBs.**

Jet and e/γ RODs

- **Different FPGA algorithms are used to process RoI data (in R-RODs) and timeslice data (in D_RODs).**

R–RODs

- **Receive RoI data over G-links**
- **Check bunch counter fields;**
- **Handle error conditions - count, signal to TTC for reset or set bits in output RoIs;**
- **Discard empty RoIs;**
- **Discard all except first 30 RoIs;**
- **Build surviving RoIs into event fragments;**
- **Inject into S-Links to Level-2;**

Tasks performed in the RODs (continued)

D–RODs

- **Receive time slice data over G-Links;**
- **Format into standard event fragments;**
- **Transmit over S-link to Level-2.**

All RODs also perform the following functions:

- **Generate & transmit messages when faults are detected (e.g. reset crates if bunch numbers are out of step).**

- **Copy data from selected events to buffer for readout & monitoring (by level-1 computer); the selection is based on trigger type or bunch number.**

- **Check test data patterns injected during LHC long gaps. Signal errors;**

- **Assist in internal timing setup of the trigger and in trigger system diagnostics & Debugging;**

- **Provide test data patterns or dummy data to level-2.**

Data Volume and Latency

Two factors determine the Data Volume:

- **Trigger rate (depends on trigger threshold settings and LHC luminosity)**
- **Diagnostic readout level.**

Some examples of readout speeds and timing:

Preprocessor readout over PipelineBus

	75 KHz	100 KHz
BCID Result	36.6	48.8
5bc Raw data	228.9	305.2
Event Format overhead	4.0	5.3
Status Bits	9.2	12.2
Total	278.7	371.6
Compressed Total (factor 2.5)	111.2	148.6

Cluster Processor readout via G-Link

RoI data: 32 bits/RoI takes 0.8 μsec.
Timeslice data: 128 bits/8 chan takes 3.2μsec
Overall data rate ~ 7 Mbytes per second at 100 KHz (~107 Mbytes/sec with diagnostic readout).

Jet/Energy Processor readout via G-Link

Overall data rate ~ 10 Mbytes per second at 100 KHz (~35 Mbytes/sec with diagnostic readout).

The trigger is being designed to allow full diagnostic readout at moderate trigger rates and essential information plus some diagnostics at 100 KHz.

Technology and Module size

- Real-time data is received onto modules over PipelineBus (PPr RODs) or G-link (all other RODs).

- Control and data-processing will probably use FPGAs.

  The FPGA code to generate S-Link packets may be common for all calorimeter trigger RODs.

- All ROD Modules are 9U with VME backplane interfaces. All ROD functions can be driven through this interface.

- Data for specialised and stand-alone monitoring will be selected in RODs, copied to memory in the ROD, and transferred to dedicated (possibly single-board) computers over a series of links starting at the RODs.

  Suitable link technologies (Gigabit ethernet, PCI,…) are evolving rapidly, but we will need to choose within the next ~2 years. Bandwidth needs are not yet defined.

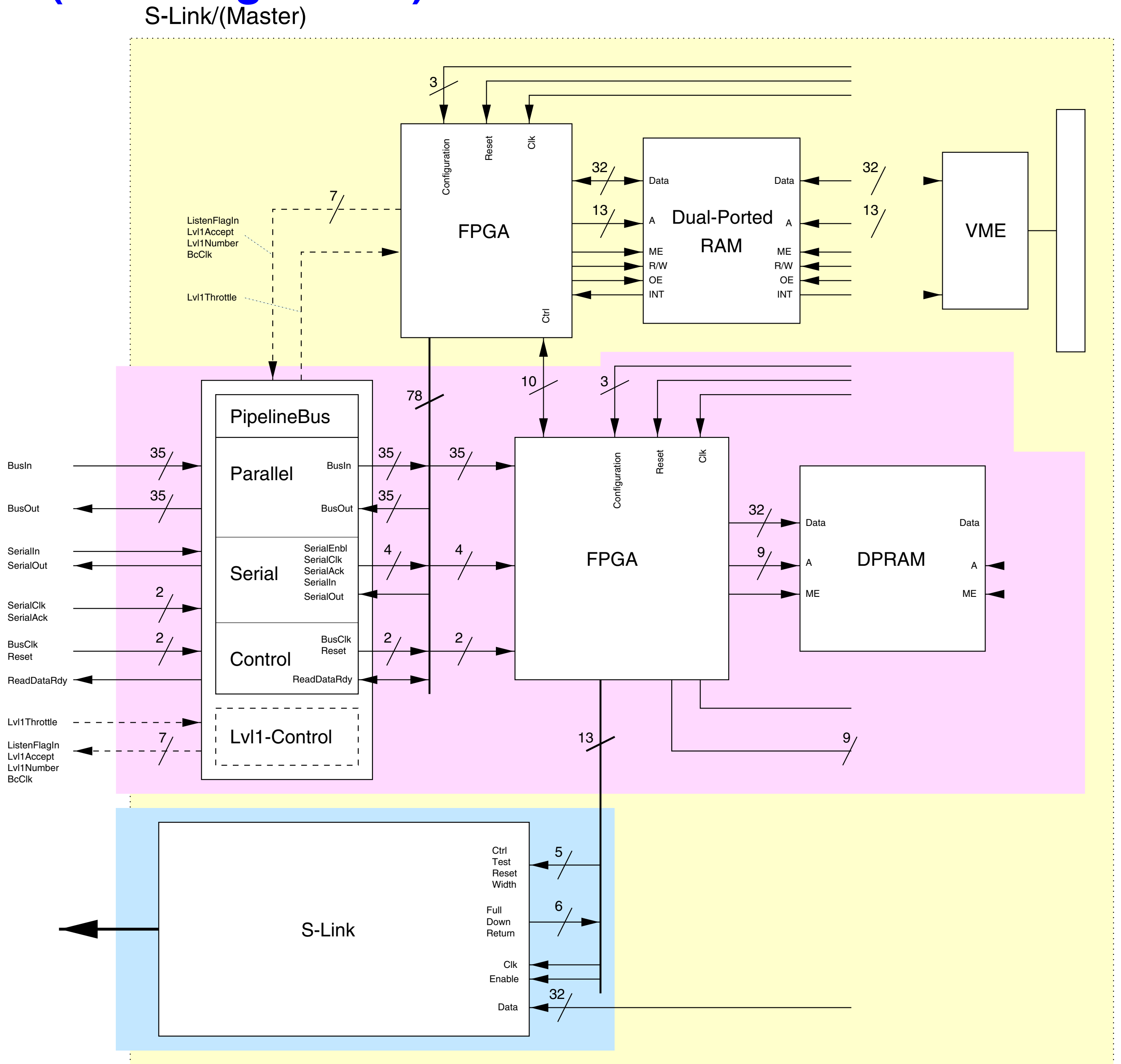
- This gives three external data paths:
  - S-Link (Event fragments & RoIs, from ROD);
  - PCI, Ethernet or… (Monitoring data, from ROD);
  - VME (Control and downloading, bi-directional).

Prototyping Programme

- **Prototyping programmes are starting for all calorimeter trigger RODs. Some joint tests are also under discussion.**

Preprocessor ROD

- **Test system under design. It will include Preprocessor, PipelineBus and ROD function tests (including S-Link)**



Prototyping Programme (continued)

E/γ and Jet RODs

Test system under design. It will consist of two modules

1. **A ROD prototype with 4 incoming G-link channels and a single S-link output. FPGA code will allow a variety of tests:**
    - **Full speed slice data processing**
    - **Zero-suppression of RoIs.**
    - **Detection and handling of error conditions**
    - **Data sampling (access via VME)**

2. **A G-link data source + S-link data sink module:**
    - **Checks of ROD prototypes in a closed loop with pseudo-random data.**
    - **The data source can be configured to emulate all data from e/γ and Jet/Energy processors.**
    - **First tests will be of e/γ slice data since this is the most demanding.**

A joint test is foreseen with the Level-2 RoI builder in the second half of 1998.

Prototypes of other parts of the calorimeter trigger are being built over the next ~2 years. As part of the testing, readout functions will be checked with the prototype ROD as they are completed.

Monitoring and Control

- **We are starting to discuss detailed requirements.**
- **We see the testing & diagnostics of prototypes and the final data acquisition & control programs as a single suite of software.**
  - **The same tools & libraries should be used throughout.**
  - **e.g. it should not be possible to run invasive diagnostics during physics data collection.**
- **All trigger Control & Diagnostics will be via the local level-1 computer system. We need to explore if/where to use a "light-weight front end" to connect to the full DAQ software.**

Special triggers

- **These will be needed to time in the trigger, to measure and check calibration (using a calorimeter pulser), to simulate data taking outside beam.**

Databases

- **We expect to read and write DCS parameters, trigger setup parameters (timing and physics), performance history, configuration details.**

Error handling,

- **Our trigger hardware includes internal error checking. Some errors may be cleared automatically by hardware resets over TTC (which should be counted). Others will indicate a failed module or corrupted settings. There should be a list of errors and corrective actions.**

Monitoring and Control (continued)

Monitoring

- **We need to check both the physics performance and the technical operation of the trigger.**
- **Physics performance checks need information from other parts of the detector - probably to be performed with complete events in the DAQ system.**
- **Technical operation can be checked in the level-1 computers (although the information will also be recorded in some events).**

Calibration

Partly internal to the trigger (e.g. internal timing), partly using calorimeter pulse systems (e.g. external timing, cable integrity checks), partly using live event data (e.g. FADC timing, energy calibration).

Trigger Installation & Commissioning

- **Needs a mixture of all the above. We will need to check that the trigger/DAQ infrastructure is present early enough.**

Project Timetable