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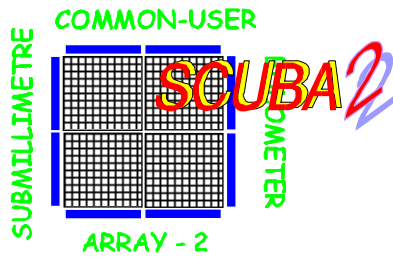
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## 1. SUMMARY

The SCUBA-2 computer network is based on one RT-Linux PC for each subarray, plus workstations for near-real-time data and status display, and separate machines for final pipeline processing and archiving. It also includes VME/VxWorks systems for interfacing to the JCMT Real Time Sequencer (RTS) and for mechanism and cryostat monitoring and control.

## 2. REFERENCES

"SCUBA 2 Modes and Data Processing", B.D.Kelly, 2001, SC2/ANA/S100/28

"WFCAM Software Top Level Design and Architecture", Alan Bridger and Andy Vick, 2001, 5.1d001S

## 3. INTRODUCTION

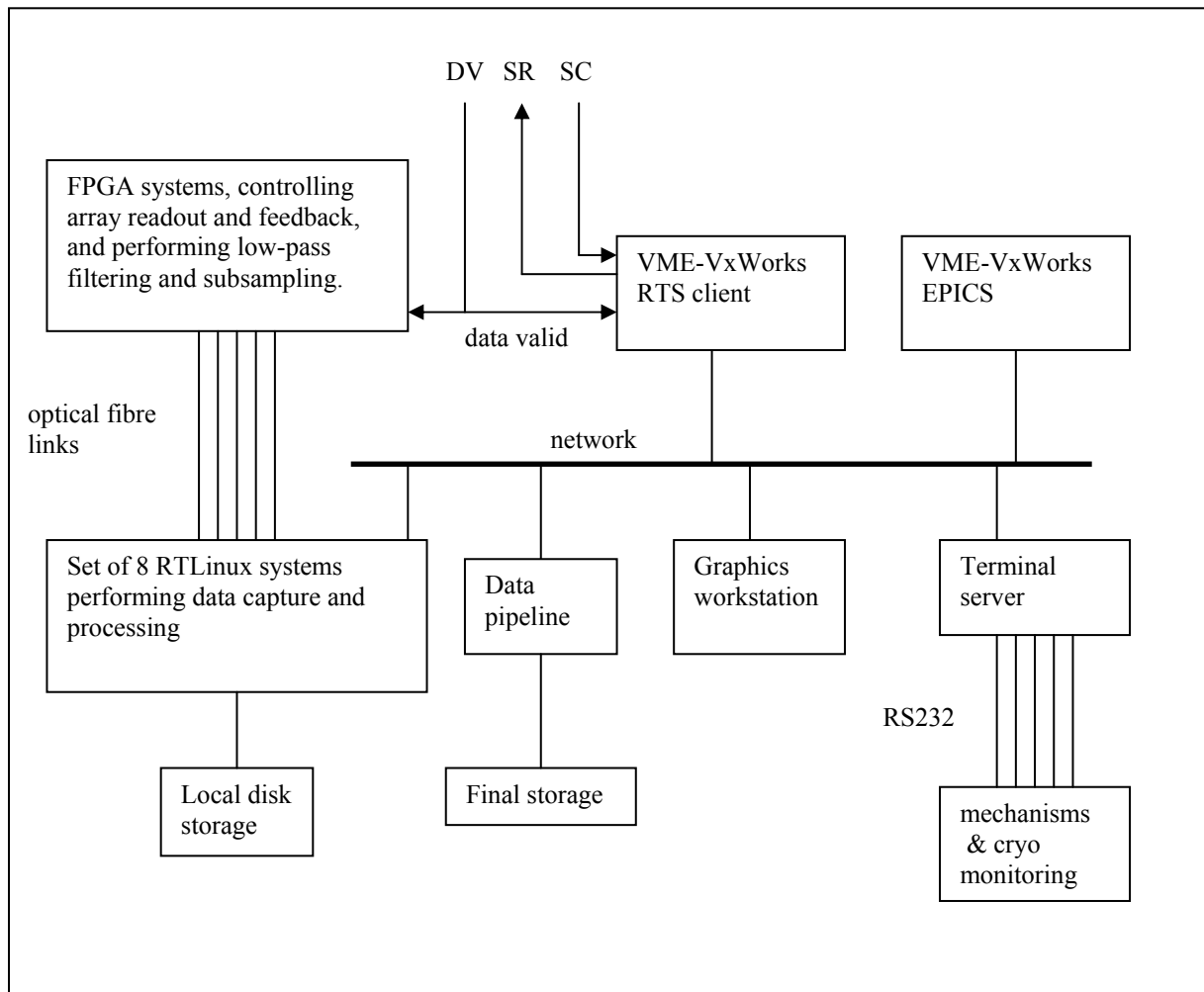
This document presents the overall design for the SCUBA-2 computer network to be considered during the SCUBA-2 Systems Analysis Review (October 2002).

## 4. GLOSSARY

EPICS	A standard "active database" system for controlling and monitoring mechanisms.
FPGA	Field Programmable Gate Array - a type of real-time programmable logic system.
OCS	Observatory Control System - a term used for the JCMT software infrastructure which supervises observing.
RTLinux	A modified kernel for the Linux operating system providing improved real-time behaviour and easy access to physical memory addresses.
RTS	Real Time Sequencer - a part of the OCS which enables real-time coordination of subsystems using a 3-wire handshaking protocol.
SQUID	Superconducting Quantum Interference Device - very sensitive magnetometers used as low-temperature amplifiers in the SCUBA-2 system.
TCS	Telescope Control System.

## 5. HARDWARE NETWORK

### 5.1 COMPUTING SYSTEMS OUTLINE



## 5.2 RTS CLIENT

This provides the SCUBA-2 client to the Real Time Sequencer. It is a DRAMA system implementing the standard JCMT commands in connection with sequencing, and is the target for commands coming from the Observatory Control System.

## 5.3 EPICS

This is responsible for mechanism and cryostat control (dark slide and flat-field illumination, temperature and pressure monitoring).

This is a separate physical machine from the RTS Client as it is not involved in actual observing, but is also expected to be operational when the observing system is shut-down. This arrangement is expected to be valuable during the development and commissioning phases, but in the operational phase it would be possible to run this software on the RTS Client if necessary.

One of its major functions is 24-hour monitoring of the state of the cryostat with the ability to raise an actionable alarm to engineering support personnel if the cryostat develops a problem.

## 5.4 FPGA SYSTEM

This performs real-time control of array readout. It also controls the pixel heaters. It has to have access to the Data Valid signal from the Real Time Sequencer.

## 5.5 SET OF RTLinux DATA CAPTURE PCS

Each PC is linked by optical fibre to the FPGA system controlling a single subarray. The PCs are responsible for downloading code, setup and calibration data into the FPGAs. They are also responsible for the high-level coordination of calibration measurements, and the near-real-time processing and storage of all data acquired from the arrays.

## 5.6 GRAPHICS WORKSTATION

This provides the observer with displays summarising the state of the instrument and showing recently acquired data, which is likely to involve resampling partly-processed DREAM and SCANMAP images onto (RA,Dec).

## 5.7 DISK STORAGE

This provides real-time temporary storage of raw and processed data. The total data rate to disk due to raw data, summed across all eight PCs, is likely to be 10Mbyte/sec (equivalent to 200 frames/sec). This actual data rate is likely to be dependent on observing mode, where some modes might reduce this rate by coadding. There is a suggestion that the maximum rate should be doubled to allow oversampling when making scanmaps. The data rate is also increased by the need to store processed data.

## 5.8 DATA PIPELINE

This collects processed and raw data from the data capture machines and serves it to the graphics workstation, as well as performing standard data processing and final storage.

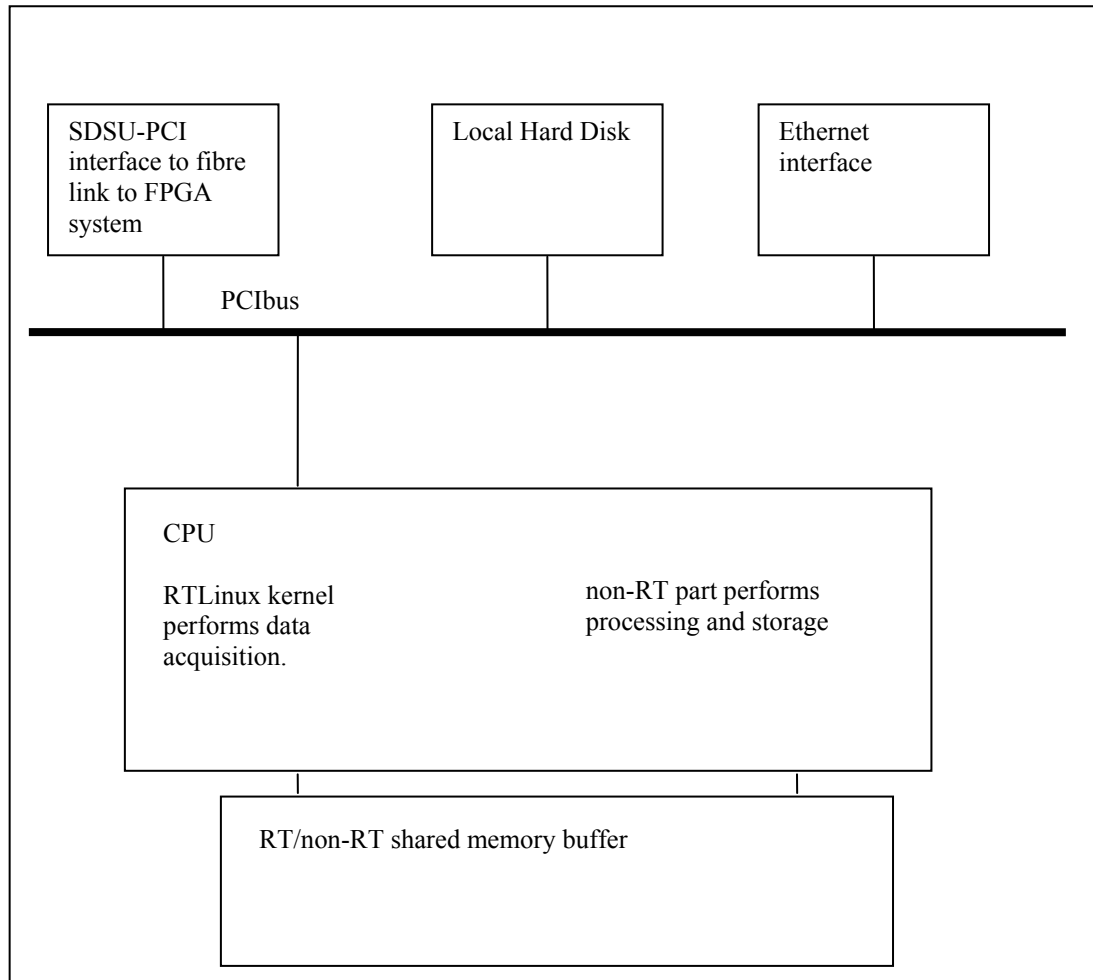
## 5.9 FINAL STORAGE

This is a catch-all name for the final archival form of the data, and also the form in which the data are exported to the observers.

## 6. DATA CAPTURE PCS

### 6.1 HARDWARE ARRANGEMENT

This system is based on the scheme devised for ULTRACAM and WFCAM.



The RTLlinux system handles all communication with the FPGA system, including sending set-up and command information and receiving data back.

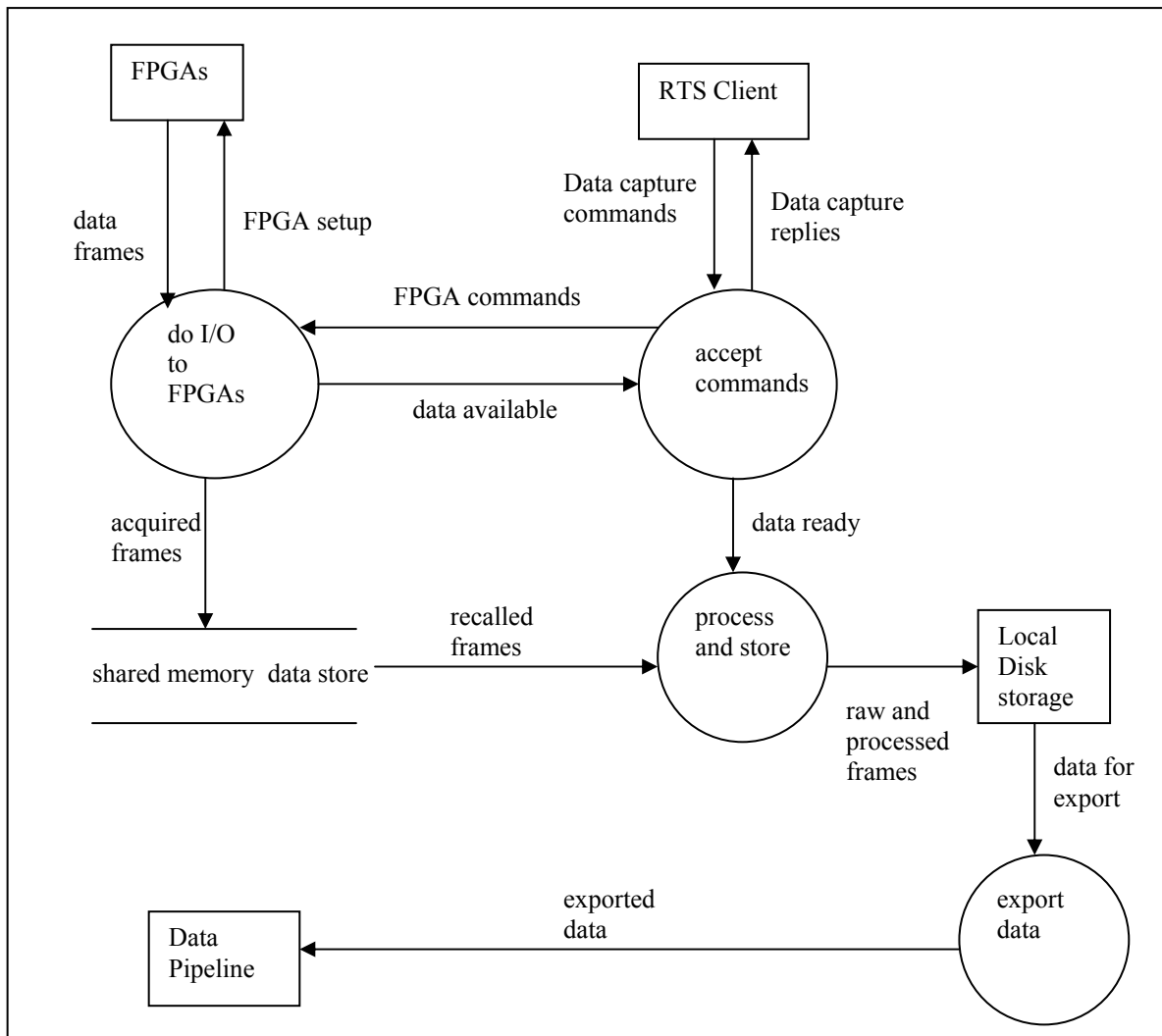
The Non-RT system handles Ethernet communication, such as commands coming from elsewhere, and is responsible for storing data onto the local disk, as well as carrying out data processing.

Communication between the software running in the RT and non-RT parts is based on a mixture of Linux FIFOs and physical addressing of the "shared memory" area.

The software in the non-RT system has to accept and acknowledge commands from elsewhere. This is achieved by running a DRAMA task.



## 6.2 SOFTWARE OUTLINE

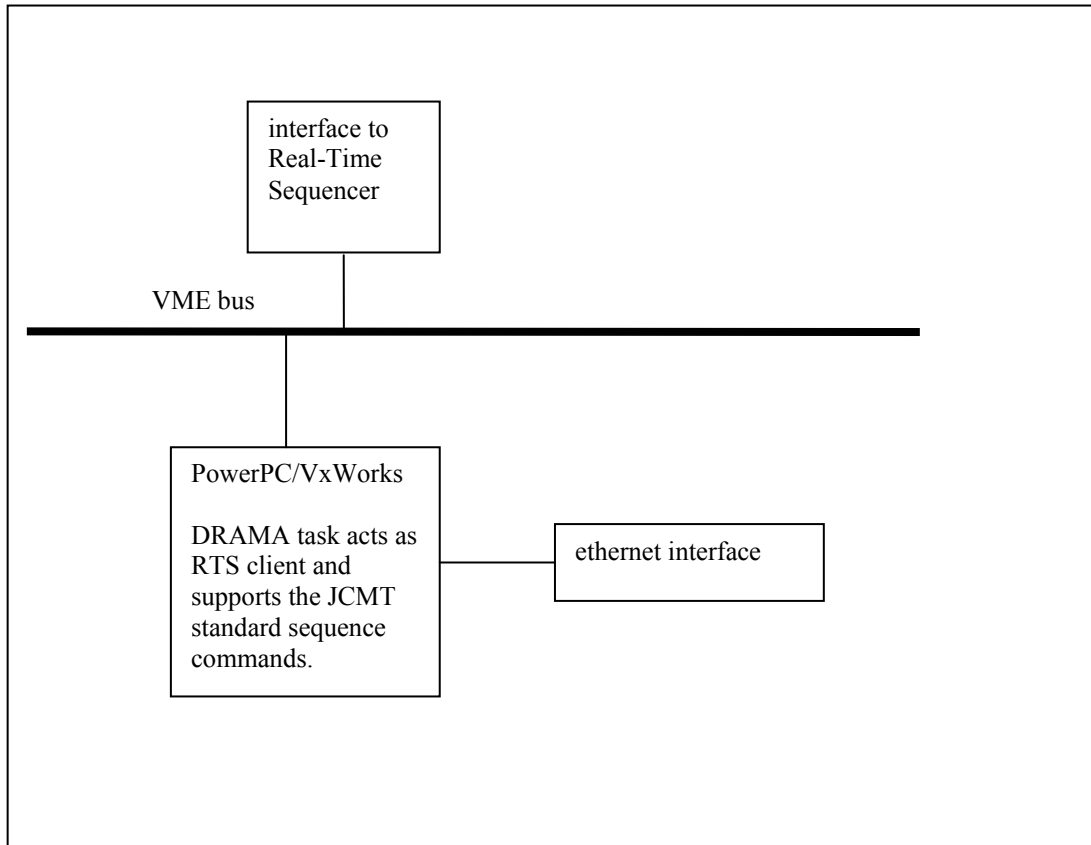


The processes are:

- **accept commands** - accepts commands from the RTS Client and returns replies and status information. Its main activity is to forward FPGA commands and to detect when data are available. It also provides header information which can be attached to the data files.
- **do I/O to FPGAs** - forwards commands and parameters to the FPGAs and accepts data frames back from them. It writes the acquired frames into the data store and informs "accept commands".
- **process and store** - it gets frames from the data store, performs any necessary processing (eg reconstruction of DREAM data) and writes both processed and unprocessed data to disk.
- **export data** - delivers data for export to the data pipeline and final storage. This might be just networked file serving.

## 7. RTS CLIENT SYSTEM

The RTS client is the main interface between SCUBA-2 and the JCMT Observatory Control System. It accepts all the information needed to set-up an observation, and forwards it to the data capture PCs using DRAMA messages.



It has an interface to a connection to the JCMT Real-Time Sequencer and implements the RTS protocols.

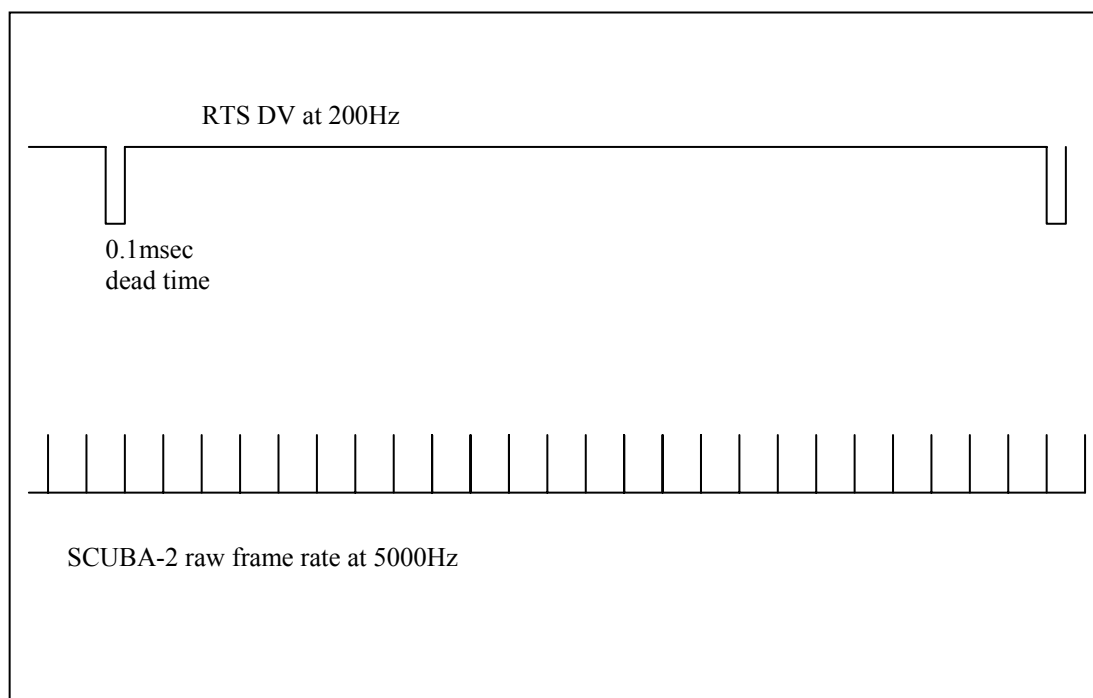
## 8. FPGA SYSTEM

### 8.1 GENERAL

The details of the FPGA system are outside the scope of this review, however, it is necessary to describe certain aspects of its required behaviour.

The FPGA system is responsible for all direct control of the array hardware, including setting the pixel heaters, setting the various bias voltages, controlling the multiplexed readout, generating the SQUID feedback signals, demultiplexing the pixel values, low-pass filtering and subsampling the data to reach the final output frame rate. The timing of the output frames has to be coordinated with the Data Valid signal from the Real-Time Sequencer (RTS).

### 8.2 FPGA REACTION TO DATA VALID



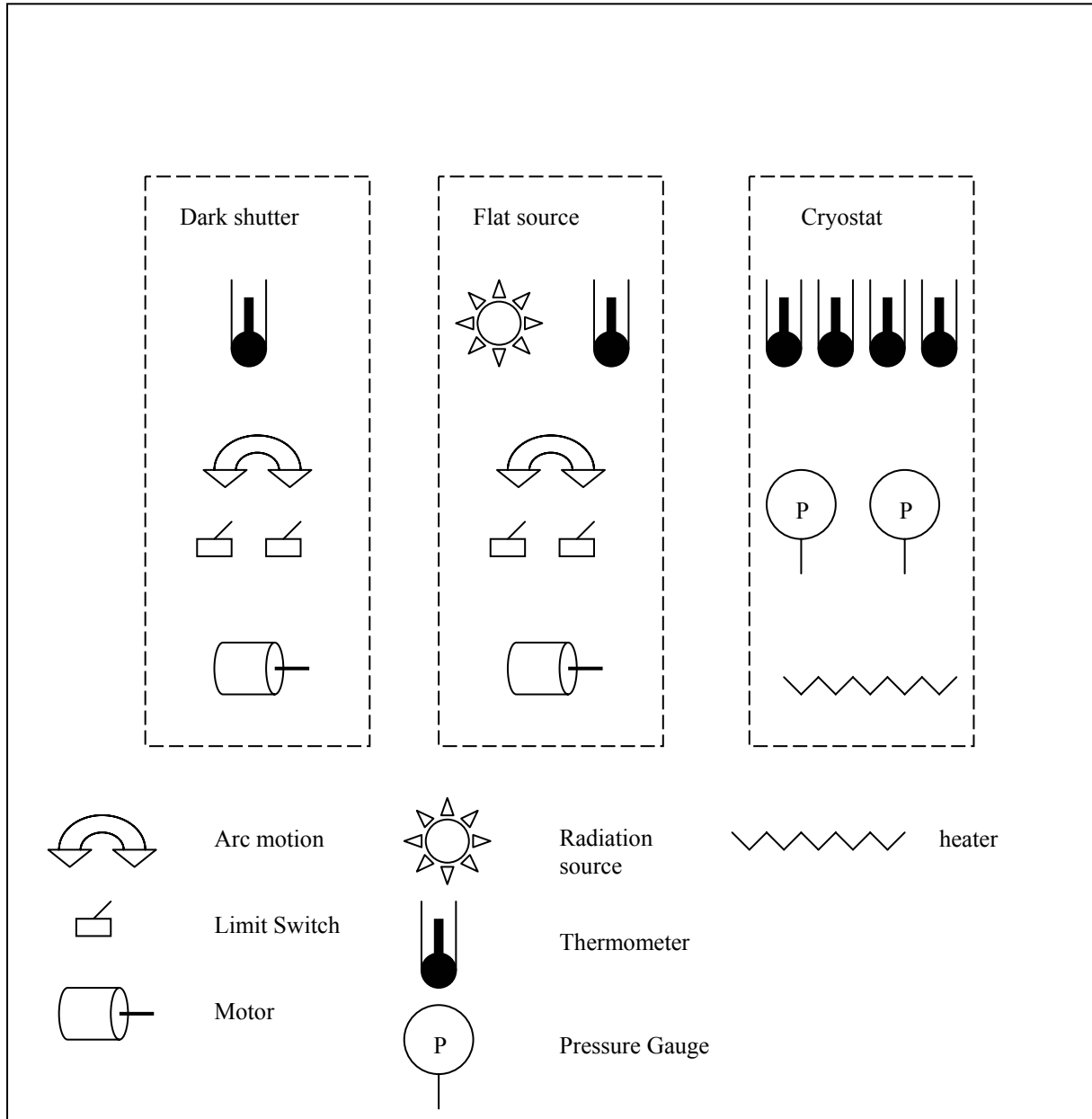
SCUBA-2 is shown digitising raw frames at 5KHz (the actual number will be at least 5.6KHz). The Real Time Sequencer is requesting integrations at 200Hz, and its Data Valid (DV) signal has a dead-time of 0.1msec. The FPGAs have to apply a low-pass filter to the 5KHz measurements and subsample them to produce a single value corresponding in time to approximately the middle of the RTS signal.

The "raw frame rate" shows the triggering times for a single bolometer. The other bolometers in the same column are triggered in turn, meaning that there is a small difference in timing (up to one raw frame interval) between the bolometers. The FPGAs will compensate for this.

Handshaking with the RTS is carried out by the VME/VxWorks system. The DV line is continued directly to the FPGA system to avoid inserting extra delays or dead-time by having the VME/VxWorks system copy DV to a separate output line.

## 9. EPICS SYSTEM

### 9.1 SUMMARY OF MECHANISMS



### 9.2 DARK SHUTTER

The dark shutter is attached to the 1K box inside the cryostat. It is driven between open and closed by a motor, and has limit switches detecting its two positions. It is likely it will be fitted with a temperature sensor.

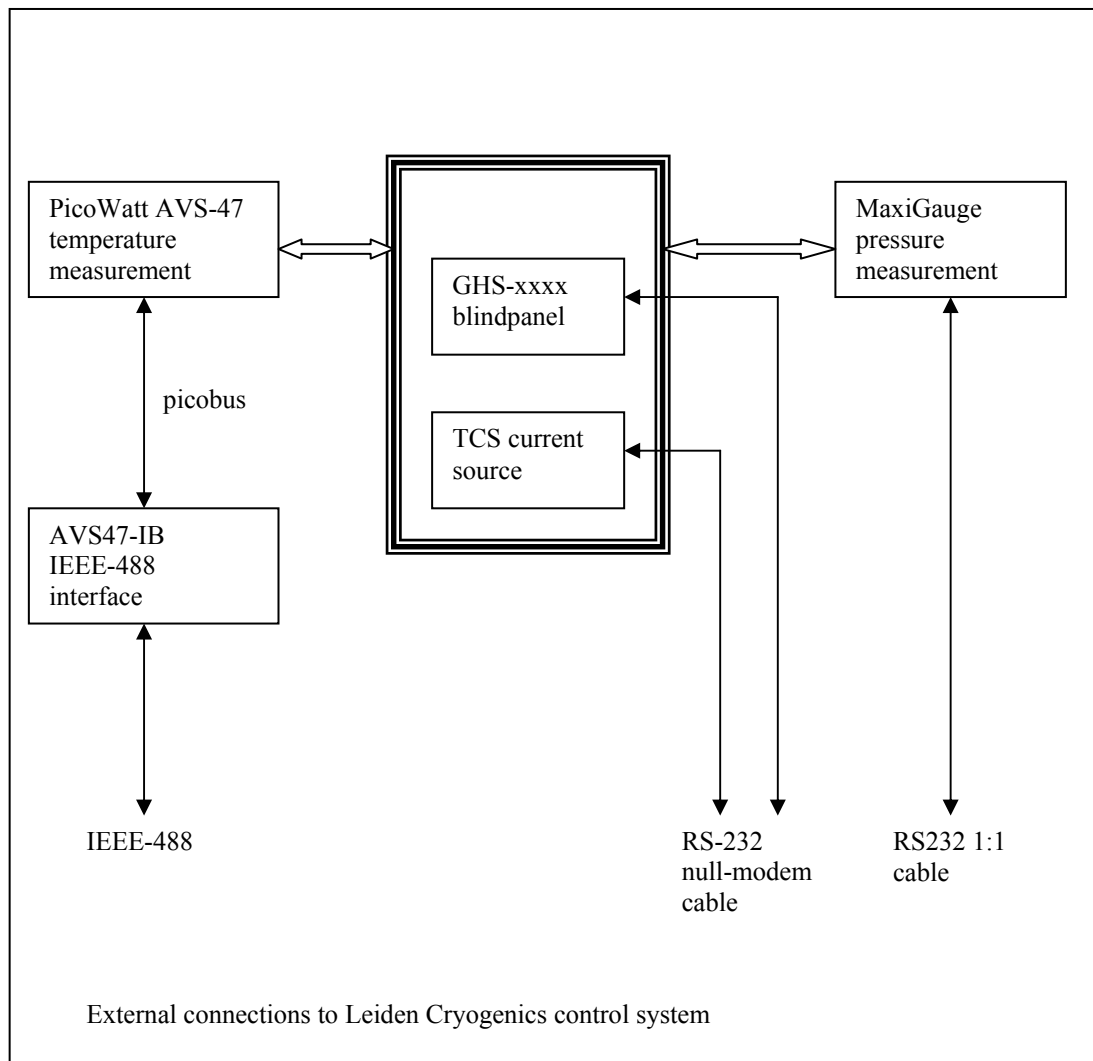
### 9.3 FLAT SOURCE

The flat source is positioned inside the JCMT receiver cabin at the entry to the hole through the altitude bearing. It is driven between being in the optical path and out of the optical path

by a motor, and has limit switches detecting its two positions. It is likely it will be fitted with a temperature sensor. The temperature of the flat source can be set to be between ambient and 60C.

### 9.4 CRYOSTAT

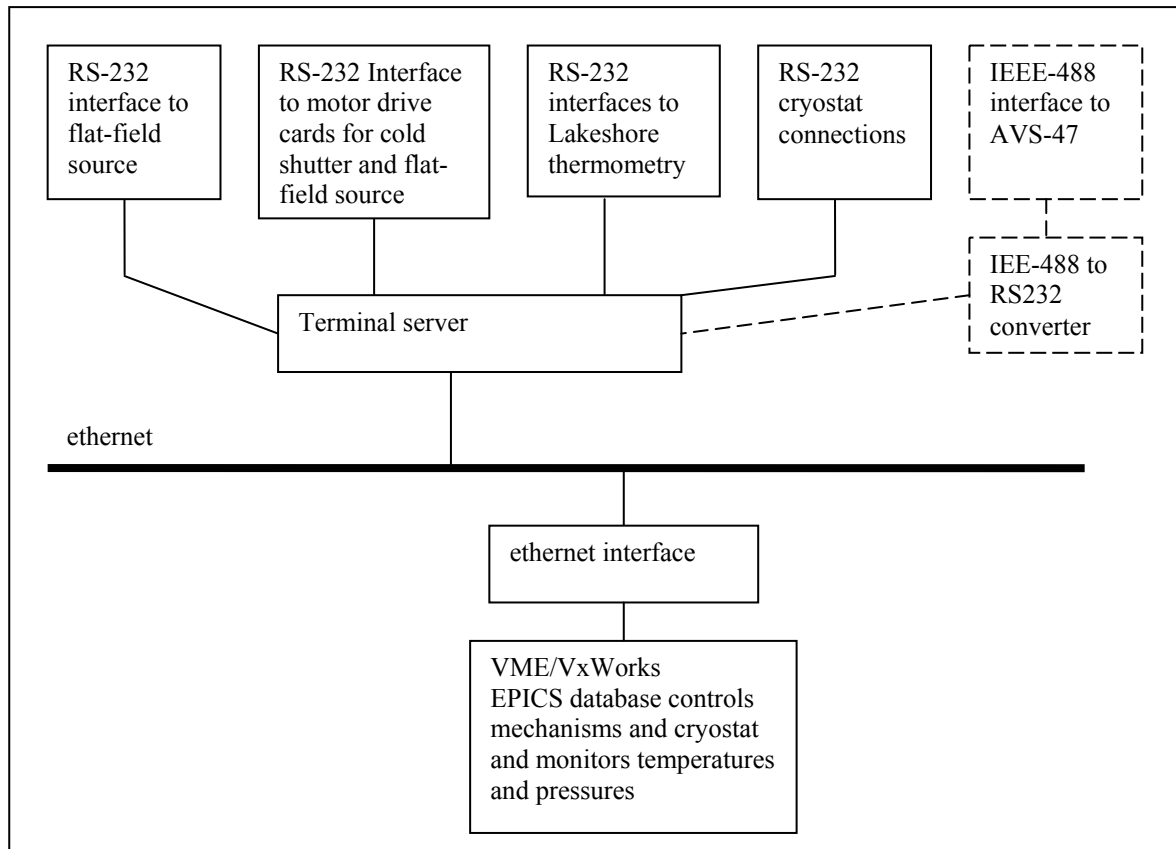
Leiden Cryogenics deliver an embedded system with automatic control initiated via front-panel switches. For optional remote operation and monitoring, a computer interface is provided which is a mixture of RS-232 1:1 cables, RS-232 null modem cables and IEEE-488. Leiden Cryogenics provide LabView drivers to enable these to be used in conjunction with a



PC, and this option will be used during initial set-up of the cryostat in the lab. In the delivered instrument they will operate with the VME/EPICS system through an ethernet connection. An alternative to the AVS-47 with direct RS-232 connection is under investigation.

For the rest of the cryostat, controllable items include a focal-plane heater, but it is yet to be decided which aspects of the cryostat system will be under the control of the overall computer system.

## 9.5 CONNECTION TO MECHANISMS



The principle has been adopted of avoiding direct hardware interfaces to the EPICS VME machine, thereby retaining flexibility in its physical positioning (eg. moving the EPICS database onto the RTS Client).

The AVS-47/IEE-488 arrangement is shown with broken lines to indicate that alternatives are still under consideration.

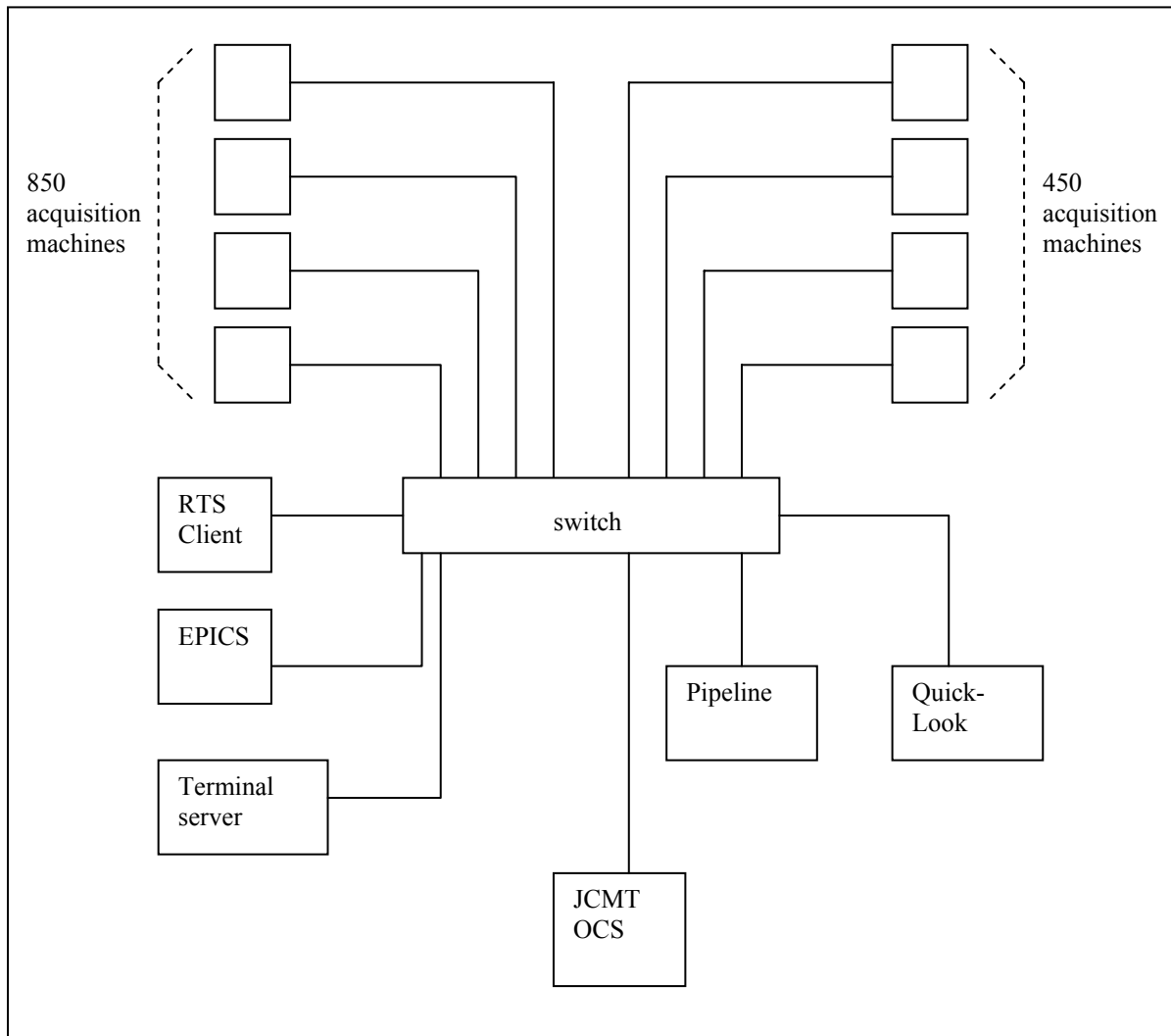
## 10. DATA PROCESSING FLOW

### 10.1 DATA RATE AND NETWORK

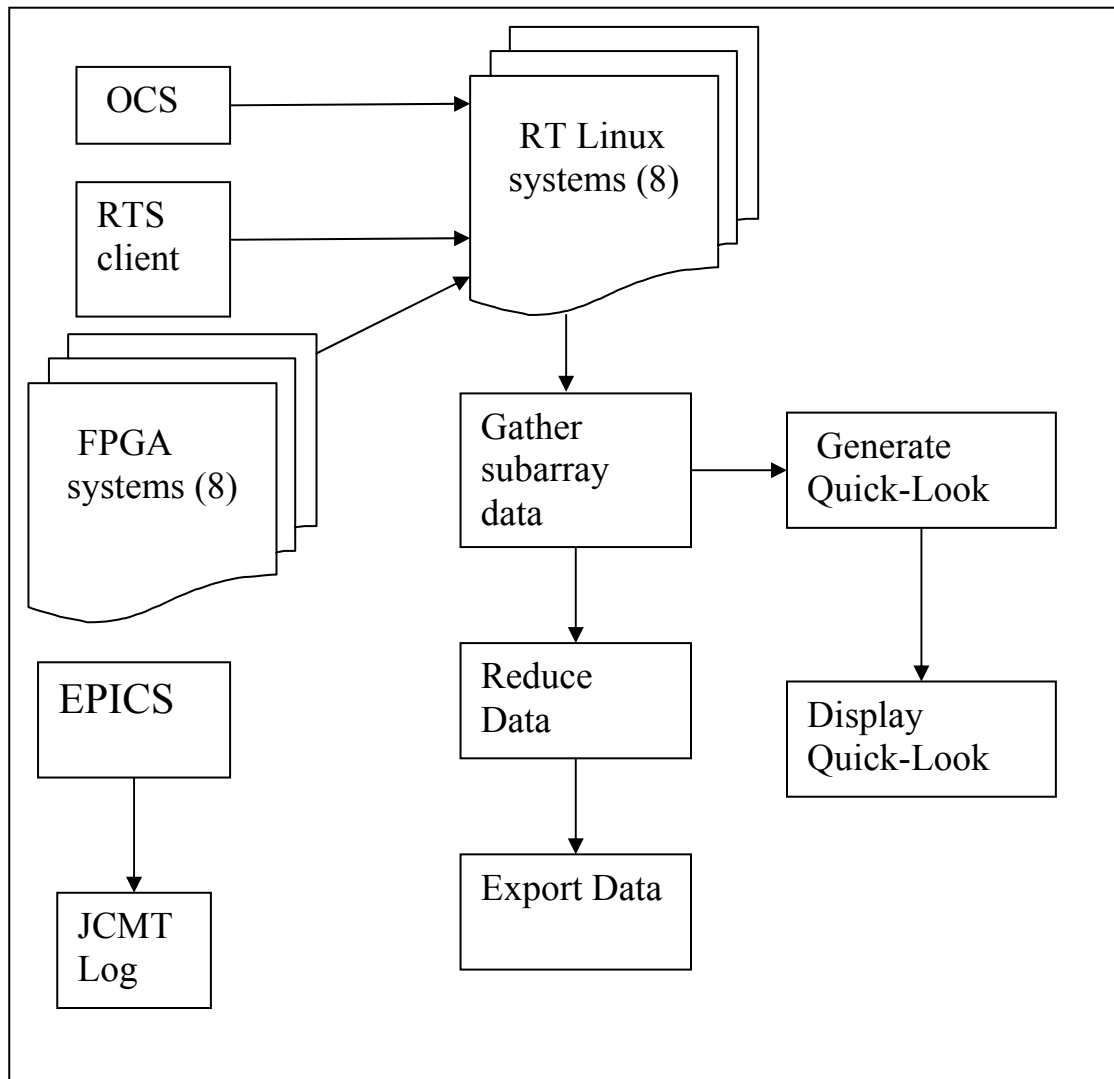
The SCUBA-2 raw data rate is 200 frames/sec. Given two 80x80 arrays, and assuming four bytes per pixel, this gives a total acquired data rate of 10,240,000 bytes per second.

To avoid loading the data acquisition PCs unnecessarily, it is assumed that the data will be exported from them only once to the pipeline. In turn, the pipeline can serve data to the quick-look system.

There are many possible ways to design a network to meet the requirements. An example is provided here to demonstrate feasibility, where all the connections are 1Gbit.



## 10.2 DATA HANDLING SYSTEM (DHS)

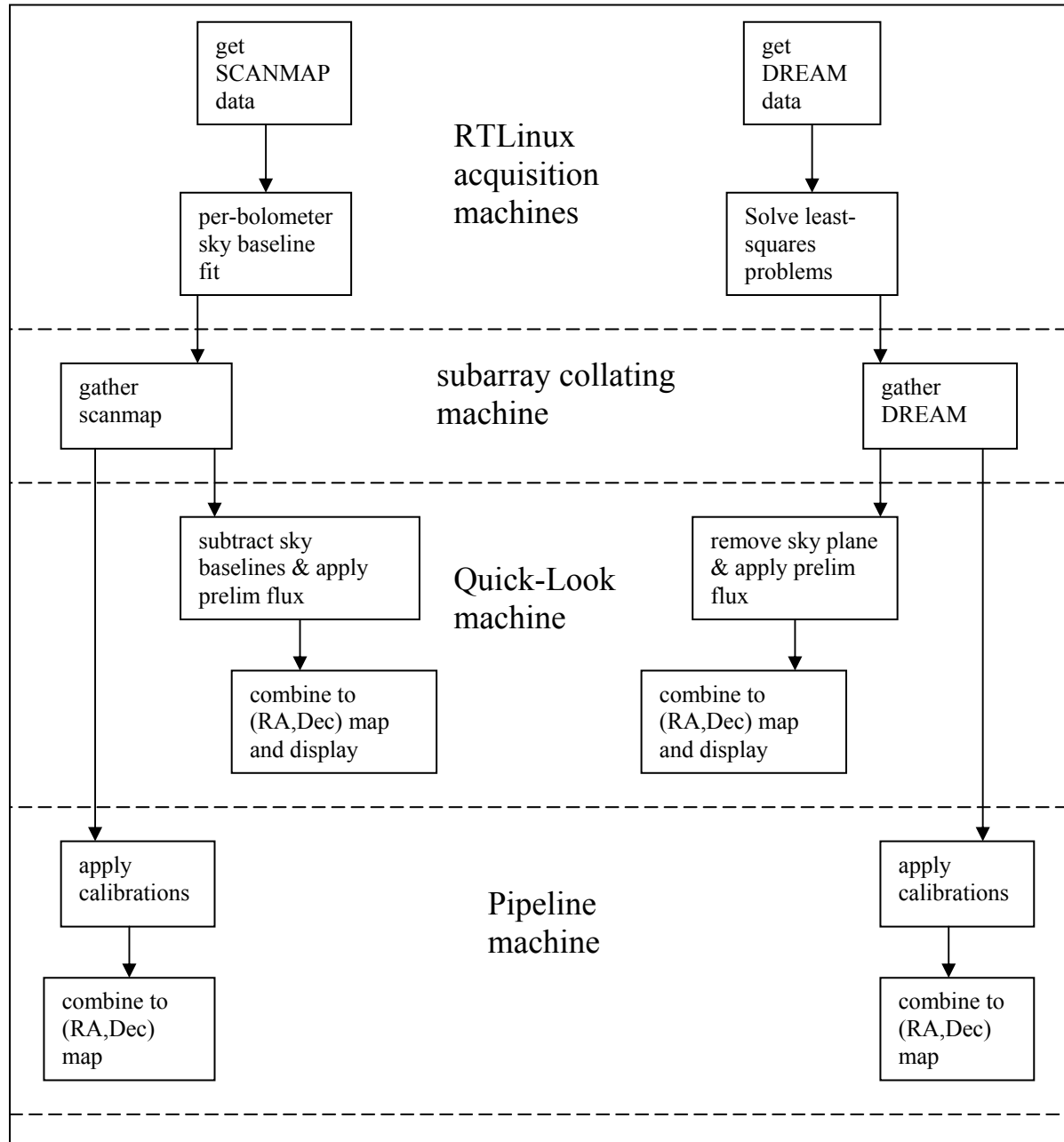


The frames from each subarray are collated with data obtained from the RTS and TCS and written in a standard format (eg FITS) as files to the local Linux disk. These files are then served across the network to the start of the pipeline, where the images from the separate subarrays are gathered and passed on to the rest of the pipeline and the quick-look machine.



### 10.3 DATA PROCESSING ARRANGEMENT

The different parts of the computer network have different data processing responsibilities for different observing modes.



## 11. GRAPHICS WORKSTATION

The Graphics workstation will allow access to quick-look data, provided by a side branch in the Data Handling System. To achieve this it is expected that "Generate Quick-Look" will have to reconstitute the data as an (RA,Dec) image.

The Graphics Workstation might also be the host for some EPICS screens displaying instrument status.

## 12. CONCLUSION

This outline design is based on the data acquisition concepts used for ULTRACAM and WFCAM and it should be capable of supporting the requirements described in the SCUBA-2 Systems Analysis document. A number of hardware details (the connection for low-temperature thermometry, the number of computers needed in the pipeline, the network layout at the telescope and the data export medium) need to be clarified as part of iterating this design.