Development of a SpaceWire-based Data Acquisition System for a semiconductor Compton Camera

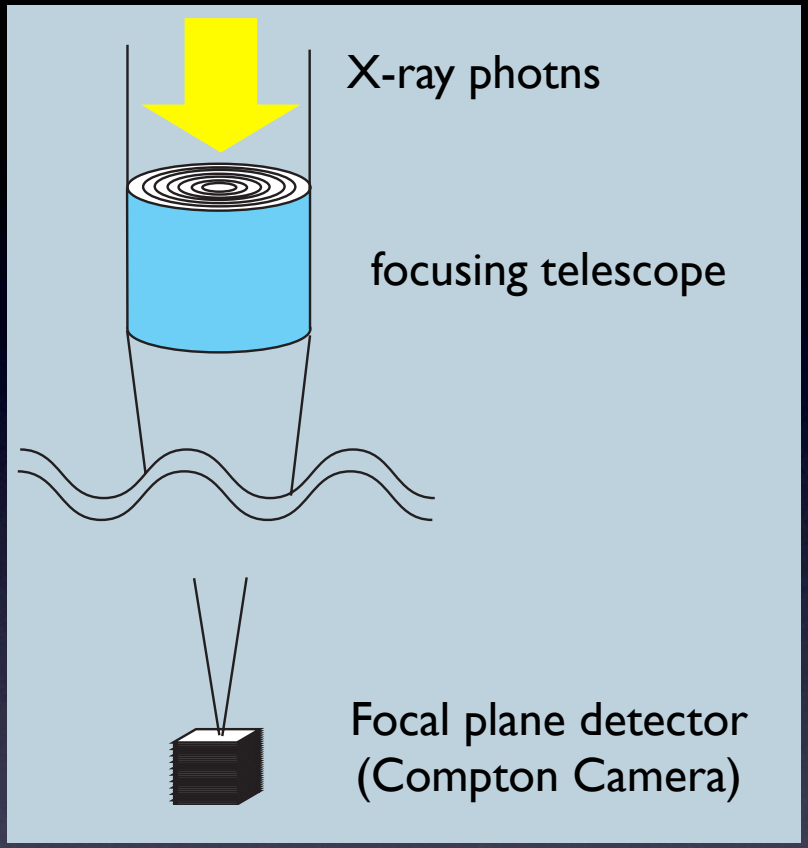
Hirokazu Odaka
(ISAS/JAXA, University of Tokyo)

M. Kokubun, S. Watanabe, S. Takeda,
T. Takashima, T. Takahashi(ISAS/JAXA),
T. Yuasa, K. Nakazawa, K. Makishima(University of Tokyo),
M. Nomachi (Osaka University),
H. Hihara(NT Space), T. Tohma(NEC)

How can we use SpW in real experiments?

Balloon-borne experiment in Australia

Hard X-ray Imaging observations



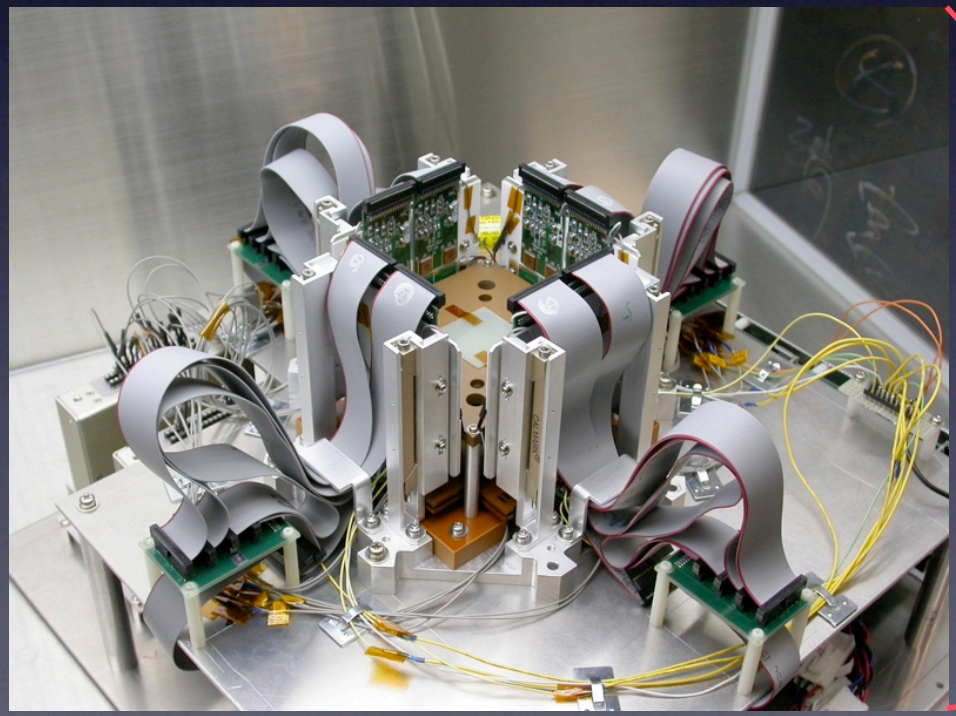
Only one graduate student (It's me!) is assigned to write all flight software/FPGA HDL to handle detectors.

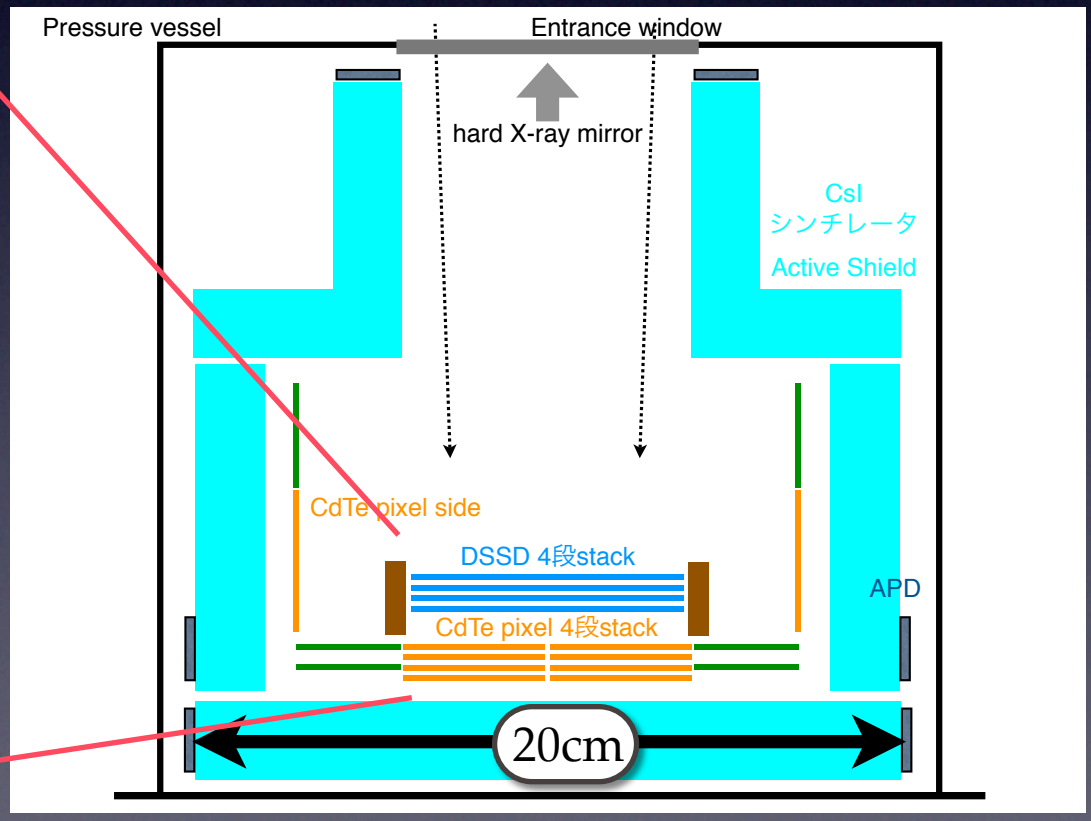
ISAS's Si/CdTe Semiconductor Compton Camera (First demonstration)

- 4-layer stack of DSSDs (double-sided Si strip detectors)
- 32 CdTe pixel detectors [Bottom/Side]

➡ Many channels to read: **TOTAL 2560 ch**

We need a compact and high-performance DAQ system.

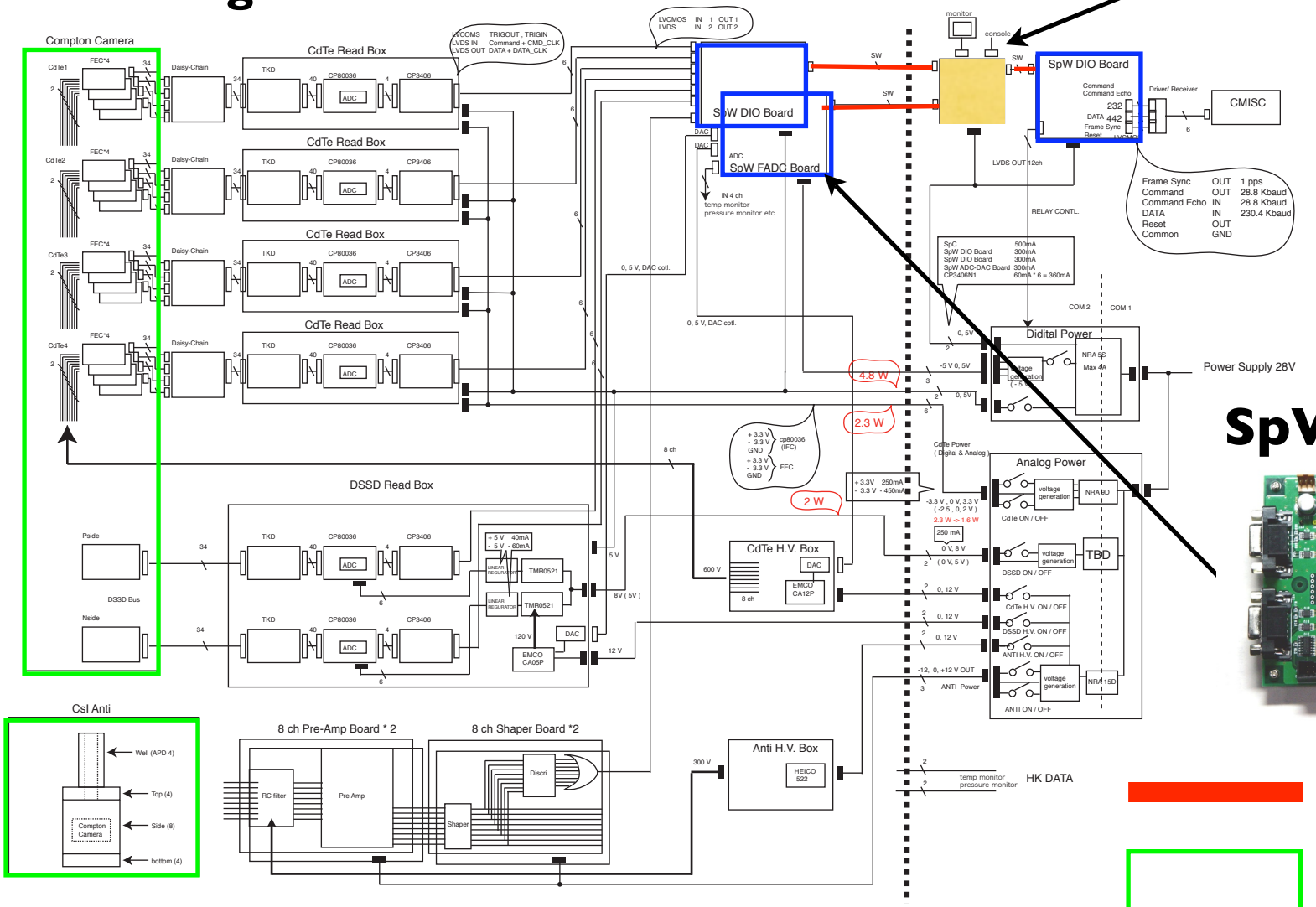




Data Acquisition System

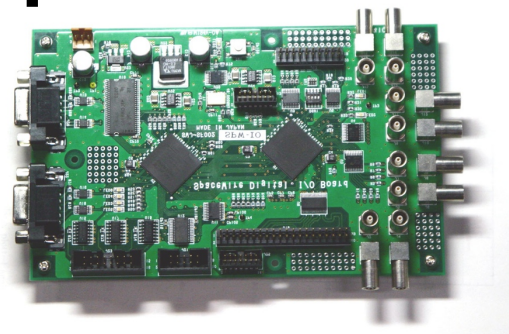
We utilize our multi-purpose DAQ framework based on SpaceWire I/F and RMAP. (Talk by T. Yuasa)

Block diagram



Space Cube

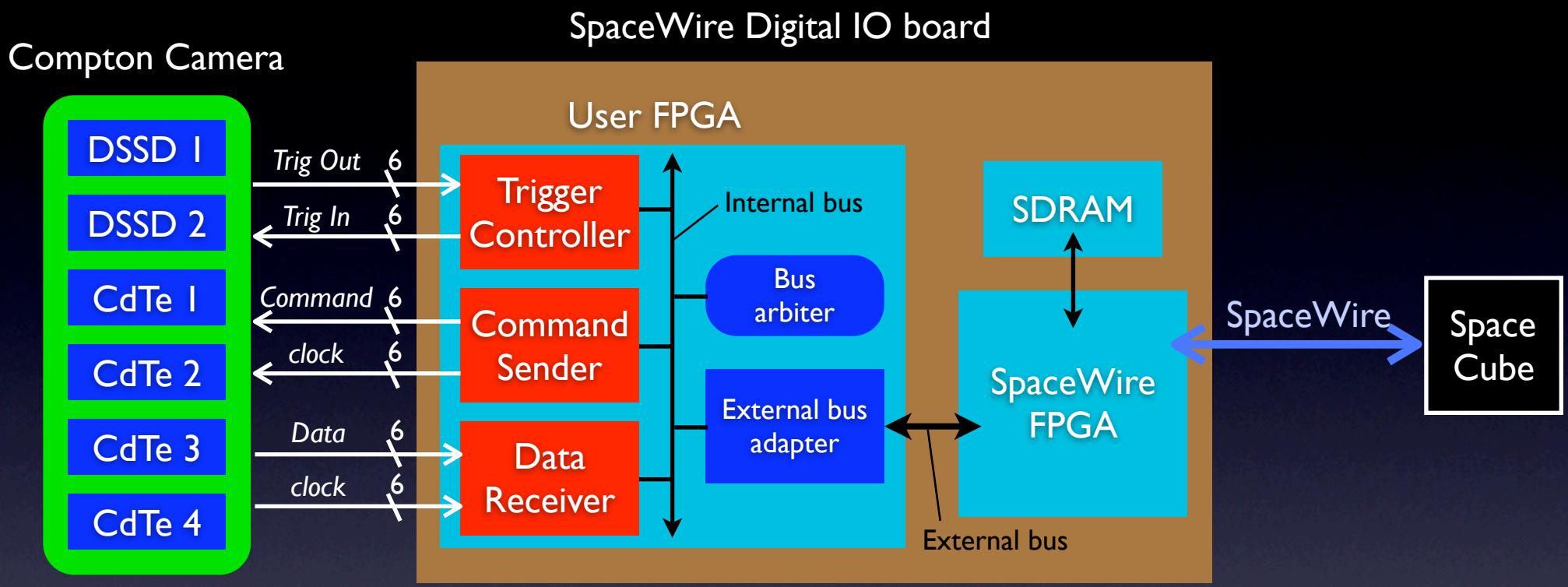
SpW I/O board



SpaceWire

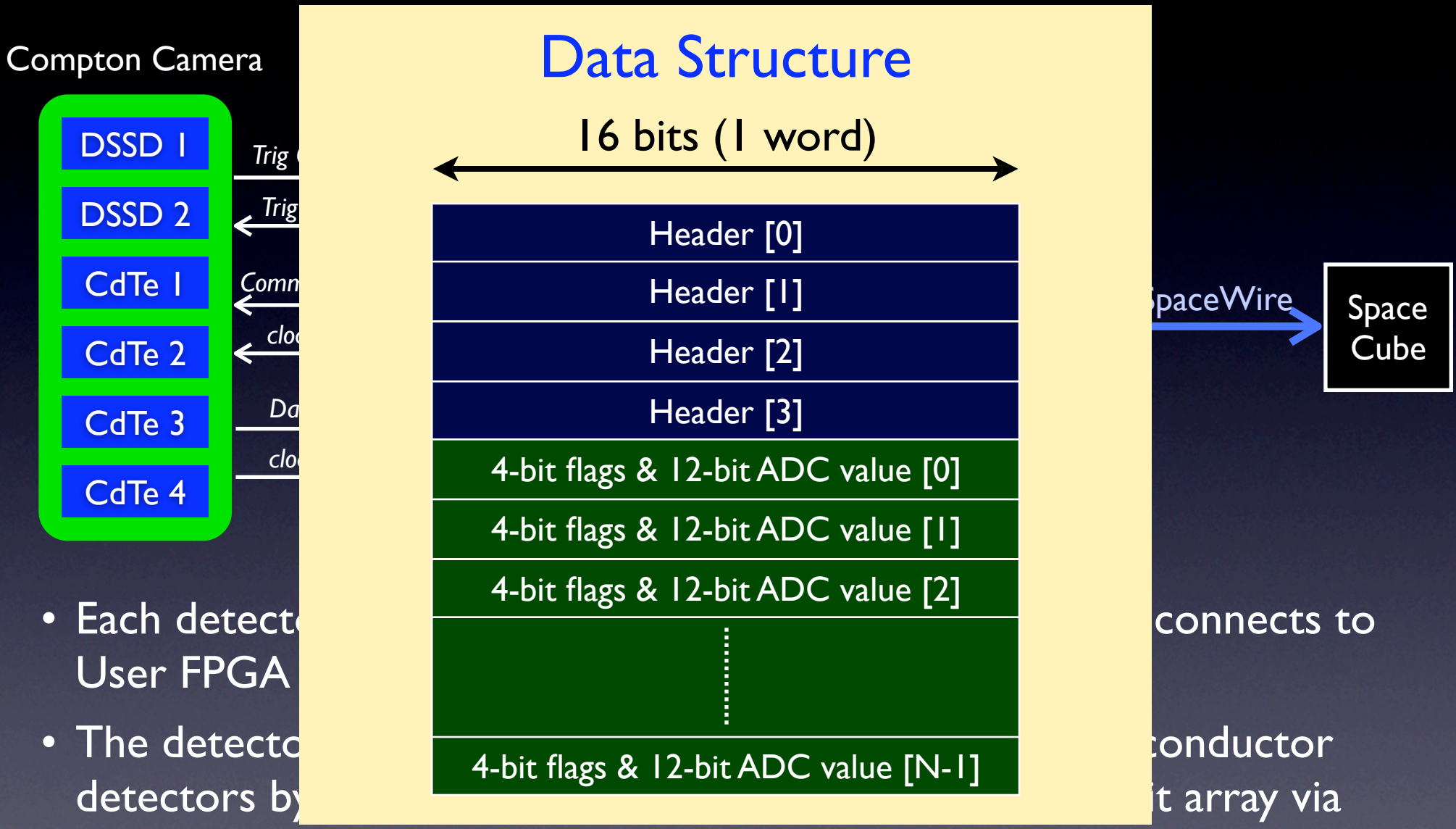
Detector

Data Acquisition - Design



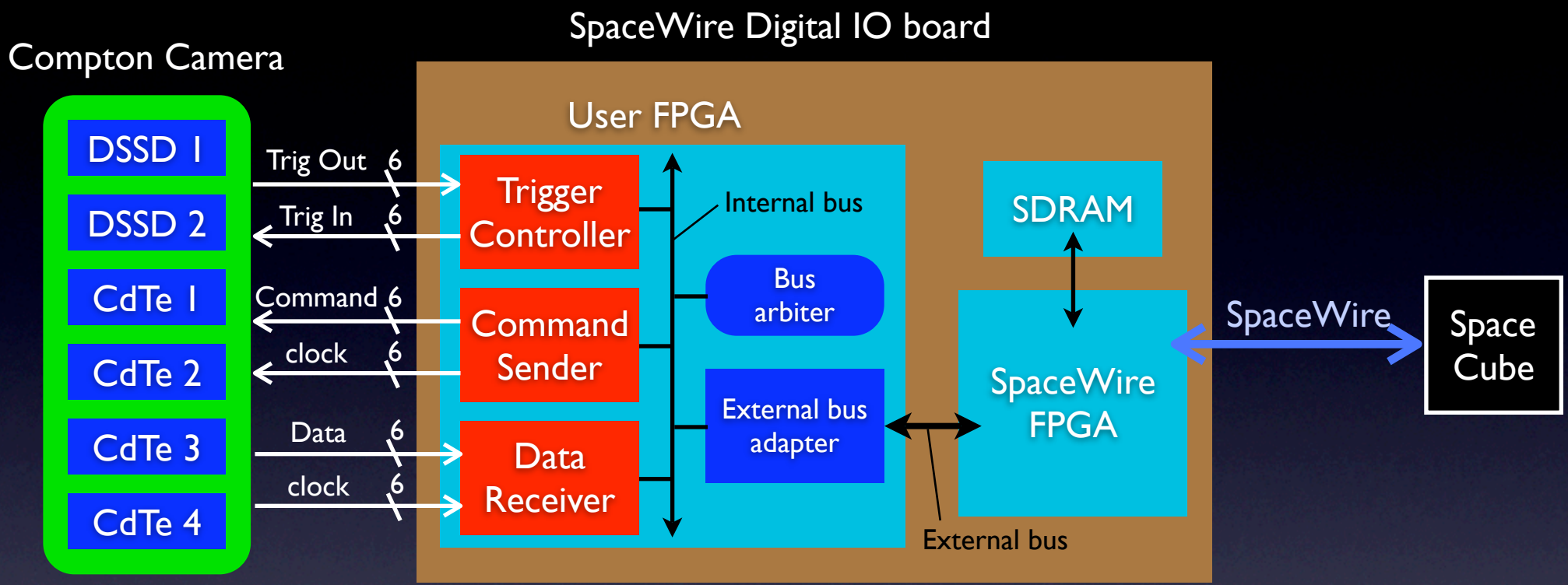
- Each detector modules composing the Compton camera connects to User FPGA via six digital lines.
- The detector module digitalize analog signals of the semiconductor detectors by an ADC and outputs the data in serialized bit array via *Data* and *Data-clock* line.
- Total data size of all the detector modules is 5168 bytes/event.

Data Acquisition - Design



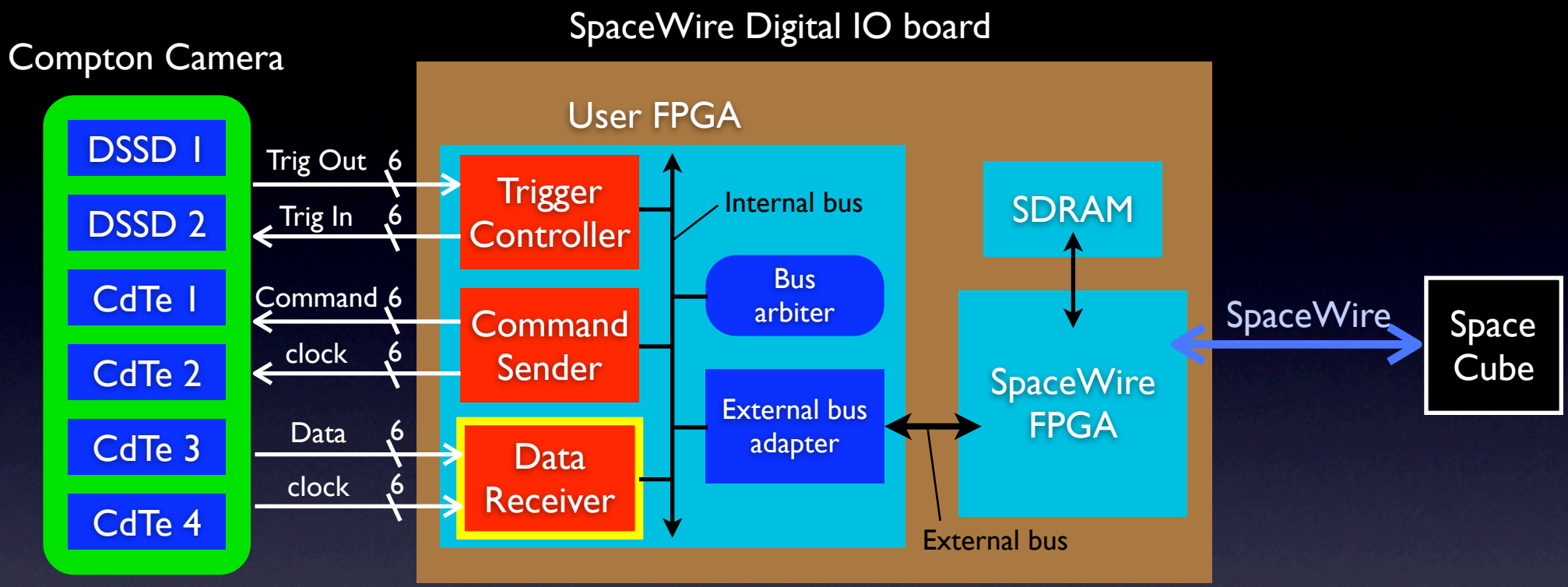
- Each detect connects to User FPGA
- The detecto conductor detectors by it array via *Data* and *Data-clock* line.
- Total data size of all the detector modules is 5168 bytes/event.

Data Acquisition - Design



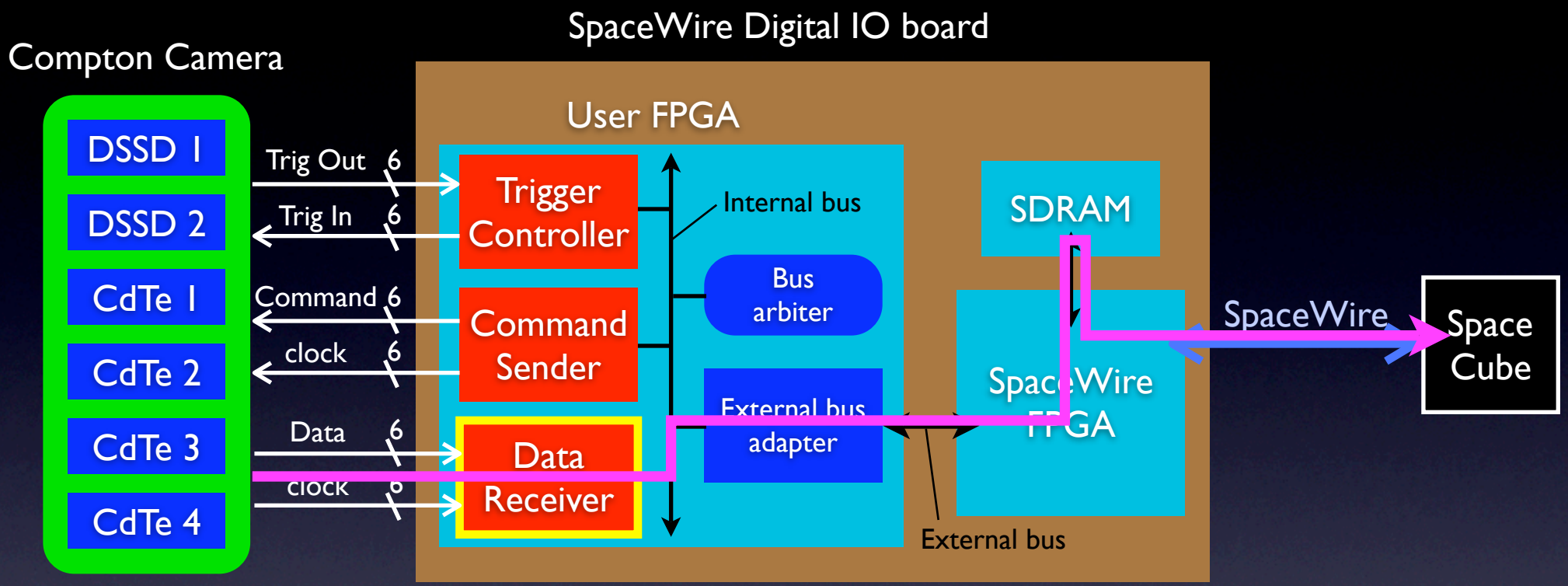
- Design of User FPGA is based on the DAQ framework.
  - Modularized internal (on-chip) bus system including bus arbiter
- In the User FPGA, there are three user-dependent modules.

Data Acquisition - Design



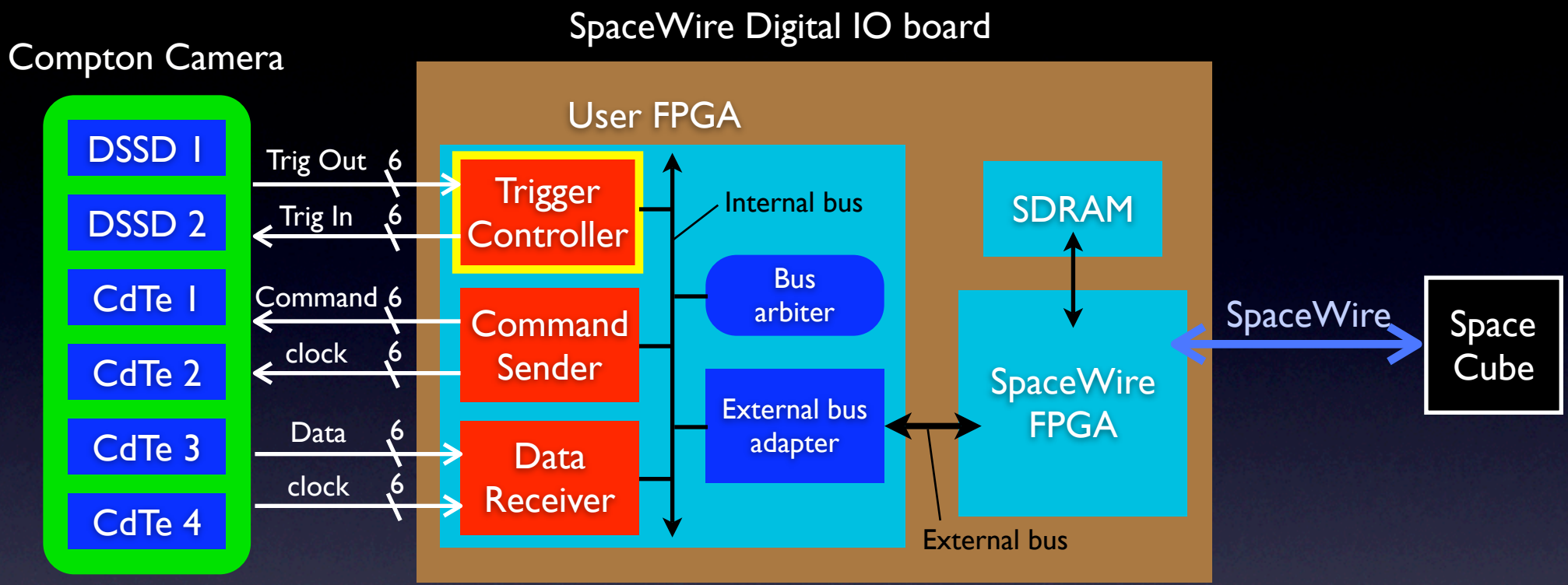
- Data Receiver receives the data from the detector modules and transfer them through the internal bus and external bus to the SDRAM.
- SpaceCube gets the data from the SDRAM by RMAP Read.

Data Acquisition - Design



- Data Receiver receives the data from the detector modules and transfer them through the internal bus and external bus to the SDRAM.
- SpaceCube gets the data from the SDRAM by RMAP Read.

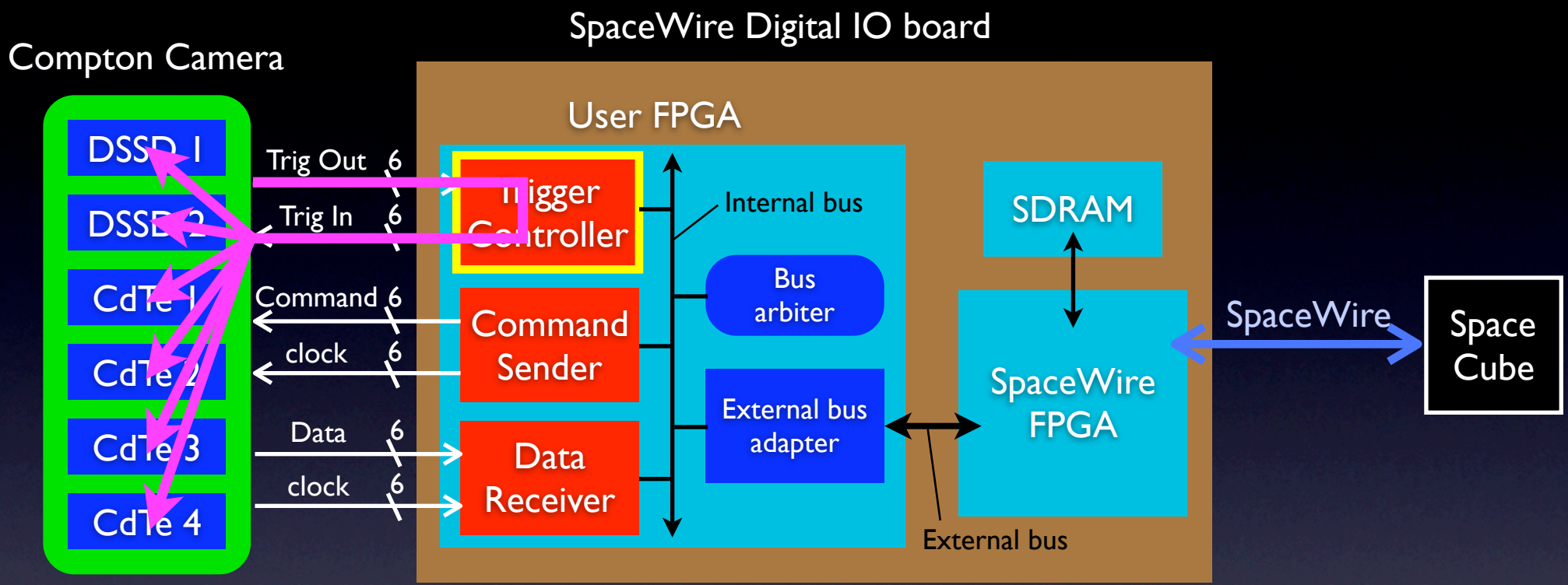
Data Acquisition - Design



- Photon-detection events occur randomly.
- Simultaneous readout from all the detector modules are required.

➡ Trigger Controller controls readout timing via *TrigOut* and *TrigIn* lines.

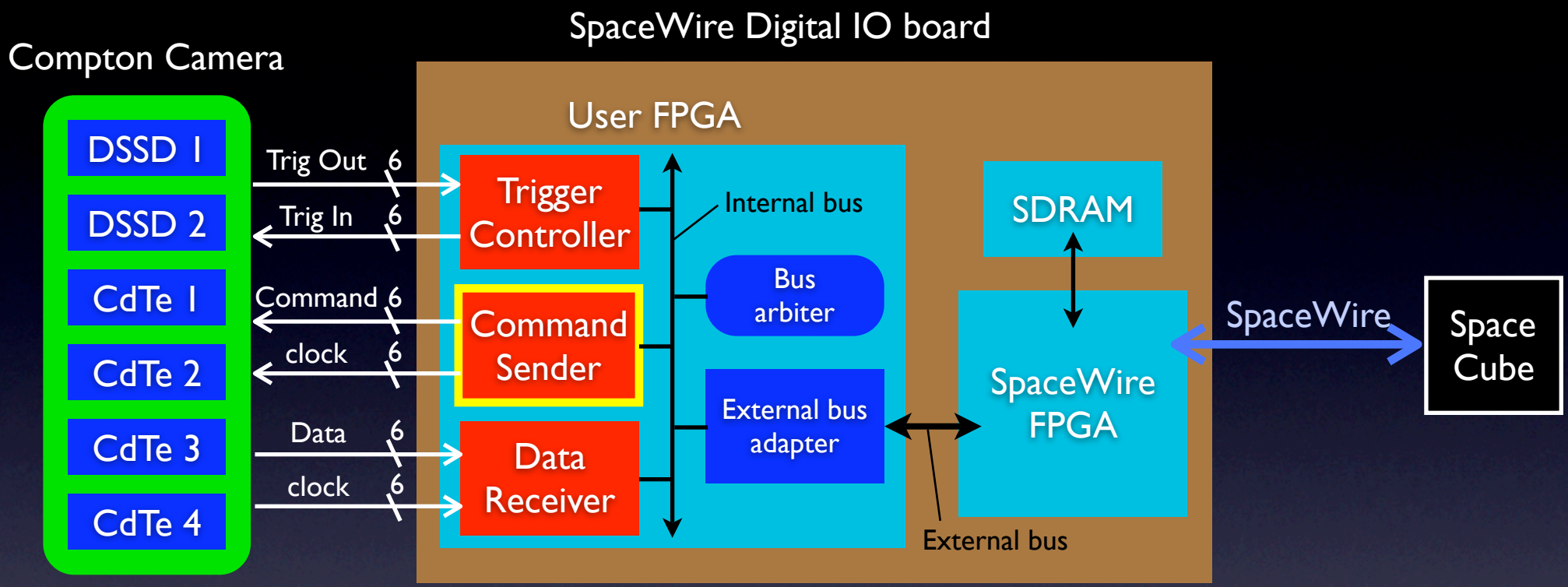
Data Acquisition - Design



- Photon-detection events occur randomly.
- Simultaneous readout from all the detector modules are required.

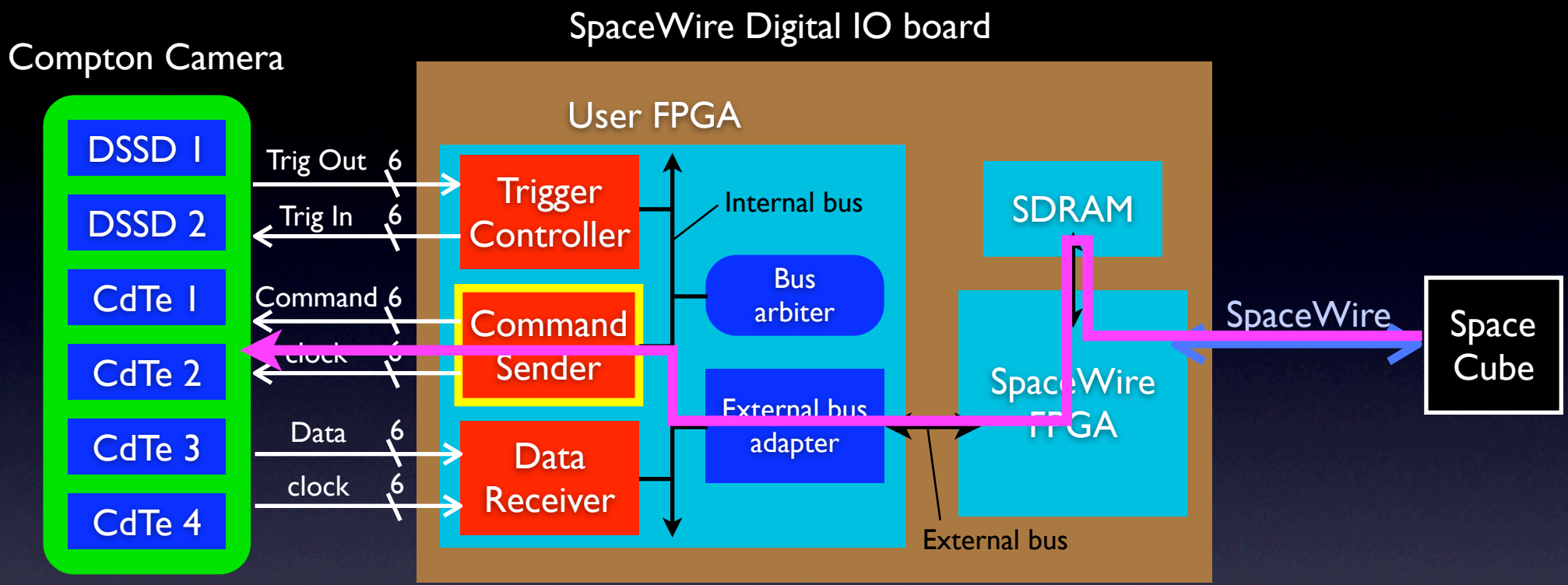
➡ Trigger Controller controls readout timing via *TrigOut* and *TrigIn* lines.

Data Acquisition - Design



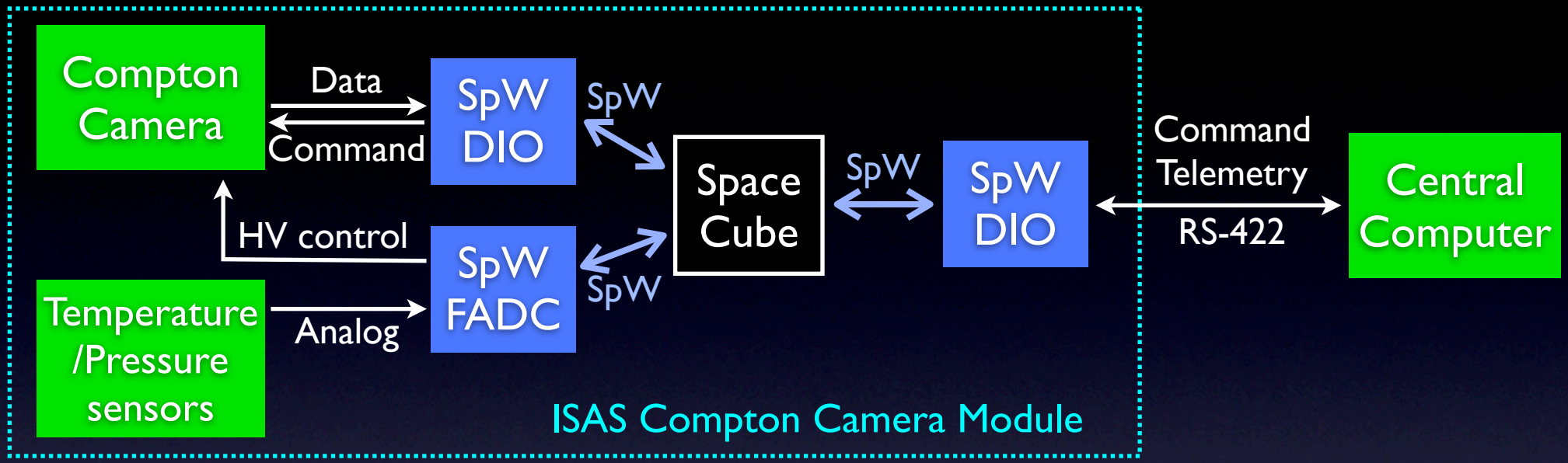
- To send command to the detector module, SpaceCube writes command data to Command Sender by RMAP Write.

Data Acquisition - Design



- To send command to the detector module, SpaceCube writes command data to Command Sender by RMAP Write.

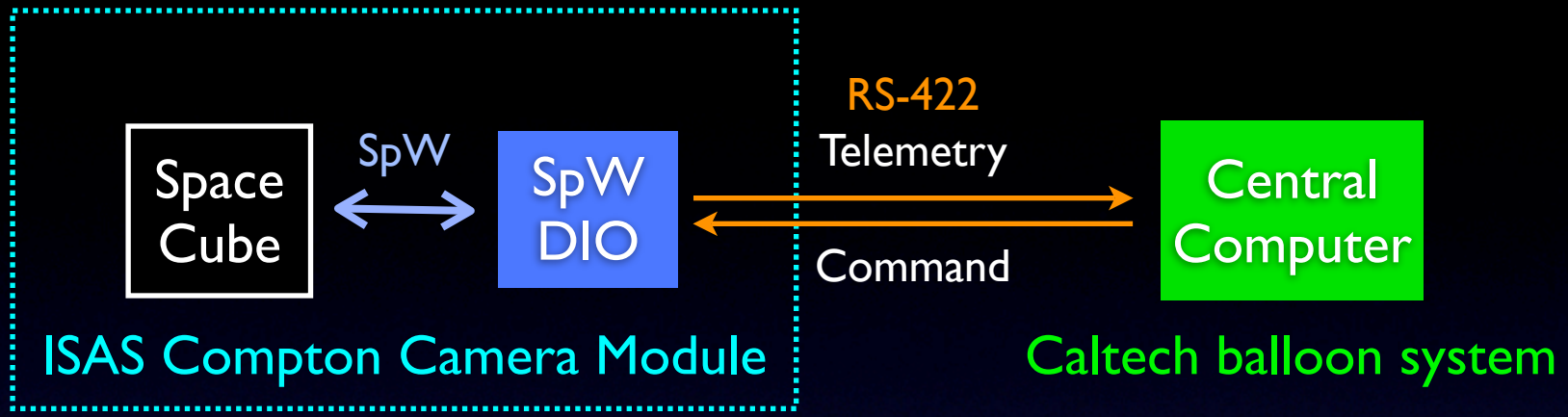
Data Processing



SpaceCube communicates via SpaceWire with

- SpaceWire Digital IO board: data acquisition of the Compton camera
- SpaceWire FADC board (with a ADC and digital I/Os)
  - to control high-voltage bias of semiconductor detectors
  - to read temperature and pressure sensors
- SpaceWire Digital IO board: Telemetry/Command

Telemetry and Command



Telemetry

1. SpaceCube writes data to data buffer in User FPGA by RMAP Write.
2. The written data is transmitted to the central computer of the balloon system via RS-422.

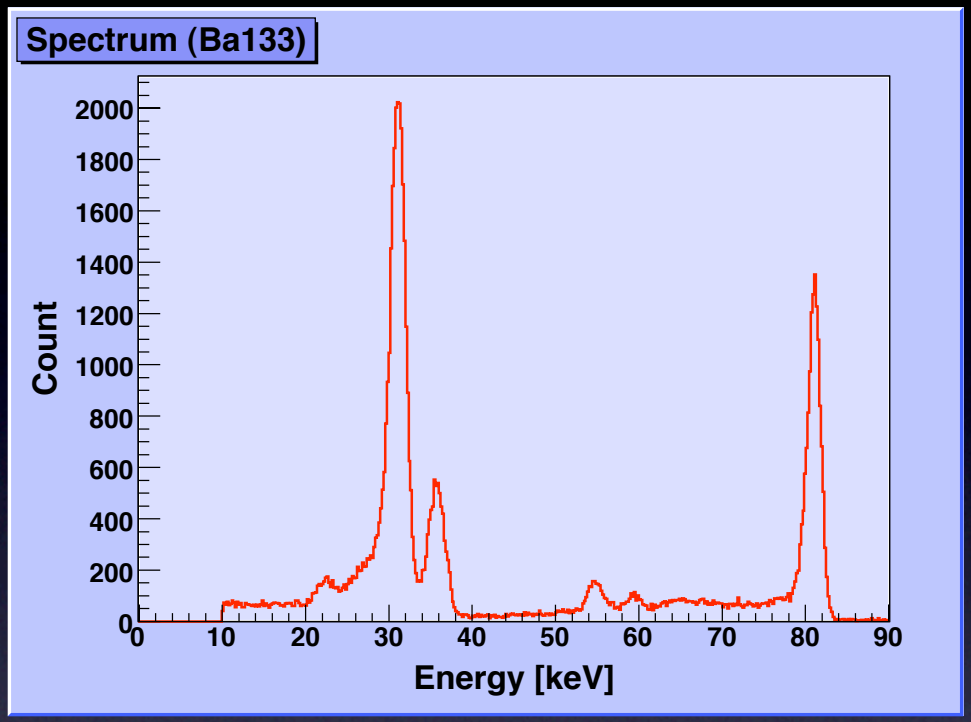
Command [Interrupt by RMAP]

1. SpaceCube reads a command to User FPGA by RMAP Read.
2. SpaceCube waits for returning RMAP Read Reply Packet.
3. When User FPGA receives a command from the central computer via RS-422, RMAP Read Reply Packet is sent back to SpaceCube.

Summary

- We are (I am) working on data acquisition system of a semiconductor Compton camera for a balloon-borne experiment, by using SpaceWire and RMAP, from scratch, but using a standard framework which provides standard functions of data acquisition for detectors.
- The system works well(!). We are now trying to speed up the data transmission rate with new SpaceWire IP core.
- SpW and RMAP are very useful!

Result and Performance



The DAQ system works well.

Proper spectrum was obtained.

Data transfer rate: 0.6 Mbps

(SpaceWire IP core beta version)

Average event rate expected	< 100 Hz
Data transfer rate required	> 4 Mbps

In order to increase the data transfer rate,
we are developing a new SpaceWire IP core which transfer data to RAM in SpaceCube by direct memory access (DMA).