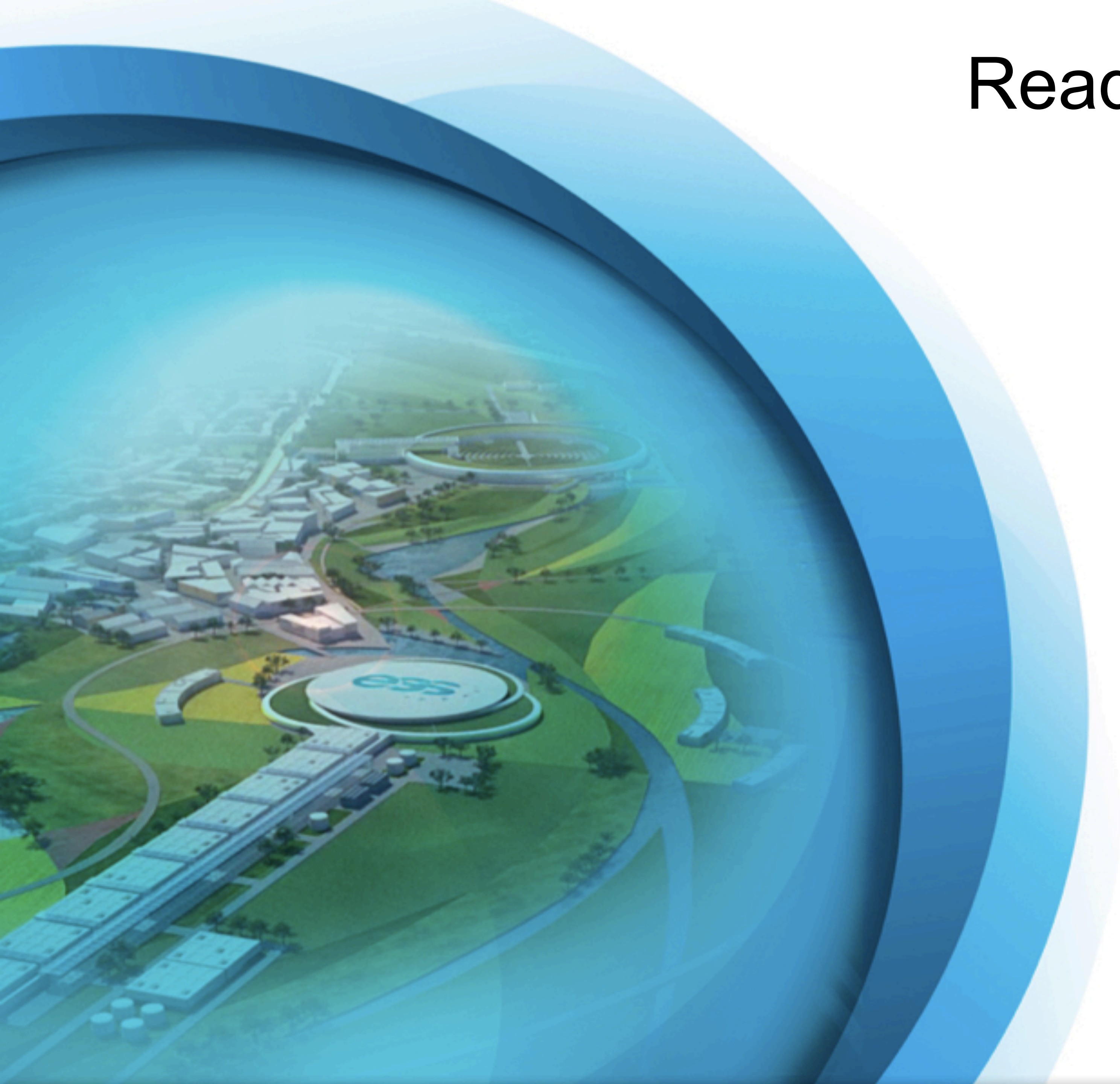


Readout for ESS Instruments

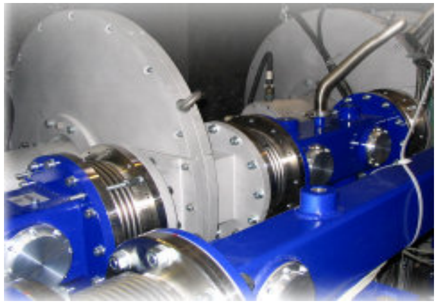
Scott Kolya

14th June 2013

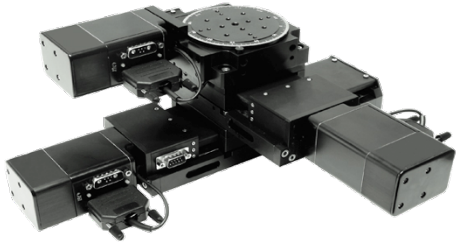
Instruments

Instruments are made up of a number of subsystems.

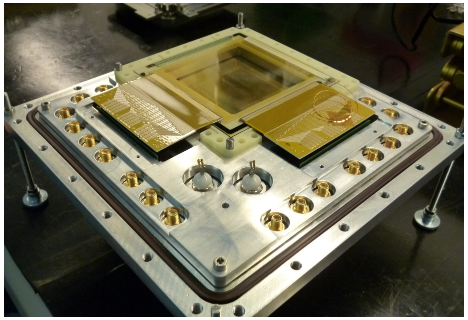
While there will be similarities between some subsystems of some instruments, the collection and layout is unique (otherwise you wouldn't build it!!), and designed to perform specific measurements dictated by the science case.

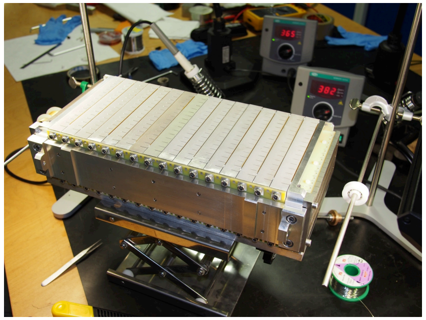


Choppers, Shutters etc



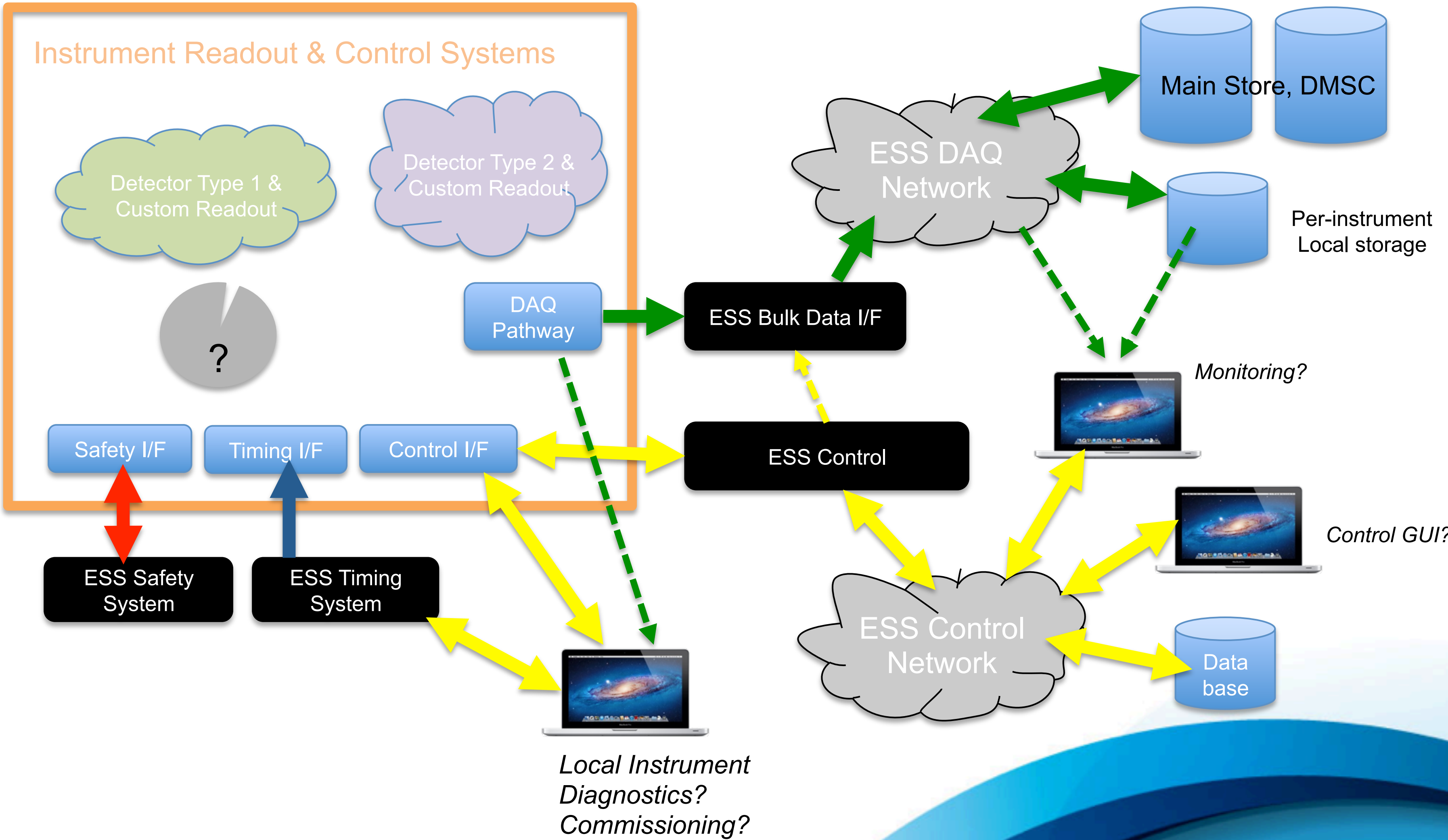
Sample Environment and Control





One or more types of detector.

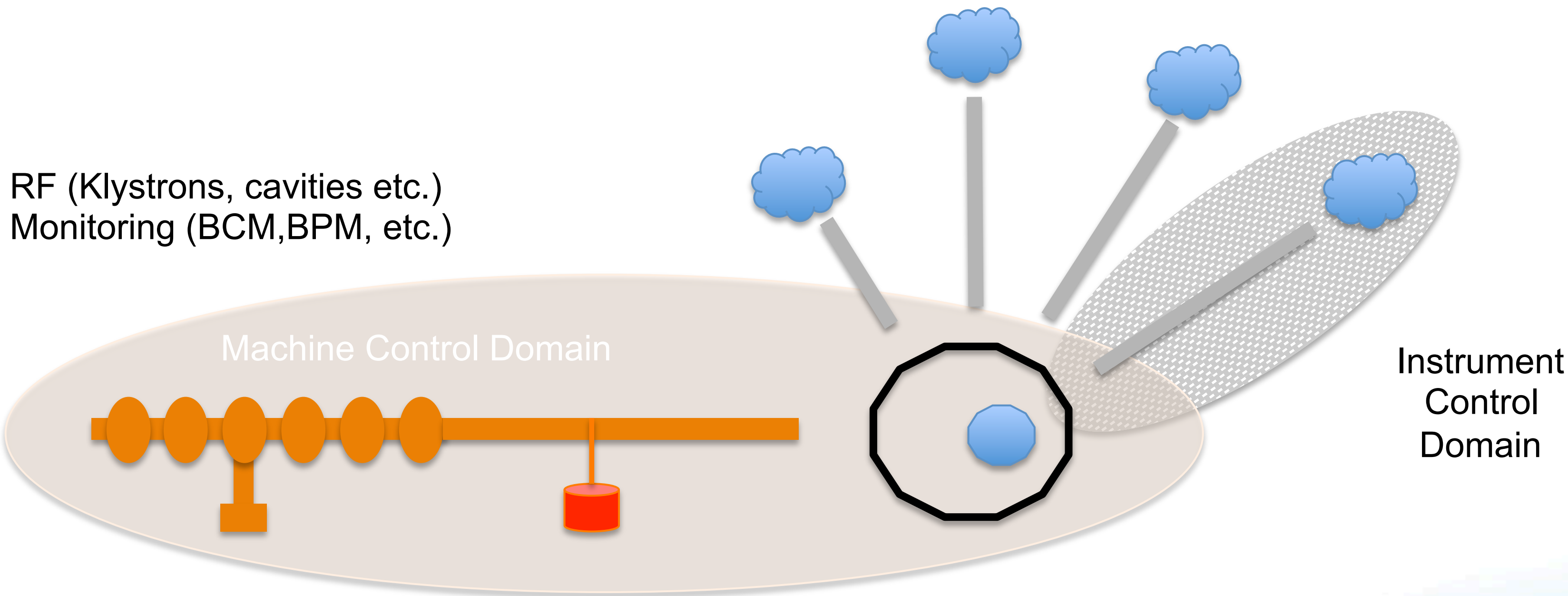
How Instruments Integrate into wider ESS systems (datawise)



Control Domains

The accelerator (and target?) is a large system with many parts that must all work together => Integrated controls essential.

Each Instrument is essentially self contained, control needs are localized.

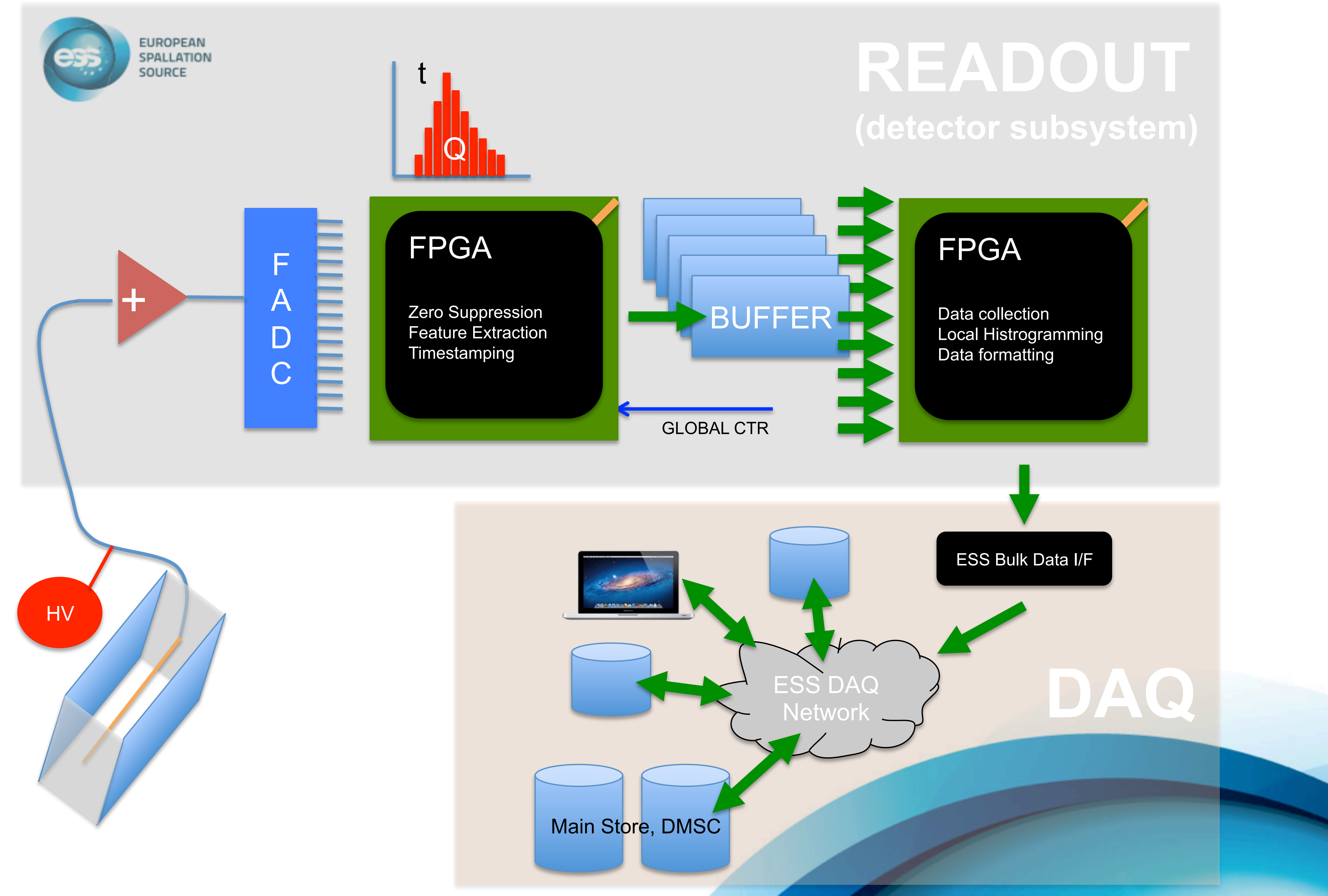


Q: Do the Instrument Control Systems have to match the Accelerator?
A: Probably not
Q: Is there any good reason for it not to match?
A: Again, probably not

Different elements are the responsibility of different groups at ESS

DG Detector Group (with in-kind external contributions)
EE Electrical Engineering, motion control, cryo control?, chopper servo, etc
ICS Integrated Controls, tie everything together

Instrument Element	Local Group	Source	Implementation Standard
Beam – Choppers, Shutters etc	EE	Bespoke	Likely to be standard across ESS
Sample - Motion Control etc	EE	COTS	Likely to be standard across ESS
Sample - Magnet	??	??	Likely to be standard across ESS
Sample - Cryogenics	??	??	Almost certainly standard at ESS
Detector HV, BIAS etc.	DG/ICS External	COTS	Usually standard system
Detector Gas	DG/ICS	Bespoke	Almost certainly standard at ESS
Detector Readout	DG External	Bespoke	Likely to be a mix of systems

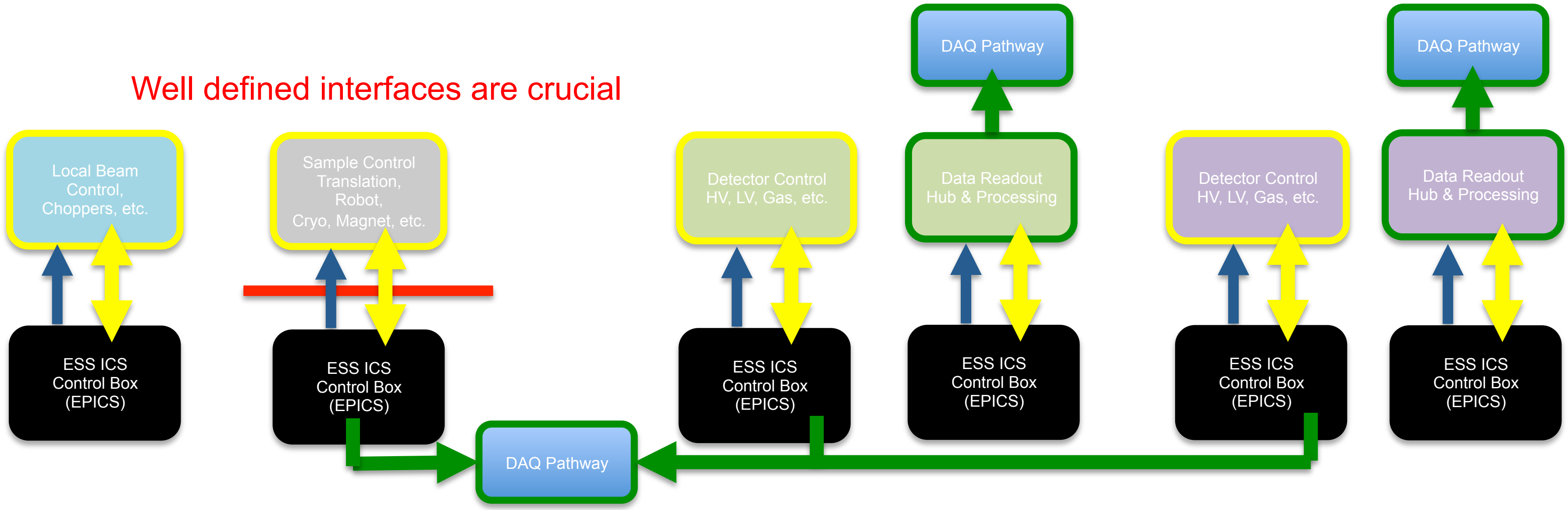

EUROPEAN
SPALLATION
SOURCE
READOUT
(detector subsystem)
t
Q
F
A
D
C
FPGA
Zero Suppression
Feature Extraction
Timestamping
BUFFER
GLOBAL CTR
FPGA
Data collection
Local Histrogramming
Data formatting
HV
ESS Bulk Data I/F
ESS DAQ
Network
Main Store, DMSC
DAQ

ESS Instrument Model

Menu approach to building instruments – a collection of independently operating sub-systems

Standardization of readout electronics increases as we get closer to interfaces.

An instrument will have one or more detector systems, each of which will have one or more subsystems



Logically one control box per subsystem (in practice can be combined)

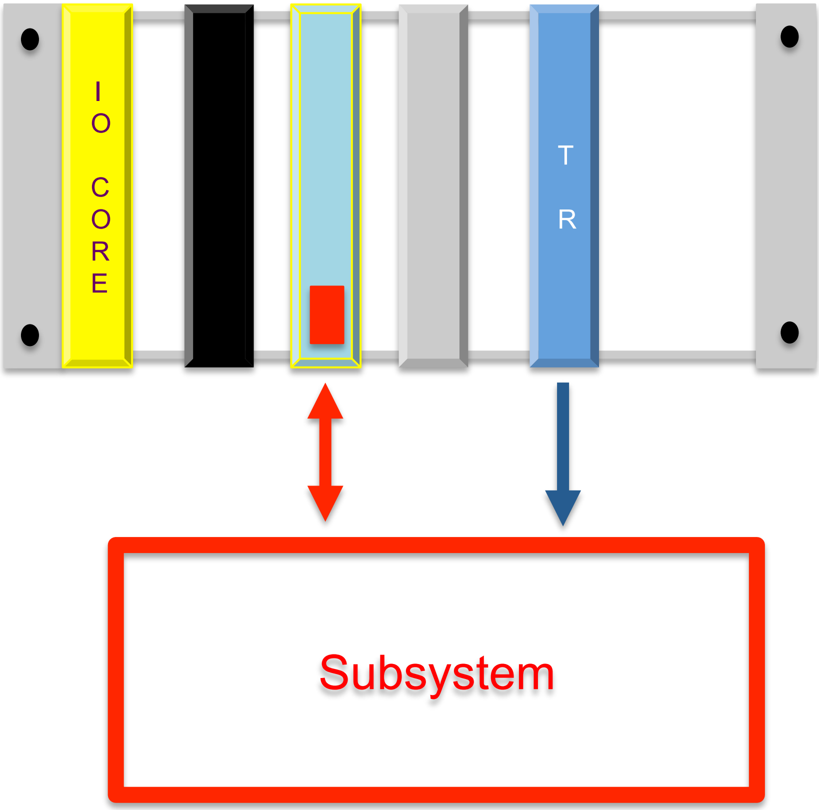
Control data handled by EPICS

Propose: Smaller data volumes can also be collected via EPICS

Propose: Larger volumes of data require dedicated interface.

How do we connect to ICS?

Control box (inc timing)



EPICS is the basis ICS

Standard connection is a Control Box

Small number of varieties of Control Box

- cPCI
- μTCA.4
- …

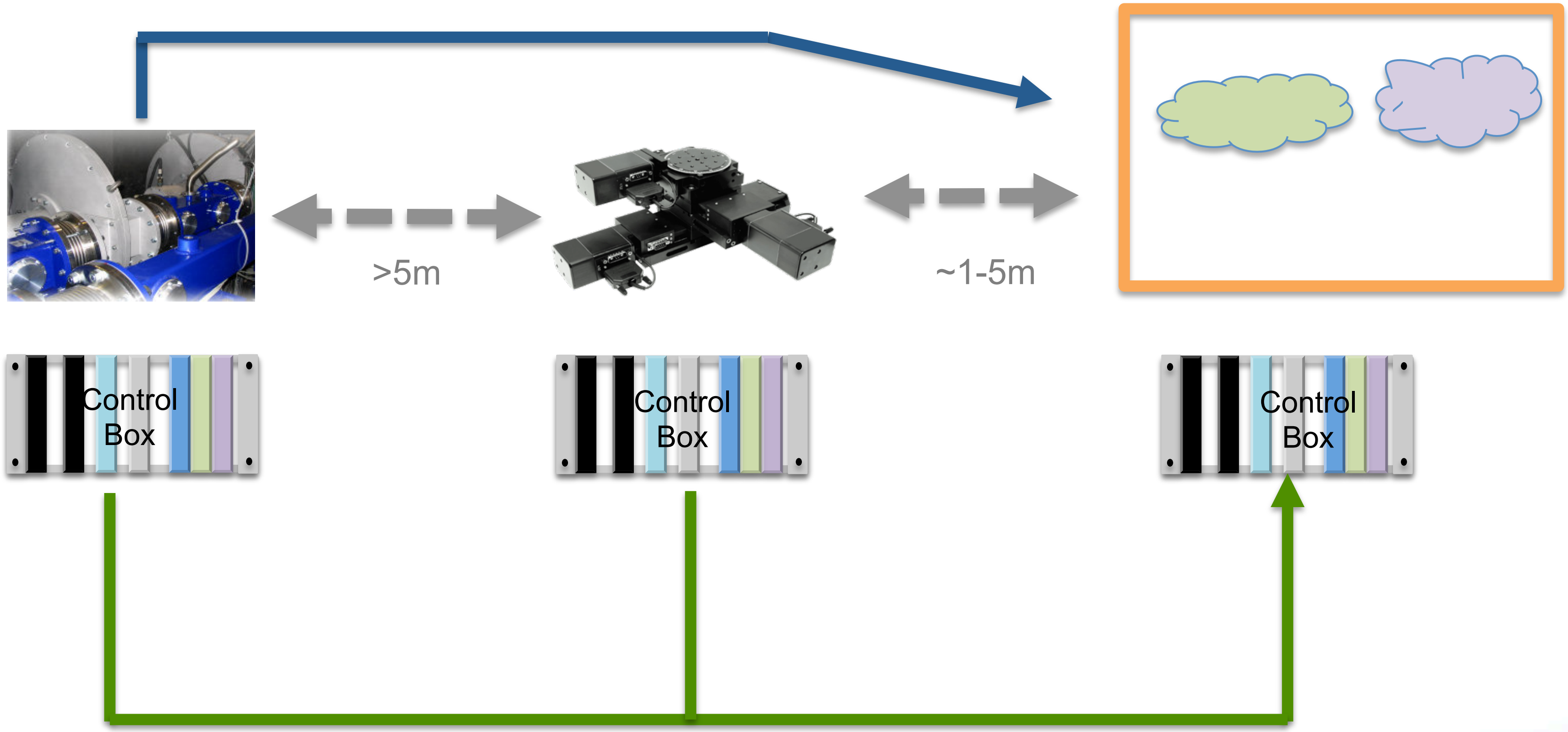
Control Box is host to Timing Receiver (TR)

If a subsystem is COTS then the interface/driver probably already exists

Otherwise the subsystem team & ICS work together to implement an interface..

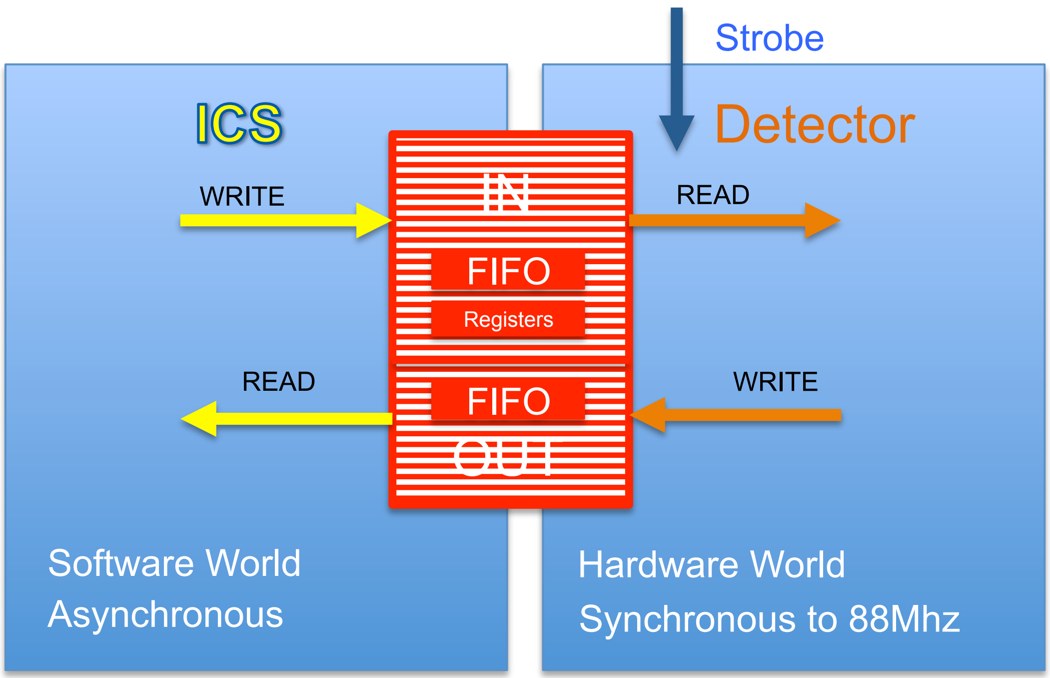
Most extended instrument data (cross communication etc) can go via EPICS.

Where totally unavoidable we allow for dedicated ‘flying leads’.



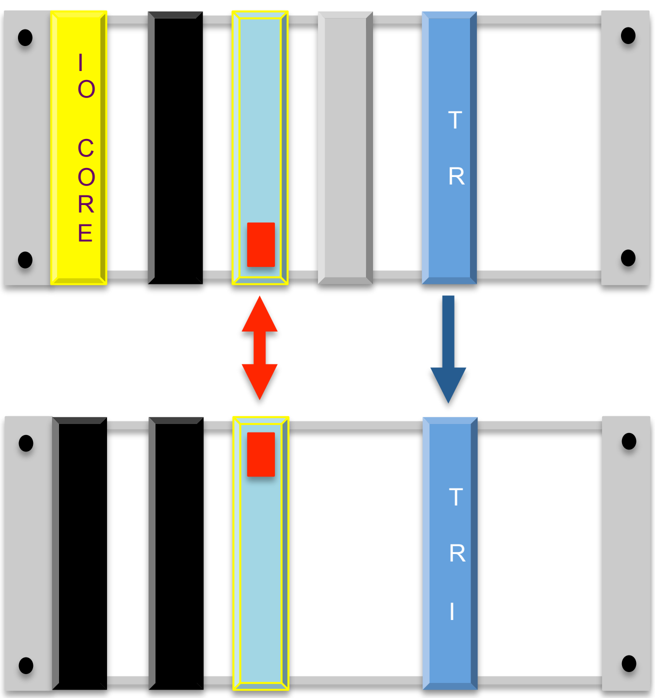
How detector readout interacts with ICS

- Interaction with control system minimal, with bursts of intense activity (change config)
- Shared memory interface, fixed locations and/or FIFO queue
- Some commands need to be synchronous, use hardware strobe from timing system to validate pre-loaded command word(s)

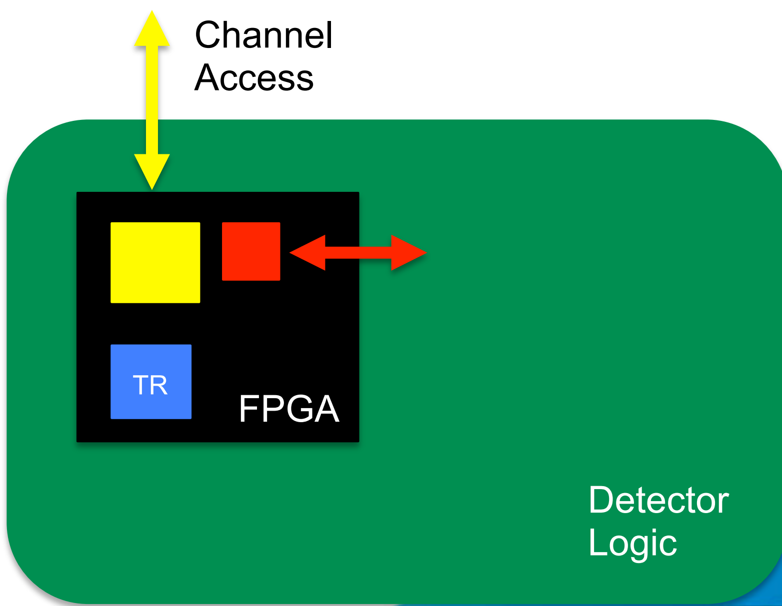


How we physically implement that…

- Inevitably, interface most likely to be implemented in an FPGA
- Could be a card in the control box, or standardized connection to card in detector master crate.
- Could also be embedded.
- Detector Group works with Controls Group to define and implement a small number of interfaces that should cover all instrument detector readout requirements.



Detector Master Crate

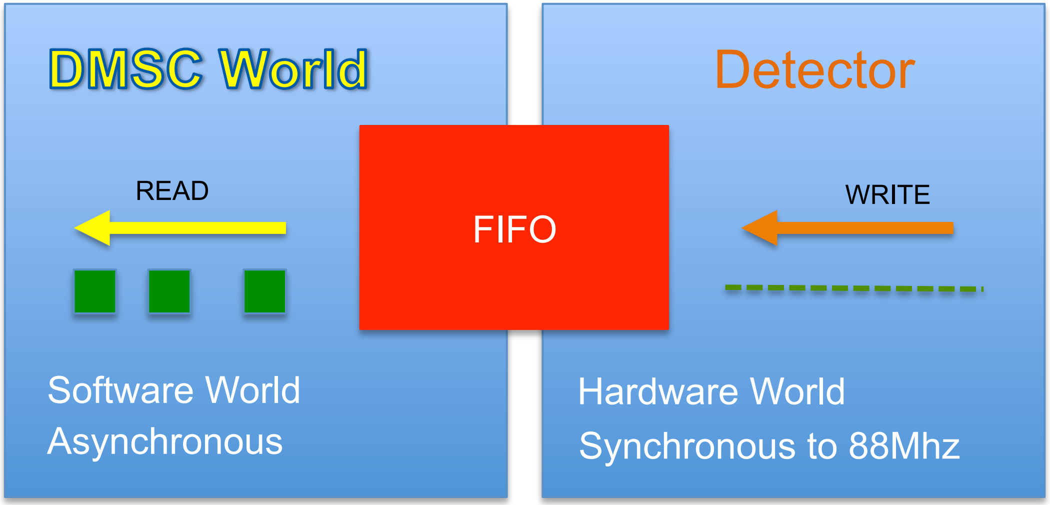


High bandwidth data connection

Simple push FIFO interface.

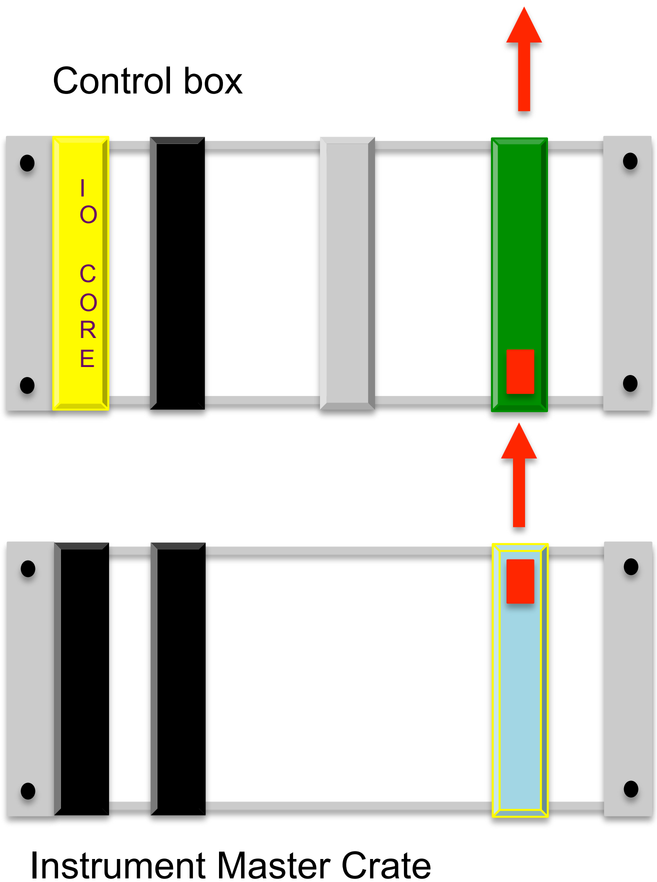
Detector subsystems sends data **in it's own optimal format (*proposal*)**

Flow control through ICS.



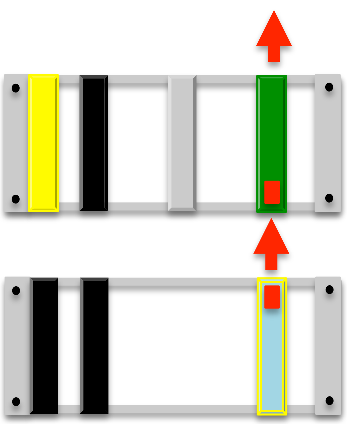
How we physically implement that (part1)

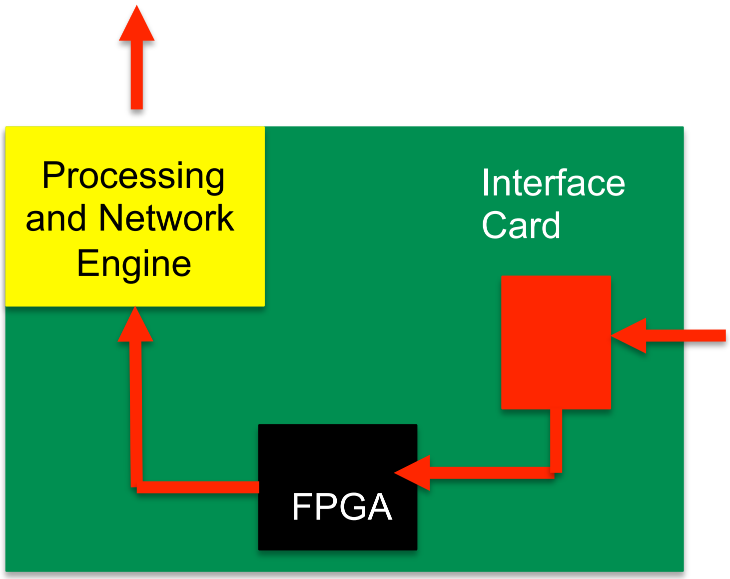
- Every subsystem has a control box - natural location for the data interface (***proposal***)
- Not dependent on control system, but some interaction might be useful (xon/xoff etc.)

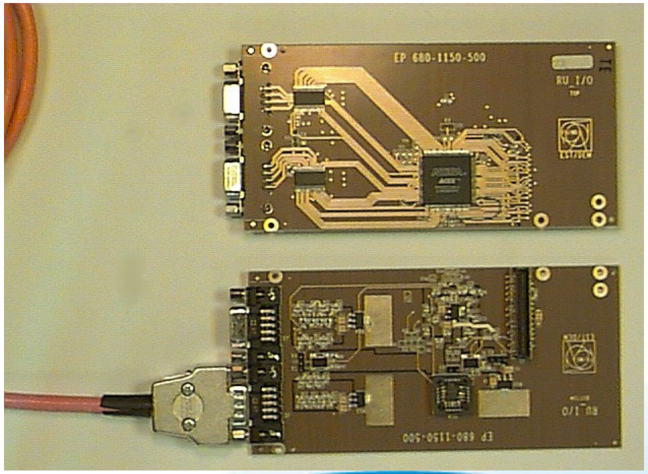


How we physically implement that (part2)

- Best to specify the interface at the connector or daughter-card level.
- Commercial FPGA carrier, COTS processor card etc act as host
- Actual location of FIFO unimportant, so long as both sides have access.
- Upgrade worst case – redesign the daughtercard.



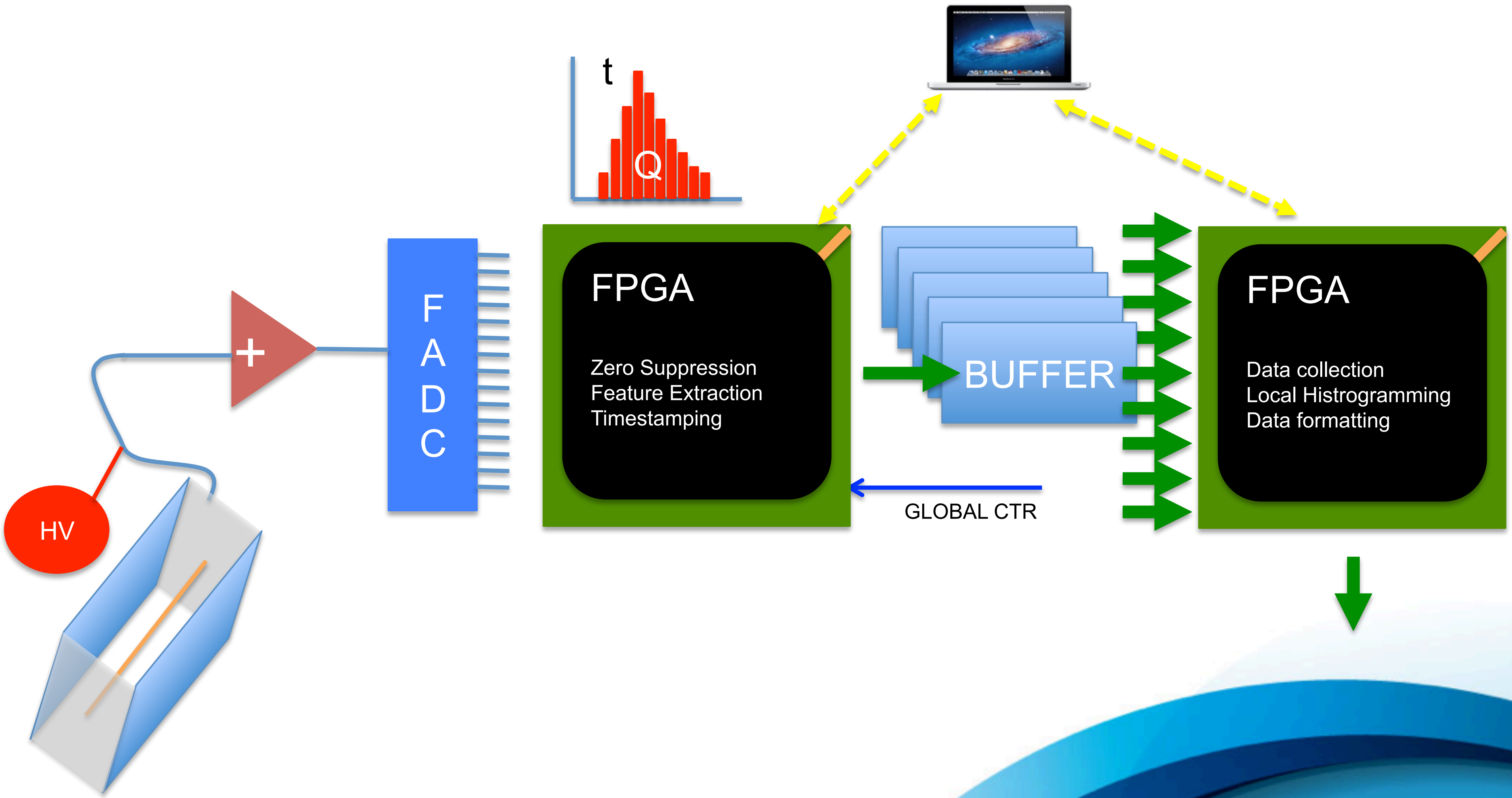


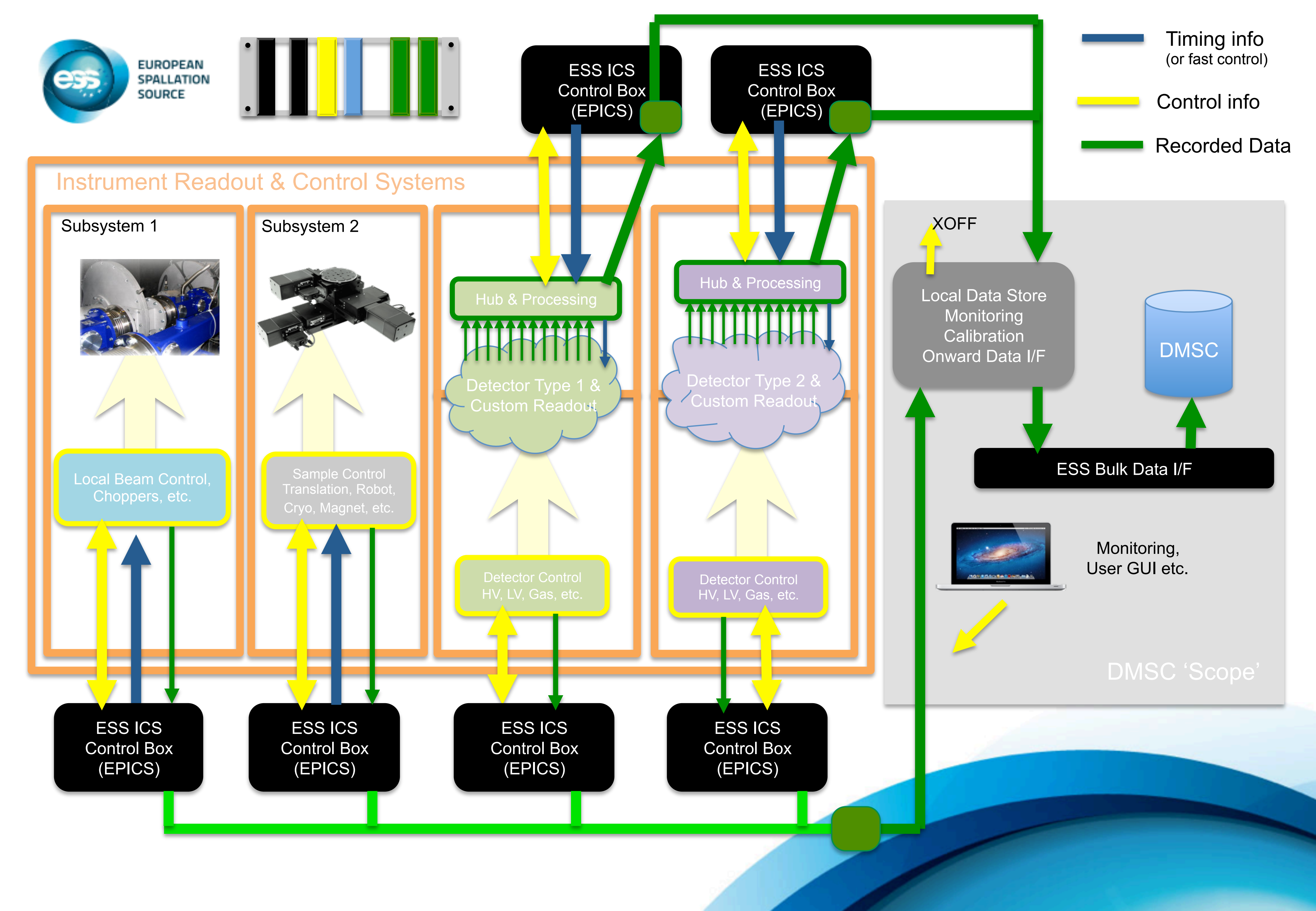


That sounds complicated, why don't you just use ethernet??

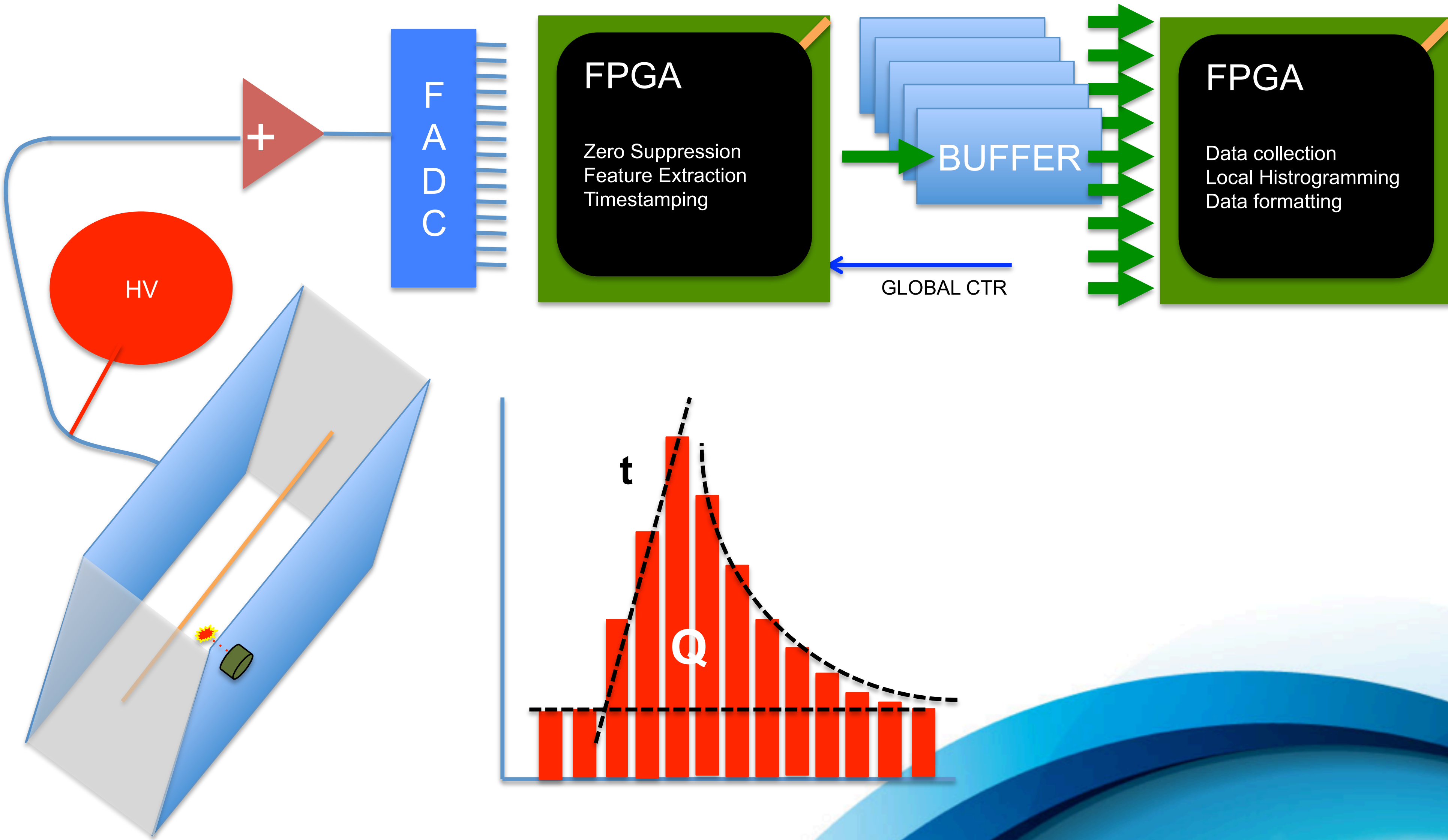
- Has to be a boundary somewhere   Hardware world <-> Software World
- Want to isolate readout hardware from computing infrastructure upgrades
- Compare to modern Oscilloscope, hybrid of PC and custom logic.
- Detector readout electronics are expected to remain the same for the life of the instrument.

- We will also have private ‘backdoor’ communication channel(s).
- Used only by experts.
- Likely to be UDP direct to the FPGAs (standardize as far as possible)
- *We must have the facility to work standalone, prototyping, debugging, etc.*



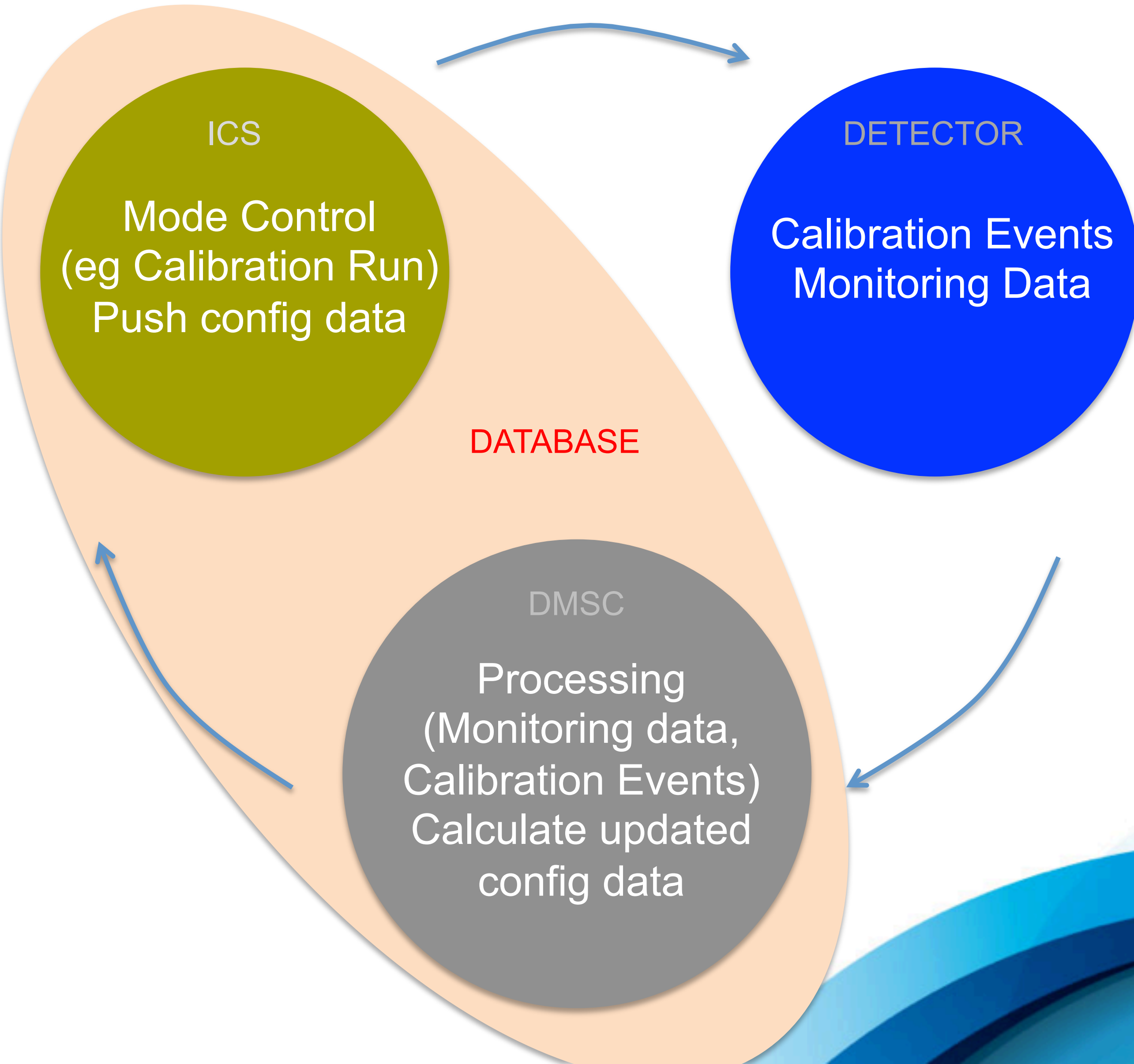

EUROPEAN
SPALLATION
SOURCE
Timing info
(or fast control)
Control info
Recorded Data
ESS ICS
Control Box
(EPICS)
ESS ICS
Control Box
(EPICS)
Instrument Readout & Control Systems
Subsystem 1
Subsystem 2
Hub & Processing
Hub & Processing
Detector Type 1 &
Custom Readout
Detector Type 2 &
Custom Readout
Local Beam Control,
Choppers, etc.
Sample Control
Translation, Robot,
Cryo, Magnet, etc.
Detector Control
HV, LV, Gas, etc.
Detector Control
HV, LV, Gas, etc.
XOFF
Local Data Store
Monitoring
Calibration
Onward Data I/F
DMSC
ESS Bulk Data I/F
Monitoring,
User GUI etc.
DMSC 'Scope'
ESS ICS
Control Box
(EPICS)
ESS ICS
Control Box
(EPICS)
ESS ICS
Control Box
(EPICS)
ESS ICS
Control Box
(EPICS)

- Data compression in front end needs to be monitored
- Monitoring data to be dumped periodically, or on demand
- Special calibration modes may be needed



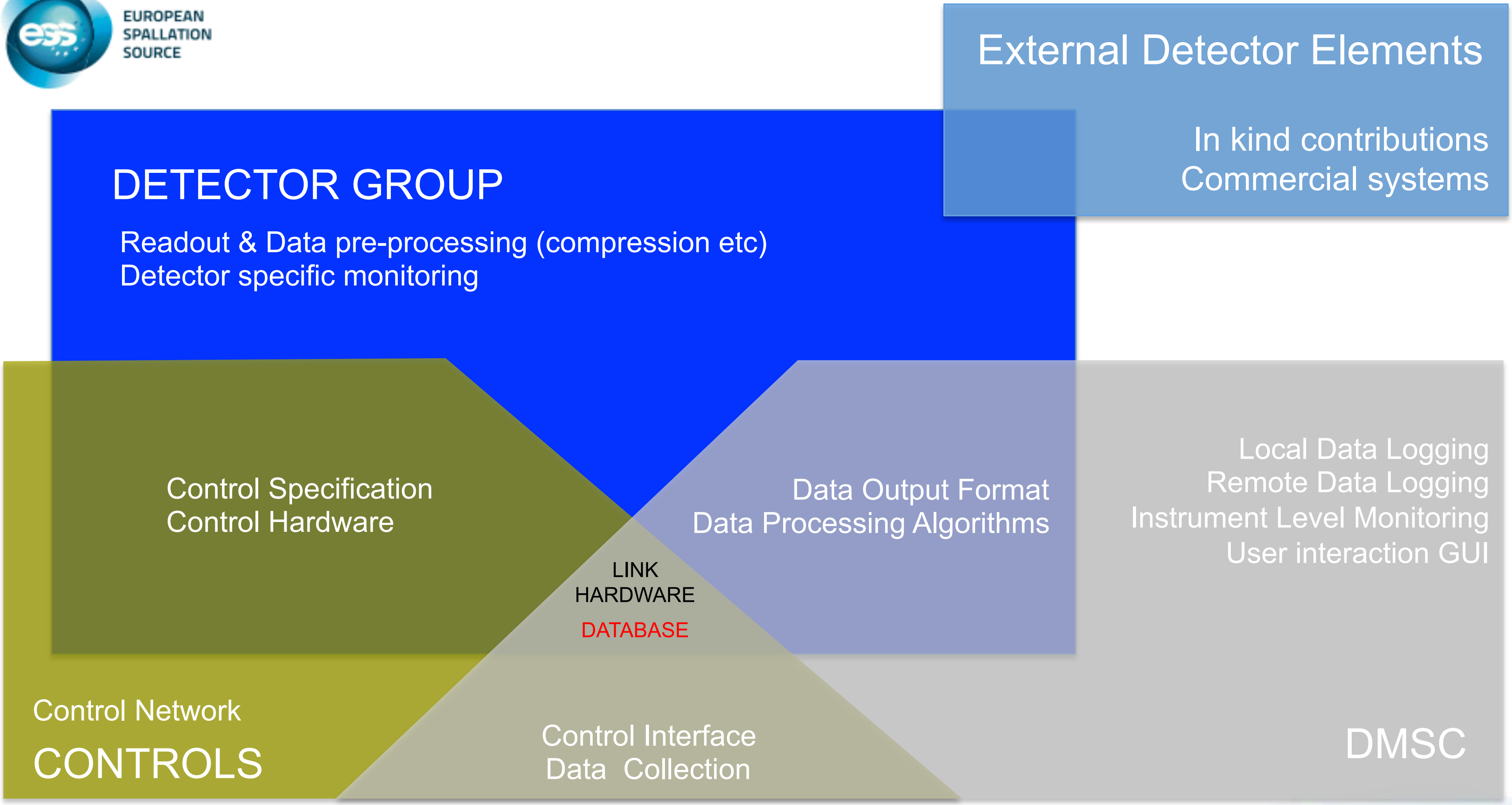
Calibration Cycle

Database location decision needed from this meeting



Detector Group Readout Integration Responsibilities

- Collaborate with Controls on interface hardware
- Collaborate on design of bulk data interface hardware
- For each detector subsystem
  - Specify command set, control variables, config tables, etc.
  - Specify data output format
  - Define an appropriate monitoring strategy
  - Provide algorithms for DMSC monitoring processing where necessary
  - Define an appropriate calibration strategy
  - Provide algorithms for DMSC calibration processing where necessary
  - Provide expert diagnostic tools with independent access that can be used to debug these interfaces.


External Detector Elements
In kind contributions
Commercial systems
DETECTOR GROUP
Readout & Data pre-processing (compression etc)
Detector specific monitoring
Control Specification
Control Hardware
LINK
HARDWARE
DATABASE
Data Output Format
Data Processing Algorithms
Local Data Logging
Remote Data Logging
Instrument Level Monitoring
User interaction GUI
Control Network
CONTROLS
Control Interface
Data Collection
DMSC