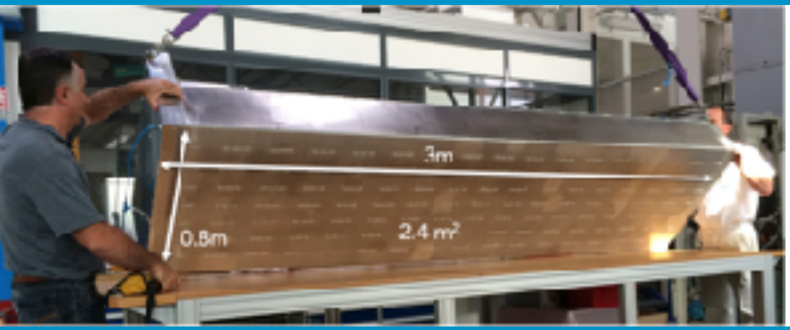
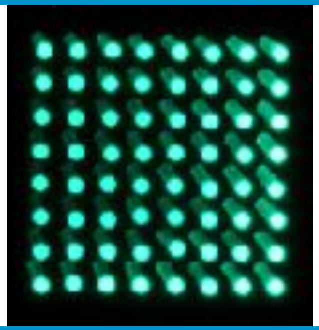
Detectors

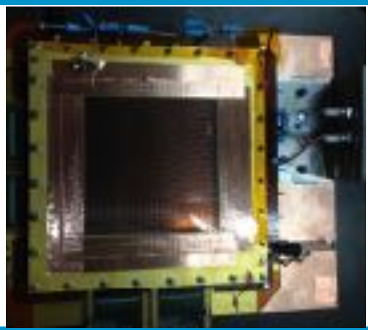
Richard Hall-Wilton, Detector Group Leader
Slides from Scott Kolya, Stephen Alcock, Fatima Issa and our DMSC friends (and probably others)

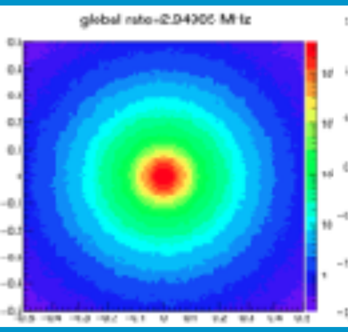
Controls Workshop

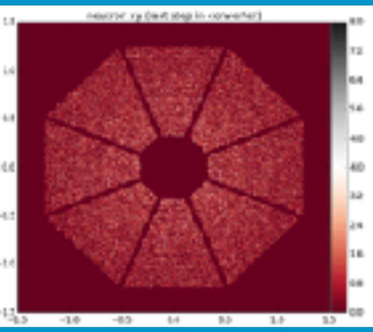
www.europeanspallationsource.se

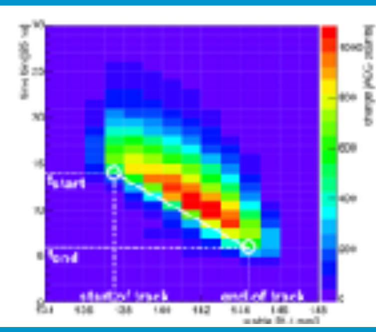


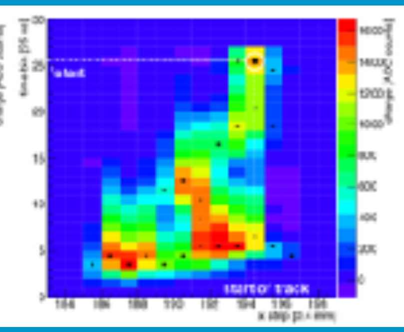


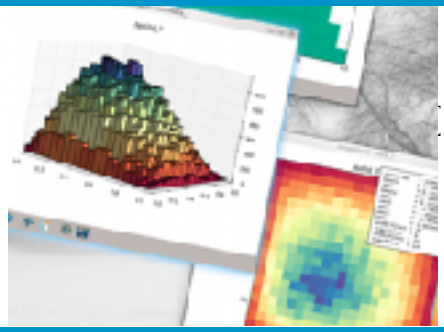


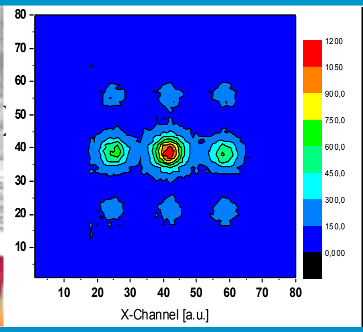


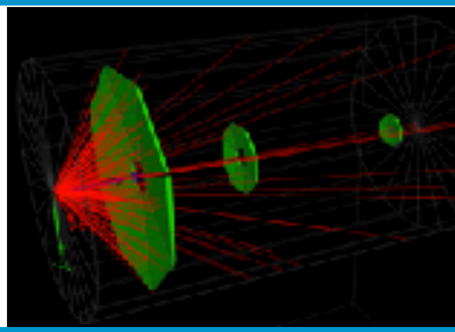












Scope

- Support and facilitate partners to be able to deliver performant detectors for world class instruments
- Act as a host institute to assist and enable in-kind partners to deliver where requested
- Act as supplier of detector systems where requested
- Facilitate installation and commissioning of detectors
- Operate and maintain detectors throughout their lifetime

- Interface management for in-kind partners with other parts of NSS and ESS and other in-kind partners
- Integrate detectors into a homogeneous ESS instruments suite
- Where necessary, assist in the design and development of detectors with partners for partners
- A technology service group capable of long term support

What we provide

- Technology Developments for particular instrument classes
- Development of a standardised detector and beam monitor readout (with STFC in-kind partners)
- Provision of B4C coatings and development effort gratis during design phase

- Support during reviewing process and consultation
- Help determine detector interfaces with other ESS groups
- Testing and Working Facilities in Lund (see next slides)

- Electronics Readout: nominal 200kEUR identified in scope setting
- Standard readout rack, UPS, readout crate, timing interface, HV+LV, Detector Cabling, adaptation to interface with Front End Electronics
- Beam Monitor standard readout at cost.

- **For construction, we can offer instrument teams at cost:**
- Provision of Detector Systems
- Coatings for detectors
- Installation and commissioning effort
- Provision of Beam Monitors
- *Please come and discuss possibilities with us, to foresee effort needed*

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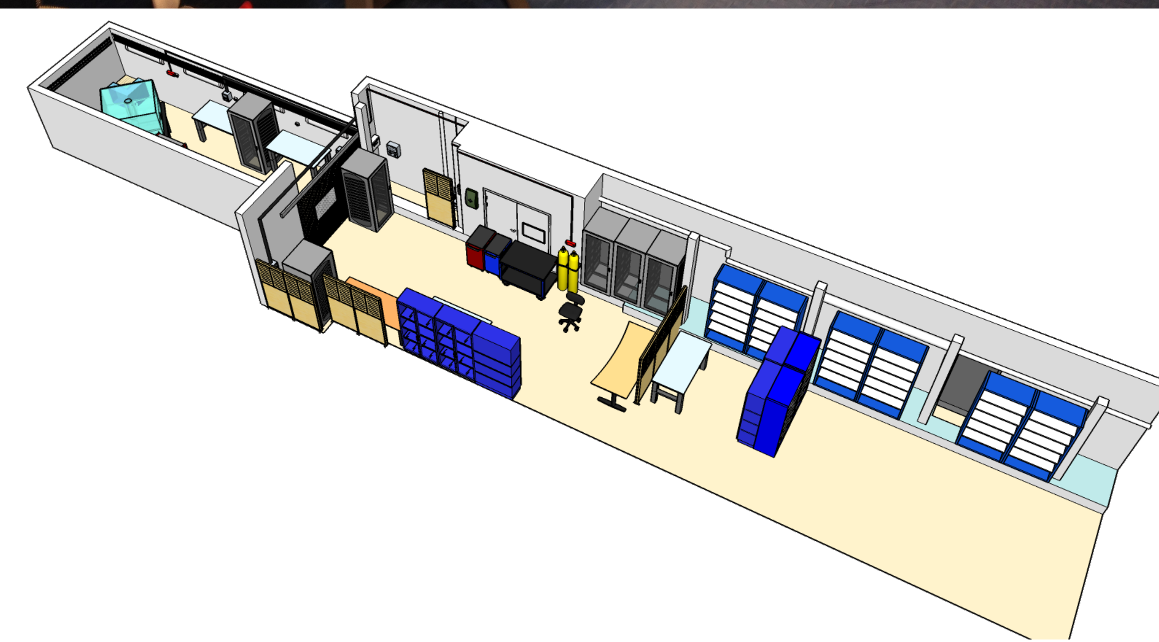
Detector Workshop (Also Mechanical and Electronic Workshops exist)

Source Facility

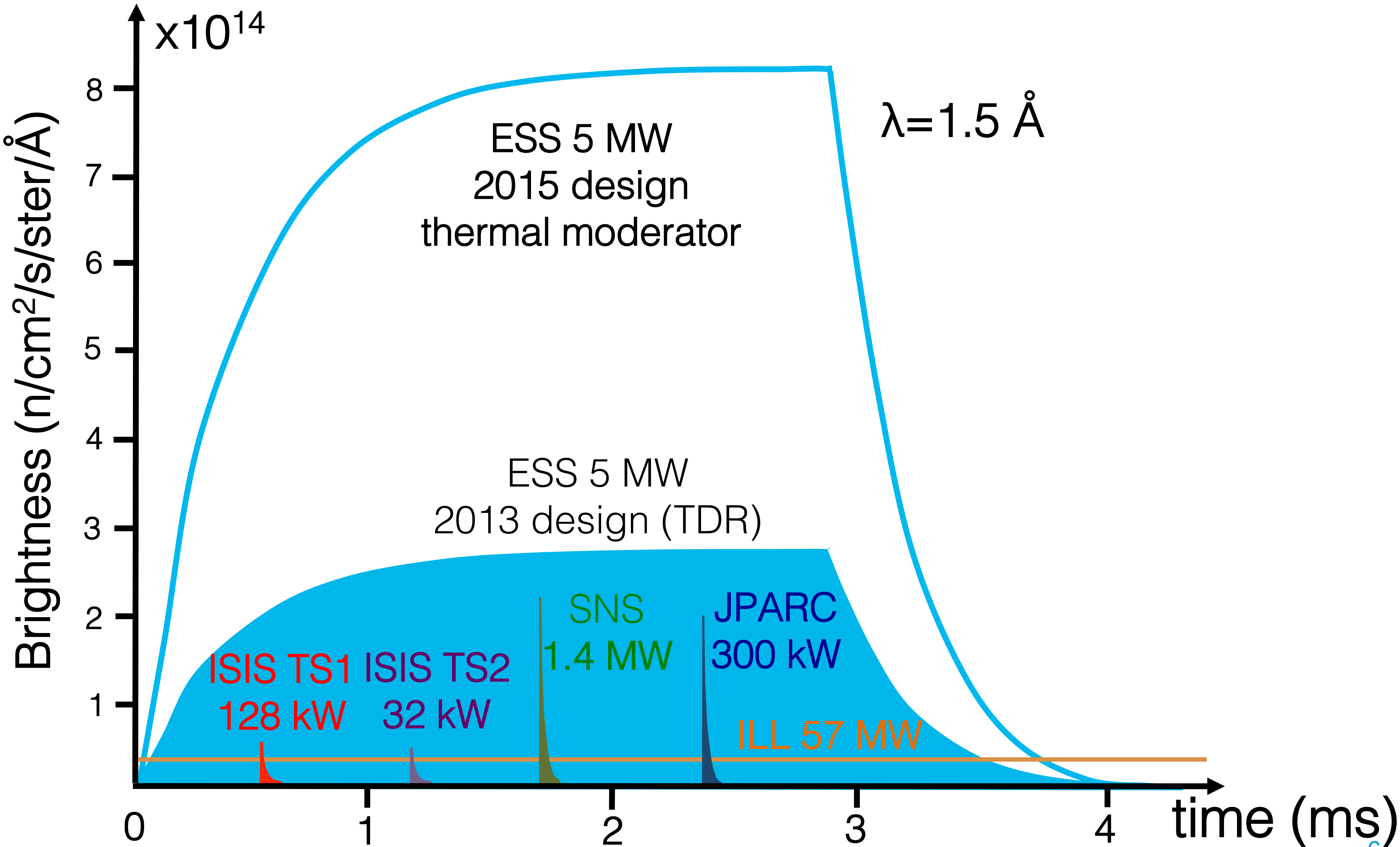
•Located in basement of Lund U physics dept
•ca. 700m from present offices
•Uses radiation source permit from Lund U
•Possibility to use radioactive sources in Lund
•ie development, testing, quality assurance, …
•SAT possible for detectors in Lund
•Heavily used over last couple of years

•Many neutron and gamma sources available
  •neutron: Am/Be
  •Gamma: Fe-55, Co-57, Co-60, Ba-133, …
•Electronics, DAQ, gas, infrastructure, elog available for testing

•Tagging method available for fast neutrons
•eg as recently used for evaluating B-loaded concrete



Challenge for Rate



What can be done with this brightness?

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Instrument Design	Implications for Detectors
Smaller samples	Better Resolution (position and time) Channel count
Higher flux, shorter experiments	Rate capability and data volume
More detailed studies	Lower background, lower S:B Larger dynamic range
Multiple methods on 1 instrument Larger solid angle coverage	Larger area coverage Lower cost of detectors

Also: scarcity of Helium-3 …

Developments required for detectors for new Instruments

What can be done with this brightness?

What does a factor 10 improvement imply for the detectors?

Implications for Detectors	Implications for Detectors
Better Resolution (position and time)	sqrt(10)
Channel count	pixelated: factor 10 x-y coincidence:sqrt(10)
Rate capability and data volume	factor 10
Lower background, lower S:B Larger dynamic range	Keep constant implies: factor 10 smaller B per neutron
Larger area coverage Lower cost of detectors	Factor of a few

Developments required for detectors for new Instruments

Requirements Challenge for Detectors for ESS: *beyond detector present state-of-the art*

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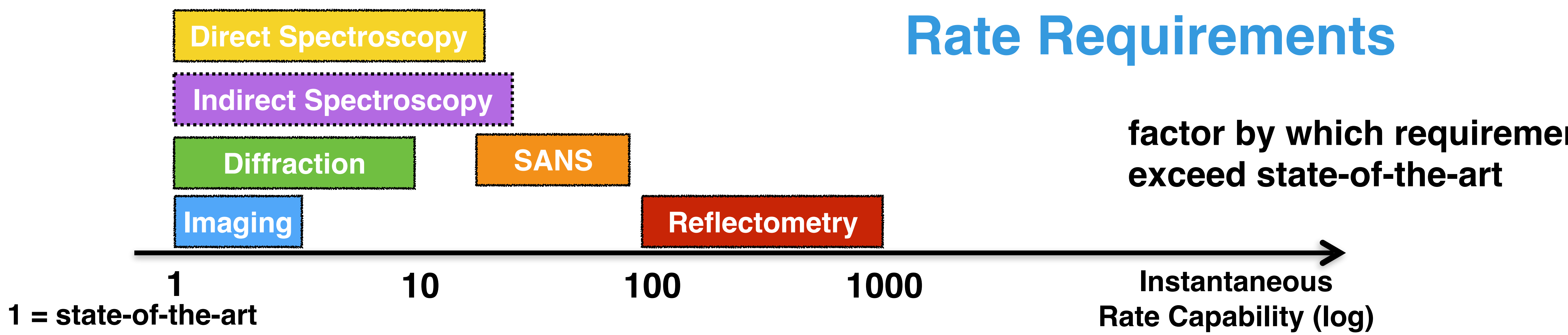
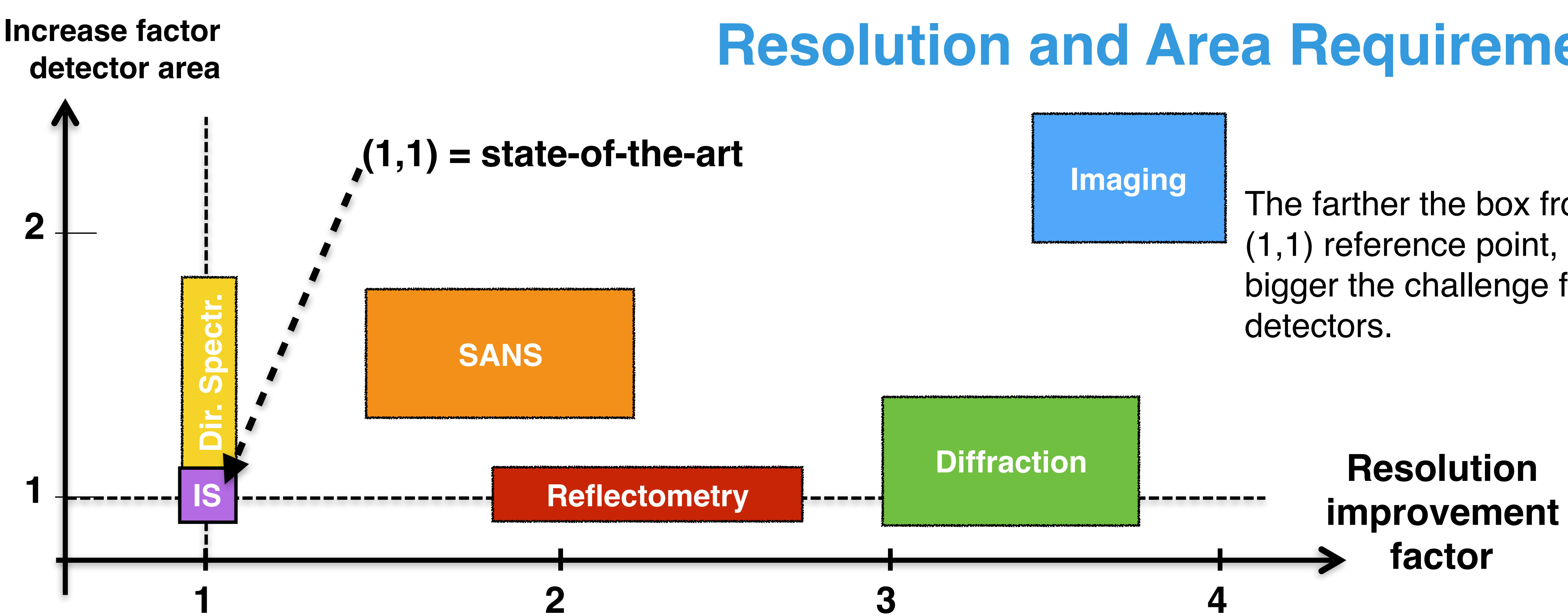
Rate Requirements



Resolution and Area Requirements



The farther the box from the (1,1) reference point, the bigger the challenge for detectors.

Baseline Detector Technologies for Initial Suite

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Detectors for ESS will comprise many different technologies

Imaging: 1 instrument
Various

NMX: 1 instrument
Gd-GEM

Indirect Spectroscopy: 3 instruments
He-3 PSD Tubes

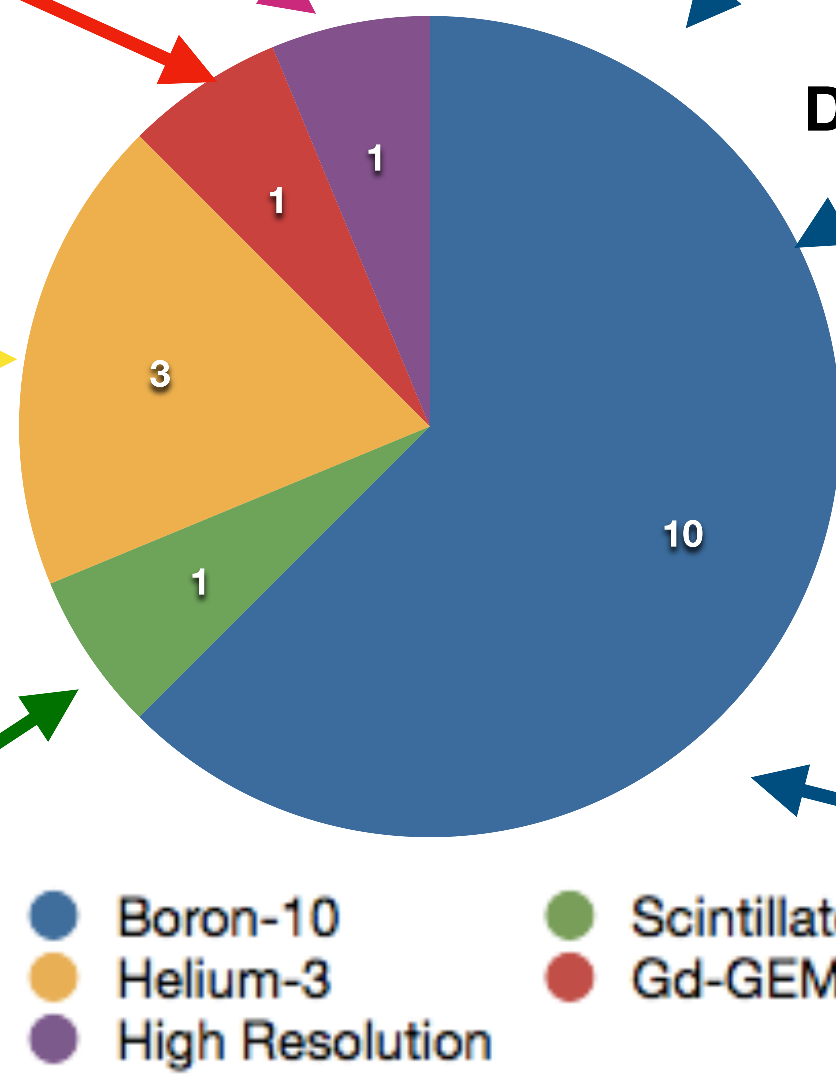
SANS: 1 instruments
SoNDe

Diffraction: 4 instruments
Jalousie (3)
Am-CLD (1): B-10 MWPC

Direct Spectroscopy: 3 instruments
Multi-Grid

Reflectometry: 2 instruments
Multi-Blade

SANS: 1 instrument
BandGEM



Schedule: Where are we for detectors?

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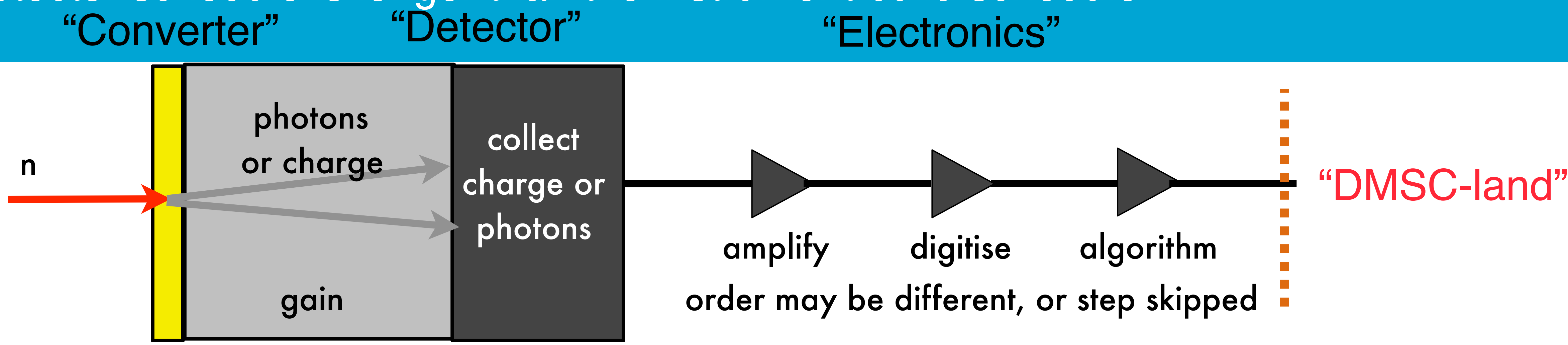
Detector schedule is longer than the instrument build schedule



2011	2012	2013	2014	2015	2016	2017
Coatings	Detector Conceptual Designs	Detector Prototype Designs	Strategy for Instruments, Instrument Designs	People, workshops and facilities, Instrument Designs	Electronics	Instrument Detector Design
					ICS/DMSC	Electronics
					Instrument conceptual design	ICS/DMSC interface

2018	2019	2020	2021	2022	2023	2024	2025
Electronics /ICS/DMSC	Design	Construction	Construction	Construction	Installation	Installation	Installation
Design	Construction	Installation	Installation	Installation	Commissionin g	Commissioning	Commissioning
Constructio n	Installation	Commissioni ng	Commissionin g	Commissionin g	Operation	Operation	Operation

How does this fit into controls?

July 2014 – ESS-ISIS Meeting
Geography of an Instrument

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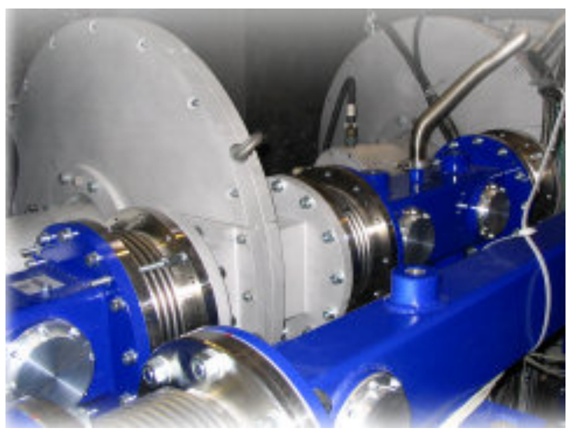
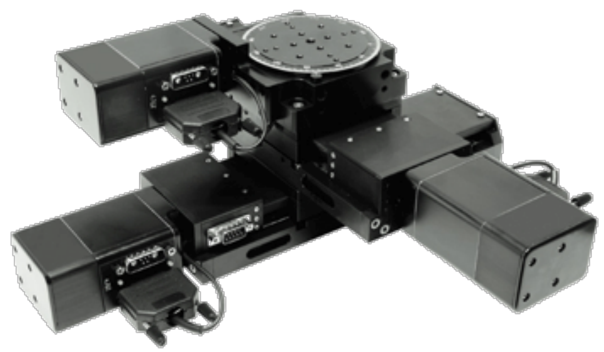
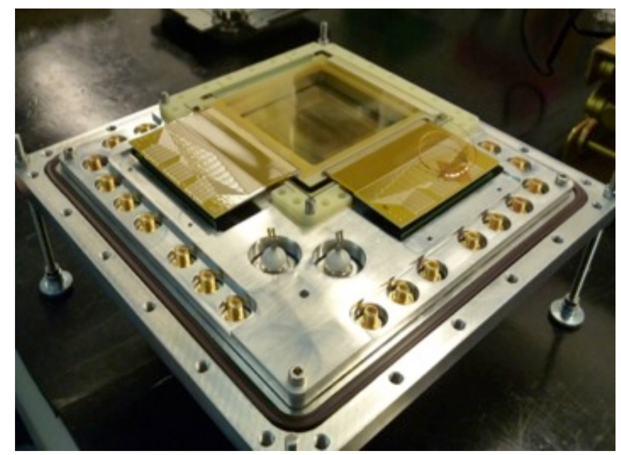
Instruments are a collection of subsystems, with some distance (often quite large) between components

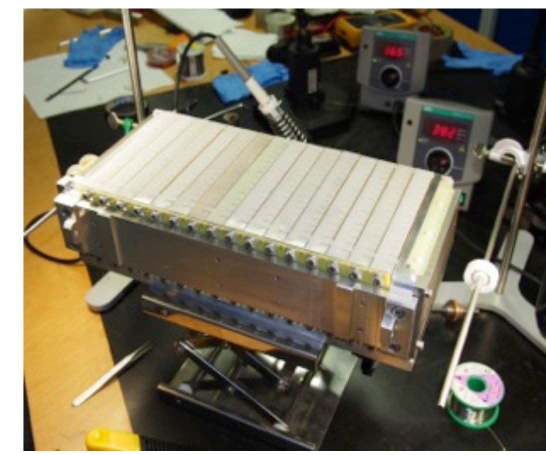


Choppers, Shutters etc

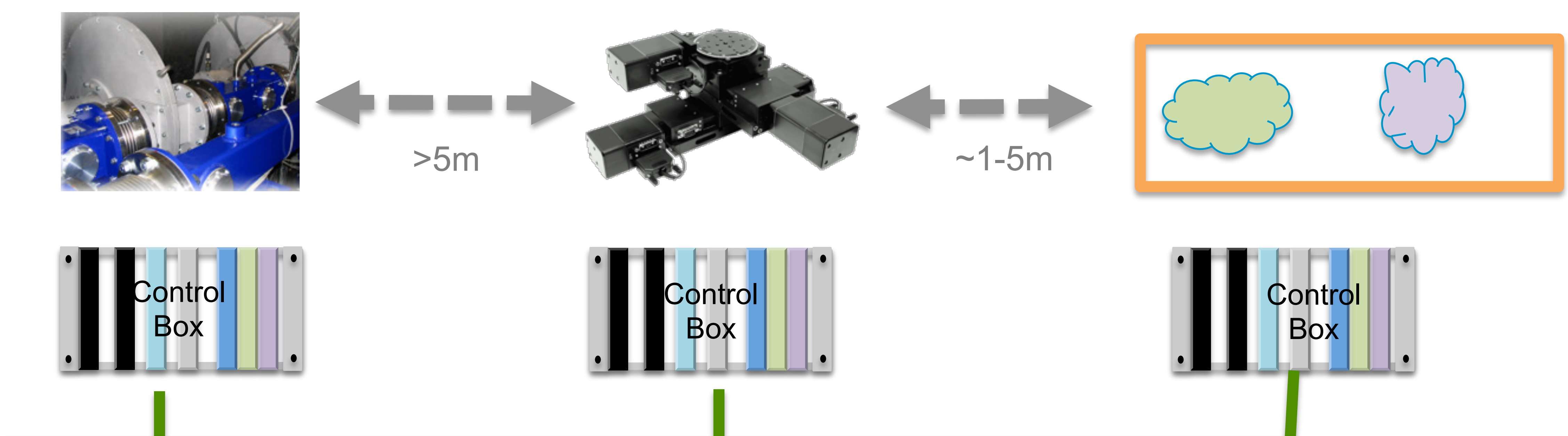


Sample Environment and Control





One or more types of detector.

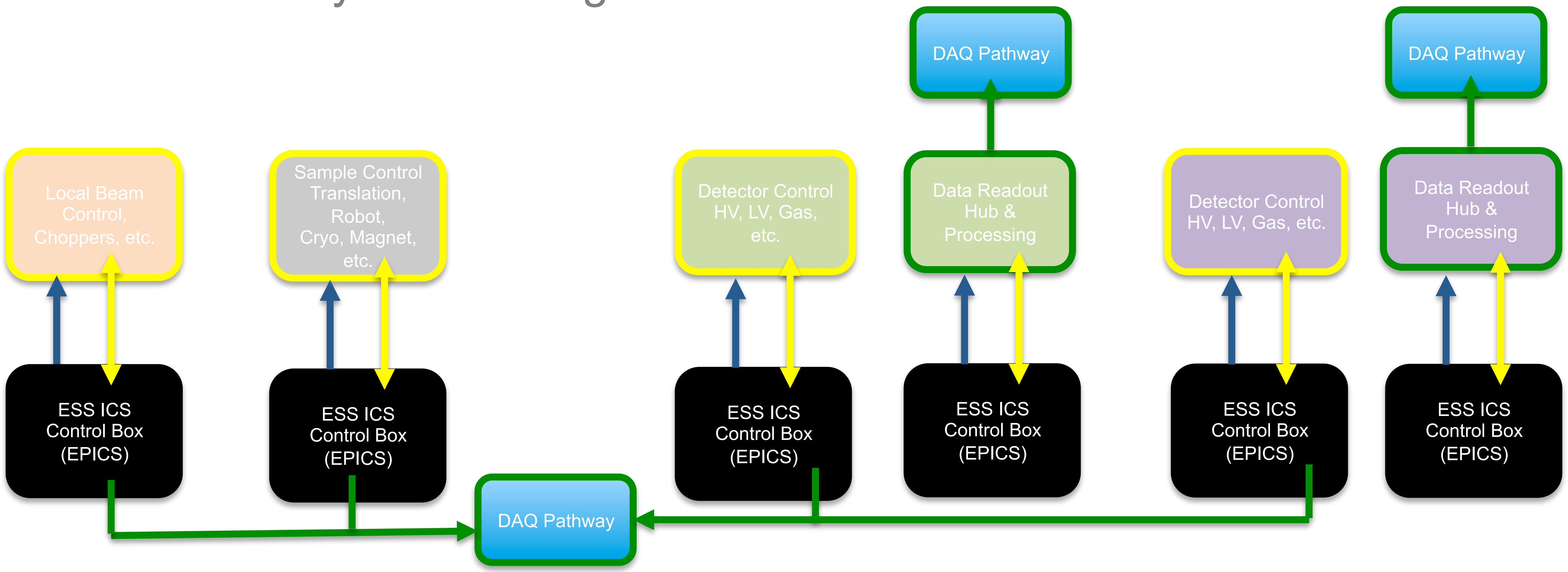


July 2014 – ESS-ISIS Meeting
Instrument Readout

Instrument is a collection of independent subsystems joined only through ICS and DMSC.

Each detector technology on an instrument will be readout as one or more subsystems.

There are two ways data can get to the DMSC



Event mode, time-stamping, and all that..

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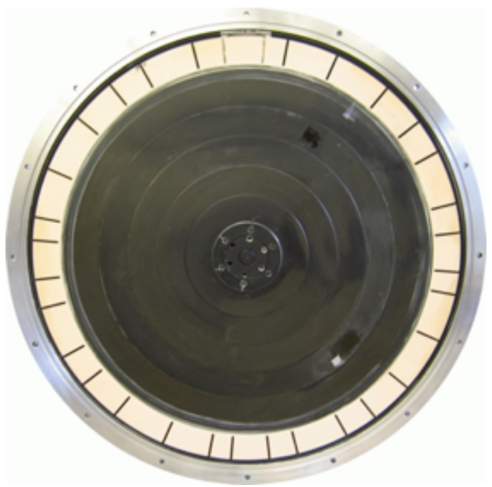
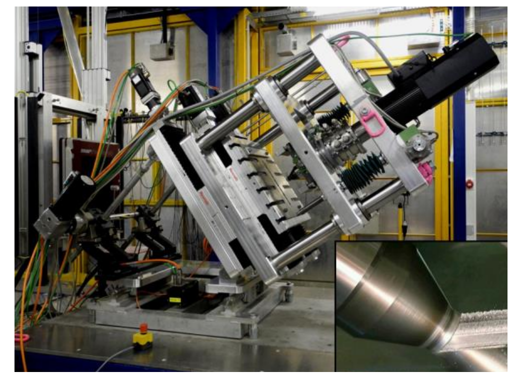




Timestamp
Top Dead Centre

Transitional Timestamp
Significant Variable Change

Timestamp Neutron
Candidate Data

Interpolate
Openings

Calculate Value
at any time

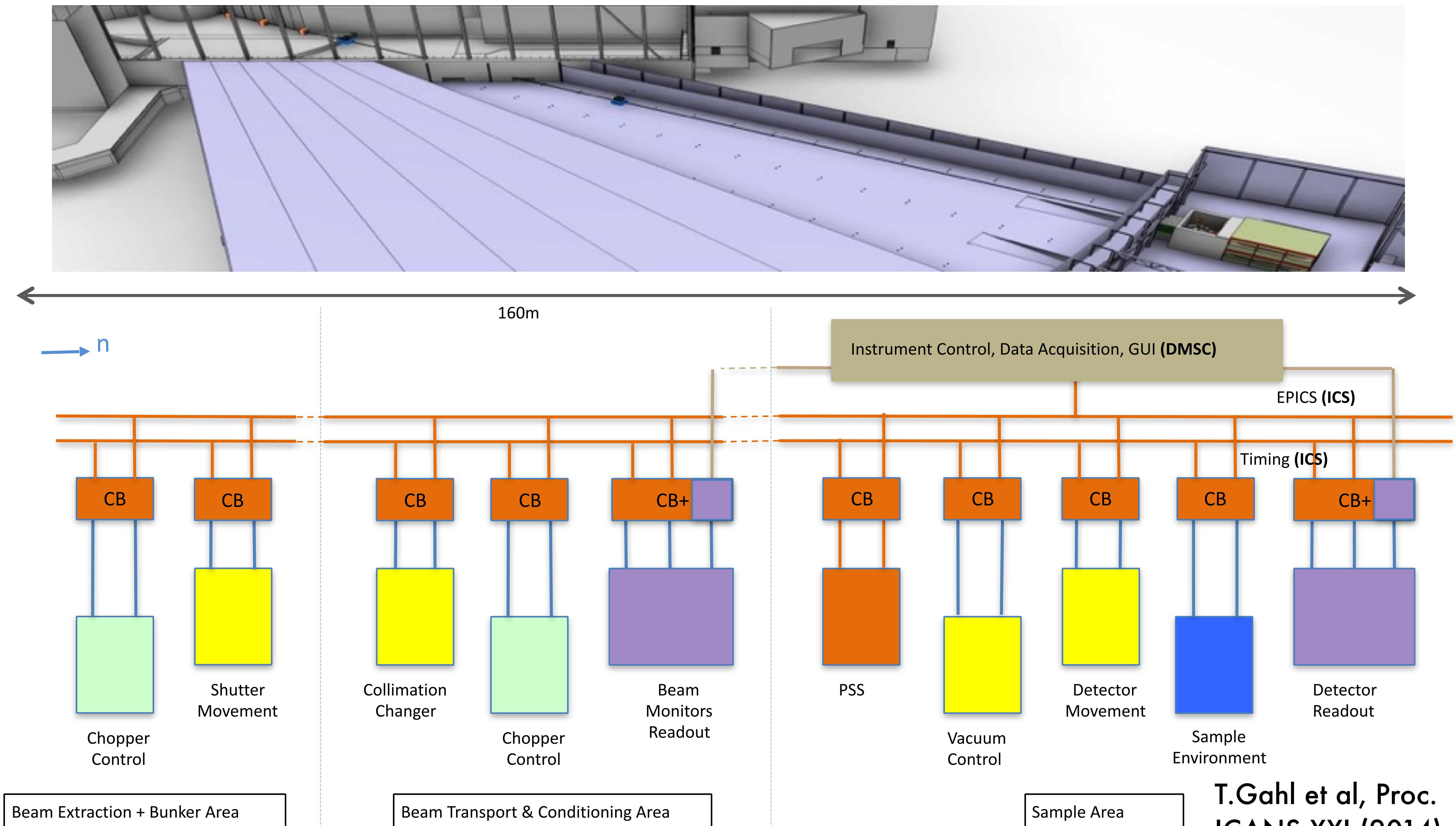
Neutron Candidate with
Time and Position

Periodically Record
Phase Error

Periodically Record
Process Variable

....Best possible flexibility, providing you have the data bandwidth

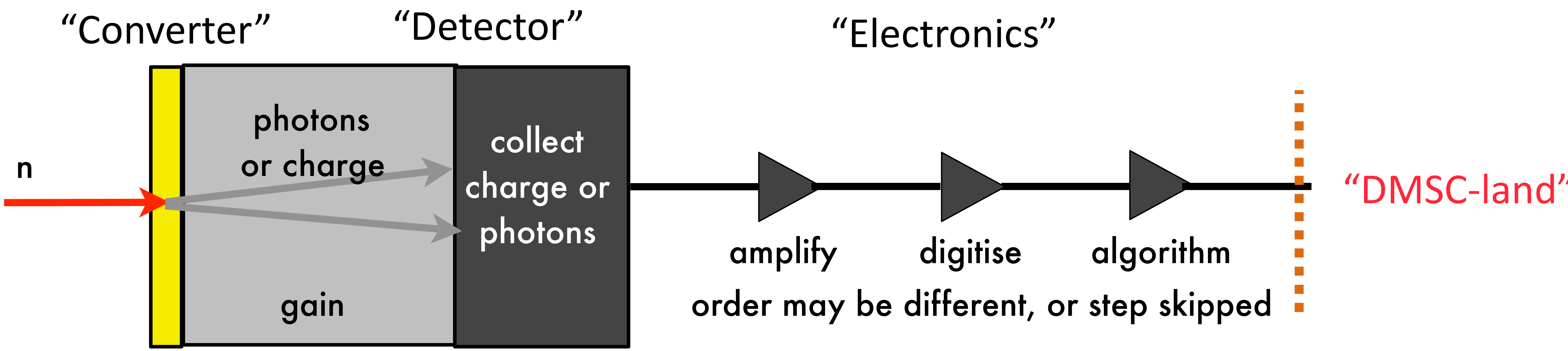
Nov 2014 – IKON meetings etc
Modular Instrument Control Concept



- Modularisation to manage key interface

T.Gahl et al, Proc. ICANS XXI (2014)
arXiv: 1507.01838

Detector Systems --- “System Analysis”



Detector Systems --- "System Analysis"

Inputs

Power
Electric mains (clean, filtered, isolated)
Safety Earth
Detector ground
HV, LV
Monitoring

Ethernet
Slow control
Monitoring

Services
Cooling water
Air / N2 (Cooling / environment)
Gas (Ar, CO2, CF4, maybe others)
Monitoring

Safety
Interlocks / Emergency buttons / Sensors
Monitoring

Signals
Clock
Telegrams
UTC Timestamp
Monitoring

Neutrons
Neutrons

x 22 detectors for instruments

Outputs

Ethernet
Data
Monitoring Data
Slow control
Monitoring

Waste
(Warm) water
(Warm) Air / N2 (Cooling / environment)
Waste Gas (Ar, CO2, CF4, maybe others)
Heat
Monitoring

Safety
Alarms
Monitoring

Environment
Temperature, pressure, humidity
Monitoring

Alignment
Alignment
Positioning
Monitoring

Most of this is "slow control"

NB Details vary for each instrument

Detector Systems --- Examples of Environmental Monitoring

→ Services

Cooling water - flow, temperature
Air / N2 (Cooling / environment) - flow, temperature
Gas (Ar, CO_2, CF_4, maybe others) - flow, temperature, composition

→ Waste

(Warm) water - flow, temperatures
(Warm) Air / N2 (Cooling / environment) - flow, temperatures
Waste Gas (Ar, CO_2, CF_4, maybe others) - flow, temperatures, composition
Heat

→ Environment

Temperature air
pressure air
humidity air
Temperature on detector
Temperatur in electronics
May be many sensors
Alignment

NB
Details vary for each instrument
Not all services needed for each instrument
Design, ranges depend upon design

Detector Systems --- Slow Control — Where are we?

ESSIIP Racks

LV/HV Devices “integrated"
Not clear whether they are usable yet …?
Not clear how to scale to test or real systems?

Detector Systems --- Slow Control — Where are we?

Presently determining what we need in terms of monitoring

Instrument #	Instrument Name	Preferred Detector Design	Contact	Comments	Gas flow	Gas pressure	Gas flow rate	Gas composition and quality	water cooling	air cooling	Temperature	Detector Positioning/Alignment	HV	LV	Current (I)
3	DREAM	Jalousie	Irina Stefanescu	still a demonstrator.	Ar/CO2	atmospheric pressure accuracy: 0.5 mbar	1.2L/h , 1/3 mbar/s)	yes	No	Yes	Environmental temperature	Yes	positive polarity, max 1.3 kV	devices that can deliver independently at least +-6V, +-12 V	minimal 100 uA
11	HEIMDAL	Jalousie	Irina Stefanescu	Still in design phase	Ar/CO2	atmospheric pressure accuracy: 0.5 mbar	1.2L/h , 1/3 mbar/s)	yes	No	Yes	Environmental temperature	Yes	positive polarity, max 1.3 kV	devices that can deliver independently at least +-6V, +-12 V	minimal 100 uA
5	BEER	AmCLD/A1CLD	Irina Stefanescu	Still in design phase	CF	2 different gas systems, one to operate the counting gas and one to ensure that the cathodes don't bend due to the electrostatic attraction when the high voltage in set on the wires.	yes	yes	No	Yes	Environmental temperature	Yes	positive and negative polarity, max 3 kV	devices that can deliver independently at least +-6V, +-12 V	minimal 100 uA
			ANTON												
Instrument #	Instrument Name	Preferred Detector Design	Contact	Comments	Gas flow	Gas pressure	Gas flow rate	Gas composition and quality	water cooling	air cooling	Temperature	Detector Positioning/Alignment	HV	LV	Current (I)
6	C-SPEC	Multi Grid	Anton Khaplanov		Ar/CO2	27 x 1 bar	1 bar overpressure on inlet		not defined yet	not defined yet	0-100°C		54 x 0-1.5kV	27 x 0-14V	for HV: 50uA, for LV: 20A
12	TREX	Multi Grid	Anton Khaplanov			10 x 1 bar	1 bar overpressure on inlet		not defined yet	not defined yet	0-100°C		60 x 0-1.5kV	10 x 0-14V	for HV: 50uA, for LV: 50A
16	VOR	Multi Grid	Anton Khaplanov	VOR is not being built yet	not defined yet	not defined yet	not defined yet	not defined yet	not defined yet	not defined yet	not defined yet	not defined yet	not defined yet	not defined yet	not defined yet
			FRANCESCO												
Instrument #	Instrument Name	Preferred Detector Design	Contact	Comments	Gas flow	Gas pressure	Gas flow rate	Gas composition and quality	water cooling	air cooling	Temperature	Detector Positioning/Alignment	HV	LV	Current (I)
7	ESTIA	Multi Blade	Francesco Piscitelli		Ar/CO2	min 0.8bar max 1.3bar, Vessel overpressure max 200mbar (outside athmospheric)	min: 0, max: 8L/h		not defined yet	not defined yet	not defined yet		0-2kV	not defined yet	200nA per channel
10	FREIA	Multi Blade	Francesco Piscitelli		Ar/CO2	min 0.8bar max 1.3bar, Vessel overpressure max 200mbar (outside athmospheric)	min: 0, max: 8L/h		not defined yet	not defined yet	not defined yet		0-2kV	not defined yet	200nA per channel

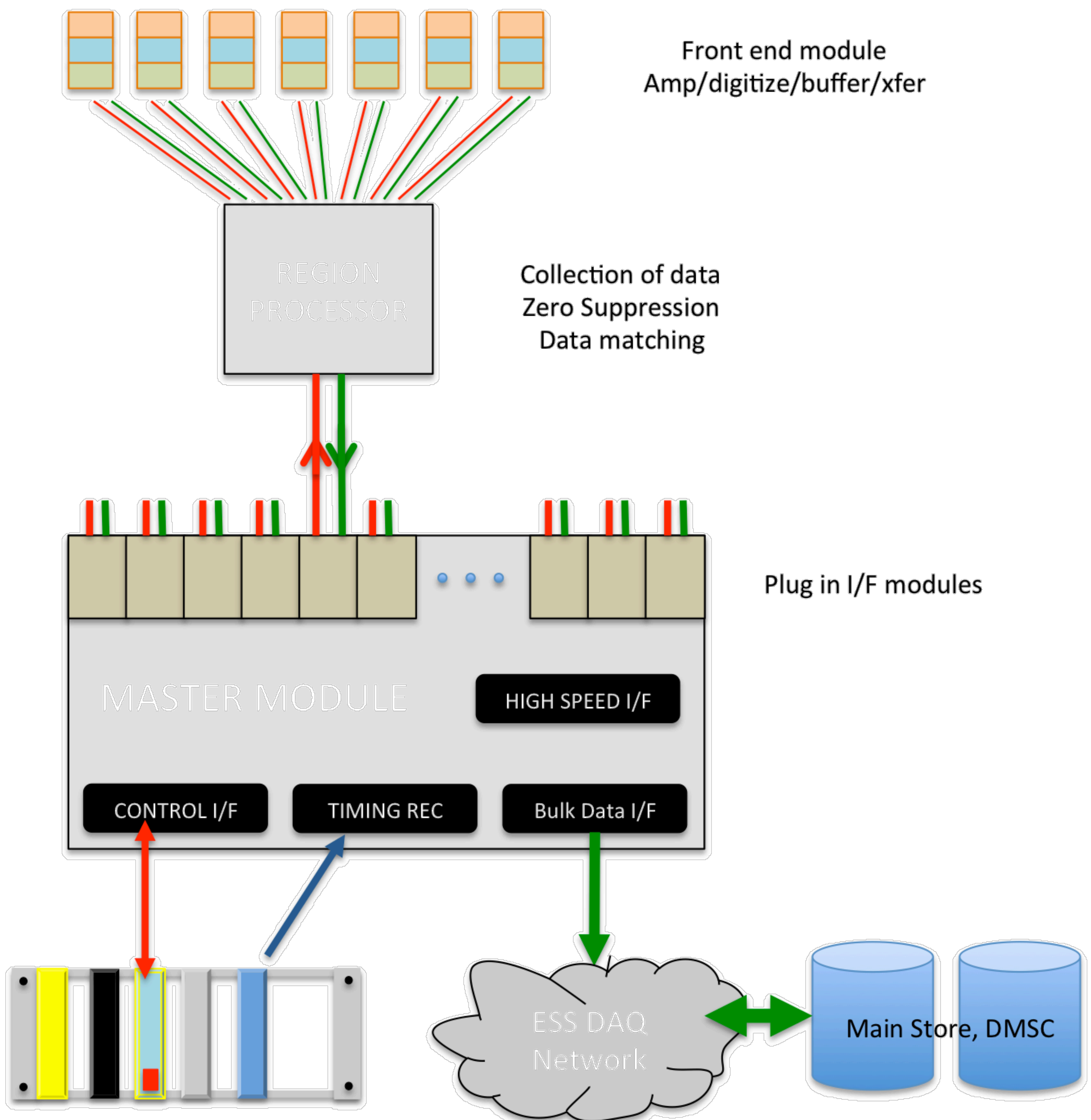
Table under construction … but a good first pass at what is needed …

Detector Systems --- Readout

https://brightness.esss.se/about/deliverables/41-integration-plan-detector-readout

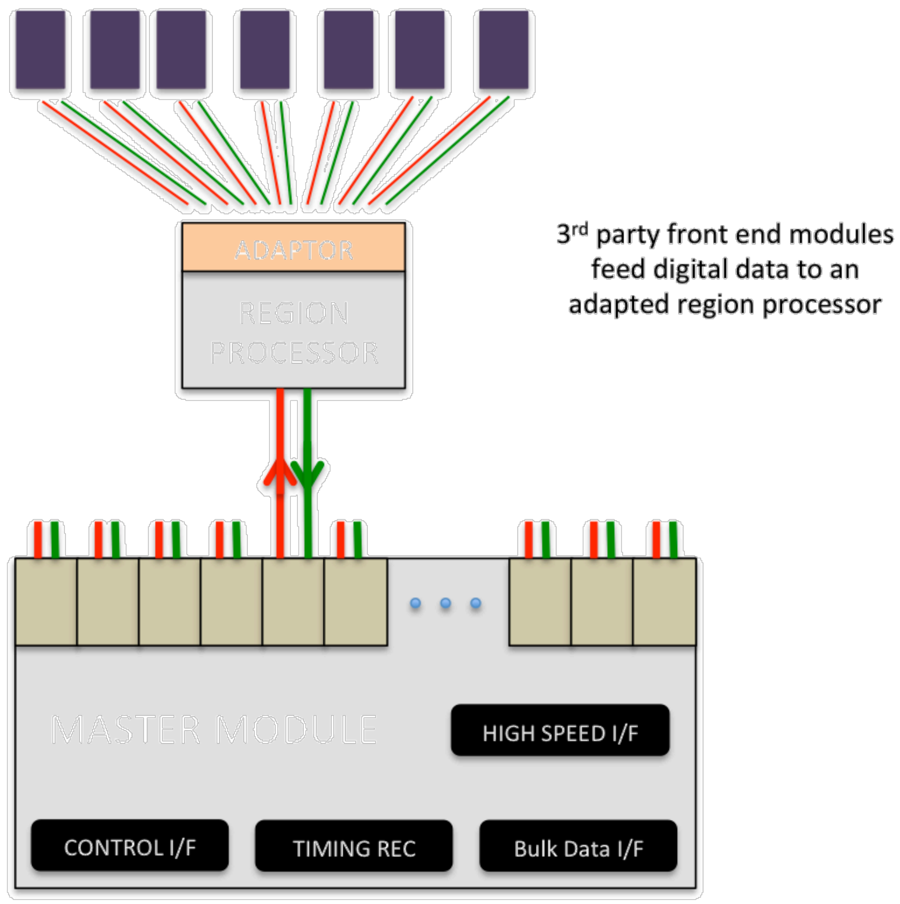
https://doi.org/10.17199/BRIGHTNESS.D4.1

This slide has been showing up since 2013



Integrating Front Ends

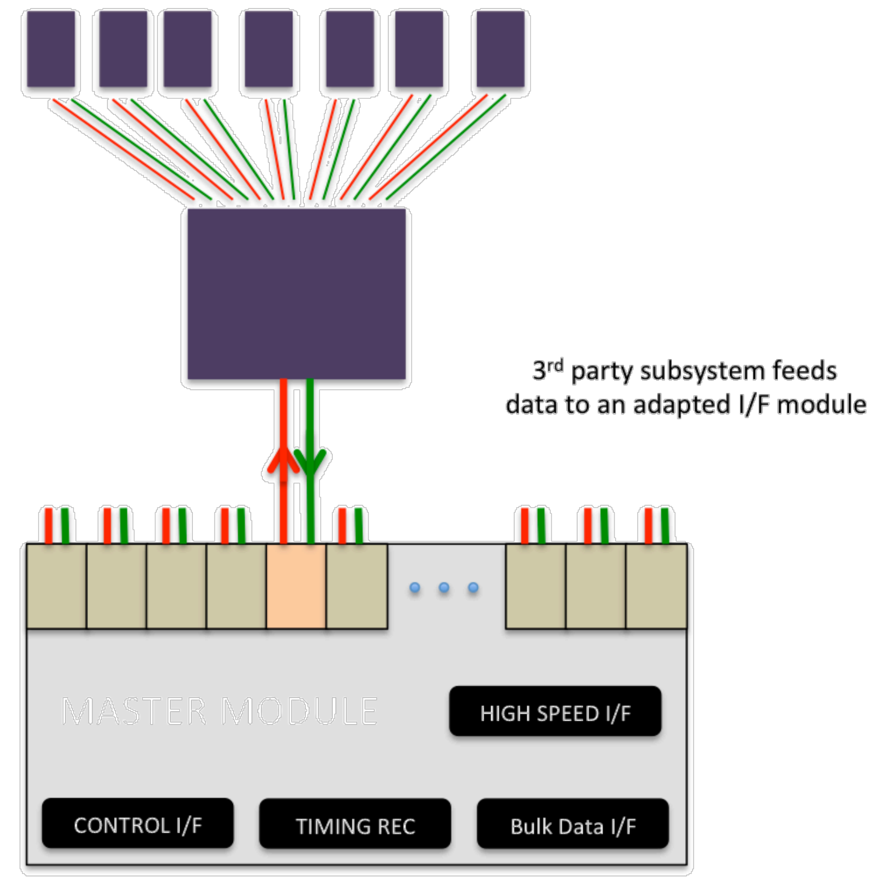
EUROPEAN SPALLATION SOURCE



Existing design for pre-amp, digitizer etc from external partner.

Adaptor in-house

In this case the data processing provided by the region processor could be in house.



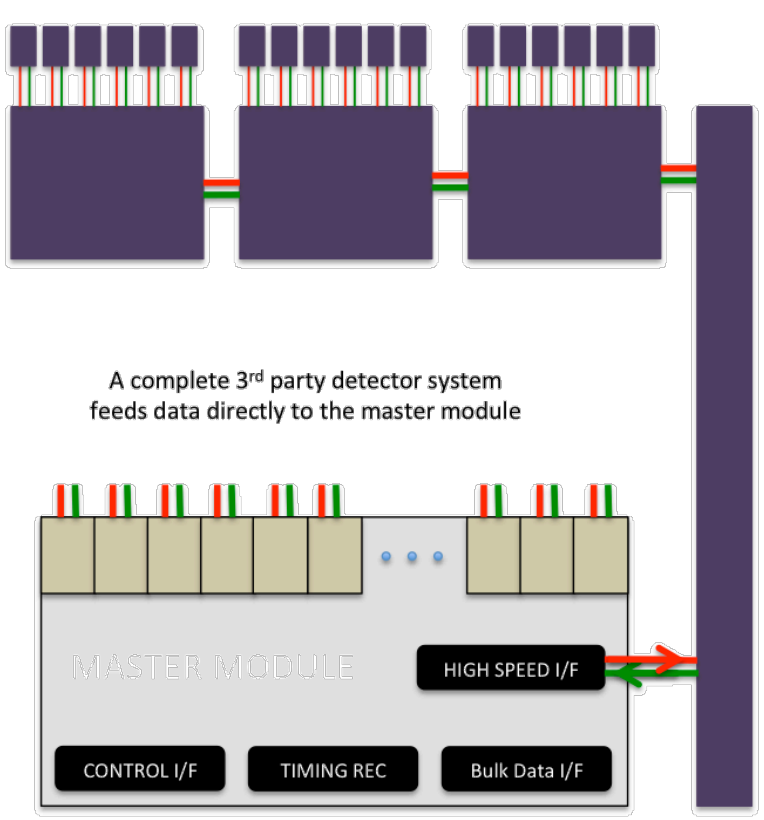
Entire subsystem provided by external partner. In this case the local region processing is handled by the external design.

Firmware for this intermediate stage would have to be provided and maintained by external partner.

Custom Interface module may be designed locally.

DISCOURAGED

Integrating Front Ends



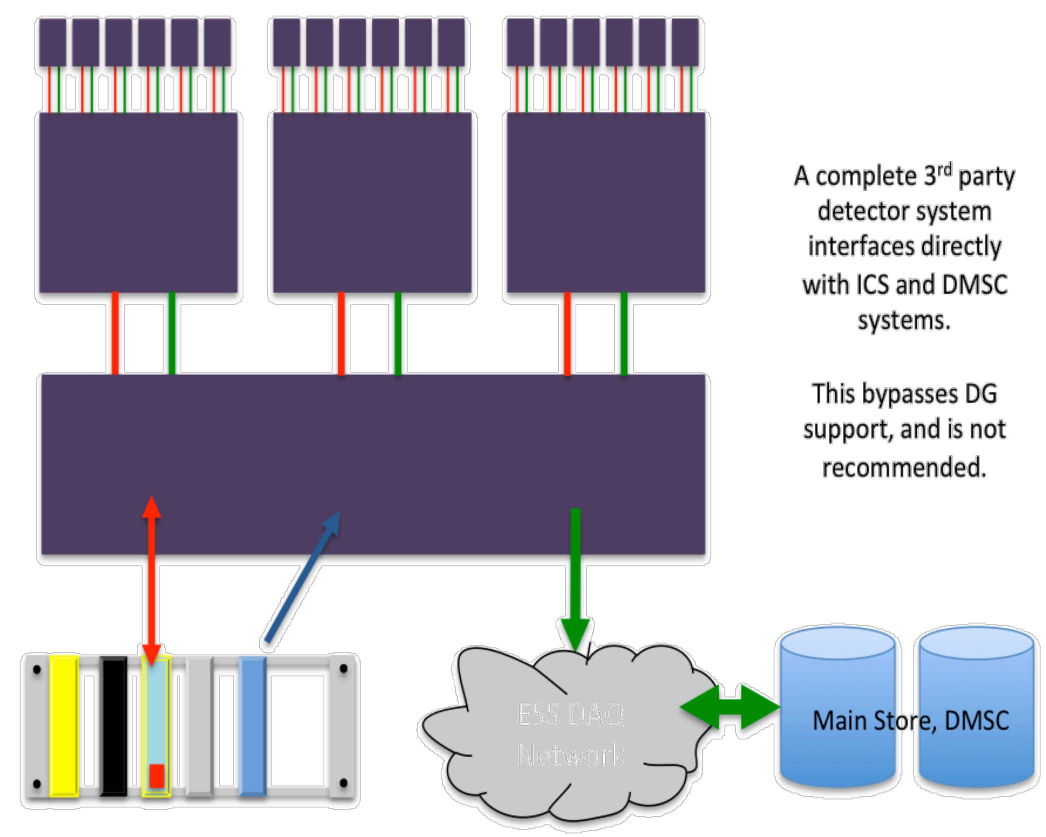
In this case the external partner supplies essentially a complete readout system for the detector array.

Interfacing hardware could be provided in house (construction cost)

ESS system acts as a bridge to ESS standard interfaces.

The entire subsystem would have to be maintained by the external partner.

STRONGLY DISCOURAGED



This is the case where an external system cannot (realistically) be adapted to use the ESS design as a bridge.

Eg a commercial system where proprietary or confidential protocols are used.

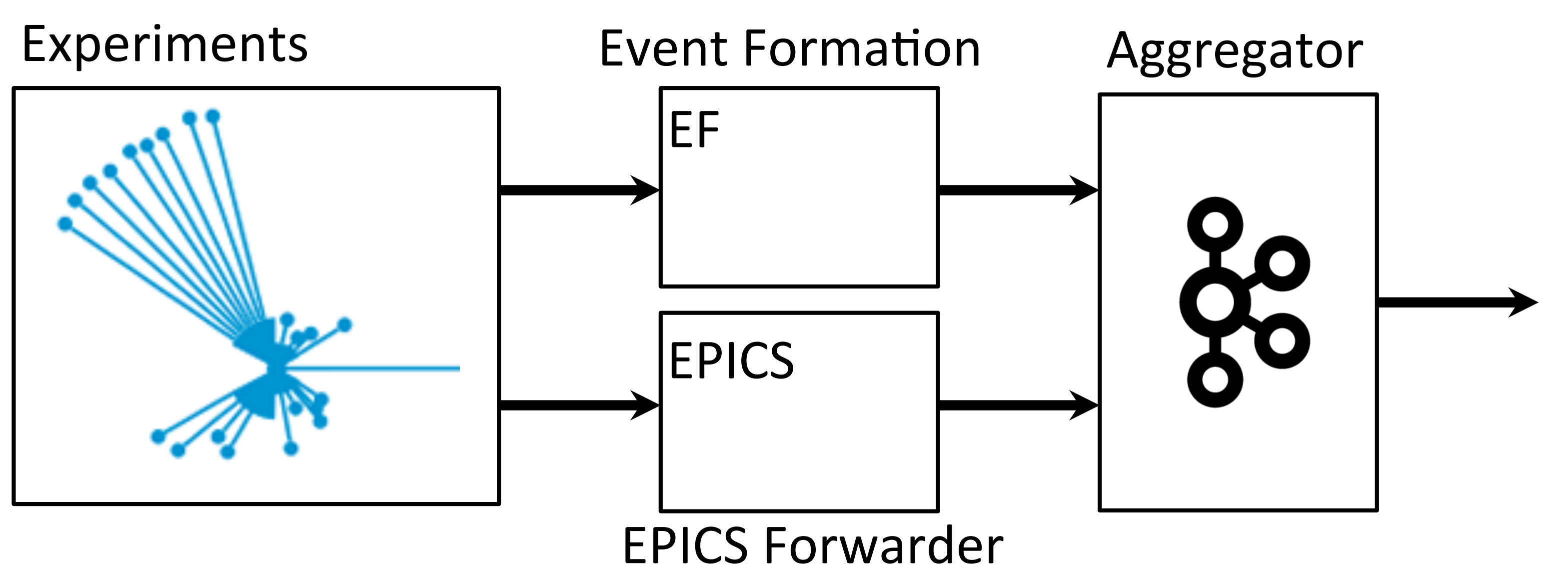
DG provide NO support!!!

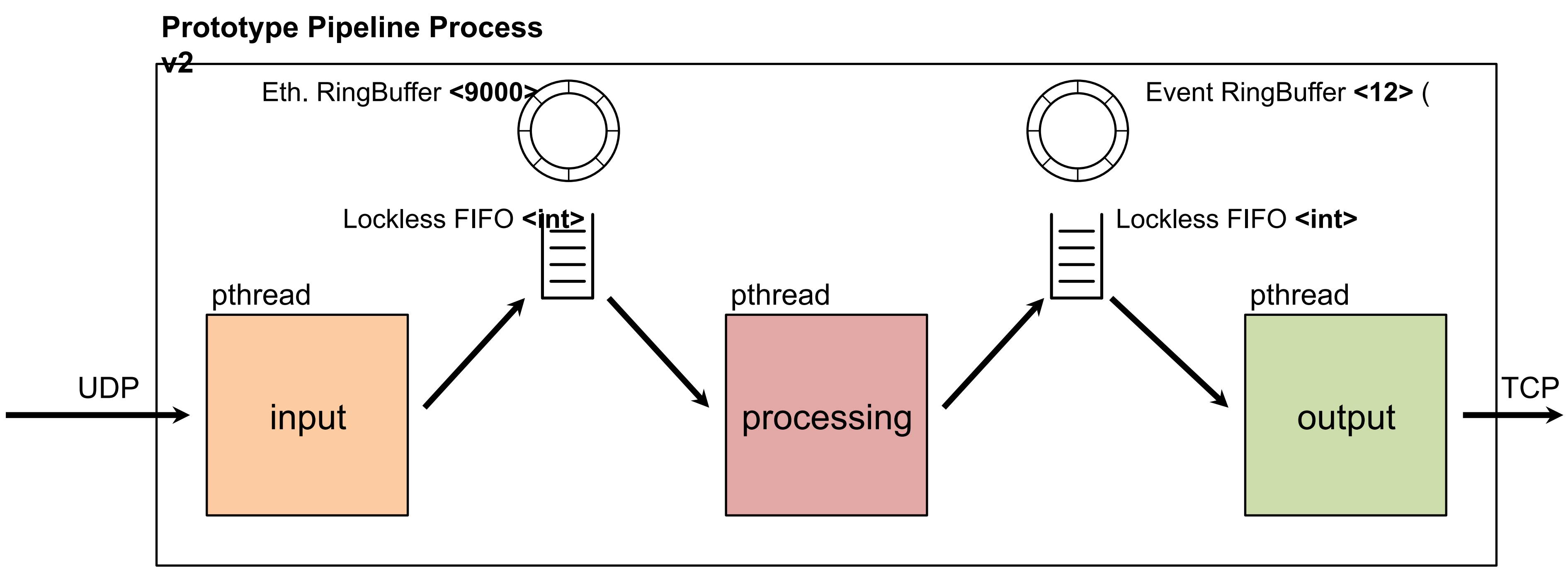
ONLY IN EXCEPTIONAL AND UNAVOIDABLE CIRCUMSTANCES…
ie **NEVER**

Event Formation

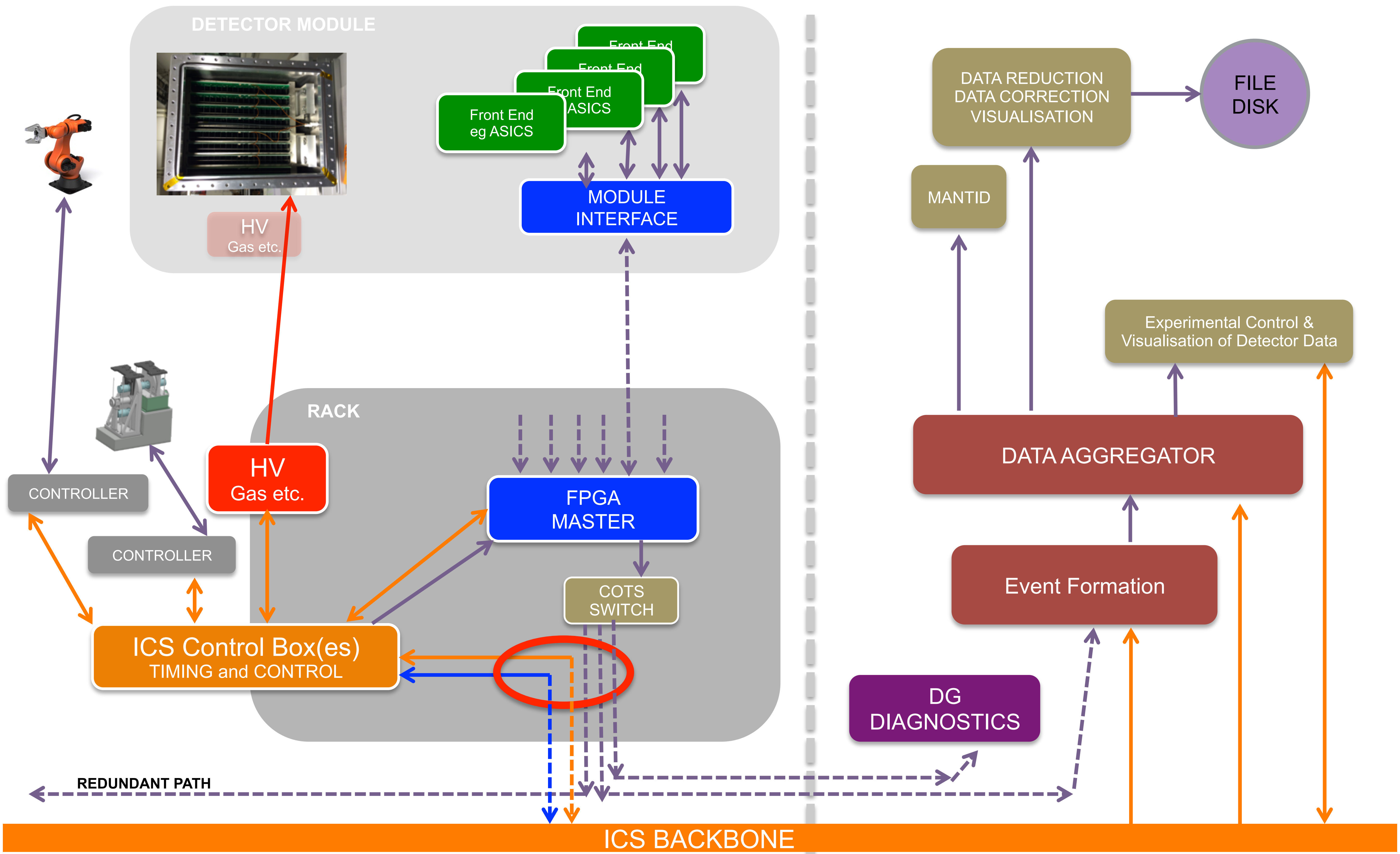
(Morten Jagd Cristensen)

Interface demonstrated



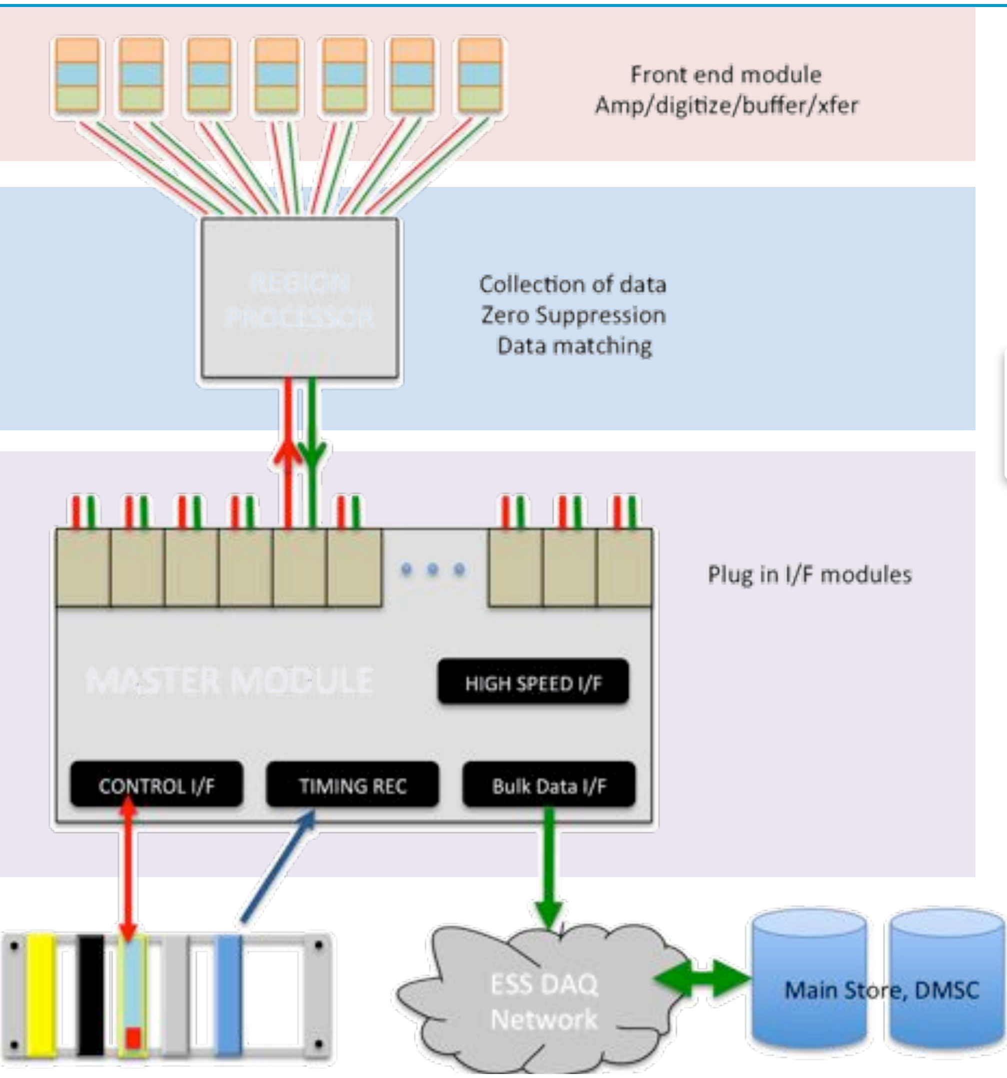


ESS Instrument Readout
(Detector Perspective)



Task4.4: Detector Realisation

- An integrated plan for integrated detector readout
- For all parts of system, prototype hardware exists

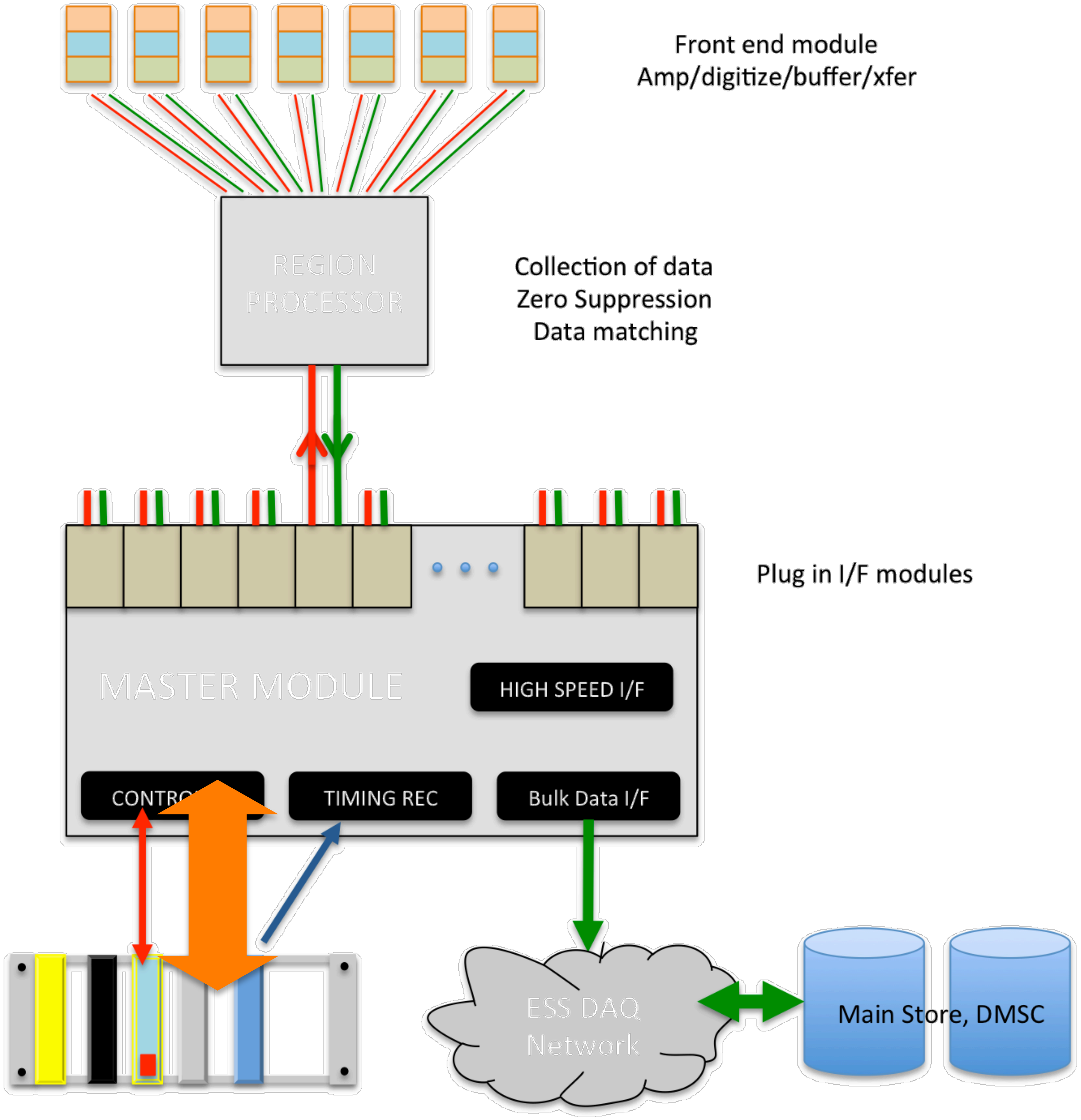


- Interface between WP4 and WP5 a key interface for ESS instruments
- The sum of this interface defines the data acquisition path for neutron detector data at ESS

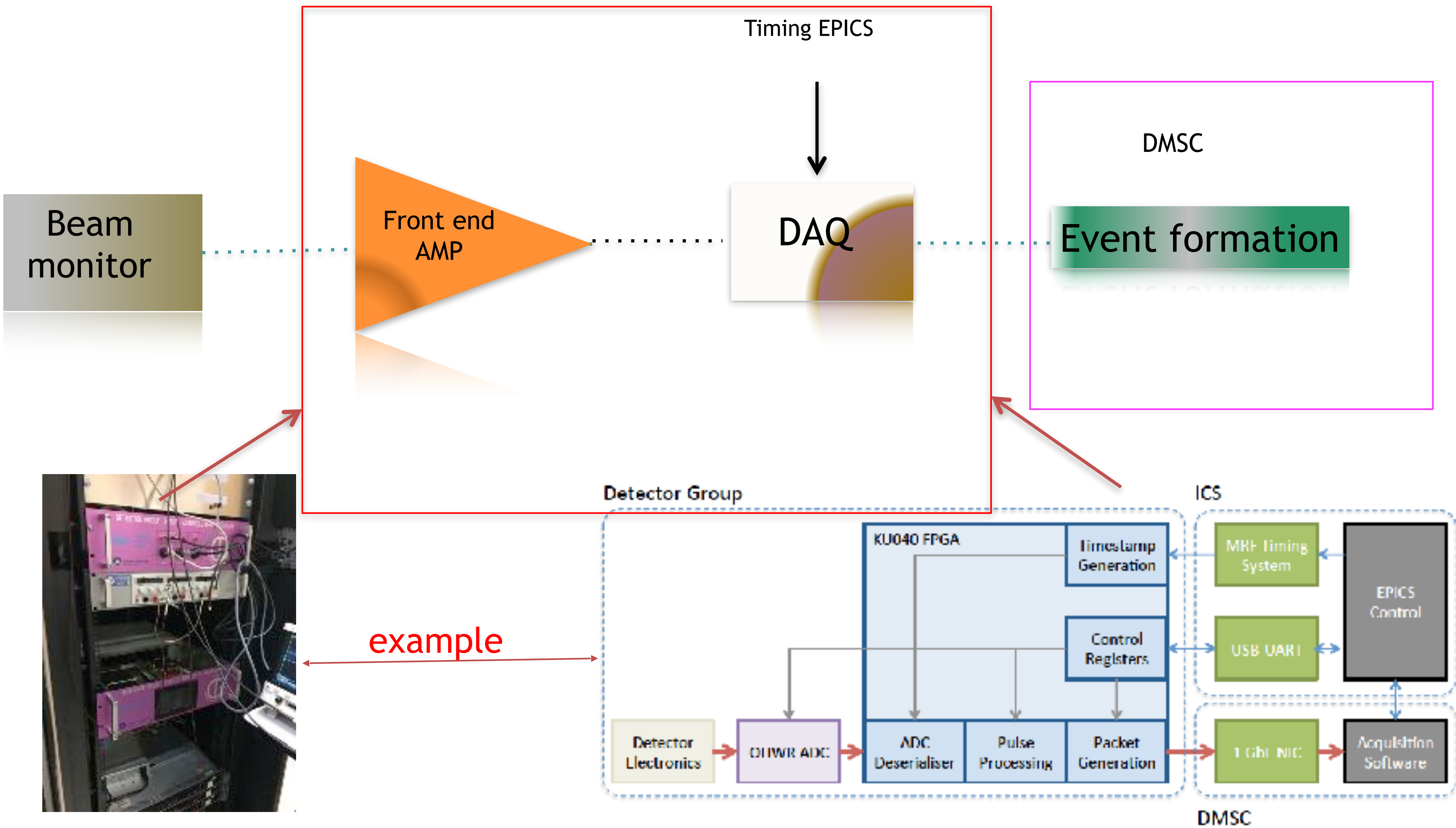
Interface shared, understood, manned and demonstrated

BrightnESS is funded by the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 676548

DGR Timing Controls Demonstrator



Beam monitor electronics



Work done by: Steven, Scott (DG) Tobias and Janos (DMSC)

V20 test at HZB

Timing EPICS

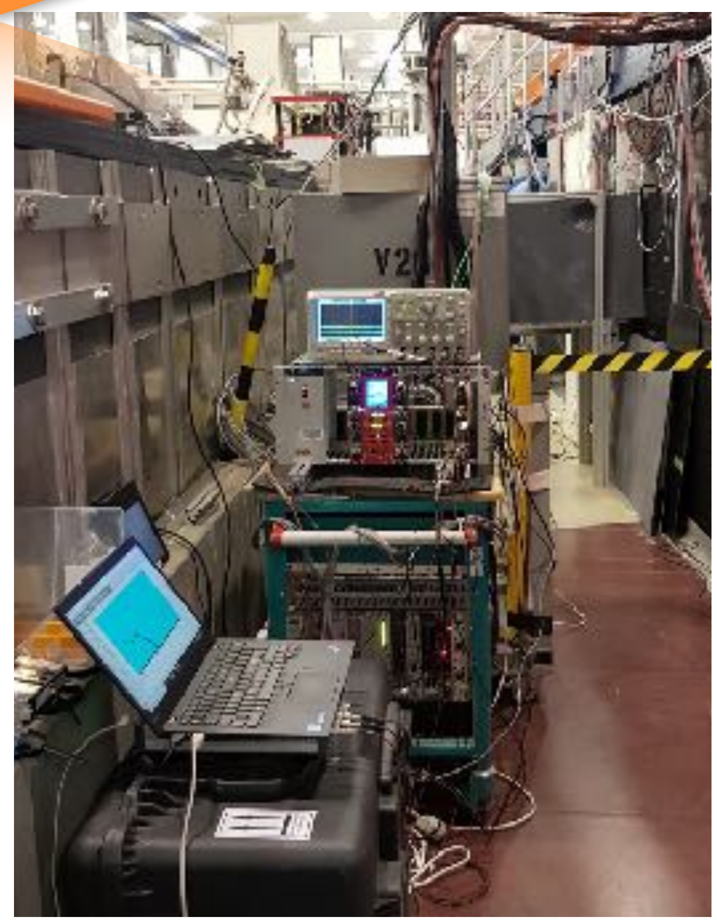
DMSC

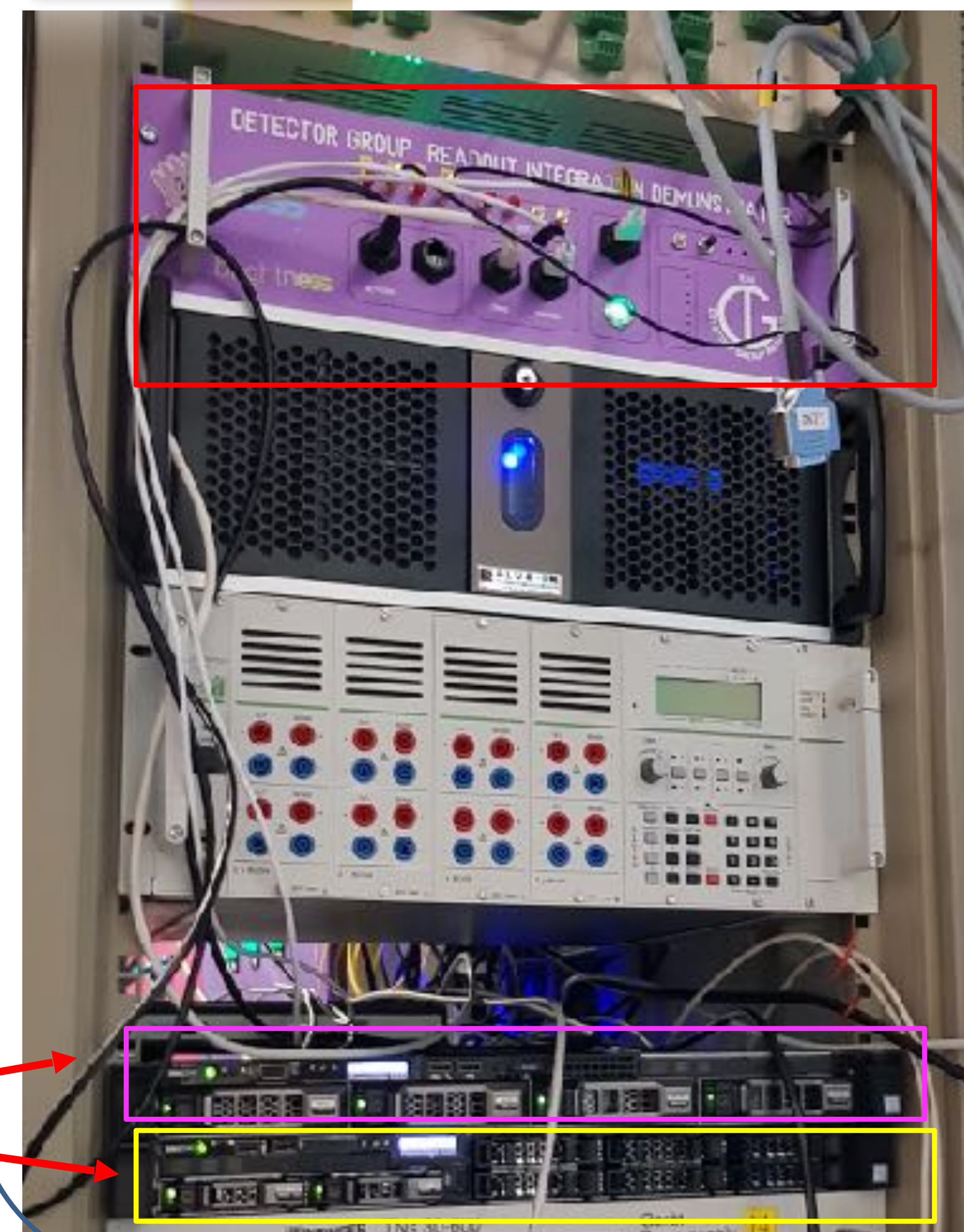
Beam monitor

Front end AMP

DAQ

Event formation





DMSC and ICS

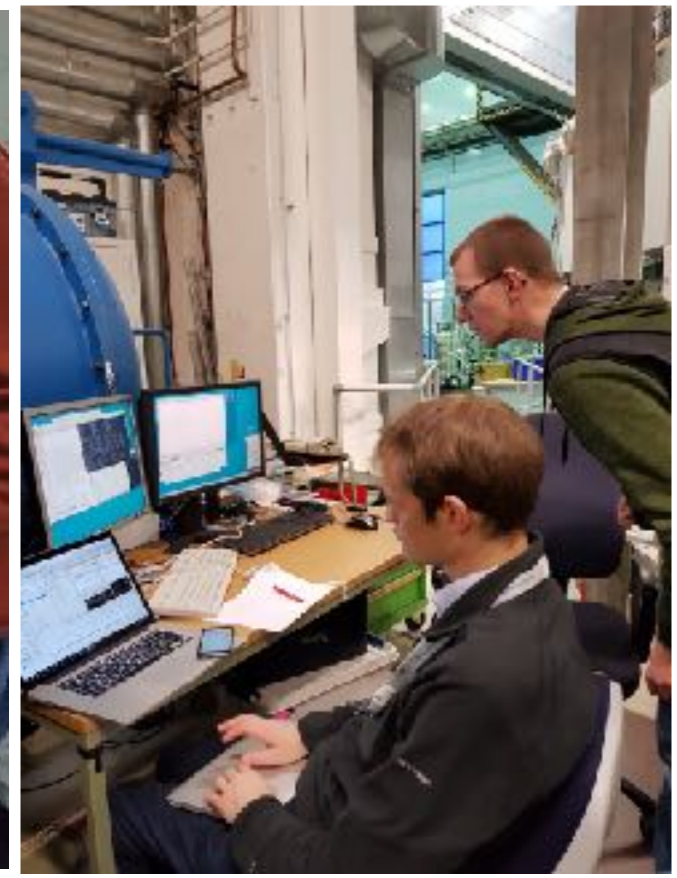
<u>BM electronics several options (for more details see Scott talk at IKON13):</u>

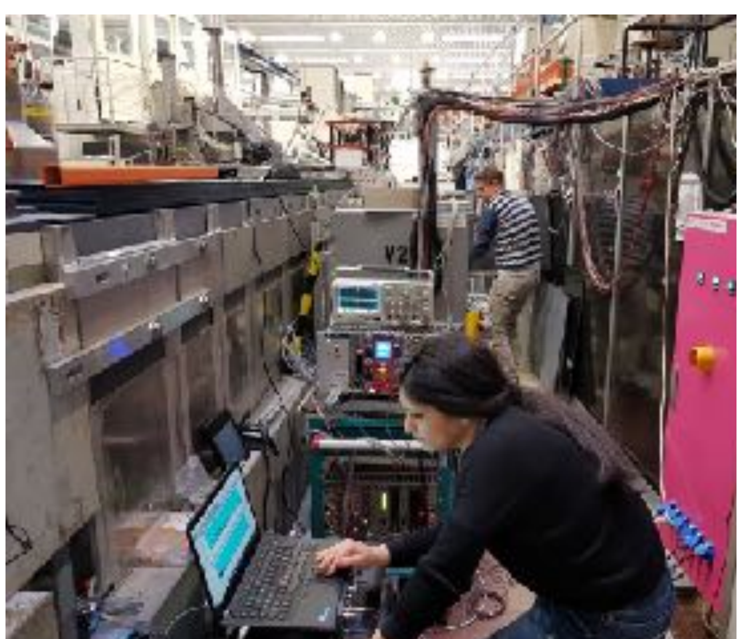
- ✓ Integration Demonstrator (Done)
- ❑ Talin
- ❑ Talin ++
- ❑ Standard detector readout

V20 test at HZB

EUROPEAN SPALLATION SOURCE







V20 test at HZB-Berlin:

- ❑ Detector Group
- ❑ Chopper Group
- ❑ DMSC
- ❑ ICS

Choppers will tell you about this ...?

System integration shown
Successful test:
DMSC produced time-of-flight spectra based on the D.G. readout from the beam monitors,
and Diagnose chopper using two BMs

Questions?

brightness

SoNDe Solid-State Neutron Detector

SINE 2020