

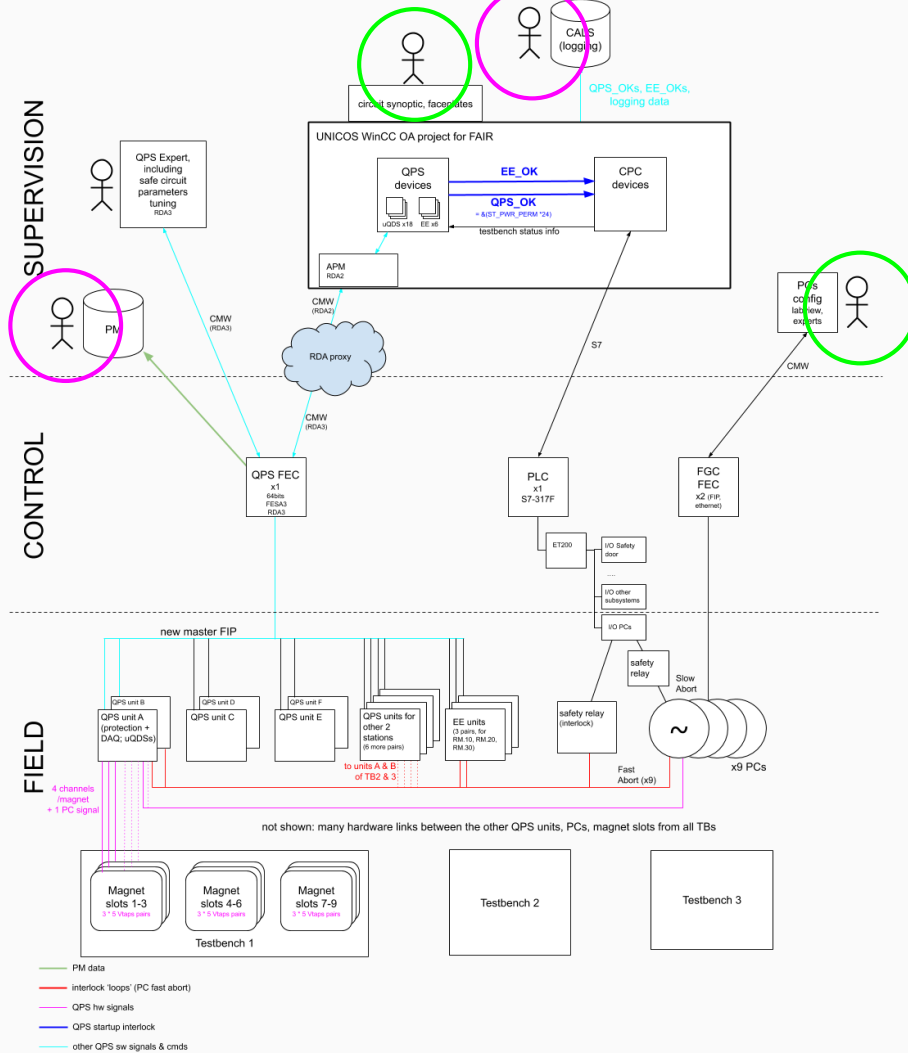
FAIR

Magnet Protection System
software layer



Protection System integration insights

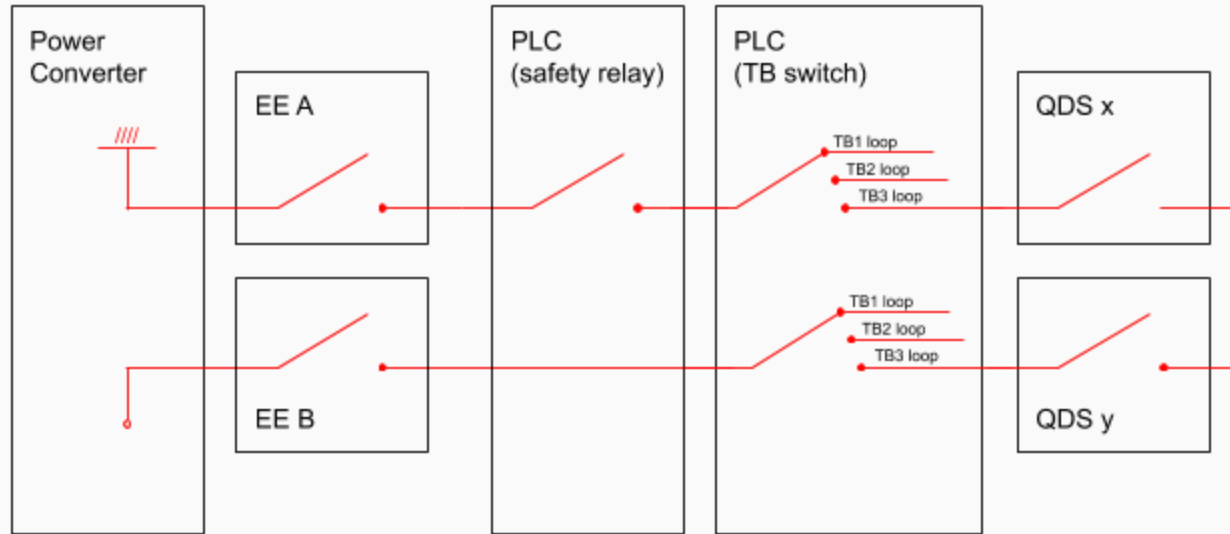
- supervision
- acquired data access



Protection, EE, Powering and Interlocks

integration overview

Protection system setup: interlock loops



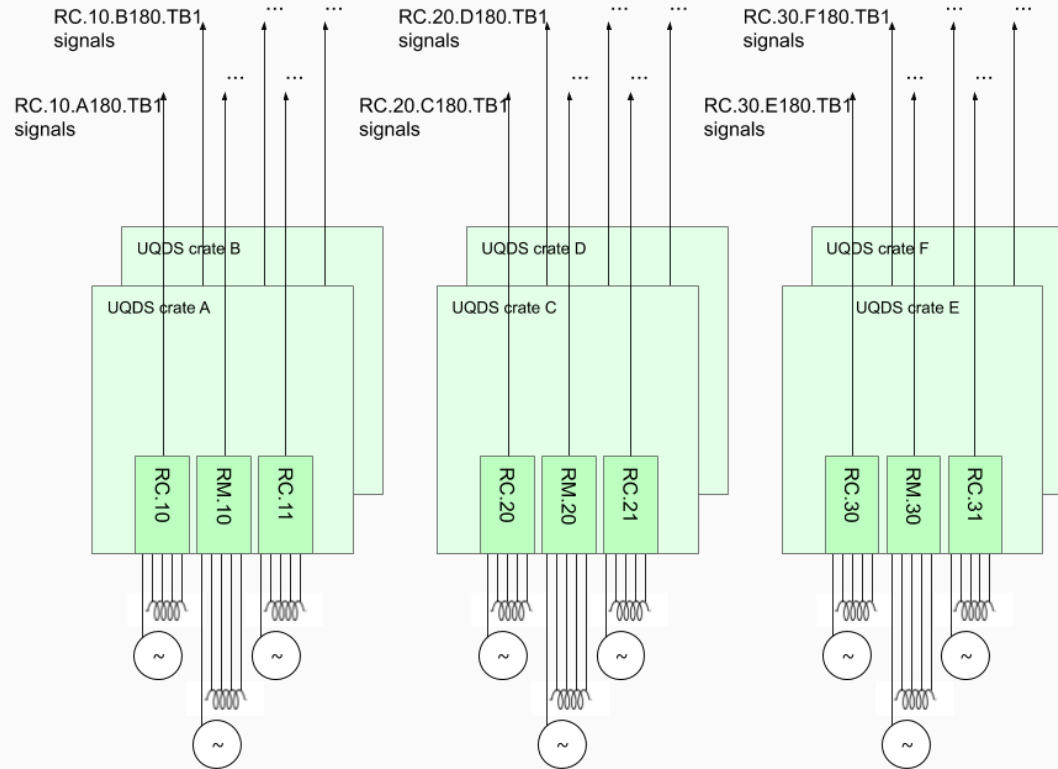
simplified diagram

- Energy Extraction is only present in 3 circuits out of 9
- Actual cabling and position within the loop may be different
- The 'red line' really represents 9 interlock loops, 1 for each circuit

Protection system setup - key points

- There is only one set of 9 Power Converters (+ their Energy Extraction units where relevant) for all 3 testbenches
- QDS units are deployed to all testbenches, not just to circuits
- A switch allows to 'complete' the interlock loop of either testbench, by plugging together PCs and QDS, and thus enabling the protection of all circuits by the protection units dedicated to a particular testbench

The origin of protection signals



each magnet slot may or may actually not be plugged to a magnet, depending on the assembly being tested

The origin of signals - key points

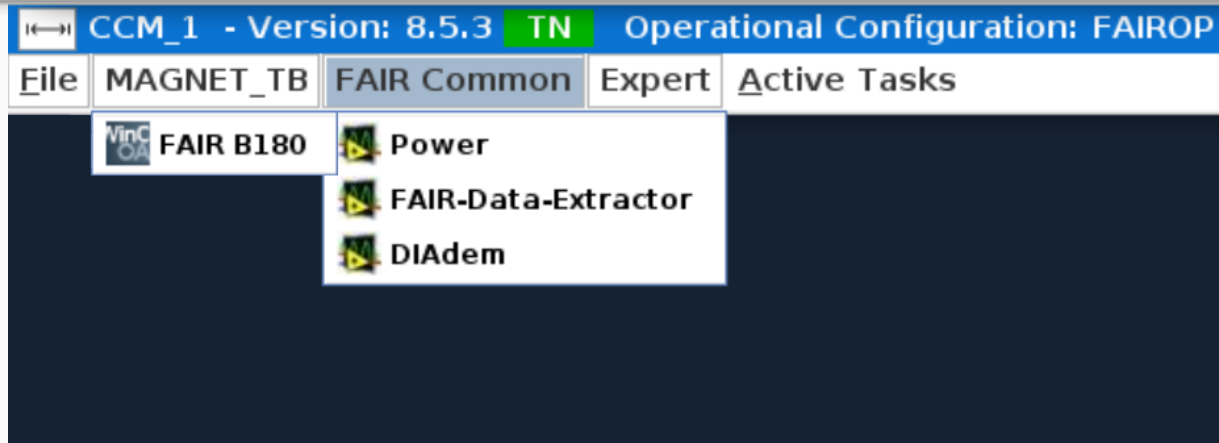
- Virtually all protection signals (measurements, interlocks, statuses, etc.) originate from field devices
- Each protection device can protect up to 3 circuits/magnets
- Each testbench has a dedicated set of 3 pairs (for redundancy) of protection devices
=> each set can protect up to 9 magnets i.e. 1 full long assembly
=> in total, 18 protection devices will be deployed to the facility
=> currently only 2 are deployed, to TB1, enough to fully protect the first assembly
- Signals are named consistently, with a clear indication of their origin:
 - The testbench, TB1 or TB2 or TB3
 - The circuit, e.g RC.10 or RM.20
 - The protection device (QDS), A, B, C, D, E or F

Protection system - detection parameters of the protection devices

- For now, detection parameters are defined and managed by the experts
- A dedicated tool to allow operators to safely adjust them has been foreseen
- It will (or not) be deployed depending on the actual requirements to adjust these parameters; return of experience from both the operators and experts after the tests on the first assembly are required on this point

Supervision tools

Supervision tools - unified access to tools via the Common Console Manager (CCM)



- WinCC OA supervision
 - Power & interlocks supervision, see Maryline's presentation
 - Protection supervision
- Power application, dedicated supervision tool for Power equipment, see Maryline's presentation
- Data extraction and analysis tools

Supervision tools - WinCC OA synoptic

The synoptic interface is divided into several functional areas:

- COMMUTATORS:** A 9x3 grid of indicators for TB1, TB2, and TB3, with rows labeled RM10 through RC31.
- ENABLE:** A vertical column of 9 diamond-shaped indicators.
- FCL CLOSE CMD:** A diamond-shaped indicator.
- FAST CONTROL LOOP:** A 9x4 grid of indicators for STATUS, ALM, IOU, and CMD, with rows labeled 1 through 9.
- POWER CONVERTER:** A 9x4 grid of indicators for STATUS, ALM, MCB, and PERMIT, with rows labeled 1 through 9.
- CURRENT:** A 9x2 grid of indicators for MEASURE and THRES.CRYO, with rows labeled 1 through 9.
- TEST BENCH 1:** A central area containing:
 - QPS:** A 3x3 grid of indicators for TB1, TB2, and TB3, with rows labeled QPS TB1, RELAY_STAT, and COMMUTE_TO BENCH_FCL.
 - ACCESS CONTROL:** Indicators for DOOR OPENED, DOOR CLOSED, DOOR LOCKED, and LATFORM FREE, with sub-sections for CRYO TOWER and ELEC TOWER.
 - CRYO SIGNALS:** Indicators for TB1_CRYO_300K_AIR, TB1_CRYO_OK, TB1_CRYO_MAINTAIN, and TB1_Q_TO_CRYO.
 - ENERGY EXTRACTION:** Indicators for RM10_OK, RM20_OK, and RM30_OK, with a sub-section labeled EE.
 - CONTROL ROOM:** Indicators for MANUAL STOP, GREEN LIGHT, and RED LIGHT.
 - GENERAL SIGNALS:** Indicators for PCS_MCB STATUS and AUE_PC_ALL.
 - TEST INTERLOCKS:** Indicators for TB1_HV_OK_300K, TB1_HV_OK_COLD, TB1_AUXPS_DC_OK, and TB1_AUXPS_AC_OK.

At the bottom, there is a navigation bar with tabs for MAIN, TB1, TB2, and TB3, and a status bar showing Remaining time, Device, and a Select button.

Supervision tools - Protection devices details

The image displays two software interfaces for monitoring protection devices. The left window, titled "QPS", shows a "QPS Testbench 1" with six testbenches (A-F) arranged in a 2x3 grid. Each testbench has a status indicator (F or P) and a color-coded square (orange or green). Testbenches C and D are green, while A, B, E, and F are orange. Below the grid are "RESET" and "RESET INTERLOCKS" buttons.

The right window, titled "1 - DQAMGNUMP.C180.TB1 DQAMGNUMP N type for circuit RC.20, RM.20, RC.21", shows the status of a specific protection device. The status is "DQAMGNUMP Status" (green) and "Logging_ON, Logging_Data" (green). The last quench occurred at "2019.06.14 08:33:09.973". Below this, there are three columns of data for Magnet: RC.20.C180.TB1 (M1), Magnet: RM.20.C180.TB1 (M2), and Magnet: RC.21.C180.TB1 (M3). Each column lists various status indicators (ST_PWR_PERM_QDS, ST_PWR_PERM, ST_INTERLOCK, ST_MAGNET_OK) and numerical values for U_LEAD_POS, U_LEAD_NEG, U_1, U_2, I_MAG, and U_RES.

M1	M2	M3
Magnet: RC.20.C180.TB1	Magnet: RM.20.C180.TB1	Magnet: RC.21.C180.TB1
ST_PWR_PERM_QDS <input checked="" type="checkbox"/>	ST_PWR_PERM_QDS <input checked="" type="checkbox"/>	ST_PWR_PERM_QDS <input checked="" type="checkbox"/>
ST_PWR_PERM <input checked="" type="checkbox"/>	ST_PWR_PERM <input checked="" type="checkbox"/>	ST_PWR_PERM <input checked="" type="checkbox"/>
ST_INTERLOCK <input checked="" type="checkbox"/>	ST_INTERLOCK <input checked="" type="checkbox"/>	ST_INTERLOCK <input checked="" type="checkbox"/>
ST_MAGNET_OK <input checked="" type="checkbox"/>	ST_MAGNET_OK <input checked="" type="checkbox"/>	ST_MAGNET_OK <input checked="" type="checkbox"/>
U_LEAD_POS <input type="text" value="0.00082 V"/>	U_LEAD_POS <input type="text" value="0.00060 V"/>	U_LEAD_POS <input type="text" value="-0.00037 V"/>
U_LEAD_NEG <input type="text" value="-0.00027 V"/>	U_LEAD_NEG <input type="text" value="0.00002 V"/>	U_LEAD_NEG <input type="text" value="-0.00027 V"/>
U_1 <input type="text" value="0.00031 V"/>	U_1 <input type="text" value="-0.00084 V"/>	U_1 <input type="text" value="0.00145 V"/>
U_2 <input type="text" value="0.00430 V"/>	U_2 <input type="text" value="-0.00170 V"/>	U_2 <input type="text" value="-0.00456 V"/>
I_MAG <input type="text" value="-0.000 A"/>	I_MAG <input type="text" value="0.000 A"/>	I_MAG <input type="text" value="0.000 A"/>
U_RES <input type="text" value="0.00391 V"/>	U_RES <input type="text" value="-0.00317 V"/>	U_RES <input type="text" value="-0.00195 V"/>

Supervision tools - Protection devices details

The image displays two windows from a supervision tool. The left window, titled "1 - Panel: vision/QPS_EE.pnl", shows a grid of six "Energy Extraction Devices" (RM.10, RM.20, RM.30) arranged in two rows (A and B) and three columns. Each device is represented by a yellow square with a black switch icon and a "P" label. Below the grid are "RESET" and "CLOSE SWITCHES" buttons. The right window, titled "1 - A180.RM.20 DQAMS N type 600A for circuit A180.RM.20", provides a detailed view of the protection device. It includes a schematic diagram of the circuit with components like "Switch A", "Switch B", "Switch Z", "Snubber Fuse", and "Snubber". A "DQEMC" status panel on the right lists various parameters and their status, such as "System Closed", "Power Permit", "Last open switch at (UTC)", "Switch A/B/Z", "Capacitor A/B/Z", "Dump Resistor Voltage", "Temperature Resistor", "Snubber Fuse", "SOF Mode", "Switch Opening/Closing Failure", "Switch Opening by itself", "Switch Opening Warning", "System failure", "Temp EQRES high", and "Fast Power Abort Received". A "DQAMSN600 Status" box and a "Logging_ON, Logging_Data" box are also visible. At the bottom, there is a "DQAMS 600 Command" section with a dropdown menu and a "Select" button.

Panel: vision/QPS_EE.pnl

Energy Extraction Devices

	RM.10	RM.20	RM.30
A			
B			

RESET CLOSE SWITCHES

1 - A180.RM.20 DQAMS N type 600A for circuit A180.RM.20

Status: Trend A180.RM.20 T D I

CFC_180_DQFAIR_180_DQFAIR DATA Connection OK

DQEMC

System Closed	<input type="checkbox"/>	Power Permit	<input type="checkbox"/>
Last open switch at (UTC)	2019.06.14 08:34:34.323		
Switch A		UPS	
Switch B		Remote	
Switch Z			
Capacitor A		2796 V	
Capacitor B		2785 V	
Capacitor Z		2784 V	
Dump Resistor Voltage		2070.0 V	
Temperature Resistor			
Snubber Fuse		Temp EQRES high	
		Fast Power Abort Received	
		Sum Faults	
SOF Mode			
Switch Opening Failure			
Switch Closing Failure			
Switch Opening by itself			
Switch Opening Warning			
		System failure	

DQAMSN600 Status

Logging_ON, Logging_Data

DQAMS 600 Command Select

Supervision tools - user actions

- 2 high level actions for the QDS devices of a testbench:
 - Plain reset
 - Unlatch of the interlocking state (interlock reset)
- 2 high level actions for the Energy Extraction devices:
 - Plain reset
 - Closing of the interlock switches
- **Procedures definition, dedicated training, to be done together, along with the other supervision tools**
- /!\ as for other systems, data consistency is conditioned by the proper input of the magnet info /!\ (assembly id, magnets details)

Data archiving and access

Data archiving and access

- Protection signals comply with the common naming convention (as mentioned, indicate the TB, circuit, ...), allowing straightforward correlation with data from other systems (Cryo, interlocks, etc.)
- Sampling rate is:
 - 10Hz for continuously logged data (aka Logging)
 - higher rate (10kHz, adjustable by experts) for event based acquired data (aka Post Mortem)
- Data has the same lifetime as CERN accelerators data, ie it is kept for the foreseeable future
- Data is accessible through the CERN standard infrastructure (PM Browser, Timber) to experts and users alike
- Data is meant to be accessed by users using the Data Extractor tool (see Antonella's and Maryline's presentations)

Post Mortem data

PM Data Browser

File Options

Catalog

Data Dumps

Event time stamp	Received	System	Class	Source	Sender
14/06/2019 09:38:50.973+113114	14/06/2019 09:39:06.911	QPS	DQAMGNUMP_PM	D180.TB1	root@cfc-180-dqfair
14/06/2019 09:41:09.873+113114	14/06/2019 09:41:25.811	QPS	DQAMGNUMP_PM	D180.TB1	root@cfc-180-dqfair
14/06/2019 09:42:49.373+113114	14/06/2019 09:43:05.311	QPS	DQAMGNUMP_PM	D180.TB1	root@cfc-180-dqfair
14/06/2019 09:43:31.473+113114	14/06/2019 09:43:47.411	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 09:45:37.473+113114	14/06/2019 09:45:53.411	QPS	DQAMGNUMP_PM	D180.TB1	root@cfc-180-dqfair
14/06/2019 09:53:34.873+113114	14/06/2019 09:53:50.811	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 09:54:27.773+113114	14/06/2019 09:54:43.711	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 09:54:01.489+000000	14/06/2019 09:54:43.811	QPS	DQAMSN600	B180.RM.20	root@cfc-180-dqfair
14/06/2019 09:54:03.504+000000	14/06/2019 09:54:45.912	QPS	DQAMSN600	A180.RM.20	root@cfc-180-dqfair
14/06/2019 09:55:17.973+113114	14/06/2019 09:55:33.911	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 09:57:50.973+113114	14/06/2019 09:58:06.911	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 09:58:40.873+113114	14/06/2019 09:58:56.811	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 10:02:04.473+113114	14/06/2019 10:02:20.411	QPS	DQAMGNUMP_PM	D180.TB1	root@cfc-180-dqfair
14/06/2019 10:04:41.273+113114	14/06/2019 10:04:57.211	QPS	DQAMGNUMP_PM	D180.TB1	root@cfc-180-dqfair
14/06/2019 10:05:40.873+113114	14/06/2019 10:05:56.811	QPS	DQAMGNUMP_PM	D180.TB1	root@cfc-180-dqfair
14/06/2019 10:07:46.573+113114	14/06/2019 10:08:02.511	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 10:08:20.673+113114	14/06/2019 10:08:36.611	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 10:11:47.773+113114	14/06/2019 10:12:03.711	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 10:20:35.373+113114	14/06/2019 10:21:09.011	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 10:23:13.873+113114	14/06/2019 10:23:29.811	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 10:24:03.673+113114	14/06/2019 10:24:36.611	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 10:24:33.773+113114	14/06/2019 10:25:08.111	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 10:30:13.873+113114	14/06/2019 10:30:29.911	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 10:30:48.073+113114	14/06/2019 10:31:04.011	QPS	DQAMGNUMP_PM	D180.TB1	root@cfc-180-dqfair
14/06/2019 10:33:09.973+113114	14/06/2019 10:33:25.911	QPS	DQAMGNUMP_PM	C180.TB1	root@cfc-180-dqfair
14/06/2019 10:33:09.923+000000	14/06/2019 10:33:52.312	QPS	DQAMSN600	A180.RM.20	root@cfc-180-dqfair
14/06/2019 10:33:09.923+000000	14/06/2019 10:33:52.411	QPS	DQAMSN600	B180.RM.20	root@cfc-180-dqfair
14/06/2019 10:34:34.373+113114	14/06/2019 10:34:50.311	QPS	DQAMGNUMP_PM	D180.TB1	root@cfc-180-dqfair
14/06/2019 10:34:34.323+000000	14/06/2019 10:35:16.712	QPS	DQAMSN600	A180.RM.20	root@cfc-180-dqfair
14/06/2019 10:34:34.323+000000	14/06/2019 10:35:16.811	QPS	DQAMSN600	B180.RM.20	root@cfc-180-dqfair

June

July

December

Load selected

Unload all

dumps in vi... 30

system QPS

class

source

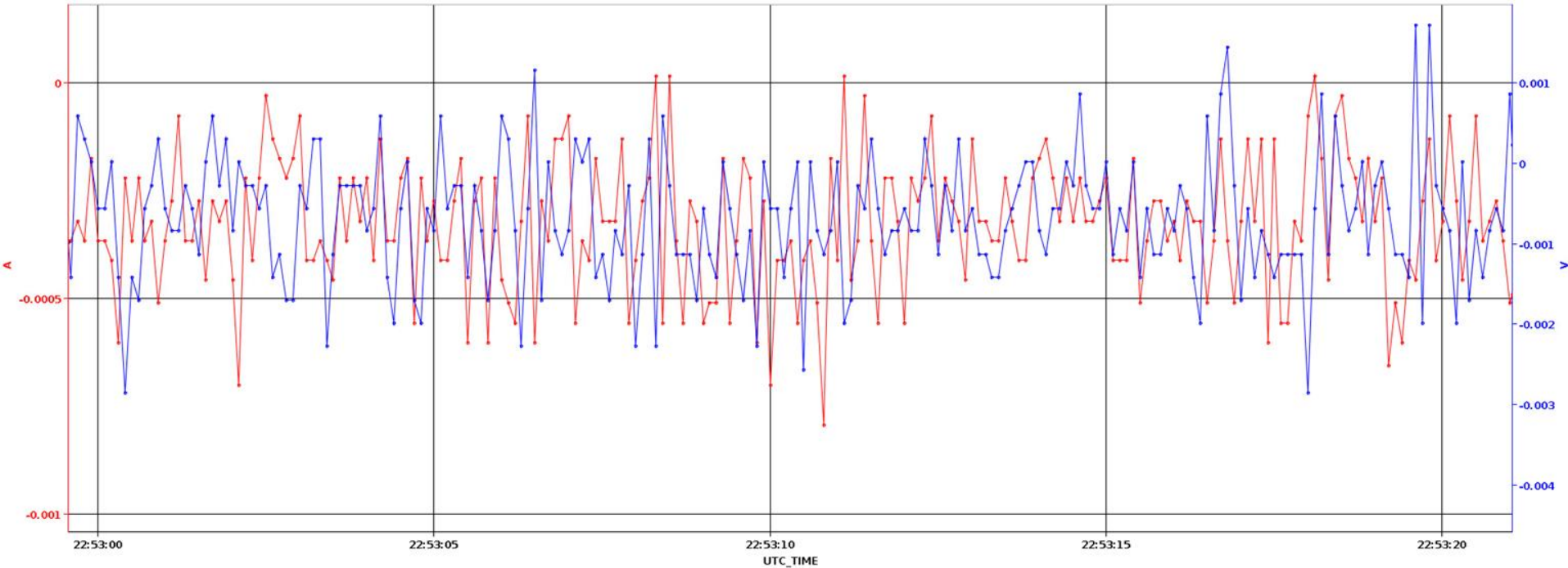
sender root@cfc-180-dqf

selected dump

Show data Save data

Logging data

RC.20.C180.TB1.L_MAG RC.20.C180.TB1.U_1



Future

Dependency on CERN Accelerators Controls stacks

- Infrastructure and services at CERN evolve, especially during LS2
- This is relevant to FAIR installations, and upgrades to the software infrastructure in particular are foreseen.
e.g.:
 - redeployment of the control layer before the end of the year, as the current middleware communication infrastructure (RDA2) is retired, superseded by RDA3
 - data acquisition services are replaced by a new generation system (NXCALS)
- In principle, transparent to end users, noting it will require a time slot in the tests plan
- The good news: new and improved tools will come along the upgrades.
e.g.: Web interfaces for raw data browsing, Advanced data analysis tools (Spark)
 - more of concern to tools providers (e.g. Data Extractor, not the end users)