Detector Software Integration

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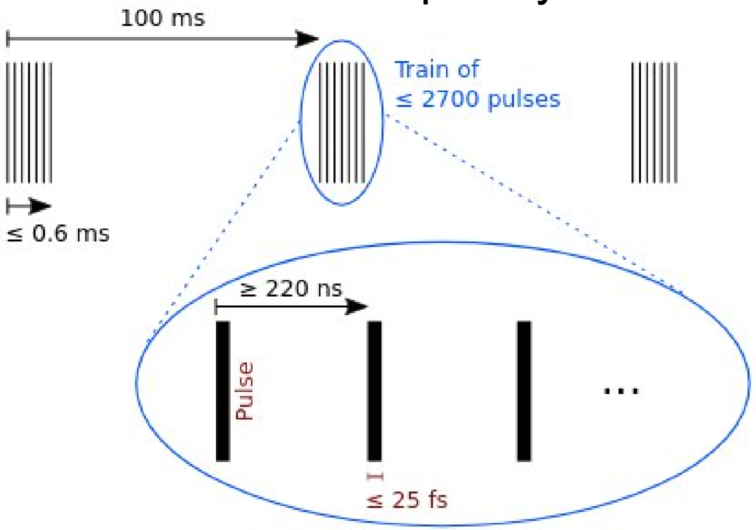
DET Workshop, 18/9/2023

The Setup

European XFEL generates a pulse train of up to 2700 individual X-ray pulses, at a rate of 10 trains per second.

Within a train, pulses arrive with a maximum frequency of 4.5 MHz.



The structure of trains and pulses at European XFEL

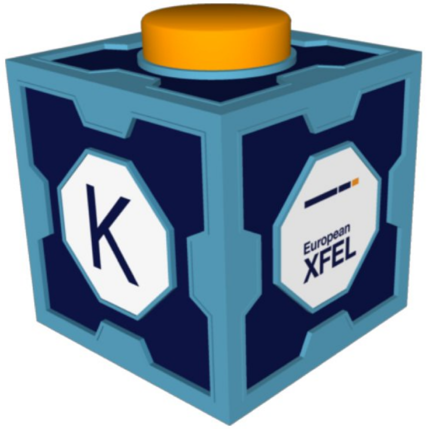
Each train receives an unique train ID, which is used to find and match up data.

Some kinds of data are recorded once per train, others may be per pulses, some have even higher sampling rates.

The Setup

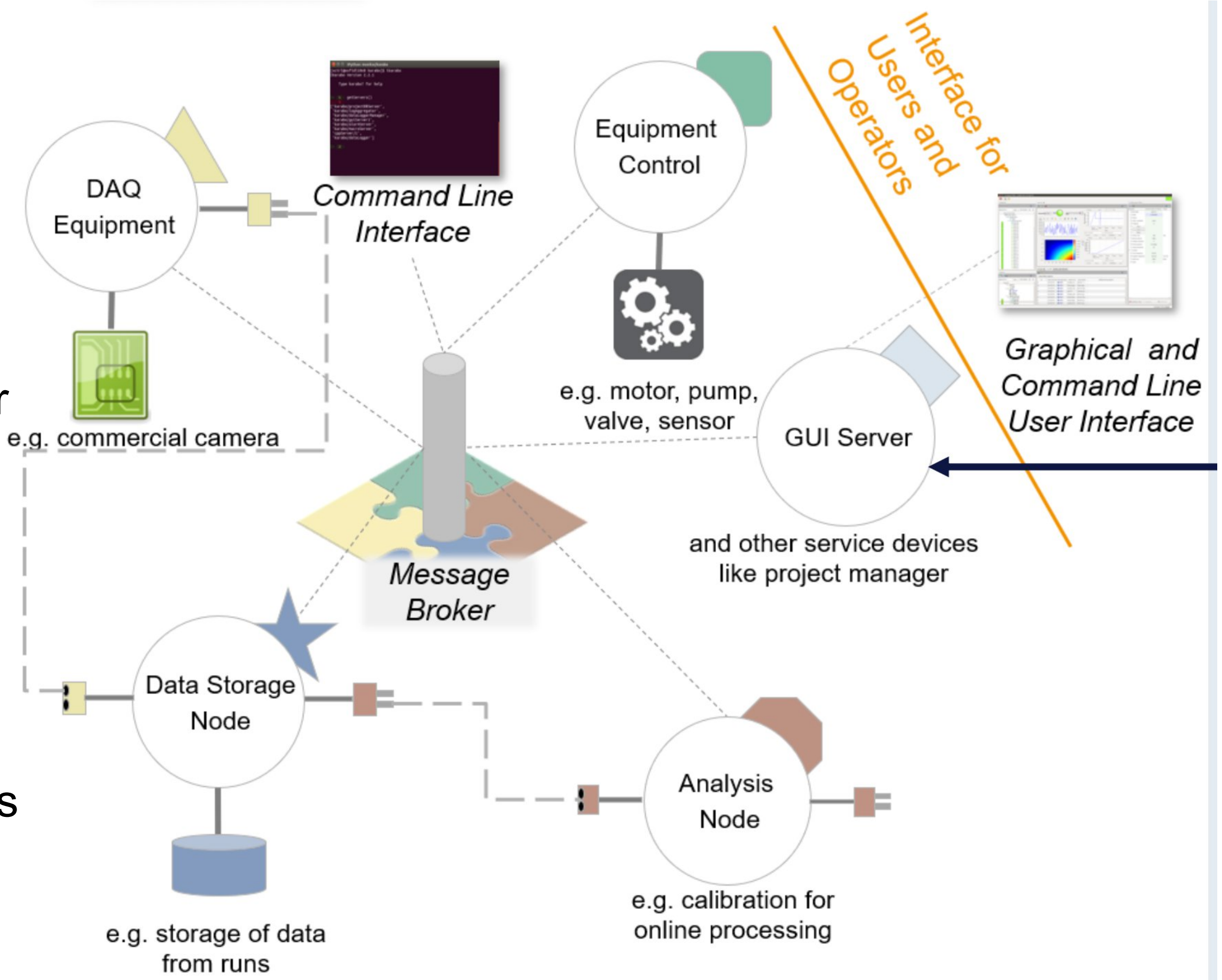
- 3 types of detectors:
  - Commercial detectors (e.g. Cameras, Spectrometers) ➔ the easiest ones to integrate
  - “Semi-commercial” detectors (eg. JUNGFRAU developed at PSI)
  - Bespoke large detectors (AGIPD, DSSC, LPD) ➔ the most complex

- Karabo: European XFEL’s Control System
  - Control
  - DAQ
  - Monitoring



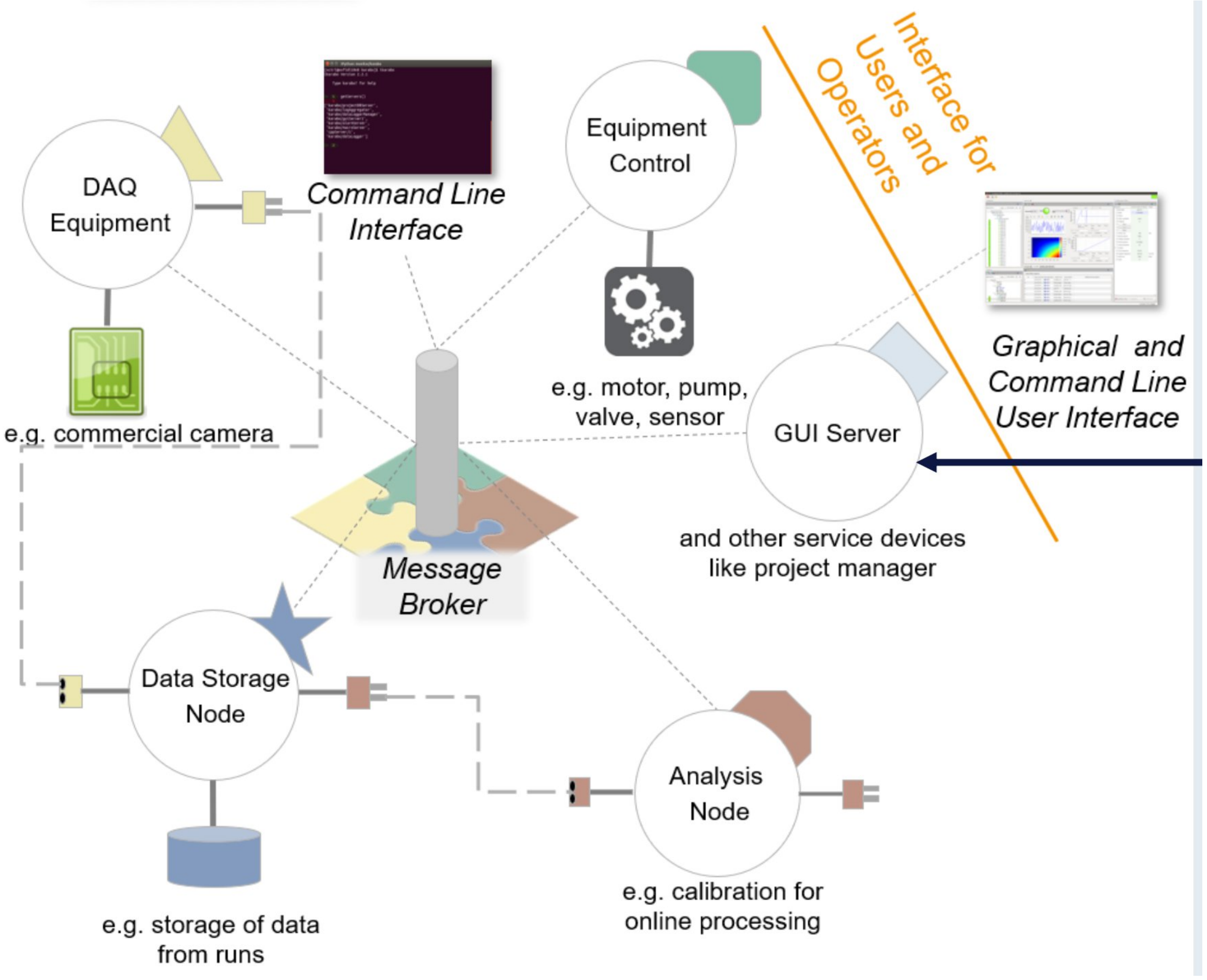
The Karabo Control System

- Distributed system of devices that communicate with each other through a message broker
- A device can be a physical device, like a motor or a camera, or a logical device
- Devices are aggregated in Topics. Each XFEL instrument has its own Topic – e.g. MID, SPB, SCS
- The GUI Client allows Scientists and Engineers to interact with and control the devices in a topic


DAQ Equipment
e.g. commercial camera
Command Line Interface
Equipment Control
e.g. motor, pump, valve, sensor
Interface for Users and Operators
Graphical and Command Line User Interface
GUI Server
and other service devices like project manager
Message Broker
Data Storage Node
e.g. storage of data from runs
Analysis Node
e.g. calibration for online processing

The Karabo Control System

- Its tight coupling of controls and DAQ is meant for large bespoke detectors
  - DAQ is generic for all data source
  - Centrally stored, centrally accessible
- Control Integration enables orchestration of different parts
  - Power procedures
  - Dark procedures
  - Interlocking ensures operations under safe conditions
  - Vitals (eg. temperatures, power)
- Data previews enable near real-time experiment feedback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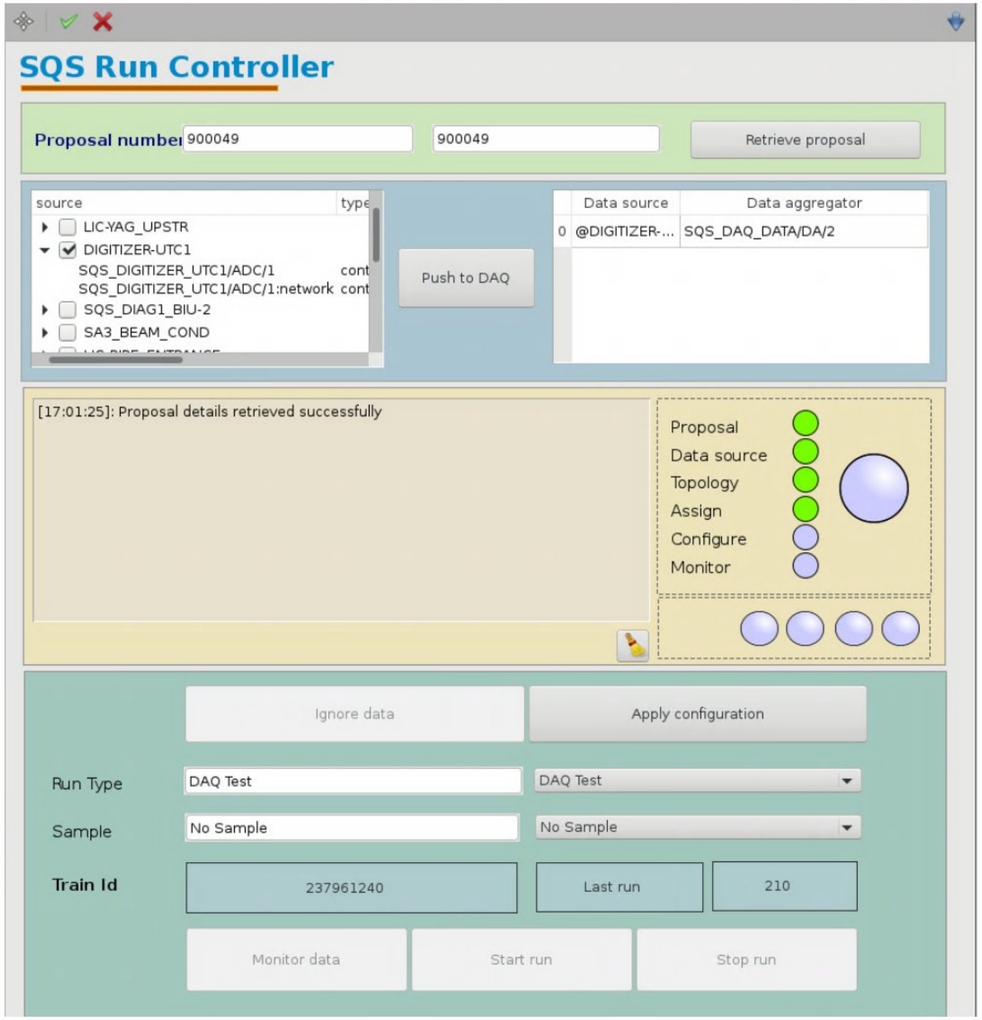
Data Storage Node
e.g. storage of data from runs
Analysis Node
e.g. calibration for online processing

The Data Acquisition (DAQ)

- Uniformity is key
- Anything in Karabo can be recorded
- One Manager
- One central storage
- One portal to access data
- Everything indexed by trainId

➔ FAIR Data

Findeable, Accessible, Interoperable, Reusable



SQS Run Controller

Proposal number: 900049 | 900049

source	type
☐ LIC-YAG_UPSTR	
☑ DIGITIZER-UTC1	
SQS_DIGITIZER_UTC1/ADC/1	cont
SQS_DIGITIZER_UTC1/ADC/1:network	cont
☐ SQS_DIAG1_BIU-2	
☐ SA3_BEAM_COND	

	Data source	Data aggregator
0	@DIGITIZER-...	SQS_DAQ_DATA/DA/2

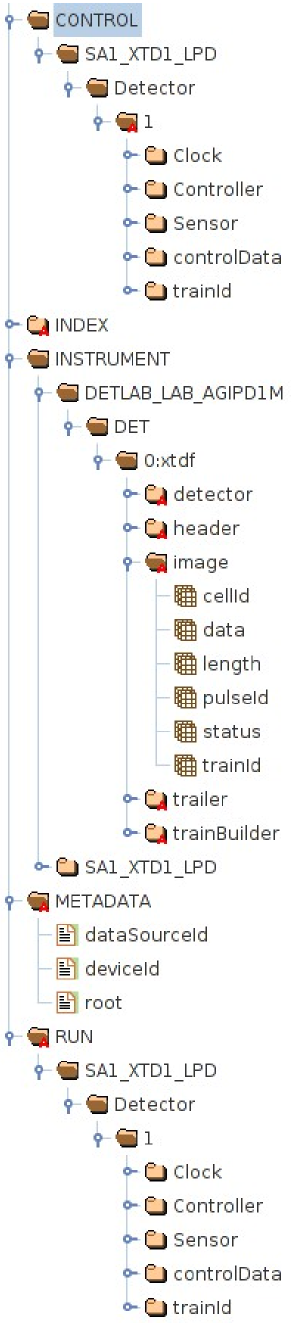
[17:01:25]: Proposal details retrieved successfully

Proposal	🟩
Data source	🟩
Topology	🟩
Assign	🟩
Configure	○
Monitor	○

Run Type: DAQ Test | DAQ Test

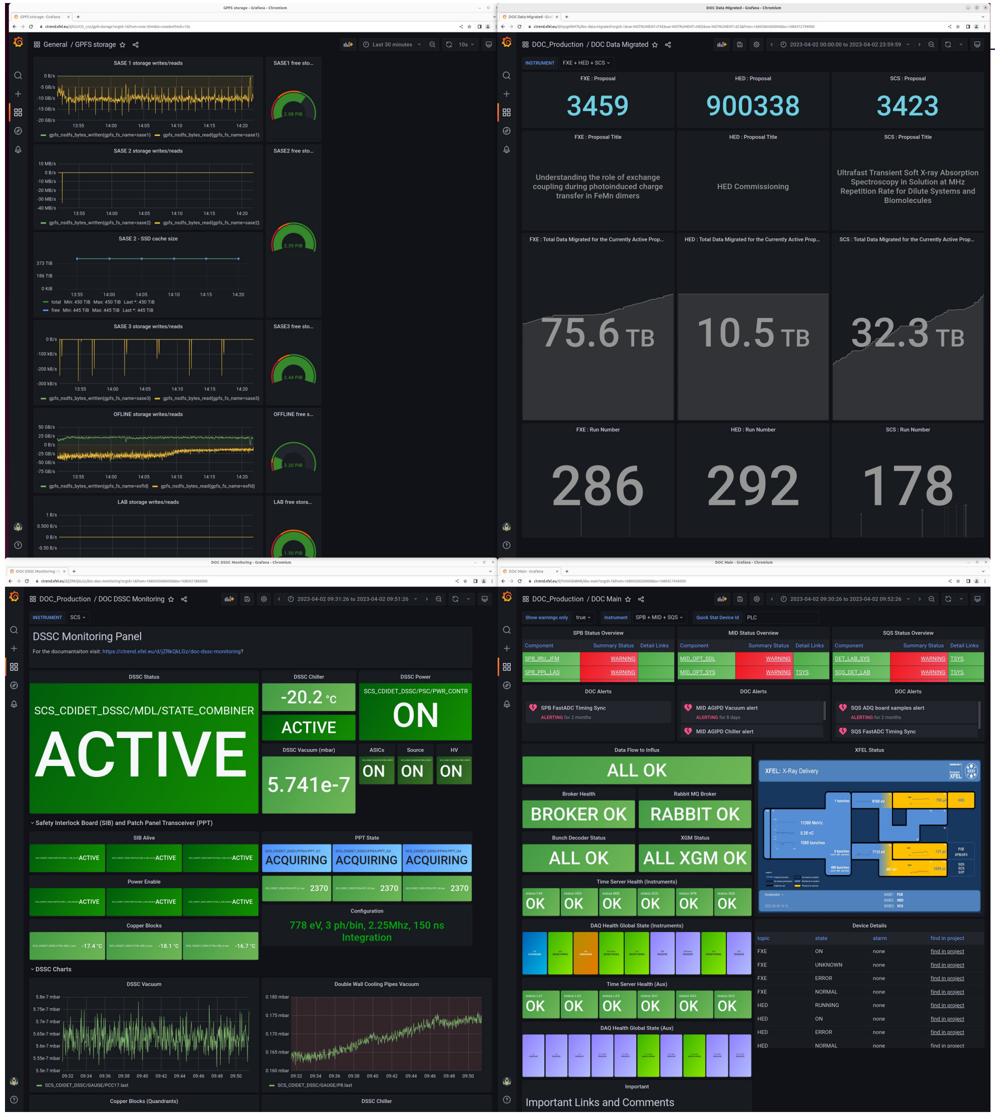
Sample: No Sample | No Sample

Train Id: 237961240 | Last run | 210

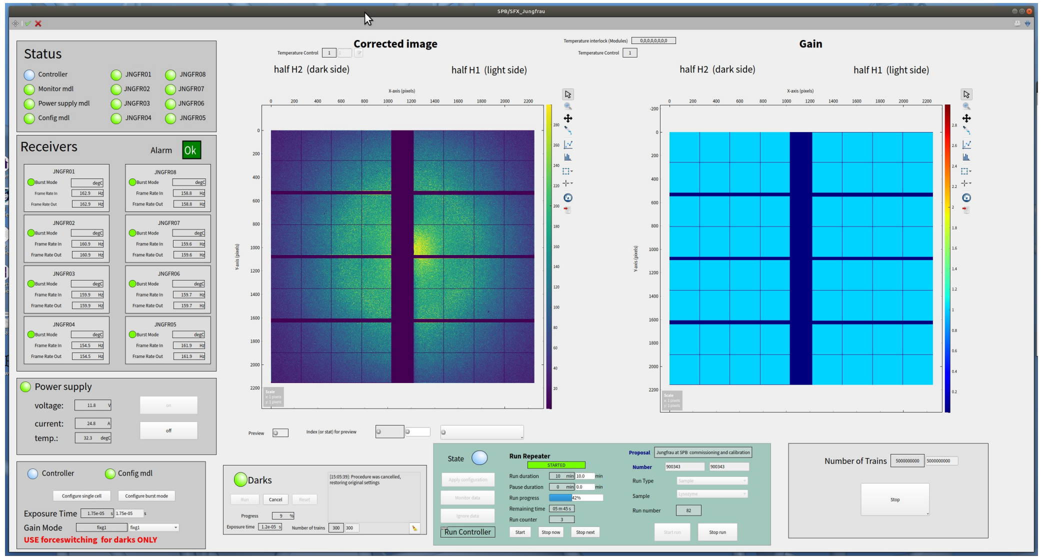


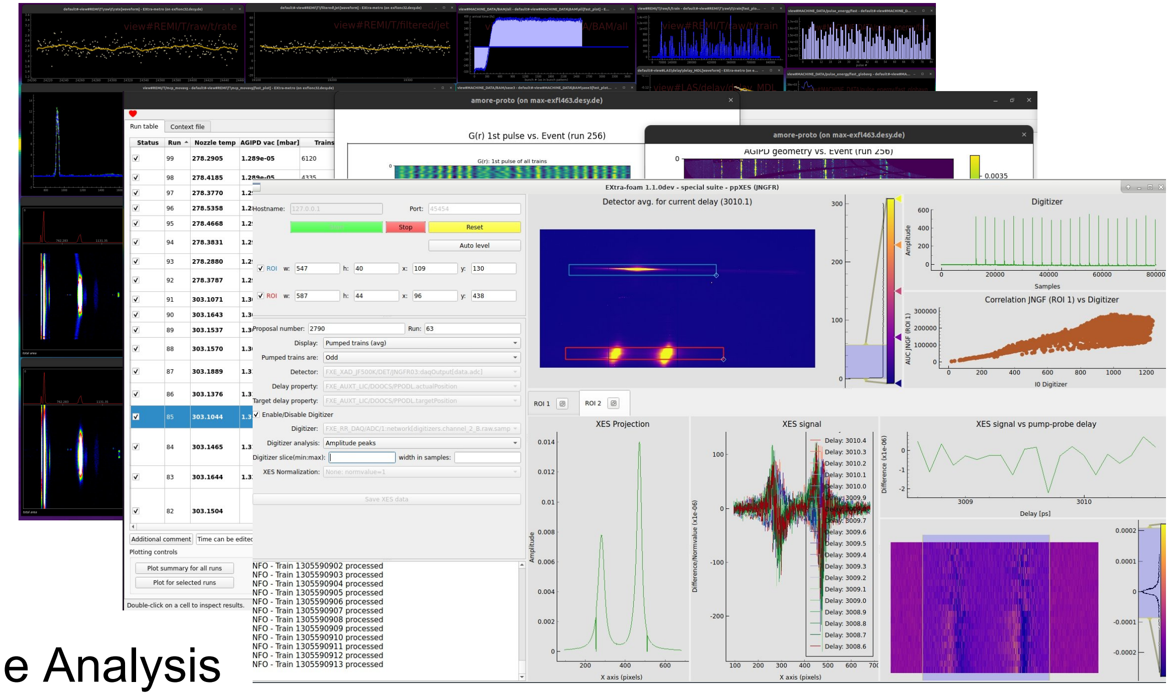
- CONTROL
  - SA1_XTD1_LPD
    - Detector
      - 1
        - Clock
        - Controller
        - Sensor
        - controlData
        - trainId
- INDEX
- INSTRUMENT
  - DETLAB_LAB_AGIPD1M
    - DET
      - 0:xtdf
        - detector
        - header
        - image
          - cellId
          - data
          - length
          - pulseId
          - status
          - trainId
        - trailer
        - trainBuilder
  - SA1_XTD1_LPD
- METADATA
  - dataSourceId
  - deviceId
  - root
- RUN
  - SA1_XTD1_LPD
    - Detector
      - 1
        - Clock
        - Controller
        - Sensor
        - controlData
        - trainId

Control and Preview


General / GPFS storage
SASE 1 storage writes/reads
SASE 2 storage writes/reads
SASE 3 storage writes/reads
OFFLINE storage writes/reads
LAB storage writes/reads
DOC_Production / DOC Data Migrated
FXE : Proposal
3459
HED : Proposal
900338
SCS : Proposal
3423
Understanding the role of exchange coupling during photoinduced charge transfer in FeMn dimers
HED Commissioning
Ultrafast Transient Soft X-ray Absorption Spectroscopy in Solution at MHz Repetition Rate for Dilute Systems and Biomolecules
75.6 TB
10.5 TB
32.3 TB
FXE : Run Number
286
HED : Run Number
292
SCS : Run Number
178
DOC_Production / DOC DSSC Monitoring
DSSC Monitoring Panel
SCS_CDIDET_DSSC/MDL/STATE_COMBINER
ACTIVE
-20.2 °C
ACTIVE
ON
5.741e-7
ON
ON
ON
ACQUIRING
ACQUIRING
ACQUIRING
778 eV, 3 ph/bin, 2.25Mhz, 150 ns Integration
DSSC Vacuum
Double Wall Cooling Pipes Vacuum
DOC_Production / DOC Main
ALL OK
BROKER OK
RABBIT OK
ALL OK
ALL XGM OK
OK
XFEL: X-Ray Delivery
Important Links and Comments

Detector and facility monitoring




amore-proto (on max-exfl463.desy.de)
G(r) 1st pulse vs. Event (run 256)
AGIPD geometry vs. Event (run 256)
Run table
Context file
Status
Run
Nozzle temp
AGIPD vac [mbar]
EXtra-foam 1.1.0dev - special suite - ppXES (JNGFR)
Detector avg. for current delay (3010.1)
Digitizer
Correlation JNGF (ROI 1) vs Digitizer
XES Projection
XES signal
XES signal vs pump-probe delay
Delay [ps]
X axis (pixels)

NFO - Train 1305590902 processed
NFO - Train 1305590903 processed
NFO - Train 1305590904 processed
NFO - Train 1305590905 processed
NFO - Train 1305590906 processed
NFO - Train 1305590907 processed
NFO - Train 1305590908 processed
NFO - Train 1305590909 processed
NFO - Train 1305590910 processed
NFO - Train 1305590911 processed
NFO - Train 1305590912 processed
NFO - Train 1305590913 processed

Online and Offline Analysis

Detector integration in Karabo

- Karabo offers C++ and Python API on Linux
- Prerequisite for a standard integration is therefore a C/C++ library, a Python module or well defined communication protocol
  - In case of external library, open-source is a plus as it enables to investigate ourselves bugs and create (or suggest) fixes
  - Use of standard protocols* can also be beneficial, as already existing and well tested libraries can be used for the integration

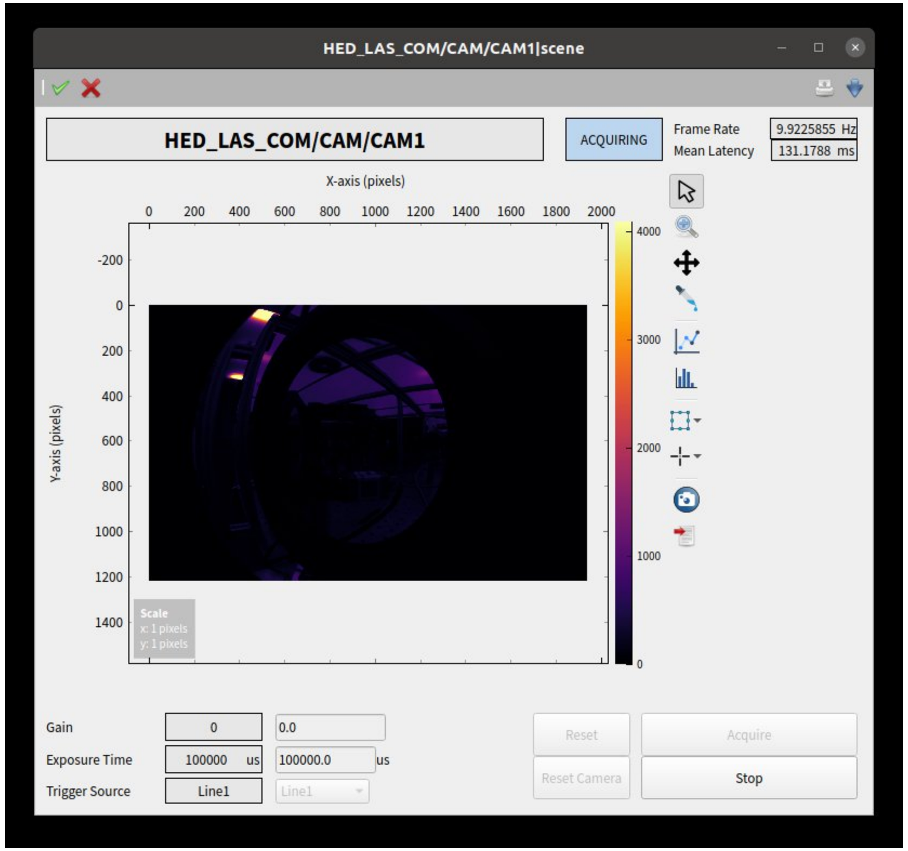
* e.g. GenICam for Ethernet or USB cameras

Zoom on Commercial Detectors: Basler Cameras

- 650+ Basler cameras in the facility, 30+ models from 1st and 2nd generation (according to the inventory)
- Selected because of standard interface (Ethernet) and standard communication protocol (GenICam)
- “Easy” to integrate: only control device and possibly remote power
- Vendor provided GUI (PylonViewer) used for first tests and diagnostic
- Integration into the control system is needed to have data stored by DAQ (NB synchronization of the sources is crucial!)
- Originally integrated in Karabo via the LImA library (Python), currently via the ARAVIS library (C)
  - Both can support cameras from several vendors, thus most of the Karabo code is in a base class
  - Integration of other “compliant” cameras can be done with “small” effort
- Large range of models supported by just two Karabo devices (for 1st and 2nd generation cameras)
- Default scene is provided by the device (and full access to all parameters via the navigator panel)
- Custom scenes can be created by instruments with no coding

Device provided scene and expert view

- The Karabo device provides a default scene with the most important settings
- All other (implemented) settings are available in the “navigator” GUI panel

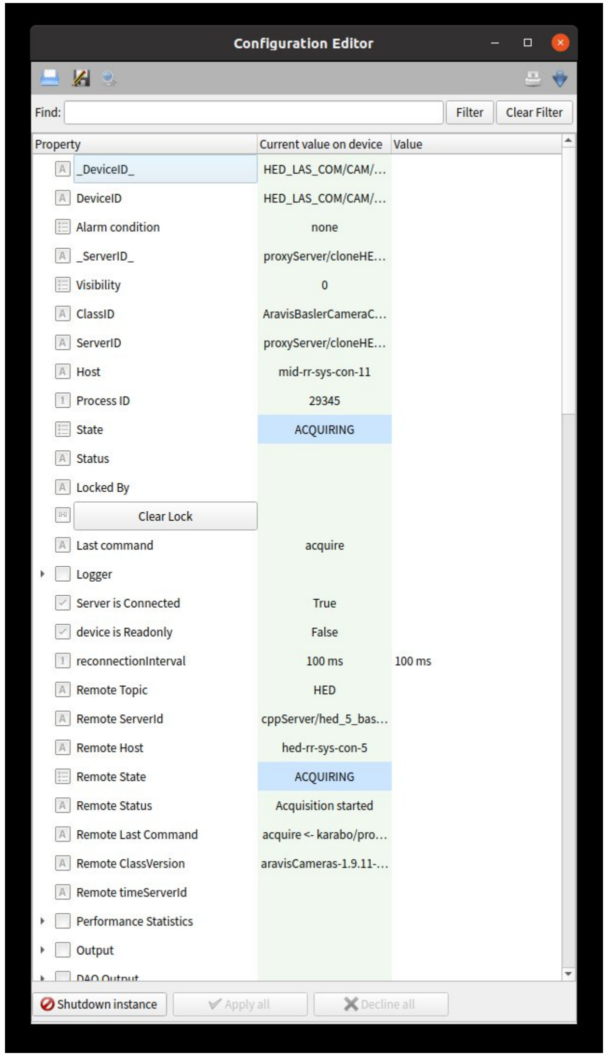


HED_LAS_COM/CAM/CAM1 | ACQUIRING

Frame Rate 9.9225855 Hz

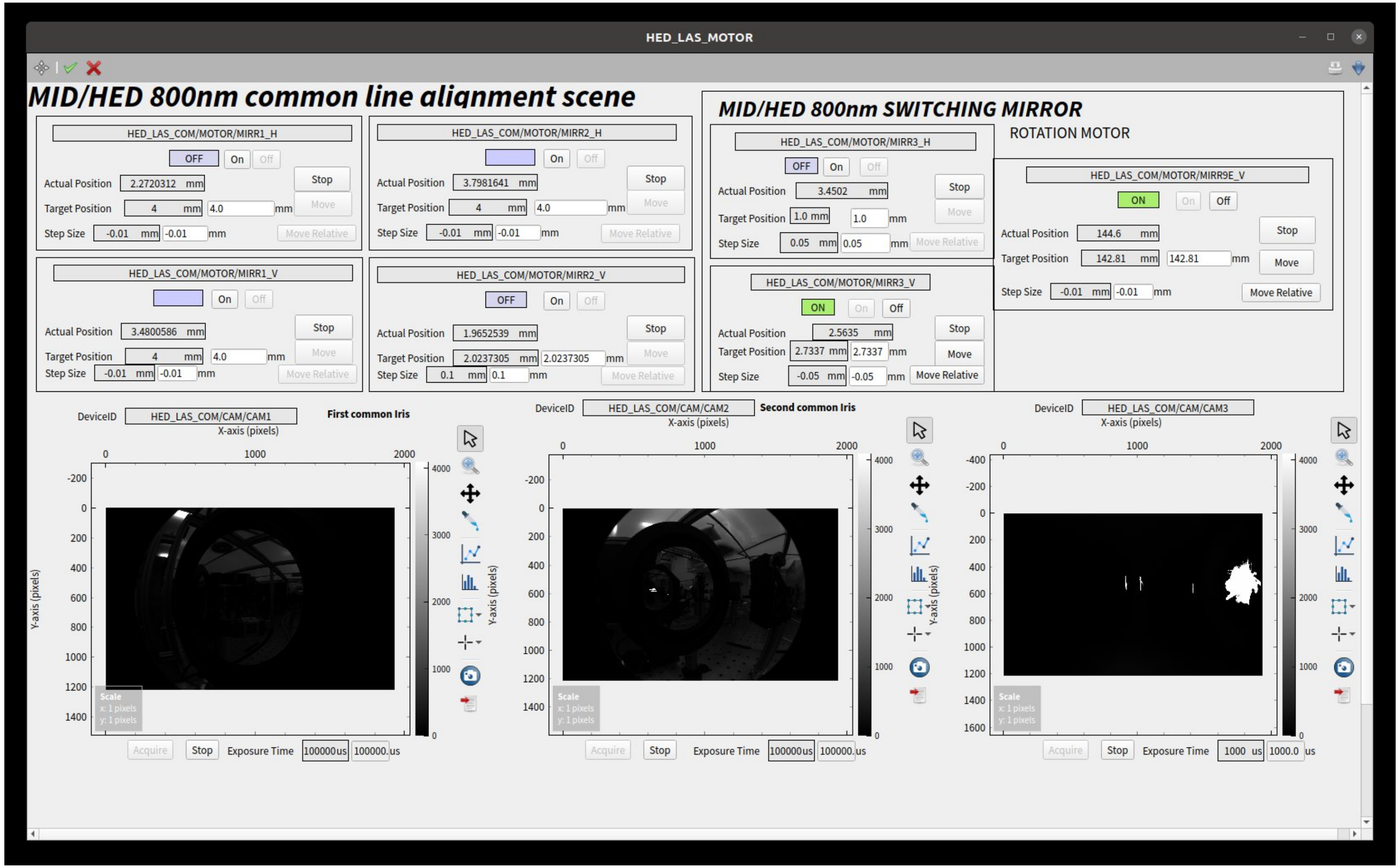
Mean Latency 131.1788 ms

Gain	0	0.0
Exposure Time	100000 us	100000.0 us
Trigger Source	Line1	Line1



Property	Current value on device	Value
DeviceID	HED_LAS_COM/CAM/…	
DeviceID	HED_LAS_COM/CAM/…	
Alarm condition	none	
ServerID	proxyServer/cloneHE…	
Visibility	0	
ClassID	AravisBaslerCameraC…	
ServerID	proxyServer/cloneHE…	
Host	mid-rr-sys-con-11	
Process ID	29345	
State	ACQUIRING	
Status		
Locked By		
Clear Lock		
Last command	acquire	
Logger		
Server is Connected	True	
device is Readonly	False	
reconnectionInterval	100 ms	100 ms
Remote Topic	HED	
Remote ServerId	cppServer/hed_5_bas…	
Remote Host	hed-rr-sys-con-5	
Remote State	ACQUIRING	
Remote Status	Acquisition started	
Remote Last Command	acquire <- karabo/pro…	
Remote ClassVersion	aravisCameras-1.9.11-…	
Remote timeServerId		
Performance Statistics		
Output		
DAQ Output		

Custom scene in MID



HED_LAS_MOTOR

MID/HED 800nm common line alignment scene

HED_LAS_COM/MOTOR/MIRR1_H
OFF On Off
Actual Position 2.2720312 mm
Target Position 4 mm 4.0 mm
Step Size -0.01 mm -0.01 mm

HED_LAS_COM/MOTOR/MIRR2_H
On Off
Actual Position 3.7981641 mm
Target Position 4 mm 4.0 mm
Step Size -0.01 mm -0.01 mm

HED_LAS_COM/MOTOR/MIRR1_V
On Off
Actual Position 3.4800586 mm
Target Position 4 mm 4.0 mm
Step Size -0.01 mm -0.01 mm

HED_LAS_COM/MOTOR/MIRR2_V
OFF On Off
Actual Position 1.9652539 mm
Target Position 2.0237305 mm 2.0237305 mm
Step Size 0.1 mm 0.1 mm

MID/HED 800nm SWITCHING MIRROR

HED_LAS_COM/MOTOR/MIRR3_H
OFF On Off
Actual Position 3.4502 mm
Target Position 1.0 mm 1.0 mm
Step Size 0.05 mm 0.05 mm

HED_LAS_COM/MOTOR/MIRR3_V
ON On Off
Actual Position 2.5635 mm
Target Position 2.7337 mm 2.7337 mm
Step Size -0.05 mm -0.05 mm

ROTATION MOTOR

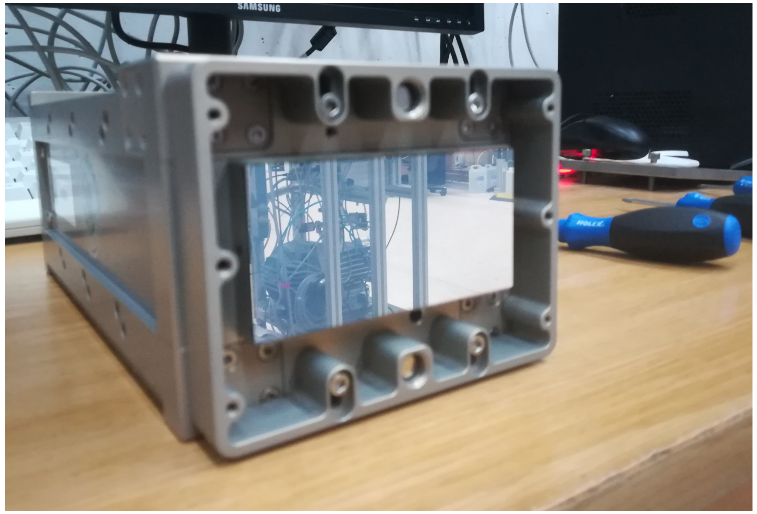
HED_LAS_COM/MOTOR/MIRR9E_V
ON On Off
Actual Position 144.6 mm
Target Position 142.81 mm 142.81 mm
Step Size -0.01 mm -0.01 mm

DeviceID HED_LAS_COM/CAM/CAM1 First common Iris
Exposure Time 100000us 100000.us

DeviceID HED_LAS_COM/CAM/CAM2 Second common Iris
Exposure Time 100000us 100000.us

DeviceID HED_LAS_COM/CAM/CAM3
Exposure Time 1000 us 1000.0 us

Zoom on Semi-Commercial Detectors: JUNGFRAU



- 18 modules in the facility
- Provided SLS command-line tools used for first tests and diagnostic
- Integrated in Karabo via the provided SLS library
  - C++ open source library
  - Good relationship with manufacturer enables rapid feedback and eases integration of new features when needed
  - Most of the features implemented in a base class, also used for Gotthard and Gotthard-II
- Control and receiver devices are just the first step of the integration

JUNGFRAU Integration: How Did We Get There?

- Low level Karabo device, based on the SLS detector library

- From manual to remote power via Karabo device

- From manually taking dark runs to a fully automatic procedure
  - Loop over detector settings
  - Automatically configure all modules
  - Automatically acquire data in the DAQ
  - Automatically create calibration constants

- Corrected online preview
  - Partial images from the 8 modules are glued together according to the geometry
  - Images are corrected used previously taken dark runs and displayed live in the Karabo GUI

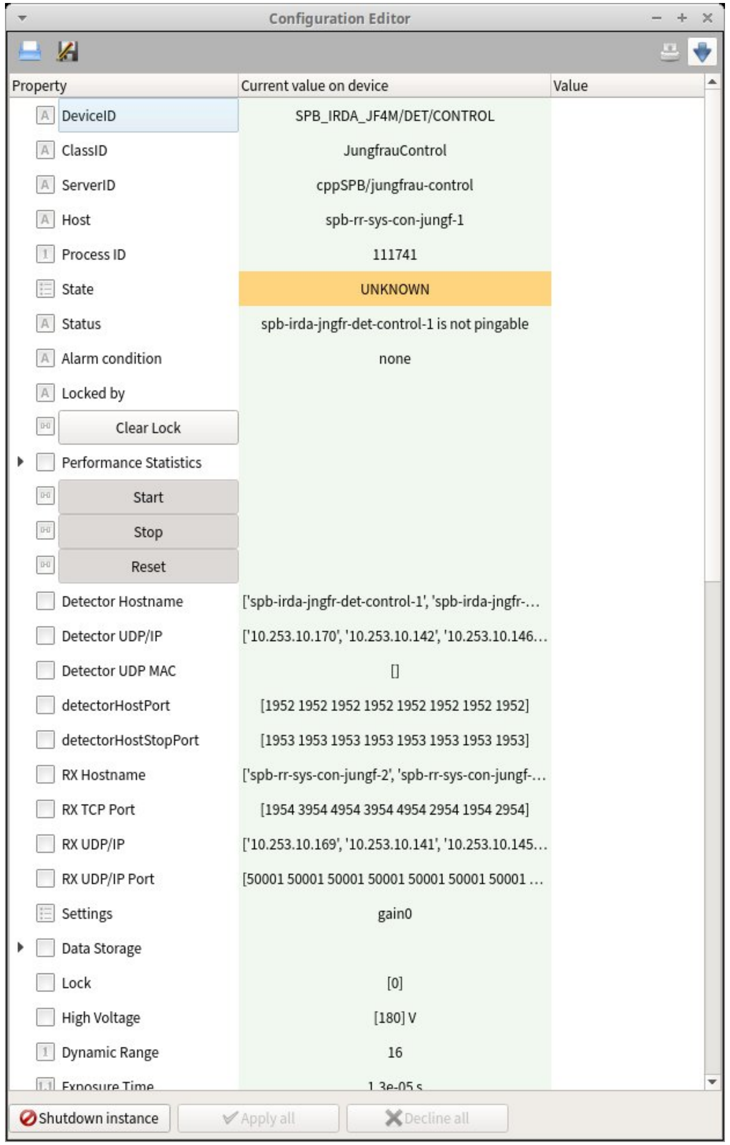
JUNGFRAU Control at SPB

- The 8 JUNGFRAU modules at SPB are controlled by Karabo devices based on PSI’s SLS detector library (C++)

- In addition to low-level control devices, high-level device have been added over time to ease detector operation:
  - Temperature monitor device
  - Configuration device
  - Power procedure device
  - Dark run device

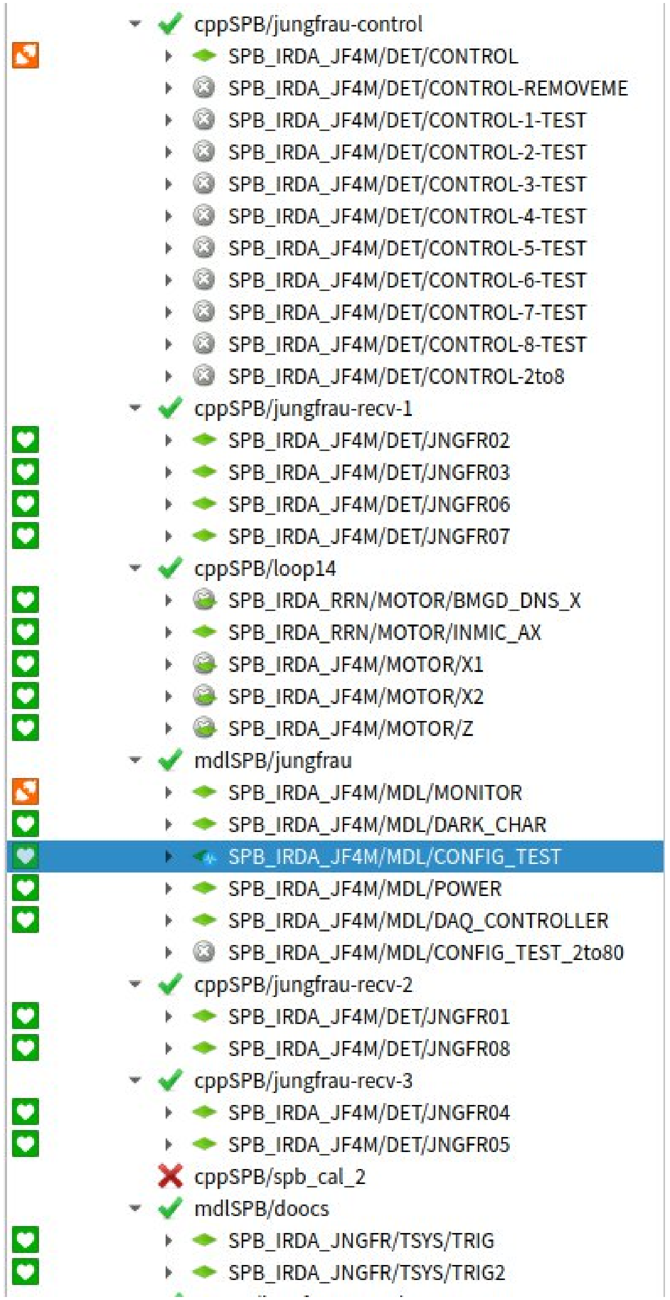
- Already pretty complex Karabo setup:
  - 1x control device
  - 8x receiver devices
  - 1x power device
  - 1x monitor device
  - 1x dark procedure device (+2 configuration devices)
  - 2x trigger configuration devices

- The overview scene can be created by the detector expert without the need of any coding.



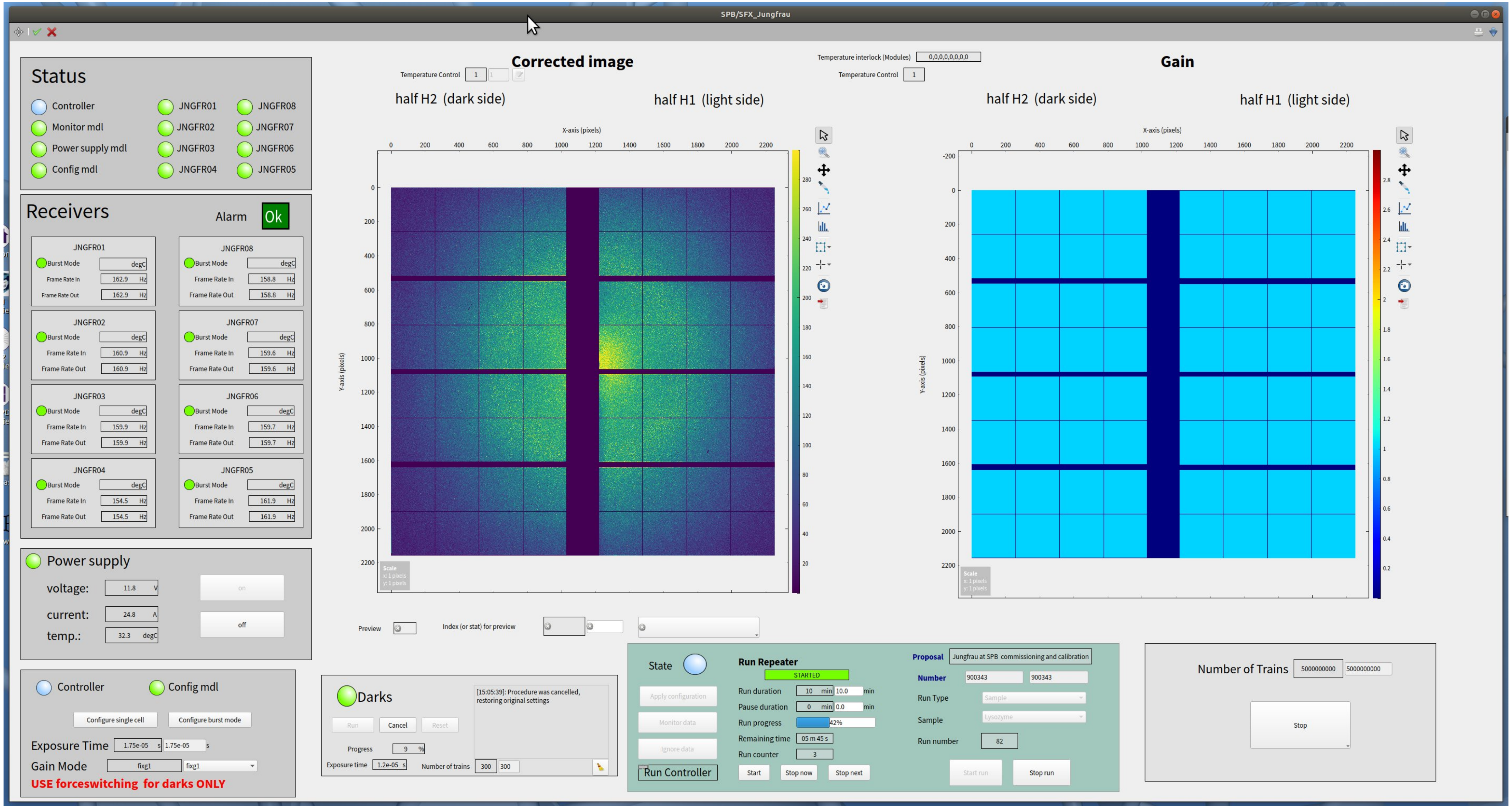
Configuration Editor

Property	Current value on device	Value
DeviceID	SPB_IRDA_JF4M/DET/CONTROL	
ClassID	JungfrauControl	
ServerID	cppSPB/jungfrau-control	
Host	spb-rr-sys-con-jungf-1	
Process ID	111741	
State	UNKNOWN	
Status	spb-irda-jngfr-det-control-1 is not pingable	
Alarm condition	none	
Locked by		
Clear Lock		
Performance Statistics		
Start		
Stop		
Reset		
Detector Hostname	['spb-irda-jngfr-det-control-1', 'spb-irda-jngfr-…	
Detector UDP/IP	['10.253.10.170', '10.253.10.142', '10.253.10.146…	
Detector UDP MAC	[]	
detectorHostPort	[1952 1952 1952 1952 1952 1952 1952 1952]	
detectorHostStopPort	[1953 1953 1953 1953 1953 1953 1953 1953]	
RX Hostname	['spb-rr-sys-con-jungf-2', 'spb-rr-sys-con-jungf-…	
RX TCP Port	[1954 3954 4954 3954 4954 2954 1954 2954]	
RX UDP/IP	['10.253.10.169', '10.253.10.141', '10.253.10.145…	
RX UDP/IP Port	[50001 50001 50001 50001 50001 50001 50001 …	
Settings	gain0	
Data Storage		
Lock	[0]	
High Voltage	[180] V	
Dynamic Range	16	
Exposure Time	1.3e-05 s	



- cppSPB/jungfrau-control
  - SPB_IRDA_JF4M/DET/CONTROL
  - SPB_IRDA_JF4M/DET/CONTROL-REMOVEME
  - SPB_IRDA_JF4M/DET/CONTROL-1-TEST
  - SPB_IRDA_JF4M/DET/CONTROL-2-TEST
  - SPB_IRDA_JF4M/DET/CONTROL-3-TEST
  - SPB_IRDA_JF4M/DET/CONTROL-4-TEST
  - SPB_IRDA_JF4M/DET/CONTROL-5-TEST
  - SPB_IRDA_JF4M/DET/CONTROL-6-TEST
  - SPB_IRDA_JF4M/DET/CONTROL-7-TEST
  - SPB_IRDA_JF4M/DET/CONTROL-8-TEST
  - SPB_IRDA_JF4M/DET/CONTROL-2to8
- cppSPB/jungfrau-recv-1
  - SPB_IRDA_JF4M/DET/JNGFR02
  - SPB_IRDA_JF4M/DET/JNGFR03
  - SPB_IRDA_JF4M/DET/JNGFR06
  - SPB_IRDA_JF4M/DET/JNGFR07
- cppSPB/loop14
  - SPB_IRDA_RRN/MOTOR/BMGD_DNS_X
  - SPB_IRDA_RRN/MOTOR/INMIC_AX
  - SPB_IRDA_JF4M/MOTOR/X1
  - SPB_IRDA_JF4M/MOTOR/X2
  - SPB_IRDA_JF4M/MOTOR/Z
- mdlSPB/jungfrau
  - SPB_IRDA_JF4M/MDL/MONITOR
  - SPB_IRDA_JF4M/MDL/DARK_CHAR
  - SPB_IRDA_JF4M/MDL/CONFIG_TEST
  - SPB_IRDA_JF4M/MDL/POWER
  - SPB_IRDA_JF4M/MDL/DAQ_CONTROLLER
  - SPB_IRDA_JF4M/MDL/CONFIG_TEST_2to80
- cppSPB/jungfrau-recv-2
  - SPB_IRDA_JF4M/DET/JNGFR01
  - SPB_IRDA_JF4M/DET/JNGFR08
- cppSPB/jungfrau-recv-3
  - SPB_IRDA_JF4M/DET/JNGFR04
  - SPB_IRDA_JF4M/DET/JNGFR05
- cppSPB/spb_cal_2
- mdlSPB/doocs
  - SPB_IRDA_JNGFR/TSYS/TRIG
  - SPB_IRDA_JNGFR/TSYS/TRIG2

The main JUNGFRAU SPB scene #1



Status: Controller, Monitor mdl, Power supply mdl, Config mdl, JNGFR01, JNGFR02, JNGFR03, JNGFR04, JNGFR08, JNGFR07, JNGFR06, JNGFR05

Receivers — Alarm: Ok

Receiver	Burst Mode	Frame Rate In	Frame Rate Out
JNGFR01	degC	162.9 Hz	162.9 Hz
JNGFR08	degC	158.8 Hz	158.8 Hz
JNGFR02	degC	160.9 Hz	160.9 Hz
JNGFR07	degC	159.6 Hz	159.6 Hz
JNGFR03	degC	159.9 Hz	159.9 Hz
JNGFR06	degC	159.7 Hz	159.7 Hz
JNGFR04	degC	154.5 Hz	154.5 Hz
JNGFR05	degC	161.9 Hz	161.9 Hz

Power supply
voltage: 11.8 V
current: 24.8 A
temp.: 32.3 degC

Controller — Config mdl
Exposure Time 1.75e-05 s 1.75e-05 s
Gain Mode fixg1 fixg1
USE forceswitching for darks ONLY

Temperature Control 1
Temperature interlock (Modules) 0,0,0,0,0,0,0,0
Temperature Control 1

Preview
Index (or stat) for preview

Darks
[15:05:39]: Procedure was cancelled, restoring original settings
Progress 9 %
Exposure time 1.2e-05 s
Number of trains 300 300

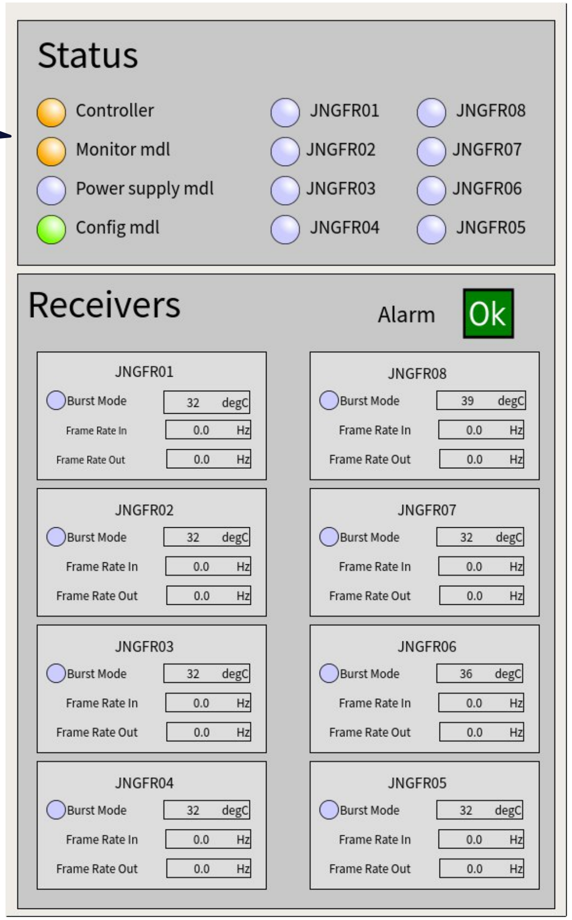
State
Run Repeater: STARTED
Run duration 10 min 10.0 min
Pause duration 0 min 0.0 min
Run progress 42%
Remaining time 05 m 45 s
Run counter 3

Proposal: Jungfrau at SPB commissioning and calibration
Number 900343 900343
Run Type: Sample
Sample: Lysozyme
Run number 82

Number of Trains 5000000000 5000000000

The main JUNGFRAU SPB scene #2

Overview of Karabo devices' states



Status

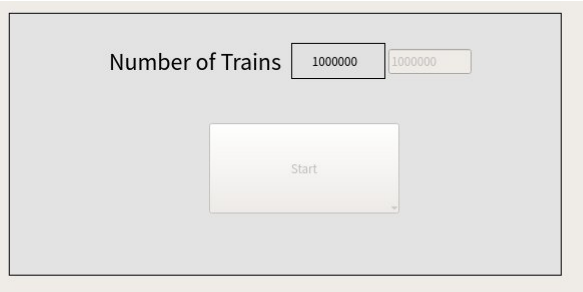
● Controller	○ JNGFR01	○ JNGFR08
● Monitor mdl	○ JNGFR02	○ JNGFR07
○ Power supply mdl	○ JNGFR03	○ JNGFR06
● Config mdl	○ JNGFR04	○ JNGFR05

Receivers — Alarm Ok

Module	Burst Mode	Temperature	Frame Rate In	Frame Rate Out
JNGFR01	○	32 degC	0.0 Hz	0.0 Hz
JNGFR08	○	39 degC	0.0 Hz	0.0 Hz
JNGFR02	○	32 degC	0.0 Hz	0.0 Hz
JNGFR07	○	32 degC	0.0 Hz	0.0 Hz
JNGFR03	○	32 degC	0.0 Hz	0.0 Hz
JNGFR06	○	36 degC	0.0 Hz	0.0 Hz
JNGFR04	○	32 degC	0.0 Hz	0.0 Hz
JNGFR05	○	32 degC	0.0 Hz	0.0 Hz

Detailed status of the modules

Configuration and start of acquisition

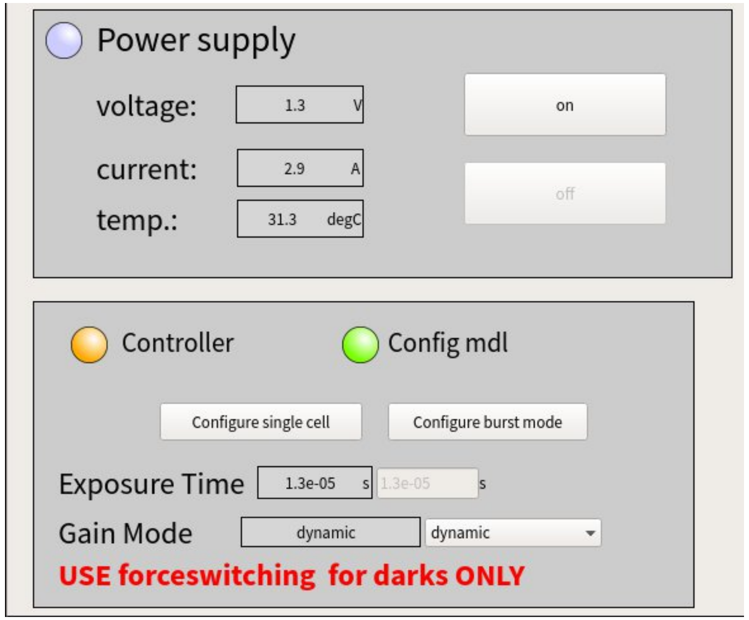


Number of Trains 1000000 1000000

Start

Power on/off the modules

Configure all modules at once



○ Power supply

voltage: 1.3 V

current: 2.9 A

temp.: 31.3 degC

on

off

● Controller ● Config mdl

Configure single cell

Configure burst mode

Exposure Time 1.3e-05 s 1.3e-05 s

Gain Mode dynamic dynamic

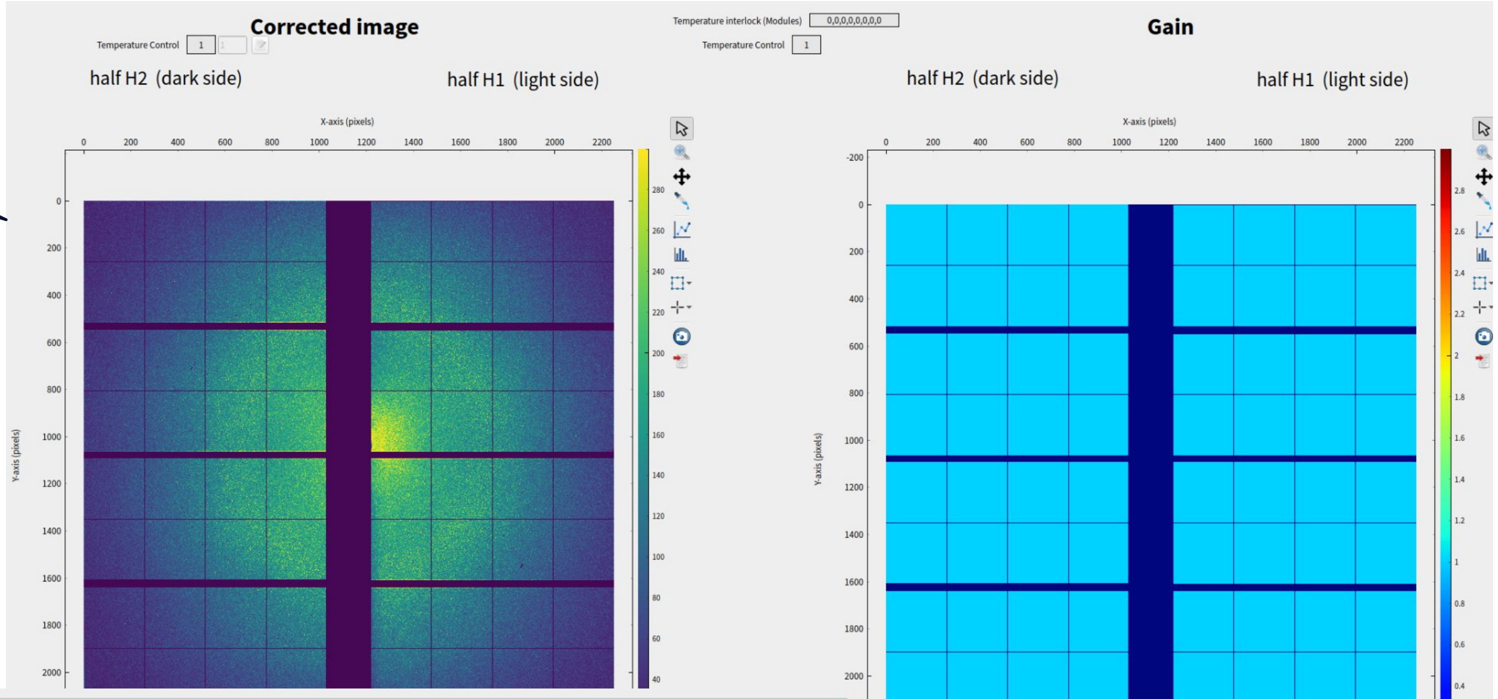
USE forceswitching for darks ONLY

The main JUNGFRAU SPB scene #3

Image online preview

The SPB run controller device

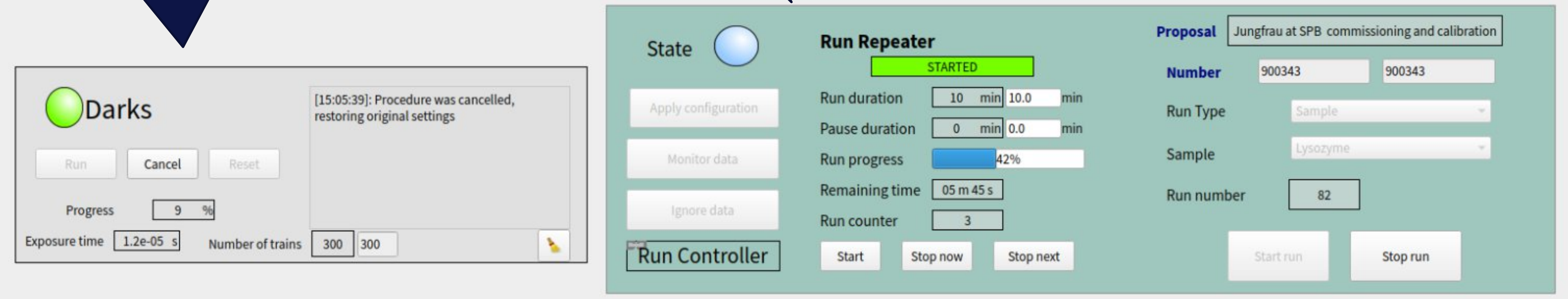
Karabo device for taking dark runs



Temperature Control 1

Temperature interlock (Modules) 0,0,0,0,0,0,0,0

Temperature Control 1



[15:05:39]: Procedure was cancelled, restoring original settings

Progress 9 %

Exposure time 1.2e-05 s

Number of trains 300 300

STARTED

Run duration 10 min 10.0 min

Pause duration 0 min 0.0 min

Run progress 42%

Remaining time 05 m 45 s

Run counter 3

Proposal Jungfrau at SPB commissioning and calibration

Number 900343 900343

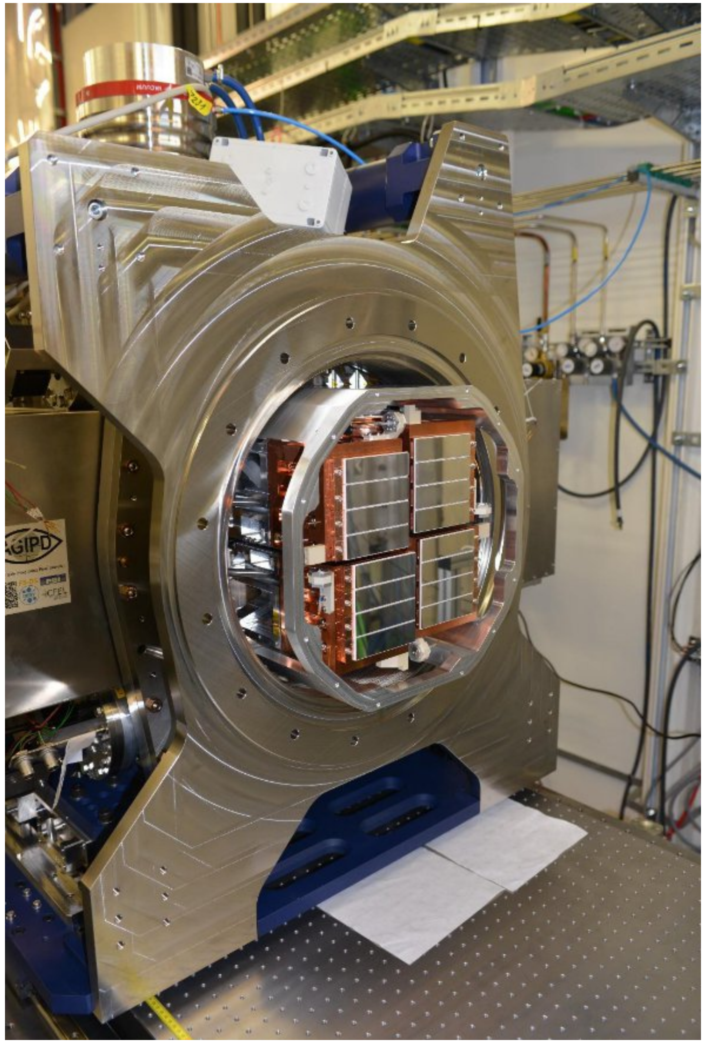
Run Type Sample

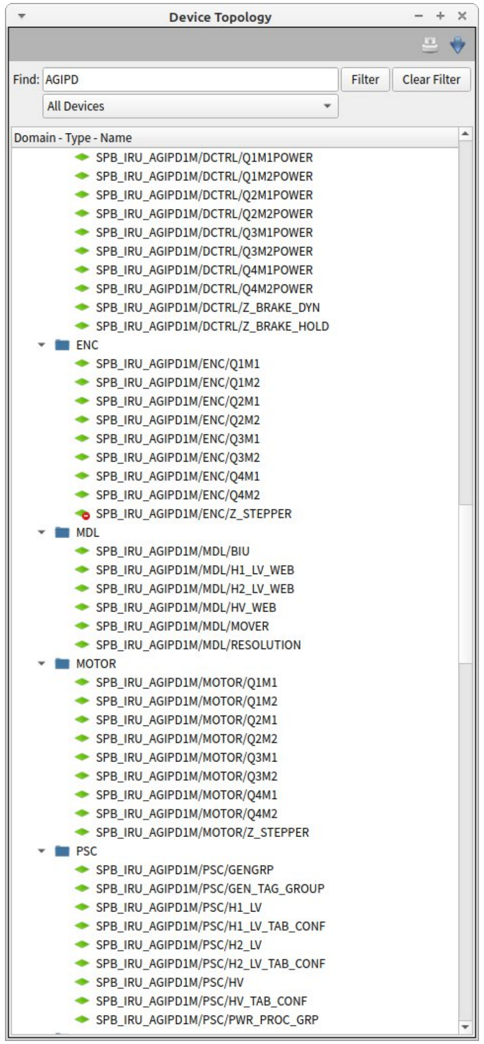
Sample Lysozyme

Run number 82

65 devices of 19 different classes

Zoom on Bespoke Detectors: AGIPD





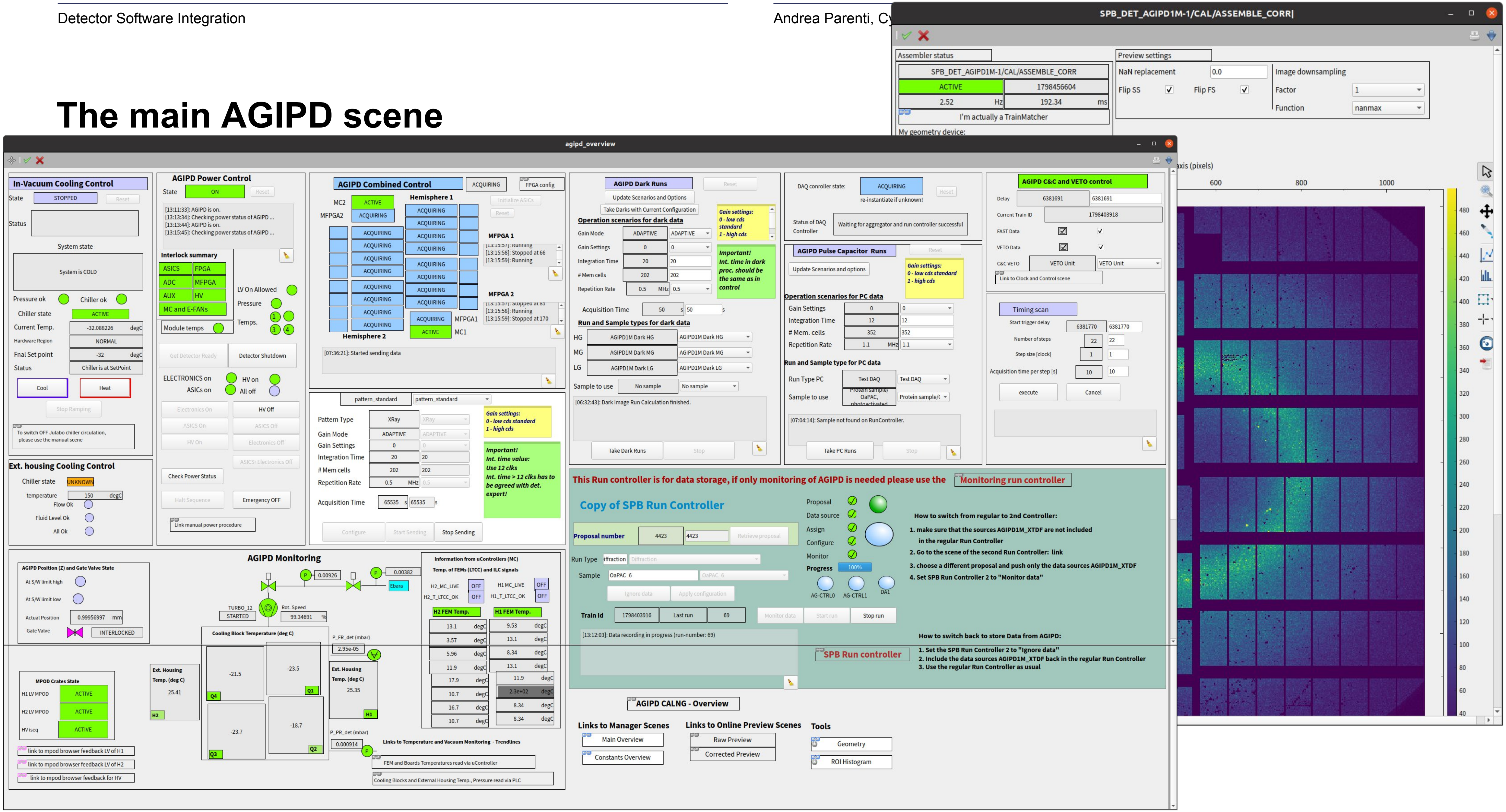
Find: AGIPD

All Devices

```
        SPB_IRU_AGIPD1M/DCTRL/Q1M1POWER
        SPB_IRU_AGIPD1M/DCTRL/Q1M2POWER
        SPB_IRU_AGIPD1M/DCTRL/Q2M1POWER
        SPB_IRU_AGIPD1M/DCTRL/Q2M2POWER
        SPB_IRU_AGIPD1M/DCTRL/Q3M1POWER
        SPB_IRU_AGIPD1M/DCTRL/Q3M2POWER
        SPB_IRU_AGIPD1M/DCTRL/Q4M1POWER
        SPB_IRU_AGIPD1M/DCTRL/Q4M2POWER
        SPB_IRU_AGIPD1M/DCTRL/Z_BRAKE_DYN
        SPB_IRU_AGIPD1M/DCTRL/Z_BRAKE_HOLD
    ENC
        SPB_IRU_AGIPD1M/ENC/Q1M1
        SPB_IRU_AGIPD1M/ENC/Q1M2
        SPB_IRU_AGIPD1M/ENC/Q2M1
        SPB_IRU_AGIPD1M/ENC/Q2M2
        SPB_IRU_AGIPD1M/ENC/Q3M1
        SPB_IRU_AGIPD1M/ENC/Q3M2
        SPB_IRU_AGIPD1M/ENC/Q4M1
        SPB_IRU_AGIPD1M/ENC/Q4M2
        SPB_IRU_AGIPD1M/ENC/Z_STEPPER
    MDL
        SPB_IRU_AGIPD1M/MDL/BIU
        SPB_IRU_AGIPD1M/MDL/H1_LV_WEB
        SPB_IRU_AGIPD1M/MDL/H2_LV_WEB
        SPB_IRU_AGIPD1M/MDL/HV_WEB
        SPB_IRU_AGIPD1M/MDL/MOVER
        SPB_IRU_AGIPD1M/MDL/RESOLUTION
    MOTOR
        SPB_IRU_AGIPD1M/MOTOR/Q1M1
        SPB_IRU_AGIPD1M/MOTOR/Q1M2
        SPB_IRU_AGIPD1M/MOTOR/Q2M1
        SPB_IRU_AGIPD1M/MOTOR/Q2M2
        SPB_IRU_AGIPD1M/MOTOR/Q3M1
        SPB_IRU_AGIPD1M/MOTOR/Q3M2
        SPB_IRU_AGIPD1M/MOTOR/Q4M1
        SPB_IRU_AGIPD1M/MOTOR/Q4M2
        SPB_IRU_AGIPD1M/MOTOR/Z_STEPPER
    PSC
        SPB_IRU_AGIPD1M/PSC/GENGRP
        SPB_IRU_AGIPD1M/PSC/GEN_TAG_GROUP
        SPB_IRU_AGIPD1M/PSC/H1_LV
        SPB_IRU_AGIPD1M/PSC/H1_LV_TAB_CONF
        SPB_IRU_AGIPD1M/PSC/H2_LV
        SPB_IRU_AGIPD1M/PSC/H2_LV_TAB_CONF
        SPB_IRU_AGIPD1M/PSC/HV
        SPB_IRU_AGIPD1M/PSC/HV_TAB_CONF
        SPB_IRU_AGIPD1M/PSC/PWR_PROC_GRP
```

- 237 Karabo devices for AGIPD 1M
  - 21 Motors
  - 38 Interlocks
  - 76 Timing and environment
  - 14 Power
  - 22 Control
  - 28 DAQ
  - 27 Online Calibration
  - 11 Analysis

The main AGIPD scene



SPB_DET_AGIPD1M-1/CAL/ASSEMBLE_CORR|

Assembler status
- SPB_DET_AGIPD1M-1/CAL/ASSEMBLE_CORR
- ACTIVE | 1798456604
- 2.52 Hz | 192.34 ms
- I'm actually a TrainMatcher
- My geometry device:

Preview settings
- NaN replacement: 0.0
- Flip SS ✓ Flip FS ✓
- Image downsampling — Factor: 1; Function: nanmax

agipd_overview

In-Vacuum Cooling Control
- State: STOPPED
- Status:
- System state: System is COLD
- Pressure ok ● Chiller ok ●
- Chiller state: ACTIVE
- Current Temp.: -32.088226 degC
- Hardware Region: NORMAL
- Fnal Set point: -32 degC
- Status: Chiller is at SetPoint
- To switch OFF Julabo chiller circulation, please use the manual scene

Ext. housing Cooling Control
- Chiller state: UNKNOWN
- temperature: 150 degC
- Flow Ok ○ Fluid Level Ok ○ All Ok ○

AGIPD Power Control
- State: ON

```
[13:11:33]: AGIPD is on.
[13:13:34]: Checking power status of AGIPD ...
[13:13:44]: AGIPD is on.
[13:15:45]: Checking power status of AGIPD ...
```

Interlock summary: ASICS, FPGA, ADC, MFPGA, AUX, HV, MC and E-FANs
- LV On Allowed ● Pressure ● Temps. ① ● ③ ④
- Module temps ●
- ELECTRONICS on ● HV on ●
- ASICs on ● All off ○

AGIPD Combined Control — ACQUIRING
- MC2: ACTIVE; MFPGA2: ACQUIRING
- Hemisphere 1: ACQUIRING (×8)
- Hemisphere 2: ACQUIRING (×8)
- MFPGA1: ACQUIRING; MC1: ACTIVE

MFPGA 1

```
[13:15:57]: Running
[13:15:58]: Stopped at 66
[13:15:59]: Running
```

MFPGA 2

```
[13:15:57]: Stopped at 85
[13:15:58]: Running
[13:15:59]: Stopped at 170
```

```
[07:36:21]: Started sending data
```

pattern_standard

Pattern Type	XRay	XRay
Gain Mode	ADAPTIVE	ADAPTIVE
Gain Settings	0	0
Integration Time	20	20
# Mem cells	202	202
Repetition Rate	0.5 MHz	0.5
Acquisition Time	65535 s	65535 s

Gain settings:
0 - low cds standard
1 - high cds

Important!
Int. time value:
Use 12 clks
Int. time > 12 clks has to be agreed with det. expert!

AGIPD Dark Runs

Operation scenarios for dark data

Gain Mode	ADAPTIVE	ADAPTIVE
Gain Settings	0	0
Integration Time	20	20
# Mem cells	202	202
Repetition Rate	0.5 MHz	0.5
Acquisition Time	50 s	50 s

Gain settings:
0 - low cds standard
1 - high cds

Important!
Int. time in dark proc. should be the same as in control

Run and Sample types for dark data

HG	AGIPD1M Dark HG	AGIPD1M Dark HG
MG	AGIPD1M Dark MG	AGIPD1M Dark MG
LG	AGIPD1M Dark LG	AGIPD1M Dark LG
Sample to use	No sample	No sample

```
[06:32:43]: Dark Image Run Calculation finished.
```

- DAQ conroller state: ACQUIRING — re-instantiate if unknown!
- Status of DAQ Controller: Waiting for aggregator and run controller successful

AGIPD Pulse Capacitor Runs

Gain settings:
0 - low cds standard
1 - high cds

Operation scenarios for PC data

Gain Settings	0	0
Integration Time	12	12
# Mem. cells	352	352
Repetition Rate	1.1 MHz	1.1

Run and Sample type for PC data

Run Type PC	Test DAQ	Test DAQ
Sample to use	Protein sample/ OaPAC, photoactivated	Protein sample/(

```
[07:04:14]: Sample not found on RunController.
```

AGIPD C&C and VETO control

Delay	6381691	6381691
Current Train ID	1798403918	
FAST Data	☑	✓
VETO Data	☑	✓
C&C VETO	VETO Unit	VETO Unit

Link to Clock and Control scene

Timing scan

Start trigger delay	6381770	6381770
Number of steps	22	22
Step size [clock]	1	1
Acquisition time per step [s]	10	10

This Run controller is for data storage, if only monitoring of AGIPD is needed please use the Monitoring run controller

Copy of SPB Run Controller
- Proposal number: 4423 | 4423
- Run Type: iffraction | Diffraction
- Sample: OaPAC_6 | OaPAC_6
- Proposal ✓ Data source ✓ Assign ✓ Configure ✓ Monitor ✓
- Progress: 100%
- Train Id: 1798403916 | Last run | 69

```
[13:12:03]: Data recording in progress (run-number: 69)
```

How to switch from regular to 2nd Controller:

1. make sure that the sources AGIPD1M_XTDF are not included in the regular Run Controller
2. Go to the scene of the second Run Controller: link
3. choose a different proposal and push only the data sources AGIPD1M_XTDF
4. Set SPB Run Controller 2 to "Monitor data"

How to switch back to store Data from AGIPD:

1. Set the SPB Run Controller 2 to "Ignore data"
2. Include the data sources AGIPD1M_XTDF back in the regular Run Controller
3. Use the regular Run Controller as usual

SPB Run controller

AGIPD Monitoring

AGIPD Position (Z) and Gate Valve State
- At S/W limit high ○
- At S/W limit low ○
- Actual Position: 0.99956997 mm
- Gate Valve: INTERLOCKED

MPOD Crates State

H1 LV MPOD	ACTIVE
H2 LV MPOD	ACTIVE
HV iseq	ACTIVE

- TURBO_12: STARTED; Rot. Speed: 99.34691 %
- P: 0.00926; P: 0.00382; Ebara
- P_FR_det (mbar): 2.95e-05
- P_PR_det (mbar): 0.000914
- Ext. Housing Temp. (deg C): 25.41 (H2); 25.35 (H1)

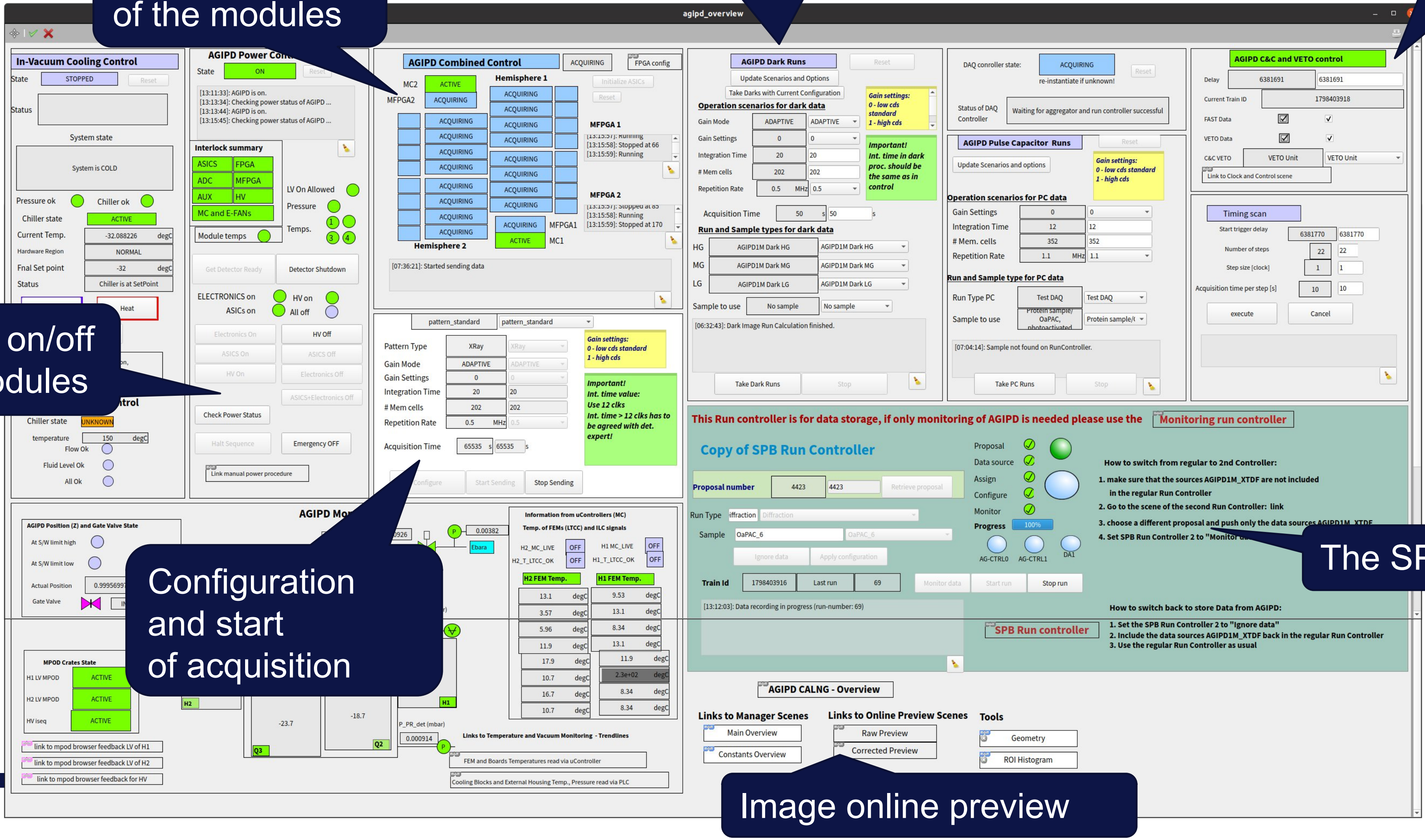
Cooling Block Temperature (deg C)
- Q4: -21.5; Q1: -23.5; Q3: -23.7; Q2: -18.7

Information from uControllers (MC)
Temp. of FEMs (LTCC) and ILC signals
- H2_MC_LIVE: OFF; H2_T_LTCC_OK: OFF
- H1 MC_LIVE: OFF; H1_T_LTCC_OK: OFF

H2 FEM Temp.	H1 FEM Temp.
13.1 degC	9.53 degC
3.57 degC	13.1 degC
5.96 degC	8.34 degC
11.9 degC	13.1 degC
17.9 degC	11.9 degC
10.7 degC	2.3e+02 degC
16.7 degC	8.34 degC
10.7 degC	8.34 degC

Links to Temperature and Vacuum Monitoring - Trendlines
- FEM and Boards Temperatures read via uController
- Cooling Blocks and External Housing Temp., Pressure read via PLC

The m ne



Detailed status of the modules

Device for taking dark runs

Devices for Timing scans

Power on/off the modules

Configuration and start of acquisition

The SPB DAQ Control

Image online preview

agipd_overview

In-Vacuum Cooling Control

State: STOPPED | Reset

Status

System state: System is COLD

Pressure ok ● Chiller ok ●

Chiller state: ACTIVE

Current Temp.: -32.088226 degC

Hardware Region: NORMAL

Fnal Set point: -32 degC

Status: Chiller is at SetPoint

Heat

Chiller state: UNKNOWN

temperature: 150 degC

Flow Ok ○

Fluid Level Ok ○

All Ok ○

AGIPD Power Con...

State: ON | Reset

```
[13:11:33]: AGIPD is on.
[13:13:34]: Checking power status of AGIPD ...
[13:13:44]: AGIPD is on.
[13:15:45]: Checking power status of AGIPD ...
```

Interlock summary

ASICS | FPGA | ADC | MFPGA | AUX | HV | MC and E-FANs

LV On Allowed ● Pressure ● Temps. ● ● 1 2 3 4

Module temps ●

Get Detector Ready | Detector Shutdown

ELECTRONICS on ● HV on ●

ASICs on ● All off ○

Electronics On | HV Off | ASICs On | ASICs Off | HV On | Electronics Off | ASICS+Electronics Off

Check Power Status

Halt Sequence | Emergency OFF

Link manual power procedure

AGIPD Combined Control ACQUIRING | FPGA config

Initialize ASICs | Reset

MC2: ACTIVE

MFPGA2: ACQUIRING

Hemisphere 1

ACQUIRING (modules)

MFPGA 1

```
[13:15:57]: Running
[13:15:58]: Stopped at 66
[13:15:59]: Running
```

MFPGA 2

```
[13:15:57]: Stopped at 85
[13:15:58]: Running
[13:15:59]: Stopped at 170
```

MFPGA1: ACQUIRING

MC1: ACTIVE

Hemisphere 2

```
[07:36:21]: Started sending data
```

pattern_standard | pattern_standard

Pattern Type	XRay	XRay
Gain Mode	ADAPTIVE	ADAPTIVE
Gain Settings	0	0
Integration Time	20	20
# Mem cells	202	202
Repetition Rate	0.5 MHz	0.5
Acquisition Time	65535 s	65535 s

Gain settings: 0 - low cds standard 1 - high cds

Important! Int. time value: Use 12 clks Int. time > 12 clks has to be agreed with det. expert!

Configure | Start Sending | Stop Sending

AGIPD Dark Runs | Reset

Update Scenarios and Options

Take Darks with Current Configuration

Operation scenarios for dark data

Gain Mode	ADAPTIVE	ADAPTIVE
Gain Settings	0	0
Integration Time	20	20
# Mem cells	202	202
Repetition Rate	0.5 MHz	0.5
Acquisition Time	50 s	50 s

Gain settings: 0 - low cds standard 1 - high cds

Important! Int. time in dark proc. should be the same as in control

Run and Sample types for dark data

HG	AGIPD1M Dark HG	AGIPD1M Dark HG
MG	AGIPD1M Dark MG	AGIPD1M Dark MG
LG	AGIPD1M Dark LG	AGIPD1M Dark LG
Sample to use	No sample	No sample

```
[06:32:43]: Dark Image Run Calculation finished.
```

Take Dark Runs | Stop

DAQ conroller state: ACQUIRING | Reset

re-instantiate if unknown!

Status of DAQ Controller: Waiting for aggregator and run controller successful

AGIPD Pulse Capacitor Runs | Reset

Update Scenarios and options

Gain settings: 0 - low cds standard 1 - high cds

Operation scenarios for PC data

Gain Settings	0	0
Integration Time	12	12
# Mem. cells	352	352
Repetition Rate	1.1 MHz	1.1

Run and Sample type for PC data

Run Type PC	Test DAQ	Test DAQ
Sample to use	Protein sample/ OaPAC, photoactivated	Protein sample/(

```
[07:04:14]: Sample not found on RunController.
```

Take PC Runs | Stop

AGIPD C&C and VETO control

Delay	6381691	6381691
Current Train ID		1798403918
FAST Data	☑	✓
VETO Data	☑	✓
C&C VETO	VETO Unit	VETO Unit

Link to Clock and Control scene

Timing scan

Start trigger delay	6381770	6381770
Number of steps	22	22
Step size [clock]	1	1
Acquisition time per step [s]	10	10

execute | Cancel

This Run controller is for data storage, if only monitoring of AGIPD is needed please use the Monitoring run controller

Copy of SPB Run Controller

Proposal number: 4423 | 4423 | Retrieve proposal

Run Type: iffraction | Diffraction

Sample: OaPAC_6 | OaPAC_6

Ignore data | Apply configuration

Train Id: 1798403916 | Last run: 69

Monitor data | Start run | Stop run

Proposal ✓ Data source ✓ Assign ✓ Configure ✓ Monitor ✓

Progress 100%

AG-CTRL0 AG-CTRL1 DA1

```
[13:12:03]: Data recording in progress (run-number: 69)
```

How to switch from regular to 2nd Controller:

1. make sure that the sources AGIPD1M_XTDF are not included in the regular Run Controller
2. Go to the scene of the second Run Controller: link
3. choose a different proposal and push only the data sources AGIPD1M_XTDF
4. Set SPB Run Controller 2 to "Monitor d...

How to switch back to store Data from AGIPD:

SPB Run controller

1. Set the SPB Run Controller 2 to "Ignore data"
2. Include the data sources AGIPD1M_XTDF back in the regular Run Controller
3. Use the regular Run Controller as usual

AGIPD Mo...

AGIPD Position (Z) and Gate Valve State

At S/W limit high ○

At S/W limit low ○

Actual Position: 0.99956997

Gate Valve

MPOD Crates State

H1 LV MPOD	ACTIVE
H2 LV MPOD	ACTIVE
HV iseq	ACTIVE

link to mpod browser feedback LV of H1

link to mpod browser feedback LV of H2

link to mpod browser feedback for HV

Information from uControllers (MC)

Temp. of FEMs (LTCC) and ILC signals

H2_MC_LIVE OFF | H1 MC_LIVE OFF

H2_T_LTCC_OK OFF | H1_T_LTCC_OK OFF

H2 FEM Temp.	H1 FEM Temp.
13.1 degC	9.53 degC
3.57 degC	13.1 degC
5.96 degC	8.34 degC
11.9 degC	13.1 degC
17.9 degC	11.9 degC
10.7 degC	2.3e+02 degC
16.7 degC	8.34 degC
10.7 degC	8.34 degC

0.00382 | Ebara

H2 | H1 | Q3 | Q2

-23.7 | -18.7

P_PR_det (mbar): 0.000914

Links to Temperature and Vacuum Monitoring - Trendlines

FEM and Boards Temperatures read via uController

Cooling Blocks and External Housing Temp., Pressure read via PLC

AGIPD CALNG - Overview

Links to Manager Scenes

Main Overview

Constants Overview

Links to Online Preview Scenes

Raw Preview

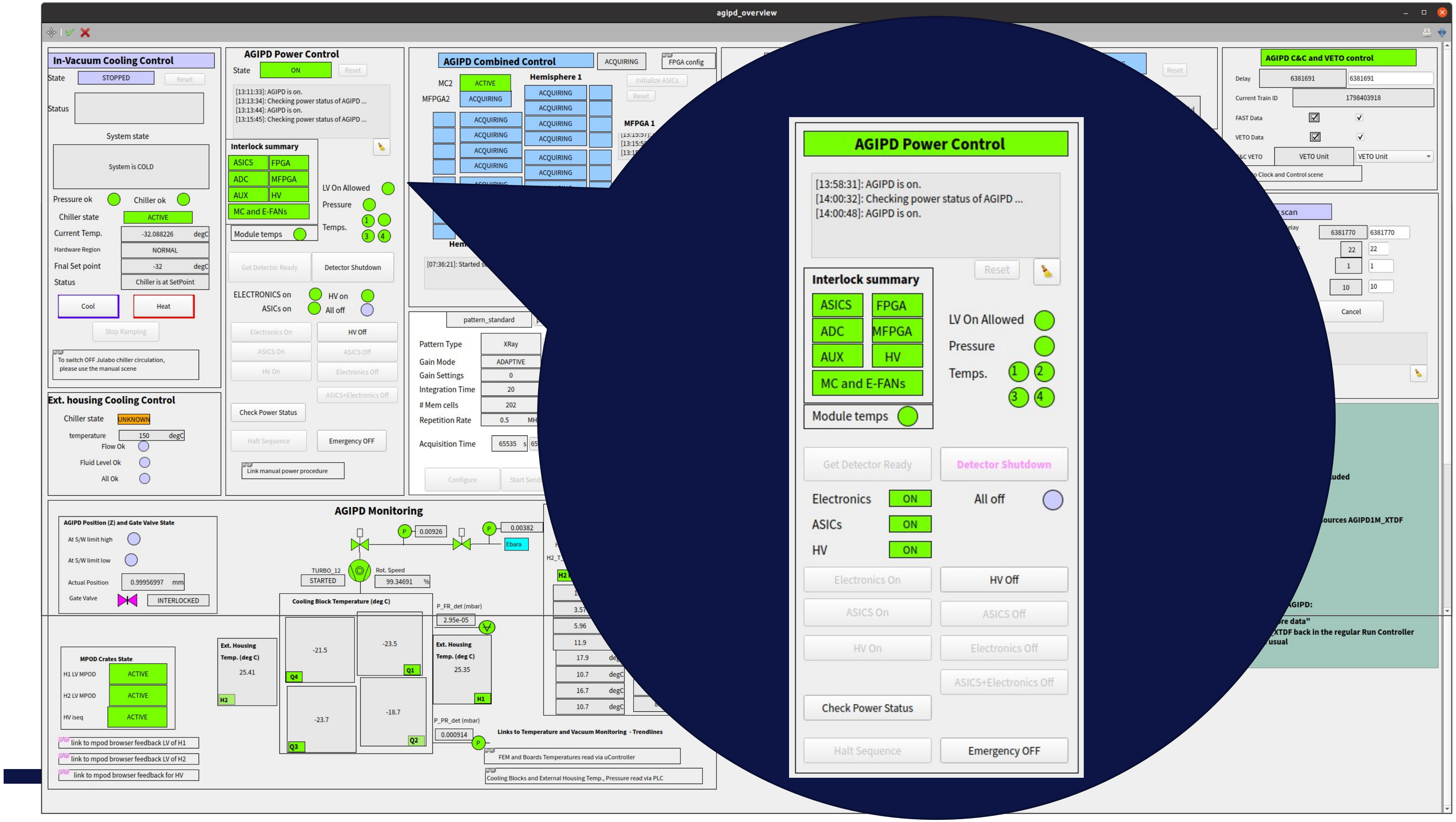
Corrected Preview

Tools

Geometry

ROI Histogram

The main AGIPD scene



AGIPD Power Control

[13:58:31]: AGIPD is on.
[14:00:32]: Checking power status of AGIPD ...
[14:00:48]: AGIPD is on.

Interlock summary: ASICS, FPGA, ADC, MFPGA, AUX, HV, MC and E-FANs

Module temps ●

LV On Allowed ●

Pressure ●

Temps. ① ② ③ ④

Electronics ON

ASICs ON

HV ON

All off ○

Integration Highlights

What Went Well

- Full integration of bespoke detectors
- Smooth integration of commercial detectors
- Near real-time correction and analysis
- Power procedures

What Could Be Better

- Power feedback independent from detector
- Expert feedback from detector
- Different interfaces makes integration difficult
- Documentation

Integration Highlights

What Went Well

- Full integration of bespoke detectors
- Smooth integration of commercial detectors
- Near real-time correction and analysis
- Power procedures

What Could Be Better

- Power feedback independent from detector
- Expert feedback from detector
- Different interfaces makes integration difficult
- Documentation

What We Want

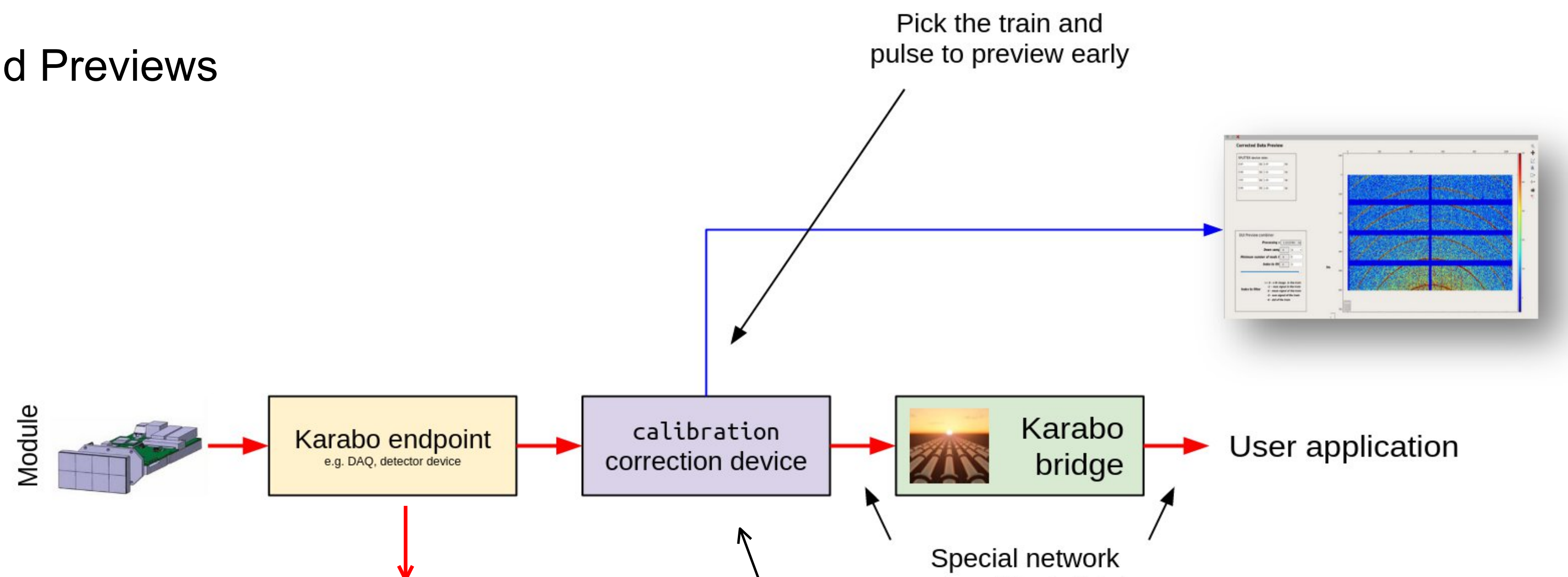
- Early Collaboration, to reduce complexity
- No Black Boxes
- Communication for faster iteration

Thank you

Karabo is a heavy-lifter when it comes to data

- Software written on top of Karabo can ingest up to 5PB of data per week, or approx. 20 GB/s from the MHz-capable detectors
- The slow data logging has an aggregate rate of >50KHz into the Influx timeseries database.
- The RabbitMQ/AMQP broker will be able to handle multi-KHz update rates from singular devices

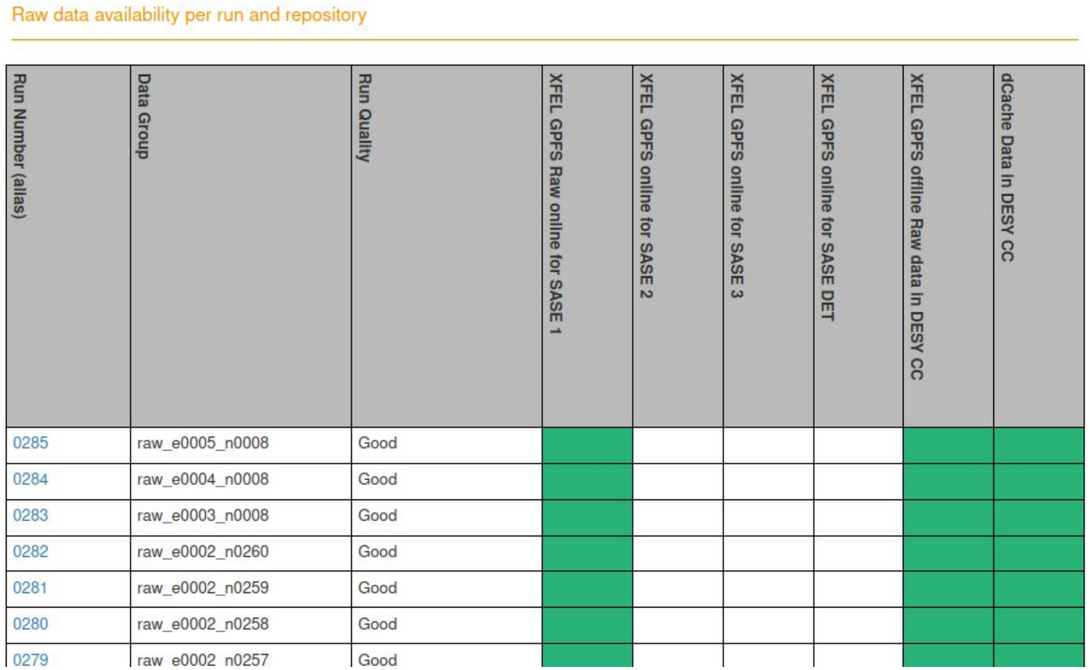
Online Corrections and Previews



Pick the train and pulse to preview early

Special network protocol for full data

One device per PDU



Raw data availability per run and repository

Run Number (alias)	Data Group	Run Quality	XFEL GPFS Raw online for SASE 1	XFEL GPFS online for SASE 2	XFEL GPFS online for SASE 3	XFEL GPFS online for SASE DET	XFEL GPFS offline Raw data in DESY CC	dCache Data in DESY CC
0285	raw_e0005_n0008	Good	🟩				🟩	🟩
0284	raw_e0004_n0008	Good	🟩				🟩	🟩
0283	raw_e0003_n0008	Good	🟩				🟩	🟩
0282	raw_e0002_n0260	Good	🟩				🟩	🟩
0281	raw_e0002_n0259	Good	🟩				🟩	🟩
0280	raw_e0002_n0258	Good	🟩				🟩	🟩
0279	raw_e0002_n0257	Good	🟩				🟩	🟩

What can we offer to users?

- Network bandwidth (56 Gib/s) fundamentally limits the number of modules in a group
  e.g. a single DSSC module may be approx. 10 Hz · 400 cells · 65 kP · (16 b + 16 b) = 7.8 Gib/s
  a single AGIPD module may be approx. 10 Hz · 352 cells · 65 kP · (32 b + 18 b) = 10.7 Gib/s
  - It is **not** possible right now to have all trains and pulses of a MHz detector on a single node
  - Current default is four modules per group
- Groups can be configured in any composition and changed quickly
- Multiple synchronized preview layers (raw, corrected, gain, …) without matching latency
- Toggleable between raw, fully corrected and any step in-between