The Karabo Control System

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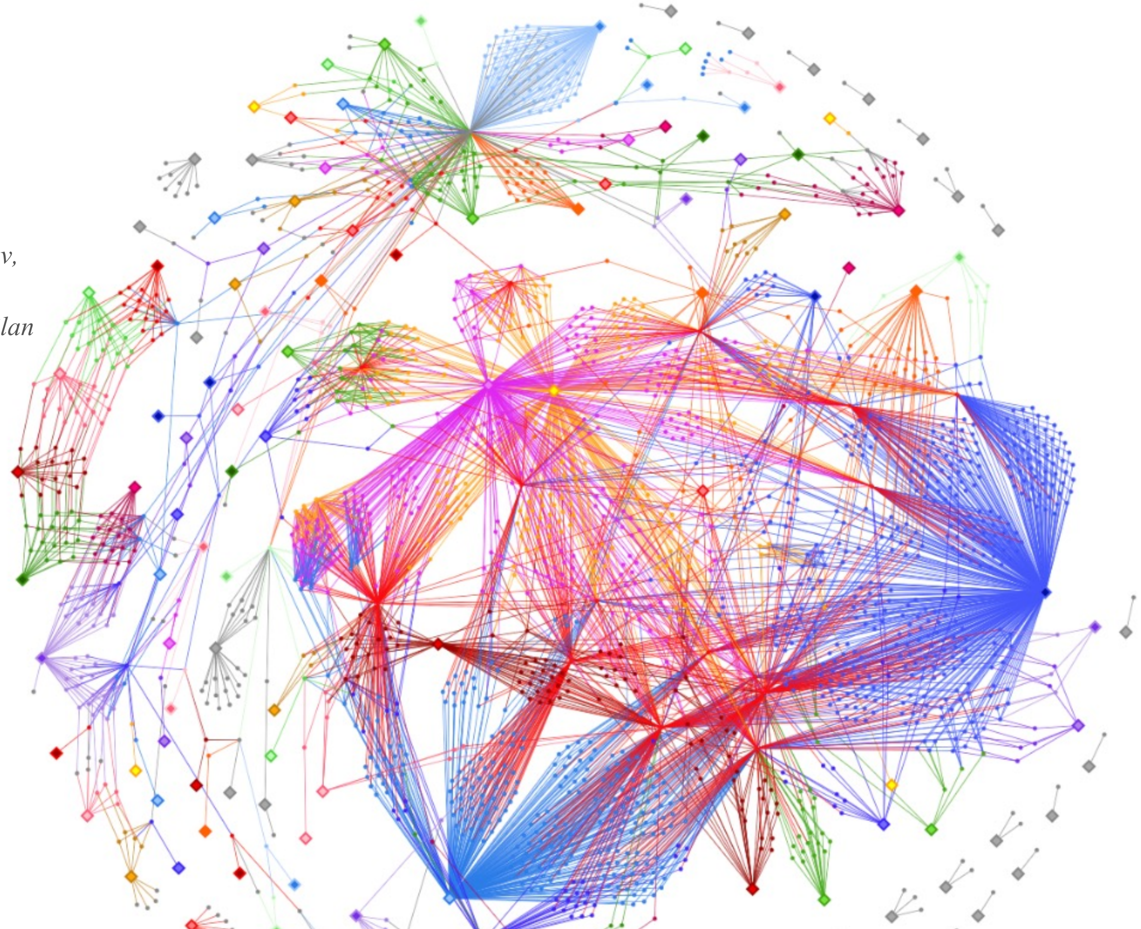
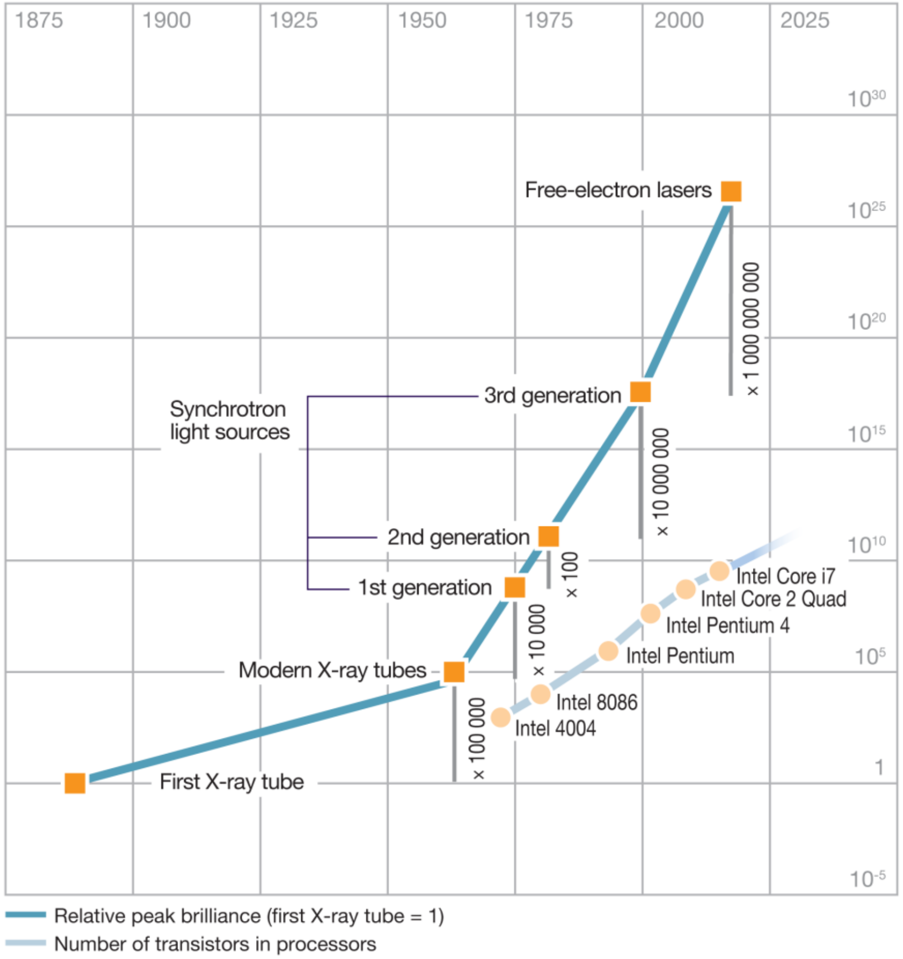
19.09.22
New Opportunities for Better User Group Software
(NOBUGS) 2022



Outline

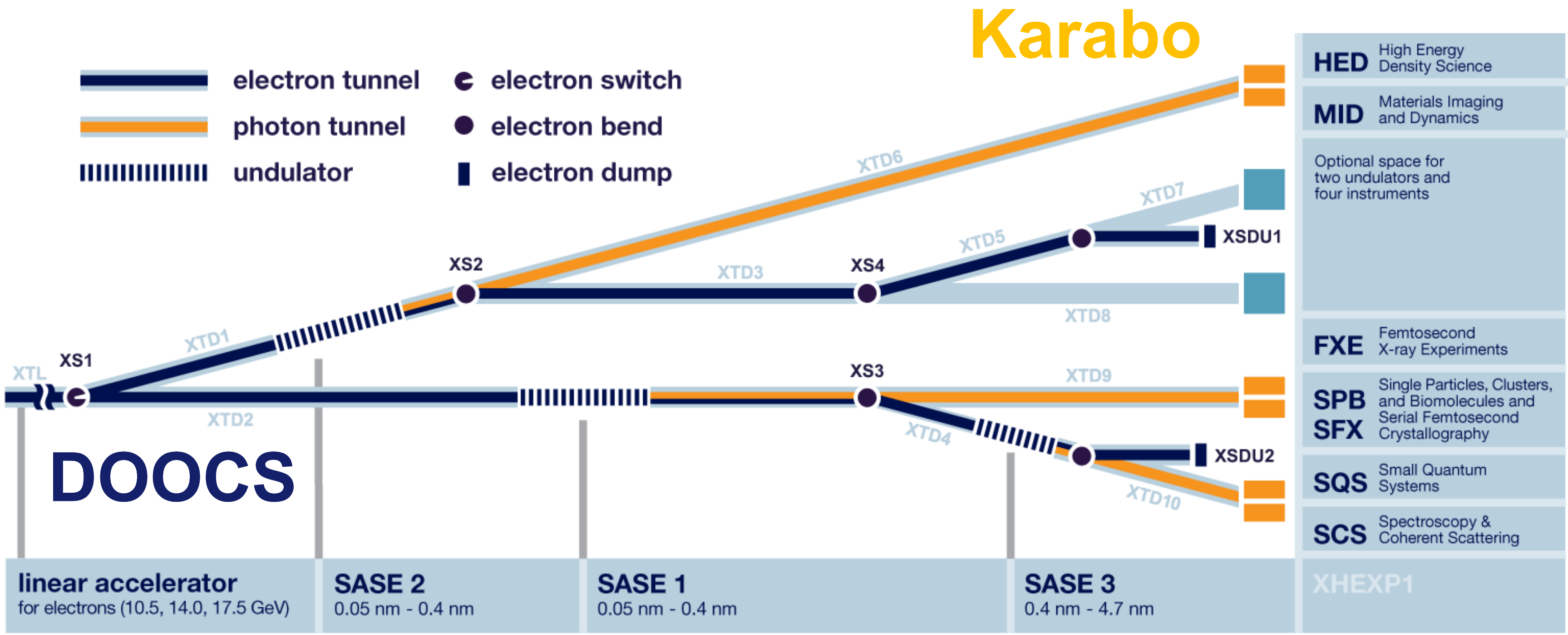
- The European XFEL – a short introduction
- Karabo – A SCADA Framework
  - Motivation
  - Architecture & Design
- Examples of Karabo at the European XFEL

The European XFEL

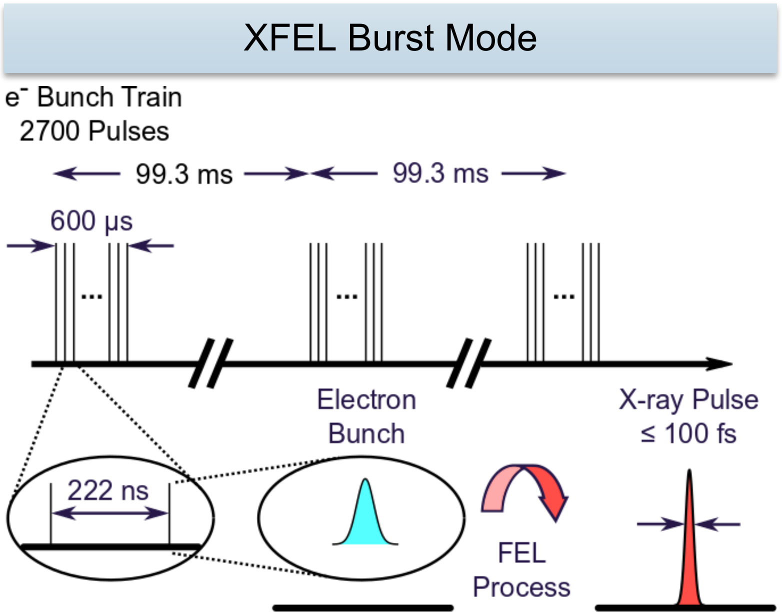


* The development of light source facilities has been faster than the increase in computer processing capacity (i.e., Moore’s Law)

Beamline layout and experiment stations


Karabo
electron tunnel
photon tunnel
undulator
electron switch
electron bend
electron dump
XTL
XS1
XTD1
XTD2
XS2
XTD6
XTD3
XS4
XTD5
XTD7
XSDU1
XTD8
XS3
XTD9
XTD4
XSDU2
XTD10
DOOCS
HED High Energy Density Science
MID Materials Imaging and Dynamics
Optional space for two undulators and four instruments
FXE Femtosecond X-ray Experiments
SPB SFX Single Particles, Clusters, and Biomolecules and Serial Femtosecond Crystallography
SQS Small Quantum Systems
SCS Spectroscopy & Coherent Scattering
linear accelerator
for electrons (10.5, 14.0, 17.5 GeV)
SASE 2
0.05 nm - 0.4 nm
SASE 1
0.05 nm - 0.4 nm
SASE 3
0.4 nm - 4.7 nm
XHEXP1

European XFEL Time Structure



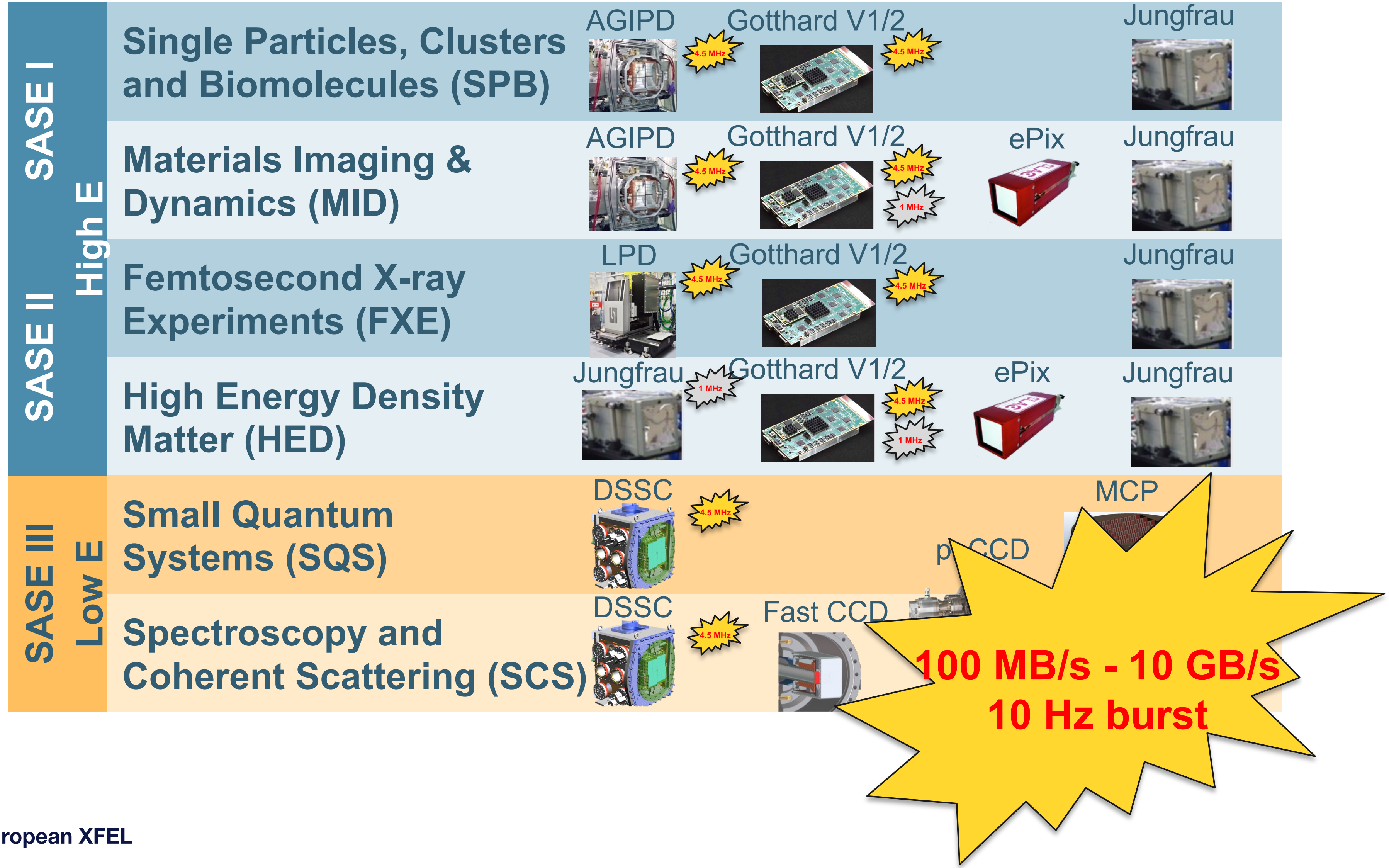
The European XFEL pulse structure poses strict constraints on detectors (e.g. intensity and time structure)

- Many applications require 4.5 MHz repetition rate detectors
- On average up to 27.000 pulses/s
- Pulse duration < 100 fs
- High peak intensities: up to 10^{12} photons/pulse
- Various different pulse patterns possible
  - 1 pulse per train
  - n pulses per train …

Linear, logarithmic or random distribution

**Most hardware controlled via Karabo has a 10Hz base frequency for timestamps.
Each of these trains has a unique identifier: the train ID**

Data Drivers: Detectors for the Scientific Instruments



SASE I	High E	Single Particles, Clusters and Biomolecules (SPB)	AGIPD	4.5 MHz	Gotthard V1/2	4.5 MHz		Jungfrau
		Materials Imaging & Dynamics (MID)	AGIPD	4.5 MHz	Gotthard V1/2	4.5 MHz 1 MHz	ePix	Jungfrau
SASE II		Femtosecond X-ray Experiments (FXE)	LPD	4.5 MHz	Gotthard V1/2	4.5 MHz		Jungfrau
		High Energy Density Matter (HED)	Jungfrau	1 MHz	Gotthard V1/2	4.5 MHz 1 MHz	ePix	Jungfrau
SASE III	Low E	Small Quantum Systems (SQS)	DSSC	4.5 MHz			p CCD	MCP
		Spectroscopy and Coherent Scattering (SCS)	DSSC	4.5 MHz	Fast CCD			

100 MB/s - 10 GB/s
10 Hz burst

Data Drivers: Digitizers & FPGAs

MicroTCA Crates

Large 12 slot 9U and small 6 slot 2U (including MCH, Power Supply and CPU)

X2Timer

XFEL Timing System module for synchronization (clocks and triggers) and pulse parameters from NAT

DAMC2

Required for Clock & Control system for fast 2D detectors, VETO System, Machine Protection System and photon beam loss monitors from DESY

SIS8300

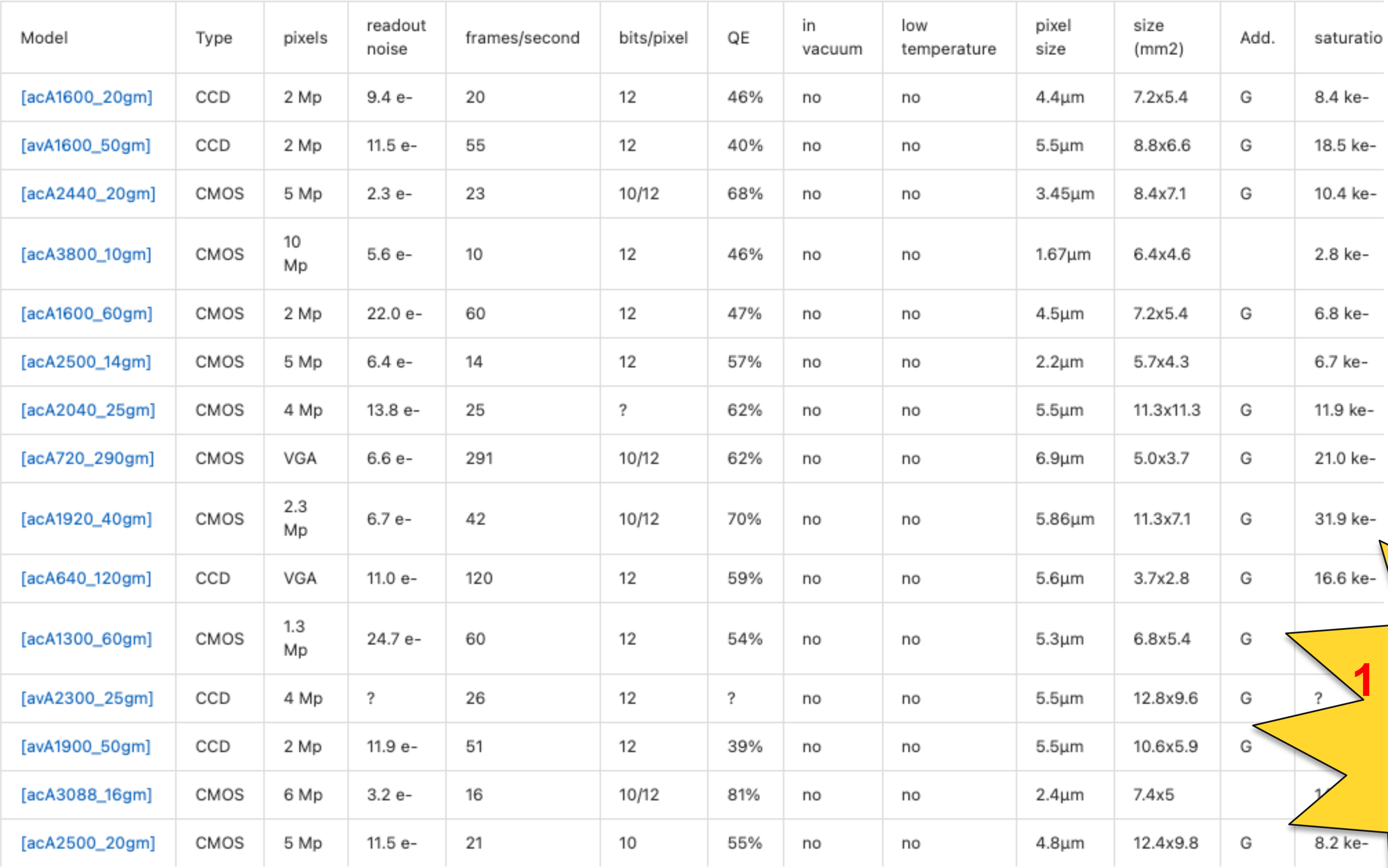
Fast 125MSPS ADC with 10 char els and 16bit resolu diagnostics dete Innovati

ADQ412/ADQ14/ADQ7

High- ed digitizers GSPS to 2 to 14 ces

1 MB/s - 1 GB/s
10 Hz burst

Data Drivers: Commercial Cameras



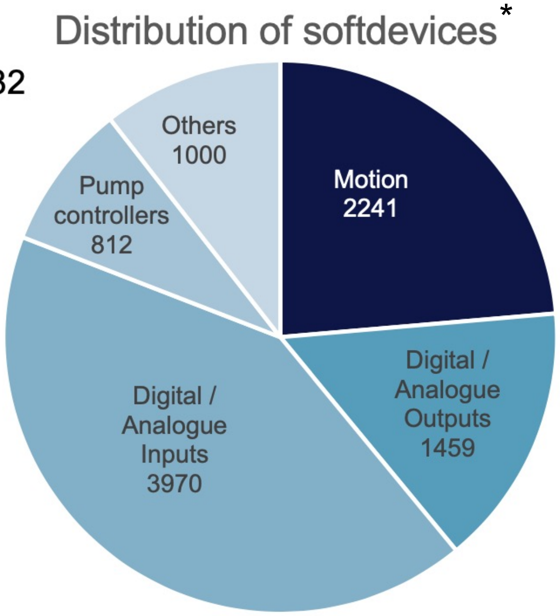
Model	Type	pixels	readout noise	frames/second	bits/pixel	QE	in vacuum	low temperature	pixel size	size (mm2)	Add.	saturatio
[acA1600_20gm]	CCD	2 Mp	9.4 e-	20	12	46%	no	no	4.4µm	7.2x5.4	G	8.4 ke-
[avA1600_50gm]	CCD	2 Mp	11.5 e-	55	12	40%	no	no	5.5µm	8.8x6.6	G	18.5 ke-
[acA2440_20gm]	CMOS	5 Mp	2.3 e-	23	10/12	68%	no	no	3.45µm	8.4x7.1	G	10.4 ke-
[acA3800_10gm]	CMOS	10 Mp	5.6 e-	10	12	46%	no	no	1.67µm	6.4x4.6		2.8 ke-
[acA1600_60gm]	CMOS	2 Mp	22.0 e-	60	12	47%	no	no	4.5µm	7.2x5.4	G	6.8 ke-
[acA2500_14gm]	CMOS	5 Mp	6.4 e-	14	12	57%	no	no	2.2µm	5.7x4.3		6.7 ke-
[acA2040_25gm]	CMOS	4 Mp	13.8 e-	25	?	62%	no	no	5.5µm	11.3x11.3	G	11.9 ke-
[acA720_290gm]	CMOS	VGA	6.6 e-	291	10/12	62%	no	no	6.9µm	5.0x3.7	G	21.0 ke-
[acA1920_40gm]	CMOS	2.3 Mp	6.7 e-	42	10/12	70%	no	no	5.86µm	11.3x7.1	G	31.9 ke-
[acA640_120gm]	CCD	VGA	11.0 e-	120	12	59%	no	no	5.6µm	3.7x2.8	G	16.6 ke-
[acA1300_60gm]	CMOS	1.3 Mp	24.7 e-	60	12	54%	no	no	5.3µm	6.8x5.4	G	[illegible]
[avA2300_25gm]	CCD	4 Mp	?	26	12	?	no	no	5.5µm	12.8x9.6	G	?
[avA1900_50gm]	CCD	2 Mp	11.9 e-	51	12	39%	no	no	5.5µm	10.6x5.9	G	[illegible]
[acA3088_16gm]	CMOS	6 Mp	3.2 e-	16	10/12	81%	no	no	2.4µm	7.4x5		1[illegible]
[acA2500_20gm]	CMOS	5 Mp	11.5 e-	21	10	55%	no	no	4.8µm	12.4x9.8	G	8.2 ke-

1 MB/s - 100 MB/s
10 Hz burst

photo from https://www.avsupply.com/ITM/18888/AVA2300-25GM.html

Data Drivers: PLCs and other “slow“ Data

- Softdevices/Equipment: 9.482
- Number of Terminals: 8.452
- PLC Loops / CPUs: 120
- PLC Modules / crates: >500
- MicroTCA Systems: 35
- Digitizer channels: >280

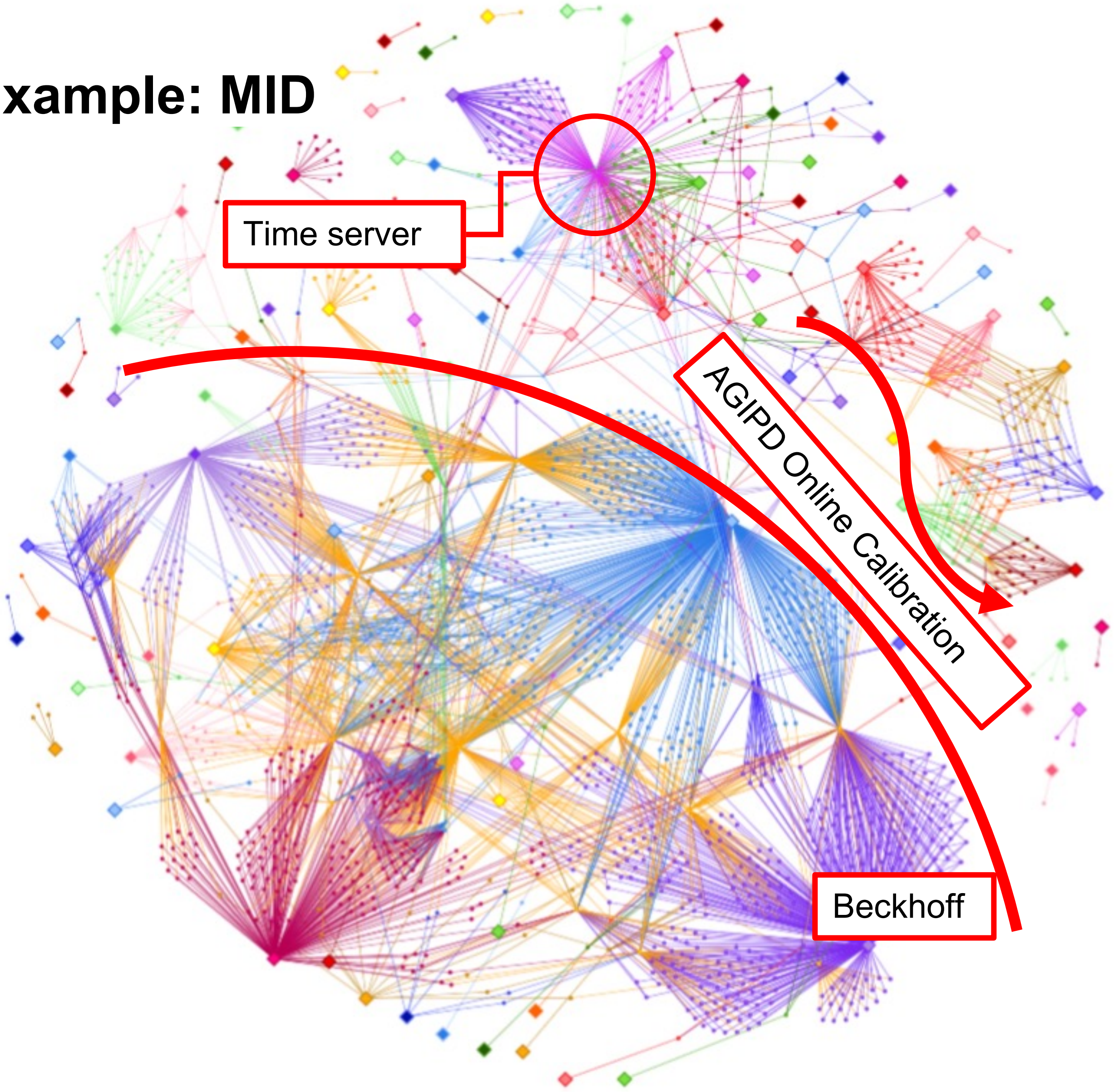


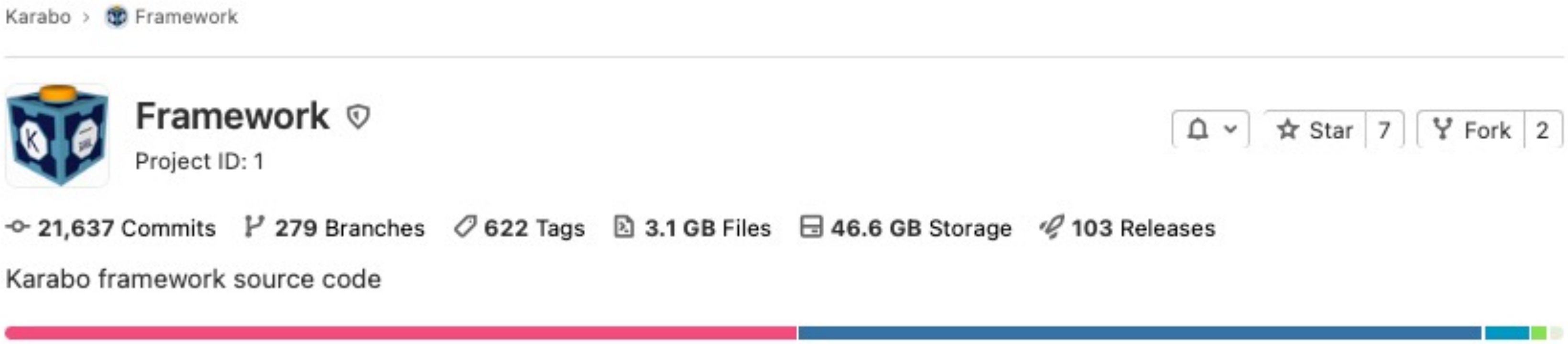
1 B/s - 1 MB/s
event driven

*Status Sept. 2019

Karabo connects them all – Example: MID

- Key features to look out for in all topics:
  - Timeserver: a central communication point for timing information
  - Large Beckhoff loops, often interconnected via middlelayer devices and interlock conditions
  - Processing pipelines, e.g. detector calibration





Karabo › Framework

Framework

Project ID: 1

21,637 Commits 279 Branches 622 Tags 3.1 GB Files 46.6 GB Storage 103 Releases

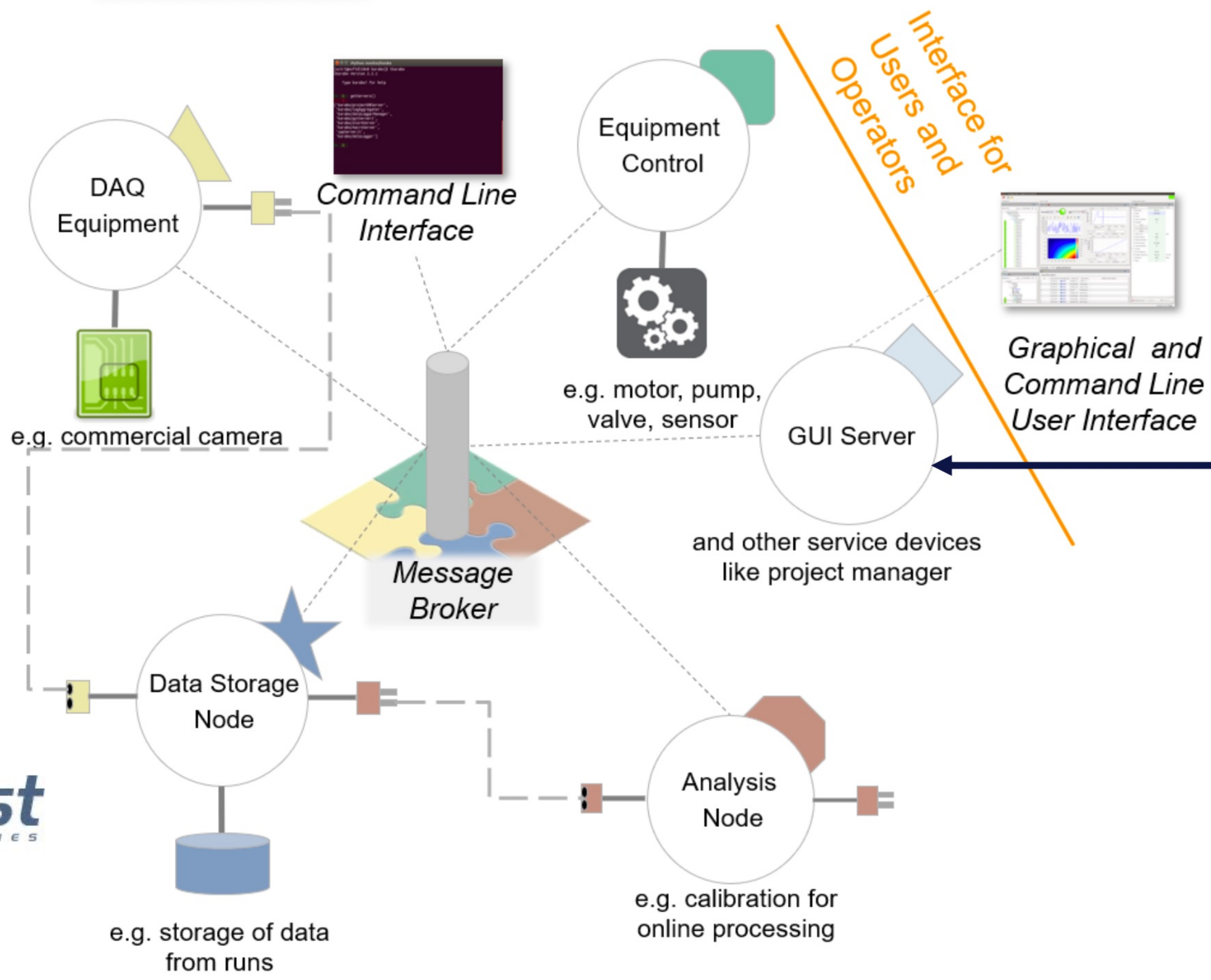
Karabo framework source code

Karabo - A SCADA Framework: Motivation

- 2010/11: Onsite review of control solutions at LCLS, ALBA, DIAMOND, ESRF, PSI, FLASH
  - DAQ (MHz detectors and others)
  - control
  - "slow control" logging
- EPICs channels were not then suited for DAQ
- Tango was in the middle of a concentrate on Java or C++
- —> exflsuite —> **Karabo** is a given name in southern Africa. It means "answer" in SePedi , Sesotho and Setswana

Karabo - A SCADA Framework: Architecture

- Central Message Broker (Control and slow data)
  - Currently: OpenMQ
  - Soon interchangeable: MQTT, RabbitMQ, ...
- Event driven:
  - Data propagates through the system when values change – push not poll
- Message driven:
  - Signal – Slot paradigm
  - Asynchronous core, synchronous convenience in middleware

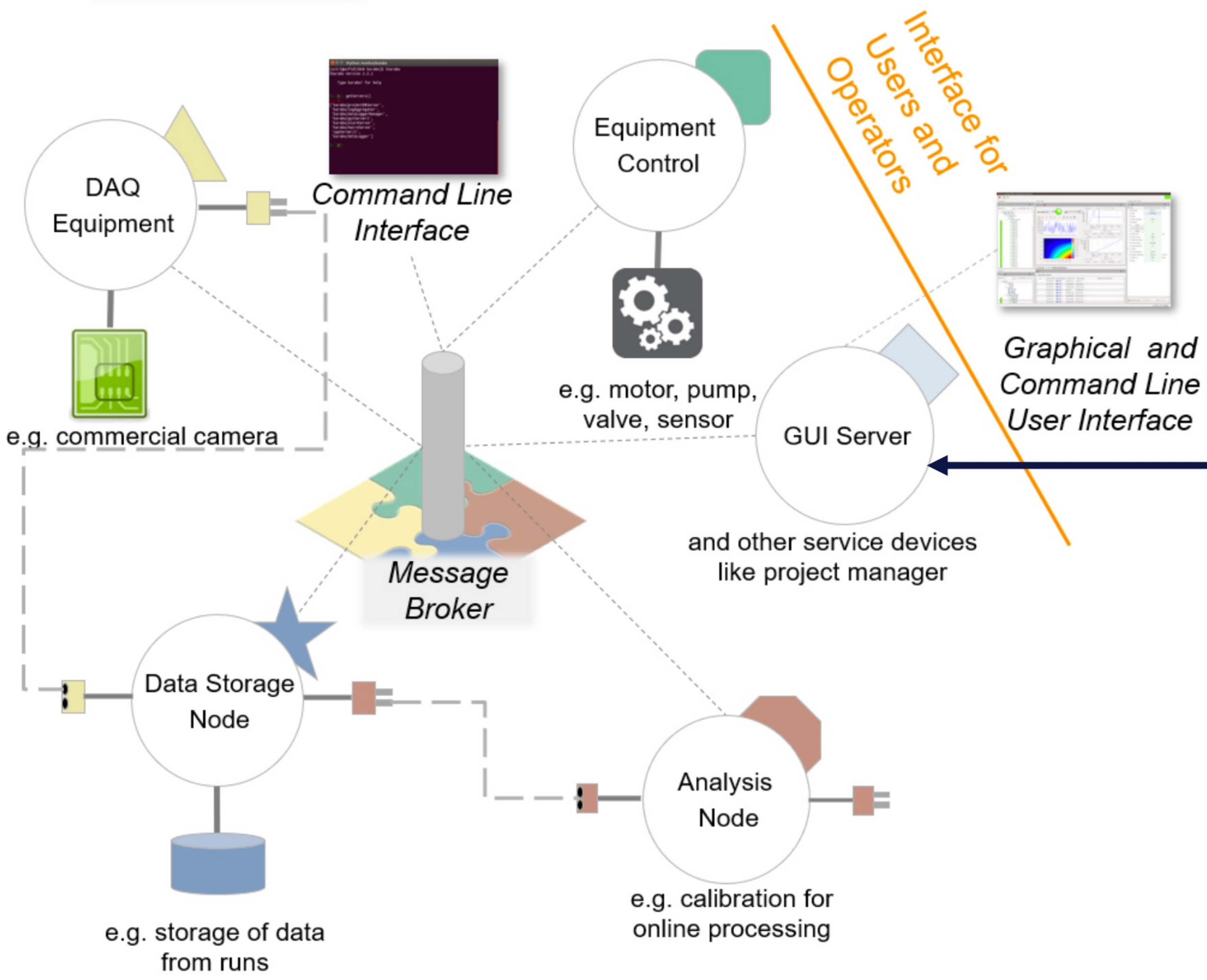

DAQ Equipment
e.g. commercial camera
Command Line Interface
Equipment Control
e.g. motor, pump, valve, sensor
Interface for Users and Operators
Graphical and Command Line User Interface
GUI Server
and other service devices like project manager
Message Broker
Data Storage Node
e.g. storage of data from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

Karabo - A SCADA Framework: Architecture

- pipeline (p2p) connections (scientific/large) data
  - Scatter/Gather/Copy/Distribute
  - Block/Drop on congestion
  - TCP
  - Also GUI Server – GUI client
  - Capable of saturating a 10G line

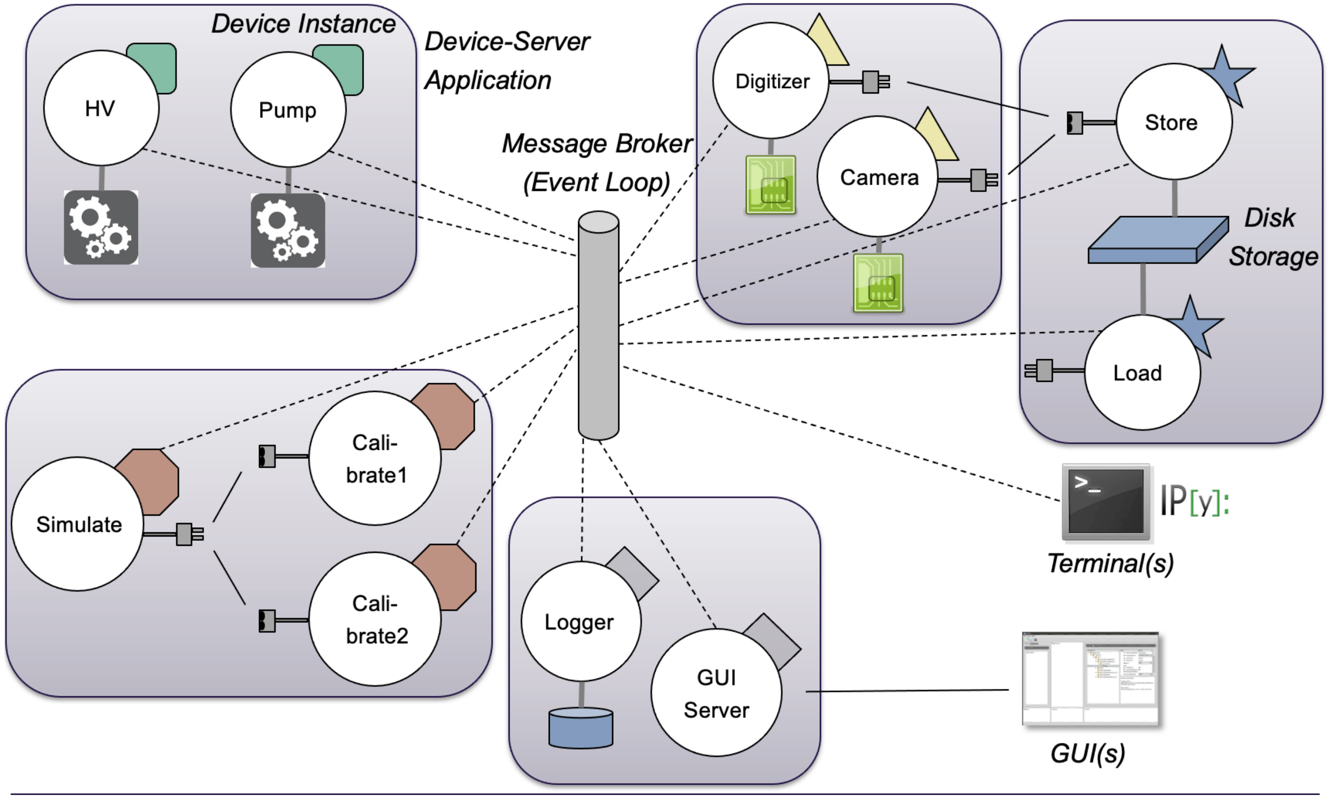
- GUI Server:
  - Gateway to the Control system

- Dynamic, discoverable topology
  - No central database instance


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

Karabo - A SCADA Framework: Architecture

- Context specific extensions (devices) run as plugins in device servers
  - Three extension APIs: C++, two Python flavors
- Device servers run as system services via daemontools
  - Services can be started, stopped, „killed“
  - Rolling text logs
  - Webservice to control services



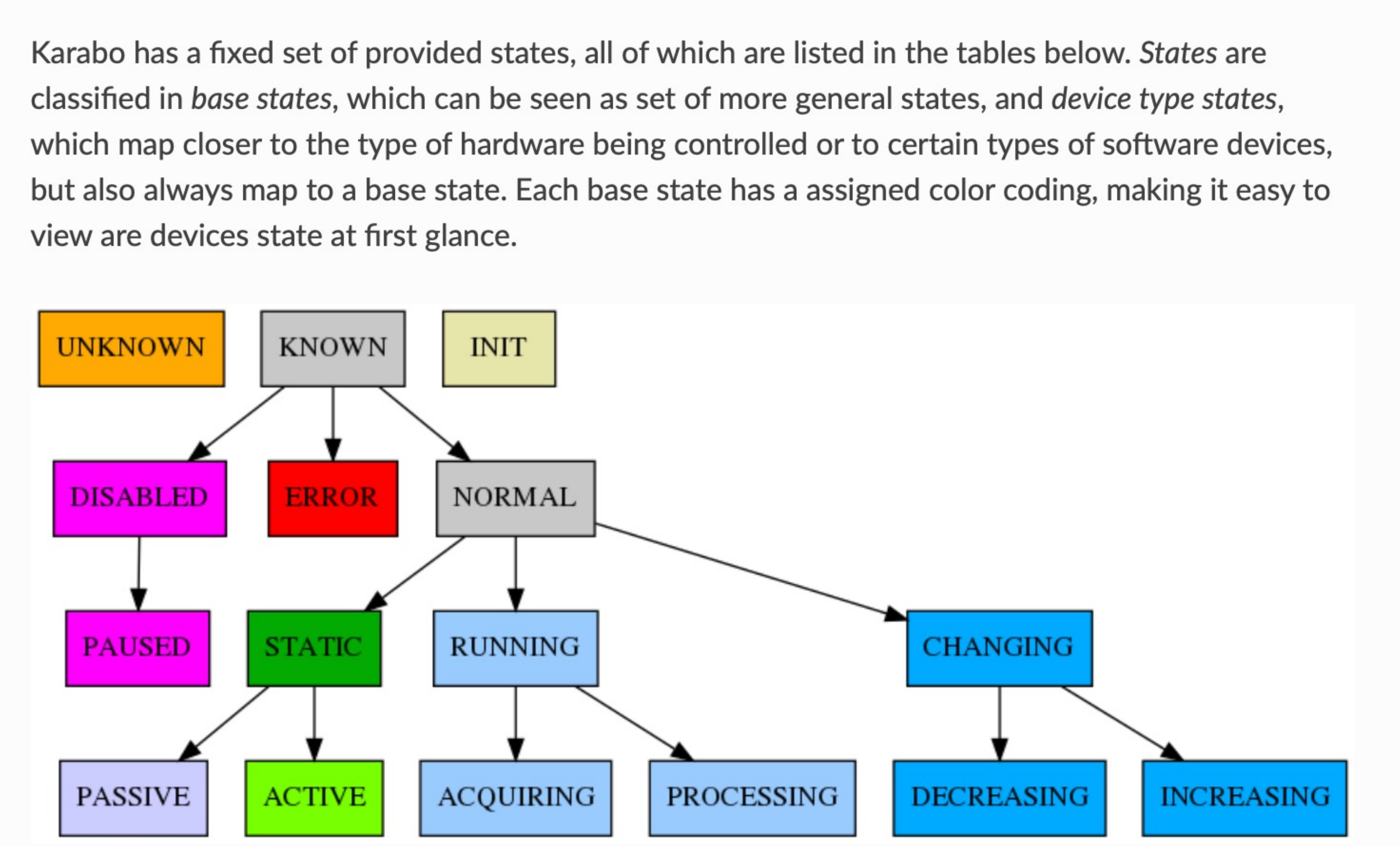
Karabo - A SCADA Framework: Data Types

- Built-In data types that cover most needs for properties to be exposed
- Addionally annotated by attributes, e.g. timestamps, acccess modes, descriptions, bounds, units, magnitudes and alarm thresholds
- Vectors of the POD types
- Composition into nodes and compound types
- Multidimensional data:
  - NDArray
  - Images
  - **Tables**
- **Hash: ordered recursive key-value container with attributes**

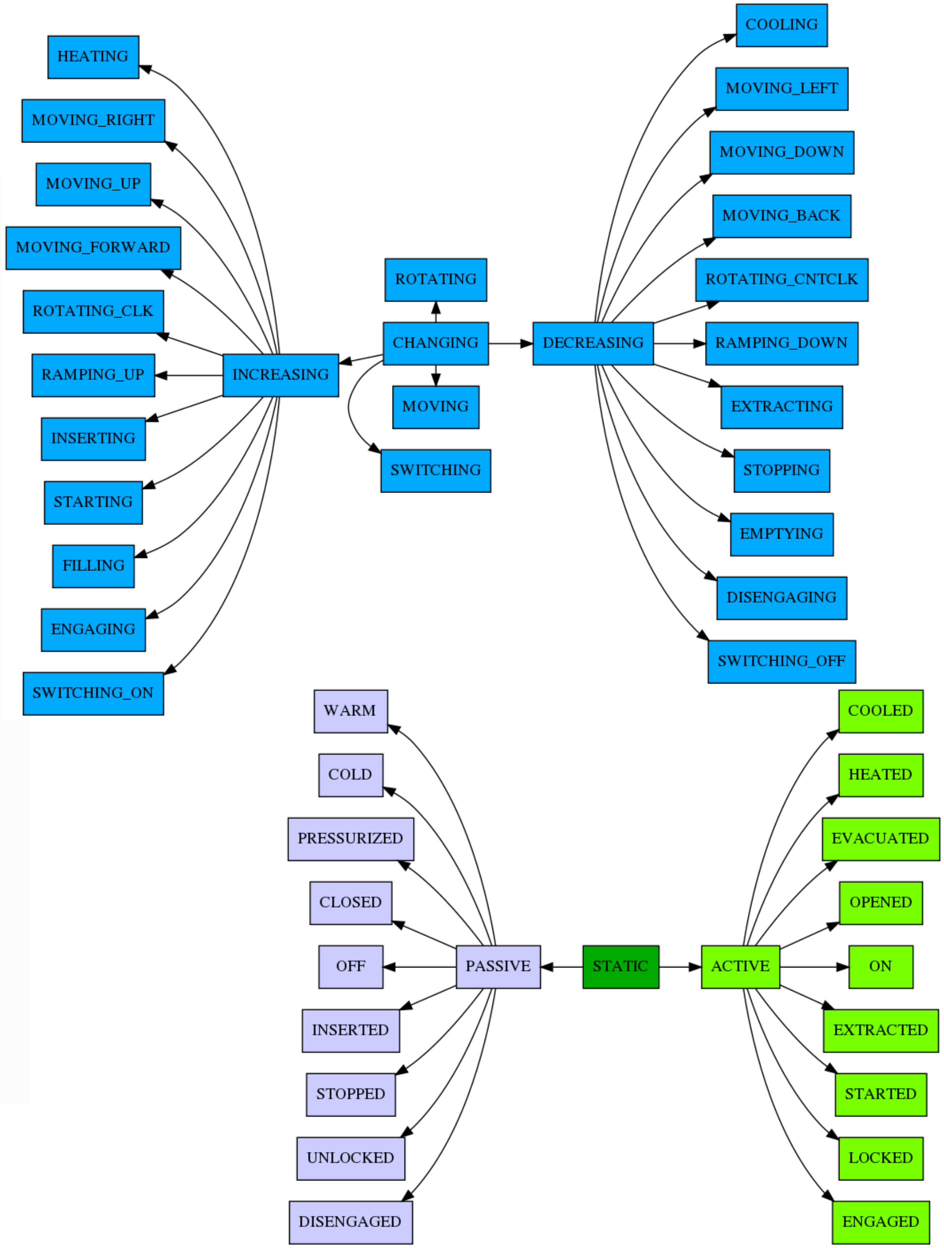
Type	Comments
State	Fixed set of states, see next slide. String repr.
Bool	
Float, Double, Complex	
Signed and Unsigned Integers	8, 16, 32, 64 bit wide
Strings	Support Unicode
Vectors	Of all of the above
Bytearray	
NDArray	Any dimensionality, np.ndarray in Python
Image	Up to 4 dimensional
Table	Cells can be any of the above, GUI supports rendering of non-compound types

XML and binary serialization

Karabo - A SCADA Framework: State Concept



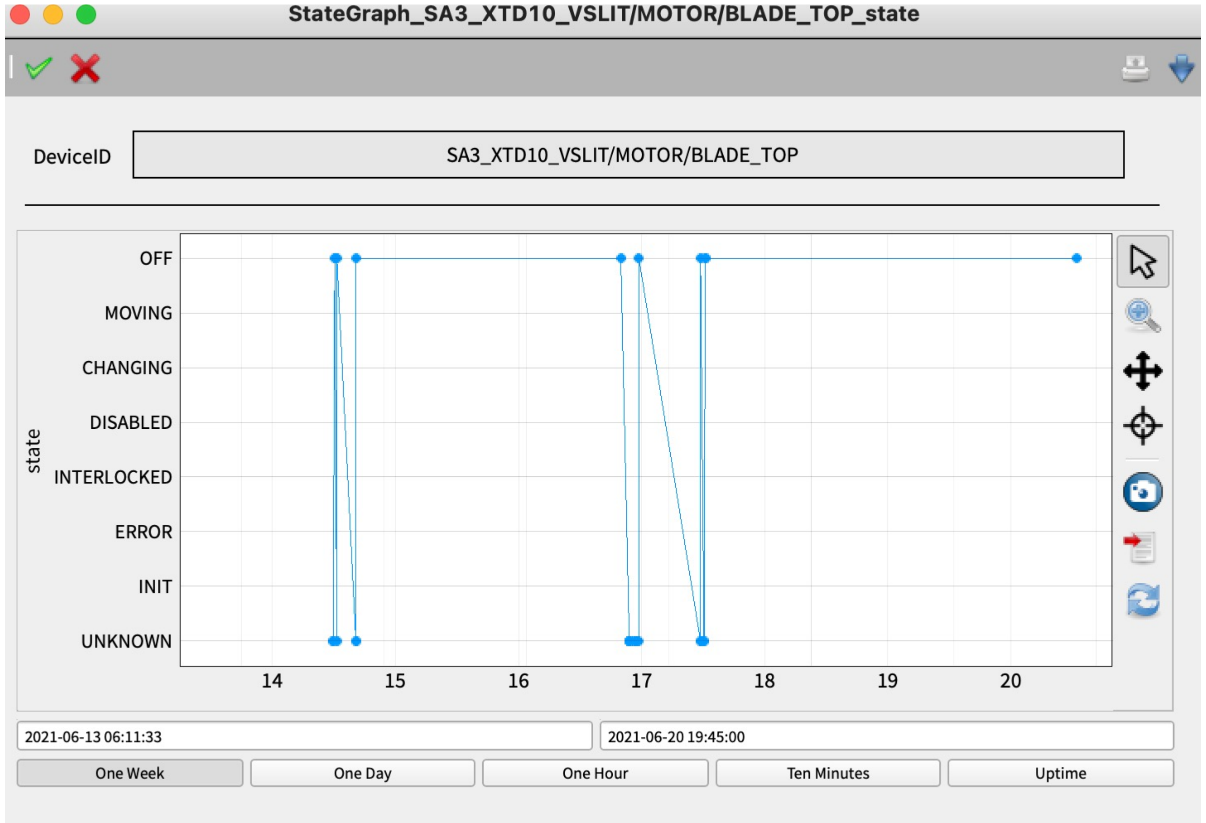
Karabo has a fixed set of provided states, all of which are listed in the tables below. *States* are classified in *base states*, which can be seen as set of more general states, and *device type states*, which map closer to the type of hardware being controlled or to certain types of software devices, but also always map to a base state. Each base state has a assigned color coding, making it easy to view are devices state at first glance.



Karabo - A SCADA Framework: Influx Data Logger

- Datalogging vs. Data Acquisition
  - Datalogging is continous for slow (broker) data
    - ▶ It is done by default
    - ▶ For all devices
    - ▶ Internal data product for maintenence
  - Data Acquisition is „run“ based
    - ▶ Explicitely started
    - ▶ Includes large and fast data
    - ▶ Subselection of slow data
    - ▶ Data product for facility users
- Karabo dataloggers
  - Proprietary text-based format
  - Influx Time-series based

Metrics in Influx: > 240 Billion
Increase per month: ~ 10 Billion

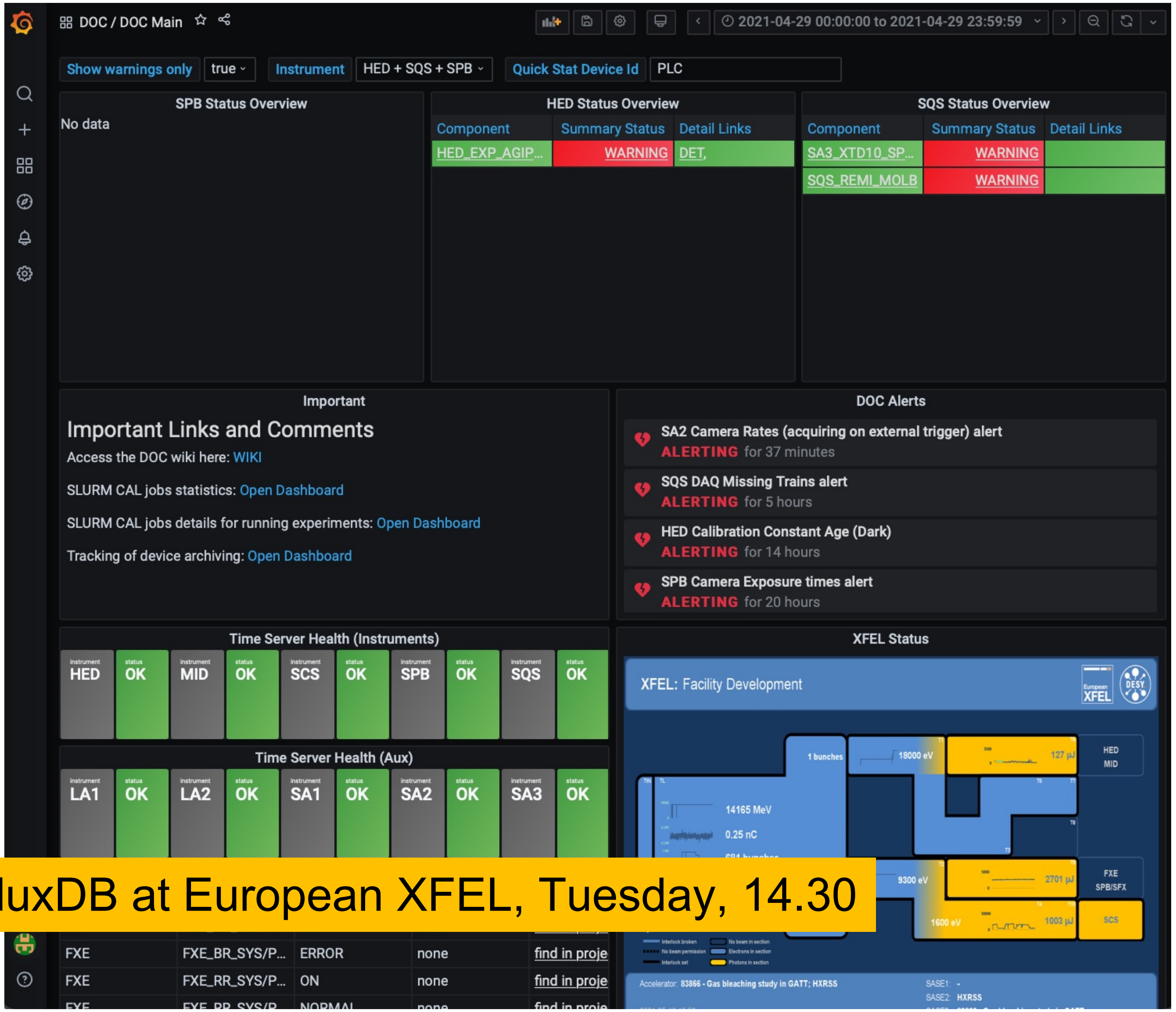

StateGraph_SA3_XTD10_VSLIT/MOTOR/BLADE_TOP_state

DeviceID: SA3_XTD10_VSLIT/MOTOR/BLADE_TOP

2021-06-13 06:11:33 2021-06-20 19:45:00

Karabo - A SCADA Framework: Influx Data Logger

DATA SUPPORT
98089
X-RAY
X-RAY
24
23
6
7
12
24
23
6
7
12
Data Operation Center
* X-ray operation issues
* Urgent problems (MPS, VAC.)
Not for new integration requests and other non-immediate requests
Data Run Coordinator
* Urgent problems (MPS, VAC.)
Not for new integration requests and other non-immediate requests



SPB Status Overview

No data

HED Status Overview

Component	Summary Status	Detail Links
HED_EXP_AGIP...	WARNING	DET,

SQS Status Overview

Component	Summary Status	Detail Links
SA3_XTD10_SP...	WARNING	
SQS_REMI_MOLB	WARNING	

Important

Important Links and Comments

Access the DOC wiki here: WIKI

SLURM CAL jobs statistics: Open Dashboard

SLURM CAL jobs details for running experiments: Open Dashboard

Tracking of device archiving: Open Dashboard

DOC Alerts

SA2 Camera Rates (acquiring on external trigger) alert
ALERTING for 37 minutes

SQS DAQ Missing Trains alert
ALERTING for 5 hours

HED Calibration Constant Age (Dark)
ALERTING for 14 hours

SPB Camera Exposure times alert
ALERTING for 20 hours

Time Server Health (Instruments)

instrument	status	instrument	status	instrument	status	instrument	status	instrument	status
HED	OK	MID	OK	SCS	OK	SPB	OK	SQS	OK

Time Server Health (Aux)

instrument	status	instrument	status	instrument	status	instrument	status	instrument	status
LA1	OK	LA2	OK	SA1	OK	SA2	OK	SA3	OK

FXE	FXE_BR_SYS/P...	ERROR	none	find in proje
FXE	FXE_RR_SYS/P...	ON	none	find in proje
FXE	FXE_RR_SYS/P...	NORMAL	none	find in proje

XFEL Status

Accelerator: 83866 - Gas bleaching study in GATT; HXRSS

SASE1: -

SASE2: HXRSS

See G. Flucke: Experiences with Datalogging to InfluxDB at European XFEL, Tuesday, 14.30

Karabo - A SCADA Framework: Framework Design

General	C++ API	Python Bound API	Middlelayer API
• Event driven • Asynchronous • Self-descriptive • Common, hierarchic data container supporting attributes on leafs: Karabo Hash • Binary and XML serialization • Extensible: core + “Devices“	• C++14 and Boost • Smart pointers • Template-heavy • Boost.asio • Eventloop based • Devices are threads on a single server • Aimed at high-performance devices	• Exposes C++ API via Boost.Python • Devices are separate processes • Was aimed at p2p heavy devices which e.g. need numpy • Not always pythonic	• Python asyncio • Decorators annotate Karabo structures • Emphasis on interaction with other devices • Pythonic

Karabo - A SCADA Framework: Framework Design - C++ API

General

- Event driven
- Asynchronous
- Self-descriptive
- Common, hierarchic data container supporting attributes on leafs: Karabo Hash
- Extensible: core + “Devices“

C++ API

- C++14 and Boost
- Smart pointers
- Template-heavy
- Boost.asio
- Eventloop based
- Devices are threads on a single server
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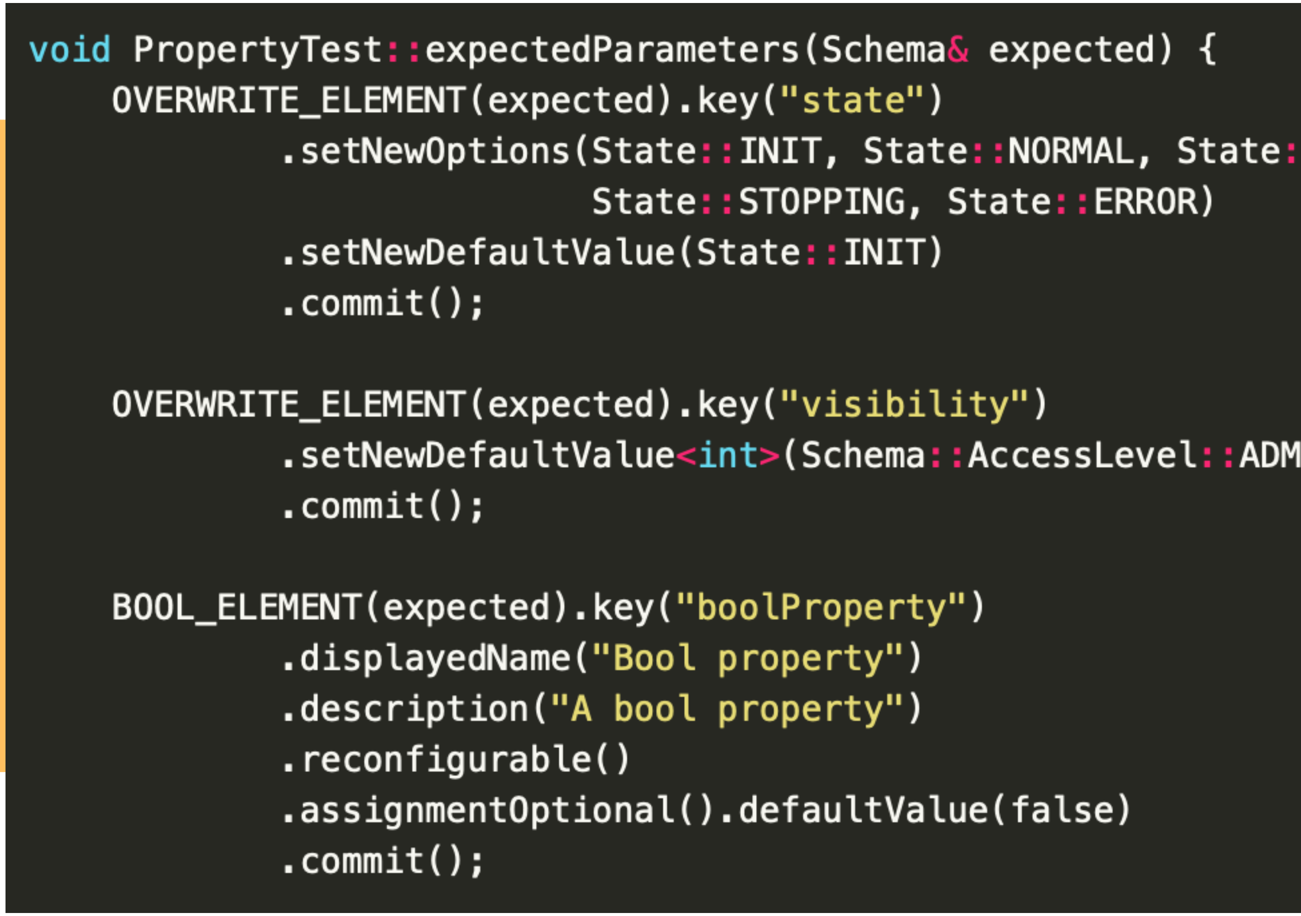


```
void PropertyTest::expectedParameters(Schema& expected) {
    OVERWRITE_ELEMENT(expected).key("state")
            .setNewOptions(State::INIT, State::NORMAL, State:
                           State::STOPPING, State::ERROR)
            .setNewDefaultValue(State::INIT)
            .commit();

    OVERWRITE_ELEMENT(expected).key("visibility")
            .setNewDefaultValue<int>(Schema::AccessLevel::ADM
            .commit();

    BOOL_ELEMENT(expected).key("boolProperty")
            .displayedName("Bool property")
            .description("A bool property")
            .reconfigurable()
            .assignmentOptional().defaultValue(false)
            .commit();
```

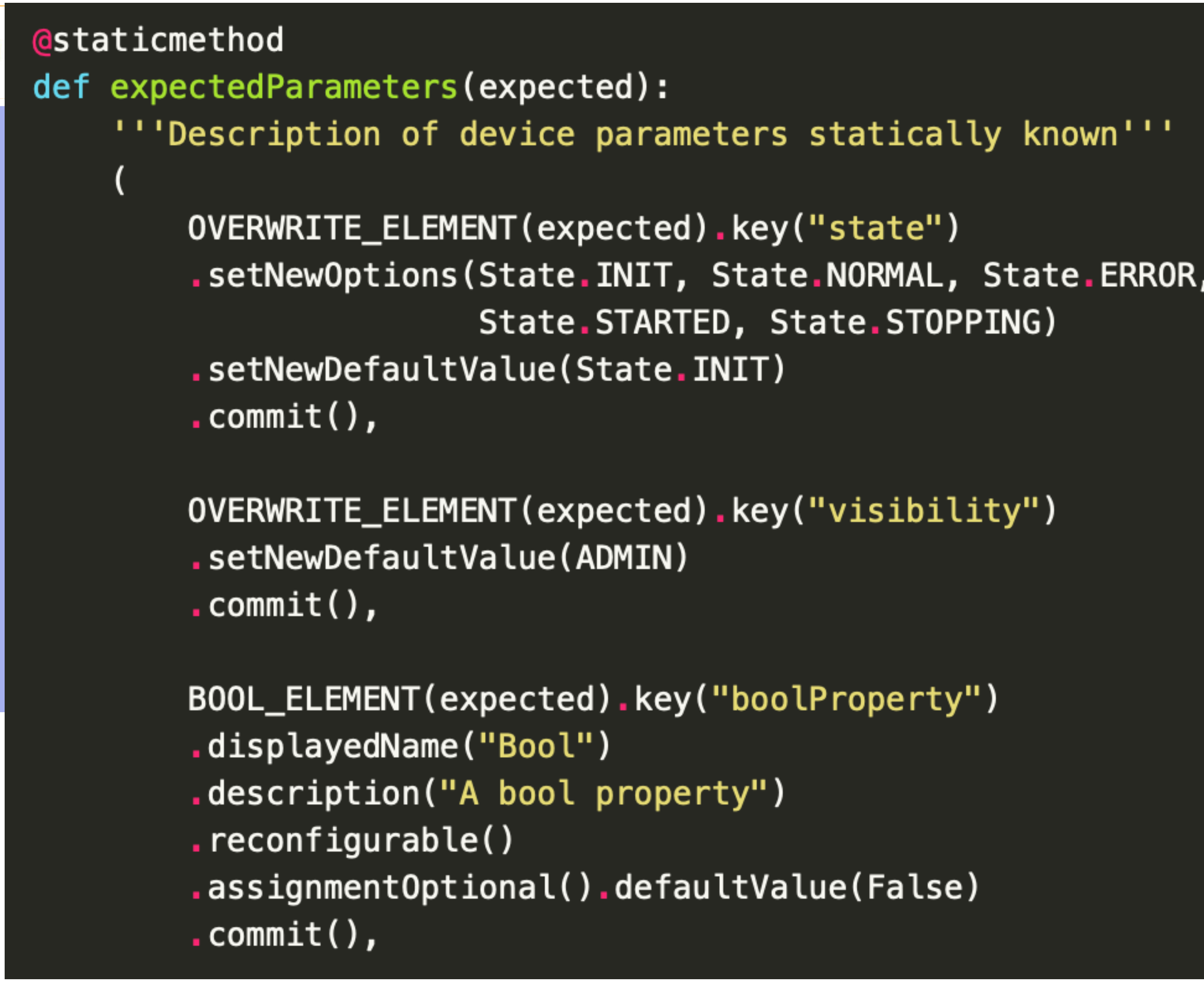
Karabo - A SCADA Framework: Framework Design – Python Bound API

General

- Event driven
- Asynchronous
- Self-descriptive
- Common, hierarchic data container supporting attributes on leafs: Karabo Hash
- Extensible: core + “Devices“

Python Bound API

- Exposes C++ API via Boost.Python
- Devices are separate processes
- Was aimed at p2p heavy devices which e.g. need numpy
- Not always pythonic



```
@staticmethod
def expectedParameters(expected):
    '''Description of device parameters statically known'''
    (
        OVERWRITE_ELEMENT(expected).key("state")
        .setNewOptions(State.INIT, State.NORMAL, State.ERROR
                       State.STARTED, State.STOPPING)
        .setNewDefaultValue(State.INIT)
        .commit(),

        OVERWRITE_ELEMENT(expected).key("visibility")
        .setNewDefaultValue(ADMIN)
        .commit(),

        BOOL_ELEMENT(expected).key("boolProperty")
        .displayedName("Bool")
        .description("A bool property")
        .reconfigurable()
        .assignmentOptional().defaultValue(False)
        .commit(),
```

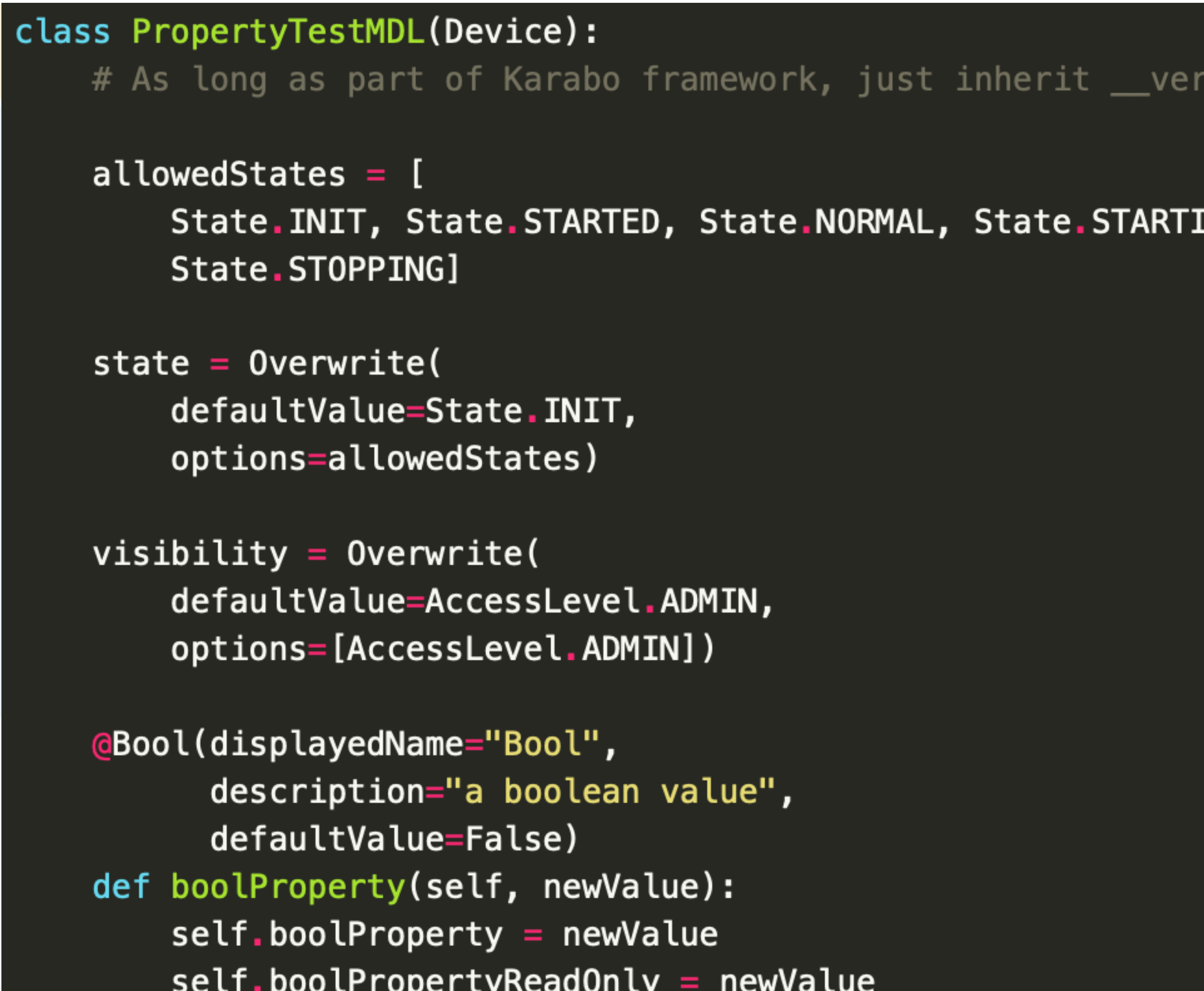
Karabo - A SCADA Framework: Framework Design – Python Middlelayer API

General

- Event driven
- Asynchronous
- Self-descriptive
- Common, hierarchic data container supporting attributes on leafs: Karabo Hash
- Extensible: core + “Devices“

Middlelayer API

- Python asyncio
- Decorators annotate Karabo structures
- Emphasis on interaction with other devices: **proxies**
- Pythonic



```
class PropertyTestMDL(Device):
    # As long as part of Karabo framework, just inherit __ver

    allowedStates = [
        State.INIT, State.STARTED, State.NORMAL, State.STARTI
        State.STOPPING]

    state = Overwrite(
        defaultValue=State.INIT,
        options=allowedStates)

    visibility = Overwrite(
        defaultValue=AccessLevel.ADMIN,
        options=[AccessLevel.ADMIN])

    @Bool(displayedName="Bool",
          description="a boolean value",
          defaultValue=False)
    def boolProperty(self, newValue):
        self.boolProperty = newValue
        self.boolPropertyReadOnly = newValue
```

Karabo - A SCADA Framework: Framework Design – Python Middlelayer API

General

- Event driven
- Asynchronous
- Self-descriptive
- Common, hierarchic data container supporting attributes on leafs: Karabo Hash
- Extensible: core + “Devices“

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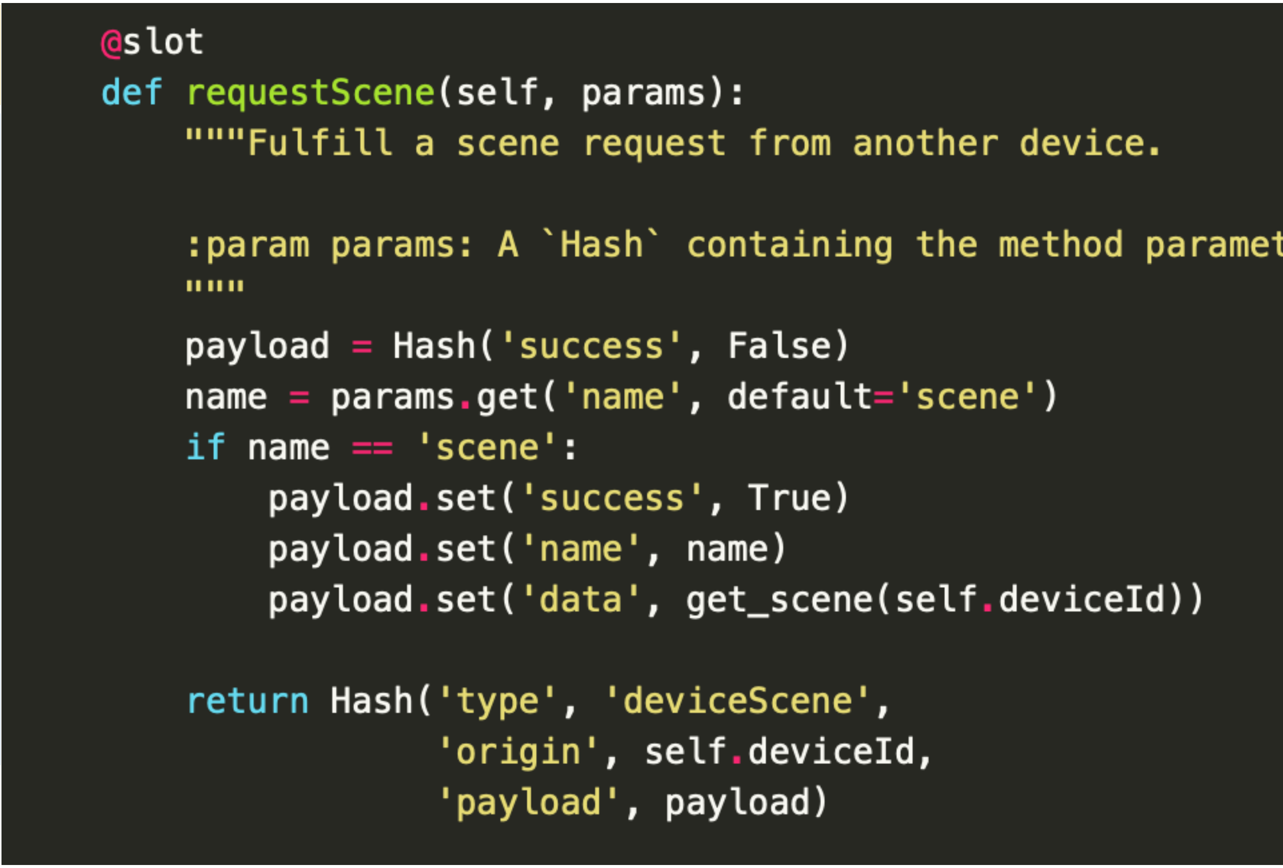

```
@slot
def requestScene(self, params):
    """Fulfill a scene request from another device.

    :param params: A `Hash` containing the method paramet
    """
    payload = Hash('success', False)
    name = params.get('name', default='scene')
    if name == 'scene':
        payload.set('success', True)
        payload.set('name', name)
        payload.set('data', get_scene(self.deviceId))

    return Hash('type', 'deviceScene',
                'origin', self.deviceId,
                'payload', payload)
```

Karabo - A SCADA Framework: Framework Design – Python Middlelayer API

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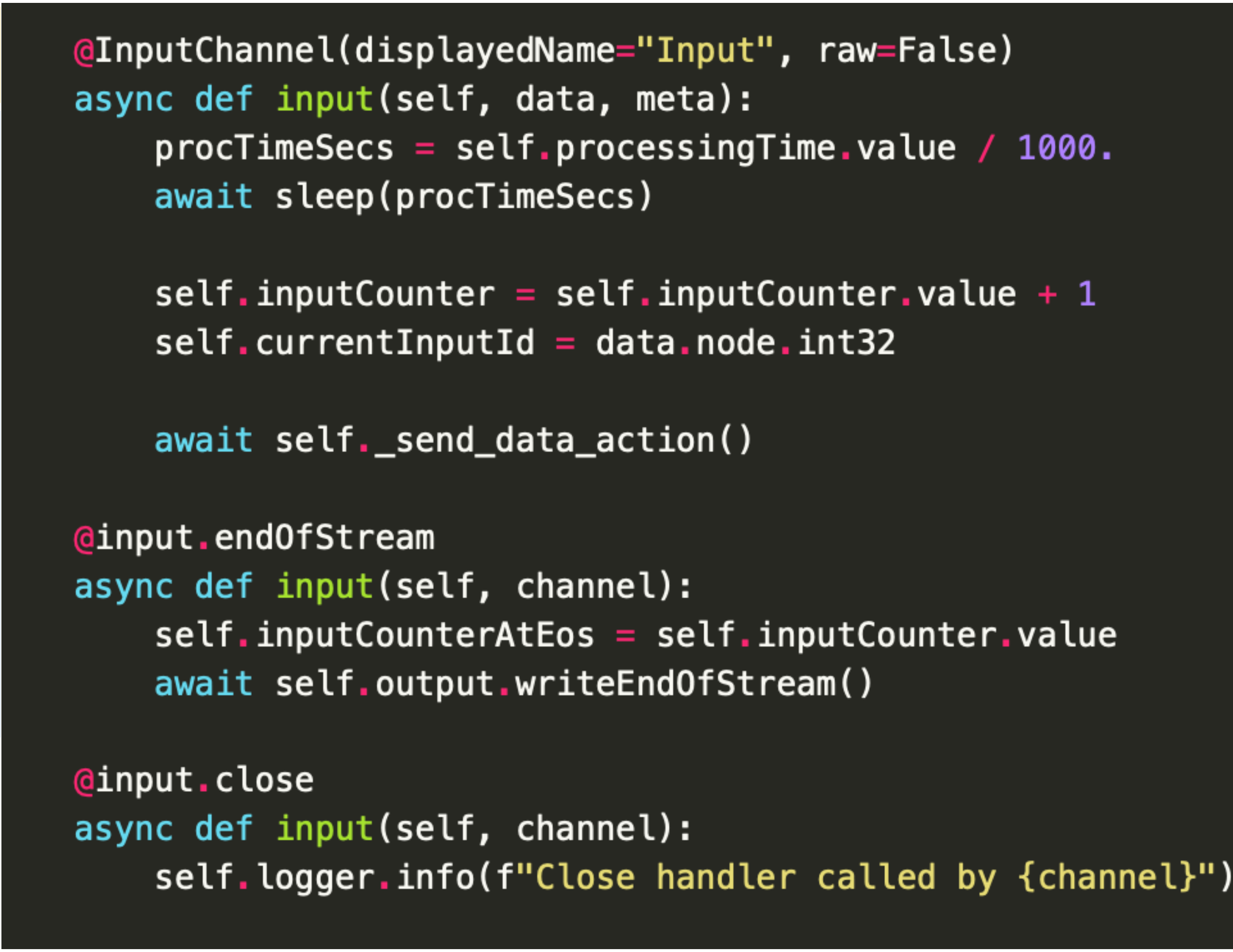

```
@InputChannel(displayedName="Input", raw=False)
async def input(self, data, meta):
    procTimeSecs = self.processingTime.value / 1000.
    await sleep(procTimeSecs)

    self.inputCounter = self.inputCounter.value + 1
    self.currentInputId = data.node.int32

    await self._send_data_action()

@input.endOfStream
async def input(self, channel):
    self.inputCounterAtEos = self.inputCounter.value
    await self.output.writeEndOfStream()

@input.close
async def input(self, channel):
    self.logger.info(f"Close handler called by {channel}")
```

Karabo - A SCADA Framework: Framework Design – Python Middlelayer API

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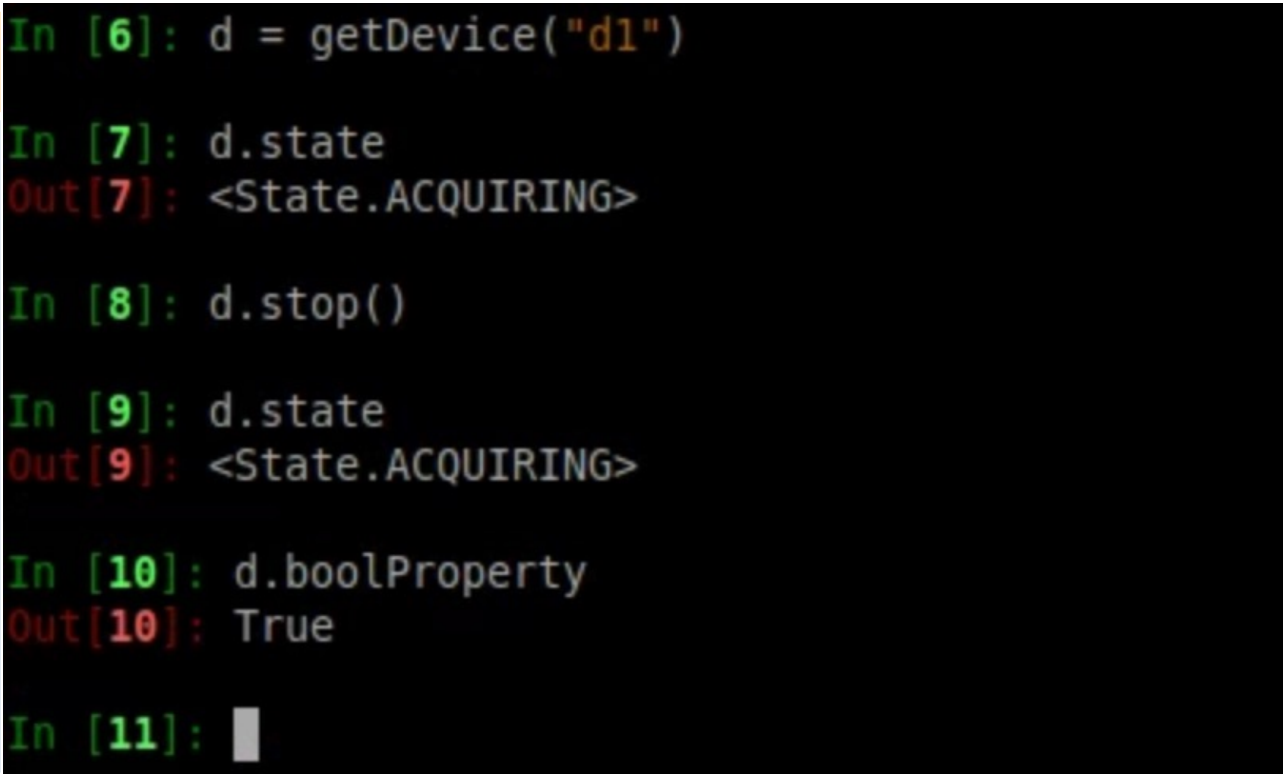
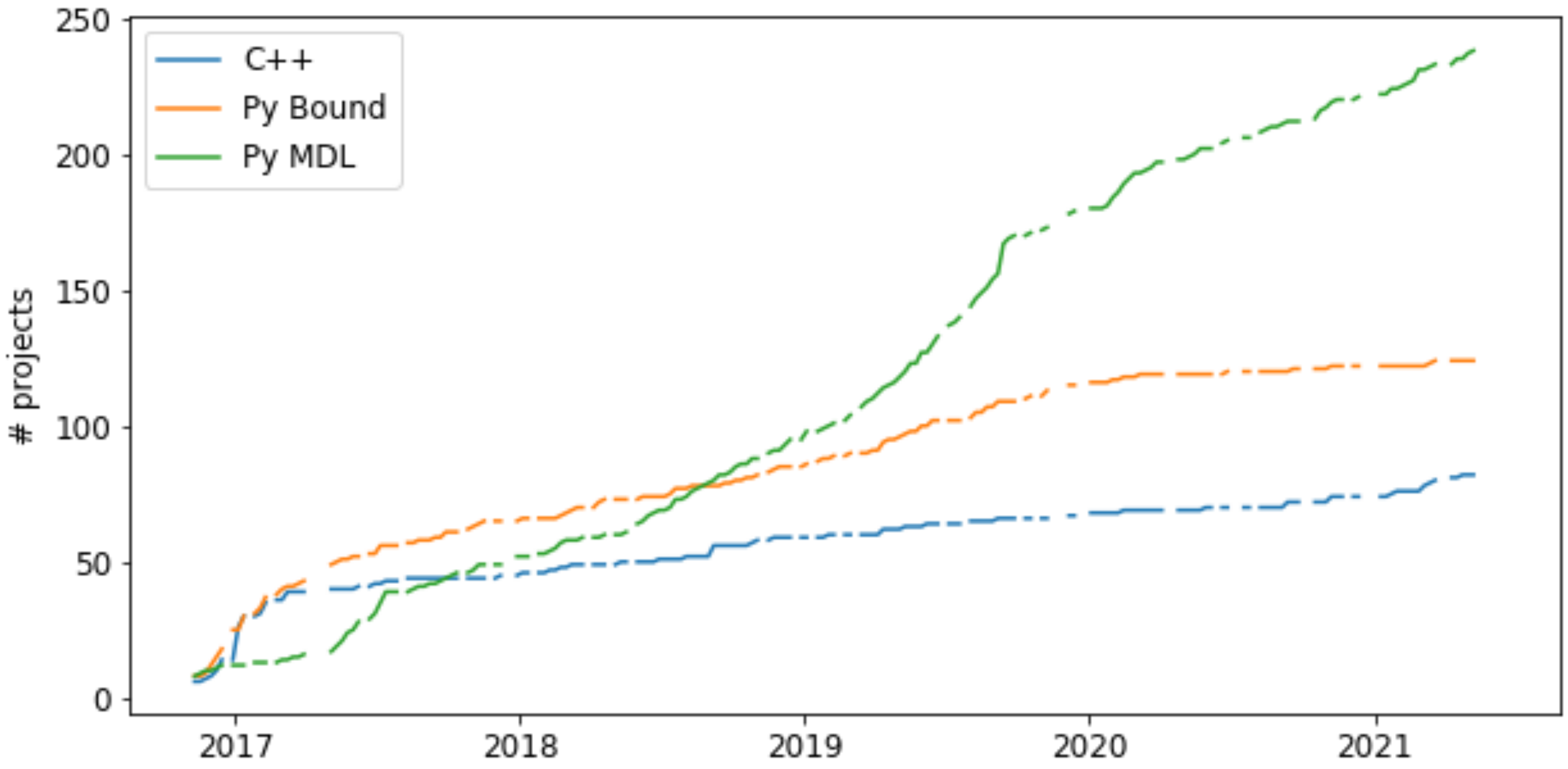
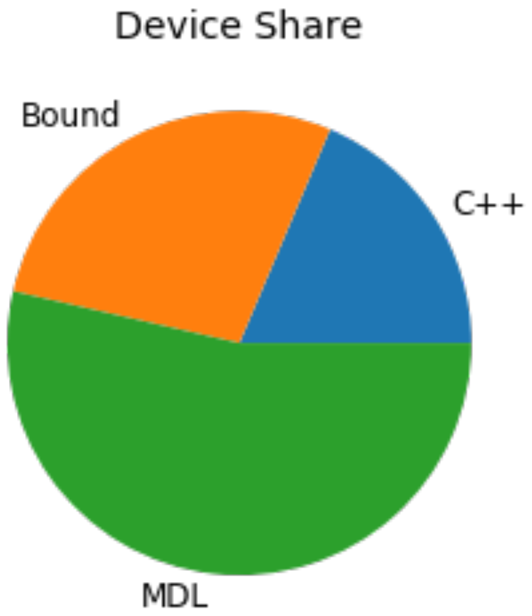
- Emphasis on interaction with other devices: **proxies**
- Pythonic



```
In [6]: d = getDevice("d1")

In [7]: d.state
Out[7]: <State.ACQUIRING>

In [8]: d.stop()

In [9]: d.state
Out[9]: <State.ACQUIRING>

In [10]: d.boolProperty
Out[10]: True

In [11]: 
```

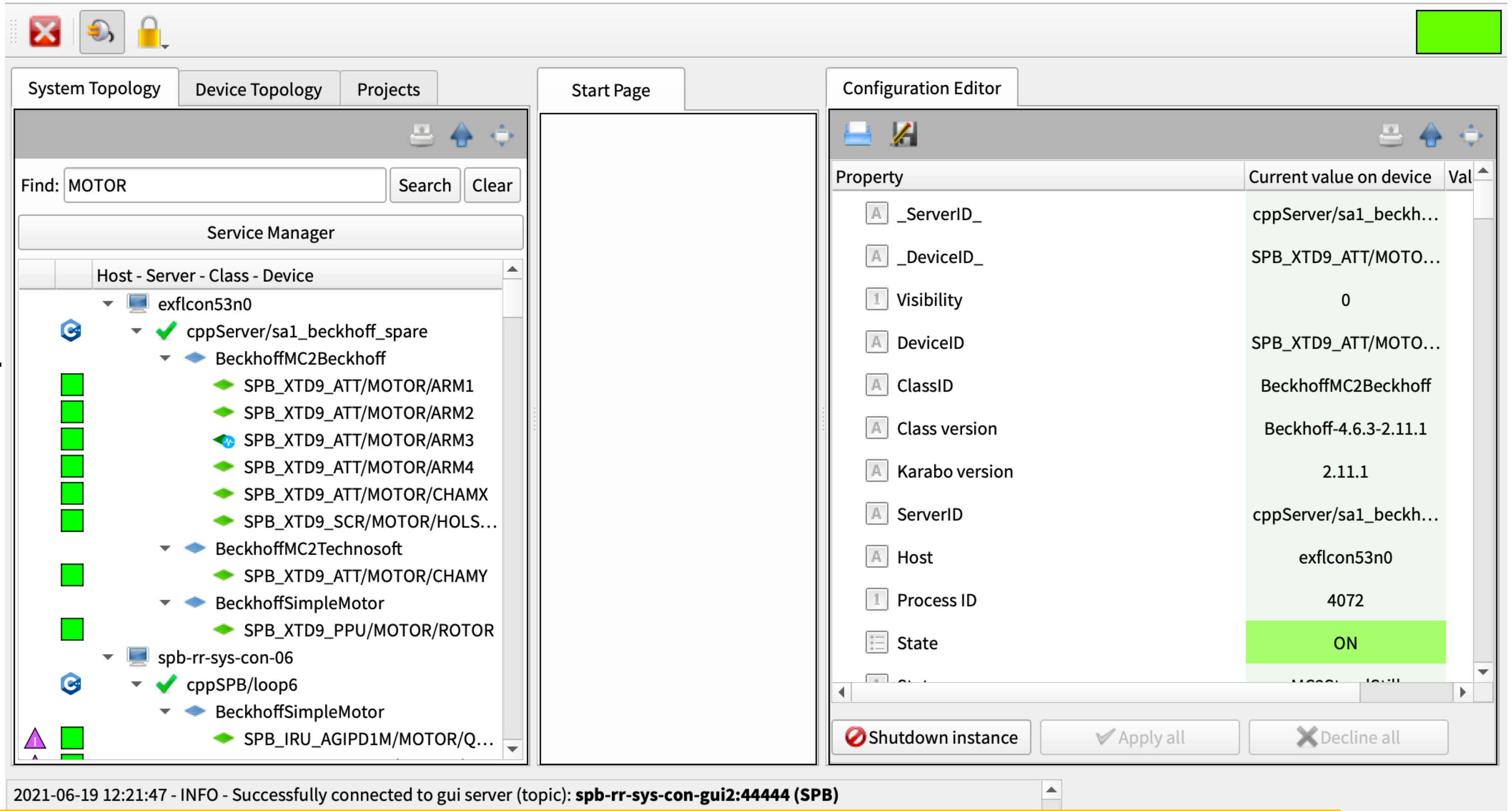
The Karabo Ecosystem – Usage of the three APIs





The Karabo GUI

- Separate Python Package, well matched to the framework
- PyQt5
- Connects to Karabo via the GUI-server (tcp, p2p)
- Extensible via „gui-extensions“
- **Distinguishing feature: GUI scene builder**



Find: MOTOR

Host - Server - Class - Device

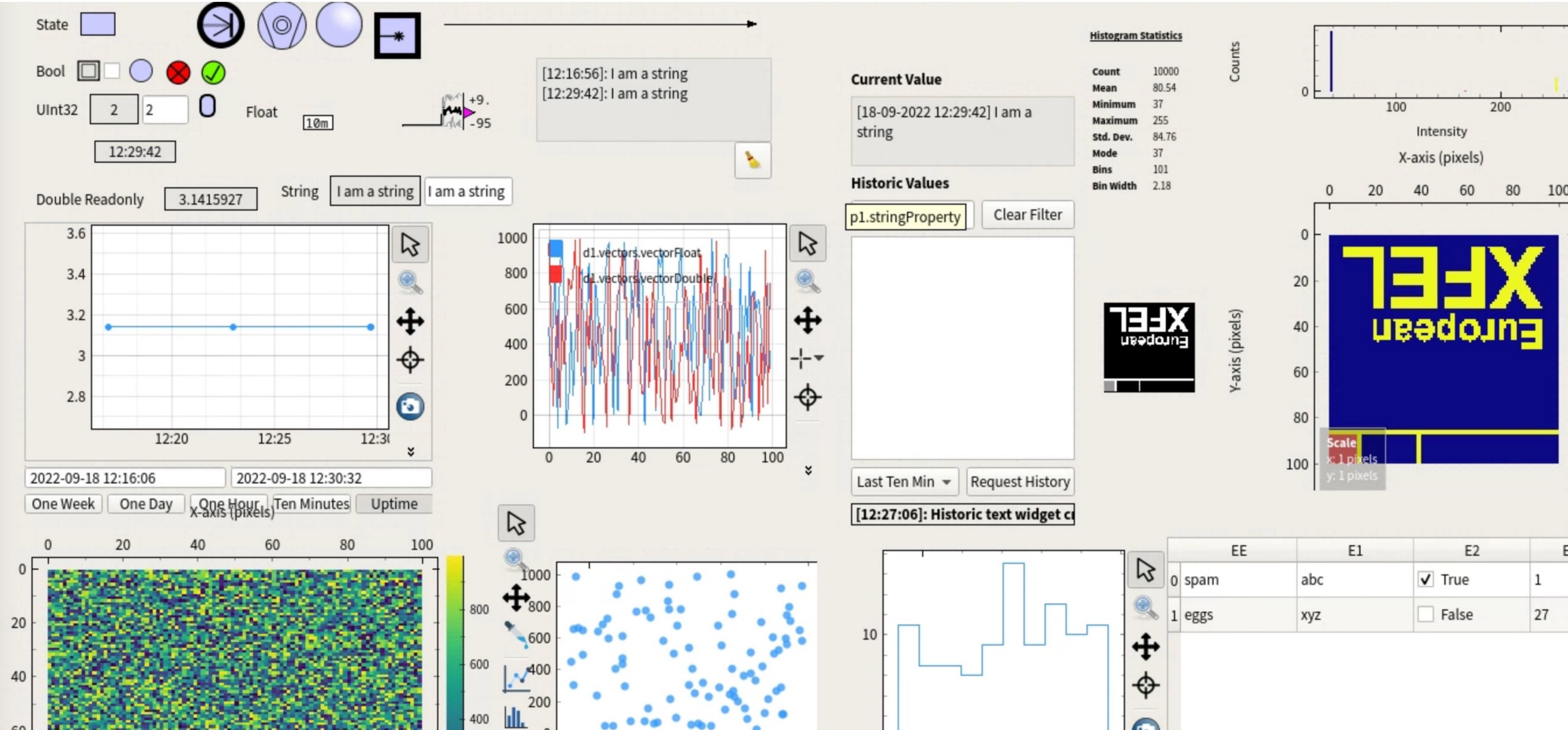
- exflcon53n0
  - cppServer/sa1_beckhoff_spare
    - BeckhoffMC2Beckhoff
      - 🟩 SPB_XTD9_ATT/MOTOR/ARM1
      - 🟩 SPB_XTD9_ATT/MOTOR/ARM2
      - 🟩 SPB_XTD9_ATT/MOTOR/ARM3
      - 🟩 SPB_XTD9_ATT/MOTOR/ARM4
      - 🟩 SPB_XTD9_ATT/MOTOR/CHAMX
      - 🟩 SPB_XTD9_SCR/MOTOR/HOLS...
    - BeckhoffMC2Technosoft
      - 🟩 SPB_XTD9_ATT/MOTOR/CHAMY
    - BeckhoffSimpleMotor
      - 🟩 SPB_XTD9_PPU/MOTOR/ROTOR
- spb-rr-sys-con-06
  - cppSPB/loop6
    - BeckhoffSimpleMotor
      - 🟩 SPB_IRU_AGIPD1M/MOTOR/Q...

Property	Current value on device	Val
ServerID	cppServer/sa1_beckh...	
DeviceID	SPB_XTD9_ATT/MOTO...	
Visibility	0	
DeviceID	SPB_XTD9_ATT/MOTO...	
ClassID	BeckhoffMC2Beckhoff	
Class version	Beckhoff-4.6.3-2.11.1	
Karabo version	2.11.1	
ServerID	cppServer/sa1_beckh...	
Host	exflcon53n0	
Process ID	4072	
State	ON	

```
2021-06-19 12:21:47 - INFO - Successfully connected to gui server (topic): spb-rr-sys-con-gui2:44444 (SPB)
```

See D. Göries: KaraboGui - The Cockpit of the Supervisory Control and Data Acquisition System Karabo at the Tuesday poster session

The Karabo GUI – Scenes & Widgets



State

Bool

UInt32 2 2

Float 10m

12:29:42

Double Readonly 3.1415927

String I am a string I am a string

[12:16:56]: I am a string
[12:29:42]: I am a string

Current Value

[18-09-2022 12:29:42] I am a string

Historic Values

p1.stringProperty Clear Filter

Last Ten Min Request History

[12:27:06]: Historic text widget cr

Histogram Statistics

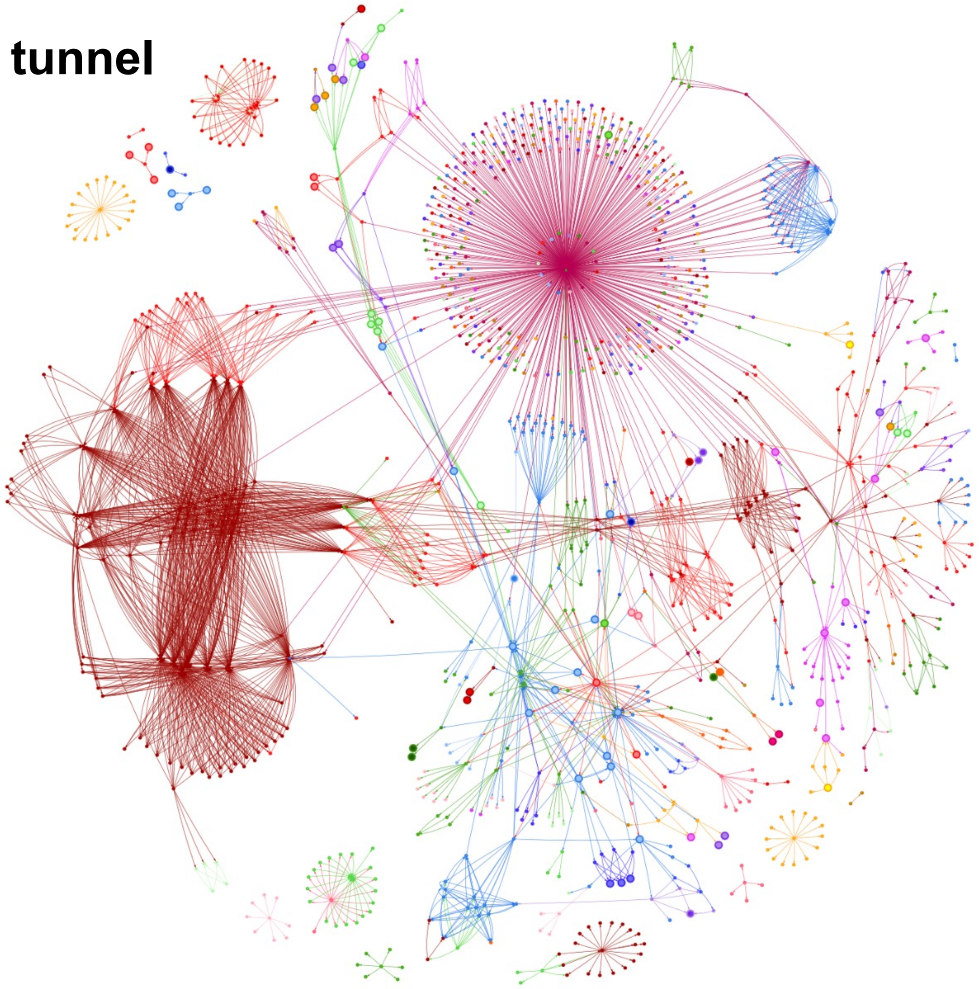
Count	10000
Mean	80.54
Minimum	37
Maximum	255
Std. Dev.	84.76
Mode	37
Bins	101
Bin Width	2.18

2022-09-18 12:16:06 2022-09-18 12:30:32

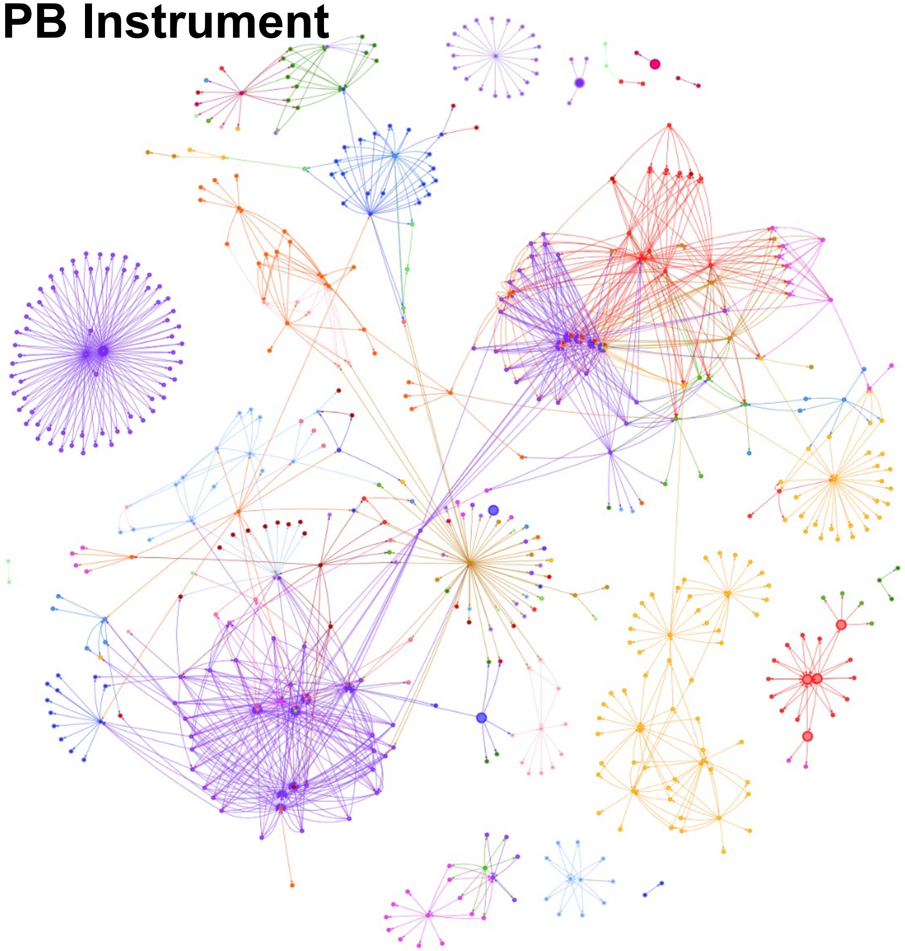
	EE	E1	E2	E
0	spam	abc	☑ True	1
1	eggs	xyz	☐ False	27

Karabo GUI – Scenes as Synoptics – Links between Scenes

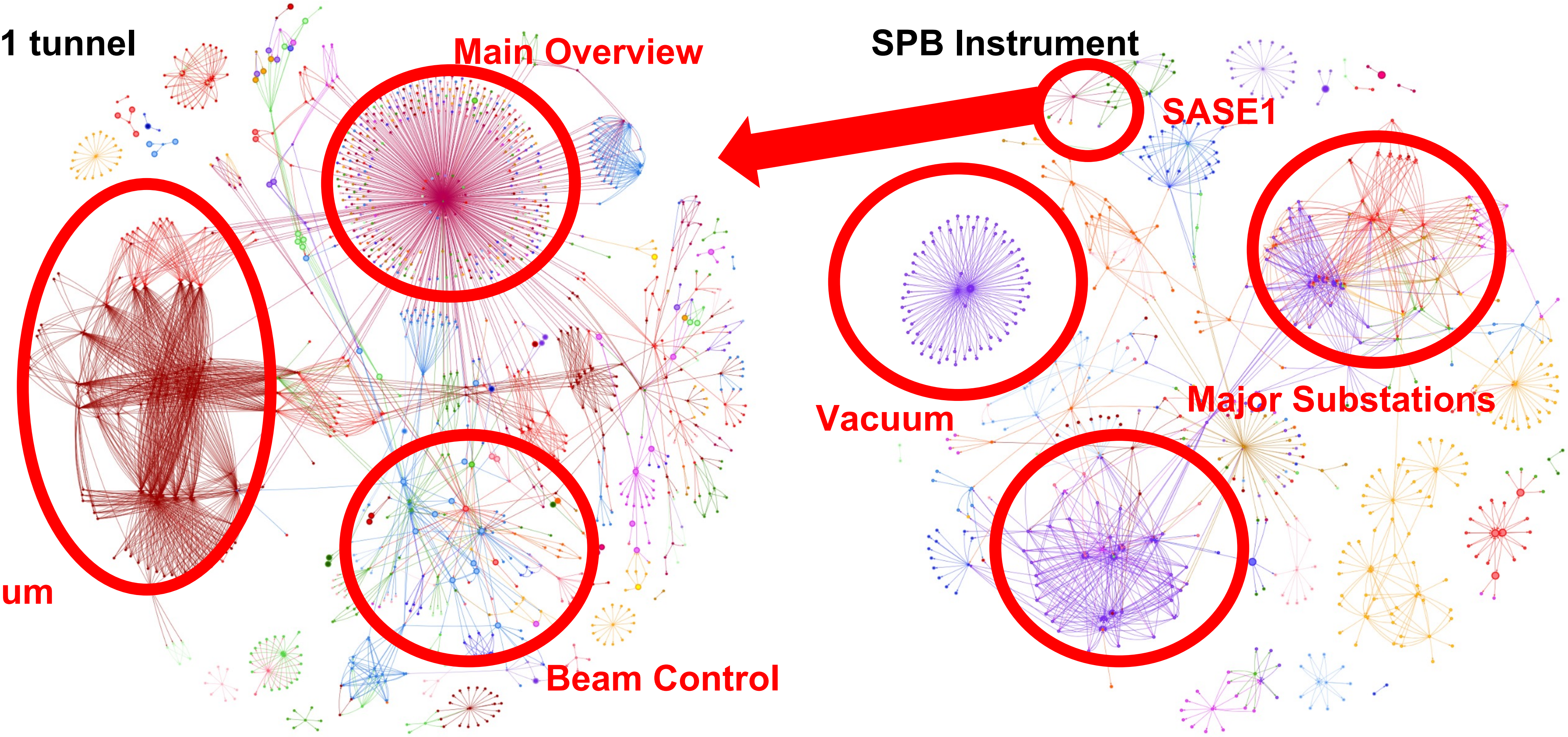
SASE1 tunnel



SPB Instrument



Karabo GUI – Scenes as Synoptics – Links between Scenes



SASE1 tunnel

Main Overview

Vacuum

Beam Control

SPB Instrument

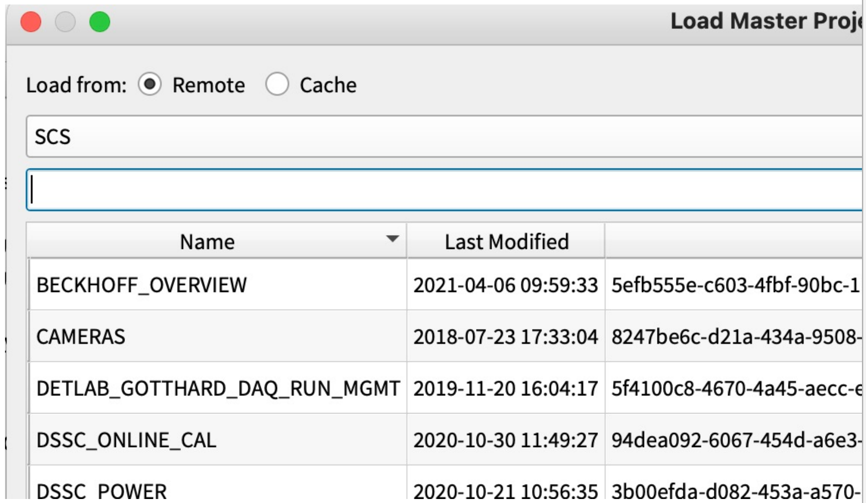
SASE1

Vacuum

Major Substations

The Karabo GUI - Projects

- Store configurations of devices
- Hierarchical, logical grouping
- Contains
  - Scenes
  - Macros
  - Subprojects
- Underlying: noSQL eXistDB
  - XML-optimized database
  - Docker available

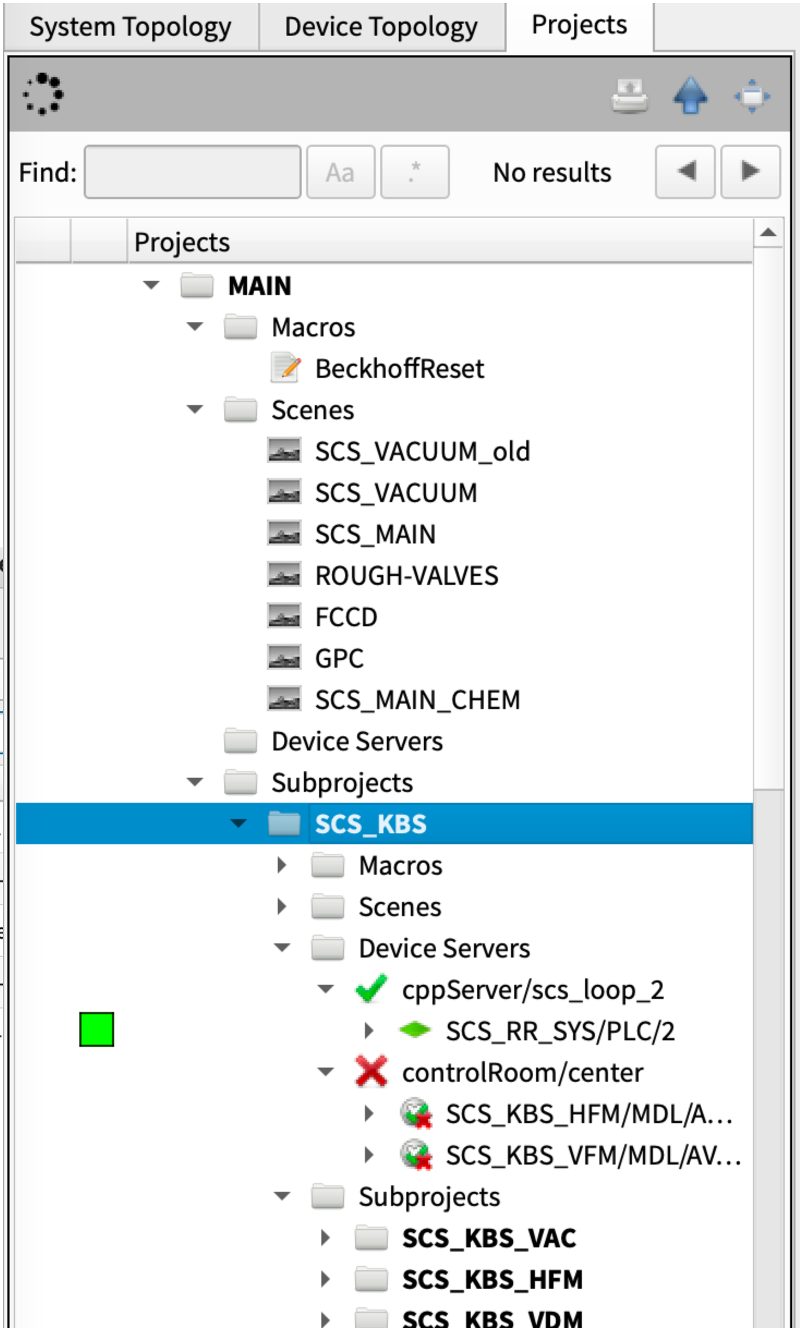


Load Master Proj

Load from: ● Remote ○ Cache

SCS

Name	Last Modified	
BECKHOFF_OVERVIEW	2021-04-06 09:59:33	5efb555e-c603-4fbf-90bc-1
CAMERAS	2018-07-23 17:33:04	8247be6c-d21a-434a-9508-
DETLAB_GOTTHARD_DAQ_RUN_MGMT	2019-11-20 16:04:17	5f4100c8-4670-4a45-aecc-e
DSSC_ONLINE_CAL	2020-10-30 11:49:27	94dea092-6067-454d-a6e3-
DSSC_POWER	2020-10-21 10:56:35	3b00efda-d082-453a-a570-

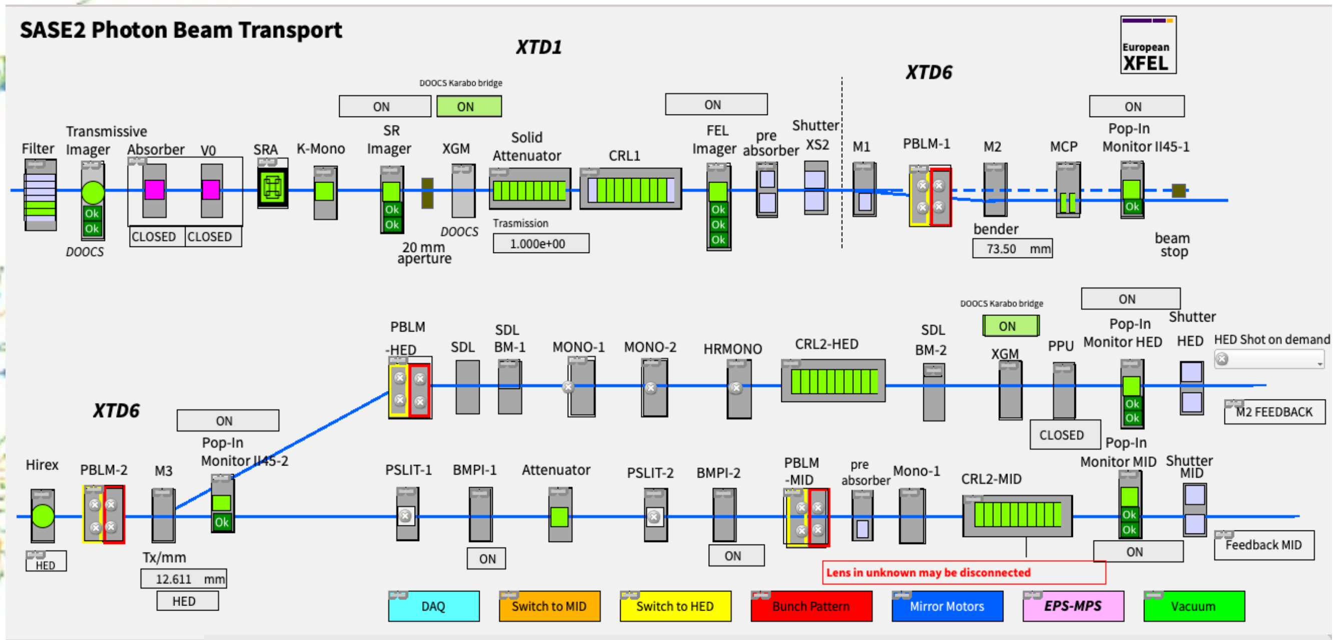


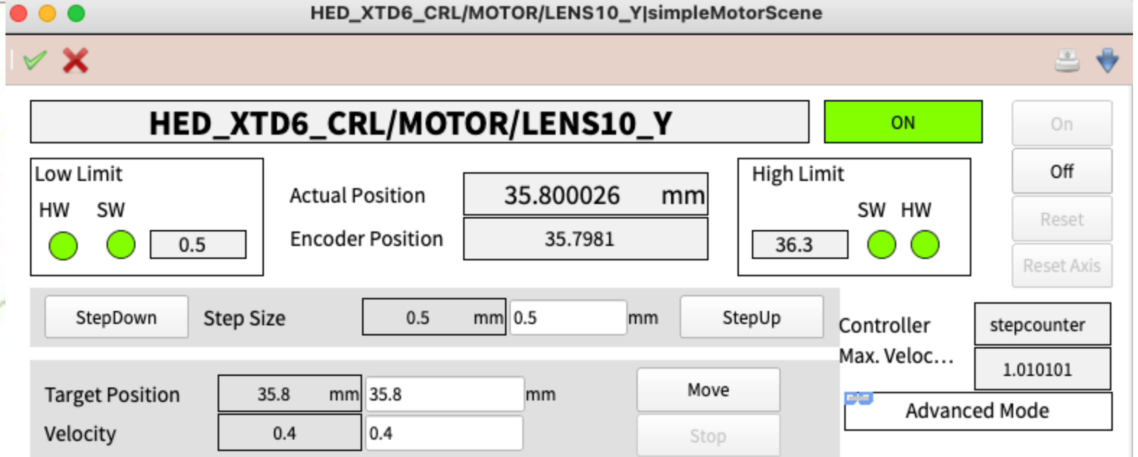
Projects

- MAIN
  - Macros
    - BeckhoffReset
  - Scenes
    - SCS_VACUUM_old
    - SCS_VACUUM
    - SCS_MAIN
    - ROUGH-VALVES
    - FCCD
    - GPC
    - SCS_MAIN_CHEM
  - Device Servers
  - Subprojects
    - SCS_KBS
      - Macros
      - Scenes
      - Device Servers
        - ✓ cppServer/scs_loop_2
          - SCS_RR_SYS/PLC/2
        - ✗ controlRoom/center
          - SCS_KBS_HFM/MDL/A...
          - SCS_KBS_VFM/MDL/AV...
      - Subprojects
        - SCS_KBS_VAC
        - SCS_KBS_HFM
        - SCS_KBS_VDM

The Karabo Ecosystem – Highlights of the three APIs: Karabo Beckhoff Interface

- API: C++
- Builds upon: boost
- Special because:
  - Controls almost all PLC solutions at the facility
  - Partially self-descriptive rendering via Karabo Schema injection
  - Event-driven, up to 1kHz updates on some devices




HED_XTD6_CRL/MOTOR/LENS10_Y|simpleMotorScene

HED_XTD6_CRL/MOTOR/LENS10_Y ON

Low Limit HW SW 0.5

Actual Position 35.800026 mm

Encoder Position 35.7981

High Limit SW HW 36.3

StepDown Step Size 0.5 mm 0.5 mm StepUp

Target Position 35.8 mm 35.8 mm

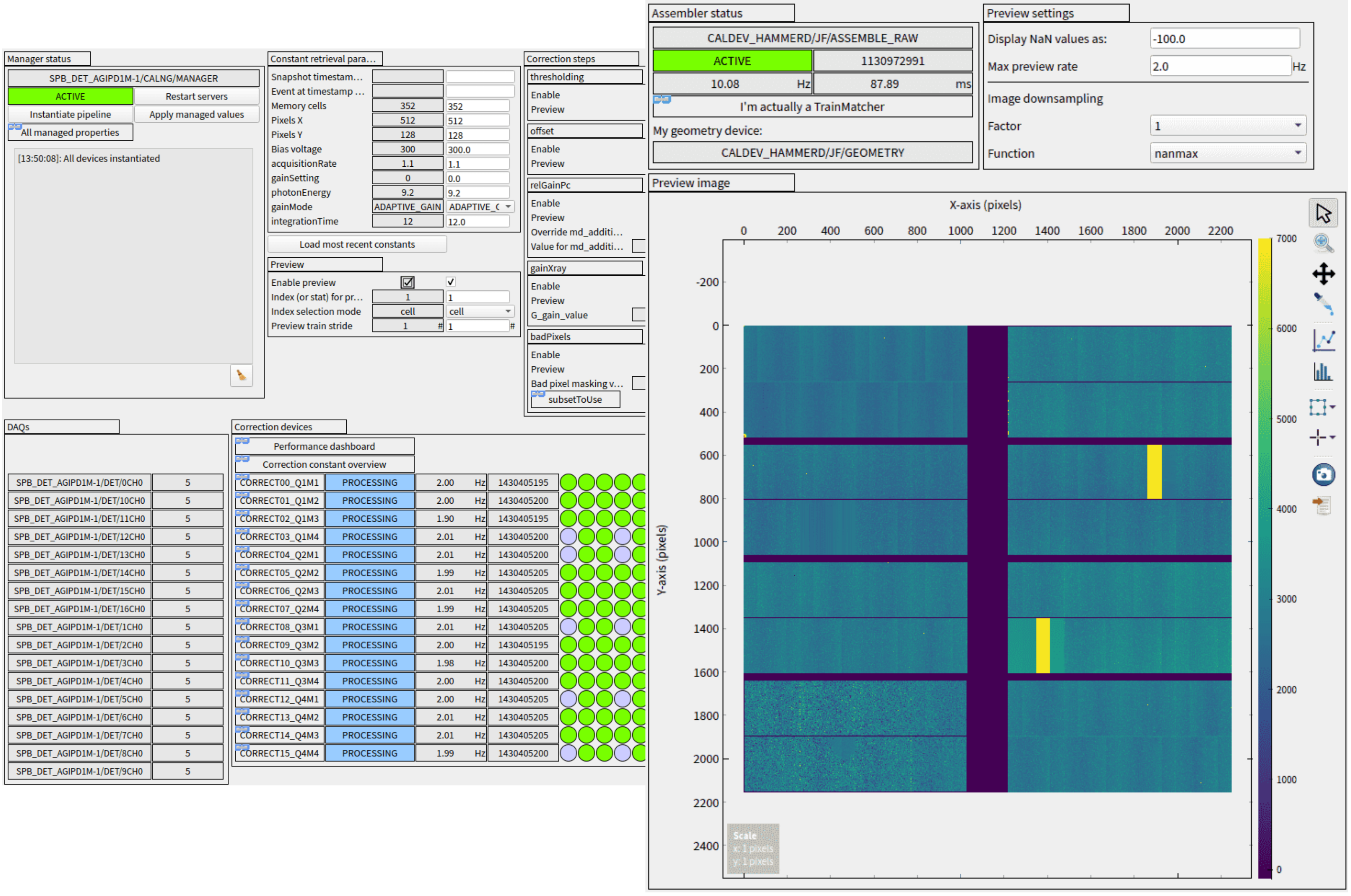
Velocity 0.4 0.4

Controller stepcounter

Max. Veloc... 1.010101

The Karabo Ecosystem – Highlights of the three APIs: Online Calibration

- API: Bound and MDL
- Builds upon: boost, numpy, CUDA, pyCUDA
- Special because:
  - online correction of up to 4kHz images
  - Highly configurable



Manager status

SPB_DET_AGIPD1M-1/CALNG/MANAGER

[13:50:08]: All devices instantiated

Constant retrieval para…

Snapshot timestam…		
Event at timestamp …		
Memory cells	352	352
Pixels X	512	512
Pixels Y	128	128
Bias voltage	300	300.0
acquisitionRate	1.1	1.1
gainSetting	0	0.0
photonEnergy	9.2	9.2
gainMode	ADAPTIVE_GAIN	ADAPTIVE_(
integrationTime	12	12.0

Preview

Enable preview	☑	✓
Index (or stat) for pr…	1	1
Index selection mode	cell	cell
Preview train stride	1 #	1 #

Correction steps

thresholding
Enable
Preview

offset
Enable
Preview

relGainPc
Enable
Preview
Override md_additi…
Value for md_additi…

gainXray
Enable
Preview
G_gain_value

badPixels
Enable
Preview
Bad pixel masking v…

DAQs

SPB_DET_AGIPD1M-1/DET/0CH0	5
SPB_DET_AGIPD1M-1/DET/10CH0	5
SPB_DET_AGIPD1M-1/DET/11CH0	5
SPB_DET_AGIPD1M-1/DET/12CH0	5
SPB_DET_AGIPD1M-1/DET/13CH0	5
SPB_DET_AGIPD1M-1/DET/14CH0	5
SPB_DET_AGIPD1M-1/DET/15CH0	5
SPB_DET_AGIPD1M-1/DET/16CH0	5
SPB_DET_AGIPD1M-1/DET/1CH0	5
SPB_DET_AGIPD1M-1/DET/2CH0	5
SPB_DET_AGIPD1M-1/DET/3CH0	5
SPB_DET_AGIPD1M-1/DET/4CH0	5
SPB_DET_AGIPD1M-1/DET/5CH0	5
SPB_DET_AGIPD1M-1/DET/6CH0	5
SPB_DET_AGIPD1M-1/DET/7CH0	5
SPB_DET_AGIPD1M-1/DET/8CH0	5
SPB_DET_AGIPD1M-1/DET/9CH0	5

Correction devices

CORRECT00_Q1M1	PROCESSING	2.00 Hz	1430405195	●●●●●
CORRECT01_Q1M2	PROCESSING	2.00 Hz	1430405200	●●●●●
CORRECT02_Q1M3	PROCESSING	1.90 Hz	1430405195	●●●●●
CORRECT03_Q1M4	PROCESSING	2.01 Hz	1430405200	○●●○●
CORRECT04_Q2M1	PROCESSING	2.01 Hz	1430405200	○●●○●
CORRECT05_Q2M2	PROCESSING	1.99 Hz	1430405205	●●●●●
CORRECT06_Q2M3	PROCESSING	2.01 Hz	1430405205	●●●●●
CORRECT07_Q2M4	PROCESSING	1.99 Hz	1430405205	●●●●●
CORRECT08_Q3M1	PROCESSING	2.01 Hz	1430405205	○●●○●
CORRECT09_Q3M2	PROCESSING	2.00 Hz	1430405195	●●●●●
CORRECT10_Q3M3	PROCESSING	1.98 Hz	1430405200	●●●●●
CORRECT11_Q3M4	PROCESSING	2.00 Hz	1430405200	●●●●●
CORRECT12_Q4M1	PROCESSING	2.00 Hz	1430405205	○●●○●
CORRECT13_Q4M2	PROCESSING	2.01 Hz	1430405205	●●●●●
CORRECT14_Q4M3	PROCESSING	2.01 Hz	1430405205	●●●●●
CORRECT15_Q4M4	PROCESSING	1.99 Hz	1430405200	○●●○●

Assembler status

CALDEV_HAMMERD/JF/ASSEMBLE_RAW

ACTIVE	1130972991
10.08 Hz	87.89 ms

My geometry device:
CALDEV_HAMMERD/JF/GEOMETRY

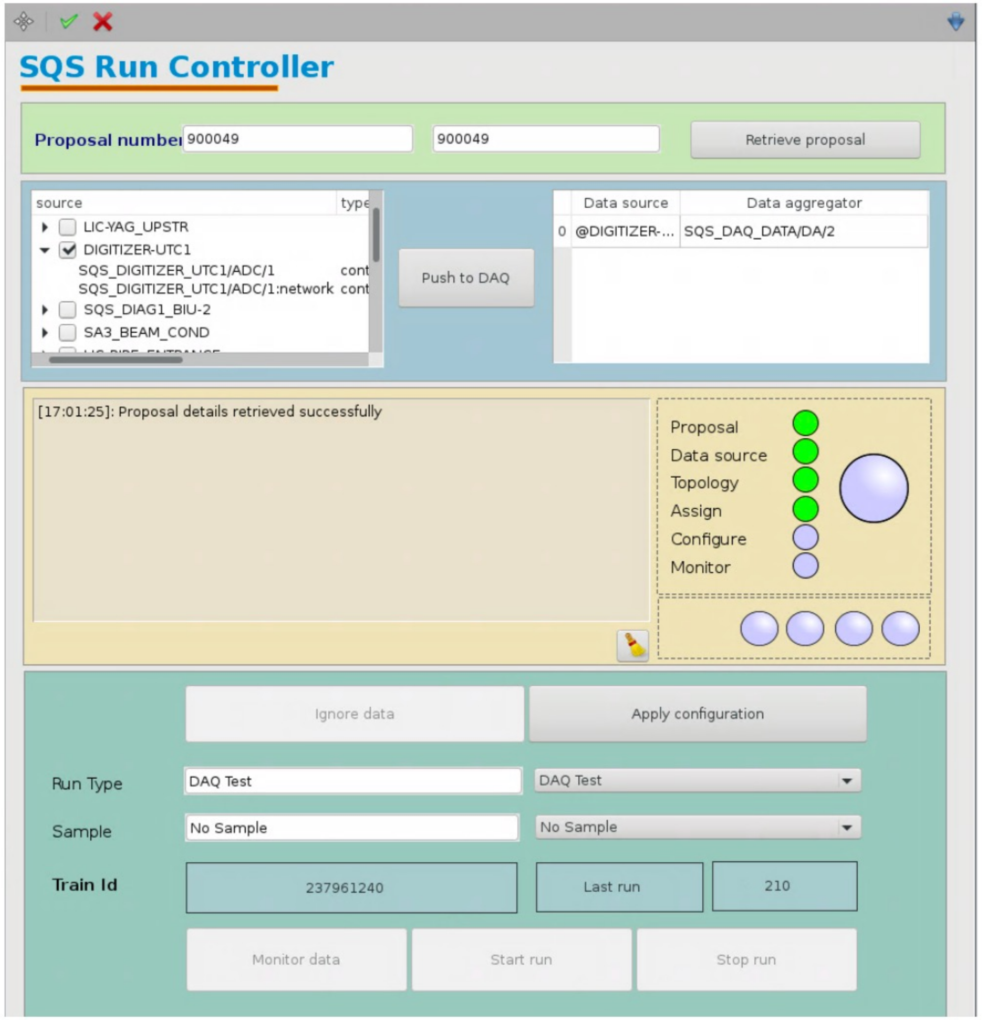
Preview settings

Display NaN values as: -100.0
Max preview rate 2.0 Hz
Image downsampling
Factor 1
Function nanmax

Preview image

The Karabo Ecosystem – Highlights of the three APIs: Data Acquistion

- API: C++
- Builds upon: boost, hdf5
- Special because:
  - Data rate of ~20 GB/s
  - Versatile in that almost any Karabo exposed parameter can be stored



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

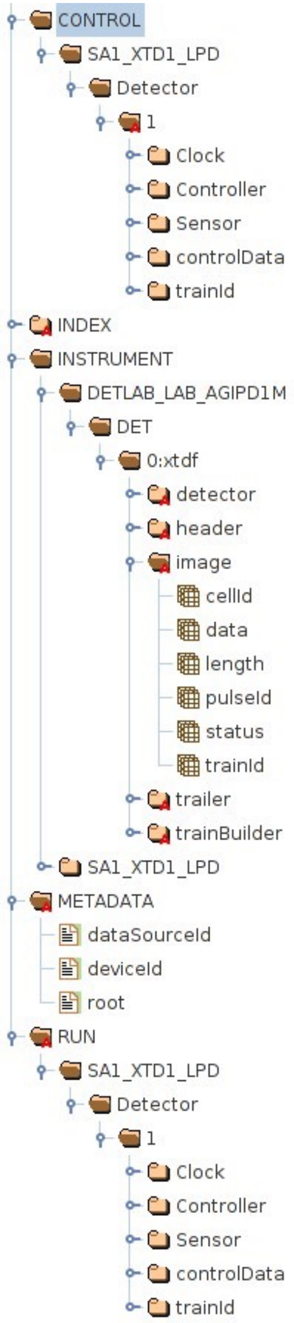
[17:01:25]: Proposal details retrieved successfully

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

Run Type DAQ Test DAQ Test

Sample No Sample No Sample

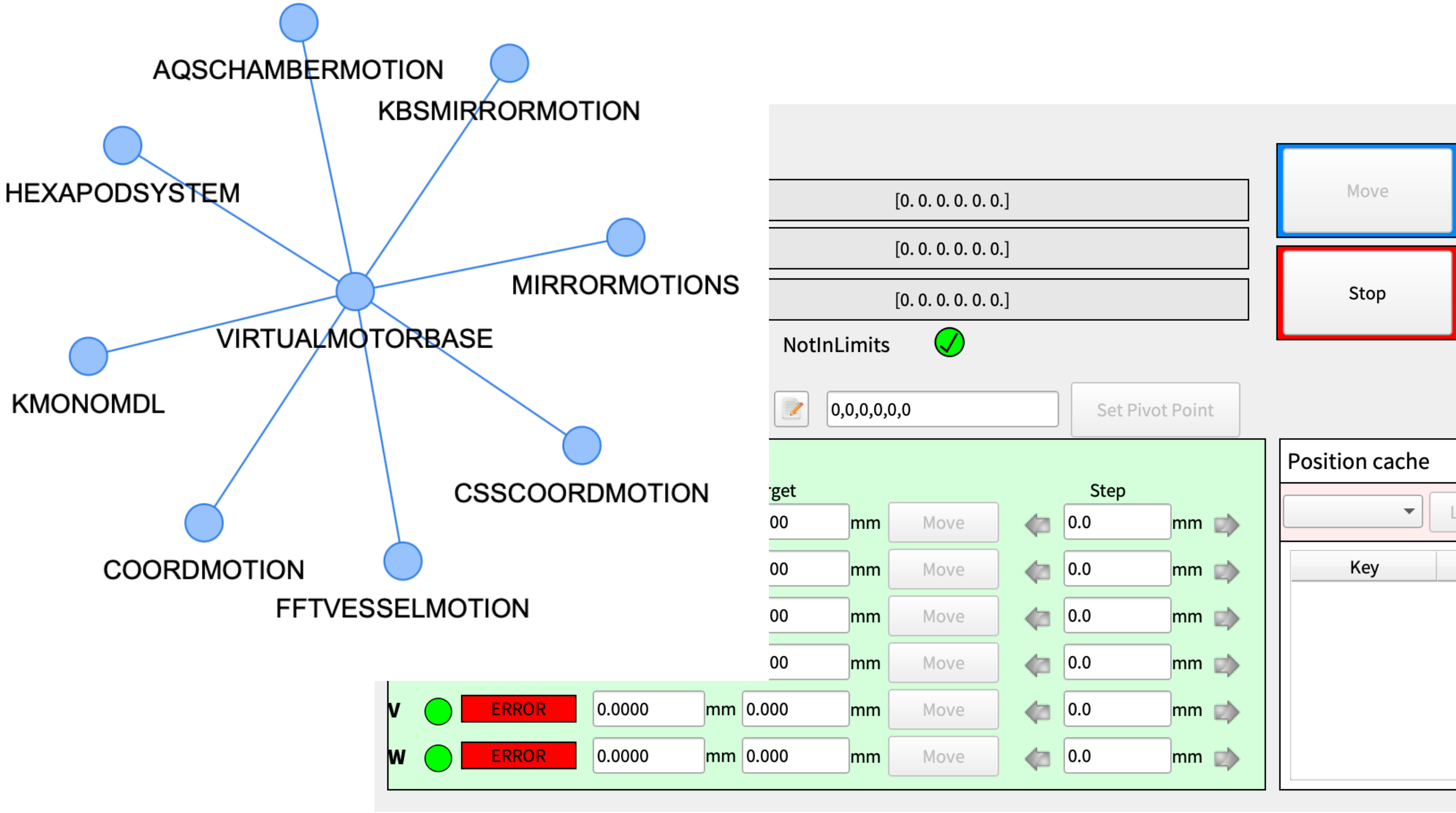
Train Id 237961240 Last run 210



- 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

The Karabo Ecosystem – Highlights of the three APIs: VirtualMotorBase MDL

- API: MDL
- Builds upon:
- Special because:
  - Exemplary usage of MDL proxy capabilities for coordinated motion on multiple axes
  - Hierarchical, extensible and pluggable, while maintaining a single interface



[0. 0. 0. 0. 0. 0.]

[0. 0. 0. 0. 0. 0.]

[0. 0. 0. 0. 0. 0.]

NotInLimits ✓

0,0,0,0,0,0

				00	mm	Move	0.0	mm	
				00	mm	Move	0.0	mm	
				00	mm	Move	0.0	mm	
				00	mm	Move	0.0	mm	
V	●	ERROR	0.0000 mm	0.000	mm	Move	0.0	mm	
W	●	ERROR	0.0000 mm	0.000	mm	Move	0.0	mm	

Karabo - A SCADA Framework: Features not Covered in Detail

- Access levels
- Unit System
- Logging Levels
- Interchangable Brokers
- Interchangable Data Loggers
- Schema Injection
- Web-proxy

#49 G. Flucke: Experiences with Datalogging to InfluxDB at European XFEL, Tuesday, 14.30

#50 D. Göries: KaraboGui - The Cockpit of the Supervisory Control and Data Acquisition System Karabo, Tuesday poster session

# 37 I. Karpics: Current and future developments of European XFEL scan tool Karabacon, Tuesday poster session

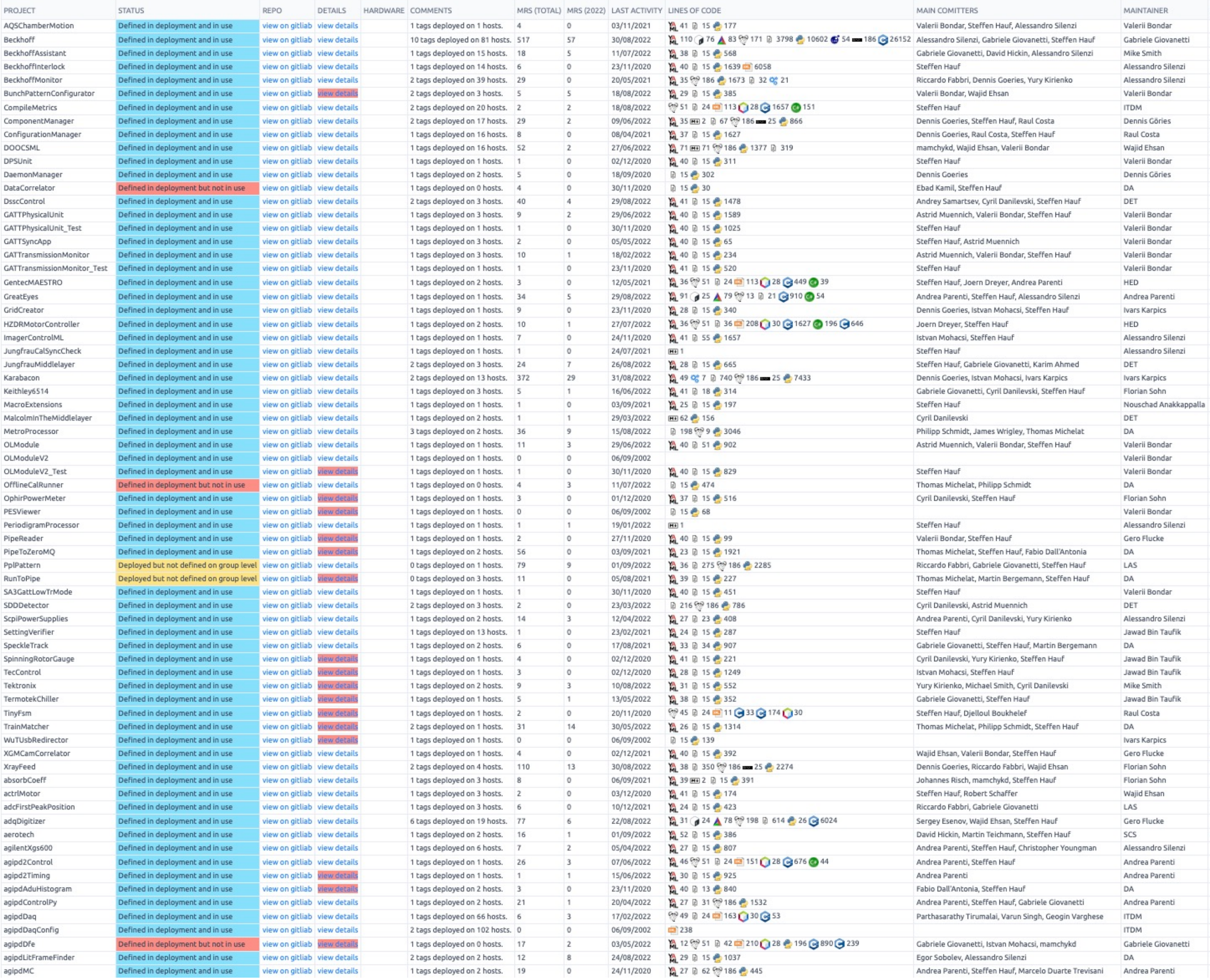
#40 A. Garcia-Tabares: Image Annotation at European XFEL, Tuesday poster session

#48 A. Parenti: Synchronization of commercial camera data at the European XFEL, Tuesday poster session

- A lot more at: https://rtd.xfel.eu/docs/karabo/en/latest/index.html

Not Covered (much): Devices

- Also not covered in much detail: devices - there's 294 projects in active use in our git repos...
- Many small ones but others in ~50k lines of code, e.g. Beckhoff integration
- Many contributions by other groups at the facility as well.



PROJECT	STATUS	REPO	DETAILS	HARDWARE	COMMENTS	MRS (TOTAL)	MRS (2022)	LAST ACTIVITY	LINES OF CODE	MAIN COMITTERS	MAINTAINER
AQSChamberMotion	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	4	0	03/11/2021	41 15 177	Valerii Bondar, Steffen Hauf, Alessandro Silenzi	Valerii Bondar
Beckhoff	Defined in deployment and in use	view on gitlab	view details		10 tags deployed on 81 hosts.	517	57	30/08/2022	110 76 83 171 3798 10602 54 186 26152	Alessandro Silenzi, Gabriele Giovanetti, Steffen Hauf	Gabriele Giovanetti
BeckhoffAssistant	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 15 hosts.	18	5	11/07/2022	38 15 568	Gabriele Giovanetti, David Hickin, Alessandro Silenzi	Mike Smith
BeckhoffInterlock	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 14 hosts.	6	0	23/11/2020	40 15 1639 6058	Steffen Hauf	Alessandro Silenzi
BeckhoffMonitor	Defined in deployment and in use	view on gitlab	view details		2 tags deployed on 39 hosts.	29	0	20/05/2021	35 186 1673 32 21	Riccardo Fabbri, Dennis Goeries, Yury Kirienko	Alessandro Silenzi
BunchPatternConfigurator	Defined in deployment and in use	view on gitlab	view details		2 tags deployed on 3 hosts.	5	5	18/08/2022	29 15 385	Valerii Bondar, Wajid Ehsan	Valerii Bondar
CompileMetrics	Defined in deployment and in use	view on gitlab	view details		2 tags deployed on 20 hosts.	2	2	18/08/2022	51 24 113 28 1657 151	Steffen Hauf	ITDM
ComponentManager	Defined in deployment and in use	view on gitlab	view details		2 tags deployed on 17 hosts.	29	2	09/06/2022	35 2 67 186 25 866	Dennis Goeries, Steffen Hauf, Raul Costa	Dennis Göries
ConfigurationManager	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 16 hosts.	8	0	08/04/2021	37 15 1627	Dennis Goeries, Raul Costa, Steffen Hauf	Raul Costa
DOOCSML	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 16 hosts.	52	2	27/06/2022	71 71 186 1377 319	mamchykd, Wajid Ehsan, Valerii Bondar	Wajid Ehsan
DPSUnit	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	1	0	02/12/2020	40 15 311	Steffen Hauf	Valerii Bondar
DaemonManager	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 2 hosts.	5	0	18/09/2020	15 302	Dennis Goeries	Dennis Göries
DataCorrelator	Defined in deployment but not in use	view on gitlab	view details		1 tags deployed on 0 hosts.	4	0	30/11/2020	15 30	Ebad Kamil, Steffen Hauf	DA
DsscControl	Defined in deployment and in use	view on gitlab	view details		2 tags deployed on 3 hosts.	40	4	29/08/2022	41 15 1478	Andrey Samartsev, Cyril Danilevski, Steffen Hauf	DET
GATTPhysicalUnit	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 3 hosts.	9	2	29/06/2022	40 15 1589	Astrid Muennich, Valerii Bondar, Steffen Hauf	Valerii Bondar
GATTPhysicalUnit_Test	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	1	0	30/11/2020	40 15 1025	Steffen Hauf	Valerii Bondar
GATTSyncApp	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 3 hosts.	2	0	05/05/2022	40 15 65	Steffen Hauf, Astrid Muennich	Valerii Bondar
GATTransmissionMonitor	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 3 hosts.	10	1	18/02/2022	40 15 234	Astrid Muennich, Valerii Bondar, Steffen Hauf	Valerii Bondar
GATTransmissionMonitor_Test	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	1	0	23/11/2020	41 15 520	Steffen Hauf	Valerii Bondar
GentecMAESTRO	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 2 hosts.	3	0	12/05/2021	36 51 24 113 28 449 39	Steffen Hauf, Joern Dreyer, Andrea Parenti	HED
GreatEyes	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	34	5	29/08/2022	91 25 79 13 21 910 54	Andrea Parenti, Steffen Hauf, Alessandro Silenzi	Andrea Parenti
GridCreator	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	9	0	23/11/2020	28 15 340	Dennis Goeries, Istvan Mohacsi, Steffen Hauf	Ivars Karpics
HZDRMotorController	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 2 hosts.	10	1	27/07/2022	36 51 36 208 30 1627 196 646	Joern Dreyer, Steffen Hauf	HED
ImagerControlML	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	7	0	24/11/2020	41 55 1657	Istvan Mohacsi, Steffen Hauf	Alessandro Silenzi
JungfrauCalSyncCheck	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	1	0	24/07/2021	1	Steffen Hauf	Alessandro Silenzi
JungfrauMiddlelayer	Defined in deployment and in use	view on gitlab	view details		2 tags deployed on 3 hosts.	24	7	26/08/2022	28 15 665	Steffen Hauf, Gabriele Giovanetti, Karim Ahmed	DET
Karabacon	Defined in deployment and in use	view on gitlab	view details		2 tags deployed on 13 hosts.	372	29	31/08/2022	49 7 740 186 25 7433	Dennis Goeries, Istvan Mohacsi, Ivars Karpics	Ivars Karpics
Keithley6514	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 3 hosts.	5	1	16/06/2022	41 18 314	Gabriele Giovanetti, Cyril Danilevski, Steffen Hauf	Florian Sohn
MacroExtensions	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	1	0	03/09/2021	25 15 197	Steffen Hauf	Nouschad Anakkappalla
MalcolmInTheMiddlelayer	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 2 hosts.	1	1	29/03/2022	62 156	Cyril Danilevski	DET
MetroProcessor	Defined in deployment and in use	view on gitlab	view details		3 tags deployed on 2 hosts.	36	9	15/08/2022	198 9 3046	Philipp Schmidt, James Wrigley, Thomas Michelat	DA
OLModule	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	11	3	29/06/2022	40 51 902	Astrid Muennich, Valerii Bondar, Steffen Hauf	Valerii Bondar
OLModuleV2	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	0	0	06/09/2002			Valerii Bondar
OLModuleV2_Test	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	1	0	30/11/2020	40 15 829	Steffen Hauf	Valerii Bondar
OfflineCalRunner	Defined in deployment but not in use	view on gitlab	view details		1 tags deployed on 0 hosts.	4	3	11/07/2022	15 474	Thomas Michelat, Philipp Schmidt	DA
OphirPowerMeter	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	3	0	01/12/2020	37 15 516	Cyril Danilevski, Steffen Hauf	Florian Sohn
PESViewer	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	0	0	06/09/2002	15 68		Valerii Bondar
PeriodigramProcessor	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	1	1	19/01/2022	1	Steffen Hauf	Alessandro Silenzi
PipeReader	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	2	0	27/11/2020	40 15 99	Valerii Bondar, Steffen Hauf	Gero Flucke
PipeToZeroMQ	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 2 hosts.	56	0	03/09/2021	23 15 1921	Thomas Michelat, Steffen Hauf, Fabio Dall'Antonia	DA
PplPattern	Deployed but not defined on group level	view on gitlab	view details		0 tags deployed on 1 hosts.	79	9	01/09/2022	36 275 186 2285	Riccardo Fabbri, Gabriele Giovanetti, Steffen Hauf	LAS
RunToPipe	Deployed but not defined on group level	view on gitlab	view details		0 tags deployed on 3 hosts.	11	0	05/08/2021	39 15 227	Thomas Michelat, Martin Bergemann, Steffen Hauf	DA
SA3GattLowTrMode	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	1	0	30/11/2020	40 15 451	Steffen Hauf	Valerii Bondar
SDDDetector	Defined in deployment and in use	view on gitlab	view details		2 tags deployed on 3 hosts.	2	0	23/03/2022	216 186 786	Cyril Danilevski, Astrid Muennich	DET
ScpiPowerSupplies	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 2 hosts.	14	3	12/04/2022	27 23 408	Andrea Parenti, Cyril Danilevski, Yury Kirienko	Alessandro Silenzi
SettingVerifier	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 13 hosts.	1	0	23/02/2021	24 15 287	Steffen Hauf	Jawad Bin Taufik
SpeckleTrack	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 2 hosts.	6	0	17/08/2021	33 34 907	Gabriele Giovanetti, Steffen Hauf, Martin Bergemann	DA
SpinningRotorGauge	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	4	0	02/12/2020	41 15 221	Cyril Danilevski, Yury Kirienko, Steffen Hauf	Jawad Bin Taufik
TecControl	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	3	0	02/12/2020	28 15 1249	Istvan Mohacsi, Steffen Hauf	Jawad Bin Taufik
Tektronix	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 2 hosts.	9	3	10/08/2022	31 15 552	Yury Kirienko, Michael Smith, Cyril Danilevski	Mike Smith
TermotekChiller	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	5	1	13/05/2022	38 15 352	Gabriele Giovanetti, Steffen Hauf	Jawad Bin Taufik
TinyFsm	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	2	0	20/11/2020	45 24 11 33 174 30	Steffen Hauf, Djelloul Boukhelef	Raul Costa
TrainMatcher	Defined in deployment and in use	view on gitlab	view details		2 tags deployed on 1 hosts.	31	14	30/05/2022	26 15 1314	Thomas Michelat, Philipp Schmidt, Steffen Hauf	DA
WuTUsbRedirector	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	0	0	06/09/2002	15 139		Ivars Karpics
XGMCamCorrelator	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	4	0	02/12/2021	40 15 392	Wajid Ehsan, Valerii Bondar, Steffen Hauf	Gero Flucke
XrayFeed	Defined in deployment and in use	view on gitlab	view details		2 tags deployed on 4 hosts.	110	13	30/08/2022	38 350 186 25 2274	Dennis Goeries, Riccardo Fabbri, Wajid Ehsan	Florian Sohn
absorbCoeff	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 3 hosts.	8	0	06/09/2021	39 2 15 391	Johannes Risch, mamchykd, Steffen Hauf	Florian Sohn
actrlMotor	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 3 hosts.	2	0	03/12/2020	41 15 174	Steffen Hauf, Robert Schaffer	Wajid Ehsan
adcFirstPeakPosition	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 3 hosts.	6	0	10/12/2021	24 15 423	Riccardo Fabbri, Gabriele Giovanetti	LAS
adqDigitizer	Defined in deployment and in use	view on gitlab	view details		6 tags deployed on 19 hosts.	77	6	22/08/2022	31 24 78 198 614 26 6024	Sergey Esenov, Wajid Ehsan, Steffen Hauf	Gero Flucke
aerotech	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 2 hosts.	16	1	01/09/2022	52 15 386	David Hickin, Martin Teichmann, Steffen Hauf	SCS
agilentXgs600	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 6 hosts.	7	2	05/04/2022	27 15 807	Andrea Parenti, Steffen Hauf, Christopher Youngman	Alessandro Silenzi
agipd2Control	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	26	3	07/06/2022	46 51 24 151 28 676 44	Andrea Parenti, Steffen Hauf	Andrea Parenti
agipd2Timing	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 1 hosts.	1	1	15/06/2022	30 15 925	Andrea Parenti	Andrea Parenti
agipdAduHistogram	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 2 hosts.	3	0	23/11/2020	40 13 840	Fabio Dall'Antonia, Steffen Hauf	DA
agipdControlPy	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 2 hosts.	21	1	20/04/2022	27 31 186 1532	Andrea Parenti, Steffen Hauf, Gabriele Giovanetti	Andrea Parenti
agipdDaq	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 66 hosts.	6	3	17/02/2022	49 24 163 30 53	Parthasarathy Tirumalai, Varun Singh, Geogin Varghese	ITDM
agipdDaqConfig	Defined in deployment and in use	view on gitlab	view details		2 tags deployed on 102 hosts.	0	0	06/09/2002	238		ITDM
agipdDfe	Defined in deployment but not in use	view on gitlab	view details		1 tags deployed on 0 hosts.	17	2	03/05/2022	12 51 42 210 28 196 890 239	Gabriele Giovanetti, Istvan Mohacsi, mamchykd	Gabriele Giovanetti
agipdLitFrameFinder	Defined in deployment and in use	view on gitlab	view details		2 tags deployed on 2 hosts.	12	8	24/08/2022	29 15 1037	Egor Sobolev, Alessandro Silenzi	DA
agipdMC	Defined in deployment and in use	view on gitlab	view details		1 tags deployed on 2 hosts.	19	0	24/11/2020	27 62 186 445	Andrea Parenti, Steffen Hauf, Marcelo Duarte Trevisani	Andrea Parenti

Summary & Outlook

- Karabo, the Control System for the European XFEL’s photon system has been presented
  - Mature Control Framework driving operation of EU.XFEL‘s photon systems and instruments for 5 years
    ► Controls 6 instruments + auxiliary systems: 16000+ devices, with 2 Million+ properties
  - Can handle 10GB/s+ data from large detector systems
  - Influx data logging backend, as of now with 200 Billion+ ingested metrics
  - Python Qt Gui with scene builder: panels without programming

- Next steps:
  - bring into the public domain – likely soon on github.com
  - authorization and authentication
  - high level configuration and topology management, snapshots, component-level configuration
  - web services and web GUIs
  - support additional broker technologies
  - ...

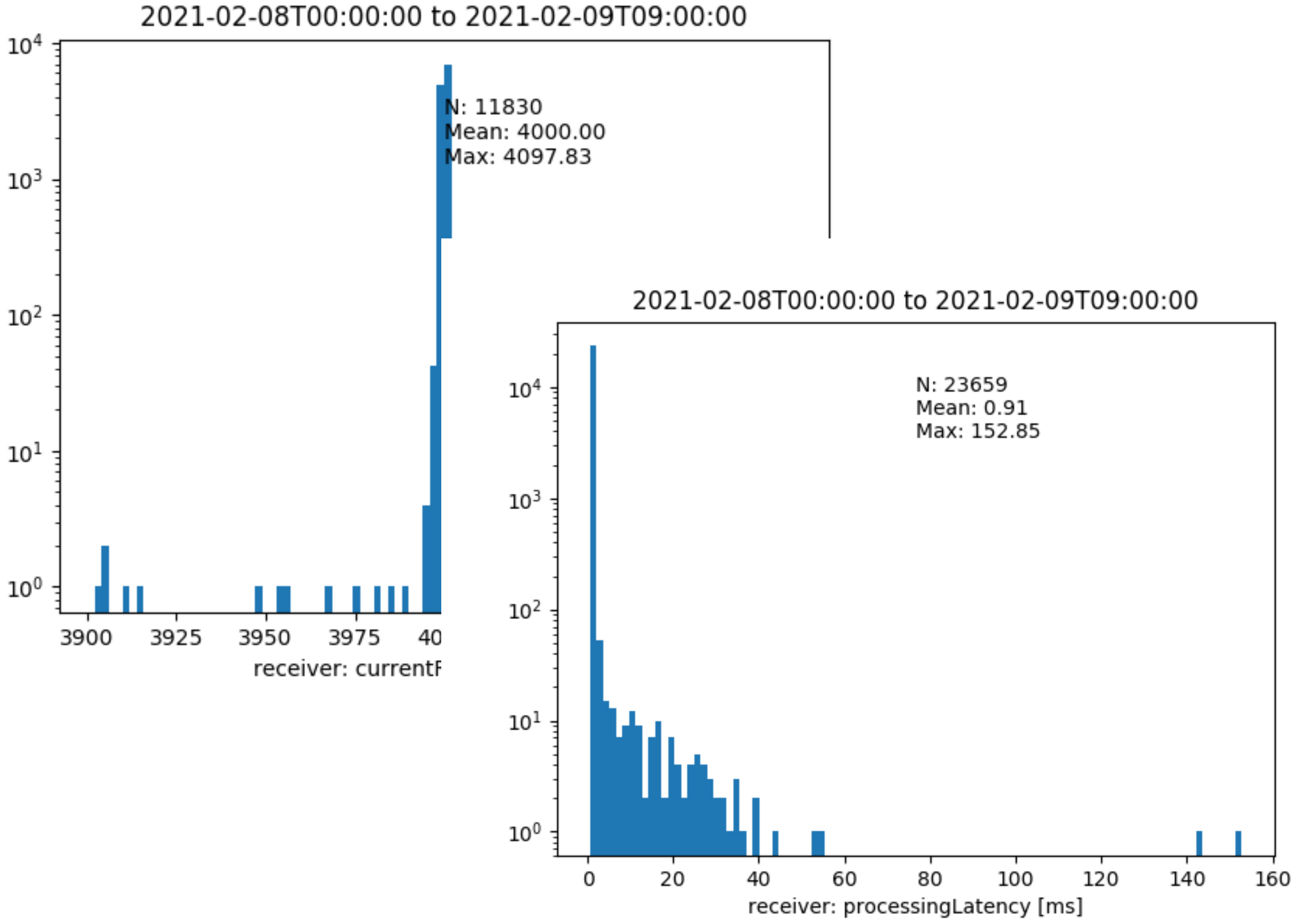
Acknowledgements

- 10+ years of work
- 40+ contributors
- Soon to be released

Backup

Karabo - A SCADA Framework: A Short Word on Performance

- The JMS Broker can sustain a message rate of 4KHz (peak)
- Latency is ~ 50 ms peak
- This is under test conditions in the production systems higher latencies are observed in fault scenarios (up to 3 seconds) with the system still stable



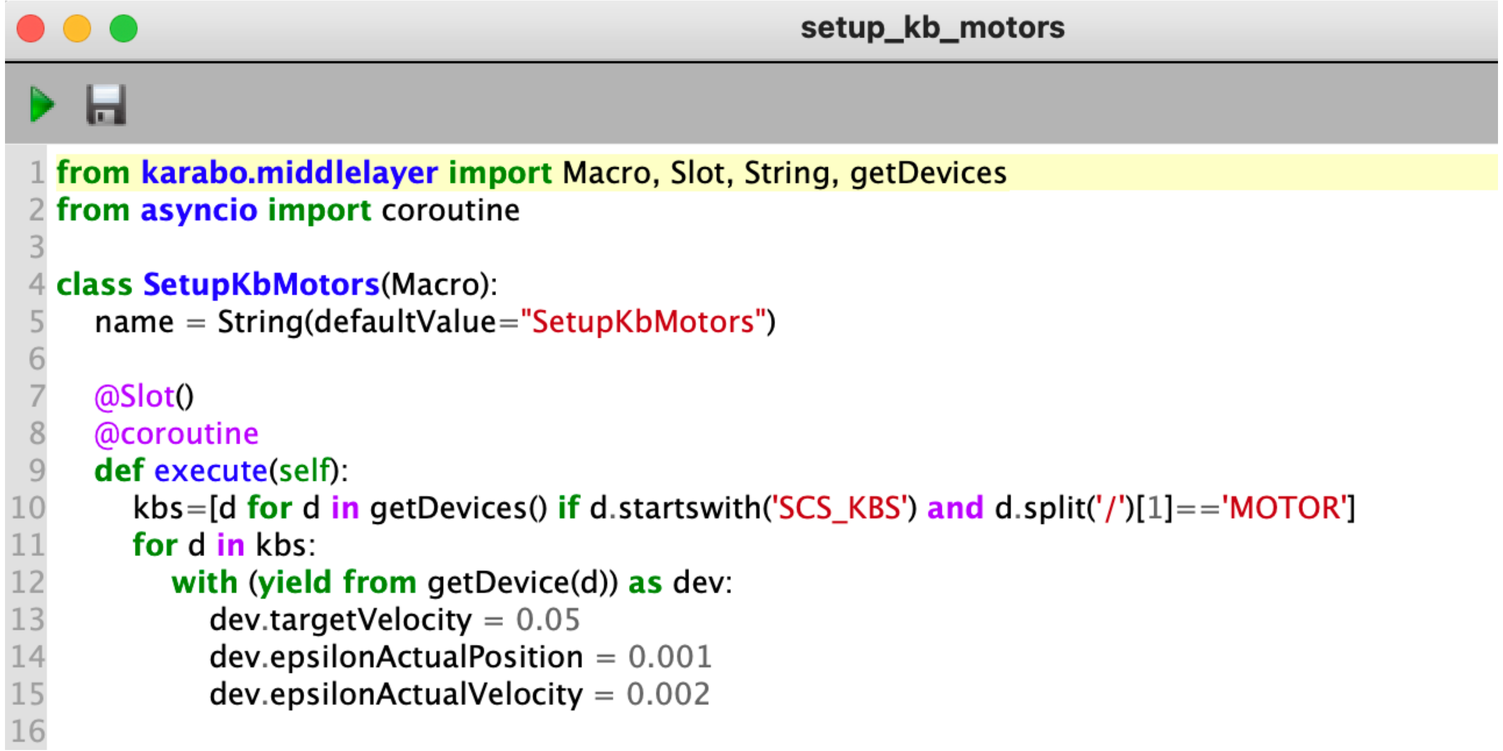
Test Coverage (Framework Only)

- Evaluated at intervals, numbers might not all be current but a good indicator
- Unit tests:
  - cover individual methods, or self-contained scenarios
- Integration tests
  - cover complete device scenarios and interaction of multiple devices / with other parts of the ecosystem

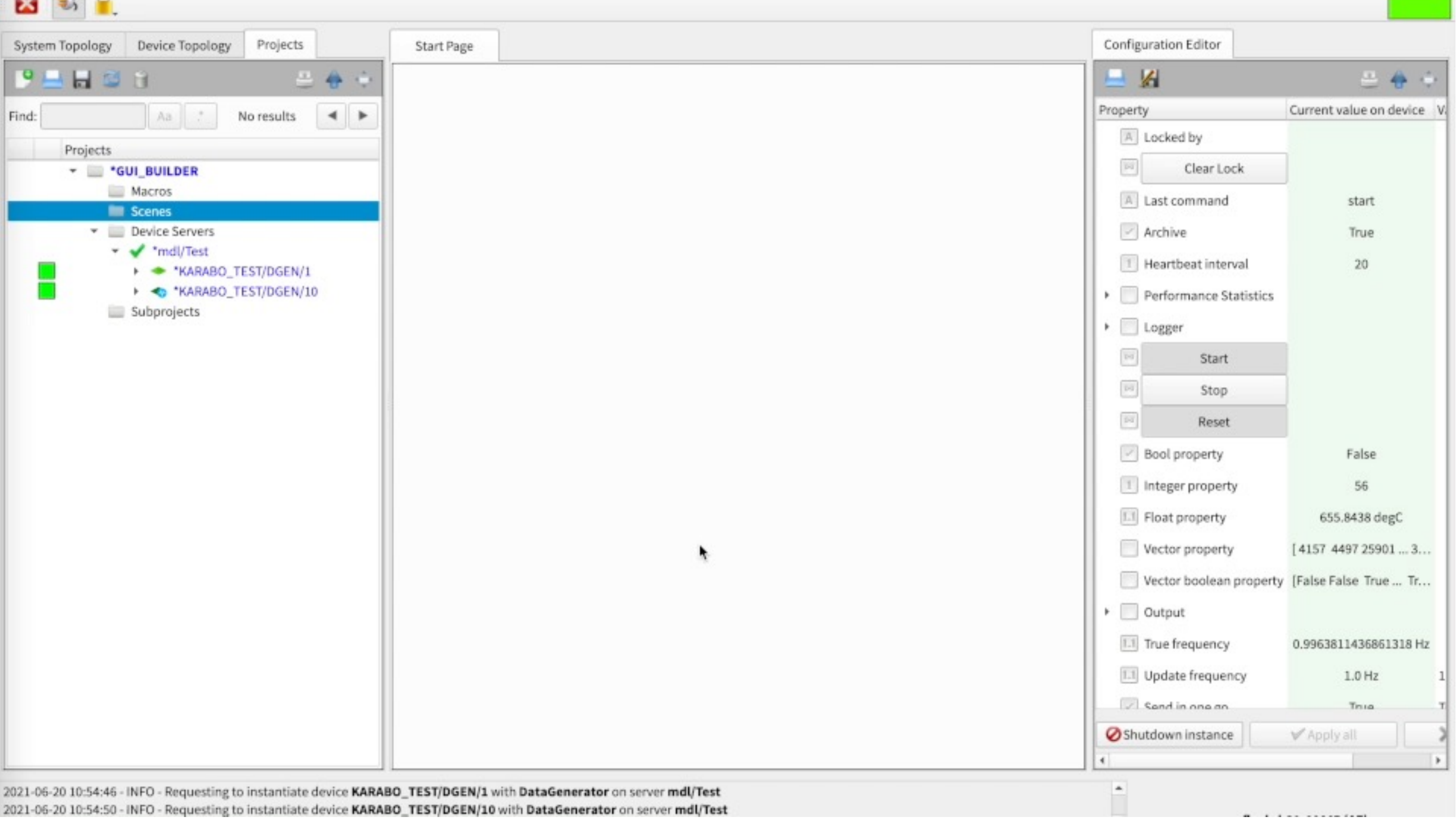
Package	Coverage
karabo.common	78%
karabo.native	72%
karabo.middlelayer	51%
All Python Karabo	> 70%
karabo.gui	64%
	40%
C++	> 65%

Karabo - A SCADA Framework: The Karabo GUI - Macros

- „Small“ Python scripts which are ad-hoc editable in the GUI
  - Use the MDL API
  - Some restrictions, e.g. state machine
  - Easy to turn into proper devices
- 100s of them by now
- Curated by users
- Some have evolved to powerful context specific tools, driving e.g. motor sequences



```python
from karabo.middlelayer import Macro, Slot, String, getDevices
from asyncio import coroutine

class SetupKbMotors(Macro):
    name = String(defaultValue="SetupKbMotors")

    @Slot()
    @coroutine
    def execute(self):
        kbs=[d for d in getDevices() if d.startswith('SCS_KBS') and d.split('/')[1]=='MOTOR']
        for d in kbs:
            with (yield from getDevice(d)) as dev:
                dev.targetVelocity = 0.05
                dev.epsilonActualPosition = 0.001
                dev.epsilonActualVelocity = 0.002

```

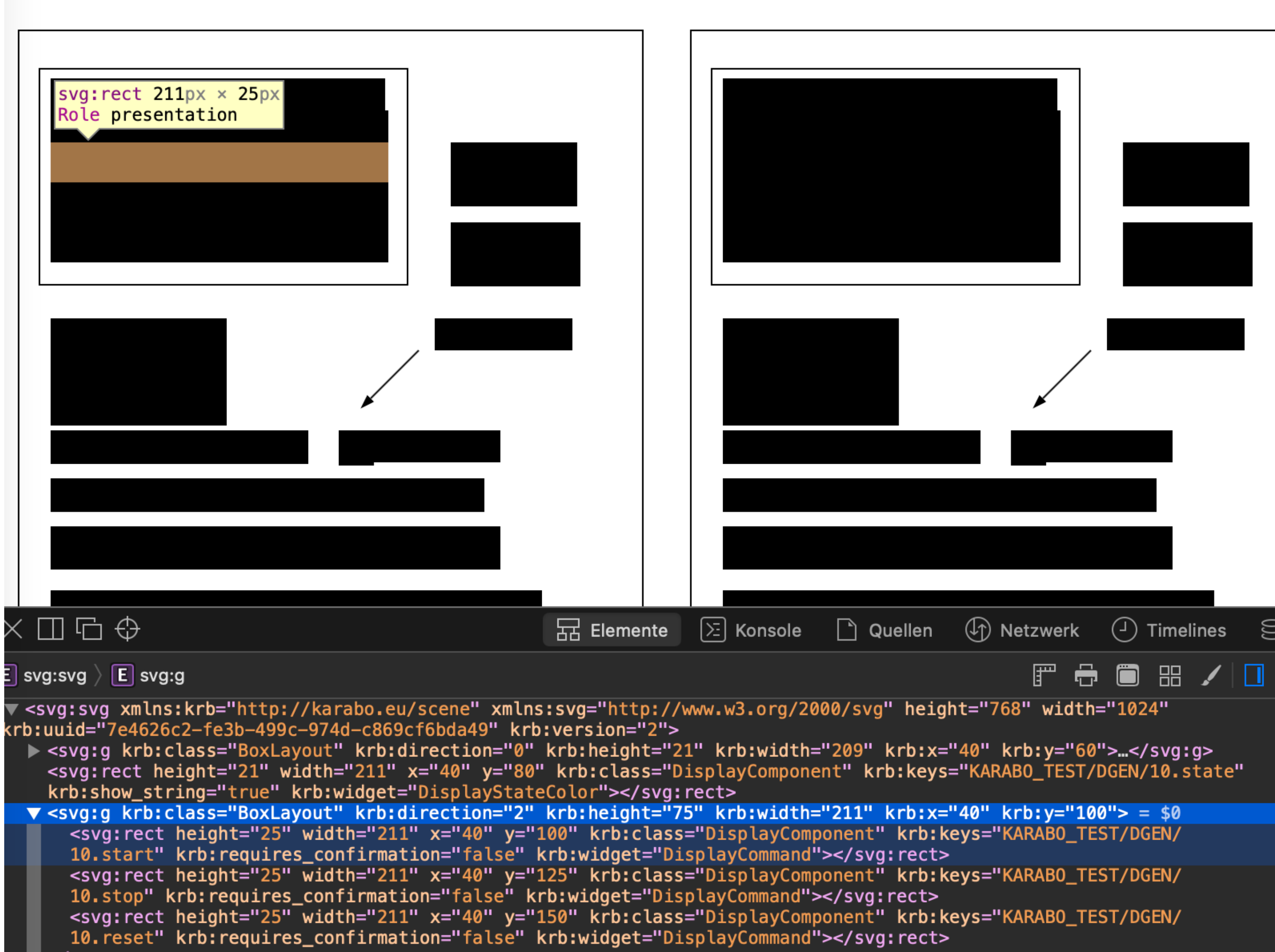


Property	Current value on device
Locked by	
Last command	start
Archive	True
Heartbeat interval	20
Performance Statistics	
Logger	
Bool property	False
Integer property	56
Float property	655.8438 degC
Vector property	[4157 4497 25901 ... 3...
Vector boolean property	[False False True ... Tr...
Output	
True frequency	0.9963811436861318 Hz
Update frequency	1.0 Hz
Send in one go	True

```
2021-06-20 10:54:46 - INFO - Requesting to instantiate device KARABO_TEST/DGEN/1 with DataGenerator on server mdl/Test
2021-06-20 10:54:50 - INFO - Requesting to instantiate device KARABO_TEST/DGEN/10 with DataGenerator on server mdl/Test
```

Karabo - A SCADA Framework: The Karabo GUI - Scenes

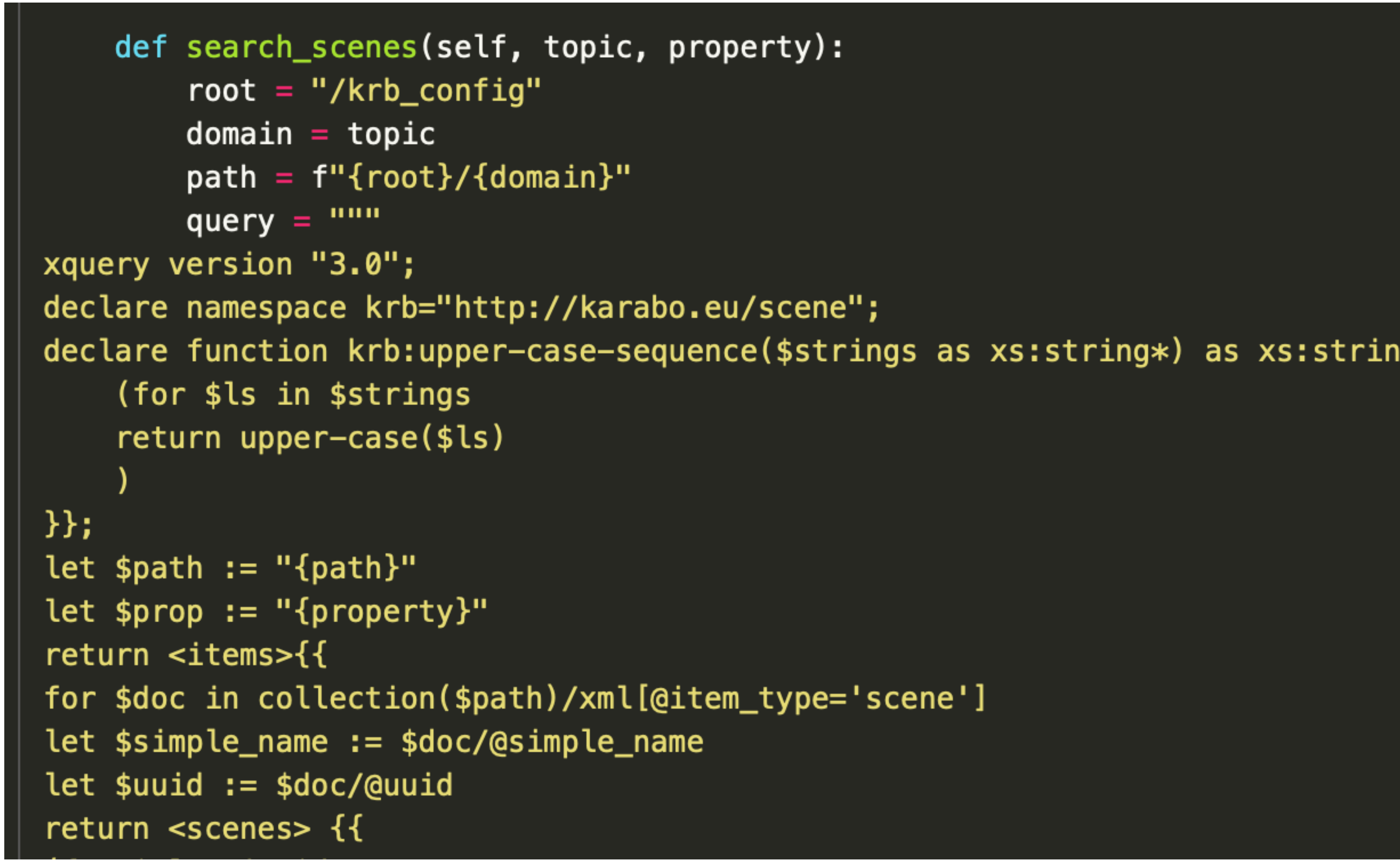
- Scenes are SVGs
- **Can be edited outside Karabo**
  - **Include images, artwork, ...**
- Flexible, extensible DOM
- Many parsers available: Karabo related informations stored as attributes to standard SVG elements
  - WebGUI
  - Scene queries
  - ...



```
▼ <svg:svg xmlns:krb="http://karabo.eu/scene" xmlns:svg="http://www.w3.org/2000/svg" height="768" width="1024"
krb:uuid="7e4626c2-fe3b-499c-974d-c869cf6bda49" krb:version="2">
  ▶ <svg:g krb:class="BoxLayout" krb:direction="0" krb:height="21" krb:width="209" krb:x="40" krb:y="60">…</svg:g>
    <svg:rect height="21" width="211" x="40" y="80" krb:class="DisplayComponent" krb:keys="KARABO_TEST/DGEN/10.state"
    krb:show_string="true" krb:widget="DisplayStateColor"></svg:rect>
  ▼ <svg:g krb:class="BoxLayout" krb:direction="2" krb:height="75" krb:width="211" krb:x="40" krb:y="100"> = $0
      <svg:rect height="25" width="211" x="40" y="100" krb:class="DisplayComponent" krb:keys="KARABO_TEST/DGEN/
      10.start" krb:requires_confirmation="false" krb:widget="DisplayCommand"></svg:rect>
      <svg:rect height="25" width="211" x="40" y="125" krb:class="DisplayComponent" krb:keys="KARABO_TEST/DGEN/
      10.stop" krb:requires_confirmation="false" krb:widget="DisplayCommand"></svg:rect>
      <svg:rect height="25" width="211" x="40" y="150" krb:class="DisplayComponent" krb:keys="KARABO_TEST/DGEN/
      10.reset" krb:requires_confirmation="false" krb:widget="DisplayCommand"></svg:rect>
```

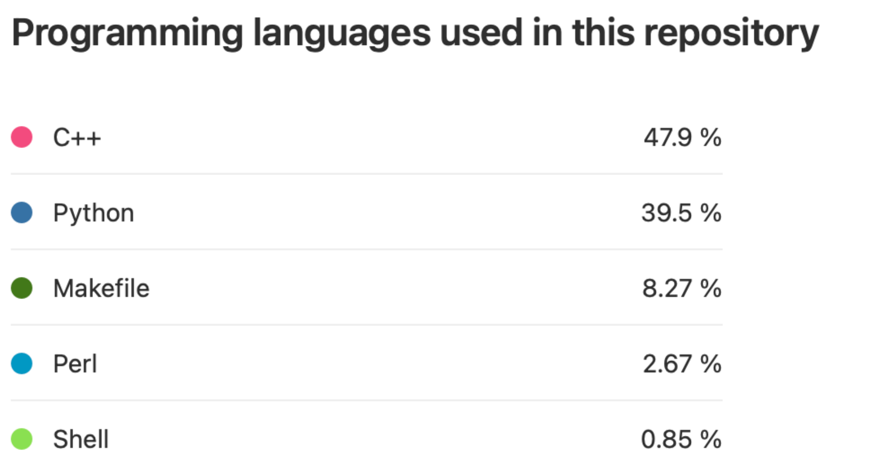
Karabo - A SCADA Framework: The Karabo GUI - Scenes

- Scenes are SVGs
- Can be edited outside Karabo
  - Include images, artwork, ...
- Flexible, extensible DOM
- Many parsers available: Karabo related informations stored as attributes to standard SVG elements
  - WebGUI
  - **Scene queries**
  - ...



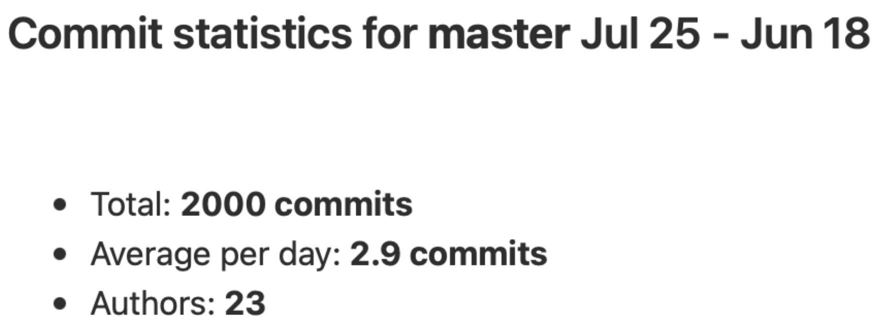
```
    def search_scenes(self, topic, property):
        root = "/krb_config"
        domain = topic
        path = f"{root}/{domain}"
        query = """
xquery version "3.0";
declare namespace krb="http://karabo.eu/scene";
declare function krb:upper-case-sequence($strings as xs:string*) as xs:strin
    (for $ls in $strings
    return upper-case($ls)
    )
}};
let $path := "{path}"
let $prop := "{property}"
return <items>{{
for $doc in collection($path)/xml[@item_type='scene']
let $simple_name := $doc/@simple_name
let $uuid := $doc/@uuid
return <scenes> {{
```

Karabo - A SCADA Framework: Code Stats and Contributors



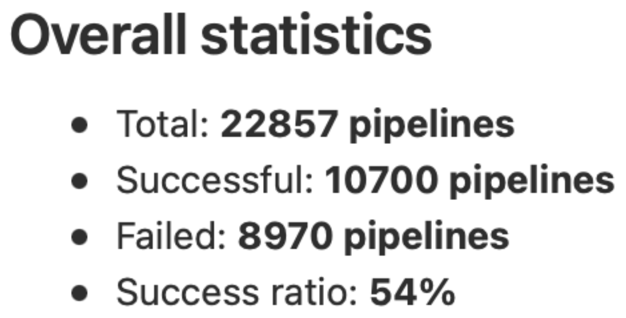
Programming languages used in this repository

●	C++	47.9 %
●	Python	39.5 %
●	Makefile	8.27 %
●	Perl	2.67 %
●	Shell	0.85 %



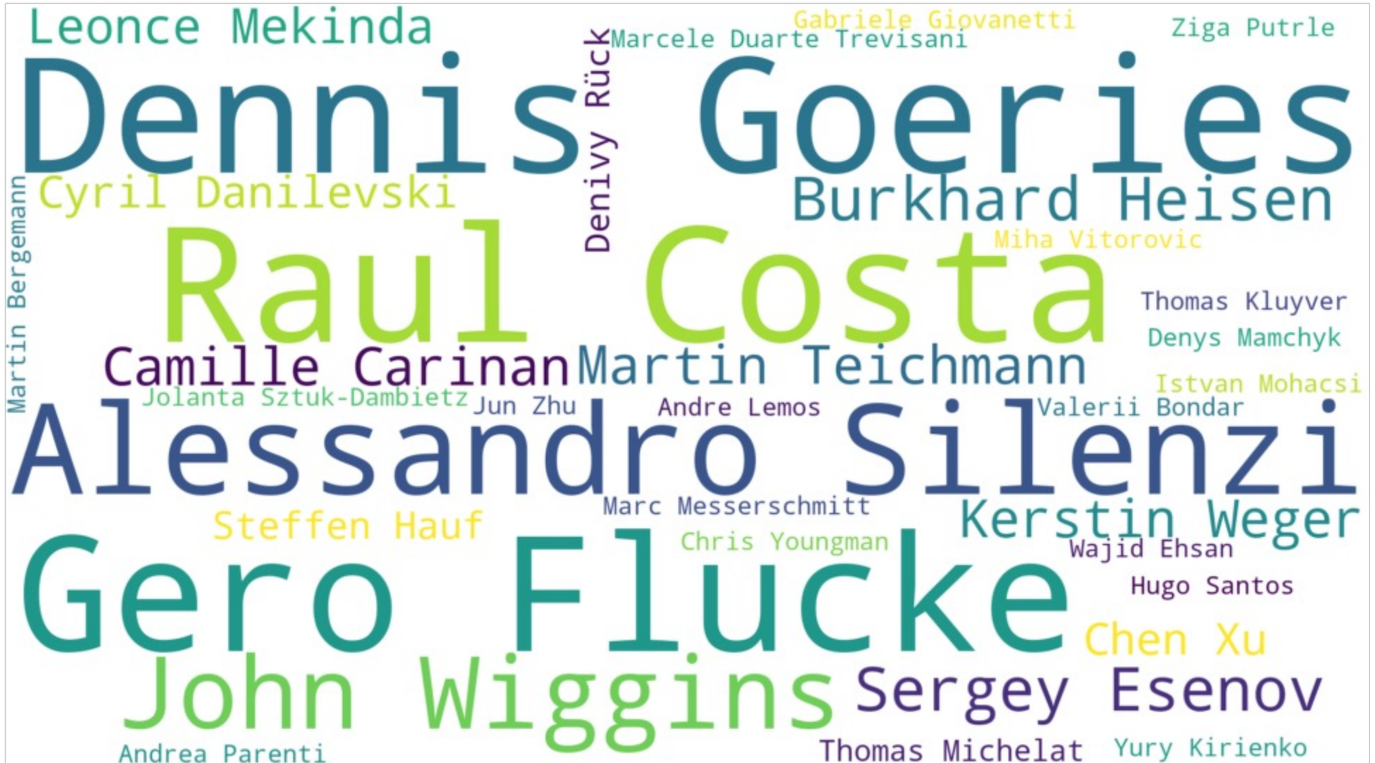
Commit statistics for master Jul 25 - Jun 18

- Total: **2000 commits**
- Average per day: **2.9 commits**
- Authors: **23**



Overall statistics

- Total: **22857 pipelines**
- Successful: **10700 pipelines**
- Failed: **8970 pipelines**
- Success ratio: **54%**



Karabo - A SCADA Framework: A MVP Setup – Batteries Included

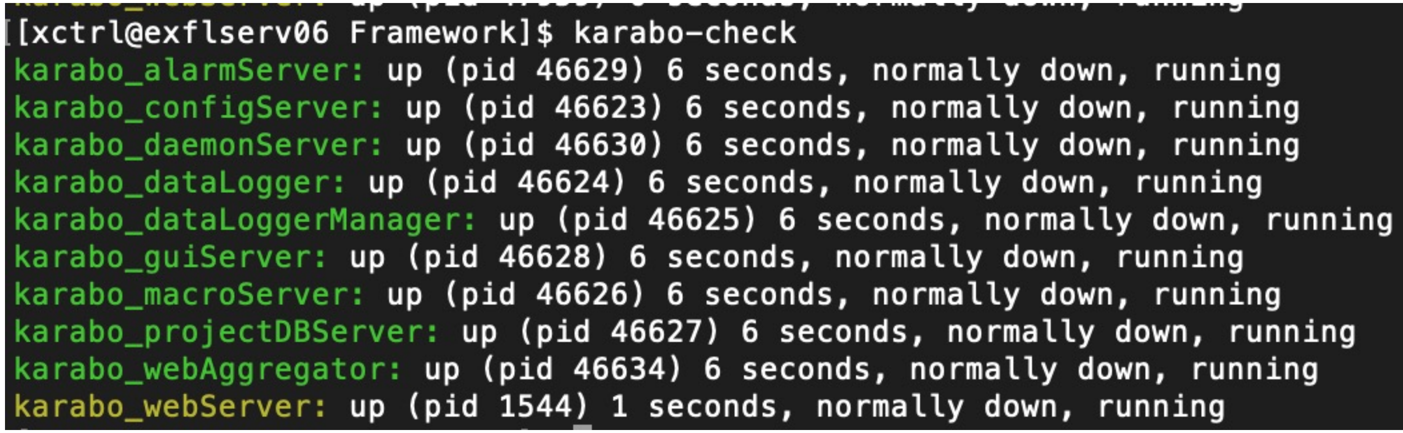
- On a supported system: CentOs7.8, Ubuntu (16),18,20
  - Install binary (sh script)
  - Install GUI (conda)
  - Make sure Docker is available

- `source karabo/activate`

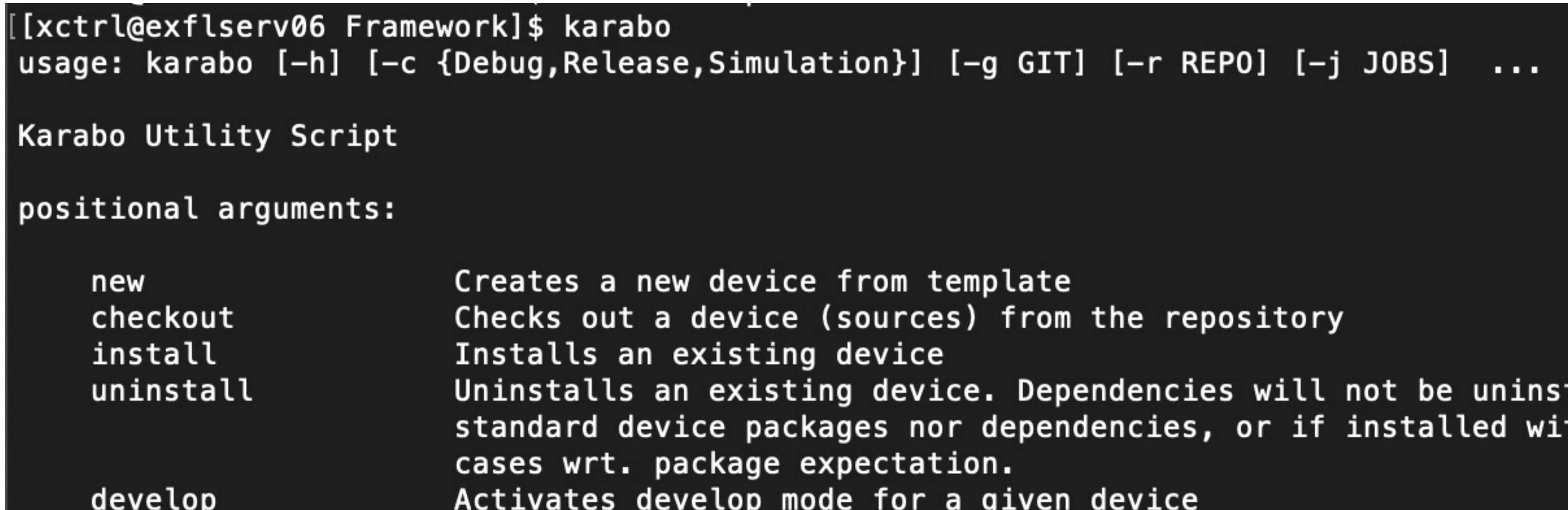
- `karabo-startbroker`

- `karabo-start`

- `karabo ...`



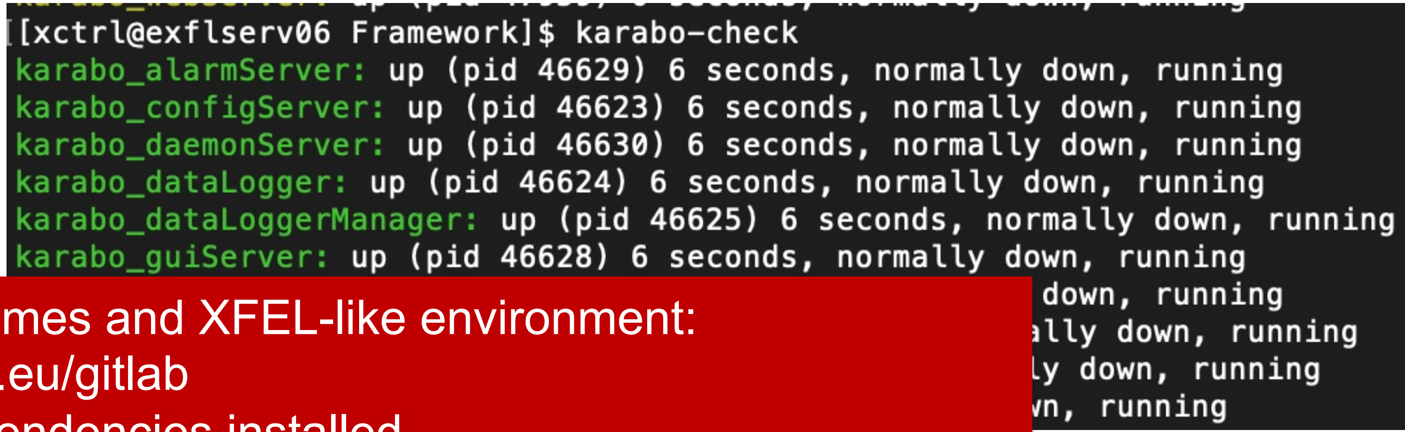
```
[xctrl@exflserv06 Framework]$ karabo-check
karabo_alarmServer: up (pid 46629) 6 seconds, normally down, running
karabo_configServer: up (pid 46623) 6 seconds, normally down, running
karabo_daemonServer: up (pid 46630) 6 seconds, normally down, running
karabo_dataLogger: up (pid 46624) 6 seconds, normally down, running
karabo_dataLoggerManager: up (pid 46625) 6 seconds, normally down, running
karabo_guiServer: up (pid 46628) 6 seconds, normally down, running
karabo_macroServer: up (pid 46626) 6 seconds, normally down, running
karabo_projectDBServer: up (pid 46627) 6 seconds, normally down, running
karabo_webAggregator: up (pid 46634) 6 seconds, normally down, running
karabo_webServer: up (pid 1544) 1 seconds, normally down, running
```



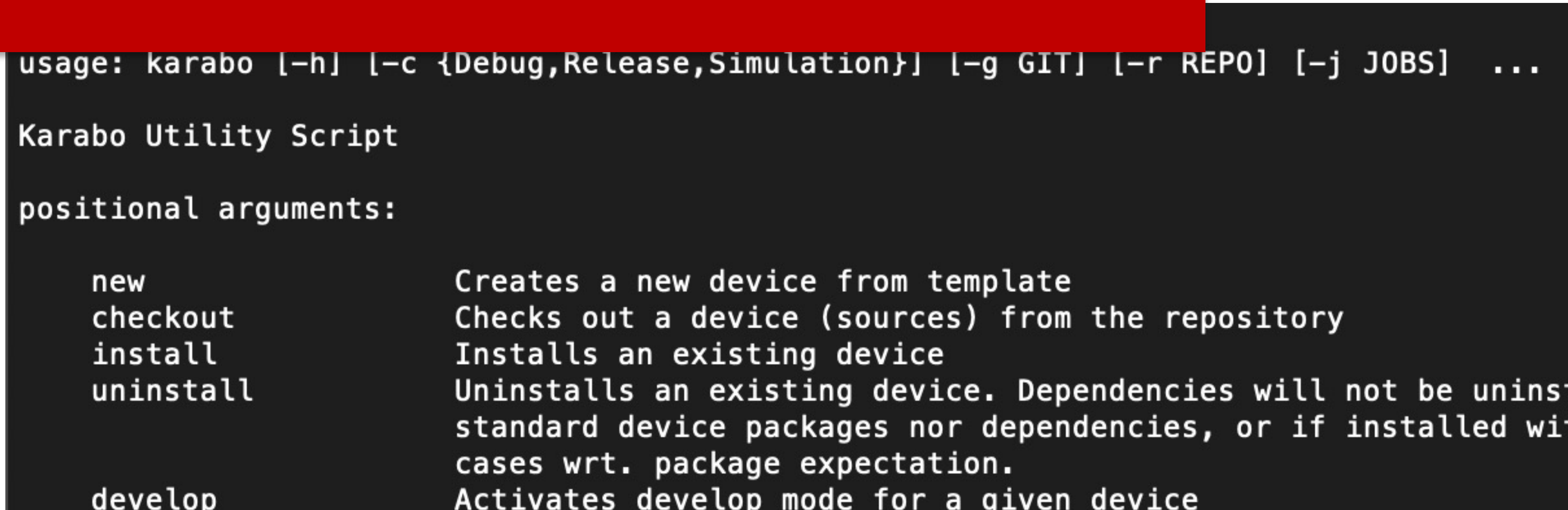
```
[xctrl@exflserv06 Framework]$ karabo
usage: karabo [-h] [-c {Debug,Release,Simulation}] [-g GIT] [-r REPO] [-j JOBS]  ...

Karabo Utility Script

positional arguments:

    new                   Creates a new device from template
    checkout              Checks out a device (sources) from the repository
    install               Installs an existing device
    uninstall             Uninstalls an existing device. Dependencies will not be unins
                          standard device packages nor dependencies, or if installed wi
                          cases wrt. package expectation.
    develop               Activates develop mode for a given device
```

Karabo - A SCADA Framework: A MVP Setup – Batteries Included

- On a supported system: CentOs7.8, Ubuntu (16),18,20
  - Install binary (sh script)
  - Install GUI (conda)
  - Make sure Docker is available
- `source karabo/activate`
- `karabo-startbroker`
- `karabo-start`
- `karabo ...`



```
[xctrl@exflserv06 Framework]$ karabo-check
karabo_alarmServer: up (pid 46629) 6 seconds, normally down, running
karabo_configServer: up (pid 46623) 6 seconds, normally down, running
karabo_daemonServer: up (pid 46630) 6 seconds, normally down, running
karabo_dataLogger: up (pid 46624) 6 seconds, normally down, running
karabo_dataLoggerManager: up (pid 46625) 6 seconds, normally down, running
karabo_guiServer: up (pid 46628) 6 seconds, normally down, running
                                             down, running
                                             ally down, running
                                             ly down, running
                                             wn, running
```



```
usage: karabo [-h] [-c {Debug,Release,Simulation}] [-g GIT] [-r REPO] [-j JOBS]  ...

Karabo Utility Script

positional arguments:

    new                 Creates a new device from template
    checkout            Checks out a device (sources) from the repository
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    uninstall           Uninstalls an existing device. Dependencies will not be unins
                        standard device packages nor dependencies, or if installed wi
                        cases wrt. package expectation.
    develop             Activates develop mode for a given device
```
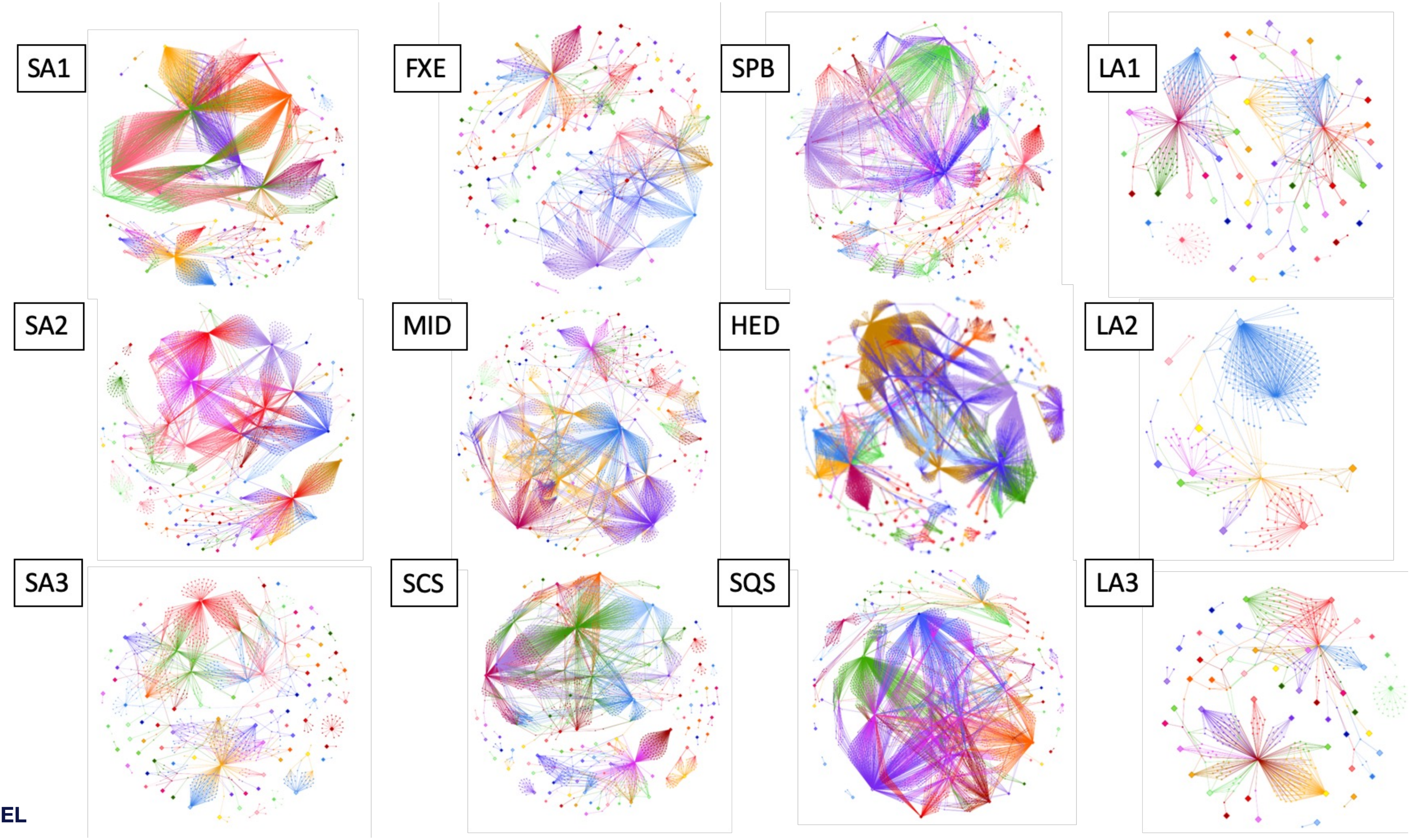
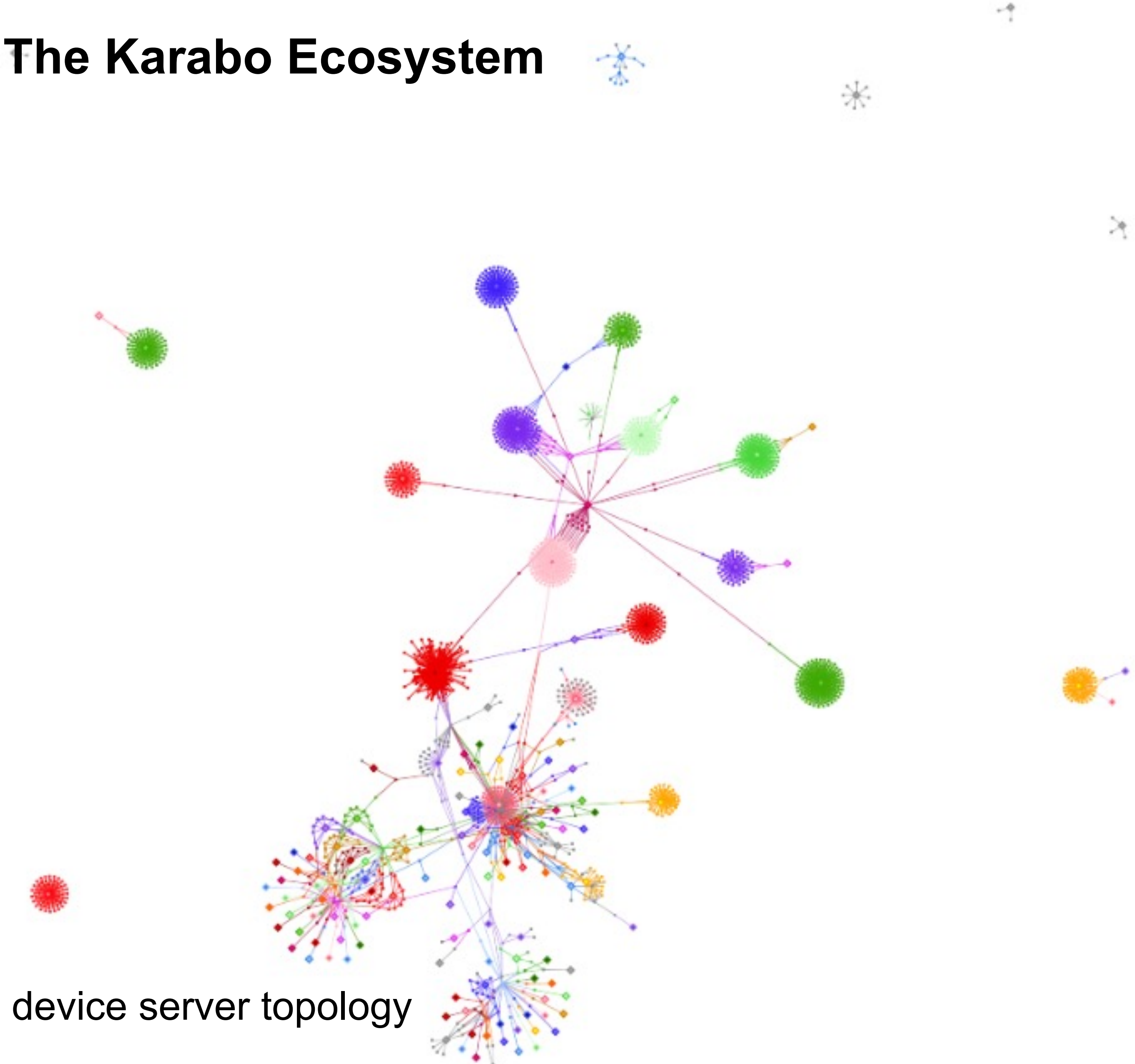

Caveat: currently assumes and XFEL-like environment:
- Code repo is in.xfel.eu/gitlab
- OS has certain dependencies installed
- ...

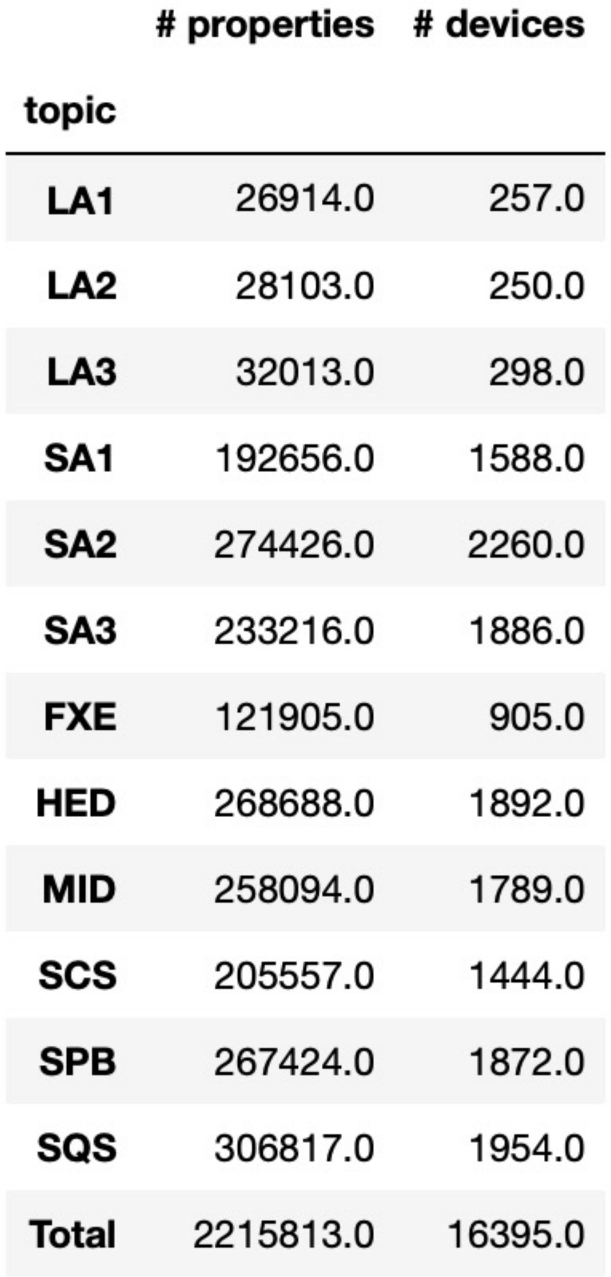
The Karabo Ecosystem



The Karabo Ecosystem



SPB device server topology



	# properties	# devices
topic		
LA1	26914.0	257.0
LA2	28103.0	250.0
LA3	32013.0	298.0
SA1	192656.0	1588.0
SA2	274426.0	2260.0
SA3	233216.0	1886.0
FXE	121905.0	905.0
HED	268688.0	1892.0
MID	258094.0	1789.0
SCS	205557.0	1444.0
SPB	267424.0	1872.0
SQS	306817.0	1954.0
Total	2215813.0	16395.0

The Karabo Ecosystem – Selection of Hardware Currently Integrated

Cameras
Basler (multiple models) via Lima, GeniCam, Aravis
Photonic Science (multiple models)
PI MTE, via picam
Andor (Newton, Zyla, Ikon), via IPC solution
Varex
Shimadzu HPvx

Digitizers (uTCA-based)
SP devices ADQ 412
SP devices ADQ 7
SP devices ADQ 14
FastADC

X-ray Detectors
PSI Gotthard (v1, 1D, strip), v2 soon
PSI Jungfrau (single cell, multi cell)
LCLS/SLAC EPICS 100a (10k)
pnCCD
fastCCD
LPD
AGIPD 1.1, AGIPD 1.X
DSSC
Amptek FastSDD
Timepix 3 (in progress)

The Karabo Ecosystem – Selection of Hardware Currently Integrated

Motion Systems
Hexapod
Smaract
Elmo
Nanocube
Technosoft
Various other controllers via Beckhoff MC2

Power supplys and multimeters
Wiener MPOD
Keithley (various models)
Agilant

Pumps and Vacuum Components
Agilant Ion Pumps
Pfeiffer (various models)
Pfeiffer Maxigauge
Adixen (various models)
Infinicon

Chillers and thermo controllers
Huber
K2
Keithley (various models)
Lakeshore
Thorlabs (various models)
Julabo

The Karabo Ecosystem – Selection of Hardware Currently Integrated

Spectrometers + Powermeters + Scopes ...
Oceanoptics (various models)
GENTEC
Techtronix (various models)
LeCroy
SRS DG645
Microvision RGA
MCS Beam Stab.

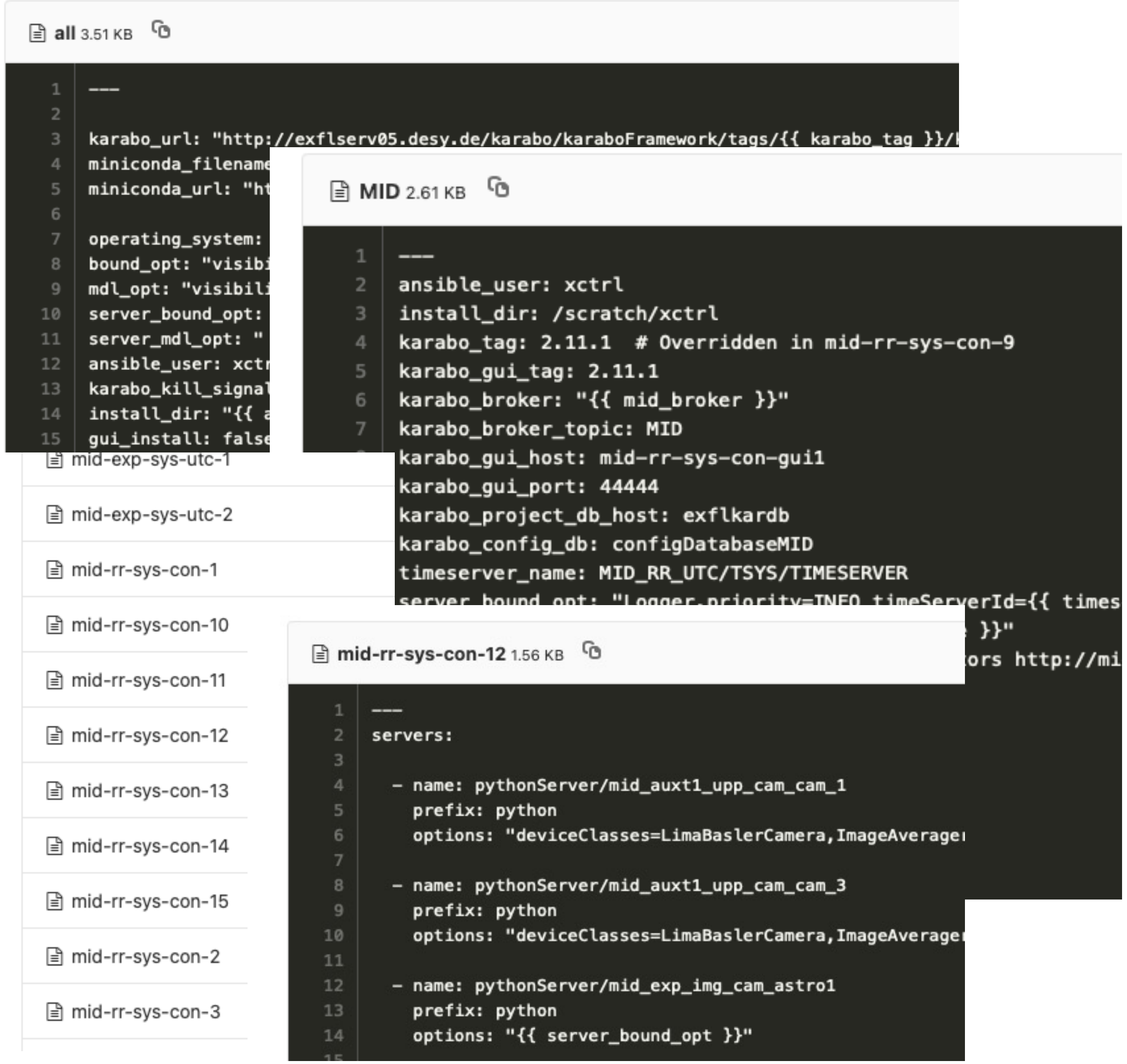
Bridge technologies
SCPI
DOOCS integration
EPICS (work in progress)
TINE

The Karabo Ecosystem - Contributors

async def t():

The Karabo Ecosystem - Deployment

- Deployment is currently done via *ansible*
  - Deployment groups represent topics
    - ▶ Lowest level is host (identified by alias)
  - Playbooks for
    - ▶ Deploying framework upgrades
    - ▶ Deploying service defintion upgrades □ think device servers
    - ▶ Deploying individual device updates
    - ▶ Start/stopping installations
  - Some consistency checks



all 3.51 KB

```
---

karabo_url: "http://exflserv05.desy.de/karabo/karaboFramework/tags/{{ karabo_tag }}/
miniconda_filename
miniconda_url: "ht

operating_system:
bound_opt: "visibi
mdl_opt: "visibili
server_bound_opt:
server_mdl_opt: "
ansible_user: xctr
karabo_kill_signal
install_dir: "{{ a
gui_install: false
```

MID 2.61 KB

```
---
ansible_user: xctrl
install_dir: /scratch/xctrl
karabo_tag: 2.11.1  # Overridden in mid-rr-sys-con-9
karabo_gui_tag: 2.11.1
karabo_broker: "{{ mid_broker }}"
karabo_broker_topic: MID
karabo_gui_host: mid-rr-sys-con-gui1
karabo_gui_port: 44444
karabo_project_db_host: exflkardb
karabo_config_db: configDatabaseMID
timeserver_name: MID_RR_UTC/TSYS/TIMESERVER
server_bound_opt: "Logger.priority=INFO timeServerId={{ times
 }}"
ors http://mi
```

mid-exp-sys-utc-1
mid-exp-sys-utc-2
mid-rr-sys-con-1
mid-rr-sys-con-10
mid-rr-sys-con-11
mid-rr-sys-con-12
mid-rr-sys-con-13
mid-rr-sys-con-14
mid-rr-sys-con-15
mid-rr-sys-con-2
mid-rr-sys-con-3

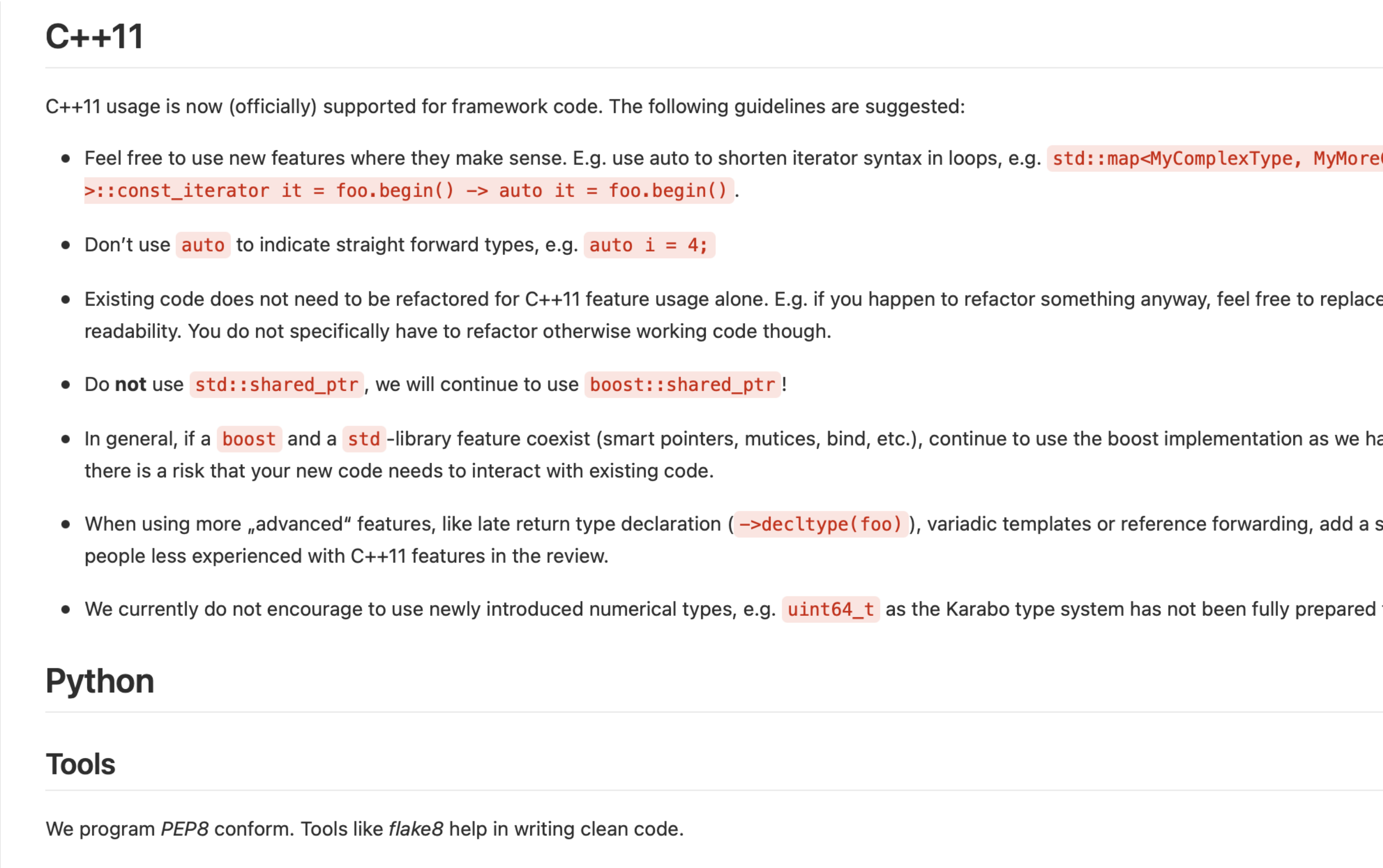
mid-rr-sys-con-12 1.56 KB

```
---
servers:

  - name: pythonServer/mid_auxt1_upp_cam_cam_1
    prefix: python
    options: "deviceClasses=LimaBaslerCamera,ImageAverage

  - name: pythonServer/mid_auxt1_upp_cam_cam_3
    prefix: python
    options: "deviceClasses=LimaBaslerCamera,ImageAverage

  - name: pythonServer/mid_exp_img_cam_astro1
    prefix: python
    options: "{{ server_bound_opt }}"
```

```
[xctrl@exflxdaqgw01 playbooks]$ ./install.yml SA1
[xctrl@exflxdaqgw01 playbooks]$ ./install_device_active.yml sa1-br-sys-con1 --extra-vars="package=Beckhoff"
```

Code Development – Standards and Guidelines

- Lightweight standards for Coding:
  - PEP8 for Python
  - A few custom rules for C++
- Emphasis nowadays on readability, not ingeniouity
  - In the past not always the case
- Aim for high test coverage
  - For quite a bit of older code quite some work needed



C++11

C++11 usage is now (officially) supported for framework code. The following guidelines are suggested:

- Feel free to use new features where they make sense. E.g. use auto to shorten iterator syntax in loops, e.g. `std::map<MyComplexType, MyMore` `>::const_iterator it = foo.begin() -> auto it = foo.begin()`.
- Don't use `auto` to indicate straight forward types, e.g. `auto i = 4;`
- Existing code does not need to be refactored for C++11 feature usage alone. E.g. if you happen to refactor something anyway, feel free to replace readability. You do not specifically have to refactor otherwise working code though.
- Do **not** use `std::shared_ptr`, we will continue to use `boost::shared_ptr`!
- In general, if a `boost` and a `std`-library feature coexist (smart pointers, mutices, bind, etc.), continue to use the boost implementation as we ha there is a risk that your new code needs to interact with existing code.
- When using more „advanced" features, like late return type declaration (`->decltype(foo)`), variadic templates or reference forwarding, add a s people less experienced with C++11 features in the review.
- We currently do not encourage to use newly introduced numerical types, e.g. `uint64_t` as the Karabo type system has not been fully prepared

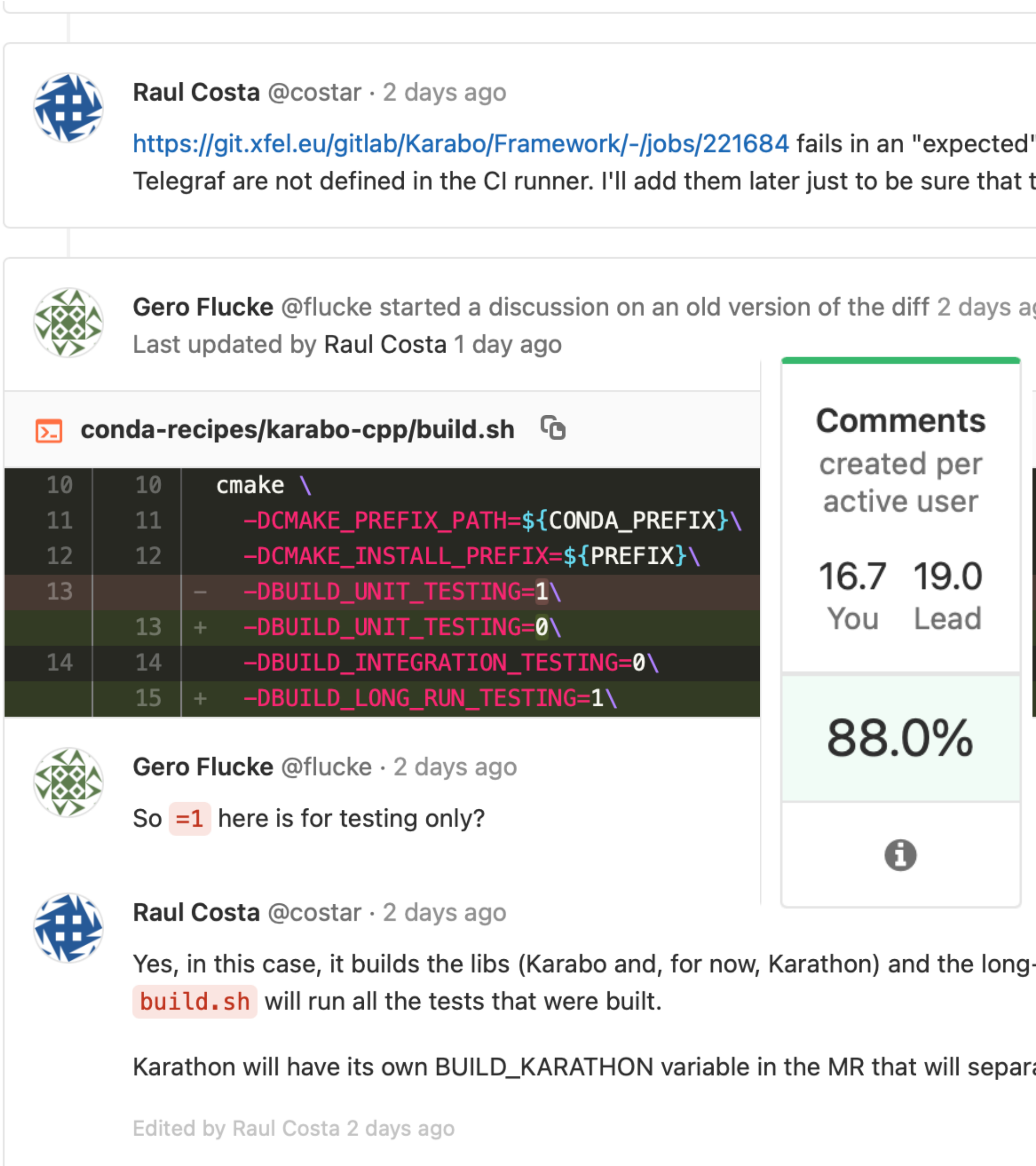
Python

Tools

We program *PEP8* conform. Tools like *flake8* help in writing clean code.

Code Development – Review

- Gitlab is used for code review
  - Review is mandatory
  - At least two people preferred
- Push to master is usually disabled
  - A merge request off a branch needs to be done
  - Code-author merges after review
- Lively and good discussions frequently happen and are encouraged
- It is okay to close a merge request
- Concept of Work In Progress is well adopted for early review



Raul Costa @costar · 2 days ago

https://git.xfel.eu/gitlab/Karabo/Framework/-/jobs/221684 fails in an "expected"
Telegraf are not defined in the CI runner. I'll add them later just to be sure that t

Gero Flucke @flucke started a discussion on an old version of the diff 2 days a
Last updated by Raul Costa 1 day ago

conda-recipes/karabo-cpp/build.sh

```
    cmake \
      -DCMAKE_PREFIX_PATH=${CONDA_PREFIX}\
      -DCMAKE_INSTALL_PREFIX=${PREFIX}\
-     -DBUILD_UNIT_TESTING=1\
+     -DBUILD_UNIT_TESTING=0\
      -DBUILD_INTEGRATION_TESTING=0\
+     -DBUILD_LONG_RUN_TESTING=1\
```

Gero Flucke @flucke · 2 days ago

So `=1` here is for testing only?

Raul Costa @costar · 2 days ago

Yes, in this case, it builds the libs (Karabo and, for now, Karathon) and the long-
`build.sh` will run all the tests that were built.

Karathon will have its own BUILD_KARATHON variable in the MR that will separa

Edited by Raul Costa 2 days ago

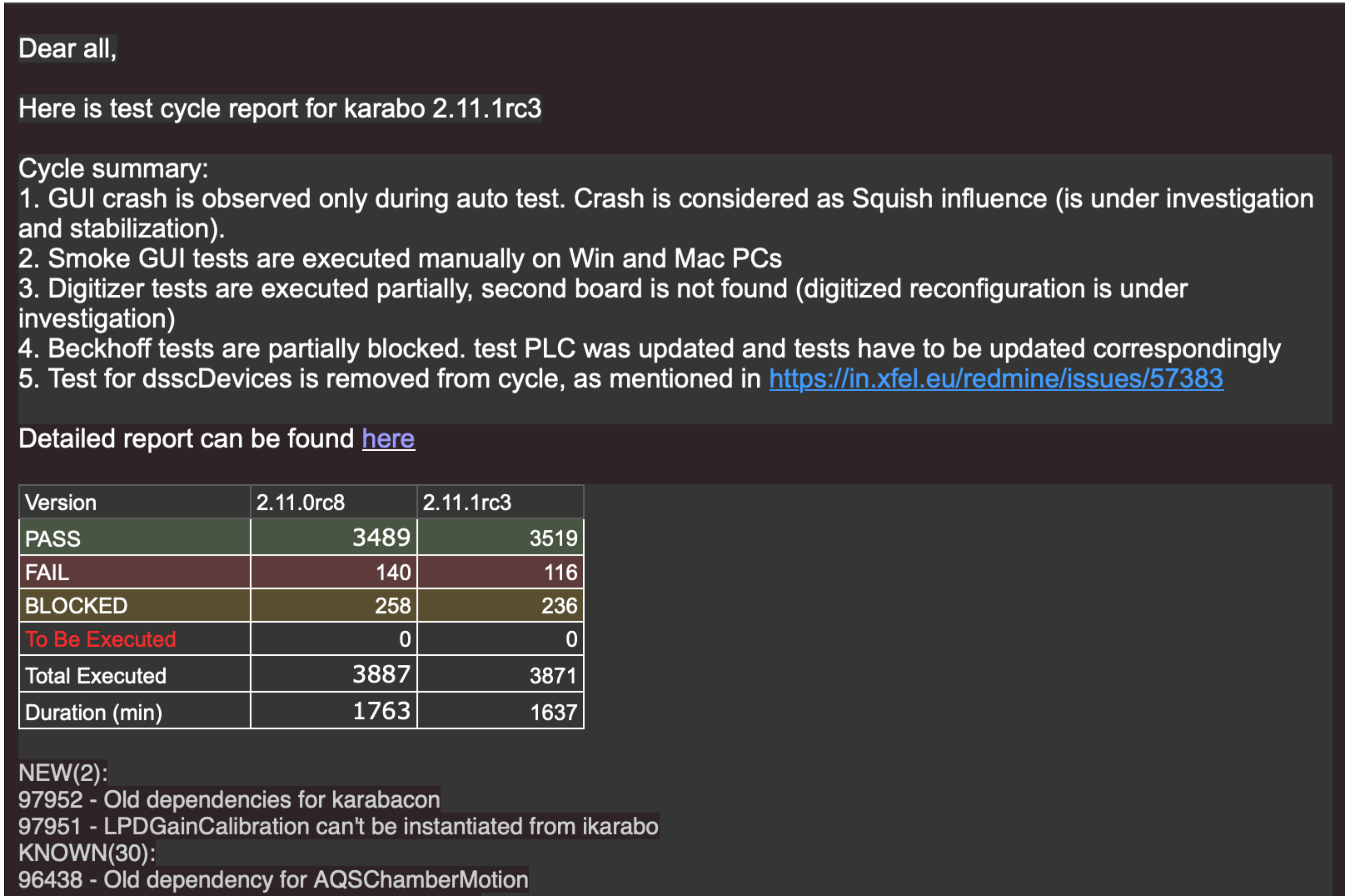
Comments
created per active user

16.7 You
19.0 Lead

88.0%

Code Development – Testing

- Dedicated Test Engineer:
  - A. Klimovskaia
- Tests for each framework release:
  - Includes GUI
  - Includes important devices
  - 3500+ tests, mostly automatic
  - 36h of test runs



Dear all,

Here is test cycle report for karabo 2.11.1rc3

Cycle summary:
1. GUI crash is observed only during auto test. Crash is considered as Squish influence (is under investigation and stabilization).
2. Smoke GUI tests are executed manually on Win and Mac PCs
3. Digitizer tests are executed partially, second board is not found (digitized reconfiguration is under investigation)
4. Beckhoff tests are partially blocked. test PLC was updated and tests have to be updated correspondingly
5. Test for dsscDevices is removed from cycle, as mentioned in https://in.xfel.eu/redmine/issues/57383

Detailed report can be found here

Version	2.11.0rc8	2.11.1rc3
PASS	3489	3519
FAIL	140	116
BLOCKED	258	236
To Be Executed	0	0
Total Executed	3887	3871
Duration (min)	1763	1637

NEW(2):
97952 - Old dependencies for karabacon
97951 - LPDGainCalibration can't be instantiated from ikarabo
KNOWN(30):
96438 - Old dependency for AQSChamberMotion

Code Development – Testing

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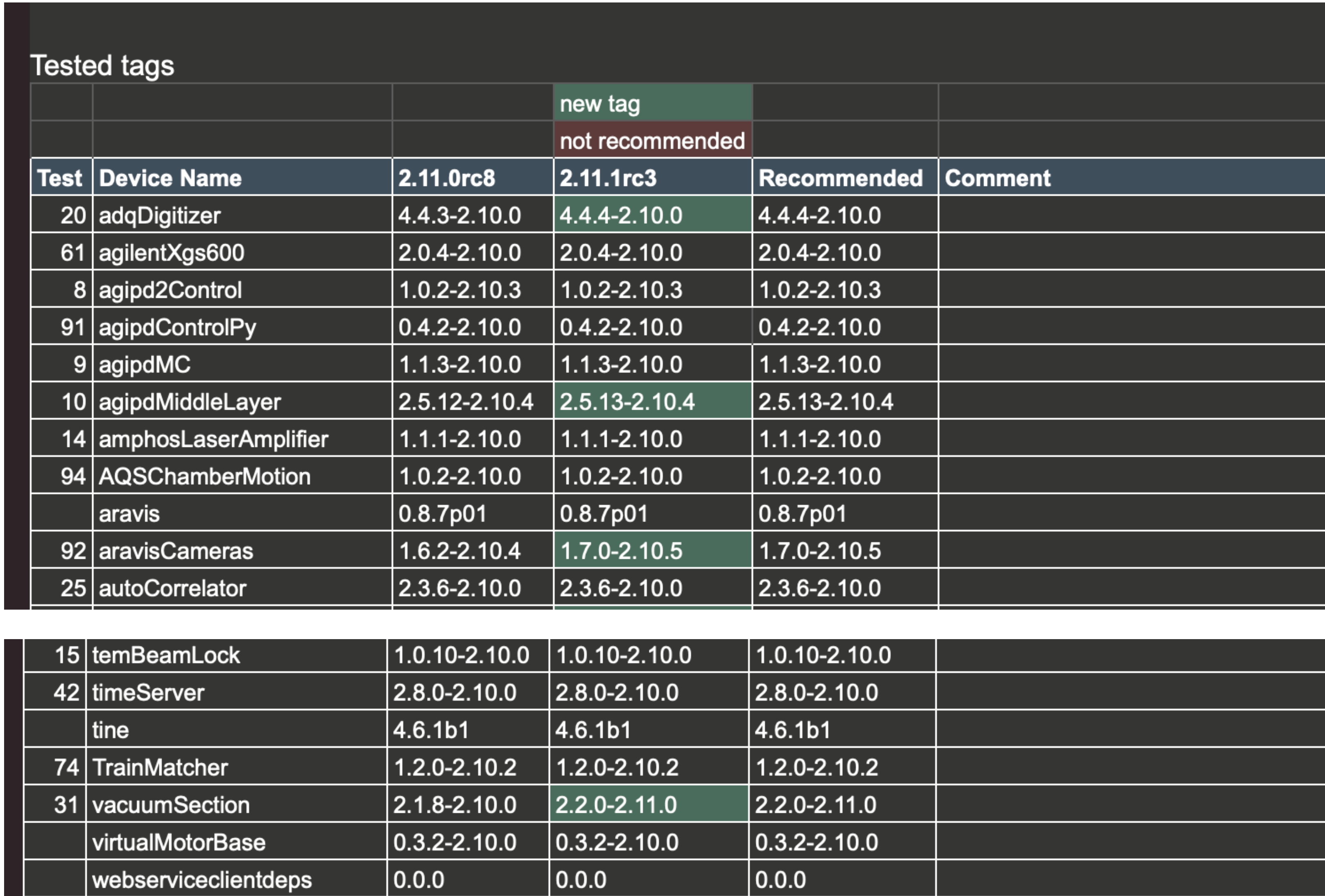


Tested tags

new tag

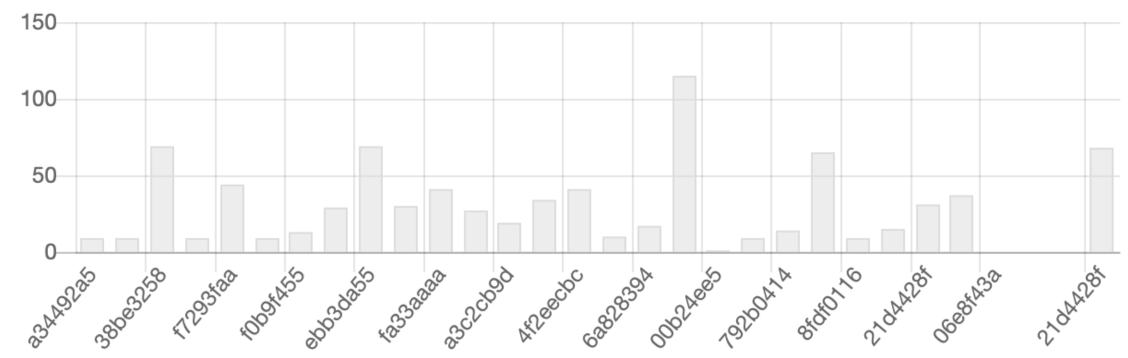
not recommended

Test	Device Name	2.11.0rc8	2.11.1rc3	Recommended	Comment
20	adqDigitizer	4.4.3-2.10.0	4.4.4-2.10.0	4.4.4-2.10.0	
61	agilentXgs600	2.0.4-2.10.0	2.0.4-2.10.0	2.0.4-2.10.0	
8	agipd2Control	1.0.2-2.10.3	1.0.2-2.10.3	1.0.2-2.10.3	
91	agipdControlPy	0.4.2-2.10.0	0.4.2-2.10.0	0.4.2-2.10.0	
9	agipdMC	1.1.3-2.10.0	1.1.3-2.10.0	1.1.3-2.10.0	
10	agipdMiddleLayer	2.5.12-2.10.4	2.5.13-2.10.4	2.5.13-2.10.4	
14	amphosLaserAmplifier	1.1.1-2.10.0	1.1.1-2.10.0	1.1.1-2.10.0	
94	AQSChamberMotion	1.0.2-2.10.0	1.0.2-2.10.0	1.0.2-2.10.0	
	aravis	0.8.7p01	0.8.7p01	0.8.7p01	
92	aravisCameras	1.6.2-2.10.4	1.7.0-2.10.5	1.7.0-2.10.5	
25	autoCorrelator	2.3.6-2.10.0	2.3.6-2.10.0	2.3.6-2.10.0	
15	temBeamLock	1.0.10-2.10.0	1.0.10-2.10.0	1.0.10-2.10.0	
42	timeServer	2.8.0-2.10.0	2.8.0-2.10.0	2.8.0-2.10.0	
	tine	4.6.1b1	4.6.1b1	4.6.1b1	
74	TrainMatcher	1.2.0-2.10.2	1.2.0-2.10.2	1.2.0-2.10.2	
31	vacuumSection	2.1.8-2.10.0	2.2.0-2.11.0	2.2.0-2.11.0	
	virtualMotorBase	0.3.2-2.10.0	0.3.2-2.10.0	0.3.2-2.10.0	
	webserviceclientdeps	0.0.0	0.0.0	0.0.0	

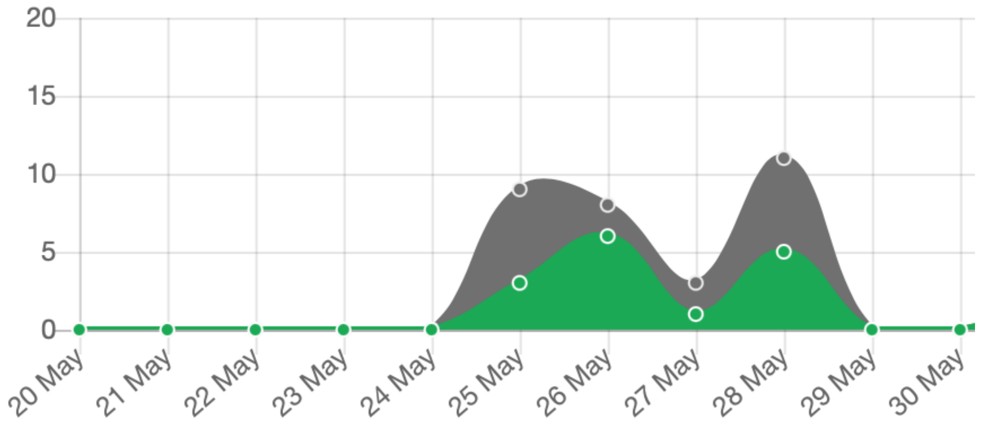
Code Development – Continuous Integration

- Gitlab based CI pipelines
  - Docker containers for supported operating systems
  - Automated test reporting
- Framework
  - Reduced test suite for commits (faster)
  - Full test suite for merge commits
- Devices
  - Differing levels of sophistication
  - Minimum: syntax and PEP8 check
  - But also: full integration, round-trip tests

Commit duration in minutes for last 30 commits



Pipelines for last month (21 May - 20 Jun)



SWOT: Strengths, Weaknesses, Opportunities, Threats

- Relatively young framework:
  - Modern technology choices: central broker, InfluxDB, C++14, Python 3.8, Asynchr
- Event-driven and asynchr. nature
  - Minimizes latency
  - Reduction of repetitive data, however engrained is a global unique id (train id) for timestamping
- Dynamic, self-describing topology and devices
  - Flexible thanks to schema injection possibilites
  - scales easily between single host system and faciltiy with 100+ control hosts
- GUI-server, Web-proxy gateway designs
  - Allows for extension outside the core framework and data flow regulation
- Built-in p2p data pipelines
- GUI Scene Builder: panels without programming

SWOT: Strengths, Weaknesses, Opportunities, Threats

- Relatively young framework:
  - Single facility usage: XFEL.EU. Impacts mainly Ecosytem which makes assumptions on XFEL.EU systems
  - Not in the public domain (yet)

- Event-driven and asynchr. nature
  - Users which are accustomed to polling data may need to learn to „trust“ the system
  - Async. programming might be new for software engineers who have not worked with such systems

- Dynamic, self-describing topology and devices: mishaving components can be more difficult to track
  - flexiblity comes at price of not have a static topology/system snapshot (is vs. should be there)

- Built-in p2p data pipelines
  - Proprietory, nowadays (also at XFEL.EU) ZMQ/MSGPACK is might be a more open technology choice

- GUI Scene Builder: panels without curation and vetting

- Lack of user authentication and authorization

SWOT: Strengths, Weaknesses, Opportunities, Threats

- Relatively young framework:
  - Expand to a user-base outside of XFEL.EU
  - In house development of framework: solutions are currently tailored to XFEL needs. If the framework has a significant shortcoming, we can deploy a fix within days usually
- Influx as a logging technology has already proven to be a game changer
  - Data mining
  - Visualization via Grafana
- The client architecture and scene DOM is foreseen to scale well with new client types
  - Web-API
  - Web-GUI
- Middlelayer API is a modern, pythonic and async. Framework with a relatively low entry level
  - Framework itself will work on small scale installations without much expert configuration
  - Light-weight: runs e.g. on Raspberry Pis and Hash can even be decoded in Micropython (R&D)
- Collaborative software engineering is well established in the XFEL CTRL group

SWOT: Strengths, Weaknesses, Opportunities, Threats

- Relatively young framework:
  - Not yet open-sourced, we don‘t have experience in supporting out-of-facility users and contributors
    ► At XFEL.EU close feedback loop between framework developers, and integration team
  - „older“ players (Tango, EPICS, ...) are more well-established, might be considered more stable
- Message broker might not scale to arbitrary installation size
- JMS (C++) is not supported by the community anymore
  - Now have MQTT, RabbitMQ and Redis in testing
- Designed against XFEL.EU time structure, global unique ids might be superfluous data at other facilities
- Batteries included dependency system is „outdated“
  - Hard to unravel though □ WIP, and drains resources

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