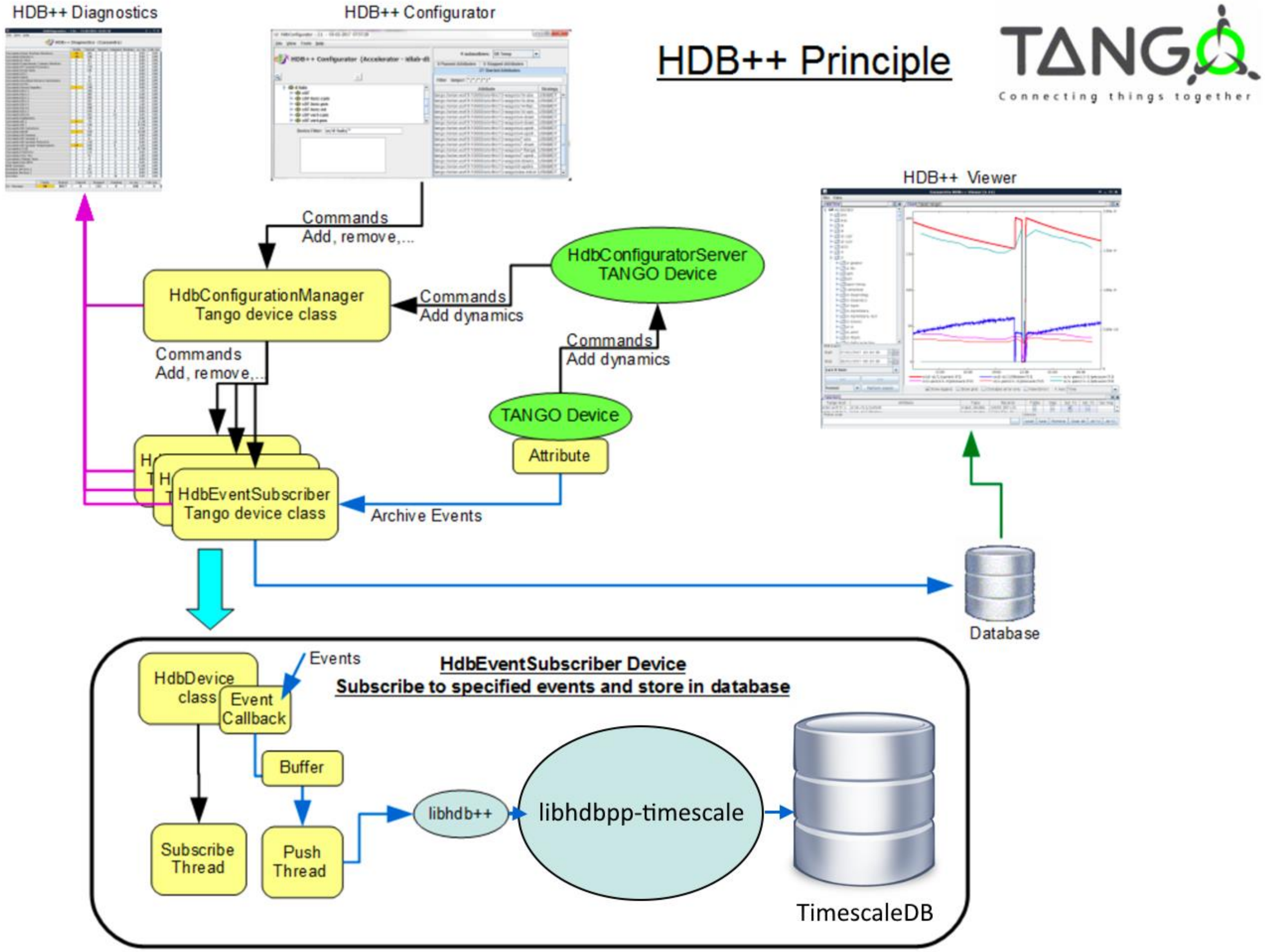
MAX IV Archiving

Dmitry Egorov

Tango HDB++



HDB++ Diagnostics

HDB++ Configurator

HDB++ Principle

TANGO
Connecting things together

HDB++ Viewer

Commands
Add, remove,...

HdbConfigurationManager
Tango device class

Commands
Add dynamics

HdbConfiguratorServer
TANGO Device

Commands
Add dynamics

Commands
Add, remove,...

TANGO Device

Attribute

HdbEventSubscriber
Tango device class

Archive Events

Database

Events

HdbEventSubscriber Device
Subscribe to specified events and store in database

HdbDevice
class

Event
Callback

Buffer

Subscribe
Thread

Push
Thread

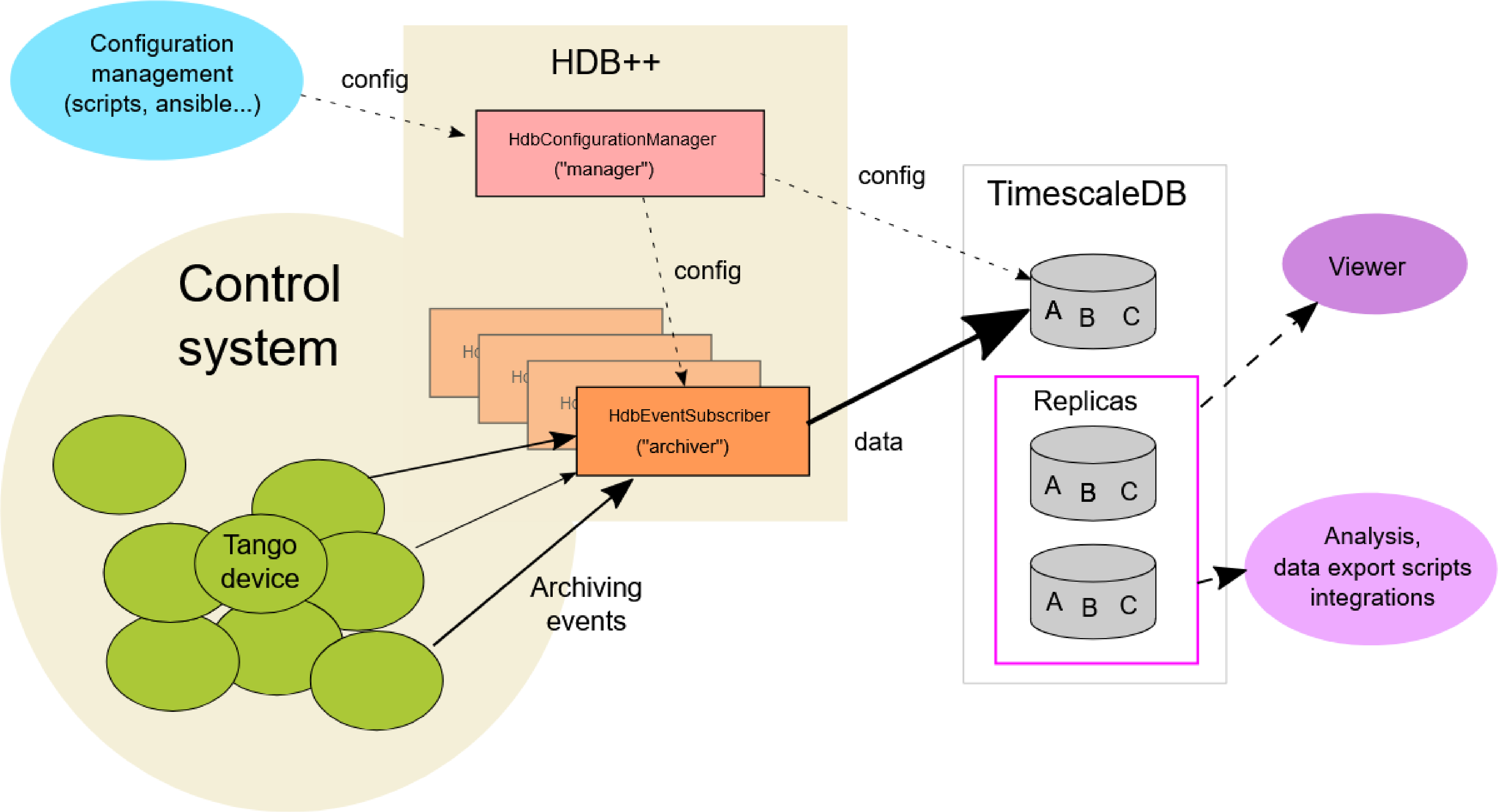
libhdb++

libhdbpp-timescale

TimescaleDB

https://tango-controls.readthedocs.io/en/latest/tools-and-extensions/archiving/HDB++.html

HDB++ at MAX IV


Configuration management (scripts, ansible...)
config
HDB++
HdbConfigurationManager ("manager")
config
config
TimescaleDB
Control system
Hd
Hd
Hd
HdbEventSubscriber ("archiver")
data
A B C
Viewer
Replicas
A B C
A B C
Analysis, data export scripts integrations
Tango device
Archiving events

Arrow direction shows data flow
Arrow size: amount of traffic
Dotted arrow: sporadic traffic

HDB++ at MAX IV

- Running HDB++ with Cassandra back-end, since late 2016
- TimescaleDB archiving in parallel since late 2022.
- Old data migrated (apart from some “complicated” attributes)
- In late 2023 stopped archiving to Cassandra. Decommissioning…

- Configuration using “yaml2archiving”

- Interest in archiving at beamlines is growing, work on standardization

Setup

- One HDB++ setup per BL, one for accelerator (~90% of data)
- Single Postgres database cluster, 3 nodes (1 write, 2 read-only)
- Separate schema for each control system

Some statistics

~ 20000 attributes
~ 2000 events per second
~ 50 archivers across 20 control systems
~ 250 billion rows in TimescaleDB
~ 10TB disk space used

Few words about Cassandra

Advantages:

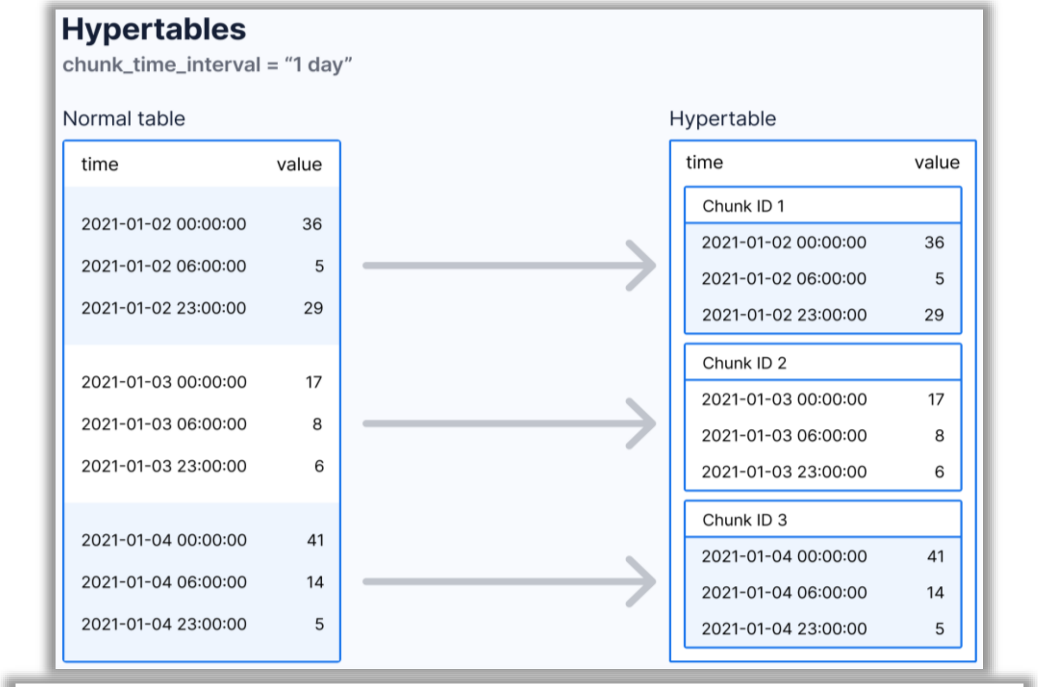
- High scalability – just add more nodes and write more data
- High write performance – efficient for low-latency writes

Disadvantages:

- Lack of in-house expertise (cluster management, CQL)
- Limited query capabilities (averaging, aggregations, etc.)
- ESRF stopped supporting Cassandra as an HDB++ backend

It has taken about 4 years to migrate from Cassandra, maintaining the old system while testing and setting up the new one.

…and about TimescaleDB



Hypertables

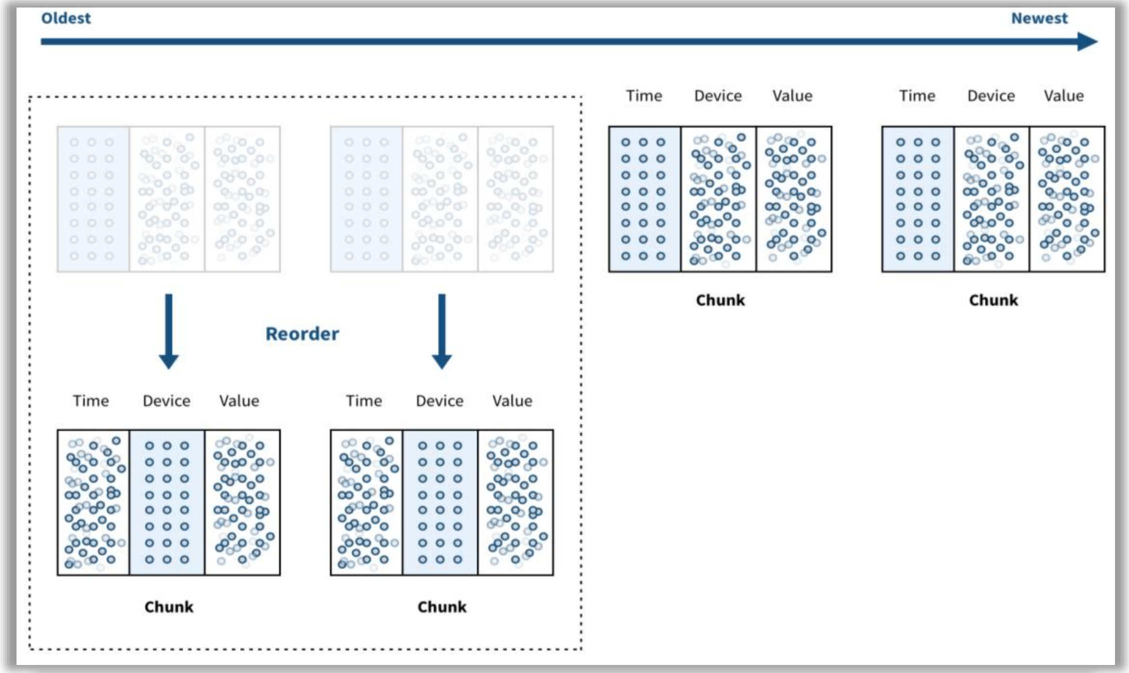
chunk_time_interval = “1 day”

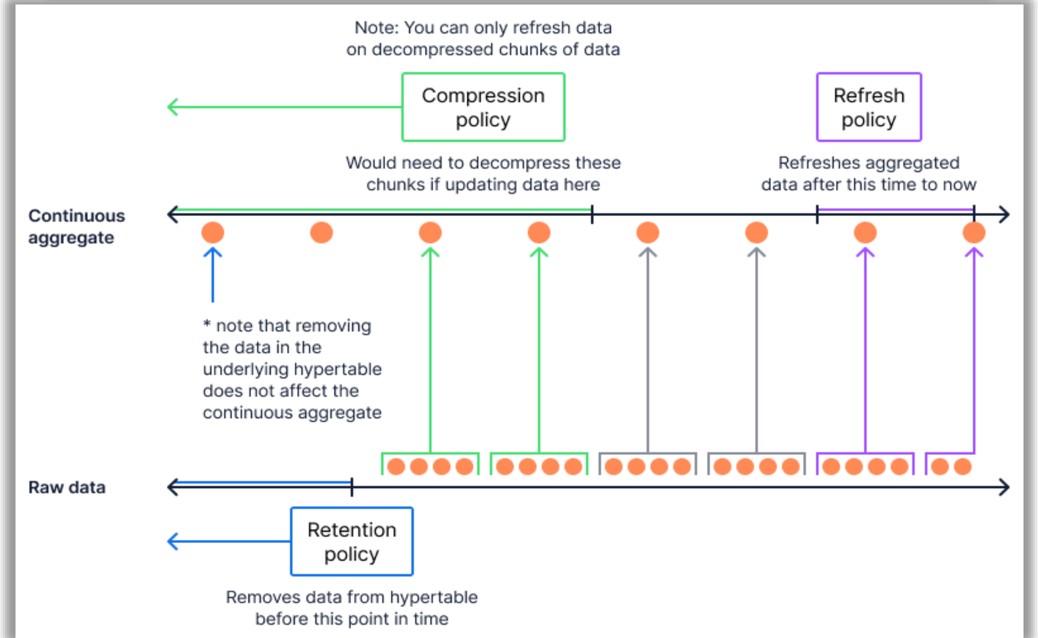
Normal table

time	value
2021-01-02 00:00:00	36
2021-01-02 06:00:00	5
2021-01-02 23:00:00	29
2021-01-03 00:00:00	17
2021-01-03 06:00:00	8
2021-01-03 23:00:00	6
2021-01-04 00:00:00	41
2021-01-04 06:00:00	14
2021-01-04 23:00:00	5

Hypertable

time	value
Chunk ID 1	
2021-01-02 00:00:00	36
2021-01-02 06:00:00	5
2021-01-02 23:00:00	29
Chunk ID 2	
2021-01-03 00:00:00	17
2021-01-03 06:00:00	8
2021-01-03 23:00:00	6
Chunk ID 3	
2021-01-04 00:00:00	41
2021-01-04 06:00:00	14
2021-01-04 23:00:00	5





Note: You can only refresh data on decompressed chunks of data

Compression policy

Would need to decompress these chunks if updating data here

Refresh policy

Refreshes aggregated data after this time to now

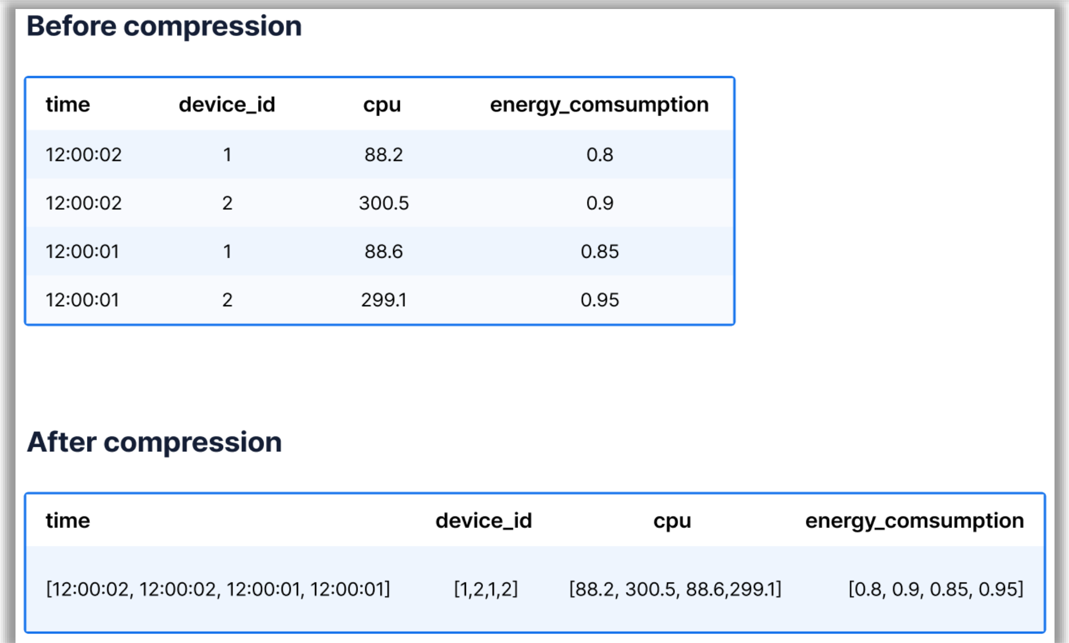
Continuous aggregate

* note that removing the data in the underlying hypertable does not affect the continuous aggregate

Raw data

Retention policy

Removes data from hypertable before this point in time



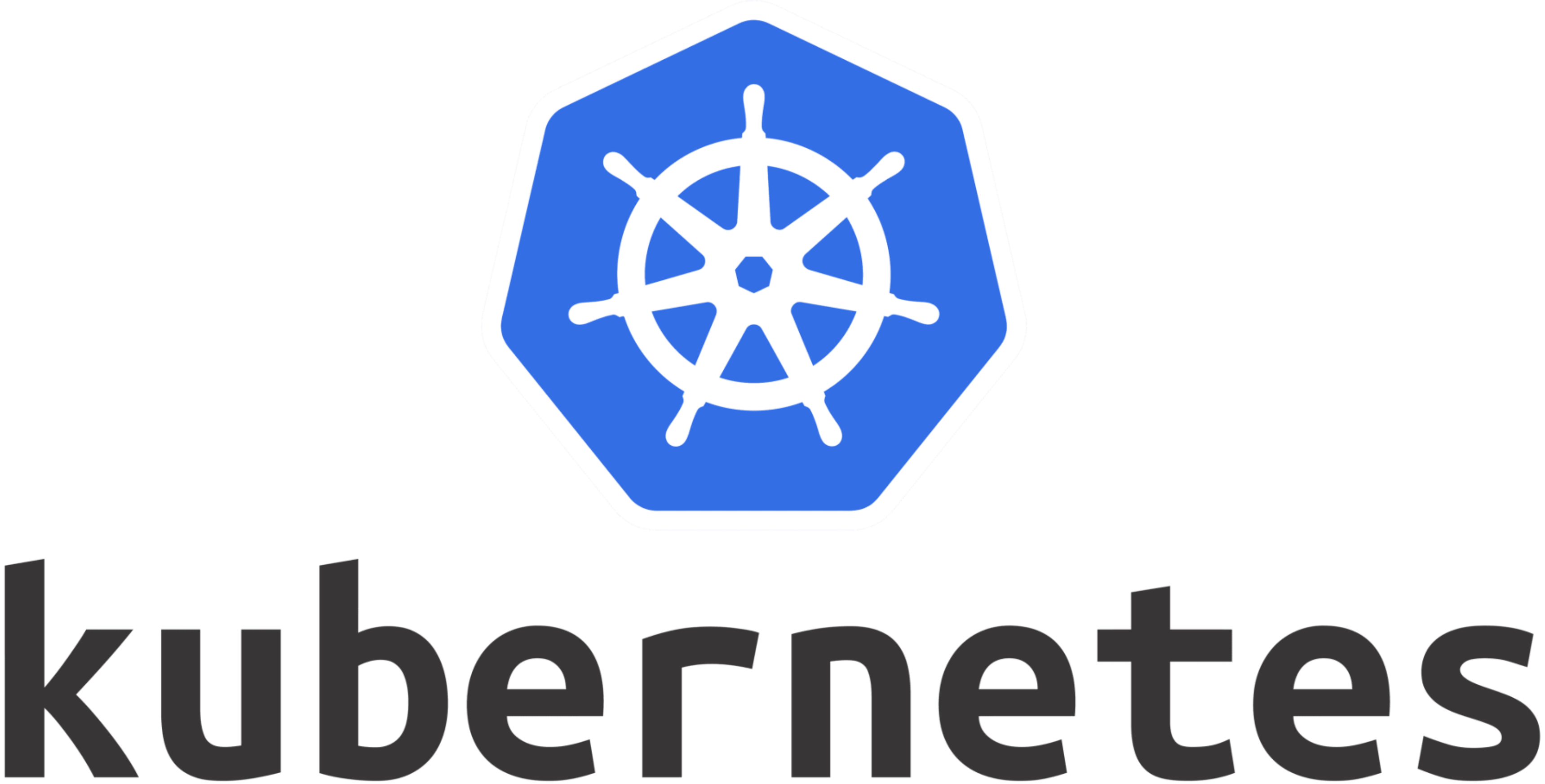
Before compression

time	device_id	cpu	energy_comsumption
12:00:02	1	88.2	0.8
12:00:02	2	300.5	0.9
12:00:01	1	88.6	0.85
12:00:01	2	299.1	0.95

After compression

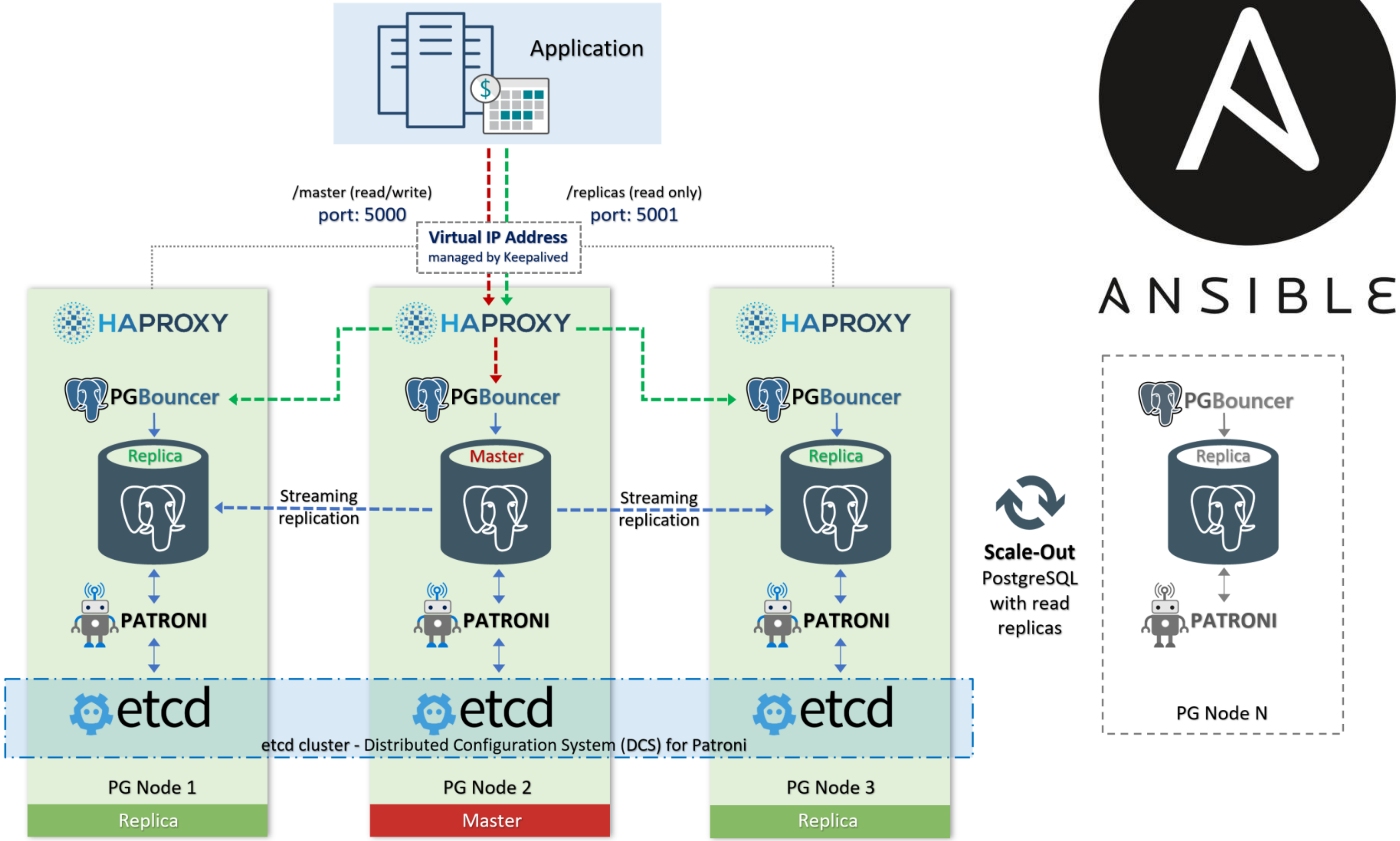
time	device_id	cpu	energy_comsumption
[12:00:02, 12:00:02, 12:00:01, 12:00:01]	[1,2,1,2]	[88.2, 300.5, 88.6,299.1]	[0.8, 0.9, 0.85, 0.95]

Infrastructure deployment at MAX IV



See presentation by Andrii Salnikov at 15.30

Another deployment option



ANSIBLE

https://github.com/vitabaks/postgresql_cluster

HDB deployment at MAX IV

CONDA

ANSIBLE

AWX

◆ Artifact (o

○ conda-f
HDB++ library

○ conda-f
HDB++ library

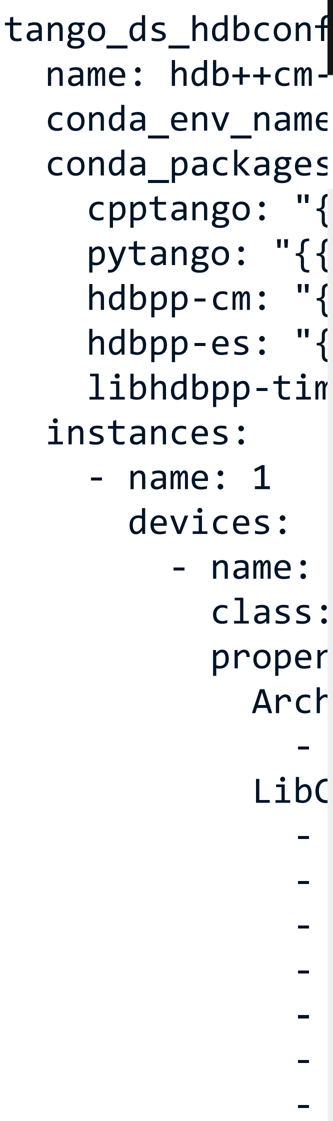
○ conda-f
Tango device

○ conda-f
Interface libra

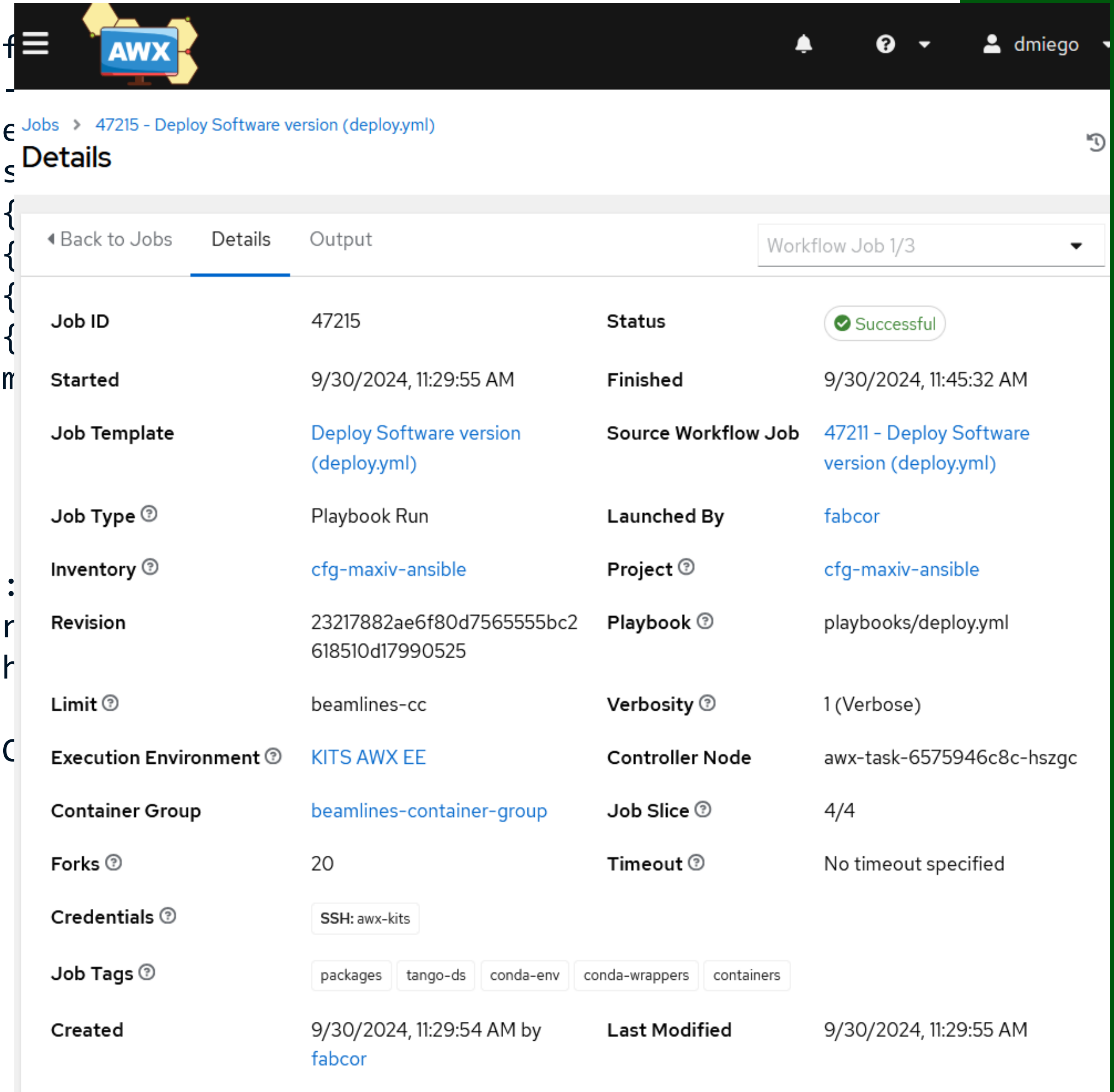
○ conda-f
Tango device

○ conda-f
Tango device

○ conda-f
hdb++ pythor



```
tango_ds_hdbconf
  name: hdb++cm-
  conda_env_name
  conda_packages
    cpptango: "{
    pytango: "{{
    hdbpp-cm: "{
    hdbpp-es: "{
    libhdbpp-tim
  instances:
    - name: 1
      devices:
        - name:
          class:
          proper
            Arch
              -
            LibC
              -
              -
              -
              -
              -
              -
              -
```



Jobs > 47215 - Deploy Software version (deploy.yml)

Details

Job ID	47215	Status	✓ Successful
Started	9/30/2024, 11:29:55 AM	Finished	9/30/2024, 11:45:32 AM
Job Template	Deploy Software version (deploy.yml)	Source Workflow Job	47211 - Deploy Software version (deploy.yml)
Job Type	Playbook Run	Launched By	fabcor
Inventory	cfg-maxiv-ansible	Project	cfg-maxiv-ansible
Revision	23217882ae6f80d7565555bc2618510d17990525	Playbook	playbooks/deploy.yml
Limit	beamlines-cc	Verbosity	1 (Verbose)
Execution Environment	KITS AWX EE	Controller Node	awx-task-6575946c8c-hszgc
Container Group	beamlines-container-group	Job Slice	4/4
Forks	20	Timeout	No timeout specified
Credentials	SSH: awx-kits		
Job Tags	packages tango-ds conda-env conda-wrappers containers		
Created	9/30/2024, 11:29:54 AM by fabcor	Last Modified	9/30/2024, 11:29:55 AM

https://gitlab.com/MaxIV/lib-maxiv-dsconfig

See presentation by Benjamin Bertrand at 16.00

Configuration (yaml2archiving)

Yaml2archiving aims to ease the configuration of the HDB++ Archiving by using YAML format files in order to add/remove/update archived attributes. Each YAML file corresponds to one HdbEventSubscriber device and can include the state of the archived attributes with their settings.

```yaml
db: b-v-dummymax-csdb-0.maxiv.lu.se:10000
manager: SYS/HDBPP/MANAGER-01
archiver: SYS/HDBPP/ARCHIVER-01

configuration:
  - class: TangoTest
    filtering:
      device: sys/tg_test/1
    attributes:
      double_scalar:
        polling_period: 3000
        archive_period: 10000
      short_scalar:
        polling_period: 3000
        archive_period: 10000
```

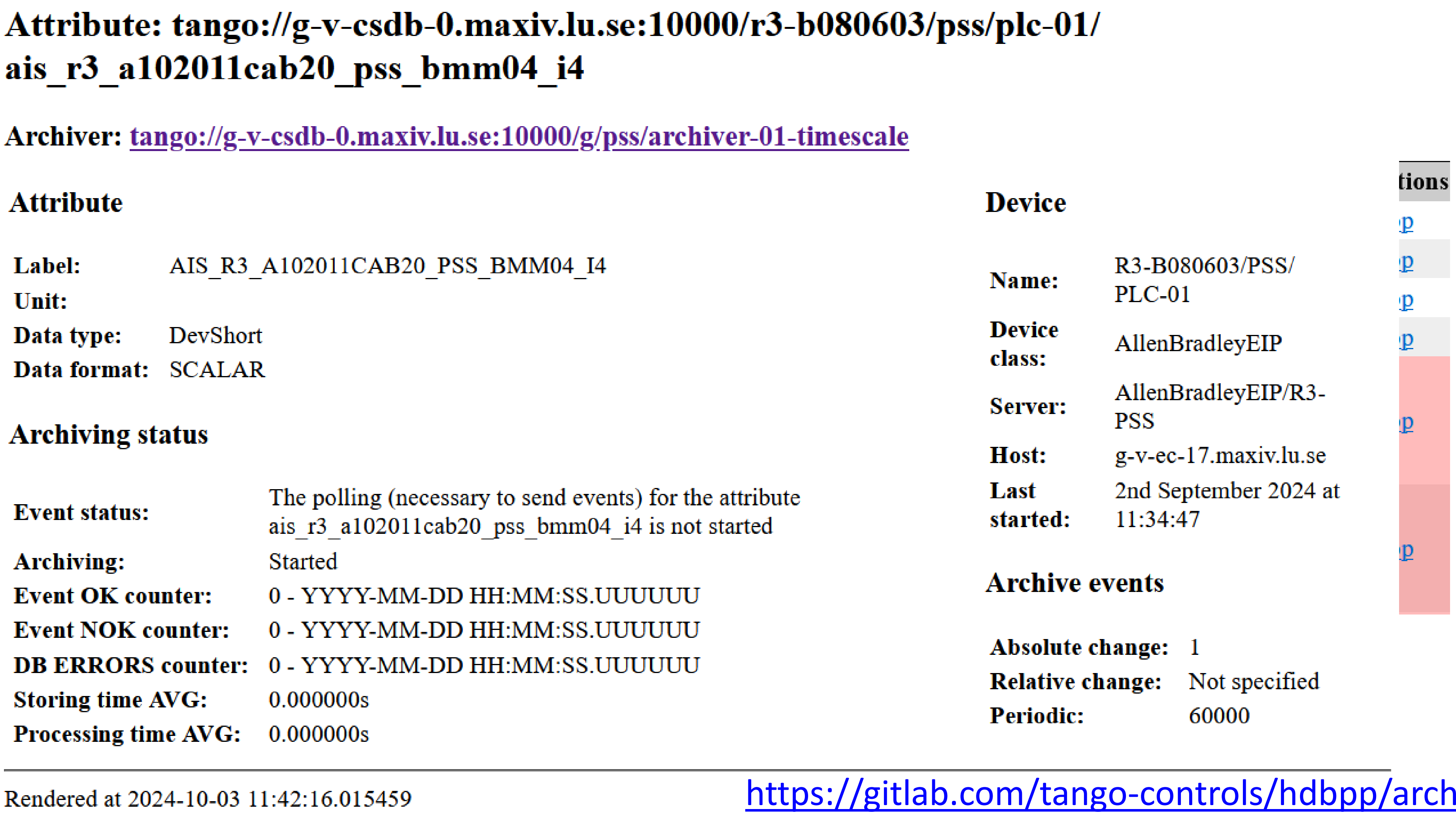
```yaml
db: g-v-csdb-0.maxiv.lu.se:10000
manager: sys/hdbpp/manager-01-timescale
archiver: i/mag/archiver-01-timescale
defaults:
  - "../mag_defaults.yaml"

configuration:
  - class: MagnetCircuit
    filtering:
      device:
        - "i-.*"
    attributes:
      mainfieldcomponent:
        archive_rel_change: 1.0
        archive_period: 60000
        polling_period: 1000
```

https://gitlab.com/tango-controls/hdbpp/yaml2archiving

Thanks to Johan Forsberg

Monitoring (ArchWizard)

"ArchWizard 🧙 " is a simple web interface to the HDB++ archiving system.
It is intended for monitoring and troubleshooting, not maintenance such as adding and removing attributes.
It's built using Python, FastAPI, Jinja2 and PyTango.



Attribute: tango://g-v-csdb-0.maxiv.lu.se:10000/r3-b080603/pss/plc-01/ais_r3_a102011cab20_pss_bmm04_i4

Archiver: tango://g-v-csdb-0.maxiv.lu.se:10000/g/pss/archiver-01-timescale

Attribute

Label:	AIS_R3_A102011CAB20_PSS_BMM04_I4
Unit:	
Data type:	DevShort
Data format:	SCALAR

Archiving status

Event status:	The polling (necessary to send events) for the attribute ais_r3_a102011cab20_pss_bmm04_i4 is not started
Archiving:	Started
Event OK counter:	0 - YYYY-MM-DD HH:MM:SS.UUUUUU
Event NOK counter:	0 - YYYY-MM-DD HH:MM:SS.UUUUUU
DB ERRORS counter:	0 - YYYY-MM-DD HH:MM:SS.UUUUUU
Storing time AVG:	0.000000s
Processing time AVG:	0.000000s

Device

Name:	R3-B080603/PSS/PLC-01
Device class:	AllenBradleyEIP
Server:	AllenBradleyEIP/R3-PSS
Host:	g-v-ec-17.maxiv.lu.se
Last started:	2nd September 2024 at 11:34:47

Archive events

Absolute change:	1
Relative change:	Not specified
Periodic:	60000

tions
p
p
p
p
p
p

Rendered at 2024-10-03 11:42:16.015459

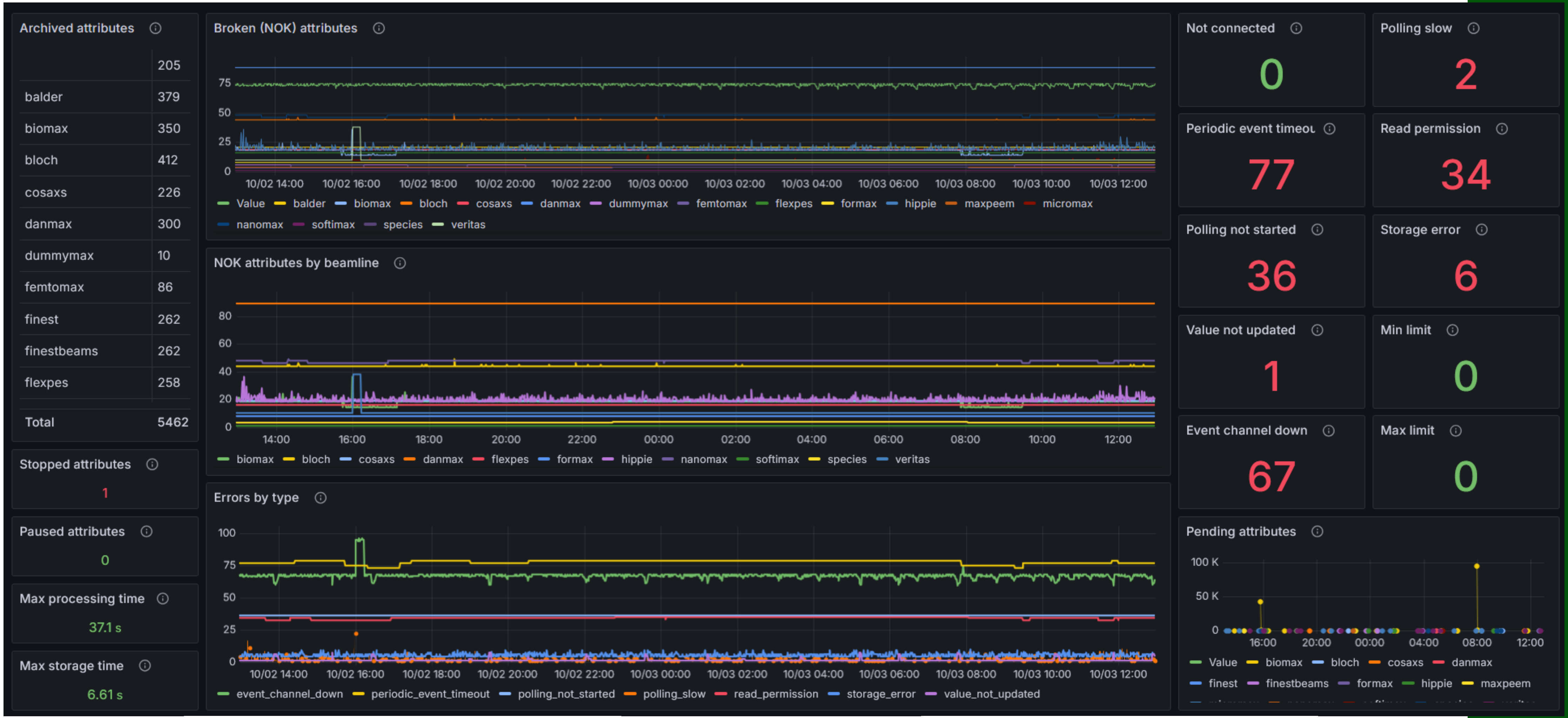
https://gitlab.com/tango-controls/hdbpp/archwizard

Monitoring (hdbpp-exporter)

Prometheus HDB++ exporter
An exporter is a small webserver that publishes metrics data in a text format readable by the Prometheus monitoring service.
This exporter connects to all HdbEventSubscriber devices and exports several diagnostics attributes, such as AttributeNumber, AttributeNokNumber etc.

```
Example output:

# HELP hdbpp_eventsubscriber_AttributeNokNumber Attribute 'AttributeNokNumber' on
HdbEventSubscriber
# TYPE hdbpp_eventsubscriber_AttributeNokNumber gauge
hdbpp_eventsubscriber_AttributeNokNumber{device="SYS/HDBPP/ARCHIVER-01"} 10.0
# HELP hdbpp_eventsubscriber_AttributeNumber Attribute 'AttributeNumber' on
HdbEventSubscriber
# TYPE hdbpp_eventsubscriber_AttributeNumber gauge
hdbpp_eventsubscriber_AttributeNumber{device="SYS/HDBPP/ARCHIVER-01"} 451.0
# HELP hdbpp_eventsubscriber_error_periodic_event_timeout Attribute
'AttributePendingNumber' on HdbEventSubscriber
# TYPE hdbpp_eventsubscriber_error_periodic_event_timeout gauge
hdbpp_eventsubscriber_error_periodic_event_timeout{device="SYS/HDBPP/ARCHIVER-01"}
10.0
```

Monitoring (hdbpp-exporter)



Archived attributes ⓘ

	205
balder	379
biomax	350
bloch	412
cosaxs	226
danmax	300
dummymax	10
femtomax	86
finest	262
finestbeams	262
flexpes	258
Total	5462

Stopped attributes ⓘ 1

Paused attributes ⓘ 0

Max processing time ⓘ 37.1 s

Max storage time ⓘ 6.61 s

Broken (NOK) attributes ⓘ

NOK attributes by beamline ⓘ

Errors by type ⓘ

Not connected ⓘ 0

Polling slow ⓘ 2

Periodic event timeou ⓘ 77

Read permission ⓘ 34

Polling not started ⓘ 36

Storage error ⓘ 6

Value not updated ⓘ 1

Min limit ⓘ 0

Event channel down ⓘ 67

Max limit ⓘ 0

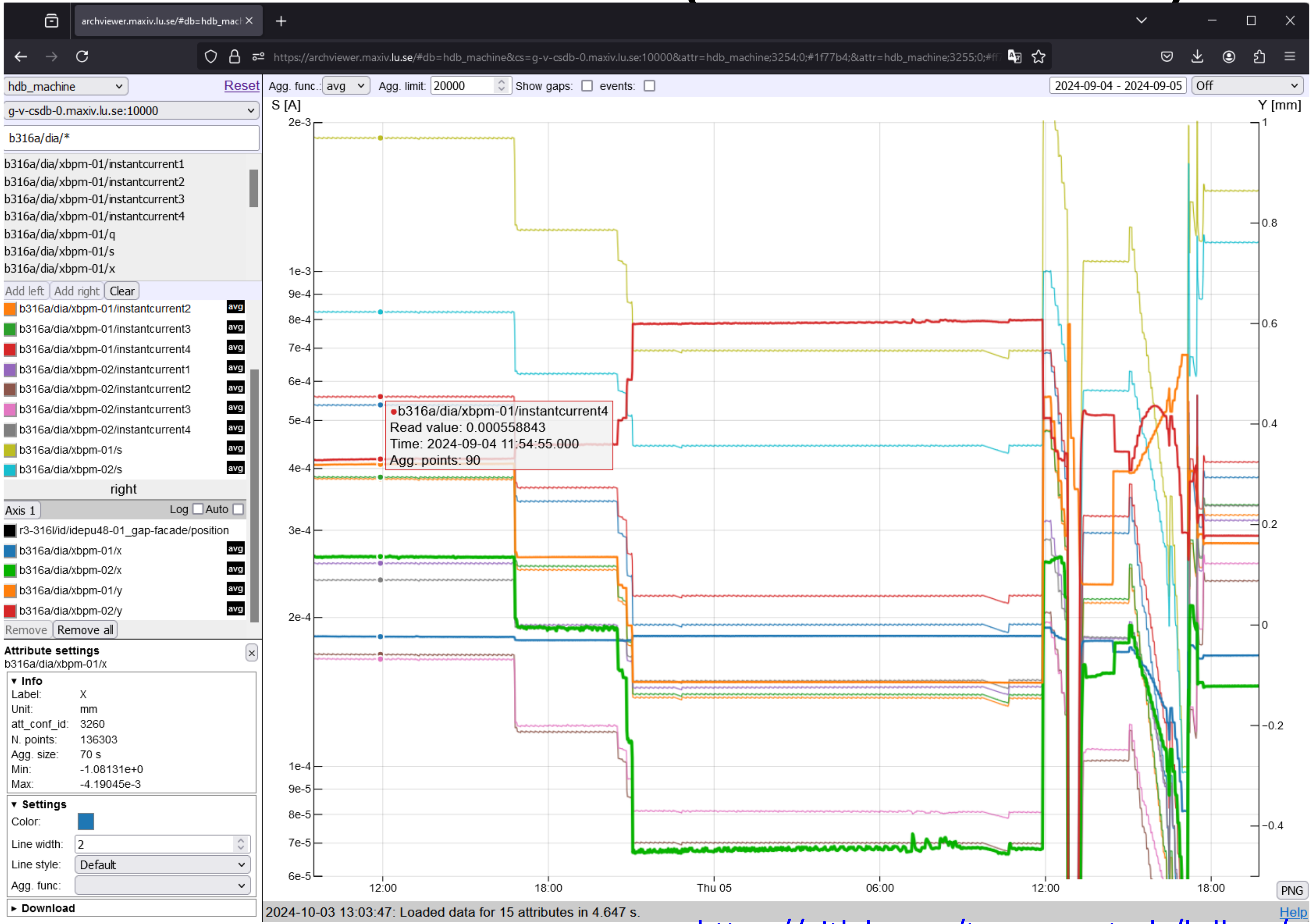
Pending attributes ⓘ

Prometheus

Grafana

MAX IV

Data viewer (Archviewer)



archviewer.maxiv.lu.se/#db=hdb_mach

https://archviewer.maxiv.lu.se/#db=hdb_machine&cs=g-v-csdb-0.maxiv.lu.se:10000&attr=hdb_machine;3254;0;#1f77b4;&attr=hdb_machine;3255;0;#ff

hdb_machine Reset

g-v-csdb-0.maxiv.lu.se:10000

b316a/dia/*

b316a/dia/xbpm-01/instantcurrent1
b316a/dia/xbpm-01/instantcurrent2
b316a/dia/xbpm-01/instantcurrent3
b316a/dia/xbpm-01/instantcurrent4
b316a/dia/xbpm-01/q
b316a/dia/xbpm-01/s
b316a/dia/xbpm-01/x

Add left | Add right | Clear

- 🟧 b316a/dia/xbpm-01/instantcurrent2 avg
- 🟩 b316a/dia/xbpm-01/instantcurrent3 avg
- 🟥 b316a/dia/xbpm-01/instantcurrent4 avg
- 🟪 b316a/dia/xbpm-02/instantcurrent1 avg
- 🟫 b316a/dia/xbpm-02/instantcurrent2 avg
- 🟪 b316a/dia/xbpm-02/instantcurrent3 avg
- ⬜ b316a/dia/xbpm-02/instantcurrent4 avg
- 🟨 b316a/dia/xbpm-01/s avg
- 🟦 b316a/dia/xbpm-02/s avg

right

Axis 1 Log □ Auto □

- ⬛ r3-316l/id/idepu48-01_gap-facade/position
- 🟦 b316a/dia/xbpm-01/x avg
- 🟩 b316a/dia/xbpm-02/x avg
- 🟧 b316a/dia/xbpm-01/y avg
- 🟥 b316a/dia/xbpm-02/y avg

Remove | Remove all

Attribute settings
b316a/dia/xbpm-01/x

▾ **Info**

Label:	X
Unit:	mm
att_conf_id:	3260
N. points:	136303
Agg. size:	70 s
Min:	-1.08131e+0
Max:	-4.19045e-3

▾ **Settings**

Color:	🟦
Line width:	2
Line style:	Default
Agg. func:	

▸ **Download**

Agg. func.: avg Agg. limit: 20000 Show gaps: □ events: □ 2024-09-04 - 2024-09-05 Off

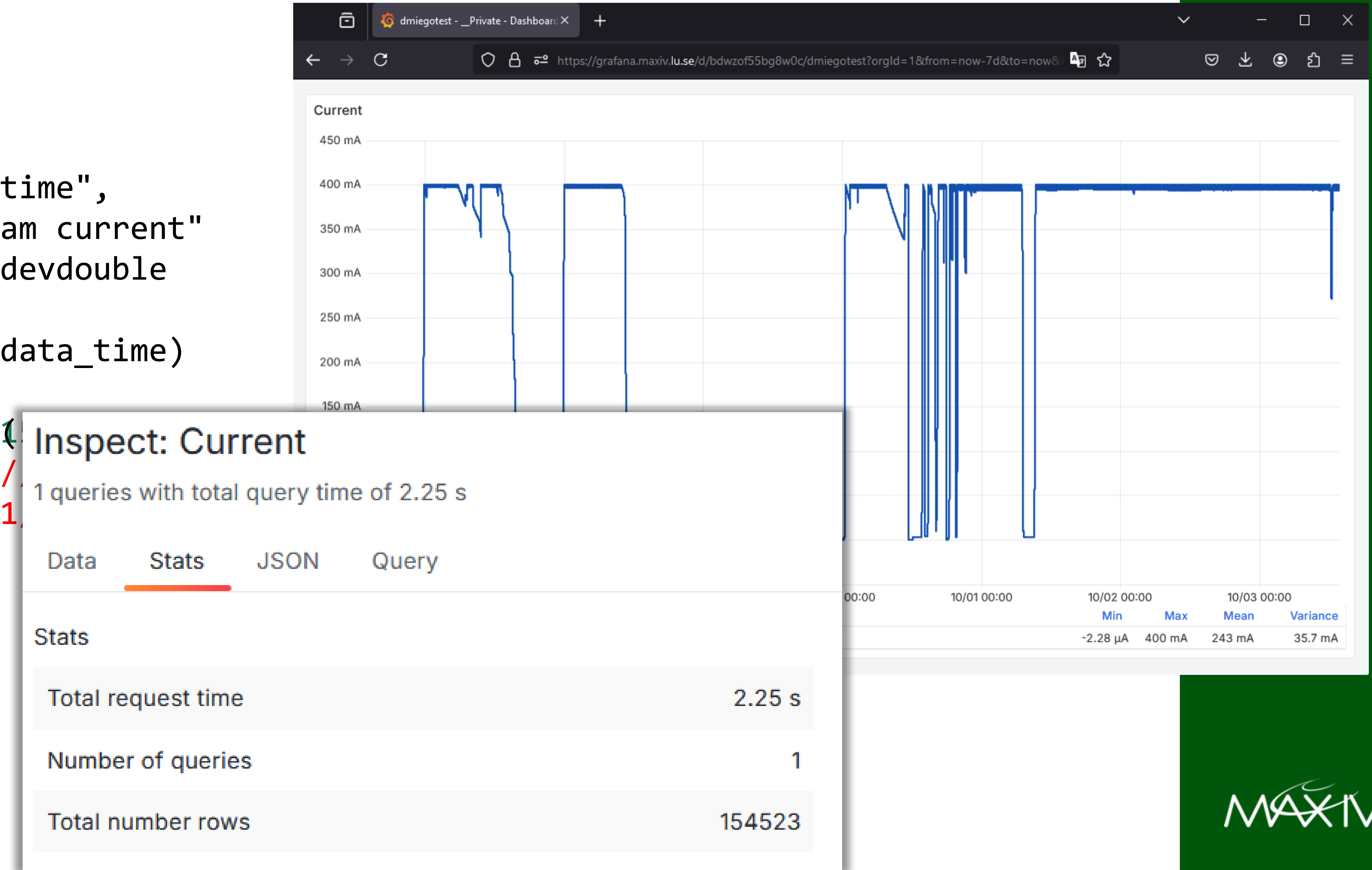
●b316a/dia/xbpm-01/instantcurrent4
Read value: 0.000558843
Time: 2024-09-04 11:54:55.000
Agg. points: 90

2024-10-03 13:03:47: Loaded data for 15 attributes in 4.647 s.

https://gitlab.com/tango-controls/hdbpp/archviewer

Data view with Grafana

```
SELECT
  data_time AS "time",
  value_r as "Beam current"
FROM att_scalar_devdouble
WHERE
  $__timeFilter(data_time)
  and
  att_conf_id = (
ORDER BY 1tango:/
319s2/dia/dcct-01/
ORDER BY 1
```



dmiegotest - _Private - Dashboard

https://grafana.maxiv.lu.se/d/bdwzof55bg8w0c/dmiegotest?orgId=1&from=now-7d&to=now&

Min	Max	Mean	Variance
-2.28 µA	400 mA	243 mA	35.7 mA

Inspect: Current

1 queries with total query time of 2.25 s

Stats

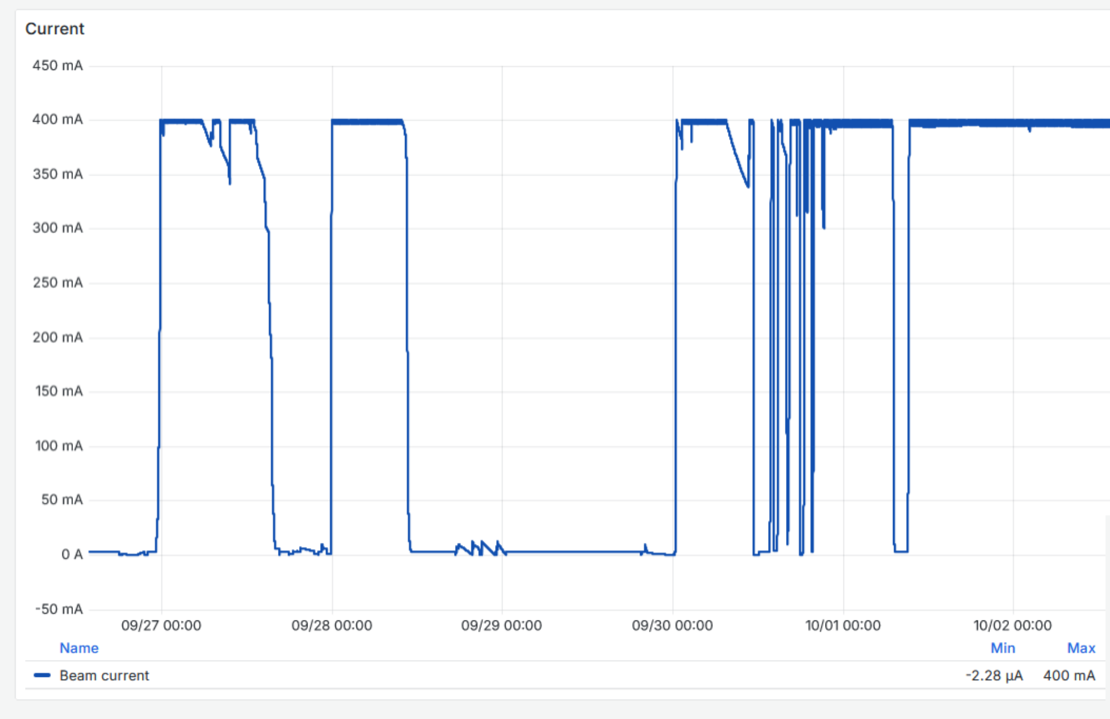
Total request time	2.25 s
Number of queries	1
Total number rows	154523

Downsampling (Timebucket)

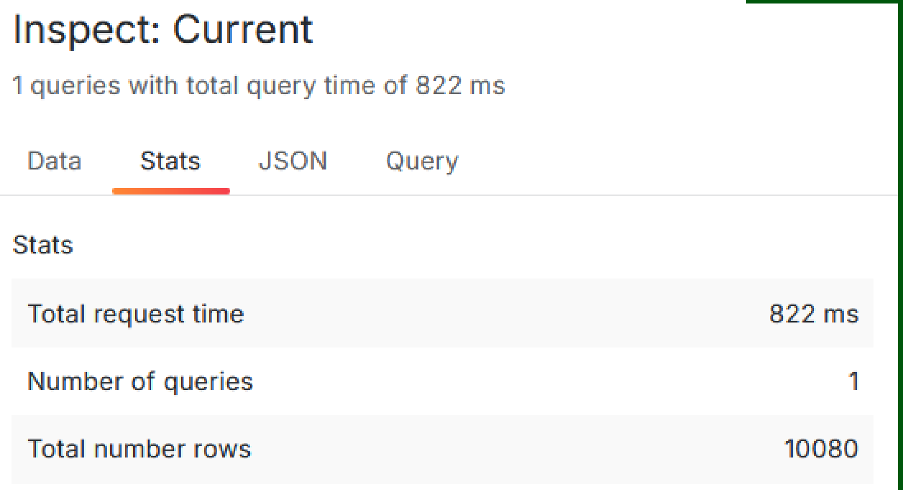
```
SELECT
  time_bucket(‘1 min', data_time) AS time,
  AVG(value_r) as "Beam current"
FROM
  att_scalar_devdouble
WHERE
  $__timeFilter(data_time)
  and
  att_conf_id = (select att_conf_id from att_conf where
att_name='tango://g-v-csdb-0.maxiv.lu.se:10000/r3-319s2/dia/dcct-
01/current')
GROUP BY
  time
ORDER BY
  time;
```

https://www.timescale.com/blog/simplified-time-series-analytics-using-the-time_bucket-function/

Downsampling (Timebucket)



Name	Min	Max
Beam current	-2.28 µA	400 mA

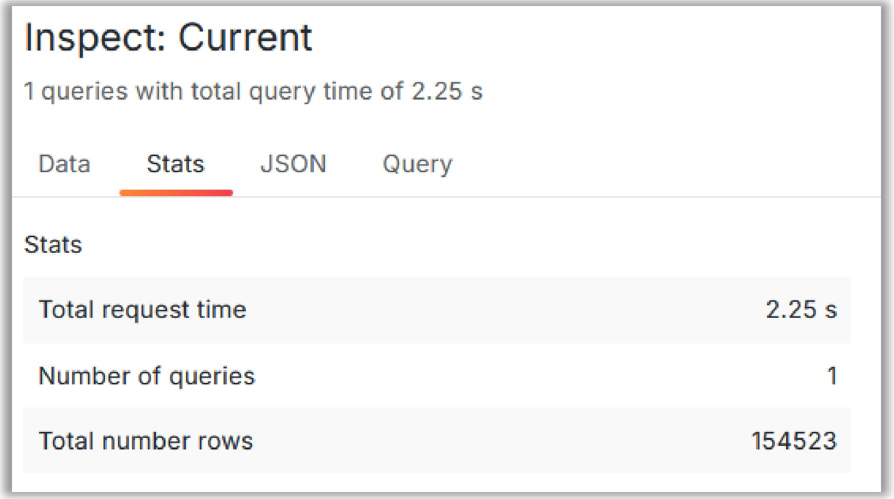


Inspect: Current

1 queries with total query time of 822 ms

Stats

Total request time	822 ms
Number of queries	1
Total number rows	10080

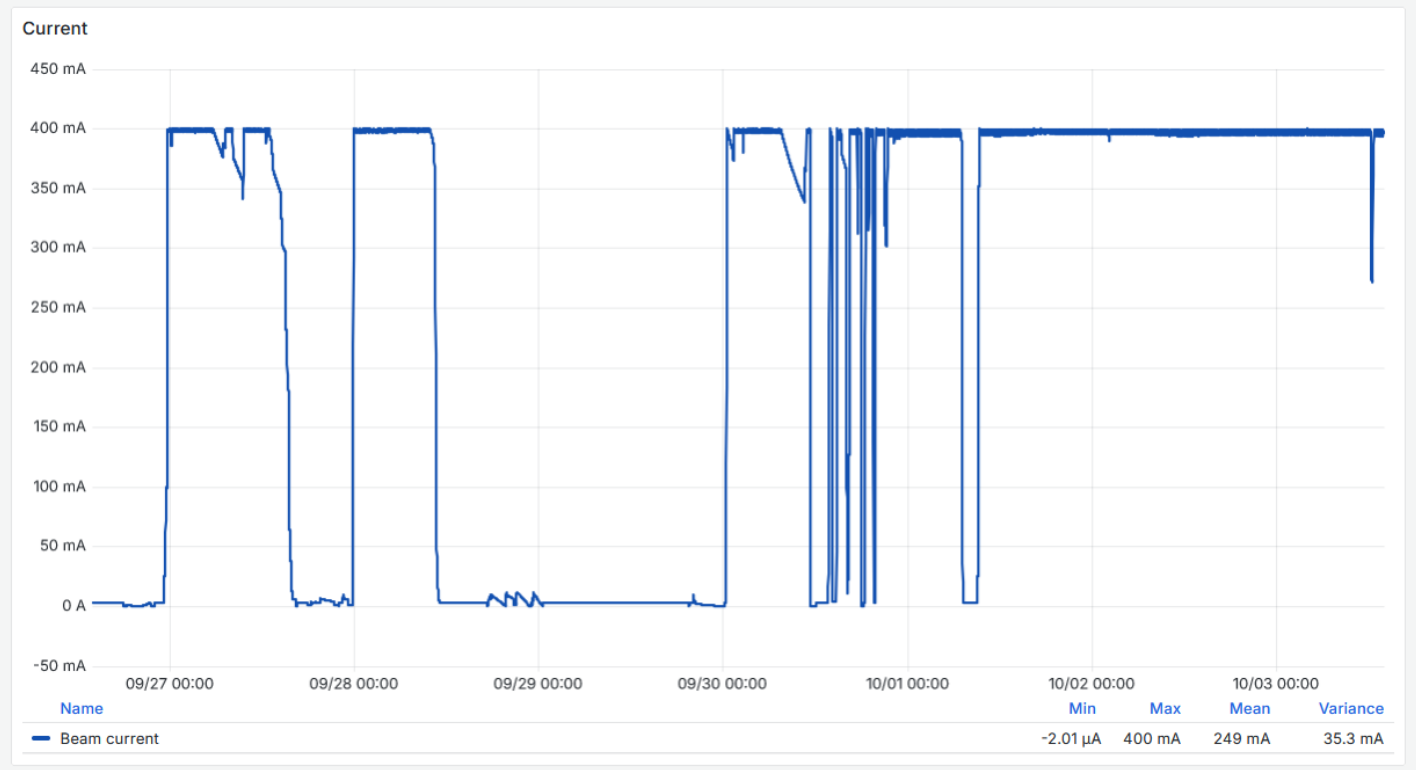


Inspect: Current

1 queries with total query time of 2.25 s

Stats

Total request time	2.25 s
Number of queries	1
Total number rows	154523



Name	Min	Max	Mean	Variance
Beam current	-2.01 µA	400 mA	249 mA	35.3 mA

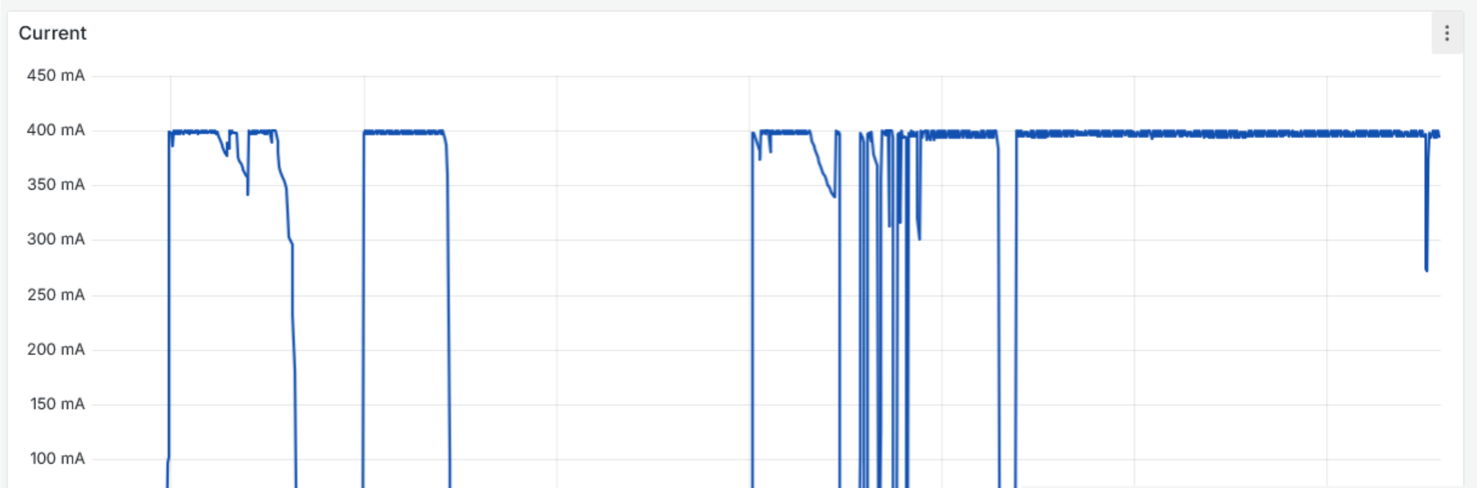
Downsampling (LTTB)

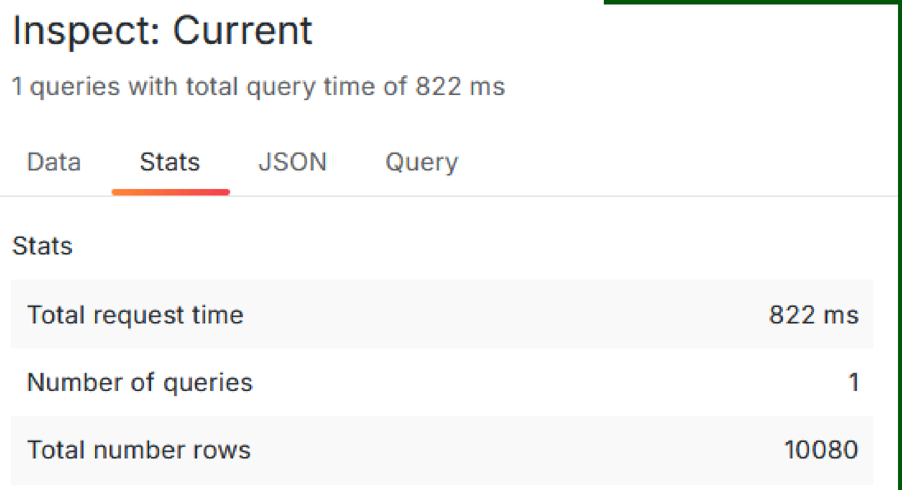
```
SELECT
  time AS "time",
  value AS "Beam current"
FROM unnest((
select lttb(data_time, value_r, (($__to - $__from) / $__interval_ms)::int)
FROM att_scalar_devdouble
WHERE
  $__timeFilter(data_time)
  and
  att_conf_id = (select att_conf_id from att_conf where
att_name='tango://g-v-csdb-0.maxiv.lu.se:10000/r3-319s2/dia/dcct-
01/current')
))
  ORDER BY 1;
```

https://www.timescale.com/blog/slow-grafana-performance-learn-how-to-fix-it-using-downsampling/

https://skemman.is/bitstream/1946/15343/3/SS_MSthesis.pdf

Downsampling (LTTB)





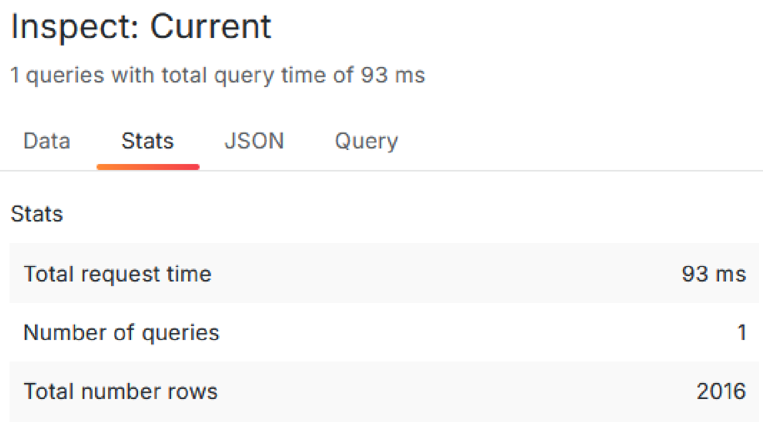
Inspect: Current

1 queries with total query time of 822 ms

Data Stats JSON Query

Stats

Total request time	822 ms
Number of queries	1
Total number rows	10080



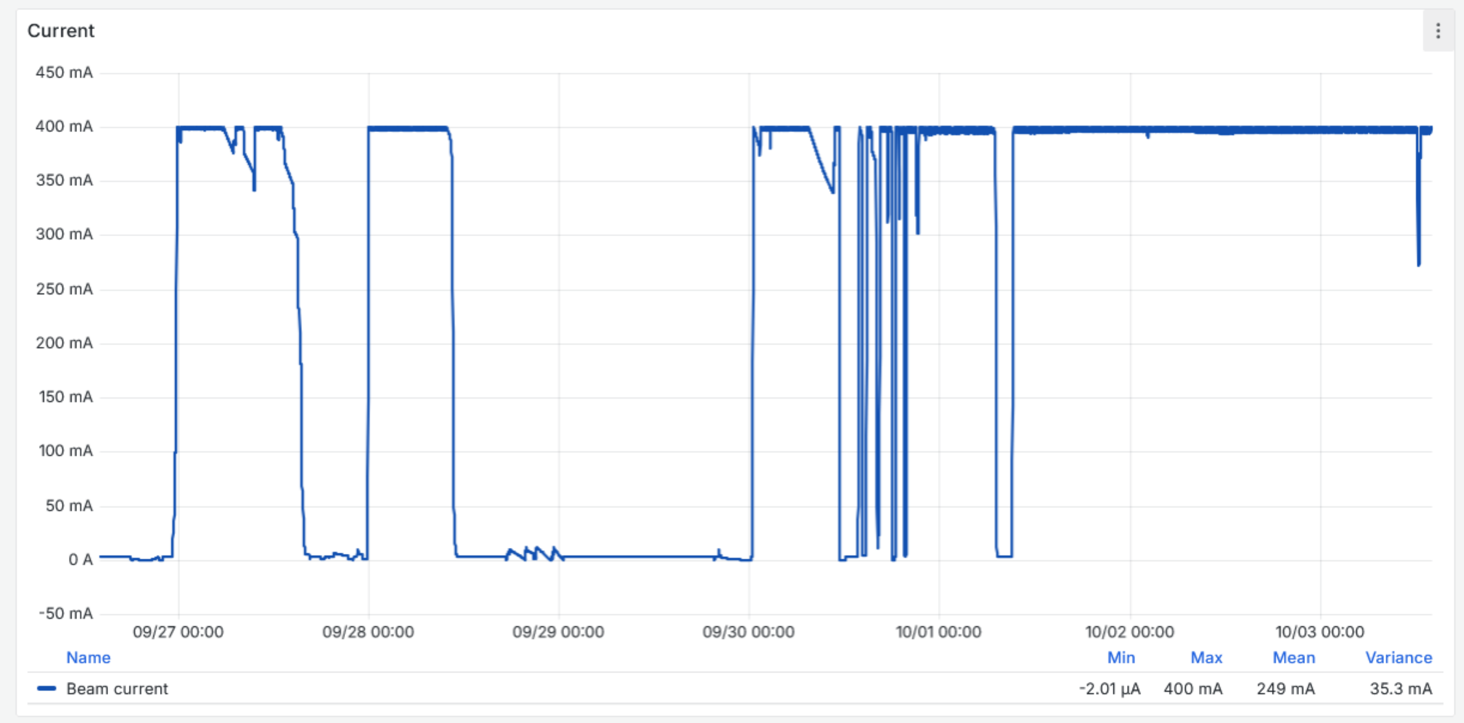
Inspect: Current

1 queries with total query time of 93 ms

Data Stats JSON Query

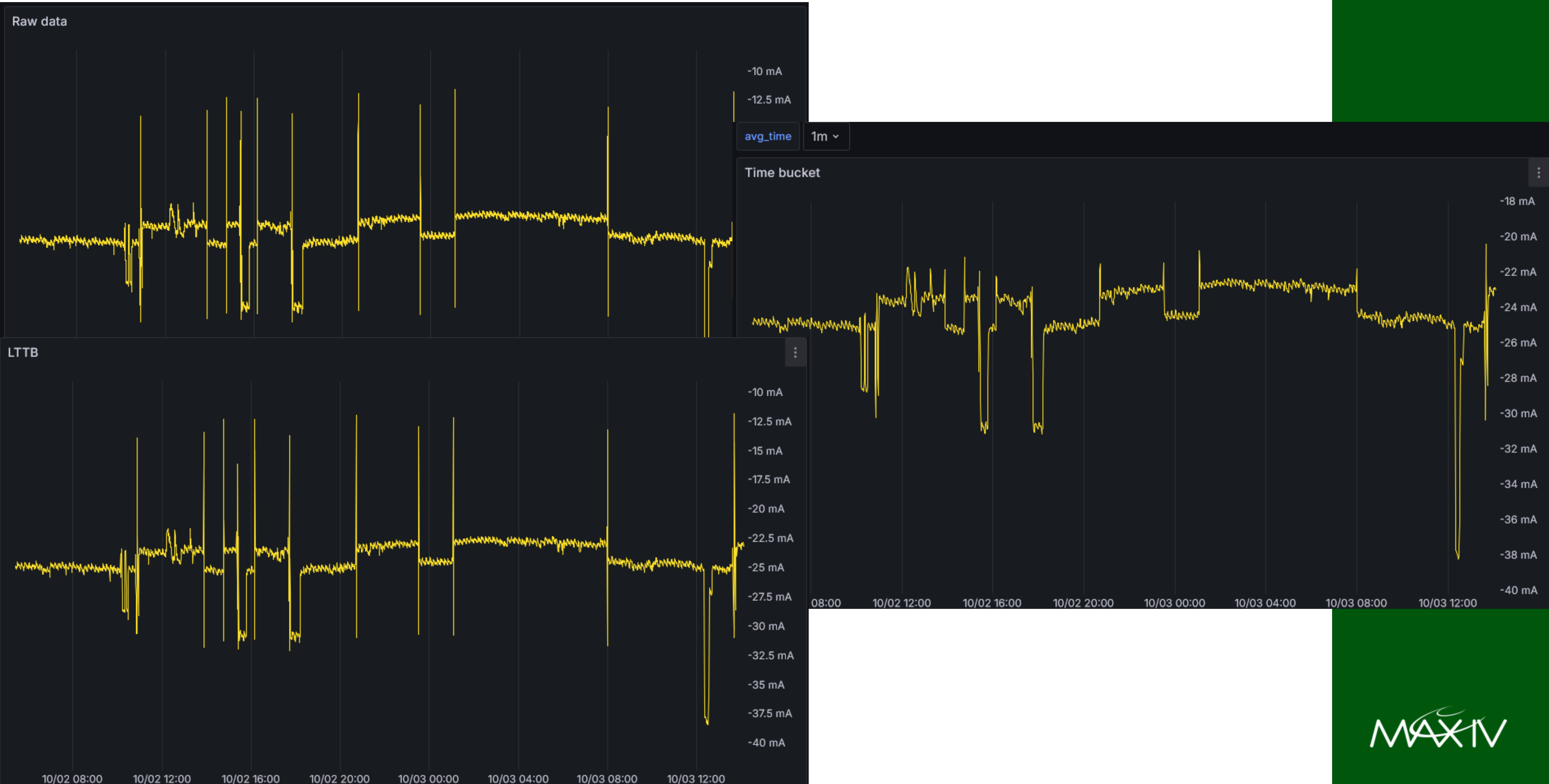
Stats

Total request time	93 ms
Number of queries	1
Total number rows	2016



Name	Min	Max	Mean	Variance
Beam current	-2.01 µA	400 mA	249 mA	35.3 mA

Downsampling trickiness



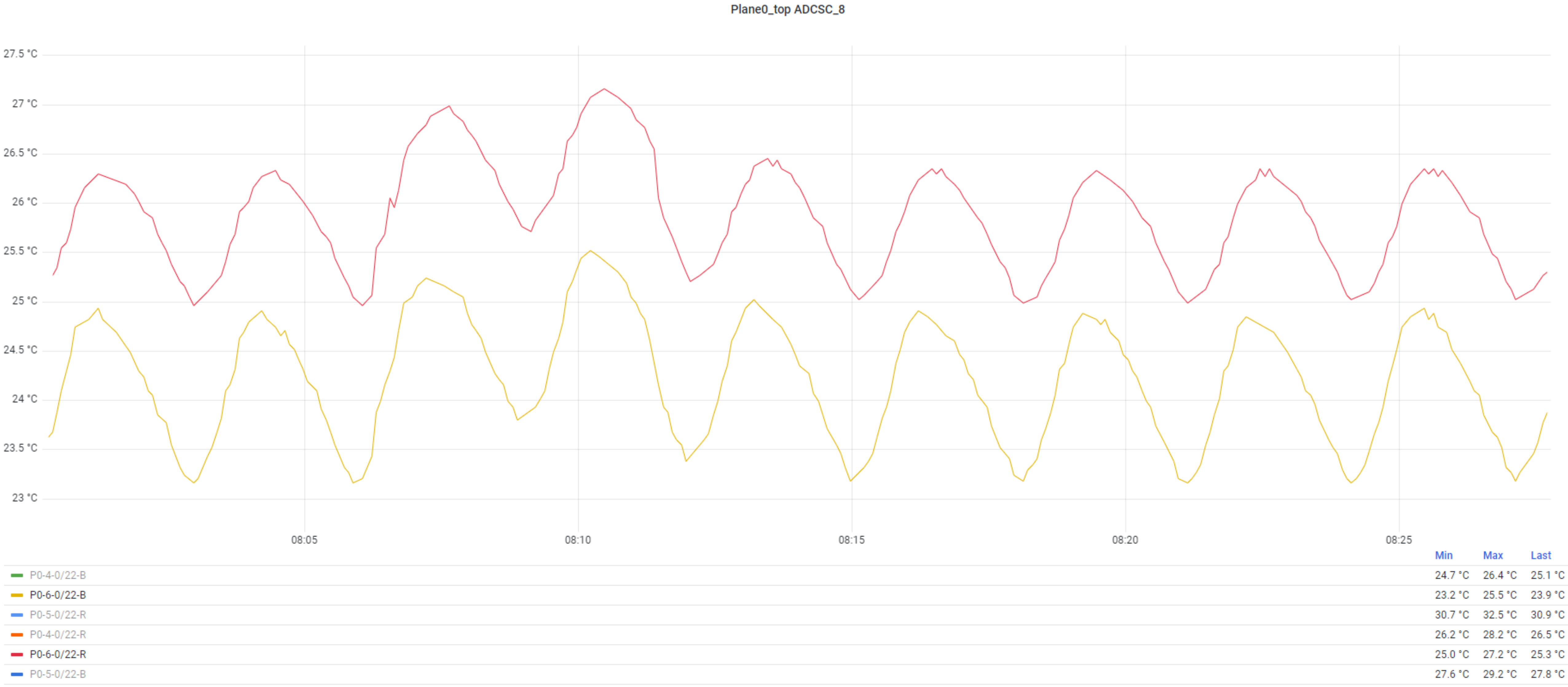
avg_time 1m

Downsampling (Continuous aggregations)

Not fully implemented at MAX IV (yet), example from another facility

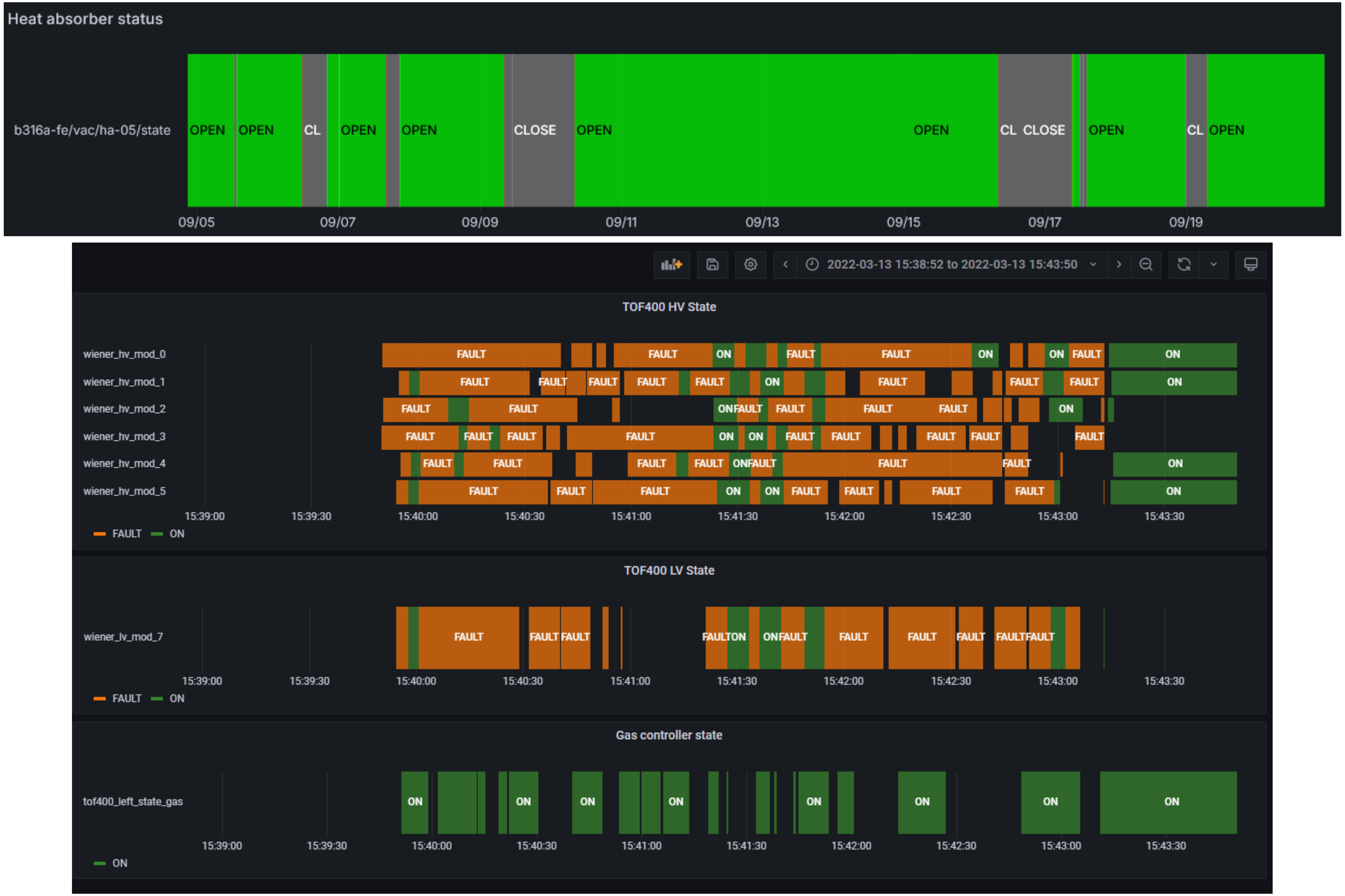
```
WITH conf_id AS (
  SELECT att_conf_id
  FROM att_conf
  WHERE att_name='tango://bmn-sc-tangodb.he.jinr.ru:10000/fsd/plane0_top/adcsc_8_temp/temp_4'
),
varname AS (
    SELECT 'P0-4-0/22-B' AS varname
)
SELECT
  data_time AS "time",
  avg_r AS varname
FROM att_scalar_devdouble_1hour
WHERE $__timeTo()::timestamp - $__timeFrom()::timestamp >= '12 hours'::interval
  AND $__timeFilter(data_time)
  AND att_conf_id = (SELECT att_conf_id FROM conf_id)
UNION ALL

…………

SELECT
  data_time AS "time",
  value_r AS varname
FROM att_scalar_devdouble
WHERE $__timeTo()::timestamp - $__timeFrom()::timestamp < '30 minutes'::interval
  AND $__timeFilter(data_time)
  AND att_conf_id = (SELECT att_conf_id FROM conf_id)
ORDER BY 1;
```

Downsampling (Continuous aggregations)



	Min	Max	Last
🟩 P0-4-0/22-B	24.7 °C	26.4 °C	25.1 °C
🟨 P0-6-0/22-B	23.2 °C	25.5 °C	23.9 °C
🟦 P0-5-0/22-R	30.7 °C	32.5 °C	30.9 °C
🟧 P0-4-0/22-R	26.2 °C	28.2 °C	26.5 °C
🟥 P0-6-0/22-R	25.0 °C	27.2 °C	25.3 °C
🟦 P0-5-0/22-B	27.6 °C	29.2 °C	27.8 °C

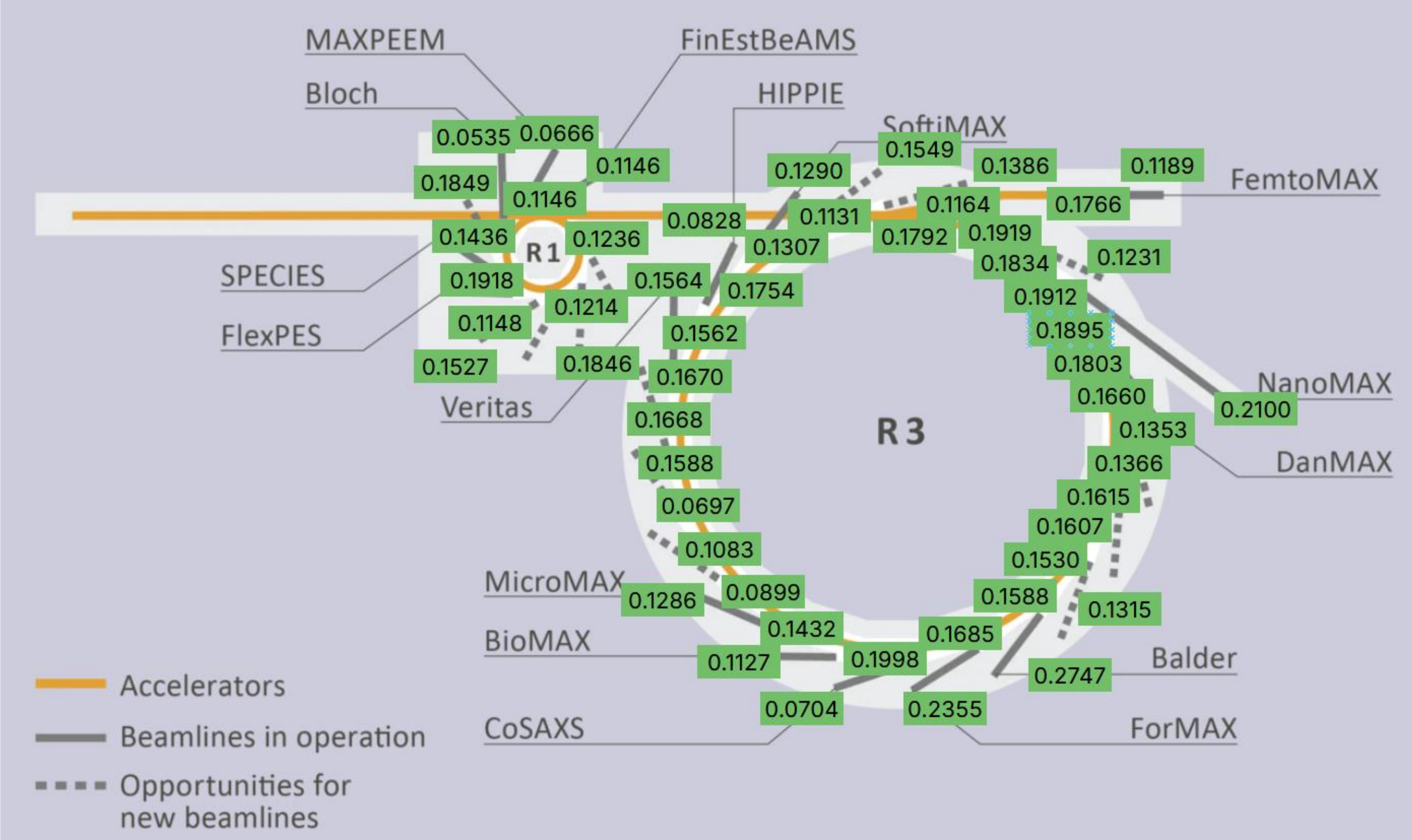
More ways to display data



2022-03-13 15:38:52 to 2022-03-13 15:43:50

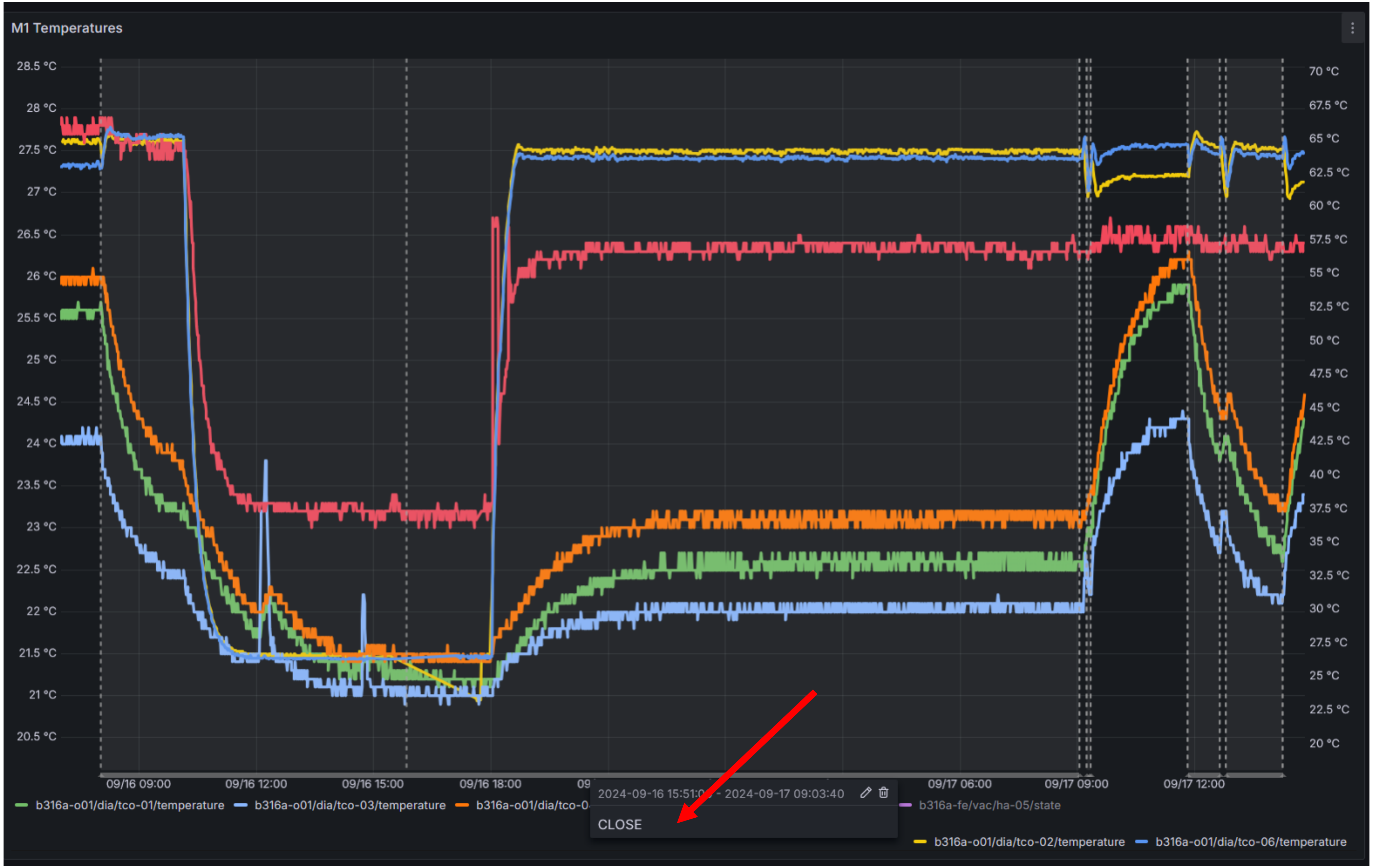
State timeline

More ways to display data



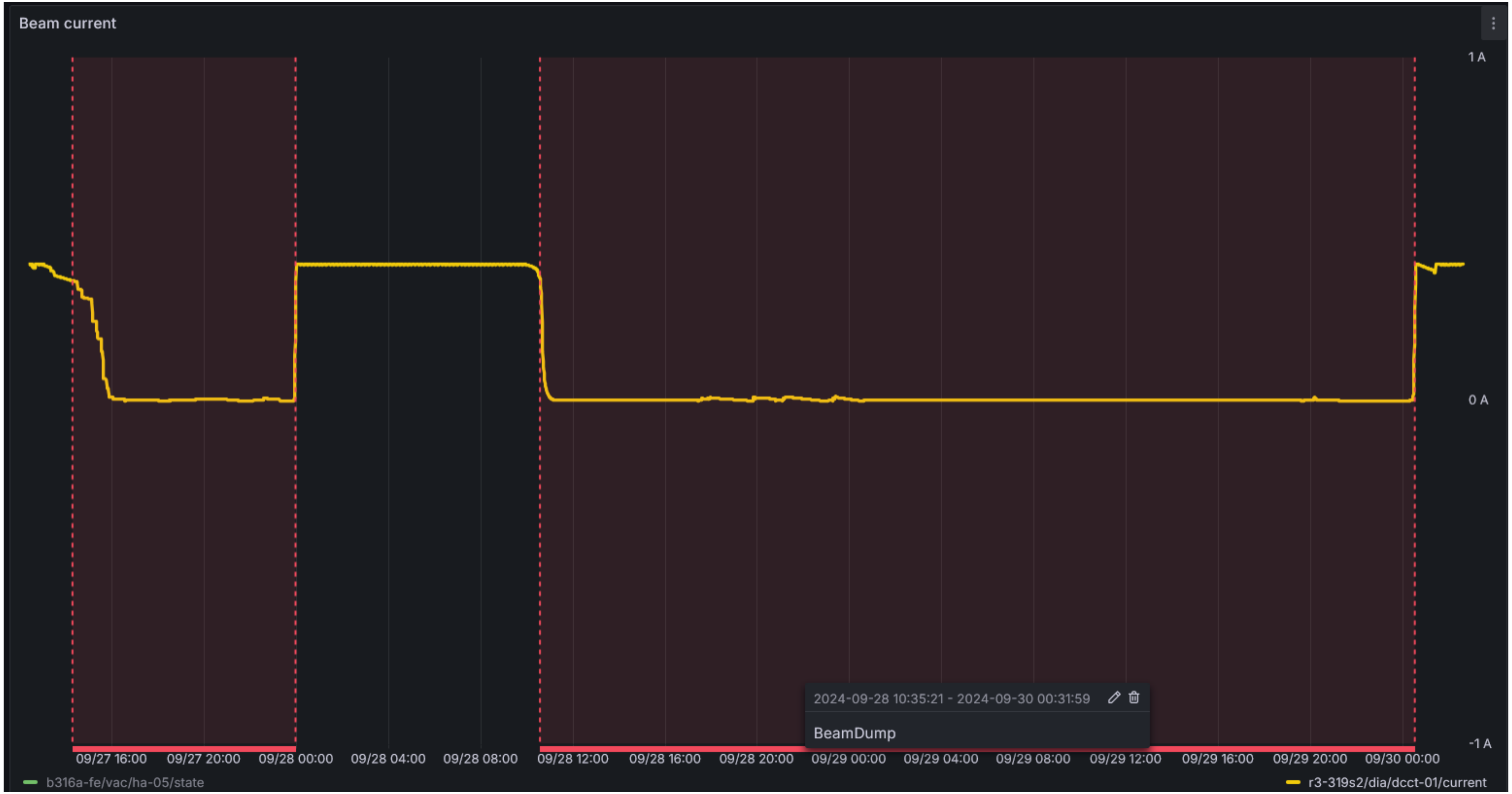
Canvas panel, radiation monitoring sensors (proof-of-concept)

More ways to display data



Display annotation when Heat Absorber is CLOSE

More ways to display data



2024-09-28 10:35:21 - 2024-09-30 00:31:59

BeamDump

Display annotation when Beam Current < 350 mA

MAX IV

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