BLISS: experiments control of EBS beamlines

ICALEPCS2017

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ESRF

Extremely Brilliant Source (ESRF – EBS) project

- 150 M€ investment over the period 2015-2022
- 4th generation light source
- 100x improved brilliance and coherence of X-ray beams
- New state-of-the-art beamline portfolio

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Full details in talk: FRAPL07

BLISS

BeamLine Instrumentation Support Software

Why BLISS ?

spec: 26 years driving experiments at ESRF

- Direct control of devices
  - easier to debug
  - restarting = reset
- Integrated tool
  - configuration
  - controllers for all kinds of devices
  - plotting
- Server mode to connect with external processes (GUI...)
- Commercial support

spec: 26 years driving experiments at ESRF

- Poor macro language
- No extensibility
- Single task operation
- Exclusive hardware control
- Per-session configuration, no sharing
- No built-in continuous scan framework
- Limited data management
- No code ownership, less freedom

Limitations ↗ Workarounds ↗ Maintenance cost ↗

The path to BLISS

- Python library + tools
- Technical choices
- Beacon: services for BLISS
- Hardware control
- Scanning & data acquisition
- Data management
- Sequences as genuine Python functions

BLISS Python library and tools

BLISS Python library and tools

Embed into any Python program

```
>>> from bliss.common.axis import Axis
>>> from bliss.controllers.motors import IcePAP
>>> iceid2322 = IcePAP.IcePAP("iceid2322",
                              {"host": "iceid2322"},
                              [("mbv4mot", Axis, { "address": 1,
                                                   "steps_per_unit": 80,
                                                   "velocity": 125,
                                                   "acceleration": 500
                                                 }
                              )], [])
>>> iceid2322.initialize()
>>> m = iceid2322.get_axis("mbv4mot")
>>> m.velocity()
125.0
>>> m.acceleration()
500.0
>>> m.position()
252.23750000000001
>>>
```

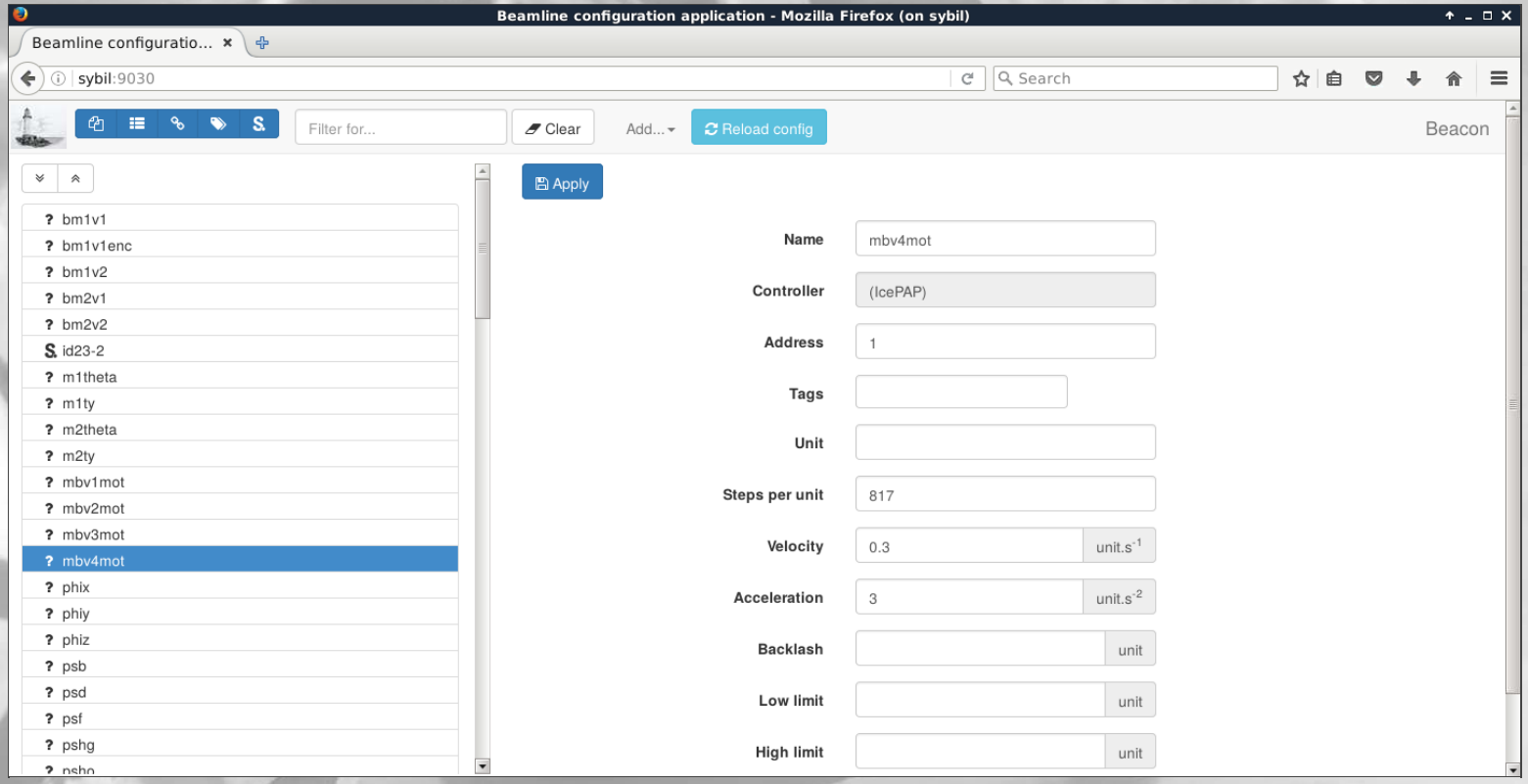
BLISS Python library and tools

Command Line Interface based on ptpython

```
matias@kashyyyk:~ % bliss -s test_session
test_session: Executing setup...
Initializing 'heater`
...
Initializing 's1hg`
Done.

>>> ascan(m1, 0, 10, 30, 0.1, diode, save=False)
Total 30 points, 3.0 seconds

Scan 4 Mon Sep 11 11:58:03 2017 <no file> test_session user = guijarro
ascan m1 0 10 30 0.1

  #  timestamp  m1  diode
  0  1.50512e+09   0  499.112
  1  1.50512e+09  0.345  500.799
...
 28  1.50512e+09  9.655  505.622
 29  1.50512e+09  10  499.883
```

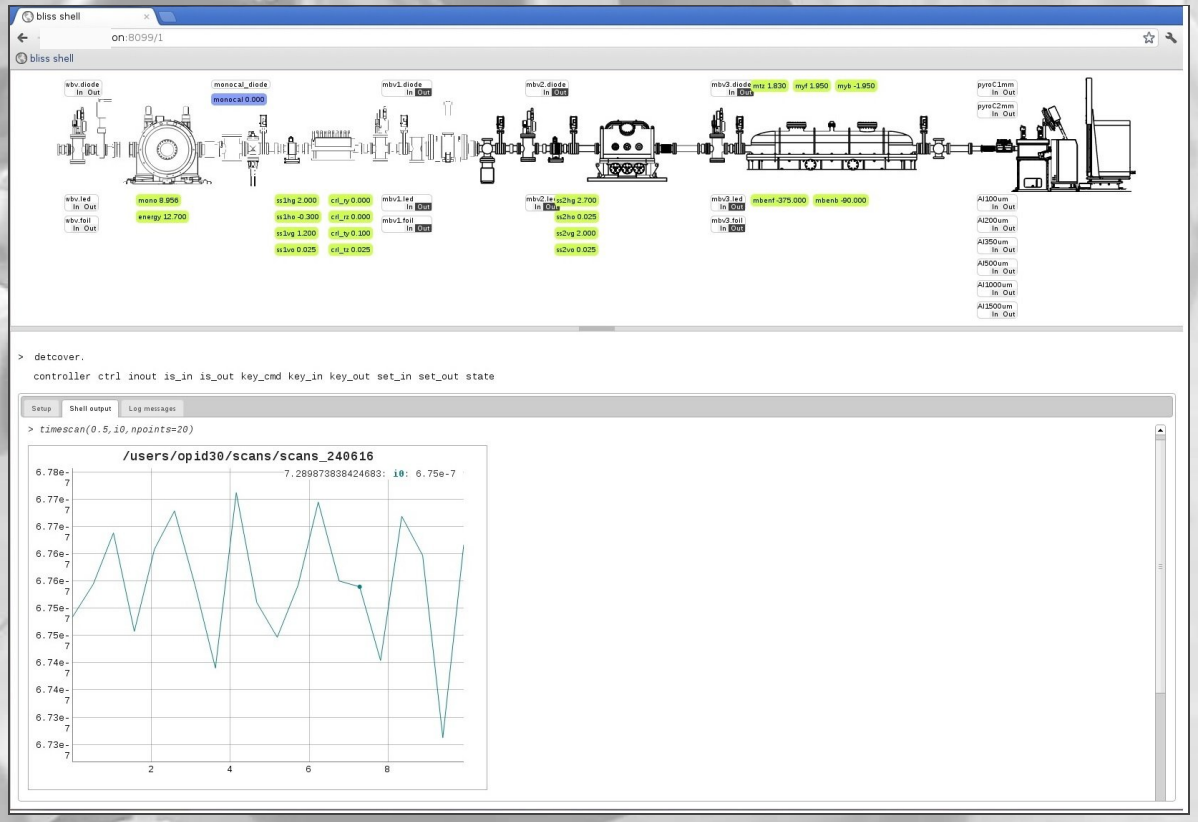
BLISS Python library and tools

Configuration web application



BLISS Python library and tools

Graphical interface for users: interactive web shell



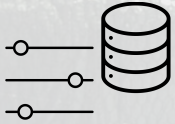
BLISS technical choices

BLISS key concepts

All I/O based on gevent
cooperative multi-tasking

Direct hardware control

Distributed control ownership & shared state

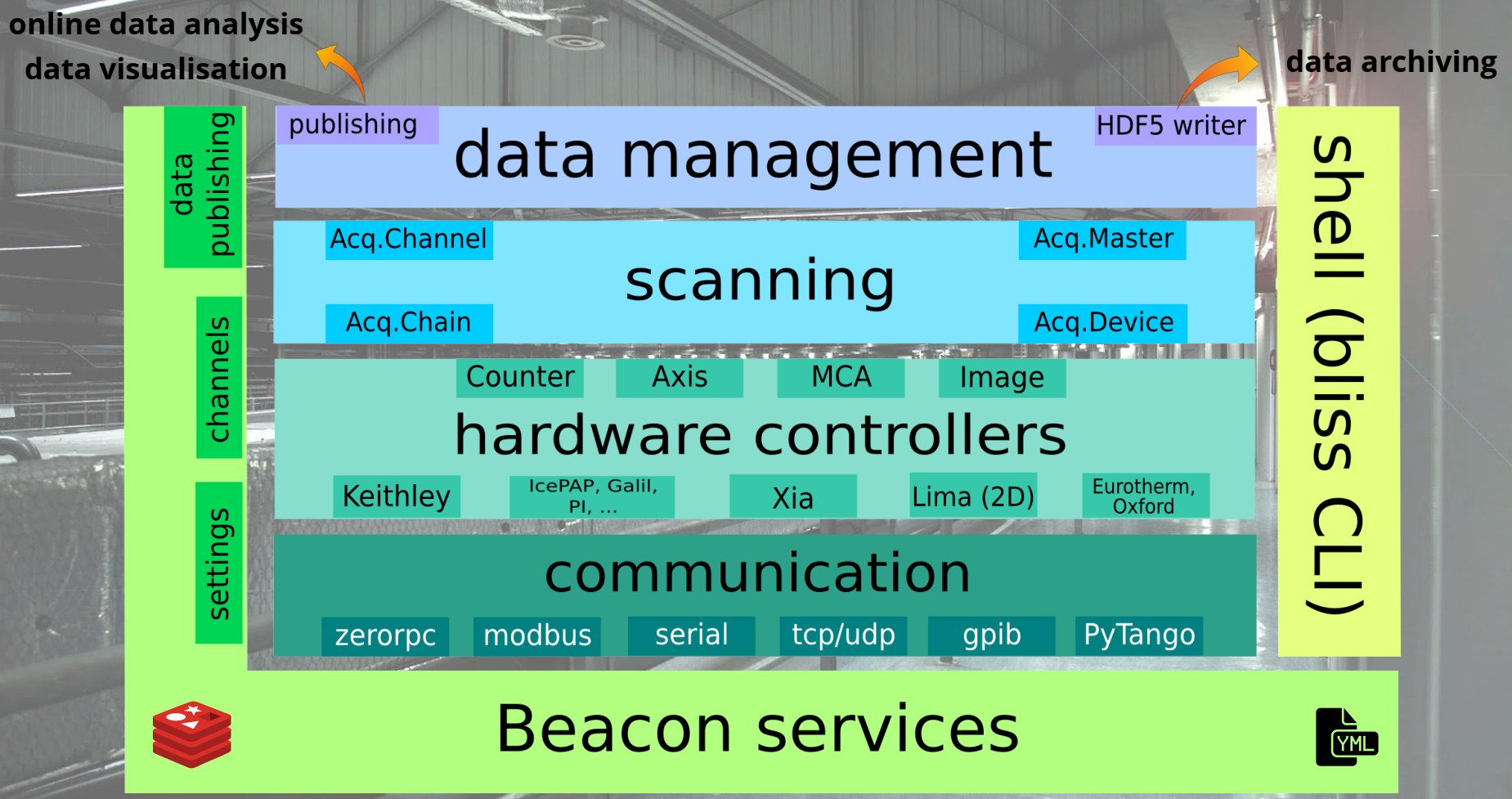


Persistent settings cache

Scan acquisition chain, represented as a tree

Transient data store

BLISS modular architecture




Beacon:
services for BLISS

Beacon static configuration service

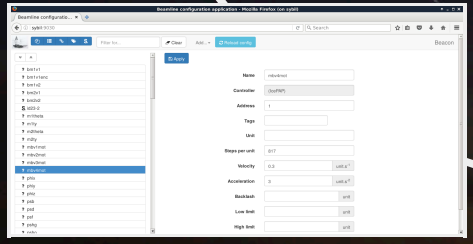
Devices & sequences configuration in YAML format

Beacon server

Sessions to group objects

Python **setup file**

User scripts



Web interface for configuration editing

Can **replace TANGO DB**

Conversion script provided

Beacon: example configuration

```
sybil:~/local/beamline_configuration % tree
.
├── beacon.rdb
├── eh
│   ├── diode.yml
│   ├── __init__.yml
│   └── motors
│       ├── bv.yml
│       ├── DtoX.yml
│       ├── __init__.yml
│       ├── md2.yml
│       ├── mirror1.yml
│       ├── slits.yml
│       └── table.yml
├── oh
│   ├── bpm.yml
│   ├── __init__.yml
│   ├── motors
│   │   ├── bv.yml
│   │   ├── __init__.yml
│   │   ├── mono.yml
│   │   ├── slits.yml
│   │   └── transfocators.yml
│   └── wagos.yml
└── sessions
    ├── id232_setup.py
    ├── id232.yml
    └── __init__.yml
```

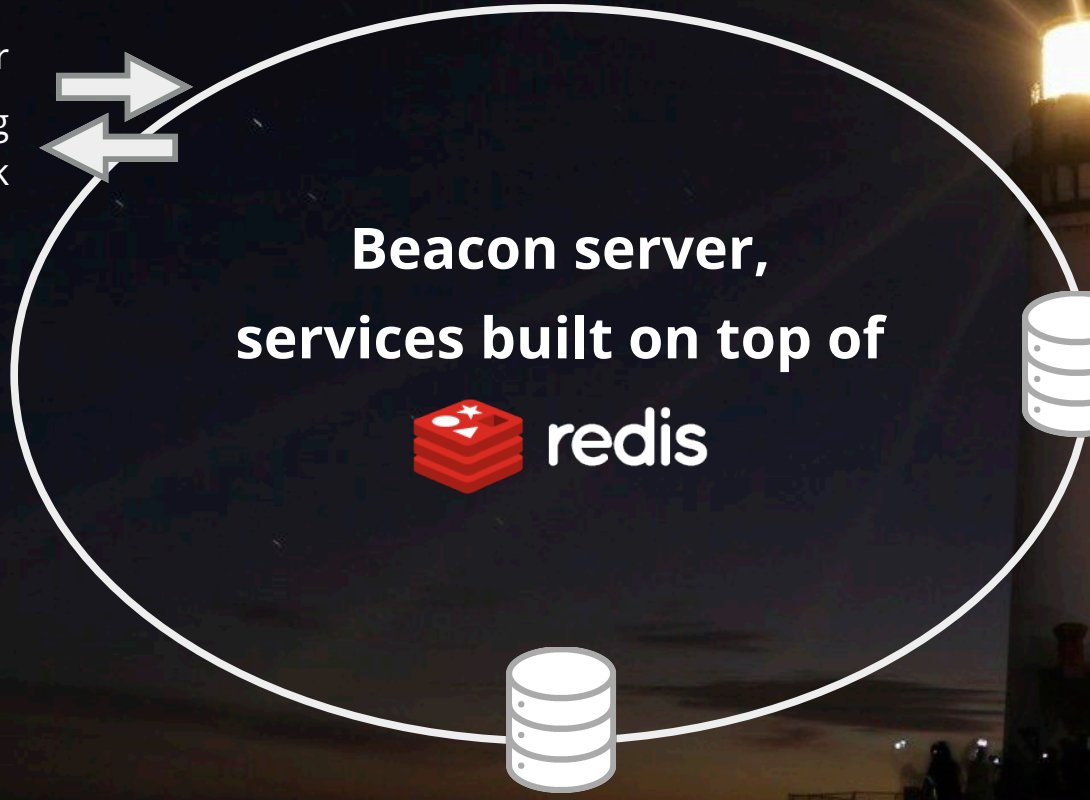
bv.yml:
motor object

```yaml
- controller:
    class: IcePAP
    host: iceid2322
    axes:
    - name: mbv4mot
      address: 1
      steps_per_unit: 817
      velocity: 0.3
      acceleration: 3
```

Beacon dynamic services

Message broker

- state sharing
- distributed lock

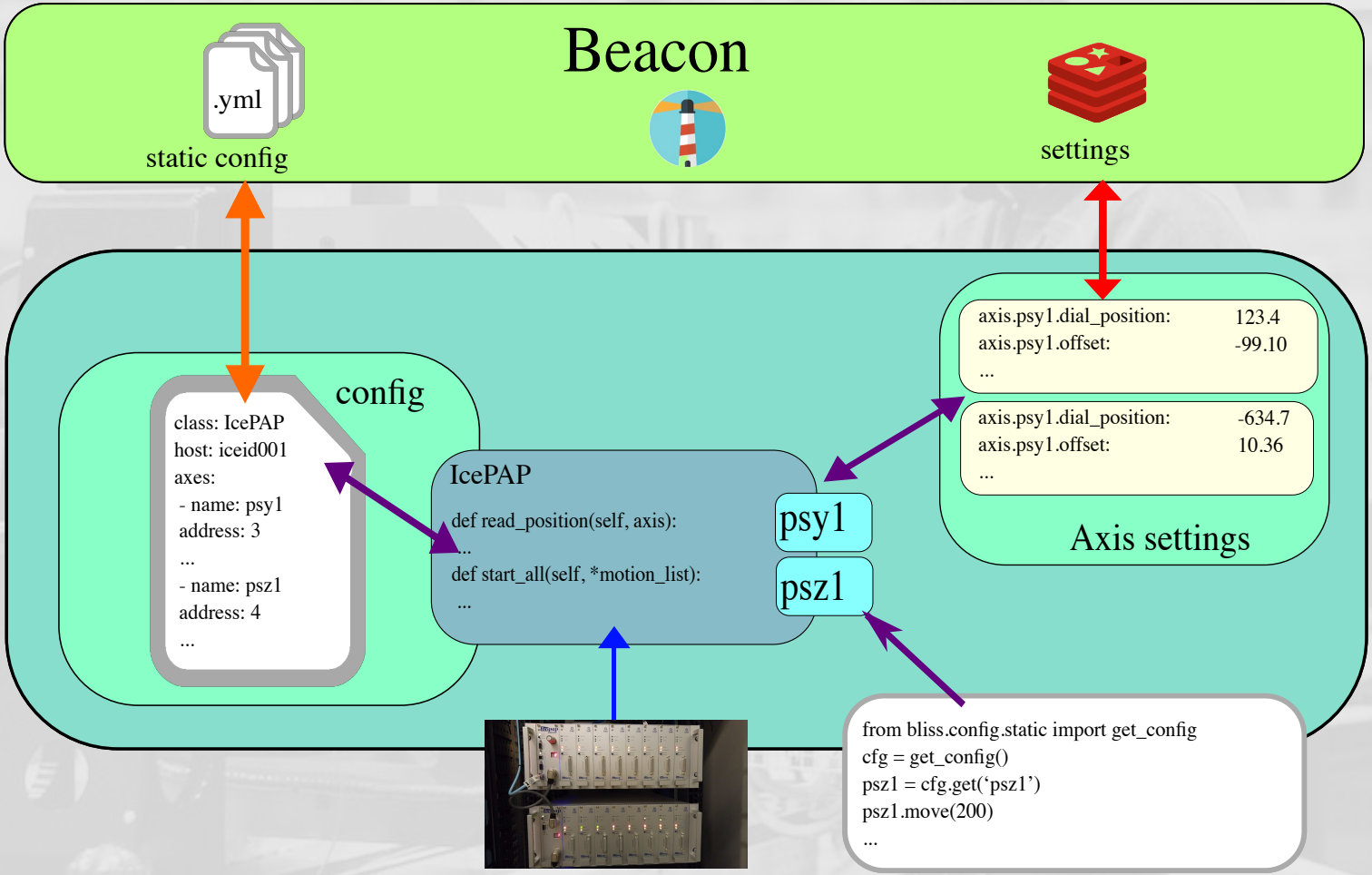


Persistent settings cache

Transient data store

BLISS Hardware Control

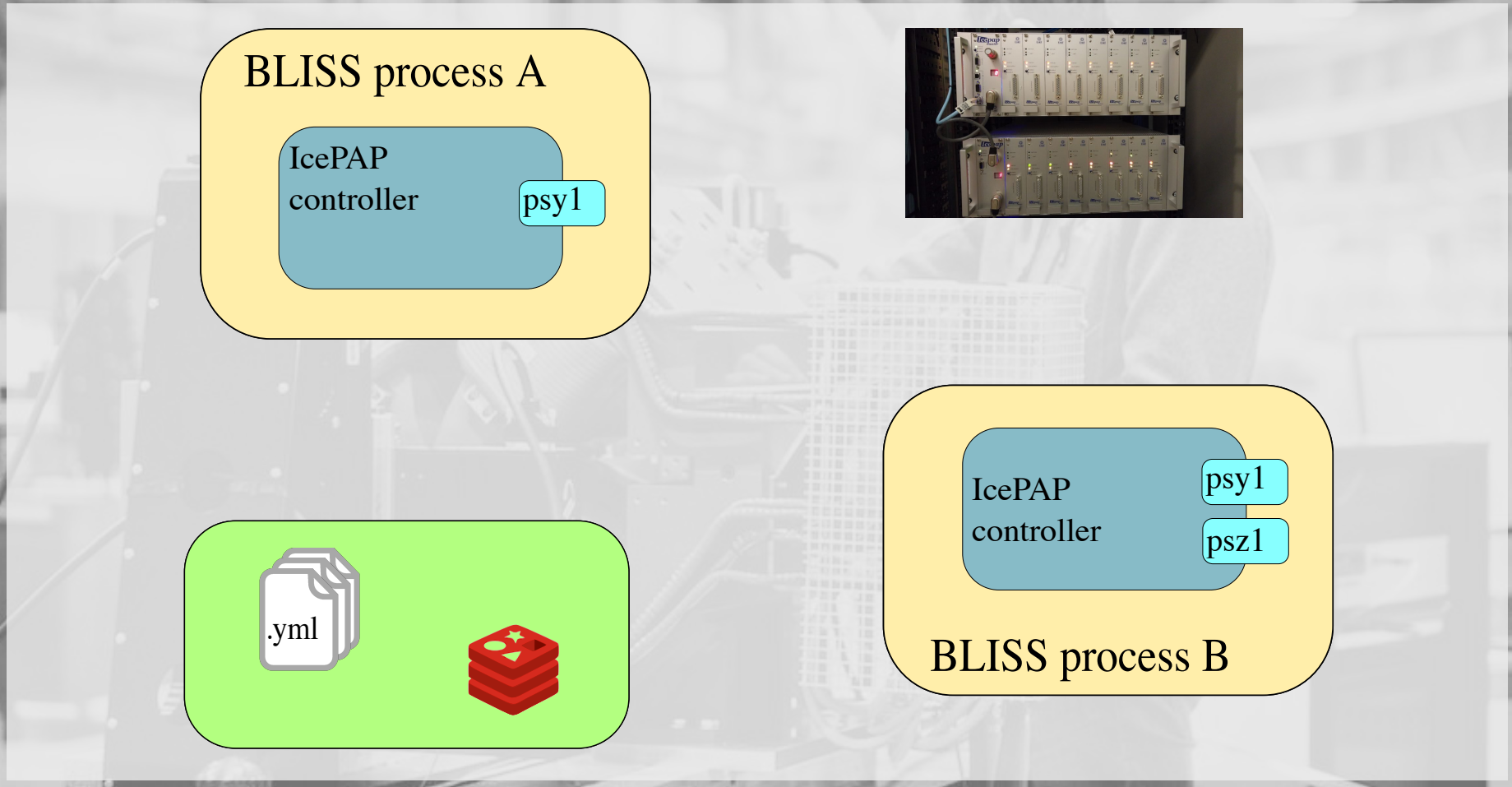
Direct hardware control



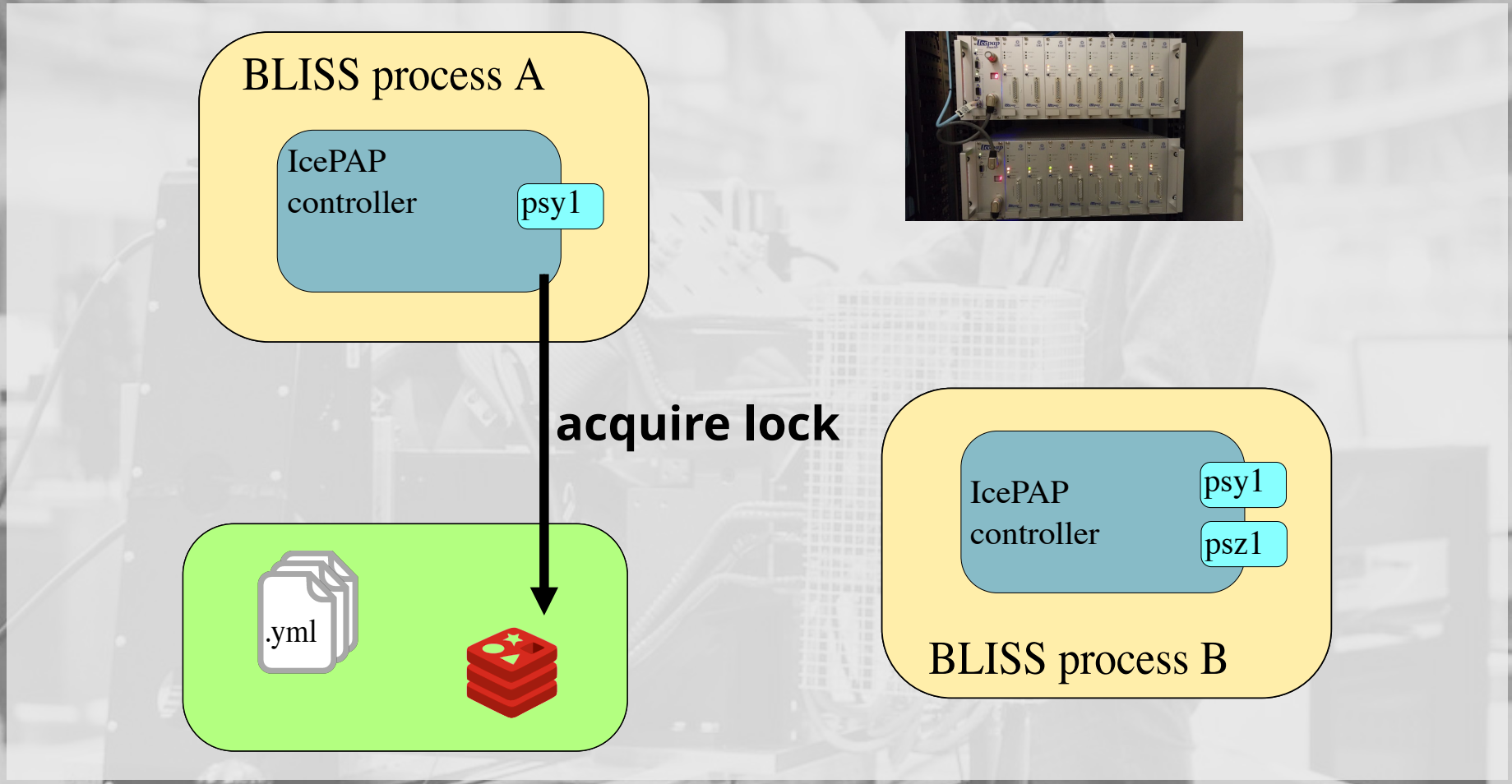
Management of concurrent access

- Multiple BLISS processes means **concurrent access**
  - distributed control ownership
  - based on a protocol: ask Beacon for permission
- **State coherence**
  - hardware state is shared between all peers via **channels**

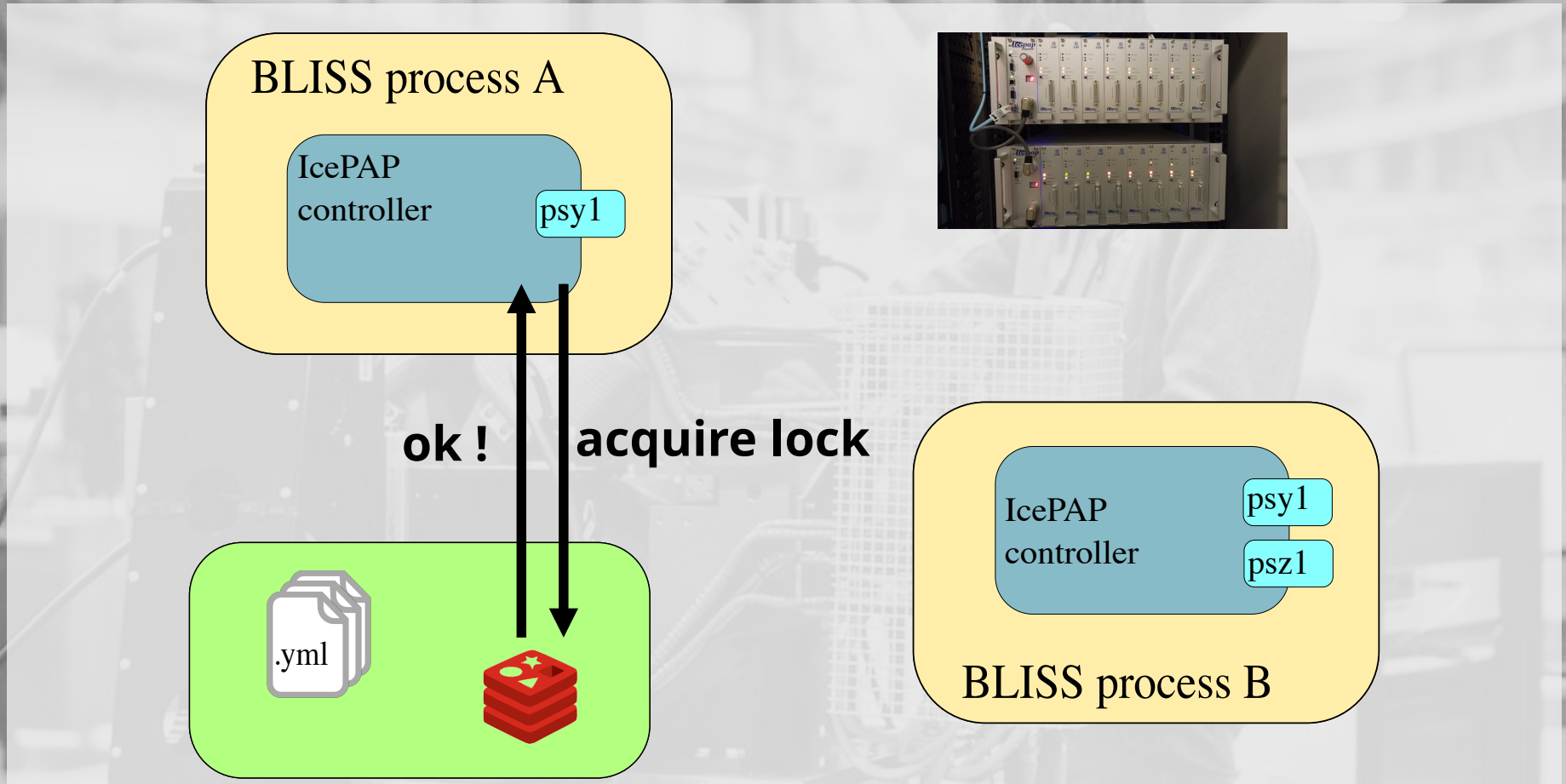
Management of concurrent access



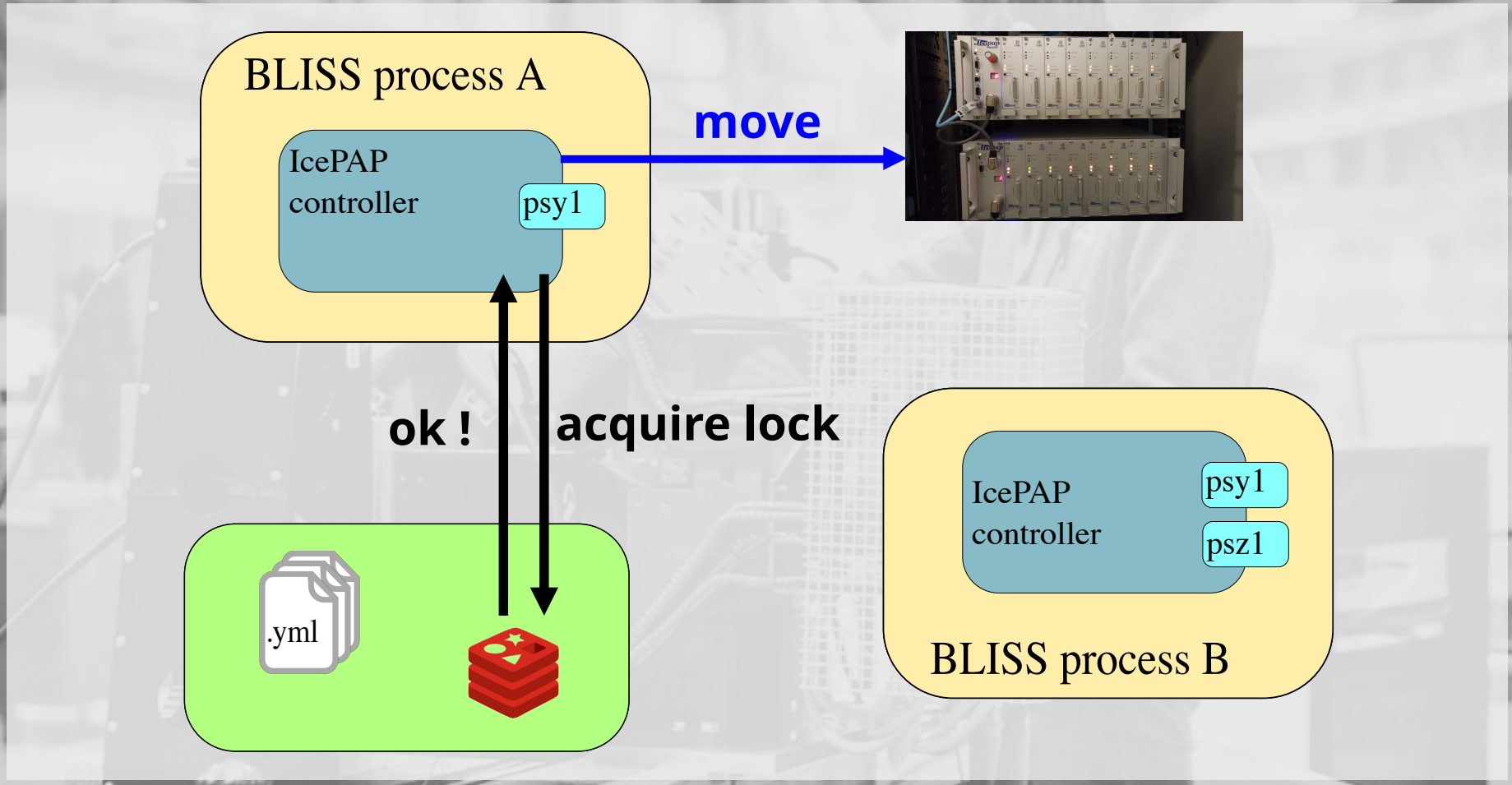
Management of concurrent access



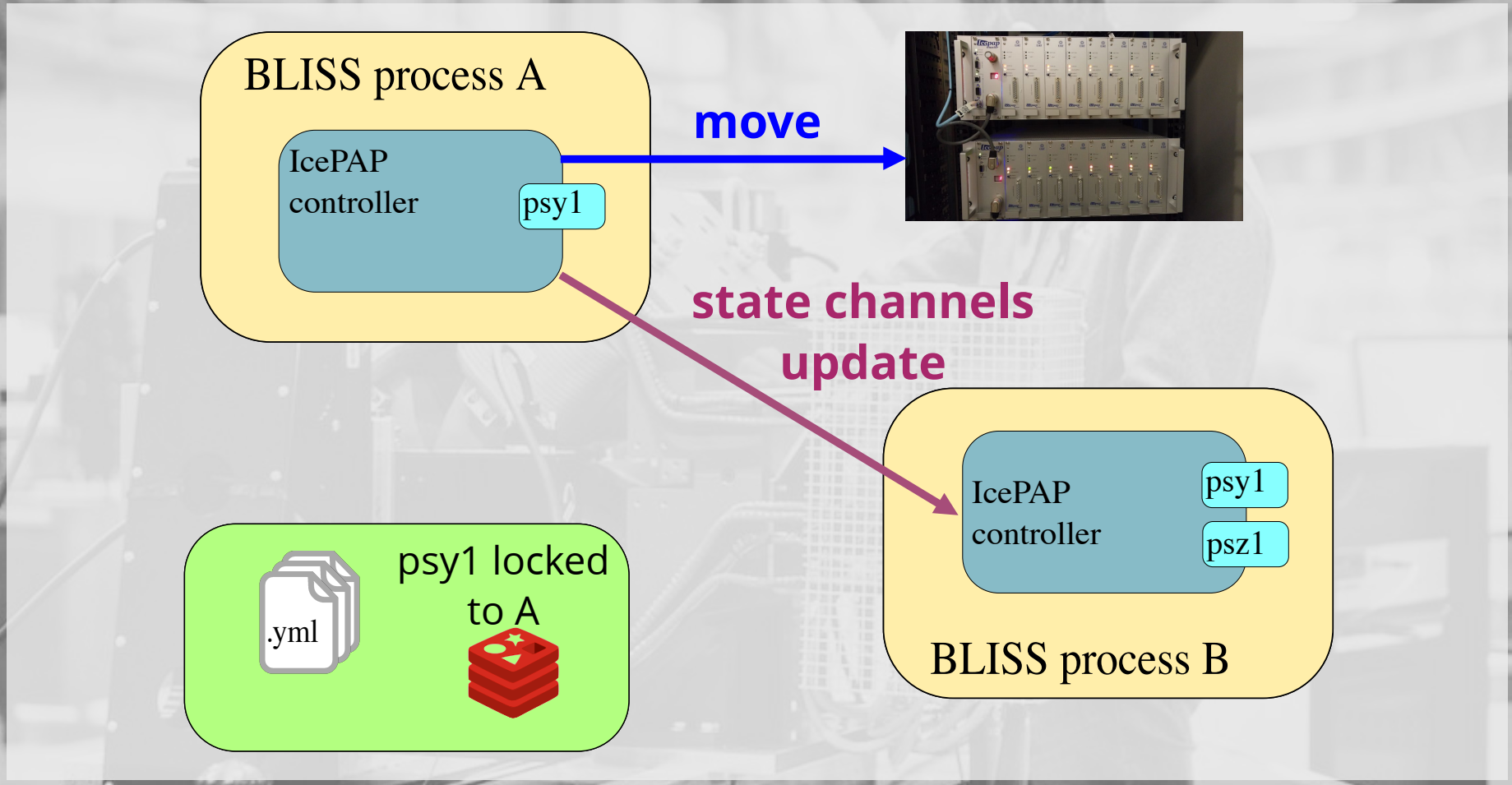
Management of concurrent access



Management of concurrent access



Management of concurrent access

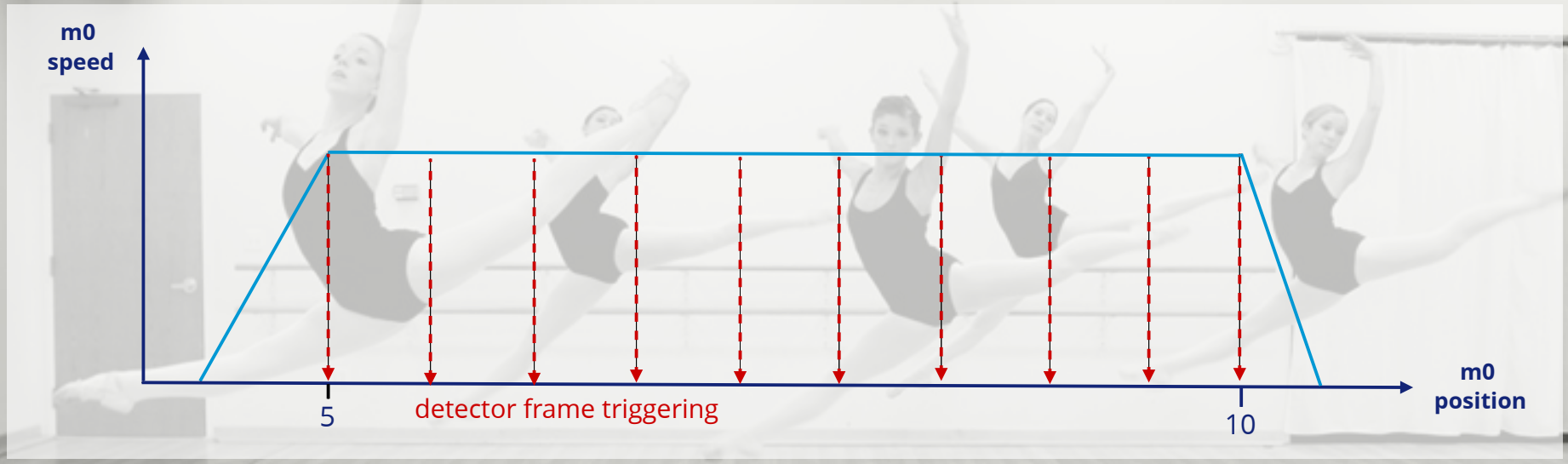



BLISS
scans

BLISS scans

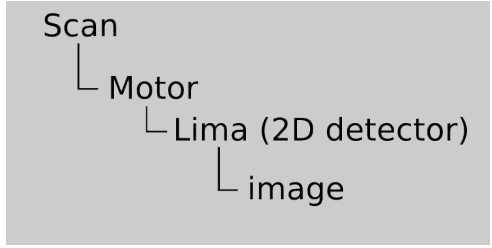
- **Acquisition chain**
  - a tree with master & slave nodes
  - master triggers data acquisition
  - slave takes data
- **AcquisitionMaster, AcquisitionDevice**
  - wrappers around BLISS control objects
- **Data writer**
  - HDF5

Continuous scan example



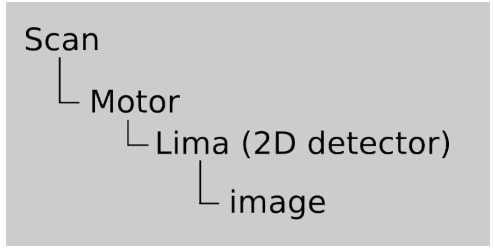
Continuous scan example

```
sybil:~ % bliss
>>> from bliss.scanning.chain import AcquisitionChain
>>> from bliss.scanning.acquisition.motor import SoftwarePositionTriggerMaster
>>> from bliss.scanning.acquisition.lima import LimaAcquisitionDevice
>>> from PyTango.gevent import DeviceProxy

>>> m0 = config.get("m0")

>>> lima_dev = DeviceProxy("id30a3/limaccd/simulation")

>>> chain = AcquisitionChain()

>>> chain.add(SoftwarePositionTriggerMaster(m0, start=5, end=10,
                                            npoints=10, time=5),
              LimaAcquisitionDevice(lima_dev, acq_nb_frames=5, acq_expo_time=0.03,
                                    acq_trigger_mode="INTERNAL_TRIGGER_MULTI"))
```



Continuous scan example

```
>>> SCAN_SAVING.template = '/data/id23eh2/inhouse/{date}/{sample}'

>>> SCAN_SAVING.sample = 'HAK1234'

>>> SCAN_SAVING.get_path()
"/data/id23eh2/inhouse/20170324/HAK1234"

>>> from bliss.scanning.scan import Scan

>>> my_continuous_scan = Scan(chain)

>>> my_continuous_scan.start()
```



Classic step-by-step scans

- **Directly available as functions** from '*bliss.common.standard*'
  - Example: *ascan(axis, start, stop, npoints, count_time, *counters)*
- **Default acquisition chain**
- **Use the same underlying framework** as continuous scans


Data Management

Model for organizing acquired data

- **Mirroring of the Acquisition Chain tree**
  - each device in the chain **has a name**
  - each device define 1 or more ***'AcquisitionChannel'*** **objects**
- **Acquisition channels**
  - must have **a name**, **a type** and **a shape**
- **Metadata**
  - *scan_info* dictionary ({ key: value, ... }) associated with scans

Online data publishing

- While a scan is running, **data is published** to the redis database provided by Beacon 
  - scalar values are **stored directly**
  - bigger data (images, spectra) is **just referenced**
  - configurable time to live (TTL)
- Any external process can access redis data to perform **online data analysis**, for example


User
Sequences

Sequences as Python functions

```
from bliss import * # imports generic scans, cleanup functions, etc
from bliss.setup_globals import * # imports objects from session (setup)
import numpy # I know you dreamt of it
import gevent

def set_detector_cover(in):
    wcidxx.set('detcover', in)

    # 5 seconds timeout waiting for detector cover to move
    with gevent.Timeout(5):
        while wcidxx.get('detcover_in') == in:
          time.sleep(0.1)

def my_super_experiment(name):
    safety_shutter.open()

    old_att = attenuators.get()

    def restore_beamline():
        set_detcover_open(False)
        attenuators.set(old_att)

    with cleanup(safety_shutter.close):  # cleanup is always called at the end
        with error_cleanup(restore_beamline):  # this will only be called in case of error
            attenuators.set(50)
            set_detcover_open(True)

            SCAN_SAVING.name = name
            MEASUREMENT_GROUP.enable('diode')

            data_node = dscan(m0, -5, 5, 10, 0.1)

            for data in data_node.walk_data():
              # do something useful with data...
```

Sequences as Python functions

```
from bliss import * # imports generic scans, cleanup functions, etc
from bliss.setup_globals import * # imports objects from session (setup)
import numpy # I know you dreamt of it
import gevent

def set_detector_cover(in):
    wcidxx.set('detcover', in)
```

Easy timeouts with gevent.Timeout

```
# 5 seconds timeout waiting for detector cover to move
with gevent.Timeout(5):
    while wcidxx.get('detcover_in') == in:
        time.sleep(0.1)
```

```
def
    safety_shutter.open()

    old_att = attenuators.get()

    def restore_beamline():
        set_detcover_open(False)
        attenuators.set(old_att)

    with cleanup(safety_shutter.close):
        with error_cleanup(restore_beamline):
```

Normal Python functions

Use of Python context managers for cleanup

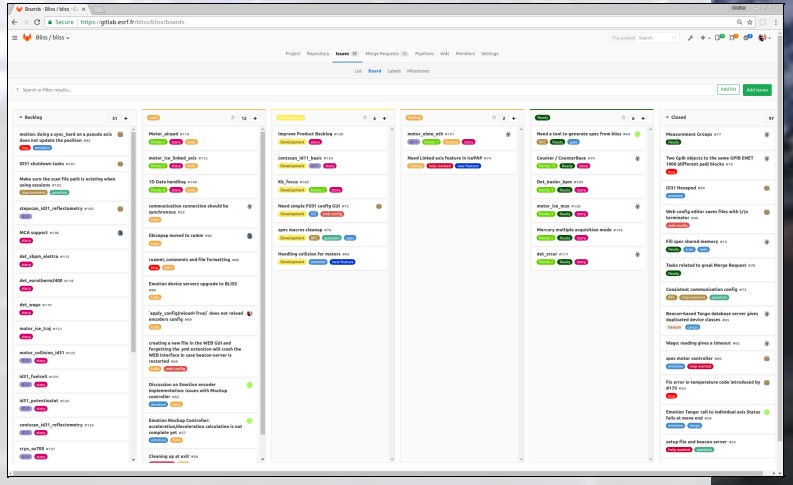
```
with cleanup(safety_shutter.close): # cleanup is always called at the end
    with error_cleanup(restore_beamline):  # only called in case of error
        ...
```

```
        for data in data_node.walk_data():
          # do something useful with data...
```

Conclusion

Project state

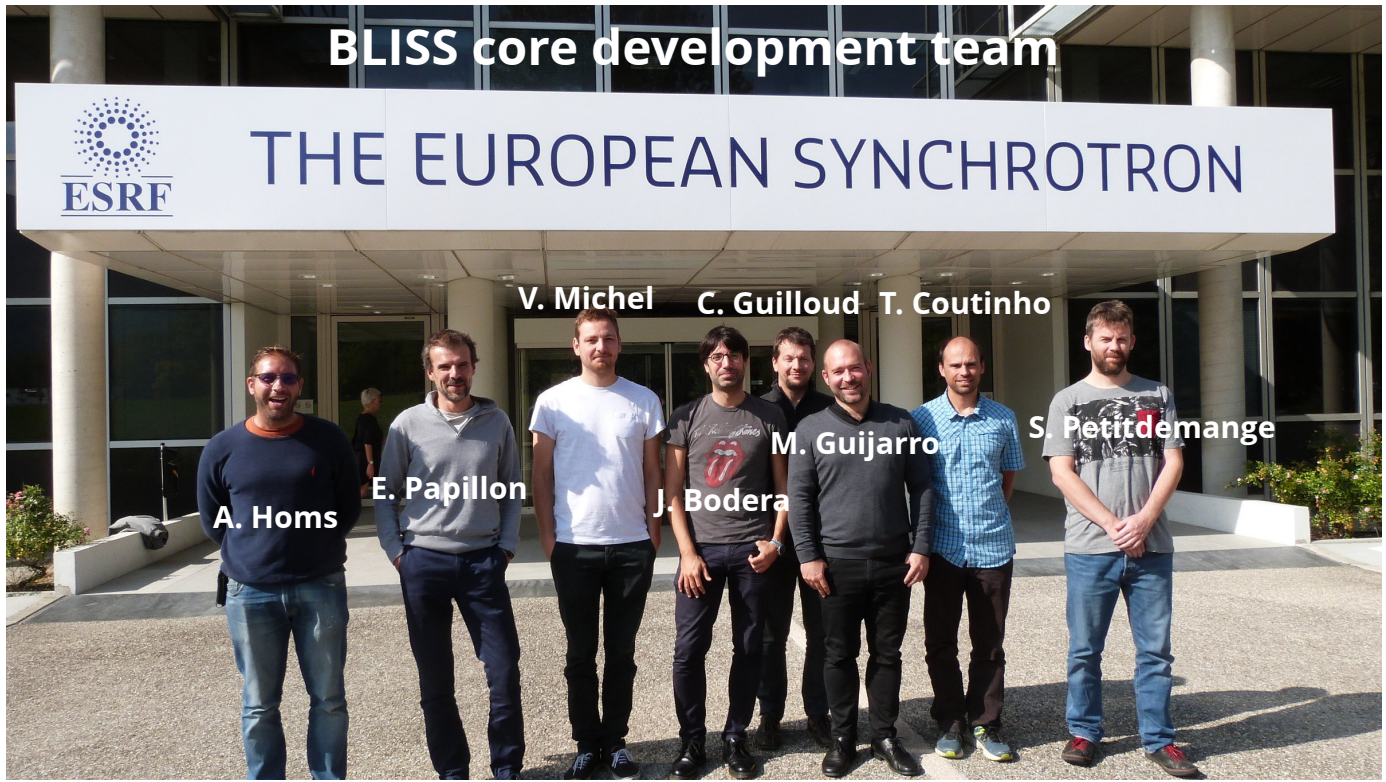
- **Current state of deployment**
  - MX beamlines are already running BLISS
  - 3 more beamlines (Materials Science) for the end of the year
  - **Full deployment in 2020**
- **Project is in active development**
  - Not ready for use outside ESRF yet
  - git repository



Conclusion

- **Long term project** for EBS beamlines
- Control paradigm: **keep what works, add new concepts**
- Python **scanning framework**
- Prepared for **current and future challenges**
  - scans with online feedback
  - data management
  - evolutive platform

Aknowledgements



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ESRF Software Group: A. Goetz