



EPICS for small Labs

H. Junkes, A. Moshantaf, W. Kirstaedter, P. Oppermann, M. Wesemann, FHI
A. Fuchs, M. Krieger, J. Lehmeyer, Universität Erlangen-Nürnberg





Use of proprietary software and hardware

- very often not to be coupled with each other
- incompatible (vendor locked) file formats
- often require (unnecessarily) expensive/
licensable special hardware and software



Infrastructure for data acquisition and processing

- Transparent, open source
- Platform independent (HW, OS)
- Driven by Science-Community (not commercial)
- Scalable
- Lifetime support

Based on the EPICS/Bluesky framework

Ensuring Digital Sovereignty and guaranteeing
FAIR principles.



Proven on a large scale: Control FEL

EPICS can also be used on microcontrollers and real-time systems.

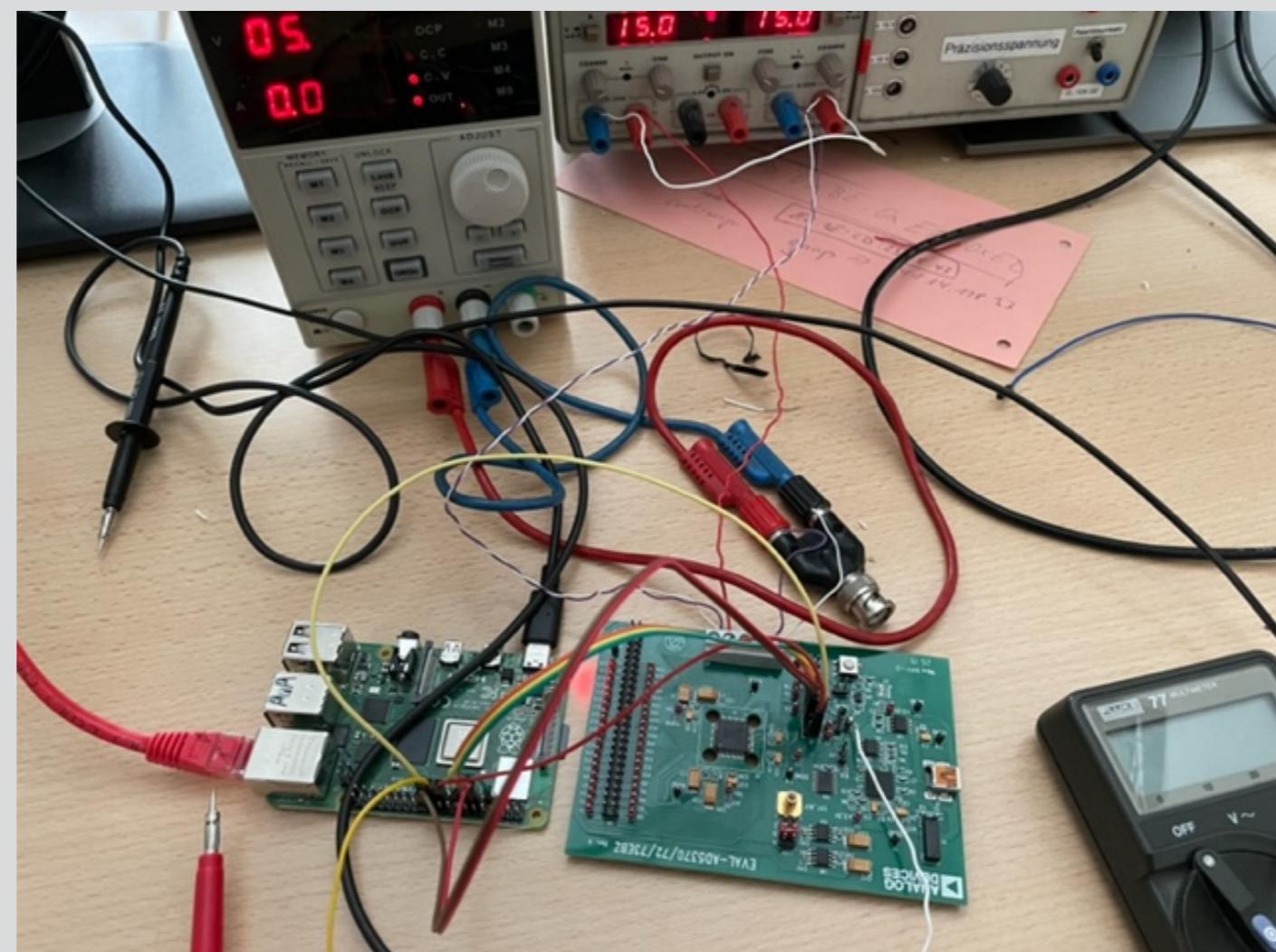


Current measurement on high voltage (20 kV)



Together with electronic lab we develop further devices that can be used directly at the Institute (without extra drivers, hardware).

e.g.
40 x 16bit DAC,





Unfortunately, the support is often not taken up

- People do not want to change anything
- The possibilities of automation are not seen
- The scientists don't want to "program"
- The engagement with IT among scientists is often not rewarded



Good scientific practice is required by funders (DFG)

This means reproducibility of results, proof of correctness, etc.

That leads to the FAIR principles, which cannot be met by vendor locked systems

Following the FAIR principles will improve the quality of results in the long run

See: <https://www.helmholtz-berlin.de/projects/catlab>

Use in CatLab



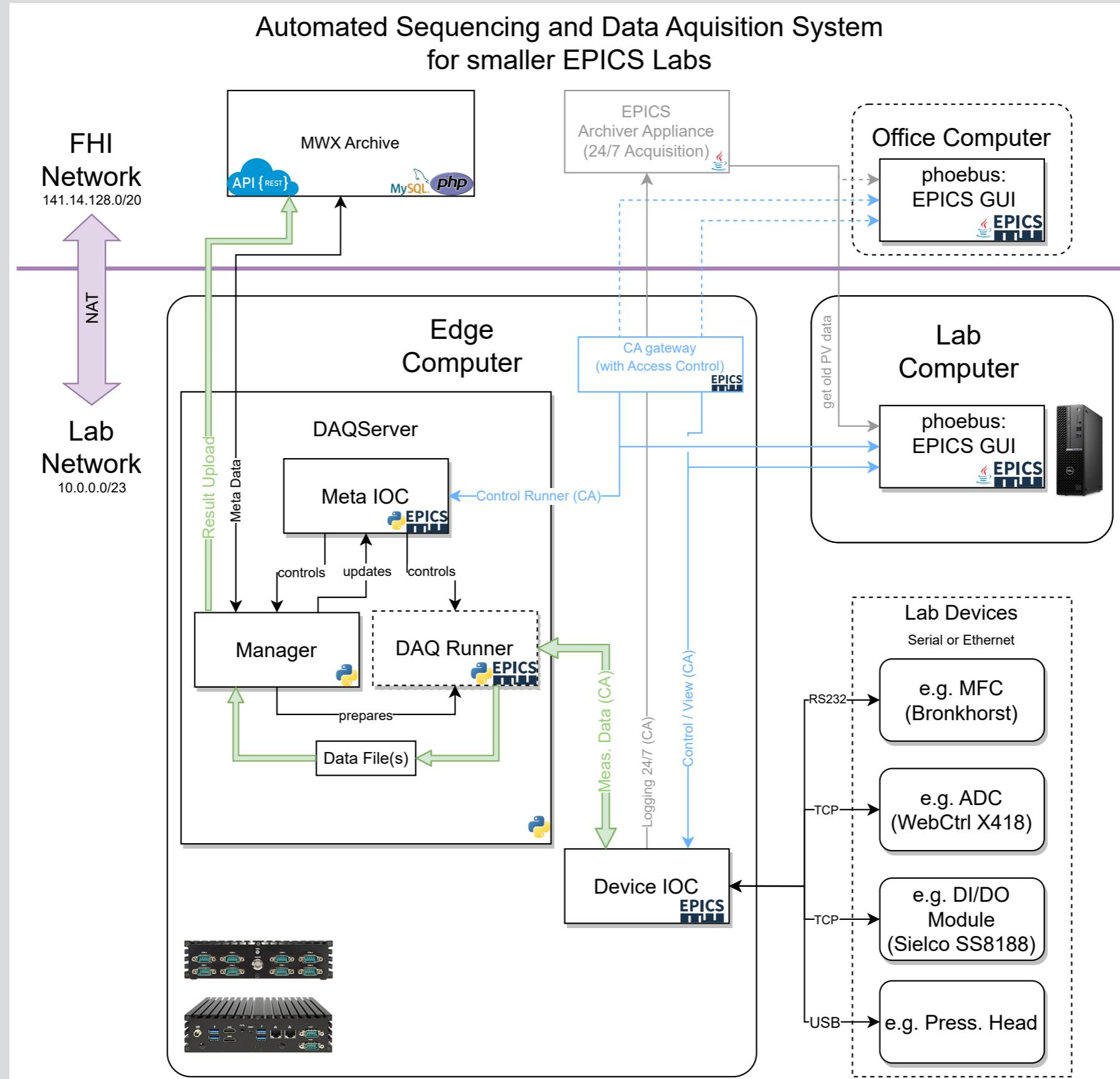
The concept idea is already being used in the CatLab.
Implemented by Abdulrhman Moshantaf (started April 2021)

To make it perfect, Mike Wesemann has modernised the document archive, which has been used in the AC department for more than 20 years -> archiv (ac-archive.fhi.mpg.de)
The complete setup can now be called LIMS ;-)

The screenshot shows a web-based document archive interface. At the top, there are navigation icons (back, forward, search, etc.) and a URL bar showing "ac.archive.fhi.mpg.de". The title "AC/CATLAB Archive v1.0.121" is displayed, along with a search bar and links for "NEW", "SEARCH", "MORE", "TAGS", "LOGOUT", and "HOME". Below this, user information "User: junkes Role: user Type: ldap" and a total result count "83861 Results, Page 1 of 839" are shown. There are also "PREV" and "NEXT" buttons. A filter section allows users to refine results by "Type" (ALL, DATA, PUBLICATION, SAMPLE, EQUIPMENT, INSTRUMENT, CHEMICALS, GAS, PROJECT) and "Project" (ALL, DEFAULT, HISTORICAL, AmmoMax, AmmoRef, BasCat, CatLab, Carbon2Chem, CatVIC, e-conversion, HydroSpin, Methusalem, Prometheus, SFB/TRR247, SPP2080, UniSysCat, Liquids, PPB). The main content area is a table listing documents:

| ID | Project | Description | Author(s) | Action | | | |
|--------|---------|---|--------------------------------------|--------|--|--|--|
| D53434 | CatVIC | TEM of S35788 - ZnO/ZrO ₂ reverse addition | F. Ennenbach, C. Marshall, C. Rohner | | | | |
| D53433 | CatVIC | TEM of S35787 - ZnO/ZrO ₂ simultaneous addition | F. Ennenbach, C. Marshall, C. Rohner | | | | |
| D53432 | DEFAULT | UV-Vis-NIR spectrum of C219 | N. Pfister | | | | |
| D53431 | BasCat | UV-Vis-NIR spectrum of S35805 | N. Pfister | | | | |
| D53430 | BasCat | UV-Vis-NIR spectrum of S35806 | N. Pfister | | | | |
| S35837 | BasCat | Impregnation_Optimax_S35155_(NH4)3[Fe(C2O4)3]_2h_30C_pH5_0.5Atoms/nm2 | N. Pfister | | | | |
| S35836 | AmmoRef | LCFO_04_SFS | B. Alkan | | | | |
| S35835 | AmmoRef | LCFO_03_SFS | B. Alkan | | | | |
| D53429 | AmmoRef | NH3_decomp S35123 _5_at_Ni_MgO | B. Alkan | | | | |
| D53428 | DEFAULT | TEM of S34741 | K. Dembélé | | | | |

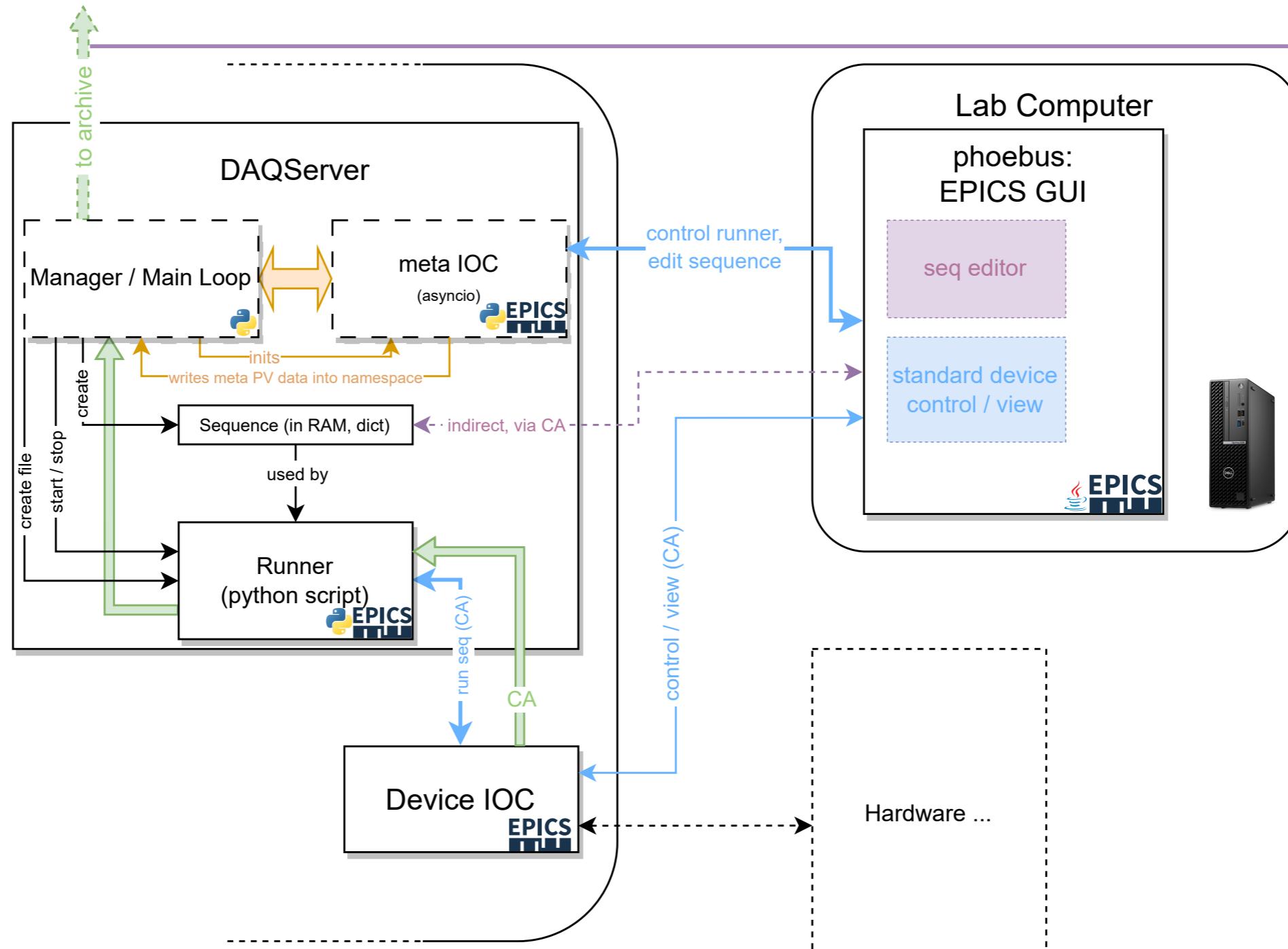
Concept idea



Concept idea



Detailed View of the DAQServer



Concept idea



FHI:GenericReactor:DAQServer

reload machine

Runner Selection: Sequence Selection:

940: slight changes D561: seq1

Currently loaded: Currently loaded:

940: slight changes D561: seq1

--> ID: 940 --> ID: D561

RunnerSelect JSON

```
[{"id": "942", "filename": "runner-min.py", "timestamp": "2023-04-04 14:34:31", "comment": "new minimal version", "size": "2400", "mimetype": "text/x-python"}, {"id": "941", "filename": "runner-min.py", "timestamp": "2023-03-22 16:39:11", "comment": "minimal version", "size": "2248", "mimetype": "text/x-python"}, {"id": "940", "filename": "seq1"}, {"id": "D562", "title": "seq2"}, {"id": "D563", "title": "seq3"}]
```

SeqSelect JSON

```
[{"link": "D561", "title": "seq1"}, {"link": "D562", "title": "seq2"}, {"link": "D563", "title": "seq3"}]
```

Sequence JSON

```
[{"dwell_time": 12.3, "DEP:MACHINE:DEVICE:PV": 1.23, "DEP:MACHINE:DEVICE:PV2": "open"}, {"dwell_time": 1, "DEP:MACHINE:DEVICE:PV": 0, "DEP:MACHINE:DEVICE:PV2": "close"}]
```

Runner Control:

stopped
stop start

Header

| | |
|----------------|-------------|
| name | my seq name |
| user name | my name |
| inner diameter | 13.3700 |
| catalyst mass | 1.3370 |
| diluent | item 0 |

Setpoints

| | |
|--------------------|----------|
| Dwell Time | 12.1000 |
| Equilibration Time | 33.5000 |
| Heater Setpoint | 100.0000 |
| Heater Ramprate | 10.0000 |
| N2 Flowrate | 5.5600 |
| Ar Flowrate | 3.7800 |
| H2 Flowrate | 1.8000 |

Method Editor

Header

| | |
|------------------------------|----------------------------------|
| Method Name: | User Name: |
| Temporal resolution: | Inner diameter of reactor (D): |
| Sieve fraction analyte low: | Partical size (D _p): |
| Sieve fraction analyte high: | Ratio of (D/D _p): |
| Diluent material: | Catalyst Mass: |
| Diluent sieve fraction low: | Bulk Volume: |
| Diluent sieve fraction high: | |

NH3 Detector

At 10 vol. % NH3 : 0.00

At 0 vol. % NH3 : 0.00

Update List

Load Method:

Recipe entry

| | | | |
|---------------------|----------|------------------------|----------|
| Setpoint: | NH3_300: | Contact Time: | 0.00 |
| Ramprate: | NH3_30: | Space Velocity (GHSV): | 0.00 1/h |
| Dwell Time: | N2: | | |
| Equilibration Time: | Ar: | | |
| Gas Flow: | H2: | | |

ADD

Simulate

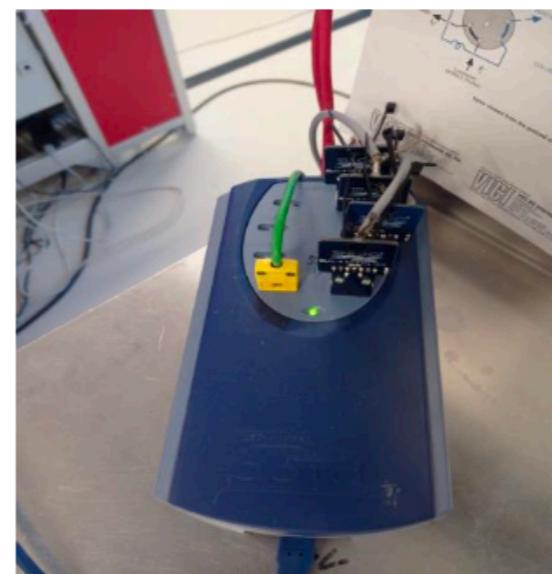
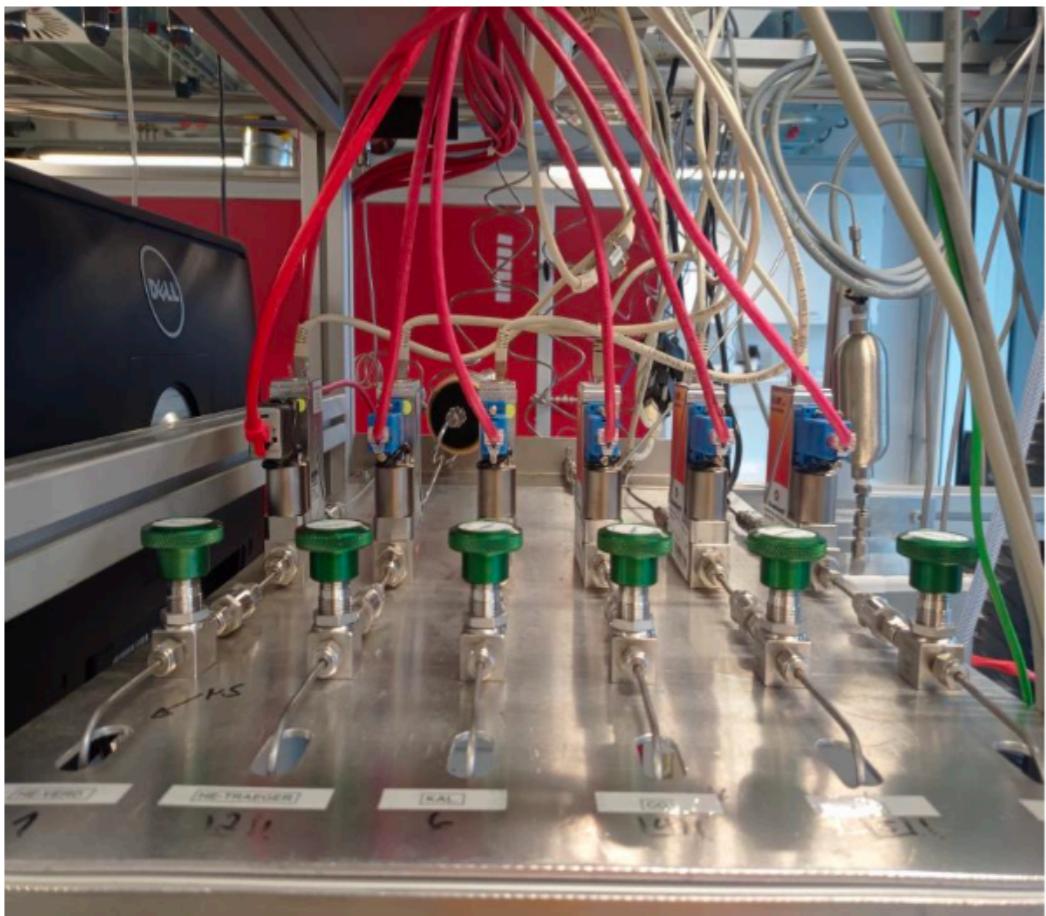
Save

Stage Equalibration Time [min] Setpoint [C°] Ramprate [C°/min] Dwell Time [min] Gas Flow [mln/min] NH3_300 [%] NH3_30[%] N2[%] Ar[%] H2[%] Contact time [gs/ml] Space velocity [1/h]

Click...

Automation of Ertl - Reactor

FRITZ-HABER-INSTITUT
MAX-PLANCK-GESELLSCHAFT



Abdulrhman Moshantaf: Group meeting presentation, EPICS Automatization

Automation of Ertl - Reactor



AC/CATLAB Archive v1.0.112

User: moshantaf Role: user Type: ldap

Metadata

| Action | | | | | |
|----------------------|----------------------|--|--|--|--|
| Id | D51544 | | | | |
| User | moshantaf | | | | |
| Project | DEFAULT | | | | |
| Access | project | | | | |
| Open Access | | | | | |
| Edit History | SHOW | | | | |
| Date Created | 2021-10-19 20:11:59 | | | | |
| Date Modified | 2022-02-16 17:29:25 | | | | |

Data

| | |
|----------------------|---|
| Title | Methods for Ertl |
| Author | Abdulrhman |
| Comment | This Data entry should contain all Methods that belongs to Ertl |
| Keywords | #Ertl, Methods |
| Document Type | UNKNOWN |
| Methods | |
| Elements | |
| Sample Number | |

Linked Entries

| Id | Project | File | Action |
|--------|---------|--|--------|
| D51545 | DEFAULT | 211019_CO_oxi_1_20_100_rate_GK Method | |
| D51546 | DEFAULT | 211019_CO_oxi_1_20_100_rate_AM Method | |
| D51551 | DEFAULT | 211020_CO_oxi_1_20_50_rate_GK Method | |
| D51577 | DEFAULT | 211027_CO_oxi_1_20_50_ramp_rate_ramp_GK Method | |
| D51619 | DEFAULT | example Method | |
| D52459 | DEFAULT | test plot Method | |

- All the entered methods are saved on the AC Archive

AC/CATLAB Archive v1.0.112

User: moshantaf Role: user Type: ldap

Metadata

| Action | | | | | |
|----------------------|----------------------|--|--|--|--|
| Id | D51577 | | | | |
| User | pallas | | | | |
| Project | DEFAULT | | | | |
| Access | project | | | | |
| Open Access | | | | | |
| Edit History | SHOW | | | | |
| Date Created | 2021-10-27 13:31:50 | | | | |
| Date Modified | 2022-02-10 17:07:33 | | | | |

Data

| | |
|----------------------|--|
| Title | 211027_CO_oxi_1_20_50_ramp_rate_ramp_GK Method |
| Author | Gregor Koch |
| Comment | |
| Keywords | |
| Document Type | UNKNOWN |
| Methods | |
| Elements | |
| Sample Number | |

Json Data

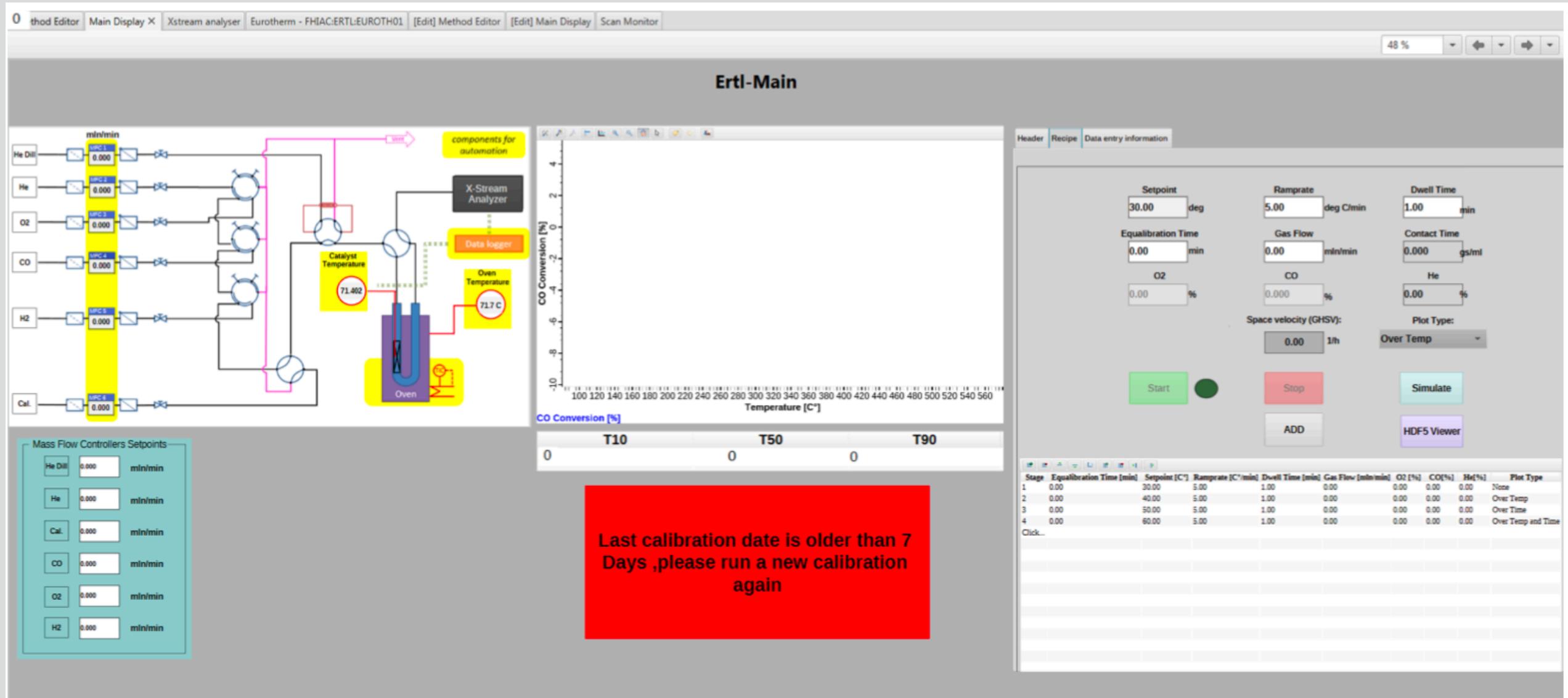
```
{
  "ertl": {
    "header": [ 13 items ],
    "stage1": [
      "stage": [ 3 items ],
      "equalibrationtime": [ 3 items ],
      "setpoint": [ 3 items ],
      "ramprate": [ 3 items ],
      "dwelltime": [ 3 items ],
      "gasflow": [ 3 items ],
      "O2": [ 3 items ],
      "CO": [ 3 items ],
      "He": [ 3 items ],
      "contacttime": [ 3 items ],
      "spacevelocity": [ 3 items ]
    ],
    "stage2": [ 11 items ],
    "stage3": [ 11 items ],
    "stage4": [ 11 items ],
    "stage5": [ 11 items ]
  }
}
```

Files (1)

| Id | File | Time | Comment | Size | Action |
|--------|---|---------------------|---------|--------|--------|
| 764337 | 211027_CO_oxi_1_20_50_ramp_rate_ramp_GKh5 | 2021-10-27 13:31:51 | | 7.3 Kb | |

Abdulrhman Moshantaf: Group meeting presentation, EPICS Automatization

Automation of Ertl - Reactor

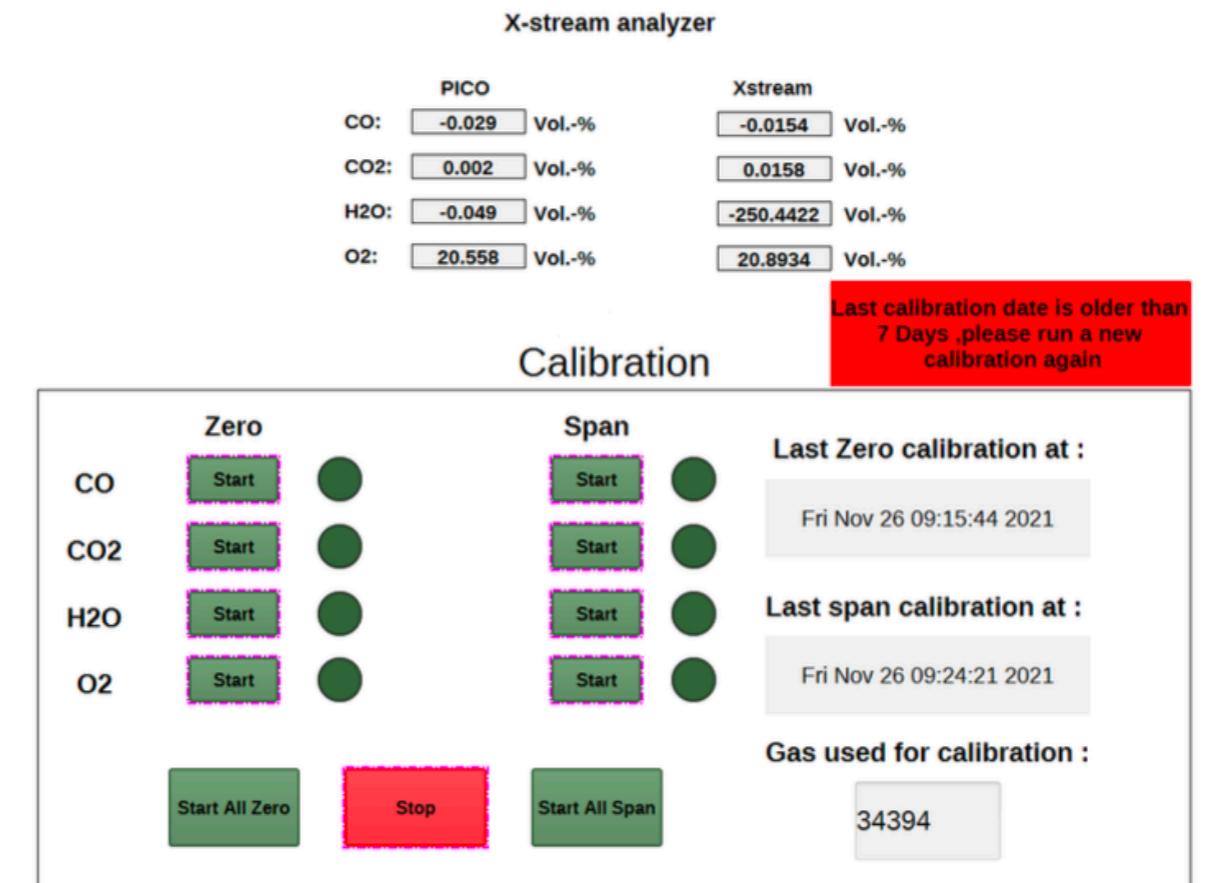


Abdulrhman Moshantaf: Group meeting presentation, EPICS Automatization

Automation of Ertl - Reactor



- **Clicking on the X-stream analyzer button will open the analyzer display**
- **Concentrations will be read from the analyzer and displayed on the window**
- **Calibration for each component can be started and stopped with buttons, the last calibration date will be saved**
- **The warning box will blink with red if the last calibration date is older than 7 days and the user can not start the experiment until the calibration is done again.**



Abdulrhman Moshantaf: Group meeting presentation, EPICS Automatization



CAMELS

A Configurable Instrument Control Software for FAIR Data

Alexander Fuchs^{1,2}, Johannes Lehmeyer^{1,2},
Michael Krieger^{1,2}, Heiko B. Weber^{1,2},
Patrick Oppermann^{1,3}, and Heinz Junkes^{1,3}

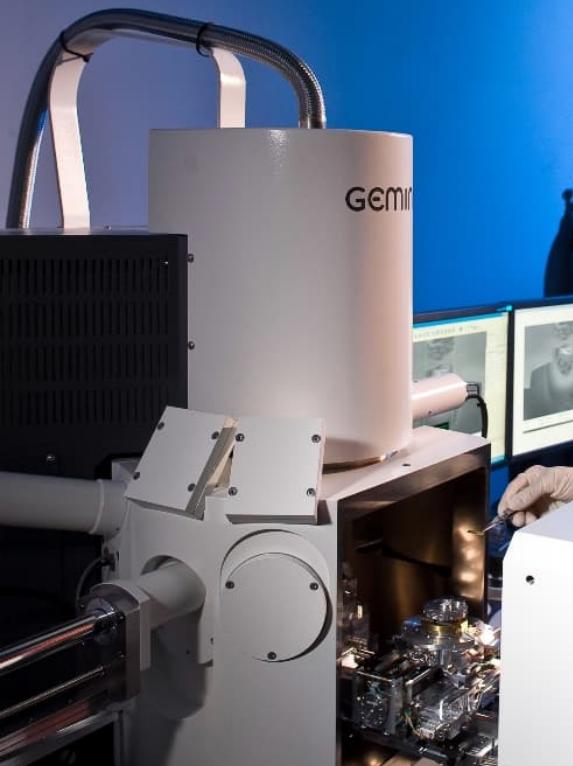
1 HU Berlin, FAIRmat

2 Lehrstuhl für Angewandte Physik, Friedrich-Alexander-Universität Erlangen

3 Fritz-Haber-Institut der Max-Planck-Gesellschaft

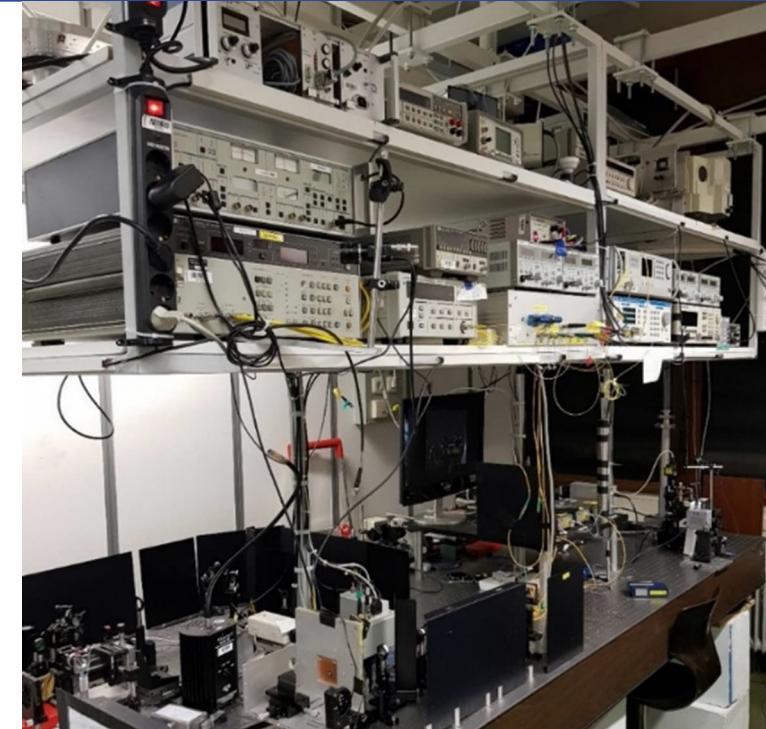
Two kinds of Experiments

Commercial integrated systems



**Vendor-provided
measurement software
→ standard data**

Specialized custom experiments

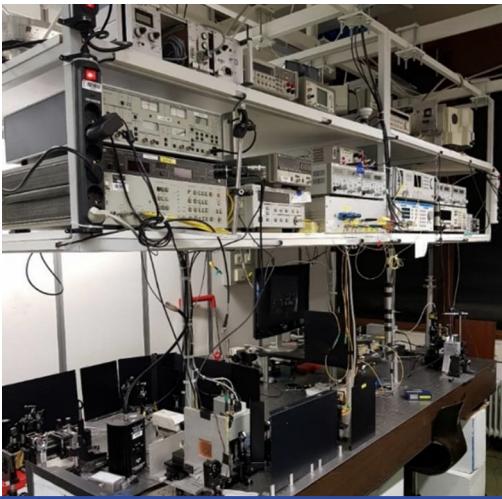


**No standard control
→ No standard data**

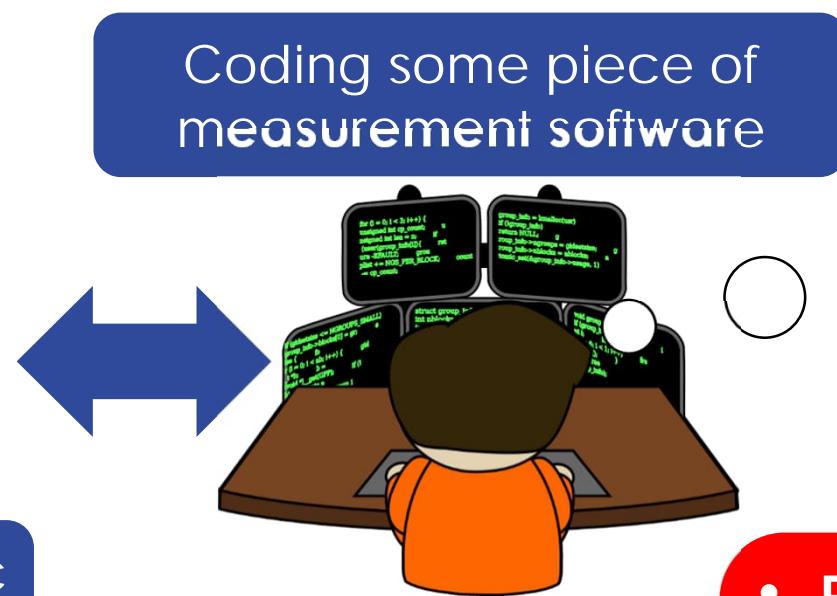
Specialized experiments

```
TestLaser.txt
1 <ThorCam:AcquireMean> <ThorCam:LastMean> <ThorCam:LastSum> <ThorCam:AcquireSum> <K2400:Voltage>
2 NaN 2.214771E+4 NaN NaN 0.000000E+0 3.671010E+9 8.999443E-1 3.671010E+9 0.000000E+0 0.000000E+0
3 NaN 2.274620E+4 NaN NaN 1.500000E+0 3.671010E+9 1.452614E+0 3.671010E+9 1.000000E+0 1.500000E+0

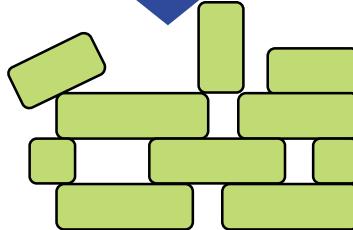
spec_fabry.txt
1 # Exposure Time: 0.500000
2 # Center Wavelength: 800.000000
3 # Grating: 149.849991 l, 800.000000 nm
4 # Input Slit Width: 1000.000000
5 628.656067 448.000000
6 630.008057 489.000000
7 631.359900 481.000000
8 632.711800 493.000000
```



Specialized ad-hoc experimental setup



- Programming skills required
- Redundant software development
- High hurdle for implementation of new measurement protocols



Raw data,
no or (little) metadata,
heterogeneous data format

not FAIR

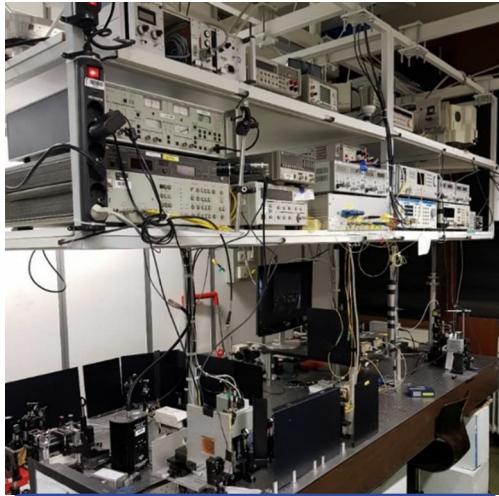


New approach

Open software framework for measurement protocol configuration:
Making research life easier; from planning to data collection

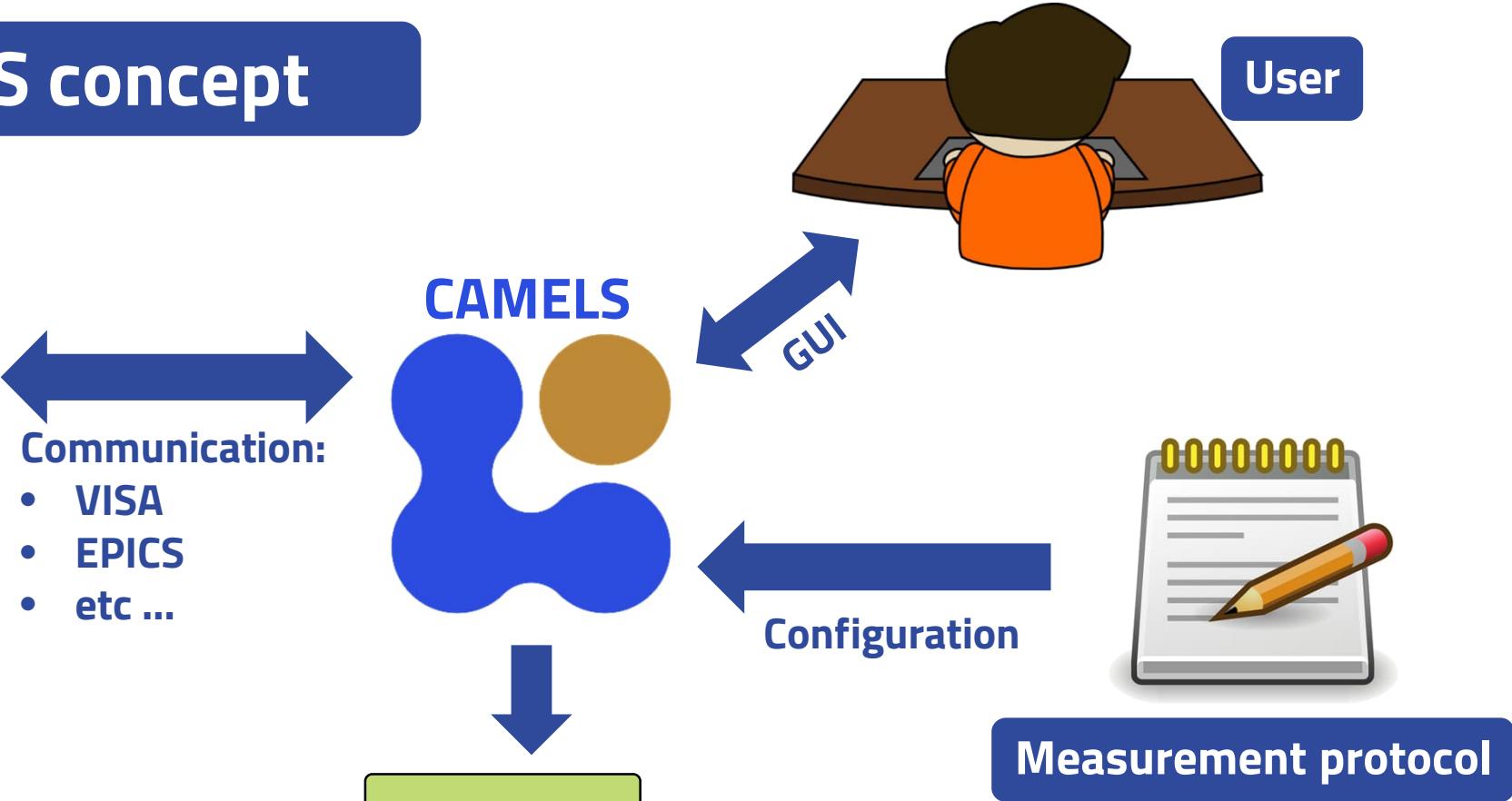


Control Application for Measurements, Experiments and Laboratory Systems



Experimental setup

CAMELS concept



- **Fast configuration of measurement protocol**
- **No programming skills required**

FAIR data*

- Raw data
- Metadata incl. devices, settings, protocol, ...
- Structured data format (HDF5)

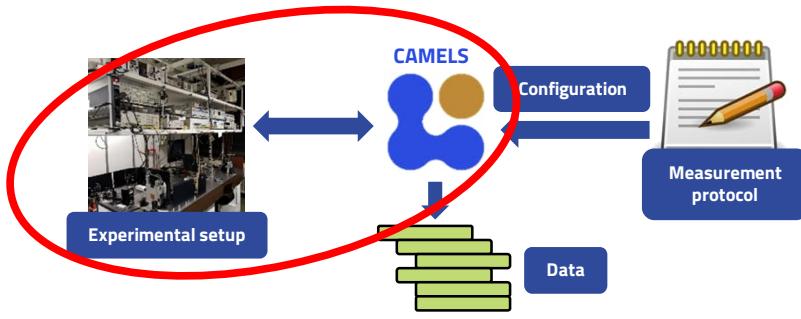
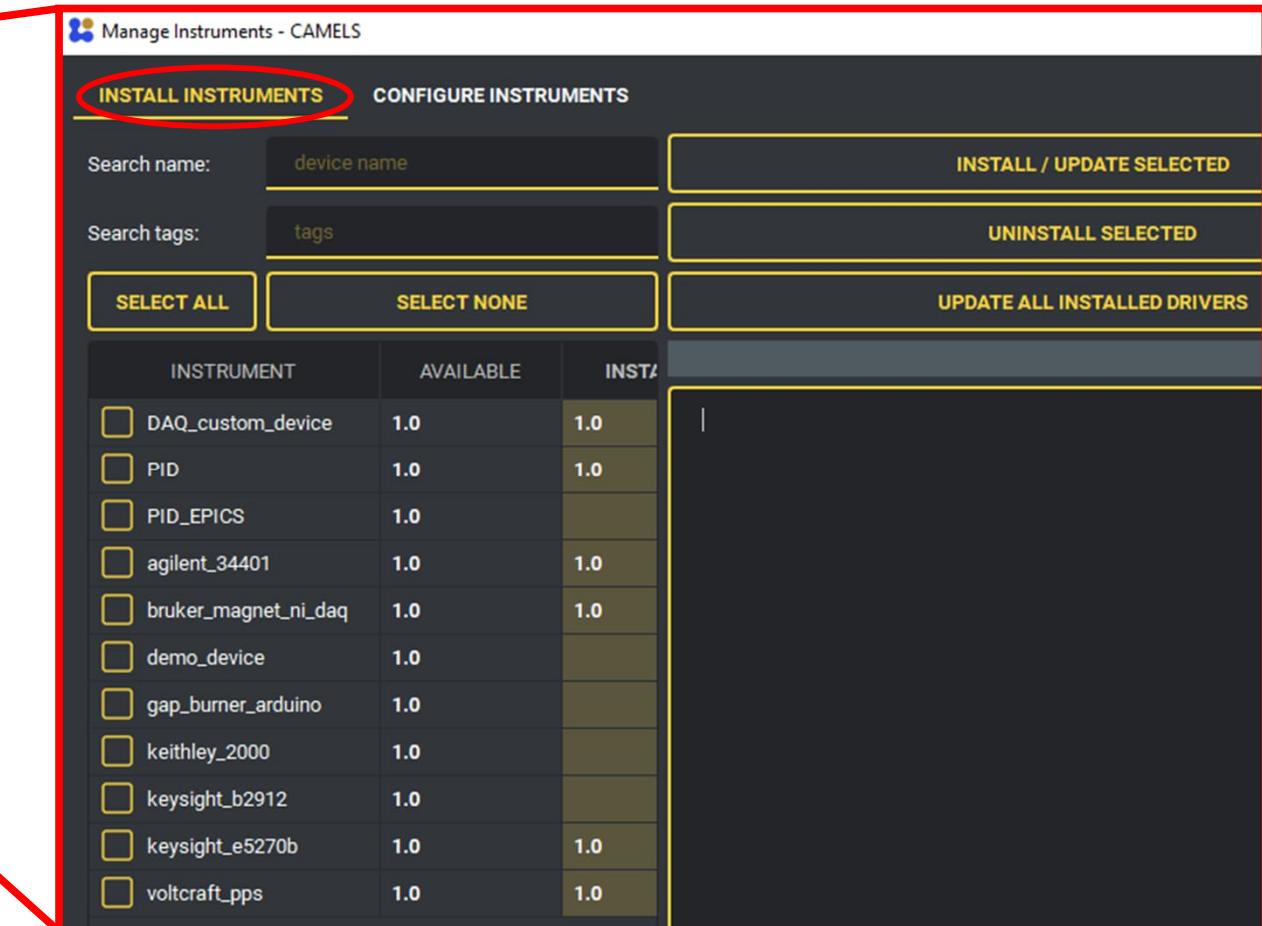
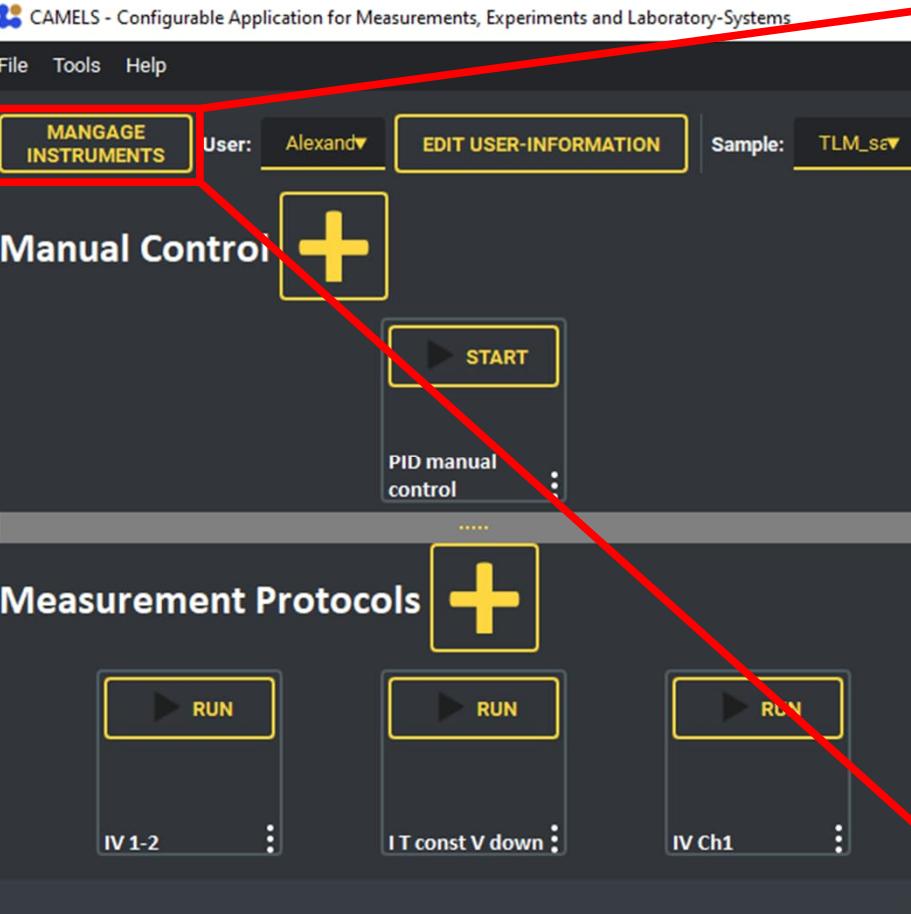
*More precisely FAIR-ready data when not connected to community standards



Features

- **Open source** (hosted on GitHub)
- Ready to start first measurement in < 30 minutes
- **GUI generates Python** (Bluesky) code → customizable
- Complete recording of **metadata**
- **Scalable**
 - Local device communication (VISA)
 - Large-scale distributed control systems (EPICS)

Features:
Currently Implemented



CAMELS: instrument communication

Basics: Installing New Instruments

The diagram illustrates the CAMELS software interface for managing instruments. It consists of two main windows:

- Main Window:** Shows a photograph of a laboratory setup with various instruments and equipment. Below it is the CAMELS application window titled "CAMELS - Configurable Application for Measurements, Experiments and Laboratory-Systems". The window includes a menu bar (File, Tools, Help), user information (User: Alexandr, Edit User-Information), and sample selection (Sample: TLM_sa). A prominent yellow box highlights the "MANAGE INSTRUMENTS" button. Other buttons include "START", "PID manual control", "Measurement Protocols" (with "RUN" buttons for IV 1-2, IT const V down, and IV Ch1), and a "Manual Control" section with a large yellow plus sign.
- Detailed Configuration Window:** Titled "Manage Instruments - CAMELS". It shows a list of installed instruments: DAQ_custom_device, PID, agilent_34401, bruker_magnet_ni_daq, keysight_e5270b, and voltcraft_pps. A yellow box highlights the "keysight_e5270b" entry. The "CONFIGURE INSTRUMENTS" tab is selected, indicated by a red circle and border. The configuration panel for the Keysight E5270B is displayed, showing fields for "Custom name" (set to "SMU"), "Connection-type" (Local VISA), "Resource-Name" (GPIB0::17::INSTR), "Baud-Rate" (9600), "In-Terminator" (\r\n), "Out-Terminator" (\r\n), and "Mode" (PLC Mode). It also lists "CHANNEL 1" through "CHANNEL 6" with various settings like "Channel active", "Output Filter", and ranges for "Voltage Source" and "Current Source". Buttons for "OK" and "CANCEL" are at the bottom right.



Basics:

Measurement Protocols

The diagram illustrates the CAMELS measurement protocol configuration process. It shows the flow from the main application interface to the detailed configuration dialog.

CAMELS (represented by a blue and yellow stylized human icon) interacts with the **Measurement protocol** (represented by a notepad icon).

Measurement protocol configuration is shown in a separate window titled **IV_Ch1 - Measurement Protocol - CAMELS**.

Sequence steps include: MOVE UP, MOVE IN, MOVE DOWN, MOVE OUT, Set Channels (Set_Channels), Simple Sweep (Simple_Sweep_1), and Set Channels (Set_Channels_1).

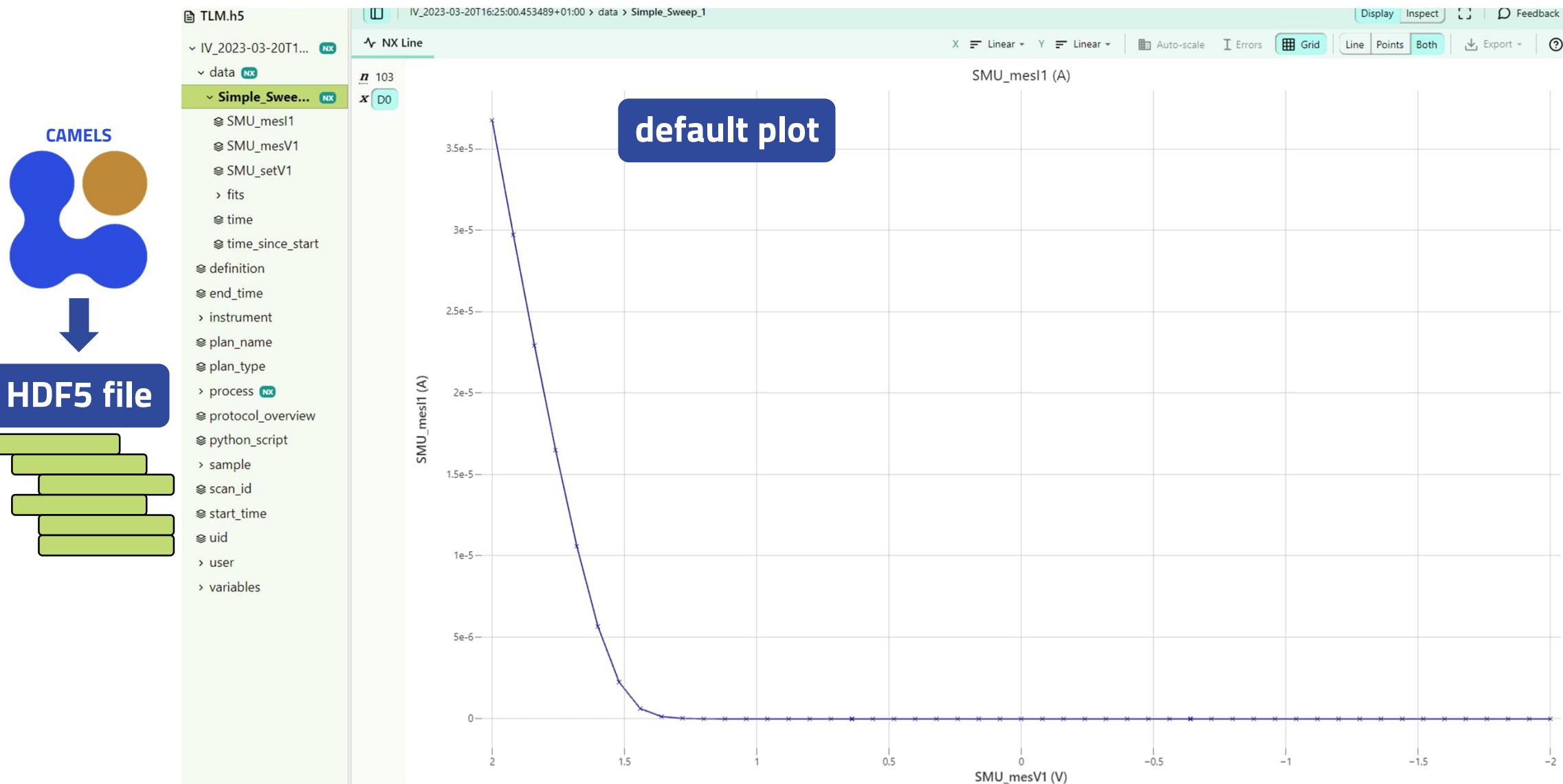
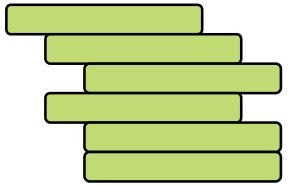
Possible steps listed in the configuration window:

- Insert Above ▶
- Insert Below ▶
- Cut
- Copy
- Paste ▶
- Delete Step
- OK
- CANCEL

Variables table:

| NAME | VALUE | ATA-TYP |
|--------|-------|---------------|
| points | 11 | <class 'int'> |
| v_max | 10 | <class 'int'> |

Measurement Protocols screen highlights the **+ New** button, which is also highlighted by a red arrow originating from the main interface.

**HDF5 file**



CAMELS: Data File

Meta data

„Classical“ data

| TLM.h5 | |
|-----------------------|----|
| `- IV_2023-03-20T1... | NX |
| `- data NX | |
| `- Simple_Sweep_1 NX | |
| `- SMU_mesl1 | |
| `- SMU_mesV1 | |
| `- SMU_setV1 | |
| `- fits | |
| `- time | |
| `- time_since_start | |
| `- definition | |
| `- end_time | |
| `- instrument | |
| `- plan_name | |
| `- plan_type | |
| `- process NX | |
| `- protocol_overview | |
| `- python_script | |
| `- sample | |
| `- scan_id | |
| `- start_time | |
| `- uid | |
| `- user | |
| `- variables | |

| IV_2023-03-20T16:25:00.453489 | |
|-------------------------------|----------|
| `- Matrix | Line |
| `- 0 | 0 |
| `- 1 | 2.600e-4 |
| `- 2 | 8.025e-2 |
| `- 3 | 1.602e-1 |
| `- 4 | 2.403e-1 |
| `- 5 | 3.203e-1 |
| `- 6 | 4.003e-1 |
| `- 7 | 4.803e-1 |
| `- 8 | 5.602e-1 |
| `- 9 | 6.402e-1 |
| `- 10 | 7.202e-1 |
| `- 11 | 8.002e-1 |
| `- 12 | 8.802e-1 |
| `- 13 | 9.602e-1 |
| `- 14 | 1.040e+0 |
| `- 15 | 1.120e+0 |
| `- 16 | 1.200e+0 |
| `- 17 | 1.280e+0 |
| `- 18 | 1.360e+0 |
| `- 19 | 1.440e+0 |
| `- 20 | 1.520e+0 |
| `- 21 | 1.600e+0 |
| `- 22 | 1.680e+0 |
| `- 23 | 1.760e+0 |

| TLM.h5 | |
|-----------------------|----|
| `- IV_2023-03-20T1... | NX |
| `- data NX | |
| `- Simple_Sweep_1 NX | |
| `- SMU_mesl1 | |
| `- SMU_mesV1 | |
| `- SMU_setV1 | |
| `- fits | |
| `- time | |
| `- time_since_start | |
| `- definition | |
| `- end_time | |
| `- instrument | |
| `- plan_name | |
| `- plan_type | |
| `- process NX | |
| `- protocol_overview | |
| `- python_script | |
| `- sample | |
| `- scan_id | |
| `- start_time | |
| `- uid | |
| `- user | |
| `- variables | |

| IV_2023-03-20T16:25:00.453489 | |
|-------------------------------|------------|
| `- Matrix | Line |
| `- 0 | 0 |
| `- 1 | -2.466e-10 |
| `- 2 | -1.925e-10 |
| `- 3 | -3.009e-10 |
| `- 4 | -1.774e-10 |
| `- 5 | -2.554e-10 |
| `- 6 | -1.700e-10 |
| `- 7 | -2.345e-10 |
| `- 8 | -2.945e-10 |
| `- 9 | -2.104e-10 |
| `- 10 | -2.475e-10 |
| `- 11 | -1.677e-10 |
| `- 12 | -1.762e-10 |
| `- 13 | 8.542e-11 |
| `- 14 | 1.128e-9 |
| `- 15 | 6.062e-9 |
| `- 16 | 2.993e-8 |
| `- 17 | 1.423e-7 |
| `- 18 | 6.270e-7 |
| `- 19 | 2.237e-6 |
| `- 20 | 5.649e-6 |
| `- 21 | 1.059e-5 |
| `- 22 | 1.647e-5 |

| TLM.h5 | |
|-----------------------|--|
| `- IV_2023-03-20T1... | |
| `- data NX | |
| `- definition | |
| `- end_time | |
| `- instrument | |
| `- plan_name | |
| `- plan_type | |
| `- process NX | |
| `- protocol_overview | |
| `- python_script | |
| `- sample | |
| `- scan_id | |
| `- start_time | |
| `- uid | |
| `- user | |
| `- variables | |

| |
|--------------------|
| `- instrument |
| `- environment |
| `- SMU |
| `- model |
| `- name |
| `- settings |
| `- SMU_ImeasRange1 |
| `- SMU_ImeasRange2 |
| `- SMU_ImeasRange3 |
| `- SMU_ImeasRange4 |
| `- SMU_IoutRange1 |
| `- SMU_IoutRange2 |
| `- SMU_IoutRange3 |
| `- SMU_IoutRange4 |
| `- SMU_VmeasRange1 |
| `- SMU_VmeasRange2 |
| `- SMU_VmeasRange3 |
| `- SMU_VmeasRange4 |
| `- SMU_VoutRange1 |
| `- SMU_VoutRange2 |
| `- SMU_VoutRange3 |
| `- SMU_VoutRange4 |
| `- SMU_currComp1 |
| `- SMU_currComp2 |



CAMELS: Data File

TLM.h5

IV_2023-03-20... NX

<> Scalar

```

Set Channels - {'Channels': ['SMU_enable1', 'SMU_setV1'], 'Values': ['1', '0']}
Simple Sweep
Sweep: SMU_setV1, Read: ['SMU_mesI1', 'SMU_mesV1', 'SMU_setV1']
Set Channels - {'Channels': ['SMU_enable1', 'SMU_setV1'], 'Values': ['0', '0']}

from camels_driver.Keysight_E5270B import Keysight_E5270B

def create_plots_Simple_Sweep_1(RE, stream="primary"):
    app = QCoreApplication.instance()
    if app is None:
        app = QApplication(sys.argv)
    if darkmode:
        plot_widget.activate_dark_mode()
    subs = []
    fits = []
    fits.append({'do_fit': True, 'predef_func': 'Linear', 'custom_func': '',
    plot_0 = plot_widget.PlotWidget(x_name="SMU_mesV1", y_names=['SMU_mesI1'])
    plots.append(plot_0)
    plot_0.show()
    subs.append(RE.subscribe(plot_0.livePlot))
    for fit in plot_0.liveFits:
        all_fits[fit.name] = fit
    return plots, subs, app

def IV_Ch1_plan_inner(devs, runEngine=None, stream_name="primary"):
    global points, v_max, v_min
    eva = Evaluator(namespace=namespace)
    runEngine.subscribe(eva)

```

vs. „old school“

| | iv_data.txt |
|----|--|
| 1 | 2.5999999999999972e-04 -2.46560000000000254e-10 |
| 2 | 8.02500000000000189e-02 -1.924899999999991e-10 |
| 3 | 1.6023999999999936e-01 -3.00930000000000144e-10 |
| 4 | 2.40260000000000013e-01 -1.77410000000000108e-10 |
| 5 | 3.2026999999999991e-01 -2.554100000000000000e-10 |
| 6 | 4.0026000000000047e-01 -1.70099999999999899e-10 |
| 7 | 4.80260000000000202e-01 -2.34459999999999844e-10 |
| 8 | 5.60239999999999602e-01 -2.94489999999999829e-10 |
| 9 | 6.4019999999999913e-01 -2.10429999999999909e-10 |
| 10 | 7.2023999999999913e-01 -2.1904000000000005e-10 |
| 11 | 8.00200000000000224e-01 -2.47519999999999890e-10 |
| 12 | 8.80199999999999824e-01 -1.676999999999999e-10 |
| 13 | 9.60200000000000535e-01 -1.7621000000000047e-10 |
| 14 | 1.0402400000000054e+00 8.5420000000000074e-11 |
| 15 | 1.12027999999999943e+00 1.12829999999999919e-09 |
| 16 | 1.20023999999999974e+00 6.0619999999999953e-09 |
| 17 | 1.2802800000000085e+00 2.99280000000000170e-08 |
| 18 | 1.36027999999999934e+00 1.4226000000000046e-07 |
| 19 | 1.44023999999999965e+00 6.26979999999999669e-07 |
| 20 | 1.5202800000000076e+00 2.23679999999999912e-06 |
| 21 | 1.60027999999999925e+00 5.64890000000000244e-06 |
| 22 | 1.68019999999999916e+00 1.0594000000000055e-05 |
| 23 | 1.76011999999999907e+00 1.64739999999999846e-05 |
| 24 | 1.84016000000000018e+00 2.29239999999999939e-05 |
| 25 | 1.92016000000000089e+00 2.97259999999999966e-05 |
| 26 | 2.00019999999999978e+00 3.67540000000000081e-05 |
| 27 | 2.000239999999999796e+00 3.67559999999999842e-05 |
| 28 | 1.92012000000000049e+00 2.97179999999999906e-05 |
| 29 | 1.84020000000000058e+00 2.29219999999999839e-05 |
| 30 | 1.76019999999999987e+00 1.64780000000000046e-05 |
| 31 | 1.68023999999999956e+00 1.05919999999999955e-05 |

Why CAMELS?

Easy to use

- Low threshold entry to device communication
- Save time communicating with devices

FAIR data

- Standardized data formats
- Rich metadata

Open source & Community driven

- Drivers written by & for the community

Customizable

- Setup consisting of several measurement instruments
- Dynamic changes of the measurement setup
- Multiple use-cases for a single setup



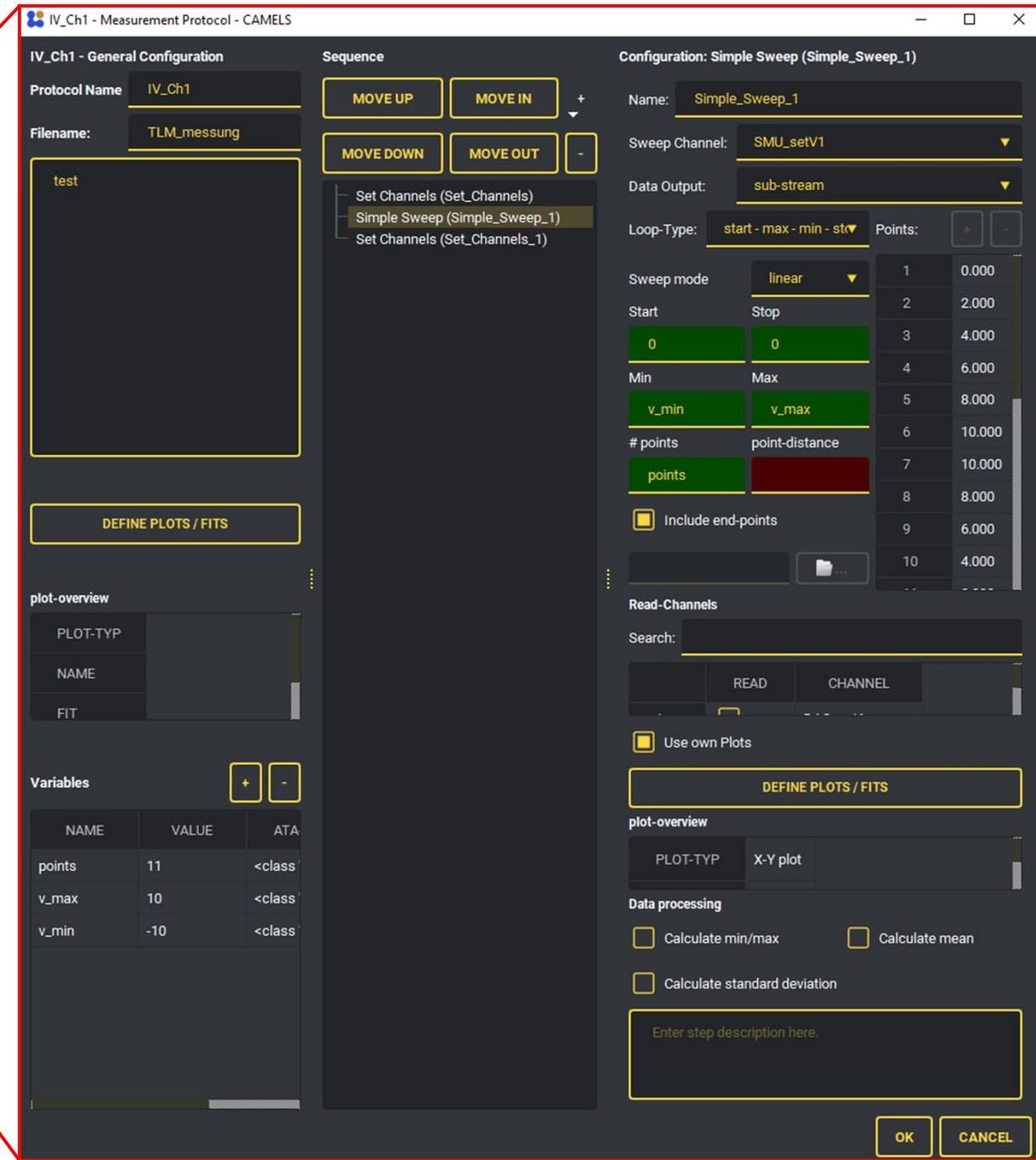
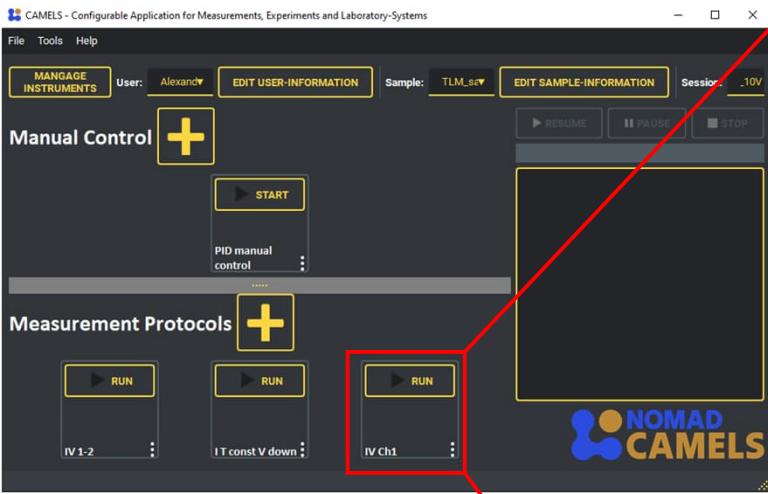


Thank you for your
kind attention!

Basics:

Measurement protocols/recipes

CAMELS basics



CAMELS basics

Basics:

Final data file

Two screenshots of the CAMELS data browser interface showing final data files.

Screenshot 1: Data for **SMU_mes1** (red box highlights the node). The data table has 23 rows (n) and 2 columns (x, D0). The first few rows are:

| n | x |
|----|-----------|
| 0 | 0 |
| 1 | 2.7e-13 |
| 2 | 1.94e-12 |
| 3 | 3.1e-12 |
| 4 | 4.06e-12 |
| 5 | 4.96e-12 |
| 6 | 5.99e-12 |
| 7 | 5.22e-12 |
| 8 | 3.2e-12 |
| 9 | 1.98e-12 |
| 10 | 7.6e-13 |
| 11 | -1.5e-13 |
| 12 | -1.24e-12 |
| 13 | -2.2e-12 |
| 14 | -3.05e-12 |
| 15 | -3.87e-12 |
| 16 | -4.86e-12 |
| 17 | -5.71e-12 |
| 18 | -4.98e-12 |
| 19 | -2.93e-12 |
| 20 | -1.59e-12 |
| 21 | -4.3e-13 |
| 22 | 5.9e-13 |
| | 1.66e-12 |

Screenshot 2: Data for **SMU_mesV1** (red box highlights the node). The data table has 5 rows (n) and 2 columns (x, D0). The first few rows are:

| n | x |
|---|----------|
| 0 | 0.000545 |
| 1 | 2.0004 |
| 2 | 4.0002 |
| 3 | 5.9992 |
| 4 | 7.9995 |
| 5 | 9.9999 |

TLM_messung_Alex.h5

```

high_temp_2023-03-17T14:43:11.729461+01:00 NX
  ✓ data NX
    ✓ Simple_Sweep_1 NX
      ◉ SMU_mes1
      ◉ SMU_mesV1
      ◉ SMU_setV1
      > fits
      > time
      > time_since_start
      ◉ definition
      ◉ end_time
      > instrument
      ◉ plan_name
      ◉ plan_type
      > process NX
      ◉ protocol_overview
      ◉ python_script
      > sample
      ◉ scan_id
      > start_time
      ◉ uid
      > user
      > variables
  ✓ instrument
  ✓ environment
    ✓ SMU
    ◉ model
    ◉ name
    ✓ settings
      ◉ SMU_ImeasRange1
      ◉ SMU_ImeasRange2
      ◉ SMU_ImeasRange3
      ◉ SMU_ImeasRange4
      ◉ SMU_IoutRange1
      ◉ SMU_IoutRange2
      ◉ SMU_IoutRange3
      ◉ SMU_IoutRange4
      ◉ SMU_VmeasRange1
      ◉ SMU_VmeasRange2
      ◉ SMU_VmeasRange3
      ◉ SMU_VmeasRange4
      ◉ SMU_VoutRange1
      ◉ SMU_VoutRange2
      ◉ SMU_VoutRange3
      ◉ SMU_VoutRange4
      ◉ SMU_currComp1
      ◉ SMU_currComp2
      ◉ SMU_currComp3
      ◉ SMU_currComp4
      ◉ SMU_idn
      ◉ SMU_measMode1
      ◉ SMU_measMode2
      ◉ SMU_measMode3
      ◉ SMU_measMode4
  ✓ python_script
  > sample
  ◉ scan_id
  > start_time
  ◉ uid
  > user
  > variables

```

Scalar

```

from CAMELS.bluesky_handling.evaluation_helper import Evaluator
from CAMELS.bluesky_handling import helper_functions
darkmode = False
theme = "default"
protocol_step_information = {"protocol_step_counter": 0, "total_protocol_steps": 0, "protocol stepper signal": None}

namespace = {}
all_fits = {}
plots = []
boxes = {}
points = 11
namespace["points"] = points
v_max = 10
namespace["v_max"] = v_max
v_min = -10
namespace["v_min"] = v_min

from camels_driver Keysight_E5270B.Keysight_E5270B_Ophyd import Keysight_E5270B

def create_plots_Simple_Sweep_1(RE, stream="primary"):
    app = QCoreApplication.instance()
    if app is None:
        app = QApplication(sys.argv)
    if darkmode:
        plot_widget.activate_dark_mode()
    subs = []
    fits = []
    fits.append({'do_fit': True, 'predef_func': 'Linear', 'custom_func': '', 'use_custom_func': False, 'guess_params': True})
    plot_0 = plot_widget.PlotWidget(x_name="SMU_mesV1", y_names=['SMU_mes1'], ylabel="current (I)", xlabel="volt")
    plots.append(plot_0)
    plot_0.show()
    subs.append(RE.subscribe(plot_0.livePlot))
    for fit in plot_0.liveFits:
        all_fits[fit.name] = fit
    return plots, subs, app

def IV_Ch1_plan_inner(devs, runEngine=None, stream_name="primary"):
    global points, v_max, v_min

```

VS.

spec_fabry.txt

```

1 # Exposure Time: 0.500000
2 # Center Wavelength: 800.000000
3 # Grating: 149.849991 1, 800.000000 nm
4 # Input Slit Width: 1000.000000
5 628.656067 448.000000
6 630.008057 489.000000
7 631.359900 481.000000
8 632.711800 493.000000

```



Tutorial – From an idea to FAIR data

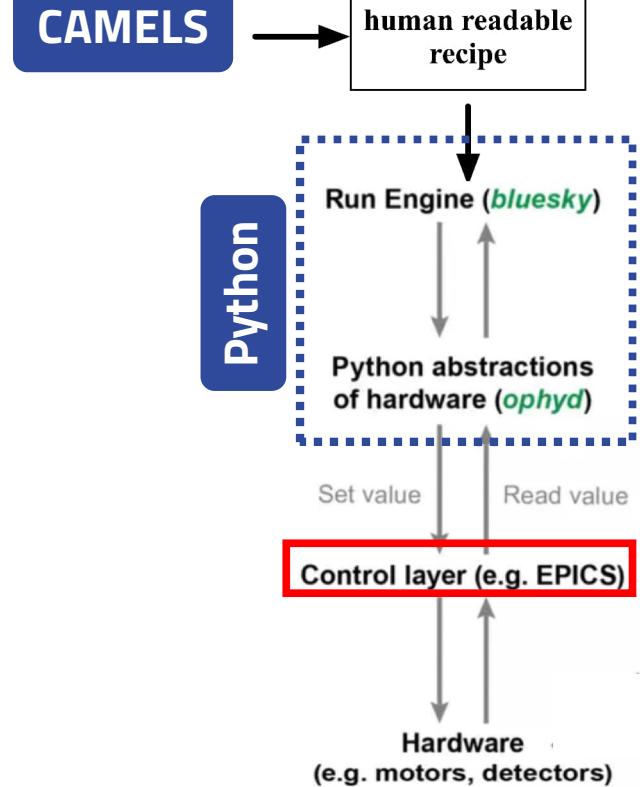
- https://www.youtube.com/playlist?list=PLrRaxjvn6FDU3HeV6byx_kUIU6UXkfhl
- <https://www.fair-di.eu/events/fairmat-tutorial-6/tutorial-6-home>



EPICS - basics

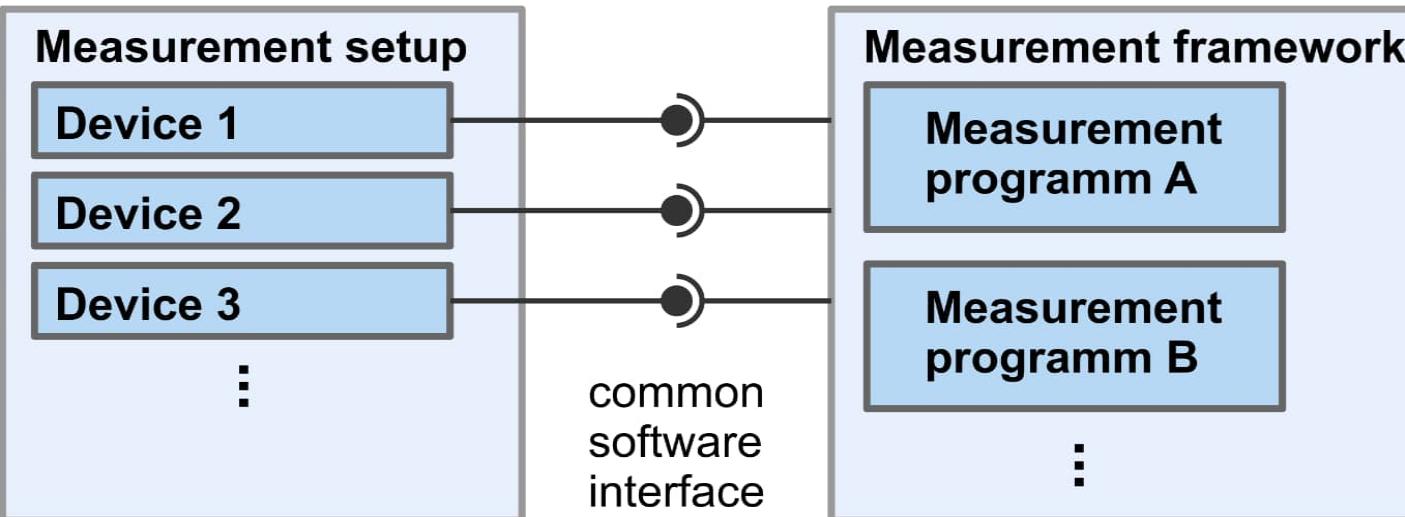
EPICS

- Collection of software tools for distributed control systems
- Runtime database
- Robust network protocols Client/Server & Publish/Subscribe
- Collection of device drivers
- Client tools for operator control and monitoring
- Includes data archiving
- OS and platform independent, open source
- Scalable (local instance ... large network infrastructure)



Typical measurement setup

| Measurement setup | | | |
|---|---|---|-----|
| Device | SMU | Lock-In amplifier | ... |
| Input channels: <ul style="list-style-type: none">• Channel A• Channel B | Input channels: <ul style="list-style-type: none">• Current | Input channels: <ul style="list-style-type: none">• X• Y | |
| Output channels: <ul style="list-style-type: none">• Channel C• Channel D | Output channels: <ul style="list-style-type: none">• Voltage | Output channels: <ul style="list-style-type: none">• Osc. Voltage• Osc. Frequency | |





FAIRmat



CAMELS

A Configurable Instrument Control Software for FAIR Data

Alexander Fuchs^{1,2}, Johannes Lehmeyer^{1,2},
Michael Krieger^{1,2}, Heiko B. Weber^{1,2},
Patrick Oppermann^{1,3}, and Heinz Junkes^{1,3}

1 HU Berlin, FAIRmat

2 Lehrstuhl für Angewandte Physik, Friedrich-Alexander-Universität Erlangen

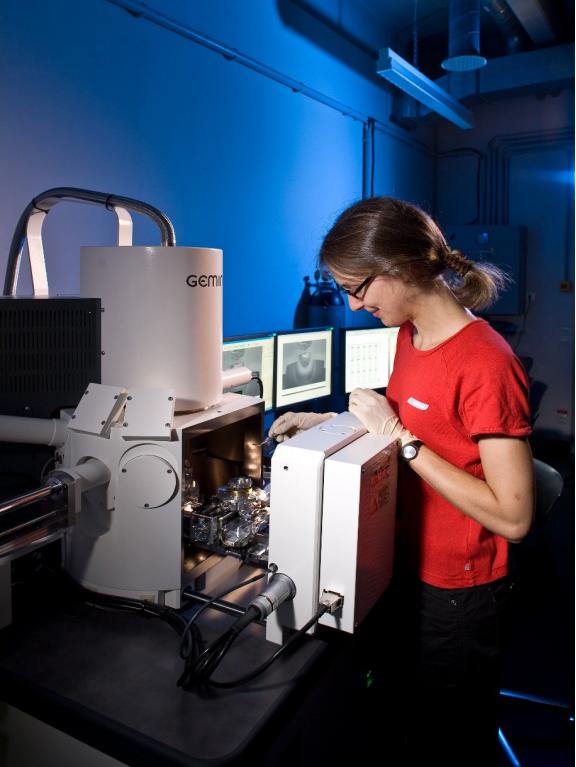
3 Fritz-Haber-Institut der Max-Planck-Gesellschaft

Introduction:

Two kinds of Experiments

Two kinds of Experiments

Commercial integrated systems

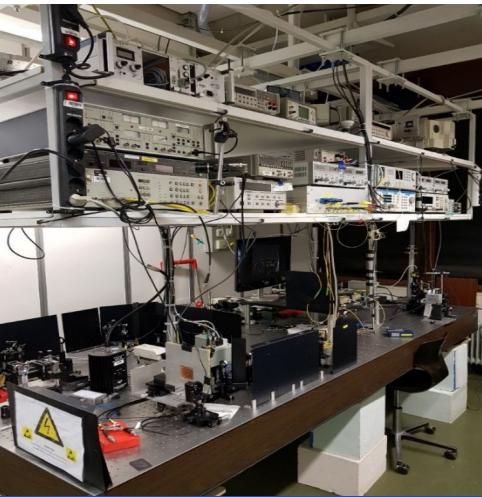


**Vendor-provided
measurement software
→ standard data**

Specialized custom



**No standard control
→ No standard data**



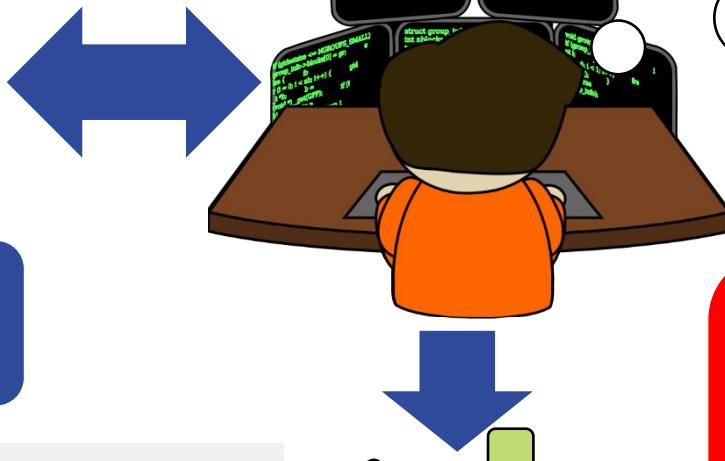
Specialized ad-hoc experimental setup

```
TestLaser.txt
1 <ThorCam:AcquireMean> <ThorCam:LastMean> <ThorCam:LastSum> <ThorCam:AcquireSum> <K2400:Voltage>
2 NaN 2.214771E+4 NaN NaN 0.000000E+0 3.671010E+9 8.999443E-1 3.671010E+9 0.000000E+0 0.000000E+0
3 NaN 2.274620E+4 NaN NaN 1.500000E+0 3.671010E+9 1.452614E+0 3.671010E+9 1.000000E+0 1.500000E+0

spec_fabry.txt
1 # Exposure Time: 0.500000
2 # Center Wavelength: 800.000000
3 # Grating: 149.849991 1, 800.000000 nm
4 # Input Slit Width: 1000.000000
5 628.656067 448.000000
6 630.008057 489.000000
7 631.359900 481.000000
8 632.711800 493.000000
```

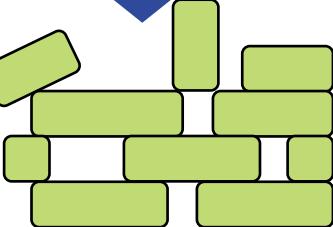
| Name |
|--------------------------------|
| Backgrounds |
| temp |
| Matrix_Scan.txt |
| Matrix_Scan_ConfigMeta.xml |
| spectrum_X1230660_Y-740076.txt |
| spectrum_X1230660_Y-740436.txt |
| spectrum_X1230660_Y-740795.txt |
| spectrum_X1230660_Y-741155.txt |
| spectrum_X1230660_Y-741514.txt |
| spectrum_X1230660_Y-741874.txt |

Coding some piece of measurement software



New measurement protocol

- Programming skills required
- Redundant software development
- High hurdle for implementation of new measurement protocols



Raw data,
no or (little) metadata,
heterogeneous data format

not FAIR



New approach

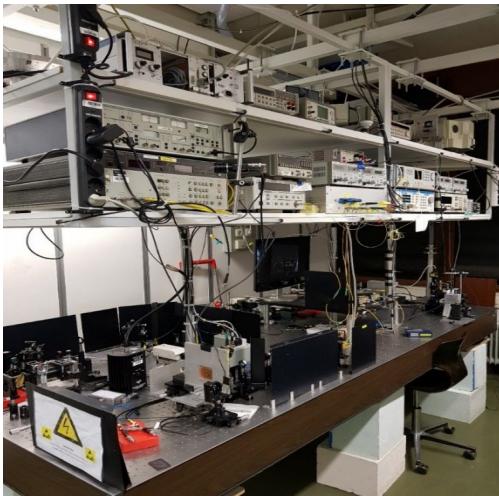
Open software framework for measurement protocol configuration:



Control Application for Measurements, Experiments and Laboratory Sys

Concept:

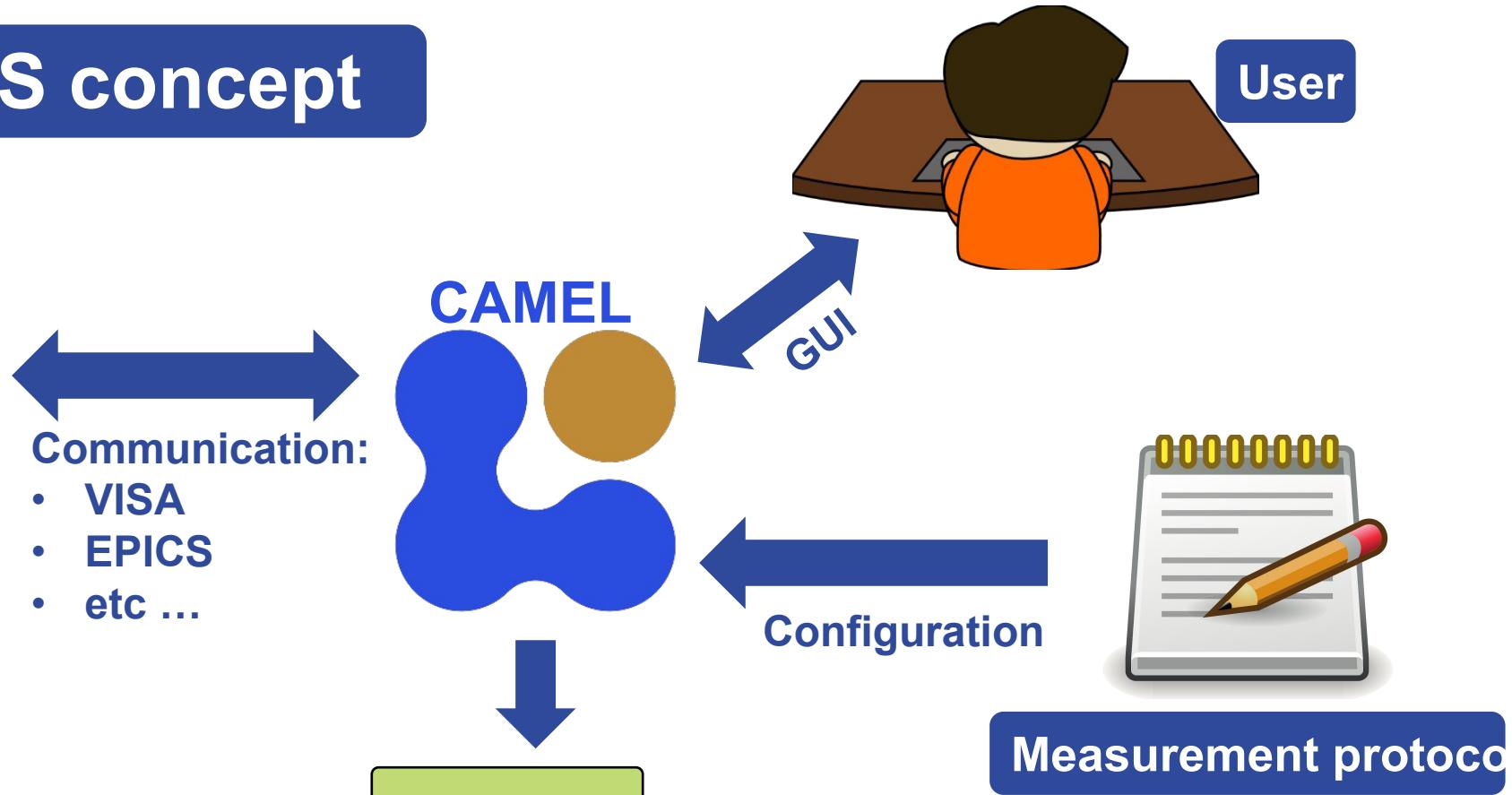
From Planning to Data Collection



Experimental setup

- **Fast configuration of measurement protocol**
- **No programming skills required**

CAMELS concept



*More precisely FAIR-ready data when not connected to community standards

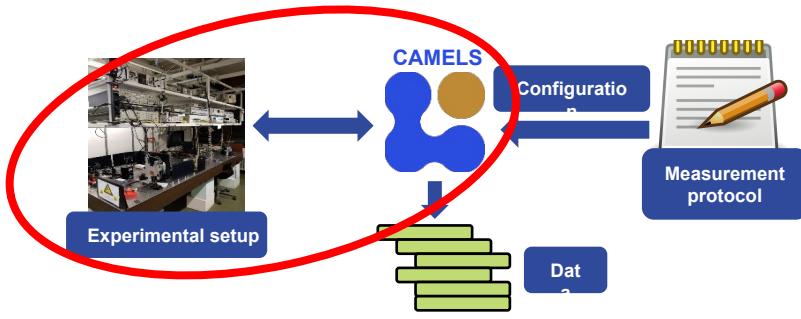
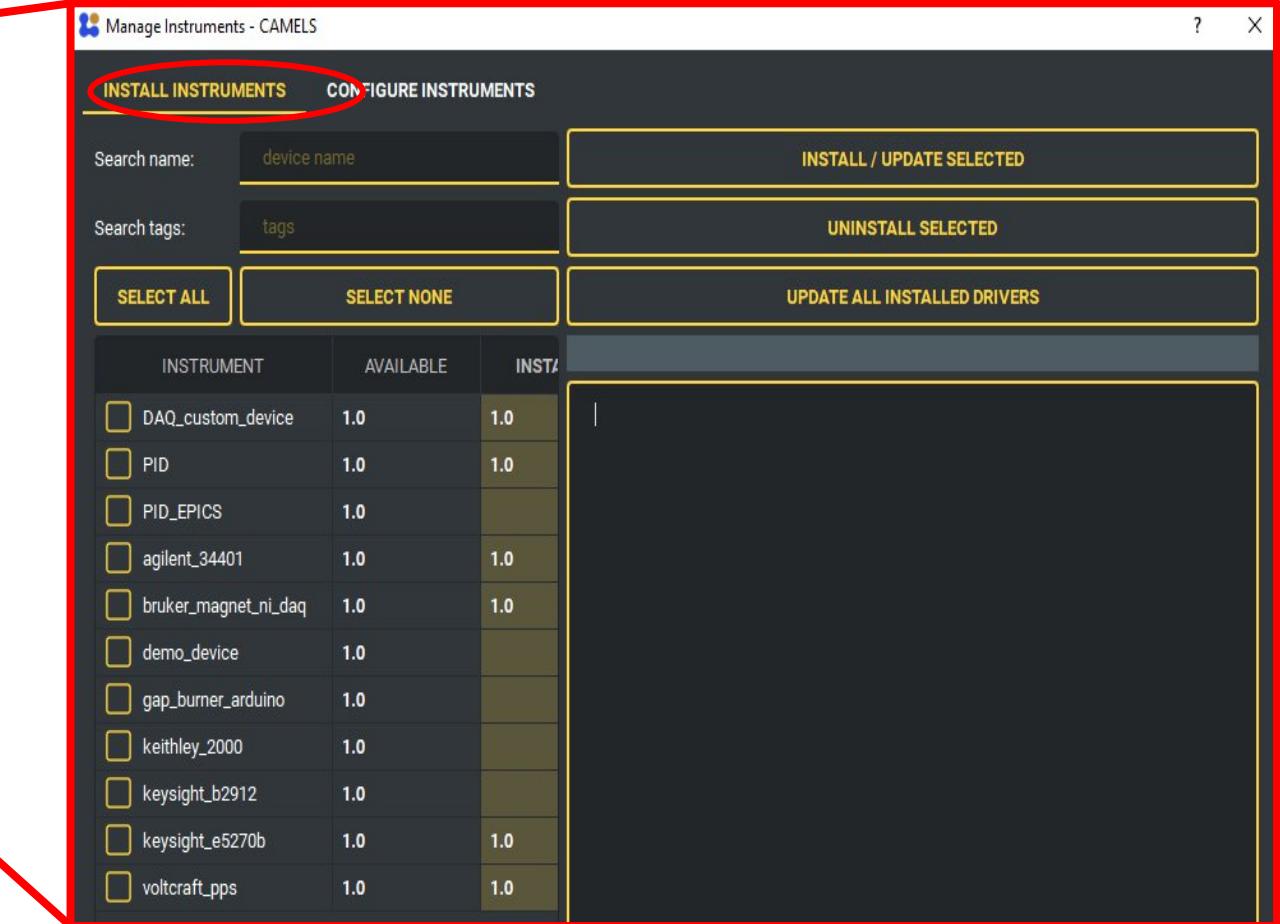
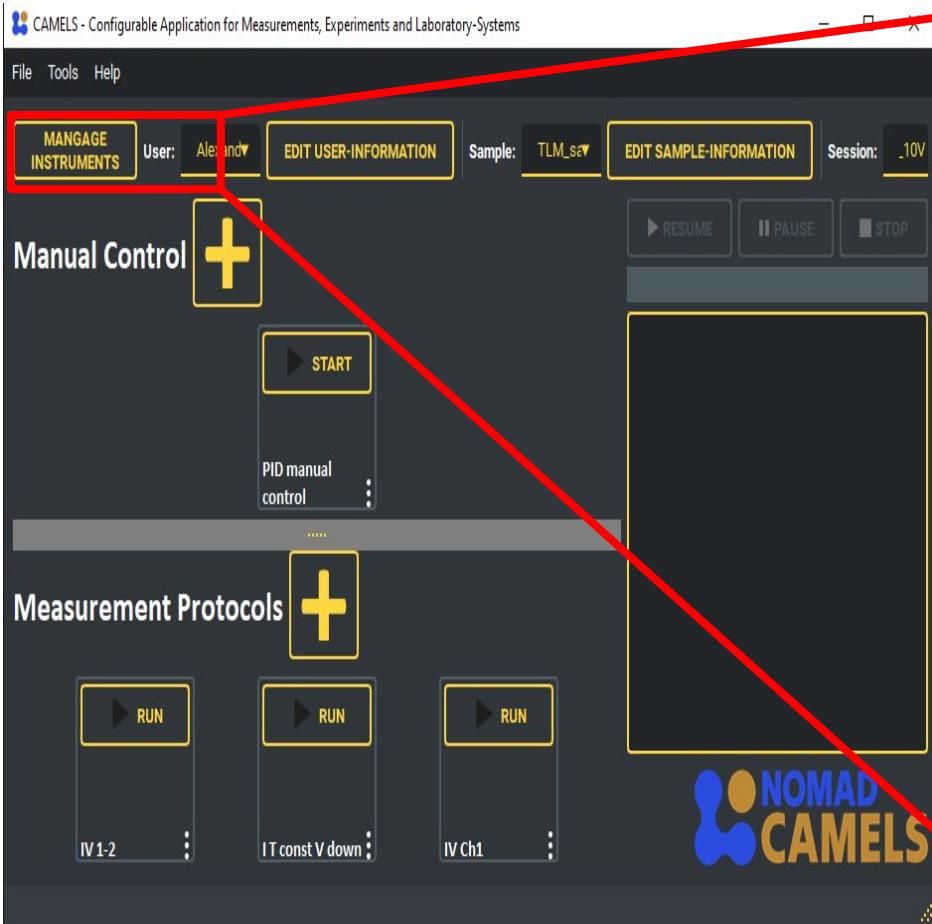
Features

Features:
Currently Implemented

- **Open source** (hosted on GitHub)
- Ready to start first measurement in < 30 minutes
- **GUI generates Python** (Bluesky) code → customizable
 - Complete recording of **metadata**
- **Scalable**
 - Local device communication (VISA)
 - Large-scale distributed control systems (EPICS)

Basics:

Installing New Instruments



Basics:

Installing New Instruments

The diagram illustrates the integration of the CAMELS software with experimental hardware. At the top, a photograph of a laboratory bench with various instruments is connected via a double-headed blue arrow to the CAMELS logo. Below this, a screenshot of the CAMELS software interface shows a main window titled "CAMELS - Configurable Application for Measurements, Experiments and Laboratory-Systems". The interface includes tabs for "MANAGE INSTRUMENTS", "User: Alexander", "EDIT USER- INFORMATION", "Sample: TLM.sav", "EDIT SAMPLE- INFORMATION", "Session: 10V", "RESUME", "PAUSE", and "STOP". It also features sections for "Manual Control" (with a "START" button and "PID manual control" sub-section) and "Measurement Protocols" (with three "RUN" buttons labeled "IV1-2", "IT const V down:", and "IV Ch1"). A large red arrow originates from the "MANAGE INSTRUMENTS" button and points to a detailed configuration dialog window titled "Manage Instruments - CAMELS". This dialog has a red border and contains several tabs: "INSTALL INSTRUMENTS" (selected), "CONFIGURE INSTRUMENTS" (highlighted with a yellow oval and a red circle), "SEARCH", and "Configure: keysight_e5270b". The "INSTRUMENT" list includes entries like DAQ_custom_device, PID, agilent_34401, bruker_magnet_ni_daq, **keysight_e5270b** (highlighted with a yellow oval), and voltcraft_pps. The "CONFIGURE INSTRUMENTS" tab displays configuration details for the Keysight E5270B, including "Custom name: SMU", "Enter your description here.", "Connection-type: Local VISA", "Resource-Name: GPIB0::17::INSTR", "Baud-Rate: 9600", "In-Terminator: \r\n", "Out-Terminator: \r\n", "High Speed ADC Mode: PLC Mode", "PLC: 5", "High Resolution ADC Mode: PLC Mode", "PLC: 5", and channel settings for CHANNEL 1 through CHANNEL 6. The "CHANNEL 1" section includes "Channel active", "Output Filter", "Voltage Source Current Compliance: 1.000e-03", "Voltage Range: Auto Range", "Current Measurement Range: 1 nA auto lim", and "Current Source Voltage Compliance: 0.000", "Voltage Range: Auto Range", "Voltage Measurement Range: Auto Range". Buttons for "OK" and "CANCEL" are at the bottom right of the dialog.



Basics:

Measurement Protocols

The diagram illustrates the CAMELS measurement protocol configuration process across three main components:

- CAMEL:** Represented by a blue stylized human icon.
- Measurement protocol:** Represented by a notepad icon.
- CAMELS Application Interface:** The central application window.

The flow of the configuration process is as follows:

- The user starts in the **CAMELS** application interface.
- The user selects the **Measurement Protocols** section.
- The user clicks the **+** button to create a new measurement protocol.
- The user is prompted to **configur** the protocol.
- The user enters the **Measurement protocol** configuration dialog.
- The user defines the **Sequence** of steps.
- The user defines the **Possible steps** available in the sequence.
- The user defines the **Plot overview**.
- The user defines the **Variables**.
- The user saves the protocol.

Sequence Tab (Visible in the detailed configuration window):

- MOVE UP
- MOVE IN
- MOVE DOWN
- MOVE OUT

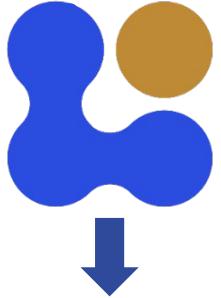
Possible steps (Listed in the detailed configuration window):

- Change Device Config
- For Loop
- Gradient Descent
- Cut
- Copy
- Paste
- Delete Step
- If
- ND Sweep
- Prompt
- Read Channels
- Run Subprotocol
- Set Channels
- Set Value Popup
- Set Variables
- Simple Sweep
- Trigger Channels
- Wait
- While Loop
- PID wait for stable

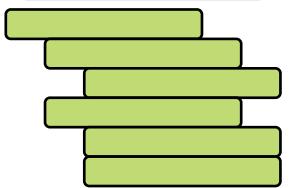
CAMELs:

Final Data File

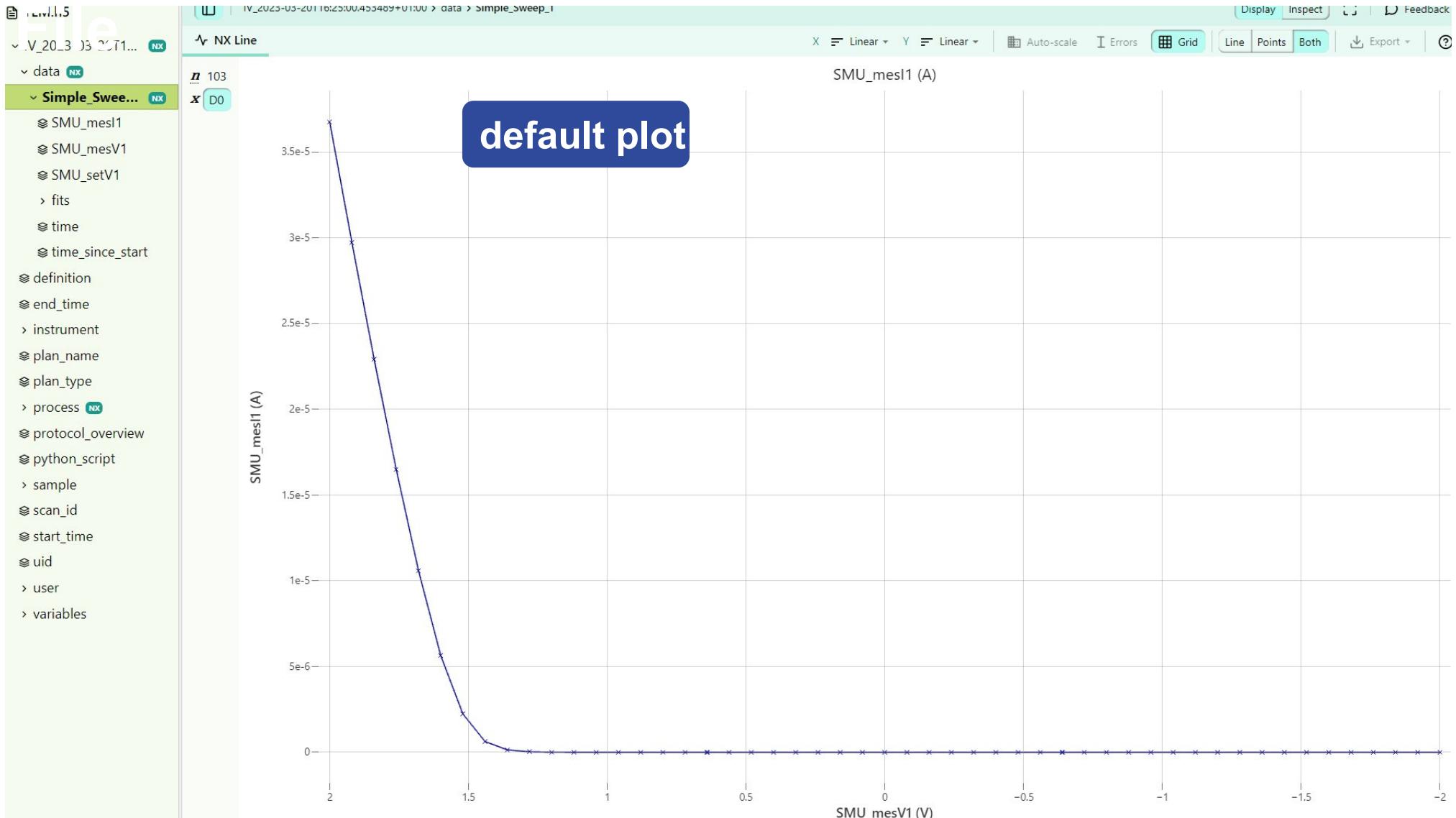
CAMEL



HDF5 file



CAMELS: Data



CAMELS: Data

Meta data

„Classical“ dat

| TLM.h5 | |
|--------------------|----|
| IV_2023-03-20T1... | NX |
| data NX | |
| Simple_Sweep_1 NX | |
| SMU_mes1 | |
| SMU_mesV1 | |
| SMU_setV1 | |
| fits | |
| time | |
| time_since_start | |
| definition | |
| end_time | |
| instrument | |
| plan_name | |
| plan_type | |
| process NX | |
| protocol_overview | |
| python_script | |
| sample | |
| scan_id | |
| start_time | |
| uid | |
| user | |
| variables | |

| IV_2023-03-20T16:25:00.453489 | |
|-------------------------------|-------------|
| Matrix | Line |
| n 103 | 0 |
| x D0 | 0 2.600e-4 |
| | 1 8.025e-2 |
| | 2 1.602e-1 |
| | 3 2.403e-1 |
| | 4 3.203e-1 |
| | 5 4.003e-1 |
| | 6 4.803e-1 |
| | 7 5.602e-1 |
| | 8 6.402e-1 |
| | 9 7.202e-1 |
| | 10 8.002e-1 |
| | 11 8.802e-1 |
| | 12 9.602e-1 |
| | 13 1.040e+0 |
| | 14 1.120e+0 |
| | 15 1.200e+0 |
| | 16 1.280e+0 |
| | 17 1.360e+0 |
| | 18 1.440e+0 |
| | 19 1.520e+0 |
| | 20 1.600e+0 |
| | 21 1.680e+0 |
| | 22 1.760e+0 |

| TLM.h5 | |
|--------------------|----|
| IV_2023-03-20T1... | NX |
| data NX | |
| Simple_Sweep_1 NX | |
| SMU_mes1 | |
| SMU_mesV1 | |
| SMU_setV1 | |
| fits | |
| time | |
| time_since_start | |
| definition | |
| end_time | |
| instrument | |
| plan_name | |
| plan_type | |
| process NX | |
| protocol_overview | |
| python_script | |
| sample | |
| scan_id | |
| start_time | |
| uid | |
| user | |
| variables | |

| IV_2023-03-20T16:25:00.453489 | |
|-------------------------------|---------------|
| Matrix | Line |
| n 103 | 0 |
| x D0 | 0 -2.466e-10 |
| | 1 -1.925e-10 |
| | 2 -3.009e-10 |
| | 3 -1.774e-10 |
| | 4 -2.554e-10 |
| | 5 -1.700e-10 |
| | 6 -2.345e-10 |
| | 7 -2.945e-10 |
| | 8 -2.104e-10 |
| | 9 -2.190e-10 |
| | 10 -2.475e-10 |
| | 11 -1.677e-10 |
| | 12 -1.762e-10 |
| | 13 8.542e-11 |
| | 14 1.128e-9 |
| | 15 6.062e-9 |
| | 16 2.993e-8 |
| | 17 1.423e-7 |
| | 18 6.270e-7 |
| | 19 2.237e-6 |
| | 20 5.649e-6 |
| | 21 1.059e-5 |
| | 22 1.647e-5 |

| TLM.h5 | |
|--------------------------|--|
| IV_2023-03-20T1... | |
| data NX | |
| definition | |
| end_time | |
| instrument | |
| plan_name | |
| plan_type | |
| process NX | |
| protocol_overview | |
| python_script | |
| sample | |
| scan_id | |
| start_time | |
| uid | |
| user | |
| variables | |

| |
|-----------------|
| instrument |
| environment |
| SMU |
| model |
| name |
| settings |
| SMU_measRange1 |
| SMU_measRange2 |
| SMU_measRange3 |
| SMU_measRange4 |
| SMU_lowRange1 |
| SMU_lowRange2 |
| SMU_lowRange3 |
| SMU_lowRange4 |
| SMU_VmeasRange1 |
| SMU_VmeasRange2 |
| SMU_VmeasRange3 |
| SMU_VmeasRange4 |
| SMU_VoutRange1 |
| SMU_VoutRange2 |
| SMU_VoutRange3 |
| SMU_VoutRange4 |
| SMU_lowComp1 |
| SMU_lowComp2 |
| SMU_lowComp3 |
| SMU_lowComp4 |
| SMU_idn |
| SMU_measMode1 |
| SMU_measMode2 |
| SMU_measMode3 |
| SMU_measMode4 |

| |
|--|
| IV_2023-03-20T16:25:00.453489 |
| Scalar |
| Agilent Technologies, E5270B, 0, 8, 81, 08 |
| high_Temp_2023-03-17T14:51:17Z4614100 |



CAMELS: Final Data File



The screenshot shows the TLM.h5 file structure. The protocol_overview node is highlighted with a red box. A red arrow points from the 'python_script' entry under protocol_overview to the code block below.

```
<> Scalar

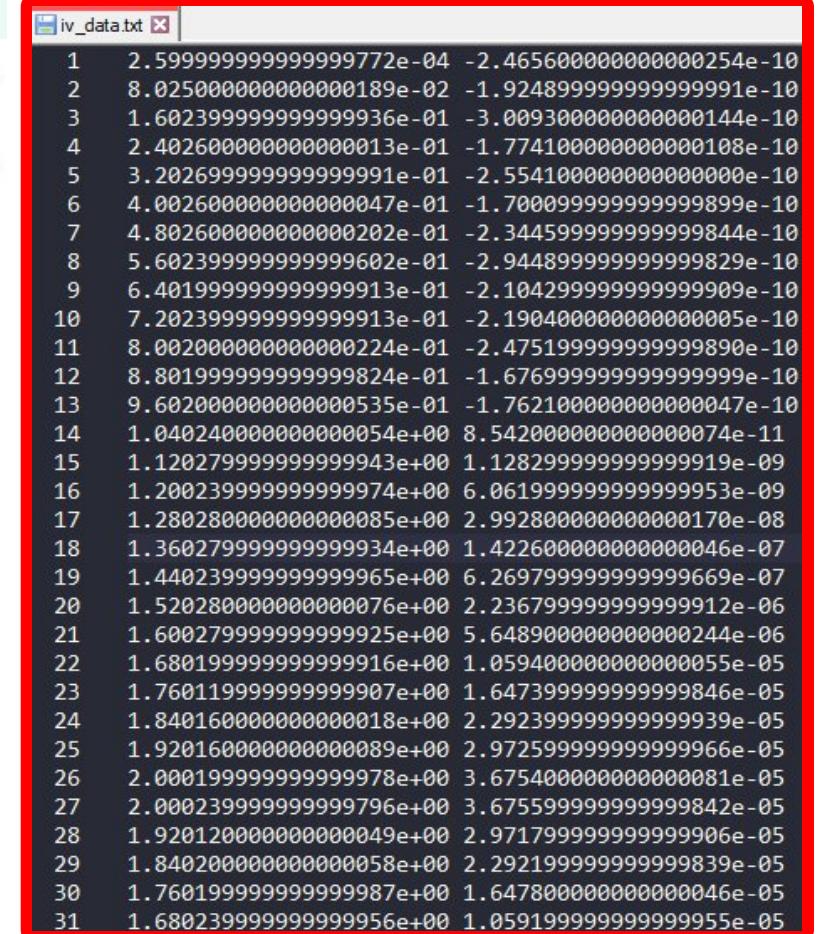
Set Channels - {'Channels': ['SMU_enable1', 'SMU_setV1'], 'Values': ['1', '0']}
Simple Sweep
Sweep: SMU_setV1, Read: ['SMU_mesI1', 'SMU_mesV1', 'SMU_setV1']
Set Channels - {'Channels': ['SMU_enable1', 'SMU_setV1'], 'Values': ['0', '0']}

from camels_driver.Keysight_E5270B.Keysight_E5270B_ophyd import Keysight_E5270B

def create_plots_Simple_Sweep_1(RE, stream="primary"):
    app = QCoreApplication.instance()
    if app is None:
        app = QApplication(sys.argv)
    if darkmode:
        plot_widget.activate_dark_mode()
    subs = []
    fits = []
    fits.append({'do_fit': True, 'predef_func': 'Linear', 'custom_func': '', 'use_custom_func': False, 'guess_params': True, 'name': 'IV'})
    plot_0 = plot_widget.PlotWidget(x_name="SMU_mesV1", y_names=['SMU_mesI1'], ylabel="current (I)", xlabel="voltage (V)", title="IV")
    plots.append(plot_0)
    plot_0.show()
    subs.append(RE.subscribe(plot_0.livePlot))
    for fit in plot_0.liveFits:
        all_fits[fit.name] = fit
    return plots, subs, app

def IV_Ch1_plan_inner(devs, runEngine=None, stream_name="primary"):
    global points, v_max, v_min
    eva = Evaluator(namespace=namespace)
    runEngine.subscribe(eva)
```

vs. „old“



The screenshot shows a text file named iv_data.txt. The file contains 31 lines of floating-point numbers, each consisting of four values separated by spaces. The first few lines are:

| Line | Value 1 | Value 2 | Value 3 | Value 4 |
|------|--------------------------|--------------------------|---------|---------|
| 1 | 2.5999999999999972e-04 | -2.46560000000000254e-10 | | |
| 2 | 8.02500000000000189e-02 | -1.924899999999991e-10 | | |
| 3 | 1.6023999999999936e-01 | -3.00930000000000144e-10 | | |
| 4 | 2.40260000000000013e-01 | -1.77410000000000108e-10 | | |
| 5 | 3.2026999999999991e-01 | -2.5541000000000000e-10 | | |
| 6 | 4.0026000000000047e-01 | -1.70099999999999899e-10 | | |
| 7 | 4.80260000000000202e-01 | -2.34459999999999844e-10 | | |
| 8 | 5.60239999999999602e-01 | -2.94489999999999829e-10 | | |
| 9 | 6.40199999999999913e-01 | -2.10429999999999909e-10 | | |
| 10 | 7.20239999999999913e-01 | -2.19040000000000005e-10 | | |
| 11 | 8.00200000000000224e-01 | -2.47519999999999890e-10 | | |
| 12 | 8.80199999999999824e-01 | -1.6769999999999999e-10 | | |
| 13 | 9.60200000000000535e-01 | -1.76210000000000047e-10 | | |
| 14 | 1.04024000000000054e+00 | 8.5420000000000074e-11 | | |
| 15 | 1.12027999999999943e+00 | 1.12829999999999919e-09 | | |
| 16 | 1.20023999999999974e+00 | 6.0619999999999953e-09 | | |
| 17 | 1.28028000000000085e+00 | 2.99280000000000170e-08 | | |
| 18 | 1.36027999999999934e+00 | 1.4226000000000046e-07 | | |
| 19 | 1.44023999999999965e+00 | 6.26979999999999669e-07 | | |
| 20 | 1.52028000000000076e+00 | 2.23679999999999912e-06 | | |
| 21 | 1.60027999999999925e+00 | 5.64890000000000244e-06 | | |
| 22 | 1.68019999999999916e+00 | 1.05940000000000055e-05 | | |
| 23 | 1.760119999999999907e+00 | 1.64739999999999846e-05 | | |
| 24 | 1.84016000000000018e+00 | 2.29239999999999939e-05 | | |
| 25 | 1.92016000000000089e+00 | 2.97259999999999966e-05 | | |
| 26 | 2.00019999999999978e+00 | 3.67540000000000081e-05 | | |
| 27 | 2.000239999999999796e+00 | 3.67559999999999842e-05 | | |
| 28 | 1.92012000000000049e+00 | 2.97179999999999906e-05 | | |
| 29 | 1.84020000000000058e+00 | 2.29219999999999839e-05 | | |
| 30 | 1.76019999999999987e+00 | 1.64780000000000046e-05 | | |
| 31 | 1.68023999999999956e+00 | 1.05919999999999955e-05 | | |

Why CAMELS?

Easy to use

- Low threshold entry to device communication
- Save time communicating with devices

FAIR data

- Standardized data formats
- Rich metadata

Open source & Community driven

- Drivers written by & for the community

Customizable

- Setup consisting of several measurement instruments
- Dynamic changes of the measurement setup
- Multiple use-cases for a single setup



FAIRmat

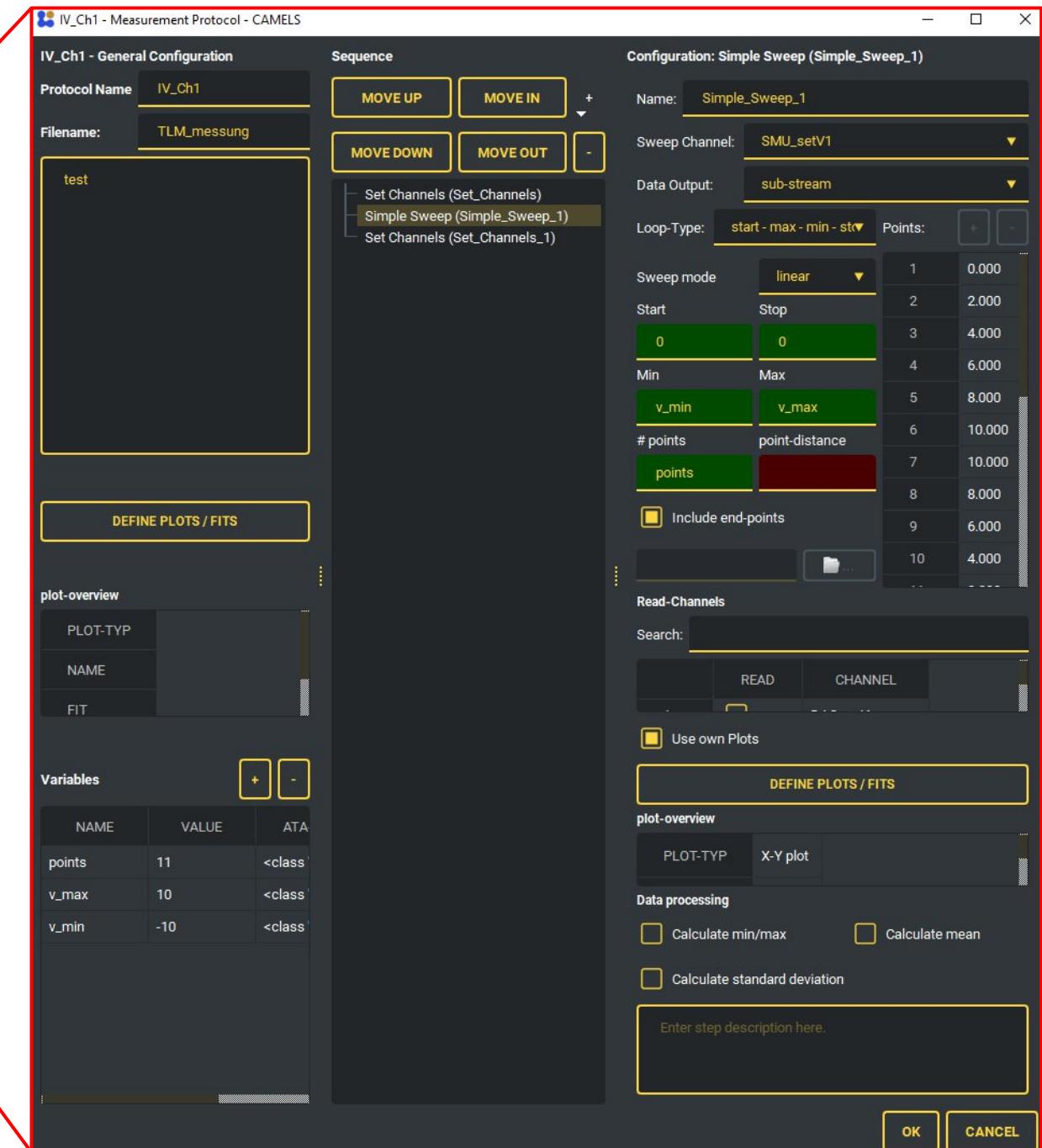
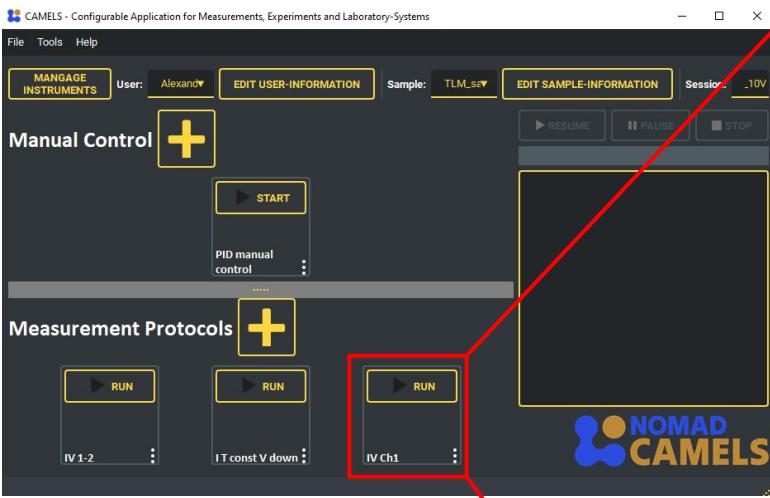


Thank you for your
kind attention!

Basics:

Measurement protocols/recipes

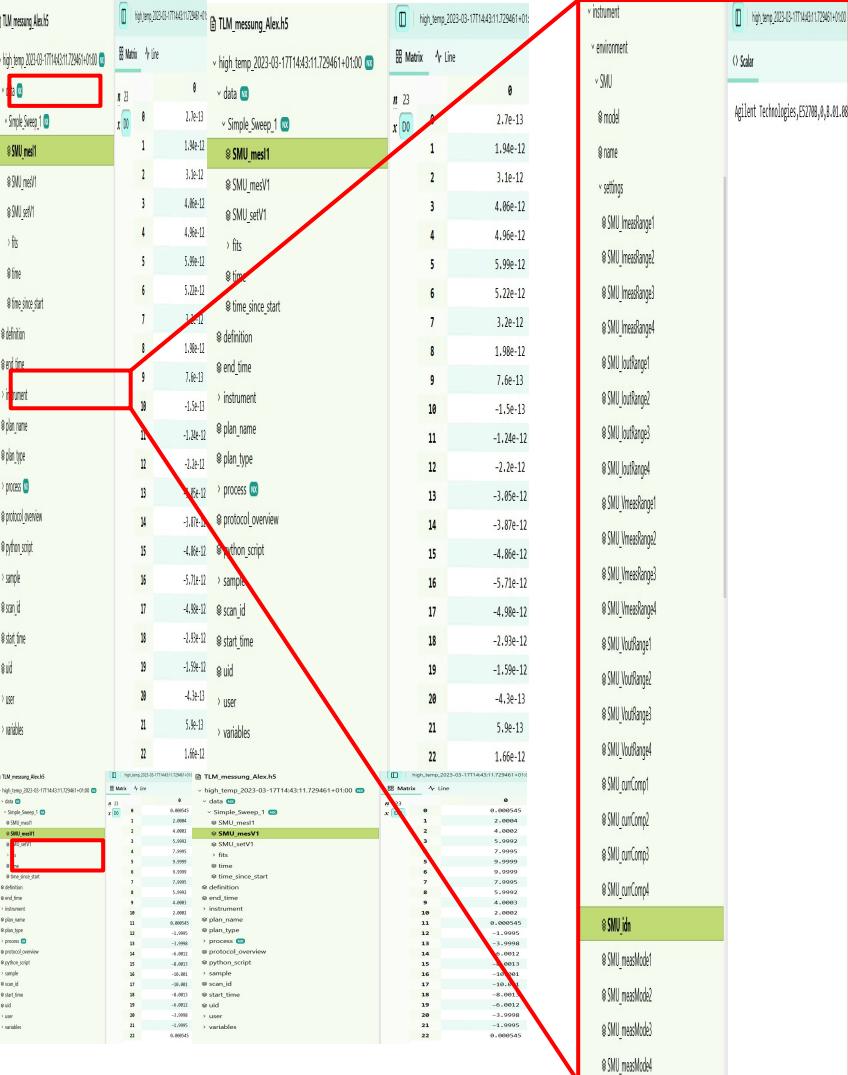
CAMELS basics



CAMELS basics

Basics:

Final data file



```
high_temp_2023-03-17T14:43:11.729461+01:00.h5

Scalar
  data
    Simple Sweep 1
      SMU_mesI1
      SMU_mesV1
      SMU_setV1
      fits
      time
      time_since_start
      definition
      end_time
      instrument
      plan_name
      plan_type
      process
      protocol_overview
      python_script
      sample
      scan_id
      start_time
      uid
      user
      variables

  Matrix
```

high_temp_2023-03-17T14:43:11.729461+01:00.h5

Scalar

```
from CAMELS.bluesky_handling.evaluation_helper import Evaluator
from CAMELS.bluesky_handling import helper_functions
darkmode = False
theme = "default"
protocol_step_information = {"protocol_step_counter": 0, "total_protocol_steps": 0, "protocol stepper signal": None}

namespace = {}
all_fits = {}
plots = []
boxes = {}
points = 11
namespace["points"] = points
v_max = 10
namespace["v_max"] = v_max
v_min = -10
namespace["v_min"] = v_min

from camels_driver_keysight_e5270b.keysight_e5270b_ophyd import Keysight_E5270B

def create_plots_Simple_Sweep_1(RE, stream="primary"):
    app = QCoreApplication.instance()
    if app is None:
        app = QApplication(sys.argv)
    if darkmode:
        plot_widget.activate_dark_mode()
    subs = []
    fits = []
    fits.append({'do_fit': True, 'predef_func': 'Linear', 'custom_func': '', 'use_custom_func': False, 'guess_params': True, 'name': ''})
    plot_0 = plot_widget.PlotWidget(x_name="SMU_mesV1", y_names=['SMU_mesI1'], ylabel="current (I)", xlabel="voltage (V)", title="IV 1",
                                    plots.append(plot_0)
    plot_0.show()
    subs.append(RE.subscribe(plot_0.livePlot))
    for fit in plot_0.liveFits:
        all_fits[fit.name] = fit
    return plots, subs, app

def IV_Ch1_plan_inner(devs, runEngine=None, stream_name="primary"):
    global points, v_max, v_min
```

VS.

spec_fabry.txt

```
1 # Exposure Time: 0.500000
2 # Center Wavelength: 800.000000
3 # Grating: 149.849991 1, 800.000000 nm
4 # Input Slit Width: 1000.000000
5 628.656067 448.000000
6 630.008057 489.000000
7 631.359900 481.000000
8 632.711800 493.000000
```



Tutorial – From an idea to FAIR data

Tutorial: Task D5

- https://www.youtube.com/playlist?list=PLrRaxjvn6FDU3HeV6byx_kUIU6UXkfhil
- <https://www.fair-di.eu/events/fairmat-tutorial-6/tutorial-6-home>

EPICS - basics

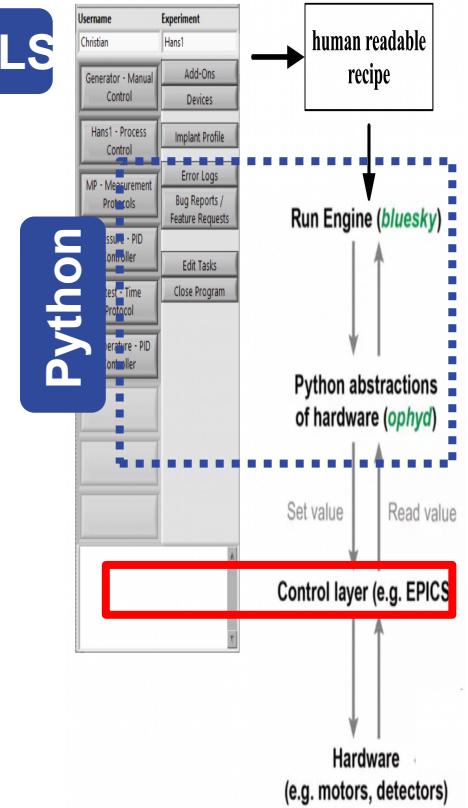
EPICS

- Collection of software tools for distributed control systems
- Runtime database
- Robust network protocols Client/Server & Publish/Subscribe
- Collection of device drivers
- Client tools for operator control and monitoring
- Includes data archiving
- OS and platform independent source
- Scalable (local) network infrastructure



EPICS

CAMELS



Task D5

Typical measurement setup

