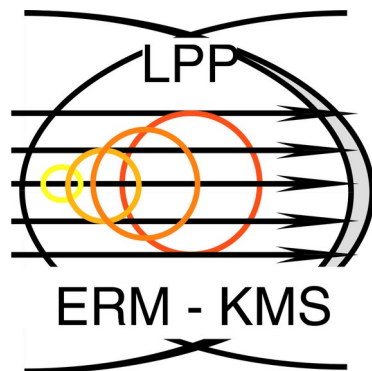


A signal viewer for Wendelstein7-X



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December 11th 2023

W7-X Christmas wishlist



- A monitor for easy access to meaningful signals

User interface with intuitive lay-out

User does not have to write code

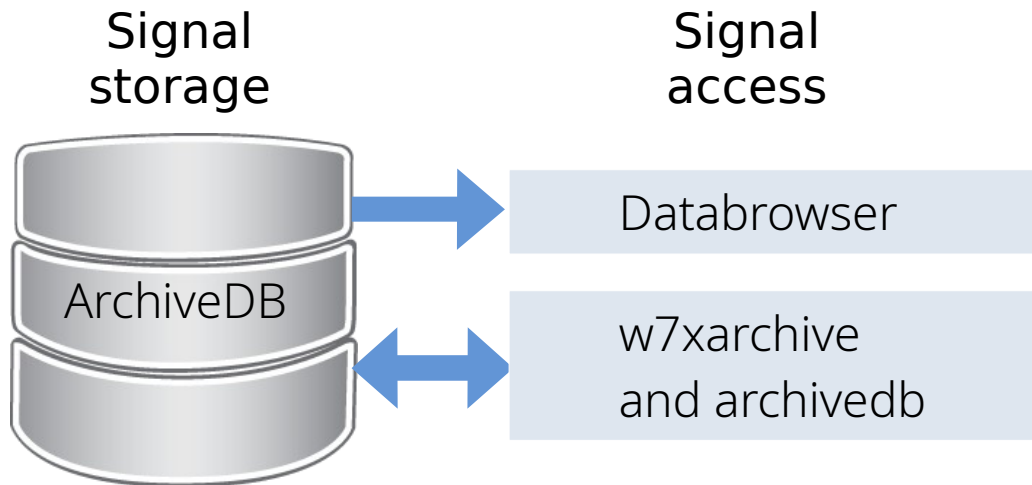
User-handles:
upload to logbook,
compare shots,
basic analysis,...

Signals are calibrated and have a unit and legend

Higher order signals are determined

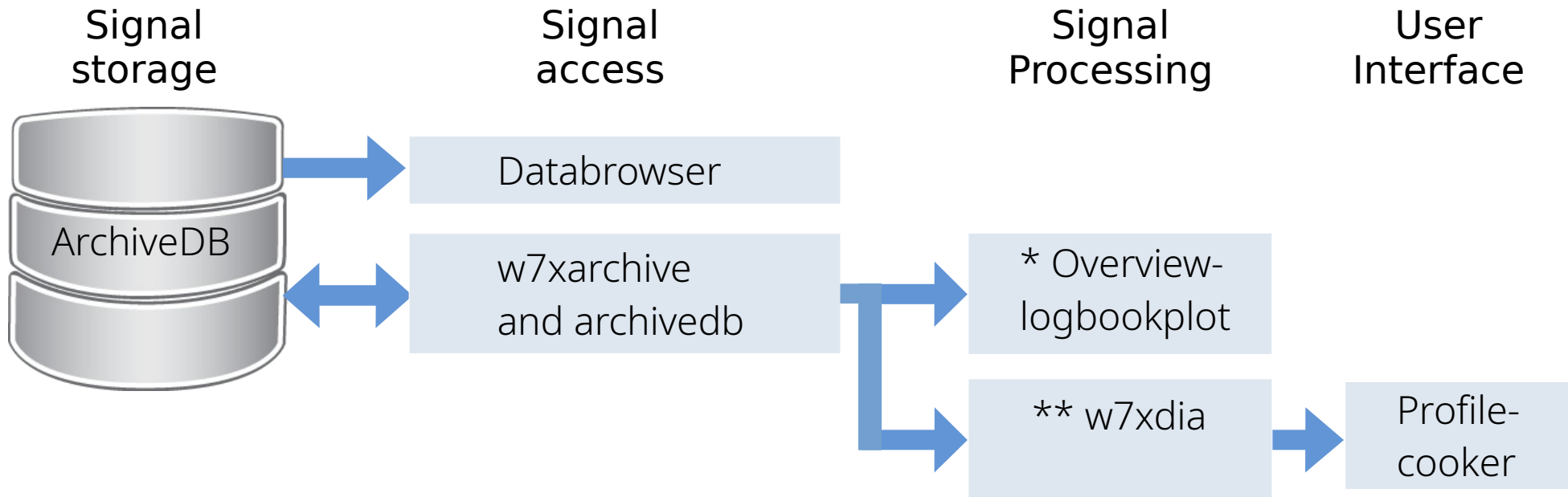
Add your own signals

Current situation



- In general, signals are not calibrated and units & legends are not clear. Interpretation of signals is prone to errors
- Information about signals is sometimes provided in component logbook, or has to be inquired from RO

Current situation



*

- Great plots in logbook
- No UI, output is fixed
- Signal information spread

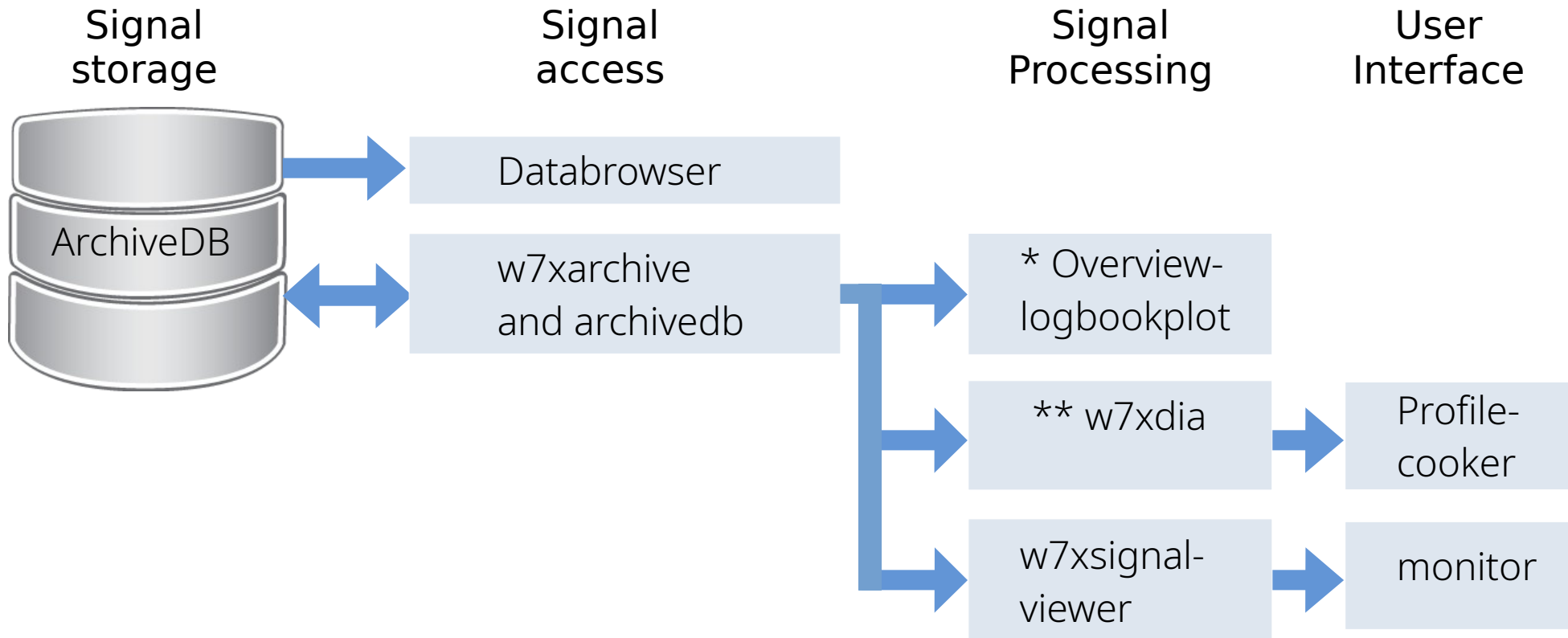
**

- Regarding profiles

=> We miss a signal viewer

- Signal processing centralised
- Convenient user interface

w7xsignalviewer



*

- Great plots in logbook
- No UI, output is fixed
- Signal information spread

**

- Regarding profiles

=> We miss a signal viewer

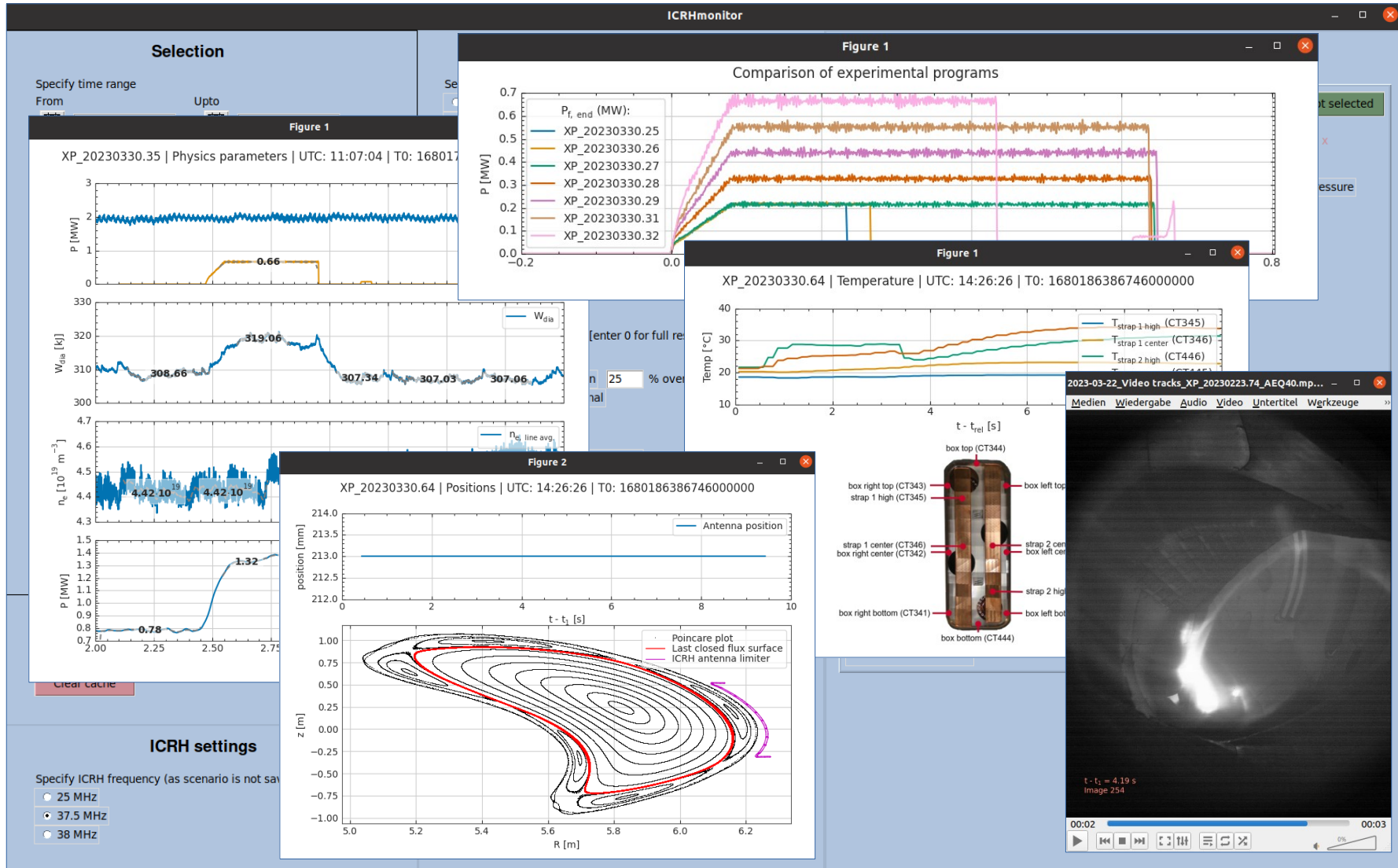
- Signal processing centralised
- Convenient user interface

w7xsignalviewer

The screenshot displays the ICRHmonitor application interface, which is divided into several functional panels:

- Selection:** Allows users to specify a time range (From: 2023-03-30 00:00:00, Upto: 2023-03-30 23:59:59) and lists experimental programs (XP) in that range. The selected program is XP_20230330.40 (XP).
- Output settings:** Configures how data is processed, including setting time (absolute, relative to t1, automatic, fixed times, or fixed triggers), scale y axis (linear or logarithmic), resolution (100 data intervals), and output handling (show output, save figures as PDF/PNG, save videos as MP4, upload plots, store time trace data).
- Plot presets:** A tabbed interface for selecting plot parameters. The 'W7-X v' preset is active, showing options for Physics parameters (Plasma heating, Stored energy, Density, Central temperature, Line integrated temperature, Zeff, Bolometry, Power deposition) and Vacuum vessel (Pressure).
- Cache:** Shows the current cache size (709M) and provides a 'Clear cache' button.
- ICRH settings:** Specifies the ICRH frequency (25 MHz, 37.5 MHz, or 38 MHz).
- Analysis:** Provides options to plot selected signals in 1 plot, open them in analysis GUI, correlation GUI, or plot them for a range of XPs.

w7xsignalviewer



w7xsignalviewer

- Installation as standard Python package, using pip

```
majve@fc-ubu3-020:~$ python3 -m pip install w7xsignalviewer
Defaulting to user installation because normal site-packages is not writeable
Looking in indexes: https://pypi.ipp-hgw.mpg.de/repository/pypi/simple
Collecting w7xsignalviewer
  Downloading https://pypi.ipp-hgw.mpg.de/repository/pypi/packages/w7xsignalviewer/2023.12.4/w7xsignalviewer-2023.12.4.tar.gz (325 kB)
    325.1/325.1 kB 224.4 MB/s eta 0:00:00
Installing build dependencies ... done
Getting requirements to build wheel ... done
Preparing metadata (pyproject.toml) ... done
Building wheels for collected packages: w7xsignalviewer
  Building wheel for w7xsignalviewer (pyproject.toml) ... done
  Created wheel for w7xsignalviewer: filename=w7xsignalviewer-2023.12.4-py3-none-any.whl size=339616 sha256=c2d1d874f33a6bc05dd8cf37e698
  Stored in directory: /tmp/pip-ephem-wheel-cache-762mllc8/wheels/be/2e/7e/0d6d44b1869cded4d435fb3725c9e58c485d99ecbb905be33a
Successfully built w7xsignalviewer
Installing collected packages: w7xsignalviewer
Successfully installed w7xsignalviewer-2023.12.4
```

- Execute as standard Python package

```
majve@fc-ubu3-020:~$ python3 -m w7xsignalviewer
```

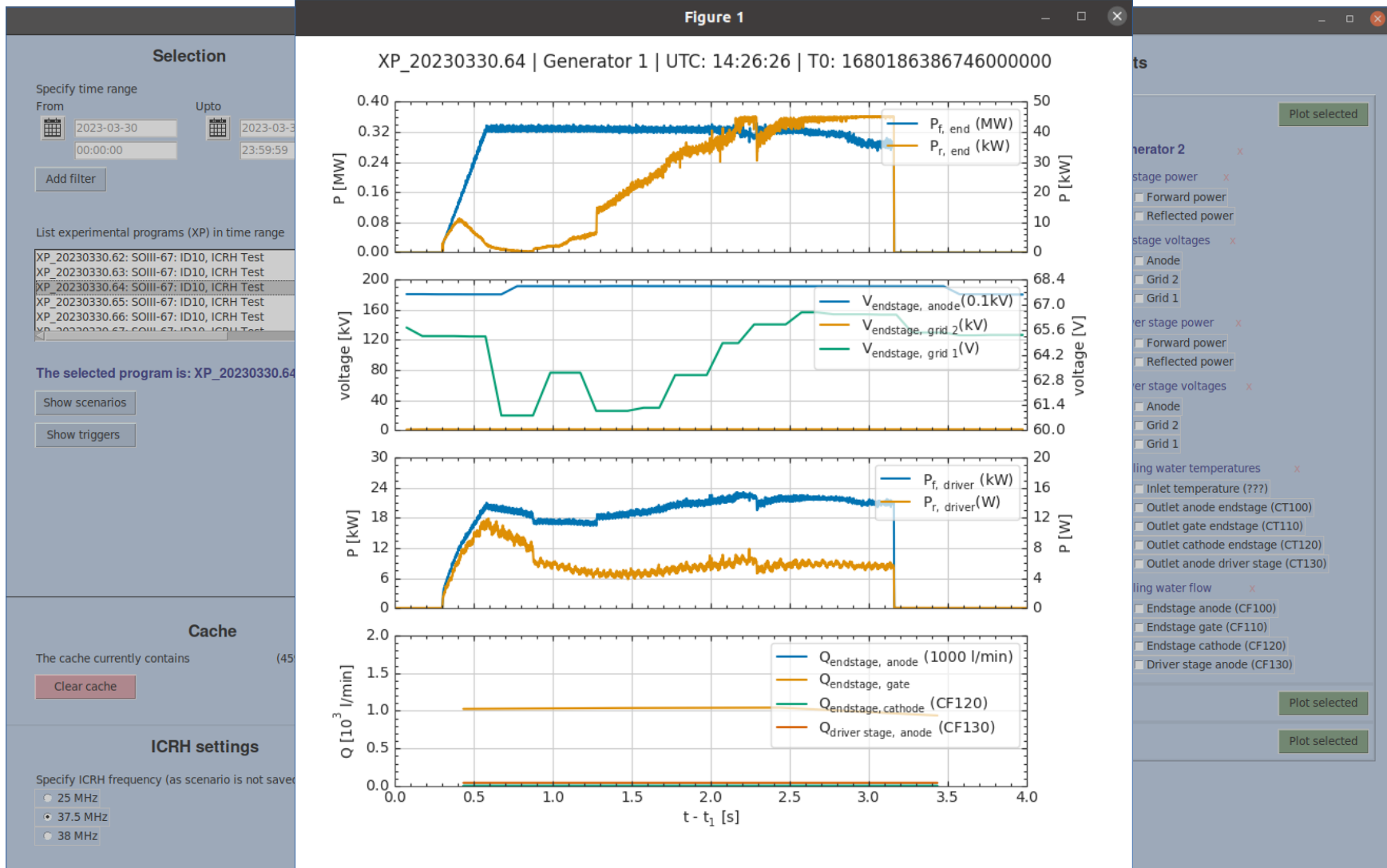

Features of the signal viewer

The signal viewer

The screenshot displays the ICRHmonitor software interface, which is divided into several functional panels:

- Selection:** Contains a "Specify time range" section with "From" and "Upto" date and time pickers. Below this is a list of experimental programs (XP) with "XP_20230330.64" selected. It also includes buttons for "Show scenarios" and "Show triggers".
- Output settings:** Features "Set time" options (absolute, relative to t1, automatic, fixed times), "Scale y axis" (linear/logarithmic), "Resolution" (100 data intervals), and "Output handling" checkboxes for saving figures and videos.
- Cache:** Shows the current cache size (459M) and a "Clear cache" button.
- ICRH settings:** Allows specifying the ICRH frequency (25 MHz, 37.5 MHz, or 38 MHz).
- Analysis:** Includes "Plot selected signals in 1 plot", "Open selected signals in analysis GUI", and "Plot selected signals for XP's (csv)" options.
- Plot presets:** A large section with tabs for "ICRH", "ECRH", and "Physics". It contains sub-sections for "Generator v", "Generator 1", and "Generator 2", each with various checkboxes for power, voltages, driver stage, and cooling water parameters. A red arrow points to a "Plot selected" button in the top right of this section.

The signal viewer



Output settings

The screenshot displays the ICRHmonitor software interface, which is divided into several functional panels:

- Selection:** Allows users to specify a time range (From: 2023-03-30 00:00:00, Upto: 2023-03-30 23:59:59) and lists experimental programs (XP) in the range. The selected program is XP_20230330.64 (XP).
- Output settings:** Configures how data is processed and displayed. Options include setting time (absolute, relative to t1, automatic, or fixed times), scaling the y-axis (linear or logarithmic), resolution (100 data intervals), and output handling (show output, save figures/videos as PDF/PNG/MP4, upload plots, store time trace data).
- Cache:** Shows the current cache size (459M) and provides a 'Clear cache' button.
- ICRH settings:** Specifies the ICRH frequency (25 MHz, 37.5 MHz, or 38 MHz).
- Analysis:** Configures how signals are aligned based on the time window, signal start, or signal maximum.
- Plot presets:** Offers pre-configured plots for various components like Generator v, Antenna, and Calorimetry. The 'Generator v' preset is currently selected.

User handles

Output settings

Set time

- absolute
- relative to t1, in time window:
 - automatic
 - fixed times, from s upto s
 - fixed triggers, from trigger upto trigger
with addition of s before and after

Scale y axis

- linear
- logarithmic

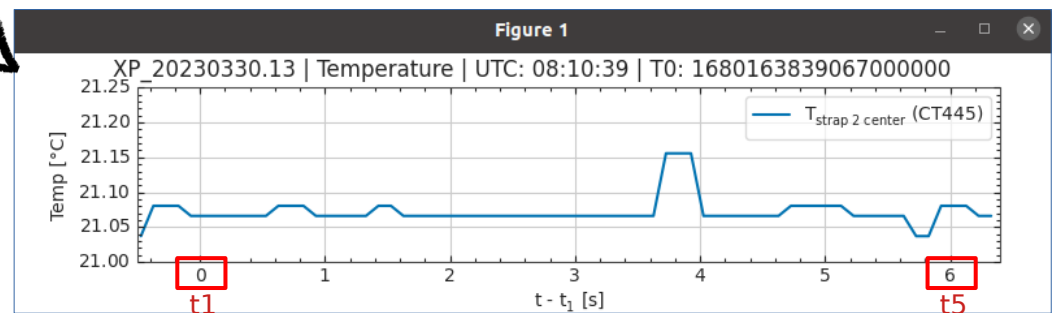
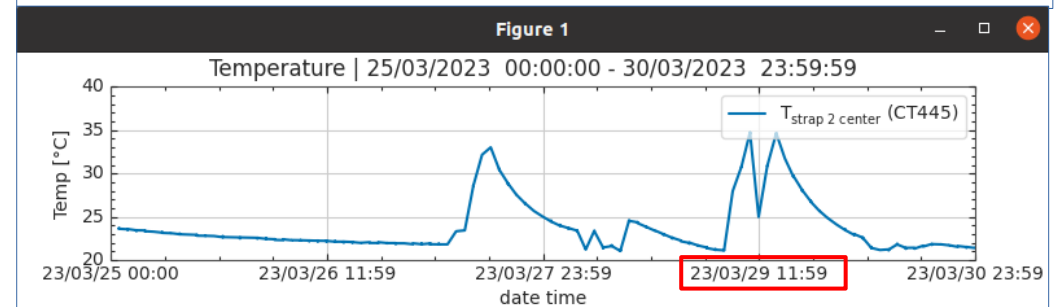
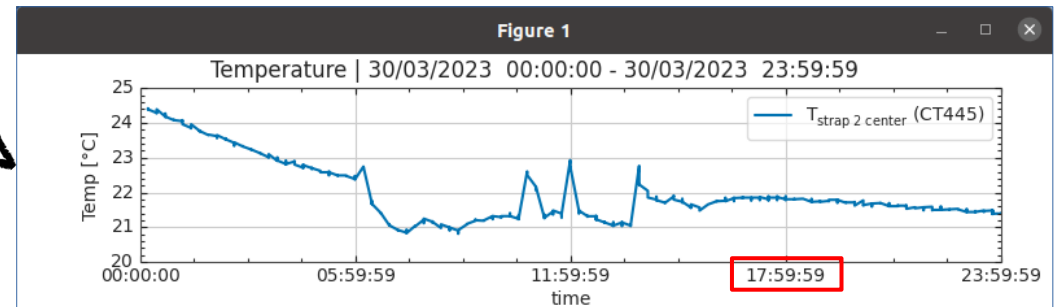
Resolution

Plot data intervals [enter 0 for full resolution]

- Annotate plateaus within % over at least s
- Annotate integral of signal

Output handling

- show output (figures and videos)
- save figures as PDF
- save figures as PNG
- save videos as MP4
- upload plots as comment to program log (XP or SAP)
- store time trace data



User handles

Output settings

Set time

- absolute
 - relative to t1, in time window:
 - automatic
 - fixed times, from s upto s
 - fixed triggers, from trigger upto trigger
- with addition of s before and after

Scale y axis

- linear
- logarithmic

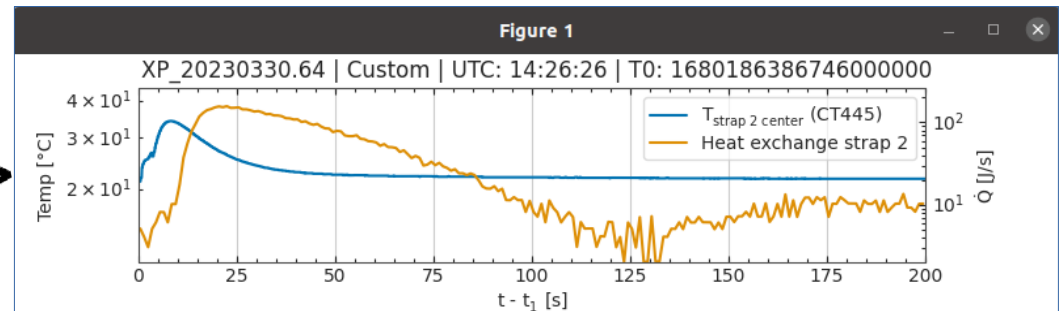
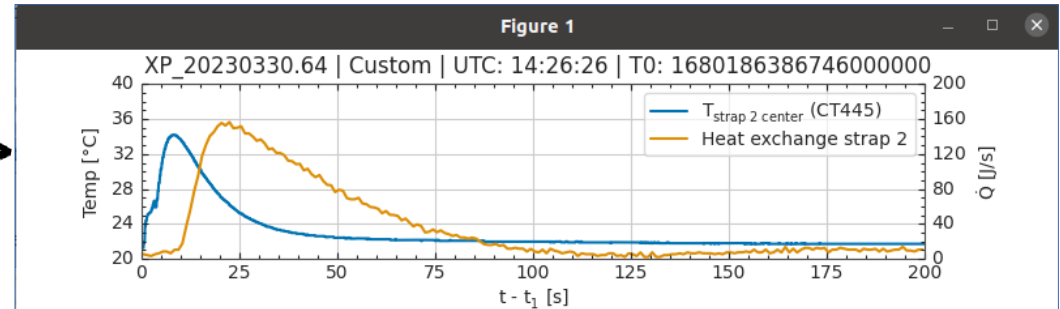
Resolution

Plot data intervals [enter 0 for full resolution]

- Annotate plateaus within % over at least s
- Annotate integral of signal

Output handling

- show output (figures and videos)
- save figures as PDF
- save figures as PNG
- save videos as MP4
- upload plots as comment to program log (XP or SAP)
- store time trace data



User handles

Output settings

Set time

absolute

relative to t1, in time window:

automatic

fixed times, from s upto s

fixed triggers, from trigger upto trigger

with addition of s before and after

Scale y axis

linear

logarithmic

Resolution

Plot data intervals [enter 0 for full resolution]

Annotate plateaus within % over at least s

Annotate integral of signal

Output handling

show output (figures and videos)

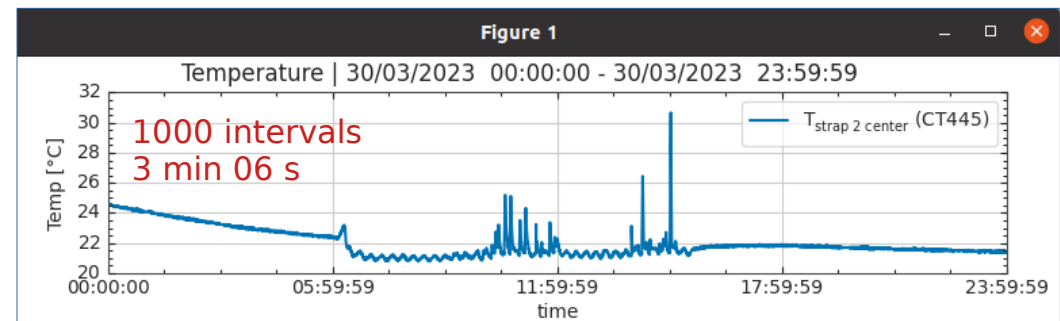
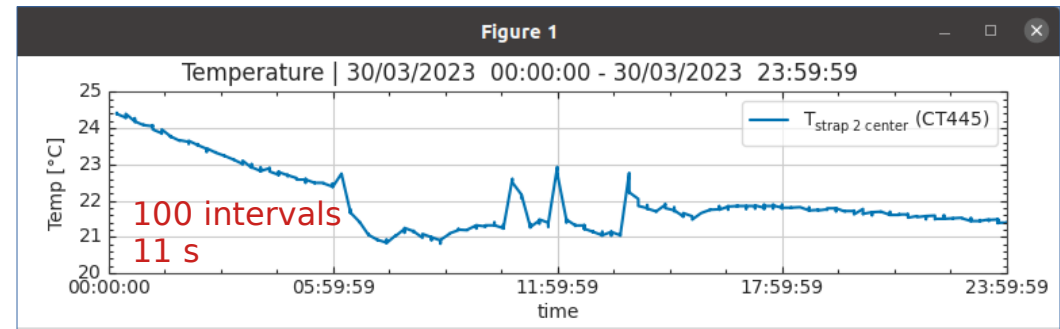
save figures as PDF

save figures as PNG

save videos as MP4

upload plots as comment to program log (XP or SAP)

store time trace data



User handles

Output settings

Set time

- absolute
 - relative to t1, in time window:
 - automatic
 - fixed times, from s upto s
 - fixed triggers, from trigger upto trigger
- with addition of s before and after

Scale y axis

- linear
- logarithmic

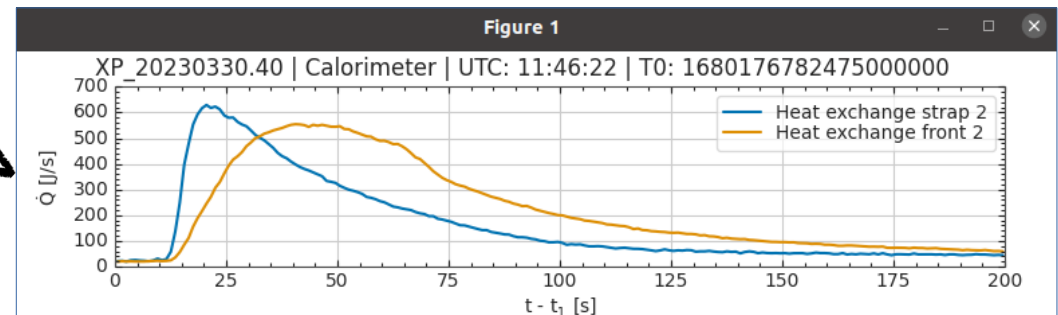
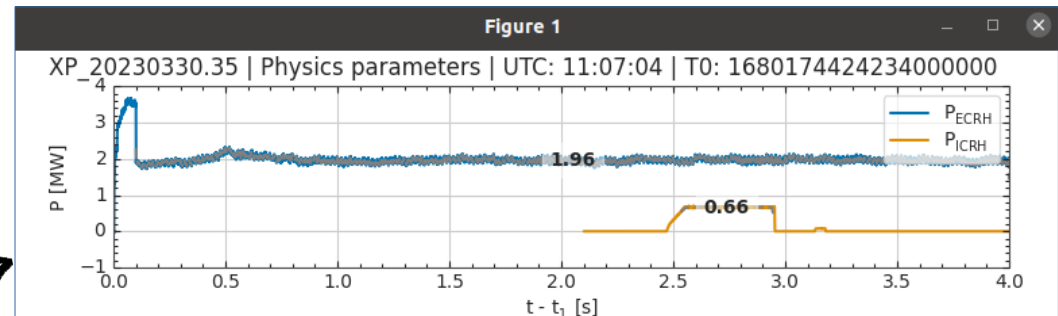
Resolution

Plot data intervals [enter 0 for full resolution]

- Annotate plateaus within % over at least s
- Annotate integral of signal

Output handling

- show output (figures and videos)
- save figures as PDF
- save figures as PNG
- save videos as MP4
- upload plots as comment to program log (XP or SAP)
- store time trace data



The integral of Heat exchange strap 2 over [0.57,199.57] s is 32476.648 J/s*s
The integral of Heat exchange front 2 over [0.57,199.57] s is 44136.463 J/s*s

User handles

Output settings

Set time

absolute

relative to t1, in time window:

automatic

fixed times, from s upto s

fixed triggers, from trigger upto trigger

with addition of s before and after

Scale y axis

linear

logarithmic

Resolution

Plot data intervals [enter 0 for full resolution]

Annotate plateaus within % over at least s

Annotate integral of signal

Output handling

show output (figures and videos)

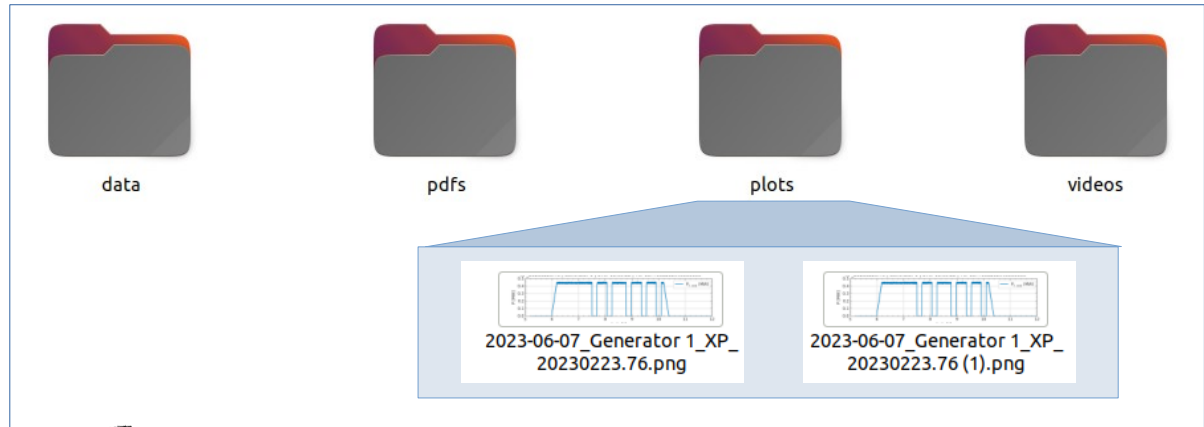
save figures as PDF

save figures as PNG

save videos as MP4

upload plots as comment to program log (XP or SAP)

store time trace data



The screenshot displays the 'Wendelstein 7-X Logbook' interface. The main log entry is for 'XP:20230328.15' on Tuesday, 28 Mar 2023 at 8:20:16 - 8:30:38 UTC. The log entry includes details for Name (SOIII-66 ID10 v2), Magnetic field (TC: XM008+2520), Fueling (Gas3-He15, Gas3-He31, Gasd-Ar17, Gas H11-He 21ms FeedForward, Gas H11-He 11901ms DensityCtrl), Pellets (inactive), Heating (ECRH: 1800.00 kW, 21.55 MJ, 12.00 s, ECRH pot: X2-mode, CS, D1, E1), and Diagnostics (D1, D2, D3, D4, D5, GPI: He). The experiment is identified as 'Type: Physics, SL: Olaf Grulke, SID: SOIII-66 #10, SO: Dirk Hartmann' with the session ID 'djh_010' and a 'Result: ok' status. The description is 'SOIII-66: ID10' and the session info is 'PP-403354'. A list of components is provided at the bottom: DBB, CBG, DCH, ACM, AAQ, QM, QXG, QME, QTB, QRG, QRT02, QSD, QMR, QOI, QRN, CBS, QMB3, QMC, QMF, QMR1, QOC, QRF, QRP02, QSK, QSR02, QSW, QXT. The right-hand side of the interface shows a 'Comments' section with a 'Timeline' and 'Components' tab. A 'Preview Plots' section is visible, showing a plot titled 'XP_20230328.15 | Positions | UTC: 08:29:17 | TO: 1679992157496000000'. The plot displays 'Antenna position' (position [mm] vs t - t0 [s]) and a 'Poincare plot' (z [m] vs R [m]) showing the 'Last closed flux surface' and 'ICRH antenna limiter'.

Analysis

ICRHmonitor

Selection

Specify time range

From: 2023-03-30 00:00:00 Upto: 2023-03-30 23:59:59

Add filter

List experimental programs (XP) in time range **Go!**

- XP_20230330.62: SOIII-67: ID10, ICRH Test
- XP_20230330.63: SOIII-67: ID10, ICRH Test
- XP_20230330.64: SOIII-67: ID10, ICRH Test**
- XP_20230330.65: SOIII-67: ID10, ICRH Test
- XP_20230330.66: SOIII-67: ID10, ICRH Test
- XP_20230330.67: SOIII-67: ID10, ICRH Test

The selected program is: XP_20230330.64 (XP)

Show scenarios

Show triggers

Output settings

Set time

- absolute
- relative to t1, in time window:
 - automatic
 - fixed times, from 0.0 s upto 4 s
 - fixed triggers, from trigger 0 upto trigger 0

with addition of 0.0 s before and after

Scale y axis

- linear
- logarithmic

Resolution

Plot: 100 data intervals [enter 0 for full resolution]

- Annotate plateaus within 5 % over at least 1 s
- Annotate integral of signal

Output handling

- show output (figures and videos)
- save figures as PDF
- save figures as PNG
- save videos as MP4
- upload plots as comment to program log (XP or SAP)
- store time trace data

Cache

The cache currently contains (459M)

Clear cache

ICRH settings

Specify ICRH frequency (as scenario is not saved in archiveDB)

- 25 MHz
- 37.5 MHz**
- 38 MHz

Plot presets

ICRH ECRH Physics

Generator v

Generator 1 x **Plot selected**

- Endstage power x
 - Forward power
 - Reflected power
- Endstage voltages x
 - Anode
 - Grid 2
 - Grid 1
- Driver stage power x
 - Forward power
 - Reflected power
- Driver stage voltages x
 - Grid 2
 - Grid 1
- Cooling water temperatures x
 - Inlet temperature (???)
 - Outlet anode endstage (CT100)
 - Outlet gate endstage (CT110)
 - Outlet cathode endstage (CT120)
 - Outlet anode driver (CT130)
- Cooling water flow x
 - Endstage anode (CF100)
 - Endstage gate (CF110)
 - Endstage cathode (CF120)
 - Driver stage anode (CF130)

Generator 2

- Endstage power x
 - Forward power
 - Reflected power
- Endstage voltages x
 - Anode
 - Grid 2
 - Grid 1
- Driver stage power x
 - Forward power
 - Reflected power
- Driver stage voltages x
 - Anode
 - Grid 2
 - Grid 1
- Cooling water temperatures x
 - Inlet temperature (???)
 - Outlet anode endstage (CT100)
 - Outlet gate endstage (CT110)
 - Outlet cathode endstage (CT120)
 - Outlet anode driver stage (CT130)
- Cooling water flow x
 - Endstage anode (CF100)
 - Endstage gate (CF110)
 - Endstage cathode (CF120)
 - Driver stage anode (CF130)

Antenna >

Plot selected

Calorimetry >

Plot selected

Analysis

Plot selected signals in 1 plot **Go!**

Open selected signals in analysis GUI **Go!**

Plot selected signals for XP's (csv): **Go!**

XP_...

where the signals are aligned based on

- the time window
- the signal start, going over threshold 0.001
- the signal maximum

Analysis GUI

Analysis

Plot selected signals in 1 plot

Go!

Open selected signals in analysis GUI

Go!

Open selected signals in Correlation GUI

Go!

Plot selected signals for XP's (csv, - for range):

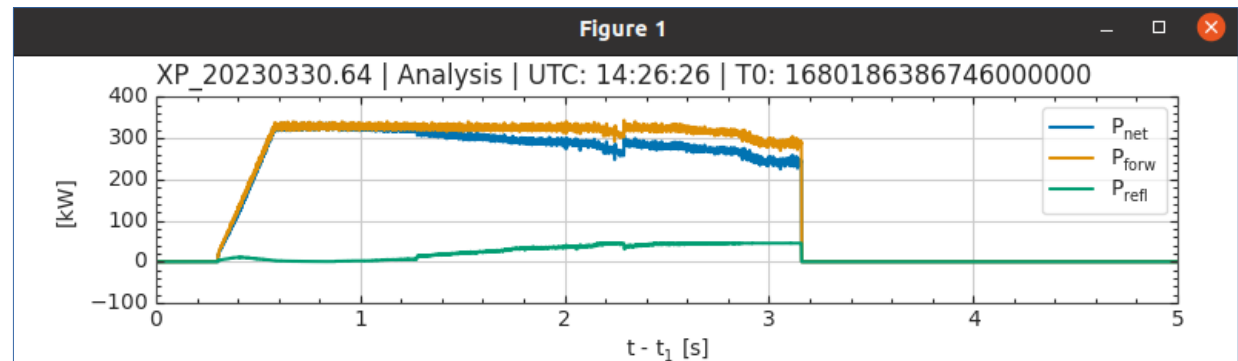
Go!

XP_...

where the signals are aligned based on

- the time window
- the signal start, going over threshold
- the signal maximum

0.001



Analyzer

Variables

<input checked="" type="checkbox"/>	a	=	Generator/Generator 1/Endstage power/Forward power	MW
<input checked="" type="checkbox"/>	b	=	Antenna/Temperature/Strap temperature/strap 2 center (CT44)	°C
<input checked="" type="checkbox"/>	c	=	W7-X/Physics parameters/Bolometry/Total radiated power	MW
<input checked="" type="checkbox"/>	d	=	Generator/Generator 1/Endstage power/Reflected power	kW
<input checked="" type="checkbox"/>	e	=		

Add signal

Functions

<input checked="" type="checkbox"/>	\$P_{net}\$	=	a*1000-d	kW
<input checked="" type="checkbox"/>	\$P_{forw}\$	=	a*1000	kW
<input checked="" type="checkbox"/>	\$P_{refl}\$	=	d	kW
<input type="checkbox"/>	W	=	0	a.u.

Add function

Plot functions

Correlations GUI

Analysis

Plot selected signals in 1 plot

Go!

Open selected signals in analysis GUI

Go!

Open selected signals in Correlation GUI

Go!

Plot selected signals for XP's (csv, - for range):

XP_...

where the signals are aligned based on

- the time window
- the signal start, going over threshold
- the signal maximum

Correlations monitor

Correlation

Signals

x = Generator/Generator 1/Endstage power/Forward power
y = Antenna/Temperature/Box temperature/box right bottom (CT)

Datapoints

- All samples
- Timestamp of maximal x value per shot
- Timestamp of maximal y value per shot
- maximal x value and maximal y value per shot

Quantify relation

- Pearson's correlation coefficient
- Spearman's correlation coefficient (non linear)
- Covariance

Fit

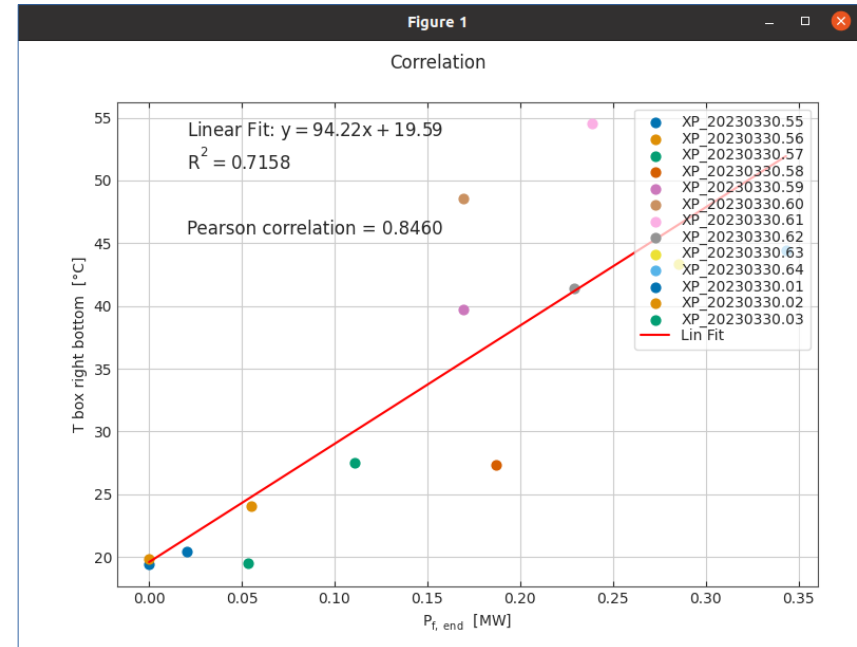
- None
- Linear
- Logarithmic
- Exponential
- Polynomial of order

Selection

Using output settings from the monitor
correlate signals, for XP's (csv, - for range):

XP_20230330.55-XP_20230330.64,XP_20

Go!



Compare programs

Analysis

Plot selected signals in 1 plot

Go!

Open selected signals in analysis GUI

Go!

Open selected signals in Correlation GUI

Go!

Plot selected signals for XP's (csv, - for range):

XP_20230330.25-XP_20230330.29, XP_20

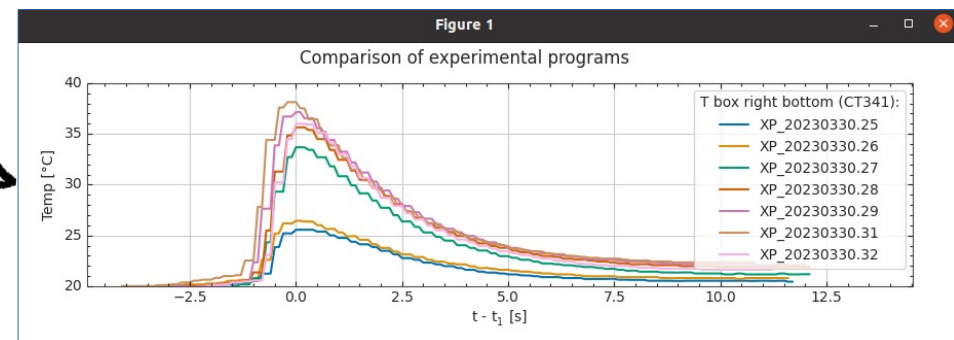
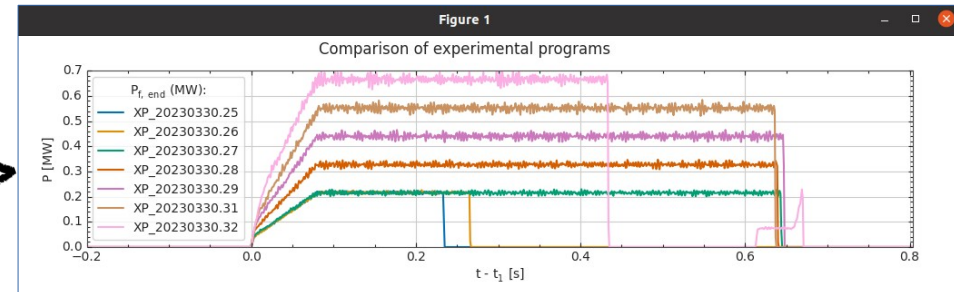
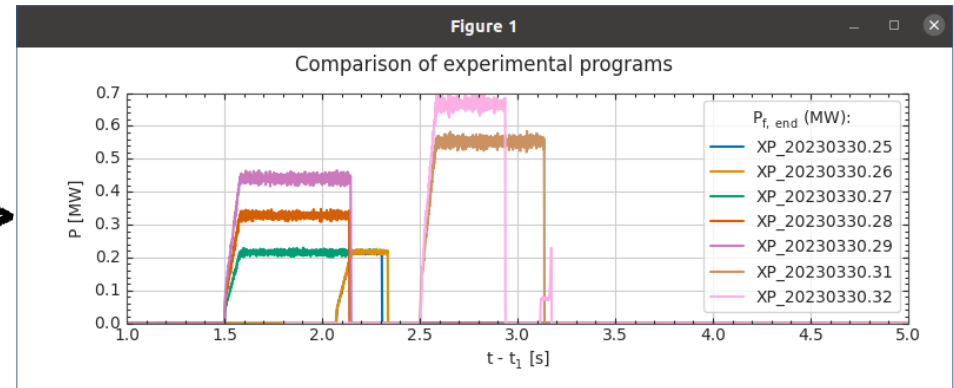
where the signals are aligned based on

the time window

the signal start, going over threshold

0.001

the signal maximum



w7xsignalviewer

The screenshot displays the ICRHmonitor software interface, which is organized into several functional panels:

- Selection:** Allows users to specify a time range (From: 2023-03-30 00:00:00, Upto: 2023-03-30 23:59:59) and lists experimental programs (XP) in that range. The selected program is XP_20230330.64 (XP).
- Output settings:** Configures how data is plotted and handled. Options include setting time (absolute, relative to t1, automatic, or fixed times), scaling the y-axis (linear or logarithmic), resolution (100 data intervals), and output handling (show output, save figures/videos as PDF/PNG/MP4, upload plots, store time trace data).
- Plot presets:** Provides pre-configured settings for different components: Generator v (Generator 1 and 2), Antenna, and Calorimetry. Each preset includes checkboxes for various parameters like endstage power, voltages, driver stage power, cooling water temperatures, and flow.
- Cache:** Shows the current cache size (459M) and provides a 'Clear cache' button.
- Analysis:** Offers options to plot selected signals in a 1D plot, open them in the analysis GUI, and plot signals for specific XPs based on time window, signal start, or signal maximum.

W7-X Christmas wishlist



✓ A monitor for easy access to meaningful signals



- A Graphical User Interface (**GUI**) to conveniently create a figure of desired signals, during a desired time period
- Based on settings on monitor and properties of signals, the **lay-out** of the figure is determined automatically
- Additional **user handles** are available: saving figures, uploading figures to logbook, caching, filtering programs, fine selection of time range, comparing programs, basic operations for analysis

W7-X Christmas wishlist



- ✓ A monitor for easy access to meaningful signals

Meaningful signals

- Signals of different types and origins are processed into meaningful signals

The image shows a screenshot of a control interface divided into two main sections: **ICRH** and **Physics**. The **ICRH** section includes sub-sections for **Antenna v**, **RF**, **Temperature**, **Thermocouples image**, **Positions**, and **Profiles**. The **Physics** section includes **W7-X v**, **Physics parameters**, **Plasma heating**, **Stored energy**, **Density**, **Line integrated temperature**, **Zeff**, **Bolometry**, and **Power deposition**. A **Video >** button is located at the bottom of the Physics section.

Annotations with arrows point to specific elements:

- timetrace: ArchiveDB + calibration** points to the **Right strap (CE303)** checkbox in the RF section.
- timetrace: higher order** points to the **ECRH power** checkbox in the Plasma heating section.
- timetrace: ArchiveDB** points to the **Wdia** checkbox in the Stored energy section.
- image: local** points to the **Thermocouples.png** checkbox in the Thermocouples image section.
- profile: fieldlinetracer** points to the **Poincare plot** checkbox in the Profiles section.
- profile: meshDB** points to the **Antenna** checkbox in the Profiles section.
- timetrace: w7xdia** points to the **H over H+He** checkbox in the Zeff section.
- Video: ArchiveDB + processing** points to the **Video >** button.

Meaningful signals

- Based on the date, signals are handled according to OP1 or OP2

Plot presets

ICRH | ECRH | **Physics**

Gyrotrons v Plot selected

Power x

Total x

- ECRH power
- Sum of gyrotron powers
- Sum of gyrotron setpoints

Series 1 x

- Gyrotron A1
- Gyrotron B1
- Gyrotron C1
- Gyrotron D1
- Gyrotron E1
- Gyrotron F1

Series 5 x

- Gyrotron A5
- Gyrotron B5
- Gyrotron C5
- Gyrotron D5
- Gyrotron E5
- Gyrotron F5

z offset x

Series 1 x

- Gyrotron A1
- Gyrotron B1
- Gyrotron C1
- Gyrotron D1
- Gyrotron E1
- Gyrotron F1

Series 5 x

- Gyrotron A5
- Gyrotron B5
- Gyrotron C5
- Gyrotron D5
- Gyrotron E5
- Gyrotron F5

phi offset x

Series 1 x

- Gyrotron A1
- Gyrotron B1

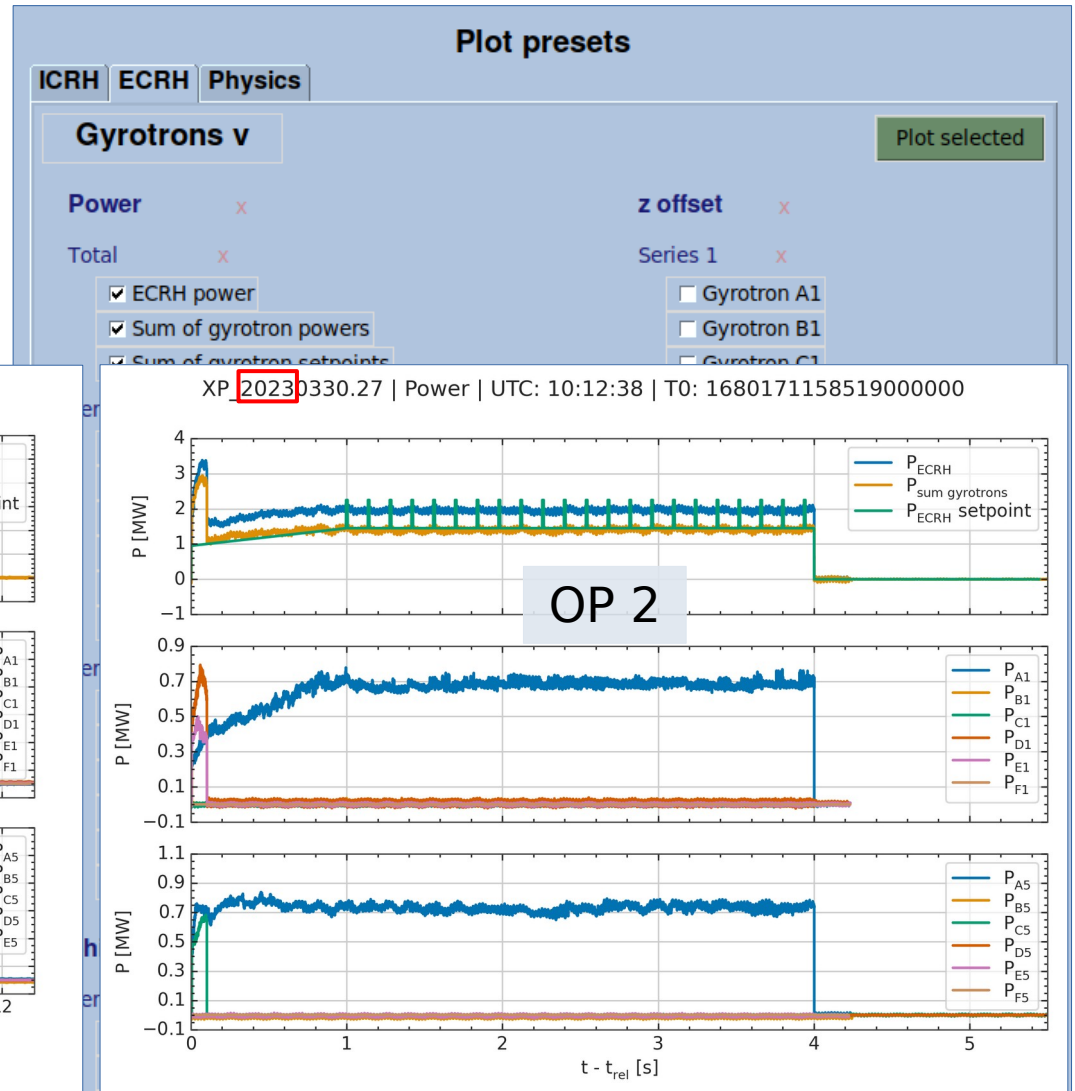
setpoint x

Series 1 x

- Gyrotron A1
- Gyrotron B1

Meaningful signals

- Based on the date, signals are handled according to OP1 or OP2



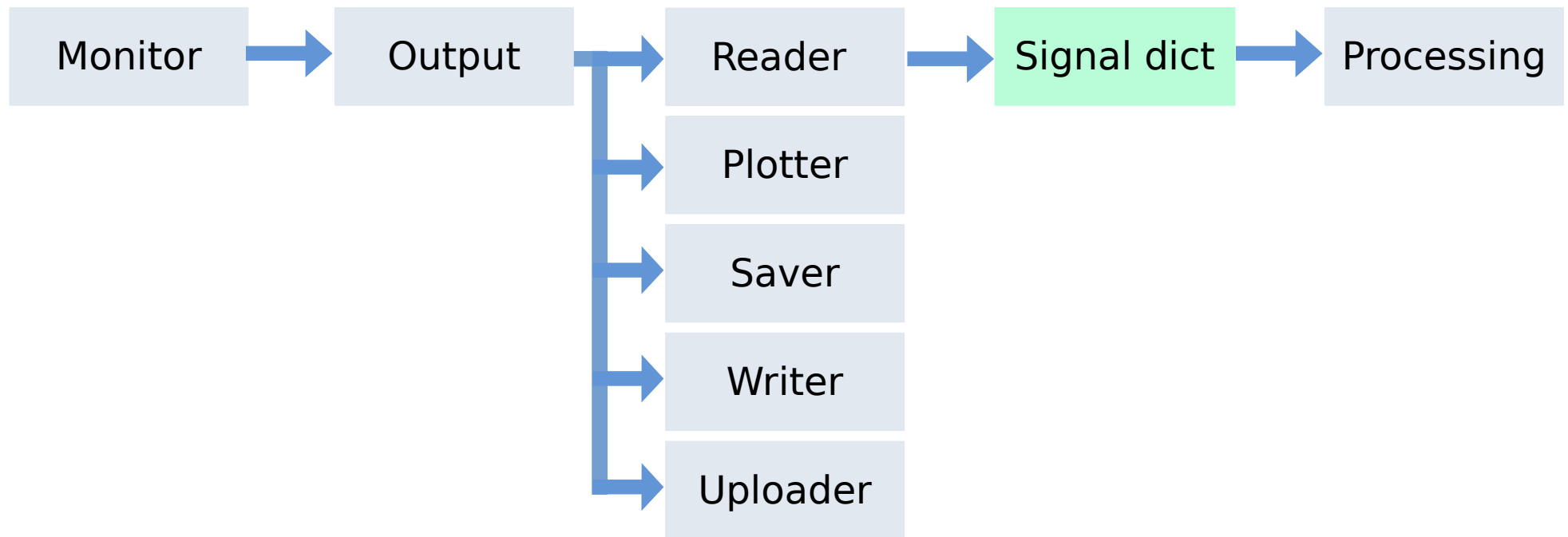
Properties

- For each signal, its properties are defined in one place, in a dictionary

```
'Generator/Generator 1/Endstage power/Forward power': {
  'url': 'ArchiveDB/raw/W7X/ControlStation.2179/CCDAQ.1_DATASTREAM/5/Channel_0222/',
  'type': 'timetrace',
  'description': "",
  'slope': 1,
  'intercept': 0,
  'valconv': 1/1000,
  'unit': "P [MW]",
  'legend': "$P_{f, \\ end}$ (MW)",
  'calibrationfunc': Calibrating.squared_voltage_to_offset,
  'calibrationsetting': {'signal': 'GEN1_ENDSTAGE_Pforw'}
},
```

Object Oriented Programming approach

- The functions for reading, plotting, uploading and storing are separated
- The scripts can be used as stand-alone-code



W7-X Christmas wishlist



✓ A monitor for easy access to meaningful signals

- Signals are **calibrated** and higher order signals are determined
- For each signal, its **properties** are defined in one place
- The functionality (e.g. reading, plotting, etc.) is **centralized**, following Object Oriented Programming

Getting started

Getting started

As user

- Install and execute the python package (see earlier)
→ ICRH experiments on 2023-02-23, 2023-03-28, 2023-03-30
- Check manuals at <https://gitlab.mpcdf.mpg.de/majve/icrhmonitor/-/tree/Manuals>
→ Frontend manual

As developer

- Code available at
<https://gitlab.mpcdf.mpg.de/majve/icrhmonitor>
- Check manuals
→ Backend manual (and LogbookAPI, pythonIDE, gitlab)
- You can add your own signals!
→ Adapting manual
→ m.verstraeten@fz-juelich.de



Conclusion

