MAX IV LABORATORY

Software and Toolchain in the MAX IV Operations Group

13th Workshop on Accelerator Operations, September 2023

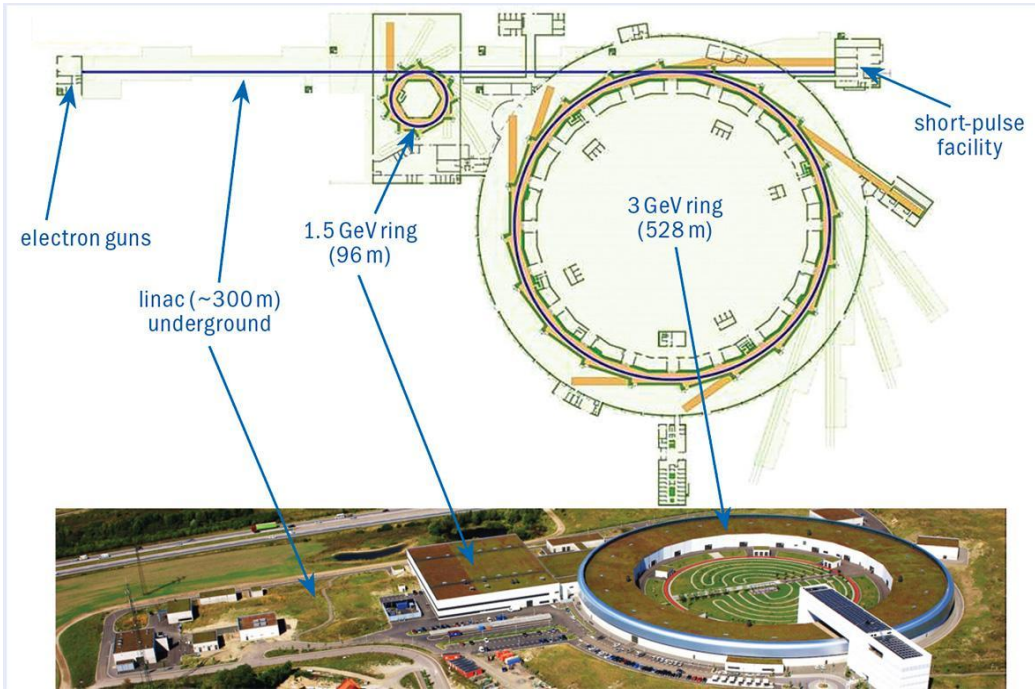
Rutger Nieuwenhuis

The work presented here is the effort of many members of the MAX IV team, both past and present. Including:

Andreas Johansson, Mathias Brandin, Per Lilja, Viktor Abelin, Klaudia Jaworska, Roberto Rocca, Ali Al-Sakeeri, Jonas Petersson, Tanvir Sayed, Bernhard Meirose, David Winchester, Stephen Molloy, Filip Persson, Hugo Serodio, Robin Svärd, Elton Giacomelli-Nilsson

MAX IV Laboratory

- Part of Lund University in Sweden
- 3 GeV Linear electron accelerator (linac) powering:
  - Short pulse facility (SPF)
  - 1.5 GeV Soft x-ray storage ring
  - 3 GeV Hard x-ray storage ring
- 16 Specialized beamlines for user access



Photographer: Perry Nordeng

“Why not just let the software teams do it?”

Why?

Software teams are absolutely necessary, but sometimes:

Software teams can be...

- Busy
- Unsure what you need
- Unable to tweak existing software

Operators are...

- Fast! (For “small” programs and scripts)
- Experts on what is needed
- Continuously improving existing software

How?

- Study: tutorials, documentation, example projects
- Discuss: with each other, the software team, other facilities
- Very important: a solid toolchain!

The MAX IV Toolchain: Software

- Versatile
- Straight-forward
- Lots of modules

- Software download with ease
- Version control with virtual environments

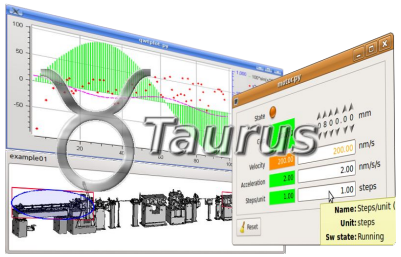
Modules:
- PyQT: complicated GUIs
- Numpy/Scipy
- Pyparsing: parse user input

etc...

The MAX IV Toolchain: Communication

PyTango

- Python API for Tango controls system
- Create and interact with physical and virtual devices using Python
- Lots of versatile tools! e.g.:



- Easy GUI design for Tango devices

git ➡ CI / CD

- Sharing code
- Tracking changes
- Automatically deploy Tango devices

Some examples of MAX IV software

ModReset

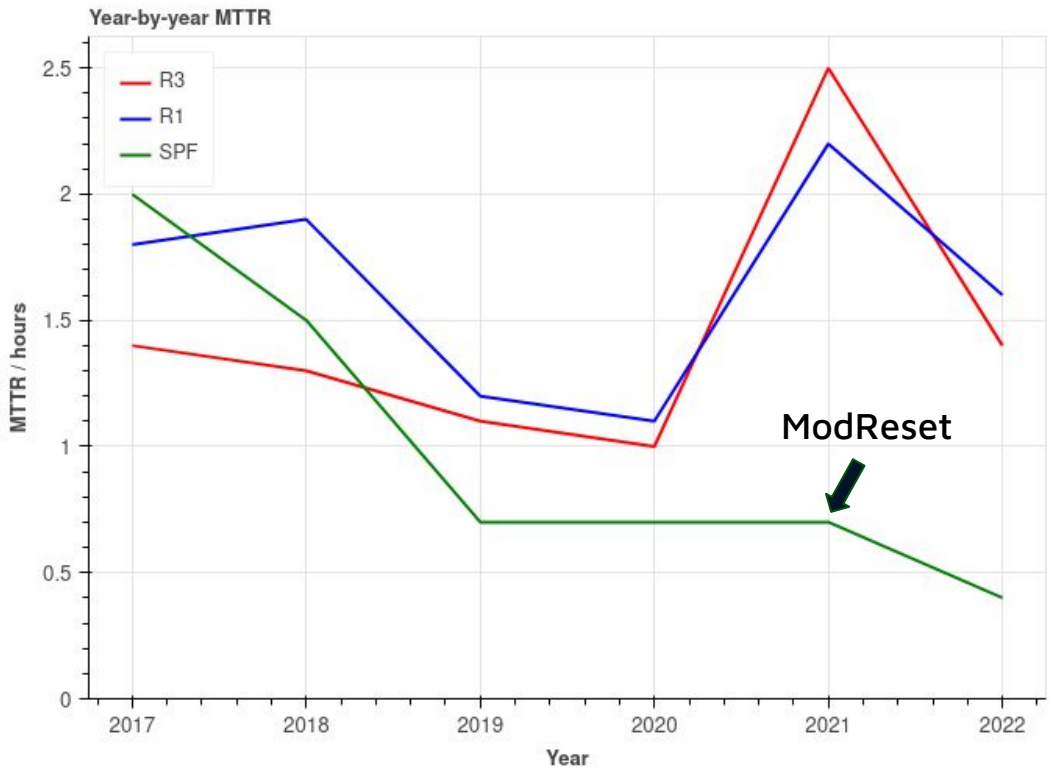
A PyTango device that automatically resets specific modulator interlocks

How does it work?

- Event subscription to modulators
- Seperate thread spawned when an interlock is received
- Standard reset procedure executed

Advantages

- Much lower mean time to repair
- No human error during recovery
- No lunch interruptions…



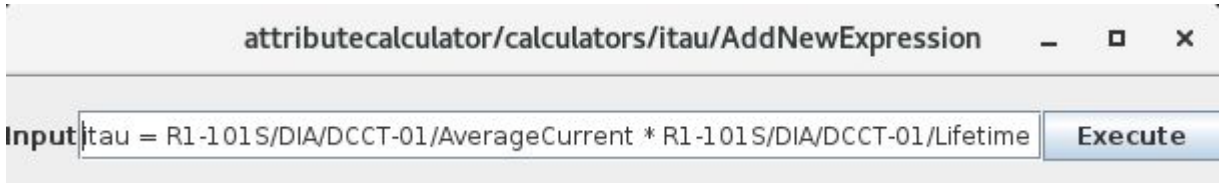
The modulator interlocks ➡ ModReset checks interlock ➡ Voltage is reduced and filltime is scaled ➡ Voltage is slowly increased and filltime decreased

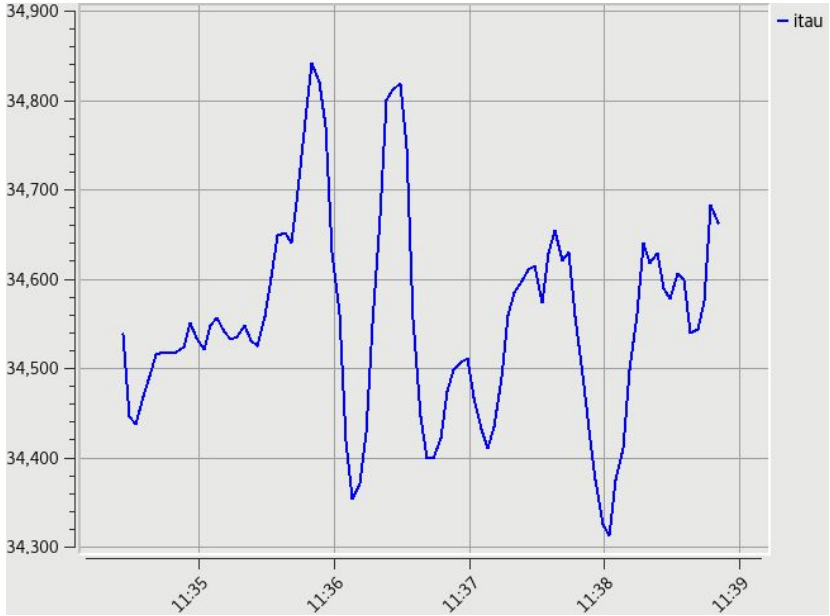
AttributeCalculator

A PyTango device that does math with Tango attributes

- One ‘Master’ device that is used to create/delete other calculator devices
- Attributes can be dynamically added to each separate calculator device
- Parsing of math formulas based on PyParsing:
  - Operators: +, -, /, *, ^
  - Variables: integers, floats and other Tango attributes
- The added attribute can be used with all other programs that rely on Tango attributes

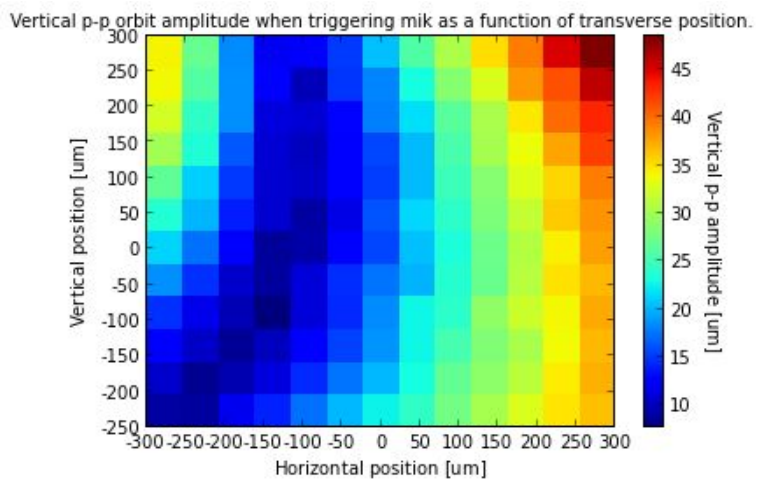
Example: current * lifetime





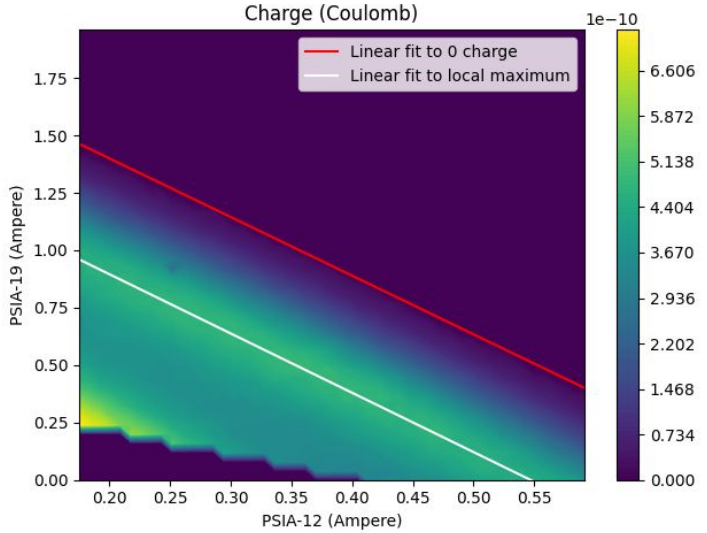
Scripting for accelerator development

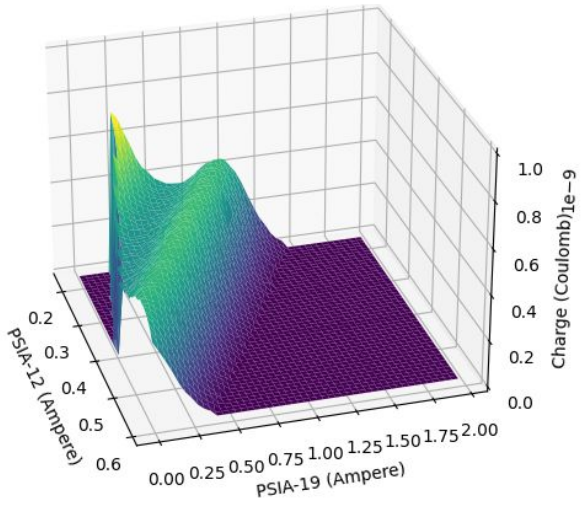
- The ease of Python interacting with Tango can automate many measurements
- In general: Change something a little, measure, and repeat
- Plotting done with Matplotlib
- MATLAB is an obvious alternative, but isn't open-source



Example: Multipole injection kicker characterization
- Change reference orbit in Tango
- Let feedbacks correct to reference orbit
- Measure oscillations

Example: Charge through aperture as function of dipoles
- Vary two dipoles to figure out the shape of the slope
- Functional fit to figure out ideal operating range for feedback device





Automatic delivery validation

- Delivery validation is done after every maintenance to ensure machine settings are returned to nominal
- Used to be a lot of work with manual checklists
- Now: Data fetched, compared and stored automatically
- GUIs using PyQT

W.36 R3 Validation

▼18:46:06, Mon Sep 4 2023 18:54:43, Mon Sep 4 2023

Per Lilja, Rutger Arend Nieuwenhuis

System R3 Type Operation

COLD BEAM PARAMETERS:

Synchrotron frequency: 788 Hz

Feedbacks:

Feedbacks:
R1/CTL/FOFB-01, state: OFF
R1/CTL/FOFB-02, state: OFF

R1/CTL/SOFB-01, state: STANDBY
SOFB-01 singular values: 195.0
SOFB-01 gain: 0.35
SOFB-01 event throttle: 0.5
SOFB-01 rf correction applied: False

Tumon Settings:

Tumon search for positive peak:	True	Tumon use gaussian fit:	True	Tumon median filter:	True
Tumon minimum sigma:	8.0 (Δ = -1)	Tumon minimum SNR:	3.0	Tumon median filter span:	9.0

Involving the software team

Traps when doing things yourself

- Insufficient documentation and commenting
- Projects get abandoned
- Inefficient code can lead to computational overloads
- Where is the code stored…

The software team

- Lots of expertise
- Rigorous protocols
- Proper documentation

When to outsource to the software team

- Specific expertise: database scheming, web programming, machine learning
- Large projects that require lots of time
- When computational efficiency is important

Finally, consider collaboration, and get the best of both worlds!


MAX IV