

SOLEIL/MAX IV Controls and Data Acquisition Meeting

Lessons Learned Embedded Devices

Áureo Freitas
On behalf of Software and Electronics Groups

Summary

- Introduction
- MAX IV Embedded Systems
- Applications - BPMs
- Conclusion

Introduction

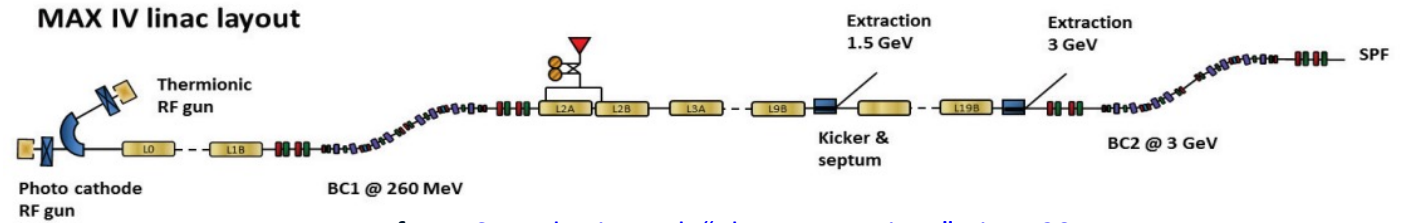
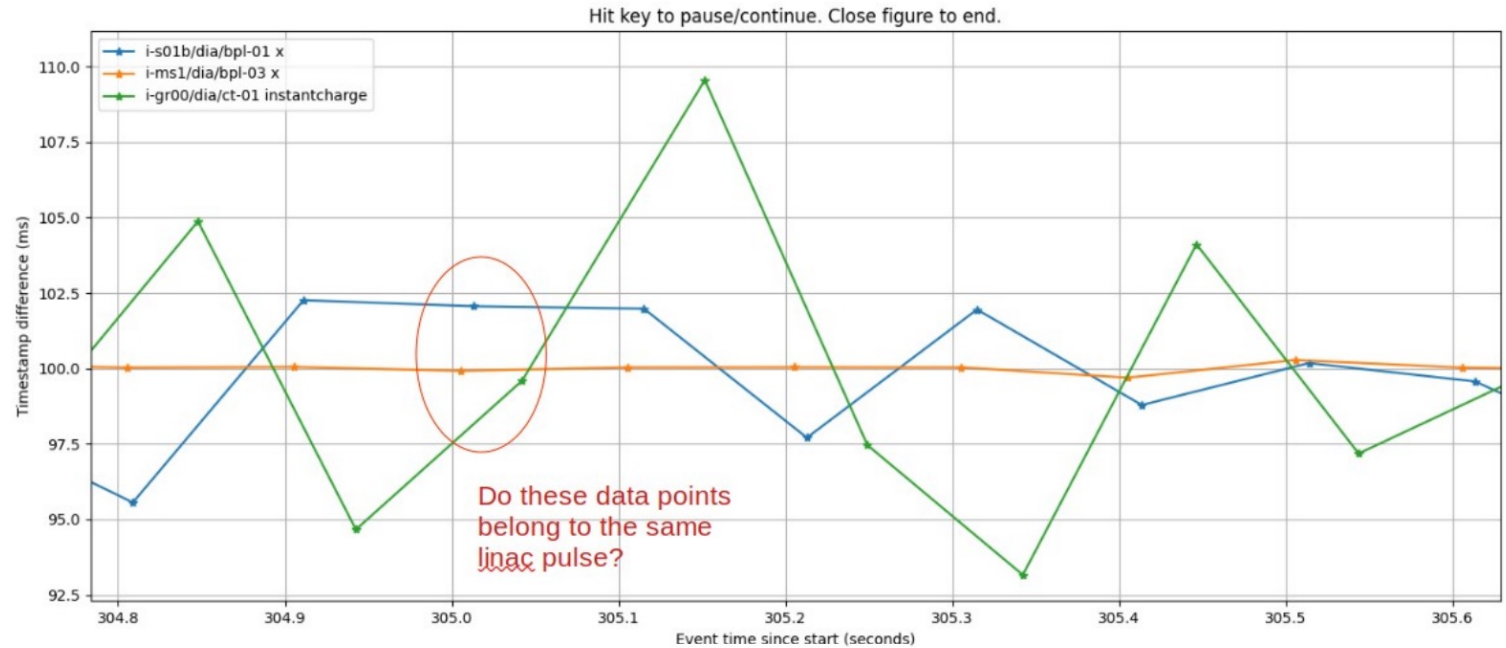


Image from: [Sara Thorin et al, "The MAX IV Linac", Linac 2014](#)

Do these data points belong to the same linac pulse ?

Demand of high acquisition rate and precise timestamping.

TIMESTAMP !



Plot from: [Oliver Grimm](#)

MAX IV Embedded Systems

Libera (I-Tech):

- Linac BPM – Libera Single Pass E: <https://www.i-tech.si/products/libera-single-pass-e/>
- Rings RF BPM – Libera Brilliance+: <https://www.i-tech.si/products/libera-brilliance/>
- Frontend XBPM – Libera Photon: <https://www.i-tech.si/products/libera-photon/>
- Digitizer – Libera Digit 500: <https://www.i-tech.si/products/libera-digit-500/>
- IVU long straight section BLM – Libera BLM: <https://www.i-tech.si/products/libera-blm/>

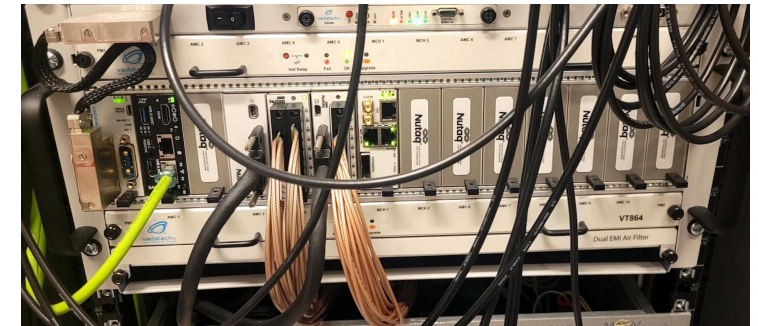
NUTAQ: LLRF: Thanks to Alba for core Tango Device!

Red Pitaya and Raspberry Pi boards:

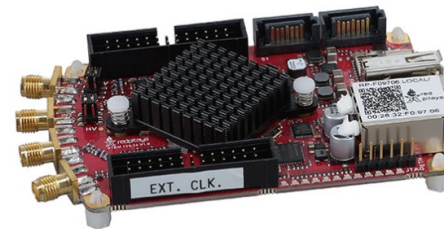
- RF sensors and other applications e.g. Mode 0 damper
- ADC/GPIO applications, e.g. gun laser valves
- Among others...



Libera Brilliance+ R3-A111411-CAB04-DIA-LIB-01



NUTAQ LLRF R3 RF ROOM Achromat 18



Images from [DigiKey](https://www.digikey.com)

Applications – BPMs

CONTROL SYSTEM SUITE FOR BEAM POSITION MONITORS AT MAX IV

Áureo Freitas*, Carla Takahashi, Mirjam Lindberg, Robert Lindvall, Robin Svärd, Vincent Hardion
MAX IV Laboratory, Lund, Sweden

[doi:10.18429/JACoW-IBIC2022-WEP38](https://doi.org/10.18429/JACoW-IBIC2022-WEP38)

Beam Position Monitor – MicroTCA based – Ubuntu 14.04

Libera Brilliance + (rings – 72 units) and Libera Single Pass E (linac – 21 units)



Schema taken from [paper above \(Figure 2\)](#)

72 Libera Brilliance+ units
21 Libera Single Pass E units

236 BPMs measurements at storage rings
50 BPMs measurements at linac
72 EVRX servers
72 GDX servers

R3 SOFB: 196 BPMs horizontal plane and 197 BPMs vertical plane
R1 SOFB: 33 BPMs horizontal plane and 35 BPMs vertical plane

Data stream:

- Slow data: 10Hz Tango change event
- Fast data: 10kHz UDP stream

Applications – BPMs Tango event usage

- Slow Orbit Feedback (SOFB)
- Linac Trajectory Feedback – MIMO Proportional Controller
- X-ray Orbit Feedback (XOFB)
- **Model Predictive Control (MPC)**
- System Identification
- User interfaces
- Events correlation

All applications are open source and available upon request!

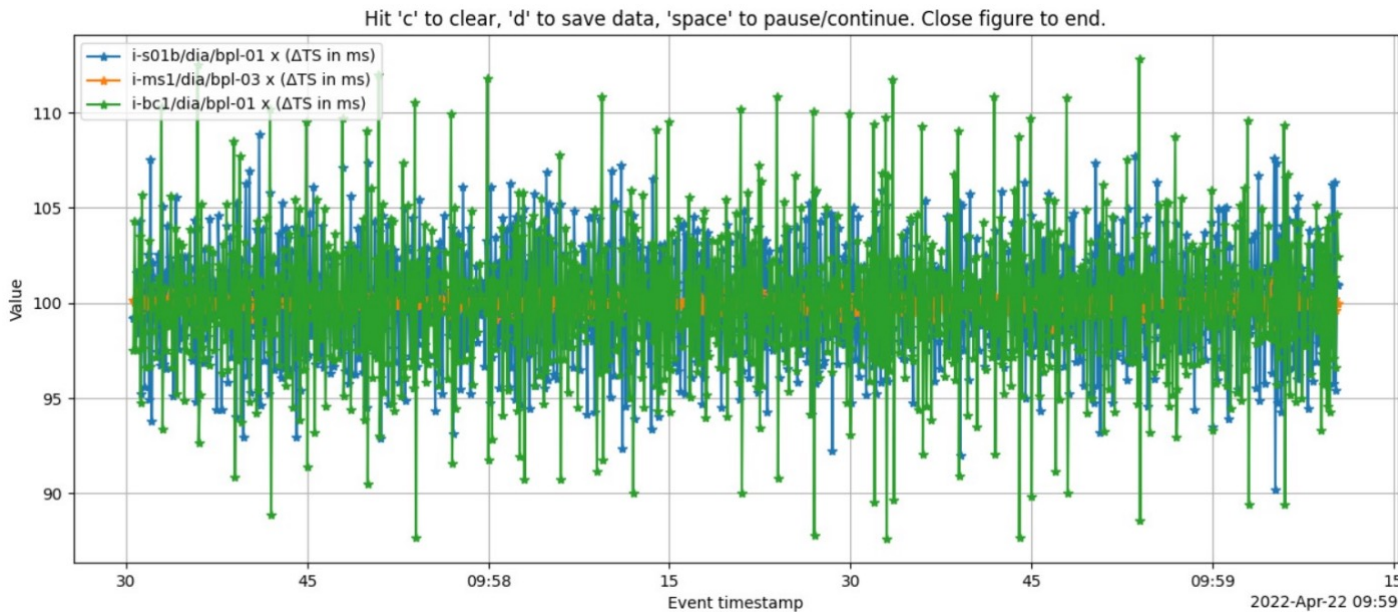
19th Int. Conf. Accel. Large Exp. Phys. Control Syst. ICALEPCS2023, Cape Town, South Africa JCoW Publishing
ISBN: 978-3-95450-238-7 ISSN: 2226-0358 doi:10.18429/JCoW-ICALEPCS2023-M03A002

IMPLEMENTATION OF MODEL PREDICTIVE CONTROL FOR SLOW ORBIT FEEDBACK CONTROL IN MAX IV ACCELERATORS USING PyTango FRAMEWORK

Carla Takahashi*, Aureo Freitas, Magnus Sjöström, Jonas Breunlin
MAX IV Laboratory, Lund, Sweden
Emory Jensen Gassheld, My Karlsson, Pontus Giselsson, LTH, Lund, Sweden

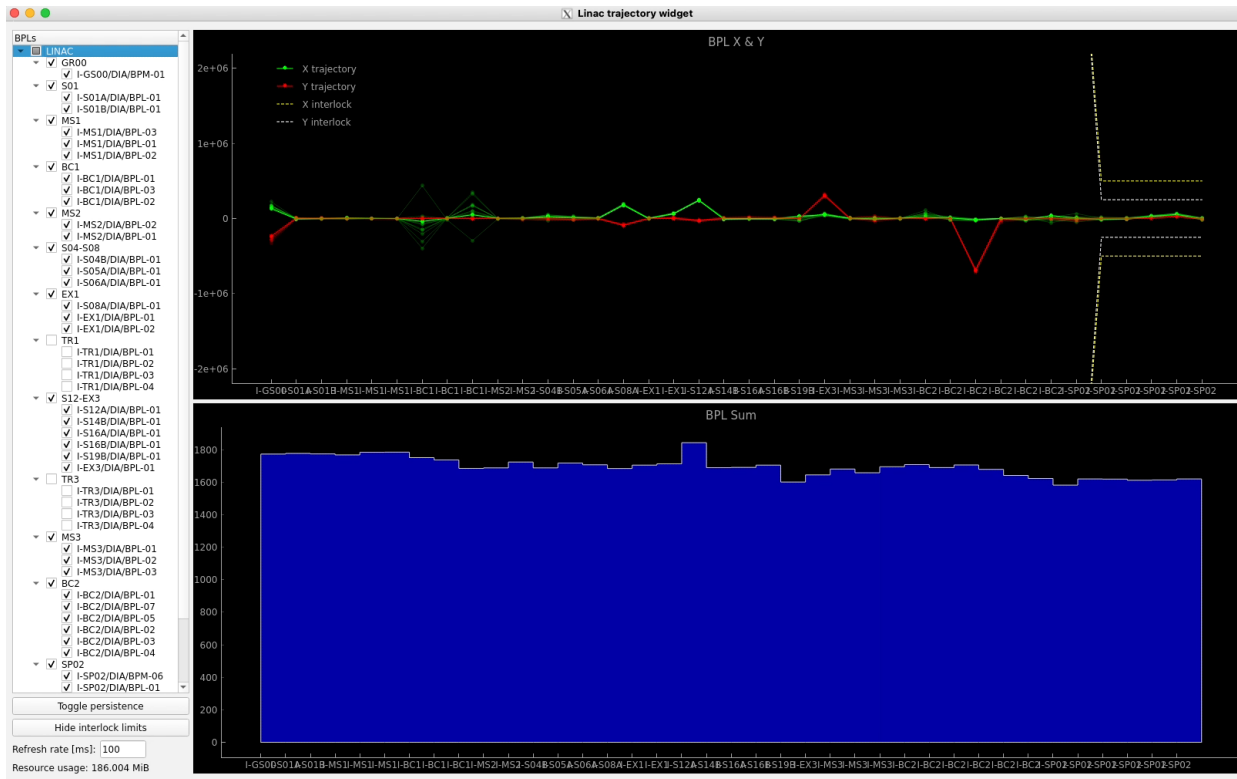
[doi:10.18429/JCoW-ICALEPCS2023-M03A002](https://doi.org/10.18429/JCoW-ICALEPCS2023-M03A002)

Applications



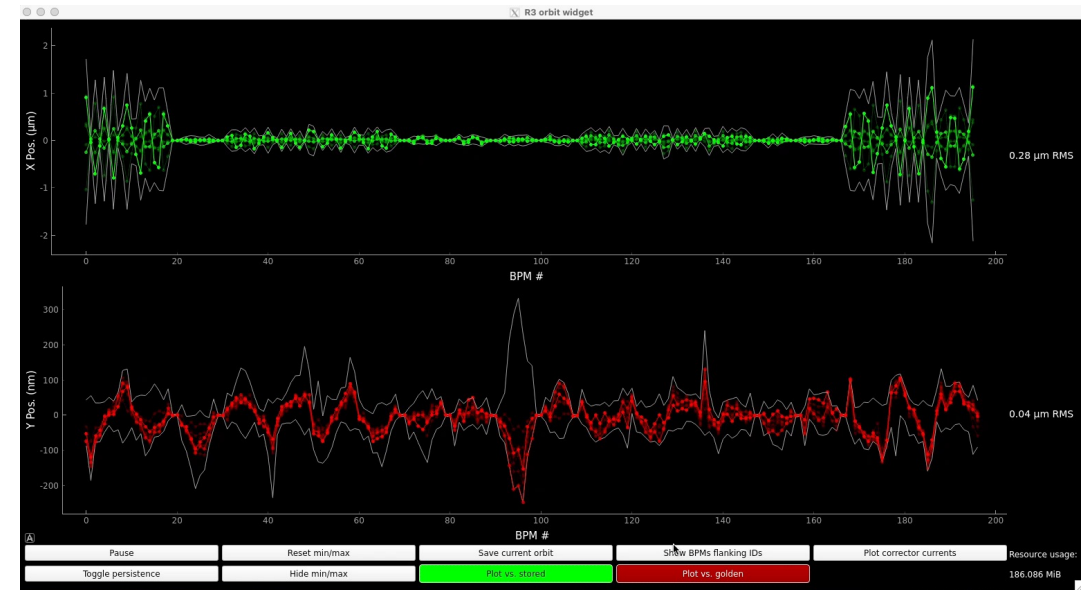
- 10 Hz slow data events – linac pulses and injection frequency
- NTP ~1ms accuracy – we haven't had the need to tune our NTP clients running on Liberas yet. Will be needed for 100 Hz linac upgrade as shown in the graph.
- 3s oscillation in our timestamp, most likely related to client polling, no verdict!
- 10 Hz correction loop for SOFB and Linac Trajectory Feedback
- SOFB synchronisation window of events at 50 ms

Applications – GUIs

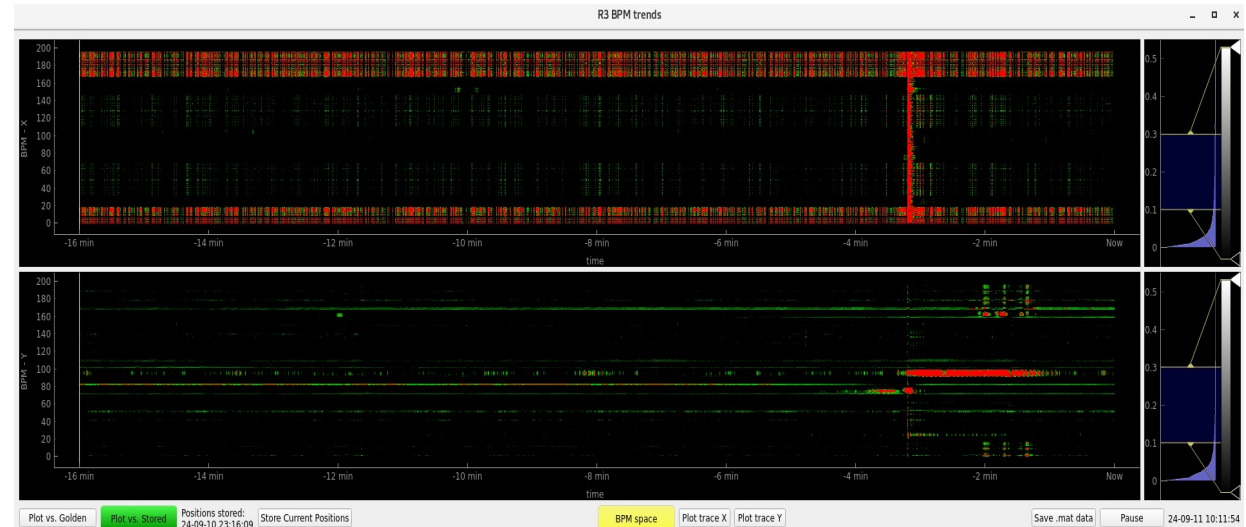


Linac trajectory widget on top-up

Thanks to operators!

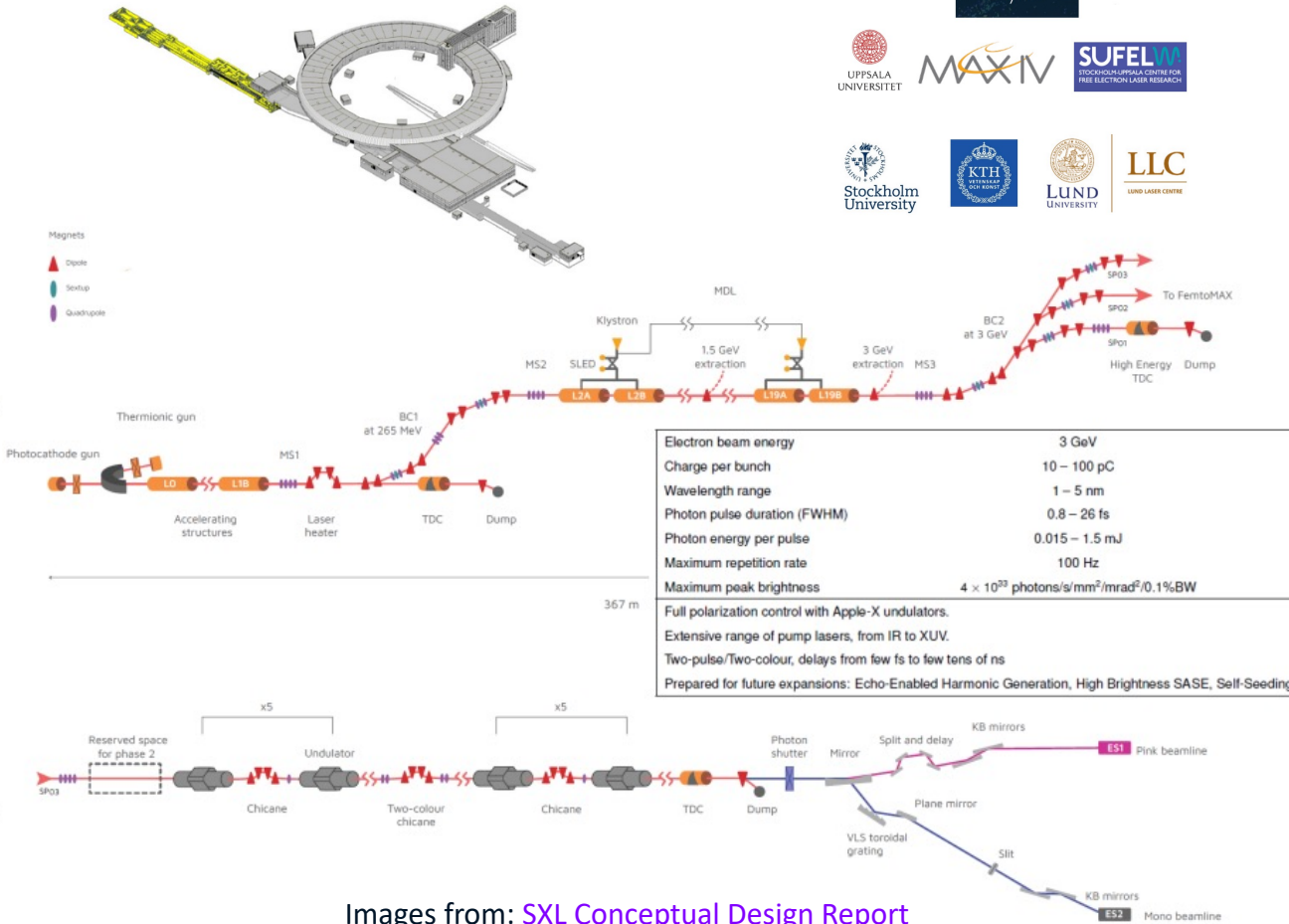


R3 SOFB BPMs orbit deviation widget



BPMs golden orbit deviation on time series. Effect of ForMAX closing IVU at minimum gap while FOFB was not optimal

Conclusion



Images from: [SXL Conceptual Design Report](#)

Lessons Learned:

- High Software maintenance cost!
- Needed where timestamp correlation is relevant using fast interruption based applications
- Diagnostics / troubleshooting

Beamlines:

- DAQ and scanning: PandABox relative timestamp and possible integration with MRF event receiver for pulse/bunch frequency (100MHz or sub-harmonics for storage rings at MAX IV and 10Hz-100Hz FemtoMAX) if needed.
- Time-resolved and TRIBs ?!

Future:

- MAX IV Soft X-RAY Free Electron Laser – SXL
 Undulator synchronism, trajectory compensation, pulse-by-pulse timestamping for diagnostics: evaluation of PTP, White Rabbit, MicroTCA based systems

The logo for MAXIV, featuring the word "MAXIV" in a stylized, white, sans-serif font. The letters are interconnected, with a prominent white swoosh or underline that curves over the top of the 'M', 'A', and 'X' and under the 'I' and 'V'.

MAXIV

Thanks!

Contact: aureo.freitas@maxiv.lu.se