

What it really means to support a (cross-continental) ML optimization loop for a user

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Disclaimer

THIS BEAMTIME WAS JUST IN 12/2023.

These slides are limited, however: We believe it's useful to share the experience.



So I met this user...

Optimizing high rep-rate radiography with machine learning

Includes slides originally presented at November 2022 ELI User Meeting

ELIUPM156 – 1st technical meeting – July 2023

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USER PROPOSAL

- Machine Learning-optimized x-ray and proton radiography
- Reliably diagnose laser-generated charged particles and x-rays at Hz rep rate
- Simultaneously vary multiple laser parameters, informed by ML techniques, to optimize and model proton and x-ray sources for improved radiographic capabilities



THIS IS NOT A TALK ABOUT ML itself.

It's a talk about all the small things you need to make it happen.

Input – and initial concept

The user wishes to implement a full machine learning feedback loop with his own interaction diagnostics (penumbra and *PROBIES*), combining E4 plasma + laser diagnostics data and controlling an acousto-optic programmable dispersion filter in L3 shot-by-shot using his own algorithm. The limiting factors for reprate are yet to be fully understood. The integration of a **new WFS** (**Optocraft**) is interesting and will be attempted as best-effort, but wasn't part of the proposal.





>30 MEETINGS WITH SUPPORT **TEAMS FROM BOTH SIDES**

Skillset limitations of physicists

MACHINE SAFETY AND COMMISSIONING CONCEPT

- Letting an algorithm apply too much chirp fries the amplifier
- Laser operators are very nervous about that.. Even if you implement a feedback loop
- The laser operator always needs to be able to stop the algorithm



Useful initial tool: algorithm requests a batch of parameters; laser operator confirms it's safe, laser is operated in bursts.



Repeat command in case something goes wrong.

	Enabl	e Remote Control fro	m GUI Off/On			CURRENT	Timeout	ote cont
hot request in	current sessio	n		Dazzler prese	ets			
Timestamp		Number of Shots	Period [ms]	"Shot" numb	er GDD	TOD	FOD	
			v					
•			►	-				•
				GDD	TOD	FOD	Timeout for Da	zzler wr
o LLNL that th	e current batch	has finished >>>	STOP STOP LLNL	22040	-67700	-29000	500 🚔	

You'll need start / stop commands for both sides. If you are not careful, they will mess up your data.



MAKING DEVICES ACTUALLY FEEDBACK-LOOP COMPATIBLE

- Dazzler are <u>not</u> designed for such feedback loops
- If you have problems with that: Get in touch, it took us some time. We're just discussing the device driver with CLF/EPAC.

SOFTWARE INTERFACES FOR DATA EXCHANGE

- The user software somehow needs to be able to send commands to the laser and get data
- Software definition changed few times; there's no standard solution

Interesting challenge: Our experimental side used a different CS Integration mechanism. We use a multi-model data concept for that.



Remote control DISABLED					
	Actual D	elta			
Order 2 0		0 fs^2	Apply		
Order 3 0		0 fs ^3	Apply		
Order 4 0		0 fs^4	Apply		



NETWORKS, POLICIES AND CYBERSECURITY CONCEPT

- User networks, policy need to be defined
- Cybersecurity concept needs to be defined deep system access
- This is about keeping systems from both sides safe (and that leads to interesting discussions on versions of protective softwares between cybersecurity teams..)

	Option 1 Scientist VLAN	Option 2 Scientist LCS	Option 3 External USER VLAN	Option 4 Fiber Point-To-Point
What is it?	HALL \longleftrightarrow CONTROL Dur switches, your devices. Kill your own toys, don't kill anyone.	HALL CONTROL ROOM FLI OFFICE	HALL \longleftrightarrow CONTROL Don't mix with internal devices	HALL HALL 1:1 via fiber
Description	Ports on our switches, between halls and control rooms. Lots of freedom, quasi unlimited bandwidth, limited services. Darwinism = feel free to selfeliminate your equipment	Ports on our switches, dedicated connection to special office machines possible. Strict Compliance required, bandwidth limitations, more network services	Ports on our switches, between halls and control rooms. Dedicated for users, to isolate unknown / not- trusted devices from internal networks. Same features as option 1.	Point-to-point fiber interconnections. Fibers + converters can often be provided by u Below you can see how specify that.
Network Type	Layer 2 VLAN, provided using ports on CS switches in laser building	VLAN, LCS, Layer 3. <u>Can</u> cover specific ports & machines in office	Layer 2 VLAN, provided using ports on CS switches in laser building	Single Mode Fibers, LC type preferred, MPO optional
Typical use- case	Cameras, Remote Control	Data Retrieval from Office	Devices brought by suppliers, users, external partners	EMP, Radiation





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Network Access / Code of Conduct for External Scientific Users at ELI Beamlines



	Position	Name	Date	
Prepared by	Central Control Systems Group Leader	Birgit Ploetzeneder	28.08.2023	PL.
Agreed by	Director of Research and Operations	Daniele Margarone	28.8.2023	Bor
Quality Assurance	Group Leader of Quality and Planning	Viktor Fedosov	20. 8. 2003	0



TIMING SYSTEMS AND SHOT ASSOCIATION

- Perhaps the hardest part
- User devices need to be synched up to facility time
- NTP and PTP require Admin rights
- Verify that all involved devices are REALLY linked up to facility time...
- The challenging part is that timestamps aren't enough, timestamps need to be associated with shot numbers...



Facility Time and Triggers



Owned by Birgit Ploetzeneder *** Last updated: Jan 31, 2024 • 2 min read • 🗠 11 people viewed • 🕛 Attachments • 🖄 Content Report • 🖾 Tasks

- Timestamps
 - Timezone
 - Timestamps
 - Time Protocols
 - NTP Network Time Protocol
 - PTP Precision Time Protocol
- Triggers
 - Available Triggers
 - Electronic timing triggers by MRF HW
 - Electronic timing triggers by Greenfield HW
 - Electronic timing triggers by WhiteRabbit HW
 - Trigger Fanouts
- Synchronization
- Training Material

Timestamps

Timezone

Our facility time is UTC (Coordinated Universal Time), and we receive it from GPS. UTC is essentially the same as Greenwich Mean Time (GMT) but is more precisely defined and with no seasonal adjustments (like Daylight Saving Time). This is for data reasons - you don't want to have gaps in your databases..



Let's take it into hard mode: The user couldn't get the software through export control.

Doesn't a spontaneous cross-continental feedback loop sound like fun?





CYBERSECURITY 2.0

 Access, authentication, firewalls between highly vulnerable networks in 2 majors labs



LATENCY

- Turns out cross-continental data communication is slow. The speed of light limits the reprate..
- (The actually limiting factors are different, but it was



Outcome and further steps

Simultaneous deployment of multiple high repetition rate (>Hz) diagnostics with integrated neural network analysis for a new paradigm of laser-driven HED experiments

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OUTCOME

- Preliminary data processing and early publication: Optimization was successful
- User wants to come back
- More users want to do the same...

NEXT STEPS

Fail better next time.

- Improved latency and transfer for live data access
- Solve shot association / data extraction
- Better (and more standard?) interfaces