Subsync

Select Status Update FLASH2020+ WP T5 and P7

Sebastian Schulz on behalf of WPs T5 and P7 and All Other Involved Parties

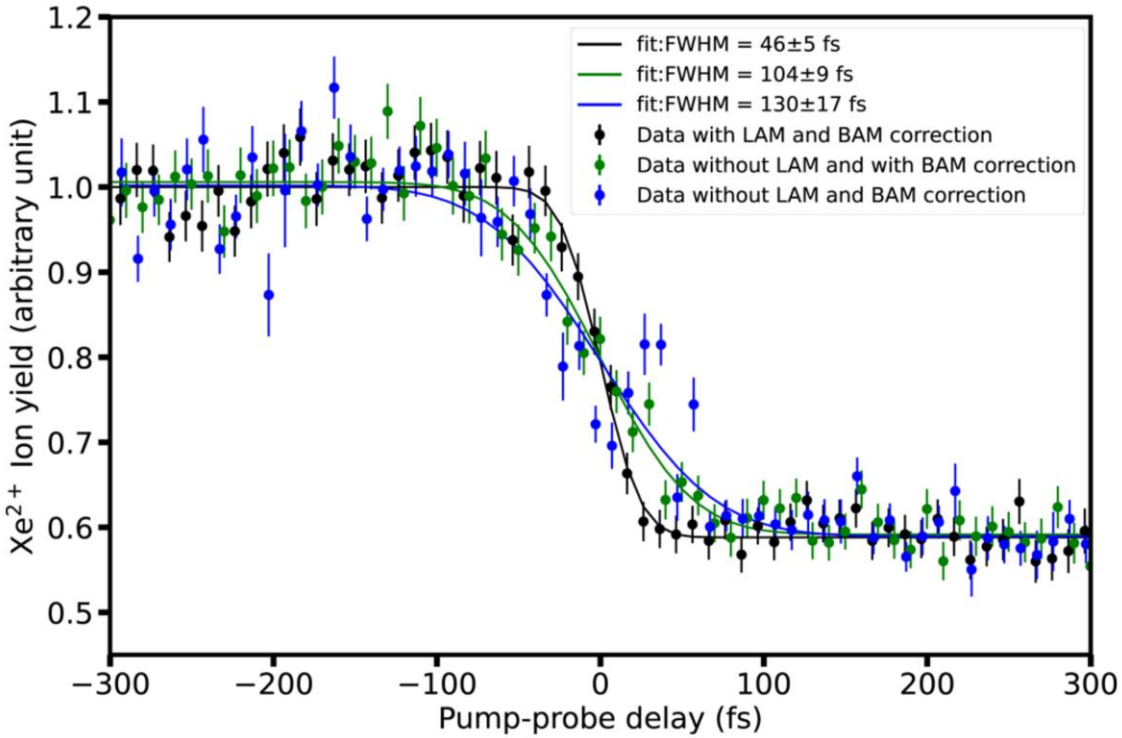
Progress Review Meeting, 8 March 2024

HELMHOLTZ

DESY.

Motivation

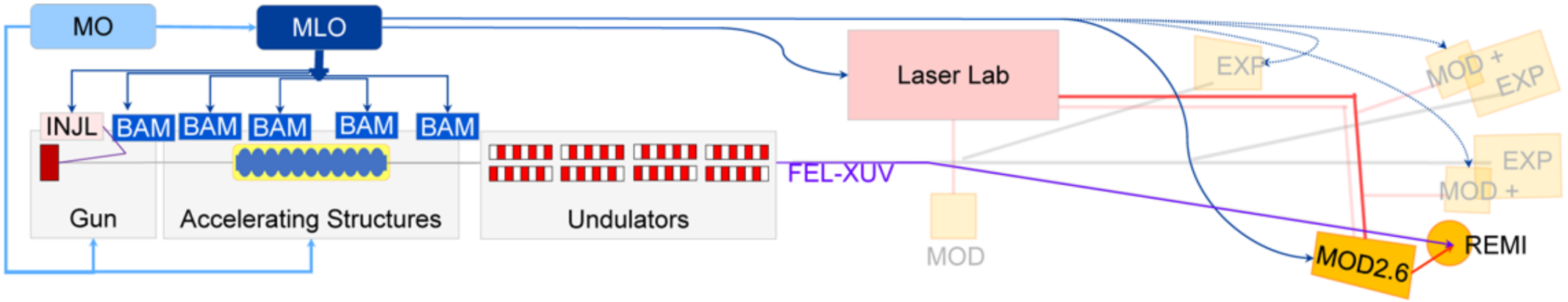
Improvement of Temporal Resolution in User Experiments



Atia-tul-noor *et al.*, Opt. Express 32(4), 6597-6608 (2024)

Linac/BAM Correction and LAM Feedback

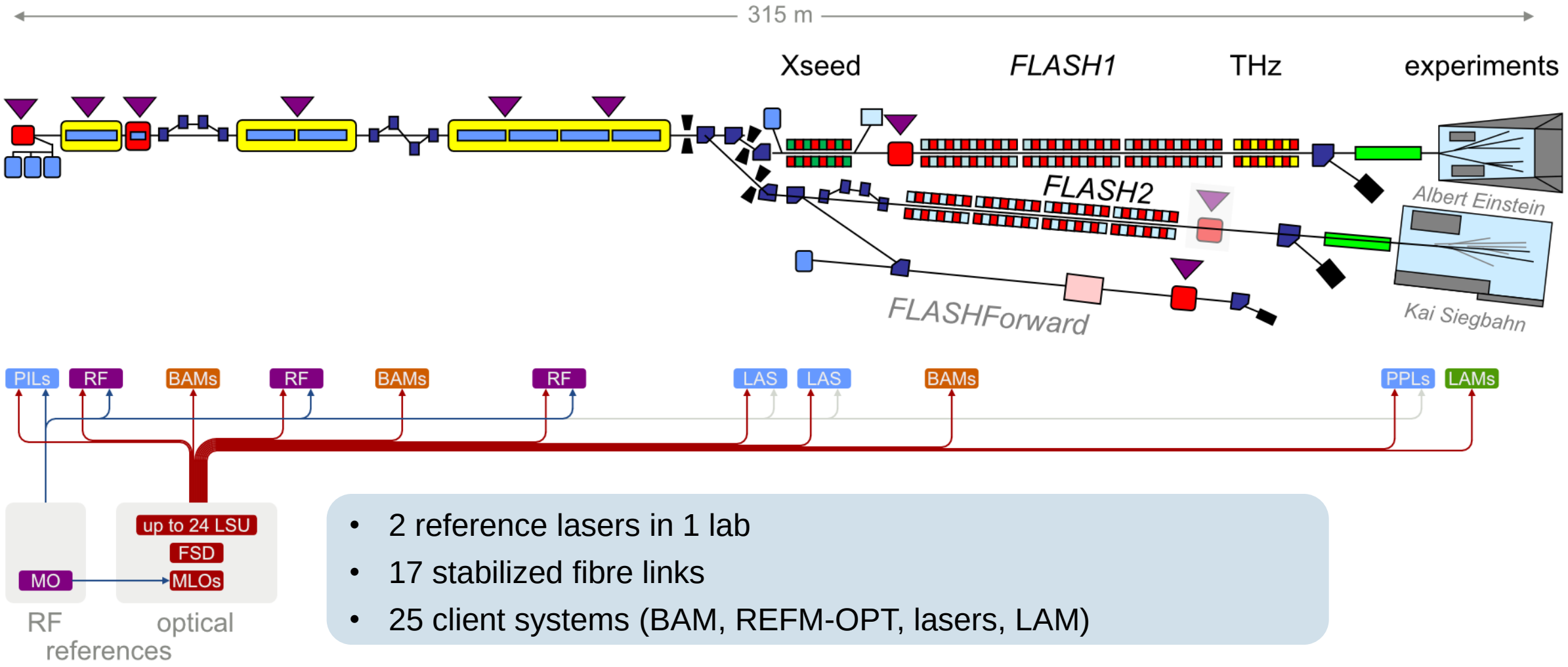
Stabilisation of Laser Pulse Arrival Time at the Actual Experiment



Atia-tul-noor *et al.*, Opt. Express 32(4), 6597-6608 (2024)

Status Quo

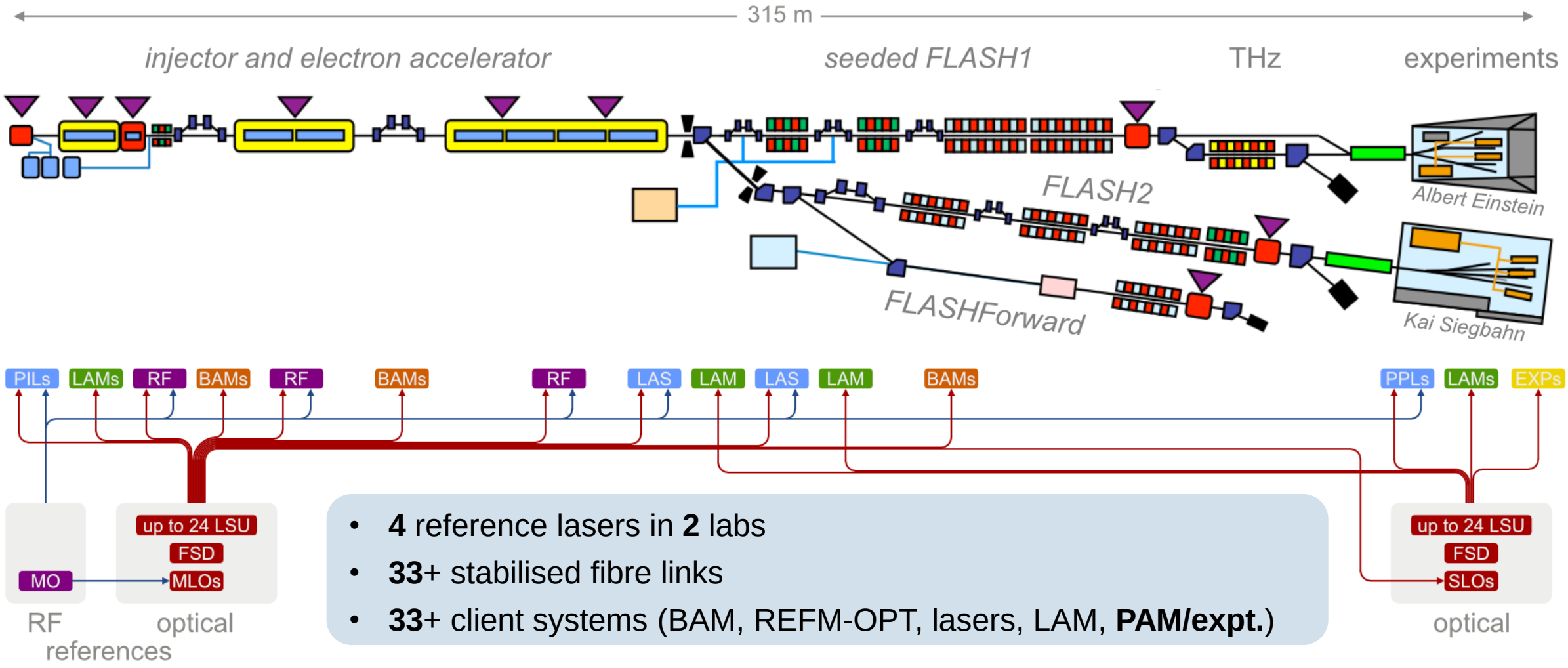
Overview of the FLASH Femtosecond Synchronisation System Before the Shutdown



- 2 reference lasers in 1 lab
- 17 stabilized fibre links
- 25 client systems (BAM, REFM-OPT, lasers, LAM)

FLASH2020+ Femtosecond Synchronisation “2025+”

System Topology with Main and Sub-Synchronisation Laboratories

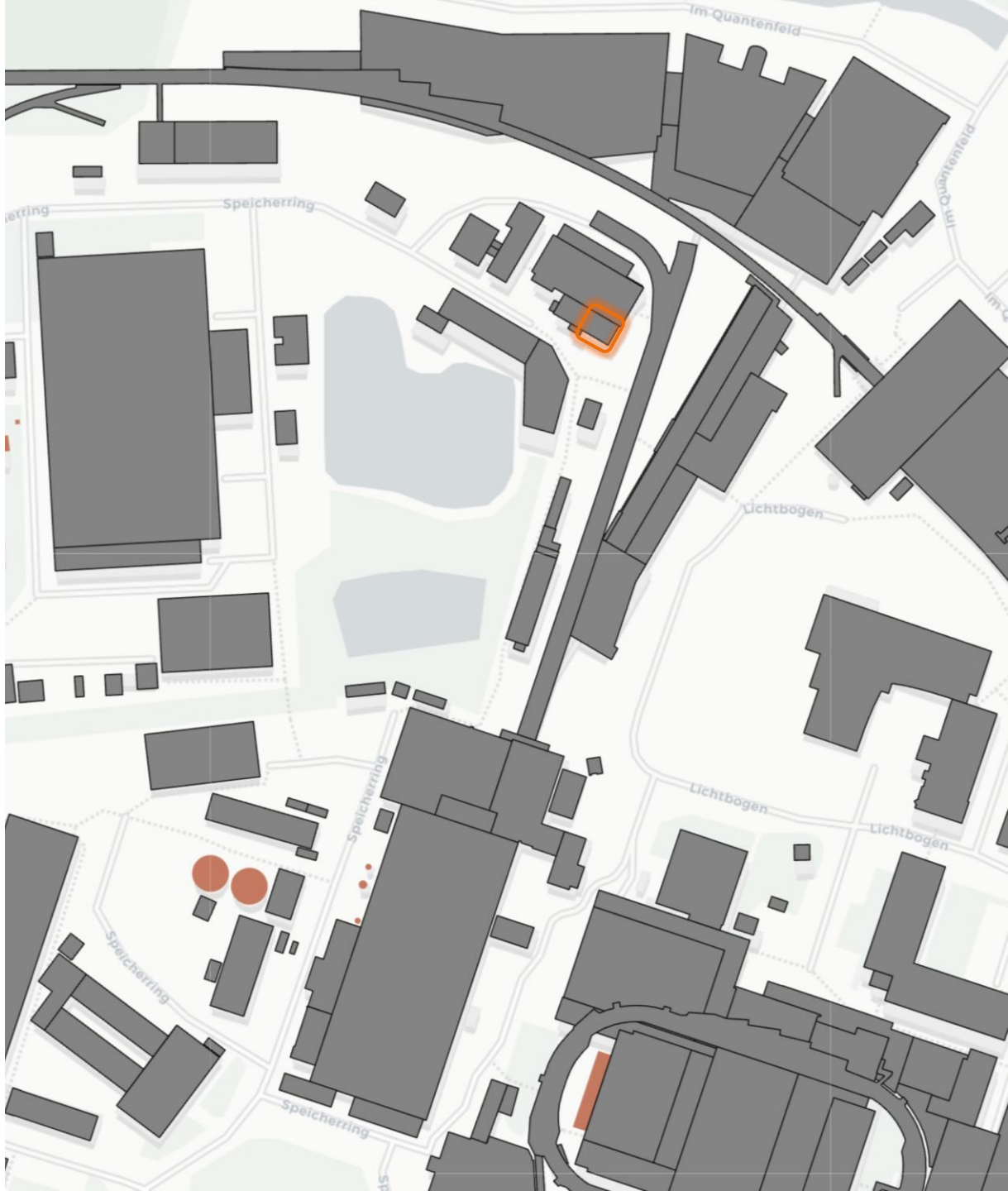


- **4** reference lasers in **2** labs
- **33**+ stabilised fibre links
- **33**+ client systems (BAM, REFM-OPT, lasers, LAM, **PAM/expt.**)

Sub-Synchronisation Lab

Building 49, New Rooms 008c, 008d, 008e

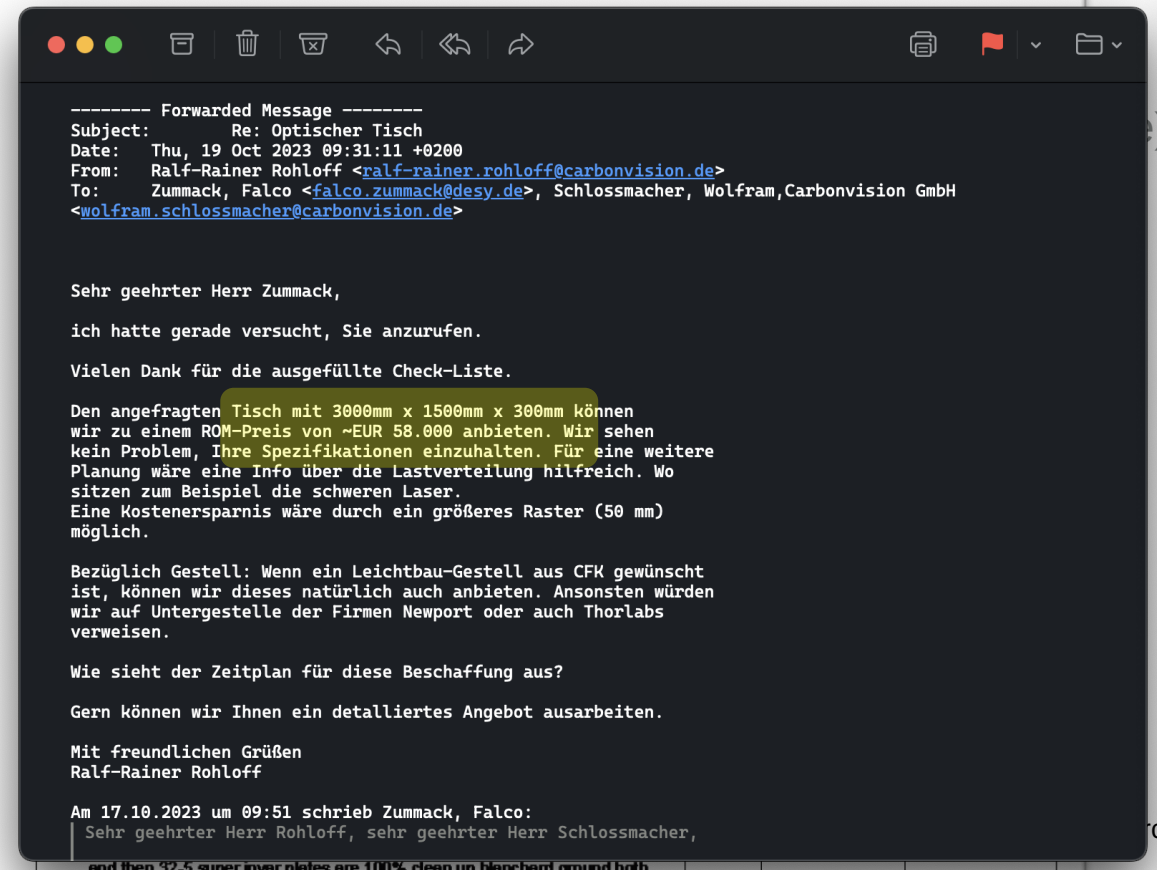
- ✅ c. 40 m² (separated into three rooms)
- ✅ precision A/C in optics area
  - 0.1 degC, RH ±1%
  - low acoustic & vibrational noise, low volume flow air exhaust for optical table
  - suspended ceiling (optics area ⇒ smaller volume)
- ⚠ EMI/grounding (central point)
- ✅ double/raised floor (electronics + optics)
- ⚠ network/IT (fibre-optical, dedicated switch, 2×10 Gbit uplink for DAQ)
- ⚠ synchronization (PMF) and timing fibres (SMF)
- ✅ 1.3 GHz reference from MO



Sub-Synchronisation Lab

Planned Installations

- optics area, c. 25 m^2
  - ⚠ **main optical table**: lasers, LSU, ODLs, user delay, diagnostic
    - req. ultra-low CTE, lowest influence on humidity



-------- Forwarded Message --------
Subject: Re: Optischer Tisch
Date: Thu, 19 Oct 2023 09:31:11 +0200
From: Ralf-Rainer Rohloff <ralf-rainer.rohloff@carbonvision.de>
To: Zummack, Falco <falco.zummack@desy.de>, Schlossmacher, Wolfram,Carbonvision GmbH <wolfram.schlossmacher@carbonvision.de>

Sehr geehrter Herr Zummack,

ich hatte gerade versucht, Sie anzurufen.

Vielen Dank für die ausgefüllte Check-Liste.

Den angefragten Tisch mit 3000mm x 1500mm x 300mm können wir zu einem ROM-Preis von ~EUR 58.000 anbieten. Wir sehen kein Problem, Ihre Spezifikationen einzuhalten. Für eine weitere Planung wäre eine Info über die Lastverteilung hilfreich. Wo sitzen zum Beispiel die schweren Laser.
Eine Kostenersparnis wäre durch ein größeres Raster (50 mm) möglich.

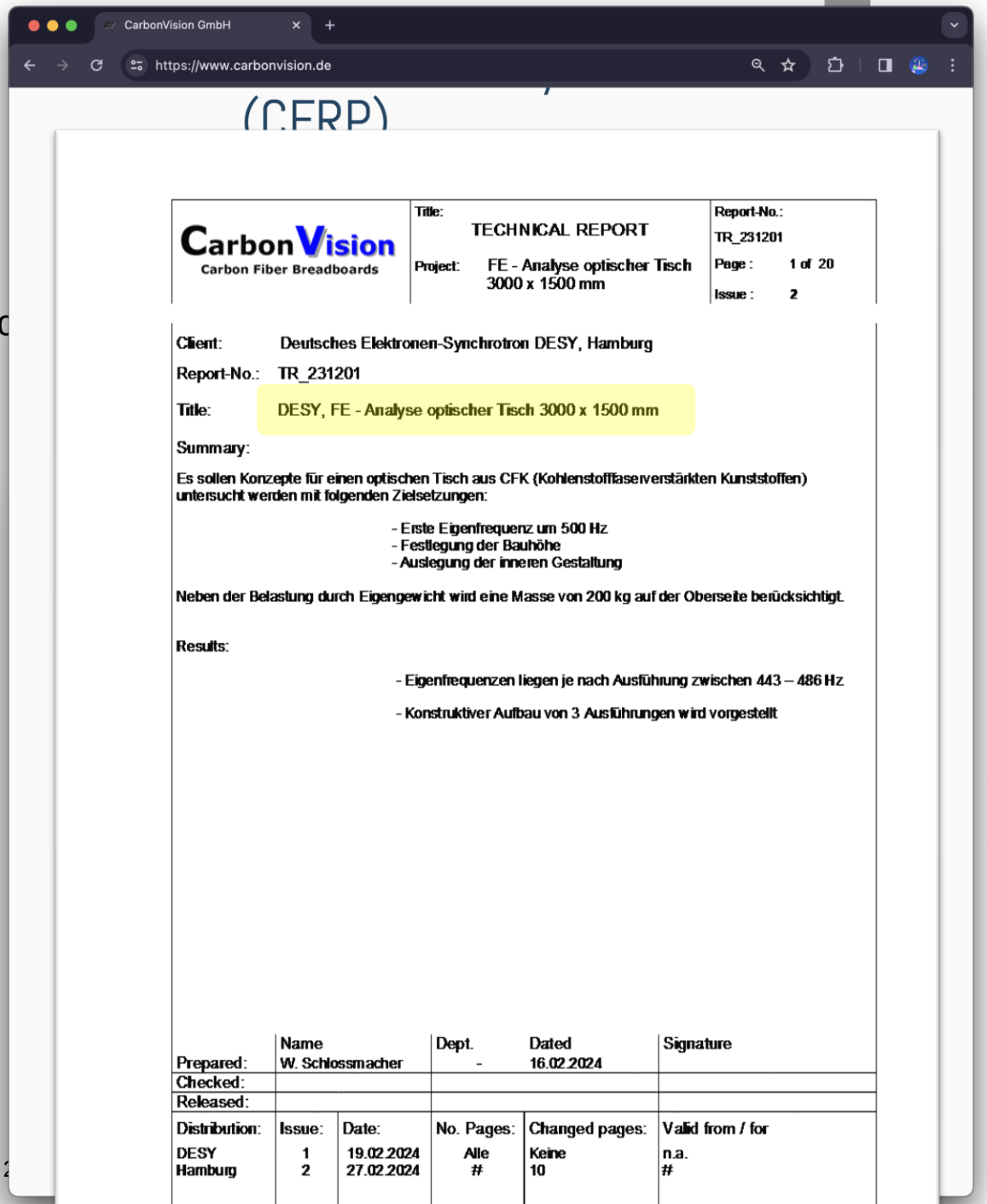
Bezüglich Gestell: Wenn ein Leichtbau-Gestell aus CFK gewünscht ist, können wir dieses natürlich auch anbieten. Ansonsten würden wir auf Untergestelle der Firmen Newport oder auch Thorlabs verweisen.

Wie sieht der Zeitplan für diese Beschaffung aus?

Gern können wir Ihnen ein detalliertes Angebot ausarbeiten.

Mit freundlichen Grüßen
Ralf-Rainer Rohloff

Am 17.10.2023 um 09:51 schrieb Zummack, Falco:
> Sehr geehrter Herr Rohloff, sehr geehrter Herr Schlossmacher,



CarbonVision GmbH
https://www.carbonvision.de

(CFRP)

CarbonVision
Carbon Fiber Breadboards

Title: TECHNICAL REPORT
Project: FE - Analyse optischer Tisch 3000 x 1500 mm
Report-No.: TR_231201
Page: 1 of 20
Issue: 2

Client: Deutsches Elektronen-Synchrotron DESY, Hamburg
Report-No.: TR_231201
Title: DESY, FE - Analyse optischer Tisch 3000 x 1500 mm

Summary:

Es sollen Konzepte für einen optischen Tisch aus CFK (Kohlenstofffaserverstärkten Kunststoffen) untersucht werden mit folgenden Zielsetzungen:

- Erste Eigenfrequenz um 500 Hz
- Festlegung der Bauhöhe
- Auslegung der inneren Gestaltung

Neben der Belastung durch Eigengewicht wird eine Masse von 200 kg auf der Oberseite berücksichtigt.

Results:

- Eigenfrequenzen liegen je nach Ausführung zwischen 443 – 486 Hz
- Konstruktiver Aufbau von 3 Ausführungen wird vorgestellt

	Name	Dept.	Dated	Signature
Prepared:	W. Schlossmacher	-	16.02.2024	
Checked:				
Released:				

Distribution:	Issue:	Date:	No. Pages:	Changed pages:	Valid from / for
DESY Hamburg	1	19.02.2024	Alle	Keine	n.a.
	2	27.02.2024	#	10	#

Fibre Link Connections

Clients and Sub-Systems – A Somewhat Final Draft without MEMS

client (reference: main*)	fibre exists	action		client (reference: subsidiary)	fibre exists	action
NEPAL-F1	yes	none		PiGLET laser	no	new
NEPAL-F2	yes	none		LAM at PG (VIS-IR)	no	new
heater laser	yes	none		FL1 PP laser	no	new
RF re-sync. ACC139	yes	none		LAM FL11	no	new
BAM UBC1	yes	none		FL1 THz exp't laser	no	new
BAM DBC1	yes	none		FL2 PP laser	partly	re-route/re-use
RF re-sync. ACC23	yes	none		LAM FL23	no	new
BAM UBC2	yes	none		LAM FL24	no	new
BAM DBC2	yes	none		LAM FL26	no	new
RF re-sync. ACC45	yes	none		TRANSALP/ErUM Pro laser	partly	re-route/re-use
BAM FL1LOLA	maybe	re-route/re-use (?)	=	BAM FL1LOLA	partly	re-route/re-use
BAM FL1RADT	no	new	=	BAM FL1RADT	no	new
seed laser (28M)	yes	re-route/re-use	=	seed laser (28M)	no	new
LAM seed laser (tunnel)	partly	re-route/re-use (?)	=	LAM seed laser (tunnel)	no	new
BAM FL2SEED5	yes	re-route/re-use	=	BAM FL2SEED5	partly	re-route/re-use
laser sub. reference "SLO FL1"	partly	re-route/re-use		laser main sync. lab	partly	re-route/re-use
laser sub. reference "SLO FL2"	partly	re-route/re-use		FL1 and FL2 exp't (e.g. PAM)	no	new

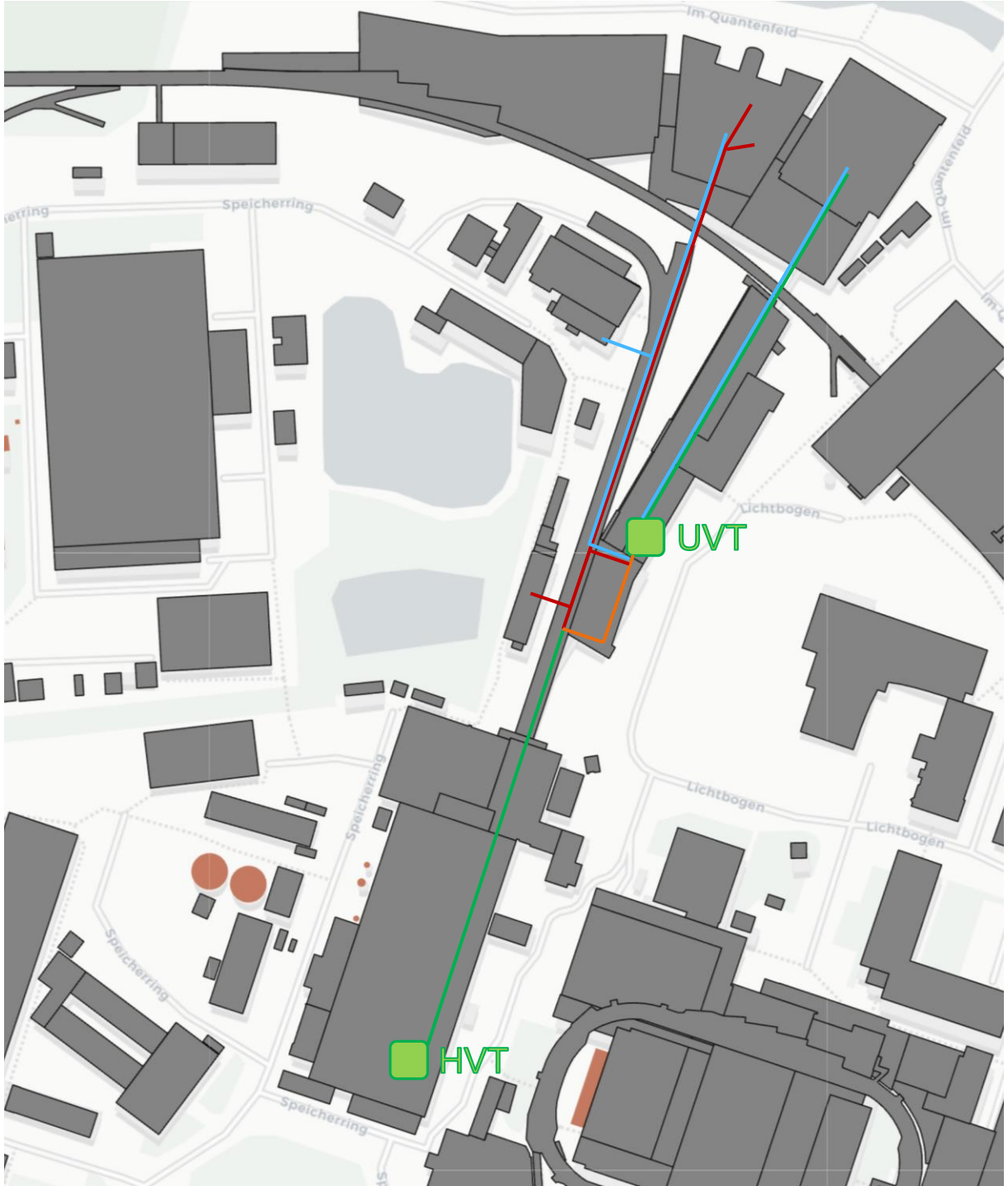
*plus two additional links for FLASHForward laser and BAM FLFMAFF, active, fibre link likely to be re-routed

Fibre Installation

Re-route and Re-use?

⚠ **work in progress**

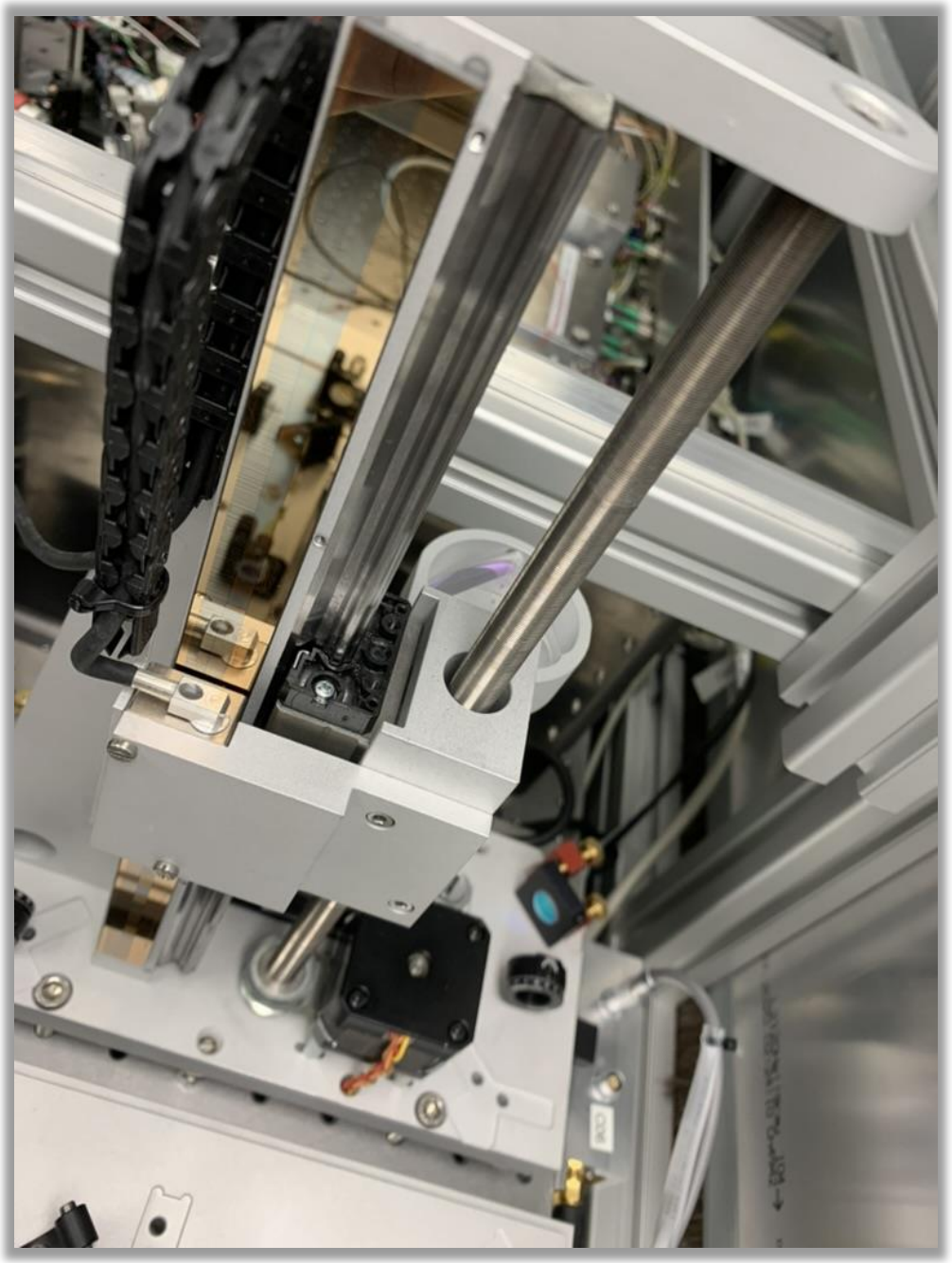
- many fibres via extraction to “UVT” (28i)
  - can/need potentially be re-routed through extraction
- fibres to 28g probably can be re-routed as well
- BAM 1SFELC (FL1LOLA) can probably be re-used
- new fibres for LAMs and exp’t in FL1 and FL2
- ideally many spare “*speedpipes”*, even to 49d
- **all “accelerator systems and lasers” from main**
- **PP, experiment lasers and LAMs from sub**
- **best utilisation, most flexible solution**
- **re-using PMF saves real money (17 USD/m)**



User Delay and Feedback Concept

Shifting Time Between Optical Laser and FEL

- in-house built 5-ns ODL **not optimised** for continuous high-precision scans
  - designed for occasional movement for link stabilisation
  - **however, presently used** at FLASH and the EuXFEL, partly equipped with position encoder
- ODL shall not be installed at the MODs
- move ODLs (partly) into synchronization lab
  - scan should neither affect other users and client systems nor the accelerator operation (e.g. BAM)
  - small, quiet ODL for user delay scans?
- user scan ranges: typically **few-10 ps**
- constraints automation & control?
  - simultaneous operation of two MODs with LAMs
  - simultaneous experiments at FLASH1/FLASH2



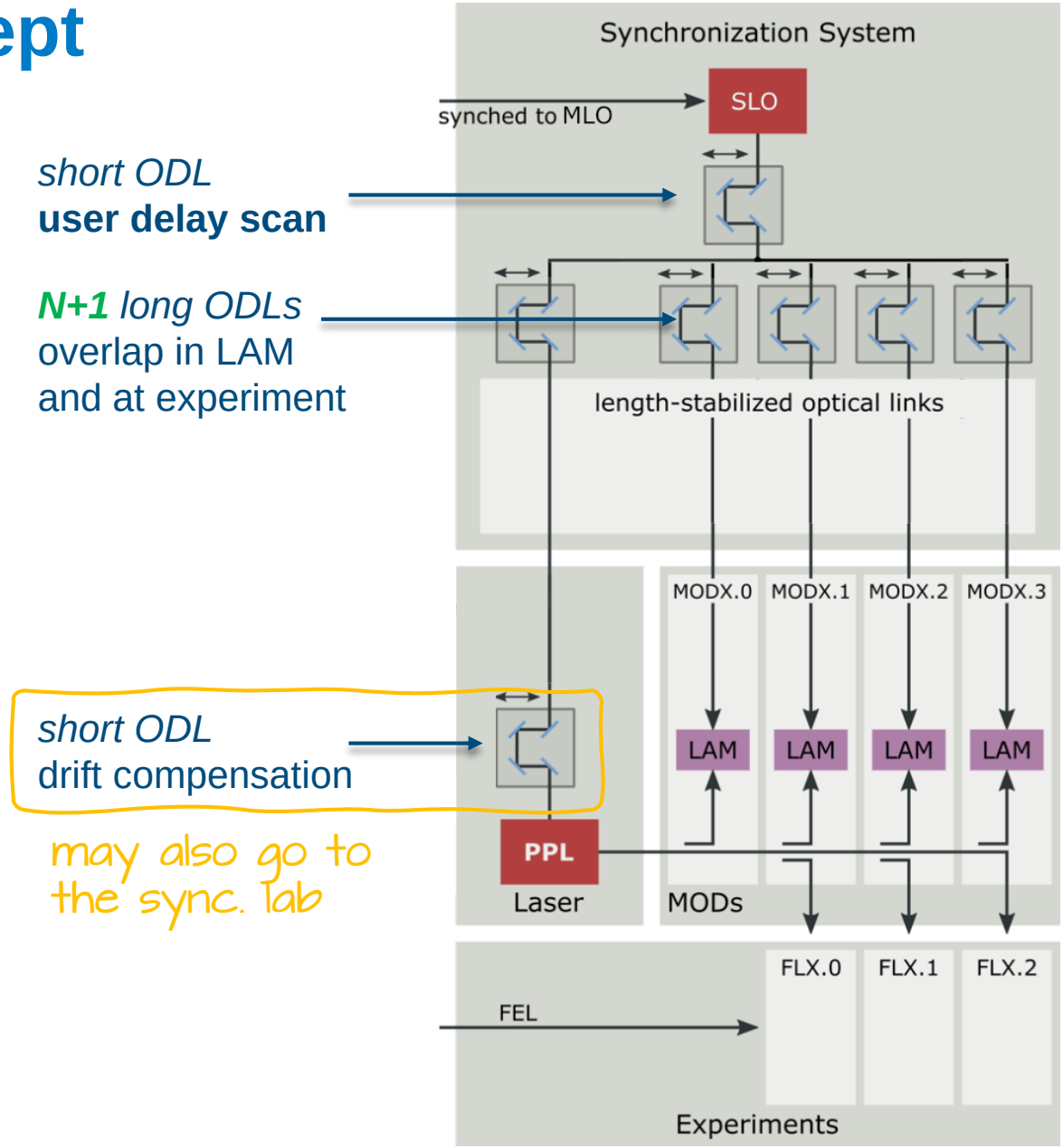
original sketch courtesy of Jost Müller

er Delay and Feedback Concept

MEMS vs. Non-MEMS Solution at FLASH

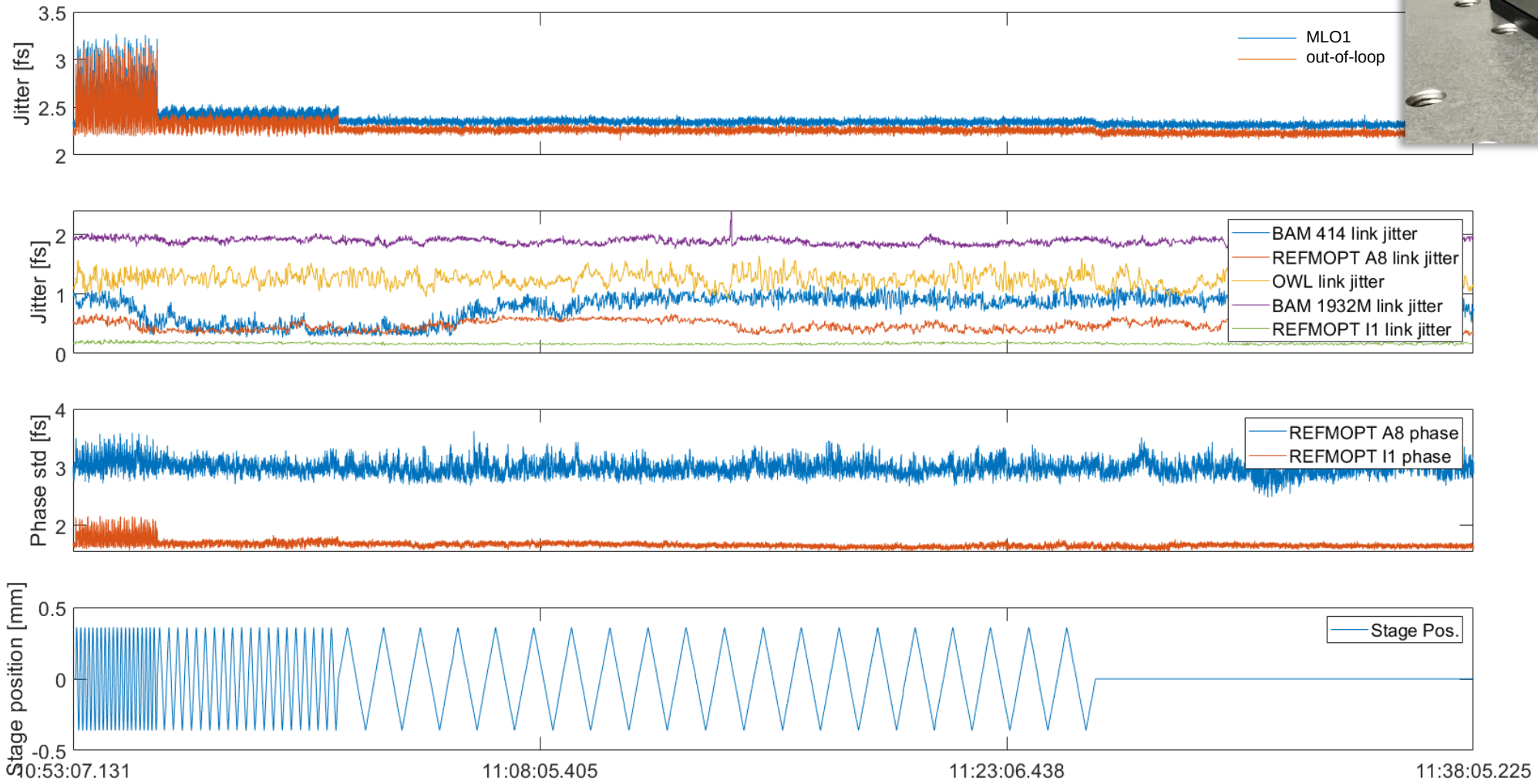
- dedicated fibre link per client
- more flexibility
- better performance
- easier to extend and upgrade
- 2x4 MEMS quite expensive
  - but, alas, 4-2 ODLs and drivers as well…
- removes “a layer” of complexity in automation
  - and no further, additional hardware (like Beckhoff)

- envisioned feature: feedback actuator for laser system drift compensation in sync. system



Optical Delay Line Selection

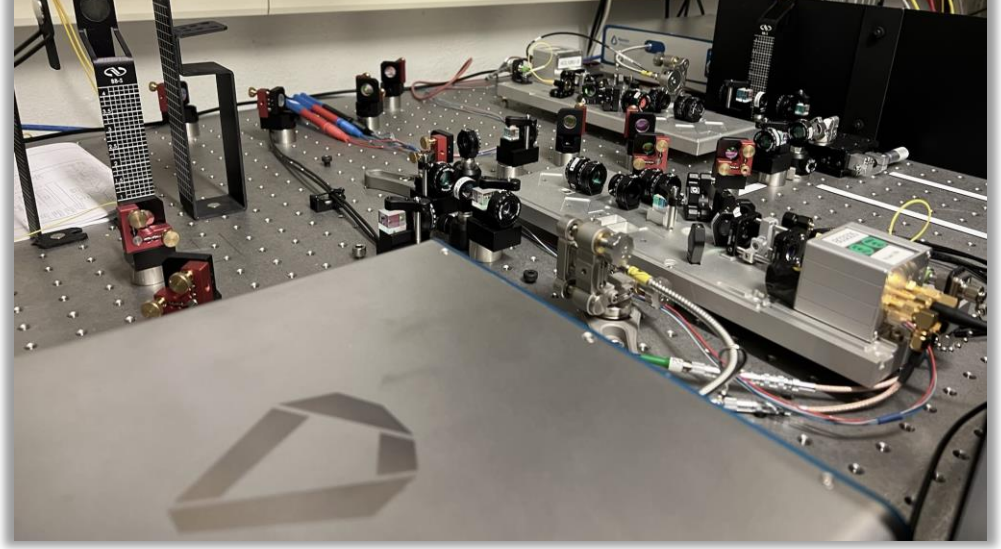
Induced Timing Error – Example of PI Inertia Driven Stage

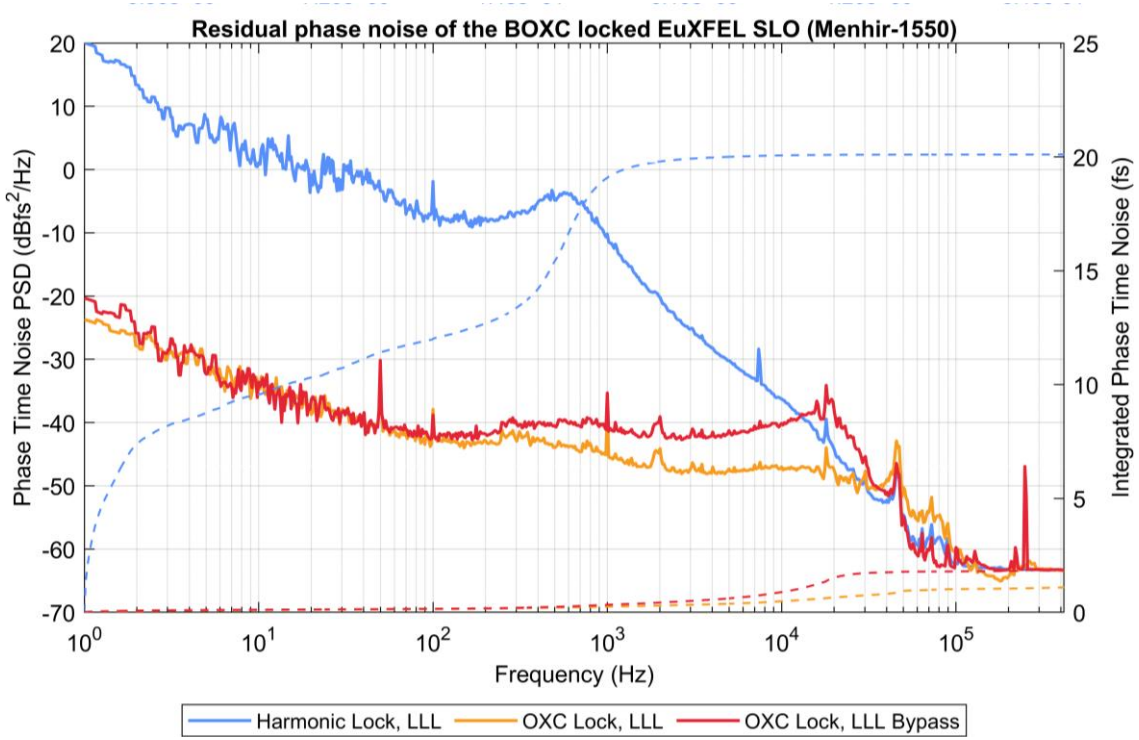


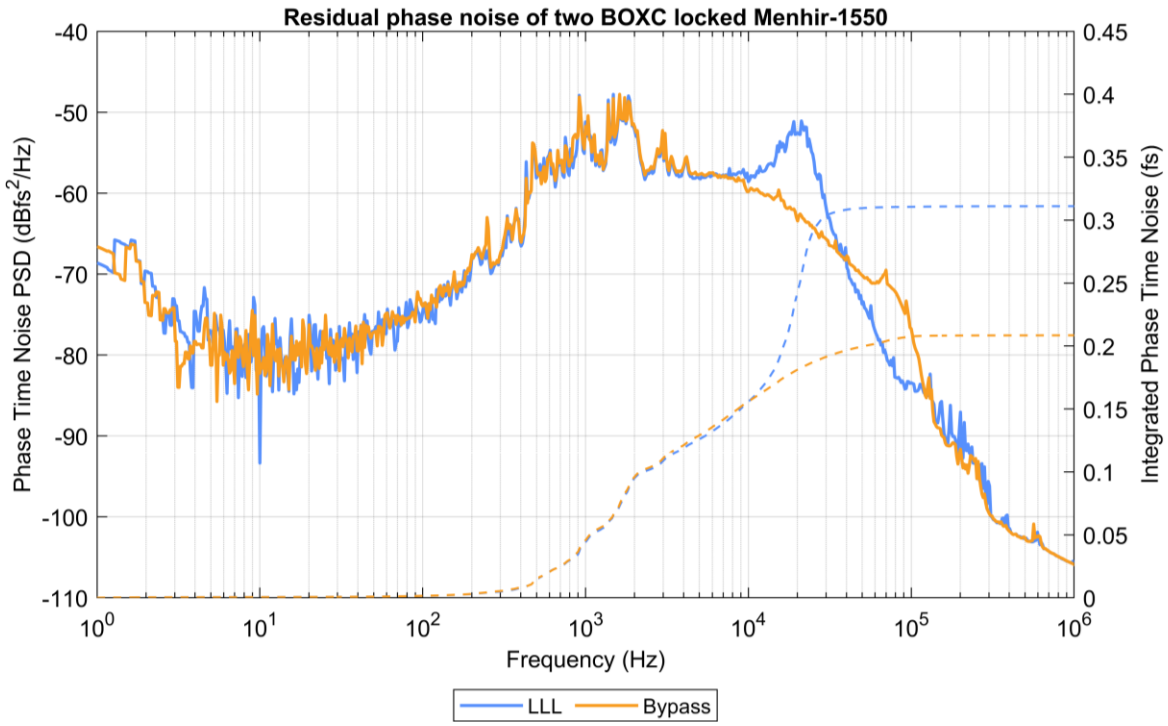
plots courtesy of Anne-Laure Calendron

Laser-to-Laser Lock

Subsidiary onto Main Laser Oscillator







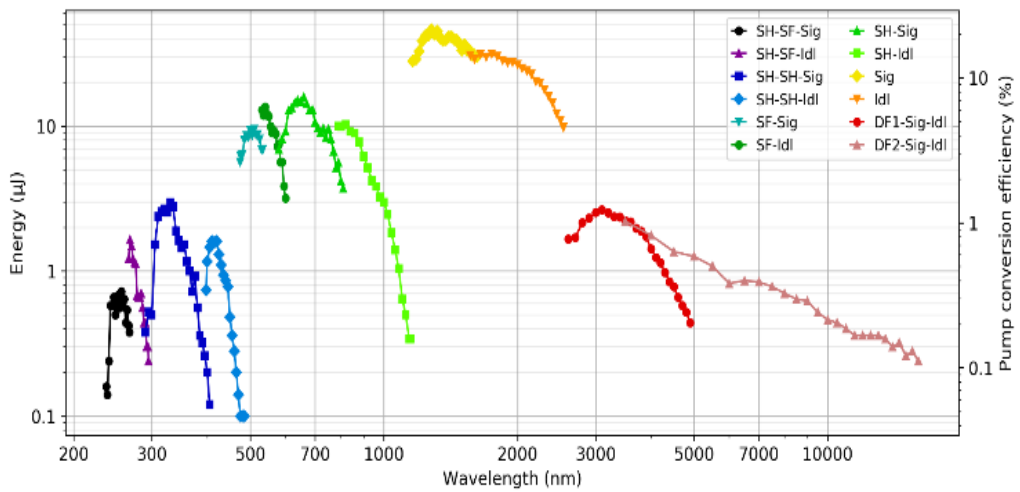
- laser-to-link (over 4 km of fibre): **1 fs** rms
- lab environment (over 1 m free-space): **0.2 fs** rms

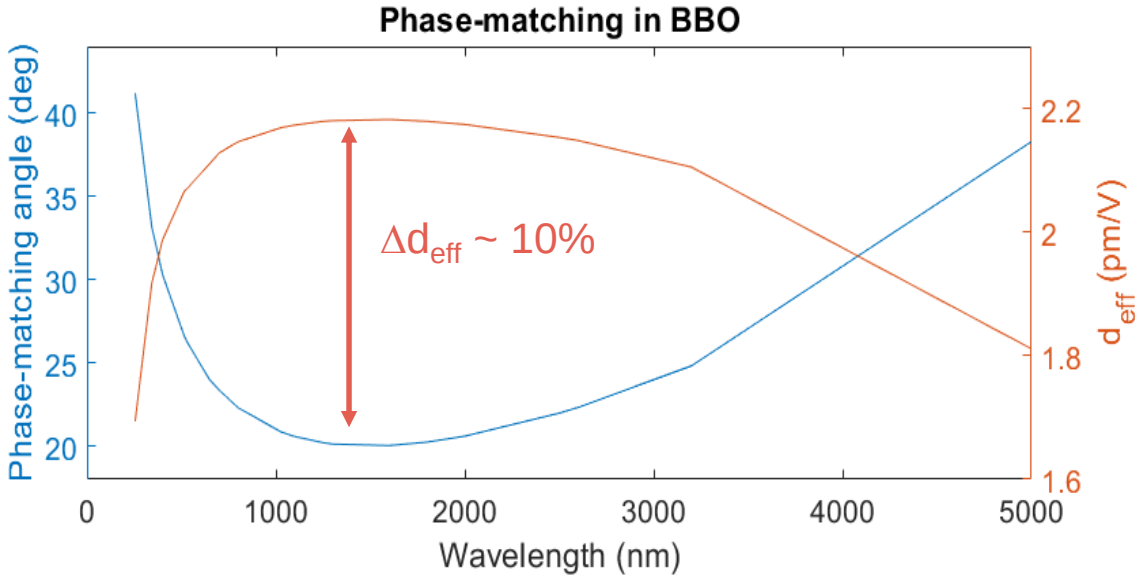
plots courtesy of Maximilian Schütte

Advanced Laser Pulse Arrival Time Monitors

One of the Challenges: Coverage of a Large Spectral Range for User Experiments

- fundamentals: 800 nm and 1030 nm
- SHG, THG, FHG: 400 nm, 266 nm, **515 nm**, 343 nm, 258 nm
- NOPA, SFG, DFG, e.g. with Topas:

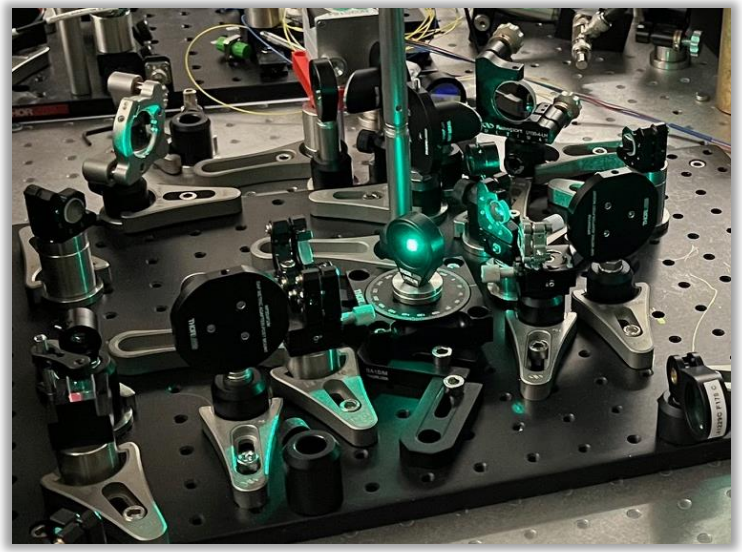


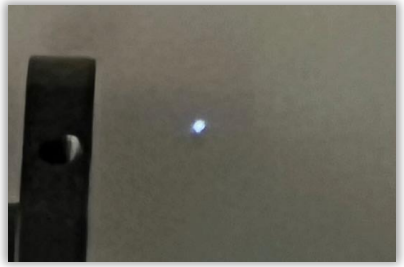


- signal separation (dichroic mirrors)?
- **non-collinear phase matching to the rescue?**

Experimental Demonstration

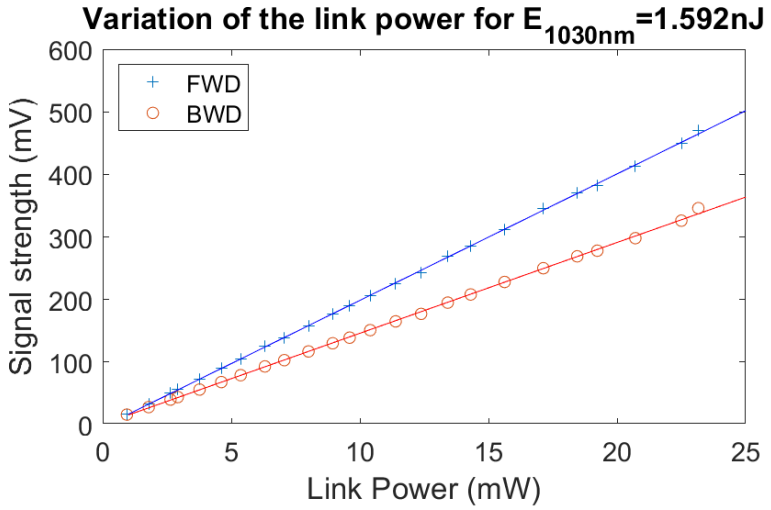
Changing from 1030 nm to 515 nm Possible by Just Tilting the Crystal

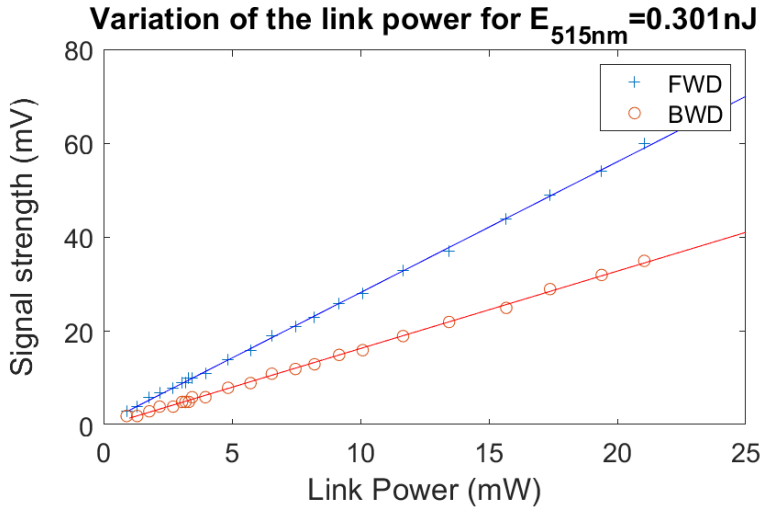


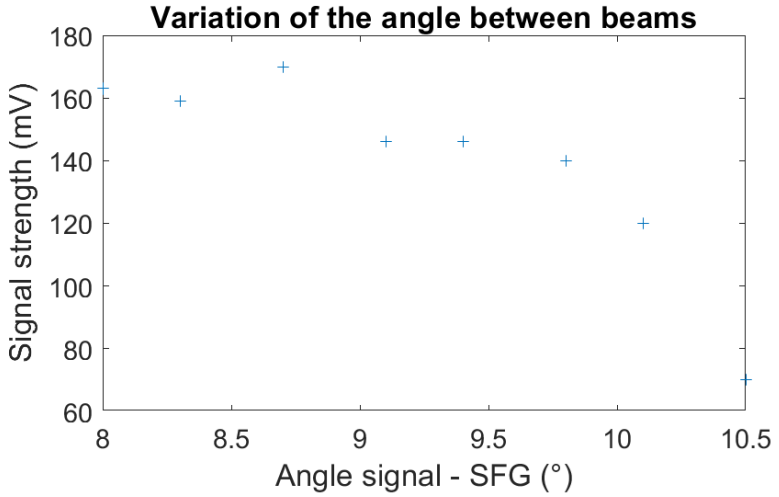


SFG of 1550 nm with 515 nm

(387 nm)







- progress on VIS-IR OXC
  - automation
- MSK, ARD, HELPFEL budget
- EuXFEL funding

Wrap-up

Progress Towards a Substantially Extended Synchronisation Infrastructure for FLASH

- sub-synchronisation laboratory planning and realisation…
  - it's really converging!
  - proven concept from EuXFEL – **with differences**
- fibre link installation drafted
  - re-use existing fibres
  - "distribution" between main and sub-synchronisation in a most flexible way
- revisited user delay and laser feedback concept
  - component selection, together with EuXFEL LAM project
- advances in laser-to-laser synchronisation (MLO-SLO)
- advances in laser pulse arrival time measurements
- **LAM measurement campaign at FL23**

Contact

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Team Leader Laser-based Synchronisation Systems

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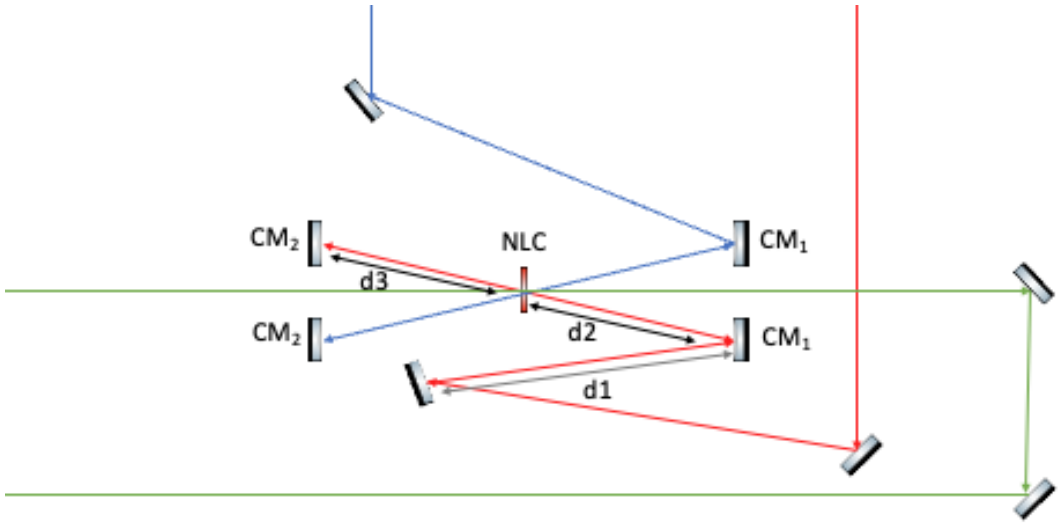
Supporting Material

Optical Design

In progress…

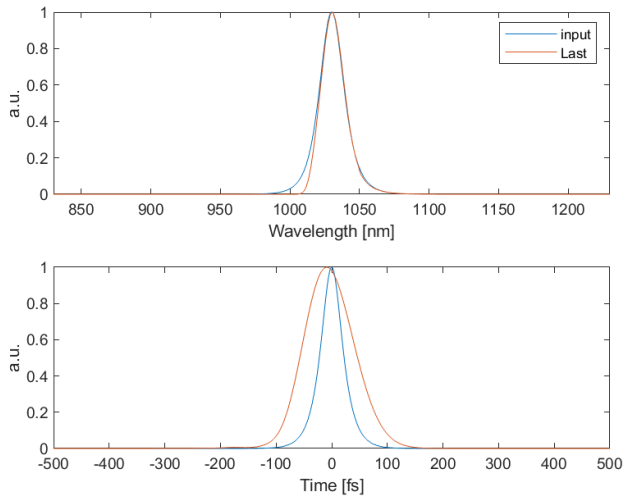
Non-collinear cross-correlator



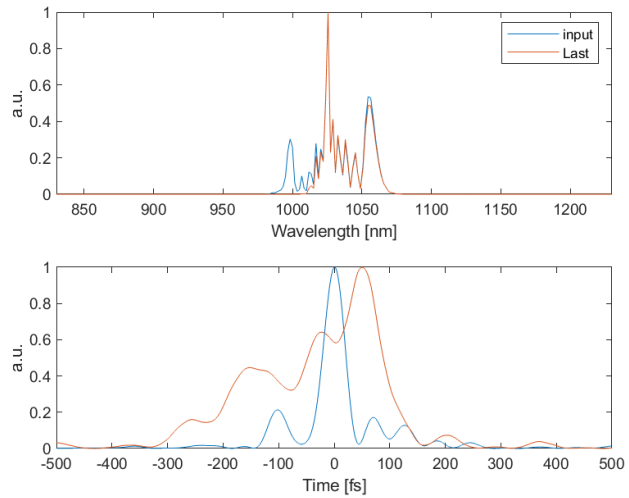
- Demonstrated at 1030 nm, inclusive laser locking.
  - However high link and laser pulse energies in the setup
- Proof-of-principle: validated when 515 nm, 343 nm will be tested

Influence of dispersion – ex. With „standard“ L2L setup

Ideal sech^2 , 40fs pulse



MPC measurement (lab)



- Obvious, but…
  - Take care!
  - Bandwidth of optics for special cases like MPC, HCF broadening, …
  - Optics in reflexion

slide courtesy of Anne-Laure Calendron