# INSTALLATION AND COMMISSIONING OF THE PULSED OPTICAL TIMING SYSTEM EXTENSION

Elettra Sincrotrone Trieste

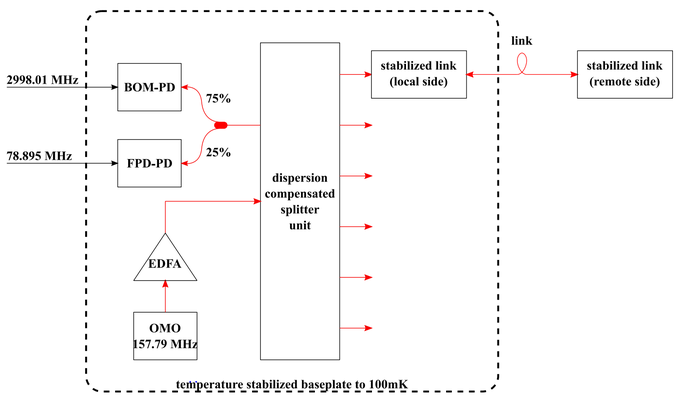
**F. Rossi**#, M. Ferianis - Elettra Sincrotrone Trieste S.C.p.A., Trieste, Italy

At the FERMI FEL user facility, a fully optical timing system has been operated, to synchronize it, since the start of machine commissioning, back in 2009. In the past years the system has been progressively extended to support more clients. The latest upgrade is focusing on the pulsed subsystem which provides the phase reference to remote lasers and the bunch arrival monitor diagnostic stations. In origin the pulsed subsystem had a capacity to feed simultaneously six stabilized fiber links. The upgrade to the original layout makes it possible to install up to eight new additional links. Here we will describe the new setup and the results achieved in terms of short- and long-term stability.

## INTRODUCTION

FERMI [1] is a fourth generation light source, a seeded Free Electron Laser (FEL), operating as a user facility in Trieste, Italy. A state-of-art all optical timing and synchronization system [2] has been deployed implementing a hybrid architecture as a combination of pulsed and continuous wave techniques.

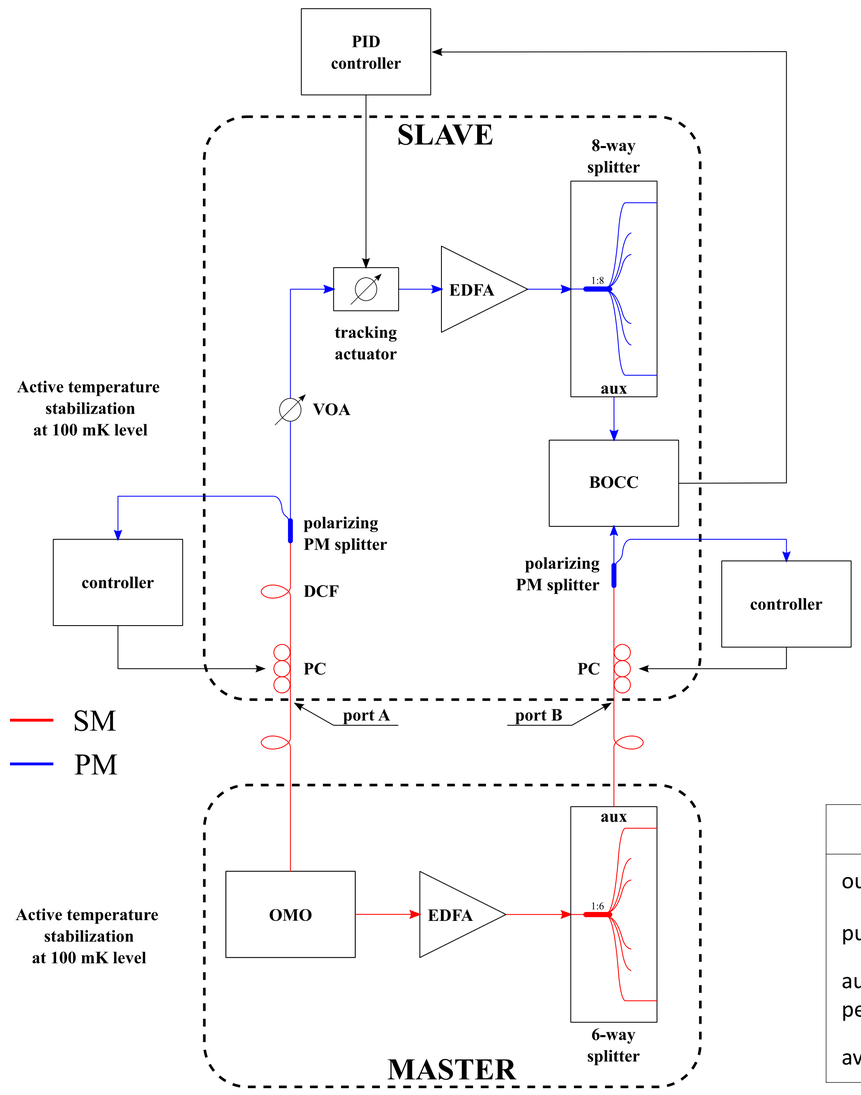
The pulsed optical timing system has been installed in 2009, it generates and delivers with 10 femtosecond precision the reference to different phase critical FERMI subsystems, like lasers and longitudinal diagnostics.

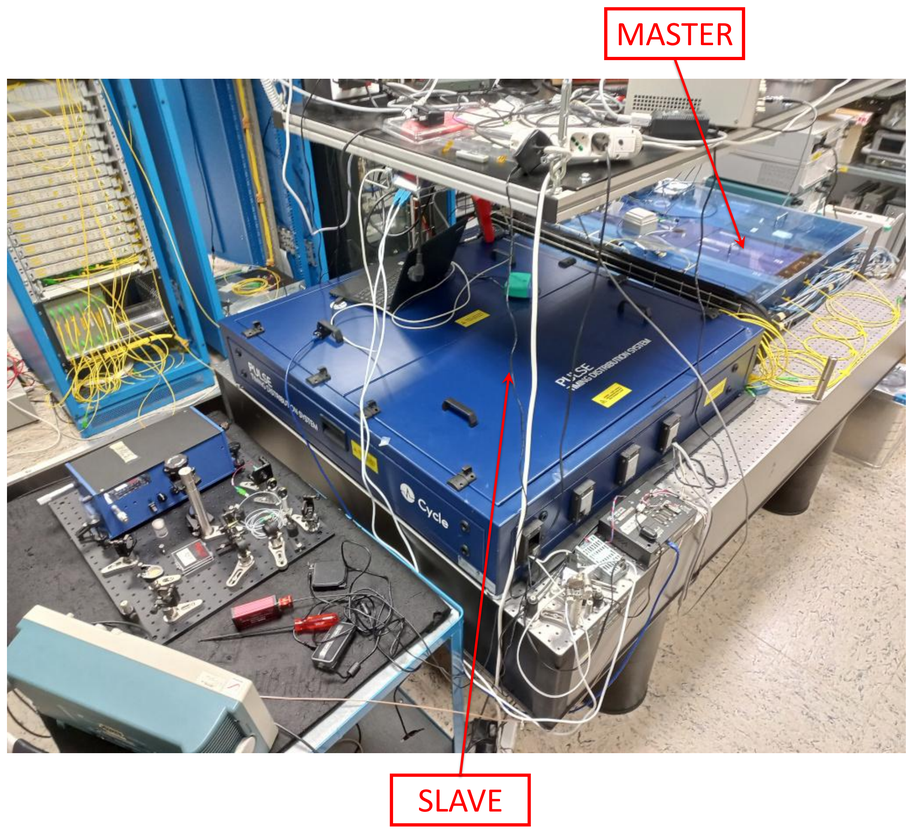



We have implemented a master-slave architecture, the original system is considered the **master** while the extension is the **slave**.

The slave is locked to the master to remove residual timing drifts and keep the pulses coming out from the outputs of the master and slave splitters synchronized.

## THE PULSED SUBSYSTEM EXTENSION



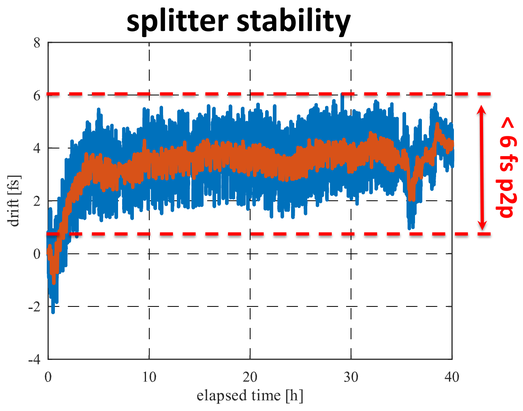




| most relevant specifications | | | |
|---|---|---|---|
| output ports | 8 | amplitude noise | < 0.1 % RMS [10 Hz - 10 MHz] |
| pulse duration | < 200 fs FWHM | additive jitter | < 10 fs RMS [10 Hz - 10 MHz] |
| autocorrelation pedestal height | < 0.15% | splitter stability | < 25 fs p2p over 24-hour interval |
| average power | > 45 mW | tracker stability | < 25 fs p2p over 24-hour interval |

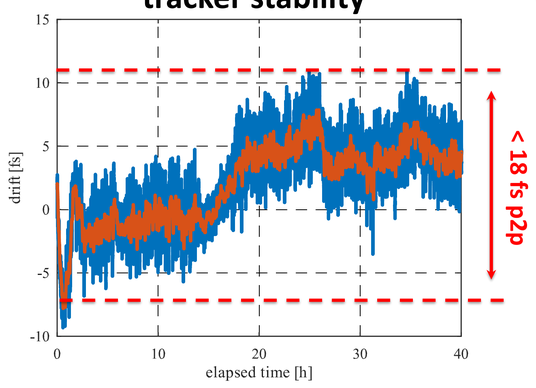
## RESULTS OF COMMISSIONING

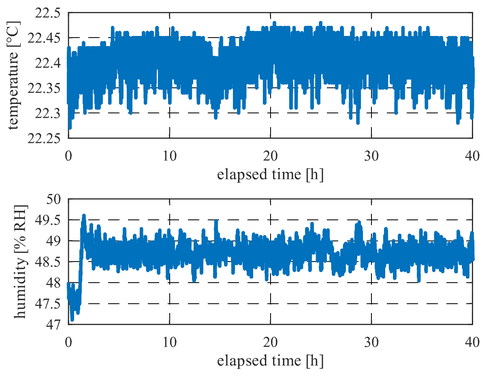
### LONG-TERM MEASUREMENTS

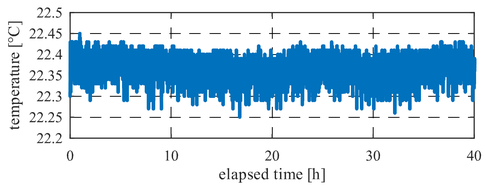
splitter stability




tracker stability

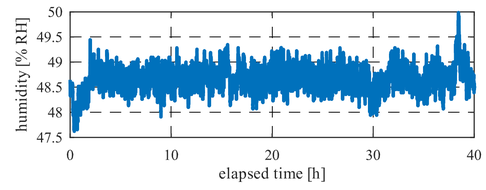


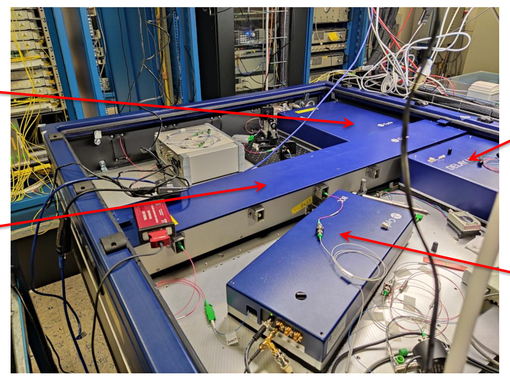





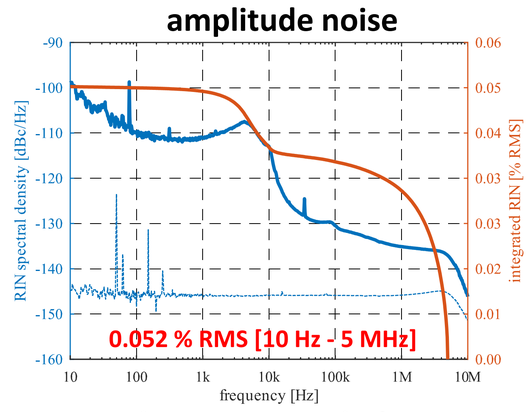




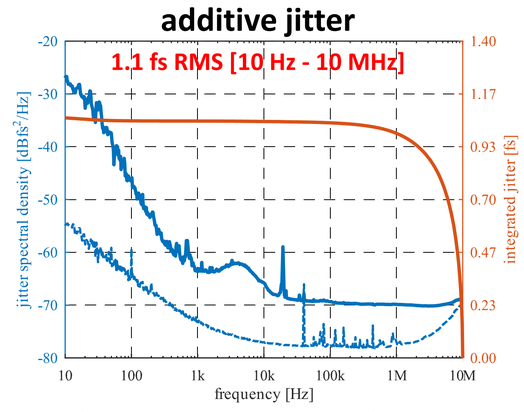




### CHARACTERIZATION

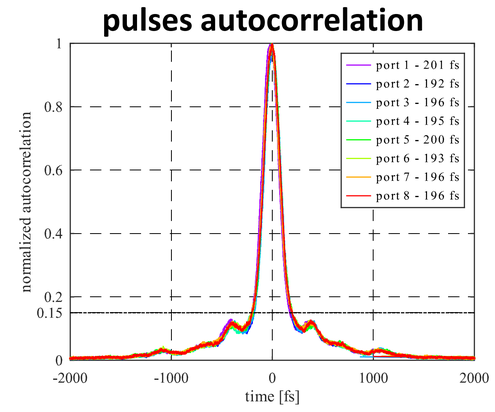
amplitude noise



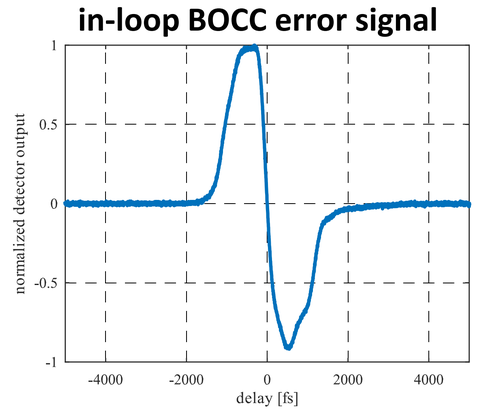

additive jitter




pulses autocorrelation




in-loop BOCC error signal




## CONCLUSIONS AND FUTURE WORK

We have validated the design and implementation of the pulsed timing subsystem extension.

Next steps:
- monitoring of the extension for a longer period to evaluate its reliability
- integration of the new hardware in the machine control system
- investigation about the polarization stability between the master and slave
- new setup for the master vs slave measurement by using one or two links

REFERENCES

[1] E. Allaria et al., Highly coherent and stable pulses from the FERMI seeded free-electron laser in the extreme ultraviolet, Nature Photonics, Vol 6, No 9, 2012, DOI:10.1038/nphoton.2012.233

[2] M. Ferianis et al., All-optical femtosecond timing system for the FERMI@Elettra FEL, Proc FEL2011

[3] https://www.cyclelasers.com

# For additional information please contact:
Fabio Rossi <fabio.rossi@elettra.eu>