DESIGN AND FIRST EXPERIENCE WITH THE FERMI SEED LASER

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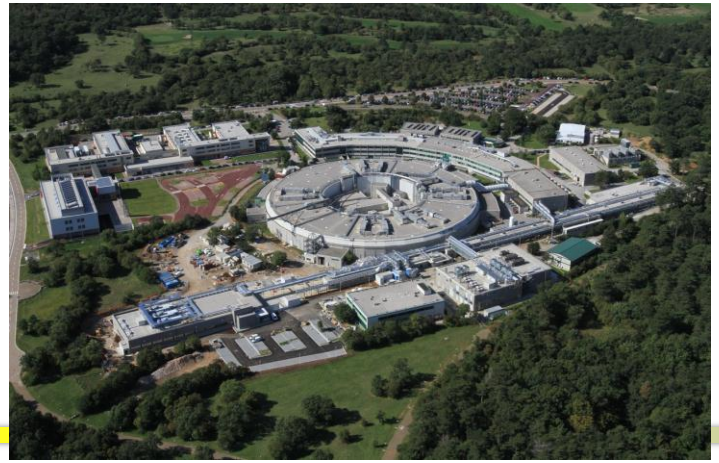
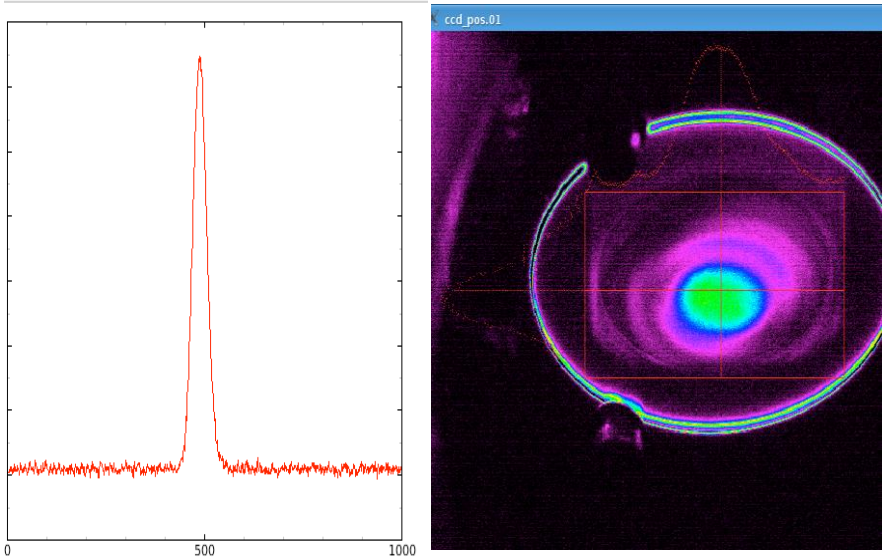


OUTLINE

- *FERMI SEED LASER REQUIREMENTS*
- *OPTICAL SCHEME AND LAYOUT LASER*
- *BEAM TRANSPORT AND INSERTION INTO FEL*
- *LOCKING/SYNCHRONIZATION TO THE FERMI MASTER OSCILLATOR*
- *SUMMARY AND PLANS FOR FUTURE UPGRADES*

FERMI SEED LASER REQUIREMENTS

HGHG WORKS WELL!!!



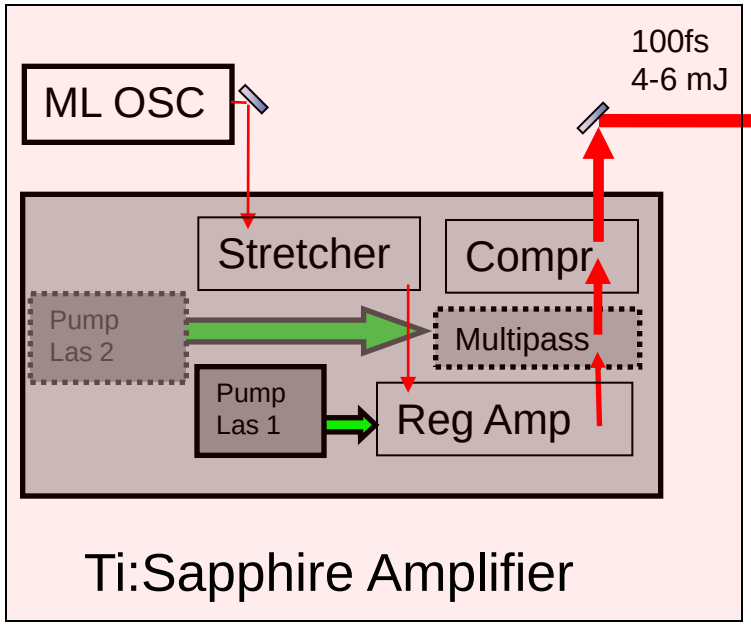
FERMI SEED LASER REQUIREMENTS

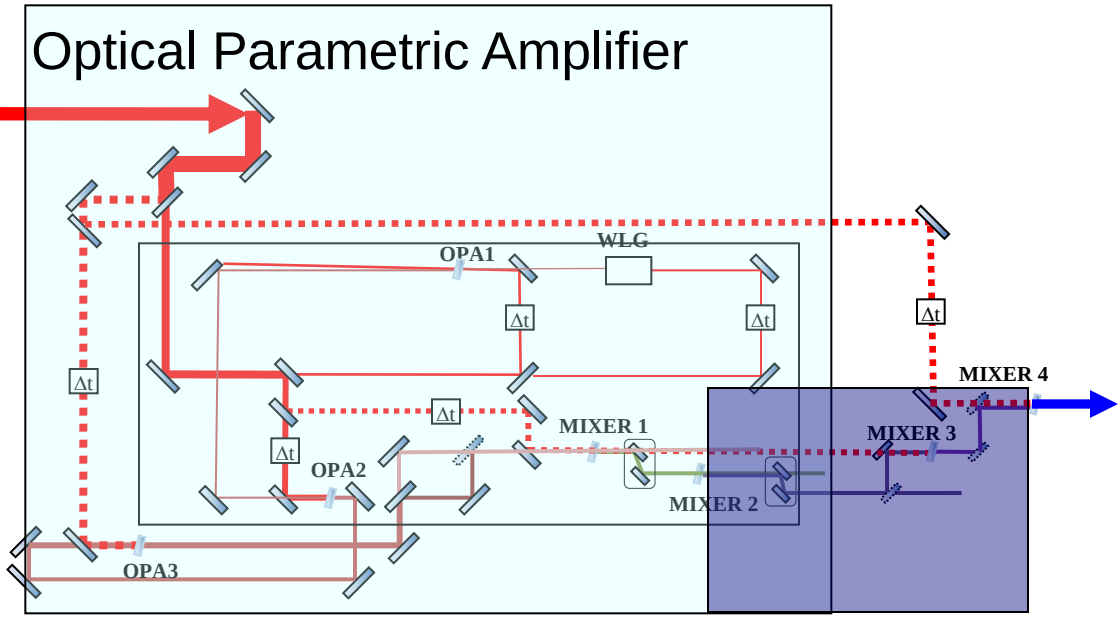
HGHG SCHEME MAIN REQUESTED PARAMETERS:

- **UV peak power ≥ 100 MW**
- **Wavelength Tuning range : 240-360 nm (initial request), 200-280 nm (current)**
- **Pulse duration (FWHM): 100 fs range, longer for the comissioning phase**
- **Pulse arrival timing jitter : <50 fs RMS**
- **Pulse energy stability: <4% , goal <2%**
- **Central wavelegth stability: 10^{-4}**
- **Beam dimention (1/e2 intensity): 0.8-1mm , possibly variable**
- **High reliability and hands-free operation**

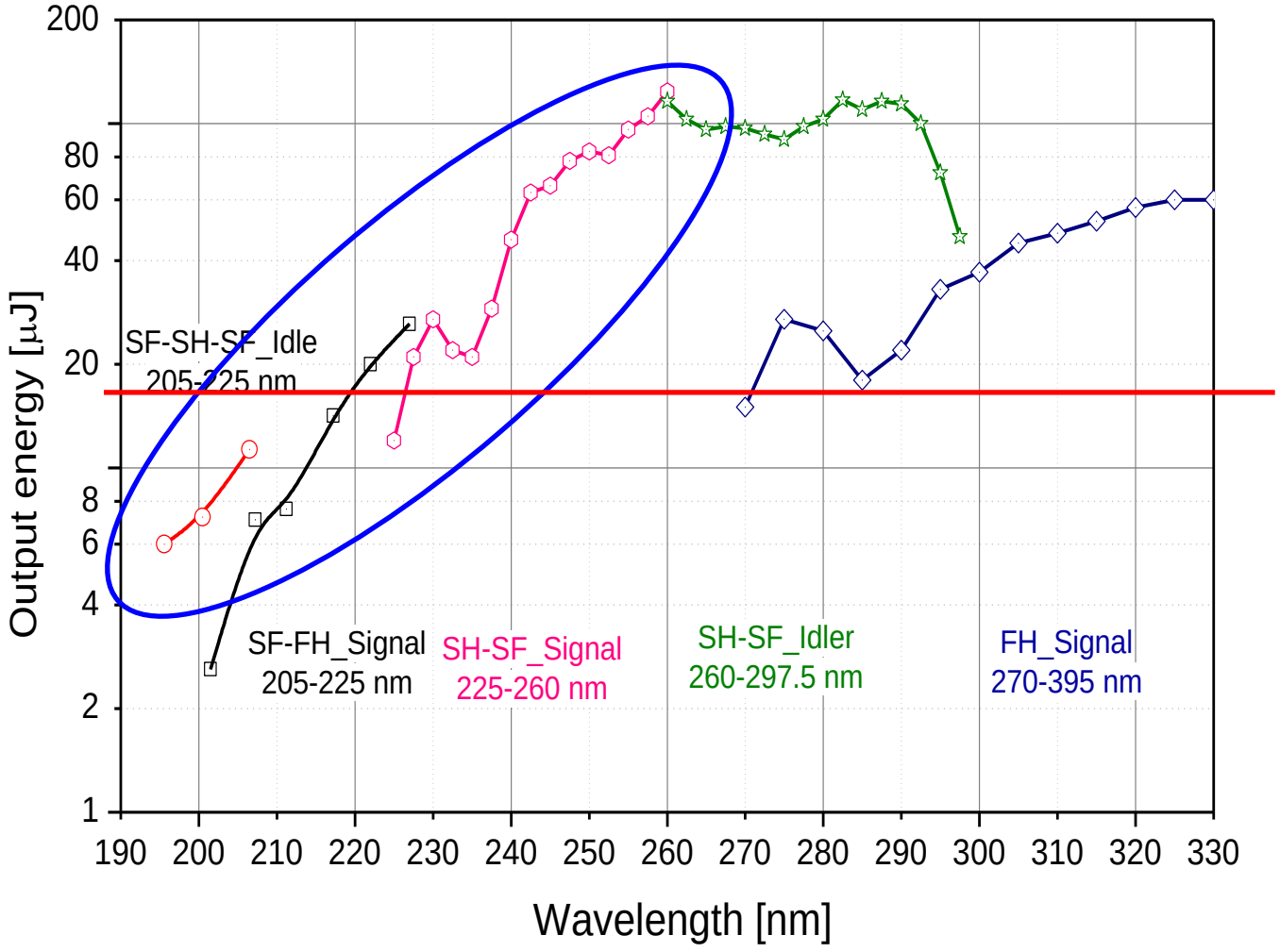
- ***Beam focus: 11.2 m from insertion window and about 20 m from laser room***

TUNABLE SEED LASER





FERMI SEED LASER TUNABILITY



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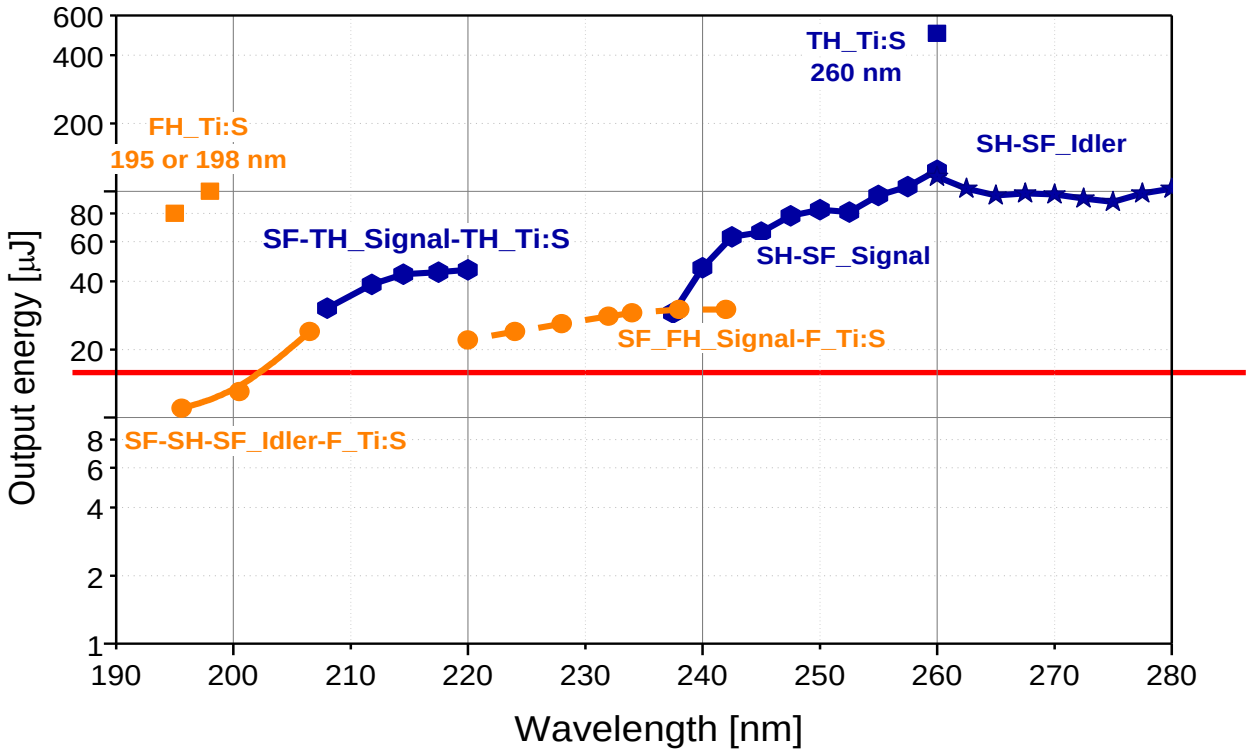


Tuning curve after upgrade

FERMI SEED LASER

STATUS:

Fixed wavelength configuration in use until July 2011

Wavelength : 260-262 nm (manually tunable)

UV peak power ≥ 400 MW

Pulse duration (FWHM): 150-220 fs range

Energy per pulse >80 μJ , smoothly variable down to nJ level

Beam dimention (1/e^2 intensity): 0.8 or 1 mm 1/e2 diameter at virtual undulator

Tunable seed for next FERMI Run:

Wavelength : 235-260 nm

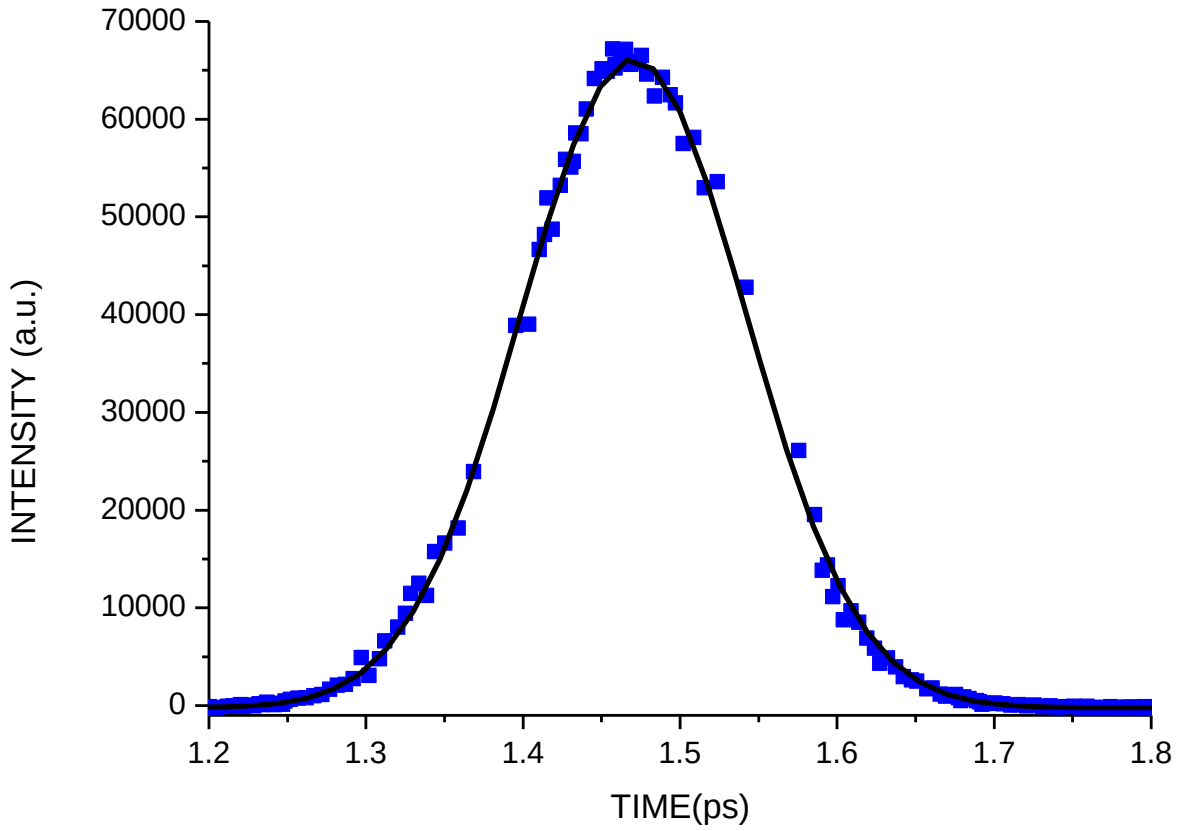
UV peak power ≥ 100 MW (>80 MW at 235 nm)

Pulse duration (FWHM): 180-200 fs range

Energy per pulse >20 μJ (>15 μJ at 235 nm), smoothly variable down to nJ level

Beam dimention (1/e^2 intensity): 1 mm 1/e^2 diameter at virtual undulator

FERMI SEED LASER



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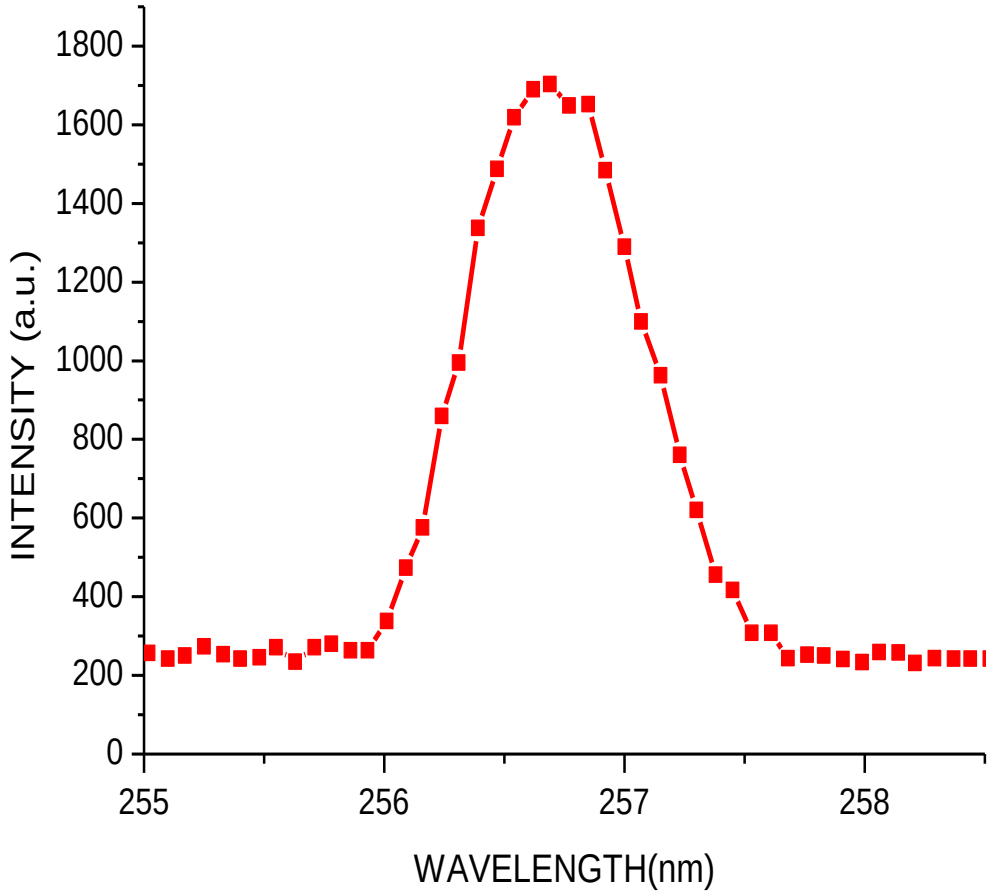
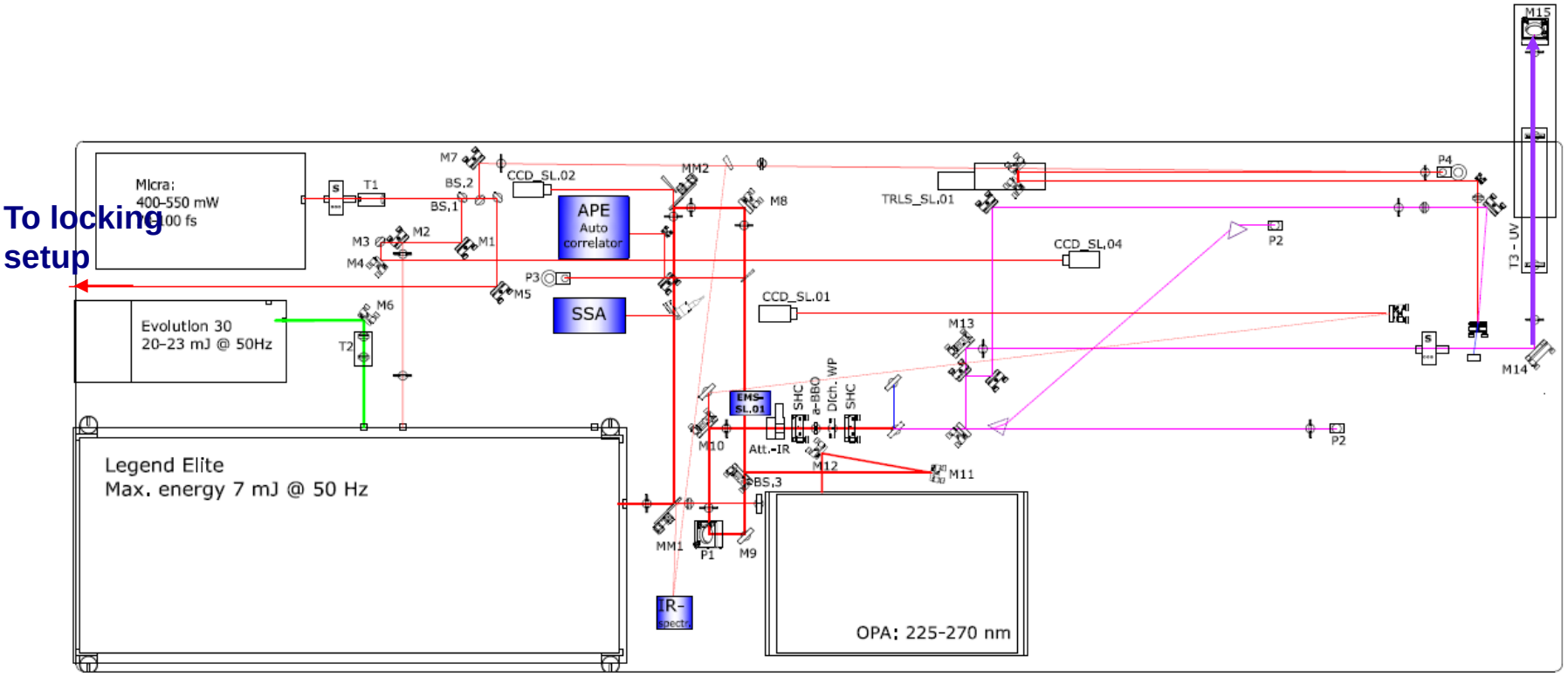


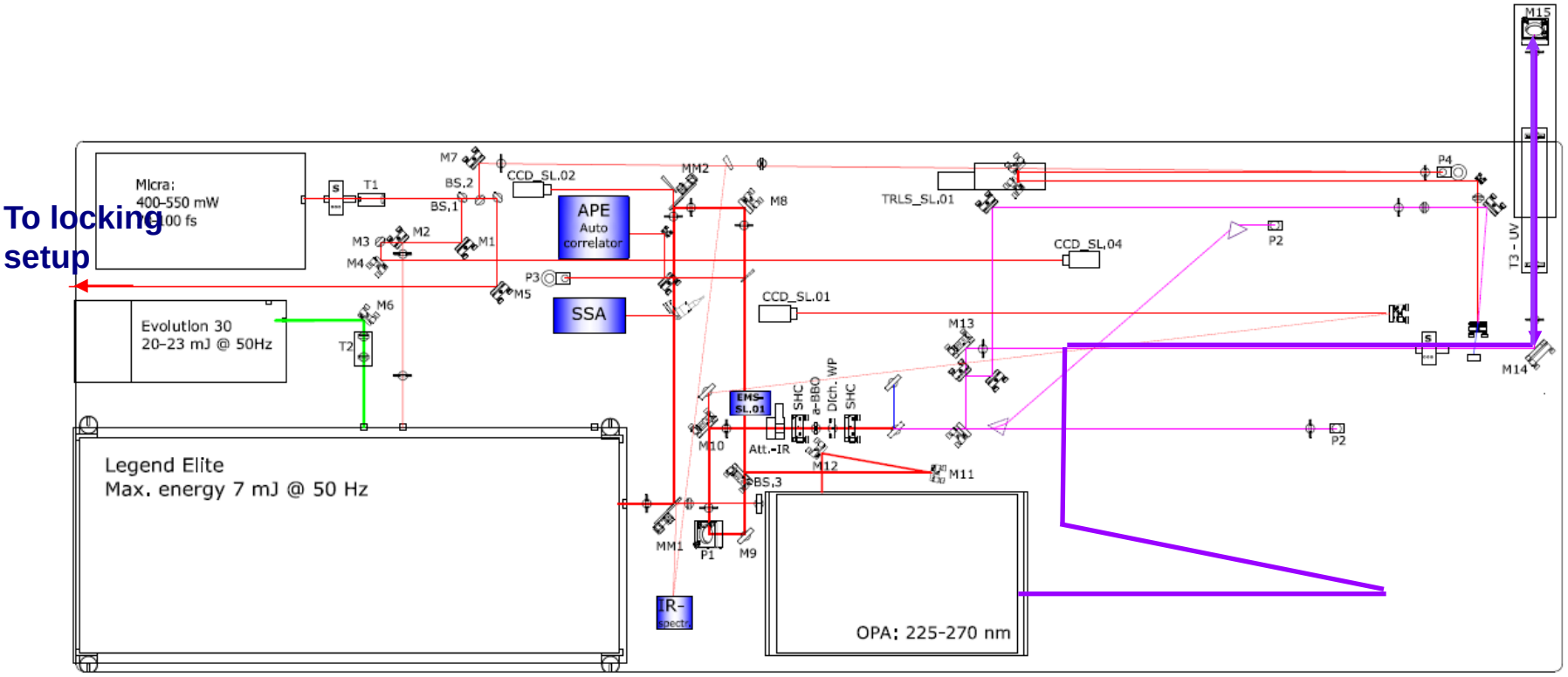
SEED LASER OPTICAL TABLE LAYOUT



Opt Table 1: main laser system

Opt Table 2 (to the left, not shown): locking setup, future HHG laser

SEED LASER OPTICAL TABLE LAYOUT



Opt Table 1: main laser system

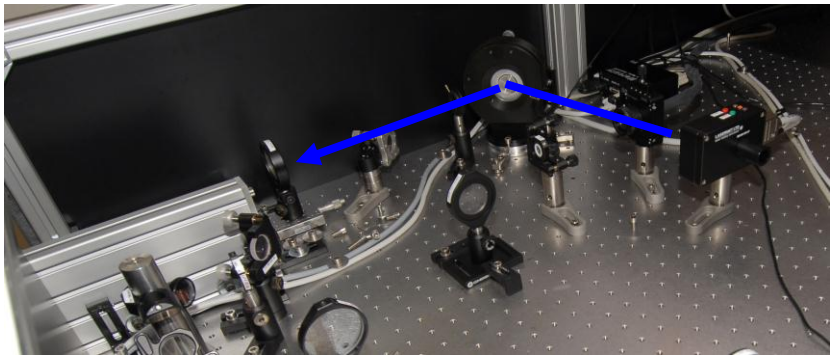
Opt Table 2 (to the left, not shown): locking setup, future HHG laser

Beam Transport and Seed Insertion Breadboard

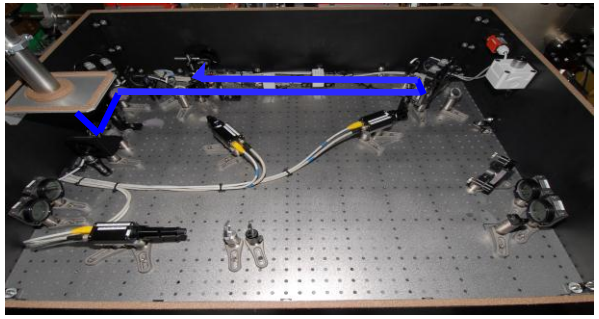
Distance Laser Exit-Undulator >20 m , with 12-18 mirrors in beam path

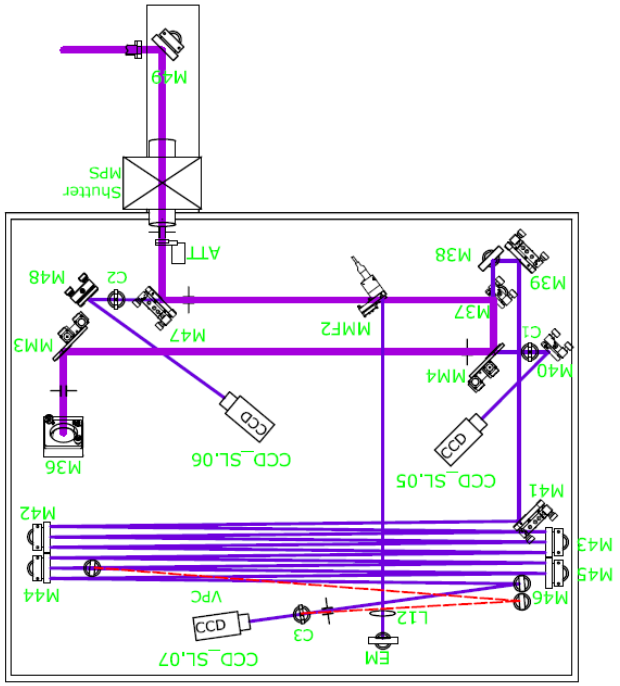
Laser beam position monitored on 7 CCD cameras

Beam steering : 2 kinematic mounts with steppers in IR and 1 piezo based tip-tilt in UV,
2 kinematic mounts with stepper motors on the insertion breadboard



UV beam on the main laser table deviated by the mirror on piezo tip-tilt mount for fine steering





SL insertion breadboard FEL1 photo (left) and optical scheme (right)

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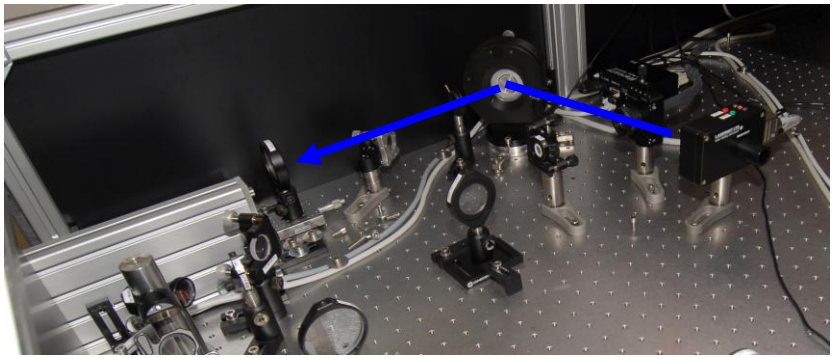

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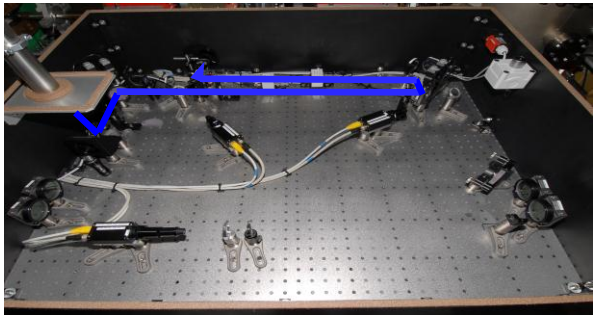

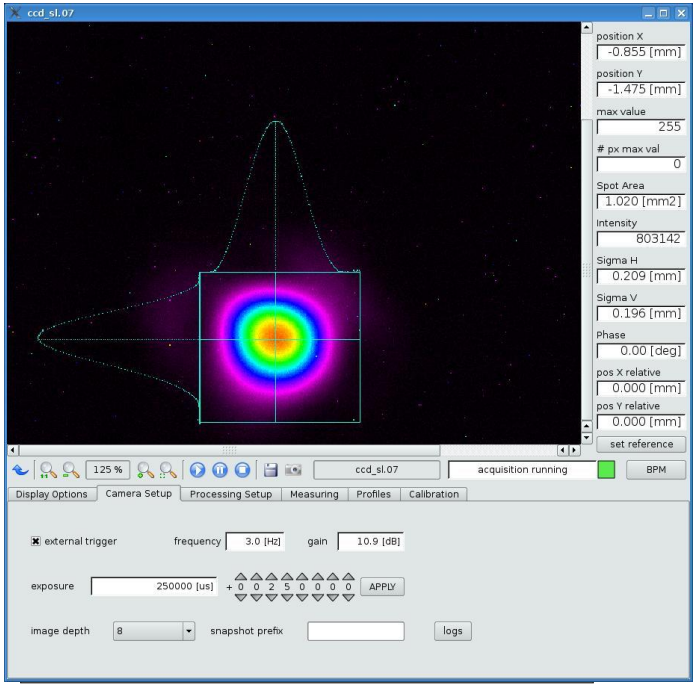

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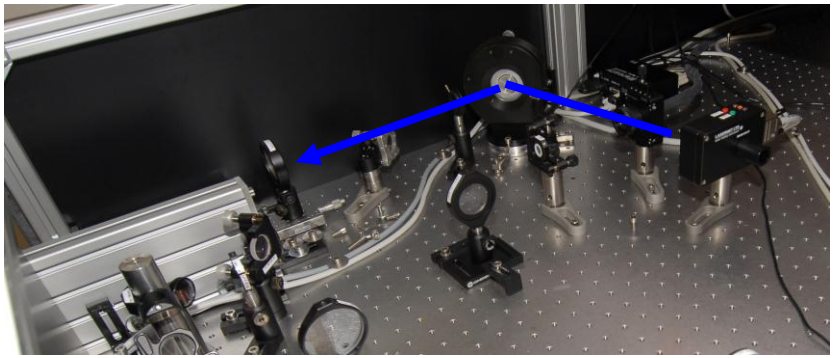

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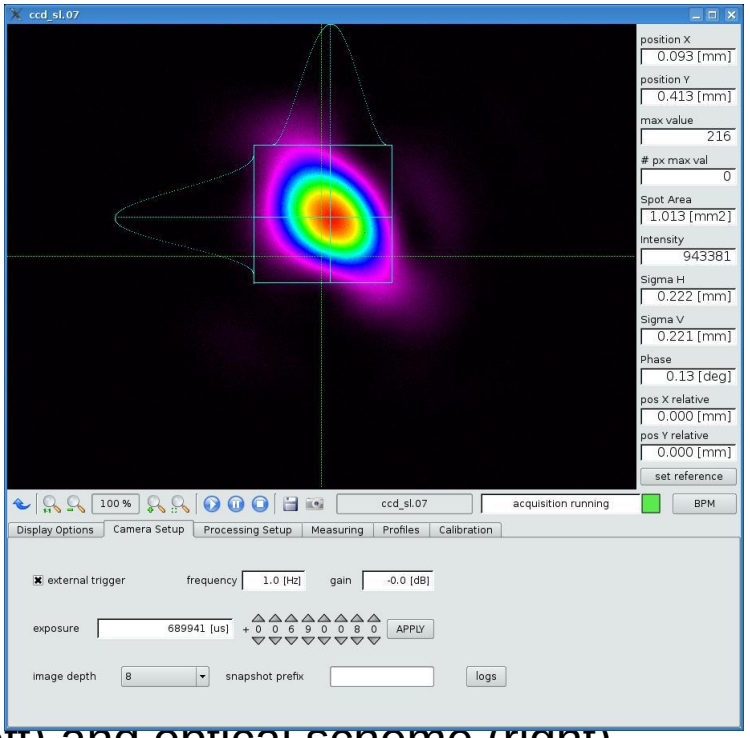
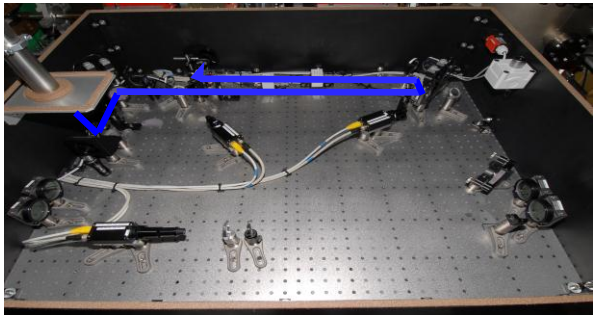
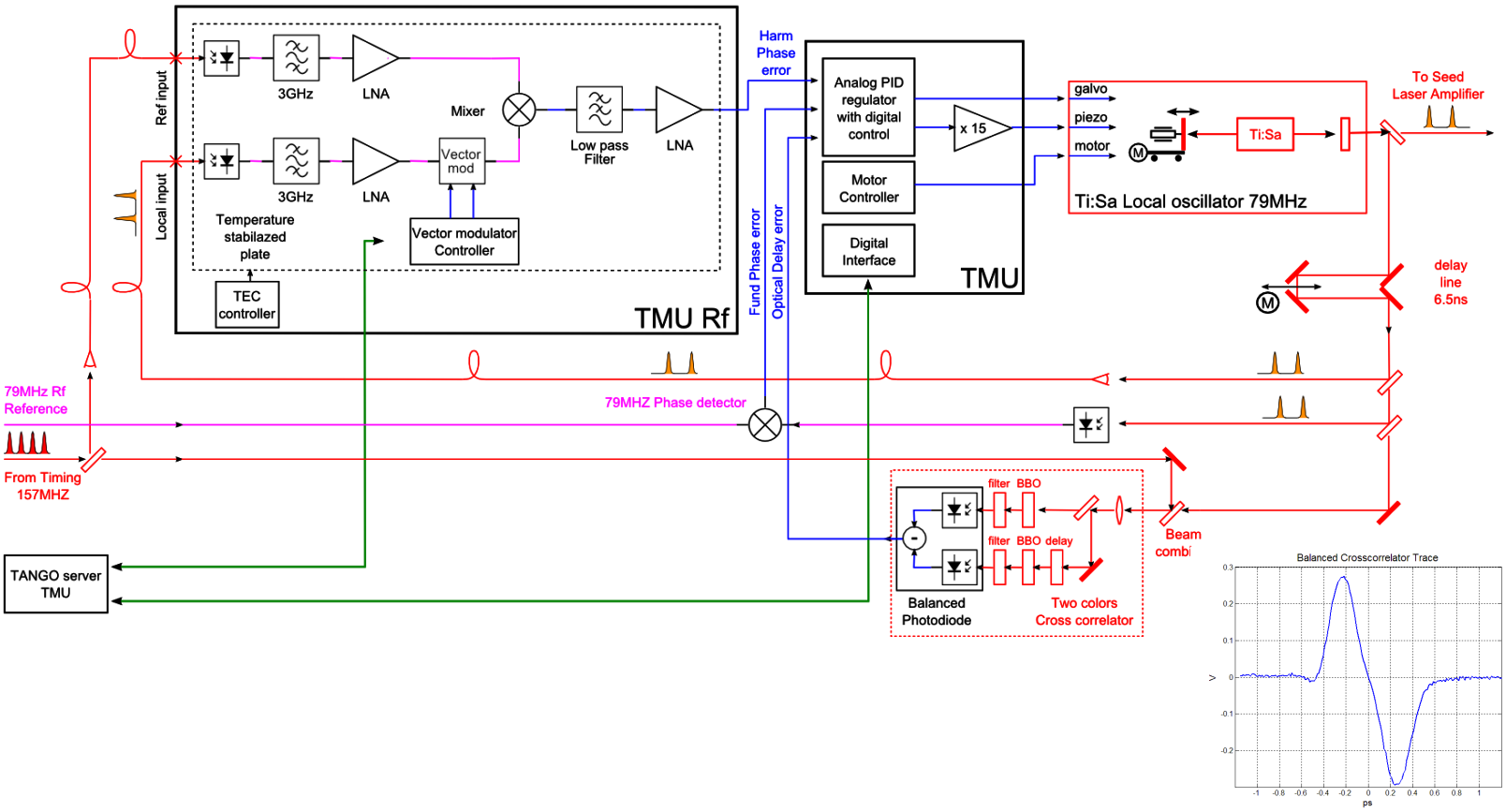




SL insertion breadboard FEL1 photo (left) and optical scheme (right)

LOCKING&SYNCRONIZATION

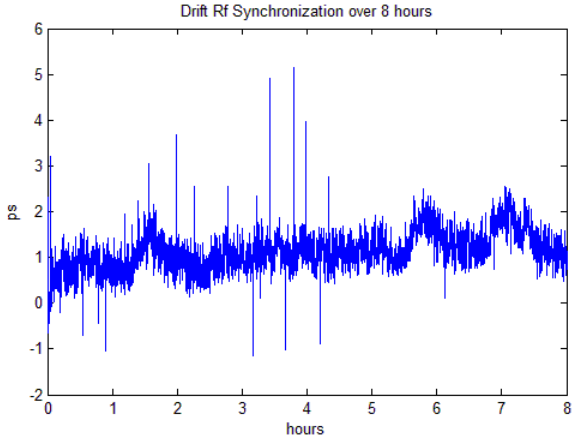
STATUS: since the beginning of last FERMI run the locking&synchronization scheme developed at Elettra is fully operational, both with RF based (3 GHz harmonic) phase detection and with optical phase detection

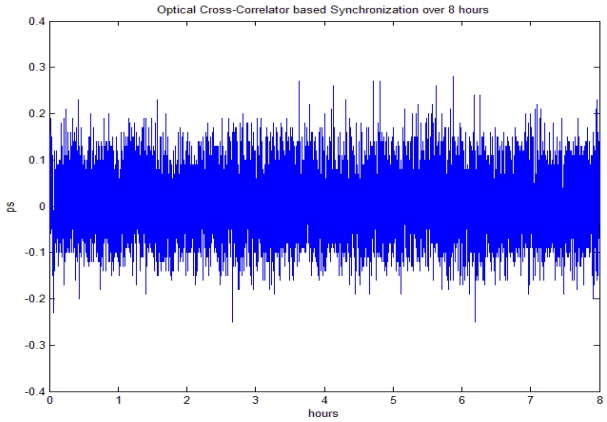


LOCKING&SYNCRONIZATION

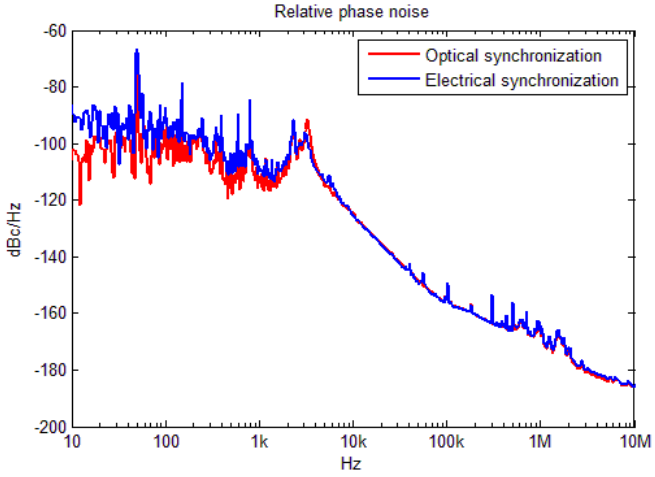
Long term (8 hours) performance of RF harmonic (left) based and optical (right) phase detection

PP ~2.3 ps
RMS 400 fs





PP ~0.3 ps
RMS 53 fs



Relative phase noise curve
Blue: RF locking, 54 fs 100 Hz-10 MHz
Red: optical locking, 51 fs 100 Hz-10 MHz

SUMMARY AND FUTURE WORKS

- FERMI comissioning during last run confirmed that HGHG seeding is valuable from both FEL physics and user point of view
- The Seed Laser met most requirements and has shown good reliability
- The Fixed Wavelength option might proove an interesting option also for the future, allowing freedom for more 'exotic' regimes
- Further impovements of the FERMI seed system:

-New version of the optics and seed insertion for FEL2
-Implementation of a beam quality measurement for the OPA based UV seed (multiplexing several images on the same CCD)
-Roots towards improving OPA beam quality under consideration
-Feedaback on beam position on the virtual undulator
-Going to shorter wavelengths (Sub-200 nm seed, HHG based seed) under study