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Athos commissioning plan 2021

Third SwissFEL Performance Workshop, 27 January 2021

- Overview:
 - General schedule
 - Main achievements and issues in 2020
- Hardware status and plans
- BD Commissioning plan for 2021
- Conclusion

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Athos schedule overview

Courtesy of Romain Ganter

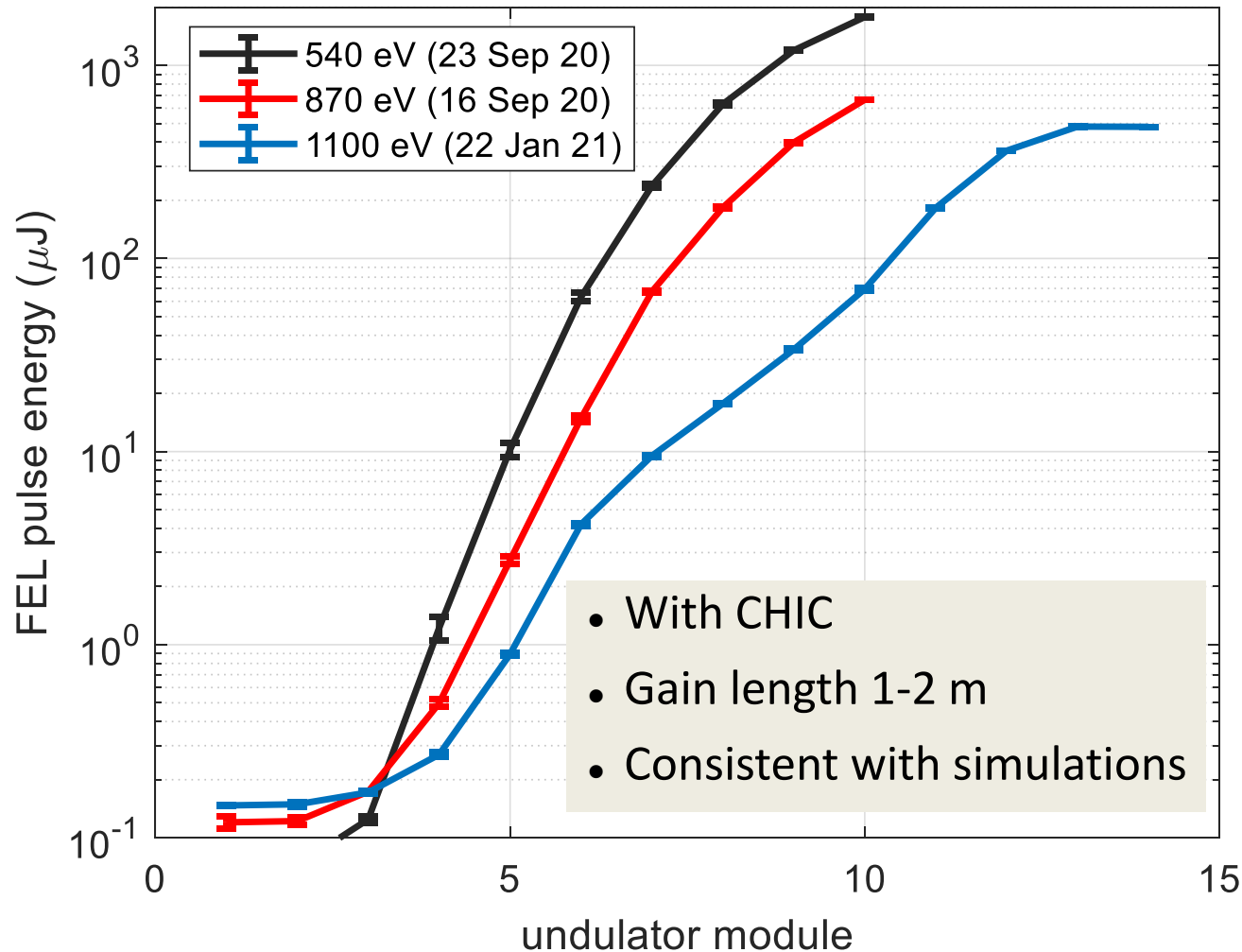
	ATHOS Master Milestones																						
	2017						2018				2019				2020				2021				
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Official Project Start	03.01.17																						
Start Commissioning Athos Transferline					16.03.18																		
Elektrons in Dog Leg (2 Bunch Operation)							21.09.18																
UE38 Prototype Delivery							06.11.18																
Tunnel Fine Cabling and Cooling done							01.01.19																
First UE38 in Tunnel									22.04.19						10.10.19								
RF Power in Athos C-Band Structures											21.11.19												
Athos Line until Athos Beam Dump under Vacuum											21.11.19												
Electrons in Athos Beam Dump											01.12.19												
First Lasing Athos FEL											19.12.19												
First light in Maloja Station																							
Pump Laser Athos ready for Commissioning															01.09.20								
PolariX RF Station ready for conditioning																							
Start Pilot Experimente Maloja																							
First light in Furka Station																							
Start User Operation Athos / Project End																							

- First lasing on time in December 2019 with only 2 undulators
- Most of the milestones in 2020 delayed due to pandemic
- First light in Maloja achieved in June 2020
- First light in Furka planned for May 2021
- Pilot experiments for Maloja in April 2021, user operation will start September 2021
- X-TDC further delayed (conditioning to start in August 2021)

Main achievements of 2020

- ✓ Installation and commissioning of many important devices: gun laser, 14 undulators, 5 passive structures for dechirping and streaking the e-beam, e- and FEL diagnostics, FEL focusing mirrors, etc.
- ✓ Development and implementation of software tools and procedures: emittance measurements, undulator BBA, CHIC control, feedback, etc.
- ✓ FEL performance:
 - ✓ ~ mJ pulse energies for photon energies up to ~1 keV
 - ✓ Demonstration of short pulses (~10 fs)
- ✓ Demonstrated parallel operation with 100 Hz in both Athos and Aramis
- ✓ First FEL beam and commissioning in Maloja. Focused FEL to ~ 1 μm

FEL gain curves



Additional information in SPM talk: <https://indico.psi.ch/event/9187/>

Issue	Solution
Non-finalized beamline, essential hardware missing: BPMs, X-band TDC, some dechirpers and undulators	Installation and commissioning of missing components Use passive streaker for temporal diagnostics (started)
Optimal e- beam quality and FEL performance not reproducible	Define, follow, and improve systematic procedures (e.g. 2-bunch setup, undulator BBA, valves and pipe alignment checks).
Losses (including dark current)	Use dechirpers as transverse collimators (started), systematic loss studies.
Parallel operation sometimes challenging	Further improvement and consolidation of 2-bunch setup and parallel operation

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Hardware status and plans (I)

Hardware	Status
Mizar laser	Successfully commissioned, regularly used for operation
Kicker and septum	Commissioned, regularly used, needs final investigations
Passive structures (8 units for dechirping, tilting and post-undulator diagnostic)	<p>4 units installed and commissioned</p> <p>1 unit installed and commissioned after the undulator (to be moved up end of 2021 or 2022)</p> <p>1 unit installed but control issues (COVID delayed),</p> <p>2 injector units to be installed in April 2021</p>
C-band RF acceleration structure	Installed, connected to modulator tests until February 2021, full (half) acceleration in April (March) 2021
X-band RF streaking structures	Structures installed, RF conditioning starting August 2021
Two-color chicane	Installed, to be commissioned early 2021
Undulators (16) and CHIC (15)	<p>14 undulators and 13 CHIC installed and commissioned.</p> <p>Remaining 2 undulators to be installed in February and April 2021</p>
HERO	Laser table, ground cabling and racks installed; laser installation in August 2021; first commissioning in 2022

Hardware status and plans (II)

Hardware	Status
Electron diagnostics	<p>BPMs: ~80% commissioned, the rest ready latest by spring 2021</p> <p>Screens and wire-scanners: screens installed and commissioned, WS ready to be tested</p> <p>Loss monitors: DRMs, BLMs and LLMs installed and in operation, additional BLMs will be available in 2022</p> <p>Compression monitor in dogleg: diffraction radiation monitor purchased, to be installed in April 2021 (part of Aramis consolidation budget)</p> <p>BAMs currently not planned</p>
Photon diagnostics	<p>Gas detector: commissioned and routinely used in operation</p> <p>Diode, screens, absorption filters: commissioned</p> <p>Gas attenuator: second half 2021</p> <p>Spectrometers:</p> <ul style="list-style-type: none"> • Maloja: e- and ion spectrometers, commissioned • Furka: high resolution, end of 2021/2022 • Monochromator: spring/summer 2021 • Time profile measurements: streaking planned in Maloja for end 2021/2022

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Task 1: Optics studies (~4 shifts, partially invasive)

- Milestone: optics matching in S20SY using WSC in S20SY03, matched beam till undulator, optimize optics for less decompression, more robustness, and best FEL performance
- Requirements: WSC, emittance tool, optics tool
- Status: matching in SATDI routinely done, rest planned from February/March 2021

Task 2: BBA of quadrupoles in transfer line (1-2 shifts)

- Milestone: align quadrupole center to BPMs of the switchyard and transfer line
- Requirements: BPMS, BBA tool
- Status: started in 2020, to be finalized by February/March 2021

Task 3: Transverse beam tilt generation (3 shifts)

- Milestone: measurement of $\sim 1\text{mm}$ beam tilt using the dechirper and the dispersion method
- Requirements: X-TDC, screens, beam tilt tool (including FB)
- Status: first tests done with dispersion method, 1 shift in February 2021, rest from March or April (final measurement when X-TDC is available)

Task 4: Losses studies (~2 shifts, invasive)

- Milestone: study losses (including dark current) for different optics and compression configurations, optimization of collimator/dechirper settings.
- Requirements: dechirpers, loss monitors
- Status: planned for February/March 2021

Task 5: Passive-streaker commissioning (1 shift)

- Milestone: commission tool to measure e- and FEL pulse duration from passive streaker, study losses.
- Requirements: passive streaker structure, passive streaker tool
- Status: planned in April 2021

Task 6: Dechirper commissioning (4 shifts)

- Milestone: align and characterize dechirpers, measure flat longitudinal phase space for different pulse profiles
- Requirements: dechirpers, emittance measurement tool, alignment tool, X-TDC
- Status: 4 dechirpers aligned, alignment of 3 more in April 2021, last one aligned when it is moved (2nd half 2021 or 2022), studies on flat longitudinal profile from May 2021.

Task 7: X-TDC measurements (3 shifts)

- Milestone: measurement of time-resolved properties (longitudinal phase space, slice emittance, etc.), comparison with passive streaker
- Requirements: X-TDC, emittance tool
- Status: planned from September 2021 (when X-TDC is available)

Task 8: R_{56} and compression control (4 shifts, partially invasive)

- Milestone: define optimum setup for different peak currents (~ 1 to ~ 6 kA), strongly compressed pulses by decompressing in BC2
- Requirements: X-TDC, compression tool
- Status: first tests with passive streaker in March/April 2021, rest from September 2021 (when X-TDC is available)

Task 9: Emittance optimization (3 shifts)

- Milestone: preserve emittance between S20SY and Athos dump with closed dechirpers, including beam tilt correction
- Requirements: X-TDC, emittance tool
- Status: 1 shift in March/April 2021, rest from September 2021 (after X-TDC is available)

Task 10: Beam Based Alignment (~5 shifts, invasive until C-band)

- Milestone: align quads with BPMs, define golden orbit, align components to golden orbit
- Requirements: BPMs, movers, undulator BBA and alignment tools, feedback
- Status: started, to be finalized during 1st half of 2021

Task 11: Basic undulator commissioning (~10 shifts)

- Milestone: K-calibration at different gaps (precision of $1e-4$), investigate undulator kicks
- Requirements: monochromator, MCP, screen, photodiode
- Status: started, to be finalized first half of 2021

Task 12: Chicanes commissioning (3 shifts)

- Milestone: delay control for two-color chicane, independent control of delay and trajectory for CHIC chicanes, phase shift control
- Requirements: BPMs, X-TDC, BAM, orbit feedback
- Status: two-color chicane and phase shift control planned for March/April 2021, rest for 2nd half of 2021

Mode 1: Standard SASE with and without CHIC (4 shifts)

- Milestone: SASE, > 400 uJ for photon energies up to 1.2 keV, 0.5% bandwidth, variable polarization
- Requirements: > 14 undulators with CHIC, dechirpers, gas detector, X-TDC, spectrometer
- Status: planned in February/March 2021 with large chirp, from May with reduced chirp

Mode 2: Short pulse mode with standard power (3 shifts per method)

- Milestone: < 10 fs, and > 50 uJ per pulse, first with beam tilt, then other methods (compression, laser heater, etc.)
- Requirements: > 14 undulator modules with CHIC, tilt generation, X-TDC, gas detector
- Status: to be started in March/April 2021

Mode 3: Two colors mode (3 shifts)

- Milestone: > 10 uJ per pulse, delay between -50 fs and 500 fs, photon energy between 240 and 1200 eV
- Requirements: 16 undulator modules, tilt generation, X-TDC, spectrometer, gas detector
- Status: to be done from June 2021 (using passive streaker as diagnostic)

Mode 4: Short pulses with high power (5-10 shifts)

- Milestone: few fs, > 400 uJ per pulse, all photon energies
- Requirements: 16 undulator modules with CHIC, tilt generation (or any method to spoil the beam), X-TDC, spectrometer, gas detector
- Status: to be started 2nd half of 2021

Mode 5: High-Brightness SASE (3 shifts)

- Milestone: SASE, > 400 uJ for photon energies up to 1.2 keV, bandwidth improvement by factor of 8 (1 keV) and 3 (0.5 keV) wrt SASE
- Requirements: 14 undulator modules with CHIC, dechirpers, flat longitudinal profile, X-TDC, high-resolution spectrometer, gas detector
- Status: to be started 2nd half of 2021

Beyond 2021: large-bandwidth with TGU, HERO, etc.

Main objectives for 2021

1. Finalize installation, commissioning and consolidate standard SASE operation
 - Installation and commissioning of missing hardware (X-band, C-band, undulators, diagnostics, etc.)
 - Further development of required software (e.g. phase shifter control)
 - BD tasks described in previous slides
 - Full line lasing for all photon energies with and without CHICs
 - Consolidate 2-bunch setup and parallel operation
2. Deliver special FEL modes (driven and in close contact with PSD-users)
 1. Short pulses (standard power)
 2. 2-colors with beam tilt and large chicane
 3. Short pulses with high power (new CROSS project)
 4. High-brightness SASE
3. Deliver best possible light for user experiments

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- Athos on track despite of COVID, last 12 months successful:
 - First lasing
 - Operation of both lines at 100 Hz
 - mJ pulse energies
 - First light to Maloja
- Plans for 2021:
 - Finalize installation and do most of the standard commissioning
 - Improve operation robustness
 - New modes
 - First users experiments
- Final comments:
 - *To keep in mind: first Athos users planned *before* machine installation and standard commissioning are finalized.*
 - *Key for reproducibility, flexibility and long-term performance: more systematics, more physics, less randomness. This is specially true for Athos.*