1.8.2. Planned beamline layout of E1 (Figure 3).

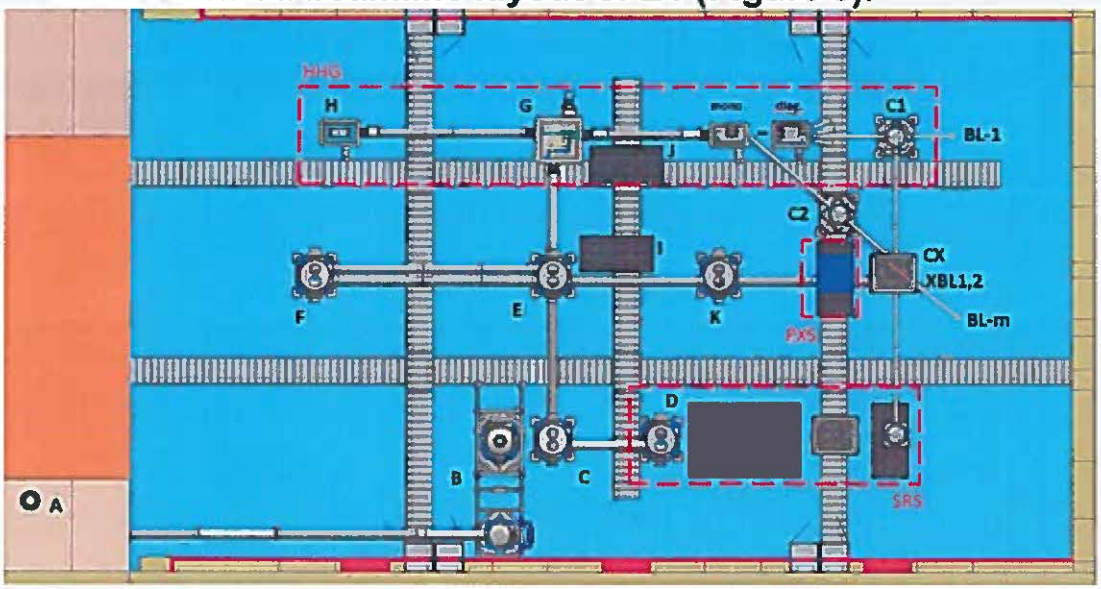


Figure 3: Planned beamline layout of E1. The ELIps instrument shall be compatible both with the C1 and C2 instrument stations.

2. Requirements on System Level

2.1. General System Requirements

REQ-008154/A

The ELIps shall be installed in the E1 experimental hall. *(D6)*

Verification method: I - inspection

REQ-008155/A

The size of the ELIps instrument shall not exceed 2 m (width) x 3 m (length) x 2.5 m (height). *(D6)*

Verification method: I - inspection

REQ-008156/A

The ELIps design shall support measurements in reflection and transmission mode. *(D2)*

Verification method: R - review

REQ-008157/A

The ELIps shall host a sample environment for solid-state samples equipped with a fast switching magnet. *(D6)*

Verification method: I - inspection

REQ-008158/A

The ELIps shall have a cryostat. *(D6)*

Verification method: I - inspection

REQ-008159/A

The ELIps shall have a sample heater. *(D6)*

Verification method: I - inspection

REQ-008160/A

The ELIps shall be equipped with exchangeable IR to UV and VUV polarizers on the incoming and reflected beams. *(D6)*

Verification method: FD - functional demonstration

REQ-008161/A

The system shall be delivered with a UHV vacuum chamber and supports. *(D6)*

Verification method: I - inspection

REQ-008162/A

The system shall be delivered with separate detector systems for the IR/vis/UV and VUV ranges. *(D6)*

Verification method: I - inspection

REQ-008163/A

The instrument shall be designed for UHV operation. *(D2)*

Verification method: R - review

REQ-008164/A

The instrument design shall be optimized for operation in the energy range between 6.5 eV and 40 eV. *(D2)*

Verification method: R - review

REQ-008165/A

The instrument shall be tested (FATs) and verified (at ELI Beamlines) in the energy range between 1 and 6.5 eV. *(D6)*

Verification method: T - test

REQ-008166/A

The instrument shall be verified (at ELI Beamlines) using the 1 kHz alignment laser. *(D6)*

Verification method: T - test

REQ-008167/A

The function of the parts necessary for VUV operations shall be verified before delivery using either a synchrotron or a HHG source. *(D6)*

Verification method: T - test

2.1.1. Design requirements: Flexible target area for absorption, reflection and ellipsometry

REQ-008168/A

The solid target sample holder shall support the sample on a goniometer stage with XYZ motion capabilities (range: 25 mm x 25 mm x 25 mm) and Tip-Tilt motion up to 5 degrees with a precision of 0.01 degrees. *(D2)*
Verification method: R - review

REQ-008169/A

The solid-state target sample holder shall have the capability of cryo- cooling to 50 K or lower. *(D6)*
Verification method: T - test

REQ-008170/A

The solid target sample holder shall have the capability of heating the sample to 450 K or higher. *(D6)*
Verification method: T - test

REQ-008171/A

The solid target sample holder shall be in an environment where the sample can be exposed to a switchable magnetic field of the order of 1.5 T. *(D2)*
Verification method: R - review

REQ-008172/A

Switching rate of the magnetic field shall match the rep. rate of the L1 laser (1 kHz). *(D2)*
Verification method: R - review

2.1.2. UV/VUV polarizers on the incoming and outgoing beams and other optics

REQ-008173/A

Polarizers (or set of polarizers) shall support a working range of the ellipsometer between 1 and 40 eV. *(D6)*
Verification method: T - test

REQ-008174/A

Polarizers shall be installed in a way that allows switching between IR to UV and VUV operation without breaking the central vacuum. *(D6)*
Verification method: FD - functional demonstration

REQ-008175/A

Polarizers shall have an aperture ≥15 mm in diameter (down to 10 mm is acceptable). *(D2)*
Verification method: I - inspection

REQ-008176/A

Changing between polarizer sets should take <40 min (total time for both polarizer and analyzer). *(D6)*
Verification method: T - test

REQ-008177/A

An "all in-vacuum" polarizer exchange system is preferable but a load-lock system is acceptable. *(D2)*

Verification method: R - review

REQ-008178/A

Rotation of the polarizers shall be motorized and performed *in situ* (without breaking vacuum). *(D6)*
Verification method: FD - functional demonstration

REQ-008179/A

Moving between two rotations shall take <10 min (total time for both polarizer and analyzer). *(D6)*
Verification method: T - test

REQ-008180/A

In the energy range 1-7 eV the extinction coefficient under crossed polarizers shall be at least 10^-5. *(D2)*
Verification method: FD - functional demonstration

REQ-008181/A

For energies above 6.5 eV the polarization ratio shall be 1-p/1+p < 0.05 and the reflection-ratio (vertical/horizontal) R_v/R_h >10. *(D6)*
Verification method: FD - functional demonstration

REQ-008182/A

The function of the VUV polarizers shall be verified by the supplier (or sub-contractor). *(D6)*
Verification method: FD - functional demonstration

REQ-008183/A

The reflection angles, surface quality and coatings of the mirrors shall be optimized for VUV operation (IR to UV operation shall be possible for reference and testing). *(D2)*
Verification method: R - review

REQ-008184/A

The supplier shall show through simulations/calculations (or experiments) that the throughput of the instrument in transmission mode (with no sample and excluding polarizer and analyzer) can be expected to be >5% in the photon energy range between 1 and 40 eV. *(D2)*
Verification method: A - analysis

2.1.3. Detectors

REQ-008185/A

The instrument shall be equipped with a photo-diode detector for VUV reflection, transmission, absorption and ellipsometry experiments. *(D6)*
Verification method: I - inspection

REQ-008186/A

The readout rate of the photo-diode detector shall be ≥1 kHz. *(D6)*
Verification method: FD - functional demonstration

REQ-008187/A

In the energy range between 3-40 eV the detector shall have a S/N of 10^3. *(D6)*
Verification method: R - review

REQ-008188/A

For the 1 to 6.5 eV application the instrument shall be equipped with a compact peltier-cooled spectrometer. *(D2)*

Verification method: I - inspection

REQ-008189/A

The instrument design shall allow for the point detector (photo-diode) to be replaced by a VUV spectrometer (transmission or reflection grating). *(D2)*

Verification method: R – review

2.1.4. Chamber with support system

REQ-008190/A

All chambers shall be made of UHV-compatible stainless steel. *(D6)*
Verification method: R - review

REQ-008191/A

The chamber shall be equipped with a load/lock system to exchange samples while keeping vacuum in the goniometer (main) chamber. *(D6)*
Verification method: FD - functional demonstration

REQ-008192/A

The chamber shall be equipped with ports and windows for pump-probe experiments using the HHG beam in combination with one of the L1 aux. beams. (The exact location of the pump-beam ports must be provided by ELI Beamlines during the design phase.) *(D6)*
Verification method: R - review

REQ-008193/A

The chamber shall come equipped with flanges that allow the chamber to be sealed up and feed-throughs and in-vacuum cables to support operation of any included in-vacuum equipment. *(D6)*
Verification method: I - inspection

REQ-008194/A

The chamber insides shall be equipped with rails or a breadboard. *(D6)*
Verification method: I - inspection

REQ-008195/A

The rails or breadboard shall be removable from the chamber. *(D6)*
Verification method: I - inspection

REQ-008196/A

The instrument shall include a basic support system (a frame) with adjustable feet for adjustable height. *(D6)*
Verification method: I - inspection

REQ-008197/A

The height of the optical axis shall be 1300 mm +/- 5 mm (from optical axis to the ground). Deviations from this may be requested from ELI Beamlines until the frame is built. *(D6)*
Verification method: I - inspection

REQ-008198/A

The ELIps shall be fitted with means to be lifted with the E1 crane. *(D2)*

Verification method: I - inspection

REQ-008199/A

The main parts of the mechanical structure shall be equipped with positioning/alignment marks for industrial 3D-measurements/survey. The specific type of the positioning/alignment marks, their number and location shall be agreed with the customer during the detailed design phase. *(D6)*

Verification method: R - review

REQ-008200/A

The chamber shall be delivered without pumps and vacuum gauges. Supplier shall provide pumping for vacuum tests at suppliers' site. *(D6)*
Verification method: I - inspection

REQ-008201/A

The chamber shall be equipped with a sample observation unit (micro/telescope with illumination and camera) for on-line inspection of the target area including alignment capabilities for the ellipsometry measurements. *(D6)*
Verification method: FD - functional demonstration

REQ-008202/A

The instrument shall include an external light source for energies between 1 and 6.5 eV (a lamp) to allow the operation as stand-alone IR to UV-ellipsometer. *(D6)*
Verification method: FD - functional demonstration

REQ-008203/A

Stepper motors shall not be used inside the main vacuum chamber. *(D2)*
Verification method: I - inspection

2.1.5. Environmental Conditions

REQ-008204/A

System shall fulfil ISO 7 cleanliness condition (10,000 dust particles per cubic meter). *(D2)*
Verification method: R - review

REQ-008205/A

System shall be fitting to be operated at humidity level within an interval from 45% to 55%. *(D2)*
Verification method: R - review

REQ-008206/A

System shall be fitting to be operated at temperature of (20.0±0.5)°C. *(D2)*
Verification method: R - review

2.2. System Functional Requirements

This section defines the functions that the system shall be able to perform on delivery and be designed to be able to perform when the ELI Beamlines HHG source becomes available. The requirements are divided into the preparation phase of an experiment, during the experiment execution, and after an experiment. Since at the time of delivery and verification of the ELIps instrument the ELI HHG source may not available it is not required that the function of the instrument is verified in the VUV range. What is required is that the overall function of the instrument is verified in the 1 to 6.5 eV range and at a 1 kHz rep rate (using th E1 alignment laser at e.g. 800 nm or some other wavelength). Furthermore, that the instrument is designed and assembeled for VUV operation, that all mechanical functions for VUV operation (including switching between IR-vis-UV and VUV

modes of operation) are verified and that the VUV polarizers, mirrors and VUV detector are tested separately.

2.2.1. Before experiments

REQ-008207/A

System shall allow alignment of the optical components, the experimental area and detector to the beam of the alignment laser. *(D6)*
Verification method: FD - functional demonstration

REQ-008208/A

System shall allow the sample to be transferred to the interaction region without breaking the vacuum of the main chamber. *(D6)*
Verification method: FD - functional demonstration

2.2.2. During experiments

REQ-008209/A

System shall perform magneto-optical reflection and ellipsometry measurements from a solid-state target in the 1 to 6.5 eV range. *(D6)*
Verification method: FD - functional demonstration

REQ-008210/A

System shall perform magneto-optical reflection and ellipsometry measurements from a solid-state target using the 1 kHz, <50 fs, >1 mJ Ti:Saphire E1 alignment laser. *(D6)*
Verification method: FD - functional demonstration

REQ-008211/A

System shall be designed and equipped to be able to perform time-resolved magneto-optical reflection, absorption and ellipsometry measurements from solid-state targets up to 40 eV. *(D6)*
Verification method: R - review

2.2.3. After experiments

REQ-008212/A

System shall allow the exchange of samples without breaking the vacuum of the main chamber. *(D6)*
Verification method: FD - functional demonstration

REQ-008213/A

System shall allow the system to be vented and reconfigured. *(D6)*
Verification method: FD - functional demonstration

REQ-008214/A

System shall allow the locally stored experimental data to be transferred for subsequent analysis. *(D6)*
Verification method: FD - functional demonstration

2.3. System mechanical, vacuum and interface requirements

2.3.1. System Mechanical Design and stability

REQ-008215/A

System shall be operated, and maintained with standard tools using the metric system. Exceptions are acceptable if they are properly marked. *(D6)*
Verification method: I - inspection

REQ-008216/A

The design shall be made to minimize vibrations, in particular from the cryostat. *(D2)*
Verification method: R - review

REQ-008217/A

If a re-circulating cryostat is used it shall be separated from the chamber by a bellows. *(D6)*
Verification method: I - inspection

2.3.2. System Vacuum Pumping Design

REQ-008218/A

The instrument shall reach a pressure below 5*10^-8 mbar with turbomolecular pumping. *(D6)*
Verification method: T - test

REQ-008219/A

The chamber shall be prepared for the addition of an ion pump. *(D2)*
Verification method: R - review

REQ-008220/A

Material of the pipes and bellows shall be AISI304. *(D6)*
Verification method: R - review

REQ-008221/A

The vacuum components shall be according to standard ISO/TS 3669-2:2007 - Vacuum technology – Bakeable flanges. Or ISO-K, ISO-F and ISO-KF standards. (NORMS: ISO 1609:1986 - Vacuum technology - Flange dimension; ISO 2861:2013 - Vacuum technology - Dimensions of clamped - type quick-release couplings). *(D6)*
Verification method: R - review

REQ-008222/A

Dimension of tubing shall be according ISO 1127:1992 Stainless steel tubes - Dimensions, tolerances, and conventional masses per unit length. *(D6)*
Verification method: R - review

2.3.3. Interfaces

REQ-008223/A

The local CS, DAQ, interlock, trigger and time-stamping systems shall be verified to be compatible with the ELI Beamlines central counterparts. *(D2)*
Verification method: R - review

REQ-008224/A

ELI beamlines shall have as an option to request support for software and hardware integration and commissioning. *(D6)*
Verification method: I - inspection

2.4. System Electrical and Electronics Requirements

2.4.1. System Electrical Design

REQ-008225/A

System electronics shall be according to valid European laws and norms. *(D6)*
Verification method: R - review

2.4.2. Diagnostics

REQ-008226/A

Output from system diagnostics (measurable quantities) shall be expressed in SI base and derived units. *(D6)*
Verification method: I - inspection

2.4.3. Control system, Data Acquisition and Storage

REQ-008227/A

Important components for operation and alignment shall be controlled through a local control system (LCS). *(D6)*
Verification method: FD - functional demonstration

REQ-008228/A

The ELIps LCS shall include an independent GUI to operate the system "of-line". *(D6)*
Verification method: FD - functional demonstration

REQ-008229/A

The ELIps shall have a local DAQ (LDAQ) system for independent operation. *(D6)*
Verification method: R - review

REQ-008230/A

The ELIps shall be able to time-stamp and send data to the LDAQ at a rate of 1 kHz. *(D6)*
Verification method: T - test

REQ-008231/A

The LDAQ shall be hardware separated from the LCS. (If the LDAQ crashes it should not be required to restart the LCS computer, or vice versa.) *(D6)*
Verification method: R - review

2.5. System Transportation and Installation Requirements

REQ-008232/A

The supplier shall train ELI personnel during the verification of the ELIps in the E1 hall. *(D6)*
Verification method: I - inspection

REQ-008233/A

Individual components shall be transportable in boxes with dimensions not exceeding (L x W x H) 3m x 2m x 2m. *(D6)*
Verification method: I - inspection

REQ-008234/A

The system shall be delivered with an installation manual. *(D6)*
Verification method: I - inspection

2.6. Safety

2.6.1. General Safety Requirements

REQ-008235/A

System shall comply with relevant EU legislation. *(D6)*
Verification method: R - review

REQ-008236/A

Supplier shall participate in the ELI Beamlines risk assessment for the normal mode(s) of operation. *(D6)*
Verification method: R - review

2.6.2. Safety requirements associated with System Functional Requirements

2.6.2.1. Before experiments

REQ-008237/A

The operation manual shall contain a recommended procedure for installing the sample as well as for aligning and pumping the main chamber and its components. *(D6)*
Verification method: I - inspection

2.6.2.2. During experiments

REQ-008238/A

The operation manual shall contain a recommended procedure controlling the sample environment during experiments. *(D6)*
Verification method: I - inspection

2.6.2.3. After experiments

REQ-008239/A

The operation manual shall contain a recommended procedure for venting the main chamber and removing the sample. *(D6)*
Verification method: I - inspection

2.6.3. Magnetic fields, cryogenics safety requirements

REQ-008240/A

The ELIps shall be delivered with technical documentation, including safety instructions for the magnetic and cryogenics system. This may be part of the operation manual. *(D6)*
Verification method: I - inspection

2.6.4. Control System Safety Requirements

REQ-008241/A

All supplied motors shall be equipped with encoders and/or limit-switches. *(D6)*
Verification method: FD - functional demonstration

REQ-008242/A

The LCS shall have a procedure for setting software limits. *(D6)*
Verification method: FD - functional demonstration

2.6.5. Hazardous materials

REQ-008243/A

The supplier shall use no EU-recognized hazardous materials in the system. *(D2)*
Verification method: R - review

2.6.6. Laser

REQ-008244/A

If applicable, laser beam-path (non-alignment beams) shall be covered in compliance with European legislation and standards. *(D6)*
Verification method: I - inspection

2.6.7. Vacuum

REQ-008245/A

The system shall have an I/O for emergency shut down. *(D6)*
Verification method: I - inspection

REQ-008246/A

In the case of emergency, especially fire, the emergency shut-down shall shut down all electronics and vent the vacuum chamber within 5 minutes. *(D6)*
Verification method: T - test

3. Quality control

3.1. Quality Plan

REQ-008247/A

The supplier shall develop a Quality Plan for the ELIps instrument based on ELI Beamlines "Requirements for suppliers quality planning". *(D2)*
Verification method: I - inspection

3.2. Documentation

REQ-008248/A

The supplier shall supply the minimum set of relevant manufacturing documents:

- Operating manual
- Maintenance manual
- Breakdown list as built (also for third-party equipment if available)
- 2D drawings
- Three versions of 3D CAD models:
  - A) Full resolution CAD and Raytracing files
  - B) Full resolution CAD files with IP related details masked
  - C) Low resolution CAD files with IP related details masked
- All approved "requests for deviation/wavier"
- Certificates of compliance and CE markings where available.

(D6)
Verification method: I - inspection

REQ-008249/A

Documentation shall be supplied in all following formats: hardcopy and PDF. *(D6)*
Verification method: I - inspection

3.3. Formats for data exchange

REQ-008250/A

Formal communication between supplier and ELI shall be in the following formats: JPG, PDF A, CAD 2D (.dwg), CAD 3D (.STEP), MS Word, MS Excel or HTML. *(D6)*
Verification method: I - inspection

3.4. Reliability

REQ-008251/A

During FATs the system shall be turned on and off 10 times without complications. *(D6)*
Verification method: T - test

REQ-008252/A

During the verification at ELI Beamlines the system shall be turned on and off 10 times without complications. *(D6)*
Verification method: T - test

3.5. Maintainability

REQ-008253/A

Supplier shall identify less reliable parts and take measures to make these easily exchangeable. *(D2)*
Verification method: R - review

REQ-008254/A

Given that a properly trained expert is available with all required parts and tools, the time required to replace these easily exchangeable parts shall not exceed 36 hours. *(D6)*
Verification method: R - review

3.6. Availability

REQ-008255/A

The ELIps system shall be designed in such a way that if properly maintained and staffed, the instrument can be expected to be brought up to operation with two weeks notice for 90 % of the time within a given year. *(D2)*
Verification method: R - review

3.7. Interchengeability/Replaceability

REQ-008256/A

The following systems of the instrument: motors, polarizers, mirrors, sample environment, microscope, load-lock system and detector, shall be designed to be interchangeable or replaceable after the warranty time is out. *(D6)*
Verification method: R - review

3.8. Testability

REQ-008257/A

The ELIps shall be equipped with an auxiliary light source that will allow of-line testing of all instrument components within the spectral range of the light source. *(D6)*
Verification method: I - inspection

3.9. Calibration/Verification

REQ-008258/A

The supplier shall supply a calibration method for the ELIps instrument (may be part of the operation manual). *(D7)*
Verification method: R - review

REQ-008259/A

The supplier shall provide two reference samples to use for calibration (same as were used for the FATs). One for reflectivity calibration and one for magneto-optical calibration. *(D6)*
Verification method: I - inspection

Program: [RP4 Applications in molecular, biomedical, and material sciences]
Subject: [Time resolved VUV Ellipsometer]. Verification Control Document (VCD)
Specification: [TC ID (00110892) B - RSD_VUV_Ellipsometer Requirements Specification TP14_130]

Requirement TC ID	Revision	Requirement text	Verification Method	Contract Phase	Close-out		VRD Verification Record Document	Comments
					Yes	No		
005730/A;VUV_Ellipsometer Requirements Specification								
REQ-008154	A	The ELIps shall be installed in the E1 experimental hall. (D6)	I - inspection	(D6)				
REQ-008155	A	The size of the ELIps instrument shall not exceed 2 m (width) x 3 m (length) x 2.5 m (height). (D6)	I - inspection	(D6)				
REQ-008156	A	The ELIps design shall support measurements in reflection and transmission mode. (D2)	R - review	(D2)				
REQ-008157	A	The ELIps shall host a sample environment for solid-state samples equipped with a fast switching magnet. (D6)	I - inspection	(D6)				
REQ-008158	A	The ELIps shall have a cryostat. (D6)	I - inspection	(D6)				
REQ-008159	A	The ELIps shall have a sample heater. (D6)	I - inspection	(D6)				
REQ-008160	A	The ELIps shall be equipped with exchangeable IR to UV and VUV polarizers on the incoming and reflected beams. (D6)	FD - functional demonstration	(D6)				
REQ-008161	A	The system shall be delivered with a UHV vacuum chamber and supports. (D6)	I - inspection	(D6)				
REQ-008162	A	The system shall be delivered with separate detector systems for the IR/vis/UV and VUV	I - inspection	(D6)				

		ranges. (D6)						
REQ-008163	A	The instrument shall be designed for UHV operation. (D2)	R - review	(D2)				
REQ-008164	A	The instrument design shall be optimized for operation in the energy range between 6.5 eV and 40 eV. (D2)	R - review	(D2)				
REQ-008165	A	The instrument shall be tested (FATs) and verified (at ELI Beamlines) in the energy range between 1 and 6.5 eV. (D6)	T - test	(D6)				
REQ-008166	A	The instrument shall be verified (at ELI Beamlines) using the 1 kHz alignment laser. (D6)	T - test	(D6)				
REQ-008167	A	The function of the parts necessary for VUV operations shall be verified before delivery using either a synchrotron or a HHG source. (D6)	T - test	(D6)				
REQ-008168	A	The solid target sample holder shall support the sample on a goniometer stage with XYZ motion capabilities (range: 25 mm x 25 mm x 25 mm) and Tip-Tilt motion up to 5 degrees with a precision of 0.01 degrees. (D2)	R - review	(D2)				
REQ-008169	A	The solid-state target sample holder shall have the capability of cryo- cooling to 50 K or lower. (D6)	T - test	(D6)				
REQ-008170	A	The solid target sample holder shall have the capability of heating the sample to 450 K or higher. (D6)	T - test	(D6)				
REQ-008171	A	The solid target sample holder shall be in an environment where the sample can be	R - review	(D2)				

		exposed to a switchable magnetic field of the order of 1.5 T. (D2)						
REQ-008172	A	Switching rate of the magnetic field shall match the rep. rate of the L1 laser (1 kHz). (D2)	R - review	(D2)				
REQ-008173	A	Polarizers (or set of polarizers) shall support a working range of the ellipsometer between 1 and 40 eV. (D6)	T - test	(D6)				
REQ-008174	A	Polarizers shall be installed in a way that allows switching between IR to UV and VUV operation without breaking the central vacuum. (D6)	FD - functional demonstration	(D6)				
REQ-008175	A	Polarizers shall have an aperture ?15 mm in diameter (down to 10 mm is acceptable). (D2)	I - inspection	(D2)				
REQ-008176	A	Changing between polarizer sets should take <40 min (total time for both polarizer and analyzer). (D6)	T - test	(D6)				
REQ-008177	A	An "all in-vacuum" polarizer exchange system is preferable but a load-lock system is acceptable. (D2)	R - review	(D2)				
REQ-008178	A	Rotation of the polarizers shall be motorized and performed in situ (without breaking vacuum). (D6)	FD - functional demonstration	(D6)				
REQ-008179	A	Moving between two rotations shall take <10 min (total time for both polarizer and analyzer). (D6)	T - test	(D6)				
REQ-008180	A	In the energy range 1-7 eV the extinction coefficient under crossed polarizers shall be at least 10^-5. (D2)	FD - functional demonstration	(D2)				

REQ-008181	A	For energies above 6.5 eV the polarization ratio shall be 1-p/1+p < 0.05 and the reflection-ratio (vertical/horizontal) Rv/Rh >10. (D6)	FD - functional demonstration	(D6)				
REQ-008182	A	The function of the VUV polarizers shall be verified by the supplier (or sub-contractor). (D6)	FD - functional demonstration	(D6)				
REQ-008183	A	The reflection angles, surface quality and coatings of the mirrors shall be optimized for VUV operation (IR to UV operation shall be possible for reference and testing). (D2)	R - review	(D2)				
REQ-008184	A	The supplier shall show through simulations/calculations (or experiments) that the throughput of the instrument in transmission mode (with no sample and excluding polarizer and analyzer) can be expected to be >5% in the photon energy range between 1 and 40 eV. (D2)	A - analysis	(D2)				
REQ-008185	A	The instrument shall be equipped with a photo-diode detector for VUV reflection, transmission, absorption and ellipsometry experiments. (D6)	I - inspection	(D6)				
REQ-008186	A	The readout rate of the photo-diode detector shall be ?1 kHz. (D6)	FD - functional demonstration	(D6)				
REQ-008187	A	In the energy range between 3-40 eV the detector shall have a S/N of 10^3. (D6)	R - review	(D6)				
REQ-008188	A	For the 1 to 6.5 eV application the instrument shall be	I - inspection	(D2)				

		equipped with a compact peltier-cooled spectrometer. (D2)						
REQ-008189	A	The instrument design shall allow for the point detector (photo-diode) to be replaced by a VUV spectrometer (transmission or reflection grating). (D2)	R - review	(D2)				
REQ-008190	A	All chambers shall be made of UHV-compatible stainless steel. (D6)	R - review	(D6)				
REQ-008191	A	The chamber shall be equipped with a load/lock system to exchange samples while keeping vacuum in the goniometer (main) chamber. (D6)	FD - functional demonstration	(D6)				
REQ-008192	A	The chamber shall be equipped with ports and windows for pump-probe experiments using the HHG beam in combination with one of the L1 aux. beams. (The exact location of the pump-beam ports must be provided by ELI Beamlines during the design phase.) (D6)	R - review	(D6)				
REQ-008193	A	The chamber shall come equipped with flanges that allow the chamber to be sealed up and feed-throughs and in-vacuum cables to support operation of any included in-vacuum equipment. (D6)	I - inspection	(D6)				
REQ-008194	A	The chamber insides shall be equipped with rails or a breadboard. (D6)	I - inspection	(D6)				
REQ-008195	A	The rails or breadboard shall be removable from the chamber. (D6)	I - inspection	(D6)				

REQ-008196	A	The instrument shall include a basic support system (a frame) with adjustable feet for adjustable height. (D6)	I - inspection	(D6)				
REQ-008197	A	The height of the optical axis shall be 1300 mm +/- 5 mm (from optical axis to the ground). Deviations from this may be requested from ELI Beamlines until the frame is built. (D6)	I - inspection	(D6)				
REQ-008198	A	The ELIps shall be fitted with means to be lifted with the E1 crane. (D2)	I - inspection	(D2)				
REQ-008199	A	The main parts of the mechanical structure shall be equipped with positioning/alignment marks for industrial 3D-measurements/survey. The specific type of the positioning/alignment marks, their number and location shall be agreed with the customer during the detailed design phase. (D6)	R - review	(D6)				
REQ-008200	A	The chamber shall be delivered without pumps and vacuum gauges. Supplier shall provide pumping for vacuum tests at suppliers' site. (D6)	I - inspection	(D6)				
REQ-008201	A	The chamber shall be equipped with a sample observation unit (micro/telescope with illumination and camera) for on-line inspection of the target area including alignment capabilities for the ellipsometry measurements. (D6)	FD - functional demonstration	(D6)				

REQ-008202	A	The instrument shall include an external light source for energies between 1 and 6.5 eV (a lamp) to allow the operation as stand-alone IR to UV-ellipsometer. (D6)	FD - functional demonstration	(D6)				
REQ-008203	A	Stepper motors shall not be used inside the main vacuum chamber. (D2)	I - inspection	(D2)				
REQ-008204	A	System shall fulfil ISO 7 cleanliness condition (10,000 dust particles per cubic meter). (D2)	R - review	(D2)				
REQ-008205	A	System shall be fitting to be operated at humidity level within an interval from 45% to 55%. (D2)	R - review	(D2)				
REQ-008206	A	System shall be fitting to be operated at temperature of (20.0±0.5)°C. (D2)	R - review	(D2)				
REQ-008207	A	System shall allow alignment of the optical components, the experimental area and detector to the beam of the alignment laser. (D6)	FD - functional demonstration	(D6)				
REQ-008208	A	System shall allow the sample to be transferred to the interaction region without breaking the vacuum of the main chamber. (D6)	FD - functional demonstration	(D6)				
REQ-008209	A	System shall perform magneto-optical reflection and ellipsometry measurements from a solid-state target in the 1 to 6.5 eV range. (D6)	FD - functional demonstration	(D6)				
REQ-008210	A	System shall perform magneto-optical reflection and ellipsometry measurements from a solid-state	FD - functional demonstration	(D6)				

		target using the 1 kHz, <50 fs, >1 mJ Ti:Saphire E1 alignment laser. (D6)						
REQ-008211	A	System shall be designed and equipped to be able to perform time-resolved magneto-optical reflection, absorption and ellipsometry measurements from solid-state targets up to 40 eV. (D6)	R - review	(D6)				
REQ-008212	A	System shall allow the exchange of samples without breaking the vacuum of the main chamber. (D6)	FD - functional demonstration	(D6)				
REQ-008213	A	System shall allow the system to be vented and reconfigured. (D6)	FD - functional demonstration	(D6)				
REQ-008214	A	System shall allow the locally stored experimental data to be transferred for subsequent analysis. (D6)	FD - functional demonstration	(D6)				
REQ-008215	A	System shall be operated, and maintained with standard tools using the metric system. Exceptions are acceptable if they are properly marked. (D6)	I - inspection	(D6)				
REQ-008216	A	The design shall be made to minimize vibrations, in particular from the cryostat. (D2)	R - review	(D2)				
REQ-008217	A	If a re-circulating cryostat is used it shall be separated from the chamber by a bellows. (D6)	I - inspection	(D6)				
REQ-008218	A	The instrument shall reach a pressure below 5*10^-8 mbar with turbomolecular pumping. (D6)	T - test	(D6)				
REQ-008219	A	The chamber shall be prepared for the addition of an ion pump. (D2)	R - review	(D2)				

REQ-008220	A	Material of the pipes and bellows shall be AISI304. (D6)	R - review	(D6)				
REQ-008221	A	The vacuum components shall be according to standard ISO/TS 3669-2:2007 - Vacuum technology – Bakable flanges. Or ISO-K, ISO-F and ISO-KF standards. (NORMS: ISO 1609:1986 - Vacuum technology - Flange dimension; ISO 2861:2013 - Vacuum technology - Dimensions of clamped - type quick-release couplings). (D6)	R - review	(D6)				
REQ-008222	A	Dimension of tubing shall be according ISO 1127:1992 Stainless steel tubes - Dimensions, tolerances, and conventional masses per unit length. (D6)	R - review	(D6)				
REQ-008223	A	The local CS, DAQ, interlock, trigger and time-stamping systems shall be verified to be compatible with the ELI Beamlines central counterparts. (D2)	R - review	(D2)				
REQ-008224	A	ELI beamlines shall have as an option to request support for software and hardware integration and commissioning. (D6)	I - inspection	(D6)				
REQ-008225	A	System electronics shall be according to valid European laws and norms. (D6)	R - review	(D6)				
REQ-008226	A	Output from system diagnostics (measurable	I - inspection	(D6)				

		quantities) shall be expressed in SI base and derived units. (D6)						
REQ-008227	A	Important components for operation and alignment shall be controlled through a local control system (LCS). (D6)	FD - functional demonstration	(D6)				
REQ-008228	A	The ELIps LCS shall include an independent GUI to operate the system "of-line". (D6)	FD - functional demonstration	(D6)				
REQ-008229	A	The ELIps shall have a local DAQ (LDAQ) system for independent operation. (D6)	R - review	(D6)				
REQ-008230	A	The ELIps shall be able to time-stamp and send data to the LDAQ at a rate of 1 kHz. (D6)	T - test	(D6)				
REQ-008231	A	The LDAQ shall be hardware separated from the LCS. (If the LDAQ crashes it should not be required to restart the LCS computer, or vice versa.) (D6)	R - review	(D6)				
REQ-008232	A	The supplier shall train ELI personnel during the verification of the ELIps in the E1 hall. (D6)	I - inspection	(D6)				
REQ-008233	A	Individual components shall be transportable in boxes with dimensions not exceeding (L x W x H) 3m x 2m x 2m. (D6)	I - inspection	(D6)				
REQ-008234	A	The system shall be delivered with an installation manual. (D6)	I - inspection	(D6)				
REQ-008235	A	System shall comply with relevant EU legislation. (D6)	R - review	(D6)				
REQ-008236	A	Supplier shall participate in the ELI Beamlines risk assessment for the normal mode(s) of	R - review	(D6)				

		operation. (D6)						
REQ-008237	A	The operation manual shall contain a recommended procedure for installing the sample as well as for aligning and pumping the main chamber and its components. (D6)	I - inspection	(D6)				
REQ-008238	A	The operation manual shall contain a recommended procedure controlling the sample environment during experiments. (D6)	I - inspection	(D6)				
REQ-008239	A	The operation manual shall contain a recommended procedure for venting the main chamber and removing the sample. (D6)	I - inspection	(D6)				
REQ-008240	A	The ELIps shall be delivered with technical documentation, including safety instructions for the magnetic and cryogenics system. This may be part of the operation manual. (D6)	I - inspection	(D6)				
REQ-008241	A	All supplied motors shall be equipped with encoders and/or limit-switches. (D6)	FD - functional demonstration	(D6)				
REQ-008242	A	The LCS shall have a procedure for setting software limits. (D6)	FD - functional demonstration	(D6)				
REQ-008243	A	The supplier shall use no EU-recognized hazardous materials in the system. (D2)	R - review	(D2)				
REQ-008244	A	If applicable, laser beam-path (non-alignment beams) shall be covered in compliance with European	I - inspection	(D6)				

		legislation and standards. (D6)						
REQ-008245	A	The system shall have an I/O for emergency shut down. (D6)	I - inspection	(D6)				
REQ-008246	A	In the case of emergency, especially fire, the emergency shut-down shall shut down all electronics and vent the vacuum chamber within 5 minutes. (D6)	T - test	(D6)				
REQ-008247	A	The supplier shall develop a Quality Plan for the ELIps instrument based on ELI Beamlines "Requirements for suppliers quality planning". (D2)	I - inspection	(D2)				
REQ-008248	A	The supplier shall supply the minimum set of relevant manufacturing documents:- Operating manual- Maintenance manual- Breakdown list as built (also for third-party equipment if available)- 2D drawings- Three versions of 3D CAD models:A) Full resolution CAD and Raytracing filesB) Full resolution CAD files with IP related details maskedC) Low resolution CAD files with IP related details masked- All approved "requests for deviation/wavier"- Certificates of compliance and CE markings where available. (D6)	I - inspection	(D6)				
REQ-008249	A	Documentation shall be supplied in all following formats: hardcopy and PDF. (D6)	I - inspection	(D6)				

REQ-008250	A	Formal communication between supplier and ELI shall be in the following formats: JPG, PDF A, CAD 2D (.dwg), CAD 3D (.STEP), MS Word, MS Excel or HTML. (D6)	I - inspection	(D6)				
REQ-008251	A	During FATs the system shall be turned on and off 10 times without complications. (D6)	T - test	(D6)				
REQ-008252	A	During the verification at ELI Beamlines the system shall be turned on and off 10 times without complications. (D6)	T - test	(D6)				
REQ-008253	A	Supplier shall identify less reliable parts and take measures to make these easily exchangeable. (D2)	R - review	(D2)				
REQ-008254	A	Given that a properly trained expert is available with all required parts and tools, the time required to replace these easily exchangeable parts shall not exceed 36 hours. (D6)	R - review	(D6)				
REQ-008255	A	The ELIps system shall be designed in such a way that if properly maintained and staffed, the instrument can be expected to be brought up to operation with two weeks notice for 90 % of the time within a given year. (D2)	R - review	(D2)				
REQ-008256	A	The following systems of the instrument: motors, polarizers, mirrors, sample environment, microscope, load-lock system and detector, shall be designed to be	R - review	(D6)				

		interchangeable or replaceable after the warranty time is out. (D6)						
REQ-008257	A	The ELIps shall be equipped with an auxiliary light source that will allow of-line testing of all instrument components within the spectral range of the light source. (D6)	I - inspection	(D6)				
REQ-008258	A	The supplier shall supply a calibration method for the ELIps instrument (may be part of the operation manual). (D7)	R - review	(D7)				
REQ-008259	A	The supplier shall provide two reference samples to use for calibration (same as were used for the FATs). One for reflectivity calibration and one for magneto-optical calibration. (D6)	I - inspection	(D6)				

Annex 2- Deliverables and Payments Schedule

Deliverable No.	deliverable	payment	date	Output	comment
D1	Contract/Acquisition	20 %	7.5.2015	Signed contract	
D2	Final technical drawings	30 %	31.10.2015	Drawings and CAD models: demonstrated in report	Report should show that technical requirements marked with D2 are fulfilled
D3	Project Execution Evaluation	15%	30.11.2015	Report	Evaluation done by supplier and verified by contractor through a visit to supplier's site.
D4	Testing of components	5%	30.04.2016	Report	
D5	FATs	20 %	31.07.2016	Report	
D6	System verification	10 %	1.10.2016	Report + data	As defined in the technical specifications. Report should show that technical requirements marked with D6 are fulfilled
D7	Commissioning (optional)		31.12.2017 at latest		Not part of contract, but an option

Annex 3– Additional Assistance

In the case the option according to par. 3.4 hereof is activated under conditions stipulated hereby, the rates listed in Table below will be applied per person and per day.

II. Additional Assistance according to art. 3.4. of the binding contract for work				
Type of services + description (Item)	Unit	Number of units	EUR excl. VAT/ Unit	EUR excl. VAT/ Item
Additional Assistance after final delivery to Dolní Břežany outside the scope of work on Client´s site (basic rate)	per day	24	€ 900,00	€ 21 600,00
Included: accommodation, salary, daily allowance (meal, public transportation, etc.)				
Additional Assistance after final delivery to Dolní Břežany outside the scope of work on Client´s site - first/ last day of a visit (each person)	per day	6	€ 1 400,00	€ 8 400,00
Included: transport costs, accommodation, salary, daily allowance (meal, public transportation, etc.)				
To be charged instead of basic rate for each first or last day of any visit for each single person				

Annex 4 - Client's Equipment

1. Standard mechanical tools (wrenches, screwdrivers, pliers, etc.)
2. Electrical tools: led flashlights, multimeters, power strip, various connectors
3. Racks and Power supplies (DC and AC, low voltage)
4. Oscilloscopes
5. Cranes and industrial trolleys

Annex 5 - Quarterly Reports

Scheme of Quarterly Reports:

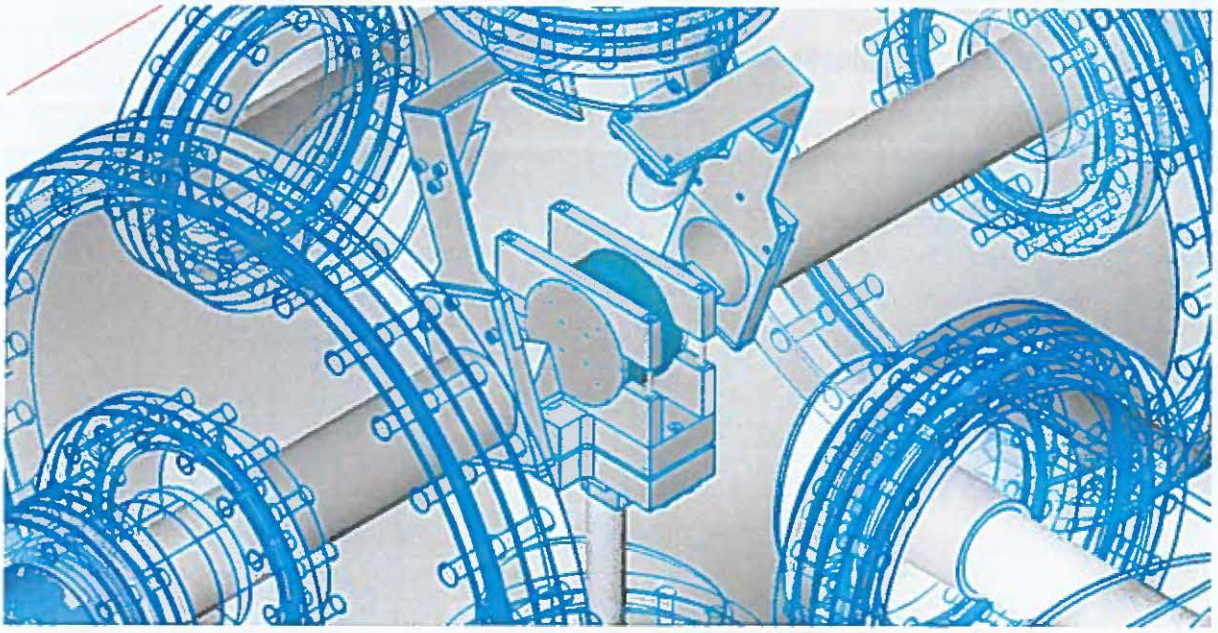
- general info (report No., period, Deliverable(s) within the given period)
- brief description of Deliverables completed in the given period
- brief description of all the other activities performed in the given period
- list of Deliverables where there is a delay on their completion, reasons of such delay, measures to be adopted to remove the delay, estimated time to remove the delay
- brief description of key activities to be carried out in the following period
- discussion on potential issues to be solved within the following period

Annex A -1 - The Contractor's bid package (technical description part)

Copy

Technical Documentation

ELIps: Time resolved VUV Ellipsometer



Please Note: SGME® and 4DOS® are registered trademarks of 4-Dimensional Optical Solutions GmbH, Postallee 29, 21279 Wenzendorf, Germany. WTC stands for Walnut Technology Consulting GmbH.

1. Introduction

Traditionally, ellipsometry techniques are performed for visible and UV photon energies due to the limited photon flux at VUV energies using conventional sources and the lack of suitable polarization optics at VUV-energies. In previous times it was necessary to combine Kerr-spectroscopy and spectroscopic ellipsometry to determine the diagonal and off-diagonal contribution of the dielectric tensor in the presence of a magnetic field.

The development of spectroscopic generalized magneto-optical ellipsometry allows to perform these measurements within one measurement from exactly the same sample area. In combination with the outstanding performance of novel VUV light sources it is possible to preform high impact experiment that specifically addresses the electronic and spin properties of modern devices and tailored materials.

The required beamline is part of the ELI facility. The available footprint is outlined in Fig. 1.

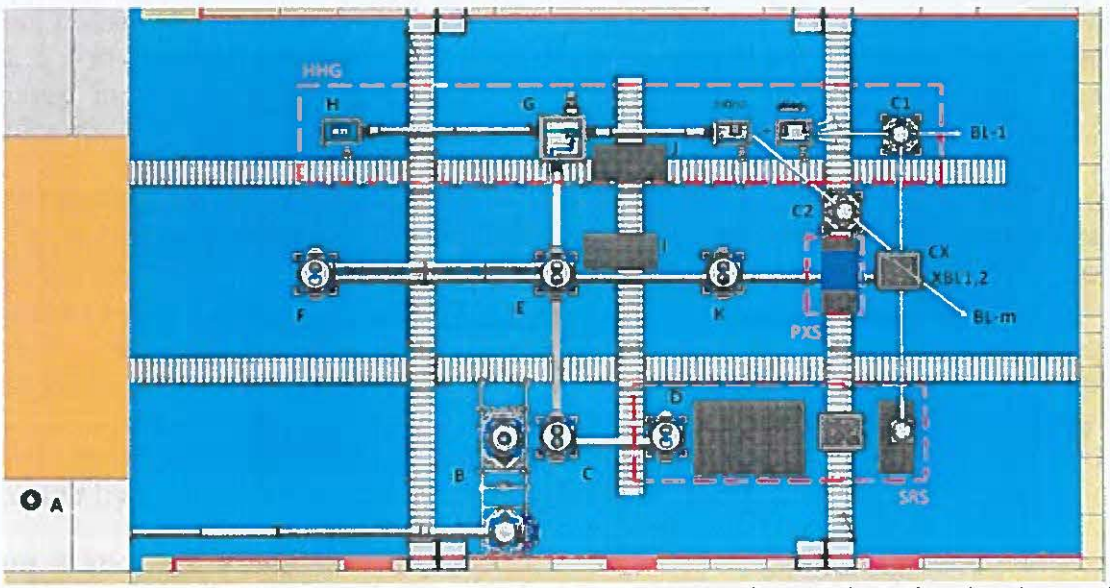


Figure. 1: Layout of the beamline E1 at ELI. The experimental station is planned for the C1 and C2 end stations allowing a footprint of about 2x3 m and 2,5 m in height.

The details outlined in the following are preliminary. The mechanical design will change drastically based on the decided coatings and consequential incidence angles (after the ray tracing phase). Therefore, the following sections serve only on an illustrative basis on how a VUV ellipsometer will work.

2. Description of the components

This chapter describes the critical opto-mechanical components of the VUV-SGME system and the stepper motor controller as well as the coupling between motor and rotation axis. Details of the magnetic field system and the stepper motor controller will be found from chapter 3 on.

2.1 Goniometer Chamber

The goniometer chamber is the main experimental chamber and shown in Fig. 2. This chamber needs to show a base pressure of below 5 10^{-8} mbar in order to avoid freeze out effects on the measured samples and to be compatible with the ELI vacuum requirements. The sample chamber is being entered from the left where the polarizer is mounted on the goniometer axis the polarized beam will be transmitted along the axis until two fold mirrors tilt the beam out of the goniometer axis to an off-axis parabolic mirror. The light enters the magnetic field system in the center of the chamber. The magnetic system as such can be adjusted manually for tip and tils and in a motorized system along the XYZ-axis.

An axial viewport together with an alignment laser monitored by a CMOS-APS camera ensure the calibration of the angel of incidence and the sample plane. After reflection from the sample the light will be collected by a second off-axis parabola and two additional fold mirrors put the collected light beam back on the goniometer axis where the light is being transmitted through the rotatable analyzer. The incidence angle will depend on the results of the ray tracing at the beginning of the project phase. Currently one option is to use Si-C optics and an operation at an angle of 22.5 ° in order to ensure the operation up to 40 eV and beyond. So the layout sketched in Fig. 2 which is based on an incindence angle of 45 ° will change significantly.

The XYZ-stage is being mounted on the bottom flange whereas the tip/tilt alignment system is being mounted on the top flange. The flange left to the beam direction hosts the closed-cycle cryostat within and additional vacuum cross. The vacuum cross also hosts the electrical feed through (measurement sensors; PT-100/PT-1000; magnetic field head system) and a flange for the adaptation of pump technology to achieve the vacuum (example shown is a high pace 300). The XYZ-stage will be outfitted by stepper motors from Nanotec (see next chapter for details). They are encoder controlled and outfitted with limit switches. These three axis can be also controlled by a Joystick for easy sample alignment or sample scanning. (see Fig. 3)

Figure 4 shows the details of the mount holder the magnetic field and the sample together with the top part oft he base that is being mounted at the inside oft he XYZ-flange (see Appendix for details). The tip/tilt manipulators operate on the screws with spring repulsion that are rotating around a cylindrically mounted metal sphere being clamped between the upper and lower baseplates. The upper base plate will be thermally connected to the cryostat by means of copper braids. This way one can ensure a cooling of the magnetic head and the sample. The mounting of two cryostats would allow an independent cooling of magnetic head and sample and by doing so enhancing the capability of high-temperature operation of the sample. Also the cooling power is no being split between cryo and sample when one uses just one cryostat.

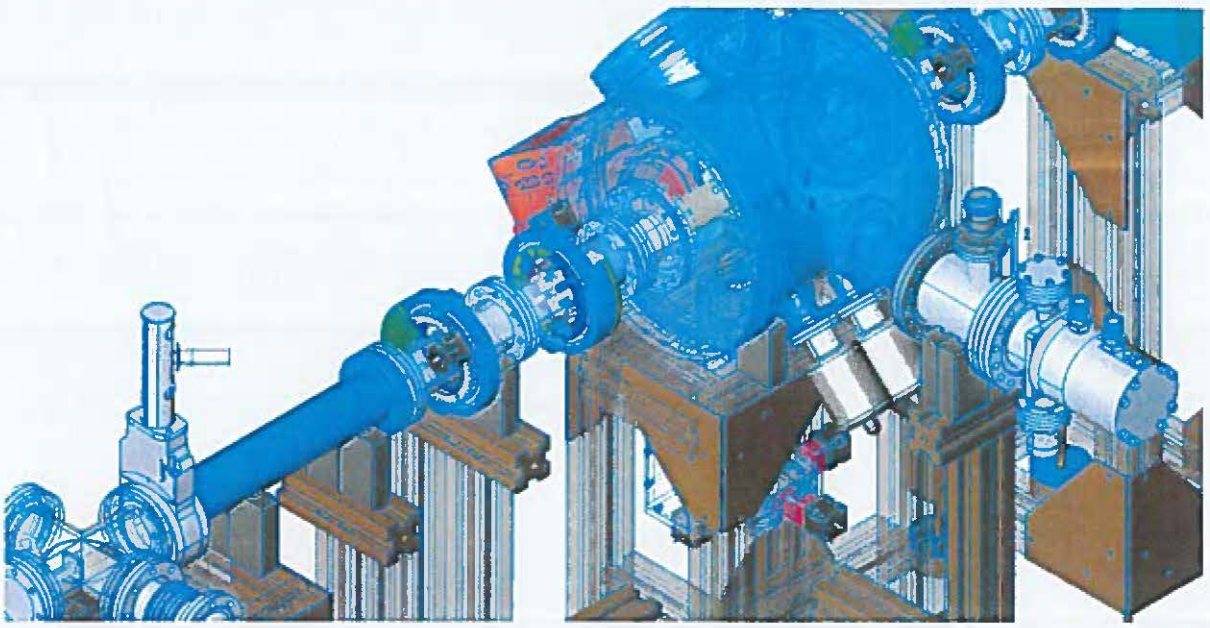


Figure 2: General layout of the sample chamber system outling critical components (From left: Valve; Polarizer; Gonimeter Arm; Sample Stage with Magnetic Field; XYZ-stage; Electrical Feedthroughs, backside View-Port, pressure gauges, and ARS closed cycle cryostat; Goniometer Arm; Analyzer) Not shown is the sample-transfer unit that can be attached tot he CF-100 window flange (replacing the window). The supports shown are Rose-Krieger 60 mm supports with damped levelling feet. The additional ports can be used for external light sources and spectrometers.

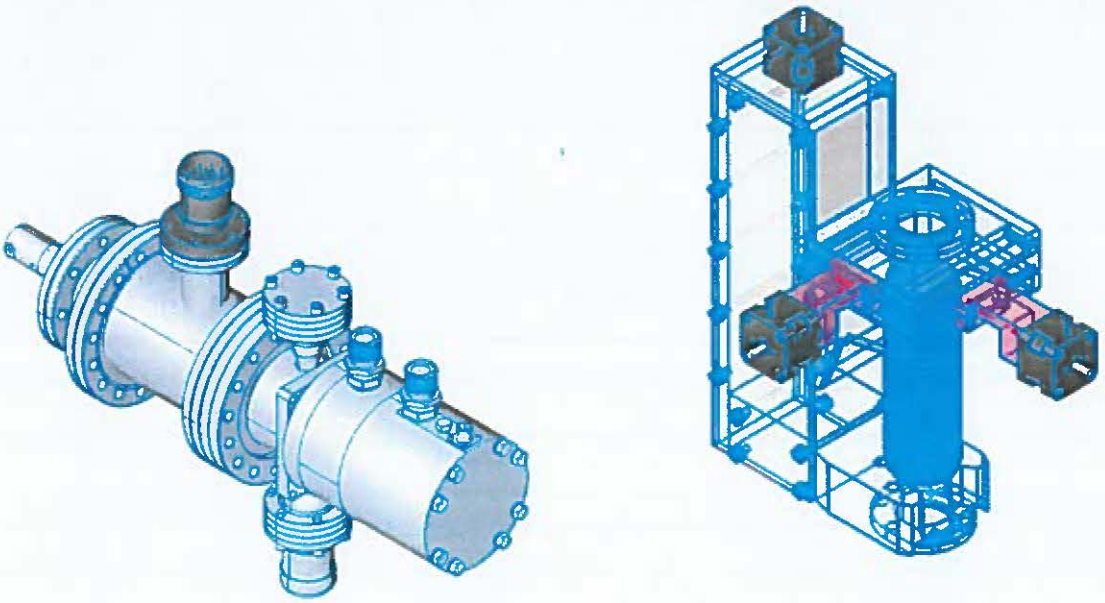


Figure 3: Drawings oft the closed cycle cryostat (here UHV version from ARS) and the motorized XYZ-stage.

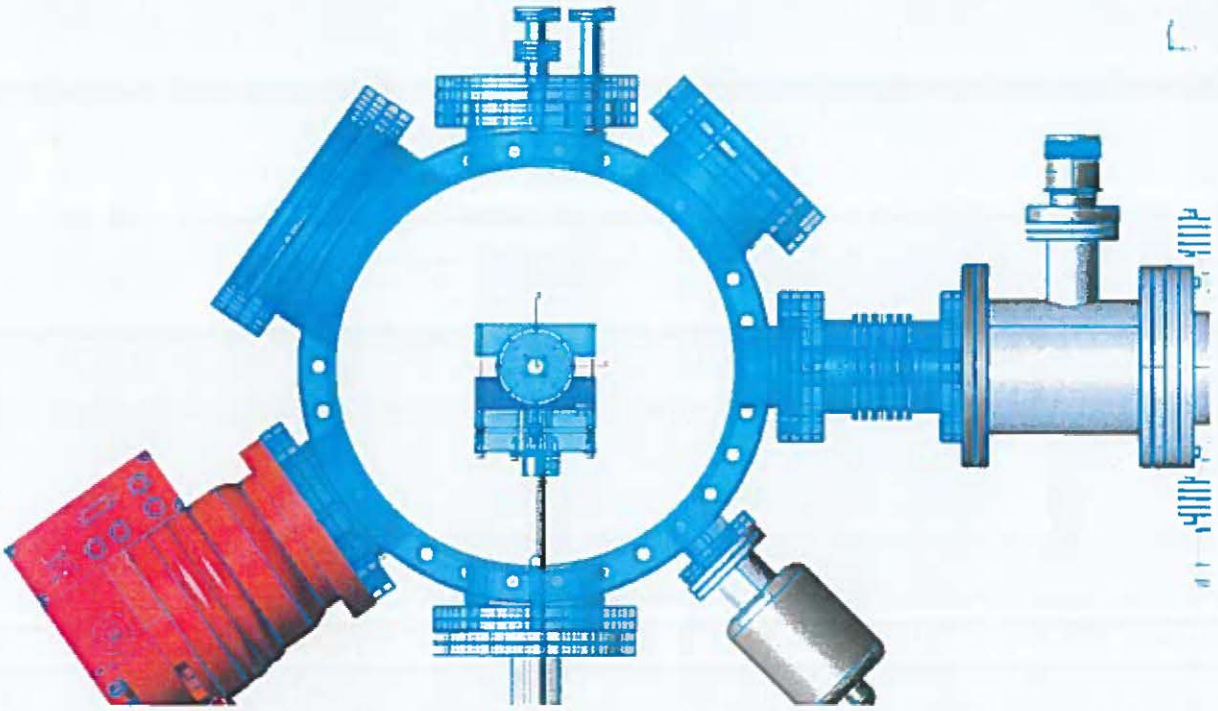


Figure 4: Drawing of the tip-tlit sample stage holding the magnetic field head. The support rests on the XYZ stage as depicted in Fig. 2 allowing together a comprehensive XYZ-tip-tilt motion. The top left CF-100 flange will be used for the sample transfer unit. The flex-bellow between cryostat and closed cylce will damp vibrations from the compressor of the closed-cycle cryostat. Copper braids and goniometer arms are not shown. (This chamber is being quoted in the price bid calculation)

For wear free operations of polarizer and goniometer arms we will employ the magnetically coupled rotation systems as shown in Fig. 9. These units will be employed for the analyzer/polarizer movements as well as for the two goniometer movements. Together with the motorized XYZ-stage this yields overall 7 motorized axis of the instrument. However, it is possible to extend the number of motors up to 30 during later upgrades.

The complete instrument will sit on a support structure made of 60 mm Rose-Krieger-profiles with damped leveling feet (not shown in the drawings except partially in Fig.2).

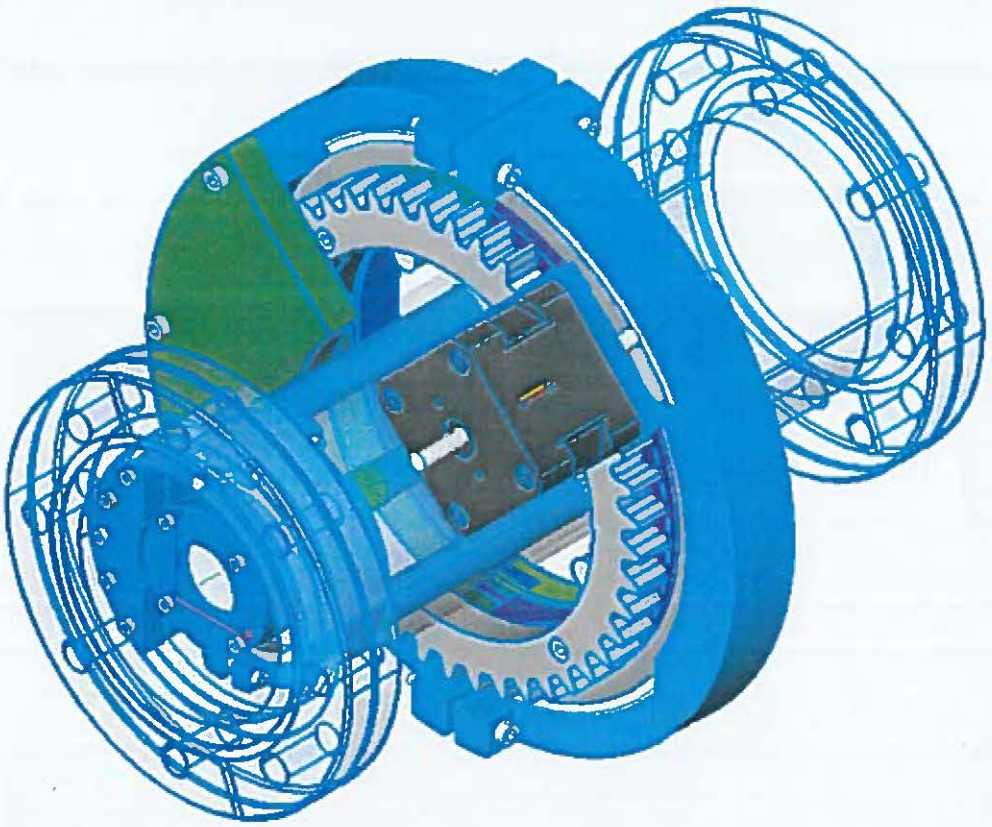


Figure 5 Drawing of the stepper motor controlled precision rotation stage with magnetic coupling. As in general encoders are not shown. This unit serves as polarizer/analyzer. The current unit can hold 25 mm optics. They will be modified for the VUV polarizers.

2.2 Other critical components

Figure 6 shows a typical stepper motor from Nanotec with an encoder mounted on the secondary axis. The mechanical coupling is being achieved by a D-cut like coupling featuring a mechanical joint to press the inner diameter of the coupling against a rotationally symmetric axis (typically the end of a precision screw). The D-Cut coupling allows z-axis motion without loosing rotational steps or generating a back lash of more than 10 µm. The approach of the stepper will be still single sided in order to allow a compensation of this remaining backlash. The advantage, however, is that a broken stepper motor can be exchanged easily without any further complication at the instrument. The stepper motors (7 axis in total) will be controlled by the KOSIM® controller, which is a 7-axis encoder controlled stepper motor driver, which allows that 3 of the 7 axis can be controlled by a 3 axis joystick. The controller features the capability of programming by Java-like applets (embedded Java). The controller is shown in Fig. 11 (together with the SGME® controller). It also features and touch screen for direct communication and can be directly connected to one of the 6 USB-Ports of the embedded PC of the SGME controller.

Figure 6: Exemplary stepper-Motor including encoder with D-cut and mechanical adapter with D-cut and mechanical joint to couple the stepper to one of the motion axis of the system. Please note – even though not drawn in the mechanical drawings all stepper motors will be outfitted with encoders as shown in this figure. The encoder is mounted on the extended motor axis that is shown in the mechanical drawings.

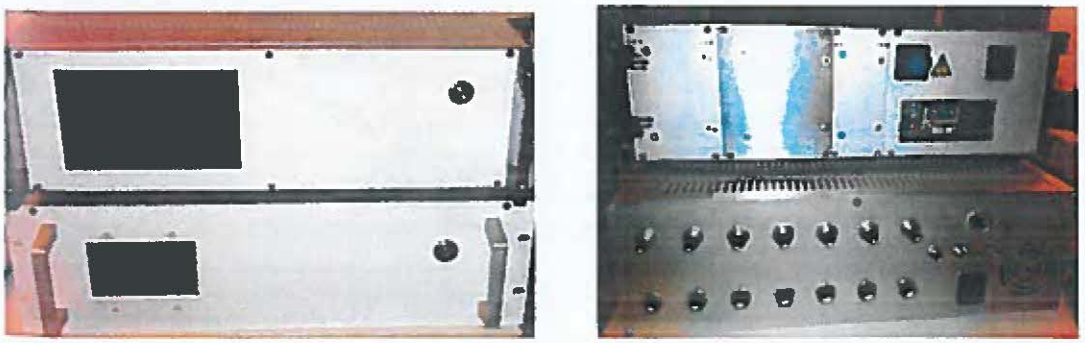


Figure 7: Exemplary electrical controllers for the operation of the beamline. The SGME controller (top unit) is being described in the next chapter. The stepper motor controller (KOSIM controller) features 7 encoder-controlled axis with the option to mount limit switches. (needed on all 7 axis) There is also a Joystick control for 3 out of the 7 axis (for the XYZ-control) and 4 rotational axis will be served (2 goniometer axis and 2 polarizer/analyzer axis) – for more details see text. The controllers will be modified due to the special requirements at the ELI facility.

3. Introduction into the magnetic field system

A typical SGME®-Device is depicted in Figure 8. It usually consists of a controller unit (Rack-Mountable) which hosts the main cable connector either at the front side (shown here) or at the backside together with its other connections. The controller is operated by an embedded PC that can be controlled through a resistive touch-screen display. The cable connecting controller and magnetic field head must be supplied by 4-dimension optical solutions GmbH, othervise we cannot guarantee your safety and the proper operation of the device. Through the cable we connect to the controller a magnetic field head. 4-dimensional optical solutions offers high-field (shown in Figure 12), low field, and custom made heads. Please contact us for details. The SGME-magnetic field head is typically cooled by cryogenic cooling using a flow through cryostat (shown in Figure 12), a closed-cycle cryostat, a water cooling system, or a thermo-electric cooling system. Please consult your documentation which cooling systems are supplied together with your magnetic field heads. All components are matched to comply with the required safety standards and to assure a proper operation. Never open or dismount these units on your own. The controller, field-heads and cable can supply high voltage.

In summary a typical system contains the following items:

1. SGME®-controller
2. SGME®-Magnetic Field Head
3. SGME®-Cable
4. Cooling Unit (optional)
5. Cryostat Unit included as closed cylce cryostat

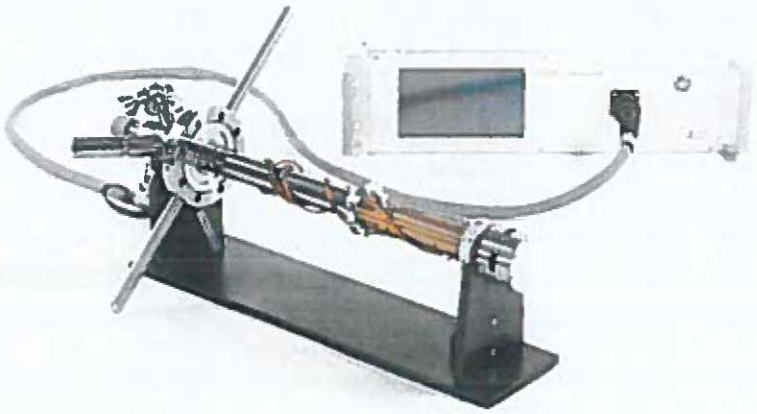


Figure 8: SGME®-controller (box with display), cable connecting controller and SGME®- Magnetic Field Head (front side) mounted on cryostat inset

4. SGME®-controller

The SGME®-controller controls the SGME-Device and is depicted in Figure 9. It hosts an embedded PC (dual core from Kontron) that is connected to the front panel through a resistive touch screen display. The front panel also hosts the main switch to turn on the device. The embedded PC communicates to microcontrollers, PLDs, and to a high-voltage power supply that runs the current in the magnetic field head. The SGME®-controller has the following connections on the back side (see Fig. 13):

1. 1 GB-Ethernet
2. 6 USB 2.0 Ports
3. Monitor Port (VGA)
4. Monitor Port (DVI)
5. Mini-USB Port
6. Audio-Ports
7. Choice of Windows XP, Windows 7 (recommended), or Windows 8
8. 1 SGME-Cable Connector if the unit is not supplied in the front side version
9. Power Supply 220 V Connection
10. Max Current 10 A
11. Trigger Board Slot
12. Fuse
13. The SGME-Controller and cable comply with the following standards:
    - DIN EN 55024
    - DIN EN 55022.
    - DIN EN 61000-6-3
    - DIN EN 61999-6-4
    - DIN EN 61000-4-2/3/4/6
    - IEC 60297-3
    - IEC 60529: IP20
    - DIN EN 50178
    - DIN EN 60950
    - DIN EN 61010-1
    - DIN EN 61010-1A2

Basic data of the controller:

Voltage: 230 V, Power: 600 W, Dimensions: 19", 3HE Climate: 15°C-40°C, Humidity: 40%-60% rel. Humidity, Weight: 5 kg

Figure 9: SGME®-controller with resistive touch screen SGME®-cable connector and power switch (Left). (Note, the cable connector can be also on the back side like shown on the right). Please note the Ethernet, 6 USB 2.0, VGA and DVI, mini-USB and Audio outputs. Note the layout will be changed to a more modern i7 embedded PC.

5. SGME®-High-Field Head

In Figure 10 we display the high-field head for fields up to 1 Tesla (see calibration chart of a conventional standard head). With the enhanced pulse mode and the application of 10 A fields of more than 1.5 T are possible. For even higher field a reduced gap size is required. The standard magnetic head holds samples with sizes of 5 mm by 12 mm. Different geometries are available upon request.

Always ensure proper cooling of the device. Ideal operating temperature is 270 K - 50 K. Operating the head above 320 K can severely damage the device. Also manipulating the PT-100 cable connections and improper settings in the SGME-control and Analysis software voids all guarantee. When overheated the head automatically stops its operation and restarts once a temperature for safe operation has been reached

The magnetic field dependence on the current is typically given as follows (parameters alpha and beta depend on the design of the head so the numbers given below need to be regarded as typical numbers for reference:

$$B = \alpha I + \beta I_{\mathrm{sat}} \tanh\left(\frac{I}{I_{\mathrm{sat}}}\right)$$

with the fitted values $\alpha=0.084$ T A^{-1}, $\beta=0.4366$ T A^{-1}, revealing $I_{sat}=1536.5$ mA and $\mu_{r,eff}=1+(\beta/\alpha)=5.2$.

I = 250 mA		B = 130 mT
I = 500 mA		B = 252 mT
I = 1 A		B = 470 mT
I = 3.3 A	→	B = 930 mT
I = 6 A		B = 1174 mT
I = 10 A		B = 1.511 mT

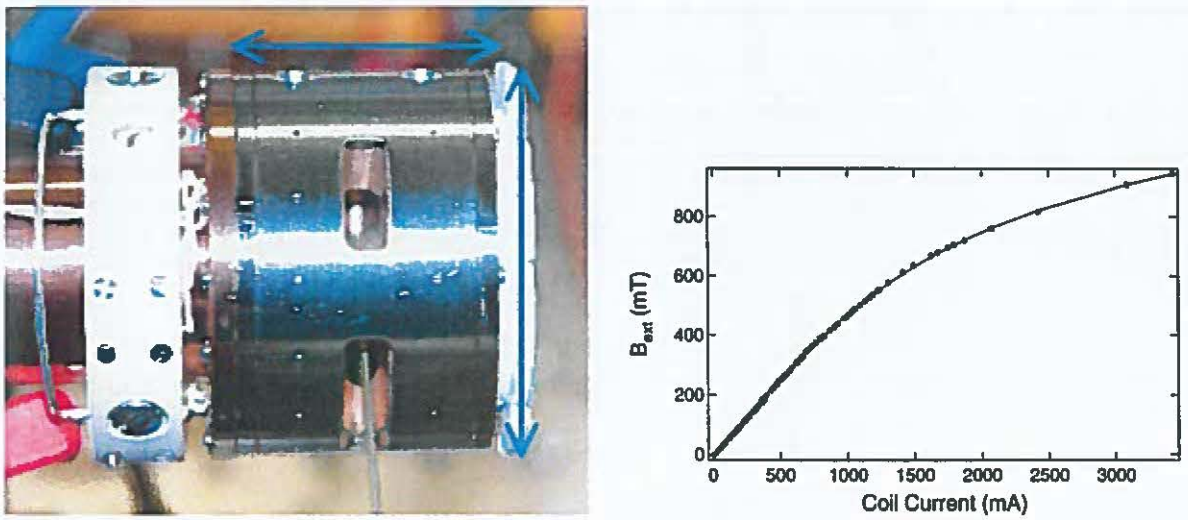


Figure 10: High –Field Head (left) used to reach magnetic fields of up to 1.6 T inside the head at the samples with marginal magnetic stray fields outside the head. Reducing the gap increases the field to values close to 2 T. The dimensions are length 38 mm, diameter 58 mm (can be hosted within a standard CF-60 tube). Right exemplary calibration chart of a standard head yielding a field of about 1 T at 3.3 A. (see Ref. [1] for details)

There are two basic concepts of operating the software of the SGME®-controller. Firstly a trained expert can run the SGME-Control and Analysis Software under administrator rights after direct training from 4-dimensional optical solutions GmbH. This software allows to reconfigure all calibration data used by the microcontrollers and improper operation can harm the operation of the SGME®-device (expert mode).

The second mode of operation is possible through the guest account of the embedded PC. It initiates at synchronized socket connection between a server that is the embedded PC of the SGME®-controller and a client. This mode of operation can be embedded into the ELI facility infrastructure upon request.

6. Software - general

Programming within the expert mode is relatively straight forward as it is based on the simple exchange of string commands through the serial port. It can be done by any framework (Java, Visual Studios etc.). A typical line of communication includes the following sequence:

Upon starting a specific magnetic field/current versus time profile (see charts at the end of the documentation. The microcontroller sends a simple

#h (hold current reached)

which is confirmed with an string command

h from the program operated at the embedded PC

The unit hold now the current and the corresponding field. It simply waits until you have finished your measurement. When you have finished your measurement the controller expects an

#o (measurement finished)

and carries on with the predefined number of measurements, magnetic field ramps, or measurements at switched negative fields.

The controller will acknowledge you by sending an

o

back to the serial port. This way programming of the device a simple exchange of string commands. (More details on setting up the COM-Port is available in the programming manual of the SGME controller)

Server-Client software should be used for the operation of the device through the local internet when being in guest mode of the windows XP-system of the embedded PC or when you want to include the socketproject.exe into your own software.

To start the server software on the embedded Pc type: C: \ Socketproject.exe -server

To start the client software on your computer simply type after dropping the socketproject.exe on C: \:

C: \ Socketproject.exe –clientType the correct TCP-IP number of the embedded PC: 192.168.0.3 . The software

should start synchronizing server and client programs automatically.

Please ensure that the your computer and the embedded PC are connected through an Ethernet connection.

7. Documentation of the voltage current profiles that can be accomplished

- Single Pulses @ TestCoil in Helmholtz Configuration @ 25 Ohm Coil Resistance
    - 1A Peak Current, 500 mA Hold-Current (1&10 Pulses)
    - 2A Peak Current, 1A Hold-Current (1&10 Pulses)
    - 6A Peak Current, 3.3A Hold-Current (1&10 Pulses)
- Max Current Demonstration @ 12.5 Ohm Coil Resistance
    - 10A Peak Current, 1 A Hold Current (1&10 Pulses)
- Permanent Current Demonstration @ 25 Ohm Coil Ressistance
    - 6 A Peak Current, 3.3A Hold Current (100 Pulses)
    - 6 A Peak Current, 3.3A Hold Current (1000 Pulses, 4 min)
    - 6 A Peak Current, 3.3A Hold Current (10000 Pulses, 40 min)
    - Temperatures at the Power-MOSFETs and Housing have been measured
- 3.3A @ 70 Ohm Coil Resistance
    - 3.3A Hold Current (1&10 Pulses)

- Ramp-Mode Testing
    - Ramp Mode 1, 6 A Peak Current, 3.3A Hold Current 100 Pulse/50-Pulse Ramp
    - Ramp Mode 1, 6 A Peak Current, 3.3A Hold Current 100 Pulse/150-Pulse Ramp (obviously impossible -> autocorrection)
    - Ramp Mode 2, 6 A Peak Current, 3.3A Hold Current 200 Pulse/50-Pulse Ramp
    - Ramp Mode 2, 6 A Peak Current, 3.3A Hold Current 200 Pulse/150-Pulse Ramp (obviously impossible -> autocorrection)
    - Ramp Mode 2, 6 A Peak Current, 3.3A Hold Current 200 Pulse/50-Pulse Ramp (no positive pulses)
- Temperature Emergency Shut-Down Procedure
    - Coil was heated by current shut off temperature 40.5 °C turn on temperature 39.9 °C, 2A Peak Current and 1 A Hold Current

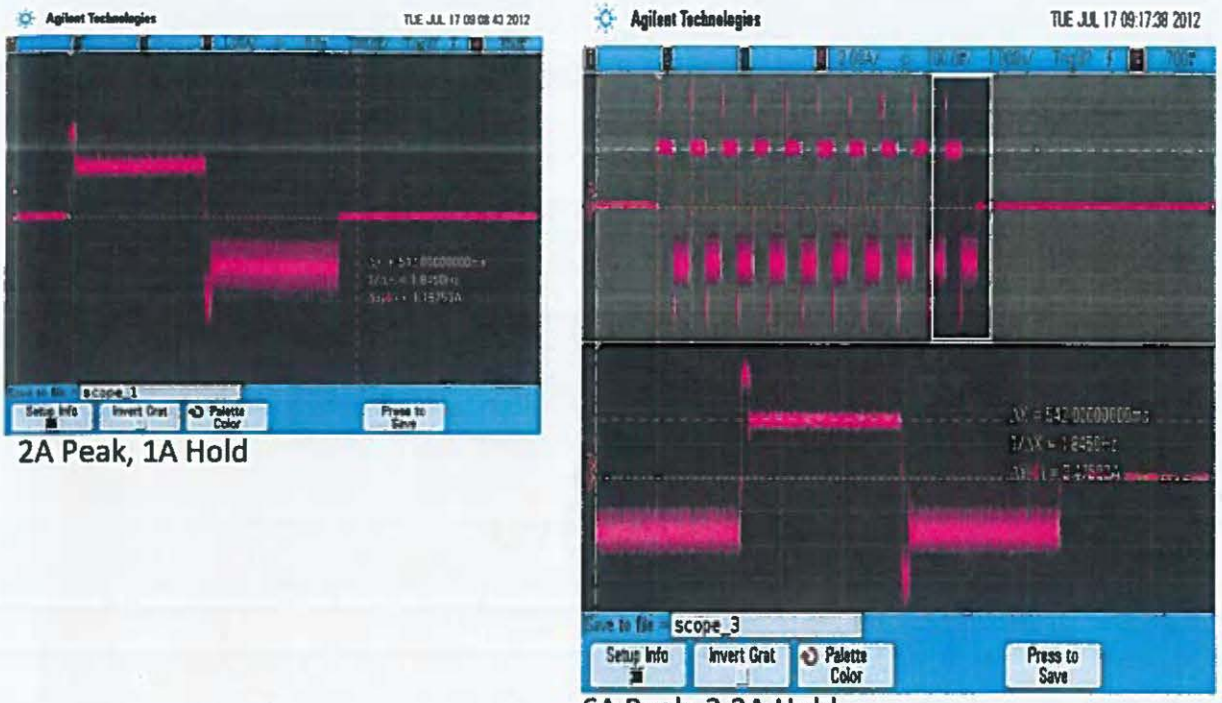


Figure 11: Peak/hold current configuration for symmetric profiles (note that asymmetric profiles - only positive currents or only negative currents are also possible). However, in due to Eddy-current compensation switching the filed from positive fields to negative fields is most demanding. The graph on the right corresponds to switching of a peak field of 1.2 T while measuring at a field of about 0.93 T.

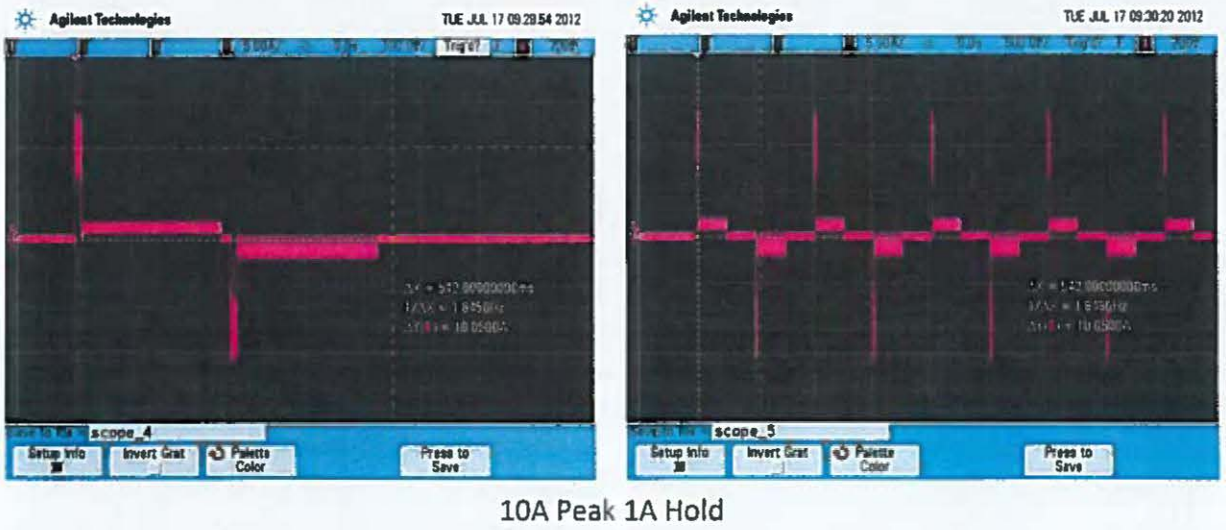
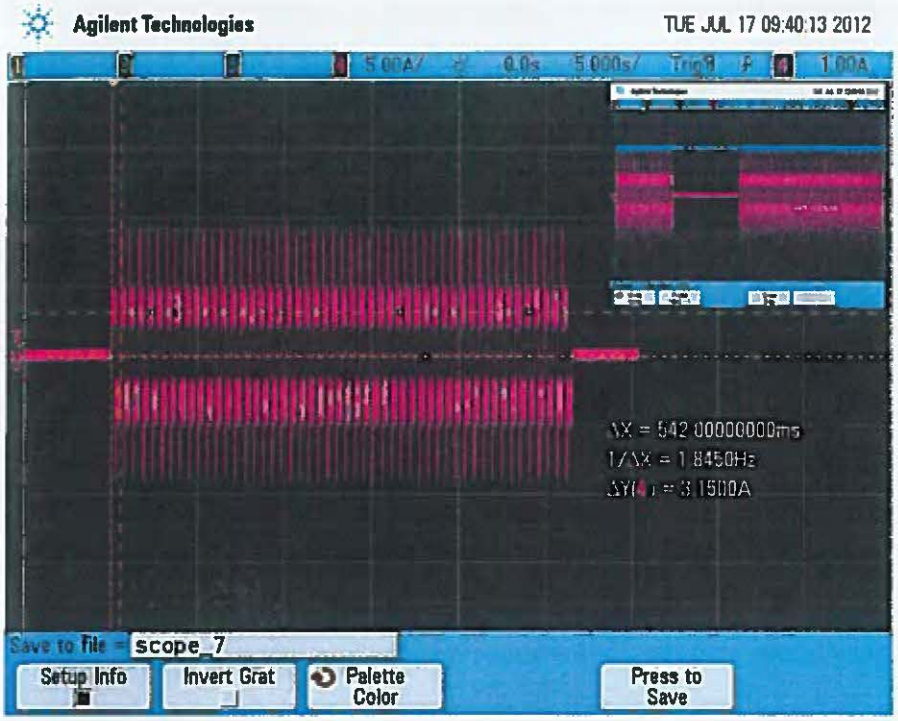


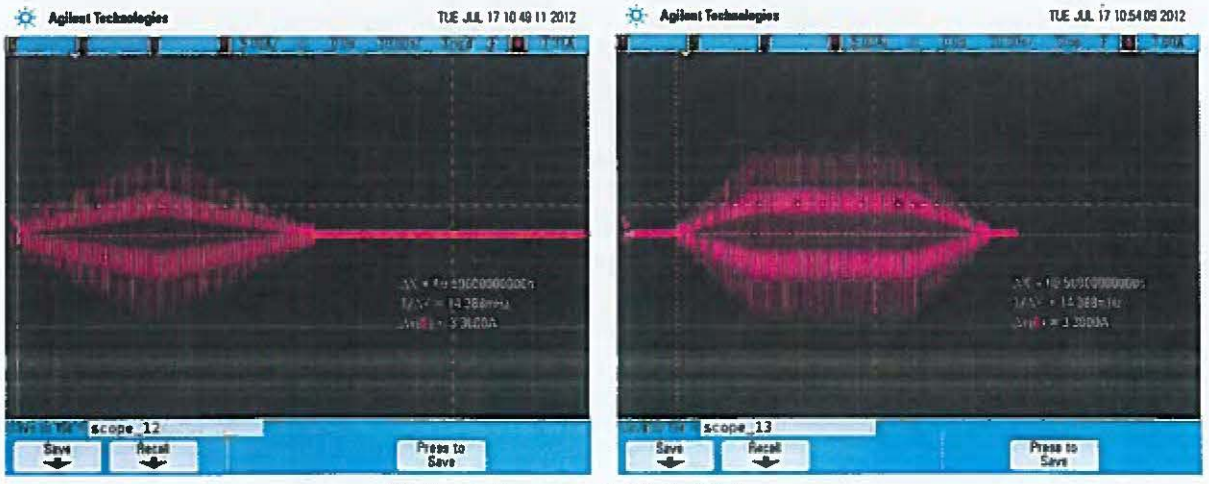
Figure 12: Peak/hold current configuration for symmetric profiles (note that asymmetric profiles - only positive currents or only negative currents are also possible). The graph on the right corresponds to switching of a peak field of 1.51 T while measuring at a field of about 0.47 T.



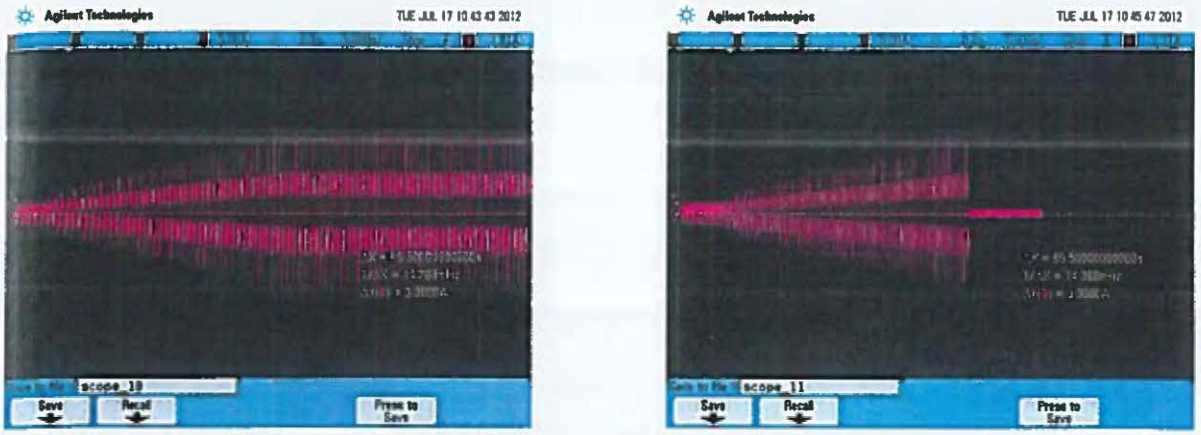
100 Pulses, 1000 and 10000 Pulses do not fit on screen !

Max. Heating 70° at Power MOSFETS (140° max temperature). 40° at heating body of the power board.

Figure 13: Peak/hold current configuration for symmetric profiles (note that asymmetric profiles - only positive currents or only negative currents are also possible). Testing the internal power MOSFETS. Please note that under heavy duty the maximum temperature (140°) is only reached by 50% (70°). However, proper cooling is required – check that the side ventilators are able to access fresh air. Mounting to close internal heat sources (e.g. high-power lamps) in a rack is not recommended.



6A Peak Current, 3,3A Hold Current



6A Peak Current, 3,3A Hold Current

Figure 14: Various demonstrations of different ramp modes. Ramps shown here are symmetric but are also available for asymmetric profiles (positive or negative currents only) allowing a straightforward measurement of hysteresis curves etc.

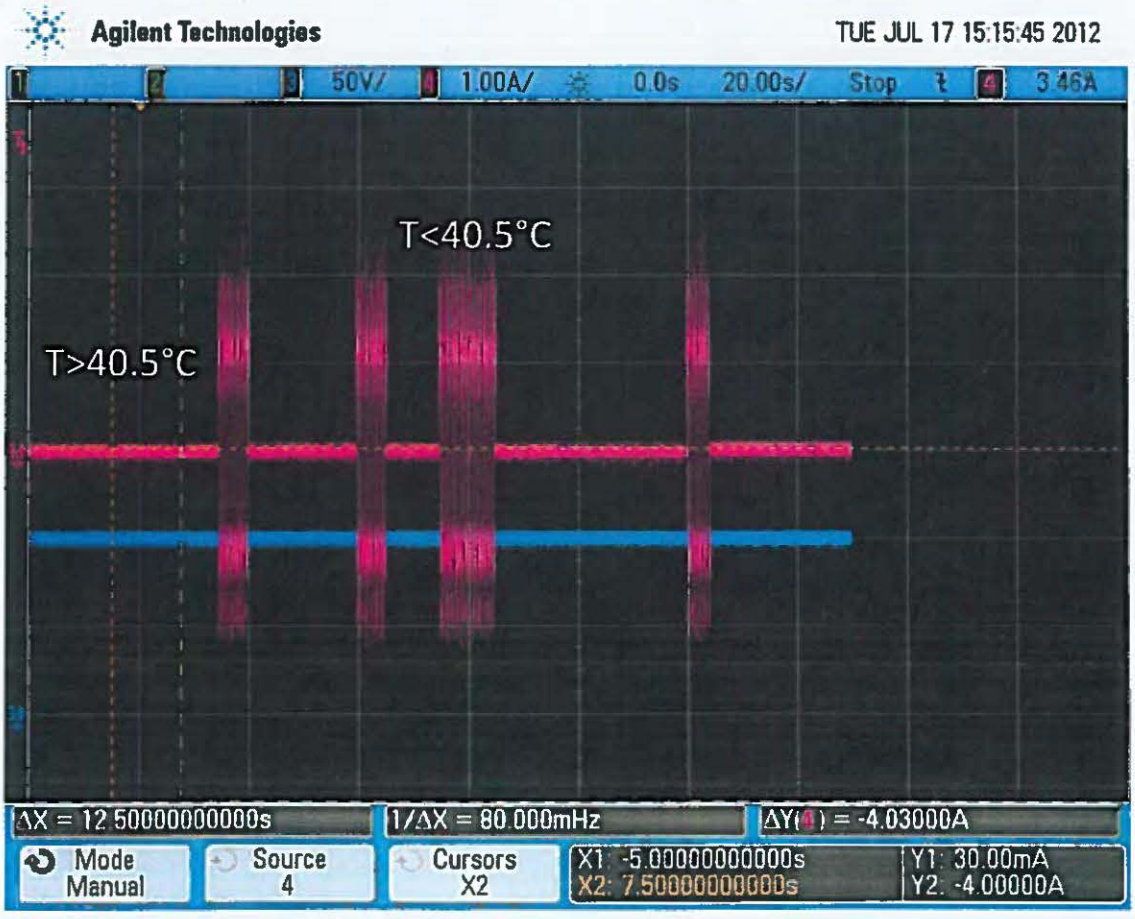


Figure 15: Demonstration of the autoprotection. The coil is being set to stop operating for temperatures above 40.5 °C and sets in at 39.5°C (Temperatures chosen for demonstration purposes only) . The actual temperatures of coil destruction are close to 400 °C. However, the set temperatures should be set to

protect coils and experimental infrastructure nearby.

10. References

[1] Temperature-dependent spectral generalized magneto-optical ellipsometry for ferromagnetic compounds
R. Rauer, G. Neuber, J. Kunze, J. Bäckström, and M. Rübhausen, Rev. Sci. Instr. **76** 023910 (2005).
[2] Temperature-dependent spectral generalized magneto-optical ellipsometry
G. Neuber, R. Rauer, J. Kunze, T. Korn, C. Pels, G. Meier, U. Merkt, J. Bäckström and M. Rübhausen, Appl. Phys. Lett. **83** , 4509 (2003).