



UNIVERSITY OF
NOVA GORICA

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Materials Research Laboratory

Transmission Electron Microscope (TEM) with STEM and EDX unit



With the microscope (model JEOL JEM 2100 UHR) it is possible to **examine the solid specimens** (powder, nanostructures, lamellas, bulk materials, ..) with atomic resolution (nominal resolution 0.1 nm). This allows to understand the crystalline structure, the different phases, the presence of defects, the interface structures, the shape of nano-objects, etc. Thanks to the STEM/EDX unit it is also possible to conduct compositional analysis with high spatial resolution (~ 1 nm), in order to know which elements are

presents in different areas of the sample (together with their concentrations).

The instrument can be operated by authorized trained users.

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Scanning Electron Microscope (SEM), with backscattered detector, EDX unit, cathodoluminescence and heating stage



With the microscope (model JEOL JSM-2700f TTL) it is possible to **examine the surface of solid specimens** (surfaces, powders, nanostructures, films, ...) with nanometric resolution (typical resolution 3 nm). Thanks to the EDX unit it is also possible to conduct compositional analysis of the phase(s) present in the sample with sub-micrometric resolution, and know which elements are present in the sample (and their concentrations). Cathodoluminescence micro-spectroscopy apparatus allows for the

study of peculiar properties of the sample, such as dopant in semiconductors, defects in optical fibers, impurities in oxides, etc. The presence of an heating stage (nominal range RT-800 °C) allows for the study of the materials during a heating treatment. When mounted on the heating stage, it is possible to expose the specimen surface to gas during heating/observation (max. pressure in 10^{-4} mbar range).

The instrument can be operated by authorized trained users.

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Electron microscopy sample preparation

In many cases specimens for the observation with SEM and TEM require a special preparation, in order to make them observable. The **sample preparation** laboratory at UNG offers a plethora of equipment dedicated to this fundamental step before the microscopy investigation. The sample preparation laboratory includes: diamond-wire saw (Well), Precision etching and coating system (PECS, GATAN), Precision Ion Polishing System (PIPS, GATAN), ultrasonic disc cutter (GATAN), dimple grinder and disc grinder (GATAN), cross-section polisher (JEOL), rotating polishing machine (STRUERS), together with additional ancillary equipment (hot, plates, vacuum box, ovens, water deionizer, stereomicroscope, ...).

We are expert in several preparations: coating/metallization of surfaces with accurate thickness (~ 1 nm accuracy), precision cutting, mechanical polishing, preparation of cross-sections, ion-polishing, resin embedding.

These instruments can be operated by authorized trained users.

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FLS920 Steady State and Fluorescence Lifetime Spectrometer



Fluorescence spectroscopy and time-resolved fluorescence are primarily used as **research tools in biochemistry, biophysics, chemistry and materials science**. The FLS920 combines a steady-state and a fluorescence lifetime spectrometer in a single instrument and is a modular system for measuring steady-state spectra in the UV-visible spectral range as well as the fluorescence decay in the time range between 40 ps and 50 μ s using the Time Correlated Single

Photon Counting method.

The system is computer controlled and the supplied software enables control of the spectrometer, performance monitoring, acquisition of steady-state and fluorescence lifetime data and data analysis. The single cuvette holder allows the measurement of samples in liquid form, while the single position front face sample holder allow to measure powdered samples.

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HD-Thermovision camera FLIR E86 24°

Thermal vision cameras provide significant advantages when heat difference is crucial. In R&D, they can primarily be used to **study the thermal properties of materials**. With FLIR E86, 24° can measure temperature differences in the T range from -20 to + 1500 °C with a precision of ± 2 °C. A hot spot or cold spot is detected automatically. Using the programme on the computer, measurements can be performed remotely (imaging or real-time movie). Recorded measurements (image or movie) can be used for pixel-by-pixel (0.90 mrad/pixel) analysis, enabling precise thermal profiling of the sample. No special sample preparation is required.

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Phoenix EC 45 Multi (pH, Conductivity, ORP, temperature)

This device equipped with suitable probes is used for **precise measurements of pH, conductivity, temperature and ORP** in various solutions or samples prepared in liquid form. It allows simultaneous measurement of 1. pH, temperature and conductivity, or 2. ORP, temperature and conductivity. Possible is also to calibrate for specific measurement of TDS (total dissolved solids). It could be used for various laboratory and process analysis, environmental and industrial monitoring and water quality testing. A 5-point calibration with standard pH buffer solutions (pH: 1, 2, 4, 7, 10) is used for pH probe. For conductivity are available low (μ S/cm) and high (mS/cm) conductivity range probes and standards. There are standards also for verifying ORP. The equipment is available primarily during regular laboratory hours, but it is possible to agree also outside regular working

schedule. We also offer training for the use and calibration of these probes to ensure accurate and reliable measurements.

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Competences in theoretical analysis

Polymer Physics and Biophysics:

Consultations on **characterization of polymers of all shapes and structures**, including MOF and COF. Studies of miscibility diagrams for polymers and soft materials. Theories of conformational transitions (unfolding, melting) in biopolymers. Description of transitions in nucleic acids and polypeptides, including interactions with solvents and ligands. Docking in proteins, modeling in general (theory and/or simulations); post-processing of experimental data, basing on developed theories.

Modelling of chemical reactions (diff. equations):

Solutions (analytical, numerical) **of systems of diff. equations** to describe kinetics. Extraction of reaction rate constants from experimental data.

Statistical and modeling data analysis: Analysis aimed at **determining predefined statistical descriptors on existing data sets**. Consultation on statistical data treatment. Solid coding skills, development and code optimization, profiling and debugging in both Windows and Linux (C, C++, C#, python, Visual Basic, bash scripting). Practical knowledge of experiment automation (Agilent, Labview).

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Powder X-ray diffractometer MiniFlex600 (Rigaku)

The Benchtop Powder X-ray Diffraction (XRD) Instrument allows qualitative and quantitative **phase analysis of poly-crystalline materials**. The MiniFlex benchtop X-ray diffractometer is a multipurpose powder diffraction analytical instrument that can determine: crystalline phase identification (phase ID) and quantification, percent (%) crystallinity, crystallite size and strain, lattice parameter refinement, Rietveld refinement, and molecular structure. It is widely used in research, especially in material science and chemistry, as well as in industry for research and quality control. The XRD device is suited for crystalline powder materials.

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Advanced X-ray diffractometer SmartLab SE (Rigaku)



With this X-ray diffractometer, we can determine the **phase composition of powdered materials**. For example, clays, cements, and pigments. Quantification of phases is also possible. In addition, thin film samples can be investigated in grazing incidence geometry. Texture analysis and preferential orientation analysis are possible with Pole figure measurements. Residual stress can be analyzed for example in thin films and metal or metal alloy foils. The additional heating stage allows to study phase transitions up to 1100°C

in air, nitrogen, or vacuum. The equipment is available primarily during working days.

Contact: andraz.mavric@ung.si

Thermogravimetric Analyzer TGA/DSC 2 with evolved gas analysis

With a thermogravimetric analyzer (Mettler Toledo), we can **investigate material mass change during heating or cooling** (room temperature to 1600°C) in air, oxygen, or nitrogen atmosphere. Mass change can occur for example due to oxidation, decomposition, combustion, evaporation, and desorption. The thermal stability of materials can be studied. Evolved gasses can be analyzed using a mass spectrometer (Pfeiffer Vacuum OmniStar GSD350). In addition to mass loss, the instrument measures heat flow to the sample for differential scanning calorimetry measurements. This allows us to study phase transitions (melting, crystallization, glass transitions, and polymorphic transformations), giving information about the thermal stability, purity, and composition of materials. We can investigate liquid or powdered samples on the scale of a few microliters or micrograms, respectively.

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Potentiostat/galvanostat/EIS analyzer SP-300 (BioLogic)

The instrument can be used to **investigate the corrosion properties of metals and the quality of corrosion-resistant coatings**. Characterization of electrolysis processes for metal plating and electrocatalysis is possible. The equipment is available primarily during working days.

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Physisorption and chemisorption gas analyser

The gas sorption analyzer (Quantachrome Autosorb iQ-XR) is available with two physisorption analysis ports for **surface area analysis and pore size measurements**. It is equipped with extended range micropore capability. The machine is available as a chemisorption enabled model that retains all the physisorption capabilities. The device is equipped with three pressure transducers in both stations: 0.1 torr + 10 torr + 1000 torr. Four degassing ports are used for automated sample preparation. The physisorption option allows estimation of Pore size distribution, pore volume, surface area, etc. using different adsorbates such as N₂, Ar, CO₂, O₂, H₂, NH₃, etc. Chemisorption studies can be conducted using a chemisorption furnace capable of reaching temperatures up to 1100°C and supporting ramp rates from 1 to 50 °C/min. The chemisorption capabilities covers measurements of active (metal) area, dispersion, crystallite size, chemisorbed monolayer, and chemisorption enthalpy studies. The gas sorption analyser is equipped with a thermal conductivity detector (TCD) for all temperature programmed techniques such as temperature programmed desorption (TPD), temperature programmed reduction (TPR), and temperature programmed oxidation (TPO). The TPD technique allows one to study the interaction of reaction gases with solid surfaces, thereby being a powerful tool for both the evaluation of active sites on catalyst surfaces and the understanding of the mechanisms of catalytic reactions including adsorption, surface reaction and desorption. The machine also allows also to perform pulse chemisorption studies using different gasses. Using this technique is possible to determine the metal dispersion and active metal area in composite catalysts such as metal decorated/metal oxides. The machine, when in vapor sorption mode, can also be used to evaluate the adsorption of liquid vapours onto solids. Comprehensive physisorption calculations include specific surface area (single and multi-point BET, Langmuir, STSA, t-plot, alpha-s, DR), total pore volume and pore size distribution (BJH, DH, DA, MP, HK, SF, Monte-Carlo, NLDFT, QSDFT) with their corresponding surface area values, Kr pore size for thin films, heats of adsorption, plus NK and FHH fractals. The machine is operated by a trained user and is available for use with prior scheduling. The types of samples for study include supported precious metals (e.g. platinum on alumina, palladium on carbon, supported transition metals (e.g. nickel on alumina), active metal oxides (e.g. cerium oxide, magnesium oxide), and zeolites (e.g. fluid cracking catalyst), Zeolites, metal organic frameworks (MOFs), activated carbon, etc.

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Electrochemical Workstation ZIVE SP1 (EDAQ)

The ZIVE SP1 is an outstanding potentiostat and galvanostat. The ZIVE SP1 is equipped with a frequency response analyzer(FRA) for system as standard and it provides high performance impedance measurements over the frequency range 10uHz to 1MHz. The ZRA (zero resistance ammeter) function can measure max. 1 Amp in galvanic corrosion technique. The electrochemical station is ideal for **conducting electrocatalytic experiments**, including water electrolysis, electrochemical synthesis, and other related studies.

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High-Temperature Furnaces (tube furnace and vacuum furnace)

The tube furnace (Protherm company) can continuously operate at a temperature of 1050°C. It features a ceramic/quartz tubes with an outer diameter of 70 mm and a length of 800 mm, providing a heat stable zone length of approximately 160 mm ($\pm 10^\circ\text{C}$). The furnace is equipped with mass flow controllers for precise gas flow regulation and can also operate under vacuum, featuring a digital vacuum gauge. It is suitable for **solid-state synthesis, carbonization of materials**, and other experiments. Additionally, a vacuum furnace is available, capable of heating up to 1200 °C and maintaining a vacuum lower than – 1.0 atm. The chamber of the vacuum furnace accommodates objects with dimensions of 10 cm \times 10 cm \times 20 cm.

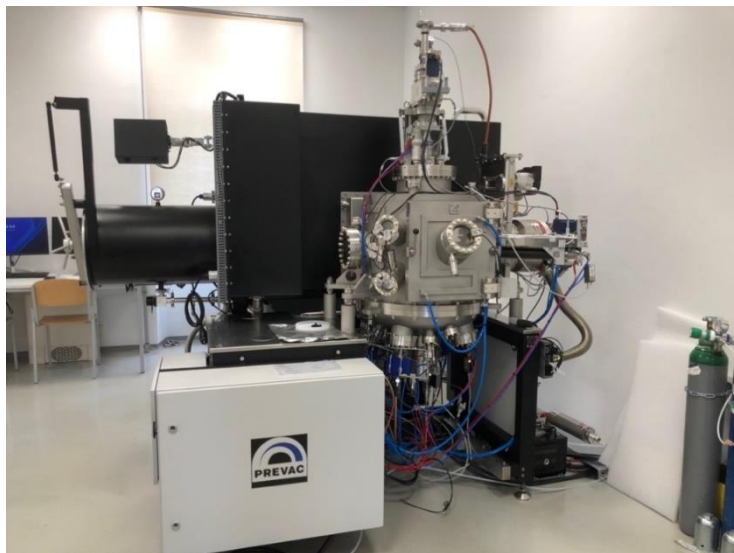
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HD UV-Vis Spectrophotometer

A UV-vis spectrophotometer makes it possible to **determine/measure the absorbed, transmitted, emitted (fluorescence) or reflected light** in the spectral region between 200-1100 nm. HD detector can perform real-time measurements with resolution ≤ 1.2 and integration time < 10 ms. Based on the optical properties of the investigated analyte, UV-vis spectroscopy provides essential data on the sample's composition, concentration and purity. Therefore, the method can be used in different fields, e.g., pharmacy, environment, food/beverage industry, material science, biomedicine, etc. Absorbance and fluorescence can be measured on liquid samples (suspensions or solutions), while reflection can be measured on solid samples.

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System for thin films deposition and physical vapor deposition (PVD)



The deposition system, from Prevac sp. z o.o., allows to **grow thin films of magnetic materials** (either alloys or layers of Fe, Ni, Co doped with transition metals for example), **oxides** (like Al_2O_3 and ITO, indium tin oxide) **and dielectrics** for applications in devices.

For better control, and better ordering, of the thin film, it is possible to heat the sample and also to apply a bias, which will help in both cleaning and getting improved quality.

The system includes:

- Glovebox with large and small antechambers from Inert
- 4 sources: 2 for RF sputtering and 2 for magnetron sputtering (controllable also simultaneously)
- Ion gun for reactive sputtering
- Sample holder for 4 inches wafers
- Heating stage (T max 900 °C)

- 5 quartz microbalances
- Rotating stage
- Masking shutter for gradient deposition
- Large front door, to introduce samples also from the »air side«
- Computer control for automated deposition

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Laboratory for Environmental and Life Sciences

Virology

Pseudoviral particles as **tools for studying viral infections and as delivery systems**. We provide a platform for the synthesis of various pseudoviral particles and their modification (including integration of different types of reporter plasmids, fluorescent labeling of viral capsids and envelopes, labeling of incorporated DA and intracellular trafficking).

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In vitro toxicity

of environmental pollutants, biocompatible materials and other substances. Use of relevant cell lines **to determine cytotoxicity**, generation of intracellular ROS, genotoxicity and immune response activation.

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Biotechnological services

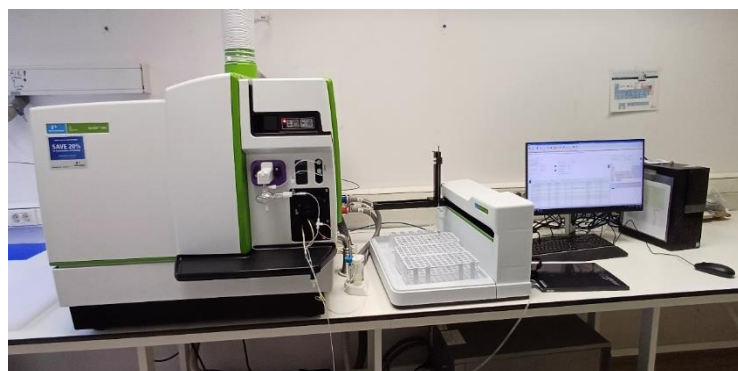
- **Protein production** in *E. coli* **and purification** of recombinant proteins
- **Panning, production and characterization of recombinant antibodies** (nanobodies and adhirons) for any antigen.

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Environmental sample analysis and chemical characterisation

Includes the **analysis of non-specific pollution parameters** (such as chemical oxygen demand, biological oxygen demand, total organic carbon etc.) **and specific chemical analyses** applying the following instrumentation:

ICP-MS



Inductively coupled plasma - mass spectrometer, Perkin Elmer Nexion 1000 for **analysis of trace elements**. This instrument offers the following performance:

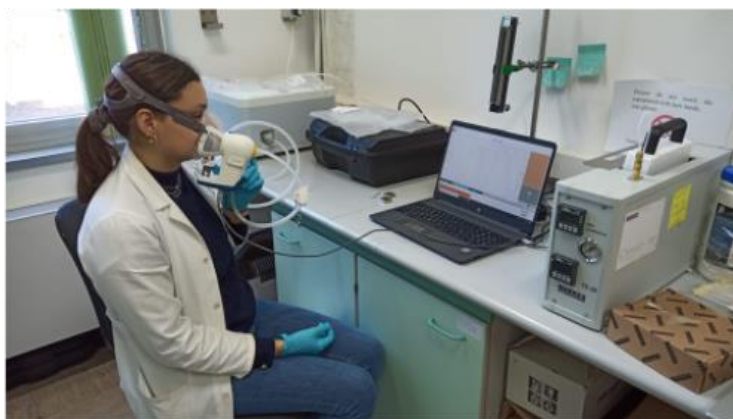
- a mass range between 1 and >258 AMU;
- the analysis of samples with a high

total TDS (Total dissolved solids) content of 35%;

- sensitivity of 100 Mcps/ppm for 205Tl;
- detection limit of 0.03 ppt for medium-range ions (^{115}In) in normal operation (without He);
- MS scan speed 5000 AMU/s
- <4% RSD;
- the possibility of analyzing water samples containing corrosive acids such as HF;
- and includes microwave oven for acid decomposition of samples.

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Breath sampling system



The system consists of:

- An Owlstone RECIVA interface: a **breath sampler** that uses disposable silicone-based medical masks and a built-in low-resistance bacterial filter (placed below the sampling ports) to prevent cross-contamination between sampled samples;
- double integrated sampling pumps (with a capacity of up to 1 L min⁻¹), which enable simultaneous sampling of different volumes and fractions of exhaled air in different test tubes;
- an internal, quick-response CO₂ sensor and a sensor for real-time monitoring of changes in the pressure of the subject's exhaled air samples;
- four ports available for sampling into standard sorbent-filled 3.5-inch stainless steel tubes;
- portable Owlstone CASPER air intake with included main air pump, which collects outside air and supplies it to the interface through the air filter;
- sorbent-filled reusable sample cartridges (containing hydrophobic sorbents: Carbograph-5TD/TenaxTA). Verified quality control, including airtight storage lids prior to instrumental analysis.
- Markes TC20 unit for chemical cleaning of sampling tubes with built-in pressure regulator and oven, mainly for removing water after sampling, for decontamination and conditioning of cartridges before reuse.

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Gas chromatographer with μ ECD and FID detector



The Hewlett Packard HP 6890 Series gas chromatograph with GERSTEL MultiPurposeSampler MPS 2XL includes a thermal desorption unit. This instrument is used **for the analysis of volatile organic compounds**, such as alcohols, aldehydes, ketones, pesticides (DDT, PCBs) etc. within various sample materials.

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Ion chromatography

The Shimadzu LC-10Ai ion chromatograph has a Shimadzu CDD-10A VP conductivity detector, **used for single column cation detection (K⁺, Ca²⁺, Mg²⁺) and suppressed chromatography for anion detection (NO₃⁻, SO₄²⁻, etc.)** in liquid samples.

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Liquid chromatography (HPLC)

Our Agilent 1100 Series liquid chromatograph is equipped with DAD, FLD and PAD detector. This instrument is mostly **used for the analysis of various compounds** (pesticides, antibiotics, levoglucosan, biogenic amines) in biological and environmental samples.

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Fast protein liquid chromatographer (FPLC)



The FPLC AKTA is mostly **used for protein purification in protein production**. Several proteins that are used as binders for markers for cancer, viruses, yeast and bacteria detection can be purified on this device.

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Laser methods

Based on photothermal techniques as applied to the characterisation of material properties and **used to determine trace concentration** of a wide range of target compounds.

- Thermal lens microscopy (TLM)
- Multifunctional photothermal spectrometer
- Photothermal beam deflection spectroscopy

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Spectroscopy instrumentation for routine analyses

- UV-Vis spectrophotometer with integrating sphere, Perkin Elmer Lambda 650S
- IR spectrophotometer (IR-ATR), Perkin Elmer Spectrum 100 equipped with PIKE Gladi ATR
- Fluorescence-activated cell sorting (FACS), Guava Luminex
- Microplate spectrophotometer (UV-Vis and Fluorescence), Tecan Infinite F200
- Microplate spectrophotometer (luminescence and fluorescence), Perkin Elmer, Viktor X2, 2030 Multilabel Reader

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Microscopy

- Fluorescent light microscope with digital camera and software for capturing and processing images, Microscope Olympus and digital camera q-color 5

- Inverted light microscope, Motic AE 20

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Cell and molecular biology

- Chemiluminescence imager, Chemiluminescence imager Uvitec

- SDS electrophoresis system and Western blot transfer, Bio Rad, Cleaver Scientific

- Instrument for polymerase chain reaction, SimpliAmp Thermal Cycler

- Incubator, Minitron

- Ultracentrifuge, Sorvale Discovery Hitachi

- Centrifuge for sample preparation in cell biology, Eppendorf

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Sample preparation

- Pressurized fluid extractor, Speed Extractor E-916, BÜCHI

- Chamber for sunlight simulation, Suntest Atlas

- Sample concentrator, miVac DUO

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Laboratory for Quantum Optics

Light source



An **ultrafast laser system** from Coherent Inc, provides 15 W of infrared light ($\lambda \approx 800$ nm) at 5 kHz repetition rate, with temporal duration of 35 fs.

The system is equipped with OPerA, an optical parametric amplifier, generating tuneable pulsed light from the UV to the NIR, (230-2600) nm.

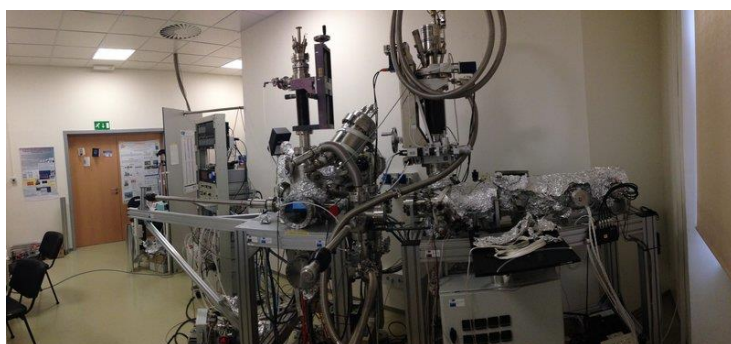
A dedicated beamline for high order harmonic generation (HHG) is also available. Pulsed Extreme UV radiation, in the range (15-70) eV, with sub 30 fs time duration, is

generated and monochromatized.

It is also possible to compress the fundamental frequency laser source to sub 10 femtoseconds pulses, by means of a fibre glass compressor and a set of chirped mirrors.

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Experimental set up for photoemission spectroscopy



The facility at the Laboratory of Quantum Optics is capable of **performing XPS (X ray photoemission spectroscopy) and UPS (ultraviolet photoemission spectroscopy) measurements** in the conventional and also in the time resolved configuration, depending on the used light source.

The experimental apparatus operates in UHV (ultra high vacuum, base pressure 10^{-10} - 10^{-11} mbar). It is equipped with two chambers: a sample preparation chamber and a measurement chamber.

The measurement chamber is equipped with:

- an hemispheric electrons spectrometer (VG-Scienta R3000),

- a monochromatized X-Ray source ($h\nu = 1486.6 \text{ eV}$),
- a 5 degrees of freedom cryogenic manipulator (minimum $T = 20 \text{ K}$).

The preparation chamber hosts:

- a 4 degrees of freedom manipulator (with e-beam heating and liquid nitrogen cooling),
- a Low Energy Electron Diffraction (LEED),
- Residual Gas Analyzer (RGA),
- evaporators,
- cleaver,
- ion sputter gun, with a leak valve for gas introduction.

An off line experimental chamber with:

- hemispherical electrons spectrometer (Specs Phoibos 150),
- a 4 degrees of freedom manipulator (with resistive heating stage),
- He discharge lamp (generating 20 eV radiation)

is still under commissioning.

This experimental set up allows for the **characterization of the electronic properties of conductive materials**.

By means of XPS it is possible to measure the core levels of the material under investigation, thus gaining knowledge of its chemical composition and relative percentages, with a surface sensitivity (1-10) nm, and a "lateral resolution" of circa 700 microns (determined by the X ray spot size).

UPS allows for the characterization of electrons in the valence band. Those electrons are the one participating in forming bonds, for example.

The possibility of performing UPS with a pulsed ultrafast laser source (i.e. in the so called "pump and probe" configuration), allows to measure the electronic properties of the system in out of equilibrium conditions.

The existence of the preparation chamber allows for in-situ preparation of the surfaces to be investigated.

It is also possible to insert the sample to the measurement system after preparation "in air".

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Experimental set up for time resolved magnetic reflectivity

Small system to generate HHG, non monochromatized magnetization stage

CCD camera

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X-ray absorption spectroscopy analysis of atomic and molecular structure of nanomaterials with synchrotron radiation

We offer expertise in **operando analysis of atomic and molecular structure** of new functional materials (different catalysts and photocatalysts, cathode materials for Li-ion, Li-sulphur batteries and other energy storage materials, ferroelectric and ferromagnetic ceramics, ...) and analysis of environmental pollution with metal cations (soil, water and plants), with X-ray absorption spectroscopy with synchrotron radiation (methods XANES, EXAFS). The experiments are performed at different European synchrotron radiation laboratories (PETRA III at DESY, Hamburg; Elettra, Trieste; ESRF, Grenoble; Albain Barcelona; Soleil, Paris). The support for external users includes preparation of proposal to obtain beamtime for (operando) XAS experiments at different synchrotron radiation (SR) facilities, prepare and execute the (operando) XAS experiments with SR, and perform state of the art analysis and interpretation of the (operando) XAS spectra to elucidate the mechanisms of chemical processes in functional materials or environmental samples on atomic level.

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Center for Astrophysics and Cosmology

Atmospheric Raman Lidar



With the lidar, we can conduct **research on the optical properties of the atmosphere above Ajdovščina**, particularly the temporal dynamics of the vertical profile of scatterers such as aerosols, clouds, and the planetary boundary layer. It is also possible to roughly characterize the type of aerosols and condensation nuclei in clouds. Lidar measurements can be performed by appointment, and we provide guidance on the interpretation of the obtained data.

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Use of Machine Learning in Analysing Large Volumes of Measurement Data

Machine learning methods have proven to be successful in **processing large volumes of data**, such as classifying different smaller sets with similar properties or identifying specific patterns. We offer consulting on the implementation of machine learning.

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Center for Atmospheric Research



Integrating nephelometer

The Ecotech Aurora 4000 **nephelometer measures the aerosol scattering coefficient and backscattering coefficient**, or the aerosol scattering coefficient and its angular distribution. No sample preparation is required, but the sampling system is important. The airflow must be greater than 5 l/min, which requires a pump. The instrument needs to be installed in an air-conditioned space. It must be calibrated with CO₂ and filtered ambient air.

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Differential Mobility Analyzer (10 – 800 nm)

The TSI 3938W50-CEN SMPS **measures the aerosol mobility diameter** between 10 nm and approximately 800 nm. It consists of an electrostatic classifier and a condensation particle counter. No sample preparation is required, but the sampling system is important. Butanol consumption is up to 1 l/week. The instrument needs to be installed in an air-conditioned environment. It must be calibrated with particles of known diameter. The instrument contains a weak radioactive source Kr TSI 3077A, for which the operator does not need training, but the transport of the instrument is controlled.

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Optical particle size spectrometer

The Grimm 11-D optical particle size spectrometer **measures the optical diameter of particles in the ambient air** between 250 nm and approximately 30 μm . No sample preparation is required, but the sampling system is important, especially for particles larger than 2.5 μm . The instrument must be calibrated with particles of known diameter.

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Pyranometer

The DeltaT SPN-1 pyranometer **measures the direct and diffuse solar irradiance** from UV to 2.5 μm . No sample preparation is required.

Contact: grisa.mocnik@ung.si

Centrifugal Particle Mass Analyzer

The Cambustion CPMA centrifugal particle classifier **separates aerosols based on the mass-to-charge ratio**. A neutralizer, typically a radioactive source similar to the one in the "Aerosol Size Distribution Meter (10 – 800 nm)," is used before the classifier, but it is not included with the instrument.

Contact: grisa.mocnik@ung.si

Aerosol Elemental Composition using XRF

The Cooper Xact 625i elemental composition meter **measures the elemental composition of particles in the ambient air**. No sample preparation is required, but the sampling system is important. Using different cyclones, particles of PM_{2.5} or PM₁₀ can be sampled. The instrument needs to be installed in an air-conditioned space. It must be calibrated with samples provided with the instrument. It contains an X-ray source, for which the operator does not need training. The instrument must not be opened during operation as it will cease to function.

Contact: grisa.mocnik@ung.si

PM_{2.5} or PM₁₀ Particle Sampler

The Digital DHA-80 PM_{2.5} or PM₁₀ sampler **samples these particles onto a filter** with a known airflow rate (typically 500 l/min). The sampler can be placed outside buildings. The typical time resolution is 24 hours, but it can be adjusted. No sample preparation is required, but the sampling system is important. Using different impactors, particles of PM_{2.5} or PM₁₀ can be sampled. The impactors need to be cleaned and greased with non-volatile grease provided with the sampler. Filters are not supplied with the sampler. Typically, quartz filters from Pall (2500 QUT) are used.

Contact: grisa.mocnik@ung.si

Measuring Station

A measuring station is **a container** where the above instruments can be installed. It requires enough space and an electrical connection.

Contact: grisa.mocnik@ung.si

Determining Sources of Air Pollution with the PMF Method

The PMF method is used to **determine sources of air pollution**. Typically, many chemical parameters are measured using real-time methods (black carbon, organic aerosols, elemental composition of particles) or by filter analysis, and then the PMF method simultaneously determines the composition of the sources (their "fingerprint") and their contributions to PM concentrations.

Contact: grisa.mocnik@ung.si

Laboratory of Organic Matter Physics

Time-of-Flight Photoconductivity

Time-of-flight photoconductivity is an experimental method to **measure charge carrier mobility in semiconducting and insulating materials**. This setup is equipped with a tunable wavelength pulsed laser. Therefore, in addition to time-resolved also the spectroscopic study of photon-to-electron conversion dynamics can be characterized.

A typical use of the method is to test materials whether they conduct charge carriers, since it directly detects the distribution of charge carrier velocities.

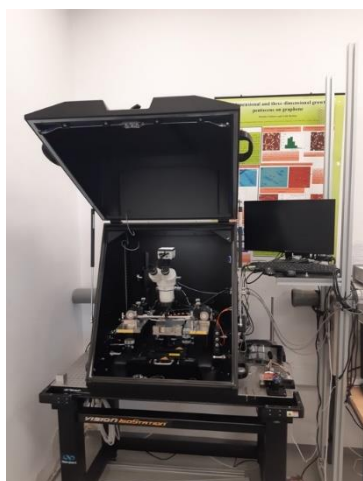
Contact: egon.pavlica@ung.si

Atomic Force Microscope (AFM) with conductive and kelvin mode probes

With this microscope (A.P.E. Research A100-AFM), we can conduct **nanoscale characterization of materials' surface topology and properties**. This equipment combines high-resolution surface imaging with detailed electrical and work function measurements, offering versatile analysis for a wide range of materials. The Kelvin Probe Force Microscopy (KPFM) mode enables non-contact potential mapping, providing insights into the electronic properties of materials. This technique is particularly useful for studying work function variations, charge distribution, and surface dipole layers. Resolution: X-Y scan size: 0.4 nm. Z scan size: 0.1 nm.

Contact: egon.pavlica@ung.si

Current-voltage measurement with Four-Probe Station



With the four-probe station, we can **measure various electrical properties of materials**, including:

- Resistance: The four-probe method accurately measures a material's resistance, eliminating the effects of contact resistance.
- Sheet Resistance: Particularly useful for thin films and layers, providing information on their uniformity and quality.
- Conductivity: This measurement directly relates to resistance and provides information about a material's ability to conduct electricity.
- Current-Voltage Curves (I-V): Detailed I-V curves can be used to analyze the electronic behavior of devices under different bias conditions.

- Impedance Spectroscopy: This enables the impedance of a material to be measured over a wide frequency range (20 Hz to 2 MHz) and provides information about its dielectric properties, capacitance, and inductance.

The system enables precise ($\sim 1\mu\text{m}$) positioning of the conductive probes. Equipped with four triaxial probes, it enables the measurement of currents in the sub-pA range. A video camera facilitates manual positioning of the probes with a microscope that allows observation of features down to the micrometer range. The probe holder (chunk) is floating and allows the measurement of the electrical current to/from the probe or the application of a bias voltage to the probe. The probe station is housed in a Faraday darkroom to reduce electromagnetic interference, and an optical workstation (Vision Isostation Newport) is used to minimize mechanical vibrations.

Using the four-probe station, we can measure a wide range of devices and materials, such as:

- Semiconductors: Characterization of wafers, layers, and individual devices such as diodes and transistors to determine their electrical properties.
- Thin Films: Evaluating the uniformity and quality of conductive and resistive layers used in various applications such as sensors and electronic devices.
- Bulk Materials: Evaluation of the resistance and conductivity of materials such as metals, polymers, and ceramics for research and industrial purposes.
- Nanomaterials: Measuring the properties of nanowires, nanotubes, and other nanostructured materials to explore their potential for advanced electronic applications.
- Solar Cells: Investigating the electrical properties of photovoltaic materials and devices to improve their efficiency and performance.

Current-voltage characterization is performed with a Keysight B2912A dual-channel source meter, and impedance spectroscopy in the frequency range between 20 Hz and 2 MHz is performed with the Agilent Precision LCR Meter E4980A.

The four-probe station is available primarily during weekdays from 8 AM to 4 PM, with extended hours available upon request. We also offer training sessions for new users to ensure they can independently operate the equipment and obtain accurate and reliable measurements from their analyses.

Contact: egon.pavlica@ung.si

Plasma cleaning chamber



Plasma chamber (Diener “NANO”) for **surface cleaning, sterilization, surface activation and improvement of material properties.**

Application examples: improving the performance of solar cells, removing contamination without damaging the sample and using chemicals.

Contact: jurij.urbancic@ung.si

Alignment system for 2D materials

The system allows **precise (~1 μ m) positioning and stacking of 2D materials**. The setup is intended for the preparation of van der Waals heterostructures and can be used to work with any other 2D materials. The system has two 3-way high-precision micro-positioners and one automatic high-precision rotary stage with a heater. The system has a microscope with 10x, 20x and 50x objectives to guide the stacking process. The system is installed in a clean room.

Contact: egon.pavlica@ung.si

Clean room with laser lithography

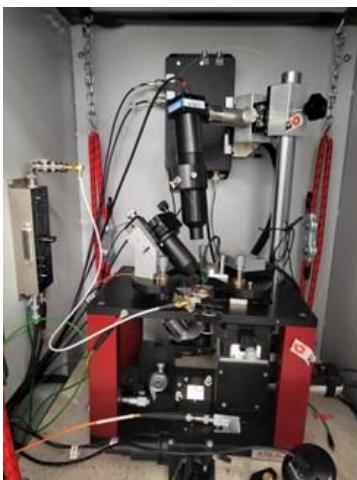


Clean room enables a **dust-free environment**. Monmouth Scientific, CAM2250 filter, dimensions 3.5m x 3.5m, internal height 2.4m, yellow light. Equipment in the clean room: (a) High-resolution laser nanolithography system or rapid prototyping on resist-coated substrates (DaLI, continuous UV laser, 2D acousto-optical deflectors for 100 kHz beam positioning, high-precision xy table, resolution of 1 μ m in a 10x10cm area) (b) Class II biological safety cabinet ISO Class 4 (Class 10) – Monmouth Scientific

MSC 1800 (c) Spin coater, hotplate

Contact: egon.pavlica@ung.si

Scanning Near-Field Microscope SNOM



Scanning Near Field Optical Microscopy (SNOM), model APE Research TriA SNOM, is an advanced imaging technique that breaks the diffraction limit of conventional optical microscopy. By using a nanoscale light source, SNOM provides **exceptional spatial resolution reaching down to 100nm and enables the visualization of structures at the nanometer scale**. At LFOS, TriA-SNOM works in aperture mode. In this mode, the near field light is created by using an appropriate SNOM probe with an aperture at the tip. The diameter of this aperture (d) is smaller than the wavelength (λ) of the used light. The incident light is coupled into a metal covered optical fiber with a tip aperture ($d \ll \lambda$). During scanning, the tip-sample distance is regulated and maintained constant by a Feedback control system based on "shear force" interaction. This is also equipped with two detectors for SNOM optical signal acquisition (reflection and transmission). The entire setup is

enclosed in a Faraday box to reduce the electromagnetic noise. Furthermore, the entire SNOM head has a passive damping system with floating marble base which is used as an anti-vibration tool.

With this microscope, we can conduct examinations of a variety of materials, including biological specimens, polymers, semiconductors, and nanostructures. At LFOS, SNOM is used to investigate the photoconductive properties of organic and 2D materials, enhancing the understanding of their potential for optoelectronic applications. Currently, the set up is equipped with a pre-amplifier, lock-in amplifier, voltage supplier thereby enabling the measurements of currents as low as pA.

Contact: egon.pavlica@ung.si

Solar cells characterization setup



The SS50AAA **solar simulator** (Photo Emission Tech. SS50AAA, monochromator CVI-240) is a sophisticated light source that approximates natural sunlight using a high-pressure xenon lamp. This is equipped with an air mass filter to closely replicate the AM 1.5G solar spectrum. It features a photo sensor and mechanical shutter (steady state) for precise control of light intensity simulating various sunlight conditions. It also allows to operate in both constant light intensity mode and also in constant lamp power mode.

Contact: egon.pavlica@ung.si

Closed-cycle He-cooled cryostat with quartz window and GHz feed-through connection (10-300K)



To **test electrooptical properties of material as a function of temperature**, the testing material should be cooled with cryostat. Cryostat is a device used to maintain low cryogenic temperatures of the sample or devices mounted in it. Our lab is equipped with closed-cycle cryostat enabling control of temperature down to 10K. Electrical and optical characterization of sample is possible in the cryostat.

Contact: egon.pavlica@ung.si

School of Engineering and Management and Center for Information Technologies and Applied Mathematics



Algebra and Logic

Our expertise covers **different branches of algebra**, including hypercompositional algebra, commutative algebra, ordered algebra, algebraic coding theory, model theory of valued fields.

Hypercompositional Algebra: identifying and studying combinatorial aspects of hypergroups, hyperrings, hyperfields and hypermodules and their connections with graph theory, fuzzy and rough set theories.

Commutative Algebra: commutative rings, modules, depth of modules, dimension theory and homological Algebra.

Ordered Algebra: different types of algebraic structures endowed with an order, as BCI-algebras, BCK-algebras, MV-algebras and EL-algebras.

Algebraic Coding Theory: binary linear codes, cyclic codes, q-ary codes, generator and Parity check matrices, double codes and their relationships with algebraic structures.

Model Theory of Valued Fields: applications of hypercompositional algebra in the area of model theory.

Traditional courses on Linear algebra, group theory, calculus in one and more variables.

Contact: info.citum@ung.si or helena.skrl@ung.si

Mathematical Modeling - Statistical Data Analysis

Our expertise in **advanced statistical methodologies**, machine learning algorithms, and data analytics tools supports a wide range of applications, including but not limited to business analytics, biology, medical research, psychology, engineering studies, and social sciences. We

ensure data integrity, accuracy, and actionable insights to drive evidence-based decision-making in both scientific research and industrial applications.

Our services encompass:

Regression Analysis: Identifying relationships between variables.

Descriptive Statistics: Summarizing and interpreting data characteristics.

Multivariate Analysis: Handling and analyzing data involving multiple variables.

Hypothesis Testing: Testing assumptions and theories using statistical methods.

Data Cleaning and Preprocessing: Ensuring data integrity and readiness for analysis.

Inferential Statistics: Drawing conclusions and making predictions based on sample data.

Training and Workshops: Providing education on statistical methods and data analysis techniques.

Custom Data Analysis Solutions: Tailoring data analysis services to meet specific research or business needs.

Advanced Statistical Analyses and Interpretation: Applying sophisticated techniques to uncover deeper insights.

Statistical Modeling and Hypothesis Testing: Developing and validating statistical models for predictive and inferential analysis.

Contact: info.citum@ung.si or helena.skrl@ung.si

Process engineering

Model based system engineering with CAPELLA software: professional system modeling

Industrial ecology: Overview of production processes. Closing material loops within production processes. Dematerialization. Products and processes: Design for Environment; Design for Recycling. Reducing the environmental impact and the production costs.

Waste management: Improving waste management in production processes. Closing loops. Cost reduction. Recycling. Analysis of the possibility of transforming waste into raw materials or energy.

Optimizing energy use in a building or company: Dynamic modeling, based on the analysis of energy use and the way it is used in the building or in the production process. Reducing energy use (and costs) by adapting production processes. Interesting also from the point of view of the new multi-tariff billing of electricity.

Technical-economic analysis of energy consumption: Environmental, economic and social assessment of investment in sustainable energy (replacement of energy source, replacement of the system, adaptation of the production process).

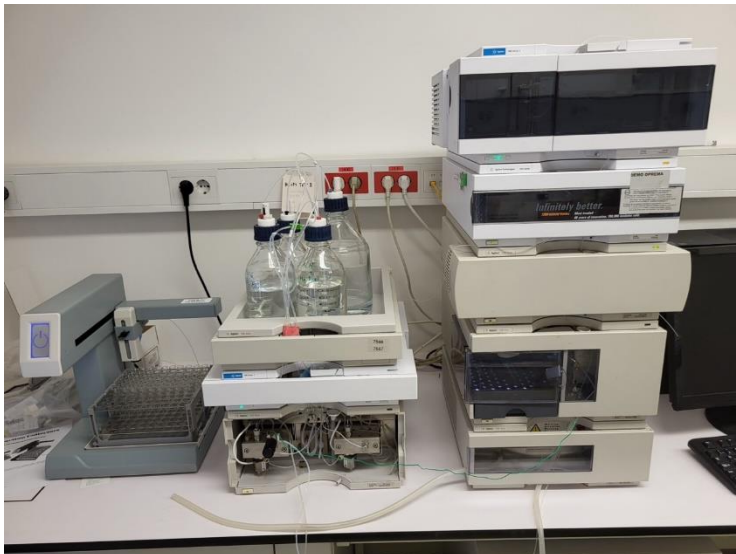
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Wine Research Centre



Chromatography

HPLC RID/UV-VIS with fraction collector (Agilent HP 1100)



High Performance Liquid Chromatography with RID and UV-VIS detector

Determination of the content of:
sugars (glucose, fructose, sucrose),
alcohol (methanol, ethanol), **acids**
(lactic, tartaric, malic, pyruvic,
salicylic, citric, acetic), **polyphenols**,
biogenic amines, **aminoacids**,
hydroxy cinnamic acids

Contact: info.crv@ung.si

Gas Chromatograph/Mass Spectrometer



Determination of the content of volatile compounds: esters, terpenes, higher alcohols, volatile phenols

Contact: info.crv@ung.si

Spectroscopy

UV/VIS spectrophotometer PerkinElmer Lambda

for **identification and quantification of different compounds** in a variety of samples (sugar, polyphenol, aminoacids, proteins etc..)

Contact: info.crv@ung.si

Sample preparation equipment

Equipment for preparation of solid, liquid material, biological samples, grapevine, grape, wine, cider, different food samples etc...

Rotavapor rotary evaporator with membrane pump –

concentration of samples

Liofilizator

lyophilization of various samples (of plant origin, biological samples....).

Ball mill

Vacuum manifold

for **solid phase extraction**

Incubator with stirrer for liquid samples

Multi-position magnetic stirrer with heating option

Ultrasonic bath

Centrifuge with cooling system with 3 rotors

Incubators with shaker

Incubator (owen)

Contact: info.crv@ung.si

Devices for determination of general parameters in beverages

Denzimeter-AntonPaar device for determining must parameters

Automatic measurement density of the liquids (measurement of alcohol and sugar content)

Gibertini with hydrostatic balance and distilling unit

Measurements of density of liquids, volatile acids (distillation + titration), **alcohol and sugar content in drinks**

Titrimo device



Measurements of pH, total acids, buffer capacity, volatile acids, free sulfur

Ebulioscope

Determination of alcohol content in drinks

Refractometer

Determination of sugar content

Turbidimeter

Measurements of water turbidity

Contact: info.crv@ung.si

Microbiology

Autoclave

for **sterilization of various solid materials**, liquids, and waste material



Tuttnauer 3850, Nuve 100

Biofermentor INFORS

for **cultivation of microorganisms** (bacteria, yeast, fungi)

Contact: info.crv@ung.si

Physiology

Scholander pressure chamber

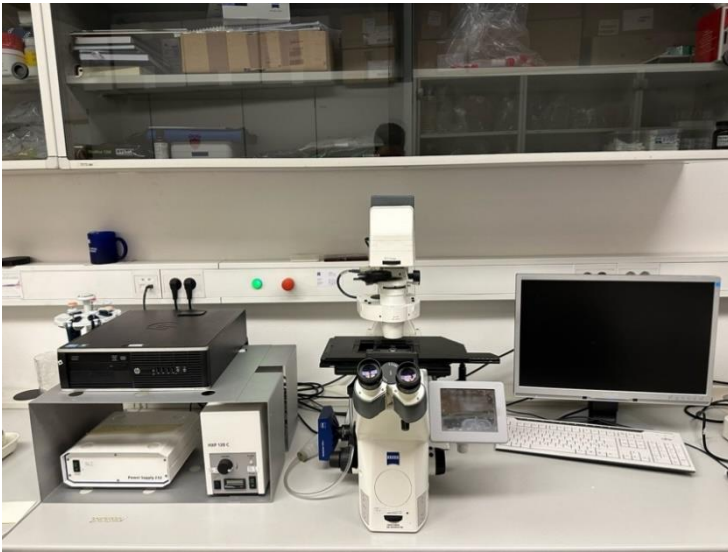
Determination of plant water potential

Weighing platform (lysimeter)

precise weighing platform is used for **monitoring and determination of evaporation and evapotranspiration** at experiments with soil or plants

Contact: info.crv@ung.si

Microscopy



Olympus IX81 inverted fluorescence microscopes

Optical microscope

PCR Polymerase Chain Reaction (PCR BIOMETRA TOne96G)

used for DNA sequencing, cloning, library generations, mutagenesis, expression profiling

G-Box documentation system

for imaging of electrophoretic gels with different staining

small equipment for basic DNA analysis (DNA electrophoresis systems)

Contact: info.crv@ung.si

Vinification equipment

Pneumatic press

for pressing of grape

Fermentation tanks

for fermentation of wine must after pressing

Bottle filling machine-

equipment for **filling the bottles** with wine or other beverages

Contact: info.crv@ung.si

Center for Cognitive Science of Language

Eye Tracking Equipment – EyeLink 1000 Plus

With the eye tracking equipment, we can conduct **eye-tracking research**, which investigates what the subject looks at, where they hold their gaze, and what they pay attention to. Eye-tracking research is useful for **studying reading**, which can be applied in **linguistic research**, as well as for examining how people **view images, websites, television, and more**.



The equipment is generally available for rental whenever it is not in use, but conducting research is not possible without technical assistance or professional support. Training for using the equipment can also be organized if necessary. Texts, sentences, or images must be prepared or arranged using the dedicated software.

More about the equipment:

<https://www.ung.si/sl/raziskave/center-za-kognitivne-znanosti-jezika/oprema/sledilec-ocesnih-premikov/>.

Contact: franc.marusic@ung.si or rok.zaucer@ung.si

Encephalography and Event-Related Potentials (ERP) Analysis Equipment



With electroencephalography equipment, we **measure the brain's electrophysiological response that occurs as a direct consequence of a perceptual event**. This is measured non-invasively using electrodes placed on the scalp. The equipment continuously records responses to stimuli, allowing for the identification of what in the processing stream is the response to each experimental item. In linguistics, this method is used to study real-time language processing and to evaluate processing models.

The equipment is generally available for rental whenever it is not in use, but conducting research is not possible without technical assistance or professional support. Training for using the equipment can be organized if necessary.

More about the equipment at <https://www.ung.si/sl/raziskave/center-za-kognitivne-znanosti-jezika/oprema/erp/>.

Contact: artur.stepanov@ung.si or rok.zaucer@ung.si

Expertise

In addition to conducting basic research in theoretical and experimental formal linguistics, the Center for Cognitive Science of Language also carries out various applied research projects both within our projects and for external clients:

Language Policy Consulting: We possess the necessary expertise for **advising on language policy**. We have addressed language policy at the macro level, such as advising the Slovenian Ministry of Culture on language policy for larger communities or countries, and at the micro level, such as advising on language policy for individuals and families (through the Multilingualism Matters Center).

Slovenian Language Education Consulting: We have extensive knowledge for **preparing expert reports and advising on teaching Slovenian**, particularly in the context of Slovenian as a minority language.

Slovenian Language Consulting: Our team has significant experience in providing **Slovenian language consulting**, developed through various advisory services (ŠUSS, JeSv, SlovSTvo).

Specialized Testing of Slovenian Language Knowledge and Comparing Proficiency Levels. We have expertise in specialized **testing of Slovenian language knowledge and comparing proficiency levels** among different populations of Slovenian speakers (e.g., monolingual and multilingual speakers), as developed in the JeRa project and the computer-based test for assessing sentence comprehension in Slovenian created in this context.

Contact: rok.zaucer@ung.si

Academy of Arts



Photo / Video Equipment

2x Semi-Professional Recording Equipment Sets: Each set includes a Magic Pro Mini Ursa 12K **camera + lens kit + audio recorders** (boom and lavalier microphones) + portable LED lights set + all necessary accessories.

5x Animation Tables (Rostrum): Each with a **photo camera and a set of LED lights** + laptop + all necessary accessories.

5x Canon **Photo Cameras**: Each with a set of lights and flashes for studio photography.

Plexiglass **Tabletop for Photography** (125x200).

3D Printer: BAMBULAB X1 CARBON COMBO (30x30x30).

3D Printer cannot be rented as a standalone equipment.

Contact: info.au@ung.si

Studios, Animation and Projection Rooms

Large Video Recording **Studio**: 100m² with wardrobe + additional space for reviewing materials + one wall (green screen).

Large Photography **Studio**: 100m² with wardrobe + additional space for reviewing materials + various fixed backdrops.

Larger Animation **Studio**: 30m² (darkened) + fixed ceiling grid with lights.

Two Smaller Animation **Studios**: 15m² each (darkened).

Animation Review Room: (well-lit) + TV screen.

Workshop for Material Work: For making objects (puppets, sculptures) and spatial structures (scenography, installations).

Projection Hall: 32 seats.

The most available times for external users to access the spaces and equipment of the Academy of Arts UNG are mainly during the periods without the educational process, typically July and August. It is necessary to announce and reserve any use of spaces and equipment or equipment rent in advance.

Contact: info.au@ung.si

Faculty of Humanities

Training of teachers and educational workers

Training of educational workers on the use of historical digital resources and platforms for teaching history, Slovenian, foreign languages, civic and homeland culture and ethics, values of multiculturalism, etc.

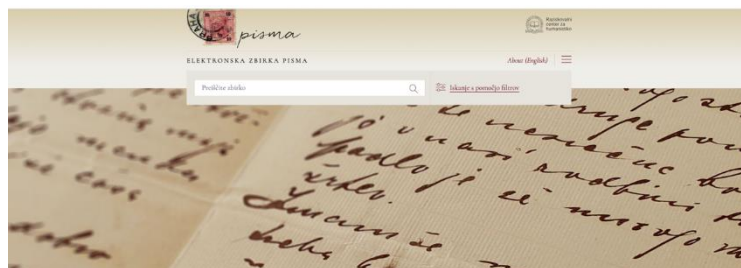
Contact: peter.purg@ung.si

Support for high schools

in **developing an open curriculum** with new interdisciplinary topics and approaches (e.g., cultural history of cross-border regions, gender studies, artistic avant-gardes, migration and intercultural studies, ecocriticism, etc.).

Contact: peter.purg@ung.si

Research Centre for Humanities



Trainings

Tourist Guides:

Training of tourist guides with content in the fields of history, ethnology, literature, cultural heritage, and multilingualism.

Contact: katja.mihurko@ung.si

Preparation of Studies

Preparation of historical, ethnological, and literary studies for the creation of museums, experiential and educational centers.

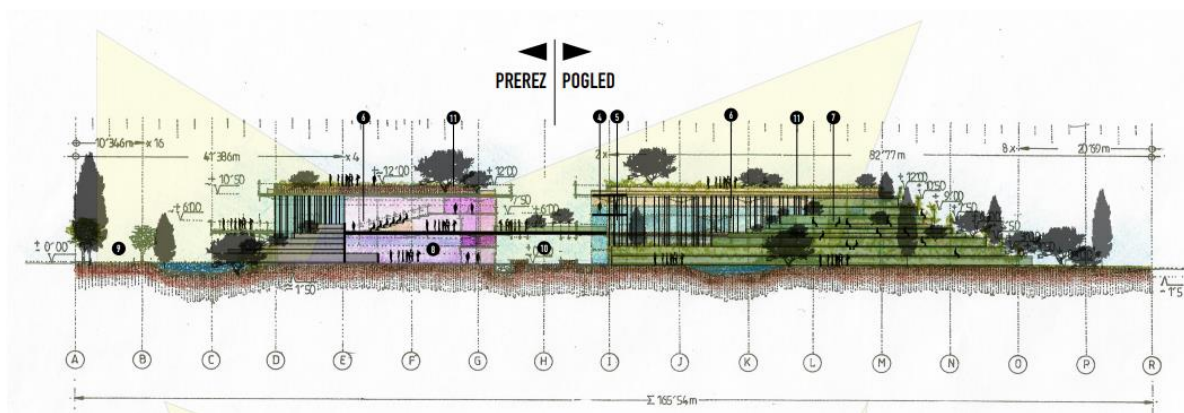
Contact: katja.mihurko@ung.si

Organisation of workshops

in the field of **digital humanities** in the virtual environment of the unique database Pisma (www.pisma.org)

Contact: katja.mihurko@ung.si

UNG Design Unit



- **Architectural, Urban, and Landscape Design:** provides large and small scale solutions aligned with circular principles, such as adaptive reuse and green regeneration.
- **Architectural Conservation:** provides solutions with distinctly integrated approach to the conservation, planning, and management of cultural heritage.
- **Nature-Based Solutions:** provides strategies for urban green regeneration and climate resilience.

Our unit emphasizes a collaborative and participatory approach, actively engaging stakeholders throughout the design and decision-making process. The UNG Design Unit operates in close collaboration with the UNG Green Technology Center to provide integrated services that combine professional expertise, research and development projects, and access to EU funding opportunities, all tailored to meet diverse client needs.

Contact: sasa.dobricic@ung.si

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