UNIVERSITÀ DEGLI STUDI
DELL'INSUBRIA

"Laser Spectroscopy"

Coordinator: Prof. Luca Nardo

Mail: luca.nardo@uninsubria.it

Keywords: Time-resolved fluorescence, single-photon time-of-flight, temporal resolution of optoelectronic components, transient absorption spectroscopy, nonlinear spectroscopy, Raman spectroscopy, time-resolved Terahertz spectroscopy

Purpose: Thanks to a large number of laser sources and state-of-the-art optoelectronic instrumentation, the implementation of on-demand designed setups, and the consolidated know-how of a highly skilled team in optoelectronics, laser physics, detector physics, spectroscopy, and the physics of light–matter interactions (both in the condensed phase—including solutions, powders, and thin films—and in the gaseous phase), the facility aims to provide high-level support to Insubria partners and external users (both academic and industrial). This support covers the design and execution of a wide range of laser-induced spectroscopy experiments aimed at the characterization of new materials, biological samples, pharmaceuticals, and cosmetics, as well as the detection and quantification of water pollutants and the analysis of atmospheric particulate matter.

Location: Department of Science and High Technology, Via Valleggio 11 (Torre building), 3rd floor.

Organization:

The facility involves eight permanent staff members and is structured into five sub-units, each dedicated to a specific branch of spectroscopy. The facility members include Prof. Alessia Allevi, Lucia Caspani, Matteo Clerici, Fabio Ferri, Marco Lamperti, and Luca Nardo, as well as two researchers from the Institute for Photonics and Nanotechnology, Dr. Maria Bondani and Ottavia Jederckiwicz, who operate within the Department facilities.

They are supported by a substantial group of students and non-permanent staff (currently 3 postdocs, 2 PhD students, and 1 MD thesis student).

In the following section, the sub-units are listed, with the coordinator and corresponding Mail details indicated for each one:

- Single-Photon Timing Unit – Prof. Nardo (luca.nardo@uninsubria.it)
- Ultrafast Characterisation Unit – Prof. Clerici (matteo.clerici@uninsubria.it)
- Raman Spectroscopy Unit – Dott. Lamperti (marco.lamperti@uninsubria.it)
- Nonlinear Spectroscopy Unit – Prof. Allevi (alessia.allevi@uninsubria.it)
- Light Scattering Unit – Prof. Ferri (fabio.ferri@uninsubria.it)
- Polarization Spectroscopy Unit – Dott. Bondani (maria.bondani@uninsubria.it)

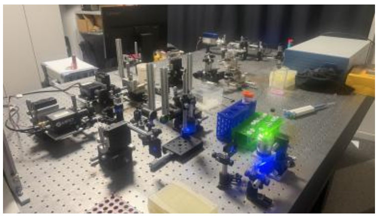
Integration with CRIETT Technological Platforms and University Scientific Facilities: The activities of the facility are integrated within the University Scientific Platform "Technologies for Energy, Health, and Environment". Among the laser systems available to the facility are the femtosecond pulsed source Pharos, and a high-power CW laser featuring intracavity second-harmonic generation and a module for fourth-harmonic generation (Verdi). Both systems are inventoried within CRIETT under the Materials Characterization Platform as instruments MAC27 and MAC22, respectively.

Sub-unit: “Single-Photon Timing””

Coordinator: Prof. Luca Nardo

Mail: luca.nardo@uninsubria.it

Keywords: Time-resolved fluorescence, fluorescence fluctuation spectroscopy, single-molecule fluorescence, photon time-of-flight, single-photon coincidence, temporal resolution of optoelectronic devices.



Brief description

The Single-Photon Timing Unit provides long-standing expertise in time-resolved fluorescence spectroscopy methods, time-resolved and single-molecule fluorescence resonance energy transfer (FRET), electronic pulse processing, transmission delay and temporal dispersion in optical fibers, and fluorescence fluctuation spectroscopy techniques (FCS, FIDA, PCH), among others.

These approaches are applied to the characterization of:

- structure and conformational dynamics of biomolecules
- optimization, photostability, and delivery of drugs and active pharmaceutical ingredients
- photosensitizers, cosmetics, and light-induced generation of reactive oxygen species
- excited-state dynamics, photocatalysis, and excitonic reactions
- biomolecule/drug interactions
- newly synthesized compounds (dyes, fluorophores, coordination compounds, and polymeric materials)
- characterization of single-photon detectors (SPAD, SPAD arrays, SiPM, hybrid photomultiplier tubes)
-

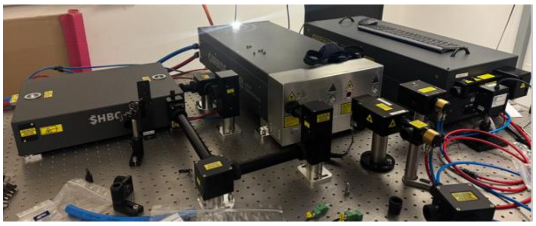
https://dsat.uninsubria.it/inspectLab/research/

Sub-unit: "Ultrafast Characterisation Unit"

Coordinators: Prof. Matteo Clerici, Prof. ssa Lucia Caspani

Mails: matteo.clerici@uninsubria.it, lucia.caspani@uninsubria.it

Keywords: Ultrafast sensing, THz time-resolved spectroscopy, ultrafast lasers.



Brief description

The Ultrafast Characterisation Unit encompasses the resources and expertise in the generation and application of ultrashort pulses for time-resolved measurements within the UNO (Ultrafast Nonlinear Optics) and QUP (Quantum and Ultrafast Photonics) groups, co-directed by Dr. Ottavia Jedrkiewicz and Prof. Lucia Caspani and Prof. Matteo Clerici.

The unit's activities include:

- Time-resolved spectroscopy of electromagnetic fields in the THz frequency range
- Material characterization using pump pulses <200 fs and tunable probe pulses spanning 700 nm to 2100 nm
- Characterization of two-photon nonlinear processes using ultrashort pulses in the quantum regime di Ultrafast Characterisation

Sub-unit: “Raman Spectroscopy Unit”

Coordinator: Prof. Marco Lamperti

Mail: marco.lamperti@uninsubria.it

Keywords: Raman spectroscopy, vibrational spectroscopy, materials characterization, molecular structure, micro-Raman

Brief description

The Raman Spectroscopy Unit provides expertise in the design, implementation, and use of Raman spectrometers with excitation in the visible or ultraviolet range, with a particular focus on resonance Raman spectroscopy.

The spectrometer systems can be configured to integrate additional molecular spectroscopy techniques, enabling multimodal optical diagnostics.

The unit’s activities include:

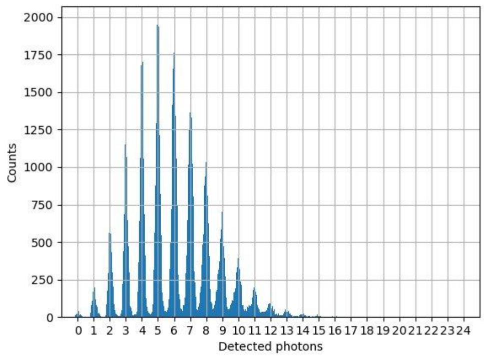
- Spontaneous Raman spectroscopy (off-resonance and resonance Raman) using 532 nm or 266 nm excitation
- Raman microscopy
- Combined Raman measurements integrated with other optical diagnostic techniques

Sub-unit: "Nonlinear Spectroscopy Unit"

Coordinator: **Prof.ssa Alessia Allevi**

Mail: alessia.allevi@uninsubria.it

Keywords: Sum-frequency generation, up-conversion fluorescence, two-photon absorption, photon-number-resolving detectors.



Brief description:

The Nonlinear Spectroscopy Unit has long-standing expertise in the generation of nonlinear optical phenomena using pulsed laser sources in the picosecond regime or with pulse durations of a few hundred femtoseconds.

Detection of the generated light is typically performed in the mesoscopic intensity regime, using hybrid photodetectors, silicon photomultipliers, and CMOS or EMCCD cameras.

The main employed methods include:

- Harmonic generation
- Correlation-based imaging
- Two-photon microscopy

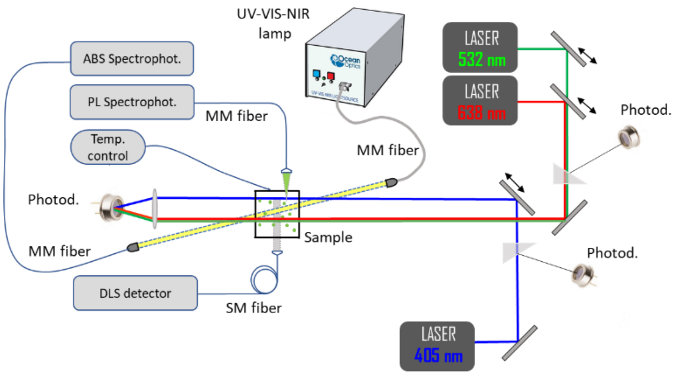
The primary application focus is the detection and characterization of photosensitive samples, both in terms of photon flux and excitation wavelength used for illumination.

Sub-unit: "Light Scattering Unit"

Coordinator: **Fabio Ferri**

Mail: fabio.ferri@uninsubria.it

Keywords: **Static and Dynamic Light scattering, software correlators, nanoparticle sizing, colloidal aggregation, ghost imaging, speckle metrology.**



Brief description:

The Light Scattering Unit has long-standing expertise in the structural and dynamical characterization of nanomaterials relevant to nano- and bio-technological applications.

The research activities of the unit include: (i) the study of fibrin gel growth kinetics and structural characterization using light scattering techniques, turbidimetry, and small-angle X-ray scattering;

(ii) the development of novel software correlators for dynamic light scattering; (iii) the design of ghost imaging protocols for biomedical and environmental applications; (iv) the development of new inversion algorithms for particle sizing based on data from light scattering, turbidimetry, and wide-angle X-ray scattering.

Sub-unit: "Polarization Spectroscopy Unit"

Coordinator: Maria Bondani

Mail: maria.bondani@uninsubria.it

Keywords: White-light spectroscopy, polarization, optical component quality control, polymer characterization, photoelasticity, birefringence mapping.

Brief description

The Polarization Spectroscopy Unit develops and applies crossed-polarization spectroscopy techniques to map internal stresses in transparent materials through the spectral analysis of photoelastic birefringence. The sample is placed between two orthogonal polarizers, and a spectrometer measures the transmitted spectrum locally, enabling spatially resolved information on thickness variations and mechanical stress distribution. Applications include: quality control of optical components, characterization of polymer materials for packaging, non-destructive analysis of displays and optical windows, study of transparent structural components under mechanical load.

Publications:

Single-Photon Timing Unit

1. G. Vesco, M. Lualdi, M. Fasano, **L. Nardo**, T. Alberio "Demonstration of fibrinogen-FcRn binding at acidic pH by means of Fluorescence Correlation Spectroscopy" Biochem. Biophys. Res. Commun. 536 (2021) 32-37.
2. G. Vesco, M. Lamperti, D. Salerno, C. A. Marrano, V. Cassina, R. Rigo, E. Buglione, M. Bondani, G. Nicoletto, F. Mantegazza, C. Sissi, **L. Nardo*** "Double-stranded flanking ends affect the folding kinetics and conformational equilibrium of G-quadruplex forming sequences within the promoter of KIT oncogene" Nucleic Acids Res. 49 (2021) 9724-9737.
3. M. Seifert, M. Termathe, **L. Nardo**, M. Höhne "Ribosomal incorporation of thioxanthone as a noncanonical aminoacid facilitates the engineering of photoenzymes" ChemCatChem 17 (2025) e00847.

Full track record of the Unit Coordinator:
https://scholar.google.com/citations?user=-WcT6fsAAAAJ&hl=en

Ultrafast Characterisation Unit

1. T. Dickinson, I. Afxenti, G. Astrauskaite, L. Hirsch, S. Nerenberg, O. Jedrkiewicz, D. Faccio, C. Müllenbroich, A. Gatti, **M. Clerici**, L. Caspani "Quantum-enhanced second harmonic generation beyond the photon pairs regime" Science Advances 11 (2025) eadw4820.
2. D. Adamou, L. Hirsch, T. Shields, S. Yoon, A.C. Dada, J. M.R. Weaver, D. Faccio, M. Peccianti, L. Caspani, M. Clerici "Quantum-enhanced time-domain spectroscopy" Science Advances 11 (2025) eadt2187.
3. B. Momgaudis, **M. Clerici**, V. Jukna, P. Di Trapani, O. Jedrkiewicz, "Dynamics of Bessel beam induced graphitization of diamond: exploring the role of in-bulk plasma" Opt. Mat. Express 15 (2025) 614.

Full track record of the Unit Coordinator:
https://scholar.google.com/citations?user=_yduRYEAAAAJ&hl=en

IR and Raman Spectroscopy Unit

1. **Lamperti M.,** Rigo R., Sissi C., Nardo L., Probing G-Quadruplexes Conformational Dynamics and Nano-Mechanical Interactions at the Single Molecule Level: Techniques and Perspectives (2024) Photonics, 11 (11), art. no. 1061
2. Gotti R., Wójtewicz S., Marangoni M., Gatti D., **Lamperti M.**, High-precision HD spectroscopy near 1.53 μm, (2024) Frontiers in Physics, 12, art. no. 1446803
3. **Lamperti M.**, et al., Stimulated Raman scattering metrology of molecular hydrogen (2023) Communications Physics, 6 (1), art. no. 67

Full track record of the Unit Coordinator:
https://scholar.google.com/citations?user=Dg4TXFgAAAAJ&hl=en

Nonlinear Spectroscopy Unit

1. S. Cassina, A. Pozzoli, G. Vesco, M. Lamperti, M. Marangoni, **A. Allevi** "Sum-frequency-based photon-number-resolving detector for telecom wavelengths" APL Photon. 10 (2025) 126104.
2. S. Cassina, G. Cenedese, M. Lamperti, M. Bondani, **A. Allevi** "On the use of superthermal light for imaging applications" Phys. Lett. A 495 (2024) 129300.
3. S. Cassina, **A. Allevi**, V. Mascagna, M. Prest, E. Vallazza, M. Bondani "Exploiting the wide dynamic range of silicon photomultipliers for quantum optics applications" EPJ Quantum Technol. 8 (2021) 4.

Full track record of the Unit Coordinator:
https://scholar.google.com/citations?user=WJEL86sAAAAJ&hl=en

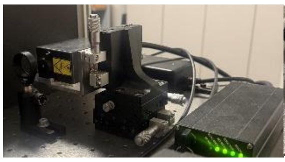
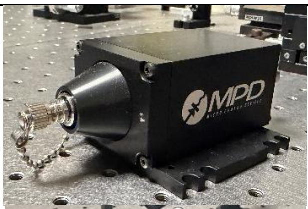
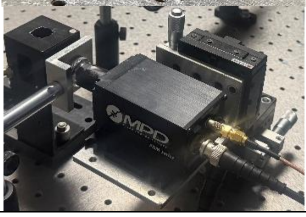
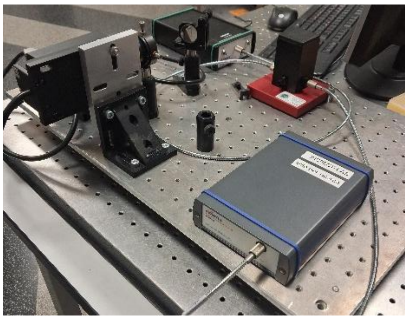
Light Scattering Unit

1. P. Anzini, M.C. Bossuto, M. Colombo, A. Vivani, I. Cherniukh, M. I. Bodnarchuk, M.V. Kovalenko, F. Bertolotti, A. Guagliardi, N. Masciocchi, and **F. Ferri**. "Simultaneous Dynamic Light Scattering, Absorbance and Photoluminescence Measurements of Colloidal Nanoparticles. Application to Colloidal Stability and Aggregation Kinetics of CsPbBr3 Nanocrystals", Small Methods, 9, (2025), e00304 (1 of 15)
2. P. Anzini, D. Biganzoli, I. Cherniukh, M.V. Kovalenko, A. Parola, and **F. Ferri**. "Variance analysis of dynamic light scattering data" Rev. Sci. Instrum. 94, (2023) 095117
3. **F. Ferri**, M.C. Bossuto, P. Anzini, A. Cervellino, A. Guagliardi, F. Bertolottia and N. Masciocchi, "Site-occupancy factors in the Debye scattering equation. A theoretical discussion on significance and correctness", Acta Cryst._A, 79, (2023).1-10

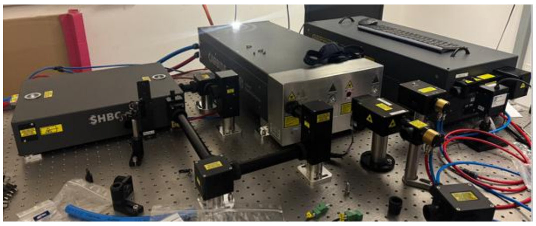
Full track record of the Unit Coordinator:
https://scholar.google.com/citations?user=3MpYqz4AAAAJ&hl=it

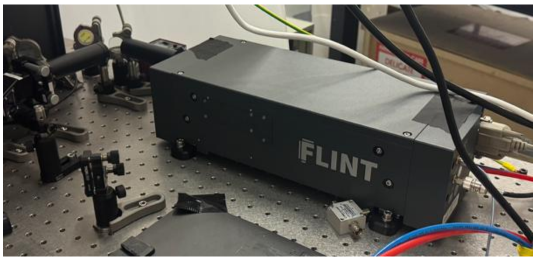
Polarization Spectroscopy Unit

Full track record of the Unit Coordinator:
https://www.scopus.com/authid/detail.uri?authorId=7003796331

• A) Single-Photon Timing Unit	
 	**Laser sources:** - CW TEM(0,0) laser Cobolt Blues (473 nm) - CW TEM(0,0) laser MSL Cnilaser (532 nm) - Pulsed laser BDS-SM-405-FBC (Becker & Hickl GmbH) - Pulsed laser BDS-SM-514 free-space (Becker & Hickl GmbH) - Pharos laser (see Nonlinear Spectroscopy Unit)
 	**Detectors:** - N° 3 SPAD PDM50, MicroPhoton Devices, temporal resolution 30 ps, maximum detection quantum efficiency 55% (@ 500 nm), DCR <50 cps, deadtime <80ns free space - N° 2 SPAD PDM50, MicroPhoton Devices, temporal resolution 30 ps, maximum detection quantum efficiency 60% (@ 500 nm), DCR <30 cps, deadtime <80 ns, fibre-coupled - N° 2 APD SPCM-AQRH-14 Excelitas, temporal resolution <350 ps, maximum detection quantum efficiency 70% (@ 560 nm) DCR <100 cps, deadtime <20 ns, fibre-coupled
	**Electronics:** - N° 2 integrated time-correlated single-photon counting modules (Becker & Hickl GmbH, model SPC150) - Function generator RIGOL DG852 Pro (max 50 MHz; standard and arbitrary waveforms; 625 MSa/s; 16-bit resolution) - Pulse generator Berkeley Nucleonics 750 (50 MHz, 4 channels; minimum pulse duration 10 ns; rise time 1 ns; jitter 50 ps) - Oscilloscope / spectrum analyzer MXO4-BMDL (Rohde & Schwarz) (1.5 GHz, 4 channels, 5 GSa/s, 12-bit vertical resolution)
	**Fiber spectrometer** SensLine AvaSpec-ULS2048x64-EVO (Avantes)
	**Spectrophotometer:** Jasco V-770 (spectr. Range 190-2700 nm, bandpass 01.-10 nm, photometric range +/- 4 Abs, nel NIR +/- 3 Abs, equipped with 60 mm integrating sphere, motorized, thermostated multi-sample holder for 6 cuvettes

- **B) Ultrafast Characterisation Unit** **B) Ultrafast Characterisation Unit**



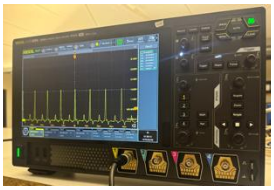


Laser Sources:

- Pulsed Light Conversion FLINT1 source operating at 1030 nm, with 80 MHz repetition rate, 8 W output power, and 120 fs pulse duration.
- Pulsed Light Conversion Carbide 80W source. Output power up to 80 W, pulse duration of 185 fs, variable repetition rate from single-shot up to 2 MHz, maximum pulse energy of 0.8 mJ (at 100 kHz), wavelength 1030 nm.
- Light Conversion SHBC spectral broadening compressor. Maximum power 13 W, wavelength 515 nm, repetition rate 400 kHz, transform-limited pulse duration 3.24 ps.
- Orpheus-F optical parametric amplifier. Maximum power 2.5 W, tunability range 650–2100 nm, repetition rate 200 MHz.

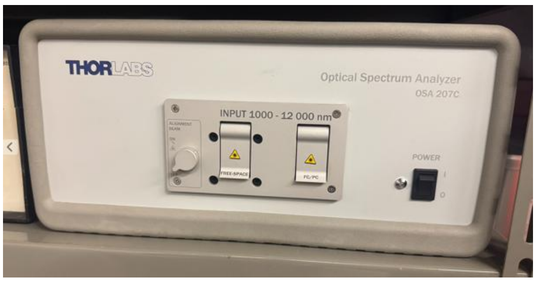
Detectors:

- MOS camera Zyla-5.5-USB3 for visible and NIR measurements.
- InGaAs camera Allied Vision SWIR 5.2 MP FXO992MCX-T for measurements from 400 nm to 1700 nm.
- THz detector Gentec THZ5I-BL-BNC for THz measurement



Electronics:

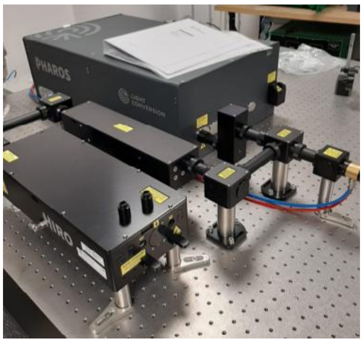
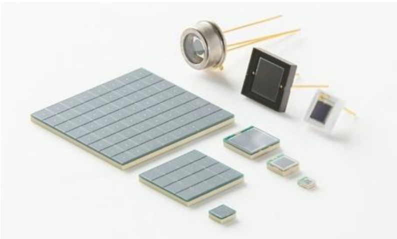
- Pulse generator Aim-TTi TGP3152 – 50 MHz.
- 5 MHz lock-in amplifier Zurich Instruments MFLI with boxcar.
- Oscilloscope Rigol DHO4204.
- Data acquisition board Spectrum Instrumentation M2P.5913-X4.
- Electrical spectrum analyzer Keysight Technologies N9010A.
- Antenna for THz radiation generation.

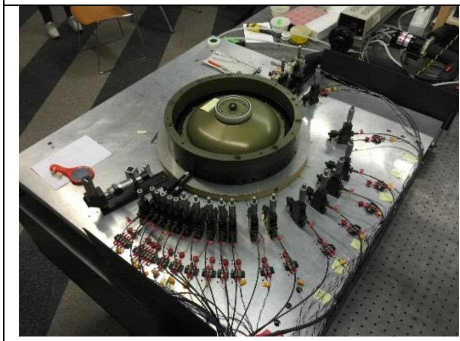


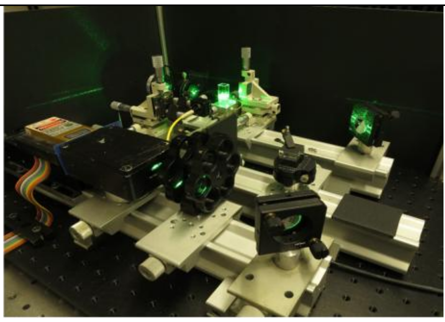
Spectrometers:

- Mini spectrometer Broadcom QMINI 2 VIS-NIR.
- Fourier-transform spectrometer Thorlabs OSA207C, with sensitivity from 1 to 12 µm.

• C) Raman Spectroscopy Unit	
	**Laser Sources:** - Green V2 laser. - MDB266 frequency-doubling cavity
	**Spectrometers:** - Imaging spectrograph f/8, equipped with 300 l/mm grating at 2 μm and 1200 l/mm grating (400–650 nm). - Andor Technology iXon Ultra EMCCD camera (see Nonlinear Spectroscopy Unit). - Custom-built Fourier-transform spectrometer with resolution better than 1 cm⁻¹.
	**Electronics:** - RIGOL Technologies DHO924S oscilloscope. - RIGOL Technologies DHO4204 oscilloscope.

• **D) Nonlinear Spectroscopy Unit**	
	**Laser Sources:** - Pharos laser (see Nonlinear Spectroscopy Unit). - Diode laser operating at 690 nm. - CW Nd:YAG laser operating at 1064 nm.
	**Detectors:** - Hybrid photodetectors mod. R10467U-40, Hamamatsu Photonics. - Silicon photomultipliers mod. MPPC S13360–1350CS, Hamamatsu Photonics. - EMCCD camera Andor Technology iXon Ultra 897. - Hamamatsu Photonics Orca-Quest2 camera (C15550-22UP).
 	**Electronics:** - Boxcar-gated integrators (SGI, SR250, Stanford Research Systems). - ADC PCI-6251, National Instruments. - Two Caen SP5600 power supply and amplification units. - Frequency generator. - Oscilloscopes/spectrum analyzers. - PIN photodiodes S3883, Hamamatsu Photonics.

<table>
<tr><th colspan="2">• E) Light Scattering Unit</th></tr>
<tr><td></td><td>Static Light Scattering System:

- CW He–Ne Spectra-Physics 127 laser (λ = 0.6328 μm, P = 25 mW).
- Scattering angle range: θ_{sca} = 1–170°; q range = 1–20 μm^{-1}.
- Probed length scales: 100 nm – 1 μm.
- High temperature stability (1 mK).
- Very low stray light.
- Fixed mechanical-optical components.</td></tr>
<tr><td></td><td>System for Simultaneous Dynamic Light Scattering (DLS), Absorbance (ABS), and Photoluminescence (PL) Measurements:
- CW lasers operating at three wavelengths (λ = 638, 532, 405 nm; P = 50–100 mW).
- DLS measurements performed using a software correlator operating in cross-correlation mode.
- Absorbance measurements in the UV–VIS–NIR range.
- Photoluminescence measurements in the visible range.</td></tr>
</table>