DTU Nutech
Center for Nuclear Technologies

Product specification

Risø TL/OSL Reader

18 August 2014

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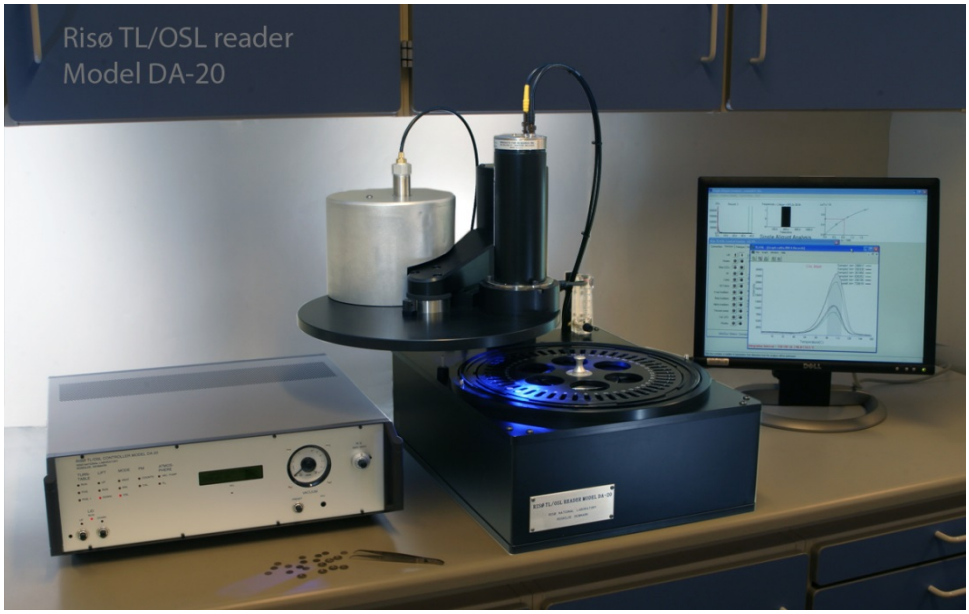
1. Reader Details



The Risø TL/OSL Reader Model DA-20 consists of:

- Automated 48-position sample changer system built into a vacuum chamber (lowest pressure < 2 * 10-2 mbar).
- Two exchangeable sample holders (each designed to hold 48 samples) for 9.7 mm diam. flat sample discs or 11.65 mm diam. sample cups.
- Vacuum sensing system with automated switching on reaching desired pressure, vacuum gauge, and combined vacuum/nitrogen solenoid valves (exclusive vacuum pump).
- Lift mechanism for heater element.
- Shaped Kanthal heater strip, endpoint temperature: 700°C.
- Filter holder to allow fitting of different optical detection filters.
- Photomultiplier housing with dynode chain and μ-metal shielding.
- 100 11.65 mm diameter stainless steel sample cups and 100 9.7 mm diameter flat stainless steel discs

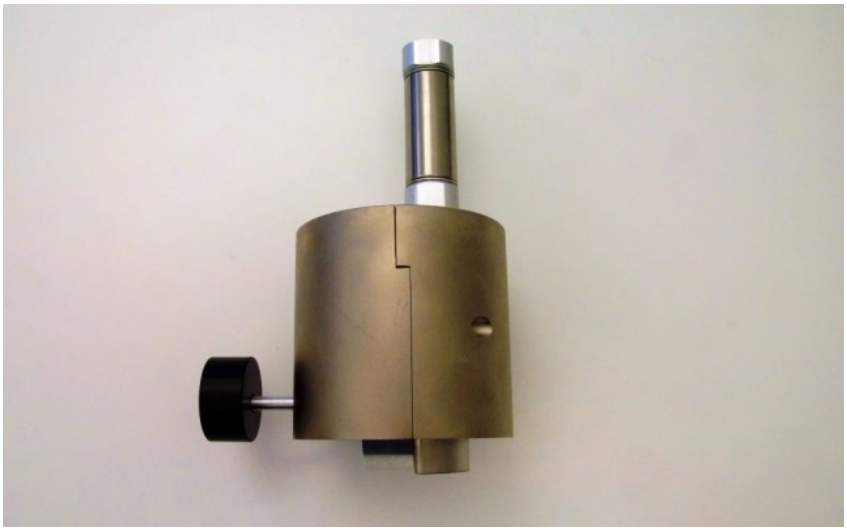
Electronics, detectors and controls

The Risø TL/OSL Controller allows for flexible control of the TL/OSL system including input/output ports, counters, and heat profile generator.

- Continuous full sine wave programmable heating system that can perform a linear heating profile for TL, preheat, and isothermal functions (endpoint: 700°C).
- Automated software-based function control for activating beta irradiator, atmosphere valves and all mechanical movements.
- Single photon counting amplifier / discriminator system.
- Stabilised, adjustable high-voltage supply for PM tube (max. 1500 V).
- Linear, up to 40 x10^6 counts per second and low dark count EMI 9235QB15 PM tube.

Beta Irradiator attachment

The irradiator normally accommodates a 1.48 GBq (40 mCi) 90Sr/90Y beta source, which emits beta particles with a maximum energy of 2.27 MeV. The dose rate in quartz at the sample position is approximately 0.1 Gy/s. The detachable on-plate automated beta irradiator including beryllium foil vacuum interface provides software-controlled in-situ irradiations of samples



Infrared/Blue Light Optically Stimulated Luminescence (OSL) attachment

Optical stimulation is achieved using an array of light emitting diodes (LEDs), which are compact, fast and enables electronic control of the illumination power density. The standard system incorporates CW as well as LM-OSL stimulation. The array of LEDs is equipped with an optical feedback servo-system to ensure the stability of the stimulation power.
The key component for this process is the combined Infrared/Blue Light stimulated luminescence (IRSL/OSL) unit attachable to the Risø TL sample changer for IRSL/OSL measurements of a variety of natural and artificial materials.

The OSL unit is based on illumination with
1) clusters of 870 nm IR LEDs providing > 135 mW/cm^2 at the sample and

2) clusters of 470 nm blue LEDs delivering > 80 mW/cm^2 at sample.

The OSL unit enables flexible and combined BLSL/IRSL/TL measurements in automated sequences. The OSL/IRSL system includes a software controlled power supply to allow illumination power to be varied during a measurement sequence (e.g. for normalisation) or to ramp of the illumination power during an OSL readout to perform linearly modulated OSL (LM-OSL) to investigate trap distributions and OSL decay rate components.

Heating system

The heating element is based around a Kanthal heater strip, which is specifically shaped to match sample discs/cups supplied with the instrument. The sample holder can be placed over the heater plate by an automated sequence and heated to the desired temperature, between room temperature and 700°C, using a user defined heating rate. The reader chamber can be evacuated and subsequently refilled/circulated with different gas(es) at adjustable flow rates for elevated temperature measurements.

Software

Sequence Editor

The *Sequence* Editor is a flexible MS Windows software that permits the easy creation of any desired automated TL/OSL measurement sequence. These sequences can include any or all operations (e.g. preheat, irradiation, OSL, etc.) individually, or in combination.
The software allows for a large number of operations to be controlled in one measurement sequence. The user may also program the reader operations using a Macro language.
Sequences can be stored and recalled for future measurement routines. Live display of TL and OSL signals on the computer screen during a sequence run is provided. Data is stored in a format accessible by *Viewer* and *Analyst* (also provided).

Control program

The *Control* program allows the individual units of the reader to be tested. It is mainly used for test, adjustment and maintenance purposes.

Viewer

The Viewer is used to display and print curves, perform integration and export data from the data files.

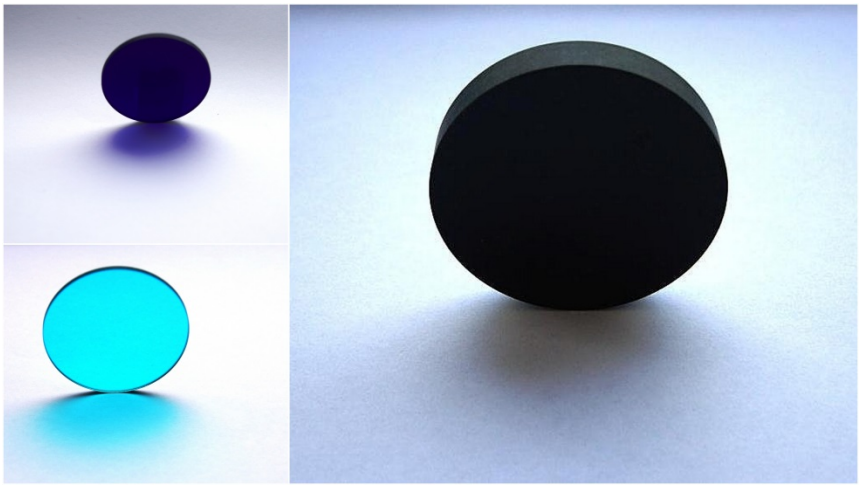
Analyst

Analyst is a program designed to view, edit and analyse luminescence data collected using the Risø TL/OSL reader. It allows data to be exported in a variety of formats so that it can be transferred to other programs.

Analyst is especially developed for the Risø TL/OSL system by Prof. G.A.T. Duller, University College of Wales, Aberystwyth, UK.

Optical filters

the intensity of the stimulation light is approximately 10-18 orders of magnitude larger than the emitted luminescence. In order to be able to measure the emitted luminescence, detection filters must be used to prevent scattered stimulation light from reaching the PMT, and the spectral stimulation and detection windows must be well separated.



The TL/OSL reader is per default supplied with a set of the following stimulation and detection filters cut to fit the filter holders:

- 7.5 mm Hoya U-340
- 2 mm Schott BG-39
- 3 mm Schott BG-3

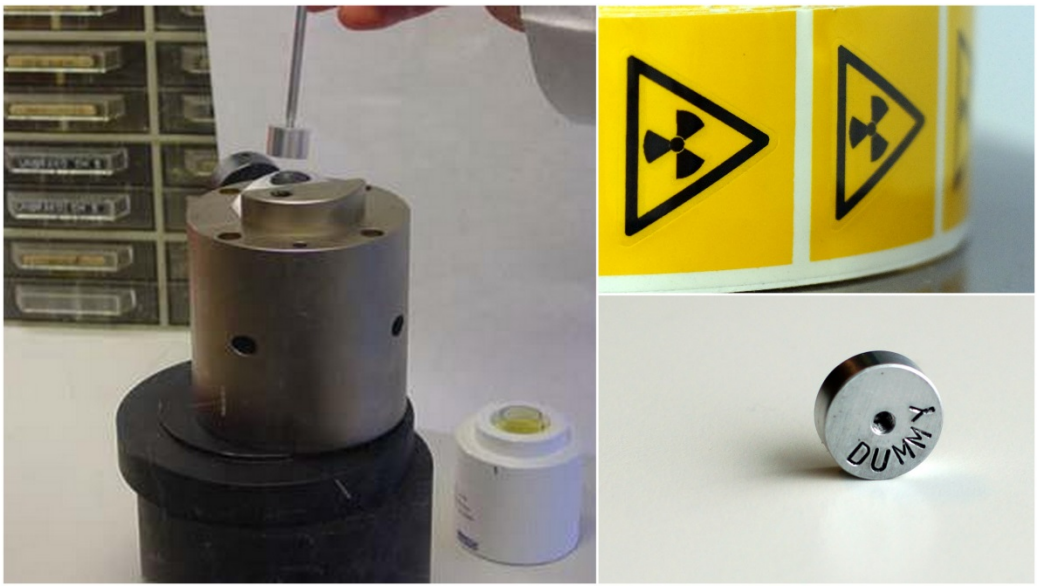
2. Irradiation sources

Irradiation
In the Risø TL/OSL reader sample irradiation can be obtained using three different irradiation sources:

a. beta
b. alpha and
c. X-ray.

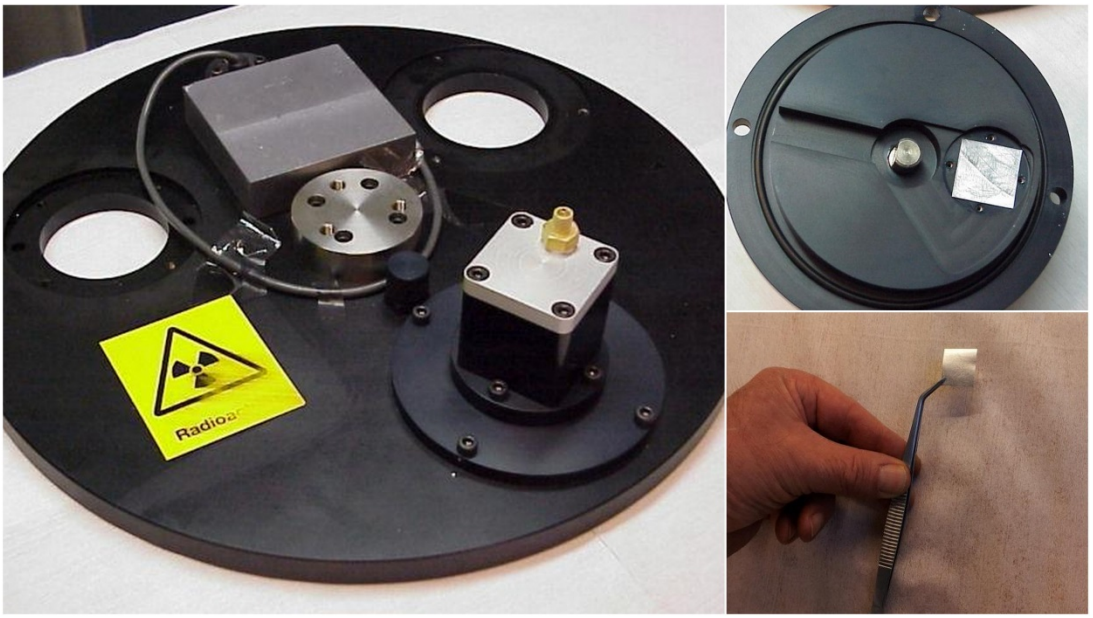
Irradiations are software controlled allowing in-situ irradiations (minimum irradiation time of 1 s).

a. ^{90}Sr/^{90}Y beta source
A detachable beta irradiator is located above the sample carousel providing software-controlled *in-situ* irradiations of samples. The irradiator normally accommodates a 1.48 GBq (40 mCi) 90Sr/90Y beta source. The dose rate in quartz at the sample position is approximately 0.1 Gy/s. (Sr90-sources with other activities are available on request)
The Sr90-source is mounted into a rotating, stainless steel wheel, which is pneumatically controlled. The distance between the source and the sample is 7.6 mm. A 0.125 mm beryllium window is located between the irradiator and the measurement chamber and acts as vacuum sealing.



b. Am241

The alpha irradiator normally accommodates a 10.7 MBq (290 mCi) ^{241}Am foil source, which is a mixed alpha/gamma emitter. The dominating alpha energy is 5.49 MeV (85.1%) and the dominating gamma energy is 59 keV. The source is mounted behind a pneumatically controlled shutter. The alpha irradiator option is integrated with the system lid and a sealed shaft allows operation of the irradiator under vacuum. The dose rate in quartz at the sample position is approximately 45 mGy/s.



c. X-ray Generator

Irradiation can also be achieved by means of X-rays. For this purpse we offer a Varian VF-50J (50 kV / 1 mA) X-ray unit with collimator, mechanical shutter, software-controlled Spellman high-voltage power supply and fail safe interlocks.

The X-ray irradiator incorporates an enhanced security control and failsafe system to meet the individual ‘‘regulations for operation’’ as issued by the different local governments.

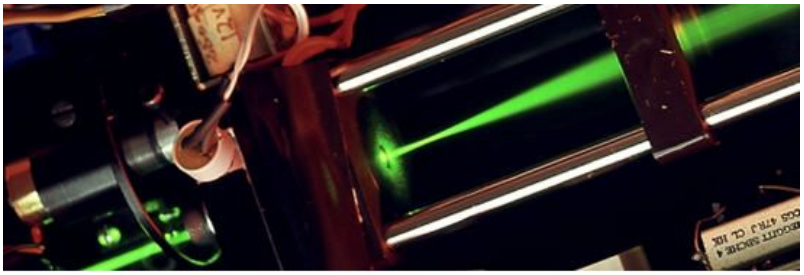
3. Single Grain

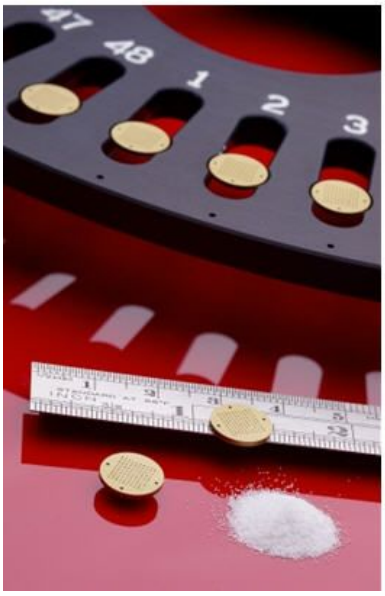
Single grain OSL attachments

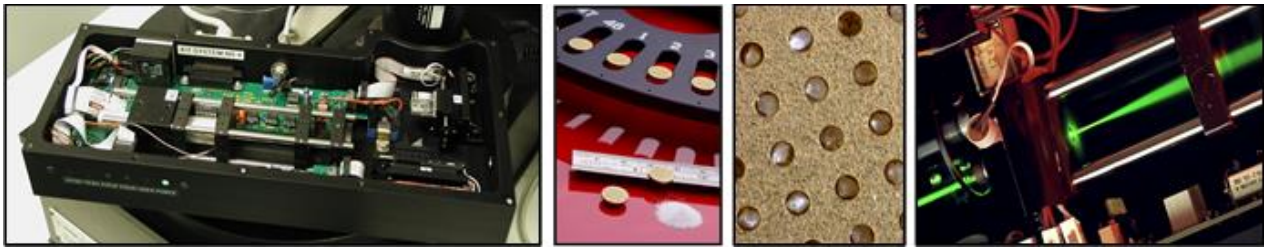
The Risø single grain OSL attachment enables routine measurements of sand-sized single grains of minerals. Individual sand-sized grains are placed in special aluminium discs containing 100 holes, 300 µm deep by 300 µm in diameter, on a 10 by 10 grid with 600 µm spacing between hole centres. Irradiation and heating can thus be performed simultaneously on all 100 grains, whereas the OSL signal can be measured separately from individual grains by using a focused laser.
The single grain attachment is available in two versions:

Single laser single grain attachment:

Attachment for measuring OSL from single grains (size 180-250 µm) of samples. The unit is based on a focused solid-state green laser beam and an X-Y scanning device using movable mirrors mounted on software controlled encoded motorised linear stages. The Laser is a green (532 nm), 10 mW stabilised DPSS laser. The green laser stimulation light can be ramped by software to perform LM-OSL on single grains.







Dual laser single grain attachment

Attachment for measuring OSL from single grains (size 180-250 µm) of samples. The unit is based on two (green and IR) focused laser beams and an X-Y scanning device using movable mirrors mounted on software controlled encoded motorised linear stages. The lasers are a green (532 nm), 10 mW stabilised DPSS laser and an IR diode (830 nm), 140 mW TTL modulated laser. The green and IR laser stimulation light can be ramped by software to perform LM-OSL from single grains. The sample is loaded into special aluminium discs each containing 100 individual grain holes (ø = 300 µm).

The IR and green laser stimulation can be used in any measurement sequence e.g. for screening of feldspar contaminated quartz grains or simply for IR stimulation of single feldspar grains.

These attachments include a special IRSL/OSL stimulation head enabling IR/Blue light stimulation of multiple grain samples. This special IRSL/OSL stimulation head makes use of the same diodes and provide the same power densities on the sample as the standard IRSL/OSL stimulation head. But as it is designed to accommodate the single grain attachment as well, the light collection efficiency is reduced by approximately 40%.

4. Stimulation sources

Violet stimulation attachment

The violet stimulation attachment is based on a 405 nm, 100 mW, laser module mounted in the type of stimulation head used for the single grain attachment. The attachment includes stimulation 2 filters ITOS GG395 (3mm) and AHF F49-402, ET bandpass 402/15 nm. A Semrock Brightline FF01-340/26 is used as detection filter. The electronics for driving the amplifier is built into the controller.

If the attachment is to be build into a reader with a standard OSL stimulation head, this has to be exchanged with a single grain OSL head.

Note:
Due to physical constraints of the TL/OSL reader the Violet stimulation attachment it cannot be used simultaneously with any of the single grain systems

5. Pulsed OSL

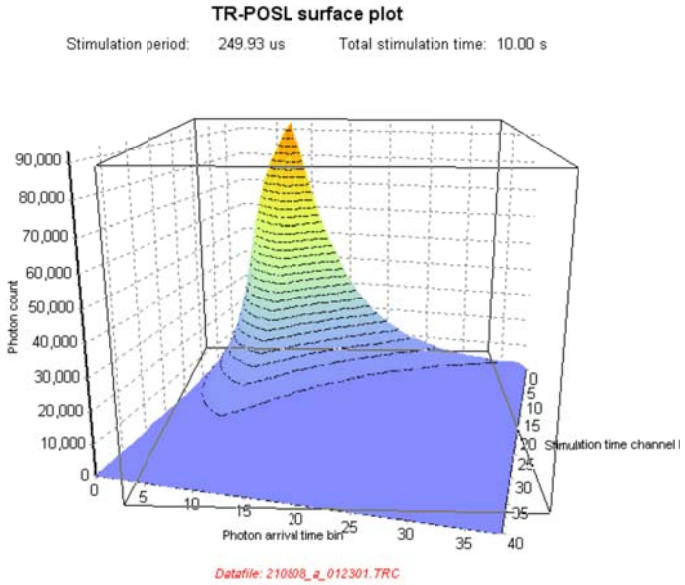
Pulsed OSL attachment

This attachment enables measurement of pulsed optically stimulated luminescence (POSL). In POSL the stimulation light is pulsed and the OSL may be measured in between the pulses. The Pulsed OSL-attachment is a plug-in board to the Risø Controller for the Risø TL/OSL luminescence reader. The pulsing unit gives full control of the power level, adjustable on/off times from 0.6 µs to 10 s and an adjustable gating of the luminescence signal in the off time. The parameters for the pulses are set from the Sequence Editor program.

The unit is e.g. suitable for separating quartz from feldspar OSL signals in feldspar contaminated samples.

Photon Timer attachment

The Photon Timer Attachment makes it possible to record when each individual photon is detected with very high time resolution (1 ns). This may be used in connection with pulsed stimulation.
All detected photons are time-stamped with respect to the start of the preceding pulse.



Data acquisition is controlled by the *Sequence Editor* program, and the software program *PTanalyse* is used for analysing the Photon Timer data. From the list of arrival times PTanlyse calculates photon arrival time distribution curves and OSL decay curves with different gating intervals. All the post-processed data may be exported to BIN-files or CSV-files for further analysis.

6. Bleaching

Bleaching facility

Bleaching of samples can be obtained using two different options for the TL/OSL reader:

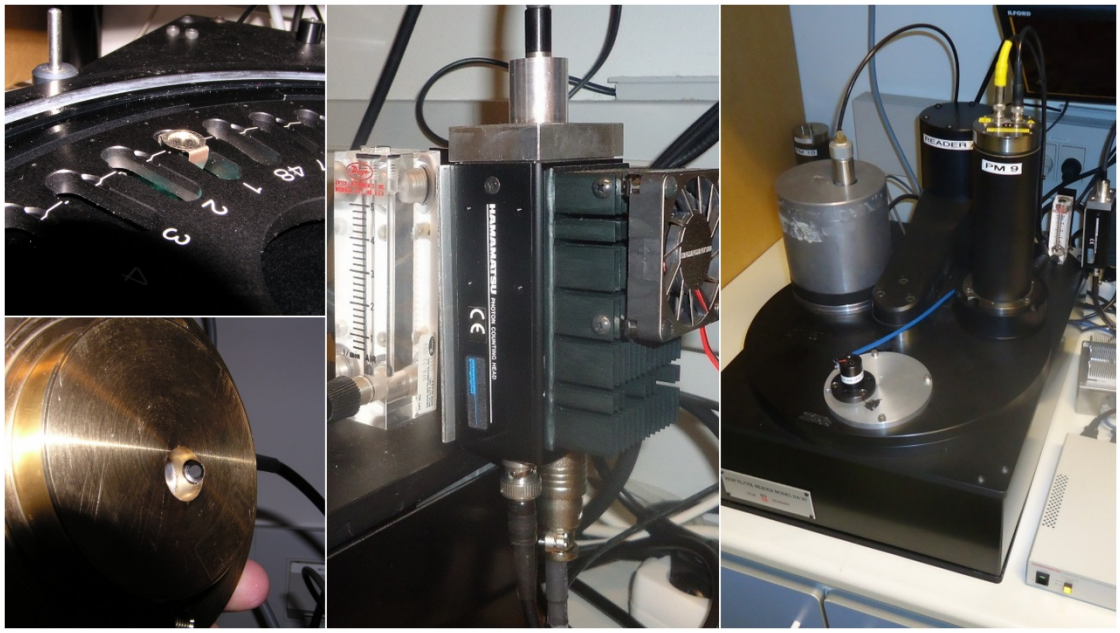
Bleaching facility – External broadband source
Powerful broadband LED stimulation system for fast bleaching of natural samples.
The Bleaching facility consist of an external high power broadband LED source, FlexiLux 4000. Optical power is 65 W, and colour temperature is 5,800 K. The light source is connected to the reader bleaching position with a liquid light guide and the bleaching may be controlled by the TL/OSL reader software.

Bleaching facility – LED module
This facility contains a powerful Violet LED (380-390 nm , 10 W) or UV LED (365 nm, 11 W) placed in a special bleaching position that may be used to bleach the samples during a sequence with the Illumination Sequence Editor command. The module is powered by a supply that is built into the Reader, and a connector on the back of the reader connects to the module.

7. Radio-luminescence

Radio-luminescence (RL) attachment
This attachment comprises:

- A beta irradiator modified to facilitate detection of light signal during irradiation. The beta source is lifted 7 mm, which reduces the dose rate to about half.
- A Hamamatsu H7421-50 Photon counting head with spectral response 380-890 nm, thermoelectrically cooled
- Lumatec liquid light guide (Transmission range of 350- 2000 nm)
- Detection filter holder and Chroma D 900/100 interference filter (bandpass : 850-945 FWHM)
- Electronics for switching between counter input from RL PMT and standard PMT (built into Controller)
- Power supply for Hamamatsu H7421-50 Photon counting head and thermoelectric cooler (built into Controller)
- A powerful UV LED (395 nm, 10 W) placed in a special bleaching position that may be used to bleach the samples during a sequence



The Sequence editor software supports a command for making RL data acquisition, and a program, *RLanalyse*, is supplied for analyzing RL decay curves

8. Sample Camera

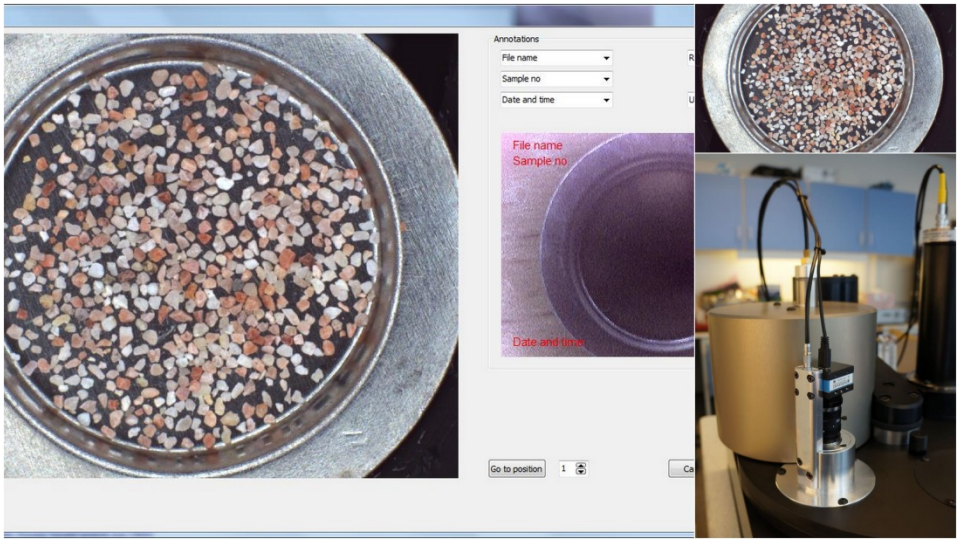
Sample camera attachment

The sample camera allows you to make an automated recording of sample appearance after the luminescence measurements – for instance for purposes like this:

- Visual inspection after luminescence data collection
- Use of image analysis for determining e.g. number of grains, coverage area, grain size distribution, colour distribution

The Sample camera attachment is based on

- TheImagingSource 1/2.5 " Micron CMOS 5Mp camera
- Computar 3Mp f=25mm lens



The camera is mounted in a mechanical fixture that is vacuum tight, light tight and holds a diffuse light illumination system to assure proper white light illumination of the samples that are photographed. A driver for the illumination light is build into the Controller. The *Sequence Editor* includes a functions that allow you to set up and use the sample camera in data acquisition sequences.

Note:
The Sample Camera occupies the X-ray irradiator position, so the X-ray irradiator cannot be ordered together with the Sample camera attachment.

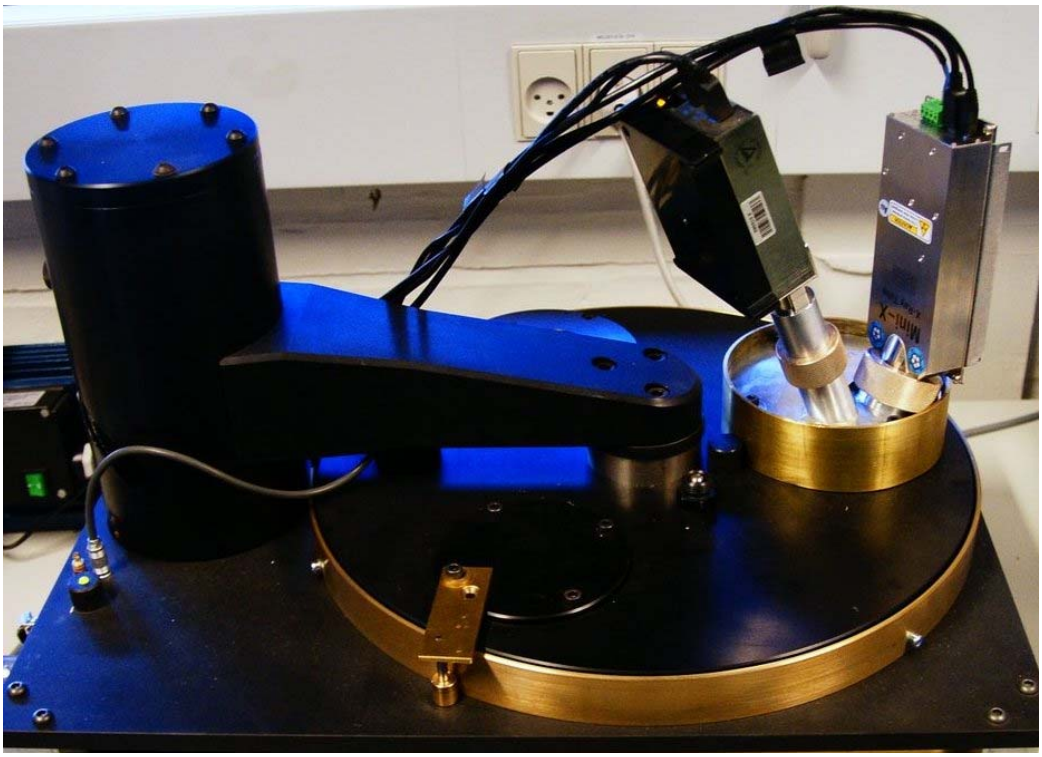
9. X-ray Fluorescence

X-ray Fluorescence (XRF) attachment

This attachment allows you to estimate the composition of feldspar samples. The relative proportion of K-/Na/-Ca-feldspar is estimated as well as the possible Quarts contamination.

The XRF attachment consist of:

- Amptek X-123 SDD Complete X-Ray Spectrometer (Si Drift 25 mm2 x 500µm / C1 Window / 1.5" Detector Extension / 2-Stage Cooler / Internal Multilayer Collimator)
- Amptek MINI-X Miniature X-Ray Tube, High Voltage Power Supply and USB Controller (Gold (Au) target)
- Sample cups specially made by molybdenum metal (200 sample cups will be delivered).



- Software:
  A special program for making the analysis of XRF data and converting this to position in the ternary diagram of K-/Na/-Ca-feldspar and giving estimated Quarts contamination.
- Reference samples for making and maintaining the K-/Na/-Ca-feldspar calibration.

The standard data acquisition software, *Sequence Editor*, will include support for making data acquisition from the XRF unit

Note:
The attachment only works with vacuum established in the reader measuring chamber which means that the Vacuum pump and accessories should be ordered as well.
The XRF spectrometer occupies the alpha irradiator position, so the alpha irradiator cannot be ordered together with the XRF attachment.