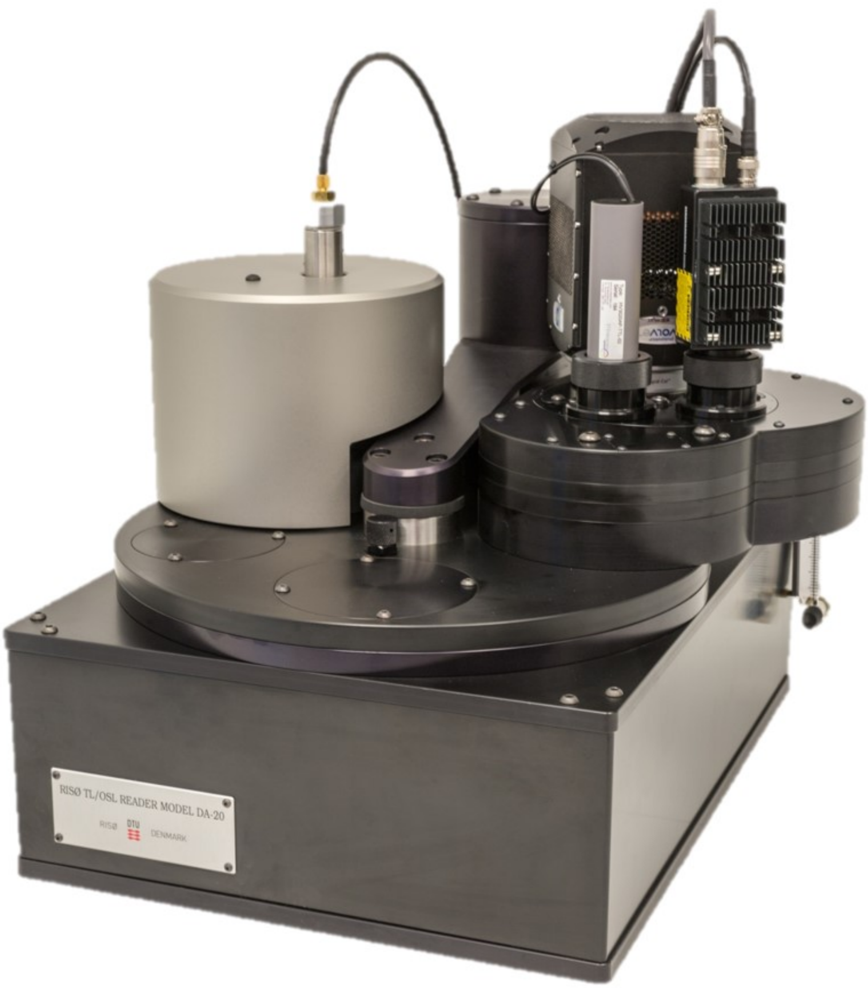
DTU Physics
Department of Physics

Guide to
The Risø TL/OSL Reader



April 2021

Precautions!

- Do not remove the signal cable before removing the HV cable from the PMT! Removing the signal cable while HV is connected may damage the amplifier inside the PMT. When the lid is open the HV is switched off automatically.

- Do not heat samples on aluminum discs higher than 500 °C! If the aluminum disc is heated above 500 °C it will be in risk of melting, and the heating element may be damaged. In the Sequence Editor a maximum temperature can be set to prevent higher temperatures.

- Do not block the rear vacuum outlet when not using the quartz window! If the quartz window is not used e.g. for single grain, the vacuum outlet must not be connected or blocked in order to be able to let out the excessive air in the chamber when closing the lid.

- Maximum sample height is 2 mm! If the sample is too high the carousel may be jammed.

- Make sure the heater element is down, before closing the lid! If the heater element is up, remove the carousel, and then close the lid. Connect with control program, and send lx command to the heater in the services tab. On later versions of Controller there is an audible alarm when the lid is closing while the heater lift is up.

- Acid fumes will seriously damage the reader! Severe corrosion and failure in instrumentation will occur from contaminated laboratory atmospheres or measurement of inadequately washed samples. It is very important to avoid any possibility of acid-fume contamination of the reader:

    1. Make sure that the atmosphere in the room containing the reader is not connected to the air circulation in a chemistry preparation room (e.g. through an air-conditioning circuit or a door).
    2. Make sure that all acid-treated samples are thoroughly washed before loading into the reader. If in doubt, check the pH is >6.

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Overview

The Risø TL/OSL reader is the result of >30 years of research and development. This automated measurement platform enables measurements of both TL and OSL in vacuum or inert gas. The system allows up to 48 samples to be

- individually heated to any temperature between room temperature and 700°C
- stimulated using various light sources in continuous wave (CW), linearly modulated (LM-OSL) and pulsed (POSL) mode
- individually irradiated by beta and alpha emitting sources (^{90}Sr/^{90}Y and ^{241}Am) or a mini X-ray generator

The luminescence is measured by a light detection system comprising a photon counter (either a photomultiplier tube, PMT or an Electron Multiplying Charge Coupled Device, EMCCD) and suitable detection filters. Measurements are carried out in a vacuum chamber. The software-controlled detection and stimulation head (DASH) contains light emitting diode (LED) modules, two filter changer wheels (enabling 16 filter combinations) and a detector changer with up to three detectors.

A schematic drawing of the system is shown in Figure 1.1.

The Risø TL/OSL reader consists of two separate units:

1. The TL/OSL Reader itself (hardware)
2. The Controller (control of hardware)

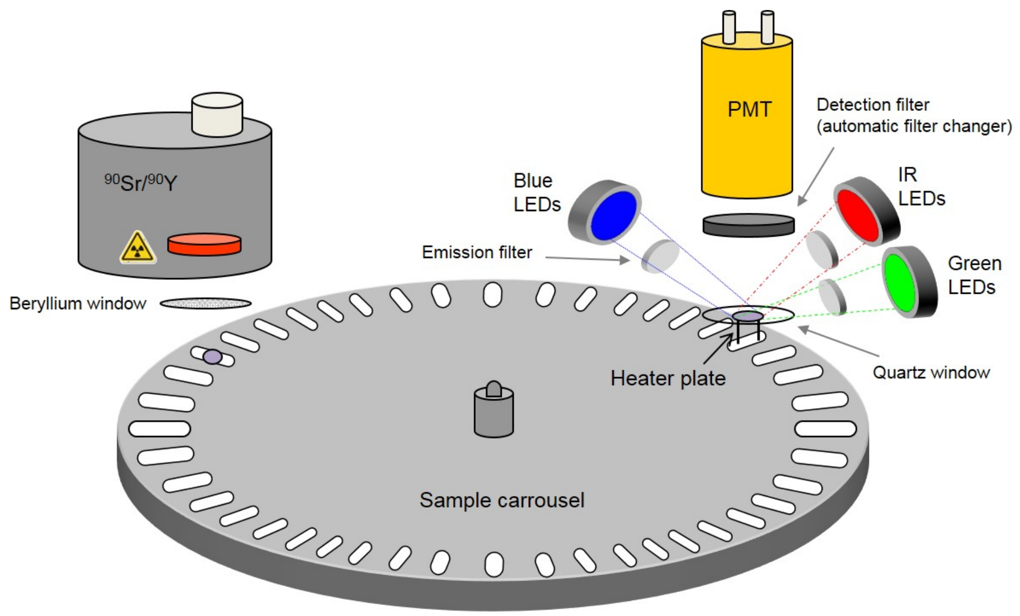

Figure 1.1: Schematic drawing of the Risø TL/OSL reader

The system is run using one of two programmes - the SEQUENCE EDITOR (used to write elaborate measurements sequences) and the CONTROL Program (used to carry out simple tests on the equipment) - installed on a standard PC.

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The standard Risø TL/OSL Reader

2.1 Sample presentation

Samples are either mounted on 9.7 mm diameter stainless steel discs using silicone oil as an adhesive or poured (as loose grains) into sample cups (see Figure 2.1). Samples are loaded onto an exchangeable sample carousel that can accommodate up to 48 samples. The sample carousel is placed in the sample chamber which can be programmed to be evacuated or have a nitrogen atmosphere maintained by a e.g. nitrogen flow.

The sample is lifted through slots in the sample carousel into the measurement position by a lift, which also functions as heating element. In the measurement position the sample can be stimulated thermally and/or optically. Thermal stimulation is obtained by linearly increasing the temperature of the heating element and optical stimulation is provided by different light sources focused onto the sample position. The emitted luminescence is measured by the light detection system.

The sample carousel rests on a motor driven turntable, which enables rotation of the sample carousel. Rotation is computer controlled and position holes drilled though the carousel in close proximity to the sample positions enable the system to keep track of the position of the carousel using optoelectronics. An infrared light emitting diode (LED) is positioned underneath the turntable, which is switched on during rotation. The measurement is initiated by moving a given sample to the measurement position located directly underneath the light detection system. The sample carrousel rotates at two different speeds (two-speed turntable) to reduce processing time. If a sample

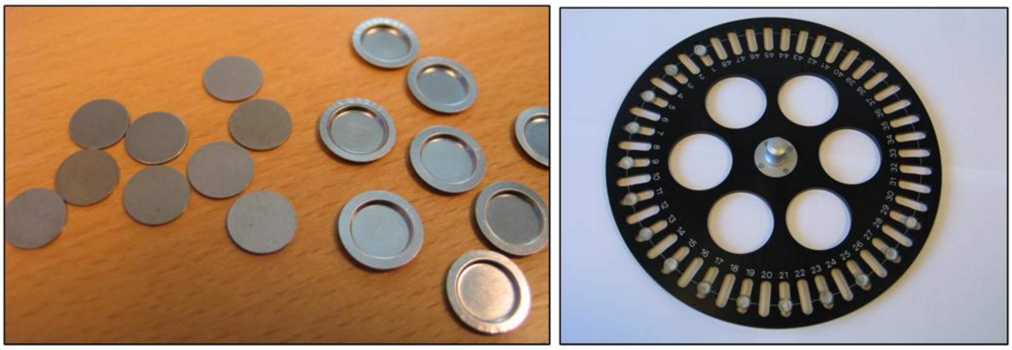

Figure 2.1: Sample discs and cups (planchettes) are shown on the left. On the right a sample carrousel (sometimes referred to as "turntable") is shown.

is moved to the next position then the turntable turns at the normal speed. If, however, the turntable must advance several positions, it is accelerated to a high speed for most of the move and decelerated to slow speed before stopping.

2.2 Detection And Stimulation Head (DASH)

The software-controlled detection and stimulation head (DASH) contains light emitting diode (LED) modules, two filter changer wheels (enabling 16 filter combinations) and a detector changer with up to three detectors (see ?). DASH allows for automated changing of detection filters and photon detector (optional) within a measurement sequence and consists of:

1. Driver and control board (plug-in board for the Reader Controller)
2. Base unit containing stimulation LEDs, feed-back diodes, collimating optics, memory, and controller for the EMCCD camera focussing optics
3. Two stacked filter changers (4 filters in each)
4. Detector changer (3 positions)

A block diagram of the DASH mounted on a reader are shown in Figure 2.2. In the following sections we describe the light detection system and the luminescence stimulation systems separately.

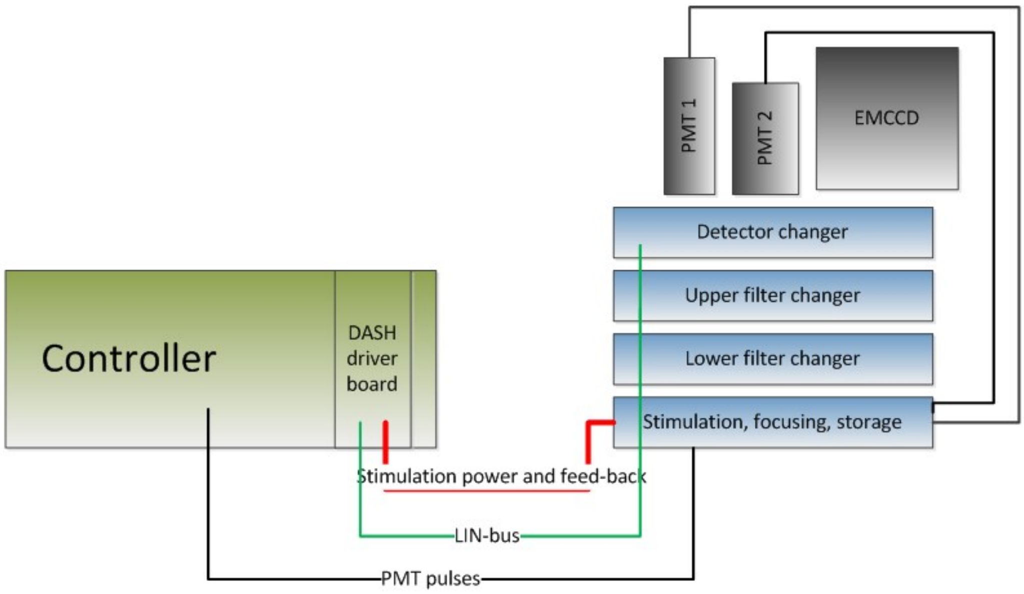

Figure 2.2: Schematic overview of the automated DASH

2.3 Light detection system

The essential components of the light detection system are 1) a photon counter (either a photomultiplier tube, PMT or an Electron Multiplying Charge Coupled Device, EMCCD)and 2) suitable detection filters. The detection filters serve both to shield the photon counter from scattered stimulation light and to define the spectral detection window.

2.3.1 Photomultiplier tube

The standard photon detector in the Risø TL/OSL Reader is a blue/UV sensitive photomultiplier tube (PMT). The emitted luminescence is detected by a photomultiplier tube (PMT). The light sensitive component in the PMT is the cathode. Typically, ten photons in the visible range striking the cathode are converted into one to three electrons. Electrons emitted from the photocathode are accelerated towards a series of dynodes maintained at a positive voltage relative to the photocathode. Electrons with sufficient velocity striking the dynode will eject several secondary electrons from the surface.

The standard PMT in the Risø TL/OSL reader is an Electron Tube PDM

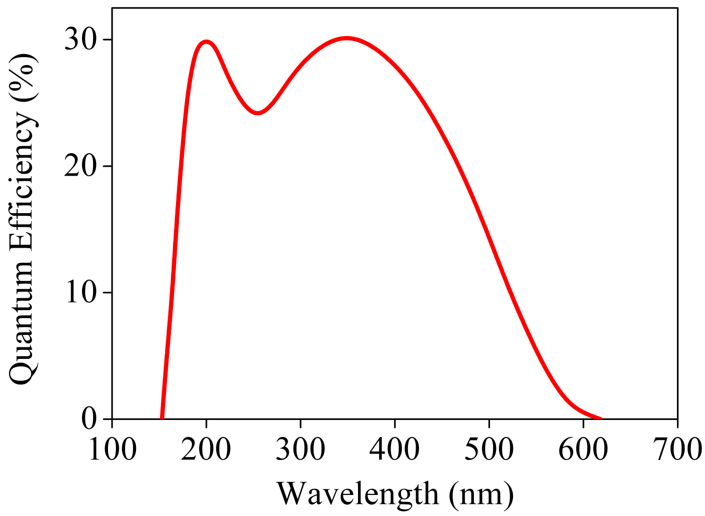

Figure 2.3: The quantum efficiency of the photomultiplier tube EMI ET 9107 PMT as a function of photon wavelength

9107-CP-TTL (160-630 nm) PMT, which has maximum detection efficiency between 200 and 400 nm, making it suitable for detection of luminescence from both quartz and feldspar (see emission spectra in Figure 2.4).

Figure 2.3 displays the quantum efficiency (i.e. sensitivity) as a function of incident photon wavelength for ET 9107. The PMT is operated in "photon counting" mode, where each pulse of charge arising at the anode is counted.

Optional detectors are i) a cooled PMT Hamamatsu H7421-50, 380-890 nm, ii) a cooled PMT Hamamatsu H7421-40, 300-720 nm, and iii) a high sensitivity EMCCD camera (Photometrics Evolve 512, Peltier cooled -80 řC) with adjustable focussing optics.

2.3.2 Automated detector changer

The detector changer has three positions for different detectors with one position dedicated for the EMCCD option. All detectors use a common collimating lens system with an aperture of 25 mm diameter and a focal length of 25 mm (see Fig. 2). If the detector changer has an EMCCD camera mounted, this common fused-silica lens system is designed to be a good compromise between imaging characteristics and optical transmission (see Kook et al., these proceedings). If imaging is not required, a simpler fused-silica based optics optimised for maximum transmission is used.

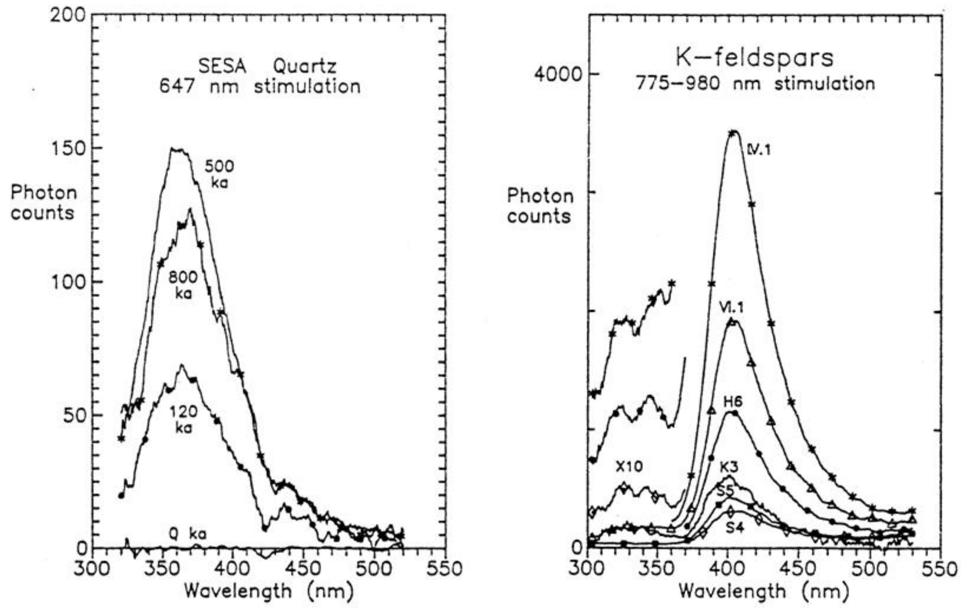

Figure 2.4: Emission spectra of sedimentary quartz and K feldspars (from ?). **a)** Emission spectra of several sedimentary quartz samples from South Australia obtained for stimulation using the 647 nm line from a Krypton laser. **b)** Emission spectra of several sedimentary K feldspars using IR diode stimulation.

2.3.3 Detection filters

The intensity of the stimulation light is $\sim 10^{18}$ 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. Quartz has a strong emission centred on 365 nm (near UV) and many types of feldspars have a strong emission centred on 410 nm (violet). In Figure 2.4 emission spectra from several samples of sedimentary quartz and K feldspars are shown.

The Risø TL/OSL reader comes with the following three detection filters:

1. Hoya U-340 (5 and 2.5 mm thick, ø = 25 mm)
2. Schott BG39 (2 mm thick, ø = 25 mm)
3. BG3 (3 mm thick, ø = 25 mm)[1]

[1] BG39 and BG3 are as a default placed in the same filter position

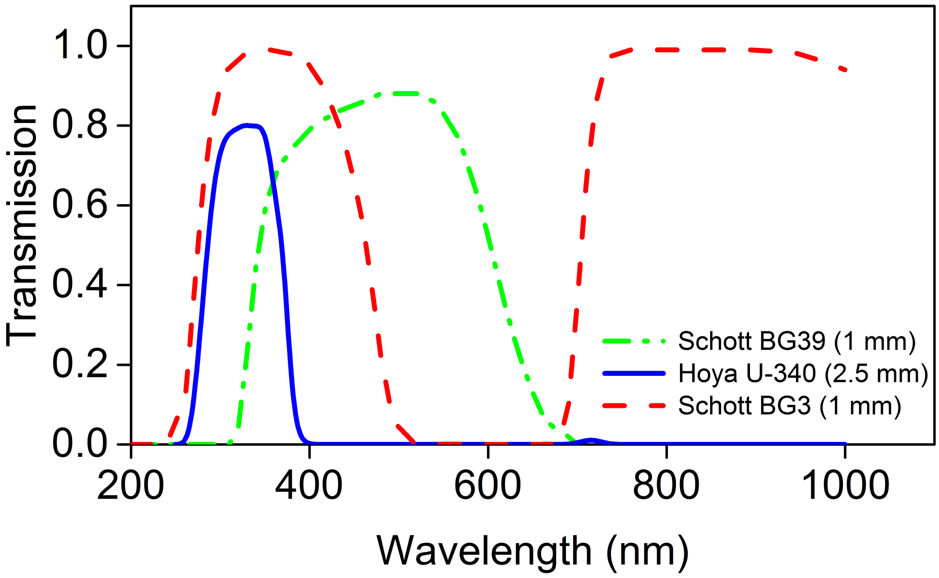

Figure 2.5: Transmission characteristics of the three detection filters (U-340, BG 39 and BG3) supplied with the Risø TL/OSL Reader.

The individual filter characteristics are shown in Figure 2.5. Quartz OSL is often detected using the Hoya U-340[2] filter, whereas feldspar OSL often is detected using the so-called blue filter pack comprising of Schott BG-39 in combination with Corning 7-59 or BG3. The transmission curves for these two combinations are shown in Figure 2.6. Also shown are the emission spectra for quartz and feldspar.

2.3.4 Automated filter changer

Two stacked filter changers are incorporated in DASH enabling automatic combination of filters. Each filter changer has 4 positions, making 16 filter combinations possible. The filter carrier is designed to accept individual filters (or stack of filters) up to 8 mm thick, and up to 25 mm diameter; the latter allows the use of standard commercially-available filters for special purposes. When mounted in the filter changers, individual filters are identified in the Sequence Editor setup by their name and unique ID number, so that when sequences (the sequence of operations) are stored, the filter IDs

[2]Even though the main transmission of the U-340 filter is slightly off-set compared to the main emission of quartz its high transmission makes it favorable compared to e.g. U-360

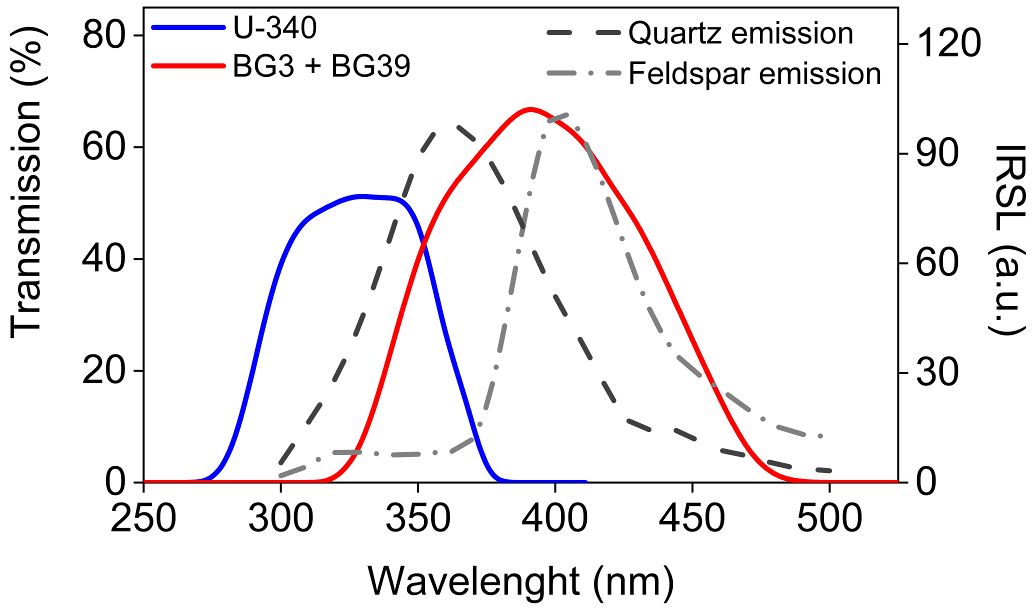

Figure 2.6: Transmission characteristics of Hoya U-340 and the blue filter pack using BG3 in combination with BG39. Also shown are emission spectra from quartz and feldspar.

selected for the particular operation are also stored. This allows the transfer of sequences from one reader to another even if filters are not mounted in the same positions. User-defined filters may also be specified by name and unique ID number.

2.4 Luminescence stimulation systems

The Risø TL/OSL reader has two luminescence stimulation systems: 1) a heating system that can be used for TL measurements and 2) a light stimulation system that can be used for OSL measurements. The two stimulation systems can be used in combination, e.g. OSL at elevated temperature is possible.

2.4.1 Heating system

The heating element and lift mechanism is located directly underneath the photomultiplier tube. The heating element (see Figure 2.8) has two functions: 1) it heats the sample and 2) it lifts the sample into the measurement position. The heater strip is made of low-mass Kanthal (a high resistance alloy) which is shaped with a depression to provide good heat transmission to

Figure 2.7: DASH mounted on a Reader. The top layer of DASH has been removed to show the upper filter changer layer. A close up of the four-position filter changer is shown in the top right corner.

the sample and to lift it securely and reproducibly into the measurement position. Heating is accomplished by feeding a controlled current through the heating element. Feedback control of the temperature employs a Cromel-Alumel thermocouple (0.5 mm) mounted underneath the heater strip. The thermocouple is fixed to the heater element using a gold rivet. Heating is provided by a continuous non-switching fixed frequency sine wave generator. The heating system is able to heat samples to 700 °C at constant heating rates from 0.1 to 10 K/s. To minimise thermal lag between sample and heater strip heating rates above 5 K/s are usually not employed. The heating strip can be cooled by a nitrogen flow, which also protects the heating system from oxidation at high temperatures.

Software corrects for systematic deviations (primarily related to electronic non-linearity) between set temperature and actual temperature of the heating element. The calibration for each heating system is unique. After calibration the systematic deviations are all within 0.5 °C of the Set temperature (see

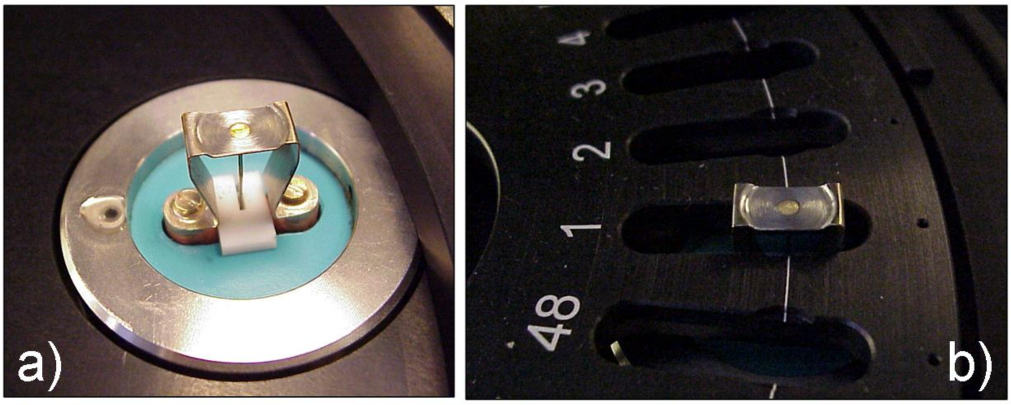

Figure 2.8: a) Picture of the heating element in the measurement position, b) Same as a) but with the sample carrousel in place. The small position holes on the sample carrousel enabling the system to keep track of the position can also be seen.

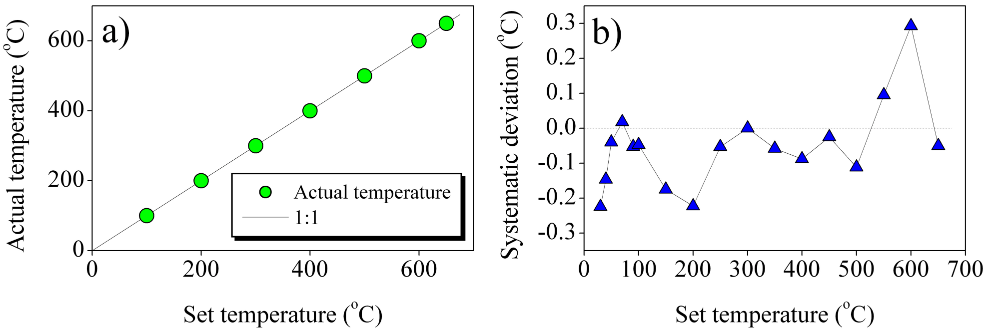

Figure 2.9: a) Actual temperature as a function of Set temperature, b) Systematic deviation between Actual and Set temperature as a function of Set temperature.

Figure 2.9).

2.4.2 Optical stimulation system

In OSL, the probability of eviction depends on the rate at which photons arrive at the trap and the sensitivity of that particular trap to photoeviction. The sensitivity of the trap depends strongly on the wavelength of the stimulating light, generally the shorter the wavelength the greater the chance of eviction. However the wavelength of the stimulation light is not the only factor to take into consideration. The wavelength of the emitted luminescence must also be considered. The intensity of the emitted luminescence is

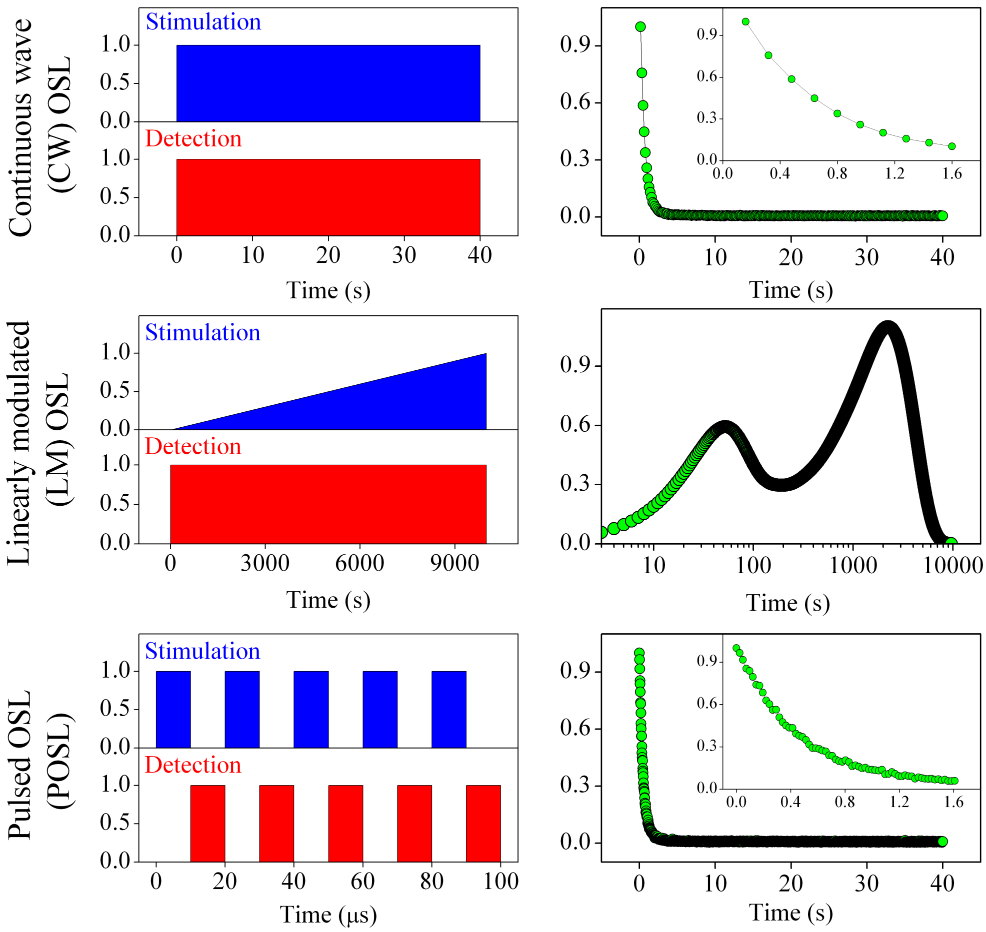

Figure 2.10: Illustration of three different stimulation modes: CW-OSL, LM-OSL and POSL. Also shown are experimental results obtained using the three stimulation modes on sedimentary quartz.

many orders of magnitude smaller than the intensity of the stimulation light, so in order to effectively prevent stimulation light from reaching the PMT, the wavelengths of the stimulation light and the luminescence must be well separated or appropriate filters used.

Conventionally, the samples are stimulated at constant light intensity (continuous wave CW-mode), which produces an exponentially decaying signal as the electron traps are being depleted. However, the decay curves for most samples contain more than one component (i.e. traps with different optical cross-sections), and require several exponential functions to adequately describe the data. In linearly modulated OSL (LM-OSL) the stimulation light intensity is varied linearly (usually from zero to a predefined value). Electrons in traps most sensitive to light will be evicted at low intensities, whereas the less light sensitive traps will empty at higher intensities. Thus, by ramping the light intensity a stimulation curve is obtained in which different peaks represent different sensitivities to light (?). In pulsed OSL (POSL, ?) the stimulation light is pulsed and the OSL is only measured in between the pulses (see Figure 2.10). Pulsing provides insight into the luminescence recombination process, reduces the need for filtering and provides an instrumental way of separating the luminescence emitted from different phosphors.

Optical stimulation unit

The optical stimulation unit in DASH includes 7 locations for LEDs (with reflectors) and one empty position enabling the use of external stimulation light sources (e.g. the single-grain attachments, the violet 405 nm laser or a user-supplied stimulation source). The standard LED configuration contains

1. Two blue LEDs (470 nm, $80\,\mathrm{mW/cm^2}$)
2. Two green LEDs (525 nm, $40\,\mathrm{mW/cm^2}$)
3. Three infrared LEDs (850 nm, $300\,\mathrm{mW/cm^2}$)

The DASH may be configured to other combinations if required. The standard system can be operated CW, LM-OSL and POSL mode. All selections/operations are software controlled, and can be user selected in a measurement sequence.

The 8 stimulation locations are evenly distributed around the periphery of a circle centred on the sample location. The beams from the individual LEDs have an incident angle of 45° at the sample (see Figure 2.11).

The LEDs are mounted in close thermal contact with the aluminium framework of the DASH to provide good thermal contact with the entire reader and so ensure long LED lifetime and stability. Three of the LED positions (normally one blue, one green and one IR) have a feed-back photodiode mounted for regulation of the power during stimulation.

To reduce the intensity of the tail of the LED emissions and thereby minimise the amount of directly scattered light reaching the light detection system, the following long pass filters are incorporated in front of the LEDs:

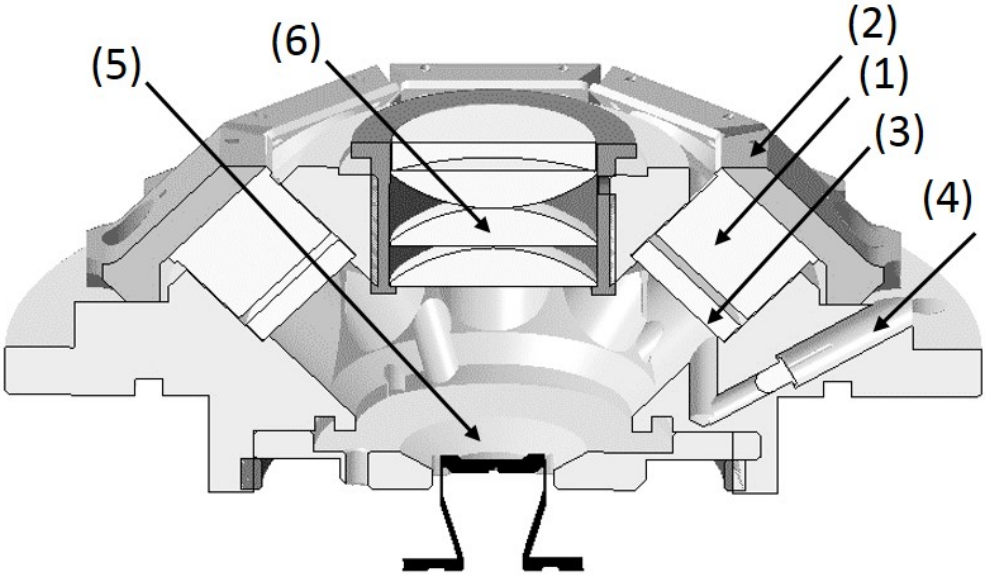

Figure 2.11: Cross section of the automated DASH base unit. (1) Stimulation LED with reflector, (2) LED cooler, (3) stimulation filter, (4) feed-back photodiode, (5) sample heater and 6) collimating optics.

- GG420 in front of the blue LEDs
- GG475 in front of the green LEDs
- RG780 in front of the IR LEDs

These long pass filters attenuates the high energy photons at the cost of 0-5% attenuation of the main emission peak. Figure 2.12 displays the LED emission spectra compared to the published transmission curve for the long pass filters incorporated in front of the LEDs.

Cross-bleaching

On a 48-sample carousel the distance between the centres of adjacent sample positions is 17 mm. The consequence of this close spacing is that optical stimulation of one sample may affect adjacent samples. This phenomenon is referred to as optical cross-talk (or cross-bleaching). Optical cross-bleaching has been shown (see e.g. **?**) to depend on the colour of the stimulation light (i.e. IR stimulation results in approximately 1 order of magnitude higher

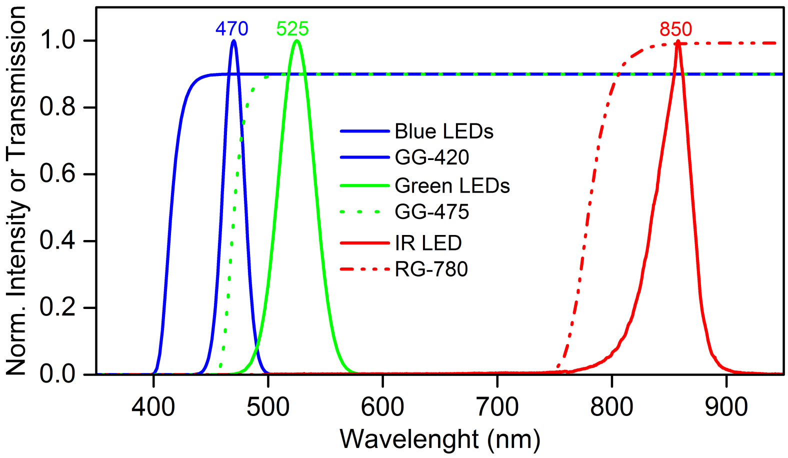

Figure 2.12: The emission spectra of the blue, green and IR LEDs. Also shown are the transmission curves for the GG-420 long pass filter (cut-off filter in front of the blue LEDs), the GG-475 long pass filter (cut-off filter in front of the green LEDs), and the RG 780 long pass filter (cut-off filter in front of the IR LEDs)

cross-bleaching than blue stimulation) and the used sample carrier (i.e. the cross-bleaching is higher for discs than cups). A summary of the cross-bleaching results presented in **?** is given in Table 2.1. Although cross-bleaching can be significant in highly sensitive samples or when employing very long stimulation times, the effects can usually be disregarded if care is taken with the measurement sequence design.

Stimulation	Mineral	Sample Carrier	Nearest [%]
Blue	Q	Cups	0.00005
Blue	KF	Cups	0.00010
IR	KF	Cups	0.00100
IR	KF	Discs	0.00300

Table 2.1: Cross-bleaching results (**?**). Values for blue cross-bleaching is lower than previously reported (e.g. **?**, **?**) because of a re-design of the flange under the OSL unit in 2012.

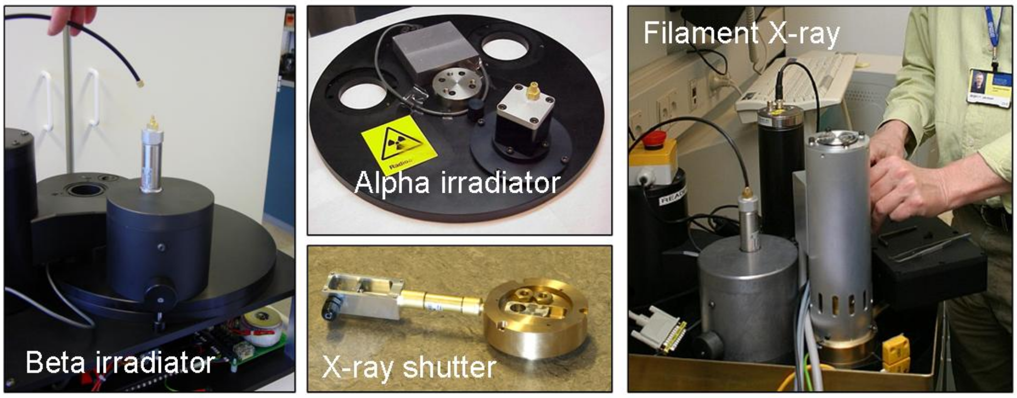

Figure 2.13: Picture of the various irradiators: beta irradiator, alpha irradiator and filament X-ray generator. All three irradiators can be fitted on the same reader.

2.5 Irradiation sources

In the Risø TL/OSL reader samples can be irradiated *in situ* using three different types of radiation.

1. Beta radiation (^{90}Sr/^{90}Y)
2. Alpha radiation (^{241}Am)
3. X-ray radiation (50 kV/1 mA filament tube)

Irradiations are software controlled allowing single irradiations (minimum irradiation time of 1 s). Figure 2.13 show pictures of the various irradiators.

2.5.1 Beta irradiation

A detachable beta irradiator is located above the sample carousel and a schematic drawing of the irradiator unit is shown in Figure 2.14. The irradiator is made of brass (outer diameter 10 cm) and is surrounded by 20 mm of lead on the sides, and 40 mm on the top. Furthermore, an aluminum safety helmet (outer diameter 222 mm) covers the entire irradiator and lead shielding. This irradiator accommodates a ^{90}Sr/^{90}Y beta source, which emits beta particles with a maximum energy of 2.27 MeV. The half life is 30 years. The source strength is usually about 1.48 GBq, which gives a dose rate in quartz at the sample position of approximately 0.1 Gy/s.

The source is mounted into a rotating, stainless steel wheel, which is pneumatically activated; it takes the source 0.11 s to rotate from the closed position to the open position (?). This off-set time is constant for all irradiations and is negligible for long radiations. In brief irradiations it can be compensated for by subtracting it from the programmed irradiation time.

The source-to-sample distance should be as small as possible to provide the highest possible dose rate at the sample, however any spatial variations in dose rate across the source will be accentuated at small source-to-sample distances, so a compromise is required. The distance between the source and the sample is 7 mm.

The source is placed inside the irradiator, directly followed by a 20 mm thick aluminum spacer, a 20 mm thick lead spacer, a spring washer, and finally a 25 mm thick aluminum spacer (see Figure 4.15). When the source is "off" (default position) it is pointing upwards directly at a 10 mm Carbon absorber. When the source is "on" (activated position) it is pointing downwards towards the measurement chamber. A 0.125 mm beryllium window is located between the irradiator and the measurement chamber to act as vacuum interface for the measurement chamber.

On a 48 sample carousel the distance between the centres of adjacent sample positions is 17 mm. The consequence of this close spacing is that irradiation of one sample will lead to a dose being absorbed in the adjacent samples. This phenomenon is referred to as irradiation cross-talk. ? measured the irradiation cross-talk to be $0.250\% \pm 0.003\%$ for adjacent samples and $0.014\% \pm 0.002\%$ for second nearest samples.

2.5.2 External dose rates arising from beta radiation

The external dose rate originates entirely from bremsstrahlung due to interaction with beta particles in surrounding materials. All dose rates reported below were measured using an Automess Scintomate 6134A, which is a calibrated plastic scintillation detector, specifically intended for measuring dose rates from photons down to 40 keV. The measurements were carried out in a room with a background dose rate of $\sim 0.15\mu$Sv/hr.

- When the source is not activated the dose rate at a distance of 1 m from the front surface of the Risø reader is $< 0.4\mu$Sv/hr. When the source is activated the dose rate is $< 0.5\mu$Sv/hr.
- The dose rate directly on the surface of the irradiator is $< 5\mu$Sv/hr both when the source is activated and not activated.
- The maximum dose rate directly on the side of the reader (the side closest to the irradiator) increases from 5μSv/h to $< 100\mu$Sv/h when

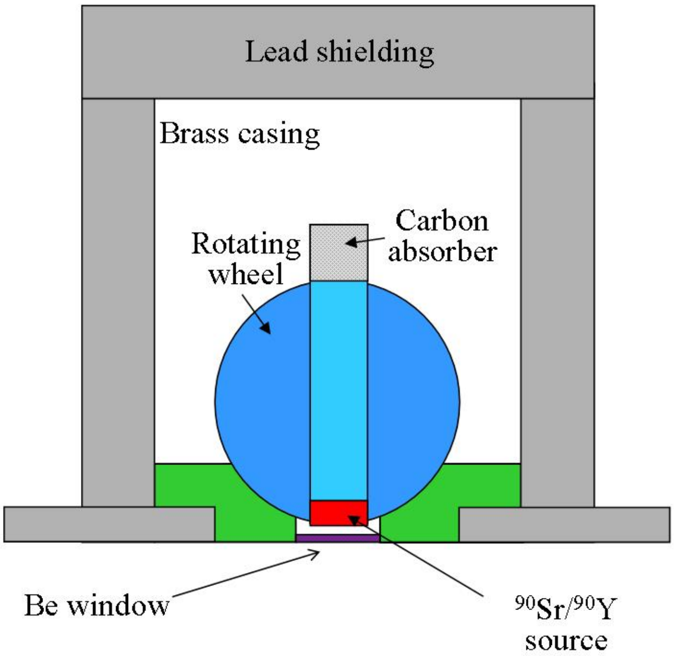

Figure 2.14: Schematic diagram of the cross section of the beta irradiator. The ^{90}Sr/^{90}Y source is placed in a rotating stainless steel wheel, which is pneumatically activated. The source is shown in the *on* (irradiating) position. When the source is *off* the wheel is rotated 180°, so that the source points directly at the carbon absorber.

the source is open. It is not possible to be situated close to this side of the reader (the 100μSv/h drops to 17μSv/h even 10 cm away from the surface), but nevertheless this dose rate can readily be reduced to $<< 1\mu$Sv/h by placing one cm of lead shielding right under the irradiator along this side of the reader. However, we do not regard it as necessary to shield either the front or the other sides of the reader. We also recommend that the reader is positioned in such a way that the space underneath it is inaccessible (the dose rate underneath a wooden table with a thickness of 25 mm is $< 3\mu$Sv/h when the source is inactivated and $< 40\mu$Sv/h when the source is activated).

The lid is both electronically and mechanically inter-locked so it cannot be opened while the source is energized. If the lid is forced open software and hardware interlocks will de-energize the irradiator and returning the source to its default safe position. An external indicator positioned next to the irradiator glows red when the source is activated and green when the source is de-energized.

2.5.3 Alpha irradiation

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.

2.5.4 X-ray irradiation

The X-ray irradiator is a filament type X-ray: Varian VF-50J X-ray tube (50 kV, 1 mA, 50 W) with tungsten target and a 4-50 kV DC Spellman high voltage power supply (**?**). The tube is mounted on a 35 mm long brass collimator (internal diameter 10 mm) with a 50μm Al end window at the exit. A 7 mm thick mechanical shutter made of stainless steel is positioned within the length of the collimator to prevent the sample from being irradiated until the X-ray output has stabilized. At the end of an irradiation the shutter is closed before the X-ray is switched off. It takes the shutter 62 ms to open and 145 ms to close. Thus, the actual irradiation time is about 80 ms longer than the programmed time. The distance from the face of the X-ray tube to the sample is 35.5 mm, and the average dose rate at 50 kV and 1 mA (maximum power) to quartz grains mounted on stainless steel discs is approximately 2 Gy/s.

? examined the spatial variation of dose-rate from a ^{90}Sr/^{90}Y beta source and found that the dose rate could vary by 15% across a 10 mm sample area for a source/sample distance of 15 mm. Others have reported higher spatial dose rate variations for their sources (**?**). The spatial variation of dose-rate for the filament X-ray is less than 1%. For the filament X-ray the irradiation cross-talk is $0.0012\% \pm 0.0001\%$ for the adjacent samples and less than $10^{-4}\%$ for second nearest samples.

There is an excellent linearity between tube current (as set by the user) and dose rate. It has a dynamic dose rate range between 10 mGy/s and 2 Gy/s at 50 kV and 2-30 mGy/s at 10 kV) when mounted on a standard OSL/TL reader. The short-term stability is better than about 0.2% (**?**). The X-ray irradiator incorporates an enhanced security control and fail-safe system to meet the individual "regulations for operation" as issued by the different local governments of different countries

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Control of the Risø TL/OSL Reader

All direct hardware control of the reader has been incorporated into the Controller (see Figure 3.1).

The Controller is a 586 processor based PC with a 32 MB flash disk and 32 MB of RAM. The Controller connects to the host computer (user PC) via an RS-232 serial cable or a USB connection (USB for Controller version D or later). The Controller is responsible for maintaining proper timing, sample positioning, data acquisition, error checking, etc. The Controller is also equipped with a two-line text display, which shows the current system status and the command which is currently being executed. This display also reports failure messages such as thermal failure and the receipt of invalid commands.

A picture of the Controller is shown in Figure 3.2. The use of the indicators and the buttons on the front panel of the Controller is described

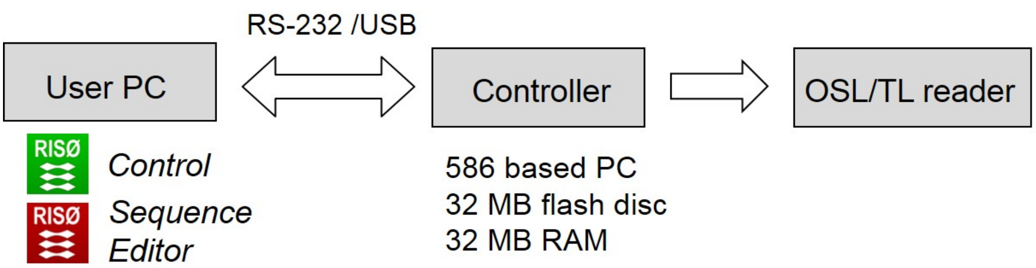


Figure 3.1: Schematic overview of the Risø system

Figure 3.2: Picture of the Controller

below.

LID The reader lid is opened and closed using the two buttons located in the lower left corner. The status of the reader lid is indicated by the three red lights positioned directly above these two buttons (e.g. when the reader lid is “DOWN” the red light above the “DOWN” button is on. This light must be on before a measurement sequence can begin)

TURNTABLE When “RUN” is on the sample carousel is rotating. When the “POS” light blinks the system has detected a sample position. When “POS.1” is on the system has located sample position 1

LIFT The three red lights indicate the status of the lift. A sample is not in measurement position before the “UP” light is on

MODE The three red lights indicate whether the heating element is heating, an irradiation is being performed and if an OSL command is being executed

PM The red light “COUNTS” blinks every time a count has been registered by the light detection system. The red light “CAL” indicates when the calibration LED is on (not relevant for systems with equipped with DASH)

ATMOSPHERE The red light “VAC. PUMP” indicates when the vacuum pump is being activated. Please note that a vacuum pump is not part of a standard Risø TL/OSL system. The “N_2” light is on when the system is requested to flush the measurement chamber with Nitrogen

Display The two-line text display showing the current status of the system is positioned in the middle of the front panel of the Controller. The light level of this display can be adjusted by gently pressing the "ADJ" button located directly below the display

VACUUM A vacuum gauge is located on the right side of the Controller. If an external vacuum pump is attached to the reader, the measurement chamber can be evacuated to a preset level. This level is selected by pressing the "PRESET" button simultaneously with a thin screwdriver inserted into the "ADJ" hole (located to the right of the "PRESET" button). For alpha irradiations we recommend a pressure of 0.4 mbar

H.V. At the very right the HV dial for the PMT is located. This dial is labelled: "H.V. 500 V - 1500 V". This dial is only of use in Readers equipped with classic OSL heads. In Readers equipped with DASH this dial has no function.

The software used to control the Controller is based on a Windows program for creating, editing and executing measurement sequences. The central feature of the Controller software is a specially designed command language interpreter. The command language consists of approximately 40 commands which allow full control of system hardware and data acquisition methods. The Sequence Editor translates commands (e.g. "OSL") into low level commands which the Controller can understand, checks that the commands have actually happened, and collects data. The software also allows the user to easily create their own high level commands. Furthermore, the command language allows users to write their own control programs (using e.g. Labview) and thus construct alternative measurement options to those included in the user application software.

4

Installation of the Risø TL/OSL reader

This section details how to install the Risø TL/OSL reader.

4.1 Components

Below is a list of the components supplied with a standard Risø TL/OSL system.

1. The Reader (40 cm × 55 cm × 55 cm)
2. The Controller (50 cm × 55 cm × 20 cm)
3. PM tube
4. Nitrogen tubing
5. Nitrogen fittings
6. Flow meter
7. Tools for loading the source
8. Manuals (e.g. Analyst)
9. Risø software (USB). Includes programmes required for running the system, analysis software, electronic versions of all manuals, short movies showing how to load the beta source, how to connect the Nitrogen supply etc.
10. Two sample carrousels

  - A 48 position sample carrousel for cups (planchettes)
  - A 48 position sample carrousel for discs

11. 100 stainless steel cups (to be used with the sample carrousel labelled "CUPS")
12. 100 stainless steel discs (to be used with the sample carrousel labelled "DISCS")
13. Circlip pliers. These pliers are only used when the beta source has to be loaded/unloaded (see section 4.5)

4.2 Installing the hardware

4.2.1 Unpacking

The Risø TL/OSL reader is shipped in a durable wooden box ($59\,\mathrm{cm} \times 66\,\mathrm{cm} \times 80\,\mathrm{cm}$). Please, keep this box in case you need to move the reader to a different location or have it sent back to Risø for repair.
The beta irradiator is surrounded by lead shielding which again is surrounded by an aluminium safety helmet (outer diameter 222 mm). The lead shielding weighs about 20 kg, so before lifting the reader out of the box it is advisable to remove this shielding. The aluminium helmet is held in place by two screws.
The reader it self weighs 80-90 kg so it is advisable that two persons lift the reader out of the wooden box using the white ropes (see Figure 4.1). Rest the reader on the corner of the wooden box while obtaining a better grip on the reader. Then place the reader on a flat, stable surface at least 90 cm long. The system is run using a standard PC (usually supplied by the customer). If this PC is also placed on the work bench, we recommend that an additional bench space of 90 cm is available, bringing the total recommended bench space to 180 cm.

If the Risø system is equipped with a beta source then it is recommended that the Controller is placed on the left side of the reader (see Picture on the front of this manual) to prevent this desk space from being used as work space. When the source is irradiating the external dose rate can be $100\mu\mathrm{Sv/h}$ directly on the reader surface.

It is further recommended that the reader is positioned in such a way that the space underneath the reader is inaccessible (the dose rate underneath a wooden table with a thickness of 25 mm is $< 3\mu\mathrm{Sv/h}$ when the source is inactivated and $< 40\mu\mathrm{Sv/h}$ when the source is activated).

Figure 4.1: Unpacking the shipment.

4.2.2 Nitrogen connections

Pressurized nitrogen is required when samples are heated above 200 °C and to activate the pneumatically-controlled beta and alpha irradiators. A high quality pressure regulator must be provided that can maintain a stable output pressure of 2.5 bar (0.25 MPa). 1/4" NPT threads will fit the nitrogen tube connectors provided by Risø.

If a single source of pressurized nitrogen is used to both flood the measurement chamber and to activate the source(s) then the main N_2 supply is connected directly to the N_2 input coupling as shown in Figure 4.2.

The consumption of nitrogen for activating the pneumatically-controlled beta and alpha irradiators is very small, but if a compressed air installation already exists in your laboratory you may chose to chose to feed the source control from a separate compressed air source. The following section describes how to do this.

Two separate compressed input sources

The numbers in the following list correspond to the picture numbers given in Figure 4.3. All required fittings can be found in the N_2-fittings bag provided by Risø.

1. Dismount the backplate using a 2 mm Allen key. The backplate is being held in place by 5 screws.

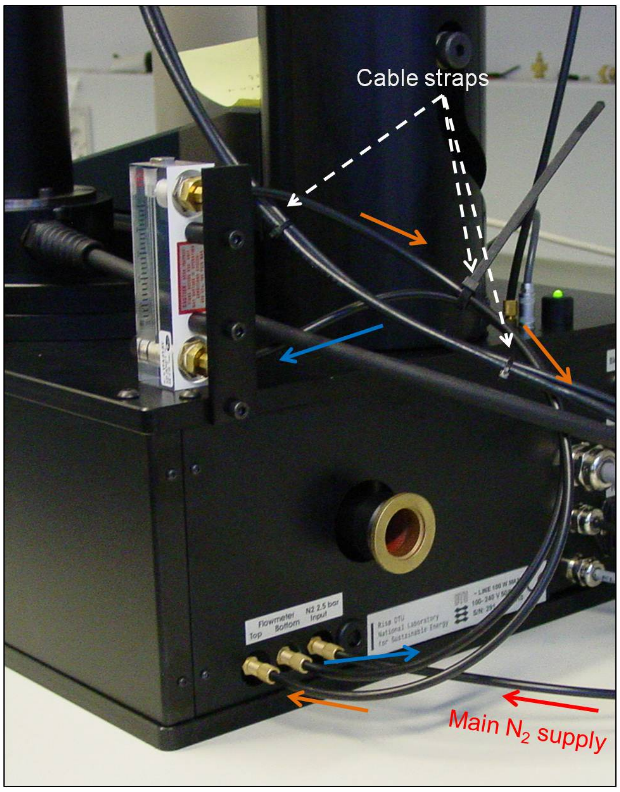


Figure 4.2: Attaching the N_2 flow meter. The arrows indicate the Nitrogen flow.

2. Remove the cap.

3. Dismount the two tube couplings on the top and the blanking plug on the side.

4. Mount two blanking plugs on the top and a tube coupling on the side of the manifold using a 7 mm key.
   Remount the backplate.

5. Connect the compressed air to the N_2 input (the third tube coupling from the left).
   Connect the tube from the N_2 main supply to the just mounted tube coupling (the fourth tube coupling from the left).
   Mount the enclosed label over the old label.

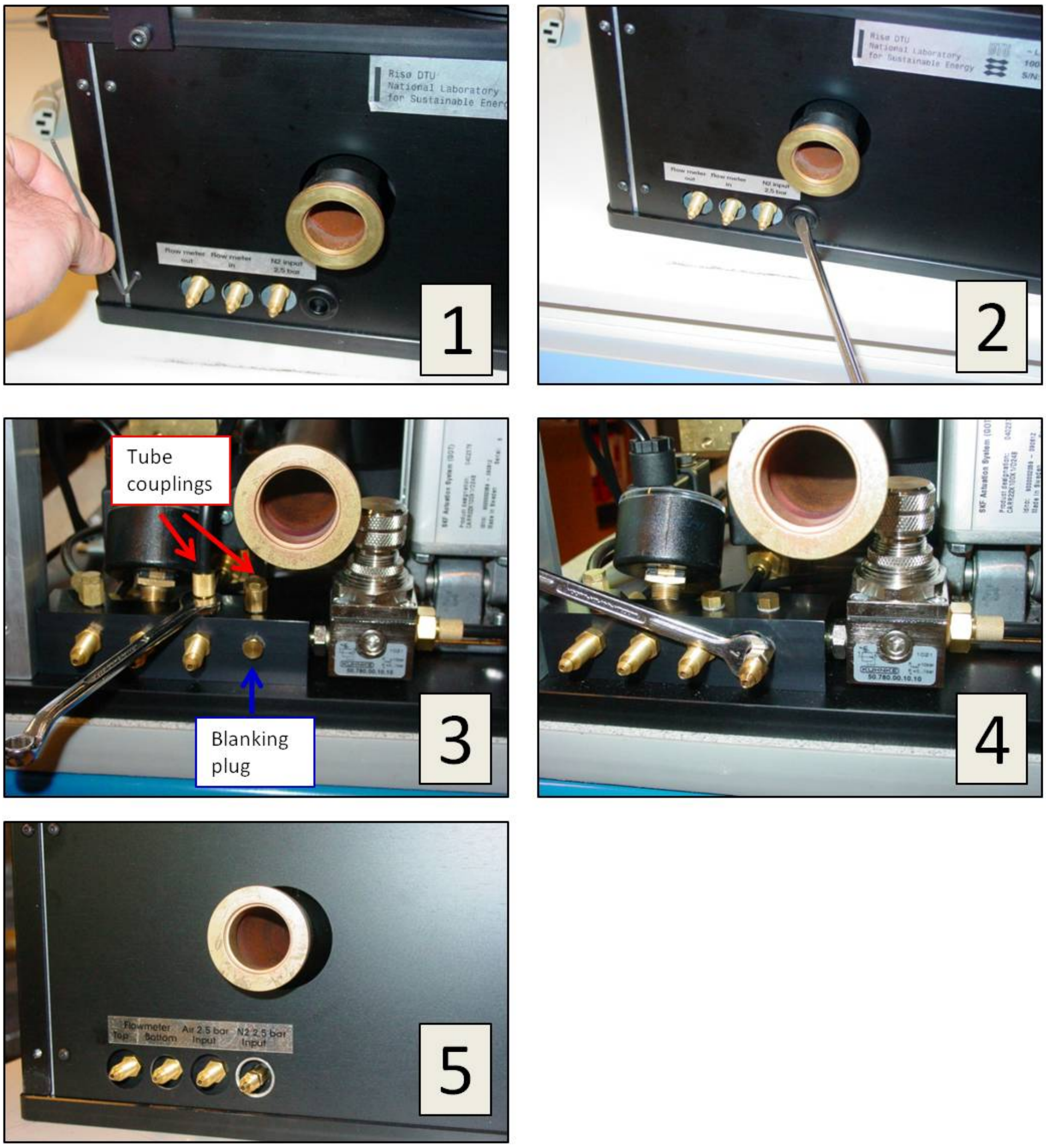
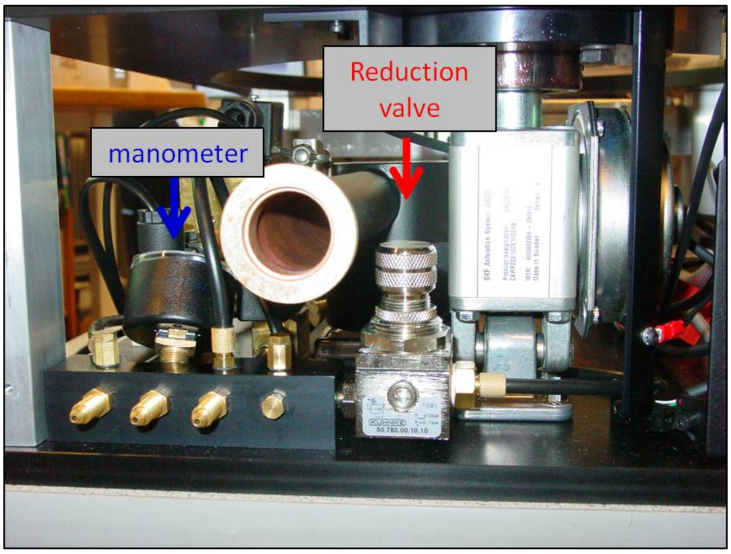


Figure 4.3: Installing two separate compressed input sources.



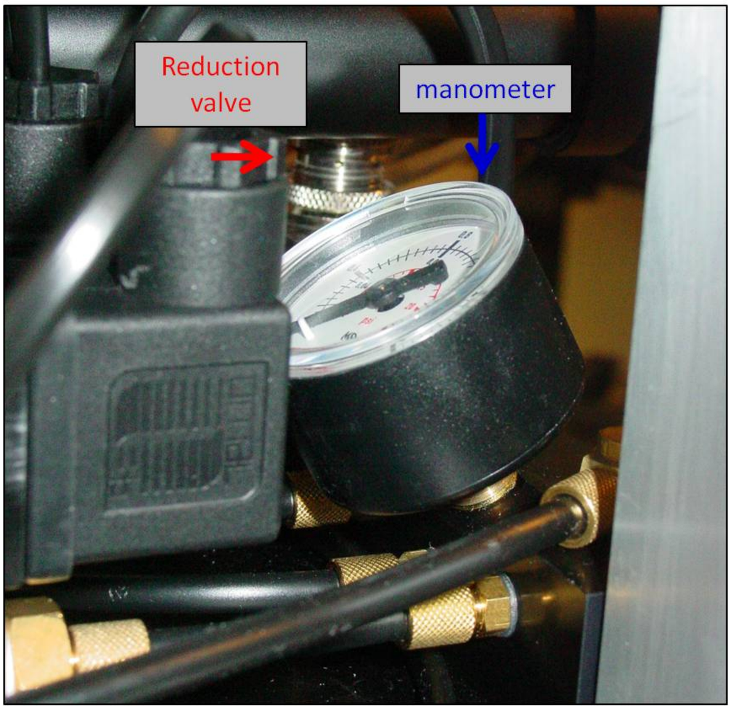


Figure 4.4: Position of the reduction valve controlling the N_2 inlet pressure seen from the back of the reader (top) and from the side (bottom).

4.2.3 Attaching the flow meter

The flow meter and its position on the reader is shown in Figure 4.2. Attach the N_2 tubes as shown. The arrows indicate the Nitrogen flow. Also shown is advantageous places to position cable straps. Using cable straps in this way reduces the risk of getting the Nitrogen tubes caught between the lid and the reader while opening and closing the lid.

The 2.5 bar N_2 input pressure is reduced to 0.4 bar to reduce the risk of discs being blown off the heater element when the measurement chamber is flooded with N_2. However, if a different flow pressure is required it can be adjusted manually using the reduction valve located on the pressured air manifold (see Figure 4.4). The inlet pressure can be read off the manometer located next to the reduction valve. To gain access to this reduction valve either remove the backplate as shown in Figure 4.3 or simply remove the cover.

4.2.4 Connecting to the Controller

DO NOT POWER THE CONTROLLER AT THIS STAGE!!!

Connecting the PMT

Connect the cables form the PMT to the DASH base unit as indicated in Figure 4.5a. Connect the PMM cable from the Controller (Figure 4.5b) to the DASH base unit (Figure 4.5c).

Connecting the rest

Figure 4.6 shows how to connect the OSL unit (located in the base unit of DASH) to the Controller. All connections are clearly indicated.
Please make all the remaining required connections. Note that not all slots need to be connected (e.g. ETHERNET, VGA, RS 422/RS 455, KEYBOARD and USB are not normally used).

Only when all connections have been made, the power to the Controller and the Reader may be switched on.

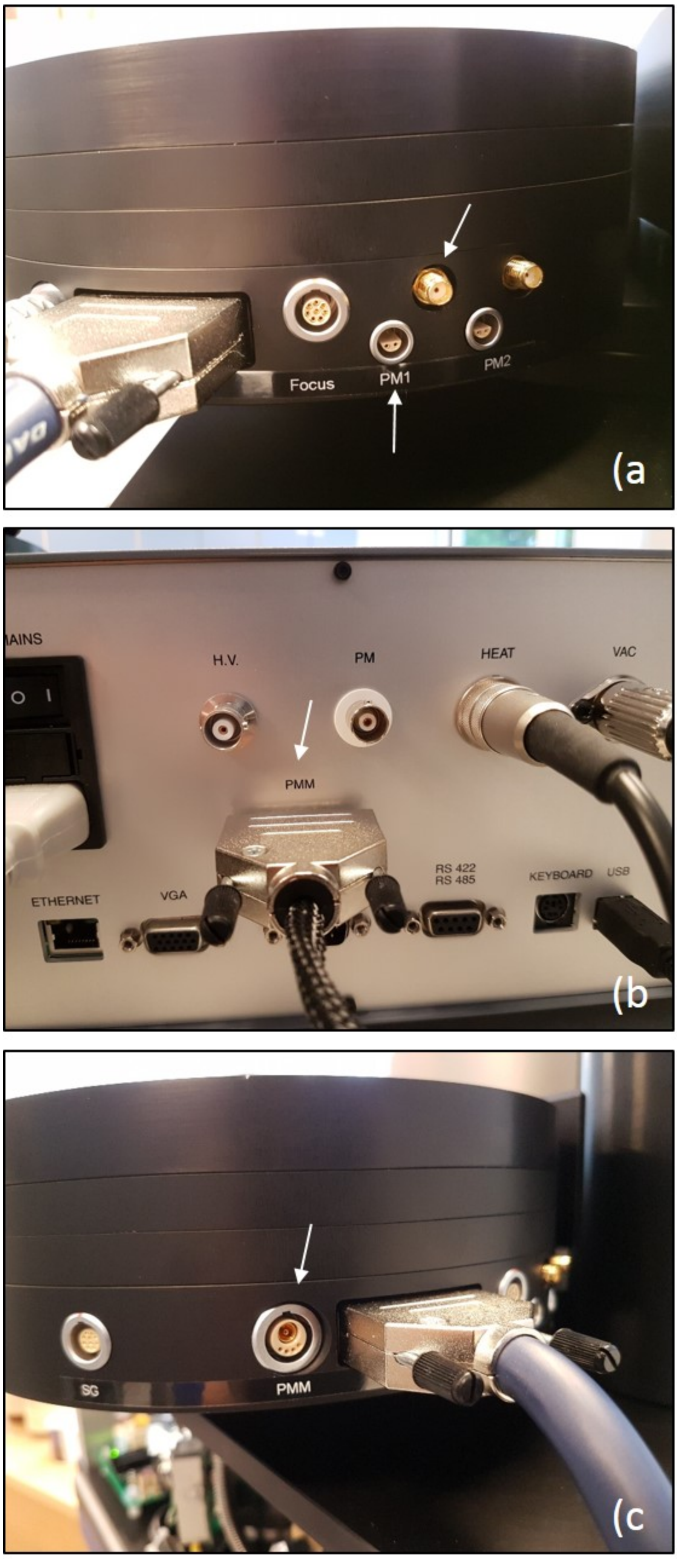


Figure 4.5: Connecting the PMT. a) connect the cables from the PMT to the DASH base unit as indicated by the arrows. b) Connect the PMM cable to the back of the Controller, c) Connect the other end of the PMM cable to DASH base unit.

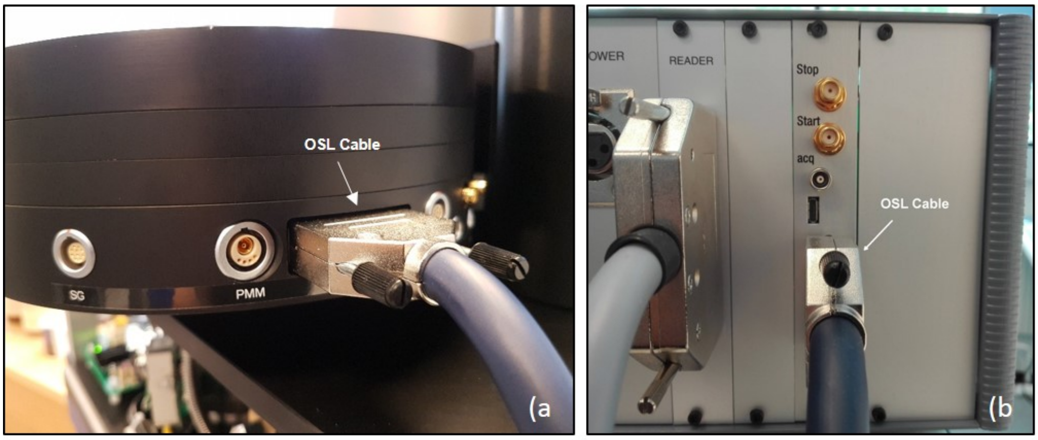


Figure 4.6: Connecting the OSL unit. a) Connect the OSL cable to the DASH base unit, b) Connect the other end of the OSL cable to the back of the Controller.

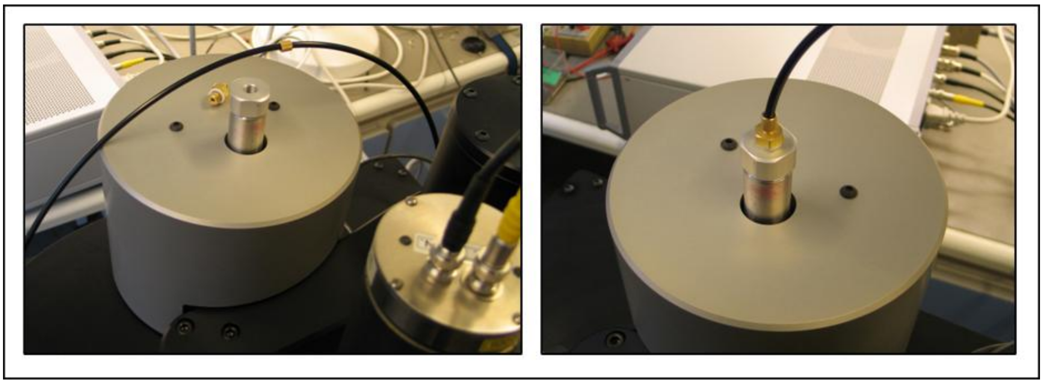


Figure 4.7: Connecting the N_2/air supply to the beta irradiator.

4.2.5 Connecting the N_2/air supply to the beta irradiator

Before connecting the beta irradiator to the N_2/air supply a coupling must be fitted to the top of the pneumatic actuator which protrudes from the top of the beta irradiator. The coupling is found in the bag with N_2 fittings. Note that a plastic washer must be fitted between the coupling and the actuator. The black plastic tube (already connected to the reader on the left hand side of the tower) should be connected to the coupling fitted to the top of the pneumatic actuator (see Figure 4.7).

4.3 Installing the Risø software package

To install the Risø software package on the user PC insert the USB in the appropriate drive (installation will begin automatically). If the installation does not start automatically, it can be started manually by running the *setup.exe* program located on the USB root directory. Follow the instructions provided by the installation program. You can choose between three different installation modes: 1) Typical, 2) Customised, and 3) Full. The features installed in "Typical" and "Full" installation modes are shown in Table 4.1. In "Customised" mode you may select which features to install. Select the installation ode and follow the instructions during the installation.

Feature	Typical	Full	Description
Sequence Editor	X	X	Used to define and run the sequence of actions you want the instrument to do
Control	X	X	Used to check the functionality of the system It is mainly used for service and maintenance
Viewer	X	X	Used to inspect the data acquired using the Sequence Editor
Analyst	X	X	Used to inspect and analyse the data acquired using the Sequence Editor
Manual	X	X	The manuals for the Reader and the available options
PTanalyse		X	Used to inspect and analyse data acquired using the Photon Timer option
Extras		X	Extra material including pictures, videos, examples etc.
Update Installer		X	Used to install a tool for updating the Controller software. The *Update installer* installs a shortcut to the *Controller Software Update* program in the Risoe program folder

Table 4.1: Features installed in "Typical" and "Full" installation modes.

You may run the installation USB at a later stage if you wish to add or remove features from your installation. The *Controller Software Update* program that can be installed using the *Update Installer* program is removed by *Add or remove programs* in the Windows Control Panel.

The Risø Controller Version D (or later) supports USB connection as an

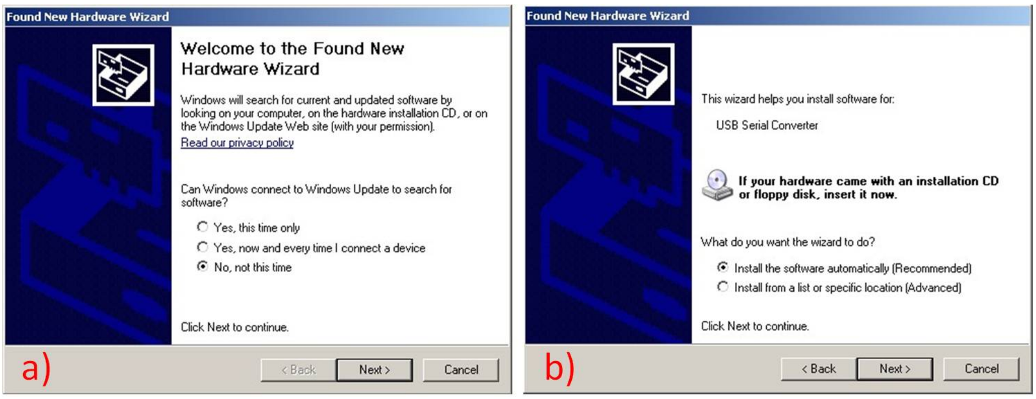


Figure 4.8: Software installation using USB connection

alternative to RS232 connection to the controlling PC. If your controlling PC uses Windows XP then you are prompted to install two drivers the first time you connect the PC and the Risø Controller. In the first screen select "*No, not at this time*" and in the second select "*Install the software automatically*" (see Figure 4.8a and b). In the dialog box informing you that the driver has not passed the Windows Logo testing select "*Continue anyway*". If your controlling PC uses Windows 7 the installation is done automatically.

The Risø Controller is now connected to a COM port. The COM port number, which you will need for setting up the Sequence Editor and the Control Program, you will find in: *Control Panel* → *System* → *Hardware* → *Device manager* as shown in Figure 4.9. If the COM port number is $>$ 8 then you need to change it to a number ≤ 8. This is done by choosing the "*Advanced...*" in the USB Serial Port Properties window and specifying a new number (which does not conflict with other ports on your computer) for the COM port (see Figure 4.9).

4.4 Testing

It is now time to test if the reader has been installed correctly. The lid of the reader is opened by pressing the "UP" button located on the front panel of the Controller (in the bottom left corner, see Figure 4.5c). The reader lid opens sideways to the left (see Picture on the title page). Insert one of the sample carrousels. After placing the sample carrousel rotate it a little to ensure that it has been positioned correctly. Close the reader lid by con-

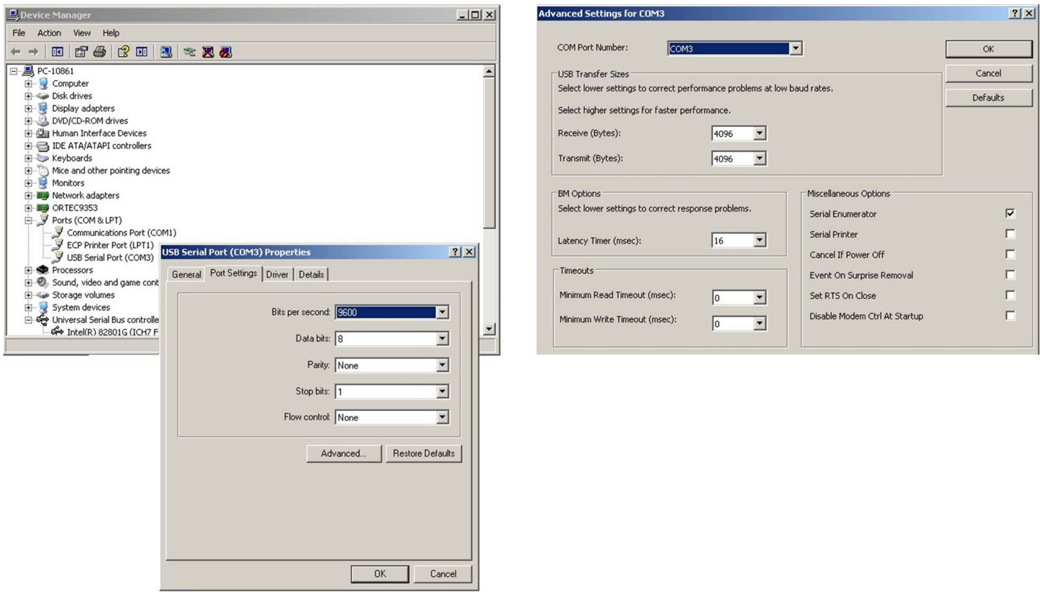


Figure 4.9: Selecting the appropriate COM port

tinuously pressing "DOWN". Continue pressing "DOWN" until the lid stops moving. For security reasons the lid will stop moving as soon as the "DOWN" button is released.
Open the CONTROL program, choose "connect to Minisys" and select the tab: "Services" (see Figure 4.10). When closing CONTROL it is important to remember to choose "Disconnect from Minisys" (only available when CONTROL is connected to the Controller) on the tab "Connection".

In the following sections the basic reader performance is tested using the CONTROL program.

4.4.1 Resetting the sample carrousel

Open CONTROL, choose "connect to Minisys" and select the tab: "Services" (see Figure 4.10). Reset the sample carrousel[1] by clicking the "Reset the Turntable" button located in the horizontal panel entitled: "Turntable" (second button from the left. Resting the cursor on the individual buttons will show an explaining text string). The system keeps track of the individual positions by the use of a weak infrared light emitting diode (LED) positioned underneath the turntable and a light sensor located directly above the LED.

[1]Resetting the sample carrousel/turntable means that position 1 on the sample carrousel will be positioned on the measurement position directly underneath the PMT

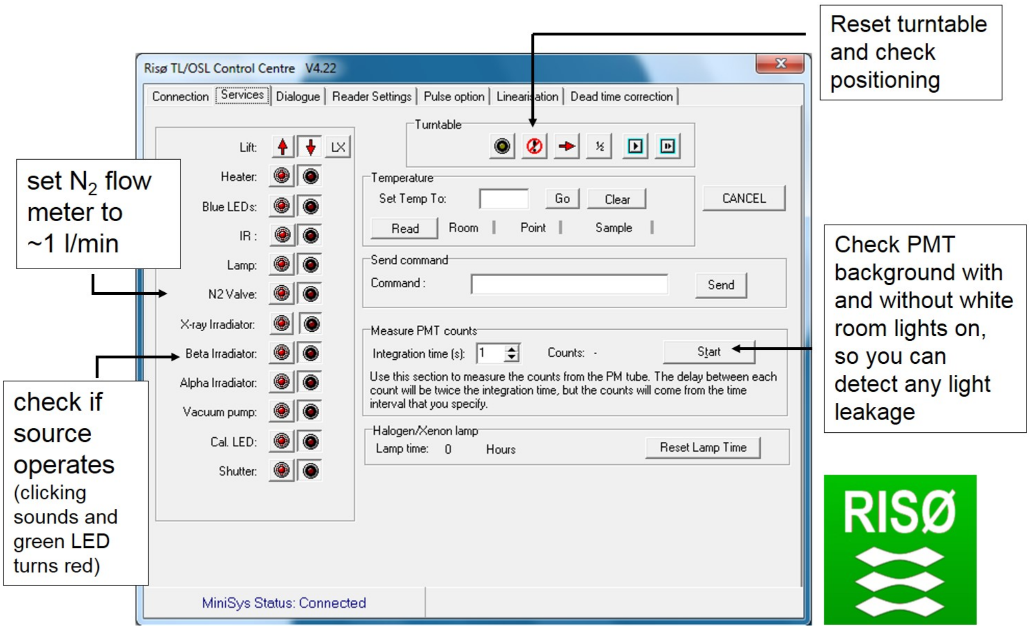


Figure 4.10: Testing the system using CONTROL.

This IR diode switches on during rotation of the sample carrousel. At each sample position a small hole (Ø = 1 mm) is drilled on the outer perimeter of the sample carrousel. Every time IR light is detected by the light sensor the system knows that it is at a new position. When the sample carrousel is rotating the display on the Controller will read: "Resetting Turntable" and the appropriate red lights will light up in the TURNTABLE column (top left corner on the Controller).

4.4.2 Checking the lift

Only carry out these instructions if the sample carrousel has been reset (see above) and is on position. It is impossible to lift the lift if the sample carrousel is not on position.
Raise the lift by clicking the "Lift up" button (arrow up, vertical columns on the left of the screen). Monitor the lights on the front of the Controller. The "LIFT RUN" light is on during movement and the "LIFT UP" light is on when movement stops. Lower the lift by clicking the "Lift down" button (arrow down, vertical columns on the left of the screen). Monitor the lights on the front of the Controller. The "LIFT RUN" light is on during movement and the "LIFT DOWN" light is on when movement stops.

4.4.3 Checking the Blue LEDs

To check that the blue LEDs can be switched on, press the "Blue LEDs" button and open the lid. The light from the blue LEDs should be clearly visible by eye. Close the lid again and switch off the Blue LEDs.

4.4.4 Adjusting the N_2 flow rate

To adjust the N_2 flow rate, switch on the N_2 flow ("N2 valve") and adjust the flow on the flow meter (see Figure 4.2) to 1 l/min using the black knob. Switch off the N_2 flow.

4.4.5 Checking the beta irradiator

To check if the beta irradiator is operational click the "beta irradiator" button. A clicking sound should be clearly audible (the sound of the pneumatically activated rotating stainless steel wheel).

4.4.6 Checking the alpha irradiator

To check if the alpha irradiator is operational click the "alpha irradiator" button. A clicking sound should be clearly audible (the sound of the pneumatically activated shutter).

4.4.7 Measure PMT counts

This section is used to measure the counts detected by the PMT. On the left the time interval being integrated can be changed (default 1 s). Measurement is started by clicking "Start". Whenever the PMT has been taken off the reader (e.g. because of filter changing) the user ought to check if any light leaks have been introduced into the system. This can be done by measuring the PMT counts with and without the white room lights switched on. If the counts increase when the room lights are switched on it means that a light leak has been introduced into the system - probably because an o-ring has been forgotten or the PMT is not mounted properly. It is normal that the dark count will be slightly elevated immediately after mounting the PMT.

Close CONTROL by choosing "Disconnect from Minisys" (only available when CONTROL is connected to the Controller) on the tab "Connection".

4.5 Loading the beta source

This section describes the procedure of loading/unloading the $^{90}Sr/^{90}Y$ source in the Risø beta irradiator. Please read the instructions carefully and watch the video showing how to load the source (C:\Risoe\Movies\Cable connection.mpg) before attempting to unload/load the source.

Before beginning the procedure of unloading/loading the beta source, make sure that

a) an empty desk space of 60×60 cm is available to handle the irradiator during unloading/loading

b) the following tools are kept within reach:

- Two hexagonal keys (Allen keys), 4 mm and 5 mm
- The circlip pliers (delivered with the Risø reader)
- The source handling rod (delivered with the source)
- 10 mm perspex/plexiglass plate and a vice to hold it. This plate is to be used as protection when the source is exposed

You should now be ready to begin the procedure of loading/unloading the beta source. The source will be exposed in item 8 and 9.

1. Remove the plastic air tube (Figure 4.11). If the irradiator module is fitted with an aluminium helmet (new models) remove it. Then remove the lid of the lead shielding

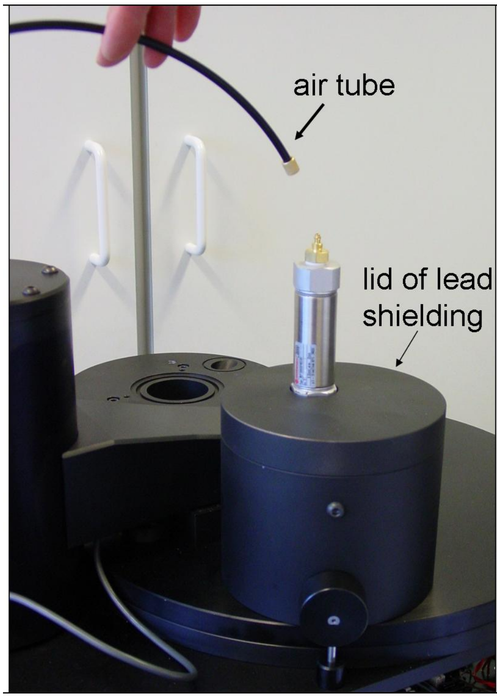


Figure 4.11: Removing the air tube.

2. Remove the lead shielding cylinder by removing the socket screw using a 4 mm hexagonal key (Allen key, see Figure 4.12)

3. Remove the irradiator from the reader by unscrewing the two screws on the top using a 5 mm hexagonal key.(Figure 4.13)

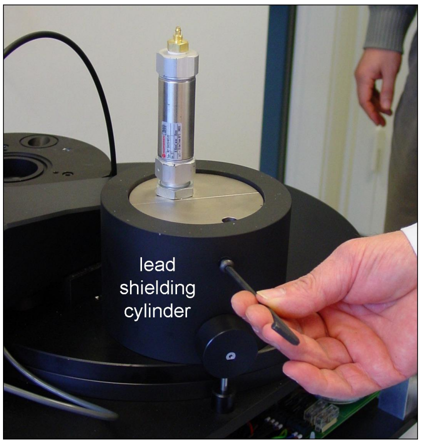


Figure 4.12: Removing Pb shielding.

Figure 4.13: Removing the irradiator.

4. Place the lid of the lead shielding UPSIDE DOWN on the circular lead shielding as shown in Figure 4.14a. Lift up the irradiator from the reader (Figure 4.14b). Place the irradiator upside down using the hole in the lid (Figure 4.14a)

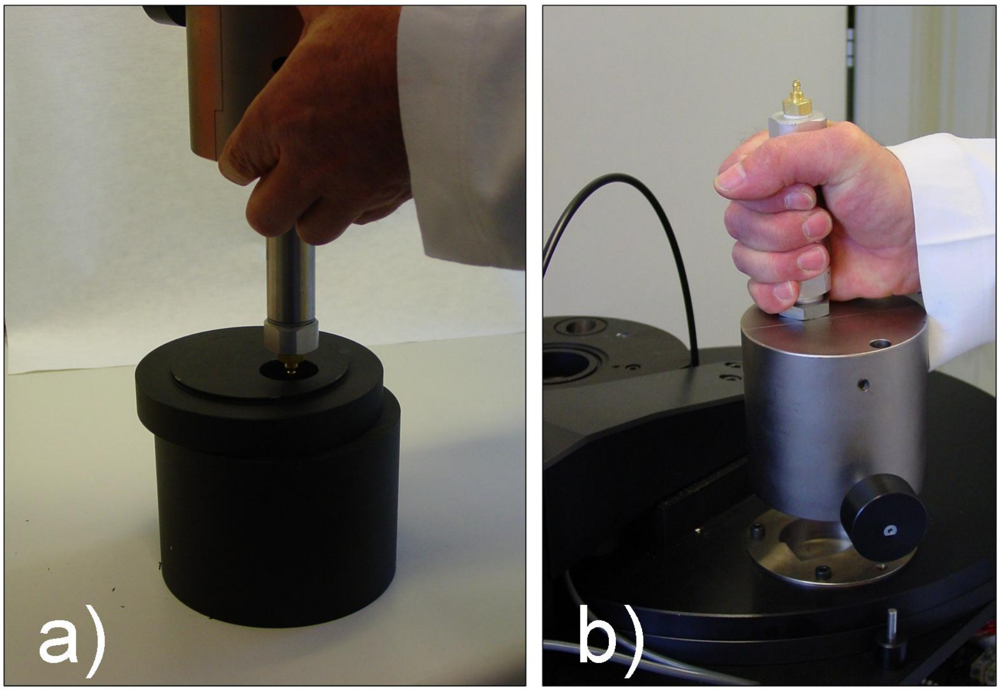


Figure 4.14: Preparing for loading/unloading.

5. The items shown in Figure 4.15 are located within the irradiator and must be removed and handled individually using the special tools delivered with the beta source. The source will only be present if the irradiator is to be unloaded

6. Remove the circlip using the circlip pliers delivered with the equipment (Figure 4.16)

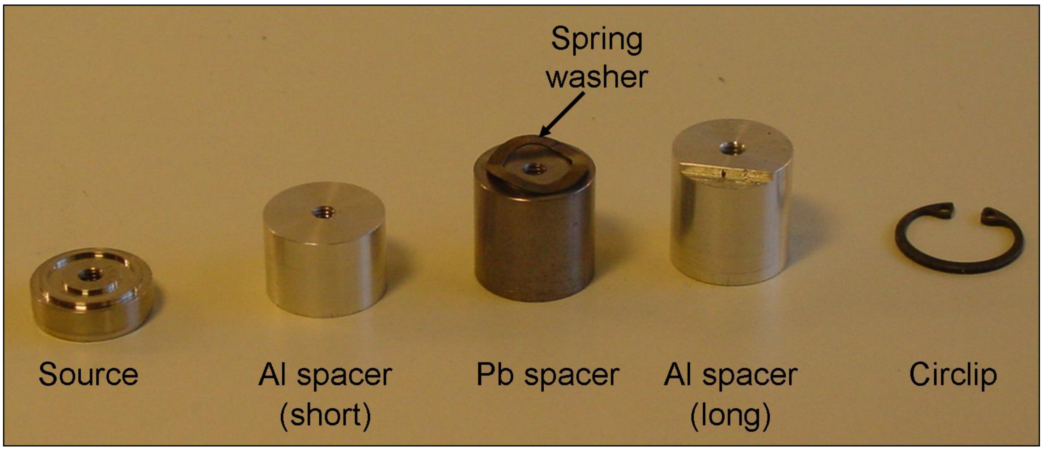


Figure 4.15: Items in the irradiator.

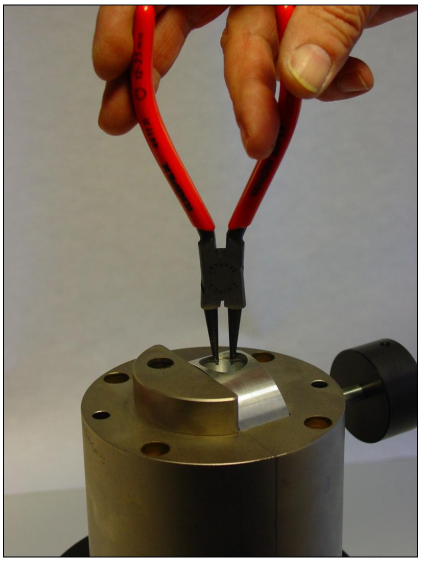


Figure 4.16: Removing the circlip.

7. Remove the long Al spacer using the special handling rod with thread (included in the beta source packing) and then the Pb spacer with spring washer and finally the short Al spacer (Figure 4.17)

Figure 4.17: Removing items in the irradiator.

8. Place a 10 mm thick perspex/plexiglass plate (or another beta-thick transparent absorber e.g. 3 mm of window glass) in front of the irradiator (this transparent sheet will absorb all beta rays during loading). Place the lead container with the source behind the perspex and take off the container lid. Remove the plastic lid from the inner container as quickly as possible. Lift out the foam plastic packing using a pair of tweezers. Then use the handling rod to lift up the source from the container (turn rod clockwise to fix it in the tread hole of the source). The source must always be pointed away from the operator. The operator must wear safety glasses and must at all times look through the perspex plate during the loading operation (Figure 4.18)

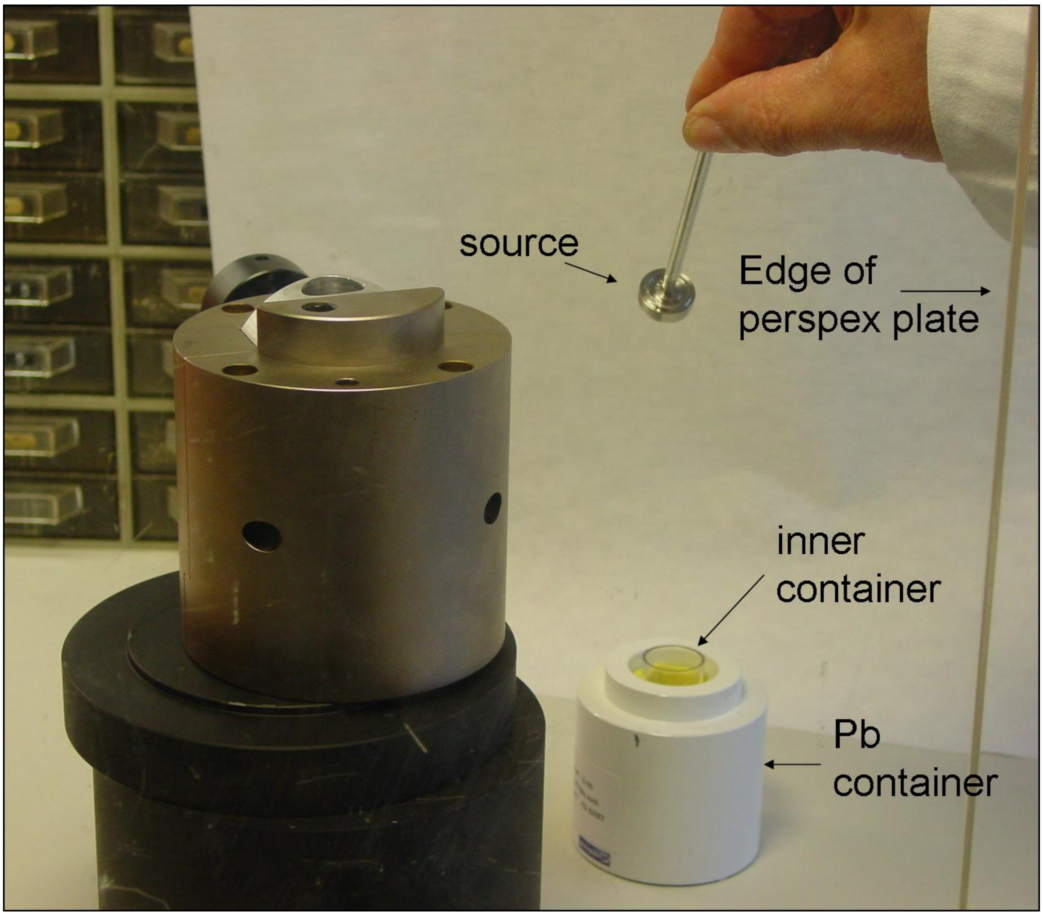


Figure 4.18: Inserting the source I.

9. Place the source in the irradiator and gently unscrew the handling rod from the source (Figure 4.19)

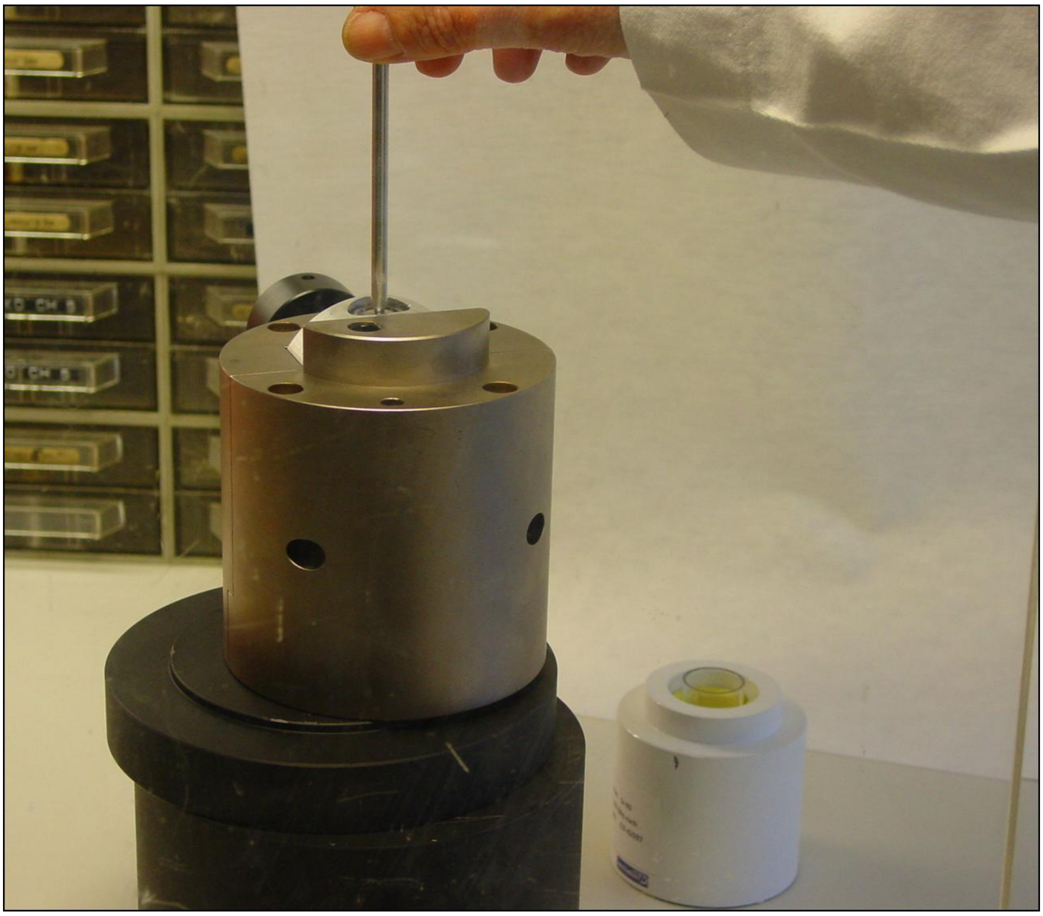


Figure 4.19: Inserting the source II.

10. The perspex plate can now be removed for ease of access. Use the handling rod to place the short Al spacer, then the Pb spacer with spring washer and finally the long Al spacer on top of the source (Figure 4.20)

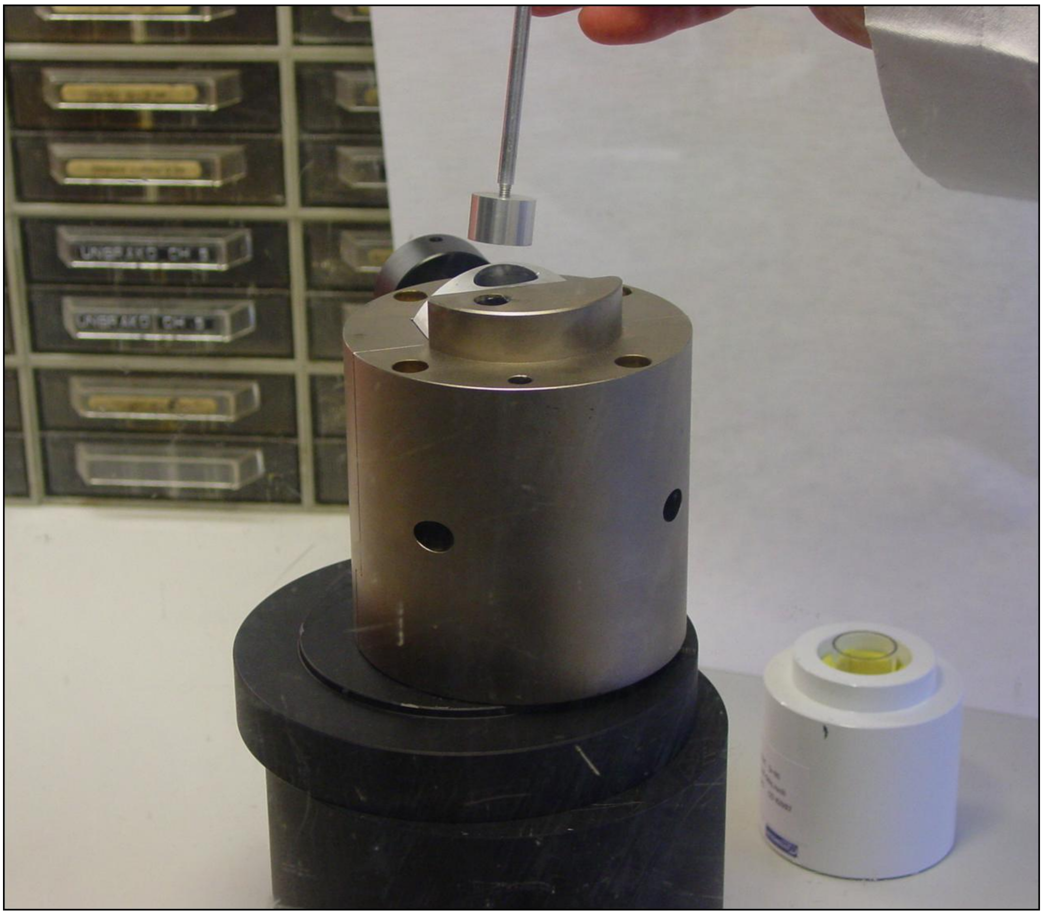


Figure 4.20: Reinsert spacers.

11. Mount the circlip using the circlip pliers (Figure 4.21a). Hold the circlip in your left hand and use the pliers to squeeze the circlip closed with your right hand. Keep holding the circlip with the left hand and the pliers and insert on the top of the irradiator. Ensure that the points of the pliers and the pliers line up with the cut step (Figure 4.21b) in the long Al spacer (already fitted in the irradiator). Use the points of the pliers to press down around the circlip to ensure that it is fitting properly in the groove of the irradiator body. (Hold the black plastic wheel (Figure 4.21a) firmly to prevent the irradiator from rotating accidentally). Ensure that the circlip is fixed securely in locked position.

12. Put the irradiator back onto the reader and bolt firmly in place

13. Place the Pb shielding around the irradiator, making sure that the slot

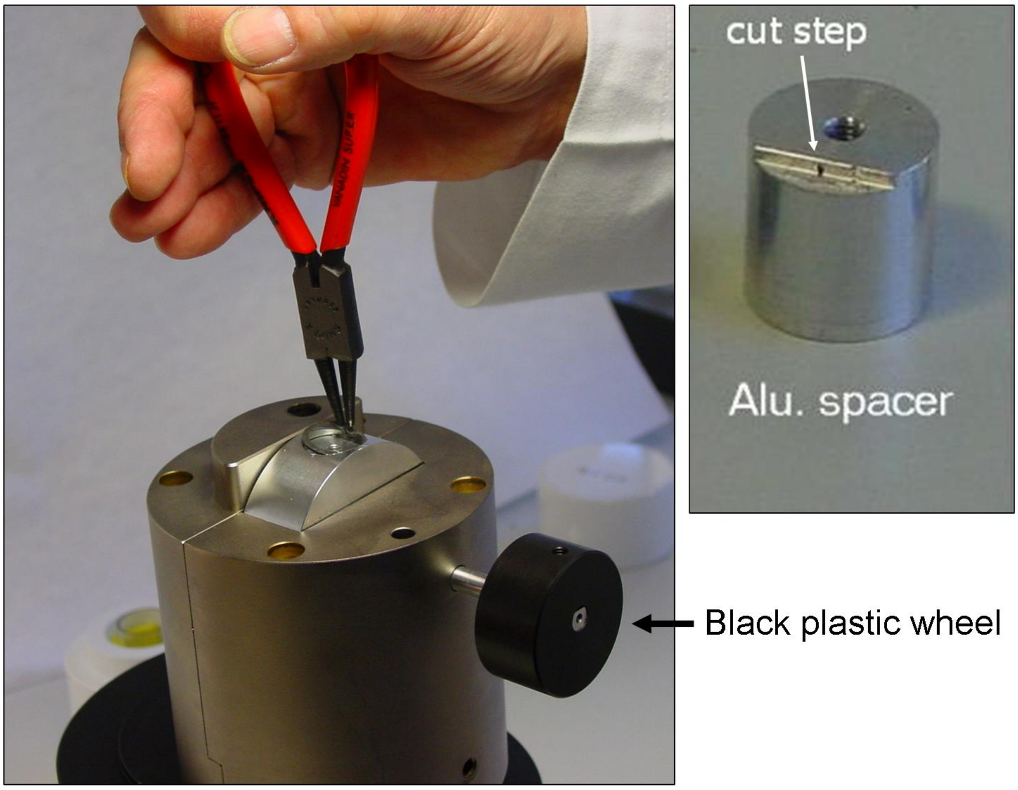


Figure 4.21: Mounting the circlip.

in the Pb cylinder fits over the metal shaft of the black plastic wheel. Insert the screw and secure. Ensure that the wheel and shaft are able to freely rotate without touching the lead shielding

14. Place the lead lid on the top and check that it is located correctly. If the source module is fitted with an aluminium helmet then replace this

15. Re-connect the plastic air tube

5

Dead time correction

When the PMT detects a photon it gives rise to a current pulse which has a duration of approximately 20 to 30 ns. In this time interval the PMT is not able to detect additional photons. As a result of this “dead time” the PMT counting system becomes significantly non-linear at high count rates. For an uncorrected system we would not recommend accepting data with count rates $>$ 5 Mcps. However, it is possible to correct for this dead time loss by enabling the “Dead time correction” in “System options” in the Sequence Editor program. This enables the system to be used up to a count rate of about 20 Mcps.

The actual dead time relevant to a particular system should be measured using the CONTROL program as described below.

1. Place a sample carrousel in the Reader with an empty disc/cup in position 1.

2. Open the CONTROL program, connect to Minisys, and press “Start” in the “Dead time correction” window.

The blue stimulation LEDs are then automatically switched on and the count rate as a function of LED power is measured. When the power reaches 100 % or the count rate exceeds 15 Mcps the program stops and the dead time is calculated.

The dead time can be saved and stored, so it can be used automatically by the Sequence Editor. This is done by pressing “Save to System Setup” in the bottom right corner of the “Dead time correction” window. The dead time correction value can also be entered manually in the “Systems Options” in the Sequence Editor.

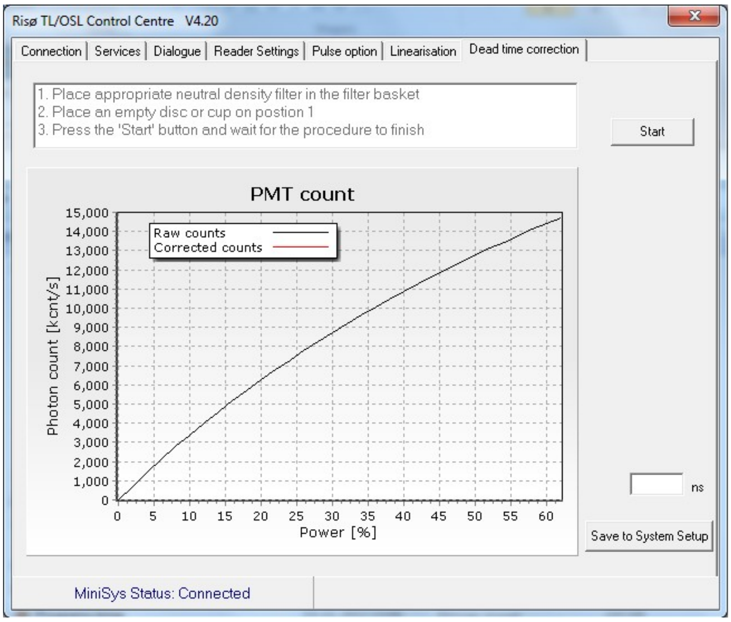


Figure 5.1: Light detected by the PMT in the dead time correction routine. The power of the blue LEDs is ramped from 0 to 100 % or until the count rate exceeds 15 Mcps. The neutral density filter NG9 is used as detection filter.

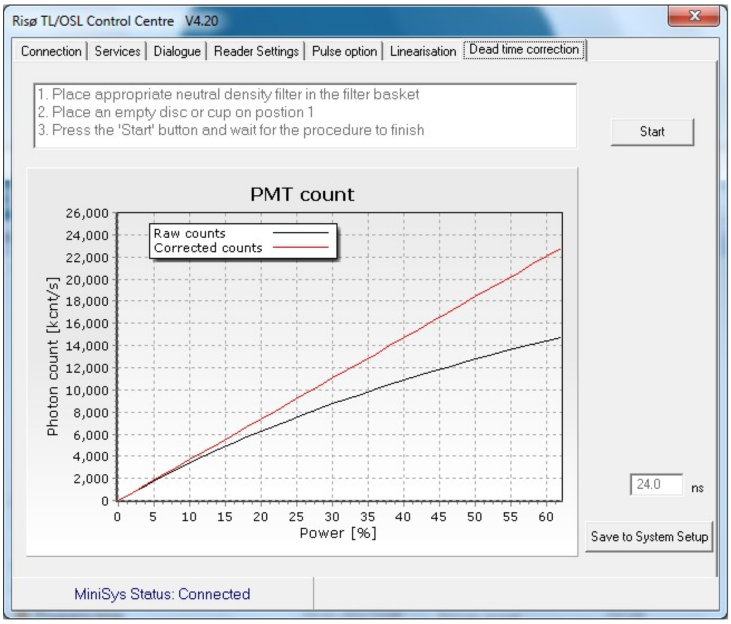


Figure 5.2: The red curve shows the dead time corrected count rate. The resulting dead time is given in the bottom right corner.

6

Frequently answered questions

In this section you will find a list of questions that we frequently answer.

6.1 Power requirements

1. *Do I need to switch off the power to the reader?* It is OK to leave the equipment ON all the time. Only turn it off if you will not be using it for a few weeks.

2. *What is the power consumption of the reader?* The peak power consumption is about 120 W. If power failure is known to occur the use of a battery driven 500 W UPS (uninterruptible power supply) is recommended, to ensure a reliable supply of power.

6.2 User PC requirements

3. *What is the recommended PC configuration?* We recommend a Pentium 4 (or better) with Windows XP or later versions installed. The PC must have a 9-pin RS-232 serial connector or a USB connector to be able to connect to the Controller.

4. *Is there a regional setting that I must choose?* It is very important that the user PC is using a "." (full stop) as decimal separator and not a "," (comma). This is setup in the Control Panel/Regional and Language Options. Most continental language options (e.g. German and French) will use the "," as a separator whereas all English language options (and many others) will use a ".". If the decimal separator is not a "." then an error message (Error 112) will appear when running the system. .

6.3 Laboratory recommendations

5. *What is the recommended laboratory lighting?* In OSL laboratories it is recommended to use subdued red/orange light during sample handling. Standard dark room lights (e.g. those used in photographic laboratories) are preferable (e.g. “Kaiser 4220 spectral 590 darkroom safelight”). If fluorescent tubes are used in the laboratory or the immediate area (e.g. corridors) it is strongly recommended that electronic starters are fitted. Glow switches emit electromagnetic noise that can be picked up by the PMT preamplifier and thus result in unwanted noise in the measurements.
   The Risø TL/OSL reader is light tight enabling the use of normal white light during measurement. It is recommended that the light switch for white light is placed high on the wall to avoid the risk of switching on white light while samples are being prepared.

6. *What is the recommended laboratory climate?* The PMT is sensitive to temperature and humidity. The laboratory temperature should not exceed 30 °C and the humidity should be below 80%.

7. *Is it a good idea to combine the OSL laboratory with the chemistry laboratory?* No! In fact air flow between the chemical sample preparation room and the reader room should be avoided. Over time acid fumes will damage the electronic components inside the reader.

6.4 Nitrogen requirements

8. *Why do I need Nitrogen?* Pressurized nitrogen is required when samples are heated above 200 °C and to activate the pneumatically-controlled beta and alpha irradiators. A high quality pressure regulator must be provided that can maintain a stable output pressure of 2.5 bar (0.25 MPa). 1/4” NPT threads will fit the nitrogen tube connectors provided by Risø.
   For the control of the irradiator(s) we suggest the use of a separate compressed air source. This can either be piped compressed air (if such an installation already exists in your laboratory) or a separate bottle of nitrogen (or air) equipped with a pressure regulator (output: 2.5 bar). The extra nitrogen bottle is recommended as this is a “clean” source and is convenient as the nitrogen consumption for the control

of the irradiators is extremely low (a normal 40 l bottle should last for more than one year).

9. *What is the required pressure on the* N_2 *bottle?* Gas pressure on the output dial on the N_2 bottle should be below 2.5 bar (0.25 MPa)

10. *What is the recommended Nitrogen flow rate?* Typical N_2 flow rate is about 1 liter/min. The flow rate is adjusted on the flow meter located on the reader (to the right). The Nitrogen must be switched on in order to adjust the flow rate. Only use N_2 when you heat above **200°C**.

6.5 Vacuum

11. *Is the system vacuum tight?* Yes, it is.

12. *How do I evacuate the measurement chamber?* A vacuum pump must be connected to the reader (at the back). The vacuum pump must have a KF NW 25 connection and a maximum power consumption of 500 W (e.g. the Leybold Trivac D8B, 220V, RED. NW25-16KF from Granzow A/S (www.granzow.dk)). It is also desirable to fit an oil mist filter to avoid air pollution in the laboratory.

13. *When do I need vacuum?* If the Risø TL/OSL reader is equipped with an alpha source or XRF attachment, the measurement chamber should be evacuated before alpha irradiation/XRF measurement is undertaken. Evacuating the chamber to about 1 mbar is usually sufficient.

6.6 Operation

14. *How do I open the reader?* The reader is opened and closed using the two buttons located in the left corner on the front panel of the Controller. Pressing "UP" will make the reader lid open up to the left (see picture on the title page). Pressing "DOWN" will make the reader lid close. Do not release the button until the reader lid stops moving. If the button is released before the lid is fully closed the lid movement will stop automatically for security reasons.

15. *Any advice with respect to placing the discs/cups on the sample carrousel?* Please ensure that you place the discs on the DISCS sample carrousel and the cups on the CUPS sample carrousel. Before placing

the discs/cups wipe the bottoms clean of grains to optimise the thermal contact between sample and heating element.

16. *Any advice with respect to placing the sample carrousel in the reader?* When you insert the sample carrousel in the measurement chamber (especially in the dark) always rotate it a little afterwards to make sure that the lift/heater is in its down position before lowering the lid.

17. *When I close the lid the is a loud noise from the Controller. Why?* Controllers delivered after 1.1.2015 will have an audible alarm that will sound, if the heater lift is up when you try to close the lid. This is to make you aware of the potential risk of damaging the heater element if the sample carousel is in the reader while closing the lid. To close the lid when the heater lift is up, remove the sample carousel first. To reset the heater lift, use the control program or switch off the Controller, and then on again.

6.7 Maintenance and comments

18. *How do I clean the reader?* We recommend that you clean the heater plate every time you change sample carrousels by wiping any grains off using tissue paper or a soft brush. Once per month we recommend that

    a) The position holes (Ø = 1 mm) in the sample carrousel (see Figure 2.8b) are cleaned with a paper clip. If grains accidentally gets stuck in the position holes the system will be unable to keep track of the sample position.

    b) The space where the lift mechanism is located is cleaned with a small vacuum cleaner

    c) The quartz window (located between the measurement chamber and DASH) is cleaned with tissue paper dipped in alcohol. This interface may become dirty as a direct result of using silicon oil to mount sample grains onto the sample discs.

    d) The outer rim of the bottom of the lid is cleaned using a little alcohol (Do NOT clean the rubber seal below the lid on the reader body).

    e) The sample carrousels are washed with water and soap to prevent contamination with sample material.

7

Technical specifications and requirements

The standard Risø TL/OSL reader consists of two separate units:

1. The TL/OSL Reader itself (hardware)
2. The Controller (control of hardware)

The system weighs about 90 kg and must be placed on a flat, stable surface at least 90 cm long. The system is run using a standard PC (usually supplied by the customer). If this PC is also placed on the work bench, we recommend that an additional bench space of 90 cm is available, bringing the total recommended bench space to 180 cm.

TL/OSL Reader

Voltage	110-250 VAC 50-60 Hz
Power	110 W
Power connection	3 Pin IEC C14 Phase/Neutral/Earth
Size Non-operation	H: 43 cm
	W: 52 cm
	D: 55 cm (D: 60 cm incl. cables and connectors)
Size Operation	H: 60 cm
(Lid open)	W: 73 cm
	D: 65 cm incl. cables and connectors
Weight	85 kg
Operating conditions	0-30°C
	0-80% humidity
Nitrogen	2.5 bar (0.25 Mpa) (36 psi)
	Bulkhead coupling for 5x1 tube 1/4" NPT thread

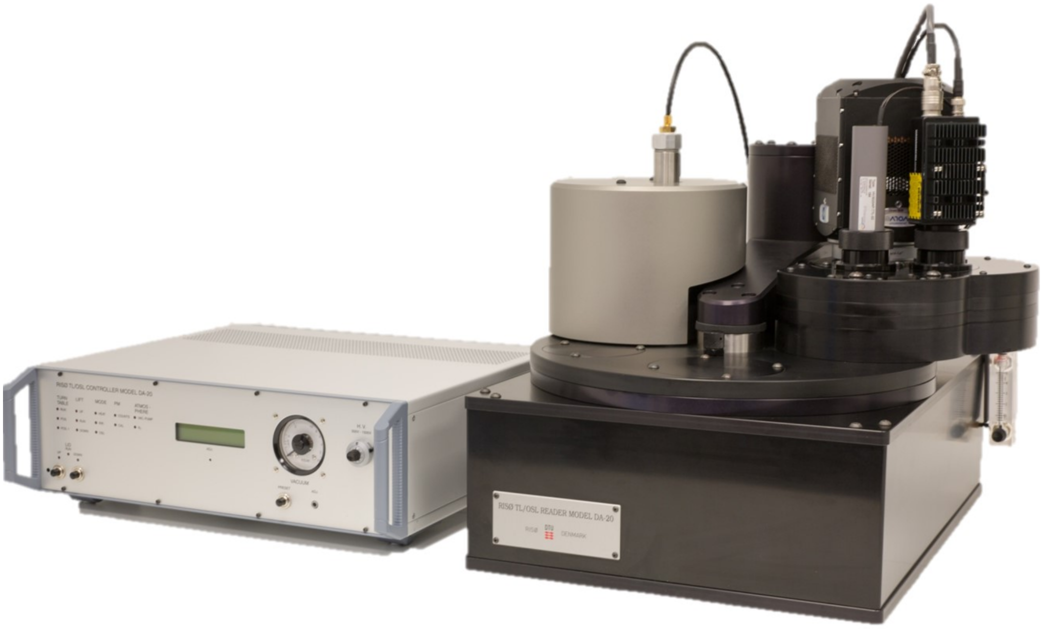


Figure 7.1: Picture of the Reader and Controller

The Controller

Voltage	230 VAC 50-60 Hz or 110 VAC 50-60 Hz
Power	110 W
Power connection	3 Pin IEC C14 Phase/Neutral/Earth
Size	H: 15.5 cm
	W: 45 cm
	D: 44 cm (D: 52 cm incl. cables and connectors)
Weight	5 kg
Operating conditions	0-30°C
	0-80% humidity
Computer connection	RS232 9 pin male
	or
	USB Type A (max 3 meter cable)