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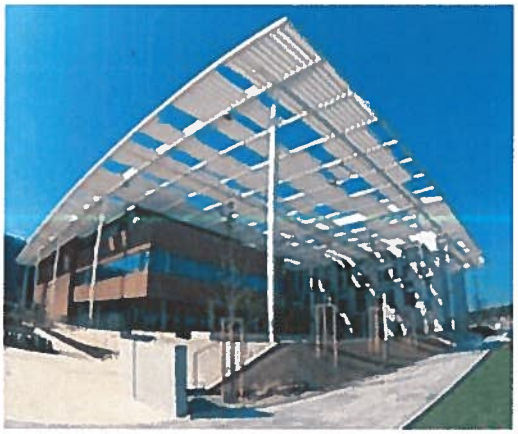
[RSD product category A]

Devices for Time Correlated Single Photon Counting (TCSPC) System

TP16_515



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Content

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1. Introduction

1.1. Purpose

This Requirements Specification Document (RSD) lists the technical requirements and constraints for the "Time Correlated Single Photon Counting experiments" (TCSPC) system. This RSD also defines specifications on the key detectors and electronic components which allow "home-built" implementation of versatile TCSPC experiments, not any specialized solution.

The requested TCSPC system is outlined by the following main parts:

- Picosecond time interval analyzer (TIA);
- Time to digital converter module (TDC);
- Photomultiplier hybrid detector for UV-VIS;
- Photomultiplier hybrid detector for VIS-near IR.

1.2. Scope

This RSD contains general technical requirements: functional, performance and design, delivery, safety and quality requirements for the following products: Devices for Time Correlated Single Photon Counting (TCSPC) System (tender number: TP16_515).

These products (Devices) are integral parts of the standalone mobile TCSPC system and will be located in the E1 experimental hall or in the Biolab at the ELI Beamlines facility. The devices are registered in the PBS software under the following PBS codes: EBIO.EQBL.TCSP.1 (TIA – 1 pc), EBIO.EQBL.TCSP.2 (TDC – 1 pc), EBIO.EQBL.TCSP.3 (UV-VIS – 1 pc) and EBIO.EQBL.TCSP.4 (VIS-near-IR – 1 pc).

These Products are **products Category A** according to the ELI Beamlines RSD categories. The category A is an Off-the-shelf Product without necessity of modifications and necessity to be subjected to a verification programme (review of design, inspection and testing) for ELI applications by the actual project specifications. All verification activities performing by a supplier shall be executed in accordance with the supplier's plan of outgoing inspection and tests. The verification of all specified parameters listed in this RSD shall be undertaken by the supplier before delivery to the ELI Beamlines facility and all items shall be furnished with a verification protocol and a declaration of conformity, to reflect their proper characteristics. Furthermore, all items may be subject to testing and verification upon delivery to the ELI Beamlines facility by qualified personnel. All non-conformances (if any) must be addressed by the supplier in a timely manner.

1.3. Terms, Definitions and Abbreviations

For the purpose of this document, the following abbreviations apply:

Abbreviation	Meaning
CA	Contracting Authority (Institute of Physics AV CR, v. v. i.)
CFD	Constant Fraction Discriminator
E1	Experimental halls E1
ELI	Extreme Light Infrastructure
FWHM	Full Width Half Maximum

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Abbreviation	Meaning
IR	Infra-Red
NA	Not Applicable
RA4	Research Activity 4
RD	Reference Document
RMS	Root Mean Square
RSD	Requirements Specification Document
TCSPC	Time Correlated Single Photon Counting
TDC	Time to Digital Converter module
TIA	Picosecond Time Interval Analyzer
TTTR	Time-Tagged Time-Resolved
USB	Universal Serial Bus
UV	Ultra-Violet
VIS	Visible

1.4. Reference documents

Number of document	Title of Document/ File
RD-01	*00163567-B_1.2_Q_M_Guide_for_Instructions_for_Use_Ver-9_EN_fully_signed.pdf*

1.5. References to standards

If this document includes references to standards or standardized/ standardizing technical documents the CA allows/permits also another equal solution to be offered. If a supplier offers another equal solution the CA shall not reject its bid, once the supplier by appropriate means in the bid proves that the offered supplies, services or works meet in an equivalent manner the requirements including references to standards or technical documents.

1.6. System Configuration

The TCSPC system is not expected as self-standing instruments but as an assembly of devices that allows constructing the TCSPC system when an appropriate optical source and assembly is installed. Individual devices also have to be constructed in such a way, that future updates to several specified direction can be exploited, in particular regarding number of independent input channels. This RSD contains specifications on four key elements of the TCSPC system:

- "**Picosecond time interval analyzer**" (further "**TIA**") – with scalability for multiple channels and supplementary signal inputs embedding (triggers, positioners, feedback etc.). It shall be connected to a PC through a USB 3.0 high speed interface. The **TIA** shall be capable of hosting up to four TDC (explained below).
- "**Time to digital converter module**" (further "**TDC**") – with two channel time to digital converter module compatible with above defined **TIA** capable of 1 ps time resolution time stamping.

- "**Hybrid Photomultiplier Detector Assembly for UV-VIS**" – Hybrid Photomultiplier Detector Assembly with sensitivity 220-850 nm, compatible with above mentioned **TDC**.
- "**Hybrid Photomultiplier Detector Assembly for VIS-near-IR**" – Hybrid Photomultiplier Detector Assembly with sensitivity 400-890 nm, compatible with above mentioned **TDC**.

2. Functional, Performance and Design requirements

2.1. General Requirements

REQ-024139/A

All devices of the TCSPC system shall be provided with necessary software together with drivers and DLL for custom development that allows control over all changeable features, parameters and measurement modes.

REQ-024140/A

The software shall be capable of running under windows 7/8/10.

REQ-024141/A

The interface between the TIA and PC shall be realized via USB 3 port.

REQ-024142/A

Overall power consumption shall be below 150 W at 100 to 240 V AC.

2.2. Picosecond Time Interval Analyser (TIA)

REQ-024015/A

The **TIA** shall allow upgrading to host up to four two-input **TDC**; eventually being capable of recording up to 8 timing channels simultaneously.

REQ-024016/A

Input channels and synchronization triggers of the **TIA** shall at least match the characteristics defined in the Table 1 below.

Parameter	Description
Discrimination	CFD included in all channels, software adjustable
Input voltage range	0 mV to -1000 mV, optimum: -100 mV to -500 mV
Trigger point	falling edge
Trigger pulse width	0.5 ns to 30 ns
Trigger pulse rise/fall time	2 ns max.
Operation ambient temperature	+15 °C to +25 °C

Table 1: Functional and performance parameters of TIA input channels and synchronization triggers

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REQ-024017/A

The **TIA** shall have Time-Tagged Time-Resolved (further "**TTTR**") mode of operation capable of the recording of individual count events directly to hard disk or computer memory. The timing of each photon shall be captured as an event record without any early data reduction (such as on-board forming of histograms) while still keeping timing performance as specified for **TDC** in the chapter 2.2.

REQ-024018/A

The TIA shall have at least two TTTR modes with the following features:

- One TTTR mode allows delivering data for each active channels independently;
- Second TTTR mode shall be with one channel as a trigger (e.g. laser 80 MHz rep rate).

2.3. Time to Digital Converter module (TDC)

REQ-024019/A

The **TDC** shall have two independent timing input channels.

REQ-024020/A

The **TDC** shall at least match the characteristics defined in the Table 2 below.

Parameter	Description
Minimum time bin width	1 ps
Electrical time resolution	< 12 ps rms
Full scale range - histogram mode	65 ns to 2.19 s (depending on chosen resolution: 1, 2, 4, ..., 33 554 432 ps)
Full scale range - time-tagged mode	infinite
Maximum count rate per input channel	Up to 12.5×10^6 counts/sec
Maximum sync rate	150 MHz
Adjustable delay range for each input channel	± 100 ns, resolution 1 ps
Dead time	< 80 ns
Differential non-linearity	< 2 % peak, < 0.2 % rms (over full measurement range)
Operation ambient temperature	+15 °C to +25 °C

Table 2: Functional and performance parameters of TDC

2.4. Hybrid Photomultiplier Detector Assembly for UV-VIS

REQ-024021/A

The UV-VIS photon counting detector shall be based on hybrid photomultiplier – avalanche photo-diode technology with inbuilt Peltier cooling.

REQ-024022/A

The performance of the UV-VIS photon counting detector shall meet or exceed the parameters given in the Table 3 below.

Parameter	Description
Wavelength sensitivity range	220 nm - 850 nm
Dark counts (cooled)	< 200 cps
Transit time spread (FWHM)	< 50 ps
Overload shutdown	80 MHz
Single electron response width	600 ps
Pulse rise/fall time (typ. value)	400 ps
Detector area diameter	6 mm
Operation ambient temperature	+15 °C to +25 °C
Quantum efficiency 230-500 nm	>10 %
Quantum efficiency 220-780 nm	>1 %

Table 3: The minimum performance of UV-VIS photon counting detector

2.5. Hybrid Photomultiplier Detector Assembly for VIS-near-IR

REQ-024023/A

The VIS-near-IR photon counting detector shall be based on hybrid photomultiplier – avalanche diode technology with inbuilt Peltier cooling.

REQ-024024/A

The performance of the VIS-near-IR photon counting detector shall meet or exceed the parameters given in the Table 4 below.

Parameter	Description
Wavelength sensitivity range	380 nm - 890 nm
Dark counts (cooled)	< 1000 cps
Transit time spread (FWHM, typ. value)	< 160 ps
Overload shutdown	80 MHz
Single electron response width	600 ps
Pulse rise/fall time (typ. value)	400 ps
Detector area diameter	3 mm
Operation ambient temperature	+15 °C to +25 °C
Quantum efficiency 500-850 nm	> 10 %
Quantum efficiency 800-890 nm	>1 %

Table 4: The minimum performance of VIS-near-IR photon counting detector

3. Environmental Conditions

3.1. General Requirements

REQ-024025/A

All the **TCSPC** devices shall be suitable for operation in the cleanrooms of class 7 according to the standard ČSN EN ISO 14644 (or equivalent, e.g. EN ISO 14644).

REQ-024026/A

All the **TCSPC** devices shall be suitable for operation at least in the following conditions:

- 45 to 55 % of humidity;
- (15-25 ± 1) °C of ambient temperature with a long-term stability.

4. Delivery Requirements

REQ-024027/A

The transportation to the final destination of the **TCSPC** devices shall be conducted by the Supplier.

REQ-024028/A

All the **TCSPC** devices and its components shall be delivered in protective package preventing damage and contamination. The **TCSPC** devices and its components shall be cleaned and packaged in compliance with the cleanliness of class 7 according to ČSN EN ISO 14644 (or equivalent, e.g. EN ISO 14644) or cleaner.

5. Safety Requirements

REQ-024029/A

The Supplier shall supply a Declaration of Conformity or any other equivalent document legally recognized and accepted in the Czech Republic for each product type if the appropriate legislation determines the Supplier's obligation to have a Declaration of Conformity (or the equivalent document) for the purposes of a Product sale in the Czech Republic to fulfil the requirements of 2001/95/EC directive or applicable Czech law.

6. Quality Requirements

6.1. General Quality Requirements

REQ-024030/A

The Supplier shall provide Instructions for use (Product User Manual) as part of the delivered Product. The Instructions for use shall be written in accordance with standard ČSN EN 82079-1 (or equivalent, e.g. EN 82079-1) and shall include the instructions and descriptions regarding the following:

- transport, handling and storage;
- installation and cleaning;
- general use of provided control software;
- safe operation and maintenance procedures.

*NOTE: As an alternative to standard ČSN EN 82079-1 (or equivalent, e.g. EN 82079-1) an internal ELI "Instructions for use" methodology can be used (see **RD-01**; chapter 1.4) which will be provided to the Supplier upon request.*

REQ-024031/A

For the TCSPC system, the Supplier shall provide a Calibration Certificate giving details of the calibration, e.g. calibrations method and results.

NOTE: Recommended calibration interval for measuring instruments shall be defined and documented in the Calibration Certificate or Instructions for use (see REQ-024030/A).

REQ-024032/A

The Supplier shall provide information on execution of outgoing check of the Product. At least this information shall comprise declaration about execution of outgoing check and declaration of conformity with technical requirements defined by the product RSD and completeness of the Product.

REQ-024033/A

The Supplier shall establish and maintain a nonconformity control system compatible with standard ČSN EN ISO 9001 (or equivalent, e.g. EN ISO 9001).

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