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1. Introduction

1.1. Purpose

This Requirements Specification Document (RSD) lists the technical requirements and constraints for the Intensified single photon sensitive camera for the ELI Beamlines facility (ELI). This instrument shall have the ability to detect optical signals on the level as low as single photon in the optical and near infrared region (280 – 850 nm of optical wavelength).

The intensified camera is a single integrated unit, however consists of these fundamental parts that come with specification of its own:

- Photocathode with ns time gating capability
- Electron multiplying microchannel plate
- Phosphorous plate for conversion of amplified electron signal into optical signal
- Optical camera for detection and digitalization of optical signal
- Data acquisition hardware and software

1.2. Scope

This RSD contains all of the technical requirements: functional, performance and design, delivery, safety and quality requirements for the following product (tender number: TP21_300): **EXP_QBIO Intensified Single Photon Sensitive Camera (ICCD/ICMOS)** (further "Camera").

The **Camera** will be placed in the BIOLAB hall and will be used as a standalone system. The product is registered in the PBS database under the PBS code EBIO.LAS.14.

This product is a **Category A product** according to the ELI Beamlines RSD categories. All verification activities performed 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 abbreviated terms are applied:

Abbreviation	Meaning
CA	Contracting Authority (Institute of Physics AV CR, v. v. i.)

Abbreviation	Meaning
CAP	Clear aperture
CCS	Central Control System
CDAQS	Central Data Acquisition System
CVS	Central Vacuum System
dB	Decibel
E1	Experimental Hall 1
E5	Experimental Hall 5
ELI	Extreme Light Infrastructure
FZU	Institute of Physics, Academy of Sciences of the Czech Republic
LxWxH	Length x Width x Height
RA2	Research Activity 2
RA4	Research Activity 4
rms	Root Mean Square
RSD	Requirements Specification Document
SI	International System of Units

1.4. 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.

2. Requirements on the System Level

2.1. General System Requirements

REQ-031702/A

The system shall be movable between experimental locations.

REQ-031703/A

The size of the Camera shall be maximally LxWxH 300 x 200 x 200 mm. Does not include power and data cables.

REQ-031704/A

Camera shall operate without need of active external chiller (only air cooling is allowed).

REQ-031705/A

Camera system shall be powered by standard 230 V/50 Hz AC standard.

2.2. Photocathode Requirements

REQ-031706/A

Photocathode shall have maximum quantum efficiency at least 35%.

REQ-031707/A

Photocathode shall have quantum efficiency at least 30% in the spectral range 410 - 680 nm.

REQ-031708/A

Photocathode shall have quantum efficiency at least 20% in the spectral range 350 - 750 nm.

REQ-031709/A

Photocathode shall have quantum efficiency at least 1% in the spectral range 280 - 800 nm.

REQ-031710/A

Minimal gating time of photocathode from fully open to half closed shall be at least 2 ns or shorter.

REQ-031711/A

Useful aperture of the photocathode shall be at least 18 mm in diameter.

REQ-031712/A

Maximum photocathode repetition rate shall be at least 500 kHz.

2.3. Electron Multiplier

REQ-031713/A

Average maximum multiplier gain defined as average number of generated electrons per one input electron shall be above 500.

REQ-031714/A

Average relative gain defined as ratio between maximum and minimum intensifier gain shall be at least 200.

2.4. Phosphorous Plate

REQ-031715/A

Image intensifier spatial resolution limit shall be 30 μm or better.

REQ-031716/A

Image intensifier decay halftime shall be maximum 2 ms or shorter.

2.5. Optical Detector

REQ-031717/A

Optical detector shall have at least 500 x 500 effective independent pixels.

REQ-031718/A

Optical detector shall have area of at least 8 x 8 mm.

REQ-031719/A

Typical read out noise of each pixel shall be below 3 photoelectrons RMS. For amplified detector this counts as read out noise in electrons divided by typical amplification gain.

REQ-031720/A

Dark current of each pixel shall be below 2 electrons per second.

REQ-031721/A

The minimal full frame rate (at above defined read out noise, sensor size a number of independent pixels, see REQ-031717/A, REQ-031718/A, REQ-031719/A) shall be at least 30 frames per second.

REQ-031722/A

Minimal spectroscopic rate defined as independently fully horizontally reading at least two lines (e.g. 2 x 500 pixels) shall be 3 kHz.

2.6. Software and Communication

REQ-031723/A

There shall be established system for data transfer from camera to PC a sufficient rate, such as GigE or USB3 keeping up with data flow at maximum read-out rate.

REQ-031724/A

Camera shall be provided with drivers and operation software that is compatible with CA's used operational system (Windows 7/8/10) 64bit.

REQ-031725/A

Camera shall be provided with System development kit compatible with CA's software (LabView) allowing straight integration of the device into experimental set-up.

2.7. Environmental Conditions

REQ-031726/A

System shall fulfil ISO 7 cleanliness condition (10,000 dust particles per cubic meter).

REQ-031727/A

System shall be fitting to be operated at humidity level within an interval from 40% to 60%.

REQ-031728/A

System shall be fitting to be operated at temperature of $(20.0 \pm 2.0)^\circ\text{C}$ with a long-term stability.

3. System Electrical and Electronics Requirements

REQ-031729/A

System shall be designed according the valid Czech and European norms.

4. Transportation and Installation requirements

REQ-031730/A

Individual components shall be transportable in boxes with dimensions not exceeding (L x W x H) 2m x 2m x 1m.

REQ-031731/A

The transportation to the final destination shall be conducted by the Supplier.

NOTE: The bid price will be considered by the CA as the final price, including transportation cost.

REQ-031732/A

The technologies and instruments shall be delivered in protective package preventing damage and contamination and a minimum of two plies separate clean packaging. The technologies shall be cleaned and packaged in compliance with the cleanliness of class 7 according to ČSN EN ISO 14644 (equivalent to EN ISO 14644).

5. Safety Requirements

REQ-031733/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-031734/A

The Supplier shall provide the Product Manual as part of the delivered Device. Completeness of the Manual shall be approved by the CA. The Manual shall include the instructions and descriptions regarding the following procedures:

- transport;
- handling;
- storage;
- installation;
- safe operation and maintenance procedures.

REQ-031735/A

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

NOTE: Alternatively the Supplier might provide the CA the information detailed enough to prove meeting all requirements stipulated herein (e.g.: catalogue/technical data sheets, product manuals or other similar documentation).

REQ-031736/A

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

REQ-031737/A

Documentation shall be supplied as hardcopy and electronically in formats specified in REQ-031738/A.

REQ-031738/A

Formal communication between supplier and CA and supplied documentation shall be in the following formats:

- *.JPG
- *.PDF/A
- CAD 2D: *.dwg
- CAD 3D: STEP type files (*.stp;*.ste;*.step)
- text processors *.doc, *.docx, OpenDocument Format
- spreadsheet processors *.xls, *.xlsx, OpenDocument Format
- presentations *.ppt, *.pptx; OpenDocument Format
- *.HTML

REQ-031745/A

Wherever possible for the supplier, the supplier shall use the most innovative products, services or procedures when performing the contract.

6.2. Reliability

REQ-031739/A

The detection systems when operated according to the manual shall not fail to function more often than once per year in the regime of daily operation.

6.3. Maintainability

REQ-031740/A

Supplier shall identify less reliable parts and take measures to make these easily exchangeable.

REQ-031741/A

Given that all required parts and tools are available, the time to repair/replace any part of the instrument shall never exceed three days.

6.4. Interchangeability and Replaceability

REQ-031742/A

All main systems of the detection instruments shall be designed to be easily interchanged or replaced.

6.5. Warranties

REQ-031743/A

Supplier shall provide a 1-year warranty for quality for the Camera.

7. Acceptance

Acceptance will be carried out by the CA on the delivered and complete product. The basis for acceptance will be a declaration of conformity with the technical requirements defined by the product RSD together with relevant documentation supporting the verification.

In case of successful acceptance phase the CA shall provide to the Supplier signed acceptance protocol. In case of unsuccessful acceptance stage the CA shall provide to the Supplier Nonconformity Report (NCR) and ELI nonconformity control process shall be applied (see REQ-031736/A).

REQ-031744/A

The Acceptance phase shall demonstrate the following:

1. Final product has been successfully verified by the Supplier and this process has been documented in an appropriate way (through checklist and test report mentioned in REQ-031735/A);
2. All detected nonconformities have been solved in accordance with REQ-031736/A;
3. The final product is free of fabrication errors and is ready for the intended operational use.