TECHNICAL SPECIFICATIONS

GOVERNING THE INVITATION TO TENDER TO SUPPLY THE ELECTRONIC EQUIPMENT FOR THE BEAM DIAGNOSTICS OF THE ALBA SYNCHROTRON LIGHT SOURCE

Dossier 69/07

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1- INTRODUCTION

The *Consorcio para la Construcción, Equipamiento y Explotación del Laboratorio de Luz Sincrotrón* (hereafter referred to as CELLS) is responsible for the construction of a 3rd generation light source in Cerdanyola (Barcelona, Spain), named ALBA. This synchrotron facility comprises a 100 MeV Linac, a Booster (BO) synchrotron for full energy beam acceleration (up to 3 GeV), and an electron Storage Ring (SR). The transfer line from the Linac to Booster is called LTB, the transfer line from the BO to SR is called BTS.
See Fig. 1 for a description of ALBA.

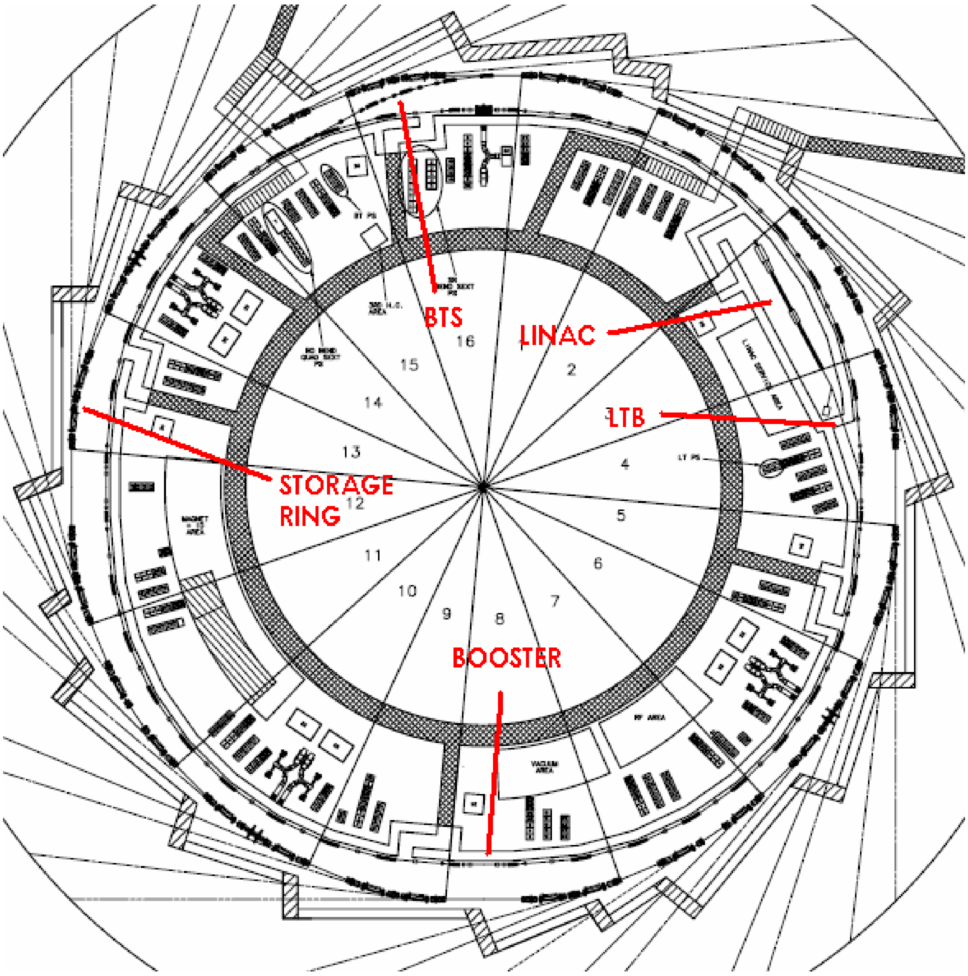

Figure 1 – ALBA facility layout

An optimum performance of ALBA requires permanent electron beam diagnostics, which is performed using several mechanical components installed in the vacuum pipe. The output of these components is analyzed by means of different electronic equipments: oscilloscopes, spectrum analyzers, streak cameras, signal generators, etc.

The object of this tender is the supply of this electronic equipment.

2- SCOPE OF THE TENDER

Since each equipment has different technical characteristics, the tender is divided into different lots (one lot for each kind of equipment). The lots are described in Sections 3 to 8. The contractor shall provide the equipment specified in each lot.

The lots described in the tender are:

- Lot 1: Analog Signal Generators (2 units)
- Lot 2: Oscilloscopes (7 units)
- Lot 3: Spectrum Analyzers (2 units)
- Lot 4: Real Time Spectrum Analyzer (1 unit)
- Lot 5: Power Amplifiers (16 units)
- Lot 6: Streak Camera (1 unit)

Candidates can bid to one or more lots. All lots share the same general conditions (Contract Management – Section 10, Acceptance Tests – Section 11, and Quality Assurance – Section 12).

Bidders are strongly encouraged to contact CELLS and discuss all details of the specifications to ensure that the bidder completely understands the requirements and implications of the specifications before making an offer. This includes any other component that might help CELLS to the purpose of the specifications described in this tender.

CELLS reserves the right to slightly modify the ranges in the below specifications at its own criteria if this benefits the performance of the ALBA synchrotron.

3 – LOT 1: ANALOG SIGNAL GENERATORS

3.1 – Description

A Signal Generator (SG) is an electronic device that generates continuous oscillating (sinusoidal) electronic signals.

The SG usually includes modulation functions such as amplitude modulation (AM), frequency modulation (FM), or phase modulation (ΦM).

3.2 – Technical Requirements

CELLS looks for a radio frequency (rf) analog signal generator with very low phase noise.
It will be mainly used at 500 ±1 MHz.

The signal shall be as pure as possible because this is the reference signal for all timing mechanisms in the machine. For this purpose, CELLS uses a rubidium oscillator (FS725 from *Standford Research System – SRS*) providing a 10 MHz output reference, which will be used as the input reference for the SG.
Therefore, the equipment offered by the bidder candidates shall be compatible with this oscillator.

Table 1 lists the specifications required for this instrument. CELLS requires two (2) identical units of this item.

Table 1. Required specifications for the rf analog signal generator.

Number of units	2
Input reference signal	10 MHz (from SRS FS275)
Output Frequency Range	~100 kHz to >3 GHz
Output power	>13 dBm at 500 MHz
Absolute SSB phase noise from a 500 MHz carrier	< -100 dBc/Hz at 100 Hz < -130 dBc/Hz at 10 kHz
Harmonics spectral purity	< - 30dBc
Switching Times	< 10 ms
Jitter	< 50 fs at 500MHz carrier
Modulation Types	AM, FM, ΦM, Pulse (minimum)
Input / Output Impedance	50 Ω
Temperature effect	< 6×10^{-9} between 10°C and 50°C
Aging Rate	< 5×10^{-10}/day after 30 days
Interface	LAN (Remote Control) and RS232
USB Ports	Yes

4 – LOT 2: OSCILLOSCOPES

4.1 – Description

An oscilloscope (also known just as *scope*) is an electronic test equipment that allows signal voltages to be viewed as a function of time in a two-dimensional graph.

The basic measure of virtue is the scope bandwidth (BW) and Sampling Rate (SR). The bandwidth is the difference between the scope upper and lower cutoff frequencies. The Sampling Rate is the number of samples per second taken from a continuous signal to make a discrete signal.

4.2 – Technical Requirements

The scopes are used to analyze different beam signals provided by different diagnostics components, located around the ALBA vacuum pipe, like Fast Current Transformers (FCT), Annular Electrode (AE), etc.

The scope bandwidth and sampling rate is given by the intrinsic bandwidth of these components, and differs depending on their location and use. This is specified in Table 2.

Table 2. Number of scopes required with a given Bandwidth and Sampling Rate.

BandWidth	Sampling Rate	# channels	# of units
≥ 2 GHz	≥ 10 GS/s (per channel)	4	4
≥ 4 GHz	≥ 20 GS/s (per channel)	4	1
≥ 8 GHz	≥ 40 GS/s (per channel)	4	2

All the scopes in Table 2 shall fulfill the general characteristics shown in Table 3.

Table 3. Number of scopes required with a given bandwidth and sampling rate.

Analog channels	Yes
External Trigger	Yes
Interface	LAN (speed ≥100Mbps)
Memory:	≥ 1MB/ch
Input impedance	50 Ω
Noise floor	better than 0.5mV for a 5mV/div scale
Resolution	≥ 8 bits (≥11 bits averaging)
USB ports	Yes (rear and front)

It is highly desirable that bidders provide the scopes with the appropriate drivers for remote control under Linux environment (SuSe 10.3).

If this is not the case, compliance with the VISA protocol is also a good asset.

5 – LOT 3: SPECTRUM ANALYZERS

5.1 – Description

A Spectrum Analyzer (SA) is a device used to examine the spectral composition of a given signal and measure its power spectrum.

5.2 – Technical Requirements

At CELLS, the SA is used to measure the fractional part of the betatron tunes the Storage Ring. That is, approximately between ~0.1 and ~1 MHz. Thus, the SA shall measure these frequencies and carry on appropriate spans around the harmonics (up to the 10^{th}) of the revolution frequency, 1.1 MHz.

In some instances (HOM or resistive wall instabilities), the SA will be used to measure harmonics of the RF frequency up to 3 GHz.

For the accelerators, one (1) of these units is required for the Storage Ring.
For tests at the workshop laboratory, one (1) unit is also required.
In total, bidders offer shall include two (2) units.

The specifications of the SAs are shown in Table 4.

Table 4. Specifications of the SAs for ALBA.

	Storage Ring	**Workshop Laboratory**
Number of units	1	1
Frequency Range	9 kHz – 3 GHz	100 Hz – 12GHz
Resolution Bandwidth	10 Hz – 1 MHz	1 Hz – 1 MHz
Frequency Span	Span zero and 100 Hz to 3 GHz	Span zero and 10 Hz to 12 GHz
Aging rate (after 30 days)	< 2 10^{-7}/year	< 2 10^{-7}/year
Sweep times	5ms to 1000 s	5ms to 1000 s
Noise Sideband at 1 kHz RBW	< -110 dBc/Hz at 100 kHz	< -110 dBc/Hz at 100 kHz
Input/Output Connector	N-type, 50 Ω	N-type, 50 Ω
External Trigger	BNC, TTL, 50 Ω	BNC, TTL, 50 Ω
Amplitude measurement range	-120 to +30 dBm	-145 to +30 dBm
Tracking Generador	9 kHz – 3 GHz, 0 dBm	Not needed
Communication ports	USB, LAN	USB, LAN

6 – LOT 4: REAL TIME SPECTRUM ANALYZER

6.1 – Description

A Real Time Spectrum Analyzer (RSA) is a device used to examine the spectral composition of a given signal and measure its power spectrum in real time, i.e. the complete frequency spectra in the span is captured simultaneously.

6.2 – Technical Requirements

At CELLS, the RSA is used to measure the fractional part of the betatron tunes in the Booster where the ramping mode does not allow the use of the standard SA.

For the accelerators, one (1) of these units is required for the Booster.

The specifications of the RSA is shown in Table 5.

Table 5. Specifications of the RSA for ALBA.

	Booster
Number of units	1
Frequency Range	DC – 3 GHz
Resolution Bandwidth	1 Hz – 10 MHz
Frequency Span SA mode	Span zero; and 50 Hz to 3 GHz
Frequency Span RSA mode	100 Hz to 10 MHz
Aging rate (after 30 days)	< 2 10^{-7}/year
Sweep times	5ms to 1000 s
Noise Sideband at 1 kHz RBW	< -110 dBc/Hz at 100 kHz
Input/Output Connector	N-type, 50 Ω
External Trigger	BNC, TTL, 50 Ω
Amplitude measurement range	-150 to +20 dBm
Communication ports	USB, LAN

7 – LOT 5: POWER AMPLIFIERS

7.1 – Description

An amplifier is a device that multiplies a small input signal to generate a large power output signal. The relationship between the input and the output of an amplifier usually depends on the frequency of the input signal, and is called Gain.

In this case, the basic measures of virtue of a power amplifier are its Gain, output power and bandwidth.

7.2 – Technical Requirements

CELLS uses the power amplifiers to feed the striplines (for tune excitation at Booster and Storage Ring – 4 units for each system), to feed the kickers (fast feedback – 4 units) and to amplify the 500 MHz reference signal from the signal generator.

The characteristics for each use differ. Table 6 lists the specifications and required number of units for each case.

Table 6. Specifications of the power amplifiers at ALBA.

Parameter	Tune Excitation	Transverse Feedback	Reference Signal
Number of units (incl. 1 spare)	9	5	2
Frequency Response (instantaneously)	9 kHz to 50 MHz	9 kHz to >250 MHz	500 ± 10 MHz
Output Power at 1dB compression	≥ 20 W	≥ 75W	≥ 20 W
Flatness	+/- 1.0 dB (max)	+/- 1.0 dB (max)	+/- 1.0 dB (max)
Gain (max. setting)	≥ 40 dB	≥ 40 dB	≥ 30 dB
Noise Figure	< 10 dB	< 10 dB	< 6 dB
Input/Output Connector	N-type (F), 50 Ω	N-type (F), 50 Ω	N-type (F), 50 Ω
Mismatch tolerance	Unconditionally stable	Unconditionally stable	Unconditionally stable
Remote control	Not needed	Not needed	Not needed

8 – LOT 6: STREAK CAMERA

8.1 – Description

The Storage Ring beam bunch length is in the order of 15ps, i.e. around 4.5mm. Table 7 lists the main parameters about the ALBA Storage Ring. A proper measurement of the very short length of the electron bunch requires the use of a very precise streak camera.

Table 7 lists the main parameters of the electron beam at ALBA.

Table 7. Main Storage Ring parameters.

Parameter	Value
Electron beam energy	3 GeV
Circumference	268.8 m
Revolution Time / Frequency	0.89 μs / 1.11 MHz
Beam Intensity	400 mA
Horizontal emittance	4.3 nmrad
Design coupling	1 %
RF frequency	500 MHz
Bunch Spacing	2 ns (0.6 m)
Rms bunch length	15 ps (4.5 mm)

The streak camera operates by transforming the (longitudinal) temporal profile of a light pulse into a transverse spatial profile on a detector.

The streak camera is composed of several subcomponents. Next, we describe the working principle of the two main components required by ALBA: the Fast and the Slow Deflection Units.

8.1.1. Fast Deflection Unit

Figure 2 shows a graphical description of the working principle of a streak camera. The pulse light coming from the synchrotron radiation is directed onto a **photocathode** by means of the **input optics**. When the photocathode is hit by the light, it produces electrons via the photoelectric effect.

These electrons are accelerated by the **accelerating mesh** and pass through the **fast deflection**: an electric field (high voltage ramp) produced by a pair of plates, which deflects the electrons in the transverse direction (for example, vertically). If the HV signal applied to these plates has the proper timing, the electrons in the head of this bunch will be deflected differently than those in the tail of the bunch. Thus, the initially longitudinal time scale has been transformed now into a transverse displacement, i.e. a *streak image*. (in the example at Fig. 2, this displacement occurs vertically).
Appropriate time sweeps range between 200ps and 2ns (approximately) to resolve the ps structure of the electron bunch.

Finally, the electrons are amplified in the Micro Channel Plate (**MCP**) by a gain typically around 10^3, to ensure that upon collision with the **phosphor screen** visible light is produced. This light forms then an image in the charge-coupled device (**CCD**) camera, a linear array that is used to measure the streak pattern on the screen. That is, the temporal profile of the light pulse.

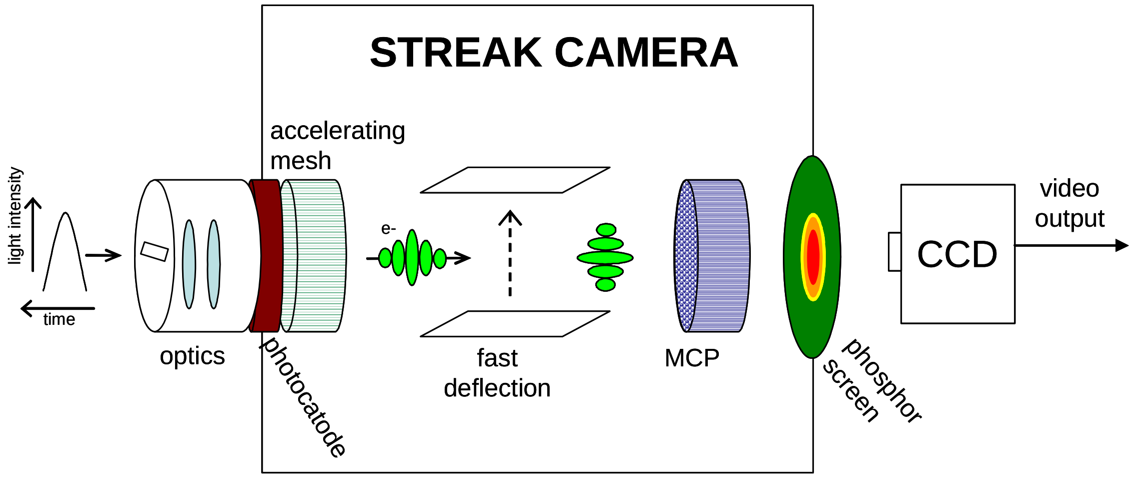

Figure 2. Working principle of a streak camera.

8.1.2 – Slow Deflection Unit

CELLS requires the bidding company to provide the streak camera with a **Slow Deflection**. The slow deflection takes place in the second direction of the transverse plane. If, for instance, the fast deflection takes place in the vertical plane (as in the previous example), the horizontal deflection occurs in the horizontal plane.

The slow deflection takes place after the electrons have suffered the fast deflection and before they arrive to the MCP (see Fig. 3).

This deflection displaces two consecutive streak images, and allows to visualize the image of two different electron bunches, i.e. allows to obtain numerous streak patterns in the same output image.

Appropriate time sweeps range from 100ns to 10ms (approximately).

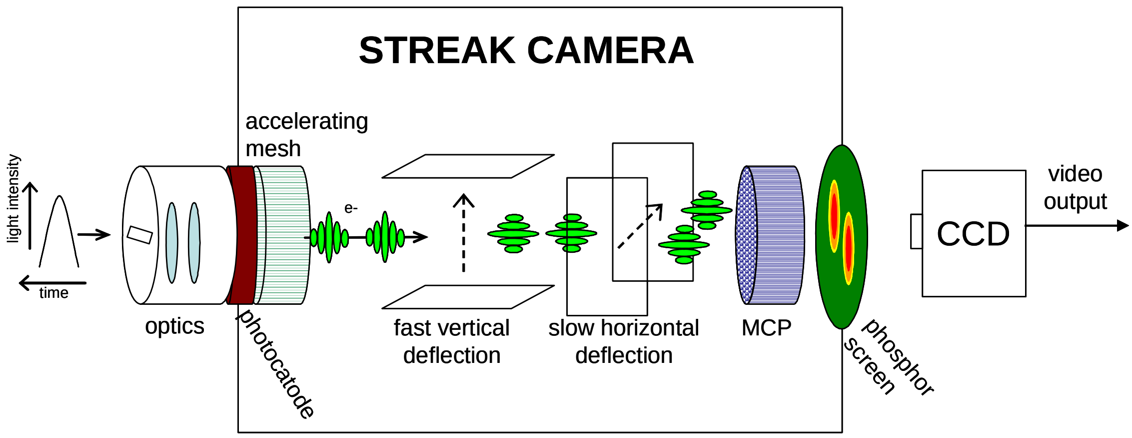

Figure 3. Working principle of a streak camera with the slow sweep unit. In this example, the fast deflection takes place in the vertical plane and the slow deflection in the horizontal plane.

8.2 – Technical Requirements

As seen in the previous section, the streak camera is composed of several modules. Next, we list the required specifications for each module.

CELLS reserves the right to slightly modify the ranges in the below specifications at its own criteria if this benefits the performance of the ALBA synchrotron.

8.2.1 – Streak Camera Main Unit: input and output optics, streak tube and MCP

Input Optics:

- Slit Horizontal length: between 10mm and 100mm
- Slit Vertical Aperture: variable, from 0 – 5mm, with micrometer precision
- Achromatic Spectral Transmission in the visible and near IR range (approximately 300 – 1000 nm)

Streak Tube and MCP:

- Photocathode Spectral Sensitivity: between 300 – 1000 nm (approximately)
- Photocathode dimensions: 1 x 5 mm (approximately)
- MCP Gain: $3 \cdot 10^3$

Bidder shall specify in the offer the performance or characteristics of the MCP Gating

Output Optics:

- Phosphor Screen Material: P43 (or similar performance)
- Required optics to transmit the image from the phosphor screen to the CCD camera.

8.2.2 – Fast Deflection (Synchroscan Unit)

- Synchroscan Frequency: 250 MHz (preferred) or 125 MHz
- Temporal resolution: better or equal than 2ps
- Sweep range: from 0.2 to 1ns (approximately)

8.2.3 – Slow Deflection Unit

- Sweep time: 100ns to 10ms (full screen)
- Sweep repetition frequency: 10 Hz (approximately)

8.2.4 – CCD Camera

- Scanning method: progressive
- Resolution: ~1300 x ~1000 pixels
- Pixel size: around 10μm x 10μm
- A/D converter: 0.1 electron/pixel/sec
- Frame rate: around 10 fps
- Exposure time: from 0.1ms to 10 s
- Dynamic range: 3000:1
- External trigger: yes (TTL level)

The camera shall be adapted to the streak output. The required optics for this adaptation is included in the tender.

All the camera functions shall be remote controlled.

Digital (Ethernet) or firewire cameras are preferred. In case the signal acquisition is done via a frame grabber, the bidding company shall provide all the required instrumentation (i.e., appropriate cards, cables, etc).

8.3 – CONTROL

The manufacturer must provide CELLS with all the required software to fully control the use of the streak camera and all its modules. This includes, but not limits to, timing synchronization, control of the streak camera parameters, image acquisition system, and data analysis.

It is desirable that the manufacturer provides CELLS with a computer with all the required software already installed.

For each module, the tender includes the peripheral components required for the control and use of the component (i.e., control software, power supplies, cables, cards, etc).

This also includes the required timing units to synchronize the image acquisition with the bunch passages (trigger units, delay units, counter units, etc). See next Subsection.

8.4 – TIMING AND TRIGGERING SIGNALS

In order to properly synchronize the data acquisition with the bunch passages (bunch lengths around 60 ps and 2 ns between bunches), CELLS provides an rf reference signal at 500 MHz, a revolution signal at 1.1 MHz, and a TTL trigger.

The bidder candidates shall specify in their offer the appropriate system (i.e., frequency dividers, delay units, etc) to properly trigger the streak camera (including the fast and slow deflection units, the CCD camera, etc).

9 – DELIVERABLES

9.1 – Contractor's responsibility

The contractor is responsible for the execution of the contract following the present specification, and in particular for the following items:

- The compliance with all the requirements presented in this specification and in the attached documents.
- The fabrication, cleaning, factory testing, inspection, assembly, packing and delivery to the CELLS site of the finished products, according to the present specification.
- The supply of a Test Certificate for each electronics unit after the Factory Acceptance Tests.
- The supply of the complete installation, operation and maintenance manuals.
- The supply of all software and firmware codes needed for the complete operation of the system.
- The compliance with all the relevant IEC safety codes, recommendations and standards.
- The supply of an effective warranty against equipment failure.

9.2 – Information required with the tender

The tender candidate shall provide sufficiently detailed documentation so that CELLS can review and assess the adequacy of the proposed project, as well as the competence of the manufacturer.

This should include, but it is not necessarily limited to, the following items:

- Confirmation of acceptance, or otherwise, of each clause of the present specification.
- A report that shall describe the technical description of the electronic equipment (and associated subcomponents when applies), including a description of the main features and their functionality.
- Details and/or datasheets of similar components manufactured by the bidder.
- Technical description of the company.
- The delivery time for the components, measurements and factory tests.
- Quality control certifications, applicable codes and applied standards.
- Complete price breakdown for the equipment and services.

9.3 – Modifications

Tender candidates are invited to suggest modifications to the present specifications, and testing procedures. In this case, the contractor must clearly indicate the technical advantages and disadvantages of these alternatives, as well as their financial and delivery time impact on the offer.

Once the contract is placed, any deviation or modifications from the agreed specification will not be allowed, except with the written CELLS authorization.

If the contractor believes that a given component will help CELLS for the purpose of this tender, the bidder is encouraged to contact the project responsible at CELLS to discuss with him this possibility.

10 - CONTRACT MANAGEMENT

10.1 – Contact engineer

At the start of the contract and throughout the duration of it, the contractor shall assign an expert engineer who will be responsible for any contact with CELLS concerning technical issues. In particular, he shall be responsible for all reporting to CELLS.

The counterpart at CELLS will be the Head of the RF & Diagnostics Section, Accelerator Division or a delegate person designated by him.

10.2 – Delivery address and dates

The contractor will deliver the product to the facilities of CELLS at Cerdanyola del Vallès, Barcelona (Spain) in February 2008. The final delivery date will be specified in the contract depending on the specific lot(s).

The contractor may propose changes to this schedule in the offer.

10.3 – Deviation from the specifications

During construction, all proposed deviations from the specification or from the offer must be submitted to CELLS in written form. CELLS will give its approval in written form.

Absence of written approval will be considered as refusal.

In the event of the contractor having misinterpreted any of the specifications or written instructions provided by CELLS, the misinterpretation will be corrected at no extra cost.

11 – ACCEPTANCE TESTS

11.1 – General

The components of each lot (and associated subcomponents, when applies) will be tested at the factory (Factory Acceptance Tests), and after delivery (Site Acceptance Test).

CELLS reserves the right to require additional or more extensive tests to be conducted in the event of dubious performance of the products tests.

Review and acceptance of CELLS shall not release the contractor from its responsibility to correct errors, oversights and omissions to ensure conformance with these specifications.

11.2 – Factory Acceptance Tests (FAT)

The contractor shall formulate acceptance test procedures for all systems and will provide the facility and instrumentation to perform all relevant tests to ensure compliance with this specification.

The contractor shall provide all measurements and recording equipment for these tests.

All measurement devices shall have calibration curves and test certificates as appropriate. CELLS reserves the right to check the calibration of all measurement devices.

At the end of the FAT, a Test Certificate for each component has to be delivered.

11.3 – Site Acceptance Tests (SAT)

CELLS will perform a Site Acceptance Test (SAT) for each equipment.

Before making its decision, CELLS may, at its discretion, repeat any of the tests and inspection performed during the FAT.

The final decision to accept or reject a given equipment of the lot will be made by CELLS within the next two months after its delivery.

The warranty period specified for each component starts after the successful pass of the SAT, or two months after the delivery in case CELLS does not perform the SAT within this period.

12 – QUALITY ASSURANCE

The contractor shall maintain and apply an adequate operational quality assurance program compliant with ISO-9001 for the design, manufacture and testing of all systems and equipment provided to CELLS.

The contractor shall also ensure that each of his subcontractors has a similar quality assurance organisation or a suitable alternative system. If this is not the case, he will undertake all the necessary measures to establish and maintain the quality of the subcontractor's components.

The supervision of the quality control by CELLS shall not release the manufacturer from his responsibility in meeting any point of the specification.

CE marking of equipment shall be applied wherever required.

All equipment shall be manufactured in accordance with the best existing techniques and recognized good engineering practices available at the time of construction.

Equipment and material shall be new unless otherwise noted.

Being a users' facility, reliability is one of the main concerns for all the equipment installed in the machine. This means that long Mean Time Between Failures (MTBF), short Mean Time To Repair (MTTR), and easy serviceability must be a basic consideration for all the components.

12.1 – Safety

The supplied equipment shall be in full compliance with the Spanish and the European Safety, Protection and Regulations and EMC Regulations in force and the relevant IEC (International Electrotechnical Commission) standards and recommendations.

12.2 - Documentation

A reference file (both in paper and electronic form in a CD-ROM) must be kept and shall be sent to CELLS at the time of delivery for each component or subcomponent. This file must contain:

- Test Certificate of the Factory Acceptance Tests as specified in Section 11.
- Complete installation, operation and maintenance manuals.
- Reports of non conformity of the lot component (if any).

12.3 - Labeling

An appropriate nomenclature shall be used to identify the component and its separate pieces, which shall be labeled in the more suitable and safe location. The label shall contain the following information:

- Name of the manufacturer
- Manufacture date
- Description
- Series number

The series number shall also be present in the test procedures.

12.4 – Packing and safe delivery

The contractor is responsible for the safe delivery of the equipment to the CELLS site.

The equipment must be packed so that excessive shocks and any damage during transportation are avoided. Shocks detectors should be installed for transportation.

12.5 - Warranty

The contractor shall guarantee their equipment against failure due to either faulty components or faulty manufacture for the period of, at least, 24 months after the equipment is accepted by CELLS. Warranty extension is a valuable asset.

This warranty shall not be invalidated by the opening of equipment covers for visual examination and diagnostic tests.

It is warranted that no modifications will be undertaken without the written permission of the contractor.