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Sincrotrone Trieste S.C.p.A.

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Technical Specifications for the production of the Delay Line for the FERMI@Elettra project

Reference Number

42768

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1. Introduction

This document describes requirements and characteristics of the chamber(s) for the realization of a delay line for the Fermi@Elettra Free Electron Laser (FEL) project carried on at Sincrotrone Trieste S.C.p.A. (hereinafter referred to as "ST"). It concerns manufacturing, testing and delivery.

The scope of the tender is the realization of the **delay line of the FERMI@Elettra project,** hosting 8 plane mirrors for the FEL radiation, the close loop laser system, and a quadrant photodiode. All the systems have to be UHV compatible and Bakeable up to 120° C. The optics, the laser and as the photodiode are not part of the tender.

As **Delay line**, object of this tender we mean:

- detailed mechanical and vacuum project to satisfy the specifications described in this document;
- the realization of all the mechanical drawings that will become property of ST;
- the realization of all the mechanical components, the supports and movement as described in this document;
- the realizations of the acceptance tests at the constructor premise or in a facility chosen by him;
- delivery of all the goods C/O ST. All the vacuum flanges must be close during the expedition. All the vacuum components must be delivered in a protect atmosphere.

1.1 Possible alternatives

Tenderers are requested to comment upon the specifications and they are encouraged to propose alternative technical solutions and manufacturing methods to ST. During execution of the contract, any deviation from this specification has to be required to ST in writing form for approval. Approval, if given, will be in written form.

2. Responsibilities of the supplier

2.1 The supplier is responsible for:

- the preparation of a detailed time schedule for the contract including all the different tasks (drawings, material procurement, machining, manufacturing, assembly, testing, etc...)
- the procurement of the necessary materials and commercial parts with the exclusion of what explicitly indicated as "excluded";
- the manufacturing process including: preparation of detailed manufacturing drawings, manufacturing of vacuum chambers and the full described system, cleaning procedures and protection of the components during manufacturing, all the tests necessary for the acceptance of the vessels as provision of necessary equipment, dimensional control;
- cleaning and vacuum tests;
- the packaging and the transportation from the supplier site to ST site;
- completing the documentation file: as-built drawings (in case of modification), quality assurance

documents and acceptance tests certificates.

2.2 The successful tenderer has to provide:

- all the manufacturing drawings in dwg file and the full assembly in step file within 18 weeks after receiving of the order;
- a certificate of dimensional checks for the delivered system, with reports of non conformity (if any) before or together the delivery of the entire system;
- results of the vacuum test before or together the delivery of the entire system;
- a final report with all technical documents and test results in English or Italian has to be sent to ST at least 2 weeks before the delivery. ST will reserve the right to repeat the tests in house and/or to participate to the final tests at the manufacturer premise.

The tenderer shall confirm its agreement with this specification and the acceptance tests.

The tenderer shall list all parts of the contract it intends to sub-contract, together with the identity of the proposed sub-contractor.

3. Drawings approval procedure

After the supplying of the final drawings, ST will reserve 2 weeks to suggest modifications or to approve the design.

4. Factory access

ST and its representatives shall have free access during normal working hours to the manufacturing or assembling sites including any subcontractor's premises during the contract period. The contractor will give a 15-day notice for ST inspections and tests.

5. General specifications

The motion specifications on the full system are imperative and will be checked during the dimensional and tests control.

The warranty period can't be less than 24 months, starting from the final approval test at ST.

All the documents and the drawings will belong to ST, and must not be divulgated without ST written acceptance.

The manufacturer will be responsible for the detailed specification of the welding procedures.

5.1 Manufacture

Manufacture of the delay line shall start only after the contractor has submitted to ST and obtained ST written approval of the following documents:

- detailed schedule showing the duration of all major activities related to the manufacturing including materials procurement, manufacturing of the components, assembly, cleaning, testing (vacuum and dimension) delivery;

- a final drawings for all the components;

5.2 Cleanliness

Ultra High Vacuum (UHV) compatibility involves high degree of cleanliness during all stages of the fabrication. This is a prerequisite to guarantee a low out gassing rate and a perfect tightness of the welding and brazing.

Each vacuum chamber must have an excellent degree of cleanliness on its inner surface. Each surface contamination such as grease, tenacious oil, which may appear during the stages of fabrication such as cutting and machining, has to be removed. Welding shall not induce contamination and guarantee leak tightness of the vacuum chambers.

After the cleaning procedure, every vacuum chamber must be handled carefully in order to avoid any further contamination. This cleanliness must be guaranteed also during the vacuum tests. Please refer to Annex sub n.2 of the invitation letter.

5.3 Inspection and testing

The contractor shall submit to ST for approval a detailed quality plan specifying the intermediate tests and checks that he will make during the whole manufacturing, assembly and testing procedures.

Approval to delivery of the goods will be given by ST after that the contractor demonstrates that the movements are conform to the specifications.

Each observed check failure shall be discussed together with ST. The contractor shall submit a corrective procedure to ST for written approval.

The tests will be done at the manufacturer site. A representative of ST can be present. The contractor will inform ST at least one week in advance of the date of the tests.

The contractor shall inspect and leak test all the vacuum chambers to ensure that they are conform to the specification. The contractor shall provide all the equipment and measuring instruments necessary to carry out the test and inspections. The contractor shall show that the delay line movements are conforming to this specification.

The delay line shall be delivered to ST only after the successful acceptance test.

6. Brief Description

The Delay Line system, is composed by 8 mirrors and 2 multilayer systems, as shown in figure 1. The first mirror M1, can be completely removed by the incoming beam or inserted to split it in two identical part (figure 2). If M1 is inserted, the beam goes to the mirror system M2-M3-M4. The other part of the beam goes to the system M5-M6-M7-M8. The mirrors M4, M5 and M8 have to be completely removed from the beam when not used, while M6 and M7 move together to define the proper delay.

Practically, M6 and M7 have to be moved together to change the path difference between the part of the beam going to M1-M2-M3-M4 and the part passing through M5-M6-M7-M8. The two mirrors have to

move for a total distance of 1m each. Dimensions and angles will be given later. To increase the delay, a set of multilayer (ml) will be inserted in the central part between M2 and M3 and in the straight part between M8 and M4.

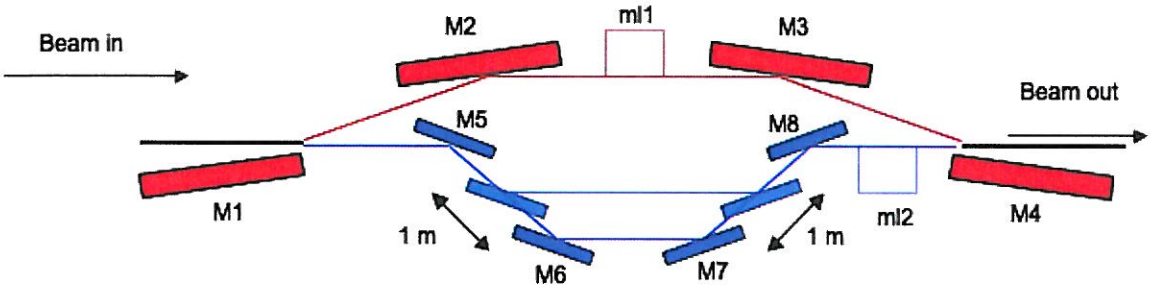

Figure 1: Side view of the Delay Line system. It must include all the mirrors and the multilayer systems (optics excluded).

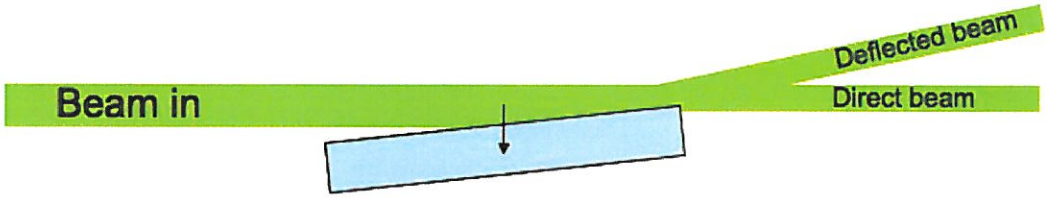

Figure 2: Splitting of the beam induced by the mirror M1.

Some minimum physical distances in operative condition are the following:

Distance M1-M2 or M3-M4: 2500 mm

Distance M1-M5 or M4-M8: 1864 mm

Height difference between M5 or M8 pole and upper beam: 130 mm[1]

Distance M5-M6 or M7-M8 variable. Minimum 290 mm maximum 1150, corresponding to a difference in beam path from 9 mm to -0.46 mm.

Distance M2-M3: 1500mm

Distance M1-M4 (direct beam) 7528 mm

VERY IMPORTANT: Distances can be changed but the difference in path between the red and blue path must be guaranteed. The length of the system (practically the distance from M1 to M4 plus the surrounding mechanics) must be as short s possible.

Mirrors dimensions and grazing angle of incidence

[1] *Revised 08/09/2010.*

M1, M4 370X50X50, useful: 350X20 Sharp edge (figure 3). Angle of incidence 2°

M2, M3: 350X40X50, Useful 330X20 (exact drawing will be available at the signature of the contract). Angle of incidence 2°

M5, M6, M7, M8: 250X40X40: Useful 230X20 (exact drawing will be available at the signature of the contract). Angle of incidence 3°

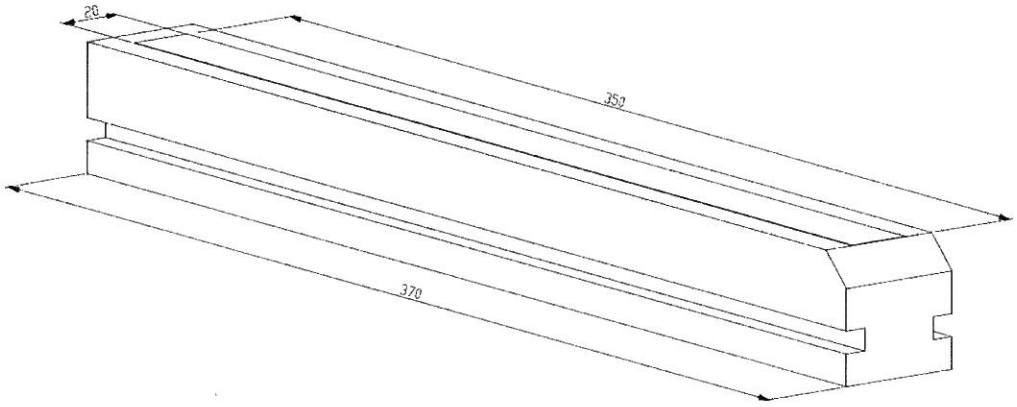

Figure 3: Splitting and recombining mirrors M1/M4.

6.1 Reference Systems

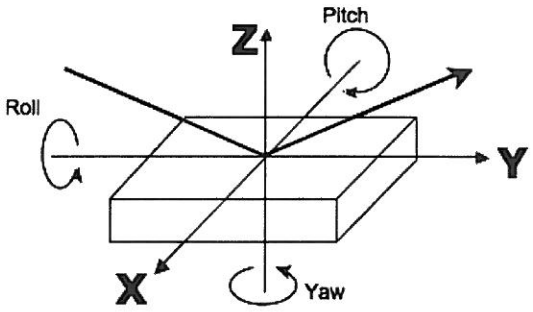

Figure 4: Reference systems used in the following tables

6.2 Mirror operation and required motorized movement

	Description	Motorized movement required
M1	Deflect the beam 4° up. Have to be inserted into the beam to deflect half of the beam into the upper photon path	Translation along Z to split the beam Pitch and roll for alignment purposes

M2	Deflect the beam of 4°	Pitch and roll for alignment purposes
M3	Deflect the beam of 4°	Pitch and roll for alignment purposes
M4	Deflect the beam 4° up. Have to be inserted into the beam to recombine the two part of the beam after the delay	Translation along Z to recombine the beam Pitch and roll for alignment purposes
M5	Deflect the beam of 6°	X to remove/insert the mirror from/into the beam Pitch and roll for alignment purposes
M6	Deflect the beam of 6°	Translation of 860 mm along Y
M7	Deflect the beam of 6°	Translation of 860 mm along Y Pitch and roll to compensate slide parasitic movements
M8	Deflect the beam of 6°	X to remove/insert the mirror from/into the beam Pitch and roll for alignment purposes

6.3 Mirror translation ranges and tolerances

M1					
Axis	*Range*	*Sensitivity (minimum step)*	*Actuator*	*Resolution*	*Resolution feedback*
X	± 2 mm	0.1 mm	Manual	-	Alignment
Y	± 5 mm	0.05 mm	Manual	0.05 mm	Dial gauges
Z	30 mm	3 μm	Motorized	3 μm	Encoder
Pitch	± 1 mrad	0.3 μrad	Motorized	1 μrad	Encoder
Roll	± 1 mrad	1 μrad	Motorized	1 μrad	Encoder
Yaw	-	-	-	-	-

M2					
Axis	*Range*	*Sensitivity (minimum step)*	*Actuator*	*Resolution*	*Resolution feedback*
X	± 2 mm	0.1 mm	Manual	-	Alignment

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Y	± 5 mm	0.05 mm	Manual	0.05 mm	Alignement
Z	± 2 mm	5 μm	Manual	5 μm	Encoder
Pitch	± 1 mrad	0.3 μrad	Motorized	1 μrad	Encoder
Roll	± 1 mrad	1 μrad	Motorized	1 μrad	Encoder
Yaw	-	-	-	-	-

M3					
Axis	*Range*	*Sensitivity (minimum step)*	*Actuator*	*Resolution*	*Resolution feedback*
X	± 2 mm	0.1 mm	Manual	-	Alignment
Y	± 5 mm	0.05 mm	Manual	0.05 mm	Alignment
Z	± 2 mm	5 μm	Motorized	5 μm	Encoder
Pitch	± 1 mrad	0.3 μrad	Motorized	1 μrad	Encoder
Roll	± 1 mrad	1 μrad	Motorized	1 μrad	Encoder
Yaw	-	-	-	-	-

M4					
Axis	*Range*	*Sensitivity (minimum step)*	*Actuator*	*Resolution*	*Resolution feedback*
X	± 2 mm	0.1 mm	Manual	-	Alignment
Y	± 5 mm	0.05 mm	Manual	0.05 mm	Dial gauges
Z	30 mm	3 μm	Motorized	3 μm	Encoder
Pitch	± 1 mrad	0.1 μrad	Motorized	0.1 μrad	Encoder
Roll	± 1 mrad	0.3 μrad	Motorized	0.3 μrad	Encoder
Yaw	-	-	-	-	-

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M5					
Axis	*Range*	*Sensitivity (minimum step)*	*Actuator*	*Resolution*	*Resolution feedback*
X	50 mm	0.01 mm	Motorized	0.01 mm	Encoder
Y	± 5 mm	0.05 mm	Manual	0.05 mm	Alignment
Z	± 2 mm	5 μm	Manual	5 μm	Alignment
Pitch	± 1 mrad	0.3 μrad	Motorized	1 μrad	Encoder
Roll	± 1 mrad	1 μrad	Motorized	1 μrad	Encoder
Yaw	-	-	-	-	-

M6					
Axis	*Range*	*Sensitivity (minimum step)*	*Actuator*	*Resolution*	*Resolution feedback*
X	2 mm	0.01 mm	Manual	0.01 mm	Alignment
Y	860 mm	0.01 mm	Motorized	0.01 mm	Encoder
Z	± 2 mm	5 μm	Manual	5 μm	Alignment
Pitch	± 2 mrad	5 μrad	Manual	5 μrad	Alignment
Roll	± 2 mrad	5 μrad	Manual	5 μrad	Alignment
Yaw	-	-	-	-	-

M7					
Axis	*Range*	*Sensitivity (minimum step)*	*Actuator*	*Resolution*	*Resolution feedback*
X	2 mm	0.01 mm	Manual	0.01 mm	Alignment
Y	860 mm	0.01 mm	Motorized	0.01 mm	Encoder

Z	± 2 mm	5 μm	Manual	5 μm	Alignment
Pitch	± 0.5 mrad	0.1 μrad	Motorized	0.1 μrad	Alignment
Roll	± 0.5 mrad	0.3 μrad	Motorized	0.3 μrad	Alignment
Yaw	-	-	-	-	-

M8					
Axis	*Range*	*Sensitivity (minimum step)*	*Actuator*	*Resolution*	*Resolution feedback*
X	50 mm	0.01 mm	Motorized	0.01 mm	Encoder
Y	± 5 mm	0.05 mm	Manual	0.05 mm	Alignment
Z	± 2 mm	5 μm	Manual	5 μm	Alignment
Pitch	± 1 mrad	0.3 μrad	Motorized	1 μrad	Encoder
Roll	± 1 mrad	1 μrad	Motorized	1 μrad	Encoder
Yaw	-	-	-	-	-

During the 860 mm long Y movement on the slits for M6 and M7, the maximum parasitic pitch and roll movement on the mirror must be smaller than 50 μrad and the maximum induced Z displacement lower than 10 μm

The slides hosting the mirrors M6 and M7 must have the chance to be pre aligned according to the following table:

Slide			
Axis	*Range*	*Sensitivity (minimum step)*	*Actuator*
X	± 2 mm	0.1 mm	Manual
Y	± 2 mm	0.1 mm	Manual
Z	± 2 mm	0.1 mm	Manual

Pitch	± 1 mrad	50 µrad	Manual
Roll	± 1 mrad	50 µrad	Manual

6.4 Close loop system

To be able to over impose the two beams into the experimental chamber, it is necessary to control the stability/precision of M6 and M7 movement with **0.1 µrad** in pitch and **0.3 µrad** in roll during the translation and during the alignment phase.

If, during the alignment, the feedback is made by looking at a proper fluorescent screen into the experimental chamber, during the scan of M6-M7, a non invasive close loop system is necessary. It must compensate the unavoidable angular waving due to the errors induced by the stages used for the mirror translation. The idea is to have a rigid connection between two small mirrors and M6 and M7. This 2 mirrors must be pre-aligned (in air) in order to be parallel to the M6 and M7 optical surfaces (within **5 µrad** or better in each directions). A laser plus a quadrant photo-diode will be used to realize the close loop system (see figure 6 for example). In this way, a tilt of M6 or M7 is measured by the quadrant photo-diode by measuring the tilt of the small mirrors connected to them. The system will use an in house developed electronic and photo-diode. Those devices and the needed laser are not part of this tender, as well as all the needed acquisition board, electronics, and so on. Note: the close loop has to act on the mirror and NOT on the slide.

Viceversa, is part of this tender a positioning system for the quadrant photo-diode with an Z-X translation (vertical and perpendicular to the beam direction) to align the photo-diode with respect the laser beam.

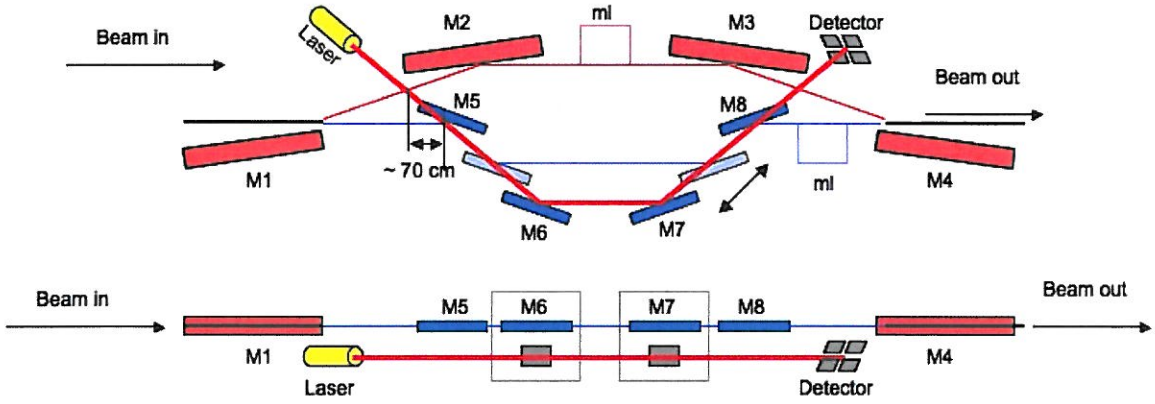

Figure 5: Side and Top view of the close loop system. The two small mirrors (gray in figure) have to be rigidly connected to M6 and M7 to suffer of the same induced angular shift during the scan along the slides. Alternative solution involving deflection on M5 and M8 can be taken into account if necessary for space reason

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The required range and precision of the movement of the quadrant photo-diode are summarized in the following table:

Quadrant photo-diode			
Axis	*Range*	*Sensitivity (minimum step)*	*Actuator*
X	± 10 mm	0.01 mm	Motorized
Z	± 10 mm	0.01 mm	Motorized

A CF40 window has to be positioned in direct view of the close loop system to permit the laser to hit the first mirror (the one connected with M6) perfectly parallel to FEL beam deflected by M5. Is up to the manufacturer to decide the lateral displacement from the FEL beam and the laser, taking into account the overall dimensions of the mirrors with its supports and movements. If necessary, one can insert a 90° tilting mirror to let the laser beam enter perpendicularly with respect the FEL beam. Such solution is accepted as any other solution witch permits the use of the close loop system in a safe, rigid and reproducible way.

6.5 Multilayer delay line system

Between M2 and M3 as well as between M7 and M4 some multilayer must be inserted (please ref to figure 1 for desired position). The system ml2 (figure 7) on the blue path is fixed while ml1 (figure 6) on the red one must be moved to increase the delay.
The two systems must support 4 groups of 4 multilayers each (figure 6). The different groups must be selected to change the operating wavelength of the delay line. Therefore there will be a working position that must be reached by every multilayer group. This is not the only required movement for ml1. In fact, the distance between ml_a and ml_b that is always equal to the distance ml_c - ml_d (figure 6) must be variable (45-230 mm) and controllable with a precision of 3 μm. The multilayer pair ml_b – ml_c must be moved with a single movement. It will be also required, as before, a close loop system described later.

The system ml2 (figure 7) consists, as the previous one of 4 groups of 4 multilayers each. In this system, the distance ml_e-ml_f as well as ml_h-ml_g stay constant. It will be required, as for the system ml1 the possibility to choose the multilayer group so, there will be a translation perpendicular to the beam.

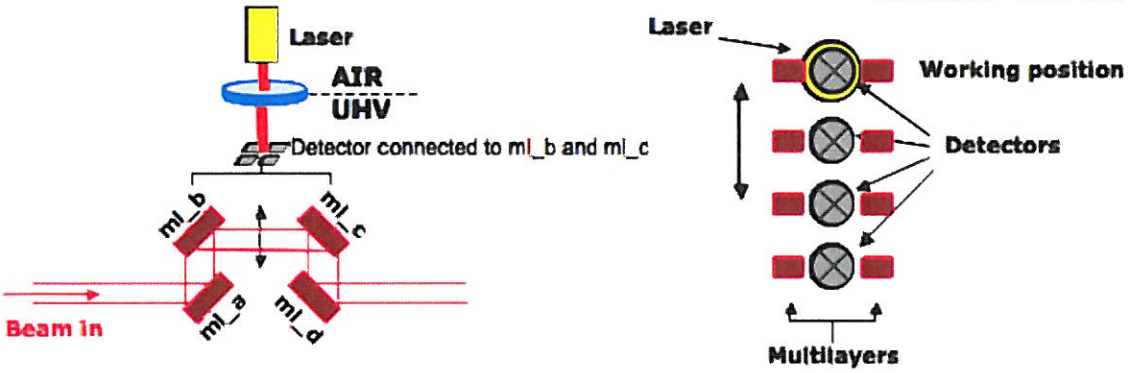

Figure 6: multilayer systems ml1: Left: side view of one of the four group of multilayers. There will be a fixed external He-Ne laser (not part of this tender) looking at a quadrant photodiode (not part of this tender). The quadrant photodiode, ml_b and ml_c have to be rigidly connected and have to be moved together to increase the delay. Right: Top view of the ml1 showng the four group of multilayers.

The fix distance ml_e-ml_f (and ml_h-ml_g) must be **50 mm**. If, during the design phase, such distance will be change, the variable distance ml_a-ml_b (and ml_c-ml_d) must be changed according t the rule: minimum distance -5 mm with respect to the system 2, maximum distance +180 mm with respect to the system 2.

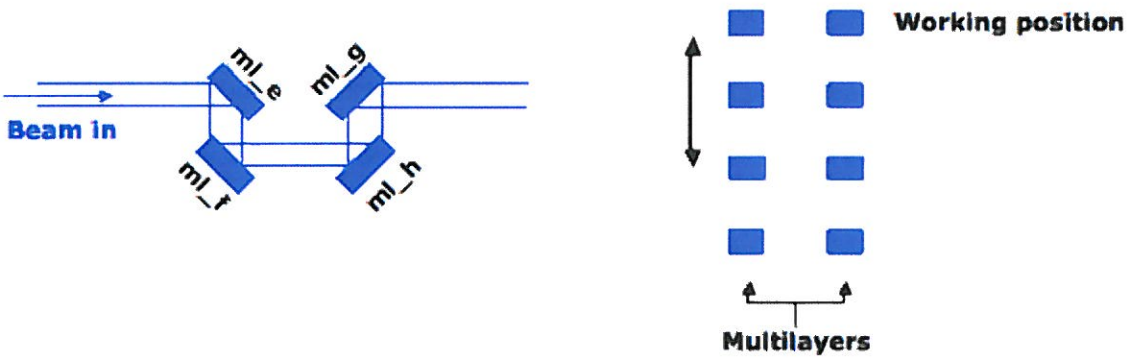

Figure 7: Multilayer systems ml2: Left: side view of one of the four group of multilayers. Right: Top view of the ml2 showing the four groups of multilayers.

Multilayer mirror dimensions and angle of incidence

The angle of incidence of every multilayer is 45°

All the multilayer mirrors will be round. There will be 2 sets of multilayer dimensions

1) Diameter 14 mm ± 0.2, thickness = 8 mm ± 0.2

2) Diameter 25.4 mm (1") ± 0.3, thickness (TO BE CONFIRMED) = 6 mm ± 0.2

At the initial stage there will be 1 group for each system of 14 mm diameter and 3 of 1" diameter. An ideal solution is one permitting to mounting both groups in each stage (by using extra pieces if necessary)

6.6 Required movement and precision

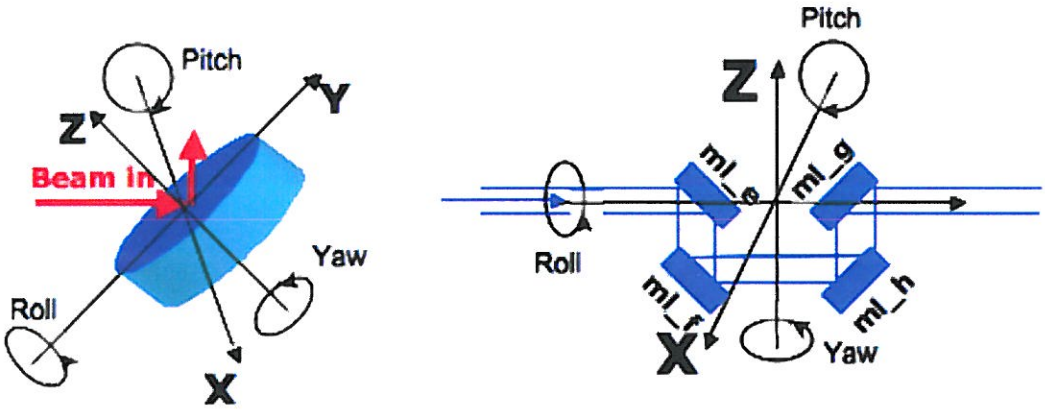

Figure 8: Reference system for the multilayers. It is valid for both ml1 and ml2.

Every single multilayer, after mounting, must be in the desired position according with the following table. The desired position is intended as the position in which the ideal photon beam hits the center of each multilayer always with an angle of 45°.

In air manual movement of each multilayer		
Axis	*Minimum range*	*precision*
X	Up to the manufacturer	0.1 mm
Y	Up to the manufacturer	0.1 mm
Z	Up to the manufacturer	0.01 mm
Pitch	± 2 mrad	100 µrad
Roll	± 2 mrad	100 µrad
Yaw	-	-

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The system ml1 must have the pair ml_b-ml_c that moves to generate the delay. The slide that moves such a pair (for each group) must satisfy the following requirement (note, it is accepted a single slide moving the four groups together or four independent slides):

Total displacement (along Z): 185 mm minimum. Larger displacement is welcome, larger than 250 mm is useless.

Step 3 μm. (with direct encoder)

the maximum parasitic pitch and roll movement on the multilayer must be smaller than 50 μrad and the maximum induced X-Y displacement lower than 10 μm. Such displacement must be corrected in the close loop system. Such system (figure 6) consist of a laser positioned in air looking trough a optical window directly a quadrant photodiode (Parameter of the photodiode ill be given, roughly it will be 10X10 mm^2), The quadrant photodiode detect an eventual misalignment due to the parasitic movement indicuced by the slide during the translation. The pair ml_b-ml_c must be mounted on a rigid base including also the photodiode and actuated by piezo motors (or alternative solutions) able to correct the parasitic movement with a precision of 0.1 μrad for the pitch and 0.3 μrad for the roll (figure 8 for reference). The optic window, the electric feed trough to read the signal, and the support for an He-Ne laser in air is part of this tender. The slide must have the possibility to be aligned with respect the ideal direction and the other slides (if the solution with four slide is used) with the following parameters:

Multilayer Slide pre alignment Movement			
Axis	*Range*	*Sensitivity (minimum step)*	*Actuator*
X	± 2 mm	0.1 mm	Manual
Y	± 2 mm	0.1 mm	Manual
Z	± 2 mm	0.1 mm	Manual
Pitch	± 1 mrad	50 μrad	Manual
Roll	± 1 mrad	50 μrad	Manual

The system ml2 must have only one of the multilayers of each group or alternatively each entire group (or system) that must be aligned in vacuum with the following precision:

ml2 in vacuum motorized required movement			
Axis	*Range*	*Sensitivity (Minimum step)*	*Actuator*
Pitch	± 1 mrad	0.3 μrad	Motorized
Roll	± 1 mrad	1 μrad	Motorized

7. Other requirements

7.1 Actuators and encoder

In case of using stepping motors, we strongly recommend to use the two-phase version. In any case motor type and version must be approved in written form by ST.

Other kinds of motors (brushless, DC...) have to be approved by ST. We will use TANGO (http://www.tango-controls.org/) based software to control all the actuator, valves, detectors and so on. If the supplier is able to provide the proper control software of the proposed solution, it is invited to explicitly mention it.

If Piezo electric actuators are used, please specify the control electronics that is supposed to be used.

The adopted encoder have to be approved by ST. The encoder directly or trough its electronics have to be interfaced with our control unit GALIL.

In every motion system two limit switches with a repeatability of ±0.05mm have to be included.

7.2 Assembling and tests

The full system (mirror excluded) have to be assembled and tested by the manufacturer.

The manufacturer has to test (and proof) at his premise or in any other facility, that the required ranges and tolerances of the movement are fulfilled, that the final base pressure is below $1X10^{-8}$ mbar, that the residual gas analysis proves that no polluting gas are present in the chamber, according to the technical specification for vacuum tests (ANNEX 2). ST will reserve the right to participate to the tests.

7.3 Alignment and mounting

There must be external reference marks or plates on the chamber(s) well visible from at least two orthogonal directions which permit to set the mirrors or slides in the proper positions from outside within a precision of 0.1 mm in each direction and 0.05° at each angle.

ST personnel will mount the FEL optics. There must be easy access to the mechanics and an easy way to pre align the optics one respect the other. If the system has to be removed from the vacuum vessel to mount the optics, the procedure have to be safe. It means that there should be no risk to touch any part of the chamber with the mirror surface when inserting or extracting the mechanics.

7.4 Chambers, supports and vacuum system

All the supports must allow a vertical positioning of ±12.5mm, the horizontal regulation in both the direction can't be less than ±20mm.

In the beam axes of each table there must be two ∅6H7 holes to allow the table alignment. Three ∅6H7 holes not belonging to the same line have to be placed in each support plate. These holes must not be colorized.

The vacuum system (pumps, gauges and controllers) are not part of this tender but it is responsibility of the successful tender to define the proper pumping system necessary to guarantee a final pressure below 10^{-8} mbar in operative condition. This information has to be given to ST as soon as possible. ST reserve the right to propose alternative pumping system of equivalent performances if the proposed solution does not fit with the ST standards.

8. List of item included in the tender

- Vacuum vessel(s) containing the mirrors, quadrant photodiode and all the mechanics and actuator for the proper use of them, as indicated in the tables above reported;
- All the mechanical movement in vacuum or in air to guarantee the fulfill of the above requested resolution and precision, including motors and controllers, excluded the 2 phase controller that will be provided by ST (not necessary for the approving test);
- All the required encoders with reading facility or GALIL interface;
- If non-standard gaskets or tools are necessary to mount any part or close the flanges, the manufacturer must provide them. Non standard gasket have to be provided in number of 5 spare item each;
- A viewport orthogonal to the photodiode (CF40 or larger);
- A view port (CF40 or larger) for the close loop laser;
- A CF63 in each chamber for the pre vacuum pumping stage including a manual all metal valve;
- **The support of the chamber**. The support must be very stable. It is suggested the use of concrete or granite. The maximum dimension of a single piece of the support must be 4X3m^2 and must not interfere with the surrounding stuff (detailed drawing will be available). NOTE: **the beam height is 1.2 m.** IMPORTANT: The chamber height must be adjustable with a range of ± 12.5 mm (0.1 mm step) **NOTE:** If the support is made by concrete, it must be covered with a protective paint. The color of the protective layer must be transparent or Red (RAL 30-20). If a metallic stabe frame is used, it must be red colored (RAL 30-20);
- The entrance CF40 flange (beam in);
- A CF40 flange for beam exit at same lave of the entrance one;
- 2 window in the center of the travel of M6 and M7 perpendicular to them for alignment purposes (CF63 or larger);
- All the actuators and all the mechanics above described;
- 0.9 m or longer scanning systems for M6 and M7 with the required resolution as in the tables above;
- All the mechanical drawings and electrical schemes, including, if used any pneumatic scheme;
- All the bellows, pipes, tools, and so on, necessary to fulfill the above described specifications.

9. Final acceptance test

The final acceptance tests will be made at ST by ST personnel. ST reserves the possibility to reject the delay line or any part of it, after the final acceptance that will be held in ST site within two months after the delivery. In case that one of the specified tests shows the nonconformity of a piece or of a system and it may not be used, the manufacturer will repair or produce it again at his own responsibility and costs,. The warranty period will start only after the successful tests of all the components or the production and test of the replacing part if needed.

10. Protection and transportation

The full chambers and the mechanics shall be properly shipped to prevent damage and contamination during transportation.

All the vacuum ports must be protected by a blank flange or a mechanical protection to preserve the integrity of the flange sealing surface.

Packing cases must be robust and suitable for lifting and transportation with a forklift or with a crane, without any damage.

For further details, questions or requests, please contact Dr. Daniele Cocco, fax number +39-040-9380906.