S16/119E

AEROTECH *Dedicated to the Science of Motion*

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About Aerotech

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Fyzikální ústav AV ČR, v.v.i. -ELI DEP. 95
Václav Mráz
Za Radnicí 835
Dolní Břežany, post code: 252 41
Czech Republic

Tel.: +420 601 560 318
E-Mail: vaclav.mraz@eli-beams.eu

Quote no.: **B 114084-1-0 C**

Date: 29-Jun-16

Dear Mr. Mráz,
thank you for your inquiry. We offer as follows:

Gimbal system prototype

Pos.	Qty.	Description	Unit Price	Total Price
1	1	***Mechanics for the Gimbal prototype + Gimbal support brackets, consisting of:***	**31.535 €**	**31.535 €**
	1	**ESXXXX- Custom 2 Axis Gimbal** Non-vacuum prepared, Non-Cleanroom prepared 2 Axis Gimbal	**22.525 €**	
	1	**ESxxxxx, Custom Payload + Custom Gimbal Support Brackets** Simulate mirror mass and inertia, Aluminum construction Gimbal bracket persicope mount, steel construction	**9.010 €**	
	1	**OTE- One Time Engineering** Aerotech to cover the cost of engineering design and analysis, as well as internal modal testing.	**0 €**	
	1	**Integration - Test as System** Testing of the system at Aerotech with a creation of a parameter file for the Aerotech control	**0 €**	
	1	**Integration - Special Testing** Special testing of the Gimbal	**0 €**	

MINISTRY OF EDUCATION YOUTH AND SPORTS

EUROPEAN UNION
European Structural and Investing Funds
Operational Programme Research, Development and Education

2	**1**	***Control for the gimbal system for loan, consisting of:***	**0 €**	**0 €**
	1	**ENSEMBLE-MC-Machine** Software of the control		
	2	**ENSEMBLE Drive** Drive for one Axis of the Gimbal (Two in total for the Azemuth and Elevation axis)		
	1	**ENET-XOVER-45** Ethernet cable for the connection drive- computer from the customer, length = 4,5m		
	1	**ENET-CAT6** Cable for the connection drive - drive		
	2	**Motor power cable** Cable for the motor power between Gimbal - drive, length = 5m		
	2	**Motor Feedback cable** Cable for the Feedback connection between Gimbal - drive, length = 5m		
3	**1**	***Start up at the ELI Beamline in Prague***	**0 €**	**0 €**
	1	**Start up** The start up will take place after the delivery of the system at the ELI Beamline in Prague		

Notes:

- The control system in position 2 in this quote will be provided to the customer for loan for the timeframe of 6 month
- Ensemble controller EPICS drivers can be downloaded at: http://www.aps.anl.gov/epics/
- Ensemble controller Tango drivers can be downloaded at: https://sourceforge.net/p/tango-ds/code/HEAD/tree/DeviceClasses/Motion/MotorControllers/Aerotech/

Gimbal system prototype

Price for the position 1 -3 : **31.535 €**

This quote includes the Annex 2, "Binding business and payment terms of the client" and the Annex 3, "TECHNICAL REQUIREMENT DOCUMENT". Both documents are confirmed by the company Aerotech.

Terms and conditions:

Validity of quotation:	**30**	**days**
Delivery time after reception of an order:	**12**	**weeks**

The delivery time of 12 weeks includes the time of 1-2 weeks for approval of the drawing.

Term of payment: The terms of payment are confirmed by Aerotech to the section "III. Payment terms" in the Annex 2 (Binding business and payment terms of the client).

Terms of delivery : EXW, manufacturing facility of the supplier

Best regards

Damian Matysik
Sales Engineer
Tel: +49 (0)911 967937-22
E-mail: dmatysik@aerotech.com

Acceptance of the Quote by Contracting Authority

Signature:
Name: prof. Jan Šibík, DrSc.
Position: Director
Date: 14.7.2016



Binding business and payment terms of the client

I. Subject matter of the contract and related terms:

The subject- matter of the contract is the commitment to supply a prototype of 1 Petawatt, 30 J, 30 fs, 10 Hz, 820 nm beam transport mirror mounts for the ELI L3 laser as specified hereby (the "**Device**") by the supplier and the commitment to take over the device and to pay the price for it by the Client.

The Device shall comply to the requirements set out in the Client´s Technical Requirement Document. Taking into account its nature of a prototype certain partial specifications of the Device might be subject of change if it will be realized by the parties during design and manufacture of the Device that any specification or requirement is unfeasible, inappropriate or another technical specification or solution is more suitable in order to meet all highly demanding abilities requested from the Device and/or entire beam distribution system for which it is intended. However, some requirements cannot be subject to change (for details see the attached Technical Requirement Document). Such specifications deviations shall be always subject to written agreement of the client and must not increase the price of the Device.

II. Fundamental Provisions:

The Buyer is the beneficiary of a subsidy from the Ministry of Education, Youth and Sports of the Czech Republic for the project "ELI: EXTREME LIGHT INFRASTRUCTURE – phase 2", reg. No. CZ.02.1.01/0.0/0.0/15_008/0000162, within the Operational Programme "Research, Development and Education.

III. Payment terms

3.1 The client agrees to pay the purchase price to the supplier based on an invoice delivered by the supplier after the following conditions are met: (1) mechanical design of the Device is accepted by the client and (2) the Device is manufactured, no obvious defects of the device occur and the Device is ready for final engineering tests.

3.2 Invoices shall be payable within 21 days of the date of their delivery to the Buyer (hereinafter the "Maturity Period"). Payment of the invoiced amount means the date of its remitting to the supplier´s account. In conformity with the applicable tax regulations of the Czech Republic, the tax documents – invoices issued by the supplier hereunder shall include particularly the following details:

a) the business name/designation and registered office of the client
b) the tax identification number of the client
c) the business name/designation and registered office of the supplier
d) the tax identification number of the supplier
e) the registration number of the tax document
f) the scope and object of the supply
g) the date of issue of the tax document
h) the price of the supply
i) a declaration that the charged supply is provided for the purposes of the "ELI: EXTREME LIGHT INFRASTRUCTURE – phase 2" project, reg. No. CZ.02.1.01/0.0/0.0/15_008/0000162.

3.3 Notwithstanding the deadline for the supply stipulated by art. IV. hereof the supplier shall not be obliged to hand over the device to the client until entire purchase price is received by the supplier.

IV. Times of performance

The supplier undertakes to duly deliver the Device to the client within 12 weeks from the date of signature of this contract.

V. Place of delivery, ownership title

The place of delivery shall be the manufacturing facility of the supplier (Incoterms 2010 EXW shall apply).

The ownership title to the Device shall pass to the Buyer on execution of the handover protocol executed by the parties upon the moment of hand over. The client is not obliged to take over the device if the documentation stipulated by the client's Technical Requirements Document is not ready to be handed over to the client together with the supply.

VI. Termination of the Contract

Both parties are entitled to withdraw from the contract without any penalty if the other party materially breaches the contract (particularly delay with the final due supply longer than 12 weeks, delay with contractual price payment longer than 30 days, insolvency proceedings are initiated against any of the parties).

VII. Final provisions

The supplier undertakes to cooperate during financial inspections carried out in accordance with Act 320/2001 Coll., on Financial Inspections, as amended.

ELI L3 first vertical mirror mount prototype to verify the most important properties of a final L3 mount

Technical Requirement Document

Dr. **Stefan Borneis**

Ing. **Martin Sokol**, PhD.

June 10th, 2016

Contents

List of Figures

1. Purpose

This Specification Document lists the technical specifications of the 1 Petawatt, 30 J, 30 fs, 10 Hz, 820 nm beam transport mirror mounts for the ELI L3 laser. These mirror mounts will guide the short-pulse compressed L3 laser from the entrance of the beam distribution entirely in vacuum with up to 18 mounted high-power precision laser mirrors over a distance of up to 88 meters to the experimental areas. The required pointing stability per turn mirror mount is 100 nrad mechanical on mirror towers that are up to 3.5 meters high.

2. Working environment

The L3 mirror mount will finally be used in a vacuum environment. The concept should allow the part to work at 10^{-5} mbar and outgassing should be kept minimal. Mount to be clean room 100 and NVR level A/10 compatible. The prototype does not have to fulfil this requirement necessarily.

3. Important dimensions

3.1. Mirror data

Drawing of mirror (MIRROR 440 x 290 x 75, Drw. N.: EL – ET – 1602 – 00 – 15 / 00) is at the end of this document. Compliance to these dimensions is binding.

Table 1 Mirror specifications

Item	Specification	Tolerance	Unit
Shape	Rectangular	N/A	N/A
Length	440	+0 / -1	mm
Height	290	+0 / -1	mm
Thickness	75	+/- 1	mm
Chamfer @ 45º	3	+/- 1	mm
Wedge	10 (0,16$\overline{6}$)	+/- 3 (0,05)	arcmin (°)

3.2. Coordinate system

All coordinates in the document are relative to the centre of gravity of the mirror according to Figure 1. Axes X and Y are horizontal and Z is the vertical axis. The pitch is defined as rotation around the horizontal Y axis and yaw as the rotation around the vertical Z axis.

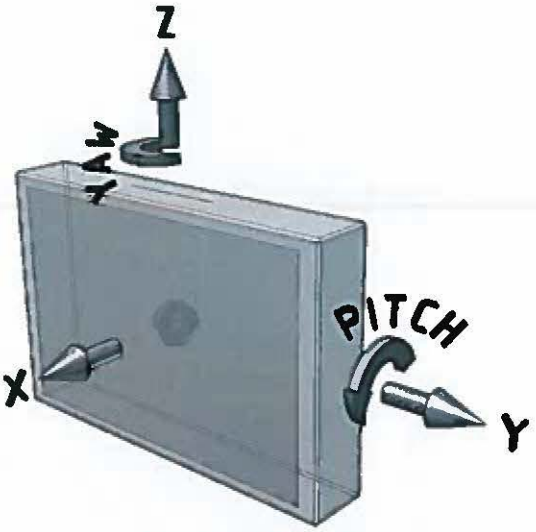


Figure 1 Definition of axes

3.3. Mirror orientation

The mirror mount shall perform according to all specifications in vertical as well as under 45 degrees periscope configuration. Mounting structures for periscope configuration are considered part of the contract.

3.4. Mirror dummy payload

The contract includes a mirror dummy payload for the evaluation of the full weight mirror + payload vibration tests. This item is binding.

3.5. Mirror degrees of freedom

The mirror should be adjustable in pitch (rotation along Y) and yaw (rotation along Z):

Table 2 Mirror adjustment

Item	Specification	Tolerances and notes	Unit
Drift	± 1.5	Less than in temperature controlled environment (23 +/- 0.5°C)	µrad
Yaw sensitivity	2	Less than	µrad
Pitch sensitivity	2	Less than	µrad
Yaw travel	+/- 17,5 (1)	More than	mrad (°)
Pitch travel	+/- 17,5 (1)	More than	mrad (°)
Actuator	Manual or motorization on loan	Motors shall be equipped with position readout/encoders or at least with end switches system	N/A

These specifications are binding.

3.6. Motorization and controls

The vendor has to provide on a loan basis full motorization and full control capability including software for 6 months.

3.7. Transport cover

The mirror surface should be protected against contamination during transport. Therefore, two cover-plates are made to shield the mirror against such risks. The design of the plates is part of the drawing package.

In addition, M 10 threaded holes should be provided to lift the framed mirror and any part with a weight greater than 20 kg should have specific anchor points for transport and loading into the experimental setup.
These transport covers are not required for this prototype, but are essential for the final product.

3.8. Alignment fixtures

Alignment fixtures (cross-hair) should be provided as part of the holder package. Two cross-hairs should be installed on the mount during alignment (and removed for operation). Repositioning of the cross hair is +/- 0.5mm. The position of the cross hair is NOT centred on the beam. Mounting and fixation of the cross-hair without screws is preferred. Their position is given in the following table and drawing:

Table 3 Cross-hair specification

Item	Front cross.	Back cross.	Unit
Plate thickness	0,5 TBD	0,5 TBD	mm
Wire width	2	2	mm
Centring hole diameter	2	2	mm
Gap between mirror and cross-hair	10 TBD	10 TBD	mm
Height (Z)	0	0	mm
H position (Y)[1]	47,5 TBD	-47,5 TBD	mm
Precision	+/-0.5	+/-0.5	mm

[1] The position is given in algebraic value, on the mirror plane, projected at 45degree on the mirror surface. The cross hair being away from the surface by δx (gap between mirror and cross-hair), the position of the cross-hair with respect to the mirror plane is shifted by $+\delta x$ for the front cross hair and $-\delta x$ for the back cross-hair.

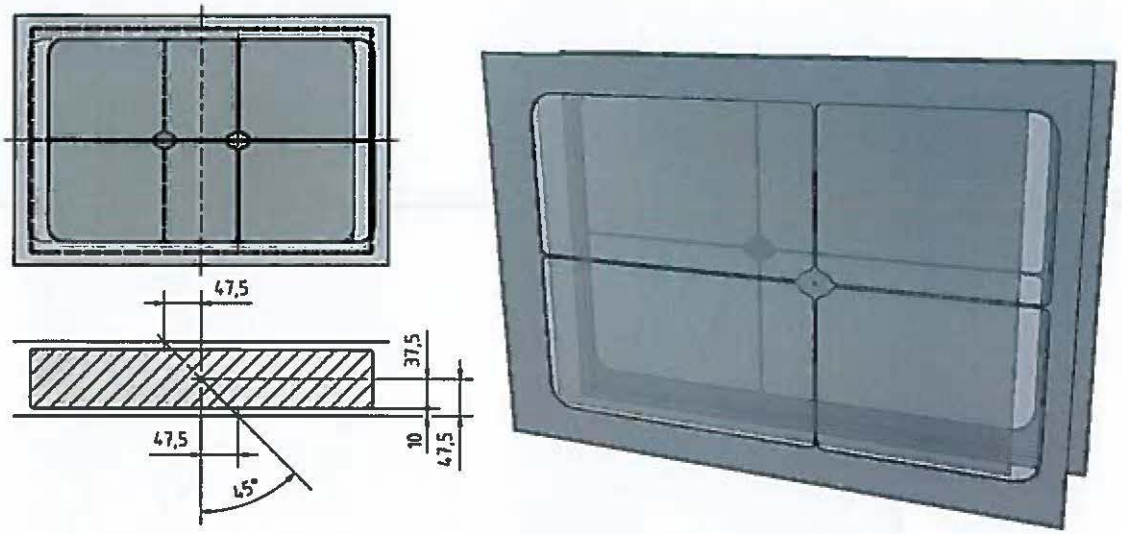


Figure 2 Sketch of cross-hair

These alignment cross-hairs are not required for this prototype, but are essential for the final product.

4. Mirror pointing stability

The reflected beam pointing (optical) stability may not exceed 200 nrad (100 nrad mechanical). Mirror mount vacuum enclosures will be de-coupled from support structure, bread boards and support will be designed with the goal to achieve < 10 nrad mechanical pointing stability on the top. Ambient vibration level from laser building is < 1 nm RMS for frequencies from 1 – 100 Hz, but mount should meet 200 nrad optical pointing spec also with a PSD input of 10^{-10} g^2/Hz, best effort 10^{-9} g^2/Hz for the frequency band 1 – 150 Hz. Pointing instabilities by acoustic excitation, air currents of ISO7 clean room, due to temperature gradients of the ± 0.5°C stabilized clean room are unknown. Design to be optimized for high first resonance frequency, i.e. > 150 Hz. All pointing specs shall be achieved with mounted optics or equivalent weight dummy payload and with full drive system/motors installed. The verification of the mirror mount pointing stability is the key parameter of the prototype that will be verified together with ELI personnel

5. Concept

5.1. Standards

All measurements, sizes and used hardware shall be specified in and compliant with ISO metric system. This include that all drawing will be in mm, using first-angle projection, all threaded parts and hardware shall be using metric threads. Other nonmetric sizes, parts or hardware may be used with prior agreement of ELI.

5.2. Materials

The approved materials for the construction are EN 1.4301 (AISI 304) steel or EN 1.4307 (AISI 304L) steel and aluminium EN AW 6082, unless specified otherwise. Uses of other

materials are possible with prior agreement of ELI. European designation of materials is mandatory. List of used materials shall be agreed upon prior to contract execution. Materials need to be compliant with radiation safety/minimal activation, because some mounts will be used in an environment with ionization radiation.

5.2.1. Surface finish

Aluminium surfaces should be nickel plated in a galvanic bath to reduce surface roughness and outgassing. Other processes such as etch surface or space qualified clear anodization are possible with prior agreement of ELI. TBD the most cost effective solution. Screws should be silver plated. This requirement is not required for this prototype, but for the final product.

5.2.2. Lubricants

Lubricant should be avoided wherever possible and only certified vacuum greases may be used with prior agreement of ELI. No lubricant should be used for the mounting.

5.3. Interfaces

For stability reasons, mechanical interface should not be hyper-static. It is anticipated that the holder will mounted onto a base plate with 3 pads (TBD) contacting to the optical bread board. Coarse adjustment in the horizontal x, y plane of the bread board will be performed by sliding the holder mounted to its base plate on the bread board Friction/scratching of the bread board should be kept at a minimum, using Delrin pads or polished metallic surfaces (TBD).

5.4. Interface to the table

The holder will be sitting on an aluminium or steel bread board. The bread board has M8 threads on a 50 x 50 mm grid that will be used to bolt the holder onto the table. From this grid, any position of the holder should be accessible in the X/Y plane. For this a clamping mechanism shall clamp the mount centric at three support plate pads onto the table (TBD).

5.5. Glass metal interface

- Contacts: there shall be no direct metal to optic contact. Contact to optic shall be done via Delrin,
- Surface of reference: The mirror should sit on its side/barrel, on two points (equal gravity). Provision should be made for the mirror not to tip during transport,
- Clamping: the mirror should be clamped stiffly into the mount to minimize pointing instabilities: 2 clamps at the bottom of the frame and a 3rd point on the middle top of the frame – potentially 2 on the to (TBD)
- Mirror deformation: The requirement for the maximum allowable surface deformation at 45 degrees is < lambda/10 at 633 nm of the mirror clear aperture (peak-to-valley) single pass reflected wavefront error.

ELI will support the development of the glass to metal interface.

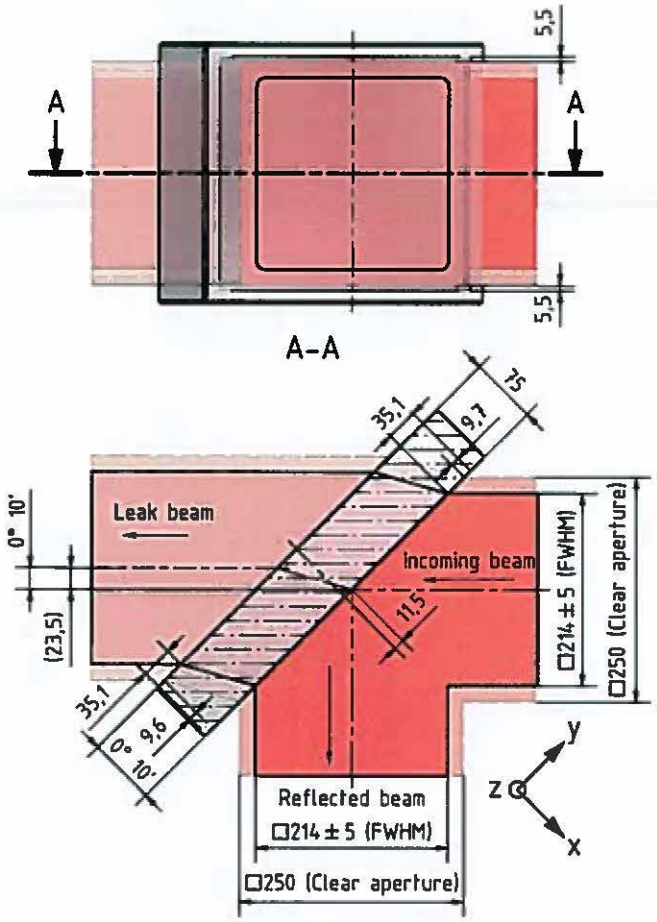


Figure 3 Laser beam reflection and leak

6. Cleaning

The parts should be free of oil. The specification is non-volatile residue (NVR) level A/10, and particle level 100 per IEST specification IEST-STD-CC1246E: Product Cleanliness Levels – Applications, Requirements, and Determination. The cleaning is not required for the prototype.

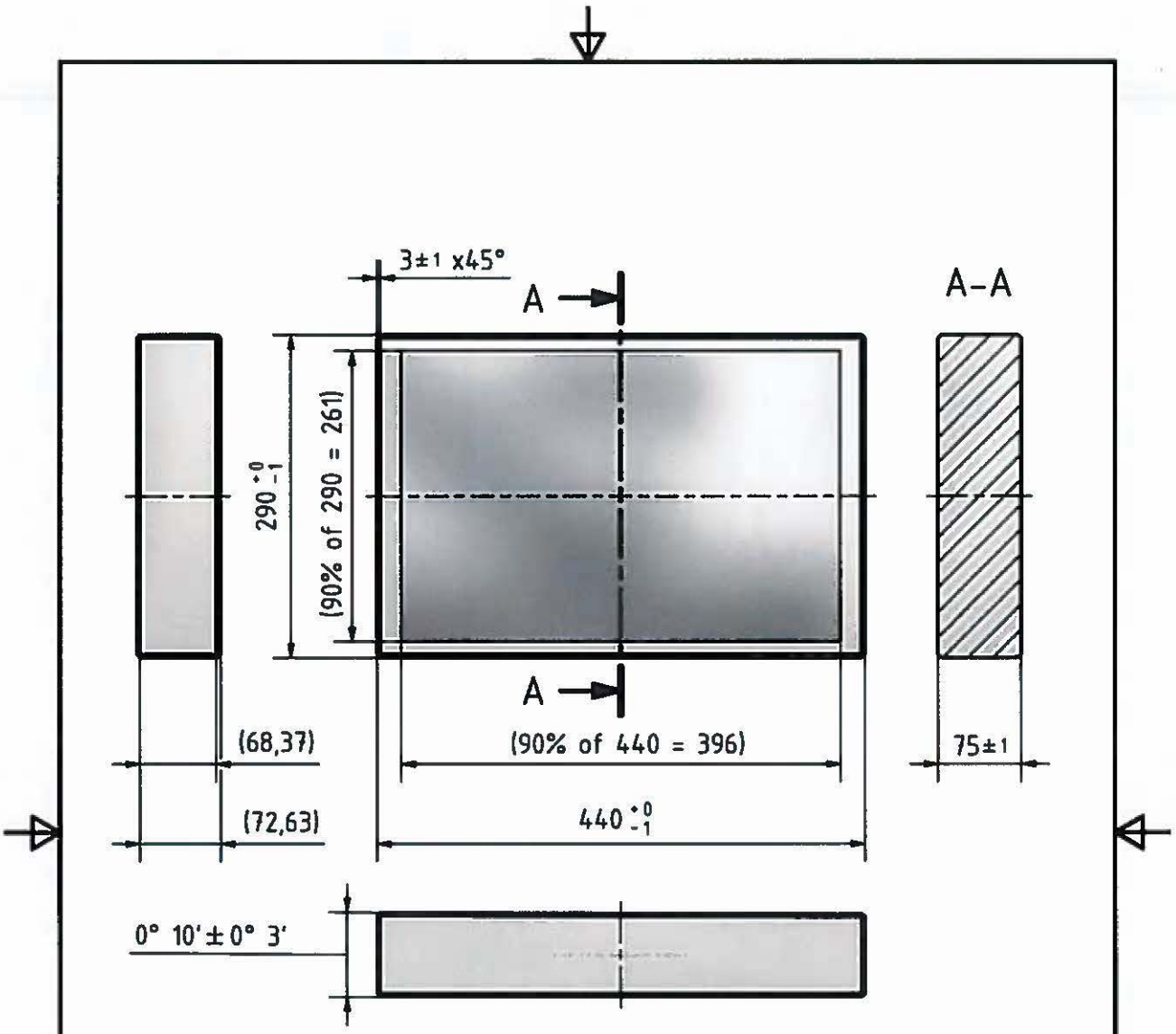
7. Verification of parameters

The most important parameter is the mirror mount pointing stability. The measurement of the performance of this mount will be a joint effort with ELI personnel. The verification procedure will be agreed on 3 weeks prior to completion of the prototype, i.e. to ELI personnel joining the verification tests at the premesis of the vendor at its own costs.

8. Acceptance of mechanical design

The execution of the contract depends on the acceptance of a design proposal that has to meet as many requirements of this TRD as possible. The pointing stability requirement shall be met. Failure of receiving sign-off from the manager of the beam transport team

for a design proposal will result in termination of the envisaged contract and no funds will be released for any performed design work.



1) FOR USE IN VACUUM

2) 3D MODEL OF MIRROR 440 x 290 x 75 AVAILABLE

The information contained in this drawing is the sole property of FZU. Any reproduction is prohibited		eli beamlines	Fyzikální ústav Akademie věd ČR, v. v. i.
Drawn by: martin.sokol	Projection	Scale 1:5	Sheet size A4	Dwg. title: MIRROR 440 x 290 x 75
Checked by:				
Date: 21.04.2016				
Material: HPFS 7980		All dimensions in mm		Dwg. no.: EB - ET - 1602 - 00 - 15	Rev.: 00
Raw mat.:		Tolerance: ISO 2768-mK		
Weight: 21.022 kg		Note:		Eli no.:	Sheets 1 of 2