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 	Detailed Specification	F-DS-SFS-en-BD_0141_AlignmentTelescopes-V001	2026-08-13
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Document Title	Alignment Telescopes with Camera system for precision positioning and alignment of the beam instrumentation at FAIR
Description	This document contains the Detailed Specification of the alignment telescopes with camera system.
Division/ Organization	Super Fragment Separator (SFS) – Beam Instrumentation
Field of Application	FAIR GmbH and GSI GmbH

Document History

Version	Prepared/Checked by	Date	Date of Release	Comments
V 0.1	M. Czogalik	04.08.2026		Initial version.
V 0.2	M. Czogalik	11.08.2026		Corrections for software and laptop.
V 0.3	M. Czogalik / J.A. Galvis Tarquino	12.08.2026		Reviewed and corrected.
V 1	M. Czogalik	13.08.2026	13.08.2026	Correction from F. Gressier (QUA) implemented. CID updated. Released version.

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Abstract

This document contains the Detailed Specification of **the alignment telescopes with camera system** for sub-millimetre position measurement and alignment of FAIR Beam Instrumentation and Experimental stations.

This document covers all items of AID/CID:

CID:06001251014	FAIR Optical Alignment System	AID:0005324
CID:06001251021	FAIR Alignment Telescope	AID:0005325
CID:06001251038	FAIR Alignment Camera System	AID:0005326
CID:06001251045	FAIR Optical Alignment System	AID:0005324
CID:06001251052	FAIR Alignment Telescope	AID:0005325
CID:06001251069	FAIR Alignment Camera System	AID:0005326

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1. Purpose and Classification of the Document

The purpose of this document is to specify technical requirements of the alignment telescopes and camera system used for sub-millimetre positioning and alignment of Beam Instrumentation and Experimental Station at FAIR [1].

It is the most detailed document within the hierarchy of beam instrumentation documentation and specifies all requirements and information necessary for the planned technical realization of the system.

No legal or contractual conditions are addressed in this document. All related information is specified in the corresponding contract.

2. Abbreviations, Terms and Definitions

AID	Article Identification Number
CDR	Conceptual Design Review
CE	Conformité Européenne
CID	Component Identification Number
FAIR	Facility for Antiproton and Ion Research GmbH
FDR	Final Design Review
GSI	GSI Helmholtzzentrum für Schwerionenforschung GmbH
PSP	Project Structure Plan
QIP	Quality and Inspection Plan
SFRS	Super Fragment Separator
FAT	Factory Acceptance Test
SAT	Site Acceptance Test

3. Scope of the Technical System

3.1. System Overview

All beam instrumentation systems—such as radiation detectors, slits, targets, beam stoppers, etc.—installed at the FAIR facility require precise alignment with the beam centre. To facilitate this alignment, a measurement system concept based on an optical telescope and two targets was developed (see Figure 1). The telescope is first aligned with the beam centre defined by the targets; subsequently, the positional deviation of each beam instrumentation system is measured, and aligned with the centre indicated by the telescope.

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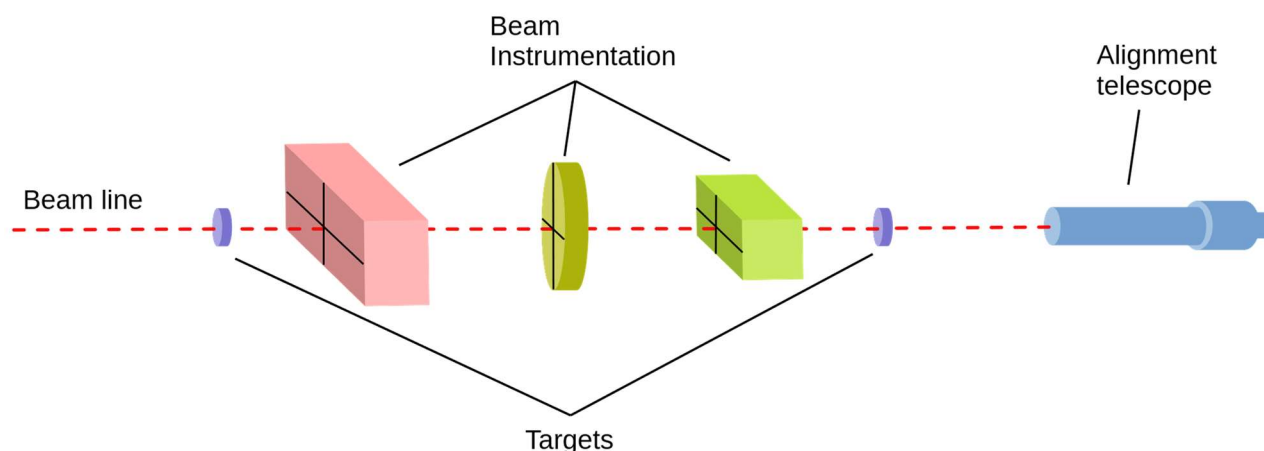


Figure 1: Concept of the beam instrumentation alignment to the center of the beam line.

To enable long-term measurements for dozens of beam instrumentation systems, it is necessary to use a camera mounted on the telescope eyepiece. This reduces the risk of eye strain and operator fatigue, minimising false measurements and helping to stabilise overall quality.

3.2. Scope of Delivery

The main components of the micro-alignment system are:

- Alignment optical telescope
- Telescope storage and transport case with shock-absorbing padding
- Camera mountable onto the telescope's eyepiece including the required clamping system for installation
- Cables for connecting the camera with the PC/laptop
- Software for reading, analysing, saving, and exporting camera images together with dedicated PC, laptop, notebook, etc.
- Instruction manuals and documentation of hardware and software

All components must be labelled with a component identification number (CID) [2] provided by SFS Department.

4. System Specification

The measurement station featuring an alignment telescope will be located in the FAIR tunnel. The alignment Telescope will be mounted on a dedicated stable stand, supplied by AMETEK (Serial Numbers: 112-471, 112-5933, 112-5817-01, 112-5820). A camera will be attached to the telescope eyepiece, and the camera output will be processed by a computer running dedicated software (see Figure 2).

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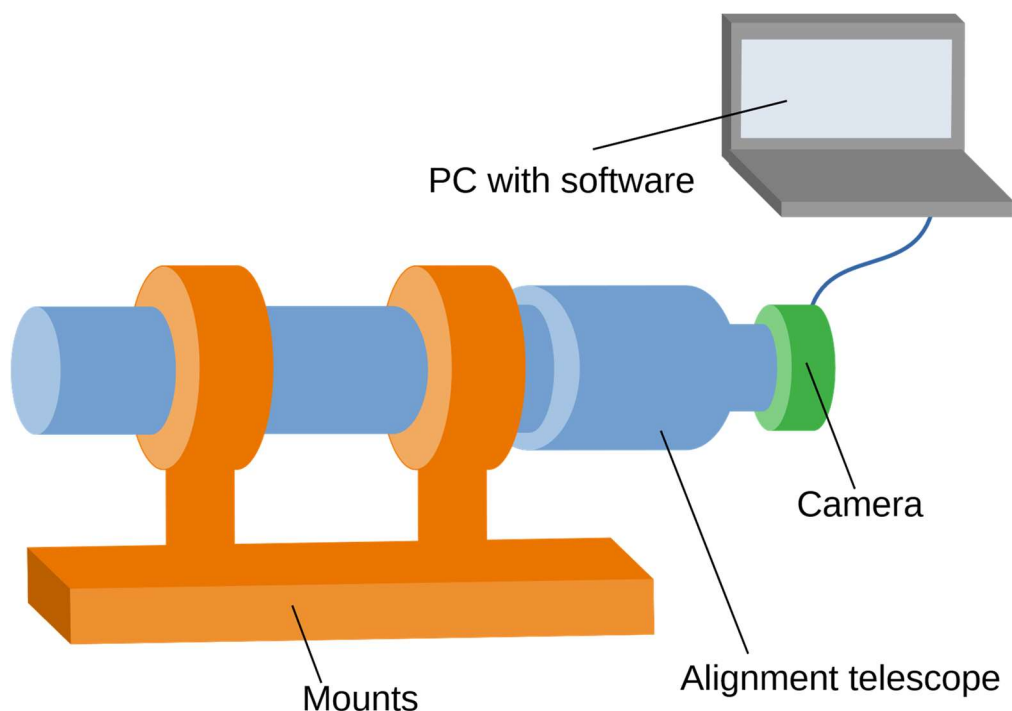


Figure 2: Overview of alignment telescope with camera system

4.1. Requirements for System Components

Table 1: Alignment telescope required parameters

Measurement units	Metric system
Working distance	0 – infinity (acceptable: 0 – 30 m)
Measuring range	min. +/-1.0 mm
Best accuracy	10 µm (acceptable: proportional decreased of accuracy at longer distances by 70 µm at 30 m)
Resolution	10 µm
Magnification	4x at minimum working distance to 34x at infinity
Barrel diameter	57.137–57.147 mm
Equipment	optical micrometer for measuring deviations from the optical axis in two directions
Accessories	storage and transport case with shock-absorbing padding

Table 2: Camera system required parameters

Camera Magnification	x2 – x8
Accessories	Cables for connecting the camera with the computer (e.g. USB or RJ45) or equivalent hardware for wireless communication
	Clamping system for installation onto telescope eyepiece

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Software	Ability for reading, analysing, saving, and exporting images (screenshots) in at least one of the formats: JPG, PNG, PDF
Computer	Preconfigured laptop, PC or notebook with Software for the camera operation. Preferred operating systems: Windows or Linux.

4.2. Interfaces

The alignment telescope and camera require the following interfaces:

- telescope <-> tripod: the mounts for the telescope, which requires a barrel diameter of 57.137–57.147 mm,

5. Procedure

5.1. Design Phase

After selection of the final hardware proposal and prior to production, compliance with this specification shall be evaluated using a test system provided by the manufacturer. The test system consists at least of one alignment optical telescope, camera, cable for the camera, computer with a software.

Selection of the final hardware and software represents the formal FAIR milestone “conceptual design review” (CDR).

Apart from technical parameters, these tests verify the integration of the hardware into the FAIR holders for the telescopes and the integration of the computers into the GSI/FAIR network, and assess the software functionality and interfaces.

Approval of the final hardware and software represents the formal FAIR milestone “final design review” (FDR). This milestone defines the approval for the series production.

5.1. Production Phase

After FDR approval, production and documentation of components is carried out by the manufacturing company according to the specifications of this document, and to European regulations and standards. CE declaration of conformity is required.

6. Quality Assurance, Tests and Acceptance

6.1. Quality Assurance System of the Contractor

The alignment telescope with camera system will be produced according to the manufacturer's quality and inspection plan (QIP).

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6.2. Factory Acceptance Test (FAT)

Prior to shipment, no additional acceptance tests are required by the Company beyond the FAT tests performed according to the manufacturer's own quality assurance plan. FAT protocols shall be supplied together with the hardware units or must be made available in electronic format, e.g. as PDF files.

6.3. Site Acceptance Test (SAT)

- SAT Aa: Incoming goods inspection (SAT Aa) will be carried out to verify the integrity of the delivered products.
- SAT Ab of FoS: Acceptance tests of hardware functionality:
 - functionality check of the alignment telescope with camera system and software according to the instructions included in user manual

7. Documentation

The following list of documents shall be included in the scope of delivery:

- User manual(s) containing information on installation, operation and maintenance for all hardware components
- Software including the corresponding manuals and documentation

Documentation should be delivered in electronic format (PDF).

8. Related Documents

RECOMMENDED

[1] <https://fair-center.eu/>

MANDATORY

[2] EDMS 1229368 F-TG-B-0.5e Component-Identification and Barcode