List of Specifications for the ATLAS Forward Alignment System

1 Introduction

The principal scheme of one octant of the ATLAS forward alignment system, as it was described in [1] - [3], is shown in Fig. 1. The

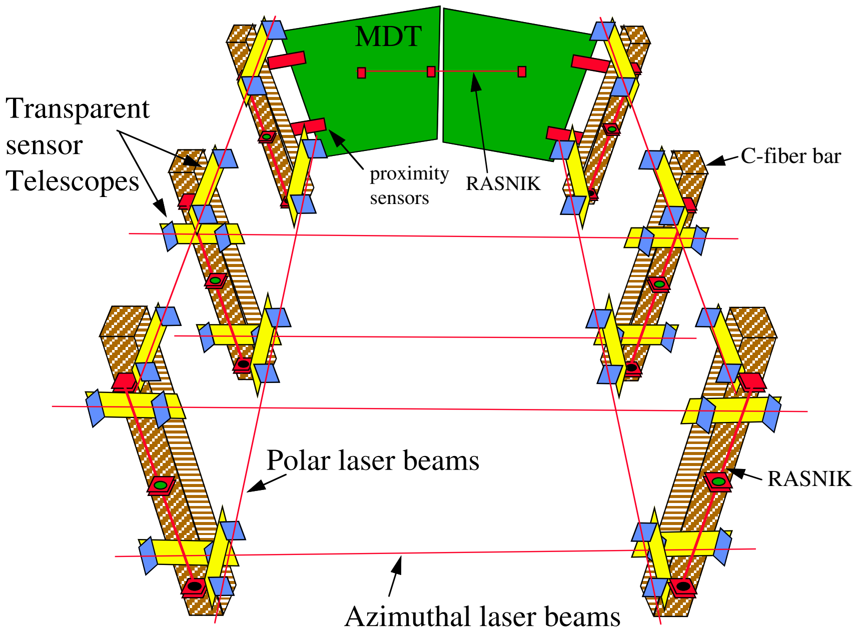

Figure 1: Principal layout of the forward alignment system. System of reference bars with polar and azimuthal bar-bar monitors, and the MDT muon chambers connected to bars with azimuthal bar-chamber monitors.

elements and subsystems of the whole system are the followings:

- polar monitors which align each triplet of bars in r-z planes;
- azimuthal monitors which connect each pair of bars in r-ϕ planes;

- proximity sensors for bar-chamber and chamber-chamber connections;
- alignment bars with optical elements mounted on them;
- the MDT chambers with alignment monitors mounted on them.

Lists of specifications for each of these subsystems are presented below.

2 Polar Monitors

The polar system of monitors has three technology options:

- multi-point monitors based on the use of the ALMY sensors (baseline) shown in Fig. 2;

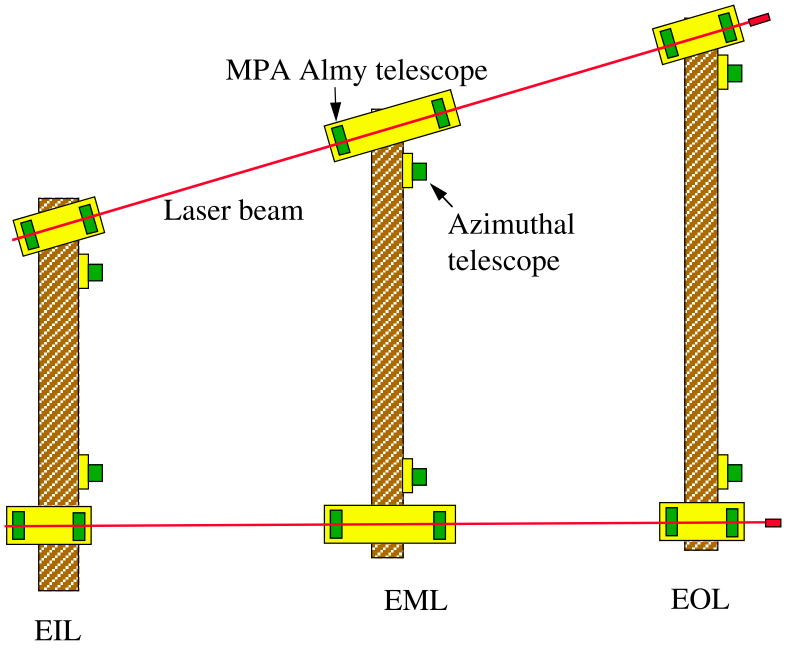

Figure 2: Principal layout of the system of polar monitors based on the ALMY sensors

- similar system of multi-point monitors based on the use of the STAMP telescopes (Fig. 3);
- combination of BCAM monitors (Fig. 4).

The following characteristics of the polar monitor elements are relevant for the performance of the alignment system:

- The multi-pont (ALMY/STAMP) monitor parameters:

  transverse coordinate resolutions, $\sigma_{x,y}^{MP}$

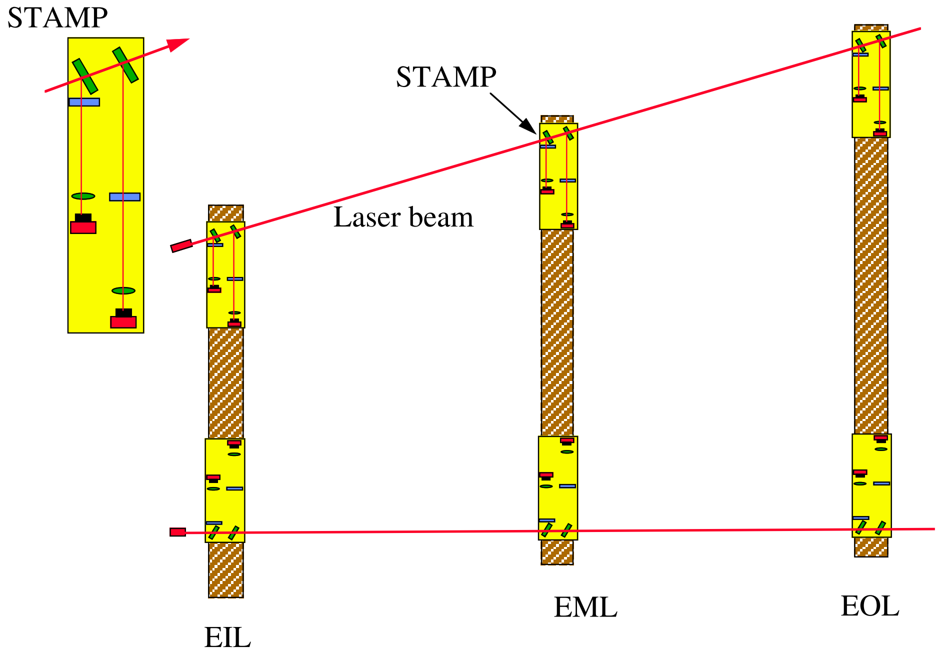

Figure 3: Principal layout of the system of polar monitors based on the STAMP telescope

angular resolution of the ALMY/STAMP telescope, σ_{angle}^{MP}

dispersion of the laser beam deflection, σ_{defl}

sensor size, S^{MP}.

the laser beam diameter, $D_{beam} = 4\sigma_{beam}$

minimal distance between beam center and sensor edge, d_b^{min}

deflection of the laser beam direction due to the air turbulence and temperature gradients, σ_b

- The BCAM parameters:

  angular resolution of the BCAM monitor, σ_{angle}^{BCAM}

  BCAM dynamic range, Δ_{angle}^{BCAM}

The specifications for these parameters are shown in Table 1.

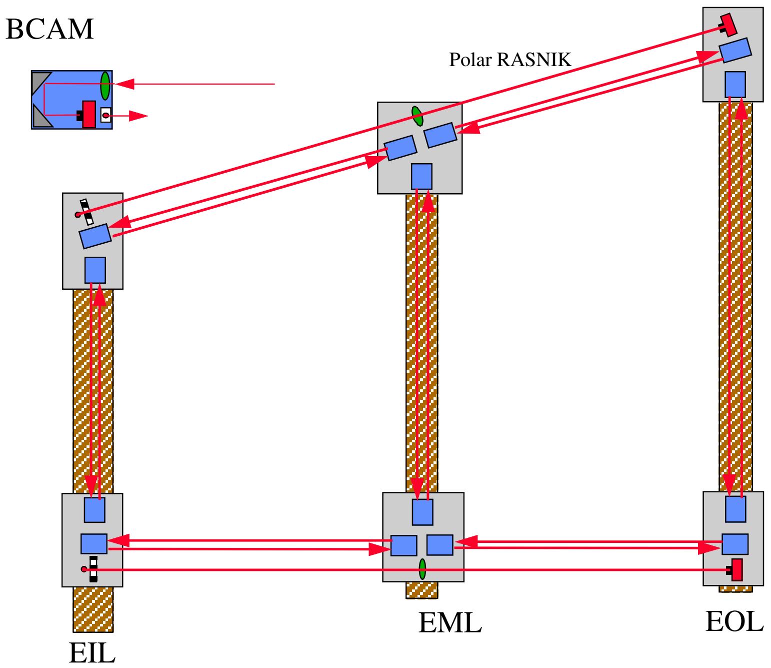

Figure 4: Principal layout of the system of polar monitors based on the combination of BCAMs

Table 1: Specifications for the polar monitors

Element	Parameter	Specification	Comment
ALMY/STAMP sensors	$\sigma^{MP}_{x,y}$	$\leq$5 μm	
	σ^{MP}_{angle}	$\leq$40 μrad	
	σ_{defl}	$\leq$4 μrad	
	S^{MP}	$2 \times 2\ cm^2$	EE,EM,EO
	S^{MP}	$3 \times 3\ cm^2$	EI
	D_{beam}	$\leq$ 4 mm	Diffr.limit
	d_b^{min}	$\geq$2 mm	
	σ_b	$\leq$5 μrad	
BCAM	σ^{BCAM}_{angle}	$\leq$5 μrad	
	Δ^{BCAM}_{angle}	$\pm$ 2 mrad	

3 Azimuthal Monitors

Requirements for the azimuthal BCAM parameters

- angle resolutions, σ_{angle}^{BCAM}
- dynamic range, Δ_{angle}^{BCAM}

are shown in Table 2.

Table 2: Specifications for the azimuthal BCAMs

Parameter	Specification	Comment
σ_{angle}^{BCAM}	$\leq$40 μrad	Calibration
Δ_{angle}^{BCAM}	$\pm$2 mrad	

4 Proximity RASNIKs

The set of parameters of the proximity RASNIKs

- transverse coordinate resolutions, $\sigma^R_{x,y}$
- magnification resolution, σ^R_{magn}
- dynamic range, $\Delta^R_{x,y,z}$

is specified in Table 3.

Table 3: Specifications for the Proximity RASNIK

Parameter	Specification	Comment
$\sigma^R_{x,y}$	$\leq 5\ \mu$m	Calibration
σ^R_{magn}	$\leq 10^{-3}$	Calibration
Δ^R_x	± 1 cm	
Δ^R_y	± 1 cm	
Δ^R_z	± 1 cm	

5 Alignment Bars

The parameters characterizing the alignment bars are the following:

- Material:

  coefficient of thermal expansion, c_T, or

  temperature measurement resolution, σ_T,

  stability to humidity changes, c_H,

- Tolerances of sensor positioning on the alignment bars:

  polar monitors, $\delta^{pol}_{x,y,z}$

  azimuthal bar-bar BCAMs, $\delta^{bb}_{x,y,z}$

  proximity bar-chamber RASNIKs, $\delta^{bc}_{x,y,z}$

  bar shape RASNIKs, $\delta^{bs}_{x,y,z}$

- Accuracy of sensor aiming on the alignment bars:

  polar monitors, δ^{pol}_{angle}

  azimuthal bar-bar BCAMs, δ^{bb}_{angle}

The specifications for these parameters are shown in Table 4.

Table 4: Specifications for the alignment bars

Element	Parameter	Specification	Comment
Material	c_T (C-fiber)	$\leq 10^{-6}\ m/m^oC$	
	σ_T (steel)	$\leq 0.1^oC$	
	σ_T (Al)	$\leq 0.05^oC$	
	c_H	$\leq 10^{-7}\ m/m\%w$	
Sensor positioning	δ_x^{pol}	$\pm 100\ \mu$m	Measurement
	δ_y^{pol}	$\pm 30\ \mu$m	-
	δ_z^{pol}	$\pm 30\ \mu$m	-
	δ_x^{bb}	$\pm 100\ \mu$m	-
	δ_y^{bb}	$\pm 30\ \mu$m	-
	δ_z^{bb}	$\pm 30\ \mu$m	-
	δ_x^{bc}	$\pm 300\ \mu$m	-
	δ_y^{bc}	$\pm 30\ \mu$m	-
	δ_z^{bc}	$\pm 30\ \mu$m	-
	δ_x^{bs}	$\pm 30\ \mu$m	-
	δ_y^{bs}	$\pm 500\ \mu$m	-
	δ_z^{bs}	$\pm 30\ \mu$m	-
Sensor aiming	δ_{angle}^{pol}	$\pm 40\ \mu$rad	Measurement
	δ_{angle}^{bb}	$\pm 80\ \mu$rad	-

6 The MDT Chambers

The parameters relevant for the alignment of the MDT chambers

- Accuracy of sensor positioning on the MDT chambers:
  chamber-bar sensors, $\delta^{cb}_{x,y,z}$
  chamber-chamber planarity sensors, $\delta^{cc}_{x,y,z}$
- Accuracy of sensor aiming on the MDT chambers:
  chamber-bar sensors, δ^{cb}_{angle}
  chamber-chamber planarity sensors, δ^{cc}_{angle}

are shown in Table 5.

Table 5: Specifications for the MDT chambers

Element	Parameter	Specification	Comment
Sensor positioning	δ^{cb}_{x}	$\pm 300\ \mu$m	
	δ^{cb}_{y}	$\pm 30\ \mu$m	
	δ^{cb}_{z}	$\pm 30\ \mu$m	
	δ^{cc}_{x}	$\pm 500\ \mu$m	
	δ^{cc}_{y}	$\pm 100\ \mu$m	
	δ^{cc}_{z}	$\pm 30\ \mu$m	
Sensor aiming	δ^{cb}_{angle}	$\pm 100\ \mu$rad	
	δ^{cc}_{angle}	$\pm 100\ \mu$rad	

References

[1] H. Kroha, A. Ostapchuk *A New Alignment Scheme for the ATLAS Muon Spectrometer*, ATLAS Internal Note MUON-NO-070, 28 February 1995.

[2] J. Bensinger, H. Kroha, A. Ostapchuk *The Forward Alignment System of the ATLAS Muon Spectrometer*, ATLAS Internal Note MUON-NO-168, 1997.

[3] *Muon Technical Design Report* , CERN/LHCC/97-22, 5 June 1997.