# Recent Developments in Angle Metrology

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**Abstract**

An overview of the current status of the state of art in angle metrology is provided by giving update information on the Joint Research Project (JRP) SIB58 'Angles' of the European Metrology Research Programme (EMRP). Current and future challenges to angle metrology are described presenting the requirements on the quality control of ultra-precise X-ray optical components for application in the Synchrotron Radiation (SR). Investigations performed on autocollimators for the first time under extremely challenging measuring conditions (performance with variable path lengths, with two axis operation, at small apertures, on curved surfaces, with aperture positioning relative to autocollimator axis), development of novel methods for determination of error sources in angle encoders and small angle generators to provide traceability with expanded uncertainties of less than 0.01" (50 nrad) are reported with the first results in addition to the highlights from the work carried out in the JRP.

## 1 Introduction

Angle metrology is a key technology for scientific and industrial applications of high value, enabling countries to be globally competitive. Precise angle measuring devices – such as angle encoders, angle interferometers, small angle generators and autocollimators – are extensively used in various applications where high precision is demanded. In precision engineering the performance of ultra-precise machines in terms of straightness, flatness, and parallelism is commonly measured by autocollimators which enable the precise non-contact measurement of angles. Their field of application also includes the ultra-precise form measurement of optical surfaces like beam guiding and shaping optics for beamlines at synchrotron storage rings and Free Electron Lasers (FEL) or flatness standards for interferometer calibration. Further industrial applications for precise angle measuring devices exist in the area of automobiles, aircraft industry and robotics as well as in several scientific applications (e.g. the measurement of the gravitational constant *G* and the angular stabilisation of X-ray optical components).

Traceability for high precision angle metrology is demanded in all these areas and is increasing continuously with ever more stringent demands. In order to address these demands and to cope with challenging issues, a Joint Research Project (JRP) called 'Angle Metrology', supported under the European Metrology Research Programme (EMRP), was started in September 2013 (EMRP SIB58) [1]. The project aims to improve the dissemination of the SI angle unit 'radian' which is currently in demand by the most challenging applications. Specifically, it aims to enable traceability of the measurand 'angle' with lower uncertainty (less than 50 nrad). The JRP includes 10 European NMIs of all sizes and capabilities with high level facilities for angle metrology, 2 leading NMIs in angle metrology from outside Europe, 2 world leading producers of angle metrology equipment and a research institute for development of precision equipment (Figure 1). The different expertise and facilities of each partner are jointly used to tackle the challenging issues.

This paper gives a summary and information on the first results of the project. We explain recent developments and the demands in angle metrology related to upcoming applications. Activities carried out in various fields of precision angle metrology concerned with the use and realisation of the SI angle unit radian are also reported. These range from the application, performance and calibration of autocollimators to the realisation of the SI unit 'radian' by means of angle encoders and small angle generators (SAGs). An overview of the first precise calibration of autocollimators with angle encoders by use of a shearing technique is given. Separation of autocollimator and angle encoder errors at an uncertainty level of 1 milliarcsec (5 nrad) has been achieved which provides a solid base for the improvement of classical autocollimator calibration methods with the aim to reach substantially lower calibration uncertainties.

The progress in work on spatial angle calibrations of autocollimators and recent investigations on applications of autocollimators in profilometry under challenging conditions are presented. The current investigations on precise angle encoders (which feature both multiple and single reading heads) to define the error sources which impede their application are explained as well as the specific needs of the end users.

These improvements will provide significant support to, e.g., the inspection of the quality and alignment of optical components at accelerator based synchrotron radiation facilities, the measurement of long distances utilising angle metrology, and angle measuring methods for nrad level rotation and tilt control in industrial production.

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*Figure 1: SIB58 Angles – Angle Metrology Joint Research Project (JRP) Partners.*

## 2 Current and future challenges in angle metrology

Autocollimators are optical instruments which measure angular displacement of reflecting surfaces. They have a wide range of applications in metrology and industrial manufacturing as they are used as a non-contact angle measurement probe [2]. They are also used in optical profilometry [3-24] and recently became very popular since autocollimator-based slope measuring profilers represent the state of the art for the inspection of ultra-precise X-ray optical components of today [13] (Figures 2 and 3).

Autocollimators are used in optical profilometry different than their classical use. An aperture is positioned in the optical axis (i.e. in front of the Surface Under Test (SUT)) in order to increase lateral resolution during inspection of optics (Figures 1 and 2). This strongly influences the angle response of the autocollimator particularly for the aperture sizes of a few millimetres. Besides, variation of optical path during inspection of optics, properties of Surface Under Test (SUT) such as reflectivity and curvature (for inspection of strong and locally curve beamline optics) have strong influence on angle response of autocollimators [14-24].

Another issue is the demand of high precision angle measurement from autocollimators in the level of 0.01" (50 nrad) under these challenging measurement conditions [13]. It is expected that future application of slope measuring profiler will become more challenging. The inspection of long ultra-precise slightly curved focusing mirrors up to a length of 1000 mm with design parameter for the residual slope deviation in the range of 50 nrad rms is under discussion [13, 25]. To measure these mirrors an angular range of about ± 50 µrad on the autocollimator is needed to cover the full slope profile of the optics [13]. New generation of highly accurate angle-measuring optical profilometers have to provide single nm-accuracy on a length scale of 1000 mm not only for flat surfaces but also for curved ones. Currently, a spatial resolution of 1 to 2 mm (depending on the aperture size used to shape the measurement beam) is state of the art [13, 26]. An improvement to a value of 0.5 mm would be a significant step forward [13].

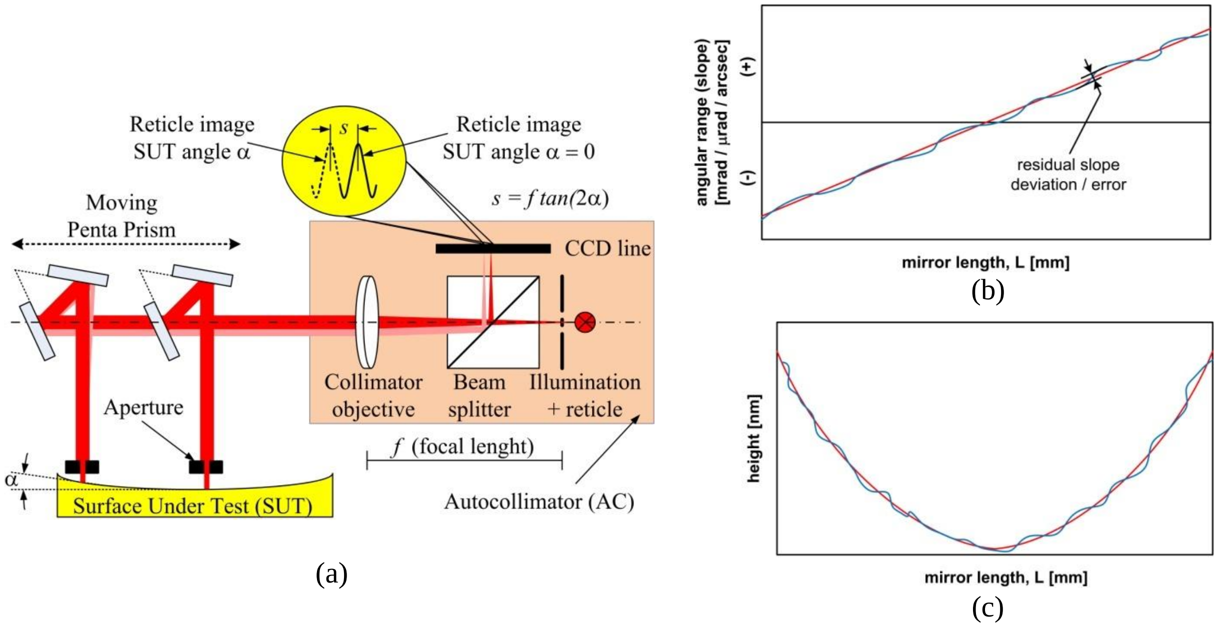



*Figure 2: Use of autocollimators in optical profilometry (a) Schematic view of a moving penta-prism slope measuring profiler (b) Angular measurement by autocollimator (c) Figure of the mirror obtained by integration of the slope data.*

In order to use the autocollimator's calibration values, the autocollimator must operate in the experimental set-up under the same measurement conditions when calibrated. In case of different conditions, additional errors in the autocollimator's angle response occur and they need to be characterised by additional calibration or ray trace modelling. This requires further extensive research to be carried which has not been done so far [3-24].

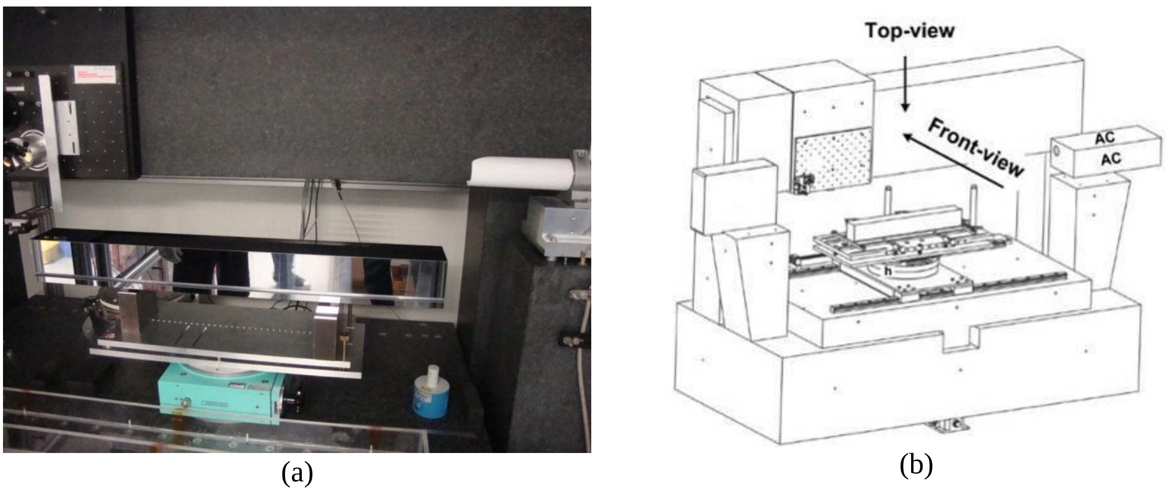



*Figure 3: Autocollimator-based slope measuring profiler (NOM) of HZB (REG of SIB58 Angles), (a) Inspection of synchrotron radiation optics in HZB (b) Schematic view of NOM.*

Autocollimators may also be calibrated in situ in order to have the autocollimator under the same operating conditions as in the specific measurement application. Several approaches to develop such on-site calibration tool are known from the last few years like the universal test mirror (UTM) [16] and the vertical angle comparator VAT [14]. Both systems were developed at synchrotron labs and are expert systems. The handling of these devices is in part complicated and time consuming.

Detailed report for a demanded on-site calibration tool was prepared under SIB58 angle project and presented to synchrotron community [13] reporting that there is a need for on-site calibration tool having ability to calibrate autocollimators in the expanded uncertainty of better than 50 nrad (0.01”). Detailed information for features and parameters of the instrument (calibrator) to be used in the metrology departments of accelerator based (ring- and linac-type) synchrotron facilities have been published in [13].

Application of autocollimators in profilometry requires more specific calibration of these devices [18, 19]. Due to special use of autocollimators in profilometers, it is also advisable to check the behaviour of both autocollimator axes (X and Y) since the crosstalk effect was observed in many autocollimators, when the axis values are used in extreme ranges (e.g. when X axis value is used with high Y axis values) [13, 27-29].

Considering these issues, tasks and work packages of SIB58 Angles have been designed (Figure 4). Particular effort is made to improve the performance of autocollimators in the first two work packages. In order to assure traceability for the required uncertainty levels, further research was planned on precise angle encoders and small angles generators which are used for realisation of SI unit radian with methods of ‘subdivision of full circle - 2π rad’ and 'ratio of two lengths' respectively in other two work packages. Below, we explain the advanced research work planned under SIB58 Angles project and report highlights from the first results.

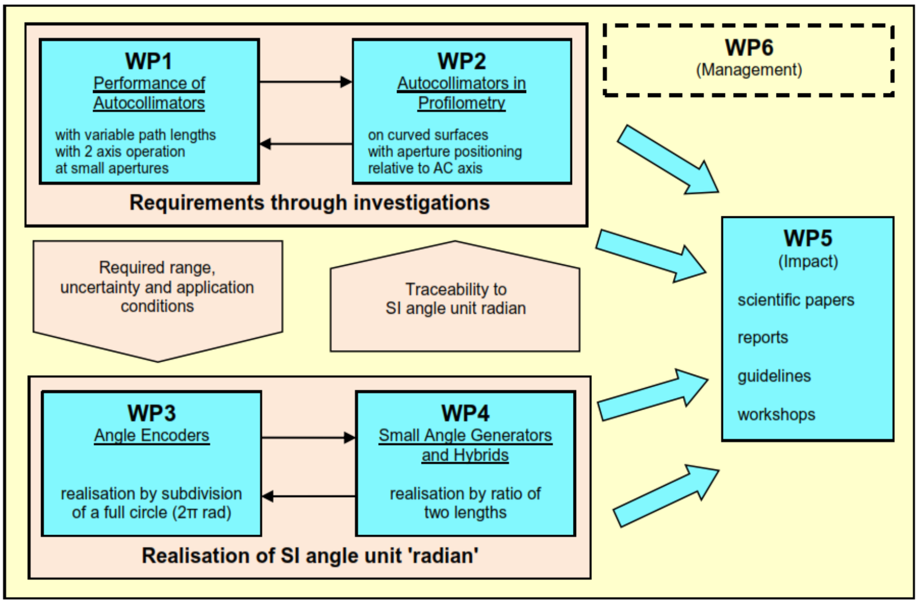



*Figure 4: Work Packages of SIB58 Angles – Angle Metrology Joint Research Project (JRP).*

## 3 Addressing the challenges in SIB58 - Angle Metrology Joint Research Project

### 3.1 Metrological characterisation of autocollimators (WP1)

Demanded precision for angle measurements carried out by autocollimators is increasing for scientific and industrial applications of high value. A review of the state of the art of autocollimator application, performance, and calibration has been prepared in the SIB58 project and can be accessed via [1]. In order to answer the challenging demands in general use of autocollimators (including profilometry), this Work Package focuses on investigations for the influence of the path length of the autocollimator beam, of the sagittal beam deflection by the Surface Under Test (SUT), and of small apertures for restricting the autocollimator beam which cause diffraction and interference.

Variation in the optical path length of the autocollimator beam has influence on the autocollimator's angular response [14, 20, and 21]. Investigations are essential for angular error (pitch and yaw) measurement of precision guides and also for deflectometric profilometers as the optical path length changes in both cases. During such measurements, the reflected beam follows different geometrical paths through the autocollimators' optics and, in conjunction with aberrations and alignment errors of the optical components, path-length-dependent angle measurement deviations are induced.

Experimental work of partners for testing autocollimators at different beam path lengths is in progress. Ray tracing simulations of an autocollimator (AC) have been completed. The ray tracing models will then be deployed to link experimental data to opto-mechanical causes.

Two-axis (2D) calibrations of autocollimators for the first time are in progress [29]. This is required since the autocollimator beam is deflected in two orthogonal angular directions by reference mirror / the SUT in most autocollimator applications resulting in the crosstalk effect due to simultaneous engagement of both measuring axes. In other words, their angle measurements are not independent of each other due to alignment errors and optical aberrations of the autocollimator's internal components, and imperfections of the reticles which are imaged onto the autocollimator's CCD [13, 27-29].

The first innovative device for two-dimensional (2D) calibrations of autocollimators was set-up and tested at the PTB including its ray tracing model [29]. It makes use of an innovative Cartesian arrangement of three autocollimators, two reference autocollimators and the autocollimator to be calibrated, all orthogonal with respect to each other [27-29]. A further approach based on angle interferometry is currently being designed at MIKES [1]. Both set-ups will complement each other due to their differing physical principles of spatial angle measurement (autocollimators vs. angle interferometry).

The work for improvement of autocollimator performance at small apertures is in progress. This is of special importance for achieving improved lateral resolution with autocollimator-based deflectometric profilometers as well as angular displacement measurement of reflecting surfaces in very small sizes. At small apertures, diffraction and interference distort the autocollimator's reticle image on its CCD detector and angle measurement errors with a period which corresponds to the CCD pixel size occur [30-36]. This is hard to characterise as the autocollimator calibration needs to be performed with high angular resolution across the entire measurement range [17, 21].

With effective cooperation between partners of SIB58 project (one partner being the autocollimator manufacturer Möller-Wedel Optical (MWO) [1, 2]), PTB will address issues such as the adaptation of the reticle pattern which is imaged on the CCD to the CCD's specific properties and the improvement of the algorithms used for the sub-pixel location of the reticle image on the CCD by use of an Elcomat Direct [2]. This work is in progress.

### 3.2 Application of autocollimators in profilometry (WP2)

The angle response of an autocollimator is strongly affected by its measuring conditions and this is of special importance to its application in deflectometric profilometers for the precise form measurement of optics. A review of the state-of-the-art of angle-based precise form measurement of optical surfaces with deflectometric profilometers has been prepared under SIB58 project and can be accessed via [1].

In this work package, a special – but not exclusive – focus was set on the form measurement of beam-guiding and -shaping optics for synchrotron and FEL beamlines which relies on autocollimator-based profilometers. The reason for this is that these applications are the most challenging ones due to the size, strong curvature, and stringent shape tolerances of the measured optics. The investigations on the influences of properties of the SUT, primarily its curvature and reflectivity (on the angle response of autocollimators) and on the highly reproducible positioning of the aperture which, in profilometers, defines the beam footprint on the SUT are being carried out.

Most optics in synchrotron and FEL beamlines posse strong and locally varying curvatures affecting both the location and the quality of the image of the autocollimator's reticle on the CCD detector. They even exhibit different radii of curvature in longitudinal and sagittal directions.

A systematic effort to characterise the influences of these surface characteristics is essential for advancing deflectometric form measurement. For this, extensive experimental characterisation of the influence of flatness deviations of the SUT on the autocollimator's angle measurement by using surfaces of different radii of curvature and different beam path lengths is in progress. Ray tracing modelling of the curvature's influence on the autocollimator's angle response has been completed. This will be used to support the experimental work.

The characterisation of the influence of the reflectivity of the SUT on the autocollimator's angle measurement is in progress. Extensive calibrations of different autocollimators at different SUT reflectivity were performed by PTB resulting in a novel knowledge first time particularly for synchrotron metrology, autocollimator application and design. It was found that autocollimators show different behaviours (even individual exemplars of the same type). In this case, ray tracing simulations are not sufficient as stray light influences cannot be modelled adequately.

The reproducible centring of the circular aperture axis (used to restrict the beam footprint on the SUT in deflectometric profilometers) relative to autocollimator's optical is a crucial task since autocollimator angle response depends sensitively on its measuring conditions (e.g. the aperture's positioning) [13, 19, 37 and 38]. The non-repeatable centring during calibration and experimental set-up (i.e. in profilometry) will restrict the use of autocollimator calibration values. Ray tracing simulations of an autocollimator with variable aperture positions were completed and the results proved that "a device and standardised procedure for the highly reproducible (<0.1 mm) positioning of small (1.5 – 2.5 mm in diameters) apertures near the SUT relative to the autocollimator's optical axis during autocollimator use and calibration" is required.

A novel aperture centring device (with reproducibility < 0.1 mm) and standardised procedure were developed first time for efficient use of autocollimators with its calibration results in deflectometric profilometry. Verification for the capabilities of the device and procedure by the project partners are in progress. This development is especially relevant to the application of autocollimators in deflectometric profilometers for the precise form measurement of beam-shaping optical surfaces for synchrotrons and FEL [3-24].

### 3.3 Metrological investigations on precise angle encoders (WP3)

In order to provide traceability during investigations and enhancement of autocollimators' performance under extremely challenging measuring conditions, small angle measurements are required at very low uncertainty values, e.g. less than 0.01" (50 nrad) with $k$=2 [13]. Precise angle encoders fitted the high precision rotary tables are utilised for small angle generation as well as large angle generations [39-46]. Angle encoders are also essential components of a wide range of rotating precision devices, such as industrial robots in manufacturing or under UHV-condition for high resolution synchrotron radiation monochromators [47, 48]. Their angle deviations need to be calibrated by comparing encoders with the reference encoders provided by e.g. NMIs. For industrial applications, however, fast and precise method for the situ calibration of encoders is preferable [24]. These challenges are tackled in SIB58 project of WP3. A review of the state of the art of angle encoder application, performance, and calibration has been prepared in the SIB58 project and can be accessed via [1]. The WP3 aims to improve the performance of precise angle encoders and specifically focuses on the development of novel concept rotary tables (based on a rotating encoder using a pair of reading heads), investigations on calibration of rotary tables fitted with multiple and one reading head angle encoders, novel methods (e.g. shearing techniques) for autocollimator calibration using angle encoders and new emerging methods for better signal interpolations in angle encoders.

Construction of a new rotary table (so called Rotating Encoder Standard, RES) was completed in INRIM aiming to reduce the non-uniformity and interpolation errors by applying a concept of using a pair of heads, one fixed and a second rotating with the measurement drum (Figures 5 and 6). The angle measurement is based on the phase difference between the fixed head signal (used as a reference) and the rotating head. The phase measurement is intrinsically free from nonlinearities and the encoder errors are cancelled by the average made each complete revolution of the encoder.

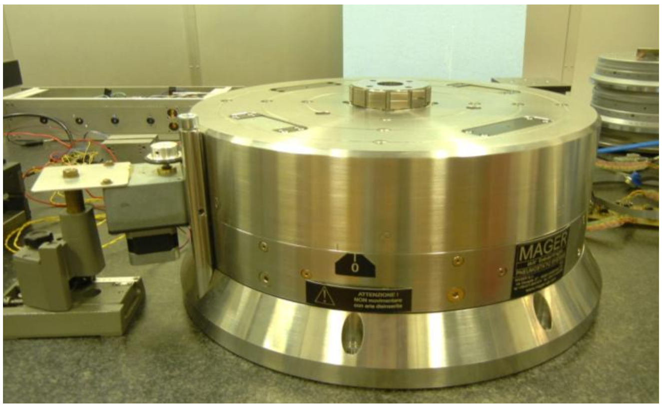
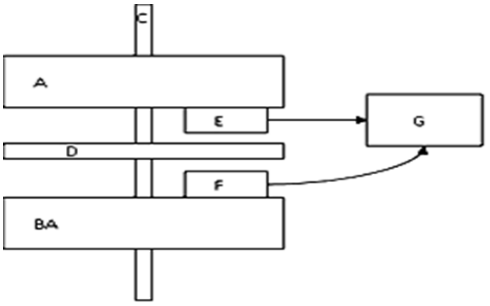



*Figure 5: INRIM Rotating Encoder Standard (RES).*

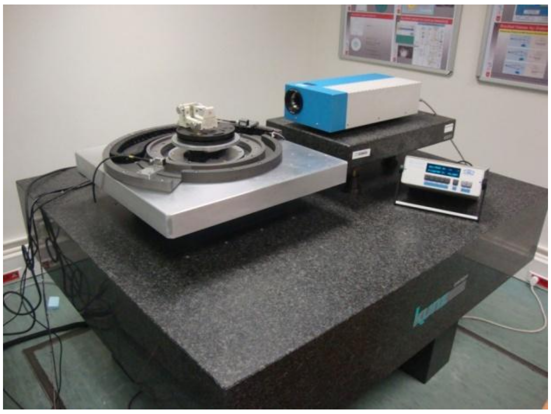



D continuously rotating optical encoder; F: reading head fixed to the reference frame BA; E: reading head fixed to the measuring table A; G: phase measurement

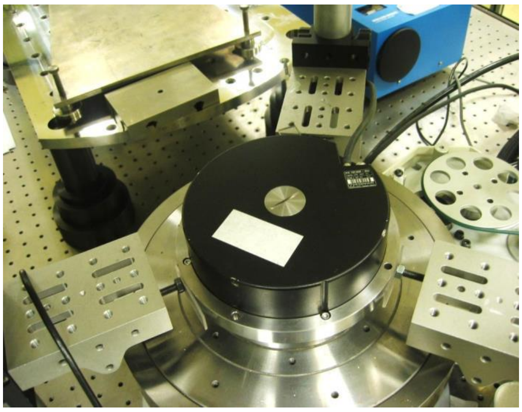
*Figure 6: Principle of RES.*

Investigations on calibration of rotary tables fitted with 'multiple reading head' angle encoders are in progress. A self-calibration method for the fast and precise in-situ calibration of multiple head angle encoders without recourse to external reference standards has been developed in PTB [1, 49]. The method relies on a suitable geometric arrangement of multiple reading heads, which read out the radial grating of the angle encoder at different angular positions. The measurement differences of pairs of heads are analysed using Fourier-based algorithms to recover the graduation error of the grating. The evaluation and correction of error influences due to lateral shifts of the centre of the encoder's grating during its rotation have been achieved and detailed results were published [49]. Determination of optimised reading head arrangements in encoder self-calibration for cost-effective industrial applications is in progress.

Investigations to develop novel methods for precise calibration of 'one reading head' angle encoders fitted to Rotary Tables (RTs) (so called angle comparators) is in progress. The aim is to achieve uncertainties less than 0.01" ($k$=2) with such angle comparators. Extensive experimental characterisation and calibration of angle comparators fitted with one reading head encoders are being carried out using various approaches in TUBITAK, CEM, FAGOR AUTOMATION, MG, AIST and LNE (Figure 7). The approaches include investigation of form errors against errors of angle encoder and their effects, calibration of angle encoders using available methods but further correcting with supplementary correction data, investigations in encoder calibration using another encoder with controlled and measured alignment methods using special set developed and investigations on calibration of encoders using self-calibration and comparison versus a second commercially available encoder taken as a standard.



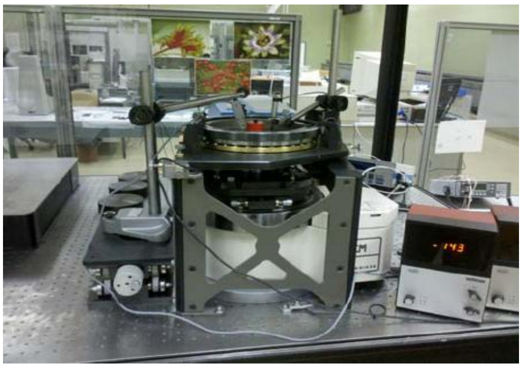
(a)



(b)

*Figure 7: Preparations for characterisation and calibration of angle comparators* (a) *in TUBITAK and (b) in CEM.*

In conjunction, practical calibration of one reading head angle encoders using another encoder is also investigated. New tool utilising flexures and micrometer actuators were developed by IK4-TEKNIKER and FAGOR AUTOMATION for measuring encoders on the angle comparators (e.g. Rotary Tables fitted one reading head angle encoder). Experimental set-up was realised in CEM and the work is in progress (Figure 8).



(a)

(b)

*Figure 8: Experimental set-up for calibration of encoders in CEM (a) adjustment of the encoder position with respect to the RT based on indications observed by inductive probes (b) Flexures plate situated below the intermediate plate fixing the encoder under calibration and commanded by micrometer actuators.*

Development and evaluation of novel calibration methods for calibration of autocollimators using angle encoders are in progress. Rotary tables fitted with angle encoders to provide traceability in autocollimator calibrations requires priory detailed calibration by use of various methods (e.g., self- and cross-calibration) limiting the uncertainty values which can be achieved in autocollimator calibration. However, it is possible to separate the errors of the autocollimator and of the angle encoder applying defined angle offsets between both systems (i.e. adapting the shearing method). In this way, simultaneous access to the angle deviations of the autocollimator and to those of the angle encoder in the rotary table is achieved and thus the uncertainty of the angle measurement with both systems is reduced.

The first adaptation of advanced error-separating shearing techniques to the precise calibration of autocollimators with angle encoders has been completed in PTB [1, 50]. Autocollimator and angle encoder errors were separated with very small residuals demonstrating systematic error influences at a level below 2 nrad (0.0004”). This achievement is impressive and provides a solid base for improvement of the classical autocollimator calibration methods to reach substantially lower calibration uncertainties. Detailed information is available in [50]. Two uncertainty models for the novel shearing technique were developed first time. One is Monte Carlo approach by PTB and the other is analytical approach by TUBITAK giving about 1 milliarcsec (5 nrad) uncertainty level for separation of autocollimator and angle encoder errors. Compared to uncertainties reachable by conventional calibration methods for autocollimators, this represents an improvement by a factor of two to three.

Three sets of calibration data (obtained by applying defined angle offsets between autocollimator and the angle encoder) are taken in the shearing method. These three sets of data are used in the shearing algorithm providing re-constructed errors of angle encoder and autocollimator. The description of the shearing method is given in Figure 9. Please refer to reference [50] for details.

Application of shearing method requires very reproducible environment conditions and very reproducible reference angle measurement devices. The first adaptation of the shearing method was carried out experimentally in clean room environment using the special angle comparator of PTB (WMT 220). Now the work is in progress to apply the shearing method to various angle measurement devices (different Rotary Tables fitted with different angle encoders and head arrangements as well as different environment conditions) of consortium members in project SIB58 Angles (TUBITAK, INRIM, MG, CEM, LNE, AIST and IPQ). The aim is to evaluate the results obtained from different types of rotary tables fitted with different angle encoders in different environment conditions for application of shearing methods.

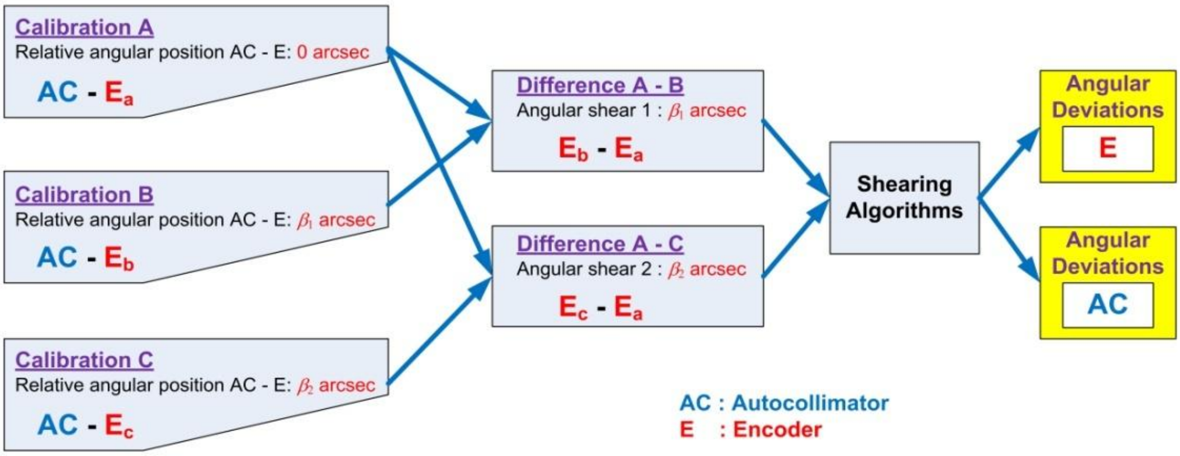



*Figure 9: Schematic description of the shearing method.*

Development of new methods for better signal interpolations in angle encoders is in progress. The aim is to measure interpolation errors and evaluate the performance of interpolators used in angle encoders in order to obtain better effective resolution (compared to basic resolution of grating's graduation lines). For this, measurement of interpolation errors will be carried out and then evaluation will be performed when compensation of interpolators is on and off. Shearing methods will be utilised here by applying to the different angle encoders of TUBITAK, INRIM, MG, CEM, FAGOR AUTOMATION for single reading heads and of AIST and PTB for multiple reading heads. First results taken in PTB [1, 50] showed that shearing method is ideally suited for the calibration of interpolation errors of the devices at small angular scales which are difficult to characterise with other methods. Additionally, KRISS completed the development of a new type reading head for encoders. This new type reading head applies a special algorithm to reduce nonlinearity errors. KRISS tested the new reading head when applied to linear encoders. Now the work is in progress for testing in angle encoders [1].

## 3.4 Small angle generators and hybrid angle comparators (WP4)

Extensive research work and new developments for improvement of small angle generators and hybrid devices are performed under work package 4 in order to provide generated small angles for extremely challenging values such as nanoradian (nrad) uncertainty and sub-nanoradian sensitivity. A review of the state of the art of Small Angle Generators and Hybrid's application, performance, and calibration has been prepared in the SIB58 project and can be accessed via [1]. The task of WP4 is to perform investigations on nanoradian uncertainty and sub-nanoradian sensitivity angle generation and measurements, measurement of small angles using Differential Fabry-Perot interferometer and frequency stabilised lasers, development of portable small angle generators for calibration of autocollimators with an uncertainty of 0.01", investigations and further improvements in hybrid angle comparators. Novel calibration methods for calibration of autocollimators using small angle generators (SAGs) is carried out by applying advanced error-separating shearing techniques in order to further investigate the errors sources since SAGs will show different systematic errors than angle encoders.

Extensive experimental investigations on small angle generation in nanoradian and sub-nanoradian level are in progress. For this, current state-of-art high precision small angle generators (i.e. nano angle generators) [51, 52] will be utilised by TUBITAK and INRIM with further improvements on the devices (new concept by INRIM) and ambient conditions. The aim is here to search the possibilities for reduction of 2 nrad repeatability to sub nanorad level. In addition, angle measurement using Differential Fabry-Perot interferometer and frequency stabilised lasers [53] are in progress at TUBITAK. Two laser heads are configured in various distances to each other (approx. 20 - 100 mm) to measure the small angles using definition of SI angle unit radian principle. The aim here is to utilise the picometre level sensitivity (with linearity error free) displacement measurement system for generation of angles in sub-nanoradian sensitivity.

The specific needs of the end users, e.g. current and also future needs of accelerator based (ring- and linac-type) synchrotron facilities, have been determined in detail for calibration of autocollimators used in challenging conditions. The report was presented to synchrotron community for further discussions and published in [13]. The report states that there is a need for on-site calibration tool having ability to calibrate autocollimators in the expanded uncertainty of better than 50 nrad (0.01”) in the range of ± 10” (±5 µrad) and expanded uncertainty of 0.04” (0.2 µrad) in the ranges of ± 1031” (±5 mrad) for currently available autocollimators and of ± 4125” (± 20 mrad) for future autocollimators [1, 13]. In order to tackle these demands, the work is in progress for development of large range small angle generators.

Three different novel angle interferometers (two of them based on displacement measurement with different configuration and the other based on Fizeau Angle Interferometer) were designed by CMI and INRIM respectively. IK-4 TEKNIKER designed a novel angle generation mechanism providing an advantageous actuator displacement to angle ratio, high stiffness and frequencies. The mechanism relies on flexures with a hybrid actuation. Design of other three novel precise angle generation mechanisms is in progress to produce different large range small angle generators (LRSAGs) by CEM, TUBITAK and INRIM.

Development of novel methods for calibration of autocollimators using different small angle generators (SAGs) are in progress to provide solutions for challenging applications at the forefront of angle metrology. A procedure for application of shearing method to calibration of autocollimators with Small Angle Generators was developed by TUBITAK and PTB. It was applied to SAG of TUBITAK using two different autocollimators and evaluation of the results and uncertainty calculations are in progress.

Error sources of hybrid angle calibrators based on the integration of rotary tables fitted with angle encoder and angular interferometer for generation of small angles are being investigated by SMD. The target uncertainty is of from $u \leq 0.001$ arcsec for angles up to 1 degree till $u \leq 0.005$ arcsec for angles up to10 degrees.

## 4 Conclusion

Joint Research Project (JRP) SIB58 ‘Angles’ of the European Metrology Research Programme (EMRP) was presented addressing the recent developments in angle metrology with current and future challenges. Highlights from the project and the first results were reported. It was shown that JRP focuses on the angle metrology investigations demanded by high level scientific and industrial applications as well as improvements in the classical angle metrology tasks. The improvement of angle metrology by challenging these tasks especially for synchrotron application is of strong strategic importance to the community as the angle measurement based form measurement of beam shaping optical surfaces currently limits their manufacturing. Such applications are the major demanded areas for lower uncertainty values less than 0.01” (50 nrad) in angle metrology. The project brings partners together with different expertise and facilities to tackle these challenging issues in a planned manner aiming to create high level impact and advances in the capabilities of the National Metrology Institutes (NMIs) and provides knowledge transfer between NMIs and synchrotron community.

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