14th International Workshop on Accelerator Alignment

Report of Contributions

https://indico.cern.ch/e/IWAA2016

Contribution ID: **1** Type: **ORAL**

Laser Scanning for the replacement of EVB2 in the ISIS Synchrotron

The EVB2 Magnet is a large vertical bending magnet located in the extraction line of the ISIS synchrotron.

The magnet is over 25 years old and increasingly unreliable.

Therefore a project was initiated to replace the EVB2 magnet; ISIS Survey Section was tasked with pre-aligning this replacement.

The existing magnet was aligned during the construction of the synchrotron, using optical instrumentation on a direct line of sight along the beamline. There are no fiducial marks and very limited data has been found relating to the initial installation.

The magnet is next to a high radiation area, which limits the time that can be spent close to the beamline.

We therefore decided that the best way to set up and pre-align the replacement magnet was to 'reverse engineer'the alignment.

The location, and high radiation levels, ruled out survey with a laser tracker and instead we opted to use the Trimble FX laser scanner.

Elements critical to the existing alignment were abstracted from the scan data and relative positions were then replicated in the pre-installation set-up of the replacement magnet, and referenced to fiducials on the magnet assembly.

The EVB2 magnet is scheduled for installation during June 2016.

Summary

Author: MILLINGTON, Tony (STFC Rutherford Appleton Laboratory)

Presenter: MILLINGTON, Tony (STFC Rutherford Appleton Laboratory)

Contribution ID: **2** Type: **ORAL**

Improvement of alignment and monitoring for cryomodule in CIADS

Because of its Invisibility and ultra-low temperature characteristics(4k), Cryomodule is the emphasis and difficulty of superconducting linac accelerator. This paper presents the alignment and monitoring of cryomodule. The author introduced, calculated and measured the vacuum and cry-deformation and displacement. As the heat conduction and expansion coefficient are both smaller, fiber glass G11 was chose as cry-monitoring target after simulated calculation. The new solutions adopted is collaborative alignment based on multi-laser tracker or portable coordinate measurement machine. The collaborative data shows a good agreement with previous. As the deformation and displacement is beyond the telescope range(±1.2mm), the dial indicator is used to reduce the error to 0.01mm. The above improvement greatly perfect the efficiency of collimating installation and the accuracy of low temperature monitoring, guarantee the success of 10 MeV CW proton beam.

Summary

Authors: Dr HE, YUAN (IMP,CAS); Prof. ZHANG, bin (imp,cas); Mr YUAN, jiandong (imp,cas); Mr YAO, junjie (imp,cas)

Presenter: Mr YUAN, jiandong (imp,cas)

Contribution ID: **3** Type: **ORAL**

Alignment Aspects of the Mu2e Magnetic Field Mapping System

This presentation outlines some facets of the new Muon Campus under development at Fermilab. Over the next years two experiments utilizing Muons will test the limits of the Standard Model of Particle Physics. The g-2 experiment tries to improve the accuracy of the measured magnetic momentum of Muons, while the Mu2e experiment is searching for Muon–to–Electron conversions predicted by some theoretical models. Both experiments require very accurate knowledge of the magnetic field properties in which these particles travel.
For the Mu2e detector solenoid a magnetic field mapping system has been proposed that utilizes a laser tracker to record the position information of the Hall–probes measuring the three dimensional magnetic properties of the solenoid field. The setup requires the operation of a laser tracker in a high magnetic field environment. Test measurements of various laser trackers under these conditions have been performed and the results will be presented.

Summary

Author: FRIEDSAM, Horst (Fermi National Laboratory)

Presenter: FRIEDSAM, Horst (Fermi National Laboratory)

Contribution ID: **4** Type: **POSTER**

Studies on transforming method of multi-system displacement monitoring system to global coordinate system in particle accelerators

The multi-system displacement monitoring system is designed and established to achieve the goals of position monitoring and benchmarks in high accuracy, by which the monitoring data can be reviewed in the global coordinate system and relative position displacement can be transformed to absolute position displacement. The system consists of Hydrostatic Leveling System (HLS), Wire Position Sensor (WPS), SpotOn and Inclination Sensors (IS). HLS is used to monitor the displacement in vertical direction, WPS and SpotOn are used to monitor the displacement in vertical and horizontal directions based on different principle. IS can obtain angle variations in biaxial directions. The calibration experiments of newly imported optical WPS are designed to obtain the accuracy, RMS and resolution. A series of experiments are executed after the installation and debugging of the whole system, including monitoring data comparison and coordinate system transformation of the data of HLS and WPS from sensors themselves to the global coordinate system. The measurement data of HLS and WPS are compared by combining with those of IS and SpotOn. The transformation from initial Sensor coordinate system to the platform coordinate system that established by some target ball bases of laser tracker in platform takes advantage of SA by combining with the measurement data of CMM and laser tracker. The transformation from five Platform coordinate systems to the SYSTEM coordinate system is made by combining with the measurement data of WPS and laser tracker. Then the SYSTEM coordinate system has been transformed to the Global system by the spatial measurement data from laser tracker.

Summary

National Synchrotron Radiation Laboratory, University of Science and Technology of China, Hefei, China

Author: HE, Xiaoye (USTC)

Co-authors: Mr ZHANG, Qiang (NRSL, USTC); Mr WANG, Wei (NSRL,USTC); Mr CHEN, Yihua (NSRL, USTC); Mr TANG, Zheng (NSRL,USTC)

Presenter: HE, Xiaoye (USTC)

Contribution ID: **5** Type: **POSTER**

Surveying and mapping of site selection for HIAF and CIADS

Chinese Accelerator Driven Sub-critical System (CIADS) is capable of transmuting radioactive nuclear wastes and meanwhile producing energy in a clean and safe way, aiming to produce a maximum design current of 15 mA at the 1.5 GeV energy with an operating frequency of 162.5 MHz. High Intensity heavy ion Accelerator Facility (HIAF) based on the experience and technological developments already achieved at the existing HIRFL facility, aims to expand nuclear and related researches into presently unreachable region and give scientists possibilities to conduct cutting-edge researches in these fields. This paper presented the geomatics of site selection for HIAF and CIADS. We introduced the surveying and mapping of 1:500 topographic map, geology exploration based on Physical detection method and Optimized Calculation of Earthwork for Leveling up Construction Site.

Summary

Author: Mr YUAN, jiandong (imp,cas)

Co-authors: Mr CAI, guozhu (imp,cas); Mr ZHOU, luncai (imp,cas); Mr WANG, shaoming (imp,cas)

Presenter: Mr YUAN, jiandong (imp,cas)

Contribution ID: **6** Type: **ORAL**

The survey and alignment of China Spallation Neutron Source

This report presents the status alignment of DTL(drift tube linac) at CSNS（China Spallation Neutron Source）.The DTL for CSNS consists of 12 tanks. A unit tank was made up of 3 tanks. The fiducialization of cavity and drift tube of the DTL had already been accomplished.The total of 153 drift tubes had been installed and aligned precisely in the DTL tank. The fisrt and second unit tank had already been fine aligned and successfully connected by using a laser tracker along with the cavity installation in the tunnel.

Summary

Author: Mr HE, Zhenqiang (Institute of High Energy Physics,Chinese Academy of Sciences)

Co-authors: Mr DONG, Lan (Institute of High Energy Physics,Chinese Academy of Sciences); Mr MA, Na (Institute of High Energy Physics,Chinese Academy of Sciences); Mr KE, Zhiyong (Institute of High Energy Physics,Chinese Academy of Sciences)

Presenter: Mr HE, Zhenqiang (Institute of High Energy Physics,Chinese Academy of Sciences)

Contribution ID: **7** Type: **ORAL**

THE APPLICATION OF SMOOTHING IN NSLS-II

Smoothing technique based on best-fit transformation is further developed during the running of NSLS-II, which is the only way to avoid the conflict between the requirement of good alignment quality and an minimum interruption of the running of beam lines.
Local deviations are generated as a first step for each interested components to avoid the approximation error caused by longitudinal alignment error. Multiple iterations can be performed to get better result and to process large amount of data.
The application of smoothing technique is a success in NSLS-II so far. It can provide relative alignment deviation report and propose one end of a specific girder to be adjusted.

Summary

Author: YU, Chenghao (Brookhaven National Laboratory)

Presenter: YU, Chenghao (Brookhaven National Laboratory)

Contribution ID: **9** Type: **ORAL**

Mechanical concept of alignment mechanisms at MAX IV Laboratory

In this presentation we address the problem of precisely aligning 140 two-ton integrated magnet-packets at MAX IV Laboratory. We present the methods and techniques we have used to align these packets with a 6-DOF kinematic arrangement in order to increase precision and to get rid of the stresses induced by the fabrication imperfections and the thermal expansion. The 6-DOF aligning mechanisms are enhanced by locking mechanisms which are designed to precisely define the position of the packets in every DOF and at the same time to avoid the stick-slip motion. Furthermore, the positions of the target holders are optimized for minimizing the iterations during alignment. These methods and techniques are successfully implemented for both the 3 GeV and the 1.5 GeV rings at MAX IV Laboratory.

Summary

Author: SOMMARIN, Bengt (Max IV Laboratory, Lund University)

Co-authors: Mrs JERREBO, Annika (MAX IV Laboratory, Lund University); Dr AFZALI FAR, Behrouz (MAX IV Laboratory, Lund University); Mr HAKANSSON, Lars (MAX IV Laboratory, Lund University); Mr ZAWIERUCHA, Tomasz (MAX IV Laboratory, Lund University)

Presenter: SOMMARIN, Bengt (Max IV Laboratory, Lund University)

Contribution ID: **10** Type: **POSTER**

Device Alignment with the Laser Tracker

The Taiwan Light Source(TPS) storage ring has a circumference of 518.4m. The devices are aligned alonge the storage ring with the relative accuracy of ±0.2mm. The Insertion Device(ID) needs higher relative accuracy of ±0.05mm to adjacent magnets in the local area. In order to evaluate the reliability performance of the Laser Tracker we test a series of the stability experiments. The first was to check the warm up behaviour. The second was to check the repeatibilty of the measuring data. The third was to check the horizontal angle measurement effect. All these tests were controlled in the stable temperature of < 0.1 ℃, like the real world application. This paper descibes how the device is aligned to accuracy position by laser tracker in detail.

Summary

Author: KUAN, Chien-Kuang (National Synchrotron Radiation Research Center)

Co-authors: Mr LIN, Chia-Jui (National Synchrotron Radiation Research Center); Mr TSAI, Chi-h-Wei (National Synchrotron Radiation Research Center); Mr HUANG, Din-Goa (National Synchrotron Radiation Research Center); Mr HSU, Keng-Hao (National Synchrotron Radiation Research Center); Mr TSENG, Tse-Chuan (National Synchrotron Radiation Research Center); Mr LAI, Wei-Yang (National Synchrotron Radiation Research Center)

Presenter: Mr TSENG, Tse-Chuan (National Synchrotron Radiation Research Center)

Contribution ID: **11** Type: **ORAL**

A GEODETIC REFERENCE FRAME FOR THE VIRGO INTERFEROMETER

The Virgo detector, currently in its 2nd generation configuration "Advanced Virgo", is a Michelson interferometer aimed at the gravitational waves research and at opening a new window on the study of the Universe. It is made of two orthogonal arms being each 3 kilometers long and is located at the site of the European Gravitational Observatory (EGO), in the countryside near Pisa, Italy.
This paper reports the development of the Virgo Reference System since 2012, established for the installation of Advanced Virgo. It consists of a wide-scale high precision reference network for the alignment of new equipments or displacement of the existing ones, periodic checks and building position monitoring activity.
The survey of the network integrates classical measurements to GNSS measurements, with all observations adjusted in an Eulerian Reference System (ERS). This allowed combining the GNSS baselines, post processed with Bernese scientific software, with the total station observations. Azimuthal and zenithal angles were corrected to take into account the terrestrial curvature and slope distances in function of the atmospheric parameters provided by the EGO meteo station.

Summary

Authors: Dr PAOLI, Andrea (EGO - European Gravitational Observatory, Pisa, Italy); Prof. NARDINOCCHI, Carla (Università di Roma "La Sapienza" - DICEA, Survey Lab, Rome, Italy); Prof. VITTUARI, Luca (Università di Bologna - DICAM, Bologna, Italy); Prof. MARSELLA, Maria (Università di Roma "La Sapienza" - DICEA, Survey Lab, Rome, Italy)

Co-authors: Dr SONNESSA, Alberico (Università di Roma "La Sapienza" - DICEA, Survey Lab, Rome, Italy); Prof. ZANUTTA, Antonio (Università di Bologna - DICAM, Bologna, Italy); Dr D'ARANNO, Peppe J.V. (Università di Roma "La Sapienza" - DICEA, Survey Lab, Rome, Italy)

Presenters: Dr PAOLI, Andrea (EGO - European Gravitational Observatory, Pisa, Italy); Prof. NARDINOCCHI, Carla (Università di Roma "La Sapienza" - DICEA, Survey Lab, Rome, Italy); Prof. VITTUARI, Luca (Università di Bologna - DICAM, Bologna, Italy); Prof. MARSELLA, Maria (Università di Roma "La Sapienza" - DICEA, Survey Lab, Rome, Italy)

Contribution ID: **12** Type: **POSTER**

AN INTERGRATED APPROACH FOR MONITORING SOIL SETTLEMENTS AT THE VIRGO SITE

The Virgo detector, currently in its 2nd generation configuration "Advanced Virgo", is a Michelson interferometer aimed at the gravitational waves research and at opening a new window on the study of the Universe. It is made of two orthogonal arms being each 3 kilometers long and is located at the site of the European Gravitational Observatory (EGO), in the countryside near Pisa, Italy.
Over the years a steady subsidence process has been observed as a consequence of the building and embankment overloads. In consideration of the subsoil characteristics, the evolution of settlements was expected and properly considered for the design of the civil engineering infrastructures, so that the vacuum tubes can be readjusted to keep the original alignment. However, along 20 years of time life, the initial estimates of the expected displacements were continuously compared with the observed effects. The measured settlements have been regularly monitored and adopted for implementing the necessary realignment activities.
This paper reports the monitoring activities conducted over the years, mainly consisting of regular high accuracy levelling measurement campaigns, periodically integrated by GPS and classical theodolite measurements. These sets of measurements allowed to perform the Virgo realignment procedure (finalized to keep the interferometer rigidly tied in a 3x3km plane) and required displacements reduced in a relative reference system with respect to the optical center of the interferometer, located in the Central Building.
In order to improve the understanding on the on-going settlements process, the evaluation of the deformation pattern based on satellite interferometer techniques using Synthetic Aperture Radar (SAR) data has been performed and compared with the outcome from in-situ data.

Summary

Authors: Dr PAOLI, Andrea (EGO - European Gravitational Observatory, Pisa, Italy); Prof. NARDINOCCHI, Carla (Università di Roma "La Sapienza" - DICEA, Survey Lab, Rome, Italy); Prof. VITTUARI, Luca (Università di Bologna - DICAM, Bologna, Italy); Prof. MARSELLA, Maria (Università di Roma "La Sapienza" - DICEA, Survey Lab, Rome, Italy)

Co-authors: Prof. ZANUTTA, Antonio (Università di Bologna - DICAM, Bologna, Italy); Mr FABOZZI, Carlo (EGO - European Gravitational Observatory, Pisa, Italy); Dr VOLANTE, Chiara (Università di Roma "La Sapienza" - DICEA, Survey Lab, Rome, Italy); Dr SCIFONI, Silvia (Università di Roma "La Sapienza" - DICEA, Survey Lab, Rome, Italy)

Presenters: Dr PAOLI, Andrea (EGO - European Gravitational Observatory, Pisa, Italy); Prof. NARDINOCCHI, Carla (Università di Roma "La Sapienza" - DICEA, Survey Lab, Rome, Italy); Prof. VITTUARI, Luca (Università di Bologna - DICAM, Bologna, Italy); Prof. MARSELLA, Maria (Università di Roma "La Sapienza" - DICEA, Survey Lab, Rome, Italy)

Contribution ID: **13** Type: **ORAL**

Exploiting the Potential of the Hydrostatic Leveling System (HLS) at the Swiss Light Source (SLS)

Only in recent years of SLS operation the potential of the HLS system with 192 Levelsensors has been fully exploited. A vertical realignment campaign as part of the quest to realize a very small vertical emittance of 1 pm.rad led to an increased interest in the HLS system in 2011. Electron beam-based measurements, alignment survey data and HLS data were compared and found to be consistent over a large range of time scales from seconds to years. Thus the HLS can not only be used for the detection of long term settlements as it was designed for in the year 2000, but also for the monitoring of deliberate girder position manipulations with the remotely controlled girder alignment system of the SLS. In addition a recent software upgrade provides a much improved handling and control system integration of the HLS system.

Summary

Author: BOEGE, Michael (Paul Scherrer Institut)

Co-author: MEIER, Edi (Edi Meier + Partner AG, 8406 Winterthur, CH)

Presenters: MEIER, Edi (Edi Meier + Partner AG, 8406 Winterthur, CH); BOEGE, Michael (Paul Scherrer Institut)

Contribution ID: **14** Type: **ORAL**

Online monitoring of the ADS test cryomodule cold mass with WPM

IHEP are taking effort to design the ADS (Accelerator Driven Sub-critical System) injector-I. In order to gain enough experience, a test cryomodule is designed to do all the relevant system joint test. The working temperature is 4K, because the cold mass contraction, it is a great challenge to preserve the alignment precision after such a big range temperature drop. So wire position monitors(WPM) is used to monitor the contraction change process in test cryomodule. The WPM is precisely calibrated. Before the commissioning, we ran a whole helium test. The contraction data and temperature data was combined to calculate the contraction coefficient of the girder system, then was compared with the thermal coefficient of stainless steel, the data matched very well. After commissioning, two thermal cycles data was recorded. The contraction's stability and reproducibility is very good. The average contraction of the two cavities and solenoids is about 1.35mm. These experiment results can be further used to realize better alignment work for the follow cryomodules.

Summary

Author: ZHU, hongyan (Institute of High Energy Physics)

Presenter: ZHU, hongyan (Institute of High Energy Physics)

Contribution ID: **15** Type: **ORAL**

Alignment and Stability of the TPS Storage Ring Auto-Tuning Girder System

An auto-tuning girder system for the Taiwan Light Source(TPS) storage ring had been designed and established to align the girders quickly also precisely with only few manpower. During the installation period, with the survey network data from the lasertrackers, this girder system demonstrated the ability and met the design requirements. Including the testing run, with only 4 times tuning, the storage ring girders were aligned within ±0.5mm precision and the first light was seen in few days after commissioning started. Within one year commissioning period afterword, several survey works had been carried out and the data show that the girder system is quite stable even suffered with some earthquakes. This paper describes the girder system and survey data in detail.

Summary

Author: TSENG, Tse-Chuan (National Synchrotron Radiation Research Center)

Co-authors: Mr LIN, Chia-Jui (National Synchrotron Radiation Research Center); KUAN, Chien-Kuang (National Synchrotron Radiation Research Center); Mr TSAI, Chih-Wei (National Synchrotron Radiation Research Center); Mr HUANG, Din-Goa (National Synchrotron Radiation Research Center); Mr HO, His-Chou (National Synchrotron Radiation Research Center); Mr WANG, Jeremy (National Synchrotron Radiation Research Center); Dr CHEN, June-Rong (National Synchrotron Radiation Research Center); Mr HSU, Keng-Hao (National Synchrotron Radiation Research Center); Ms CHEN, Mei-Ling (National Synchrotron Radiation Research Center); Mr PERNG, Shen-Yaw (National Synchrotron Radiation Research Center); Mr LAI, Wei-Yang (National Synchrotron Radiation Research Center)

Presenter: TSENG, Tse-Chuan (National Synchrotron Radiation Research Center)

Contribution ID: **16** Type: **ORAL**

Estimation of Magnet Alignment Accuracy for SPring-8 Upgrade using Resonance-Frequency Tracked Vibrating Wire

SPring-8 major upgrade, SPring-8-II, is being designed. The new storage ring requires alignment errors of 25 micro-meters (one standard deviation) or less for multi-pole magnets on a straight line between adjacent two bending magnets. Using a test bench consisted of five multi-pole magnets with typical field gradients, we have demonstrated an alignment of these magnets by introducing a vibrating wire method (VWM) without conventional fiducialization. A systematic error due to a wire sag and kink was dominant in static errors during the alignment procedure. Maximum displacement from the theoretical catenary curve along longitudinal axis was 10 micro-meters for a 3.6 m-long wire with 0.24 mm of sag. The other static errors, for example, a deviation of vibration amplitude, a systematic error caused by background field gradients due to remanent fields, etc., were negligibly small compared with the above displacement. In addition, a long-term drift of the magnetic center caused by a temperature rise of water-cooling magnet and a deformation of the girder was observed. In order to track the drift, we developed a resonance-frequency tracked vibrating wire for a sustainable measurement. Actual accuracy of our alignment procedure including these dynamic errors will be described in this paper.

Summary

Author: Dr FUKAMI, Kenji (JASRI/RIKEN)

Co-authors: Dr ZHANG, Chao (JASRI); Dr KIMURA, Hiroaki (JASRI/RIKEN); Mr KIUCHI, Jun (SPring-8 Service Co., Ltd.); Mr AZUMI, Noriyoshi (JASRI/RIKEN); Dr MATSUI, Sakuo (RIKEN); Dr WATANABE, Takahiro (JASRI/RIKEN); Mr KAI, Tomoya (SPring-8 Servise Co., Ltd.)

Presenter: Dr FUKAMI, Kenji (JASRI/RIKEN)

Contribution ID: **17** Type: **POSTER**

Optimize the work flow!

We did some investigations for optimizing our measurement processes. Main points are time saving, error avoidance and quality assurance. The poster shows very different spots of finished and current projects e.g. simultaneously measurements with two laser trackers, using barcodes for point ID encoding, an approach using a Leica AT402 in geodetic network measurements as a centered measurement system in a classical sense, the use of photogrammetry in monitoring welding processes, and more.

Summary

Author: Mrs KNAPPMEIER, Kerstin (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany)

Co-authors: Mr JUNGE, Andreas (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany); Mrs PSCHORN, Ina (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany); Mr MIERTSCH, Torsten (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany); Mr VELONAS, Vasileios (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany)

Presenter: Mrs KNAPPMEIER, Kerstin (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany)

Contribution ID: **18** Type: **ORAL**

Measuring through glass windows with Laser Tracker under cold-vacuum conditions: investigations and results

Direct measurements through glass windows with a Laser Tracker onto reflectors installed within a cryostat are not readily possible. Nevertheless these kind of measurements were investigated to accomplish the given requirements.
The high precise monitoring requirements regarding deformations of the cold mass along with movements vs. cryostat of superconducting components in 3D were initially the trigger for this investigation. Relative as well as absolute coordinates between reference points in known coordinate systems are essential for these evaluations. The aim is to develop a robust alternative measurement concept compared to our existing method with theodolite in order to evaluate these displacements of the components.
Considering the whole measurement method as a complex system all parameters needs to be taken into account. In this case, not only physical parameters of the environment, the Laser Tracker itself as well as of the glass window, but also the consequences in terms of the stochastic mathematical model need to be studied carefully.

Summary

Author: Mr VELONAS, Vasileios (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany)

Co-authors: Mr JUNGE, Andreas (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany); Mrs PSCHORN, Ina (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany); Mrs KNAPPMEIER, Kerstin (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany); Mr MIERTSCH, Torsten (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany)

Presenter: Mr VELONAS, Vasileios (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany)

Contribution ID: **19** Type: **ORAL**

New approaches in the use of laser trackers for measurements of geodetic networks

During a network measurement campaign 2015 the Leica laser tracker AT402 was considered and applied as a centred instrument. Therefore a methodology was developed to use it in such a way. One aim was to analyse the precision of the centring of this instrument. Another task was the analysis how this method of reciprocal observations influenced the evaluation and especially the adjustment of the geodetic networks. Different combinations were investigated to get a better possibility in handling on the reliability, accuracy and comparability regarding future network measurement campaigns.
Further the distinctive possibility of the AT402 as a laser tracker and as a tachymeter was considered in several variants of evaluations which were taken with the program PANDA.
The single sub-networks were determined by laser trackers of different manufacturers. In some areas an overlap of such laser tracker measurements occurred so that the influence of the combination of different instruments was also analysed and investigated.

Summary

Author: Mr MIERTSCH, Torsten (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany)

Co-authors: Mr JUNGE, Andreas (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt, Germany); Mrs PSCHORN, Ina (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt, Germany); Mrs KNAPPMEIER, Kerstin (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt, Germany); Mr VELONAS, Vasileios (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt, Germany)

Presenter: Mr MIERTSCH, Torsten (GSI Helmholtz Centre for Heavy Ion Research, Darmstadt / Germany)

Contribution ID: **20** Type: **ORAL**

Laser Tracking Measurement System Based on Femtosecond Frequency Comb

Laser tracking measurement system is widely used in large-scale and high-precision measurement in the fields of particle accelerator positioning, automobile assembly, ship-building and other manufacturing. It obtain 3D coordinates of measured object by measuring the distance from the object to the origin of machine coordinate system as well as the horizontal and vertical angles of object. Traditional laser trackers measure the distance using interferometer or range finder with the accuracy of 5-10ppm. In this paper a novel laser tracking measurement system was presented which realized the distance measurement using femtosecond laser frequency comb with the accuracy of 0.5ppm. Firstly the measuring principle and overall design of the system were introduced. Then the components of the instrument were analyzed and designed including femtosecond laser frequency comb, dual-comb distance measurement, precision angular encoder , miss-distance detection, tracking control, calibration & error compensation and data processing software. The test results showed that the stability of repetition rate and carrier envelop offset of optical frequency comb reaches 3.0×10-12@1s and 1.0×10-10@1s respectively. The stability of miss distance measurement was better than 2.0μm. The angle measurement errors were compensated to less than 0.60″. The tracking control module is built based on DSP and FPGA, which can track a moving optical target with speed of 2m/s. Finally a prototype of the measurement system was completed. The system reached the measurement accuracy of better than 10ppm which showed its superiority over traditional laser tracking systems. Laser tracking measurement system as well as distance measurement device based on femtosecond light frequency comb are expected to have broad application prospect in accelerator alignment and positioning and other manufacturing fields.

Summary

Author: Ms ZHANG, Zili (Academy of Opto-electronics, Chinese Academy of Sciences)

Co-authors: Mr LAO, Dabao (Academy of Opto-electronics, Chinese Academy of Sciences); Mr DONG, Dengfeng (Academy of Opto-electronics, Chinese Academy of Sciences); Mr ZHOU, Weihu (Academy of Opto-electronics, Chinese Academy of Sciences); Mr WANG, Yanqing (Academy of Opto-electronics, Chinese Academy of Sciences)

Presenter: Mr ZHOU, Weihu (Academy of Opto-electronics, Chinese Academy of Sciences)

Contribution ID: **21** Type: **POSTER**

Status Report on the Sirius Girder Development and Alignment Concept

The new Brazilian synchrotron light source is currently in construction, with components installation planned to 2017-2018 and comissioning intended to early 2018. The alignment requirement is of 0.080 mm for girder translations in the beam traverse directions and 0.3 mrad for rotations. The girder-to-girder alignment will be made using laser trackers, both for network survey and precision positioning. The magnet-to-magnet alignment concept is to use dimensional tolerances to achieve an alignment by definition. This work will present preliminary results on girder design, vibration response, assembling and adjustment mechanisms, spatial positioning, and geometrical characterisation.

Summary

Author: JUNQUEIRA LEAO, Rodrigo (LNLS)

Co-authors: Mr MESA, Andre (LNLS); Mr RODRIGUES, Flavio (LNLS); Mr ROVIGATTI, Gustavo (LNLS); Mr COSTA, Marcelo (LNLS); Mr ROCHA, Milton (LNLS); Mr NEUENSCHWANDER, Regis (LNLS); Mr JASSO, Thiago (LNLS); Mr RICARDO, Wellington (LNLS)

Presenter: JUNQUEIRA LEAO, Rodrigo (LNLS)

Contribution ID: **22** Type: **ORAL**

IFMIF/EVEDA 125mA CW 9 MeV D+ Linac alignment status and potential improvements

IFMIF (International Fusion Material Irradiation Facility) will be a Li(d,xn) neutron source providing equivalent neutron spectrum of DT fusion reactions and comparable neutron flux of future commercial reactors. Such a facility is an essential step in world fusion roadmaps to qualify suitable structural materials capable to hold the unrivalled neutron irradiation inside the nuclear vessel of a fusion reactor. IFMIF, presently in its EVEDA (Engineering Validation and Engineering Design Activities) phase is installing LIPAc (Linear IFMIF Prototype Accelerator) in Rokkasho (Japan), a 125mA CW 9MeV deuteron beam as validating prototype of IFMIF accelerators. Beam dynamics calculations demand accuracies and precision of alignment within ± 0.1 mm in an assembly hall of about 8x40 m to keep beam losses below defined threshold and allow future hands-on maintenance activities. According to the F4E QA metrology handbook, a ratio of 5 between tolerance and uncertainty is acceptable. A network of about 130 fiducials currently exists in the assembly vault. In order to optimize installation schedule and reduce as much as possible potential risk on the alignment process, we decided to test and validate the assembly and alignment of each subsystem when possible before the delivery to Japan. The results of these campaigns as well as some potential improvements related with the utilization of photogrammetry technique and displacement sensors to monitor all the accelerator line will be presented in this paper. IFMIF (International Fusion Material Irradiation Facility) will be a Li(d,xn) neutron source providing equivalent neutron spectrum of DT fusion reactions and comparable neutron flux of future commercial reactors. Such a facility is an essential step in world fusion roadmaps to qualify suitable structural materials capable to hold the unrivalled neutron irradiation inside the nuclear vessel of a fusion reactor. IFMIF, presently in its EVEDA (Engineering Validation and Engineering Design Activities) phase is installing LIPAc (Linear IFMIF Prototype Accelerator) in Rokkasho (Japan), a 125mA CW 9MeV deuteron beam as validating prototype of IFMIF accelerators. Beam dynamics calculations demand accuracies and precision of alignment within ± 0.1 mm in an assembly hall of about 8x40 m to keep beam losses below defined threshold and allow future hands-on maintenance activities. According to the F4E QA metrology handbook, a ratio of 5 between tolerance and uncertainty is acceptable. A network of about 130 fiducials currently exists in the assembly vault. In order to optimize installation schedule and reduce as much as possible potential risk on the alignment process, we decided to test and validate the assembly and alignment of each subsystem when possible before the delivery to Japan. The results of these campaigns as well as some potential improvements related with the utilization of photogrammetry technique and displacement sensors to monitor all the accelerator line will be presented in this paper.

Summary

Author: SCANTAMBURLO, Francesco (IFMIF/EVEDA)

Co-authors: Mr LO BUE, Alessandro (F4E Barcelona); Dr DZITKO, Herve (F4E Garching); KNASTER, Juan (IFMIF/EVEDA); Dr SEMERARO, Luigi (F4E Barcelona); ICHIMIYA, Ryo (KEK)

Presenter: SCANTAMBURLO, Francesco (IFMIF/EVEDA)

Contribution ID: **23** Type: **ORAL**

An estimation of vertical slow drift between Storage Ring and NANOSCOPIUM long beamline with HLS & beam diagnostics at Synchrotron SOLEIL

Hydrostatic Levelling system and beam diagnostics have revealed vertical slow drift between Storage Ring and the long beamline at SOLEIL. An Experimental hall air conditioning effect is even the origin of the SR slab deformation at the beamline source point. We analyse the situation with metrology tools as spatial differential processing of data, metrology loop, stability time constant and by applying the heat diffusion equation to a wall.Both HLS and beam diagnostics are compared into the tunnel. The perturbations are finally analysed through a simplified optics model of the beamline optics.

Summary

Author: LESTRADE, Alain (Synchrotron SOLEIL)

Presenter: LESTRADE, Alain (Synchrotron SOLEIL)

Contribution ID: **24** Type: **POSTER**

Application of Terrestrial Laser Scanner in Particle Accelerator and Reverse Engineering Solutions

Terrestrial Laser Scanners can collect a million points per second and it is a technology widely used in fields such as: topography, forensics, building, mining, as-built surveying, architecture, archaeology, monitoring, civil engineering and urban modeling. In this paper a novel application for particle accelerators is presented. The Leica ScanStation P20 has been used to collect point cloud data and HDR images of the inner wall of the Advanced Light Source particle accelerator main storage ring tunnel; sub-millimeter accuracy registration of multiple setups was performed on sphere shaped targets using an existing monument network previously surveyed by laser tracker. Data was exported in a web-based point cloud with HDR images. Direct surface reconstructions in Autodesk Inventor 3D CAD provide a parametric solid model of all significant features such as wireways, pipelines, air ducts and electrical boxes. A validation analysis was conducted comparing the constructed model to the actual tunnel wall by laser tracker.

Summary

Author: BIANCULLI, Davide (LBNL)

Co-author: Mr HUMPHRIES, David (LBNL)

Presenter: BIANCULLI, Davide (LBNL)

Contribution ID: **25** Type: **ORAL**

Alignment Strategy for APS Upgrade

The Advanced Photon Source (APS) at Argonne National Laboratory is a 7GeV third generation light source providing X-ray beams for research to scientific community since 1995. In order to remain the world-leading synchrotron radiation facility in the western hemisphere, delivering X-ray beams of high-brightness and high-energy is critical. In 2013, the Department of Energy (DOE) identified the national need for the APS Upgrade (APS-U) project. Currently, the detailed preliminary design is under development to replace existing APS storage ring with lattice incorporating multi-bend achromat (MBA) technology. The extremely strict alignment tolerances in combination with very aggressive installation schedule pose unique alignment challenges. The geodetic control network configuration, design of magnet support and alignment systems, magnet mapping and fiducialization, as well as alignment strategy for assembly, testing, and installation in the APS storage ring are discussed.

Summary

Author: PENICKA, Jaromir M. (Argonne National Laboratory)

Co-authors: DOOSE, Charles (Argonne National Laboratory); PREISSNER, Curt (Argonne National Laboratory); COLLINS, Jeffrey (Argonne National Laboratory); NUDELL, Jeremy (Argonne National Laboratory); GWEKOH, Rolando (Argonne National Laboratory); JANSMA, William (Argonne National Laboratory)

Presenter: PENICKA, Jaromir M. (Argonne National Laboratory)

Contribution ID: **26** Type: **ORAL**

Straightening of APS LINAC Accelerating Structures Utilizing a Portable Articulating Arm CMM

The Advanced Photon Source linear accelerator system utilizes 3-meter long SLAC-type 2856 MHz accelerating structures. Surveys of the APS LINAC indicated distortion in the straightness of the accelerating structures over time, with 7 mm of sag detected in the worst case. A long-term project to straighten the accelerating structures, swapping them out one-by-one and straightening those removed, was implemented. The straightening is intended to improve charge transportation efficiency and minimize wakefield effects in the structures. The first straightened structure was installed in fall of 2015, and the swaps will continue until all 13 APS LINAC accelerating structures have been straightened. A portable 3-D articulating arm CMM is utilized accomplish the straightening of the structures to a tolerance of +/- 200 microns. Techniques used at the APS to straighten the LINAC accelerating structures and achieved results are presented.

Summary

Author: JANSMA, William (Argonne National Laboratory)

Co-authors: Mr BROMBEREK, David (Argonne National Laboratory); PENICKA, Jaromir (Argonne National Laboratory)

Presenter: JANSMA, William (Argonne National Laboratory)

Contribution ID: **27** Type: **POSTER**

Survey of the Fermilab NOvA Detectors

The NOvA experiment is looking to answer fundamental questions about neutrinos and the role they play in the universe. NOvA currently uses two detectors, the near detector located underground at Fermilab and the far detector located 810 km from Fermilab on the US-Canada border in Ash River, Minnesota. The 15 kTon far detector and the 222 ton near detector are composed of several cells of extruded PVC plastic in a cellular structure. This poster summarizes the survey of the NOvA detectors using the Laser Tracker and the Laser Scanner. The survey was completed in 2014 and the experiment is currently fully operational..

Summary

Author: OSHINOWO, Babatunde (Fermi National Accelerator Laboratory (Fermilab))

Co-author: FRIEDSAM, Horst (Fermi National Laboratory)

Presenter: OSHINOWO, Babatunde (Fermi National Accelerator Laboratory (Fermilab))

Contribution ID: **28** Type: **ORAL**

Analysis of the Vertical Floor Deformation in SPring-8 Ring Tunnel

In the case of large accelerator facilities, as SPring-8, of which circumference is about 1.5 km, a long term and seasonal stability of a floor in the accelerator tunnel is one of the important factors. The SPring-8 storage ring is located on bedrock area. So, a re-alignment of the storage ring, corresponding floor deformation, has never been performed since starting operation in 1997.
SPring-8 upgrade plan is being designed. The ultra-low emittance storage ring requires about 50 micro-meters (1-sigma) as a tolerance between neighboring two girders. The tolerance is 4 times smaller than that for the present SPring-8. Then we have investigated vertical floor deformations in the tunnel, and identified the position and the cause of large local deformations.
In 1996, before the starting operation, a difference in height of one round of the ring was 1 mm. In 2015, the difference had increased to 4 mm. For analysis, changes of height difference between neighboring two control points were used instead of changes of height. The long-term deformation was mainly found over the underground RF rooms. The seasonal deformation was mainly found over the drain pipes and underground passages. The result of the observation and the analysis are summarized.

Summary

Author: Dr KIMURA, Hiroaki (JASRI/RIKEN)

Co-authors: Dr ZHANG, Chao (JASRI); Mr AZUMI, Noriyoshi (JASRI/RIKEN); Dr MATSUI, Sakuo (RIKEN); Dr OKAYASU, Yuichi (JASRI)

Presenter: Dr KIMURA, Hiroaki (JASRI/RIKEN)

Contribution ID: **29** Type: **POSTER**

Several components of alignment system of electron positron injector linac in KEK

Improvement of alignment system of injector linac is a one of major issue in the upgrade plan for SuperKEKB project, in which very low emittance high charge injection beam is required. To suppress the emittance growth during acceleration and transportation, it is naively required to align all the components within 0.1 mm from the ideal position locally (20-30m range) and 0.3 mm globally (500 m). To realize these requirements, position measurement of girders using He-Ne laser and quad-divided photo diode sensors is under progress. Expansion joint of the tunnel is monitored by dial gauge. A new magnet support using screw jack and a mover mechanism which is compatible with existing girder are under test.

Summary

Author: ENOMOTO, yoshinori (KEK)

Co-authors: Mr KAKIHARA, Kazuhisa (KEK); Mrs TANAKA, Madoka (KEK); HIGO, Toshiyasu (KEK); Dr SUWADA, Tsuyoshi (KEK)

Presenter: ENOMOTO, yoshinori (KEK)

Contribution ID: **30** Type: **ORAL**

Real time measurement in slow displacement of the tunnel floor due to dynamic ground motion at the KEKB injector linac

A new remote-controllable sensing system in a laser-based alignment system is in progress to measure slow tunnel floor displacements due to dynamic ground motion in real time at the KEKB injector linac. The 600-m-long linac comprises two (125 m and 476 m) straight sections, by which directly inject electron and positron beams into the Super KEKB rings. Two independent laser-based alignment systems are installed in each straight section.
Ten remote-controllable quadrant photo-detectors (QPDs) were installed in summer shutdown of 2015 just close by plural locations of expansion joints of the building along the linac tunnel, while two detectors of them were installed at the middle location in 2014. The real time measurement pursues to take data since Jan. 2016.
Based on the preliminary analysis, we have observed non-negligible slow floor displacements due to dynamic ground motion, while the required alignment is to attain the precisions of 0.1 mm (rms) level in a local region. The correlation and displacement vector analyses depending on each location were carried out based on the data in this duration. In this report, the detailed experimental results and the present status are described in the laser-based alignment system of the injector linac.

Summary

Author: Dr SUWADA, Tsuyoshi (KEK)

Co-authors: Mr MIKAWA, Katsuhiko (KEK); Mr KAKIHARA, Kazuhisa (KEK); Prof. HIGO, Toshiyasu (KEK); Dr ENOMOTO, Yoshinori (KEK)

Presenter: Dr SUWADA, Tsuyoshi (KEK)

Contribution ID: **31** Type: **ORAL**

An Eigenfrequency Wire Alignment System under Development for Magnet Fiducialization

The magnets of the SPring-8 storage ring have critical alignment tolerances. And, in the phase of magnetic field measurement, the positions of the fiducial points on magnets usually need to be precisely calibrated relative to magnetic center. We have been used the laser CCD-camera system for the calibration. Recently, in renewing the magnetic field measurement device, an eigenfrequency wire alignment system (eWAS) is attempted to do the fiducialization in view of followings. It makes almost simultaneous measurements for a group of points. It is easy to make continuous measurement and record the positional change due to the variation of magnet current. And, the measurement is less influenced by working environments such as room temperature or airflow. The system in developing is composed of four WPS sensors which are well used in alignment, combined with the carbon wire, and vibration measurement devices. Aim of this alignment system is to calibrate the magnet fiducials with an accuracy of ±10 um.

Summary

Author: ZHANG, Chao (JASRI/SPring-8)

Co-authors: MITSUDA, Chikaori (JASRI); KAJIMOTO, Kazuyuki (SES)

Presenter: ZHANG, Chao (JASRI/SPring-8)

Contribution ID: **32** Type: **POSTER**

Precise alignment monitor by using optical frequency comb for the muon g-2/EDM experiment at J-PARC

The muon g-2/EDM experiment at J-PARC aims to measure muon's anomalous magnetic moment, g-2 with an precision of 0.1 ppm; and to search for electric dipole moment, EDM with a sensitivity of 10−21 e·cm.
In the experiment, tracks of decay positrons in a storage ring with a 3 T of uniform magnetic field are to be measured by a positron tracking detector. It consists of 48 rectangular platy parts called a vane, with a size of approximately 250 mm × 750 mm. They are aligned radially in the storage ring and form a cylindrical array with a diameter of approximately 600 mm and a height of 750 mm. In order to measure the track enough accurately, alignment accuracy for each vane was estimated to be better than 0.01 mrad around a normal line for each vane.
We consider adopting a fiber-introduced absolute distance meter based on interferometry using optical frequency comb for monitoring the alignment. Basic concept for detecting the alignment change and studies for installing the alignment monitoring system into our tracking detector are to be presented.

Summary

The muon g-2/EDM experiment at J-PARC aims to measure muon's anomalous magnetic moment, g-2 with an precision of 0.1 ppm; and to search for electric dipole moment, EDM with a sensitivity of 10−21 e·cm.
In the experiment, tracks of decay positrons in a storage ring with a 3 T of uniform magnetic field are to be measured by a positron tracking detector. It consists of 48 rectangular platy parts called a vane, with a size of approximately 250 mm × 750 mm. They are aligned radially in the storage ring and form a cylindrical array with a diameter of approximately 600 mm and a height of 750 mm. In order to measure the track enough accurately, alignment accuracy for each vane was estimated to be better than 0.01 mrad around a normal line for each vane.
We consider adopting a fiber-introduced absolute distance meter based on interferometry using optical frequency comb for monitoring the alignment. Basic concept for detecting the alignment change and studies for installing the alignment monitoring system into our tracking detector are to be presented.

Author: Dr KUME, Tatsuya (KEK)

Presenter: Dr KUME, Tatsuya (KEK)

Contribution ID: **33** Type: **POSTER**

MATHIS Software for controlling BCAM-based monitoring and alignment systems

The MATHIS Software (Monitoring and Alignment Tracking for HIE-Isolde Software) aims at providing 3D positions of physical components of the HIE-Isolde superconducting modules, accurately and permanently measured by well-designed networks of BCAM devices (Brandeis Camera Angle Monitoring). Although it is originally intended for the HIE-Isolde project, its architecture and its use cases have been extended and optimized for more general setups. Most of the configuration data are stored either within XML-formatted files or within databases. The adaptation of MATHIS for different BCAM monitoring systems thus does not require any further code rewriting. Moreover, the software is fully cross-platform and can either be run on the specific Linux machines driving the accelerator electronic devices, or be used on independent Windows workstations as a stand-alone software. In the first case, the software mainly relies on FESA (Front End Software Architecture) which is an object-oriented real-time framework that ensures equipment software portability across CERN accelerators. Through this standardized module, MATHIS communicates with dedicated servers networks and publishes in real-time the computed positions to any workstation, and more specifically to the concerned control room operators. This paper describes the main features and explains the modular architecture of the software.

Summary

Author: Dr KLUMB, Francis (CERN)

Co-authors: KAUTZMANN, Guillaume; GAYDE, Jean-Christophe (CERN)

Presenter: Dr KLUMB, Francis (CERN)

Contribution ID: **34** Type: **ORAL**

Evaluation of stretched wire measurements based on photogrammetry in the context of CERN

Offset Measurements with respect to stretched wires are traditionally used for accelerator alignments at CERN i.e. for the SPS and the LHC, the position of the wire being measured either by an optical sensor or a capacitive sensor. In recent years the resolution of digital cameras increased so that wires of few tenth of millimetres get visible in images at limited distances of 1-2 m. A method based on photogrammetry is able to measure the reference (wire) and the magnet fiducials simultaneously using the same measurement system. As an optical non-contact method it offers easier possibilities of automation in comparison to the manual procedure employed in the SPS and LHC so far. At the same time other uses of wire measurements like the calibration of wire chambers and detectors seem interesting.
The presented photogrammetric measurements are based on the feature measurement of the commercial software from AICON 3D systems. An evaluation has been done of the wire axis measurement without special signalisation and the magnets fiducials at distances of 1-2 m as for the LHC. For this different hardware components and parameters have been tested like lenses, light conditions or different wires. An estimation of the reachable precision is verified on a dedicated test bench and a scale 1:1 mock-up with respect to the classical offset measurements. The aim is to understand the capacities and constraints of the system that reaches precisions of few hundreds of millimetres in the tested setups.

Summary

Authors: BEHRENS, Antje (CERN); VENDEUVRE, Camille (Institut National des Sciences Appliquees de Strasbourg (FR)); MERGELKUHL, Dirk (CERN)

Presenter: BEHRENS, Antje (CERN)

Contribution ID: **35** Type: **ORAL**

The Atlas DEtector POsitioning system (ADEPO) to control moving parts during ATLAS closure

ATLAS is one of two general-purpose detectors at CERN's Large Hadron Collider (LHC). It is 46 m long, 25 m wide and 25 m in height and has a total mass of 7000 tons. During the Shutdown periods of LHC machine, intensive maintenance and/or upgrade programs are performed in the experiment. Such activities require that various large size detectors of up to 900 tons are moved from their "Run position"to an "Maintenance position". Before the end of the shutdown, these detectors have to be moved back to the "Run position"within mechanical accuracy of 0.3 mm. The system described in this article is an upgrade of the general procedure of Detector positioning in ATLAS that is currently based on a geodetic measurement, with a delivery time of hours for the results.
A multi-disciplinary team developed and integrated the Atlas DEtector Positioning (ADEPO) system into the already assembled experiment to control re-positioning of seven major sub-detectors. The system is based on BCAMs (Brandeis CCD Angle Monitor) as sensors in combination with prisms. ADEPO replaces partially the manual measurement and saves time in the critical path of the detector closure and increases the accuracy of the relative repositioning. In this article are treated the specification and technical constraints resulting in the system design and layout. Further are presented challenges of installation and commissioning up to the first measurement results in the maintenance period 2015/2016. The relative precision reaches up to few hundreds of mm. It is integrated in the ATLAS work flow of the movements system for the detectors and data storage in the ATLAS detector database.

Summary

Authors: MERGELKUHL, Dirk (CERN); GAYDE, Jean-Christophe (CERN); RAYMOND, Michel (CERN)

Co-authors: Mr DONSZELMANN, Mark (Nikhef National institute for subatomic physics (NL)); DAAKIR, Mehdi (E)

Presenter: GAYDE, Jean-Christophe (CERN)

Contribution ID: **36** Type: **POSTER**

3DIMPact online - an online knowledge base of portable 3D metrology

University College London (UCL) has provided seed funding to UCL's 3DIMPact group for the development of a prototype website which will support the development of portable 3D metrology and related technologies. For the first time this will provide a consolidated, structured resource offering knowledge transfer in these fields.

The website will provide three key elements to achieve this objective:

- An online knowledge base of 3D metrology
- An area focused on research and development where 3DIMPact and its research partners can engage with industry
- A directory area where commercial and non-commercial organizations and groups can promote their products, services, skills and resources

This 12-month proof-of-concept project runs from March 2016 –March 2017. The prototype website will act as a tool for evaluating audience interest and the potential to generate revenue which will make it self-sustaining in a second, operational phase.

The poster will present the current status of the website and encourage the participation of the IWAA in its further development.

Summary

A poster presenting the status of an online metrology knowledge base under development at University College London

Author: KYLE, Stephen (University College London)

Presenter: KYLE, Stephen (University College London)

Contribution ID: **37** Type: **ORAL**

Compensating for the effects of refraction in photogrammetric metrology

As part of the recently completed LUMINAR project, lead by the UK's National Physical Laboratory (NPL), the 3DIMPact group at University College London (UCL) was given the task of evaluating and correcting the effects of refraction on photogrammetric metrology applications.

Refraction causes light rays to bend. This results in pointing errors which potentially can be corrected. Simulations suggest that the effects over short ranges are small, and possibly negligible, but potentially significant over longer ranges, e.g. 10m - 30m. These are certainly found in application areas such as aircraft assembly and therefore deserve attention.

Refraction errors are dominated by thermal changes in the atmosphere. They have been evaluated in some detail in geodesy, and to a much lesser extent in photogrammetry. General atmospheric refraction in metrology applications has not been investigated in detail before.

This paper summarizes the work in the LUMINAR project and outlines its further potential application in an ongoing, parallel project, the Light-Controlled Factory. Currently a level of correction seems achievable if real-time temperature sensing in the local measurement environment is possible. Here the authors would like to engage with the IWAA to locate suitable applications in accelerator alignment.

Summary

An overview of work by University College London to evaluate and correct the effects of atmospheric refraction in photogrammetric metrology applications.

Author: KYLE, Stephen (University College London)

Co-authors: Dr BOEHM, Jan (University College London); Dr MACDONALD, Lindsay (University College London); Prof. SHORTIS, Mark (RMIT University); Prof. ROBSON, Stuart (University College London)

Presenter: KYLE, Stephen (University College London)

Contribution ID: **38** Type: **POSTER**

GEODE: a new DB interface with APEX

The Survey database and its interface called Geode were created in 1985. From the beginning, Geode was developed by the Survey team with an Oracle development tool, Oracle Forms.
Over the years, both Geode and Oracle Forms have evolved together. However, this changed after migrating to Oracle Forms 10g, when we were actively encouraged to change to another development tool. Although not ideal in all aspects APEX (Oracle Application Express) was the alternative selected. The migration began in 2010 and was finally finished in 2015/16.
After presenting the pros and cons of each development tool, APEX and Oracle Forms, this paper details the current situation of the Survey database and Geode. It reviews the changes in the database, Geode and the development process; and outlines the difficulties of maintaining and evolving two different coexisting interfaces, as well as the DB business logics and structures. Finally, it overviews the next steps for the consolidation of the DB before other necessary changes are implemented.

Summary

Author: NAEGELY, Anne Valerie (CERN)

Co-authors: FOUAD BENSAHLA TALET, Adel (CERN); ILIEV, Iliyan (CERN)

Presenter: NAEGELY, Anne Valerie (CERN)

Contribution ID: **39** Type: **POSTER**

Fiducialisation and Initial Alignment of the CLIC Components within a Micrometric Accuracy

We propose a new solution to fiducialise the 3 major components of the CLIC collider: quadrupoles, BPM and accelerating structures. This solution is based on the use of a Copper/Beryllium wire to materialize the reference axes of the components (respectively their magnetic axis, electromagnetic axis and electric zero axis) and to determine their position in the common support assembly coordinate system and with respect to the fiducials. These alignment targets will be used later to align the support assembly in the tunnel. With such a method, several components of different types, supported by a dedicated adjustment system can be fiducialised and pre-aligned with respect to the same wire, at the same time, at a high accuracy in the environment of a 3D CMM. Alternative solutions based on Frequency Scanning Interferometry and micro-triangulation are also under development, to perform or check such fiducialisation and initial alignment directly in the tunnel, after the transport of the components on their common support. Complementary studies have also been undertaken on the development of a new seismic sensor, on a high stiffness nano-positioning system with a millimetric stroke, on miniature rotating search coils and on the extrapolation of the uncertainties of measurements considering variations of temperature. These developments are part of the PACMAN project (a study on Particle Accelerator Components'Metrology and Alignment to the Nanometre scale), an innovative Doctoral Programme, where 10 PhD students hosted at CERN work towards their PhD thesis. The methods and tools developed are presented, as well as the first obtained results.

Summary

We propose a new solution to fiducialise the 3 major components of the CLIC collider: quadrupoles, BPM and accelerating structures. This solution is based on the use of a Copper/Beryllium wire to materialize the reference axes of the components (respectively their magnetic axis, electromagnetic axis and electric zero axis) and to determine their position in the common support assembly coordinate system and with respect to the fiducials. These alignment targets will be used later to align the support assembly in the tunnel. With such a method, several components of different types, supported by a dedicated adjustment system can be fiducialised and pre-aligned with respect to the same wire, at the same time, at a high accuracy in the environment of a 3D CMM. Alternative solutions based on Frequency Scanning Interferometry and micro-triangulation are also under development, to perform or check such fiducialisation and initial alignment directly in the tunnel, after the transport of the components on their common support. Complementary studies have also been undertaken on the development of a new seismic sensor, on a high stiffness nano-positioning system with a millimetric stroke, on miniature rotating search coils and on the extrapolation of the uncertainties of measurements considering variations of temperature. These developments are part of the PACMAN project (a study on Particle Accelerator Components'Metrology and Alignment to the Nanometre scale), an innovative Doctoral Programme, where 10 PhD students hosted at CERN work towards their PhD thesis. The methods and tools developed are presented, as well as the first obtained results.

Author: MAINAUD DURAND, Helene (CERN)

Co-authors: CHERIF, Ahmed (CERN); GADDI, Andrea (CERN); SANZ, Claude (CERN); TSHILUMBA, David (CERN); CAIAZZA, Domenico (CERN); SEVERINO, Giordana (CERN); DOYTCHINOV, Iordan Petrov (CERN); GAYDE, Jean-Christophe (CERN); FUCHS, Jean-Frederic (CERN); ARTOOS, Kurt (CERN); WENDT, Manfred (CERN); BUZIO, Marco (CERN); MODENA, Michele (CERN); GALINDO MUNOZ, Natalia (CERN); CATALAN LASHERAS, Nuria (CERN); NOVOTNY, Peter (CERN); ZORZETTI, Silvia (CERN); KAMUGASA, Solomon William (CERN); RUSSENSCHUCK, Stephan (CERN); VLACHAKIS, Vasileios (CERN)

Presenter: MAINAUD DURAND, Helene (CERN)

Contribution ID: **40** Type: **POSTER**

HIE-ISOLDE –Commissioning and first results of the MATHILDE system monitoring the positions of cavities and solenoids inside Cryomodules

The new superconducting HIE-ISOLDE Linac replaced most of pre-existing REX ISOLDE facility at CERN. This upgrade involves the design, construction, installation and commissioning of 4 high-β cryomodules. Each high-β -cryomodule houses five superconducting cavities and one superconducting solenoid. Beam-physics simulations show that the optimum linac working conditions are obtained when the main axes of the active components, located inside the cryostats, are aligned and permanently monitored on the REX Nominal Beam Line (NBL) within a precision of 0.3 mm for the cavities and 0.15 mm for the solenoids at one sigma level along directions perpendicular to the beam axis.
The Monitoring and Alignment Tracking for HIE-ISOLDE (MATHILDE) system has been developed to fulfil the alignment and monitoring needs for components exposed to non-standard environmental conditions such as high vacuum or cryogenic temperatures. MATHILDE is based on opto-electronic sensors (HBCAM) observing, through high quality viewports, spherical retroreflectors made of high index (˜2) glass. Precise mechanical parts, metrological tables and the, so called, MATHIS software were designed to be able to reconstruct the position of the active elements within a precision of 0.1mm.
The commissioning of MATHILDE and its first results to monitor the cavity and solenoid positions, especially during the installation and tests of the two first cryomodules on the HIE-ISOLDE Linac, are reviewed in this contribution.

Summary

Authors: KLUMB, Francis (CERN); KAUTZMANN, Guillaume; GAYDE, Jean-Christophe (CERN)

Presenter: KAUTZMANN, Guillaume

Contribution ID: **41** Type: **ORAL**

Recent development of micro-triangulation for magnet fiducialization

In the frame of the Particle Accelerator Components'Metrology and Alignment to the Nanometre scale (PACMAN) project, we develop the micro-triangulation method for the magnet fiducialization. The wire detection algorithm and the wire reconstruction algorithm are the most important parts of this study. High accuracy robotic theodolites observe the stretched wire, used for the determination of the magnetic axis, and the fiducial points in one coordinate system. The theodolites are equipped with the QDaedalus measuring system, mainly consisting of a CCD camera and a focusing mechanism. The advantage of QDaedalus is the capability to perform accurate, automatic, remote controlled angle measurements. The dedicated software controls the hardware and applies online computer vision techniques to detect and measure the targets. We examine how variation of environmental factors, such as light condition, focus, camera calibration, etc., may affect the measurements, and what is the precision of the QDaedalus system in a considerably stable environment. Preliminary results of simulations reveal the level of precision we can achieve given the instrumentation and the configuration constraints of the final PACMAN bench.

Summary

In the frame of the Particle Accelerator Components'Metrology and Alignment to the Nanometre scale (PACMAN) project, we develop the micro-triangulation method for the magnet fiducialization. The wire detection algorithm and the wire reconstruction algorithm are the most important parts of this study. High accuracy robotic theodolites observe the stretched wire, used for the determination of the magnetic axis, and the fiducial points in one coordinate system. The theodolites are equipped with the QDaedalus measuring system, mainly consisting of a CCD camera and a focusing mechanism. The advantage of QDaedalus is the capability to perform accurate, automatic, remote controlled angle measurements. The dedicated software controls the hardware and applies online computer vision techniques to detect and measure the targets. We examine how variation of environmental factors, such as light condition, focus, camera calibration, etc., may affect the measurements, and what is the precision of the QDaedalus system in a considerably stable environment. Preliminary results of simulations reveal the level of precision we can achieve given the instrumentation and the configuration constraints of the final PACMAN bench.

Author: VLACHAKIS, Vasileios (CERN)

Co-authors: MAINAUD DURAND, Helene (CERN); FUCHS, Jean-Frederic (CERN)

Presenter: VLACHAKIS, Vasileios (CERN)

Contribution ID: **42** Type: **POSTER**

LGC: A new revised version

A new version of LGC (Logiciel Général de Compensation) has been developed over the last few years. A completely different functional model and an improved stochastic model have been implemented, and the software has effectively been rewritten.
New observation types have been developed to respond to new requirements such as: unlevelled stations making polar measurements; more flexibility when processing offset observations (lines and planes introduced); and processing camera sensors (BCAM). For a new accelerator line monitoring system a way to define assemblies of objects has also be implemented.
The stochastic model has also been modified to allow a better breakdown and parametrization of the instrument and observation errors; and a better error propagation by means of weighted unknown parameters (coordinates and transformation parameters).
Special care has been taken testing the program. Unit and functionality tests have been added to assure future development, and an in depth comparison with the previous version has been made.
Furthermore, the calculation structure has also been designed to allow new processing modules, such as a pre-processing model to calculate initial coordinate values, to be added more easily.
This paper will give an overview of the new program.

Summary

Author: BARBIER, Marie (CERN)

Co-authors: JONES, Mark (CERN); DORLEAT, Quentin (CERN)

Presenter: JONES, Mark (CERN)

Contribution ID: **43** Type: **ORAL**

EXPERIENCE WITH THE ALIGNMENT OF LINAC4

LINAC4 (L4) is an H- linear accelerator that will deliver, for the High Luminosity LHC (HL-LHC) project requirements, a beam of protons at 160 MeV energy to the PS complex and then to the LHC. Its connection to the PS booster will take place during the Long Shutdown 2 (LS2) in 2019-2020 or earlier if any major failure of the LINAC2.
The Linac4 project requires the precise alignment with a tolerance of about +/- 0.2 mm in both the horizontal and vertical planes, of elements along approximately 150m beam line until the first bending magnet. The commissioning will take place in 2017 after the final smoothing of the L4 and the L4 transfer line (L4T) components in few months.
The presentation will give an overview of the challenges of the alignment, the issues solved by the survey section, the techniques and methodology used to realise the survey activities over the last 5 five years.

Summary

Author: FUCHS, Jean-Frederic (CERN)

Presenter: FUCHS, Jean-Frederic (CERN)

Contribution ID: **44** Type: **POSTER**

Improving 3D longitudinal network measurement by using stretched wire

Standard 3D measurements showed that it is difficult to align accurately the components of a particle accelerator in a narrow and straight tunnel due to the configuration of the network. When one makes use of a total station or a laser tracker for example, the radial alignment of the components diverges quickly if conventional alignment methods are used.

We propose to add measurements w.r.t a stretched wire to free stations (laser tracker or total stations) 3D measurements in order to make a longitudinal network more robust. First, we describe our adjustment method, based on the least squares method, with the addition of special constraints on the point coordinates due to the presence of the wires. Then, results of the simulations and of real measurements are discussed.

Summary

Author: DUQUENNE, Mathieu (Conservatoire National des Arts et Metiers - CNAM (FR))

Co-authors: MAINAUD DURAND, Helene (CERN); Mr DURAND, Stéphane (Conservatoire National des Arts et Metiers - CNAM (FR)); TOUZÉ, Thomas (HES-SO : UAS Western Switzerland); RUDE, Vivien (Ecole Superieure des Geometres et Topographes (FR))

Presenter: DUQUENNE, Mathieu (Conservatoire National des Arts et Metiers - CNAM (FR))

Contribution ID: **45** Type: **ORAL**

TSUNAMI –An unified software application for field measurements and alignments in experiments and accelerators at CERN large scale metrology section

TSUNAMI, The Survey Unified Notepad for Alignment and Measurement Interventions is a new software designed to replace two existing software, mainly dedicated to data acquisition and beam component alignment using geodetic instruments at CERN. The use of different programs has been justified historically by the different needs, equipment and types of user. The two main ones have been written in obsolete VB 6.0 and VBA. Maintained for 20 years by different persons the code is now a mix of procedural and Object Oriented programming.
The motivation is to create a single, modular and easy to maintain software written in a popular language for Windows applications (C#), that can be used in a "Standard mode"guided through well-defined steps or in a free "Advanced mode".
The approach is to build the application as a collection of wizards guiding the user through alignment and measurement modules, composed of more basic ones such as management and compute sub-modules.
This paper presents the functionalities and the development strategy of TSUNAMI.

Summary

TSUNAMI, The Survey Unified Notepad for Alignment and Measurement Interventions is a new software designed to replace two existing software, mainly dedicated to data acquisition and beam component alignment using geodetic instruments at CERN. This paper presents the functionalities and the development strategy of TSUNAMI.

Authors: SAINVITU, Pascal (CERN); DEWITTE, Philippe (CERN)

Co-authors: MERGELKUHL, Dirk (CERN); MISSIAEN, Dominique (CERN); GAYDE, Jean-Christophe (CERN)

Presenters: SAINVITU, Pascal (CERN); DEWITTE, Philippe (CERN)

Contribution ID: **46** Type: **POSTER**

Survey Status Report on AWAKE, ELENA, and CENF

Abstract
Besides the main survey activities, which are presented in dedicated talks or poster, some projects are also progressing at CERN.
ELENA, a small compact ring for cooling and further deceleration of 5.3 MeV antiprotons delivered by the CERN Antiproton Decelerator, is being installed and aligned, for commissioning later this year.
AWAKE, a project to verify the approach of using protons to drive a strong wake field in a plasma which can then be harnessed to accelerate a witness bunch of electrons, will be using the proton beam of the CERN Neutrino to Gran Sasso, plus an electron and a laser beam. The proton beam line and laser beam line are ready to send protons inside the 10m long plasma cell in October. The electron beam line will be installed next year.
The CERN Neutrino Platform is CERN's undertaking to foster and contribute to fundamental research in neutrino physics at particle accelerators worldwide. Two secondary beamlines are extended in 2016-18 for the experiments WA105 and ProtoDUNE. In parallel the detectors for WA104 are refurbished and the cryostats assembled.
This paper gives an overview of the survey activities realised in the frame of the above mentioned projects and the challenges to be addressed.

Summary

Author: DEWITTE, Philippe (CERN)

Co-authors: MERGELKUHL, Dirk (CERN); DOBERS, Tobias (CERN)

Presenter: DEWITTE, Philippe (CERN)

Contribution ID: **47** Type: **POSTER**

Status report on survey and alignment activities @ GANIL-SPIRAL2 facilities (CEA/CNRS, Caen, France)

The over 30 years old GANIL laboratory (heavy ions national accelerator) is still delivering beams that interest the nuclear physicist community. That is why AGATA (Advanced GAmma Tracking Array, a European collaboration of 12 countries) settled at GANIL for a 4 years campaign. This ¼ π gamma-ray detector requested a quite strong effort in term of 3D positioning metrology and in term of environment adaptation.

Furthermore, since 2013, GANIL is constructing and installing the SPIRAL2 facility: a superconducting linear accelerator and experimental areas that represent 150m long beam lines. Two injectors (ions, protons and deutons), a RFQ, a medium energy beam line, a 30m long LINAC (26 supraconducting accelerating cavities) and high energy beam lines supplying two experimental halls: one dedicated to neutron and the other containing S3 (Super Separator Spectrometer).
This project requested full time survey and alignment work from the underground network linked to historical GANIL coordinates system to the process installation still in progress.

Summary

Author: Mr LEFEVRE, Alexis (GANIL (CEA-CNRS))

Co-author: Mr LEGRUEL, François (GANIL (CEA-CNRS))

Presenter: Mr LEFEVRE, Alexis (GANIL (CEA-CNRS))

Contribution ID: **48** Type: **ORAL**

HYDROSTATIC LEVELLING SYSTEM GOING MOBILE

The LHC Collimator Survey Train has already shown that automated survey measurements in the LHC are technically feasible. Nevertheless many constraints apply when making automated measurements in an accelerator environment. The research of adapted measurements techniques and strategies is an essential part in the development process of a new generation survey train.
From the automation point of view, the measurements in the vertical plane are particularly challenging and one solution would be the use of a Hydrostatic Levelling System. They are frequently used in high precision monitoring applications but with a few compromises a mobile and very flexible version can be build. This paper describes the approach, development and tests of a mobile HLS which is able to cope with the constraints and boundary conditions given by the LHC.

Summary

Author: BESTMANN, Patrick (CERN)

Co-author: DIONISIO BARRETO, Cristovao Andre (Universidade do Porto (PT))

Presenter: BESTMANN, Patrick (CERN)

Contribution ID: **49** Type: **ORAL**

Frequency Scanning Interferometry for CLIC component fiducialisation

We present a strategy for fiducialisation of CLIC's Main Beam Quadrupole (MBQ) using Frequency Scanning Interferometry (FSI). We are developing a device to complement a commercial FSI system to enable multilateration for coordinate determination of fiducials. Using spherical high index glass targets with a wide acceptance angle, we optimise the geometry of the measurement stations with respect to the fiducials –thus improving the precision of coordinates. We demonstrate through simulations that the 10 micrometre uncertainty required in the vertical and lateral axes for the fiducialisation of the MBQ can be attained using FSI multilateration.

Summary

Author: KAMUGASA, Solomon William (CERN)

Co-authors: MAINAUD DURAND, Helene (CERN); GAYDE, Jean-Christophe (CERN)

Presenter: KAMUGASA, Solomon William (CERN)

Contribution ID: **50** Type: **POSTER**

Issues and feasibility demonstration of CLIC supporting system chain active pre-alignment using a multi-module test setup (mock-up)

The implementation study of the CLIC (Compact LInear Collider) is under way at CERN with a focus on the challenging issues. The pre-alignment precision and accuracy requirements are part of these technical challenges: the transverse position tolerances of the linac components are typically 14 micrometers over sliding windows of 200m. To validate the proposed methods and strategies, the Large Scale Metrology section at CERN has performed campaigns of measurements on the CLIC Two Beam Test Modules, focusing inter alia on the alignment performance of the CLIC "snake"- girders configuration and the Main Beam Quadrupoles supporting structures.
This paper describes the activities and results of tests which were performed on the test mock-up for the qualification of the CLIC supporting system chain for active pre-alignment. The lessons learnt ("know how"), the issues encountered in the girder position determination as well as the behavior of the mechanical components are presented.

Summary

Author: SOSIN, Mateusz (CERN)

Co-authors: ZEMANEK, Anna (AGH University of Science and Technology (PL)); MAINAUD DURAND, Helene (CERN); JAROS, Jakub Aleksander (AGH University of Science and Technology (PL)); KEMPPINEN, Juha (Eidgenoessische Tech. Hochschule Zuerich (CH)); GUTT-MOSTOWY, Marek Leslaw (CERN); RUDE, Vivien (Ecole Superieure des Geometres et Topographes (FR)); KOSTKA, Zbigniew Stanislaw (AGH University of Science and Technology (PL))

Presenter: SOSIN, Mateusz (CERN)

Contribution ID: **51** Type: **ORAL**

Validation of the crab cavities internal monitoring strategy

The High Luminosity LHC (HL-LHC) project aims at upgrading the long straight sections of the LHC on each side of the two main LHC experiments, ATLAS and CMS. One of the innovative key technology is the superconducting cavities for beam rotation. These "crab cavities"are working in vacuum and cryogenic environment under radiation conditions. An alignment of the inner tank of the crab cavities to 0.5 mm at 3 is needed. A continuous monitoring system is also requested during the cool-down and the operation of the crab cavities in order to follow the movement of the inner tank with respect to the outer part of the cavities.

Two alignment systems have been tested on a prototype to provide the position monitoring: the BCAM system (Brandeis CCD Angle Monitor) which is based on optical elements, and the FSI (Frequency Scanning Interferometry) which is an absolute distance measurement device. The two systems have been compared without vacuum and without cryogenic environment in order to validate their accuracy. In parallel, they are validated regarding radiation and cryogenic aspects.
The results of the two types of measurement are compared and referenced to Laser Tracker measurement.

Summary

Author: RUDE, Vivien (Ecole Superieure des Geometres et Topographes (FR))

Co-authors: HERTY, Andreas (CERN); MAINAUD DURAND, Helene (CERN); SOSIN, Mateusz (CERN); DUQUENNE, Mathieu (Conservatoire National des Arts et Metiers - CNAM (FR)); DIJOUD, Thibault (CERN)

Presenter: RUDE, Vivien (Ecole Superieure des Geometres et Topographes (FR))

Contribution ID: **52** Type: **ORAL**

Smoothing the LHC during the Long Shut-down 1

The two-years Long Shut-Down 1 (LS1), triggered by the repair of the splices in the interconnections of the Large Hadron Collider (LHC) cryo-magnets, gave the opportunity to the survey and alignment team to smooth the position of the 27km of the LHC in order to guaranty its best performance for the RUN2 expected between 2015 and 2018. For the first time after the starting of the LHC, the roll angle of the LHC cryo-magnets as well as their position in vertical and in horizontal (transverse) were measured. This large measurements campaign has allowed a realignment of many components and will be an important source of information useful for the analysis of the stability of the LHC, allowing then the survey team to predict the areas where the future movements are going to take place. This paper gives an overview of the techniques and the software used for the smoothing, the realignment process and a preliminary analysis of the stability of the LHC

Summary

The two-years Long Shut-Down 1 (LS1), triggered by the repair of the splices in the interconnections of the Large Hadron Collider (LHC) cryo-magnets, gave the opportunity to the survey and alignment team to smooth the position of the 27km of the LHC in order to guaranty its best performance for the RUN2 expected between 2015 and 2018. For the first time after the starting of the LHC, the roll angle of the LHC cryo-magnets as well as their position in vertical and in horizontal (transverse) were measured. This large measurements campaign has allowed a realignment of many components and will be an important source of information useful for the analysis of the stability of the LHC, allowing then the survey team to predict the areas where the future movements are going to take place.
This paper gives an overview of the techniques and the software used for the smoothing, the realignment process and a preliminary analysis of the stability of the LHC

Author: MISSIAEN, Dominique (CERN)

Co-author: FUCHS, Jean-Frederic (CERN)

Presenter: MISSIAEN, Dominique (CERN)

Contribution ID: **53** Type: **ORAL**

Hydrostatic levelling sensors based on extrinsic fibre Fabry-Perot interferometer technology

With the high luminosity upgrade of the Large Hadron Collider, some zones in the Long Straight Section will expect annual radiation doses of 100 kGy. Hydrostatic levelling systems will be deployed for vertical and tilt monitoring. To resist to this high radiation doses, the electronics have to be placed up to 200 m apart from the sensors. A candidate for this task is a hydrostatic levelling sensor based on extrinsic fibre Fabry-Perot interferometer technology. Any variation in the level of the reference surface is detected as a variation in the optical path length between the fibre probe situated in the sensor head and the mirror that is submerged in the liquid. In laboratory conditions the prototype operated at a range of 10 mm with a resolution of 5 nm. Thermal and atmospheric influences as well as the internal drift of the interferometer are compensated for by the differential measurement carried out with a single laser source. The sensing fibre can be several kilometres long and the systems allows signal processing up to 10 kHz. These design parameters have been tested in two field tests, one at the Laboratoire Souterrain à Bas Bruit for a sensor validation test. The other one at CERN in comparison with the currently used capacitive hydrostatic levelling sensor type. The results show that the technology can be applied for future hydrostatic levelling sensors. The approach to an absolute measurement solution is still under investigation.

Summary

Authors: HERTY, Andreas (CERN); BOUDIN, Frédéric (CNRS); SEAT, Han-Cheng (LAAS-CNRS)

Co-authors: CAVAILLOU, Alain (LSBB); BOYER, Daniel (LSBB); LIZION, Françoise (LAAS-CNRS); MAINAUD DURAND, Helene (CERN); CATTOEN, Michel (LAAS-CNRS)

Presenter: BOUDIN, Frédéric (CNRS)

Contribution ID: **54** Type: **POSTER**

Status OF SESAME

The synchrotron Light Source for Experimental Science and Applications in the Middle East (SESAME) is now in its final stage. This paper also presents the alignment strategy for the storage ring of SESAME.

Summary

Author: Mr ABU-HANIYI, Ta'er (Mechanical Engineer)

Presenter: Mr ABU-HANIYI, Ta'er (Mechanical Engineer)

Contribution ID: **55** Type: **ORAL**

Analysis and Evaluation of the CERN Reference Systems

The work that will be presented has been driven mainly by the Future Circular Collider (FCC) study, a proposed next-generation particle collider with a circumference of 100 km and the aim of reaching collision energies of 100 TeV.

The new machine would be located in Swiss and French territories, and it would cover more than 10 times the area of the existing LHC facilities. For this reason, a better integration of the French and Swiss data is needed. The large dimensions of the future machine and the high alignment precision requirements make it necessary to review and analyse the reference and coordinate systems used at CERN, as well as to evaluate the extension of those to cover a much larger area. The current definitions of the CERN reference systems and the transformations between them have been analysed and tested. The proposed modifications and the future work that has to be done to prepare a conceptual design report for the FCC project by 2018 will be presented.

Summary

Author: IBARROLA SUBIZA, Nerea (CERN)

Co-author: JONES, Mark (CERN)

Presenter: IBARROLA SUBIZA, Nerea (CERN)

Contribution ID: **56** Type: **POSTER**

Future Circular Collider Study

The Future Circular Collider (FCC) Study, hosted by CERN, is an international collaboration of more than 70 institutes from all over the world. The FCC is a proposed next-generation circular collider with a circumference of 100 km and its goal is to push the energy and intensity frontiers of particle colliders in the search for new physics. This FCC accelerator complex would be the next large research facility after the High-Luminosity Large Hadron Collider (HL-LHC), when these approach the limits of their discovery potential around 2035. Three different types of machines are currently under study: the FCC-hh, a proton-proton collider; the FCC-ee, an electron-positron collider and the FCC-he with proton-electron collisions.

The CERN Survey team is implicated in all stages of the assembly and installation of accelerator beamline and experiment detector components for any new project. Our studies are concentrated on those aspects which present new challenges: the need of extensive areas of Permanent Monitoring and Alignment Systems, a potential remote maintenance system, development of new methods and instrumentation in order to meet the high alignment precision requirements and the extension of the geoid model and reference systems used at CERN.

Summary

Author: JONES, Mark (CERN)

Co-author: IBARROLA SUBIZA, Nerea (CERN)

Presenter: JONES, Mark (CERN)

Contribution ID: **57** Type: **POSTER**

Study on Remote Acute Repositioning Error for CSNS RTBT Equipment

The equipment of CSNS RTBT interface couldn't be aligned and fixed in short distance because of the high radiation, so all the devices should be remotely installed and disassembled. In order to meet requirements, first pre-align the devices on the upper girder, and then remotely hoisting the upper girder toward the underneath girder installed inside the interface. Therefor the positioning balls will automatically fix the ball seats between the upper girder and underneath girder. Analysis and calculate the remotely hoisting errors, aligning errors, and machining errors, take measures to restrict the errors'range to achieve the high repositioning accuracy.

Summary

Author: HE, Huayan (IHEP)

Co-authors: Mr ZHU, Donghui (IHEP); Mr WANG, Guangyuan (IHEP); Mr QU, Huaming (IHEP); Mr ZHANG, Junsong (IHEP); Ms KANG, Ling (IHEP)

Presenter: HE, Huayan (IHEP)

Contribution ID: **59** Type: **POSTER**

Electron and laser beams mutual alignment in SPARC (INFN)

In the SPARC accelerator the electron beam and the laser beam crosses at an interaction point of really small size. So both the beams has to be precisely and mutually aligned.
As for the laser, scientists use to make manual alignment by means of mirrors and irises, using a low power pointing laser. This is definetely unpractical in the accelerator environment, where the access is forbidden during the operation: so the laser beam has to be aligned precisely with respect to the nominal path before turning on the electron beam.
A special support for the pointing laser has been designed and fabricated. The support has three mounting holes for the laser tracker CCR, so it can be aligned with respect to the nominal beam line. In the paper the procedure for the pointing laser characterization, the alignement work, as well as the evaluation of the accuracy obtained, are reported.

Summary

Authors: PUTINO, Francesco (INFN); PELLEGRINO, Luigi (INFN - National Institute for Nuclear Physics); PARIS, Marco (INFN); DEL FRANCO, Mario (INFN)

Presenters: PELLEGRINO, Luigi (INFN - National Institute for Nuclear Physics); DEL FRANCO, Mario (INFN)

Contribution ID: **60** Type: **POSTER**

A technique for the transport of an alignment network through a small hole

In the CNAO accelerator for adrontherapy, a new experimental line and a dedicated hall have been added. The main accelerator hall and the experimental hall are separated by a 2 m thickness concrete wall. The only communication between the two hall is a 20 cm hole, normally closed by a concrete plug.
The alignment network of the main hall has to be connected to a new network in the experimental hall, but using only the laser tracker through the hall would cause unacceptable errors.
Therefore a mixed technique has been developed using a Taylor Hobson telescope and a laser tracker with an inclinometer to obtain a good connection accuracy. In the paper the procedure for the telescope positioning by laser tracker, and for the alignment network expansion in the experimental hall, as well as the evaluation of the accuracy obtained, are reported.

Summary

Authors: PUTINO, Francesco (INFN); PELLEGRINO, Luigi (INFN - National Institute for Nuclear Physics); PARIS, Marco (INFN); DEL FRANCO, Mario (INFN)

Presenters: PELLEGRINO, Luigi (INFN - National Institute for Nuclear Physics); PARIS, Marco (INFN)

Contribution ID: **61** Type: **ORAL**

Survey Support to Magnetic Measurement

Preferably the magnetic center of a magnet is the one to be referred during alignment. This requires cooperation between magnetic measurement and survey group so that the difference between magnetic and mechanical center is taken into account. By establishing local frame of magnetic measurement equipment initially and then aligning magnet or insertion device precisely relative to it, the magnetic center can be recorded and used for future installation.

Summary

Author: KE, Ming (Brookhaven National Laboratory)

Presenter: KE, Ming (Brookhaven National Laboratory)

Contribution ID: **64** Type: **ORAL**

A rotary mount for submicrometric positioning of a stretched wire axis within a coordinate measuring machine

As part of its role as world-wide leader in high energy particle physics, CERN studies the feasibility of a Compact Linear Collider (CLIC). One of the biggest challenges of this electron-positron collider is the alignment required for all the components acting on the beam: thousands of components will have to be assembled and aligned at the micrometre level. PACMAN, a study on Particle Accelerator Components Metrology and Alignment to the Nanometre scale, is a Marie-Skłodowska Curie Program supported by the European Commission (FP7 Program) whose aim is to develop and build a pre-alignment bench on which components are assembled and aligned to the required accuracy using a stretched wire.
During the process of this measurement, the centre of a stretched wire is aligned with respect to the reference axis of the components. The Cu-Be wire with a diameter of 0.1 mm considered for this task has been evaluated and its quality led to the conclusion that a form measuring sensor should be used to increase the precision of the measurement. The Shape Evaluating Sensor: High Accuracy & Touchless SESHAT is being designed for this task: its challenge is to measure the form error of this stretched wire with 0.1 µm accuracy and its axis position with 0.5 µm precision on the coordinate measuring machine. The singularity of the SESHAT's design is an opening in the radial direction. Indeed, this paper introduces the requirements: no magnetic fields created, high accuracy on the positioning, low error motion, and open on the side; and it describes and discusses the technical solutions: from the material to use to the bearings, including the kind of sensor.

Summary

A rotatory mount is being designed in CERN to determine the position of the axis of a 0.1 mm in diameter stretched wire with a sub-micron repeatability.

Author: SANZ, Claude (CERN)

Presenter: SANZ, Claude (CERN)

Contribution ID: **65** Type: **ORAL**

Geometry Survey of the Time-of-Flight Neutron-Elastic Scattering (Antonella) Experiment

The Antonella experiment is a measurement of the ionization efficiency of nuclear recoils in silicon at low energies [1]. It is a neutron elastic scattering experiment motivated by the search of dark matter particles. In this experiment, a proton beam hits a lithium target and neutrons are produced. The neutron shower passes through a collimator that produces a neutron beam. The beam illuminates a silicon detector. With a certain probability, a neutron interacts with a silicon nucleus of the detector producing elastic scattering. After the interaction, a fraction of the neutron energy is transferred to the silicon nucleus which acquires kinetic energy and recoils. This kinetic energy is then dissipated in the detector producing ionization and thermal energy. The ionization produced is measured with the silicon detector electronics. On the other hand, the neutron is scattered out of the beam. A neutron-detector array (made of scintillator bars) registers the neutron arrival time and the scattering angle to reconstruct the kinematics of the neutron-nucleus interaction with the time-of-flight technique [2]. In the reconstruction equations, the energy of the nuclear recoil is a function of the scattering angle with respect to the beam direction, the time-of-flight of the neutron and the geometric distances between components of the setup (neutron-production target, silicon detector, scintillator bars). This paper summarizes the survey of the different components of the experimental arrangement, which made possible the off-line analysis of the collected data. Measurements were made with a API Radian Laser Tracker and the I-360 Probe. The survey was completed at the University of Notre Dame, South Bend, Indiana in February 2015.

Summary

Author: OSHINOWO, Babatunde (Fermilab)

Co-author: IZRAELEVITCH, Federico (FCEN - Universidad de Buenos Aires, Argentina / Fermilab)

Presenter: OSHINOWO, Babatunde (Fermilab)

Contribution ID: **66** Type: **POSTER**

SLAC Status Report

This poster presents the survey and alignment activities at the SLAC National Accelerator Laboratory since 2014. The major projects during the last two years have been a revised coordinate system for the SPEAR3 ring, changing the monumentation in the SLAC Linac from a girder based system to a monument based system and the reconfiguration of the Linac Laser Alignment System in preparation for LCLS II installation. A variety of smaller projects are also under way. This poster will give a brief overview of the various projects and the actual implementations in the field.

Summary

Author: GASSNER, Georg (SLAC National Accelerator Laboratory)

Co-authors: Mr FUSS, Brian (SLAC National Accelerator Laboratory); Mr GAYDOSH, Michael (SLAC National Accelerator Laboratory)

Presenter: Mr GAYDOSH, Michael (SLAC National Accelerator Laboratory)

Contribution ID: **67** Type: **ORAL**

Re-configuration of the Linac reference system at SLAC

Up to now the linear accelerator (Linac) alignment at SLAC was based on fiducials on the girders of the Linac. These were directly tied to the Linac Laser Alignment System which had a target at every subsector (270 targets for the 3048m length). For the new LCLS II a superconducting Linac will be installed in the first third of the accelerator housing and the Linac light pipe will be removed from these sectors. This makes two procedures necessary. For the LCLS II area, the reference monuments must be transferred from the girders to the walls and floor of the accelerator housing. For the last two thirds of the accelerator, the Linac Laser Alignment System optics have to be modified. This paper will report on these two activities.

Summary

Author: GASSNER, Georg (SLAC National Accelerator Laboratory)

Co-author: Mr GAYDOSH, Michael (SLAC National Accelerator Laboratory)

Presenter: GASSNER, Georg (SLAC National Accelerator Laboratory)

Contribution ID: **68** Type: **ORAL**

Alignment of SuperKEKB Main Ring Magnet System

SuperKEKB is an electron-positron double-ring B-factory machine, which aims to achieve a peak luminosity 40 times higher than that of KEKB by using the “nano-beam”scheme.
A major upgrade to the Main Ring magnet system was needed in order to realize this scheme. Approximately 2600 magnets were aligned, using ˜1200 reference points in the tunnel.
Commissioning of the SuperKEKB main ring started in February, 2016. The circumference as measured by the beam agreed with the prediction from analysis of alignment data to within 1 ppm.
The circumference difference between two rings was found to be approximately a few hundred microns over ˜3 km.
The good alignment of the main ring magnets contributed to the smooth start up of the SuperKEKB beam commissioning. The alignment strategy and results will be presented in this report.

Summary

Author: MASUZAWA, Mika (KEK)

Co-authors: KAWAMOTO, Takashi (KEK); Prof. ADACHI, Toshikazu (KEK); OHSAWA, Yasunobu (KEK)

Presenter: MASUZAWA, Mika (KEK)

Contribution ID: **70** Type: **ORAL**

SLRS Finals

The Straight Line Reference Surveyor is getting installed and comissioned.

Summary

The Straight Line Reference Surveyor is getting installed and comissioned.

Author: PRENTING, Johannes (DESY)

Co-authors: NOAK, Martin (DESY); BRIECHLE, Sebastian (DESY)

Presenter: PRENTING, Johannes (DESY)

Contribution ID: **71** Type: **POSTER**

Status Report on the alignment efforts @ DESY

Status Report on the alignment efforts @ DESY

Summary

Status Report on the alignment efforts @ DESY

Author: BENECKE, Wolf (DESY)

Co-author: NOAK, Martin (DESY)

Presenter: BENECKE, Wolf (DESY)

Contribution ID: **73** Type: **POSTER**

Sextupole magnets with variable tilt angles for SuperKEKB

SuperKEKB is an electron-positron collider with the design peak luminosity of 8×10ˆ35cmˆ-2sˆ-1. In order to achieve this high luminosity, it is important to make the beam size small at the interaction point, especially in the vertical direction. Skew sextupole magnets were found to be effective in order to make the small beam sizes during KEKB operation. At SuperKEKB, a novel idea of tilting the normal sextupole magnets to control the ratio of skew sextupole field component to normal sextupole field component has been proposed for the positron ring. Twenty-four sextupole magnets were modified and new tilting tables were fabricated to control the normal/skew component ratio by tilting the magnets. The tables were designed so that the sextupole magnets can be tilted from -30 degrees to +30 degrees (-523.58 mrad to +523.58 mrad), with a setting accuracy of 0.1 mrad. Magnet movers for controlling the horizontal and vertical positions, as well as the tilting angles, had been developed elsewhere before, though a table of such a large range, with 0.1 mrad setting accuracy for optics correction and luminosity tuning, is unique. The first commissioning of the tilting sextupole magnets at SuperKEKB will be presented.

Summary

Author: MASUZAWA, Mika (KEK)

Co-authors: Prof. SUGAHARA, Ryuhei (KEK); KAWAMOTO, Takashi (KEK)

Presenter: MASUZAWA, Mika (KEK)

Contribution ID: **74** Type: **POSTER**

Level changes in the SuperKEKB main ring tunnel

SuperKEKB is a next-generation B-factory machine, which aims to achieve a peak luminosity 40 times higher than that of KEKB. It was built utilizing the pre-existing KEKB tunnel. The SuperKEKB construction started in 2010, and beam circulation in the main rings was achieved in February 2016. The floor level change along the 3 km main ring tunnel has been surveyed using DNA03 and N3 periodically. The south arc section continues to sink with respect the interaction point at an average speed of a few millimeters per year, resulting in a net sinkage of more than 35 mm. The floor level around the interaction point has been monitored continuously with the BINP HLS system. The level is affected by the outside temperature and rainfall. We see tidal effects, and earthquakes which took place a thousand kilometers away from KEK with this system. The SuperKEKB tunnel level change is summarized in this report.

Summary

Author: KAWAMOTO, Takashi (KEK)

Co-authors: MASUZAWA, Mika (KEK); UEKI, Ryuichi (KEK); OHSAWA, Yasunobu (KEK)

Presenter: KAWAMOTO, Takashi (KEK)

Contribution ID: **79** Type: **ORAL**

Uncertainty budgeting for large scale components production and micron precision accelerators pre-alignment as required by CLIC project

A new strategy for uncertainty budgeting estimation following the International Standard (GUM - Supplement 1) is proposed as alternative to current classical methods of error budgeting applied in the domain of accelerator components. This strategy applies stochastic modelling on the uncertainty contributing factors for providing probability density function as quantification of global pre-alignment uncertainty. As a case study the methodology is applied to the PACMAN pre-alignment project providing a 'measurement specific'uncertainty budget for accelerator pre-alignment components according to GUM - Supplement 1. With this methodology the global uncertainty budget can be determined as function of the exact conditions of each specific contributing factor (temperature and its gradients, measurement strategy, instrumentation, etc.). We believe that this methodology would provide a more accurate approach on the tight uncertainty budgeting allocated for the alignment requirements of the future particle accelerators projects. The method could be easily extrapolated/applied for uncertainty budgeting of different type metrology systems.

Summary

A new strategy for uncertainty budgeting estimation following the International Standard (GUM - Supplement 1) is proposed as alternative to current classical methods of error budgeting applied in the domain of accelerator components. This strategy applies stochastic modelling on the uncertainty contributing factors for providing probability density function as quantification of global pre-alignment uncertainty. As a case study the methodology is applied to the PACMAN pre-alignment project providing a 'measurement specific'uncertainty budget for accelerator pre-alignment components according to GUM - Supplement 1. With this methodology the global uncertainty budget can be determined as function of the exact conditions of each specific contributing factor (temperature and its gradients, measurement strategy, instrumentation, etc.). We believe that this methodology would provide a more accurate approach on the tight uncertainty budgeting allocated for the alignment requirements of the future particle accelerators projects. The method could be easily extrapolated/applied for uncertainty budgeting of different type metrology systems.

Author: DOYTCHINOV, Iordan Petrov (CERN)

Presenter: DOYTCHINOV, Iordan Petrov (CERN)

Contribution ID: **80** Type: **ORAL**

Geodetic and Alignment concepts for PIP-II

Proton Improvement Plan-II (PIP-II) is Fermilab's plan for upgrading the accelerator complex with the goal of providing proton beam power of 1.2 MW on target at the start of operations of the Long Baseline Neutrino Facility (LBNF). It will also create a platform for long term development to multi MW capabilities to support a broader Fermilab research program.

This paper summarizes the concepts, methodology, implementation, and current results of the geodetic surveying and precise positioning efforts to support the PIP-II conceptual development and its associated R&D programs.

Summary

Author: BOCEAN, Virgil (Fermi National Accelerator Laboratory)

Presenter: BOCEAN, Virgil (Fermi National Accelerator Laboratory)

Contribution ID: **81** Type: **ORAL**

Survey, Alignment and Metrology at the European Spallation Source

In 2014, civil engineering works started for the construction of the European Spallation Source in Lund, south of Sweden, aiming to be the world's leading neutron source for the study of materials. This spallation source will include a 600 m long linear accelerator delivering a 2GeV proton beam to a rotating tungsten target wheel. A large suite of neutron instruments will then be installed to take advantage of the thermal and cold neutron beams generated.
An overview of on-going Survey, Alignment and Metrology activities will be presented, describing geometry of the machine, technical requirements and major challenges for the collaboration of our more than 100 partner laboratories.

Summary

Author: REY, Fabien (ESS ERIC)

Co-author: Mr GARSZTKA, Pawel (ESS ERIC)

Presenter: REY, Fabien (ESS ERIC)

Contribution ID: **82** Type: **POSTER**

3D laser scanning applications at ESS ERIC in Lund, Sweden

The Survey Alignment and Metrology team at ESS is capable of providing a digital 3D representation of the on-going construction and installation activities to many different users. During the design phase, for integration purposes, to support as-built documentation or simply to visualize progressing installation works, this tool becomes crucial for such a complex project.
Field data are captured using 3D laser scanning solution, and the processing of the point clouds enables to publish the resulting models via web based application while more advanced users can use it directly in our CAD platform.

Summary

Author: Mr GARSZTKA, Pawel (ESS ERIC)

Co-author: REY, Fabien (ESS ERIC)

Presenter: Mr GARSZTKA, Pawel (ESS ERIC)

Contribution ID: **83** Type: **POSTER**

ALIGNMENT OF A 240 KeV ECR COLUMN AT DUKE UNIVERSITY LENA

In spring of 2015 construction of a new 240 KeV particle accelerator column and its extraction system were completed at the Laboratory for Experimental Nuclear Astrophysics (LENA) at Duke University. This was done as part of an upgrade to the existing Electron Cyclotron Resonator (ECR) Ion Source at LENA, located in the basement of Duke University Physics Department.
In this report, survey and alignment of this ECR accelerator column and its extraction system will be discussed in details.

Summary

In spring of 2015 construction of a new 240 KeV particle accelerator column and its extraction system were completed at the Laboratory for Experimental Nuclear Astrophysics (LENA) at Duke University. This was done as part of an upgrade to the existing Electron Cyclotron Resonator (ECR) Ion Source at LENA, located in the basement of Duke University Physics Department.
In this report, survey and alignment of this ECR accelerator column and its extraction system will be discussed in details.

Author: Mr EMAMIAN, Mark (Duke University)

Presenter: Mr EMAMIAN, Mark (Duke University)

Contribution ID: **84** Type: **ORAL**

Alignment Database at DESY

Since 2009 a relational database is used to store alignment data of accelerators at DESY. This includes magnets and other components together with their fiducialization data, nominal positions of accelerator components (”the lattice”) and actual measurement data of components. Nominal alignment data for field work is produced “on the fly” by the database management system. After the alignment process the actual data is used to estimate the difference between nominal and actual lattice.
After a brief introduction to relational database management systems an overview of the internal table structure of the DESY coordinate database is given. The composition of the various tables into views that are suitable for everyday use is shown, as well as the database technology used for the adjustment of small measurement data sets.

Summary

Author: SCHLÖSSER, Markus (DESY)

Presenter: SCHLÖSSER, Markus (DESY)

Contribution ID: **91** Type: **ORAL**

ESRF presentations

Summary