International Workshops on Accelerator Alignment (IWAA) 2018

Report of Contributions

https://indico.fnal.gov/e/iwaa2018

Contribution ID: **1** Type: **Paper**

Deformation and Alignment of the Cryostat in the CADS Injector II

Tuesday, October 9, 2018 3:30 PM (30 minutes)

Thermal contraction and expansion of the Cryostat will affect its reliability and stability. To optimize and upgrade
the Cryostat, we analyzed the heat transfer in a cryo-vacuum environment from the theoretical point first.
The simulation of cryo-vacuum deformation based on a finite element method was implemented respectively.
The completed measurement based on a Laser Tracker and a Micro Alignment Telescope was conducted to verify
its correctness. The monitored deformations were consistent with the simulated ones. After the predictable
deformations in vertical direction have been compensated, the superconducting solenoids and Half Wave
Resonator cavities approached the ideal “zero” position under liquid helium conditions. These guaranteed the
success of 25 MeV@170 uA continuous wave protons of Chinese accelerator driven subcritical system Injector II.
By correlating the vacuum and cryo-deformation, we have demonstrated that the complete deformation was the
superposition effect of the atmospheric pressure, gravity and thermal stress during both the process of cooling
down and warming up. The results will benefit to an optimization for future Cryostat’s design.

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Session Classification: Survey & Alignment Aspects of Superconducting Devices

Track Classification: Survey & Alignment Aspects of Superconducting Devices

Contribution ID: **2** Type: **Paper**

Configuration and Operation status of HLS and WPS system installed in PAL-XFEL

Thursday, October 11, 2018 9:30 AM (30 minutes)

All components of PAL-XFEL (Pohang Accelerator Laboratory's X-ray free-electron laser) were completely installed in December 2015, and Hard X-ray 0.1nm lasing achieved through its beam commissioning test and machine study on March 16, 2017. The beam line users are use the hard x-ray since March 22, 2017.

Several parts that comprise the large scientific equipment should be installed and operated at precise three-dimensional location coordinates X, Y, and Z through survey and alignment to ensure their optimal performance. As time goes by, however, the ground goes through uplift and subsidence, which consequently changes the coordinates of installed components and leads to alignment errors ΔX, ΔY, and ΔZ. As a result, the system parameters change, and the performance of the large scientific equipment deteriorates accordingly.

Measuring the change in locations of systems comprising the large scientific equipment in real time would make it possible to predict alignment errors, locate any region with greater changes, realign components in the region fast, and shorten the time of survey and alignment. For this purpose, HLS and WPS system are installed in PAL-XFEL.

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Session Classification: Survey & Alignment Aspects of Light Sources

Track Classification: Survey & Alignment Aspects of Light Sources

Contribution ID: **5** Type: **Poster**

Status report on the monitoring systems for Sirius

Sirius is a synchrotron light source being assembled in Brazil. It will have a 3 GeV electron storage ring and an emittance of 0.25 nm.rad. The alignment tolerances for Sirius is in the order of 0.040 mm between adjacent magnets and 0.080 mm for adjacent girders. Also, the maximum allowed vibration for these components is approximately 0.010 nm, which requires the whole mechanical structure to be very stiff and thus resonate in high frequencies. The slab and foundation of the building also have very special requirements in terms of stability. On the other hand, the flatness of the slab has a targeted tolerance of 20 mm in its whole extension, to accommodate for levelling wedges with only 5 mm range. Not only the machine needs to comply with several challenges, but the building where it will be installed needs to face demanding requirements difficult to achieve for traditional civil construction. Several factors may influence the stability of the slab and radiation shielding over time, such as temperature, vibration, rain levels and so on. This paper will describe monitoring systems being installed on the building, such as a network of hydrostatic levelling sensors on top of the tunnel, and temperature and strain-gages embedded in the concrete. Plans for future installation of seismic and weather stations will be presented, and focus will also be given to the layout of the monitoring systems and the tests already performed.

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Contribution ID: **7** Type: **not specified**

Reference networks and coordinate systems for the alignment of Sirius accelerators and beamlines

During the construction of the building for the new Brazilian synchrotron light source, Sirius, several reference networks and coordinate systems were defined. The references used from the initial locations of the civil construction area were expanded, and the old coordinate system was maintained during all phases of the civil works. Also, different references were used depending on the phase of the project. After the main slab was concreted, due to structural motion of the building structure new references were installed on the radiation shielding and special slab. For the alignment of the Linac, a new reference network was installed inside its tunnel. The same occurred for the main tunnel, where approximately 1200 points were materialized with target holders, surveyed and adjusted to serve as a reference for the alignment of the components of the Booster and Storage Ring components. This paper deals with details about these coordinate systems and reference networks, from the point of view of management, establishment, survey and adjustment. Also, this work will describe the six degree-of-freedom transformations applied over time to coordinate systems adequacy. GNSS measurement campaigns for the central monuments used to georeferencing the building will be reported. In addition, this work will present the geometry of the reference network to be installed on the experimental hall, long beamlines, and the first experimental hutches. The issue of connecting those networks together and simulations to evaluate the networks in terms of measurement uncertainty will be reported.

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Contribution ID: **10** Type: **Poster**

Aligning the new Brazilian synchrotron: initial results

This paper describes the first alignment results for the accelerators of Sirius, the new Brazilian synchrotron. It comprises the positioning of the Linac, Booster and Storage Ring components. A complete description of the Linac installation will be given, including the smoothing of the components positions. Initial results are presented for the Booster and Storage Ring magnets. Details of the installation are given, such as the transportation of heavy components, blueprinting and positioning. Also, several procedures related to laser tracker positioning, the use of special measuring instruments and other particularities related to measurement uncertainty estimation are given. Other equipment applied during the alignment will be presented, for example high accuracy digital inclinometers, high precision spirit levels, rotating laser alignment systems and gauge blocks. The installation and alignment of the Linac was performed in cooperation with the Shanghai Synchrotron Radiation Facility, SSRF. For the beamlines, focus will be given to the fiducialization of the components for the first two front-ends.

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Contribution ID: **11** Type: **Poster**

Alignment network measurement and adjustment software development at FRIB

The alignment group at FRIB has developed software to interface with our Leica AT402 laser trackers to take network measurements and perform real-time least squares network adjustment and statistical analysis. The software is named NETOBS (for Network Observation). NETOBS was written in MATLAB with the supporting Leica software development toolkit .dll file over the course of several years and compiled to run on any windows computer. NETOBS was written to expedite the time it takes to measure and analyze network measurement data. NETOBS greatly reduces network measurement monument naming errors and blunders, automates measurements, and does least squares adjustment analysis all in one software solution. Using NETOBS improved the network measurement campaign time to less than half that of previous campaigns.

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Contribution ID: **12** Type: **Poster**

The alignment of the energy degrader applied in the proton therapy

A new proton therapy facility based on a 250MeV/500nA superconducting cyclotron has been under construction in Huazhong University of Science and Technology (HUST) in Wuhan, China. Due to the fixed beam energy extracted from the cyclotron, an energy degrader is essential for the proton beam with variable energy to reach various tumor depth in human body. Becausae of the interaction between the protons and the energy degrader material, the beam emittance and the energy spread will be increased while the beam current will be significantly decreased. The alignment accuracy will have an obvious impact on the performance of the degrader. This paper will discuss how the beam energy, beam emittance and beam losses are influenced by the alignment accuracy including the positional accuracy, the angular accuracy, the coaxiality and others. Moreover, the detailed alignment program will be proposed.

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Contribution ID: **13** Type: **Paper**

Introduction of the Alignment of Wuwei Heavy Ion Medical Machine

Wednesday, October 10, 2018 8:30 AM (30 minutes)

Wuwei heavy ion medical machine is the most compact heavy ion accelerator cancer treatment device in the world. The perimeter of the synchronous ring is as small as 56.1m, and the height difference between the high energy line climbing section of the device is about 19m, which is the height difference in the domestic accelerator. The device with the largest span spans tens of thousands of components, and many critical components require sub-millimeter installations. Wuwei heavy ion cancer treatment installations require high positioning accuracy components including beam position detectors, high-frequency cavity, electrostatic deflection plate, peeling film, etc., in which the accuracy of the synchronization ring quadrupoles requirements 0.1mm, part of the oversized, overweight components problems such as narrow installation and installation space and inadequate visibility conditions have caused many difficulties in the installation of collimation. Through the application of new techniques and methods in alignment, the technical difficulties of various alignmentinstallations are solved, and all the components of the device are installed in place with high efficiency and high precision in a short time.The collimated installation of Wuwei's heavy ion cancer treatment equipment began in April 2014 and completed the installation of the global control network, the encryption of local control networks, and the placement and scribing of various beamline components. Completed installation in September 2014, from the ion source to the cyclotron injection system, to the alignment of the medium energy transport line, the synchronous storage ring, to the high energy transport line, and the various treatment terminals. It took more than a year . Through the continuous efforts and cooperation of the staff of various systems of heavy ion cancer treatment devices, Wuwei's heavy ion cancer treatment device successfully emerged in December 2015, enabling the Wuwei heavy ion medical machine to achieve full-line carbon ion beam acceleration and The nonlinear resonance of the synchronization loop leads slowly. The injected energy is 7 MeV/u, the flow intensity is 11euA, and the terminal energy is more than 400 MeV/u, which fully meets or exceeds the original physical design index. This also proves that the basic work of Wuwei Heavy Ion Accelerator is perfect and in place, and the alignment work has also been fully affirmed.

Summary

Wu Wei heavy ion medical machine (HIMM) is the most compact accelerator treatment facility in the world, which includes a synchrotron ring with a circumference about 56.1 m. The height of the high energy climbing segment is up to 19 m that is the highest complex among the accelerators in china. HIMM consists of thousands of elements and some elements require sub-millimeter installation accuracy especially. The devices for higher positioning accuracy are BPM (beam position monitor), RF cavity, electrostatic deflector, stripping film. For quadrupole, the positioning accuracy is less to 0.1 mm. Because some very large and heavy elements need to install hanging in the air as well as the lack of installation space and visibility, the work to mount and align becomes extremely difficult. By using the new technology and method of alignment measurement that solves various alignment challenges, all the elements of this complex are installed with high accuracy efficiently in a short time. The deviation of all the key components is under 0.1mm and the installation error of the vacuum pipe and the diagnostic element is less than 0.5 mm. Cur-

rently, Wu Wei heavy ion medical machine has been commissioned successfully and some beam parameters are better than the design target, which in turn verify the reliability and feasibility of alignment and measurement.

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Session Classification: Survey & Alignment Aspects of Medical Accelerator Developments

Track Classification: Survey & Alignment Aspects of Medical Accelerator Developments

Contribution ID: **14** Type: **Poster**

Alignment and Measurement of SSC-Linac RFQ

The first high-charge, heavy-charge, continuous-wave four-bar RFQ (Radio Frequency Quadrupolec) accelerator jointly developed by the Institute of Modern Physics of the Chinese Academy of Sciences and the Institute of Heavy Ion Physics, Peking University is the first of its kind in the Institute of Modern Physics, Chinese Academy of Sciences. The injector of the ion linear accelerator is designed to operate at a frequency of 53.667 MHz, an implantation energy of 3.728 keV·u−1, an output energy of 143 keV·u−1, a mass/charge ratio of 3–7, and a length of 2.5 m. Its machinery manufacturing process and welding tolerance requirements are extremely high, and whether its processing accuracy can meet the requirements is a key indicator of whether RFQ can be successfully delivered. The measurement problem of the mechanical workpiece shape and position error occupies an important position in the machinery manufacturing industry, especially the shape error of a large workpiece directly determines its work performance. The traditional part-shaped position error detection usually uses calipers, squares, height scales and other measurement tools, and there has been a lack of complete and feasible methods and means for on-site detection of large-scale parts shape and position errors. The laser tracker and measuring arm provide the possibility of applying the “measurement coordinate value principle” to achieve on-line detection of workpiece machining error with its portability, accuracy, reliability and ease of operation. In the assembly position detection, in order to complete the RFQ mechanical position tolerance measurement, we used the combination of laser tracker and joint measuring arm to measure the two tasks to complete the inspection task.

Summary

SSC-Linac RFQ (Separated Sector Cyclotron Linac Radio Frequency Quadrupolec) is the first high-charge, strong-current, heavy ion continuous wave four-bar accelerator jointly developed by the Institute of Modern Physics of the Chinese Academy of Sciences and Peking University. The precision of machining is RFQ. One of the key steps to successful delivery. In order to detect the mechanical position tolerances, a new measurement method using a reasonable combination of a laser tracker and a joint measuring arm is adopted, so that the two high-precision measuring instruments can overcome the shortcomings and overcome the shortcomings of the traditional measurement methods for large-scale workpiece shape tolerances. To make it work in the measurement process to its optimal use and operability, effectively improve the work efficiency, thus ensuring RFQ high-precision measurement results.

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Contribution ID: **16** Type: **Paper**

A Precision 2-D Laser Scanner for Measurement of Thermal Shift in Superconducting Devices

Tuesday, October 9, 2018 4:00 PM (30 minutes)

A novel method developed at Argonne National Laboratory for laser scanning two-dimensional (2-D) profiles has been applied to a new instrument, the Cryoscanner, for measurement of cold mass thermal shift within the cryostat vessels of superconducting devices for particle accelerators. This paper presents the hardware, controls and data acquisition / processing methods utilized for the Cryoscanner, as well as the measurement results for the first deployment of the instrument to measure thermal shift within APS Helical Superconducting Undulator (HSCU), commissioned in 2018. Recent progress toward improving the internal laser targets for the Cryoscanner will also be presented.

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Session Classification: Survey & Alignment Aspects of Superconducting Devices

Track Classification: Survey & Alignment Aspects of Superconducting Devices

Contribution ID: **17** Type: **not specified**

Leica Absolute Laser Tracker operation in magnetic field environment

Friday, October 12, 2018 10:30 AM (30 minutes)

Leica Laser Trackers provided by Hexagon have a long-standing relationship with alignment groups of several particle accelerator facilities.

In recent years customers requested information about possibilities and limitations of operating laser trackers in special environments, exposing the instruments to magnetic fields.

At Hexagon we have followed up this new interest and investigated in a dedicated experiment the effect of magnetic fields of up to 400 Gauss on two types of our instruments, Leica Absolute Tracker AT403 and Leica Absolute Tracker AT960.

In this paper / poster we would like to present an overview of our findings and give some guidance to customers on the operation of our instruments exposed to this environment.

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Session Classification: Other Geodetic and Survey Topics

Track Classification: Other Geodetic and Survey Topics

Contribution ID: **18** Type: **not specified**

Recent developments for a photogrammetric system to measure offsets to stretched wires at CERN

Thursday, October 11, 2018 3:30 PM (30 minutes)

Manual offset measurements with respect to stretched wires are used since decades for accelerator alignments at CERN, e.g. for the SPS and the LHC. A measurement system based on photogrammetry offers appreciated possibilities of automation in comparison to the manual method used so far for the radial offset measurement. Such a system built with pre-calibrated cameras is under development for different possible applications e.g. measurements in the LHC arcs or the upgrade of the LHC collimator measurement train.

The article deals with the use of image processing techniques like morphological operators and the Hough transformation for the identification and precise sub-pixel edge measurement of the stretched wire in the 2D images. The magnet fiducials are measured by means of an ellipse operator in the images. In addition, the calculation process to get the positions of the straight wire and the fiducials in 3D with CERN's compensation software LGC is described. The related algorithms have been evaluated based on image data acquired in the LHC accelerator. The attained accuracy is typically of a few hundreds of millimetres.

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Session Classification: Other Geodetic and Survey Topics

Track Classification: Other Geodetic and Survey Topics

Contribution ID: **19** Type: **not specified**

Frequency Scanning Interferometry to monitor the position of accelerator cold components inside their cryostat

Thursday, October 11, 2018 2:00 PM (30 minutes)

In the frame of the High Luminosity LHC (HL-LHC) project, we propose a novel method to monitor the position of accelerators components inside their cryostat, based on Frequency Scanning Interferometry (FSI). We achieve such a result by installing retroreflective measurement targets on the internal cold components and by using specialized feedthroughs or viewports for the FSI laser beam delivery. This configuration allows micrometric ditsance measurements between the FSI beam origin and the target. The final accuracy depends on the number of distance measurements and their configuration. We present two examples of application: the position determination of two crab cavities inside their cryostat, in a cold and radioactive environment, and the monitoring of a cold mass inside a dipole cryostat, at cold. In both cases, we introduce the context of measurements, the chosen configuration after simulations, the results achieved and lessons learnt. We conclude by extrapolating these two setups to the HL-LHC project.

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Session Classification: Other Geodetic and Survey Topics

Track Classification: Other Geodetic and Survey Topics

Contribution ID: **20** Type: **Paper**

Technical challenges for High Luminosity LHC alignment and associated solutions

Thursday, October 11, 2018 4:30 PM (30 minutes)

The High Luminosity LHC (HL-LHC) is an upgrade of the LHC to achieve instantaneous luminosities of a factor five larger than the nominal LHC values. The project will comprise the replacement of 1.2 km of accelerator components such as magnets, collimators and radiofrequency cavities in 2024. The upgrade relies on a number of key innovative technologies. The alignment solutions chosen to answer the requirements of the project are challenging as well. They consist of alignment systems including Wire Positioning Sensors (WPS), Hydrostatic Levelling Sensors (HLS), and Frequency Scanning Interferometry (FSI) to determine the position of components, combined with motorized jacks and adjustable platforms. This paper introduces first these concepts. It then details the R&D undertaken to develop low cost alternatives of HLS and WPS, to improve the acquisition chain of the WPS, to make easier and quicker the installation and maintenance of the WPS and to propose innovative solutions of adjustment. It presents the direction of studies followed and the first results achieved.

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Session Classification: Other Geodetic and Survey Topics

Track Classification: Other Geodetic and Survey Topics

Contribution ID: **21** Type: **not specified**

CLIC pre-alignment strategy: final proposal and associated results

Tuesday, October 9, 2018 11:45 AM (30 minutes)

A Project Implementation Plan for the Compact LInear Collider (CLIC) is under preparation for consideration by the European Strategy Update process. The document will integrate all changes and improvements since the Conceptual Design Report submitted in 2012. One of the technical challenges covered is the pre-alignment of CLIC. This paper presents the final strategy chosen, and more particularly the configuration of alignment sensors defined following the results obtained on different test setups. It proposes two methods for the fiducalisation of the components, based on the results obtained in the PACMAN*project combined with R&D on an adjustment platform. The paper concludes by an estimation of the budget of error for the pre-alignment stage.*PACMAN is a study of Particle Accelerator Components' Metrology and Alignment to the Nanometer scale.

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Session Classification: Survey & Alignment Aspects of Beamline and machine Components

Track Classification: Survey & Alignment Aspects of Beamline and Machine Components

Contribution ID: **22** Type: **Poster**

Validation of micro-triangulation with direct wire measurements in the LHC tunnel

In the past few years, we developed the micro-triangulation method with direct wire measurements for magnet fiducialisation applications. The method was previously validated in metrology laboratory conditions and on close range measurements of a few meters, where uncertainties of a few tens of micrometres were achieved, in comparison with a coordinate measurement machine. Here, we attempt to validate the method for alignment applications on field, by organising and executing a test measurement in the LHC tunnel, with observations up to 25 m, in an elongated network of about 80 m. The paper describes the simulation, the instrumentation used and the methodology of the measurement, as well as the advantages and the limitations of the method, in general and in relation with the conditions and constraints imposed by the tunnel environment. Finally, we evaluate the uncertainty of the measurement in comparison with the standard ecartometry method which is used for the LHC alignment.

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Presenter: Mr FUCHS, Jean-Frederic (CERN)

Contribution ID: **23** Type: **Paper**

Measurements with laser tracker through different media: the MIDAS system

Tuesday, October 9, 2018 4:30 PM (30 minutes)

The request of high precise 3D-monitoring of a superconducting component in cold condition regarding the deformation of a cold mass along with movements vs. cryostat, was the trigger to develop a measuring system, capable to provide absolute coordinates with high accuracy of points in vacuum behind a glass window.
Based on the presentation of the last IWAA2016, the independent validation of the measuring method presented at that time will be shown here. The largely commercially available hardware has been supplemented by an easy-to-use software that includes the inevitable necessary mathematic model for obtaining corrected distance and angle measurements, and that leads you carefully through the necessary measurement steps. The so-called MIDAS system (Measurements In Different media Adaptation System) will be used in the near future in the general magnet test program for the superconducting multiplets for FAIR.

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Session Classification: Survey & Alignment Aspects of Superconducting Devices

Track Classification: Survey & Alignment Aspects of Superconducting Devices

Contribution ID: **24** Type: **Poster**

Monitoring measurements during the construction work for FAIR and re-alignment for GSI machines for the beam time 2018

Due to the current construction work for FAIR (Facility for Antiproton and Ion Research), significant deformations in the area of the existing GSI synchrotron (SIS18) and adjacent beamlines occurred in 2017/2018. During the construction progress, high-precision 3D-network measurements were carried out at different epochs to monitor the magnitude of ground settlement. In order to be able to realize the beam time 2018, a new alignment strategy was developed based on these measurements and with the aim of minimizing the adjustment values. For this purpose, the complete synchrotron, parts of the transfer channel and the high-energy beamline were aligned intentionally on an inclined plane instead of the usual horizontal plane for the first time. The poster gives an overview about the current situation and the achieved results.

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Contribution ID: **25** Type: **not specified**

Geodetic Activities at CERN for Current and Future Projects

Tuesday, October 9, 2018 10:45 AM (30 minutes)

A number for geodetic activities are in progress to provide the necessary infrastructure for the High Luminosity LHC (HL-LHC) project. The results from these activities will also provide the opportunity to investigate and resolve known anomalies identified in the CERN geodetic reference systems, and related parameters, which would benefit this and future projects.
A new high precision GNSS measurement of 15 pillars of the surface geodetic reference network has been integrated into the network, and the Gyromat-2000 and Mekometer ME5000 instruments have been put back into service. Work to control and establish reference azimuths for the HL-LHC, at two points around the LHC ring for the new civil engineering works, are in progress, and our long distance geodetic baseline has also been re-measured with the Mekometer ME5000, for the use of the civil engineering teams. These activities, together with the ongoing and planned future work, are presented.

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Session Classification: Survey & Alignment Aspects of Beamline and machine Components

Track Classification: Survey & Alignment Aspects of Beamline and Machine Components

Contribution ID: **26** Type: **Poster**

ALIGNMENT STATUS OF THE LENA ECRIS AT DUKE UNIVERSITY

Alignment procedure and detailed design of an Electron Cyclotron Resonator Ion Source (ECRIS) was presented in our last IWAA conference in Grenoble, France. Since then, a new design for the beam extraction section of the accelerator was implemented to ease the alignment and operation of this ECRIS.
In this report, survey and alignment of this modified beam extraction section will be discussed in details.

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Presenter: Mr EMAMIAN, Mark (Duke University)

Contribution ID: **27** Type: **Poster**

“Life on construction site of FAIR”

One of the largest accelerator systems in the world is being built at GSI in Darmstadt / Germany. The centerpiece is a ring accelerator with 1100 meters circumference in about 18 meters below ground. From the year 2025 approximately 3000 scientists from all over the world will work at FAIR, the Facility for Antiproton and Ion Research in Europe.
After a period of preliminary work, the groundbreaking ceremony for FAIR took place in summer 2017. Since then great impressive ground work is done, accompanied by surveying activities done by a subcontractor, like monitoring the earth excavation, survey of in-ground pipelines, settlement measurements on existing neighboring GSI facility, control measurements of the surface network and marking main tunnel axes within the deep building pit. Furthermore, work on transfer points is presented, which will already in this status serve as interface between pure construction surveying and precise accelerator alignment.

Primary authors: Mr STENGLEIN, Matthias (ÖbVI Heinen und Fischer, Groß-Zimmern/Germany); Mr GRUB, Timo (ÖbVI Heinen und Fischer, Groß-Zimmern/Germany)

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Presenters: Ms 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)

Contribution ID: **28** Type: **not specified**

Validation of Wire Measurements in the LHC Tunnel

Thursday, October 11, 2018 4:00 PM (30 minutes)

The High Luminosity LHC (HL-LHC) is an upgrade of the LHC accelerator to achieve instantaneous luminosities a factor of five larger than the LHC nominal value This challenging project requires the installation of new high-technology components along more than 200 m of the current machine on each side of Interaction Point 1 (ATLAS) and Interaction Point 5 (CMS).

The radiation level will increase during beam operation after Long Shutdown 3 (2024-2025). Therefore, in order to reduce dose to personnel during the alignment, all these new sections will be online monitored by Hydrostatic Levelling System and Wire Positioning System sensors and equipped with motorized jacks.

The HL-LHC component positions need to be taken into account for the alignment process during the LHC smoothing activities. The survey sections of the EN-SMM group (Engineering Department - Survey, Mechatronics and Measurements) are studying various wire measurement solutions in order to be able to geometrically link the HL-LHC components, monitored by sensors, and the LHC components measured by standard methods.

While the design study and R&D are still in progress, a global comparison of different solutions, including all the constraints and working conditions, has been organized inside the LHC tunnel environment during the last winter technical stop. A common “wire measurement” campaign along 80m of LHC magnets has been performed with the following techniques : offset manual measuring device, oWPS associated with laser tracker (AT40x), photogrammetry (D3X, Aicon software) and micro-triangulation with a Leica TS60 total station.

The paper will give an overview of the methodologies used, the issues and the results.

Primary author: Mr FUCHS, Jean-Frederis (CERN)

Co-authors: Mr VENDEUVRE, Camille (CERN); Mr DUQUENNE, Mathieu (CERN); Mr VLACHAKIS, Vasileios (CERN); Mr RUDE, Vivien (CERN)

Presenter: Mr FUCHS, Jean-Frederis (CERN)

Session Classification: Other Geodetic and Survey Topics

Track Classification: Other Geodetic and Survey Topics

Contribution ID: **29** Type: **Poster**

Development of a stand-alone software for real-time data acquisition

At CERN, EN-SMM-ASG section (Engineering Department – Survey, Mechatronics and Measurements – Accelerators Survey and Geodesy) is responsible for the metrology and alignment of the accelerator components and their associated beam transfer lines.
As there is no commercial solution for the straight data acquisition of leveling, offset ecartometry and roll angle measurements, CERN developed, in 2005 for the LHC installation, the Pocket Field Book (PFB) software supplied on PDA platform. Hardware obsolescence and evolving needs led this year to the development of a new application called SMART - Survey Measurement Acquisition in Real Time - that allows data collection on Android smartphones and tablets.
This nomadic tool proposes several controls on the field and thus minimizes user mistakes. In addition, the online acquisition mode saves time and eliminates the risk of typing errors. The commissioning of this software before the beginning of LS2 (Long Shutdown #2) will bring more comfort to users and increase productivity.
The presentation will start with focusing on the information technology strategy as well as on the development difficulties encountered. Then, the testing protocol, which allowed the validation of the software, will be described. Finally, main functionalities will be presented, as well as most likely improvements planned in the future.

Primary authors: Mr FUCHS, Jean-Frederis (CERN); Mr VALENTIN, Pierre (CERN)

Co-authors: Mr KLUMB, Francis (CERN); Mr MENETREY, Geoffrey (EPIA); Mr BOUCHET, Mayron (EPIA)

Presenter: Mr FUCHS, Jean-Frederis (CERN)

Contribution ID: **30** Type: **not specified**

SLRS revisited

Wednesday, October 10, 2018 10:45 AM (30 minutes)

Update on the Status of the Straight Line Reference System for the European XFEL.

Summary

Results from latest measurement campaigns are presented and the alignment process is introduced.

Primary author: Dr PRENTING, John (DESY)

Presenter: Dr PRENTING, John (DESY)

Session Classification: Survey & Alignment Aspects of Large Linear Research Structures

Track Classification: Survey & Alignment Aspects of Large Linear Research Structures

Contribution ID: **32** Type: **not specified**

FIDUCIALIZATION PRECISION OF MECHANICAL METHOD

Thursday, October 11, 2018 9:00 AM (30 minutes)

Vibrating wire technique is mainly used in NSLS-II project to fulfil the alignment specification of ±30 micron to 6 or 7 main magnets in each girder assembly. The center of magnet can be characterized with an accuracy of better than 10 micron.
The magnets have been fiducialized mechanically so that they can be coarsely aligned on girder within 100 micron accuracy. Although vibrating wire technique makes the fiducialization process less important, each magnet has been precisely surveyed mechanically.
By comparing the mechanical center deviation of magnets when they are aligned with respect to each other by vibrating wire technique, the fiducialization precision of mechanical method can be estimated. This information is useful for the accelerators which adopt the method of fiducialization mechanically.

Primary author: Dr YU, Chenghao (Brookhaven National Laboratory)

Co-authors: ILARDO, Matthew (Brookhaven National Lab); KE, Ming (BNL); Dr SHARMA, Sushil (Brookhaven National Lab)

Presenter: Dr YU, Chenghao (Brookhaven National Laboratory)

Session Classification: Survey & Alignment Aspects of Light Sources

Track Classification: Survey & Alignment Aspects of Light Sources

Contribution ID: **33** Type: **Paper**

ALIGNMENT ISSUES AND TECHNIQUES FOR PROTON THERAPY CLINICS

Wednesday, October 10, 2018 9:00 AM (30 minutes)

Abstract
The use of Protons to treat cancer tumours was first proposed by R R Wilson in 1946 [1], the first experimental treatments were done at Berkeley and Uppsala in the 1950's and Massachusetts General Hospital in 1961. Over the past 50 year some 50 clinics are now in operation worldwide. All clinics use cyclotrons or synchrotrons to produce protons or other heavy ions. The facilities employ beam transport systems, rotating gantries and patient positioning systems. The accelerator and beam transport system use conventional alignment techniques such as laser trackers and FARO arms. Determination of isocenter and patient positioning present unique challenges.

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Presenter: Dr VOLK, James (ProNovasolutions)

Session Classification: Survey & Alignment Aspects of Medical Accelerator Developments

Track Classification: Survey & Alignment Aspects of Medical Accelerator Developments

Contribution ID: **34** Type: **Paper**

Construction and alignment of test half-cell of SPring-8-II

Thursday, October 11, 2018 10:30 AM (30 minutes)

SPring-8 upgrade plan (SPring-8-II) has been discussed and examined to realize an ultra-low emittance storage ring with two boundary conditions to be cleared; high alignment precisions and 10 months of short replacing period. Comprehensive system and scenario of both installation and alignment have been designed for these above conditions. Half-cell with actual components has been assembled and constructed at experimental hall in SPring-8 in this year. We present the alignment scenario and an alignment system for girders and magnet supports. Also, an alignment procedure and effects of girder transportation with magnets are estimated and discussed.

Primary author: Dr KIMURA, Hiroaki (JASRI/RIKEN)

Co-authors: Dr ZHANG, Chao (Japan Synchrotron Radiation Research Institue(SPring-8)); Dr FUKAMI, Kenji (JASRI/RIKEN); Mr KAWASE, Morihiro (Japan Synchrotron Radiation Research Institute(SPring-8)); Dr WATANABE, Norihiro (JASRI/SPring-8); Mr AZUMI, Noriyoshi (JASRI/RIKEN); Dr MATSUI, Sakuo (RIKEN); Dr TANIUCHI, Tsutomu (Japan Synchrotron Radiation Research Institue(SPring-8)); Dr AOKI, Tsuyoshi (Japan Synchrotron Radiation Research Institue(SPring-8)); Dr OKAYASU, Yuichi (Japan Synchrotron Radiation Research Institute (SPring-8))

Presenter: Dr KIMURA, Hiroaki (JASRI/RIKEN)

Session Classification: Survey & Alignment Aspects of Light Sources

Track Classification: Survey & Alignment Aspects of Light Sources

Contribution ID: **35** Type: **Paper**

A numerical alignment error estimation for the SPring-8-II

Thursday, October 11, 2018 11:00 AM (30 minutes)

Trends of accelerator components coordinates on the storage ring, which are designed as the SPring-8-II, are calculated with ground deformation growth rates. The rates are evaluated based on survey data measured since 1996 for the existing SPring-8 accelerator components.

Next, alignment errors for all neighboring two magnet-girders are numerically estimated as relative error ellipses via a surveying network analysis assuming our current measurement schemes and confirmed to be settled within a tolerance, which is designed by our beam optics group.

Levels of the storage ring components are known to be displacing ~2.5 mm for almost 20 years clearly depending on underground components such as underpasses, RF wave-guides, tunnels and cutting or banking structures. A necessity of the realignment for the upgrade configuration are estimated.

In addition, a verification of the ATL-law application via a classical approach for variances of the storage ring level is briefly introduced and discussed.

Primary author: Dr OKAYASU, Yuichi (Japan Synchrotron Radiation Research Institute (SPring-8))

Co-authors: Dr KIMURA, Hiroaki (Japan Synchrotron Radiation Research Institute (SPring-8)); Dr MATSUI, Sakuo (RIKEN)

Presenter: Dr OKAYASU, Yuichi (Japan Synchrotron Radiation Research Institute (SPring-8))

Session Classification: Survey & Alignment Aspects of Light Sources

Track Classification: Survey & Alignment Aspects of Light Sources

Contribution ID: **36** Type: **Poster**

IMPROVING THE GEOMETRY OF A 3D LONGITUDINAL NETWORK USING A STRETCHED WIRE

At CERN, stretched wires are widely used for over 50 years for the alignment of accelerators. Nowadays, 0.4 mm diameter conductive wires are used for the monitoring and alignment of machine elements, together with capacitive wire positioning sensors. Wires are used as well for wire-offset measurements during the radial smoothing of the magnets over 150 m.

In this paper, we show that using common stretched wire in a 3D longitudinal network improve the geometry of the geodetic network, both in terms of accuracy and reliability. In this work, we use a polypropolen braided rope type, lightly tensed wire with a sag value of the order of half a meter. In our 3D longitudinal test network, angle and distances measurements performed between points using a total station constitute the basic network. In addition, vertical and horizontal angle measurements are performed on marks located on the wire to densify the network. In the first part of this contribution, we detail the functional models developed to take into account points on the wire. We also describe a test campaign carried out with a wire stretched over 50 m, within a 5 m wide and 60 m long network. In the second part, we present and discuss our results, and show that using a stretched wire can improve significantly the accuracy and reliability of the network points determination.

Primary authors: Mrs MAINAUD-DURAND, Hélène (EN/ACE Large Scale Metrology, CERN); Mr DURAND, Stéphane (Cnam/GeF); Mr TOUZÉ, Thomas (Institut G2C, HEIG-VD); Mr RUDE, Vivien (EN/ACE Large Scale Metrology, CERN)

Presenter: Mrs MAINAUD-DURAND, Hélène (EN/ACE Large Scale Metrology, CERN)

Contribution ID: **37** Type: **Poster**

Fiducialisation for the next LHC magnet generation

With the end of the series production of the 1232 Dipoles and 474 quadrupoles in 2008, the majority of the fiducialisation activities ended. During the last ten years, only spare magnets and prototypes have been fiducialised and the systems (hardware and software) are obsolete today. The magnets to be exchanged in the LHC during the Long Shut-down 2 as well as the upcoming HL-LHC production (about 60 new magnets) are requiring again more measurements using state of the art measurement systems, applications and procedures.
The measurement systems used in the past were laser trackers from the Leica LTD500 Series together with the AXYZ software. These laser trackers have been used extensively for almost 20 years and largely exceeded their expected lifetime. The software as well as the hardware are not maintainable anymore and need to make place for new systems.
The hardware was updated to the LEICA AT900 Series and the software to Spatial Analyzer. A new in-house software is taking care of the automatic data processing, calculation and the database upload. This software combines the advantages of using Spatial Analyzers‘s functionalities and measurement plans with a powerful architecture and data structure in C#. It operates on a universal data structure independent from the individual magnet design and allows covering the current and future magnet types. This paper describes the new equipment and software along with the strategy for the data treatment and storage in a universal data object.

Summary

With the end of the series production of the 1232 Dipoles and 474 quadrupoles in 2008, the majority of the fiducialisation activities ended. During the last ten years, only spare magnets and prototypes have been fiducialised and the systems (hardware and software) are obsolete today. The magnets to be exchanged in the LHC during the Long Shut-down 2 as well as the upcoming HL-LHC production (about 60 new magnets) are requiring again more measurements using state of the art measurement systems, applications and procedures.
The measurement systems used in the past were laser trackers from the Leica LTD500 Series together with the AXYZ software. These laser trackers have been used extensively for almost 20 years and largely exceeded their expected lifetime. The software as well as the hardware are not maintainable anymore and need to make place for new systems.
The hardware was updated to the LEICA AT900 Series and the software to Spatial Analyzer. A new in-house software is taking care of the automatic data processing, calculation and the database upload. This software combines the advantages of using Spatial Analyzers‘s functionalities and measurement plans with a powerful architecture and data structure in C#. It operates on a universal data structure independent from the individual magnet design and allows covering the current and future magnet types. This paper describes the new equipment and software along with the strategy for the data treatment and storage in a universal data object.

Primary author: Mr BESTMANN, Patrick (CERN)

Co-authors: Mr FUCHS, Jean-Frederic (CERN); Mr MEES, Joachim (CERN)

Presenter: Mr FUCHS, Jean-Frederic (CERN)

Contribution ID: **38** Type: **Poster**

Survey of the Fermilab Short-Baseline Neutrino Far Detector

The Short-Baseline Neutrino Far Detector comprises the ICARUS neutrino detector which measures 20 meters long and weighs 760 tons. It consists of two cryostats, ICARUS1 and ICARUS2. Each cryostat holds liquid argon time projection chamber modules and photodetectors. ICARUS1 and ICARUS2, also known as Cold Vessels, are installed in a Warm Vessel inside the Short-Baseline Neutrino Far Detector Building at Fermilab. This poster summarizes the survey of the Short-Baseline Neutrino Far Detector using the Laser Tracker. The installation and survey of the detector was completed in August 2018.

Primary author: Dr OSHINOWO, Babatunde O'Sheg (Fermi National Accelerator Laboratory)

Co-author: Mr WILSON, Charles (Fermi National Accelerator Laboratory)

Presenter: Dr OSHINOWO, Babatunde O'Sheg (Fermi National Accelerator Laboratory)

Contribution ID: **39** Type: **not specified**

Survey and Alignment of the Fermilab ICARUS Neutrino Detector

Tuesday, October 9, 2018 1:30 PM (30 minutes)

The ICARUS neutrino detector, which measures 20 meters long and weighs 760 tons, serves as the Short-Baseline Program Far Detector. It consists of two cryostats, ICARUS1 and ICARUS2. Each cryostat holds liquid argon time projection chamber modules and photodetectors. ICARUS1 and ICARUS2, also known as Cold Vessels, are installed in a Warm Vessel inside the Short-Baseline Neutrino Far Detector Building at Fermilab. This paper summarizes the survey and alignment of the ICARUS Neutrino Detector using the Laser Tracker. The installation and survey of the detector was completed in August 2018.

Primary author: Dr OSHINOWO, Babatunde O'Sheg (Fermi National Accelerator Laboratory)

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Presenter: Dr OSHINOWO, Babatunde O'Sheg (Fermi National Accelerator Laboratory)

Session Classification: Other Geodetic and Survey Topics

Track Classification: Other Geodetic and Survey Topics

Contribution ID: **40** Type: **Poster**

MIRAS INFRARED MICROSPECTROSCOPY BEAMLINE INSTALATION

MIRAS is the first Phase II beamline constructed at ALBA Synchrotron. MIRAS is dedicated to infrared microspectrospcopy. Its installation started in November 2015 and the beamline received its first users on October 2016. The radiation of this beamline is covering a wavelength range from 0.4 to 100 μm. The beam size at the sample varies between 3x3 and 30x30 μm^2. The source of the light is a bending magnet; a slotted flat mirror is inserted horizontally into the bending magnet vacuum chamber to let the more energetic radiation pass through the slot, collect the rest of the radiation and direct it through a transfer system built by eight mirrors leading it to the end station. Three of these mirrors are flat, one is toroidal, two are cylindrical, one is parabolic, and lastly, another flat one which acts as a beam splitter, that lets the light be shared between the first end station and a future second branch. All the mirrors have been fiducialized to guarantee their final position. The motion of the extraction mirror has been characterized in order to check that the full insertion movement does not cause a collision between the mirror and the vacuum chamber. Most of the mirrors have a diagnostics camera to check the position and the shape of the visible beam at the mirrors. Since part of the collected beam includes visible radiation, a comparison between the infrared simulated beam and the real footprint on the mirrors has been done

Summary

MIRAS is the first Phase II beamline constructed at ALBA Synchrotron. MIRAS is dedicated to infrared microspectrospcopy. Its installation started in November 2015 and the beamline received its first users on October 2016

Primary author: Mr LADRERA, Jon (ALBA Synchrotron)

Co-authors: Mr CRISOL, Alejandro (ALBA Synchrotron); Dr NÚRIA, Benseny (ALBA Synchrotron); Mr COLLDELRAM, Carles (ALBA Synchrotron); Dr YOUSEF, Ibraheem (ALBA Synchrotron); Dr SICS, Igors (ALBA Synchrotron); Dr MARTÍNEZ-ROVIRA, Immaculada (ALBA Synchrotron); Dr NICOLÀS, Josep (ALBA Synchrotron); Mr RIBÓ, Llibert (ALBA Synchrotron); Ms LLONCH BURGOS, Marta (ALBA Synchrotron); Dr KREUZER, Martin (ALBA Synchrotron); Dr PEDREIRA, Pablo (ALBA Synchrotron)

Presenter: Mr LADRERA, Jon (ALBA Synchrotron)

Contribution ID: **41** Type: **not specified**

The alignment of the drift tube linac for the Compact Pulsed Hadron Source

Friday, October 12, 2018 9:30 AM (30 minutes)

The Compact Pulsed Hadron Source (CPHS) at Tsinghua University is one multi-purpose pulsed neutron source. The linac of the CPHS mainly consists of a proton source, a low energy beam transport line (LEBT), a radio frequency quadrupole (RFQ) and a drift tube linac (DTL). DTL is positioned downstream the RFQ accelerator and accelerates the beam from 3 MeV to 13 MeV with the peak current of 50 mA, so as to meet the energy demands for the beam bombarding the target. The main structure of the DTL consists of 2 cavities, 39 drift tubes, 2 base plates and 2 flanges. There are 41 permanent magnet quadrupoles (PMQs) mounted in drift tubes and flanges to focus the beam. The mechanical design and machining process of the drift tubes are complicated, and each PMQ needs to be installed within the error tolerance of ±0.2mm in the transverse direction and ±0.3mm in the longitudinal direction. The machining and alignment measurement of the drift tube are one of the key technologies of the CPHS DTL. This paper presents the progress of the CPHS project, together with the alignment result of the drift tubes inside the cavity and the DTL cavity in the beam line.

Primary author: Mr GUO, Qiankun (Tsinghua University)

Presenter: Mr GUO, Qiankun (Tsinghua University)

Session Classification: Other Geodetic and Survey Topics

Track Classification: Other Geodetic and Survey Topics

Contribution ID: **42** Type: **not specified**

Vibrating Wire Method and related positioning study at NSRRC

Friday, October 12, 2018 9:00 AM (30 minutes)

The vibration wire method for magnets centering alignment is restudied at NSRRC. It is prepared for the replacement of magnets on a girder at TPS in case of out of order. The good resolution data as NSLS II had shown is admired and expected. Moreover, due to the quick decay of the laser PSD system between straight section girders, the wire method to replace the laser PSD system is also studied simultaneously. This paper presents the study results.

Primary author: Mr TSENG, Tsechuan (NSRRC)

Co-authors: Mr KUAN, Chien-Kuang (NSRRC); Mr WANG, Jeremy (NSRRC); Mr PERNG, Shen-Yaw (NSRRC); Mr LAI, Wei-Yang (National Synchrotron Radiation Research Center)

Presenter: Mr TSENG, Tsechuan (NSRRC)

Session Classification: Other Geodetic and Survey Topics

Track Classification: Other Geodetic and Survey Topics

Contribution ID: **43** Type: **Poster**

NCD-SWEET Beamline Upgrade and Realignment

The SAXS/WAXS Experimental End sTation Beamline (NCD-SWEET) at ALBA Synchrotron has undergone a comprehensive upgrade and a full realignment in order to perform demanding Small Angle X-ray Scattering (SAXS) and Wide Angle X-ray Scattering (WAXS) experiment requirements. The former Double Crystal Monochromator (DCM) has been replaced by a new Channel-Cut Monochromator (CCM) which improves the beam stability and reduces the vibration amplitudes under 1% of the beam size. In the recently installed CCM the diffracted beam is 12 mm upward unlike the DCM, in which the exit beam was 30 mm downward. This entails to realign the beamline components to a new beam height. The SAXS/WAXS end station has been also upgraded by introducing improved mechanical elements like a sample table and a SAXS detector table with submicron resolution movements. The beam conditioning optics has been also enhanced adding new in vacuum components like an on axis sample viewing system or a set of refractive beryllium lenses for micro focusing the beam. The new optical layout and the new equipment installation required a complete characterization, consisting in metrology and fiducialization processes, as well as survey and alignment at the final installation place according to the reference network maintaining the beamline consistency and the coherence with the accelerator machine.

Primary author: Ms LLONCH BURGOS, Marta (ALBA Synchrotron)

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Presenter: Ms LLONCH BURGOS, Marta (ALBA Synchrotron)

Contribution ID: **44** Type: **not specified**

Geodetic and Alignment Concepts for the LBNF/DUNE

Tuesday, October 9, 2018 9:45 AM (30 minutes)

In the context of today's global interest in the neutrino research programs, with special emphasis on long baseline neutrino oscillation experiments, the LBNF project at Fermilab receives special attention as the world's highest-intensity neutrino beam to be sent 1,300 kilometres straight through the earth's mantle to the massive high-precision DUNE experiment's detectors located one mile deep underground at the Sanford Underground Research Facility (SURF) in Lead, South Dakota. This paper presents an overview and an update of the concepts and proposed methodology to implement geodetic and industrial alignment procedures to support the project recent reconfiguration and optimization design of the LBNF particle beam line and the DUNE detectors.

Primary author: Dr BOCEAN, Virgil (Fermi National Accelerator Laboratory)

Presenter: Dr BOCEAN, Virgil (Fermi National Accelerator Laboratory)

Session Classification: Survey & Alignment Aspects of Beamline and machine Components

Track Classification: Survey & Alignment Aspects of Beamline and Machine Components

Contribution ID: **45** Type: **Poster**

SLAC Status Report 2018

This poster presents the survey and alignment activities at the SLAC National Accelerator Laboratory since 2016. The major projects during the last two years have been the LCLSII (Linac Coherent Light Source) project and LSST (Large Synoptic Survey Telescope).
The LCLSII project includes a new 700 m long superconducting Linac, 3 km of beam transport lines, a new beam switch area to switch between the superconducting beam source and the Cu beam source, 2 new undulators and 4 new experimental hutches. We installed and mapped a new monument network in 3km of tunnels, aligned stands and components in the warm sections and the gun area.
For the LSST project we are mainly involved with quality inspection of parts and alignment of parts on the camera.
Smaller projects include alignment support for the SPEAR3 synchrotron ring, setup of experimental hutches for both LCLS and SSRL and our GIS services.

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

Co-authors: Mr FUSS, Brian (SLAC National Accelerator Laboratory); Mr GASSNER, Georg (SLAC National Accelerator Laboratory)

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

Contribution ID: **46** Type: **not specified**

Alignment Activities for the LCLSII Project at SLAC

Wednesday, October 10, 2018 11:15 AM (30 minutes)

The LCLS-II (Linac Coherent Light Source II) project is an upgrade to the world's first hard X-ray free-electron laser moving from 120 pulses per second to 1 million pulses per second. The LCLSII project includes a new 700 m long superconducting Linac, 3 km of beam transport lines, a new beam switch area to switch between the superconducting beam source and the Cu beam source, 2 new undulators and 4 new experimental hutches. We installed and mapped a new monument based network in 3km of tunnels, aligned stands and components in the warm sections and the gun area. Supported the development of undulators with interferometer and autocollimator measurements, fiducialized undulators, magnets and other beam components and monitored floor movements for the new experimental hutches.

Primary author: Mr GASSNER, Georg (SLAC National Accelerator Laboratory)

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

Presenter: Mr GASSNER, Georg (SLAC National Accelerator Laboratory)

Session Classification: Survey & Alignment Aspects of Large Linear Research Structures

Track Classification: Survey & Alignment Aspects of Large Linear Research Structures

Contribution ID: **47** Type: **Paper**

Our experience with vibration and damping material

Tuesday, October 9, 2018 2:00 PM (30 minutes)

The KEKB accelerator is being upgraded to SuperKEKB, using the same tunnel as KEKB.
The upgrade is based on the "Nano-Beam" scheme, wherein the beam size is reduced to 50 nanometers in the vertical direction and 10 microns in the horizontal direction at the interaction point (IP).
Vibration in the tunnel, especially at the IP, could be a critical issue that may result in luminosity degradation.
Vibration in the SuperKEKB tunnel will be reported along with our test results with the damping material called "M2052" alloy, which is a manganese-based alloy containing copper, nickel and iron.

Primary author: Dr MASUZAWA, Mika (KEK)

Co-author: YAMAOKA, Hiroshi (KEK)

Presenter: Dr MASUZAWA, Mika (KEK)

Session Classification: Other Geodetic and Survey Topics

Track Classification: Other Geodetic and Survey Topics

Contribution ID: **48** Type: **Paper**

Alignment Activities at the Fermi National Accelerator Laboratory

Tuesday, October 9, 2018 9:20 AM (25 minutes)

Currently the Fermi National Accelerator Laboratory is transitioning to an institution functioning like CERN to provide the foundation for an International Neutrino research facility. For that a Short and Long Base Line Neutrino program has been established. With the recent installation of the ICARUS detectors the Short Base Line Neutrino (SBN) construction is nearing completion. Over time the long Base Line Neutrino Facility (LBNF) has evolved to now include a proton driver for the increased production of neutrinos. Recently this Proton Improvement Program (PIP II) achieved Critical Decision CD-1 by DOE.
In addition to the Neutrino activities, the laboratory is moving forward on finishing the construction of the Muon campus and is working together with CERN on the CMS improvements and High Luminosity -LHC upgrades. In a cooperative program between Jefferson Laboratory and the Stanford Linear Accelerator Center the laboratory is constructing cryo-modules for the Linear Coherent Light Source II.
All these activities require our services that will be briefly addressed in this presentation.

Summary

Overview of the Alignment Activities at the Fermi National Accelerator Laboratory

Primary author: FRIEDSAM, Horst (FNAL)

Co-authors: Dr OSHINOWO, Babatunde (Fermilab); Mr WILSON, Charles (FNAL); BARKER, Jana; Mr KYLE, John (FNAL); Dr BOCEAN, Virgil (Fermi National Accelerator Laboratory)

Presenter: FRIEDSAM, Horst (FNAL)

Session Classification: Survey & Alignment Aspects of Beamline and machine Components

Track Classification: Survey & Alignment Aspects of Beamline and Machine Components

Contribution ID: **49** Type: **Paper**

Alignment of the ESRF Extremely Brilliant Source (EBS)

Thursday, October 11, 2018 11:30 AM (30 minutes)

After 20 years of success and scientific excellence, the ESRF, embarked upon an ambitious and innovative modernisation project – the Upgrade Programme. The first phase of this programme was completed over the period 2009-2015. In May 2015, the ESRF launched the second part of this programme, the Extremely Brilliant Source (ESRF – EBS) project.

The highlight and major technological challenge of the ESRF EBS project is the creation of an ultra-bright synchrotron source with performances 100 times superior to present day synchrotrons. This new light source will produce more intense, coherent and stable X-ray beams. It is a strategic project for the future of the ESRF that will open new perspectives for X-ray science.

The EBS is sum of the myriad related sub-parts and pieces. The quality of assembly, alignment and control of the key accelerator components are critical for the ultimate success of the EBS. The importance of alignment is expressed in the requirement that close to 900 magnetic elements comprising the EBS accelerator must be placed to within of 50 µm to 80 µm of their nominal positions for the new machine to function correctly. These tolerances include all of the possible positional errors from fabrication to final placement in the tunnel.

In this paper, we will examine the full alignment of the EBS accelerator. We will pay particular attention to the expression of the measurement and alignment uncertainty as expressed by the GUM: Guide to the Expression of Uncertainty in Measurement published by the International Bureau of Weights and Measures (BIPM).

Summary

In this paper, we will examine the alignment of the EBS accelerator presently being assembled and installed at the ESRF in Grenoble France.

Primary author: Dr MARTIN, David (ESRF)

Presenter: Dr MARTIN, David (ESRF)

Session Classification: Survey & Alignment Aspects of Light Sources

Track Classification: Survey & Alignment Aspects of Light Sources

Contribution ID: **51** Type: **Poster**

Research on the alignment methods for the super-long beamlines at SSRF

Three super-long beamlines will be built at SSRF. These beamlines' core parts are usually distributed in several large and isolated spaces, it's necessary to guarantee the alignment precision in the whole range. In other words, the continuous precision of 3D control network in the whole range must be ensured. To reach this purpose, the transferring station precision is studied at first. By changing the layout of control network and adding some more constraints between transferring stations, to study the change of 3D control network precision, constraints usually are reference meters. Besides, a theodolite and a digital levelling instrument are used to evaluate and calibrate the rough error of 3D control network. The theodolite has a high precision angle measurement performance. Its measuring process is affected less by the circumstance outdoors. Two theodolites can form a triangular net, which can be used to measure long distance control network and maintain measuring precision. The digital levelling instrument can be used to obtain elevation deviation directly and applied as elevation reference for 3D control network. Based on these methods, a reliable method can be used for ensuring the continuous precision of 3D control network in the large and complex spaces.

Primary author: Mr ZHANG, Yifei (Shanghai Institute of Applied Physics, Chinese Academy of Sciences)

Co-authors: Mr JIN, Limin (Shanghai Institute of Applied Physics, Chinese Academy of Sciences); Mr ZHU, Wanqian (Shanghai Institute of Applied Physics, Chinese Academy of Sciences); Mr ZHAO, Wenbin (Shanghai Institute of Applied Physics, Chinese Academy of Sciences)

Presenter: Mr ZHANG, Yifei (Shanghai Institute of Applied Physics, Chinese Academy of Sciences)

Contribution ID: **52** Type: **not specified**

Current developments of Laser Tracker testing standards

Friday, October 12, 2018 11:00 AM (30 minutes)

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Three major standards have been published defining an acceptance and verification test procedure for Laser Trackers.
• ASME B89.4.19
• VDI/VDE 2617-10
• ISO 10360-10

However, these standards have not reached a wide acceptance by Laser Tracker users when testing the performance of a system due to the large effort performing the test. Currently the test procedures of ASME B89.4.19 and ISO 10360-10 are being reviewed to improve usability and user acceptance. This paper will give an overview about the current state of the revisions of ASME B89.4.19 and ISO 10360-10 and an outlook about the goals and timeline for both standards.

Primary author: Mr SAURE, Matthias (Leica Geosystems AG)

Presenter: Mr SAURE, Matthias (Leica Geosystems AG)

Session Classification: Other Geodetic and Survey Topics

Track Classification: Other Geodetic and Survey Topics

Contribution ID: **53** Type: **not specified**

A high-precision Measurement Design to Obtain Super Instrument Height

Thursday, October 11, 2018 1:30 PM (30 minutes)

Abstract: Since the accuracy of centering leveling and instrument height measurement is poor when the permanent point of device area in tunnel of the Chinese spallation neutron source (CSNS) being observing in the conventional GPS tripod observation mode, a high precision measurement scheme is proposed. In the scheme, the fine-tuned roof bracket and the hemisphere plumbing mirror are designed to ensure stable placement and precise alignment; GPS antenna head bracket is modified to be suitable for placing the target ball and use laser tracker to obtain high-precision large instrument height. Finally, six permanent points are measured twice individually using laser tracker which result is compared with the measurement result using the ruler and the results show that the scheme can achieve a high accuracy of 0.2mm in centering and 0.2mm in height measuring , Which avoids the influence of stretching using ruler to measure, and effectively improve the precision of centering and large instrument height measurement of the permanent point of device area of the CSNS. In addition, the new scheme also provides reference for centering and instrument height measurement of similar points.

Primary author: MA, Na (Institute of high energy physics, Chinese academy of sciences)

Presenter: MA, Na (Institute of high energy physics, Chinese academy of sciences)

Session Classification: Other Geodetic and Survey Topics

Track Classification: Other Geodetic and Survey Topics

Contribution ID: **54** Type: **Paper**

LIGO: The alignment requirements and strategy

Wednesday, October 10, 2018 10:15 AM (30 minutes)

In Sep 2015, the Laser Interferometer Gravitational-wave Observatory (LIGO) initiated the era of gravitational wave astronomy with the first direct detection of gravitational waves (ripples in the fabric of space-time), resulting from the merger of a pair of black holes. In Aug 2017 the U.S.-based LIGO, the Europe-based Virgo, and some 70 ground- and space-based observatories jointly made the first direct detection of gravitational waves associated with a gamma ray burst and subsequent kilonova afterglow emission (visible, infrared, radio) from the collision of two neutron stars. This marks the beginning of multi-messenger astronomy.
The two LIGO detectors (Hanford, WA and Livingston, LA) employ coupled optical cavities in a specialized version of a Michelson interferometer with 4 kilometer long arms in a ultra-high vacuum system. The initial alignment of these observatories was accomplished with differential GPS and optical surveying techniques. Optical lever sensors are used to retain alignment reference for key optics. Active feedback control using wavefront sensors enables precision alignment of the resonant optical cavities. The alignment requirements and strategy are described.

Primary author: Dr TORRIE, Calum (Caltech employee giving invited talk)

Co-author: Mr COYNE, Dennis (Caltech employee)

Presenter: Dr TORRIE, Calum (Caltech employee giving invited talk)

Session Classification: Survey & Alignment Aspects of Large Linear Research Structures

Track Classification: Survey & Alignment Aspects of Large Linear Research Structures

Contribution ID: **55** Type: **Poster**

Metrology in the R&D for a High Repetition Rate Multi User X-ray Free-Electron Laser User Facility

Under development at Argonne National Laboratory is a High Repetition Rate Multi User X-ray Free-Electron Laser user facility. The machine will be driven by an array of highly efficient compact collinear wakefield accelerators (CWA) where the Čerenkov radiation of a 400 MeV high charge drive bunch is used to accelerate a low charge witness bunch to 2 GeV to produce soft x-rays in the FEL. The CWA design is based on a cylindrical corrugated waveguide with a 2 mm internal diameter embedded into a focusing channel of quadrupole magnets with a 3 mm aperture. This poster presents metrology techniques utilized in the exploration of various fabrication methods for producing miniature corrugated Cu waveguide accelerating structures, as well as micro-alignment techniques for a compact quadrupole wiggler array.

Primary author: Mr JANSMA, William (Argonne National Laboratory)

Co-authors: Mr ZHOLENTS, Alexander (ANL); Mr TRAKHTENBERG, Emil (ANL); Mr SUTHAR, Kamleshkumar (ANL); Mr KASA, Matthew (ANL); Mr DORAN, Scott (ANL); Mr SORSHER, Semyon (ANL)

Presenters: Mr KASA, Matthew (ANL); Mr JANSMA, William (Argonne National Laboratory)

Contribution ID: **56** Type: **Paper**

Alignment of the Mu2e Experiment

Wednesday, October 10, 2018 9:30 AM (30 minutes)

The Mu2e experiment is a physics experiment at Fermilab. It will probe a fundamental symmetry of the Standard Model with the potential to probe physics well beyond the reach of collider experiments such as the LHC. The experiment mainly consists of several large volume, high magnetic field, solenoids: the Production Solenoid, Upstream and Downstream Transport Solenoids, and the Detector Solenoid.
The construction of the Mu2e experiment poses many alignment, metrology, and geodesy challenges. Some of the challenges will be described, along with overview and status of the project, in this presentation. In particular, a novel method for non-contact characterization of vibrations is presented.

Primary author: BARKER, Jana (Fermilab)

Co-authors: WILSON, Charles (Fermilab); BRADFORD, Craig (Fermilab); SWANSON, Doug (Fermilab); DIJAK, Ed (Fermilab); COPPOLA, Gary (Fermilab); TEAFOE, Gary (Fermilab); Mr KYLE, John (FNAL); O'BOYLE, Mike (Fermilab); SMEGO, Mike (Fermilab); WYATT, Randy (Fermilab)

Presenter: BARKER, Jana (Fermilab)

Session Classification: Survey & Alignment Aspects of Medical Accelerator Developments

Track Classification: Survey & Alignment Aspects of Medical Accelerator Developments

Contribution ID: **57** Type: **Poster**

Multiple Laser Tracker Synchronization for Vibration Analysis

Measuring the mechanical coupling and rigidity of a large apparatus presents unique challenges for 3D metrology. In this case the motion of well separated points attached to a rotor blade must be rapidly and repeatedly measured and the resulting data synchronized. This presentation describes the methodology and results for the mechanical coupling test of the magnetic field mapping system (FMS) for the Mu2e experiment at Fermi National Accelerator Laboratory. Three laser trackers, 2 API Radians and an API T3, simultaneously measured the position of three cylindrical corner cube reflectors mounted on the FMS while the system was in motion and after coming to rest. The laser trackers took measurements at 83Hz for the T3 and 100Hz for the Radians, with fine spatial resolution, resulting in over 20,000 points measured per instrument in observation cycle. The laser tracker hardware and utilized software are unable to synchronize the three independent data streams directly during the measurement process. Instead a custom software program was developed to perform this synchronization of the data sequences during post-processing using features of the targets motion common to all three fiducial locations.

Primary author: BARKER, Jana (Fermilab)

Co-authors: Dr BARKER, Anthony (Purdue University); WILSON, Chuck (Fermilab)

Presenter: BARKER, Jana (Fermilab)

Contribution ID: **58** Type: **Paper**

The photogrammetry application R&D in CEPC

Thursday, October 11, 2018 2:30 PM (30 minutes)

Circular Electron Positron Collider (CEPC) will be a very huge accelerator, current alignment methods can not significantly increase efficiency when it still demands the same precision requirement. So we introduced photogrammetry into accelerator tunnel measurement, because of its high efficiency. But accelerator tunnel which is a long and narrow space with few targets is very different form the usual photogrammetry circumstances, lots of research need to be done, this talk will cover several parts of the research work.

Primary author: Ms ZHU, Hongyan (IHEP)

Co-authors: Prof. DONG, Lan (IHEP); Ms LIANG, jing (Institute Of High Energy Physics ,Chinese Avademy of Sciences)

Presenter: Ms ZHU, Hongyan (IHEP)

Session Classification: Other Geodetic and Survey Topics

Track Classification: Other Geodetic and Survey Topics

Contribution ID: **59** Type: **Poster**

RESEARCH ON MECHANICAL & ALIGNMENT SYSTEM FOR HEPS-TF

HEPS is a new generation synchrotron facility with a challenging requirement of very low emittance, and the key technology difficulties are supposed to be overcome during the stage of HEPS-TF. For the mechanical & alignment system, the requirements are very stringent. The alignment error of magnets on a girder should be less than 30μm. Besides, the girder should be capable of doing beam-based alignment remotely to minimize the magnets position error during the runtime. To meet these requirements, studies on vibrating-wire alignment technique and auto-tuning magnet girder were carried out in HEPS-TF. This paper will describe the design and progress of those work.

Primary author: Ms LI, Chunhua (IHEP)

Co-authors: Ms WANG, Haijing (IHEP); Mr LIU, Jia (IHEP); Ms WU, Lei (IHEP); Mr LI, Shujin (IHEP); Mr WANG, Xiaolong (IHEP); Mr WANG, Zihao (IHEP)

Presenter: Ms LI, Chunhua (IHEP)

Contribution ID: **60** Type: **Poster**

Status Report on the Alignment Efforts @ DESY

A summery of the current survey and alignment activities.

Primary authors: Dr PRENTING, John (DESY); Mr NOAK, Martin (DESY); Mr BENECKE, Wolf (DESY)

Presenters: Dr PRENTING, John (DESY); Mr BENECKE, Wolf (DESY)

Contribution ID: **61** Type: **Paper**

Preliminary design of CEPC survey & alignment

Tuesday, October 9, 2018 11:15 AM (30 minutes)

China Electron Positron Collider (CEPC) is a huge particle collider aim to measure the precise properties of the Higgs boson, its collide energy will be 240 GEV. The CEPC was first proposed in 2012 and by June 2018 its conceptual design report is finished.
The CEPC mainly includes a 1.6km length Linac and LTB transport line, a 100km booster and a 100 km double-ring in which electron and positron beams will circulate in opposite directions in separate beam pipes and collide at two interaction points. The Linac will be built on the ground, the booster and the double-ring will be built in one tunnel underground.
This report will introduce the preliminary design of CEPC survey and alignment, includes precision requirement, alignment control network design, component fiducialization, tunnel installation alignment, interaction region alignment, component position monitor, workload estimate and main challenges.

Primary author: Mr WANG, xiaolong (IHEP)

Co-authors: Ms ZHU, Hongyan (IHEP); Prof. DONG, Lan (IHEP); MA, Na (Institute of high energy physics, Chinese academy of sciences)

Presenter: Mr WANG, xiaolong (IHEP)

Session Classification: Survey & Alignment Aspects of Beamline and machine Components

Track Classification: Survey & Alignment Aspects of Beamline and Machine Components

Contribution ID: **62** Type: **Poster**

Integrating SLRS results into Geodetic Network Adjustment

Straigt Line Reference Systems, developed at DESY over the last years,
produce observation types that can not be integrated in geodetic networks using standard software packages.
A new software for network adjustment has to be developed to overcome this restriction. This poster shows some early ideas and concepts.

Primary author: Mr SCHLOESSER, Markus (DESY)

Presenter: Mr SCHLOESSER, Markus (DESY)

Contribution ID: **63** Type: **not specified**

Fiducialization for the CBETA Magnets

Friday, October 12, 2018 8:30 AM (30 minutes)

The Cornell-BNL Energy Recovery Linac (ERL) Test Accelerator (CBETA) is a prototype for the future Electron Ion Collider (EIC) to prove the principle of accelerating electrons with energy recovery. There will be more than 200 magnets to be installed. Currently the major survey work is the fiducialization of magnets. The fiducials, measurement method, instrument and frame definition will be presented. Measurement plan (MP) is used to automate the data collecting and analyzing and it improves efficiency significantly.

Primary author: KE, Ming (BNL)

Presenter: KE, Ming (BNL)

Session Classification: Other Geodetic and Survey Topics

Track Classification: Other Geodetic and Survey Topics

Contribution ID: **64** Type: **not specified**

The Long-Baseline Neutrino Facility: Supporting a Global Neutrino Experiment

Tuesday, October 9, 2018 8:45 AM (20 minutes)

The Long-Baseline Neutrino Facility: Supporting a Global Neutrino Experiment

Primary author: MOSSEY, Christopher (FNAL)

Presenter: MOSSEY, Christopher (FNAL)

Session Classification: Keynote The Long-Baseline Neutrino Facility: Supporting a Global Neutrino Experiment [Mr. Mossey, Chris]

Track Classification: Keynote The Long-Baseline Neutrino Facility: Supporting a Global Neutrino Experiment

Contribution ID: **65** Type: **not specified**

Final Participants List

Presenter: SAPERSTON, Melody (Fermi National Accelerator Laboratory)