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Method for Constructing a KOMAC Accelerator Tunnel Survey Network Using a Spatial Analysis Program

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1. Introduction

In order to check the alignment status of the accelerator and electromagnet in the proton accelerator, the alignment network is measured twice a year during the maintenance period [1]. The coordinate axis of the accelerator tunnel is set by measuring the AN (alignment network) installed in the accelerator tunnel using a laser tracker [2]. The alignment status of the accelerator and electromagnet is expressed differently depending on the coordinate axis setting of the accelerator tunnel [3][4]. In order to improve the irregularity of the coordinate axis setting results, we plan to use the alignment network measurement and data integration processing technology used in the KEK e-e+ injector linac [5]. In this paper, a method of measuring using a laser tracker and a digital level and integrating the results using a spatial analysis program are reported.

2. Methods and Results

The measurement method for measuring instruments and data process procedure for constructing a survey network were provided by Dr. Yuichi of KEK.

2.1 Spatial Analyzer program

The SA program is a meter-independent and traceable 3D graphics software that allows users to easily integrate data from multiple meters and perform complex tasks simply.

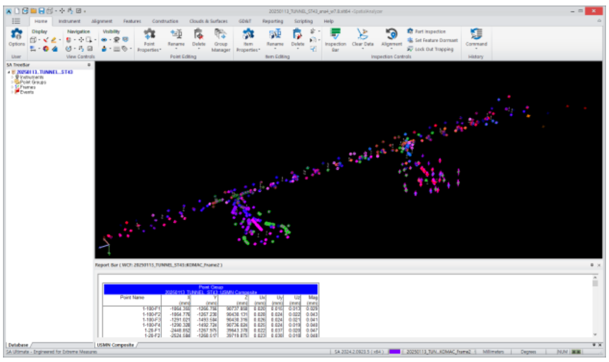

Fig. 1. SA program main screen after 100MeV proton accelerator measurement network

2.2 Unified Spatial Metrology Network

USMN(Unified Spatial Metrology Network) solves multi-station networks simultaneously, intelligently utilizing measurement information to yield an ideal network of common points. It provides uncertainty information for all measurements, can be used to characterize measurement system performance, and delivers results both numerically and graphically. Notably, it optimizes instrument and target positions by weighting measurement uncertainty [6].

The USMN for the results after the measurement is an iterative process until a suitable result is obtained. Fig. 2 below is a screen of the USMN process after the measurement network of the 100 MeV proton accelerator.

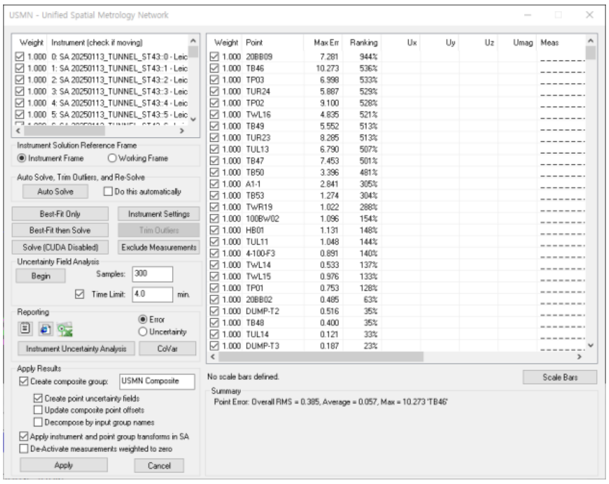

Fig. 2. USMN screen after 100 MeV proton accelerator measurement network

2.3 Survey network construction procedure

The survey network construction process can be roughly seen in the survey network construction flow chart in Figure 1 below. The first step is the process of preparing and measuring the measuring device. Each measuring device must comply with the inspection and calibration cycle to confirm the basic uncertainty of the device. The measuring device consists of one set of digital level, two sets of staff, one set of laser tracker, and an extension stand. The second step is the integration of measurement results. In this process, incorrectly measured data must be confirmed, and re-measurement is required if necessary.

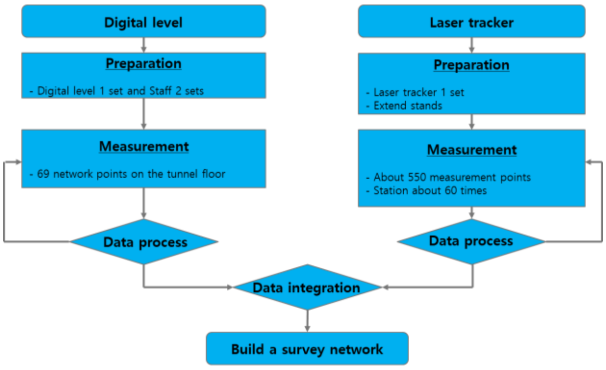

Fig. 3. Flow chart of survey network construction

2.4 Data integration

There are two measurement results: the laser tracker result and the digital level result. Here, the digital level result needs to be converted into a file for the SA program. The figure below is a flow chart of the process of integrating measurement results. The process of integrating data uses the USMN function of the SA program. There are two analysis processes in USMN. The first is the process of reducing numerical errors that occur in measurements. In the process of integrating a large number of stations, the distribution of numerical errors of the measurement points is displayed by ranking them. The second is the process of determining the weight of the digital level. The weight of the digital level is determined by referring to the uncertainty of the digital level confirmed while measuring the digital level. For reference, in the measurements taken with a digital level at a 100 MeV proton accelerator, the average distance between the digital level and the staff is 6.363 m. Given the digital level's accuracy of 0.2 mm/km, the average uncertainty is 1.273 µm.

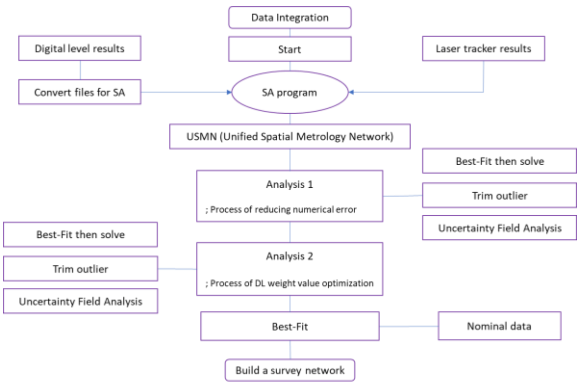

Fig. 4. Flow chart for data integration

3. Conclusions

The construction of a survey network for the 100 MeV proton accelerator has been challenging for over a decade to accurately determine the positions of accelerator components and electromagnets. Relying solely on laser tracker measurements over a wide area has limited reliability for a variety of uncertainties. To address these issues, the survey network measurement and data processing methodology used by KEK has been adopted. This approach is expected to provide consistent and reliable survey network results during continuous maintenance periods, thereby improving the overall precision and reliability of the accelerator alignment.

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