THE SURVEYING AND ALIGNMENT FOR THE PROSCAN PROJECT

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The PSI-Surveying group is involved in the PROSCAN project. In this report, some conceptual aspects of the network and the alignment of the components are described.

THE PROSCAN PROJECT

PROSCAN is a new facility for medical research now being realized at PSI. Since the facility will be independent of the rest of PSI, it can be run 365 days a year, which is essential for the continuity of patient treatment.

Fig. 1: COMET: **Co**mpact **Me**dical **T**herapy Cyclotron. The pole cap is lifted for access; the four dees, the magnet hills and the two superconducting coils with their cryogenic helium vessel can be seen. (By courtesy of ACCEL).

Because PSI will install this facility in an existing hall and because there is already an operating gantry, which will later be connected to the new accelerator, some specific problems arise. Since the therapy program with the existing Gantry 1 will continue during the installation of the new facility, we are obliged to perform many important tasks during the annual shutdown of the existing PSI accelerator facility. In order to complete our work within this limited time, we need extremely well thought out concepts.

THE SURVEY TASK

The Network

Our task is to build a network, which will allow adjustment of neighbouring components with an accuracy of one tenth of a millimetre in all directions (relative accuracy). For several reasons we have to divide the build up of the network into three parts. The first part has been measured last summer.

Our aim is to build the network with a minimum of points. This means that the points have to be placed at good locations, which of course are related to the layout of the whole machine complex. Furthermore, it was necessary to define them in a general layout, so that other occupational groups (for cooling, electricity, construction) working on this project could easily recognise them. This avoided other installations being planned at these places and no points had to be omitted. Especially the shielding (built of standardised concrete blocks at PSI) caused some problems, because it was changed with every new design of the beam line and accordingly also the network points had to be changed. The definite location of the points we had to measure could be fixed only a few days before we started with the network measurements.

The network is built in three steps. This is necessary because:

- Not all the beam lines are built in one step.
- We had to “save” our existing points, which will be destroyed during the construction work.
- The binding to the existing Gantry 1 is, from the point of view of survey, more complicated because it is now separated from the rest of the hall and from the rest of the network (concrete shielding), but has to be linked with it.

The first step was completed this summer, before construction work begun. The goal of this step was to save our existing points and to ensure that there are enough points left for the next steps. Of course these new points have been placed where they can be used later – in the beam line area where no shielding is planned.

The next step involves the network in the accelerator bunker and in the new Gantry 2 area. There have to be enough points to do all alignment necessary to adjust these huge components.

The final step involves the network in the beam line area for the existing Gantry 1.

The shielding is movable and therefore all points are located on the floor of the hall. The one exception is in the accelerator bunker, where the shielding is built of “normal” concrete walls. There, we will also install points at various heights. They are necessary for the installation and alignment of the accelerator itself.

Since the machine and the beam lines will be built oriented to gravity, the network has to follow. The laser tracker does not normally work oriented to gravity and therefore the measured and calculated network has to be oriented afterwards. To do so we levelled all points and transformed them. This proceeding is shown in Fig. 2 below.

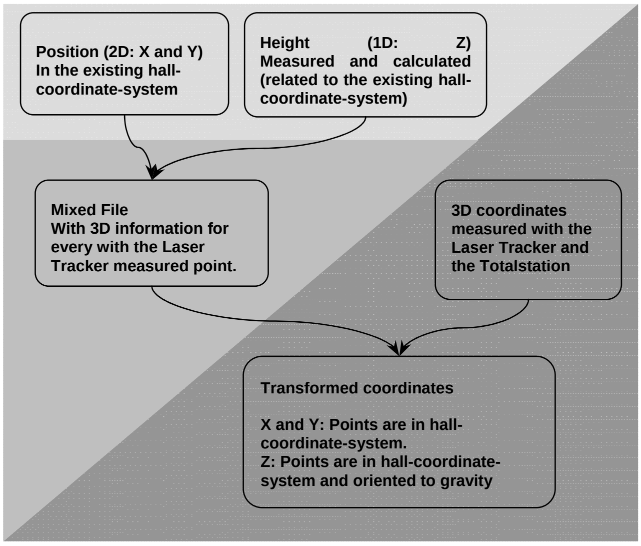

Fig. 2: Flow diagram for 3D coordinates oriented to gravity out of a 2D plus 1D initial system.

Remarks:

- We had to start with this “2D+1D-coordinate-system” because, due to the shielding, the height was the only dimension that could and, because the height changes the most, that had to be checked in the old network. During the period of 10 years the hall was used for other projects and experiments.
- This procedure assumes that the X and Y positions of the existing points have not changed. If this is not the case, the newly defined highly accurate levelled heights of the points become less accurate because the errors in X and Y have an effect on the heights (→ 3D transformation).

One of the most important prerequisites of working with the laser tracker is that there are no other actions taking place in the hall during measurements. Even a draught can make it impossible to reach the required accuracy. If the time schedule is tight it is not always easy to convince everybody that these environment conditions are necessary in order to get the high accuracy of the results.

Alignment Concept for Beam Line Components

At PSI, most beam lines have the same structural concept: several beam line components are mounted on a girder. The components are adjustable in all directions relative to each other and to the girder. The girders stand on the floor in the hall and are also adjustable. Only the dipole magnets are “standalone”. This makes sense since they are much heavier than the rest of the components and therefore, only the supports for the dipole magnets have to be dimensioned to carry their weight.

The biggest advantage of this system is that most of the assembly work can be performed outside the beam line areas. Inside, where the radioactive environment limits the intervention time, only three points per work piece have to be checked. It is also useful for deformation measurements: fewer points have to be measured to determine the position of each single component.

There is only one major difference between the concepts of the beam line for the PROSCAN project and other beam lines at PSI. We have foreseen an intermediary plate between the girder and the components. The attachment holes for the lower part of the adjustment devices are not in the girder itself. If the position of any component has to be changed, only the intermediary plate has to be modified or replaced. This is easier because the work piece is smaller and any modification is therefore faster and cheaper.

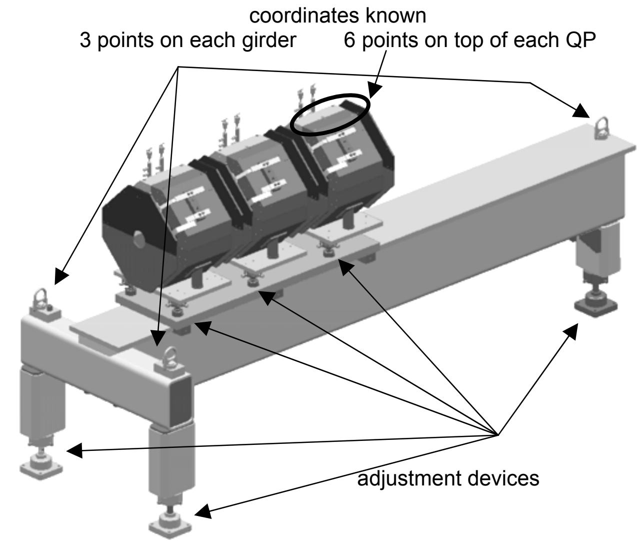

Fig. 3: Girder with quadrupole (QP) triplet.

The procedure for the beam line assembly and the alignment of the components is as follows:

1. Mark the beam line axis and the positions of the feet of the girders on the floor.
2. The girders are placed in the hall and attached to the floor.
3. The girders will be levelled and adjusted in position with an accuracy of ±1 mm.
4. A packet (e.g. a quadrupole triplet) is placed on a girder. These packets will be assembled outside the beam line area but will not be adjusted there.
5. Each single beam line component will be adjusted in height and position: quadrupoles with an accuracy of ± 0.1 mm, diagnostic elements with an accuracy of ± 0.5 mm.
6. The three reference points on the girder as well as the points on the beam line components will be measured (control measurement).