STATUS REPORT ON THE SURVEY AND ALIGNMENT OF ACCELERATORS AND STORAGE RINGS AT DESY

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1. INTRODUCTION

In general the conversion of new ideas of scientists and physicists into engineering projects is joined with questions about measurement and survey under various conditions for accuracy, availability or object size. For major projects of DESY the survey and alignment group has to present solutions for this requirements. Personnel and financial resources are necessary to follow up the responsibilities in research and development of alternative measurement systems, new survey concepts and basic networks. In the last years the R&D work was mainly concentrated on the HERA Luminosity Upgrade, the TESLA Test Facility TTF and also the Photo Injector Test Facility 'PITZ' at the DESY site in Zeuthen close to Berlin.

This report presents projects and activities of the survey and alignment group at the Deutsches Elektronen-Synchrotron during the years 1999 to 2002. It focuses on the most important project in supporting the extension and operation of existing accelerators and related facilities - the ‚HERA - Luminosity Upgrade', realized in 2000/2001 during a ten month shut down period. Many different duties had to be followed up, while DESY celebrated its 40th anniversary in May 2000.

As an additional center of activities, the wide range of tasks for the planned future project TESLA, a 33-km super-conducting linear accelerator with an X-Ray Free Electron Laser, was rapidly increasing during the past four years. After presentation of the projects technical design report in March 2001 a detailed planning started in all concerned fields (see [3] for details).

2. PERSONNEL CHANGES – THE DESY SURVEY & ALIGNMENT GROUP

In the past, the alignment group was settled at the DESY Machine-Division, therefore the accelerator related jobs have been in the focus of interests. Other services in providing geometric data for various departments of DESY had to be managed with a minor priority. Later on, the survey and alignment group has been integrated into the DESY Central-Division as a general service group. Again - in adaptation to requested tasks a reorganization and bundling of several service groups was done in 1998. Increasing requests of up to date geometric information from many different departments and groups of DESY are a visible confirmation for this necessary process.

After nearly 40 years of work, Prof. Franz Löffler the former chief of the survey department left DESY in 1998 and retired finally after a period as consultant (see fig. 1). With his great experience of a lifetime for accelerator-geodesy, he supported the survey and alignment group for two more years.
At the end of the year 2001 the team is changed, seniors from the beginning of DESY are retired and new engineers have been engaged additionally for research and development of future projects. Altogether four years of personnel changes are over and the new team now is able to take care for the future named TESLA.

Fig. 1: Senior surveyors during the geodetic event at the DESY-EXPO-2000 exhibition

3. ACCELERATORS AND SYNCHROTRON RADIATION FACILITIES

3.1 HERA

The 30/920 GeV electron/positron and proton storage ring HERA (see fig. 2) is actually the most important facility in operation. The former and longtime updated accelerators DESY and PETRA are still in use as pre-accelerators for HERA. In order to achieve up to five times more luminosity for the experiments data-collection than designed in the early eighties, in 1996 DESY decided to extend the performance of the HERA storage ring (see fig. 2) by a major reconstruction and partial updates of the pre-accelerators DESY II/III and PETRA.

After an intensive period of planning, design and construction of new components for the HERA storage ring, the installation began in September 2000 with a shut down period of all HERA related accelerators. Restart for HERA and concerned experiments has been in July 2001.

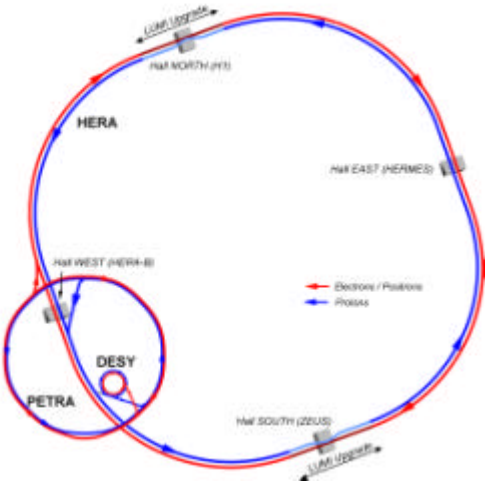

Fig. 2: HERA – Luminosity upgrade shut down, concerned locations

For both collision regions, H1 in Hall North and ZEUS in Hall South, nearly similar optics have been designed. From the interaction point back to 70 m inside the tunnel, the machine has completely been dismantled and rebuilt from the concrete floor on both sides of each detector.

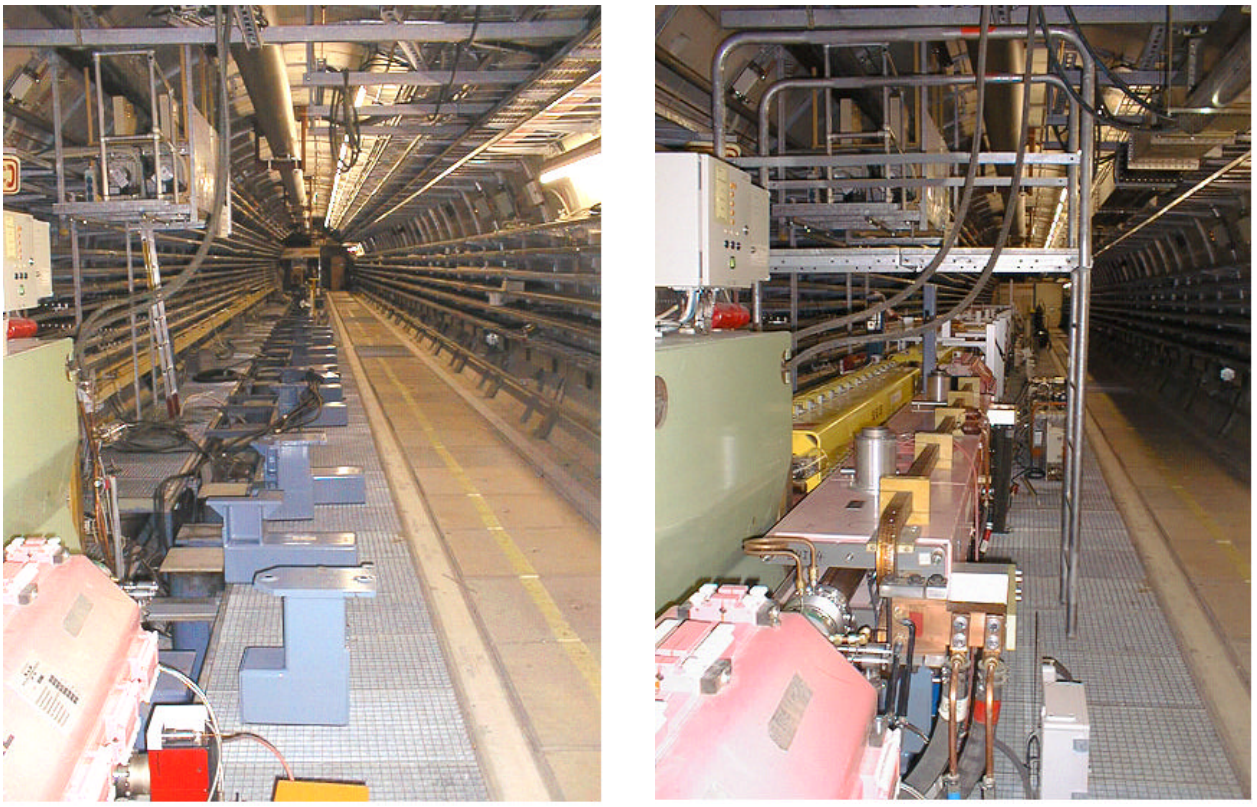

Fig. 3: Luminosity upgrade area at different states of completion

Altogether supports and pillars of nearly 100 new components over about 280 m length in total have been necessary. To connect the storage ring with the detectors of the experiments, four new steel bridges of about 20 tons of weight, with pre-installed magnets were built up to allow the transition between tunnel and halls.

Based on good results of the former implemented ‚Electron Spin Rotator' at the eastern straight section of HERA some years before, DESY decided to build up similar constructions in the northern and southern sections too. Again about 280 m in total of the electron machine were concerned and needed to be rebuilt with 44 dipoles and 20 quadrupoles (see fig. 4).

Further on, 35 magnets of the electron and proton machine and some cavities of the electron machine around the HERA ring needed maintenance and have been moved or changed and needed to be realigned besides the major sites of interests in North and South.

Fig. 4: Electron spin rotator area at different states of completion

The survey and alignment group was involved in the geometric design from the beginning. For installation and geodetic alignment of the components an accuracy of less than 0.3 mm is required as it is standard for DESY accelerators. Measurements had to be carried out for transference of the magnet axes to the magnets fiducial marks and for quality control in case of 82 normal and 4

superconductive magnets of the Luminosity Upgrade area. Correspondingly the Spin-Rotator magnets had to be surveyed and pre-installed once for a mock up test.

In September 2000 the Luminosity Upgrade shut down started with a major geodetic survey of the existing HERA machine and the basic traverse in order to examine and verify the existing reference points. After that all components of the upgrade areas were dismantled to the empty tunnel. New pillars have been staked off (see fig. 5), installed and surveyed. Installation of new magnets, pre-alignment, installing the beampipes, connecting magnets and final alignment have been the consecutive steps. For more than six month the complete survey team supported the extensive installation work diverted on several sites all over HERA and the experiments.

Fig. 5: Staking off the new pillars during the HERA-lumi upgrade

3.2 Experiments H1 and ZEUS

As soon as the installation of the upgrade area had been finished, the main interest changed to the experiments H1 and ZEUS. The longtime shut down period of the accelerators was used by each collaboration to open the main parts of their detectors for maintenance. Both collision experiments had to prepare the central detector for the implementation of new superconductive final-focus-magnets on both sides of the interaction point. The detectors were fully opened, checked and updated. The new components have been integrated and the detectors and its components needed to be realigned. After finishing the major installation work in the tunnel in June 2001, all capacity of the survey group was necessary for the realignment of the experiments.

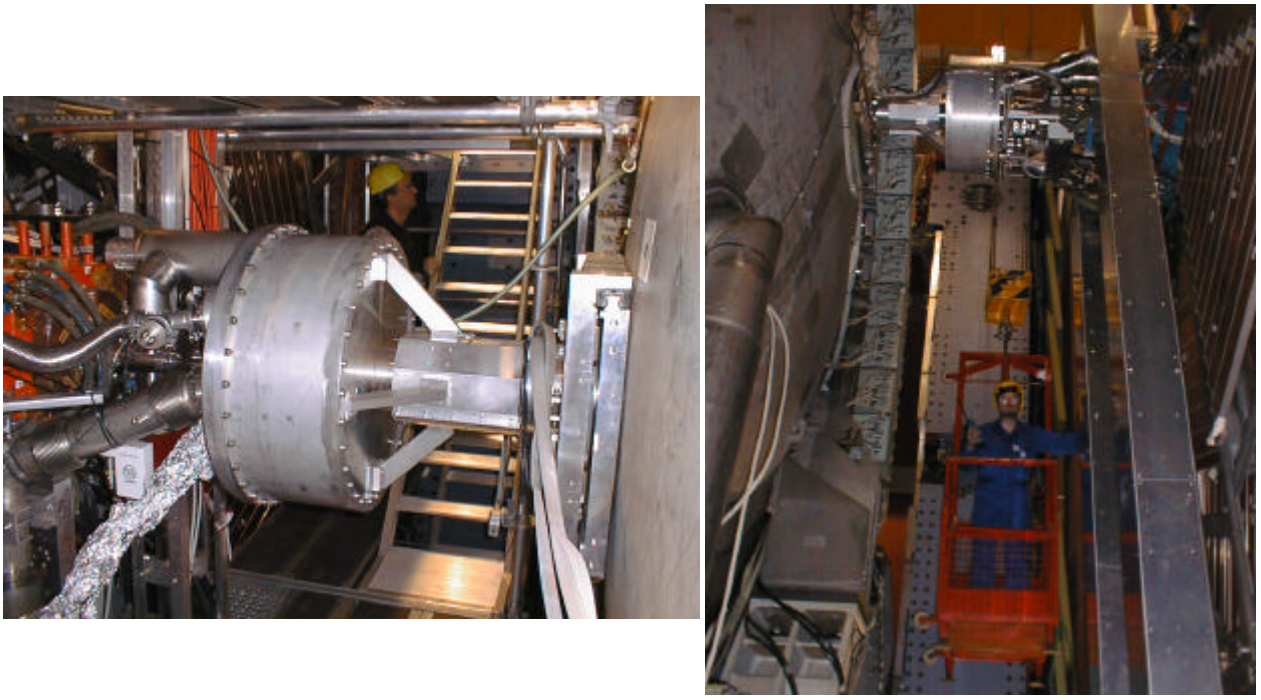

Fig. 6: Superconductive magnet between bridge and the detector of H1

3.3 Update of the permanent geodetic monitoring system at H1 and ZEUS

From the beginning of the operational phase of HERA in 1992 the survey group was requested to present online data, showing possible movements of magnets, detector and concerned buildings close to the interaction regions. So far a combined measurement system of capacitive hydrostatic leveling sensors (HLS), incremental length gauges and a wire alignment system has been in operation. As shown in [1] the HLS has been working well and provided suitable information about vertical movements of the detectors and bridges relative to the halls floor. This constellation has not been possible to provide absolute values about movements of the HERA storage ring, the tunnel building as a basic reference and the concerned building of the experimental hall with included detector.

A new independent survey system, which has to be able to report and analyze movements of the HERA storage ring versus the experiments H1 and ZEUS had been requested by the Machine Division for operation and control of the reconstructed areas of HERA. With such information, the HERA control team should be able to realize and react to dynamic changes of the complete system in time before major problems would arise. After a long discussion, DESY Machine Division decided to install an updated wire alignment system on each side of the interaction point as suggested by the survey group. Consisting of two parallel wires with a total length of about 60 m each, 32 monitors for magnet-movements have been arranged at selected magnets. The mean

average values of magnets in the stable part of the tunnel serve as a reference to predict movements of single magnets or even the complete steel bridge near the interaction region.

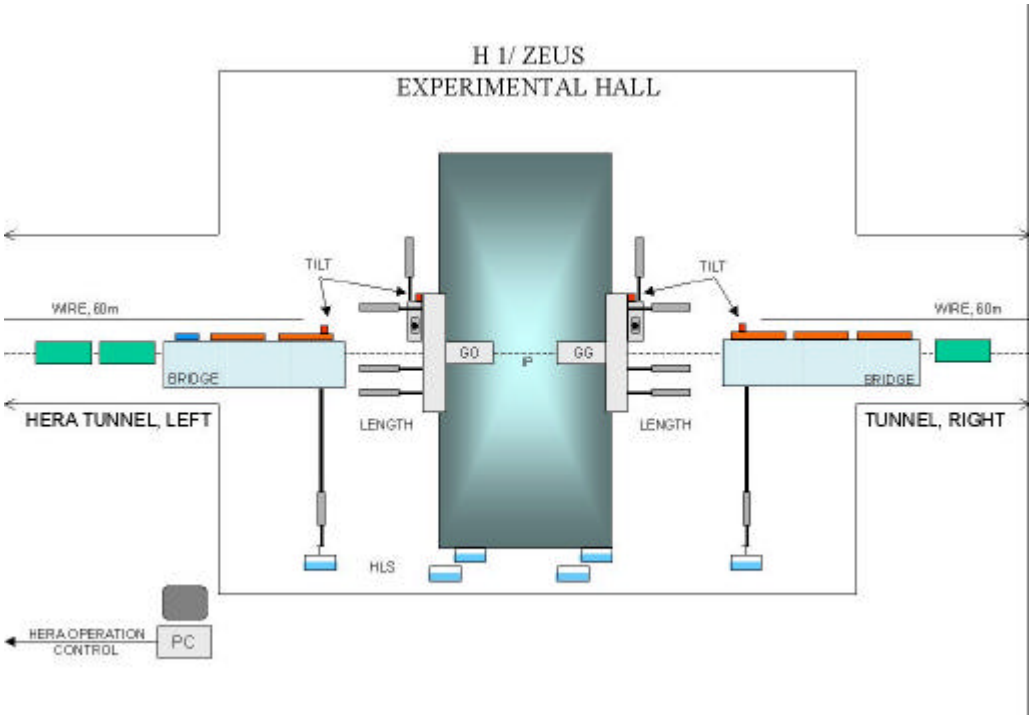

Fig. 7: Movement monitoring system of HERA and detector

The wire system has been constructed by a group of the DESY machine division and is not under responsibility of the survey and alignment group. Up to now the wire system is not fully implemented as decided. A lack of time and bad conditions during the installation period may have been the reasons for this. The stretched wire system ends at the last magnet on the steel bridge, which is 6,25m (-left side) resp. 4m (-right side) away from the interaction region. This magnet is linked to the former installed HLS system by means of invar rods. The final superconductive units close to the interaction point are installed partly inside the detector so that it was impossible to extend the wire for monitoring them in the same way. Information about movements of this components are available from additionally installed incremental length gauges and high precision tilt sensors on the front plate of the superconductive magnet and the last magnet on the bridge (see fig. 8, 9). The survey group took care of the construction of four special supports and installed the monitoring system finally. New software for data collection of various newly installed sensors and the existing hydrostatic leveling system had been programmed or updated. The other parts of the monitoring system have been built up and are operating since August 2001. First results are available, final geometric analysis and calculations with data from the wire alignment systems are not yet fully implemented.

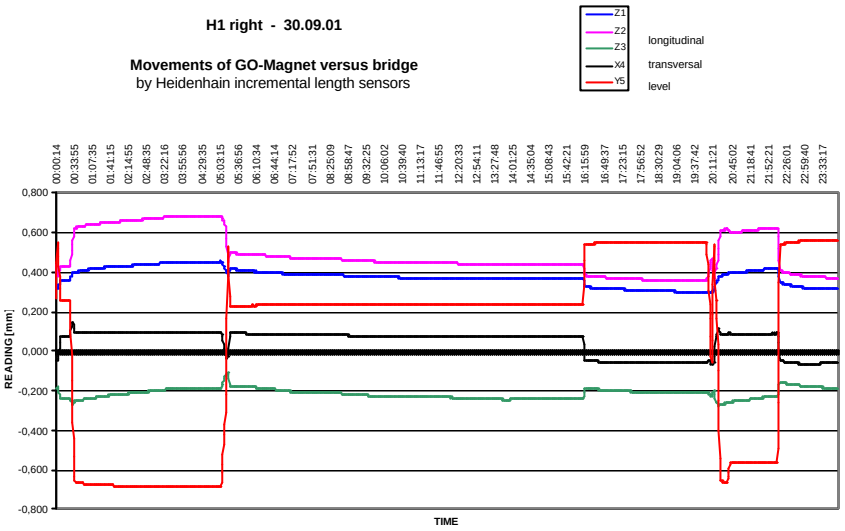

Fig. 8: Detected movements during machine studies

At the end of the experiment shut down period, the HLS and extended monitoring system have been installed and a final survey of all reconstructed areas of HERA has been done. By closing the experiments of H1 and ZEUS in late July, the HERA Luminosity Upgrade and all associated shut downs ended in time.

3.4 Other shut down activities

3.4.1 PETRA

To optimize the performance of the pre-accelerator PETRA, a synchronous shut down to the HERA Luminosity upgrade was planned. Many magnets have been surveyed, opened to install new beampipes or coils and then have been realigned again. A periodic control survey showed local settlements of the machine up to 8 mm over an approximately 120m long section (see fig. 9) where the newly constructed tunnel of the TESLA Test Facility crosses PETRA near to the newly built experimental hall. Heavy load and construction work had been the reason for the settlement. PETRA was realigned and the settlement locally adjusted.

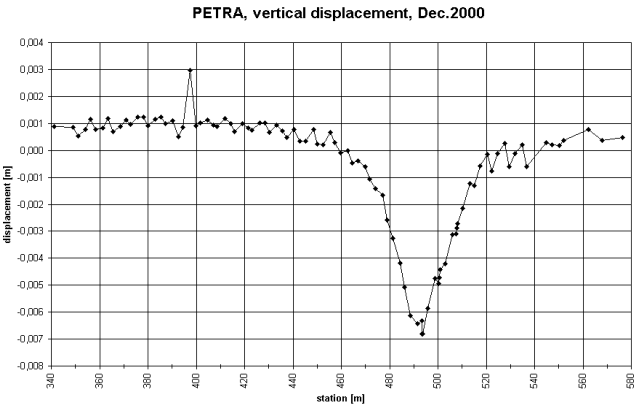

Fig. 9: Vertical displacement of an area at PETRA

3.4.2 DORIS

For research and experiments using synchrotron radiation, DESY provides actually more than 42 separate beams for various experiments with the storage ring DORIS and the 'Hamburger Synchrotron Radiation Laboratory' HASYLAB (see fig. 10). Many scientists from biology, chemistry, geology or pharmaceuticals industry build the wide community of synchrotron users at HASYLAB.

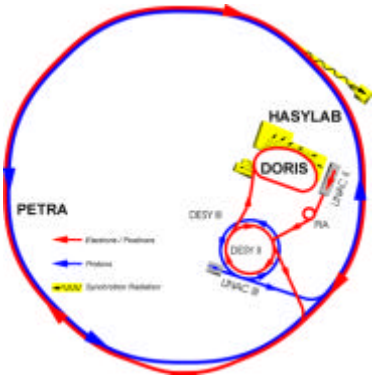

Fig. 10: DESY Synchrotron radiation facilities

Maintenance and increasing the performance have been the reasons for a four-month shut down of the synchrotron light source DORIS. Apart from general survey jobs for changing components, a major project was the extension of the accelerators' circumference of about 8 mm (see figure 11).

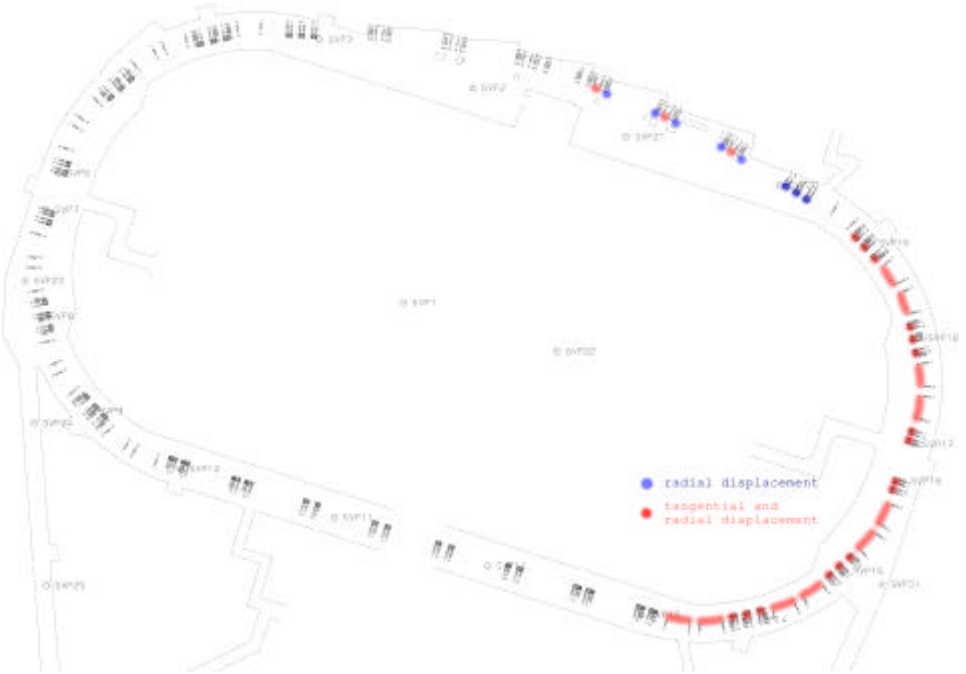

Fig. 11: Components that have been moved at DORIS

Nearly half of the components of the DORIS magnets had to be moved, depending on the type of magnet (dipoles, quadrupoles or sextupoles) and its position. Some have been moved only radially, the most in longitudinal and radial direction.

3.4.3 TESLA TEST FACILITY

In direct relation with the development of TESLA and the accompanied VUV Free Electron Laser a 100m test facility named TTF is in operation at the DESY site and will be extended to 260m (see fig. 11).

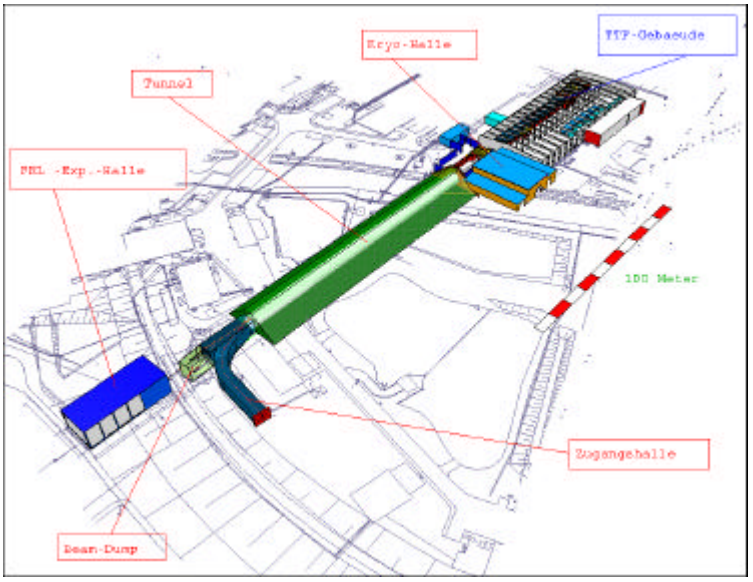

Fig. 12: TESLA Test Facility TTF with FEL

Several tests and research projects for TESLA hardware and future operation are in the works. Many important aspects like optimizing production processes, quality control, handling and operation of components can be monitored and improved for TESLA to save time and financial resources.
In February 2001 the first successful operation of the Free-Electron-Laser could be documented with a 100-nm laser light. A decisive milestone was achieved with the VUV FEL in September 2001 in a maximum light amplification of about 10 million. See [6] for details

4. SUMMARY AND OUTLOOK

After major personnel changes in the last years, the survey and alignment group of DESY set priority in supporting the HERA shut down 2000/2001. With its completion, the main interests and activities were focused on the next major DESY projects like TTF II, TESLA and X-FEL.

More than in the past, supporting the administration in case of property and estate occurs in the urban surrounding of DESY inside the city of Hamburg. A lot of topographic survey requested by the construction department is necessary for any design and construction of new buildings and facilities on DESY area and for future TESLA sites. The actual documentation of accelerators, buildings, existing utilities, like pipes, cables or drainage is realized and to be updated in a geo-

information system called GEBIS. Security, rescue and emergency services are very interested in detailed plans of office floors, basements, labs and stores for example. As support for several groups, different thematic maps must be prepared and included in a master system. In the next future extensive basic geometric information is required in modern geographic information and facility management systems.

Another increasing field of survey tasks is the geometric quality control for components or completely assembled experiments prior to their installation into accelerators and facilities under condition of less time and space. The survey and alignment group must be involved in nearly all such projects from the beginning design, throughout the production process and preparation for final installation. To neglect this in any case or any stadium will very likely force problems in project management later on.

5. REFERENCES

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