ALIGNMENT STATUS AT THE SUPERCONDUCTING SUPER COLLIDER LABORATORY

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Organization

The department is part of the Accelerator Systems Division with an acknowledgment of the global nature of our charge by upper management. The department is divided into three groups, the Machine Alignment Group, the Detector Alignment Group, and the Support Group. Staffing continues to be a problem due to budgetary constraints. The current department size is 13 people but we expect to expand to ~25 during FY94.

Definition of Roles and Responsibilites

Due to the large and varied scope of the survey and alignment requirements of the project it was necessary to formally identify the scope, the groups responsible for each task, and the interface between the Department of Applied Geodesy and other section of the laboratory. This was drafted and approved through our Management Overview Document, Doc. No. AGA1010001 (copy enclosed). Additional copies are available on request In summary it covers the following:

1. PRACTICAL GEODESY i.e., the mathematics required to locate the machines and detectors in the correct “earth” position - A task mostly complete and enshrined in code.

2. CIVlL CONSTRUCTION is concentrated on tunnel construction. Approximately 27% (23.6 km) of the basic tunnel is excavated. One large surface complex including the Magnet Development Lab and the Magnet Test Facility are complete but no permanent administration facilities are under way. Site grading and infrastructure construction are in progress at the Large Detector sites. Surveying to support the civil construction is provided by the Architect/Engineer and tunneling sub-contractors. The DAG provides QA/QC for submitted surveying procedures and verification of the control surveys provided by the AE. This includes the surface network (GPS and spirit leveling), surface to tunnel transfers, and the underground traverse. For each 4.4 km underground traverse DAG performs a centerline traverse using the DMT Gyromat at 500 meters, 2.0 km and 3.5 km. This survey verifies the direction between wall brackets monuments used for primary tunnel control. Vertical control is also verified using the Leica NA2002 with fiberglass bar coded leveling staves, This system was in place and working well when the plug was pulled; literally for one TBM. All four TBMs are now stopped pending the Senate vote and next years funding.

3. MACHINE ALIGNMENT will be a joint effort between the DAG and the installation contractor. To avoid any impact on installation schedules, the installation contractor will make required installation alignments before interconnects are made. DAG however will provide the Tunnel Reference Network, Quality Control of the installation alignment, and the Final Smoothing. Additionally, the DAG will provide to the installation contractor the alignment procedures, instrumentation, software, training and certification of personnel as required. Scope of Collider includes ~1800 quadrupoles and ~9200 1.5m Dipoles to be installed in ~88 km of

Current challenges include:

- A continuing controversy over the means to transfer control from surface to tunnel - offset utility shafts vs. direct access via vertical pipes.
- Design of the magnet support/adjustment system for magnet installation. DAG strongly supports a minimally constrained 6 strut system similar to the one developed at LBL. (see VHS tape of prototype)
- Budgetary means to fulfill our scope.

Current achievements include:

- Concepts are in place for alignment strategy but still require considerable development. The video contains a simulated strategy for dipole alignment.
- The tunnel reference network monument socket selected - a variation of the CERN 3.5” reference socket in the tunnel floor, 30 meter spacing = 3 per half cell.
- Component fiducial for SSC defined as 1.5” fiducial socket compatible with laser tracker instrumentation for primary alignment, An “active fiducial” providing repeatable mounting of instrumentation directly to quadrupoles for final smoothing is under development.
- The Laser Tracker is selected as the primary tool for magnet alignment. Based on our testing the Chesapeake was more compatible with our need than the Leica.
- A monopod is designed to provide quick repeatable mounting of instrumentation vertically above monument sockets at a comfortable sitting height. The prototype was successfully incorporated in the survey of LINAC.
- LINAC alignment will be used to test alignment procedures developed for other machines, It is ~320 meters in length with monuments at 4 - 6 meter spacing.
- LINAC Tunnel Reference Network has been installed and measured, More than 1000 observations including Mekometer distances, small angles, and N3 vertical distances were made. Relative errors perpendicular to beam line better than 0.1mm at 95% were achieved. Installation of components will start in FY94.

4. DETECTOR ALIGNMENT is still in the process of defining requirements. To date two experiments are active, GEM - the Gamma Electron Muon Detector and SDC - the Solenoidal Detector Collaboration.

   Configurations and Challenges include:

   - Enormous Objects 40 meters long by 19 meters diameter, 35,000 tonnes (SDC)
   - Underground halls designs 30 X 30 X 100 meters
   - Typical alignment requirement is trigger placement to 0.5 mm relative to the silicon tracker. Many alignment requirements are impossible to achieve by survey alone. Systems of stepping motors driven by beam position monitors are being developed
   - The theoretical beam position must be maintained throughout the installation period of 5 years. The detectors are assembled in place.
   - Alignment systems to meet the complex internal requirements are being developed using straight line monitors similar to those used at LHC.
   - "Range only" measurement devices will he incorporated to monitor real time shape during operation. This will include hydrostatic levels and EDM instruments developed by the SDC collaborators providing precision of < 0.1 mm.

   The alignment conceptual design for each of the experiments is in early development. Our activities include field support of component development such as QC measurements on a 10.7 cubic meter block of steel for prototyping at Volgodonsk, Russia

5. SUPPORT SERVICES is a group set up to awage those tasks that can be provided most efficiently by disregarding political and geographical boundaries. Primary among these are Instrument Calibration, Computing, Procurement and inventory maintenance, and mechanical design.

   Achievements and Concerns include:

   - Database hardware and system delivered. Oracle Data Base selected. Interface implementation progress slower than anticipate. This is hampered by a severe lack resources partly due to under estimation of the size of the job (both by us and the professionals).
   - Data organization, naming schemes, etc. near completion
   - A first version data flow integration is in place with sufficient options to support civil engineering Quality Control activities.
   - Data Capture sequences include Pre-processing (conversion from real world measurements to 3D Cartesian equivalent), and Post-processing (Helmet and weighted iterative similarity transformations)
   - A calibration facility is a major concern that we must get started this coming fiscal year.