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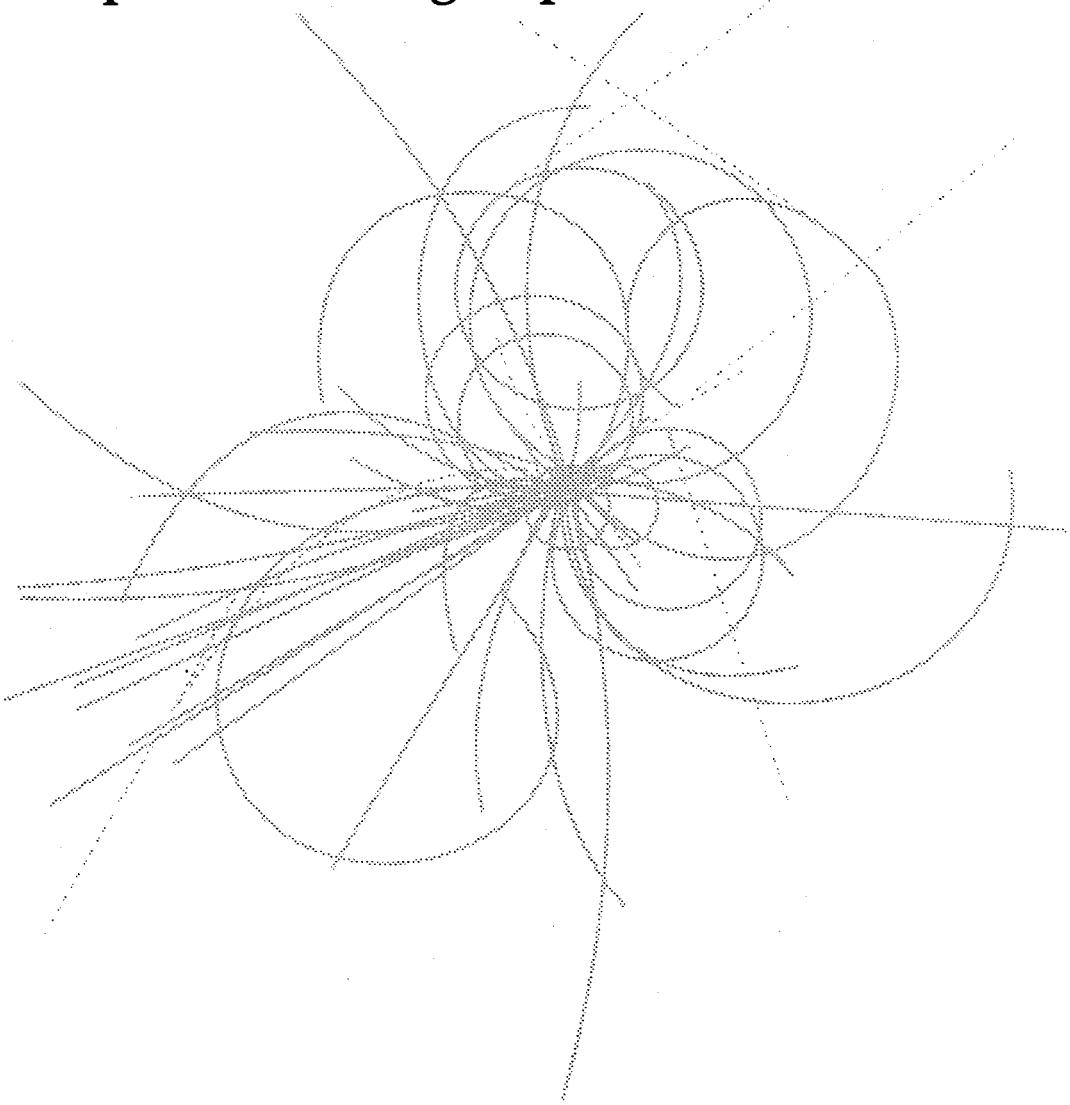

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March 1992

*Presented at the International Industrial Symposium on the Super Collider, New Orleans, March 4–6, 1992.

†Operated by the Universities Research Association, Inc., for the U.S. Department of Energy under Contract No. DE-AC35-89ER40486.

THE MAGNET DATABASE SYSTEM

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ABSTRACT

The Test Department of the Magnet Systems Division of the Superconducting Super Collider Laboratory (SSCL) is developing a central database of SSC magnet information that will be available to all magnet scientists at the SSCL or elsewhere, via network connections. The database contains information on the magnets' major components, configuration information (specifying which individual items were used in each cable, coil, and magnet), measurements made at major fabrication stages, and the test results on completed magnets. These data will facilitate the correlation of magnet performance with the properties of its constituents. Recent efforts have focused on the development of procedures for user-friendly access to the data, including displays in the format of the production "traveler" data sheets, standard summary reports, and a graphical interface for *ad hoc* queries and plots.

FUNCTION

The superconducting magnets for the Superconducting Super Collider Laboratory (SSCL) accelerator complex will be provided by the Magnet Systems Division (MSD). Some of these magnets will be built "in house," but most will be built by industrial vendors under contract to MSD. The Data Management Group of the MSD Test Department is developing and operating a data management system to integrate all the data that is relevant for the analysis of test results on these magnets. An important aspect of this system is provision of user interfaces that facilitate access to this data from local workstations or network connections.

The data management effort relies primarily on the use of the SYBASE relational database management system in a UNIX environment, plus tools for database design and data access, and file management strategies for archiving the large quantities of test data. The focal

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point of the data management system is a central database that we have named MagCom. This database will include test results for critical component materials, configuration information (serial or batch numbers) for critical components in all magnets, data collected at major production steps, summaries of warm and cold test results on all magnets, and reference "pointers" to the computer files that have the full data. It will serve as the source for the standard information needed by the magnet analysis programs, the QA (Quality Assurance) monitoring system, the Accelerator Division controls databases, and any *ad hoc* requests for information.

The size of the data file generated by a single test run is expected to range between 60 and 800 kilobytes, depending on the particular test. The data for the total set of magnets (from R&D through full production) is estimated to be 100 gigabytes. We plan to store the full test files outside the database, with only summary data and pointers in the database itself. We plan a user-friendly interface to allow simple access and manipulation of any magnet data, whether it is in the database or in the external files archive, so that users will not need to know the directory structures or physical locations. Consolidating the data in one data management system allows development of a unified storage approach and integrated applications interfaces (which can be sophisticated, flexible, and easy to use).

There are multiple advantages to a central database that is available to all. It ensures that everybody is using the same information for decisions on magnet performance and for input to their analysis programs. The same data is available for magnet builders, accelerator designers, and accelerator operators (when that phase is reached). Having the relevant data on all magnets, from different designs and even different vendors, in the same database allows easy comparison between magnets. This facilitates study of trends and correlation of performance to design or manufacturing features. Having all the data managed from a central system will allow us to maintain good security and backup procedures. We need to protect against loss due to hardware, software, or human malfunction.

HARDWARE & SOFTWARE

The current workstation setup of the Test Department consists of 2 servers and more than 35 client workstations on the SSCL ethernet. All of the workstations are SUN-compatible machines, running SUN OS v. 4.1 (a combination of BSD and System V UNIX) with a choice of window environment (SunTools, X11R4, and OpenWindows). The servers are a SUN 4/280 (grumpy.ssc.gov) and a SUN 4/470 (cranky.ssc.gov) on Internet; grumpy is also connected to DECnet as node name SSCSUN. We plan to upgrade to a faster server in FY92, to add mass storage capability via optical or magnetic disks, and to convert to use of SUN Solaris 2.0 (based on System V release 4). A discussion of the philosophy of the system architecture and security considerations is given in another report.[1]

The MagCom database is implemented using the Sybase relational database management system (version 4.01) on grumpy. Sybase modules provide interactive window (dwb) and batch command file interfaces (isql) for knowledgeable users. In addition, we have implemented a simple text menu system that can be used for local or network access to standard reports. This is described in the next section.

Our software approach is to acquire multi-user floating licenses, keep the software on a server, and use automount to make it transparently available from any workstation. The database software, mail, and printing facilities reside on grumpy; users' accounts and general analysis software reside on cranky. We are using C and C++ (and related utilities) for our system and data manipulation programming, but most of the users' analysis programs are written in FORTRAN.

We are using some design tools that were developed by the Data Management Group of the Information and Computing Sciences Division at Lawrence Berkeley Laboratory (LBL).

ERDRAW[2] is an X-window based tool for graphical specification of the entity-relationship model of the database, including key relationships, and SDT[3] is the related Schema Definition Tool. ERDRAW includes a meta-database feature for entering descriptions of the entities and attributes. SDT generates a SYBASE schema definition, including the triggers for maintaining referential integrity when adding, deleting, and updating data. A graphical browsing tool called QUEST[4] is expected in the next year; it will use the metadata from ERDRAW to guide users through the database.

We are also looking into the use of the ISTK[5,6] (Integrated Scientific Tool Kit) UNIX tools being developed for the SSCL Accelerator Controls system. These include a self-describing data structure (SDS) that provides a general way to store test data files so that they are easily used by analysis programs on either SUN or VAX systems. We are now using the graphics interface tools in the ISTK set for some simple graphical displays. However, we expect to develop applications interfaces to connect to more complex tools such as the graphical visualization product PV-WAVE or the LBL QUEST browser.

USAGE

There are several alternative ways to connect to grumpy. Network users can connect via the UNIX rlogin command or the VAX/VMS set host command. Macintosh users at the SSCL can obtain a set of macros that facilitate the connection and file transfer over our local ethernet. External users can dial in to the SSCL central system (214-708-9500) and then specify "connect grumpy."

If the user does not have an account on grumpy, he can use our public account, user name mdbuser. This account is recommended for users who are not familiar with UNIX because it has very restrictive permissions and will not allow any actions other than reading from the database and running the standard reports; also it has the appropriate environment setup for using the database. To learn the password for the mdbuser account or to register for a regular account, call our system manager (214-708-2968) or send an email message to sysadmin@grumpy.ssc.gov. The UNIX operating system is case-sensitive, so all commands must be typed precisely as they are specified.

The database menu system is accessed by typing the command magcom. Some help messages and the main menu will then appear. There is a tree of menus that allow selection from our standard reports (see Figure 1). The user is given the option of seeing the screen display of the selected report, writing a file copy of the report, or both. The file version is written to a directory called results in the login account (either mdbuser or the user's own grumpy account); it can then be transferred by ftp to the user's host computer system for printing.[7]

We do not allow the data suppliers to enter data directly into the database or archive. Data files from the magnet building or testing operations can be transferred to a special directory on grumpy[8] and then processed by our input procedures.

SSC CABLE DATABASE MAIN MENU

1. Data by Cable ID
2. Data by Coil ID
3. Data by Magnet ID
4. Strand data
5. Documents
6. Help menu
X. EXIT

1. CABLE MENU

1. Configuration summary, cable-coil-magnet
2. Electrical data summary
3. Electrical data detail
4. Magnetization data summary
5. Magnetization data detail
6. Mechanical data summary
7. Mechanical data detail
8. Cable production summary
9. Cable production detail
10. Coil detail
11. Cable strand map detail
X. Exit to main menu

2. COIL MENU

1. Configuration summary, coil-cable-magnet
2. Winding detail
3. Cable detail
4. 17M Coil size data summary
5. 17M Coil size data detail
6. Koldweld summary
7. Koldweld detail
X. Exit to main menu

3. MAGNET MENU

1. Configuration summary, magnet-coil-cable
2. Cable properties summary
3. Configuration detail
4. Coil and cable detail
5. Magnet features menu
6. LBL dipole menu
7. Quench summary
8. Magnet instrumentation menu
9. Koldweld summary
10. Koldweld detail
11. Transfer functions detail
12. Collared coil mole measurements detail
13. Magnet mole measurements detail
14. Coil RRR summary
X. Exit to main menu

4. STRAND MENU

1. List id: billet vendor job no. or strand spec.
2. Strand ic summary
3. Strand ic detail
4. Strand production summary
5. Strand production detail
6. Strand specification detail
X. Exit to main menu

5. DOCUMENTS MENU

1. List available documents
2. Retrieve a document
3. Store a document
X. Exit to main menu

6. HELP MENU

1. General info. and how to transfer files
X. Exit to main menu

Figure 1. MagCom menu level 1.

PRESENT STATUS

Past effort[9,10] has focused on development of database structures, data import procedures for R&D data, and standard reports available through the magcom menu. The reports are based on formats of the data tables in the travelers used at the labs and other formats requested by the analysis staff. Detail reports give results for one item (for instance, a cable, coil, or magnet), and summary reports give results for a series of items beginning at a specified identifier. Sample summary and detail reports are shown in Figures 2 and 3.

The data available includes cable production (including strand data), cable electrical and magnetization tests from Brookhaven National Laboratory (BNL), configuration (cable to coil to magnet), quench run summaries, and R&D magnet design features (baseline and variants). Work in progress is focusing on strain gauge data (including cold mass assembly steps and test runs), quench run data, magnet test instrumentation descriptions, selected coil production traveler data sheets, and selected cold mass assembly traveler data sheets.

KoldWeld Summary by Magnet
Search strings: magnet: DCA209

Magnet	Coil	Cable	Pos	Welds
DCA209	DCAI-2005	SSC-3-O-00044	Inner	6
DCA209	DCAI-2006	SSC-3-O-00044	Inner	6
DCA209	DCAO-2005	SSC-4-O-00030	Outer	13
DCA209	DCAO-2006	SSC-4-O-00031	Outer	14

Figure 2. Sample summary report: number of Koldwelds per coil.

Koldwelds Reference Location by Magnet
Search strings: magnetid-DCA209

Magnet	Coil	RefType	Turn	MinDist	MaxDist	Side	CoilFt
DCA209	DCAI-2005	REF-BNL	6	11.417	11.75	RIGHT	
DCA209	DCAI-2005	REF-BNL	8	7.916999		RIGHT	
DCA209	DCAI-2005	REF-BNL	10	7.5		RIGHT	
DCA209	DCAI-2005	REF-BNL	12	7.375		RIGHT	
DCA209	DCAI-2005	REF-BNL	14	2.832999		RIGHT	
DCA209	DCAI-2005	REF-BNL	16	.9479999		RIGHT	
DCA209	DCAI-2006	REF-BNL	4	35.33300		LEFT	
DCA209	DCAI-2006	REF-BNL	7	34.31200		LEFT	
DCA209	DCAI-2006	REF-BNL	8	34.96900		LEFT	
DCA209	DCAI-2006	REF-BNL	10	37.552		LEFT	
DCA209	DCAI-2006	REF-BNL	12	42.83300		LEFT	
DCA209	DCAI-2006	REF-BNL	14	44.698		LEFT	
DCA209	DCAO-2005	REF-BNL	4	29.74000		RIGHT	
DCA209	DCAO-2005	REF-BNL	6	18.16700		LEFT	
DCA209	DCAO-2005	REF-BNL	7	32.75		RIGHT	
DCA209	DCAO-2005	REF-BNL	9	16.31200		LEFT	
DCA209	DCAO-2005	REF-BNL	10	34.85399		RIGHT	
DCA209	DCAO-2005	REF-BNL	12	9.917000		LEFT	
DCA209	DCAO-2005	REF-BNL	13	40.625		RIGHT	
DCA209	DCAO-2005	REF-BNL	16	41.25		RIGHT	
DCA209	DCAO-2005	REF-BNL	18	4.187999		LEFT	
DCA209	DCAO-2005	REF-BNL	19	49.08300		LEFT	
DCA209	DCAO-2005	REF-BNL	20	2.041999		RIGHT	
DCA209	DCAO-2005	REF-BNL	22	44.54200		LEFT	
DCA209	DCAO-2005	REF-BNL	24	5.75		RIGHT	

Figure 3. Sample detail report: Koldweld locations in specified coil.

At the present we are concentrating on importing the data for the R&D series of 50-mm-aperture dipole magnets. These include seven magnets constructed at Fermi National Accelerator Laboratory (FNAL) by a team from General Dynamics and five magnets constructed at BNL by a team from Westinghouse. These two dipole series have the same magnetic cross section but differ in collar, yoke, and end design. There are also several quadrupoles constructed at LBL. The five dipoles and one quadrupole for the Accelerator Systems String Test (ASST) to be conducted in fall 1992 will come from this set. Each of the

three labs provides a final package of data summarizing the construction and test results for each magnet; however, the reporting formats are different from the three labs. We are developing input procedures, both manual and automated, for consolidating all this data into our database structure.

We are investigating approaches to development of a graphical user interface (GUI) with pull-down menus that will allow *ad hoc* selection of data to be displayed in tabular or plot format. An example based on the X windows and ISTK tools is shown in Figure 4. This version allows access to only one table (type of data) at a time.

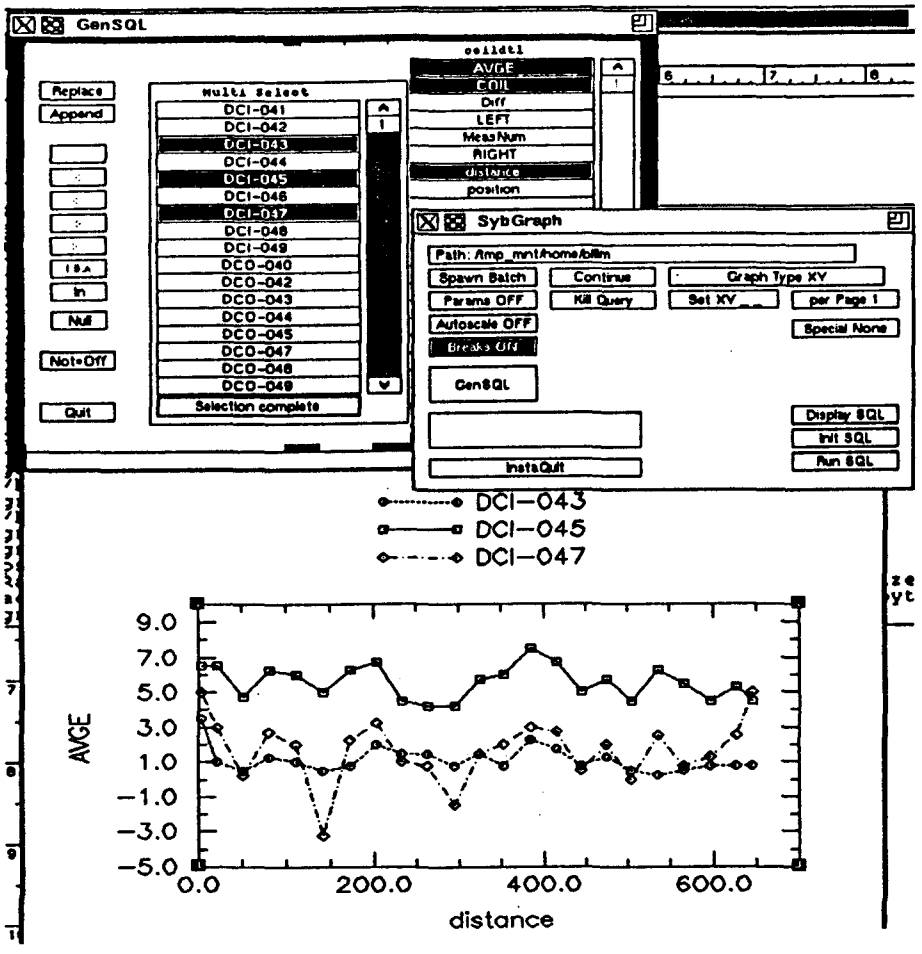

Figure 4. Screen display for user interface based on ISTK tools.

We are also developing interfaces between the database and the standard analysis programs used by Test Department physicists. The goal is to get the data into the database as soon as it is released by the magnet builder, and to have a computer procedure that runs the standard analysis programs and generates the tabular reports and graphs used by the magnet

analysis staff. An example of a graph of the cable short sample quench current versus the magnet quench current is given in Figure 5. We are developing an interface to the strain gauge analysis procedures; the user specifies the desired parameters via an interactive program, which then extracts the data and formats it for PV wave plots.

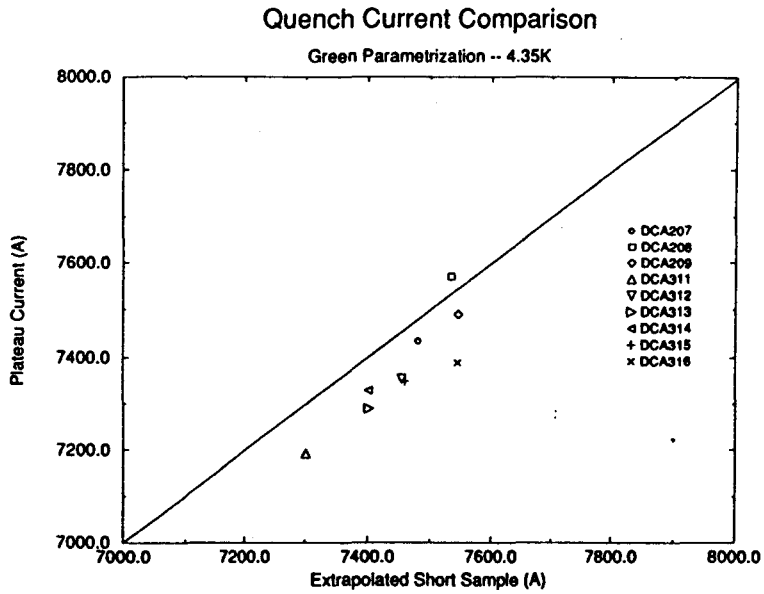

Figure 5. Comparison of component property with magnet property.

LONG RANGE GOALS

In the longer term, we will incorporate data from the industrial vendors and the SSCL "MAKE" magnets. This will require development of format specifications and transfer protocols to retrieve the desired data from their computer systems and enter it into our data management system. It is desirable to have this as automatic as possible, with programs that initiate file creation and network transfer during the night. We will develop programs to validate the files that are received, including checking data ranges and referential integrity, before entering the data into our database.

It is desirable to have a general graphical user interface (GUI) that will allow users to make *ad hoc* selections of data items from multiple tables and to specify the tabular or plot output that is desired. We hope the data selection portion of this GUI will be served by the QUEST tool being developed by the Data Management Group at LBL Computer Science Division. QUEST is a general query system that will allow users with no knowledge of database structure or SQL query language to browse the database and select the items they want. It works with metadata for entities and relationships that is maintained by the LBL database definition programs (ERDRAW and SDT), which we have been using. We will develop the connections between the data selected by QUEST and the input to the selected report or graphics processing.

The goal is to make all magnet data easily available for processing through any of the standard analysis procedures or for input to the user's personal program.

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