Roll measurements in the Tevatron
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Abstract

Since 2003 measurements of the rolls in all the Tevatron dipoles and quadrupoles have been made. This has been done using digital levels and fixtures. The data can be quickly collected and analyzed during a typical multi week shutdown allowing for corrections to be made to those magnets with rolls greater than 1 milli-radian. By having historical data problem areas in the Tevatron can be identified. This paper presents the basic operations and calibration information for doing a complete set of roll measurements.

Introduction

For the past 5 years periodic measurements of rolls of Tevatron dipoles and quadrupoles have been made. The roll is defined as the difference in height between the beam left side of the magnet and the beam right side of the magnet. See Figure 1.This is possible by the manner in which the dipoles and quads are fiducialized. When the magnets were built survey lugs were attached at four points near the top of each magnet near the location of the support stands. The lugs are eccentrics and positioned such that when the upstream and downstream pairs of lugs are level with respect to gravity the field in the magnet aperture is vertical. The alignment groups refers to the lugs as A,B,C,D where A and B are on the upstream of the magnet and C and D on the downstream.

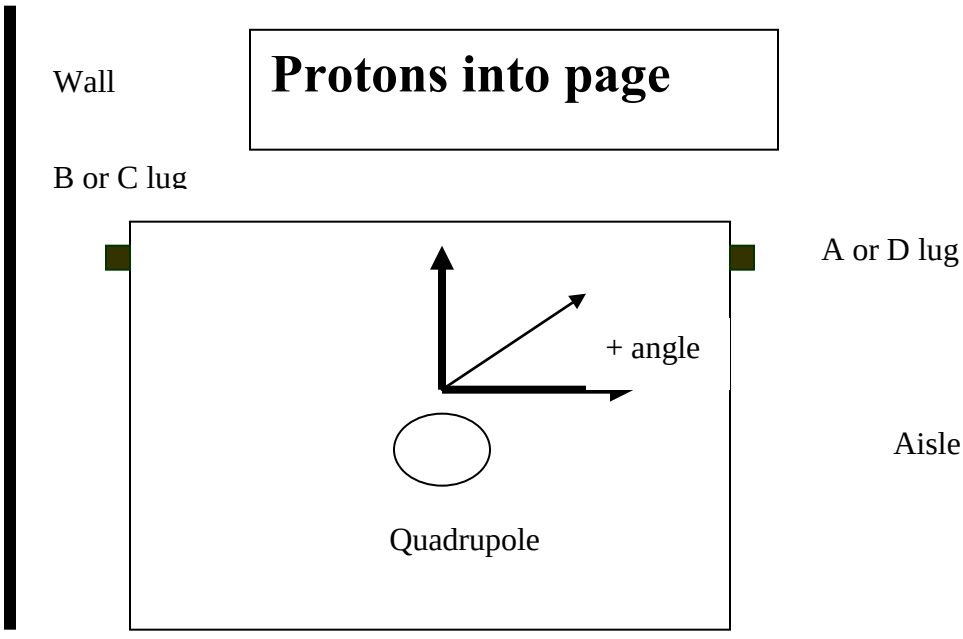


Figure 1

In 2003 roll measurements were done using a fixture and a Talyvel level. The Talyvel put out a voltage proportional to the roll of each dipole. The voltage was read and entered by hand into an EXCEL spread sheet. The Talyvel was calibrated by setting shims under the fixture there by making known angles and recording the voltage. This was a cumbersome method; in addition the Talyvel was very delicate and prone to breakage.

In 2004 a LABVIEW program using a Mitutoyo digital level was developed by Fred Nobrega and Luciano Elementi of Technical Division. A carbon fiber fixture that spanned the magnet and engaged the survey lugs was built. See Figure 2. This is a much more straight forward system. Don Poll has two laptops that are setup to run the LABVIEW program. Jim Volk keeps the fixtures, carts, extensions cords, stools, and lights, needed for measurements.

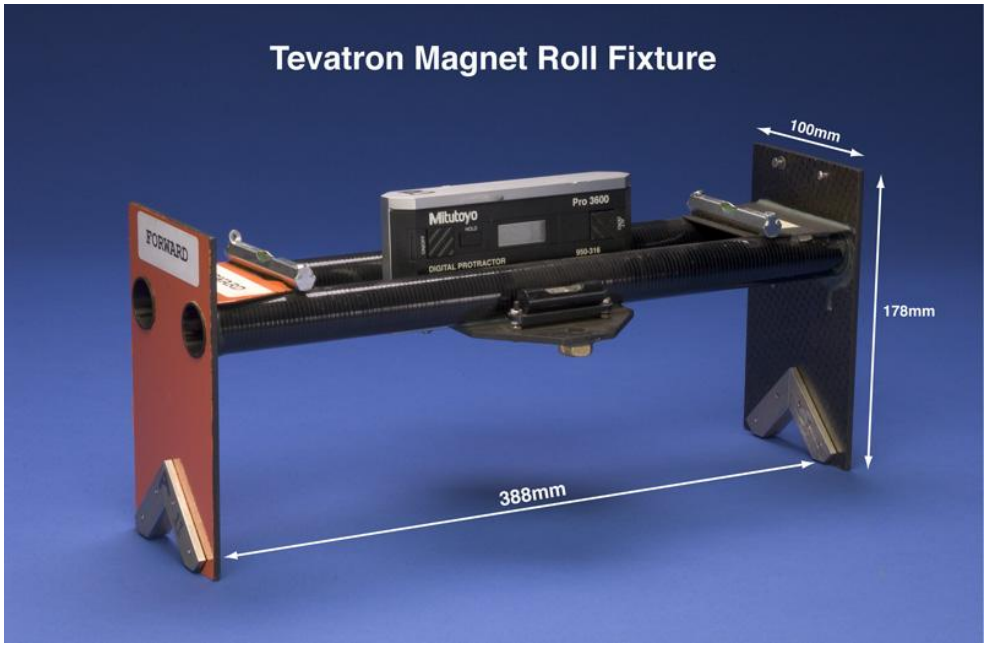


Figure 2

Magnet Data Base

The process requires two people to do the measurements. The first is the computer operator and the second is the fixture operator. The program requires an EXCEL input file of all the magnets in the Tevatron. This is obtained from the Dave Augustine FILEMAKER PRO database of all magnets. To generate the file;

1. Start File maker pro on any AD computer.
2. Under file tab select Open Remote
3. Under View select Favorite Hosts
4. Left Click Add button
5. Type in beams-fmpro-2

6. Log in: see Dave Augustine if you do not have a FILEMAKER PRO account
7. Right click on Tevatron systems
8. Right Click on Tevatron magnets
9. Under File select EXPORT
10. Give a file name to export to and a location
11. In the dialogue box save-as Tab Separated file
12. In the Save dialogue box save
    a. Device_Serial
    b. Location
13. Open the file named in step 10 with EXCEL
14. Select delimited and click next
15. Check tab box
16. Delete first 10 lines
17. J Volk has a MACRO DBcut that will remove most of the spool pieces and non magnetic devices
18. Copy to flash drive and install on lap tops in C:\data as Tev_serial_2.xls

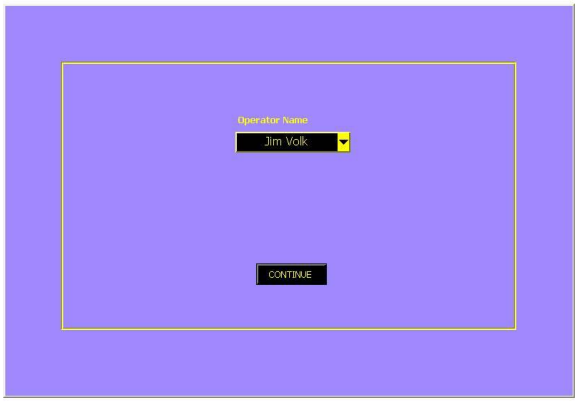
There is some hand work required to remove bypasses, low beta quads, and the like. Inspect the database to be sure all necessary magnets are there. Once the data base is installed on the laptops the following set of instructions are needed to run the program.

Running the LABVIEW Program

Start the laptops

- Username is localadmin
- Password just hit the enter key

Double click the application icon to begin the program. The first screen to appear asks for Operator name.



Select your name or your crew name (D0 crew and CDF crew choices are at the bottom)

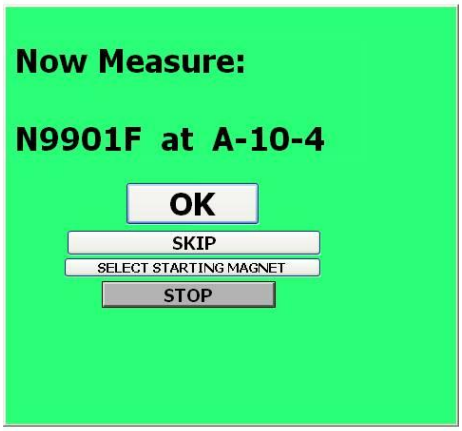
Press continue

Select the appropriate database file for the magnets you will be working with (The default will not normally be changed).

Press OK.

Select the appropriate Measure file (The default will not normally be changed)

A prompt will come up displaying the magnet number to be tested, choose one of four options:



- OK – Selects the displayed magnet for the measurement
- Skip – Cycles to and displays the next magnet
- Choose starting magnet – Displays a prompt: Enter a magnet serial number, hit enter, and the program will cycle to and display that magnet
- Stop – Ends prompts, no more data will be acquired

The next screen is for magnet measurement. It is color coded with the same colors as the fixture. Orange is forward and black is for reverse.

Take the four readings on the magnet in this order: Upstream forward (orange), upstream reverse (black), downstream forward (orange), downstream reverse (black). Put the fixture on the survey lugs wait 5 to 10 seconds for the digital level to settle then click the foot switch. A sound will be made when the computer acquires the data. Move onto the next measurement. The background will change from orange to black for each measurement. Figures 3 and 4 show the setting of the fixture.

Note there are a few magnets that either the upstream or downstream survey lugs are not accessible and cannot be measured. In that case measure the lugs that are accessible twice and note it in the comments.

After the 4th reading a new window will pop up

If the readings are acceptable (i.e. none of the readings are greater than 4 mrad) the window will show green and prompt an acceptance of the measurement. The operator can enter comments by typing them in the box provided. Press "accept" (or enter) to accept the reading, or press "remeasure" if the operator decides to re-take the reading for any reason

If the reading is over 4 mrad the window will show red and prompt a re-measure of the magnet (enter in this case will prompt to re-measure for the four readings on the same magnet). The operator can enter comments by typing them in the box provided. Overriding this re-measure is possible by pressing "accept" for example if the operator is sure of the readings. Some comments are automatically generated; operator comments in the box are logged.

Pressing accept with a reading over 25 mrad will open another red window because this is a highly unlikely reading. Re-measure by typing "yes" or "y" (default) and pressing ok or enter. It is still possible to accept the reading and move-on by typing "no" and pressing ok, this should only be done sensibly since highly unlikely.

When the measurement has been accepted the original four choices prompt will pop up again for the next magnet in the database and the process repeats.

Figure 3 shows the fixture on a magnet the operator and the cart.

Figure 3 Operations in the Tunnel at A 48

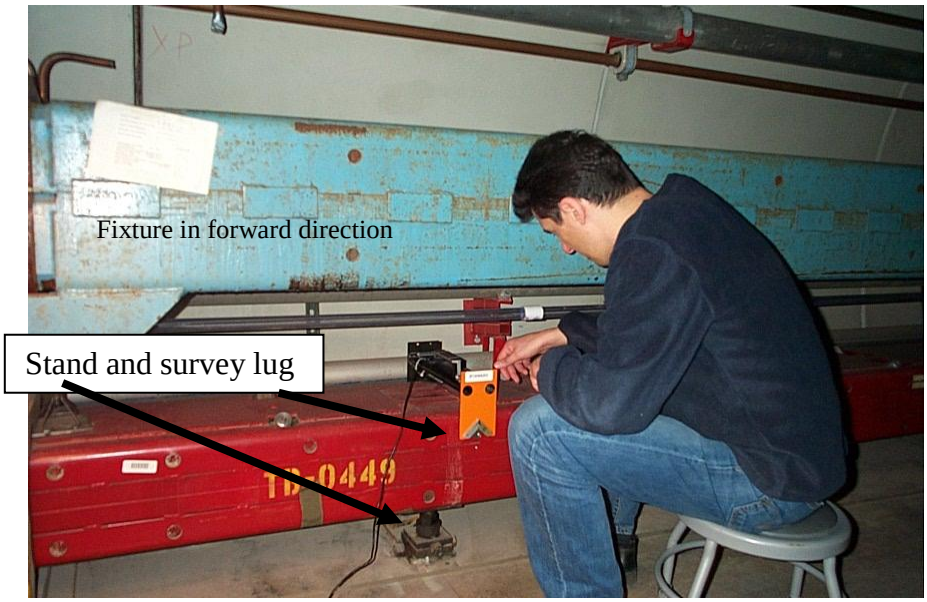


Figure 4 fixture on dipole

The measurement file is saved under c:\data typically (default) in a text file named rollMeasure.xls and a back-up copy (a new file every time the program runs) is saved under c:\ bu\data. The file contains the magnet name/position, the time, the measures, eventual automatically generated comment(s), and the optional operator comments entered at the end of the measure of each magnet. The data are saved every time you hit accept or remeasure. If the program crashes only the data for the magnet under measurement is lost.

Preparations of the Digital Level

Before taking data the batteries in each digital level should be replaced. To do this removed the levels from the fixture and take the back cover off. There is a single 9 volt transistor battery. With the level out of the fixture there is a calibration procedure from Mitutoyo to do that will ensure the level is accurate and within factory specifications.

Superset®

Superset® recalibrates the Pro 3600 through its entire 360° range by electronically recording four horizontal and four vertical settings. It should be performed whenever the accuracy test shows a discrepancy of 0.1° or more.

How to Perform Superset®

Turn on the Pro 3600 and place it on a flat surface. You can use any horizontal surface within 10° of level and any vertical surface within 10° of plumb to perform Superset®. You must use the same surfaces throughout the entire process.

Note: *Each time you reposition the Pro 3600 during Superset®, wait a minimum of 10 seconds before pressing the HOLD button to advance to the next step.*

Starting Superset®

• Press and hold the HOLD and ALT ZERO buttons simultaneously. Keep them depressed for approximately three seconds. Release the buttons when the symbol **"SUP"** appears. A **"0"** within flashing brackets will then appear. These brackets are composed of four horizontal and four vertical segments.

Note that as you proceed through the eight steps of Superset®, a new segment will hold steady after you complete each step.

Superset® - Horizontal Settings

[1]

• Unit faces you and white lettering on face is right-side up.
• Align with an edge or line - wait 10 seconds.
• Press HOLD button until **[1]** appears.

[2]

• Rotate unit so it faces away from you, the lettering. should still be right-side up.
• Align with same edge or line - wait 10 seconds.
• Press HOLD button until **[2]** appears.

[3]

• Roll unit so it faces you, the lettering should now be upside-down.
• Align with same edge or line - wait 10 seconds.
• Press HOLD button until **[3]** appears.

[4]

• Rotate unit so it faces away from you, the lettering should still be upside-down.
• Align with same edge or line - wait 10 seconds.
• Press HOLD button until **[4]** appears.

You have completed one half of Superset® (continued on next page)

Superset® - Vertical Settings

[5]

• Place unit against vertical surface so it faces you, the lettering on the face ("Pro 3600, etc.) should read from bottom to top.
• Align with an edge or line - wait 10 seconds.
• Press HOLD button until **[5]** appears.
[6]
• Roll the unit so it faces away from you, the lettering should still read from bottom to top
• Align with same edge or line - wait 10 seconds
• Press HOLD button until **[6]** appears.
[7]
• Rotate unit end-for-end so it faces you, the lettering should now read top to bottom.
• Align with same edge or line - wait 10 seconds
• Press HOLD button until **[7]** appears.
[8]
• Roll the unit so it faces away from you, the lettering should still read top to bottom.
• Align with same edge or line - wait 10 seconds
• Press HOLD button. **[8]** will very briefly appear, followed immediately by regular angle measuring.
Your Pro 3600 has been Superset® back to manufacturer's spec's.

With the level calibrated re-install the levels in the fixtures. Note that the B level and fixture has a small shim on one side. This is needed to remove a systematic shift in the data.

To set the levels with the fixture use the calibration stand set on a level granite table. I use the one at 33 Blackhawk. Put the fixture on the calibration stand and rotate it between forward and reverse while taking data. I add 40 fictitious magnets at the end of the data base TD0001 through TD0040 to capture the data. The angles should repeat and be the same to 0.175 degrees as seen on the LABVIEW program. Adjust the mounting screws on the bottom of the fixture until the level read the same in the forward and reverse position. Do this for both fixtures. Ten readings should be taken for each fixture and compared to be sure the angle is distributed around a value of 0 milli-radians.

Operations in the tunnel

Once this is done the fixtures are ready for use in the Tevatron. Carts with lights, laptops, fixtures and 150 feet of extension cords should be staged at the A0 and D0 major vehicle access points. The CDF crew starts at A11-1 and works toward C49, the D0 crew starts at D11-2 and works toward F49. With two setups and two crews using each setup it takes 3 to 4 days to measure all the magnets. Note there are 12 magnets that cannot be measured due to obstructions of the survey lugs. Normal ODH rules apply to the measurement crews. For most shutdowns the tunnel is in supervised access mode.

Data handling

Data should be collected everyday and checked. Opening the spreadsheet remove all blanks rows by hand. In addition there may be duplicate entries due to re measurements.

The best measurement should be kept. All of these need to be checked and removed as needed. The worst 100 magnets should be re checked to ensure accuracy.

Once the data is reduced it can be added to the summary file that starts in 2003.