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The Operation of the Tevatron Vacuum system

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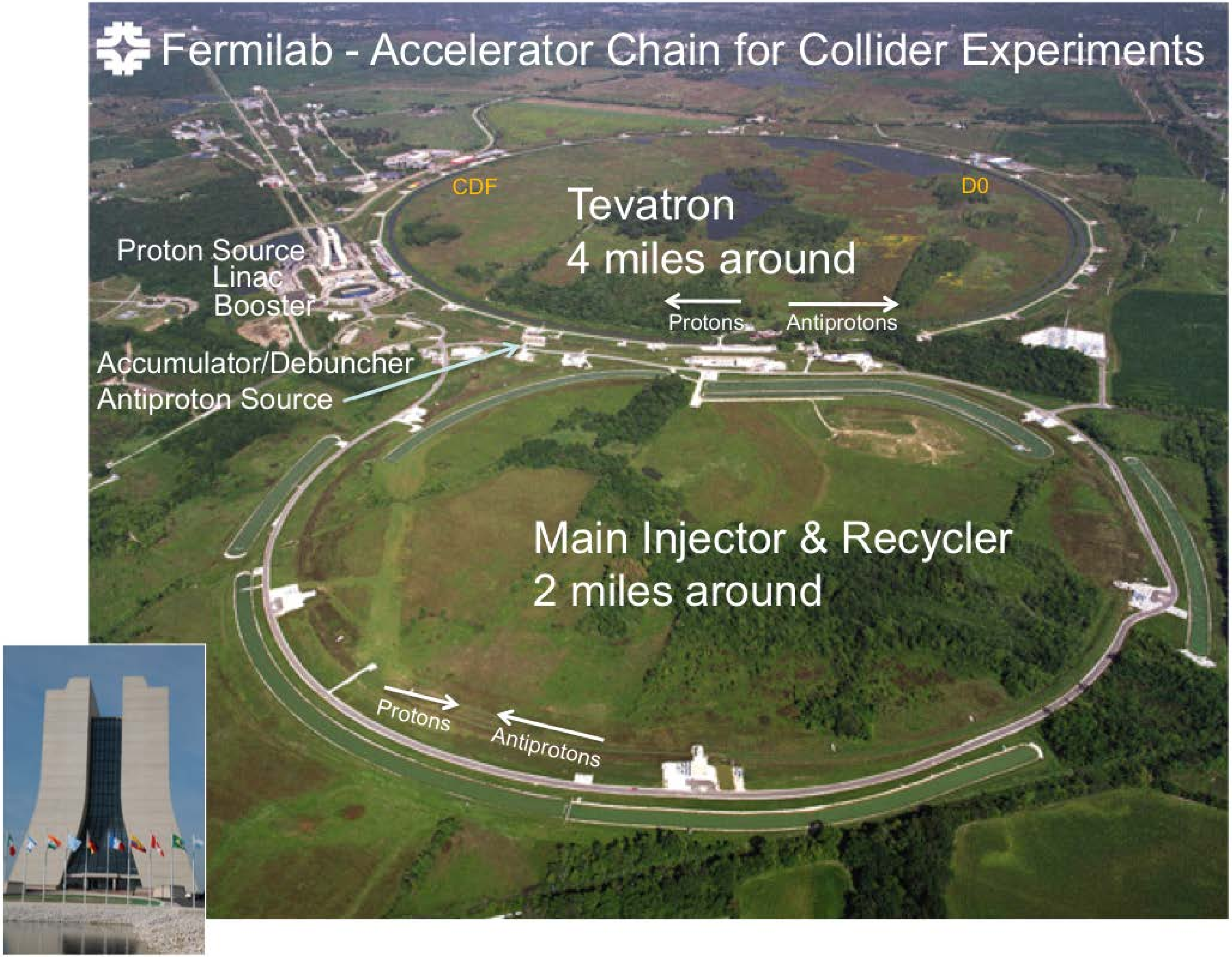
Outline

- Tevatron overview and some history
- Vacuum upgrades
- Cryogenic upgrades
- Maintenance and records
- Vacuum diagnostics
- Failures
- Lessons Learned

Fermilab Site Overview



The Tevatron contains

- 24 Cryogenic loops.
- 48 Insulating vacuum systems
- 24 Cryogenic beam vacuum systems
- 29 Major and minor warm straights
- A cornucopia of gauges, valves, mechanical pumps, ion pumps, titanium sublimation pumps, and NEG

The Tevatron is installed under the original Main Ring Accelerator

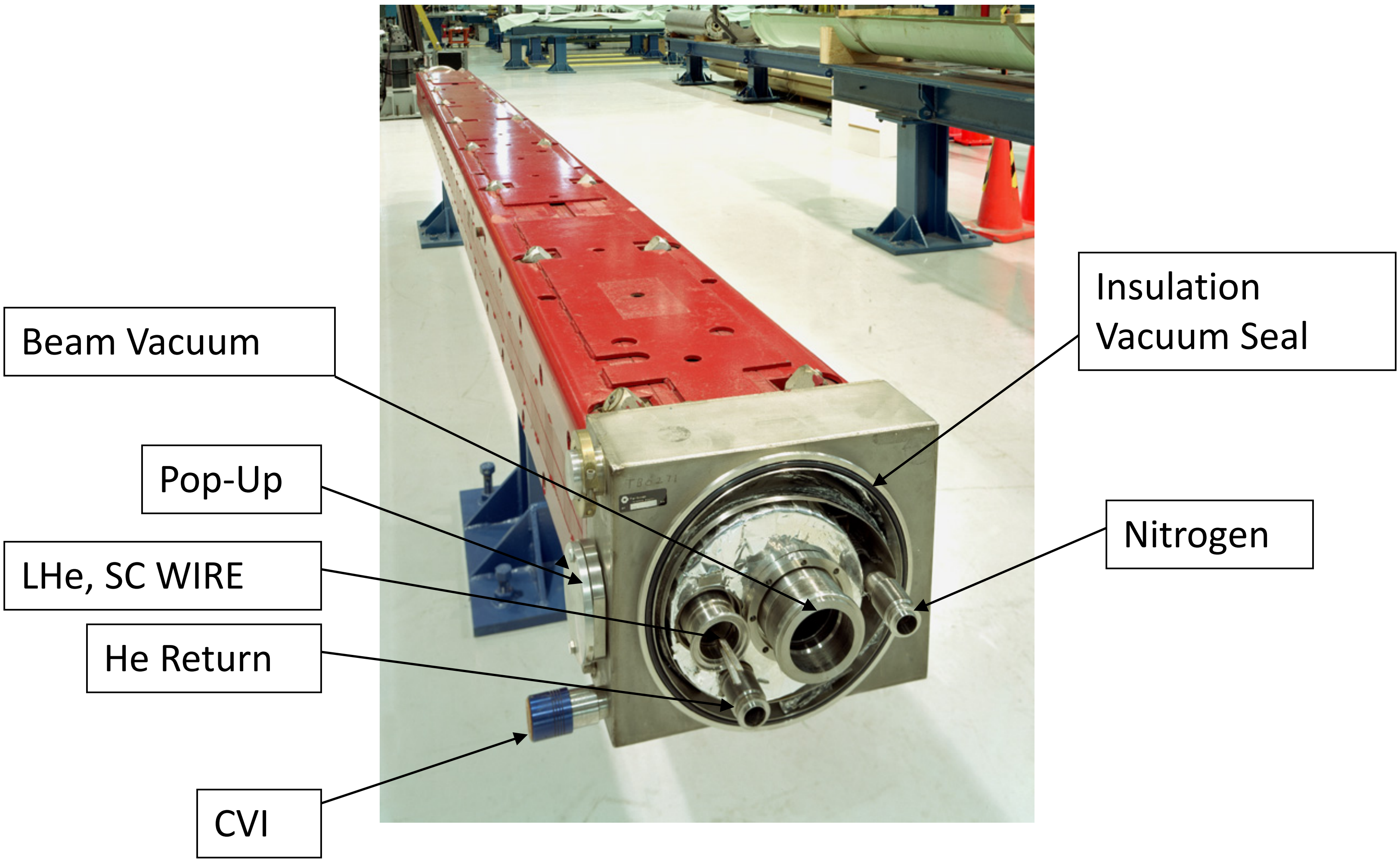
Some history

- Originally Tevatron operated in fixed target mode
- Vacuum in warm insertion points was 10^{-8} Torr
- Insulating vacuum was 10^{-4} to 10^{-8} Torr
- Cryogenic temperature was 4 to 4.5 K

Cryogenic and vacuum upgrades

- Cryogenic system was upgraded
  - Magnets now operate colder which allows higher current on buss without quenching
- Warm vacuum insertion points were upgraded
  - Better choice of materials
  - Improved cleaning technique
  - Vacuum baking
- Reduced beam scattering due to poor vacuum

Tevatron Superconducting Dipole



Cryogenic Beam Vacuum System

- No elastomers between the beam vacuum and atmosphere
- Ion pumps various types, area dependent
- Seals are all metal
- Gauges are thermocouple, cold cathode, and ion
- Vacuum pump out valves are all metal
- Isolation valves are metal sealed on the outside but o-ring sealed on the gate

Warm Beam Vacuum

- No elastomers between beam vacuum and atmosphere
- System mostly electro-polished stainless steel or ceramic
- Non metal objects are measured for out gas rate prior to installation
- Many objects vacuum baked *in situ*
- Electrostatic separator areas have all metal gate valves

Cryogenic Insulating Vacuum system

- One turbo molecular and roughing pump every 450 feet
- Vacuum breaks every 100 feet with isolation valves
- EPDM (Ethylene Propylene) o-rings specified
- Almost everything on the insulating vacuum system is sealed with o-rings

Maintenance records

- Then
  - Originally all installations and repairs entered into paper log books
  - Information difficult to find

- Now
  - All log books are web driven databases
  - Most accessible and editable outside of the Main Control Room
  - Electronic work list for work on operational equipment

Tevatron E-Log Maintenance entry

Start Studies | Make Entry | End Studies | Prev | Next | Latest | Contents | Search | Add Graph | Fix List | MCR Elog | Machine Logs | Archive

HomePage | Turn Image Load Off

Tevatron E-Log 2011 17:27:17 Tue May 31 2011

-- Shot setup for store 8784 --

MemoPad | Bottom

Studiers: Sequencer

Start of Studies Notes:

Wed Jun 1 10:52:21-

- xz,bh

-- *Wed Jun 1 10:53:04 comment by...xz,bh* -- Tables showing the change to proton horizontal tune of +.001 at collisions

Wed Jun 1 10:54:44- We lowered the Tev injection energy from 150.11 to 150.10 in order to reduce synchrotron oscillations at injection. - xz,bh

Wed Jun 1 16:53:10- Inspected TEL2 A-11 and A-12 Turbo carts OK, A-1 helium background E-9, A-2 helium background E-9. TEL2 helium background 3.5 E-5. No outside air leaks found at TEL2, A-1 or A-12. Turbo cart replaced at TEL 2 because of age. Ref: Scott McCormick - James Williams

-- *Fri Jun 3 07:37:55 comment by...Bob Steinberg* -- Access to A-E and Transfer Hall. In addition to above entry techs Sali Sylejmani and James Williams installed turbo cart JF-1 on TEL-2. Techs Bob Steinberg and Bill Dymond changed out turbo stations at B-37 and A-47 locations. B37: Rougher out #32385, Turbo out #34972, Rougher in #41622, Turbo in #34932. A47: Rougher out #099403476 Edwards18, Turbo out #39152, Rougher in #35940, Turbo in #34962. Also did small solenoid work in E0 to help re-open valves after compressor/air loss. Supervisor Scott McCormick.

Electronic Work List

Work Request

* - indicates required field

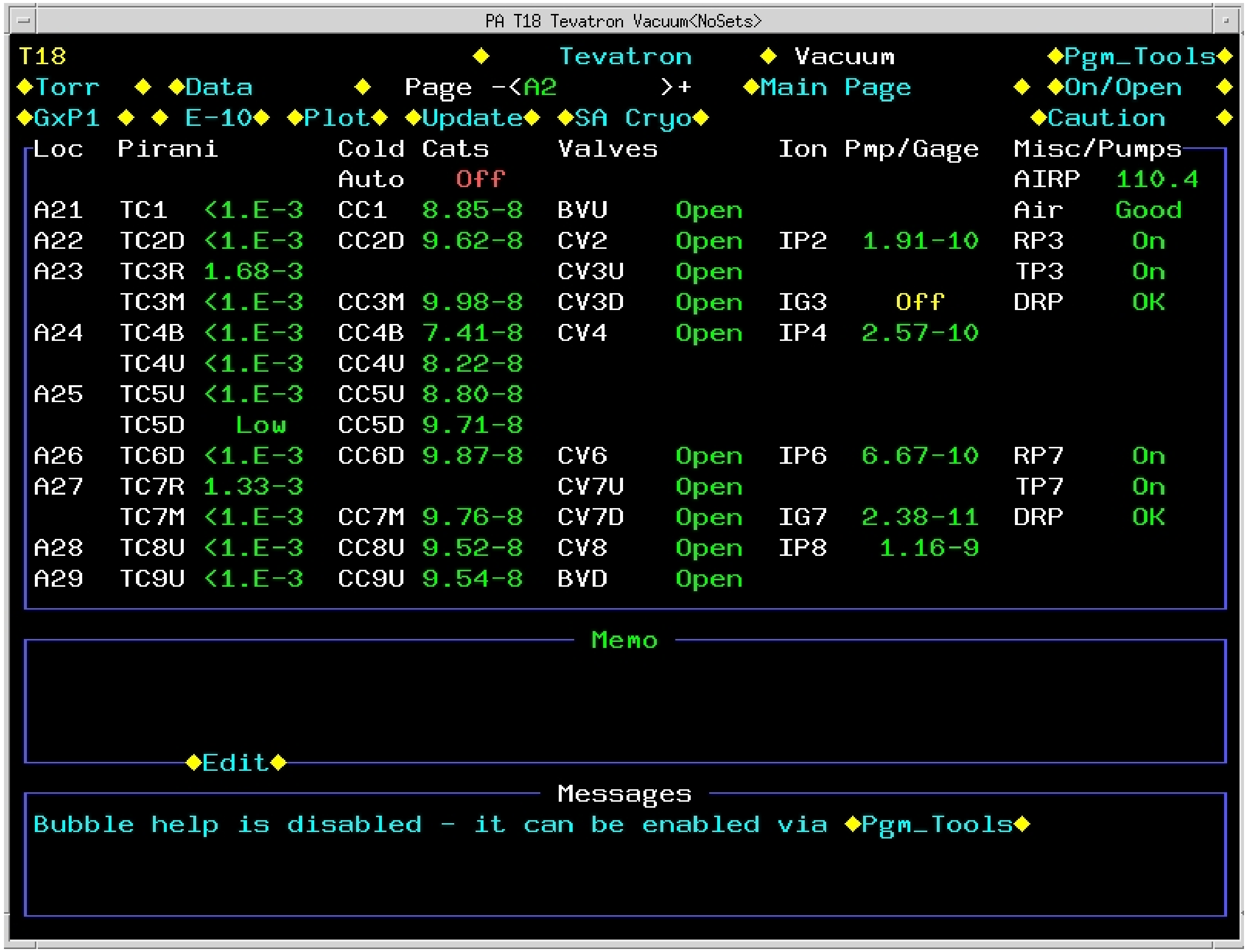
Job List

Submitted by* (e-mail): Example	@fnal.gov
Pick a Task Type*: Example	Choose Wisely
Priority: Example	Normal
After Hour Call In*: Example	
Area*: Example	Select Area
Type*: Example	Select Type
Task Location*: Example	(be as specific as possible)
Job Title*: Example	Characters left: 32
Descriptive Job Summary*: Example (510 characters)	Characters left: 509
Duration*: Example	hour(s) **TOTAL** over 1 calendar day(s) Example
To the Attention of* Example	☐ Alignment ☐ Controls ☐ Cryo ☐ EE Support ☐ ES&H ☐ Electricians ☐ Ext Beams ☐ FESS ☐ Instrumentation ☐ MI ☐ MTA ☐ Mech Support ☐ NuMI ☐ Operations ☐ Pbar ☐ Projects ☐ Proton ☐ RF ☐ Recycler ☐ Telecom ☐ Tevatron
Manpower (Not Required) Example	☐ Carpenters ☐ Construction Task Manager ☐ Contractor Other ☐ Electrical Task Manager ☐ Electricians ☐ Engineers ☐ Ironworkers ☐ Janitorial ☐ Machinists ☐ Operators ☐ Physicists ☐ Pipefitters ☐ Piping Task Manager ☐ Rigging Task Manager ☐ Surveyors ☐ Technicians ☐ Welders
Does this job require keys?* Example	○ Yes ○ No
Work Crew*: Example	Characters left: 255
LOTO coordinator*: Example	@fnal.gov / ☐ This job does not require a LOTO coordinator

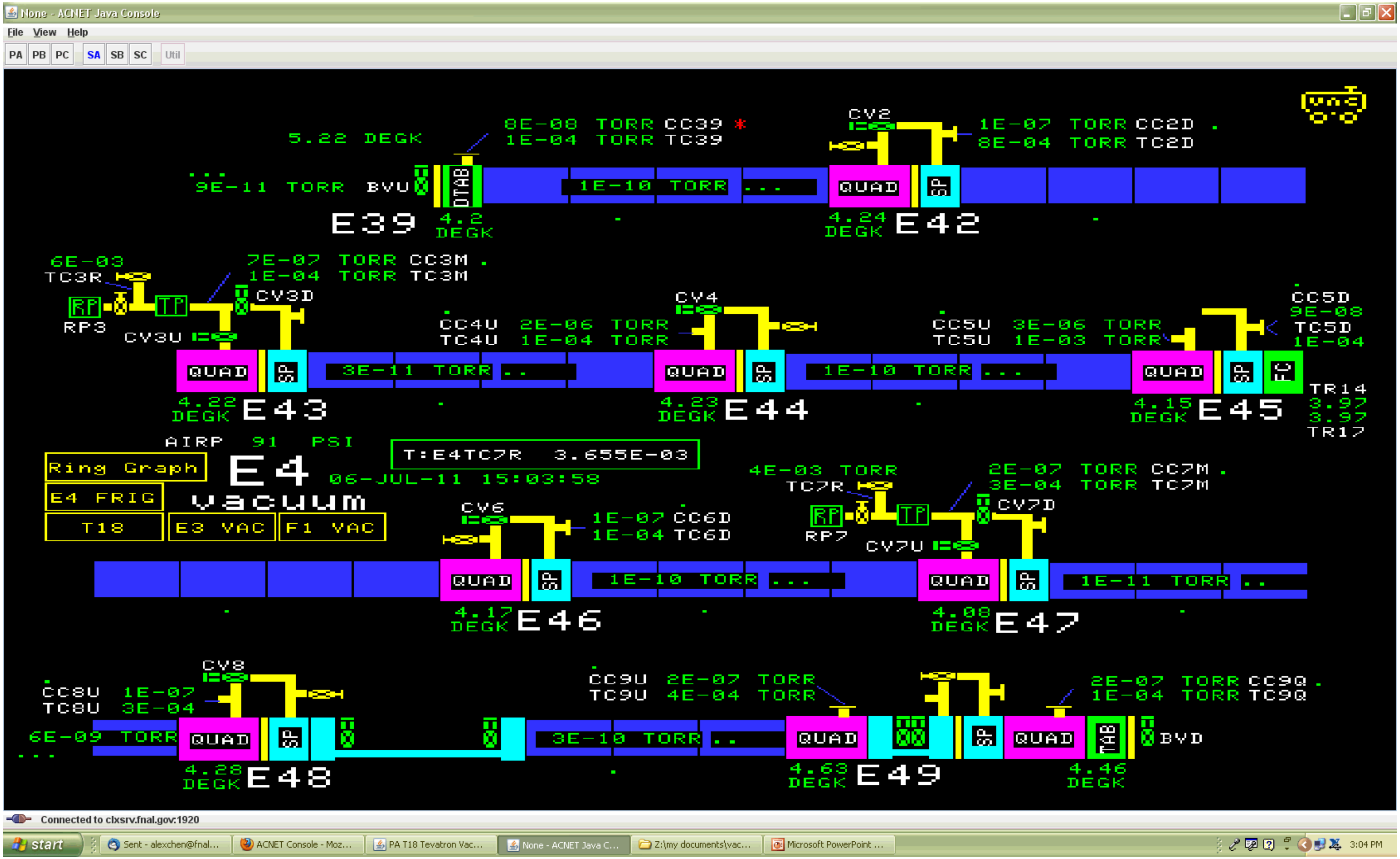
Vacuum remote readouts

- Then
  - Limited remote control of vacuum hardware
  - Limited ability to data log past history of an individual device
- Now
  - Lots of computing power to data log thousands of devices
  - Vacuum read out and control pages readily accessible

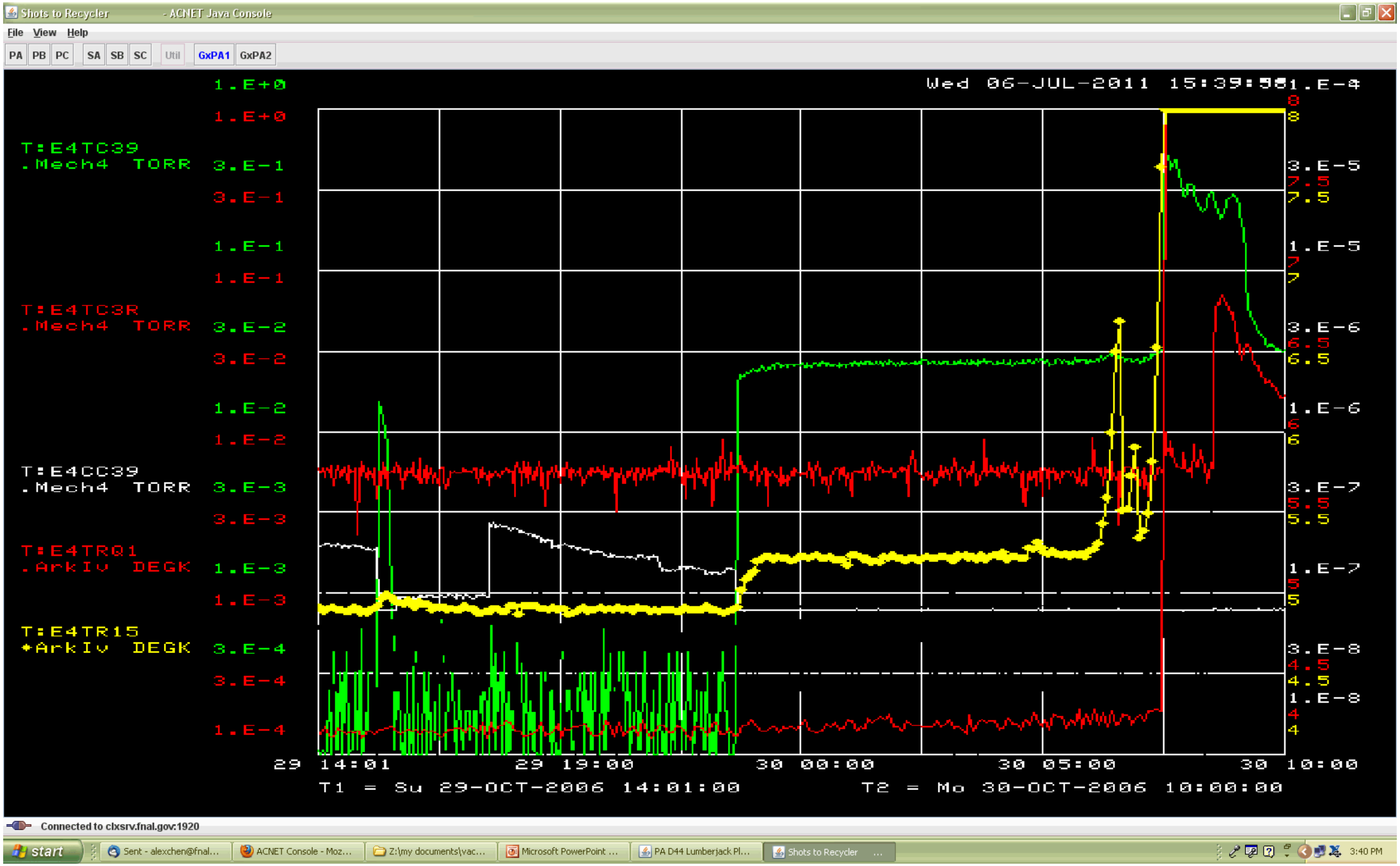
An example of a Tevatron Vacuum page, house A-2 ACNET driven



An Example: Vacuum and Cryo @E4



An Example of Diagnosis



Failures

Tevatron repair

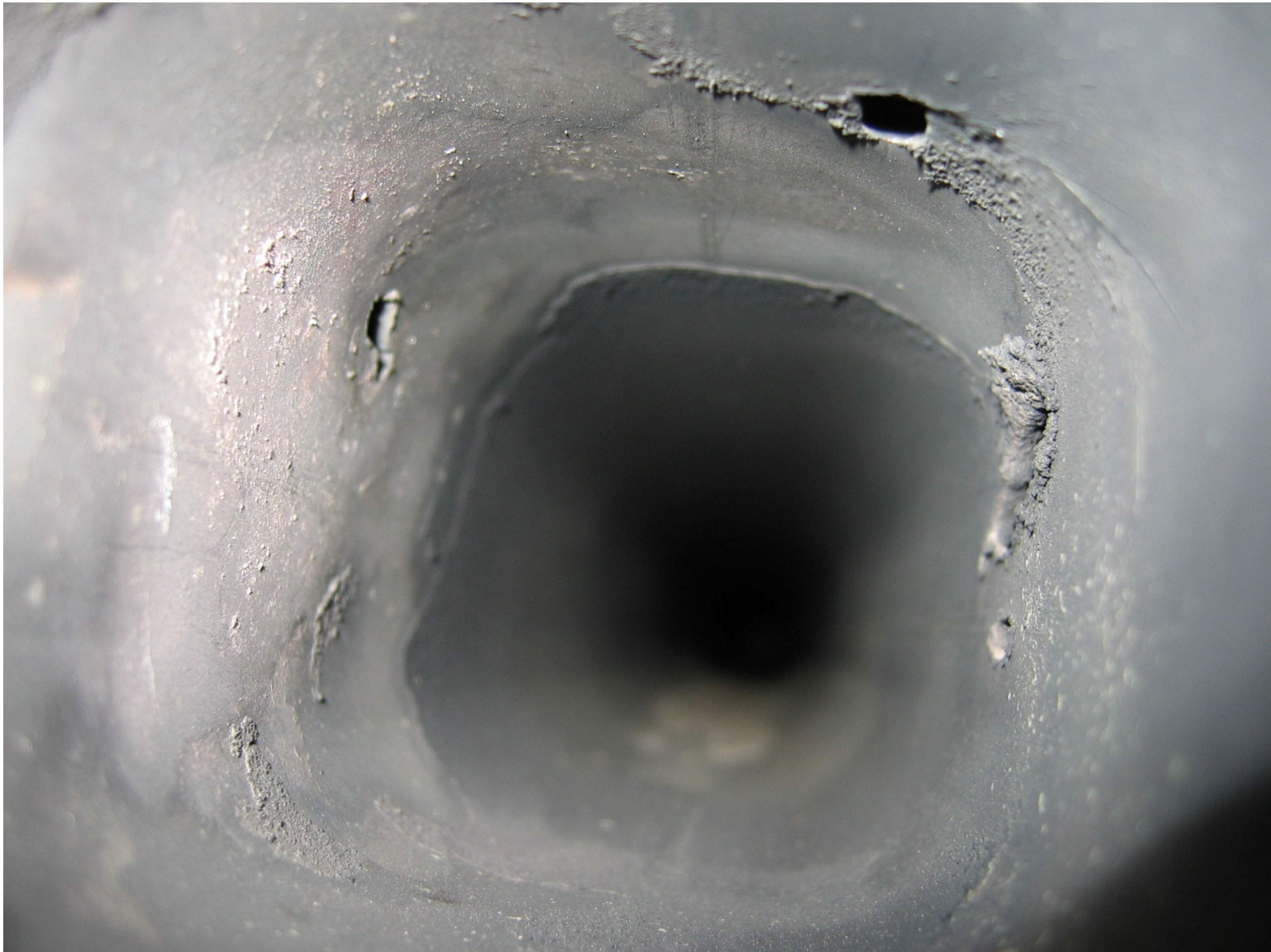
- Normal cryoloop
  - Seven days cold to cold with around the clock shifts
- Low Beta cryoloop
  - 12 days cold to cold with around the clock shifts

Typical Repair Routine

- During Warmup
  - Crews assigned
  - Insulating vacuum spoiled to assist warmup
  - Spares selected and tested
  - Equipment stationed in tunnel
- When Warm
  - Insulating vacuum pumped out
  - Insulating vacuum leak checked first
  - Cryogenic circuits leak checked next
  - Sometimes damage obvious ie a 4000 amp ground fault

Ground Faulted magnet

View of beam tube



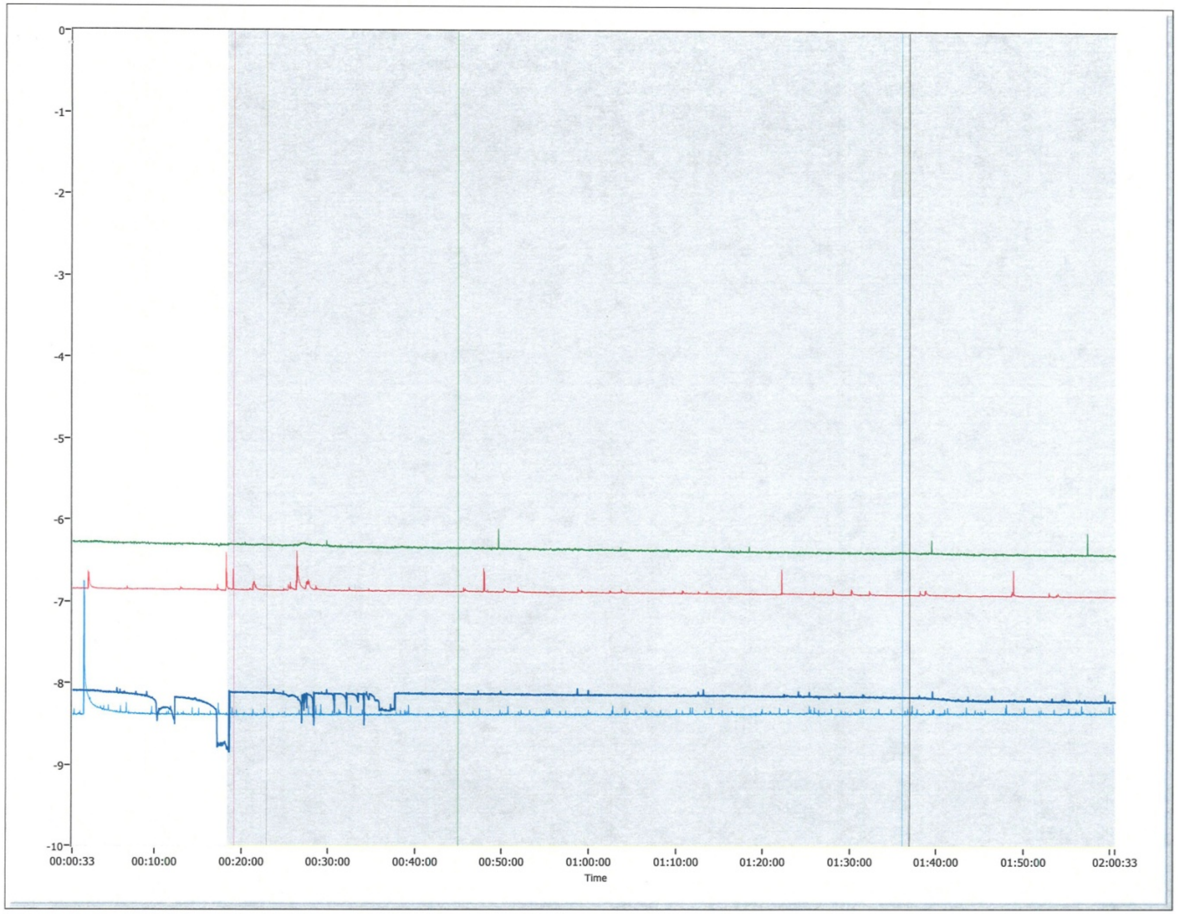
Equipment

- Diffusion pump based leak detectors with upgraded electronics
- Electronic signal from all leak detectors fed to one custom computer (1 to 16 channel chart recorder lab view based)
- All signals can be analyzed at one time and compared to one another

Leak Detector

Chart Recorder

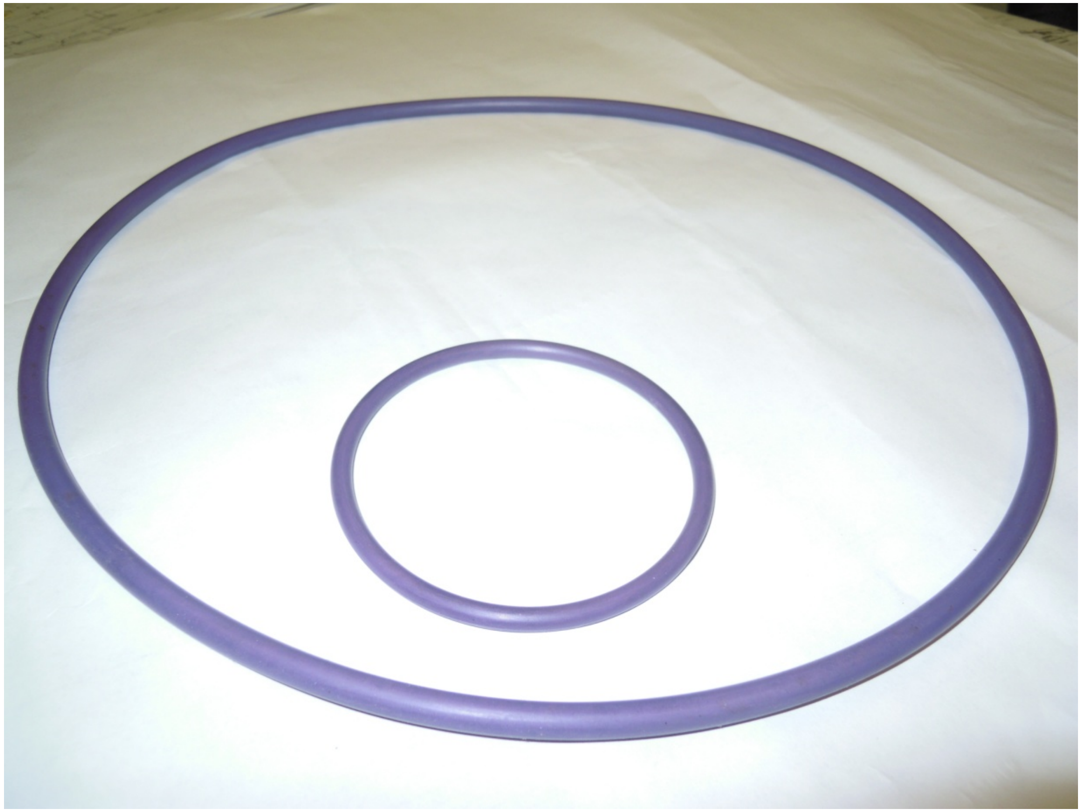
Chart of test



Lessons Learned
O-rings

Problem: original EPDM o-rings cleaned with acetone, causing o-ring to melt over time

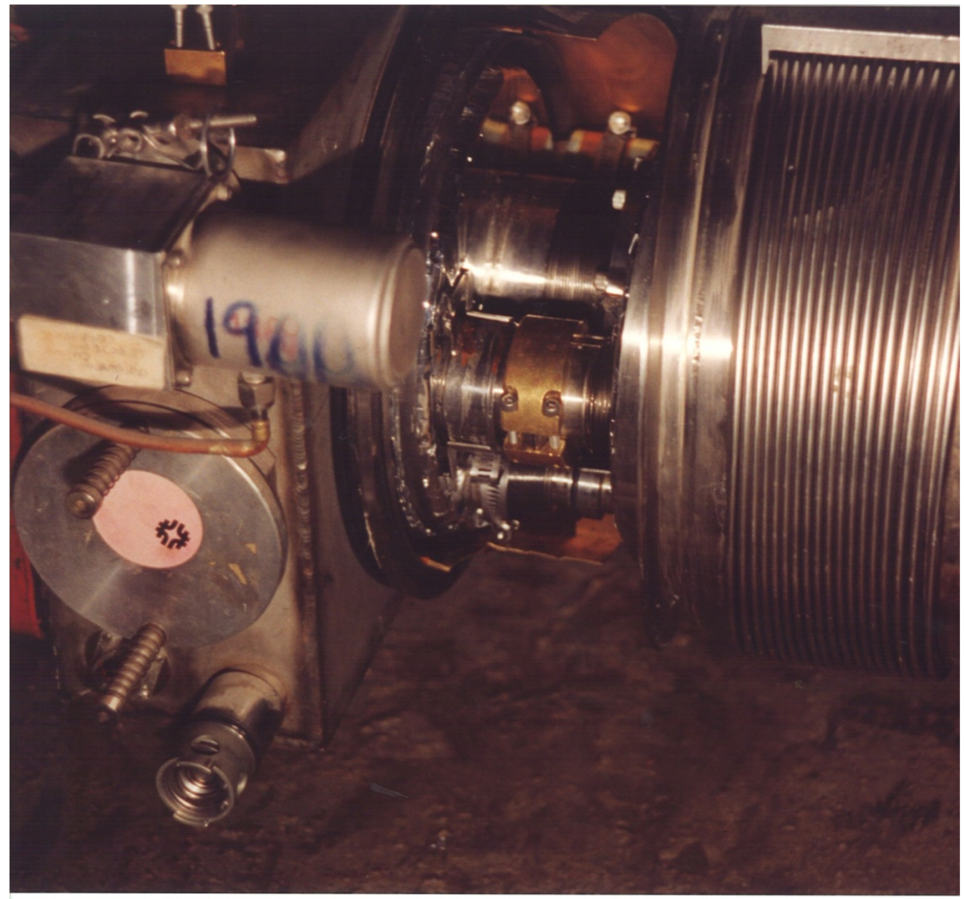
Solution: switched to EPDM colorized series o-rings for easy identification to choose correct cleaning solvents



The O-ring fix continued

It takes many hours to disconnect, replace and o-ring

We decided to vulcanize a new o-ring around the interface saving ~4 hours per interface



The end of a great run

- Collider run to end FY 2011
- Performance of collider chain was stellar
- The Tevatron will be warmed to room temp
- Much of the vacuum infrastructure will be used in future neutrino projects

Acknowledgements

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- Lucy Nobrega, Cryomodule Test Facility Vacuum Engineer
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