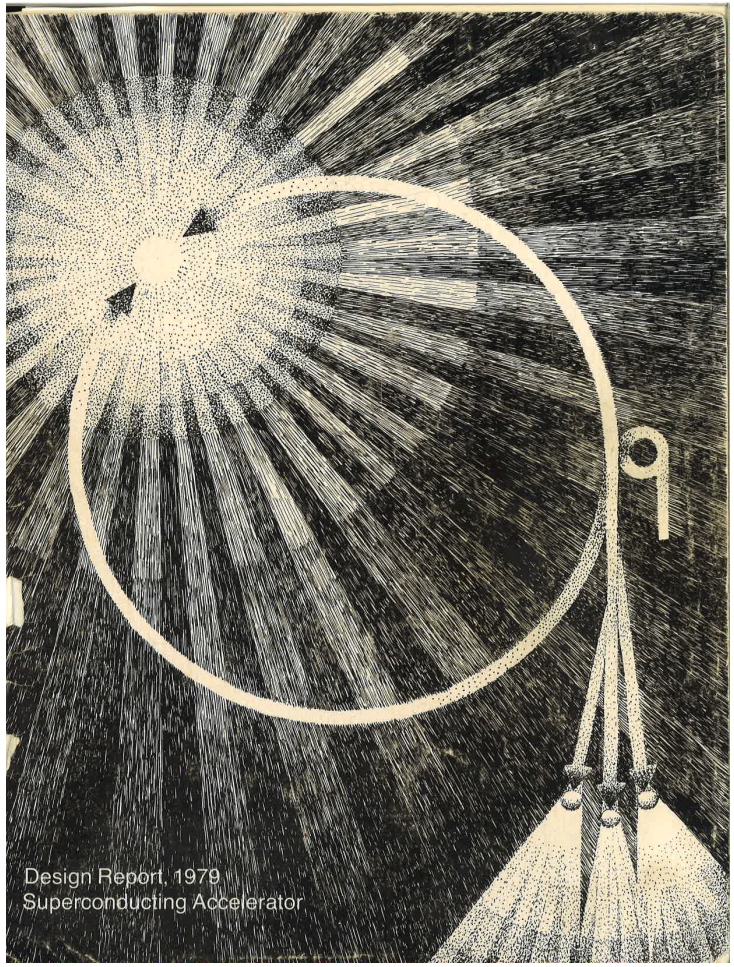
Alvin and the Tevatron

Alvin Tollestrup, Leon Lederman and Robert Wilson at the 1970 NAL Summer Study picnic



Alvin, Leon & Bob 1970

Energy Doubler/Saver - Tevatron time line

- NAL started, Wilson Director 1967
- MR reaches 200 GeV 03/72
- SC Magnet R&D established 01/73
- Energy Doubler Design Study FN263 03/1974
- The NAL becomes Fermi National Accelerator Lab 05/74
- Alvin joins FNAL , leave from CalTech 07/75
- The Amateur Magnet Builders Handbook UPC#86 02/79
- Design Report Superconducting Accelerator 05/79
- Leon becomes Director , All out Lab effort on Tevatron 06/79
- DoE authorization 07/79
- Last ED magnet installed 774 03/83
- ED 512 GeV beam 07/83
- Alvin becomes co-spokesman CDF /83
- TEV collisions 10/85
- TEV off 9/11

Energy Doubler/ Saver-Tevatron

Wilson TM 421 05/73

EXCERPT OF A STATEMENT BY ROBERT R. WILSON,
DIRECTOR, NATIONAL ACCELERATOR LABORATORY
BEFORE THE JOINT COMMITTEE ON ATOMIC ENERGY
MARCH 9, 1971

03/71

- Wilson notes that the 1968 JCAE SubComm on R&D,Rad recommended trying for higher energy and advised continued study of the possibility of higher energy by use of superconductivity (seeTM 421)
- Such a possibility may be feasible, the concept the "Energy Doubler" and should enable higher energies, as much as 1000 BEV

Wilson, Goldwasser FN263 03/74

- Still more exciting are the possibilities of really high energy collisions through the use of intersecting beams
- Energy shortage and operating funds less than anticipated-imperative to find new ways to reduce power
- Questions to be answered in order to demonstrate feasibility:
  - Ramp rate
  - Accurate magnetic field in mass production
  - Simple and reliable components installed & operated without serious impact to experimental program
  - Can the beam be extracted
  - Can this be done economically

Alvin comes to Fermilab

- The legend has it that Alvin passed through Fermilab on his way to CERN to see about spending a sabbatical from CalTech there.
- Bob convinced him that he <u>really</u> needed help!
- He came in July 1975 But it took two years before he accepted a permanent position
- It was very important that Bob trusted Alvin and had confidence that he could solve the difficult magnet problems.
- Alvin was able to dissuade Bob of some of his wilder ideas

ALVIN TOLLESTRUP JOINS FERMILAB

1977

A. Tollestrup

Alvin Tollestrup has joined the Fermilab staff as a physicist in the Energy Doubler/Saver Group. Tollestrup also will assume responsibility for a new group in the Research Division's Department of Research Services, That group will be responsible for carrying on research and development on electronic detectors and data acquisition techniques.

For the past two years Tollestrup has been serving as a member of the Energy Doubler/Saver Group. He joined the Laboratory in a temporary capacity while on sabbatical leave and leave of absence from California Institute of Technology. During the past two years he has taken a major responsibility for the development of Doubler magnets and has played the key role in transforming the production of those magnets from an art to a science.

The new group which Tollestrup will head in Research Services will combine the Detector Development Group now led by Muzaffer Atac and the Experimental Systems Support Group of Tom Droege. This new group will still perform services for the Laboratory as it has in the past. Alvin has been in the physics department at CalTech for the last 27 years. During that time he was involved in converting the quarter scale model of the Bevatron into a 500 MeV and later a 1200 MeV electron synchrotron. The 500 MeV energy was fortunate in that it enabled the famous "first resonance" to be completely investigated; whereas the 300 MeV machines, as at Cornell, were limited to just reaching the peak of the resonance.

After early photoproduction experiments at CalTech he spent a year at CERN. There he participated in the planning and execution of the first experiment at the CERN Cyclotron which was the first observation of the π-e decay. Other "good" experiments he has worked on include the first measurement of the π° lifetime by the Primakoff effect, and pp annihilation to e+e-. He also developed with R. L. Walker the x-ray detector used in experiments 110, 268, and 350.

Source: The Village Crier Vol. 9 No. 30, August 4, 1977

Where to put the Energy Doubler?

1975

...Alvin Tollestrup (L), William Fowler, Doubler prototype in Lab 5 in the Village...

1981

Alvin and Fowler –cryo string in village

String Test in MR Tunnel

Bob when asked (by experimenters) would say the magnets would be installed on a monorail and slid into the tunnel during MR operation, and hooked up during down days

I would like to think that Alvin was one <u>to gently SUGGEST</u> there might be a better location In the tunnel for the Doubler.

UPC's

- There were a number of us who had gone through the exhausting MR commissioning experience and were worried that Bob was only focused on the magnets and that we better do something to make sure as best we could that the ED would work as an accelerator. We began meeting and producing unofficial notes.
- If you look on the web under fermilab reports you will find a category UPC ("underground physics committee"). What's that?
- Actually Alvin created the name and it stood for "Underground Parameters Committee", a slightly different spin.
- I am sure Bob was kept well informed.
- Alvin is a major author to the UPC's. Of special note is:
  - "The Amateur Magnet Builders Handbook " and
  - "Properties of Superconducting Magnets"

The length shootout

- After Leon took over, one of the questions that there was disagreement on was just how much space was needed for the quad and correction coils
- The correction coils were important. They had to go to full ramp excitation and they were not going to be easy to change. Many of us thought they should be separated from the quad assembly.
- This meant shortening the bend magnet from 22 to 20 ft even though a number of magnets had been made
- There was a vote by about 20 of us, 19 to shorten, one voted "torn". Alvin was loyal.

It is next to impossible to cover all the areas of magnet R&D that Alvin worked on and led the direction toward viable solutions.

- For instance:
  - Magnetic field quality, Magnet measurement, QC, feedback
  - Magnet preload, coil distortion with excitation
  - Quench propagation, detection, protection
  - Ramp rate dependence, hysteresis, eddy currents
  - Training and Quench limits

Alvin's Attributes

- Inventive, ingenious
- Versatile
- Persistent and perseverant
- Physics & mechanical sense and intuition

- Patient at explaining, (especially if he really wants to really convince or get something done)
- Nurtures young students and fellows (and the rest of us)

- Natural logical analysis of problems
- Recognition of the physics behind a problem
- Cuts problems open
- A virtuoso ability to use basic classical physics

Amateur Magnet Builder's Handbook

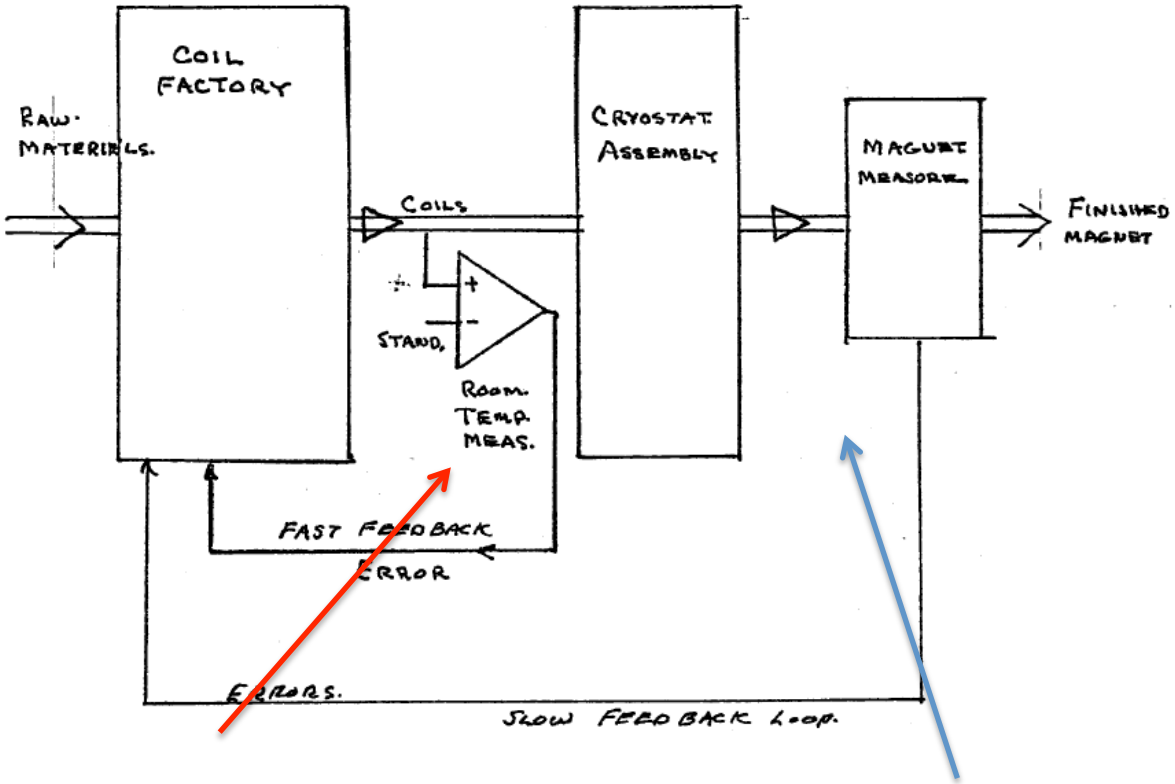
UPC 86, 135,136

- Troubles controlling- shorts, wire size, tolerances, short sample tests, quality of the test program
- Philosophy of magnet construction and control of errors
  - Simple calculation of needed accuracy- conductors must be placed to 0.001"
  - Not clear can be done for reasonable cost
- New Philosophy- Absolute shape is not important-only its reproducibility
  - Multpoles 14 & higher driven by the sharp edges, cant do anything about ,and not likely to change
  - Sextapole and decapole can be adjusted with key angle
- A feedback control system with 2 loops,
  - room temperature fast loop to control slow changing systematic errors, eg wear, wire or insulation size,
  - cold measurement of completed magnet-ultimate verification

The Tev Magnet Field Quality Feedback Loop

Collared Coil

Cryostat Assembly



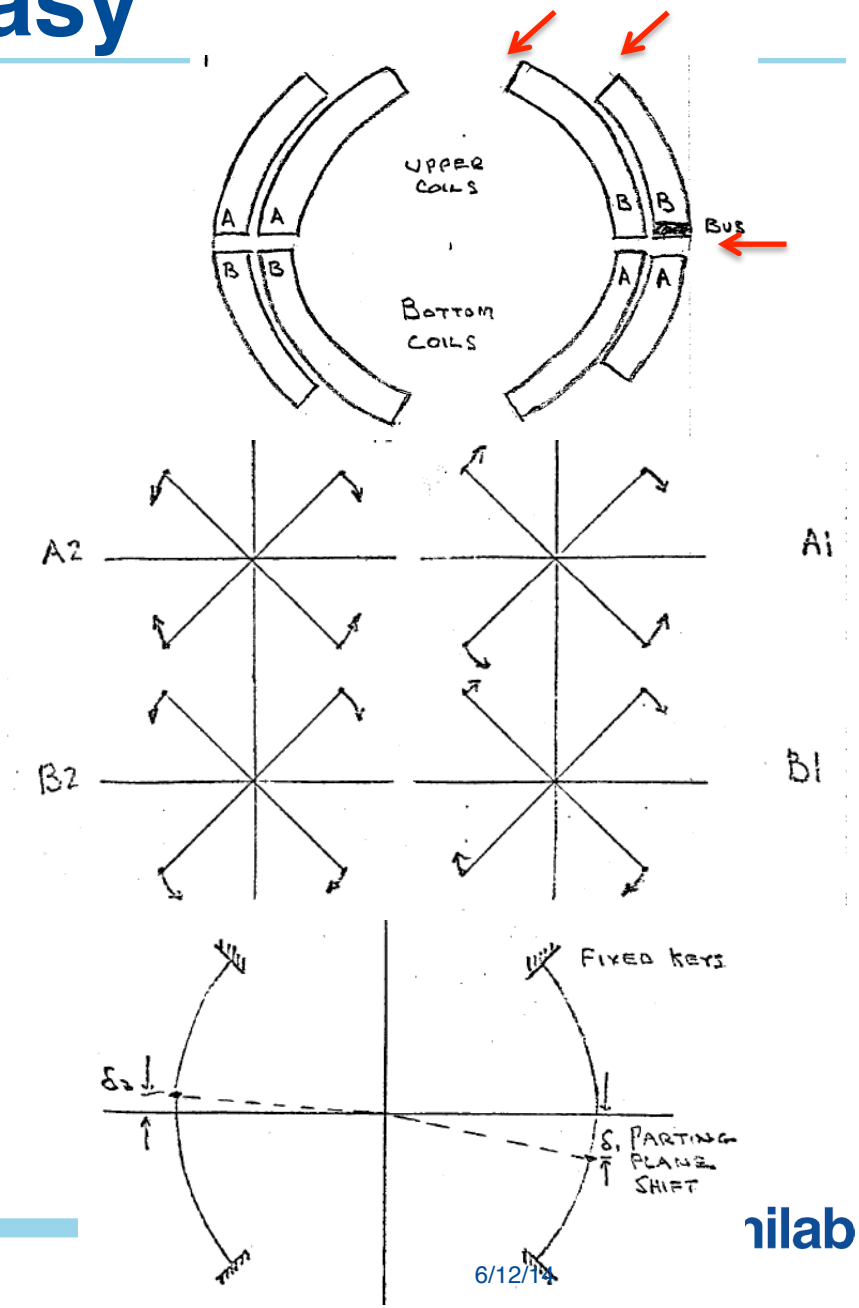
Finished Magnet

Fast Warm coil measurement loop

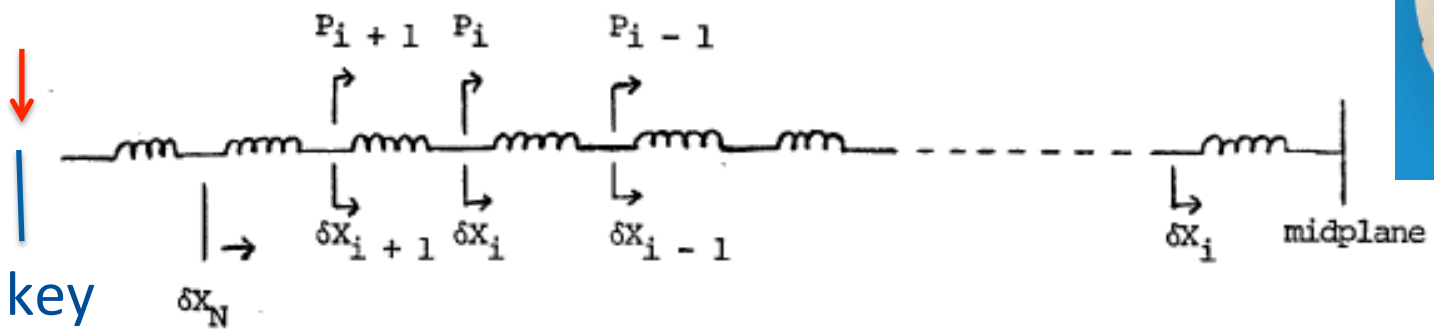
Final Cold Magnet measurement loop

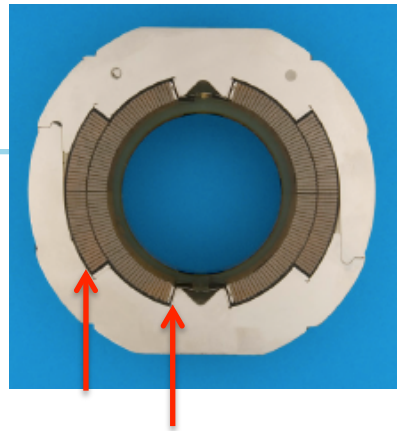
But not so easy

- How do you calibrate measurements
- How do you relate Room Temp to Cold measurements
- How do you relate the measurements to mechanical errors and corrections for the next coil packages



Coil preload





Coil is bigger than collars & must be compressed

Coil and collars contract when cold

Coil contracts more than collars

Magnet excitation has forces that pull coil away from key toward mid plane

Too much preload may result in coil shorts

Preload must be maintained at key when cold

If not coil will move > QUENCH, train

Preload to close collars ~10,000lb/in

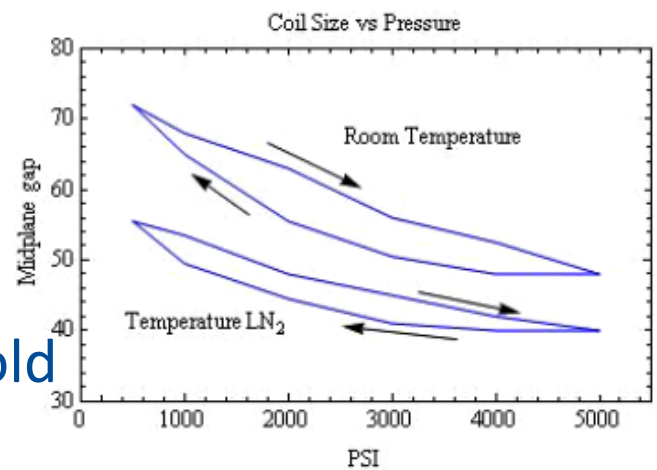
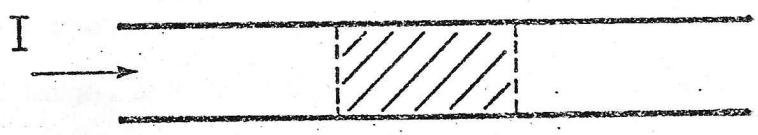


Fig. 8. Compressibility of the coil package at room temperature and at that of liquid nitrogen.

Quench protection MIITs



cable

$$I^2 R\,dt = C\,dT \quad \text{if He disregarded.}$$

$$\int_{t=0}^{t} I^2 dt = \int_{T_i}^{T_f} \frac{C(T)}{R(T)}\,dT$$

known

MIITs

For 200C deltaT one must limit to 7*10^6 A^2s (7Miits)

12 Miit will damage coil

Magnet current ~ 4000A

So must remove current in fraction of second

Active protection system- heaters in magnet coils

Increase magnet resistance, decrease decay time

Would the Tevatron have been such a success without Alvin?

The Tevatron, the world's highest-energy proton-antiproton collider, shut down on Sept. 30, 2011. Since 1983, the

1983

2011

A well deserved honor

Postscript

In 2009, Alvin started and led the Very High Field Superconducting Magnet Collaboration with David Larbalestier, which studied the applications of high-temperature superconductors to accelerator superconducting magnets. After only two years and a support of $4 million, the collaboration increased the critical current density of the Bi2Sr2CaCu2Ox, the only round wire high-temperature superconductor, by several folds that now we have a new conductor technology that can be used to construct magnets to generate fields of >22 T, beyond the limits of Nb3Sn magnets. For his contributions to Tevatron and his leading role with the VHFSMC, Alvin received an award from the IEEE council on superconductivity for "significant and sustained contribution in the field of large-scale applications of superconductivity".

Tengming Shen

Alvin
Thank you
on behalf of all of us students
young and not so young