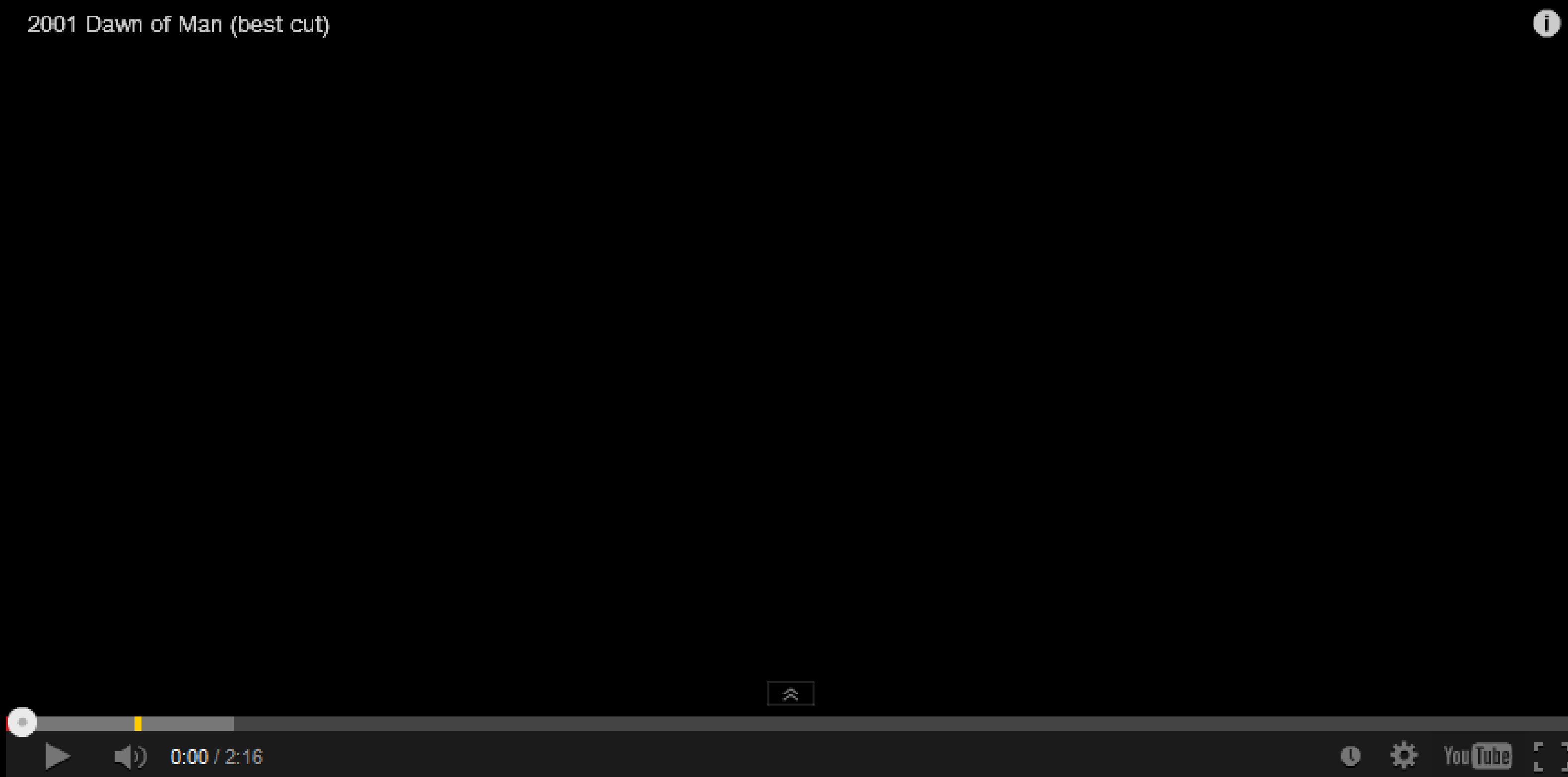
The Dawn of DØ

I apologize that much of this was shown at the 2007 DØ Workshop and a University of DØ talk … but the history is what it is.

P. Grannis – Last DØ Collaboration meeting June 10, 2014

A pictorial view – a decade in 2 minutes



The work was complete. Armed with the new DØ tool, our intrepid heros went forth to slay the CDF dragons.

Call for proposals for DØ IP in 1981

Lederman: “small, simple and clever”

19 Letters of intent

Partly amalgamated into DØ

- Pope et al.: 2 Pb glass fwd arrays; MWPC tracking
- Marx et al.: LAPDOG; Pb glass, 600 tons
- Green et al. : Muon scint hodoscopes above ground
- Ferbel et al.: move ISR R807 axial field spectrometer

Elements of these groups came together after all proposals were rejected.

Jockeying among the component proposals led to the plain vanilla name:

Several more large (~4π) detectors

Special purpose: magnetic monopoles, forward physics, elastic scattering, particle multiplicities

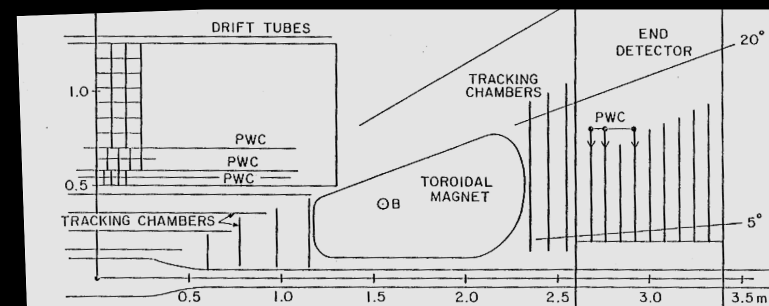
e–p collisions: (2 proposals went to HERA)

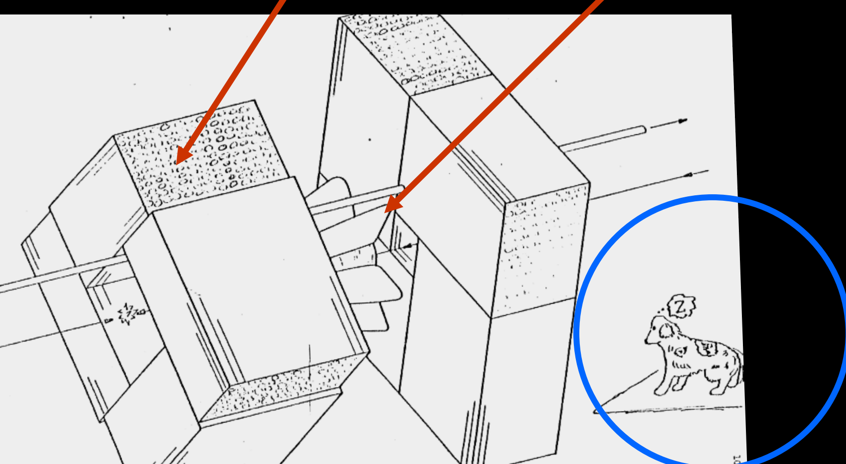
A flavor of an original proposals – LAPDOG

Large **A**ngle **P**article **D**etector **O**r **G**ammas

Focussed on W/Z and high p_T hadron physics with extruded lead glass bar EM calorimeter. By 1983, it had merged with a proposal to build a muon spectrometer (in the berm) that morphed into a hadron calorimeter.

- Detector ~ 7m along beam (~1/3 of DØ)
- Central cal. rotated to accommodate MR.
- Note (ATLAS folks) the air toroids in the forward direction.
- Note advanced CAD system!





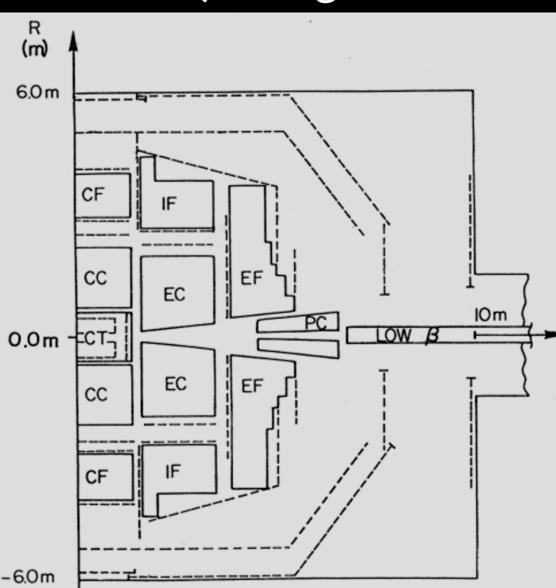
The "DØ dog" was born as the logo for LAPDOG, courtesy George Booth, my Stony Brook neighbor.

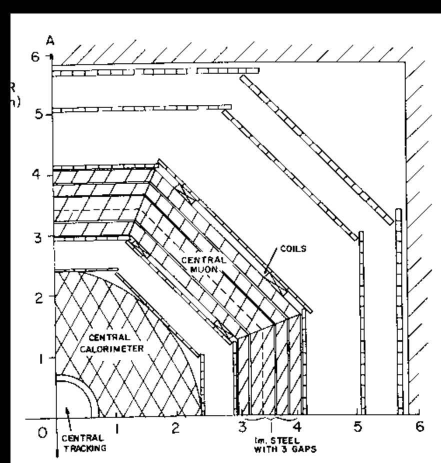
1983 Design Study

First DØ idea in August 1983 was built around scintillating glass bar calorimetry. Due to segmentation, radiation damage problems, we switched to liquid argon calorimetry with Uranium absorber (ensuring considerable delay while learning the LAr business). The December 1983 conceptual design was presented to the PAC and approved with a standing ovation (but no funds).

71 names on the 1983 proposal (9 still authors) from 12 institutions (all in the US).

Unwieldy design: 5 LAr cryostats,5 muon toroids, octagonal geometry





B. Pifer
University of Arizona

. Ahrens, S. Aronson, P. Connolly, B. Gibbard, H. Gordon, R. Johnson, S. Kahn, M. Month, M. Murtagh, S. Protopopescu, S. Terada, D. Weygand, D. H. White, and P. Yamin
Brookhaven National Laboratory

D. Cutts, J. Hoftun, R. Lanou, and T. Shinkawa
Brown University

P. Franzini, D. Son, P. M. Tuts, and S. Youssef
Columbia University

C. Brown, B. Cox, C. Crawford, R. Dixon, H. Fenker, D. Finley, D. Green, H. Haggerty, M. Harrison, H. Jostlein, E. Malamud, P. Martin, P. Mazur, J. McCarthy, and R. Yamada
Fermi National Accelerator Laboratory

H. Goldman
Florida State University

S. Kunori and P. Rapp
University of Maryland

M. Abolins, R. Brock, D. Edmonds, D. Owen, B. Pope, S. Stampke, and H. Weerts
Michigan State University

D. Buchholtz and B. Gobbi
Northwestern University

E. Gardella, W. Kononenko, W. Selove, G. Theodosiou, and R. Van Berg
University of Pennsylvania

M. Adams, R. Butz, R. Engelmann, G. Finocchiaro, L. Godfrey, P. Grannis, D. Hedin, J. Horstkotte, J. Kirz, J. Lee-Franzini, S. Linn, D. Lloyd-Owen, M. Marx, R. McCarthy, L. Romero, R. D. Schamberger, and H. Weisberg
State University of New York at Stony Brook

and

J. Ficenec
Virginia Polytechnic Institute

1984 Design

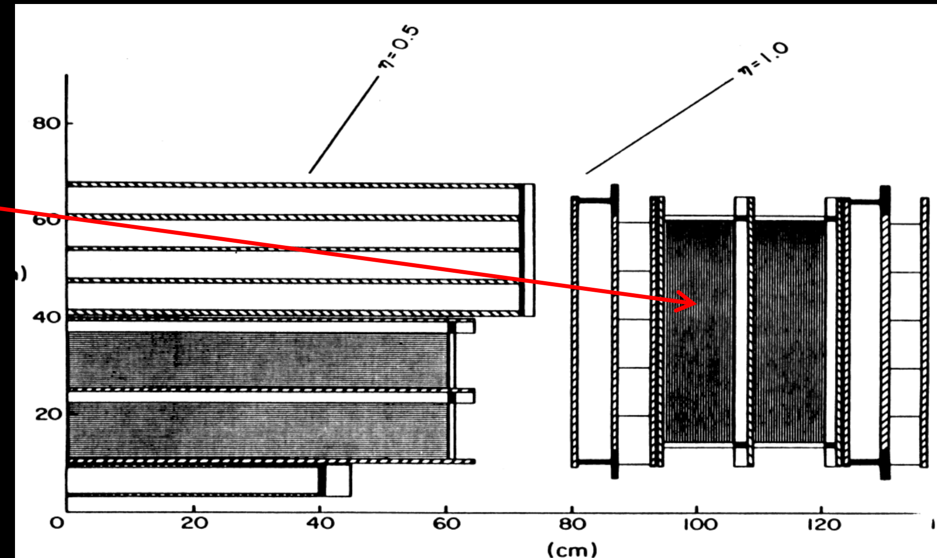
Early 1984: HEPAP decided to give priority to SLD, nearly killing DØ. It was a gloomy time but we pressed on toward a buildable design, and planning the R&D and test beam prototypes. DOE agreed to review in fall '84.

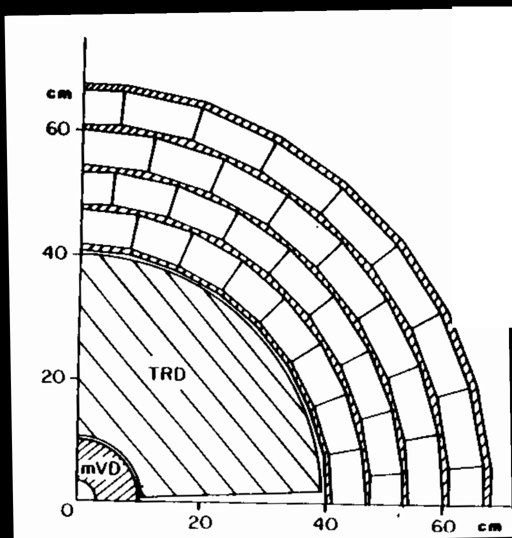
Full collaboration meeting in Snake Pit, 1984

First annual DØ workshop MSU July 1984. Focus was on fixing the design for the 1984 TDR and DOE Review

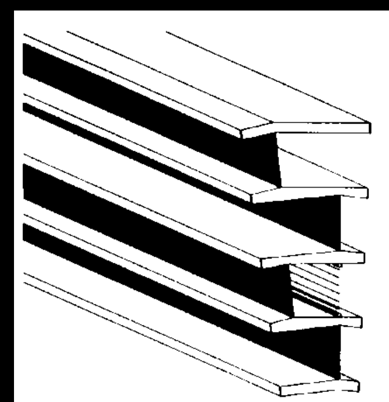
1984 Design Report

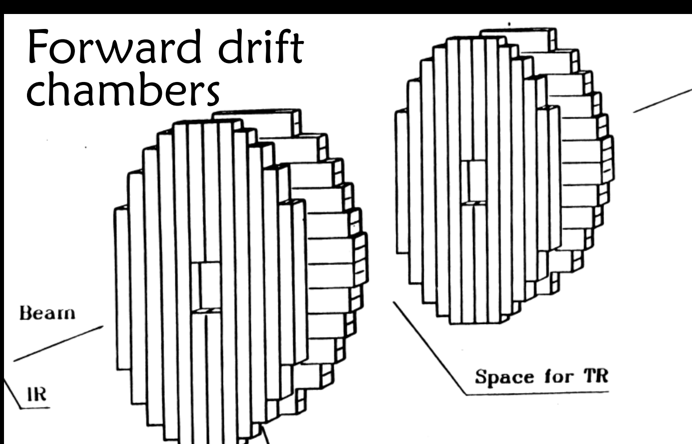
Tracking layout; central CDC, TRD, Vertex Det. The forward TRD later removed due to space constraints.



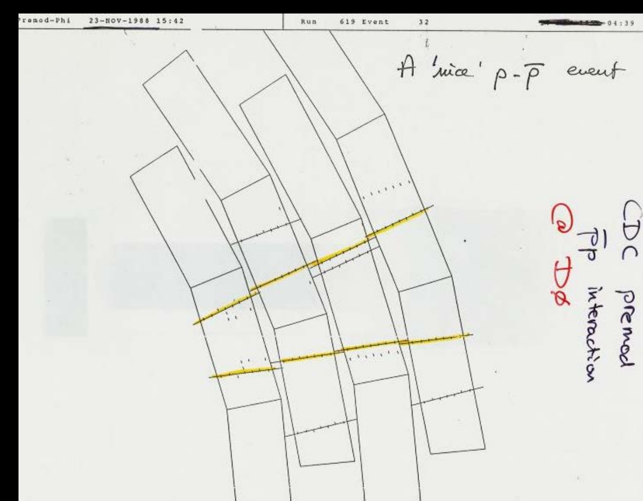


CDC sector





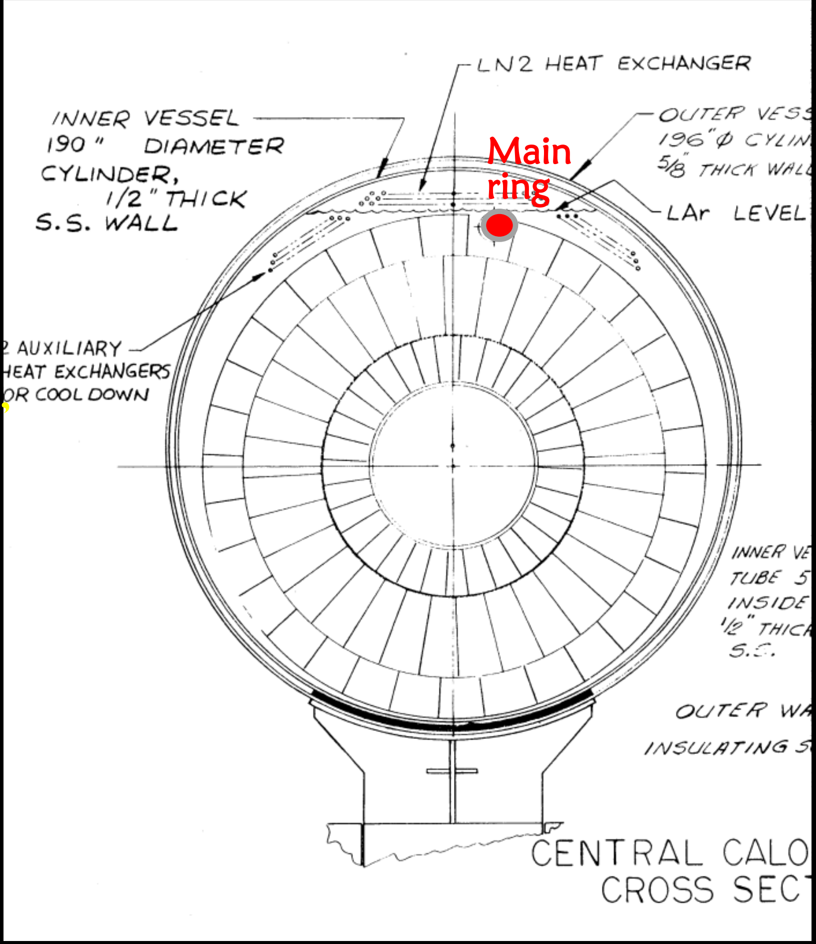
Four sectors of CDC in 1988 saw first collisions at DØ IP.



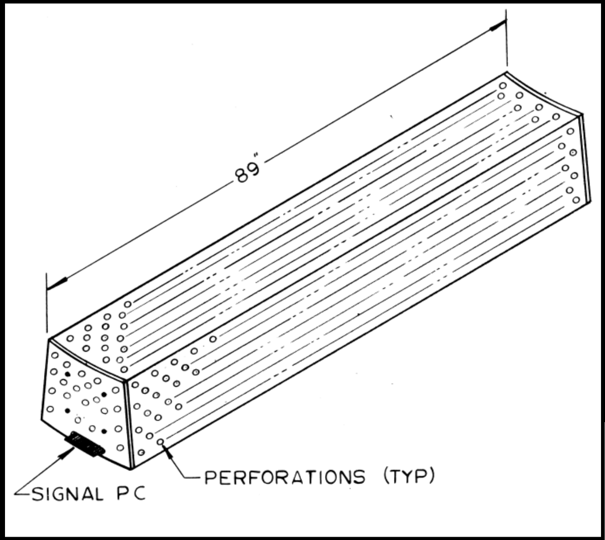
1984 Design Report

Calorimeter became realistic with engineered support design, projective geometry in ϕ.

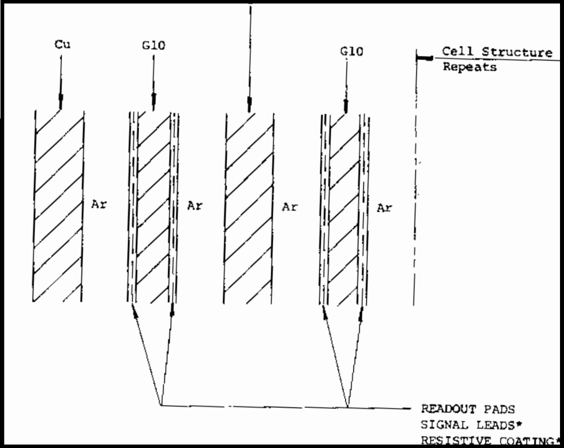
Barrel CC with EM, FH, CH structure



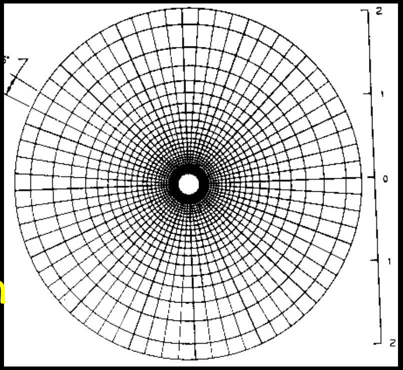
CC modules



2.3 mm Ar gap with resistive coat on signal boards

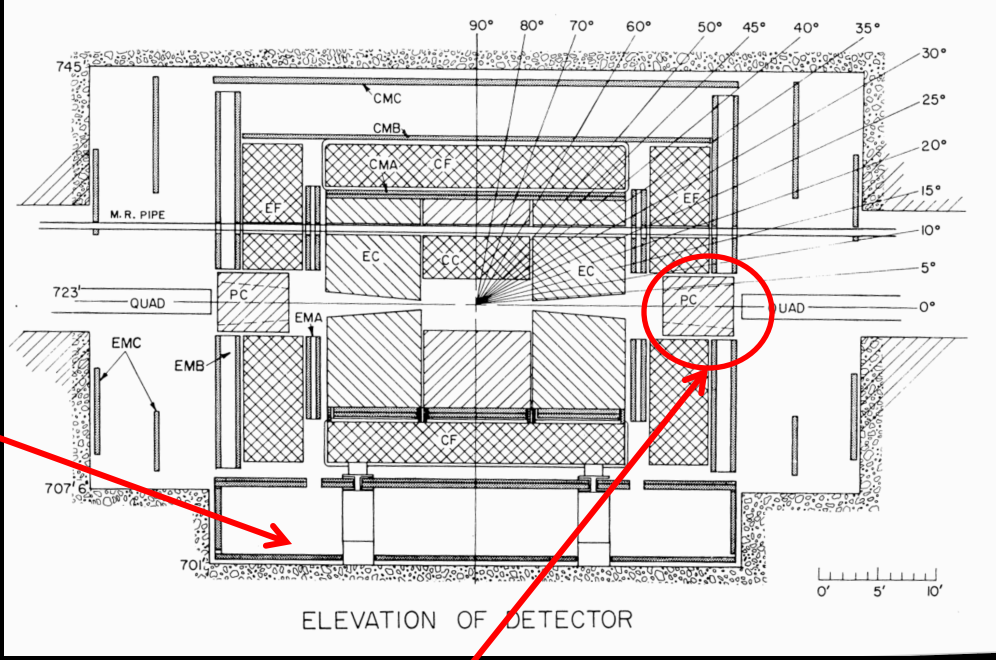


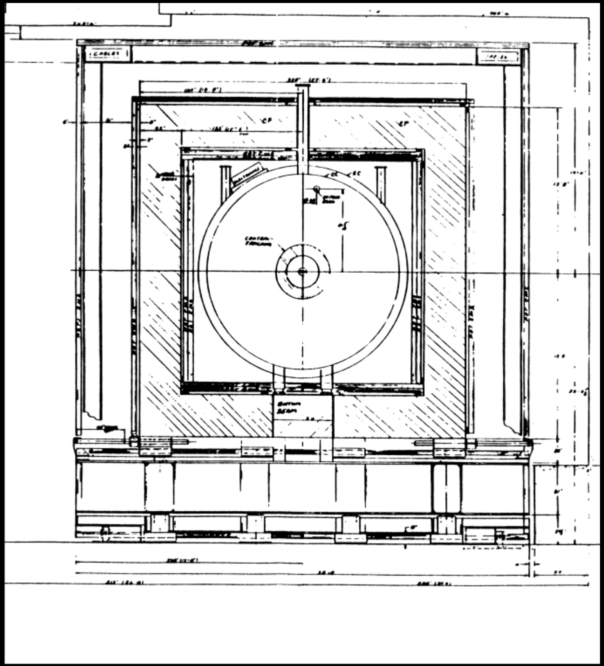
ECEM pad segmentation



1984 Design Report

Squared up the toroids. Eliminated intermediate toroid. Detector rolls on movable platform.

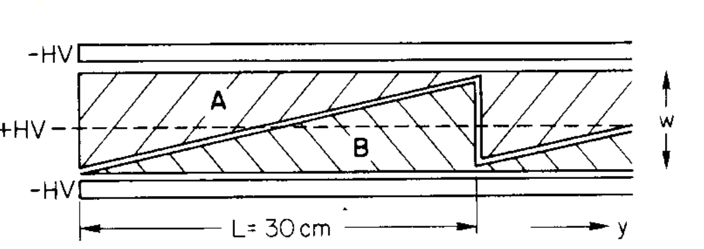




Ultimately the plug calorimeter was replaced by SAMUS toroid/muon detector

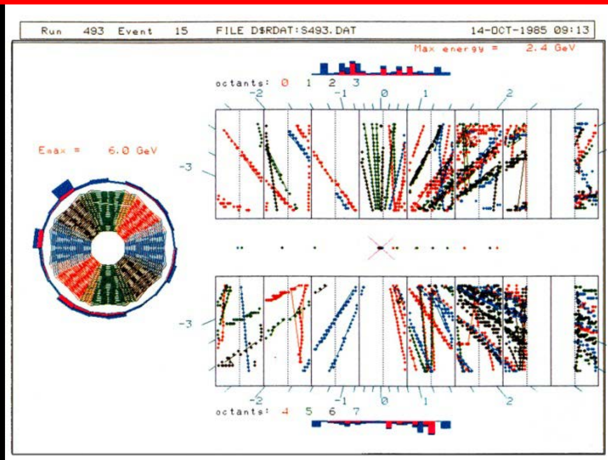
1984 design was close to what we ultimately built.

Muon PDT cells, with vernier pads for z-coordinate.



November 1984 DOE Review (Temple/Lehman) gave a positive recommendation. Some funding awarded for R&D.

Getting underway

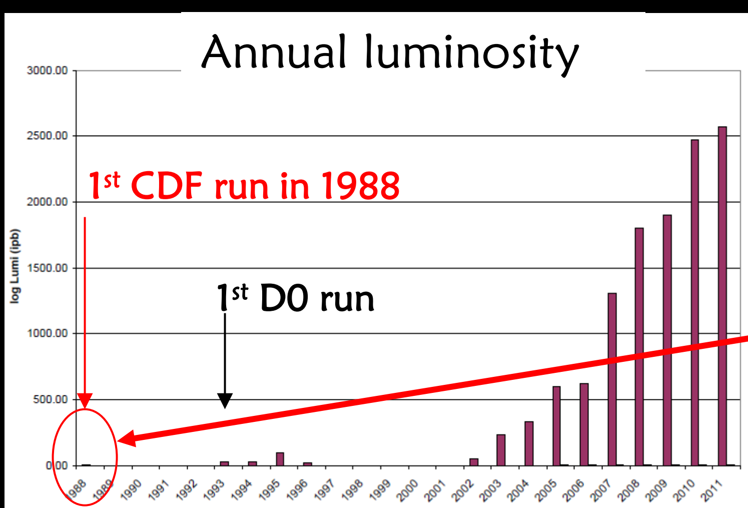


Oct. 14, 1985

First Tevatron collisions were recorded in the (partially complete) CDF detector.

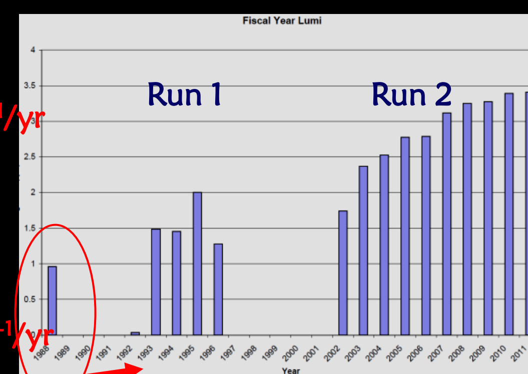
DØ was still a hole in the ground.

How did DØ overcome the 4-5 year CDF head start? The answer lies in the performance of the Tevatron. The luminosity steadily grew, making the head start irrelevant!



Luminosity on linear scale

Lumi on log scale



Putting it together 1986 – 1991

Toroids

By 1986, the hall construction was well along. First job was welding the CF and EF toroids in place using steel from the Newport News cyclotron.

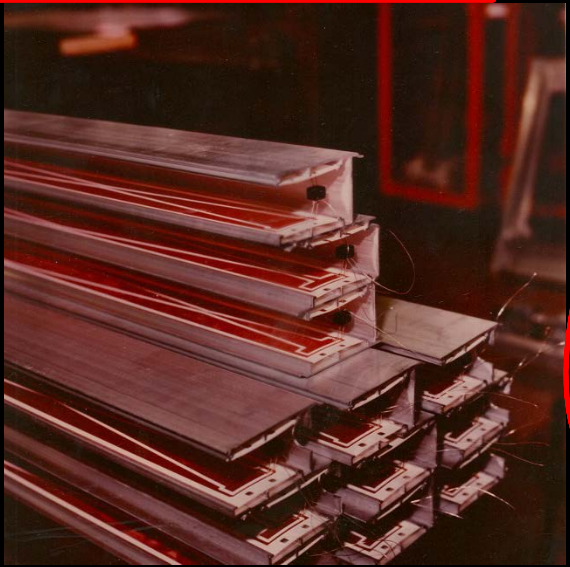
DAB in 1986

Welding

Red CF and Blue EFs

SAMUS Toroids

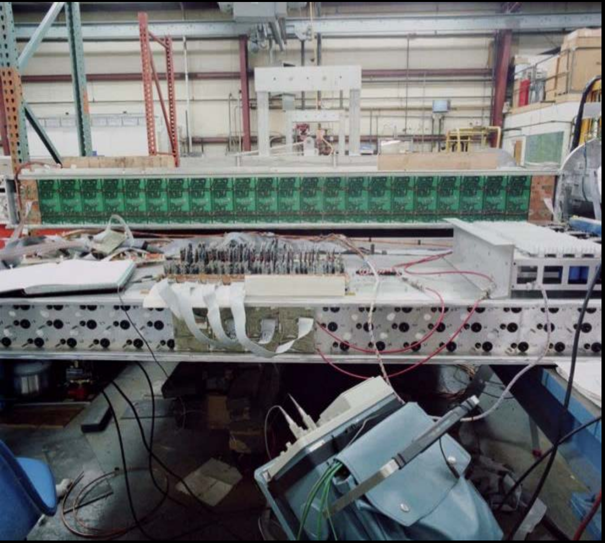
Muon PDTs



Install cathodes in extrusions

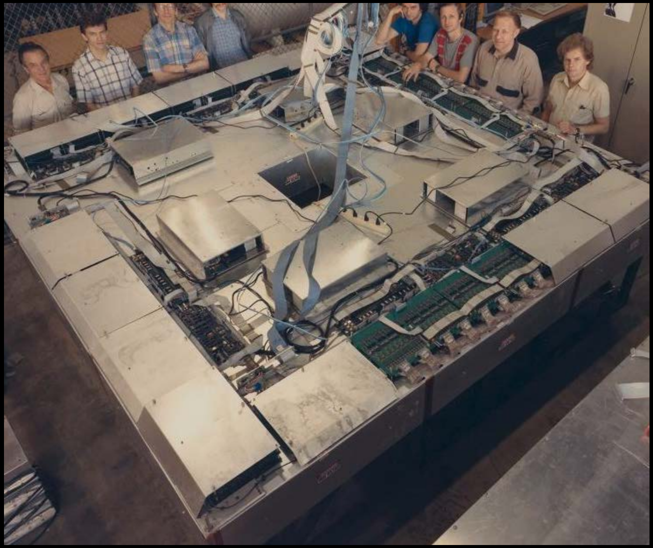
PDTs used Al extrusions with diamond shaped cathode pads.   Factories at FNAL (CF/EF) and Protvino (SAMUS)

Routing PDT cathodes on Thermwood machine



Assemble into PDT panels

Gas/signal connections

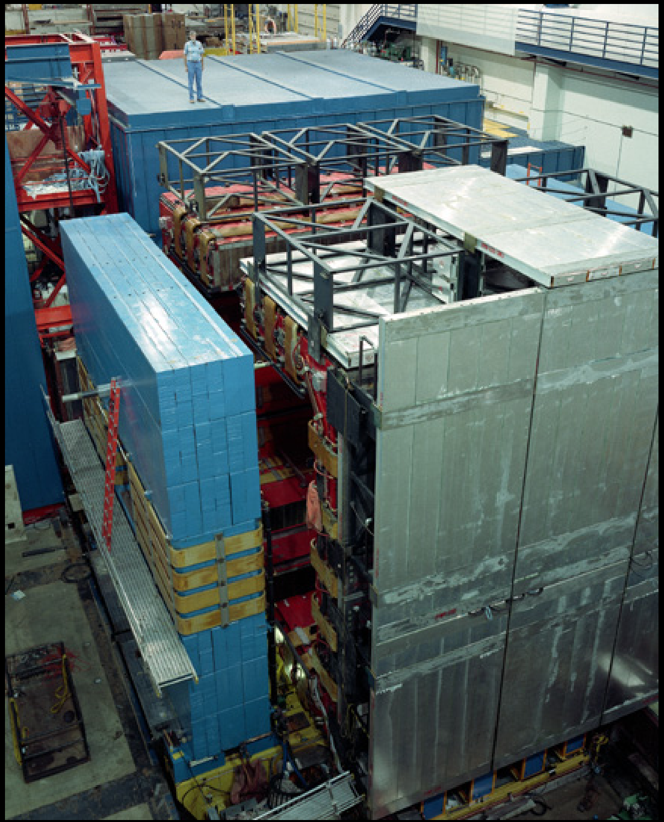


Completed SAMUS chamber

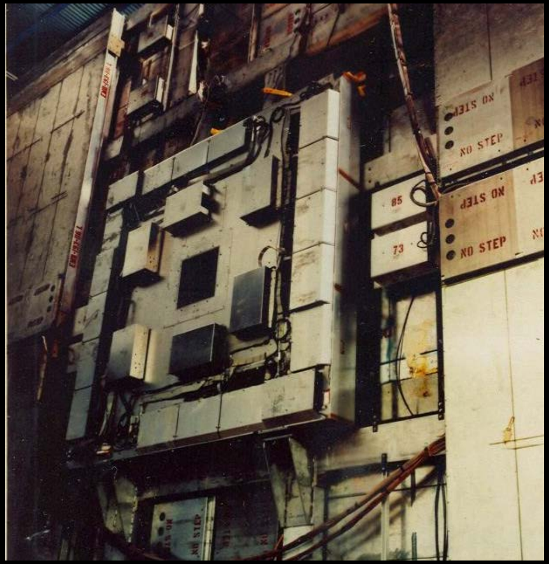
PDT installation

Scintillator installation

Install PDTs in DAB, followed by CF/EF scintillator wall, and finally the SAMUS PDTs



PDT installation

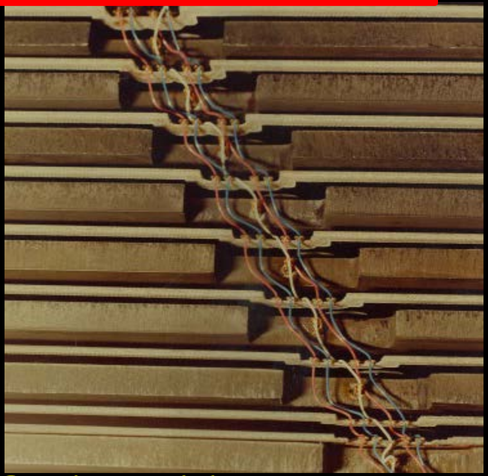


SAMUS installation

Install electronics in cathedral

Learning to do U/LAr calorimetry

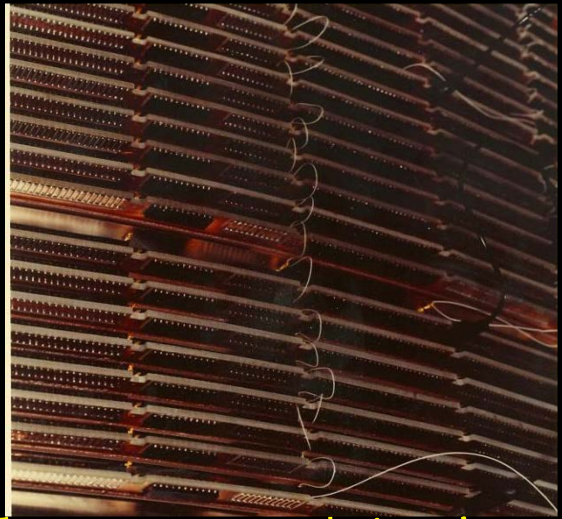
Rout signal board
into ηϕ pads



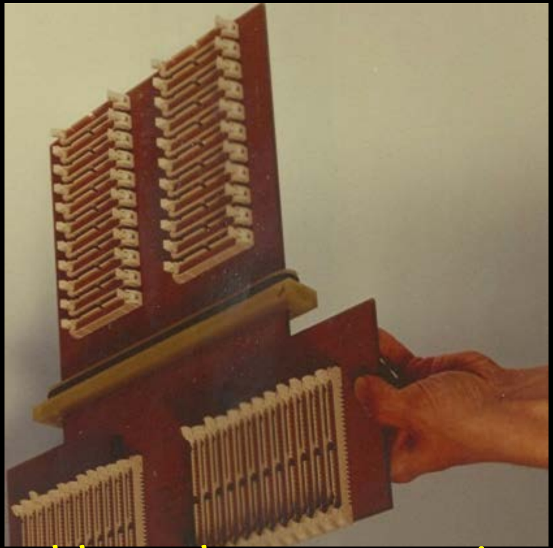
Can't weld to uranium.
Supersonic Indium darts
for HV connections

UO_2 is insidious. Oxide flakes
cause shorts, Malter current
and discharges. Repeated
scrubs, washes etc.

Learn to make 100 MΩ/□
resistive epoxy coating

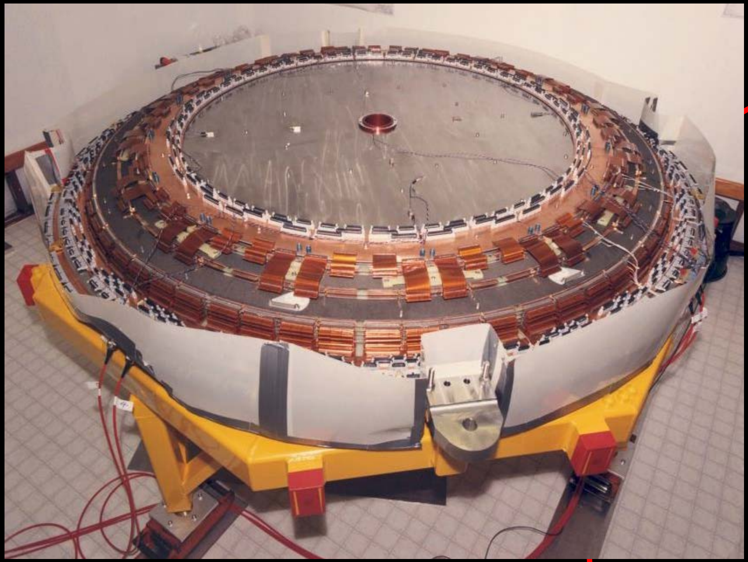


Traces to gang ηϕ signals
from a fixed depth segment.



Feedthroughs to reorganize from
depth segments to ηϕ towers

Making calorimeter modules



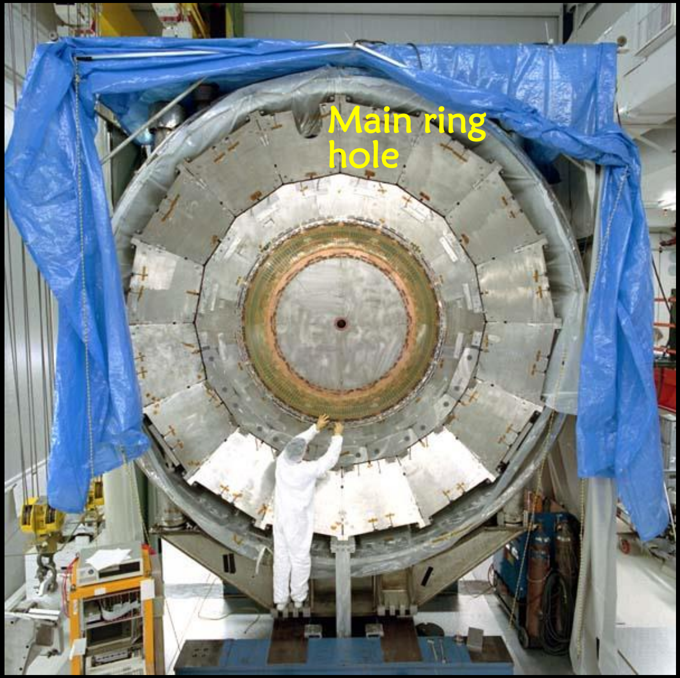
ECEM module

ECIH module

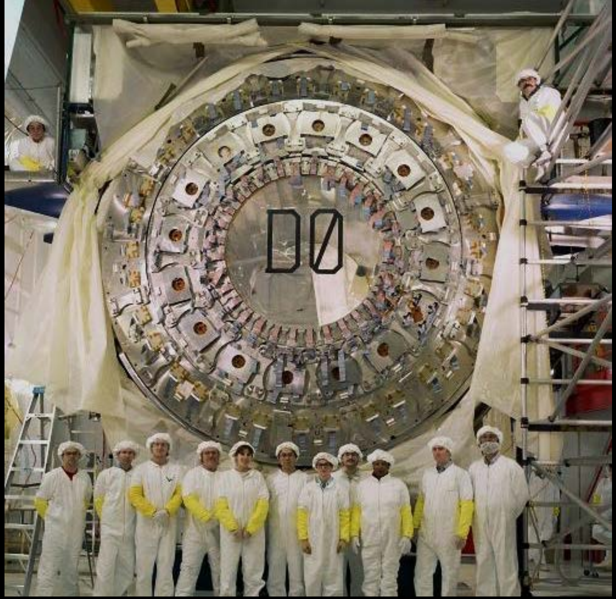
Probing CCFH module for defects after scrubbing

Last step: Power vacuuming; gate valve to evacuated tank made a huge sucking noise carrying out UO_2 dust

Assembly into cryostats in DAB

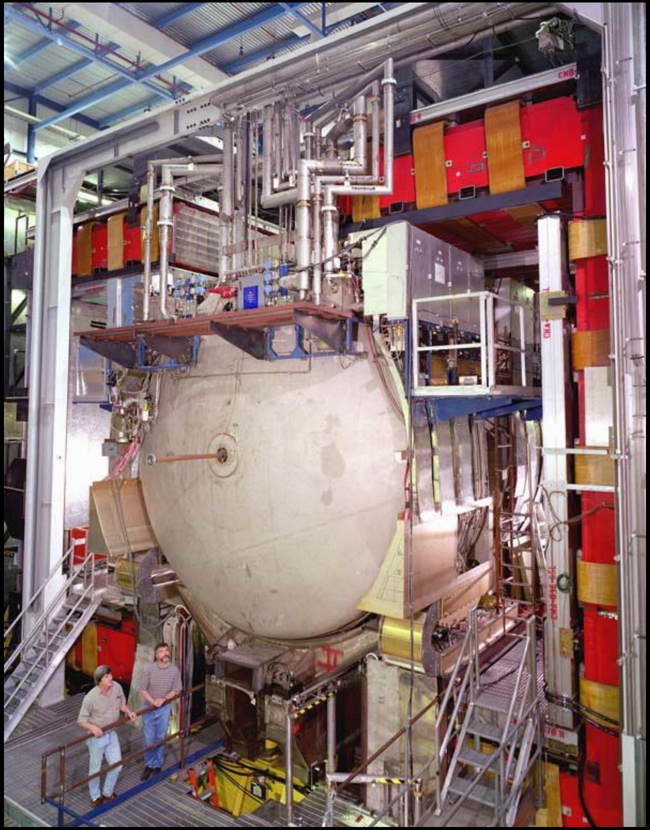


CC finished



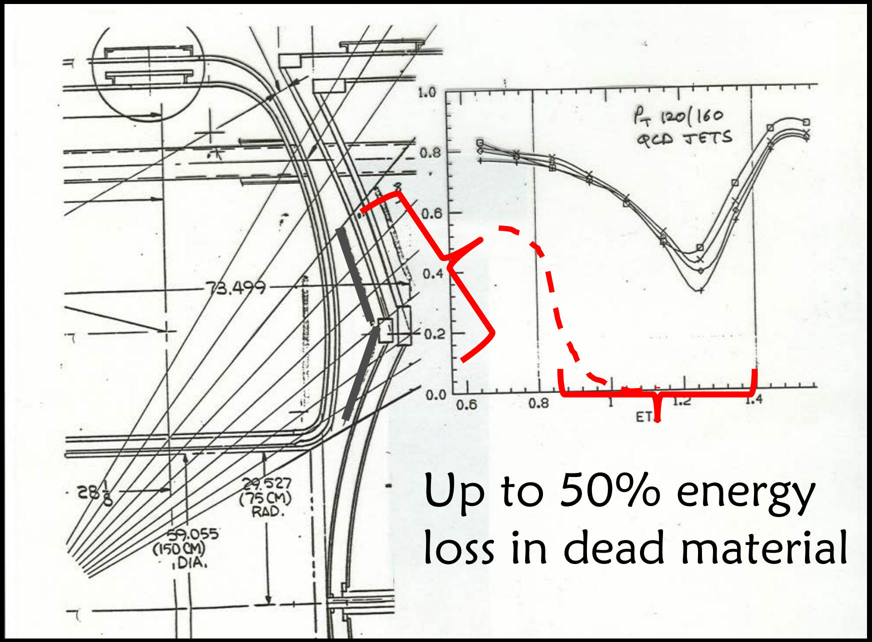
ECS last to be installed

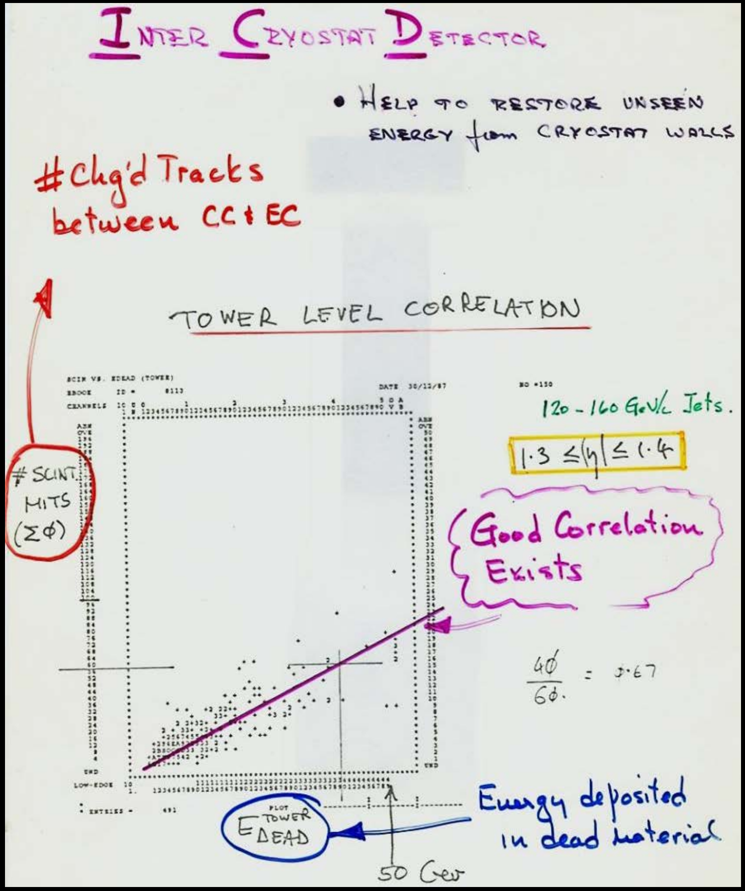
Move the three cryostats (gently) into the toroids.



ICD

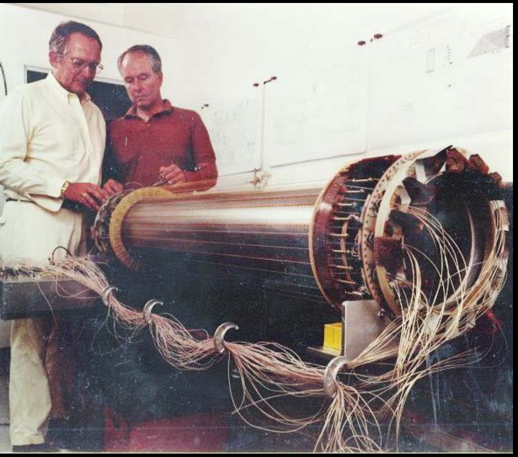
Around 1986 we realized that the energy degradation for jets traversing the cryostat walls would lead to large degradation of MET and jet energy resolution. The solution was the ICD between cryostats (amd massless gaps inside them).





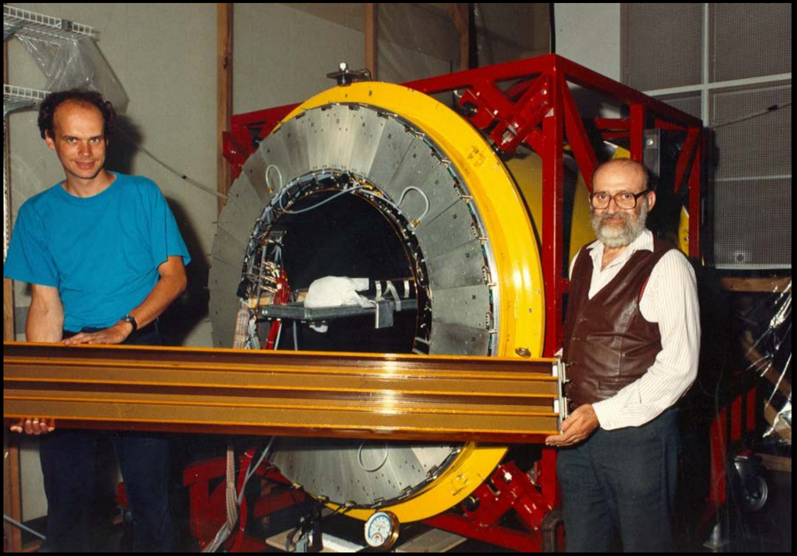
Mount ICDs on EC face

Central tracking

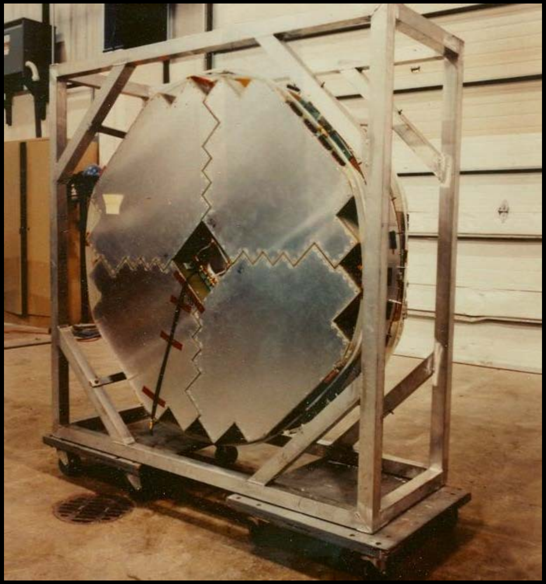


Vertex chamber

TRD in its support tube

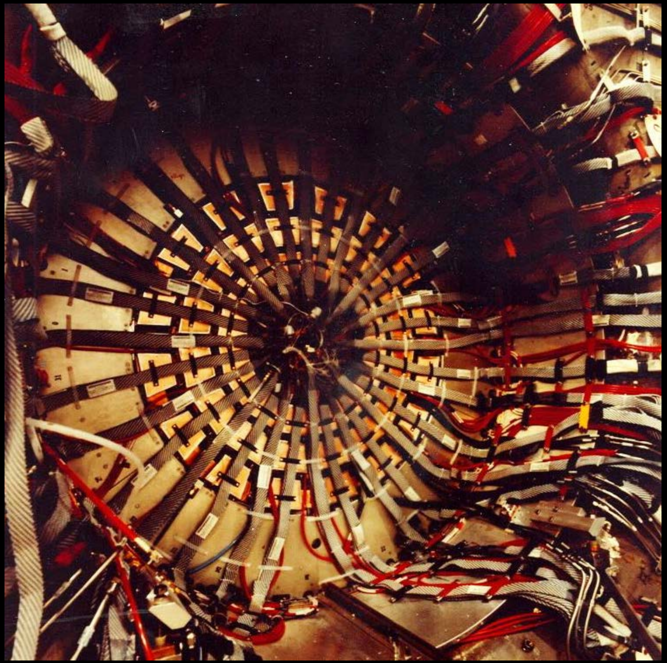


Central drift chamber sector and full detector



Forward drift chamber

Install and cable the central tracking detectors



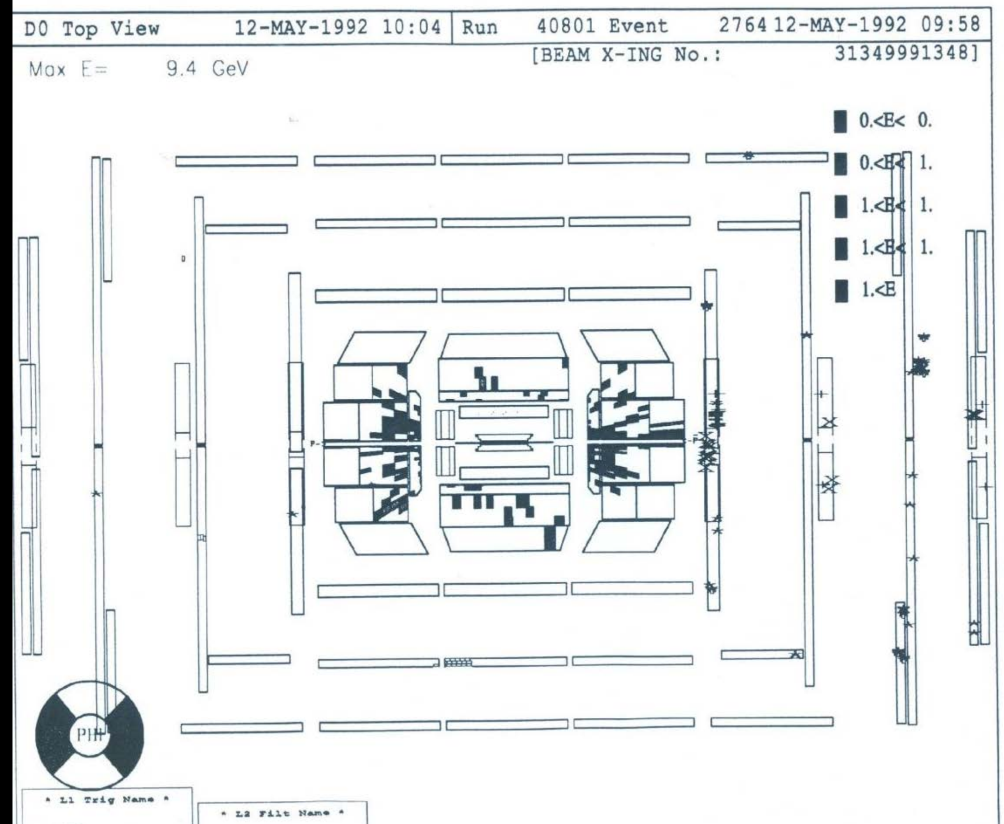
Roll-in

Feb. 14, 1992: DØ gathers to help push the detector into the collision hall

Feb. 15, 1992; at rest in collision hall.
6 inches to spare under the lintel !

Lift off

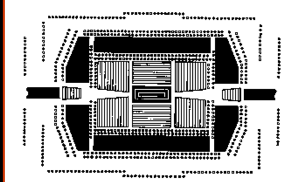
First collision in Run I



May 12, 1992: First $p\bar{p}$ collisions in DØ. Almost 9 years to form the collaboration, design, test, build, install and debug and ~$75M EQ funds (+R&D, operations)

Physics landscape in 1983

A decade of startling discoveries preceded.



1983 Proposal

1974: J/Ψ discovery (BNL/SPEAR)

1975: SPEAR jets observed

1976: Open charm, tau discoveries (SPEAR)

1977: Upsilon discovery (FNAL E288)

1982: Open beauty meson discovery (CLEO)

1983: W/Z discoveries (UA1 and UA2)

1984: High p_T jets seen at UA2

There was some suspension of disbelief when new indications emerged at SppS:

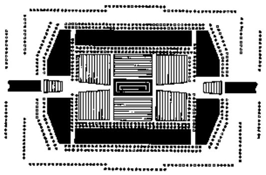
- UA1: Monojets (jets with large missing E_T) – Susy??
- UA1/UA2: anomalous $Z \rightarrow \ell^+ \ell^- \gamma$ – new resonance??
- UA1: top quark observation in $W \rightarrow t\, b$? … well maybe not !!

DØ Proposal: "Although the popular notions (for Beyond the SM) may be wrong, it is useful to note that almost all such models postulate observable new phenomena emerging in the mass region 100 < M < 500 GeV, or in deviations from orthodoxy in W and Z parameters at the level of radiative corrections. Thus the role of Tevatron experiments will be to search for evidence of these new ingredients."

What physics did we say we would do?

1983 Proposal

5 pb^{-1}



DØ

<u>Electroweak physics</u>

- M_W to 0.5% and $\sin^2\theta_W$ to 0.0025. Measurement of m_W/m_Z (ρ) would constrain m_{top} < 130 GeV
- Γ_Z to 130 MeV, Γ_W to 200 MeV
- Given anomalies in $Z \rightarrow \ell^+ \ell^- \gamma$, search for $X \rightarrow Z\gamma$ resonance
- Search for $t\bar{t}$ resonances up to 55 GeV (!)
- Leptonic asymmetry in W production/decay
- Diboson production and $W\gamma$ radiation amplitude zero
- W,Z production, and W+jets
- W/Z decays to quarks, with flavor tagging via semileptonic decays

What physics did we say we would do?

QCD and searches

Inclusive jets to p_T = 500 GeV

3 jet/2 jet XS to get α_s

Ratio α_{EM}/α_s from comparison γ to g production

Direct photon production

Search for heavy charged and neutral leptons; lepton compositeness

Search for heavy W/Z to 150/230 GeV

SUSY searches (jets + MET)

Heavy quark searches

Technicolor/ leptoquarks

Quark gluon plasma

What we did not advertise:

- Top quark discovery
- Single top
- Higgs
- ** B physics and CPV

The Dawn and Sunset of DØ

There were a lot of itches to scratch. We did, and it felt good.

Many very dedicated and talented people made DØ a success.

It has been a wonderful experience!