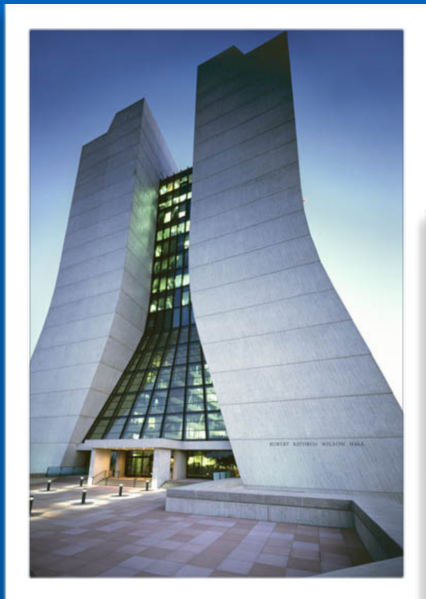
The US-Japan Cooperation for the CDF Experiment

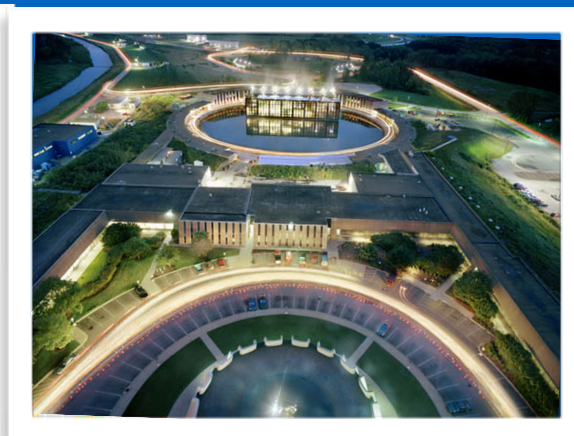
Luciano Ristori

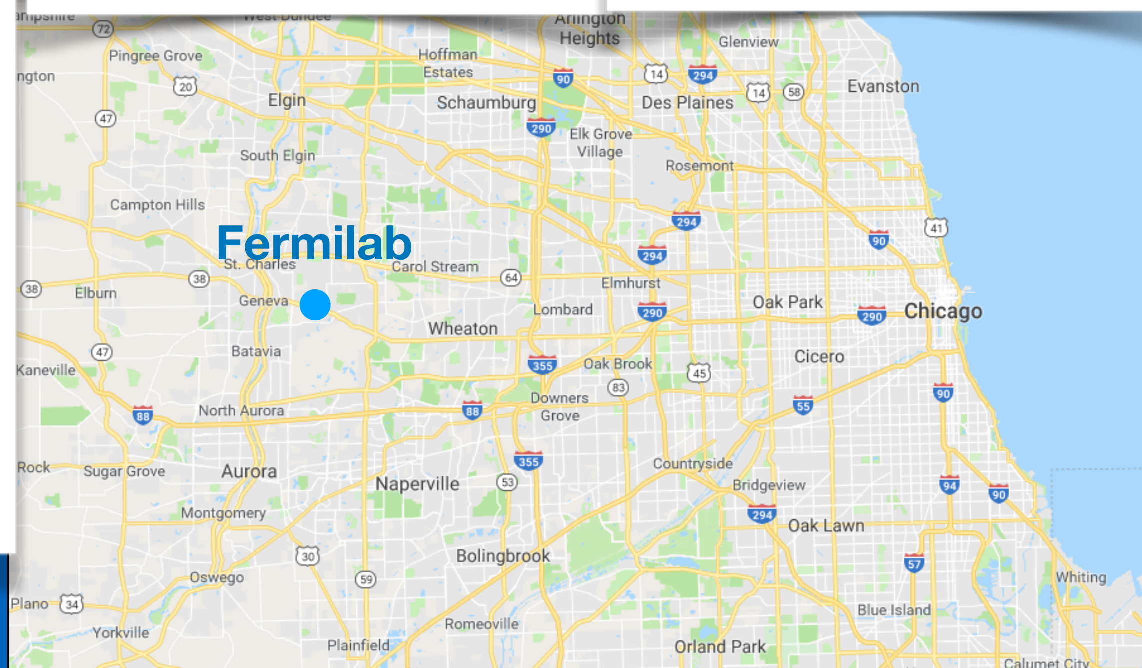
40th Anniversary Symposium of the US-Japan Science and Technology Cooperation in High Energy Physics

April 15^{th} 2019

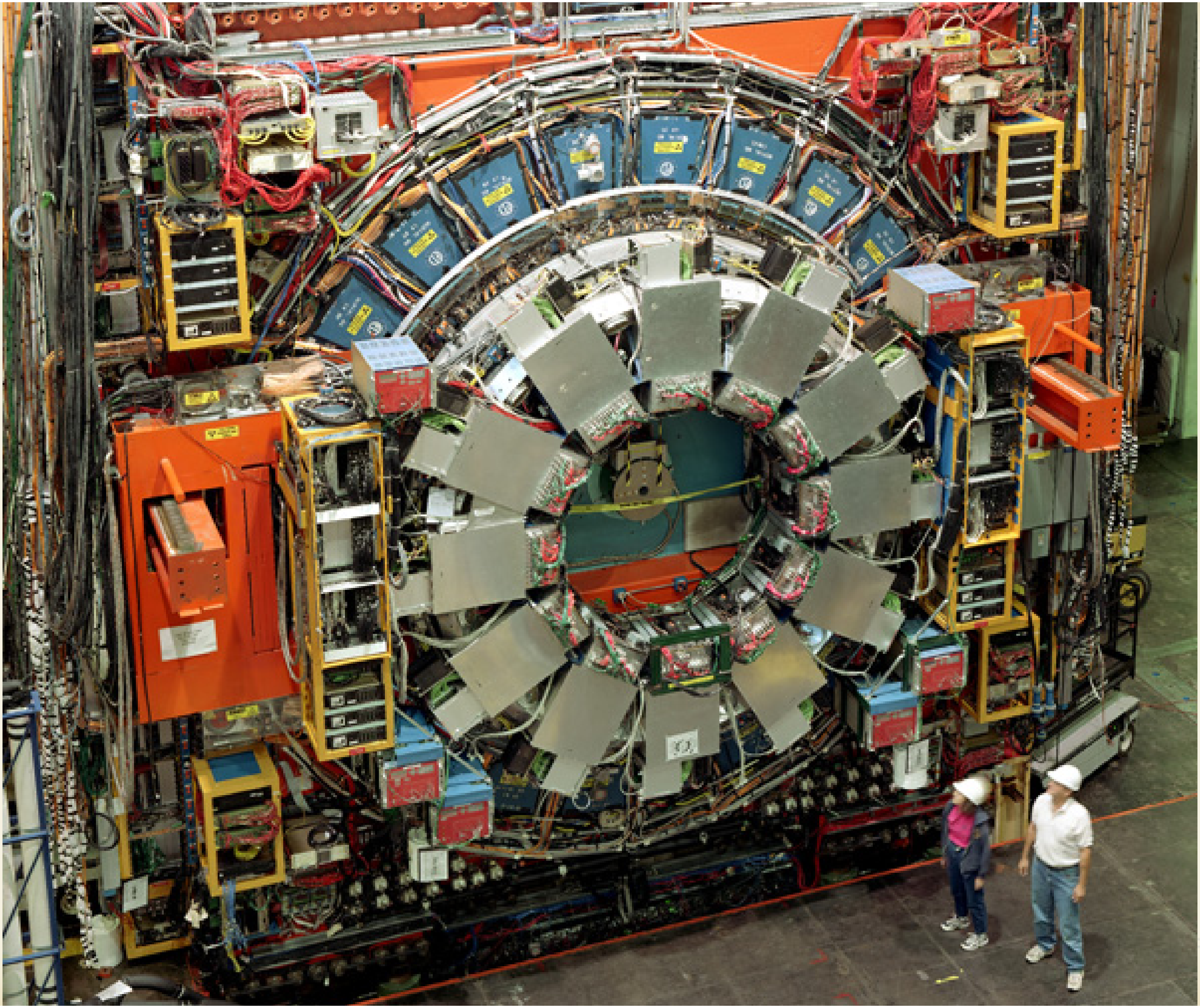
Fermilab

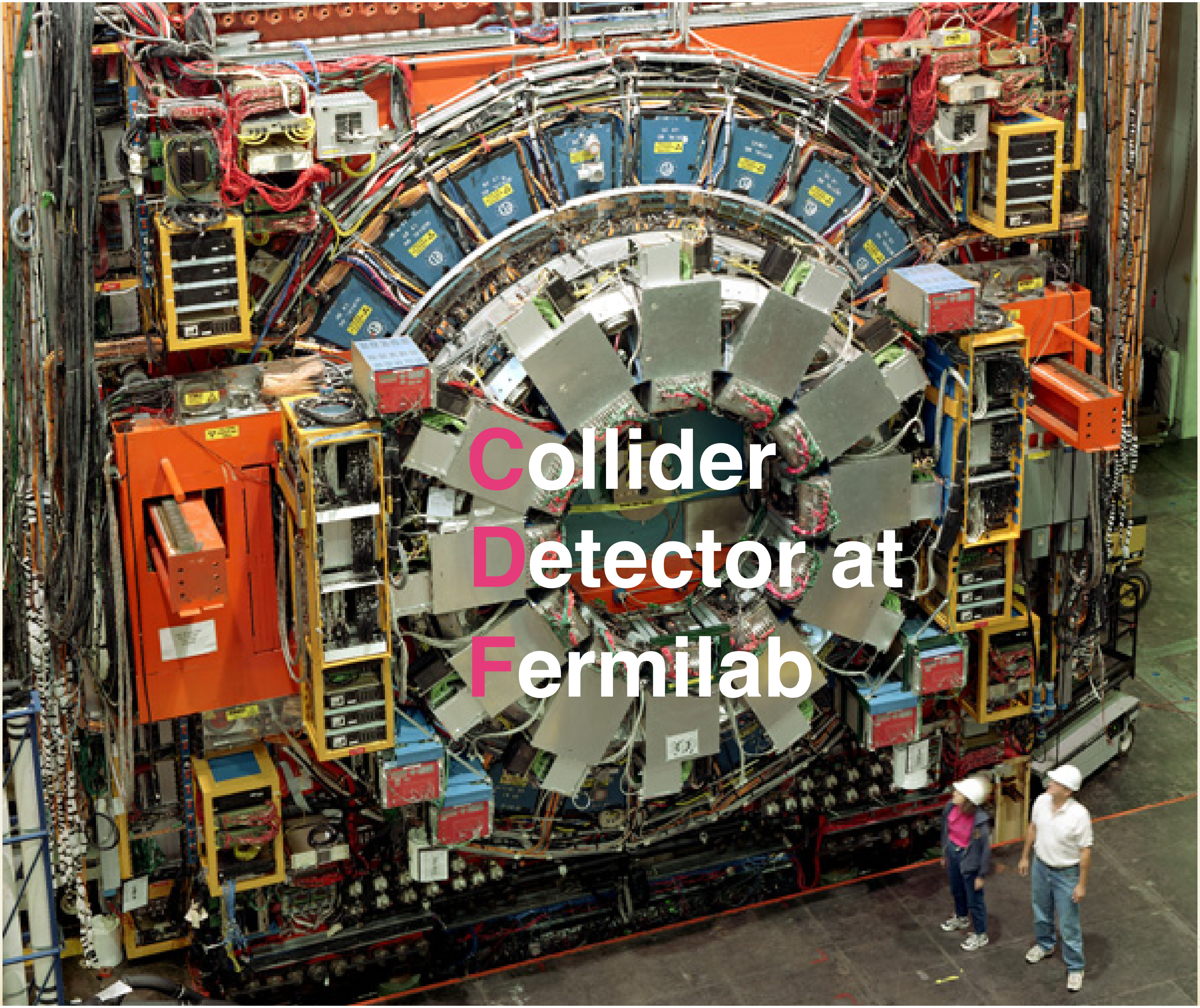





Fermilab
Pingree Grove
Hoffman Estates
Glenview
Evanston
Elgin
Schaumburg
Des Plaines
Elk Grove Village
South Elgin
Rosemont
Campton Hills
St. Charles
Carol Stream
Elmhurst
Elburn
Geneva
Lombard
Oak Park
Chicago
Wheaton
Batavia
Oak Brook
Cicero
Kaneville
North Aurora
Downers Grove
Sugar Grove
Aurora
Naperville
Countryside
Bridgeview
Oak Lawn
Montgomery
Bolingbrook
Oswego
Whiting
Plano
Blue Island
Yorkville
Romeoville
Plainfield
Orland Park
Calumet City

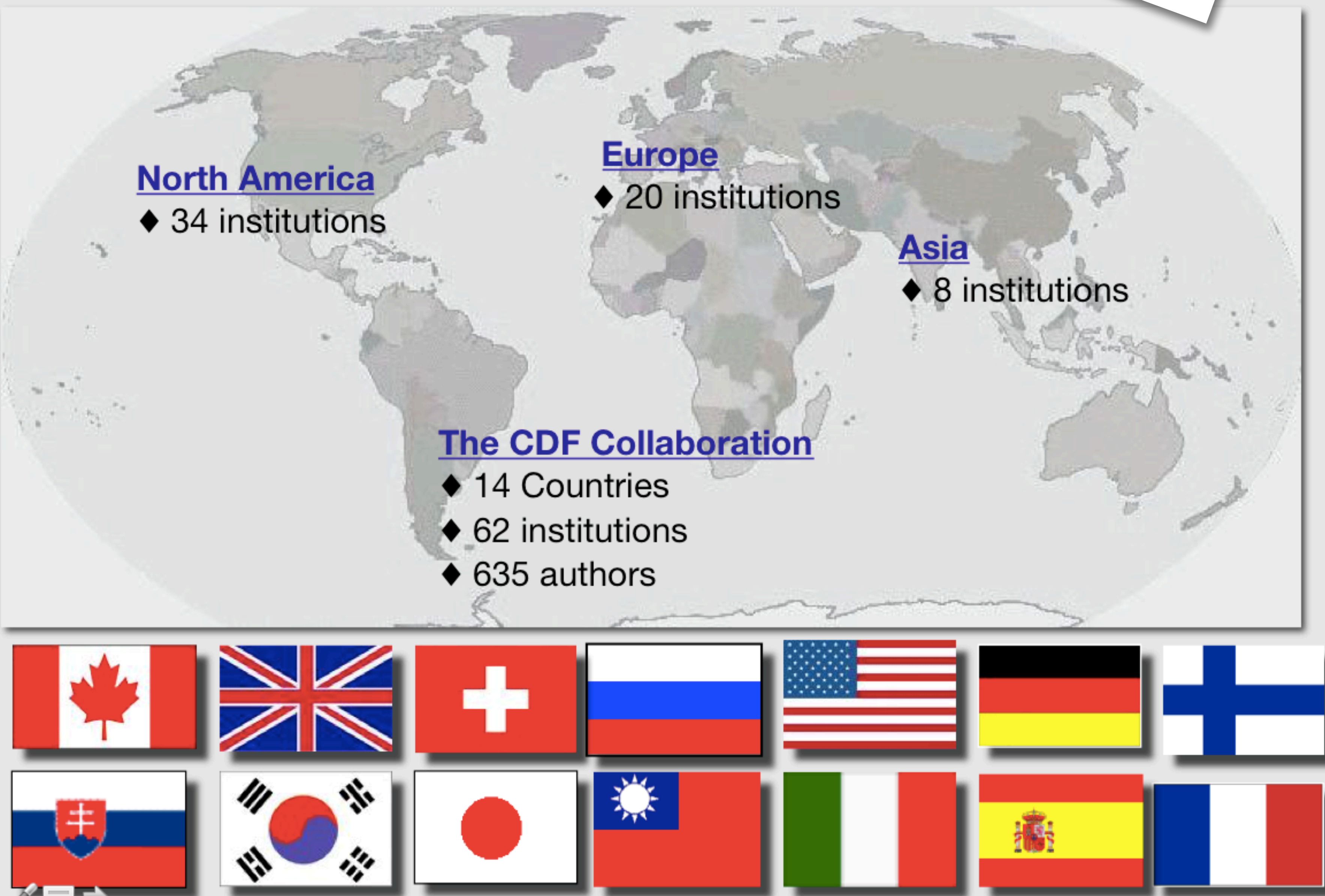

Tevatron
p-pbar 1TeV+1TeV
CDF
DØ




Collider
Detector at
Fermilab

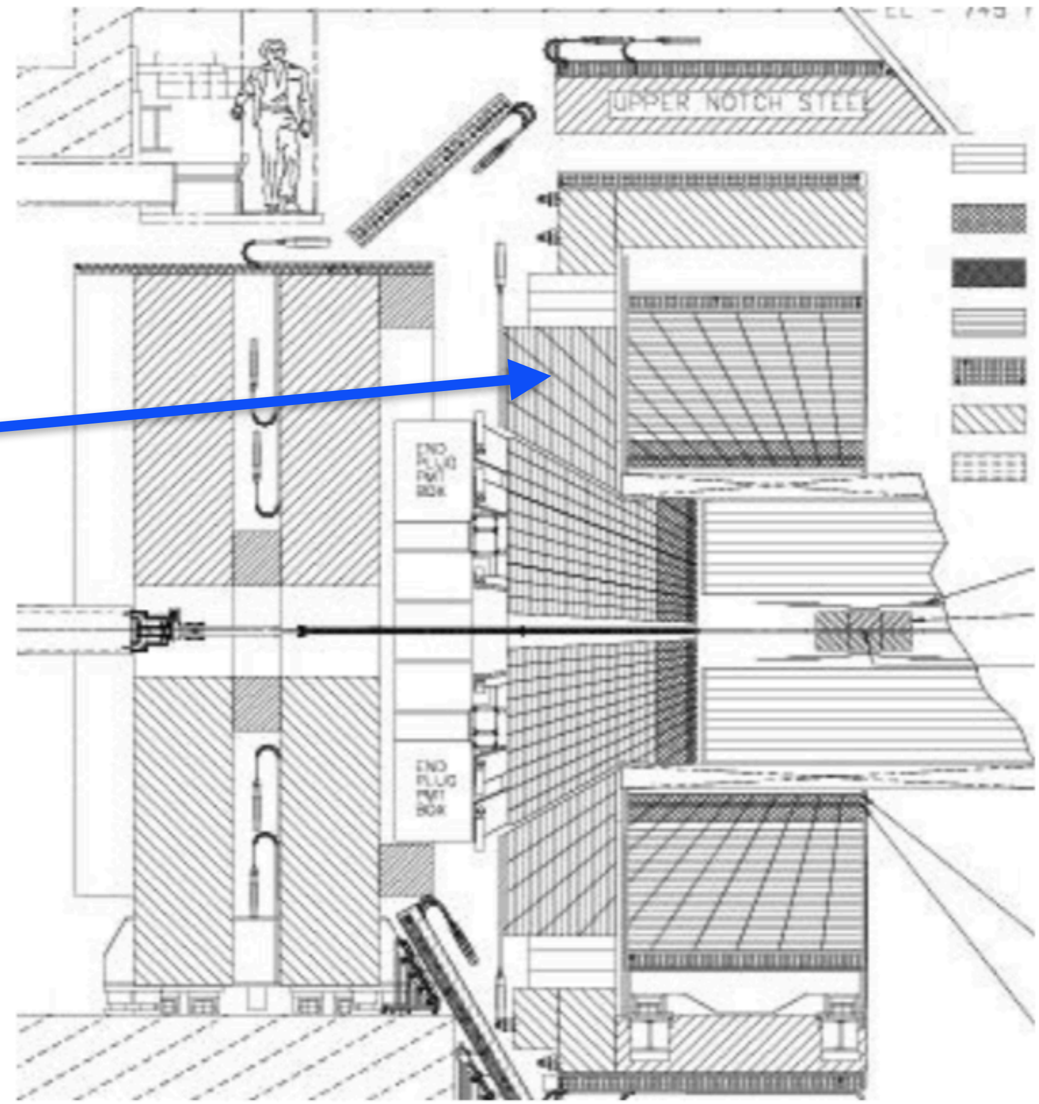
The CDF Collaboration

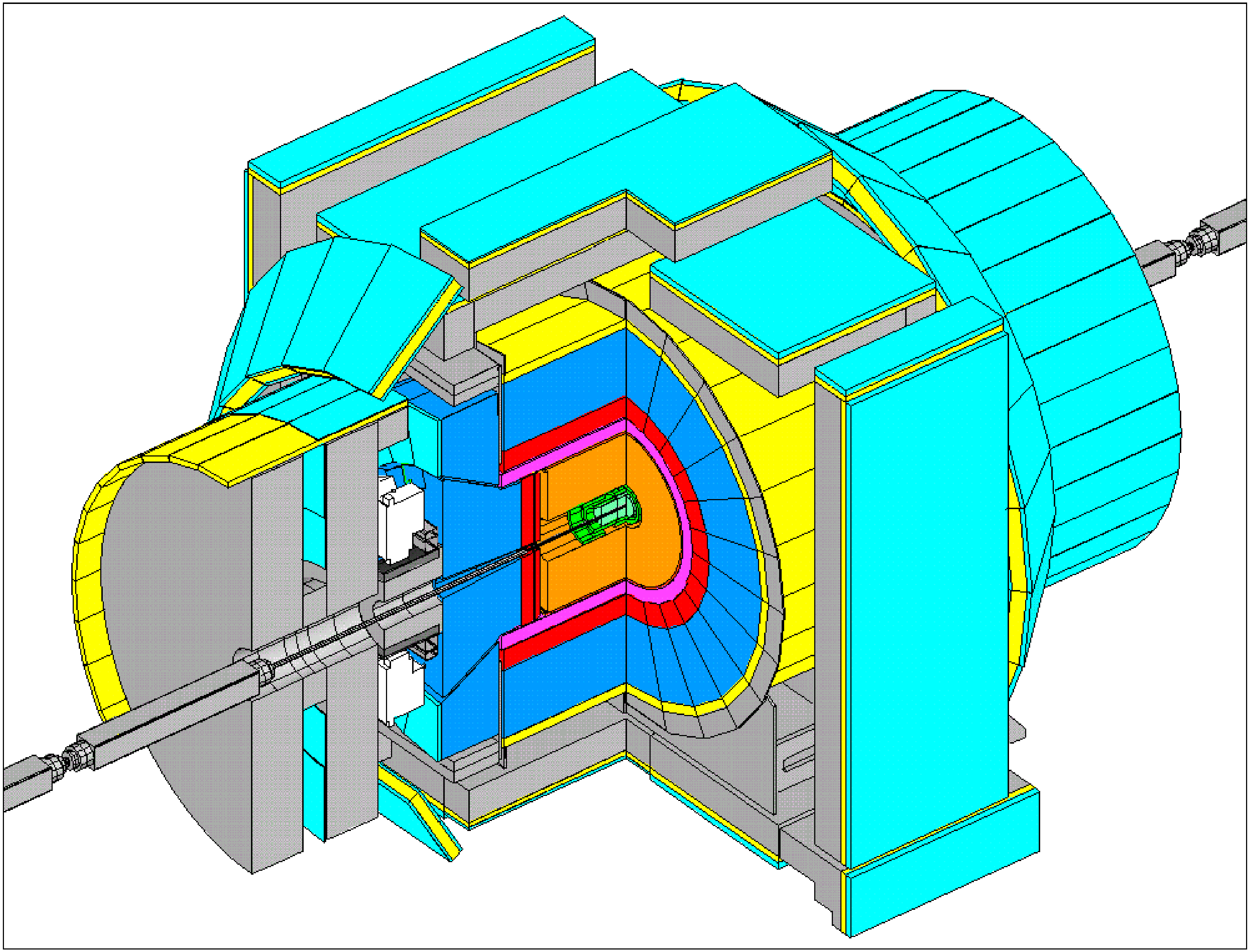
in 2007

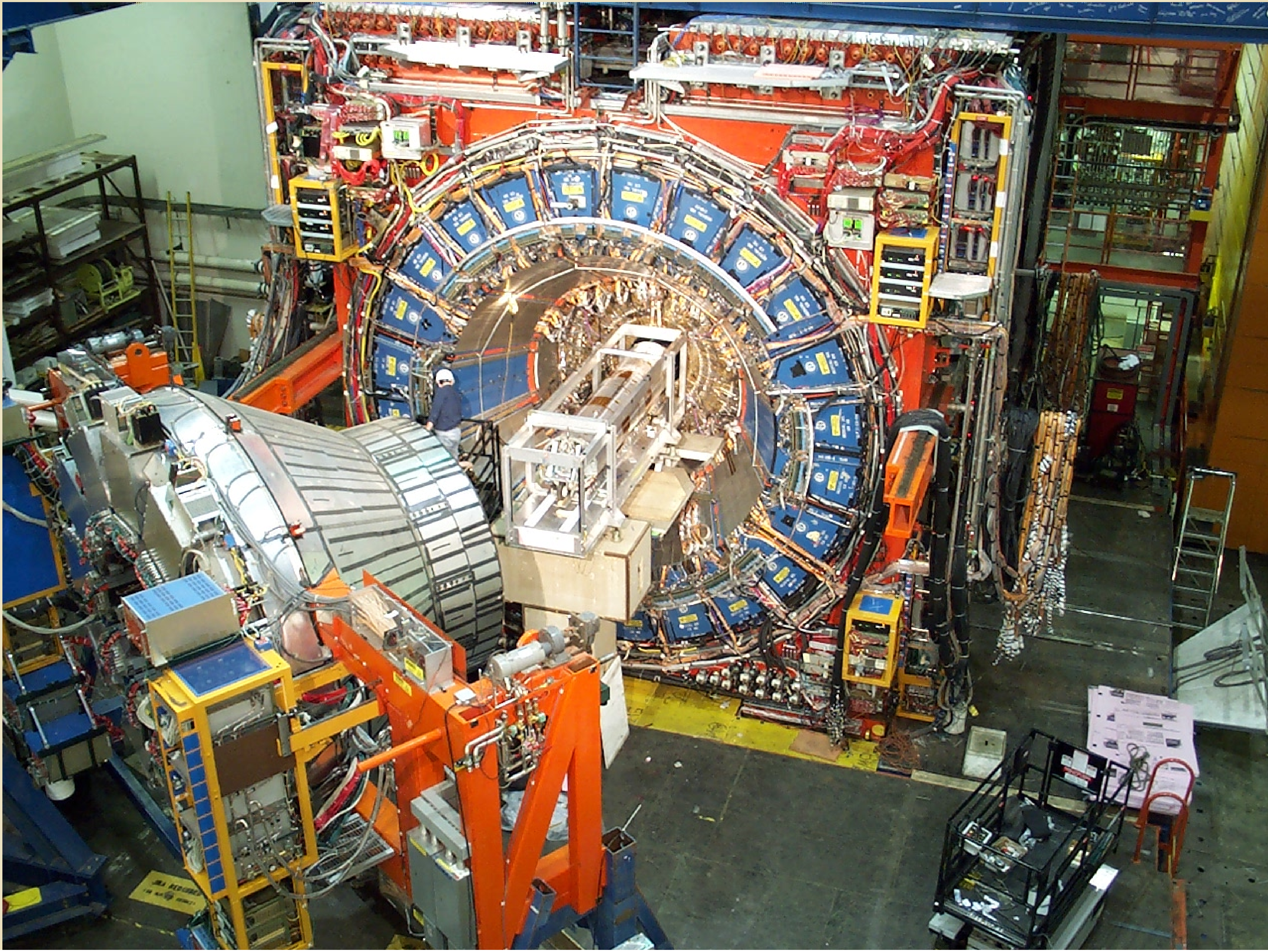


CDF Detector fundamentals

- Axially symmetric
- 4π coverage
- Hermeticity
- Projective towers







Some of CDF Major Achievements

- Discovery of the Top quark in 1995
- Top mass
- W mass is world leading, still improving
- Discovery of B_s mixing
- Precision Heavy Flavor Physics (CP asymmetries, Lifetimes…)
- …

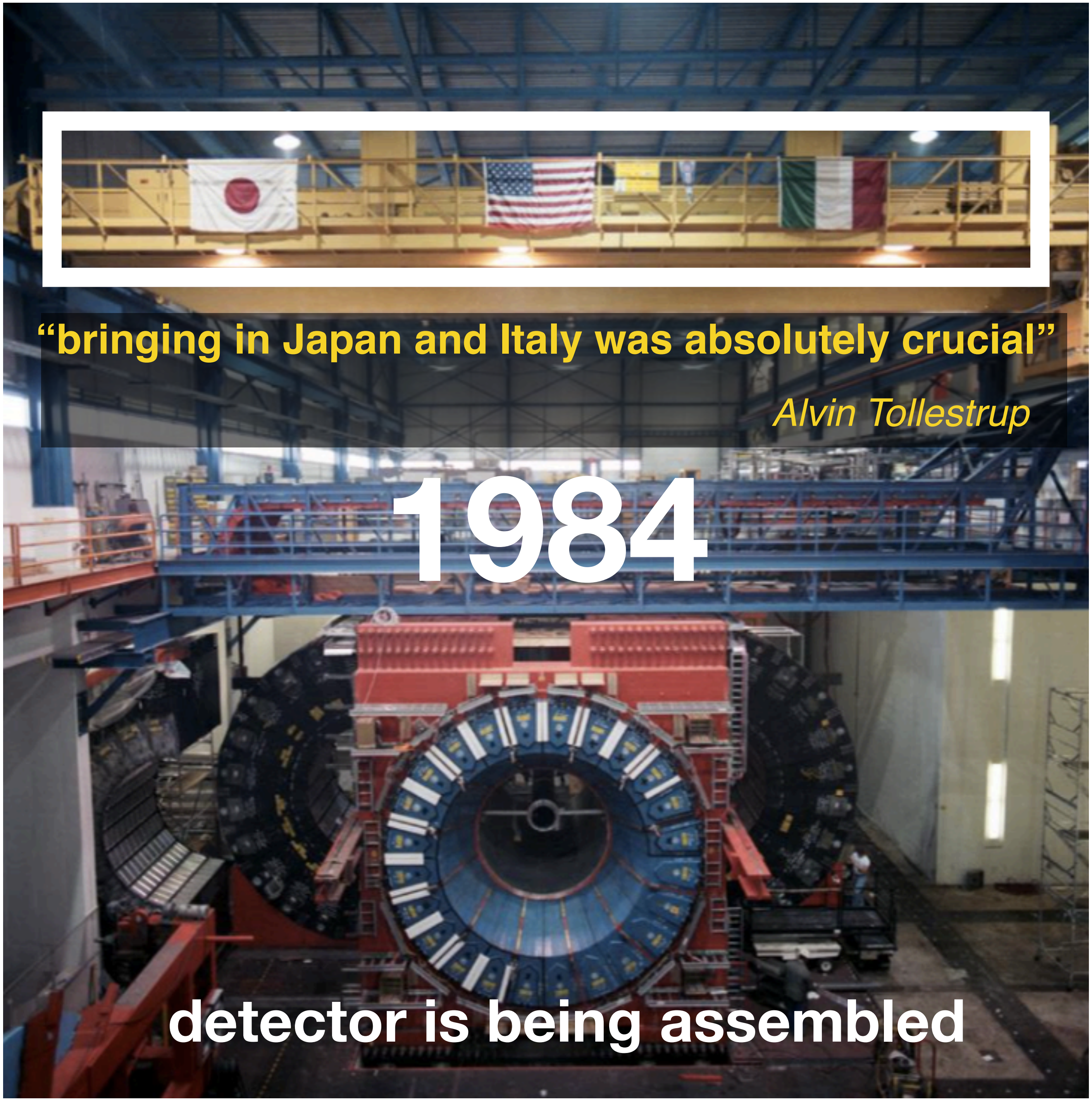
- **More than 700 papers published**
- **~650 PhD's**

CDF Chronology

- Collaboration established in 1980
- Tevatron first p-pbar collisions: 1985
- CDF Run I: 1987-1995
  - integrated luminosity ~ 110/pb
- CDF Run II: 2001-2011
  - integrated luminosity ~ 10/fb


1984
detector is being assembled


1984
detector is being assembled


"bringing in Japan and Italy was absolutely crucial"
Alvin Tollestrup
1984
detector is being assembled


Japan
USA
Italy
Kuni Kondo
Alvin Tollestrup
Giorgio Bellettini

- “Kuni was almost everything about the contribution of Japan to CDF. He was the leader from the beginning to the end”

Masa Mishina

Kuni Kondo
(1934-2011)

Fermilab

May 15, 1980

DRAFT MAY 15 1980

MEMORANDUM OF UNDERSTANDING
between
FERMI NATIONAL ACCELERATOR LABORATORY
(hereinafter referred to as "the Laboratory")
and
THE JAPANESE PARTICIPANTS
(hereinafter referred to as "the Participants)
concerning
THE COOPERATIVE RESEARCH UNDER JOINT JAPAN/UNITED STATES
COLLABORATION IN HIGH ENERGY PHYSICS

EXHIBIT "A"

Collaboration with Fermi National Accelerator Laboratory (Fermilab)

Definitions: The High Energy Physics Delegation of the Government of Japan - Delegation

Fermi National Acceleratory Laboratory - Fermilab

1. Superconducting solenoid
2. Central hadron calorimeter
3. Endcap hadron calorimeter
4. Central electron calorimeter
5. Endcap electron calorimeter
6. Forward muon detector
7. Wide angle muon detector
8. Electronics and data processing system
9. Central tracking system
10. Experiment 605

1. The experiments and projects which the Participants shall engage in shall be those approved by the Laboratory Director and the Participants. Attached as Exhibit "A" is an outline of the initial cooperative program that the Participants and the Laboratory will conduct.

Japan Contributions to CDF

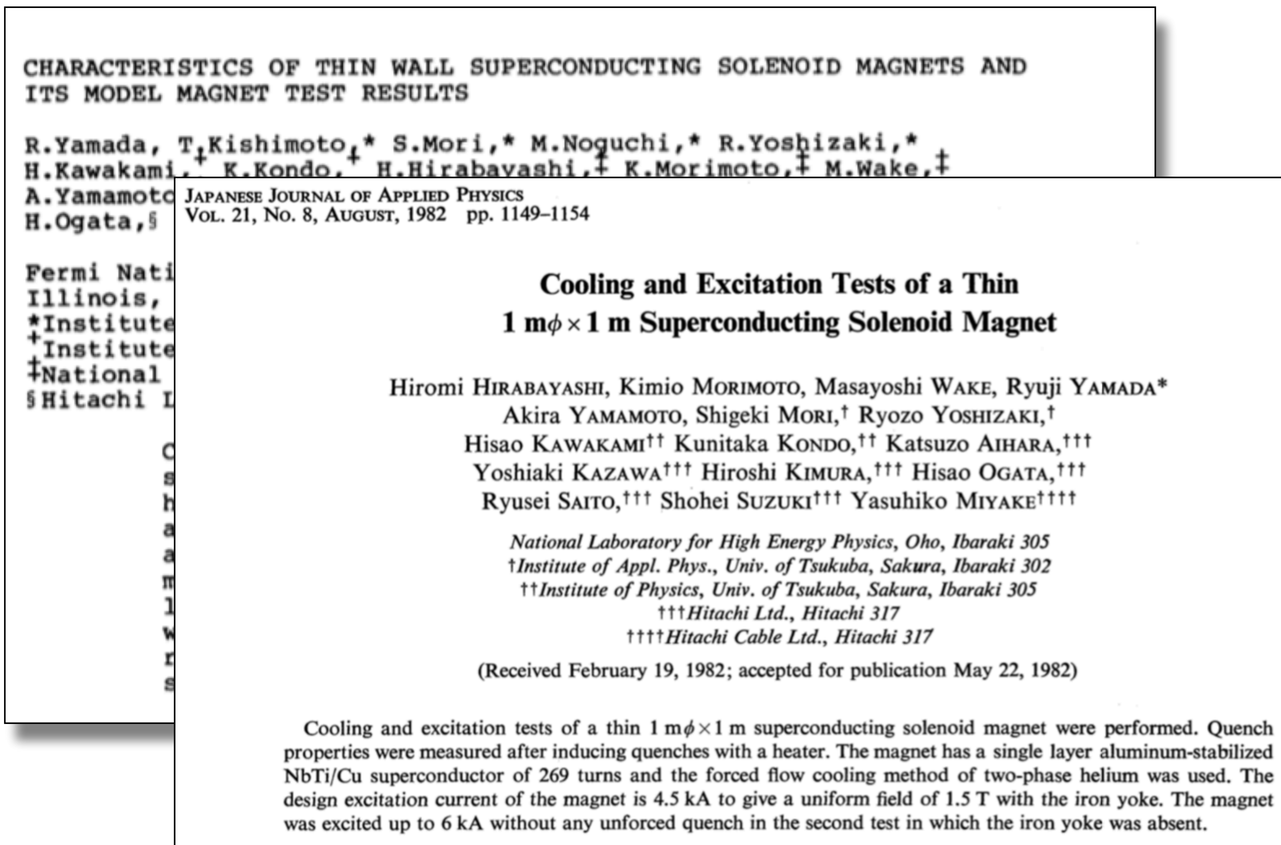
Among the many contributions that the Japanese group gave to CDF, the ones that are probably the most relevant are:

1. **Superconducting Solenoid**
2. **Plug Electromagnetic Calorimeter for Run I**
   - Based on proportional gas drift tubes
3. **Plug Electromagnetic Calorimeter for Run II**
   - Based on scintillator and wave shifter fibers
4. **Physics Data Analysis**

The CDF Superconducting Solenoid

The CDF Superconducting Solenoid

- Ryuji Yamada proposed to Kuni Kondo that the Japanese group take the responsibility of designing and building it
- Worked at a prototype at KEK



CHARACTERISTICS OF THIN WALL SUPERCONDUCTING SOLENOID MAGNETS AND ITS MODEL MAGNET TEST RESULTS

R.Yamada, T.Kishimoto,* S.Mori,* M.Noguchi,* R.Yoshizaki,*
H.Kawakami,† K.Kondo,† H.Hirabayashi,‡ K.Morimoto,‡ M.Wake,‡
A.Yamamoto
H.Ogata,§

Fermi Nati
Illinois,
*Institute
†Institute
‡National
§Hitachi L

JAPANESE JOURNAL OF APPLIED PHYSICS
VOL. 21, No. 8, AUGUST, 1982 pp. 1149–1154

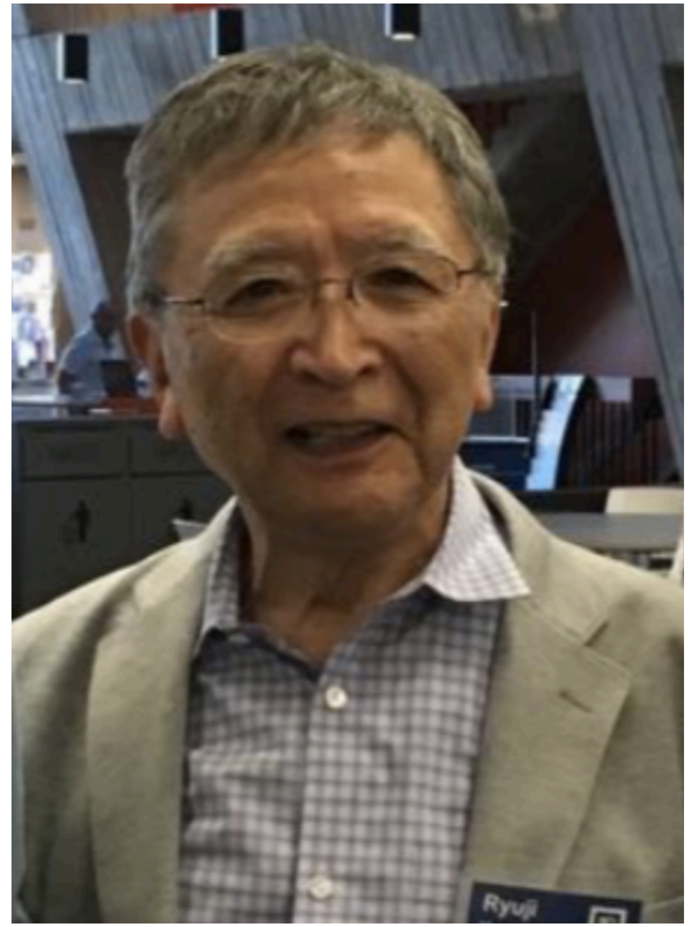
Cooling and Excitation Tests of a Thin 1 mϕ × 1 m Superconducting Solenoid Magnet

Hiromi HIRABAYASHI, Kimio MORIMOTO, Masayoshi WAKE, Ryuji YAMADA*
Akira YAMAMOTO, Shigeki MORI,† Ryozo YOSHIZAKI,†
Hisao KAWAKAMI†† Kunitaka KONDO,†† Katsuzo AIHARA,†††
Yoshiaki KAZAWA††† Hiroshi KIMURA,††† Hisao OGATA,†††
Ryusei SAITO,††† Shohei SUZUKI††† Yasuhiko MIYAKE††††

National Laboratory for High Energy Physics, Oho, Ibaraki 305
†Institute of Appl. Phys., Univ. of Tsukuba, Sakura, Ibaraki 302
††Institute of Physics, Univ. of Tsukuba, Sakura, Ibaraki 305
†††Hitachi Ltd., Hitachi 317
††††Hitachi Cable Ltd., Hitachi 317

(Received February 19, 1982; accepted for publication May 22, 1982)

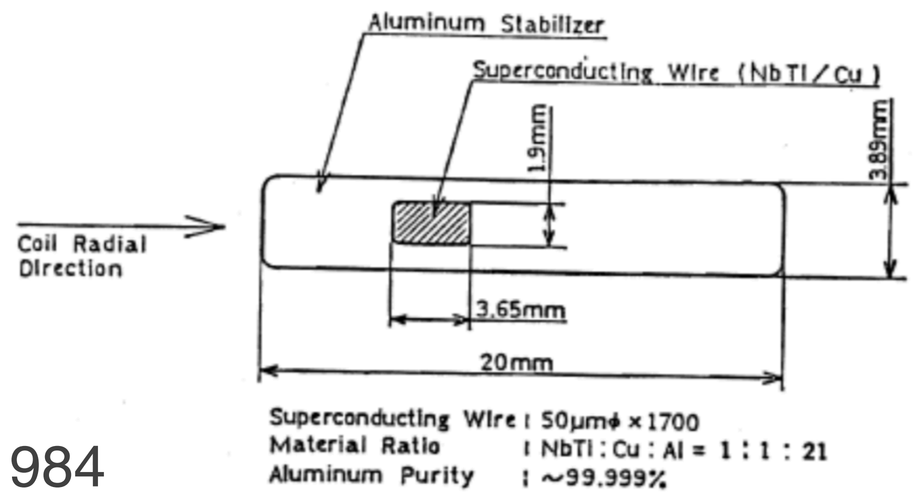
Cooling and excitation tests of a thin 1 mϕ × 1 m superconducting solenoid magnet were performed. Quench properties were measured after inducing quenches with a heater. The magnet has a single layer aluminum-stabilized NbTi/Cu superconductor of 269 turns and the forced flow cooling method of two-phase helium was used. The design excitation current of the magnet is 4.5 kA to give a uniform field of 1.5 T with the iron yoke. The magnet was excited up to 6 kA without any unforced quench in the second test in which the iron yoke was absent.



Ryuji Yamada

The CDF Superconducting Solenoid

- Aluminum stabilizer co-extruded with superconducting cable
  - Invented by Hitachi
  - Better mechanical bonding (point of failure of some previous magnet)



- Fabrication by Hitachi completed in 1984
- Important contributions by Shigeki Mori
- Successfully commissioned up to 1.5 Tesla with no quenches
- Then was limited to 1.4 Tesla due to a minor leak
- The leak was later repaired, but the field was kept at 1.4 T to preserve field map

The CDF Superconducting Solenoid

vs. its predecessors

		CELLO	CLEO	TPC	CDF
		PETRA DESY	CESR Cornell	PEP SLAC	TEVATRON
Bore					
Diameter	m	1.656	2	2.18	2.858
Length	m	3.4	3.25	3.3	5.067
Radial Thickness	Rad L	0.5	0.75	0.75	0.84
Central Field	Tesla	1.3	1	1.5	1.5
Current	kAmp	3.2	1.6	2.23	5
Stored Energy	MJ	5.4	9.4	10.9	30
Conductor					
Superconductor		NbTi/Cu	NbTi/Cu	NbTi/Cu	NbTi/Cu
Stabilizer			Al(2ndary)	Al/Cu(2ndary)	Al
NbTi-CuAl ratio					1:01:21
Cross Section	$(mm)^2$	2.24 x 10.6	1.83 x 3.43	1 x 3.7	3.89 x 20
Fabrication Process		NbTi soldered	NbTi/Cu	NbTi/Cu	NbTi/Cu-Al
		on Cu			Co-extruded
Frame		Al Bobbin	Al Bobbin	Al Bobbin	Outer Frame
Completion		1979	1981	1983	1984

Significant step forward in magnet technology

CDF Solenoid coil winding at Hitachi


HeavyLift


HeavyLift
G-BEPS


米国FNAL納超電導ソレノイド
成田 シカゴ間 チャーター輸送
株)日立製作所・日立運輸(株)・日通航空(株)
1984年7月16日
MTR
1505


SIZE LOAD

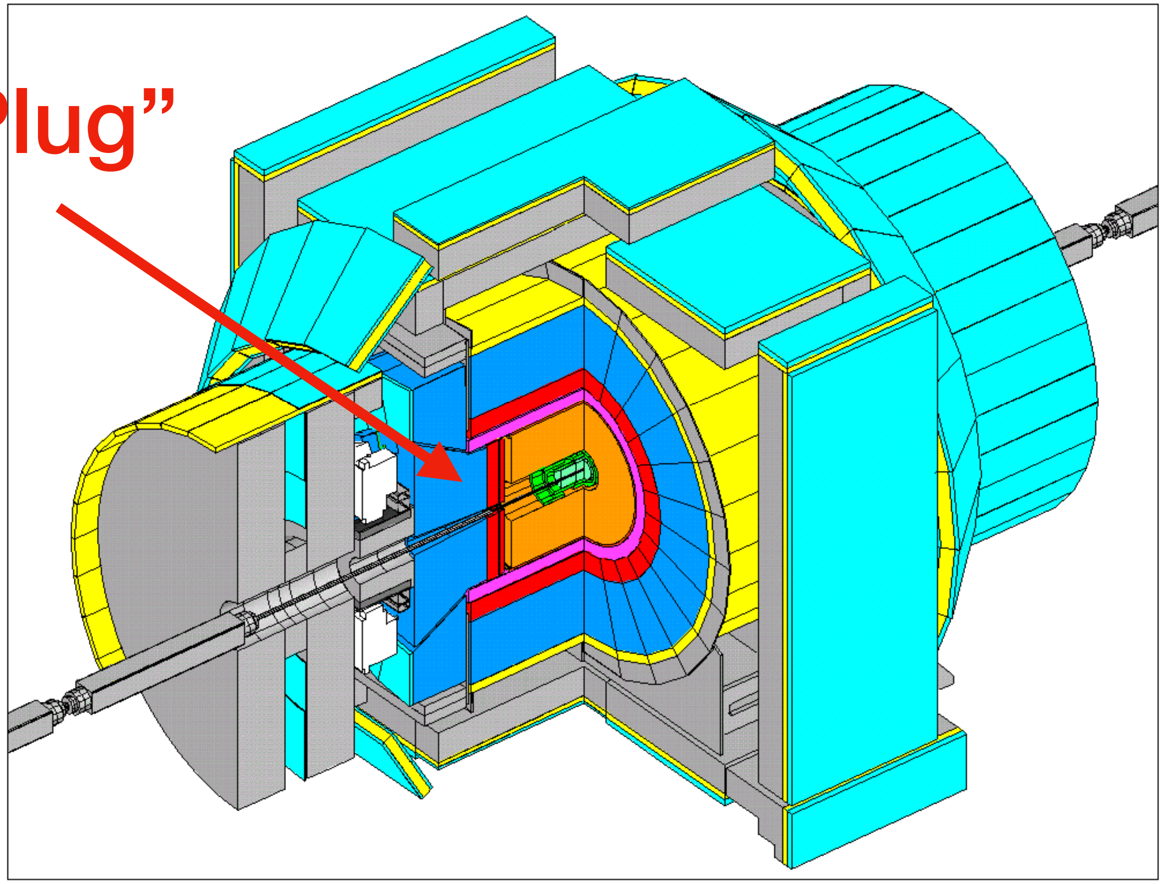

LIFT-A-LOFT

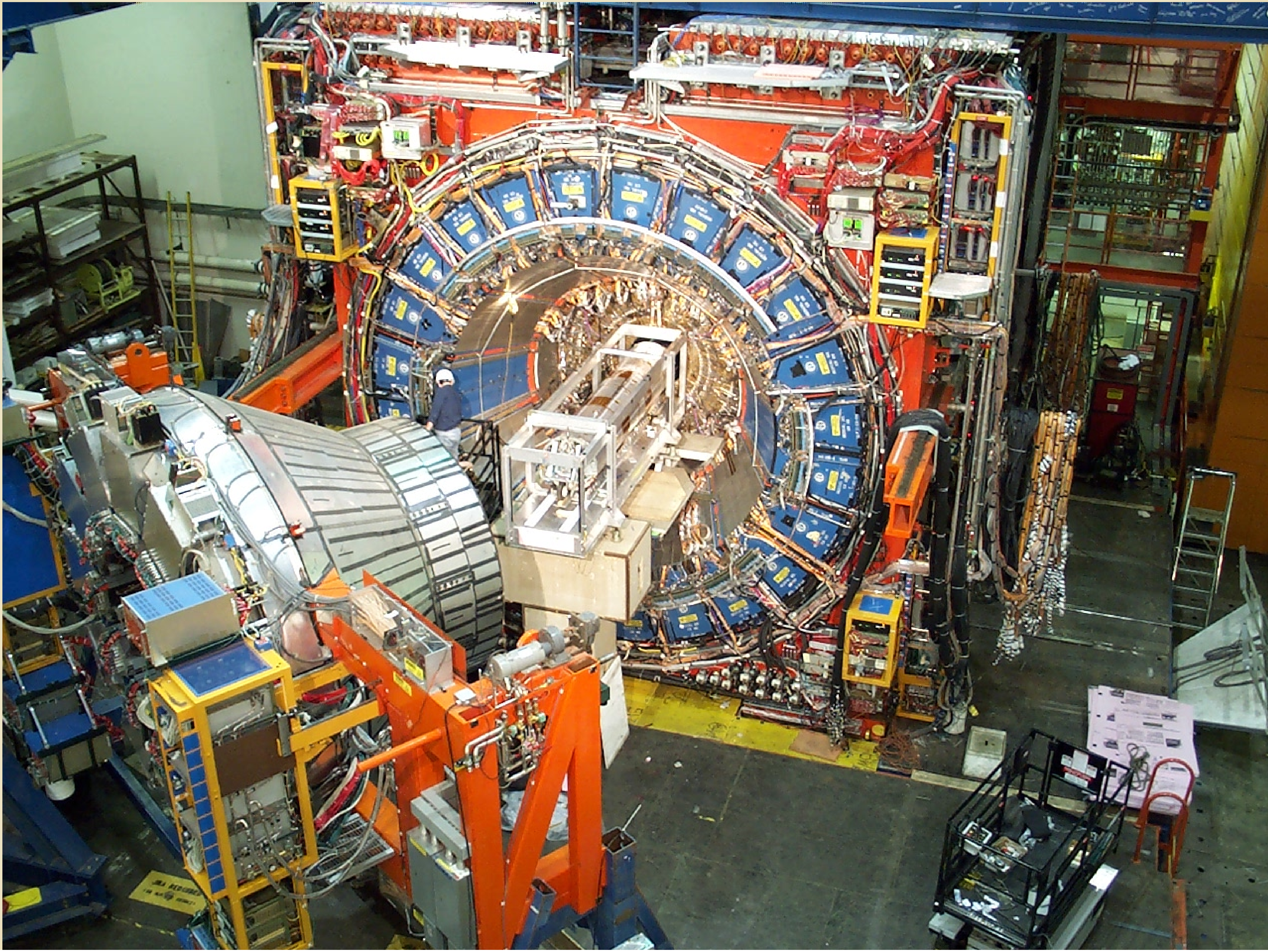
The Plug Electromagnetic Calorimeter

(Run I : 1987-1996)

The Plug Electromagnetic Calorimeter

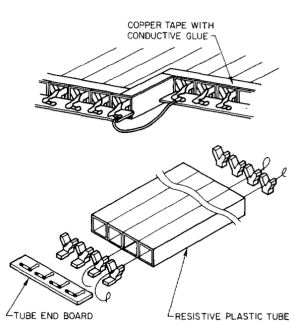
-

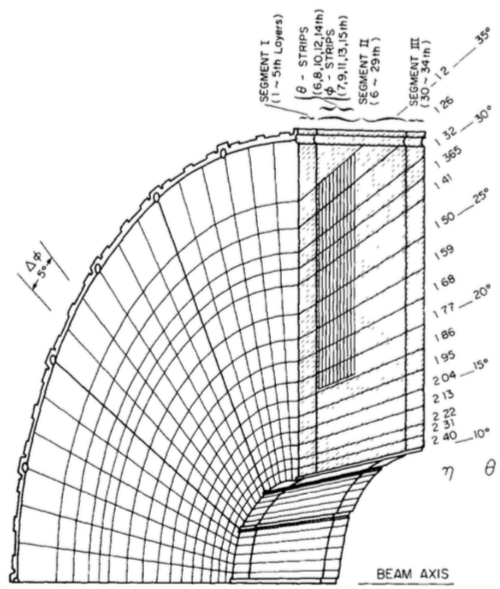


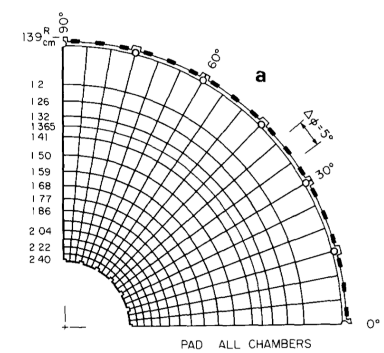


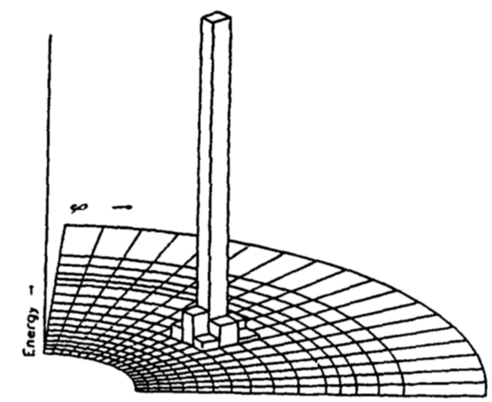
The Plug Electromagnetic Calorimeter

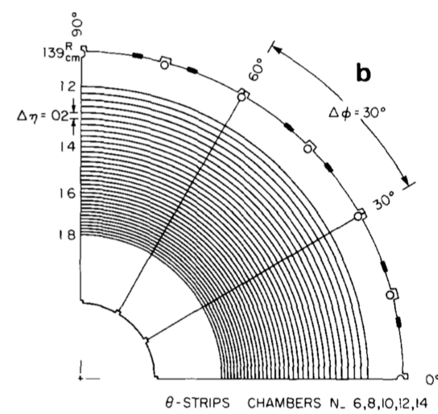
- Conductive plastic proportional tubes
  - sandwiched with lead absorber layers
- Capacitive coupling cathode readout
- Pads and strips etched on printed circuit boards

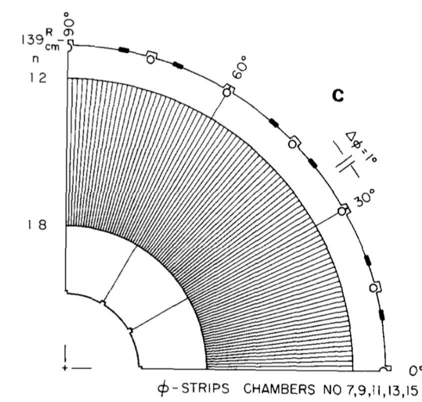












The Plug Electromagnetic Calorimeter

Nuclear Instruments and Methods in Physics Research A267 (1988) 280–300
North-Holland, Amsterdam

CDF END PLUG ELECTROMAGNETIC CALORIMETER USING CONDUCTIVE PLASTIC PROPORTIONAL TUBES

Y. FUKUI and M. MISHINA

National Laboratory for High Energy Physics, KEK, Oho-machi, Tsukuba-gun, Ibaraki-ken, 305, Japan

Y. HAYASHIDE, S. KANDA, S. KIM, K. KONDO, S. MIYASHITA, H. MIYATA, Y. MORITA, M. SHIBATA and K. TAKIKAWA

Institute of Physics, University of Tsukuba, Niihari-gun, Ibaraki-ken, 305, Japan

S. MORI

Faculty of Engineering Science, University of Tsukuba, Niihari-gun, Ibaraki-ken, 305, Japan

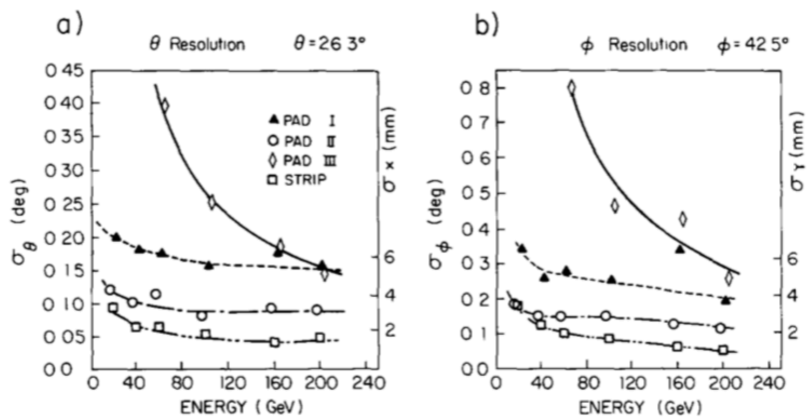
Y. MURAKI

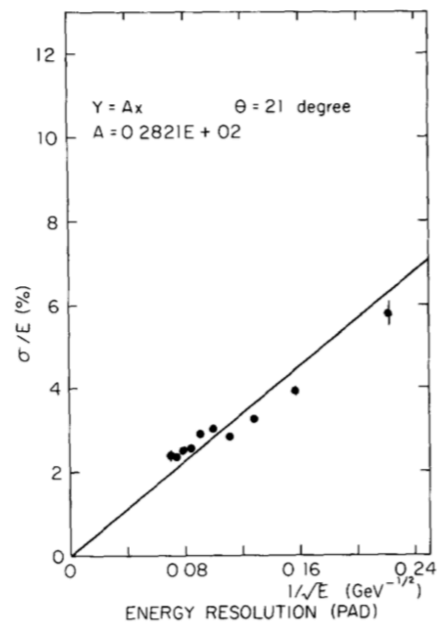
Institute for Cosmic Ray Research, Tokyo University, Midori-cho, Tanashi-shi, Tokyo, 188, Japan

Received 6 August 1987

$$\text{energy resolution} \approx \frac{28\%}{\sqrt{E}}$$

$$\text{position resolution} \approx 2\ mm$$

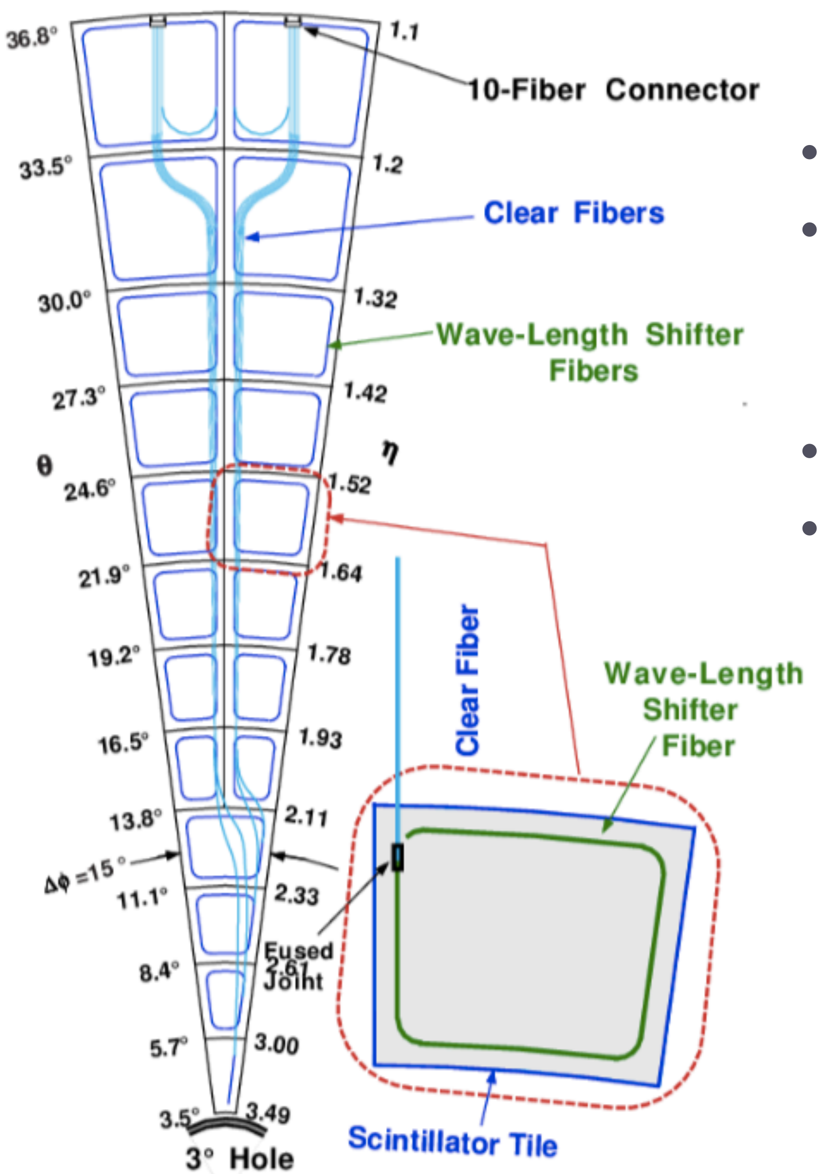




The Upgraded Plug Electromagnetic Calorimeter

(Run II : 2001-2011)

The Upgraded Plug Electromagnetic Calorimeter



- Proportional tubes worked well for Run I
- In Run II the Tevatron was upgraded to higher luminosity and higher bunch crossing frequency
- Detector needed to be faster
- A Japanese team (Tsukuba-Keke-Saga-Osaka City), in collaboration with Fermilab, worked to refine a technique pioneered by UA1, that is using scintillator tiles and light collection through wavelength shifter fibers.

The Upgraded Plug Electromagnetic Calorimeter

ELSEVIER
Nuclear Instruments and Methods in Physics Research A 480 (2002) 524–546
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

The CDF plug upgrade electromagnetic calorimeter: test beam results

M. Albrow[a], S. Aota[b], G. Apollinari[c], T. Asakawa[b], M. Bailey[d], P. de Barbaro[e], V. Barnes[f], K. Biery[a], A. Bodek[e], L. Breccia[g], R. Brunetti[g], H. Budd[e], D. Cauz[h], L. Demortier[c], I. Fiori[g], M. Frautschi[i], Y. Fukui[j], O. Ganel[i,1], Y. Gotra[k,2], S. Hahn[a], T. Handa[l], K. Hatakeyama[m,3], H. Ikeda[b], G. Introzzi[n], J. Iwai[m], T. Kikuchi[b], S.H. Kim[b], W. Kowald[o], A. Laasanen[f], J. Lamoureux[p], M. Lindgren[q], J. Liu[e], S. Lusin[r], P. Melese[c,4], H. Minato[b], S. Murgia[s], H. Nakada[b], J. Patrick[a], G. Pauletta[h], W. Sakumoto[e], L. Santi[h], Y. Seiya[b,*], A. Solodsky[c], R. Wigmans[i], S. Zucchelli[g]

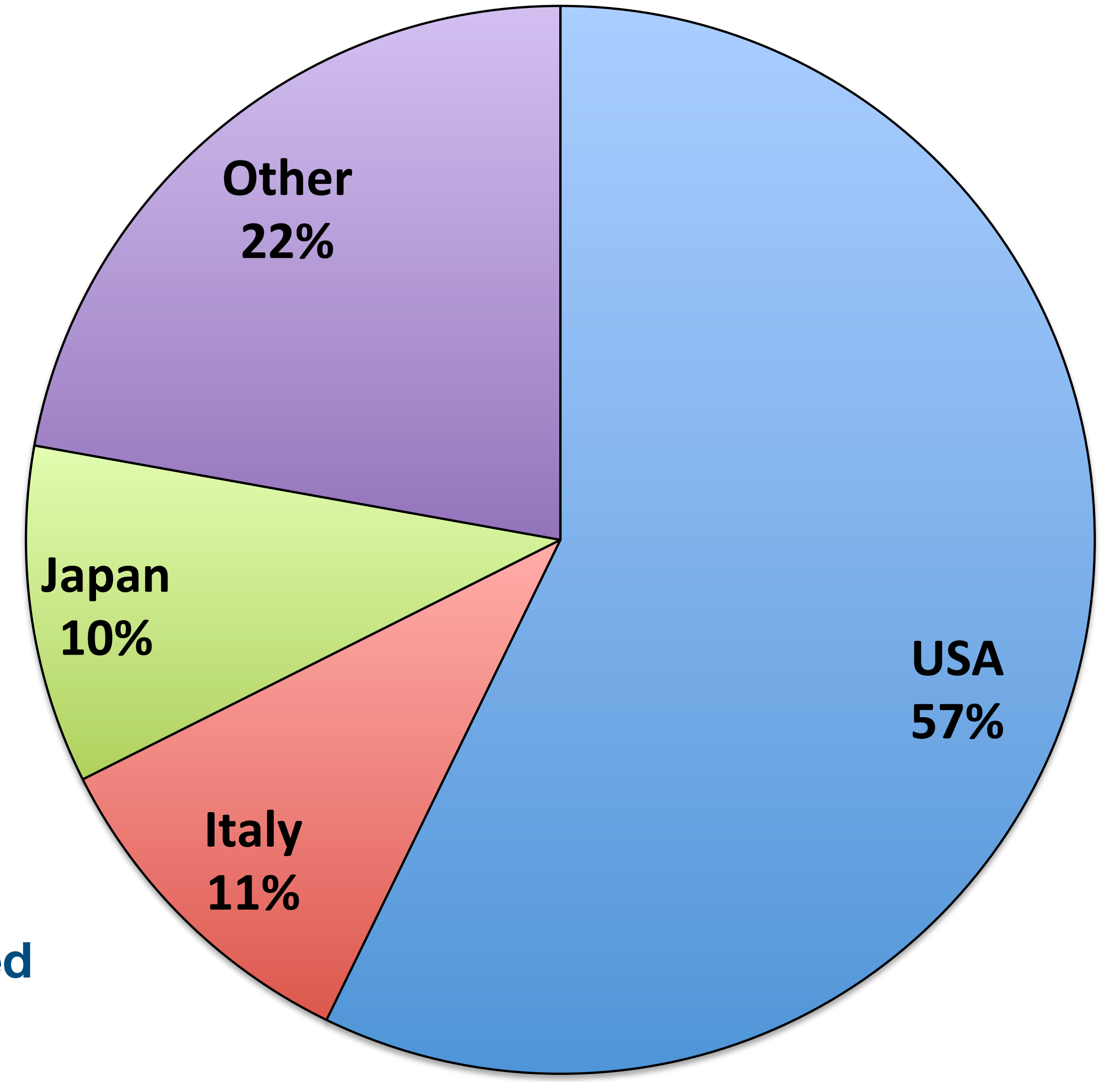
$$\text{energy resolution} \approx \frac{16\%}{\sqrt{E}}$$

$$\text{position resolution} \approx 5\ mm$$

Physics analysis

CDF PhD Theses
by country

USA	369
Italy	67
Japan	66
Other	143
TOTAL	645



compare to ~700 papers published

Dynamical Likelihood

Kuni Kondo

Journal of the Physical Society of Japan
Vol. 62, No. 4, April, 1993, pp. 1177–1182

Dynamical Likelihood Method for Reconstruction of Events with Missing Momentum. III. Analysis of a CDF High P_T $e\mu$ Event as $t\bar{t}$ Production

Kunitaka KONDO, Takeshi CHIKAMATSU and Shin-Hong KIM

Institute of Physics, University of Tsukuba, Ibaraki 305

(Received November 12, 1992)

A high P_T dilepton event observed in 1.8 TeV $\bar{p}p$ collisions at CDF is analyzed with Dynamical Likelihood Method. A likelihood function for the dilepton decay channel in the $t\bar{t}$ production is given. We illustrate how the method can be applied to eliminate some typical Standard Model processes that could generate spurious events. By assuming that the event comes from the $t\bar{t}$ production, the maximum likelihood mass and the expectation value of mass are evaluated as 124 and 136 GeV/c^2, respectively, and a mass range at the 68% confidence level is estimated to be (119,151) GeV/c^2, including measurement errors.

Final Considerations

- Japan's contribution to CDF was crucial
  - It is not obvious that the CDF experiment would have received support without the early establishing of the international collaboration with Japan. Consequently the whole Tevatron program might have been in danger

- Several individuals from Japan were key to the success of CDF. These include **Kuni Kondo, Masa Mishina, Ryuji Yamada, Shigeki Mori**

  and please forgive me for all those I am forgetting…

- Some of Japan's contributions to CDF turned to be in fact contributions to the whole field
  - For example:
    - ATLAS and CMS magnets designed and built in Japan
    - Scintillator light collection using wave shifter fibers is widely used today

my personal special thanks go to

Giorgio Bellettini

Masa Mishina

Alvin Tollestrup

for their invaluable help in putting together this talk