Physics at the Fermilab Tevatron Collider

1984: discovery of the W, Z bosons at CERN, $\sqrt{s}$ = 630 GeV.
1985: start of the Tevatron Collider, $\sqrt{s}$ = 1800 GeV.
1988-89 : first physics run ("run 0") of the Tevatron.
1991: shut down of the CERN SpS collider.
1992-95: Tevatron run1 and discovery of the top quark.
2001: start of Tevatron run2, $\sqrt{s}$ = 1980 GeV.

Spring 2002: Tevatron run2 is on-going.
For several year to come, discovery of the Higgs boson and of new particles or structures indicative of physics beyond the standard model will only be possible at the Tevatron Collider.

THE RUN1 TEVATRON

Two machines ran in the same tunnel of 1000 m. radius. The superconducting 900 GeV Tevatron ring was below the 400 GeV Main Ring.

At CDF the Main Ring beam was deviated upwards and run through the experimental hall ~ 6m above the detector. During collider operation it ran at 120 GeV onto the antiproton production target.

At D0 the Main Ring crossed the detector calorimeter.

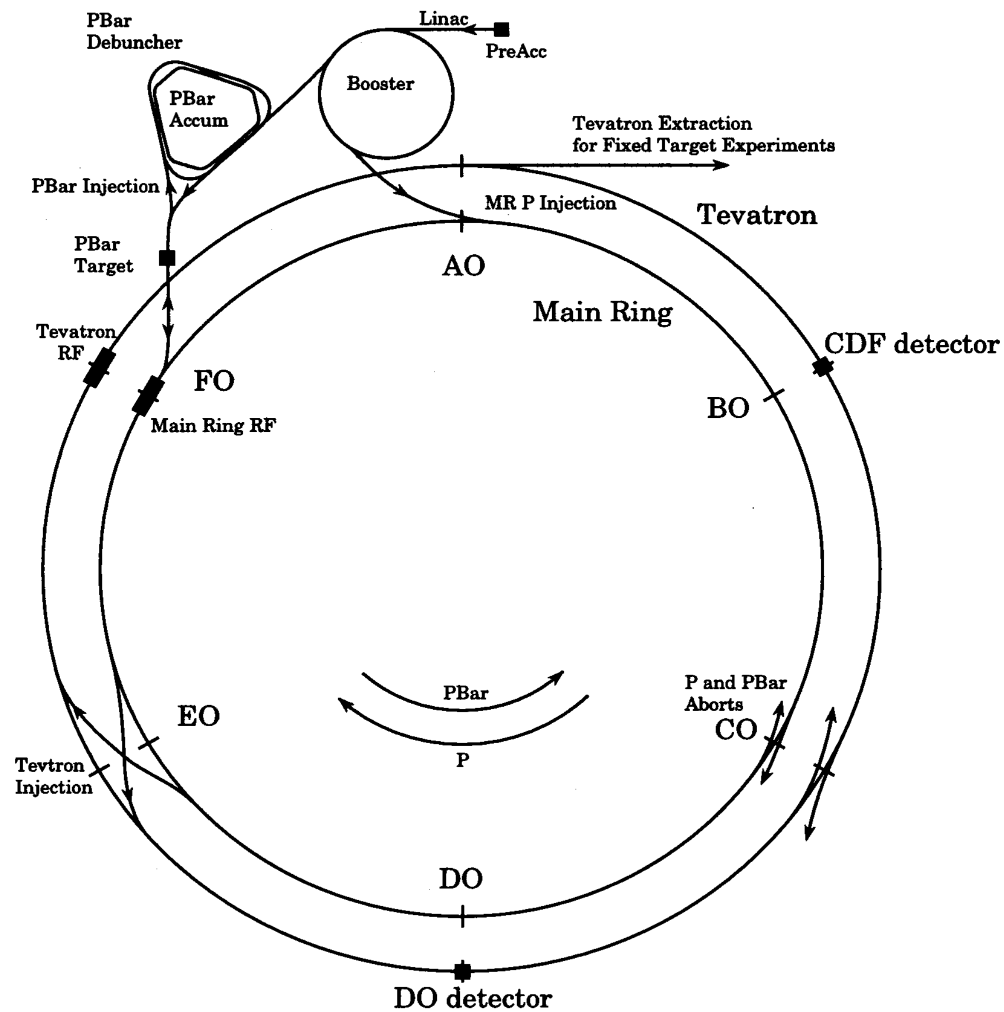


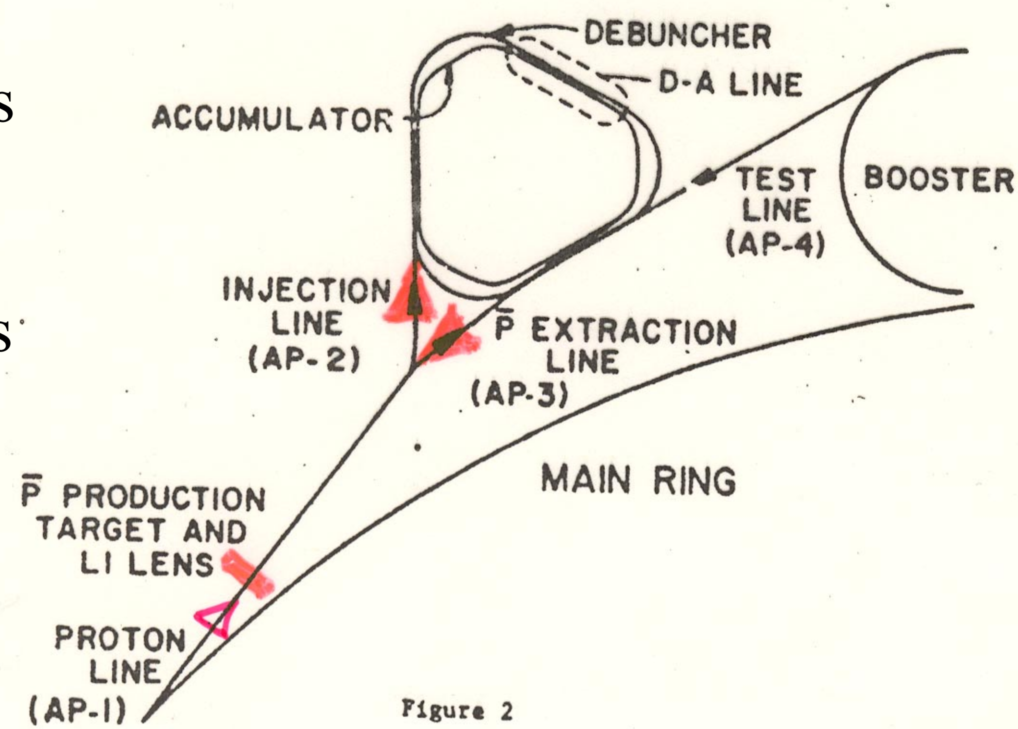
Figure 2.1: The Tevatron collider and the system of pre-accelerators.

PBAR SOURCE CICLE

a) ~$3x10^{12}$ 120 GeV protons on production target every 2 s.

b) ~$7x10^{7}$ 8 GeV antiprotons into debuncher every 2 s.

c) Δp/p from ~4% to ~0,2% in ~2s by precooling in debuncher



d) transfer bunches and cool them in the accumulator for many hours. Cold 8 GeV pbars injected into main ring (into main injector in run2) accelerated to 150 GeV and transferred to Tevatron

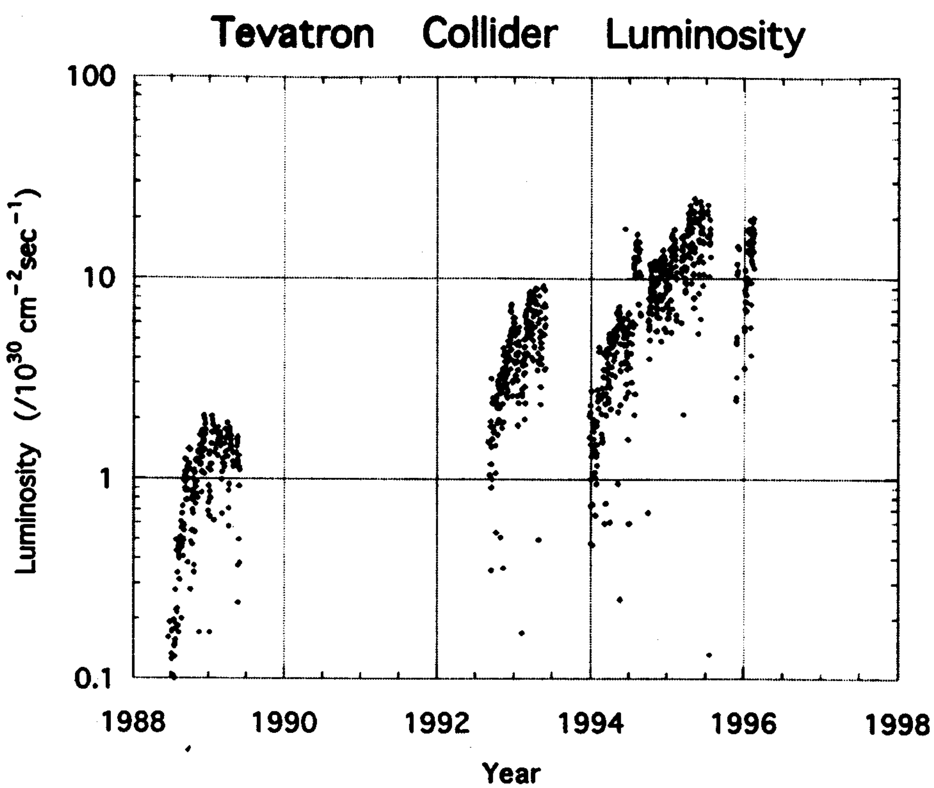
e) 3 bunch Tevatron operation in 1988, 6 bunch in 1992, 36 bunch in 2001. ~ 120 bunch operation planned in 2006.

24 events were collected by CDF in a test run in 1985.

~4,7 pb^{-1} were integrated in 1988-1989 (run0).

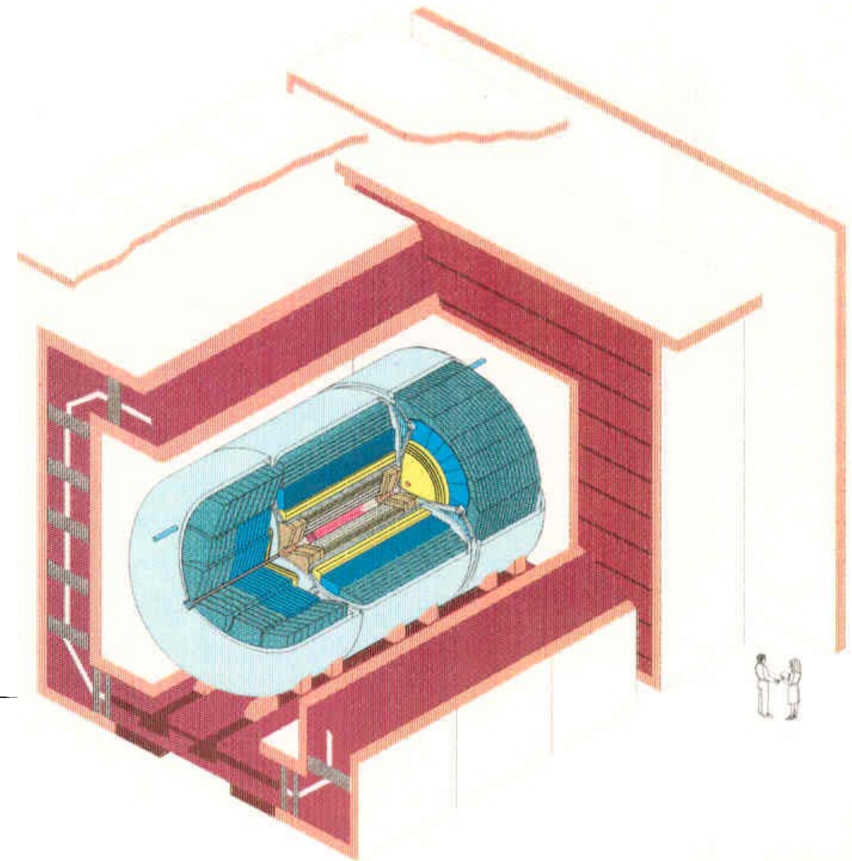
~110 pb^{-1} were integrated in 1992-1995 (run1).

Tevatron Collider Luminosity History



D0
DETECTOR PARAMETERS

- TRACKING
  - No magnetic field
  - $R - \phi$ resolution $\approx 200\ \mu$m (60 μm Vertex Detector)
  - Z-Vertex resolution ≈ 6 mm
- CALORIMETRY
  - Coverage $|\eta| < 4(\Theta > 2^0)$
  - $\Delta\eta \times \Delta\phi$=0.1 × 0.1
  - Longitudinal Segmentation 8-10 layers
  - Electron energy resolution 15 % $\sqrt{E}$ (for top analysis use electrons in fiducial region $|\eta| < 2.5$).
  - Hadron Energy Resolution 50 % $\sqrt{E}$
  - Jet Energy resolution 80 % $\sqrt{E}$
- MUON SYSTEM
  - Coverage $|\eta| < 3.3(\Theta > 5^0)$ (for top analysis use muons in fiducial region $|\eta| < 1.7$).
  - Punchtrough $< 10^{-4}$
  - Modest Momentum resolution: $\sigma_p/p = \sqrt{(0.2)^2 + (0.01 \cdot p)^2}$



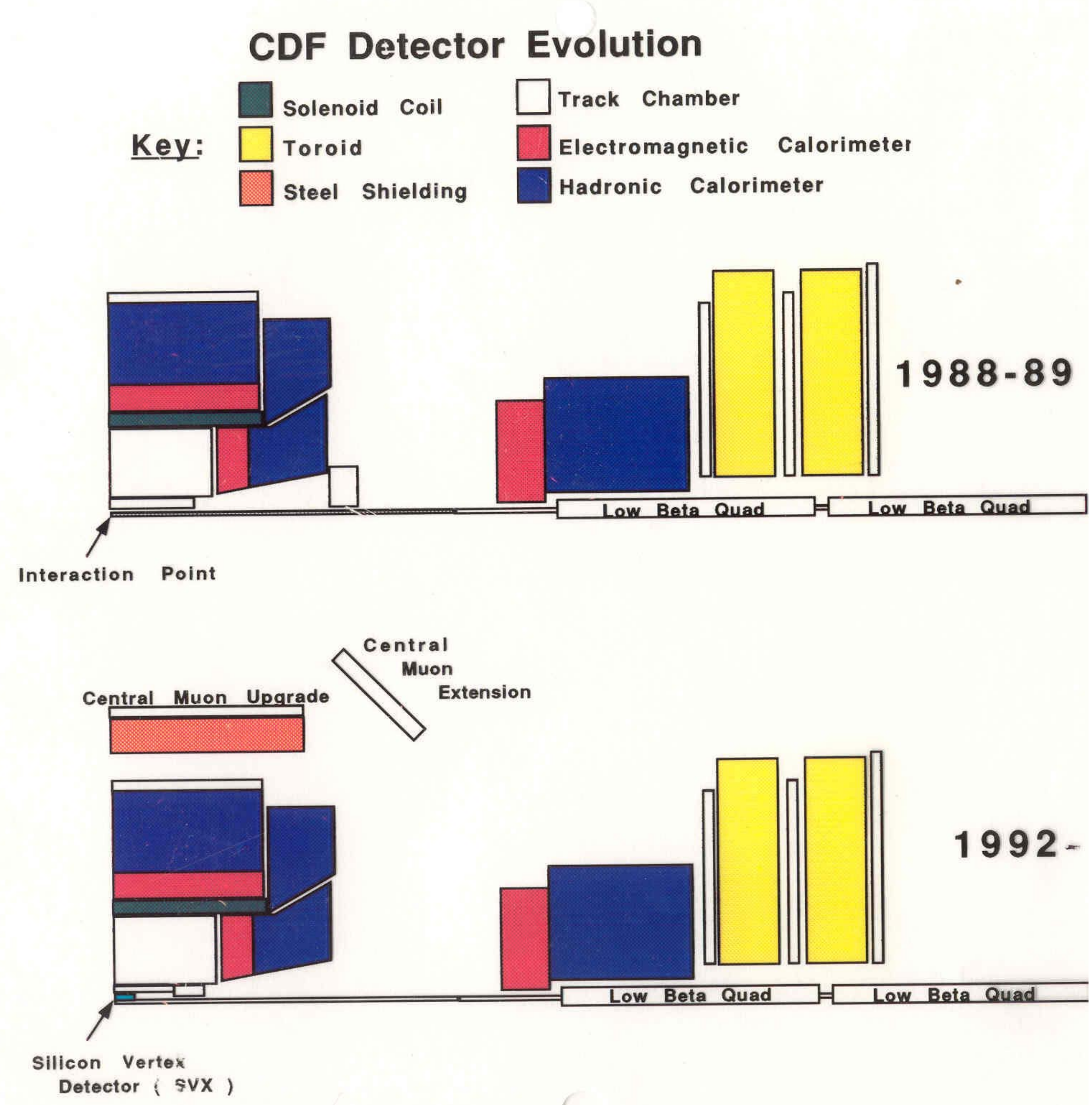
Electrons detected at $|\eta| < 2{,}5$. Muons detected at $|\eta| < 3{,}3$ and momentum analyzed by 3 telescopes of proportional drift tubes in front, inside and on the rear of magnetized toroids.

Between run0 and run1 a number of important additions were made to CDF:

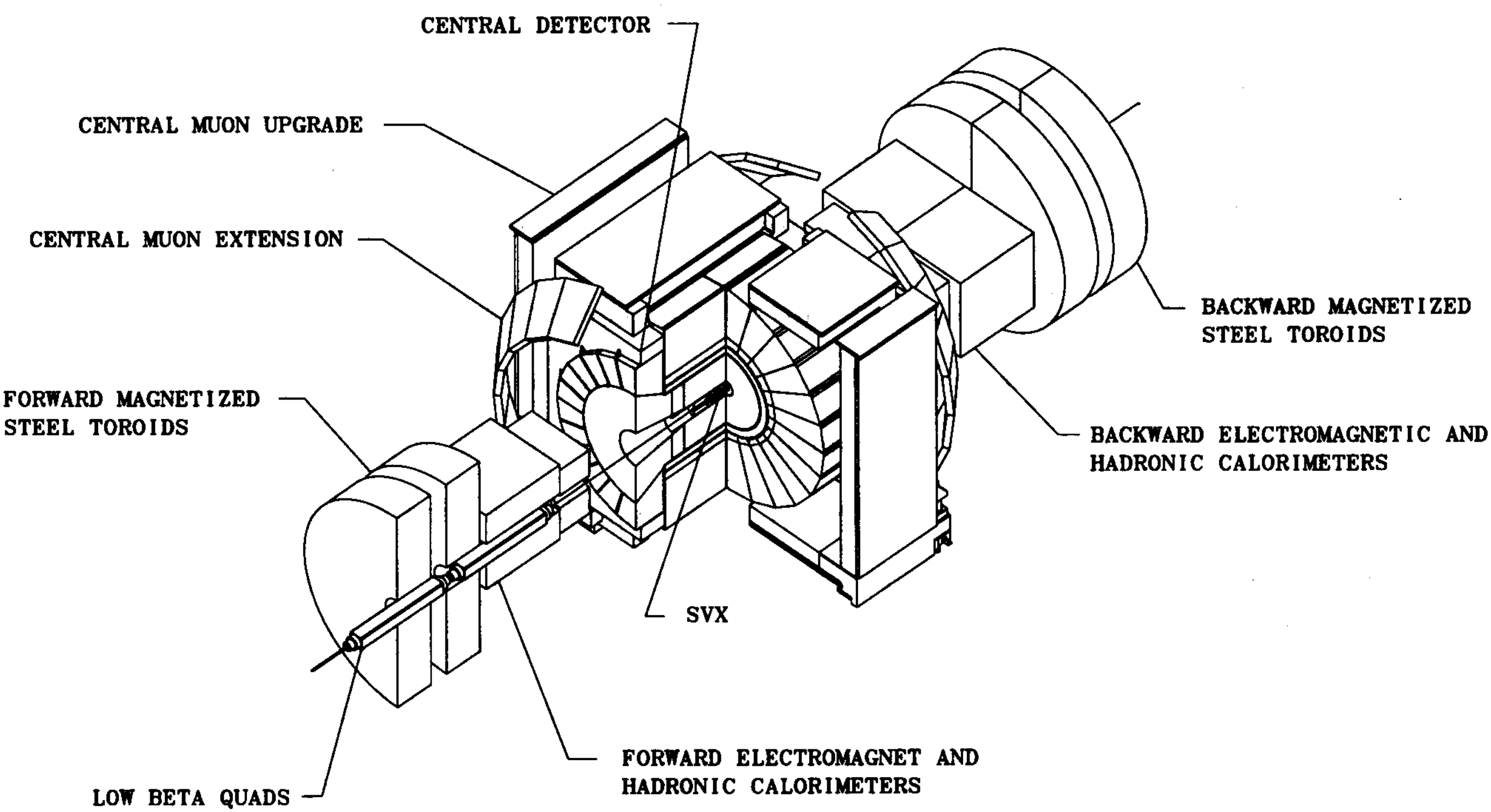
a) additional absorber and muon tracking chambers at large angles

b) extended muon coverage at intermediate angles

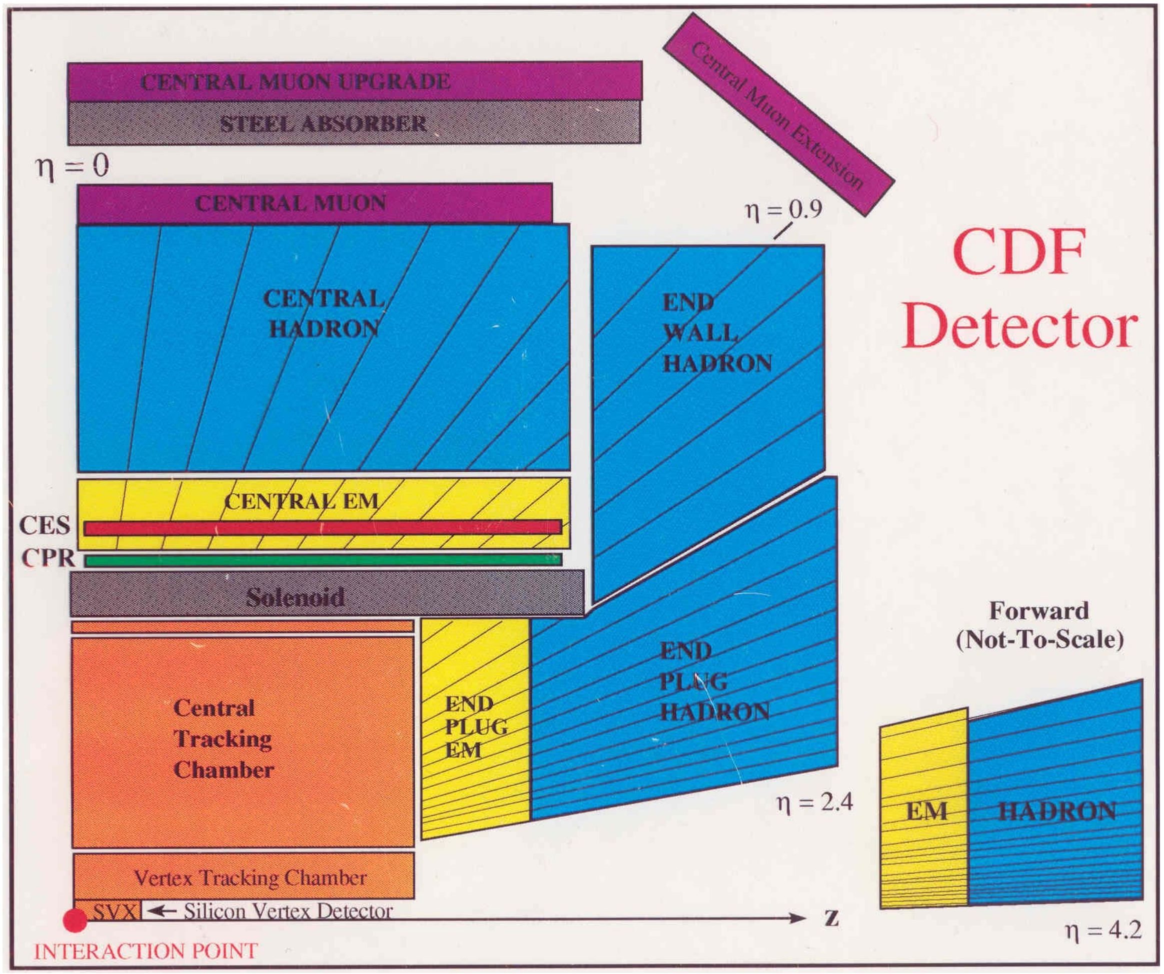
c) most important, a silicon vertex detector.



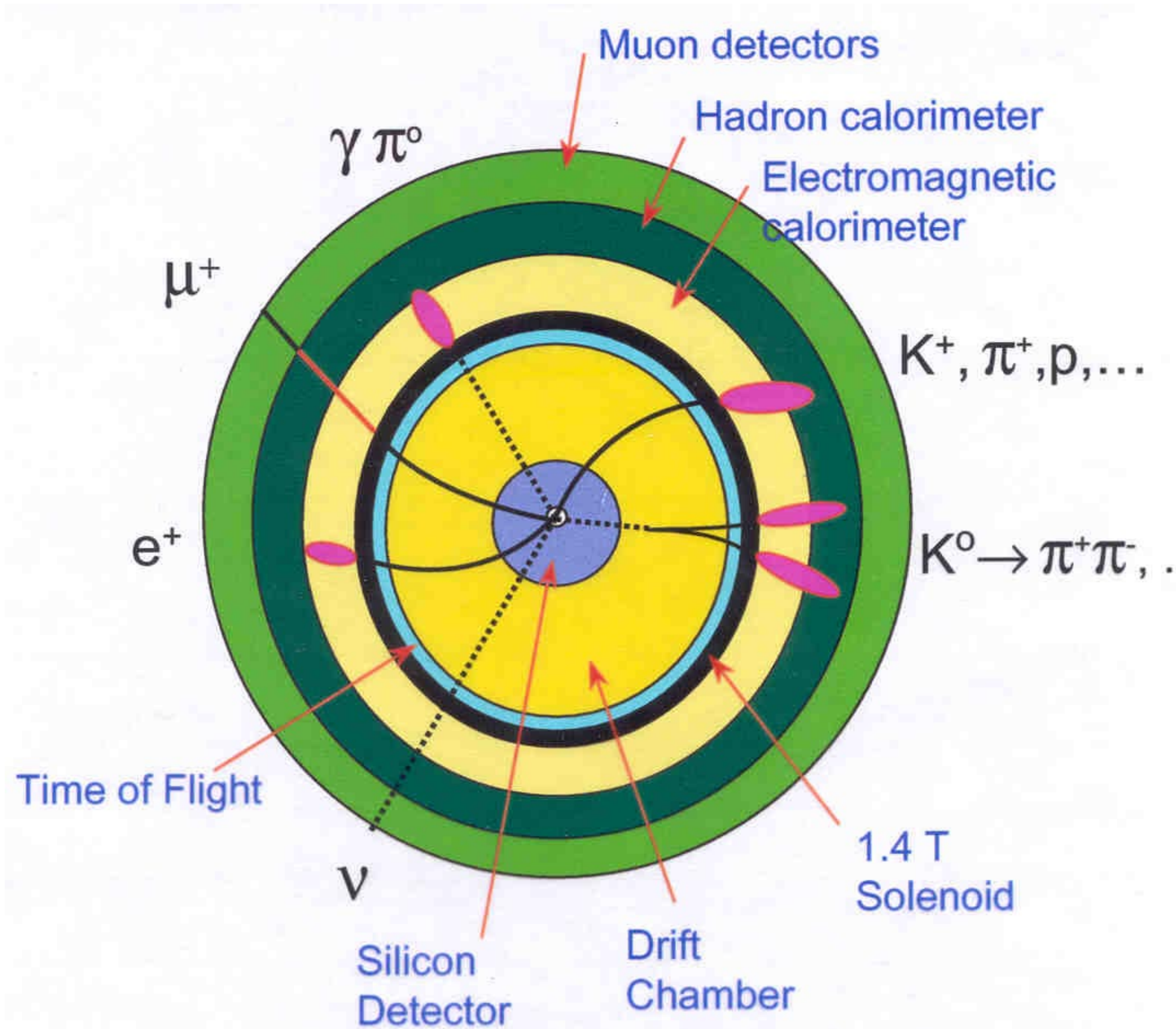
THE RUN1 (1992-1995) CDF DETECTOR



luminous region	$\sigma_z \sim 30$ cm
beam size	$\sigma_r \sim 30$ μm
silicon layers	4 single-sided
COT superlayers	8 axial, 4 stereo
track resolution	$\sigma_{r\phi} \sim 20$ μm $\sigma_z \sim 1$ cm
B field	1.4 T
momentum resolution	$0.1\% \times p_T$
CEM calorimeter	lead/scintillator
CES shower max.	axial wires, strips
CHA calorimeter	iron/scintillator
forward cal.	gas sampling
μ detection	multilayer drift tubes, scintillator



All calorimeters are split into η,φ projective towers pointing to the source. The sensitive medium was plastic scintillator in the central and wall calorimeters, and proportional chambers (run1) in the plug and forward calorimeters.

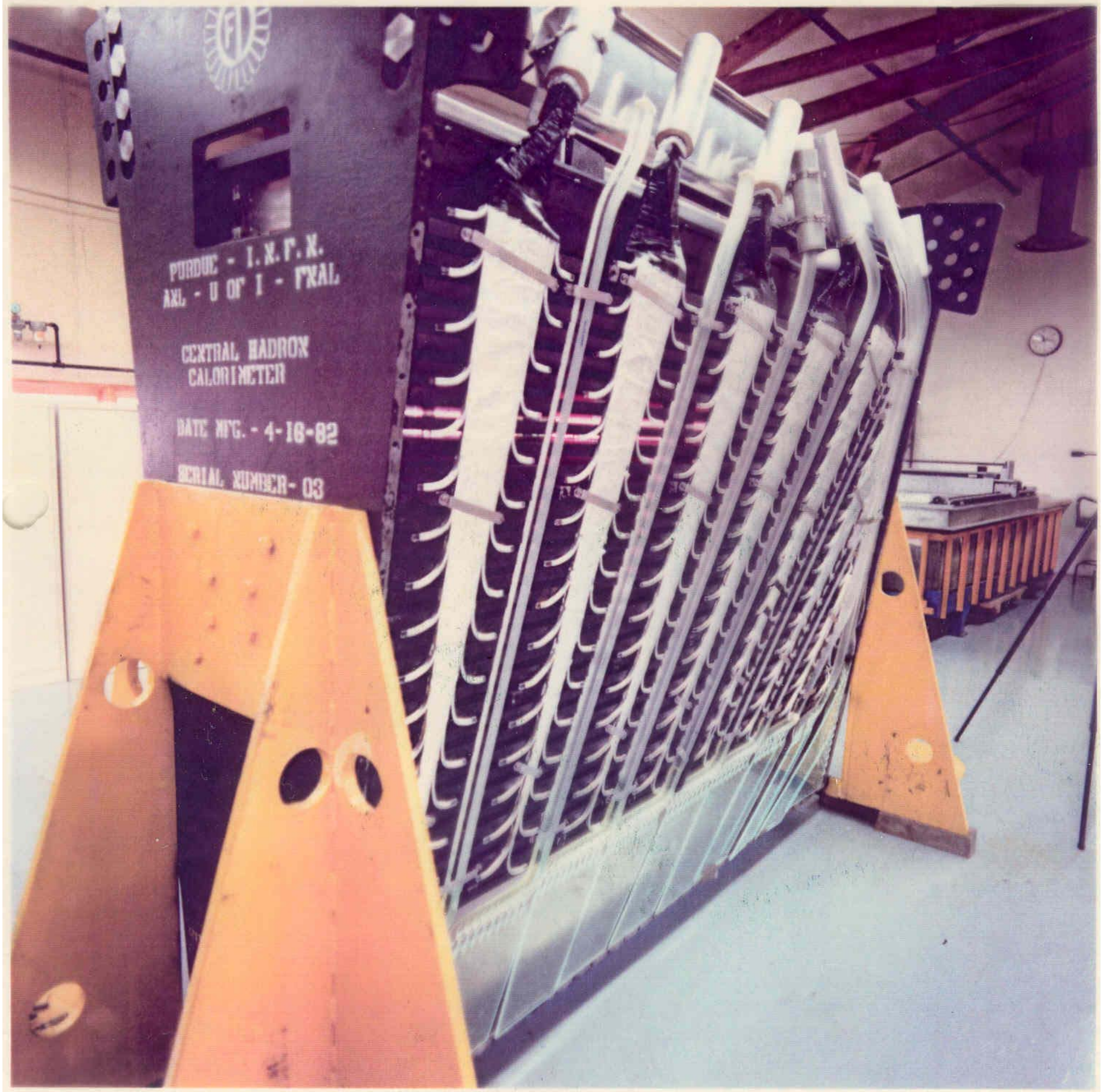


The CDF detector shells select e, μ, hadrons and $E_{t,miss}$

CENTRAL CALORIMETER WEDGES

Scintillators, light guides and tubes of the central and wall hadron calorimeter were a major contribution by INFN to CDF.

48 wedges were arranged in 4 π-wide “roman arches” left and right of the coil.



Central Calorimeter
module with Light
Guide 9/28/82

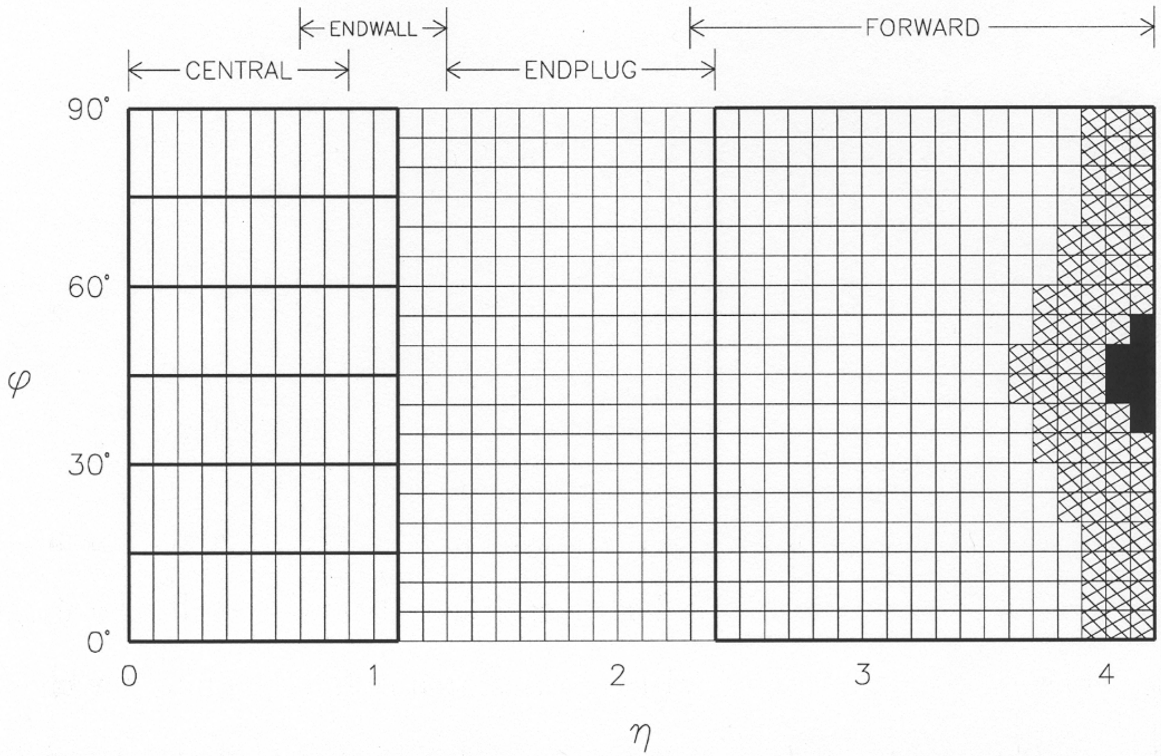


Figure 2.5: Map of the calorimetry coverage which shows the η-ϕ coverage of the separate calorimeters. The figure shows the sections from $\phi = 0°$ to $90°$ and η from 0.0 to 4.2 (East side). The small squares represent the tower segmentation of the calorimeters.

The central hadron calorimeter covers $|\eta| < 0{,}9$. The central e.m. covers $|\eta| < 1{,}2$ and is backed by the hadron walls at $|\eta| > 0{,}7$.
The plug calorimeter at $1{,}2 < |\eta| < 2{,}4$ is split in twelve 30° sectors.
The forward calorimeter is split in quadrants and extends to $|\eta| < 4{,}2$.

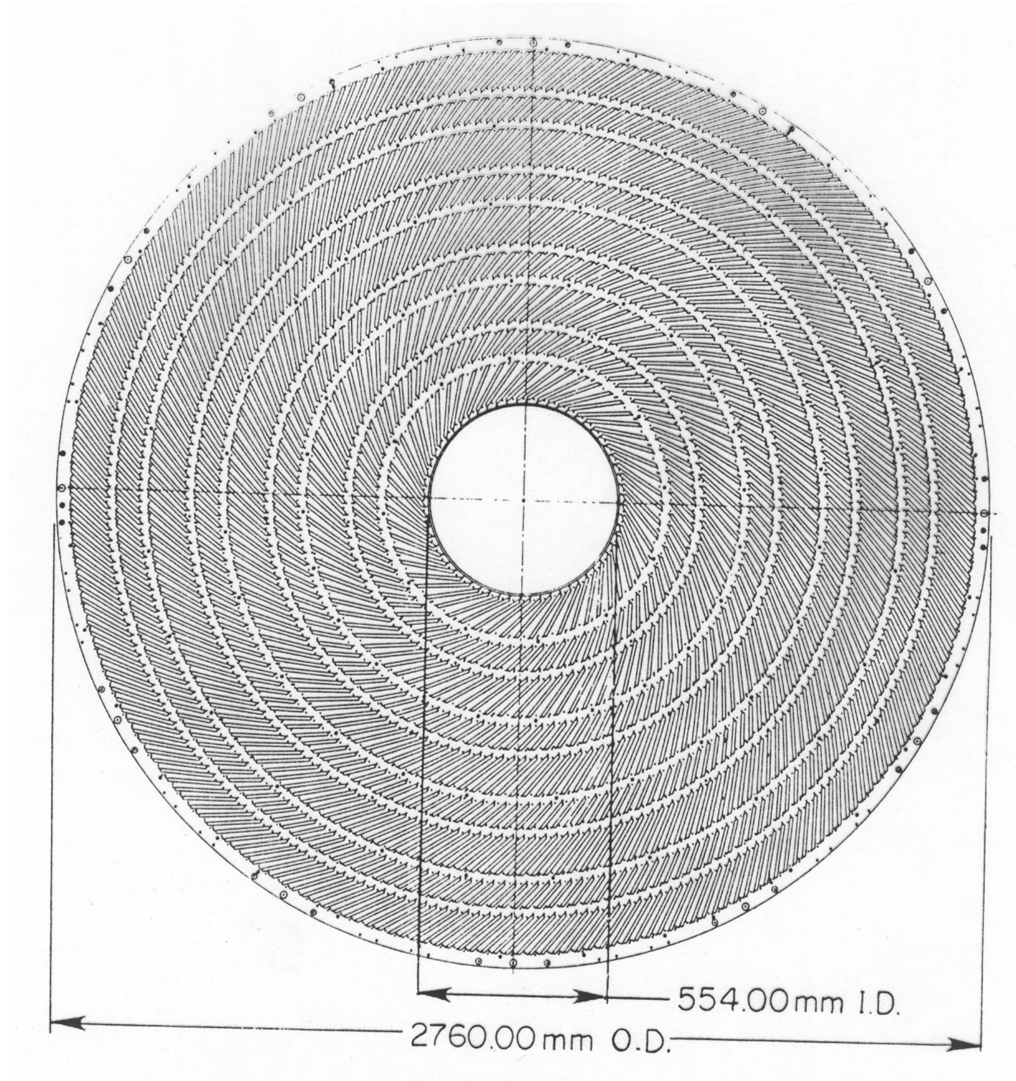
CENTRAL TRACKING CHAMBER

Cells are tilted in order to have the electrons in the magnetic field drifting perpendicularly to the camber radius.

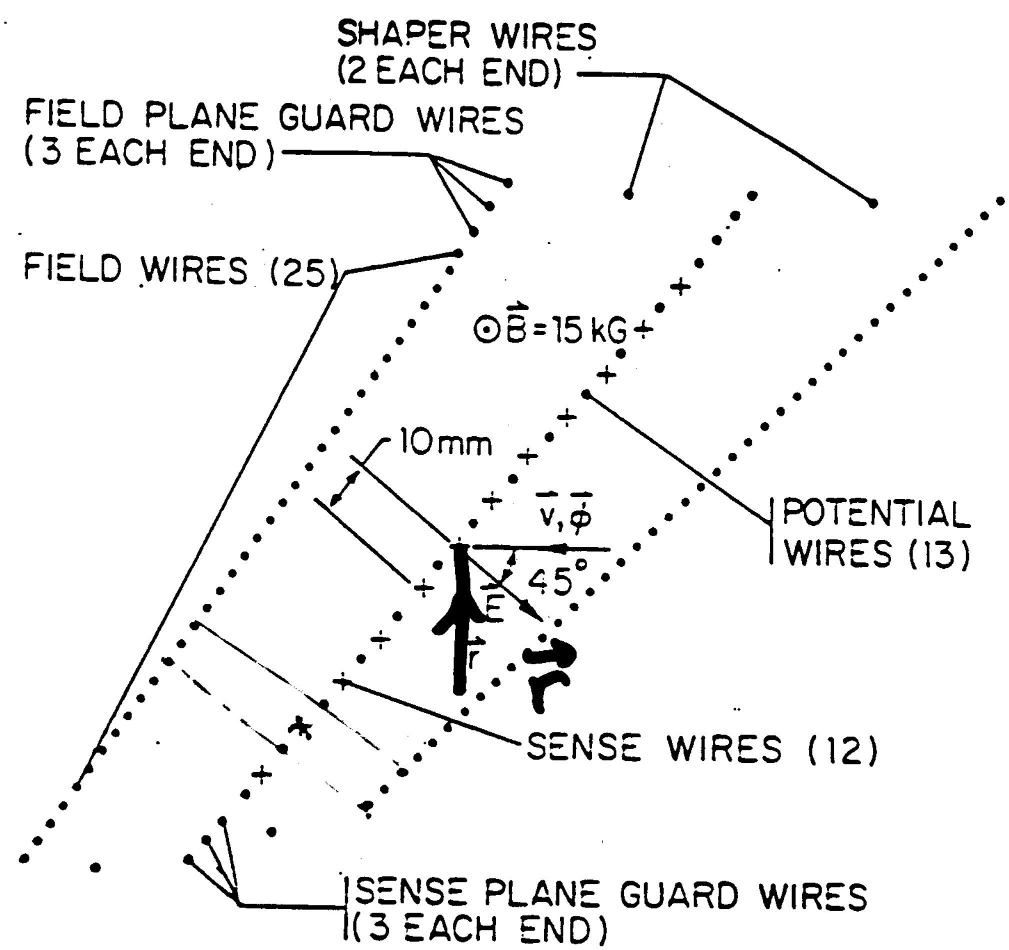
5 axial, 4 2°-stereo superlayers

4 cm wide drift cells, ~ 800 ns maximum drift time in 50%Ar-50%$N_2H_{8,}$

~6,500 sense wires, ~29,000 field wires, 84 radial measurements



Electrons heading towards the field wires with an inverse speed of 20 μs per mm, drift transverse to the chamber radius in the 1,41 T solenoid field.



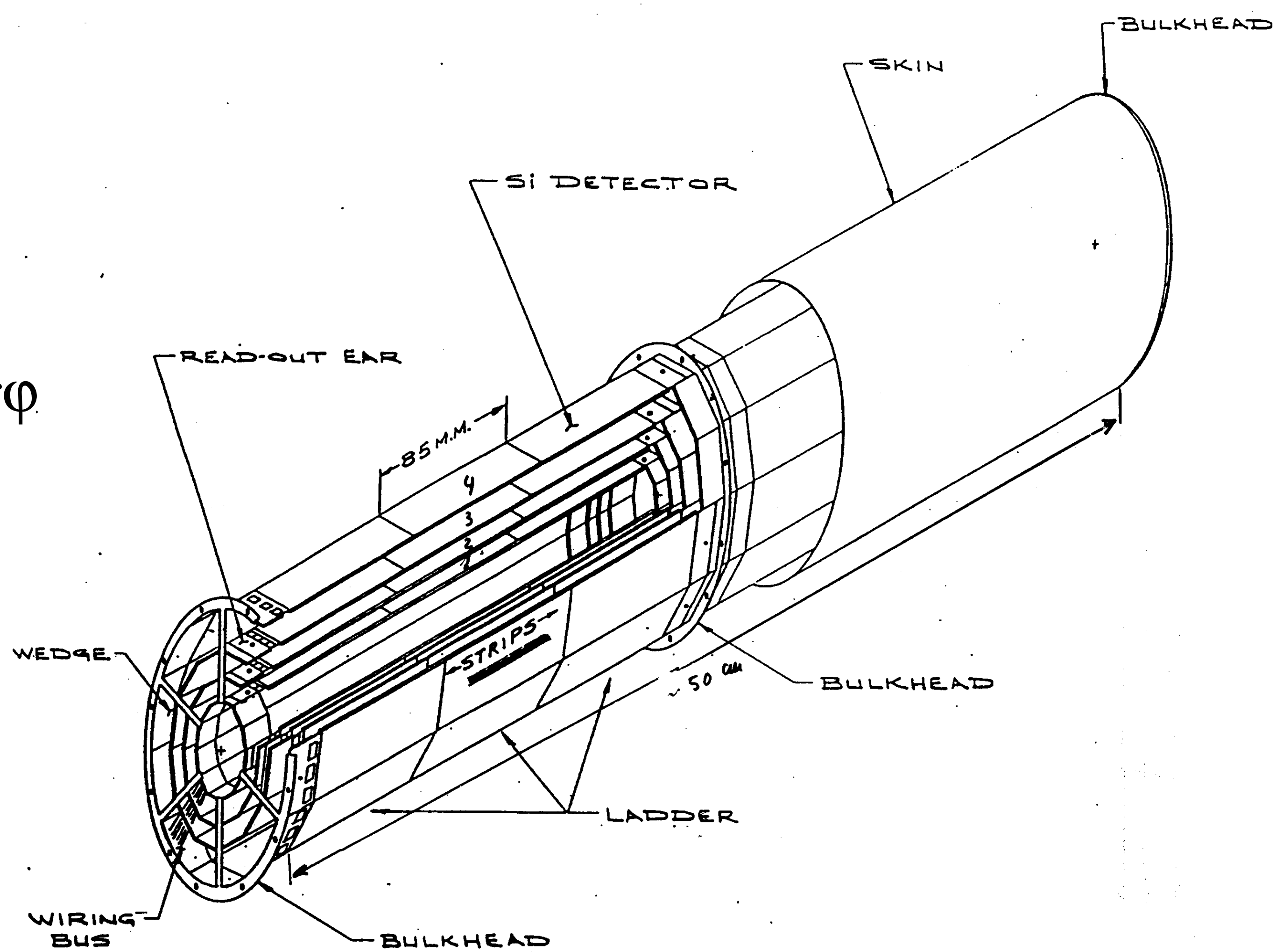
SILICON VERTEX DETECTOR

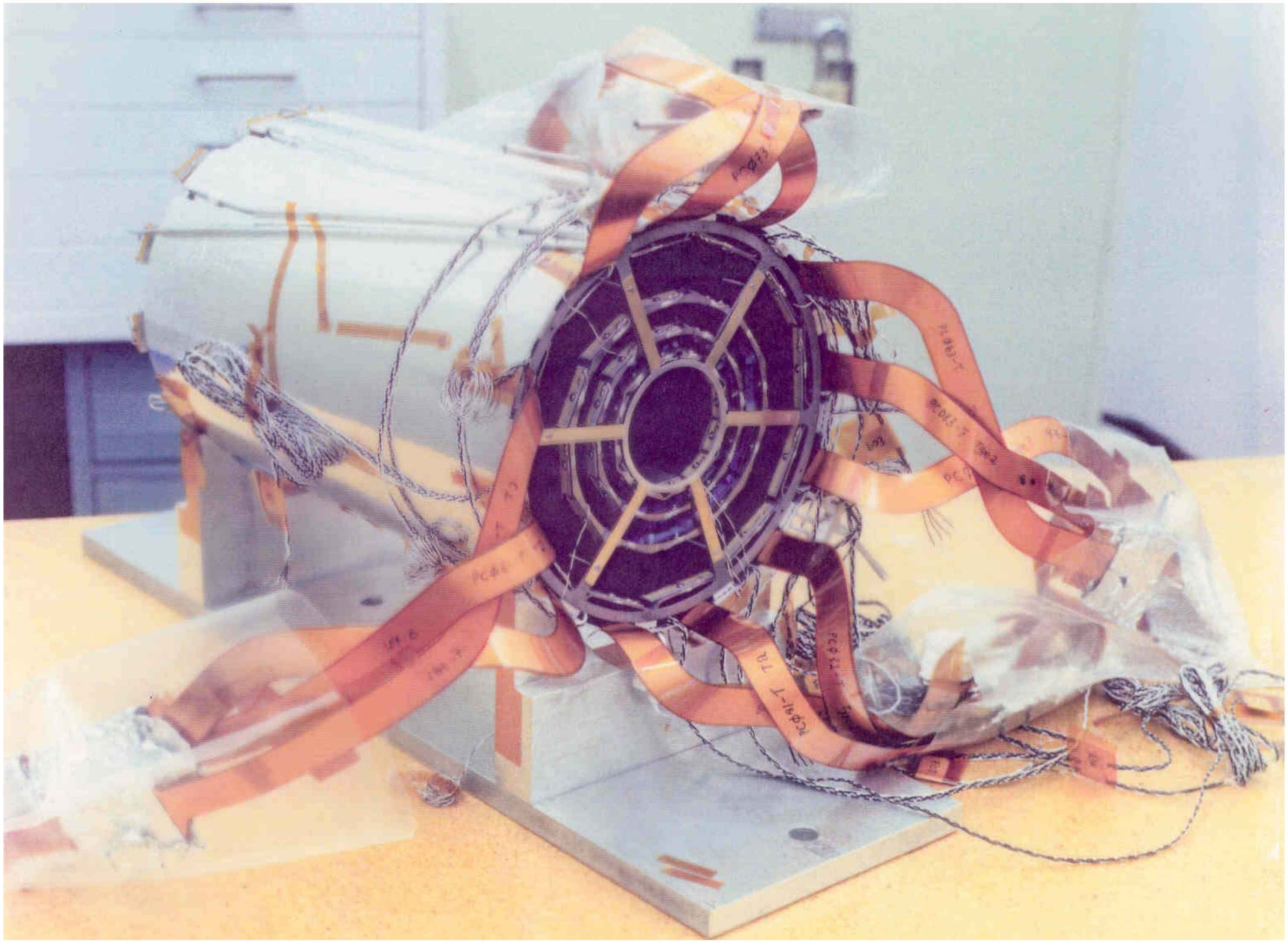
4 layers of sensors

46,000 channels of longitudinal strips

~13 μ resolution in rφ

resolution on impact parameter
~30μ at p_t=1GeV
~10μ at p_t=10GeV





The SVX was split into 2 halves, 25 cm long each. One of them is saved in the Fermilab museum, one in the Pisa University museum.