THE FORWARD DETECTORS OF CDF

(Details can be found in http://rock16.rockefeller.edu)

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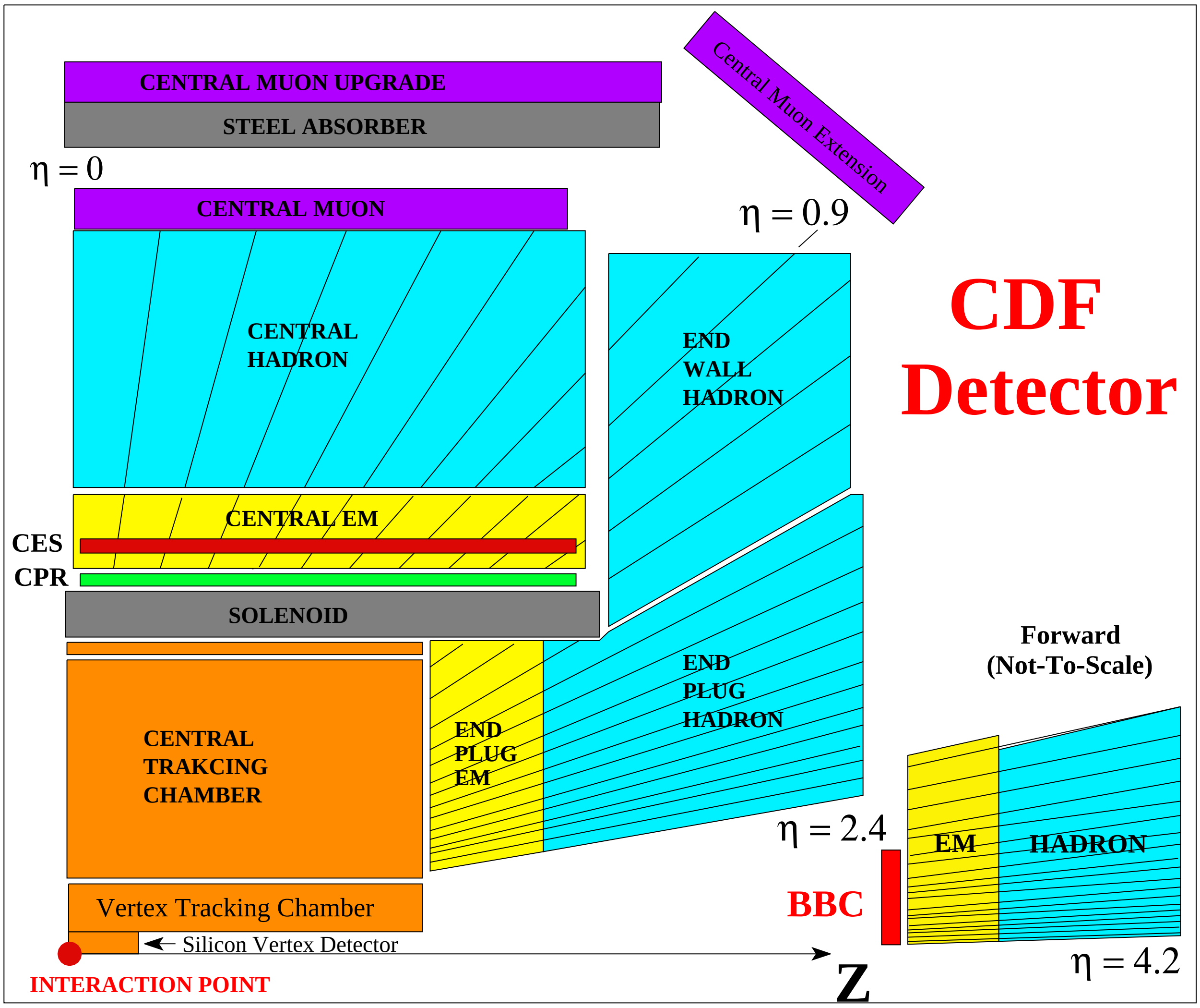
OUTLINE

- Run I Detectors
  - Beam-Beam Counters (BBC)
  - Forward Calorimeters (FCAL)
  - Roman Pot Spectrometer (RPS)
- Run II Detectors
  - Beam Shower Counters (BSC)
  - MiniPlug Calorimeters (MPC)
  - Roman Pot Spectrometer (RPS) - as in Run I

Run I

CDF Detector

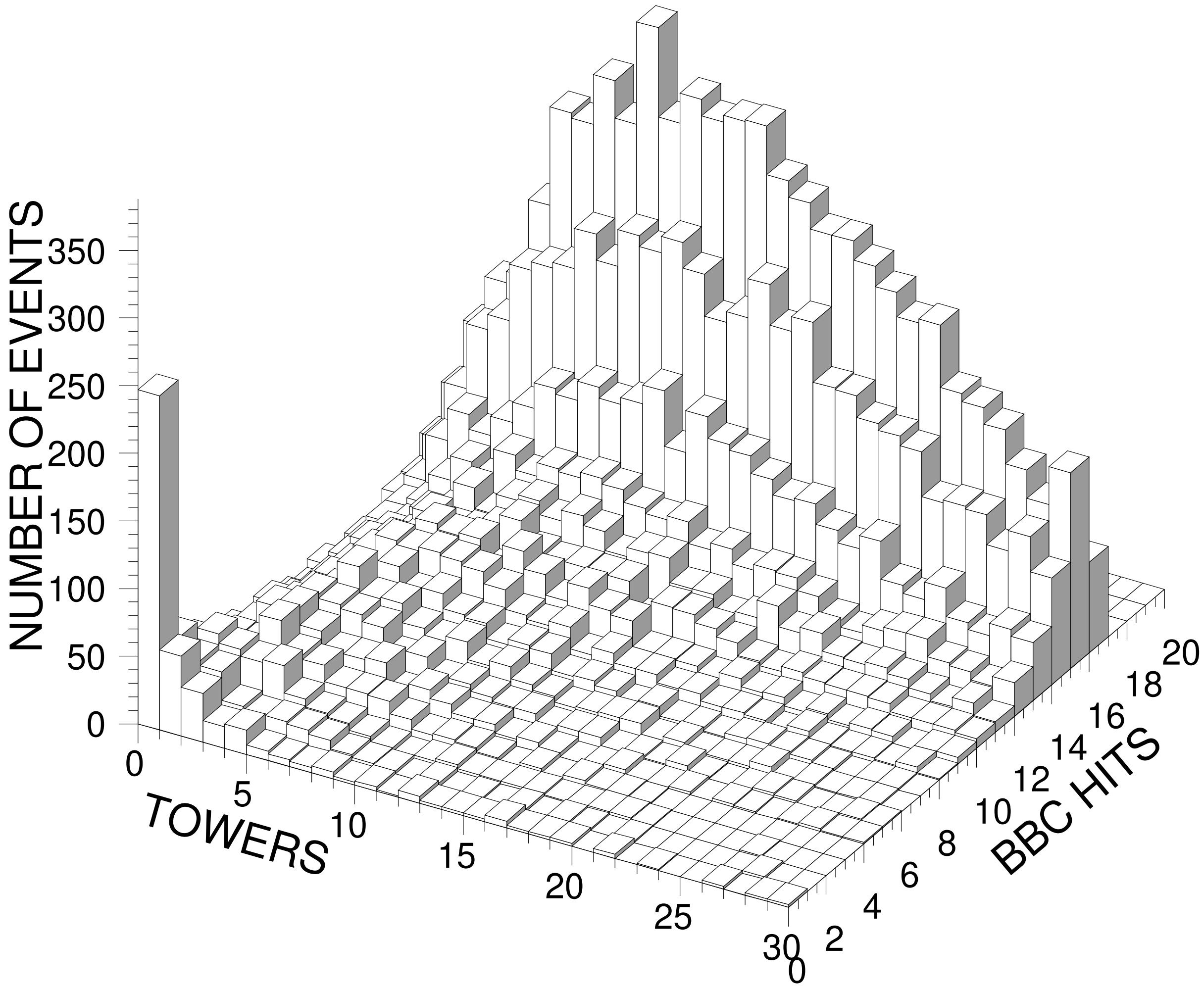


BBC $3.2 < \eta < 5.9$

FCAL $2.4 < \eta < 4.2$

Rapidity Gap Data

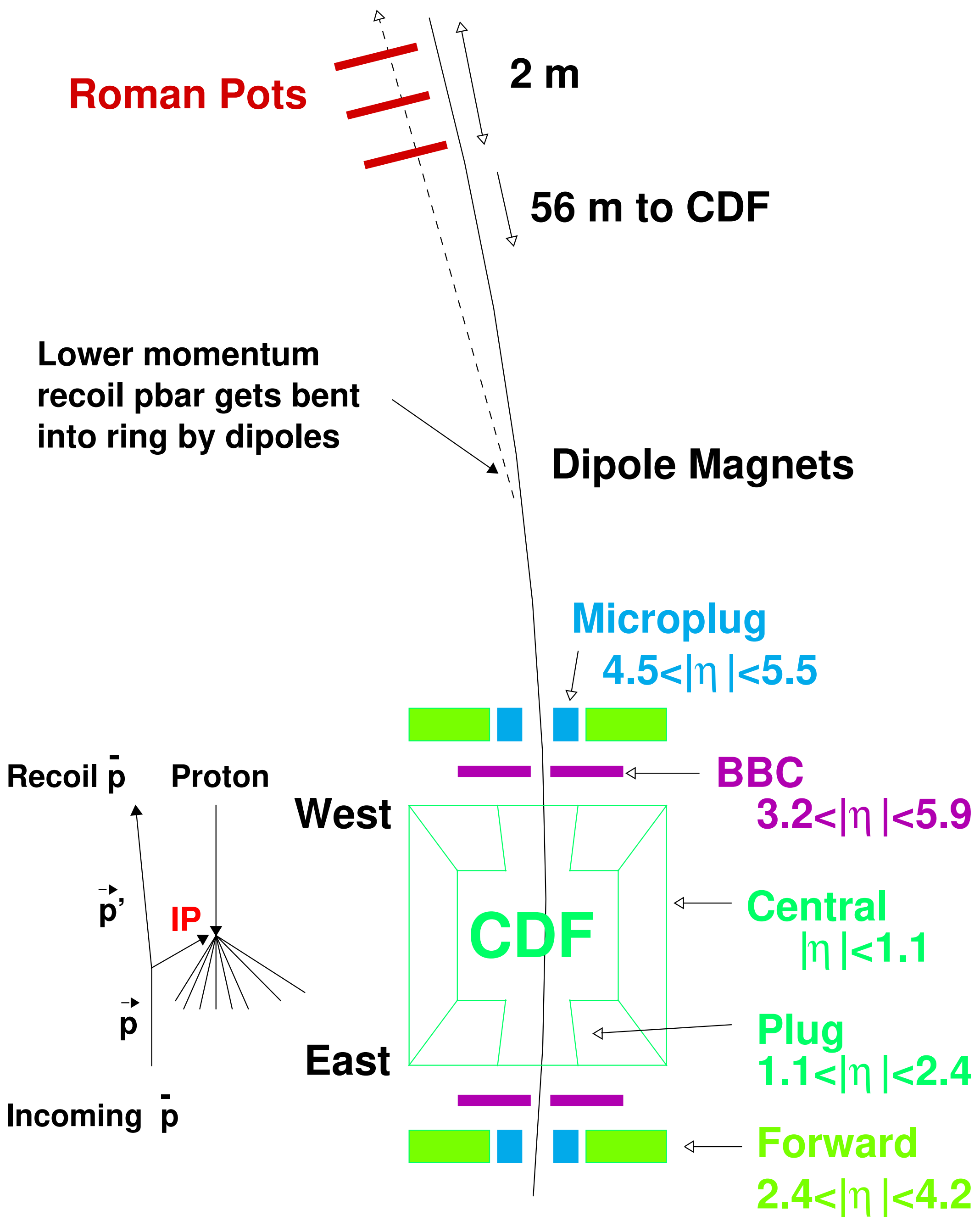
Diffractive dijet signal



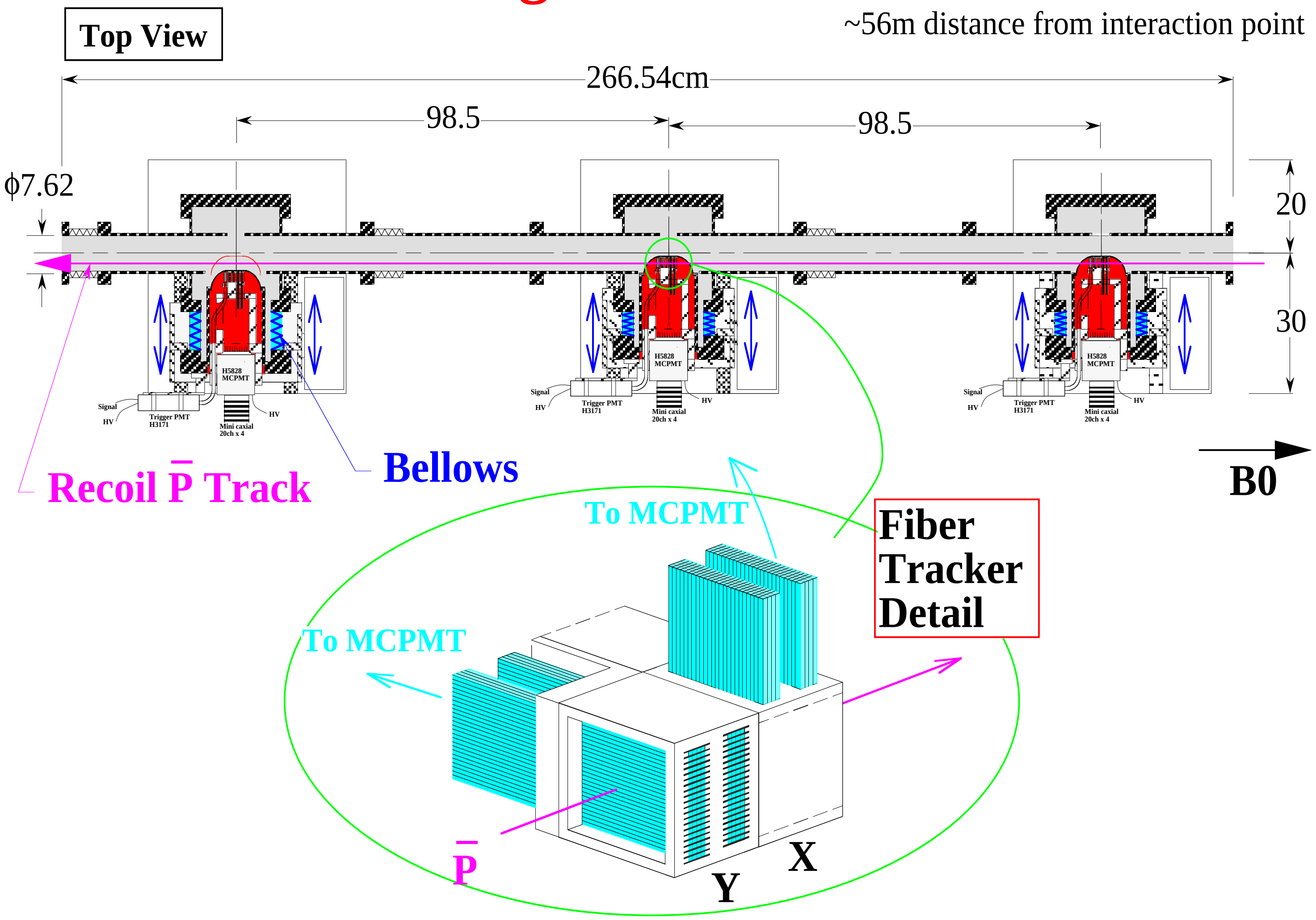
BBC vs CAL hits in the 'forward' region opposite the dijet system.

$$\boxed{R_{JJ}\left[\frac{diff}{non-diff}\right] = (0.75 \pm 0.1)\%}$$

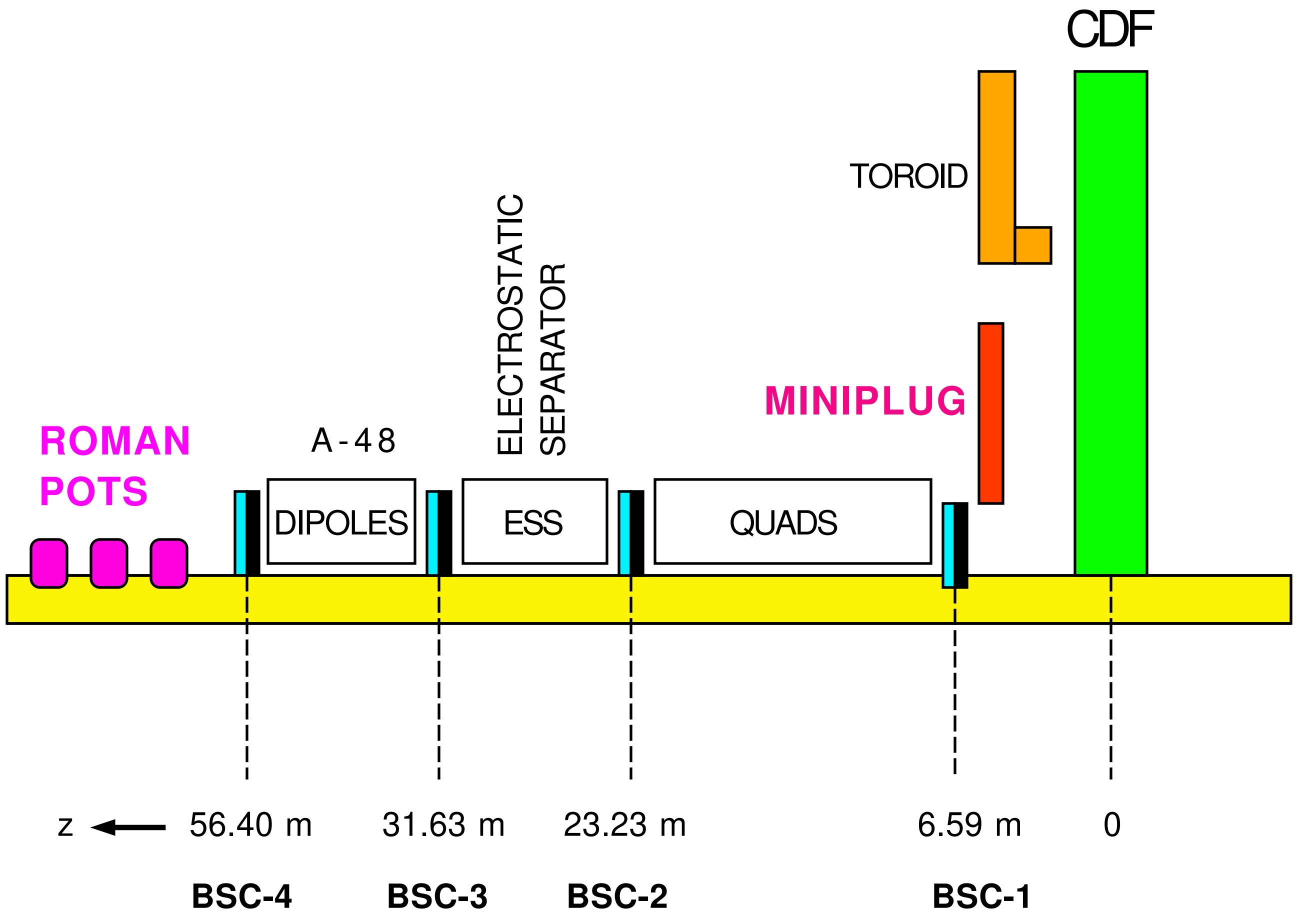
Diffractive Studies with Leading Antiproton



Roman Pot Arrangement



Run II Forward Detectors



RPS Roman Pot Spectrometer on $\bar{p}$ side

BSC Rapidity Gap Trigger Counters: $|\eta| > 5$

MPC $3.5 < |\eta| < 5.0$ (MiniPlug Calorimeters)

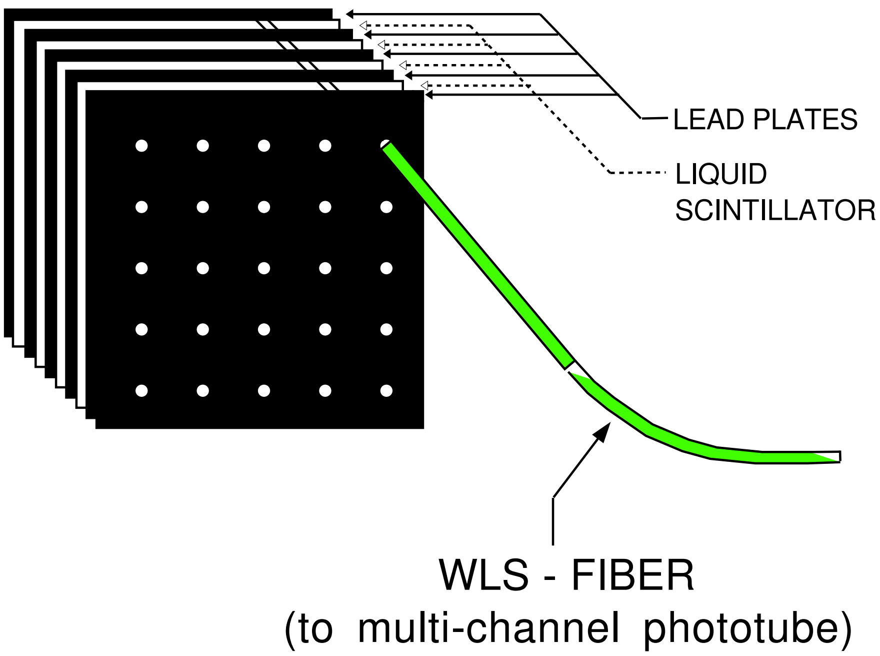
$\boxed{\textbf{The Miniplug Calorimeters}}$

Documentation of prototype tests

- Brookhaven AGS test beam
  Nucl. Instrum. Meth. A372:117-124,1996
- Fermilab test beam
  Nucl. Instrum. Meth. A430:34-47, 1999

The MiniPlug Calorimeter

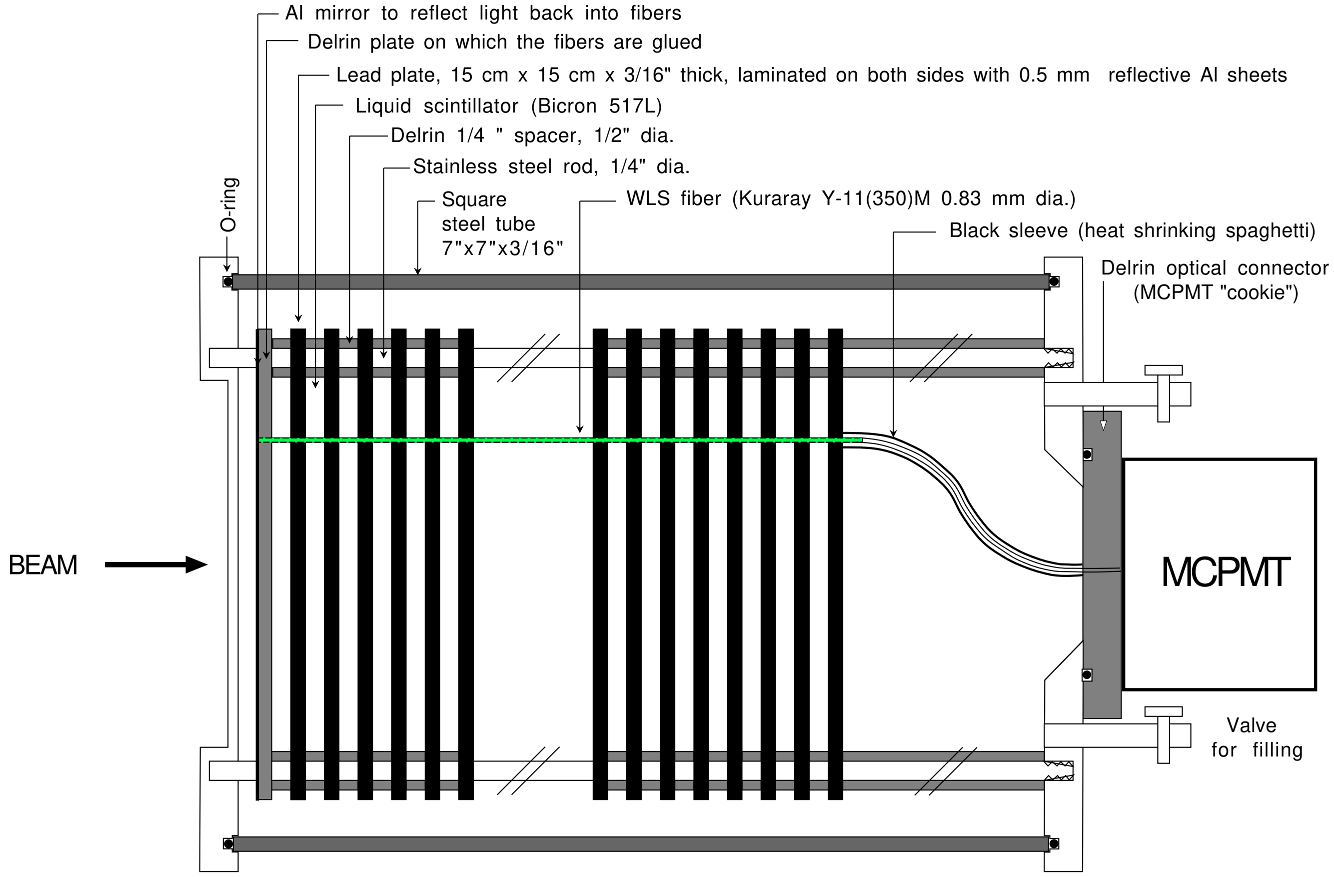
Conceptual Design

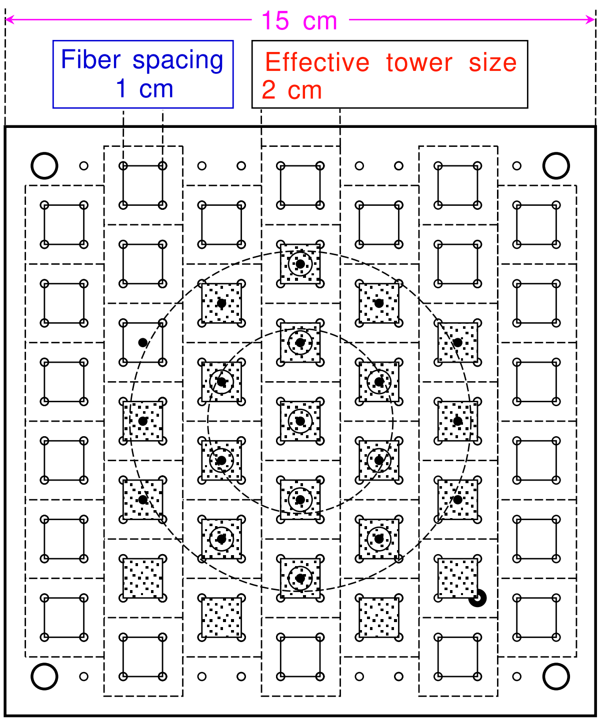


The MiniPlug consists of a set of parallel lead plates immersed in liquid scintillator. The scintillation light is wavelength shifted and guided to MCPMT's.

Calorimeter "towers" are formed by combining the desired number of fibers to be viewed by a single MCPMT pixel.

Schematic side view of the MiniPlug prototype

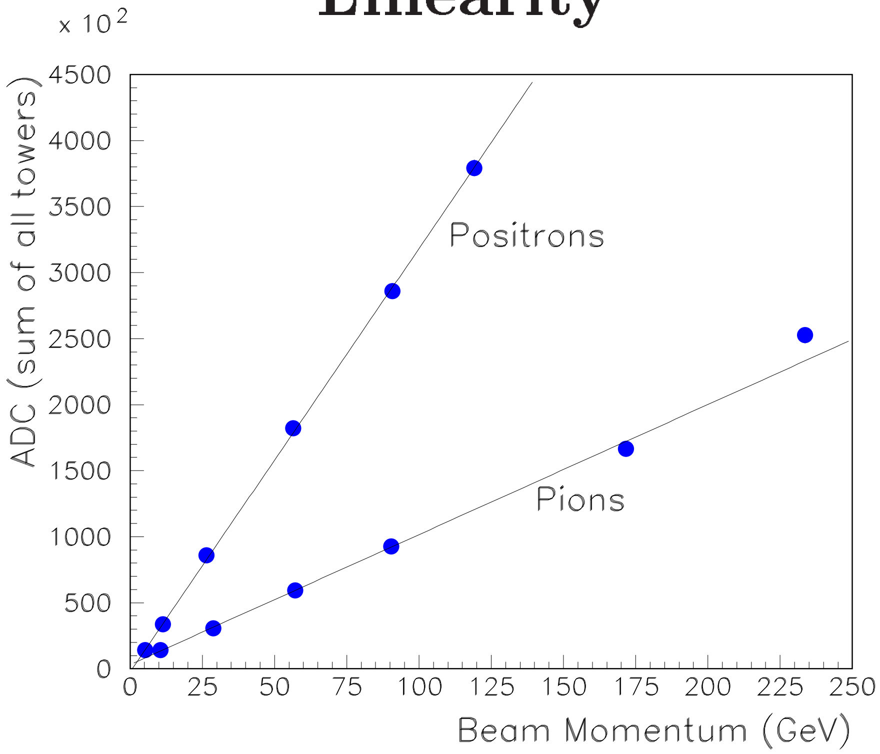




Front view of the MiniPlug prototype. Each group of four fibers in a square is read by the same MCPMT channel. Only the shaded squares and encircled single fibers were instrumented for the test beam results presented here. The beam was directed into the "tower" at the center.

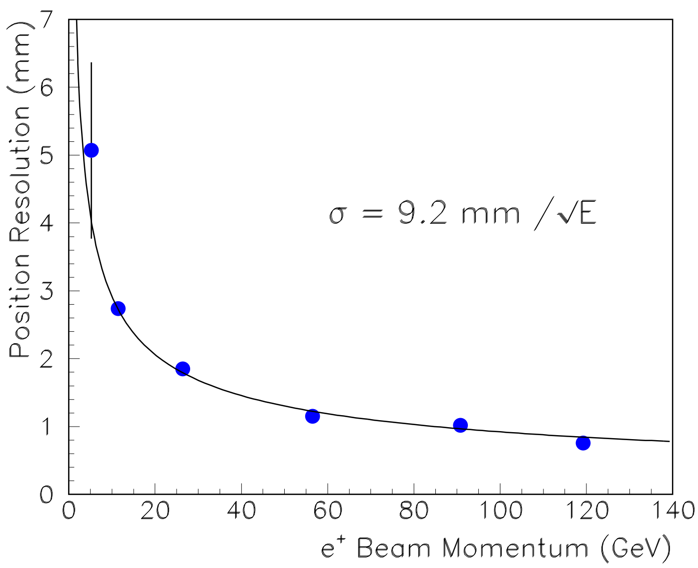
Results from the MiniPlug Prototype

Linearity

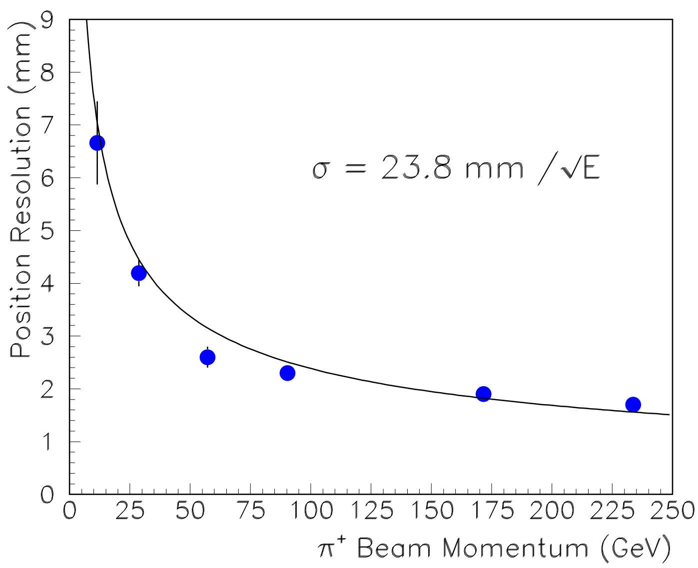


Position Resolution

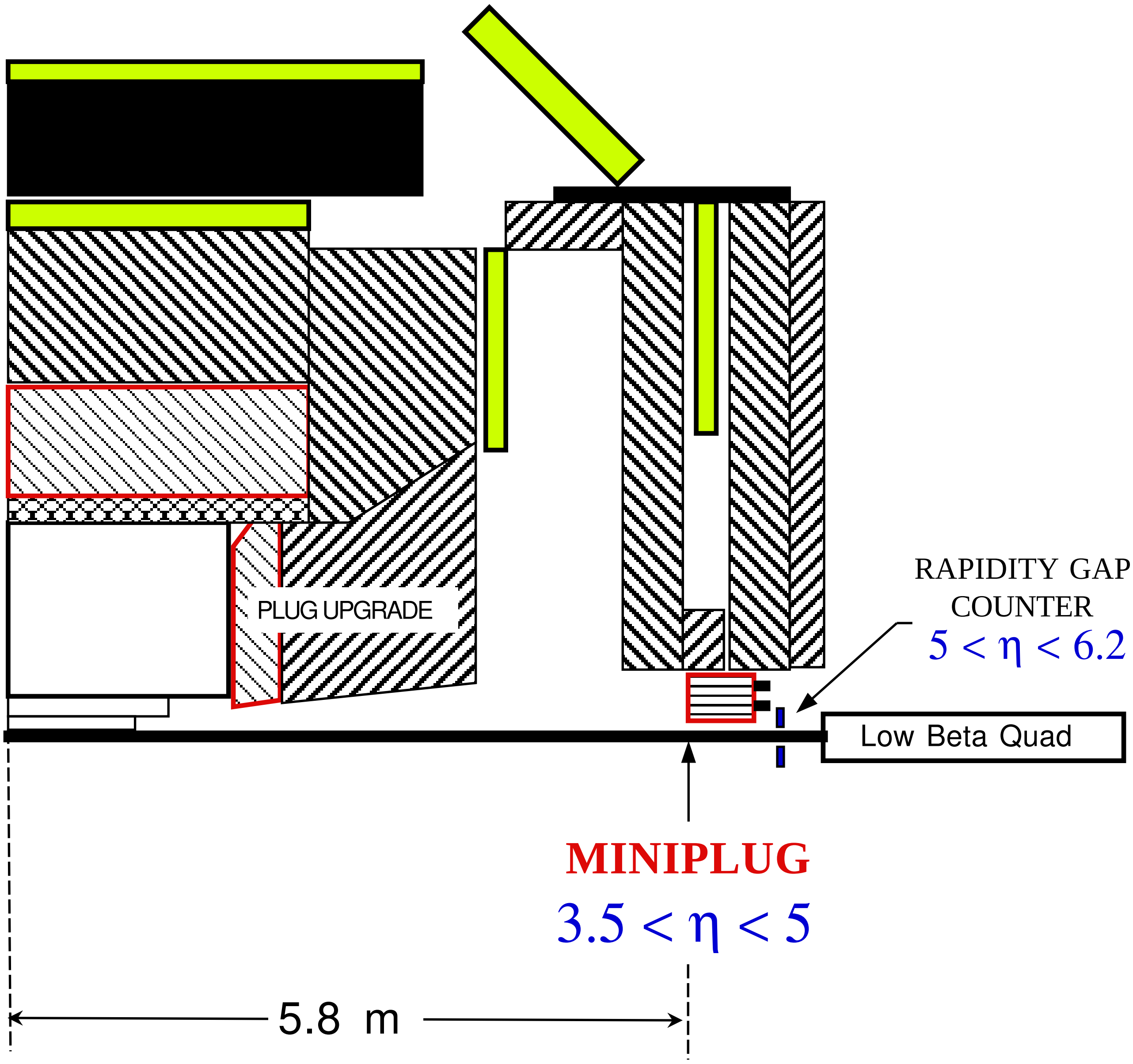
Electrons



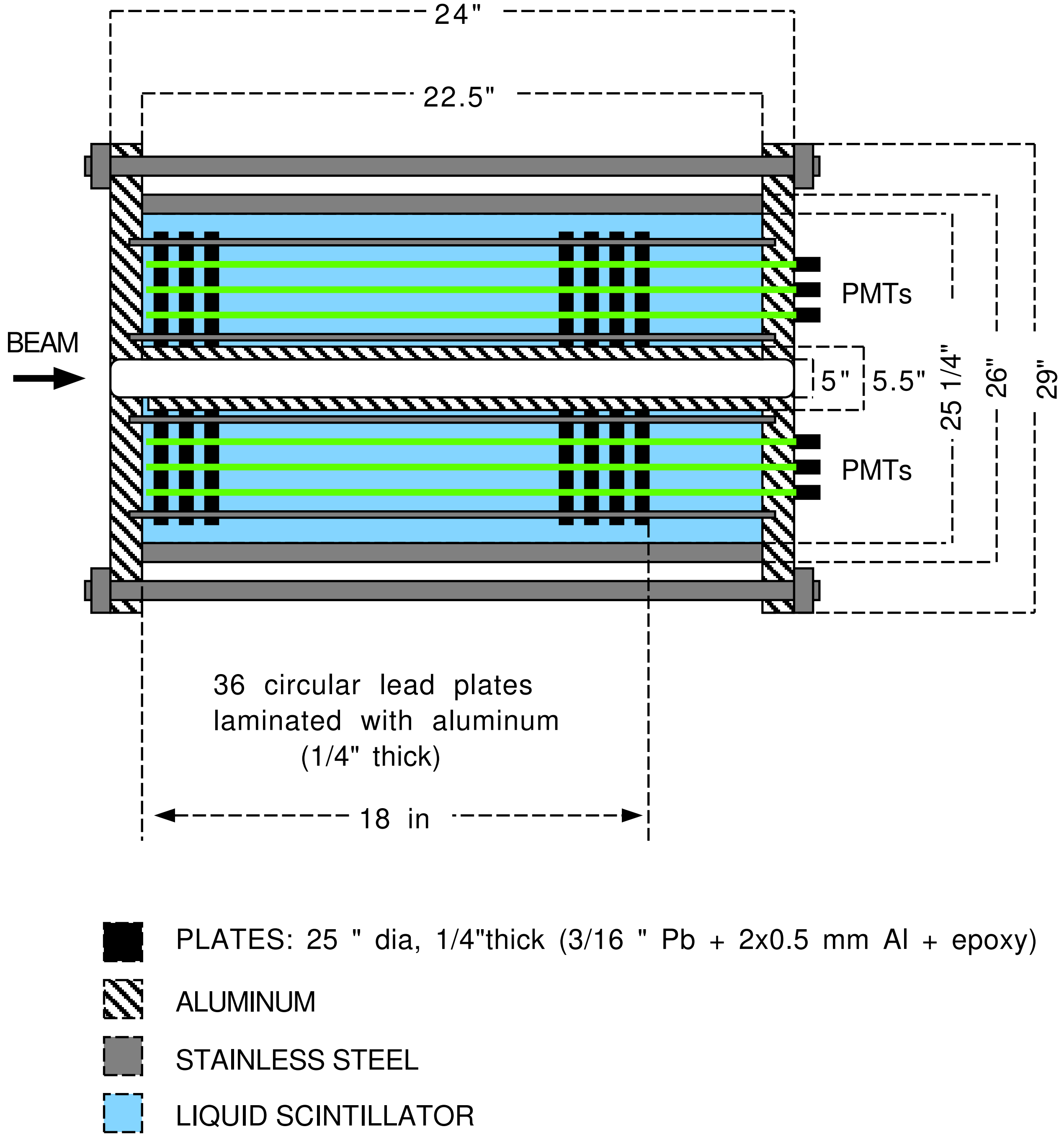
Pions

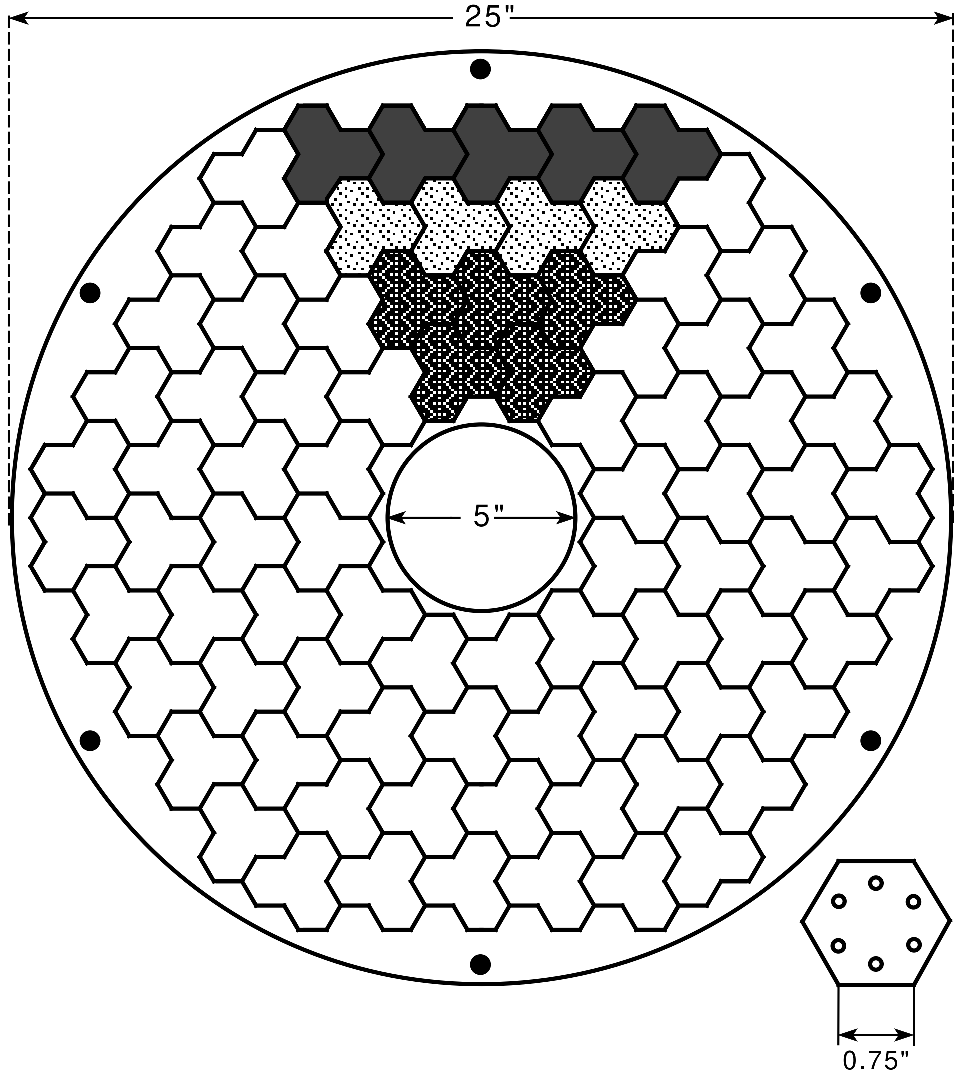


MINIPLUG IN CDF-II



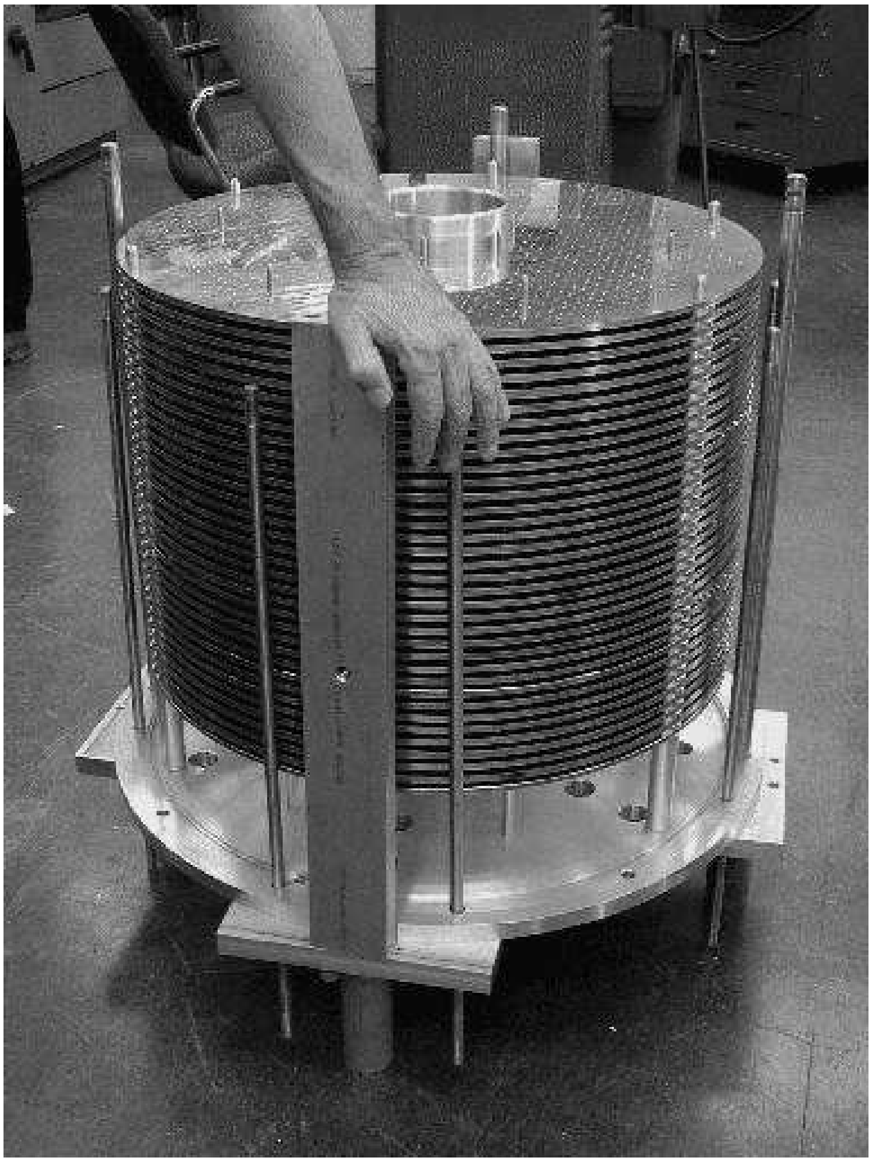
MINIPLUG SIDE VIEW
(not to scale)



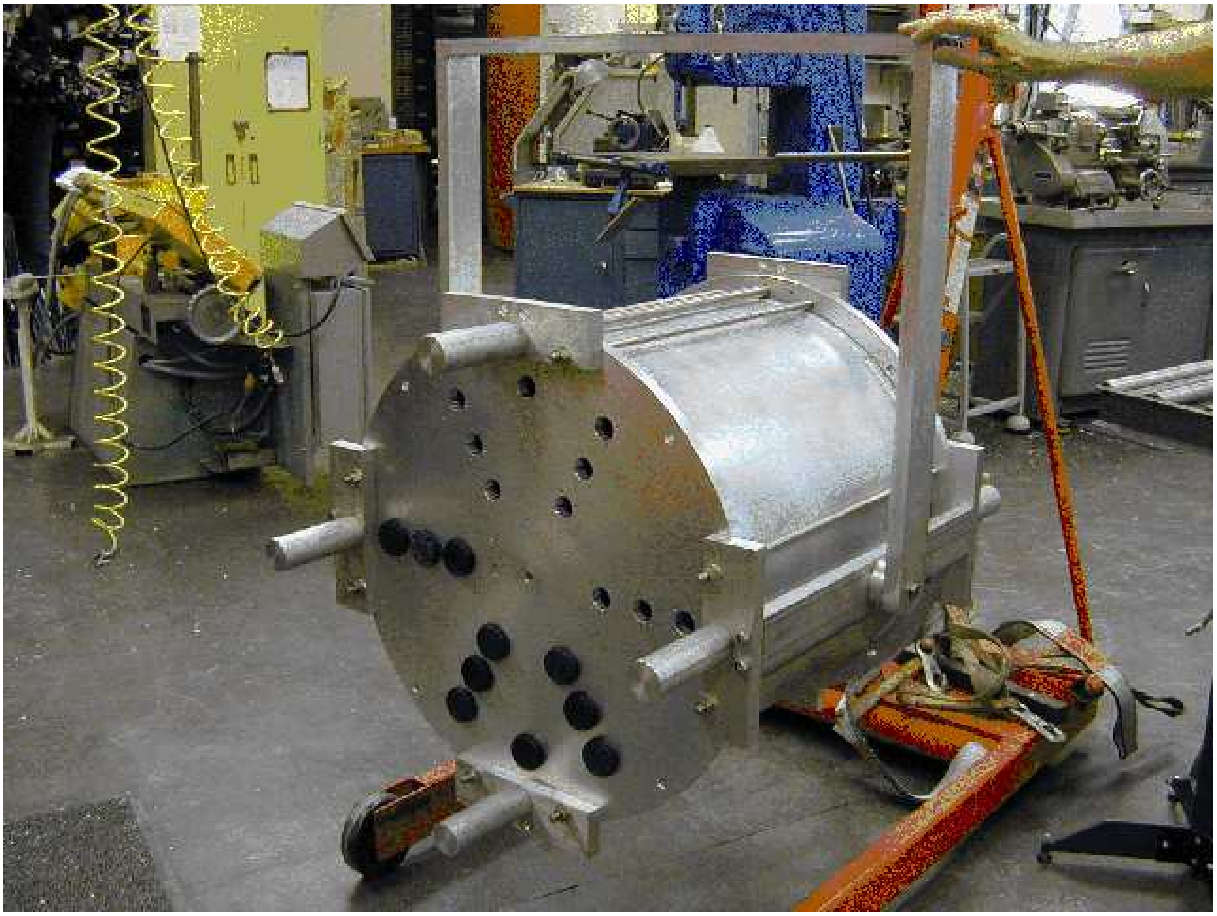


MiniPlug lead plate. The design is based on a hexagon geometry. Each hexagon has six holes, with a WLS fiber inserted in each hole. The six fibers of a hexagon are grouped together and viewed by one MCPMT channel.
There are 252 hexagons in each MiniPlug viewed by 18 16-channel MCPMTs. The MCPMT outputs are added in groups of 3 to form 84 calorimeter “towers”. The shaded areas represent tower groups viewed by a single MCPMT.

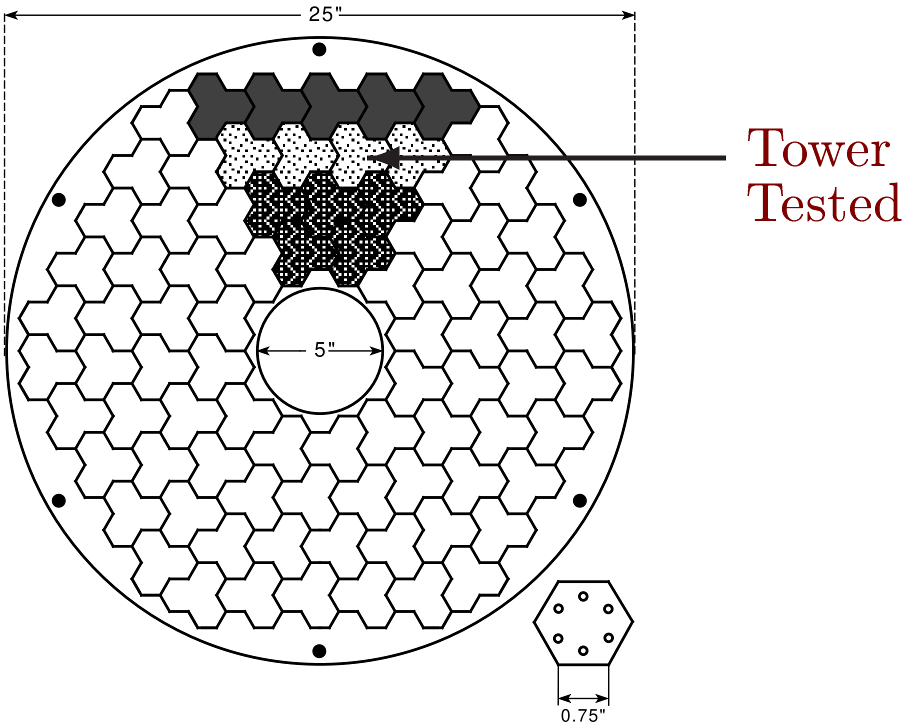
MiniPlug with all plates assembled

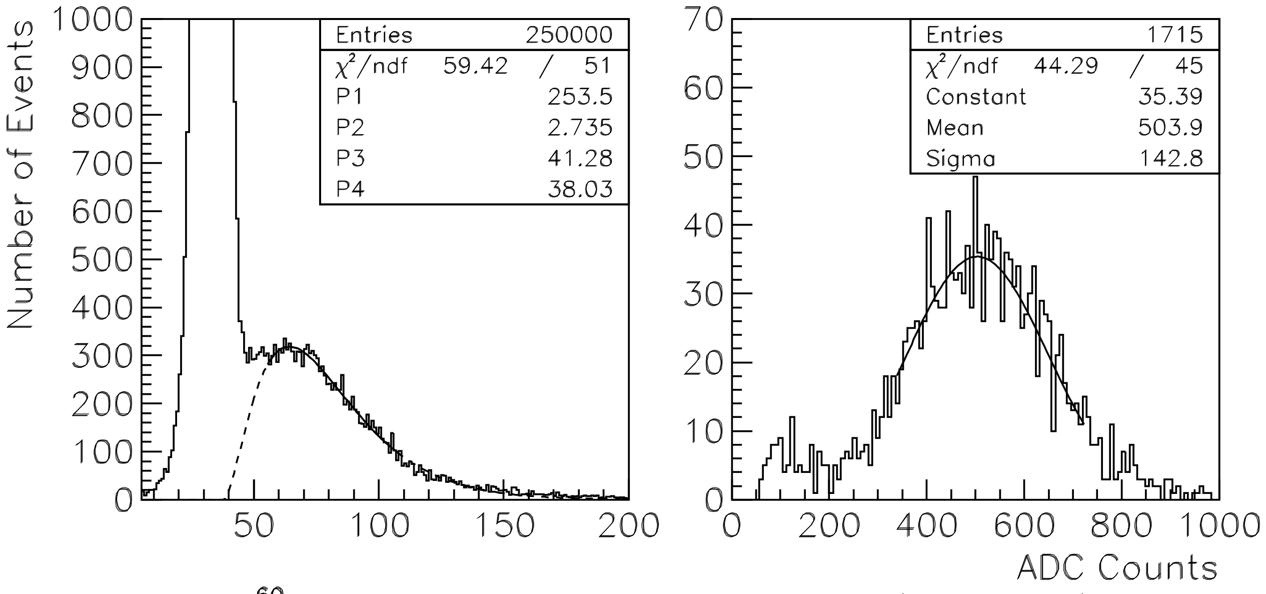


MiniPlug Vessel



Miniplug Cosmic-ray Test





^{60}Co Source | Cosmic Ray Signal

Single photoelectron
($\times$10 amplification)

$\approx$ 120 photoelectrons

Run 2 plans for hard diffraction studies in CDF

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We summarize briefly the CDF proposal for "Further Studies in Hard Diffraction and Very Forward Physics with CDF in Run II" and discuss the present status of the proposed detectors.

A program has been proposed for studies of hard diffraction and very forward physics with CDF in Run 2, which requires adding to CDF three detector components (see Fig. 1):

1) A Roman Pot Spectrometer (RPS) to detect leading antiprotons.

2) Two MiniPlug (MP) calorimeters covering the pseudorapidity region $3.5 < |\eta| < 5.5$ to detect particles and jets and measure their energies.

3) A set of Beam Shower Counters (BSC) positioned around the beam pipe at four (three) locations along the $\bar{p}$ (p) beam direction to tag rapidity gaps within $5.5 < |\eta| < 7.5$.

The Roman Pot Spectrometer will be the one used in Run 1C. It consists of X-Y scintillation fiber detectors placed in three Roman Pots located at a distance of 57 m downstream in the $\bar{p}$ direction. The detectors have a position resolution of $\pm 100\,\mu m$, which makes possible a $\sim 0.1\%$ measurement of the $\bar{p}$ momentum. In Run 1C, the $\bar{p}$-beam was behind the proton beam, as viewed from the RPS side. An inverted polarity (with respect to Run I) of the electrostatic beam separators will enable us to move the RPS detectors closer to the $\bar{p}$-beam and thereby gain acceptance at small $|t|$ down to $\xi \equiv 1 - x_F(\bar{p}) = 0.03$ (at larger $|t|$ lower ξ values can be reached with good acceptance).

The MiniPlugs will be placed within the holes of the muon toroids (see Fig. 2). They consist of layers of lead plates immersed in liquid scintillator (Fig. 3). The signal is guided by 1 mm dia. WLS fibers strung through holes in the plates, as shown, to be read out by multi-cannel PMT's. The "tower" structure, defined by the way the fibers are grouped to be read out, is shown in Fig. 4. A full depth ($\sim 30\,rl$) MiniPlug prototype has been constructed and tested in high energy muon, electron and pion beams with excellent results [1,2]. As of December 1999, the final Miniplug design has been completed, the vessels and all mechanical parts have been fabricated, a prototype lead plate of the final design (laminated with reflective aluminum) has been procured, and several Hamamatsu R5900-M16 PMT's have been acquisitioned and tested.

Beam Shower counters are rings of scintillation counters "hugging" the beam pipe. In stations #1 the rings are segmented into four quadrants, and in the other stations into two. As of December 1999, all 18 counters are ready for installation.

The physics topics to be addressed include:

Hard single diffraction

W, b, J/ψ and dijet production; dependence of the cross section on ξ and t; third-jet activity in jet production; extraction of the pomeron structure function.

Soft and hard double diffraction
(central rapidity gaps)

Dependence of cross section of dijet events with a rapidity gap between jets on jet E_T and jet η separation and comparison with predictions from BFKL and other models; measurement of the differential soft double diffraction cross section and comparison with phenomenological predictions; relationship between gap fractions in minimum bias and dijet events.

Double pomeron exchange (DPE)

Measurement of dijet cross section in events with a DPE topology (pomeron-pomeron collisions); extraction of the diffractive proton structure function from DPE dijet events and comparison with the diffractive antiproton structure measured in single diffraction (test of factorization); measurement of soft DPE cross section (test of soft factorization); connection between soft and hard diffractive processes; opportunities for new physics in exclusive DPE channels.

Small-x/large-x physics:

Measurement of proton parton distribution functions in the range $4\times10^{-5} < x < 0.8$; x_{max} can be measured as a function of the E_T scale down to E_T of 5 GeV.

Centauros and Disoriented Chiral Condensates

The signature for Centauros/DχCs is multiparticle clusters of large $dN/d\eta$ with abnormal charge to neutral ratios.

REFERENCES

1. S. Bagdasarov, K. Goulianos, A. Maghakian and Q. Wang, *Test-beam results of a prototype position sensitive towerless calorimeter*, Nucl. Instrum. Meth. **A 372** (1995) 117-124.
2. K. Goulianos and S. Lami, *Performance of a prototype position sensitive towerless calorimeter*, Nucl. Instrum. Meth. **A 430** (1999) 34-47.

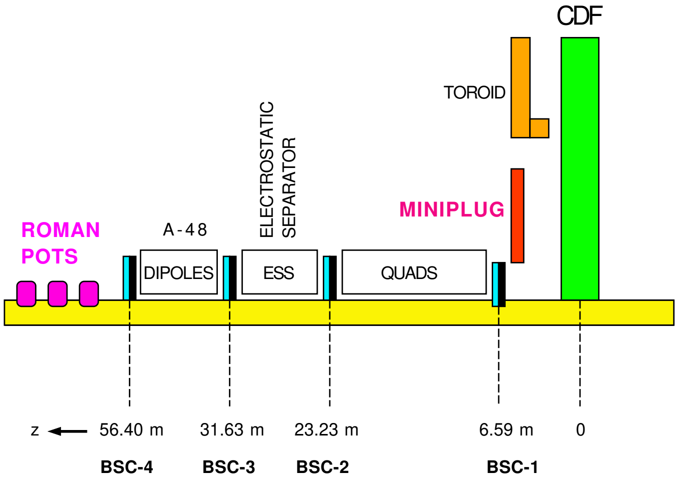

Figure 1. Location of the Beam Shower Counter stations along the $\bar{p}$ direction on the West side of CDF (not to scale). On the East side only the first three BSC stations will be installed, as there is no room for BSC-4.

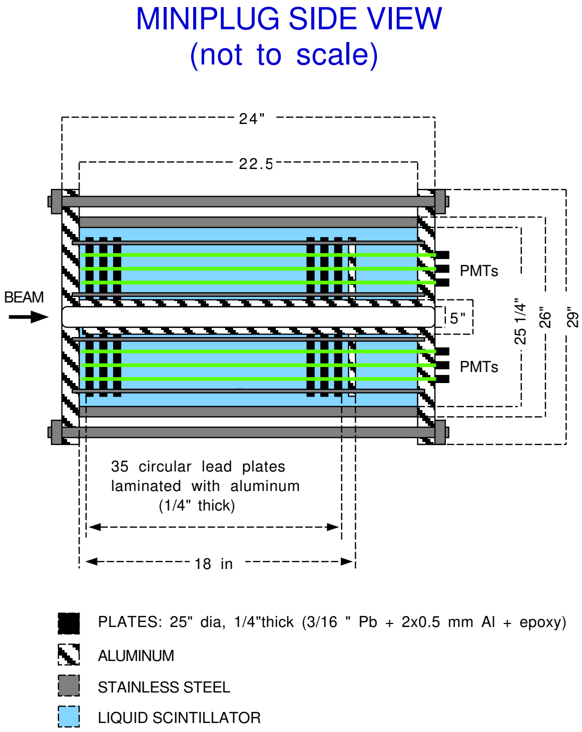

Figure 3. Schematic side view of a Miniplug.

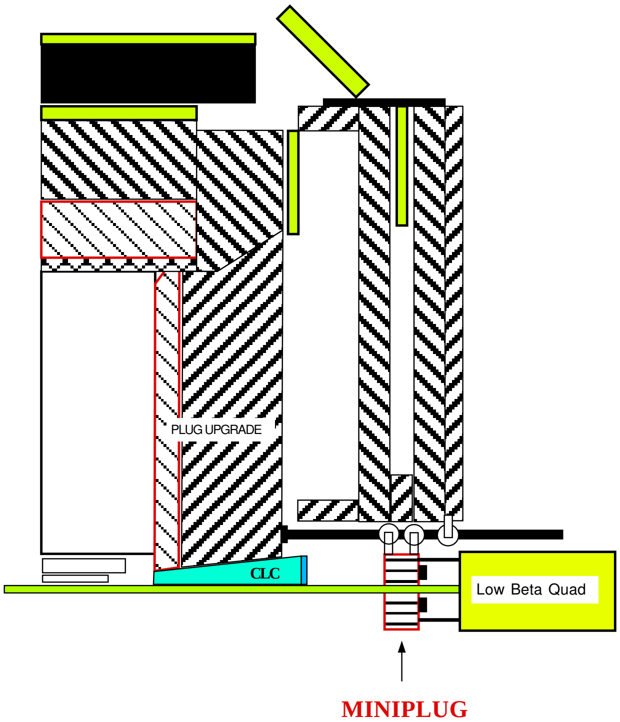

Figure 2. Schematic drawing showing a MiniPlug hanging from two beams supported on one end by the plug and on the other by the toroid (not to scale). This scheme allows for moving the toroids and/or the plug while the MiniPlug remains stationary.

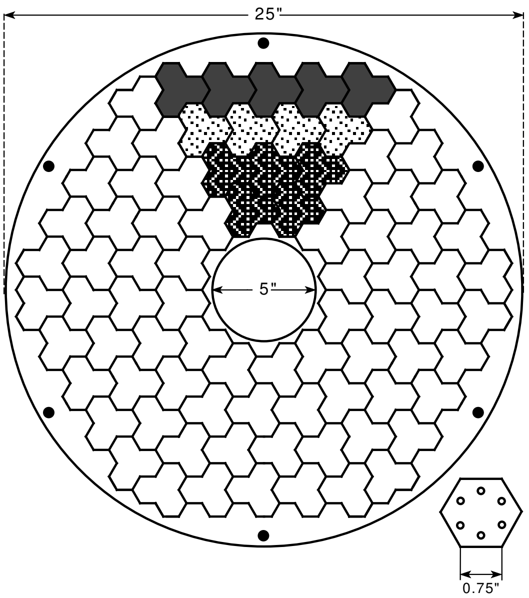

Figure 4. Proposed MiniPlug lead plate. The design is based on a hexagon geometry. Each hexagon has six holes, with a WLS fiber inserted in each hole. The six fibers of a hexagon are grouped together and are viewed by one MCPMT channel. There are 252 hexagons in each MiniPlug viewed by 18 16-channel MCPMTs. The MCPMT outputs are added in groups of 3 to form 84 calorimeter "towers".