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Tracking System for BCD

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Goals:

- Momentum measurement for $1 < P \lesssim 100$ GeV
  $\Rightarrow \ell \gtrsim 1$ m in 1 T field
- Track pattern recognition $\Rightarrow \gtrsim 64$ samples
- Fast P_T trigger
- Tracking TRD (?) [Whitaker]

Why not Silicon?

- $$!
- Multiple scattering ($\sim 2\times10^{-3} X_0$ in 200 μm)

Why Straw Tubes?

- Tube walls support wire tension
  $\Rightarrow$ no massive end plates
- 1 mil walls $\Rightarrow \sim 2\times10^{-4} X_0$
- Good resolution: $\sigma \sim 50 \mu m$ in 1 atm dimethyl-ether

$$\sigma \sim \frac{1}{\sqrt{\text{pressure}}}$$

- Isolation of broken wires

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Constraints

① Small-diameter tubes (3-4 mm)
- Hold pressure
- Short drift times ($\lesssim 100$ ns)
- Reduced occupancy

② 'Superlayer' construction
- Single, long tubes may buckle!

$\Rightarrow$ Glue tubes together in modules ~ 8 layers thick

$\Rightarrow$ Track vector from hits in 1 superlayer

(sagitta $\sim \frac{30 \mu m}{P[\text{GeV}]}$ in 1 T field)

③ Only 1 coordinate measured well
- Small-angle stereo
- Current division on resistive anode
- Timing on spiral cathode (Yager)
- Cathode pads

④ Timing on 1st cluster to arrive

$\Rightarrow$ won't resolve 2 tracks in 1 tube

⑤ Align tubes along $\vec{B}$

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15.3

STRAW-TUBE TRACKING SYSTEM

25×10^5 TUBES

75-100 SAMPLES PER TRACK

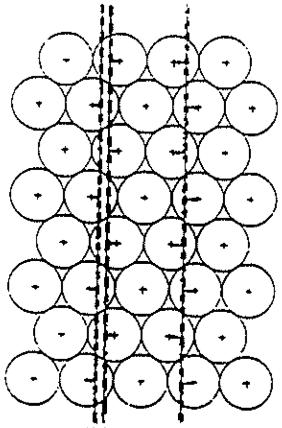


Figure 15: A "superlayer" of 8 rows of straw tubes.

TUBES SUPPORT WIRE TENSION WITHOUT ENDPLATES (Ceramic)

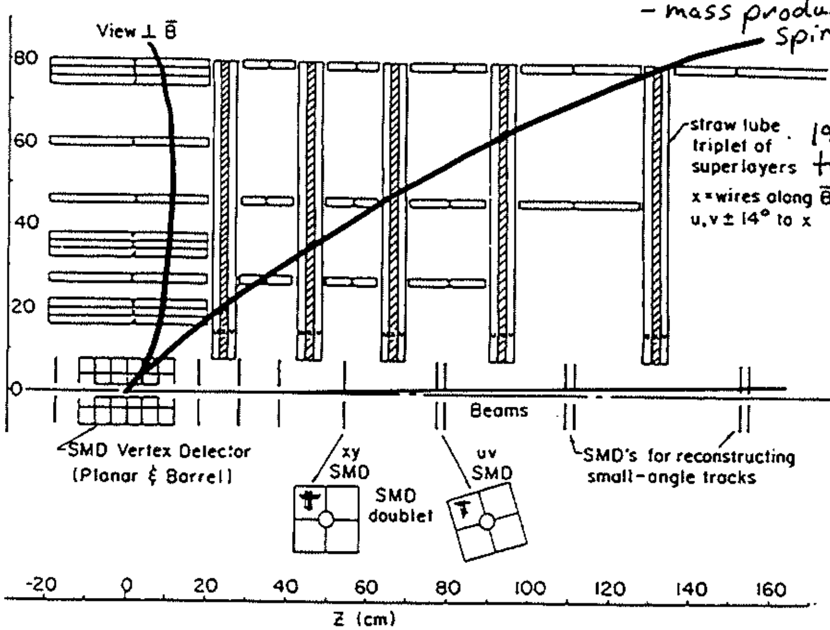
3mm DIAM. - exist

30-μm WALL THICKNESS exist

3 ATMOS. PRESSURE

⇒ 40μm σ PER HIT

Small detectors have been made at Princeton.
- pressure tests
- mass production



spiral winding machine. 19th century technology.

Figure 16: Plan view section through the median plane of one quadrant of the tracking system, showing the location of straw-tube panels and silicon microstrip detectors. The dipole magnetic field and the wires in the z straws are perpendicular to the page.

15.4

(6) ORGANIZE SUPERLAYERS FOR GOOD PATTERN RECOGNITION:
- FOLLOW CIRCULAR SYMMETRY OF 'CYCLOTRON' MAGNET
- BOX STRUCTURE - LIKE UA1

(7) NEED ~ 2.5×10^5 TUBES:
- 64 LAYERS
- AVERAGE PERIMETER ~ 6 m
- ~ 300 TUBES/m IF 3-mm DIAMETER

(8) MUST EXTRAPOLATE STRAW-TUBE TRACKS INTO SILICON PLANES

(9) RADIATION DAMAGE NEAR PIPE

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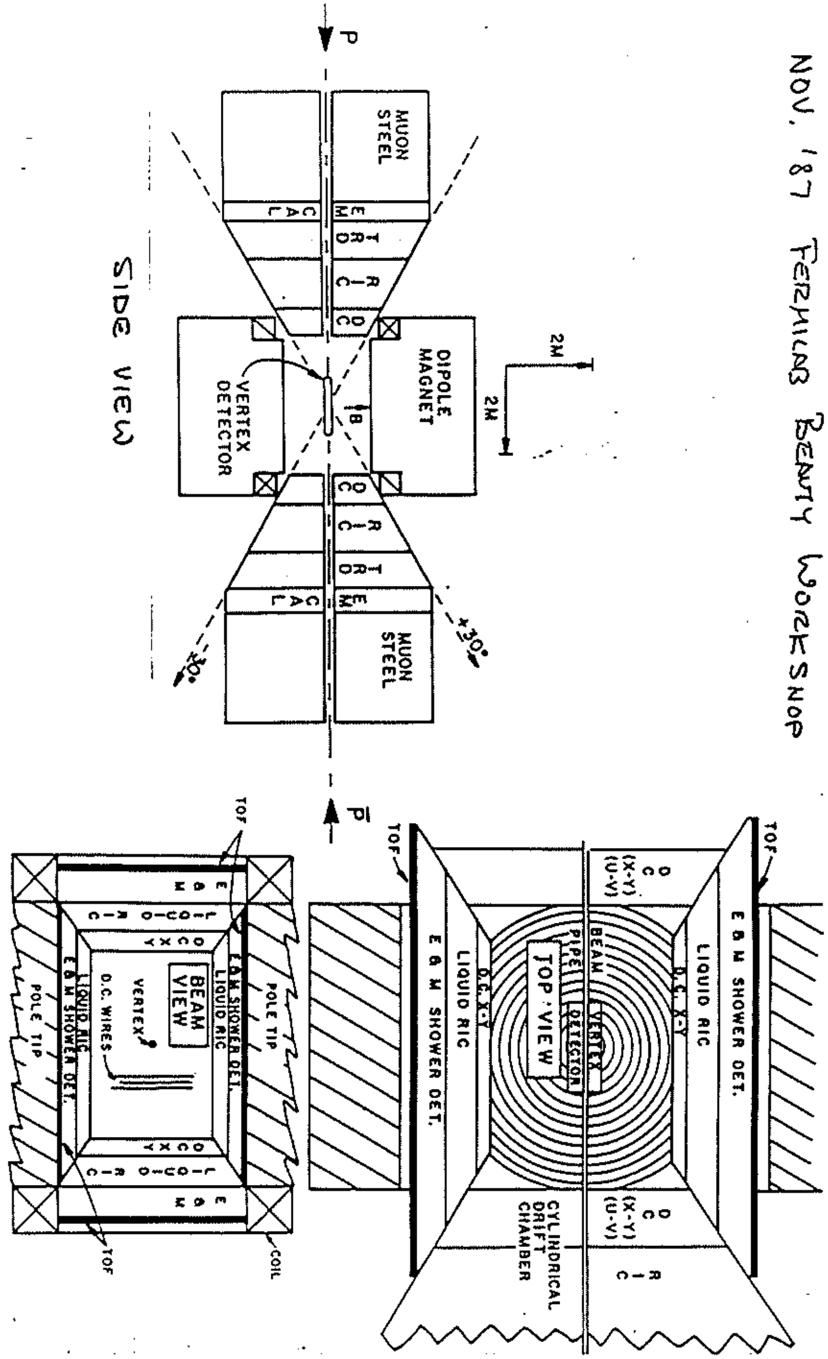
15.5



15.6

SIMULATIONS

① OVERALL LAYOUT [SLAUGHTER, STUTTE]

- HITS PER TRACK
- HITS PER TUBE

② PATTERN RECOGNITION (IN PROGRESS)

- FIND VECTORS IN SUPERLAYERS
- LINK VECTORS INTO CURVED TRACKS
- MATCH TO SILICON HITS

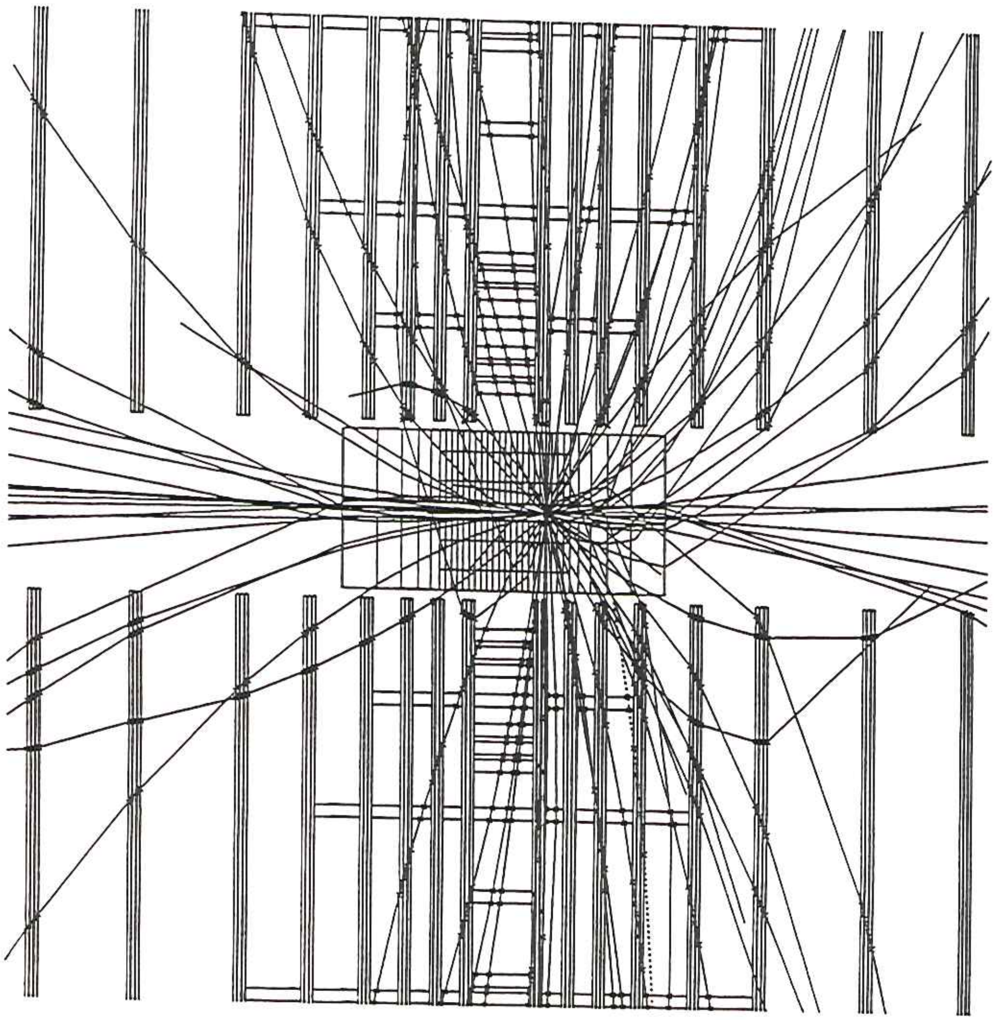
③ TRACK FITTING [AVERY]

- HELICES
- MULTIPLE - SCATTERING CORRELATIONS

④ P_T TRIGGER [HARTOUNI, STUTTE]

- VECTOR FROM OUTER SUPERLAYER
+ VERTEX ESTIMATE FROM FIBER-TRACKER

15 7



15 8

Customated Spiral-Wound Products

Stone Industrial/a member of the CLARCOR precision products group

The first spiral-wound product was the drinking straw. It was patented by Marvin Stone in 1888. Thus began what is now the Stone Industrial Division. Today we make thousands of small diameter spiral tubes that serve as packaging protection and/or insulation against electrical, thermal, chemical, physical or atmospheric phenomena. Essentially these tubes are laminations of plastic films, papers and other substrates, with or without resin impregnation . . . alone or in virtually every known combination. To insure meeting your exact need, we "Customate" these products through a full spectrum of services customized to take them from concept to quality volume production as expeditiously as possible.

Stone Industrial
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51st Avenue & Cree Lane
College Park, MD 20740
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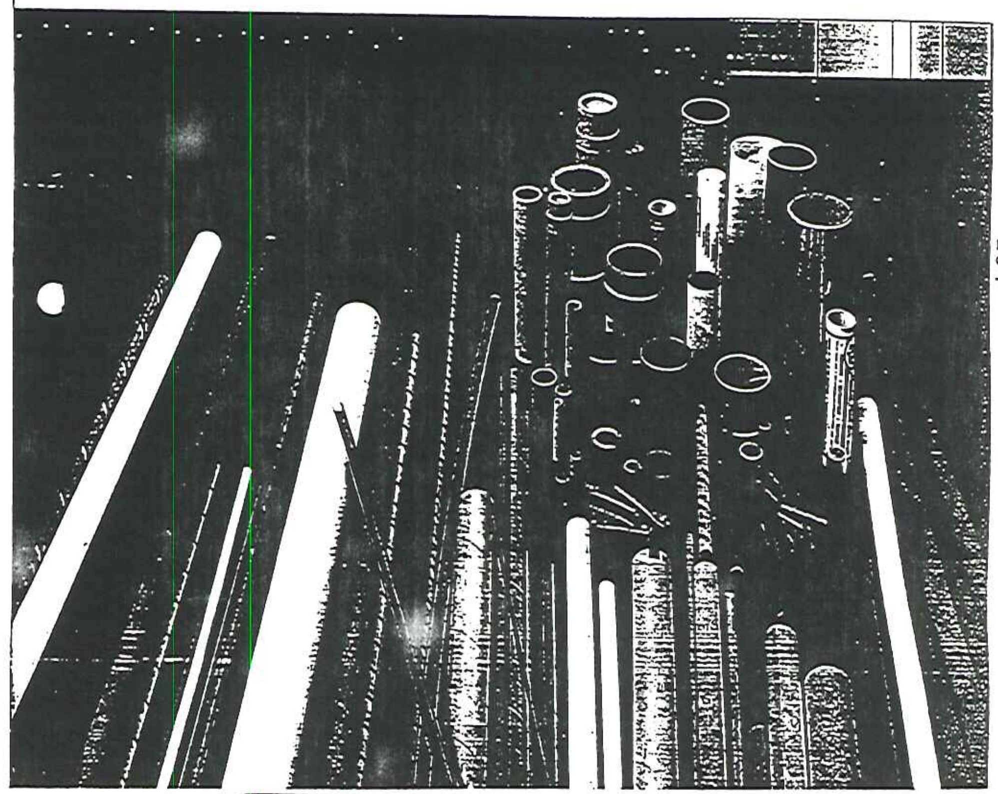

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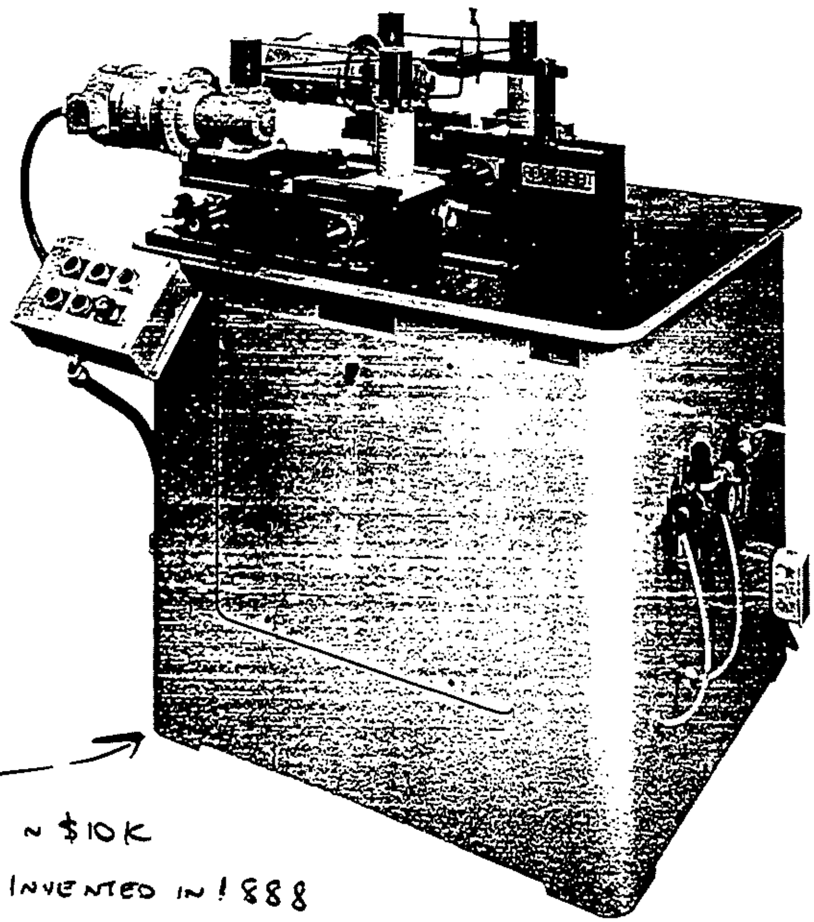
15.9

ROCKPORT

TUBE WINDING SYSTEMS



~ $10K

INVENTED IN 1888

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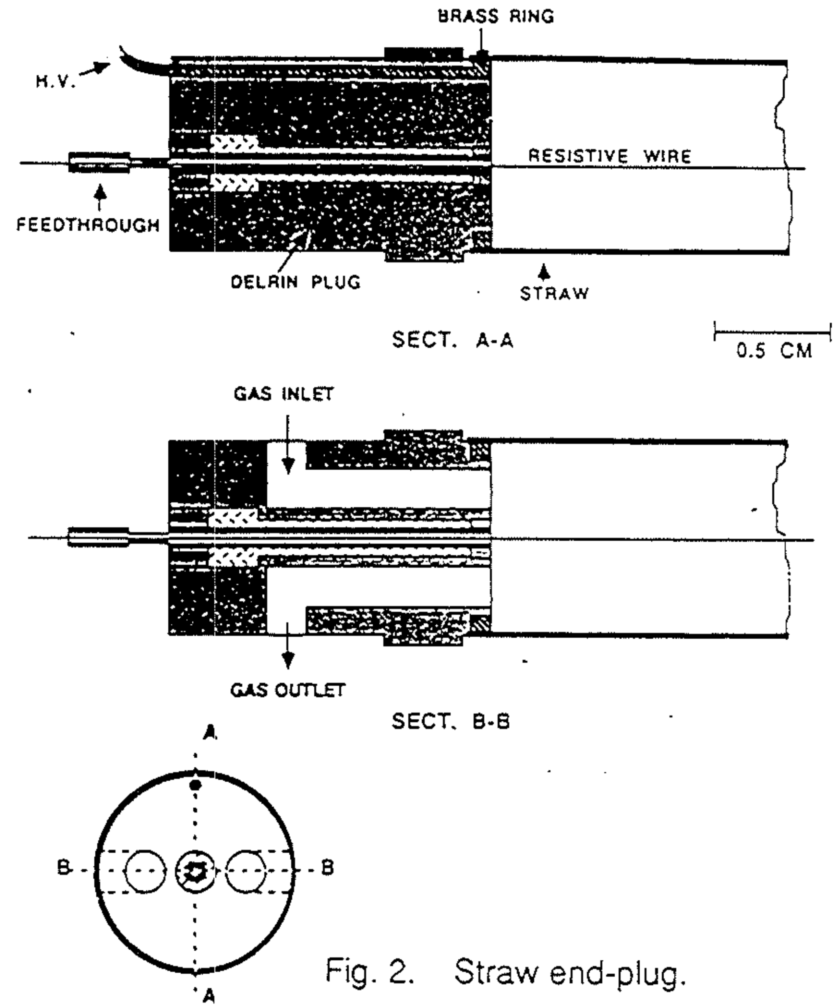

Fig. 2. Straw end-plug.

15.11

HARDWARE PROTOTYPES

① 'KIT' FROM KAGAN (OSU)

② ~ 1000 TUBES FOR FIXED-TARGET TEST (1990)

③ ≲ 10 K TUBES FOR CØ COLLIDER TEST (1991)

ISSUES

① ECONOMICAL PRODUCTION OF TUBES

② END PLUGS

③ GAS DISTRIBUTION (> 1 ATM ?)

④ LOW-MASS END PLATES (ALIGNMENT ONLY)

⑤ READOUT (PENN)

⑥ CALIBRATION ; COLLIMATED X-RAY PULSE...

15.12

C. Phased Prototype Studies

Our development of a straw-tube stracking system for a hadron collider experiment is part of an R&D project approved at Fermilab for use of a fixed-target test beam in 1990, with a test in the C0 intersect in 1991 pending approval.

In [redacted] we should produce a prototype of some [redacted] for the test in a fixed-target beam at Fermilab, and in [redacted] we should have produced some [redacted] for a system test at the C0 intersect at the Fermilab Tevatron. The full chamber system for the Bottom Collider Detector will consist of about 250,000 tubes. As no existing straw-tube detector exceeds 1000 tubes, this will be a sizable project.

Some of the major tasks in constructing the straw-tube chambers are:

1. Economical and reliable [redacted], which are 3 mm in diameter, with 1 mil walls, and which must hold 4 atmospheres pressure.
2. Production of [redacted] for the tubes, which include feedthroughs for the sense wire and the chamber gas.
3. The high-pressure [redacted]
4. The [redacted] that provide mechanical alignment (but not structural rigidity) and distribution of electrical signals.

The [redacted] are being prepared at U. Penn in close collaboration with the mechanical work at Princeton.

Work to date at Princeton on this project has been primarily concerned with the manufacture of the straw tubes. The main present source of tubes, Precision Paper Tube of Wheeling, Il, now charges rather high prices: at least $10 per tube in large quantities. We are evaluating two new vendors: Electrolock of Chagrin Falls, OH, and Stone Industrial (the inventor of the sprial-wound straw) of College Park, MD. In addition, we have contacted a manufacturer of straw winding machines, Rockport of Cleveland, OH; the basic machine is an elegant application of 19th century technology, and costs about $10k. Some skill is required in the winding of multilayer small-diameter tubes!

We have found the work of Kagan *et al.* of O.S.U. quite useful in pointing the way for future straw-tube development, and we have obtained a 7-tube 'kit' from them for initial bench tests. The next chamber will be of our own design, and will be built over the summer of 1989.

Funding needs in [redacted] for the straw-tube development include

1. Parts and supplies for tube construction $25k
2. 1/2 year of a mechanical technician $25k
3. Parts and supplies for the gas-distribution system $10k
4. Parts and supplies for chamber end plates, frames and mounting $10k
5. Parts and supplies for tube endplugs $10k
6. 1/2 year of an electrical technician $30k
7. Class-100 clean room for chamber assembly $60k
8. AutoCad system for mechanical design $10k
9. Toolroom lathe for parts fabrication $25k

Total .... [redacted]

Items 7-9 are of long-range utility, but needed now to insure a strong capability for work on the very large straw-tube system in the following years.

The inclusion of labor costs in the above list indicates the need for technical support beyond that provided in our present DOE contract base. Labor at the level indicated can be obtained through hourly wages paid to Departmental Shops.

15.13

COLLABORATION ON SYSTEM R&D

PRINCETON
FERMILAB
UC DAVIS
IIT
PENN
YALE
} BCD

FLORIDA

INDIANA
COLORADO
} LSD

SLAC
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