Bottom Collider Detector (BCD)

An Intermediate- and Low-$P_t$ Detector for the SSC

BCD Collaboration

H. Castro, B. Gomez, F. Rivera, J.C. Sanabria, Universidad de los Andes
J.F. Arena, G. Jernigan, U.C. Berkeley, Space Sciences Lab
P. Vager, U.C. Davis
E. Bassetti, M. Bowden, S. Childress, P. Lebrun, C. Lindenmeyer, J. Morse
L.A. Roberts, R. Stefanetti, L. Stutte, C. Swoboda, Fermilab
F. Avery, J. Yelton, U. Florida
K. Lau, University of Houston
Hughes Aircraft Company
M. Adams, C. Halliwell, U. Illinois, Chicago
R. Burnstein, H. Rubin, Illinois Institute of Technology
J. Rattner, Intel Scientific Computers
E. McTinney, Y. Ouel, U. Iowa
M.S. Alam, S.U. New York
C. Alverson, W. Faisler, H. Fenker, D. Garlick, M. Glasman, J. Leedom, S. Reucroft,
Northeastern U.
G. Alley, H. Brashear, C.L. Britton, Oak Ridge National Lab
N.S. Lockyer, R. Van Berg, U. Pennsylvania
D. Judd, D. Wagoner, Prairie View A&M U.
A.M. Lopez, J.C. Palathingal, Universidad de Puerto Rico
B. Hoehein, Universidad San Francisco de Quito
S. Shapiro, Stanford Linear Accelerator Center
M. Sheaff, U. Wisconsin
P.E. Karchin, A.J. Slaughter, Yale University
3 The BCD Detector

3.1 Introduction

As discussed in Section 2, the most interpretable signals of CP violation in the B-B system are in the decays of B0s to a CP eigensate. To exploit this information it must be determined whether the parent was a B or a B̄, which requires 'tagging' of the second B in the event. Hence the experiment must be capable of reconstructing pairs of B-mesons with high efficiency.

Such considerations lead to a detector architecture containing 11 subsystems:

1. A large dipole magnet with field transverse to the beams. This can be thought of as the limit of two large-aperture forward spectrometer magnets as the distance between them goes to zero. As a bonus, good central coverage is obtained.

2. The Silicon Vertex Detector, with silicon as close as 1.5 cm to the beams.

3. The Tracking System. It is too costly to perform all tracking in silicon detectors, so these must be supplemented with tracking chambers, composed of straw-tube detectors in the current design.

4. The Very Small Angle Fiber Tracking System, a fast tracking system designed to measure tracks at rapidities beyond those covered by the main detector. It provides a minimum bias trigger, luminosity measurements, and a fast method of determining the longitudinal location of the primary vertex to within ± 1 cm.

5. Ring-Imaging Čerenkov Counters and Time-of-Flight Counters to provide identification of charged pions, kaons, and protons.

6. Transition Radiation Detectors to provide identification of electrons vs. pions, in conjunction with item 7.

7. An Electromagnetic Calorimeter, to complete the electron identification and to provide a trigger and tag on the decays B → eX.


9. A Fast Trigger to reduce the event rate by a factor of 50 before the event information is moved off the detector.

10. A Barrel-Switch Event Builder capable of organizing the data streams from 10⁶ events per second into individual events.

11. An online Processor Farm of about 10⁶ MIPS (= 1 TIP) capability to provide the higher-level triggering needed to reduce the event rate to 1000 per second for archival storage.

A view of this detector concept is shown in Figure 2. In the remainder of this section we expand on some of the design considerations of BCD.

Heat Resistance and Air Pressure Drop

in a Model of the BCD Silicon Vertex Detector

Hans Jösslein and Jacqueline Miller

We have measured both the heat transfer from simulated amplifier chips to the cooling air and the pressure drop per module on a fairly realistic model of part of a large silicon tracking detector for the BCD experiment.

The observed temperature rises are quite moderate, about 10 K in the worst locations. The air flow used may be on the low side if total air temperature rise needs to be reduced (see TM Ref.1). In that case, the heat transfer will get even better.

The total pressure needed to drive the cooling air is 12 inches of water for the 75 g/s flow used here. This flow may be on the low side of what will be needed, depending on the total air temperature rise allowed. The pressure presents, however, no serious technical challenge. Cables will add as yet unknown restrictions to the air flow, which were not modeled here.
PROPOSED METHOD OF ASSEMBLY FOR THE BCD SILICON STRIP VERTIX DETECTOR MODULES

Fermilab

CD: 1977  October 14, 1981
CHALLENGING REQUIREMENTS FOR VERTEX TRACKING DETECTOR

NO. OF PIXELS = $10^7$
PIXEL SIZE = $30\mu m \times 30\mu m$
NOISE LEVEL = 50 ELECTRONS RMS
TAG TIME PER HIT = 15 NANO SECONDS
READOUT TIME = 1 MICROSECOND
RADIATION HARDNESS = 1–10 MRAD
HYBRID THICKNESS = 500 MICRONS

NEAR TERM PIXEL READOUT REQUIREMENTS DEFINITION

ARRAY SIZE = $256 \times 256/N$
PIXEL SIZE = $30\mu m \times 80\mu m \times N$
TAG TIME = 15ns
READOUT TIME = 600ns/MET
RADIATION HARDNESS = > 500K RAD
NOISE LEVEL = 200 ELECTRONS RMS
UNIT CELL FUNCTIONS = AMPLIFICATION
ANALOG BITS = 5–8
PERIPHERAL CIRCUIT FUNCTIONS = TIME REGISTER; FAST SCAN PATTERN MATCHING
POWER = 10\mu W/PIXEL
COMPOSITE STRAW BUNDLES

PROTOTYPE STUDY OF THE STRAW TUBE PROPORTIONAL CHAMBER

C. Lu, K.T. McDonald and D. Secrest
Joseph Henry Laboratories, Princeton University, Princeton, NJ 08544

Fig. 3. Model fits to the gas gain in Ar/Ethane (50/50) gas.

\((d\sigma/dT)/(d\sigma/dT)\) vs. Gas Gain

Fig. 5. The ratio of relative gain change \((d\sigma/dT)\) to the relative temperature change \((d\theta/dT)\) as a function of the gas gain in P-10 and Ar/Ethane (50/50) for 9.8 mm and 9.0 mm diameter anode wires.

Table 2. A sample of wire instability measurements.

<table>
<thead>
<tr>
<th>T (°C)</th>
<th>V (V)</th>
<th>V_a (V)</th>
<th>((V_a/V)^2 - 1)</th>
<th>D_stra (mm)</th>
<th>D_tube (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>0</td>
<td>0</td>
<td>1718</td>
<td>0.003</td>
<td>0.032</td>
</tr>
<tr>
<td>800</td>
<td>0.12</td>
<td>2.64</td>
<td>0.033</td>
<td>0.05</td>
<td>0.15</td>
</tr>
<tr>
<td>1200</td>
<td>0.11</td>
<td>1.10</td>
<td>0.320</td>
<td>0.51</td>
<td>0.75</td>
</tr>
<tr>
<td>1250</td>
<td>0.28</td>
<td>0.89</td>
<td>0.320</td>
<td>0.51</td>
<td>0.75</td>
</tr>
<tr>
<td>1300</td>
<td>0.51</td>
<td>0.75</td>
<td>0.320</td>
<td>0.51</td>
<td>0.75</td>
</tr>
<tr>
<td>1350</td>
<td>unv</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A Fast Low-Power Time-to-Voltage Converter for High Luminosity Collider Detectors

A. E. STEVENS
AT&T Bell Laboratories, Whippany Rd., Whippany, NJ 07981

V. BUDIHARTONO, R. P. VAN BERG, J. VAN DER SPIEGEL, H. H. WILLIAMS
University of Pennsylvania, 209 S. 33rd St., Philadelphia, PA 19104

L. CALLEWAERT, W. EYCKMANS, W. SANSEN
Catholic University of Leuven, Kardinaal Mercierlaan 94, Heverlee, Belgium

Abstract—A new CMOS integrated circuit has been designed to measure the time interval between two digital voltage pulses. The measurement is stored as an analog voltage on a capacitor for later digitization. The targeted range of measurable times is 5–25 nanoseconds, with a resolution of 0.5 nanoseconds. An additional feature of the circuit is a storage depth of 8 samples, i.e. 8 consecutive time measurements may be recorded individually. Hence, the chip is a combination of a time-to-voltage converter (TVC) and an analog memory.
OPTIMISATION OF THE TRANSITION RADIATION DETECTOR

Angel M. Lopez
and
Jose C. Palathingal

Department of Physics
University of Puerto Rico
Mayaguez
Puerto Rico

10 modules, 13 cm thick
~137 Cu foils/module, 13 μm thick
~ x-ray peak ~5 keV ⇆ Ar + Kr gas
~1 detected x-ray module
Readout: pixels vs. strips?

E-M CALORIMETRY

Dave Anderson: combined C + SCINTILLATION
PbF: p = 8, χ^2 = 9, source = FAST e/m\n+
TBF scintillator (low concentration) = SLOW (e/m)
Separate QIT based on FAST components
SLOW
Readout: photo multiplier (~1300 photo/eV)

A HIGH-THROUGHPUT DATA ACQUISITION ARCHITECTURE
BASED ON SERIAL INTERCONNECTS

M. Bowden, H. Gonzalez, S. Hansen, A. Baumbach
Fermi National Accelerator Laboratory
Batavia, Illinois 60510

Generalized Data Acquisition System Architecture

Data Acquisition System Goal:
Open System Architecture
For The Online Processor Farm

Open System Architecture... Any commercial or in-house built online farm
can be used in the Data Acquisition System
Initial Experience with the Intel i860 Microprocessor

L. D. Gladney, P. T. Keener, N. S. Lockyer, and K. J. Ragan
University of Pennsylvania, Philadelphia, Pa. 19104

J. G. Heinrich and K. T. McDonald
Joseph Henry Laboratories, Princeton University, Princeton, N.J. 08544

January 13, 1990

Our results for the various programs of the standard benchmark suite follow:

<table>
<thead>
<tr>
<th>Program</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dhrystone V1.1</td>
<td>64000 dhrystones/second</td>
</tr>
<tr>
<td>Dhrystone V2.1</td>
<td>52000 dhrystones/second</td>
</tr>
<tr>
<td>Single P. Whetstone</td>
<td>24000 whetstones/second</td>
</tr>
<tr>
<td>Double P. Whetstone</td>
<td>19000 whetstones/second</td>
</tr>
</tbody>
</table>

Our results for the crude benchmark using ISAJET follow. Note that the result for the Amdahl was taken during the day with users on the system.

<table>
<thead>
<tr>
<th>Machine</th>
<th>Result (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vax 3100</td>
<td>409</td>
</tr>
<tr>
<td>Dec 3100 (16MHz)</td>
<td>129</td>
</tr>
<tr>
<td>Amdahl</td>
<td>110</td>
</tr>
<tr>
<td>i860</td>
<td>101</td>
</tr>
</tbody>
</table>
3-D COMPUTER

1987

INTERMEDIATE 3-D COMPUTER
- CURRENT AIR FORCE CONTRACT
- 15 WAFER STACK
- 128 x 128 ARRAY
- SUN WORKSTATION

1990

10 x 10^9 OPERATIONS/sec
<100 WATTS
<20 inches ^3

1994

FINAL 3-D COMPUTER
- 25 WAFER STACK
- 512 x 512 ARRAY

1 x 10^12 OPERATIONS/sec
<500 WATTS
<100 inches ^3

FEASIBILITY DEMONSTRATED
- 5 WAFER STACK
- 32 x 32 ARRAY OF PROCESSORS
- CONTROL UNIT
- SYSTEM SOFTWARE
- SOME APPLICATION SOFTWARE

2 x 10^7 OPERATIONS/sec
1.3 WATTS
8 inches ^3

BCD in 1990

- EOI to SSC
- Beam Tests in M-Test @ Fermilab

Silicon Detectors: AC & DC Coupled Strips
Hughes Pixel Array

Readouts: SUX, CAMEX
Straw Tubes: ~800 W/Cou-Mass EoM Struc
Readout: Penn/MIT Bipolar

- Simulation: ISAJET/GEANT + Pattern Recognition

Silicon Vertex, Straws, RICH, TRD, E-M Cal
⇒ Lots Of CPU Time!!

Trigger: o's; Secondary Vertex; 'Topoecty'

- R&D
Above Systems + Rich, TRD, E-M Cal,
Event-Build Switch

- Future Beam Tests in C^7 @ Fermilab
⇒ B-Physics At Entry Level

685