Drift Chamber Status

Gilchriese Review
September 17-19, 1997

D. MacFarlane
McGill University
Drift Chamber Structure

- Flat aluminum rear (24 mm) and forward (24+12 mm) endplates
  - Forward endplate with thin outer section to minimize material
  - Preamplifier and digitizer electronics on rear endplate only
- Load-bearing inner and outer walls to reduce deflections
  - Inner wall of 1 mm-beryllium (40% load)
  - Segmented outer wall of 2x1.5 mm CF skins on Nomex core (60% load)
Drift System Layout

- 40-layer small-cell chamber
  - Cells are 12x18 mm² in size
  - 7104 drift cells with hexagonal field wire pattern
  - 7104x20 µm gold-plated rhenium-tungsten sense wires
  - 7104x80 and 14560x120 µm gold-plated aluminum clearing & field wires
- Layers organized into superlayers with same orientation
  - Wire directions for 4 consecutive layers: Axial-U-V-Axial
  - Allows fast reduction of input to L1 trigger via segment finding
  - Transition field shaping voltages to maintain uniform performance
Institutional Responsibilities

- **IPP/TRIUMF**: Assembly and stringing, design & fabrication of assembly fixtures, stringing tooling, QC & tension testing, clean room, slow controls, aging tests
- **INFN-Pisa, Padova, Rome**: Automation for stringing, outer CF cylinder, HV & LV power supplies, collaboration on inner cylinder & funding
- **IN2P3-Annecy**: Gas system, monitors & controls
- **Colorado**: Service boards, tension measurement
- **Colorado State**: Feedthrough design & procurement, aging tests, wire replacement techniques
- **Maryland**: Environmental controls
- **Princeton**: Collaboration on endplate design, procurement & QC of endplates, fabrication of assembly fixtures, wire procurement & testing, tension magnet
- **SLAC**: Integration, mechanical design center, electronics and support structures, prototype construction, inner cylinder design and procurement
Technical Progress since January 1997

- Fabrication of endplates, inner cylinder, and outer cylinder completed
- All assembly fixtures & clean room modifications completed
- Wire procurement completed; production and QC of feedthroughs continuing in timely fashion
- Completion of assembly & alignment of structural components; measurement and confirmation of deflection properties, test mount of outer cylinder, test of vertical rotation
- Installation and commissioning of wire transport robots
- Training of all stringing crews, development of all tooling for stringing and QC; start of stringing August 18
- Development of endcap containment design
- System level test of readout with two FEAs mounted on Prototype II endplate
## Activities for Next 8 Months from January

<table>
<thead>
<tr>
<th>Anticipated</th>
<th>Actual</th>
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<tbody>
<tr>
<td>Complete inner cylinder (March)</td>
<td>May 9</td>
</tr>
<tr>
<td>Complete wire delivery (early April)</td>
<td>September</td>
</tr>
<tr>
<td>Complete outer cylinder (April)</td>
<td>June 9</td>
</tr>
<tr>
<td>Electronics system test on Prototype II with 2 readout assemblies (May)</td>
<td>September</td>
</tr>
<tr>
<td>Complete feedthrough production (May)</td>
<td>October</td>
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<tr>
<td>Assemble and align chamber structural components (May)</td>
<td>May 23</td>
</tr>
<tr>
<td>Complete robot testing in Rome (April)</td>
<td>May 12</td>
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<tr>
<td>Establish alignment and software controls</td>
<td>August 6</td>
</tr>
<tr>
<td>Begin stringing (late June)</td>
<td>August 18</td>
</tr>
<tr>
<td>Complete stringing (November)</td>
<td>December</td>
</tr>
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**Difficulties Encountered & Addressed**

<table>
<thead>
<tr>
<th>Problem</th>
<th>Response &amp; Implications</th>
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<tbody>
<tr>
<td>✓ Beryllium section of inner tube damaged during machining</td>
<td>➡ Beryllium section truncated without physics impact</td>
</tr>
<tr>
<td>✓ BES molded delrin insulators show fracture problem under stress</td>
<td>➡ Extensive investigation of possible effect for celanex insulators at BABAR</td>
</tr>
<tr>
<td>✓ Chosen optimization of creep &amp; yield strength for aluminum wire</td>
<td>➡ Late discovery of wire breakage while crimping</td>
</tr>
<tr>
<td>✓ Lengthy commissioning time for wire transport robots</td>
<td>➡ Expand training schedule &amp; hire all crews for fast stringing start</td>
</tr>
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</table>

- Two month delay used to practice assembly & alignment
- Discovered & addressed many procedural & design problems
- Conclude no discernable problem, but re-mold long sense feedthroughs with no schedule delay
- Adjustments to crimping, installed tension, expedite re-order of 80 $\mu$m wire
Installation of First Wire on August 18

Stringing started at 16:00 on August 18 with two crews of two people and one robot each; 91 wires installed on first shift.
Endplate Procurement

- Order placed July 3, 1996 with Brenner Tool & Die
  - Vendor for CLEO III endplates
  - Subsequently chosen for new CDF endplates
  - Located within 30 minutes of Princeton
- Manufacture complete: Dec 23, 1996
- Coordinate measurements completed at Brenner Dec 30, 1996
- Analysis of CMM data completed at Princeton Jan 7
  - All tolerances well within specifications
- Electroless nickel plating (2 μm thick) completed at Techmetals, Dayton OH on Jan 21
- Final CMM check at Brenner Jan 27
- Received at TRIUMF January 31
  - Minor deburring and cleanup during February
# Hole Location Measurements

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<tr>
<th>Class</th>
<th>#</th>
<th>Tolerance: Sigma</th>
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<tr>
<td></td>
<td>Spec</td>
<td>Front</td>
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<tr>
<td>Sense</td>
<td>7104</td>
<td>37.5</td>
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<tr>
<td>Field</td>
<td>656</td>
<td>37.5</td>
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<tr>
<td>Clearing</td>
<td>320</td>
<td>37.5</td>
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</table>

All sense and 5% of field/clearing wire hole locations measured with Brenner’s large CMM (calibrated Nov 1996). Each measurement consisted of 4 hits at 2 different depths.
Inner Cylinder Procurement

- Complicated precision part with few available vendors
  - Hot-formed beryllium sheet brazed together to form tube
  - 1100 aluminum transition pieces brazed to ends and machined
  - 5083 aluminum flanges ebeam welded to ends of assembly
  - Final precision machining cuts on 3 m-full length part
- Order placed July 17, 1996 with Electrofusion, Fremont, CA
  - At last review delivery had slipped from Jan 27 to Mar 17
- Disaster strikes January 27, 1997
  - 2.5 inch diameter hole punched into beryllium section near one end by machining subcontractor while working on transition piece
- Solution adopted after considering available options
  - Cut out damaged section with no loss in solid angle coverage
  - Re-do all steps from time beryllium tube section completed
- Further schedule loss of 2 months, delivered to TRIUMF May 8
Completed Beryllium Tube

Rollup and braze of central Beryllium section completed at Electrofusion in late November
Outer Cylinder Procurement

- Two clam-shelled half-cylinders for easy assembly
  - Two 1.5 mm carbon fiber skins on 6 mm Nomex core
  - rf shielding with 50 and 100 μm aluminum skins
  - Carbon fiber-aluminum end rings for attachment, thereby minimizing material

- Order placed with Monfrini, Milano on Oct 15, 1996
  - Mandrel completed and inspected by mid-March
  - Parts fabricated between March 17 and April 10

- Parts tested at Monfrini May 23-30 and again through June 9
  - 180 μm compression under 2050 kg load; no slippage of circumferential friction joint (96 screws)
  - Adjusted for mistake in circumferential screw locations
  - Gas sealing good to 20 mbar, some leakage at 30 mbar

- Ship to TRIUMF for arrival on June 17; test fit and load transfer on June 20
Fabrication of Outer Cylinder in Milan

Mandrel for forming Outer Cylinder Half Shells

Completed Outer Cylinder Half Shell before application of inner & outer aluminum rf shields
Assembly Preparations

- Clean Room upgraded from January-March
  - Roof raised, temperature & humidity control installed
- Mobile Assembly Frame: completed mid-February
  - Consists of central shaft, spider to hold endplate rims, framing structure, and 3-point mounting system
  - Temporary alignment fixture allows precision movement of endplates
  - Inner cylinder and endplates held on a central shaft mounted to bearings at ends, coupling to rotation motor
- Trial assembly using dummy inner cylinder from March-May
  - Worked systematically through all procedures for mounting and aligning chamber components
  - Discovered alignment hardware was too flexible, but established procedures to work within this constraint
    » Able to demonstrate required concentricity alignment and capability for measurement of azimuthal alignment at required precision
Assembly Preparations

- Performed a 50% load test on endplates in early verification of FEA calculations
- Corrected problems with cable hardware used to attach endplates to spider at 24 points

- Experience implemented improvements invaluable for final assembly; saved many weeks from schedule

- Fixed Assembly Frame: completed for service May 12
  - Consists of a transition piece, a large fixed frame with platforms, and a hoist system
  - Allows for rotation of mobile frame with chamber into the near vertical position for buried wire replacement
    » Vertical stringing test performed in late May to demonstrate feasibility
    » Repeated in June to confirm reproducibility of 3-point alignment system and mechanical stability of structure
Assembly Fixture Components

- Inner Cylinder
- Spider
- Alignment Fixtures
- Central Shaft
- Mobile Frame
- Fixed Frame
Components Installed in Assembly Fixtures
Assembly & Alignment

- Final mount and align of chamber structure: May 9-23
  - Mount endplates to support fixture with alignment hardware
  - Mount endplates and inner cylinder onto central shaft
  - Set concentricity of inner cylinder
  - Set concentricity and relative azimuthal rotation of endplates
    » Parallelism set by inner cylinder fabrication
    » Concentricity established to ±30 (±75) µm for front (rear) endplates
    » Relative alignment with tiltmeter and precision level better than 20 µm

- Pre-tension & deflection test in June 12-20
  - Set location of endplate outer radius with load applied, compensate for forward endplate load imbalance
  - Apply equivalent of 100% wire load using 48 cables & spring-scales
  - Measure endplate deflections vs radius; compare to FEA model
    » Only modest accuracy required due to small total deflection
  - Mount outer cylinder and transfer load from spider structures
Test Mount of Outer Cylinder
Deflection Test Results

- Excellent agreement between measurements and FEA model
- Mounting outer cylinder left rear endplate slightly out of flat (0.6 mm)
  - Slight adjustment in pre-load position of forward endplate to balance forces
    - Consistent with possible range of moments carried by OC joint
  - Better control over bolt tightening to ensure even load transfer
- Minor re-design of cable hardware for spider allows easy adjustment
  - Established that endplate rim could be re-positioned during stringing
  - Will measure endplate location after each superlayer
Feedthrough Production

- Design with minor improvements validated by Prototype II
- Main production has been underway for some time
  - Crimp pins & metal feedthroughs ordered from Medelac Nov 1996
  - Insulator molds produced in Dec 1996
  - Increased order in January to 40% overage in QC accepted parts
  - Assembly & QC planning and personnel trained and working well
  - Production keeping pace with demand at TRIUMF

- Current status of production:

<table>
<thead>
<tr>
<th>Type</th>
<th>Number at CSU</th>
<th>Number at TRIUMF</th>
<th>Number to make</th>
<th>Comments</th>
</tr>
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<td>Metal ground</td>
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<td>19492</td>
<td>0</td>
<td></td>
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<tr>
<td>Long field</td>
<td>0</td>
<td>16149</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Long sense</td>
<td>0</td>
<td>8188</td>
<td>3000</td>
<td>Awaiting crimp pins, to be last</td>
</tr>
<tr>
<td>Short field</td>
<td>7000</td>
<td>0</td>
<td>14000</td>
<td>7000 ship 16/9</td>
</tr>
<tr>
<td>Short sense</td>
<td>1200</td>
<td>0</td>
<td>7000</td>
<td>1200 ship 16/9, molding finishes 12/9</td>
</tr>
</tbody>
</table>
Sample Feedthroughs and Tooling
Feedthrough Insulator Studies

- Problems discovered with molded Delrin insulators for BES chamber
  - Traced to low mold-temperature causing improper crystallization
  - Results in long-term HV-stress induced damage to dielectric
    » Seen in BES chamber and reproduced by laboratory testing
    » Cracks visible in electron microscope images

- Investigated whether analogous problems with glass-filled Celenex insulators for BABAR
  - Longitudinal slices of larger sense insulators show small voids in interior surface created by hot core pin
  - Analysis by Hoechst Technical Polymers shows modest polymerization degradation due to slightly elevated melt temperature
    » Higher temperature needed to allow simultaneous filling of narrow field and larger sense molds at same time
  - No leakage current problems seen in 100+ day HV test of 200 feedthroughs at twice normal voltages, sample baked at 150C, or Prototype II operations

- To be absolutely sure, re-molded all insulators operating at HV, keeping within recommended temperature range
  - No schedule impact on stringing
Aluminum Wire Procurement

- Field and Clearing Wire: 120 and 80 µm gold-coated aluminum
- Order placed Oct 15, 1996 with California Fine Wire for 300000 ft x 120 µm, 150000 ft x 80 µm
- Entire 450000 ft at Princeton by early December 1996, but had unacceptable creep rate of more than 10%/10 days
  - Annealing at 300°C for few minutes shown to reduce this by factor 3
  - All wire sent back to CFW, annealed, and returned to Princeton for QC testing
- During July, while doing test installation at maximum tensions, discovered wire breaks routinely at crimp at tensioning end due to reduced yield point
  - Crimp size and maximum installation tension adjusted so that 120 µm acceptable; but no safe point discovered for 80 µm wire
  - Decided to replace 80 µm supply with wire annealed at 150°C, which reduces creep by 40% but retains 90-95% of yield
- New 80 µm wire delivered in early September and accepted by QC inspection
Optimization of Annealing Temperature

Annealing point for new 80μm aluminum wire

Original annealing point for aluminum wire

- **Yield**
- **Creep**
- **Elongation**
Sense Wire Procurement

- Sense Wire: 20 µm gold-coated tungsten-rhenium (3%) alloy
- Higher resistance than pure tungsten, but shown to represent negligible contribution to signal degradation
- Order for 150,000 ft placed with Luma, delivered in April 1997
  - Matches strength and surface quality requirements, but 80% rejected for failing curliness specification
- Luma agreed to replacement, with partial delivery by July 1
  - Full replacement received July 18 and satisfies all requirements

“It ain’t over till it’s over.” --- Yogi Berra
Pneumatic Crimping Tools Developed

- Ten pneumatic crimping tools with custom designed jaws produced after two rounds of prototyping
  - Foot pedals being used for production versions
- All tools adjusted to correct jaw size and fixed with Loctite
  - Size tested again after 500 crimps and again at start of each shift
  - One tool tested to 16000 crimps with no sign of wear
Crimp Size Settings

- Studies performed to determine range of acceptable final crimp size
  - Wire slips if crimp too large; wire breaks if too damaged by crimping
  - Aim to have 100 µm window to allow for tool and operator variation

- Performance depends on whether wire is under tension or not, when crimped
  - However, possible to find single setting for good results at both ends
  - For good crimps, wire breaks about 50% of time at crimp, 50% elsewhere

- Discovered that not possible to use same tools for all three wire types

<table>
<thead>
<tr>
<th>Crimp Size [10^{-3} inches]</th>
<th>Wire µm</th>
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</thead>
<tbody>
<tr>
<td>18.0 - 22.5</td>
<td>20</td>
</tr>
<tr>
<td>18.0 - 20.0</td>
<td>80</td>
</tr>
<tr>
<td>20.5 - 22.5</td>
<td>120</td>
</tr>
</tbody>
</table>

- Maximum installed tension reduced to 34% (27%) over nominal for 80 (120) µm wire or 100 (200) g to compensate for deflection & creep
Studies of Optimal Crimp Size

Annealed 120 micron CFW @ 300g Pretension (New Crimp)

Annealed 120 micron CFW @ 225g Pretension (New Crimp)

Annealed 120 micron CFW @ 265g Pretension (New Crimp)

Annealed 120 micron CFW @ 0g Pretension (New Crimp)

Crimp Size

Drift Chamber System

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Gilchriese Review Sept 17-19, 1997
Automated Tooling

- Robots, rotation motor, power supplies, and electronics arrived at TRIUMF on May 27
  - Robot 1 controls and software well exercised on mockup in Rome prior to shipment
- Mechanical and electrical installation for two robots began June 2 and completed June 12
- Robot 1 aligned to endplates using CCD camera
  - Discovered new degrees of freedom, which took several weeks to investigate and find correction
  - Torsion in central shaft and inner cylinder creates phi-dependent location correction
- Intensive software development from mid-June, allowing single robot evaluation with stringing crews starting July 18
  - Several wires successfully strung; changes and improvements to robot procedures identified
- Second robot brought online, and full software system commissioned and debugged through August 6
## History of Assembly Steps before Stringing

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<tbody>
<tr>
<td>Finish concentricity and rotational alignment:</td>
<td>completed May 23</td>
<td>Mount motor: completed June 6</td>
<td>Chamber placement: completed June 12</td>
<td>OC test fitting, load transfer: completed June 20</td>
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<tr>
<td>3-point alignment:</td>
<td>completed May 29</td>
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<tr>
<td>Vertical motion test:</td>
<td>completed May 29</td>
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<td></td>
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<tr>
<td>Wilkens survey:</td>
<td>completed May 30</td>
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<tr>
<td>Robot</td>
<td>Unpack: completed May 30</td>
<td>Install and align base 1 &amp; 2: completed June 3</td>
<td>Cabling: completed June 11</td>
<td>Control boxes, encoders: completed June 20</td>
<td>Commission R1: started July 14</td>
<td>R2 systematics: ongoing</td>
<td>R2 calibration: ongoing</td>
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<tr>
<td></td>
<td>Install arms 1 &amp; 2: completed June 6</td>
<td></td>
<td></td>
<td></td>
<td>R1 calibration: completed July 12</td>
<td></td>
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<tr>
<td></td>
<td>Vertical restring: completed May 29</td>
<td>Test completed crimp tools: completed July 4</td>
<td></td>
<td></td>
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<td>New strings training: ongoing</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Install magnet coil for tension measurement: completed August 7</td>
<td>Go to clean conditions: completed August 11</td>
</tr>
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</table>
Stringing Procedures

- Stringing steps validated on Prototype II & TRIUMF mockup
  - Wire spool beyond endplate on dispenser
  - Attach wire to magnetic needle and pass through endplate to robot for transport to other end of chamber
  - Thread feedthroughs and glue into endplates at each end
  - Apply and measure tension at far end (front endplate)

- Using two crews per shift, two shifts per day (7-15:00, 15-23:00)
  - Stringing crew consists of 2 people (new hires) and 1 robot
  - Senior stringer used as shift supervisor for overall coordination
  - Fifth person hired for both shifts as backup and for preparatory & robot support work

- Train crews on mockup in May-July; full 8 on payroll by July 1
  - Tables, dispensers, clamps, and crimp tools all built up for training use
  - Stringing used 1/16th endplate segments with realistic ergonomics
  - Wire and feedthrough handling, gluing techniques, refinement and optimization of techniques, use of robot when available in August
Stringing operation in progress
Robot1 at home position near rear endplate
Robot1 at tension test location
Closeup of rear endplate feedthroughs
QC Procedures

- **Shift procedures**
  - Crimp tools tested before each shift and recorded, along with tool number, wire and feedthrough batch numbers
  - All wire and feedthroughs inspected at source, recorded on travelers
- **QC shifts** run at 12:00, 18:00, and 23:00 each day, require 3 people each
  - Visual inspection of wires, crimps, and sealing
  - Tension and resistance-to-ground measurements
  - SLD “Twanger” and commercial Hungarian meters used in minimum 50 gauss-m field generated by coils on mobile frame
    - 5% tolerance window on measured tensions
    - Signal-to-noise marginal for sense wires in inner superlayer
  - Pull and clean feedthroughs of bad wires
  - Wire replacement rate started at 2.4% and has dropped to 0.7% in last week
- **Periodic re-measurement of superlayer tensions** to monitor tensions
- **QC database** established with storage in Oracle at SLAC
  - Wire, feedthrough, tooling, personnel, environmental data
  - Automated data from robot system, including tensions
History of Stringing Rates

BaBar Drift Chamber Stringing Progress

- Day shift
- Evening shift
- Cumulative (right hand scale)
- Cumulative bad wires (left-hand scale)
## Stringing Plan

### Wires Installed - Plan vs. Actual

<table>
<thead>
<tr>
<th>Week Ending</th>
<th>7/18</th>
<th>8/1</th>
<th>8/15</th>
<th>8/29</th>
<th>9/12</th>
<th>9/26</th>
<th>10/10</th>
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<tr>
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<td>0</td>
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<td>4513</td>
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<tr>
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<tr>
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<td>21000</td>
<td>25000</td>
<td>28768</td>
<td>28768</td>
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Ongoing Prototype II Work

- Being used for system test of service board & front-end assembly readout system
  - Close to achieving preamp limited discriminator thresholds
  - Expect to use pre-production ROM later this fall
- Also serves as development bed for online and offline software

Sample resolution result: consistent with simulation

Running Conditions:
- Helium:Isobutane = 80:20
- HV = 2020V, Gain = $1.8 \times 10^6$
- Threshold = 1.5 electrons

Prototype preamplifier IC on prototype amplifier card

Verified expected resolution vs MC
Electronic Mounts

- Design and development of mounting scheme well advanced
- Consists of modular readout assemblies containing preamplifier-digitizer boards
- 16 radial arms provide mechanical support and cooling
- 16x3 readout assemblies mount to signal connectors at back of service boards
- Signals brought out by 24 trigger and 4 data optical fibers
- Full-scale mockup using pre-production parts to study all design issues
- 2 front-end readout assemblies mounted on Prototype II this summer
- Expect production of all modules by January 1997
Forward Cover Design

- Crowded region, in physics acceptance, with many penetrations
  - Gas sealing using electrically conductive o-rings verified by prototype tests
- Expect production of components by January 1997
Initial Test & Checkout

- DCH stringing assumed completed in Dec 1997
  - Replace rejected wires and mount outer cylinder
    » So far no buried wires requiring replacement, but can rotate chamber periodically during stringing or at completion
  - Complete program of tension, gas sealing, HV testing at TRIUMF
    » Developing a version of the “Twanger” which automates tension measurement of a 4x2 cell block for use on superlayer level QC
    » Second technique using HV pulsing may also be available
  - Ship to arrive at SLAC by beginning of March 1998

- Initial checkout at SLAC in LAB (3 weeks)
  - Redo tension, gas sealing & HV testing
  - Vertical frame available if wires need to be replaced; past experience shows not very likely

- Install rear endplate cover components & utilities (5 weeks)
  - Cylinder extensions, bulkheads, ribs, water, gas, and cables
  - Ready for electronics installation around April 24
DCH Electronics System Test

- Install forward endplate cover components (8 days)
  - Assumed in parallel with electronics mounting
- Install & test electronic readout system (3 weeks)
  - Front-end assemblies, trigger & data boards, environmental monitors, cables & fibers
- System and cosmic ray testing (12 weeks)
  - System level testing for 6 weeks, ready to install July 1, 1998
  - Planned insertion date allows 6-week cosmic ray run
  - Ideally would use production ROM; backup of using presently available vROM from Prototype II
  - Trigger provided by scintillator in center of chamber
  - Aim to achieve complete checkout while chamber endplate still fully accessible
  - Could also test production gas system; non-flammable gas
Installation into BABAR

- Installation into BABAR (4 weeks)
  - Anticipate erecting insertion tooling, installing DCH, dismantle tooling August 12-19
    » Assumes installation separate from DIRC
    » Fits well within master installation plan period of Aug 12-24
  - Estimate 2 weeks to complete water, gas, HV, and signal connections
    » Assume after August 24 can proceed in parallel with other activities around experiment
  - Initial checkout with cosmic rays can continue for about 6 weeks
  - Plan to route utilities from front through conduit down center of chamber to rear
    » Reaching conclusion of cable and utilities length implications
    » Allows rollup of DIRC SOB without disconnecting utilities
    » Need to understand possible interference with FCAL later in the fall
Cosmic Ray Data Accumulation

- Cosmic Ray running periods
  - Parasitic use of available time
  - 6 weeks for system checkout until mid-October
  - 4 weeks with magnet on and helium:isobutane gas mixture
    » Minimum period for reasonable track sample
    » First look at space time relationship before April 1999
    » Aim to reach fast turn-on of calibrated data
  - 3-4 weeks for optimization and alignment studies until mid-Dec, assuming no interference from FCAL installation
- Need to understand trigger source, requirements for testing tracking components of BABAR trigger

Test and Commissioning Plan the subject of DCH Meeting at TRIUMF on September 20-21
L3 Milestones

- Automated Tooling Assembly & Testing Complete (-67 days)
  - Challenging problem of industrial robot development for new problem
  - Delays in shipping partly reflect decision to wait until needed on site at TRIUMF following Inner Cylinder delivery

- Components at TRIUMF - Ready for Assembly (-35 days)
  - Reflects accident with Inner Cylinder production

- Stringing 25% Complete (-55 days; projected Oct 2)
  - Reflects delays of IC, 80 µm wire problem, lengthy robot installation

- Stringing Complete (-36 days; projected Dec 23)
  - Same as above, but with some improvement due to faster stringing start
  - See Master Stringing plan with projected finish 1st week of December

- Drift Chamber arrives at SLAC (0 days, projected March 3)
  - Reflects compression of previously relaxed post-assembly testing schedule at TRIUMF

- Drift Chamber available for installation (0 days; projected July 1)
  - Requires carefully planned test & commissioning plan
Activities for Next 6 Months

<table>
<thead>
<tr>
<th>Anticipated</th>
<th>Actual</th>
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<tbody>
<tr>
<td>Complete production stringing (December)</td>
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<tr>
<td>Complete electronics system test on Prototype II with 2 readout assemblies and ROM (December)</td>
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<tr>
<td>Complete design and fabrication of endcap containment components (January)</td>
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<tr>
<td>Complete fabrication of electronic mounts (January)</td>
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<tr>
<td>Complete initial DCH checkout at TRIUMF (Feb)</td>
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<tr>
<td>Complete Gas System (March)</td>
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<tr>
<td>Begin test &amp; Commission plan at SLAC (March)</td>
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<tr>
<td>Complete service boards (December)</td>
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<tr>
<td>Complete FEAs (April) and mount (May)</td>
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Conclusions

- Drift chamber team continues to work together very effectively
  - Manpower and technical resources are sufficient to do the job
- Project on schedule for installation in July 1998
  - Production stringing began August 18 and is already close to desired installation rate, should complete in December
  - Design for remaining few components well advanced, with procurements to be placed shortly
- Preparations for DCH test and commissioning at TRIUMF and SLAC are well underway
  - Plan incorporates necessary extensive cosmic ray testing, including magnet on periods, for fast start of crucial tracking component
  - Meeting at TRIUMF 20-21/9 will add detailed planning
- Electronics schedule is tight, with 2 new chips in pre-production phase and heavy integration of FEAs
  - Emphasizes need for early system debugging with final electronics, scheduled to start in April 1998