SDC-92-265

Solenoidal Detector Collaboration

Monthly Report

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SDC
TECHNICAL PROGRESS

1. UNIVERSITY OF WISCONSIN (PSL) - MUON SYSTEM

Muon Chamber

Efforts in this project were concentrated in three areas:

Intermediate Chamber Design and Analysis
More detailed analysis of deflections and reaction loads for all octant were performed. The preliminary results indicate that IW3 supports deflect by approximately 2.5 mm in all octants which results in a rigid body motion of IW3 as a unit. More work is needed to reduce this deflection. IW2 unit does not move more than 0.5 mm. A tube layout for IW3 which is reverse of the layout of BW3 was derived. This results in good theta, phi and stereo coverage around the 90 degree closed BW3-IW3 comer.

Intermediate Chamber Integration
The area between the end of the barrel toroid and IW2 was investigated in detail. Coil ends have been modeled in great detail. Coil cooling, muon chamber gas, muon cable routing, interference with bridge, coil power, and access issues were investigated and incorporated into Intergraph models. This is the area that IW modules mount on the toroid and needs more study to arrive at the mounting scheme.

Intermediate Chamber Design Tasks
A detailed list of all known tasks for the design of the Intermediate System was prepared with rough guesses of the duration of each task for various labor categories. This list was presented at the muon engineering meeting to be incorporated into the overall schedule and resource allocation models. These tasks and durations are for the adaptation of the design of the Barrel System to the Intermediate system. The estimate is for 4 person-years of engineering and 2 person-years of drafting.

Preliminary Design (Iron and Coils)

Further structural analysis, investigation of the bolted comer joint, and the production of new drawings for the preliminary design report have been the focus of the work on the Muon Barrel Toroid (MBT). The results from the 3D analysis at FNAL and SSCL have been searched for the maximum corner joint loads and moments. These loads and moments were resolved by hand calculations into stresses in the corner bolts and keys. The results for all the normal load cases have a considerable safety margin. Accidental load cases such as earthquake loads, and large floor motion also result in acceptable stress levels. Further work on combined load cases will be done. Other analysis work includes study of buckling of the inclined plate (8 inch and 12 inch cases), dynamic loading during assembly, and the results of cylinder failure. Comer bolt specification and tightening methods were also addressed. Superbolts, supernuts, hydraulic wrenches, torque multipliers, and stud tensioners have been investigated. Superbolts are tensioned by tightening an array of small jack screws in the bolt head. These fasteners are very attractive because even a M56 can be tightened with a small wrench. The cost of superbolts is currently high, but under negotiation. The drawings for the design are being updated for the preliminary design report at PSL and SSCL. The plates, bolt, and key

pieces were drawn this month. A considerable effort was spent preparing for the presentation to the PAC on the magnet design.

A new low profile barrel coil joint design was developed this month. Use of the new joint design provides more room for cables and utilities, better access to the water hoses, and easier joint clamp assembly. A brazing fixture for the coil joints was designed and fabricated. This fixture will be used to test induction brazing of the coil joints, and hopefully for production brazing as well.

2. UNIVERSITY OF WISCONSIN (PSL) - TRIGGER SYSTEM

Calorimeter Level 1 Trigger

Jet Trigger Studies

We have studied the revised design for a calorimeter level 1 jet trigger based on tower sums. We have produced new results.

Jet trigger performance is a strong function of tower size. The best performance was found with an overlapping grid of 1.6 times 1.6 towers or an overlapping grid of 3.2 times 3.2 towers. The choice between these is not obvious. At luminosity of 10^{33}, 95% efficiency is reached by the overlapping grid of 3.2 times 3.2 towers at 186 GeV, assuming a 3 kHz rate. When the luminosity increases to 10^{34}, 95% efficiency is not reached until 330 GeV.

At the luminosity of 10^{34}, small size jet triggers do not reach full efficiency at 400 GeV unless a rate in excess of 10 kHz is taken. A single trigger tower jet trigger, for instance, requires 30 kHz rate to reach 95% efficiency at 284 GeV. For comparison, a 3.2 times 3.2 jet trigger reaches 95% efficiency at 251 GeV with a 10 kHz rate; i.e., with a rate a factor of three smaller, it displays better efficiency.

The disparity in performance between these two extremes is present at 10^{33} as well. For instance, a single trigger tower at 3 kHz reaches 95% efficiency at 287 GeV. A 3.2 times 3.2 tower at 1 kHz reaches 95% efficiency at 243 GeV; thus again, despite having a rate three times smaller, the 3.2 times 3.2 size has better efficiency.

With the tower size of 3.2 times 3.2, there is less of a difference between using overlapping and non-overlapping towers than with smaller sizes. This may indicate that almost all jets are contained in a 1.6 times 1.6 region of the calorimeter.

The choice of an integer scale does not seem to be an important consideration in determining the performance of a jet trigger.

Trigger System Engineering

System Design

We have continued detailed studies of the new system design of the Level 1 trigger. This includes a new version of the Level 1 Muon trigger that correlates the muon system with the outer tracker and quiet regions in the calorimeter with only 64 phi bins. We have verified the trigger timing. We have also begun the process of evaluating the feasibility of various hardware realizations of the design. As part of this we have designed, simulated and are having fabricated a 4 x 12-bit CMOS adder, which is a common component of several boards in the present circuit design. As part of the development of the interface

between trigger and front end electronics and trigger and data acquisition, we have begun development of the Trigger Emulation Module described below.

CMOS 4 x 12-bit Adder

A common component found in several places in the present trigger system design is an Application Specific Integrated Circuit (ASIC) that adds 4 12-bit numbers and can operate in the clocked 16-ns trigger structure. As a result, we have designed a pipelined domino logic two-stage adder. The device has been simulated in CMOS technology and has achieved the design goal step time of less than 13 ns. The ASIC is being fabricated by MOSIS. We are now designing an evaluation board. The device takes as input 4 12-bit operands and as output a single 12-bit number. Carry in and out, reset, overflow, and diagnostic inputs and outputs are provided for.

Level 1 Clock & Control

System Design

We have studied the revised the global clock and control system. We have evaluated the overall system timing and potential impact of the revised correlated muon trigger.

Trigger Emulation Module

We have produced preliminary specifications for the Trigger Emulation Module (TEM). The TEM is designed to emulate much of the clock and control functionality anticipated for the final SDC Global Trigger System. Its purpose is to aid in the test bench debugging of Subsystem DAQ and trigger circuits, and to serve the basic functions of a trigger module for test beam experiments. The TEM is designed to operate as part of a bench test of front end electronics, where it provides patterns of Level 1 and 2 Trigger and clock signals that can be fed in from either pulsers, an external Pattern Generation Module (see below) or a DAQ processor. The TEM is also designed to operate in a test beam, where the clock is externally provided by the accelerator RF signal and the triggers are produced by beam hodoscopes. The TEM provides the gating logic necessary to handle the interface to the DAQ processor, providing interrupts when triggers occur, and holding off triggers while the processor is busy, as well as monitoring this dead time. The goal of the TEM development is to provide a module to which front end electronics and DAQ systems can interface that resembles the final interface to the trigger clock and control system. The TEM is designed so that a subsystem that operates with it should find minimal difference when the TEM is replaced with the final interface to the trigger clock and control system. This should ease eventual integration of detector electronics subsystems into the global SDC trigger clock and control system.

The TEM provides the Level 1 Accept/Reject, Level 2 Accept, Level 2 Reject, Level 1 Synch, Level 1 Reset, and Bunch Crossing signals. It provides a test trigger output that can be used as an empty bunch indicator. It also carries a bit that is used to stop the clocks. The bits that indicate the state of these signals can either be filled up in a FIFO memory by the DAQ processor and played back at 16 nsec speed. The 60 MHz clock can be generated internally or by an external RF clock. If the DAQ processor can only read one event at a time, then for each Level 1 Accept, the TEM checks if the DAQ processor is busy. If not, it issues the trigger, and raises the busy until the DAQ processor reads out the event and lowers the busy. If the DAQ system is buffered, the TEM does not raise a busy and wait for the DAQ to clear it. Instead, the TEM issues Level 1 accepts until the DAQ raises the busy. It then stops Level 1 Accepts until the busy is cleared. The busy is brought in and out on external connectors so the busy can be chained with other modules. The TEM counts the number of Level 1 Accepts that should be issued and the number that are actually able to be issued when the DAQ processor is not busy. The TEM counts

the time when the DAQ processor is busy and produces an interrupt if this time exceeds a preset value. The TEM can be reset via the DAQ processor or a front panel button.

3. ARGONNE NATIONAL LABORATORY

Design of a Lead Scintillator Plate Calorimeter

Calorimeter Conceptual Design (ANL)
Single plate test molds were completed and contract for test casting was awarded to Taracorp, Granite City, IL, to produce three (3) sample castings each of the following allows:

1. Pure Lead
2. .06% Ca/.5 Sn
3. .06% Ca/1.3 Sn

In addition, Taracorp will product test sample strips 1/4" x 8" to be used for tensile and hardness tests at Argonne. These strips will be of the same alloys listed above, plus two sets of sample lead antimony alloy.

Radiation Hard Scintillator Development (Bicron Corporation)
Fiber test materials to be used in spanning the range of characteristics expected in the optical system were shipped to Argonne. These comprised fiber of three different diameters. Production of the first batch of 4 mm sheets was unsuccessful due to an unfortunate error in the mold preparation process. This error was immediately corrected for the first production run of 2.5 mm sheet.

Barrel Calorimeter Conceptual Design (WSTC)
Pre-prototype (18 cell) casting. In March, the 18-cell mold was assembled and shipped to Taracorp, Granite City, IL. A purchase order was placed with Taracorp to make a lead alloy casting from this mold. The alloy is 0.08% calcium and 0.5% tin.

Central Calorimeter Engineering Design
Prototype Program: Work on a 10- tower mechanical test model was performed to provide proof of principal for bulkheads that only penetrate shower maximum at eta = .1. In addition, a test of terminating bulkheads in the lead plates immediately before and after shower max. is represented in the test model.

Barrel EM
Further work was performed to reduce the number of bulkheads that penetrate the shower maximum space, possibly at eta = .2 boundaries.

Endcap
Endcap model is being run with the exact configuration as represented in the Technical Design Report baseline design. No major differences are anticipated. An SDC note will be published on these results.

4. LOS ALAMOS NATIONAL LABORATORY

Materials Science Studies

Progress has been made on the fabrication and testing of compression-molded cooling ring arc segments. 120° arc segments have been fabricated from graphite fibers and epoxy as well as cyanate ester resins. Efforts are being directed towards perfecting this process,

thus diminishing the reject rate and improving component quality simultaneously. A new technique used with success entails spraying the material charge into the mold to obtain a more isotropic fiber distribution. This process is being demonstrated using P75 fibers and TEM 9000 toughened epoxy as well as 954-3 cynate ester resins. The immediate milestones for this technique are to produce arc segments with approximately 60% fibers and 40% resin whose sides and bottoms are nearly 20-mils thick and are well filled with resin bearing an isotropic fiber distribution. The fiber distributions and orientations of arc segments have been examined using scanning electron microscopy (SEM). The improvement in fiber isotropy experienced by spraying the charge rather than shaping it by hand was determined using this system. Nondestructive evaluation (NDE) is being used to characterize the mechanical properties of arc segments. Ultrasonic techniques for determining the components of the elasticity tensor for arc segments as well as their shear moduli and Poisson's ratios are in use. This NDE information augments that of the SEM by quantifying the mechanical properties of the arc segments non destructively. Matrix consolidation and overall use efficiency, i.e., shear transfer behavior, can also be quantified ultrasonically. A full 360° cooling ring mold is receiving attention. The desire to begin making prototypes of an actual cooling ring for use in stability demonstrations provides this incentive. The experience gained in using the 30° and 120° arc segments is valuable to this enterprise. Additional features desired for the tool to meet the stringent tolerance requirements of actual cooling rings are under consideration. Vendor contributions have been sought and construction drawings will follow.

Wick Composition

The basic foam wick composition is a cross-linked polystyrene. The emulsion used to make the foam is styrene/divinylbenzene, surfactant, and water with an initiator ($K_2S_2O_8$). The amount of styrene/divinylbenzene determines the density of the final foam. The amount of divinylbenzene determines the amount of cross linking and, hence, the stiffness and brittleness of the foam. The amount of surfactant determines the openness of the foam. The level of the oil components (styrene/divinylbenzene plus the surfactant) determines the flow characteristics of the emulsion: the higher the oil level, the less viscous the emulsion. We can make emulsions below ~75 mg/ml, but the viscosities are higher than we would like to use in filling the molds. We have made approximately 75 moldings of many different compositions: oil from 0.05 - 0.15 g/ml with divinylbenzene from 10 - 50 %; and surfactant from 20 - 50 % of the oil plus surfactant phase. The de ionized water always contained 0.15 g of initiator/ml. We have found compositions that give satisfactory stiffness and mold release.

The method and degree of mixing of the emulsions are very important in determining the size of the cells and, hence, the interconnecting pores. Pores of the most open foams are general about 30% the size of the cells. We are able to control the porosity of the foam wick in a range that should meet the porosity requirements of the wick.

Mold Material

A number of materials are possible for use a mold materials. Emulsions stick to metals, however, and Teflon and polyethylene give a skin. Ceramic and graphite-filled Teflon were also possible candidates. Glass gives the best surface and release properties, but is difficult to fabricate in complex geometries. We have chosen Delrin as our mold material, because it has the highest oxygen content and, therefore, is the most like glass of the common polymers. It is easy to machine and is reasonably stiff at room temperature. It has worked satisfactorily without producing a skin. Freshly machined Delrin gives good molded surfaces and releases the molded material. With use, the molding surface releases the cured emulsion more reluctantly. This can be offset by: 1)

cleaning the mold with a 44% solution of concentrated nitric acid in water for about five minutes or 2) keeping the mold surface clean with methanol after each emulsion cure cycle. The acid treatment did not produce a skin on the molded foam, but long exposure times etch the Delrin too much and shorter times are ineffective; higher concentrations of acid etch the surface badly within a very short time. Our one try with a "black" Delrin proved to be unacceptable.

Preliminary Mold Designs

A very complex mold design was tried in the early stages. The emulsion was fed into the mold through holes in the bottom of the mold that eventually entered and exited the molding cavity in the sides of the molded piece. The holes in the sides were plugged during cure, but we were never able to make foam moldings that were not defect-free in the region. This early mold also did not allow room for extra emulsion needed to account for shrinkage. The next attempt addressed both of these issues and simplified the mold construction. Made of Delrin with an O-ring seal, this single action mold has proven to be quite versatile and has served as the model for our wick mold.

Cooling Wick Mold Designs

A mold to make a cooling wick for a 390 mm diameter ring has been designed and is currently being building. The dimensions of the cavity have been designed to mate with the 120° carbon support arcs already in hand. This mold is made entirely of Delrin and requires only three pieces. The male component moves up to allow filling and then down to force the emulsion into the desired shape. This design is required as the thin dimensions of the mold do not permit the emulsion to be pushed through the mold easily and without changing the structure of the emulsion. Construction is expected to be complete by mid-April. Production of cooling rings will commence shortly thereafter.

Alignment and Stability Studies

Precision hardware for the purpose of constructing silicon detector assemblies has been fabricated and is in use. Assemblies comprising 4 edge-bonded silicon detectors with graphite/epoxy reinforcement edge strips have been produced. Efforts are being directed towards controlling bondline thickness and micro precision. Tests of the mechanical integrity of these assemblies will be conducted as functions of bondline thickness and other process parameters.

5. ICF KAISER ENGINEERS

Activities during the month were limited to the conceptual design of the Forward Toroids Steel and the design of the Forward Toroids Transfer Bridges.

Forward Toroids Steel

Finite element analysis to determine block-to-block bolt sizes and shear keys was completed. As a result, shear key length can be reduced substantially. Drawings of the Forward Toroids blocks and the support system have been updated and transmitted to the SSC Laboratory for cost estimating. Preparation of a conceptual design report is in progress.

Forward Toroids Transfer Bridges

Calculations for the transfer bridges have been completed. Drawings are being updated to show all member sizes for cost estimating. Preparation of the conceptual design report is in progress.

6. LAWRENCE BERKELEY LABORATORY

Cost and Scheduling

The LBL C/S coordination effort was directed towards on and off-site assistance to the SSCL team in assembling the data for the subsystems detailed cost and schedule books in preparation for the May review of the Technical Proposal. New scheduling and cost capabilities were developed in Open Plan to make it more effective. We reintegrated the Silicon Tracker Schedules and produced the custom reports needed by that team.

Scintillating Tile Calorimeter Design

Replaceable Hadronic Plug
The Scope of Work/Requirements Document for a parametric FEA model and initial analysis work on the Plug was completed. A responsive quote of $10k was received from MCR Associates, Sunnyvale, Calif. (local bay area ANSYS representative) with a completion date of 6/1/92. All purchase order paperwork has been completed; we will place the order with MCR on 5/11/92. Work on formal absorber plate/absorber structure drawings to obtain vendor quotes is about 70% complete.

Monolithic Endcap EM
Design, fabrication, and assembly proceeded in parallel to ready the ECEM 4 x 4 beam test assembly for Brookhaven in June. With the exception of the supporting carriage, all the mechanical parts were available for assembly by the end of the month.

The ECEM design progressed on several fronts. An updated, illustrated design description of the monolithic ECEM (SDC-92-237) was presented and distributed at the SDC collaboration meeting at Fermilab on April 9-10. A write-up was sent to the SDC integration group outlining a rationale for estimating access intervals for rebuilding radiation damaged zones. Specific "megatile" configurations were examined, which look very promising for cost reduction and edge crack minimization.

7. MARTIN MARIETTA

Muon System Cost & Scheduling

Cost and Schedule
Completed, published, and delivered the "SDC Muon System Costs and Schedules (Supporting Documentation for Technical Proposal)" final report to the PRD.

Generated a 21-viewgraph colored presentation to be shown at the May Review of the SDC Detector TDR.

Attended cost/schedule working meetings at the SSCL from 4/13-4/15 to support development of the SDC Cost/Schedule summary book. The muon system cost and schedule book was delivered at this time, cost summaries and schedules were

incorporated into the summary book, and an evaluation of PRD's Open Plan system was made with recommendations for additional capabilities to be added.

Generated muon system cost parametric equations. Total cost impacts for each of the muon subsystems are calculated by entering a new barrel toroid length and inside radius.

Resource Allocation Modeling (RAM)
Work continued on the muon facility layout to show the sequential usage of the facility in conjunction with the RAM and barrel production schedules being compressed in order to fit the forward and intermediate chamber assemblies into the building.

Forward and intermediate chambers were incorporated into the RAM including alignment and checkout tests.

Tool concepts for the forward chamber assembly and supermodule structure assembly were developed to support the RAM. Designs include the transport/rotation of the supermodules, handling spreader for lowering structures into the hall, transfer from the headhouse hoist to the hall hoist, vertical stand to hold the structure during the octant chamber installation, and octant chamber lifting/rotation tool and spreader beam to move the assembled supermodules to the detector for installation.

Updated manufacturing flows for the assembly of the forward muon octant chambers, resource lists, time span estimates, and resource loading for the RAM.

Work began on the muon chamber installation sequence on the toroid in the hall. Assembly flows are being developed for the supermodule structure and assembly of the octant modules, transport, rotation and lowering into the hall for installation on the detector.

The first run of the RAM was completed with the data currently being analyzed and manufacturing flows being further refined for future runs.

Steel Structural Analysis
Prepared an ANSYS input file of the solid ring model. Transferred it to Bob Wands to perform independent verification of the model, the material elemental orientation, and the shear modulus scaling factor.