

Technical Progress Report

G-2 and CMS fast Optical Calorimetry

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To

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(A) CMS Forward Calorimetry

Progress on CMS Forward Calorimetry was incremental, but important. For the first time, the US groups on CMS have confidence that the brazed matrix absorber for the quartz fibers will be fabricated within specs.

We provided a novel PMT base with individual dynode HV taps, for tests of high rate performance and linearity during beam operations (and to help with a Forward Calorimeter Group study of raddam of the quartz fibers, damaged in-situ by the PS proton beam). The novel base concept of ganging dynodes together on PMT in rings of constant rapidity (see same irradiation), and powering them with an individual HV power supply, was developed by Fairfield. This concept has 3 virtues over Cockcroft-Walton or active bases: (a) it eliminates all active devices at PMT itself, a high radiation/high absorbed dose area. PMT bases failures are a major difficulty with PMT; (b) it allows arbitrary & perfect tapering of the dynode voltage chain for optimal calorimeter performance; (c) is a low cost alternative when the number of PMT ganged together exceeds the number of PMT stages. However, it does require: (a) that the PMT signals be digitized before being used in a trigger, as the tubes cannot be perfectly balanced (fortunately this is the case in CMS), and (b) that the PMT are measured and then preselected to have gains within ~ 50% of each other. Such is the case in CMS. Unfortunately, the group did not install this base, as the quartz fiber calorimeter raddam test module (provided by Texas Tech) failed to perform adequately, and there was no point in changing bases for a comparison.

A PMT downselect was made with the help of the Fairfield Group in collaboration with U.Iowa. The PMT selected is a Hamamatsu R7525, an 8 stage variant with a hemispherical low mass window and transit time (~15 ns) considerably less than the 25 ns beam crossing time, first proposed and obtained by Fairfield. This past year, Fairfield worked closely with the Iowa group on the tests needed and the design of the hardware for the main PMT test station at Iowa. A small fraction (2%) of the PMT were shipped to Fairfield for confirming/duplicate tests, in the existing Fairfield PMT test station which was refined this year, upgrading the computer data acquisition system. The duplicate tests give a measure of confidence in the test procedures. These tests include data to back out the quantum efficiency and the gain separately, by using multicolored LED and the statistical method of obtaining the number of p.e. and gain from the shape of the ADC

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histogram of a pulsed light source. A constant alpha source/NaI light source, triggered by a coupled PMT, was used to obtain a photon source with less than 1/3 photon per trigger, and is used in tests to confirm the absolute quantum efficiency of a PMT, and the width of the 1 p.e. distribution.

The Fairfield group continued to refine the optical reflectors using the novel (Brewster's angle $> 90^\circ$) multilayer dielectric reflector material from 3M that the Fairfield group introduced to high energy physics technology 3 years ago. A paper is in preparation describing general uses for this material, with reflectance exceeding 99%, which makes it competitive with total internal reflection (TIR) in many high energy physics light collection and light transport applications. It enables effective numerical apertures (N.A.) approaching 1, and, for example light-pipes blue-green light through a 1 meter x 1" diameter air light guide transmitting 90% of light emitted isotropically into 2π SR at 1 end, far exceeding TIR with plastic light guides.

The Fairfield group sent 2 personnel to the CMS calorimeter test beams using this FY's funds. We provided the first samples of air light guides and bases. We tested the linearity and pulse response of the bases.

(B) Muon g-2 BNL E821

Muon g-2 is in the final stages of analysis, assuming that no more running is possible. The group has published results in PRL, and recently have prepared a precision magnetic field paper. Work continues on muon edm and analyses that look at variations in g-2 according to the relative orientation of the muons wrt galactic coordinates, the sun, and other astroparticle physics properties. Because negative muons were taken in the last running, analyses comparing positive & negative muons are ongoing. The Fairfield Group participated in group discussions of the analysis and paper preparation. We continue to have tested and available the equipment to modify the laser test pulse system to provide a precision double pulse interval for timing studies in future running or post-running tests of the calorimeters in test beams. Summer labor was used for maintenance and technician work at BNL. Attached is a list of references of the latest results.

(C) R and D

- (a) Muon Collider/Neutrino Factory: The Fairfield group delivered a novel Silicon micromachined microchannel plate (MCP), obtained to spec from NanoSciences Corporation, to the Muon Collider/Neutrino Factory group at Argonne (J.Norem) for tests for use in the muon ionization cooling experiment (MICE). This novel SiMCP had a much lower Z and density than Pb-glass-based MCP, and a much higher open area (~80%), making them a potential candidate to measure in situ a single muon passage by amplifying secondary emission electrons from the passage of a relativistic muon through the MCP placed at 45° to the muon trajectory. The gain of the SiMCP was shown before shipment to be above 10,000 per electron, sufficient when imaged to the side of a beam pipe by electrostatic fields to detect the x-y position of the muon to a precision of 20 microns. The

- final tests of this device will be performed this summer at Argonne, and at U. Iowa medical sciences facility.
- (b) OWL/EUSO: This same SiMCP is proposed as the basis of a novel ultra-low-mass phototube (Gene Loh, U.Utah/NSF) for the OWL/Airwatch/EUSO space detector (similar to Fly's Eye). The goal is to obtain photodetector pixels ~ 1-3 mm diameter with 1 p.e. sensitivity at 370 nm (nitrogen scintillation). This FY, Fairfield, in collaboration with NanoSciences Corporation, demonstrated that polycrystalline GaN and diamond photocathodes can be directly deposited in the input side of the SiMCP, with good QE. This is a novel feature, as photocathodes cannot be deposited on glass MCP due to the Pb which poisons them, and due to the low melting temperature of the glass.
 - (c) NLC: We have proposed development of a novel form of high precision hadron calorimetry with U.Iowa to use a Cerenkov signal detectable in a hadron or jet shower in an ionization calorimeter to compensate (make $e=h$ at same energy) the energy response. Monte Carlo has indicated it may be possible to measure the energy of an incident hadron to $15\%/ \sqrt{E}$.

THE MUON ANOMALY: EXPERIMENT AND THEORY.

By Muon g-2 Collaboration (J.P. Miller *et al.*). Nov 2001. 17pp.

To appear in the proceedings of 20th International Symposium on Lepton and Photon Interactions at High Energies (LP 01), Rome, Italy, 23-28 Jul 2001

RECENT PROGRESS ON THE BNL MUON (G-2) EXPERIMENT.

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TESTING CPT AND LORENTZ INVARIANCE WITH THE ANOMALOUS SPIN PRECESSION OF THE MUON.

By Muon g-2 Collaboration (M. Deile *et al.*). Oct 2001. 6pp.

To appear in the proceedings of 2nd Meeting on CPT and Lorentz Symmetry (CPT 01), Bloomington, Indiana, 15-18 Aug 2001.

A NEW PRECISE MEASUREMENT OF G-2 OF MUON.

By Muon g-2 Collaboration (I. Logashenko *et al.*). Jul 2001. 5pp.

Published in *Budapest 2001, High energy physics* hep2001/108

Results From the Beam Test of the CMS Forward Quartz Fiber Calorimeter Pre-Production-Prototype (PPP-I), Feb. 2002, Authors: P. Bruecken et al., CMS NOTE-2002/021, submitted to NIM

Abstract: We summarize the beam test results of the first pre-production-prototype (PPP-I) of the quartz fiber calorimeter of the CMS detector. The calorimeter consists of quartz fibers embedded in an iron

matrix. The results presented are on the energy resolution of the prototype for electrons and pions, the signal uniformity and linearity, and the longitudinal shower profiles.

Radiation Effect Studies on High Efficiency Mirror (HEM) and Aluminized Mylar for the HF Optical Design, Authors: P. Bruecken et al., CMS IN-2002/031, May, 2002.

Abstract: Reflectivity of two materials, high efficiency mirror (HEM) and aluminized Mylar, under intense radiation were compared. In the UV range, Mylar seems to perform better. At longer wavelength (400+ nm) region, there seems to be no significant difference.

LINEAR COLLIDER PHYSICS RESOURCE BOOK FOR SNOWMASS 2001.

PART 1. INTRODUCTION. By American Linear Collider Working Group (T. Abe *et al.*). SLAC-R-570, SLAC-R-0570, SLAC-570, SLAC-0570, BNL-52627, CLNS-01-1729, FERMILAB-PUB-01-058-E, LBNL-47813, UCRL-ID-143810-DR, LC-REV-2001-074-US, Jun 2001. 85pp. Available as [hep-ex/0106055](#) (part 1), [hep-ex/0106056](#) (part 2), [hep-ex/0106057](#) (part 3), and [hep-ex/0106058](#) (part 4). Resource Book APS / DPF / DPB Summer Study on the Future of Particle Physics (Snowmass 2001), Snowmass, Colorado, 30 Jun - 21 Jul 2001.

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