Project name

R&D for luminosity monitor

Classification (accelerator/detector:subsystem)

Accelerator

Institution(s) and personnel

University of Iowa, Department of Physics and Astronomy:
Yasar Onel (professor) Co-PI, E. Norbeck (professor), J.P.Merlo, A.Mestvirisvili (post-doc), U.Akgun, A.S. Ayan, F. Duru (grad.students), I.Schmidt (Mechanical Engineer), M.Miller (electronics engineer), Jon Olson (undergrad. scholar)

Fairfield University, Department of Physics:
Dave Winn (professor) Co-PI, V.Podrasky (engineer), C.Sanzeni (programmer)

Bogazici University, Department of Physics, Istanbul, Turkey:
Erhan Gülmez (professor)

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Gulsen Onengut (professor)

METU, Department of Physics, Ankara, Turkey:
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Project Overview

Introduction:

We propose R& D for a novel method for calorimetry at high rates, for doses exceeding 100 Giga Rad. The method collects an amplified secondary emission signal resulting from absorbed radiation sampled in a shower. The basic detector concept consists of absorber plates interspersed with secondary emission surfaces followed by sheet dynodes. The R&D will investigate: (A) materials to obtain high secondary emissive surfaces for mips, based largely on SEM monitors used for accelerator beam diagnostics, and various dynode technologies, based on new planar PMT dynode technologies (electrochemically etched metal dynodes, others) appropriate for gains of few x 1000 per secondary electron; (B) GEANT Monte Carlo of predicted performance based on the results of (A), for incident particles and jets between ~1 GeV-3 TeV, including secondary electron optics; (C) Engineering Point Designs for assembly, vacuum integrity, signal presentation, and costs; (D) Construction & Tests (including raddam) of a single secondary emission detector package at least 5cm x 5cm square.

It is well-established that many secondary emission surfaces are radiation-hard. Typical Sb- coated SS dynodes (g~5) used in most PMT today survive 50-100 GRad of internal electron bombardment, and MgO or BeO dynodes survive higher doses, albeit at lower yield (g~2.5-3). Similar surfaces are used to monitor accelerator beams at high doses. We propose to use SEM surfaces to sample the shower caused by jets and particles in the forward region (3<eta<7). Secondary emission for a m.i.p. typically falls to a gain g between g~ 1.1-1.5. Conservatively, we thus anticipate that 10% of through-going mips will create one secondary electron, and 50% of electrons with energies less than 100 KeV will produce one extra secondary electron. On this basis we estimate, by scaling from scintillator or quartz fiber calorimetry, that with 2.5 cm thick sampling plates in Cu we would detect >10 vacuum secondary electrons/GeV. With a gain of ~1000, this would be sufficient for forward calorimetry (the equivalent of ~1 p.e./GeV, with an intrinsic pre-gain fluctuation of ~30% per p.e., to translate to optical calorimetry), with excellent timing characteristics.

A default gain mechanism is to use large area planar metal dynodes with micro-machined apertures for secondary electron impingement and transport, such as metal meshes, or structures similar those used in the Hamamatsu R5900. The micromachining is a relatively low-cost electrochemical etch. The planar dynodes can be made from ~1 mm thick metal sheets as large as 50 cm on a side. An assembly might use simple insulating supports between secondary emission cathode, dynode and anode plane. The areal size in not a restriction as in a planar PMT assembly, where the glass window thickness becomes prohibitive if the span is unsupported, whereas a metal thickness could be made sufficient for any vacuum and be counted as part of the absorber, and the presence of internal supports of the vacuum envelope (non-glass window) are not as disruptive as in a PMT. For example, the supports might obscure as much as 10% of the SEM cathode or dynode (on a few cm areal scale), with little effect on the performance of a forward calorimeter, as the effective open detection area is not as critical as in a PMT for single photon detection. In one realization, for example, the sem cathode, mesh dynodes, and anode are all supported by simple stackable ceramic support grids, fired from a molded greensheet. The dynodes can be spaced at ~1 mm apart, as in modern PMT. Given that a 10 stage PMT at 2 KV typically has a gain of 10^6, a 5 stage gain section with g=1,000 at 1 KV is reasonable. The SEM cathode, dynode stack, and anode could be less than 1 cm thick. A simple metal package could use ~5-15 mm thick plates on top & bottom to withstand vacuum over a 30+ cm span, with a 1 mm thick x 1 cm deep metal wall between them, with a brazed ceramic fitting on the anode side for feedthru of HV and signal. As an example, an effective 2.5 cm Cu thickness with an effective 1 cm of vacuum SEM detector would have a density ~ 70% of Cu. A tile might be ~3.5-4 cm thick, with a ~30 cm major diameter, in square or hexagonal cross-section to the beam, or even as sectors, with the anode segmented appropriately for the eta-phi sectors, and with appropriate bias for signal and HV to pass through a stacked calorimeter. With care, the dead region between tile edges could be as small as 3-4 mm, which could be ameliorated by alternating overlap in subsequent longitudinal tiles.

For the phase I R&D on this project, we propose studying the possibility of this to a sufficient level where information on performance and cost are sufficient to enable a decision to build a prototype calorimeter in subsequent proposal phases. The R&D will investigate: (A) materials to obtain high secondary emissive surfaces for mips, based largely on SEM monitors used for accelerator beam diagnostics, and various dynode technologies, based on new planar PMT dynode technologies (electrochemically etched metal dynodes, others) appropriate for gains of few x 1000 per secondary electron; (B) GEANT Monte Carlo of predicted performance based on the results of (A), for incident particles and jets between ~1 GeV-3 TeV, including secondary electron optics; (C) Engineering Point Designs for assembly, vacuum integrity, signal presentation, and costs; (D) Construction & Tests (including raddam) of a single secondary emission detector package at least 5cm x 5cm square.

Budget-FY03-04

Institution	Item	Cost
Iowa	½ post-doc	$25,000
Iowa	¼ grad. student	$6,000
Iowa	Detector and raddam testing	$5,000
Iowa	2 months engineering salary	$6,000
Iowa	Travel	$8,000
Fairfield	Detector and raddam testing	$5,000
Fairfield	Secondary emission detector package	$10,000
Fairfield	Partial support for two undergrad. Student	$6,000
Fairfield	Travel	$2,000
Iowa	Iowa total	$50,000
Fairfiled	Fairfield total	$23,000
	Grand total	$73,000

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