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SDC
SOLENOIDAL DETECTOR NOTES

REPORT OF THE SDC CALORIMETER CALIBRATION REVIEW COMMITTEE

January 11, 1993

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Report of the SDC Calorimeter Calibration Review Committee

C. Hearty, Chairman
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Introduction

The charge and membership of the calibration review committee is attached in Appendix A. The committee met during the SDC collaboration meeting, Dec. 9--12, 1992 and was presented with talks on all aspects of the calibration system discussed in the Charge. In addition to this report, the committee produced 50 action items, which are summarized in Appendix B. After presenting general observations and concerns, the report briefly outlines the committee's major concerns for each subsystem, then discusses the specific issues of shower-max calibration and safety.

General Comments

There are six aspects of the calibration system that were addressed in this review: source calibration, light flasher, charge injection, *in situ* calibration, beam tests, and cosmic rays. Good progress is being made in all subsystems. However, work is need to combine these individual components into a complete system. The committee recommends that the performance requirements on each subsystem be defined in the context of an overall system, including a detailed specification of the relationships between the subsystems and the degree of redundancy required. The complete system must enable the electromagnetic calorimeter to meet the design goal of a 1% constant term. For example, the PMT stability required over the period of time to do an *in situ* calibration needs to be established. Furthermore, there is confusion as to the meaning of the linearity requirements presented in the technical design report. These requirements were intended to limit the deviations from linearity of the average of all channels, not each channel independently. The difference in interpretation has an impact on the constant term.

Source Calibration System

The source calibration system will allow every tile to be exposed to the moving radioactive source during installation and assembly, and during extended shutdowns once normal operations have commenced. During data taking, approximately 10% of tiles will be accessible in the hadron calorimeter and in the barrel EM compartment. All tiles of the endcap EM compartment---where

radiation damage is most severe---will be accesisible. The goals of the system include:

- Quality assurance during assembly;
- determine initial tower calibration; carry beam calibration to untested modules;
- determine tile-to-tile mask (if needed);
- study B-field on/off effects;
- check for scintillator/fiber aging;
- measure radiation damage profile.

Major Issues:

• Engineering is needed to study driver and source wire reliability and fatigue; evaluate commercial drivers; and study alternative source wire designs. Current design does not easily work in ECEM.

• Evaluate alternative isotopes.

Light Flasher System

The flasher system is used to monitor the gain stability of PMT and to measure the linearity of the PMT and the front-end electronics. The system distributes nitrogen laser UV light to a number of distribution points ("cows"), where it is wavelength-shifted to green and distributed to the PMTs. There is one optical fiber per PMT. Pin photodiodes and phototubes monitor the stability of the system.

Major Issues:

• Stability of monitoring system and parts of distribution system not monitored by the photodiodes;

• Integration (number and location of lasers; space required on outer radius of calorimeter);

• Requirement on PMT stability during the 3--5 month period necessary to collect data for the *in situ* calibration;

• Interaction between linearity and constant term, and the corresponding requirements on the neutral density filters;

• Does the flasher provide an adequate distributed timing signal in the period before *in situ* calibration is possible.

Charge Injection

The charge injection system measures linearity and absolute gain of the front end pulse-monitoring electronics. It is currently not planned to calibrate current-monitoring circuits.

Major Issues:

The committee did not have the expertise to evaluate this subsystem. However, it appeared that it might, by itself, account for the full 1% constant term that is the goal in the EM calorimeter, if it is used to determine the linearity.

In Situ Calibration

The *in situ* calibration establishes the tower-to-tower relative calibration (to the level of a few tenths of a percent); determines the absolute energy scale of the calorimeter; and fixes the timing of each front-end electronics channel relative to the main clock. In the electromagnetic calorimeter, the ratio of the calorimeter energy to the momentum measured by the tracker can be used for electrons from W and Z decays to establish the calibration. An alternative that does not use the tracker would be to reconstruct the Z mass from its decay to electrons. Initial studies indicate that either method could work in a reasonable amount of time.

The hadronic calorimeter can be calibrated with γ/Z+jet events, or with dijet pt-balance.

Major Issues:

- Studies are in an early stage. Eventually these studies need to determine systematic errors, rather than statistical.

- hadronic section needs to be quantitatively studied.

Test Beam/Cosmics Rays

Some fraction of the modules will be calibrated in a test beam at SSCL or FNAL. In addition, cosmic rays may be used to study modules. The calibration in tested modules will be transfered to untested modules using the source calibration system to achieve a calibration accuracy of 2% at beam turn-on.

Major Issues:

- Experience with 1993 barrel prototype will guide decisions in this area. Decisions have impact on assembly area and procurement. In particular, the amount of time and space required in the assembly area for cosmic ray testing must be understood.

Shower Maximum System

The standard source tubes fully illuminate eta-measuring shower max strips. The phi-measuring strips, however, run parallel to the source tubes, so the signal induced in the strip depends on its location. This problem is addressed during assembly by temporarily installing additional tubes that allow all strips to be calibrated. During operation, the relative channel calibration will be derived data, including comparisons between the EM and shower-max energy measurements and between the phi and eta-measuring strips.

One to three optical fibers from the flasher system are connected to extra pixels in each shower-max multichannel PMT. This will monitor the overall gain variations of the tube, due, for example, to high voltage fluctuations. Pixel-to-pixel variations, which could be due to longer-term effects such as photocathode aging, would be reflected as channel-to-channel variations.

The front end electronics are not yet defined for the shower maximum system, but a digital design would be compatible with the charge injection system of the calorimeter electronics.

Major Issues:

- Verify that the stated requirement of 10% relative channel calibration is appropriate for all functions of the shower-max system. Is is feasible to achieve this calibration *in situ* without the source calibration?

- Investigate the feasibility of adding additional source tubes specifically for the phi-measuring strips.

- Determine the time stability of the relative gain of multichannel PMT pixels, and establish that it is compatible with the required channel-to-channel calibration.

Safety

It is anticipated that the source size will be comparable to those used previously in source drivers, so existing experience is applicable. Because the source is exposed during operation, an interlock system will be needed to ensure that personel are excluded from the area of the source drivers during those times. The details of this interlock and the specifics of the labeling and/or fencing requirements when the driver is not in operation need to be determined in consultation with the SSCL ES&H group.

Interlocks may be needed on the flasher laser. The connections between the laser and the distribution fibers must ensure that there is no laser light leakage.

Appendix A.

SDC CALORIMETER CALIBRATION REVIEW

December 11, 8:30 - 12:30, SSCL

Charge

The committee will evaluate the overall calibration plan, progress on hardware development, and implementation of the calibration system in the prototype. The review will cover charge injection, light flashers, source system, cosmic ray and in situ calibration. The evaluation should also address safety issues such as source radiation hazards. The committee will prepare recommendations on the calibration system and its implementation.

The review committee:

Christopher Hearty - Chair
Steve Gourlay
Richard Kadel
Jim Freeman
Virgil Barnes
Andy White
Bob Wagner
Jean Ernwein
Steve Hahn
Jim Missig - ex officio
Paul Mantsch - ex officio

SDC CENTRAL CALORIMETER
Calibration Design Review
December 11, 1992
Action Items

1 - Calibration - General

#	Originator / Assignee	Short Title	Actions to be Accomplished
3	Jim Missig / Craig Blocker	"Robust" System	Plan of method to repair failures that may occur in the calibration system.
10	Jim Freeman / Craig Blocker	Project Management	Project manager should set up design reviews of major components (for example, source driver). For this case, SSCL radiation safety officer should attend.
18	Steve Gourlay / Craig Blocker	Calibration - monitoring requirements	Distinguish requirements for mask operating / QA/QC / rad damage monitoring / stability. How can we take advantage of this? Ex: consider impact on position and number of in situ source tubes.
21	Steve Gourlay / Craig Blocker	Sourcing used for QA	Assess possible damage scenarios. Try to anticipate questions which might arise during assembly / checkout. What is the repair threshold?
24	Steve Gourlay ; Craig Blocker	Longitudinal Masking	Evaluate and document the need for longitudinal masking. Match to SDC calorimeter geometry (fiber length variations, tile uniformity, etc.) Outline a plan to use prototype for evaluation.
33	J. Proudfoot / C. Blocker	Definition of electronics non-linearity	Need to better understand the "piecewise" linearity as a function of binary range and its effect on calorimeter response.
37	C. Hearty / C. Blocker	Linearity of EM calorimeter	Understand impact of errors in linearity correction on EM _____.

2 - Source System

#	Originator / Assignee	Short Title	Actions to be Accomplished
1	R. Kadel / Craig Blocker	Source System Engineering	The current source driver lacks adequate engineering support. A crude estimate would be 1 FTE engineer + designer to finalize source driver mechanism, including source wire, driver locations, routing of source holes in the various _____, etc.
2	R. Kadel / Craig Blocker	Source calib for 1993 BNL Test	Need source calibration system for LBL test @ BNL. This should include hardware and software to _____ source driver into 88 source channels
9	Jim Freeman / Craig Blocker	Source Driver Safety	Want hardware interlock on source driver so you are sure that the source is garaged.
16	S. Gourlay / Craig Blocker	LBL Source Wire	Work on LBL source wire. Incorporate into Barnes source driver. What is minimum diameter?
19	S. Gourlay / C. Hearty	Preferred Isotopes	Can we obtain preferred isotopes? What is the fall back position and implications?
39	Jim Freeman / Craig Blocker		Quantitatively evaluate acceptability of source calibration for EM, given 0.5mm plate deflection.
40	Jim Freeman / Craig Blocker		Want to park source at absolutely known location ~±1mm.
41	Jim Freeman / Craig Blocker		What does SSCL ES&H have to say about source types (Rv, Cs, ...) and packaging schemes?
43	B. Wagner / V. Barnes	Effect of source tube location	Measurements have been made of the change of scintillator response as source tube location is changed. This has been done for both lead and air. A definitive study needs to be done for the calorimeter using EGS, for instance, that provides information on how much our calibration suffers from displacement of the source tubes from both casting and sagging of the lead.

2 - Source System (Cont'd)

#	Originator / Assignee	Short Title	Actions to be Accomplished
45	B. Wagner / V. Barnes	Longitudinal Source Scanning	Is it necessary to do longitudinal (radial) source scanning? 1. What is the goal? 2. Can the goal be met with tubes that require source Y's to penetrate two towers? That is, providing tubes that are near the interior towers of the em calorimeter module is difficult.
46	B. Wagner / C. Blocker	Engineering of source driver and wire.	Engineering effort should be provided for source calibration system to improve driver and to provide a source of wire that has improved fatigue properties and provides safe encapsulation of the source. Considerations to include in the design: 1. Space allocated on the module to the source driver and where it will be located. 2. Need for tighter bending radius for wires. r=1.5" seems desirable. Is it achievable? 3. Readout of source position is desired. Readout of the indexer that indicates which tube is selected is required. 4. Indexer allowing ≥200 source tubes needs to be provided.

3 - In Situ Testing

#	Originator / Assignee	Short Title	Actions to be Accomplished
8	J. Freeman / Yarba	Redo MC Study	Julia's study needs to include photostatistics, otherwise conclusions are questionable.
13	S. Gourlay / C. Blocker	Compensation for Rad Damage	Choose location and number of source tubes to provide sufficient information on longitudinal damage profile.
14	S. Gourlay / Turcortte	In Situ Calibration Scheme	Continue (accelerate) evaluate of realistic in situ calibration schemes.
17	S. Gourlay / C. Blocker	Number & location of in situ source tubes.	What is the required number and location of in situ source tubes? Match to specific requirements of in situ sourcing.
20	S. Gourlay / J. Ernwein	SM Calibration / QA	Examine other methods of calibrating SM to overcome shortcomings of source tube coverage. Separate issues of calibration / QA with rad damage stability monitoring.
27	V. Barnes / C. Blocker	Quantify accuracy of gain monitoring for in-situ calibrations	Quantify how well we must follow day to day (or hour to hour) response variations of each tower in order to average over weeks or months of electronic forms W's or Z's for in situ calibration to 0.2%
29	C. Hearty / C. Blocker	Longitudinal masking / source calib.	. How well does response measured with source calibration system correlate with response to showers? (or maybe just muons). . Develop techniques to produce reliable longitudinal masks.
36	J. Proudfoot / Turcotte	Cell-Cell calibration without tracking	Consider using $\eta^\circ \times \pi^\circ \rightarrow \delta\,\delta$ decays as a source of calibration data in region E_T^δ ~5-20 gev (at least for a cross check).
38	C. Hearty / J. Ernwein	Shower max channel - channel calibration	- 10% value should be justified - What is the calibration requirement when using shower max to correct rad. damage?
42	J. Freeman / Blocker - Kadel		Too many end cap source tubes.

3 - In Situ Testing (Cont'd)

#	Originator / Assignee	Short Title	Actions to be Accomplished
48	R. Kadel / Yarba	Radiation damage and M.C. studies	Current M.C. studies stop at ~100 gev. An electron from a Z delay at η = 3 has E~500 gev. Simulations should be extended to ~1Tev E to see if there are constant items introduced at high energy by _____.
50	R. Kadel / A. Byon-Wagner	Longitudinal Masking	Rad dam modules should have longitudinal mask installed to see if resolution can be recaptured.

4 - Calibration Electronics and Flasher

#	Originator / Assignee	Short Title	Actions to be Accomplished
4	J. Ernwein / Draper	Change injector for SMD F.E. electronics	Look at compatibility of charge injection system with shower max front-end electronics
7	J. Freeman / Foster	EM Waveform	We need to resolve what the calorimeter waveform really will look like: 16ns clipped or what. Peter Limon has high quality waveforms from EM CDF prototype: look at them.
12	S. Gourlay / G. Pauletta	Fiber lengths for flasher system	What is tolerance on matching fiber lengths from PMT to distribution cookie?
26	V. Barnes / L. Sawyer	YAG laser option	What is pulse to pulse variation of YAG laser? Number needed vs. using N_2 laser? Cost? What benefits does YAG laser provide compared to N_2 laser?
30	Jim Proudfoot / Craig Blocker	Scheme to monitor PMT gain with time	Scale of precision is ~<0.5%. How is this to be achieved? The time scale is 12-24 hours rather than O(7) days. Does the present flasher system realize this? Is this space adequate / _____. I think we need more data.
31	R. Kadel / G. Pauletta	Laser system fiber length	The current laser system assumes a 50m silica fiber from the N_2 laser to the modules. This may be inconsistent with cable plant for detector. Need to check location of N_2 laser in detector hall to see how long the silica fiber needs to be.
32	R. Kadel / G. Pauletta	Location of laser flasher	Work with integration group to locate N_2 laser in detector & site (i.e., above panel, below panel, etc.)

5 - Testing (prototype and production)

#	Originator / Assignee	Short Title	Actions to be Accomplished
5	R. Kadel / S. Gourlay	Cosmic ray DAQ	If the "real" bases for the PMT's are not ready _____ cosmic ray test in late '93, what bases will be used? How does this interface with the rest of calibration system (i.e., charge injection, current _____, etc.)
6	M. Turcotte / M. Lamm	Self triggering cosmic test	Investigate the possibility of doing cosmic tests using a self trigger of calorimeter wedges using PS / SM / EM / HAD combination. Reason: Could do it almost anywhere with a minimum set up.
11	J. Freeman / M. Lamm	Cosmic study	How long do you need to run cosmics (given photostatistics and landau) to get 2% (or 1%) relative calibration? Transverse map?
15	S. Gourlay / S. Gourlay	Calibration DAQ	Define standard readout / DAQ for calibration / monitoring system. Prototype
22	S. Gourlay / S. Gourlay	Sourcing procedures	Define actual sourcing procedures. What do we need to know?
23	S. Gourlay / Wagner	Production cosmic ray testing	Do we do it? On all modules? Where ? SSCL, FNAL, ANL?
25	V. Barnes / M. Lamm	Need Muon hardening for cosmic rays telescope test fixture	1. Need to ensure that muons exit the calorimeter with some minimum momentum - e.g., 8"Fe was used in CDF. 2. What are effects of uniform exit hardening [$\eta = 0$ vs. η = large] giving different muon spectra in EM section? Should you harden to equalize μ spectrum in EM?
28	B. Wagner / B. Wagner	Cosmic rays testing	1. Need a detailed plan of what will be done on prototype and why it is being done. Potential to waste lots of time and manpower. 2. Hardener needed in stand. 3. Hardware required (initially and longer term) will depend on what you want to do (1)
34	P. Mantsch / J. Seigrist	Modules for ongoing beam testing	In order to determine procurement requirements, we need to determine what the configuration of modules is needed for ongoing studies in a test beam.

5 - Testing (prototype and production) (Cont'd)

#	Originator / Assignee	Short Title	Actions to be Accomplished
35	P. Mantsch / J. Siegrist	Module beam testing	It is important to clarify the beam test requirements including the fraction of modules to be tested in order to effectively argue for beam time. We need to determine the objectives of such testing and the penalty (risk) of not measuring modules.
44	B. Wagner / S. Gourlay	Source calibration plan for prototype	A plan detailing source measurements to be performed on the barrel calorimeter prototype needs to be drafted. Plan should include: 1. Goals 2. Statements of what the outputs of each measurement will be. 3. Source characteristics required. 4. Required readout, precision, expected signal.
47	B. Wagner / S. Gourlay	Plan for QA source measurements	I suggest a first version of a plan for source measurement during module assembly be drafted. The plan should state the goal of the measurements, an envisioned procedure, and most importantly what the output of the measurements will be. A couple of suggested issues: 1. Will tile responses be characterized b y a single number, or will there be a response 'map' as a function of source position? 2. How will tile response be unfolded: low energy n source vs. something else?
49	J. Ernwein / S. Gourlay	What DAQ for source calibration?	Set guidelines for DAQ system to be used in source monitoring. How do we ensure compatibility between sites?