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Supplemental Environmental Analysis of the GEM Magnet

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Abstract:

The text of the environmental analysis document submitted for DOE approval on May 14, 1992. This document's designation was reclassified from an Internal Note to a Tech Note on September 23, 1992.

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Superconducting
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May 13, 1992

Mr. Joseph R. Cipriano
Project Director, SSC Project Office
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2550 Beckleymeade Avenue, Mail Stop 1020
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Dear Mr. Cipriano:

The SSC Laboratory is engaging in a detailed design effort to optimize the GEM (Gammas, Electrons, and Muons) detector for the Superconducting Super Collider (SSC). As a part of this effort, the GEM Collaboration recommends adopting a single-coil solenoid configuration, without iron flux return. The proposed conceptual design methodology, will maintain compliance with applicable DOE Orders, the SSC Final and Supplemental Environmental Impact Statements (FEIS, SEIS), their Records of Decision (RODs), the SSC Mitigation Action Plan (MAP), and applicable regulatory codes and standards. In brief, the proposed single-coil magnet design will: (1) allow for the necessary high resolution measurements of muons: (2) improve the muon system's physics performance (compared to a double-coil magnet) in the forward direction, by modification of the magnet poles, and in the central region by allowing additional muon chambers outside the single-coil: (3) reduce the basic cost of construction of the magnet (it is estimated that a double-coil design would cost an additional $90-$100 million); (4) improve the probability of technological and operational success; and (5) reduce construction and assembly time within the hall, reduce magnet components procurement requirements, and reduce operational costs throughout the life of the detector.

The SSCL has prepared a Supplement Analysis which provides information that validates that the environmental impacts of the proposed action fall within the assessment envelope considered in the SSC FEIS, SEIS, and their respective RODs, and therefore, that no further NEPA documentation is required. A copy of this Supplement Analysis is transmitted herewith.

Sincerely,

Roy F. Schwitters

RFS/PES/md

SUPPLEMENT ANALYSIS

1.0 DESCRIPTION AND PROPOSED ACTION

1.1 Introduction

The U.S. Department of Energy (DOE) is engaging in a detailed design effort to optimize the GEM (Gammas [photons], Electrons, and Muons) detector for the Superconducting Super Collider (SSC). As a part of this effort, the GEM Collaboration recommends adopting a single-coil solenoid configuration, without iron flux return. The proposed conceptual design methodology, will maintain compliance with applicable DOE Orders, the SSC Final and Supplemental Environmental Impact Statements (FEIS, SEIS), their Records of Decision (ROD), the SSC Mitigation Action Plan (MAP), and applicable regulatory codes and standards. This proposed design action, presented in Section 1.2, is described more fully in the *GEM Magnet Technical Panel Reports 1-3*. The proposed shielding scheme is defined in *Considerations Leading to the Choice of Open Field Magnet, GEM Note # GEM TN-91-30.*

The environmental impacts associated with static magnetic fields were addressed in the FEIS and the SEIS for the Superconducting Super Collider. The purpose of this Supplement Analysis is to provide information to validate that the proposed action has been assessed adequately by the SSC FEIS, SEIS, and their respective Records of Decision.

The GEM magnet will produce a static magnetic field, one which does not change with time. The earth has a static magnetic field that varies from around 0.3 to over 1 Gauss, depending upon location, and is around 0.6 Gauss at the SSC site in Ellis County Texas (U.S. Geologic Survey data on geo-magnetic anomaly mapping indicates that the earth's field in the area of the GEM site is approximately 0.56 Gauss). In addition, a magnetic field is produced whenever electric current flows. A static magnetic field is formed in the case of direct current, and a time-varying magnetic field is produced by alternating current sources. In the case of static magnetic fields, protection limits are primarily stated in terms of the field strength (in Gauss) or magnetic flux density and the duration of exposure. A human body located in a magnetic field causes virtually no perturbation of the field. For static magnetic fields of less than 20,000 Gauss, there exists a body of experimental data that indicates the absence of adverse health effects in higher organisms.

Posting levels in excess of 10 Gauss satisfies the Occupational Safety and Health Administration (OSHA)-approved (American Conference of Governmental Industrial Hygienists [ACGIH]-specified) limit for pacemaker interference and is orders of magnitude below the level where adverse health effects begin to appear (~20,000 Gauss in laboratory animals—World Health Organization [WHO] Magnetic Fields Environmental Health Criteria 69). Preliminary studies indicate that the 0.5 Gauss surface field "edge" attributable to the proposed GEM design will not extend beyond the site's property boundary lines. The surface magnetic field strength decreases rapidly with distance from the center of the GEM magnet and is equal to 0.5 Gauss within a footprint of 200 meters x 250 meters. One advantage of the GEM site is that the detector magnet is at a depth of approximately 51.5 meters, which serves to reduce considerably the strength of the magnetic field at the surface.

1.2 Purpose and Need

With the SEIS Record of Decision (ROD) signed in February 1991, the DOE is currently designing and constructing the SSC and associated facilities, primarily in Ellis County, Texas. The detector design concepts presented in the *GEM Letter of Intent (11/30/91 GEM TN-92-49)* are evolving into detailed designs. The GEM Collaboration's evaluation favors selection of the single-coil magnet option (described below in section 1.2), to optimize the GEM detector's technical and operational feasibility.

The construction of the SSCL's detectors is a critical requirement of the entire project, which offers new insights into the structure of matter. With its much greater energy and luminosity (than existing high-energy experiments), the SSC project will greatly extend the boundary of particle measurements. The two large, general purpose particle detectors, GEM and SDC, are required to gather data from the collisions that occur within them, where the counter-rotating particle beams collide. Both detectors have similar designs, but are experimentally different because they focus upon different particle measurements. Each detector has unique particle-identifying characteristics, yet their results will prove complementary in our increased understanding of High Energy Physics. To study the "short-distance" collisions that will occur within the detectors, it is advantageous to design GEM so that it can focus on certain particles (gammas, electrons, and muons). This ability to focus allows more freedom to concentrate on the most accurate possible measurement of the fundamental particles, and to adopt detection strategies that enable operation at an extremely high rate of collision. The GEM detector has been designed on these principles. Precise measurement of these particles is GEM's goal, and the probability of successfully attaining this is enhanced by the advantages (resolution, weight, and cost/installation time) of a single-coil magnet design.

In brief, the proposed single-coil magnet design will: (1) allow for the necessary high resolution measurements of muons; (2) improve the muon system's physics performance (compared to the double-coil magnet) in the forward direction, by modification of the magnet poles, and in the central region by allowing additional muon chambers outside the single-coil; (3) reduce the basic cost of construction of the magnet (it is estimated that the double-coil design would cost an additional $90-$100 million); (4) improve the probability of technological and operational success; and (5) reduce construction and assembly time within the hall, reduce magnet components procurement requirements, and reduce operational costs throughout the life of the detector.

1.3 Proposed Action

1.3.1 Conceptual Design

The DEIS' Safety *Study for Main Ring Tunnel* and the SSC SR-1037 *Safety Review Document*, which are incorporated by reference into the FEIS, state that "magnetic fields around the detectors will be appropriately posted without any surface commitment." The DOE believes that the conceptual design elements set forth below are reasonable and will be effective in complying with its EIS commitments and that the single-coil magnet can be safely and compliantly operated by installation and implementation of these surface-safety-systems and the Standard Operating Procedures, which will be instituted prior to the Beneficial Occupancy Date for the GEM detector. These design elements are similar to those used in other DOE facilities, such as the Fermi National Accelerator Laboratory (FNAL) and the Lawrence Livermore National Laboratory (LLNL), which have demonstrated safe operation.

1) As with other detector sites, a continuous fence with security-controlled access would be constructed around the entire GEM site. The perimeter fence around the GEM site would enclose all surface areas with fields above 5 Gauss (see attached figure). A magnetic field strength monitoring program will be implemented. Mapping of all surface facilities,

grounds (out to and beyond the perimeter fence), and airspace will be completed upon start-up and periodically repeated to determine the overall field size and strength of the protected area.

2) Within the perimeter fence, pacemaker warning signs will be strategically placed at all 10 Gauss field strength limit areas, both on and within buildings as well as at Interaction Region (IR) hall access shaft entry-ways. The public will not be exposed to any magnetic fields in excess of the earth's background level. Laboratory personnel will not be allowed in detector hall areas where the magnetic field exceeds the WHO and ACGIH safe limits. Public and visitor access to the site would be controlled at all entry-gates, such that entry would either be disallowed or would be screened and cleared prior to escorted entry. This is the same approach used at both FNAL and LLNL.

3) The Federal Aviation Administration (FAA) will be notified as to the characteristics of the magnetic field. It should be noted that the FAA mandates a minimum operational flight ceiling of 500 feet, while the 5 Gauss field is expected to extend vertically less than 300 feet.

4) Through its Medical Office, the SSC Laboratory maintains an Occupational Medicine program for screening medically-vulnerable personnel. In the case of the GEM detector, this program will identify, notify, and appropriately prohibit the exposure of those personnel having cardiac pacemakers, ferromagnetic implants or prostheses, or blood disorders. All employees' exposure levels will be monitored and restricted to work durations in high magnetic fields in compliance with OSHA and ACGIH limits. Only a restricted number of employees will be allowed within the IR hall during magnet operation.

5) Although a final decision has not been made at this time, the Detector Operations Center will either be provided with local shielding to prevent any field intrusion or be located outside of the 5-10 Gauss field. Local shielding will be provided for all magnetically-sensitive devices, reducing the field below levels that would interfere with their operation. Safety systems designed so as to be functional within the field, or which are shielded by the manufacturer, will be utilized. The distribution and use of ferromagnetic tools and objects will be controlled.

1.3.2 Discussion

The 5 Gauss limit proposed to be allowed within the perimeter fence controlled area is essentially no different in it's effects than the earth's background level, demonstrating no adverse effects upon human health, equipment operation, or aircraft instrumentation. All static magnetic field animal and human study results clearly indicate that there are no negative human health (blood, cellular, organ, or reproductive) effects from very-long term exposures at the 5 Gauss level (refer to WHO Magnetic Fields Environmental Health Criteria 69). Initial indications are that sensitive aircraft instrumentation begins to be affected at approximately 10 Gauss. Thus, the fringe magnetic field attributable to the proposed GEM design at aircraft flight elevations will pose no problem to the local air traffic or airports. The DOE and SSCL have made written responses to enquiries about potential interference with aircraft navigation equipment, relative to the O'Brien and Waxahachie-Midlothian Airports. No equipment interference problems were found.

It is important to note that the public is routinely exposed to common sources of static magnetic fields that exceed the 5 Gauss level. The public can be exposed to as much as 100 Gauss near hospital Magnetic Resonance Imaging (MRI) facilities (MRI machines typically expose patients to 5,000-20,000 Gauss); 25 to 35 Gauss levels arise in retail store theft-prevention gates; levels approaching 6 Gauss appear at airport metal detectors; ordinary kitchen magnetic utensils and refrigerator magnets range from 2-5 Gauss; magnetic fields ranging from 0.3 - 3 Gauss exist around other typical household appliances. In comparison, the counting rooms and tunnels adjacent to GEM will have 10-30 Gauss levels, the Operations Center will have ≤ 5 Gauss, and the remaining adjacent Utility and Calorimeter Assembly buildings will have 1.5-15 Gauss levels. All of these areas, with the exception of the Operations Center Building, will be intermittently occupied for controlled periods of time.

1.4 Project Approach

The project approach is to finalize the design and build the GEM detector with a single-coil solenoid configuration, without iron flux return and with implementation of the additional safety measures noted above.

2.0 LOCATION OF THE PROPOSED ACTION

The GEM site is unchanged from the Interaction Region Hall locations described in the SEIS.

2.1 General Site Information

General site information is unchanged from that provided in the SEIS. See Figure 2 for additional details.

2.2 Alternatives to the Proposed Action

The GEM Magnet Design Group considered three viable options: 1) Single-coil superconducting solenoid without iron flux return; 2) Double superconducting solenoids with return flux path provided by concentric coils; and 3) Superconducting solenoid with iron yoke. One additional option was considered, but proved to be non-viable—a resistive magnet (negative factors included a 12 MWatt power demand, marginal performance at best and associated high technical risk, excessive cost, and unacceptable schedule slip). The three technically viable options were examined for their relative environmental impacts as well as for cost, construction schedule, and technical risks of design and construction. Option 1 was the preferred choice, considering cost, technical risk, and schedule.

There are three alternatives to the proposed action:

2.2.1 No Action. The SSCL will not build the GEM Detector. This alternative is not consistent with the initial SSCL goal of successful operation of two large, general purpose detectors, as set forth in the FEIS, SEIS, and their respective RODs. From the experimental physics standpoint, there is no alternative to the requirement being met by the GEM Collaboration.

2.2.2 Double-Coil Magnet. Build the GEM Detector with two solenoidal magnets, involving placement of a return flux path outer coil magnet that is concentric to the inner magnet. Under this alternative, most of the flux is returned and does not extend spatially about the magnet. This alternative calls for installation of a very technologically-complex magnet to minimize the fringe magnetic field. However, even if technically feasible—and there is considerable doubt at this time—this alternative effectively disallows construction and operation of the detector, due to greatly increased design, assembly, schedule, and cost factors.

2.2.3 Single Coil Magnet With Iron Yoke. This action would involve devising a method of placing highly permeable metal (such as iron) as close to the magnet coil as possible to absorb the magnetic flux, thus greatly reducing the fringe field. Technological, schedule, and cost impacts of pursuing this alternative will severely deter successful accomplishment of the SSC detector goals.

3.0 ENVIRONMENTAL CONSIDERATIONS

The Superconducting Super Collider FEIS and SEIS examined the environmental impacts based upon the configuration specified by the DOE Invitation for Site Proposals, from which the proposed action represents no environmental change. The intent is not to produce any measurable negative effects upon the public or the environment. The existence of a small static magnetic field produces no adverse environmental impact. The SEIS Record of Decision (ROD) stated that the overall potential for adverse environmental impacts is small and that a substantial potential to mitigate impacts exists. Alternative approaches (described above in sections 2.2.1, 2.2.2, and 2.2.3) produce significant obstacles toward achieving project completion and EIS goals. This is not the case with the proposed mitigating action strategy (see mitigative actions 1 through 5 in *section 1.2*).

3.1 Environmental Information

Earth Resources

A magnetic field has virtually no effect upon the medium (soil, air, water) in which it would exist. There would be no translational or rotational forces exerted upon the surrounding soil components and thus no soil/rock movement. The field outside of the detector hall would not be of sufficient strength to produce transportation of any buried ferromagnetic objects. A magnetic field produces no permanent physical or chemical changes in the absorbing media. The proposed action will have no effect upon the excavation required at the GEM site (Section 4.1.2.2 of the SEIS describes the placement of spoils from the experimental halls).

The proposed single-coil magnet design is not dependent upon the type of hall construction excavation, and therefore there is no change in spoil quantity due to the hall cut-and-cover type of construction.

Water Resources

The proposed action has no impact upon water resources that was not fully assessed in the SEIS.

Biological Resources

The proposed action has no impact upon biological resources.

Magnetic Field Hazards

The proposed single-coil GEM magnet will produce above-surface ellipsoidally-shaped contours of equal field strength (see attached figure), and incorporation of the proposed mitigative actions will fully comply with all conditions set forth in the FEIS & SEIS. These are that:

(1) At a point next to the accelerator ring tunnel wall, the magnetic field from any of the superconducting or conventional magnets will be about the same magnitude as the earth's magnetic field. Thus, no magnetic field source term would be present at the surface of the SSC site or at it's boundaries.

(2) The field would be less than the earth's magnetic field (i.e., negligible cumulative contribution) in such [operations] areas, and operating personnel would be unaffected. Since no personnel would be allowed in the tunnel [or detector hall] when the accelerator magnets would be energized, and since there is no residual magnetic field when the machine is not operating, there is no operational (worker) source term.

(3) The magnets used in the SSC will not expose the public to measurable magnetic fields.

The proposed action involves a static, non-time-varying magnetic field only, and thus produces no radiation. Therefore, all conditions that were imposed for the definitive baseline design assessed in the SEIS, will be maintained.

Land Resources

Land resources requirements are unaffected by the proposed action.

Air Resources

The proposed action has no impact upon air resources.

Socioeconomics and Infrastructure

The proposed action has no impact upon socioeconomic considerations or infrastructure requirements. Air traffic at nearby airports would not be affected.

Cultural Resources

The proposed action has no impact upon cultural resources.

Hazardous Materials

The proposed action has no impact upon the use of hazardous materials or the generation of hazardous wastes.

Noise and Vibration

The proposed action has no incremental effect upon noise and vibration generation. There would actually be a net overall reduction in the level of noise and vibration assessed, due to the decrease in transportation and construction activity of the outer magnet coil assembly, and the reduced period of construction.

Visual Impacts

As noted above, the proposed action will result in the installation of a fence or other barrier, but it would be well within the DOE property boundary and, therefore, should have no impact on visual resources not assessed in the SEIS. The highest structure (Assembly Head House) on top of the GEM site would be approximately 30 meters, resulting in a top elevation that is no different from that which was previously assessed in the SEIS. Thus, there would be no change in the visual landscape of the GEM site as a result of the proposed action.

3.2 Environmental Issues

Environmental issues associated with the construction of the GEM hall have been identified and evaluated for impacts related to making this detector design refinement to optimize the physics performance, cost, and schedule compliance factors for the GEM Detector. It is believed that there are no activities associated with the proposed single-coil magnet action that were not sufficiently assessed in the SEIS and related NEPA documentation for the SSC. The mitigation measures identified in this Supplement Analysis and the SEIS and MAP are appropriate and adequate for optimized detector operation, technological risk reduction, and associated cost and schedule benefits. Thus, all impacts from implementing the proposed action fall within the impact envelope considered in the SEIS. Therefore, there are no environmental issues associated with the optimized GEM magnet design that were not addressed in the SEIS and its Record of Decision.

4.0 PROJECT REFERENCE SCHEDULE

The proposed GEM magnet design and performance action would not affect the official SSC Project schedule. Therefore, the Project reference schedule used in the SEIS is still valid.