# VitaTech Engineering, LLC

EMF Measurements, Surveys & Risk Assessment
EMF Mitigation - Shielding & Cancellation
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Subject: Report – DC/AC ELF EMF Site Survey, EMI Risk Assessment & Mitigation

Dear Mr. Gonzalez,

VitaTech Engineering was commissioned to record and assess the EMI (electromagnetic interference) levels of the proposed Valentine Lab on the second floor of Ellings Hall at the University of California: Santa Barbara. This area, adjacent to an electric room containing various transformers and switchboards, has been designated for renovation as two quiet labs are to be implemented. VitaTech performed AC (alternating current), DC (direct current) and VLF (very-low frequency) AC tests to determine the current EMI situation of room 2404 and to provide optimization recommendations moving forward. The site survey was conducted on the days of Wednesday, January 9th and Thursday, January 10th by EMF Technician Greg Slonka.

## AC ELF Electromagnetic Interference (EMI)

Electromagnetic induction occurs when time-varying AC magnetic fields couple with any conductive object including wires, electronic equipment and people, thereby inducing circulating currents and voltages. In unshielded (susceptible) electronic equipment (computer monitors, video projectors, computers, televisions, LANs, diagnostic instruments, magnetic media, etc.) and signal cables (audio, video, telephone, data), electromagnetic induction generates electromagnetic interference (EMI), which is manifested as visible screen jitter in displays, hum in analog telephone/audio equipment, lost sync in video equipment and data errors in magnetic media or digital signal cables. Placement of each scientific tool and instrument depends on the actual EMI susceptibility under defined thresholds, which are often not easy to ascertain from the manufacturer's performance criteria. Magnetic flux density susceptibility can be specified in magnetic field strength (A/m) or one of three magnetic flux density terms: Brms, Bpeak-to-peak (Bp-p) and Bpeak (Bp) according to the conversion formula atop the next page:

$$\text{Equation 1:} \quad Brms = \frac{Bp-p}{2\sqrt{2}} = \frac{Bp}{\sqrt{2}}$$

High resolution imaging instruments require 0.2 mG horizontal and 0.3 mG vertical Bp-p (less than 0.18 Brms) levels, so VitaTech recommends 0.1 mG and less in EMI Quiet Labs. New Super STEM tools can demand levels as low as 0.01 mG. It is possible to identify the appropriate levels acceptable for each tool *if the correct EMI susceptibility figure can be ascertained from the manufacturer's specifications. Therein, lies the real EMI challenge.*

Generally, for AC ELF sources the minimum EMI threshold is 10 mG in unshielded electronic equipment, especially 14" to 17" CRT color computer monitors and analog signal cables; however, the AC ELF EMI threshold for high-resolution 17" to 21" CRT color monitors is only 5 mG. Scientific instruments are typically susceptible to 1 mG while field emissions TEMs and SEMs are susceptible down to 0.1 mG Br RMS and less for optimal performance.

Based upon VitaTech's EMI experience working on similar projects around the United States, the following EMI AC & DC Magnetic Field Performance Specifications in Chart #1 are recommended for the NMR area, Instruments & Quiet Labs and Cleanrooms:

| |
|---|
| **Ideal AC ELF & DC EMI Magnetic Field Performance Specs:** |
| **NMR Maximum Requirement:**<br>**1 mG Br RMS (2.83 mG p-p)** |
| **Quite & EM Laboratories Maximum Requirements:**<br>**0.1 mG Br RMS (0.3 mG p-p)** |
| **Cleanroom Maximum Requirements:**<br>**0.3 Br RMS (0.85 mG p-p)** |

Chart #1, AC ELF EMI Magnetic Field Performance Specs

VitaTech recommends 0.1 mG Br RMS for Quiet and EM Laboratories to accommodate the tool AC ELF and DC EMI performance requirements of current and next generation research tools. Achieving 0.1 mG Br RMS levels without the use of AC ELF and DC magnetic shielding can be very challenging in most research buildings because of external EMI sources (i.e., moving vehicles loading dock activities, underground electrical feeders, etc.) and internal EMI sources (i.e., elevators, electrical switchgear room, conduit runs, motors, electric rooms and panels, etc.). Since cleanrooms are normally filled with significantly more environmental support equipment generating higher EMI emissions within electromechanical equipment proximity, VitaTech recommends a slightly higher performance requirement of 0.3 mG Brms, which is more practical considering the complex EMI environments.

There will be selected locations within the cleanroom where tool environments will meet the 0.1 mG Br RMS criteria. Accurately predicting the differences between a 0.1 mG and 0.3 mG isolines from *AC ELF and DC magnetic emission sources, considering the number of variables, is* very challenging when compared to measuring the actual EMI environment after the building is constructed and fitted with equipment and research tools. Finally, it is very difficult to measure the difference between 0.1 mG and 0.2 mG AC ELF and DC EMI levels after the research facility is operational due to the typical variations in electric power loads (i.e., HVAC systems turning on/off, normal diurnal variations in power demand, etc.) and nearby moving ferromagnetic masses (i.e., truck sizes are all different with variable loads, actual elevator sizes and masses are all different, etc.). *Eventually, based upon hands-on experience and tool use, the researchers will determine to optimal time of the day when to perform complex and high-resolution experimentation with minimal EMI interference.*

**AC ELF Magnetic Flux Density Site Survey Assessment**
VitaTech recorded mapped AC ELF magnetic flux density levels at 1-meter above grade with a survey wheel, button-push (used when an area is too difficult to navigate with the survey wheel), and the FieldStar 1000 gauss meter. It should be noted that all AC magnetic flux density levels were recorded in units of milligauss RMS (root-means-square). A detailed assessment of the recorded magnetic flux density data are presented as a series of hatch, profile and three-dimension plots, Figures #1 – 7.

> Figure #1, Electrical Room, presents the magnetic flux density levels recorded at one-meter within Electric Room 2402 of Ellings Hall. Electrical equipment situated in room 2402 include five (5) 225 Amp panelboards, two (2) 600 Amp switchboards, an 1000 amp switchboard, 480 volt conduit risers, and transformers of five (5) 225 Amp panelboards, two (2) 600 Amp switchboards, an 1000 Amp switchboard, 480 volt conduit risers, and transformers of 45 kVA, 112.5 kVA and 300 kVA. The contour hatch plot was recorded beginning at the front door, and ending in the opposite corner. A peak magnetic flux density level of 166 mG (see marker 'C') was recorded adjacent to the 600 Amp switchboard and 45 kVA transformer in the collective corner. An average magnetic flux density level of 14.1 mG was recorded within the electrical room. This test was performed to determine a worst-case emission profile for room 2402.

Figure #2, Lab A, AC, presents the magnetic flux density levels recorded at one-meter within the area designated for the proposed Lab A (please see Figure #2 to relate this referral) of room 2404. Using the FieldStar 1000 and survey wheel, a contour was performed to determine the emission profile at one-meter of Lab A. A peak of 28.2 mG was recorded along the wall shared with the electrical room, and an average of 3.41 mG was recorded for this assessment. Letters A & B were included to assist in relating each of the graphs.

Figure #3, Lab B, AC, presents the magnetic flux density levels recorded at one-meter within the area designated for the proposed Lab B (please see Figure #3 to relate this referral) of room 2404. Using the FieldStar 1000 and survey wheel, a contour was performed to determine the emission profile at one-meter of Lab B. A peak of 2.64 mG was recorded aside the wall shared with the electrical room (nearest label 'Start'), and an average of 0.96 mG was recorded for this assessment. Letters A, B & C were included to assist in relating each of the graphs.

Figure #4, Lab A & B, AC, presents the magnetic flux density levels recorded on floor within the area designated for both proposed Labs A & B (please see Figure #4 to relate these referrals) of room 2404. Using the FieldStar 1000 and survey wheel, a contour was performed to determine the emission profile at floor level of both proposed labs. A peak of 34.7 mG was recorded on the corner wall shared with the electric room (nearest label 'End'), and an average of 3.1 mG was recorded for this assessment. Letters A, B & C were included to assist in relating each of the graphs.

Figure #5, Contour Hatch Plot, presents the magnetic flux density levels recorded at one-meter within the entire existing area of room 2404. Using the FieldStar 1000 and survey wheel, a complete contour was performed to determine the general emission profile for the Valentine Lab and surrounding areas. A peak of 35 mG was recorded on the corner wall (nearest label 'D'), and an average of 0.99 mG was recorded for this assessment. The gaps for this assessment represent the area consumed by the existing tables within Room 2404. Letters A, B, C & D were included to assist in relating each of the graphs.

Figure #6, Timed Lab Plots, present the timed magnetic flux density levels recorded for a 10-minute duration at the center of both proposed labs. For Lab A, a peak emission level of 2.44 mG and an average emission level of 2.35 mG were recorded, while a peak emission level of 1.2 mG and an average emission level of 1.13 mG were recorded for

Lab B. Although each of the two (2) timed assessments present the minute fluctuations, this is representative of the proximity to the electrical equipment and should be considered normal. These two assessments were performed to determine the accuracy and precision of the previous tests.

Figure #7, Vertical Lab Plots, present the magnetic flux density levels recorded from floor to ceiling at 1-foot increments. For Lab A, a peak emission level of 1.28 mG was recorded at 8 feet, and a minimum level of 0.96 mG was recorded at 6 feet. For Lab B, a peak emission level of 0.68 mG was recorded at floor level, and a minimum level of 0.4 mG was recorded at 6, 7 & 8 feet. These two assessments were performed to determine whether any additional sources in addition to the electrical room would need to be considered.

Figure #10, VLF/ELF readings, present the lower frequency (12 Hz – 50 kHz) AC readings for the two proposed Valentine Labs. Spot readings were recording at 9 locations for each lab, and presented in a color instrumented grid pattern. Color thresholds are 0.5 mG, 1 mG, 2.5 mG. At this frequency, emission levels peaked at 3.81 mG Bx, 4.58 mG By, 4.67 mG Bz and 6.97 mG Br for Lab A; 1.2 mG Bx, 3.53 mG By, 2.95 mG Bz, and 4.75 mG Br for Lab B.

***Conclusion – Due to the close proximity, elevated magnetic flux density levels are emanating from the electrical room into the two (2) proposed Valentine labs. Sensitive EMI equipment will be exposed to emissions greater than 1 mG throughout the area, unless shielding is implemented. At floor level, the emissions are even greater. VitaTech proposes a six-sided enclosed AC ELF magnetic shielding system for the two labs supplemented by a dual substrate wall shield in the adjacent electrical room to reduce AC EMI levels as demonstrated in Figure #11, Recommended Shielding System.***

## DC Electromagnetic Interference (EMI)

Large and small ferromagnetic masses in motion such as elevators, cars, trucks, and metal doors produce geomagnetic field perturbations in the sub-extremely low frequency (SELF) 0 – 3 Hz band that radiate (similar to throwing a pebble in a pond) from the source generating DC electromagnetic interference (EMI) in sensitive scientific tools and instruments. The magnitude of the geomagnetic field perturbation and radiated distance from the source depends on the size, mass and speed of the moving ferromagnetic object. Theoretically, DC magnetic emissions sources (i.e., ferromagnetic objects, magnets, etc.) decay according to the inverse cube law, in practice the decay rates are not ideal. Other problematic DC EMI sources include electromagnetic pulse (EMP) devices, which are usually high-voltage discharge instruments, subways, trolleys, NMRs, and MRIs. Electron microscopes (SEMs, TEMs, STEMs), Focus Ion Beams (FIB) writers and E-Beam writers are also very susceptible to DC EMI emissions and require clean DC environments with dB/dT 1 mG and less differentials.

Placement of scientific tools depends on the actual DC EMI susceptibility under defined thresholds, which are often not easy to ascertain from the manufacturer's performance criteria. Electron microscopes are sensitive at 1 mG Brms from DC disturbances while SEMs and TEMSs have 0.4 mG horizontal and 0.2 mG vertical performance requirements while next generation EM tools are less than 0.1 mG Brms and Super STEMs (also known as ultra-high resolution STEMs) have a 0.01 mG DC EMI threshold. DC susceptibility in typical 1.5 to 4 Tesla MRIs can range from 1 mG to over 0.5 Gauss depending on the magnetic field strength, resolution and type (open vs. closed, active shielding, etc.). Furthermore, to ensure a safe working environment around MRIs and NMRs, adequate signage must be posted at 5 and 10 Gauss lines to warn staff and visitors with implantable devices and to minimize inadvertent data corruption (coercivity) of credit cards and other valuable magnetic media. On the next page is a list of DC EMI Thresholds in Gauss that will impact CRT displays, electronic instruments and magnetic media:

Chart #2, DC EMI Threshold Chart

| DC EMI Thresholds - CRT screen shift, noise & coercivity (data errors) |
|---|
| 0.001 Gauss & Less SEMs, TEMs E-Beams / FB Writers |
| 0.75 Gauss CRT Monitors & Electronic Instruments |
| 5 Guass Cardiac Pacemakers & Implantable Devices Warning Sign |
| 10 Gauss Credit Cards & Magnetic Media Warning Signs |
| 300 Gauss Low Coercivity Mag-Stripe Cards |
| 700 Gauss High Coercivity Mag-Stripe Cards & Video Tapes |
| *1000 milligauss (mG) = 1 Gauss (G) & 1 mG = 0.001 G = 0.1 uT (microTesla)* |

Based upon VitaTech's EMI experience working on similar Nanotechnology projects around the United States, the DC EMI Magnetic Field Performance Specifications in Chart #3 below are recommended:

| **Ideal AC ELF & DC EMI Magnetic Field Performance Specs:** |
|---|
| **NMR Maximum Requirement:**<br>**1 mG Br RMS (2.83 mG p-p)** |
| **Quite & EM Laboratories Maximum Requirements:**<br>**0.1 mG Br RMS (0.3 mG p-p)** |
| **Cleanroom Maximum Requirements:**<br>**0.3 Br RMS (0.85 mG p-p)** |

Chart #3, DC EMI Magnetic Field Performance Specs

**DC Magnetic Flux Density Site Survey Assessment**
A summary of the DC magnetic flux density levels recorded within Room 2404 of Ellings Hall is presented below. The data was sampled at 0.2-second intervals and measured at 1-meter above grade at the test locations shown in Figure #8 and #9.

Figure #8 presents the timed 10-minute DC magnetic flux density data recorded in Room 2404 for Lab A. It is important to notate that this was not an assessment upon the elevator, but the entire surrounding area, as the elevator is positioned at a distance of greater than 75 feet from the testing location and would not generate noticeable transients on the data. VitaTech recorded DC magnetic flux density levels on three axes (Bx, By, Bz) as well as their Br resultant. The resultant (Br) magnetic flux density was calculated as presented in Figure #8. The graph displays a minimum resultant magnetic flux density level of 495.44 mG and a maximum resultant magnetic flux density level of 495.64 mG. For this evaluation, the fluxgate magnetometer recorded component transients of 0.19 mG dB/dt Bx, 0.23 mG dB/dt By, 0.08 mG dB/dt Bz, and 0.15 mG dB/dt Br (resultant).

Figure #9 presents the timed 10-minute DC magnetic flux density data recorded in Room 2404 for Lab B. Again, it is important to notate that this was not an assessment upon the elevator, but the entire surrounding area, as the elevator is positioned at a distance of greater than 75 feet from the testing location and would not generate noticeable transients on the data. VitaTech recorded DC magnetic flux density levels on three axes (Bx, By, Bz) as well as their Br resultant. The resultant (Br) magnetic flux density was calculated as presented in Figure #8. The graph displays a minimum resultant magnetic flux density level of 458.92 mG and a maximum resultant magnetic flux density level of 459.08 mG. For this evaluation, the fluxgate magnetometer recorded component transients of 0.06 mG dB/dt Bx, 0.08 mG dB/dt By, 0.07 mG dB/dt Bz, and 0.07 mG dB/dt Br (resultant).

***Conclusion: The DC magnetic field emissions are acceptable and do not require DC magnetic shielding.***

***Typically, DC magnetic interference is caused by perturbations in the geomagnetic field of the earth from moving ferromagnetic objects (i.e., vehicles, subways, elevators, metal carts, etc.) – something like a pebble in the pond. These perturbations are captured by the fluxgate***

***magnetometer and presented as differential changes dB/dt in the recorded timed geomagnetic field data.***

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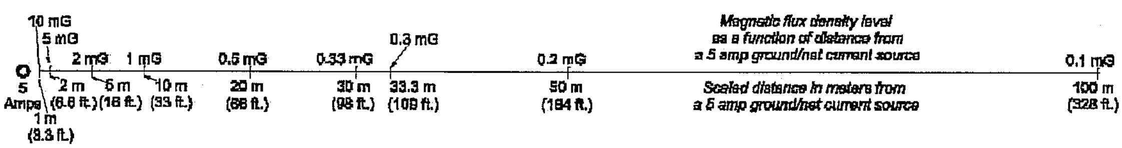
## Ground/Net Current Issues

Ground and net currents are due to N.E.C. violations (i.e., grounded neutrals, wiring errors, etc.) in the electrical service, distribution and grounding systems of a building and N.E.S.C. violations (i.e., grounding problems, etc.) on distribution and transmission lines. Unbalanced phases on medium voltage distribution lines and 480V/208V low-voltage feeders generate zero-sequence currents, which return on the neutrals and grounding conductors. Most utilities maintain 5% and less unbalanced phases on high voltage transmission lines and 10-15% unbalanced phases on distribution lines (power quality issues) except in local neighborhoods where unbalanced phases may exceed 20%. A percentage of the zero-sequence neutral currents on distribution lines travel along other electrically conductive paths (i.e., underground water pipes, earth channels, grounded guy wires, building neutrals/grounding systems, etc.) back to the substation. If all the zero-sequence currents were to return via the multi-ground neutral system (MGN) wire mounted on the pole under the three phase conductors (sum of all phase and neutral currents are zero), then the magnetic fields would decay at the normal inverse square rate ($1/r^2$ in meters) from the single-circuit distribution line (same for transmission lines and low-voltage feeders). However, if only a fraction of the zero-sequence current returns on the MGN system or low-voltage neutral conductor, then there is a net current missing (amount of current returning via other paths) – this net current emanates a magnetic field similar to a ground current (electrical current of low voltage returning on a ground wire, water pipe or other conductive path) that decays at a linear 1/r (in meters) rate based upon the following formula:

**BmG = 2(I)/r** where I is amps and r meters

Magnetic fields from ground and net (zero-sequence) currents decay at a slow, linear rate illustrated below, using a 5 amp ground/net current source: 10 mG is 1m away, 1 mG is 10 m away, 0.5 mG is 20 m away and 0.1 m is 100 m away:




Since there is a proportional relationship between current load and magnetic flux density levels, the above chart can be used to predict the emission levels based upon ground/net current loads. Using 2.5 amps of ground/net current, the levels above the selected decay distance are calculated by dividing by 2, which is 50% of 5 amps. The ground/net current decay chart is indispensable in ascertaining the acceptable operating distance from ground and net (zero sequence) currents based upon a specified instrument performance criteria (i.e., 1 mG, 0.1 mG or 0.01 mG).

Ground and net current magnetic field emissions are difficult to shield using flat or L-shaped ferromagnetic and conductive shields -- the most effective shielding method for AC ELF ground/net current emissions requires a six-sided, seam welded aluminum plate shielding system with a waveguide entrance.

**AC ELF & DC Test Instruments**

FieldStar 1000 Gaussmeter - AC ELF Magnetic Flux Density

VitaTech recorded the AC ELF magnetic flux density data using a FieldStar 1000 gaussmeter with a NIST traceable calibration certificate manufactured by Dexsil Corporation. The FieldStar 1000 has a resolution of 0.04 mG in the 0 - 10 mG range, 1% full-scale accuracy to 1000 mG and a frequency response of 60 Hz (55 - 65 Hz @ 3dB). Three orthogonal powdered-iron core coils are oriented to reduce interference to less than 0.25% over the full dynamic range. The three coils are arranged inside the unit holding horizontal with the display forward: Bx horizontal coil points forward, By horizontal coil points to the right side, and Bz vertical coil points upward. The microprocessor instantly converts the magnetic field to true RMS magnetic flux density (milligauss) readings of each axis (Bx, By, Bz) and simultaneously calculates the resultant *Rrms* (root-means-square) vector according to the following formula:

$$R_{rms} = \sqrt{Bx^2 + By^2 + Bz^2}$$

When collecting contour path data, a nonmetallic survey wheel is attached to the FieldStar 1000 gaussmeter and the unit is programmed to record mapped magnetic flux density data at selected (1-ft., 5-ft., 10-ft. etc.) intervals. The FieldStar 1000 is exactly 39.37 inches (1 meter) above the ground with the survey wheel attached. Along each path the distance is logged by the survey wheel and the relative direction (turns) entered on the keyboard. Up to 22,000 spot, mapped and timed data points can be stored, each containing three components (Bx, By & Bz), event markers and turn information. After completing the path surveys, magnetic flux density data is uploaded and processed. All plots display a title, time/date stamp, ID path number, and the following statistical data (in milligauss) defined on the next page:

**Peak** - maximum magnetic field (flux) value measured in group.
**Mean** - arithmetic average of all magnetic field (flux) values collected.

The following is a quick description of the Hatch, Profile and 3-D Contour plots presented in the figures of this report on the next page:

**Hatch Plot** - data is represented by four difference hatch marks (0 mG, 0.25 mG, 1 mG and 5.0 mG thresholds) based on width and color as a function of distance along the survey path that shows 90 and 45 degree turns. Note: the site drawing and all Hatch Plots were scaled in feet to verify actual recorded distances and correct survey locations.

**Profile Plot** - data shows each recorded component (Bx, By, Bz) axis and the resultant (Br) levels as a function of distance: Bx (red) is the horizontal component parallel to the survey path, By (green) is the horizontal component normal (perpendicular) to the survey path, and Bz (blue) is the vertical component with the computed Br resultant RMS (root-means-square) summation of the three components.

**3-D Plot** - data is presented along survey with Br resultant level in the vertical direction using eight (8) color thresholds on an horizontal plane.

MEDA FVM-400 DC Three-Axis Magnetometer

Timed three-axis DC magnetic flux density levels were recorded from moving vehicles with a three-axis fluxgate magnetometer at 1 second intervals over a 10-minute periods. The MEDA FVM-400 three-axis fluxgate magnetometer has 1 nT (0.01 mG) resolution and 1.2 Gauss (1,200 mG) maximum range with 1% full scale accuracy from 0-10 Hz. Data is downloaded directly to a computer during data collection and then processed for graphical presentations.

MEDA 8532 AC ELF Single-Axis Magnetometer (VLF/ELF Meter)

The MEDA Model 8532 is very accurate single-axis gaussmeter for measurements of RMS magnetic flux density levels. The Model 8532 utilizes an induction coil sensor mounted in a separate probe that is immune to errors caused by sensor movement within the Earth's magnetic field. The induction coil sensor measures magnetic fields from 0.01 mG to 2000 mG. Measurement results are the same throughout the frequency range of 12 Hz to 50 kHz. Accuracy of the Model 8532 is better than +5% (typically 1%) of the displayed value plus one digit over the entire frequency range, and is traceable to NIST. The Model 8532 also utilizes true RMS detection circuitry, so all types of waveforms, including square wave or sawtooth waveforms can accurately be measured.

## AC ELF Magnetic Field Health Issues, Standards & Guidelines

*Currently, there are no Federal standards for AC ELF electric and magnetic field levels.* The National Energy Policy Act of 1992 authorized the Secretary of the Department of Energy (DOE) to establish a five-year, $65 million EMF Research and Public Information Dissemination (RAPID) Program to ascertain the affects of ELF EMF on human health, develop magnetic field mitigation technologies, and provide information to the public. In May 1999, the NIEHS Director Kenneth Olden, Ph.D. delivered his final report, *Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields*, to Congress that stated the following in the Cover Letter and Executive Summary below:

> *The scientific evidence suggesting that ELF-EMF exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and* ***chronic lymphocytic leukemia in occupationally exposed adults... The NIEHS concludes that ELF-EMI exposure cannot be recognized at this time as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard.***

U.S. & International Organizational AC ELF EMF Standards

The International Commission on Non-Ionizing Radiation Protection (IRPA/INIRC) have established 833 mG maximum human exposure limit over 24 hours for the general public and 4,167 mG for occupational workers. Whereas The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a 10,000 mG (10 Gauss) exposure limit over 24 hours for occupational workers, but specifies only 1,000 mG (1 Gauss) as a maximum exposure for workers with cardiac pacemakers.

New York State Public Service Commission AC ELF EMF Standards

Effective September 1990, the State of New York Public Service Commission (PSC) "began a process looking toward the adoption of an interim magnetic field standard for future major electric transmission facilities". The Commission concludes that a prudent approach should be taken that will avoid unnecessary increases in existing levels of magnetic field exposure. Therefore, future transmission circuits shall be designed, constructed and operated such that magnetic fields at the edges of their rights-of-way will not exceed 200 mG when the circuit phase currents are equal to the winter-normal conductor rating. They also established an electric field strength interim standard of 1.6 kV/m electric transmission facilities.

IARC June 2002 Report

In June 2002, the International Agency for Research on Cancer (IARC) issued a 400+ page report formally classifying extremely low frequency magnetic fields as ***possibly carcinogenic to humans*** based on studies of EMF and childhood leukemia. **This is the first time that a recognized public health organization has formally classified EMF as a possible cause of human cancer**. IARC found that, while selection bias in the childhood leukemia studies could not be ruled out, pooled analyses of data from a number of well-conducted studies show a fairly consistent statistical association between childhood leukemia and power-frequency residential magnetic fields above 4 milliGauss (mG), with an approximately twofold increase in risk that is unlikely to be due to chance.

IARC is a branch of the World Health Organization. The IARC classification of EMF was made by a panel of scientists from the U.S. National Institute of Environmental Health Sciences, the U.S. Environmental Protection Agency, the U.K. National Radiological Protection Board, the California Department of Health Services, EPRI, and other institutions around the world.

<u>Switzerland's February 2000 AC ELF Standard</u>
The Swiss Bundersrat in February 2000 set by law an emission control limit of 10 mG from overhead and underground transmission lines, substations, transformer vaults and all electrical power sources.

<u>VitaTech's & NCRP Draft Recommended 10 mG Standard</u>
_Section 8.4.1.3 option 3 in the National Council of Radiation Protection and Measurements (NCRP) draft report published in the July/August 1995 issue of *Microwave News* (visit the Microwave News Homepage <www.microwavenews.com> for the entire draft report) recommended the following:

> **8.4.1.3 Option 3:** *An exposure guideline of 1 μT (10 mG) and 100 V/m: A considerable body of observations has documented bioeffects of fields at these strengths across the gamut from isolated cells to animals, and in man. Although the majority of these reported effects do not fall directly in the category of hazards, many may be regarded as potentially hazardous. Since epidemiological studies point to increased cancer risks at even lower levels, a case can be made for recommending 1 μT (10 mG) and 100 V/m as levels not to be exceeded in prolonged human exposures. Most homes and occupational environments are within these values, but it would be prudent to assume that higher levels may constitute a health risk. In the short term, a safety guideline set at this level would have significant consequences, particularly in occupational settings and close to high voltage transmission and distribution systems, but it is unlikely to disrupt the present pattern of electricity usage. These levels may be exceeded in homes close to transmission lines, distribution lines and transformer substations, in some occupational environments, and for users of devices that operate close to the body, such as hair dryers and electric blankets. From a different perspective, adoption of such a guideline would serve a dual purpose: first, as a vehicle for public instruction on potential health hazards of existing systems that generate fields above these levels, as a basis for "prudent avoidance"; and second, as a point of departure in planning for acceptable field levels in future developments in housing,*

*schooling, and the workplace, and in transportation systems, both public and private, that will be increasingly dependent on electric propulsion.*

This completes *DC/AC ELF EMF Site Survey, EMI Risk Assessment Report for the proposed Valentine labs, University of California: Santa Barbara.*

The contents of this report are intended for the exclusive use University of California at Santa Barbara. VitaTech Engineering, LLC shall not be responsible for any magnetic shield designs based upon the information contain within this report, except those designs and bids exclusively submitted by VitaTech Engineering, LLC.

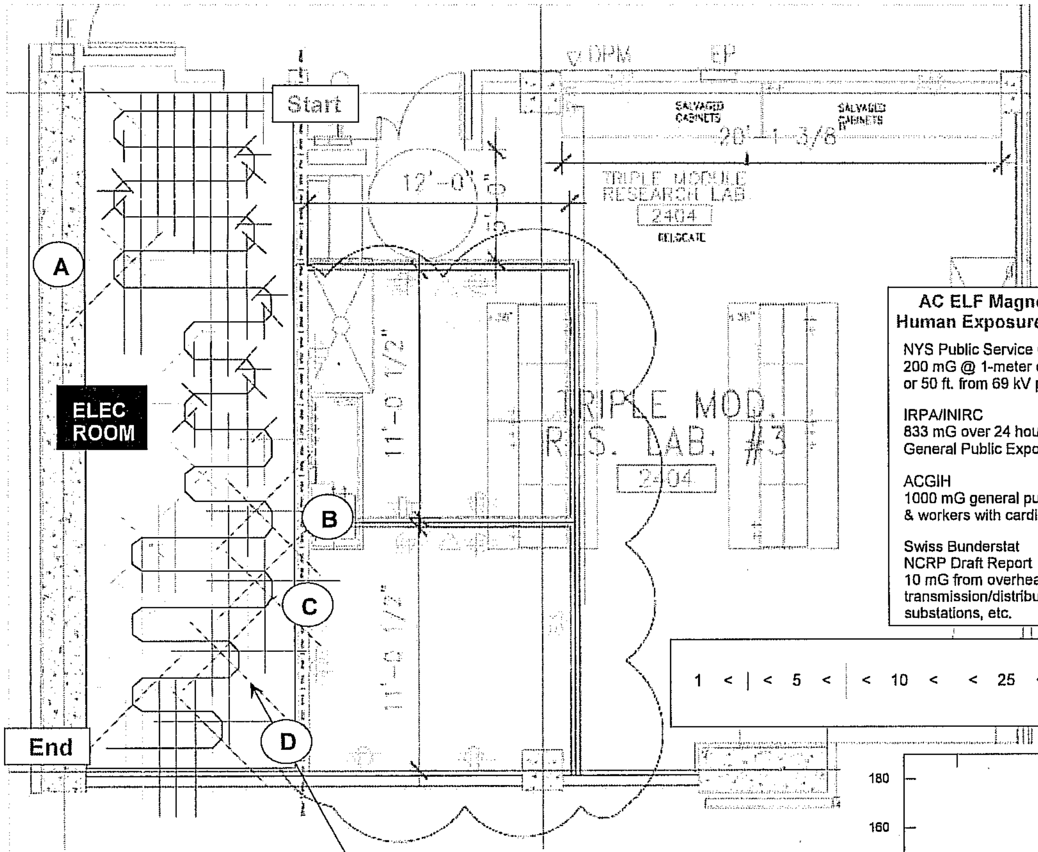
Please call if you have any further questions

Best regards,

Louis S. Vitale, Jr.
President & Chief Engineer

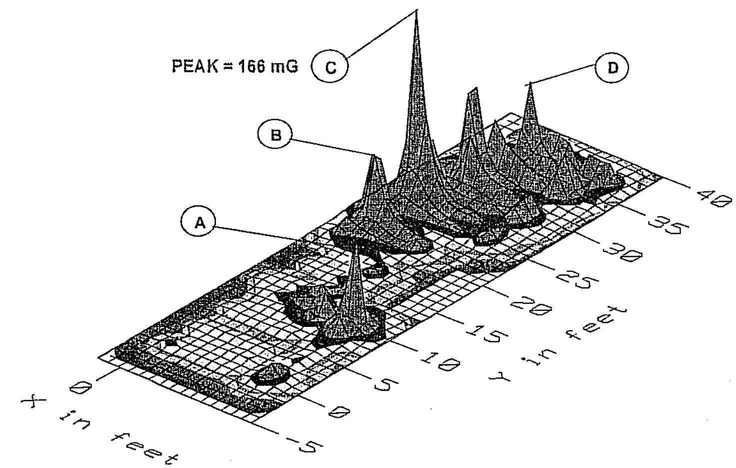
Attachments: Figures #1 to #11

# Figure #1, Electrical Room
# Magnetic Flux Density Levels @ 1-Meter
# 2nd Floor Electric Room 2402
# University of California at Santa Barbara, CA




PEAK = 166 mG, MEAN = 14.1 mG
Rec 1 File UCSB Taken 1/9/8 ID-UCSB ELEC

0 < | < .1 < | < .25 < | < .5 < | < .75 < | < 1 < | < 2.5 < | < 5 < | (Br in mG)




**AC ELF Magnetic Field Human Exposure Standards**

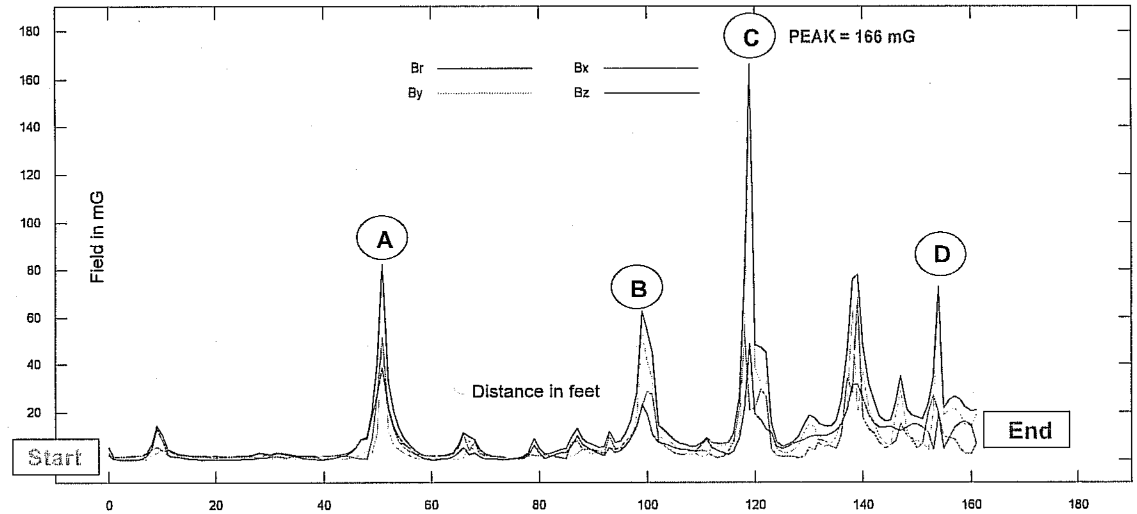
NYS Public Service Commission
200 mG @ 1-meter on Edge -ROW
or 50 ft. from 69 kV poles

IRPA/INIRC
833 mG over 24 hours
General Public Exposure

ACGIH
1000 mG general public
& workers with cardia pacemakers

Swiss Bunderstat
NCRP Draft Report
10 mG from overhead/underground transmission/distribution lines, substations, etc.

1 < | < 5 < | < 10 < | < 25 < | (Br in mG)




*All magnetic flux density data recorded with a FieldStar 1000 gaussmeter and survey wheel*

**AC ELF EMI Thresholds (screen jitter & noise)**

10 mG for 12-15 inch computer monitors & audio/video equipment
5 mG for 17-21 inch CRT monitors & medical (i.e., EEGs, ECGs, EMGs,. etc.).
1.0 mG minimum for scientific tools (STEMs, TEMs, FIB, I-Beam, etc.)
0.1- 0.3 mG optimum for next generation Nano & Pico Tech scientific tools


**VitaTech Engineering, LLC**

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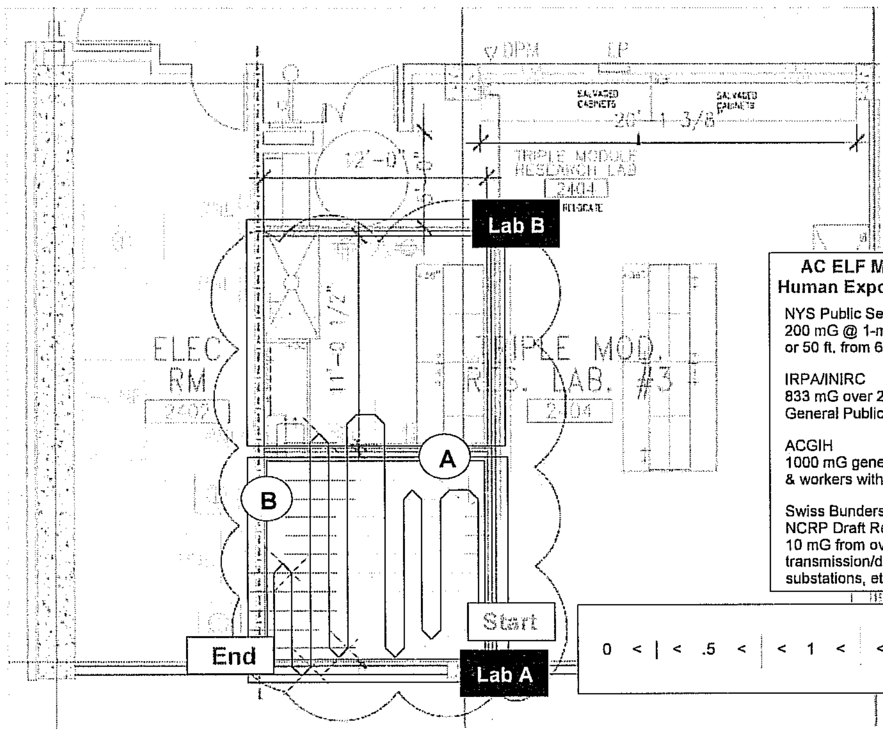
# Figure #2, Lab A, AC
## Magnetic Flux Density Levels @ 1-Meter
## 2nd Floor Lab A, Room 2404
## University of California at Santa Barbara, CA




0 < | < .5 < | < 1 < | < 3 < | (Br in mG)

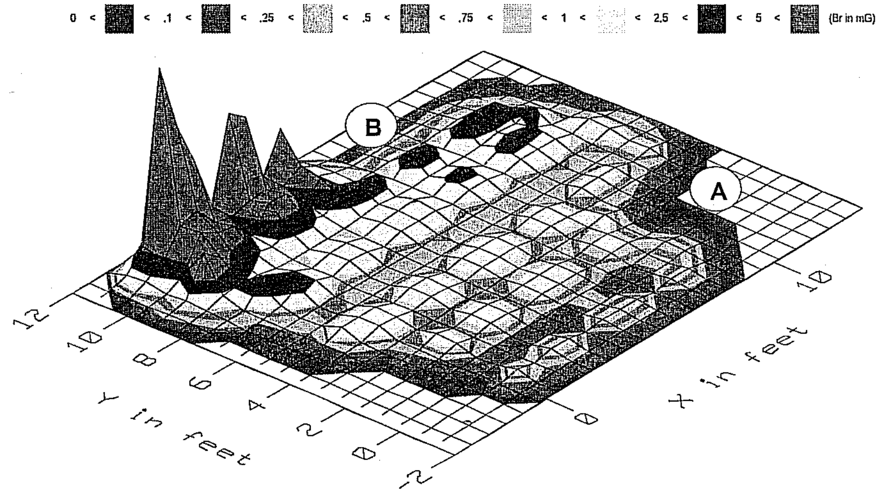
**AC ELF Magnetic Field Human Exposure Standards**

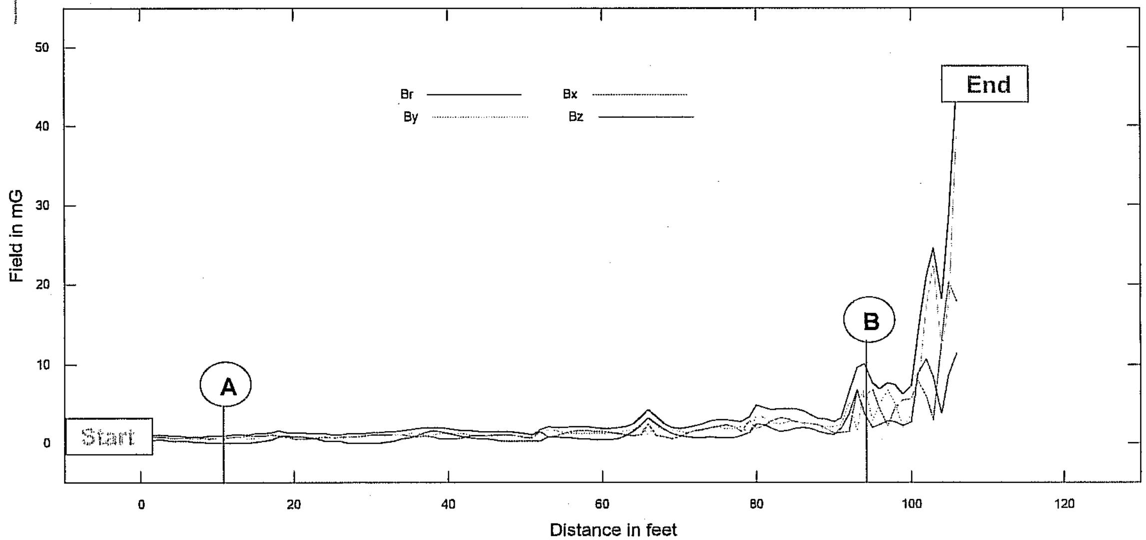
NYS Public Service Commission
200 mG @ 1-meter on Edge -ROW
or 50 ft. from 69 kV poles

IRPA/INIRC
833 mG over 24 hours
General Public Exposure

ACGIH
1000 mG general public
& workers with cardia pacemakers

Swiss Bunderstat
NCRP Draft Report
10 mG from overhead/underground transmission/distribution lines, substations, etc.




**PEAK = 28.2 mG, MEAN = 3.41 mG**
**Rec 3 File UCSB Taken 1/9/8 ID-UCSB RLB 1M**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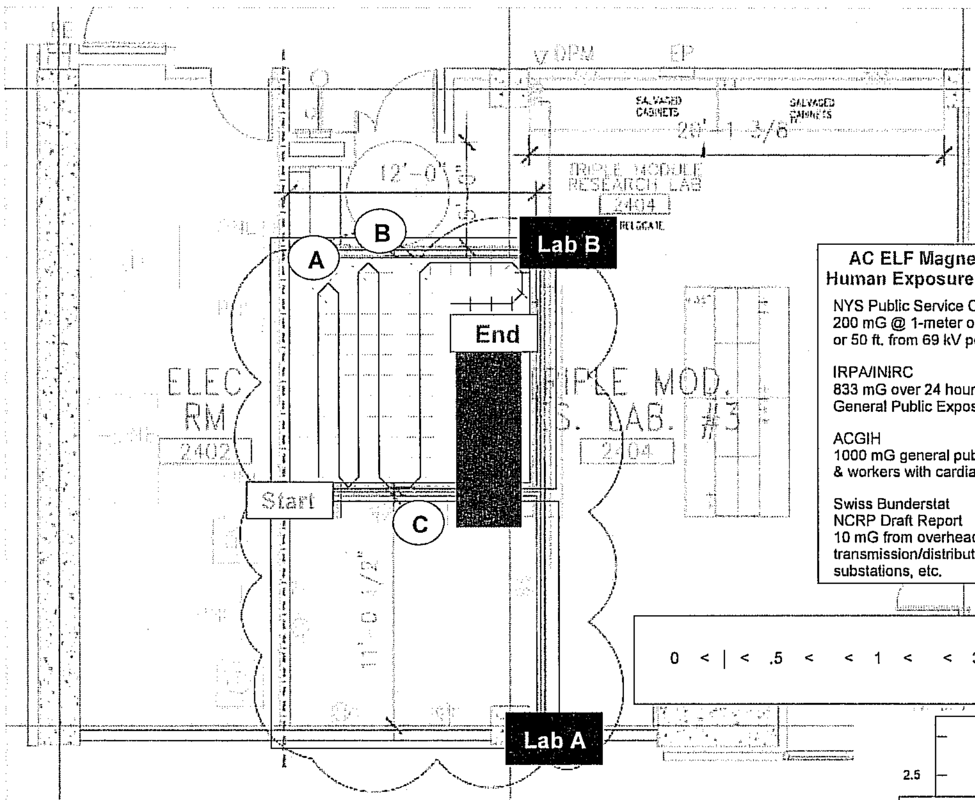
***All magnetic flux density data recorded with a FieldStar 1000 gaussmeter and survey wheel***

**AC ELF EMI Thresholds (screen jitter & noise)**

- 10 mG for 12-15 inch computer monitors & audio/video equipment
- 5 mG for 17-21 inch CRT monitors & medical (i.e., EEGs, ECGs, EMGs,. etc.).
- 1.0 mG minimum for scientific tools (STEMs, TEMs, FIB, I-Beam, etc.)
- 0.1- 0.3 mG optimum for next generation Nano & Pico Tech scientific tools

# Figure #3, Hatch Plot
## Magnetic Flux Density Levels @ 1-Meter
## 2nd Floor Lab B, Room 2404
## University of California at Santa Barbara, CA




**AC ELF Magnetic Field Human Exposure Standards**

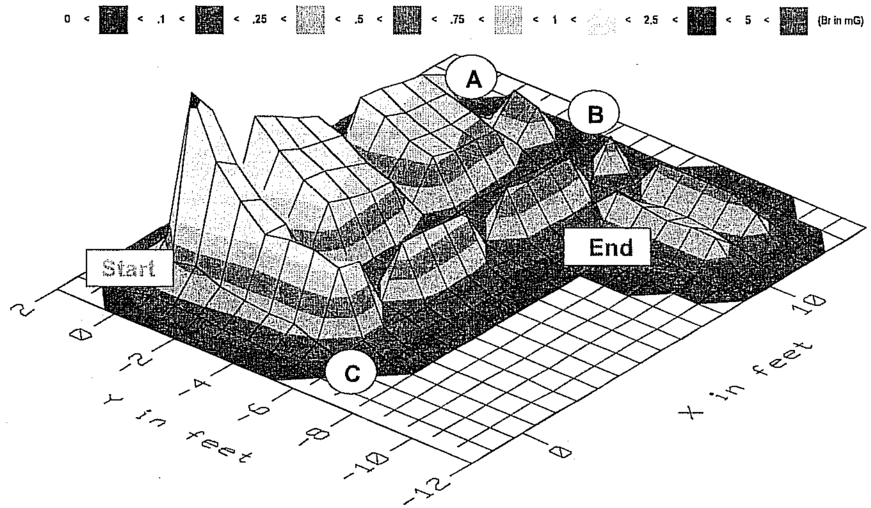
NYS Public Service Commission
200 mG @ 1-meter on Edge -ROW
or 50 ft. from 69 kV poles

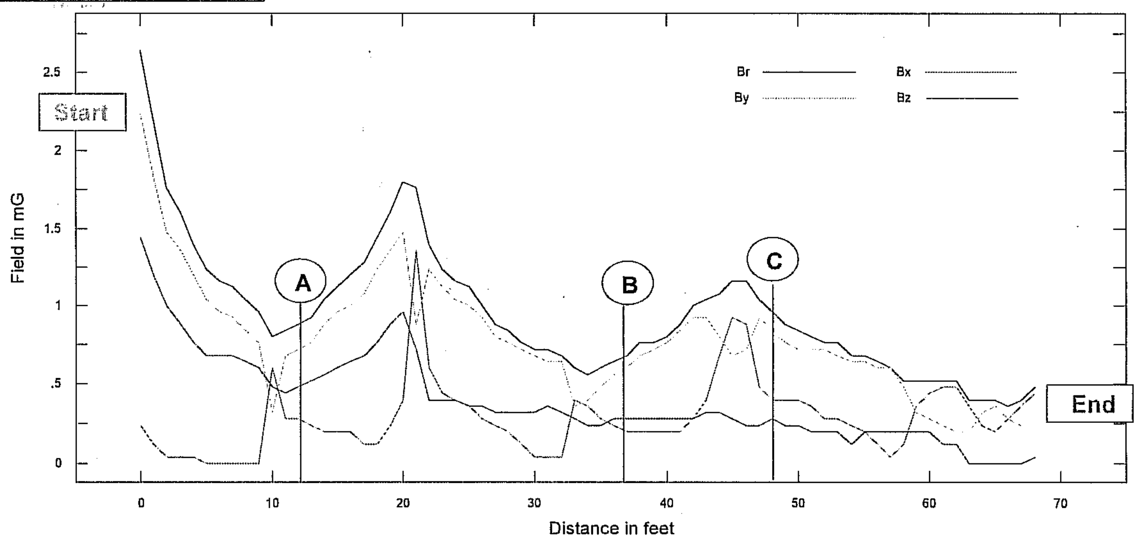
IRPA/INIRC
833 mG over 24 hours
General Public Exposure

ACGIH
1000 mG general public
& workers with cardia pacemakers

Swiss Bunderstat
NCRP Draft Report
10 mG from overhead/underground transmission/distribution lines, substations, etc.

0 < | < .5 < < 1 < < 3 < (Br in mG)




**PEAK = 2.64 mG, MEAN = .959 mG**
**Rec 4 File UCSB Taken 1/9/8 ID-UCSB RLA 1M**

*All magnetic flux density data recorded with a FieldStar 1000 gaussmeter and survey wheel*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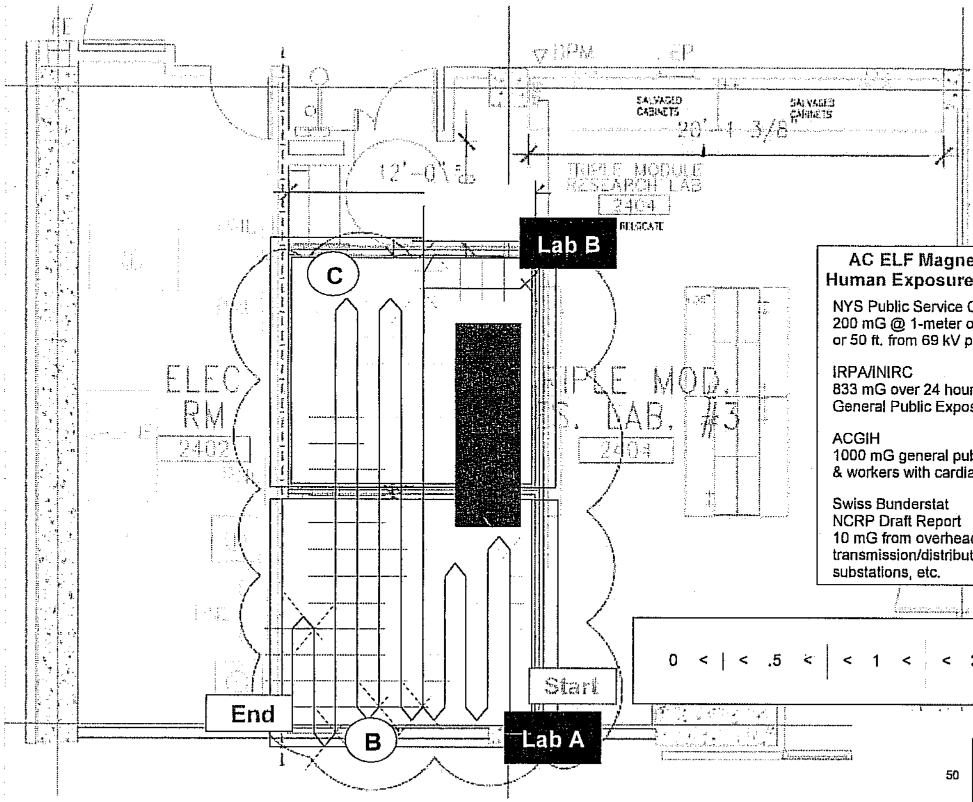
**AC ELF EMI Thresholds (screen jitter & noise)**

10 mG for 12-15 inch computer monitors & audio/video equipment
5 mG for 17-21 inch CRT monitors & medical (i.e., EEGs, ECGs, EMGs,. etc.).
1.0 mG minimum for scientific tools (STEMs, TEMs, FIB, I-Beam, etc.)
0.1- 0.3 mG optimum for next generation Nano & Pico Tech scientific tools

# Figure #4, Labs A & B, AC
# Magnetic Flux Density Levels @ Floor Level
# 2nd Floor Labs A & B, Room 2404
# University of California at Santa Barbara, CA




| 0 < | < .5 < | < 1 < | < 3 < | (Br in mG) |
|---|---|---|---|---|

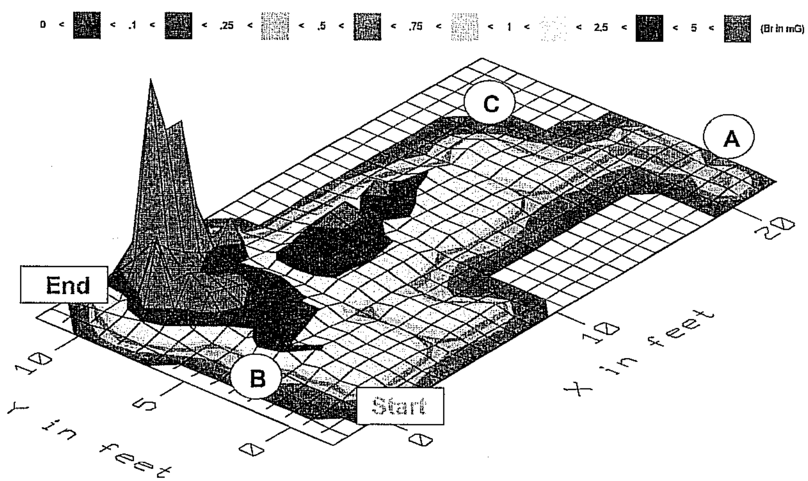
**AC ELF Magnetic Field Human Exposure Standards**

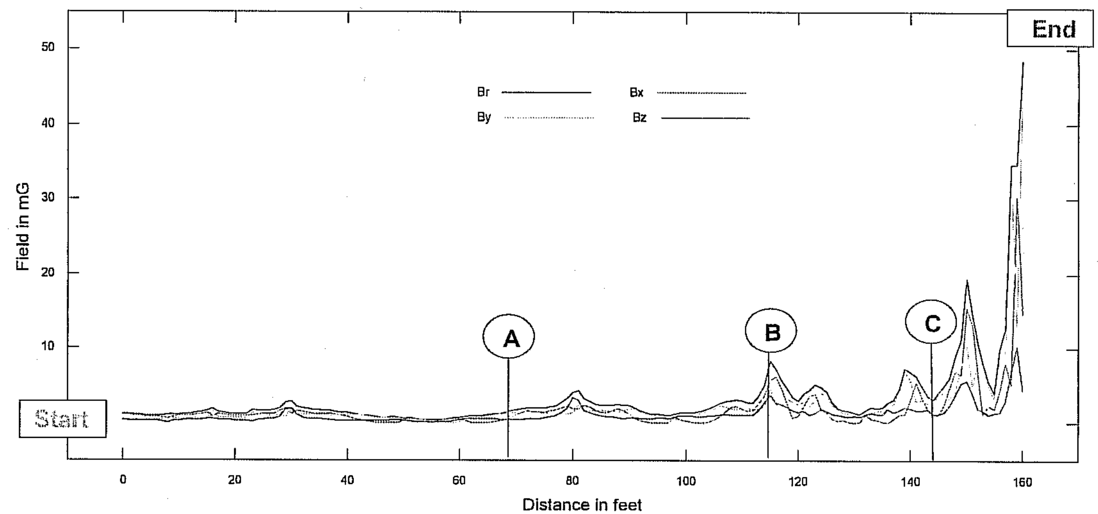
NYS Public Service Commission
200 mG @ 1-meter on Edge -ROW
or 50 ft. from 69 kV poles

IRPA/INIRC
833 mG over 24 hours
General Public Exposure

ACGIH
1000 mG general public
& workers with cardia pacemakers

Swiss Bunderstat
NCRP Draft Report
10 mG from overhead/underground transmission/distribution lines, substations, etc.




**PEAK = 34.7 mG, MEAN = 3.1 mG**
**Rec 5 File UCSB Taken 1/9/8 ID-UCSB RLAB FL**


**VitaTech Engineering, LLC**
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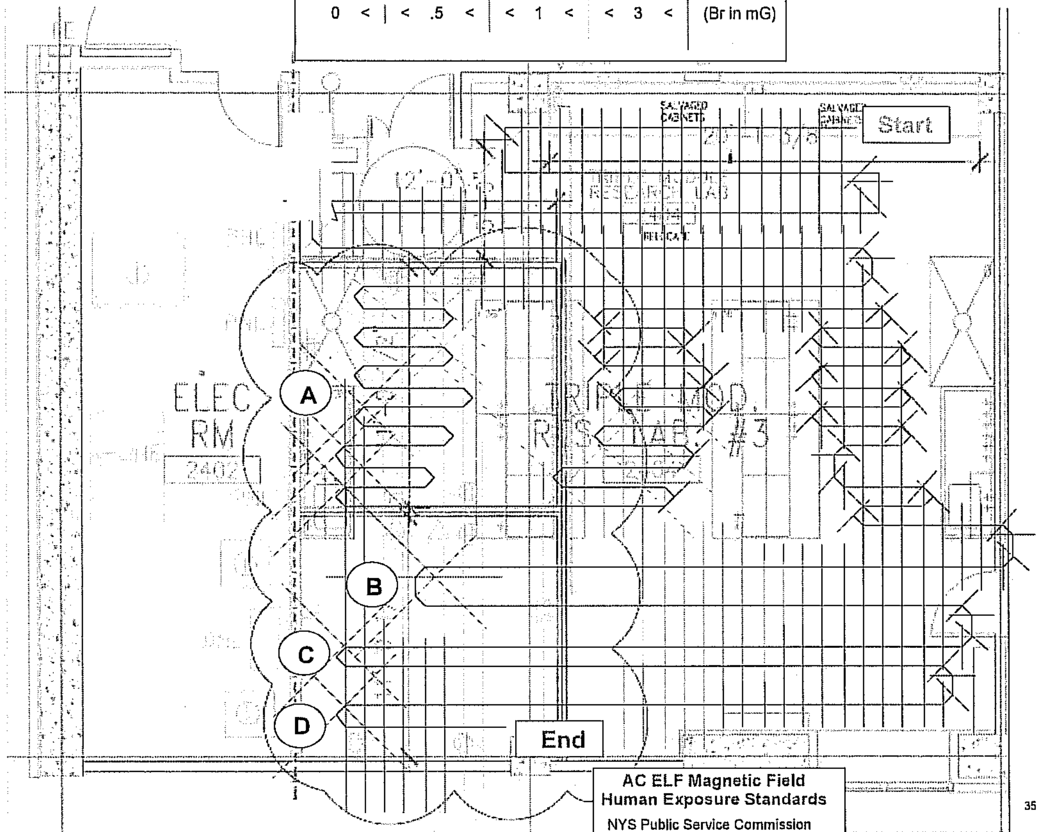
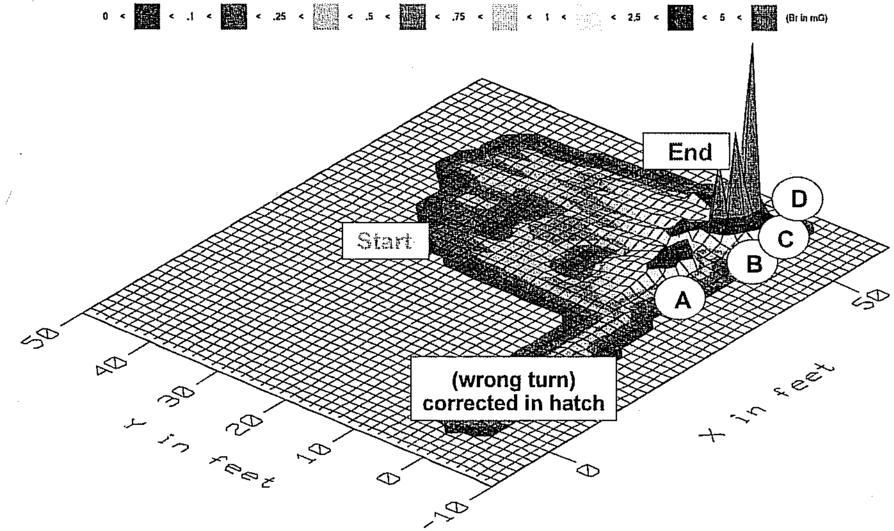
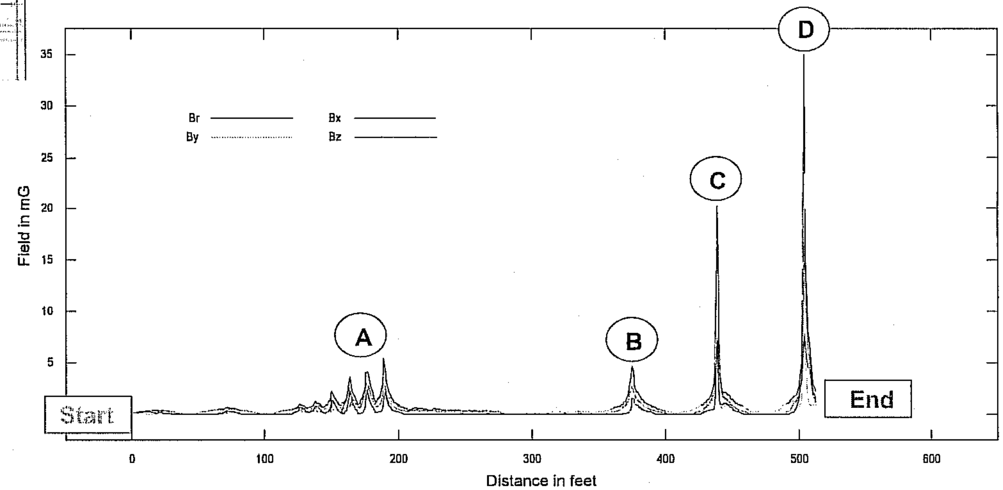
***All magnetic flux density data recorded with a FieldStar 1000 gaussmeter and survey wheel***

**AC ELF EMI Thresholds (screen jitter & noise)**
- 10 mG for 12-15 inch computer monitors & audio/video equipment
- 5 mG for 17-21 inch CRT monitors & medical (i.e., EEGs, ECGs, EMGs,. etc.).
- 1.0 mG minimum for scientific tools (STEMs, TEMs, FIB, I-Beam, etc.)
- 0.1- 0.3 mG optimum for next generation Nano & Pico Tech scientific tools

# Figure #5, Contour Hatch Plot
# Magnetic Flux Density Levels @ 1-Meter
# 2nd Floor Existing Lab Room 2404
# University of California at Santa Barbara, CA




PEAK = 35 mG, MEAN = .989 mG
Rec 2 File UCSB Taken 1/9/8 ID-UCSB 2404

***All magnetic flux density data recorded with a FieldStar 1000 gaussmeter and survey wheel***

**AC ELF Magnetic Field Human Exposure Standards**

NYS Public Service Commission
200 mG @ 1-meter on Edge -ROW
or 50 ft. from 69 kV poles

IRPA/INIRC
833 mG over 24 hours
General Public Exposure

ACGIH
1000 mG general public
& workers with cardia pacemakers

Swiss Bunderstat
NCRP Draft Report
10 mG from overhead/underground transmission/distribution lines, substations, etc.

**AC ELF EMI Thresholds (screen jitter & noise)**

10 mG for 12-15 inch computer monitors & audio/video equipment
5 mG for 17-21 inch CRT monitors & medical (i.e., EEGs, ECGs, EMGs,. etc.).
1.0 mG minimum for scientific tools (STEMs, TEMs, FIB, I-Beam, etc.)
0.1- 0.3 mG optimum for next generation Nano & Pico Tech scientific tools

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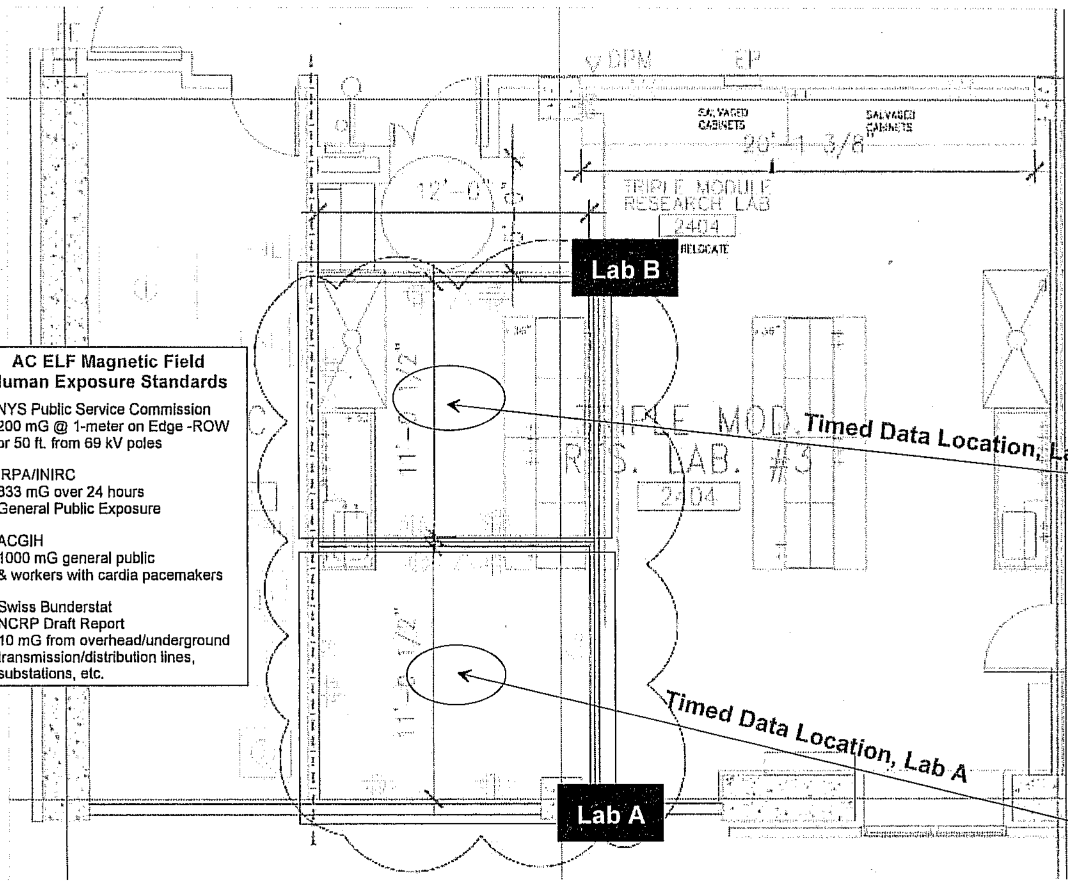



**AC ELF Magnetic Field Human Exposure Standards**

NYS Public Service Commission
200 mG @ 1-meter on Edge -ROW
or 50 ft. from 69 kV poles

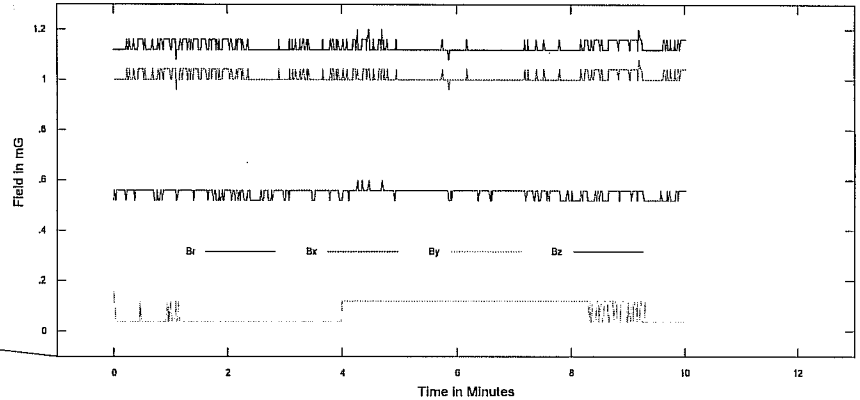
IRPA/INIRC
833 mG over 24 hours
General Public Exposure

ACGIH
1000 mG general public
& workers with cardia pacemakers

Swiss Bunderstat
NCRP Draft Report
10 mG from overhead/underground
transmission/distribution lines,
substations, etc.

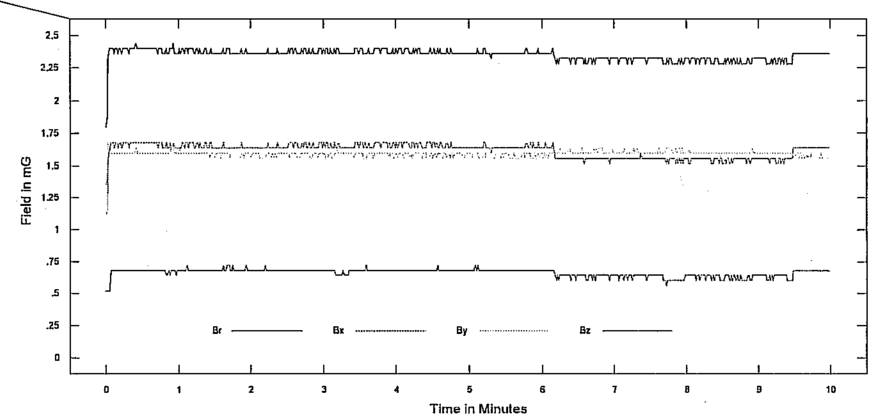
PEAK = 1.2 mG, MEAN = 1.13 mG

**Rec 4 File UCSB2 Taken 1/9/8 ID-UCSB RLB TMD**




PEAK = 2.44 mG, MEAN = 2.35 mG

**Rec 1 File UCSB2 Taken 1/9/8 ID-UCSB RLA TMD**





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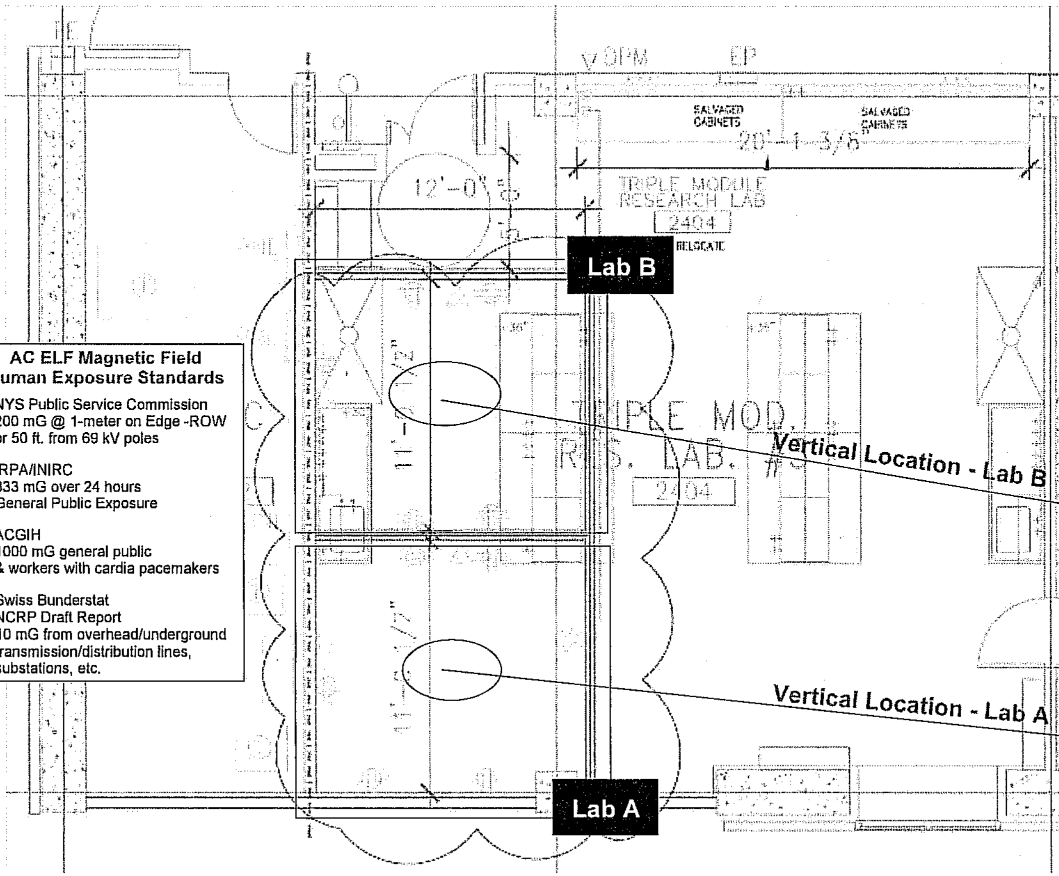
**AC ELF EMI Thresholds (screen jitter & noise)**

10 mG for 12-15 inch computer monitors & audio/video equipment
5 mG for 17-21 inch CRT monitors & medical (i.e., EEGs, ECGs, EMGs,. etc.),
1.0 mG minimum for scientific tools (STEMs, TEMs, FIB, I-Beam, etc.)
0.1- 0.3 mG optimum for next generation Nano & Pico Tech scientific tools

***All magnetic flux density data recorded with a FieldStar 1000 gaussmeter and survey wheel***

## Figure #6, Timed Lab Plots
## Magnetic Flux Density Levels @ 1-Meter
## 2nd Floor Labs A & B, Room 2404
## University of California at Santa Barbara, CA



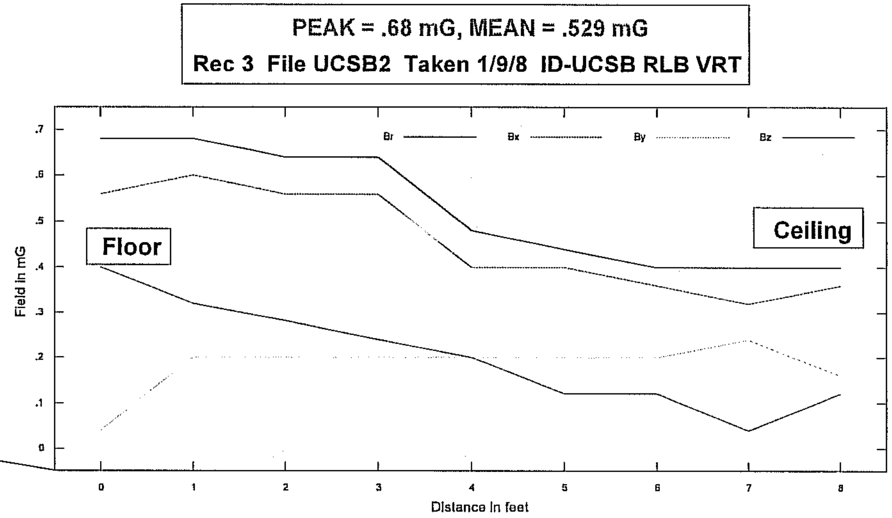

**AC ELF Magnetic Field Human Exposure Standards**

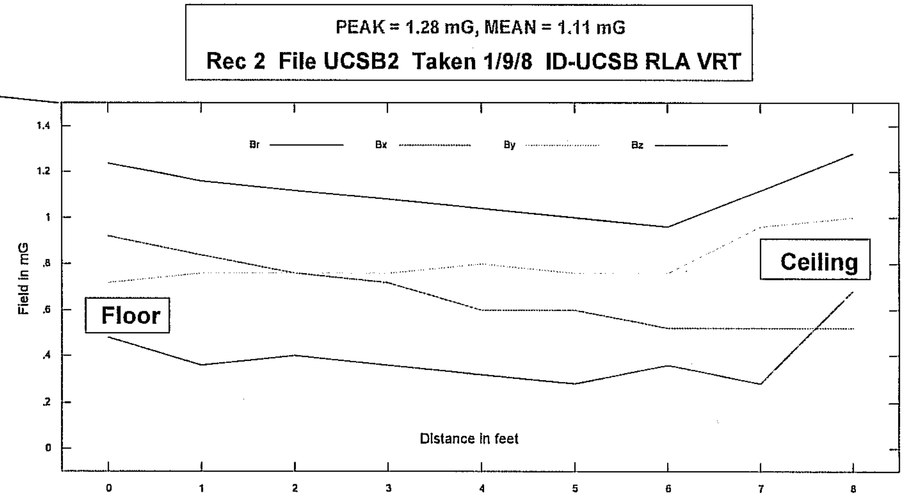
NYS Public Service Commission
200 mG @ 1-meter on Edge -ROW
or 50 ft. from 69 kV poles

IRPA/INIRC
833 mG over 24 hours
General Public Exposure

ACGIH
1000 mG general public
& workers with cardia pacemakers

Swiss Bunderstat
NCRP Draft Report
10 mG from overhead/underground transmission/distribution lines, substations, etc.

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**AC ELF EMI Thresholds (screen jitter & noise)**

10 mG for 12-15 inch computer monitors & audio/video equipment
5 mG for 17-21 inch CRT monitors & medical (i.e., EEGs, ECGs, EMGs,. etc.).
1.0 mG minimum for scientific tools (STEMs, TEMs, FIB, I-Beam, etc.)
0.1- 0.3 mG optimum for next generation Nano & Pico Tech scientific tools

***All magnetic flux density data recorded with a FieldStar 1000 gaussmeter and survey wheel***

**Figure #7, Vertical Lab Plots**
**Magnetic Flux Density Levels @ 1-Meter**
**2nd Floor Labs A & B, Room 2404**
**University of California at Santa Barbara, CA**

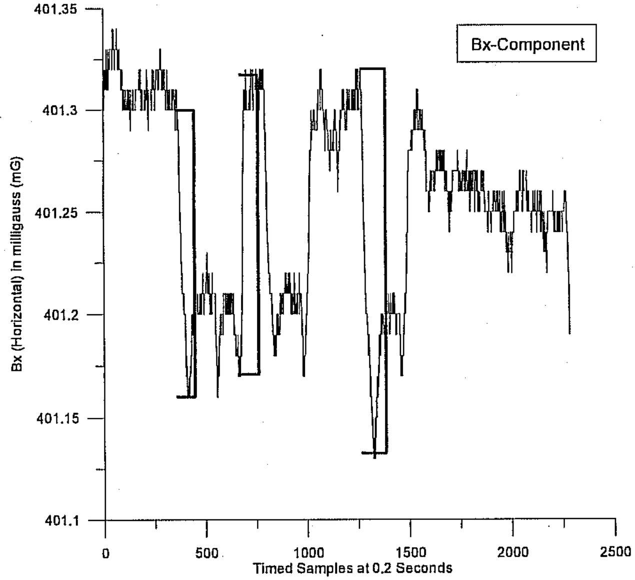
# Figure #8, Timed DC Data
## Magnetic Flux Density Levels @ 1-Meter
## 2nd Floor, Lab A, Room 2404
## University of California at Santa Barbara, CA

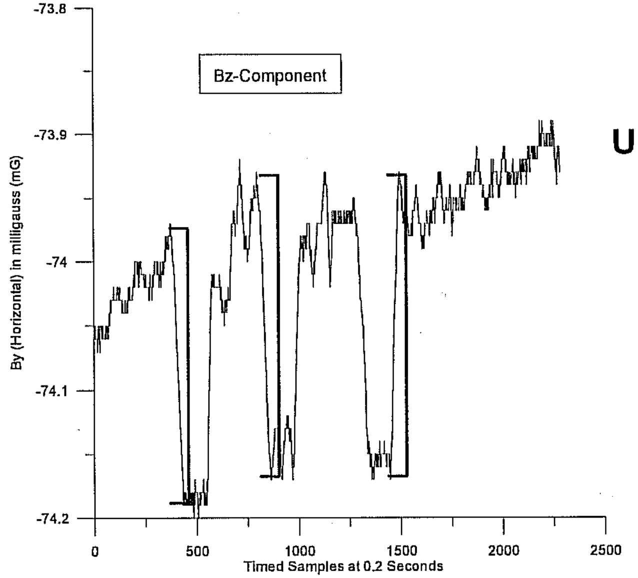
**Component Transients**

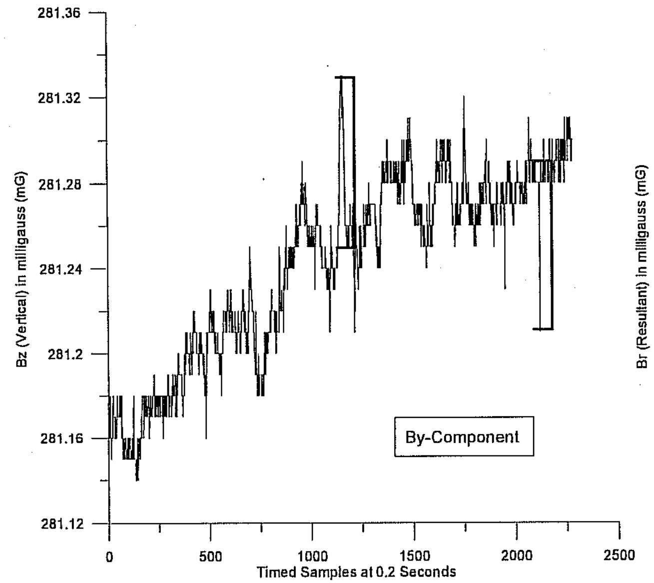
| | |
|---|---|
| ***Bx:*** | **0.19 mG dB/dt** |
| ***By:*** | **0.23 mG dB/dt** |
| ***Bz:*** | **0.08 mG dB/dt** |

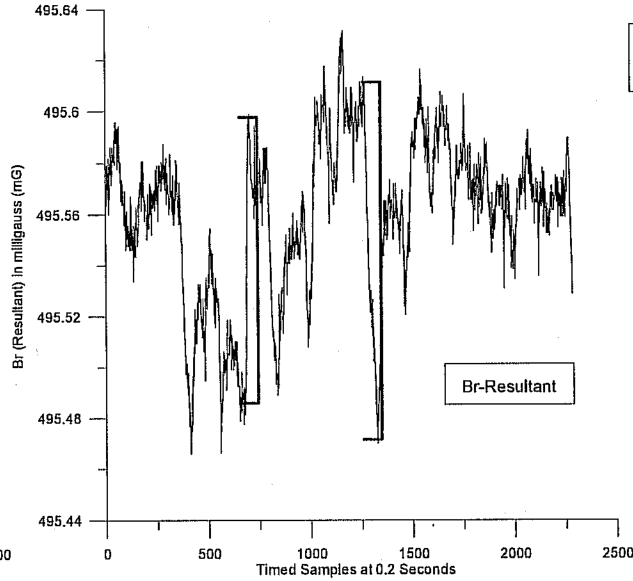
**Resultant Transient**

| | |
|---|---|
| ***Br:*** | **0.15 mG dB/dt** |



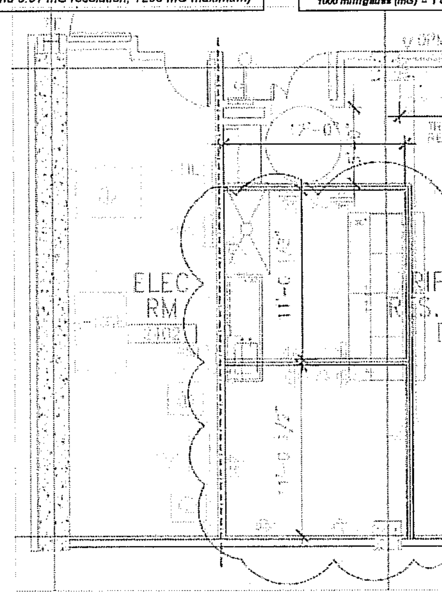




*Timed DC magnetic flux density levels recorded with MEDA FVM-400 three-axis fluxgate magnetometer (bandwidth DC - 10 Hz and 0.01 mG resolution, 1200 mG maximum)*

**DC EMI Thresholds - CRTscreen shift, noise & coercivity (data errors)**
0.001 Gauss & Less SEMs, TEMs E-Beam/FIB Writers
0.75 Gauss CRT Monitors & Electronic Instruments
5 Gauss Cardiac Pacemakers & Implantable Devices Warning Sign
10 Gauss Credit Cards & Magnetic Media Warning Sign
300 Gauss Low Coercivity Mag-Stripe Cards
700 Gauss High Coercivity Mag-Stripe Cards & Video Tapes
*1000 milligauss (mG) = 1 Gauss (G) & 1 mG = 0.001 G = 0.1 uT (microtesla)*





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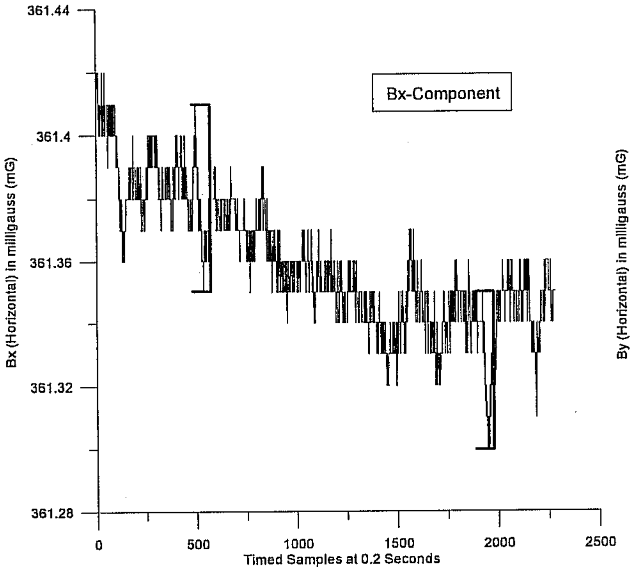
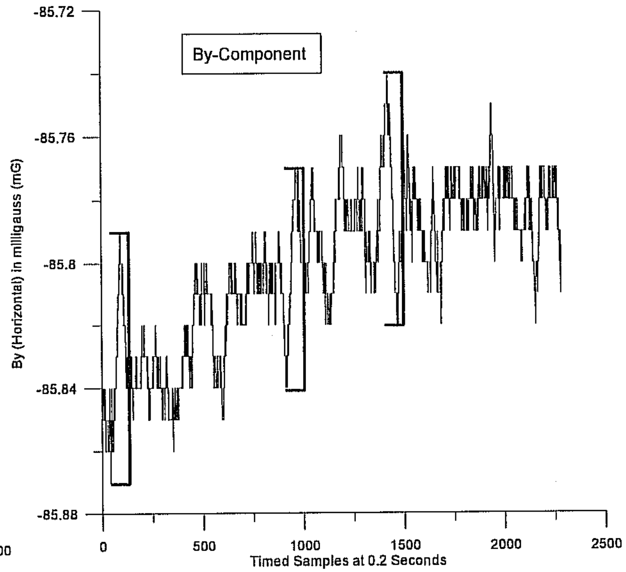
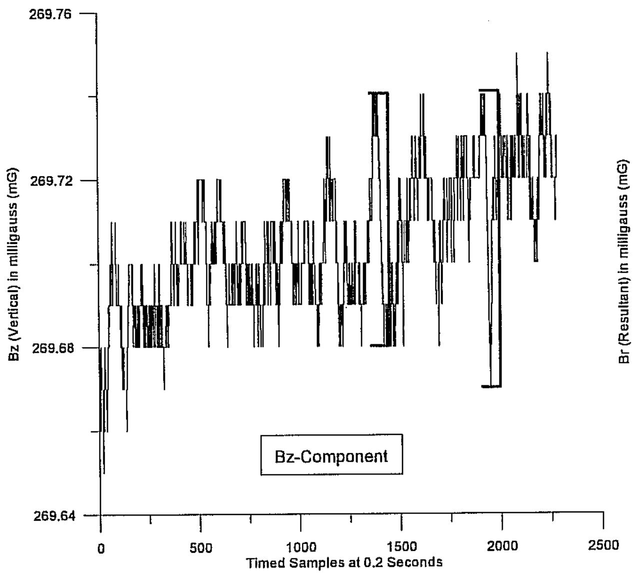
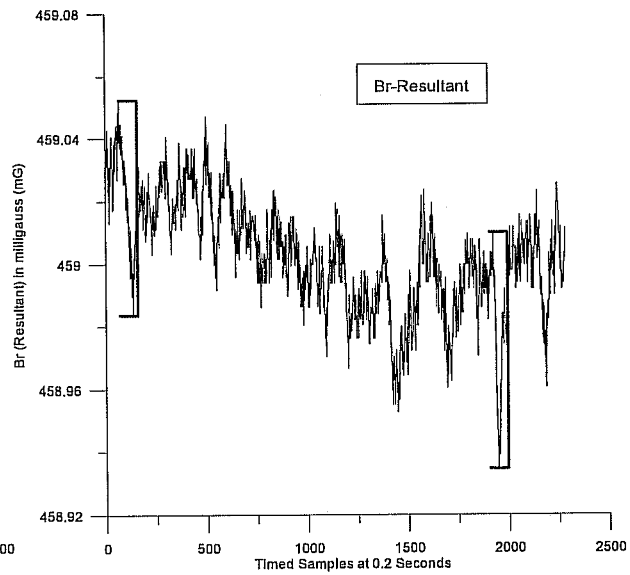
# Figure #9, Timed DC Data
## Magnetic Flux Density Levels @ 1-Meter
## 2nd Floor, Lab B, Room 2404
## University of California at Santa Barbara, CA




**Component Transients**

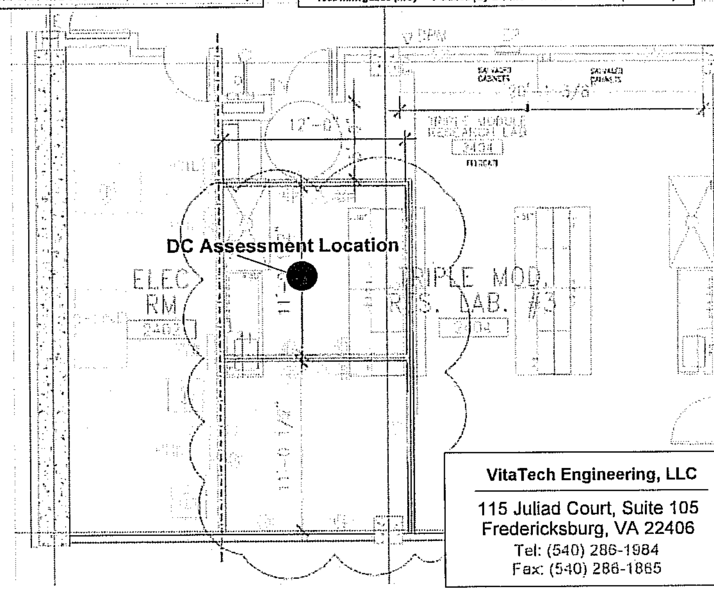
*Bx:* 0.06 mG dB/dt
*By:* 0.08 mG dB/dt
*Bz:* 0.07 mG dB/dt

**Resultant Transient**

*Br:* 0.07 mG dB/dt

*Timed DC magnetic flux density levels recorded with MEDA FVM-400 three-axis fluxgate magnetometer (bandwidth DC - 10 Hz and 0.01 mG resolution, 1200 mG maximum)*

**DC EM Thresholds - CRTscreen shift, noise & coercivity (data errors)**
0.001 Gauss & Less SEMs, TEMs E-Beam/FIB Writers
0.75 Gauss CRT Monitors & Electronic Instruments
5 Gauss Cardiac Pacemakers & Implantable Devices Warning Sign
10 Gauss Credit Cards & Magnetic Media Warning Sign
300 Gauss Low Coercivity Mag-Stripe Cards
700 Gauss High Coercivity Mag-Stripe Cards & Video Tapes
*1000 milligauss (mG) = 1 Gauss (G) & 1 mG = 0.001 G = 0.1 uT (microtesla)*





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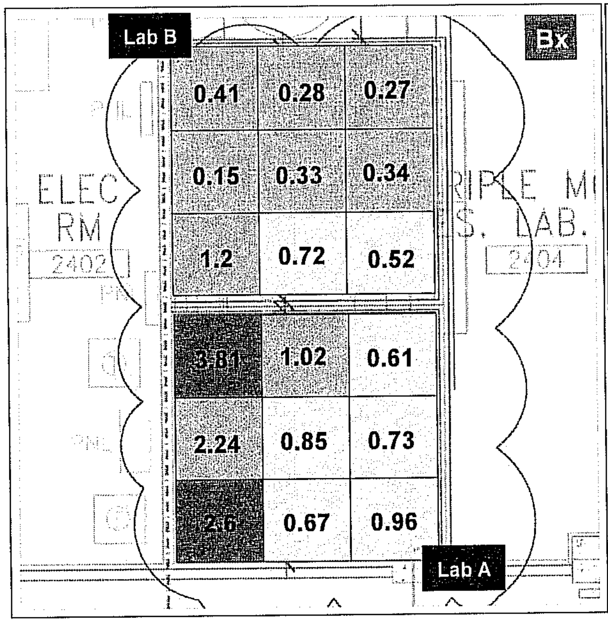
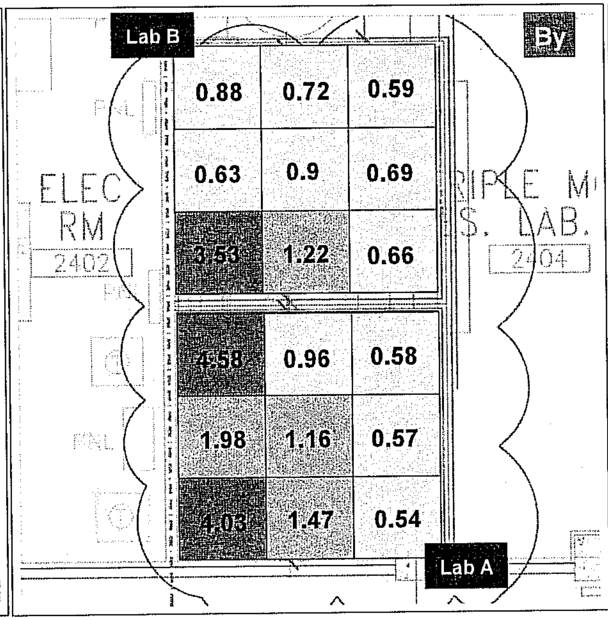
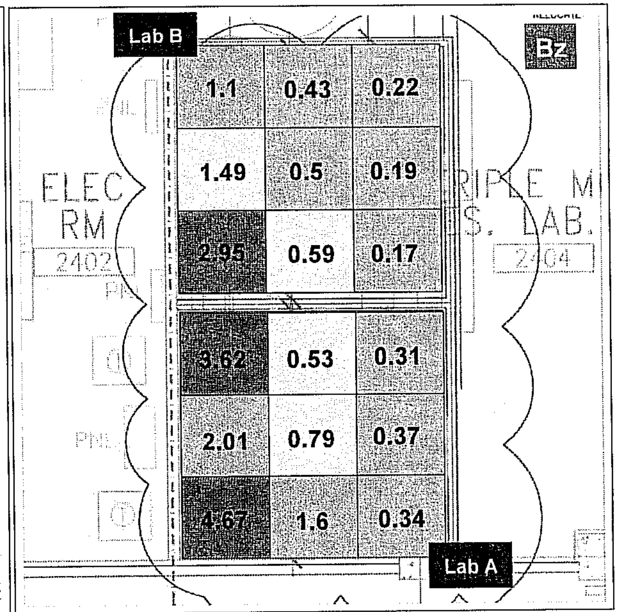
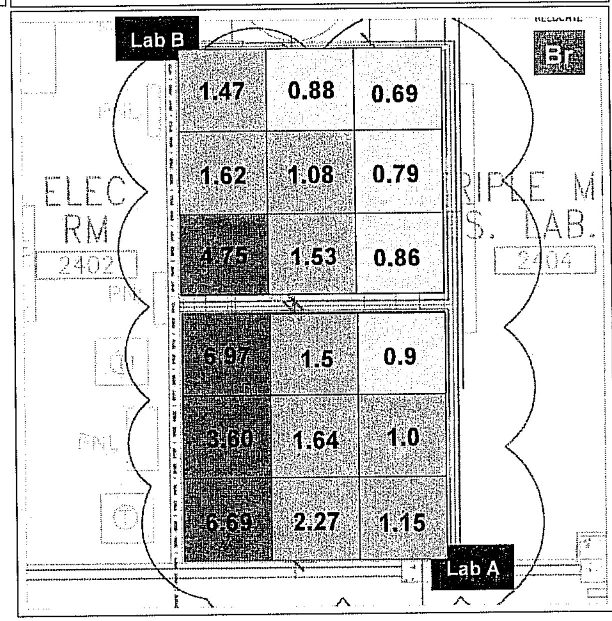
## All readings in milligauss (mG)




RESULTANT

Frequency Range 12 Hz to 50 kHz

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**Figure #10, VLF/ELF Readings**
**Magnetic Flux Density Levels @ 1-Meter**
**2nd Floor Labs A & B, Room 2404**
**University of California at Santa Barbara, CA**