VitaTech Engineering, LLC

EMF Measurements, Surveys & Risk Assessment
EMF Mitigation - Shielding & Cancellation
E-mail: lvitale@vitatech.net
Homepage: www.vitatech.net

115 Juliad Court, Suite 105
Fredericksburg, VA 22406
(540) 286-1984
FAX: (540) 286-1865

September 1, 2006

Mark Jamison, P.E.
HDR One Company
8404 Indian Hills Drive
Omaha, NE 68114

Tel: (402) 399-4908

Subject: Future NSLS-II Brookhaven Labs EMI/RFI Site Assessment Study

Dear Mr. Jamison:

VitaTech Engineering was engaged by HDR to perform an EMI/RFI Site Assessment Study for the future NLSL-II building site located at Brookhaven Labs in Long Island, New York. The EMI/RFI data contained in this report was recorded on 14 June 2006 by the author of this report and Mr. Eric Friedlein of VitaTech Engineering. The proposed NSLS-II site has underground distribution circuits traveling east-west along Brookhaven Avenue and other electrical feeders west of Seventh Avenue running north-south. *VitaTech must return in late September to record additional RF data from the NEXRAD Dopper Radar 2200 ft. from the site.*

AC ELF Electromagnetic Interference (EMI)

Electron microscopes (SEMs, TEMs, STEMs), Focus Ion Beam (FIB) writers and E-Beam Writers are very susceptible to AC ELF (extremely low frequency) 3 Hz to 3000 Hz magnetic fields emanating from various electrical power sources outside of the NLSL-II building and within. VitaTech recommends a maximum of 1 mG Br (resultant) RMS AC ELF magnetic flux density emissions for NMRs and MRIs, 0.3 mG Br (resultant) RMS AC ELF magnetic flux density emissions for Cleanrooms and 0.1 mG Br (resultant) RMS AC ELF magnetic flux density emissions for SEMs, TEMs, STEMs, FIBs and E-Beam Writers as shown in the Chart #1 below:

EMI AC & DC Magnetic Field Performance Specs
NMR Maximum Requirement:
1 mG Br RMS (2.83 mG p-p)

Instrument & Quite Labs Maximum Requirement:
0.1 mG Br RMS (0.3 mG p-p)

Cleanrooms Maximum Requirement:
0.3 mG Br RMS (0.1 mG p-p)

Chart #1, Recommended EMI AC & DC Magnetic Performance Specs

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 (computers 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 in milligauss (mG) using one of three magnetic flux density terms: Brms, Bpeak-to-peak(Bp-p) and Bpeak (Bp) according to the following conversion formula below.

$$B_{rms} = \frac{Bp-p}{2\sqrt{2}} = \frac{Bp}{\sqrt{2}}$$

To convert magnetic field strength to units of milligauss (mG), simply multiple the magnetic field strength by 4π. For example, 3 A/m is equal to 37.7 mG (3 x 12.57 = 37.7 mG). Using simulated emission profiles and the correct conversion formula, 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. *Analog audio/video equipment and cables are susceptible to EMI noise less than 5 mG including diagnostic medical instruments such as EEGs, EKGs, EMGs, ECGs, and other electrode contract devices.*

The semiconductor industry has specified AC EMI threshold performance requirements in SEMI E33-94, Specification For Semiconductor Manufacturing Facility Electromagnetic Compatibility, as shown below in Chart #2 - The AC ELF EMI Threshold Charts:

Chart #2 – AC ELF EMI Threshold Chart

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 for standard scientific tools (STEMs, TEMs, FIB, I-Beam, etc.)

0.1- 0.3 mG high resolution Nanotech scientific tools

0.01 mG for optimum superhigh resolution STEM tools.

SEMI E33-94 AC ELF EMC Standards

Level A - less than 0.25 mG
Level B - less than 0.50 mG
Level C - less than 1.00 mG
Level D - less than 2.00 mG
Level E - 2.0 mG and greater

AC ELF EMI Recorded Data & Assessment

On 14 June 2006 VitaTech recorded lateral AC extremely low frequency (ELF) magnetic flux density levels at 1-meter above grade with a survey wheel and the FieldStar 1000 gaussmeter (see Test Instruments for details) within the proposed NLSL-II building site. The following is an AC ELF magnetic flux density assessment of the RMS recorded data:

Figure #1 shows five lateral Hatch Plots recorded across the proposed NLSL-II building site. Each lateral data path has four color hatch marks (0.1 mG, 0.25 mG, 1.0 mG and 5.0 mG) representing the threshold level recorded at each one-foot interval (no hatch marks indicate levels less the 0.1 mG). Figure #2 presents five Profile Plots of the Figure #1 Hatch Plots with resultant Br (black) levels and three Bx (red), By (green) and Bz (blue) components shown as a function of distance.

The three north-south laterals (records #1 - #3) in Figures #1 and #2 shows the recorded magnetic fields emanating from the east-west underground distribution lines on Brookhaven Avenue (peaks 1.5 to 3.4 mG). The three north-south laterals rapidly decay to less than 0.1 mG 75 to 100 feet from the Brookhaven Avenue south curb. The levels were also very low along the east-west lateral in the center of the field rapidly decaying to 0.00 mG between Seventh and Fifth Streets except within 75 feet south of Brookhaven Avenue. The proposed NLSL-II site has very low AC ELF magnetic flux density levels 75 feet south of Brookhaven Avenue, ranging from 0.1 mG to 0.00 mG as shown in the five Figure #2 Lateral Profile Plots.

Figure #3 shows the timed wideband 3 Hz to 3,000 Hz AC ELF magnetic flux density field levels at the proposed NLSL-II site recorded with the MultiWave System II three axis fluxgate magnetometer sampled at 15 second intervals for 42 minutes. The timed Br resultant peak was 0.192 mG with an average 0.18 mG over the 42 minute period: this is the noise floor of the MultiWave System II where the actual levels are below the recording range. Therefore, the actual timed levels are 0.0 mG at this distance (200 – 250 ft) south of Brookhaven Ave.

Conclusions: The recorded AC ELF magnetic flux density emissions were very low ranging from 0.1 mG at 75 to 100 feet south of Brookhaven Avenue rapidly decay to 0.00 mG at 100 feet all the way to the other side of the site including the wooded areas. The NSLS-II site complies with all four of the following AC ELF magnetic flux density performance requirements 100 feet south of Brookhaven Avenue between Seventh and Fifths Streets:

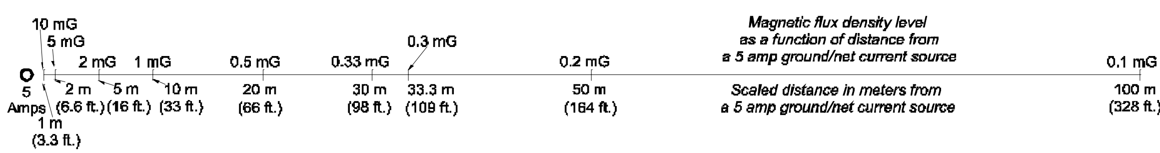
- ***0.01 to 0.1 mG EMI threshold for ultrahigh resolution STEMs;***
- ***0.1 to 0.3 mG EMI threshold for scientific tools (i.e., SEMs, TEMs, FIB, E-Beam Writers, etc.);***
- ***0.25 mG Level A SEMI E33-94 AC ELF EMF Standard; and,***
- ***10 mG long-term human exposures threshold recommended by the Swiss Bunderstat and NCRP Draft Report (see AC ELF Magnetic Field Health Issues, Standards & Guidelines)***

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:

$$\mathbf{B_{mG} = 2(I)/r} \quad \text{where I is amps and r meters}$$

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 1 m 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. *Finally, low ambient magnetic field levels can be achieved inside a research laboratory and imaging suite* *by adhering to the N.E.C. and good wiring practices. However, these low levels can only be achieved under the most pristine conditions and without any circulating ground/net currents present on the primary electrical distribution system outside of the building, low-voltage 480/208V distribution feeders and branch circuits inside the building systems and the grounding system.*

DC Electromagnetic Interference (EMI)
Large and small ferromagnetic masses in motion such as elevators, cars, trucks, trains, subways 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 emission 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 traction currents from underground/surface electric DC trolleys/subways, electromagnetic pulse (EMP) devices with high-voltage discharge, and finally unshielded NMRs and MRIs.

Electron microscopes (SEMs, TEMs, STEMs), Focus Ion Beam (FIB) writers and E-Beam Writers are very susceptible to DC EMI emissions and require clean DC environments. VitaTech recommends a maximum of 1 mG dB/dt Br (resultant) RMS DC EMI for NMRs and MRIs, 0.3 mG dB/dt Br (resultant) RMS DC EMI for Cleanrooms and 0.1 mG dB/dt Br (resultant) RMS DC EMI for SEMs, TEMs, STEMs, FIBs and E-Beam Writers as shown in the Chart #1 below:

EMI AC & DC Magnetic Field Performance Specs
NMR Maximum Requirement:
1 mG Br RMS (2.83 mG p-p)

Instrument & Quite Labs Maximum Requirement:
0.1 mG Br RMS (0.3 mG p-p)

Cleanrooms Maximum Requirement:
0.3 mG Br RMS (0.1 mG p-p)

Chart #1, Recommended EMI AC & DC Magnetic Performance Specs

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 TEMs such as the TEM JOEL 2010 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.*** Below is a list of DC EMI Thresholds in Gauss that will impact CRT displays, electronic instruments and magnetic media:

Chart #3 – DC EMI Threshold Chart

DC EMI Thresholds - CRT screen 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-Sripe Cards & Video Tapes
1000 milligauss (mG) = 1 Gauss (G) & 1 mG = 0.001 G = 0.1 uT (microtesla)

According to the **National Geophysical Data Center (NGDC),** the average Br resultant DC magnetic flux density level at Brookhaven National Labs is 528.5 mG at 0 ft. elevation. Depending on the location and distance from ferromagnetic materials (pipes, steel beams, rebar, cars, etc.), the recorded average time DC Br resultant RMS levels at the site was 536.9 mG (see Figure #3), which is only a 8.4 mG differential.

<u>Moving Vehicle DC EMI Emission Profiles & Impact</u>

As discussed the DC EMI emissions from moving vehicles (cars, SUVs, VANs, trucks and busses), and trains can compromise sensitive research tools. Normally, VitaTech recommends adequate spacing between the proposed building site, roads with heavy traffic, parking garages, trains, subways and other DC EMI emission sources to minimize potential EMI problems with sensitive instruments and tools.

Figure #4 shows the timed (15 second interval) resultant (Br) and component (Bx, By and Bz) RMS DC data recorded with the MultiWave System II three-axis fluxgate magnetometer more than 200 feet from Brookhaven Avenue. The only noticeable DC dB/dt EMI data was generated from an SUV that drove up to our location (200 – 250 feet south of Brookhaven Avenue) within 10 feet of the fluxgate probe. The Br resultant chart shows a 4 mG dB/dt square pulse from the SUV vehicle as it approached the fluxgate probe.

VitaTech recorded timed DC EMI data from moving vehicles at the University of Florida several years ago as shown in Figure #5. Calculated car and bus vehicle profiles were generated by applying the decay data to Curve Fitting software – this data was overlaid on the NSLS-II site plan. Similarly, the vehicle decay chart should be used to evaluate the DC EMI impact from cars driving on Brookhaven Avenue and Seventh/Fifth Streets adjacent to the proposed site. It should be noted that in practice the magnetic fields decay more rapidly after 30 meters than the calculated levels indicate (see recorded data). Nevertheless, the calculated DC differential dB/dt emissions from a moving bus at 40 meters would be 0.2 mG while in practice the actual bus levels will be less than 0.1 mG.

Conclusions: Standard resolution imaging tools with dB/dt differential DC EMI resultant RMS thresholds of 1 mG to 0.1 mG can be located between 12 meters (40 ft) to 40 m (131.2 ft) south of Brookhaven Avenue assuming cars and busses are moving east and west. High resolution imaging tools with differential dB/dt DC EMI resultant RMS thresholds of 0.1 to 0.01 mG can be located from 40 m (131.2 ft) to 60 m (197 ft.), which is the predicted 0.01 mG isoline) south of Brookhaven Avenue. Similar separation distances are required from the north-south Seventh and Fifth streets to ensure adequate DC EMI immunity for moving vehicles of similar mass.

Radiofrequency Interference (RFI)

The Federal Communications Commission (FCC), not the local municipal zoning authorities or law enforcement, has legal jurisdiction over radiofrequency interference (RFI). Simply stated RF devices (intentional and unintentional emitters) are not permitted to cause RFI with other radio services, electronic equipment and systems. At present, there are no mandated radiofrequency interference (RFI) susceptibility government standards in the United States. The only equipment susceptibility standards that exist are unique to equipment (quality control) internal standards written by equipment manufacturers based on radiated emission standards for intentional radiators set forth by the FCC. In other words, an equipment manufacturer in United States must design the equipment to function properly within a radiated emission field level from intentional radiators set forth by the FCC, Part 15. Like any other communications facility, wireless broadband facilities must comply with these FCC limits. The following FCC parts apply to electromagnetic interference (EMI) and radio frequency interference (RFI) conducted and radiated emissions (see below):

Radio Frequency Devices - Part 15
Multipoint Distribution Service - Part 21, subpart K
Paging and Radiotelephone Service - Part 22, subpart E
Cellular Radiotelephone Service - Part 22, subpart H
Personal Communications Services - Part 24
Satellite Communications - Part 25
General Wireless Communications Service - Part 26
Wireless Communications Service - Part 27
Radio Broadcast Services - Part 73
Experimental, auxiliary, and special broadcast and other program distributional services - Part 74
Experimental Radio Service - Part 5
Stations in the Maritime Service - Part 80
Private Land Mobile, Paging Operations - Part 90
Private Land Mobile, "Covered" Specialized Mobile Radio - Part 90
Amateur Radio Service - Part 97
Local Multipoint Distribution Service - Part 101, subpart L

Mobile and portable devices used as follows:

- Cellular Radio Service
- Personal Communications Service
- Satellite Communications Branch
- General Wireless Communications Service
- Wireless Communications Service
- Maritime Service
- "Covered" Specialized Mobile Radio Service

In Europe, there are susceptibility (radiated immunity) standards, such as the EN 61000-6-1, that states 3 V/m level for residential electronic equipment, while 10 V/m is standard for industrial electronic equipment in the EN 61000-6-2. Engineers in the United States utilize the European susceptibility standards as a guideline. The SEMI E33-94 EMC Standard is 10 V/m and 3 V/m depending on frequency (see below):

Chart #4 – RFI Threshold Chart

Electric field strength RF levels were recorded in volts-per-meter (V/m) for 10 minutes sampled at 0.04-second intervals with a Narda ERM-300 electric field meter using a Probe 18 from 100 kHz to 3 Ghz (range of 0.2 to 320 V/m) and Probe 9C from 3 MHz to 18 GHz (range of 0.5 to 1000 V/m). The objective is to investigate sources of radio-frequency interference (RFI) over a wide bandwidth. It should be noted that 3 V/m is the industry standard RFI threshold and 1 V/m the medical/scientific instrument RFI threshold.

SEMI E33-94 RF Immunity Standards
Enclosure Ports
Radiated AM Immunity: 10 V/m 450-520 MHz and 800-950 MHz @ 80% AM
Radiated Pulse Modulated: 3 V/m 1.89 GHz 50% Duty cycle
Signal Line Ports & Ports for Process, Measurement & Control
RF Common Mode: 3 V/m 0.15 - 100 MHz @ 80% AM
Input/Output DC/AC Power Ports
RF Common Mode: 3 V/m 0.15 - 100 MHz @ 80% AM

RFI Electric Field Strength Site Assessments & Conclusions

Timed Wideband 100 kHz – 18 GHz RF Electric Field Strength Data

VitaTech recorded timed RF electric field strength data in volts-per-meter (V/m) was recorded at 1-meter above grade from 100 kHz to 3 GHz and 3 MHz to 18 GHz at 0.4 second intervals for two 10 minute periods on 14 June 2006 as shown in Figures #6 and #7. A summary of the 14 June 2006 recorded RF electric field strength levels are presented in Tables #1 and #2 below:

Table #1: 100KHz - 3GHz RF Data 14 June 2006

Site	Max (V/m)	Min (V/m)	Average (V/m)
NSLS-II	0.31	0.00	0.12

Table #2: 3MHz - 18GHz RF Data 14 June 2006

Site	Max (V/m)	Min (V/m)	Average (V/m)
NSLS-II	0.25	0.0	0.12

Tables #1 and #2 present 20 minutes of recorded RF electric field strength at the NSLS-II site as shown in Figure #6. These are very low RF electric field strength levels considering the NEXRAD Doppler Weather Radar is only 2200 ft. away from the site, therefore the radar was not operational or under low power during data collection. Figure #7 shows the maximum electric field strength thresholds recorded during two ten minute sampling periods. Again, very low maximum peak threshold levels were recorded from 100 kHz to 3 GHz and from 3 MHz to 18 GHz indicating the radar was not operational or under low power during the testing.

The NEXRAD Doppler Radar transmitter frequency range is 2.7 to 3.0 GHz with a peak output power of 750 kW (pulse width - short at 1.57 microsecond and 4.5 microsecond wide) from an S-Band center-feed parabolic dish (28 ft. outside-diameter) with a 0.95 degree pencil beam, 6 RPM azimuth rate and -1 to +20 degree elevation. VitaTech will return in late September 2006 with our new spectrum analyzer, the Narda SRM-3000 Selective Radiation Meter, to record the electric field strength and FCC Bulletin 65 (MPE) maximum permissible exposure levels at the proposed NSLS-II site with the NEXRAD Doppler Radar at maximum power (must be scheduled with the NEXRAD engineers and operators).

VitaTech previously recorded electric field strength levels for the Center for Functional Nanomaterials on the roof of the existing LightSpeed building. The RF emission levels around scientific tools such as the E-Beam Writers, NMRs, and Mass Spectrometers should be 20 mV/m or less. *Based upon the previously recorded RF emission levels at that site, RF shielding was recommended on the façade of the Center for Functional Nanomaterials, but budgetary issues deleted the RF shielding. Nevertheless, the existing LightSource building had RFI problems from the NEXRAD Dopper Radar, and RF shielding was installed around selected laboratory and research areas to reduce the RFI problems.*

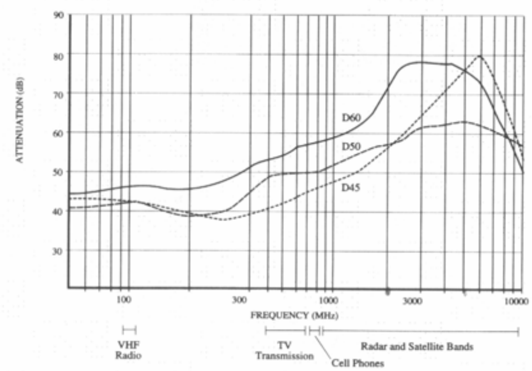
<u>Center for Functional Nanomaterials RF Shielding Assessment/Mitigation Options</u>
The following section was extracted from the Center For Functional Nanomaterials report on RFI shielding options. It should be noted that the estimated prices are not accurate and should be increased by 30% for budgetary reasons:

> The nearby NEXTRAD Doppler Radar operates between the 2.7 to 3 GHz frequency range with up to 750 kW of effective radiated power (ERP) depending resolution and weather conditions. Building materials will provide natural shielding attenuation based upon frequency and distance from the façade facing the RF emission source. At 3 GHz the aluminum metal building façade (0.04 inches thick) would provide 50 dB to 60 dB of attenuation due to the high reflection and absorption characteristics of the exterior interlocking aluminum siding/roofing. The second floor heavy gage steel floor pans (0.034 inches thick) would add another 50 dB to 60 dB of attenuation (i.e., reflection and absorption) to the roof figures for a total of 100 to 120 dB attenuation in the vertical plane. If the east façade windows and walls were not shielded the natural horizontal attenuation factor would be 25 dB at 5 meters inside the exterior wall, over 35 dB at 10 meters, and over 60 dB at 20 meters deep inside the building. Although the east façade exterior wall is covered with aluminum panels providing at least 50 to 60 dB of attenuation, the large unshielded windows provide an open portal allowing the Doppler RF energy to penetrate deep into the building. ***Therefore, RF shielding the windows is necessary to minimize potential RFI problems in the adjacent ground floor laboratories.***

VitaTech presents two RF window shielding options: transparent conductive RF film that can be applied to the windows when needed and conductive RF shielded glass with conductive gaskets and aluminum window frames. The best conductive RF film available is from 3M and sold under the Scotchtint trademark providing from 26 to 36 dB of attenuation depending on the type of film purchased (i.e., tint, conductivity, UV block and other parameters). When installed by professionals, the 3M Scotchtint has a 10 year warranty. It is supplied in 100 ft. by 5 ft. wide rolls costing from $1,200 to $1,500 per roll (not including installation) depending on the tint, shielding performance and energy rating. VitaTech provided samples of the P-18AR High Performance Silver (26 dB at 2.5 GHz) and RE35AMARL (36 dB at 2.5 GHz) to HDR several week ago. *It would cost $40,000 - $60,000 to install 3M RF film on 2,380 sq. ft. of windows including labor, expenses and profit.*

The other option is to use recently developed RF shielded glass "DATASTOP" sold by Pilkington and Tempest Security Systems, Inc. of Troy, OH. Shielding performance of the sealed double glazed DATASTOP windows ranged from 62 dB for the D50 with neutral tint up to 78 dB for the D60 with gold tint as shown below:

Figure 1
Double Glazing Shielding



The DATASTOP double glazed windows are typically two layers of ¼-inch thick glass separated by a ½-inch air gap mounted with conductive gaskets in an aluminum window frame shown below:

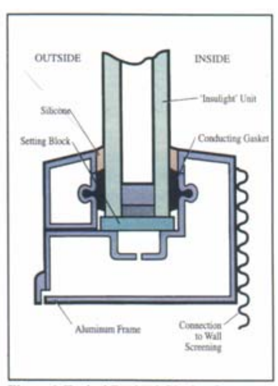


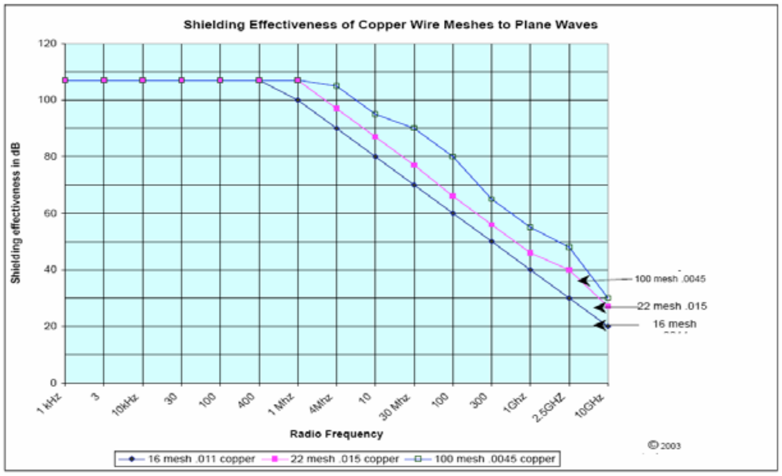
Figure 6. Typical Drained Glazing System

The basic no tint double glazed DATASTOP window costs \$60 per square foot (not including installation). It has a 10 year warranty and would provide an average of 60 dB of attenuation, which is similar in attenuation to the exterior aluminum façade and aluminum roof. RF energy may penetrate into the building interior through various holes, openings, and mechanical seams in the aluminum exterior east façade wall: any space more than a 1/2λ of 3 GHz, which is 1.95 inches in diameter (see mesh section for formula). Since the DATASTOP aluminum window frames will not be conductively bonded and/or RF sealed to the exterior east aluminum wall panels, RF penetration through any 2 inch and large space will occur around the windows, doors and other separation joints between the conductive and metallic surfaces. *It would cost \$290,000 - \$325,000 to install 2,380 sq. ft. of DATASTOP D50 double glazed windows with no tint, fames and conductive gaskets including labor, expenses and profit.*

Shielding the east building façade with wire mesh behind the aluminum exterior panels would significantly attenuate any RF energy leakage into thorough holes and penetrations the research laboratories while providing an extra layer of RF protection. First, the wavelength of 3 GHz must be calculated using $C = \lambda f$ where C is the speed of light (2.997×10^8 m/s) and f is frequency of attenuation (3.0×10^9 in cycles per second). The wavelength λ of 3 GHz is 0.0999 meters (99.9 mm or 3.9 inches) while any wavelength greater than 1/2 λ (1.95 inches) is attenuated (i.e., lower the frequency the longer the wavelength).

Next, the ideal shielding effectiveness (SE) in decibels for wire mesh is calculated where λ (lamda) is the wavelength of the incident Doppler microwave in meters and g is the airgap in meters: $(SE)_{dB} = 20 \log_{10} (0.5 \lambda/g)$

Assuming 60 dB of attenuation is the objective, than the calculated wire mesh spacing (airgap g) is 0.04995 mm (0.002 inches), which is equivalent to a 270 mesh. Only stainless steel fine mesh wire cloth is available in a 270 mesh size and is not used in RF shielding because of the difficulty in seam bonding and grounding. There are two other reasonable alternatives: 100 Mesh copper or aluminum screening. The calculated SE for 100 Mesh (0.0045 copper) with a 0.14 mm airgap is 51 dB while the measured SE is 47 dB as shown in the diagram below:



The 100 Mesh copper comes in 100 ft. rolls, 48 inches wide, and costs $1.30 to $1.50 per square foot (F.O.B). Aluminum 100 Mesh of the same length and width is a custom weave (must be an alloy with lower conductivity because of the needed tensile strength during the weaving process) costs $1.50 to $1.75 per square foot (F.O.B). The 100 Mesh copper and aluminum screens are easy to apply (staples, screws and adhesives) to the outside wall, can be mechanically bonded to the aluminum window frames using screws, and seam bonded (overlap edges and soldered) and grounded. Therefore, 47 dB of attenuation is available using the 100 Mesh copper and 40 dB using 100 Mesh aluminum alloy RF screening. *It would cost $55,000 - $80,000 to install 5,660 sq. ft. of aluminum 100 Mesh on the exterior walls beneath the aluminum panels and mechanically bonded to the aluminum window frames including labor, expenses and profit.*

VitaTech does not recommend applying copper and aluminum tapes with conductive adhesive backings over wire mesh seams, on window frames or other conductive structures because overall shielding performance will seriously degrade over time due to weathering and temperature variations. If wire mesh RF shielding is used on the east façade wall behind the exterior aluminum panels, it must be mechanically bonded to the window frames and all other metallic surfaces to ensure long-term performance with minimal failure (warning to avoid galvanic reactions only aluminum can be mechanically bonded to aluminum window/door frames).

<u>RF Shielding Options & Estimated Costs</u>
VitaTech presents the following RF shielding options with costs to minimize RFI interference from the nearby Doppler radar inside the new Center for Functional Nanomaterials building laboratories and offices:

Option 1: Additional RF shielding is not installed because the aluminum exterior east wall and roof building surfaces will provide at least 50 to 60 dB of attenuation coupled with the interior attenuation characteristics of the building. It should be noted that the east side 1st floor windows will provide open portals to the Doppler RF energy with only the office doors and walls to absorb and reflect the microwave energy. If RFI problems are identified and measured in specific laboratories, localized RF shielding should be applied to the area of concern to mitigate the problem, where practical. However, two alternative RF solutions are offered below with Option 1 where improved RF shielding is required:

Alternative #1: apply 3M conductive film to 1st floor windows for additional 36 dB of attenuation for an estimated cost of \$40,000 - \$60,000 including labor, expenses and profit. Shielding performance will be marginal because the edge between the conductive window film and window frame is difficult to bond (ground). Therefore, RF leakage around the inside glass window frames will present a serious problem.

Alternative #2: to reduce RF leakage through holes and seams along windows, doors and other openings apply 5,600 sq. ft. of aluminum 100 Mesh for an estimated costs of \$55,000 - \$80,000 including labor, expenses and profit. Special Note: aluminum 100 Mesh can not be applied after exterior aluminum wall panels are installed.

Option 2: Install DATASTOP RF shielded windows, conductive gaskets and frames in ground and 2nd floor east wall façade (2,380 sq. ft. area) as shown in Figure #11. Assume conductivity with aluminum exterior wall and roof to provide a reasonable RF shielding system of 60 dB and higher. Estimated cost: \$290,000 - \$325,000 for windows, frames, gaskets including labor, expenses and profit. Additional RF shielding is required to minimize RF leakage and improve overall shielding performance:

Alternative #3: seams with minimal electrical conductivity between DATASTOP aluminum window frames and exterior east aluminum walls will cause RF leakage penetrating into the interior building laboratories – install 100 Mesh aluminum screen to ground and 2nd floor walls behind aluminum panels and mechanically couple to the DATASTOP window frames RF sealing the east side of the building. Estimated cost: \$55,000 - \$80,000 for *5,660 sq. ft. of aluminum 100 Mesh includes labor, expense and profit.*

VitaTech recommends shielding the east exterior wall with the DATASTOP windows and 100 Mesh aluminum screen presented in Option 2 and Alternative #3 to provide the maximum RF shielding attenuation especially with close proximity to the ground floor research labs just several feet from the east side offices. Unfortunately, the Option 1 RF shielding solutions with Alternatives #1 and #2 will be marginally effective.

Conclusions: The four ambient timed recorded 100 kHz to 18 GHz electric field strength average and maximum peak data does not reflect the actual conditions since the Doppler Radar was probably not operational or at very low power. VitaTech will return in late September 2006 to record additional RF data with a spectrum analyzer (coordinate with engineers).

AC ELF, DC & RF 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 R_{rms} (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 below:

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:

Hatch Plot - data is represented by four difference hatch marks (0.1 mG, 0.25 mG, 0.5 mG and 1.0 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.

EMR-300 RF Meter - Electric Field Strength Data 100 kHz - 18 GHz

The EMR-300 is an radiofrequency (RF) electric field strength meter for broadband measuring and monitoring from 100 kHz to 18 GHz. The isotropic non-directional field probe with high sensitivity records average, maximum, peak and timed data in electric fields strength volts-per-meter (V/m), magnetic field strength amps-per-meter (A/m) and power levels. Ten minute timed data was sampled at 0.4 seconds intervals from 100 kHz – 3 GHz with a Probe 18 (range 0.2 V/m to 320 V/m) and from 3 MHz to 18 GHz with Probe 9C (range 0.5 V/m to 1000 V/m) at each location.

MultiWave System II – Magnetic Flux Density 0 Hz – 3000 Hz

Geomagnetic and static DC magnetic emission measurements were recorded with a fluxgate triple-axis MultiWave System II magnetometer (serial #1045). The MultiWave System II consists of a hand-held LCD display and keyboard controller unit, wideband 10 Gauss (G) peak (DC – 3 kHz) tri-axial fluxgate magnetometer, data acquisition and processing unit with 3.5" floppy disk drive unit and 0 to 10 Gauss range, 1% accuracy, 0.1 mG resolution.

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 two-fold 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.

Switzerland's February 2000 AC ELF Standard

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.

VitaTech's & NCRP Draft Recommended 10 mG Standard

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.

RF Human Exposure Standards

Presently, four major RF standards are used in the United States: IEEE, ACGIH (American Conference of Governmental Industrial Hygienists), NCRP (National Council on Radiation Protection and Measurements) and the ICNIRP (International Commissions of Non-Ionizing Radiation Protection). In 1991, the IEEE released a revised RF human exposure standard IEEE C95.1-1991, *Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHZ*. However, in August 1997 the Federal Communications Commission (FCC) Office of Engineering & Technology (OTE) released Bulletin 65 *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields*, which became the defacto RF exposure standard in the United States. Both standards are very similar for Occupational/Controlled and General Population/Uncontrolled maximum permissible exposure (MPE), except for some minor differences -- the FCC standard is more restrictive and used in RF Safety & Exposure Testing.

The FCC's Bulletin 65 specifies separate maximum permissible exposure (MPE) limits for Occupational/Controlled and General Population/Uncontrolled exposure over a 0.3 MHz to 100 GHz bandwidth as shown below:

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

(A) Limits for Occupational/Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	6

3.0-30	1842/f	4.89/f	$(900/f^2)$*	6
30-300	61.4	0.163	1.0	6
300-1500	--	--	f/300	6
1500-100,000	--	--	5	6

Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

(B) Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	$(180/f^2)$*	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

f = frequency in MHz *Plane-wave equivalent power density

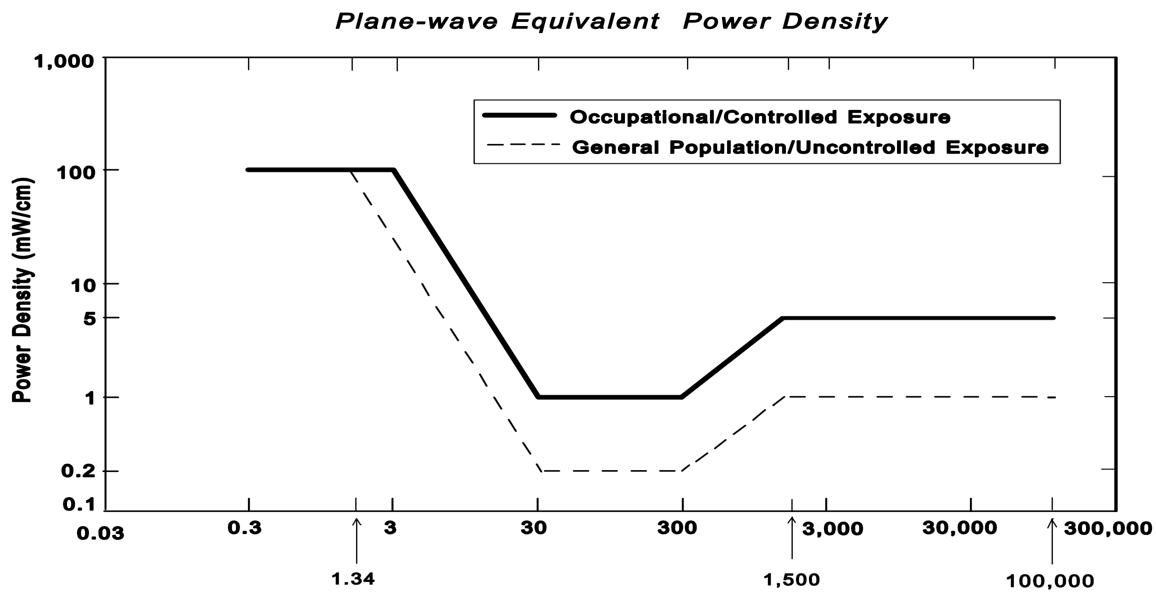
General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

Specific Absorption Rate (SAR) is the basis of most safety standards, when applied in the far-field, plane-wave conditions. It is the rate of energy absorption per unit of body mass. When the human body is exposed to the RF field, the SAR experienced is proportional to the squared value of the electric field strength induced in the body. At an absorption level of 4 W/kg, reversible behavioral disruption is noted. Levels above 5 W/kg can result in permanent adverse affects. Therefore, most standards have been based on SAR's of 0.4 W/kg to conservatively limit exposures to 1/10th of the levels to account for biological uncertainty and to add an additional safety factor.

Unfortunately, the Occupational Safety & Health Administration (OSHA) has not revised the standard since 1978 (see OSHA Regulations Standards - 29 CFR, Non-ionizing Radiation - 1910.97), but has already cited and fined organizations for exceeding the new standards. OSHA has the right to enforce based on consensus of scientifically-based standards under its general duty clause. **Nevertheless, OSHA uses 10 mW/cm^2 as the maximum SAR exposure over an averaged period of 6 minutes from continuous or intermittent RF sources between 10 MHz and 100 GHz.**

Figure 1, below presents the FCC Limits for Maximum Permissible Exposure (MPE) in units of Power Density (mW/cm²):

Figure 1. **FCC Limits for Maximum Permissible Exposure (MPE)**

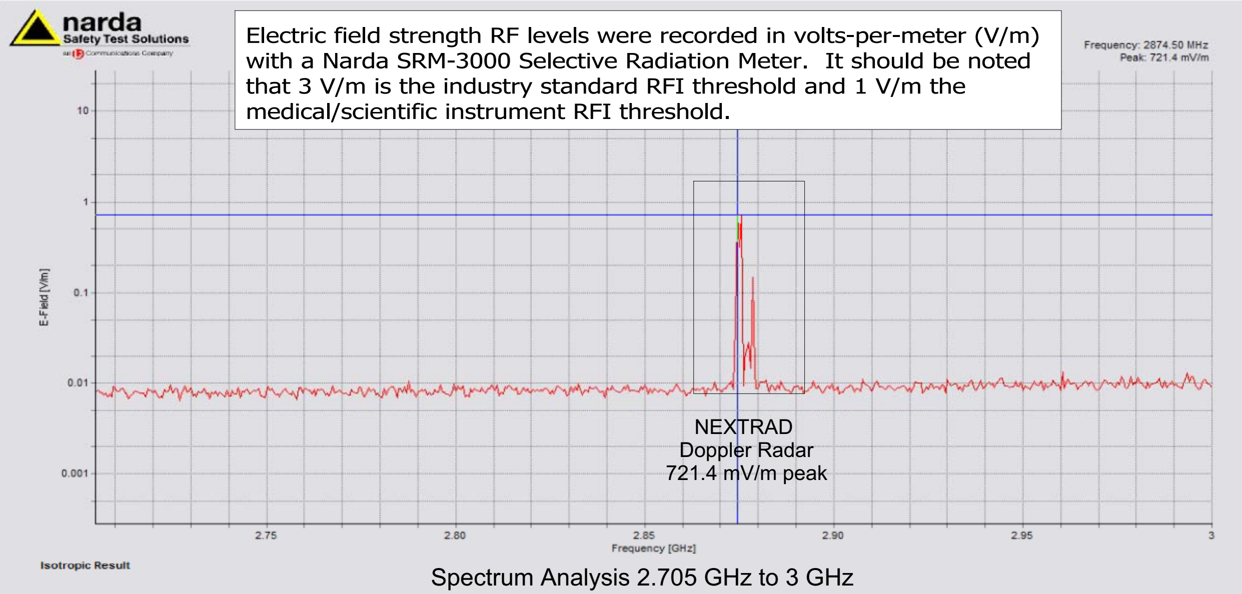


This completes the *Future NSLS-II Brookhaven Labs EMI/RFI Site Assessment Study.*

Best regards,

Louis S. Vitale, Jr.
President & Chief Engineer

Attachments: Figures #1 - #7.



Peak Chart By Frequency & Level

Index	Frequency	Level
1	2874.50 MHz	721.4 mV/m
2	2875.50 MHz	698.0 mV/m
3	2878.50 MHz	146.6 mV/m
4	2877.37 MHz	29.03 mV/m
5	2960.51 MHz	13.30 mV/m
6	2993.46 MHz	12.80 mV/m
7	2994.64 MHz	11.95 mV/m
8	2976.09 MHz	11.78 mV/m
9	2978.51 MHz	11.62 mV/m
10	2980.52 MHz	11.37 mV/m
11	2944.16 MHz	11.36 mV/m
12	2985.95 MHz	11.29 mV/m
13	2930.14 MHz	11.14 mV/m
14	2997.95 MHz	11.05 mV/m
15	2907.64 MHz	11.03 mV/m
16	2961.96 MHz	10.96 mV/m
17	2936.35 MHz	10.72 mV/m
18	2938.88 MHz	10.69 mV/m
19	2881.86 MHz	10.68 mV/m
20	2971.65 MHz	10.66 mV/m

Dataset Type	SPEC
Store Mode	MAN
Date	09/19/2006
Time	09:52:16
Minimum Frequency [Hz]	2.705 GHz
Maximum Frequency [Hz]	3 GHz
Resolution Bandwidth [Hz]	1 MHz
Measurement Range [V/m]	2.5 V/m
Unit	V/m
Result Type	MAX
Number of Averages	64
Average Flag	OK
Overdrive Flag	OK
Threshold [V/m]	25 µV/m
Y-Scale Reference [V/m]	28 V/m
Y-Scale Range [dB]	100
Axis	RSS
Standard Name	ICNIRP GP
Comment	G1
Device Serial No.	J-0016
Device Calibration Date	05/15/2006
Device Firmware Version	V1.4.10
Cable Name	
Cable Serial No.	
Cable Calibration Date	
Antenna Name	3AX 75M-3G
Antenna Serial No.	G-0147
Antenna Calibration Date	05/18/2006

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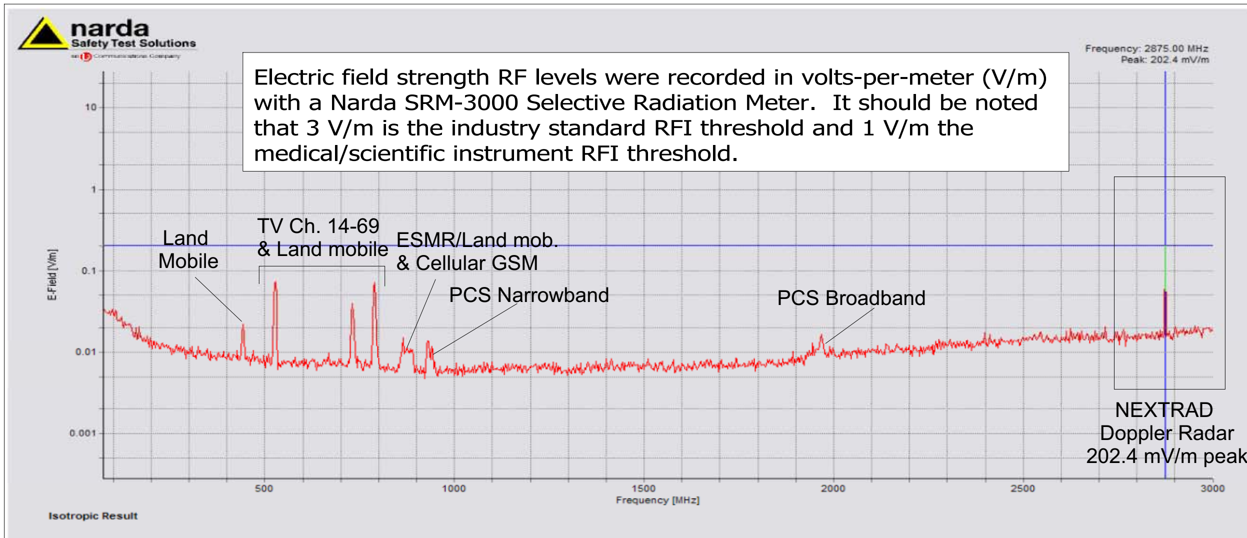
Fredericksburg, Va

Figure #1 - RF Spectrum 2.7 - 3 GHz NEXTRAD Doppler Radar @ 1-meter
NSLS-II Brookhaven National Labs Proposed Site

RF Data Recorded
9/19/2006



Peak Chart By Frequency & Level

Index	Frequency	Level
1	2875.00 MHz	202.4 mV/m
2	526.38 MHz	76.24 mV/m
3	789.27 MHz	73.45 mV/m
4	730.05 MHz	39.06 mV/m
5	77.28 MHz	33.71 mV/m
6	96.96 MHz	33.43 mV/m
7	105.52 MHz	33.09 mV/m
8	89.69 MHz	31.85 mV/m
9	121.75 MHz	27.17 mV/m
10	114.79 MHz	24.80 mV/m
11	130.33 MHz	23.81 mV/m
12	143.68 MHz	22.49 mV/m
13	138.11 MHz	21.94 mV/m
14	442.51 MHz	21.88 mV/m
15	2952.42 MHz	20.77 mV/m
16	2715.16 MHz	20.76 mV/m
17	2902.43 MHz	20.65 mV/m
18	2960.28 MHz	20.65 mV/m
19	167.63 MHz	20.56 mV/m
20	2988.98 MHz	20.52 mV/m

Dataset Type	SPEC
Store Mode	MAN
Date	09/19/2006
Time	10:00:21
Minimum Frequency [Hz]	75 MHz
Maximum Frequency [Hz]	3 GHz
Resolution Bandwidth [Hz]	5 MHz
Measurement Range [V/m]	2.5 V/m
Unit	V/m
Result Type	MAX
Number of Averages	64
Average Flag	OK
Overdrive Flag	OK
Threshold [V/m]	25 µV/m
Y-Scale Reference [V/m]	28 V/m
Y-Scale Range [dB]	100
Axis	RSS
Standard Name	
Comment	
Device Serial No.	J-0016
Device Calibration Date	05/15/2006
Device Firmware Version	V1.4.10
Cable Name	
Cable Serial No.	
Cable Calibration Date	
Antenna Name	3AX 75M-3G
Antenna Serial No.	G-0147
Antenna Calibration Date	05/18/2006

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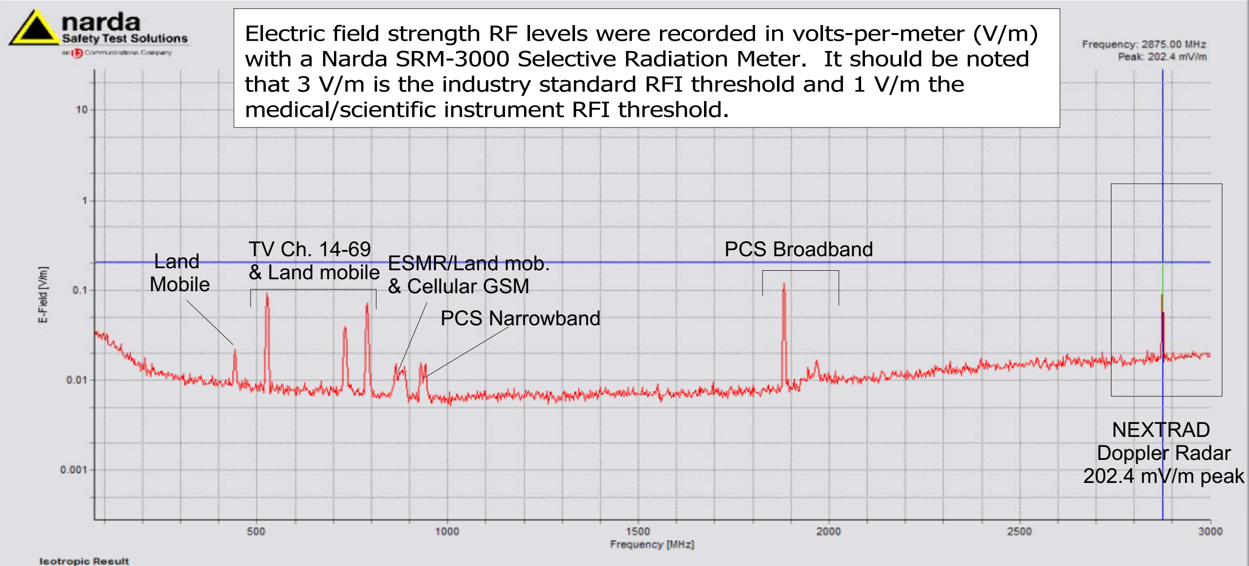
Figure #1A - RF Spectrum 75 Mz - 3 GHz @ 1-meter
NSLS-II Brookhaven National Labs Proposed Site

RF Data Recorded
9/19/2006



Spectrum Analysis 75 MHz to 3 GHz

Peak Chart By Frequency & Level

Index	Frequency	Level
1	2875.00 MHz	202.4 mV/m
2	1882.32 MHz	120.5 mV/m
3	525.70 MHz	97.07 mV/m
4	789.27 MHz	73.45 mV/m
5	730.69 MHz	39.49 mV/m
6	82.26 MHz	35.32 mV/m
7	97.02 MHz	33.77 mV/m
8	105.52 MHz	33.09 mV/m
9	88.52 MHz	32.23 mV/m
10	123.96 MHz	27.72 mV/m
11	142.63 MHz	25.48 mV/m
12	114.28 MHz	24.84 mV/m
13	130.42 MHz	23.77 mV/m
14	137.95 MHz	21.93 mV/m
15	442.51 MHz	21.88 mV/m
16	2835.09 MHz	21.26 mV/m
17	2952.94 MHz	20.85 mV/m
18	2715.16 MHz	20.76 mV/m
19	2902.43 MHz	20.65 mV/m
20	2960.11 MHz	20.62 mV/m

Dataset Type	SPEC
Store Mode	MAN
Date	09/19/2006
Time	10:02:18
Minimum Frequency [Hz]	75 MHz
Maximum Frequency [Hz]	3 GHz
Resolution Bandwidth [Hz]	5 MHz
Measurement Range [V/m]	2.5 V/m
Unit	V/m
Result Type	MAX
Number of Averages	64
Average Flag	OK
Overdrive Flag	OK
Threshold [V/m]	25 µV/m
Y-Scale Reference [V/m]	28 V/m
Y-Scale Range [dB]	100
Axis	RSS
Standard Name	ICNIRP GP
Comment	G4
Device Serial No.	J-0016
Device Calibration Date	05/15/2006
Device Firmware Version	V1.4.10
Cable Name	
Cable Serial No.	
Cable Calibration Date	
Antenna Name	3AX 75M-3G
Antenna Serial No.	G-0147
Antenna Calibration Date	05/18/2006

Figure #2 - RF Spectrum 75 MHz - 3 GHz @ 1-meter
NSLS-II Brookhaven National Labs Proposed Site

RF Data Recorded
9/19/2006

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Power Spectrum Chart By Service, Level & Frequency Band

RF Data Recorded
9/19/2006

Service	Value	Lower Frequency	Upper Frequency
FM Radio	375.5 pW/cm²	88.000 MHz	108.000 MHz
Paging	56.83 pW/cm²	152.000 MHz	159.000 MHz
TV Ch. 7-13	166.3 pW/cm²	174.000 MHz	216.000 MHz
TV Ch. 14-69	2.169 nW/cm²	470.000 MHz	806.000 MHz
SMR Tx	14.06 pW/cm²	806.000 MHz	821.000 MHz
Privat Ind mob	3.397 pW/cm²	821.000 MHz	824.000 MHz
Cellular AMPS	21.99 pW/cm²	824.000 MHz	849.000 MHz
ESMR/Land mob.	48.83 pW/cm²	849.000 MHz	869.000 MHz
Cellular AMPS	82.96 pW/cm²	869.000 MHz	894.000 MHz
aerontical mobl	2.285 pW/cm²	894.000 MHz	896.000 MHz
private Ind mob	4.556 pW/cm²	896.000 MHz	901.000 MHz
pcs narrowband	1.013 pW/cm²	901.000 MHz	902.000 MHz
land mobile&Ham	57.99 pW/cm²	902.000 MHz	930.000 MHz
pcs narrowband	2.817 pW/cm²	930.000 MHz	931.000 MHz
Paging	26.71 pW/cm²	931.000 MHz	932.000 MHz
pcs narrowband	21.94 pW/cm²	940.000 MHz	941.000 MHz
public land mob	14.88 pW/cm²	941.000 MHz	960.000 MHz
PCS Broadband	283.3 pW/cm²	1850.000 MHz	1990.000 MHz
NEXTRAD Dopple	972.4 pW/cm²	2700.000 MHz	2900.000 MHz
Others	3.874 nW/cm²		
Total	8.201 nW/cm²	88.000 MHz	2900.000 MHz

Electric field strength RF levels were recorded in volts-per-meter (V/m) with a Narda SRM-3000 Selective Radiation Meter. It should be noted that 3 V/m is the industry standard RFI threshold and 1 V/m the medical/scientific instrument RFI threshold.

Service Chart By Level & Frequency Band

Service	Value	Lower Frequency	Upper Frequency
FM Radio	37.63 mV/m	88.000 MHz	108.000 MHz
Paging	14.64 mV/m	152.000 MHz	159.000 MHz
TV Ch. 7-13	25.04 mV/m	174.000 MHz	216.000 MHz
TV Ch. 14-69	90.43 mV/m	470.000 MHz	806.000 MHz
SMR Tx	7.281 mV/m	806.000 MHz	821.000 MHz
Privat Ind mob	3.579 mV/m	821.000 MHz	824.000 MHz
Cellular AMPS	9.105 mV/m	824.000 MHz	849.000 MHz
ESMR/Land mob.	13.57 mV/m	849.000 MHz	869.000 MHz
Cellular AMPS	17.68 mV/m	869.000 MHz	894.000 MHz
aerontical mobl	2.935 mV/m	894.000 MHz	896.000 MHz
private Ind mob	4.144 mV/m	896.000 MHz	901.000 MHz
pcs narrowband	1.954 mV/m	901.000 MHz	902.000 MHz
land mobile&Ham	14.79 mV/m	902.000 MHz	930.000 MHz
pcs narrowband	3.259 mV/m	930.000 MHz	931.000 MHz
Paging	10.03 mV/m	931.000 MHz	932.000 MHz
pcs narrowband	9.094 mV/m	940.000 MHz	941.000 MHz
public land mob	7.489 mV/m	941.000 MHz	960.000 MHz
PCS Broadband	32.68 mV/m	1850.000 MHz	1990.000 MHz
NEXTRAD Dopple	60.55 mV/m	2700.000 MHz	2900.000 MHz
Others	120.8 mV/m		
Total	175.8 mV/m	88.000 MHz	2900.000 MHz

Dataset Type	TAB
Store Mode	MAN
Date	09/19/2006
Time	10:06:25
Minimum Frequency [Hz]	88 MHz
Maximum Frequency [Hz]	2.9 GHz
Measurement Range [V/m]	2.5 V/m
Unit	V/m
Result Type	MAX
Number of Averages	4
Average Flag	OK
Overdrive Flag	OK
Threshold [V/m]	25 µV/m
Display	DETAIL
Axis	RSS
Standard Name	ICNIRP GP
Service Table Name	FCC STD
Comment	G5
Device Serial No.	J-0016
Device Calibration Date	05/15/2006
Device Firmware Version	V1.4.10
Cable Name	
Cable Serial No.	
Cable Calibration Date	
Antenna Name	3AX 75M-3G
Antenna Serial No.	G-0147
Antenna Calibration Date	05/18/2006

Figure #2A - FCC Spectrum 75 MHz - 3 GHz @ 1-meter
NSLS-II Brookhaven National Labs Proposed Site

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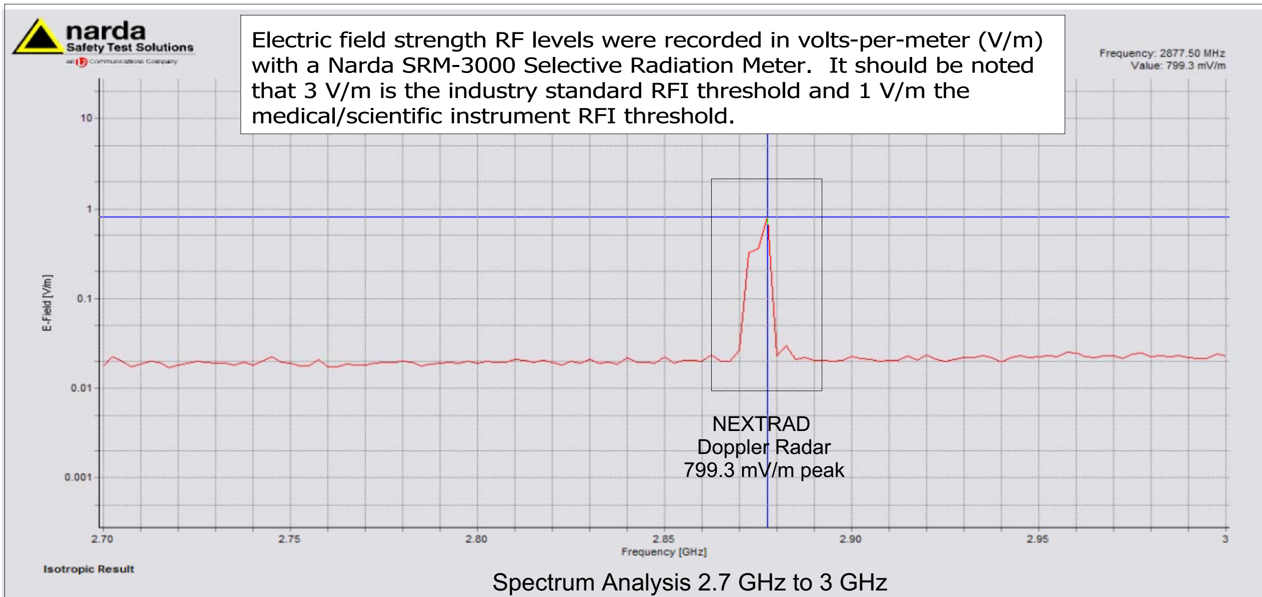


Spectrum Analysis 2.7 GHz to 3 GHz

Peak Chart By Frequency & Level

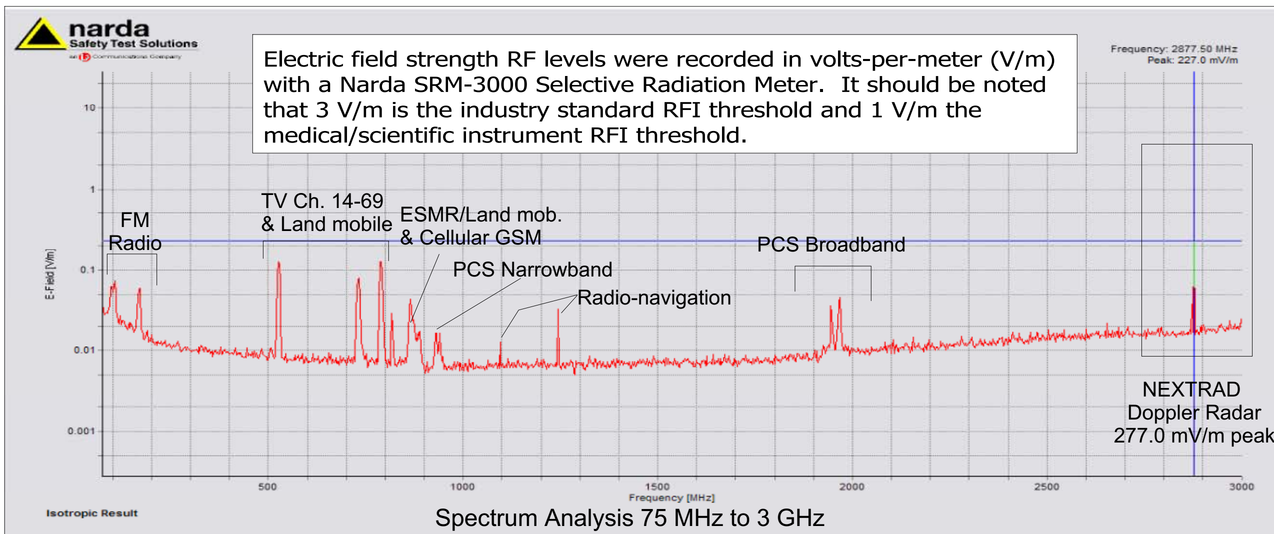
Index	Frequency	Level
1	2877.50 MHz	799.3 mV/m
2	2882.33 MHz	29.75 mV/m
3	2958.57 MHz	25.45 mV/m
4	2976.75 MHz	24.74 mV/m
5	2998.20 MHz	24.10 mV/m
6	2920.20 MHz	23.58 mV/m
7	2969.14 MHz	23.33 mV/m
8	2862.48 MHz	23.32 mV/m
9	2987.01 MHz	23.30 mV/m
10	2982.76 MHz	23.07 mV/m
11	2944.80 MHz	22.96 mV/m
12	2952.63 MHz	22.96 mV/m
13	2702.93 MHz	22.82 mV/m
14	2935.21 MHz	22.82 mV/m
15	2914.99 MHz	22.79 mV/m
16	2744.92 MHz	22.69 mV/m
17	2900.43 MHz	22.65 mV/m
18	2849.97 MHz	22.51 mV/m
19	2887.17 MHz	21.96 mV/m
20	2840.23 MHz	21.96 mV/m

Dataset Type	SPEC
Store Mode	MAN
Date	09/19/2006
Time	10:41:34
Minimum Frequency [Hz]	2.7 GHz
Maximum Frequency [Hz]	3 GHz
Resolution Bandwidth [Hz]	5 MHz
Measurement Range [V/m]	2.5 V/m
Unit	V/m
Result Type	MAX
Number of Averages	64
Average Flag	OK
Overdrive Flag	OK
Threshold [V/m]	25 µV/m
Y-Scale Reference [V/m]	28 V/m
Y-Scale Range [dB]	100
Axis	RSS
Standard Name	
Comment	
Device Serial No.	J-0016
Device Calibration Date	05/15/2006
Device Firmware Version	V1.4.10
Cable Name	
Cable Serial No.	
Cable Calibration Date	
Antenna Name	3AX 75M-3G
Antenna Serial No.	G-0147
Antenna Calibration Date	05/18/2006

RF Data Recorded From Cherry-Picker 9/19/2006

VitaTech Engineering, LLC
(540) 286-1984
Fredericksburg, Va

Figure #3 - RF Spectrum 75 MHz - 3 GHz @ 15.2 m (50 ft)
NSLS-II Brookhaven National Labs Proposed Site



Spectrum Analysis 75 MHz to 3 GHz

Peak Chart By Frequency & Level

Index	Frequency	Level
1	2877.50 MHz	227.0 mV/m
2	788.89 MHz	130.6 mV/m
3	526.03 MHz	129.3 mV/m
4	731.52 MHz	83.46 mV/m
5	104.60 MHz	73.53 mV/m
6	168.81 MHz	67.70 mV/m
7	96.37 MHz	64.39 mV/m
8	1966.71 MHz	47.85 mV/m
9	865.03 MHz	42.70 mV/m
10	2872.50 MHz	37.88 mV/m
11	1945.85 MHz	37.86 mV/m
12	1245.00 MHz	32.78 mV/m
13	84.61 MHz	29.72 mV/m
14	817.50 MHz	29.29 mV/m
15	119.93 MHz	26.91 mV/m
16	2997.38 MHz	24.93 mV/m
17	871.60 MHz	24.34 mV/m
18	126.17 MHz	23.81 mV/m
19	2970.19 MHz	23.73 mV/m
20	142.21 MHz	22.54 mV/m

Dataset Type	SPEC
Store Mode	MAN
Date	09/19/2006
Time	10:46:07
Minimum Frequency [Hz]	75 MHz
Maximum Frequency [Hz]	3 GHz
Resolution Bandwidth [Hz]	5 MHz
Measurement Range [V/m]	2.5 V/m
Unit	V/m
Result Type	MAX
Number of Averages	64
Average Flag	OK
Overdrive Flag	OK
Threshold [V/m]	25 µV/m
Y-Scale Reference [V/m]	28 V/m
Y-Scale Range [dB]	100
Axis	RSS
Standard Name	
Comment	
Device Serial No.	J-0016
Device Calibration Date	05/15/2006
Device Firmware Version	V1.4.10
Cable Name	
Cable Serial No.	
Cable Calibration Date	
Antenna Name	3AX 75M-3G
Antenna Serial No.	G-0147
Antenna Calibration Date	05/18/2006

RF Data Recorded From Cherry-Picker 9/19/2006

VitaTech Engineering, LLC
(540) 286-1984
Fredericksburg, Va

Figure #3A - RF Spectrum 75 Mz - 3 GHz @ 15.2 m (50 ft.)
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