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Nederlands Forensisch Instituut
Ministerie van Justitie en Veiligheid

Nederlands Forensisch Instituut
Divisie Chemische en Fysische Sporen

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Site Planning Report from June 29th, 2025

[redacted] Bruker Nederland BV, Leiderdorp
[redacted] Bruker BioSpin AG, Fällanden

1. Overview

This document is a follow-up to the site survey for a NMR System that was conducted at the Nederlands Forensische Instituut (NFI) in Den Haag on the 29th of January. The survey consisted of reviewing the location of the current 400 MHz AVIII NMR spectrometer with an Ascend magnet. And the new location for the new 400MHz spectrometer.

From the technical side there are no restrictions and no concerns for an installation, for the operation and service of an NMR system on this 2nd floor. The floor vibrations can be eliminated by vibration isolation posts. The electromagnetic field measurements obtained only minor disturbances.

2. In this document

3. Situation

Figure 1 (from Google Map): The NFI is located in the West of Den Haag about 300m off the highway

Figure 2 (from Google Map): The very modern laboratory building made from glass, steel and concrete

4. Possible room layout for a 400 MHz NMR System

Figure 3: the 400 MHz AvanceIII NMR system with the console on the left hand side, this system is on the third floor and will be removed. The new 400MHz system will be installed in a similar setup, in the corner of the room next to the entrance.

A layout can be drawn if we receive a plan of the room.

5. Utility Requirements

Magnet Systems:

The 400 MHz Evo magnet system will be equipped with posts of 700 mm height as standard. The minimum ceiling height for all magnet systems is depending to the helium transfer line. The standard type with smallest helium losses requires a height of at least 2885 mm.

Electricity, Network:

The NMR console for the 400 MHz does need 230 V / 16 A single phase(we prefer CEE16A), the BCU I need 230 V / 10 A single phase connection each. With the operator desk some connections to the network system should be planned. The computer needs the same Ethernet cable connection which is installed already.

Heat dissipation and air conditioning:

The standard Avance NEO console has a dissipation power of maximum 2.5 kW; with four transmitter channels, the TwoBay console with standard MAS configuration has 3 kW. The minimum distance should be about 20 cm to the wall. The heat dissipation of the BCU-I temperature unit is about 450 W and the cryo platform unit 450 W.

The NMR system, especially the electronic is very sensitive to fast temperature changes. For such an instrument we recommend a fluctuation of < 1 ° C / 24 h when special lineshape performance or drift test without any Autoshim or 2H lock mode must be reached.
For standard operation working with 2H lock system and “Autoshim On” the temperature fluctuation can be < 3 °C/ 24 h without any reduction of the performance.

Gas:

For standard experiments including the exchange of samples a minimum pressure of 6 bar and minimum flow rate of 100 l/min. is expected. The BCU I is asking for a dew point of < - 50 °C. All the High Resolution probes will can run with nitrogen gas or compressed air. There is a Nitrogen gas line already in the lab. For certain units with high gas consumption the air pressure connections can be used together with a Nitrogen separator.

6. Floor vibration measurements

Instrumentation

The entire data acquisition electronics is a third party product. It is based on the platform Compact Data Acquisition (*cDAQ*) of National Instruments (*http://www.ni.com/dataacquisition/compactdaq*).

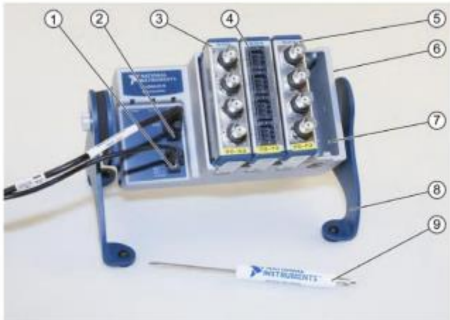
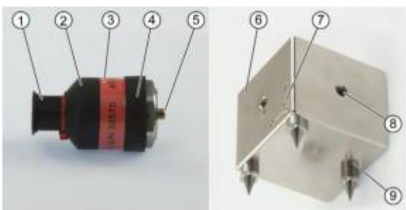


Figure 4: Vibration measurement equipment

1	Power Supply Plug	2	USB Plug
3	cDAQ Module 9234	4	cDAQ Module 9219
5	cDAQ Module 9215-BNC	6	Earthing connection at the cDAQ Chassis
7	cDAQ Chassis with 4 slots	8	Desktop Mounting Kit
9	NI Screwdriver		

The accelerometer sensor setup is based on third party products from PCB Piezotronics (*www.pcb.com* and *www.imisensors.com*), National Instruments data acquisition electronics and on internal developments for the sensor mounting. The sensors are *IEPE* based sensors (*ICP* is the corresponding registered trademark of PCB's IEPE sensors). IEPE sensors have built in signal amplification, which considerably enhances signal to noise ratio and sensitivity. The system can detect the acceleration at frequencies between 0.15 Hz to 1 kHz in a range of ± 4.9 m/s^2 (10 % variation depending on calibration constant) with a resolution of 1 $\mu m/s^2$.

Depending on the selected bandwidth the actual noise floor lies considerably lower than this due to oversampling. The accuracy of the measurement depends on the frequency range, degree of transversal acceleration and on temperature (see also specification sheet in the sensor manual). Under ideal conditions, the accuracy is better than 1 % of the measured value. Using the sensor mounting cube allows to measure 3 perpendicular directions



1	Sensor socket	2	Accelerometer
3	Sensor label	4	Rubber protection
5	Sensor mounting stud 1/4-28 to M6x1 x 8.6 mm long, BeCu with shoulder	6	Sensor mounting cube
7	Coordinate system	8	Mounting thread (M6x1)
9	Carpet needle		

Figure 5: The accelerator and the mounting cube

Floor Vibration Measurement 1:

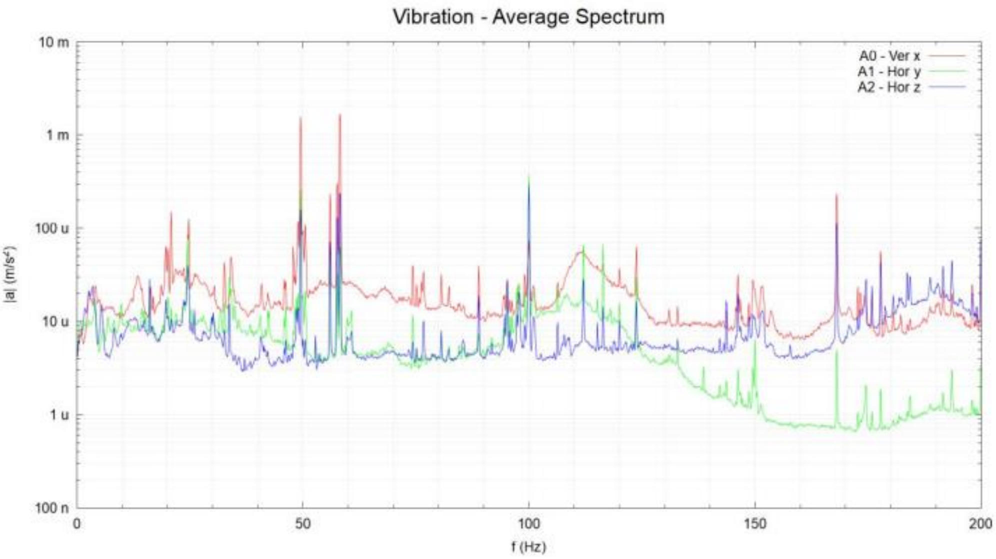


Diagram 1: The diagram above does show the acceleration in different directions. Most important for NMR is the low frequency part up to 50 Hz. Acceleration between 10…50 µm/s² is harmless. Bruker is following the velocity limits of VDI2038 and Amick/Gordon for very sensitive lab equipment which means for acceleration data a dividing by 2π * Frequency (see next page)

Some principles of the Bruker vibration guidelines

External vibrations may cause field modulations in the sample cavity. This could result in vibration sidebands, matched NMR signals that appear on either side of a main signal peak. The effect of vibrations on NMR performance will depend on the type of work being carried out, the type of system and the site building materials.

Ideally the site should be at basement level, or on the ground floor (slap on grade), to minimize building vibrations.

Possible sources of vibrations are generators, compressors, fans, machinery etc. Vibrations from external sources such as cars, trains, and construction sites can also cause problems.

The following thresholds represent the maximum velocities and accelerations that could be tolerated on the floor of the laboratory where the magnet is going to be located.

Criterion Curve	Amplitude µm/s (11µi/s)*	Description of Use
Workshop (ISO)	800 (32 000)	Distinctly perceptible vibration. Appropriate to workshops and nonsensitive areas.
Office (ISO)	400 (16 000)	Perceptible vibration. Appropriate to offices and nonsensitive areas.
Residential day (ISO)	200 (8 000)	Barely perceptible vibration. Appropriate to sleep areas in most instances. Usually adequate for computer equipment, hospital recovery rooms. semiconductor probe test equipment, and microscopes less than 40x.
Operating theater (ISO)	100 (4 000)	Vibration not perceptible. Suitable in most instances for surgical suites, microscopes to 100x and for other equipment of low sensitivity.
VC-A	50 (2 000)	Adequate in most instances for optical microscopes to 400x, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25 (1 000)	Appropriate for inspection and lithography equipment (including steppers) to 311m line widths.
VC-C	12.5 (500)	Appropriate standard for optical microscopes to 1000x, lithography and inspection equipment (including moderately sensitive electron microscopes) to 1 11m detail size, TFT-LCD stepper/scanner processes.
VC-D	6.25 (250)	Suitable in most instances for demanding equipment, including many electron microscopes (SEMs and TEMs) and E-Beam systems.
VC-E	3.12 (125)	A challenging criterion to achieve. Assumed to be adequate for the most demanding of sensitive systems including long path, laser- based, small target systems, E-Beam lithography systems working at nanometer scales, and other systems requiring extraordinary dynamic stability.
VC-F	1.56 (62.5)	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for evaluation.
VC-G	0.78 (31.3)	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for evaluation.

*As measured in one-third octave bands of frequency over the frequency range 8 to 80 Hz (VC-A and VC-B) or 1 to 80 Hz (VC-C through VC-G).

The information given in this table is for guidance only. In most instances, it is recommended that the advice of someone knowledgeable about applications and vibration requirements of the equipment and processes be sought.

Source: Reprinted with permission from Colin Gordan Associates.

Table 1: Vibration criteria from Colin Gordon Associated

Some principles of the Bruker vibration guidelines

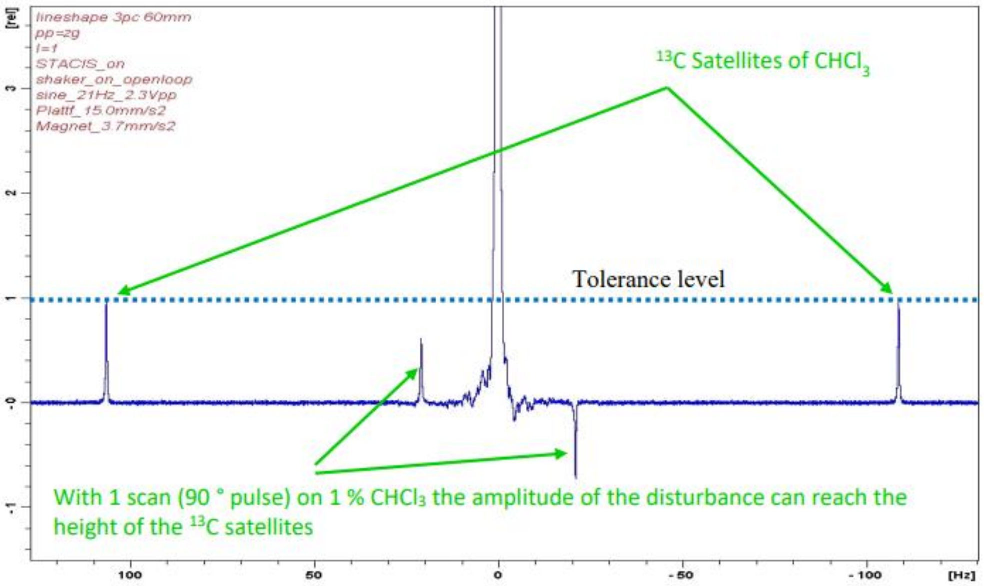


Figure 6: Example of the definition of the Bruker floor vibration tolerance level

The thresholds listed below correspond to vibration related NMR sidebands reaching **the height of ^{13}C satellites** in the $CHCl_3$ line shape spectrum. These thresholds might not meet the needs for demanding NMR applications.
The height of vibration sidebands is approximately linear with the floor acceleration levels, meaning that an NMR application requiring smaller sidebands than the height of ^{13}C satellites would need to have reduced floor acceleration thresholds by the same percentage factor.

According to VDI 2038 (2013) Bruker is following the threshold values of sensitive laboratory equipment. Bruker implemented a Nano-C limit which is less critical as Nano-D. The only big difference in observing these data is to use a higher resolution as only 1/3 octave. We recommend to measure with a resolution of < 0.1 Hz to get the right amplitudes in the low frequency part (average spectra)

NMR Vibration Guidelines in vertical and horizontal direction

With the good experience of damping with the so called API dampers (**A**ir **P**iston and Damped **I**solators) we recommend to go also with the 400 MHz for the same damping system

API damping system:

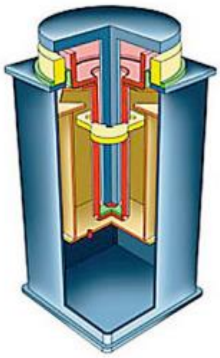
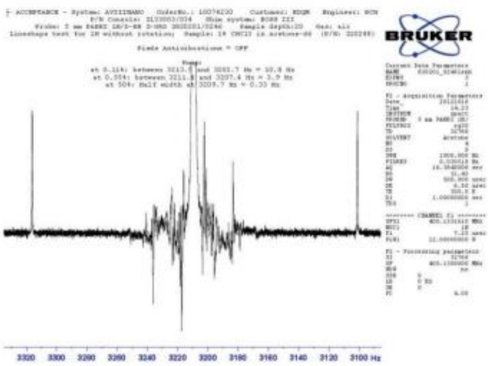


Figure 7 and Figure 8: As a good solution for this site at NFI (with also these high horizontal vibrations) we like to offer again the **API** dampers (**A**ir **P**iston and Damped **I**solators) or Gimbal dampers from TMC, which reduces vibrations in vertical and also in horizontal directions.



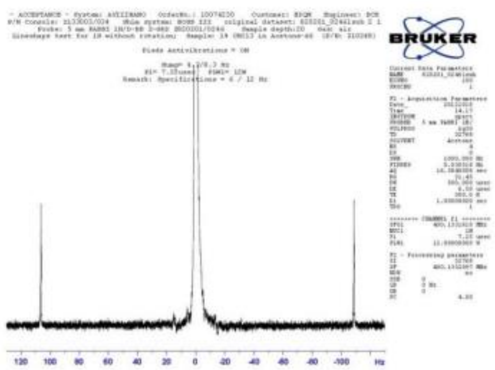


Figure 9 and Figure 10: Lineshape test with the damping system not active (left) and active on the right hand side

Measurement position:

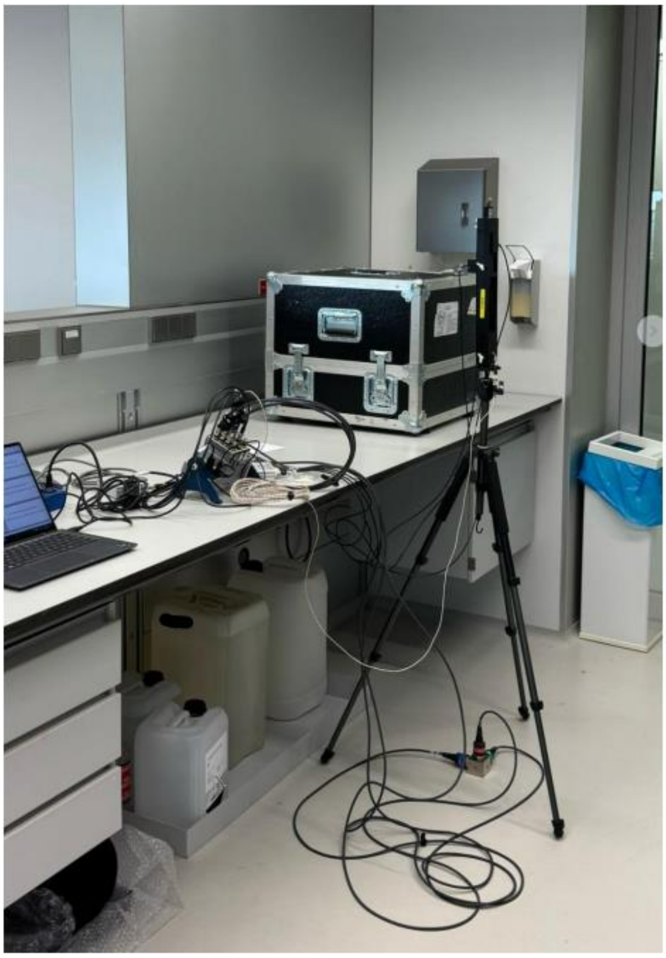


Figure 11: Measurement position of the accelerator sensors. Sensor A0 (red) is mounted in vertical direction, sensor A1 (green) in horizontal direction towards South East or the operator room and A2 (blue) is in horizontal direction towards North East

Nano-C tolerance level criteria:

Vertical and Horizontal direction:	**1 - 5 Hz:**	**3 µm/s**
	5 - 20 Hz:	**3 …12 µm/s**
	> 20 Hz:	**12 µm/s**

Measurement:

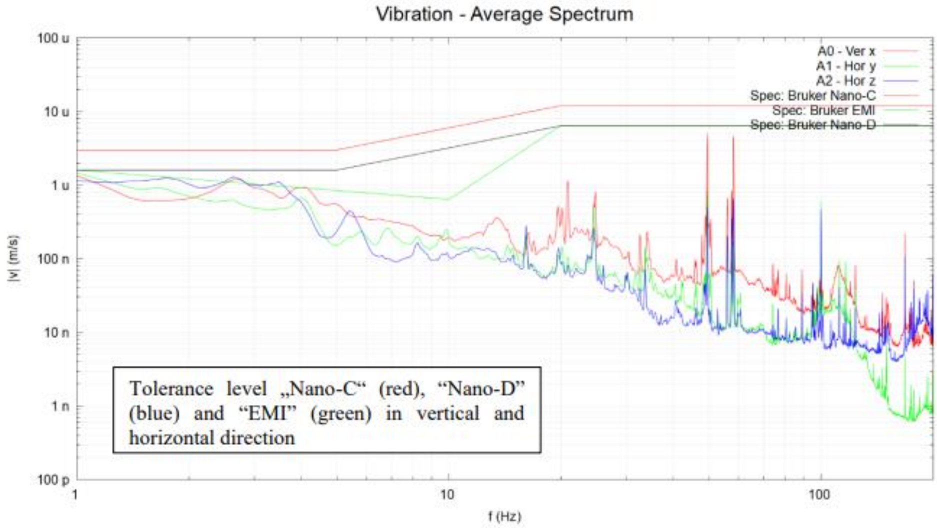


Diagram 2: The acceleration spectra transformed to velocity and with the tolerance level of the API dampers which can be used also with 400 MHz Evo magnets.

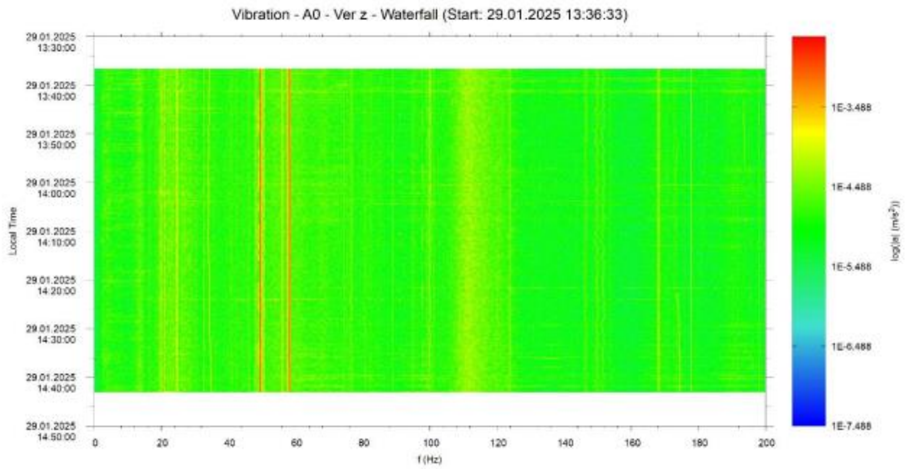


Diagram 3: Waterfall vibration spectra over 60 min. measurement time. (Starting time was 13:38, the local time on the left hand side is GMT and 1 h behind European time)

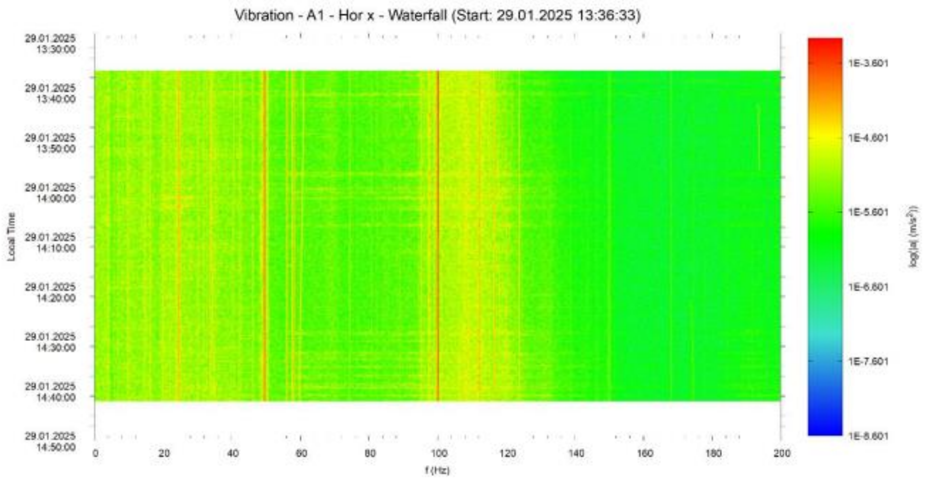


Diagram 4: Waterfall diagram in horizontal direction towards the operator room

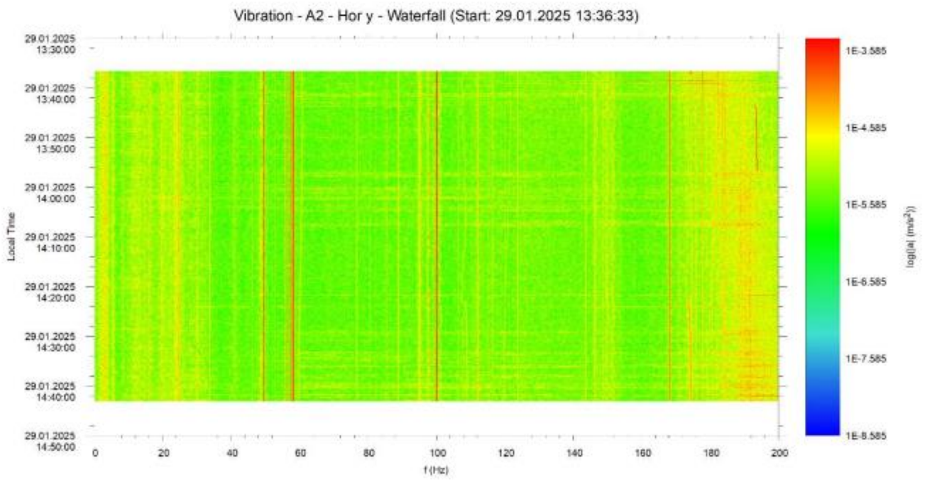
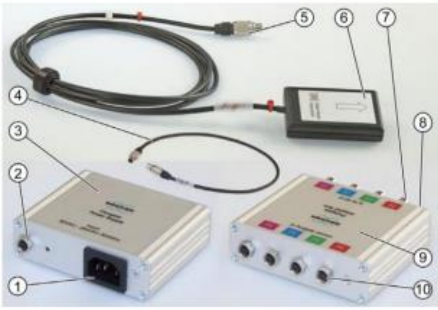


Diagram 5: And in horizontal direction towards the corridor: The 21 Hz disturbance is only in this direction strong

7. DC magnetic field fluctuation

Instrumentation



1	80 – 264 VAC 50/60 Hz	2	Power OUT (+ 12 V, – 12 V, 0 V)
3	Power supply	4	Power supply cable
5	Sensor plug	6	Fluxgate sensor
7	Signal socket (to NI 9215)	8	Power IN (+ 12 V, – 12 V, 0 V)
9	Fluxgate adapter box	10	Sensor socket

Figure 12: The flux gate measurement kit

The system can detect the magnetic field component along the direction of the sensor from DC to 1 kHz in a range of ± 100 µT with a resolution/accuracy of 3 nT. The actual noise floor is less than 0.1 nT. Using the sensor support allows to measure 3 perpendicular directions of the magnetic field (X, Y, Z).
1 μT_{pp} is equivalent to 42 Hz ^{1}H frequency shift. Non shielded magnets do have a suppression of about 70 % of the DC field fluctuation, newest type like Ascend magnets can shield up to 99 %. It means DC changes of 1 μT_{pp} outside the magnet will be seen as 0.01 μT_{pp} or 0.42 Hz frequency shifts. The digital 2H lock system will improve the situation for a another factor of >100, depending to the solvent. Vertical NMR magnets are sensitive for vertical DC magnetic field fluctuations because of the open bore in this direction, in horizontal directions the shielding is at least for a factor 100 better.
For AC frequencies above 10 Hz Bruker's threshold value for Evo magnets is at 700 nT.

Measurement:

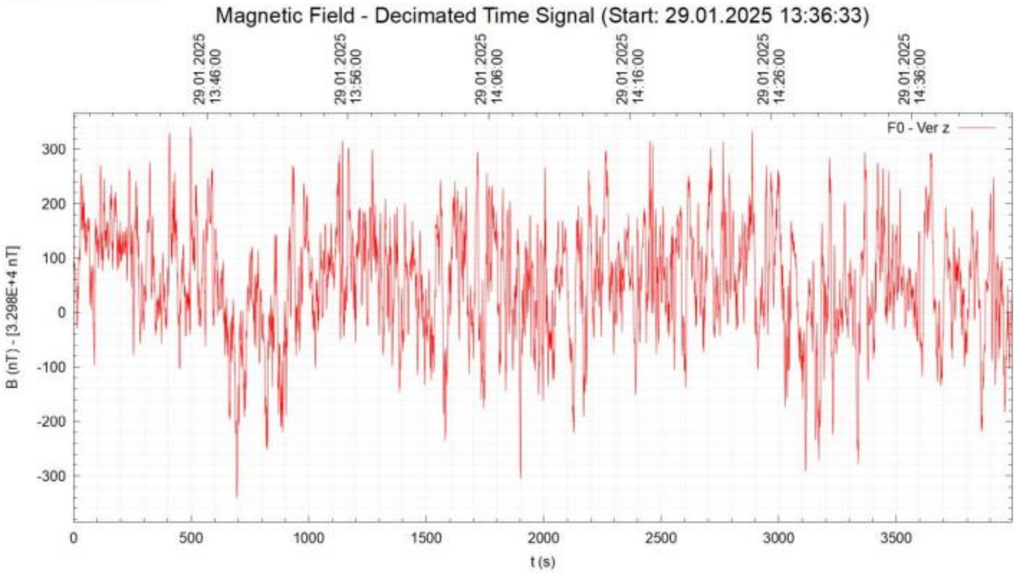


Diagram 4: The time signal of sensor F0 does show DC magnetic field changes of up to 700 nT_{pp}.

7.3.2.2 Guidelines for DC Interference

When determining the effect of fluctuating magnetic fields, two parameters are important: the size of the fluctuation and the rate of change, as follows:

- In a moving window of 1000 seconds the difference of the maximum and minimum values from the filtered and sub-sampled data set should not exceed:
  - $\Delta B = B_{max} - B_{min} < 1400$ nT (peak to peak) for the frequency range 0…1 Hz.

    Note this guideline is shown with a red line in the figure *Figure 7.10 [▸ 57]* (the threshold of 700 nT represents 0 to peak).
- The absolute value of the derivative should not exceed:
  - $\left|\frac{dB}{dt}\right| < 314\, nT/s.$

Table 2: The Bruker site planning guideline shows a limit of DC field changes of 1400 nT_{pp} and a maximum gradient change of 314 nT/s

Electromagnetic Disturbance Suppression

Because a Digital Lock is not always present, the suppression efficiency of the magnet itself needs to be considered. Generally, superconducting magnets suppress external disturbances efficiently above 5-10 Hz, and the higher the frequency, the better the suppression. In the frequency range between DC and 10 Hz, the suppression is very dependent on the magnet design. Recent magnet generations (UltraShieldPlus and Ascend) not only exhibit a strongly reduced stray field with respect to the previous models, they also suppress external disturbances by typically 97-99% (2 orders of magnitude). Previous models of NMR magnets (Non-shielded and UltraShield) have poor suppression in the low frequency regime ranging from 5% to 80%, depending strongly on individual designs.

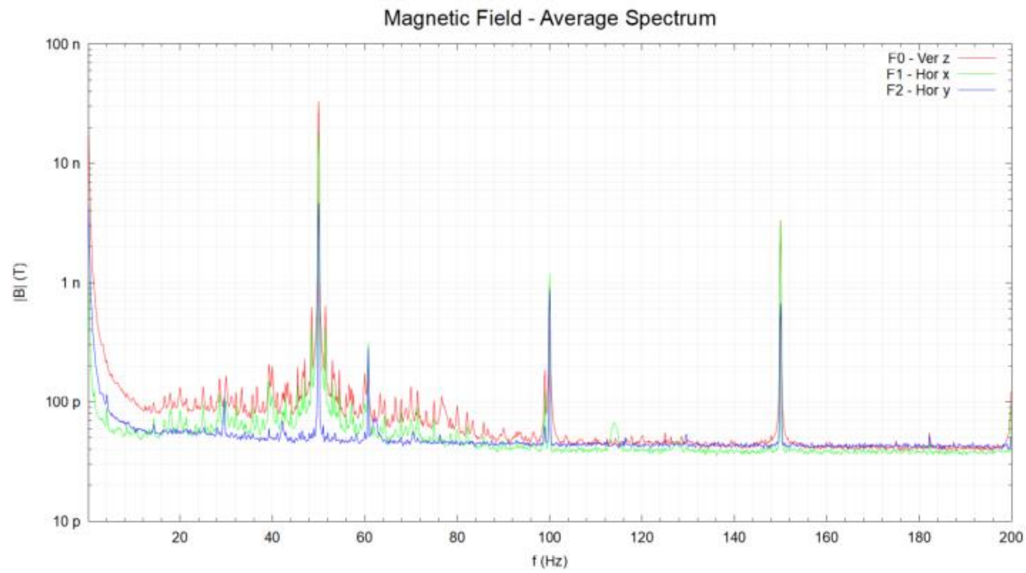


Diagram 7: The Fourier transformed diagram from the first measurement does show only very small signals at 50, 100 and 100 Hz. This means also, there are no strong power lines or transformers in the near neighborhood of these rooms. The high voltage power lines are too far away to create high amplitudes of disturbances. With a threshold of 700 nT the disturbances are far away from these limits

Above 10 Hz: Maximum 700 nT magnitudes (0 to peak) can be tolerated for interferences with frequencies above 10 Hz.

Rough Guidelines for EMF Disturbances

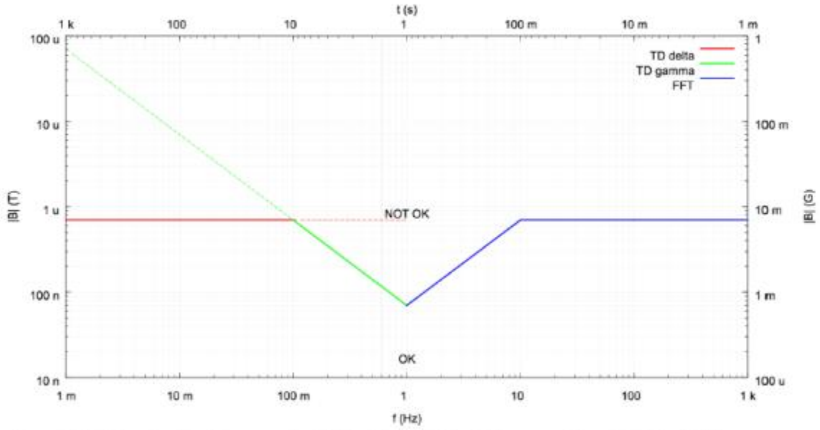


Figure 7.10: Specification Framework with the Magnetic Field Represented as 0 to Peak Values

Table 1: Bruker's threshold values for AC magnetic field disturbances

Magnetic Field - Average Spectrum

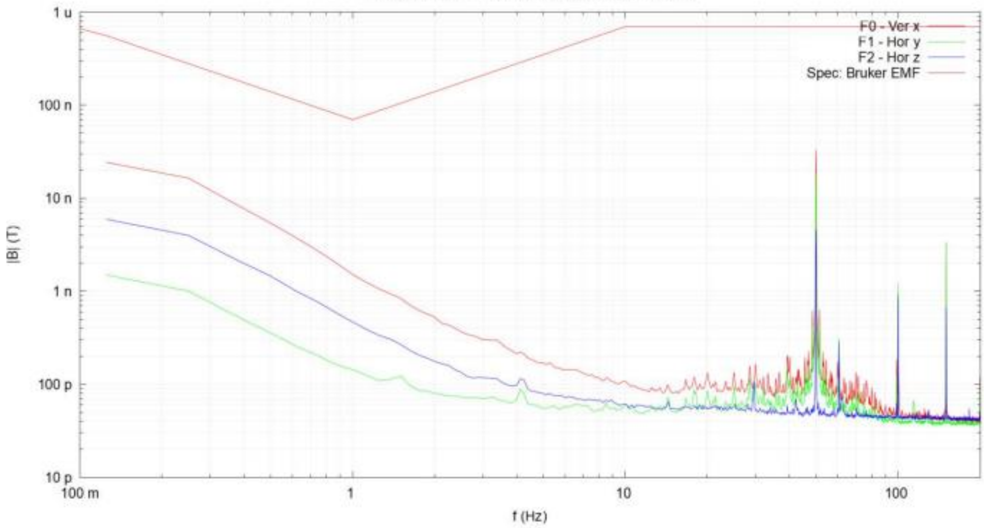


Diagram 5: Log-log display of the Fourier transformed magnetic field disturbances and the Bruker threshold values. All AC magnetic field disturbances are far below

8. Room Temperature Stability

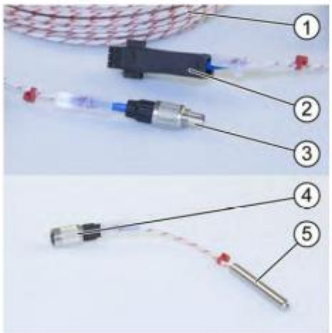


Figure 13: The temperature senor

The temperature sensors of the BSPS are based on class A *Pt100* 4 wire *RTD*s from Watlow (*www.watlow.com*). Class A Pt100 sensors are characterized in the standard DIN/IEC 60751 or by IEC751. At room temperature, the absolute temperature error is approx. 0.2 K. The usual drift of the absolute temperature accuracy indicated by producers is less than 0.05 K / year.
Together with the 24 bit data acquisition module NI 9219 in high resolution mode, one can measure relative temperatures (temperature changes) with an accuracy of at least 0.03 K. The actual noise on the temperature signal is less than 1 mK.

1	10 m cable	2	Connector to module NI 9219
3	4 pin connector (male)	4	4 pin connector (female)
5	Pt100 sensor		

Measurement 1:

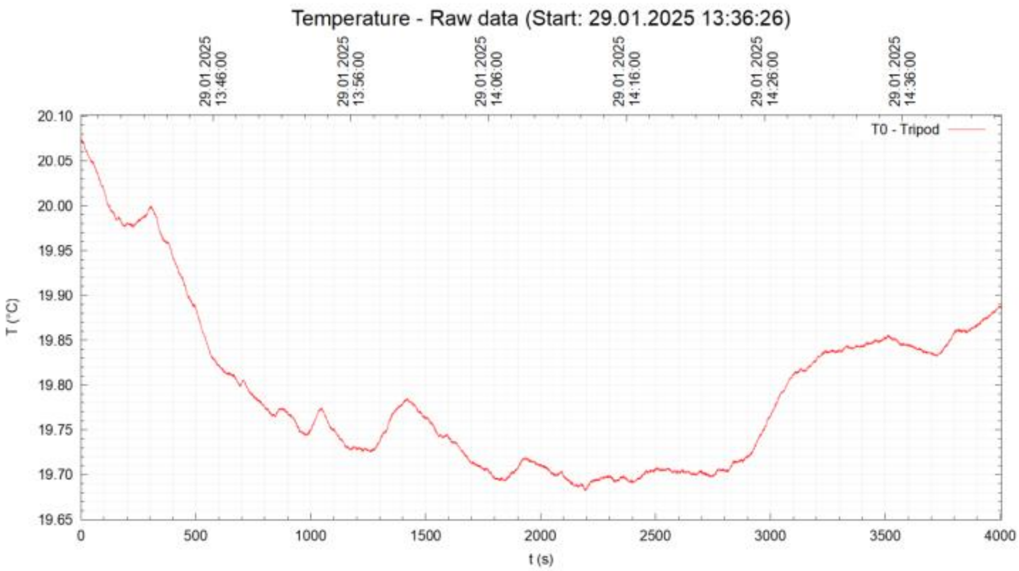


Diagram 8: The PT100 sensor T0 was placed on the Tripod. The maximum changes are below 1 °C