

Study of Electrical Noise Induced by Synchrotron Radiation

Yasuhide Ishizawa, Toru Ohata

JASRI/SPring-8

Controls and Computing Division

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Outline

- **Problem: unstable X-ray intensity**
- **Tools for noise study**
- **Result of noise measurements**
- **Solution**
- **Conclusion**

Problem: unstable X-ray intensity



staff's voice

We don't know why,
but X-ray intensity fluctuates.

**Repeated
for 14 years**



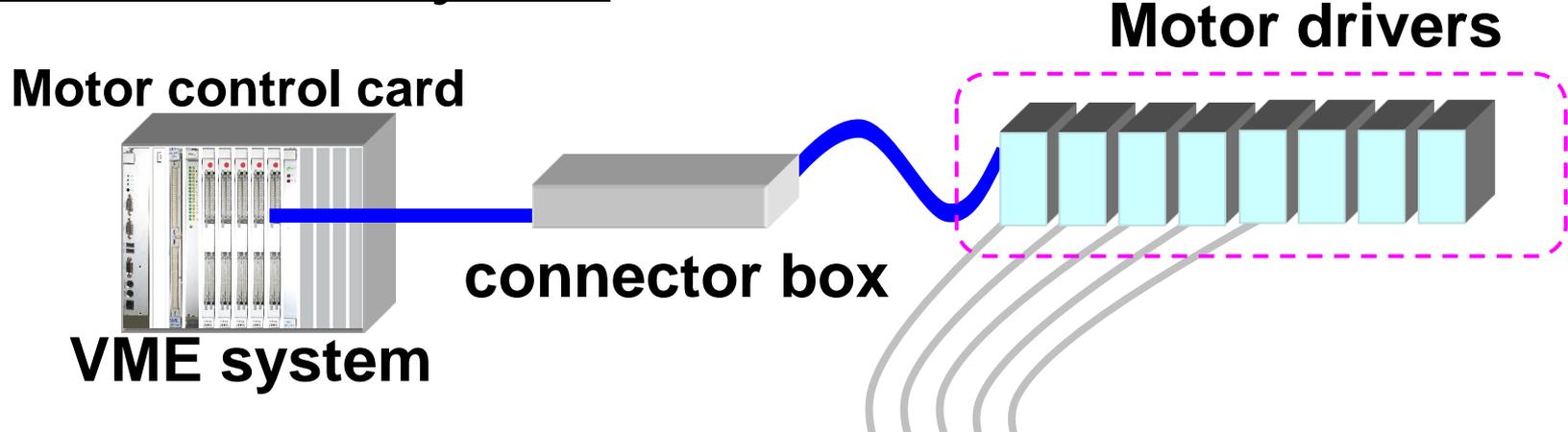
**Temporal X-ray stabilization
by components tuning.**



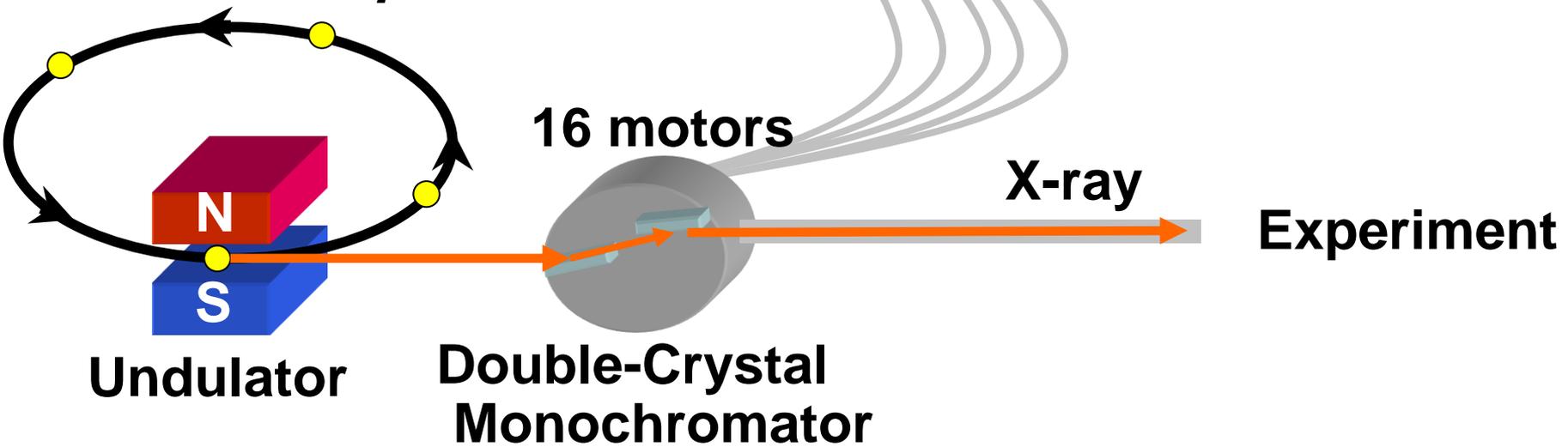
We need fundamental solution!

Motor Control System & Beamline Components

Motor Control System



Beamline components



Problem: unstable X-ray intensity

(continued)

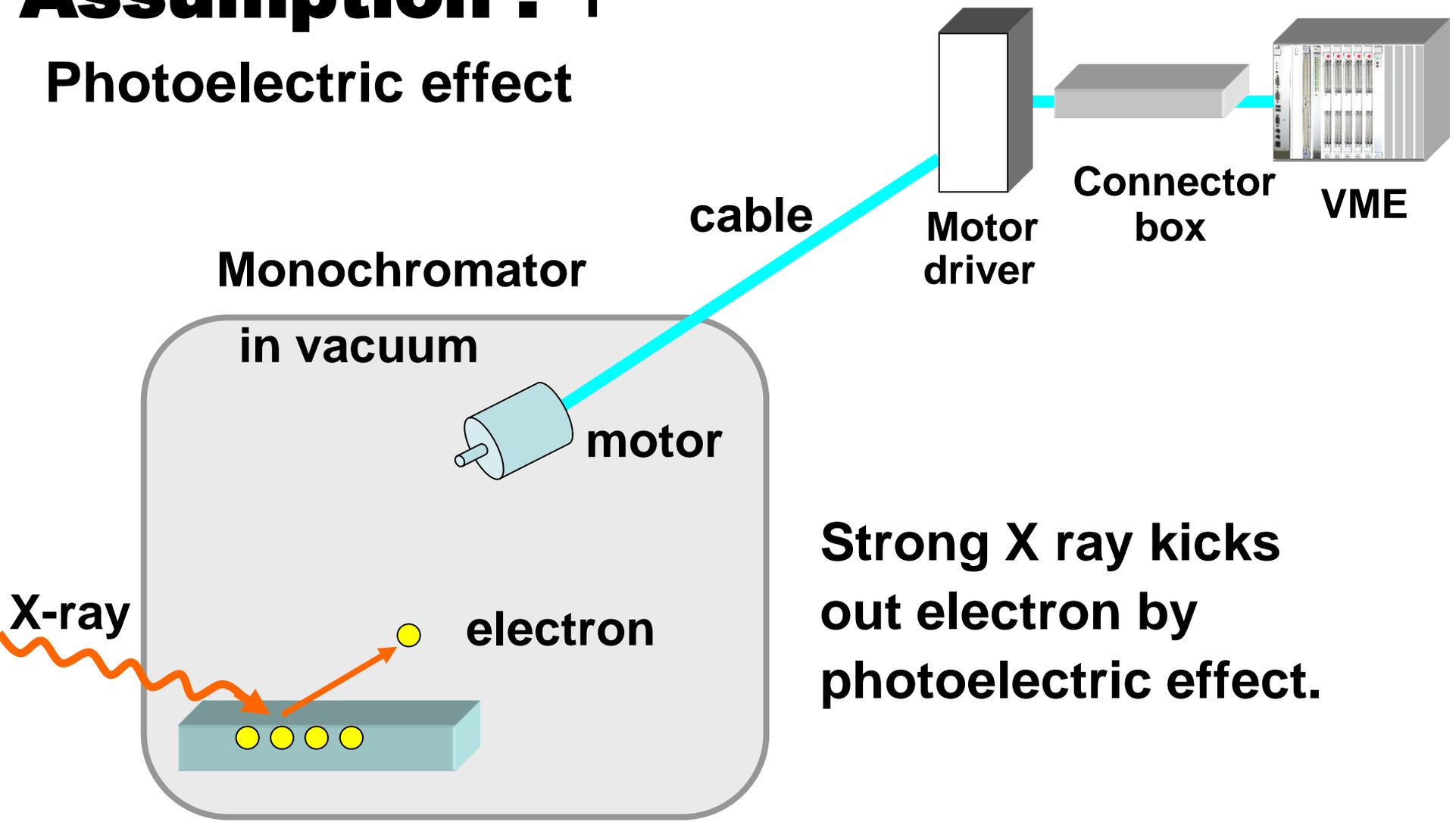


- **Problem1**
 - The motor attached to the monochromator moved without any control pulse.
- **Problem2**
 - Electronic devices sometimes broken.
(ex. VME card)
 - Previous experience
 - Cable charged up by noise induced by synchrotron radiation
 - » We modified cables, ground and circuits.

We started the noise investigation.

Assumption : 1

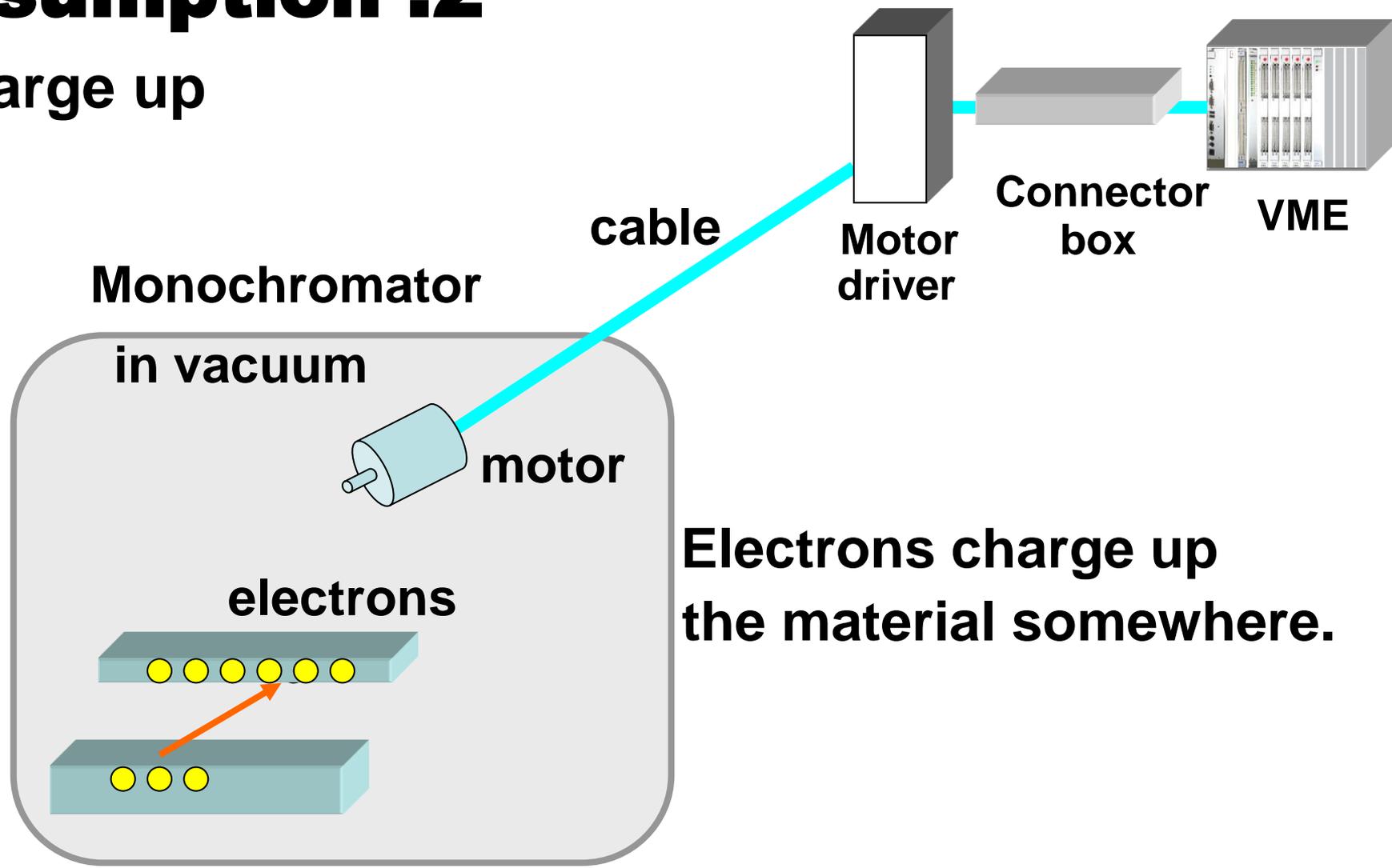
Photoelectric effect



Strong X ray kicks out electron by photoelectric effect.

Assumption :2

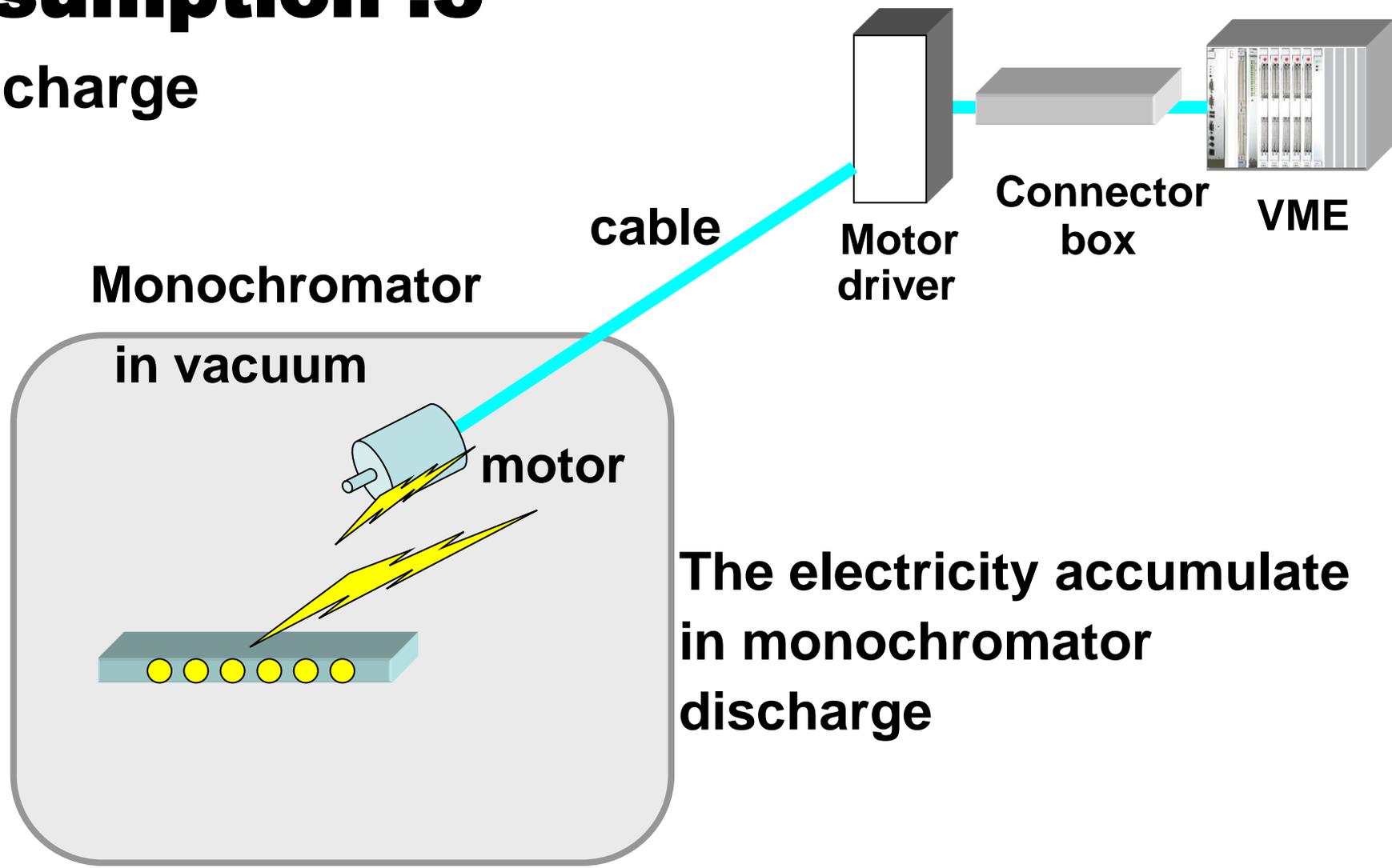
Charge up



Electrons charge up the material somewhere.

Assumption :3

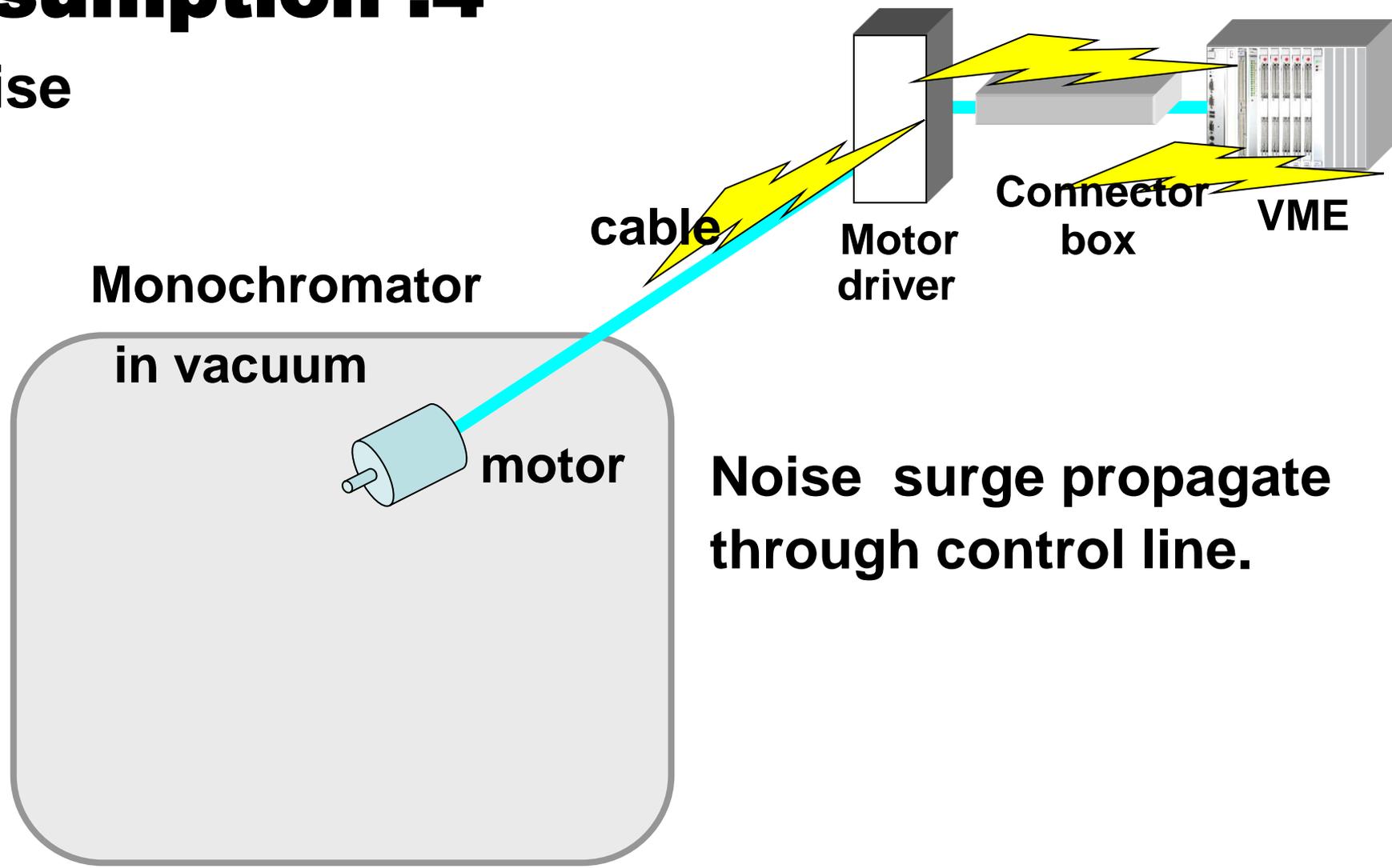
Discharge



The electricity accumulate in monochromator discharge

Assumption :4

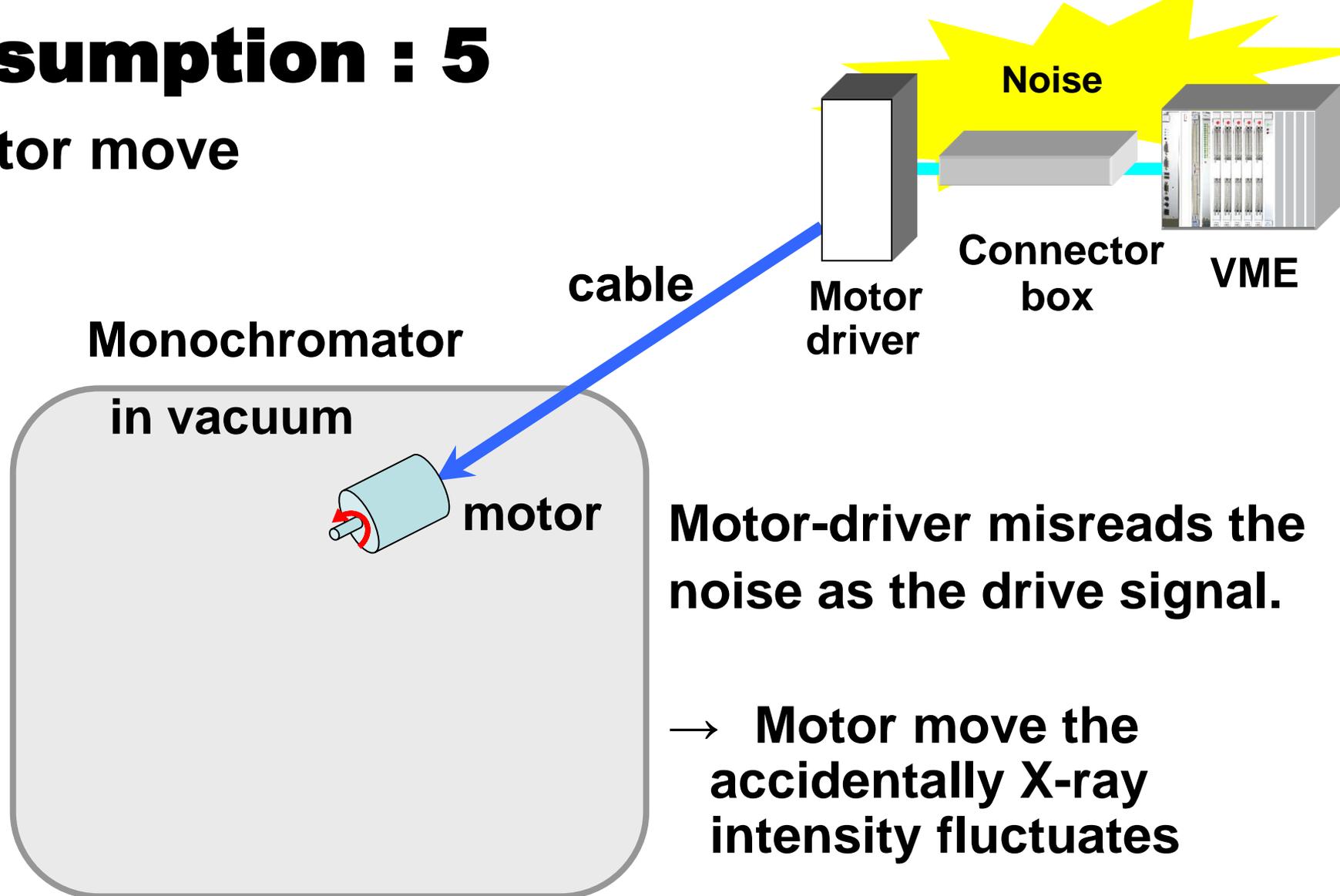
Noise



Noise surge propagate through control line.

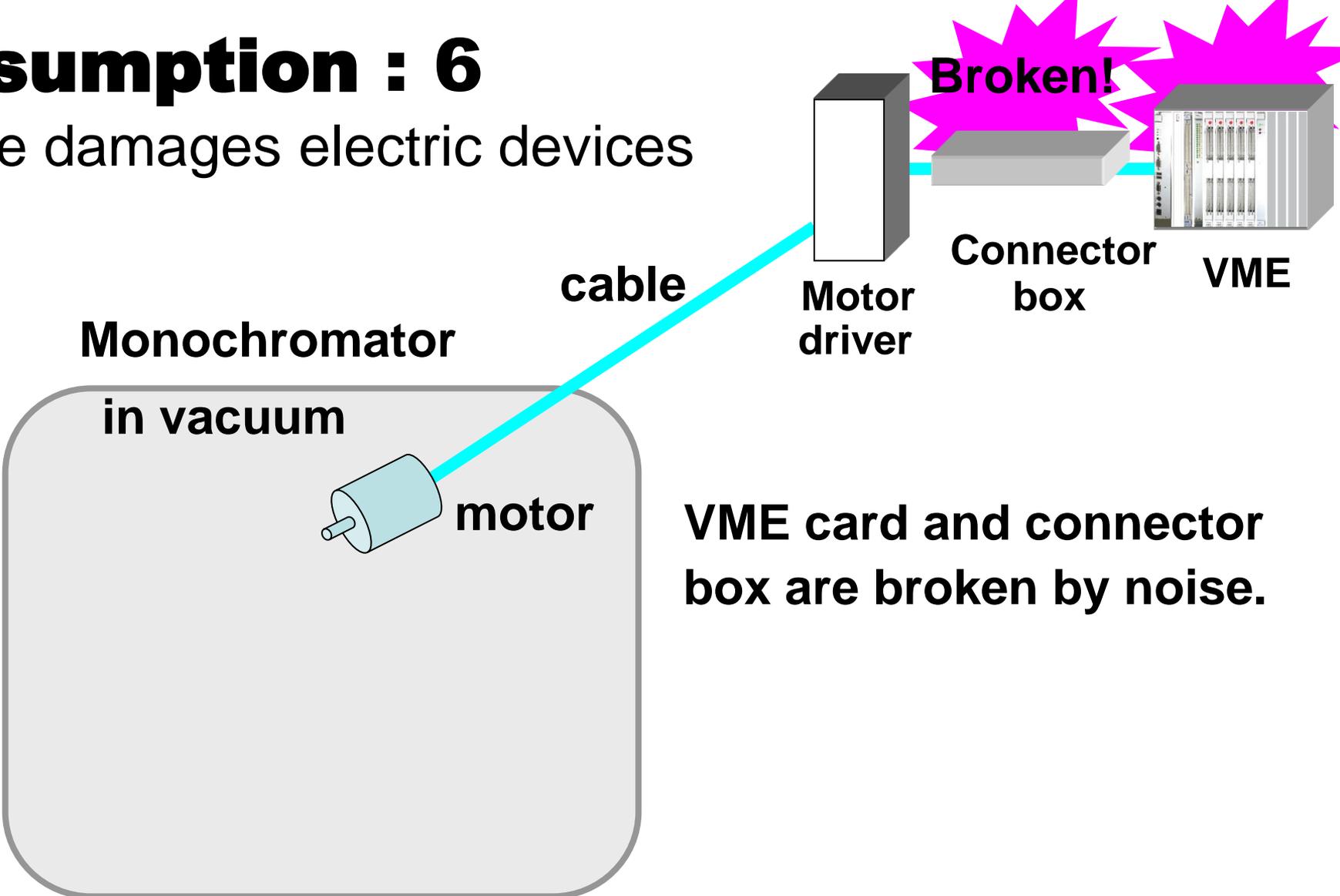
Assumption : 5

Motor move



Assumption : 6

Noise damages electric devices

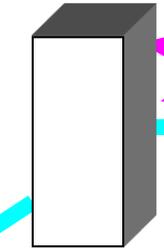


Monochromator

in vacuum



cable



Motor driver



Connector box



VME

Broken!

VME card and connector box are broken by noise.

Tools for the noise study

We used three tools

Power quality analyzer



AC power quality

Close Field Probe



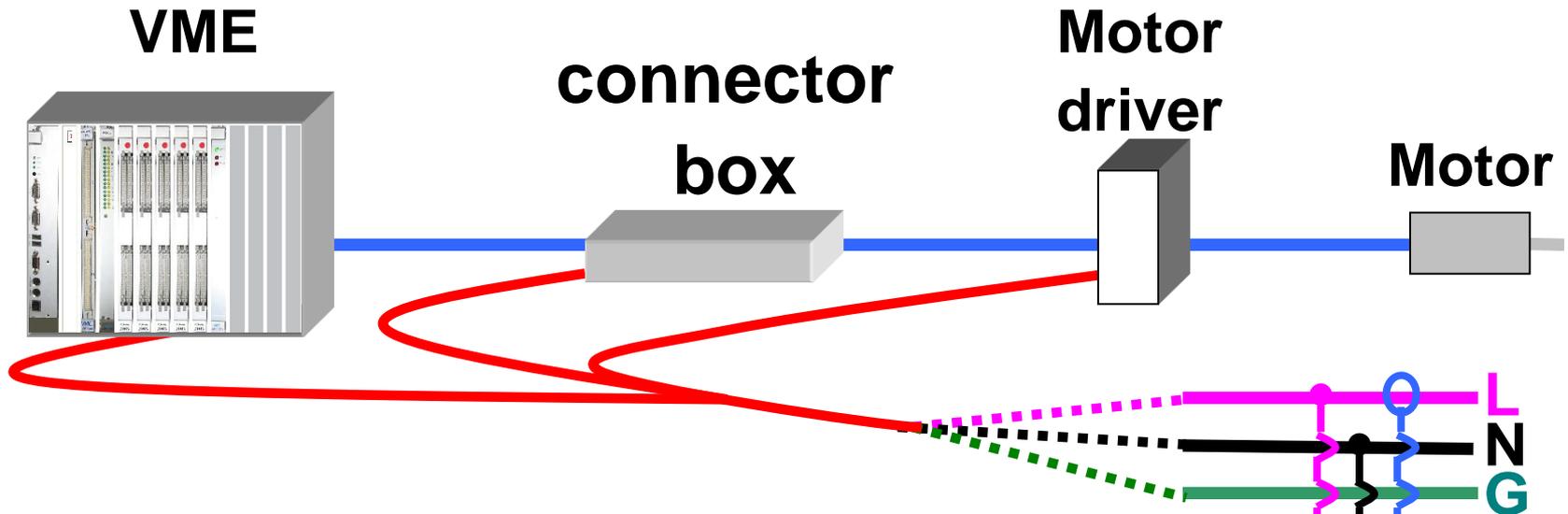
Magnetic field

Clamp on Noise Sensor



Noise in signal/power cable
Powerful tool for noise study!

AC Power quality analyzer



Power quality analyzer 3197

measurement instrument to monitor and analyze

- AC voltage
- Frequency
- Waveform
- Current value
- Harmonic
- etc,

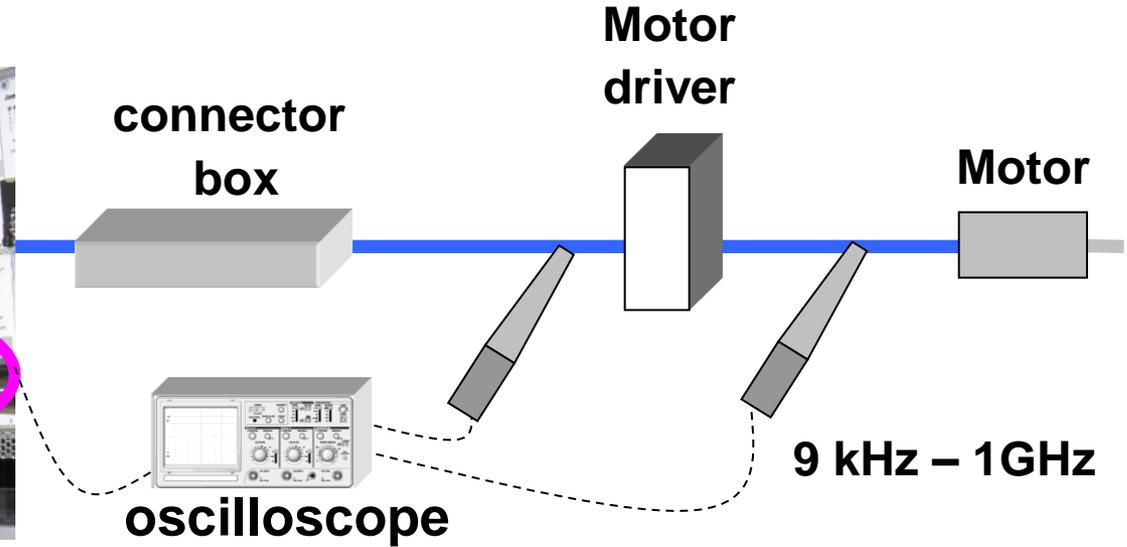
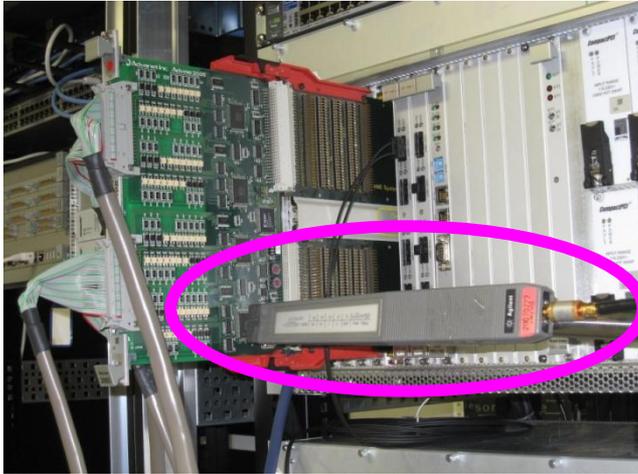


HIOKI

I find power line no problem.

Magnetic near-field probe

VME



Joint slot for the maintenance

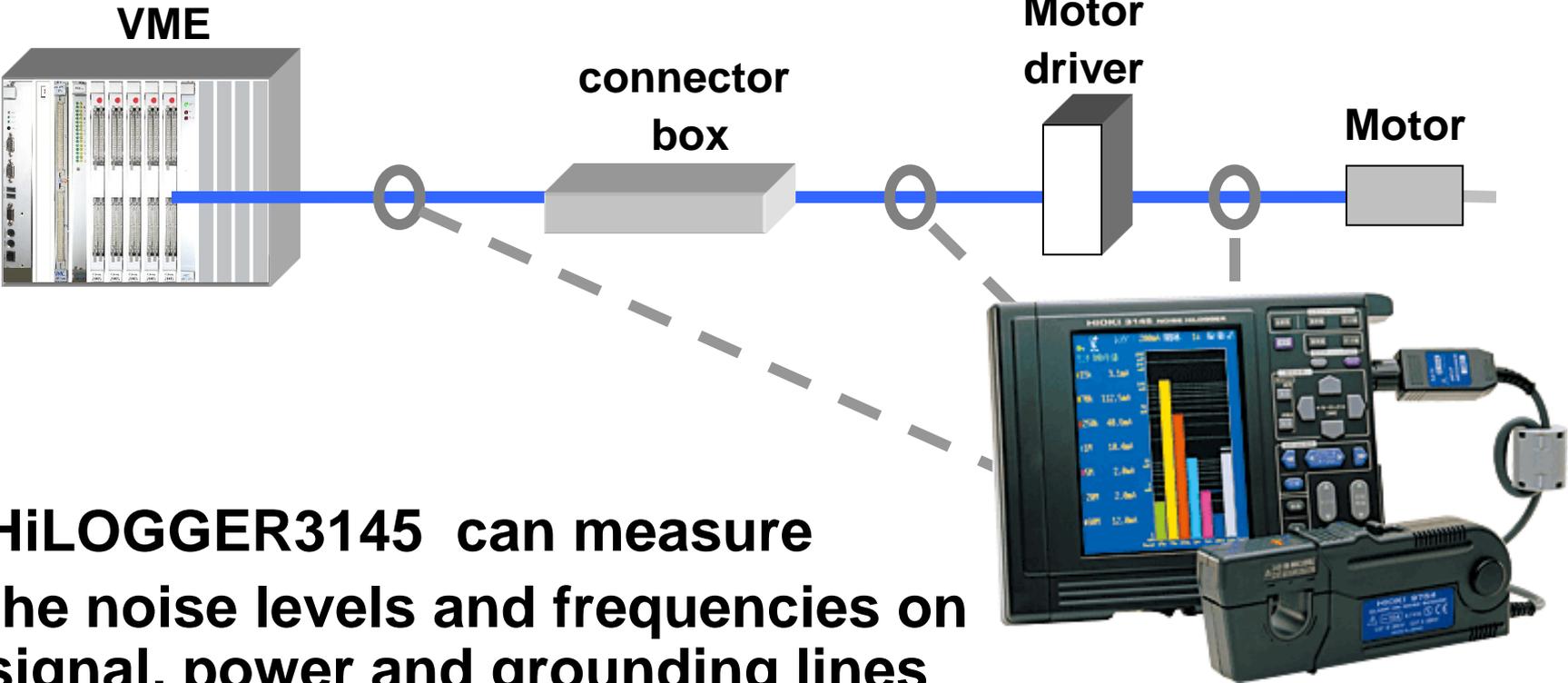
11941A Close Field Probe

measures magnetic field radiation from surface currents, slots, cable.

HP Agilent

Quantitative measurement difficult.

CLAMP ON NOISE SENSOR



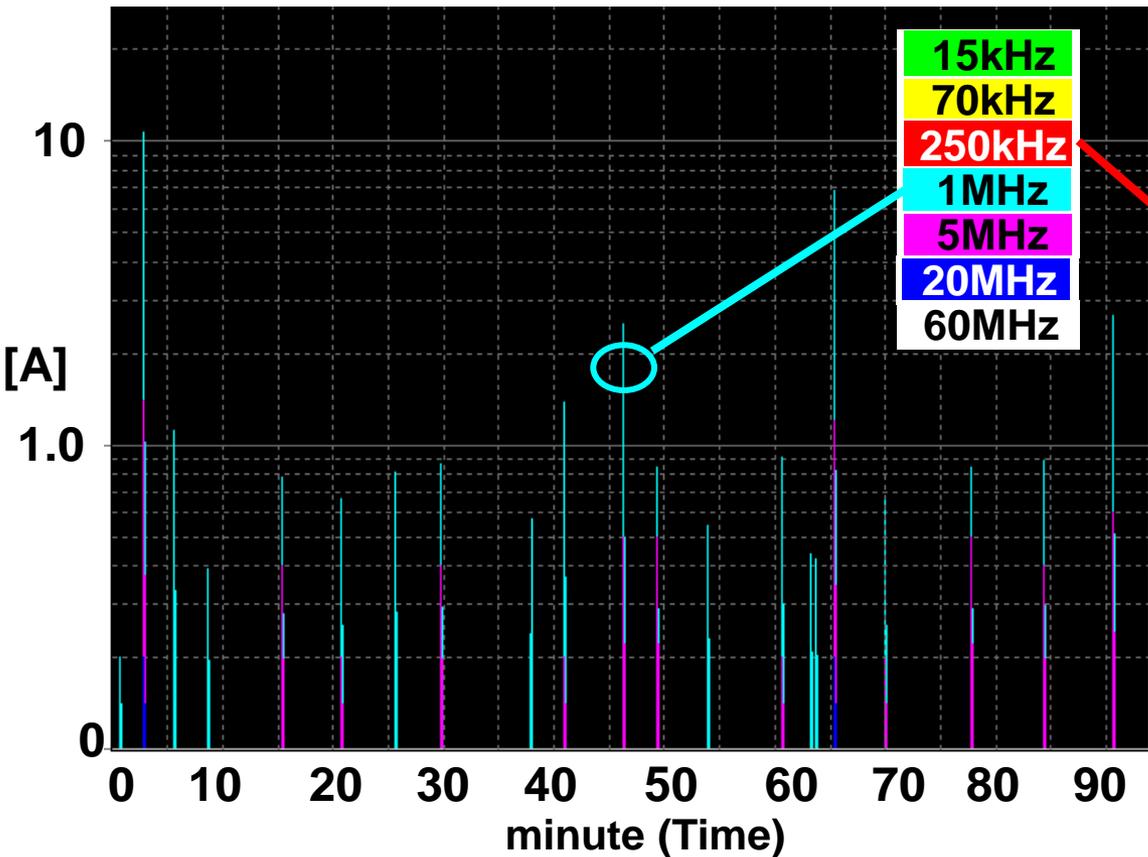
HiLOGGER3145 can measure the noise levels and frequencies on signal, power and grounding lines connected to electronic devices.

Noise sensor 9754

HIOKI

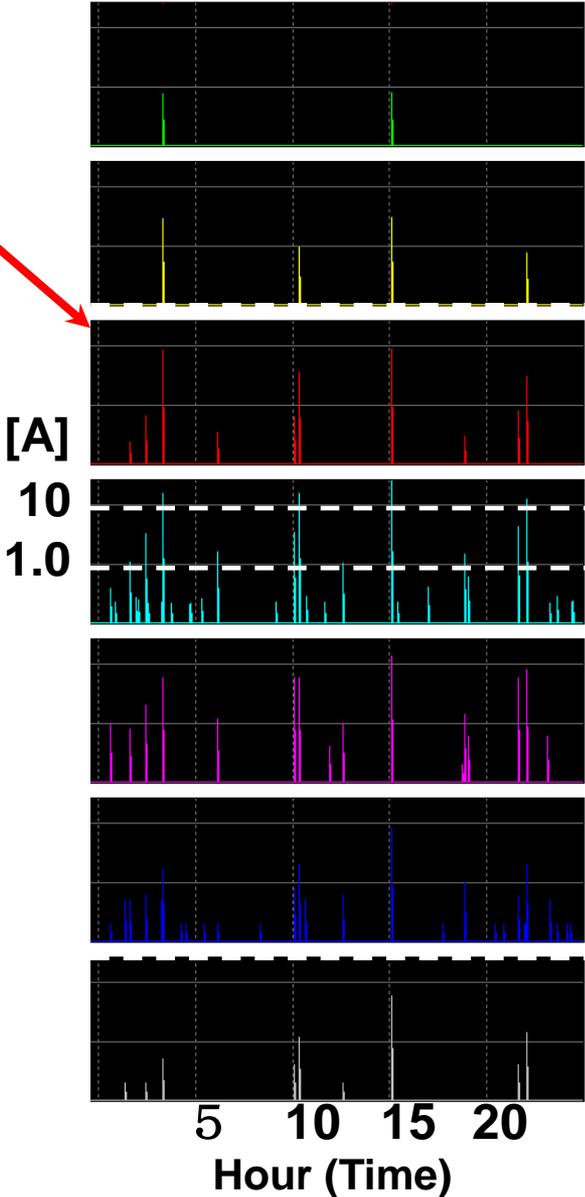


CLAMP ON NOISE SENSOR



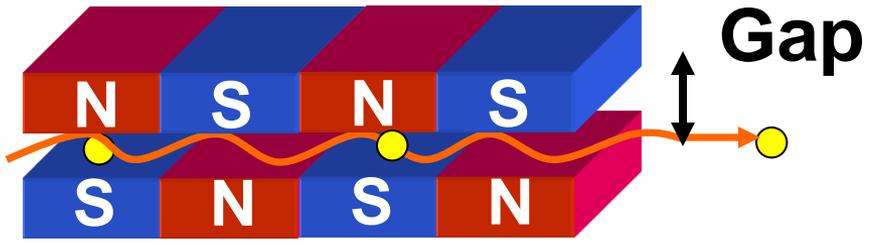
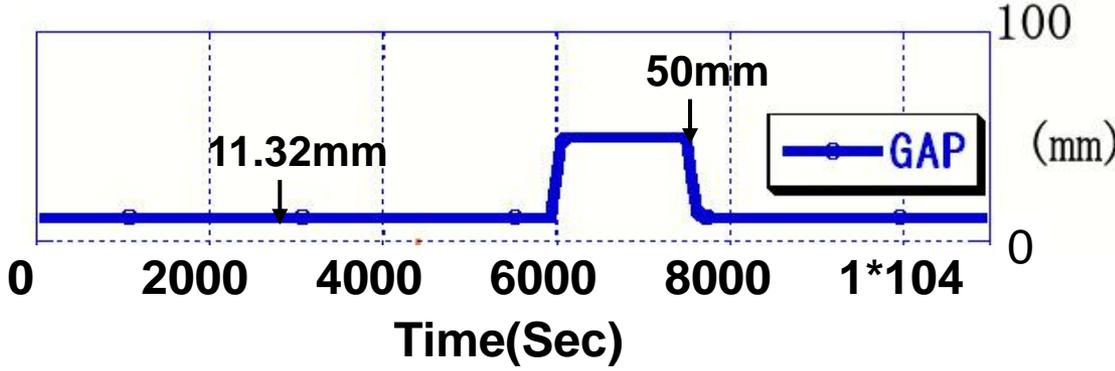
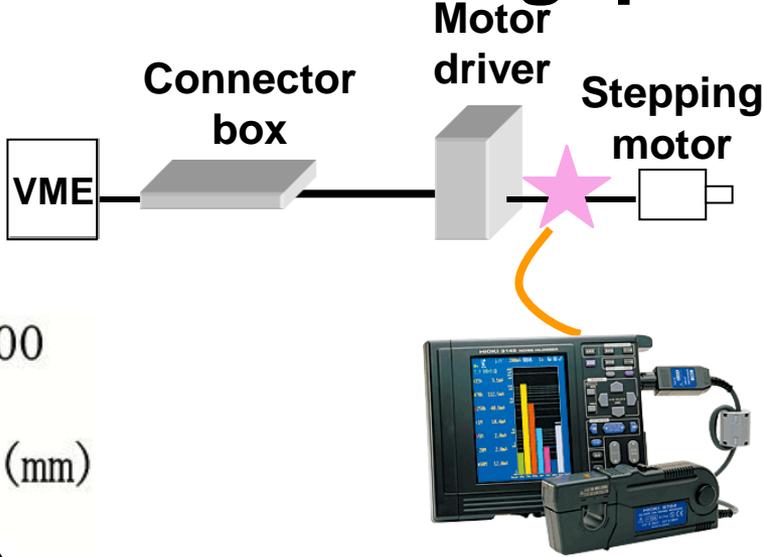
Display real-time peak-to-peak value in 7 frequency band on level meters.

CLAMP ON NOISE SENOER



Noise measurement

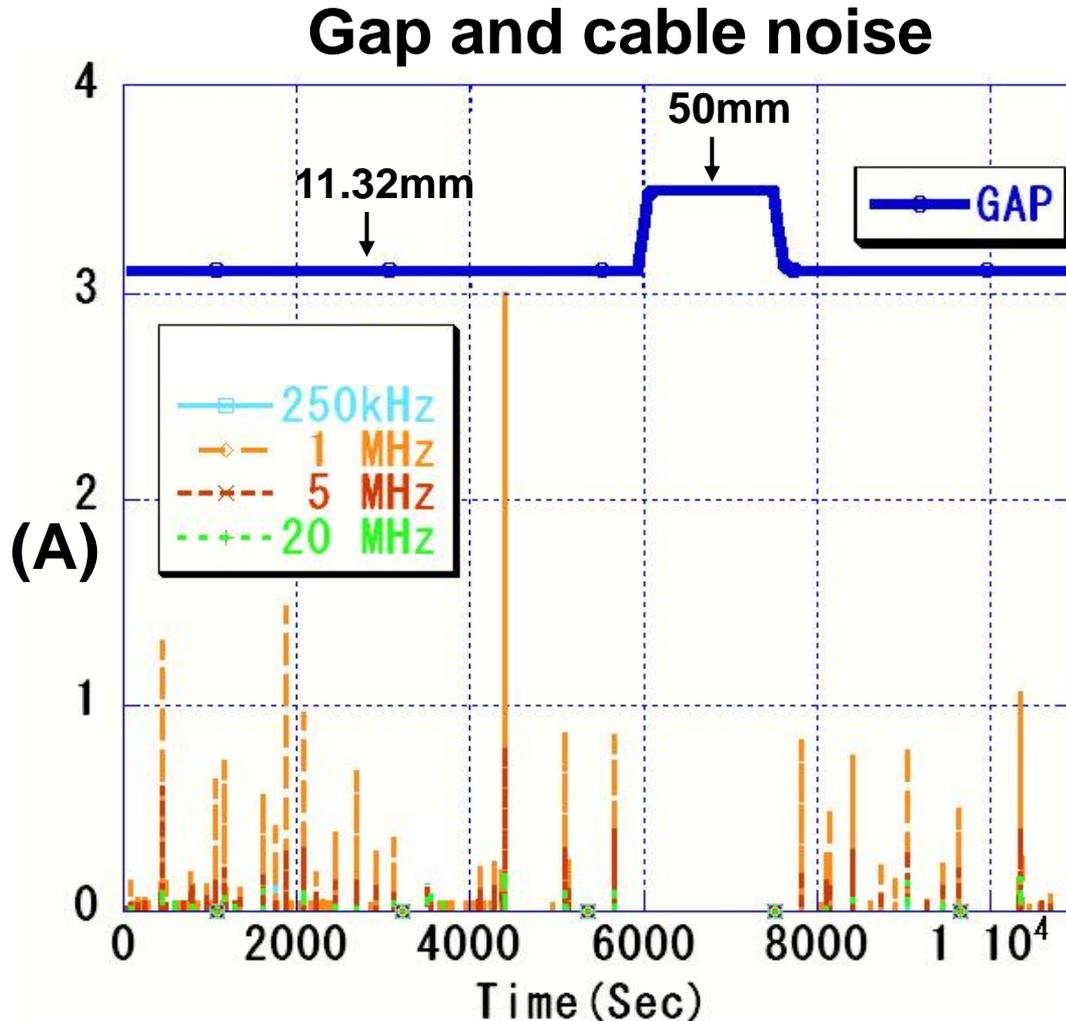
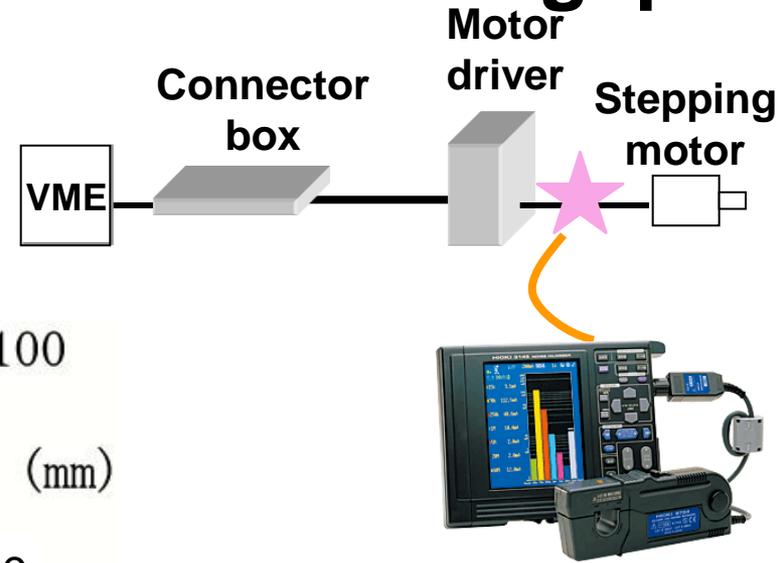
Correlation between noise and undulator gap



Undulator

Gap open → Low flux
Gap close → High flux

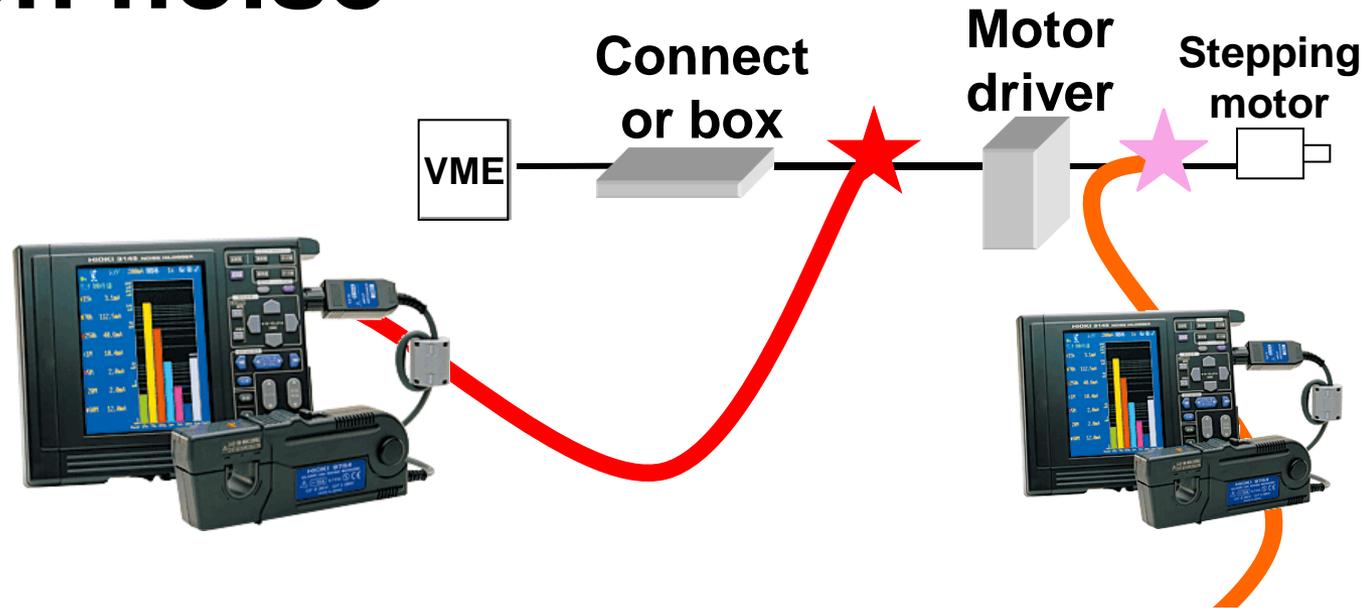
Correlation between noise and undulator gap



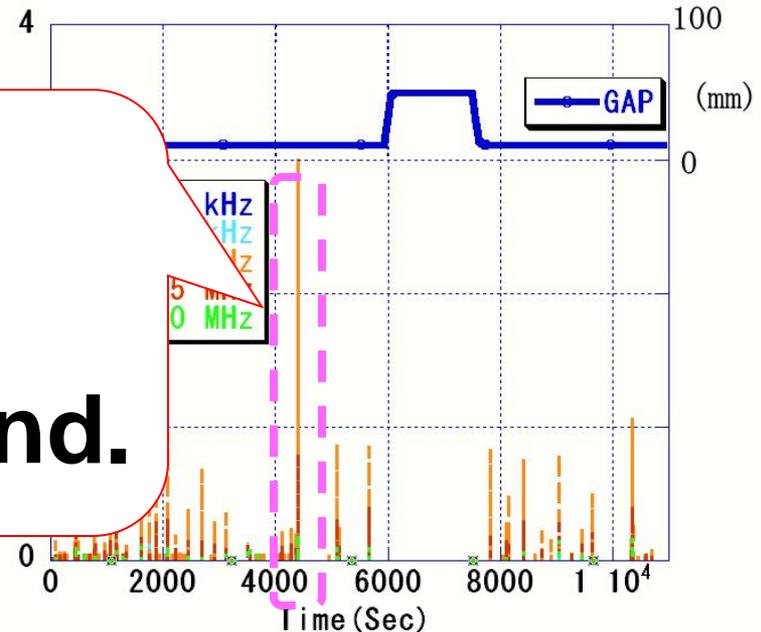
Low flux: no noise
High flux: high noise level

The noise is correlated with high X-ray flux.

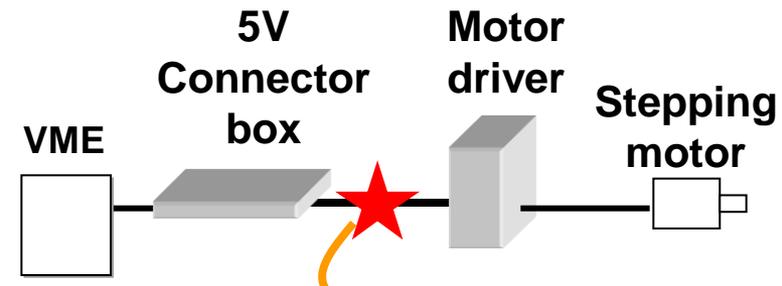
Correlation noise



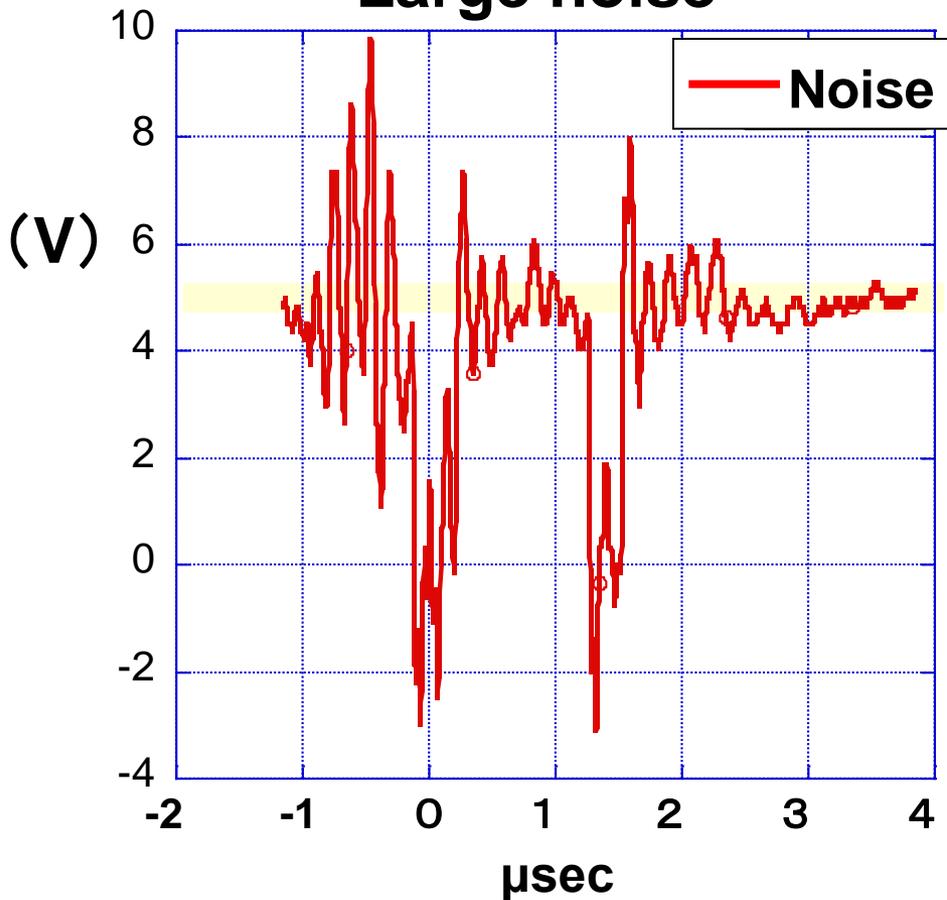
When this noise occurred ,
noise (★) was found.



Large noise measured



Large noise



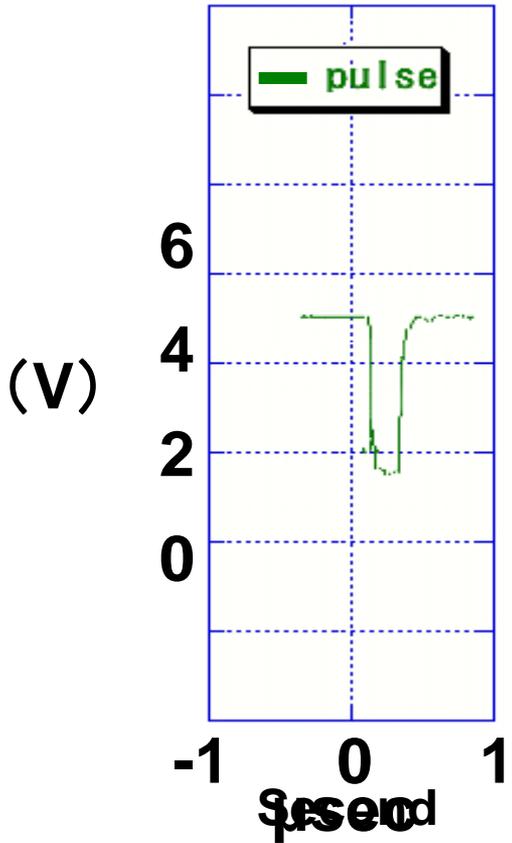
Voltage of a motor control signal

★

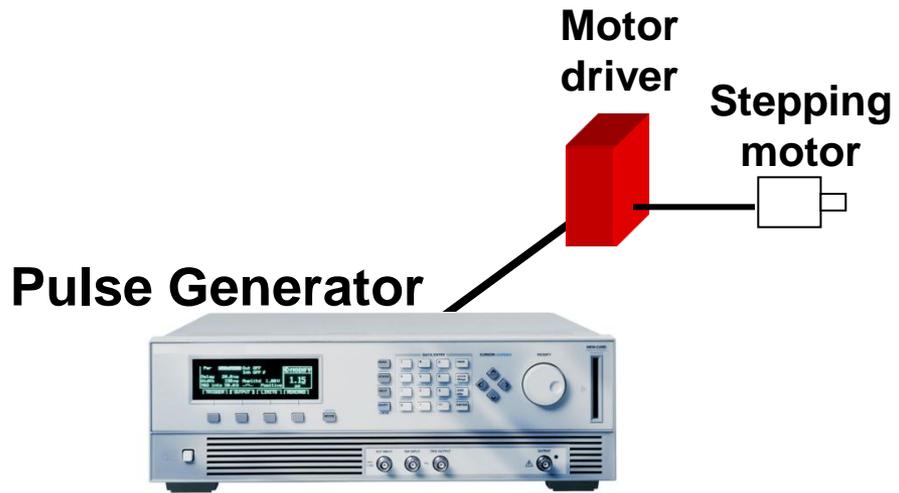
Waveform : showering noise
Frequency: about 1 MHz
Amplitude: over 12V

Measured minimum pulse

Motor driven by one minimum pulse

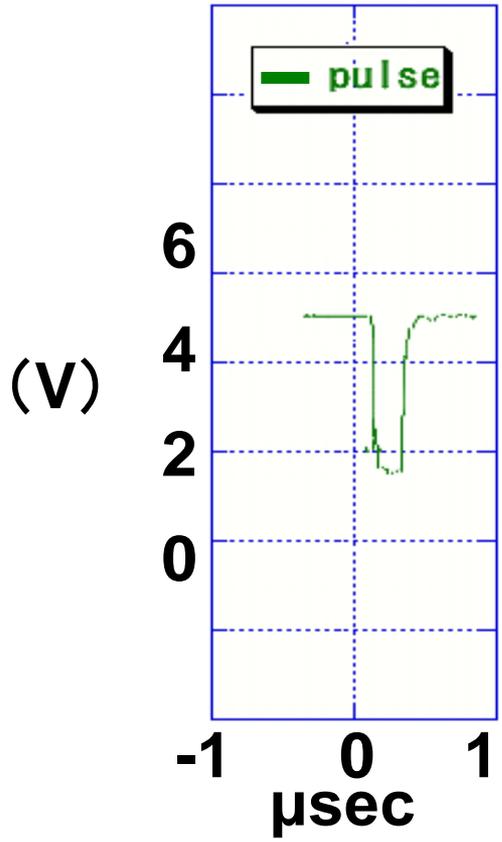


Pulse width: 216nsec
Voltage : 3.3V

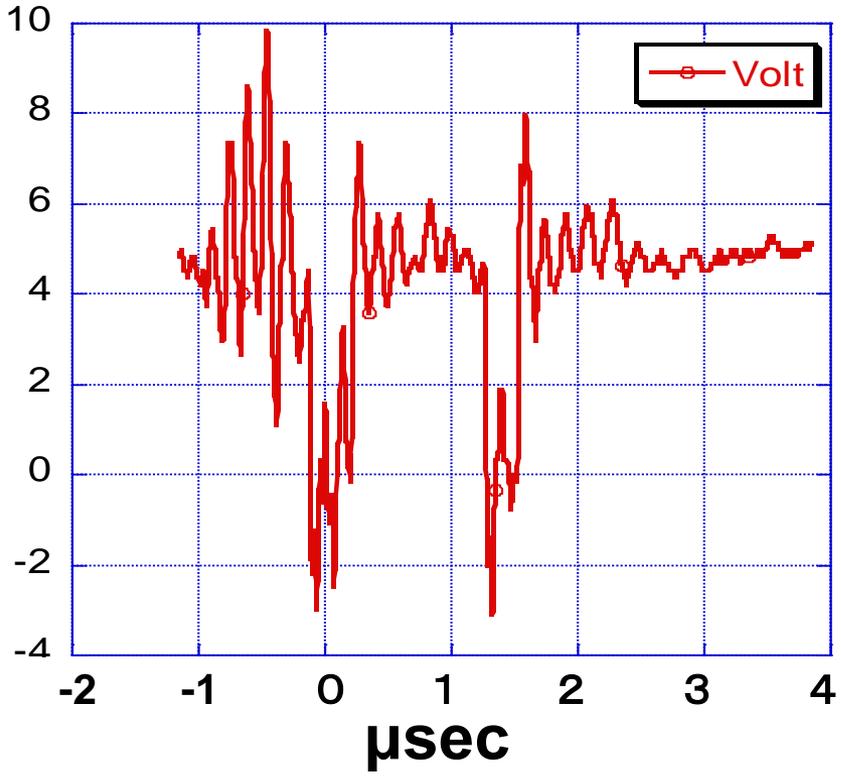


Comparison between showering noise and signal

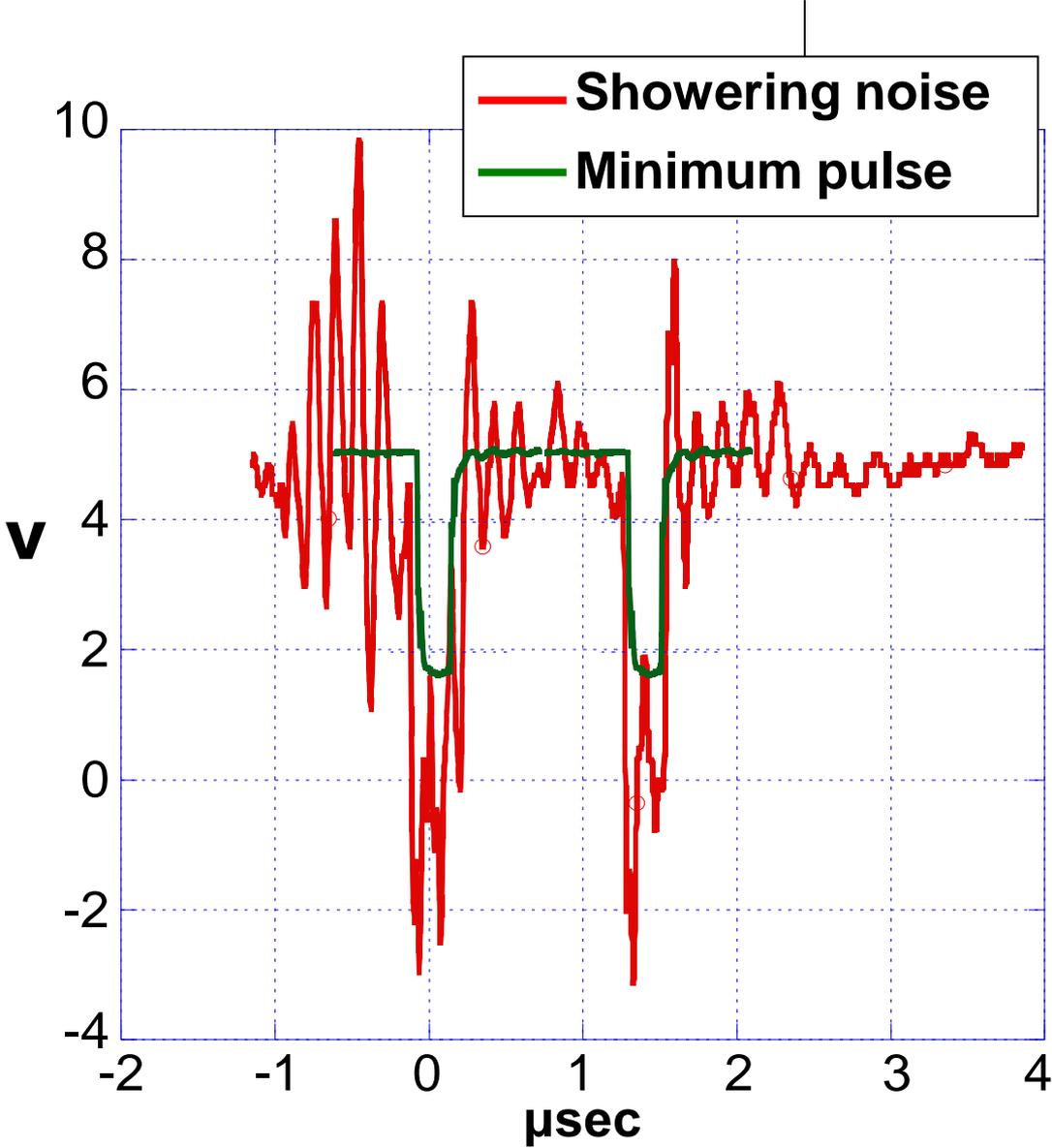
Motor driven by one minimum pulse



showering noise



Comparison between showering noise and signal



**Showering noise is over
Minimum pulse voltage.**

**Showering noise drive the
motor 2 pulses.**

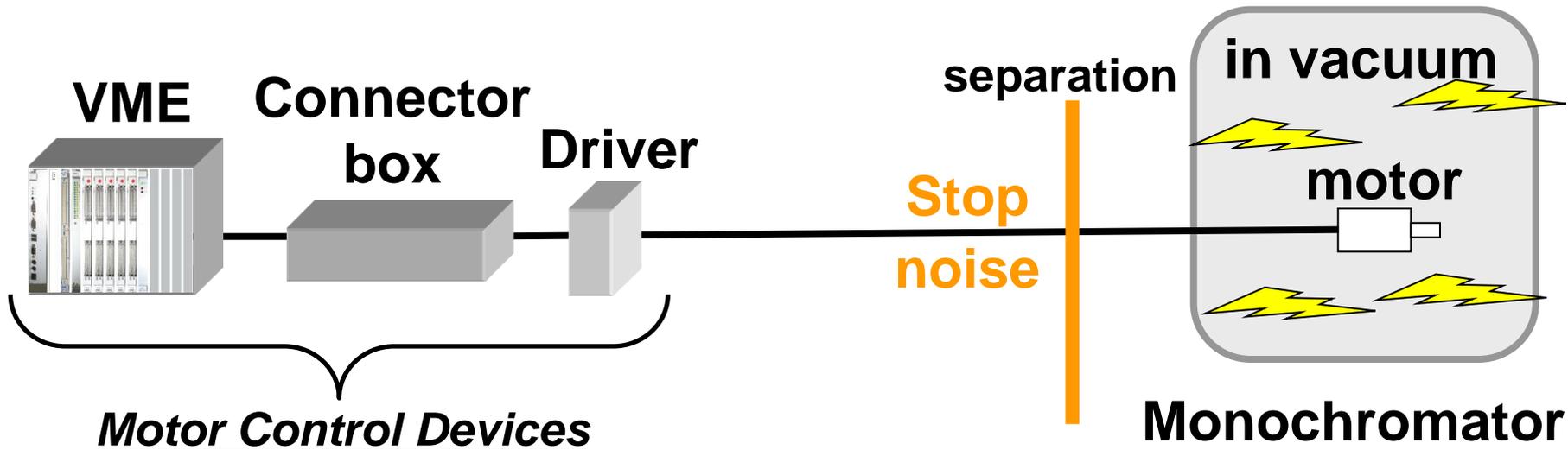
Noise measurement results

- **The noise is generated when strong X-ray.**
- **Main component of electric noise is about 1MHz.**
- **Large electric noise can move a motor.**

Solution

Strategy

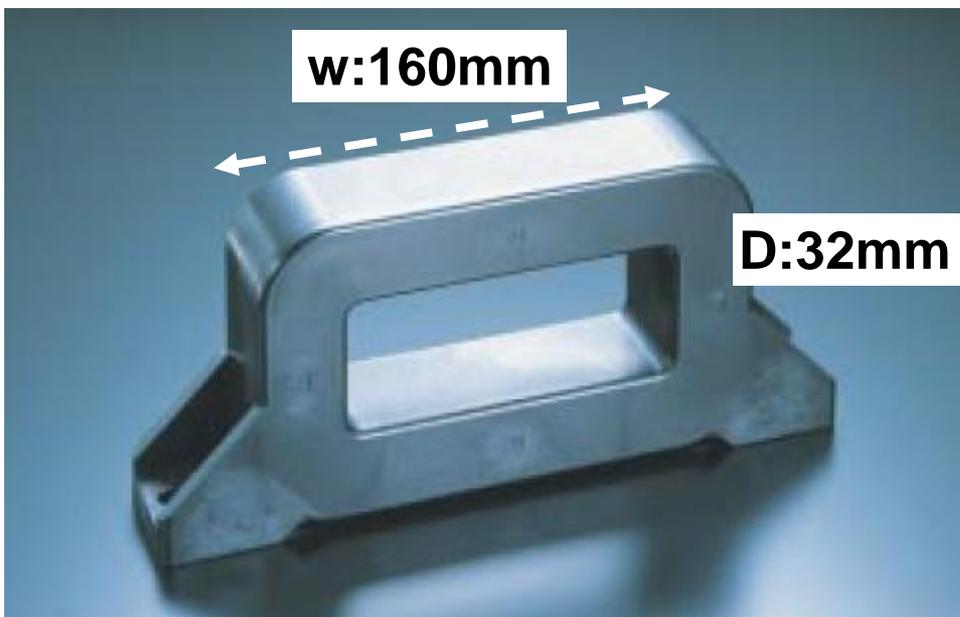
- **Separation strategy**
 - **Separate monochromator distant from the motor control devices**
 - **Stop noise current penetrating into control system!**



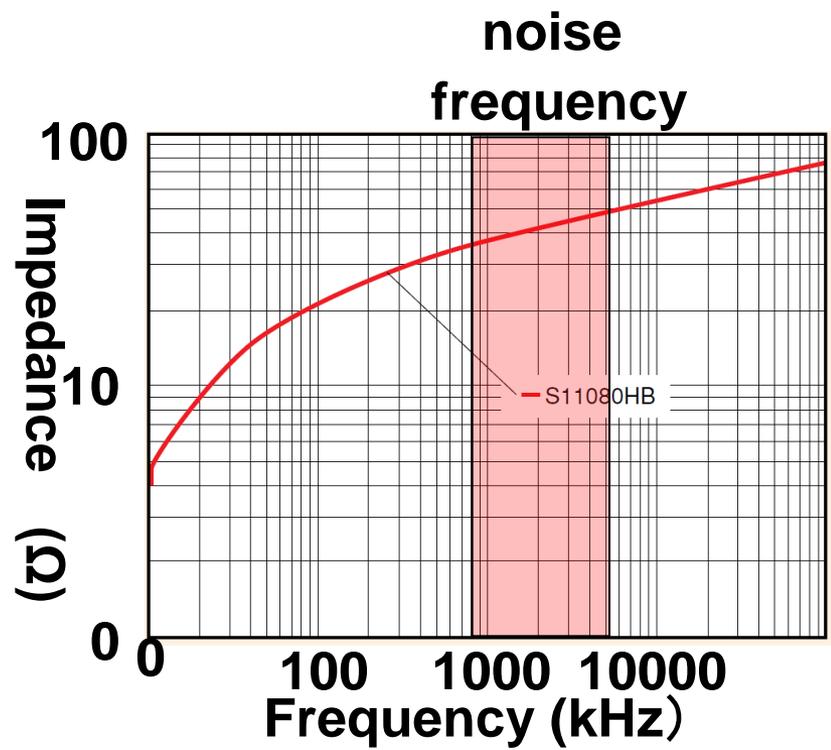
We try to use ferrite core for noise reduction.

Ferrite core

- We selected ferrite core.



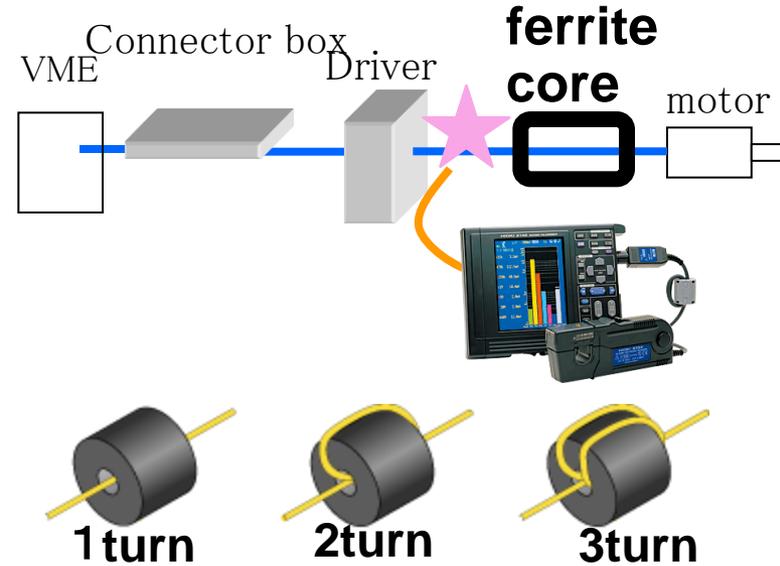
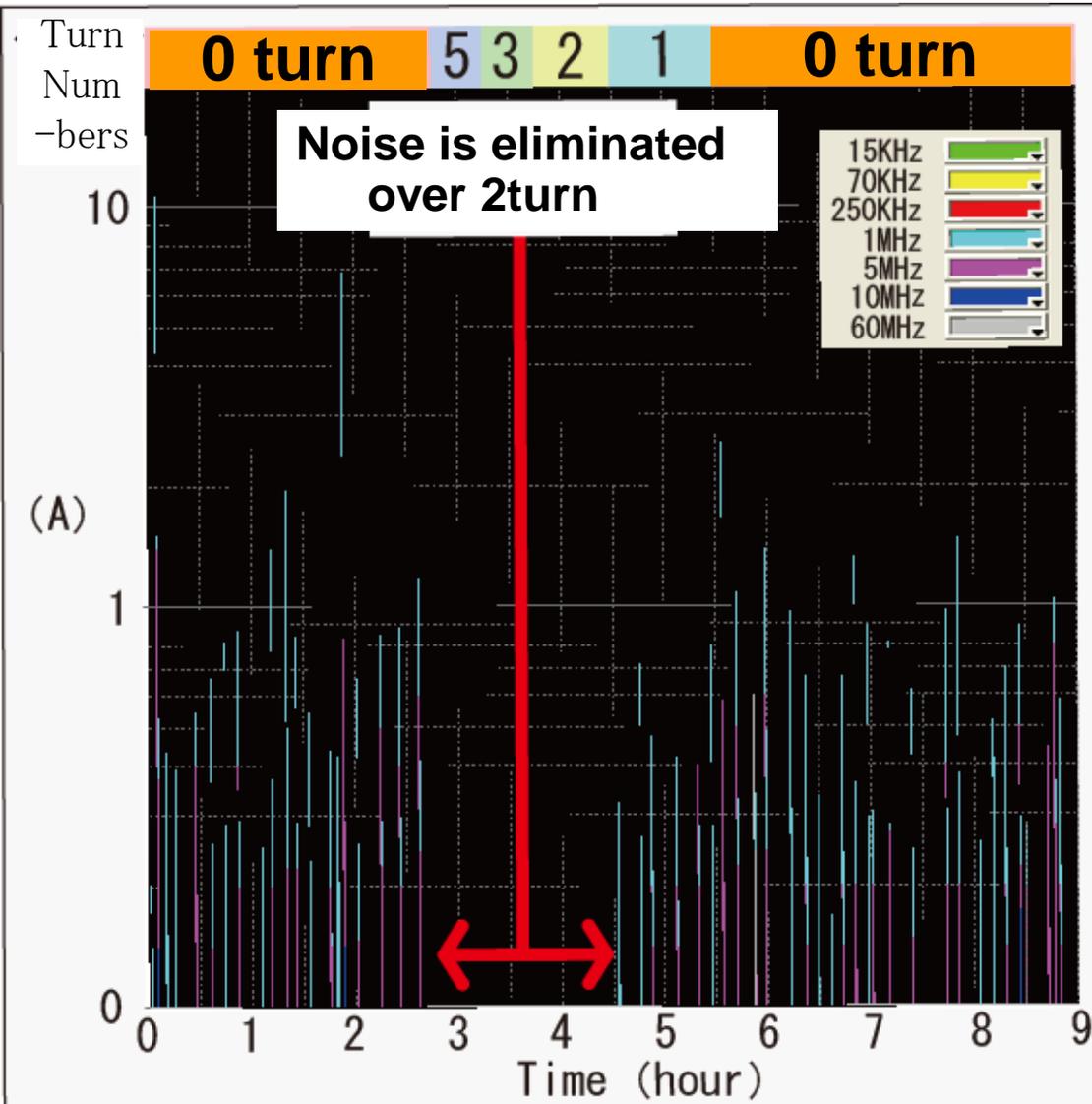
model number: FT3KM S11080HB
quality of material : **FINEMET**
Hitachi metals



impedance character

This ferrite core is the simple solution to reduce the noise.

Prevent inrush electric noise into control system by using ferrite core



$$\text{Impedance} = \text{an Impedance} \times N^2$$

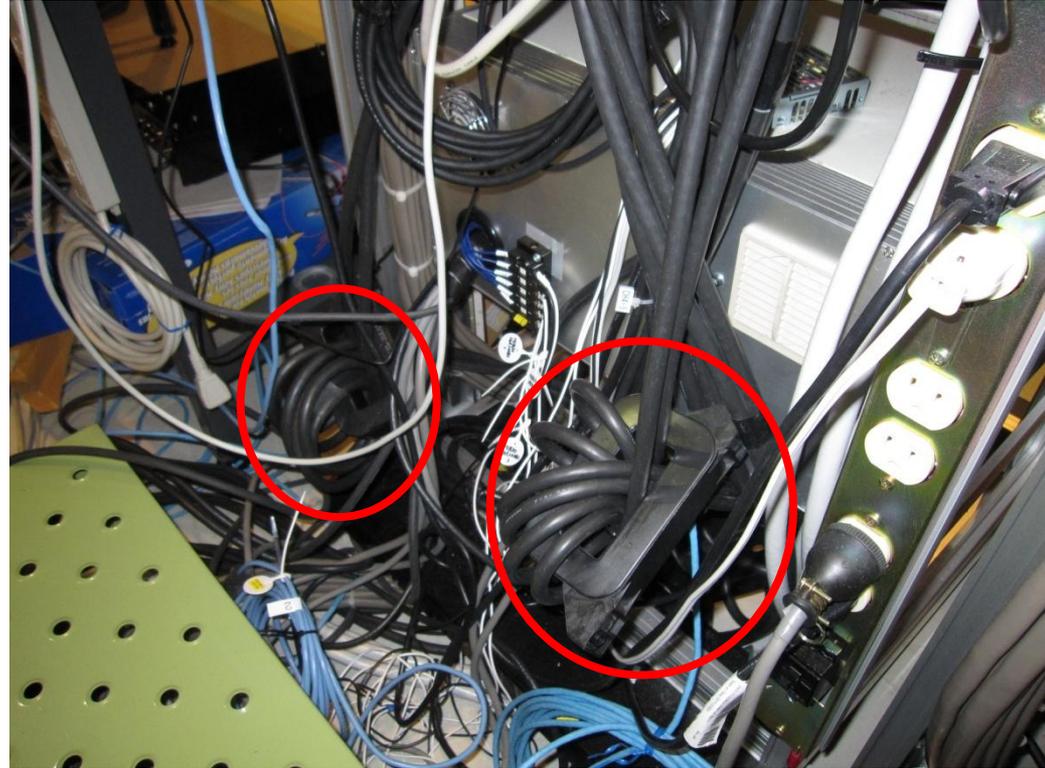
$N = \text{turn number}$

The noise was not dropped over 2 turns.

Installation Problems

It was not practical for us!

- There are not enough space for core.
- Cable winding is difficult.



We searched the new core to install easily to existing cables

Ferrite core selection



**PE22
TDK**



**FINEMET
Hitachi metals**

Installation	easy	difficult
Impedance character	20Ω :1MHz:1turn	38Ω :1MHz:1turn
Noise reduction	Not-measure	2turn is enough
Total Impedance	20Ω × 8 piece=160Ω ≐	152Ω ← 38Ω × 2turn²

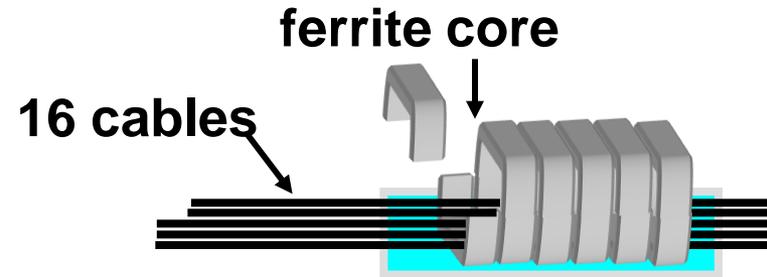
8 pieces of ferrite core clumps cables with 1 turn

Impedance = an Impedance × N²
 N = turn number

Installation of Ferrite core



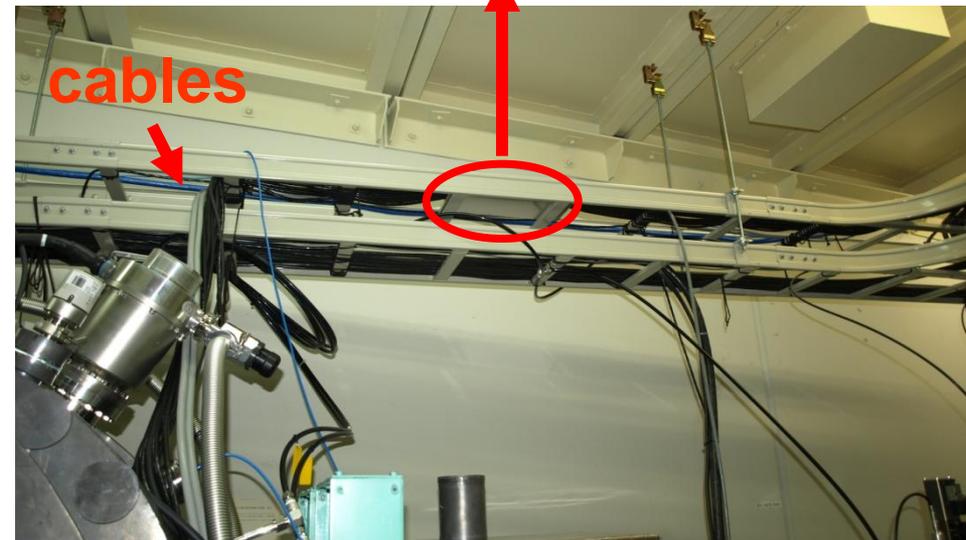
PE22 TDK



- We can install the ferrite core, easily.
 - 8 cores clamped 16 cables.

- NO noise.
- X-ray intensity stabilized.

SPRING-8 staffs and users
become **very HAPPY!**



bottom view

Conclusion

- The noise is generated when strong X-rays.
- Main frequency of electric noise is about 1MHz.
 - Motor-driver mistakes the noise for the drive signal.
 - Problems of motor malfunction is solved by installing ferrite core.
 - No noise.

Please contact me

when there is a similar case in your institute.