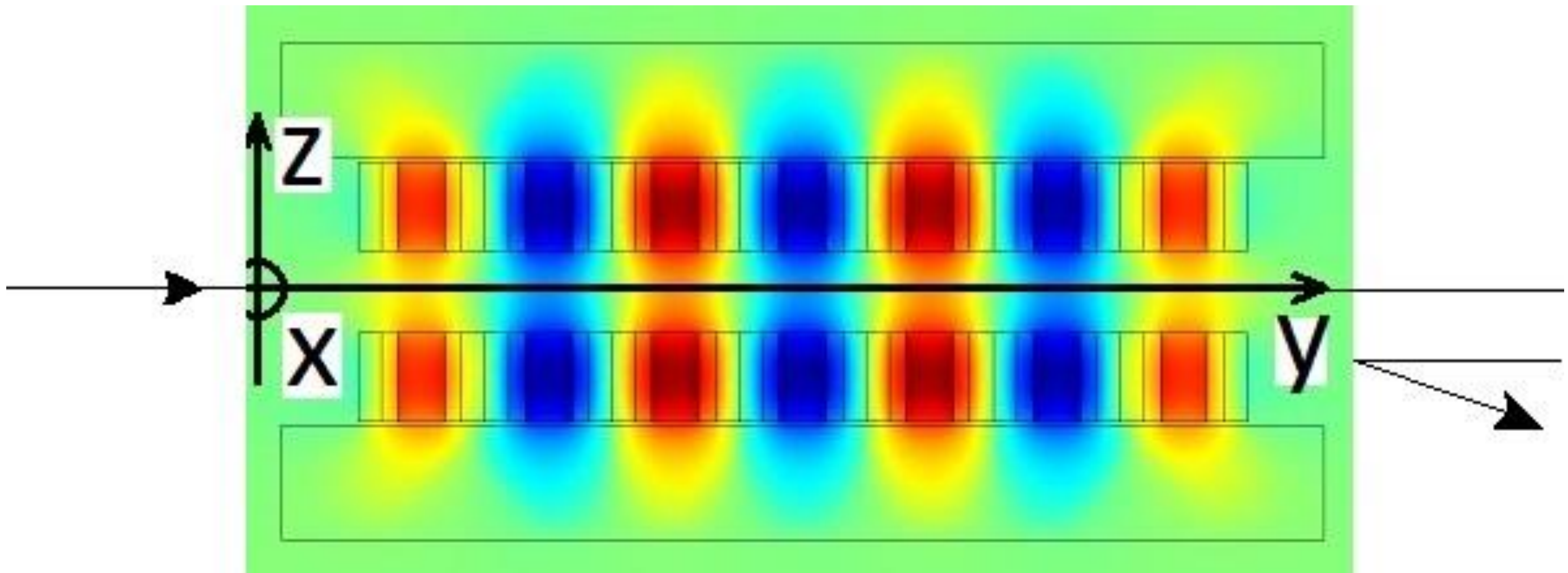
SFR-2016
X-ray apparatus

Current driven wire based magnetic measurement systems

ZORIN, Artem
Dr. MEZENTSEV, Nikolay
KANONIK, Pavel
Budker Institute of Nuclear Physics, lab 8-2



Electron beam + magnetic field = synchrotron radiation.

A wiggler/undulator = many magnets, but it is not a bending magnet.

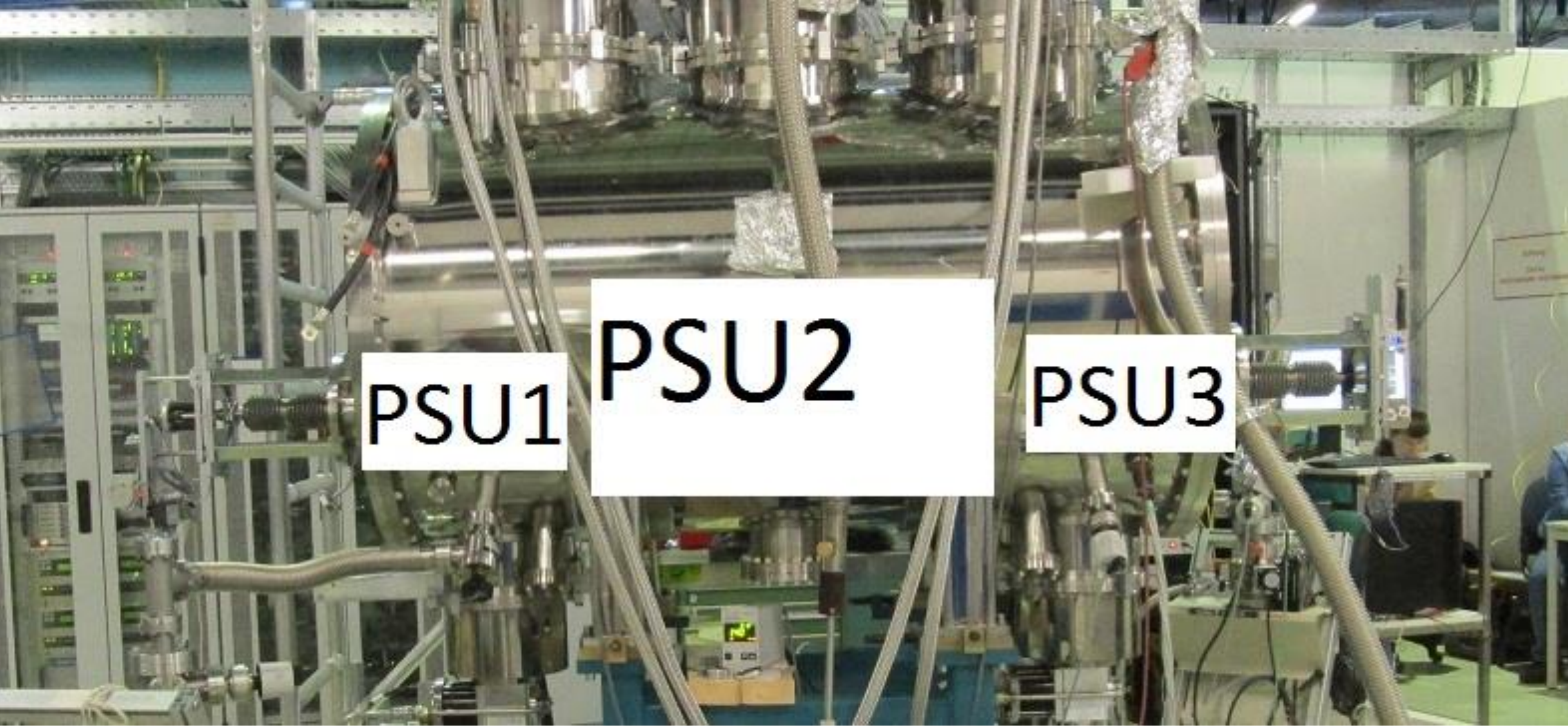
Electron beam trajectory shouldn’t change.

J1 means angle, J2 means shift.

Tasks: minimize and measure J1, J2 and some other parameters.

$$J_1 = \int_0^L B(s) \cdot ds$$

$$J_2 = \int_0^L ds \int_0^s B(s') \cdot ds'$$

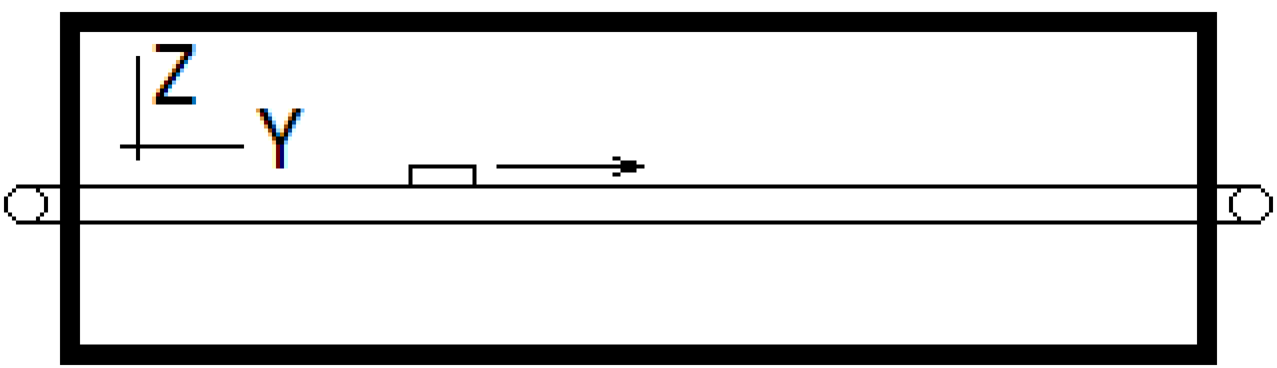


3 PSU = B, J1, J2

Hall probe sensor

- Much space
- Much time, no ramping
- Mechanics
- Calibration

- Liquid He

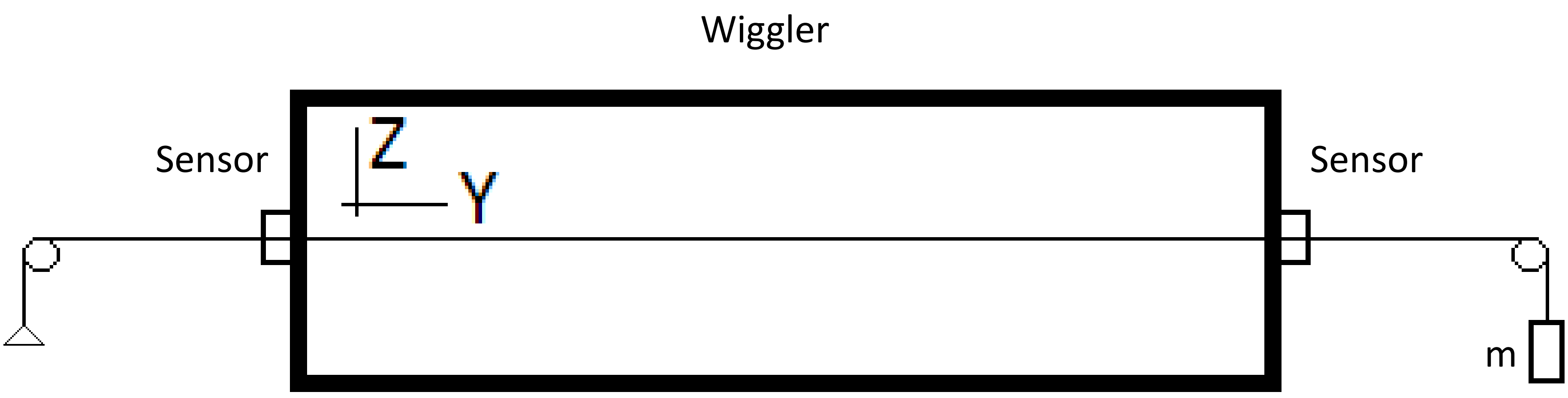


Moving wire based systems

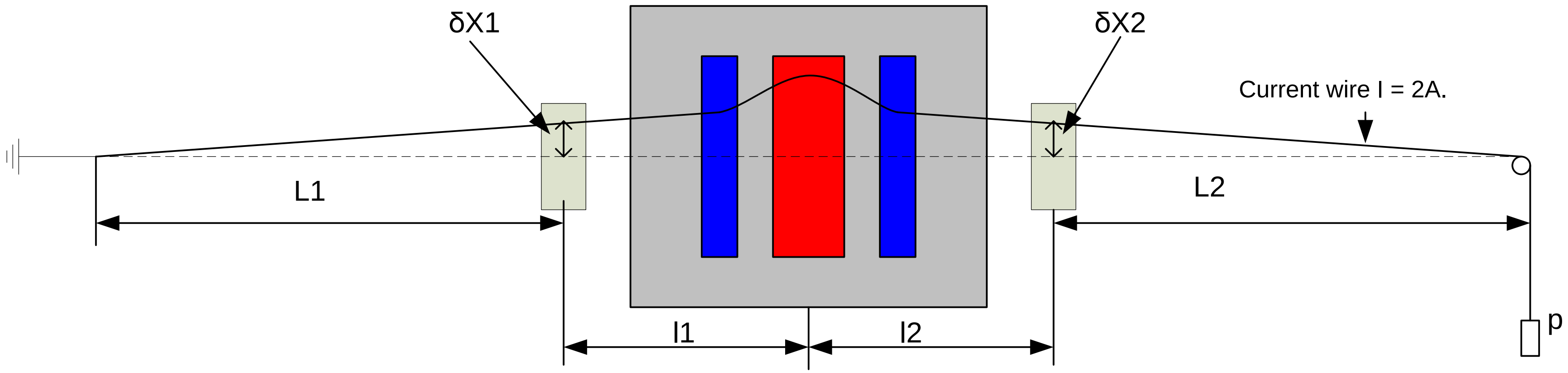
- Faraday's law of induction: moving wire + magnetic field = voltage
- Different configurations of wire are possible: straight wire, coil, eight-form coil…
- Mechanics
- Much space

Current driven wire based systems

- Current moves through stretched wire and interacts with magnetic field (Ampere force). The wire deflects, and its position is measured.



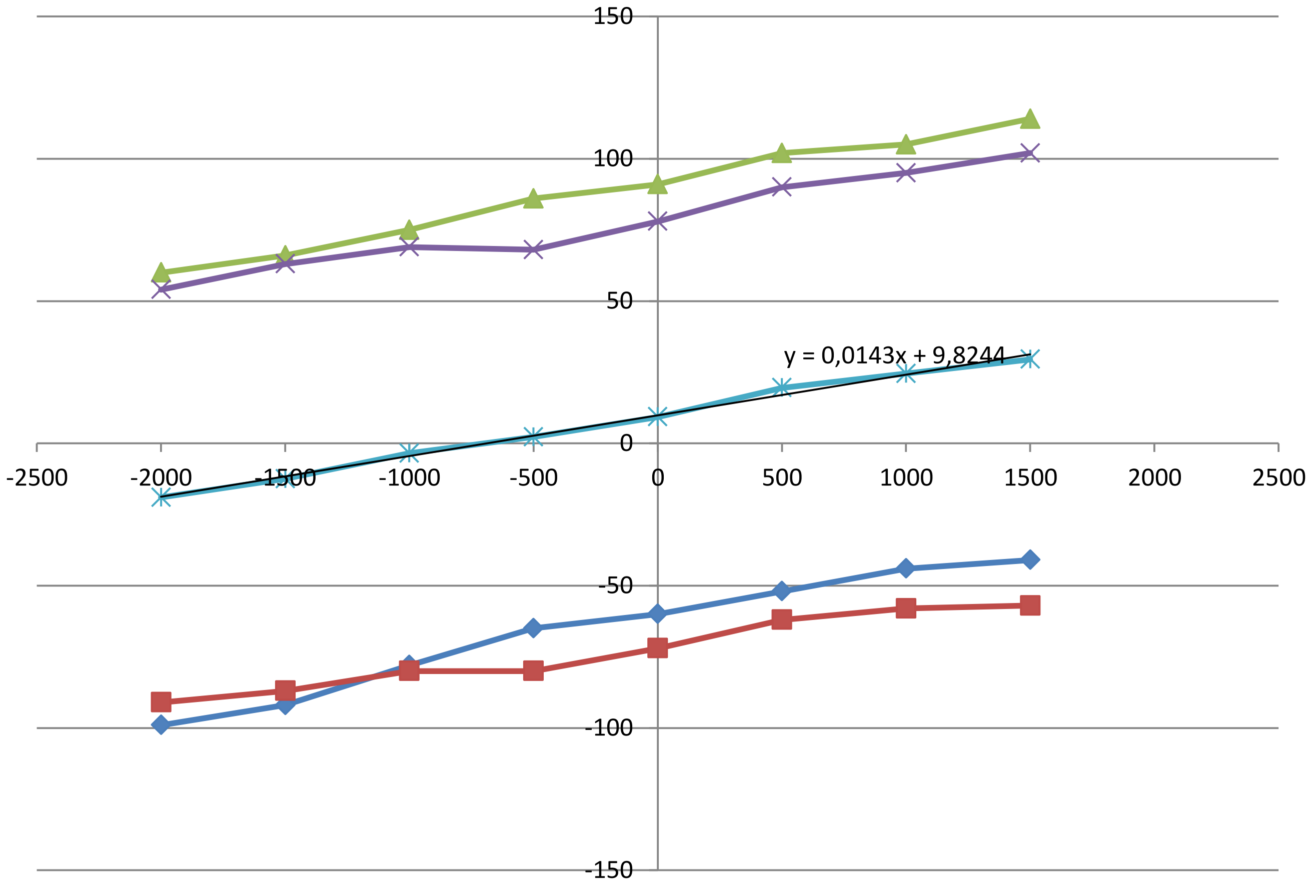
Constant current method



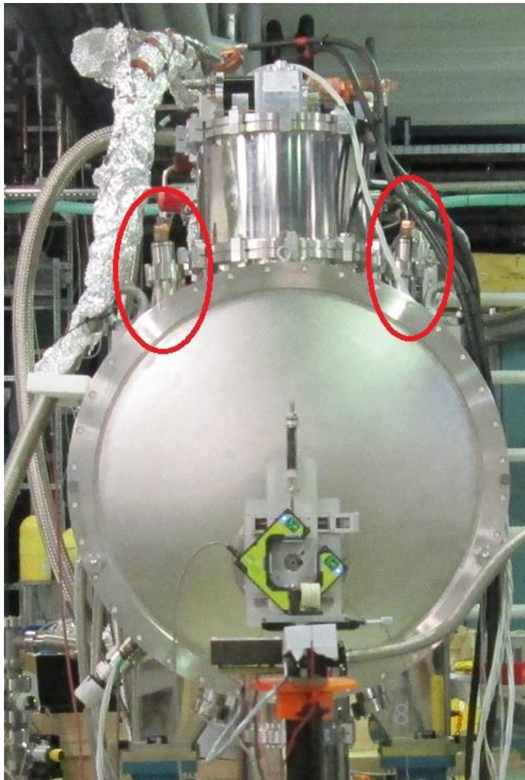
$$I_{first} = I_1\left(\frac{L}{2}\right) = \delta\alpha * \frac{T}{I} = \frac{T}{I}\left(\frac{\delta x1}{L1} + \frac{\delta x2}{L2}\right)$$ -first field integral

$$I_{second} = I_2\left(\frac{L}{2}\right) = \delta x \cdot \frac{T}{I} = \frac{T}{I}(\delta x2 - \delta x1)$$ -- second field integral

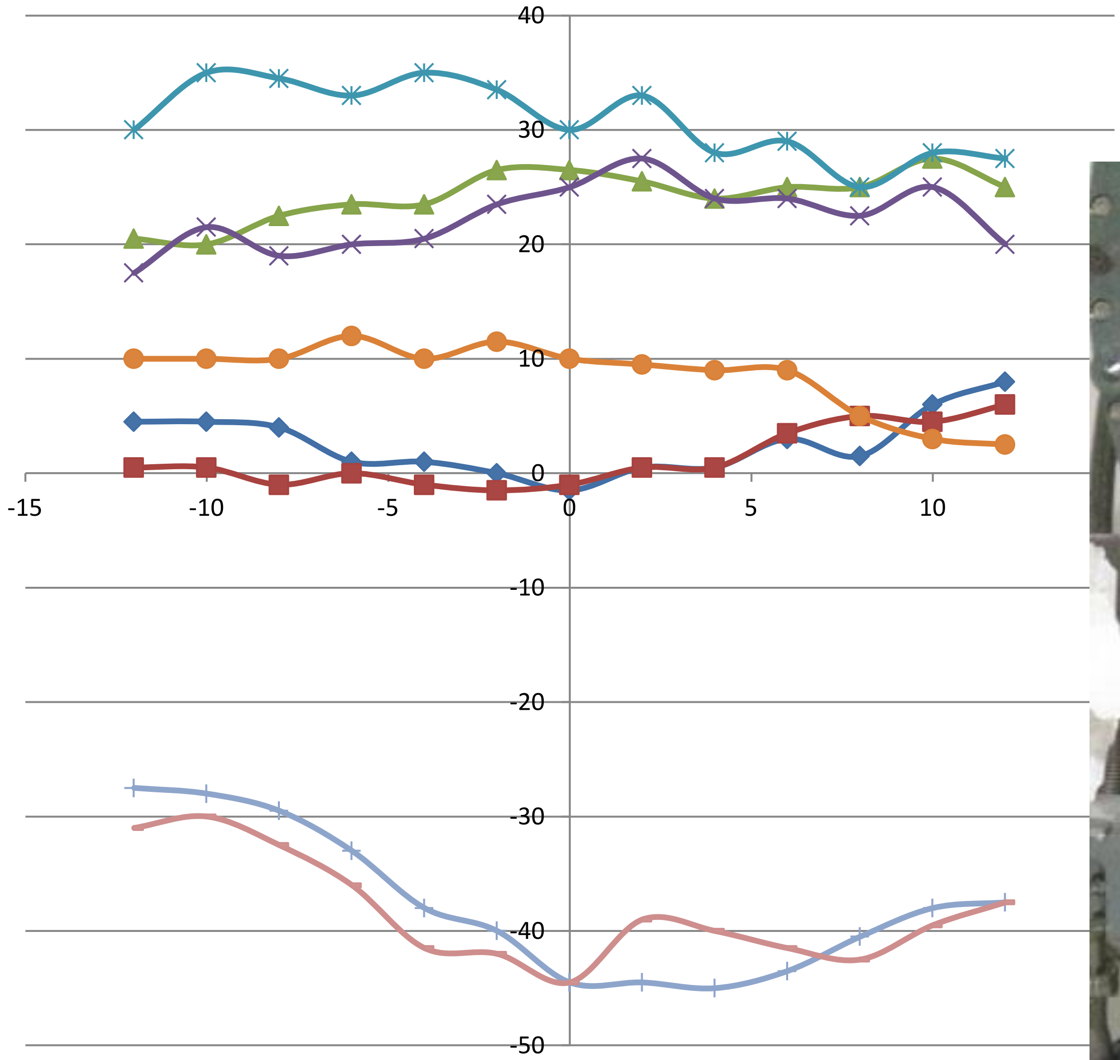
Median plane



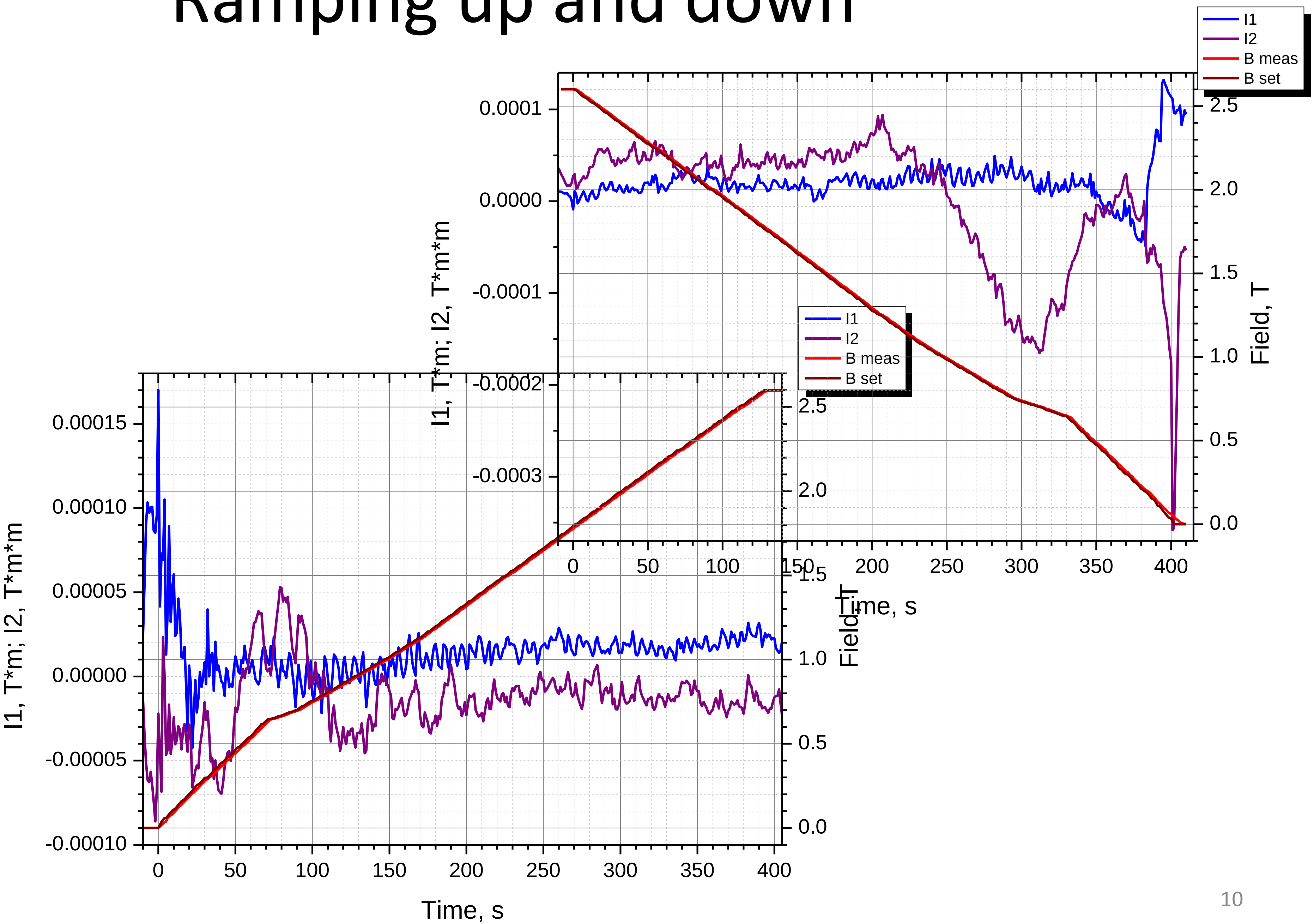
Wiggler focuses



Sextupole measurement



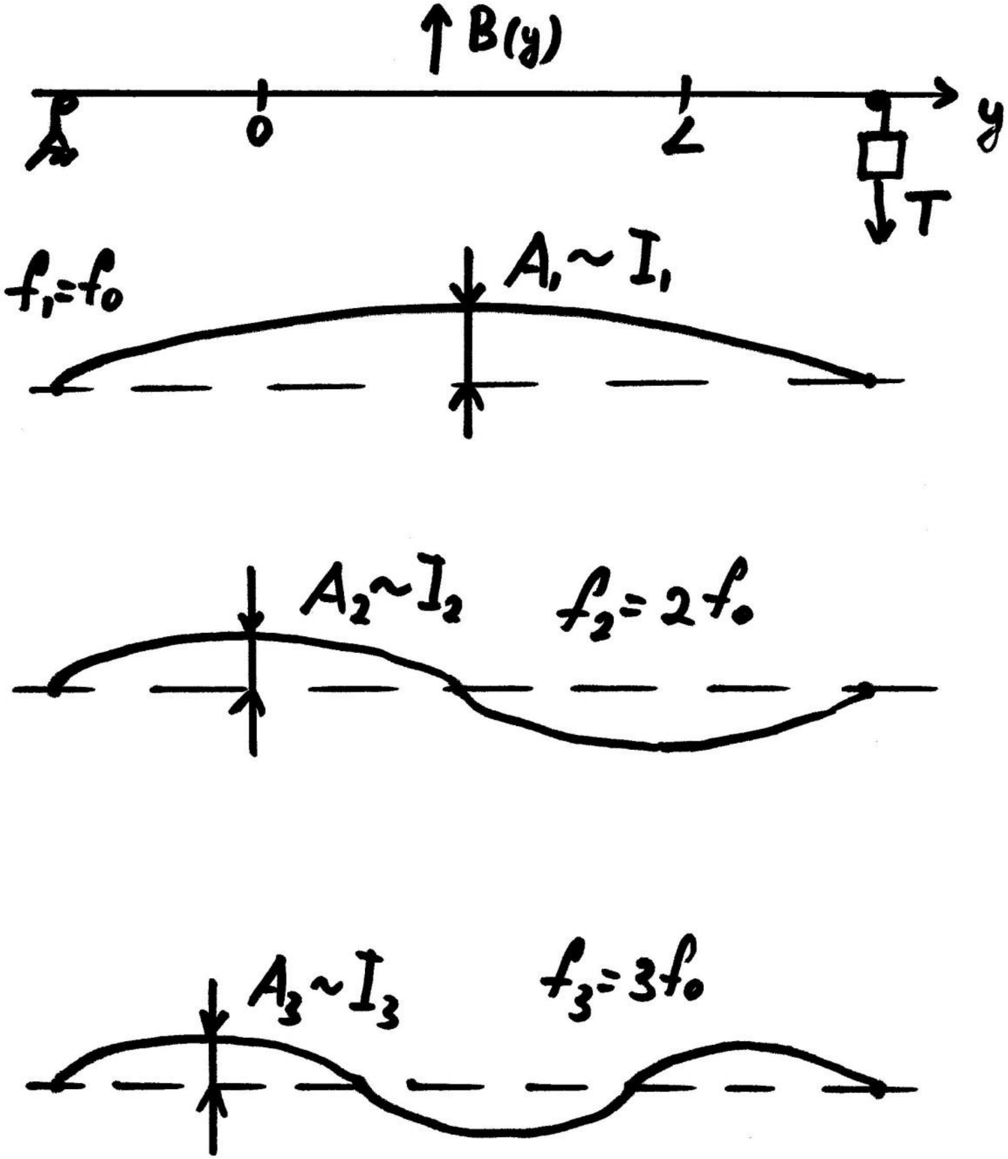
Ramping up and down



Vibrating wire technique (resonant method)

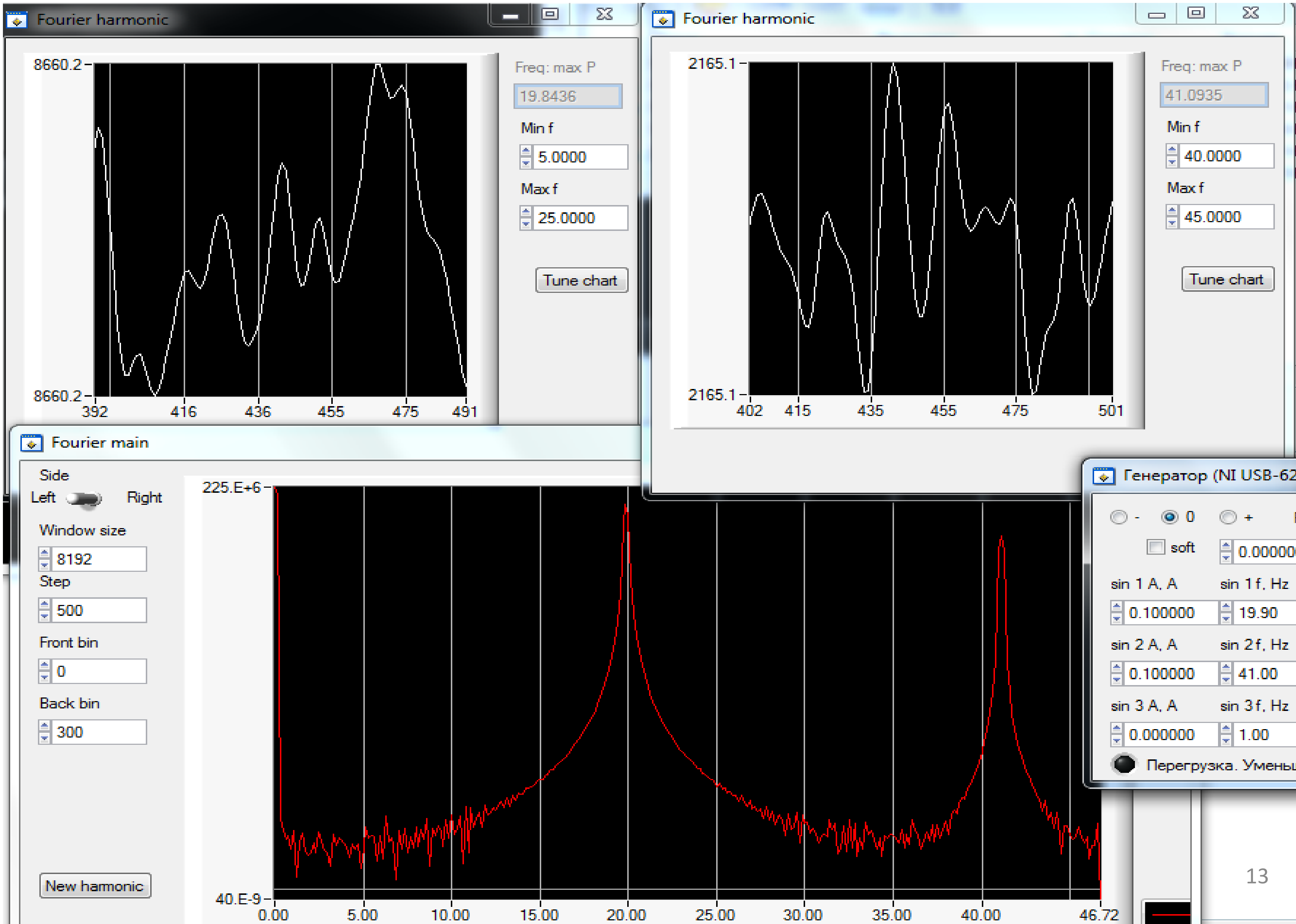
- Let f_0 is wire self-resonant frequency
- Let A is amplitude of oscillation (measured by a sensor) when the wire is driven by harmonic current frequency f
- It is possible to show that $I_{first} \sim A(f = f_0)$, $I_{second} \sim A(f = 2f_0)$, and so on

$$I_1 = \int_0^L B\,dy; \quad I_2 = \int_0^L dy' \int_0^{y'} B\,dy \;; \quad I_3 = \dots$$

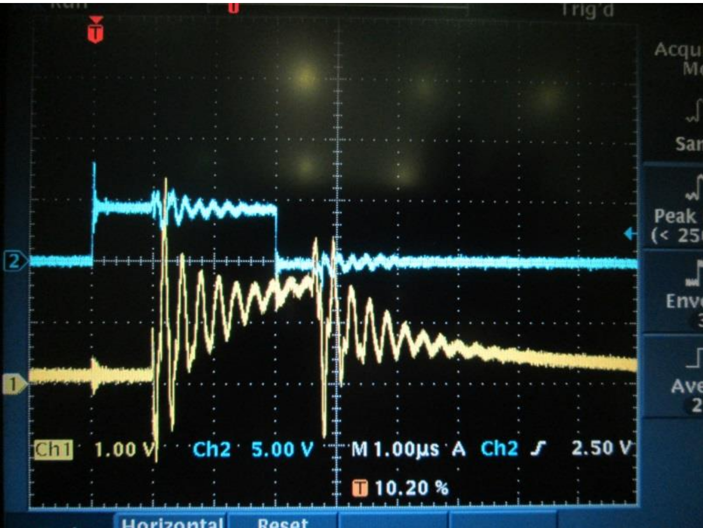


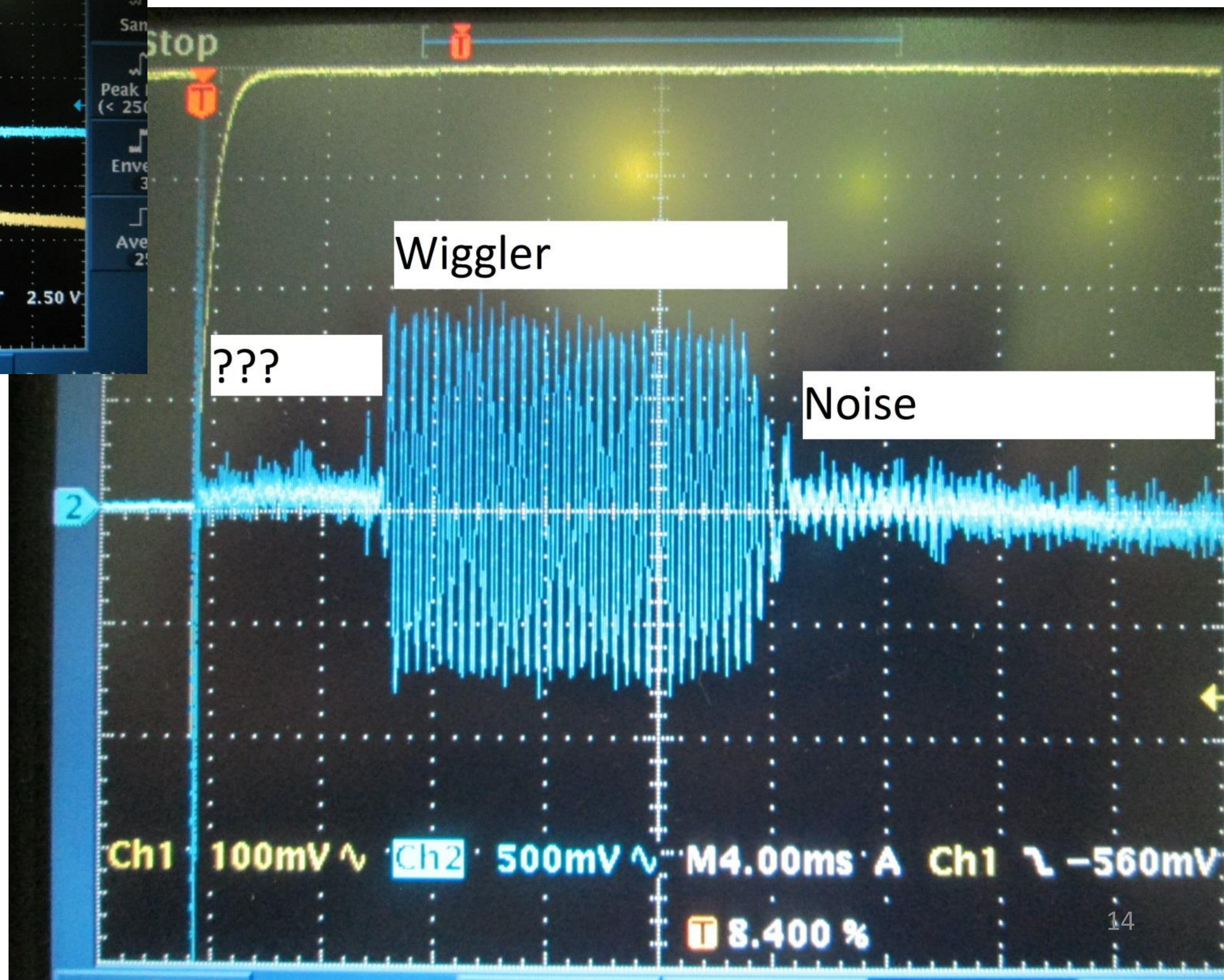
- Sensor position
- Phase detection
- Coefficients, supports, calibration
- Q-factor, time

Software interface

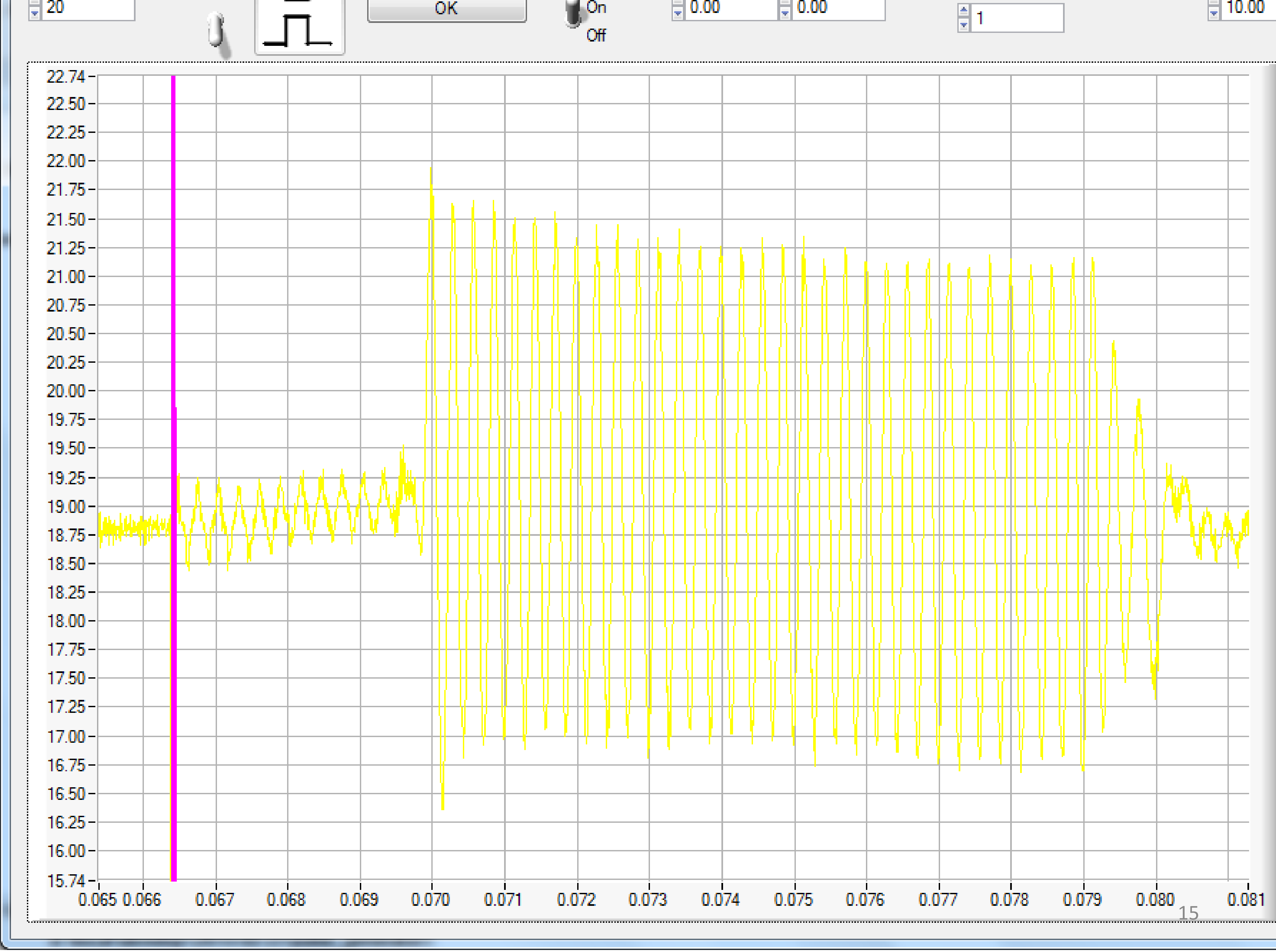


Pulsed Wire Method





- J1
- J2
- Axis tilt
- Axis offset


20
OK
On
Off
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1
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16.25
16.00
15.74
0.065 0.066 0.067 0.068 0.069 0.070 0.071 0.072 0.073 0.074 0.075 0.076 0.077 0.078 0.079 0.080 0.081

Problems

- Sag, tension, sensitivity, I, diameter
- Noise: wind, acoustic waves, vibration
- Earth magnetic field
- Wire imperfectness (for pulsed method)

Conclusion

- Hall probe: liquid helium, constant field
- Constant current method: the best for wigglers. Accuracy is better 5*10^-5 T*m, limited by PSUs
- Vibrating wire (resonant) method: good for zeroing integrals, problems with calibration
- Vibrating, pulsed methods: perspective for superconducting undulators

Thank you!