The “long term” temperature measurements for the magnet spectrometer

1. Discussion of the time stability
2. The technical solutions
3. Current activity
4. Proposals for the test runs

1. Discussion of the time stability

Demand on the time stability of magnetic field in spectrometer is very high. In order to decrease the errors in the beam energy measurements, one has to achieve time stability better than 5ppm within one experimental run.

1.Discussion of the time stability

Drifts in power supply and changes of magnet temperature and electronics temperature within these several months can be significant.

Therefore the best solution is sophisticated current stabilizer, equipped with the thermostatic control electronics and thermostatic selected parts as well.

1. Discussion of the time stability

Theoretically there are following problems, which have potential influence on time stability of the static magnetic field:

- temperature stability of magnet coils and supporting magnet construction
- current feedback temperature properties

Temperature stability of magnet coils and supporting magnet construction

Generally, power consumption of resistive magnet is very high with corresponding demands on cooling efficiency. Inevitably, temperature of magnet rises until steady-state is reached.

Due to rise of coil temperature, coil material dilates. Magnet dimensions are linearly proportional to the temperature, therefore magnetic field is inversely influenced by this effect.

Temperature stability of magnet coils and supporting magnet construction

- In our case, coil is made of copper with $\lambda=16.10^{-6}$ °C^{-1} and temperature change is up to 1°C. Relative dilatation is 16 ppm.
- Moreover, one have observed step changes in magnetic field intensity, which are probably caused by the tension in magnet construction.

Current feedback performance

Critical parameters of current feedback control circuit are as follows:

- shunt resistor thermal coefficient
- reference voltage temperature drift
- differential amplifier input offset voltage drift and open loop gain
- instrumentation amplifier gain temperature dependence and input offset voltage drift

Supposing severe demands on the stability of current feedback control circuitry, the good way is to use the thermostatic housing with the temperature stability better than ±0.5°C

Magnet resistance

For temperature change of magnet by 1°C, it corresponds to relative change of resistance by 4%. To reduce influence of this change to less than 1 ppm, the loop gain has to be at least $6 \cdot 10^4$. Taking into account drifts in power distribution system (inrush currents of elevators, milling machines, airconditioners etc.), open loop gain of differential amplifier should be even much higher. This puts also requirements for the reaction time of the regulation circuitry.

Similar tasks – NMR-tomography

(but the long term stability required)

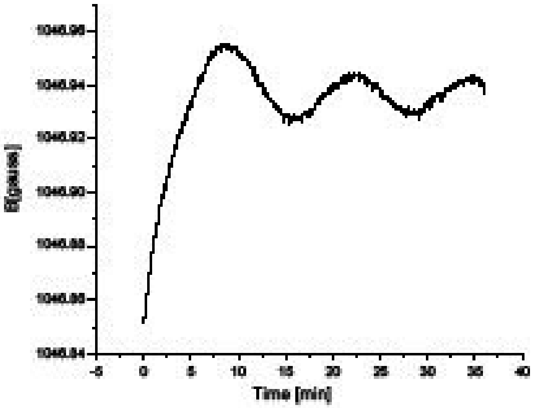


Fig. 2 Transition period of the static magnetic field B_0 as function of time

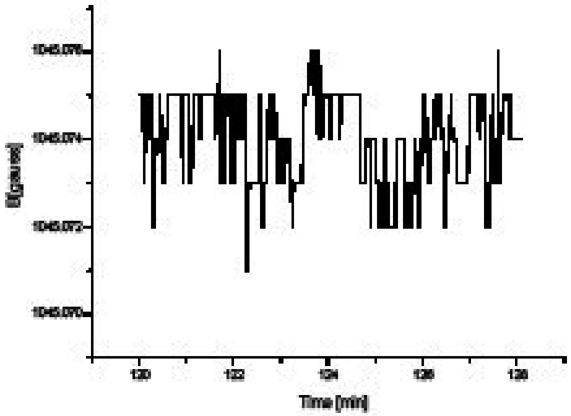
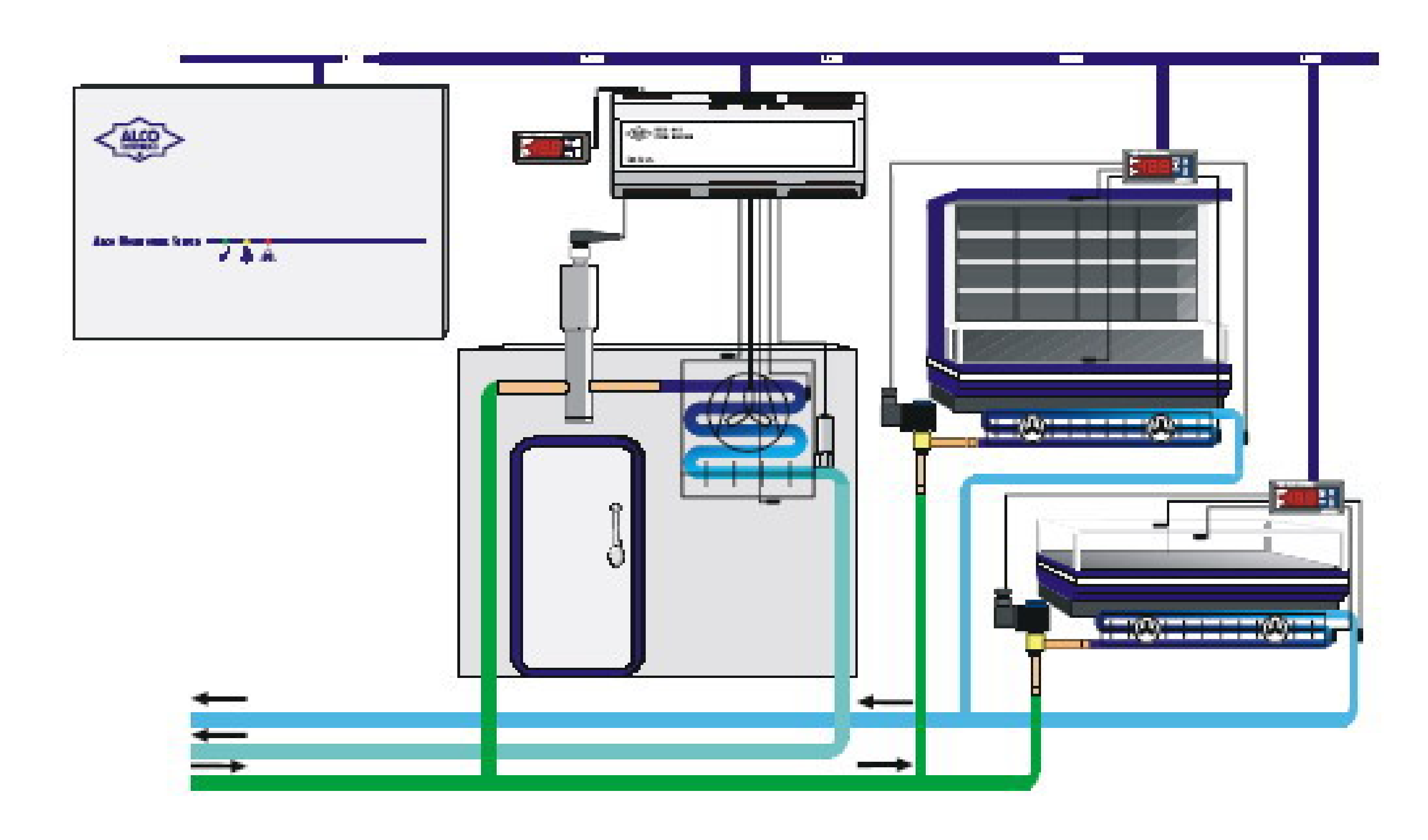


Fig. 3 Stabilized period of the static magnetic field B_0 as a function of time

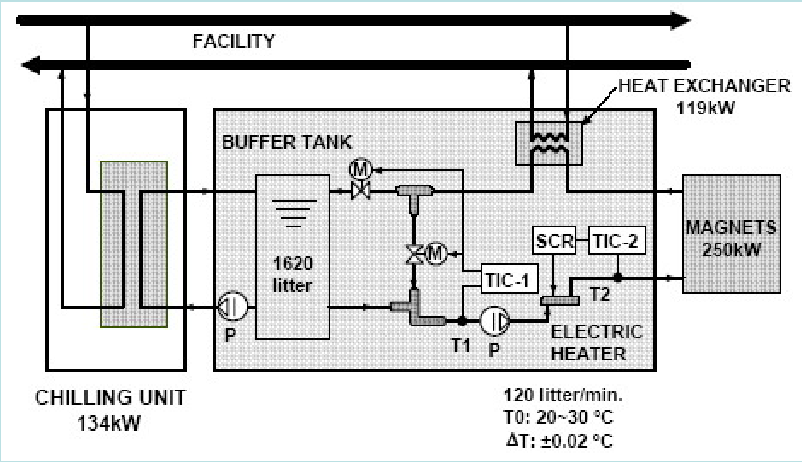
The examples of the typical time characteristics of the NMR-tomography magnets

Technical solutions



An example of thermo stabilization by the “ALCO controllers”

Technical solutions



Stabilization system with closed loop water contours for the magnetic elements.

[“DEVELOPMENT OF A TEMPERATURE CONTROL SYSTEM FOR LARGE SCALE ELECTRON-POSITRON COLLIDERS” M. Yoshioka, et al, APAC98.]

3. Current activity

We started the design of the thermo control of the magnet:

- Digital Voltmeter Keythley-2000 Scan
- Software for the temperature measurements
- The measurements of the long range temperature drifts

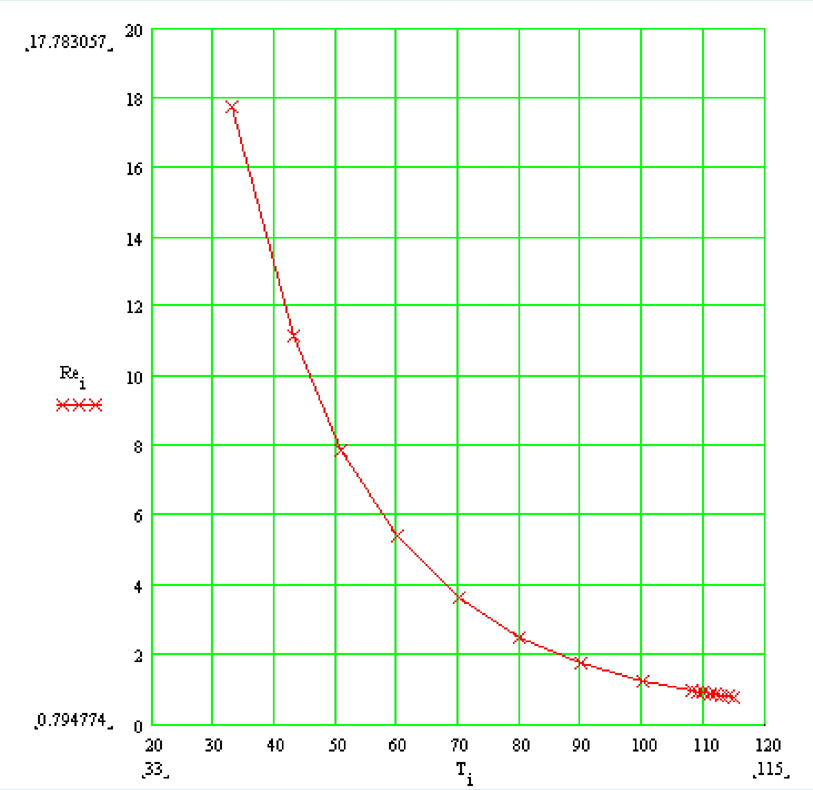
Keythley 2000 C

- a fast, accurate, and highly stable instrument
- 0.002% 90-day basic accuracy
- switch cards enable multiplexing up to 20 different input signals

Software (with V.Olshevsky)

- C++
- FreeBSD (Linux)
- RS-232 (RS-485) interface
- Commutation – measurement – write data
- Alarm (E-mail, SMS)

Thermistors (MMT-1, MMT-4)

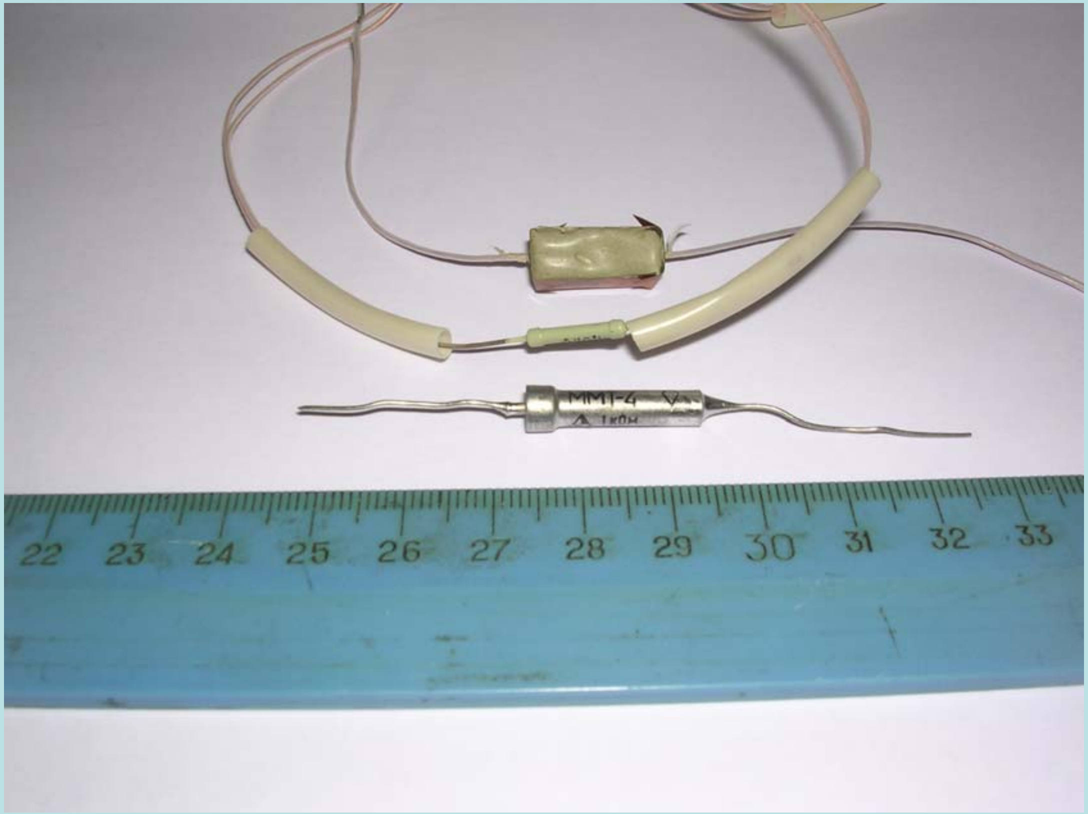


$$\alpha = -\frac{B}{T^2}$$

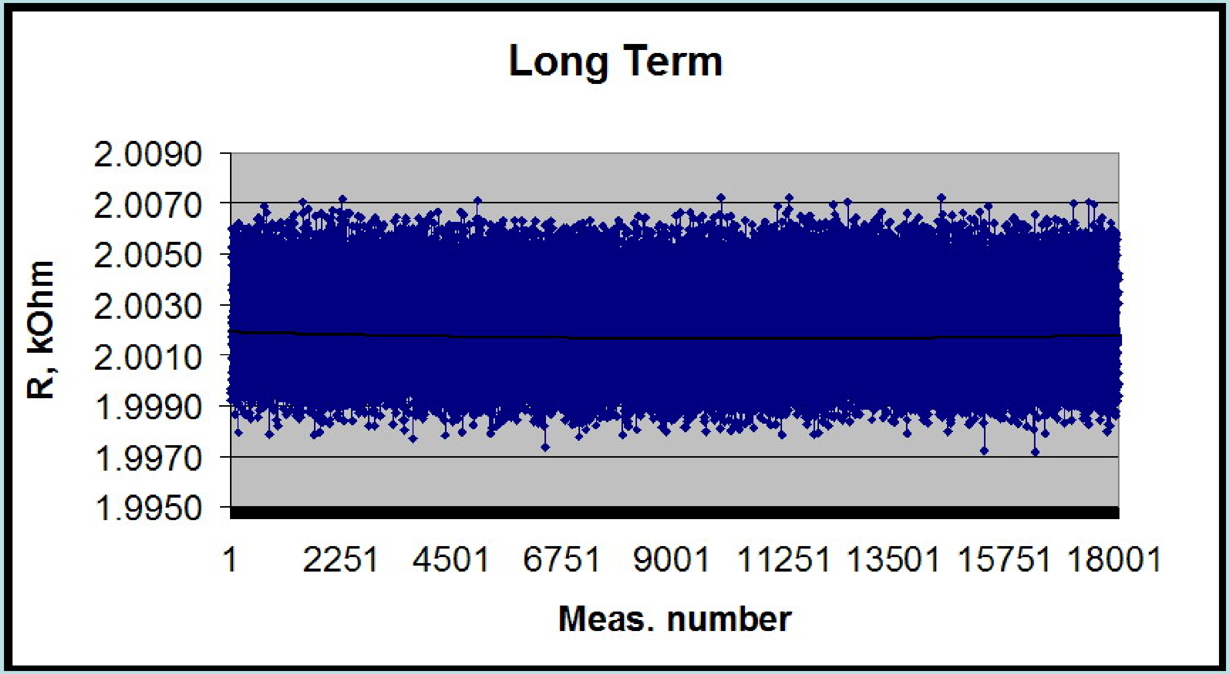
$$R_T = A\exp\left(\frac{B}{T}\right)$$

Typical graduation curve
(semiconducting metal-oxide)

Thermistors (MMT-1, MMT-4)

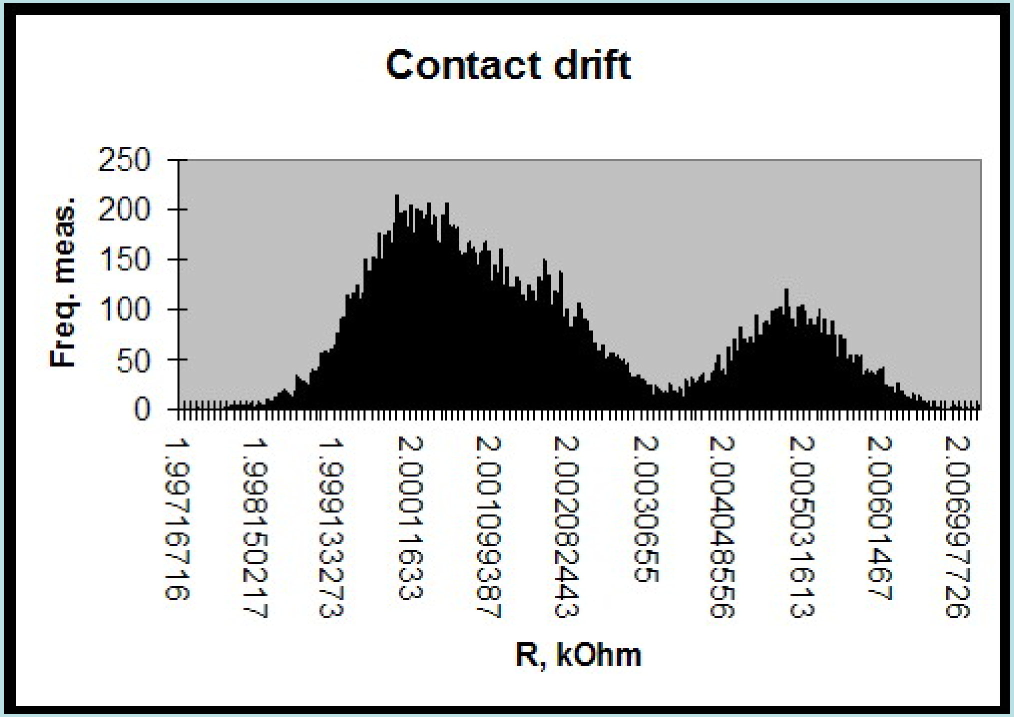


Some results



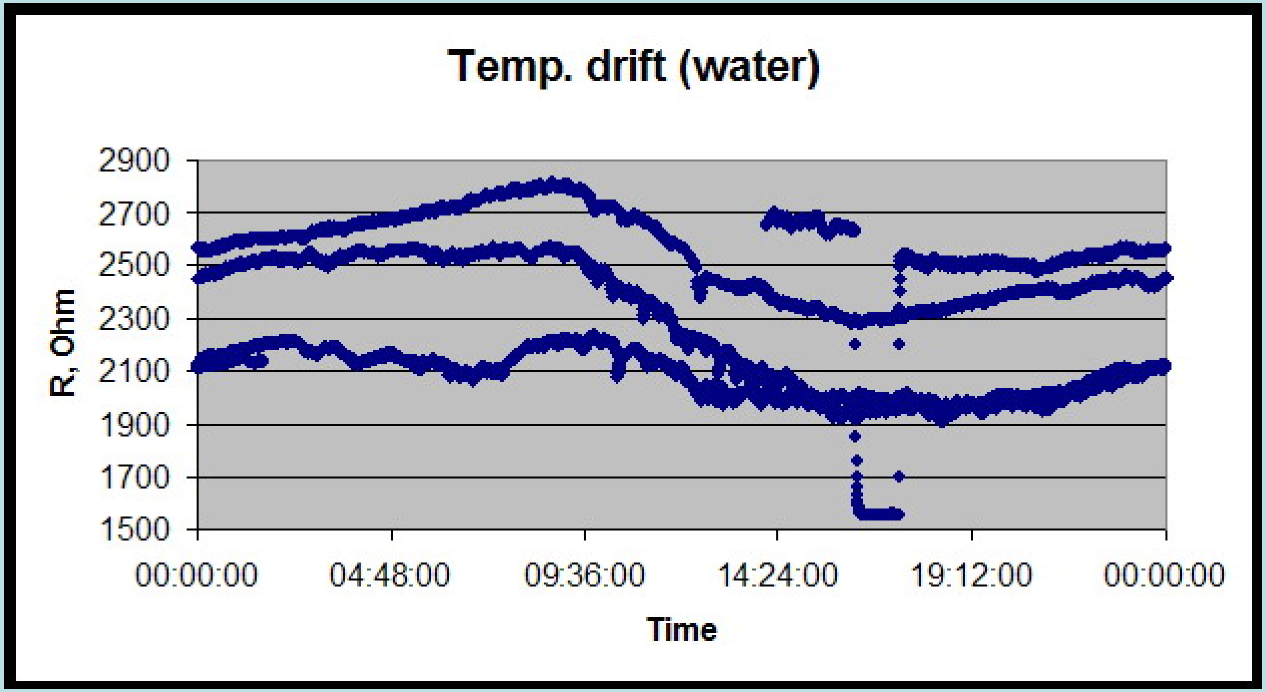
Study of the multiplexer with a stable resistor – good for the thermistors

Some results



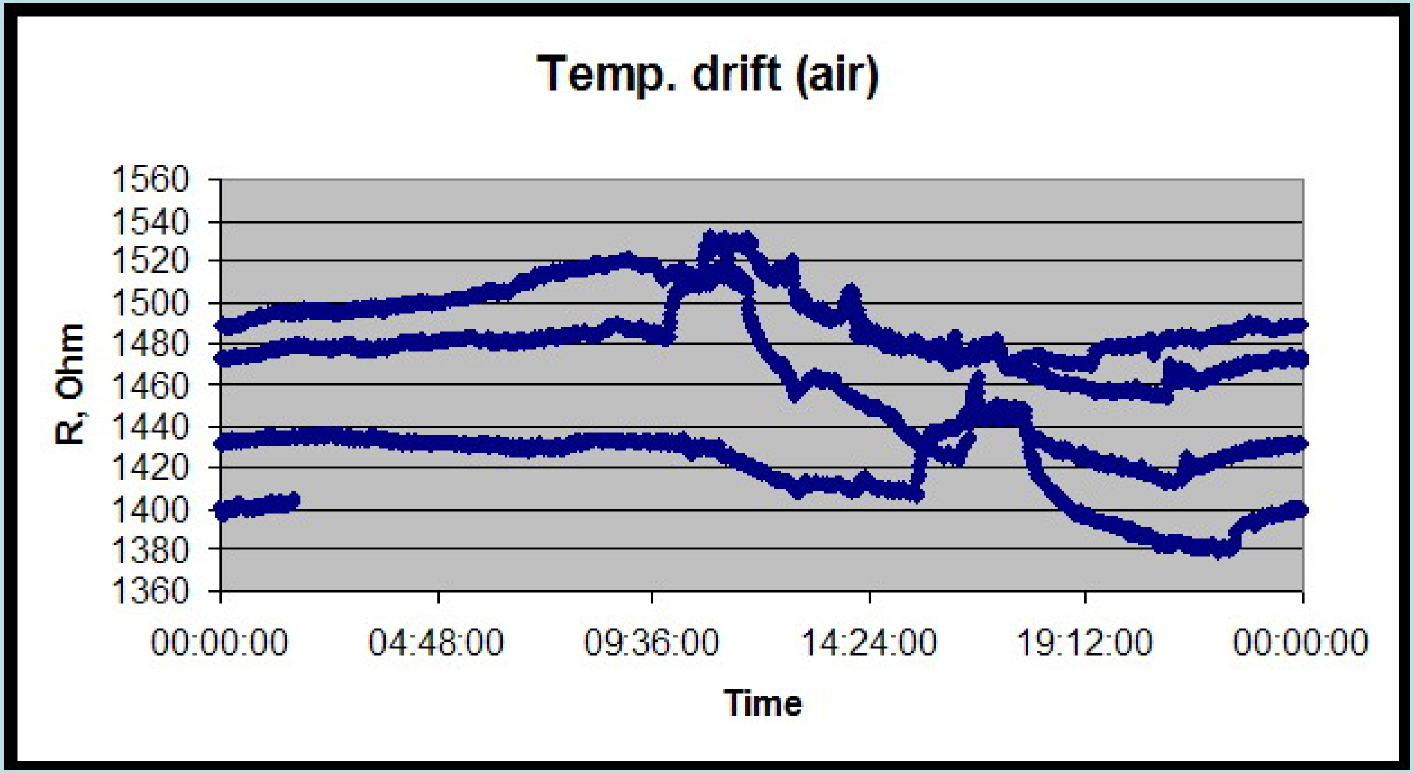
A thermistors (MMT-1) and a stable resistor

Some results



4-Day measurement of the water temperature without stabilization 12 – 15 ^{0}C

Some results

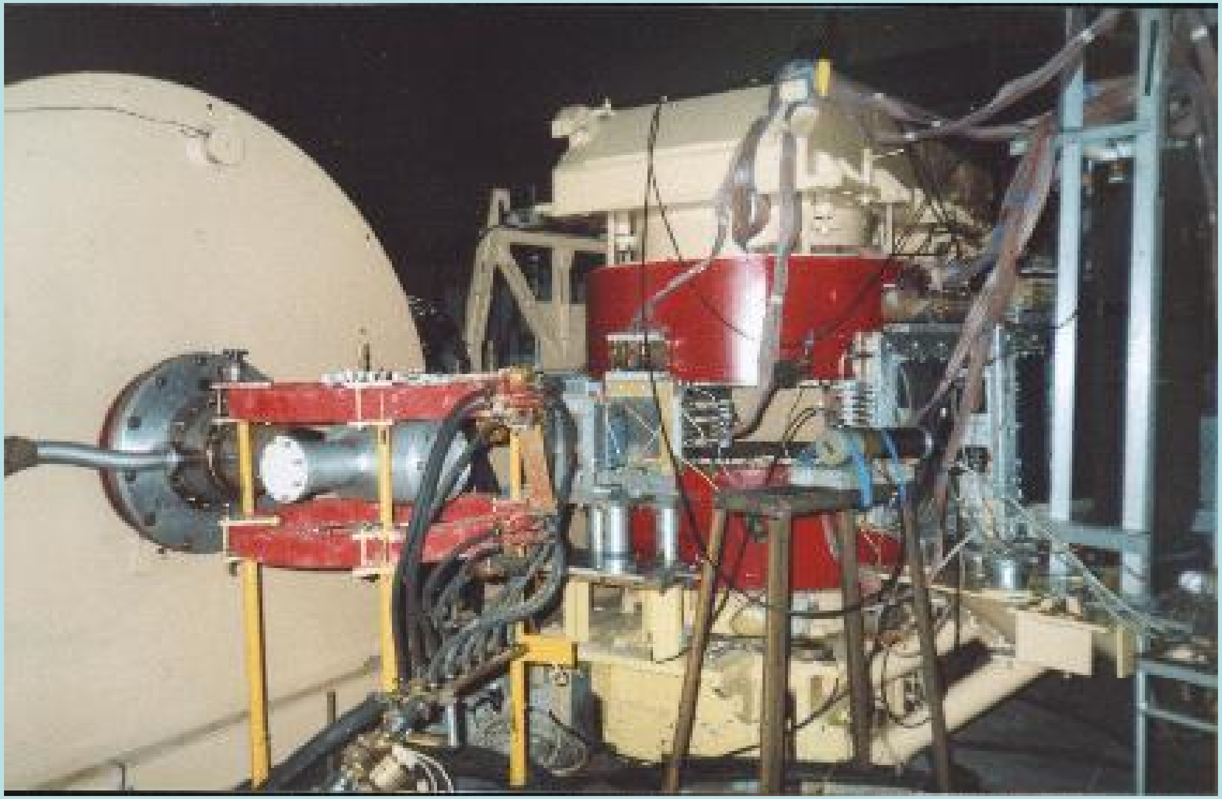


Simultaneous 4-day measurement of the air temperature in the room. (16 – 19 ^{0}C)

4. Plans

We suppose:

- to reincarnate our magnet(s)
- to stabilize the magnet temperature



Perspectives

Non contact thermometry

- *Good progress*
- *ROI option available*

Perspectives

Detector Unit	Temperature and Spectral Configurations:	Standard: See table on Page 2 for Options
	Measurement Accuracy:	±2% or 2°C of reading
	Field of View:	21°(H) x 16°(V)
	Focus Range:	30 cm to infinity
	Instantaneous FOV:	1.2 mrad
	Detector:	320 x 240 Uncooled Focal Plane Array (Microbolometer)
	Image Update Rate:	30 Frames/sec
	Sensitivity/NETD:	0.06°C @ 30°C
	A/D Resolution:	14 bit
	Ambient Correction:	Provided (Including interval NUC)
	Interface:	100 Base T Ethernet

Sensitivity/NETD: 0.06°C @ 30°C

Thank you!