Comparison of Arepoc and Sentron Hall Sensors using Undulator A at the APS Magnetic Measurement Facility

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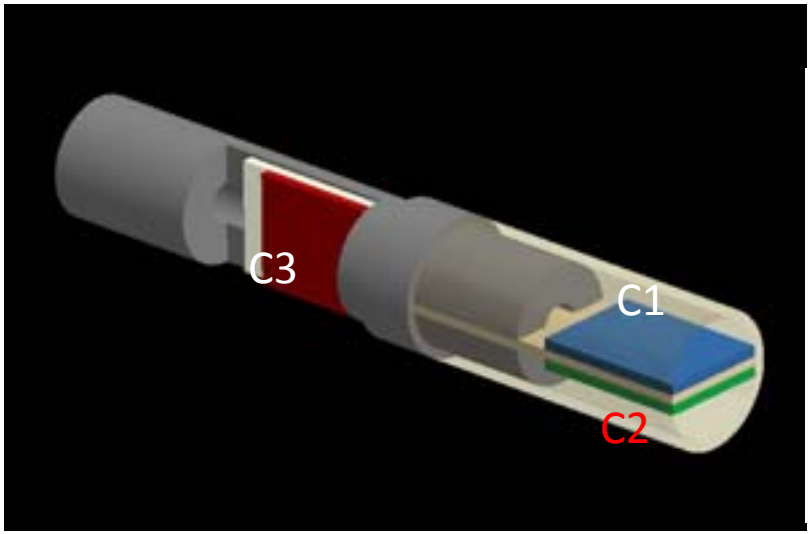
Introduction

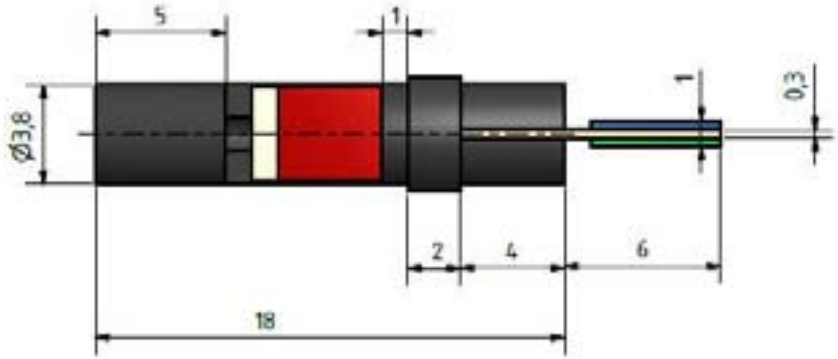
- Arepoc 3 sensor Hall probe was used for this test.
- The calibration of Hall sensors from Arepoc s.r.o. indicates that their sensitivity is strongly dependent on temperatures above 250 deg K.
- The sensor's temperature, on the other hand, is a function of the magnetic field, because the sensor's resistance depends on the strength of the magnetic field [1] (see slide 5). Therefore calibration results can be directly applied only if the calibration and operation environments are identical. But during ID magnetic measurements, a Hall sensor is exposed to rapidly changing strengths of the magnetic field, while the calibration process utilizes static fields and therefore stable temperatures.
- Some Hall sensors, such as a Sentron probe, are integrated with a circuit that compensates for the variation of the Hall voltage signal from the temperature variation. Therefore, the Sentron probe could be used as a temperature-independent standard for non-compensated probes.

Introduction(cont)

- A short 33-mm period device was used for the test, L=2 m.
- Gap 11.5 mm, B (effective)=0.81 T.
- Calibration files were used for both C1 and C2 sensors for temperature T=299.7 K. Real temperature was 296.7 K.
- The most challenging option was used for this test: all three sensors were powered on.
- A conversion script to calculate the median plane field from two separated in Y sensors was created and tested.

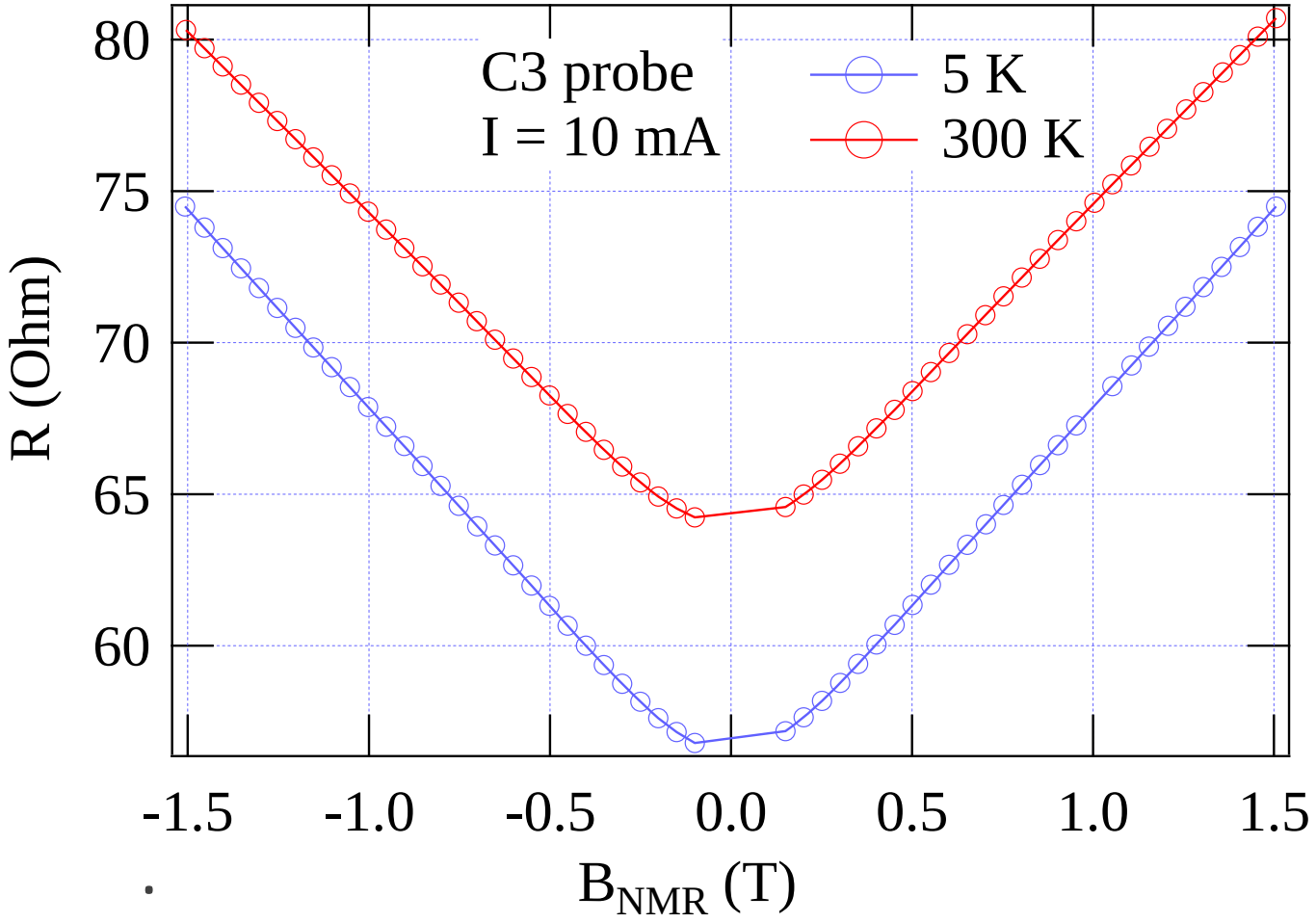
Arepoc 3 sensor Hall probe



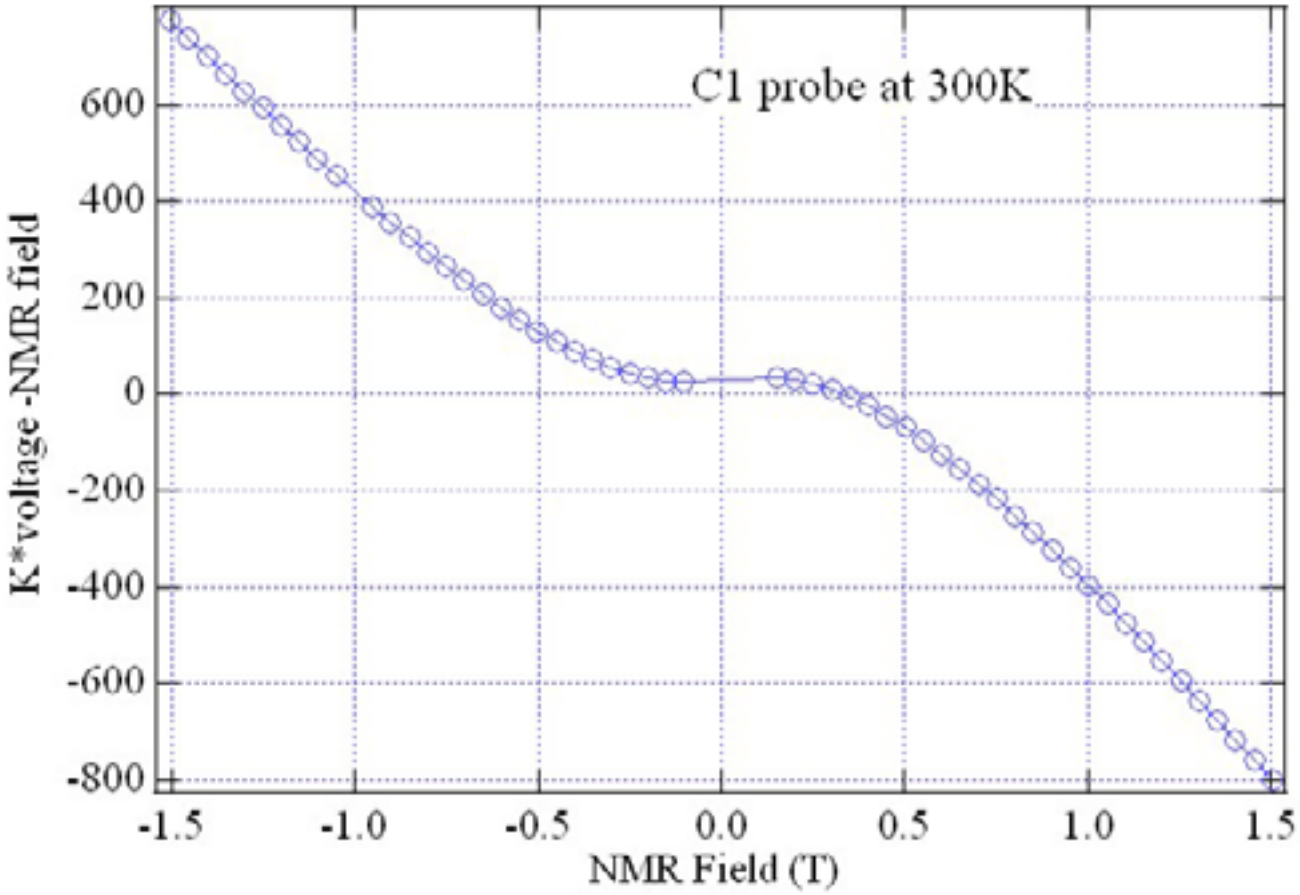


C1, C2: vertical field sensors; C3: horizontal field sensor, temperature sensor is located close to C3 probe.

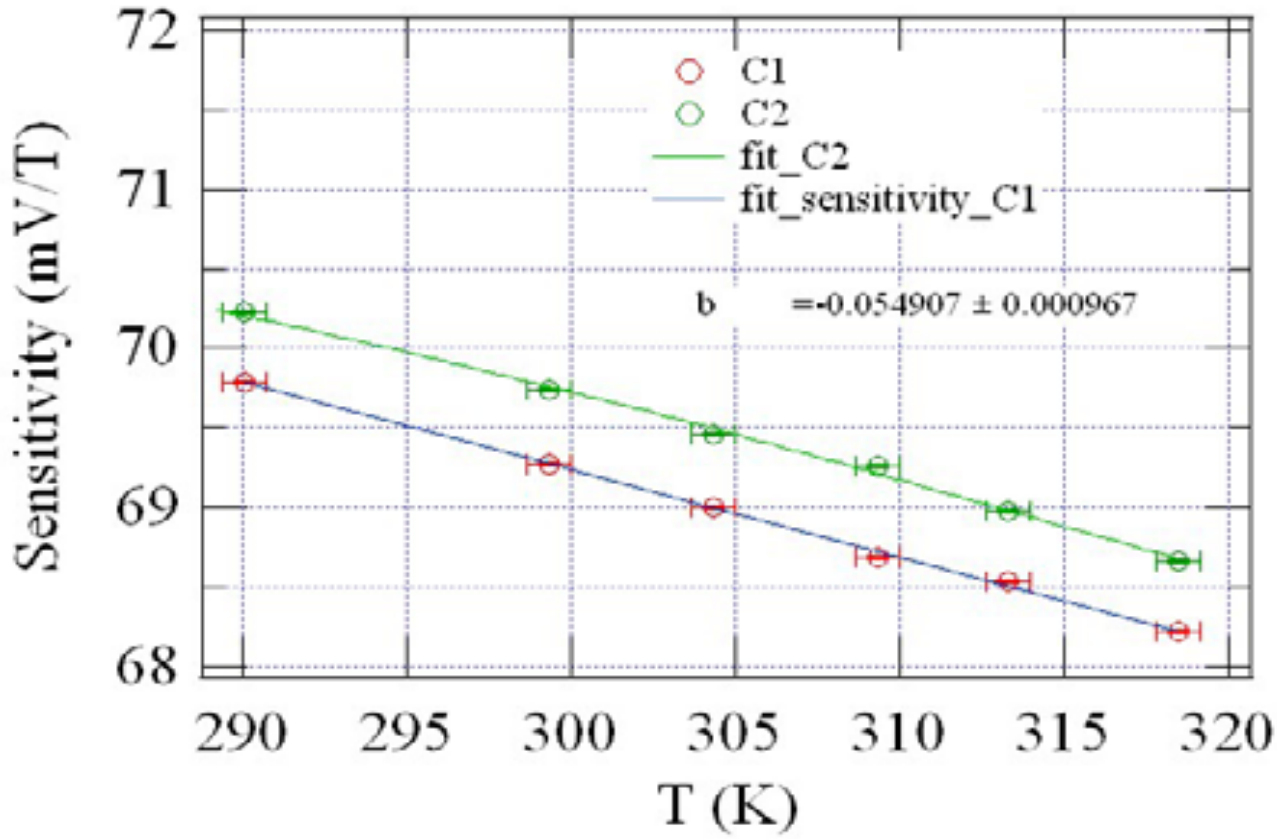
Magnetoresistance of Hall sensor vs. field [2]



Calibration result of Hall Sensor



Vertical Field Sensor Sensitivity vs. T



From linear fitting:

$U=U_0+b*T$

$U-U_0=b*T$

$(U-U_0)/T=b=-0.55$

$(U-U_0)/T/U_0=$

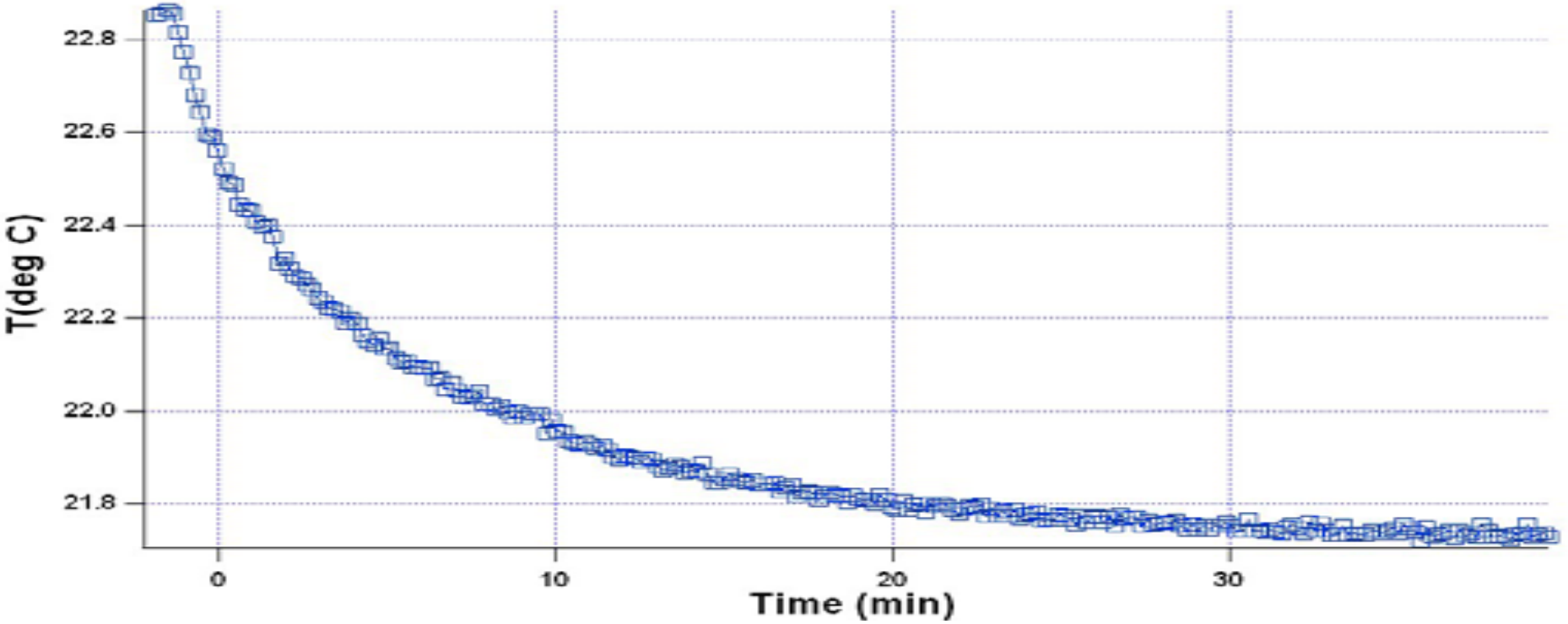
$-0.055/69=0.08\%$

Linear fitting is done in the region of temperature 290<T<320.

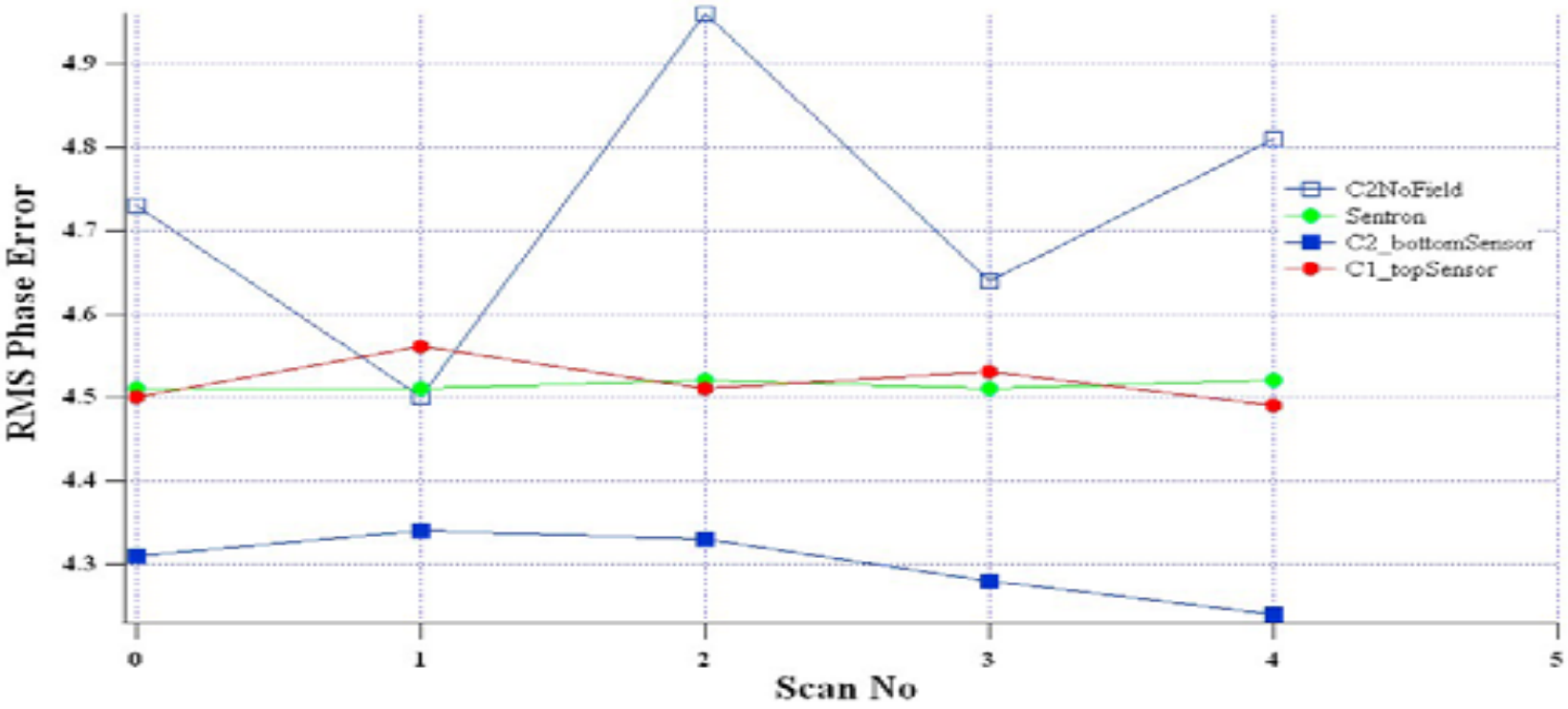
Change of the sensitivity is 0.08% per 1 degree K.

All 3 sensor power is switched off

Temperature of Hall probe vs. time



RMS phase errors for different probes and initial conditions



For all Arepoc scans, except C2NoField, start point is half-field location. C2No field start point is no-field location.

Two sensor Hall probe

- It will be difficult to know the vertical position of the Hall sensor when it is being used to measure the field of the superconducting undulator [3].
- We calculate the actual vertical position of the Hall sensors and the field in median plane by using two sensors separated vertically by a gap ΔY.
- Assuming that the field profile in the vertical direction is known, one can find the exact position of the sensors and magnetic field in the median plane by solving the following system of equations:

$$B_{1y} = B_0 \cosh(2\pi Y_1/\lambda)$$

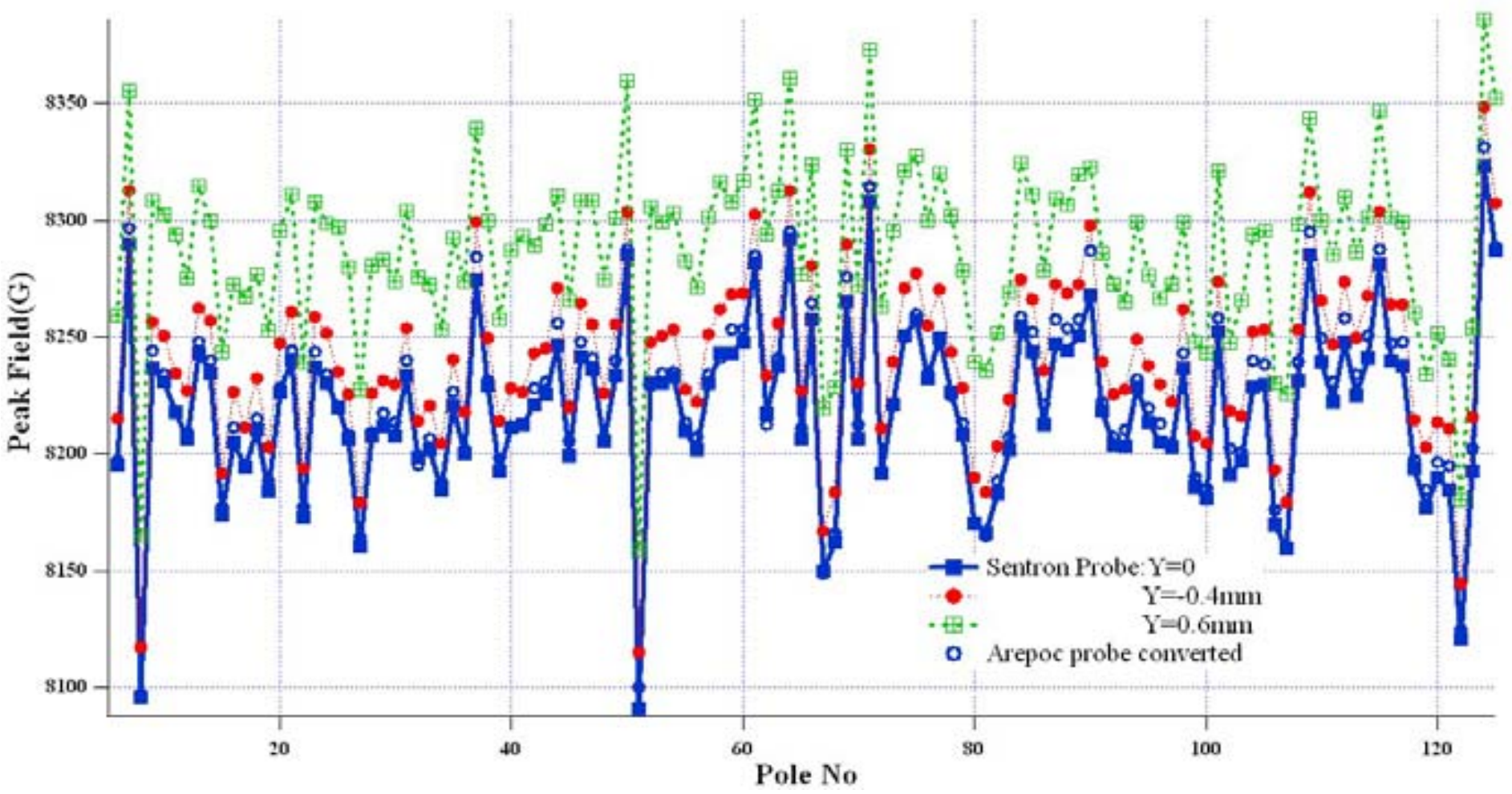
$$B_{2y} = B_0 \cosh(2\pi Y_2/\lambda)$$

$$Y_2 = Y_1 + \Delta Y$$

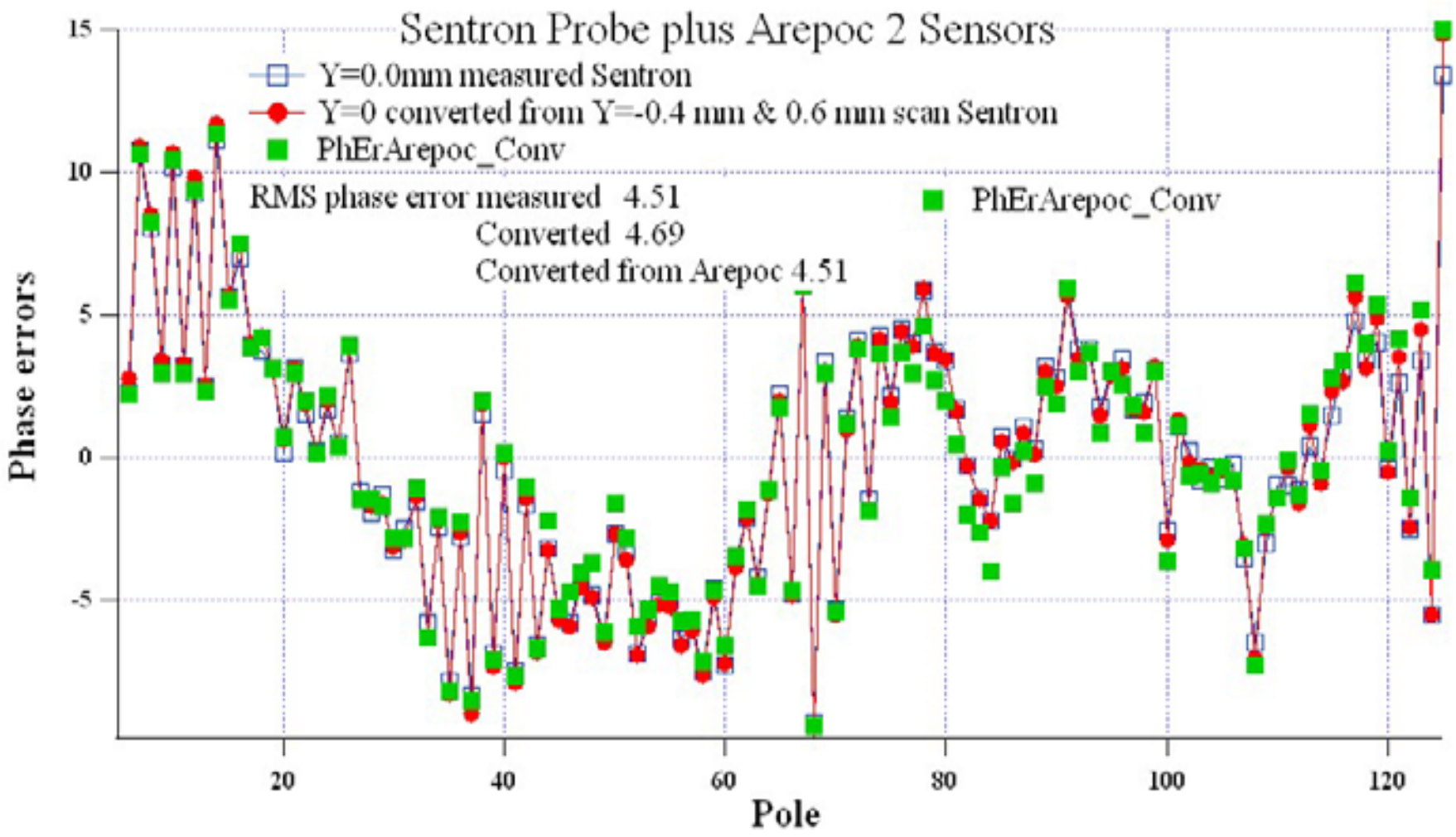
  Where B_0 is the field in the median plane
- A special script was written to convert the data of the scan from these two sensors to the median plane.
- The results are shown below.

Conversion to the median plane

Sentron & Arepoc probe data for peak field



Conversion to the median plane (cont)



Discussion

- B effective:

  Sentron probe: 8101G

  C1 and C2 after conversion: 8115 G

- Temperature difference 3 deg C (measurement – calibration).

  Difference in the field:

  0.08%*3*8100=19 Gauss.

  Measured difference with Sentron probe is 8115-8101=14 Gauss

- Very minor differences between phase errors in median plane and out of plane
- It may change for SC device with shorter period (16 mm vs. 33 mm)

Conclusion

- It takes about 30 min for temperature stabilization of all of the Arepoc 3 sensors after power is on. This is the time to wait before to start any measurements, otherwise phase errors measurements can go up to 16° instead of 4.5° real number.
- Measurements performed after stabilization show some small dependence on the initial start position of the probe. The best option to choose is the location with B=1/2 B(max), which is close to the average field during the scan.
- The probe is ready to use.

References

[1]R. S. Popovic "Hall Effect Devices/ Second Edition," Institute of Physics Publishing, Bristol and Philadelphia, IOP Publishing, LTD, 2004.

[2] M. Abliz, I. Vasserman et al., "Temperature-Dependent Calibration of Hall Probes at Cryogenic Temperature" PAC 2011, New York, March, 2011.

[3] Y. Ivanyushenkov et al., "Status of R&D on a Superconducting Undulator for the APS" PAC 2009, Vancouver, May, 2009.