The development and performance of high current shunts (> 20 A....100 A / 100 kHz) for power measurement

Dissemination Meeting „Power & Energy“, Noordwijk

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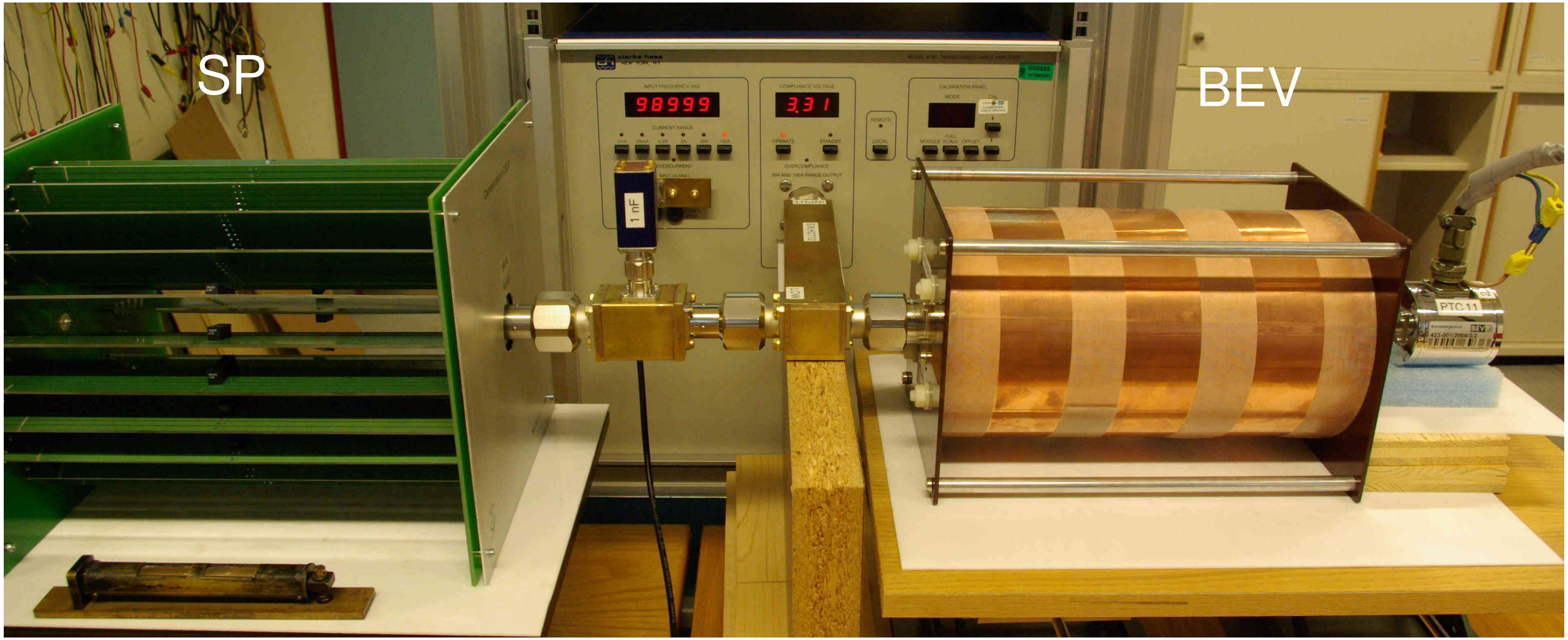
Outline

Start April 2008: existing shunts for ac-dc
existing measurement methods

development of new measurement methods

BEV part:
development of foil shunts for power measurement
mechanical modification
measurements

April 2008: starting point



SP: Cage Design
ac-dc ~ - 50 µA/A

BEV: Foil Design
ac-dc ~ + 50 µA/A

measurement capabilities:

existing:

BEV: ac-dc
SP: ac-dc, dc, phase up to 1.500 Hz calculated from L and C

new developed measurement methods:

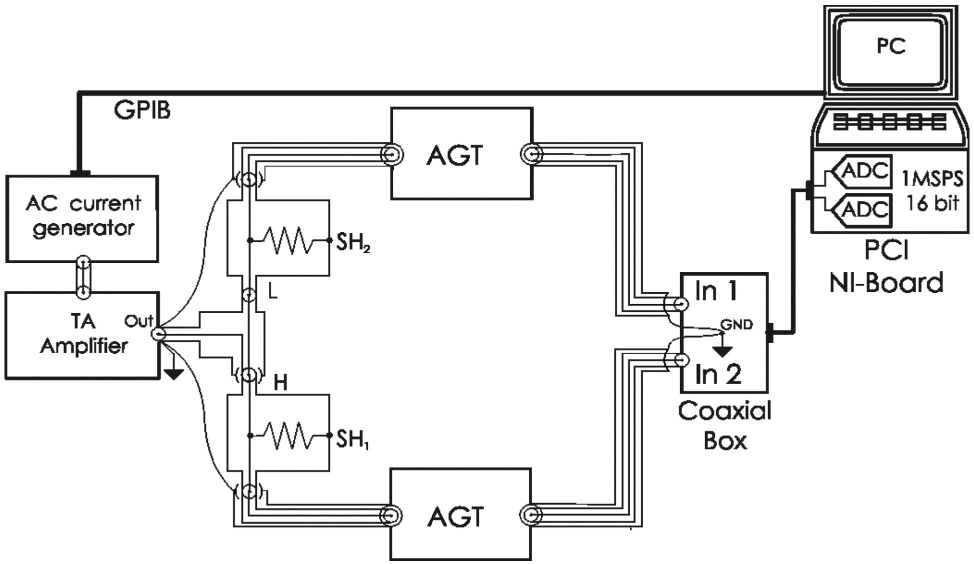
INRIM: phase angle error
CMI: TCR (temperature coefficiant of resistance)
PCR (power coefficient of resistance)

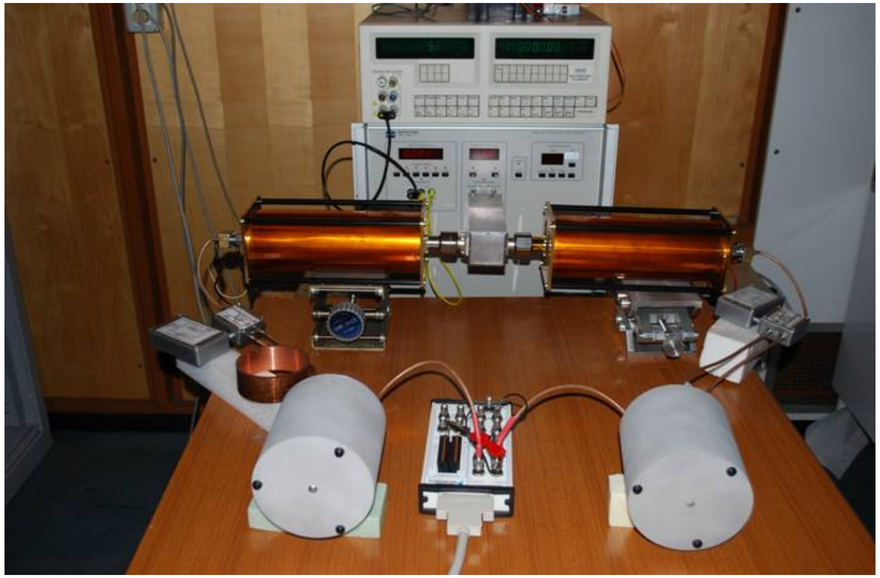
work in progress:

SP: expanding L to pH and 100 kHz
PXI phase comparator
CMI: impedance

Phase comparator

A phase comparator was built for the measurements of phase differences between two shunts.





Basic circuit of the phase comparator. SH_1 and SH_2 denote the two shunts being compared. Two active guarded transformers (AGTs) are employed as wideband decoupled precision transmitters.

The current generator was assembled by connecting a calibrator in the ac voltage function that supplies a transconductace amplifier.

ISTITUTO NAZIONALE DI RICERCA METROLOGICA

DC characterization of the shunts

- Method: **measurement of ratio of output voltages of the tested and the reference standard** by dual channel multimeter

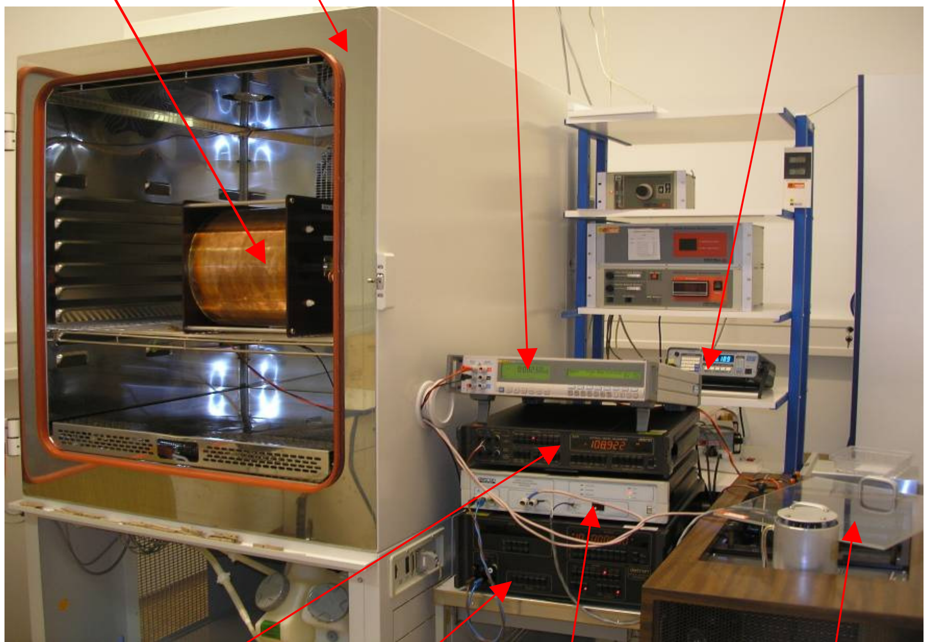
$$R_X = \frac{U_X}{U_E} \cdot R_E$$

- PC measured and calculated **in current range of 50% - 100% of nominal current**
- TC measured **in temperature range from 18 °C up to 28(30) °C at 1/10 of nominal current**

- **Typical values for foil shunts:**

PC < ± 4 ppm
TC from -2.8 ppm to +8 ppm

Set up for TC measurement



motivation for new foil shunts

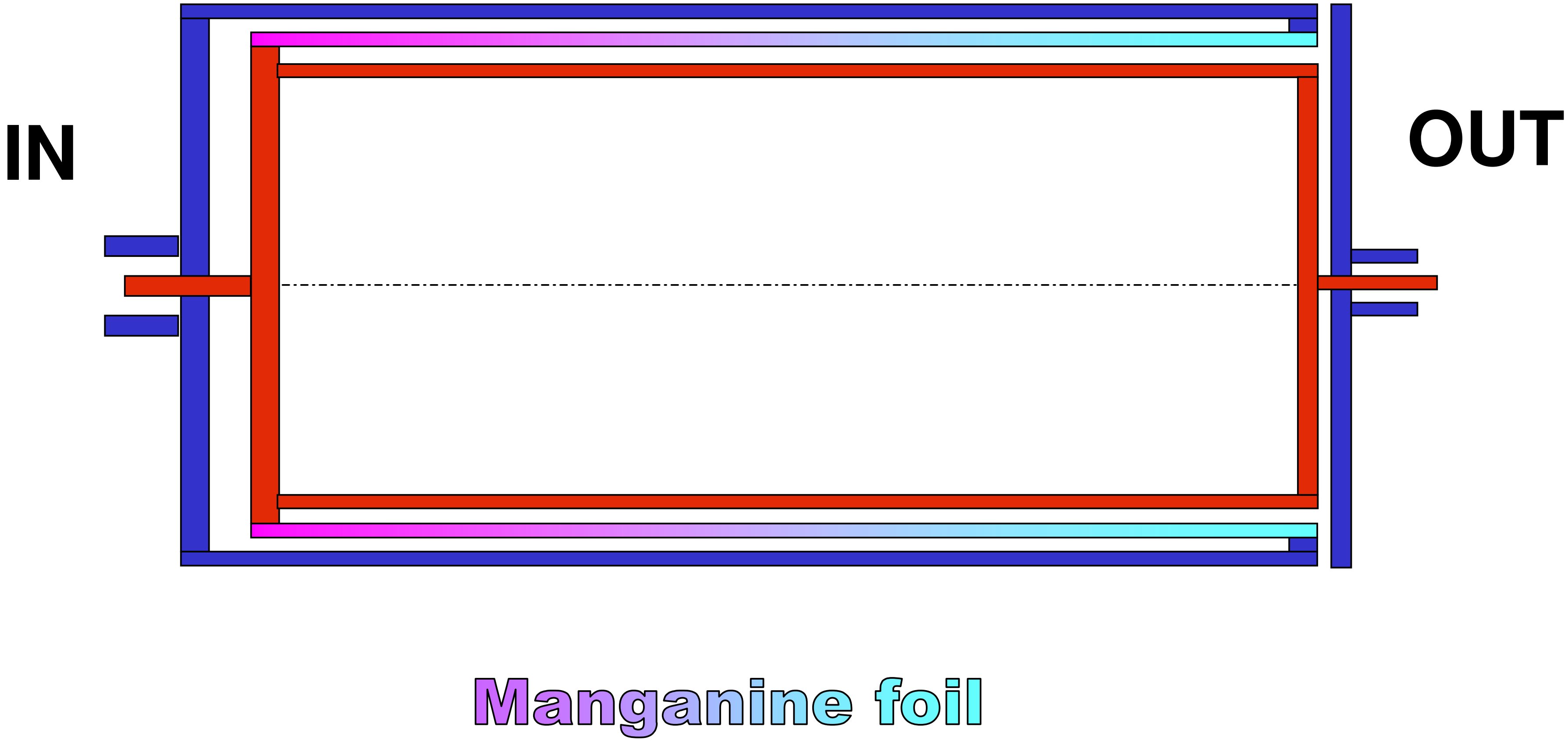
„Old design“

- very heavy units (28.5 kg for 100 A)
- long warmup time (~ 2 hours)
- dc properties not satisfying
- very time- consuming fabrication

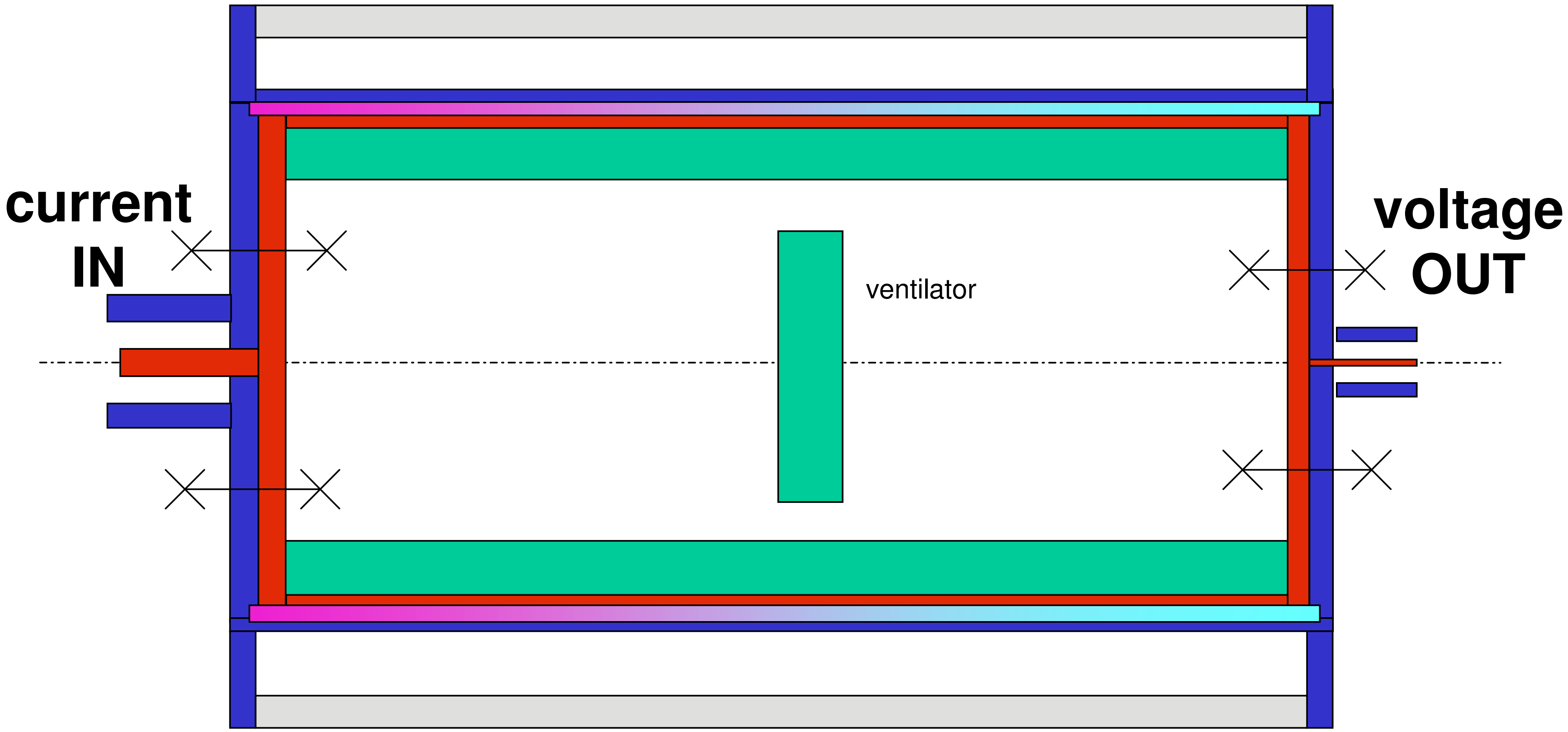
„New design“

- reduced weight (2.9 kg for 100 A)
- warmup time ~ 10 min
- dc property?

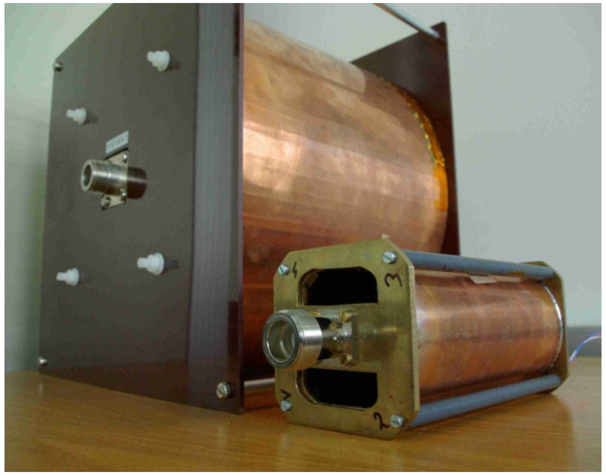
foil shunt - principle

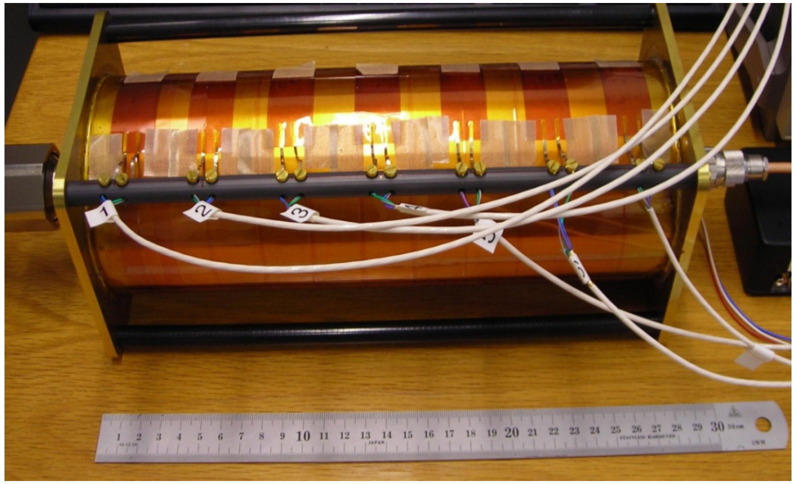


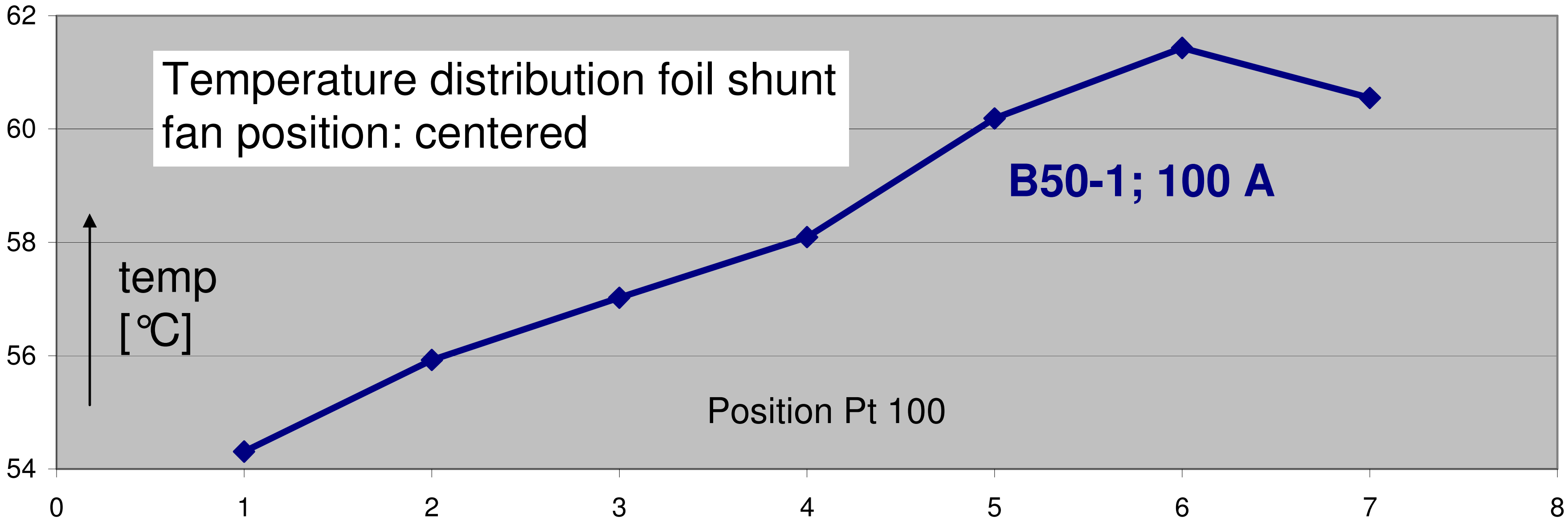
mechanical modification



temperature distribution forcerd air cooled foil shunts

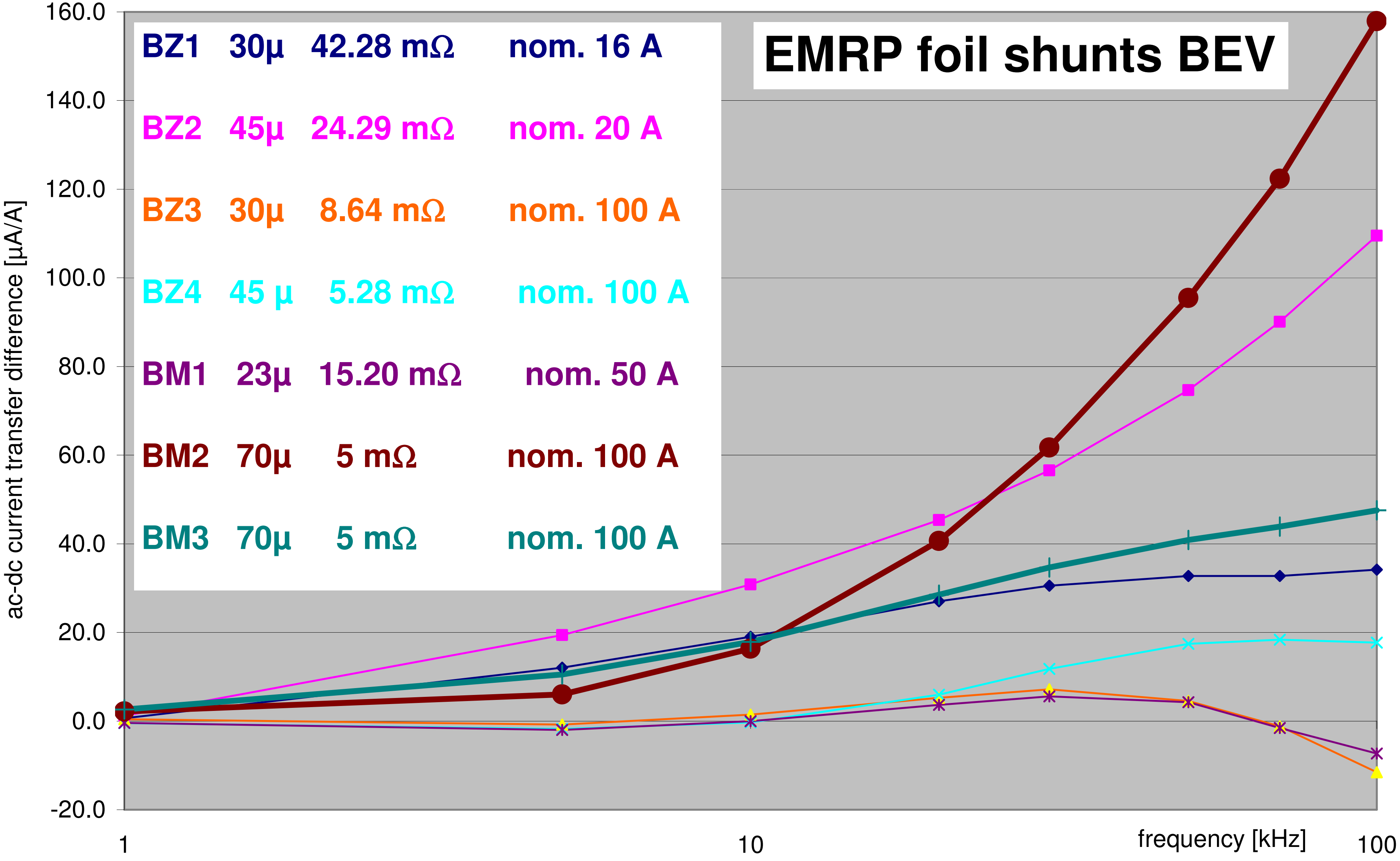




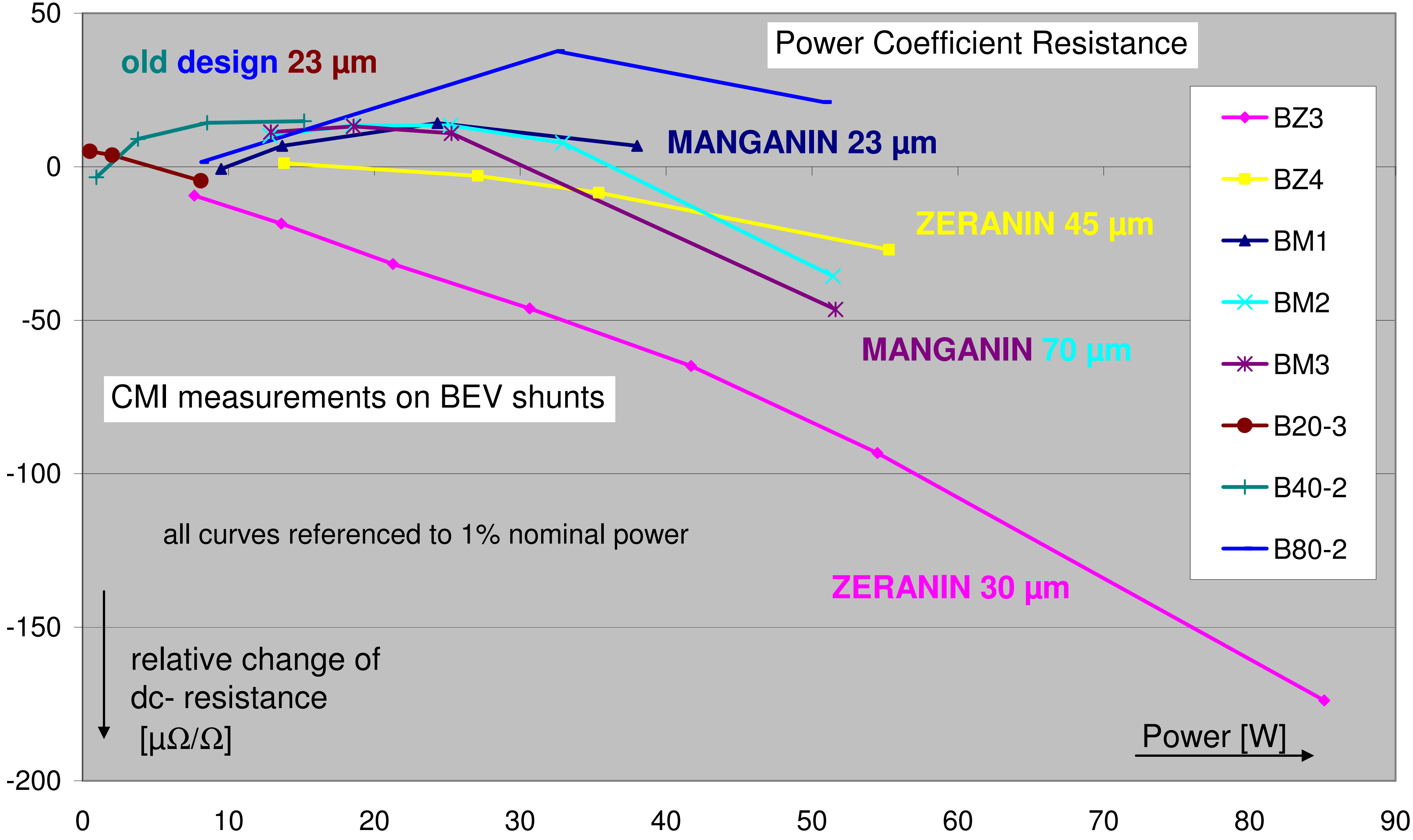


EMRP Coaxial Foil Shunts

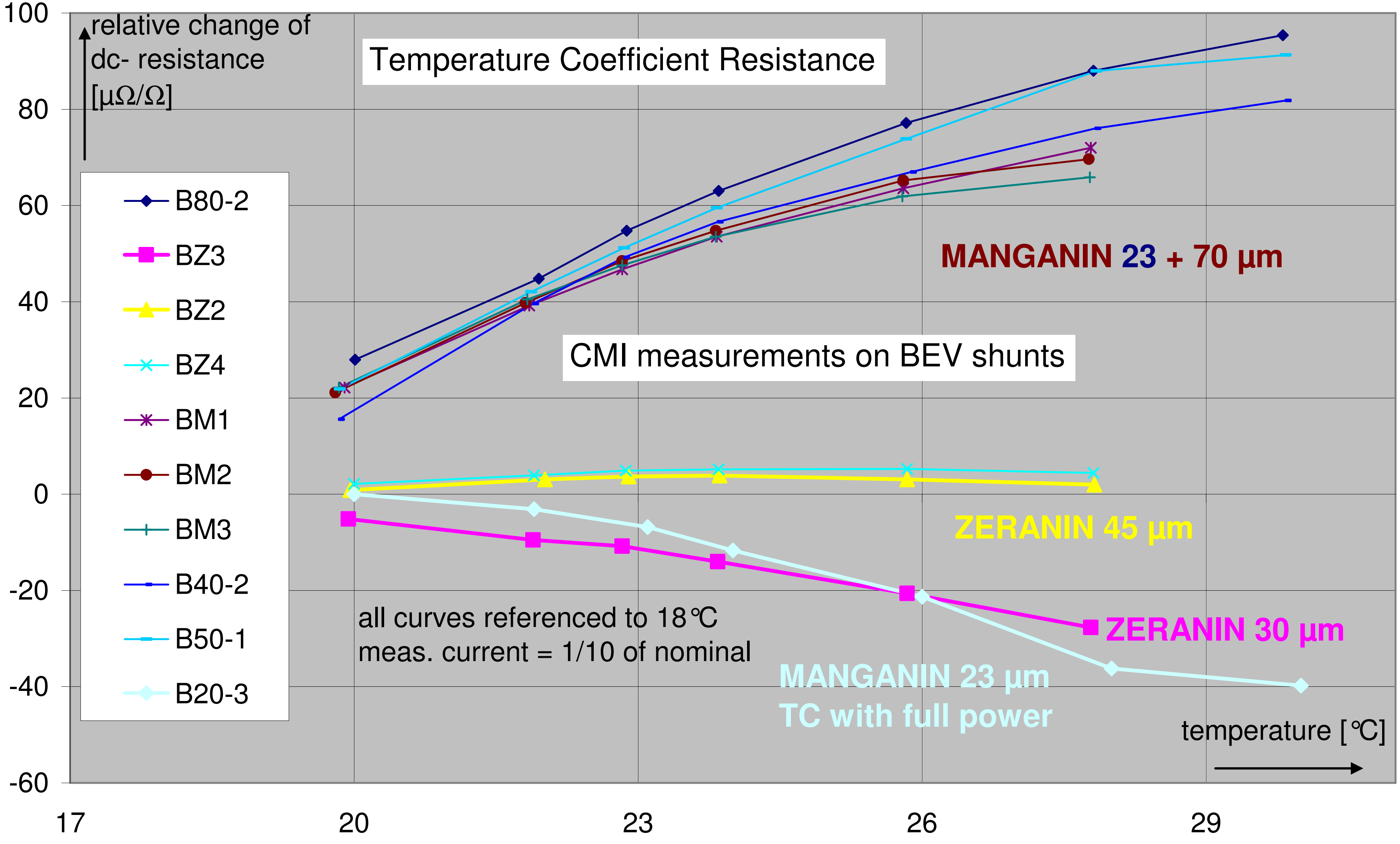
coaxial foil shunts ac-dc values



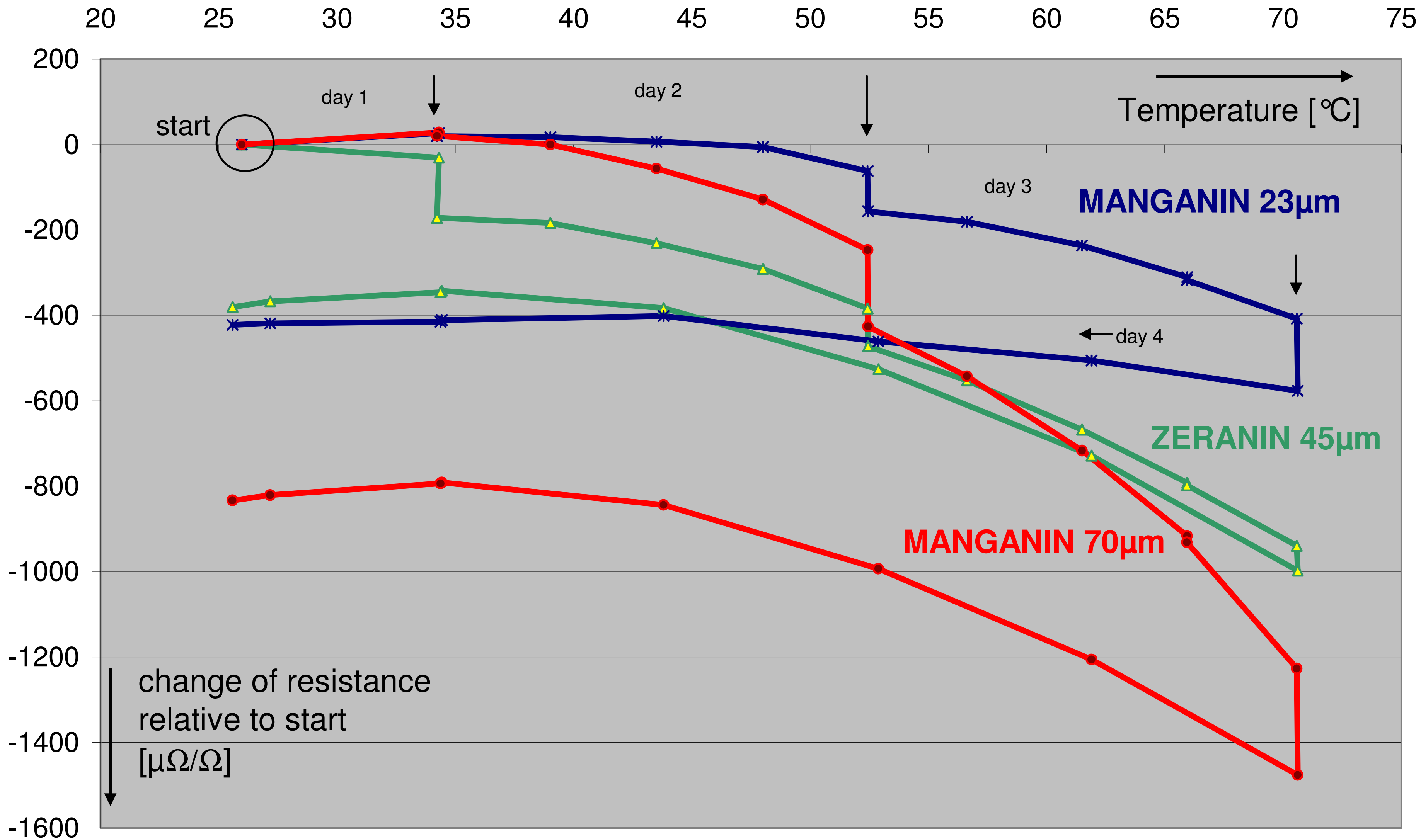
DC - Power Coefficient



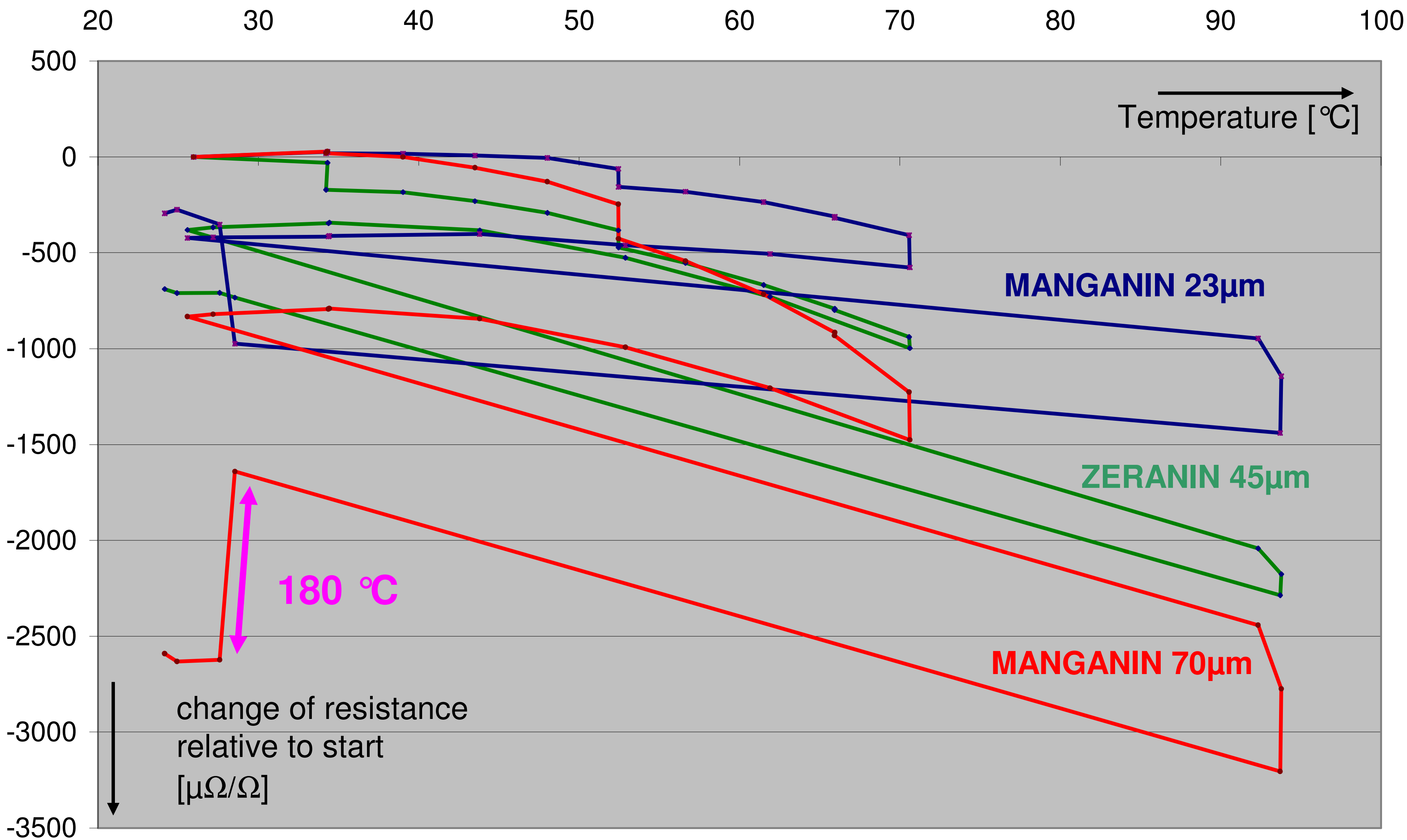
DC - Temperature Coefficient 20...30 ℃



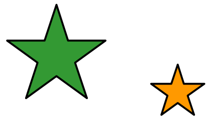
Temperature Coefficient 20...70 °C



thermal treatment



cage design versus foil design (>20 A...100 A)

	ac-dc	dc	phase
Cage Design			
Foil Design 			

<u>Measurements performed:</u>

BEV: ac-dc; some dc

CMI: dc temperature + power coefficient; impedance measurements

INRIM: phase angle error measurements

SP: ac-dc; inductance; phase