THM$\overline{\text{P}}$ and Temperature Sensor Production

Miriam Kümmel

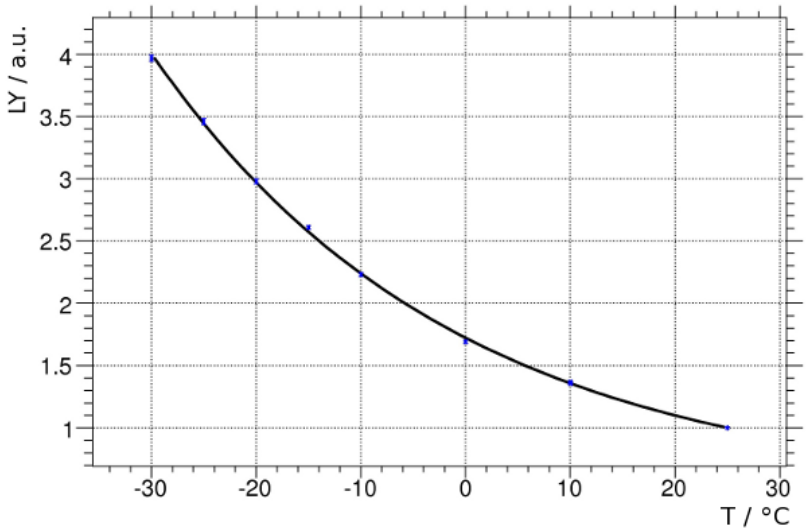
Ruhr-Universität Bochum
Institut für Experimentalphysik I

LIX. $\overline{\text{P}}$ANDA-Collaboration Meeting
December 2016

RUHR UNIVERSITÄT BOCHUM RUB

Why and How Do We Measure Temperatures?

PWO-II: LY depends on T with $\frac{d(LY)}{dT} = 3\,\%/°\mathrm{C}$ at -25 °C



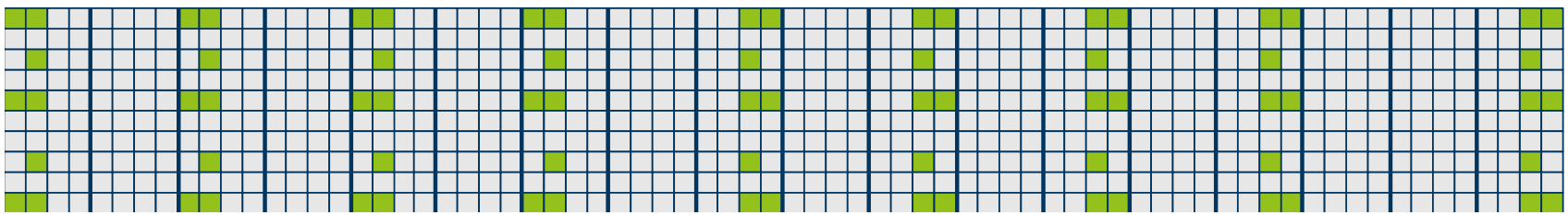
- Goal for $\overline{\mathrm{P}}$ANDA: $\Delta T < 0.1\,°\mathrm{C} \rightarrow$ sensors with $\sigma_T < 0.02\,°\mathrm{C}$
- R vs T relation of platinum quite linear

$$R(T) \approx R(0\,°\mathrm{C})(1 + \alpha_{\mathrm{Pt}} \cdot T), \quad \alpha_{\mathrm{Pt}} = 3.89 \cdot 10^{-3}\mathrm{K}^{-1}$$

- Accuracy for temperature sensors translates to accuracy for the THM$\overline{\mathrm{P}}$: $\sigma_R \approx \frac{\partial R(T)}{\partial T} \cdot \sigma_T \approx 7.8\,\mathrm{m}\Omega$

Status of Temperature Sensor Production

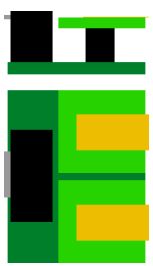
- Need:
  - 482 temperature sensors designated for forward endcap
  - 1152 temperature sensors designated for barrel (72/slice)
    (Mainz is taking care of backward endcap)



positioning by Markus Moritz

Status of Temperature Sensor Production

- Need:
  - 482 temperature sensors designated for forward endcap
  - 1152 temperature sensors designated for barrel (72/slice)
    (Mainz is taking care of backward endcap)
- Status:
  - 613 temperature sensors produced
  - 545 temperature sensors calibrated (uptodate setup!)
    (64 shortcut / bad connection)
  - 83 high quality sensors provided for test slice (11 spare)
  - Adapter boards for test slice designed and printed,
    currently equipping with connectors

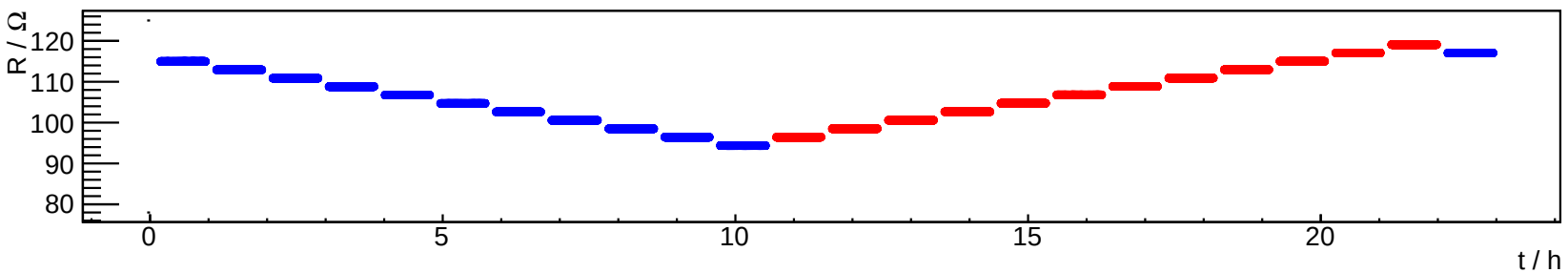


Status of Temperature Sensor Production

- Need:
  - 482 temperature sensors designated for forward endcap
  - 1152 temperature sensors designated for barrel (72/slice)
    (Mainz is taking care of backward endcap)
- Status:
  - 613 temperature sensors produced
  - 545 temperature sensors calibrated (uptodate setup!)
    (64 shortcut / bad connection)
  - 83 high quality sensors provided for test slice (11 spare)
  - Adapter boards for test slice designed and printed,
    currently equipping with connectors
- Keep running:
  - Sufficient amount of platinum wire bought and delivered
  - Boards (plugs) ordered
  - Inviting offers for copper coated polyamid foil (ultrathin wires)

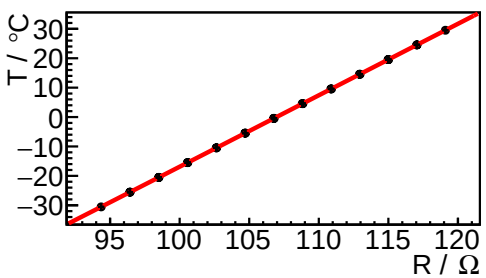
Quality Assurance

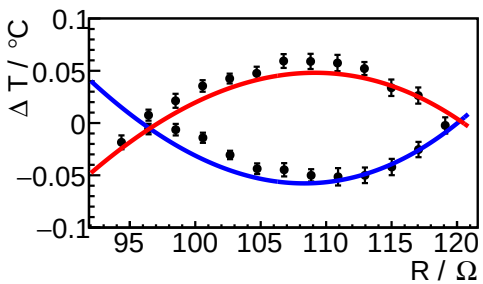
- Data selection: Consider all data except
  first 10 minutes after change of temperature set value
- Split the data into two sets to respect hysteresis

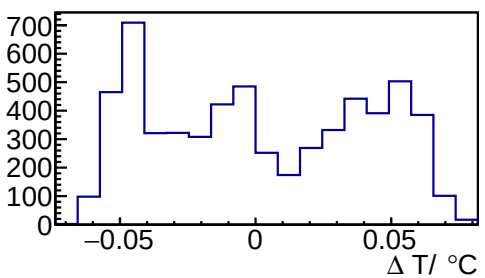


Quality Assurance

- Data selection: Consider all data except
  first 10 minutes after change of temperature set value
- Split the data into two sets to respect hysteresis

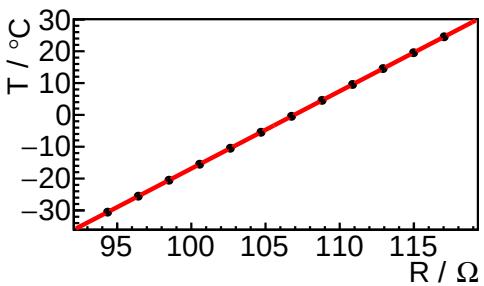


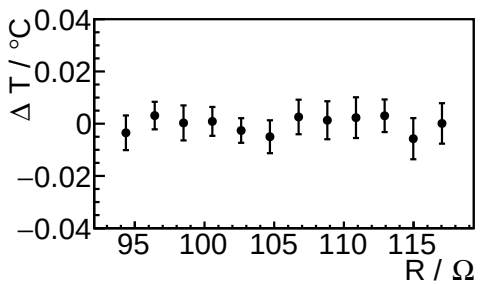


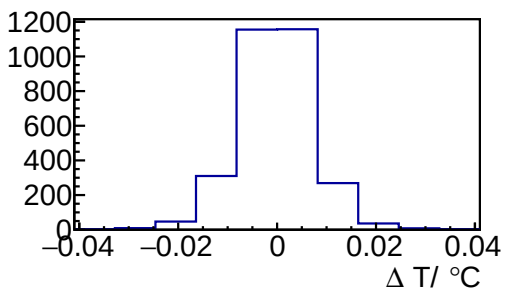


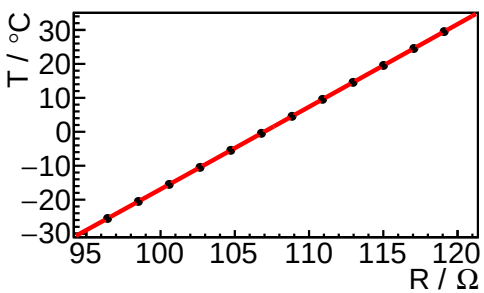
Quality Assurance

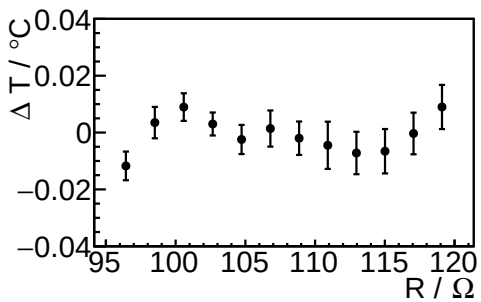
- Data selection: Consider all data except
  first 10 minutes after change of temperature set value
- Split the data into two sets to respect hysteresis
- Consider the distance of each datapoint to the fitted function

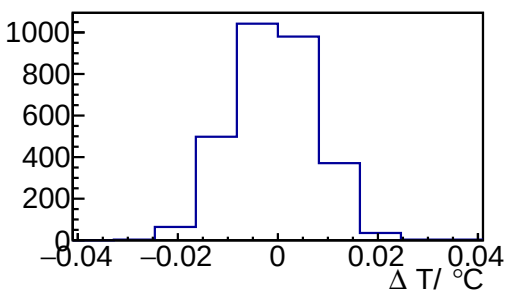






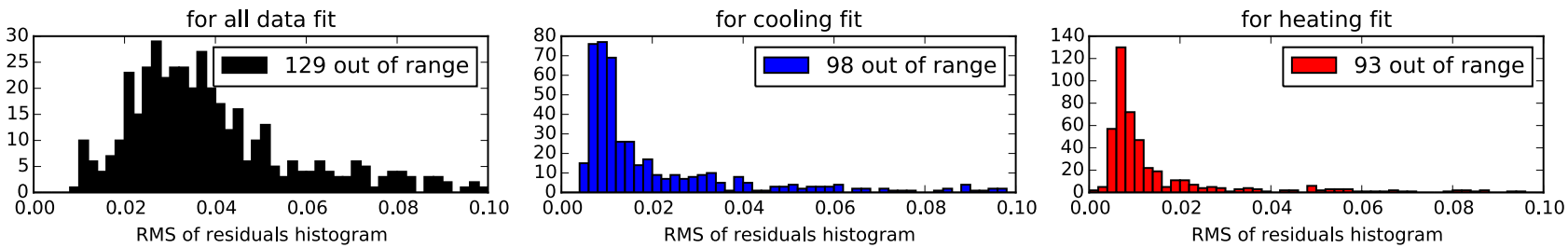






Quality Assurance

- Data selection: Consider all data except
  first 10 minutes after change of temperature set value
- Split the data into two sets to respect hysteresis
- Consider the distance of each datapoint to the fitted function
- Determine the RMS of the distribution



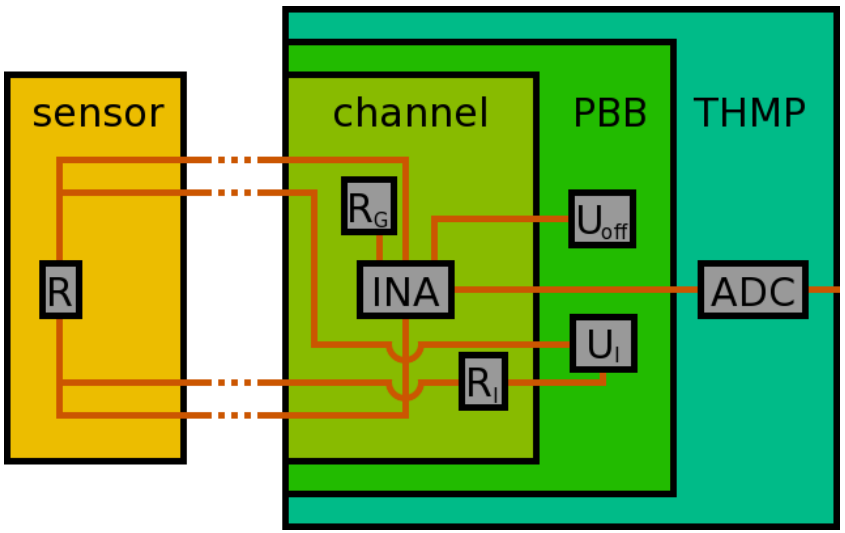
- 305 of 545 sensors (55%): RMS$<$ 0.02 for both subsamples

Status of THM$\overline{\text{P}}$ Production

- Need:
  - 10 THM$\overline{\text{P}}$s designated for forward endcap
    (74 T-PBBs, 6 p-PBBs)
  - 2 THM$\overline{\text{P}}$s designated for barrel test slice
    (12 T-PBBs, 4 p-PBBs)
- Status:
  - 15 fully equipped and tested THM$\overline{\text{P}}$-mainboards
    12 of which in cases
  - 92 fully equipped and tested T-PBBs
  - 25 fully equipped and tested p-PBBs
- Next steps:
  - Calibrate the THM$\overline{\text{P}}$s (temperature dependent)
    $\rightarrow$ 8 cot 24 h measurements per THM$\overline{\text{P}}$

THMP Concept

- 4-wire measurement
- constant current $I = \frac{U_I}{R_I}$
- gain $G = 5 + \frac{200\,\mathrm{k\Omega}}{R_G}$
- offset voltage U_{off}
- ADC conversion factor C



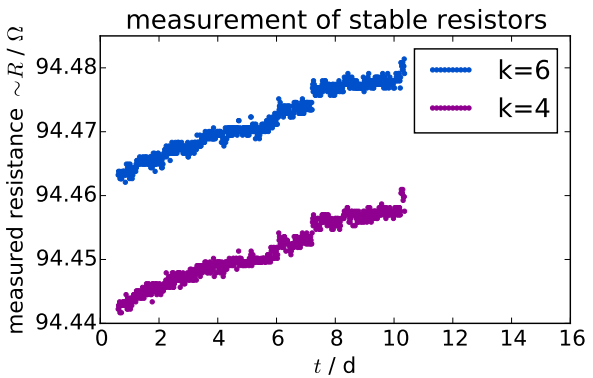
$$(R \cdot I \cdot G + U_{\mathrm{off}}) \cdot C = R \underbrace{\cdot I \cdot G \cdot C}_{m} + \underbrace{U_{\mathrm{off}} \cdot C}_{n} = N$$

$\rightarrow$ σ_R corresponds to 3.5 ADC channels for optimized values of U_I, R_I, R_G and U_{off}

Drift

! There was an additional PBB-wide drift of unknown origin (t)!

- constant current $I_k(T,t) = \frac{U_I(T,t)}{R_{I,k}(T)}$
- gain $G_k(T) = 5 + \frac{200\,\mathrm{k}\Omega}{R_{G,k}(T)}$
- offset voltage $U_{\mathrm{off}}(T,t)$
- ADC conversion factor C



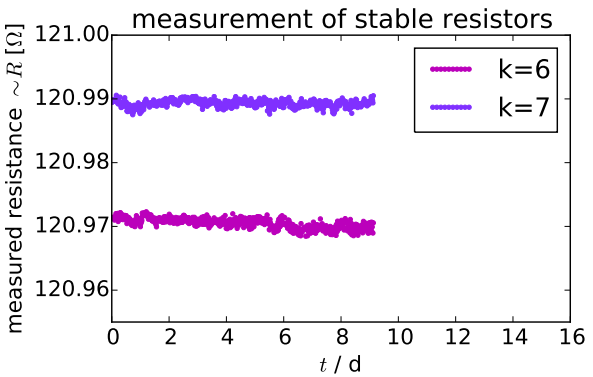
$$R_k \cdot \underbrace{I_k(T,t) \cdot G_k(T) \cdot C}_{m_k(T,t)} + \underbrace{U_{\mathrm{off}}(T,t) \cdot C}_{n(T,t)} = N_k(T,t)$$

Drift

! There was an additional PBB-wide drift of unknown origin (t)!

✓ With the new configuration there is no drift anymore!

- constant current $I_k(T,t) = \frac{U_I(T,t)}{R_{I,k}(T)}$
- gain $G_k(T) = 5 + \frac{200\,\mathrm{k\Omega}}{R_{G,k}(T)}$
- offset voltage $U_{\mathrm{off}}(T,t)$
- ADC conversion factor C



$$R_k \cdot \underbrace{I_k(T,t) \cdot G_k(T) \cdot C}_{m_k(T,t)} + \underbrace{U_{\mathrm{off}}(T,t) \cdot C}_{n(T,t)} = N_k(T,t)$$

→ No reference resistors needed!

Summary and Outlook

- ✓ Almost all produced temperature sensors calibrated
- ✓ 305 approved temperature sensors (≈50%)
- ! Improving the fitting to temperature sensor data will most probably increase approved share
- ! Study hysteresis effect
- ✓ THM$\overline{\text{P}}$ hardware is ready!
- ✓ No drift visible anymore!
- ! Next: Temperature dependent calibration of all THM$\overline{\text{P}}$s

Questions? Comments?