# Studies for a Contactless Temperature Measurement for ATLAS MDT Chambers

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The ATLAS detector will develop a vertical temperature gradient. The MDT chambers of the muon spectrometer sit in an upward flow of heat dissipated from its own readout electronics and from the central parts of the ATLAS detector. Temperature sensors, distributed over the many MDT detector modules, can detect local changes of the detector's temperature but the MDT modules might experience hot spots from air flows without being notified by a sensor.

Since physical access to the MDT-detector modules is mostly impossible, a contactless temperature measurement was investigated using an infrared sensitive camera to survey the MDT detector modules. Two types of infrared cameras were studied: FLUKE TI20 and NEC TH9100pro. These devices do provide temperature measurements for a limited range of emissivity $\epsilon$ of the surface but no access to the raw data. So, tests were pursued to derive the temperature, $T$, from a camera's measurement of the thermal radiation power, $P$, with consideration of the environmental background temperature, $T_{\text{BG}}$, according to the generalized Stefan-Boltzmann law

$$P = A \cdot \sigma_{\text{SB}} \cdot \left(\epsilon \cdot T^4 + (1 - \epsilon) \cdot T_{\text{BG}}^4\right) \qquad (1)$$

for any value of emissivity, $\epsilon$, of the surface area, $A$.

The largest visible part of the MDT modules is a protective cover made from aluminum plates. Since the emissivity of aluminum depends significantly on the mechanical and chemical processing of its surface and on its temperature, dedicated measurements were necessary to determine the emissivity of the protective covers, its dependence on temperature and angle. An emissivity of $\epsilon_{\text{Cover}} = 0.054 \pm 0.020$ at an angle of 30 deg was found. The large error is due to the high reflectivity of the aluminum plates. It was found that the emissivity increased slightly with the angle of observation (+0.00055/deg). This could be due to diffuse reflections affecting the measurement.

The microstructure on the surface of the covers did not noticably affect the temperature measurement but it contributed to the diffuse reflection from the surface. This diffuse contribution was measured at different angles and extrapolated to the solid angle over the plate yielding a total diffuse reflection of $2.6 \pm 1.1\%$ of the impinging intensity.

Using the value for the emissivity of the aluminum covers, a temperature of $37°C$ of the cover could be measured with roughly 20% precision. The large uncertainty is mainly due to the small value and the large uncertainty of the emissivity $\epsilon_{\text{Cover}}$ and due to the large contribution from thermal background radiation which is reflected by the protective cover.

As an alternative it was investigated to measure the thermal radiation from the structured surface of MDT drift tubes directly. Figure 1 shows a part of the MDT chambers, heated to $33°C$. A multilayer of three tubes is visible below the mechanical support bar (longbar) of the chamber, which has a hole for means of detector handling. The left hand side of the chamber was covered by an aluminum plate to reduce reflections from the heated chamber and to provide an unstructured surface for comparison. Additional temperature sensors were attached to the plate and the longbar. A longterm measurement (see Fig. 1) showed, that the emissivity of the drift tubes is $\epsilon_{\text{Tubes}} = 0.11 \pm 0.04$, i.e. higher than for the protective covers. An $\epsilon$ of $0.57 \pm 0.02$ results for the cavity behind the hole in the longbar.

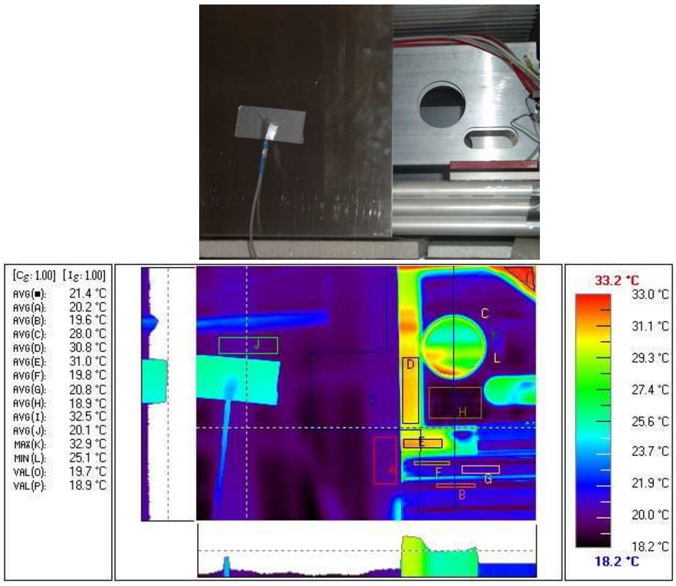


Fig. 1: (top) Photography; (bottom) Infrared image. Labelled areas B and G, J, D and H and C were used to determine temperatures. G is the hottest, B the coldest point of the visible multilayer. Area J is on the aluminum plate. D and H are areas on the longbar. C is the hole in the longbar. D is a reflexion of radiation emitted from behind the aluminum plate and reflected to the longbar. A temperature sensor was sticked on the aluminum plate.

It was also verified that an infrared camera can be operated in magnetic fields of up to 0.4 Tesla. So, although the precision of the measurement will be limited due to the low emissivity and thermal background radiation, a contactless measurement of the MDT chambers temperature and the detection of thermal hot spots is possible using an infrared camera.