1 Investigation of bubble formation on the HEC PSB boards

The power dissipation of the GaAs chips in the LAr could lead to bubble formation. If these bubbles enter into the active gaps of the calorimeter module they would cause serious high voltage problems.

Based on the known power dissipation of the MPI-95 chip, model calculations have been done. The thermal flow density turned out to depend rather strongly on the model assumptions. Therefore a test experiment in the HEC cryostat has been carried out.

A video system has been installed in the cryostat providing a direct visual inspection of the chips under real conditions. One HEC module equipped with the full electronics has been placed in the cryostat in the position corresponding to the bottom module in a final calorimeter wheel. This means that the PSB boards were positioned below the module, simulating the worst condition: bubbles can reach the active gaps most easily. The video system has been housed in a vacuum insulated special cryostat and has been kept at constant temperature using special heating elements. Two different optics were available: a close up view, showing essentially one chip, and a normal view showing one full board and part of the neighbouring one. The focus could be adjusted using special camera drives. A ring of LED's surrounding each camera was providing the requested illumination. The light output could be varied by varying the LED power.

In the final ATLAS cryostat the LAr is subcooled with respect to the nominal vapour pressure curve, the operating temperature being 87 K to 89 K. The HEC cryostat can be operated only at the vapour pressure curve under normal conditions. Changing rapidly the gas pressure allows to simulate the ATLAS operation mode temporarily. It takes many hours for the cooling system to return to the equilibrium at the vapour pressure curve. Therefore the pressure has been increased rapidly, starting from different initial temperatures along the vapour pressure curve. Thus a large area in the P-T plane could be investigated. At each step the direct observation of the GaAs electronics allowed to test for bubble formation. As expected, rather close to the vapour pressure curve a strong bubble formation is observed. The green line in the figure indicates the transition from large bubbles to small ones, with a residual passlength of a few mm only. A further pressure increase suppresses finally even the small bubble formation. Only streaks remain, which indicate a strong LAr flow (blue line). The regime of operation in ATLAS is shown in red, corresponding to the difference in pressure between the top and bottom LAr level due to the hydrostatic LAr pressure. ANY bubble formation stops far beyond this regime.

For comparison a special chip housing with a resistor replacing the chip has been installed. The power dissipation of the resistor could be varied externally. Thus for any given point in the P-T plane the power dissipation can be determined, at which small bubble formation sets in. From this measurement we find, that using the MPI-95 chip there is a safety factor of two when comparing to the ATLAS operation regime. In comparison to the MPI-95 chip the present chip MPI-96 has a factor of two lower power dissipation. Therefore we conclude, that we have in total a safety factor of at least four when the chips are operated at the worst condition in the ATLAS operation regime.