Thermal Performance of the Petal Prototype

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Abstract

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1 Introduction

The high-luminosity upgrade for the LHC planned to be ready to run in 2026 imposes new challenges on detectors. For instance, an enhanced luminosity is immediately related to elevated radiation levels which constitute heat development. To avoid a thermal runaway and ensure reliable measurements, the electronics must be held at a constant temperaturewhich requires some kind of cooling system for all detector components.

Which year should I put?

How cold should it be?

1.1 Petal

During my time in the DESY summer school, I participated in testing the thermal performance of the inner tracking detector of the ATLAS experiment. Figure 1 illustrates its position within the big detector and the planned upgraded design. The parts studied at DESY are the so-called petals that are assembled perpendicularly around the beampipe to track particles with low transversal energy. Figure 2 displays a picture of the tested petal prototype.

Maybe without the last sentence.

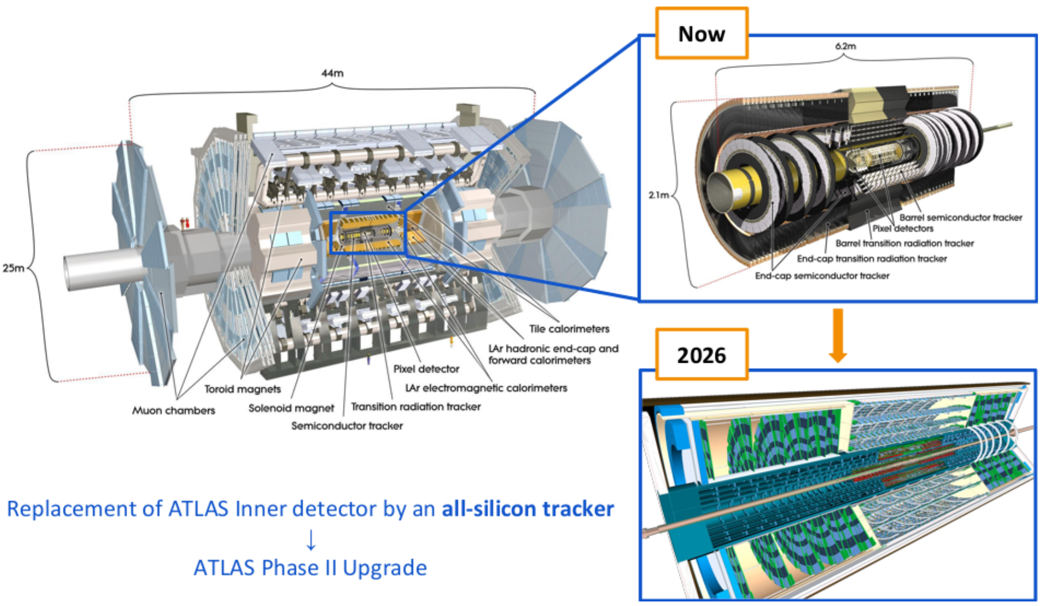

Figure 1: Schematics of the upgrade of the ATLAS inner tracking detector.

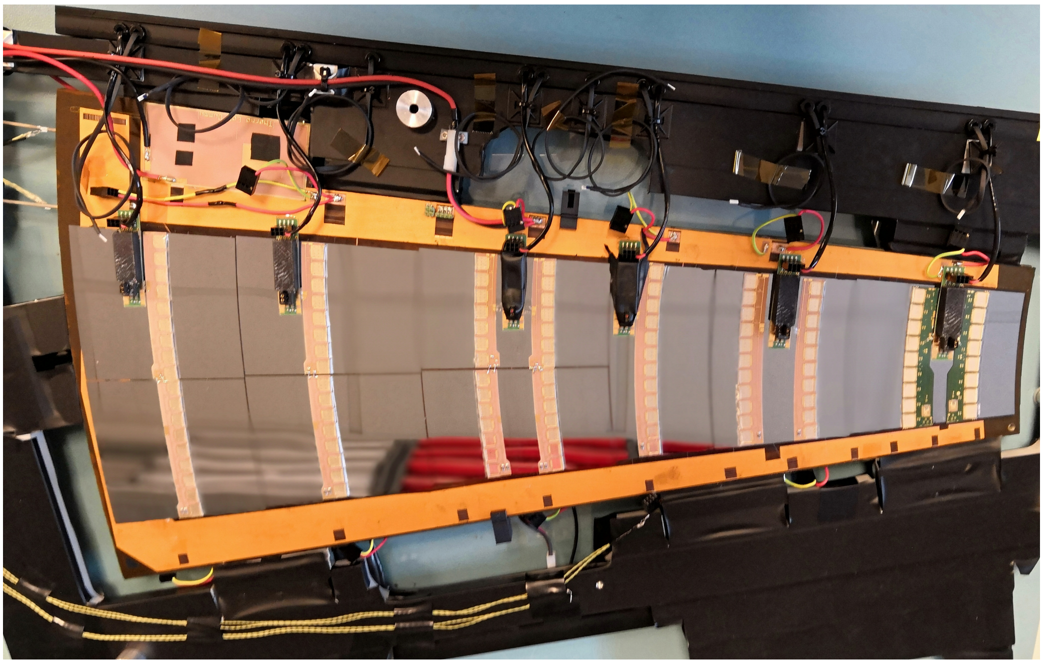

Figure 2: Picture of the tested petal prototype.

1.2 Cooling System

Figure **??** shows a prototype of the bare cooling loop. The cooling system is based on the energy taken by a phase change. Liquid CO_2 is pumped into the cooling loop where some of it evaporates if exposed to heat. This evaporation takes energy (enthalpy of evaporation) which is taken from the heat source.

Find better wording.

2 IR

To assess the thermal performance of the petal, we measure the emitted radiation in the infrared (IR) spectrum. To properly evaluate the data measured with the IR camera, we need to understand the behaviour of IR radiation and camera software. This section gives an overview over these topics.

2.1 Emissivity

Every body emits IR radiation depending on its temperature. Light in the IR spectrum behaves identical to the more intuitive visible light. This means that surfaces can emit, absorb, and reflect IR radiation. Being purely interested in the *emitted* power, we need to minimize reflection in the IR region. The emissivity ϵ describes the ability of a surface to reflect IR radiation. It is a value between 0 and 1, where 0 corresponds to total reflection, whereas 1 corresponds to no reflection. So, to achieve good results using IR measurements, we cover the petal with a high emissivity coating. The determination of the exact emissivity value for the chosen paint is described in section 3.

Is it really only IR or is there an emissivity for all ranges?

2.2 Software

2.3 Theory

To fully comprehend and also for being able to check the camera data, a theoretical relation between the emitted power and temperature is crucial. As we are trying to approach an ideal black body using the high emissivity paint, Planck's law for black body radiation,

$$p(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{\exp\left(hc/(\lambda k_\mathrm{B} T)\right) - 1} \ , \qquad (1)$$

can be a good start. The IR camera measures radiation over a range of wavelengths, so we need to integrate this and obtain

Describe variables!

$$P(T) = \int_{\lambda_\mathrm{min}}^{\lambda_\mathrm{max}} \frac{C_1}{\lambda^5} \frac{1}{\exp\left(C_2/(\lambda T)\right) - 1} \,\mathrm{d}\lambda \ . \qquad (2)$$

Taking account of reflections of the ambiance, we propose the following equation

$$P_\mathrm{tot.}(T) = \underbrace{\epsilon P(T)}_{\text{emission}} + \underbrace{(1-\epsilon) P(T_\mathrm{amb.})}_{\text{reflection of ambiance}} \ . \qquad (3)$$

Describe variables!

2.3.1 Test of

3 Emissivity Measurements

4 Tests on the Petal

4.1 Preparations

4.2 First Results

5 More

References

[1] Study of ... *Author name*