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Upgrade plans for ATLAS Forward Calorimetry for the HL-LHC

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Even though data taking has just started with the LHC, plans are being developed to operate the machine and its detectors at up to 10 times the original design luminosity. This has an impact on many components of the ATLAS detector, particularly the Forward calorimeter, which is exposed to some of the highest radiation rates in ATLAS.

The FCal detector and its associated components were designed for operation at the maximum LHC luminosity of 1034 cm2s-1. However at the higher luminosities (HL), which are projected for the HL-LHC, operation of the FCal will be compromised. Beam heating in the FCal which is located on a liquid argon filled cryostat could lead to the formation of argon bubbles in the detector, the ionization rate will result in space charge effects that will reduce the signal and the current draw will result in a voltage drop across the HV current limiting resistors. The space charge and ionization rates will result in the FCal becoming insensitive to particles at its inner edge and the insensitive region will grow as the luminosity increases.

There are two possible solutions being considered to maintain FCal operation at HL-LHC, one is a complete replacement of the FCal system. A replacement FCal would have a similar design to the current calorimeter except for additional cooling, lower value HV protection resistors and the use of smaller ionization gaps; as small as 100 microns in the first compartment. There have been a number of recent studies of the effectiveness of small gap FCal style detectors for high luminosity environments. The drawback to the complete replacement of the FCal is the mechanical difficulty of extracting the current detector from its cryostat, relocating the highly radioactive detector and installing a new detector in a limited time window. These concerns led to the development of a second option which is the installation of a small warm calorimeter to be placed in front of the FCal which has been named the Mini-FCal. This addition would reduce the ionization load in the first FCal compartment at small radius by up to a factor of three, which would keep a larger region of the FCal active and reduce the heat load to an acceptable level.

The current concept for the Mini-FCal is a standard parallel plate calorimeter with 12 copper disc absorbers and 11 layers of sensors. The key to the design of the Mini-FCal is the selection of a sensor technology that will produce an adequate signal for a significant number of years at HL-LHC intensities. The first choice for this is the use of diamond detectors due to their inherent radiation resistance. It is anticipated that neutrons will be the major cause of damage to the diamond sensors and the integrated flux of neutrons in the Mini-FCal after 10 years running at the HL-LHC will be up to 5x1017 neutrons/sq cm. Recent irradiation tests carried out by members of the ATLAS LAr group show that these sensors can still operate after irradiation up to these levels although with a large reduction in signal.

The talk will discuss a number of aspects of the upgrade work for ATLAS forward calorimetry and outline the continuing experimental development program.

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