Milli-charged Particle Detector for LHC P5

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Abstract

We propose a dedicated experiment for detecting "milli-charged" particles produced in pp collisions at the LHC. The experiment would be a plastic scintillator array subdivided into three sections, sensitive to charges of order $10^{-3}e$ for mass 1 GeV and charges of order $10^{-2}e$ for mass 10 GeV with 300 fb^{-1} of integrated luminosity. This greatly extends the parameter space explored for small charges above 100 MeV.

Detector

The detector would be placed in an existing tunnel, 33m from the CMS P5 interaction point, behind 17m of rock. Due to fire load and access requirements, it is required that the detector support must allow for a passage of at least 60 cm through the tunnel.

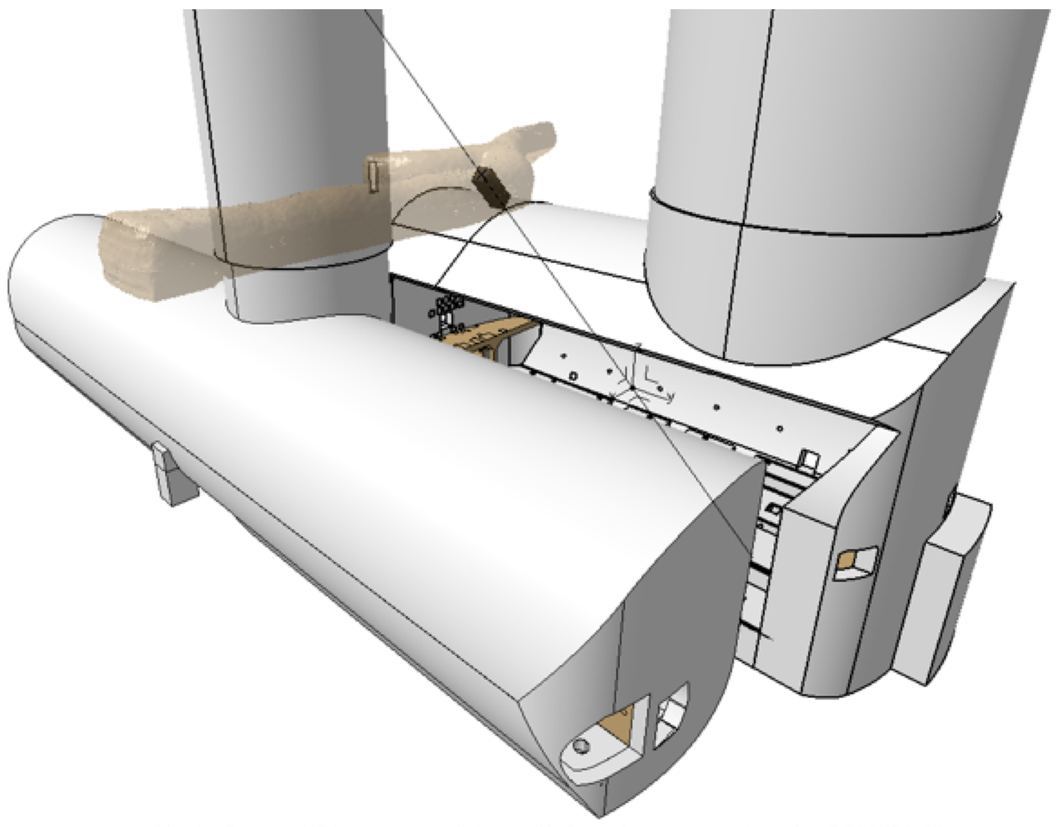
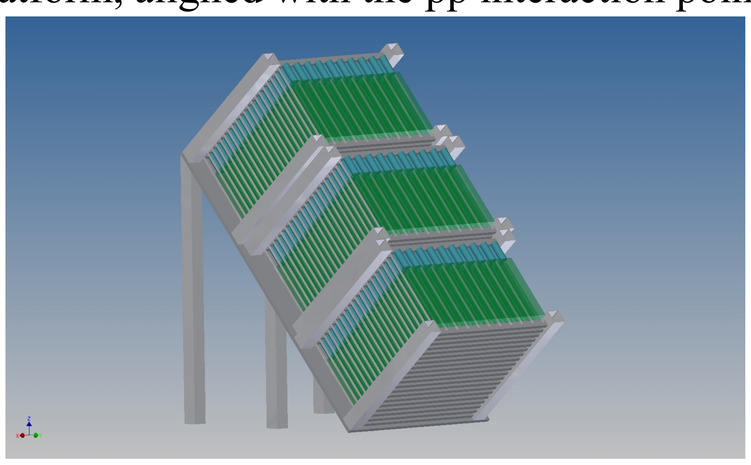
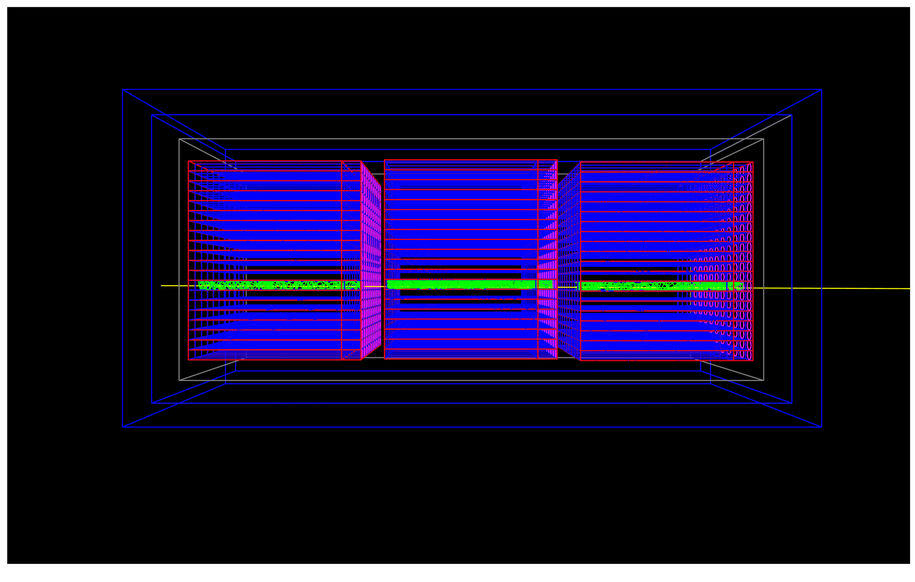


Fig1. Optimal Placement of the milliQan detector within the PX56UXC

The detector will be a 1m x 1m x 3m array of plastic scintillators, each attached to a photomultiplier. It will be sub-divided into three stacks with 400 5x5x80 cm scintillators each mounted on an adjustable platform, aligned with the pp interaction point.



The detector will operate without interference to CMS operations. All that is required is power, ethernet, and information on luminosity delivered to P5.



Background Estimation and Minimization

Dark current in the PMT is expected to be the dominant background Preliminary bench testing suggests a 2.3 kV/PM optimal voltage for rate reduction. At room temperature we expect 1 kHz background rates, but with cooling and optimal voltage, these rates are expected to be below 500 Hz.

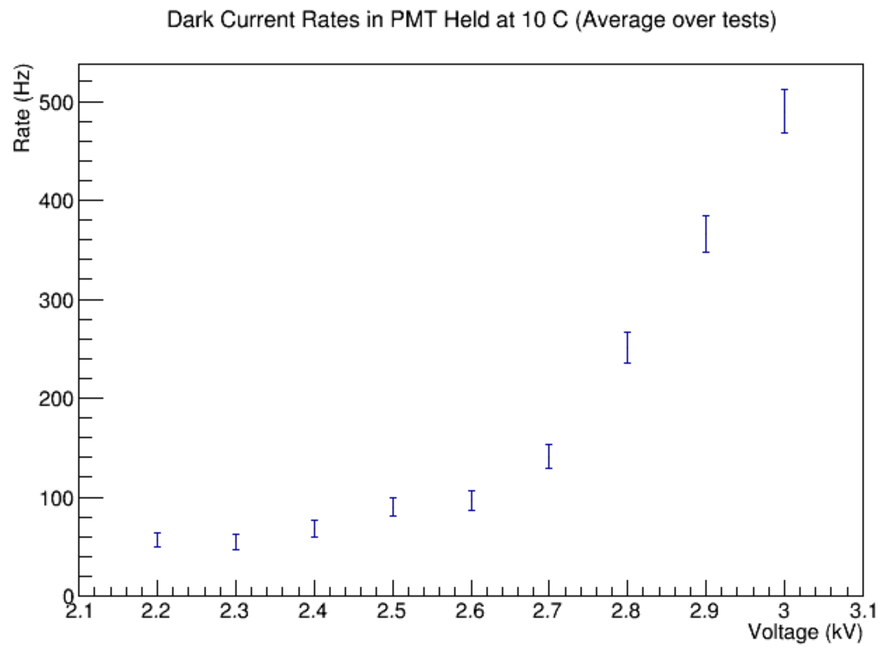


Fig 1. Dark Current rates in PMT from Bench Tests

Using a total background rate of ν_B=500Hz /PMT, it is expected that we will have an overall background rate of 75 Hz in double coincidence, since the rate per board (for the 50 boards):

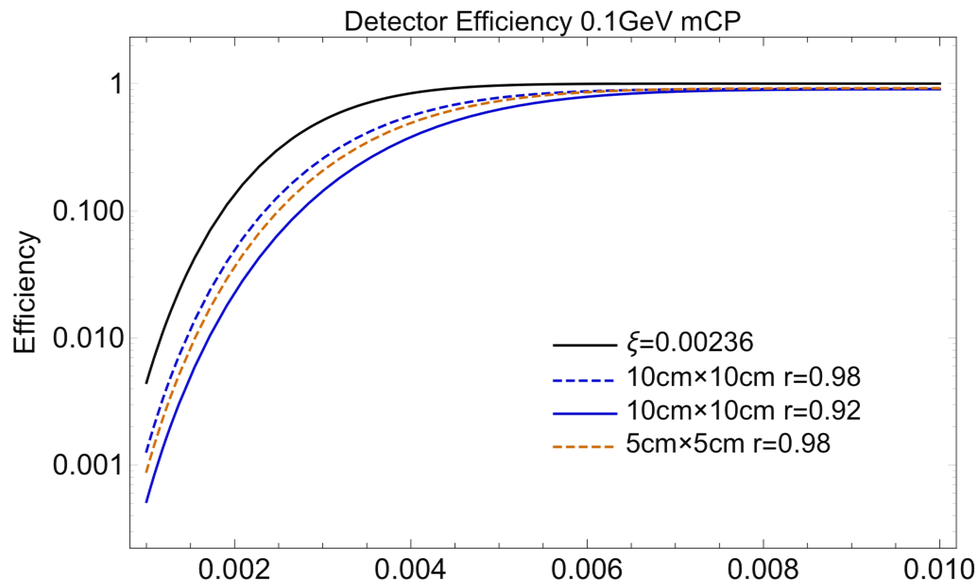
$$\binom{6}{2}(2\nu_B)^2(\Delta t)_{online} = 1.5 \text{ Hz}$$

We expect the offline time window to be closer to 15 ns, and then applying a triple coincidence, we expect the offline background rates for each group of three scintillators to be

$$\nu_B^3(\Delta t)_{offline}^2 = 2.8 \times 10^{-8} \text{Hz per set}$$

Thus, as there are 400 sets, the total offline background rate is 1.1×10^{-5} Hz, corresponding to ~150 events in 300 fb^{-1}. By applying cuts on timing and pulse shape, we expect to reduce the total background to around ~50 (100) events at 300 (3000) fb^{-1}.

Expected Sensitivity



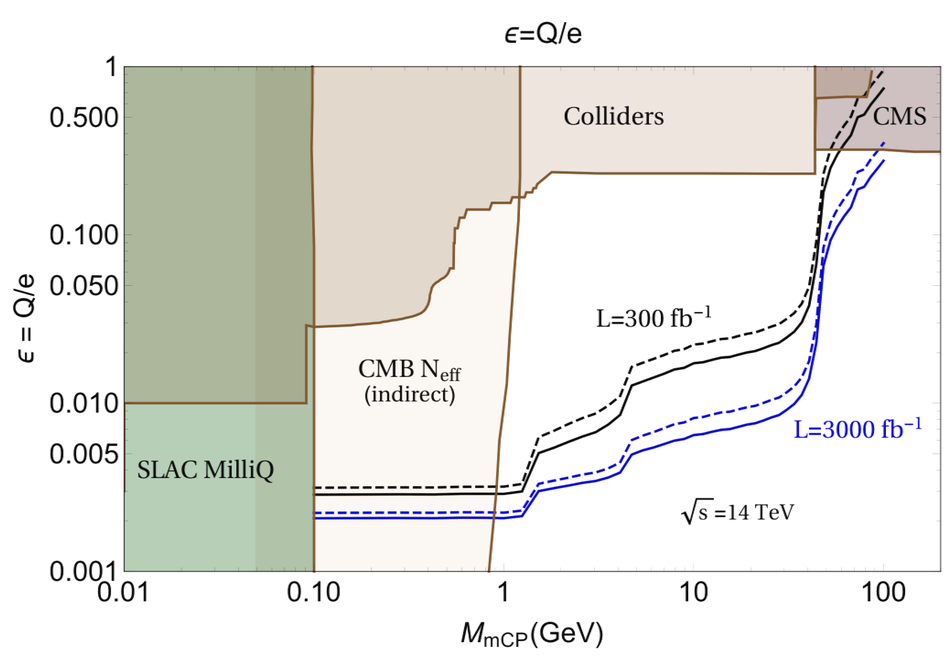


Fig 4. Efficiency and expected sensitivity as approximated by modeling in Geant4