MEASUREMENT OF RELATIVE GAS CHAMBER PRESSURE IN NARROW STRAIGHT SECTION VACUUM VESSELS BY OBSERVING GAS BREMSSTRAHLUNG.

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Abstract

The measurement of gas pressure inside long, small cross section vacuum vessels is difficult due to the distance between the centre of the vacuum vessel and the vacuum gauges (leading to a low vacuum conductance). Following initial chamber installation, significant out-gassing is observed leading to a significant pressure bump within the chamber. A modified beam loss detector has been developed in order to monitor the gamma radiation produced by the collision of the 6GeV electrons in the storage ring with residual gas atoms. The narrow beam of gamma radiation is intercepted at various points by high Z materials in the beam line front-end allowing a radiation shower to be detected outside the vacuum vessel proportional to the gas pressure in the corresponding storage ring straight section. Various locations are considered and results shown

INTRODUCTION

Electrons interacting with residual gas atoms in the storage ring vacuum vessels produce the emission of a cone of electromagnetic radiation extending from long wavelength photons down to gamma ray photons at the energy of the electron beam. The majority of the emitted radiation energy is in gammas with an opening angle of $1/\gamma$ rms, where γ is the relativistic factor of the electrons. At the ESRF this opening angle is 0.1 mrads so passes substantially down the front-ends into the beamlines. Various techniques have been investigated to intercept this beam and measure its intensity.

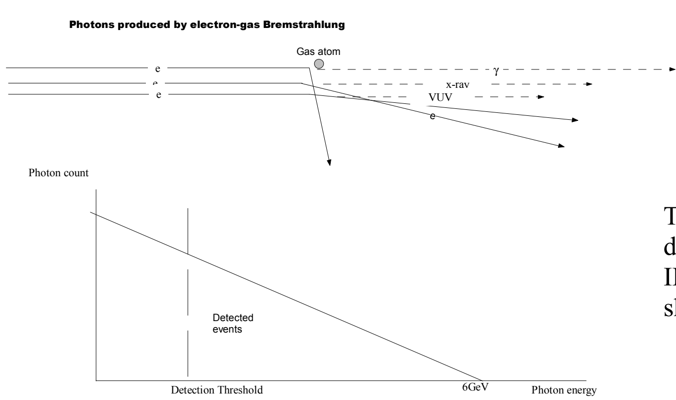

Figure 1

DETECTOR LOCATIONS

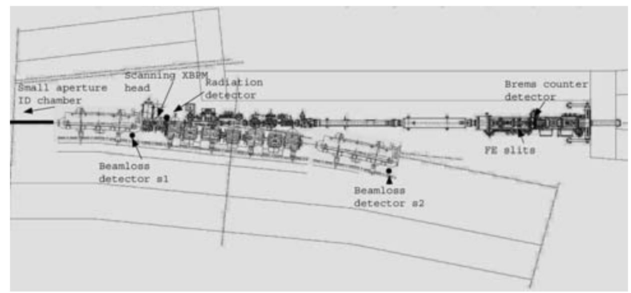

Figure 2: Front-end Layout

Fe-layout2: 2 beamloss detectors mounted on the inside downstream end of the dipoles collect radiation due to losses in the preceding straight section (ID vessel or achromat). 2 prototype ‘Bremsstrahlung detectors’ mounted around the beam-line front-end are sensitive specifically to electron-gas Bremsstrahlung.

Comparison of different detector measurements

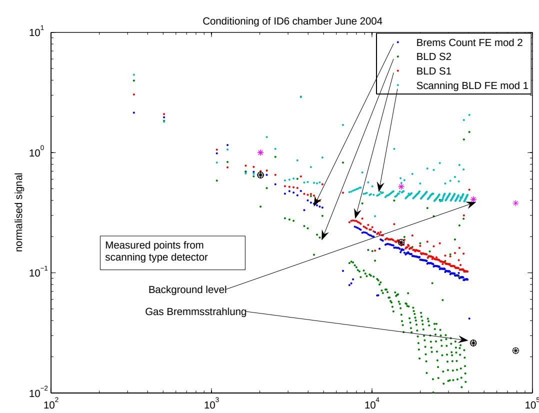

Figure 3

The drop of in signal level is compared in fig. 3 for the 4 different types of detector on a straight section with a new ID straight section vacuum vessel installed. The detectors show two limiting types of behaviour:

1) A slow decay in signal due to the electrons lost on the narrow gap ID vacuum vessels. This signal from lost electrons is due partly to Touchek losses (fairly constant during a run) and gas scattering elsewhere in the ring, giving rise to lost electrons locally. This latter contribution

decreases slowly due to the general conditioning of the whole ring.

2) A rapid decrease due to Bremsstrahlung from electron-residual gas collisions in the newly installed chamber which is reduced by rapid conditioning of the chamber by the internal neg coating.

The normalised signal is determined by dividing the detected signal by the stored beam squared (as the gas pressure is dependent on the current and the Bremstrahlung signal is proportional to the gas pressure and the beam current). The level of the different detectors is then renormalised so as to have similar starting values.

Discrete points indicate the 'Bremsstrahlung' measurement made by a scanning detector to distinguish the narrow gas Bremsstrahlung cone from the background radiation.
The best gas Bremsstrahlung monitoring is achieved by the beamloss detector on the second dipole and the scanning type detector.

Scanning gas-Bremsstrahlung monitor

X-ray beam position monitors (XBPM) installed at the entry of the front end, consisting of tungsten blades are scanned through the cone of Bremsstrahlung. When the blades pass through the cone scattered radiation is detected outside the vacuum chamber by a radiation detector (similar in design to beam loss detectors, consisting of a plastic scintillator and photomultiplier shielded from synchrotron radiation by 1cm of lead).

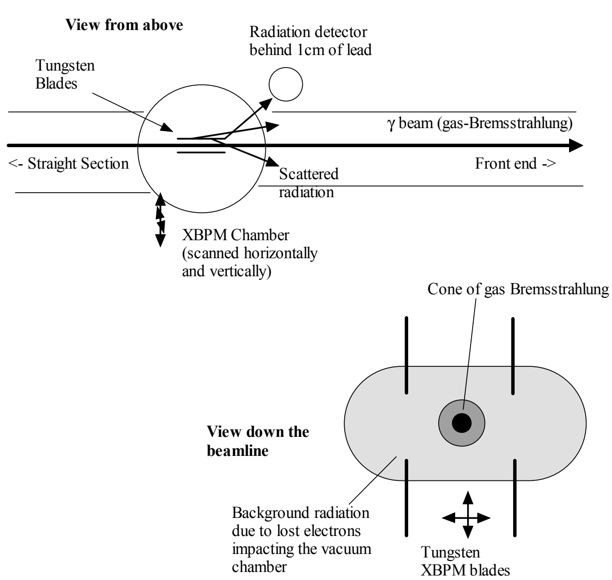

Figure 4

3d plots of scattered radiation signal as a function of XBPM transverse position with background and with the background subtracted are shown in the figure opposite. The background level is due to radiation from electrons hitting the chamber wall. The gas-Bremsstrahlung level is determined by measuring the peak heights. The two peaks are due to the two blades scanned through the beam.

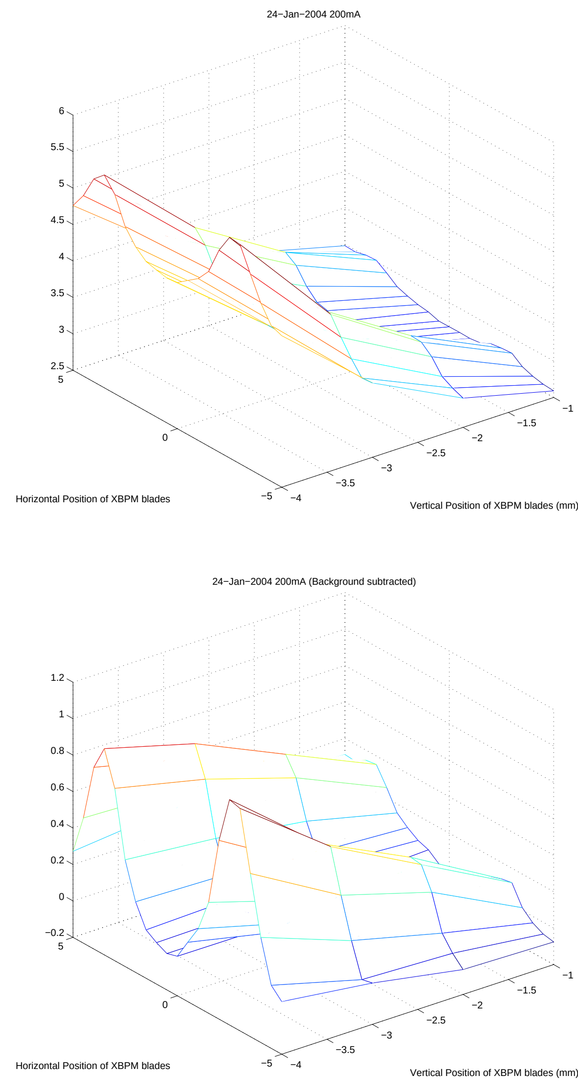

Figure 5

The conditioning of two chambers are compared in different cells in the fig 6 below. The cell 31 chamber is initially better due to its pre-conditioning on a previous run, however the chamber in cell 6 shows more sustained conditioning.

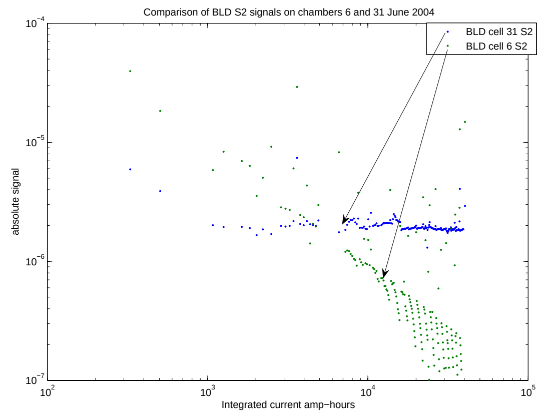

Figure 6

Two different chambers conditioned in cell 6 are compared from different runs. The chamber installed in run 3 shows better sustained conditioning. The signal from two different detectors are used to show the difference in conditioning.

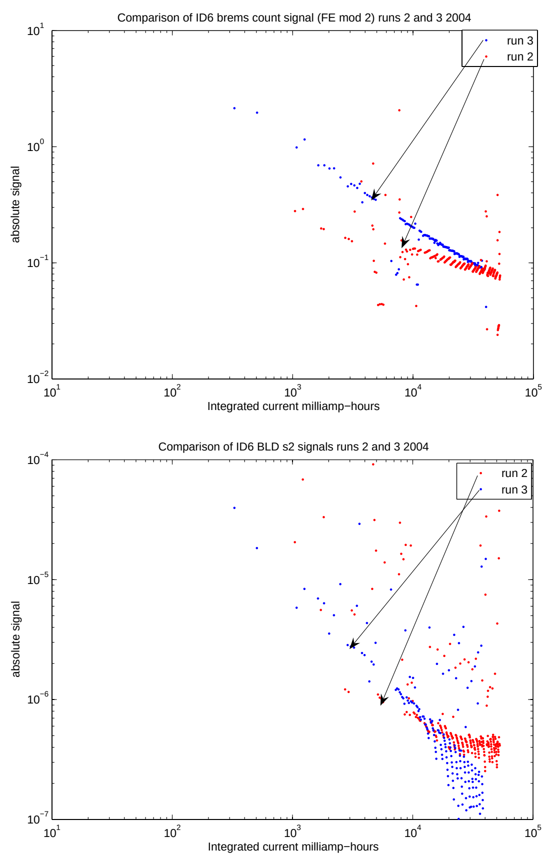

Figure 7

CONCLUSIONS

Various detector types and positions have been compared. In order to monitor the radiation signal due to gas pressure as a means of determining the variation in straight section gas chamber, two detectors are show to be suitable:

i) The beamloss detector mounted inside the second dipole of the cell.

ii) A radiation detector placed after the module 1 XBPM with a recording of the variation of the scaterred radiation as the XBPM blades are scanned through the beam.