A RETARDING FIELD DETECTOR TO MEASURE THE ACTUAL ENERGY OF ELECTRONS PARTECIPATING IN E-CLOUD FORMATION IN ACCELERATORS.

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Abstract

Electron cloud related phenomena can cause potentially detrimental effects on beam stability in many planned and under construction accelerators. The possibility to reduce such unwanted phenomena lies on the observation that, machine commissioning does reduce Secondary Electron Yield (SEY). Such SEY reduction ("scrubbing") is due to the fact that electrons produced during e-cloud formation hit the accelerator walls, modifying their surface properties. 'Scrubbing" has been studied only as a function of impinging electron dose but never as a function of the e-cloud electron energy. Simulations predict that the e-cloud is formed by electrons with very low energies (<50 eV)[1]. Given the potentially lower scrubbing efficiency for equal dose of very low energy electrons compared to medium energy one, it would be important to measure the actual energy of the electrons forming the cloud in real accelerators. For this reason we decided to construct an optimized Retarding Field Energy Electrometer to be installed in accelerators. Here we will describe what solutions has been adopted during the design phase of such "home made" detector and some laboratory test that will be performed.

INTRODUCTION

For a number of reasons it could be extremely interesting to actually measure not only the number of electrons involved in electron cloud formation in accelerators, but also their energy distribution curves (EDC). Such EDC's can be directly compared with simulations to verify the validity of the calculation assumptions, and of the algoritms used to simulate e-cloud formation and build-up. The avaible simulation codes first compute the actual acceleration of the existing electrons as due to their interaction with the beam, than use the calculated EDC's to simulate the resulting multipacting build-up [2,3]. A direct comparison between directly measured EDC's and calculated ones could than be very useful. Also, recently [4] the scrubbing efficiency of the electrons hitting the accelerator walls has been suggested to depend on their actual kinetic energy, being lower than expected at low energy (< 50 eV). This strengthen the usefulness of measuring EDC's.

Measuring EDC's of the electrons hitting the real internal walls of particle accelerators, with emphasis on the low energy region (0 to 50 eV) is by no means a trivial issue. One should design a detector which can be used in an accelerator environment and should fulfil several constrain. It should be compact, non-perturbing the accelerator inpedence, easy to operate, economic, and robust. Pick ups, strip detectors and RFA has been used [5,6], but their energy resolution, their efficiency at low energy and their transmission were hard to define. Moreover the number of total electron current induced by the e-cloud is measurable with a simple biased anode, while if grids are set to select energies, the number of energy dependent electrons will give a too small current to be easily and accurately measured by standard picoammeters expecially for low energy electrons. Surface science community has a longstanding tradition in measuring EDC with very constant, stable and high resolution electron analysers. Their costs and handling in an accelerator environments did not suggest to use such cylindrical or spherical analysers. One more option, used in Surface Science is to use the 4 curved grid optics for LEED to perform Auger studies, hence energy resolved spectra. This is done by using a LEED-AUGER optic in connection with an etherodine technique to clean up the small signal by locking it to a oscillating band pass filter.

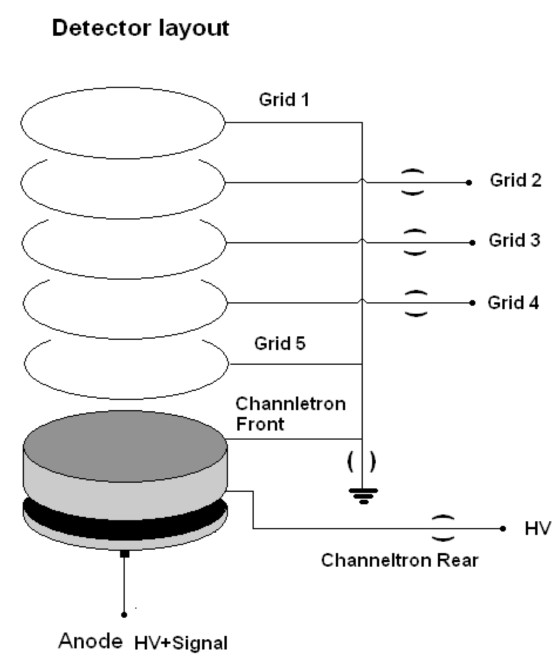

Figure 1: View of the LNF-Retarding Field Detector.

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It is by looking at those working analysers we planned to construct a small, robust and compatible to accelerator environment detector using already existing electronic control units and new acquisition programs.

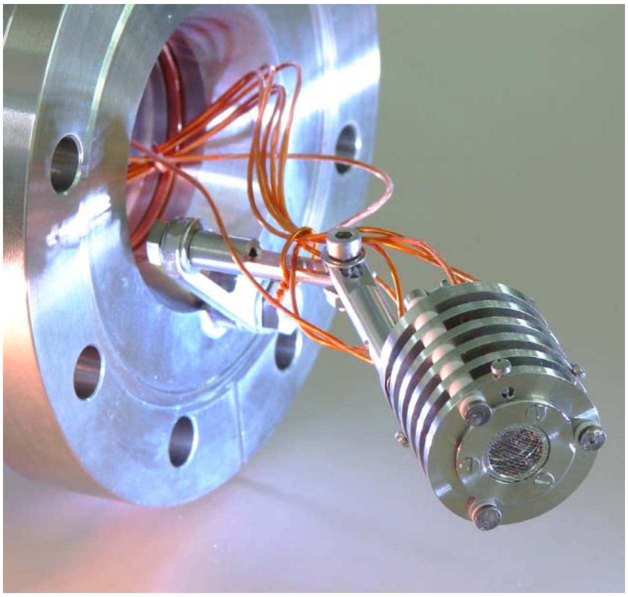

Figure 2: Photograph of the LNF-Retarding Field Detector built at LNF mounted on a CF 63 Conflat flange.

EXPERIMENTAL

We designed a small home made 5 flat grid band pass analyser ready to be connected with a slightly LEED-Auger electronic of OMICRON. In fig. 1 the schematic view of the analyser is shown, while in fig.2 and fig.3 some photos of the real object are shown. The first grid is held at ground so that the beam passing in the accelerator ring will not be disturbed by “seeing” any applied voltage, and, like all the other four grids, has in its centre a 5mm in diameter 90% metallic mesh. The second grid was inserted to measure the total current of electrons entering in the detector by applying on it a positive bias like a simple Faraday cup. In usual LEED Auger system this grid is absent, but one of the problem we faced by the choice of using a channelplate to multiply our signal, was that all the data than collected are in arbitrary units, since the multiplication factor of a channelplate depends not only on its voltage, but also on its history. For this reason, this grid, will give the integral values in number of electrons of the EDC measured. During EDC acquisition this grid will be at ground. The third and fourth grids are used as a band pass filter to obtain electron energy selection and their voltage oscillate to reduce noise, as normally done when acquiring data with an etherodine technique. Their voltage, and the modulation intensity are directly controlled by the OMICRON control unit. The fifth grid is held at ground, to isolate the counting system from the grid voltage. Then the electrons will be energy selected by passing through the grids and will be multiplied by a quantum sub-miniature advanced performance Detector from BURLE. This channelplate is constitued of a grounded front end and a rear which is biased positively with a voltage varying from 0 to 1000 V from a computer controlled HV Spellman Power supply. Such channelplate has a collection diameter of 3.9 mm and, if biased at 1000V, can multiply the signal up to 10^3. We estimate such multiplication to be necessary and sufficient to measure EDC from E-cloud induced electron fluxes. The anode voltage is given by an home made floating battery box, to cancel eventual noise to the signal as due to HV commercial power supplies. The standard OMICRON LEED–Auger plug has been modified to accept current signal from our anode placed at 1050 V rather than the 300 V usually given at wich the LEED screen is normally biased to be used as the collector in standard Omicron LEED Auger.

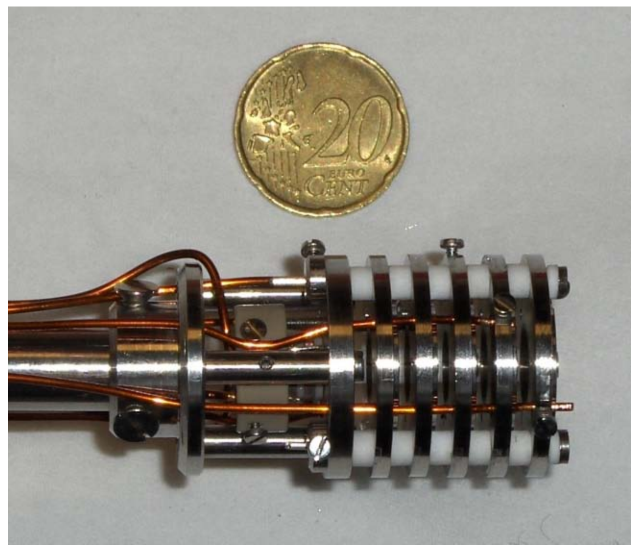

Figure 3: Photograph of the LNF-Retarding Field Detector compared to a 20 Cent Euro coin.

Fig 4 shows a block diagram of the electric lay-out of the Detector control system. The core of it is the standard OMICRON SpectaLEED control unit [7] which has been slightly modified to acquire EDC’s from a channelplate. The control of the detector is than performed through an interface “Prototype Box”. Such box allows to transmit lock-in oscillations to grid 3 and 4, drive the Spellman power supply for biasing the channelplate, and read on the second grid the total current of the electrons entering in detectors. The standard Omicron unit controls also the lock-in amplifier and define the frequency and the amplitude for the grid modulation signal via a Data Auger software acquisition system. It is not scope of this note to describe the LEED-Auger functioning principle, which can be found in textbook and literature [8,9]. This system will allow us to acquire EDC curves varying incident electron energies and to measure the actual energy of the electrons forming the cloud in real accelerator.

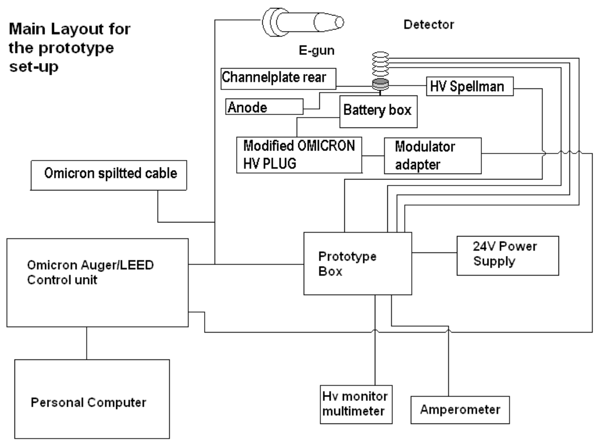

Figure 4: Electric lay-out of the Detector control system.

Such detector has been produced as a prototype to be tested by irradiating it with electrons at different intensities and energies from a Omicron e-gun. We are ready to test it, measuring its efficiency, its transmission curve (i.e. the efficiency of detecting equal intensity electron beams at different energies) with special attention to linearity at low electron energies. We plan to insert 2 of such detectors in the DAFNE storage ring [10] to measure in equivalent places in the positron and the electron ring EDC's, observing their intensities and studying in details the differences expected from the two rings [11]. The detectors in the ring are planned to be mounted as shown in fig 5, and will "look" at the beam, trough the vacuum slots of similarly placed interconnects. The electronic to be used will be only one since we developed a "distribution" board, in order to measure EDC's from different detectors by choosing which one is measuring by remote control, i.e. without need to enter into the accelerator hall.

After final testing we could mount this detector also at ANKA in connection with the COLDIAG diagnostic set up described in this proceedings [12].

CONCLUSION

We described the adopted solutions used for the construction of an optimized Retarding Field Energy Electrometer to be installed in accelerators. Such "home made" detectors use existing LEED–Auger technology developed for Surface science experiments. Its aim is to acquire EDC's and to measure the actual energy of the electron forming the cloud in accelerators during operation.

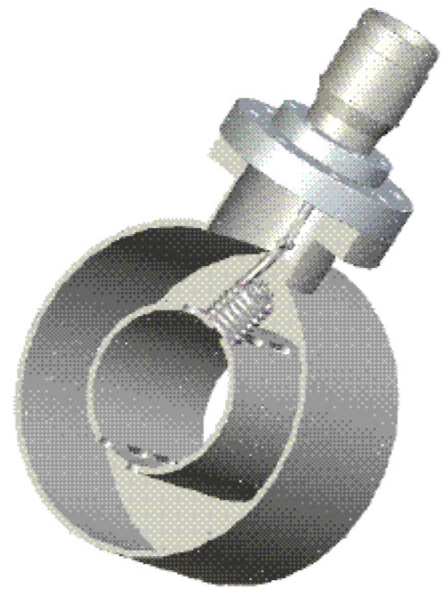

Figure 5: View of the LNF-Retarding Field Detector mounted in DAFNE ring

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