DEAR Technical Note IR-9

DEAR - first beam test at $DA\Phi NE$ with a simplified 2 CCD setup

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1 DEAR test setup

A simple DEAR setup was installed at the $DA\Phi NE$ machine, in the FINUDA pit, on 14 October 1998, in order to perform background measurements with and without beams circulating in $DA\Phi NE$. The results of a period of 3 weeks of data taking are reported in this note.

The setup consists of 2 CCDs (I411 and I412), with two readout boxes (RB5, RB6), with an aluminium window of 50 μm, placed in the interaction region (IR) at a distance from the pipe of about 60 cm in the horizontal plane and of about 10 cm in the vertical plane. This setup stays in an asymmetrical position with respect to the Interaction Point (IP), namely is located in front of the flanges between the central quadrupole and the first quadrupole of the DAY-ONE IR - shifted of about 36 cm upstream the electrons-coming-in direction.

2 Installation and calibration

After the installation of the setup in the FINUDA pit the vacuum and cryogenics were started. The pressure inside the CCD housing was almost constant during the run - period at $2 \cdot 10^{-6}$ mbar. The temperature of the CCDs was constant, within 1 K, at 163 K.

In the first day after the stabilization of vacuum and temperature, the CCDs were tuned.

The noise peaks position (initially at 10 channels for CCD A, 30 for C, 170 for B and 180 for D) was adjusted at about 120 channels for all the 4 half-CCDs. These noise peak positions were stable during the run period, except for a sudden jump (of unknown origin) of about 10 channels for each CCD which occured in the middle of the interval.

An energy scale calibration was performed, using an Fe source, and the scale was calibrated such that the Mn K_α peak position was at the same position (320 channels) for each half CCD. The resolutions of the CCDs were measured as follows:

- CCD A FWHM for Mn K_α peak: 272 eV;
- CCD B FWHM for Mn K_α peak: 298 eV;
- CCD C FWHM for Mn K_α peak: 272 eV;
- CCD D FWHM for Mn K_α peak: 250 eV;

the average resolution of the system being of 272 eV.

After having adjusted the CCD electronics, the run period, with and without beam, started.

In the next Section the results of these measurements are reported.

3 Experimental results for "non-machine" background

The first and last days of the run-period were dedicated to "non-machine" background measurements in the pit.

Data were taken with a duration per run of 15 and 30 minutes; occupancies of the CCDs during this run-period were less than 1%.

The results we obtained can be summarized as follows:

- for what concerns the CCD-blindness a number of (300 $\pm$ 30) clusters/hour/ half-CCD was measured;
- for what concerns the X-ray background a number of (0.85 $\pm$ 0.07) X/hour/CCD/keV in the region of interest (6.5 keV) was measured;

- the ratio between the total number of clusters and X rays in all the dynamical range (2 - 18 keV) was (50 $\pm$ 5).

The X-ray spectrum during this period was smooth, not showing any structure. To be mentioned that the X-ray background in the region of interest measured in the pit is smaller by about 40% than the one measured in the DEAR Laboratory. In order to be sure that this decrease is site-dependent (and not setup dependent) the 2CCDs setup measurement will be repeated in the DEAR Laboratory.

4 Experimental results for "machine" background

Electrons or/and positrons beams circulated at $DA\Phi NE$ from 19 October 1998 to 2 November 1998. During this interval $DA\Phi NE$ staff did many tests and adjustments of the beam parameters. Injections in the rings were made quite often and conditions were rather unstable. However, there are few periods in which beam lifetime measurements were performed and, consequently, beam was rather stable for longer periods (at the level of few hours).

The electron and positron rings are not in the same condition: namely, the average pressure in the positron ring is actually better than that in the electron ring (few units 10^{-9} mbar). This situation is reflected by a shorter beam lifetime for electrons, due to the larger losses from beam-gas interactions.

When injections were frequent and not efficient we had "occupancy-problems", in the sense that CCD images were almost white, even for read-outs of about 30 seconds.

Stable beam-conditions, useful from the point of view of performing an analysis of the results, occurred during the following periods:

- 21 October, beam of positrons, with initial intensity of about 2 mA;
- 26-27 October, beam of positrons, with initial intensity of about 9 mA;
- 28 October, 2 beams of electrons, with initial intensity of about 23 mA;
- 30 October, beam of positrons, with initial intensity of about 38 mA.

In what follows we shall briefly present the results of these runs.

4.1 Positron beam of 21 October

In the night of 21 October '98 a measurement of the beam lifetime of a positron beam was performed at $DA\Phi NE$. A positron beam with an initial intensity of about 2 mA was injected and then left to decay.

We performed measurements with the test setup during a time of 3.75 hours with runs of 15 minutes each. In Fig. 1 the beam intensity, as measured by $DA\Phi NE$ staff, is reported, while in Fig. 2 the number of clusters versus time, as recorded by DEAR, is presented (a cluster of hit pixels occurs whenever a charged or a neutral particle deposits energy in the CCD).

Numerical results relative to this beam are:

- Ratio between total number of clusters and X rays in the (2-18) keV region (mean value): (53 ± 5);
- X-ray background in the 1 keV region of interest (mean value): (1.67 $\pm$ 0.42) X/hour/CCD/keV.

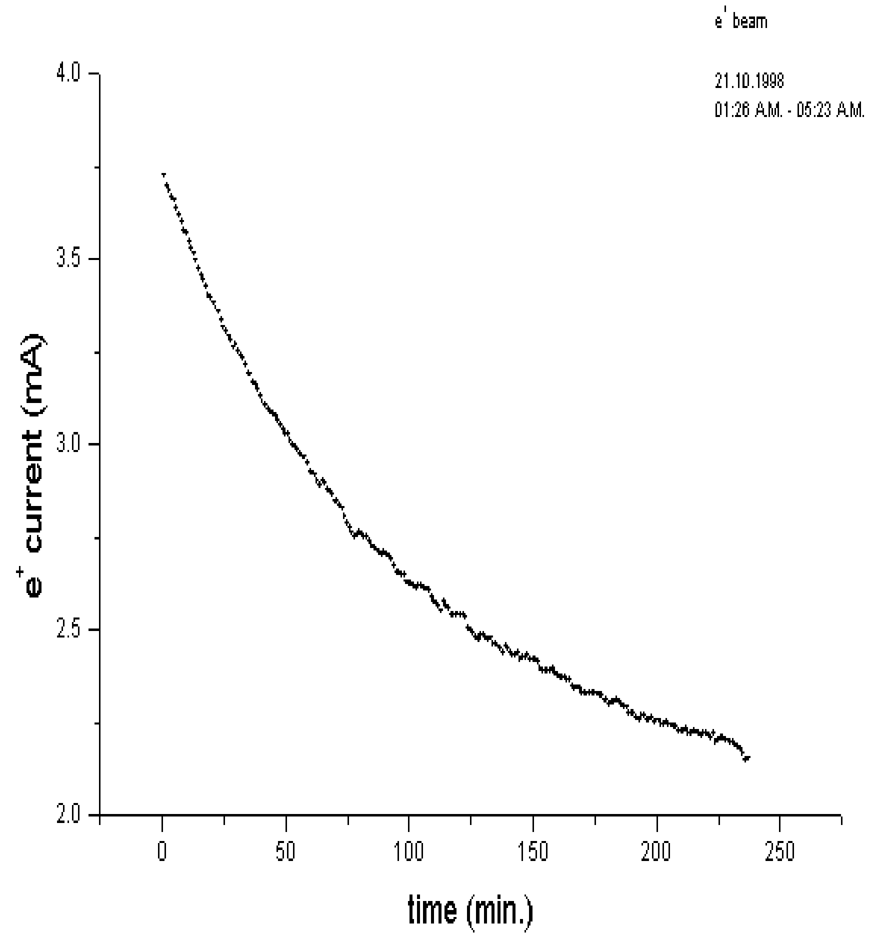

Figure 1: Positron beam intensity (values reported must be corrected by subtracting the pedestal), 21 October 1998

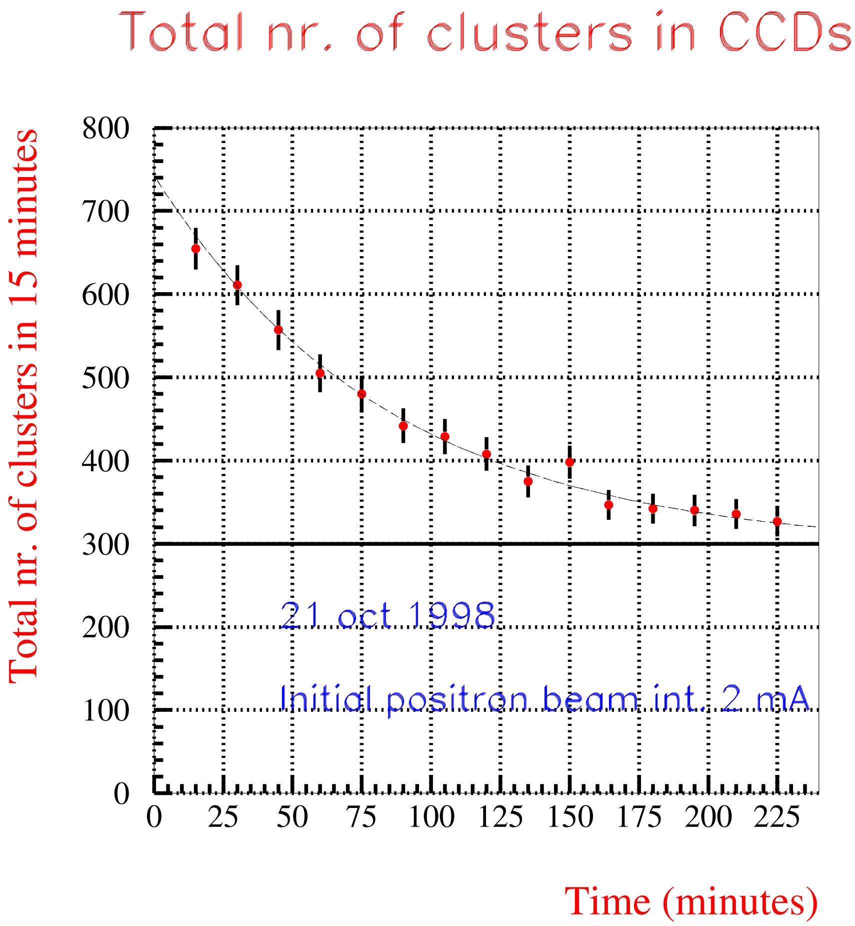

Figure 2: Total number of clusters for runs of 15 minutes as a function of time, with the test setup, during the night of 21 October 1998.

4.2 Positron beam of 26-27 October

In the night between 26 and 27 October '98 a relatively constant positron beam, with initial intensity of about 9 mA, was circulating at $DA\Phi NE$.

We performed measurements with the test setup during a time of 1.5 hours with runs of 10 minutes each. In Fig. 3 the beam intensity, as measured by $DA\Phi NE$ staff, is reported, while in Fig. 4 the number of clusters versus time, as recorded by DEAR, is presented.

Numerical results relative to this beam are:

- Ratio between total number of clusters and X rays in the (2-18) keV region (mean value): (70 $\pm$ 5);
- X-ray background in the 1 keV region of interest (mean value): (7.21 $\pm$ 1.44) X/hour/CCD/keV.

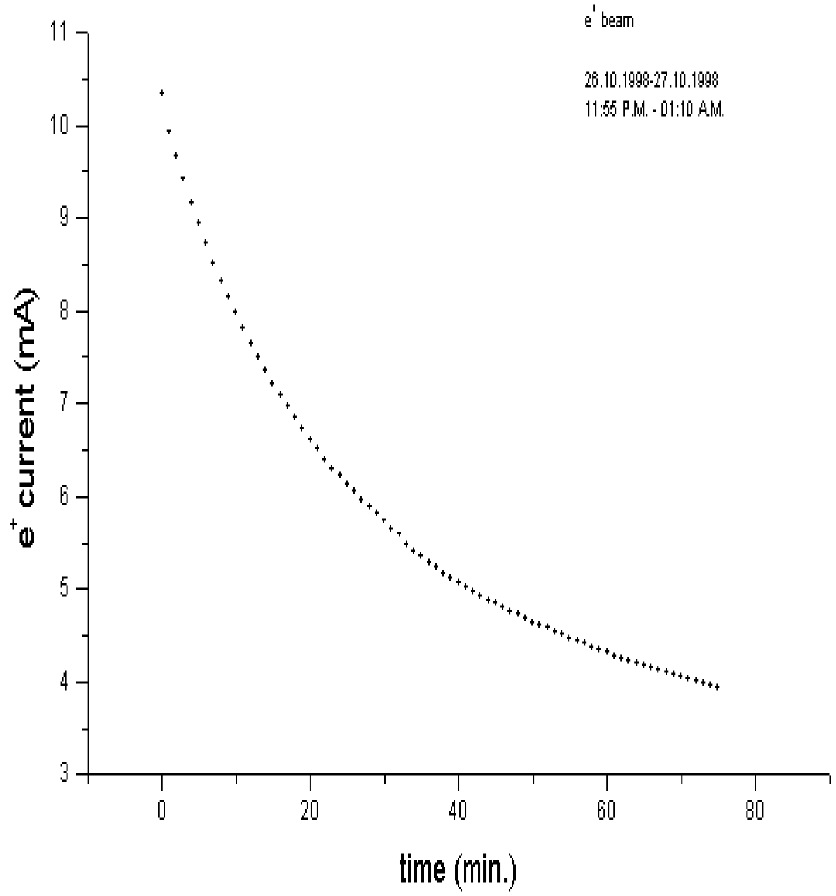

Figure 3: Positron beam intensity (values reported must be corrected by subtracting the pedestal), 27 October 1998

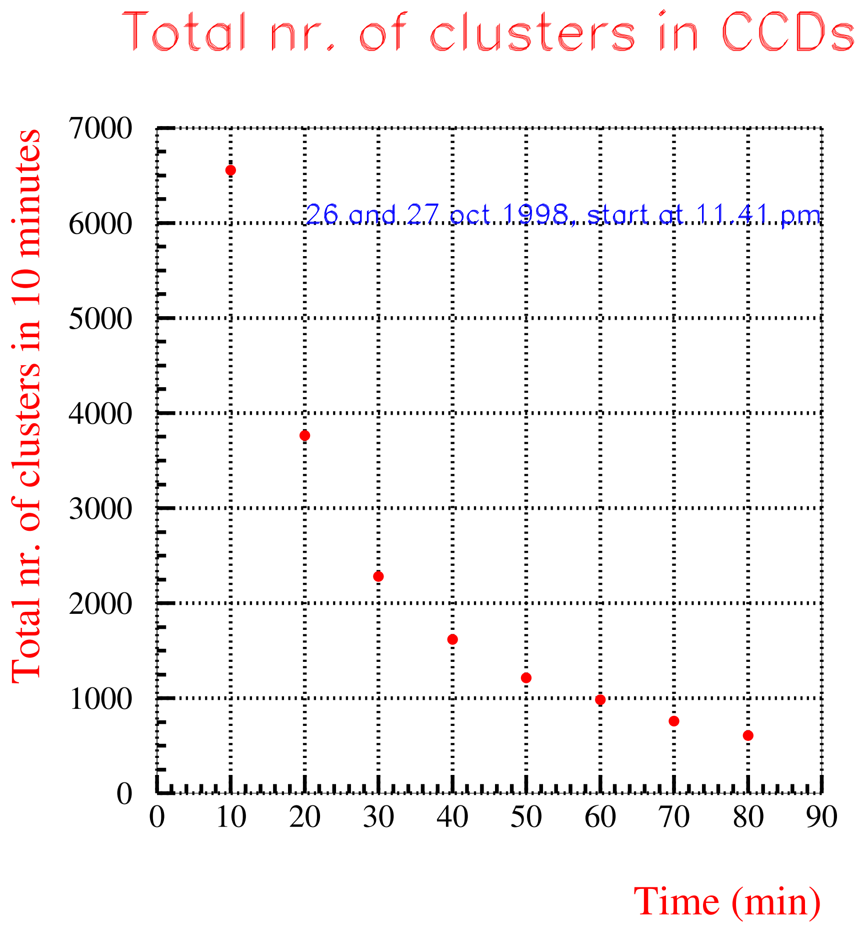

Figure 4: Total number of clusters for runs of 10 minutes as a function of time, with the test setup, during the night between 26 and 27 October 1998.

4.3 Electron beam of 28 October

On the morning of 28 October '98 a relatively constant electron beam, with initial intensity of about 23 mA, was circulating at $DA\Phi NE$.

The lifetime of this beam was shorter than those corresponding to the electron beams, due to the above mentioned vacuum asymmetrey of the 2 rings.

We performed measurements with the test setup during a time of 1.0 hours with runs of 5 minutes each. In Fig. 5 the beam intensity, as measured by $DA\Phi NE$ staff, is reported, while in Fig. 6 the number of clusters versus time, as recorded by DEAR, is presented.

Numerical results relative to this beam are:

- Ratio between total number of clusters and X rays in the (2-18) keV region (mean value): (106 $\pm$ 5);
- X-ray background in the 1 keV region of interest (mean value): (10.4 $\pm$ 2.2) X/hour/CCD/keV.

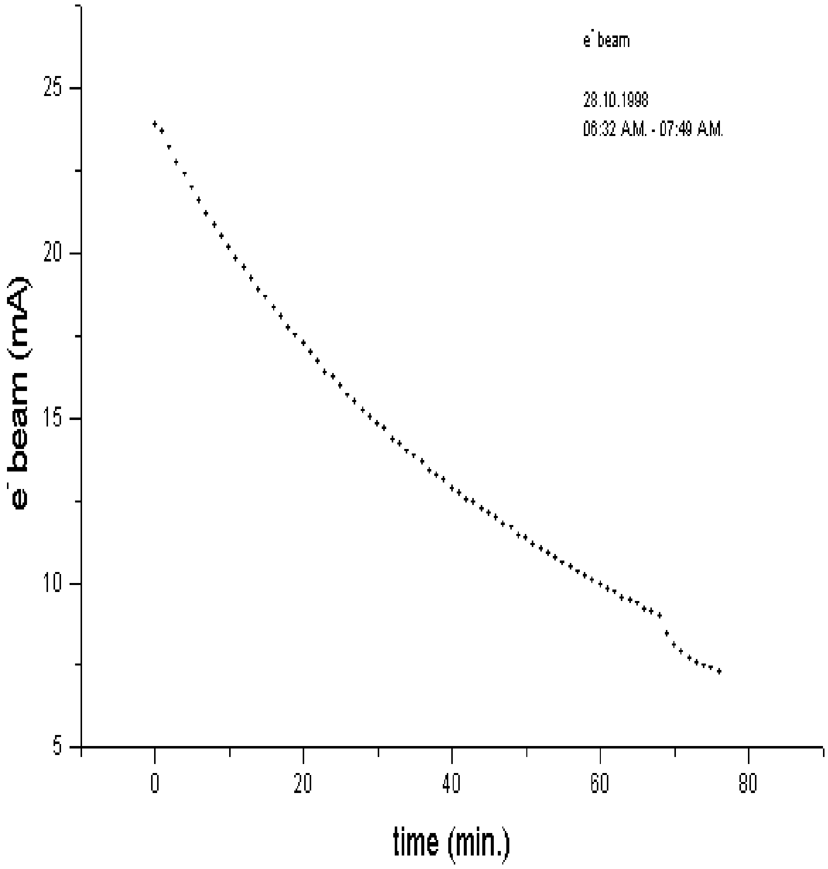

Figure 5: Electron beam intensity (values reported must be corrected by subtracting the pedestal), 28 October 1998

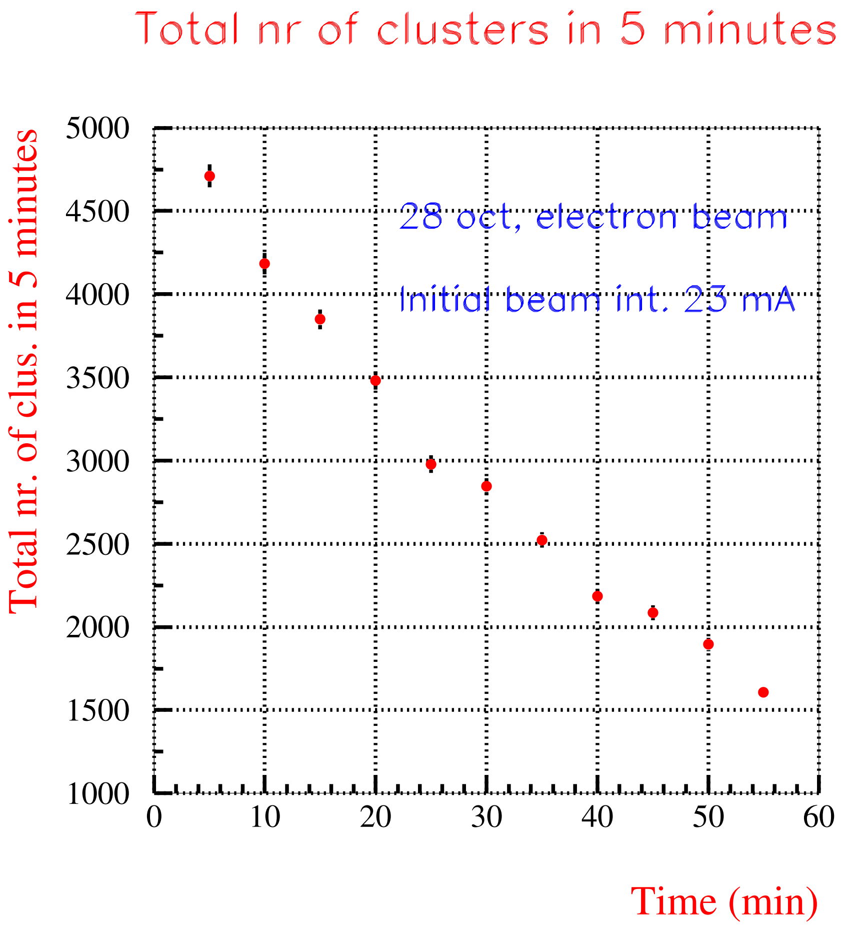

Figure 6: Total number of clusters for runs of 5 minutes as a function of time, with the test setup, in the morning of 28 October 1998.

4.4 Positron beam of 30 October

On the morning of 30 October '98 a positron beam, with initial intensity of about 38 mA, was circulating at $DA\Phi NE$.

The measurement corresponding to this beam was the longest and the most interesting out of all we performed. We could perform more accurate studies and analyses of the data corresponding to this period, the results being reported below.

We performed measurements with the test setup during a time of 5.0 hours with runs of 15 minutes each. In Fig. 7 the beam intensity, as measured by $DA\Phi NE$ staff, is reported, while in Fig. 7 the number of clusters versus time, as recorded by DEAR, is presented.

As one can see looking at the two Figures, after a first period, in which the beam intensity droped quite rapidly from 38 to 15 mA, a period with a longer lifetime followed. In Fig. 9 the total number of clusters, as registred by our simple 2 CCDs setup in this period, are reported.

Numerical results relative to this beam are:

- Ratio between total number of clusters and X rays in the (2-18) keV region: it ranges between (146 $\pm$ 5) at the beginning of the run, and (42 $\pm$ 10) at the end of the run (when the intensity of beam was small);
- X-ray background in the 1 keV region of interest: it ranges between (10.8 $\pm$ 2.1) X/hour/CCD/keV and (1.3 $\pm$ 0.8), with a mean value of (3.88 $\pm$ 0.56)

The signal, as registred by us, presented 3 regions, in which the losses from primary beam were due to different mechanisms, characterized by the following lifetimes:

- a first region, for the first 50 minutes, where the lifetime was about (40 $\pm$ 0.3 $\pm$ 2) min;
- an intermediate region, lasting about 150 minutes, where the lifetime was of the order of (82 $\pm$ 2 $\pm$ 10) min;
- a last region, where the lifetime was of the order of (134 $\pm$ 7 $\pm$ 15) min.

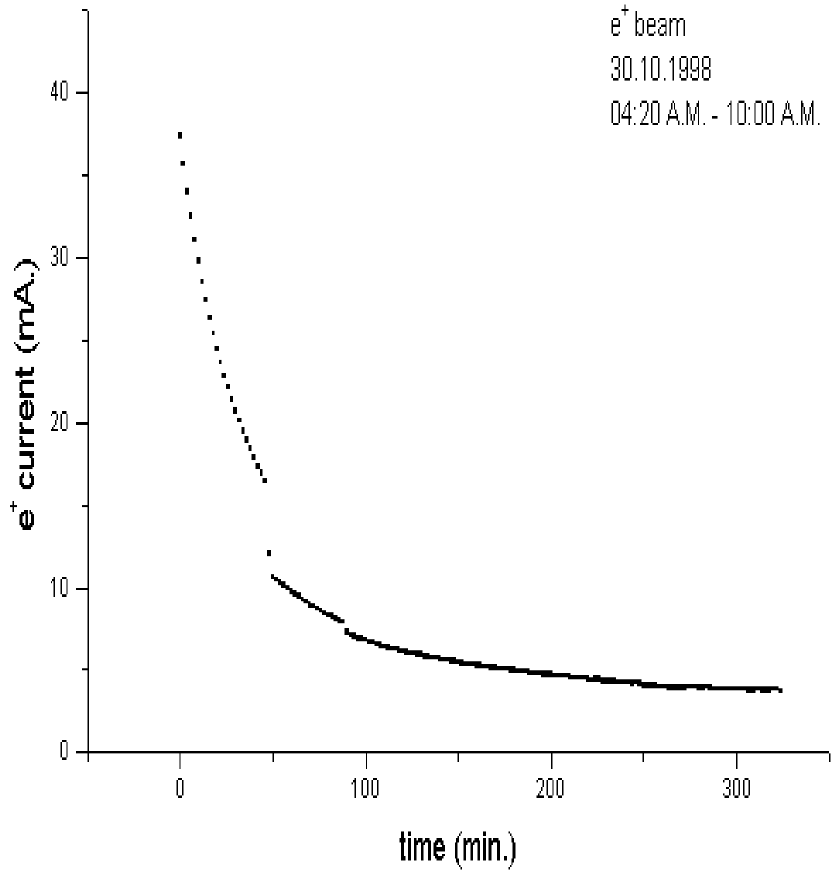

Figure 7: Positron beam intensity (values reported must be corrected by subtracting the pedestal), 30 October 1998

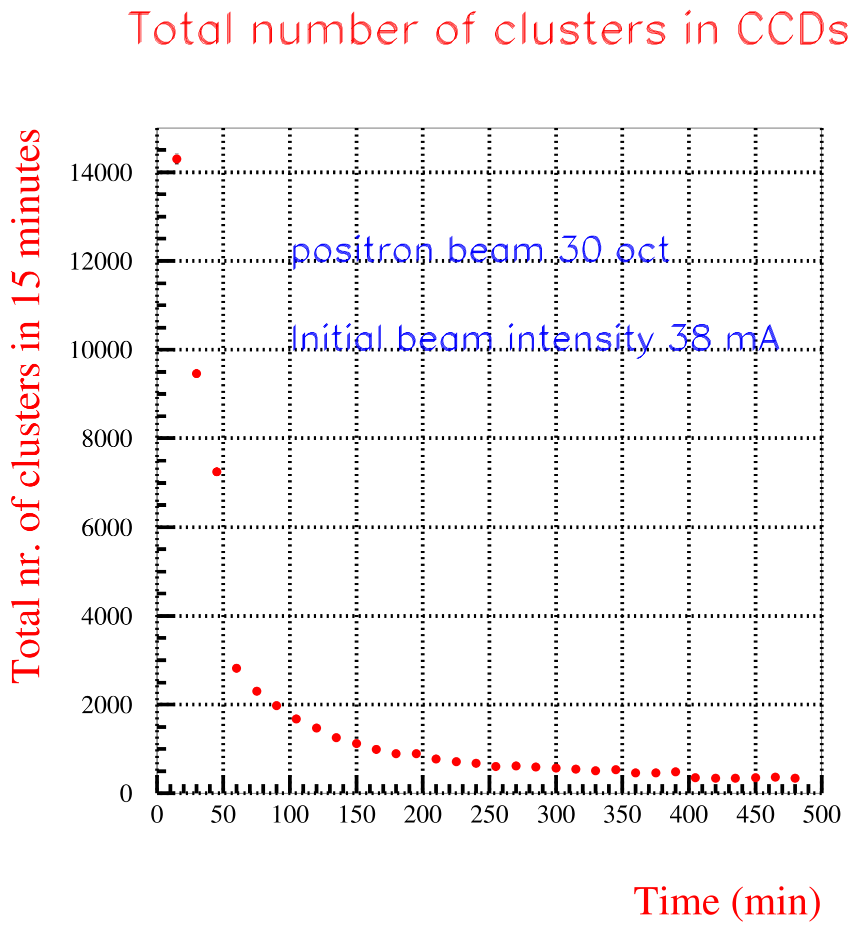

Figure 8: Total number of clusters for runs of 15 minutes as a function of time, with the test setup, during the morning of 30 October 1998.

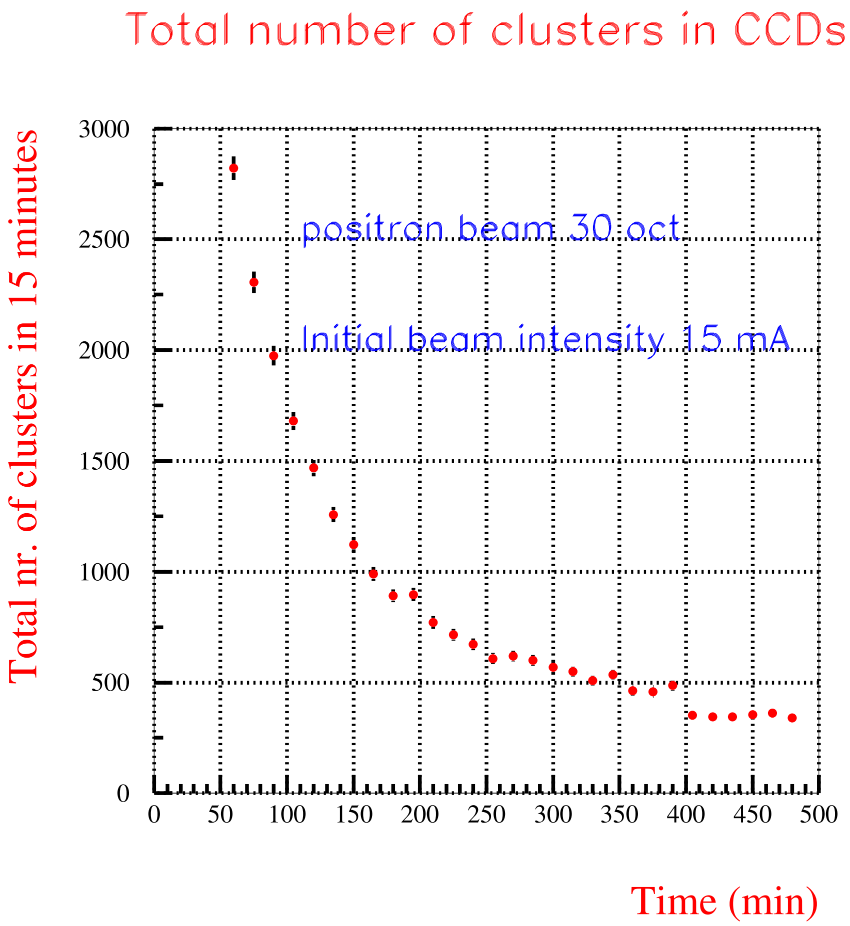

Figure 9: Total number of clusters for runs of 15 minutes as a function of time, with the test setup, during the morning of 30 October 1998, for the period with relatively stable positron beam.

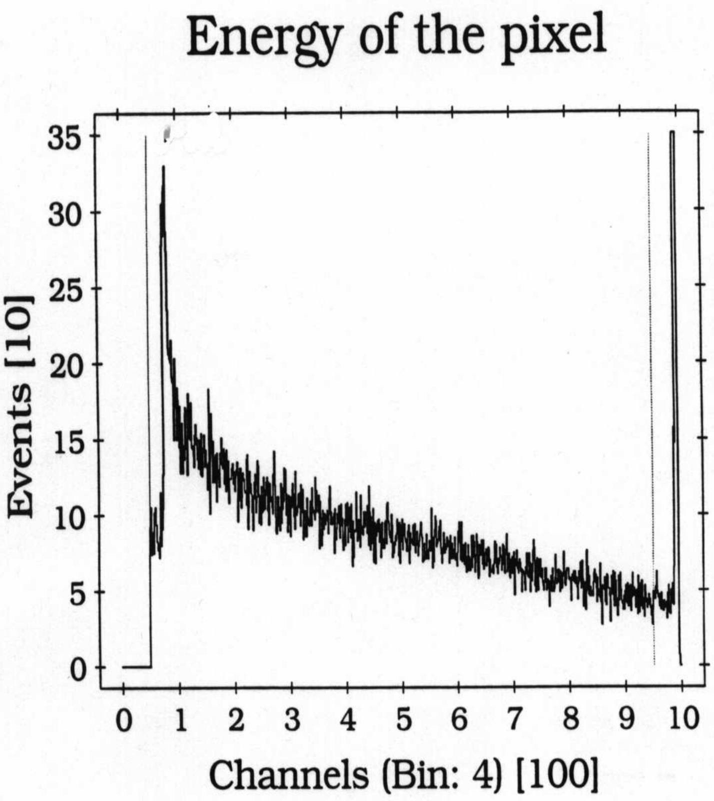

Figure 10: X-ray energy spectra.

4.5 Miscellaneous

During this period of data taking, we observed that for the electron beam, the CCD closer to the coming-in direction of electrons registred (20-30)% more signal than the CCD further away.

In the same time for a positron beam the external halves CCDs registred (10-15)% more signal than the internal ones.

In Figure 10 an overall X-ray energy spectra representing data taken during this period (with electron and positron beams, as well as without beam) is shown. This spectra is without structures, except for the K_α peak of electronic Aluminium (at 1.49 keV).

Another observation is correlated with the number mean value of the cluster size in case of a positron or of an electron beam. It was observed that the mean value of the cluster size for the electrons beam is about 6, while the value corresponding to a positron beam is about 7. The value of the cluster mean size for non-machine background is again about 7. This effect will be further studied (new position of the 2CCD setup).

5 What have we learned so far or Conclusions

After having performed these measurements with the DEAR test setup, without shielding and with the CCDs pointing at the beam pipe, we learned the following things:

- with machine turned off, the X-ray background in the energy region of interest is of the order of 0.85 counts/CCD/keV/hour; this value is somewhat lower than the results obtained in the DEAR laboratory;

- when a positron beam with intensity 2-15 mA is circulating with stable conditions, the X-ray background in the region of interest is enhanced very little: it is on average (1.7 ± 0.4) counts/CCD/keV/hour;

- the number of clusters in the CCD varies approximately linearly with beam current; therefore the beam lifetime cam be measured to a precision of about 20%;

- the ratio between the total number of clusters and the X-ray background in the (2-18) keV dynamical range varies as a function of beam current from about 40 to 100 for a positron current variation from 2 to 30 mA;

- background events have a different cluster size in case of electrons and positrons; this feature deserves further studies;

- if the beam is lost during injection, a large X-ray peak appears at 1.49 keV, corresponding to the electronic K_α X-ray line in aluminium;

- good qualitative agreement of the results of the DEAR Monte Carlo with the performed machine background measurements was obtained [1].

References

[1] C. Petrascu, "Monte Carlo calculation for Touschek lost positrons hitting a simplified DEAR setup", DEAR Technical Note, IR-8, 2 Nov. 1998.