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Development of Diamond Tracking Detectors for High Luminosity Experiments at the LHC

The RD42 Collaboration

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◇ Spokespersons

Abstract

Over the past year the RD42 collaboration continued to improve CVD diamond detectors for high luminosity experiments at the LHC. We have made extensive progress on diamond quality and radiation hardness studies using the highest quality diamond were performed up to fluences of 20×10^{15} p/cm^2. Transforming this technology to specific requirements of the LHC has begun. The first ATLAS diamond pixel module was constructed using the same bump-bonding and electronics that the present ATLAS pixel modules use. Both ATLAS and CMS have tested and are planning to use diamond for their beam conditions monitoring systems. In this report we present the progress made and the requirements specific to the programme.

1 The RD42 2004 Research Program and Milestones

Chemical Vapor Deposition (CVD) diamond has been discussed extensively as an alternate sensor material for use very close to the interaction region of the LHC where extreme radiation conditions exist. The availability of very radiation hard detector material and electronics will be of great importance in view of possible future luminosity upgrades for the LHC [1]. During the last few years the RD42 collaboration manufactured and tested diamond devices with LHC electronics toward the end of creating a detector usable by any LHC experiment. Extensive progress in the areas of diamond quality, the development of diamond trackers and radiation hardness has been made. Transforming the technology to the specific requirements of the LHC has now started.

1.1 The LHCC Milestones

The RD42 project was last approved for continuation with the following objectives:

- to improve the charge collection distance of polycrystalline CVD (pCVD) material above 250 μm,
- to develop devices useful at the LHC by ATLAS and CMS,
- to pursue the development of single crystal CVD (scCVD) diamond material,
- to test the radiation hardness of the highest quality pCVD and scCVD diamond and,
- to continue the development of systems for beam monitoring for the LHC.

1.2 Summary of Milestone Progress

The development of new diamond material came about as a result of a series of material studies. The primary result of this work showed that our understanding of the growth processes is correct and a clear path to higher quality diamond can be pursued. A decision to pursue such a research program was made and work on it has finished. Our industrial partner had hinted that diamonds with a collection distance above 300 μm collection distance diamonds are reachable. The result of this work proved that this hypothesis was correct and produced a diamond wafer with 305 μm collection distance. Fig. 1 shows such a diamond wafer.

The production of high quality pCVD material has allowed RD42 to develop applications of diamond to high energy physics experiments. In collaboration with the groups developing front end electronics for both ATLAS and CMS, RD42 has constructed new pixel detectors. This past year we constructed the first full diamond ATLAS pixel module using diamond from the wafer described above, with the final ATLAS IBM 0.25 micron rad-hard electronics, and tested it at CERN. During this test we found that all 16 chips work, observed hits in over 90% of the pixels and mapped out the beam profile. Unfortunately the test was cut short before the complete module test was completed.

Last year RD42 began a three year research program to develop single crystal CVD (scCVD) diamond. This type of CVD diamond has the potential to solve many if not all of the issues associated with pCVD material. This past year both the thickness and size of the scCVD diamonds was increased. The thickest part produced with full charge collection was 770 μm. The largest area part produced was just over 1cm^2.

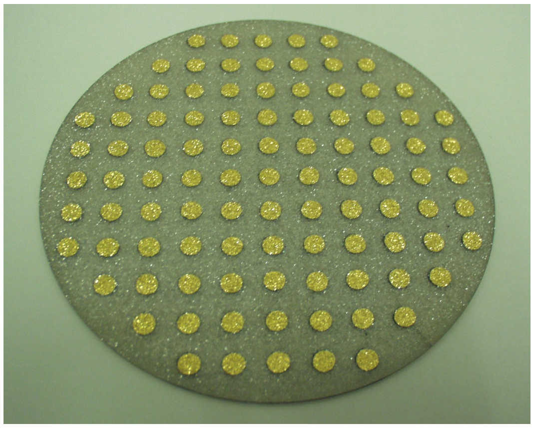


Figure 1: Photograph of the growth side of the full 12 cm wafer metallised with dots 1cm apart for testing. The charge collected was measured at each dot on the wafer using a ^{90}Sr source in the laboratory. The collection distances range from roughly 200 μm at the edge to 305 μm near the center.

As part of the radiation hardness program, RD42 irradiated the highest quality pCVD and scCVD diamond. This past year we reached a fluence of 20×10^{15} p/cm^2 with pCVD diamond and 6×10^{15} p/cm^2 with scCVD diamond. After these fluences the diamonds were still working and were tested in a CERN test-beam. We observed that after 20×10^{15} p/cm^2 the diamonds still function well with 25% of the un-irradiated charge.

RD42 together with BaBar, Belle, CDF, ATLAS, and CMS are developing diamond detectors to provide radiation monitoring and abort protection for the various experiments. BaBar has taken the lead here and installed two pCVD samples in the IR between the beam-pipe and silicon vertex detector. Belle has installed two equivalent devices, CDF has installed one device and ATLAS and CMS have just completed radiation tests and beam tests of pCVD diamonds. As a result of these tests the ATLAS Beam Conditions Monitoring (BCM) system is now based on diamond.

The details of the work summarised above are presented in the next sections.

2 Progress on the Improvement of CVD Diamond

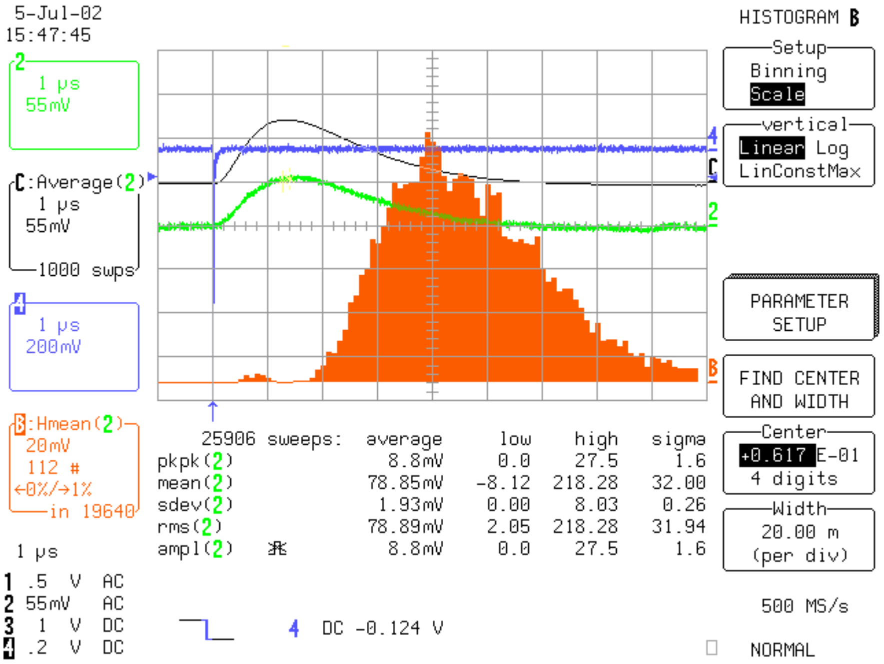
Over the last few years, we have worked closely with the Element Six [2] (previously De Beers Industrial Diamond Division) to achieve major improvements in the charge collection distance and uniformity of CVD diamond.

- CVD diamond purchased from production reactors now regularly reaches 250 μm charge collection distance.

This past year marked the end of the pCVD research program. The research recipes are being migrated to production reactors. Production quality samples are now planned for use in various experiments. The measured pulse height distribution, using a ^{90}Sr source, of a typical sample as-received from the manufacturer is shown in Fig. 2. To obtain this distribution we metallised the diamond with circular electrodes on each side. The gain of the system was 124 e/mV. Operating at an electric field of 1 V/μm we observe a Landau distribution well separated from zero. We also observe that the charge collection is symmetric with applied voltage. The most probable charge is ≈ 7600 e and 99 % of the distribution is above 3000 e. From the mean value, $\langle Q \rangle$, of the signal spectrum one derives the charge collection distance

$$\bar{d} = \frac{\langle Q \rangle \ \ [e]}{36 \ e/\mu\mathrm{m}} \tag{1}$$

where 36 e/μm is the mean number of electron-hole pairs generated by a minimum ionizing particle along 1 μm in diamond. The mean charge of 9800 e in CDS-114 corresponds to a charge collection distance of 275 μm.



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  25906 sweeps:   average     low    high   sigma
pkpk(2)             8.8mV     0.0    27.5     1.6
mean(2)           78.85mV   -8.12  218.28   32.00
sdev(2)            1.93mV    0.00    8.03    0.26
rms(2)            78.89mV    2.05  218.28   31.94
ampl(2)   ⁂         8.8mV     0.0    27.5     1.6
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Figure 2: Pulse height distribution of the final production diamonds from the Research Program. This diamond sample was measured using a ^{90}Sr source in the laboratory. The histogram is taken for each scintillator trigger (upper trace). An individual single diamond pulse is shown in the third trace and the average of all pulses is shown in the second trace.

In the course of our work with Element Six the charge collection distance improved from several 10 μm to over 300 μm. As stated earlier, this research program is now complete. Element Six believes that gains will still be made as the production reactors are operated over time.

In late fall 2002 we received the first single crystal diamonds grown by a chemical vapor deposition process [3]. The samples they produced were synthesized with a microwave plasma-assisted CVD reactor using a specially prepared $\langle 100 \rangle$ oriented single crystal synthetic diamond substrate. The RD42 group has entered into a three year research contract with Element Six to develop this material.

In Fig. 3 we show the pulse height spectrum observed from four single crystal CVD diamonds. The diamonds are 210, 330, 435, and 450 μm thick. We observe collection distances consistent with full charge collection; most probable charges of 5,500e, 9,500e, 13,400e and 13,500e; FWHM's of 3000e, 3000e, 4000e, and 4000e; and more than 4,000e, 7,000e, 10,000e and 10,000e separation between the pedestal and the beginning of the charge distribution. The FWHM/MP for these single crystal CVD diamonds is approximately 0.3-0.5, about one third that of polycrystalline CVD diamond and about two thirds that of correspondingly thick silicon.

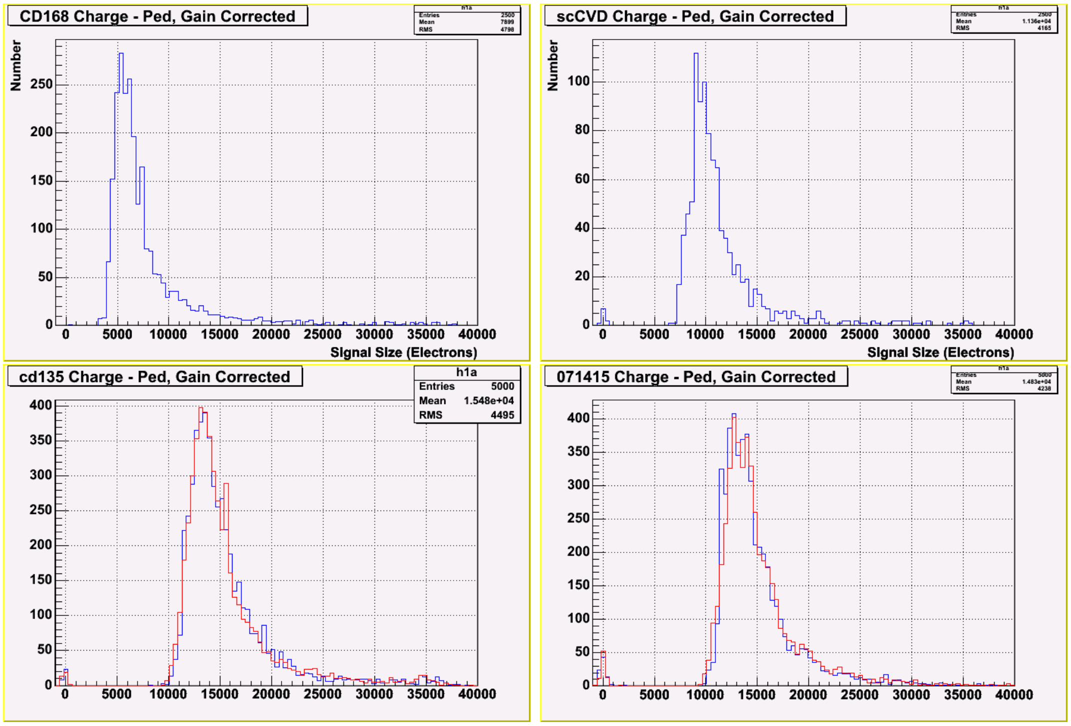

Figure 3: The pulse height distribution of various scCVD diamonds. The thicknesses of the diamonds are, from top left to to bottom right 210, 330, 435, 450 μm. When there are two curves they are the results for positive and negative applied voltage.

In Fig. 4 we show the most probable charge for scCVD diamond versus thickness of the material. A clear linear relationship is evident out to thicknesses of 770 μm. In order to understand the basic properties of this new material we began a program to measure the carrier lifetime and mobility by observing the transient current pulse when a particle penetrates a diamond and stops near the entrance electrode. In Fig. 5 we show the current pulses created by alpha particles injected on one surface of the scCVD diamond as a function of time. The parameters we are able to extract from the data include transit time, velocity, lifetime, space charge independently for electrons and holes. Our first results [4] indicate that the carrier lifetimes in scCVD diamond are of the order of 35ns and that this particular diamond has an internal space charge. Results such as this should help in our understanding of the CVD process and in the manufacturing of still better material. Based on our test results, this new material seems extraordinary: single crystal CVD diamond may resolve many if not all of the issues associated with polycrystalline material. We are looking forward to measuring more samples of this material as the research contract proceeds.

3 Radiation Hardness

This past year RD42 extended its irradiation results of CVD diamonds from 3×10^{15} p/cm^2 to 20×10^{15} p/cm^2. The results from previous irradiations show that up to 3×10^{15} p/cm^2 pCVD diamonds lose at most 15% of the most probable charge and improve their resolution by roughly 40%. In Fig. 6, we show the previous results for the collected charge of

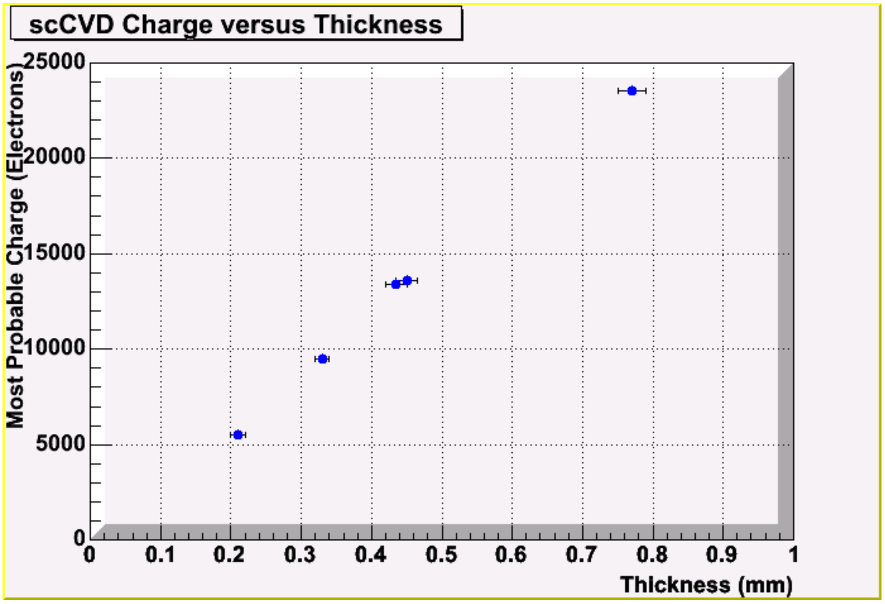

Figure 4: The most probable pulse height versus thickness for scCVD diamonds.

a polycrystalline diamond strip detector after irradiation with a fluence of 24 GeV protons of 1 × 10^{15} p/cm^2 and after 2.2 × 10^{15} p/cm^2. While the strip contacts before and after irradiation with fluences of 1×10^{15} p/cm^2 were unchanged the contacts were replaced after a fluence of 2.2×10^{15} p/cm^2 and then characterized in the test beam. At 1×10^{15} p/cm^2 we observe that the shape of the signal-to-noise distribution is narrower than before irradiation and entries in the tail of the distribution appear closer to the most probable signal. At 2.2×10^{15} p/cm^2 and after re-metalization we observe essentially the same signal-to-noise distribution (measured with a low noise VA chip amplifier) as at 1×10^{15} p/cm^2 indicating that very little further damage occurred to the diamond bulk. The most probable signal-to-noise was 41 before irradiation and 35 at 1×10^{15} p/cm^2 and also at 2.2×10^{15} p/cm^2. We find a reduction of maximum 15% in the most probable signal-to-noise after irradiation with 2.2×10^{15} p/cm^2. The noise was measured to remain constant at each beam test. Since the

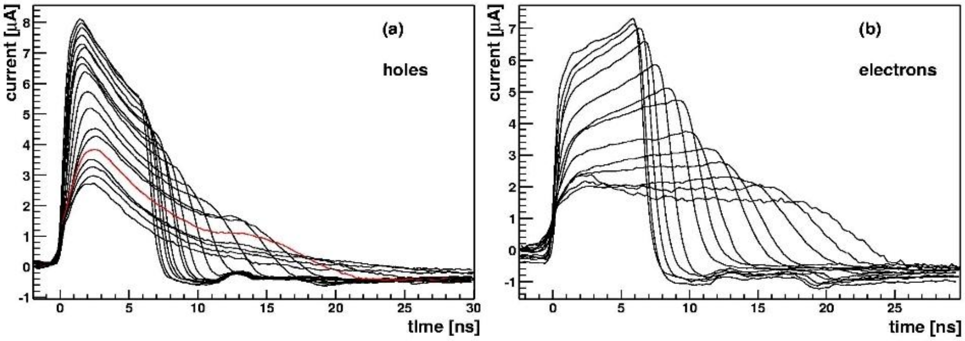

Figure 5: The observed current pulses created by alpha particles injected on one surface of the sCVD diamond as a function of time. The different curves are for different voltages in the range -40 volts to -375 volts and +70 volts to 690 volts.

beam test with the detector irradiated with a fluence of 2.2×10^{15} p/cm^2 used new contacts the observed decrease of 15% is attributed to damage in the diamond bulk.

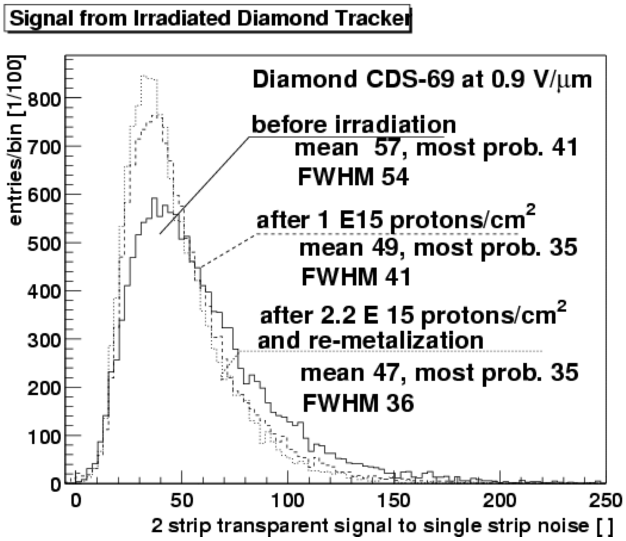

Figure 6: Transparent 2-strip charge signal-to-noise distributions before (solid line), after proton irradiations with 1×10^{15} p/cm^2 (dashed line) and after 2.2×10^{15} p/cm^2 (dotted line).

Fig. 7 shows residual distributions before and after irradiation for the same diamond at 1×10^{15} p/cm^2 and 2.2×10^{15} p/cm^2. We observe that the spatial resolution improves from (11.5 ± 0.3) μm before irradiation to (9.1 ± 0.3) μm at 1×10^{15} p/cm^2 and to (7.4 ± 0.2) μm at 2.2×10^{15} p/cm^2. At present the explanation for this effect is that the irradiated material is more uniform in the sense that the probability of large signals has been reduced by the irradiation. The spatial resolution of nearly 7 μm with a detector of 50 μm strip pitch is comparable to results obtained with silicon detectors.

The RD42 group has now extended these irradiations to fluences up to 20×10^{15} p/cm^2 for pCVD material. This figure corresponds to a dose of roughly 500Mrad. In Fig. 8 we show the pulse height distribution before and after the irradiation to 20×10^{15} $\mathrm{p/cm}^2$. At this fluence the pCVD diamond retains 25% of its original pulse height.

In Fig. 9 we show a summary of the proton irradiation results described above. We find that all of the irradiations fall along an exponential curve. The diamond signal is down by 1/e at 12.5×10^{15} $\mathrm{p/cm}^2$. In Fig. 9 we also show the results of the first irradiation of any scCVD diamond. Our preliminary data indicates that scCVD diamond is damaged more easily than pCVD material. These results are in the process of being checked.

4 ATLAS Pixel Module

During the past years RD42 worked closely with the Fraunhofer Institute for Reliability and Microintegration (IZM) [5] to develop the procedures to bump-bond small detectors individually. Using this technology, tests performed on $1\mathrm{cm}^2$ diamond pixel detectors based on older diamond samples showed that pixel efficiencies above ~98 % and spatial resolutions slightly better than digital were achievable. Fig. 10 shows a photograph of one of the ATLAS devices. In Fig. 11 we show the spatial resolution from a $1\mathrm{cm}^2$ ATLAS diamond pixel detector. As is shown the resolution obtained with the ATLAS pixel detector was 12 μm in the x-view

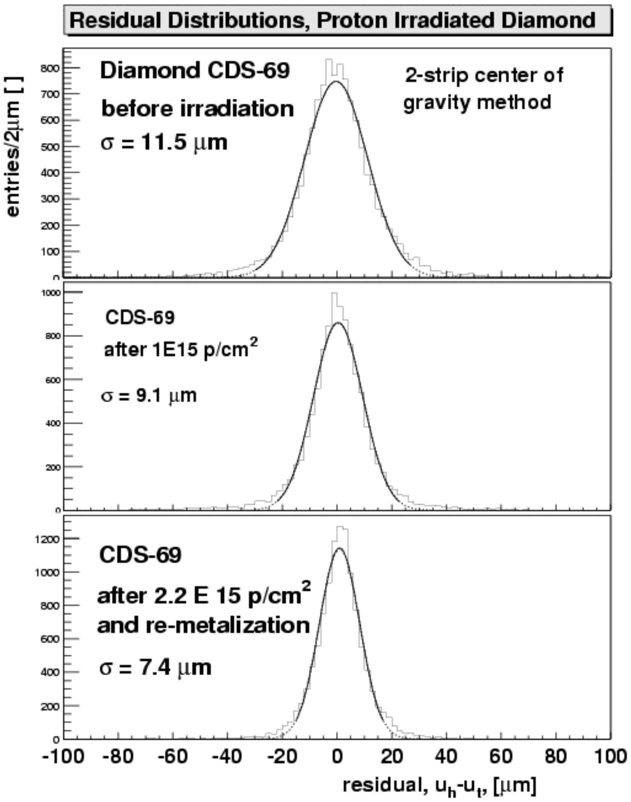

Figure 7: Residual distributions before and after proton irradiation.

where the pixels have 50 μm pitch and a characteristic 'top-hat' distribution in y where the pixels are 400 μm long. The efficiency for finding hits in the pixel detector that correspond to tracks reconstructed in the reference telescope was above 98%.

With the success of the 1cm^2 pixel detectors and the availability of the new high collection distance diamond RD42 decided to try to produce a full diamond 2cm × 6cm ATLAS pixel module. In order to accomplish this task RD42 worked closely with IZM to insure that the various procedures used were compatible. IZM performed the bump-bonding and this project would not have succeeded without their effort. Since the diamond wafer could not be cut after bump-bonding without graphitizing the surface we decided to first remove the diamond part from the wafer, do the photolithography on the 2cm × 6cm part and then install the diamond in a carrier for bump bonding. In Fig. 12 we show the diamond mounted in the carrier wafer ready for bump bonding. In Fig. 13 we show the metal pixel pattern on the diamond part before and after the under-bump metal is applied. In Fig. 14 we show the final diamond pixel module with 16 pixel chips ready for external cables and testing. This module was tested in the ATLAS telescope at CERN. However there were complications during this test and the diamond pixel module only received a small amount of beam time and then was removed, while the module was still working perfectly well. Moreover, during that data taking period the beam was not centered in the telescope yielding very poor tracking results in the ATLAS telescope. Even with these hardships we were able to obtain an image of the beam in the ATLAS diamond pixel module. In Fig. 15 we show the hit map in the diamond pixel module. A clear beam image is evident indicating that a substantial fraction (> 90%) of the detector was operating as expected. All indications are that the module performed quite similarly to

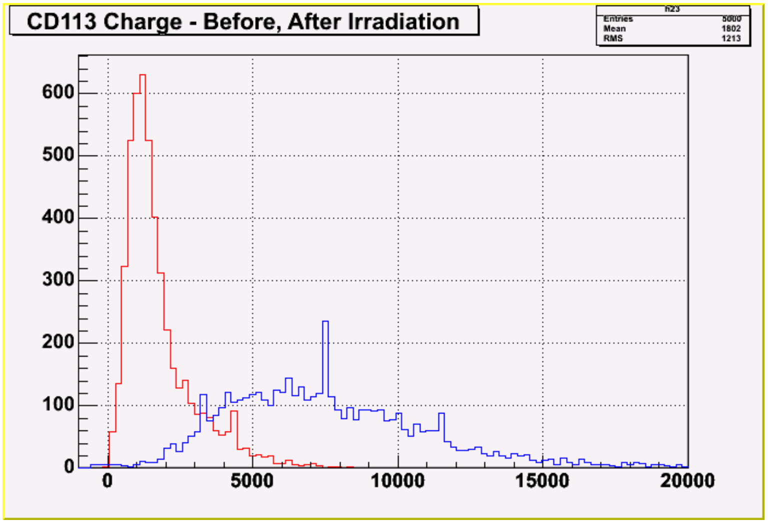

Figure 8: Pulse height distributions before (blue curve) and after (red curve) the irradiation to 20×10^{15} p/cm^2.

the silicon modules. To continue these tests the diamond module and Bonn telescope were moved to DESY. We are also investigating the possibility of using the Fermilab test beams to complete the characterization of this module. It now seems evident that this generation of pixel detectors which uses the newly available larger collection distance material is probably suitable for applications at the LHC.

5 Beam Monitors a New Application

Radiation monitoring plays a crucial role in any experiment which operates a high precision tracking system close to the interaction region. Experience has shown that to protect the inner tracking devices systems must be provided which can abort the beams on large current spikes. In addition, radiation monitoring allows for the measurement of the daily dose and integrated dose which the tracking systems receive and thus allow the prediction of device lifetimes, etc.

Presently BaBar and Belle use silicon PIN diodes for radiation monitoring inside of their silicon vertex detectors. After 100fb^{-1} the signal size for stable beams is approximately 10nA while the leakage current in the PIN diodes is approximately 2μA. Thus in these systems radiation monitoring is already becoming very difficult. Couple this with the fact that the PIN diodes must be temperature corrected continuously and one quickly finds that the radiation monitoring systems are a large effort to keep working. As a result both BaBar and Belle are pursuing diamond replacements for the silicon PIN diodes. The main advantages of CVD diamond over silicon for this application is its small leakage currents, radiation hardness and temperature independent operation.

Recently ATLAS, CMS and CDF have studied possible beam losses and their implication for the inner detectors. Such simulations have led groups being formed in each experiment to investigate diamond for their applications as well. For ATLAS, for example, an international working group has already designed and tested a nearly final system.

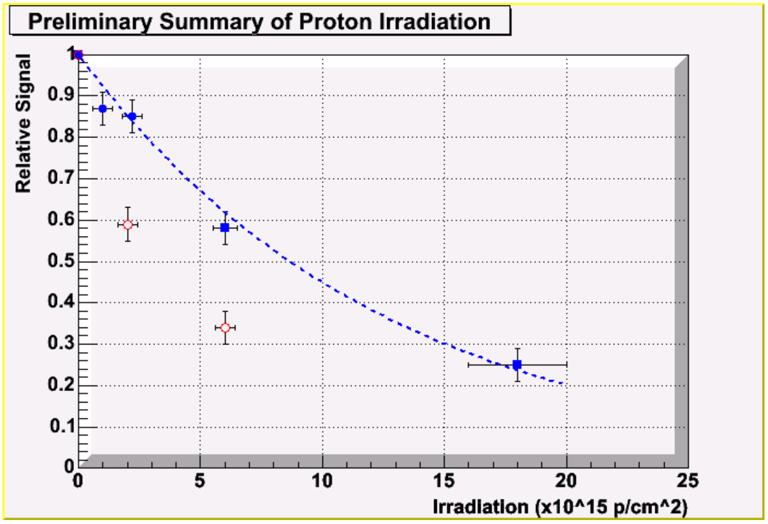

Figure 9: Summary of proton irradiation results for pCVD material up to a fluence of 20×10^{15} p/cm^2 (filled data points). The blue curve is an exponential with exponent -0.08×fluence indicating a radiation lifetime for this material of 12.5×10^{15} p/cm^2. Also shown are the results of the irradiation of the first scCVD diamond (open data points).

5.1 BaBar/Belle/CDF Studies

With the help of RD42 BaBar, Belle and CDF have constructed radiation monitor devices. Two pCVD diamonds were installed inside BaBar in the Fall 2002. They were placed in the horizontal plane of the detector about 15cm from the interaction point and 5cm from the beam line. Their position is similar to that of the silicon PIN diodes. In Belle two pCVD diamonds were installed in 2003 in similar positions. Finally one diamond was installed in CDF in the fall 2004. All of these devices are similar in design. Fig. 16 and Fig. 17 shows pictures of these diamonds. Fig. 18 shows a device in the BaBar detector.

The BaBar experiment has been in the fortunate position to accumulate almost two years of data with diamond beam monitors. Fig. 19 shows the diamond and silicon signals in similar locations along with the Low Energy Ring (LER) current. Throughout the data taking the leakage currents in the diamond have remained negligible and with no detectable temperature sensitivity. To date neither of the two diamonds installed have shown any degradation in signal nor increase in leakage current. Moreover the dose rates calculated from the diamonds have agreed with the PIN diodes and as a result the diamonds are now used in the fast abort system and to provide prompt feedback the the machine operators. Fig. 19 shows two very interesting aborts. One fast and one slow both of which were detected in the diamonds. As a result of the year long data taking diamonds are presently the primary replacement option for the silicon PIN diodes in the next shutdown in 2005.

During the Fall 2004 shutdown CDF installed one diamond to test as a radiation monitor. The CDF experiment has already had many beam incidents that have caused failures in its silicon detector. During the last year of data taking alone CDF reports it lost or damaged 2.5% of all SVXII chips due to beam incidents. As this is the closest environment to the LHC it was decided to install a diamond to see how it performs.

In Fig. 20 we show the diamond response to the first beams at CDF. One observes that the diamond current is very small (pA) with no beams in the Tevatron (before 19:54) and generally follows the structure of the proton beam. The diamond monitor should be more correlated with the anti-proton beam but that data was not available. The instantaneous

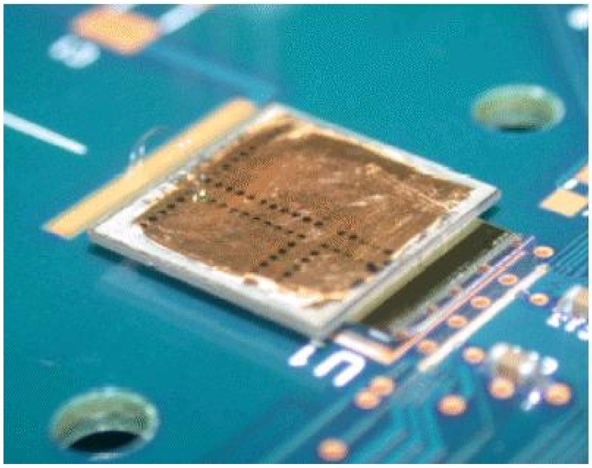

Figure 10: Photograph of a 1cm × 1cm diamond pixel detector.

peaks of the order of 65 nA are easy to follow. CDF estimates that their signal to noise is between 100:1 and 1000:1. They are so pleased with the operation of the diamond that they have asked RD42 for additional diamonds.

5.2 ATLAS/CMS Studies

ATLAS and CMS have a similar application to BaBar/Belle/CDF. They are considering diamond beam monitors which would act as part of the radiation monitoring system for equipment safety and radiation level/beam monitoring. They would address similar issues:

- Protect equipment during instabilities/accidents
- Provide feedback to the machine thereby helping them to routinely produce optimum conditions
- Monitor the instantaneous dose during normal running

Fig. 21 shows a photograph of one of the devices tested by ATLAS and CMS. This detector was tested for its response in the T7 PS testbeam and met or exceeded every specification. The parameters of the testbeam were similar to that expected to a worst case scenario.

- Beam intensity: 8x10^{11} protons per spill
- Fluence: 4x10^{10} protons/cm^2/spill at the centre of the beam spot - 1x10^8 protons/cm^2/spill in the halo
- Train of 40ns-wide bunches extracted from PS with 260ns gap

In Fig. 22 we show the current signal observed for a single MIP (5 GeV/c pions) in an ATLAS BCM prototype module (see Fig. 21). The detector was read out through a 2-stage 500MHz current amplifier as envisaged for the BCM and a 16m long analog signal cable. The signal rises in under 1 ns and the average pulse width is 2.1ns These very successful tests will be continued by both ATLAS and CMS in the future.

After these successful tests ATLAS now has a schematic plan for its diamond Beam Conditions Monitoring system. This is shown if Fig. 23 where the diamond monitors are placed on the forward disks of the pixel detector. The parts to construct this system are now being ordered. The system is planned to be installed in the Fall 2005.

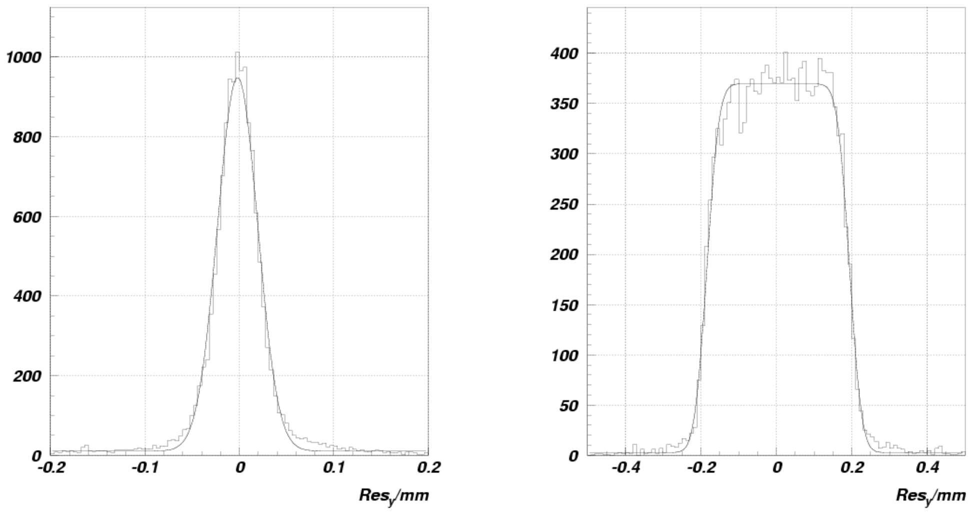

Figure 11: Measured residual distribution from an ATLAS pixel detector in the x-view and y-view.

6 Proposed Research Program for 2005

The goal of the RD42 research program is to develop best electronic grade CVD diamond and to demonstrate the usefulness and performance of CVD diamond as a radiation sensor material capable of detecting minimum ionizing particles in extremely high radiation environments. In order to achieve this goal the following main program steps had to be performed:

- Characterization of the electrical performance of specific CVD diamond samples grown by Element Six and continuous feed back of results to the manufacturer.
- Irradiation of samples up to fluences of 20×10^{15} particles/cm^2.
- Material science studies on these CVD diamond samples for defect characterization.
- Test of CVD diamond tracking devices with tailor made radiation hard front-end electronics for strip detectors and pixel detectors, including beam tests.

A large part of this program has been successfully achieved over the last years. There are however a number of important and decisive measurements still to be performed in this research program.

- RD42 has achieved in collaboration with Element Six to have material produced which shows on a regular basis charge collection distances between 250 μm and 275 μm. This work was achieved with a special program in the form of a research contract between RD42 and De Beers/Element Six. Now that single crystal CVD diamonds are a reality a second research contract - 100 % financed by the US part of RD42 - has been started with Element Six in 2003 to attempt to produce such material. This work will not conclude until 2006.
- While there have been many promising results from irradiation studies with pions, protons, neutrons, electrons and photons with material of increasing quality, there are

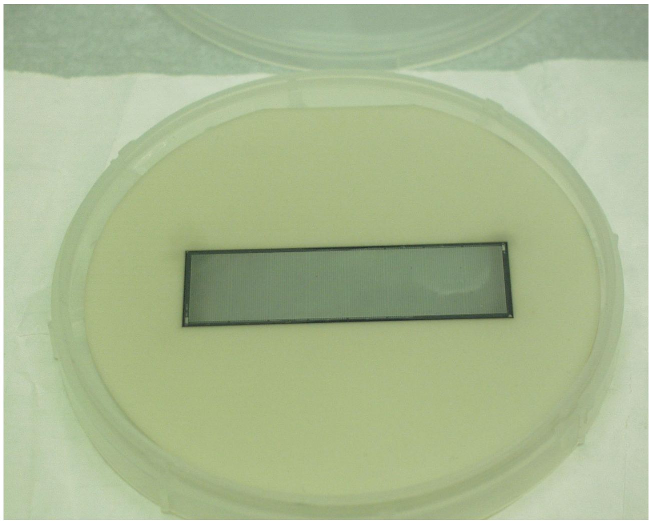

Figure 12: Photograph of the ATLAS pixel diamond mounted in the carrier ready for bump bonding.

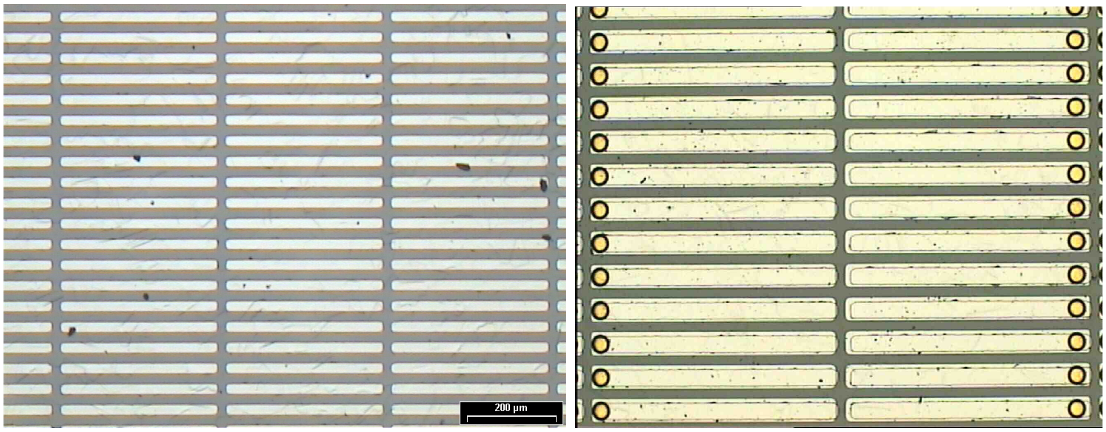

Figure 13: Photograph of the pixel pattern on the final ATLAS pixel module before and after the under-bump metal is deposited.

more measurements, in particular with pions, needed for the latest, highest quality CVD diamond samples.

- Material science studies have been pursued in a number of RD42 institutes. New methods and techniques had to be developed specific to CVD diamond. These are now in place, in particular TCT at CERN, need to be employed to study mobilities and lifetimes of electrons and holes. This will be very important in view of producing reliably high quality CVD diamond radiation sensors.

In summary, RD42 proposes to concentrate its efforts in 2005 to the following topics

- Pixel detectors, using the top quality CVD material available: implementation of rad hard contacts and reliable, efficient bump bonding, construction and test of modules with the latest radiation hard ATLAS and CMS front-end chips, and test these modules at DESY or Fermilab.
- Characterization of the new, highest quality scCVD diamond material produced by Element Six under the research contract.

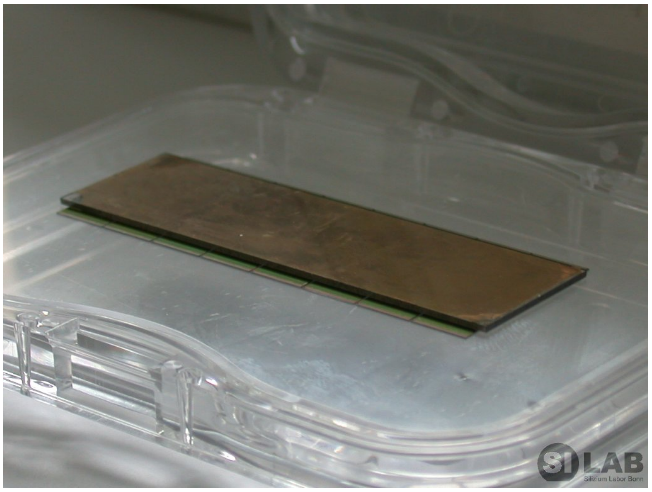

Figure 14: Final ATLAS pixel module with IBM pixel chip electronics mounted.

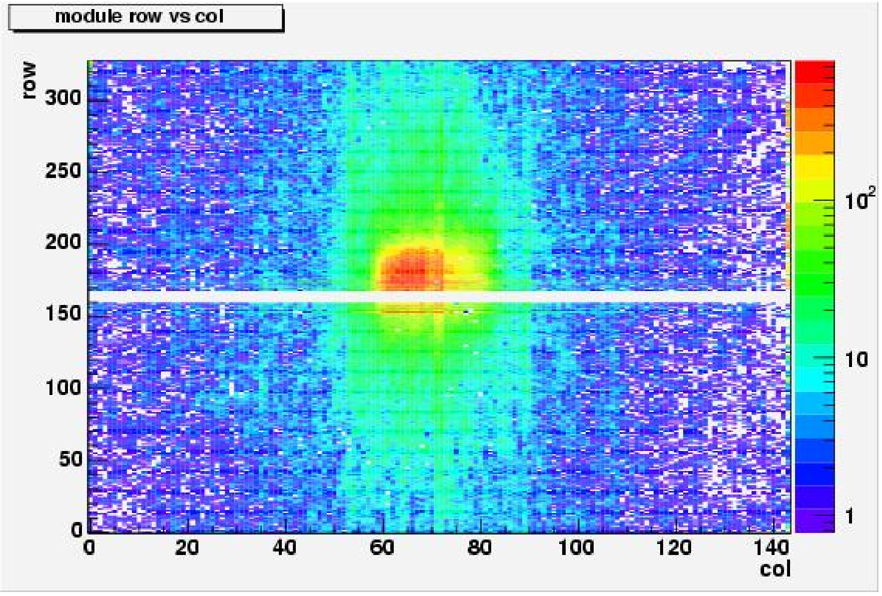

Figure 15: First ATLAS pixel module results in the 180 GeV pion beam at CERN.

- Proton, neutron and pion irradiations with the highest quality material.
- Tests of beam monitors for use in BaBar, Belle, ATLAS and CMS.

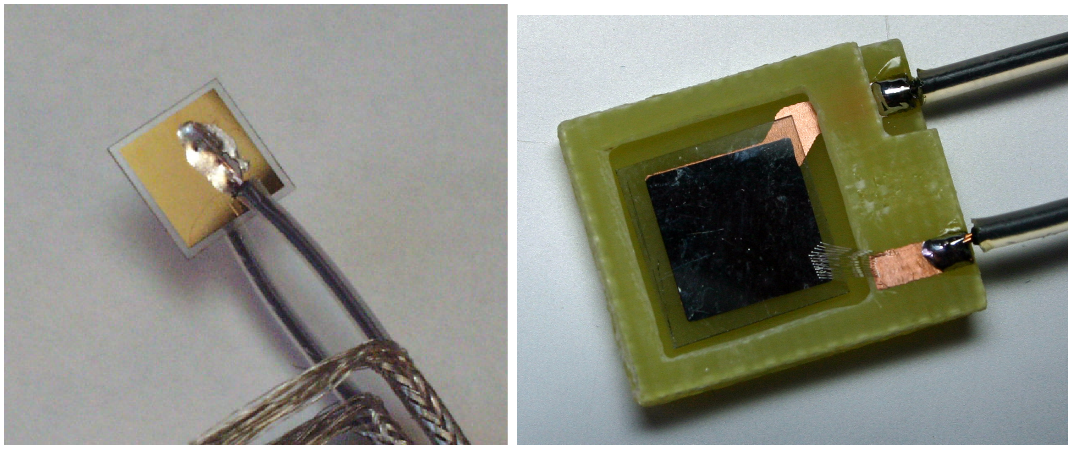

Figure 16: A photograph of one of the pCVD diamonds prepared for BaBar and one prepared for CDF.

Figure 17: A photograph of one of the pCVD packaged diamonds for Belle.

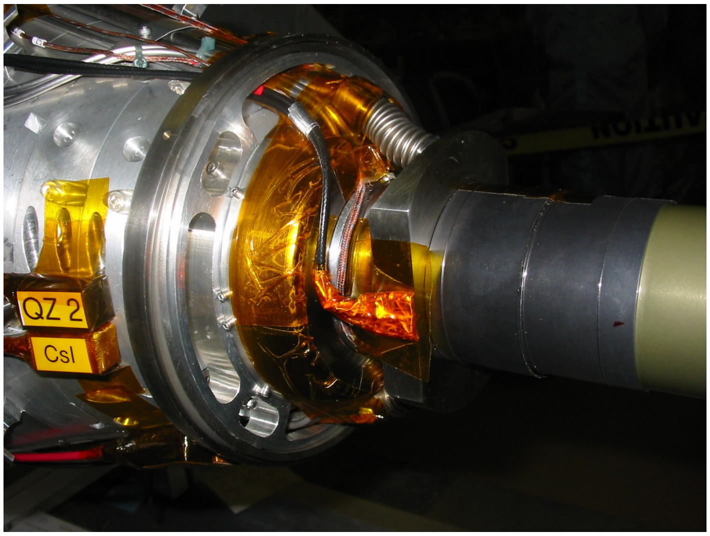

Figure 18: A photograph of the installed pCVD diamond devices in BaBar.

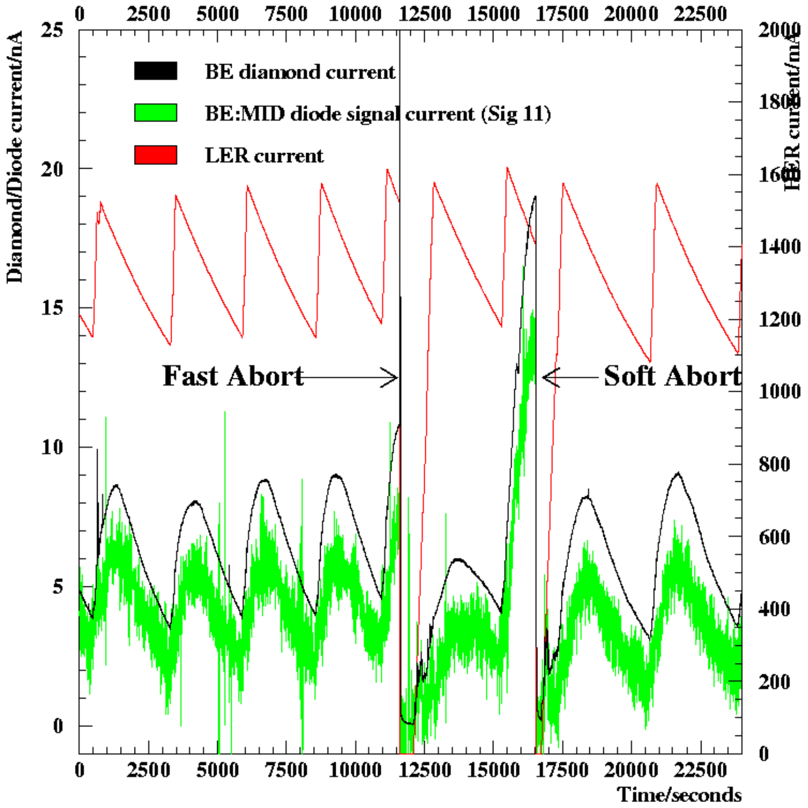

Figure 19: A comparison of a pCVD diamond sensor and a silicon PIN diode monitoring radiation in BaBar. Radiation levels in the innermost tracking detectors routinely track the electron beam current. The beam current gradually decreases between successive fills. The diamond sensor current is comparable to that of the silicon PIN diode. At two points the beam has been aborted to protect the innermost tracking detectors. The first abort is due to an acute spike in the does rate; the second abort is due to a smaller but longer lived increase in the dose rate. Both aborts are seen in the diamond sensor and the silicon sensor.

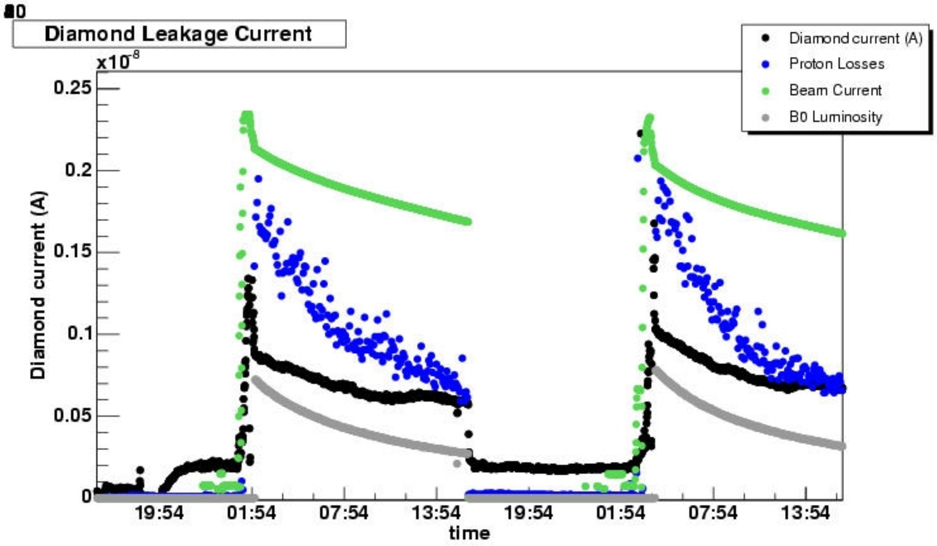

Figure 20: The operation of the CDF diamond beam monitor. The proton beam current is the upper trace (green); the measured proton beam loss is the second curve (blue); the diamond current is the third curve (black); the luminosity is the bottom curve (gray). One can see the turn on of the Tevatron at 19:54 and the residual beam current between fills.

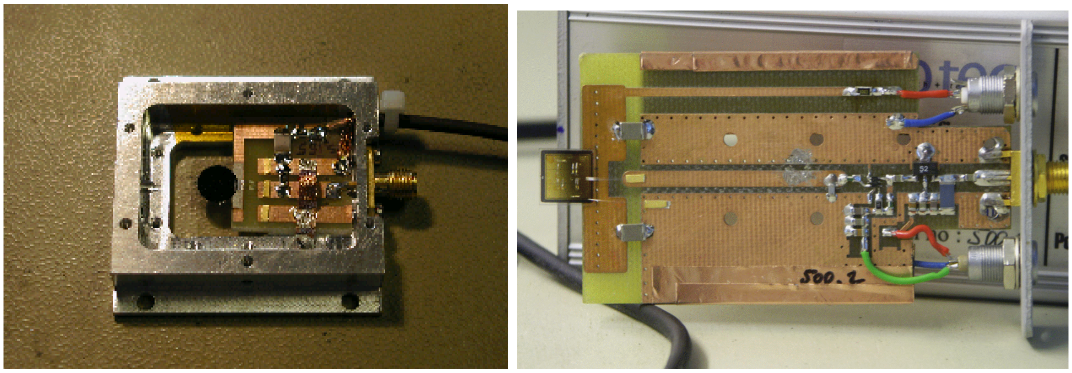

Figure 21: A photograph of the diamond devices tested by ATLAS/CMS (left) in the T7 proton beam and by ATLAS (right) in the pion beam.

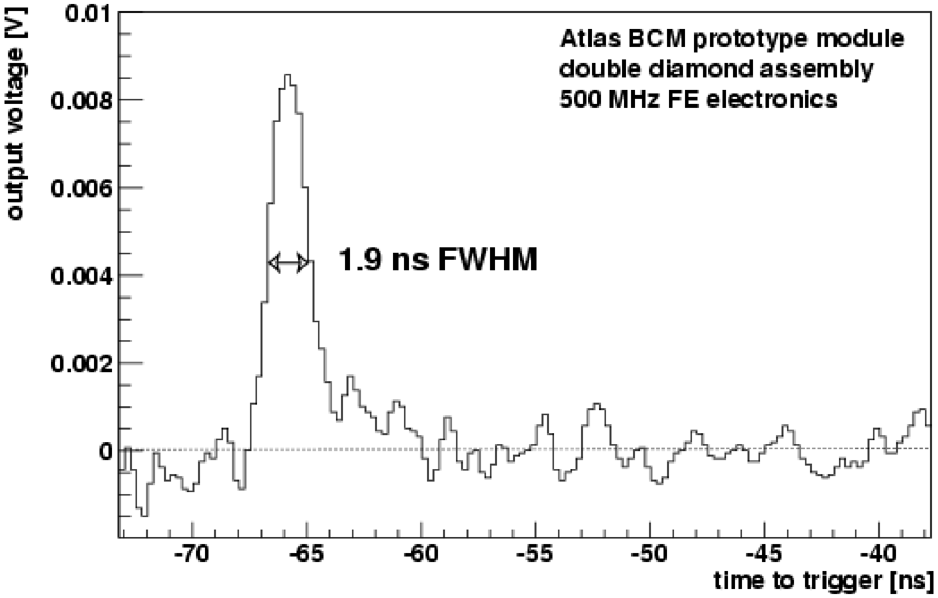

Figure 22: A scope trace of a MIP pulse observed in two diamond detectors in the ATLAS/CMS beam test.

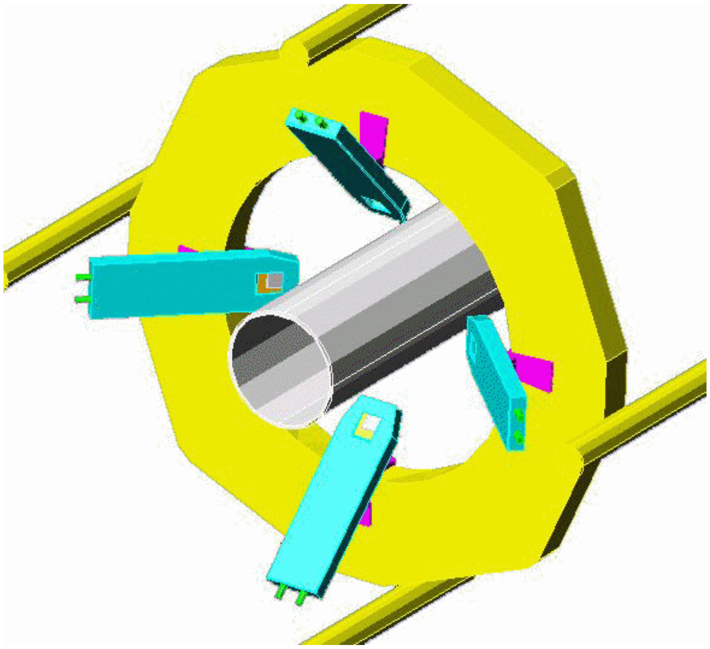

Figure 23: A schematic view of the ATLAS BCM system.

7 Funding and Requests for 2005

As a result of the ongoing progress the RD42 project is supported by many national agencies and the total anticipated funding from sources outside CERN in 2005 is foreseen to be 250 kCHF. The majority of this funding is now through our North America colleagues which are funding the new scCVD Research Program with Element Six. One reason why our collaborating institutes obtain national funding is that the RD42 project is officially recognized by CERN within the LHC R&D program. Official recognition of RD42 by CERN with the LHC R&D program has helped in the past to obtain funding from national agencies. For the continuation of the RD42 program as described in section 6 we request 55 kCHF of direct funds from CERN and that the LHCC officially approve the continuation of the program. This is essential to ensure future funding from national agencies. Furthermore a continuation of the RD42 program will be the basis of future diamond sensor development in the framework of R&D for future very high luminosity upgrades of the LHC, which is at present implemented [1]. It is foreseen that a minimal infra-structure for sample characterization and test preparation is maintained at CERN. In this context two fully automated characterization stations have been put into operation at CERN as part of an PH Department common project. The facility will be mainly used by external RD42 collaborators specifically ATLAS and CMS. We therefore request

- Maintain the present 20 m^2 of laboratory space for test setups, detector preparation and electronics development.
- Maintain the present minimal office space for full time residents and visiting members of our collaboration.

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[4] H. Pernegger *et al.*, "Measurement of Charge Carrier Properties in Synthetic Single Crystal Diamond using the Transient-Current-Technique", J. Appl. Phys./Manuscript JR04-2140, accepted for publication.

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