Development of a versatile beam loss monitor

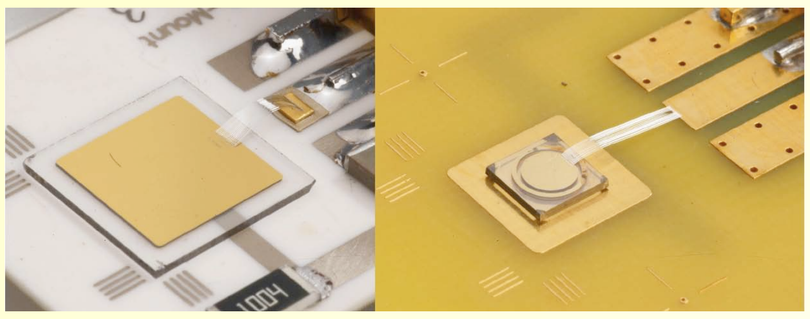
Pavel Kavrigin

Abstract

Diamond detectors can be used in a variety of applications in particle physics due to their unique qualities. The main focus of this project is research and development of detector setups and dedicated software for data processing, as well as experimental and theoretical studies of detector performance.

This research project in the framework of oPAC is supported by CIVIDEC Instrumentation GmbH and supervised by Dr. Erich Griesmayer.

Diamond detectors



Diamond is highly versatile and efficient material for beam detectors due to its properties:

- Low leakage current
- Low capacitance
- High e-h mobility
- High sensitivity
- Excellent timing resolution
- High radiation resistance
- High thermal conductivity

Diamond detectors with dedicated electronics are used in this project for neutral and charged particle detection. One of the primary research goals is development of solutions for effective photon and neutron measurements.

Software and hardware

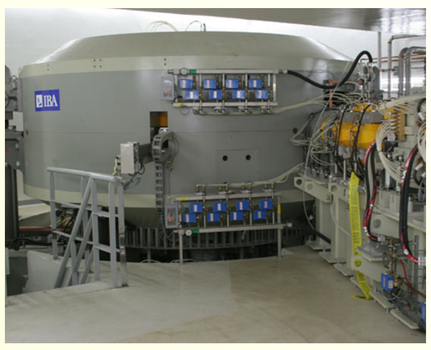
Readout System (ROSY) was designed by CIVIDEC for data acquisition and analysis of detector signals. The system has 4 analog inputs, external trigger input, DAC output, Ethernet and USB ports, COM and VGA interfaces. ROSY provides a full functionality of digital oscilloscope, Linux-based server for connection to control systems and various dedicated applications for data acquisition, analysis and recording – one of the aims of this research project is design of such software solutions[1]:

- Oscilloscope mode
- Beam current monitoring
- Beam position monitoring
- Spectrometer
- Analysis of phase shift between RF and detector signals
- Histogram of turn-by-turn losses in LHC
- Beam loss data recording during UFO events in LHC

Design of a detector setup for photon and neutron measurements requires extensive simulations of interaction of particles with matter. Another aim of the project is development of simulation software for studies of detector response to neutral and charged particles, and employment of existing codes such as Geant4 and FLUKA for modeling of detector setups for various experiments.

[1] "Diamond detectors for LHC". E.Griesmayer, P.Kavrigin, B.Dehning, E.Effinger, T.Baer, M.Hempel. H.Pernegger, D.Dobos. // Proceedings of IBIC2012

Experiment

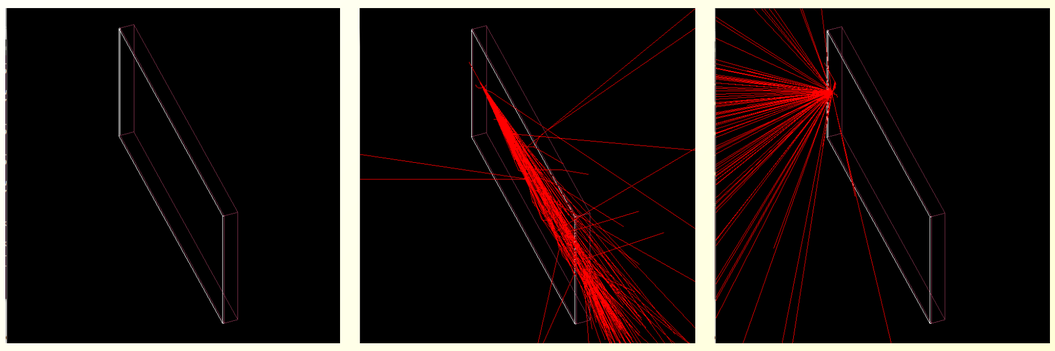


Experimental part of the project involves:

- Calibration of diamond detector and data analysis software with radioactive sources
- Beam tests of diamond detectors, electronics and software at various accelerator facilities[2]
- Measurements in photon and neutron physics
- Recoiled proton spectrometry and angular distribution analysis in neutron flux measurements

[2] Beam tests were performed at IBA cyclotron facilities at Louvain-la-Neuve (Belgium) and Trento (Italy) in 2012-2013; beam loss monitoring with data analysis was performed at the LHC/CERN in 2013

Theory



One of the aims of the project is theoretical research in topics related to the diamond detector physics:

- Charge transport and collection in diamond
- Development of numerical codes for charge transport simulations
- Analysis of detector efficiency
- Investigation of trapped charge influence on bias field and charge collection
- Study of photon interactions with diamond and converter materials
- Study of neutron interactions with diamond and converter materials
- Analysis of spectral and angular distribution of recoiled protons in neutron interactions with converter foil
- Theoretical analysis of various detector setups for neutral particle detection