Institute of Physics of the ASCR, v.v.i.

Na Slovance 2, 182 21 Prague 8, Czech Republic

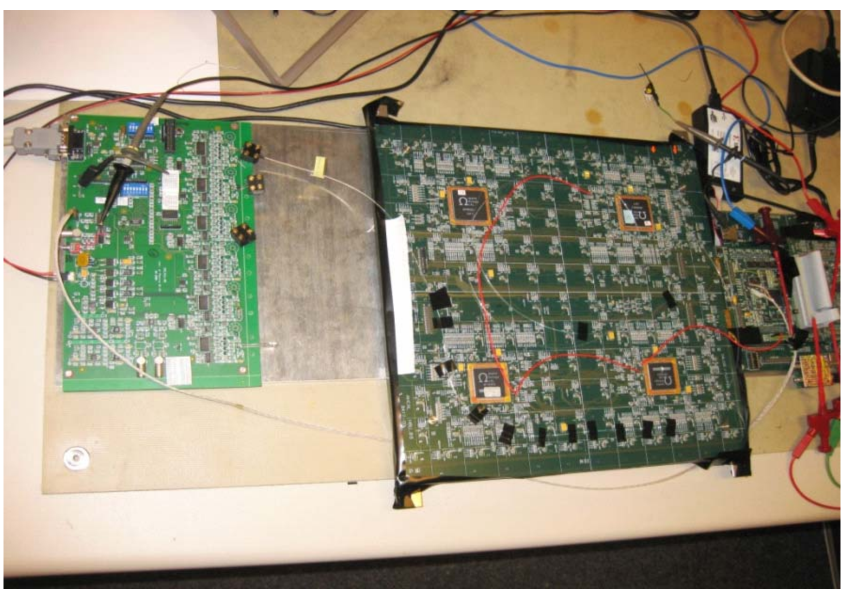
Prague, June 22, 2010

Proposal for the characterization of subcomponents of the AHCAL module using EUDET infrastructure "CALO" in the period July 19-31, 2010.

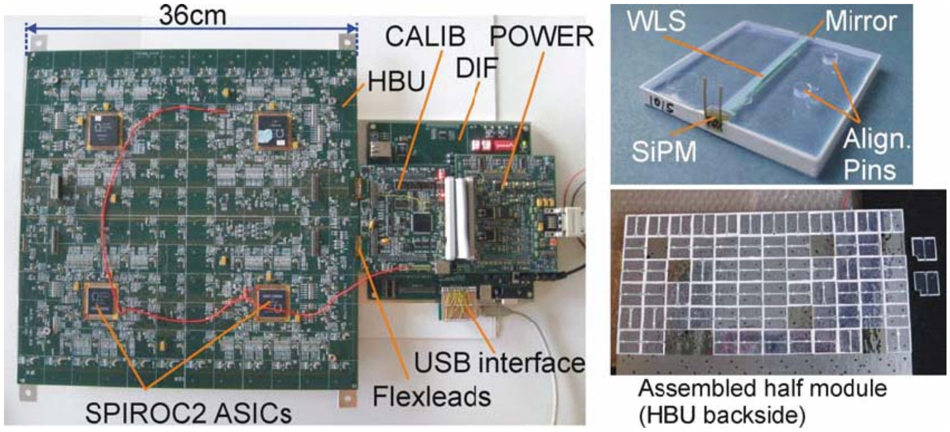
Project Leader: Jaroslav Cvach (Institute of Physics of the ASCR, v.v.i.)

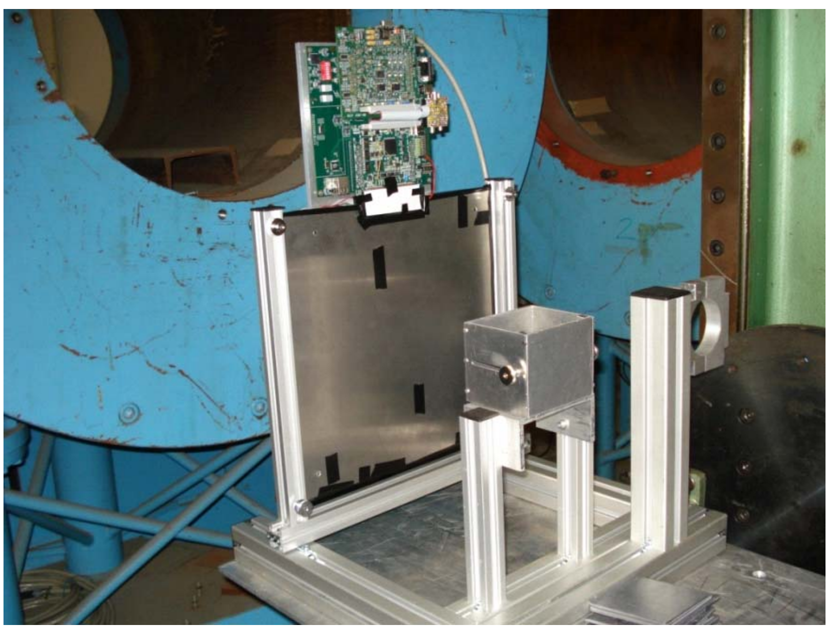
The groups from Prague participated at different phases of the calorimeter development for the detector at the ILC since 2000 within the CALICE collaboration and specialized mainly in the LED calibration system construction. The ITEP(Moscow) group in the same time developed together with DESY a functional new photodetector – SiPM – which matured in the 1 m^3 prototype and is further improved for the EUDET AHCAL module.

A first subunit (HCAL Base Unit: *HBU0*) of the 2200-channel calorimeter plane has been made with 144 detector channels (scintillating tiles) and a size of 36 x 36 cm^2. Along with the detector module HBU, an integrated calibration and gain-monitoring system based on UV-LEDs has been developed. Additionally, a power-supply module has been realized that incorporates switching of the detector's power duty within the ILC bunch-train structure. A new data acquisition has been set up, including a graphical user-interface based on Labview 8.6. In the test beam period foreseen we shall focus on the first realized HBUs and their measurement characterizations by charge-injection, incitation by the integrated LED calibration system and results from the 6 GeV DESY electron test beam. Next, we shall install a complementary LED calibration system developed by the Prague laboratories which allows to control the amplitude of the LED light in the whole dynamic range of the expected scintillator signal from hadron showers at the ILC energies. In the figure you can see the test setup with the HBU0 module in the middle right and the Prague QMB6 board with 6 LED drivers. The calibration light is carried to a row of scintillator tiles on the HBU0 by a notched fibre fixed at the left edge of the HBU0 by a tape. For the absolute SiPM signal calibration the beam data exposure to any individual scintillator tile is needed.



A more detailed photo of the HBU0 module, along with the interface modules (CALIB, POWER and DIF) to the data acquisition (DAQ), is shown in next picture. The HBU0 integrates 144 scintillating tiles each with SiPMs together with the front-end electronics and the light calibration system. The tiles are connected to the HBU's printed circuit board (PCB) by a new concept using alignment pins that are plugged into holes of the PCB (cf. the top-right picture). Tile assembly (cf. the bottom-right picture) is realized with a nominal distance between tiles of 100ìm. The analogue signals of the SiPMs are read out by four 36-input-channel ASICs. The HBUs of a detector layer are interconnected by flex-leads and ultra-thin connectors with a stacking height of 0.8mm. The signals are guided to the DAQ interface at the end of the segment layer, where an interface electronics collects the readout data and controls the detector's run configuration and power-pulsing.





Description of the installation setup in the test beam

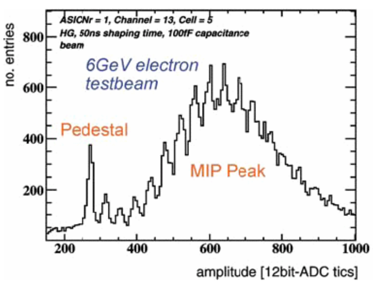
The HBU itself is placed inside a light-tight aluminium cassette to prevent the SiPMs from being illuminated by light not coming from the signal in the tiles (see the photo on the left). On top of the cassette the Central Interface Board (CIB) is mounted, hosting the modules for the SiPM calibration and the powering of the system. The whole setup is mounted on a movable stage to ensure that the signal from the beam can be measured with all available tiles. The beam trigger consists of two 10 cm long scintillator counters, which are placed in front of the module and which are required to give coincident signals. The trigger starts the data taking on the board in case the gate is open, which is triggered by the spill signal from the machine. Due to the spill structure of the test beam this gate is 40 ms long and is followed by a 280 ms long dead time that is used for the read-out. The beam energy is steerable between 1 and 6 GeV and one can choose having either electrons or positrons.

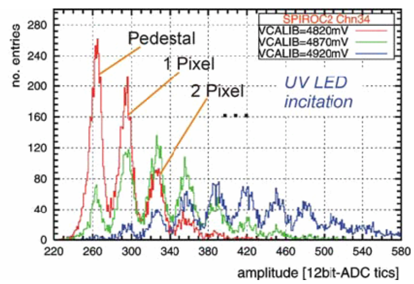
The prototype is connected to the preliminary DAQ system that connects the system via a USB-bus to a Linux PC with Labview as the graphical user interface. A Labview program exists with which the slow-control programming can be done, as well as the steering of the on-board LED system and the details of the data taking. When the prototype will be extended to a larger system, the DAQ will be replaced by the final CALICE DAQ.

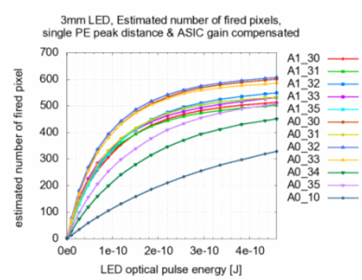
The results we want to get

1) Light Yield

In the prototype SiPMs are used as photo detectors. These are devices with 556 pixels, which are operated in Geiger mode, such that each pixel either gives a signal or not. Depending on the amount of deposited energy in the tile, a certain amount of scintillator photons will be produced, which then can trigger an avalanche in each pixel. One of our goals for the test beam campaign is to measure the light yield of the scintillator tiles produced by ITEP. They are designed in a way that a MIP from the test beam produces such an amount of light in the scintillator that on average 10 pixels from the SiPMs give a signal to the read-out electronics. It has to be tested if this goal has been successfully achieved. An example of the ADC signal distribution of one tile is shown on the figure left below.







2) LED system

To measure the amount of energy deposited in a tile from the output of the read-out electronics one has to know the gain factor of each SiPM. This can be extracted from single photon spectra, where the amount of light shining on the SiPM is so low that individual pixels can be distinguished. The gain is then given by the distance of the peaks in these spectra. The light needed for seeing a single photon spectrum comes from LEDs, which can be integrated in the tiles or mounted on the tiles and which can produce a certain amount of light depending on the steerable bias voltage. We already started to investigate the performance of the on-board LED system concerning the amplitude variation from LED to LED and the impact on the gain determination (see the figure above in the middle). This has to be compared to the LED system constructed by the Prague group and finally the gain factor of each SiPM has to be determined.

Besides the determination of the SiPM gain the LED system is also used to determine the saturation curve of each SiPM. Since the SiPMs have a limited amount of pixels, their signal saturates at a certain amount of light which reaches the photo detector. It has to be tested if the LED system is capable to saturate the SiPMs and if the calibration curves can be measured for each SiPM (the first attempt to obtain saturation curves see the figure above right).

3) Auto trigger

Up to now the data taking has been successfully triggered using an external scintillator counter, as described above. Nevertheless, in a realistic ILC environment the read-out electronics needs the capability of auto-triggering. The auto-trigger is a system which is integrated into the read-out electronics and triggers the data taking by comparing the incoming signal with a pre-defined, adjustable threshold. Hence, this system is completely independent of the external triggers that have been used so far. Some measurements concerning the functionality of the auto-trigger have already been performed with the integrated LED system and an important goal for the test beam campaign is to use the EUDET module to commission the auto-trigger with real MIP signals.

We apply for the financial support for the visit of four persons from two Prague Institutions and one person from ITEP Moscow for the period July 19 to July 31, 2010.

Two engineers from IPASCR, Ivo Polak and Jiri Kvasnicka are members of CALICE collaboration and work already long time on LED calibration system for scintillator tile hadron calorimeter, recently they finished a six channel prototype for the EUDET AHCAL module. Two undergraduate students from CUNI Vit Kucera and Peter Berta have finished the third year of physics studies (bachelors) and will gain experience and knowledge during the data taking. We expect that at least one of them will chose ILC calorimetry as a topic for the diploma project. The scientist from ITEP has long experience with SiPM and scintillator tile properties as ITEP is the main supplier of these components for all scintillator tile AHCAL prototypes, therefore his participation in the beam time is very important for success of the measurements.

Best regards

Dr. Jaroslav Cvach
Group leader IPASCR