Status of the ALIBAVA system

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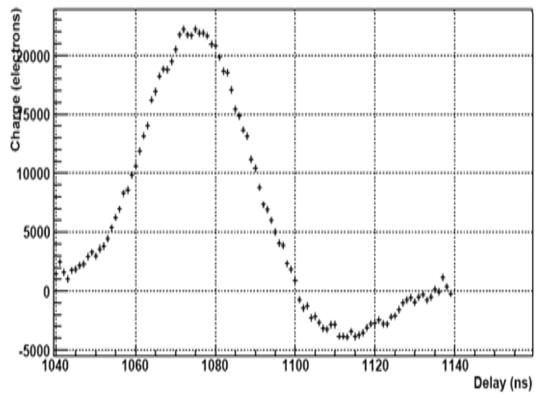
Outline

- Main system characteristics.
- System architecture.
  - Daughter board.
  - Mother board.
  - PC software.
- Processing of acquired data.
- Measurements with non-irradiated detectors.
- Measurements with irradiated detectors.
- Data correction factors.
- Production status.
- Summary.

Main system characteristics

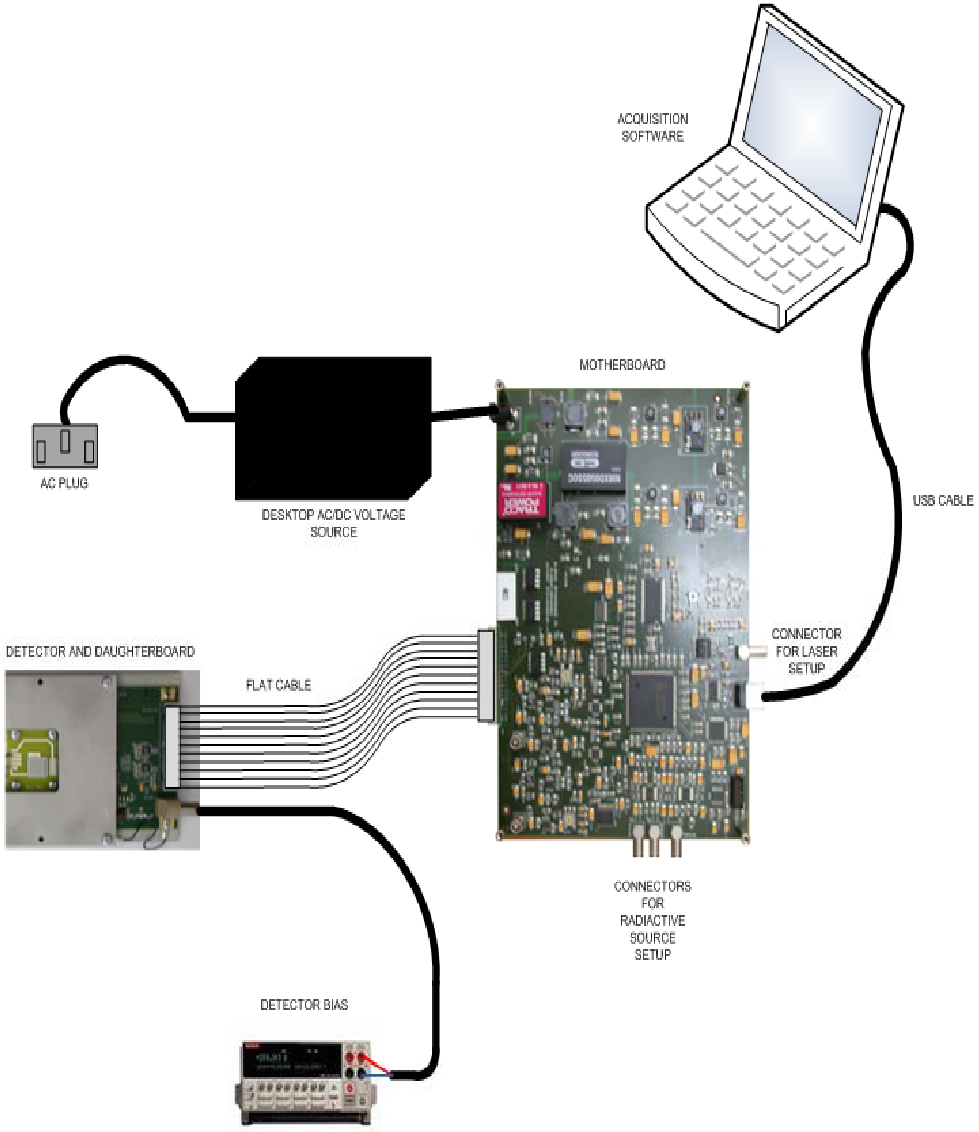
- A compact and portable system.
- The system can be used with two different laboratory setups:
  - Radioactive source: external trigger input from one or two photomultipliers.
  - Laser system: synchronized trigger output generated internally for pulsing an external excitation source.
- The system contains two front-end readout chips (Beetle chip used in LHCb) to acquire the detector signals.
- USB communication with a PC which will store and will process the data acquired.
- System control from a PC software application in communication with a FPGA which will interpret and will execute the orders.
- Own supply system from AC mains.

The main goal is reconstructing the analogue pulse shape from the readout chip front-end with the highest fidelity from the acquired data.



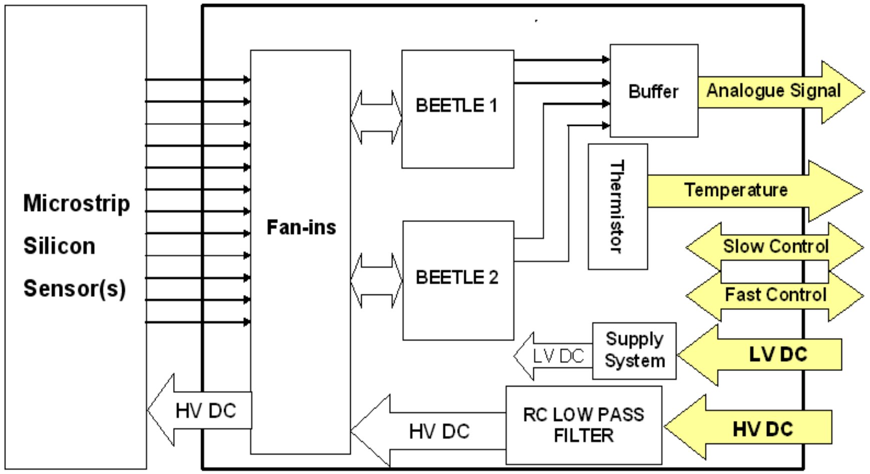
System architecture

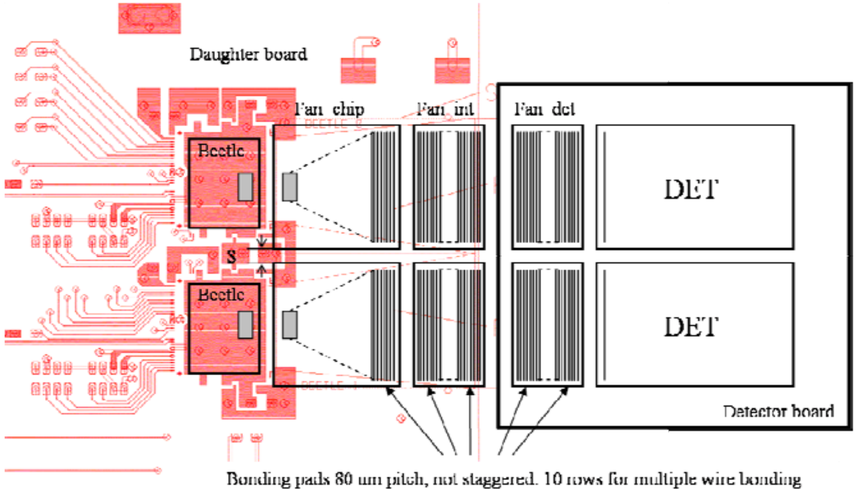
- Software part (PC) and hardware part connected by USB.
- **Hardware part**: a dual board based system connected by flat cable.
  - **Mother board** intended:
    - To process the analogue data that comes from the readout chips.
    - To process the trigger input signal in case of radioactive source setup or to generate a trigger signal if a laser setup is used.
    - To control the hardware part.
    - To communicate with a PC via USB.
  - **Daughter board** :
    - It is a small board.
    - It contains two Beetle readout chips
    - It has fan-ins and detector support to interface the sensors.
- **Software part**:
  - It controls the whole system (configuration, calibration and acquisition).
  - It generates an output file for further data processing.

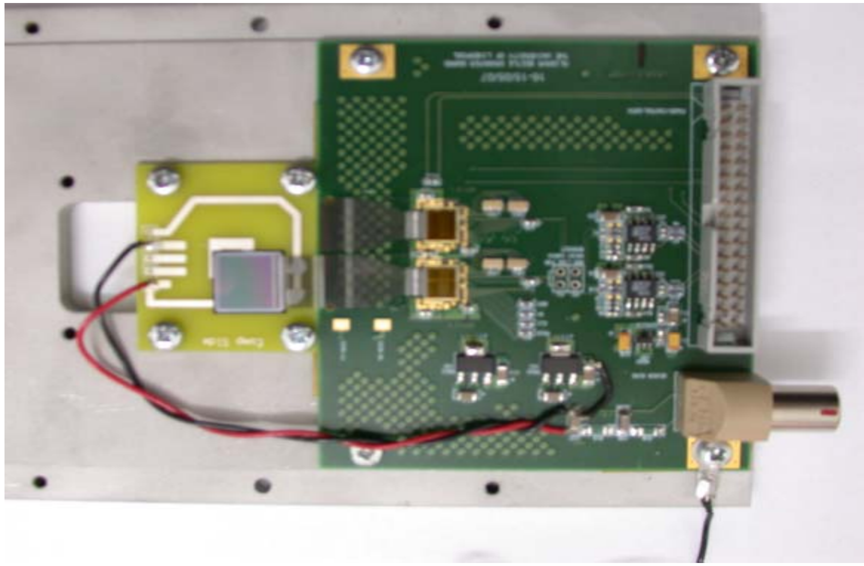


Daughter board

- Two Beetle readout chips in parallel mode.
  - 256 input channels.
  - Analogue front-end with 25 ns of peaking time.
  - Analogue multiplexed readout of each chip.
  - Output dynamic range ~ ±110000 electrons.
- Buffer stage for sending the analogue output signals to the mother board.
- Control signals provided by the mother board and shared by both Beetle chips.
- A thermistor (NTC) for sensing the temperature close the Beetle chips.
- Low voltage DC level (5 V) for Beetle chips (2.5 V) and buffer stage power supply (3 V): provided by the motherboard.
- High voltage DC level for silicon detector(s) bias: external power supply.
- Fan-ins and detector board: multiple wire bonding and two different sensor sizes.

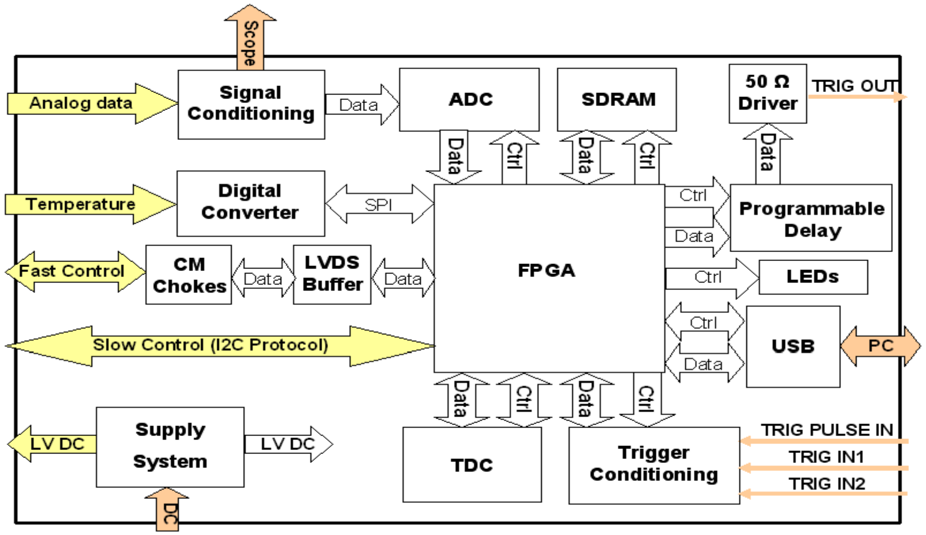


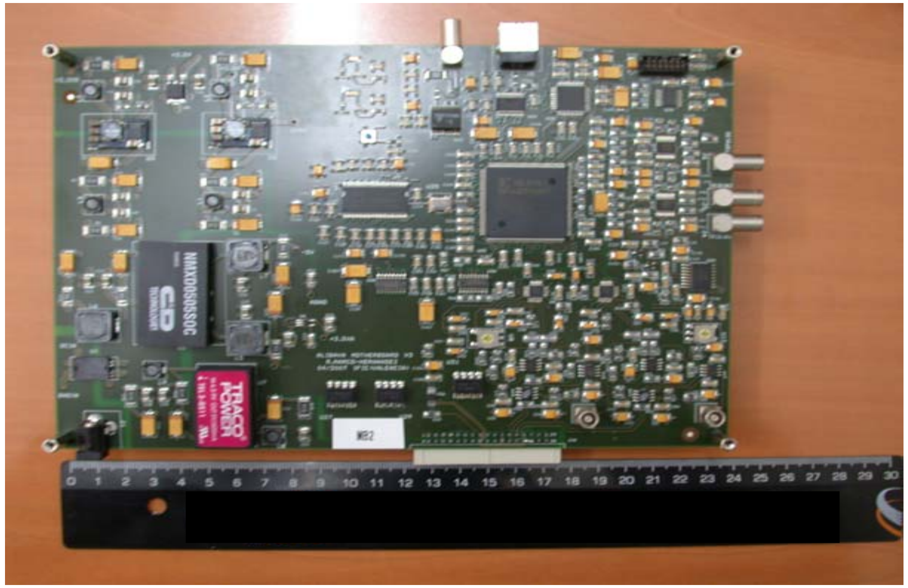




Mother board

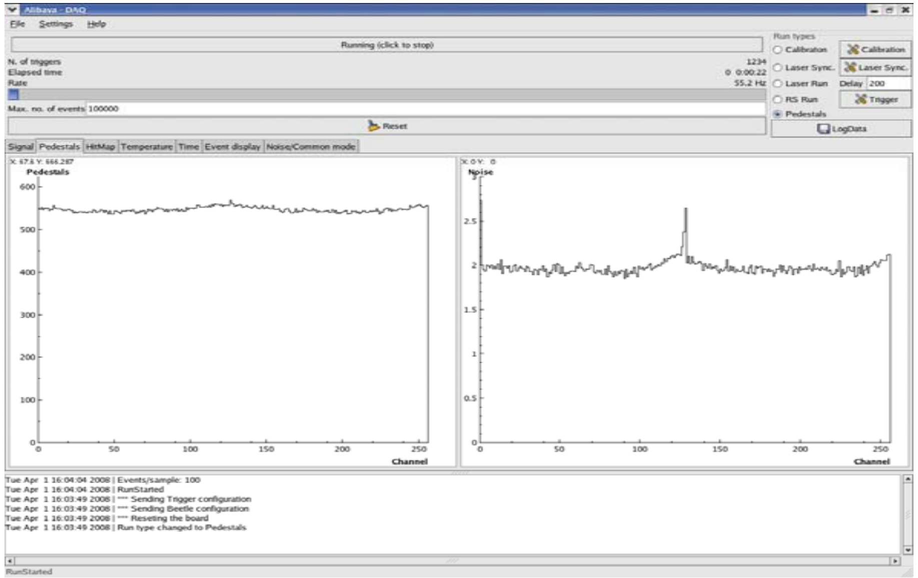
- Analogue signal conditioning:
  - Amplification and filtering: minimization of noise.
  - Buffering: two copies of the Beetle multiplexed analogue outputs for spying with a scope
- ADC: digitalization at 40 MSps of the Beelte analogue multiplexed signals.
- Digital converter: temperature analogue signal digitalization.
- Generation of control signals for Beetle chips by FPGA: DAQ sequences and configuration.
- Trigger conditioning and TDC for obtaining a time stamp of each trigger with radioactive source setup.
- Generation of a trigger output with programmable delay for the laser source.
- USB controller.
- SDRAM (512 Mb) for temporal storage of acquired data.
- FPGA (40 MHz): custom logic and embedded µP.
  - Control of the hardware.
  - Synchronization of DAQ sequences.
  - Generation of Beetle control signals.
  - Communication with the software.
- Supply system: from AC/DC desktop power supply (5V).
  - Generation of MB and DB supply levels.

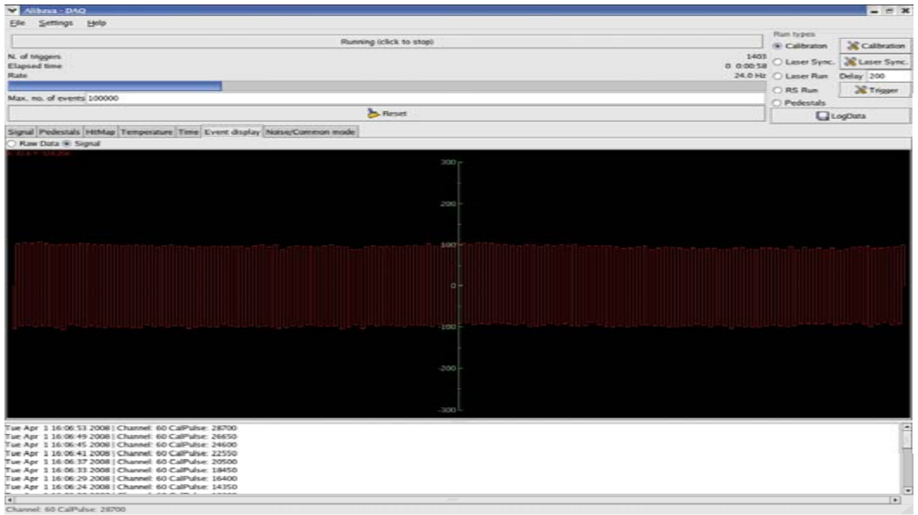




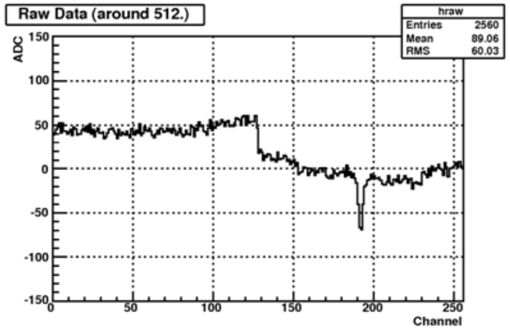
PC software

- Functions:
  - Control the whole system (configuration, calibration and acquisition).
  - Processing and monitoring of acquired data.
  - User interface with the system (GUI).
  - Generation of information (output files).
- Two software levels:
  - Low level:
    - Software/mother board communication by USB: VCP (virtual com port) driver (2.4 Mb/s) used.
    - Processing of acquired data.
  - High level:
    - GUI: control of the system and data monitoring.
    - Output file generation for further processing and analysis.
- Programmed in C++.
- Operating system compatibility:
  - Linux version fully operational.
  - Maybe Windows in the future.
- There are also macros for ROOT in order to process the data acquired with the software.





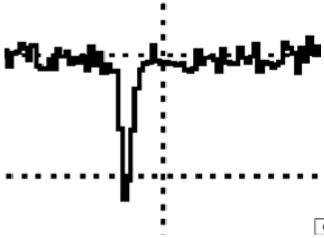
Processing of the aquired data



Raw data (ADC counts vs channel number): digitalization of the Beetle analogue multiplexed output signal

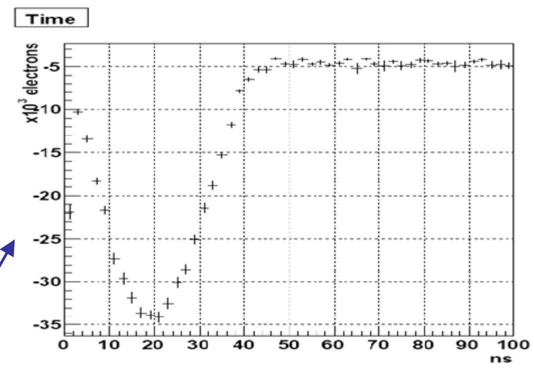
Pedestals correction

Signal is computed as the sum of strips in a cluster.
➔Feed S/N > 6.
➔Neighbours S/N > 2.5.

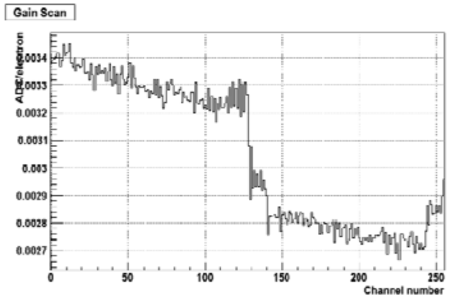


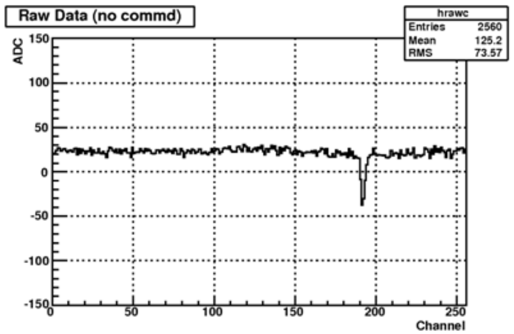
Signal computation of acquired data from each trigger

We can obtain different representations of acquired data from a given number of triggers. We use the calibration data for ADC counts to electrons conversion



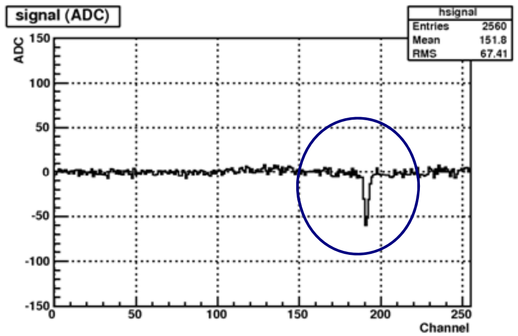
Pulse shape reconstruction: collected charge (electrons) vs. delay (ns)



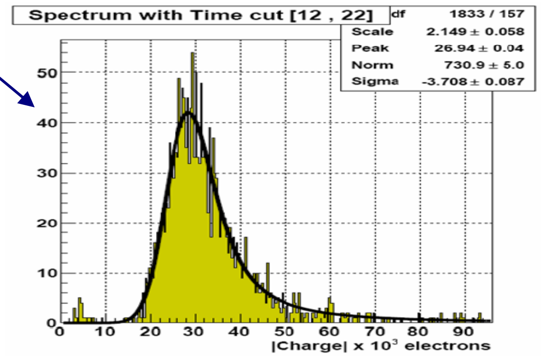


Raw data with pedestal value for each channel corrected (ADC counts vs channel number)

Common mode correction



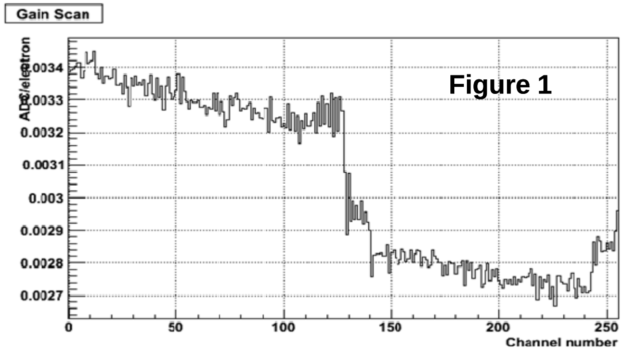
Signal corresponding to an event (trigger): ADC counts vs channel number

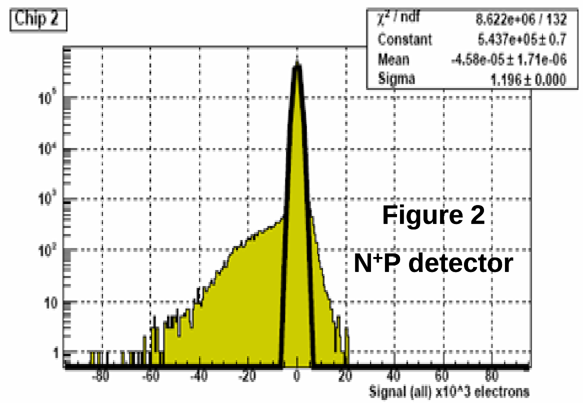


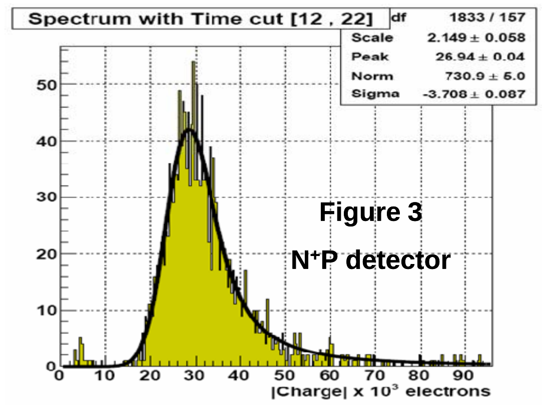
Signal spectrum with a time cut: number of events vs. collected charge (electrons)

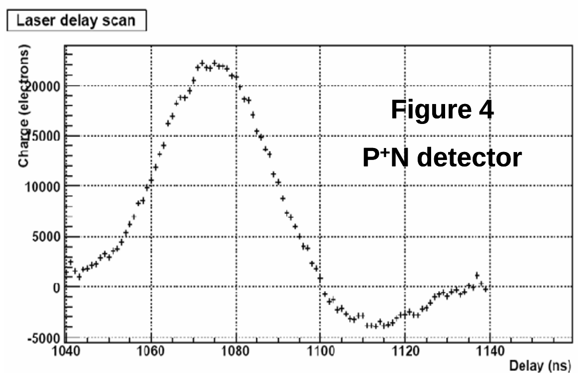
Measurements non-irradiated detectors

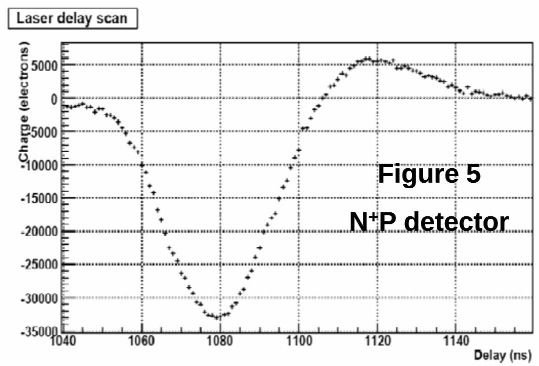
- Carried out with both non-irradiated **$P^{+}N$** and **$N^{+}P$ detectors.**
- At T = 20 ºC with both laser setup and radioactive source setup.
- Calibration data is ok at T = 20 ºC: we calculate the ADC counts/electrons rate for each input channel (figure 1).
- Measurements with β source (^{90}Sr) as expected.
  - We can calculate the noise from the signal spectum (figure 2): σ ~ 1200 electrons.
  - Also the charge corresponding to a mip from the signal spectrum with a time cut (figure 3): peak of the distribution 26940 electrons
  - SNR as mip charge divided by noise: ~ 22.
- Measurements with laser setup as expected as well.
  - We can obtain the pulse shape reconstruction (figure 4 and figure 5).
  - Also the spectrum of the signal acquired.





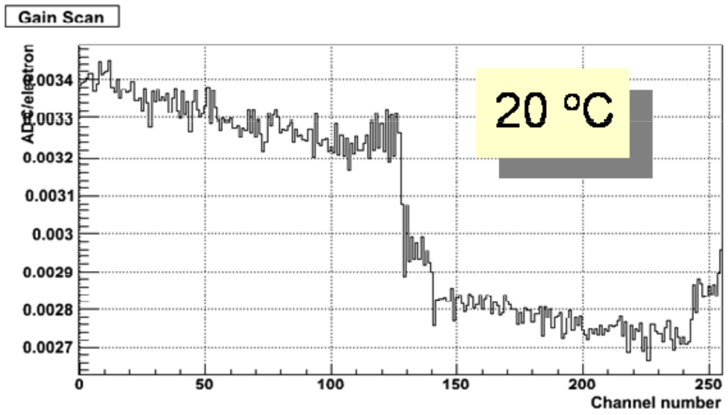


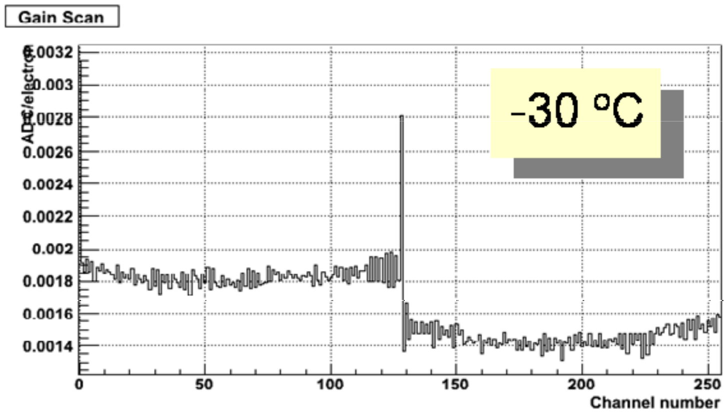


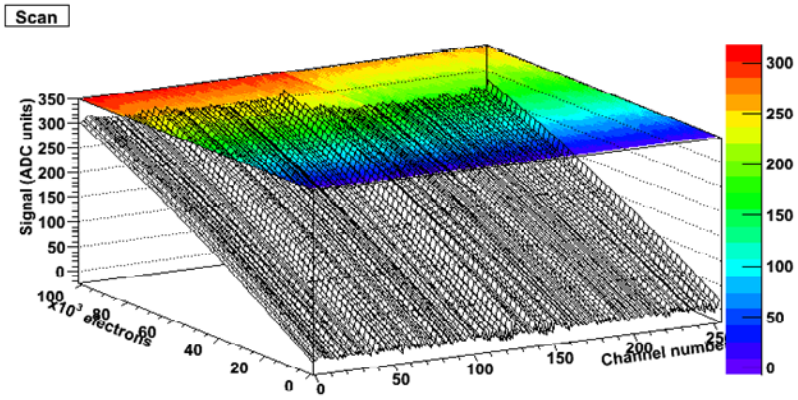


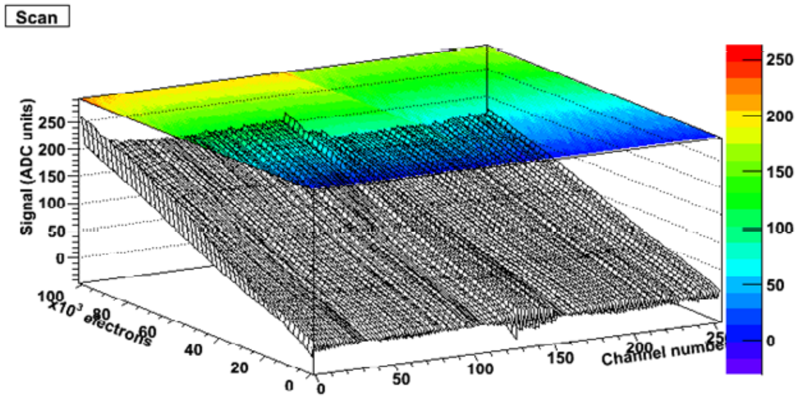
Measurements with irradiated detectors (I)

- We have to operate the system inside a fridge (DB) @ -30 ºC.
- Two effects on the Beetle chip front-end circuit:
  - Gain changes.
  - Calibration circuit becomes almost useless…





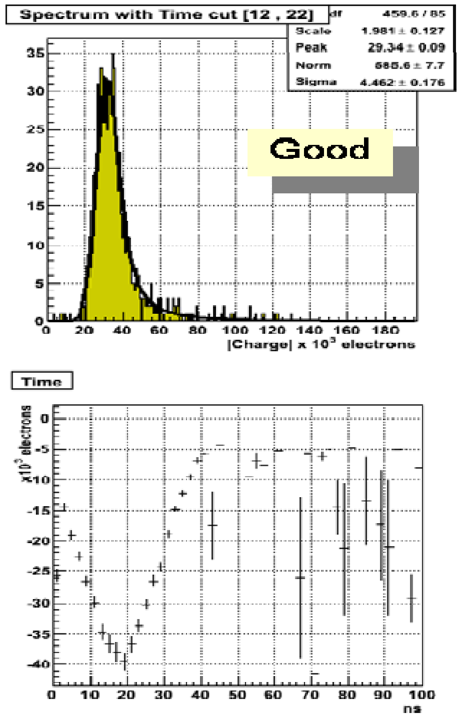




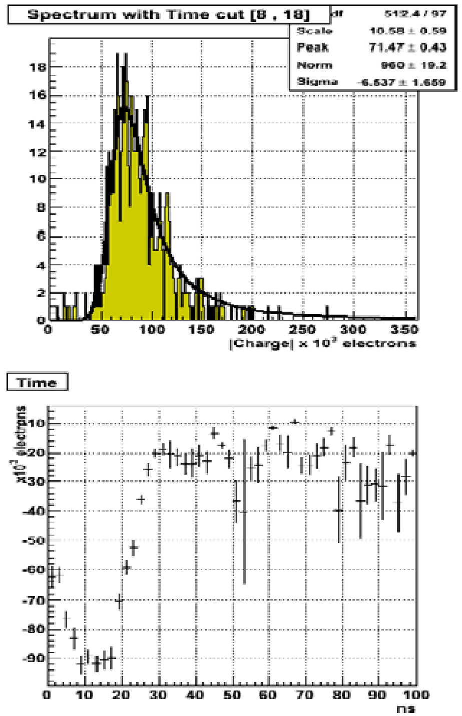
Measurements with irradiated detectors (II)

- We have to operate the system inside a fridge (DB) @ -30 ºC.
- Two effects on the Beetle chip front-end circuit:
  - Gain changes.
  - Calibration circuit becomes almost useless…

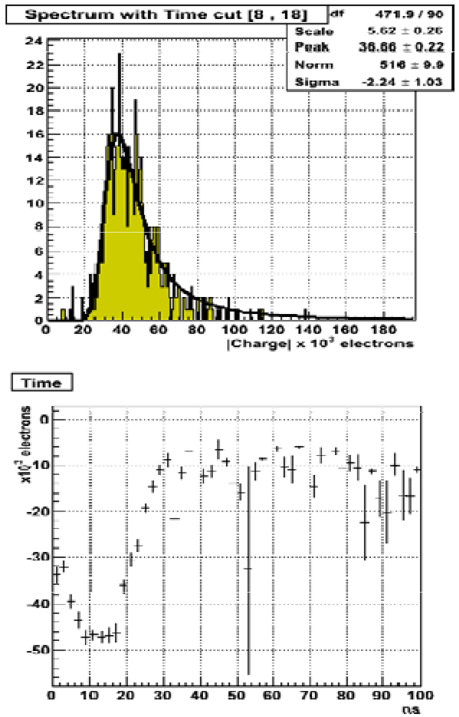
β source @ outside/cal. out.



β source @ inside/cal. in.



β source @ inside/cal. out.

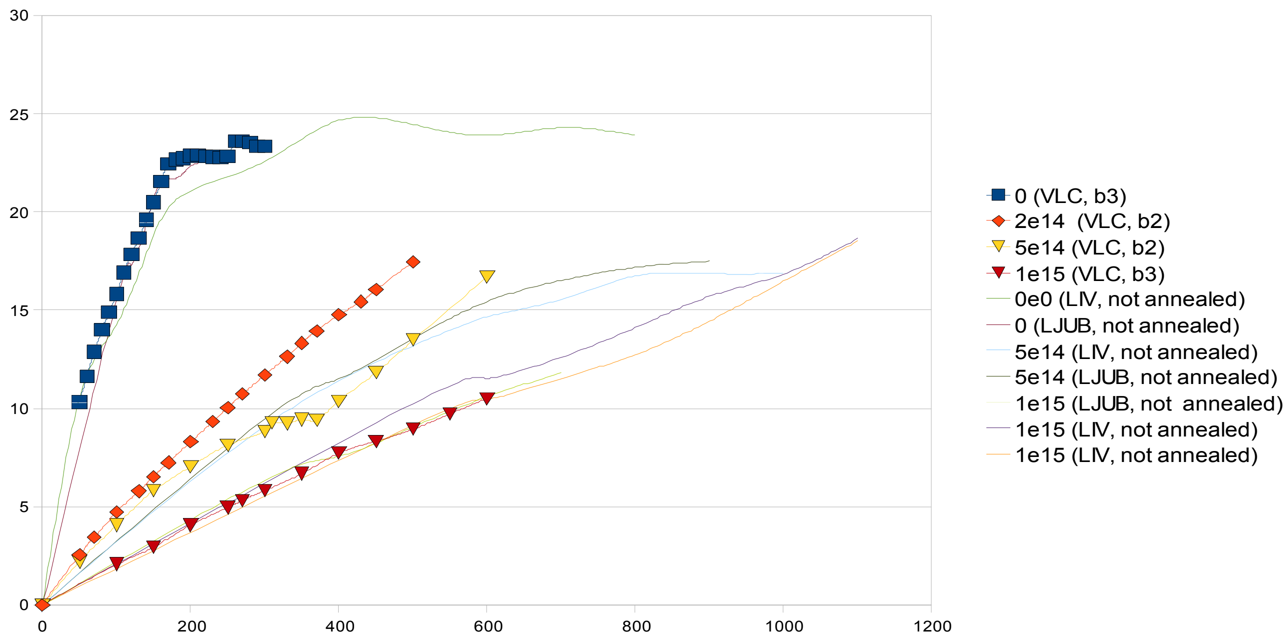


Use calibration at 20 ºC and Gain correction factor: Rcal = Qoutside/Qfridge

Data correction factors

- We measure on ADCs
- We scan the voltages with laser and measure with β source for a few voltages (low activity source)
  - We compute $R_{src} = Q_{source}/Q_{laser}$
- From the calibration we have R_{cal} (previous slide): gain correction factor and calibration data at room temperature.
- We *normalize* so that the peak of the source in non-irradiated sensors is at 24000 electrons.
  - R_{24ke}
- All in all, for the laser data:

$$Q = R24ke \times Rcal \times Rsrc \times ADC$$



Measurements of collected charge carried out with ALIBAVA system in Valencia. ATLAS07 sensors irradiated with neutrons presented by C. Lacasta in ATLAS Tracker Upgrade Workshop, NIIKHEF,November 2008.

Production status

- We are producing currently 20 ALIBAVA systems for the RD50 collaboration members.
- We envisage to have these systems ready to distribute by December of 2008.
- What are going to be included with each system?
  - MB and DB with their corresponding boxes.
  - Software (Linux version).
  - AC/DC desktop power supply.
  - USB cable and flat cable.
  - Two lemo connectors for the detectors power supply cable.
  - A number of fan-ins sets (to be determined).
  - A number of detector boards (to be determined).
  - Documentation for using the system.
- How much are going to cost the system?
  - About 7k€.
- We can produce more systems if required.

Summary

- The readout system has been developed and is fully operational.
- The system can operate with different types and different sizes of microstrip detectors:
  - n-type.
  - p-type.
  - Irradiated and non-irradiated.
  - Up to 256 input channels.
  - Two flavours of detector boards to accommodate detectors of different sizes (1 cm^2 or 3 cm^2).
- The system is designed to work with a radioactive source setup and laser setup: useful for comparing results with the same detector.
- The system has been tested with laser setup and a β source:
  - It works correctly: already used for carrying out measurements with ATLAS 07 detectors.
  - With p-type and n-type detectors.
  - SNR is enough for irradiated and non-irradiated detectors.
  - Calibration factor must be calculated for measurements at low T (-30 ºC).
- Data acquired with the system can be easily processed using ROOT framework: some macros already developed.
- The system will be distributed among RD50 Collaboration members (currently under production).
- Future work:
  - Upgrade of the system for testbeam acquisition by synchronizing various ALIBAVAs.

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