# A Digital Readout for CALIFA*

T. Le Bleis, M. Bendel, R. Gernhäuser, W. Henning, P. Klenze, R. Krücken and M. Winkel
Physik Department E12, Technische Universität München, for the CALIFA/R$^3$B collaboration

CALIFA [1] is the $\gamma$-ray and large-angle high-energy particle detector for the R$^3$B setup at FAIR. Due to the physics requirements, CALIFA is split into two detector units: a barrel that surrounds the beam axis and an end cap that closes the barrel in the forward direction.

The barrel is composed of 1952 up to 22cm long CsI crystals connected to APD sensors [1]. The signals from the APDs are preamplified using Mesytec MPRB-16, then digitized and processed in hardware on an FPGA. Design and electronics of the end cap is still under investigation.

The MPRB-16 allows for the preamplification of up to 16 channels, with powering of the APD and temperature compensation. The slow control of the modules is achieved using the remote control protocol of Mesytec and a "Plug PC" on which we developed a web interface to allow a full flexibility to the user.

The preamplified signals are sampled by 50 MHz, 14 bit fast sampling ADCs on the FEBEX3 boards [2] developed at GSI. A special add-on board FAB (FEBEX Add-on Board) was developed to adjust the baseline and gain of the preamplified signals. Furthermore the FAB also implements a Nyquist filter to avoid the issues of the sampling of high frequencies. The first prototypes of FAB have been implemented and tested, validating the principle of the boards. In a second revision, currently being tested in our laboratory, the noise figure and dynamic range of the FAB have been further improved.

Aside from the two 8-channels fast sampling ADCs, the FEBEX3 features a Lattice LFE3-150 FPGA. On the FPGA, the sampled signal is analysed in order to determine the deposit energy in the CsI(Tl) crystal. We derived an algorithm to identifty the type of the particle that was detected in the CsI(Tl) [3]. In order to test that algorithm, we performed two experiments at the MLL Tandem accelerator with the C(p,p$'$)C$^*$ reaction at a beam energy above 20 MeV. Those were unique opportunities to measure protons and $\gamma$-rays in coincidence, using simple systems and small detector prototypes with clear beam conditions. The resulting separation between protons and $\gamma$-rays is illustrated in fig. 1.

From the same concepts, another algorithm was derived for an adaptation to real-time implementation in logic electronics. It has been first tested during a beam test at MLL and further with a higher energy proton beam in Krakow.

Once a particle has been detected a readout request signal is emitted by the FEBEX3. Due to the required flexibility of the R$^3$B setup, different scenarii have been planed. In a typical configuration where the complete setup runs with common event triggers, the request is forwarded to the trigger logic of the setup, and if accepted a readout trigger will be returned. The data are collected from the FEBEX to a PC using GOSIP protocol running on optical fibers. The combination from the different branches of the setup are coordinated using MBS [4].

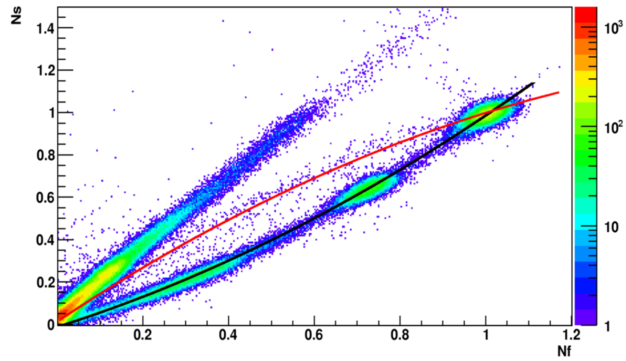


Figure 1: Slow decay constant factor ($N_s$) as a function of the fast decay constant factor ($N_f$) of CsI(Tl). The $\gamma$-rays (top curve) can be distinguished from the protons (bottom black curve). Punched-through protons can also be identified, as indicated by the red curve. Figure and details from [3]

For larger systems, the detector runs quasi standalone. In that case the readout request is handled locally and several events will be buffered in the FEBEX modules. Data are collected as above. The synchronisation with the rest of the setup is made using time stamping protocols. First solutions have been tested during a beam time at GSI at the end of 2012 [4]. For the running of CALIFA at FAIR, the time stamping should be achieved using the so-called White Rabbit modules [4].

Current development focuses on high level triggers like total energy or multiplicities, which have to collect and process the information of all crystals within 1 $\mu$s. A beam test with a demonstrator for the CALIFA Barrel is planned in the second part of 2014.

## REFERENCES

[1] CALIFA Collaboration, "Technical Design Report for the CALIFA Barrel.", November 2011.

[2] J. Hoffmann *et al.*, GSI Scientific Report 2011, p. 253.

[3] M. Bendel *et al*, Eur. Phys. J. A. (2013) **49**:69

[4] T. Le Bleis *et al*, GSI Scientific Report 2012, p. 201.

* Work supported by BMBF(05P12WOFNF), BMBF(05P12WOFNUE) and DFG (EXC153).