MTCA UPGRADE OF THE READOUT ELECTRONICS FOR THE BUNCH ARRIVAL TIME MONITOR AT FLASH

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INTRODUCTION

Bunch Arrival time Monitor (BAM) is an electro-optical device used at FLASH accelerator in DESY for the high precision, femtosecond scale, measurements of the moment when electron bunch arrives at the reference point in the machine. The arrival time is proportional to the average bunch energy, because electrons with different energies travels over different trajectories (shorter or longer) in the bunch compressor. Estimated average bunch energy is used to implement fast feedback, which is stabilizing beam energy by real-time RF field amplitude control. Calculated RF field amplitude correction is sent to the LLRF system in less than 10 us. Existing VME based BAM readout system has been used successfully for several years, but now its performance is limited by the technology used. This poster presents new MTCA BAM readout electronics design based on the MTCA.4 - "MTCA for Physics", and FMC mezzanine boards standards.

BEAM ENERGY FEEDBACK AT FLASH

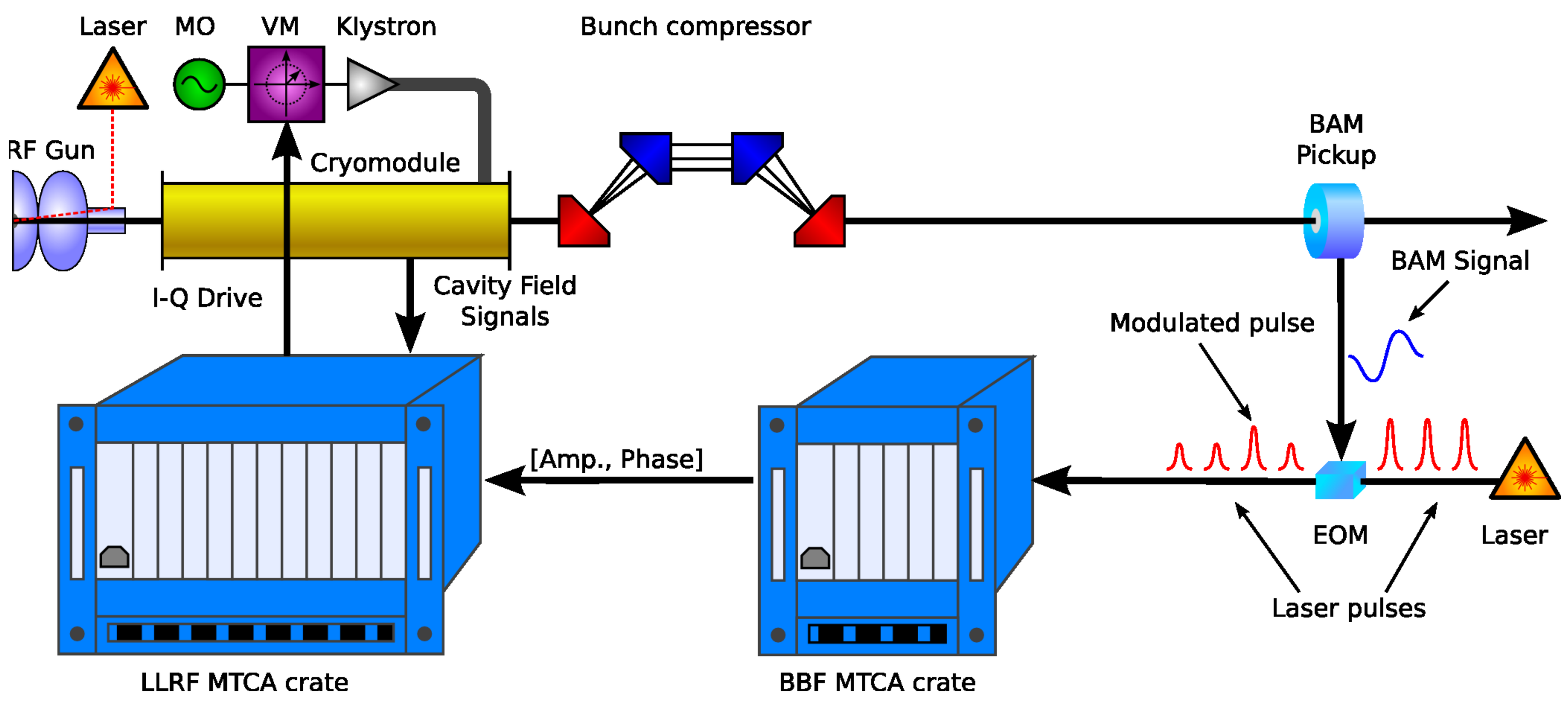


Figure 1: Beam energy feedback layout

The LLRF systems are focused on the RF field (amplitude and phase) stabilization, and they do not know much about the actual beam conditions (except beam loading). This is not enough to stabilize beam parameters directly, and additional devices are needed. BAM detectors and its readout electronics are used to calculate average bunch energy and send this information to the LLRF system.

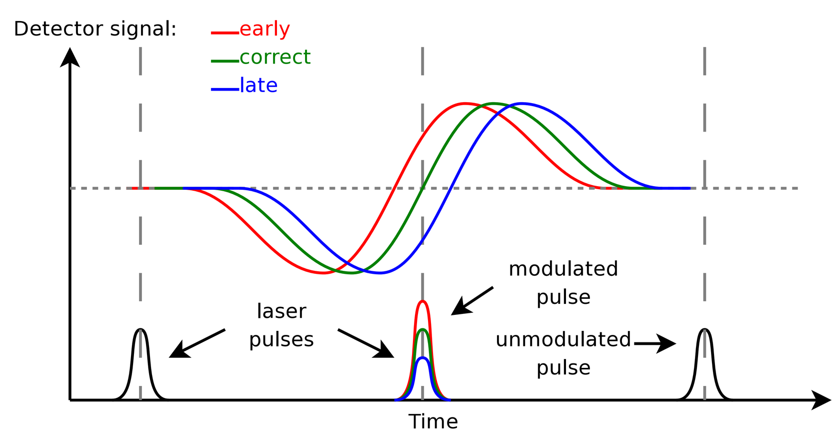


Figure 2: Modulation of the laser pulses by the signal from the BAM detector

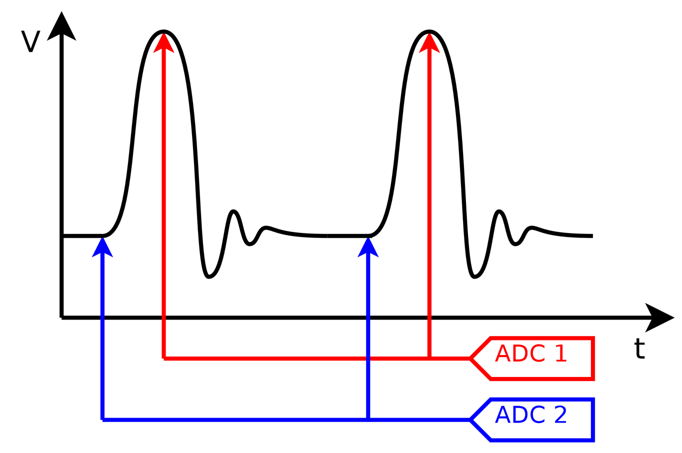
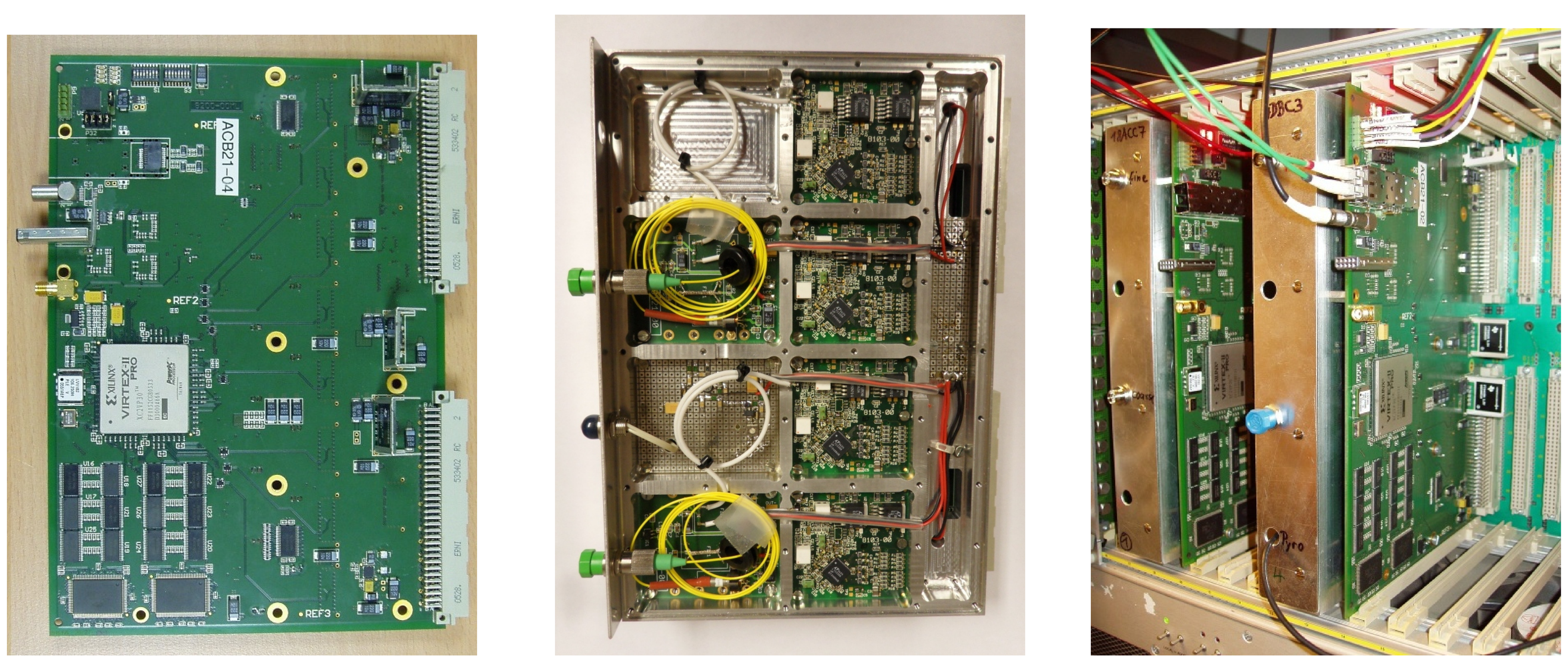


Figure 3: Peak and baseline sampling principle with two ADCs with shifted clock phase.

Signals from the BAMs are used to modulate the amplitude of the laser pulses by the electro-optical modulator (EOM). The characteristics of the BAM pickup is adjusted in such way, that femtosecond changes of the arrival time may be observed (Fig. 2).

The aim of the electronic readout system is to measure relative height of laser pulse amplitude. It is done using two ADCs, with slightly shifted phase (Fig. 3). Both ADC are sampling signal with the same frequency as laser pulses are generated (216 MHz), one ADC is always reading the peak value, and second one is reading baseline level before the pulse.

EXISTING VME BASED BAM READOUT SYSTEM



(a) VME carrier board (b) Optical and analog input unit (c) Installation in VME crate

Figure 4: VME based BAM readout electronics.

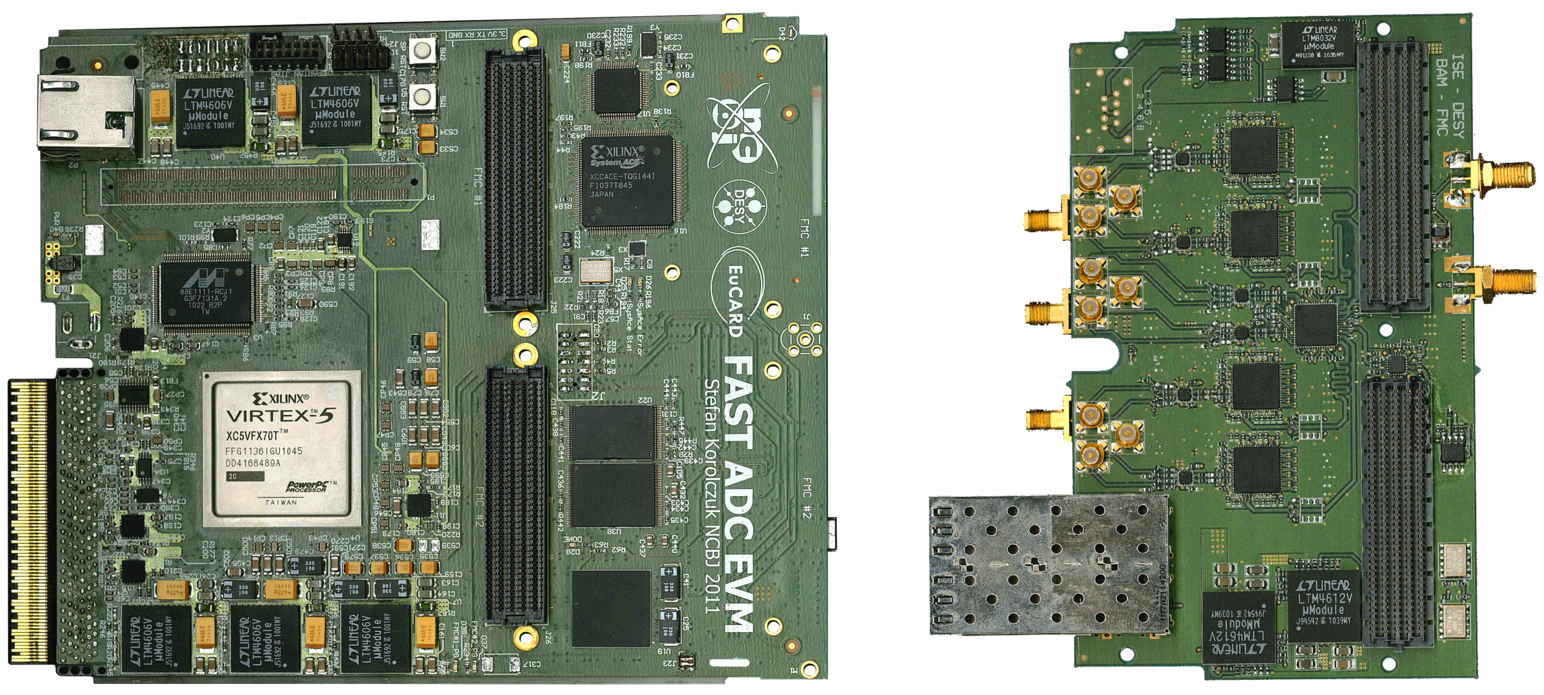
Major VME based BAM system problems:

- Backplane throughput (bandwidth shared with all boards)
- Non-hotswap devices (full crate power cycles required)
- No remote management of the individual boards

Feature	VME System	MTCA System
ADC sampling frequency	108 MSPS (max. 125 MSPS)	216 MSPS (max 250 MSPS)
FPGA	Virtex-II Pro	Virtex-5
Mezzanine type	custom	Dual FMC HPC
Communication interface	VME	PCIe x4
ADC clock distribution	on the mezzanine and on the carrier	entirely on mezzanine

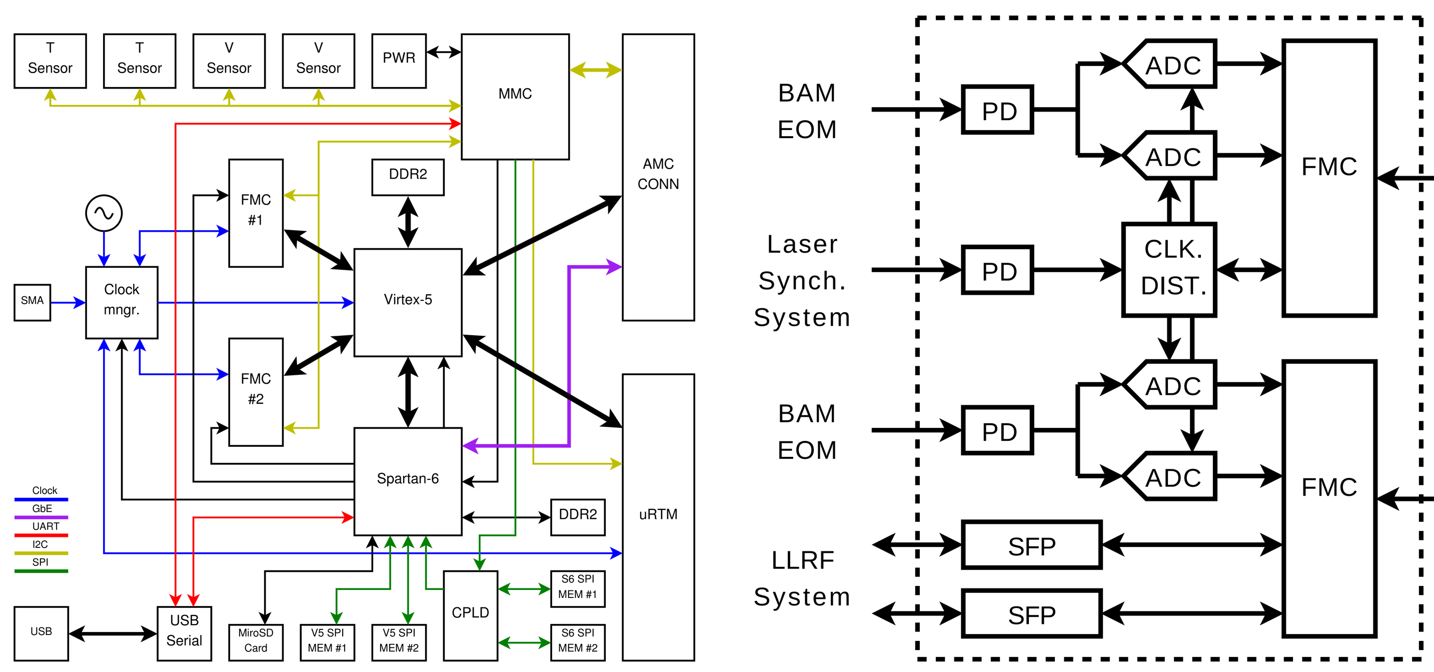
Table 1: Parameters of the old and new system

PROTOTYPE MTCA BAM READOUT DEVICES



(a) Prototype FMC carrier (b) Prototype FMC mezzanine with ADCs

Figure 5: Prototype devices, FMC Carrier (a), ADC mezzanine (b).



(a) Carrier block diagram (b) Mezzanine block diagram

Figure 6: Block diagrams, FMC Carrier (a), ADC mezzanine (b).

MTCA design main advantages:

- Boards, fans ans power supplies hot-swap capable
- IPMI based management, including temperature and power consumption control
- Remote management of individual boards
- Fast backplane communication (PCIe x4)
- Point-to-point connections on the backplane (no multidrop bus)

RESULTS

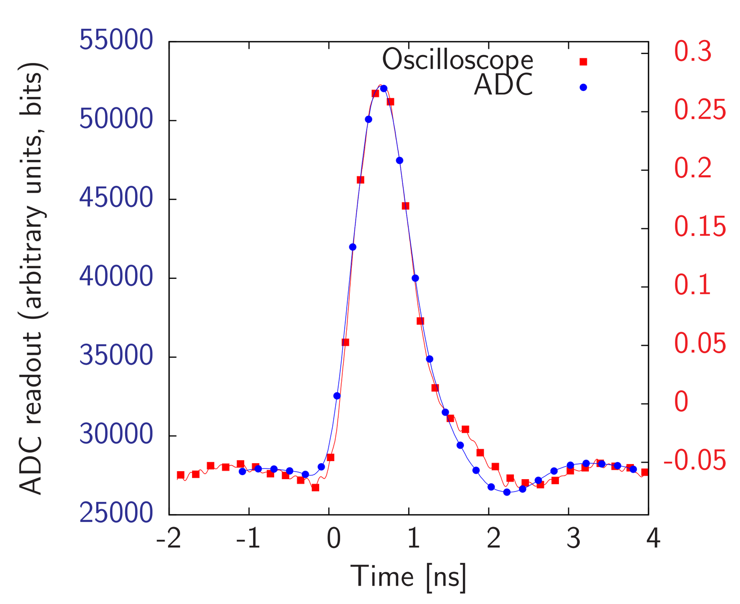


Figure 7: Laser pulse measured with the new MTCA BAM prototype devices and 8 GHz bandwidth oscilloscope.Marks in this figure does not indicate sampling points, but they are placed to identify two nearly overlapping pulses.

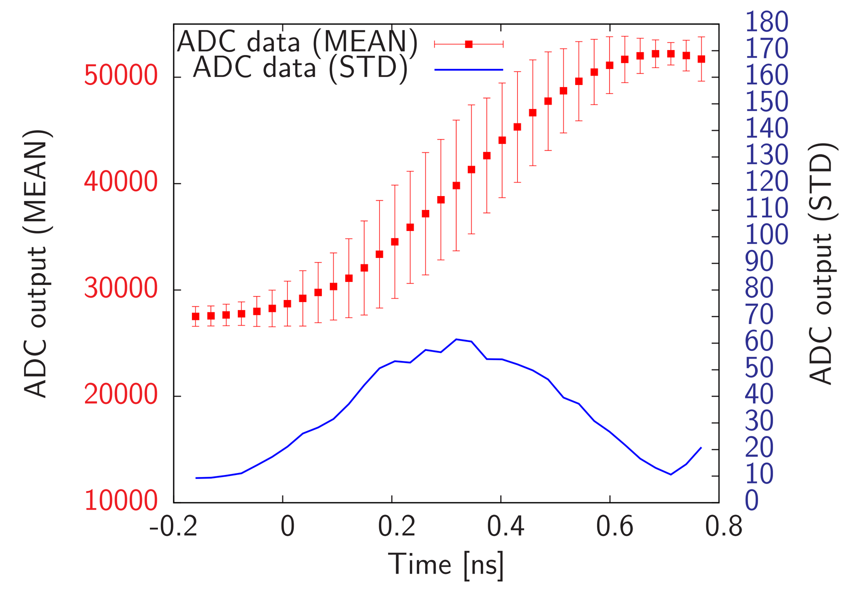


Figure 8: Single measurement of the rising edge of the laser pulse. Error bars around the mean values (red color) has been intentionally magnified,the numerical values of the STD are shown on the sub-plot (blue color) on right vertical scale.

With the presented prototype MTCA devices (Fig. 5), initial measurements has been made. By shifting ADC clock phase w.r.t. the laser pulses, a shape of the laser pulse has been measure (Fig. 7). For comparison, laser pulse from the same source has been measured with the 8 GHz bandwidth oscilloscope. Both measurements are shown in the Fig. 7.

By the analysis of the standard deviation (STD) of the measured ADC data in the flat regions and on the rising edge of the pulse (Fig. 8), the relative jitter of about 1 ps has been estimated. According to the clock distribution chip datasheet, 1 ps of additive jitter is contributed by the *fine delay* blocks used for clock phase adjustment, and this is major jitter contribution.

CONCLUSION

The prototype MTCA BAM readout electronics was able to provide in the first measurements session very good results, much better than existing VME based system. Except the data readout with faster ADCs and signal processing with better FPGA, the MTCA based environment will solve many problems observed in the VME system with long-term operation stability and system maintenance.

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