# CBM Projectile Spectator Detector Readout Chain

Aleksandr Makhnev, Dmitry Finogeev, Nikolay Karpushkin, Dmitry Serebryakov, Fedor Guber

Institute for Nuclear Research of RAS

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## Objectives

- The Compressed Baryonic Matter (CBM) experiment at FAIR needs a detector to measure the nucleus-nucleus collision centrality and orientation of the reaction plane. The Projectile Spectator Detector (PSD) as a sampling lead/scintillator forward hadron calorimeter with transverse and longitudinal segmentation will be used for this purpose.
- PSD requires a special readout apparatus to function because of its high radiation load.

## Introduction

- The aim of the future Compressed Baryonic Matter (CBM) experiment at the Facility for Antiproton and Ion Research (FAIR) is to explore the Quantum Chromodynamics (QCD) phase diagram in the region of high baryon densities. The beam energy range of 2 - 11 AGeV and heavy ion interaction rates up to 10 MHz will be achieved at the CBM experiment.
- The PSD (Projectile Spectator Detector) is the forward hadron compensating lead/scintillator calorimeter, which will be used in the CBM experiment to measure the collision centrality and the reaction plane orientation in heavy-ion collisions.
- The PSD has transverse and longitudinal segmentation. The light readout performed via multipixel photon counters (MPPCs).
- Calibration of the PSD is performed through an optically-coupled LED and cosmic ray runs.

## Readout chain architecture

- As the PSD is exposed to a severe dose load, the readout chain should be split into a radiation-hard front-end part and a radiation-sensitive readout parts.
- Radiation-hard part consists out of FEE (Front-End-Electronics) boards.
- Radiation-sensitive parts consists out of Readout Modules and service devices (high voltage supply, calibration pulse generator)

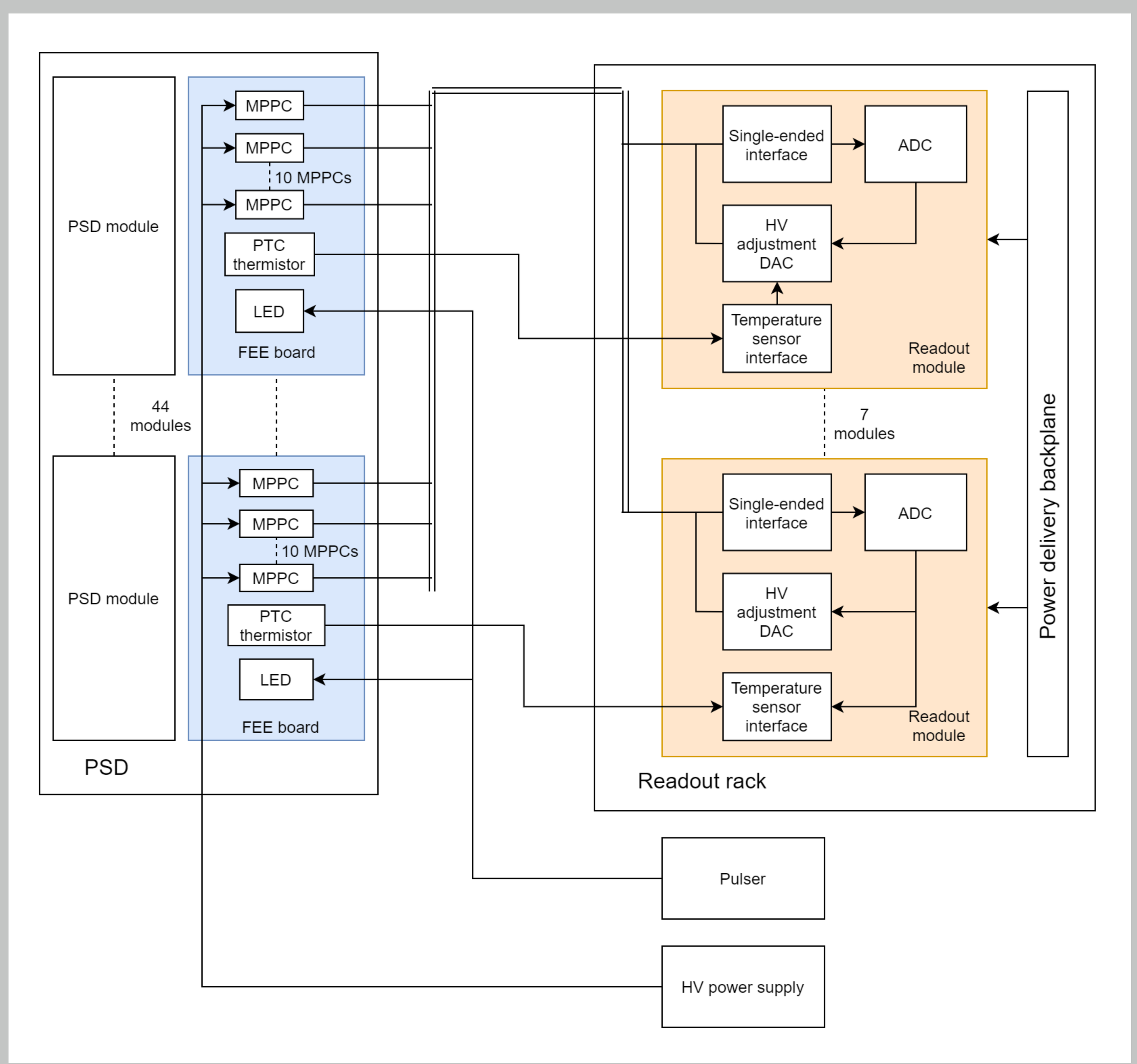


Figure: Readout chain architecture

## Readout function and control

- FEE boards register light pulses from the output optical fibers of the PSD, provide optical calibration through a pulsing LED, as well as measure the module's temperature through a PTC thermistor
- Readout modules provide amplification, digitizing and preprocessing of the pulse data, adjustment of the high-voltage bias provided to MPPCs, as well as implementing a temperature compensation of the MPPC's gain.
- Power supply provides a high-voltage bias for the MPPCs with current monitoring and short-circuit protection
- Pulse generator drives optical calibration LEDs

## Front-end boards

- 10 MPPCs and their output connectors
- Light-shielding parts
- Calibration LED mount
- Temperature sensor
- Installation of the light-shielding parts improves dark current and noise characteristics
- Overall noise level is 0.17V RMS at 50m of DRAKA 5mm coaxial cable

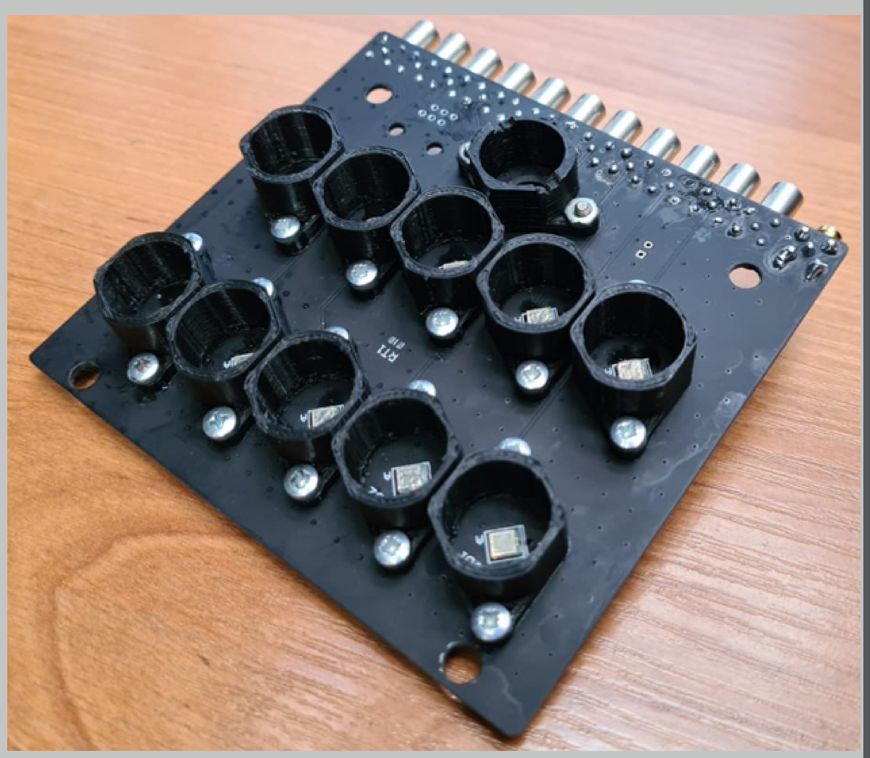

Figure: Front-end board production prototype

## Readout modules

- Single-ended to differential converters with amplification and adjustable zero levels
- High-voltage bias adjustment via compensation with high-resolution remote digital control
- On-the-fly waveform fitting and particle charge calculation

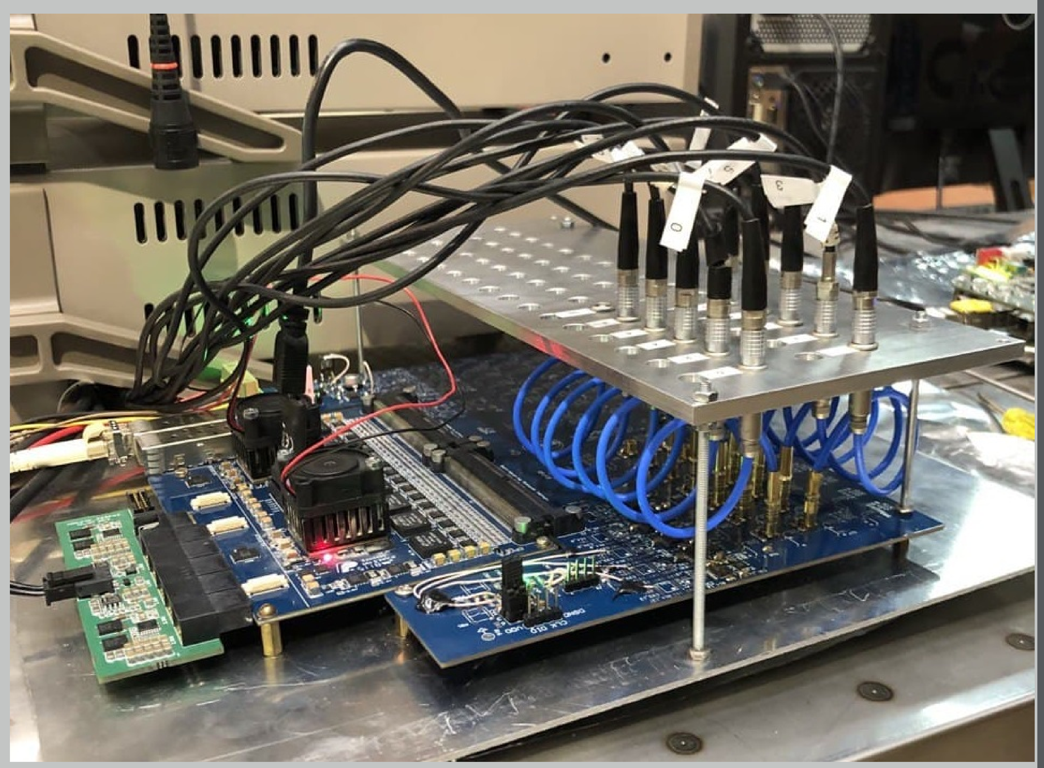

Figure: Readout module production prototype

## Tests and results

- PSD readout chain was tested at INR with calibration LED, cosmic rays and at mCBM@FAIR/GSI during test beam runs.
- LED tests show operation of MPPC's gain adjustment via high-voltage compensation.
- Cosmic ray tests show clear separation of the MIP peak from the noise pedestal
- All of the tests were performed with the front-end boards connected via 50m long cables.

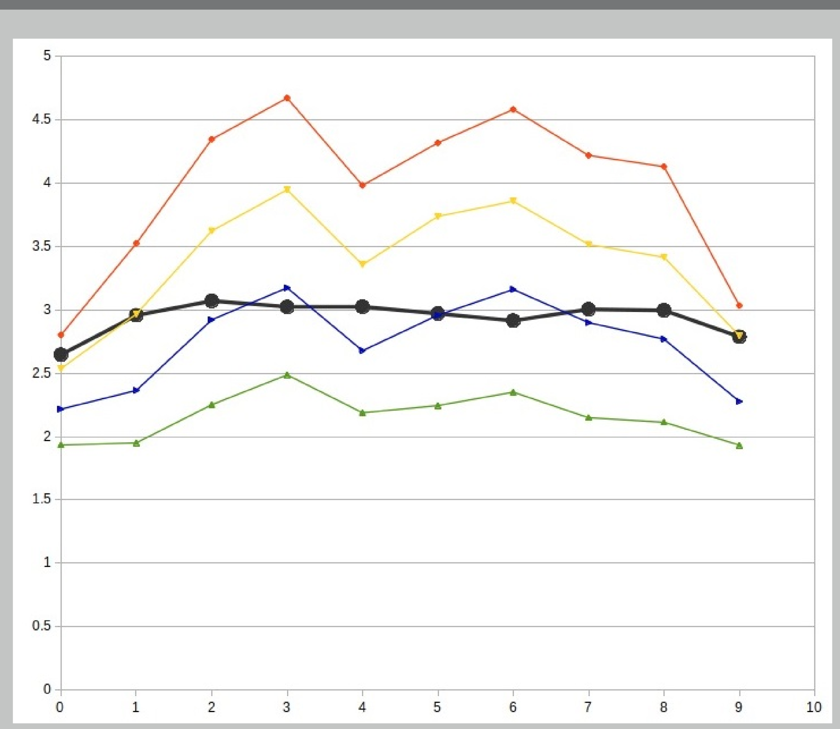

Figure: Optical gain variation with different voltages applied to MPPCs through the compensation system (colored) and compensated gain brofile (black)

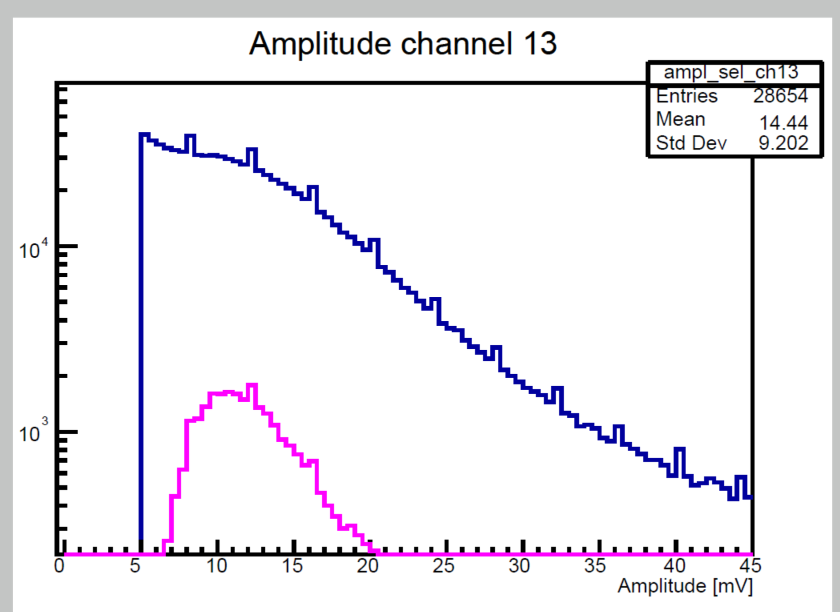


Figure: Cosmic rays spectra. Blue - all the accumulated data, purple - data with spacial rejection applied to distinguish cosmic ray events from background noise

## Conclusion

- The readout chain overall architecture is completed, as well as production prototypes for all the major parts of the system.
- At the current state, PSD's readout chain is almost identical to the one planned to be deployed at CBM, with deviation lying in non-signal-related areas.



makhnev.a@phystech.edu