ISAB FAIR-RO / 2018

Annual Summary Document

1. Cover Page

- Project Team:

- Prof. Dr. Mihai Petrovici (physicist) – team leader
- Scientific Researcher III Dr. Cristian Andrei (physicist)
- Senior researcher III Daniel Bartos (physicist)
- Senior researcher II Dr. Alexandru Bercuci (physicist)
- Senior researcher II Gheorghe Caragheorgheopol (electronics engineer)
- Senior researcher II Dr. Vasile Catanescu (electronics engineer)
- Senior researcher II Dr. Florin Constantin (physicist)
- Senior researcher II Viorel Duta (mechanical engineer)
- Scientific Researcher III Dr. Andrei Herghelegiu (physicist)
- Senior Engineer I Dr. Gheorghe Mateescu
- Senior researcher II Dr. Mariana Petris (physicist)
- Senior researcher I Dr. Amalia Pop (physicist)
- Senior engineer II Dr. Laura Radulescu (mechanical engineer)
- Senior researcher II Dr. Victor Simion (physicist)
- Computing coordinator Claudiu Schiaua (physicist)
- PhD student Madalina Tarzila (physicist)
- Technician Valerica Aprodu
- Technician Lucia Prodan
- Technician Andrei Radu
- Technician Constanta Dinca
- Lathe and milling machine operator Dima Gheorghe
- Financial coordinator Georgiana Toma (economist)

1. **Specific scientific focus of group**

Contributions to the CBM TOF and CBM TRD R&D activities

- **Highlights of accomplishments in the last year**

- Analysis of the data obtained in the radioactive source and cosmic ray tests of the TRD prototype
- Design, construction and tests of FASP-0.3 with chip interconnectivity and associated motherboard.

- Design and construction of 2 RPC prototypes
- Design of a new FASPRO motherboard
- Simulation of GETS functionality on the present FASPRO hardware
- 5 contributions to CBM Progress Report
- 9 presentations to CBM Collaboration Meetings
- 2 presentation to International Conferences
- 2 published paper
- 1 paper sent to ISI journal for publication
- A Summer Student Program with 5 participants, successfully accomplished.

2. Scientific goals

- TRD data analysis;
- Implementation of the TRD Bucharest module in the CBM Root environment
- design, manufacturing and tests of an improved version of the FASP ASIC – FASP-0.3;
- design of FASPRO motherboard as core of a free running DAQ system prototype;
- UrQMD code implemented and suitable to be used for energies from SIS ($\sqrt{sNN} \sim 2$ GeV) to RHIC ($\sqrt{sNN} \sim 200$ GeV).

3. Scientific achievements in the last year corresponding to the actual program funding:

Analysis of the data obtained in the radioactive source and cosmic ray tests of the TRD prototype

The analysis of various sets of data were done to estimate the performances of the TRD system and its associated trigger less DAQ based on FASP. The aim of these measurements were two folded: to estimate the stability of the DAQ chain over time and, secondly, to characterize the TRD/FASP chain as function of detector and FEE characteristics. Both performance evaluations are mandatory for including ou~~t~~r system in the CBM experiment, especially for its phase 0, the mCBM experiment.

The stability rate was performed on a cosmic rays set-up with two chambers mounted on a telescope like structure. The experiment was running for periods of 24 and 48 hours. The main focus was to check that the clock synchronization in the free-running DAQ can be kept for long periods. We found that clock glitches do appear in the DAQ without obvious causes. A similar experience was reported by colleagues involved in other sub-systems of CBM. The conclusion of this study shows the need to introduce in the TRD DAQ a new digital module, targeted at checking periodically the time synchronization of slave components against a master clock (i.e. introducing a time synchronization protocol), coupled with a reset and restart mechanism. This component will be first developed, as prototype for our TRD detector, and eventually proposed as a general protocol for the collaboration.

The measurements done for the radioactive source of ^{55}Fe were performed at various anode multiwire electrode potentials ranging from 1.7 to 2.0 kV anode voltages. A full reconstruction of the X-ray clusters was performed in order to estimate energy and 2D position resolution performances of the TRD.as function of cluster size. The output of these measurements were:

1. The energy calibration of the TRD detector, using a model for the ^{55}Fe spectrum including the two lines α (5.895 keV) and β (6.492keV) with their respective branching ratios (BR_α=89% and BR_β= 11%) and the corresponding escape peaks (probability 12%) for Auger electrons emission.

2. Estimation of the missing energy per cluster due to cluster signals under threshold and corrections.

3. Estimation of the Bucharest-TRD chamber gain as a function of anode voltage

All results listed above were included as calibration parameters in the CbmRoot and tested in 10MHz interaction rate MC simulations for the mCBM setup. Results on cluster properties (signal and time shapes) were found to agree well with the measured values.

FASP-0.3 ASIC: design, manufacturing and tests including two chips interconnection motherboard.

FASP-0.3 ASIC microcircuit is an improved version of the previous FASP-0.2 ASIC. The main specifications, especially those concerning the analogue input and output features are the same. So the dynamic input and output ranges, the output type shape signals (semi-Gaussian and flat top), the analogue channel gain and shaping time are identical for the two microcircuit ASICs. The differences between the to ASICs are detailed in the followings:

a- One difference consist in the improvements added to digital parts of the microcircuit implying system triggering: trigger of the own channel when an event arises to its input and also the forced trigger of the two its neighboring channels. This system triggering allows a better selection of the true useful signals in neighbors channels associated to one initial event in the central channel which will generates also a correct master trigger signal.

b- Much more simulations were done for FASP-0.3 microcircuit. Extensive sets of simulation in schematics and also in layout were performed for one FASP-0.3 analog channel and for the whole chip. The extensive main typical simulations, parametric simulations and also corner analysis were done to fulfill all the foundry requirements for a successfully submission of the FASP-0.3 ASIC. All types of simulations had various stimulus sets as inputs to emulate a large signals of a real fast counting rate TRD detectors.

c- Although the both FASP-0.3 and also the previous FASP-0.2 ASICs are designed in AMS 0.35 μm CMOS technology, FASP-0.3 ASIC was developed in four metals for a better grounding and shielding. The real (physical) FASP-0.3 ASICs microcircuits were manufactured by Austriamicrosystems (AMS) foundry according to the project and Cadence design files, coming all from IFIN-HH HPD department.

The real FASP-0.3 ASICs in dice form, such they were coming from AMS foundry, were tested having as input signals from electronic pulse generators as well with signals delivered by TRD detectors. For these purposes a set of printed circuit test boards were designed in IFIN-HH DFH department using CAD software. Manufacturing of all PCB is done by a company. An ASIC bonding board, one ASIC intermediate board and few test/acquisition motherboards having one or two of the first two board mentioned before and some additional circuits , will be listed bellow:

ASIC bonding board: is the smallest, 18mmX13mm, 4 layers PCB used to bond the manufactured die form FASP-0.3 ASIC. All these three steps, including PCB design are performed in IFIN-HH HPD. The bonding operation with 35 μm diameter Al+4% Si wire is achieved using HPD semiautomatic bonding machine. This board is part of the intermediate PCB board mentioned earlier or part of the large motherboard for acquisitions.

ASIC intermediate board: is 46mmX42mm, 4 layers PCB accommodating ASIC bonding board to different mother boards for test /acquisition purposes. The ASIC bonding board is fixed with two small screws and one dedicated array contacts on the intermediate board. Having 4 DIL connectors, the intermediate boards allow access to all ASIC pads for farther connectivity.

ASIC test motherboard for two chips: is 164mmX122mm, 4 layers PCB for simultaneous testing of ~~up~~ two FASP-0.3 ASICs. It contains connectors for input stimulus test signals and for power supplies, parameter setting jumpers (input polarity, output type semi-Gaussian/flat top signals, neighbor on/off triggering), additional functional circuits: clock generation and distribution, manual reset logic, levels generation for reference/threshold /base line and power supplies circuits. Additional circuits are implemented beside of the chips enabling the board to test one or two ASICs. Two ASIC intermediate boards should be inserted on one ASIC test board for a whole range test. This board will allow full sets of test for one or two FASP-0.3 ASICs, including inter ASICs communications.

FASPRO motherboard for data acquisition: is a 170mmX118mm, 4 layer PCB for high level test and also acquisition using FASP-0.3 ASIC. On FASPRO board beside one ASIC intermediate board and additional functional circuits there are also 16 analog to digital converters (ADCs) - one for each analog channel of the FASP-0.3 -, and other logic and analog circuits associated to ADCs. FASPRO motherboard assures analog to digital data conversions and also facilities for digital data acquisition from the 16 analog signals supplying the FASP-0.3 inputs. These types of test/acquisition are useful for testing the ability of the FASP-0.3 ASICs to drive the ADCs, to work in complex data management and for their future use in much complex data acquisition systems.

The FASP-0.3 ASIC having some features of previous version FASP-0.2, but also some new and many improvements was designed, manufactured and tested. The tests carried out show the good results in concordance with the extensive and various simulations in schematics and layout which were done in the design phases of the FASP-0.3 ASIC microcircuit.

Excitation function of collective flow

UrQMD (Ultra relativistic Quantum Molecular Dynamics) is a fully integrated Monte Carlo simulation package for proton - proton, proton - nucleus and nucleus - nucleus interactions.

UrQMD contains hadronic (and string) degrees of freedom -- all hadronic states can be produced in string decays, s-channel collisions or resonance decays. Tabulated and parameterized experimental cross sections are used when available. Resonance absorption, decays and scattering are handled via the principle of detailed balance. The UrQMD model has been extensively tested in the SIS, AGS and SPS energy domain and provides a robust description of hadronic heavy-ion physics phenomenology. It is suitable to be used for energies from SIS ($\sqrt{s_{NN}}$ ~ 2 GeV) to RHIC ($\sqrt{s_{NN}}$ ~ 200 GeV) and thus for the studies foreseen to be done in the present project. The code has been implemented and used to calculate transverse momentum distributions for π^+, K^+ and p in central Au-Au collisions at $\sqrt{s_{NN}}$ ~ 7 GeV. The agreement with spectra measured at RHIC is good.

4. Group members

Nr. Crt.	Name	Surname	Position within project	R&D (%)	Infrastructure planning Financial issues (%)	TOTAL %
1	Petrovici	Mihai	Project director	4%	1.25%	5.25%
2	Pop	Amalia	Team member/Specialist			0.00%

3	Constantin	Florin	Team member/Specialist			0.00%
4	Catanescu	Vasile	Team member/Specialist	26.73%		26.73%
5	Caragheorgheopol	Gheorghe	Team member/Specialist	24.89%		24.89%
6	Simion	Victor	Team member/Specialist	21.84%		21.84%
7	Duta	Viorel	Team member/Specialist			0.00%
8	Giolu	Gheorghe	Team member/Specialist			0.00%
9	Bercuci	Alexandru	Team member/Specialist	5.14%		5.14%
10	Petris	Mariana	Team member/Specialist	4.00%	1.42%	5.42%
11	Radulescu	Laura	Team member/Specialist			0.00%
12	Mateescu	Gheorghe	Team member/Specialist		12.78%	12.78%
13	Bartos	Daniel	Team member/Specialist	27.13%		27.13%
14	Andrei	Cristian	Team member/Specialist			0.00%
15	Herghelegiu	Andrei	Team member/Specialist			0.00%
16	Schiaua	Claudiu	Team member/Specialist	3.50%	1.36%	4.86%
17	Rosu	Georgiana	Team member/Specialist			0.00%
18	Tarzila	Madalina	Team member/Phd student			0.00%
19	Dima	Gheorghe	Team member/Turner	4.80%		4.80%
20	Radu	Andrei Bogdan	Team member/Technician			0.00%
21	Prodan	Lucia	Team member/Technician			0.00%
22	Aprodu	Valerica	Team member/Technician			0.00%
23	Dinca	Constanta	Team member/Technician			0.00%

5. Publications, Conferences and Meetings

CBM Collaboration Meetings:

A. Bercuci et al.
Status of TRD software
31st CBM Collaboration Meeting GSI-Darmstadt, Germany 19-23 March 2018.
https://indico.gsi.de/event/5862/session/14/contribution/76

A. Bercuci, et al.
FASP based FEE- Status and Performances
31st CBM Collaboration Meeting GSI-Darmstadt, Germany 19-23 March 2018.
https://indico.gsi.de/event/5862/session/21/contribution/32

A. Bercuci, et al.
Hitting the 100k particle/cm^2/s rate - Detector performance
31st CBM Collaboration Meeting GSI-Darmstadt, Germany 19-23 March 2018.
https://indico.gsi.de/event/5862/session/21/contribution/38

M. Petris et al.
Status of CBM-TOF RPC activities in HPD
31st CBM Collaboration Meeting, GSI-Darmstadt, Germany 19-23 March 2018.
https://indico.gsi.de/event/5862/session/18/contribution/111

A. Bercuci et al.
Bucharest TRD prototype for mCBM - status and timeline
32nd CBM Collaboration Meeting, GSI-Darmstadt, Germany, 1 – 5 October 2018
https://indico.gsi.de/event/5863/session/25/contribution/28

A. Bercuci et al.
Characterization of the BU TRD prototype - laboratory tests and software
32nd CBM Collaboration Meeting, GSI-Darmstadt, Germany, 1 – 5 October 2018
https://indico.gsi.de/event/5863/session/25/contribution/28

M. Petris et al.
MGMSRPC 2018 prototype for the inner zone of the CBM-TOF wall
32nd CBM Collaboration Meeting, GSI Darmstadt, 01-05 October 2018
https://indico.gsi.de/event/5863/session/17/contribution/133

Laura Radulescu et al.,
TOF Inner Zone – structure, services, mechanical support
32nd CBM Collaboration Meeting, GSI Darmstadt, 01-05 October 2018
https://indico.gsi.de/event/5863/session/17/contribution/134

M. Petrovici et al.
TOF IFIN IKC
32nd CBM Collaboration Meeting, GSI Darmstadt, 01-05 October 2018
https://indico.gsi.de/event/5863/session/17/contribution/125

International Conferences

M.Petris et al.
Performance in heavy -ion beam tests of a high time resolution and two-dimensional position sensitive MRPC with transmission line impedance matched to the FEE
XXXIX International Conference on High Energy Physics (ICHEP2018), July 4-11, 2018, Seoul, Korea; https://indico.cern.ch/event/686555/contributions/2973828/

L.Radulescu et al.
Integration of the HPD detectors in the mCBM experiment using CAD
18th International Balkan Workshop on Applied Physics and Material Science, July 10-13, 2018, Constanta, Romania. http://ibwap.ro/#program

Published papers:

D. Bartos¸ M. Petris¸ M. Petrovici, L. Radulescu, V. Simion
"A method to adjust the impedance of the transmission line in a Multi-Strip Multi-Gap Resistive Plate Counter"
Romanian Journal of Physics 63, 901 (2018)

M. Petris, D. Bartos, M. Petrovici, L.Radulescu, V.Simion, I Deppner, N. Herrmann, C. Simon, J. Fruehauf, M. Kiss, P.Loizeau
"In-beam test of the RPC architecture foreseen to be used for the CBM-TOF wall"
Journal of Physics:Conference Series, Vol. 1023(2018), 012007

Contributions to CBM Progress Report 2017 (2018)
A Bercuci et al.
Time Based CbmRoot simulations of the Bucharest protype for mCBM
CBM Progress Report 2017 ISBN 978-3-9815227-5-4, (2018) 186;

A Bercuci et al.
Laboratory tests of the TRD Bucharest prototype in close to realistic high counting rates environment
CBM Progress Report 2017 ISBN 978-3-9815227-5-4, (2018) 89;

M. Petris et al.,
Performance tests of the MGMSRPCs using a free streaming readout
CBM Progress Report 2017 ISBN 978-3-9815227-5-4, (2018), 102;

L. Radulescu et al.
Mechanical design of the CBM-TOF inner wall
CBM Progress Report 2017 ISBN 978-3-9815227-5-4, (2018), 107;

L. Radulescu et al.
CAD integration of the mCBM systems
CBM Progress Report 2017 ISBN 978-3-9815227-5-4, (2018), 176;

Summer Student Program:
Quite successful, i.e. 5 participants: 3 students from Birmingham University,
1 from Bucharest Technical University and 1 from Sherbone High School, England.

Outreach:

- - Numerous visits of Romanian and foreign delegations, Romanian pupils winners of
- International Competitions in Physics
- - "My experience within the ALICE experiment at LHC", A. Herghelegiu, Summer

- School for pupils, prepared for International Competitions in Physics, Busteni,
- 18-26 July, 2018
- - Interview for Romanian Radio Broadcast
- - Visit of Paulo Giubellino – Scientific Managing Director of FAIR/GSI
- - Visit of some SMEs of Magurele Tech. Park
- - More details could be seen in:
- https://niham.nipne.ro
- https://www.youtube.com/watch?v=OJd4fA0xUh0
- https://www.facebook.com/Hadron-Physics-Department-211078852968333/
- https://www.youtube.com/watch?v=ZHBgGKamUc8&feature=youtu.be