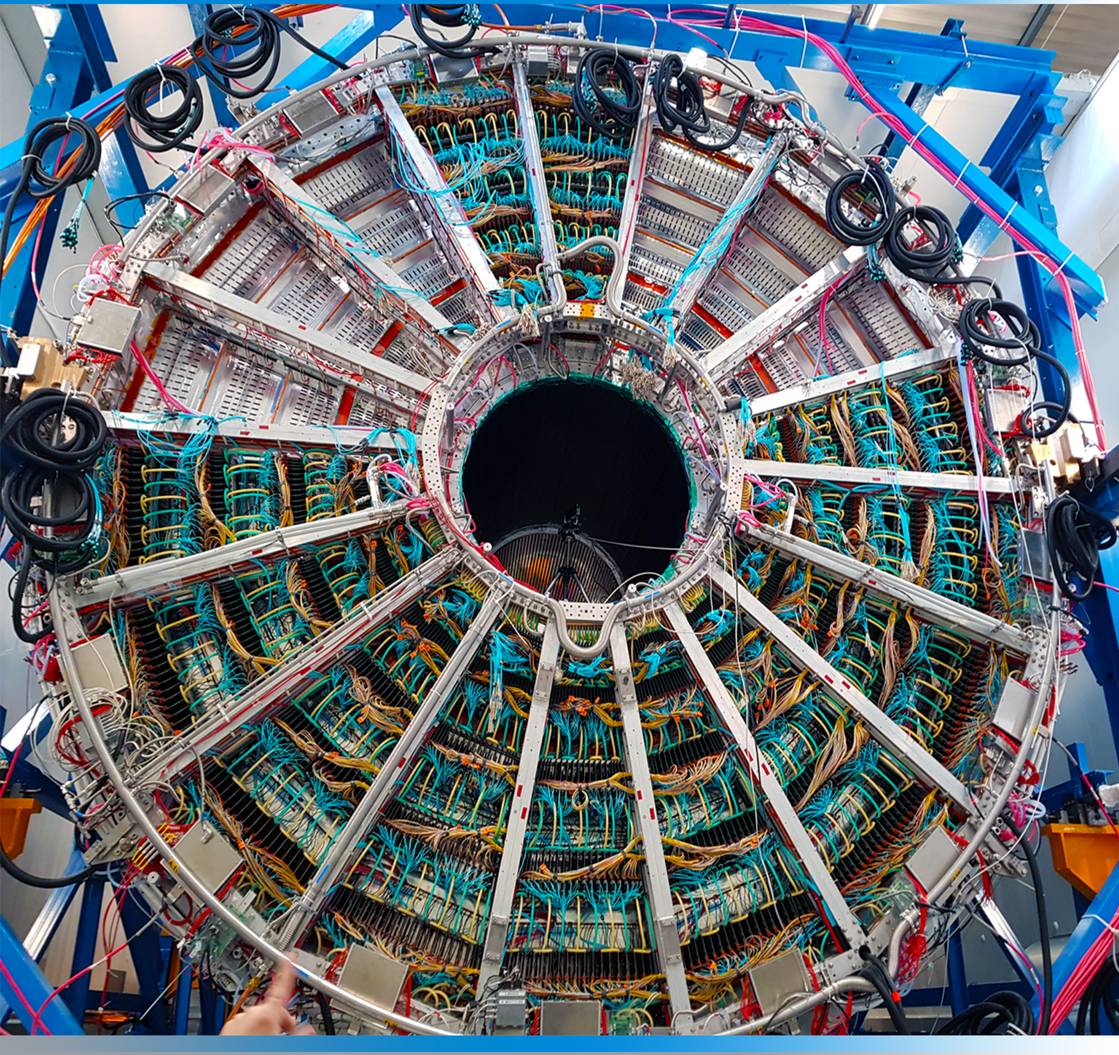
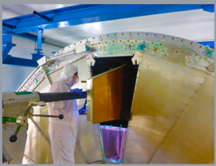
HPD Courier

Number 3 | April 2020



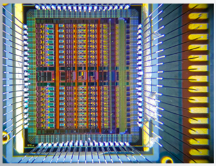


ROCs

Assembling of ROCs based on GEMs in the ALICE-TPC

FASP

New version of Fast Signal Processor (FASP) for CBM-TRD



Contents

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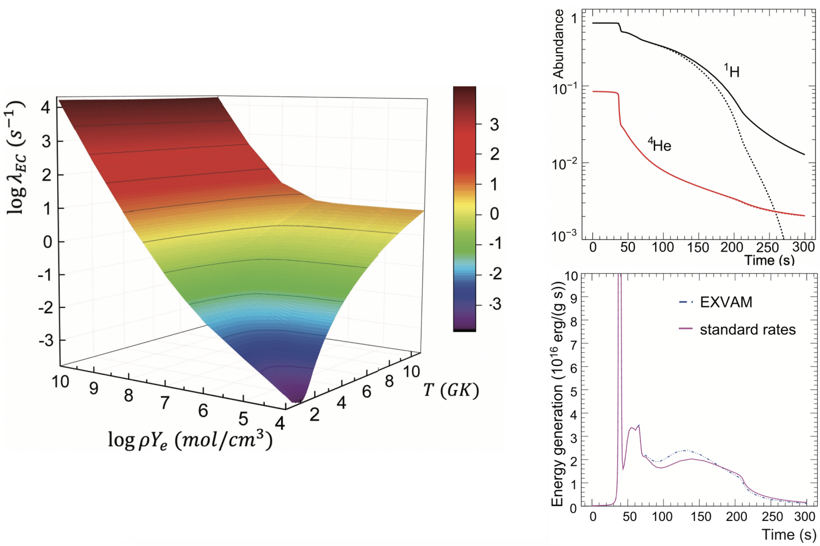
Achievements

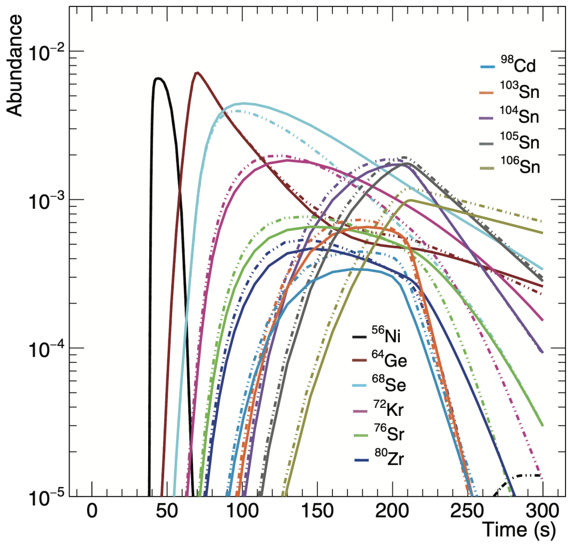
Nuclear Structure and Dynamics

Impact of stellar weak interaction rates of A≈70 waiting points on *rp*-process nucleosynthesis and energetics

The exotic proton-rich N≃Z nuclei in the A=70 mass region play a critical role in *rp*-process in type I X-ray bursts and their associated nucleosynthesis. The competition between the proton capture rates and the rates of the weak interaction processes at the waiting points affects the process significantly influencing the nuclear energy production rate that finally translates into the luminosity curves, the main direct observable of a type I X-ray burst. Robust predictions of Gamow-Teller strength distributions for the ground state and thermally populated low-lying excited states in the stellar environment and the temperature dependence of the β^+−decay rates together with the temperature and density evolution of the continuum electron capture rates are needed to realistically evaluate the impact of weak interaction rates of the waiting point nuclei on nucleosynthesis.



The beyond mean-field description of the effects of shape coexistence and mixing in the structure of parent and daughter nuclei on the stellar weak interaction rates is obtained within the complex Excited Vampir approach using a realistic effective interaction derived from a nuclear matter G-matrix starting from the Bonn CD potential and an adequate model space. To explore the impact of the ^{68}Se and ^{72}Kr stellar weak interaction rates on burst simulations we used a post-processing approach based on a one-zone model that was adjusted to match a 1-D multizone hydrodynamic result as closely as possible. We performed a series of calculations based on different initial combinations of hydrogen/helium mixing and metallicity. The enhanced weak decay flow through ^{68}Se and ^{72}Kr using the EXVAM rates leads to a faster consumption of free protons in the burst. Enriched reaction flow through ^{68}Se and ^{72}Kr with the EXVAM rates leads to a 20% increase in energy production in the middle point of the burst duration.



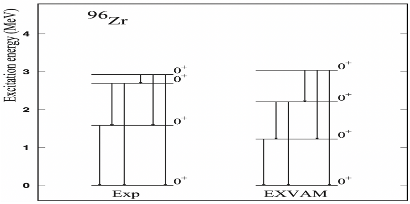
The final composition of the burst ashes for modeling neutron star crust properties is strongly influenced. The maximum ratios between the abundances based on standard weak interaction rates and the ones including EXVAM rates are 3.8 and 3.3 for ^{68}Se and ^{72}Kr, respectively.

For details

A. Petrovici, A. S. Mare, O. Andrei, B. S. Meyer, Phys. Rev. C 100, 015810 (2019)
A. Petrovici, Talks: ILL-Workshop - Bucharest 2019, ANPC 2019 - South Africa, NuSYM2019 - Vietnam
A. S. Mare, Master thesis 2019 - currently PhD student
A. S. Mare, Talks: ASC, Faculty of Physics - Bucharest 2019

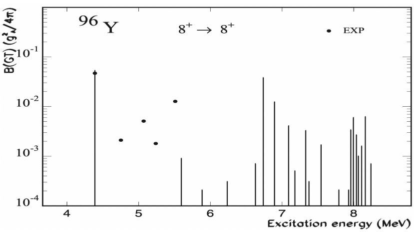
Triple shape coexistence and β decay of ^{96}Y to ^{96}Zr

The effects of shape coexistence in ^{96}Y and ^{96}Zr on the β^- first-forbidden decay of the 0^- ground state and Gamow-Teller decay of the 8^+ isomer of ^{96}Y to ^{96}Zr were studied within the beyond-mean-field complex Excited VAMPIR model. The structure of the parent and daughter states and the β^--decay properties have been investigated using an effective interaction derived from a G-matrix based on the charge-dependent Bonn CD potential and a large model space.



Transition	EXVAM
$\rho^2(E0; 0_2^+ \to 0_1^+)$	0.0215
$\rho^2(E0; 0_3^+ \to 0_1^+)$	0.0048
$\rho^2(E0; 0_3^+ \to 0_2^+)$	0.0525
$\rho^2(E0; 0_4^+ \to 0_1^+)$	0.0084
$\rho^2(E0; 0_4^+ \to 0_2^+)$	0.0104
$\rho^2(E0; 0_4^+ \to 0_3^+)$	0.0155

The influence of shape coexistence and mixing on the properties of the states involved in the investigated allowed and first-forbidden β^- decays is discussed and comparison to the available data is presented. The comprehensive treatment of different identified characteristics includes the description of significant E0 transitions between the lowest four 0^+ daughter states in ^{96}Zr, fingerprint of the predicted triple shape coexistence underlying their structure.



I[$\hbar$]	$\epsilon_{mec} = 1.15$	$\epsilon_{mec} = 1.19$	Exp.
0_{gs}^+	5.60	5.53	5.59 (1)
0_2^+	6.40	6.32	6.97 (4)
0_3^+	6.52	6.45	7.41 (6)
0_4^+	6.48	6.42	7.92 (9)

For all investigated observables the comparison with the available experimental data indicates good agreement giving support to our scenario on the evolution of the shape coexistence and mixing with increasing spin and excitation energy in both the odd-odd parent nucleus and the even-even daughter nucleus.

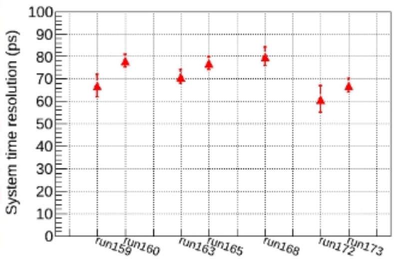
For details

A. Petrovici and A. S. Mare, Phys. Rev. C 101, 024307 (2020)
A. S. Mare, Master thesis 2019

R&D activities

MSMGRPC prototypes @ mCBM

High granularity Multi-Strip, Multi-Gap Resistive Plate Counters (MSMGRPC) will equip the innermost zone of the CBM-TOF wall. Two identical MSMGRPC prototypes were designed with the signal transmission line impedance matched to the value of front-end electronics (FEE). In-house cosmic ray test confirmed the impedance matching and a very good performance in terms of efficiency (~95%) and time resolution (64 ps). This performance was reproduced in the in-beam tests using reaction products produced by 1.6A GeV ^{107}Ag beam incident on a Au target. The in-beam tests were performed in a dedicated CBM test setup called mCBM, installed at SIS18/GSI Darmstadt. The MSMGRPC signals were processed by a free streaming readout system, close to the one which will be used in the CBM experiment.



For such an operating mode the matching of the signal transmission line to the input of the FEE is mandatory in order to avoid processing a large amount of fake signals produced by reflections. The obtained system time resolution (including the contribution of both reference counter and detector under study) was of in the range of 62 ps – 78 ps. If an equal contribution of the two identical counters to the time resolution is supposed, a single counter time resolution of 44 ps – 55 ps (including electronics contribution) is estimated. The multi-dimensional data analysis is on-going and further results will follow.

For details

D. Bartoş *et al.*, Rom. J. of Phys. 63 (2018) 901

M.Petriş *et al.*, 34thCBM Collaboration Meeting, Kolkata, India

M. Petriş *et al.*, Nucl. Instrum. Meth. A, 920 (2019) 100

M. Petriş *et al.*, Talks: EPS-HEP2019 - Belgium, XXIII International School on Nuclear Physics, Neutron Physics and Application - Bulgaria 2019

TRD - Implementation in CBMRoot & Performance

A group in HPD was continuously involved for the past 16 years in developing a Transition Radiation Detector (TRD) for high particle rates detection with high position resolution capabilities. The detector is proposed for the inner zone of the TRD wall of the Compressed Baryonic Matter (CBM) experiment which will be commissioned in 2024 at FAIR-GSI. Measurement performances set forward when starting the development were particle rates exceeding 100 kHz/cm^2 with better than 10% energy resolution at 6 keV and uniform space-time behavior. Particle identification capabilities have to be paralleled by x-y position sensitivity all over the active area of 150 × 800 μm resolution. Additionally, such performances are to be obtained in a trigger-less measuring environment, which initiated the development of the corresponding Front End Electronics (FEE) and Data Acquisition (DAQ) in our group, to fully take advantage of the detector special design.

The detection system answering the design requirements stated above was tested during the R&D phase using prototypes in various irradiation conditions with very good results. In parallel, dedicated Monte Carlo (MC) simulation were performed on the full CBM setup, to characterize the system (detector+FEE+DAQ) and obtain the production readiness for our group CBM contribution (40 fully equipped chambers). Lately the tool for modeling the experimental setup, CbmRoot, was extend with various components detailing our detector design and functional parameters. In Figure 1 the geometry modeler of ROOT is used to export the CAD designs of all experimental components of CBM. The TRD system developed by us is marked in blue in the central part of the TRD wall. Other detection systems are also presented and detailed in the figure to give a perspective of our contribution. The detector physics and FEE response are detailed in the digitization part of CbmRoot by importing results from specific simulations tools such as GARFIELD and CADENCE. Spatial and temporal particle pileups are particularly considered in the model for rendering a realistic free-running data stream simulation. Finally the detector response is converted to reconstructed in-

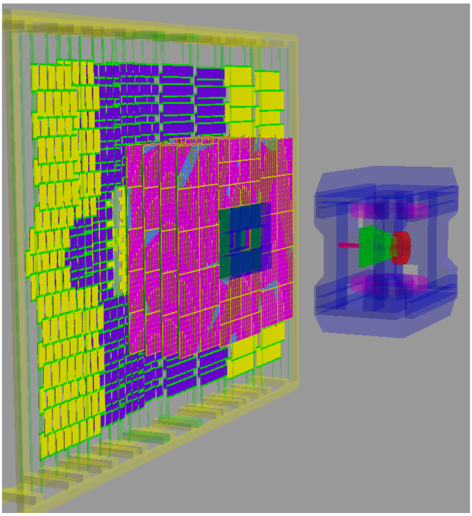


Figure 1: A view of the simulated CBM setup in which, starting from right to left, some (not all) experimental components are shown; the Silicon Tracking System (STS), the TRD and the Time of Flight (ToF). Our detectors are emphasized in blue in the central part of the TRD wall.

formation in a procedure, MC information free, identical as if applied to measured data.

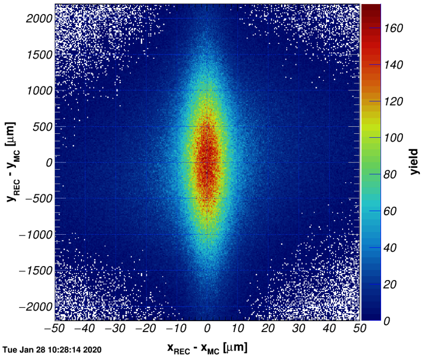


Figure 2: x-y residuals between MC position of a particle crossing the detector and its reconstructing image. Results correspond to no event pile-up scenario and detector tuned for tracking ($ArCO_2$ UA=1.9 kV).

Qualifying our system for CBM integration means matching with the rest of the CBM experimental components (detection units and reconstruction algorithms) and demonstrating the improvement for various physics channels. These studies are performed on the simulated model and are by necessity incomplete as they depend on the status of other systems in the setup. Our input to the global physics of CBM is represented by particle position and energy deposit and their uncertainties estimated for realistic measuring conditions. In Figure 2 a summary plot of the spatial performance of our TRD system is shown in which the residuals of the reconstructed particle position wrt to the MC particle are shown on the orthogonal directions attached to the detector surface.

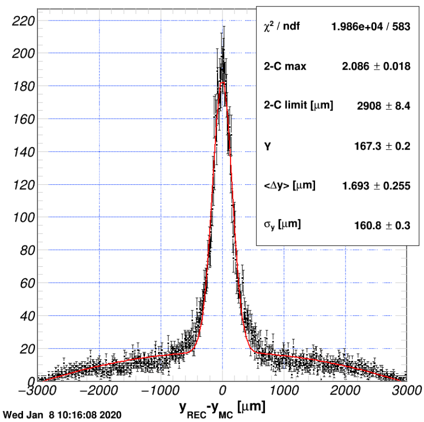


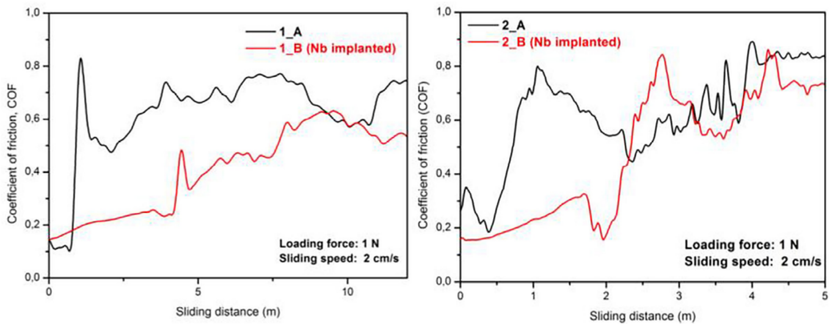
Figure 3: For the wire cross region there are 2 components in the residual distribution. The "prompt 2 wire" with typical resolutions of 200 μm (top around 150) and "asynchronic 2 wire" which is a flat distribution spanning the 2 amplification regions.

A particular resolution plot specific to our detection concept is shown in Figure 3 where the y direction residuals from Figure 2 are shown only for particles hitting close to the boundary of two neighboring amplification cells. It is thus demonstrated that for limited spatial regions of the active are position precision estimates can reach up to $100 \times 150\ \mu m^2$. The TRD system (detector/FEE/DAQ) developed by us was fully modeled in the CBM framework. Tests in realistic, low interaction rates scenario for CBM confirm the exceptional performances of the system demonstrated in various prior measuring setups. Reconstruction of all available observables and matching with CBM systems is ongoing to asses the status of our component as core detection facility of the large experimental setup.

Improvement of tribological surface properties by vacuum thin film deposition and ion implantation

The coefficient of friction in vacuum, as unfolding medium for a lot of physical experiments, grows by an order of magnitude than in normal environment with standard conditions of pressure and temperature.

Magnetron sputtering deposition of tungsten carbide (WC) that exhibits besides good COF also high hardness, and tungsten disulfide (WS_2), with excellent COF, generates surfaces with improved tribological properties. WC and WS_2 targets are used for confocal DC and RF magnetron sputtering deposition in a multifunctional vacuum thin film deposition system in argon atmosphere at 400°C temperature for three hours.



Two kinds of samples, having different concentrations of WC, are presented (1_A, 2_A). Nb ion implantation (Nb^+) with energy of 1.5 MeV and a dose of 6×1014 ions/cm^2 at room temperature made at 3 MV Tandetron™ accelerator leads to a further decrease of COF and a better tribological behavior for a longer sliding distance (1_B, 2_B), probably due to creation of phase transformations and discrete amorphous zones.

For details

I. Burducea, A. O. Mateescu, G. Mateescu, C. Ionescu, M. Straticiuc, L. S. Craciun, C. P. Lingu, G. O. Pompilian, P. M. Racolta, Nuclear Inst. and Methods in Physics Research B 450, 357-360 (2019)

Events

CBM Collaboration Meeting in Kolkata

The 34th CBM Collaboration Meeting took place between 29th of September and 3rd of October in Kolkata, India. The progress in the CBM R&D activities developed by our group was highlighted in five talks presented in the sections dedicated to TOF and TRD subsystems.

Talks

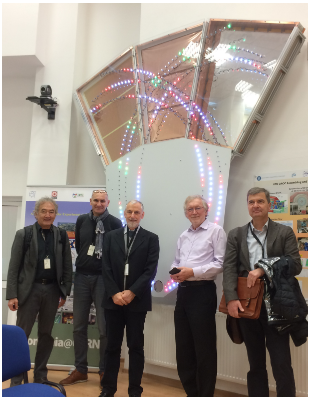
A.Bercuci *et al.*	Optimized Position Resolution TRD for the Inner Zone. Software and Measurements Performance
A.Bercuci *et al.*	Motivations for an Optimized Position Resolution TRD in the Inner Zone of the TRD wall
A.Bercuci *et al.*	FASP based FEE solution for the Inner Zone of the TRD wall
M. Petriș *et al.*	Status of the activities for the inner zone of the CBM-TOF wall
L. Rădulescu *et al.*	Towards the Engineering Design of the TRD Inner Zone for the TDR Addendum

Visits

Among many visits to Hadron Physics Department we mention: the visit of pupils participating at the Physics and IT Olympiad (Top Left), a group of master, PhD students and PostDocs from Bern, Zurich and Heidelberg (Top Right), members of the International Scientific Advisory Board (ISAB) for Romania-

CERN projects (Bottom Left) and participants to the ALICE Tier-1/Tier-2 Workshop (Bottom Right).






Summer Student Program

2019

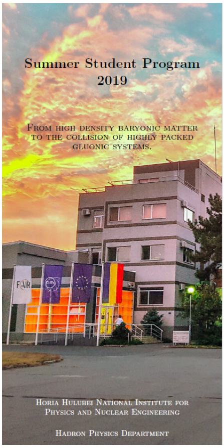
The 2019 Summer Student Program organized by HPD, was attended by three students, one student from the Complutense University of Madrid and two students from the University of Bucharest.

During this period they followed lectures, presentations of the activities and infrastructures of HPD, being involved in activities related to different theoretical approaches for understanding some aspects of pp and heavy-ion collisions at relativistic and ultra relativistic energies under investigations at LHC-CERN or will be studied at FAIR-GSI using the CBM experiment. One of them decided to continue the master studies in close collaboration with our Department.

The results obtained by them during the Summer Student Program were summarized in a flyer.

2020

This program will be organized also in the next coming years. Due to present COVID-19 circumstances, the edition of this year, already announced, has to be canceled.



Students' Activity

Annual Scientific Meeting of Physics Faculty

Talks

A. Lindner	Color Glass Condensate Inspired Scaling Variable and System Size Dependence
A. S. Mare	Allowed and first-forbidden nuclear β-decay of exotic medium-mass nuclei. Analytical solutions for the reduced single-particle matrix elements

Master Theses

Thesis

A. Lindner	Color Glass Condensate Inspired Scaling and Gluon Saturation
A. S. Mare	Allowed and first-forbidden nuclear β-decay of exotic medium-mass nuclei. Analytical solutions for the reduced single-particle matrix elements

IFIN-HH Young Scientist' Day

Talks

A. Lindner	Towards understanding new features of hadron production mechanisms at LHC energies
A. S. Mare	Impact of ^{68}Se and ^{72}Kr stellar weak interaction rates on rp-process nucleosynthesis and energetics Serban Titeica award, 1st place
D. Avramescu	Simulating the initial stage of hadron-hadron collisions Serban Titeica award, 2nd place

International events

Talks

A. S. Mare *et al.*	Impact of ^{68}Se and ^{72}Kr stellar weak interaction rates on rp-process nucleosynthesis and energetics Vth Topical Workshop on Modern Aspects in Nuclear Structure, 4-9 February 2020, Bormio, Italy

Schools

D. Avramescu	Frontiers in Nuclear and Hadronic Physics, 25 February-4 March 2020, Florence, Italy

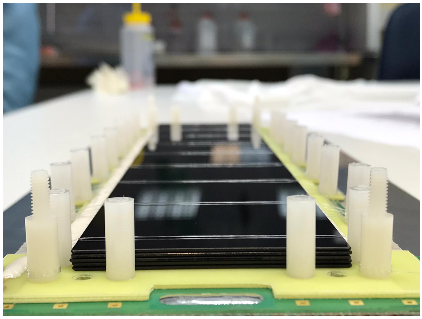
In Progress

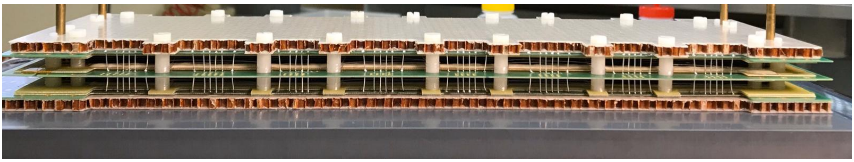
HPD Contribution to CBM

Assembling of MSMGRPC

As PADI fast amplifier designed for CBM ToF Wall has a lower gain relative to NINO fast amplifier designed for ALICE ToF Barrel, an increase of the counter signal at the input of the PADI FEE is required.

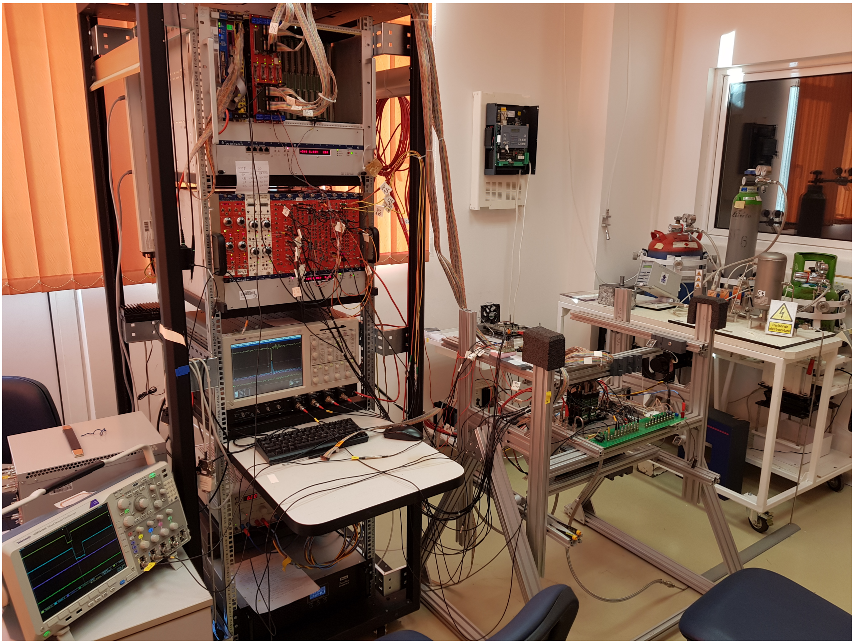
The solution was to assemble two new MSMGRPCs prototypes with an increased gap size of 200μm and identical inner geometry and architecture for the high voltage and readout electrodes as of those used for the former prototypes.





Two such counters were assembled and tested with cosmic rays and ^{60}Co radioactive source in the detector laboratory of Hadron Physics Department. A 95% efficiency plateau at applied fields larger than 120 kV/cm (2 x 6 kV) was obtained. The single counter time resolution is 67ps for an applied high voltage in the efficiency plateau region. Using a special collimator, it was evidenced a position independent efficiency along the strips.

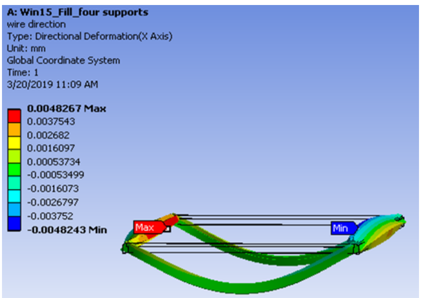
The aging studies will be done at the Multipurpose Irradiation Centre (IRASM) of our Institute.

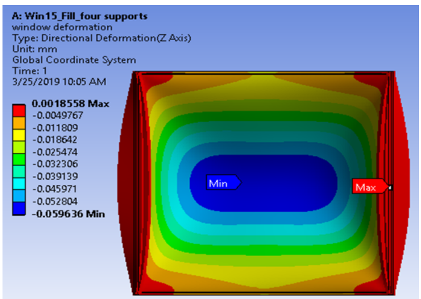


The RPCs test laboratory of the Hadron Physics Department.

Studies of mechanical stress for the high resolution TRD

The inner zone of the Transition Radiation Detector (TRD) wall of CBM experiment has to fulfill strict conditions in terms of construction and operation to accommodate high particle rate measurements with a minimum material budget. The light structure of the TRD-HR, on the other hand, has to sustain the internal stress induced by the multi-wire cathode electrode ~ 100 cN/wire tension.

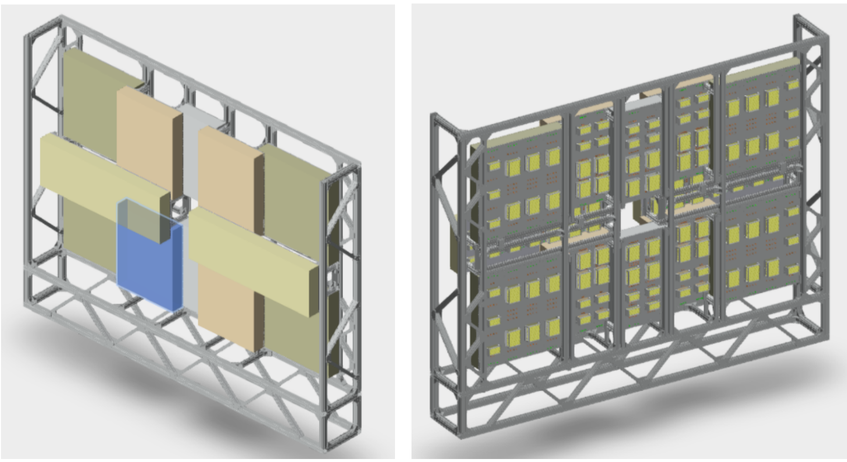




In order to optimize the structure a mechanical stress simulation inside the ANSYS™ framework was performed. The study was concentrated on the frame and entrance window deformations. The construction of a new real size TRD prototype taking into account these estimates is in progress.

Update of the CBM-ToF inner wall design

The design of the inner zone of the CMB Time-of-Flight wall is driven by the high counting rates and low occupancy. The anticipated counting rate for the inner zone is ranging from $\sim$ 30 kHz/cm^2, in the region of the beam pipe, $\sim$ 5 kHz/cm^2 at the larges polar angles of this zone. Different architectures, from cylindrical to planar, were investigated.



CBM-ToF inner wall architecture in the support frame.

The current design is the result of the optimization in terms of wall thickness along beam direction, a minimum overlap between the RPCs as well as between the modules such to have a continuous coverage of active area and cost in terms of number of counters and electronic readout channels.

All these constrains led to a modular concept defined by 12 modules of 4 types (M1, M2, M3, M4), staggered in z direction. A versatile mechanical frame was designed and mechanic stress estimates for modules and mechanical support is in progress.

HPD during COVID-19

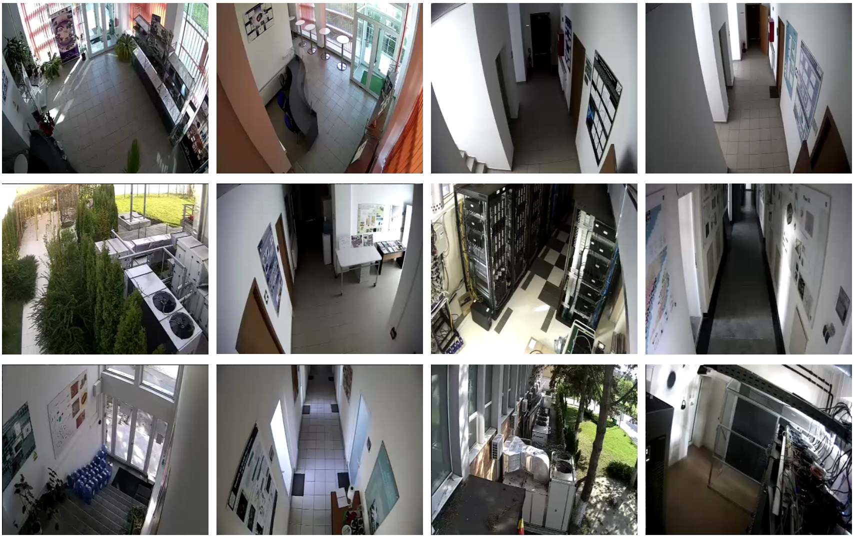
Because of the Coronavirus urgent ordering issued on March 16 in Romania, the activities in our Institute were substantially reduced and on March 23 Hadron Physics Department switched to "Safe Mode" operation.

Besides running at full capacity NIHAM Tier2 center of ALICE Grid, as well as the NAF computing center for local needs, completely operated in remote way, the other activities continue as home work, all usual meetings of HPD taking place remote way via video as well as the regular meeting taking place within ALICE and CBM Collaborations.

Snapshot of NIHAM connections to the other ALICE Grid centers.

In similar way we followed the last ALICE week and CBM collaboration meeting. Calibration and data analysis of the results recently obtained in ^{60}Co and cosmic rays tests of the latest prototypes of RPCs developed for CBM, track reconstruction using inner zone of CBM TRD layers and middleware development for continuous mode data processing and acquisition delivered by these detectors are in progress.

We hope that this difficult period will be over in not too far future such that our commitments within ALICE and CBM Collaboration will continue once ALICE, GSI/FAIR and our Institute will progressively approach normal activity.



All internal zones and on site infrastructures are continuously monitored.

Job opportunities

Physicist

Physicist from master student to postdoc level, to be involved in Experimental Heavy Ion Nuclear Physics. The successful candidate will participate in research with members of the Hadron Physics Department from IFIN-HH, focusing on new generation of detectors construction, simulations, tests and their implementation in the CBM Experiment at FAIR. The candidate will also be involved in data analysis obtained in the test experiment at mCBM or in ALICE Experiment during Run3, starting from 2021.

Electronic Engineer

PhD or postdoc with some experience in CHIP design to be involved in development of analog and digital CHIPs for dedicated front-end electronics for the detectors developed in Hadron Physics Department for the present and future experimental devices. The successful candidate will participate also in the test activities of the present CHIPs designed in HPD and produced, associated mother boards and should have knowledge on FPGA programming. The activities will be related to the CBM Experiment at FAIR and later to the future Heavy Ion Experiment at LHC.

Technician

Technician with a post high school certificate. The successful candidate will be involved in preparation of detector components, detector construction, operation and tests, maintenance and operation of the DetLabs infrastructure.

Contact

Prof. Dr. Mihai Petrovici
Email: mpetro@nipne.ro

Selected candidates will have a temporary position for 1 year with the possibility to be extended to 2 years. In case of high performance and adequate involvement in the HPD activities, the position could become permanent once the successful candidates for Physicist and Electronic Engineer have a PhD degree.

The spring is there, we are also waiting to be there soon!

Editors

Dana Avramescu, Mihai Petrovici
Production editor: Adrian Socolov

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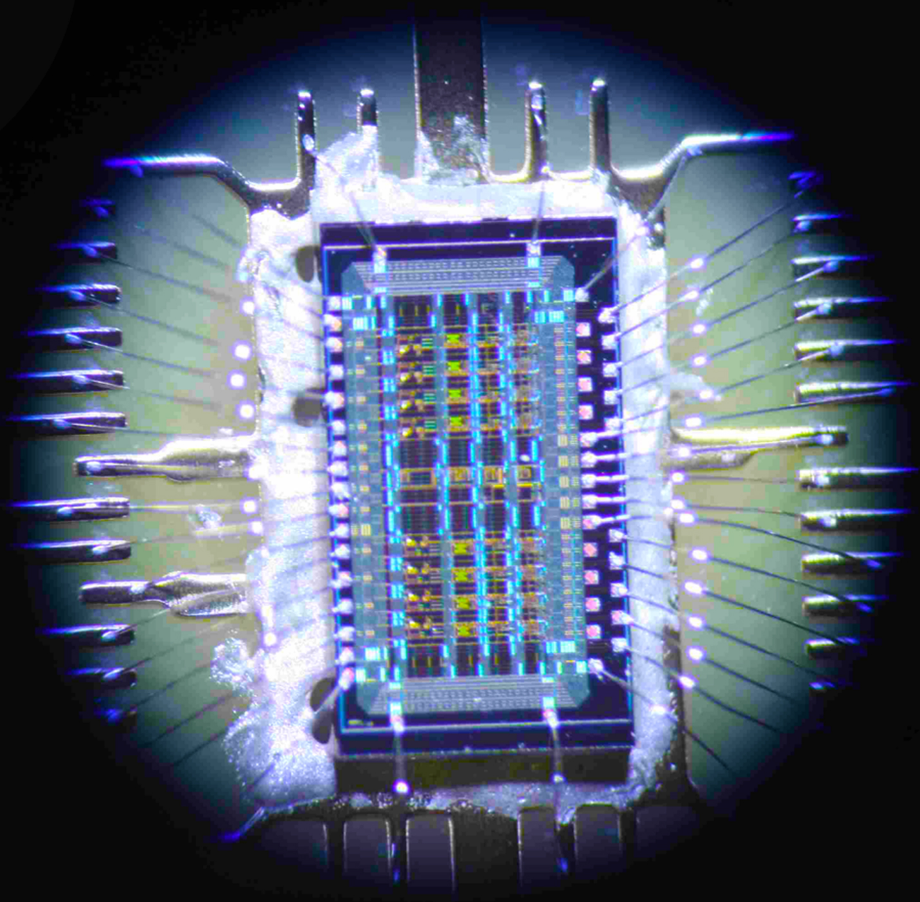

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