Form B2_EN – Project description

Programme / Sub-programme / Module	5.9/5.9.2/FAIR-RO		
Project type	RD		
Experiment	CBM	**Scientific Domain**	Nuclear Matter Physics
Project title / Acronym	CBM experiment on the horizon - detectors, electronics, data acquisition and physics/CEHDEP		
Project duration	2024-2026		

PROJECT DESCRIPTION

1. Contribution to the FAIR experiment through the proposed project

The impressive amount of experimental information obtained in ultra-relativistic heavy ion collisions at RHIC and LHC energies, supports the expectations based on Quantum Chromo-Dynamics (QCD) on the possibility to produce deconfined strongly interacting matter formed by basic constituents, quarks and gluons, at high temperature and negligible baryonic chemical potential, supposed to have happened in the Universe during the first few microseconds after the Big Bang. Equally interesting is the study of the possibility to produce deconfinement at large baryon densities where the constituent quarks and gluons of the highly packed nucleons become free and a deconfined fireball is also expected to be produced. Highly dense and cold nuclear matter is expected to exist in the core of neutron stars. Recent theoretical models predict that in neutron stars with 2 solar mass, about 40% of their core is in a deconfined state. The collisions of relativistic heavy ions offer the possibility to study different regions of the complex phase diagram of strongly interacting matter, critical points and boundaries between different phases predicted by QCD. These were the main motivations behind the beam energy scan program at RHIC-Brookhaven, the ongoing experiments at SPS-CERN energies, the fixed target experiments at RHIC and the future Facility for Antiproton and Ion Research (FAIR) at Darmstadt. SIS100 at FAIR, under construction at the moment, will deliver unprecedented interaction rates (~10^7 Hz) at laboratory energies up to 11 AGeV for gold beam, up to 15 AGeV for N=Z nuclei and up to 30 GeV for protons. Exploration of the QCD phase diagram at large baryon chemical potential started at AGS and SPS (at low energies). These experiments, based on the detector technologies of that period, were restricted to a limited type of hadrons abundantly produced at those energies. The STAR collaboration at RHIC, within the beam energy scan program, performed measurements starting from the top $\sqrt{s_{NN}}$ = 200 GeV down to $\sqrt{s_{NN}}$ = 7.7 GeV energies in Au+Au collisions and even lower, 3 GeV, in the fixed target experiments. However, due to TPC-readout time and RHIC accelerator luminosity limitations, the reaction rates are limited from about 800 Hz down to a few Hz at the lowest measured energies. Therefore, any detailed multidifferential analysis is not feasible to be performed at the existing facilities so far.

The Compressed Baryonic Matter (CBM) at FAIR fixed target experiment is designed to run at interaction rates up to 10 MHz for selected observables like J/Ψ, 1-5 MHz for multi-strange hyperons and dileptons and of 100 kHz without any on-line event selection. In order to cover the range from small polar angles up to the midrapidity region, the CBM detector will have a polar acceptance between 2.5 to 25 degrees. Combining the high-intensity beams of SIS100 with the high rate / high multiplicity performance of the CBM experiment, worldwide unique conditions for a comprehensive series of experiments aimed to produce and understand QCD matter at the high net-baryon densities will be provided. The CBM experiment will be based on a new generation of detectors, front-end electronics and data processing and acquisition architectures having at least the performance of presently running experiments but for orders of magnitude higher counting rates. State of the art two-dimensional position sensitive Multi Strip Multi Gap Resistive Plates Counters (MSMGRPC) and two-dimensional position sensitive Transition Radiation Detectors (TRD) with their dedicated front-end electronics, developed by our group, will be used for the most demanding regions (small polar angles) of the CBM-ToF and TRD subdetectors, respectively. Our group is involved in the CBM Collaboration starting from 2003, having essential contributions up to now in developing a new generation of high counting rate RPC and TRD detectors (TRD-2D), dedicated Front-End Electronics (FEE) including ASIC chips (FASP) for TRD-2D and their integration within the CBM Software and FEE-DAQ infrastructure. Also, different versions of free running mode Data Acquisition (DAQ) were implemented. Based on these results the CBM-ToF TDR was accomplished and positively evaluated. The most forward region of the CBM-ToF wall will be equipped with state of the art two-dimensional position sensitive Multi Strip Multi Gap Resistive Plates Counters (MSMGRPC) with time resolution in the region of 50 psec and efficiency better than 95%, developed by our group. The latest RPC prototypes have a strip architecture which gives the possibility to tune the impedance of the transmission line to the value of the front-end electronics for a given strip pitch chosen to fulfill the granularity requirements with a reasonable number of electronic channels. The intensive in-beam test campaigns at COSY-Julich, SIS18-GSI, PS, SPS-CERN and mini-CBM (mCBM) at SIS18 – GSI, Darmstadt confirmed their performance in close to real conditions foreseen for the CBM experiment at SIS100 at FAIR. As it is well known, the long term operation of RPCs with C2H2F4 and SF6 based gas mixtures in high irradiation environment leads to aging effects. In order to maintain the detector performance over the CBM lifetime, detailed aging investigation are mandatory. In the aging studies performed up to now using a high activity ^{60}Co source of the Multipurpose Irradiation Facility (IRASM) of IFIN-HH, Bucharest, depositions of chemical radicals on the anode side and ablation/etching processes on the cathode side of the resistive electrodes of a high counting rate MSMGRPC prototype were observed. Enhanced depositions and higher noise rates were localized around the spacers used for defining the gas gaps between resistive electrodes. In such studies, the gas exchange inside the gas gaps of the counter takes place via diffusion process. In order to avoid the deterioration of the counter performance and to keep the electrode surfaces as clean as possible, MSMGRPC prototypes with a direct gas flow through the gaps between resistive electrodes were designed, assembled and successfully tested in-house using high flux X-ray tubes and in-beam at the mCBM experimental setup installed at SIS18/GSI Darmstadt. The obtained results will be used for an optimization of the detector design, gas composition and gas flow rate in order to minimize the aging effects and further in-house and at mCBM tests will be done. Replacement of the present fishing line spacers by discrete spacers and the impact on the aging effects will be studied. The results will be important for the final design of the inner-zone of the CBM-ToF subdetector.

The performance of the TRD-2D in terms of position and energy sensitivity was successfully confirmed in mCBM tests at SIS18 by correlating it with a reduced version of the final detectors of CBM, the mSTS and the mToF, for a close to final Software and DAQ infrastructure. The in-beam tests using free running data flow also confirmed the performances of the in-house developed front-end electronics based on in-house designed FASP ASICs. They have been validated by a continuous recording of real data at various data flow rates compatible with the CBM configuration. Further developments of the system, foreseen within the current project, include a substantial reduction of the material budget by a higher integration of the Front-End Electronics and an optimization of some critical components of the entrance window. A transition from the development version of a two-layered Front-End Board (FEB) structure used so far in mCBM to a single layer, with additional elements of integrated control and calibration features is foreseen. The upgraded TRD-2D system, will be tested in house and in the mCBM setup for preparing the mass production for the CBM experiment.

The collective flow of the produced hadrons is driven by the initial state spatial anisotropy and the resulting pressure gradients. Comparison between theoretical calculations and experimental results, on different flow harmonics, namely directed (v1) and elliptic (v2) flow coefficients, help to get insights about the equation-of-state (EoS) governing the evolution of the produced medium. We have implemented computing codes based on theoretical transport models (JAM, UrQMD, PHSD) on the local Data Centre of our Hadron Physics Department (NAF) and succeeded to describe the experimental excitation function of the elliptic flow coefficient, v2, measured by several experiments, which evidenced a transition from squeeze-out to in plane elliptic flow. Calculations based on these theoretical models gave the possibility to study the different flow observables, in Au-Au collisions, in a multidifferential way. Based also on the experience and results obtained by our group at lower and higher energies within the FOPI and ALICE collaborations, respectively, we will focus our physics program on multidifferential studies of physics observables sensitive to the high-density equation-of-state of nuclear matter and to new phases of Quantum Chromo Dynamics matter at high densities, for different collision centralities and system sizes, within $\sqrt{s_{NN}}$ = 2−4.9 GeV energy range, with the aim to understand the fundamental properties of QCD in the corresponding region of the phase diagram. For signal extraction and physics interpretation, the results of different phenomenological models, i.e. UrQMD, SMASH, JAM and AMPT will be systematically analyzed.

2. Project objectives

O1. New in-house architecture of the MSMGRPC detector and its integration in CBM-ToF.
1.1 Design and construction of a versatile architecture of MSMGRPC with direct gas flow through the gas gaps.
1.2 Extensive in-house tests of the performance of the detectors in terms of time resolution and efficiency based on cosmic rays and aging effects using high flux X-ray tubes.
1.3 Extensive tests of the performance of the detectors in terms of time resolution, efficiency and aging effects using the mCBM environment with the readout electronic chain designed and built for the inner zone of the CBM-ToF wall.
1.4 Design of the inner zone of the CBM-ToF using the new architecture of MSMGRPC in order to cope with the granularity and counting rate requirements as a function of polar angles.
1.5 Finalize the construction of different components, assembling and tests of M0 module as the production readiness prototype.

O2. TRD-2D prototype and its performances.
2.1 Optimizations studies of the TRD-2D entrance window to enhance the transmission of low transition radiation photons.
2.2 Construction and in-house tests of several TRD-2D prototypes of identical CBM design.
2.3 Correlated analysis of CBM formatted TRD-2D data, measured in the mCBM setup with STS and ToF detectors, for an unbiased characterization of the position and energy resolution.
2.4 Development of a versatile QA stand for the TRD-2D modules (chamber + FEE) characterization in view of their commissioning to CBM.

O3. Front-end electronics, Data Processing Hardware and Firmware and mechanical devices for assembling and operation of the TRD-2D detector.
3.1 Design and construction of a versatile motherboard for testing large amount of encapsulated FASP CHIPs from production engineering.
3.2 Firmware optimizations of the new front-end board for the TRD-2D in correlation with its usage on the detector in the CBM.
3.3 Development of an integrated control and calibration motherboard to be incorporated in the CBM Detector Control System (DCS).

3.4. Design and realization of a mechanical device for control and quality assurence of the assembling process of the TRD-2D detector.

O4. Physics studies at CBM of interest to our group, based on theoretical models.
4.1 Multidifferential studies based of theory predictions using different phenomenological models for the behaviour of physics observables sensitive to new phases of QCD matter at high densities. Dependence on collision energy, geometry and system size.
This goal is closely related to the physics we want to approach at CBM using both the capabilities of the high-performance detectors we develop and the experience gained in other experiments in which we were and are involved.

3. Main project activities

The CBM-ToF inner-wall covers about 14 m^2 area in the polar angular range 2.5-12 deg. The anticipated counting rate for the inner zone is ranging from 30 kHz/cm^2 close to the beam pipe, to about 5 kHz/cm^2 at the largest polar angle covered by the inner wall and an occupancy below 5% is required. Our R&D activity has been focused on the development of a Multi-Strip, Multi-Gap Resistive Plate Chamber (MSMGRPC) for the forward polar angle region of the CBM-ToF wall, the most challenging region in terms of counting rate and hit multiplicity [1]. The prototypes developed by us, have an original architecture of Cu strips geometry on a FR4 substrate not only for the readout electrodes but also for the high voltage electrodes. This gives the possibility to tune independently the signal transmission line impedance in order to match it to the input of the front-end electronics and in the same time to fulfill the granularity/occupancy requirement by adjusting the strip length for a certain strip pitch. In order to maintain their performance in the mentioned high particle flux, the prototypes were equipped with resistive electrodes made of special glass with resistivity lower than the one of the commercial glass used up to now for similar detectors. The obtained performance of such prototypes in terms of efficiency and time resolution, in cosmic ray tests, direct beam exposure or with exposure to reaction products over the full active area, in triggered [2, 3, 4] as well as free streaming readout [5] mode, recommend them as solution for the inner zone of the CBM-ToF wall. The inner wall design was driven by the mentioned counting rate and granularity requirements. It has a modular concept defined by 12 modules of 4 types (M0, M1, M2, M3), staggered in z and x-y directions for a continuous coverage of the active area. Inside a module, the counters are staggered on four layers in z directions with a minimum overlap between them in x-y such to obtain a continuous coverage of the active area within the module. As it was mentioned above, the C2H2F4 and SF6 based gas mixtures used to operate such counters lead to aging effects in high irradiation environment. In order to maintain the detector performance over the CBM lifetime, detailed aging investigations are mandatory. Such studies using a high activity ^{60}Co source of the Multipurpose Irradiation Facility (IRASM) of IFIN-HH, Bucharest, were performed and depositions of chemical radicals on the anode side and ablation/etching processes on the cathode side of the resistive electrodes of a high counting rate MSMGRPC prototype were observed [6]. Enhanced depositions and higher noise rates were localized around the spacers used for defining the gas gaps between resistive electrodes. In such studies, the gas exchange inside the gas gaps of the counter takes place via diffusion process. In order to avoid the deterioration of the counter performance and to keep the electrode surfaces as clean as possible, MSMGRPC prototypes with a direct gas flow through the gaps between resistive electrodes were designed, assembled and successfully tested in-house using high flux X-ray tubes and in the mCBM experimental setup installed at SIS18/GSI Darmstadt [7-9]. The obtained results will be used for an optimization of the detector design, gas composition and gas flow rate in order to minimize the aging effects, in-house and at mCBM tests will be done. Replacement of the present fishing line spacers by discrete spacers and the impact on the aging effects will be studied. The results will be important for the final design of the inner-zone of the CBM-ToF subdetector. Before going into the construction phase, a production readiness review will be performed, proving the feasibility of the concept. For this step a fully equipped M0 module will be assembled and tested.

The TRD detectors in the CBM setup are organized in four planar stations of maximum 70 cm width each, with the first layer starting at approx 410 cm from the target. The physics program where the TRD system plays an important role, according to the TDR, is to increase RICH electron identification for momenta below 8 GeV/c, additional π-suppression at higher momentum and nuclear fragments identification in conjunction with ToF. The improvements in tracking performances realized by replacing TRD-1D with TRD-2D version [10], opened new possibilities for the CBM experiment such as: TRD stand-alone tracking of low p_T protons, background reduction for the RICH electron identification procedure and ghost reduction for ToF. The position resolution of approximately σ_x x σ_y= 100 x 300 μm^2 of the TRD-2D design coupled with a relative fast FEE is of paramount importance in the free running data taking of events with high multiplicities taken at high interaction rates, where, hit combinatorics can be easily dominated by space-time particle pile-ups. The TRD prototype developed by us uses an original architecture of the readout electrode, i.e. triangular shaped pads of 1 cm^2 area, coupled with a dedicated signal readout amplifier, the Fast-Analog-Signal-Processor (FASP) ASIC [11]. The FASP pairs input signals to rectangles and parallelograms to conserve S/N ratio over detection surface. The combination of pad-plane segmentation and ASIC paring renders effectively a two-fold coverage of the active area with the net outcome of identifying the anode wire(s) where the amplification takes place. The complete TRD-2D system developed by us was tested for both its current implementation, in mCBM, and also, for its potential, within the CBM setup. In CBM simulations, its potential was demonstrated with respect to the stand-alone reconstruction of low p_T protons but also as an important intermediate tracker between STS (RICH) and ToF. The approval of an Addendum to the TRD TDR proved the CBM Collaboration's acknowledgment for our solution. For the running mCBM experiment, the detector worked smoothly together with the rest of CBM components under test i.e. STS, TRD-1D and ToF. Time response and signal rates as well as position and energy resolution performances were compared with the rest of systems yielding results in-line with expectations. Due to its x-y position sensitivity, the detector can be used successfully for system alignment but its potential for PID is not negligible. Preparing for the CBM realization, we aim, within the present project, to prepare and test the assembly line, methodology and QA of the TRD-2D modules (chamber + FEE) and extend our mCBM contribution. TRD-2D prototypes with an optimized entrance window for lower absorption of soft X-rays will be realized to provide use cases for CBM integration (to be installed at mCBM) and demonstrators of a versatile QA stand developed in-house. On the front-end and data processing side, two FEBs, FASPRO and GETS, will be further integrated in order to minimize the material budget. A new DCS board will be added for the integration with the CBM services. A mechanical device will be designed and realized for the control and quality assurance of the assembling process of the TRD-2D detector.

In high energy heavy-ion collisions different phases of hot and dense nuclear matter can be formed. Changes of physics observables highlighted in multidifferential analyses of the experimental data, when varying the beam energy (the excitation function), the system size, and the centrality of the colliding systems, can reveal the properties of the produced fireballs in different regions of temperature and baryonic chemical potential. The CBM experiment is designed to measure physics observables in high-energy heavy ion collisions which are expected to be sensitive to the high-density equation of state of nuclear matter and to new phases of QCD matter at high baryonic densities [12]. Our group has significant contribution to key detectors for such type of measurements. The CBM experiment will dramatically improve the statistics such that detailed multidifferential analyses for light and heavy flavour hadrons as well as for electrons will become feasible. Thus new types of observables that highlight the highly compressed baryonic matter and critical point properties, recently predicted by theory, will be scrutinized by the CBM experiment. A study of identifying such types of physics observables will be done and based on theoretical models their excitation functions for different centralities and varying system size will be obtained. This involves MC simulations of events and the construction of various observables. When they are available, the comparison with the experimental data will be made. These theoretical predictions could motivate and orient the experimental multidifferential analyses of different physics observables which our group will address at SIS100 energies. These studies will also benefit of the experience and results obtained by our group at lower and higher energies within the FOPI and ALICE collaborations, respectively [13-20]. The natural continuation in future projects will be the analysis of MC generated events filtered with the detector response function implemented in GEANT with emphasis on the reconstruction performance in the region of low transverse momentum values, where the inner zones of TRD and ToF subdetectors play an important role. Based on this we are planning to look at the real data once the CBM detector will become operational, in the region where enhancement of the transverse momentum spectra is expected to be highlighted as signature of the moat regime, quarkyonic matter, or in the region of the critical point, as predicted by theoretical models.

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4. Milestones and expected results

Objective Code	Objective description	Milestones	Expected results	Time schedule justification
O1-1.1	Versatile architecture of MSMGRPC with direct gas flow through the gas gaps.	- Design drawings of two prototypes and their mechanical components - Components manufacture - Prototype assembling - Gas distribution system for equal direct flow in each MSMGRPC - Experimental setup for functionality tests.	- Protypes with direct flow with different granularities for different polar angle regions of the CBM-ToF inner zone - In-house tests of their functionality.	30.12.2024
O1-1.2	Aging effects investigations using high flux X-ray tubes. Extensive in-house tests of the MSMGRPC performance using cosmic rays.	- Experimental setup for aging investigations - Expose the MSMGRPC to cummulative X- ray dose - Measurement of MSMGRPC current up to highest delivered counting rate by the X-ray tubes - Dark current and dark counting rate behaviour in time after successive exposures at high X-ray flux - Study of the effect of the gas rate flow on the recovery of the dark current and dark counting rate - Experimental setup for cosmic ray tests - Data taking with DAQ trigger defined by two MSMGRPCs and in self-trigger operation.	- Current versus counting rate calibration curve - Optimization of the gas rate flow for minimization of aging effects reflected in the dark current and dark counting rate recovery after successive exposures - Time resolution, efficiency and position resolution estimated after detector exposures to high X-ray fluxes.	30.12.2024

Series and PoS-sissa and presented to international conferences in the field like EPS-HEP2019, Ghent, Belgium, ICHEP2018, Seoul, Korea, International School on Nuclear Physics, Neutron Physics and Applications, September, 2017, Varna, Bulgaria, International Balkan Workshop on Applied Physics and Material Science, Constanta, Romania (2016,2017,2018,2019) and Workshop on Resistive Plate Chambers and Related Detectors, 2016, Ghent, Belgium and 2022, CERN, Geneva and Pisa Meeting on Advanced Detectors, 2022, Elba, Italy. They are also published annually in CBM Progress Reports and are reported regularly to the CBM Collaboration meetings. The results expected to be achieved in the present project will materialize according to the programming and development of the activities, in technical drawings, RPC and TRD prototypes, associated electronics modules, mechanical components, firmware development, computing codes development and implementation, a detailed documentation on the obtained results, assembling and testing manuals for MSMGRPCs and TRD-2Ds, internal and CBM Collaboration weekly dedicated seminars. They will be published each year in Journals with impact factor, will be presented to the international Workshops and Conferences, regular videoconferences of different Working Groups of CBM Collaboration, CBM Collaboration Meetings and annual Progress Reports. Our results will be made known regularly in the HPD web page http://niham.nipne.ro and HPD Courier (https://niham.nipne.ro/HPD_Courier.html).

The considerable know-how and achievements obtained by the HPD/IFIN-HH group as partner in different international collaborations, quite well known by now at national level, will be transferred into the country and will have a strong impact on the field of design and production of detection systems, ASIC chip design for the associated front-end electronics, special motherboards for interfacing the ASIC chip with different type of detectors. The present visibility of the group will be increased updating continuously the web page (http://niham.nipne.ro) and organizing international events in Romania. Based on the very good results obtained in the R&D activities, we are going to be involved in the construction of the detectors for the inner zones of the CBM-ToF wall and CBM-TRD stations as in-kind contribution to the CBM experiment.

Nevertheless, unpredictable parameters can influence the outcome of the project. These are related to the financial support of the project and general circumstances connected to the international context:

- level and periodicity of local financing
- Russian war against Ukraine: energy crisis, inflation, explosion of prices.

Taking into account all these factors that can disturb the smooth development of the project, measures will be taken to reduce their impact in the sense of searching for the best price/quality ratio and viable offers, carrying out purchases and activities according to the plan or, when possible, in advance. A special attention will be given to the interaction with the partners in the CBM collaboration in order to realistically plan the common actions in order to be able to carry them out with the best results.

Based on the experience of the group involved in the present project we do not foresee major risks in fulfilling the project goals once a proper and regular financial support will be received and present manpower will be conserved. As everywhere in the world hiring new young physicists, electronic engineers and technicians dedicated to the field is a delicate aspect. Via our regular Summer Student Program, outreach activities, announcement of open positions, the scientific projects and the high level local infrastructure, we hope that we will be able to maintain an optimum level of the expertise in all segments of activity and to transfer the accumulated experience to the younger generations.

6. Project impact

Some of the implications of the present project on the physics research, economy and society in our country are listed below:

The successful, visible and competitive participation of the HPD/IFIN-HH group to the R&D activities

and further to the production, test, installation and monitoring of the detectors for two important subsystems of the CBM experimental setup guarantee future participation of Romanian scientists in physics experiments with extreme impact on human knowledge, accessible only on the basis of common scientific and financial efforts at the international level.
Fitting out of a technological infrastructure and training people for detector design, construction and test allowed not only to participate in R&D activities for TRD and ToF subdetectors for the CBM experiment, but later on, to be involved in other projects at international level, of similar complexity.
Experience in modern electronics design situates our group in a leading position in establishing and disseminating state of the art technology for chip design in Romania. Funds invested in such a design capability will surely pay back in the coming years. As already mentioned, the confirmation of the results obtained over the years in developing such a new architecture, dedicated front-end electronics and DAQ and of the results obtained in the mCBM configuration was a successful evaluation of the CBM-TRD-2D Addendum.
Hardware and software structures of distributed computing network type which are and foreseen to be implemented in our group will serve not only the group's needs for computing, but also connect Romania to the international efforts to develop the new technology of grid computing. Our NIHAM Data Center had the largest contribution among the Romanian sites in LCG – CERN.
As a common practice in scientific research domain, students and graduate students will continue to be involved in the group's activities to prepare their diploma, master and PhD theses. They will become highly qualified specialists, extremely useful in various branches of activity. As our previous experience shows, it is essential for a young physicist to be involved in the construction phase of a given experiment before starting calibration and data analysis. Knowing details on the detector performance they could have a deep understanding of the calibration and correction algorithms used later for obtaining trustable reconstructed information.
Construction of instruments for such large experiments is a real challenge, not only for young scientists. The work is done in teams and tightly scheduled. The components of the work are not only research or technical. They also include an international team, advanced tools, equipment and software, complex variety of laboratory equipment, conditions and methods of work, management of the research team, schedules, system implementations and commissioning, frequent seminars, joint decisions, very accurate estimates of the cost and labour involvement, feasibility studies, weighting risk-taking and research responsibility for the team and for individual members. These factors together shape in a unique way the personality of a young researcher. All these aspects are also taken into account in our „Summer Student Program" which becomes already a tradition în HPD gaining visibility among students abroad. Outreach activities contribute to motivate future students to embark on this domain.
Our results could constitute for instance an input for Applied research and Technological transfer with application to high sensitivity whole–body PET imaging.

7. Project indicators

Besides the impact mentioned in the previous chapter, based on our previous achievements in the field the present project follows the expectations of the National Plan for Research, Development and innovation 2022-2027, https://www.mcid.gov.ro/transparenta-decizionala/planul-national-de-cercetare-dezvoltare-si-inovare-2022-2027/ and of NuPECC Long Range Plan 2024 https://indico.ph.tum.de/event/7629/contributions/8953/attachments/6020/8072/Full_LRP2024_Report_03042024_clean.pdf for European Nuclear Physics in terms of physics, detectors and associated front-end electronics, data processing hardware and software.
The present project follows many of the strategical guidlines outlined in the "National Strategy of RDI

and Smart Specialization", https://www.mcid.gov.ro/transparenta-decizionala/strategia-nationala-de-cercetare-inovare-si-specializare-inteligenta-2022-2027/. The development of Romanian research (OG.1) is supported by closely aligning our activities to the first objective (OS.1.1.) by providing the opportunities for young reaserchers to evolve (bachelor, master, PhD) in a local environment highly connected to the European reasearch infrastructures (ALICE @ CERN and CBM @ FAIR). At the same time, our technological involvment in TRD and RPC detector development for CBM @ FAIR and the participation to various levels of data processing clearly aligns our project with OS.1.3. Moreover the inteligent specializations which are covered by our project agree with the second field of national specialization, "2. Digital economy and spatial technologies" as detailed in the strategical document. We are developing microelectronic circuitry for inteligent devices (2.1 - "Microelectronic devices and systems for smart products") by applying FPGA technologies in our front-end electronics (FEE) of the TRD-2D detector thus enabling responsiveness to the radiation environment. The high radiation dose to which our FEE will be subjected is very similar to the environment requirements of spatial electronics (2.3 - "Tehnologies for the spatial economy") and thus our developments are ready to be ported to spatial application. The online data processing, to which TRD-2D is a component, is a good example of distributed parallel computing (2.2 - "Networks of the future, communications, the Internet of Things") aiming at online data filtering and inteligent event selection.
In accordance with the above, the proposed indicators of the project are:

Type*	**Planned Value For RDI Institutions**	**Planned Value For SMEs Institutions (if the case)**	**Total Planned (if it is not the same for both institutions)**	**Short description (if the case)**
	(1)	**(2)**	**(1) + (2)**	
Publications				
Number of published scientific articles indexed in Web of Science	4	-	4	Group papers published in highly ranked journals in the field
Number of open access scientific articles indexed in Web of Science				
Number of co-publications indexed in Web of Science	4	-	4	CBM Collaboration papers published in highly ranked journals in the field
Number of published articles in the top 10% most cited publications				
Number of published articles in the top 1% most cited publications				
Number of citations of articles in patents (and legislation)				
Number of international co-publications				
Number of public-private co-publications				
Number of scientific articles with open access research datasets				
Number of Books				
Number of Books indexed indexed in Web of Science				