HPD COURIER

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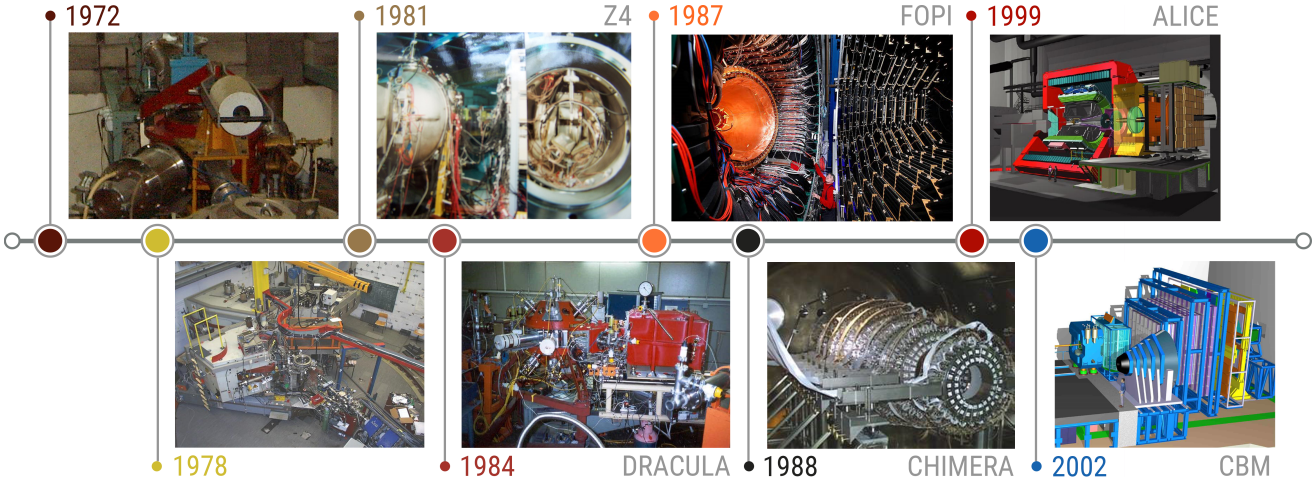
70th IFAR Anniversary

Contents

Achievements

Experiments

The roots of our Hadron Physics Department trace back close to 50 years ago, when the Tandem accelerator of the Institute for Atomic Physics, follow-up of the Institute for Physics of Romanian Academy founded by Horia Hulubei 70 years ago, was in the commissioning phase. Few months later, spring 1973, the first experiments started, based on ORTEC type reaction chambers and silicon detectors.



The Tandem column has been destroyed by a severe earthquake in 1977. Supported by French community, we proposed and performed measurements at the Saclay Tandem using the Q3D magnetic spectrometer. 1981 was the year when our collaboration started with GSI-Darmstadt. The experiments performed at UNILAC used large size spherical and cylindrical reaction chambers housing experimental configurations close to 4π geometries in the center of mass, based on large area position sensitive ionization chambers, position sensitive parallel plate avalanche counters, plastic scintillators and silicon telescopes. With such an experience, we initiated in Bucharest a rather ambitious project to build a versatile experimental set-up DRACULA foreseen to be used at the Bucharest Tandem and room temperature resonators as post acceleration.

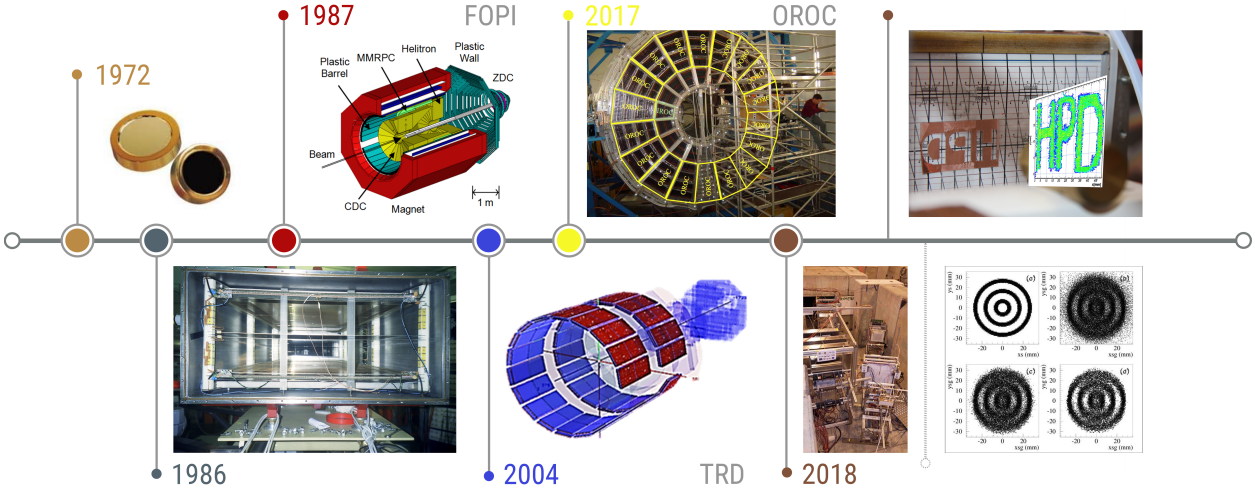
Late 1990, DRACULA was transported at LNS-Catania and mounted on a dedicated beam line of the LNS-Tandem. Following the fruitful collaboration with GSI, in 1987 we joined from the very beginning the FOPI Collaboration who built the FOPI Experiment at SIS18 for studying the heavy ion collisions at energies up to 2 A·GeV. In the same period we joined for couple of years CHIMERA Collaboration at LNS. As a natural follow-up, in 1999 we became member of ALICE Collaboration at CERN, a dedicated experiment to study heavy ion collisions at ultra-relativistic energies foreseen to be delivered by Large Hadron Collider (LHC),the main physics motivation being the production of deconfined matter and study the dynamics and properties of this new state of matter supposed to be characteristic at few μs after Big-Bang.

Although the Facility for Anti-proton and Ion Research (FAIR) Project officially started by Fall 2007, the idea of an heavy ion experiment for mapping the QCD Phase Diagram in the region of phase transition and critical point was launched in 2002. Members of Hadron Physics Department joined this CBM Collaboration from the very beginning. In the following are reviewed the HPD main contributions over the years in developing detection systems, associated front electronics and DAQ, assembling and testing significant components of different LARGE SCALE experiments using HPD infrastructure, computing, physics, training and organization of international events in Romania.

Detectors

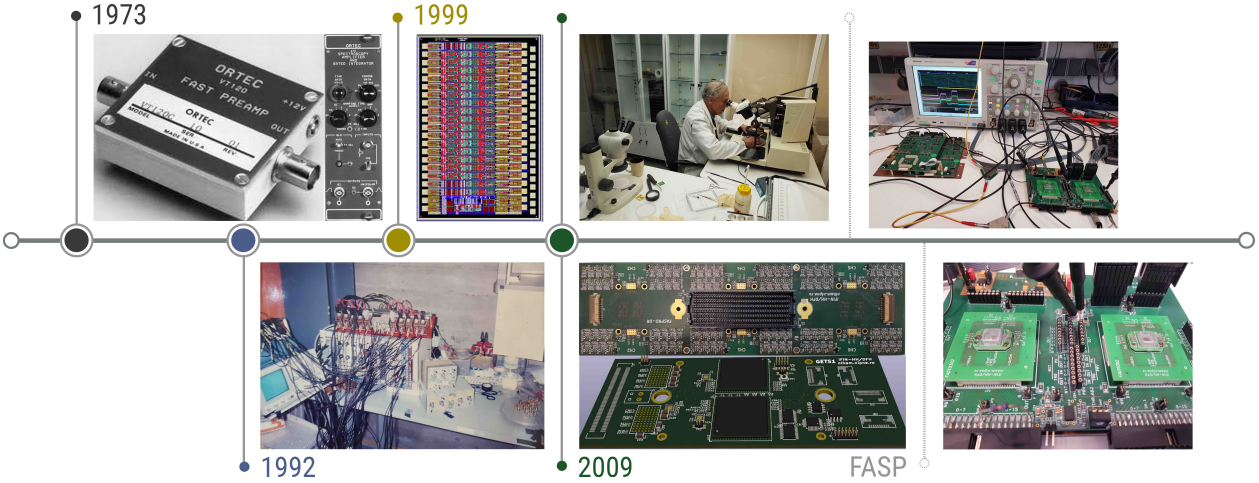
As it was mentioned above, 50 years ago, the experiments performed at the Bucharest Tandem accelerator were based on commercially available ORTEC silicon detectors. The activities to build new type of detectors as large area ionization chambers, position sensitive hybrid (proportional counter + plastic scintillator) or multi-segmented hybrid detectors (Bragg

geometry ionization Chamber backed by a stack of fast, slow and liquid scintillators) become mandatory once we started to build DRACULA experimental device in 1986. Starting from 1987, as members of FOPI Collaboration, we designed the geometry of the forward Plastic Wall (PW). Later we had significant contribution in assembling this subdetector, bringing at high performance the PW discriminators and the flash ADCs for the Central Drift Chamber. The CDC was rewired with an important contribution of us. The replacement of the forward region of the ToF barrel surrounding the CDC, using Multi Gap Multi Strip RPCs was based on an RPC architecture developed by us. In the HPD DetLab, inaugurated in 2004, we assembled and tested 130 TRD chambers (24%) of the ALICE-TRD Barrel. In the same period we embarked on R&D activities for developing a new generation of high counting rate RPCs and TRDs for CBM Experiment. In-house tests and in-beam tests at different accelerators, SIS18, ELBE, COSY, CERN, confirmed their performance and recommended them as solution for the inner region of CBM-TRD and CBM-ToF subdetectors. Recently, assembling and tests of 50% of the outer read-out chambers (OROC) using GEM technology for ALICE-TPC upgrade have been finalized.



Electronics

Most of the experiments performed 50 years ago at the Tandem accelerator used silicon detectors and commercially available preamplifiers and amplifiers. Starting from 1992, for operating DRACULA detectors, we had to develop in-house preamplifiers and trigger modules with at least the same performance as those commercially available or developed in other Institutes abroad. As members of the FOPI Collaboration and contributors in realization of the forward plastic wall (PW), we committed to develop a sector wise multiplicity box, to be used for the multiplicity hardware trigger.



The production of all necessary modules was based on this prototype. Once we embarked on ALICE Collaboration, it become obvious that highly integrated and dedicated electronics was required. We had an essential contribution in designing the PASSA CHIP for ALICE-TRD using KIP-Heidelberg infrastructure. For the new type of high counting rate two-dimension position information, TRDs developed by us, dedicated amplifiers FASP, dedicated mother boards FASPRO, for signals conversion and transfer to a special event time serializer and their processing based on FPGAs, compatible to the general CBM trigger-less read-out concept, were designed, bonded, tested, in Hadron Physics Department. The TRD performance mentioned above was obtained using such FEE and data processing hardware and middleware implemented on it.

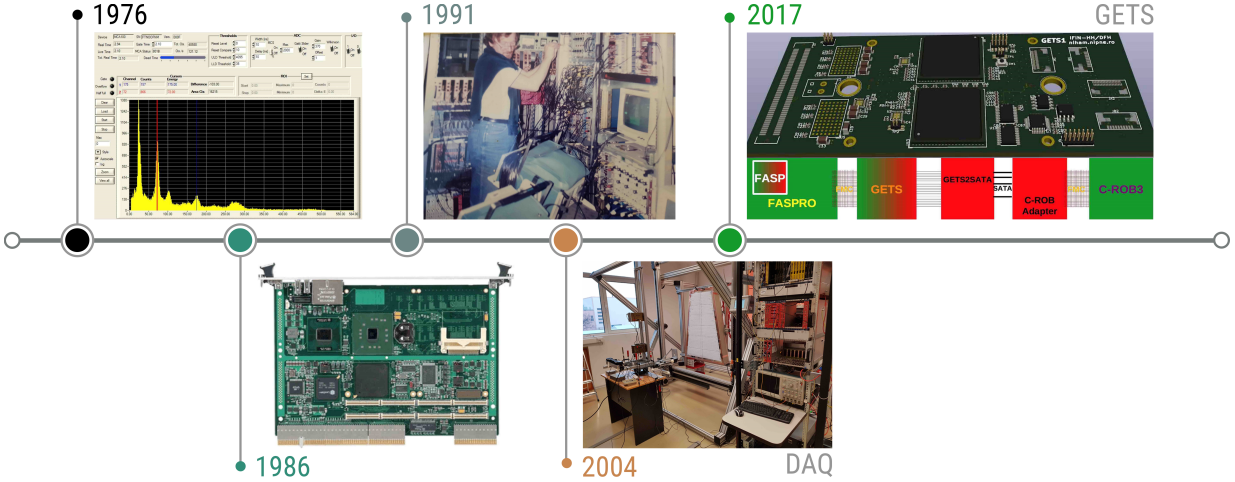
Data Acquisition

In early 70ies, the data taking and handling for the experiments at the TANDEM accelerator were based on CANBERRA 4 channels analyzer. The data acquisition system with 8 NIM ADCs connected to an ADC transfer controller, interfaced by a CAMAC dataway to a PDP11/34 operational in 1981 at the TANDEM accelerator was inadequate for a multiparametric experiment as DRACULA.

Therefore, a dedicated effort to implement an Advanced IPNE Data Acquisition system (AIDA) based on commercially available multichannel ADC and TDC CAMAC modules interfaced to the PDP11/34 via a dedicated CAMAC Crate Controller 3912KS or to an Auxiliary Crate Controller J11 was initiated. Such an architecture was used in processing more than 50 parameters delivered by DARACULA experiment starting from 1986 during the commissioning phase and later, starting from 1991, in the experiments performed at LNS. In the same period, a CAMC based DAQ using a dedicated CAMAC Crate Controller interfaced with a PC developed at GSI for detectors test was also implemented in our group. A more complex DAQ based on J11 interfaced with a PC was developed in parallel.

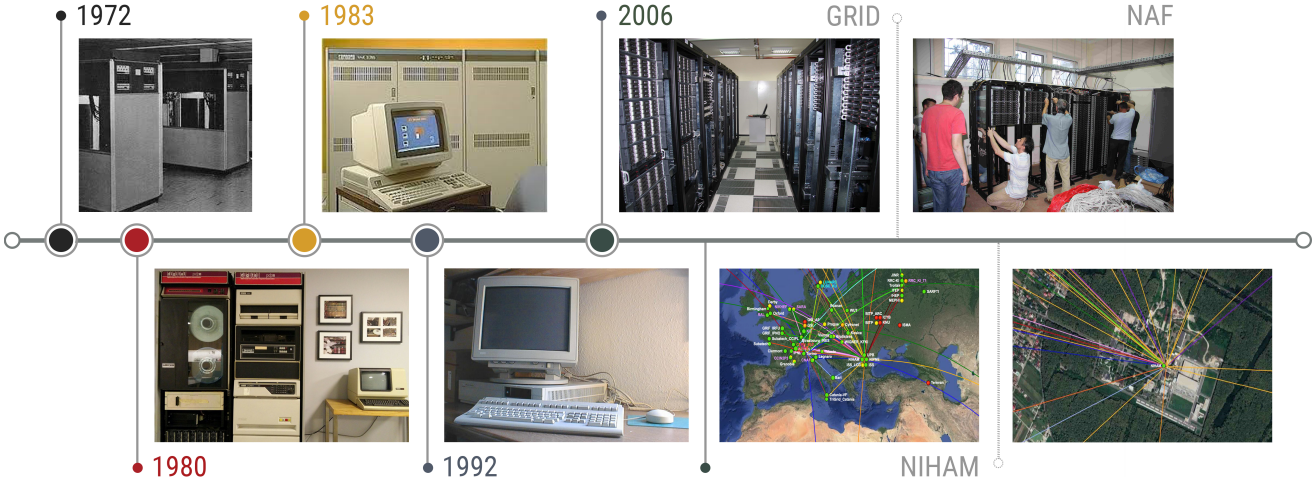
In order to operate complex detectors foreseen to be developed in our Department and perform tests of detectors assembled by us for large scale Experiments like ALICE and CBM, the Multi Branch System (MBS) DAQ, developed at GSI, was implemented in our Lab in 2004.

It has been intensively used in tests of the TRD chambers and GEM based TPC Outer Read Out Chambers (OROCs) for ALICE experiment. It was and is currently used for in-house tests of the RPC and TRD prototypes developed for CBM experiment at FAIR and their in-beam tests at different accelerators: SIS18-GSI, ELBE-Rossendorf, COSY-Julich, PS and SPS-CERN. In order to make use of the special architecture TRD developed by us for CBM experiment foreseen to be operated in high counting rates experiments at SIS100, a dedicated data processing concept was developed in our department. It was designed a General Event Time-stamping Serializer board based on 2 Polar Fire FPGAs which will transport data from FASPRO to central read-out boards.



Computing

Starting from 1972, the main computing facility of the Institute for Atomic Physics (IFA) was an IBM 370/135. the programs being created, edited and stored line by line on punch cards. The Tandem Laboratory was equipped in 1983 with a PDP11/34 and a few years later with a CORAL computer, a Romanian version of PDP11 computer. A real step forward was achieved by our group in 1992 when a DEC Station 5000/125 has been received within a project supported by Soros representative in Romania. Was the time when we were able to launch jobs in a remote way on clusters of similar computers from GSI where the large volume of experimental data delivered by FOPI experiment were stored and transfer results on our local DEC Station and represent different histograms or final plots of our own data analysis.



In 1999, being aware of the activities taking place at CERN for developing internationally distributed computing and storage infrastructures, called GRID, to be used by the large international collaborations structured around the four large experiments for the future LHC, similar activities were initiated also in our group having in mind the ambitious target to become in time a significant member of the ALICE GRID. In 2003, a local distributed system connected to the ALICE GRID, become the first international GRID application in Romania.

Following a coherent strategy in developing a consistent computing and data storage of our department we used every financial support to purchase different components, such that presently our NIHAM Data Centre is one of the most efficient Tier2 component of the ALICE GRID. A continuous running of 24 hours per day and 7 days a week is guarantied by additional infrastructure consisting of a 600 kW Diesel generator, industrial UPS, anti-fire Protection network and temperature and humidity sensors. In parallel with NIHAM Data Centre, a rather similar infrastructure was developed, NIHAM Analysis Facility (NAF), dedicated for HPD members, used for independent large scale theoretical models calculations, Monte Carlo simulations, developing and testing data analysis software before being launched on ALICE GRID.

Infrastructure

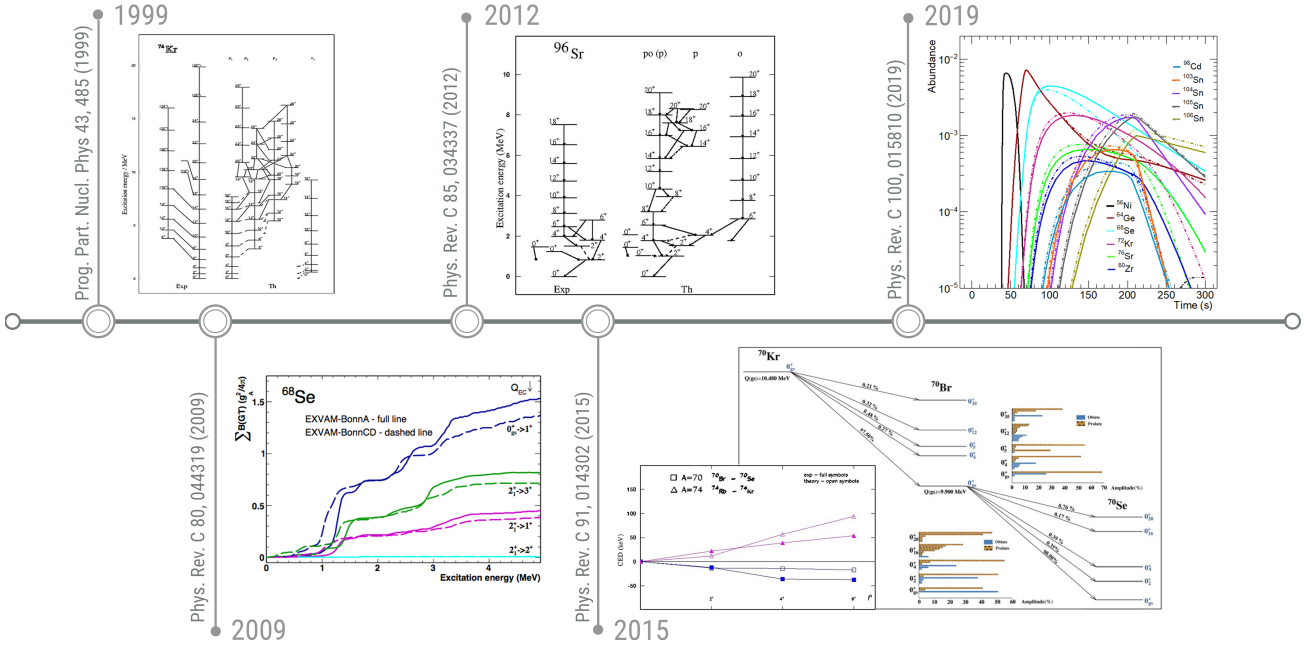
When we started DRACULA project, the working place for our team was in the area where the experiment was assembled and connected to the beam pipe in the Post Accelerator hall, rather improper for such activities. After installing DRACULA at LNS Tandem, the R&D activities of our group took place in a rather limited space in the basement of the Bucharest TANDEM building. Our project launched in 1999, focused on our activities in the ALICE Collaboration, approved in 2003, gave us the possibility to organize a Detector Laboratory with proper clean rooms and infrastructure. Inaugurated in autumn 2004, the. DetLab, organized in an existing building, was intensively used for assembling and tests of 130 TRD chambers for ALICE and assembling and tests of the very first TRD and RPC prototypes for CBM experiment.

These results substantiated our further request to the National Agency for Scientific Research (NASR) to continue this support, such that we were able to organize a proper room for the Data Centre and offices for the members of our group. Considering the impact of our activities within large international collaborations and the European initiative to help the Eastern European countries to bring their scientific infrastructures to West European standards, we received a substantial financial support from

NASR within Large Infrastructures National Program. Started in 2010, the extension of the building was finalized in 2012. At present we have, besides the former clean rooms of the DetLab, three detectors testing laboratories, two laboratories for electronics, a bonding laboratory, an extension of the Data Centre, housing NIHAM - the component of ALICE GRID and NAF (Niham Analysis Facility), a new workshop, meeting rooms and a large Conference Room, all equipped with integrated video-conference infrastructure, new offices for HPD members, guests, master and PhD students.

Physics

Nuclear Structure and Dynamics



Beyond-mean-field approach to shape coexistence phenomena in medium mass proton-rich and neutron-rich nuclei, isospin-symmetry-breaking effects, weak interaction processes and impact of rp-process waiting point nuclei on X-ray burst nucleosynthesis.

Strongly Interacting Matter

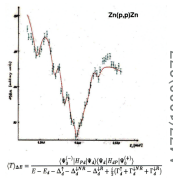
The huge efforts on different segments of research, previously mentioned, were motivated by physics cases we considered worth to be followed, proposed and worked out by the members of our Department within the experiments in which we were involved or other data published in the literature. A rather short summary of the main results are mentioned here. The interesting studies of intermediate structures in region of isobaric analog resonances and molecular type resonances were carried at our and Saclay Tandem, respectively.

An exhaustive studies of different aspects revealed in heavy ion dissipative collisions were carried out in the period 1981-1988 at UNILAC and GANIL. Such studies were continued at LNS using DRACULA device for light heavy ion interactions. A general scaling of width of charge distributions as a of TKEL/lg being established for all collision energies and mass of the colliding nuclei. We brought also our contributions in multi-fragmentation studies based on CHIMERA experiment. A hybrid phenomenological model coupling a hydrodynamic expansion with a statistical multi-fragmentation at break-up time succeeded to explain many features evidenced by FOPI Collaboration at SIS18. Multi-differential analysis of the transition energy of elliptic flow from in-plane to out-of-plane and of the transverse flow shown their sensitivity to the EoS of nuclear matter at baryonic densities and temperatures achievable in heavy ion interaction at SIS18 energies.

End 2010, within ALICE Collaboration, we evidenced the first signatures of collective type phenomena in pp collisions at 7 TeV. Detailed studies of Core-Corona relative contributions have shown that many features revealed in yields, $< p_T >$ and Bjorken energy density centrality dependence could be explained by the interplay between Core and Corona contributions. A very interesting scaling of the slope of $< p_T >$ as a function of mass and average transverse expansion for all collision energies and mass of the colliding systems, from RHIC to LHC, as a function of geometrical variable $\sqrt{(dNch/d\eta)/S_{\perp}}$, suggested by CGC model, was obtained.

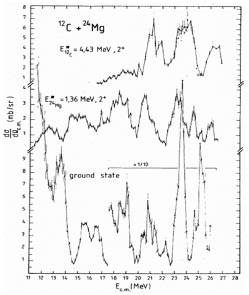
1973

Proc. Int.Conf. on Nucl.Phys.(1973)529



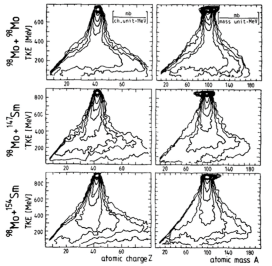
1978

Phys. Rev. C24(1981)1512



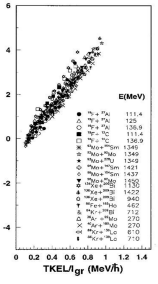
1988

Nucl.Phys. A477(1988)277



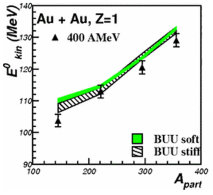
1997

Phys.Lett. 397B(1997)25



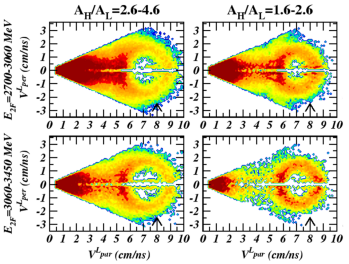
2004

Phys.Rev.Lett. 92(2004)072303



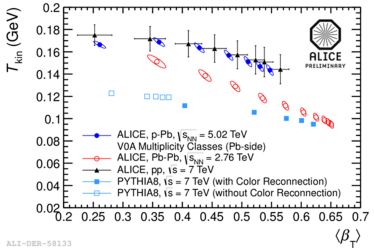
2010

Phys.Rev. C81(2010)064605

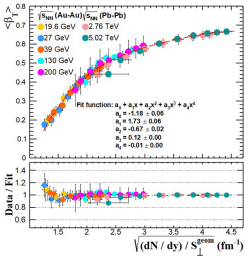


2019

Nucl.Phys. A931(2014)c888



AIP Conf. Proc. 2076(2019) 040001



Other Activities

International Events

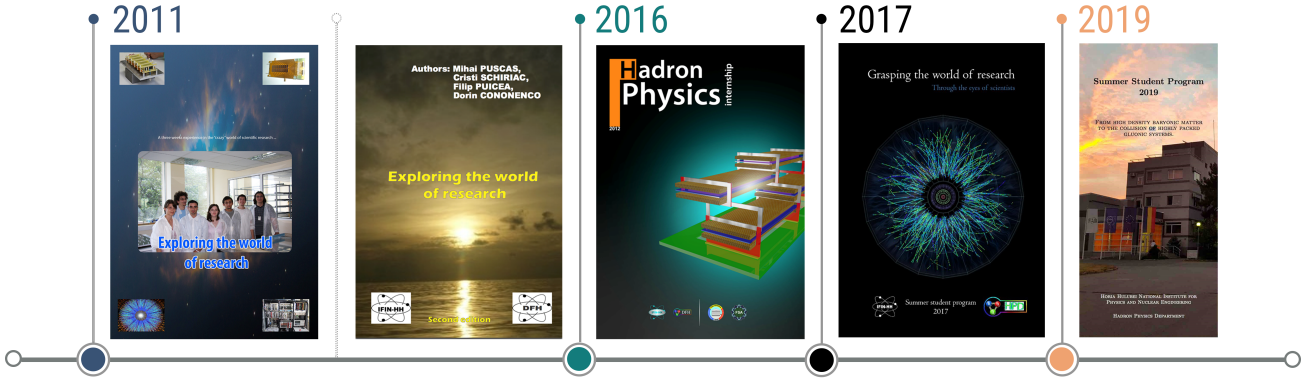
Over the years we organized international meetings focussed on aspects related to the main activities within the experiments we were involved in. A FOPI Meeting combined with an workshop related to heavy ion studies at different collision energies based on close to 4π experimental configuration was organized in 1996 in Poiana Brasov, one of the most beautiful touristic resort in Romanian Carpathian Mountains.

Once we started the commitment and assembling of ALICE TRD chambers and producing the first TRD prototype for CBM experiment, we organized a Workshop at Cheile Gradistei, a rather new touristic resort on Prahova Valley. After realizing the first GRID application in Roamnia in 2003, in 2006 we organized in collaboration with particle physics, computing, theory IFIN departments and Technical University of Bucharest a dedicated International GRID Workshop at Sinaia.

Before starting the experiments at LHC, we organized in Sibiu an ALICE Workshop focused on TRD subdetector, offline software, GRID activities and physics. As a result of our contribution in developing high counting rate TRD and RPC Detectors for CBM experiment, in 2010 we organized a CBM Meeting focused on R&D activities, Monte Carlo Simulations, free streaming mode DAQ and Physics in Mamaia, the famous touristic resort on the Black See beach and a unforgettable one day excursion in Delta of Danube.

Training and Teaching

Over the years we payed a particular interest in provide for student the opportunity to enhance their educational experience over. Many diploma, master and PhD thesis were accomplished under the coordination of members of our Department. In the last decade we are organizing regular "Summer Student Program" attended by Students from Romanian and foreign universities. The participants were asked to issue booklets or flyers with their results obtained during the two month periods spent in our Department. We are please to mention that very good participants to such programs decided to stay with us and prepare their diploma, master or PhD thesis along the the topics in which they were involved during the Summer Student Programs. Last but not least, is worth mentioning that we received messages from many of them confirming the high standards of infrastructure., scientific atmosphere and the challenge of activities in which there were involved, relative to other places were they have been for similar training programs.



The Actors

The main, present and former, actors behind the achievements summarized above (**former members*, †*deceased*):

Contributors

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In 1949, Horia Hulubei, PhD student of Jean Perrin, has founded the Institute of Physics of Romanian Academy, precursor of National Institute of Physics and Nuclear Engineering.


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