LHCb - study of hadron production, heavy flavour physics and the upgrade program - yearly report to International Scientific Advisory Board (ISAB) 2016.

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1 LHCb-Romania Cover page

The Bucharest and Suceava groups are formed by 18 members: 8 physicists and researchers; 6 PhD students (one just finished her dissertation with highest honor, and the PhD title will be soon confirmed by the Romanian Education Ministry); one WLCG Grid and Programming staff expert (also a PhD student counted separately), one Grid and LHCb-Online specialist (a second PhD counted separately as he does not have a topic related with LHCb), one M.Sc.Eng. student and one accounting staff, with about 9.5 Full Time Equivalent (FTE). Though the latter number if the same as last year, we do hope to increase the team size by 2 to 3 members by the end of the next year.

IFIN-HH subgroup

1. Florin MACIUC, physicist	2. Alexandru Tudor GRECU physicist
open position physicist	3. Mihai STRATICIUC physicist
open position senior physicist	4. Lucian-Nicolae COJOCARIU PhD student
5. HUTANU Ovidiu-Emanuel MSc student	6. Vlad PLACINTA PhD student
7. Lavinia Elena GIUBEGA PhD student (defended on 26 September)	8. ALEXANDRU Ene Cătălin MSc student
9.Teodor IVANOAICA staff independent PhD theme	10. Nicoleta-Ileana DUMITRU staff
11. Laurentiu DUMITRU staff independent PhD theme	open position PhD student

Elena GIUBEGA has defended successfully her thesis "Hadron Production and Rare Decays studies at LHCb" at University of Bucharest Faculty of Physics, and awaits title confirmation from the Romanian Ministry of Education and Science. The University of Suceava (USV) group has: 5 physicists and engineering researchers, two PhD students - both dissertations without an LHCb main topic, though some degree of synergy exists with respect to the project scientific program. In total there are about 2 FTE allocated by USV.

USV subgroup

1. Mihai DIMIAN physicist and electronics professor	2. Cristian-Andy TANASE researcher
3. Marius Prelipcean researcher engineering	4. Adrian BODNARESCU PhD student
5. Camelia PÎRGHIE physicist	6. Cristian PÎRGHIE physicist
7. Lucian-Nicolae COJOCARIU PhD student	8. Dorin-Andrei ANTONOVICI PhD student

Adrian BODNĂRESCU has defended his PhD thesis "Extended Gravitational Models with Applications to Cosmology and Astrophysics", at Al. I. Cuza University of Iasi.

Main research topics of the group include:
1. Soft-QCD physics and strangeness production in proton-proton collisions and in Minimum Bias data samples;
2. Hard-QCD themes like heavy baryon production and decays in proton-proton collisions and their decays, $\Xi^{\pm}$, $\Omega^{\pm}$ and Λ_b;
2a. Angular analyses of baryon decays with application on rare radiative decays of b-hadrons and not only;
2b. Production and decays of resonances at LHCb: for heavy flavour sector;
2c. Double charm baryons Ξ_{cc} and Ω_{cc} feasibility study (for 2021 and beyond to HL-LHC);
3. LHCb Proton-Ion collision data analysis and simulation, important also in context of secondary interactions in detector and heavy ion production in RICH electronics and sensors for LHCb-Upgrade studies;
5. Jet physics and flavour production in proton-proton at LHCb, plus a possible extension into proton-ion studies;
5a. Particle correlations when produced in pairs like strange anti-strange pair;
5b. Comparative studies of LHC physics with respect to Cosmic ray generators and observables in Minimum Bias physics;
6. Tests of electronics and sensors (Multi Anode Photo Multiplier Tubes - MaPMT) in LHC environment - aging effects on MaPMTs and field-temperature-radiation effects on RICH readout electronics;

6a. Integrated Circuits FPGA[1] and ASIC[2] aging and radiation hardness;
5b. MaPMT aging at LHC, and efficiency extrapolation beyond 50 fb^{-1} in context of HL-LHC;
5c. Estimation of heavy ion fluencies in RICH for Upgrade and HL-LHC phases;
5d. Estimation of SEU - or software single event upset - and SEL - or hardware latch-up - rates for LHCb-RICH Upgrade phase;
7. Programming and Monitoring of data flow through RICH-LHCb Digital board to Online Farm, for LHCb-Upgrade setting;
8. RICH LHCb Upgrade construction - R&D studies focused on the future assembly and testing of RICH digital boards;
9 GRID and WLCG studies, e.g. Dirac studies on Ro-11.
Compared with the large collaborations, our group research topics are for most part independent of other LHCb groups, though we do contribute to common goals like radiative decay studies of b-hadrons and RICH-Upgrade electronics.

The LHCb RICH Upgrade studies were one of priorities, and we acquired successfully enough data at the Heavy Ion Facility in Louvain and at Proton Irradiation Facility at PSI to allow a first estimation of cross-sections for software and hardware errors in FPGA integrated circuits. The results on Single Event Effect (SEE) cross-sections were included in a CERN/LHCb EDR (Engineer Design Report) [3] related to the construction of LHCb-RICH Upgrade - digital communication boards for MaPMTs and front-end electronics. A first estimate of software and hardware SEE rates for LHCb-RICH Upgrade phase will be released in December, and we prepare 2 or more papers with NIM A as targeted journal Here a first estimation of high-Z ion production fluencies will be added, based on simulations and extrapolation of the observed values.

Publication status this year: 2 journal and proceeding papers, 1 EDR contribution, 1 Romanian Journal of Physics article accepted. Several talks in LHCb groups and Upgrade meetings. Two LHCb analyses reviewed, 2 LHCb talks at International conferences, 1 Upgrade Talk, 1 Poster, etc - for the talk given at a local Workshop organized by the group see below.

Team development is essential even for this second LHCb project, as the group dynamics is very fluid. A new generation of PhD students were prepared with focus on High Energy Physics and related subjects. After a rigorous and demanding selection process implemented for the IFIN-HH sub-group, besides the team leader and 2 other senior researchers, there are now 4 PhD students with LHCb dissertations plus other 2 PhD students with independent dissertations. From these two, one has a high degree of synergy with the project, implementing and developing computing tools for an LHCb-dedicated Grid site (RO-11), and the other has, at least, the possibility to use project results and acquired experience to advance his dissertation. For both, the group-published papers will count towards their PhD.

Specific to the 4 PhD students which have 100 % involvement in LHCb Collaboration, two of the PhD dissertations have LHCb topics on data analysis, decay models and collision generator physics. These PhD students are required to finalize at least 2 independent papers as first author. The two PhD students specializing on LHCb-RICH Upgrade are required to have between 4 to 6 papers independently with respect to LHCb collaboration. Given the doctoral program rules and the PhD requirements, the LHCb papers.and Analysis notes do not add to the previous numbers. Yet, due to successful data taking at PSI and Louvain, the previous papers and excellent evolution of these students we are confident they will defend successfully their dissertations.

One local workshop "SHEP 2016" at University of Suceava was organized by our group. Our group expects at the beginning of next year to have more than 5 articles in Romanian Journal of Physics based on the workshop themes. The integration of the USV sub-group in LHCb physics and Upgrade programs continues, pending the official USV acceptance to LHCb Collaboration as IFIN-HH partner. To achieve this goal, the visibility of USV scientists and engineers in collaboration needs to be increased during the next couple of years.

Grid Tier-2 Site Ro-11 is fully operational and approaches 100% occupancy over this year - Ro-11 is an LHCb-VO virtual organization dedicated Grid site. The local cluster is operational and is being upgraded

[1] RICH Digital Board component - Field Programmable Gate Array

[2] Application specific Integrated Circuit

[3] the following link might not be accessible, but we shall include this note in the open session talk, `https://indico.cern.ch/event/515232/`

to allow for more computing power and storage. Outreach activities are plentiful with one LHCb-CERN Masterclass session (March) this year covered by necessity from separate funding.

2 Scientific Goals

The scientific goals are threefold: first LHCb data analysis and Standard Model physics, second LHCb Upgrade tasks and goals, and third computing and GRID. In our project the first two are of particular importance, but there is already a high degree of overlapping between the three fields, as for example the Upgrade tests of radiation-hardness and the simulations which allow total ionization dose estimation for Upgrade phase and hopefully the high-Z ions fluencies from secondary interactions in detector.

2.0.1 Soft-QCD, HepData and Minimum Bias physics

We are currently continuing the strangeness production analyses with new members and PhDs. The objective is to turn back to neutral Kaon production in LHCb acceptance at 13 TeV as soon as the new members from USV and the new PhD is ready to tackle an LHCb analysis under Team Leader supervision. Since the project started, for the last 6 months we concentrated on introducing the new members and PhDs to the intricacies of high energy physics, the LHCb detector physics and analysis methods. In this respect one of the PhD students was started on a study of comparison between PYTHIA generator models and the results obtained using the cosmic ray generators through CRMC package (EPOS, QGSJET etc.). Here CRMC [4] stands for Cosmic Ray Monte Carlo, and it is an interface to Cosmic Ray generators, which allows easy comparison to LHC measurements. Studies for hyperon production at LHCb and ratios are also ongoing, though we tuned down this analysis till the new set of Upgrade papers are ready - due to limited experienced workforce in the project and the involvement in Upgrade tasks.

Here other subject of interest are Monte Carlo studies related to Monte Carlo generator tuning. In this context the integration of LHCb Measurements in RIVET [5] and High Energy Physics data repository HepData [6] is a considerable tasks, and we have a key member managing and supporting this integration tasks for tens of LHCb measurements and also acting as LHCb and HepData liaison. Though not a scientific goal per se, making the LHCb data available in RIVET plugin and HepData format is very convenient for high energy physics community especially for phenomenologists whom it allows to tests their models and tune them directly on LHC data. It is also convenient for the tuning of PYTHIA generator with "LHCb flavour" in the forward high-rapidity region. Recently a first version of tuned PYTHIA was tested by our collaboration.

A special entry will be included later in Upgrade context for proton-Ion studies where we highlight the overlap between the LHCb studies and the production of secondary ions in electronics.

2.1 Heavy flavour production and decay and Hard-QCD events

In the context of Hard-QCD events the status is the following: we investigate jet production models and do feasibility studies for certain particle-jet measurements. Simultaneously, we look in certain heavy flavour resonance production mechanisms a prepare the ground for a potential study.

Besides the Hard-QCD production, we also continue the polarization studies using Monte Carlo simulation data for $\Lambda_b \to \gamma p^+ K^-$ decay channel with several intermediate resonances Λ^* of various spin values - from 1/2 and up to 9/2. We have already a PhD student fully dedicated to these studies. Depending on the PhD availability and the evolution of the other studies, the plan is to allocate in the near future 2 FTE for these studies as soon as this is feasible. For now the long term objective is to expand the studies of angular distributions and mass resonances to other decays and other channels. In perspective, there is the possible measurement of new resonance in some known channels or a measurement of the spin state or polarization state for some already known resonant states - though not charm and beauty, the strange states Ξ or Ω and the CP-conjugate states would be good candidates. Besides b-baryons we plan to look into other heavy baryons, e.g., charm baryons, and also explore in parallel the multi-body decay spectrum of heavy-flavour meson decay.

[4] `https://web.ikp.kit.edu/rulrich/crmc.html`
[5] `http://rivet.hepforge.org/`
[6] `https://hepdata.net/`

2.2 LHCb-RICH Upgrade R&D, Integrated Circuit radiation-hardness and aging, FPGA programming, ion production

2.2.1 R&D

In R&D tasks of LHCb Upgrade, our PhDs in Engineering have developed two test benches for radiation harness testing of FPGA and ASICs. The FPGA under test is one of the most complex and new commercial integrated circuits. The ASICs under tests are provided by Omega Micro Lab from Paris[7] and are and will be used in our institute laboratory for front-end electronic read-out of Multi-anode PhotoMultiplier Tubes MaPMT sensors.

The third test bench is for MaPMT testing, and is independent with respect to the RICH choice of front-end electronics. However, this choice is closer to the present setup of the MaPMT testing bench, test bench developed by LHCb-RICH group for quality control of these last generation Hamamatsu Multi-anode Photomultipliers with 64 independent detection channels, Our setup will be upgraded to allow testing of the MaPMT in a beam of high energy protons and maybe other types of radiation if appropriate facilities are found. This last point is a long term plan and objective of the group, in the context of sensor aging.

2.2.2 Integrated Circuits, radiation hardness tests and aging

The integrated circuits when subject to radiation, especially the hard and mixed radiation at LHC, are prone to errors and potential significant damage. The errors are typically Single Event Effect (SEE) or permanent/cumulative effects. The first type of errors are software Single Event Transient (SET) or Single Event Upset (SEU), and hardware, i.e. Single Event Latch-Up (SEL). The main objective of these studies is to measure the cross-section and production rates of SEE for various sources and extrapolate them to the LHC environment or more exactly to the RICH electronics and expected environment therein for the Upgrade Phase. Besides these SEE effects there is also the permanent damage like Single Event Gate rapture (SEGR) and Single Event Burnout (SEB) plus the cumulative damage effects from Total Ionization Dose effects and Displacement Damage (DD) effects. The last two could induce effects that lead to increased power and in extreme cases break-down. All these effects are mapped and quantified function of configuration load on the device and device resource type: e.g. configuration memory, IO banks and rails, flip-flops, Block RAM Memory.

The SEE dependence on Linear Energy Transfer (LET) or Stopping Power is also mapped. The SEL threshold and the nature of SEU cause at low LET is investigated.

Given that SEE depend strongly on LET values we investigate the production of slow ions with high-Z which might be produced inside the dice or close to the FPGA. These ions are produced with low momenta close to or at Bragg peak. For effects like SEL these are the main culprits in low-Z and high-momentum hadron environment similar to LHC.

2.2.3 Ion production in integrated circuits for LHCb Upgrade Phase

Strongly correlated with the simulation studies on ion-proton Monte Carlo data for LHCb, there is also the possibility to study the ion production inside electronics through secondary interactions between a light hadron and a nucleus. The End-Product of this study besides its intrinsic academic and scientific value is to extract an ion production rate when the interaction point is close to the integrated circuit surface. Of special interest are the elastic collisions in Silicon wafer and the remnant ion production in collision of proton/pion and nuclei with large atomic number like Hafnium, Copper, Germanium. All these, present in non-negligible fractions inside the chip itself, the package or the PCB.

2.2.4 FPGA Programming

Regarding the configuration programmed on the FPGA, we have tested several version of firmware, each time testing a certain FPGA resource resistance to the radiation. The programming is a study in itself as there are a number of Error Mitigation Methods and Tools, some of these already tested. The error mitigation methods are essential to protect the logic configured on the FPGA and allow removal of SEU. The SEL require power-cycling and the permanent effects could be seen in configuration changes and even more in the global operating parameter of the device like consumed power, core temperature, voltage and

[7] `http://omega.in2p3.fr/`

electric current or currents through the device. Here,the task of designing a correct and optimal interface to the test bench and to the device under test is a rather complex problem, which was for most parts solved by the group, thogh some upgrades are pending especialy for FPGA IO control and monitoring.

2.3 Computing and WLCG GRID tasks

For the end of this section, it is worth mentioning the group efforts and interests in LHCb Computing tasks, like: LHCb Monte Carlo and RIVET integration support, plus the support offered to the LHCb groups wanting to upload their individual LHCb measurements in the HepData frame. The Grid maintenance will be doubled by a DIRAC study on Ro-11 in collaboration with the IT department of IFIN-HH. The local infrastructure includes a cluster for which we tests and develop student work and allow students to perform computing mini-projects. On this cluster we also have the possibility to test and improve the CERN/LHCb software tools and services.

3 Scientific achievements in the last three years corresponding to the actual program funding

3.1 Results in 2014-2015

The deliverable include: 3 proceeding papers and one journal paper independent of LHCb Collaboration, 10 conference and workshop talks and posters, members of our LHCb group acted as reviewers for 3 reviews of LHCb Analyses finalized in a published paper, multiple talks at LHCb working group meetings, participation in LHCb tasks of paper reviewing, data quality control, QEE sub-convener-ship for the LHCb soft-QCD task force, etc.

3.1.1 LHCb Data analysis, Physics signals and Monte Carlo

The following is a summary of the previous report with data on the results for 2014 and 2015, for more details see the previous reports and the public data given on the group homepage for the past LHCb project "From strangeness to b-physics and beyond" [8]. A summary is available at this site:[9] and in the following I shall outline the main aspects and results.

From point of view of physics we had contributions in many of the LHCb working groups and analyses. The most prominent contributions were registered within the soft-QCD/Electroweak/Exotica (QEE) group of LHCb with heavy weight on the soft-QCD studies, Stripping/Preselections and Monte Carlo simulation and models. The work on the tuning of PYTHIA 8 generator "LHCb-flavored" for forward physics was also achieved in this context. The integration of LHCb measurement in HepData and the support offered is also worth mentioning, and for a more exact description of these activities see 2016 results.

An other set of activities were concentrated in rare decay group, here the radiative decays of b-hadrons were a dissertation subject of one PhD student, whcih carried simulation studies of $\Lambda_b \to \gamma p^+ K^-$ channel with 12 intermediate resonances Λ^*. She also provided support for other LHCb-groups studies concerning this critic channel where γ helicity and decay branching fraction are of interest in context of New Physics searches. The other aspects in this context is to estimate the background generated by this channel in other topologically equivalent channels like $B_s \to (\phi \to K^+K^-)\,\gamma$, $B_d \to (K^* \to p^+K^-)\,\gamma$, channels with the same discovery potential, and very interesting especially for the program of Upgrade-phase physics.

The other activities include a new University group joining and a CERN workshop organization by our team. A new partner was welcomed in the project, University "Stefan cel Mare" of Suceava (USV) and by the end of 2015 its PhD and Master students already had a large impact on the results, plans and activities of the group especially for the Upgrade phase. We are integrating them in the LHCb structure especially their PhD students and we offer support for their physicists and engineers to integrate in the LHCb analyses and R&D. We have co-organized in 2014 an workshop at CERN in collaboration with our Polish partners in LHCb. The topics discussed in this workshop were "LHCb workshop on quantum interference effects, QCD measurements and generator tuning" [10].

3.1.2 LHCb Upgrade, RICH and R&D

Regarding the Upgrade team, two new PhD Engineering students were included in the project and together with the other members of the group they started working on test benches of ASIC chips MAROC3 and SPACIROC2. These two are possible front-end chips for the same generation of MaPMT like the ones uses in RICH-Upgrade. Though the LHCb Upgrade Construction is not including the MAROC3 chip anymore - it was considered as a backup solution to the actual front-end chip - ,both chips are ideal to read-out multiple MaPMT characteristics and allow completed description of the MaPMT operation especially in view of future aging tests and radiation-hardness tests of these sensors. The LHCb quality control testing bench actually uses MAROC chips, though the are not to be used in the actual construction. In 2014 we had 2 tests for MAROC3 design under X-ray radiation.for an estimated of 1 Mrad Total Ionization Dose in one device. An MaPMT testing bench was also assembled to allow measurement of MaPMT signals.

For the radiation harness test program of FPGAs, we have acquired 9 Xilinx Kintex-7 FPGA for radiation hardness tests, and sent 6 flipped FPGA chips to be thinned from 250 micrometers to 60 micrometers

[8] http://www.nipne.ro/dpp/Collab/LHCb/grantLHCb_2011-2015.html

[9] http://www.nipne.ro/dpp/Collab/LHCb/grant_2k12-15/RezumatEngleza3Pagini.pdf

[10] https://indico.cern.ch/event/329946/contributions/

or better so that the test ion beam reaches the active layer of the integrated circuit. A first test using Oxygen and Florine ions was performed at Legnaro National Laboratory, and it showed the deficiency of an old test firmware. The limitation of the firmware was generated by the basic assumption that the SEU rate per second would be small, thing that was disproved on this occasion and a small set of measurements were done due to the lack of error mitigation and automatic control in the FPGA interface.

For the next months after the Legnaro testing, the group managed to include in project a new USV member with experience in FPGA programming for this FPGA generation. The two PhD students with the added help improved significantly the FPGA firmware and LabView monitoring interface for the test bench. The much improved version was designed specifically to test the FPGA programming in conditions of high SEU rate and had a robust triple modular redundancy configuration and logic. The testing setup was part of two conference talks and the next FPGA set of measurements are covered in the next subsection for 2016 activities.

3.2 Scientific work and results in 2016

3.2.1 Studies of Physics processes and LHCb measurements

As already stated the $\Lambda_b \to (\Lambda^* \to p^+K^-)\,\gamma$ study was integrated in a dissertation by one of our PhD and she successfully defended her thesis with the best level of distinction awarded by University of Bucharest: excellent. The work integrated aspects of beauty baryon decay and soft-QCD studies like strangeness production. We are pleased that together with her we have also a new LHCb member whom we hired as a Master Student, and now, he was accepted in a PhD program at University of Bucharest. We currently prepare his official integration in the LHCb collaboration. The first PhD student has 2 published papers this year, one LHCb proceeding and one Journal paper:

• L.E Giubega on behalf of the LHCb Collaboration, "Radiative Decays at LHCb", Physics of Atomic Nuclei, 2016, Vol. 79, No. 10, pp. 47–52, ISSN 1063-7788;

• L.E. Giubega, A.I. Jipa, A.C. Ene, "Study of the resonances structure appearance in the $\Lambda_b \to \Lambda^*(\to p^+K^-)\gamma$ decay using helicity formalism", Romanian Journal of Physics.

• L.E. Giubega "Hadron Production and Rare Decays studies at LHCb" thesis at University of Bucharest.

The second PhD Student in our group working on LHCb physics analysis and simulation studies has finished his M.Sc. thesis on an LHCb subject and graduated in the program "Physics of the atom, nucleus, elementary particles, Astrophysics and applications" of University of Bucharest with the Master's thesis "Particle production in pp collisions at LHC energies" graded with maximal grade. More recently a study of PYTHIA 8 generator and Cosmic Ray generators interfaced through CRMC was started for collisions at LHC energies. The purpose of this study is to compare the results of the generators with the LHCb results in Minimum Bias data and also check the differences between generators. The latter will be included in a paper with topic independent of LHCb to be submitted to Romanian Journal of Physics this year.

We also have coordinating with USV members of the group to prepare them to take responsibility of an LHCb analysis first using Monte Carlo simulation and than data to measure strangeness production at various energies. Two USV physicist are preparing a study on the statistical methods for High Energy Physics, and the USV PhD has just defended a thesis independent of LHCb. Since a relative recent date they began a process of integration at LHCb and in our group.

A huge work was done integrating the LHCb measurements in the HepData repository. One of our members has supervised or was involved in integrating 16 LHCb measurements in this repository:

1. "Measurement of $\psi(2S)$ meson production in pp collisions at $\sqrt{s} = 7$ TeV", Eur. Phys. J. C72 (2012) 2100; 2. "Observation of double charm production involving open charm in pp collisions at $\sqrt{s} = 7$ TeV", JHEP 1206 (2012) 141; Addendum: JHEP 1403 (2014) 108; 3. "Measurement of the fraction of $\Upsilon(1S)$ originating from $\chi_b(1P)$ decays in pp collisions at $\sqrt{s} = 7$ TeV", JHEP 1211 (2012) 031; 4. "Measurement of J/ψ production in pp collisions at $\sqrt{s} = 2.76$ TeV", JHEP 1302 (2013) 041; 5. "Measurement of the $\chi_b(3P)$ mass and of the relative rate of $\chi_{b1}(1P)$ and $\chi_{b2}(1P)$ production", JHEP 1410 (2014) 88; 6. "Measurement of the $\eta_c(1S)$ production cross-section in proton-proton collisions via the decay $\eta_c(1S) \to p\bar{p}$", Eur.Phys.J. C75 (2015) no.7, 311; 7. "Measurement of B_c^+ production in proton-proton collisions at $\sqrt{s} = 8$ TeV", Phys.Rev.Lett. 114 (2015) 132001; 8. "Measurement of the forward Z boson production cross-section in pp collisions at $\sqrt{s} = 7$ TeV", JHEP 1508 (2015) 039; 9. "Forward production of Υ mesons in pp collisions at $\sqrt{s} = 7$ and 8TeV", JHEP 1511 (2015) 103; 10. "Measurements of prompt charm production cross-sections in pp collisions at $\sqrt{s} = 13$ TeV", JHEP 1603 (2016) 159; 11. "Production of associated Υ and open charm hadrons in pp collisions at $\sqrt{s} = 7$ and 8 TeV via double parton scattering", JHEP 1607 (2016) 052; 12. "Measurement of forward W and Z boson production in pp collisions at $\sqrt{s} = 8$ TeV", JHEP 1601 (2016) 155; 13. "Angular analysis of the $B^0 \to K^{*0}\mu^+\mu^-$ decay using 3 fb^{-1} of integrated luminosity", JHEP 1602 (2016) 104; 14. "Measurements of prompt charm production cross-sections in pp collisions at $\sqrt{s} = 5$ TeV", arXiv:1610.02230 [hep-ex]; 15. "Measurement of the exclusive Υ production cross-section in pp collisions at $\sqrt{s} = 7$ TeV and 8 TeV", JHEP 1509 (2015)

084; 16. "Measurement of forward J/ψ production cross-sections in pp collisions at $\sqrt{s} = 13$ TeV", JHEP 1510 (2015) 172;

The group member who acts as LHCb liaison to HepData and MC production liaison for the QEE physics work group continued these software activities for the collaboration at CERN. The activity at HepData (16+ data sets encoded and released) was focused on supervising the release of LHCb, mainly heavy flavour production, measurements to be used in future campaigns of generator tuning. This is synchronized with the upgrade of the RIVET interface to the LHCb software stack, so that the latest stable versions of the library are made available to the simulation software and documented on dedicated Twiki pages. In parallel we started to install, test and deploy for production various MC event generators (PYTHIA, CRMC, URQMD) on the local cluster. These were already successfully used in developing and testing new, fast simulation algorithms to be implemented in the LHCb simulation software.

3.2.2 R&D Upgrade studies

This year we manage to do two irradiation tests. First irradiation tests was financed through AIDA-2020[11] program from Horizon-2020 and the host institute was Universite Catolique de Louvain la Neuve, Centre de Recherche du Cyclotron, Heavy Ion Facility. The beam cocktail used during the 12 hour of tests had ions ranging from Carbon with LET value of 1.1 MeV cm^2/mg.to Krypton at 32.6 MeV cm^2/mg. We have measured the SEU and SEL cross-sections function of LET in FPGA for configuration CRAM resources and mapped the threshold region for SEL production at 15 MeV cm^2/mg. Our results were included in the LHCb EDR for the Photon detector module digital board (PDMDB - see previous link). There are also 3 talks at local and international conferences on this subject given by members of the group. In a last measurement at Louvain we have also measured the SEU cross-section in BRAM memory using only the Carbon beam.

A second radiation hardness test was done using 200 MeV protons at Paul Scherrer Institute, Proton irradiation Facility (PIF). Three FPGAs were subject to 500 krad of Total Ionization Dose each, the results are promising, though the SEU rate remains high even at this low LET value, which might indicate significant production of secondary ions already at these low energies. A simulation study was started to estimate the produced ion fluencies and spectra. The results have to be extrapolated to LHC values and the FPGA actual numbers.

For these tests we have used multiple firmware versions to test separately the single bit SEU, multi-bit SEU, SEL and also to study the effects on logic of SEU. The SEU rate for each FPGA resource was investigated by using different FPGA configurations with Flip-Flops, CRAM, BRAM and we also tested the IO Voltage stability.

The data collected is being analysed and we shall release the first papers at the end of the year, plus we shall give to collaboration the first estimates for SEU and SEL rates in LHCb upgrade phase in RICH by the next LHCb week meeting in December. In the beginning of next year a second paper will be published on FPGA proton testing and ion production in the device under test. Besides the 2 papers outlined, we intend to prepare an additional set of 2 papers to be sent to Romanian Journal of Physics. These papers will describe in better detail the experimental setup, FPGA firmware versions, ions production studies.

For the next year we have also applied successfully for 3 irradiation sessions with proton and ions at Juliech and again at Legnaro LNL. The outline of the radiation hardness tests planned for next year will be discussed later in the 7th section of this report. The work was done by 2 PhD students in collaboration with other members of the group. The papers, talks and measurements will be selectively part of the two dissertations.

[11] Advanced European Infrastructures for Detectors at Accelerators `http://aida2020.web.cern.ch/`

4 Group Members

The ratios in the table below are counted from the start of the project 16.03.2015 to present plus an estimate for November and December.

No	Name	position	ratio FTE and domain
1	Florin MACIUC	physicist	10 % analysis and 40 % R&D (40 % analysis in an other LHCb project at IFIN-HH)
2	Alexandru Tudor GRECU	physicist	45 % analysis (45 % in an other LHCb project at IFIN-HH)
3	Mihai STRATICIUC	physicist	50 % R&D
4	Lucian-Nicolae COJOCARIU	PhD student	90 % R&D for Upgrade 10 % other LHCb project
5	Vlad PLACINTA	PhD student	90 % R&D for Upgrade 10 % other LHCb project
6	Lavinia Elena GIUBEGA	PhD student	50 % analysis (50 % in an other LHCb project at IFIN-HH)
7	Alex Catalin ENE	PhD student	50 % analysis 50 % in an other LHCb project
8	Laurentiu DUMITRU	staff	50 % LHCb Online group and local cluster admin. R&D Upgrade
9	Teodor IVANOAICA	programmer admin	20 % LHCb Grid Computing and R&D (20 % in an other LHCb project at IFIN-HH)
10	Nicoleta-Ileana DUMITRU	staff	30 % accounting
11	Ovidiu HUTANU	M.Sc. student	10 % R&D for Upgrade
12	Mihai Dimian	physicist	8 % analysis and 10 % R&D
13	Cristian Andy TĂNASE	researcher	30 % R&D
14	Cristian PIRGHIE	physicist	28% analysis
15	Camelia PIRGHIE	physicist	30 % analysis
16	Marius PRELIPCEANU	researcher	30 % R&D
17	Dorin-Andrei ANTONOVICI	PhD student	26% R&D
18	Adrian BODNĂRESCU	PhD student	28% analysis

Since I am in this group since middle of 2012, some information on 2011 might be inaccurate. The list is not complete as we do not know the full list of PhD and Master students that left an LHCb project before 2012. The following former members of this group, Bogdan Paul POPOVICI and Ion BURDUCEA have received their PhD when involved in the former LHCb project. Mihai STRATICIUC, presently member of the group, took his PhD title also during the former project. Marius ORLANDEA has received the PhD title and left the project in 2014. Ana-Elena Dimitriu has left the project after MSc graduation for a PhD position in ATLAS, Catalin HANGA after taking the M.Sc. in our group has left to follow a carer in physics. Except for Catalin Hanga the previous members are still IFIN-HH employees.. Other former students: Ionut Nastasa – working in the telecommunication industry; Marius Dogaru – working in industry; Eliza Teodorescu - changed field to astrophysics and is a researcher in the neighboring institute: Institute of Space Science - ISS; George Musat was hired by DELL-Romania.

Besides these students there are present members of the group like Alex Catalin ENE and Vlad PLACINTA which finished an M.Sc thesis on LHCb themes, and now they started a PhD with an LHCb topic. In addition two PhD students Elena Giubega and Adrian BODNĂRESCU just defended their PhD thesis in September and await the official title confirmation.

No	Name	former position in group	present position	Institute
1.	Bogdan Paul POPOVICI	PhD student	researcher 3rd grade	IFIN-HH
2.	Ion BURDUCEA	PhD student	researcher 3rd grade	IFIN-HH
3.	Eliza TEODORESCU	PhD student	researcher 3rd grade	Institute of Space Science
4	Mihai STRATICIUC	PhD student	researcher 3rd grade	IFIN-HH (LHCb group)
5.	Marius ORLANDEA	PhD student	researcher	IFIN-HH
6.	Ana-Elena Dimitriu	M.Sc. student	PhD student	IFIN-HH and Marseilles
7.	Catalin HANGA	M. Sc. student	PhD student (2015)	Zurich UZH (2015)

5 Papers and talks in last year

5.1 Papers and EDR contribution

Group papers:

• L.E Giubega on behalf of the LHCb Collaboration, "Radiative Decays at LHCb", Physics of Atomic Nuclei, 2016, Vol. 79, No. 10, pp. 47–52, ISSN 1063-7788;

• L.E. Giubega, A.I. Jipa, A.C. Ene, "Study of the resonances structure appearance in the $\Lambda_b \to \Lambda^*(\to p^+K^-)\gamma$ decay using helicity formalism", accepted for publication to Romanian Journal of Physics, `http://www.nipne.ro/rjp/accpaps/019-ElenaGCDC0D9.pdf`

• L. N. Cojocariu, V. M. Placinta, and L. Dumitru, "Monitoring System for Testing the Radiation Hardness of a KINTEX-7 FPGA", 9th International Physics Conference of the Balkan Physical Union (BPU-9), AIP Conf. Proc. volume 1722, p 140009 (2016); `http://dx.doi.org/10.1063/1.4944199`, 2016;.

• A.C. ENE, A. GRECU, "“Comparison of cosmic ray models with PYTHIA at energies near the 2nd ‘knee’ of the cosmic ray spectrum”", in preparation;

• L. N. Cojocariu, V. M. Placinta, F. MACIUC, et al. "Measurement of Single Event Effect Cross-Sections and Thresholds on a Xillinx Kintex-7 FPGA device under ion beam", in preparation.

• V. M. Placinta, L. N. Cojocariu, F. MACIUC, A. GRECU et al. "Radiation-hardness of a Xillinx Kintex-7 FPGA device for 0.5 Mrad Total Ionization Dose in 200 MeV proton beam", in preparation.

• F. MACIUC, L. N. Cojocariu, V. M. Placinta, et al. "Extrapolation of Single Event Effects from a low energy ion and proton beam spectrum to the LHC environment", in preparation.

• Other Upgrade papers are being prepared.

• F. MACIUC, L. COJOCARIU, V. PLACINTA, S. WOTTON, A. TANASE, A.GRECU, "RICH Upgrade PDMDB EDR - Kintex-7 FPGA Radiation Hardness Tests and Implications", LHCb RICH Upgrade PDMDB EDR , `https://indico.cern.ch/event/515232/`, Jun 2016;

LHCb papers where one of the members was involved in the analysis evaluation and the internal LHCb approval

• Alex Grecu - reviewer for an LHCb analysis, one publication pending, for reasons of LHCb policy we wait for the paper to be submitted to Journal or at least to preprint.

• F. MACIUC - review of an LHCb analysis published this year: LHCb Collaboration, "Study of the production of Λ_b^0 and $\overline{B}^0$ hadrons in pp collisions and first measurement of the $\Lambda_b^0 \to J/\psi p^+K^-$ branching fraction", arXiv:1509.00292; LHCB-PAPER-2015-032; CERN-PH-EP-2015-223,, Chin. Phys. C 40 (2016) 011001;

5.2 Conference and Workshop talks

Here we include the international and national events, the EDR talk and the "LHCb Weeks" plenary talks:

• Lucian Nicolae COJOCARIU, Florin MACIUC, Vlad-Mihai PLACINTA "Experimental study on Soft Error Mitigation Core (SEM IP) efficiency", Workshop on Sensors and High Energy Physics (SHEP 2016), Stefan Cel Mare University of Suceava (USV), Suceava, Romania, 21 – 22 October 2016.

• Vlad-Mihai PLACINTA, Lucian Nicolae COJOCARIU "Test bench for ASIC radiation hardness evaluation", Workshop on Sensors and High Energy Physics (SHEP 2016), Stefan Cel Mare University of Suceava (USV), Suceava, Romania, 21 – 22 October 2016.

• Vlad-Mihai PLACINTA, Lucian Nicolae COJOCARIU, "KINTEX-7 Irradiation, test bench and results", Topical Workshop on Electronics for Particle Physics (TWEPP 2016) radiation hardness dedicated session within the workshop, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, 25 – 29 September 2016.

• Florin MACIUC on behalf the radiation-hardness RICH group "RICH Upgrade PDMDB EDR - Kintex-7 FPGA Radiation Hardness Tests and Implications", talk at LHCb RICH Upgrade PDMDB EDR meeting, `https://indico.cern.ch/event/515232/contributions/2200003/attachments/1298523/1939936/talk_PDMDB.pdf`

• Florin MACIUC, "High Energy Physics Measurements, Status and Prospects" Workshop on Sensors and High Energy Physics (SHEP 2016), Stefan Cel Mare University of Suceava (USV), Suceava, Romania, 21 – 22 October 2016.

• Florin MACIUC, "Measurements and Physics of Single Event Effects in Integrate Circuits" Workshop on Sensors and High Energy Physics (SHEP 2016), Stefan Cel Mare University of Suceava (USV), Suceava, Romania, 21 – 22 October 2016.

• LHCb 63rd Analysis and Software Week, CERN, 9-13 May 2016, Geneva, Switzerland, `https://indico.cern.ch/event/442259`

- Alex GRECU, "HEPData mini workshop summary", 09.05.2016 (plenary)

• The new HEPData mini-workshop, CERN, 25 April 2016, Geneva, Switzerland `https://indico.cern.ch/event/512652`

- Alex GRECU"LHCb and HEPData", 25.04.2016 (plenary)

• QCD@LHC 2016, UZH & ETH, 22-26 August 2016, Zuerich, Switzerland `https://indico.cern.ch/event/516210`

- Alex GRECU "Gauge boson physics in the forward region at LHCb", 22.08.2016 (parallel)
- Alex GRECU "Impact of LHCb results on the tuning of Monte Carlo generators", 22.08.2016 (parallel)

• SHEP 2016, Stefan cel Mare Univ. of Suceava, 21-22 October 2016, Suceava, Romania `https://indico.cern.ch/event/574939`

- Alex GRECU, "Overview of the LHCb Monte Carlo Simulation Framework", 21.10.2016 (plenary)

5.3 List of talks of LHCb-RO group members at CERN during LHCb group meetings

Some of the following data is not public, hence use the links with care:

1. Lucian Cojocariu, "Kintex-7 FPGA radiation hardness studies, test bench, firmware, error mitigation & scrubbing", LHCb Upgrade Electronics, February 11th 2016, `https://indico.cern.ch/event/490512/`.
2. Lucian Cojocariu, "Firmware, error mitigation & scrubbing for Kintex-7 FPGA radiation hardness studies", Mini-meeting on irradiations for RICH Upgrade, February 26 th 2016, , `https://indico.cern.ch/event/503375/`;
3. Lucian Cojocariu, "Preliminary results of KINTEX-7 irradiation with heavy ions at Louvain", RICH Upgrade Meeting, June 14 th 2016, `https://indico.cern.ch/event/540695/`.
4. MACIUC Florin, "Radiation hardness-tests Kintex-7 - preliminary report for Louvain test",RICH Upgrade Meeting, June 14 th 2016, `https://indico.cern.ch/event/540695/`.
5. Florin MACIUC, "Radiation hardness-tests Kintex-7 FPGA :firmware and irradiation facilities", RICH Upgrade meeting, April 29th, 2016, `https://indico.cern.ch/event/524567/`;
6. Florin MACIUC,"Radiation hardness of Kintex-7", RICH Upgrade Meeting 31 Aug 2016, `https://indico.cern.ch/event/564099/`
7. Alex Grecu, "GenTune migration to Rivet 2.x", Simulation Meeting, 24.11.2015;
8. Alex Grecu, "Report from QEE: MinBias", Simulation Meeting, 16.02.2016
9. Alex Grecu, "Data Quality(DQ) Report", Physics Performance, Trigger & Stripping, 06.06.2016
10. Alex Grecu, "HepData and RIVET usage in LHCb", LHCb Physics Planning Group meeting, 21.07.2016
11. Alexandru T. Grecu, "MCStatTools. Patching for Spill-over Productions", Simulation Meeting, 30.08.2016
12. Alex Grecu, "Data Quality(DQ) Report", Physics Performance, Trigger & Stripping, 16.10.2016
13. Alex Catalin ENE, "Particle production in pp collisions at LHC energies", University of Bucharest Faculty of Physics Annual Scientific Session 2016, Bucharest, June 2016.

14. Alex Catalin ENE, "Particle production in pp collisions at LHC energies", Faculties of Physics Pentagon Conference 2016, Cluj-Napoca, July 2016, first prize at Master-PhD level;

15. Adrian Bodnarescu, "Quantum Chromodynamics and the Renormalization Theory", Workshop on Sensors and High Energy Physics (SHEP 2016), 21-22 October 2016, Stefan cel Mare University of Suceava,

16. Cristian-Andy Tănase, "Designing of radiation tolerant architectures implemented on FPGA Kintex7 within the LHCb project", Workshop on Sensors and High Energy Physics (SHEP 2016), 21-22 October 2016, Stefan cel Mare University of Suceava,

17. Marius Prelipceanu, "Detection and Investigation of localized states in new electron transporting heterocyclic polymers and oligomers suitable for optoelectronics devices", Workshop on Sensors and High Energy Physics (SHEP 2016), 21-22 October 2016, Stefan cel Mare University of Suceava,

18. Cristian Pîrghie, "European Researchers Night at Suceava", Workshop on Sensors and High Energy Physics (SHEP 2016), 21-22 October 2016, Stefan cel Mare University of Suceava,

19. Ana-Camelia Pîrghie, "Astronomy and Astrophysics Olympiad – Selection process at USV", Workshop on Sensors and High Energy Physics (SHEP 2016), 21-22 October 2016, Stefan cel Mare University of Suceava,

5.4 Schools and PhD admission

1. Vlad PLACINTA "International School of trigger & Data Acquisition- ISOTDAQ 2016, Weizmann Institute of Science, Rehovot-Tel Aviv, Israel, 24 January-3 February 2016;

2. Alex Catalin ENE, "Frontier in particle physics: Flavour physics", 7-11 November 2016, Niels Bohr Institute Copenhagen, `https://indico.nbi.ku.dk/conferenceDisplay.py?ovw=True&confId=897`

3. Alex Catalin ENE, "Observation of production and decay of particles in the forward region at the LHCb experiment", admission talk to the Doctoral School of "Physics of the atom, nucleus, elementary particles, Astrophysics and applications" PhD program of the Faculty of Physics of the University of Bucharest in September 2016.

5.5 LHCb papers

Since the start of the new LHCb project on 16.03.2016, there were published 38 LHCb Collaboration papers, and 50 over all 2016. The scientific output of the collaboration remains as strong as previous years.

5.6 Other deliverables from IFIN and USV

- Workshop on Sensors and High Energy Physics (SHEP 2016), 21-22 October 2016, Stefan cel Mare University of Suceava `https://indico.cern.ch/event/574939/overview` The event was organized by USV and IFIN-HH, the IFIN-HH subgroup was funded for this event through a different project. The workshop contained 3 sessions: CERN Physics and Standard Models of Particle Physics, Detection – sensors and electronics, reconstruction methods, Outreach & Education activities for physics, electronics and astrophysics. The interdisciplinary SHEP 2016 workshop had 28 presentations and approximately 100 participants from Romania, France, Belgium, USA, Ukraine and Republic of Moldova, of these a high fraction were USV students and the high-school olimpic team (Astronomy and Astrophysics).

- Recently, a series of patches were written to restore full functionality to the collaboration internal tool for creating and managing the MC production statistics reports. We also managed to re-commission the whole storage of the private cluster using rather fast (3 TB/day) specifically designed filling and testing software.

- The GRID site Ro-11 is under the management of the group and we have provided its services to the LHCb Virtual Organization for Grid Computing. We also provided support for few packages and of

LHCb simulation software, e.g. RIVET and LHCb software. We have organized several Outreach activities from which 2 were Masterclasses at University of Suceava and at IFIN-HH in collaboration with the Outreach group of LHCb for live feed from CERN.

- CERN/LHCb shifts done by one member of the group: 21 full-day shifts DQ (off-line Data Quality), May,31 - June, 6 at CERN June, 14 - 20 at CERN, October, 10 - 17 remote. Data Quality is the monitoring of reconstruction efficiency and subdetector performance or alignment, for LHCb collision data, within a maximum of few days after recording ti;

- MC liaison for the QEE physics working group - person responsible for creating, submitting and testing simulated data samples for physics analyses. He also has to validate new LHCb simulation software stack for soft-QCD analyses

- One position of convener for soft-QCD physics within the sub-group of QEE working group - end of mandate in March, 2017

6 Further group activities

6.1 Collaborations

There are two partners in the project IFIN-HH and USV, each with relative weights of 7.5 and 2, respectively, ratios reflectig the the human resources alocated to the project. We collaborate on physics analyses, and on technological and scientific applications for LHCb Upgrade program.

We have a relation of collaboration with the universities that host the Doctoral programs of our PhD students: University of Bucharest, University of Suceava, University "Politehnica" Bucharest.

Regarding the facilities used in the radiation hardness tests, we had used the services provided by the following institutes:
⋆ INFN National Laboratory of Legnaro (Padova, Italy) - SIRAD facility was accessed through the local program;
⋆ Universite Catolique de Louvain la Neuve Centre de Cyclotron - Heavy Ion Facility accessed through the AIDA2020 program,
⋆ Paul Scherrer Institut Villigen Switzerland - the tests at Proton Irradiation Facility were covered partially through the IFIN-HH Core funding.

We also have an agreement for a next set of irradiation tests in 2017 with: 1. Forschungszentrum Jüelich, Julic/COSY cyclotron facility where we intent to use the beam with 35-45 MeV protons, and 2. National Laboratory of Legnaro again for two runs with proton and ion-cocktail beams.

The scientific program of the group involves collaborations with our partners from Omega Micro Lab and with our LHCb-RICH partners like the CERN group, the Cambridge group, and the Oxford group.

6.2 Local Synergies

We benefit from a high degree of synergy between the program of this project and the second LHCb project PN-II-ID-PCE-2011-3-0749; contract no. 56/07.10.2011, with title "Studies of Flavour Production Mechanisms in the pp Interaction", funding agency Executive Agency for Higher Education, Research, Development and Innovation Funding (UEFISCDI). We also benefit from synergy between the project objectives and the IFIN-HH Core funding project "Frontier research in the physics of elementary particles".

6.3 Education and Outreach

As stated, we have currently 4 PhD students in the group working full time on an LHCb subject, plus 2 PhD students at University of Suceava working part time for the LHCb project. We also have in group other PhD students hired as Computing support staff within IFIN-HH group.

Besides the PhD programs which we support directly or indirectly, we have, like in the past years, a strong outreach program:

1. "LHCb International Masterclass", Suceava, 2 March 2016, CERN (LHCb), IFIN-HH, and "Ştefan cel Mare" University of Suceava `http://www.nipne.ro/dpp/Collab/LHCb/outreach_ro.html`. The event

was organized in collaboration with CERN (LHCb). More than 40 participants, mostly high school students from Suceava region, were at University of Suceava for one day and participated to lectures and applications on elementary particles or LHCb experiment. The event concluded with a dedicated LHCb tutorial on D0 lifetime measurement at the LHC.

2. Selection process and training for International Olympic events in Astrophysics and Astronomy. The selection process and the student training for International Olympiad on Astronomy and Astrophysics (IOAA) and International Olympiad on Astronomy (IOA) was held at University of Suceava by members from within the LCHb group – Suceava being involved in the organization, selection, and training. They have taught the students some aspects of particle physics and High Energy Physics (HEP), including LHCb experiment and how to solve some problems related to matter-antimatter and decay process investigated by LHCb experiment. Romanian team ranked first in the world at the IOA, in October 2016. `http://www.issp.ac.ru/iao/2016/ia16pw.html`

4. European Researcher Night, September 2016 – Suceava, LHCb team has widely publicized the LHCb experiments, astrophysics and astronomy among approximately 3000 participants at this event at the University of Suceava.

5. Museums Night, May 2016 – Suceava, LHCb team has widely publicized the LHCb experiments, astrophysics and astronomy among approximately 2500 participants at USV Astronomic Observatory and Planetarium.

7 Research plan and goals for each of next three years

7.1 Scientific objectives - General context and specifics

7.1.1 Physics - LHCb analyses and Monte Carlo Models

In the next years the group needs to finalize the tasks began in the past like some of the strangeness production studies, and decide if we continue the effort towards a better understanding of the phenomenological models applied in the non-perturbative domain of QCD interactions. Though the soft-QCD and Minimum Bias physics measurements at LHCb were one of the main component of the physics program, a second objective was always the studies of particle production in hard-QCD events were components originating directly in the main parton-parton collision are investigated. Here other aspects like heavy flavour physics in the decay of heavy hadrons were studied.

The plan for the next years is subject to the constrains dictated by PhD and Post Doc personal evolutions, and also how successfully the new team from University of Suceava could integrate in the scientific program of LHCb collaboration and how proficient will the new members become in high-energy physics activities. Hence, with the previous caveat, the plan is to allocate enough resources to continue the work in the soft-QCD physics aspects at level of both LHCb measurements and ass well as Monte Carlo models of particle production in proton-proton collisions at LHC energies. As in the past years, the intent is to dedicate at least an important segment of our resources to the domain of hard-QCD measurements and heavy flavour decay studies. The main objective remains integration in the mainstream analyses of the LHCb like beauty and charm decay studies.

The very long term goal is to prepare the ground for the next LHCb measurements for the Upgrade-phase of the detector with target luminosity of 50 fb^{-1}. For this, as the workforce is evolving, we propose to use the more experienced members on complex beauty and charm analyses and concentrate the future PhD studies towards Minimum Bias physics. For the Upgrade phase the target are the rare penguin-loop type of heavy flavour decays and polarization studies for these particles. For these more complex tasks it is clear the need to integrate our members in larger LHCb work-group studies which target these measurements.

7.1.2 Upgrade studies - Physics and Technology

The Upgrade scientific objective become in the last year one of the main objective of the group. SEE cross-section measurements on complex Integrated Circuits (IC) are now an established task of the group. Also important here is to be able to propagate through extrapolation the measurements done for the fixed radiation source and low beam particle energy to the LHC environment or to space applications. The former extrapolation procedure involves simulation of the basic nuclear processes in the IC and an approximate description of the mixed radiation environment existent at LHC. The displacements, high-LET events, the total ionization dose (TID), and non-ionizing energy loss (NIEL) effects need to be carefully balanced in this extrapolation procedure.

For each fixed source experiment, a separate analysis will conducted and published. The process will involve the estimation of measured quantities function of LET and TID, e.g. SEE cross-sections per bit. The next stage is simulation of underlying physics, like nuclear collisions and radiation propagation through material. All these aspects will be highlighted in parallel with the technological aspects of the problem.

7.2 Outline of the Work Plan for next 3 years

7.2.1 LHCb data analyses in 2017

1. Strangeness production like V0 at $\sqrt{s} = 13$ TeV, hyperon production in RUN 1 data.
2. Tuning of a proton-proton collisions event generator: PYTHIA 8 "LHCb-flavored" configuration.
3. LHCb measurements integration in HepData repository, together with RIVET plugin development.
4. Beauty hadron rare decays involving penguin-loop type of processes. The radiative decay studies will continue and integration in the larger work group is considered.
5. Searches for new resonances and measuring properties of the known intermediate states of beauty and charm decays. At this stage it consists mostly of feasibility studies.

6. CRMC - EPOS, QGSJet, SYBILL - and PYTHIA, physics description of the proton-proton collision with possible extension to proton-ion. The intent here is to use some of the cosmic ray physics to improve the LHCb Monte Carlo event description and also use some for the air shower measurements information if possible.

The workforce allocation plan is not yet ready at this stage, and anyway from past experience it will suffer continuous changes as the PhD students and Post Doctoral personal will gain experience. Here is were the scientific work plans differ with respect to industry projects and timetables.

7.2.2 Upgrade in 2017

1. Radiation harness test for IC: FPGA and ASICs: Julic and Legnaro testing and possible one or two other facility application.
2. Test bench for MaPMT aging studies and radiation hardness.
3. Involvement into RICH-Upgrade construction: Photon Detector Module (PDM) construction and testing of individual components
4. PDMDB - digital board testing and firmware testing in radiation with high TID.
5. PDMDB construction and testing of optical link boards.
6. PDMDB - digital board test bench, design and beginning of actual mass testing.

As stated in the previous section, the intention is to expand both the physics analyses group as well as the Upgrade task force. For the technical aspects we need to include one or even 2 new members, depending on the funding directed to LHCb projects.

7.2.3 Long Term Plans 2018-2019, Phase II in the HC-LHC time-frame

The next set of tasks will depend on the 2017 task rate of completion. The physics analyses will slowly shift weight to high-pt studies in hard-QCD particle production, and also the decay and resonance formation in beauty and charm sector should receive more resources. The feasibility studies for key channels of interest in LHCb Upgrade-phase physics will also begin in earnest.

The upgrade will concentrate on testing several hundreds RICH Digital Board communication test boards or more exactly of their sub-boards. The activities will include the aging and radiation-hardness tests for sensors and some PDMDB components. In the second long shutdown we will provide workforce for PDMDB assembly and testing and also on-site installation.

Regarding the discussion of Phase II Upgrade of the LHCb in parallel with HL-LHC, we investigate the possibility to participate to the Upgrades of RICH detectors. The first estimates for the RICH Upgrade costs in Phase II is in the range lower than 10 million CHF, which might indicate a contribution down-scaled by a factor of 2 compared with the present Upgrade. The phase II Upgrade is also expected to be longer in time with respect to the present upgrade.

7.2.4 Computing support for LHCb and Outreach

We shall continue to support Ro-11 WLCG Tier-2 site and we shall support some computing and LHCb software tasks for collaboration. The educational and Outreach activities should increase in scope and horizon.

We are looking for partners for LHCb new projects at other calls and we continue the effort to develop the vital human resource and to increase the size of the group by bringing motivated and efficient personal on-board.

7.2.5 Personnel Table with expected evolutions

The following FTE ratios include for the personal with permanent position the funding from additional projects, this in case the project objective are synergistic with LHCb tasks.

No	Name	expected position 2017-2018	ratio FTE and domain
1	Florin MACIUC	physicist	50 % analysis and 50 % R&D
2	Alexandru Tudor GRECU	physicist	100 % analysis
3	Mihai STRATICIUC	physicist	50 % R&D
4	Lucian-Nicolae COJOCARIU	IDT	100 % R&D for Upgrade
5	Vlad PLACINTA	PhD student	100 % R&D for Upgrade
6	Lavinia Elena GIUBEGA	researcher	100 % analysis
7	Alex Catalin ENE	PhD student	100 % analysis
8	Laurentiu DUMITRU	staff	50 % Computing
9	Teodor IVANOAICA	programmer	30 % Computing and R&D
10	Nicoleta-Ileana DUMITRU	staff	30 % accounting
11	Ovidiu HUTANU	PhD. student	25 % R&D for Upgrade
12	Doctoral position	PhD student	100 % anaalysis
13	senior position	researcher	100 % anaalysis
14	Post Doctoral	researcher	100 % R&D and programming
15	Mihai Dimian	physicist	10 % analysis and 10 % R&D
16	Cristian Andy TĂNASE	researcher	30 % R&D
17	Cristian PIRGHIE	physicist	30% analysis
18	Camelia PIRGHIE	physicist	30 % analysis
19	Marius PRELIPCEANU	researcher	30 % R&D
20	PhD or researcher	physicist	50% R&D
21	Adrian BODNĂRESCU	physicist	28% analysis
22.	PhD or Post Doc	physicist	50% R&D and programming

IDT stands for Research engineer with PhD in Engineering Sciences. The hope is to get funding for part of the upper positions from other sources of funding, hence for IFIN and USV the change would be form 9.5 FTE to 11.5 FTE only. And also the PhD positions would be covered in much larger ratios from the project with respect to permanent staff, i.e. researchers and physicist.

7.2.6 Budget request

The proposed budget is outlined in the tables at the end of the report.