ANEXA 1.A

Call: ELI-RO/RD/2024 **Project acronym: ELITE**

ELI-NP Thematics: GDE/I.5 Photo-fission studies; GDE/I.7 Techniques and instrumentation for production, transport and diagnostics of radioactive ion beams; GDE/I.11 Development of common data format for VEGA experiments.

Annual Summary Document[1]

Year: 2025

Months: January – December

Project Title: Frontier nuclear fission studies at ELI-NP / ELITE

Project Work Plan

Stage: II.

Activities:

II. 1. Spontaneous fission experiments with a ^{252}Cf source at ELI-NP (part II)

II. 2. In-beam photo-fission experiments (part II)

II. 3. Innovative solutions for FF detectors and RF carpets (part II)

II. 4. Digital pulse processing and automation of fission detectors (part II)

Allocated budget: 1.686.400,00 lei

Realized budget: 1.686.400,00 lei

[1] Please fill in all the required items and do not alter the template

1. Cover Page:

- Group list (physicists, staff, postdocs, students): The project team is the following:

1. Dimiter L. Balabanski, Project Director, CS I;
2. Alexandru N. State, Activity Responsible, Post-Doctoral Assistant;
3. Adrian I. Rotaru, Activity Responsible, Research Scientist, CS;
4. Sohichiroh Aogaki, Activity Responsible, IDT II;
5. Par-Anders Soderstrom, CS II;
6. Paul Constantin, CS III;
7. Asli Kusoglu, CS III;
8. Deepika Choudhury, CS III;
9. Sangeeta Dhuri, Post-Doctoral Assistant;
10. Midhun Cherumukku, Post-Doctoral Assistant;
11. Kabita Kundalia, Post-Doctoral Assistant;
12. Teodora Andreea Madgearu (Petruse), Post-Doctoral Assistant;
13. Rebeca Ban, Engineer, Master Student;
14. Radu Vasile Corbu, Engineer, Master Student;

- Specific scientific focus of group (state physics of subfield of focus and group's role);

The group works in the field of nuclear physics, addressing the emerging field of nuclear photonics. The PI and the members of the team address cutting-edge problems related to fission. The approach is twofold, by performing experimental work and subsequent data analysis and by designing and construction of innovative experimental equipment, implementation of next generation electronics, e.g., FPGA programmable digitizers, and improvement of the digital pulse processing, e.g., upgrades of the existing digital data-acquisition system.

- Summary of accomplishments during the reporting period.

In the second year of the project, for activity II.1 Spontaneous fission experiments with ^{252}Cf source at ELI-NP (part II), the work on analysis of prompt fission neutron energy-angular correlations (PFN) was finalized and submitted for publication. The data taking of FF-PFN-PFG (fragment-neutron-γ) correlations with ^{252}Cf source was finalized and the data analysis is in an advanced phase. For activity II.2 In-beam photo-fission experiments (phase II), the data analysis of the 2022-2023 HIγS, Duke U. experiment on ^{234}U was finalized and the results are in preparation for publication. A LoI for building a fission experimental setup and two experimental proposals have been approved by the 2025 IFIN-HH PAC. A paper describing the ternary-fission process was submitted. For activity II.3 Innovative solutions for FF detectors and RF carpets (part II), a prototype of a THGEM cascade detector was designed, mounted and tested in the laboratory and at the CCB cyclotron in Krakow, Poland. Eight of these modules will be used in an in-beam fission experiment at CCB in 2026 and within the fission campaign at the 9 MV Tandem accelerator of IFIN-HH. The results from the gas-jet characterization tests for RF carpets were analysed and prepared for publication. For activity II.4 Digital pulse processing and automation of FF detectors (part II), the performance of the digital DAQ DELILA was described in several publications. Tests with FPGA programmable digitizers were carried out and they can be implemented in DELILA and used in experiments in 2026. The procurement of the foreseen equipment for stage II (2025) has been completed. Six papers and two conference proceedings were published or submitted to peer-reviewed journals. Project results were presented 14 times at international conferences or invited seminars. Two post-doctoral researchers, Dr. Midhun Cherumukku and Dr. Kabita Kundalia have been hired, filling in the vacant positions.

2. Scientific accomplishments (max. 3 pages) – Results obtained during the reporting period.

Activity II.1 "Spontaneous fission experiments with ^{252}Cf source at ELI-NP (part II)": Spontaneous fission experiments with ^{252}Cf source at ELI-NP (part II), the work on analysis of prompt fission neutron energy-angular correlations (PFN) was finalized and prepared for publication; the data taking of fission fragment (FF) – PFN – prompt fission gamma (PFG) FF-PFN-PFG correlations was finalized and the data analysis is in an advanced phase.

Energy-angular neutron correlations measured with stand-alone ELEGANT-GN array: The ELIGANT-GN array was used for measurements of energy-angular neutron correlations. First results related to the two- and three-neutron angular correlations were reported in the 2024 report. For the comparison with the present experimental results, 10^7 FREYA events were generated, corresponding to about 5 minutes of ^{252}Cf decay with activity of 3.7 MBq. Results related to three-neutron angular correlations are shown in Fig. 1.

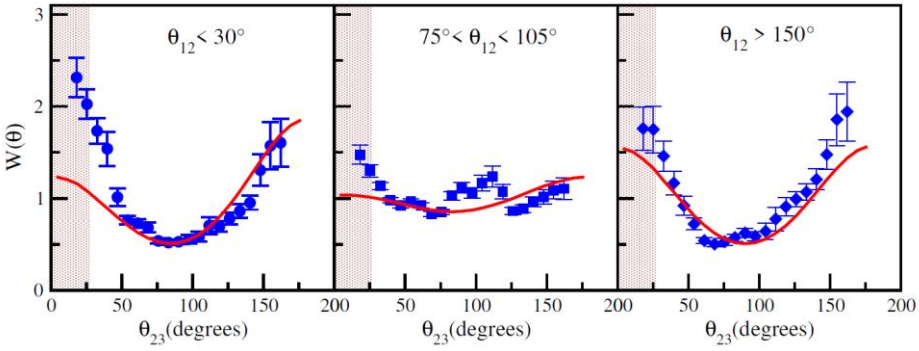

Fig.1. Three-neutron angular correlations with various neutron energies [1]: (left) Two neutrons are emitted within 30°; (middle) Two neutrons are emitted perpendicular to each other; (right) Two neutrons are emitted in opposite directions. The shaded region is most sensitive to cross-talk. The neutron yield *vs* the emission angle of the third neutron is compared with FREYA calculations in red.

The most important result from this study is displayed in the central part of Fig. 1. In this case, all the three neutrons are emitted perpendicular to each other. The experimental observation shows that if the first two neutrons are emitted perpendicular to each other, the third neutron does have a higher probability of being emitted either in the direction of one of the first two neutrons or perpendicular to both of them. Those events where three neutrons are emitted perpendicular to each other may have contribution from the scission neutrons. Such events are not included in the FREYA algorithm, as demonstrated in Fig. 1. The results from this experiment are submitted as a letter to Physical Review C [1].

Measurement of FF-PFN-PFG correlations with the ELIGANT-GN array coupled to a FF trigger: A Si DSSD detector was integrated with the ELIGANT-GN array for measurements of the vector of the fission fragment. For this purpose, a prototype vacuum chamber was constructed and used in the experiments. The data taking started in September 2024 and ended in March 2025. The digital DAQ, DELILA was upgraded to integrate the FF Si DSSD detector, which serves as a fission trigger. The data analysis is in an advance stage. Correlations related to the two-neutron emission from the light fragment are displayed in Fig. 2. First results from these measurements were reported [2].

Activity II.2 "In-beam photo-fission experiments (part II)": The analysis of the 2022-2023 photo-fission experiment of ^{238}U at the HIγS free-electron laser facility, Duke University was finalized and first results were reported at the 2025 Nuclear Photonics conference [3]. Results related to the pre-neutron mass distributions at different energies of the γ beam are presented in Fig. 3.

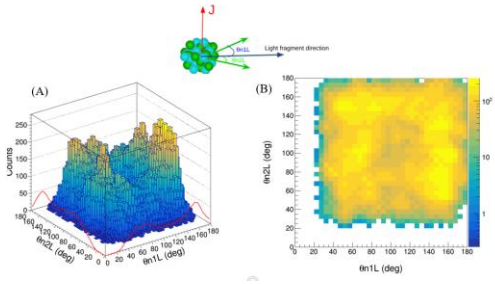

Fig. 2: (A) Two-neutron angular correlation between form light-fragment emision. The red solid lines shows the projections of the distributions on respective axes, and (B) Top view of fragment distributions shown in (A).

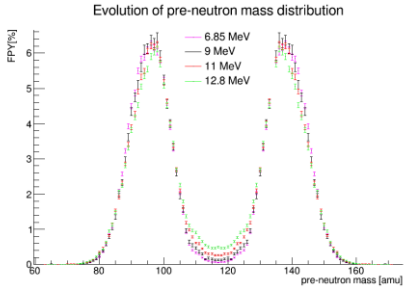

Fig. 3. Pre-neutron mass distribution in photo-fission of ^{238}U at different γ-beam energies.

A LoI for fission has been submitted to the 2025 IFIN-HH PAC. A CAD drawing of the experimental setup is shown in Fig. 4. Two experiments with this setup were suggested, namely a study of fragment distribution and prompt fission neutron multiplicity in the fission of ^{215}Fr and probing of equilibrium and quasi-equilibrium fission modes in ^{221}Ac. In addition, a theoretical description of fission dynamics was developed. Results are illustrated in Fig. 5. A paper describing the fission process was submitted to Physical Review Letters [4].

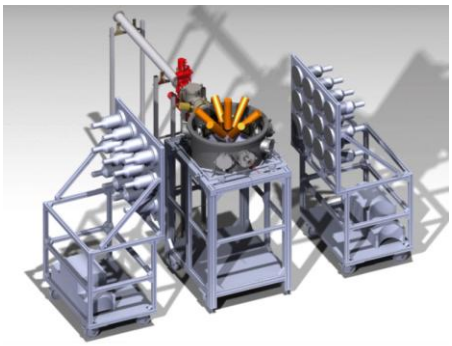

Fig. 4. CAD design of the fission setup which will be built at line 6 of the IFIN-HH 9 MV tandem.

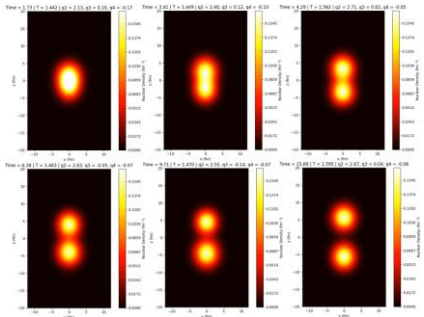

Fig. 5. Calculations of fission dynamics using time-dependent density-functional theory [4].

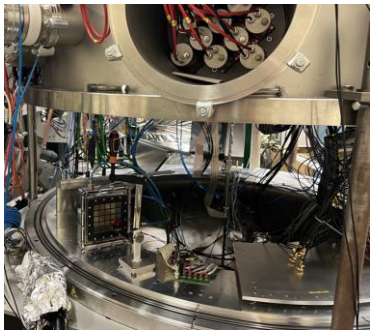

Fig. 6. The THGEM prototype detector module mounted for test in the reaction chamber at CCB, Krakow.

Activity II.3 "Innovative solutions for FF detectors and RF carpets (part II)": A prototype of a cascade THGEM detector assembly was designed. It was tested in the laboratory and at the CCB cyclotron in Krakow, Poland, as shown in Fig. 6. Eight of these modules will be used in an in-beam fission experiment at CCB in 2026 and at the 9 MV Tandem accelerator of IFIN-HH. In addition, the characterization supersonic gas-jets which are used for heavy-ion extraction from ion-catchers was finalized and the results were submitted for publication [5]. Results related to the measured velocity contours of the supersonic jets are presented in Fig. 7. The ions are further delivered to and trapped by RF carpets. The characterization of the RF carpets is ongoing and will be finalized in 2026.

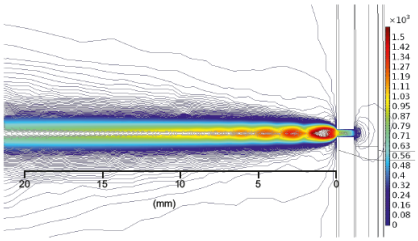

Fig.7. Velocity contour plot of a supersonic helium jet formed in a 0.5 mm nozzle [5]. The velocity is in m/s.

Activity II.4 "Digital pulse processing and automation of FF detectors (part II)": the performance status of digital DAQ DELILA was described in two publications [6,7]. A PHA algorithm was integrated into the open-FPGA digitizers, which can now be used for fission-fragment detection with silicon detectors. The current custom firmware which is based on a trapezoidal filter, can operate on 32 channels at a sampling rate of 125 MS/s and additional processing algorithms may be added in the future. The ongoing plan is to develop and evaluate a fully digital DAQ approach using the VX2730 for fission-fragment detection, applying digital pulse-processing techniques to THGEM waveforms. Results from these tests have been published [8].

References:

[1] D. Choudhury, P.-A. Söderström, D.L. Balabanski, and M. Cuciuc, Phys. Rev. C (2025) submitted
[2] D.L. Balabanski, A. Kusoglu and P.-A. Söderström, EPJ Web of Conferences **342**, 01002 (2025)
[3] V. Wende *et al*., *Abstract*, 5th International Conference on Nuclear Photonics, Oct. 6th-10th, 2025, Darmstadt, Germany
[4] Midhun C.V., D.L. Balabanski and A. Oberstedt, Phys. Rev. Lett. (2025) submitted
[5] A. State *et al*., Eur. Phys. J. Plus (2025) submitted
[6] S. Aogaki and S. Nicolae, EPJ Web of Conferences **337**, 01156 (2025)
[7] S. Aogaki *et al*., IEEE Trans. Nucl. Sci. (2025) in print
[8] S.R. Ban *et al*., UPB Bulletin **87**, 165 (2025)

3. Group members (table):

No.	Name	Academic position	Realized FTE 2025 Jan. 1 – Dec. 31, 2025	PhD/Master students
1	Dimiter L. Balabanski	CS I	0.559	-
2	Alexandru N. State	Post Doc	0.405	-
3	Adrian I. Rotaru	CS	0.389	-
4	Sohichiroh Aogaki	IDT II	0.313	-
5	Par-Anders Soderstrom	CS II	0.173	-
6	Paul Constantin	CS III	0.388	-
7	Asli Kusoglu	CS III	0.267	-
8	Deepika Choudhury	CS III	0	-
9	Sangeeta Dhuri	Post Doc	0.322	-
10	Midhun Cherumukku	Post Doc	0.177	-
11	Teodora Andreea Madgearu (Petruse)	Post Doc	0.279	-
12	Kabita Kundalia	Post Doc	0.081	-
13	Rebeca Ban	Engineer	0.285	Student
14	Radu Vasile Corbu	Engineer	0.153	Student

1. Deliverables since the project started: July 2024 – Dec. 2025

The foreseen deliverables for stages I (Year 2024) and II (Year 2024) are Year Reports YR1 and YR2, which report the achieved milestones. The progress is displayed in the following table.

Milestones (table):

Activity	Milestone	Result	Related deliverables
Year Report I (YR1)			
AI.1.1	M1: Data analysis of PFN energy-angular correlations	achieved	Publications: [3,4] Conference presentations: [2,8,10,12,14]
AI.3.1	M10: PCB THGEM design	achieved	THGEM PCB prototype (in use) THGEM Frisch-grid prototype (in use)
AI.3.3	M12: Improvement of the RF concentric carpet technology	partly achieved	Publication: [6] Conference presentations: [3,4,19]
AI.4.2	M17: Slow-control system	achieved	Gas system slow-control prototype (in use)
Year Report II (YR2)			
AII.1.2	M2: Data analysis of FF-PFN-PFG energy-angular correlations	partly achieved	Conference presentations [12,14,15]
AII.1.3	M3: THGEM integration with the fission setup	partly achieved	Conference presentations [14,20] Proposals for experiments [1-3]
AII.2.1	M7: Data analysis of HIγS photo-fission experiments	achieved	Conference presentation [8]
AII.3.2	M11: THGEM detector	achieved	Conference presentations: [19,20] Prototype of THDEM detector (in use)
AII.3.3	M13: Improvement of RF spiral carpet technology	ongoing	Conference presentations: [4]
AII.3.4	M14: FBIC detector	delayed	

AII.4.1	M15: Integration of charged-particle and FF detectors with DELILA	achieved	Publications: [1,2,7-10] Conference presentations: [1,5-7,9,11,18]

The data analysis for the neutron energy-angular correlations in the spontaneous fission of ^{252}Cf within activity A.1.1 and for the photo-fission of ^{234}U within A.1.2 was finalized. A prototype of a cascade THGEM detector with a Frisch grid was delivered within activity A.3.2, and a PHA algorithm was integrated into the open-FPGA digitizers within activity A.4.1. In addition, the team members gave 14 conference talks and seminars, published or submitted six peer-reviewed paper and two conference papers, took part in several experiments led by our collaborators, and prepared three proposals for experiments which were approved by the 2025 IFIN-HH PAC. A CAD design for the in-beam FF-PFN-PFG experimental setup at the 9 MV tandem accelerator of IFIN-HH was finalized. The prototype THGEM cascade detector was tested at the beamline of CCB, IFJ PAN, Krakow, Poland.

- ***List of papers (journal or conference proceeding; journal papers are marked with *):***
  2024
  - [1] A. Kusoglu, D.L. Balabanski *et al.*, "*γ-ray spectroscopic study of self-conjugate ^{10}B nucleus with inelastic proton scattering*", EPJ Web Conf. **311**, 00020 (2024)
  - [2]* A. Kusoglu, "*The amazing world of the light nuclei*", Science Bull., **69**, 3303 (2024)

  2025
  - [3] D.L. Balabanski, A. Kusoglu, P.-A. Söderström, "*While waiting for γ beams at ELI-NP: First results from ELIGANT and ELIFANT experiments*", EPJ Web Conf. **342**, 01002 (2025)
  - [4]* D. Choudhury, P.-A. Söderström, D.L. Balabanski, and M. Cuciuc, "*Neutron energy-angular correlations in the spontaneous fission of ^{252}Cf: Evidence for scission neutrons*" Phys. Rev. C (2025) submitted
  - [5]* Midhun C.V., D.L. Balabanski and A. Oberstedt, "*Dynamical evolution of ternary particles from the neck region in the fission of ^{236}U*", Phys. Rev. Lett. (2025) submitted
  - [6]* A. State, P. Constantin, D.L. Balabanski *et al*., "*Characterization of supersonic helium jets used for heavy ion extraction from ion catchers*", Eur. Phys. J. Plus (2025) submitted
  - [7] S. Aogaki and S. Nicolae, "*Implementation and development of a DAQ system DELILA at ELI-NP*", EPJ Web Conf. **337**, 01156 (2025)
  - [8]* S. Aogaki *et al*., "*DELILA: A scalable data acquisition system for multi-detector nuclear physics experiments at ELI-NP"*, IEEE Trans. Nucl. Sci. (2025) in print
  - [9]* S.R. Ban *et al*., "*Hardware simulation of particle identification algorithms for silicon detectors*", UPB Bull. **87**, 165 (2025)
  - [10]* C.A. Ur, D.L. Balabanski *et al*., "*Extreme Light Infrastructure – Nuclear Physics: First Results"***,** Eur. Phys. J. A **61**, 248 (2025)

- ***List of talks of group members (title, conference or meeting, date):***
  2024
  - [1] A. Kusoglu, "*Pilot experiments with an array of large-volume $LaBr_3$:Ce and $CeBr_3$ scintillators with anti-Compton shields*", The 40th International Physics Congress of the Turkish Physical Society (TPS-40), Sep. 02-05, 2024, Bodrum, Türkiye

- [2] D. Choudhury, "*Neutron observables in the spontaneous fission of ^{252}Cf*", International Symposium on Nuclear Science (ISNS24), Sep. 9-13, 2024, Sofia, Bulgaria
- [3] A. N. State, "*Characterization of supersonic helium jets used for heavy ion transport in ion catchers*", International Symposium on Nuclear Science (ISNS24), Sep. 9-13, 2024, Sofia, Bulgaria.
- [4] A. Rotaru, "*Enhanced Ion Manipulation Using Harmonic Ion Transport System and Spiral RF Carpets*", International Symposium on Nuclear Science (ISNS24), Sep. 9-13, 2024, Sofia, Bulgaria.
- [5] A. Kusoglu, "*Understanding better the PDR strength through (d,pγ) reactions: N = 28 and 50 nuclei*", International Symposium on Nuclear Science (ISNS24), Sep. 9-13, 2024, Sofia, Bulgaria.
- [6] S. Aogaki, "*Implementation and development of a DAQ system DELILA at ELI-NP*", Conference on Computing in High Energy and Nuclear Physics (CHEP2024), Oct. 19-25, 2024, Krakow, Poland.

2025

- [7] J. Hauf *et al*., "*Determination of the energy-resolvable E1- and M1-strength distribution in ^{70}Zn*", DPG 2025 Spring Meeting, Cologne, Germany, March, 10-14, 2025
- [8] D.L. Balabanski, "*Nuclear photonics with gamma beams*", invited seminar, Babes-Bolyai University (BBU), April 16, 2025, Cluj-Napoca, Romania
- [9] D.L. Balabanski, "*Lessons learned from the g-RISING campaign at GSI*", Workshop on Nuclear Moments (WNM'25), May 12-14, 2025, IJCLab, Orsay, France
- [10] D.L. Balabanski, "*While waiting for γ beams at ELI-NP: ELIGANT and ELIFANT"*, 14th International Spring Seminar on Nuclear Physics, May 19-23, 2025, Ischia, Italy
- [11] T. Petruse *et al*., „*ELISSA detection system at ELI-NP*", International Symposium on Nuclei in the Cosmos XVIII (NIC XVIII), June, 15-20, 2025, Girona, Spain
- [12] D.L. Balabanski, "*News from ELI-NP: ELIGANT, ELIFANT and ELISSA*",Workshop on photonuclear science, August 9-10, 2025, Fudan University, Shanghai, China
- [13] D.L. Balabanski, "*Adam Maj, ELI-NP and the Giant future*", Workshop "Giant resonances and beyond" in honor of Professor Adam Maj, August 28, 2025, IFJ PAN, Krakow, Poland
- [14] D.L. Balabanski, "*Waiting for γ beams at ELI-NP: ELIFANT, ELIGANT and ELISSA*", New Frontiers in Nuclear Physics and Astrophysics (NNPA25), Sept. 1-4, 2025, Ankara, Turkiye
- [15] S. Dhuri, D.L. Balabanski *et al.,* "*The measurement of fragment–prompt neutron energy–angle correlations from 252Cf (sf)*", Theory-6 Scientific Workshop on „Nuclear Fission Dynamics and the Emission of Prompt Neutrons and Gamma Rays", Oct. 7th-10th, 2025, Aci Castelo, Italy
- [16] Midhun C.V., A. Obestedt, D.L. Balabanski, „*Microscopic insights into ternary fission through neck excitation dynamics*", Theory-6 Scientific Workshop on „Nuclear Fission Dynamics and the Emission of Prompt Neutrons and Gamma Rays", Oct. 7th-10th, 2025, Aci Castelo, Italy
- [17] V. Wende *et al*., "*Correlation experiments in photon-induced fission*", 5th International Conference on Nuclear Photonics, Oct. 6th-10th, 2025, Darmstadt, Germany

- [18] A. Kusoglu, D.L. Balabanski et al., "*Direct observation of the competing M1 and isospin-forbidden M3 transitions from the decay of the IAS in ^{10}B*", 5th International Conference on Nuclear Photonics, Oct. 6-10, 2025, Darmstadt, Germany,
- [19] T. Petruse, „*The charged-particle programme at ELI-NP*", invited seminar, Dec. 4, 2025, TU-Dresden, Germany
- [20] D.L. Balabanski, "*Sydney Gales: The first Scientific Director of ELI-NP – a teacher and a friend*", Workshop "Tribute to Sydney Gales", Dec. 15, 2025, IJCLab, Orsay, France

- ***Prototypes delivered within the project:***
  2024
  - THGEM PCB
  - THGEM Frisch grid
  - Gas system slow-control graphical user interface (GUI)

  2025
  - THGEM cascade detector assembly

- ***Proposals for experiments prepared within the project:***
  2025
  - [1] D.L. Balabanski *et al*., "*Setting in operation a multi-detector setup for fission and reaction studies at beamline 6 of the 9 MV tandem*", proposal to the 2025 IFIN-HH PAC, Nov. 28, 2025
  - [2] S. Dhuri *et al*., "*Measurement of fragment distribution and prompt fission neutron multiplicity in the fission of ^{215}Fr*", proposal to the 2025 IFIN-HH PAC, Nov. 28, 2025
  - [3] Midhun C.V. *et al*., "*Probing equilibrium and quasi-equilibrium fission modes in ^{221}Ac formed in the $^{12}C + ^{209}Bi$ reaction*", proposal to the 2025 IFIN-HH PAC, Nov. 28, 2025

- ***List of experiments performed within the project (participants, name of experiment, lab, dates):***
  2024
  - D.L. Balabanski, A. Kusoglu, "*E845 –Nuclear moment studies of short-lived excited states using TDRIV on H-like ions. Resolving the ^{22}Ne puzzle on the way to a study of ^{42}Ar and ^{44}Ar*", GANIL, Caen, France, Sep. 17-24, 2024
  - D.L. Balabanski, A. Kusoglu, "*IS748 – A study of seniority-2 configuration on N=126 and 124 isotonic chains*", ISOLDE CERN, Geneva, Switzerland, Sep. 28- Oct. 02, 2024
  - D.L. Balabanski, P.-A. Söderström, A. Kusoglu, S.R. Ban, "*Study of M4 stretched configurations decay in ^{12}C*", CCB, Institute of Nuclear Physics (IFJ), PAN, Krakow, Poland, Oct. 18-21, 2024
  - D.L. Balabanski, A. Kusoglu, "*Precision measurement of the $1_2^+ \rightarrow 0_1^+$ isovector transition of ^{14}N*", Triangle Universities Nuclear Laboratory, Durham, North Carolina, USA, Nov. 03-10, 2024
  - A. Kusoglu, S.R. Ban, "*NP2212-RIBF225-Nuclear moment of short-lived isomeric states using the TDPAC technique*", RIKEN Nishina Centre, Wako, Japan, Nov. 14-24, 2024
  - P.A. Söderström, A. Kusoglu, "*Influence of N=40 and shape coexistence on the dipole response of ^{70}Zn*", Triangle Universities Nuclear Laboratory, Durham, North Carolina, USA, Nov. 30-Dec.12, 2024
  - P.A. Söderström, A. Kusoglu, "*Benchmarking nuclear level density models in the quasi-continuum region of ^{140}Ce*", Triangle Universities Nuclear Laboratory, Durham, North Carolina, USA, Nov. 30-Dec.12, 2024

2025

- D.L. Balabanski, A. Kusoglu, P.A. Söderström, T. Petruse, "*Photo-nuclear reactions of ^{16}O, ^{26}Mg, ^{40}Ca, and ^{56}Fe*", RCNP, Osaka University, Oct. 13 – Nov. 3, 2025
- D.L. Balabanski, A. Kusoglu, P.-A. Söderström, "*IS720-Transition probabilities of low-lying excited states in ^{210}Po and ^{210}Pb*", CERN ISOLDE, Geneva, Switzerland, Nov. 4-7, 2025
- S.R. Ban, "*PDR in ^{64}Ni as systematic sequel of the study in 58,62Ni isotopes using the inelastic proton scattering at CCB*", CCB, Institute of Nuclear Physics (IFJ), PAN, Krakow, Poland, Nov. 27 – Dec. 1, 2025
- D.L. Balabanski, A. Kusoglu, P.-A. Söderström, "*Evolution of the internal decay branching ratio of the GDR in the Samarium isotopic chain*", High Intensity Gamma-Ray Source, TUNL, Duke University, Durham, NC, USA, Dec. 1-14, 2025
- D.L. Balabanski, A. Kusoglu, P.-A. Söderström, "*First study of the giant dipole resonance's γ-decay behavior across a shape-phase transition*", High Intensity Gamma-Ray Source, TUNL, Duke University, Durham, NC, USA, Dec. 1-14, 2025

5. Further group activities (max. 1 page):

Within the project, the team collaborates with a number of research groups from all over the world. First of all, the team is involved in experiments at the HIγS free-electron laser facility, Duke University, gaining experience in experiments with γ beams. These experiments are led by the TU Darmstadt team. Team members were involved in experiments at GANIL, Caen, France, ISOLDE, CERN, the RIKEN Nishina Centre and RCNP, Osaka University, Japan, and IFJ PAN, Krakow, Poland. In all these cases experience related to different novel aspects related to the methodology of the experiment was accumulated by the team. To give one example, in the experiments at IFJ PAN at Krakow particle identification was done using pulse shape waveforms from a DSSD detector, a technique which is applied for our in-house FF-PFN-PFG correlation measurements.

For the HIγS photo-fission experiments we collaborate with the groups of Prof. Enders (TU Darmstadt, Germany) and Dr. Tonchev (LLNL, USA). For the development of the THGEM technology, we collaborate with the groups of Dr. Cortesi (FRIB, MSU) and Dr. Bressler (Weizmann Institute,Rehovot, Israel). For the development of the RF-carpet technology we collaborate with the group of Prof. Scheidenberger (GSI Darmstadt and the University of Giessen, Germany). For the construction of the position-sensitive FGIC we collaborate with the group of Prof. Enders (TU Darmstadt, Germany). The group of Prof. Enders is also involved in the FF-PFN-PFG correlation measurements, which are carried out at ELI-NP.

A new collaboration on photo-fission with virtual photons has been initiated within the project. A proposal has been approved at the CCB, IFJ PAN, Krakow "Evolution of prompt fission γ-ray emission with excitation energy and the Thorium anomalies", suggested by C. Schmitt (IPHC Strasbourg), M. Ciemala (IFJ PAN Krakow), and J.N. Wilson (IJCLab Orsay). We were contacted by the Dr. Ciemala and discussed to integrate a THGEM detector assembly with the PARIS-KRATTA detectors. The TGEM prototype was tested at the CCB beamline in Krakow. Eight cascade THGEM modules, the ELIGEM assembly, will be produced within the project and will be delivered for the experiment. The commissioning of the PARIS-KRATTA-ELIGEM setup will be done in May-June 2026, and the ^{232}Th fission experiment will be carried out in the summer of 2026. After that ELIGEM will assembly will come back to Magurele and will be integrated in the ELI-NP fission setup at beamline 6 of the 9 MV tandem.

6. Financial Report (budget usage) for the reporting period (see the Annex).

7. Research plan and goals for the next year (max. 1 page).
The research plan for stage III of the project (Year 2026) includes the following activities:

Activity III.1 "Spontaneous fission experiments with ^{252}Cf source at ELI-NP (part III)":

- The analysis of FF-PFN-PFG correlation measurements will be finalized and the results will be presented at conferences and prepared for publication.
- In the first part of 2026 a neutron-γ correlation measurement will be carried out using a 37 MBq ^{252}Cf source. The goal will be to obtain a data set with enough statistics and address few-neutron-few-γ coincidences, as well as multi-neutron events. The data analysis will be carried out in 2026.

The 2026 goals are to finalize the analysis of the 2025 data, successfully start to accumulated data with the ELIGANT-GN array, and publish one peer reviewed paper and two conference papers.

Activity III.2 "In-beam photo-fission experiments (part III)":

- In 2026 the results of the HIγS photo-fission experiments related to ^{234}U will be published.
- A further experimental proposal of the TU Darmstadt group will be submitted to the HIγS PAC, which aims at photo-fission studies in ^{236}U around the fission barrier, and the project team is part of this proposal. The publication delay of the ^{234}U results delayed submission since the requirement at HIγS is that the results from previous experiments should be published/submitted for publication prior application for further beam time.
- The data for ^{238}U are analysed by Dr. Malone (US Naval Academy, Annapolis). He is supposed to finalize the analysis of these data and publish them as soon as possible.
- The PARIS-KRETTA-ELIGEM setup will be realized at CCB IFJ PAN, Krakow and the photo-fission of ^{232}Th will be measured. The experiment will be carried out in the summer of 2026.
- The fission setup will be mounted at the IFIN-HH 9 MV in the fall of 2026 and the fission of ^{215}Fr and ^{221}Ac will be studied.

The 2026 goals are to finalize the analysis of the 2022-2023 data, get an accepted proposal at HIγS, and publish one/two papers in a peer refereed journals.

Activity III.3 "Innovative solutions for FF detectors and RF carpets (part III)":

- In May-June 2026 the PARIS-KRETTA-ELIGEM setup, where an eight-detector cascade THGEM assembly is integrated, will be commissioned.
- In 2026 we expect to finalize the optimization of the performance of RF carpets and THGEM assemblies transport and detection of FF and start using them in experiments.
- The design of a FGIC will be finalized, and a prototype will be fabricated and tested.

The 2026 goals are to define the optimal operational conditions of the RF carpets, deliver a robust THGEM detector, build a THGEM assembly for fission experiments, and construct and test a FGIC prototype. The results will be published in three peer refereed papers, and two patent applications will be submitted.

Activity III.4 "Digital pulse processing and automation of FF detectors (part III)":

- In 2026 the upgrading of DELILA will continue. The implementation of programmable FPGA digitizers for the ELIGANT-GN detectors will be finalized, the corresponding firmware will be tested. The firmware will be installed on CAEN VX2730 digitizers. FF detection will be done in experiments with THGEM detectors which will be integrated in DELILA, and used in experiments.
- The 2024 prototype of the gas system was used in experiments in stage II of the project (2025). In this period, the focus was on improving the gas system architecture that is flexible enough to be used both for the THGEM detectors, as well as for the FBIC setup. In 2026 start FBIC tests will start with α and FF sources, to optimize for gas pressure and voltages on each electrode for the designed detector geometry.

The goals for 2026 are to upgrade DELILA for handling THGEM detectors, to implement FPGA programmable digitizers, to use the slow-control system in experiments, to upgrade it to handle FGICs, and to publish one peer refereed paper and one conference proceeding.

Annex

Financial Report

according to the regulations from H.G. 134/2011

			lei
Type of expenditures		**Year 2025**	
		Value	
		Planned	**Realized**
1	**PERSONNEL EXPENDITURES**, from which:	**814.960,00**	**813.862,00**
	1.1. wages and similar income, according to the law	797.027,00	795.953,00
	1.2. contributions related to wages and assimilated incomes	17.933,00	17.909,00
2	**LOGISTICS EXPENDITURES**, from which:	**437.930,00**	**448.637,82**
	2.1. capital expenditures	400.000,00	385.338,25
	2.2. stocks expenditures	36.890,00	62.331,57
	2.3. expenditures on services performed by third parties, including:	1.040,00	968,00
3	**TRAVEL EXPENDITURES**	**100.000,00**	**78.881,66**
4	**INDIRECT EXPENDITURES – (OVERHEADS) ***	**333.510,00**	**345.018,52**
TOTAL EXPENDITURES *(1+2+3+4)*		**1.686.400,00**	**1.686.400,00**

* Specify the rate (%) and key of distribution (excluding capital expenditures).

To be filled in for:

- the project leader;

- for each of the partners (if any);

- for the whole project.