ANEXA 1.A

Annual Summary Document
~2016~

1. Cover Page (1 page):

- Group list (physicists, staff, postdocs, students);

Nr. crt	Name	Role in the project	OBS
Project coordinator: UVT			
1	*Vizman Daniel*	Director	physicist
2	Nicoara Irina	Researcher	physicist
3	Paulescu Marius	Researcher	physicist
4	Stef Marius	Researcher	physicist
5	Bunoiu Madalin	Researcher	physicist
6	Popescu Alexandra	Researcher	physicist
7	Buse Gabriel	Asist. Researcher	physicist
8	Panica Silviu	Asist. Researcher	Post-Doc
9	Tatomirescu Dragos	Asist. Researcher	PhD student
10	Sabadus Andreea	Asist. Researcher	Master student
11	Ivanovici Delia	Financial Responsible	Staff
12	Sarbu Ion	Technician	Staff
Partner 1: IFIN-HH			
13	Florin Negoita	Researcher	Physicist
14	Marius Gugiu	Researcher	Physicist
15	Cristian Manailescu	Asist. Researcher	Post-Doc
16	Ming Zeng	Asist. Researcher	Post-Doc
17	Negut Daniel C-tin	Researcher	Physicist
18	Cutrubinis Mihalis	Researcher	Physicist
19	Moise ioan Valentin	Researcher	Physicist

- Specific scientific focus of group is on the high energy radiation effects on some fluoride and semiconducting crystals
- Summary of accomplishments in the last year.

In the frame of objective *O1: Investigation of gamma radiation effects on the rare earth doped fluoride crystals* were performed the activities:

1. *A1.1 Optimization of crystal growth process (UVT)*
2. *A1.2 Preparing the gamma irradiation experiments (IFIN-HH)*

In the frame of objective *O2: Optimization of the gamma flux production obtained via laser interaction through numerical simulations* were performed the activities:

1. *A2.1 Adaptation of the PIC code EPOCH on the IBM BlueGene/P super-computer and comparison with the PICLS code for electron acceleration (UVT)*
2. *A2.2 Scaling analysis for EPOCH on two clusters (UVT BG/P and IFIN-HH cluster) (IFIN-HH)*

In the frame of objective *O4: Investigation of proton irradiation effect on solar cells operation* were performed the activities:

1. *A4.1 Preparing the proton irradiation experiments (IFIN-HH)*

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

Activity 1.1: Optimization of crystal growth process (UVT)

An important component in the crystal growth set-up is the **heating system** that provides the necessary melting temperature of the material and the gradient of temperature. In our experiment, the heater is a cylindrical graphite resistor with variable thickness. In order to obtain a higher power stability the electronic system was replaced with a new one which can ensure a better voltage adjusting in order to achieve an appropriate temperature gradient for higher quality crystals. The electronic system contains a variable AC power source with external power reference (signal 4-20 mA) and ultra-fast fuses. Besides the variable power source having above specified features, the electronic system contains:

- a digital temperature controller for temperature measurement with *S*-type thermocouple with external reference of temperature and built-in PID regulators.
- software SCADA-PC type which allows the control and monitoring of electrical power (automatic settings cycles, operating ramps, etc.)

AC variable source is mounted on the existing transformer's secondary winding (5 kVA, 300/30 VAC, 50 Hz). The spectrally-pure graphite resistor used to provide the temperature gradient is supplied from this electric source according to the selected power regime. This system ensure the established electrical power regardless of external disturbances (variations in voltage or variations of electrical resistance with temperature). The entire assembly is designed to ensure control, monitoring and relevant data storage (the temperature and power reference, the temperature and power measurements, etc.).

Figure 1. Crystal growth set-up from Crystal Growth Laboratory, Faculty of Physics (UVT).

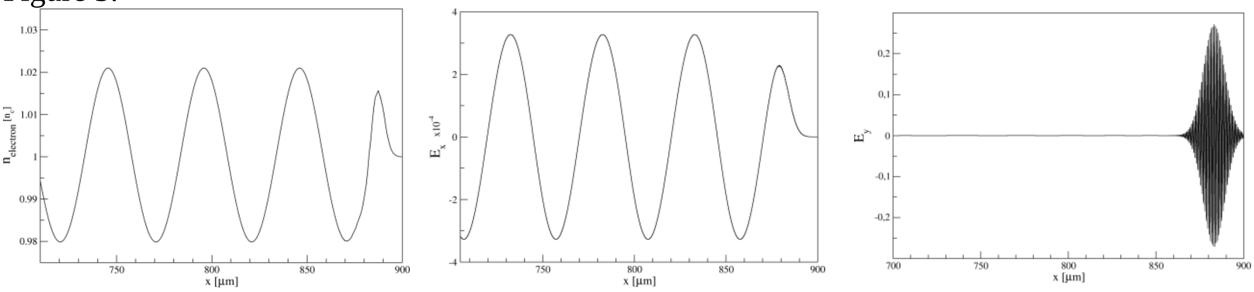
Activity 1.2. Preparing the gamma irradiation experiments (IFIN-HH)

For the gamma irradiation experiments using the Co-60 gamma source of IRASM facility in IFIN-HH, the main objective of this phase was to determine, by dozimetric mapping, various irradiation geometries for rare earth doped MeF2 crystals (Me=Ca, Ba). We searched for irradiation geometries for which the dose rate vary with at least one order of magnitude in order to evaluate its effect, and at the same time, to fulfill the condition that the uniformity of the absorbed radiation dose, defined as Dmax/Dmin, is less than 1.05.

At this stage we have identified some areas inside our irradiation chamber of the SVST Co-60 irradiator, which allow simultaneous irradiation of several crystal samples with a better uniformity of the absorbed radiation dose than the recommended value of 1.05. The minimum value of the average radiation dose at which the probes can be exposed for the two selected irradiation geometries is 20 Gy. Doses of 100Gy-10kgy can be obtained with our both irradiators, GC-5000 and SVST Co-60/B. Higher doses, up to 1000 kGy, can also be obtain in a useful period of time with the GC-5000 irradiators only for high rates.

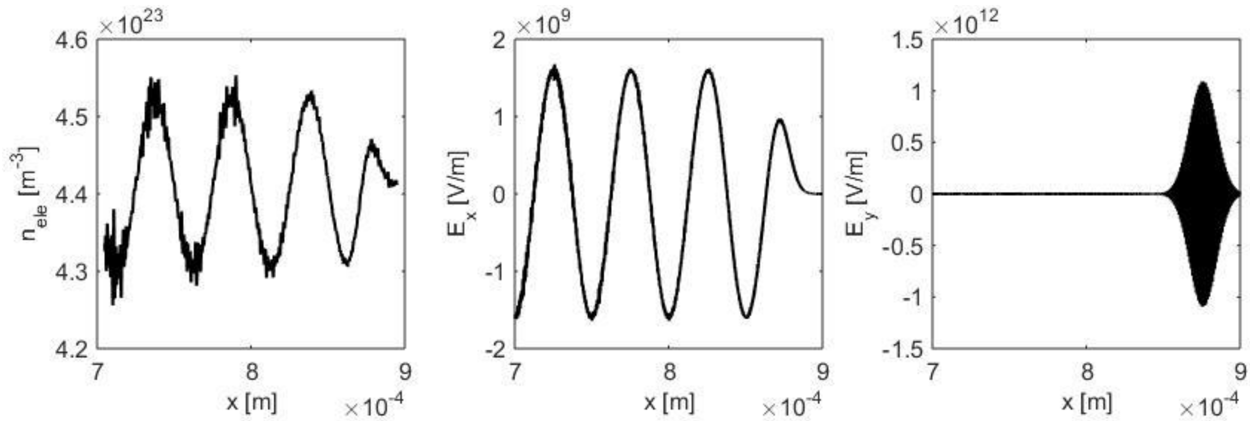
Activity 2.1 Adaptation of the PIC code EPOCH on the IBM BlueGene/P super-computer and comparison with the PICLS code for electron acceleration (UVT)

The numerical simulations comprised in this research project will be carried out using PIC (Particle-in-Cell) codes (PICLS [Sentoku, Y. et al., J. Comput. Phys. 227, 6846 (2008)] and EPOCH [Ridgers, C. P. et al., J. Comput. Phys. 260, 273–285 (2014)]). The PICLS code was previously compiled and run successfully on the IBM BlueGene/P supercomputer. In the case of the EPOCH code, due to the particular architecture of the BlueGene/P machine, several adaptations had to be performed to ensure the successful compilation of the code. Patchfiles were written in order to adapt all 3 versions of the code (1D, 2D and 3D) for the IBM compiler. Also a new level of compilation optimizations had to be chosen in order to ensure a correct compilation process. After all these changes were implemented the code was successfully compiled and test runs were made on the IBM BlueGene/P supercomputer. In order to test the accuracy of both chosen PIC codes, a test scenario was devised, that was ran on both codes, with the same parameters. The test case was laser wake field acceleration, in a 200x200 μm moving window, with a 0.8 μm wavelength Gaussian electromagnetic wave, linearly polarized. The obtained results for the PICLS1D code are represented in Figure 2 while the EPOCH1D results are plotted in Figure 3.



(a) Electron density (b) x component of the electrical field (c) y component of the electrical field

Figure 2. Simulation results from PICLS1D



(a) Electron density (b) x component of the electrical field (c) y component of the electrical field

Figure 3. Simulation results from EPOCH1D

In order to compare the results obtained with the two codes, plots were made for the electron density (Fig.2(a) and Fig.3(a)), electric field in the longitudinal direction (Fig.2(b) and Fig.3 (b)) and electric field in the laser polarisation direction (Fig.2(c) and Fig.3 (c)).

From these figures, it can be seen that the particle density and the field components for the two simulations follow the same trends on both simulation software used in this test, although we can observe a higher quality output smoothing being done in the PICLS code. The EPOCH graphs were obtained by smoothing the output with a MATLAB routine.

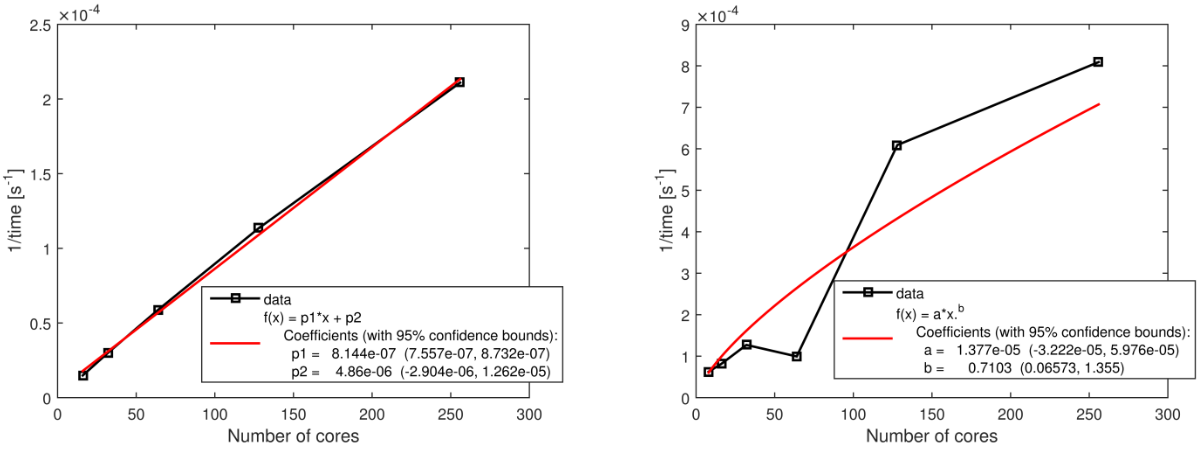
Activity 2.2: Scaling analysis for EPOCH on two clusters (UVT BG/P and IFIN-HH cluster) (IFIN-HH)

A scaling analysis study was carried out for the EPOCH code on two machines, the IBM BlueGene/P at UVT and IFIN-HH cluster.

Table 1. Simulation time duration in unit of seconds with different number of cores, machine and dimension cases

Dimension and machine / Core Number	1D		2D	
	IFIN cluster	UVT BlueGene/P	IFIN cluster	UVT BlueGene/P
1	1244	10352	RAM insufficient	>24 hours
2	680	5255	RAM insufficient	>24 hours
4	388	2673	RAM insufficient	>24 hours
8	270	1368	15953	>24 hours
16	94	715	12302	67221
32	212	390	7866	33345
64	39	222	10063	16983
128	42	143	1642	8807
256	34	120	1236	4740

The time efficiency of the test scenario chosen for the scaling analysis study on the two machines under use in this project can be seen in Fig.4. Despite the fact that the simulations on the IFIN-HH cluster are having a better time efficiency, due to the limited number of cores available on the IFIN cluster, and the unreliability in run-time estimation, the BlueGene/P machine is better suited for EPOCH simulations, showing better scalability of BlueGene.



c) EPOCH2D efficiency on the IBM BlueGene/P machine at UVT

d) EPOCH2D efficiency on the IFIN-HH cluster

Figure 4 Efficiency graphs for the EPOCH code on the IBM BlueGene/P at UVT and the IFIN-HH cluster

Activity 4.1. Preparing the proton irradiation experiments (IFIN-HH)

The solar cell proton irradiation experiments has been prepared mainly through the development of a remote control irradiation set-up at one of the beam lines of Tandem accelerator in IFIN-HH. The set-up consisted in a two axes linear translation stages working in vacuum on which the sample can be mounted together with on-line diagnostics for beam dimensions visualization (phosphor screen coupled to a CCD camera operated in vacuum) and beam intensity (faraday cage coupled to an ampermeter). Defocusing of the proton beam provided by the accelerator and sample movement during irradiation are solution for achieving a uniform dose distribution over the cell surface. The possibility to perform proton irradiation at a laser facilities was studied during an experiment performed at LULI facility, aiming to develop a method to monitor the laser accelerated proton flux based on nuclear isomer activation.

3. Group members (table):

- List each member, his/her role in project and the Full Time Equivalent (FTE) time in project. The FTE formula to be used is: FTE = Total number of worked hours /Total number of hours per reporting period*;

Nr. crt	Name	Role in the project	Worked hours	Full Time Equivalent
Project coordinator: UVT				
1	*Vizman Daniel*	Director	53	0.32
2	Nicoara Irina	Researcher	40	0.24
3	Paulescu Marius	Researcher	40	0.24
4	Stef Marius	Researcher	40	0.24
5	Bunoiu Madalin	Researcher	20	0.12
6	Popescu Alexandra	Researcher	40	0.24
7	Buse Gabriel	Asist. Researcher	0	0
8	Panica Silviu	Asist. Researcher	80	0.48
9	Tatomirescu Dragos	Asist. Researcher	120	0.71
10	Sabadus Andreea	Asist. Researcher	60	0.36
11	Ivanovici Delia	Financial Responsible	30	0.18
12	Sarbu Ion	Technician	108	0.64
Partner 1: IFIN-HH				
13	Florin Negoita	Researcher	0	0
14	Marius Gugiu	Researcher	0	0
15	Cristian Manailescu	Asist. Researcher	559	3.31
16	Ming Zeng	Asist. Researcher	0	0
17	Negut Daniel C-tin	Researcher	0	0
18	Cutrubinis Mihalis	Researcher	0	0

- List PhD/Master students and current position/job in the institution.

Nr. crt	Name	Position in the university	Obs.
1	Tatomirescu Dragos	Asist. Researcher	PhD student
2	Sabadus Andreea	Asist. Researcher	Master student

4. Deliverables in the last year related to the project:

- List of papers (journal or conference proceeding);
- List of talks of group members (title, conference or meeting, date);
- Other deliverables (patents, books etc.).

Activity reports for all activities.

* Total number of hours (for a certain period) = 170 average monthly hours x number of months (e.g., for a full year: 170 hours/month x 12 months = 2040 hours)

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

- Collaborations, education, outreach.

Dragos Tatomirescu is doing a PhD thesis on Particle-In-Cell simulations of high intensity laser plasma interaction with a double coordination : Prof.dr. Daniel Vizman, West University of Timisoara and Associate Professor Emmanuel d'Humières, Centre Lasers Intenses et Applications, CELIA, University of Bordeaux, France.

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

7. Research plan and goals for the next year (max. 1 page).

In the frame of objective *O1: Investigation of gamma radiation effects on the rare earth doped fluoride crystals* will be performed the next activities:

1. *A1.3 Growth of pure CaF_2 and BaF_2 crystals UVT (UVT)*
2. *A1.4 Gamma irradiation of pure CaF_2 and BaF_2 crystals (IFIN-HH)*
3. *A1.5 Characterization of CaF_2 and BaF_2 crystals before / after irradiation (UVT)*

In the frame of objective *O2: Optimization of the gamma flux production obtained via laser interaction through numerical simulations* will be performed the next activities:

3. *A2.3 Numerical study for electron acceleration from CO2 and N2 gas targets. Optimizations for different laser spot sizes and plasma densities (IFIN-HH)*

In the frame of objective *O3: Optimization of large-flux proton beams generated via laser interaction through numerical simulations* will be performed the next activities:

1. *A3.1 Parametric numerical study for laser proton acceleration from gas and foam targets using the PICLS code. (UVT)*

In the frame of objective *O4: Investigation of proton irradiation effect on solar cells operation* were performed the activities:

1. *A4.2 Preparing the experimental setup for characterizing the solar cells and the probes (UVT)*
2. *A4.3 Mono-junction solar cells irradiation with protons (IFIN-HH)*

Annex

Financial Report (whole Project)

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

			lei
Type of expenditures		**Year 2016**	
		Value	
		Planned	**Realized**
1	**PERSONNEL EXPENDITURES**, from which:	**70.068,00**	**68.081,00**
	1.1. wages and similar income, according to the law	55.658,00	55.533,00
	1.2. contributions related to wages and assimilated incomes	14.410,00	12.548,00
2	**LOGISTICS EXPENDITURES**, from which:	**3.012,96**	**0,00**
	2.1. capital expenditures	0,00	0,00
	2.2. stocks expenditures	3.012,96	0,00
	2.3. expenditures on services performed by third parties, including:	0,00	0,00
	....	0,00	0,00
3	**TRAVEL EXPENDITURES**	**2.575,00**	**7.008,68**
4	**INDIRECT EXPENDITURES – (OVERHEADS) (UVT: 27% from (1.1+1.2+2.2+2.3+3); IFIN-HH 50%: 15% from (1.1+1.2) + 35% from direct costs (minus capital expenditures))**	**25.126,04**	**25.692,00**
TOTAL EXPENDITURES *(1+2+3+4)*		**100.782,00**	**100.782,00**

* 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.

Financial Report (Project coordinator UVT)

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

			lei
Type of expenditures		**Year 2016**	
		Value	
		Planned	**Realized**
1	**PERSONNEL EXPENDITURES**, from which:	**46.025,00**	**46.868,00**
	1.1. wages and similar income, according to the law	37.560,00	38.266,00
	1.2. contributions related to wages and assimilated incomes	8.465,00	8.602,00
2	**LOGISTICS EXPENDITURES**, from which:	**1.000,00**	**0,00**
	2.1. capital expenditures	0,00	0,00
	2.2. stocks expenditures	1.000,00	0,00
	2.3. expenditures on services performed by third parties, including:	0,00	0,00
	....	0,00	0,00
3	**TRAVEL EXPENDITURES**	**2.575,00**	**1.850,00**
4	**INDIRECT EXPENDITURES – (OVERHEADS) (UVT: 27% from (1.1+1.2+2.2+2.3+3))**	**12.400,00**	**13.281,40**
TOTAL EXPENDITURES *(1+2+3+4)*		**62.000,00**	**62.000,00**

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

Financial Report (Partner 1 IFIN-HH)

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

			lei
Type of expenditures		**Year 2016**	
		Value	
		Planned	**Realized**
1	**PERSONNEL EXPENDITURES**, from which:	**24.043,00**	**21.213,00**
	1.1. wages and similar income, according to the law	18.098,00	17.267,00
	1.2. contributions related to wages and assimilated incomes	5.945,00	3.946,00
2	**LOGISTICS EXPENDITURES**, from which:	**2.012,96**	**0,00**
	2.1. capital expenditures	0,00	0,00
	2.2. stocks expenditures	2.012,96	0,00
	2.3. expenditures on services performed by third parties, including:	0,00	0,00
	....	0,00	0,00
3	**TRAVEL EXPENDITURES**	**0,00**	**5.158,08**
4	**INDIRECT EXPENDITURES – (OVERHEADS) (IFIN-HH 50%: 15% from (1.1+1.2) + 35% from direct costs (minus capital expenditures))**	**12.726,04**	**12.410,92**
TOTAL EXPENDITURES *(1+2+3+4)*		**38.782,00**	**38.782,00**

* 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