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Project Full Name: Fast Tracker for Hadron Collider Experiments

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Periodic Report

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Prof. Mauro Dell'Orso

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UNIVERSITA DI PISA

Periodic Report

PROJECT PERIODIC REPORT

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DECLARATION BY THE PROJECT COORDINATOR

I, Prof. Mauro Dell'Orso, as co-ordinator of the project (324318, FTK), hereby confirm that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;

- The project has fully achieved its objectives and technical goals for the period;

- The project Website is up to date.

- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project and if applicable with the certificate on financial statement.

- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 5 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

PUBLISHABLE SUMMARY

Comments:

PROJET OBJECTIVES. In recent years there has been substantial development in image detector technology that has led to a great increase in both resolution and produced data. These detectors target several different application fields from everyday applications (such as smart phone cameras) to complex and demanding applications (high energy physics, medical imaging, security applications and others). Such applications demand an effective method for data reduction with minimal loss of information. Pattern matching is a common algorithm used for such processes.
Pattern matching algorithms look for a given sequence of tokens (data) that constitute a predefined pattern. It is not limited to image processing, but is extended to other fields such as data servers (e.g. search engines, data) and all types of data processing that require identification of patterns. The primary goal of the project is the construction of a system that can execute on a single chip, the Associative Memory (AM) chip [1], 1 million comparisons every 10ns, while 64 chips work in parallel on each system board. The complete system can integrate as many boards as required, all working in parallel. Such high performance requirements can be found in high energy physics (HEP) experiments executed in hadron colliders. These HEP experiments search for extremely rare processes hidden in much larger background samples. The experiments are performed with data from overlapping proton-proton collisions that produce particles that leave traces in the detector's millions of detecting elements (100 million detector elements are used in ATLAS). Each set of these overlapping proton-proton collisions is called an "event". The data flow is so massive that only a very small fraction of the collisions can be stored for later analysis. A drastic real-time data reduction must be obtained with minimal loss of useful information.
A multi-level trigger is an effective solution for an otherwise impossible problem. The level-1 trigger, historically based on custom processors, reduces the rate from the machine event production (40 MHz at the Large Hardon Collider, LHC) down to many tens of kHz. The level-2 trigger, implemented with dedicated hardware in the past, and with standard CPUs more recently at LHC, has usually an output rate of few kHz. The output of the level-3 selection, always performed by CPU farms, must satisfy the offline data storage limitations.
These multilevel triggers work by quickly identifying those events with the greatest scientific potential. Tracking devices, and in particular silicon devices that are the predominant tracking technology, play an essential role in the identification of interesting events. In fact, they provide very detailed information for each particle and can separate most of the different particle trajectories in all of the overlapping collisions in the same recorded image. However these detectors contain hundreds of thousands or millions of channels, so they require huge computing power for full track reconstruction. They make the problem of complete tracking a formidable challenge even for off-line analysis. As a consequence, complete high-quality tracking for real time event selection at very high rates has been considered impossible in LHC experiments. Real-time tracking was planned for a limited detector region or on a small subset of events, previously selected using other detectors. With the FTK project, we overcome this problem by providing real-time tracking for all the events using a massively parallel high performance system.
WORK PERFORMED SINCE THE BEGINNING OF THE PROJECT - The implementation was developed for the Fast TracKer Processor (FTK) [2], which is an approved ATLAS upgrade. The implemented strategy is based on the optimal mapping of a complex algorithm onto different technologies. The target is to get the best results by combining the high performances of dedicated hardware with the distinctive flexibility of general-purpose but lower-performance CPUs. A key role in the architecture is played by high-performance field programmable gate arrays (FPGAs), while most of the computing power is provided by full-custom ASICs named Associative Memories (AM). Powerful highly parallel dedicated hardware provides excellent performance, reaching resolutions, efficiencies and fake track rejection typical of offline algorithms. The latencies are short (few tens of microseconds), power usage is low (the AM chip, a device able to execute 1 Million comparisons each 10 ns, has a power consumption below 3 W), and the system is small (4 racks of electronics are able to perform a task that would need a farm of thousands of commercial CPUs).
The AM, the central device of our system, shares some features with the Content-Addressable Memory (CAM) [3] usually used in very high speed searching applications. Even if AMs and CAMs are similar devices, there are conceptual design differences. The innovation in the Associative Memories used in our system is that each pattern is stored in a single memory location like in the commercial CAM, but it consists of 8 independent words of 16 bits each. Each of these words is

separately compared to its own input data stream. Data are sent on 8 parallel buses, one for each word of the pattern. Each word is provided with its own hardware comparator and a match flip-flop. All words in the AM make independent and simultaneous comparisons with the data serially presented on its own bus. Any time a match is found, the match flip-flop is set and remains set until the end of the data stream for that event. A pattern matches when a majority of its flip-flops are set. FPGAs control, configure and handle the AM, providing the flexible computing power to process the selected patterns. Distributed debugging and monitoring tools suited for a pipelined, highly parallelized structure and a high degree of configurability have been developed to cope with different applications.

A DESCRIPTION OF THE MAIN RESULTS ACHIEVED SO FAR – We have built the AM [4] and clustering [5] system prototypes, tested and integrated them in the global FTK system at CERN. The design of the AM system, in particular, was a challenging task, due to the following factors: (1) the high pattern density (8 million patterns per board), which requires a large silicon area for the AM ASICs: (2) the I/O signal congestion at the board level, which requires the use of serial links; and (3) the power limitation due to the cooling system: as we are fitting 8 000 AM chips in 8 VME crates and 4 racks, the power should not exceed 250 W per AM board. The infrastructures (crates, fans, heater exchangers, power supplies) were studied and optimized.

THE EXPECTED FINAL RESULTS AND THEIR IMPACT - The described system was developed and tested for HEP detectors. It will have an extraordinary impact on the physics potential of experiments at LHC. However the system is essentially able to solve an image processing problem. Therefore it can be adapted for use in more generic image processing applications.

The AM system fundamentally executes a filtering function that can be applied to images of different kinds. The AM-based processor can simulate the preliminary stages of image processing performed by the brain for vision, such as the identification of shape edges [6]. The most convincing models that try to validate brain function hypotheses are extremely similar to the real time architectures developed for High Energy Physics experiments. A multilevel model seems appropriate also to describe the brain organization which performs a synthesis certainly much more impressive than what is done in HEP triggers. The AM pattern matching has proven to play a key role in high rate filtering/reduction tasks [6]. We follow the conjecture that the brain works by dramatically reducing input information by selecting for higher-level processing and long-term storage only the input data that match a particular set of memorized patterns. The double constraint of finite computing power and finite output bandwidth determines to a large extent what type of information is found to be "meaningful" or "relevant" and becomes part of higher level processing and longer-term memory. The AM-based processor will be used for a real-time hardware implementation of fast pattern selection/filtering of the type studied in these models of human vision and other brain functions. Shapes extracted by the AM from the images would be analysed exploiting the computing power of the FPGAs to identify clusters of contiguous pixels above a programmable threshold [4]. The AM, working with FPGAs could have a new application in the field of Smart Cameras. In summary, this multi-chip system will try to reproduce the initial stages of the brain visual processing: the ASIC will extract object contours and the FPGA will analyse their shape.

The system’s miniaturization will be achieved by producing a System In Package (SIP) where the FPGA, an external large memory and a single AM chip are packaged together [7].

[1] Annovi, A., et al. 2006. VLSI Processor for Fast Track Finding Based on Content Addressable Memories. IEEE Transactions on Nuclear Science. 53, 4, (August 2006) 2428-2433.

[2] Andreani A. et al. 2012. The FastTracker Real Time Processor and Its Impact on Muon Isolation, Tau and b-Jet Online Selections at ATLAS. IEEE Transactions on Nuclear Science 59, 2, 348-357.

[3] Pagiamtzis, K. and Sheikholeslami, A. 2006. Content-addressable memory (CAM) circuits and architectures: A tutorial and survey. IEEE Journal of Solid-State Circuits. 41, 3, (Mar. 2006), 712-727.

[4] Andreani A. et al. 2014. The Associative Memory Serial Link Processor for the Fast TracKer (FTK) at ATLAS. JINST 9 C11006

[5] Sotiropoulou, C.-L. et al. A Multi-Core FPGA-based 2D-Clustering Implementation for Real-Rime Image Processing" In IEEE Transactions on Nuclear Science. 61, 6, (December 2014), 3599-3606.

[6] Del Viva, M., Punzi, G., and Benedetti, D. 2013. Information and Perception of Meaningful Patterns. PloS one 8.7 (July 2013): e69154.

[7] Gentsos, C. et al. 2014. Future evolution of the Fast TracKer (FTK) processing unit. Proceedings of Science. 209

DRAFT

PROJECT OBJECTIVES FOR THE PERIOD

Comments:

The work is organized in 5 areas, or work packages (WP). Here follows a short description.
WP1, “Prototype Construction & Production validation”, includes board and chip logic design, printed circuit board construction and assembly, standalone test for a first validation of prototypes. It is important that the designer can participate also to the first tests, before his product is integrated on the complete system. The board and chip design is based on electronic design automation tools. The board assembly is complex, especially for the mezzanine that holds 16 AM chips (bold grid array packages) and other control devices, in a small space. The experience gained on prototypes by the companies will allow the assembly of the FTK boards at production time and validate them at the company before commissioning.
The WP1 objectives are:
O.1.1. Construction of prototypes
O.1.2. Transfer of knowledge to PRIELE for board assembly and validation before integration or commissioning
O.1.3. Standalone validation of prototypes
O.1.4. Standalone validation of FTK production
O.1.5. Transfer of knowledge between research institutions about AM technology

WP2, “Infrastructures and Integration”, takes care of crates, power supplies and space for integrated lab tests. We use 9U VME crates with custom VME VIPA backplane, 48V power source and a large DC-DC converters from 48 Volts down to 12 V, and from there many DC-DC converters allow to reach 1-1,2-2,5 V to provide the needed power for 64 AM chips per board. The AM board has a power consumption of ~250 W and a weight of 2 Kg, the crate has to support a total weight of ~40 kg and provide roughly 6 kW of power. Cooling and mechanical tests have to be performed. The air flow must be sufficient to keep cold the boards. Each rack contains two crates and one power supply serving both crates. The power supply has grids on the top and bottom sides to be transparent as much as possible to air flux. These realistic experimental conditions have to be reproduced by simulation. Enough complex tests have to be performed with Monte Carlo data to guarantee the hardware is complete and can run flawlessly. Software will be developed to monitor and control the processor. The detector data will be produced in the lab by a “pseudo front-end” (a CPU).
The WP2 objectives are:
O.2.1. Infrastructure construction and validation: racks, crates, power supplies, cooling system
O.2.2. Integration of prototypes from Europe, Japan and USA, validation before production
O.2.3. Software development for system control, monitoring, and test
O.2.4. Transfer of knowledge between CAEN and research institutions for integration, commissioning, and
maintenance
O.2.5. Transfer of knowledge between research institutions about FTK technology for any kind of applications

WP3, “Commissioning”, closes the research path described above. After tests in the laboratory, the new hardware will be moved to the experiment and will spy real data during normal data taking. In fact commissioning implies the insertion in the experiment, the development of monitoring and control software compatible with its rules, long tests to validate the system, data taking and data understanding.
The WP3 objectives are:
O.3.1. Infrastructure Installation and validation at point 1: racks, crates, power supplies, cooling system
O.3.2. Board installation and validation
O.3.3. Running control and functional monitoring
O.3.4. Transfer of knowledge between CAEN and research institutions for board commissioning and maintenance
O.3.5. Transfer of knowledge between research institutions about FTK technology for any kind of future application

WP4 is “Architecture Simulation”. It is just software, but it has an important impact on hardware

choices. A complex package, FTKsim has to simulate the hardware on Monte Carlo data, or real data. It is used to optimize the hardware design, to specify, build and test the internal data paths needed for the LHC high luminosity, to determine the optimal size of the AM system, to produce the Physics case. The simulation is an essential part of all tests since it allows to predict the hardware output, starting from the inputs, in order to validate the hardware (sometime the simulation) functionality.
The WP4 objectives are:
O.4.1. Definition of Level-1, Level-2 architectures optimizing the physics reach
O.4.2. Validation of tests: production of test vectors to validate HW configurations

WP5, “Image Processing” was not active the first 2 years, see below point 2 of “Feedback and recommendations from the Mid Term Review”, the roadmap to expand the technology of the project towards other fields.

WP6, “Silicon Detector R&D”, has a reduced role in our project, compared to the electronics for pattern recognition; however it provides a solid link with the evolution of the on-going R&D for the silicon sensors and the front-end readout electronics in view of the high luminosity upgrade of the LHC. This link is important for FTK since a constant dependence connects the evolving features of the future tracker (segmentation, geometry, expected hit efficiency, noise, readout speed) with the future of the FTK architecture. To resist in the high-radiation environment of the SLHC interaction region, new pixel sensors are being developed. Prototypes of a chip in 65nm CMOS process are being developed for the readout chip, to increase the component density and to allow a further reduction of the sensor pixel size. In all this, the power dissipation will play an important role and the high voltage distribution system will be one of the key ingredients in the evolution of the detector design. Even if the detector is operated at a below-zero temperature, a power supply system able to provide 1kV tension at a maximum current of about 10mA per channel will be necessary, with excellent temperature stability and excellent ripple/noise specifications even at full current. The test-stand for the module evaluation has been assembled at CAEN in Viareggio, Italy, to test how the CAEN devices can perform in these difficult conditions. The silicon sensors with their readout electronics are used with the CAEN high- and low-voltage distribution system.
The WP6 objective is:
O.6.1. CAEN Power supply (PS) optimization for Phase-II LHC pixel detectors

The WP7, “Outreach” objectives are:
O.7.1. Communication promotion between the scientific community and the general public
O.7.2. Awareness of science increase

The WP8, “FTK workshops and Trainings”, objectives are:
O.8.1. Communication promotion between the participants to the project
O.8.2. Offer a suitable environment for trainings, to facilitate the sharing of knowledge and culture between the participants
O.8.3 Improve the chance of career opportunities to the project young researchers

FEEDBACK AND RECOMMENDATIONS FROM THE MID TERM REVIEW.

1. LIST OF THE TRAININGS that each fellow attended in the framework of the project. All trainings are included (technical and soft trainings), see table 1 in the attached file FTK-Additional_info.pdf.

2. ROADMAP TO BE FOLLOWED in order to EXPAND THE TECHNOLOGY of the PROJECT TOWARDS OTHER FIELDS, in accordance to the original proposal.
The WP5, “Image Processing”, represents our efforts to expand the project technology outside HEP . We plan to use our AM-based Processor to process “static images” and “movies” in real time. We will check the capability of the AM system to extract from the images and from movies the relevant features and substantially suppress the not-relevant information. For static images groups of 3x3 pixels (black and white) are detected in the images and each particular configuration constitutes a 9-bit pattern. For films we need to add a third dimension, the time, so patterns becomes 3x3x3 wide, made of 27 bits (128 million possible configurations). For each of these patterns the frequency of appearance has to be measured. This is the “training phase”. The pattern frequency is the determinant

feature to decide if a pattern is relevant or not. After this learning phase, the relevant patterns are selected and downloaded in the AM bank and the processor is ready to filter the images/movies selecting only ~5% of the input data (a maximum number of ~2 million patterns can be downloaded today). The AM system always monitors the pattern frequencies, even during image processing: if the frequency distribution changes, the list of good patterns is updated, so that the system is able to adapt itself in an unknown, new environment. The 2-D clustering algorithm developed to process bi-dimensional pixel detector data, could process the AM output, the filtered image.
------- The WP5 objectives are ambitious:
O.5.1. Test AM real time capability to extract relevant features of natural and medical images
O.5.2. Evaluate the impact on medical imaging and diagnosis
O.5.3. Evaluate the impact on robotic automation
------- The Roadmap for WP5 is defined and constrained by the WP5 Deliverables and Milestones included in Annex 1:
D.5.1. Infrastructure at CAEN for Image Processing – delivery date M26 (March 2015)
D.5.2. Software & firmware ready for training and image processing - delivery date M30 (July 2015)
D.5.3. Performances of natural still image processing - delivery date M34 (November 2015)
----M.5.1. Hardware still-image processor running flawlessly – M34
D.5.4. Results of tests on movie processing - delivery date M40 (May 2016)
----M.5.2. Filtering and data reduction of natural movies running flawlessly – M40
----M.5.3. Procurement of medical image data – M42 (July 2016)
D.5.5. Results of tests on medical image processing - delivery date M48 (January 2017)
----------PROGRESS ON THIS ROADMAP:
Given the complexity of the WP5 and our inexperience in this field we have made some actions to reinforce this important area of our project:
(a) We have extended and anticipated the recruitment position at Pisa to have more chances to complete the plan. We also succeeded to recruit an “Imaging” expert researcher.
(b) During summer and autumn 2014 we have organized meetings to collaborate in Tuscany with other entities that could help to identify areas of application and exploitation of results of deliverables D.5.3 and D.5.4. In particular we had a positive interaction with CNIT & TeCIP - Scuola Superiore Sant’Anna in Pisa, and two companies (N Zero Srls of Igor Barsanti and EMC srl, in Poggibonsi) interested to use our technologies in Smart Cameras applications (many meetings, in particular for May 19, October 8 2014 we have the agendas here: https://agenda.infn.it/categoryDisplay.py?categId=407). In January 2015 we have applied together for Tuscany funds (BANDO FAR-FAS 2014) to exploit eventual results of deliverables D.5.3 and D.5.4. This would be an important result for the objective O.5.3.
(c) We had some contact with personnel working on medical imaging, Piergiorgio Cerello and some members of his group that belongs to INFN Torino, to clarify better what to do for the objective O.5.2. It was suggested to start with public databases to check the quality of the filtered image to produce the Deliverable D.5.5 and see if the selected regions of interest are really successful identifying the diseases. Here is the list of the provided data bases by Piergiorgio Cerello and his group:
brain MRI:
Harmonized Hippocampus Protocol - http://www.hippocampal-protocol.net/
ADNI database - http://adni.loni.usc.edu/data-samples/mri/
Hippocampus Segmentation Database -
http://www.radiologyresearch.org/HippocampusSegmentationDatabase/
Internet Brain Segmentation Repository - http://www.cma.mgh.harvard.edu/ibsr/
Mammography : DDSM : http://marathon.csee.usf.edu/Mammography/Database.html
CT pulmonary: LIDC : http://imaging.cancer.gov/programsandresources/informationsystems/lidc
PET/CT whole body: they can provide us access to images.
Only good results on public databases would justify a second step towards medical personnel and involving real patients.
In addition we have recently acquired an important contact with a young researcher, Guido Buonincontri, recently winner of a Marie Curie to work in Pisa on “Magnetic resonance fingerprinting” (MRF), very interested to use our technology to speed up his algorithms that are based on pattern matching. In his implementation he constructs a dictionary that contains signal time evolutions from all foreseeable combinations of materials and system-related parameters. Once this dictionary of possible signal time evolutions is generated, a matching or pattern recognition algorithm is then used to select a signal vector from the dictionary that best correspond to the

observed signal evolution (each measured vector is a set of 1000 measurements performed on a single pixel of a matrix 128x128 pixels). With this technique all the parameters that were used to build the selected signal vector in the dictionary can then be retrieved simultaneously.
(d) We also did work in 2015 to define the "Infrastructure for Image Processing", the first Deliverable that should be ready for the end of March. During the application we were planning to use the VME 9U crate and the AMBSLP board itself. Instead we are now able to connect a LAMB mezzanine board with 16 AM chips to a Xilinx FPGA evaluation board so we decided to use this more compact and transportable, more easy to reproduce hardware for our developments; this hardware allows also a much easier fast connection with a PC (we could use PCI express). We decided to start with a
Xilinx Virtex-6 HTG-V6-PCIE hitechglobal
On FPGA XC6VLX240T - Logic Cells 241,152 - Slices 37,680 - Max RAM (Kb) 14,976
On board: DDR3 2 GB - Flash 256Mb
connected to a mezzanine with a single AM chip AM05 for the first studies and a larger mezzanine with 16 AM06 chips for following studies, as soon as available. The memory on board is large enough for both still image and movie processing. We will start with images and movies on data bases. We have established contacts with Michela Del Viva and Giovanni Punzi, to collaborate in the implementation of their algorithm [6] on fast hardware.
With the experience of the first developments we will choose a future, more powerful evaluation board, for example based on Ultrascale Xilinx chips.

3. RISKS ASSOCIATED WITH THE WORKING PLAN (recruitment, delays due to technological reasons, etc) and DEVELOPMENT OF A MITIGATION PLAN.
We don't see for the moment motivations for delays due to recruitments and secondments since all of them are going ahead following our schedule or even anticipating the timing expected in the previously approved Gantt Charts. The UNIPISA recruitment was implemented perfectly on time and the application for the CERN recruitment is expiring on March 23, so we will be able soon to select the researcher well in advance compared to the start of the contract that should begin in September 2015.
For the scientific plan:
(1) We see instead potential risks of delays in the production phase of boards for the FTK processor, due to the fact that the AM06 chip is not submitted yet and could delay more. We cannot fully test our boards before production, if the AM06 chip is not available. So delay on our FTK production and commissioning schedule is possible, due to facts external to our project. The ATLAS experiment is conscious and has a backup solution, since the baseline trigger menu without the use of FTK tracks is still in use, and it will remain active until FTK will be ready.
(2) The delay of AM06 could have also an impact on the deliverable D.5.4, results on movie processing, since we need a substantially large AM memory for that study, while D.5.3 and D5.5 can be executed even with AM05. If the movie processing gets delayed due to the AM06 we will anticipate the research in the area of medical still image processing, analysing medical images from the large set of public databases we know to be available. Movie processing will then be delayed to the last period of the project.
(3) Regarding Milestone M.4.3. "Approval of SLP1 architecture in Atlas – M30" we know already since the end of 2012, before the start of our IAPP project, (see section "WORK PROGRESS and achievements during the period" subsection g.b) that the muon community in ATLAS rejected the Associative Memory technology for the muon detectors, so the SLP1 is pursued for PHASE II and not PHASE I applications, as described by the Risk analysis of Milestone 4.3 in the Appendix 1. Since PHASE I is planned for 2018 and PHASE II will instead come after 2020, it is really premature to have the SLP1 review at M30. No installation is expected anymore on a short timescale and all the SLP1 deliverables will be results of R&D development. In conclusion we plan to delay M4.1 roughly by one year, while M1.4 and 2.5 are still suitable for the prototype development.
(4) For similar reasons, the Milestone M6.1 "CAEN PS Atlas review" that is for Phase II applications is premature at the month 32, and given the fact PHASE II is shifted far in time, we think will be delayed some months later, when the discussion will be more fruitful.

4. ETHICAL ISSUES IDENTIFIED AT THE REVIEW (possible access to patient data of confidential nature).
As explained above, we will execute our WP5 plan using public data bases. However we have invited Pierluigi Cerello, expert on this subject, to train our group on the Ethical issues we will need

to face when we will request the access to patient data of confidential nature, even if it will not be needed during WP5 execution.

5. BETTER FUTURE ACHIEVEMENTS of OBJECTIVE “O.7.1. Communication promotion between the scientific community and the general public”. MOST APPROPRIATE ACTIONS.
In the first two years most of the activities have been implemented in Pisa. We have understood that it is important to associate our programs to larger events, organized by the University or the town, because in that occasion the number of persons attracted by the "show" is much larger.
For the future 2 years we plan to extend our activities. AUTH and LPNHE will also organize OPEN DAYS, AUTH also a Workshop and a SCHOOL each year:
-- UNIPISA will continue to offer FTK dissemination in the occasion of the Dipartimento di Fisica congress and Day of Research each April. In addition will organize a dissemination event for only women in 2016, associated with the Master Class event at INFN.
-- LPNHE will participate to la Fete de la Science (end of Summer) each year.
-- AUTH will organize a SCHOOL in the University Laboratory for University students and an Open Day in the occasion of “University on Sundays” event, each year. End of March 2015 and also in 2016, they will invite other University classes for a Workshop day. After a pilot presentation of the FTK activities in AUTH with a poster in the International Fair in Thessaloniki, last September (2014), the plan is to make a more stand for the occasion of the 2015 and 2016 Fairs which atttract huge crowds.
-- We plan a Workshop day at CERN for people working in medical applications and imaging. This will be an important occasion to meet them and know their opinion about our technology.

6. MORE AMBITIOUS DISSEMINATION PLAN THROUGH JOURNALS AND CONFERENCES. Up to now we disseminated our results into conferences that are typical for High Energy Physics results. They are listed into our public web page:
http://ftk-iapp.physics.auth.gr/Dissimination/talks.html. Important examples of this list were IEEE Nuclear Science Symposium (NSS) or IEEE Real Time Conference (RT) and the related Journal IEEE Transaction on Nuclear Science (TNS). Now that we move towards applications outside of HEP, it is important also to disseminate to a wider community, increasing the possibility to meet new potential stakeholders outside the HEP community.
We have just now submitted a paper at Distributed Event-Based Systems (DEBS) 2015.
We are taking in consideration to apply for 2015 and 2016 to some other occasions selected from this list of important conferences on electronics:
MOCAST --> Deadline in March (Conf is in May)
FPL --> Deadline in March (Conf is in September)
HiPEAC --> ACM TACO Journal Submission before June (Conf is in January)
ICECS --> Deadline in July (Conf is in December)
ISCAS --> Deadline in September (Conf is in May)
DATE --> Deadline in September (Conf is in April)
IEEE IIMTC --> Deadline in December (Conf is in May)
And on Imaging:
IEEE ICIP --> Deadline in January (Conf is in September)
IEEE CVPR --> Deadline in November (Conf is in June)
We plan also to have at least 2 other papers to peer review Journals. For HEP papers we plan to continue with IEEE TNS, but for other fields we should try with at least a couple of new Journals from this list:
TCAS, TBioCAS, TVLSI, TACO, TIP, IET computer vision, Elsevier Computer Vision and Image Understanding

7. DEFINITION AND IMPLEMENTATION OF A MORE DETAILED PLAN, WITH SPECIFIC TASKS AND OBJECTIVES, REGARDING THE OUTREACH OF POTENTIAL STAKEHOLDERS OUTSIDE THE CERN COMMUNITY.
During the Mid Term Review we got suggestions from Octavian Buiu, our reviewer, about companies that could be interested to our developments. We plan to contact them as soon as D.5.3. and D.5.4. will be ready. The objective is to find companies that already have a strong role in the market of image processing and could appreciate our results, could be interested to add value to their products exploiting our technology.
This is the list:

(1) http://www.andor.com/scientific-cameras : Andor technology, based in Belfast, part of Oxford Instruments as of 2014, “Global leaders in the development and manufacture of high performance scientific digital cameras for academic, industrial and government applications. Through continuous dialogue with their customers and strong teamwork they continue to innovate ground-breaking products, improving the world in which we live.”
(2) http://www.specim.fi/ Hyperspectral Imaging Cameras and Systems – SPECIM
To this day, in order to reach the high-ends of precision, durability and functionality, SPECIM has been in the forefront with new technological solutions applied to hyperspectral imaging. World class research, business, and defense organizations are relying on Specim quality when performance and reliability matters.
(3)
http://www.photonic-science.co.uk/news/index.php?post/2013/05/06/new-cooled-ingaas-camera-quantitative-SWIR (Scientific Detector Systems - SWIR imaging) - Photonic Science Limited, with head offices in the UK.- In the last few years a whole new waveband of the electromagnetic spectrum has been opened up for exploitation: the Short Wave Infra Red (SWIR). The band runs from the edge of the near IR region at 900 nm up to 1700 nm, and has traditionally been invisible to all detectors. Now, Indium Gallium Arsenide sensors can image within this waveband, for a wide range of applications. For example, solar cells can be made to emit in this waveband, allowing in-line inspection of their internal structure during manufacture. Bruising of fruit can be detected by imaging the sub-surface accumulation of water. Surveillance applications can benefit from reduced atmospheric scattering due to mist in the SWIR band, and can take advantage of the SWIR band “night glow” of a clear night sky. SWIR band laser illuminators, invisible to most detectors, can provide high quality night vision when coupled with a SWIR camera.
(4) http://www.arm.com/ ARM - The Architecture for the digital world, a UK based company.
In addition of these very advanced companies in Europe, we plan to continue our research of companies in Tuscany (research already activated, see the description of the roadmap of WP5) to reinforce our regional consortium. An interesting example of company in Tuscany we plan to collaborate with is: http://www.alkeria.com/

8. BETTER DESCRIPTION OF THE TRAINING ACTIVITIES, IN PARTICULAR MORE DETAILS ABOUT HOW THE EVENTS WERE ORGANIZED OF ATTENDED.
----------TRAININGS
The trainings were established in the Annex 1, in the context of WP8, and we followed exactly that plan. The specific organization and dates were established during the GA meetings, by the collaboration, trying to optimize the fellow participation, described by the table 1 in the attached file FTK-Additional_info.pdf and by the photos shown in the deliverables of the trainings. The trainings were associated with other events to maximize the participation. They were organized in all partner’s locations to allow the fellow to reach and know all the partner’s institutions.
(A) ---- UNIPISA HOSTED THE FIRST WORKSHOP AND TRAINING in March 2013:
“The AM system”: kick-off at UniPisa, for specific experience. Hands-on activity in Lab. As the opening event of the network, a set of seminars has been given on (1) global architecture and data rate problems, (2) specific logic and existing boards analysis, (3) AM chip status and future evolution, (4) existing tests, laboratory tools and test stands, (5) knowledge of the collaboration (6) career opportunities and importance of managerial skills inside the FTK project. This was also a nice occasion to meet a large number of collaborators at the very beginning and to plan in detail the content of the first secondments. It was a three days training (see the attached deliverable D8.1&8.2_2013_FTK_wUNIPI&TrUNIPI.pdf)
(B) ---- CAEN OFFERED THE SECOND TRAINING in July 2013, when a lot of secondments were active between Pisa and CAEN itself. These interesting arguments, based on the CAEN specific experience where treated:
“Silicon Photomultiplier read out-SIPM”, “Past experience at LHC”, “Overview of EU projects” at CAEN. A set of seminars were given by CAEN personnel:
(1) EU Collaborative Projects: How to build up a successful project proposal for the European Framework Porgramme A. Iovene
(2) Workshop on CAEN Silicon Photomultipliers Educational Kit; M. Locatelli
(3) The CAEN experience at CERNfor the development of custom electronicsfor the LHC experiments C. Raffo
It was a one afternoon training (see the deliverable D8.2_2013_CAEN_Training.pdf).
(C) ----- AUTH ASSOCIATED THE MOCAST WORKSHOP with its TRAINING, in March 2014.

Based on the experience of the electronics division, AUTH has offered these trainings:
"Embedded System Design Using FPGA Technology", "VHDL Verification Techniques" and "Design Exploiting FPGA Resources" with lab sessions, at AUTH. The training included (a) laboratory sessions using the existing equipment of the electronics division, such as training FPGA boards and design suites; (b) a training on "Machine Vision Implementations for Lab-On-Chip applications". It was a two days training (see the deliverable D8.2_2014_AUTH_Training.pdf).
(D) ----- FINALLY PRIELE OFFERED ITS TRAINING :“Overview of a successful PRIELE project: Laros. Remote Monitoring and Condition Based Maintenance in Maritime Industry” in Athens, October 7 2014. It was the same week of the HiPEAC computing week, where we organized an FTK Session, to maximize the participation. PRIELE described one very successful project from the idea to the market:
(1) Introduction to Ship Control Technologies / Introduction to Condition Based Maintenance and E-Maintenance / Introduction to Ship Performance Analysis
(2) Specifications of a Monitoring System and differences from a Control System
Wireless versus Wired Monitoring Solutions / The transition from Sensors to Intelligent Sensors
(3) LAROS in depth / Real Life Use Cases / Data Analysis
(4) Workshop : Hands-on LAROS Wireless Nodes
One day training (see deliverable D8.2_2014_CAEN_Training.pdf).
---------- SOFT TRAININGS
The soft trainings were generically planned on Annex 1 in the WP8, as task 8.3 “Provision of courses in transferable skills. For example project management, language and presentation skills, IPR, ethics, ...”
We developed this plan starting with the trainings that collected the higher interest from the fellows. A particular interest was demonstrated about learning how to apply for funds, so a collection of information taken from more than one NCP meeting, was made available about Horizon 2020. A second important argument for fellows was language lessons and we did the best to provide them. A “Communication” training and many conference occasions were offered as tools to improve presentation skills. All these trainings were planned during the GA and EB meetings, performed via skype with slides organized on an agenda, to allow the maximum participation in the network, see table 1 on the FTK-Additional_info.pdf. In the next couple of years we will complete the list organizing trainings about Intellectual Property Rights, and also Ethics problems. A subgroup of us from LPNHE and UNIPISA started already to follow the first 2015 webinar of the European IPR Helpdesk 2015 series “Introduction to IP”, and got a first contact with a company that helps to deposit patent’s requests:
Hoffmann Eitle | Patent- und Rechtsanwälte PartmbB www.hoffmanneitle.com
Arabellastraße 30 | 81925 München T +49. (0)89. 92 409. 1054| F +49. (0)89. 91 83 56
In addition in Pisa we will also offer in 2015 a course of Scientific English, to improve further the capability of not English researchers to write a paper, to give a seminar, to do a presentation.
Here follows a detailed description of the soft trainings done in the first 2 years:
-------- LANGUAGE Trainings – Goal: improve integration of the foreign researchers in the hosting country environment: (a) 2 months Italian course for Mermikli and Sakellariou; (b) 4 months Italian course for Gentsos; (c) 10 private lessons for Sampsonidis; (d) long course of French lessons for Beccherle. (f) 4 months of Italian lessons for Sotiropoulou.
--------SECURITY & SAFETY at WORK (July 2013). Half day training about the employer’s and employee’s responsibility to adhere to the legislation that affects them. Health, safety and security procedures.
--------COMMUNICATION Training (June 2014). Goal: increase knowledge of the importance of communication skills, dissemination, planning, etc. One-afternoon training based on available documents:
(1) “Communicating EU Research & Innovation”, A guide for project participants, European Commission.
(2) “Good practice examples”, A guide for project participants, European Commission.
(3) “How to write a dissemination plan”, APRE, Italian NCP.
Agenda: https://agenda.infn.it/conferenceDisplay.py?confId=8278
-------- MANAGEMENT training - Horizon 2020 (July 2014). Goal: increase knowledge of the opportunities available in Horizon 20202. One-afternoon training based on available documents:
(1) “Horizon 2020 – General”, APRE, Italian NCP.
(2) “The role of SMEs in Horizon 2020 projects - Several opportunities to strengthen the collaboration between Research Institutions and SME”, Alessandro Iovene, CAEN

(3) “How to apply”, APRE, Italian NCP.
(4) “ERC & FET: excellent science”, Anfossi INFN
Agenda: https://agenda.infn.it/conferenceDisplay.py?confId=8424
-------- HiPEAC training (July 2014) - Goal: increase knowledge of the opportunities available in Embedded System organizations. Two hour seminar by C-L. Sotiropoulou and discussion.
Agenda: https://agenda.infn.it/conferenceDisplay.py?confId=8425
-------- SPECIFIC TRAININGS FOR A SINGLE FELLOW: personal trainings were offered following the particular interests of single fellows.
(1) Attended by F. Crescioli, CNRS: Analyse bionformatique des sequences nucleiques et proteiques.
(2) Attended by Beccherle: (a) Cadence training: Encounter Bottom Up Flow, (b) Doulos training: SystemVerilog for Verification Specialists with an introduction to UVM, (c) Cadence VCAD: Analog and Mixed Signal Workshop with 65nm Design Kit
(3) Attended by Piendibene: Accelerate System Performance with ALTERA SoC
(4) Attended by Gentsos: (a) DVCon Europe 2014, Munich; (b) Avnet X-Fest 2014 workshop, Milan.
(5) Attended by Sakellariou: Quality assurance for developing and production of high standards electronics for Space, Military and Scientific projects

9. AS THE PROJECT DID NOT REACH ITS GOALS FOR GENDER BALANCE, description of an outreach activity dedicated in order to present the project to female students. The project is invited to implement this, if feasible.
We spoke with Sandra Leone, that was INFN member of the FP7 GENISLAB project and is the person that organizes each year the Master Class session at INFN Pisa. We decided to have an FTK session for only female students in the same days the Master Class session will be executed in Pisa. High-school students get invited to a research institute or University to be scientists for one day. The International Master Classes provide the occasion to them to analyse LHC data. There are introductory talks, for 2 hours they can work with LHC data, and there are also video conference connections with CERN/FERMILAB and other institutions. Only a small fraction of students can participate from each school and usually the majority of them are male students, because they are classified as “more interested”. We will profit of the contact that INFN will have with all the High schools around Pisa to invite an additional group of female students that will have the occasion to listen to introductory talks on modern electronics and will have a short experience on the use of FPGAs. The goal is to attract their attention on a field that is totally unknown to female students. We plan also to invite an expert member of the committee “Pari Opportunita’” of INFN to give a seminar on the argument “gender balance in science and engineering”

10 CLEAR DESCRIPTION OF HOW TRANSFER OF KNOWLWDGE IS IMPLEMENTED IN THE PROJECT AND WHAT ARE ITS RESULTS/IMPACT TO BOTH THE PROJECT AND THE FELLOWS
As requested by the Milestone 8.1, we evaluated the transfer of knowledge (ToK) within the collaboration and the training results of the first 2 years. We were extremely satisfied of the obtained integration of the collaboration, well announced by the strong interaction during the first FTK workshop in Pisa and the many results presented in the second workshop in Greece (D.8.1 in 2013 and 2014 folders). The ToK followed exactly the expected plan, as described in the Deliverables and the Reports of the Scientific Program, mentioned in the next section. An important goal of this complex project is the transfer of competencies to new teams that should be strong enough to support the new applications and developments. The new members (PRIELE, CAEN and AUTH) after a first period dedicated to learn the technology became the leading actors of new tasks. UNIPISA, LPNHE and CERN interacted strongly to achieve at best the integration of the new members since they are fundamental collaborators for the FTK production phase. We can summarize here the main results obtained by the collaboration:
(1) Personnel from PRIELE entered the project on 3 different areas: (a) design of boards with the Cadence tool: a very successful ToK was activated between Sakellariou and UNIPI personnel (Citraro and Piendibene) during his secondments (spring 2013 and end of summer 2014); (b) firmware development and related tests: ToK was activated between D. Dimas and personnel from UNIPISA (2013 secondment), and AUTH (2014 secondment); (c) software development: ToK is iniziated with Mermikli's secondment at UNIPI (2014). Piendibene and Donati have been seconded to Alexandroupolis to build a setup for tests of future production. PRIELE has learnt a lot about the

boards to assembly; in fact, the first AMBSLP and LAMBSLP have been successfully assembled in Alexandroupolis and the AMBSLP was tested by AUTH personnel, with more test to come.. Overall, we became a strong unified team ready for production.
(2) Secondments of Crescioli, Calderini and Piendibene at CAEN resulted in two integration test stands, one for WP2 and one for WP6, where board prototypes and silicon detectors have been tested, interacting with CAEN personnel, Paola Garosi, Alessandro Iovene and Stefano Petrucci (see WP2 and WP6 Deliverables). Stefano Petrucci produced a first power supply in CAEN, and installed it at CERN in collaboration with Piendibene. This setup was used for cooling tests, defining the final architecture of the infrastructures. Petrucci's experience on power supplies was precious for Piendibene, who in turn taught Petrucci about FTK. The power consumption has been discussed with CAEN engineers and they collaborate with Piendibene for the design of the final device. The groups are well integrated.
(3) AUTH had a very fast integration in FTK. Sotiropoulou and Gentsos, two very brilliant Ph.D students, have chosen the most complex algorithms in FTK to be implemented for their thesis. Their long secondments to CAEN allowed them to learn deeply about FTK from Crescioli, Piendibene and very quickly they became pillars of the project. Kordas (on hardware with Piendibene) and Sampsonidis (on software with G. Volpi) worked for the tests of the integrated system at CAEN. Volpi was recruited by UNIPISA on WP4, as he is the most expert on the FTK simulation. Both Kordas and Sampsonidis increased the background knowledge of the AUTH group. Finally, Naoki Kimura from Japan was recruited in AUTH. He is a very experienced researcher who has worked in FTK since the beginning, before 2010. Naoki has reinforced the group, which has now an important position in the full ATLAS FTK collaboration.
(4) CNRS has provided a lot of knowledge to the new Institutions, but has also recruited a very experienced researcher in the field of WP6. Beccherle participated to the construction and commissioning of the front end electronics of the pixel detector now installed in ATLAS, so he is a perfect element to reinforce the group R&D for pixel upgrades (WP6).
(5) CERN has provided its great experience in board layout, placement and routing, collaborating with PRIELE and UNIPI to complete the AMBSLP and LAMBSLP prototypes.
IMPACT - We have a strong collaboration that has a good probability to become lasting and tackle future developments. The complexity increase of FTK compared to the state of the art, requires this level of organization also for possible future expansions at other experiments like CMS and applications outside High Energy Physics. In addition, a new market could be opened to our companies: intensive, parallel computation based on FPGAs and specific VLSIs is a field where electronics has an enormous potential, and this is obviously very interesting for the SMEs participating to this network.
At an individual level, the researchers have great visibility and the success of the project reflects on them increasing their capability to develop an interesting career. Each Researcher has prepared a Career Development Plan discussing it with his/her supervisor. These documents are collected in the internal FTK web page: http://ftk-iapp.physics.auth.gr/Collaboration/Docs/Career-Dev/

WORK PROGRESS AND ACHIEVEMENTS DURING THE PERIOD

Comments:

Our final goals (real time tracking for Level 2 and Level 1 trigger selections at LHC experiments) are very challenging, so we need to advance in our research program by steps. For this reason we organized our work plan in such a way that design, tests and commissioning are performed in parallel, in cycles, instead of executing them sequentially, just once, as usually is done. It is important that test results and commissioning provide a feedback on design before the system is frozen for a large production. For this reason in the first two years we started in parallel the test (WP2) of prototypes already designed for the FTK Demonstrator before the creation of our network, and the design of a new prototype (WP1), the Serial Link Processor (SLP2), to choose at the end of developments the best solution, a decision to be made on real test results. Commissioning and production also will be done by steps to be able to introduce in the last steps needs that eventually were born from the first data taking done with the first FTK pieces. The methodology of parallel design, tests, commissioning and future R&D is demanding in terms of manpower and infrastructures. For this reason the transfer of knowledge goal of the project is the involvement of new institutions and new companies that can learn about the project in the development phase and be fundamental in the future at the production and running time.
As described in the section “Project Objectives for the period”, the work is organized in 5 areas, or work packages (WP). The first two years of the project have been devoted to: (a) validate and integrate the already developed prototypes (WP2-“Infrastructure & Integration” and WP4-“Architecture simulation”); (b) develop a new version of a more modern processor (WP1); (c) validate and integrate the new developed prototypes (WP2 & WP4); (d) study of the FTK impact on the ATLAS trigger selections; (e) study and optimize the infrastructures to be installed at CERN; (f) install the demonstrator at CERN as a first step of the commissioning (WP3); (g) expand and anticipate the original project program; (f) WP6 activities.

(a) The already designed boards for the FTK Demonstrator (AMBFTK, LAMBFTK and AMchip04) were integrated successfully and tested during the WP2 activities according to the schedule (in D2.2 a publication reporting about the tests of this system). The prototypes perform correctly the pattern matching function, in agreement with the simulation (WP4). However the AMchip04 used in these tests is a reduced version of the FTK final Associative Memory (AM) chip. It can host only 8000 patterns while the final one will host 128000 patterns. Extrapolations of the TSMC 65 nm technology to the final chip size, allowed us to understand that the final chip would not be compatible with the old package. This conclusion pushed the collaboration to choose the more modern processor SLP2.
(b) In parallel, within WP1, we have designed the alternative to the AMBFKT, the SLP2 processor for applications at “Level 2” triggers, strongly based on intense exploitation of the modern high performance serial links and the most modern FPGAs (see D1.1). This new processor exploits the new chip AM05, fully equipped with serialized I/O. We purchased an IP core by the Silicon Creation, to have such a powerful I/O. Unfortunately, the AM05 required a long developing time, especially to design the new custom cells characterized by very low power consumption. The tests of consumption executed in Italy and CERN demonstrated the difficulties to use the commercial power supplies and cooling devices. So the AM chip design effort was strongly focused on the consumption reduction. As a consequence, AM05 was submitted with a delay of some months and it was available for tests with the final LAMBSLP only in July 2014. FTK has therefore produced a preliminary small AM chip, the “mini@sic”, neither complete, nor providing the final package, but complex enough to validate the functionality of the new I/O.
(c) Tests (WP2) of the new SLP2 have been executed using the mini@sic, to guarantee the new chip compatibility with the developed boards (see D2.5 and Crescioli's 2014 report). In order to use the mini@sic on the new motherboard (AMBSLP), a special mezzanine card named “miniLamb” has also been produced. The SLP2 processor has been fully tested with the miniLamb and the mini@sic, first, and recently tested also with AM05 and the real mezzanine LAMBSLP. Both set of prototypes (the AMBFTK and the AMBSLP with their relative mezzanines and AM chips) have passed a detailed review by the ATLAS Collaboration and the LHC Committee (LHCC). The FTK TDR [https://cds.cern.ch/record/1552953/files] has been produced during summer 2013 and FTK has been approved by ATLAS in July 2013 and by LHCC in September 2013. In particular, the AMBSLP that was proposed as the favourite solution in the TDR, was finally selected as the best prototype to build FTK. This was discussed during the meeting on the review of the Associative Memory system that

happened in October (agenda and presentations https://indico.cern.ch/conferenceDisplay.py?confId=274456). The conclusions drawn at this meeting are summarized in the final report (https://edms.cern.ch/document/1322190/1). The power consumption of the FTK system was also presented and discussed at this review. In conclusion, FTK was approved with the use of the new SLP2 processor and the AMBFTK system has been abandoned (Milestone 2.4). The integration activity has provided the creation of a new infrastructure in CAEN, thanks to the secondments of Kordas and Crescioli (see D2.1 and Crescioli's 2013 report) and a new test stand in PRIELE (see the reports of Donati and Piendibene at PRIELE in 2013). At CAEN both the AMBFTK (see D2.2) and the AMBSLP (see D2.5) have been integrated successfully inside the PU. The board level simulation and the test vectors have been implemented (WP4, see D4.1 D4.2 and D4.3). Hardware simulation is a powerful tool that predicts the processor unit output as a function of its input. The tests require the prediction to be equal to the HW output.
(d) We studied intensively with the FTK simulation (WP4) the impact of FTK on the ATLAS trigger to produce the "FTK Physics case". This work was initially inserted in the FTK TDR mentioned above. Further studies produced a public note (deliverable D4.4) that had a very relevant impact on the final approval of the processor in the experiment. The core of this studies shows the big advantages due to the fact that FTK provides global track reconstruction in the full inner silicon detector, with resolution comparable to the offline algorithms, in approximately 100 microseconds. A fast and precise detection of the primary and secondary vertex information is thus possible. The track and vertex information is then used by the high-level trigger (HLT) algorithms, allowing highly improved trigger performance for the most difficult signatures, such as b-jets and tau-jets. The expected physics performance in the harsh environment at high pile-up and high luminosities expected for LHC run2 are presented in the deliverable D4.4.
(e) The power consumption of the full system is one of the major concerns of the FTK project. We built a complex system (WP2) to measure the temperatures inside the crates in realistic conditions inside the FTK racks in "USA15", the cavern where the ATLAS trigger logic will be placed (see D.2.4 and Petrucci's report). CAEN has built an ad hoc power supply exploiting a box particularly transparent to air flow (see D2.3 and Piendibene 2014 report) that satisfies the FTK extreme power requirements. The results of the cooling where particularly good, demonstrating that the Wiener Hyper Blower fans added to a turbine are powerful enough to cool the very large consumption of the FTK electronics.
(f) The Processing Unit has been installed in the experiment, in its final version with the only exception of the AMchip, that is the AM05 version with only 2000 patterns per chip instead of 128000 (AM06). Milestone 3.1 is satisfied with AM05. The tests of the integrated PU commissioned at CERN are described in the deliverable D3.1. As soon as AM06 will be available it will be replaced on the boards. The PU is successfully working in the FTK demonstrator that is functionally complete, but covers only a very thin section of detector. More boards will be installed only when AM06 will be available. The PU is scheduled to take data for the first time at the end of 2015, but the real schedule is mainly dependent on AM06 schedule, uncertain today because the design is not ready for submission. ATLAS will keep active the baseline trigger menu working without FTK, until AM06 and FTK will be available.
(g) Finally, the collaboration demonstrated immediately that was strong and provided of different competencies, in particular we had two AUTH Ph.D students, whose research should fit in their final thesis. They showed themselves so active and enthusiastic, interested to the most complex algorithms, that we decided not only to cover the first two year program, but also to enlarge the research to new areas concerning the FTK integration and to anticipate some developments concerning the SLP1 program which were originally scheduled for a later stage. With this strategy the Ph.D students Sotiropoulou and Gentsos assumed tasks that where particularly complex and adequate for their thesis. (a) Sotiropoulou worked on the firmware of the first part of the FTK pipeline, the board that prepares input data to the AM system. She developed a 2-D clustering algorithm transforming the raw pixel data into the best measurement of the particle position on the silicon module (see Sotiropoulou's report and relative presentations to conferences, in particular TIPP2014 where Sotiropoulou was awarded the award "Best Presentation by a PhD student"). (b) Gentsos has started to work on the application of the Associative Memory at Level 1 triggers (SLP1) to achieve further technology performance, miniaturization and integration of the current state of the art prototypes (see Gentsos' report and the TIPP2014 proceeding). The level 1 trigger is much more demanding in terms of a higher rate of events to be processed and a shorter processing latency time. To face the increase of complexity Gentsos plans to increase the FPGA parallelism by associating one FPGA to each AM chip. The FPGA configures and handles the AM and provides a flexible

computing power to process the shapes selected by the AM. He designed the FPGA logic performing all the complementary functions of the pattern matching inside the AM. He simulated the AM and FPGA logic attached together. Originally at the time of the application (2012) AUTH was interested to study the SLP1 architecture for real time track reconstruction applied to their detectors, the new muon chambers that they are going to build for the LHC PHASE I upgrade (AUTH has built muon chambers since the beginning of ATLAS). The possibility to use it for the more complex option of performing tracking in the silicon ATLAS detector for PHASE II operation of LHC was lower priority. However the muon community dropped the option to use Associative Memories even before our IAPP project was activated, so our main SLP1's goal now is R&D for PHASE II LHC operations.
(g) The WP6 work has been successfully started and developed following the plans by Calderini and CAEN (see D6.1 and D6.2) independently from the digital processor activity. The test bench has been created and interesting measurements executed. The activity is on going at LPNHE with prototype productions and test beam verifications.
The Milestones of the scientific program where all satisfied (see next section).
The list of talks and papers presented to conferences is in the attached file FTK-Additional_info.pdf

DELIVERABLES AND MILESTONES TABLE

SECONDMENT / RECRUITMENT

Fellow First Name	Fellow Surname	Recruiting participant	Seconded from participant	Seconded to participant	Type of Contract	Category	Location of origin	Gender	Family charges	Start date of secondment/ recruitment	Duration of secondment / recruitment	End date of secondment/ recruitment	Working time commitment	Full-time equivalent person-months covered during the reporting period	Declaration of Conformity submitted
Dimitrio s	Dimas	UniPisa	PRIELE	UniPisa	A	ER 4-10	EL-Greece	Male	No	01/06/2013	2	31/07/2013	Full Time	2	Yes
Andreas	SAKELLARIOU	UniPisa	PRIELE	UniPisa	A	ER 4-10	EL-Greece	Male	No	01/04/2013	25	30/04/2015	Other	4	Yes
Guido	Volpi	UniPisa			A	ER 4-10	IT-Italy	Male	Yes	20/10/2013	14	19/12/2014	Full Time	14	Yes
Konstant ina	Mermikli	UniPisa	PRIELE	UniPisa	A	ESR	EL-Greece	Female	No	01/09/2014	2	31/10/2014	Full Time	2	Yes
Kalliopi L ouiza	Sotiropo ulou	CAEN	AUTH	CAEN	A	ER 4-10	EL-Greece	Female	No	04/04/2013	4	03/08/2013	Full Time	4	Yes
Dimos	Sampsoni dis	CAEN	AUTH	CAEN	B	ER >10	EL-Greece	Male	Yes	04/06/2014	26	03/08/2016	Other	2	Yes
Giovanni	Calderin i	CAEN	CNRS	CAEN	B	ER >10	FR-France	Male	No	29/07/2013	27	28/10/2015	Other	2	Yes
Francesc o	Cresciol i	CAEN	CNRS	CAEN	B	ER 4-10	FR-France	Male	Yes	22/07/2013	31.6	10/03/2016	Other	4	Yes
Christos	Gentsos	CAEN	AUTH	CAEN	A	ESR	EL-Greece	Male	No	03/09/2013	15	02/12/2014	Other	11	Yes
Marco	Piendibe ne	CAEN	UniPisa	CAEN	B	ER >10	IT-Italy	Male	Yes	16/10/2013	31	15/05/2016	Other	7.5	Yes
Kostanti nos	Kordas	CAEN	AUTH	CAEN	B	ER >10	EL-Greece	Male	Yes	15/05/2013	40	14/09/2016	Other	2	Yes
Stefano	Petrucci	CERN	CAEN	CERN	B	ER >10	IT-Italy	Male	Yes	01/07/2014	2	31/08/2014	Full Time	2	Yes
Dimitrio s	Dimas	AUTH	PRIELE	AUTH	A	ER 4-10	EL-Greece	Female	No	02/06/2014	8.9	28/02/2015	Other	1.77	Yes
Naoki	Kimura	AUTH			A	ER 4-10	JP-Japan	Male	No	02/06/2014	24	01/06/2016	Full Time	8	Yes
Marco	Piendibe ne	PRIELE	UniPisa	PRIELE	B	ER 4-10	IT-Italy	Male	Yes	26/07/2013	35.2	01/07/2016	Other	2.17	Yes
Simone	Donati	PRIELE	UniPisa	PRIELE	B	ER 4-10	IT-Italy	Male	Yes	12/07/2013	2	11/09/2013	Full Time	2	Yes
Roberto	BECCHERLE	CNRS			A	ER >10	IT-Italy	Male	Yes	01/04/2014	12	31/03/2015	Full Time	10	Yes
Kalliopi -L	Sotiropo ulou	UniPisa			A	ER 4-10	EL-Greece	Female	Yes	19/01/2015	24	18/01/2017	Full Time	0.5	No

ouiza															

No. of full-time equivalent months covered during this reporting period: 80.94

M - Months

RESR - Researcher

FAC B - Fixed amount contract B (%)

SECONDMENT																									
Participants	**S.1**	**S.2**	**S.3**	**S.4**	**S.5**	**S.6**	**S.7**	**S.8**	**S.9**	**S.10**	**S.11**	**S.12**	**S.13**	**S.14**	**S.15**	**S.16**	**S.17**	**S.18**	**S.19**	**S.20**	**S.21**	**S.22**	**S.23**	**S.24**	**S.25**	**S.26**	**S.27**
UniPisa	2	1		2	1			0		8	2		6	2		2	0			0						0	
CAEN	6	1		11	1		-5	0		17	3	33	8	2	50	9	1	NaN	28	4	100	13.5	4	100	14.5	0	
CERN	2	1			0		2	1			0			0			0		6	1	100	2	1	100	4	0	
AUTH		0			0			0		6	3		1.8	1		4.25	2			0			0			0	
PRIELE		0			0			0		8	2			0		8	2		6	2	100	4.17	2	100	1.75	0	
CNRS		0			0			0			0			0			0			0			0			0	
Total	10	3		13	2		-3	1		39	10	33	15.8	5	50	23.25	5	NaN	40	7	300	19.67	7	300	20.25	0	

S.1 : Foreseen months (ESR<4)
S.2 : Foreseen researchers (ESR<4)
S.3 : Foreseen Fixed amount contract B (%)(ESR<4)
S.4 : Implemented months (ESR<4)
S.5 : Implemented researchers (ESR<4)
S.6 : Implemented Fixed amount contract B (%) (ESR<4)
S.7 : Difference months (ESR<4)
S.8 : Difference researchers (ESR<4)
S.9 : Difference Fixed amount contract B (%) (ESR<4)
S.10 : Foreseen months (ER 4-10)
S.11 : Foreseen researchers (ER 4-10)
S.12 : Foreseen Fixed amount contract B (%)(ER 4-10)
S.13 : Implemented months (ER 4-10)
S.14 : Implemented researchers (ER 4-10)
S.15 : Implemented Fixed amount contract B (%) (ER 4-10)
S.16 : Difference months (ER 4-10)
S.17 : Difference researchers (ER 4-10)
S.18 : Difference Fixed amount contract B (%) (ER 4-10)
S.19 : Foreseen months (ER>10)
S.20 : Foreseen researchers (ER>10)
S.21 : Foreseen Fixed amount contract B (%) (ER>10)
S.22 : Implemented months (ER>10)
S.23 : Implemented researchers (ER>10)
S.24 : Implemented Fixed amount contract B (%) (ER>10)
S.25 : Difference months (ER>10)
S.26 : Difference researchers (ER>10)
S.27 : Difference Fixed amount contract B (%) (ER>10)

M - Months

RESR - Researcher

FAC B - Fixed amount contract B (%)

RECRUITMENT																	
Participants	**R.1**	**R.2**	**R.3**	**R.4**	**R.5**	**R.6**	**R.7**	**R.8**	**R.9**	**R.10**	**R.11**	**R.12**	**R.13**	**R.14**	**R.15**	**R.16**	**R.17**	**R.18**
UniPisa	38	2		14.43	2		23.5	0			0			0			0	
CAEN		0			0			0			0			0			0	
CERN	12	1			0		12	1			0			0			0	
AUTH	24	1		8	1		16	0			0			0			0	
PRIELE		0			0			0			0			0			0	
CNRS		0			0			0		12	1		10	1		2	0	
Total	74	4		22.43	3		51.5	1		12	1		10	1		2	0	

R.1 : Experienced Researcher (ER 4-10) - Foreseen months
R.2 : Experienced Researcher (ER 4-10) - Foreseen researchers
R.3 : Experienced Researcher (ER 4-10) - Foreseen Fixed amount contract B (%)
R.4 : Experienced Researcher (ER 4-10) - Implemented months
R.5 : Experienced Researcher (ER 4-10) - Implemented researchers
R.6 : Experienced Researcher (ER 4-10) - Implemented Fixed amount contract B (%)
R.7 : Experienced Researcher (ER 4-10) - Difference months
R.8 : Experienced Researcher (ER 4-10) - Difference researchers
R.9 : Experienced Researcher (ER 4-10) - Difference Fixed amount contract B (%)
R.10 : Experienced Researcher (ER>10) - Foreseen months
R.11 : Experienced Researcher (ER>10) - Foreseen researchers
R.12 : Experienced Researcher (ER>10) - Foreseen Fixed amount contract B (%)
R.13 : Experienced Researcher (ER>10) - Implemented months
R.14 : Experienced Researcher (ER>10) - Implemented researchers
R.15 : Experienced Researcher (ER>10) - Implemented Fixed amount contract B (%)
R.16 : Experienced Researcher (ER>10) - Difference months
R.17 : Experienced Researcher (ER>10) - Difference researchers
R.18 : Experienced Researcher (ER>10) - Difference Fixed amount contract B (%)

Comments:

All the requested and approved changes to the Gantt Chart are described in the attached file FTKAdditional_Info.docx.
There is one deviation from ANNEX 1, visible in the above table, submitted to and approved by the PO: the 11 months secondment from AUTH to CAEN in the ESR section has 5 months more than expected. The 5 months have been implemented using the funding of 5 months scheduled in the ER section, that will not be implemented since the ER researcher Calliope Sotiropoulou left the consortium July 2014. She was substituted by the ESR researcher Gentsos. The change was approved by an e-mail of Dr. Emanuela Marinelli dated 07/02/2014.

In addition some secondments that originally were planned as 2 months without interruptions have been divided in 3 periods of duration shorter than one month, some secondments were also delayed. These cases were approved by e-mails of Dr. Lucia Pacillo dated 06/09/2013 and by Dr. Emanuela Marinelli dated 07/02/2014. For all details of changes approved by the Project Officers please refer to the attached file FTKAdditional_Info.docx.

Both the recruitment at CNRS and AUTH started with some months of delay. Both changes were approved by an e-mail of Dr. Emanuela Marinelli dated 07/02/2014 (see the attached file FTKAdditional_
Info.docx)

INTERNATIONAL CONFERENCES / EVENTS OPEN TO EXTERNAL RESEARCHERS

Event Number	Participant hosting the event	Type of Event	Month when the event took place	Start date of the event	End date of the event	Total number of researchers outside the network attending the event	Total number of researcher days for researchers from outside the network attending the event	Website of the event
1	UniPisa	FTK Workshop	2	11/03/2013	12/03/2013	8		
2	AUTH	ISOTDAQ2013 at AUTH	1	01/02/2013	08/02/2013	10		https://isotda q.web.cern.ch /isotdaq /isotdaq/2013.html
3	CERN	FTK session during the TDAQ weel	11	04/12/2013	04/12/2013	20		https://indico .cern.ch/even t/232459/
4	AUTH	FTK Session during MOCAST 2014	14	14/03/2014	15/03/2014	30		http://mocast. physics.auth. gr/
5	AUTH	FTK Session during HiPEAC Comp uting Systems Week in Athens	21	09/10/2014	09/10/2014	20		http://www.hip eac.net/add/r es/117/5 17

Total number of researchers outside the network attending the event	Total number of researcher days for researchers from outside the network attending the event
88	0

Planned number of researcher days for researchers from outside the network attending the event: 0

Remaining number of researcher days for researchers from outside the network attending the event: 0

I declare that the events in category F for which a contribution is claimed did not give rise to a profit: Yes

Comments:

MILESTONES

Milestone no.	Milestone name	Due achievement date from Annex I	Achieved	Actual / Forecast achievement date
41	Demo general simulation ok	31/07/2013	Yes	31/07/2013
11	Slp2 prototype ok at Priele	31/01/2014	Yes	31/01/2014
12	Prototypes Atlas Review	31/01/2014	Yes	31/10/2013
21	Demonstrator ok at Caen	31/01/2014	Yes	31/01/2014
22	Slp2 ok at Caen	31/10/2014	Yes	31/10/2014
23	Infrastructure ok at CAEN	31/10/2014	Yes	31/10/2014
24	Compare_technologies	31/10/2014	Yes	31/10/2013
31	Demonstrator ok at Atlas	31/01/2015	Yes	31/01/2015

Comments:

Each number of the Milestone is composed of two digits. The first one on the left is the WP number and the second digit is the number of the milestone for that WP.

ADDITIONAL INFORMATION

Fellows First name	Fellows Surname	Living allowance (€)	Mobility allowance (€)	Travel distance (km)	Travel allowance (€)	Career allowance (€)
Dimitrios	Dimas	5196.75	746.20			
Andreas	SAKELLARIOU	5196.75	746.20			
Guido	Volpi	5196.75	1066.00			
Konstantina	Mermikli	3375.67	746.20			
Kalliopi Louiza	Sotiropoulou	5196.75	1066.00			
Dimos	Sampsonidis	3886.46	1066.00			
Giovanni	Calderini	3886.46	1066.00			
Francesco	Crescioli	2598.38	1066.00			
Christos	Gentsos	3375.67	746.20			
Marco	Piendibene	3886.46				
Kostantinos	Kordas	3886.46	1066.00			
Stefano	Petrucci	4006.77	769.30			
Dimitrios	Dimas	4621.50				
Naoki	Kimura	4621.50	663.60			
Marco	Piendibene	3456.25	948.00			
Simone	Donati	3456.25	948.00			
Roberto	BECCHERLE	8465.63	1161.00			
Kalliopi Louiza	Sotiropoulou	5196.75	1066.00			

Indicate any additional information, which may be considered useful to assess the work done during the reporting period. The socio-economic aspect of the project may be addressed in this section. If applicable, propose corrective actions related to discrepancies between planned and executed deliverables and milestones.

There were no significant discrepancies between planned and executed deliverables and milestones. Secondment's and recruitment's implementation changes are described below in the sub-section "PROBLEMS WHICH HAVE OCCURRED AND HOW THEY WERE SOLVED" in the Project Management description section.

DISSEMINATION ACTIVITIES

Comments:

DISSEMINATION ACTIVITIES EXECUTED DURING THE REPORTING PERIOD
Our dissemination activity is organized into 2 Work Packages, WP7 devoted to the generic public (Objectives are “Communication promotion between the scientific community and the general public” and “ Awareness of science increase”) and WP8 devoted to the scientific - industrial public directly involved into our research, even our network itself since the primary goal of our project was the increase of the real time tracking community expertise.
Communication with potential, direct users of the project results, was outstanding in the high energy physics environment (CERN), as can be demonstrated by the success of the project inside ATLAS and the interest of CMS to use in the future the same technology. Other projects like IMPART and INFIERI (see the subsection “POSSIBLE CO-OPERATION WITH OTHER PROJECTS” inside the management section) are interested to exploit our results.
We have been less successful for dissemination outside HEP. We tried to communicate with important European Companies during our application "Neurons" at the call FP7-ICT-2013-10, topic ICT-2013.3.4,but we were not successful. The application was considered over threshold, but we were criticized because we didn't appear strong enough to enter really on the market.
However in January 2015 we succeeded to apply for funds with companies in Tuscany to exploit results of the WP5 activities. This is the result of our previous attempts of establishing contacts with the scientific Tuscan world (see below in the Project Management section). In addition, as described in the section above “DEFINITION AND IMPLEMENTATION OF A MORE DETAILED PLAN, WITH SPECIFIC TASKS AND OBJECTIVES, REGARDING THE OUTREACH OF POTENTIAL STAKEHOLDERS OUTSIDE THE CERN COMMUNITY” we will do a new effort to contact a list of suggested companies in Europe, that could be interesting to our “image reconstruction” processor.
Here follows a detailed description of the task execution for WP7 and WP8, that we implemented exactly as planned in Annex 1.
---------- WP7 – The WP 7 requires each year, for a public not expert in our field, the implementation of:
(a) An Open Day
(b) A School
(c) A Workshop.
We have implemented in Pisa the first (2013) and second (2014) IAPP Open Day and Summer School.

FTK OPEN DAYs
- IAPP Open Day 2013. One day of seminars and poster session, April 17 2013, Aula Magna Edificio E, Area Pontecorvo, Pisa. The first IAPP Open day has been organized in Pisa in the occasion of the (https://www.df.unipi.it/eventi/congressino-2013) “Department congressino”. Taking this opportunity, FTK has provided posters and communicated to students, about the importance of the Trigger for difficult discoveries in High Energy Physics, the importance of the new powerful modern electronics. More details are available in the deliverable D7.1_2013.
- IAPP Open Day 2014. The second Open IAPP day has been organized in Pisa in the occasion of the Italian “Open Day della Ricerca”, April 10-11 in Piazza Cavalieri. Taking the Research Open Day opportunity, FTK has provided posters, boards and chips to the UNIPI stand, to communicate for 2 days to students and very generic public, about the importance of the Trigger for difficult discoveries in High Energy Physics, the importance of the new powerful modern electronics. Shifts of couple of teachers have been organized with FTK personnel to cover the whole period. More details are available in the deliverable D7.1_2014.

FTK SCHOOLS
- VHDL Design, Pisa, Italy, July 1 - July 4, 2013. The goal was to learn how to complete in steps a simple project that required simple object VHDL descriptions (like a register, a MUX, a counter and a Finite State Machine), the addition of Xilinx modules, like FIFOs and RAMs and to simulate them by steps first, and finally all together. We organized lessons during the morning (teacher Calliope-Louisa Sotiropoulou, seconded to CAEN)and exercises related to the argument of the lesson were executed immediately after in each afternoon, with the help of teacher assistants. More details are available in the deliverable D7.3_2013.

- Bootcamp on Scientific Software, Pisa, June 5-June 6, 2014. It was organized in cooperation with Mozilla Science Lab (http://software-carpentry.org/) for 40 persons; a two days hand-on camp aimed at improving the software scientific skills of students (mostly undergraduates) in physics, engineering and computing science majors. A third day included an FTK session with three talks and an afternoon session with the visit to the FTK laboratory with simple demonstrations of FPGA simulation, programming and testing, organized in small groups. More details are available in the deliverable D7.3_2014.

Regarding the two Workshop days, one was organised in Pisa (2013) and one (2014) in Thessaloniki.

IAPP WORKSHOPS

- IAPP Workshop, Pisa, July 2013. Workshop day "LHC e l'ago nel paglaiio". The FTK laboratory has been made available for a short visit in the afternoon and seminars were offered to students during the morning on: (a) the Higgs discovery, (b)the problem of triggering interesting physics, (c) the associative memory technology and (d) modern FPGA electronics. More details are available in the deliverable D7.2_2013.
- IAPP Workshop: Mocast Workshop, Tessaloniki, March 2014. This year the 3rd MOCAST Workshop was organized on March 14-15. In this Workshop a one morning session was dedicated to the FTK-IAPP project and also the first plenary speech was dedicated to high performance embedded systems for HEP using FTK as a working example. A representative from almost all FTK IAPP partners made a presentation in the Fast TracKer (FTK) IAPP Session. More details are available in the deliverable D7.2_2014.

As requested by the Milestones M7.1, M7.4 and M7.7 the results of the events during the first two years were analyzed and the critical points were identified in order to improve the organization of the future events. All the presentations and visits of these events where well organized. However, during the first year while the School audience was consistent, for the Open Day and the Workshop Day the attendance was quite low in 2013. This was probably due to inadequate advertising; we substantially improved in 2014 with very nice posters (see the Deliverables) produced months in advance and shown everywhere in the town around the University and exposed on the web. The MOCAST workshop in AUTH (2014) collected more than 250 people from the general public, University students and professors. For the Open Day in Pisa (2014) we joined the event organized by the whole University, so we had a stand in Piazza Cavalieri, right in the middle of the town, for 3 days. The impact on the public was substantially higher than the previous year, and in addition we could meet researchers of other fields that could become potential users of our technology in the future. We started in this way our first contacts with CNIT's researchers.

OTHER DISSEMINATION FTK EVENTS NOT SCHEDULED IN ANNEX 1.

- Kostas Kordas(AUTH) is part of the advisory board of the ISOTDAQ school ("International School of Trigger and Data Acquisition"), a school on trigger and data acquisition techniques. As a result AUTH hosted the school in 2013 (see the report http://www.isotdaq2013.physics.auth.gr/photos/) and a lecture on the FTK project has been planned for each following year. The talk "Intelligent triggering: pattern recognition with Associative Memories and other tools") was presented in the 5th ISOTDAQ, in Budapest (http://isotdaq2014.wigner.mta.hu/index.html January 28 to February 5, 2014, and http://indico.cern.ch/event/274473/other-view?view=standard#2014-02-05) and has be given again at the 6th ISOTDAQ (Rio, Brasil, Feb. 2015)..
- Thematic session on FTK in HiPEAC Computing Systems Week, Athens, Greece, October 8 -10, 2014, Jan 28 - Feb 5, 2014, organized by Spiros Nikolaidis, Calliope-Louisa Sotiropoulou (AUTH). For more information please refer to http://www.hipeac.net/add/res/117/517. Here is the link to the official HiPEAC newsletter with the report for the FTK session. This is distributed to more than 500 scientists in the field of Embedded Systems.

https://www.hipeac.org/assets/public/publications/newsletter/hipeacinfo41.pdf

- FTK session during the TDAQ week (04/12/2013, CERN, Building 40). The FTK community organizes periodic sessions of one afternoon to discuss the advancement of the project inside the TDAQ community of the ATLAS experiment.

---------- WP8 – The WP 8 requires each year, for a public expert in our field, the implementation of:

(a) An FTK Workshop

(b) A Training

(A) FTK WORKSHOPS

----- The first FTK Workshop was organized in Pisa (March 2013) in coincidence with the Kick-off meeting and the “The AM system” training. This event allowed spreading the FTK knowledge to the new collaborators. Researchers outside the IAPP network from Milan, Pavia and Frascati participated to maximize the knowledge transfer. Activities carried out in the FTK laboratory and seminars were organized to clarify details of the tasks to be executed during the secondments (see D.8.1&8.2 2013). This point was especially important for the two AUTH Ph.D students, whose research should fit in their final thesis. It was a very successful program that demonstrated immediately that the collaboration was strong and provided of different competencies.
----- In March 2014, we had the second FTK workshop (D.8.1 2014) at Alexandroupolis where we verified the very successful work performed during the first year. The Delta TV visited us during this FTK event and produced this video:
(http://www.youtube.com/watch?feature=player_embedded&v=lyRPXxa7_bs).
----- During March 2015 we will have our third FTK Workshop in Paris. It will be open to all the FTK collaborators, also outside the network.
Trainings- they have been described in the previous section “Project Objectives for the period” of this report, answering the specific open issues 1 and 8 of the subsection “FEEDBACK and RECOMMENDATIONS from the MID TERM REVIEW”.
----- ACTIVITIES PLANNED FOR THE NEXT PERIOD.
It is already described in the section “Project Objectives for the period” answering the specific open issues 5, 6, 7 and 9 of the subsection “FEEDBACK and RECOMMENDATIONS from the MID TERM REVIEW”.

PROJECT MANAGEMENT

Comments:

- CONSORTIUM MANAGEMENT TASKS AND ACHIEVEMENTS;
- Organization of the network (task delegation, reporting)

Progress reports, Mid-term report, periodic reports and final report is responsibility of the coordinator. They are based on the WP reports. The financial statements (Form C) and the certificate on the financial statements are responsibility of both the coordinator and the participants. The coordinator delegates to an external person the preparation of documents necessary for financial reports and production of mandatory certificates.

- Supervisory board composition, function and competences. Rules for internal co-ordination, monitoring and reporting

The management scheme of the network consists of two boards: the Steering Committee (identified with the General Assembly in the consortium Agreement) that is primarily responsible for the financial and administrative aspects of the network and the Scientific Board (identified with the Executive Board in the consortium Agreement) that is in charge of the scientific operation of the network, the implementation of the training program and the recruitment processes in consultation of the Steering committee.

o Steering Committee (Annex I terminology) = General Assembly (our terminology): it is responsible of the financial management of the project and the dissemination issues. They play a consultant role in the selection of the network researchers. One member of the Steering committee has been appointed as gender officer. The gender officer was present during the selection procedure of the researchers. Each partner appointed their representative to the SC, chosen to have a longstanding experience and international reputation in leading research teams and multi-institute projects, in order to guarantee the smooth operation of the network. The seconded/recruited researchers have members in the SC (Kordas, Donati, Calderini and Sotiropoulou). This is the SC composition:

1. M. Dell'Orso - University of Pisa, Italy (Chair)
2. K. Kordas - Aristotle University of Thessaloniki, Greece
3. A. Iovene - Costruzioni Apparecchiature Elettroniche Nucleari S.p.A., Italy
4. G. Calderini - IN2P3, Centre National de la Recherche Scientifique, France
5. B. Magnin - European Organization for Nuclear Research, Switzerland
6. P. Soukoulias - PRISMA Electronics SA, Greece
7. S. Donati - University of Pisa, Italy (rep of seconded/recruited people)
8. C.L. Sotiropoulou - Aristotle University of Thessaloniki, Greece (gender officer), left the project on August 1, 2014, replaced by Chiara Roda after that.
9. C. Roda - University of Pisa, Italy (gender officer since August 1, 2014)

o Scientific Board (Annex I terminology) = Executive Board (our terminology): the Scientific Board tasks are (a) to ensure the implementation of the network's scientific and training program, (b) to monitor the progress of the research teams, (c) to ensure good communication and exchange of information among the teams (d) to be responsible for the recruitment process in consultation with the SC. The composition of the SB consists of the representative of each participant institution, the work package managers (see below) including seconded/recruited researchers' representatives (Kordas, Sampsonidis, Crescioli, Sakellariou, Piendibene and Sotiropoulou):

1. M. Dell'Orso - U niversity of Pisa, Italy (chair)
2. K. Kordas (WP7 leader)- Aristotle University of Thessaloniki, Greece
3. D. Sampsonidis (WP8 leader)- Aristotle University of Thessaloniki, Greece
4. P. Garosi(WP2 leader) - Costruzioni Apparecchiature Elettroniche Nucleari S.p.A., Italy
5. F. Crescioli (WP6 leader)- IN2P3, Centre National de la Recherche Scientifique, France
6. A. Sakellariou (WP1 leader)- PRISMA Electronics SA, Greece
7. M. Piendibene (WP5 leader)- University of Pisa, Italy
8. C. Roda (WP4 leader)- University of Pisa, Italy (gender officer since August 1, 2014)
9. B. Magnin (WP3 leader)- European Organization for Nuclear Research, Switzerland
10. C.L. Sotiropoulou - Aristotle University of Thessaloniki, Greece, (gender officer), left the project on August 1, 2014, replaced by Chiara Roda.

o Work Package leaders: for the implementation of the milestones and deliverables of each WP, one leader per WP is appointed (the chosen persons are listed above).
The Steering committee and the Scientific Board are chaired by the project coordinator.
- ----------PROJETC PLANNING AND STATUS - from management point of view;
------ Rules for effective decision making including contingency planning
We follow the working plan description with its deliverables and milestones and risk analysis. Any deviation with that has been discussed with the ATLAS collaboration, to generate a proposal to be submitted to REA. The proposal has been discussed and voted by our Scientific Board before going to REA.
------ Methods and tools for effective network communication
We have created and maintained a dedicated webpage for dissemination, outreach and ongoing research documentation, for management also (see D7.4 and D8.3 for 2013 and 2014). All our meetings have used the Indico software for agendas, slide collection and minutes. Secure access to both the webpage and the Indico pages is guaranteed, for reserved information. In addition, the communication among the partners is assured through telephone-conferences, video-conferences and a dedicated e-mailing list.
------ Financial management
All the categories have a clear expenditure path, well defined by the list of secondments and recruitments and by "The Marie Curie Actions FP7 Financial Guidelines". Each participant provides the expenditure details to the coordinator one month in advance of each financial report.
Changes on expenditures from the original secondment/recruitment plan have been evaluated carefully and a proposal has been submitted to the PO to reallocate the not used funds in such a way that the network gets advantage from that,
------ Recruitment strategy
We had 4 ER recruitments: UNIPISA recruitment for WP4, CNRS recruitment for WP6, AUTH recruitment for WP1-3-4 and recently UNIPISA again for WP5. The procedures followed the European Charter for researchers and the Code of Conduct for their Recruitment. When enough valid applications were available (only for AUTH recruitment happened) a short list has been drawn. The short- listed candidates have been invited for an interview made by skype. In the other two cases only one candidate had a pertinent curriculum. The value of the recruited researcher for the execution of the scientific program is described in the section where TOK is described in detail, answering a request generated at the MID TERM REVIEW. Recruitment detailed documents are collected in the web protected area (user: ftk-iapp, pass: ftk-iapp2013)
http://ftk-iapp.physics.auth.gr/Collaboration/Organisation/SecRec. In all cases, the recruited fellows are real experts on their fields, and thus they have a great impact on the success of the project. The first three recruited fellows were present at the mid-term review in Brussels. The most recent recruitment in UNIPISA was also very successful since C.-L. Sotiropoulou decided to apply and was selected. She is very expert on FPGA design and specifically on Imaging techniques.
------ GENDER ASPECTS
One member of the Steering committee has been appointed as gender officer. The gender officer has been present during the selection procedure of the recruited researchers to reach a recruitment target of 40% women researchers in the project, however we are far from that goal. The fraction of female seconded/recruited researchers is 18 %. Looking at recruited researchers only, this fraction is slightly better (25%).. . We plan a dissemination action of our project only for young women in 2016.
------ INTELLECTUAL PROPERTY
IPR strategy is in line with grant agreement provisions. Publication policy follows the FTK and ATLAS rules: each publication on specific piece of hardware or software is signed by people that worked on the content of the publication and their supervisors, while results on integrated systems are signed by the whole FTK collaboration. Publications with ATLAS data are signed by the ATLAS collaboration.
We started a training action inside our network to understand better Intellectual Property Rights before we develop possible applications of our technology into fields different from HEP.
------ LIST OF PROJECT MEETINGS, DATES AND VENUES;
------ Meeting calendar for management including mid-term review
The Steering Committee meets twice per year to deal with administrative issues of the project. The Scientific Board meets 3 times each year, to assess the progress in the research and training aspects of the project. The meetings are usually based in Pisa, but Skype is provided to allow to connect from all the countries of the network. Once per year the General Assembly (=Steering Committee)

and Executive Board (=Scientific Board) are clustered together in the same week with also the annual FTK Workshop, and the training offered by a partner. We call these occasions “FTK weeks”, they have always been in March, each year they are hosted by a different partner in a different country. Each autumn we group together GA and EB meetings, while the 3rd EB meeting is a single meeting in the summer. Here is the list of all management events:
---------- FTK weeks: Executive Board, General Assembly Meetings, with agenda links:
• Kickoff Meeting, and management/financial meetings, Pisa, March 11-13, 2013 https://agenda.infn.it/conferenceDisplay.py?confId=5960
• PRIELE Meeting, Alexandroupolis, March 10, 2014 https://agenda.infn.it/conferenceDisplay.py?confId=7686
---------- Executive Board, General Assembly Meetings organized together:
o Pisa, November 5, 2013 https://agenda.infn.it/conferenceDisplay.py?confId=6997
o Pisa, December 12 2014 https://agenda.infn.it/conferenceDisplay.py?confId=9007
---------- Executive Board Meetings
• Pisa, June 27, 2013 https://agenda.infn.it/conferenceDisplay.py?confId=5754
• Pisa, July 21, 2014 https://agenda.infn.it/conferenceDisplay.py?confId=8419
---------- Mid Term Review
• Brussels, November 7, 2014 https://agenda.infn.it/conferenceDisplay.py?confId=8768
------ CO-ORDINATION ACTIVITIES, COMMUNICATION BETWEEN BENEFICIARIES
In addition of the coordination meetings, listed in the previous section, we had a lot of technical meetings, handled inside the single Work Packages. To improve partners’ relationships, in addition to the WP8 meetings (Transfer of knowledge events) described in the relative Deliverables and in the dissemination section, other meetings have been organized. We classify them as technical meetings, where FTK participants exchange information on their specific work. We had skype “weekly meetings” since the beginning for WP1 and WP2, while we started them in 2014 for WP3 and WP4. We are starting in 2015 equivalent meetings for WP5.
------ POSSIBLE CO-OPERATION WITH OTHER PROJECTS
Our project is collaborating with other projects and communities.
As described above in the section “Roadmap towards new application areas” we have established contacts with the research Institute CNIT (Consorzio Nazionale Interuniversitario per le Telecomunicazioni) in Pisa and some companies in Tuscany, to apply together in January 2015 for funds (FAR-FAS 2014) for Smart Camera developments that could exploit our IAPP WP5 results. The title of the submitted common project is “Intelligent System Integration”.
We are also collaborating with two other independent projects:
• Innovative Multi-Chip System for Mutli-Purpose Pattern Recognition Tasks (IMPART), an INFN project, whose goal is the production of a new AMchip design with the 28 nm advanced technology and the production of the first AM-FPGA System In Package (AMSIP) where the firmware developed by Genstos in our project will be used.
• INFIERI, an FP7-People-ITN ongoing project, that is interested to use both Gentsos’ firmware and the IMPART AMSIP to develop a L1 tracking processor at the CMS experiment.
Finally the LPNHE group is part of the RD53 community at CERN to influence on items that belong to WP6. RD-53 is a collaboration between institutions that will develop the tools and designs needed to produce the next generation of pixel readout chips needed by ATLAS and CMS at the HL-LHC. The need to operate irradiated detectors during the Phase-II of the LHC requires to develop the front-end readout electronics as a function of the expected behaviour of the pixel sensors after an equivalent fluence of radiation of the order of 1-2 10^16 n_eq/cm^2. In this sense many developments done or still under way in the WP6 of the FTK IAPP project regards new sensors and new powering schemes for the ATLAS pixel modules require the handshaking and the discussions with external projects, such as RD53.
------ DEVELOPMENT OF THE PROJECT WEBSITE;
The FTK project web (http://ftk-iapp.physics.auth.gr/, see D7.4&8.3 for 2013 and 2014) includes a public section and a classified section. The public section gives a description of the project goals and of its origin, describes the state of the art and contains a Dissemination section listing conference presentations, papers for peer reviewed Journals, and a list of public FTK events. The classified section collects information private to the consortium. Some of the sections in the protected area (user: ftk-iapp, pass: ftk-iapp2013) contain information relevant for the report:
• Deliverables: one folder per year, (2013, 2014, etc.);
• Reports: one report per secondment;
• Meetings: minutes and agendas of restricted FTK workshops, meetings of the General Assembly

and Executive Board (“Steering Committee” and “Scientific Board”, according to Annex I terminology, with composition shown in http://ftk-iapp.physics.auth.gr/Collaboration/Organisation/managment.html);
• Public documents: drafts of public documents are collected in this section until approval than are transferred to the public area;
• Career Development plans: one document per seconded/recruited researcher;
• Web site Development plan: program of the web site evolution.
------- JUSTIFICATION OF REAL COSTS (MANAGEMENT COSTS);
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UNIPISA MANAGEMENT COSTS DESCRIPTION:
---------- NAME OF THE PERSON: Prof. Mauro Dell’Orso
--- Occupation and relation to the project: Full Professor, Scientist in charge and International Coordinator
--- Description of the management tasks:
• management of the funds of the network; period: February/March 2013; 3 days ~15 hours
• organization and management of meetings (GA, EB, Mid Term review); period: the month before and during the meetings (see above the list of dates); 5 days/meeting ; 10 days for MTR. Total 5days*6 meetings + 10 days for MTR = 40 days ~200 hours
• interface work between the beneficiaries and the Project Officer (PO): mainly questions for better understanding of rules; 5 days ~ 25 hours
• reports organization/preparation, communication with beneficiaries; period: one-two months before the reports (Progress Report February 2014, Mid Term Report October 204, Periodic Report February 2015). 3 days per report -> 9 days ~ 45 hours
• Gantt Chart changes management; period: the month before the letters of the PO cited in the document FTK - Additional_info.pdf. 5 days ~25 hours
• used funds computation and evaluation of available resources to be reallocated; proposals of different budget plans evolution following different requests of the beneficiaries; period: December 2014, January-February 2015; 5 days ~25 hours
--- Hour rate: € 65
--- number of person-days = 67. - 335 hours - € 21775
---------- NAME OF THE PERSON: Alessandro Antonelli
--- Occupation and relation to the project: Administration at University of Pisa
--- Description of the management tasks:
• contracts preparation and management: 1 days/contract*5 contracts =5 days - 36 hours; period: at researcher arrival
• call preparation for recruitments: 1 day/competition*2 competitions = 2 days – 14,4 hours;
• Documents for secondments of UNIPI researchers to PRIELE; 2,5 days/secondment*2 secondments=5 days - 36 hours; period: before July 2013.
• Financial report preparation: 1 day 7,2 hours; period: February 2015.
--- Hour rate: 23,36 €
--- number of person-days= 13. - 93,6 hours – 2186,5 €
--- Total personnel costs: € 23961,5
-------- Travel for Mid Term Review € 1954.52 (Dell’Orso, Giannetti, Donati, Piendibene, Volpi)
-------- Total Management costs € 25916,02
==========
CAEN MANAGEMENT COSTS DESCRIPTION:
---------- NAME OF THE PERSON: Alessandro Iovene
--- Occupation and relation to the project: Project Manager; Member of the General Assembly and Scientist in charge since October 2014.
--- Description of the management tasks:
• general project management; period: the month before and during the meetings (see above the list of dates);
• support for the hosted researchers; period: the month in which the researcher arrives
• support for legal and administrative issues;
--- Hour rate: € 20,56
--- number of person-days= 46. - 368 hours - € 7,566.08
---------- NAME OF THE PERSON: Stefano Petrucci
--- Occupation and relation to the project: Marketing Manager; Scientist in charge up to September 2014.

--- Description of the management tasks:
• management of CAEN activities and hosted researcher;
• support for legal and administrative issues
--- Hour rate: € 31,81
--- number of person-days =15.- 120 hours - € 3817,2
---------- NAME OF THE PERSON: Raffo Claudio
--- Occupation and relation to the project: R&D Manager;
--- Description of the management tasks:
• management of CAEN activities and hosted researcher (space and resources allocation);
--- Hour rate: € 54,36
--- number of person-days 19.- 152 hours - € 8262,72
---------- NAME OF THE PERSON: Lemmi Francesco
--- Occupation and relation to the project: Administrative Manager
--- Description of the management tasks:
• management of cost receipts, payments, preparation of financial report;
--- Hour rate: € 27,61
--- number of person-days= 20,5 - 164 hours - € 4,528.04
---------- Cost of the Travel at Brussels for the Mid Term Review € 625.36
-------- Total Management costs € 24799.40
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CERN MANAGEMENT COSTS DESCRIPTION:
---------- NAME OF THE PERSON: Seamus Hegarty
--- Occupation and relation to the project: HR support;
--- Description of the management tasks:
• Person in charge of administrative, legal and financial aspects in this project;
--- Hour rate: € 140.89
--- number of person months. 0.05 PM
---------- NAME OF THE PERSON: Marie Trabaud
--- Occupation and relation to the project: Financial support;
--- Description of the management tasks:
• Financial management, preparation of Financial Report;
--- Hour rate: € 71.96
--- number of person months. 0.26 PM
---- Total personnel costs: € 3,576.91
---- Cost of the Travel at Brussels for the Mid Term Review 06-07/11/2014 - B. Magnin € 584.73
---- Total Management costs € 4,161.64
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AUTH MANAGEMENT COSTS DESCRIPTION:
---------- NAME OF THE PERSON: Panagiotis Neroutsos
--- Occupation and relation to the project: freelancer working on administration duties
--- Description of the management tasks:
• management of cost receipts, payments, support for the hosted researchers; period: the month before the researcher arrives and during their stay;
• administrative organization and logistic issues for events: Mocast Workshop, HiPEAC session, Mid Term Review;
--- Hour rate: € 15
--- number of hours: 189.33 (= 1.35 person months) - € 2,840.00
---- Cost of the Travel at Pisa, for the Kick-off meeting and first (2013) GA-EB meetings (Kordas, Petridou, Nikolaidis, Gentsos,Sotiropoulou; Prof. Petridou and Prof. Nikolaidis are part of this IAPP proposal and they bring experience from managing similar projects) € 4283,05
---- Cost of the Travel at Alexandroupouli, for the 2014 GA-EB meetings (Kordas, Sampsonidis, Nikolaidis, Sotiropoulou) € 1528,80
---- Cost of the Travel at Brussels, for the (2014) Mid Term Review (Kordas, Sampsonidis, Kimura) € 2283.00

---- Total Management costs € 10934,85
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PRIELE MANAGEMENT COSTS DESCRIPTION:
---------- NAME OF THE PERSON: Amanda Soukoulia

--- Occupation and relation to the project: freelancer, working for administration duties
--- Description of the management tasks:
• financial management, support for the host researcher
--- Hour rate: € 22,73
--- 132 hours - € 3,000.00
--- Cost of the Travel at Pisa, Kick-off meeting and first GA-EB meeting, K. Mermikli, A. Sakellariou and P. Kalaitzidis (10/3/2013) € 1,306.75
---Cost of organization of GA & EB Meetings at Alexandroupolis - Host Expenses (10-11/3/2014) € 1,086.91
--- Cost of the Travel at Brussels, for A. Sakellariou, K. Mermikli, D. Dimas (Mid Term Review) (7/11/2014) € 1,623.58
--- Total Management costs € 7017,24
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CNRS MANAGEMENT COSTS DESCRIPTION:
---------- NAME OF THE PERSON: Giovanni Calderini
--- Occupation and relation to the project: Scientist in charge;
--- Description of the management tasks:
• Person in charge of administrative and legal aspects in this project;
--- day rate: € 455.92, number of person days 18; € 8206,60
---------- NAME OF THE PERSON: Francesco Crescioli
--- Occupation and relation to the project: Financial, logistic support;
--- Description of the management tasks:
• management of cost receipts, payments, support for the hosted researcher, space and resource allocation;
--- day rate: € 266,91, number of person days 5,5 ; € 1467,99
---- Total personnel costs: € 9674,59
---- Cost of the Travel at Brussels for the Mid Term Review 06-07/11/2014 - € 1051,72
---- Total Management costs € 10726,31
==========
------ PROBLEMS WHICH HAVE OCCURRED AND HOW THEY WERE SOLVED or envisaged solutions;
- Secondment's and recruitment's implementation changes
The consortium had many requests (see section 5 of the attached file FTK - Additional_info.pdf for a full description of them) about (a) adjusting the planned periods of secondments with delays or splits, (b) substitutions of people that left the network, some of them even before the project could start, especially in Greece where the working conditions are particularly unstable. The requests believed important were approved by the network and submitted to REA. All the changes we got approved were motivated by unexpected conditions that we list here:
(1) The FTK schedule inside the ATLAS experiment changed a lot, as explained in the section "Work organization", with respect to the one available at the time of Annex 1 description. We had to adjust the secondments to the experiment plans.
(2) Many substitutions of researchers were necessary, in particular in Greece, where the economic difficulties constraint people to changes. These changes provided some extra money when experienced researchers were substituted by less experienced personnel. We asked to exploit this extra money for younger researcher's opportunities, better transfer of knowledge and trainings. This is particularly important for our project that misses manpower.
(3) PRIELE company had unexpected requests of deliveries of material, this caused unexpected difficulties to the company. For this reason secondments from PRIELE were moved and split when necessary.
(4) Our inexperience caused delays: we participate to such a complex European project for the first time and we found a lot of unexpected administrative difficulties, like for example the interaction with "Corte dei Conti" in Italy that has to approve each contract, and the visa problems.
However, all changes where submitted to REA and approved. The rules have been always respected for both secondments and recruitments, with a single exception of Petrucci, who left CAEN before one year after his secondment, however he was approved by REA.
------ ETHICAL ISSUES: not applicable;
------ CHANGES IN THE CONSORTIUM:
(1) Two Scientists in charge left the Network: Fabio Formenti was moved by CERN management in a different management area, so he left the project and Betty Magnin was selected as the new

Scientist in charge. Stefano Petrucci, as mentioned above, left CAEN after is first secondment, so he was replaced by Alessandro Iovene, who already was also the representative inside the General Assembly.
(2) The Coordinator's banking details indicated in Article 5.3 of the grant agreement has recently changed. We will communicate the updated information it just after the Report will be submitted.
------ CHANGES TO THE LEGAL STATUS of any of the beneficiaries, in particular, SME status: not applicable;
------ IMPACT OF POSSIBLE DEVIATIONS from the planned milestones & deliverables: described in the point 3 “RISKS ASSOCIATED WITH THE WORKING PLAN” of the subsection “FEEDBACK and RECOMMENDATIONS from MID TERM REVIEW.” in the above section “Project Objectives for the period”
------ JUSTIFICATION OF SUBCONTRACTING: not applicable;
------ JUSTIFICATION OF SME EQUIPMENT: not applicable;

FINANCIAL STATEMENTS – FORM C AND SUMMARY FINANCIAL REPORT

Comments:

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CERTIFICATES

List of Certificates which are due for this period, in accordance with Article II.4.4 of the Grant Agreement.

Beneficiary	Organisation short name	Certificate on the financial statements provided?	Any useful comment, in particular if a certificate is not provided
1	UniPisa	No	
2	CAEN	No	
3	CERN	No	
4	AUTH	No	
5	PRIELE	No	
6	CNRS	No	

Attachments	
Name	
Date	

This declaration was visaed electronically by Mauro DELL'ORSO (ECAS user name ndelloma) on

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