

Open Call 2020 - HiDRa

Title: High-Resolution Highly Granular Dual-Readout Demonstrator – HiDRa

Area: Detector development

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Abstract

The project aims at designing, constructing and qualifying a prototype of a longitudinally unsegmented, highly granular, fibre-sampling dual-readout calorimeter to assess:

- a) a hadronic resolution, for both single hadrons and jets, around $30\%/ \sqrt{E}$ or better, while maintaining a resolution for isolated electromagnetic (*em*) showers close to $10\%/ \sqrt{E}$;
- b) a transverse resolution of $O(1 \text{ mrad})/\sqrt{E}$ and a longitudinal one of a few cm;
- c) a modular construction and assembly technique;
- d) an innovative readout architecture based on SiPMs.

Dual-readout sampling calorimetry has emerged as the likely most promising technology to overcome the most limiting factor in hadron calorimetry. i.e. the fluctuations in the hadronic-shower *em* fraction, and achieve high-resolution results in both *em* and hadronic shower measurements.

Moreover, the advancements in solid-state light sensors such as SiPMs has opened the way for highly granular detectors with the capability to resolve the shower angular position at the mrad level or better. Readout ASICs providing timing information with ~ 100 ps precision may allow to resolve the longitudinal shower position with ~ 5 cm precision, but the large number and density of channels call for an innovative readout architecture. New digital devices (digital SiPMs, dSiPMs) could pave the way for simplifying it.

Our ultimate goal is to demonstrate that a longitudinally unsegmented calorimeter with highly granular readout is technically feasible and can provide outstanding performance for hadrons and jets as well as electrons and photons, as required in future e^+e^- colliders. Several novel technologies are being developed to achieve this goal. New analysis techniques exploiting the large amount of information provided are also being studied.

1. Scientific Proposal

1.1 State of the art

High-resolution high-granularity calorimetry is one of the main components of any experimental programme at future high-energy colliders. All heavy-boson factories rely on the capability to correctly resolve complex final states containing several non-isolated objects. In cases like $H/Z/W \rightarrow jj$ or $H \rightarrow ZZ/WW \rightarrow 4j$, the final states have very similar kinematic properties. In order to discriminate among them, excellent energy and spatial resolution for all detector objects are a key requirement.

For hadronic showers, the energy resolution is normally dominated by the event-by-event fluctuations of the em fraction, f_{em} . For many years, there have been two main lines of research to tackle the problem. The first [1] exploits Particle Flow Algorithms (PFA), employing very-high-granularity 3D/4D calorimetry systems, to unfold neutral- and charged-particle contributions and use the inner tracker measurements to estimate the latter one.

The second approach [2] is based on the measurement of all the energy deposits through two different processes, namely scintillation (S) and Čerenkov (C) light emission, the former produced by all ionising particles, the latter only by relativistic charged particles (i.e., mostly electrons and positrons). After calibration with electrons, the combination of the two signals allows the event-by-event measurement of f_{em} , therefore dramatically improving the hadron-shower energy measurement. The DREAM/RD52 collaboration, over 20 years, built and tested both crystal [3-5] and fibre-sampling solutions [6-9].

They demonstrated that the principle works and that an excellent e/π separation can be obtained [10] but the hadronic performance was seriously limited by the lateral leakage. The most advanced prototype consisted of a $\sim 28 \times 28 \times 250 \text{ cm}^3$ Pb matrix containing $\sim 37\text{k}$ longitudinally running fibres. Because of its effective radius of $0.55 \lambda_1$, the resolution was found to be $\sim 70\%/\sqrt{E}$, still far from the interesting range and dominated by lateral leakage fluctuations and light attenuation effects. Geant4 simulations support the statement that a resolution of $\sim 30\%/\sqrt{E}$ would be reachable when removing them.

The impact of time stamping in the reconstruction of the longitudinal shower position and in particle ID was explored with test-beam data. Using a set of 4 observables (C/S ratio, lateral shower profile, time of arrival, charge-to-amplitude ratio) a 500 rejection power against pions was measured at a $\sim 99\%$ electron efficiency.

A huge step forward was recently made thanks to the advent of solid-state light sensors that allow to readout each of the high density of fibres in the transverse plane. A very small brass-fibre prototype ($\sim 1.2 \times 1.2 \times 100 \text{ cm}^3$) was equipped with Hamamatsu SiPMs and tested with electrons and muons [11]. The lateral profile of em showers was reconstructed with unprecedented resolution showing very interesting features (a core so surprisingly narrow that a single scintillating fibre may carry about 10% of the total signal). It was also proven that the huge number of channels can be successfully reduced with analogue grouping but this critically requires a linear sensor response over the full operating

range.

Digital SiPMs could provide an even more appealing solution and several implementations have been proposed in the last 10 years [12-16]. However this technology has not yet reached maturity and so far, almost all the scientific applications are based on PMTs and analogue SiPMs. The main reasons for this delay in the adoption of CMOS-based SiPMs are due on one hand to their performance, that requires extreme customisation of the processes to be optimised, and on the other hand to the ease of use of analogue detectors if compared to the digital counterpart. More recently, commercial applications, like laser ranging, have triggered the interest in integrated Single-Photon Avalanche Diode (SPAD) sensors from several companies for working on the optimisation of CMOS production processes. Thus, the currently available portfolio of SPAD-enabled CMOS processes is steadily increasing. The detector performance has considerably improved, with peak detection probabilities approaching 50% and Dark Count Rates (DCR) lower than 1 MHz/mm² [17]. The use of highly scaled technologies brings the benefit of fast, compact and low-power electronics and is fostering the introduction of time-tagging circuits with a resolution of the order of 10s of ps [18].

Readout electronics has many open questions and possible answers. Commercial ASICs are available for either signal integration or sampling. Together with total charge, additional information on timing and signal shape may provide powerful input for event reconstruction. It would also enable PFAs to be applied to dual-readout detectors.

Preliminary studies showed that the Citiroc 1A [19] has good performance in terms of dynamic range, linearity and multi-photon quality even with SiPMs with wide dynamic range (i.e. 15 and 10 μm pitch size) and small gain (i.e. $1-3 \times 10^5$). This ASIC, integrated into the CAEN A5202 multipurpose board, may provide a ~ 100 ps resolution timestamp. In the FERS 5200 scalable platform, it would enable to handle and read out a large number of SiPMs. Still the possibility of extracting additional information from the sensors and the need to sum analogue SiPM signals has a high relevance for the project. Thus also alternative ASICs will be qualified and in case integrated into similar readout systems in collaboration with CAEN.

About mechanics, many different strategies have been considered for the construction of single elements and module assembly. None is yet solid as needed for mass production but the gluing of capillary tubes, for the construction of $O(10 \times 10 \text{ cm}^2)$ modules, looks affordable and reliable. It is being followed for the construction of an *em* prototype.

1.2 Scope and research methodology

The scope of the project is to set a clear milestone in hadronic calorimetry, close a 20-year-long R&D programme on the dual-readout technique and offer to the community a solid way for designing detectors with unprecedented performance. Furthermore, a longitudinally-unsegmented detector is far simpler to be understood and calibrated. Ideally, only a global calibration constant (at the *em* scale) is required and the longitudinal shower position can be reconstructed using timing information.

The project aims to:

- develop the technology for successfully building a Hadronic-Scale Prototype (HSP) made of 17 Hadronic-Scale Modules (HSM), $\sim 13 \times 13 \times 200$ cm³ each, 2 modules would be equipped with SiPMs, the rest with PMTs;
- develop a scalable readout system with the capability to reconstruct the 3D shower position with a transverse resolution of $O(1 \text{ mrad})/\sqrt{E}$ and a longitudinal resolution of a few-cm;
- demonstrate a hadronic resolution, for both single-hadrons and jets, around $30\%/\sqrt{E}$ or better, together with a resolution for *em* showers close to $10\%/\sqrt{E}$. The constant terms should be $\sim 1\%$ or below. This requires the sampling fraction and frequency to be both high and constant over the full detector.

An innovative readout system is needed in order to extract the required information and reduce the data volume at a manageable level. Both charge-integrator and waveform-sampling ASICs will be qualified in a scalable commercial platform. Digital SiPMs may allow to strongly reduce both cost and system complexity and will be explored in a small prototype setup.

An accurate task breakdown has been built over the ongoing experience of a collaboration of INFN, Croatian, British and Korean groups, for constructing an *em* prototype with capillary tubes.

1.2.1 Module construction

The main goal is the construction of a modular full-containment hadronic prototype. Experience (in the members of the DREAM/RD52 collaboration) exists and understanding is improving but a scalable effective solution has not yet been established.

We plan to use the first year of the project for deciding:

- absorber material (brass, iron and lead being the options);
- dimensions and construction method of the building elements;
- dimensions and assembly procedure of single towers with a self-supporting structure.

As absorber material, brass is our baseline option for both mechanical and shower development properties. It is being used for the construction of an *em* prototype, $\sim 10 \times 10 \times 100$ cm³, which was meant to be tested at the end of 2020. Commercial capillary tubes with 2 mm outer diameter will be glued together to build 9 modules, 1m long. The assembly of the 9 modules in a 3×3 structure will form the *em* prototype. The main issue is the precision required to guarantee the uniformity of both the single modules and the overall structure. Thanks to the excellent mechanical tolerance, a simple solution with

quickly piling up and gluing the layers is being exploited. Assuming the method works, it will have to be scaled up for the construction of the HSMs that will form the HSP.

Alternatives to the usage of capillary tubes, based on molding, extruding, rolling or even 3D printing solutions, will be investigated by our Korean colleagues, in the frame of a National Research Foundation grant on dual-readout calorimetry.

We also plan to develop, at the design level only, a realistic design of projective towers in a 4π geometry. Besides construction issues, a key requirement is to minimise and understand the impact of dead space and sampling-fraction changes at the boundary between towers. An engineering design of a full detector will be implemented and analysed, including the impact of global support structures and other services.

In the first year, we plan to investigate (semi-)automatic techniques for fibre insertion. Both custom solutions and commercial products from FIMT (Fibre in Metal Tube) companies will be considered. Efficient ways to collect and interface fibres to sensors would be needed on the same time scale.

1.2.2 Fibre optimisation and qualification

Fibre and couplings need to be optimised to increase S signal attenuation length, improve the C light yield and minimise optical cross-talk of S in C signals. Thanks to the very large S yield, a tuned light filtering should be sufficient to reach an appropriate attenuation length. Other possible improvements may come from depositing an aluminised surface on the inner face. The C light yield can be improved by increasing the numerical aperture or again with light reflection at the inner face.

Identifying candidate solutions is to be done during the first year.

The quality control of fibres, optical couplings and light sensors requires know-how to be expanded and spread. Light yield, spectral response and attenuation length are the main parameters to analyse.

1.2.3 Light sensors

Solid-state sensors allow for a significant step toward high granularity in fibre-sampling calorimetry. For their different properties, S and C signals may be better exploited with specific sensor choices such as yellow-tuned (for S) or UV-enhanced (for C). A linear response up to a few k of photoelectrons is also required, to afford analogue signal grouping. Experience with Hamamatsu SiPMs has been highly positive but progress is needed in order to have sensors with wide dynamic range (10 or 15 μm pitch), reduced dead area (in compact SMD package to allow the one-to-one connection with fibres) and reasonably low costs. In this respect, options from different vendors will be investigated (i.e. Hamamatsu, KETEK and NDL from Beijing) together with a long-prospective custom-design sensor based on a digital SiPM architecture, that would greatly reduce the readout complexity.

The proposed dSiPM implementation will be based on an array of SPADs with pixel-level signal digitisation and on-chip counting and timing functions. SPAD arrays with an overall area of the order of 1mm^2 will be designed, focusing on the maximisation of the PDE in the blue region, with the constraint of a maximum cell size between 15 and 25 μm in order to provide a high dynamic range. A deep submicrometer process optimised for the integration of optical sensors and SPADs will be employed (LFoundry being a possible candidate for). If needed, the cell layout will be refined with the

help of TCAD simulations and the setup of optimised processing options will be discussed with the foundry. Since in a single MPW the typical minimum area is several mm^2 , different versions of the chip, with different cell sizes and including conservative and aggressive design rules will be designed. The option of monolithically integrating more sensors within a single chip will also be considered, to ease the construction of the final system.

The integrated electronics will include the basic circuitry for time-tagging each event with a programmable threshold and for counting the number of cells fired within an event. A latch will be included in each cell to disable defective SPADs, thus improving the overall Signal-to-Noise ratio. Packaging constraint will be accounted for in the definition of the layout.

To account for possible problems in the first fabrication run and to fine-tune the design, a second run is foreseen for the second year of the project.

A readout board for the qualification of the produced dSiPM will be designed and fabricated, and the qualification procedures will be shared with the collaboration. A thorough electro-optical characterisation will be carried out on selected samples, and a minimum set of basic measurements will be defined and performed on all the produced sensors, in order to select a set of 64 sensors that will be integrated in a large tile. We will compare the performance at the single-sensor level and on beam using a small ($\sim 1 \times 1 \times 100 \text{ cm}^3$) 64-sensor demonstrator.

1.2.4 Front-end electronics and readout system

The operation of a large number of SiPMs poses a series of system-integration challenges: the reduced space available on the rear end of the calorimeter, the number of channels and the costs. The optimal solution would be the custom design of a SiPM with on-board intelligence. This is the reason why the investigation of dSiPMs is part of the project.

ASICs integrated into a scalable architecture are needed for investigating system issues while also assessing the HSP performance. Both charge integrators and waveform samplers with Feature EXtraction (FEX) are available on the market and we plan to qualify at least two of them: the Citiroc 1A (already integrated in the CAEN FERS system) and the SiREAD.

Channel grouping would allow us to save space and costs. We are considering a flexible design based on a dedicated board to be possibly compliant with future evolutions. Depending on sensors or packages, the grouping could also be implemented at a different stage, either using an adaptor front-end board or an ASIC like MUSIC.

Most relevant for FEX is the definition of the optimal set of information. We are presently considering: total charge, ToA, ToT and also time and value of current peak. The performance (i.e. the measurement resolution) that could be obtained is under study with detailed simulations. Qualifying each-item impact and the correlations is the first step. We also want to analyse the performance of neural networks for triggering purposes. Offline studies for the identification of τ -decay final states have started and first results look promising.

The outcome of this activity will be the system specification definition, the selection on the market of the ASIC that better fits requirements and boundary conditions, and the qualification of the readout

boards and the data collector needed to operate the central HSP core.

1.2.5 Performance and data analysis

An integral part of the program is the evaluation of the detector performance both through comparison of detailed simulations with test-beam data and through the reconstruction of fully simulated events for an e^+e^- collider.

To this purpose, a Geant4 simulation program is under development, with two different geometries: one replicating the shape of the HSMs to build and test, and one describing a projective 4π detector. The aim of the HSM simulation is the validation of the Geant4 predictions for hadronic showers through detailed comparison with data. A robust assessment of the performance in any realistic experiment relies on it.

To allow a meaningful comparison, the simulation of the energy deposition in the calorimeter is complemented with a detailed simulation of the light propagation in the fibres, and of the response of SiPMs and electronics chain.

The main performance benchmarks will be:

1. Energy resolution for both single particles and hadronic jets;
2. Angular and position resolution, in particular for the identification of the two γ s from π^0 decays;
3. Reconstruction of the longitudinal shower development position through timing measurements;
4. Particle id of single particles, both isolated and within jets;
5. Identification and reconstruction of final states from τ decays;
6. Identification and reconstruction of final states from $Z/W/H \rightarrow jj$, $H \rightarrow ZZ^*/WW^* \rightarrow 4j$, $HZ \rightarrow 6j$, $H \rightarrow \gamma\gamma$, $Z/H \rightarrow \tau\tau$ decays.

1.2.6 Data selection and processing with deep-learning algorithms

The dual-readout technique has the potential for achieving a groundbreaking precision in the measurement of the Higgs decay products at future e^+e^- colliders.

This precision is a result of its excellent properties combined with the flexible readout granularity which, with solid-state sensors, can be pushed up to the single-fibre level. This corresponds to a huge amount of information that should be better exploited with deep-learning algorithms. Thus we started working at the implementation of convolutional neural networks for data selection and processing. A detailed simulation of the detector response convoluted with the SiPM transfer function was developed and τ -decay samples were produced for the first training and performance assessment with a reduced granularity. Preliminary results are very encouraging. Next steps will consist in adding background processes and increasing the network and information complexity. Other topics which can be addressed

with ML techniques are the calibration of single particles and jets, the determination of position and direction of photons and particle identification.

Over the full project, the performance assessment will ultimately address the points described in the previous section, as well as its dependence on the readout granularity, necessary for the cost/performance optimisation of a future detector.

This plan is being developed in Pavia, Como, Sussex and Roma. In particular the Roma group holds an advanced know-how on machine-learning techniques which will be exported to other groups in the course of the project.

1.3 Research team

Solid and fairly diverse and complementary expertise is distributed in the different groups. The Pavia, Pisa and Milano groups were part of the DREAM/RD52 project for dual-readout calorimetry, now closed. The activity is continuing in the context of the IDEA proposal, in collaboration with the University of Sussex, RBI and a cluster of Korean universities. The groups of Roma 1, Catania and Bologna joined those efforts during last year.

Long-standing expertise in detector R&D and high-qualified support from technical services is very well distributed in the collaboration. Bologna, Catania, Milano and TIFPA will be mainly focused on the sensor and readout system qualification, Pavia and Pisa on the mechanical issues and Roma 1 on the implementation of neural network architectures. The total manpower amounts to ~6.3 FTE that, with postdocs, is expected to evolve in average to ~10 FTE but half of the additional manpower will be charged on external funds.

Table 1.3.1 summarises, for each research unit, the expected FTE commitment including added resources. The work package assignment, responsible, role and competences and infrastructures for each research unit are described in Table 1.3.2. A sketch of the proposed geometry is in Figure 1.3.1.

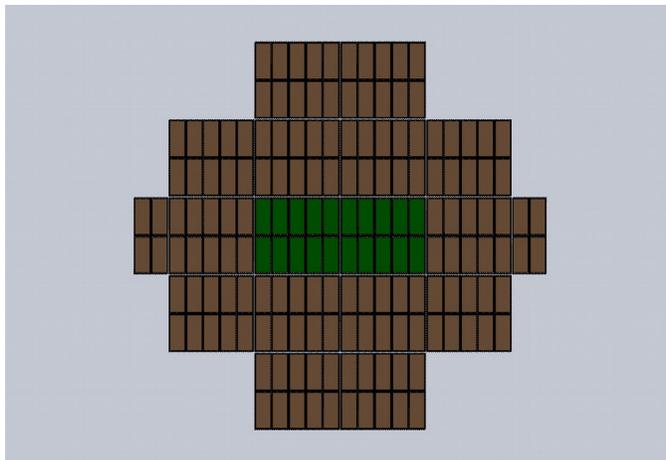


Figure 1.3.1. A possible geometry for the Hadronic-Scale Module.

RU	FTE and Numer of people (without AdR requests)						FTE and Numer of people (with AdR requests)					
	2021		2022		2023		2021		2022		2023	
	FTE	People	FTE	People	FTE	People	FTE	People	FTE	People	FTE	People
Bologna	0,7	2	0,7	2	0,7	2	1,7	3	1,7	3	0,7	2
Catania	0,6	3	0,6	3	0,6	3	0,6	3	1,6	4	0,6	3
Milano	1	3	1	3	1	3	1	3	2	4	2	4
Pavia	1,8	7	1,8	7	1,8	7	2,3	7,5	2,8	8	2,3	7,5
Pisa	0,8	4	0,8	4	0,8	4	0,8	4	1,8	5	1,8	5
Roma 1	0,2	1	0,2	1	0,2	1	1,2	2	1,2	2	0,2	1
TIFPA	1,2	3	1,2	3	1,2	3	1,2	3	1,2	3	1,2	3
Total	6,3	23	6,3	23	6,3	23	8,8	25,5	12,3	29	8,8	25,5

Table 1.3.1. Summary of FTE per each RU during the 3 years of the project.

Research Unit	Local coord.	WP Tasks	Role and Contributions	Competences and Infrastructures	Intl. Collabs.
Bologna	P. Giacomelli	2,3	Test setup preparation, design of interface boards and flat cables for modules equipped with SiPM and dSiPM, qualification of ASICs and dSiPM	Detector construction, data acquisition, trigger and readout electronics for SiPM-based detectors. Clean room, mechanical workshop, gas detector and electronic labs.	CMS, AIDA-2020, RD_FA
Catania	S. Albergo	2, 3	Tests of ASICs performances in SiPM readout, SiPM qualification tests	Solid state detectors and photosensors (rad-hardness; sensor and hybrid tests; bonding; qualification), trigger, data analysis and simulation. Large clean room - Electronic Lab.	CMS, ATLAS, RD48, RD_FA
Milano	R. Santoro	1, 2, 3, 4	Analogue and Digital SiPM qualification, ASICs comparison and readout system specification and qualification	Silicon detector development and qualification. Silicon detector and optics lab, electronics service and clean room in Milano and Como	RD_FA, ARCADIA, ORIGIN (H2020)
Pavia	G. Gaudio	1, 3, 4	QAQC calorimeter components and construction. Definition of the RO system specification. Simulation and data analysis	Detector construction, compensating calorimetry in particular, data acquisition and data analysis. Mechanical workshop, Electronic lab and large size clean room and lab area	NOMAD, ATLAS, DREAM/RD52, RD_FA
Pisa	F. Bedeschi	1	Mechanical design engineering, tooling development and QAQC of mechanical elements	Detector construction, of calorimeters in particular. Mechanical workshop, Electronic lab and large size clean room and lab area. Mechanical engineer pool.	CDF, NOMAD, DREAM/RD52, ATLAS, RD_FA, GMINUS2
Roma 1	S. Giagu	4	AI algorithms for feature extraction, particle id and reconstruction. Performance and detector design optimisation.	Data analysis, Machine Learning and Deep Learning (real time and offline applications). Trigger and offline software design for HEP experiments. AI supercomputer (2 petaFlops), Electronic Lab, Mechanical workshop.	CDF, ATLAS, NEPTUNE, MUCCA
TIFPA	L. Pancheri	2, 3	Digital SiPM design and qualification and readout system specification and qualification	Modelling, layout design, electrical and functional characterization of silicon integrated detectors. Available facilities include probe stations and standard electronic instrumentation for radiation detector characterization.	ATLAS, ARCADIA

Table 1.3.2. Synopsis of participants, WP task, description and management.

1.4 External contributions

We expect to have small funding for running expenditures from CSN 1, for the RD_FA activities and to find some local support (e.g. for readout or HV boards) for test-beam running needs.

We also assume to have all the AdR positions 50:50 co-funded. Being part of the EU AIDAInnova proposal, with a specific sub-task on dual-readout calorimetry, we will get some funds, in case of success, mainly meant for covering post-doc positions.

As previously stated, we are already (or even better, always) making our developments in an international context. Since the closure of the RD52 project, we are aiming to establish a new official collaboration among the engaged groups. All groups are highly motivated for staying committed to the evolving programme, of course with a specific role, responsibility and funding. Our European partners are planning to apply for national funds both in Croatia and in the UK (Royal Society) and we are sure that an approval of this proposal will trigger positive feedback.

In Korea, an R&D fund of about 2M USD over 5 years (2020-2025), has been recently granted by the National Research Foundation (NRF) to our collaborator, prof. Hwidong Yoo, for building a full-hadronic-scale projective prototype, addressing the main engineering, operating and readout issues. The schedule foresees 3 years of pure R&D followed by 2 years of construction of the prototype. Additional soft funding is also available for simulation study to support postdoc positions and graduate students in each Korean institute (Kyungpook National Univ., Seoul National Univ, Univ. of Seoul, Yonsei Univ.). We fully agree that we need to identify and exploit all possible synergies and share as much as possible developments and results, while having a different horizon and target. This would strongly help in avoiding useless duplication of efforts and optimising the success rate of each program. The plan is to constitute a partnership and possibly an official collaboration.

1.5 Active or recently closed programs on the same field

In the 2013-2018 period, the DREAM/RD52 program was running only with US funding. The activity was closed with the test of the small “~1 cm²” prototype equipped with SiPMs. Since then, we started planning the “~100 cm²” module with a SiPM core within the CSN 1 RD_FA project. The module is under construction with funds from INFN (~40 k€), RBI (~15 k€) and University of Sussex (~5 k€). The design and assembly of the proof of concept pertaining to the mechanical structure is ongoing at RBI, in collaboration with members of the ERA Chair PaRaDeSEC project.

Progress has been substantially slowed due to the COVID-19 crisis but the results should arrive within ~6-10 months. The actual schedule is unknown but the final test with beam at DESY should likely happen in less than one year from now.

1.6 Relevance and impact of potential results

We are convinced that the demonstration that a single-volume fibre-sampling calorimetry system may provide unprecedented hadronic performance without sacrificing any other relevant feature would be a significant step forward for the experimental programme at e⁺e⁻ colliders. Hadronic calorimetry would be able to reach a precision of few % in a range that is crucial for today’s particle physics. The fact that

the detector needs to be calibrated at the *em* scale only would greatly simplify detector commissioning and operation. Moreover, the high granularity achievable with SiPM readout could also be exploited in Particle Flow Algorithms where tracking and calorimetry measurements would be combined with the best possible resolution. Last but not least, the validation of the Geant4 hadronic simulations with a precision level that could only be reached with compensation would also be a benefit for the HEP community.

On the other hand, even if at present, we do not have in mind applications outside HEP, the technical developments on the digital SiPMs and on the readout system are of a very general and broad interest. We think that the endorsement letters from FBK and CAEN strengthen this view. In particular, digital SiPMs can foster a change of paradigm in many application domains and provide the basis for many future developments of detector systems.

1.7 Risk assessment and reduction

The current description of the detector layout and baseline material is based on the present developments in the RD_FA project. Success in reaching the required tolerances will be assessed in the next months. In case of failure, alternative solutions will be considered both at the level of: 1) tools and assembly procedure; 2) absorber design and production. In this respect, studies on possible mechanical structures were done in the past. Some of them were limited, and therefore not conclusive, due to fund shortness, but can be further investigated as alternative solutions. Similar studies will also be performed in parallel by the Korean colleagues and the exploitation of the results will be shared among the collaboration. We will study different independent methods and this should maximise the success probability.

The strategy considered for the readout is quite challenging but the proposed strategy should mitigate the risks allowing the possibility to investigate prospective solutions. The detector design has been thought to maximize the chances to assess the pure calorimetric performance by instrumenting the majority of the modules (all but 2) with consolidated light sensors (PMTs) in a readout schema largely experienced in the DREAM/RD52 projects. On the other hand, to meet the request for high granularity and longitudinal position reconstruction, we started to investigate solutions where each single fibre is coupled to a dedicated SiPM. A certain expertise in the field has been acquired in the past years when the collaboration succeeded in demonstrating the feasibility of the technique identifying and overcoming some issues i.e. light cross-talks among scintillating and Čerenkov signals and a better understanding of the requirements in terms of SiPM dynamic range. The next beam test, scheduled at the end of this year, should consolidate the results obtained so far. In fact, 320 SiPMs will be read out with a system based on the Citiroc 1A ASIC. This project would represent a further large step forward: 1) an important scaling in numbers of SiPMs to be read out, with the goal of addressing all the challenges related to system integration and performance; 2) a visionary solution which would allow to demonstrate the possibility of using dSiPMs: SPADs implemented in CMOS technology with on-board intelligence which could have an impact on reducing costs and readout complexity. In this schema, the proposal is to equip two modules with SiPMs to minimise the risks and to guarantee a proper assessment of the challenges discussed before and, only a proof of concept will be addressed, at this early stage, for the dSiPMs. In fact, even if the latter is highly prospective, the collaboration will design

and produce only a small quantity of these sensors to be qualified and compared with standard SiPMs together with the possibility of assembling a small prototype based on 64 dSiPM.

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2. Project Organisation

The work plan is scheduled over the period 2021-2023, for a duration of 3 full years. In the event of a substantial delay on the scientific achievement due, e.g., to technical or even external problems, we may consider the possibility to extend the project duration by one more year. Such extension would be handled without further funding requests.

The project implementation is organised in 4 Work-Packages and the management of the resources and tasks assigned to each participating Research Unit is defined by the WP Responsible. The activity, resources, deliverables and milestones of each WP are described herein.

2.1 Work Package 1: Mechanics and fibre characterisation

WP1 Responsible: Gabriella Gaudio

WP1 Contributors: MI, PI, PV

WP1 Activity: Choice of baseline options for scintillating and Čerenkov fibres, choice of baseline options for absorber material and layout, choice of PMTs for external ring readout. Definition of construction procedure, including the coupling of fibres to light sensors. Construction of prototypes and modules for full-containment calorimeter. Qualification on test-beam.

WP1 Description of Work and Role

- T1.1. Identification of candidates for Čerenkov and scintillating fibres [M1-12][MI,PI,PV]
- T1.2. Definition of Quality Control (QC) procedure and criteria for Čerenkov and scintillating fibres [M1-12][MI,PI,PV]
- T1.3. Absorber material choice [M1-12][PI,PV]
- T1.4. PMTs choice and layout optimization [M1-12][PI,PV]
- T1.5. Definition of QC procedure and criteria for PMTs [M1-12][PI,PV]
- T1.6. Dimensions and construction method of the building elements [M6-18][MI,PI,PV]
- T1.7. Dimensions and assembly procedure of single towers with a self-supporting structure [M12-18][PI,PV]
- T1.8. Definition of QC procedure and criteria for single towers [M12-18][MI,PI,PV]
- T1.9. Engineering design of projective towers [M18-28][PI]
- T1.10. Construction of full-containment modules [M18-30][PI,PV]
- T1.11. Qualification on test-beam [M30-36][MI,PI,PV]

WP1 Milestones

- M1.1. Identification of baseline options: absorber, fibres and PMTs choice [M12]
- M1.2. Identification of baseline constructing method [M18]
- M1.3. Construction of final modules [M30]
- M1.4. Performance assessment [M36]

WP1 Deliverables

- D1.1. Full characterisation of chosen baseline options [M12]
- D1.2. Single tower of final dimension built with the selected absorber and with the final procedure [M18]
- D1.3. Percentage of the module to be built should be defined based on agreement with Korean colleagues [M30]
- D1.4. Results of TB with performance assessment [M36]

2.1 Work Package 2: Light Sensors

WP2 Responsible: Massimo Caccia

WP2 Contributors: BO, CT, MI, TIFPA

WP2 Activity: Light sensors qualification. The aim of the work package is the study of two light-sensor technologies capable of equipping the highly granular calorimeter in the respect of the expected performances. The sensors of interest are the analogue and digital SiPMs. The first option (baseline) is based on a mature technology that would immediately allow to equip and operate the core (~10000 sensors) of the demonstrator, while the second (a proof of concept) is a prospective solution that, in case of success, would allow to reduce the cost of the sensors and the readout complexity with comparable and in some cases better performance (i.e. timing).

WP2 Description of Work and Role

- T2.1. Definition of a qualification protocol [M1-3][CT,MI,TIFPA]
- T2.2. Test setup preparation to qualify the different sensors [M1-6][CT,MI,TIFPA]
- T2.3. Procurement and qualification of SiPMs produced by different vendors (i.e. Hamamatsu, Ketek, NDL) [M3-15][CT,MI]
- T2.4. dSiPM design and fabrication (includes 2 runs) [M5-20][MI,TIFPA]
- T2.5. dSiPM qualification [M12-24][BO,MI,TIFPA]
- T2.6. Test of all the SiPMs needed to equip the central part of the demonstrator [M18-30][CT,MI]
- T2.7. Test of the 64 dSiPMs used to equip the small 64-fibre prototype [M24-30][BO,MI,TIFPA]

WP2 Milestones

- M2.1. Definition of a list of SiPMs of interest [M3]
- M2.2. Definition of a SiPM characterization protocol [M3]
- M2.3. Definition of a dSiPM specification for Run1 [M6]

- M2.4. Selection of the SiPM that will be used to equip the central part of the calorimeter [M15]
- M2.5. Definition of a mass production characterization protocol [M18]
- M2.6. Definition of a dSiPM specification for Run2 [M16]

WP2 Deliverables

- D2.1. Qualification protocol ready [M3]
- D2.2. Setup to qualify SiPMs ready [M6]
- D2.3. Setup to qualify dSiPMs ready [M14]
- D2.4. Test of all SiPMs needed to equip the central part demonstrator completed [M30]
- D2.5. Test of the 64 dSiPMs needed to equip the small module-prototype, completed [M30]

2.1 Work Package 3: Front-end and DAQ development

WP3 Responsible: Romualdo Santoro

WP3 Contributors: MI, TIFPA, BO, PV, CT

WP3 Activity: ASIC qualification and readout board production. This work package will qualify the different ASICs designed for SiPMs available on the market. Candidates of interest for this kind of application are Citiroc 1A, SiREAD and MUSIC. After a full qualification, the ASIC that better fits all requirements and constraints will be integrated into the flexible readout system (FERS) designed by CAEN. This system will allow the calorimeter to be operated in a beam test. Thanks to the experience gained during the qualification phase, the team will contribute to the definition of the readout specification and system qualification. The 20 boards needed to readout the core of the demonstrator will be delivered to the collaboration for the final test on beam.

WP3 Description of Work and Role

- T3.1. Definition of the ASIC qualification protocol [M1-3][BO,MI,PV]
- T3.2. ASIC procurement with the proper evaluation board [M1-8][BO,MI]
- T3.3. Design and production of a series of passive boards and cables needed to interface the SiPMs to the evaluation boards [M1-8][BO,MI]
- T3.4. ASIC qualification and performance comparison in response to the SiPMs of interest for the application [M6-12][BO,CT,MI]
- T3.5. Setup preparation to qualify the dSiPMs [M6-12][BO,MI,TIFPA]
- T3.6. Definition of the readout system specification which will integrate the selected ASIC [M6-12][BO,MI,PV]
- T3.7. Design and production of the interface boards and flat cables required to equip the central part of the calorimeter [M12-18][BO,MI]

- T3.8. Prototype readout board qualification [M18-24][BO,CT,MI]
- T3.9. Final readout board qualification [M24-30][BO,CT,MI]
- T3.10. Design and production of the interface boards and flat cables required to equip the small prototype with dSiPMs [M24-30][BO,MI]
- T3.11. Final qualification on beam [M30-36][BO,CT,MI,PV,TIFPA]

WP3 Milestones

- M3.1. Definition of a list of ASICs of interest [M1]
- M3.2. Definition of the ASIC characterization protocol [M3]
- M3.3. Selection of the ASIC that will be integrated into the readout system [M12]
- M3.4. Definition of the readout system specification [M12]

WP3 Deliverables

- D3.1. ASIC qualification protocol ready [M3]
- D3.2. ASIC setup station ready [M6]
- D3.3. Setup to qualify the dSiPM [M12]
- D3.4. Prototype readout board [M18]
- D3.5. Interface boards and cables to equip the calorimeter with SiPMs [M24]
- D3.6. Final readout board [M24]
- D3.7. Interface boards and cable to equip the small prototype with dSiPMs [M30]

2.1 Work Package 4: Performance assessment

WP4 Responsible: Giacomo Polesello

WP4 Contributors: MI, PV, RM1

WP4 Activity: Evaluation of the performance of the proposed calorimeter both through comparison of detailed detector simulations with the data from the test beam modules and through the reconstruction of fully simulated events from an e+e- collider. Validation of Geant4 hadron interaction models. Development of ML algorithms for the identification of hadronic τ decays.

WP4 Description of Work and Role

- T4.1. Development of a Geant4 simulation of the modules with testbeam geometry [M1-12] [PV]
- T4.2. Development of a detailed simulation for light propagation, SiPM response and related electronics chain [M1-12][MI]
- T4.3. Comparison of the simulation with test beam data and validation of the Geant4 hadronic

- model [M12-36][PV]
- T4.4. Development of a Geant4 simulation of a 4pi geometry solution [M1-12][PV]
 - T4.5. Development of a calibration strategy for single particles and jets, both analytical and based on ML algorithms [M12-18][PV]
 - T4.6. Assessment of the energy resolution for single particles and jets [M18-24][PV]
 - T4.7. Angular and position resolution for photons (in particular for non-pointing ones) [M24-36][PV]
 - T4.8. Identification of single particles, both isolated and within jets [M24-36][MI,PV]
 - T4.9. Identification and reconstruction of heavy-boson decays in 2-photon, 2-tau, 2-, 4-, 6-jet final states [M24-36][PV]
 - T4.10. Development of a baseline DNN architecture based on Convolutional models [M1-12][RM1]
 - T4.11. Development of an evolutionary DNN based on combined Recurrent and Convolutional NNs [M12-21][RM1]
 - T4.12. Development of novel DNNs based on Graph NNs optimised for a realistic detector simulation [M21-30][RM1]
 - T4.13. Study of an optimised design of the DNN model developed for real-time applications (trigger, feature extractions) [M30-36][RM1]
 - T4.14. Test beam data analysis [M30-36][MI,PV,RM,]

WP4 Milestones

- M4.1. Full simulation of TB module running and validated [M12]
- M4.2. Full simulation of a 4pi detector running and validated [M12]
- M4.3. Performance studies for single particles [M20]
- M4.4. Jet performance studies [M24]
- M4.5. Trained and optimised CNN model ready [M8]
- M4.6. Trained and optimised RNN+CNN model ready [M20]
- M4.7. Novel GNN deployed [M29]
- M4.8. Results of TB with performance assessment [36]

WP4 Deliverables

- D4.1. Full simulation of TB modules [M12]
- D4.2. Full simulation of a 4 π detector [M12]
- D4.3. Simulation of readout [M12]
- D4.4. Full calibration procedure for single particles and jets [M24]
- D4.5. Validation of Geant4 hadronic model [M36]
- D4.6. Physics performance assessment on benchmark physics processes [M36]
- D4.7. Baseline performances obtained with the best CNN model [M12]
- D4.8. Assessment of performances wrt design readout strategy based on evolutionary models [M24]
- D4.9. Final physics performances assessment for the selected DNN model and its deployment for general use [M24]

2.2 Funding Requests

The detailed description of the requested funding, per RU, WP type and FY is depicted in Table 2.2.1 while in Figure 2.2.1 there is the breakdown of the costs over the different activities.

#	Title	Given Work	Given Earliest Start	202	2021				2022				2023				202						
				Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1						
0 HiDRa				01/01/...																			
1 WP1: module construction																							
2	T1.1 Identification of candidates for Cerenkov and scintillating fibres	12 months																					
3	T1.2 Definition of Quality Control (QC) procedure and criteria for Cerenkov and scintillating fibres	12 months																					
4	T1.3 Absorber material choice	12 months																					
5	T1.4 PMTs choice and layout optimization	12 months																					
6	T1.5 Definition of Quality Control (QC) procedure and criteria for PMTs	12 months																					
7	T1.6 Dimensions and construction method of the building elements	12 months	01/07/2...																				
8	M1.1: Identification of baseline options: absorber, fibres and PMTs choice		01/01/2...																				
9	T1.7 Dimensions and assembly procedure of single towers with a self-supporting structure	6 months	01/01/2...																				
10	T1.8 Definition of QC procedure and criteria for single towers	6 months	01/01/2...																				
11	M1.2: Identification of baseline constructing method		01/07/2...																				
12	T1.9 Engineering design of projective towers	10 months	01/07/2...																				
13	T1.10 Construction of full-containment modules	12 months	01/07/2...																				
14	M1.3 Construction of final modules		01/07/2...																				
15	T1.11 Qualification on test-beam	6 months	01/06/2...																				
16	M1.4 Performance assessment		31/12/2...																				
17 WP2: light sensors																							
18	T2.1 Definition of a qualification protocol	3 months																					
19	T2.2 Test setup preparation to qualify the different sensors	6 months																					
20	M2.1 Definition of a list of SiPMs of interest		01/04/...																				
21	M2.2 Definition of a SiPM characterization protocol		01/04/...																				
22	T2.3 Procurement and qualification of SiPMs from different vendors																						
23	M2.3 Definition of a dSiPM specification for Run1		01/06/...																				
24	M2.6 Definition of a dSiPM specification for Run2		02/05/...																				
25	T2.4 dSiPM design and fabrication (includes 2 runs)	15 months	01/06/...																				
26	T2.5 dSiPM qualification	1 year	01/01/...																				
27	M2.4 Selection of the SiPM that will be used to equip the central part of the calorimeter		01/01/...																				
28	T2.6 Test of all the SiPMs needed to equip the central part of the demonstrator	12 months	01/07/...																				
29	M2.5 Definition of a mass production characterization protocol		01/07/...																				
30	T2.7 Test of the 64 dSiPMs used to equip the small 64-fibre prototype	6 months	01/01/...																				
31 WP3: Front-end and DAQ development																							
32	T3.1 Definition of the ASIC qualification protocol	3 months	01/01/...																				
33	M3.2 Definition of the ASIC characterization protocol		01/04/...																				
34	M3.1 Definition of a list of ASICs of interest		01/02/...																				
35	T3.2 ASICs procurement with the proper evaluation board	8 months	01/02/...																				
36	T3.3 Design and production of a series of passive boards and cables needed to interface the SiPMs to the evaluation boards	8 months																					
37	T3.4 ASIC qualification and performance comparison in response to the SiPMs of interest for the application	6 months																					
38	T3.5 Setup preparation to qualify the dSiPM	6 months	01/07/...																				
39	T3.6 Definition of the readout system specification which will integrate the selected ASIC	6 months	01/07/...																				
40	M3.3 Selection of the ASIC that will be integrated into the readout system		01/01/...																				
41	M3.4 Definition of the readout system specification		01/01/...																				
42	T3.7 Design and production of the interface boards and flat cables required to equip the central part of the calorimeter	6 months	03/01/...																				
43	T3.8 Prototype readout board qualification	6 months	01/07/...																				
44	T3.9 Final readout board qualification	6 months	02/01/...																				
45	T3.10 Design and production of the interface boards and flat cables required to equip the small prototype with dSiPMs	6 months	02/01/...																				
46	T3.11 Final qualification on beam	6 months	03/07/...																				
47 WP4: performance and data analysis																							
48	T4.1 Development of a Geant4 simulation of the modules with testbeam geometry	12 months																					
49	M4.1 Full simulation of TB module running and validated		03/01/...																				
50	T4.2 Development of a detailed simulation for light propagation, SiPM response and related electronics chain	12 months																					
51	T4.3 Comparison of the simulation with test beam data and validation of the Geant4 hadronic model	24 months	01/01/...																				
52	T4.4 Development of a Geant4 simulation of a 4pi geometry solution	12 months																					
53	M4.2 Full simulation of a 4pi detector running and validated		03/01/...																				
54	T4.5 Development of a calibration strategy for single particles and jets, both analytical and based on ML algorithms	6 months	01/01/...																				
55	T4.6 Assessment of the energy resolution for single particles and jets	6 months	01/07/...																				
56	M4.3 Performance studies for single particles		01/11/2...																				
57	M4.4 Jet performance studies		02/01/...																				
58	T4.7 Angular and position resolution for photons (in particular for non-pointing ones)	12 months	02/01/...																				
59	T4.8 Identification of single particles, both isolated and within jets	12 months	02/01/...																				
60	T4.9 Identification and reconstruction of heavy-boson decays in 2-photon, 2-tau, 2-, 4-, 6-jet final states	12 months	02/01/...																				
61	T4.10 Development of a baseline DNN architecture based on Convolutional models	12 months																					
62	M4.5 Trained and optimised CNN model ready		01/09/...																				
63	T4.11 Development of an evolutionary DNN based on combined Recurrent and Convolutional NNs	9 months	03/01/...																				
64	M4.6 Trained and optimised RNN+CNN model ready		01/09/...																				
65	T4.12 Development of novel DNNs based on Graph NNs optimised for a realistic detector simulation	9 months	03/10/...																				
66	M4.7 Novel GNN deployed		30/06/...																				
67	T4.13 Study of an optimised design of the DNN model developed for real-time applications (trigger, feature extractions)	6 months	01/07/...																				
68	T4.14 Test beam data analysis	6 months	01/07/...																				
69	M4.8 Results of TB with performance assessment		28/12/...																				

Researcher	RU	FTE	Contribution to Work Packages (months)			
			WP1	WP2	WP3	WP4
P. Giacomelli	BO	0,10		1,1	2,2	
I. Lax	BO	0,60		4,4	15,4	
AdR (50% on project funds)	BO	0,67		6	16	
S. Albergo	CT	0,20		5	1,6	
G. Cappello	CT	0,20		4	2,6	
A. Di Mattia	CT	0,20		2	4,6	
AdR (50% on project funds)	CT	0,33		11		
R. Santoro	MI	0,50	2	5	8,5	1
M. Caccia	MI	0,30	1	5,9	2	1
RUTD-a	MI	0,20		2	2	2,6
AdR (50% on project funds)	MI	0,67		11	11	
F. Bedeschi	PI	0,20	6,6			
C. Roda	PI	0,20	6,6			
V. Cavasinni	PI	0,20	6,6			
A. Basti	PI	0,20	6,6			
AdR (50% on project funds)	PI	0,67	22			
G. Gaudio	PV	0,20	3,6			3
J. Agarwala	PV	0,30	5			4,9
R. Ferrari	PV	0,50	6,5		5	5
A. Negri	PV	0,10				3,3
L. Pezzotti	PV	0,30	4			5,9
G. Polesello	PV	0,20				6,6
S. Sottocornola	PV	0,20	2			4,6
AdR (50% on project funds)	PV	0,67	16			6
S. Giagu	RM1	0,20				6,6
AdR (50% on project funds)	RM1	0,67				22
L. Pancheri	TIFPA	0,20		5,6	1	
A. Taffelli	TIFPA	0,80		18	8,4	
T. Corradino	TIFPA	0,20		5	1,6	

Table 2.1.1. Synopsis of Participants and Personnel/Month (normalised to 11 months/yr) assignment to each Work-Package.

Unit	WP	Item Description	Required funds (k€)			type
			2021	2022	2023	
BO	3	D-SiPM: Readout Boards	5	5		inv
	2	SiPM: Test station	15			inv
	3	FERS	20	50	50	inv
	2,3	Human resources (AdR)	12.5	12.5		AdR
	2,3	meetings, conference	1	1	0.8	travel
	2,3	test beam			1.4	travel
			Total Bologna	53.5	68.5	52.2
CT	2	SiPM: Test station	15			inv
	2	Human resources (AdR)		12.5		AdR
	2,3	meetings, conference	1	1	0.4	travel
	2,3	test beam			1.2	travel
			Total Catania	16	13.5	1.6
MI	2	D-SiPM: Design	40			cons
	2	D-SiPM: Production	20	20		cons
	2	D-SiPM: Test		20		cons
	2	A-SiPM: Procurement	30.3	45		cons
	2	SiPM: Test station	15			inv
	3	Adapter boards, grouping and cabling	10	10	5	cons
	2,3	Human resources (AdR)		12.5	12.5	AdR
	2,3	meetings, conference	1	1.5	1.5	travel
	2,3	test beam			2	travel
			Total Milano	116.3	109	21
PV	1	fibres		40	14.7	cons
	1	capillary		23	13.5	cons
	1	Mech: sample for material choice	9.2			cons
	1	Mech: calorimeter box			2	cons
	1	Mech: patch pannel			9	cons
	1	Mech: assembly system		15		inv
	1	Mech: fibres qaqc	5			inv
	1	Mech: calorimeter QAQC	2			cons
	1,4	Human resources (AdR)	6	12.5	6.5	AdR
	1,4	meetings, conference	2.4	2	2	travel
	1,4	test beam			3.2	travel
	all	Project Coordination	2	2	2	travel
		Total Pavia	26.6	94.5	52.9	174
PI	1	PMT	10.2	30	30	inv
	1	fibres		40	15	cons
	1	Mech: sample for material choice	9.2			cons
	1	Mech: assembly system		15		inv
	1	Mech: fibres qaqc	5			inv
	1	Human resources (AdR)		12.5	12.5	
	1	meetings, conference	1.1	1.1	1	
	1	test beam			1.6	
			Total Pisa	25.5	98.6	60.1
	4	Human resources (AdR)	12.5	12.5		AdR

RM 1	4	meetings, conference	0.4	0.4		travel
	4	test beam			0.4	travel
	Total Romal		12.9	12.9	0.4	26.2
TIFPA	2	SiPM: Test station	15			inv
	2,3	meetings, conference	1.6	1.6	1.6	travel
	2,3	test beam			2.4	travel
	Total TIFPA		16.6	1.6	4	22.2
Total requested funds			267.4	398.6	192.2	858.2

Table 2.2.1. Detailed expense profile and funding request.

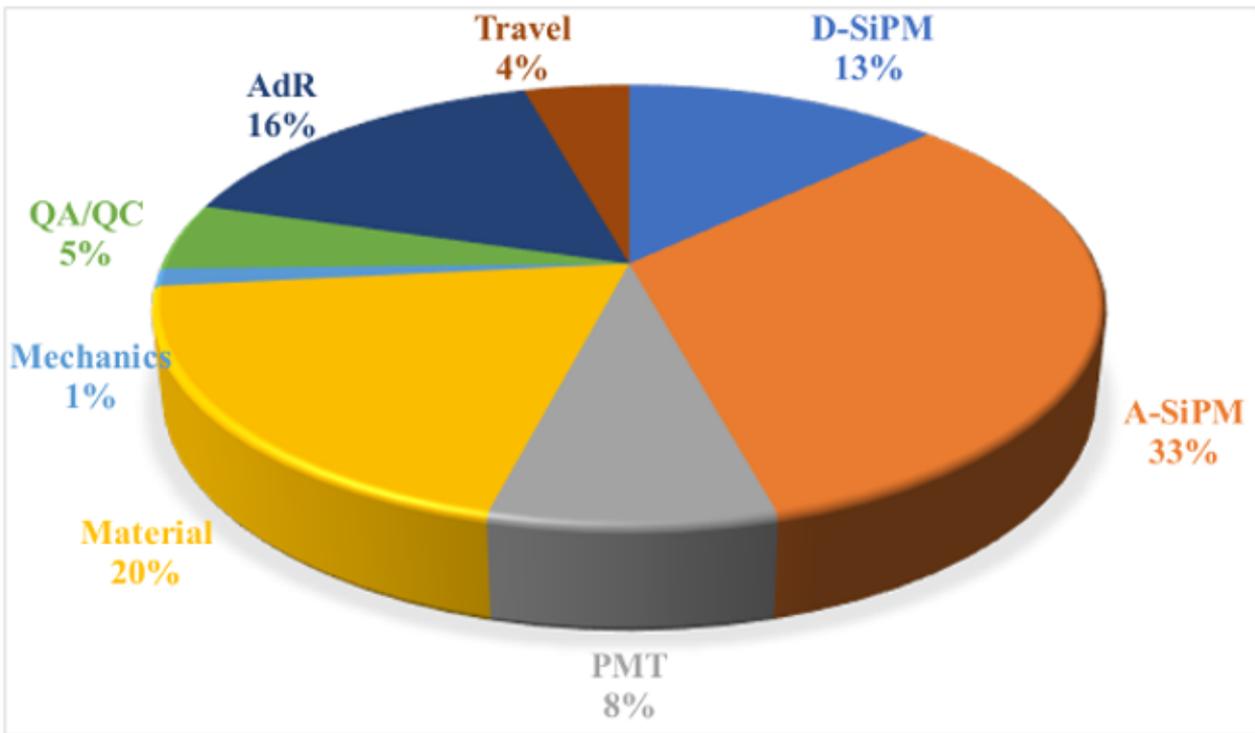


Figure 2.2.1. Budget breakdown.



Dr. Hwidong YOO

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To Whom It May Concern,

With this letter, I would like to support the INFN HiDRa proposal to the fifth National Committee, with Roberto Ferrari as Principal Investigator, for the development of a Dual Readout calorimeter for future lepton colliders.

To introduce myself, I am an associate professor at Yonsei University in South Korea and have participated and played leading roles in the past and present major experiments such as BELLE at KEK (2000 – 2002), D0 at Fermilab (2002 – 2008), CMS at CERN (2008 – present). I am currently a Non-member state (Asia/Pacific) delegate to Advisory Committee of CERN Users (ACCU) since 2018. Also I am leading Korean consortium of Dual-Readout (DR) R&D team for future collider projects as Principal Investigator, with national R&D funding (about \$2M from 2020 to 2025).

Korean DR R&D team shares completely common physics and research goals for the DR R&D project with INFN and European R&D consortium. Both teams have variety of expertise and knowhow for not only DR calorimeter but also many other relevant detectors in experimental particle physics. We are working together with certainly efficient scientific strategy to explore various options and methodologies for the DR calorimeter in order to get a maximum synergy from the collaboration. Such strategy should be expected to bring us the ultimate design and construction of the DR Calorimeter for future collider projects.

For instance, INFN team is mainly focusing spaghetti-style module construction with commercial capillary tubes, while Korean team is alternatively focusing on the possibility to build a module based on metal 3D printing or molding. Furthermore, the R&D on both digital SiPMs and the readout system looks very prospective. We have certain synergic and orthogonal approaches for all other aspects of the DR Calorimeter R&D program as described in their proposal. Besides, we have a regular working meeting together to share all the progress and plan. We believe the bright future of the powerful and fruitful DR Calorimeter

for future collider projects and the contribution on the dramatic improvement of physics and detector knowledges for the entire world-wide HEP community.

Conclusively I am very happy to support their scientific proposal fully and strongly. Please do not hesitate to contact me at +82-2-2123-2613 or hdyoo@yonsei.ac.kr if you have further questions.

May. 30th, 2020

Professor Hwidong YOO

A handwritten signature in black ink, appearing to be 'H. Yoo', written in a cursive style.

29 May 2020

To whom it may concern:

The School of Mathematical and Physical Sciences at the University of Sussex welcomes the HiDRa proposal with Roberto Ferrari as Principal Investigator as a milestone of our common work towards the development of a Dual Readout calorimeter for future lepton colliders. Members of our Experimental Particle Physics group (Iacopo Vivarelli, Antonella De Santo, Fabrizio Salvatore) are already collaborating with Roberto Ferrari and colleagues in a proto-collaboration involving, besides INFN and Sussex, institutes from Croatia and Korea. The current activities focus on the construction of a prototype to be put on beam in 2020 to test a new concept of mechanical assembly and readout, and on the development of the simulation and reconstruction software. We are contributing to the prototype with the purchase and characterisation of the optical fibres. Vivarelli is also one of the persons in charge of the calorimeter software development.

HiDRa is clearly the right step forward: after many years of test beam work (members of our Experimental Particle Physics group were involved in 2017 and 2018), the concept of the Dual Readout is now based on solid experimental ground. The challenge is scaling the system to a full-scale prototype, bearing in mind the challenges that the future construction of the full detector and its integration in a particle-physics detector will impose. HiDRa aims to address these challenges, being therefore not only a high-profile scientific project, but also timely and highly relevant for the future development of our common efforts.

We are therefore extremely pleased by this proposal submission of our Italian partners, and we look forward to continuing our fruitful collaboration in order eventually to offer to the scientific community a calorimeter with unprecedented performance.

Yours sincerely,



Prof. Philip Harris
Head of School of Mathematical and Physical Sciences



R u đ e r B o š k o v i ć I n s t i t u t e

Address: Bijenička cesta 54, HR-10000 Zagreb, CROATIA | Tel: +385 1 4561 111 | Fax: +385 1 4680 084 | www.irb.hr

To whom it may concern

Subject: Support Letter for the HiDRa research proposal

I am writing this letter in support of the HiDRa proposal, submitted to INFN CSN 5, for building a highly granular dual-readout hadronic demonstrator. Members of the project team of the Horizon2020 project PaRaDeSEC are convinced that dual-readout fibre-sampling calorimetry may provide a very powerful way for dealing with the physics cases at e+e- Higgs factories. It may provide at the same time high 3D granularity and high energy resolution. Dual-readout may push the hadronic resolution down to an unprecedented level. Fibre sampling coupled to solid-state sensors may provide an amazing transverse readout granularity and compelling longitudinal information. Moreover, the proposed studies on sensors and readout system will have benefits far beyond this use case.

Our interest for this project is clearly demonstrated by the fact that members of our research team are actively participating into the present developments for an electromagnetic prototype built with capillary brass tubes.

The INFN groups are ideally placed to make a pivotal contribution through this R&D proposal, addressing all significant open issues. There is world-leading expertise across all areas: on mechanics, on sensors, on front-end electronics and readout systems, on data simulations and data analysis.

I see excellent prospects for future collaboration of the INFN groups with RBI as a result of this proposal.

In summary, this proposal identifies key technical challenges for high-resolution high-granular calorimetry at future e+e- colliders, has assembled world-leading expertise to address these challenges, and the results will be of general interest.

This proposal has strong support of key PaRaDeSEC researchers and we look forward to collaboration between our project team and the proponents of this project.

Yours faithfully,

Dr.sc. Neven Soić, senior scientist
Project leader of Horizon2020 ERA Chair project PaRaDeSEC
Division of Experimental Physics, RBI Zagreb

Spett.le
Dott. Roberto Ferrari
I.N.F.N Sezione di Pavia
Via Agostino Bassi, 6
27100 Pavia (PV)

Viareggio, 29 maggio 2020

Oggetto: Manifestazione di interesse per il progetto HiDRa - High-Resolution Highly Granular Dual-Readout Demonstrator

Egr. Dott. Ferrari,

il progetto da voi proposto prevede lo studio di soluzioni di read-out alternative basate su alcune tipologie di ASIC di front-end.

CAEN, avendo una linea di prodotti di read-out per rivelatori basati su ASIC e chiamata **FERS Platform**, comprendente già un'ampia lista di prototipi basati su chip di Weeroc, Nalu Scientific e altri, ha inoltre nella sua roadmap di sviluppo l'implementazione su questa piattaforma di eventuali altri ASIC utilizzati nella comunità della fisica delle alte energie.

Dai colloqui intercorsi abbiamo capito che tra gli scopi principali del vostro progetto c'è quello di confrontare le soluzioni migliori di read-out per la calorimetria altamente granulare realizzata con rivelatori tipo Silicon Photomultipliers.

Confermiamo che l'attività in corso di CAEN consiste nel realizzare nel breve-medio periodo una famiglia di prodotti in grado di gestire un'ampia varietà di rivelatori presenti negli attuali e nei futuri esperimenti, ivi compresi i calorimetri.

Con la presente confermiamo pertanto il nostro interesse verso la vostra iniziativa e a valutarne i risultati.

Cordiali saluti,



Ing. Franco Vivaldi
Vicepresidente di CAEN SpA

Prot. n. 30/2020-UFR

Trento, 28 May 2020

INFN - Sezione di Pavia
Via Agostino Bassi, 6
27100 Pavia (PV)

To the kind attention of Roberto Ferrari

Subject: Letter of endorsement for the proposal “High-Resolution Highly Granular Dual-Readout Demonstrator – HiDRa”, to be submitted to the Call INFN GR5 by the Principal Investigator Roberto Ferrari, INFN Pavia

The undersigned Prof. Gianluigi Casse, acting as Director of the Centre for Materials and Microsystems, on behalf of Fondazione Bruno Kessler confirms that Fondazione Bruno Kessler endorses the proposal “High-Resolution Highly Granular Dual-Readout Demonstrator – HiDRa”, to be submitted to the Call INFN GR5 by the Principal Investigator Roberto Ferrari, INFN Pavia.

In case of acceptance of the project proposal and prior signature of a specific agreement on the terms and conditions, I undertake that Fondazione Bruno Kessler (IRIS research unit, Matteo Perenzoni will be the contact person) will support and assist the work planned in the project proposal through:

- 1) participation to HiDRa call for tender for the design and realization of digital SiPM devices in CMOS technology;
- 2) use of background knowledge for research purposes within the project consortium for the digital SiPM devices realization.

Yours sincerely,



Centre for Materials and Microsystems
Director
Prof. Gianluigi Casse

Al Presidente della Commissione Scientifica Nazionale V

Dr. Valter Bonvicini

della Sezione.

Oggetto: Progetto HIDRA

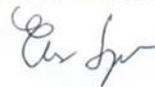
Caro Valter,

in relazione al progetto HIDRA presentato come Call della Commissione Scientifica Nazionale V (responsabile nazionale: Dr. Roberto Ferrari della Sezione INFN di Pavia; responsabile locale per Bologna: Dr. Paolo Giacomelli), desidero comunicarti il mio parere positivo sull'iniziativa.

Questo progetto si inserisce perfettamente nella *roadmap* della Sezione per i prossimi anni, che ha tra le priorità lo sviluppo di nuove tecnologie e in particolare i rivelatori basati sul silicio. Oltre allo sforzo del test dell'ITK di Atlas ci sono infatti vari esperimenti che fanno uso di SiPM (DarkSide, Dune, Ship, etc) e la sezione sta cercando di potenziare le proprie infrastrutture per supportare al meglio gli esperimenti. Assicuro pertanto non solo il mio nulla osta per quanto riguarda l'utilizzo di risorse e/o strumentazione dell'INFN-Bologna per lo svolgimento del progetto, ma anche un fattivo sostegno all'iniziativa.

Un caro saluto,

ISTITUTO NAZIONALE DI FISICA NUCLEARE
SEZIONE DI BOLOGNA
IL DIRETTORE
(Dott. Eugenio Scapparone)



Al Presidente della
Commissione Scientifica Nazionale V
INFN

Egr. Dr. Valter Bonvicini

Oggetto: Progetto **HiDRa**

Catania, 01 giugno 2020

Caro Valter,
in relazione al progetto HiDRa presentato come Call della Commissione Scientifica Nazionale V (responsabile nazionale: Dr. Roberto Ferrari della Sezione INFN di Pavia; responsabile locale per Catania: Prof. Sebastiano Albergo), desidero comunicarti il mio parere positivo sull'iniziativa, e in particolare assicurarti che nulla osta per quanto riguarda l'utilizzo di risorse e/o strumentazione della Struttura da me diretta per lo svolgimento del progetto.

Cordiali saluti,



Digitally signed by TRICOMI
ALESSIA RITA SE
C=IT
O= ISTITUTO NAZIONALE DI
FISICA NUCLEARE



Istituto Nazionale di Fisica Nucleare
Sezione di Milano

Milano, 30 Maggio 2020
Trasmissione via mail

Alla Cortese Attenzione del
Presidente della Commissione Scientifica Nazionale V
Dott. Valter Bonvicini

E p.c.:
ai referenti locali

***Oggetto: Parere del Direttore in merito all'adesione della Sezione di Milano
al Progetto HiDRa***

Caro Valter,

in relazione al progetto HiDRa presentato come Call della Commissione Scientifica Nazionale V con responsabile nazionale: Dr. Roberto Ferrari della Sezione INFN di Pavia, responsabile del WP2 Prof. M. Caccia e responsabile del WP3 e responsabile locale per Milano Prof. R. Santoro, desidero comunicarti il mio parere positivo sull'iniziativa, e in particolare assicurarti che nulla osta per quanto riguarda l'utilizzo di risorse del Servizio di Elettronica e/o strumentazione della Struttura da me diretta per lo svolgimento del progetto.

Con i migliori saluti

Il Direttore

A handwritten signature in black ink, appearing to read 'Mauro Citterio', with a stylized flourish at the end.

Mauro Citterio



Istituto Nazionale di Fisica Nucleare
SEZIONE DI PAVIA
Il Direttore

Pavia, 29 maggio 2020

Al Presidente della
Commissione Scientifica Nazionale V
INFN
Egr. Dr. Valter Bonvicini

Oggetto: Progetto **HiDRa**

Caro Valter,
in relazione al progetto HiDRa presentato come Call della Commissione Scientifica Nazionale V (responsabile nazionale: Dr. Roberto Ferrari della Sezione INFN di Pavia; responsabile locale per Pavia: Dr.ssa Gabriella Gaudio), desidero comunicarti il mio parere positivo sull'iniziativa, e in particolare assicurarti che nulla osta per quanto riguarda l'utilizzo di risorse e/o strumentazione della Struttura da me diretta per lo svolgimento del progetto.

Cordiali saluti,

Valerio Vercesi

Digitally signed by
VERCESI VALERIO ITALO
C=IT
O=ISTITUTO NAZIONALE
DI FISICA NUCLEARE



Istituto Nazionale di Fisica
Nucleare
codice fiscale 84001850589

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Tel.+39+382987.430-431-432 - Fax +39+382423241 - email: direzione@pv.infn.it
PEC: pavia@pec.it

Pisa, 28 maggio 2020

Al Presidente della
Commissione Scientifica Nazionale V
INFN
Egr. Dr. Valter Bonvicini

Oggetto: Progetto HiDRa

Caro Valter,

in relazione al progetto HiDRa presentato come Call della Commissione Scientifica Nazionale V (responsabile nazionale: Dr. Roberto Ferrari della Sezione INFN di Pavia; responsabile locale per Pisa: Dr. Franco Bedeschi), desidero comunicarti il mio parere positivo sull'iniziativa, e in particolare assicurarti che nulla osta per quanto riguarda l'utilizzo di risorse e/o strumentazione della Struttura da me diretta per lo svolgimento del progetto.

Cordiali saluti,

IL DIRETTORE
Dott. Marco Grassi *

 Digitally signed by GRASSI MARCO
C=IT
O=ISTITUTO NAZIONALE DI FISICA NUCLEARE

* Documento informatico firmato digitalmente ai sensi della legge 241/90 art. 15 comma 2, del testo unico D.P.R. 28 dicembre 2000 n. 445, del D.Lgs. 7 marzo 2005, n. 82 e norme collegate, il quale sostituisce il testo cartaceo e la firma autografa.





Trento Institute for
Fundamental Physics
and Applications

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38123 Trento, Italy
www.tifpa.infn.it
Director:
Dr. Giuseppe Battistoni
direzione@tifpa.infn.it
Tel: +39 0461 283294

Trento, 28 Maggio 2020

Al Presidente della
Commissione Scientifica Nazionale V INFN
Prof. V. Bonvicini
INFN Trieste

Oggetto: **CALL CSN5 2020 – Progetto HiDRa**

Caro Presidente

Ti scrivo in relazione alla proposta denominata HiDRa (High-Resolution Highly Granular Dual-Readout Demonstrator) presentato come Call della Commissione V (responsabile nazionale: Dr. Roberto Ferrari, Sezione INFN di Pavia; responsabile locale per TIFPA: Dr. Lucio Pancheri).

Desidero comunicarti il mio parere positivo sull'iniziativa, e in particolare assicurarti che nulla osta per quanto riguarda l'utilizzo di risorse e/o strumentazione del TIFPA per lo svolgimento del progetto.

Cordiali saluti,

Il Direttore

Dr. Giuseppe Battistoni

 INFN Joint Initiative with Trento University, Bruno Kessler Foundation and Trento APSS



Istituto Nazionale di Fisica Nucleare

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tifpa@pec.infn.it

Roberto Ferrari

Born October 6, 1959, in Bardi (PR), Italy

Education:

- MSc degree in physics with honours (1985), University of Parma
 - INFN fellowship for HEP (1986-88) in the UA2 experiment
-

Work position:

- Researcher at INFN Pavia since December 1988. "Dirigente di ricerca" (research manager) since January 2009.
-

INFN institutional commitments:

2004-2011:

- coordinator of the HEP Pavia activities and, as such, member of the INFN Commissione Scientifica Nazionale 1 (INFN committee for the planning and funding of the HEP experiments)
- referee of the LHCb experiment
- referee for the planning and funding of the INFN LHC computing resources (INFN TIERS)

2011-14:

- referee for the INFN Commissione 5 (committee for the technological R&D planning and funding) for the experiment TWICE (dual-readout calorimetry with crystals and fibres)

2010-2014:

- group leader of the ATLAS Pavia group

2014-2017:

- national coordinator of the ATLAS upgrade activities

Since 2017:

- technology transfer contact person for the department of Pavia

2017-18:

- referee for the INFN Commissione 5 for the 3-year funding calls for innovative technological projects

Since 2018:

- national coordinator of the work package on dual-readout calorimetry for the INFN R&D activities for future accelerators
-

Experience:

Long-standing experience in different fields. Expert in data acquisition, readout and interfacing, calorimetry and (tracking) gas detectors. Strong contribution (often leading) to design, construction, commissioning, online monitoring, data quality control, for:

- a) Gas detectors: end-cap proportional tubes for the UA2 upgrade, ATLAS MDT and Micromegas.
 - b) Calorimetry: SPACAL/RD1 fibre-sampling compensated calorimeters, NOMAD lead-glass em calorimeter, DREAM/RD52 crystal and fibre-sampling dual-readout calorimeters.
 - c) data acquisition: UA2, LHCTb/RD13, NOMAD, ATLAS, DREAM/RD52.
-

Author of more than 1000 publications, more than 20 talks and seminars, about 40 conferences for high schools and general public (outreach).

Detail about the professional activity is below

UA2 Experiment (1985-1990)

End Cap Proportional Tubes:

- responsible of chamber production QA/QC, online monitoring, detector control system
- development of pattern recognition for tracking

Reconstruction of electromagnetic shower energy in the end cap calorimeters

Analysis of single photon events

Study of four-jet events

Spacal/RD1 (1990-1995)

Compensating fibre-sampling calorimetry:

- responsible of PMT QA/QC
 - detector design and construction
 - study of systematics arising from local disuniformity and attenuation length effects
 - test-beam operation
-

LHCTb/RD13 (1990-1995)

A scalable data acquisition system for LHC

- development of front-end readout libraries
 - implementation of readout interfaces
 - implementation of interrupt handling on a real-time unix system
 - development of a driver for the readout of front-end electronics
-

NOMAD (1992-1997)

Search for neutrino oscillations

- design, construction and calibration of the lead-glass em-calorimeter modules
- development of the readout and calibration sw for the em-calorimeter
- development of the calorimeter calibration system
- development of the multicrate VME/FASTBUS readout system

- responsible of the online software
 - responsible (project leader) of the Trigger and Data Acquisition system
 - development of tracking reconstruction software
 - analysis of neutrino interactions
-

ATLAS experiment (member since 1994), working on:

Detectors:

- MDT chamber (many aspects: design, construction, QC, integration, commissioning, online monitoring, data quality)
- Muon spectrometer data quality coordinator (2008-2010)
- Micromegas readout panel construction and QC

TDAQ:

- design, development, commissioning and maintenance of different sw packages for readout and online monitoring
- Phase-II upgrade TDAQ readout package (co-responsible of the activity)

Physics analysis:

- Analysis of final states from ZZ production and decay (cross section measurements and search for anomalous gauge couplings in the ZZ->llvv channel)
-

ATLAS Commitments:

2010-2014:

- team leader of the Pavia group
- member of the Collaboration Board
- member of the muon spectrometer Institute Board

2012-2014:

- member of the Collaboration-Board-Chair Advisory Group

Since 2015:

- deputy team leader of the Pavia group
-

DREAM/RD52 collaboration for dual-readout calorimetry (since 2006):

- R&D for both crystal and fibre-sampling prototypes
 - in particular, developer and responsible of the electronics, trigger and data acquisition system(s)
-

IDEA proto-collaboration for experiments at future e⁺e⁻ colliders (FCCee, CEPC)

- main editor of the dual-readout calorimeter sections of both FCCee and CEPC CDRs
 - coordinator of the dual-readout calorimeter activity
 - leader of an international proto-collaboration composed of groups from Italy (INFN Bologna, Catania, Pavia, Milano, Pisa, Roma 1), UK (University of Sussex), Croatia (Rudjer Boskovic Institute, Zagreb), South Korea (Kyungpook National University, Yonsei U., Korea U.), US (Iowa State University)
-

Lecturing/teaching (since year 2000)

2001-2006:

- professor at the University of Parma for the course of "Data acquisition and analysis" (MSc in physics)

Since 2019:

- professor at the University of Pavia for the course of "Digital technologies for data acquisition"

Since 2016:

- lecturer on "Electronics, DAQ and Triggers" for the CERN summer student lecture programme course

In 2019:

- lecturer at the INFN Cogne school on detectors about "Calorimetry in High Energy Physics"

Since 2016:

- lecturer and lab tutor at the International School of Trigger and

Data Acquisition (ISOTDAQ)

Outreach

- contributor to many INFN and CERN activities (CERN open days, European researchers' nights, public and private CERN visits)
 - author of more than 30 conferences for high schools and general public (in Italy)
-

1. "First test-beam results obtained with IDEA, a detector concept designed for future lepton colliders"
R. Aly et al. [INFN RD_FA Collaboration]
DOI: 10.1016/j.nima.2019.04.042
Nucl. Instrum. Meth. A 958, 162088 (2020).
2. "Development of a Silicon Photomultiplier based dual readout calorimeter: The pathway beyond the proof-of-concept"
M. Antonello et al. [RD52 and INFN RD_FA Collaborations]
DOI: 10.1016/j.nima.2018.10.169
Nucl. Instrum. Meth. A 936, 127 (2019)
3. "Tests of a dual-readout fiber calorimeter with SiPM light sensors"
M. Antonello et al. [DREAM/RD52 Collaboration]
arXiv:1805.03251 [physics.ins-det]
DOI: 10.1016/j.nima.2018.05.016
Nucl. Instrum. Meth. A 899, 52 (2018)
4. "Hadron detection with a dual-readout fiber calorimeter"
S. Lee et al. [DREAM/RD52 Collaboration]
DOI: 10.1016/j.nima.2017.05.025
Nucl. Instrum. Meth. A 866, 76 (2017)
5. "The electromagnetic performance of the RD52 fiber calorimeter"
N. Akchurin et al. [DREAM/RD52 Collaboration]
DOI: 10.1016/j.nima.2013.09.033
Nucl. Instrum. Meth. A 735, 130 (2014)
6. "Particle identification in the longitudinally unsegmented RD52 calorimeter"
N. Akchurin et al. [DREAM/RD52 Collaboration]
DOI: 10.1016/j.nima.2013.09.024
Nucl. Instrum. Meth. A 735, 120 (2014)
7. "Lessons from Monte Carlo simulations of the performance of a dual-readout fiber calorimeter"
N. Akchurin et al. [DREAM/RD52 Collaboration]
DOI: 10.1016/j.nima.2014.05.121
Nucl. Instrum. Meth. A 762, 100 (2014)
8. "Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC"
G. Aad et al. [ATLAS Collaboration]
DOI: 10.1016/j.physletb.2012.08.020
Phys. Lett. B 716, 1 (2012)
9. "Measurement of the ZZ production cross section and limits on anomalous neutral triple gauge couplings in proton-proton collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector"
G. Aad et al. [ATLAS Collaboration]
DOI: 10.1103/PhysRevLett.108.041804
Phys. Rev. Lett. 108, 041804 (2012)
10. "ATLAS-detector operations with beams: the data-acquisition perspective"
Ferrari, R. for the ATLAS TDAQ Group
DOI: 10.1016/j.nuclphysbps.2011.04.010
Nucl. Phys. B Proc. Suppl. 215, 208 (2011)

PERSONAL INFORMATION

Gabriella Gaudio✉ gabriella.gaudio@pv.infn.it

Date of birth 6th February 1974 | Nationality Italian

PROFESSIONAL EXPERIENCE

Contracts

- 2/2011 - today Full-time researcher - INFN Pavia
- 9/2014 - 3/2015 Maternity leave
- 4/2008 - 1/2011 Fixed-term researcher (art.23) - INFN Pavia
- 7/2007 - 4/2008 Research Associate - University of Washington
- 7/2003 - 7/2007 Postdoc position - INFN Pavia
- 2/2000 - 3/2003 PhD in Physics (XV ciclo), at Pavia University
"Study of Gauginos Production and Decay in the Trilepton Channel at High Energy Colliders"
PhD and International Certificate of Doctoral Studies in Physics, University of Washington, Seattle

Appointments

- 9/2016 - 10/2018 Coordination Group Member for Micromegas project of the NSW ATLAS upgrade
- 3/2016 - 3/2020 Team Leader ATLAS-Pavia
- 2014 - 2017 INFN-Pavia contact person for "La notte dei Ricercatori" - European projects "DREAMS" and "Made in science"
- 1/2013 - today INFN-Pavia contact person for the "International Masterclasses"
- 3/2010 - 3/2014 National coordinator for MDT project in ATLAS-Italy
- 12/2009 - 12/2012 Technical Coordinator and GLIMOS RD52 project at CERN
- 2006 Responsible for MDT-BIL installation in the ATLAS experiment.

Financial Management

- National coordinator for MDT project in ATLAS-Italy (150k€/y)
- Team Leader ATLAS-Pavia (80k€/y)
- Contact person for "La notte dei Ricercatori" (2k€/y)

Educational Activities

- Supervisor for 9 Undergrad and PhD thesis
- Lectures in several courses, mainly on detector physics

National and International Conference Organization

- 25-27/10/2017 XIII workshop ATLAS Italia Fisica e Upgrade workshop organising committee
- 4-6/6/2012 CALOR12 session convener
- 26-30/5/2008 CALOR08 workshop organising committee and proceedings co-editor

AWARDS

NIMA Young Scientist Award for the best poster presentation

- "New results from the DREAM project"
- 12th Vienna Conference on Instrumentation, 2010

NATIONAL AND INTERNATIONAL
 CONFERENCES AND SCHOOLS

- 20-22/1/2020 **"Dual Readout Calorimeter"**
 talk at "IAS Program High Energy Physics", Hong Kong
- 18-20/11/2019 **"Overview of Dual-Readout Calorimetry"**
 talk at "2019 International Workshop on the High Energy CEPC", Beijing
- 21-24/1/2019 **"Present Status of Dual Readout for Future Accelerator"**
 talk at "IAS Program High Energy Physics", Hong Kong
- 8-11/1/2019 **"Expected performance of the IDEA dual-readout calorimeter"**
 talk at "11th FCC-ee workshop", CERN
- 6/11/2018 **"INFN: tra ricerca e innovazione"**
 invited talk at "3DEXPERIENCE Forum Italy 2018"
- 25-27/10/2018 **"NSW upgrade"**
 invited talk at "XIII workshop ATLAS Italia Fisica e Upgrade", Pavia
- 24-30/9/2018 **"The ATLAS experiment. Status and prospects"**
 talk at "New Trends in High-Energy Physics", Budva, Montenegro
- 21-23/3/2018 **"DREAM-like approach to calorimetry"**
 lecture at "Frascati Detector School", LNF
- 16-18/12/2016 **"New trends in calorimetry"**
 invited talk "IFD2015 - INFN Workshop on Future Detectors, Torino
- 8-10/5/2013 **"Search for natural SUSY"**
 invited talk "VI Workshop Italiano sulla Fisica p-p a LHC", Genova
- 1-6/10/2012 **"Search for pair production of supersymmetry particles in R-parity conserving scenarios in ATLAS"**
 talk at "LHC Days in Split", Split, Croazia
- 4-8/6/2012 **"Crystals for dual-readout calorimetry"**
 talk at "CALOR12", Santa Fe, USA
- 10-14/5/2010 **"Performance of a dual readout calorimeter with a BGO electromagnetic section"**
 talk at "CALOR10", Beijing
- 10-14/5/2010 **"Optimization of the crystals for applications in dual-readout calorimetry"**
 talk at "CALOR10", Beijing
- 15-20/2/2010 **"New results from the DREAM project"**
 poster at "12th Vienna Conference on Instrumentation", Vienna
- 20-25/7/2009 **"The Art of Calorimetry"**
 lectures at "Radiation and particle detectors" alla International School of Physics "Enrico Fermi", Varenna
- 21-26/6/2009 **"Searches for SUSY at the LHC"**
 talk at "XXIemes Rencontres de Blois", Blois
- 24-30/5/2009 **"Crystals for dual-readout calorimetry"**
 poster at "11th Pisa Meeting on Advanced Detectors", La Biodola, Isola d'Elba
- 22-27/9/2008 **"Electroweak bosons early physics and cross section measurement for ATLAS experiment"**
 talk at "XCIV Congresso SIF", Genova
- 26-30/5/2008 **"Effects of the Temperature Dependence of the Signals from Lead Tungstate Crystals"**
 talk at "CALOR08", Pavia
- 26-28/3/2008 **"Stato dei rivelatori ad LHC"**
 invited talk at "IFAE", Bologna

- 23-25/11/2006 “Stato del commissioning e integrazione. Risultati dai test-beam e cosmic run”
invited talk at “IV Workshop Italiano sulla Fisica di ATLAS e CMS”, Bologna
- 21-27/5/2006 “Test of the BIL tracking chambers for the ATLAS muon spectrometer”
poster at “10th Pisa Meeting on Advanced Detectors” La Biodola, Isola d’Elba
- 24-29/10/1999 “An electromagnetic micrometer to measure the wire centring in high-resolution aluminium drift tubes”
talk at “1999 IEEE Nuclear Science Symposium and Medical Imaging Conference”, Seattle, USA

SCIENTIFIC CURRICULUM

ATLAS Monitoring Drift Tubes (MDT) for the Muon Spectrometer

G. Gaudio (GG) has started her activity in the ATLAS experiment mainly contributing to the MDT sub-detector in the muon spectrometer.

The MDT chambers of the barrel inner region (BIL) have been built by a cluster of 4 Italian institutes, among which Pavia. In this framework, GG contributed to the hardware development of the detector, to the development of quality control tools, and to the design and characterisation of the mechanical tooling for chamber assembly. GG has also covered management roles both for the assembly phase and the chamber preparation. In a second stage, GG has participated in the commissioning and installation activities at CERN. She was responsible for BIL installation in the experiment, in close connection with the ATLAS Technical Coordination.

ATLAS Monitoring Online and Data Quality

Starting in 2005, GG has joined the MDT online monitoring effort, concerning the early identification of detector problems during operation. This is based on modular framework integrated in the ATLAS TDAQ system. Within this framework, libraries specific for the MDT online monitoring has been developed. Until 2014, GG has been co-responsible for development and maintenance of this software. As such, she participated in the ATLAS Monitoring WG. In the same period, GG was in the group which defined procedure and criteria for the detector DQ.

ATLAS Micromegas development for ATLAS Upgrade

Starting 2013 the ATLAS Pavia group joined the muon spectrometer upgrade project concerning the New Small Wheel (NSW). In particular, the group was involved in the development of MicroMegas (MM).

In 2013-14 the Pavia group built a mechanical prototype of a MM chamber, which characterisation provided important input for the detector design. GG coordinated the development, together with the mechanical workshop. She was part of the Layout & Design Working Group of the NSW upgrade project, which had a mandate to define the final layout of the MM chambers.

The layout of the NSW features 4 different types of chambers. The SM1 modules are responsibility of a cluster of INFN groups, among which Pavia which devoted to the construction of the readout panels. They are the more complex to built, due to stringent mechanical tolerances. GG contributed to the improvement of the mechanical tools previously developed and followed all the activities connected with the production phase.

GG was both part of the QAQC Working Group and coordinator of the Module Validation Working Group with mandate to define all the parameters and procedures for both panel and assembled detectors QC. She was also member of the coordination WG (project management)

ATLAS Physics Studies

Within the Internationalisation program of the PhD, GG has spent working period both at University of Washington (Seattle) and Fermilab. She joined the D0 experiment, developing physics analysis for associated production of the lightest chargino and next-to-lightest neutralino, predicted by SUSY models, and decaying to trileptons final state. Further developments of these studies in the context of the ATLAS experiment were carried on, and the comparative analysis in the D0 and ATLAS experiments was the subject of the PhD thesis.

Between 2011 and 2014, GG has actively participated in the ATLAS data analysis within the SUSY group, studying the inclusive two-leptons final state, as a first stage, and later devoted the efforts to optimise the analysis for top SUSY partner search in different decay final states.

DREAM - RD52 - RD_FA R&D project for high-resolution calorimeter

Starting 2006, GG has joined the DREAM project, an R&D effort aiming at improving the hadronic energy resolution by means of reduction of fluctuations in the electromagnetic fraction in hadronic showers. This is achieved through the simultaneous readout of Cherenkov and scintillation light produced in the calorimeter. DREAM is an international collaborations and the R&D was approved at CERN as RD52 program, now closed, for which GG was also contact person.

In 2008-2009 this R&D was funded as DRC experiment in CSNV, devoted to the development of DR method in crystals. GG and the Pavia group developed crystals for the separation of the two types of light.

Later, another experiment devoted to the DR was funded in CSNV: Newdream. This aimed at development of dual-readout fiber calorimeter. GG actively worked in the design and construction of fiber-lead calorimeter, which were tested in 2012 TB which results are now reference for the DR performance results.

GG has participated in all testbeam phases. She presented results in many collaboration meetings as well as in international conferences. From 2009 GG was Technical Coordinator e GLIMOS for all the DREAM testbeams.

From 2016, the dual-readout technique has grown in interest as candidate for future accelerator experiments. CSNI has included a WP on DR calorimetry in the *RD_FA* project. GG is actively working both on the improvement of the construction technique for this type of detectors and on performance studies in the framework of the proposed proto-experiment IDEA.

Elenco delle pubblicazioni allegate

1. **“An electromagnetic micrometer to measure the wire centering in high-resolution aluminium drift tubes”**
M. Cambiaghi, A. Cardini, S. Casani, R. Ferrari, G. Gaudio, G. Iuvino, A. Lanza and M. Prata.
10.1109/23.856516
IEEE Trans. Nucl. Sci. **47**, 784 (2000).
2. **“Construction of the Inner Layer Barrel Drift Chambers of the ATLAS Muon Spectrometer at the LHC”**
P. Bagnaia, M. Barisonzi, C. Bini, D. Calabrò, R. Caloi, M. Cambiaghi, G. Capradossi, A. Cavallari, V. Cecconi, G. Ciapetti, C.H. Daly, A. DeSalvo, G. DeZorzi, A. Di Domenico, A. Di Mattia, R. Ferrari, M. Fraternali, A. Freddi, G. Gaudio, P. Gauzzi, S. Gentile, M. Iannone, G. Iuvino, F. Lacava, A. Lanza, M. Livan, H.J. Lubatti, C. Luci, A. Mattei, C. Nardoni, A. Negri, A. Pelosi, C. Piscitelli, L. Pontecorvo, D. Rebuffi, C. Scagliotti, D.A. Scannicchio, P. Valente, F. Vercellati, L. Zanello
10.1016/j.nima.2005.02.040
Nucl. Instrum. Meth. A **546**, 481 (2005).
3. **“The Barrel-Inner-Large Tracking Chambers for the ATLAS Muon Spectrometer: Ready for Installation”**
M. Bellomo; P. Branchini; G. Ciapetti; D. De Pedis; G. De Zorzi; A. Di Domenico; R. Ferrari; G. Gaudio; P. Gauzzi; E. Graziani; M. Iodice; L. La Rotonda; F. Lacava; A. Lanza; A. Passeri; F. Petrucci; D. Rebuffi; D. A Scannicchio; M. Schioppa; A. Tonazzo; P. Valente; W. Vandelli
10.1016/j.nima.2006.12.044
Nucl. Instrum. Meth. A **573**, 340 (2007).
4. **“Construction techniques and performances of a full-size prototype Micromegas chamber for the ATLAS muon spectrometer upgrade”**
T. Alexopoulos et al
10.1016/j.nima.2019.04.040
Nucl. Instrum. Meth. A **955**, 162086 (2020).
5. **“The art of calorimetry”**
G. Gaudio, M. Livan and R. Wigmans.
10.3254/978-1-60750-630-0-31
Proc. Int. Sch. Phys. Fermi **175**, 31 (2010).
6. **“The electromagnetic performance of the RD52 fiber calorimeter”**
N. Akchurin *et al.*.
10.1016/j.nima.2013.09.033
Nucl. Instrum. Meth. A **735**, 130 (2014).
7. **“Lessons from Monte Carlo simulations of the performance of a dual-readout fiber calorimeter”**
N. Akchurin *et al.*.
DOI:10.1016/j.nima.2014.05.121
Nucl. Instrum. Meth. A **762**, 100 (2014).

8. **“Hadron detection with a dual-readout fiber calorimeter”**
S. Lee *et al.*.
arXiv:1703.09120 [physics.ins-det]
DOI:10.1016/j.nima.2017.05.025
Nucl. Instrum. Meth. A **866**, 76 (2017)
9. **“Tests of a dual-readout fiber calorimeter with SiPM light sensors”**
M. Antonello *et al.*.
arXiv:1805.03251 [physics.ins-det]
DOI:10.1016/j.nima.2018.05.016
Nucl. Instrum. Meth. A **899**, 52 (2018)
10. **“ATLAS Run 1 searches for direct pair production of third-generation squarks at the Large Hadron Collider”**
G. Aad *et al.* [ATLAS Collaboration].
arXiv:1506.08616 [hep-ex]
DOI:10.1140/epjc/s10052-015-3726-9, 10.1140/epjc/s10052-016-3935-x
Eur. Phys. J. C **75**, no. 10, 510 (2015), Erratum: [Eur. Phys. J. C **76**, no. 3, 153 (2016)]
CERN-PH-EP-2015-138

Massimo Caccia is Full Professor of Experimental Physics and Research Associate at the National Institute of Nuclear Physics (I.N.F.N.) and CERN, the European Laboratory for Particle Physics located in Geneva, Switzerland.

M. Caccia's research is focused on the use of solid state detectors of ionizing particles and photons for High Energy Physics experiments, instruments and methods in Medicine, Radioprotection, Homeland Security and High Level Education. Since 2006, the core of his activity is related to Silicon Photomultipliers (SiPM), state-of-the-art sensors of light with single photon sensitivity and photon number resolving capability.

Since 2001, his prevailing interest is in applied physics projects based on the technology developed for Particle Physics experiments. He has been the project coordinator of SUCIMA, an European Commission Framework Program (FP) 5 project related to high granularity dosimetry for intravascular brachytherapy, and RAPSODI, an FP6 project addressing the development of instruments based on SiPM in collaboration with European small and medium enterprises. He has been member of MODES-SNM, an FP7 project focused on instrument development for homeland security. Since May 2019, M. Caccia is leading the project named "Random Power: in-silico quantum generation of random bit streams", one of the 170 projects out of 1211 submissions approved within the EC-ATTRACT initiative. In July 2019, the HORIZON2020 project named ORIGIN, led by Uni. Limerick and targeting real-time, in-vivo dosimetry for oncological brachytherapy was approved; within the project, M. Caccia is leading the work-package on the development of the SiPM based instrument and the data acquisition.

As far as particle physics, after a 15 year-long activity within DELPHI at LEP on the development of the microvertex detector, M. Caccia joined the ATLAS pixel group for a short time. He has been involved since the early days in the International Linear Collider activities and today he is part of the RD-FA INFN collaboration, involved in the activities for the next lepton colliders.

Massimo Caccia is author or co-author of more than 390 articles published in peer reviewed journals and conference proceedings. He presented the results of his activity in more than 120 conferences and seminars.

N.	Prodotto
1	Caccia, M., Nardo, L., Santoro, R., Schaffhauser, D. (2018). Silicon Photomultipliers and SPAD imagers in biophotonics: Advances and perspectives. NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH. SECTION A, ACCELERATORS, SPECTROMETERS, DETECTORS AND ASSOCIATED EQUIPMENT, vol. 926, p. 101-117, ISSN: 0168-9002, doi: 10.1016/j.nima.2018.10.204
2	M. Caccia, R. Santoro, V. Arosio, M. Beretta (2017), A robust and semi-automatic procedure for Silicon Photomultipliers characterisation. JOURNAL OF INSTRUMENTATION, vol. 12, p. C03030, ISSN: 1748-0221, doi: 10.1088/1748-0221/12/03/C03030
3	Holzscheiter Michael H, Alsner Jan, Bassler Niels, Boll Rebecca, Caccia Massimo, Knudsen Helge, Maggiore Carl, Petersen Jørgen B, Sellner Stefan, Straße Tina, Singers Sørensen Brita, Overgaard Jens (2016). The relative biological effectiveness of antiprotons. RADIOTHERAPY AND ONCOLOGY, vol. 121, p. 453-458, ISSN: 0167-8140, doi: 10.1016/j.radonc.2016.12.007
4	Belzunze, Martin A., Lomazzi Samuela, Beretta Monica, Caccia Massimo, Reader, Andrew J. (2018). Simulation and Design Considerations of a Dual Layer Plastic Scintillator Intraoperative Probe for Radiolabeled Tumours. IEEE TRANSACTIONS ON RADIATION AND PLASMA MEDICAL SCIENCES, vol. 2, p. 432-443, ISSN: 2469-7311, doi: 10.1109/TRPMS.2018.2838662
6	G. Chesi, L. Malinverno, A. Allevi, R. Santoro, A. Martemyanov, M. Caccia and M. Bondani (2019), Optimising Silicon Photomultipliers for Quantum Optics, Scientific Reports, (2019) 9:7433 https://doi.org/10.1038/s41598-019-43742-1
7	V. Arosio et al., EasyPET: A novel concept for an affordable tomographic system. NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH. SECTION A, ACCELERATORS, SPECTROMETERS, DETECTORS AND ASSOCIATED EQUIPMENT, vol. -, ISSN: 0168-9002, doi: 10.1016/j.nima.2016.05.004
8	G. Chesi, L. Malinverno, A. Allevi, R. Santoro, M. Caccia and M. Bondani (2019), Measuring nonclassicality with silicon photomultipliers, Optics Letters Vol. 44, No. 6 , 1371-1374 https://doi.org/10.1364/OL.44.001371
9	M. Antonello et al. (2018), Tests of a dual-readout fiber calorimeter with SiPM light sensors, Nucl. Instruments and Methods in Phys. Research, A 899 (2018) 52-64 https://doi.org/10.1016/j.nima.2018.05.016
10	Rainero A. et al. (2018), GDNA qPCR is statistically more reliable than mRNA analysis in detecting leukemic cells to monitor CML. CELL DEATH & DISEASE, vol. 9, p. 349, ISSN: 2041-4889, doi: 10.1038/s41419-018-0387-2

Romualdo Santoro is Associate Professor at the Physic Department of the Insubria University with a national Full professorship habilitation (2018). R. Santoro's research field is focused on silicon detectors and detection techniques for ionising particles and photons (Silicon Pixel Detectors and Silicon PhotoMultipliers). The use of such detectors, with the dedicated methodology, has a large area of interest that goes from fundamental to applied research.

R. Santoro started his scientific activity in the field of High Energy Physic in the ALICE (A Large Ion Collider Experiment) Experiment at LHC (Large Hadron Collider). He spent almost 10 years in the collaboration and, he followed all the aspects which allowed to build, qualify and operate the Silicon Pixel Detector (SPD); the closer detector to the colliding beams. Among the main responsibilities covered by R. Santoro in the ALICE Collaboration it is worth mentioning: 1) SPD Detector Control System (DCS) responsible with a key role in the software finalization and integration inside the ALCIE-DCS framework, 2) SPD System Run Coordinator from the detector commissioning phase [ref. 8] up to when the experiment was collecting the first p-p and Pb-Pb physics data [ref. 9,10] and 3) SPD Deputy Project Leader. He finally was appointed as Convener for one of the 4 working groups which have been leaded the studies that allowed to design the new vertex detector for the ALICE experiment upgrade which is now close to be installed.

Since 2012 R. Santoro's interests moved towards the Silicon Photomultipliers (SiPM) and their use in applications spanning from high-energy physics to medicine, homeland security and instrumentation for high education [ref. 1,5,6,7]. In this context, he effectively contributed in setting up and consolidate collaborations with scientific and R&D company teams (i.e. CAEN s.p.a., AWE, Kromek and Nuclear Instruments s.r.l.). He effectively contributed on different granted projects:

- [2013 - 2015] Partner in the MODES-SNM project (FP7-project id 284842), led by Università di Padova. The project addressed the development of a novel fast neutron detector for homeland security using ^4He gas in a high-pressure tube. His contribution in the project was the design and qualification of a module based on the SiPM readout. The activity demonstrated the viability of the concept which convinced the main partner company (ARKTIS detectors) to engineer the prototype which is currently on the market.
- [2016 - 2020] Co-PI of a collaboration with AWE, the U.K. Atomic Weapons Establishment, focused on the characterization of a new class of neutron sensitive plastic and inorganic scintillator with neutron-gamma discrimination properties [ref. 3]. The collaboration involves as well KROMEK, a British based company active in the field of protection against nuclear threats.
- [2019 - 2021] Responsible of the work package "Application and system characterization" in the ARCADIA project (INFN – CSN V - Grant), led by INFN-TO. The project goal is the development of a novel sensor platform that allows to have monolithic pixel sensors operated in full depletion mode produced on standard CMOS fabrication processes [ref. 2].
- [2020 - 2022] Partner in an HORIZON2020 project named ORIGIN, led by Uni. Limerick and targeting real-time, in-vivo dosimetry for oncological brachytherapy.

Since 2016 R. Santoro started to collaborate to the DREAM project. In this contest, he played a key role in the design, commissioning and qualification on beam of a small calorimetric module which detects and readout with SiPMs the scintillating and Cherenkov light produced in the shower. The latest test-beam demonstrated that the Dual Readout Calorimeter can be instrumented with SiPMs

with potential improvements with respect to the versions equipped with PMTs [ref. 4]. This activity is now continuing in the INFN RD_FA project and the Dual readout calorimeter instrumented with SiPMs is included in IDEA, a detector concept proposed for the next generation of electron-positron circular collider (FCC-ee and CepC).

Dr. Santoro's most significant scientific publications:

1. SiPM Silicon Photomultipliers and SPAD imagers in biophotonics: Advances and perspectives, M. Caccia et al., NIM-A Vol 926 (2019), 101-117
2. Fully Depleted MAPS in 110-nm CMOS Process With 100-300- μm Active Substrate, L. Pancheri et al., IEEE Transactions on Electron Devices, Vol 67-6 (2020), 2393 - 2399
3. Qualification of a compact neutron detector based on SiPM, R. Santoro et al., JINST Vol 15 (2020)
4. Test of a dual-readout fiber calorimeter with SiPM light sensor, M. Antonello et al., Nucl. Instr. and Meth. in Phys. Res. A899 (2018) 52 - 64.
5. Optimizing Silicon photomultipliers for Quantum Optics, G. Chesi *et al.*, *Sci Rep* **9**, 7433 (2019).
6. Reconstruction of the statistics of photons by a pulsed LED using a Silicon Photomultiplier based set-up", V. Arosio, et al., NIMA, JINST 10, C08008 (2015)
7. A simple and robust method to study after-pulses in Silicon Photomultipliers", M. Caccia, R. Santoro and G. A. Stanizzi, JINST 9, T10004 (2014)
8. Alignment of the ALICE Inner Tracking System with cosmic-ray tracks. ALICE Collaboration, JINST, 5, ISSN: 1748-0221 (2010)
9. Charged-particle multiplicity density at mid-rapidity in central Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. ALICE Collaboration, Phys. Let. B, ISSN: 0370-2693 (2010)
10. First proton-proton collisions at the LHC as observed with the ALICE detector: measurement of the charged-particle pseudorapidity density at $\sqrt{s}=900$ GeV. ALICE Collaboration, THE EUROPEAN PHYSICAL JOURNAL. C, PARTICLES AND FIELDS, vol. 65, p. 111-125, ISSN: 1434-6044 (2009)

Giacomo Polesello

Curriculum Vitae

Employment

- 03/2016-03/2017** CERN Scientific associate
01/2004-06/2006 CERN Scientific associate
06/2019- today: Dirigente di Ricerca (Research Director),
INFN, Sezione di Pavia
02/2002-06/2019: Primo Ricercatore (Senior Research Physicist),
INFN, Sezione di Pavia
12/1990-02/2002 Research Physicist (permanent position),
INFN, Sezione di Pavia
01/1989-12/1990: CERN Fellow
09/1986-08/1988: INFN Scholarship, INFN, Sezione di Milano

Education

- 07/1999:** Ph.D., Université Denis Diderot, Paris (Paris VII).
07/1985: Degree in Physics (Laurea in Fisica), Università di Milano, *cum laude*.
07/1980 Maturità Classica, Liceo Classico P.Verri, Lodi (Italy)

Timeline of research activity

- **2018- today:** RD-FA detector and physics studies for IDEA proto-experiment:
 - Jet calibration for IDEA dual readout calorimeter
 - Simulation of searches for Axion Like Particles at FCC-ee/CEPC
- 1992- today:** ATLAS experiment and studies of LHC physics (from 1990):
 - Chair of the ATLAS Publication Committee (2015-2017).
 - Leading role in the ATLAS publication process. Editorial Board chair for 9 papers and 7 conference notes, spokesperson delegate for final sign-off of papers. Member of Physics Office. (2010-today).
 - Key role in LHC data analysis. Key author of 8 analyses on searches for superymmetric particles and Dark Matter; contact editor for 3 papers and 3 conference notes (2010-today)
 - Coordination of physics at experiment level (2003-2006)
 - Phenomenological studies of signatures for Supersymmetry (SUSY) and other models of new physics, study of implications for Dark Matter (1992-today).
 - Coordination role in the simulation studies of signatures for physics beyond the Standard Model, in particular SUSY (1992-2009).
 - Trigger-DAQ: Leading role on the test beam DAQ as test bed for the development of the ATLAS DAQ, participation in the Event Filter development work, simulation work for evaluation of trigger rates. (1997-2003)
 - Muon spectrometer: test beam activity, participation to MDT construction in Pavia with responsibility for the cosmic ray test stand (1994-2003).

- **1993-2000:** NOMAD experiment:
 - EM calorimeter: device construction and testing; design, implementation and running of the DAQ for the beam calibration.
 - DAQ: development of the monitoring control of the experiment, member of the DAQ support team.
 - Data analysis: search for $\nu_\mu \leftrightarrow \nu_\tau$ oscillations in the $\tau^- \rightarrow e^- \bar{\nu}_e \nu_\tau$ channel
- **1990-1996** LHC R&D projects:
 - RD13 (1990-1996): DAQ development.
 - Spacal/RD1 (1990-1993): Calorimetry development.
 - Fermi/RD16 (1993-96): Front-end electronics development.
- **1986-1992:** UA2 experiment:
 - Data analysis: Supersymmetry (SUSY) searches, QCD (single and double prompt photon production).
 - Calorimetry: participation in the beam calibration (1986-1987), work on the calibration of the readout electronics.
 - Trigger-DAQ: design, implementation and running of the E_T^{miss} trigger, member of the DAQ support team.
- **1984-1985:** WA70 experiment:
 - undergraduate work on data analysis.

Official responsibilities in experiments

- Member of the ATLAS Physics Office, with the task of handling the publication process of ATLAS papers (04/2018-today)
- Chair of the ATLAS Publication Committee, member of the Executive Board of the experiment (03/2016-03/2017).
- Deputy chair of the ATLAS Publication Committee (03/2015-03/2016).
- ATLAS Physics Coordinator, member of the Executive Board of the experiment (10/2003-09/2006).
- Convener of the ATLAS SUSY analysis group and member of the Physics Coordination group of the experiment (1992-2004 e 10/2007-10/2009).
- ATLAS Test Beam DAQ Coordinator, and member of the DAQ Steering group' (1995-96).
- NOMAD Run Coordinator (10/1997).
- Responsibility for the DAQ system of the following test beams: NOMAD EM Calo (1993), Fermi/RD16 (1994), ATLAS Muon detectors (1996).

Official responsibilities at CERN and INFN level

- Member of the CERN Scientific Information Policy Board (03/2016-03/2017)
- Team Leader ATLAS Pavia (04/2014-04/2016).
- Convener of the groups “Beyond Standard Model” and “Dark Matter” of the “What Next” process of INFN. (02/2014-2016).
- Referee for the INFN Funding Committee for accelerator physics (Commissione Scientifica Nazionale 1, CNS1) of the BES III experiment(2013-2018).
- Referee for CNS1 of the CDF2 experiment (2011-2015).
- Member for Pavia of CNS1 (06/2011-06/2015).
- Analysis coordinator for ATLAS Italy (02/2007- 2010).

Professional activities

Committees of international and national conferences

Scientific Program Committee: *13th Rencontres di Vietnam, SUSY 2007*

International Advisory Committee: *SUSY 2013, Tools 2008,2010,2012, C2CR 2004*

Co-Chair of Program Committee: *Physics at the LHC*, 2004, 2006

Co-chair of Organising Committee:

Workshop sui Monte Carlo, la Fisica e le simulazioni all'LHC 2006

International Advisory Committee:

Centre International de Physique des Hautes Energies d'Annecy-le-Vieux 2006-2008

International Organising Committee: *Physics at TeV Colliders* , Les Houches 2005,2007

Local Organising Committee: Workshop *Flavour in the era of LHC* , CERN 2005-2006

Organising Committee: Workshop *HERA for LHC* , CERN and DESY 2004-2007

Scientific Committee: *Workshop italiano sulla fisica di ATLAS e CMS* 2004-2007

Session organiser in international conferences

SUSY Phenomenology and experiment, SUSY 2015

SUSY Phenomenology, SUSY 2013

Hadron Collider Physics Symposium 2007

Convenerships in workshops

Implications of LHC results for TeV scale physics, CERN 2012

From the LHC to a Future Collider , CERN 2009

Workshop IFAE , 2008

Physics at TeV Colliders , Les Houches 1999,2007

Workshop italiano sulla fisica di ATLAS e CMS , 2004,2005

Convener of the group *SUSY Models for Colliders* of Euro-GDR SUSY 2001-2006

Refereeing activity

- Project evaluations for:
 - PPARC (UK), 2005-6
 - ISF (Israel), 2007, 2017
 - SNSF (Svizzera), 2010
 - ANR (Francia), 2009-2013
 - Università di Catania, 2014
 - ERC (EU), 2017. Invited to perform evaluation, but declined because of close ties with candidate.
- Evaluation of candidates to jobs/promotions for:
 - Leverhulme Trust (UK),
 - Pittsburgh University (US),
 - Bonn University (Germania),
 - Cambridge University (UK),
 - Jesus College, Cambridge (UK),
 - Sussex University (UK),
 - University of California Irvine (US).
- Peer reviewer for international journals:
 - Physics Letters B
 - JHEP
 - Computer Physics Communications
 - EPJ C
 - Particle Data Group,
- Member of 9 PhD committee (2006-2016), SNS Pisa; Annecy, Milano, Orsay, Oxford, Cambridge, Marsiglia, Barcelona.
- External referee for 4 Italian PhD theses.

Student supervision

- Supervisor of co-supervisor of 6 master theses for Pavia University:
- Supervision of the 3 PhD theses

Conference talks

- 4 official talks on Atlas data:
 - 07/2018** *Search for direct pair production of stops and sbottoms with the ATLAS detector*
XXXIX International Conference on High Energy Physics (ICHEP 2018)
Seoul (Corea del Sud)
 - 03/2015** *SUSY: Blind spots @ run1, perspectives at Run2 and beyond*
50th Rencontres de Moriond, La Thuile
 - 11/2011** *SUSY status and next steps*
Hadron Collider Physics Symposium (HCP 2011), Parigi (FR)
- 33 Talks on LHC physics. Only most relevant ones are given below
 - 04/2018** *Turning every stone at the LHC: diverse signatures with the 2HDM+a model*
Dark Matter @ LHC 2018, Heidelberg (Germania)
 - 07/2010** *Dark Matter and the LHC*
IV Particle Physics and Cosmology Workshop PPC 2010, Torino
 - 03/2010** *Dark Matter at the LHC*
“Evening talk”, 45th Rencontres de Moriond, La Thuile
 - 06/2006** Panel Discussion: *Getting ready for LHC*
SUSY 2006 Conference, Irvine (USA)
 - 05/2005** *Physics opportunities of an upgraded LHC*
Invited talk, APS April Meeting, Tampa (USA)
 - 02/2005** *New physics at the LHC*
Brookhaven Colloquium - Brookhaven National Laboratories (USA)
 - 06/2004** *Prospects for SUSY at the LHC*
Invited plenary talk, SUSY 2004 Conference, Tsukuba (Giappone)
 - 06/2000** *SUSY at the LHC*
Invited plenary talk, SUSY 2000 Conference, CERN (Switzerland)
 - 07/1995** *Searches for SUSY at the LHC*
International Europhysics Conference on High-energy Physics (HEP 95)
Brussels, (Belgio).
 - 03/1993** *Searches for SUSY at LHC*
SUSY 1993 Conference, Boston (US)
- 6 talks on UA2, NOMAD, RD1 (1989-1998)
- Seminars:
 - 2004-19** 19 seminars at Rutherford Laboratories (2), DESY , and at universities of:
Aachen, Bonn, Cambridge, Kobe, Lecce, London (UCL and RHUL),
Lund, Lisbona, Oxford (2), Pisa, Sussex (2), Udine, Valencia

Giacomo Polesello - 10 most relevant papers

1. **“ATLAS Run 1 searches for direct pair production of third-generation squarks at the Large Hadron Collider,”**
G. Aad *et al.* [ATLAS Collaboration],
arXiv:1506.08616 [hep-ex].
Eur. Phys. J. C **75** (2015) no.10, 510 Erratum: [Eur. Phys. J. C **76** (2016) no.3, 153]
2. **“Search for direct production of charginos, neutralinos and sleptons in final states with two leptons and missing transverse momentum in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector,”**
G. Aad *et al.* [ATLAS Collaboration],
arXiv:1403.5294 [hep-ex]
JHEP **1405** (2014) 071 arXiv:1403.5294 [hep-ex]
3. **“Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC”**
G. Aad *et al.* [ATLAS Collaboration].
arXiv:1207.7214 [hep-ex]
Phys. Lett. B **716**, 1 (2012)
4. **“Search for squarks and gluinos using final states with jets and missing transverse momentum with the ATLAS detector in $\sqrt{s} = 7$ TeV proton-proton collisions”**
G. Aad *et al.* [ATLAS Collaboration].
arXiv:1109.6572 [hep-ex]
10.1016/j.physletb.2012.02.051
Phys. Lett. B **710**, 67 (2012)
5. **“SUSY searches at the LHC”**
T. Plehn and G. Polesello
Chapter of the book:
“Particle Dark Matter: Observations, Models and Searches”
Edited by Gianfranco Bertone
Cambridge University Press 2010 ISBN-13: 9780521763684
6. **“Supersymmetric particle mass measurement with the boost-corrected contranverse mass”**
G. Polesello and D. R. Tovey.
10.1007/JHEP03(2010)030
JHEP **1003**, 030 (2010)
7. **“Physics interplay of the LHC and the ILC”**
G. Weiglein *et al.* [LHC/LC Study Group Collaboration].
hep-ph/0410364
Phys. Rept. **426**, 47 (2006) editor
8. **“Final NOMAD results on muon-neutrino \rightarrow tau-neutrino and electron-neutrino \rightarrow tau-neutrino oscillations including a new search for tau-neutrino appearance using hadronic tau decays”**
P. Astier *et al.* [NOMAD Collaboration].
hep-ex/0106102
Nucl. Phys. B **611**, 3 (2001)

9. **“Electron, pion and multiparticle detection with a lead / scintillating - fiber calorimeter”**
D. Acosta, S. Buontempo, L. Caloba, M. Caria, R. DeSalvo, A. Ereditato, R. Ferrari and G. Fumagalli
et al.
Nucl. Instrum. Meth. A **308**, 481 (1991).
10. **“A Search for Squark and Gluino Production at the CERN $\bar{p}p$ Collider”**
J. Alitti *et al.* [UA2 Collaboration].
Phys. Lett. B **235**, 363 (1990).