Ministero dell'Istruzione dell'Università e della Ricerca

Dipartimento per la formazione superiore e per la Ricerca

Direzione Generale per il Coordinamento, la promozione e la valorizzazione della Ricerca

PRIN: PROGETTI DI RICERCA DI RILEVANTE INTERESSE NAZIONALE – Bando 2017
Prot. 2017E5FAMM

PART A

1. Action line

Main line/Linea Principale

2. Research project title

KLEVER-Cal: Development of innovative high-performance calorimeters and photon veto detectors for a future experiment to measure ultra-rare KL decays at the CERN SPS (KLEVER)

3. Duration (months)

36 months

4. Main ERC field

PE - Physical Sciences and Engineering

5. Possible other ERC field

6. ERC subfields

1.	PE2_2 Particle physics
2.	PE2_1 Fundamental interactions and fields
3.	

7. Key Words

nº	Testo inglese
1.	elementary particles
2.	flavour physics
3.	physics of detectors
4.	rare kaon decays

8. Principal Investigator

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Ricercatore (Category)	
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9. List of the Research Units

nº	Associated Investigator	Category	University/ Research Institution	Registered office (address)	e-mail address
1.	MOULSON Matthew David	Ricercatore	Istituto Nazionale di Fisica Nucleare	Via Enrico Fermi, 40 - Frascati (Roma) (RM)	matthew.moulson@lnf.infn.it
2.	PETRUCCI Ferruccio Carlo	Professore Associato confermato	Università degli Studi di FERRARA	Ex Convento di S.Lucia-v.Ariosto 35 - FERRARA (FE)	petrucci@fe.infn.it

3.	MASSAROTTI Paolo	Ricercatore a t.d. (art. 24 c.3-b L. 240/10)	Università degli Studi di Napoli Federico II	C.so Umberto I, 40 - NAPOLI (NA)	paolo.massarotti@na.infn.it
4.	SOZZI Marco Stanislao	Professore Associato confermato	Università di PISA	Lungarno Pacinotti, 43/44 - PISA (PI)	marco.sozzi@cern.ch
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10. Brief description of the research proposal

The branching ratios (BRs) for the K -> pi nu anti-nu decays are strongly suppressed and calculated very precisely in the Standard Model, and so are sensitive to new physics at mass scales of hundreds of TeV. Hints of anomalies from the rare decays of B mesons are tantalizing but require confirmation from other flavor sectors. The BR for the decay KL -> pi0 nu anti-nu has never been measured. An unexpected result for this BR could upend the Standard Model, leading to a period of renewal in particle physics. We are designing an experiment, KLEVER, to measure BR(KL -> pi0 nu anti-nu) to within 20% using a high-energy neutral beam at the CERN SPS. The goal of the present proposal, KLEVER-Cal, is to make the KLEVER experiment possible by firmly establishing the technological solutions for the main calorimeter and principal photon vetoes (upstream, large-angle, small-angle), as well as for the readout systems for these detectors. We will construct prototypes for the main calorimeter, large-angle and small-angle subsystems and test them with high-energy tagged photon beams CERN SPS after the LHC restart in 2021. The members of our project team have a track record of success in developing cutting-edge instrumentation for high-energy physics with applications in other technology sectors.

11. Total cost of the research project, per single item

Associated Investigator	item A.1	item A.2.1	item B	item C	item D	item E	sub-total	item F	Total
MOULSON Matthew David	32.886	47.702	48.353	0	0	52.000	180.941	24.248,49	**205.189,49**
PETRUCCI Ferruccio Carlo	21.750	47.702	41.671	0	0	100.000	211.123		**211.123**
MASSAROTTI Paolo	14.656	47.702	37.415	0	0	25.000	124.773		**124.773**
SOZZI Marco Stanislao	22.110	47.702	41.887	0	0	27.000	138.699		**138.699**
MENICHETTI Ezio	31.515	47.702	47.530	0	0	26.000	152.747		**152.747**
Total	**122.917**	**238.510**	**216.856**	**0**	**0**	**230.000**	**808.283**	**24.248,49**	**832.531,49**

- item A.1: Enhancement of months/person of permanent employees
- item A.2.1: Cost of contracts of non-employees, specifically to recruit
- item B: Overheads (flat rate equal to 60% of the total cost of staff, A.1 + A.2.1, for each research unit)
- item C: Cost of equipment, instruments and software
- item D: Cost of consulting services and similar
- item E: Other operating costs
- item F: Prize (automatically calculated as 3% of total cost of the project)

PART B

1. Abstract

The branching ratios (BRs) for the decays K -> pi nu anti-nu (KPNN) are among the observables in the quark-flavor sector most sensitive to new physics. Because these BRs are strongly suppressed and calculated very precisely in the Standard Model, they are potentially sensitive to new physics at mass scales of hundreds of TeV, surpassing the sensitivity of B decays in most Standard Model extensions [1]. Observations of lepton-flavor-universality-violating phenomena are mounting in the B sector. Measurements of the KPNN BRs are critical to interpreting the data from rare B decays, and may demonstrate that these effects are a manifestation of new degrees of freedom such as vector leptoquarks [2, 3], fundamentally disrupting the Standard Model and ushering in a period of renewal in particle physics, both theoretical and experimental. The NA62 experiment at the CERN SPS will measure the BR for K+ -> pi+ nu anti-nu (K+PNN) decays to within 10% by the end of LHC Run 3 [4], but in order to distinguish between different NP scenarios, it is necessary to measure the BR for KL -> pi0 nu anti-nu (KLPNN) decays as well.

We are designing an experiment to measure BR(KLPNN) to within 20% using a high-energy neutral beam at the SPS starting in LHC Run 4 [5]. The basic design of the experiment, called KLEVER (KL Experiment for Very Rare events), was developed with funding under an earlier PRIN grant [6] and further progress has been made as part of the CERN Physics Beyond Colliders study. The goal of our proposal, KLEVER-Cal, is to firmly establish the technological solutions to be adopted for key KLEVER detector subsystems, specifically, for the main calorimeter and principal photon vetoes (upstream, large-angle, small-angle), via the construction and in-beam testing of prototype instruments.

At the heart of the measurement of BR(KLPNN) is the main electromagnetic calorimeter (MEC), which both reconstructs signal events from the pi0 decay into two photons, and rejects events with extra photons. KLEVER must develop a cost-effective solution for the MEC, with excellent efficiency and time resolution, good two-cluster separation, and the capability to distinguish between neutron and photon interactions. Shashlyk calorimetry with a novel longitudinal readout technique is a promising candidate. The same technology can be used in the design of the upstream veto calorimeter (UVC), for which the required performance characteristics are similar.

To effectively reject background from KL -> pi0 pi0 decays, the large angle veto (LAV) system must have a detection inefficiency for high-energy photons of at most a few 1e-6. At the same time, the large surface to be instrumented (25 LAV stations are required to cover the decay volume) demands an economical solution. These conflicting demands can be met through an appropriately optimized lead/scintillating-tile veto.

The small-angle calorimeter (SAC) sits squarely in the beam and intercepts photons from background decays escaping through the beam pipe. Although the efficiency requirements at small angle are less stringent, the design of this detector is complicated because it must be insensitive to near-GHz fluxes of neutral hadrons in the beam. We will develop a tungsten/silicon-pad sampling calorimeter making innovative use of crystalline tungsten for the absorber to take advantage of the decrease of the effective radiation length for high-energy photons from coherent effects [7].

Finally, all of the KLEVER photon detection systems will require high-frequency digitizing readout to efficiently veto background events without being blinded by pile-up. While it may be desirable to monitor continued technological progress before locking in a specific solution, the needed characteristics of the readout system can be specified via studies including processing of signals from the detector prototypes. We envision the development of a common platform for the front-end and readout systems for all of the above detectors.

We foresee the construction of small prototypes for the LAV, MEC/UVC, and SAC subsystems, to be tested with high-energy tagged photon beams at the CERN SPS after the LHC restart in 2021. The members of our project team made key contributions to the proposal, design, construction and operation of NA62 and have a track record of success in developing instrumentation for rare decay physics at fixed target.

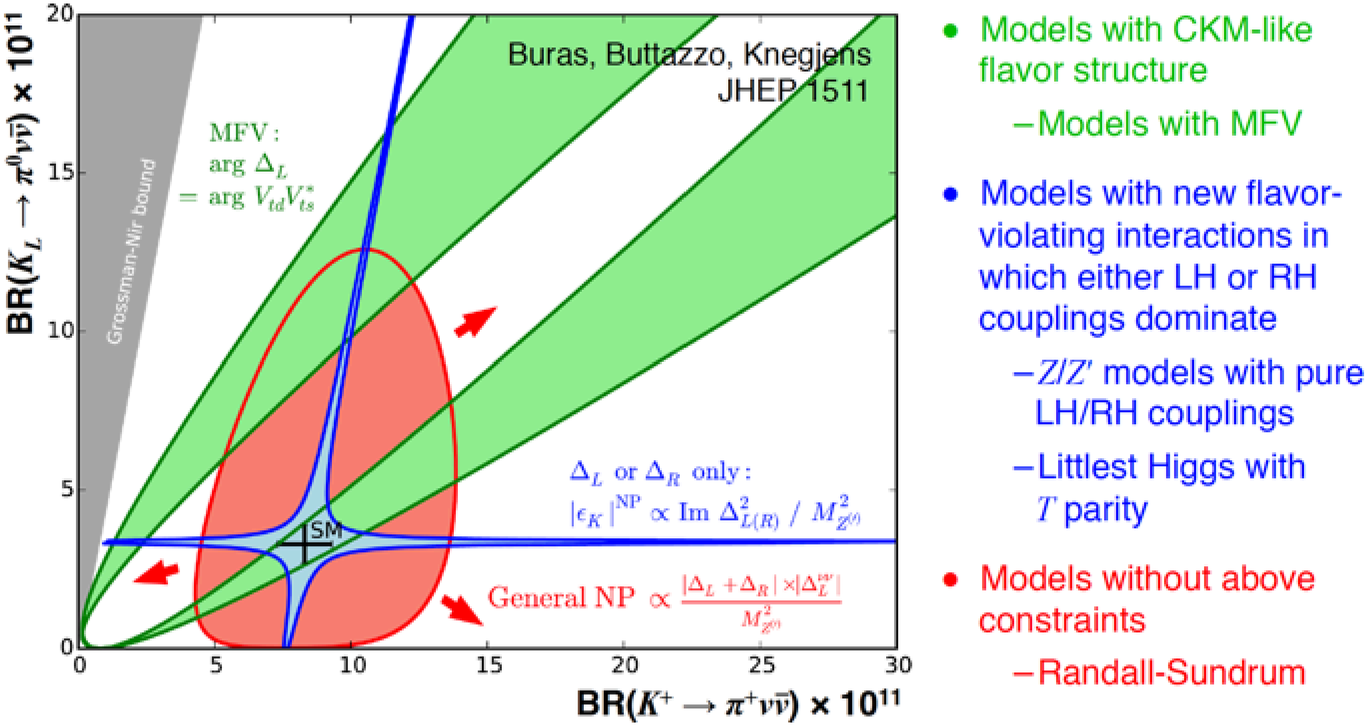
To ensure that the ramifications of our work on rare decays are effectively communicated to the scientific community and society at large, we will organize both topical seminars and outreach initiatives for the general public. Young researchers will play a prominent role in our project and will mature valuable experience in the construction of cutting edge detectors for high-energy physics, with possible applications in other sectors of technological research.

2. Detailed description of the project: targets that the project aims to achieve and their significance in terms of advancement of knowledge, state of the art and proposed methodology

Searches for new physics (NP) at the high-energy frontier have long dominated the public imagination due to successes such as the 2012 discovery of the Higgs boson at CERN. However, by looking for tiny contributions from NP in the decays of known particles, the search can be extended to much higher mass scales than can be reached at the highest energy accelerators. The latter approach requires either measuring known processes to very high precision or studying decays that are highly suppressed within the Standard Model (SM), as in the study of the rare decays of B and K mesons.

The branching ratios (BRs) for the flavor-changing neutral current decays K -> pi nu anti-nu (KPNN) are among the observables in the quark-flavor sector most sensitive to NP. Because the SM decay amplitudes are strongly suppressed and predicted very precisely [8], the KPNN BRs are potentially sensitive to NP effects at mass scales of hundreds of TeV, surpassing the sensitivity of B decays in many SM extensions [1]. Observations of lepton-flavor-universality-violating phenomena are mounting in the B sector. Most explanations predict strong third-generation couplings and thus significant changes to the KPNN BRs through couplings to final states with tau neutrinos [2, 3].

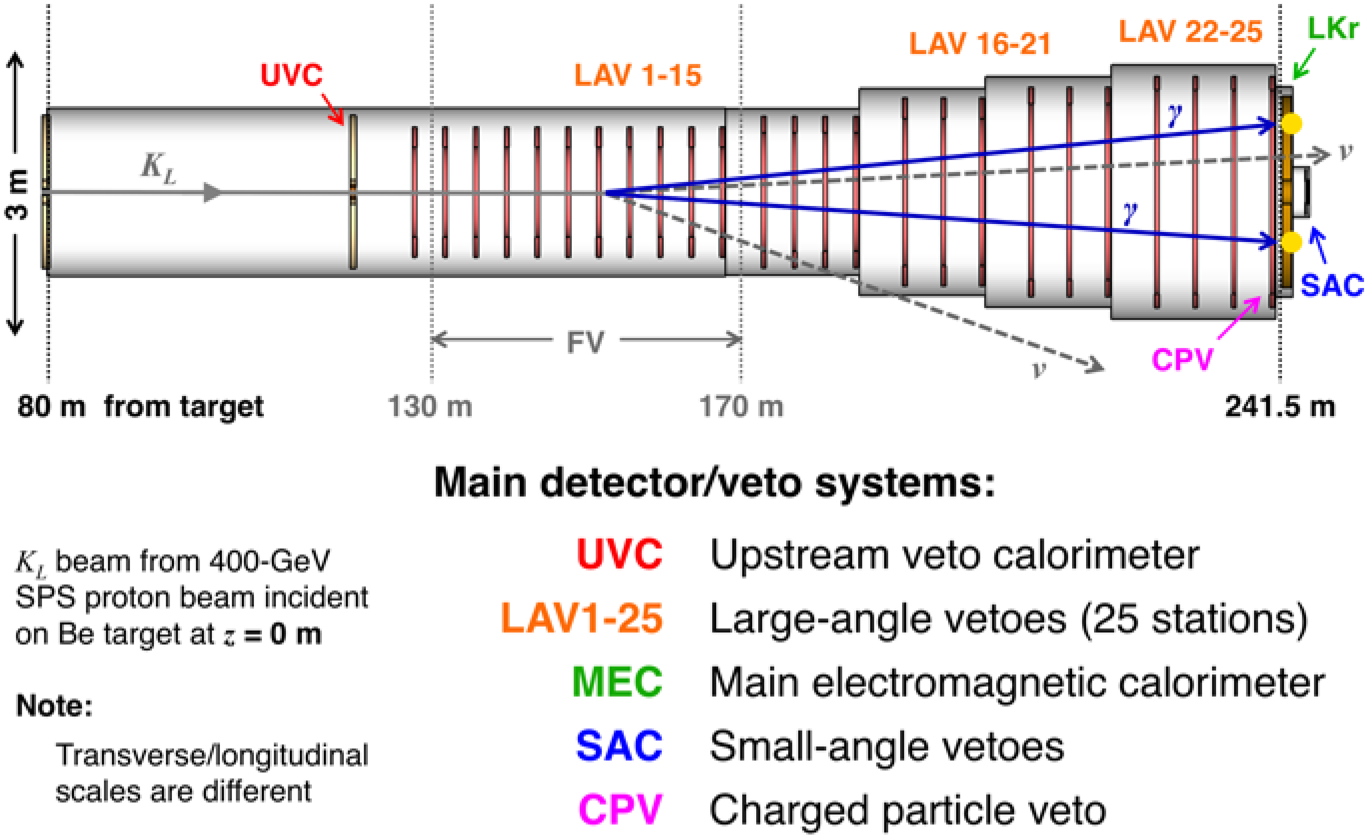
The SM BRs for the decays K+ -> pi+ nu anti-nu (K+PNN) and KL -> pi0 nu anti-nu (KLPNN) are (8.4+/-1.0)e-11 and BR(KLPNN) = (3.4+/-0.6)e-11, respectively [9]. The uncertainties are entirely dominated by the CKM inputs. Without these parametric errors, the BRs would be known to 3.5% and 1.5%. It is important to measure both BRs, because different NP scenarios affect each of them in different and specific ways, as schematized in the figure below, from [10].



The BR for the K+PNN decay has been measured by the Brookhaven experiments E787/E949. The combined result, obtained with seven candidate events, is BR(K+PNN) = 1.73(+1.15/1.05)e-10 [11]. The NA62 experiment at the CERN SPS [12] is currently running and is expected to collect about 20 signal events (assuming the SM BR) before the LHC shutdown at the end of 2018. An additional three-year run after the LHC restart in 2021 should allow 100 signal events to be collected in total [4].

Measurement of BR(KLPNN) is a greater challenge. The signature is the appearance in a neutral beam of a pi0 decaying to two photons with missing transverse momentum. Almost all other KL decays contain two or more extra photons or tracks, so rejecting backgrounds is mainly a question of vetoing events with additional particles. The principal background is from KL -> pi0 pi0 (KL2P0) decays with two unobserved photons. The BR for KL2P0 is 8.65e-4, more than seven orders of magnitude larger than that for KLPNN.

Although BR(KLPNN) has never been measured, the KOTO experiment at J-PARC has a good chance of observing the decay [13]. With a continuing program of upgrades to increase the beam power and reduce backgrounds, the experiment should reach single-event sensitivity for the SM BR by about 2021.



KLEVER is a planned experiment to measure BR(KLPNN) with a high-energy KL beam at the SPS [5]. The main elements of the experiment are illustrated in the figure above and include:

- An intense, high energy neutral hadron beam, produced from the 400-GeV SPS proton beam (incident from the left side of the figure). The high beam energy facilitates the detection of photons from background decays like KL2P0. In addition, because of the forward boost for photons from background decays, the coverage of the photon vetoes does not need to extend beyond 100 mrad in the polar angle.
- Precise measurement of energies, positions, and times for photons from pi0 -> gamma gamma decays with the main electromagnetic calorimeter (MEC), both for the reconstruction of KLPNN events and the rejection of events with extra photons.
- An active final collimator for the beam, surrounded by an electromagnetic calorimeter (UVC) to detect extra photons from decays upstream of the fiducial volume.
- Hermetic coverage of the fiducial volume out to 100 mrad by the large-angle photon veto (LAV) system: 25 ring-shaped detectors placed at intervals of 4 to 5 m along the walls of the vacuum tank.
- A small-angle calorimeter (SAC) that intercepts the neutral beam and detects photons from KL decays that pass through the beam pipe.

The experiment can be installed in the NA62 hall and reuse some of the NA62 experimental infrastructure. Simulations show that about 60 signal events (assuming the SM BR) could be collected in five years of data taking, with a signal-to-background ratio of about unity, allowing the BR to be determined to about +/-20% [14]. The natural target date for the experiment to turn on would be at the start of LHC Run 4, in early 2026.

The basic feasibility of KLEVER was established in studies carried out in 2013-2016 with an earlier PRIN grant [6]. Since that time, work on KLEVER has continued as part of the Physics Beyond Collider initiative at CERN [15]. Through these studies, the design of the experiment has advanced to the point at which prototyping of specific hardware solutions for the key detector and readout systems is the next logical step. This is the goal of the present proposal. The project is divided into the following work packages:

- WP1: Shashlyk calorimetry for the Main Electromagnetic Calorimeter (MEC) and Upstream Veto Calorimeter (UVC)
- WP2: Large-Angle Vetoes (LAV)
- WP3: Small-Angle Calorimeter (SAC)
- WP4: Common readout, data-acquisition, and trigger platform

For WPs 1-3, the goals are to address the relevant design issues, construct prototype instruments, and test them with photon beams. WP4 seeks to design a common readout system for the detectors in WPs 1-3, in parallel with the development of the detectors themselves.

The ultimate significance of our project is to enable the measurement of KLPNN, unlocking its unique discovery potential, but each detector technology that we will develop also has potential applications to other areas in particle physics and related fields, as discussed briefly in each case, below.

WP1: Shashlyk calorimetry

State of the art:

KLEVER will require the development of a cost-effective solution for the MEC with excellent efficiency and time resolution, good two-cluster separation, and capability to distinguish between neutron and photon interactions. The same technology will also be used in the design of the upstream veto calorimeter (UVC), for which the required performance is similar. Shashlyk calorimetry is a promising alternative. Studies have demonstrated that a fine-sampling (0.275 mm Pb + 1.5 mm scintillator) shashlyk calorimeter can provide an energy resolution of 3%/sqrt(E, GeV) and a time resolution of 72 ps/sqrt(E, GeV) [16]. We seek to develop a shashlyk design specific to KLEVER needs.

Goals:

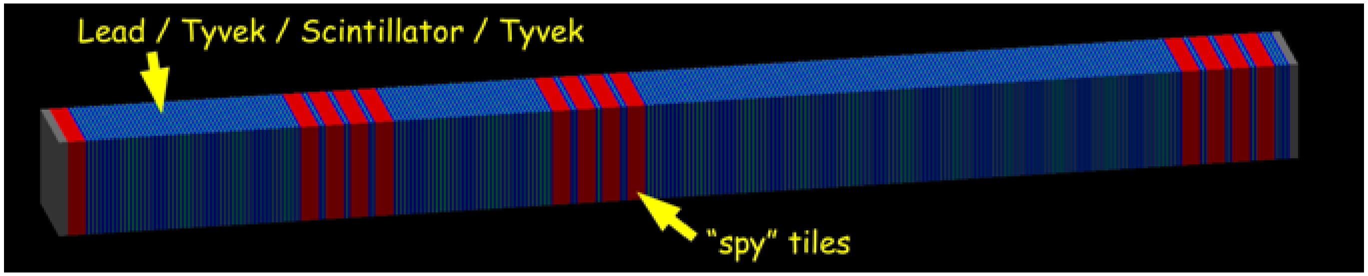
First, the basic shashlyk design—the thicknesses of lead and scintillator, overall depth in radiation lengths (X0), etc.—needs to be optimized for the KLEVER energy range. Avalanche photodiodes were used as photosensors for the study in [16], while silicon photomultipliers (SiPM) may be a better choice for KLEVER.

Second, the transverse segmentation necessary in order to avoid inefficiencies in pi0 rejection from merging of overlapping clusters must be optimized. The transverse segmentation will also assist in distinguishing electromagnetic showers from the interactions of muons, pions, and neutrons.

Finally, although existing shashlyk designs do not incorporate longitudinal segmentation, the possibility of obtaining information from the MEC on the longitudinal shower development would be very useful. Above all, this would provide additional information for particle identification, especially for photon/neutron discrimination. As the experience with KOTO indicates, this is key for rejecting background from neutrons scattered on the collimator edges or on residual beam gas [13]. Additionally, the signal from a primary photon conversion at a depth of 50 cm (15X0, probability 1e-5) may arrive 1-2 ns earlier than a promptly converting photon, an interval that is about the size of the anticoincidence window with the KLPNN event time.

Methodology:

The KLEVER group at the Institute for High Energy Physics in Protvino, Russia, has developed a simple but elegant concept for obtaining longitudinal shower information from a shashlyk calorimeter. As illustrated in the figure below, groups of optically isolated “spy tiles” are independently read out with dedicated wavelength-shifting (WLS) fibers at specific positions in the shashlyk stack—at the front of the module, to help identify charged particles, near shower maximum, and at the end of the module, to identify mips and hadronic interactions. Geant4 simulations have demonstrated the validity of the concept.



In collaboration with Protvino, modules incorporating the basic longitudinal readout concept could be constructed for testing with 5 GeV electrons in the OKA beamline at IHEP as soon as spring 2019. This would leave significant time for optimization studies of a realistic detector prototype module with associated readout for testing at the SPS with a high-energy tagged photon beam in 2021.

Significance:

The development of longitudinal readout for shashlyk calorimeters will establish a new technique for low-cost, high-performance electromagnetic calorimetry providing particle-identification capability, with potentially broad uses in all types of nuclear and particle physics experiments.

WP2: Large-angle vetoes (LAV)

State of the art:

To sufficiently contain the background, the LAV coverage must extend to at least 100 mrad and the LAVs must have high efficiency down to at least 100 MeV [14]. One possible design for the KLEVER LAVs would be similar to that of the system described in [17]: a fine-sampling (1 mm lead + 5 mm scintillating tile) calorimeter with wedge-shaped tiles stacked into modules and arranged to form a ring-shaped detector. The scintillation light is collected by WLS fibers in radial grooves. In KLEVER, the LAVs would consist of 100 layers, for a total thickness of 60 cm, corresponding to 18X0.

The E787/E949 experiment at Brookhaven used a similar design, and measured inefficiencies for photon detection of 1e-3 at 50 MeV and 1e-4 at 200 MeV [18, 19]. The efficiency of a prototype module was also measured using 200-500 MeV electron beams of energy 200-500 MeV at the Frascati Beam-Test Facility (BTF) [20] and 500-1200 MeV at the Jefferson National Laboratory [17]. An inefficiency of 3e-06 was found at 1200 MeV. Simulations of the KLEVER layout incorporating these efficiency values for the LAVs demonstrate that this performance would be satisfactory.

Goals and methodology:

A specific design based on the concept described above will be developed for the LAV detectors. Issues to be addressed will include:
• Optimization of the module geometry for KLEVER.
• Identification of candidates for plastic scintillators and WLS fibers that are both economical and suitable for use in a high-efficiency photon veto.
• Optimization of the light readout. In the design of [17], the fibers from the tiles were bundled and brought to optical windows viewed by photomultiplier tubes outside of the vacuum. Readout by SiPMs inside the vacuum would facilitate the design. We will reduce the readout complexity by summing signals from multiple SiPMs in the analog front end before digitization (WP4).
• Development of a mechanical design for the LAV stations, featuring an overlap scheme to avoid cracks in coverage. The design must allow for SiPMs to be changed. The LAV modules must also be tested for compatibility with operation in vacuum.

Significance:

The LAVs will be the largest and most expensive detector system in KLEVER, so the feasibility of the experiment depends on the development of a cost-effective design. In turn, the KLEVER LAVs will represent a versatile, low-cost solution for high-performance electromagnetic calorimetry adaptable for use in other large-scale particle physics experiments.

WP3: Small-angle calorimeter (SAC)

State of the art:

According to FLUKA simulations [21], there are 240 MHz of KL and 670 MHz of neutrons in the secondary beam, as well as 50 MHz of photons with E > 5 GeV. The SAC must operate inside of this beam without being blinded. The task is made a little easier by the fact that photons from KL decays in the SAC acceptance have very high energy: the SAC need only have very high efficiency (99.99%) for photons with E > 30 GeV. The key to developing this detector is to make it as insensitive as possible to the neutral hadrons in the beam. In addition, the detector must possess the following characteristics:
• Excellent time resolution (< 140 ps)
• Transverse segmentation sufficient to keep the single-channel rate below a few MHz and to assist in gamma/n discrimination by shower profile.
• Longitudinal segmentation, also for use in gamma/n discrimination.
• Good radiation tolerance: the beam delivers an annual fluence of about 1e13 n/cm2.

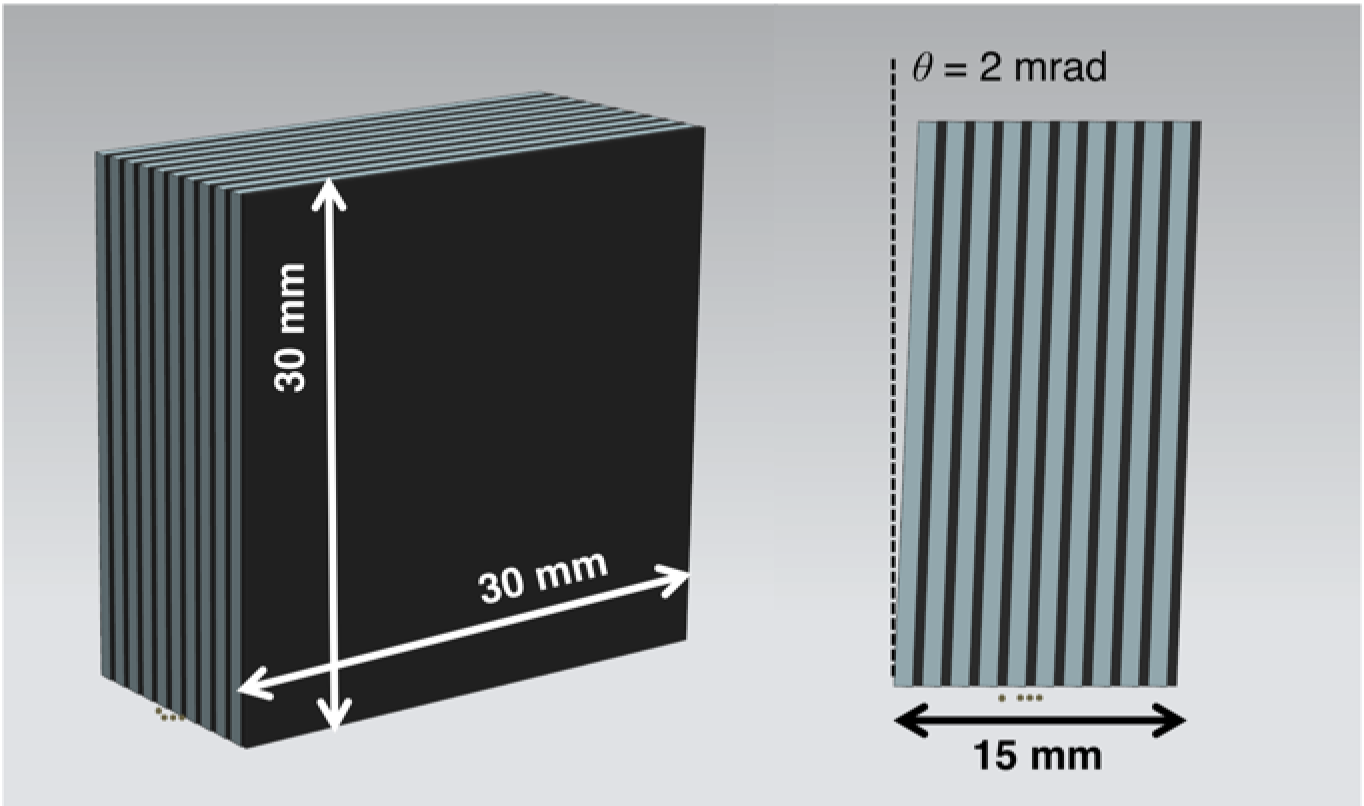
Goals:

We propose to develop a tungsten/silicon-pad (W/Si) sampling calorimeter making innovative use of crystalline tungsten for the absorber. The coherent interaction of photons with the crystal lattice enhances the probability for conversion to e+e- pairs (see, e.g., [7]). Bremsstrahlung emission from e+ and e- in the shower is similarly enhanced. As a result, the radiation length, and hence the ratio X0:Lint, is reduced. The effect is greatest for high-energy photons: for 30 GeV photons incident at an angle of 2 mrad, the pair-production cross section is enhanced by a factor of about three [14]. A calorimeter with a crystal metal absorber may therefore have good transparency to neutral hadrons.

We will test this principle in a multilayer configuration. In an electromagnetic shower, the enhancement from coherent effects will become less important in successive generations because of the decreasing energy and angular spread of shower particles. We seek to understand how much the conversion efficiency and compactness of a W/Si calorimeter can be improved by use of a crystal metal absorber, in particular when using commercially available crystals, which have a notable mosaic spread (0.2 deg).

Methodology:

For this test, we will construct a reduced scale, single-tower calorimeter consisting of 10 layers, with 30 x 30 cm2 x 1-mm-thick crystalline tungsten absorber tiles in a mechanical structure allowing the inclination of the planes to be adjusted, as sketched below.



The prototype will be tested with a 10-100 GeV tagged photon beam in the SPS North Area. In the best (enhancement observed for all early shower development) and worst (performance equal to that of amorphous tungsten) case scenarios, the test assembly would have a total effective thickness of 8.5X0 and 3X0, respectively, so the effect of the coherent interaction should be clearly revealed. Prior to testing at CERN, the basic functionality of the prototype can be verified in the laboratory with cosmic rays and, if necessary, with low-energy single-electron beams at the BTF. Since the main focus of the test is the study of the electromagnetic shower development, we plan to adapt an existing hybrid sensor/readout design for the active layers.

Significance:

The development of an electromagnetic calorimeter with excellent timing resolution, transparency to neutrons, and good radiation resistance is a novel challenge in high-energy physics, with applications to a variety of fixed-target measurements at high beam intensity, such as searches for rare decays and hidden-sector particles.

WP4: Common readout, data-acquisition, and trigger platform

State of the art:

Digitization of the signals from the KLEVER detectors with FADCs at high frequency (~1 GHz) would help to efficiently veto background events without inducing dead time. For the SAC, this is strictly necessary, since the signal duration will be long compared to the mean interval between events on a single channel. Detailed signal analysis may also assist with particle identification and discrimination of uncorrelated background, for example, from muon halo.

Various advantages can be obtained from a readout system capable of continuous data framing and transmission without a low-level hardware trigger:
• No latency issues: the system is limited by throughput.
• No front-end data buffering, reducing the likelihood of radiation-induced data corruption.
• Data to be retained can be selected by a higher-level software trigger, in principle, implementing the full offline analysis criteria.
• High-level trigger criteria can be updated as needed.
• No emulation of hardware trigger logic is needed for efficiency studies.

On the other hand, a free-running, continuously digitizing readout implies very challenging data rates. Assuming 100 MHz of interactions in the SAC and current hit multiplicity and event size estimates, the data flow from the SAC would be 100 GB/s. Hardware zero suppression is essential in reducing the data load from inactive channels. For the scheme to work, the data flow must be further reduced by more than a factor of 4 by autonomous, parallel signal processing implemented on FPGAs or ASICs. This requires the digital filtering to be developed to the point at which the full signal information is not needed.

Goals and methodology:

To design the common readout platform, we will perform comprehensive simulations of the hit rates (including from beam induced background) and expected signal characteristics from the detectors. We will determine which of the detectors must be read out with FADCs and which (if any) can be read out with TDCs. We will also evaluate the cost and complexity of a free-running readout scheme that includes the SAC. We will use this information to conceptually develop:
• A common analog front-end stage with configurable signal shaping and amplification, to be tested using the detector prototypes constructed in WPs 1-3.
• A digital front-end stage implementing digitization, zero suppression, and digital signal processing as above, providing information for a low-level trigger stage if necessary.
• A common readout board interfacing to the digital front-end stage, to handle trigger and clock distribution, merging of channels and trigger information, additional signal processing if necessary, and data transmission over a standard network protocol.
• A fully pipelined trigger based on information from the MEC, in the event that the dataflow from the SAC proves to be too high to allow continuous data transmission.
• A networking and online computing architecture to unify the above components, providing the needed bandwidth for dataflow from the readout boards to the event-building farm and from high-level event selection to permanent storage.

We intend to monitor technological progress before locking in a specific set of solutions for the readout platform, so most of this work will be simulation driven. We do envision prototyping of the common analog front-end stage for use in the beam tests of the detector prototypes at CERN in 2021.

Significance:

For the measurement of KLPNN, the design of the readout system cannot be separated from that of the detectors. The requirements for the readout must be defined in parallel with the development of the detectors themselves.

The development of triggerless readout concepts will be critical in the high luminosity LHC era. The data transfer rates required in KLEVER are on the same scale as those for the LHC upgrades. The development of the readout architecture to handle these data flows will require collaboration with industry, and may lead to commercial applications.

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3. Project development, with identification of the role of each research unit with regards to expected targets, and related modalities of integration and collaboration

Personnel:

The KLEVER-Cal team members have made key contributions to the proposal, design, construction, and operation of NA62 and have a track record of success in developing instrumentation for rare decay physics. The roles of all participants are summarized in the following table and detailed in the descriptions of each WP below.

WP	Coordinator	Participants	Postdoctoral contracts (2-yr)
1 - Shashlyk	P. Massarotti (Naples)	F. Ambrosino (Naples), M. Moulson (INFN Frascati)	1 (Naples)
2 - LAVs	M. Moulson (INFN Frascati)	F. Ambrosino (Naples), P. Massarotti (Naples)	1 (INFN)
3 - SAC	F. Petrucci (Ferrara)	A. Gianoli (INFN Ferrara), C. Biino (INFN Turin), A. Filippi (INFN Turin)	1 (Ferrara)
4 - Readout	M. Sozzi (Pisa)	E. Menichetti (Turin), S. Giudici (Pisa), D. Soldi (Turin)	2 (Pisa, Turin)
Outreach	G. D'Ambrosio (Naples)	F. Ambrosino (Naples), S. Giudici (Pisa) P. Massarotti (Naples)	

One 2-year postdoctoral contract (assegno di ricerca) is requested for each WP, except for WP4 for which two contracts are requested. The project is designed to allow young scientists to take on prominent roles in detector development, enabling them to make significant achievements during their involvement.

Column E funding requested is broken down (in kE) in the table below.

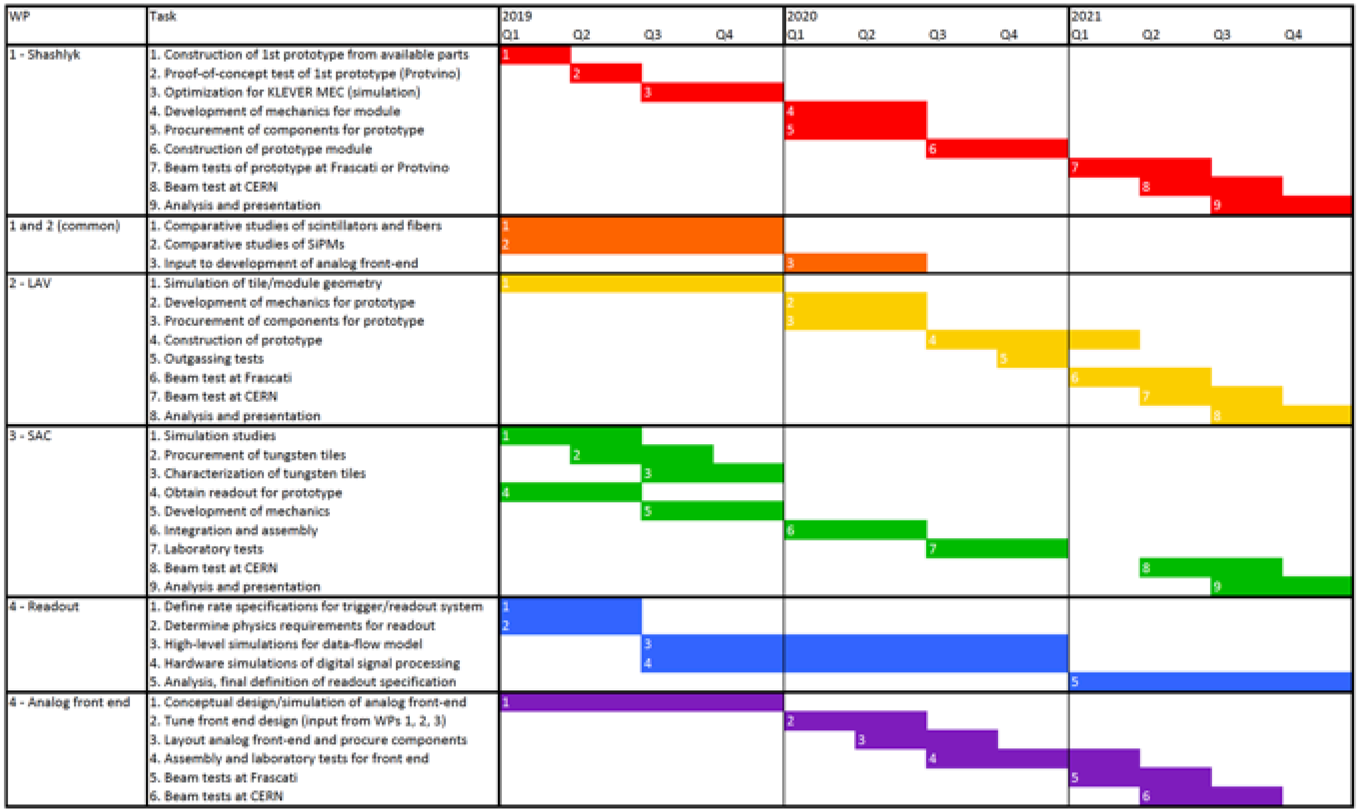
WP1 - Shashlyk			21 total, allocated to Naples
	Scintillator, WLS fiber	5	
	SiPM, readout materials	4	
	Ultralight mechanics	10	
	Materials for mechanical testing	2	
WP2 - LAV			40 total, allocated to INFN
	Scintillator, WLS fiber	18	
	SiPM, readout, development of analog sum	16	
	Mechanics	4	
	Materials for vacuum test	2	
WP3 - SAC			118 total: 96 to Ferrara, 22 to Turin
	Tungsten crystal tiles	86	
	Precision mechanics	10	
	Readout components	22	
WP4 - Readout			23 total, allocated to Pisa
	Components for front-end prototypes	23	
Other costs			28 total, distributed among units
	Foreign travel for test beam (5 months FTE)	20	
	Foreign travel for conferences	5	
	Organization of seminars and outreach events	3	

External collaboration:

Under the leadership of M. Moulson, studies for KLEVER have progressed as part of the Physics Beyond Collider initiative at CERN to provide input to the update of the European Strategy for Particle Physics, with contributions from groups from George Mason University (USA), the University of Birmingham (UK), and the Institute of High-Energy Physics at Protvino (IHEP, Russia), as well as the CERN Secondary Beams and Areas group. Collaborators from these institutions will make in-kind contributions to the detector development planned for KLEVER-Cal at zero cost to the project.

Work packages and project tasks:

The master project timeline is illustrated in the following figure.



The items for each work package, personnel involved, and interdependencies are discussed below. We assume that the CERN T9 and North Area test beams will be available in Q2 and Q3 2021. Since the time typically needed for each beam test is 1-2 weeks, it is likely that all beam tests at a given location (Frascati BTF, CERN T9, CERN North Area) will be conducted together as part of a common effort between WPs.

WP1: Shashlyk calorimetry

P. Massarotti (coordinator) and F. Ambrosino have direct experience with scintillator/WLS systems read out with SiPMs through their work in construction of the NA62 Charged Anti-counter at Naples. All three WP members participated in the prototyping, testing, and construction of the NA62 LAV system at Frascati, with P. Massarotti and M. Moulson in coordinating roles. Ambrosino and Moulson have direct experience testing NA62 LAV prototypes at the Frascati BTF [20]. Moulson is the coordinator for an approved beam test with tagged photons at the H2 line in the CERN North Area in August 2018.

Collaboration with the IHEP Protvino group is a key aspect of WPs 1 and 2. IHEP Protvino manages a facility for the production of plastic scintillator and scintillating fibers, which can be customized to meet specific performance requirements (brilliance, decay lifetime, etc.). As such, the group can source scintillating components for prototype construction and facilitate test beam measurements at the OKA beamline at IHEP.

For WP1, a 2-year postdoctoral contract at Naples is requested.

WP1 includes the following tasks illustrated in the chart:

• A basic test of the longitudinal readout concept, with rapid construction of a first prototype based on existing components [22] and validation with electrons and charged hadrons in the OKA beamline.
• Laboratory studies of detector components for the construction of a prototype module of the KLEVER MEC. The following items will be carried out in common for WP1 and WP2:
--- Tests of scintillator and WLS fiber samples (light emission, decay time, attenuation length for fibers). The choice of plastics may be different for spy tiles and normal shashlyk tiles.
--- Evaluation of different SiPMs (noise, gain, and stability measurements; packaging considerations).
--- Collaboration with the readout group (WP4) to guide development of the common analog front-end stage.
• Simulation studies to optimize depth and transverse and longitudinal segmentation for the KLEVER energy range.
• Development of the mechanical design for the prototype.

• Construction of the prototype.
• Tests of basic functionality with electrons at the BTF (500 MeV) or in the OKA beamline (5 GeV).
• Beam tests at CERN with tagged photon and Cerenkov-identified charged secondary beams, both in the T9 beamline (0.5-10 GeV) and in one of the North Area beamlines (10-100 GeV).

WP2: Large-Angle Vetoes (LAVs)

The experimental activity in WPs 1 and 2 is similar, and both will be carried out concurrently by the same team members, with M. Moulson as WP2 coordinator. The qualifications of the team members with respect to the goals of the work package and the role of external collaborators from Protvino in helping to source detector components are the same for both WPs.

For WP2, a 2-year postdoctoral contract at INFN Frascati is requested.

WP2 includes the following tasks illustrated in the chart:
• Detailed simulation studies to optimize the tile geometry, with attention to the impacts on light output, efficiency, and time resolution.
• Laboratory studies of scintillator and WLS fiber samples and comparison of SiPMs to be carried out in common with WP1 as described above.
• Collaboration with WP4 on the definition of the front-end stage, including an analog sum over adjacent channels for the LAV SiPMs.
• Development of the mechanical design for the KLEVER LAV prototype.
• Construction of the prototype.
• Outgassing tests of prototype components.
• Efficiency tests with 200-500 MeV electrons and tagged photons at the BTF.
• Tests with 0.5-10 GeV electrons and tagged photons in T9.

WP3: SAC

F. Petrucci (coordinator) is the leader of the NA62 Ferrara group, which, together with the NA62 Turin group, shared responsibility for the development of the readout for the NA62 GTK (a very high rate silicon-pixel tracker) as well as other elements of the NA62 readout system [12]. F. Petrucci and A. Gianoli collaborate with the Ferrara University Sensors and Semiconductors Laboratory, which will provide technical services for the preparation of the tungsten tiles. C. Biino, who is currently the coordinator of the NA62 Turin group, was a leader in early studies at the SPS of pair-production enhancement in crystals for the development of the NA48 AKS counter [23, 24]. The WP3 team will participate in an approved beam test to study coherent interactions in crystals with tagged photons at the H2 line in the CERN North Area in August 2018, thus gaining direct experience in beam tests with tagged photons in the North Area.

For WP2, a 2-year postdoctoral contract at Ferrara is requested.

WP3 includes the following tasks illustrated in the chart:
• Simulation studies to guide the development of the prototype and establish expectations for baseline performance.
• Procurement of tungsten tiles and measurement of dislocation density, mosaic spread, and uniformity, with assistance from the Ferrara Sensors and Semiconductors Laboratory.
• Identification of a suitable existing silicon detector and readout scheme for use in the test and procurement on loan if possible. Alternatively, adaptation of a scintillating tile/WLS fiber/SiPM solution based on components from WP2.
• Development of mechanics for test rig.
• Integration and assembly of prototype.
• Laboratory tests of basic functionality, including possibly tests with 500-MeV electrons at the BTF.
• Tests with high-energy electrons and tagged photons in one of the CERN North Area beamlines (10-100 GeV).

WP4: Readout
M. Sozzi (coordinator), as convener of the NA62 trigger/data-acquisition (TDAQ) working group, had a key role in the design of the TEL62 board, a central component of the NA62 readout system developed at Pisa [25]. The NA62 Turin group shared responsibility for the development the NA62 GTK readout and other elements of the NA62 readout system [12]. In particular, D. Soldi developed the NA62 level-0 trigger [26].

D. Soldi is currently a postdoctoral researcher whose contract can be extended with internal funding from the University of Turin (i.e., without funding from the KLEVER-Cal budget), allowing him to contribute 6 months FTE to the project in 2019. For WP4, two 2-year postdoctoral contracts are requested: one at Pisa to be filled at the start of the project, and one at Turin at the end of D. Soldi’s contract.

WP4 includes the following tasks illustrated in the chart:

• Simulation of the rates on KLEVER detectors from signal, background KL decays, and beam background (muons and neutrons), as well as rates for possibile trigger topologies, to obtain rate specifications for the trigger and readout system
• Determination of the physics requirements of the readout system, such as number of bits of dynamic range for signal amplitudes. Identification of the detectors to be read out with TDCs, if any.
• Conceptual development of the networking and data flow model for the readout system, including high-level (Monte Carlo) simulation of the flow of information from high-rate detectors and its use in a low-level trigger
• Conceptual development of the digital front-end and readout boards, including hardware-level simulation of autonomous digital signal processing for continuously sampled data, including algorithms. Estimation of the required per-channel logic resources. Determination of the feasibility of a free-running readout scheme that includes the SAC.

• Development of an analog front-end stage with configurable signal shaping and amplification of detector signals for input to FADCs (or TDCs) with 1-2V dynamic range, including validation with signals from the detector prototypes. The timescale for receiving input from WPs 1, 2, and 3, and for the design and construction of the prototype board is separately detailed on the chart above. The front-end stage will be used for beam tests of the MEC (WP1) and LAV (WP2) prototypes for the beam tests at Frascati and CERN.

4. Possibile application potentialities and scientific and/or technological and/or social and/or economic impact of the project

The principal impact of the KLEVER-Cal project is to enable the construction of the KLEVER experiment and the success of the measurement of BR(KLPNN) to within 20%. This unique measurement will help to resolve some of the most significant questions unanswered by the SM, such as the origin of the observed flavor structure, paving the way to an understanding of the fundamental interactions at energy scales much larger than those that can be reached at any collider existing or currently being designed. The measurement of a significant deviation from the precise SM predictions would constitute a breakthrough in the current picture of particle physics and has the potential to revolutionize our understanding of nature. The presence in our team of G. D'Ambrosio, a leading theoretician in the field of flavor physics beyond the SM, will facilitate effective collaboration with the theory community. In particular, we will contribute to the organization of topical seminars to bring together the international communities in rare decay physics, both theoretical and experimental, to stimulate progress in the larger field. At least two such seminars are foreseen within the duration of the project.

We expect a number of technological benefits from the development of photon detectors with cutting-edge performance (excellent time resolution, high rate capability, insensitivity to neutrons) by application of novel detection concepts, such as the use of coherent effects in crystals to enhance pair production in the SAC and spy-tile readout to provide longitudinal shower information in the MEC. These techniques can easily find applications in other particle physics experiments, as well as in other fields where photon and/or electron-positron detection techniques are currently used, such as radiation monitoring, materials science and metrology, medical applications such as radiology, and so forth. The challenging performance required by the KLEVER trigger and data-acquisition system will also require partnership with industrial third parties for the development of high-performance digitization and high-rate data transfer systems. High-energy physics experiments like KLEVER have often spurred commercial development in this sector.

To ensure effective communication of the scientific and technological achievements attained, Column E funds requested for the INFN unit contain an allocation for participation in international conferences. We foresee a priority role for our young researchers in the presentation of these results.

Apart from the obvious social implications of the possible discovery of physics beyond SM with the KLEVER experiment, we envisage two outreach initiatives, with objectives that can be attained within the project timescale.

The first objective is to make the role of virtual processes in the indirect search for physics beyond the SM familiar and accessible to the general public. We will do this by organizing open seminars and science café meetings involving both experimentalists and theorists active in the field, so as to create public awareness of the different ways in which physicists search for new phenomena. These initiatives will be carried out by leading scientists, both internal to the team and invited from the international community.

The second objective is to introduce high schools and young undergraduate students to the techniques of particle detection in high-energy physics, while at the same time, helping them to consolidating their knowledge about the fundamentals of electromagnetism and their understanding of light. This will be done by reusing the prototypes of the detectors developed for the KLEVER-Cal project in user-friendly and didactically interactive contexts within the participating institutes. Students will have the opportunity to experiment with these detectors as part of the existing programs at the university and laboratory units involved in the project, such as the Hands-on Particle Physics program [27] and OpenLabs events [28]. Thus, the educational benefits from the construction of prototypes for the KLEVER-Cal project will live on, even after the project's scientific aims have been achieved.

Team members F. Ambrosino, S. Giudici, and P. Massarotti have a history of active involvement in science popularization and outreach efforts and, with the involvement of the rest of the team, will contribute their experience towards realization of both of the above objectives.

5. Costs and fundings, for each research unit (automatically calculated)

nº	Associated or principal investigator	Total cost (euro)	Co-funding (item A.1) (euro)	MIUR funding (other items) (euro)
1.	MOULSON Matthew David	205.189,49	32.886	172.303,49
2.	PETRUCCI Ferruccio Carlo	211.123	21.750	189.373
3.	MASSAROTTI Paolo	124.773	14.656	110.117
4.	SOZZI Marco Stanislao	138.699	22.110	116.589
5.	MENICHETTI Ezio	152.747	31.515	121.232

	Total	**832.531,49**	**122.917**	**709.614,49**

6. Bibliography

1. A.J. Buras et al., J High Energy Phys 1411 (2014) 121
2. D. Buttazzo et al., J High Energy Phys 1711 (2017) 044
3. M. Bordone et al., Eur Phys J C 77 (2017) 618
4. R. Marchevski for the NA62 Collaboration, “K+ -> pi+ nu anti-nu: first NA62 results”, talk at Moriond EW, 11 March 2018 https://indico.in2p3.fr/event/16579/
5. M. Moulson for the NA62-KLEVER Project, J Phys Conf Ser 800 (2017) 012037
6. PRIN proposal 2010Z5PKWZ
7. J.F. Bak et al., Phys Lett B 202 (1988) 615; J.C. Kimball and N. Cue, Phys Rep 125 (1985) 69; V.G. Baryshevski and V.V. Tikhomirov, Sov Phys Usp 32 (1989) 1013
8. V. Cirigliano et al., Rev Mod Phys 84 (2012) 399
9. A.J. Buras et al., J High Energy Phys 1511 (2015) 033
10. A.J. Buras et al, J High Energy Phys 1511 (2015) 166
11. A.V. Artamonov et al. (E949 Collaboration), Phys Rev D 79 (2009) 092004
12. E. Cortina Gil et al. (NA62 Collaboration), J Instrum 1712 (2017) P05025
13. K. Nakagiri for the KOTO Collaboration, “Status of KL -> pi0 nu anti-nu analysis at J-PARC KOTO”, talk at Moriond EW 2018, ibid
14. A. Bradley et al., KLEVER-INT-16-01 (2016)
15. Physics Beyond Colliders Kickoff Workshop, 6-7 September 2016, https://indico.cern.ch/event/523655/
16. G.S. Atoian et al., Nucl Instrum Meth A 584 (2008) 291
17. E. Ramberg et al., IEEE Trans Nucl Sci 51 (2004) 2201
18. M.S. Atiya et al., Nucl Instrum Meth A 321 (1992) 129
19. J.R. Comfort et al. (KOPIO Project), Conceptual Design Report, April 2005
20. F. Ambrosino et al., Proceedings, 2007 IEEE Nuclear Science Symposium and Medical Imaging Conference: Honolulu, Hawaii, 28 October-3 November 2007, p. 57-64, arXiv:0711.3398
21. http://www.fluka/org
22. B. Singh et al. (PANDA Collaboration), Technical Design Report for the PANDA Forward Spectrometer Calorimeter, April 2017, arXiv:1704.02713
23. R. Moore et al., Nucl Instrum Meth B 119 (1996) 149; K. Kirsebom et al., Nucl Instrum Meth B 135 (1998) 143
24. V. Fanti et al. (NA48 Collaboration), Nucl Instrum Meth A 574 (2007) 433
25. B. Angelucci et al., J Instrum 1409 (2014) C00155
26. D. Soldi et al., Nucl Instrum Meth A 845 (2017) 623
27. http://www.physicsmasterclasses.org/index.php?cat=country&page=it
28. http://edu.lnf.infn.it/openlabs2018/

B.2

1. PI’s Curriculum Vitae

Curriculum Vitae: Matthew David Moulson

Date and place of birth: 26 July 1969, Bellefonte PA, USA

Education:
- 6/1987: Diploma, Wayzata High School, Plymouth MN, USA
- 5/1991: B.A. in Physics, magna cum laude, Columbia University, New York, USA
- 5/1994: M.A. in Physics, Columbia University
- 10/1996: M.Phil. in Physics, Columbia University
- 2/2001: Ph.D. in Physics, Columbia University. Thesis: Production of the phi meson in Si+Au collisions at the BNL AGS.

Professional history:
- 1/1989–6/1991 Undergraduate Research Assistant, Liquid Xenon Gamma-Ray Astronomy Group, Columbia Astrophysics Laboratory, Columbia University

• 7/1991–2/1992 Project Associate (unpaid), RD-4 Collaboration, CERN
• 9/1992–5/1993 Faculty Fellow, Department of Physics, Columbia University
• 6/1993–10/1998 Graduate Research Assistant, Heavy Ion Physics Group, Nevis Laboratories, Columbia University, Irvington NY, USA
• 11/1998–11/2000 INFN Foreign Post-Doctoral Fellow, KLOE Collaboration, INFN Laboratori Nazionali di Frascati
• 3/2001–12/2004 Research scientist, level III (term contract, Art. 23), KLOE Collaboration, INFN Laboratori Nazionali di Frascati
• 12/2004–present Research scientist, level III (permanent staff), INFN Laboratori Nazionali di Frascati
• 9/2014–11/2015 Scientific Associate, NA62 Collaboration, CERN

Significant responsibilities:
• Offline convener, KLOE experiment, 2001-2008
• Scientific secretary, Scientific Committee of the Laboratori Nazionali di Frascati, 2005-2008
• Construction coordinator for the Large-Angle Veto (LAV) system, NA62 Experiment, 2018-2014
• Run coordinator, NA62 Experiment, 2014-2017
• Coordinator, KLEVER Project, 2014-present
• Principal author of the chapter of the INFN CSN1 White Paper on the future of kaon physics, 2015
• Representative of the KLEVER Project in the CERN Physics Beyond Colliders future-study initiative, 2016-present

Research experience:

Columbia Astrophysics Laboratory (1/1989–5/1991): Contributed to the development of a liquid-xenon time-projection chamber (TPC) for gamma-ray astronomy, helping to design and construct various prototype instruments, as well as to study the ionization, scintillation, and electron-transport properties of liquid xenon.

CERN RD-4 (7/1991–2/1992): As part of an R&D project on calorimetry in detectors for the Large Hadron Collider, conducted systematic studies of ionization yields, electron drift velocities, and electron lifetimes in doped liquid argon.

Brookhaven Experiments 859, 866, and 917 (6/1993–4/2004): Centrally involved in detector construction, run planning, data taking, reconstruction, and physics analysis for a series of fixed-target survey experiments in heavy-ion physics performed using a magnetic-dipole spectrometer at the Brookhaven AGS. Performed a comprehensive analysis of data on phi-meson production in Si Au collisions from E859.

Brookhaven Experiment 910 (1/1994–2/1995): Played a key role in the planning and proposal for the experiment, which used a large-acceptance TPC to make exclusive measurements in p+A collisions. Developed strategies for searches for H0 dibaryon decays.

KLOE at DANE (11/1998–12/2009): Made significant contributions in the areas of detector calibration, run coordination, and data taking, and particularly, in the development of the offline analysis environment (data reconstruction and Monte Carlo simulation) and in physics analysis:
• As convener of offline computing group from 2001 to 2008, was responsible for planning and execution of all data processing and Monte Carlo (MC) event production, as well as the development of reconstruction and simulation software for the experiment.
• Contributed significantly to the analysis of KLOE data, with primary focus on the development of techniques to measure the BRs of KS and KL decays to final states with charged particles. Developed a library of tools for event selection and measurement of reconstruction efficiencies and resolutions that was subsequently used in many KLOE analyses.
• Performed the first KLOE measurement of BR(KL -> pi+ pi-) using a double-tag method. The analysis framework was quickly extended to include other KL final states (Ke3, Kmu3, Kpi3), and ultimately, to allow measurement of the KL lifetime, leading to the KLOE determination of the CKM matrix element Vus.
• Served as internal referee for the KLOE hadronic cross section analysis via the measurement of e+ e- -> pi+ pi- gamma from mid-2002 through the publication of the final result in early 2009.
• Served as internal referee for the KLOE search for the rare CP-violating decay KS -> 3pi0.

FlaviaNet Working Group on Kaon Decays (11/2006–11/2010): Founding member of a group operated with support as a European Research Network to unite theorists and experimentalists to combine world data on kaon decays to obtain sensitive tests of the Standard Model.
• Served as representative of the KLOE experiment within the group.
• Led the analysis of data on leptonic and semileptonic kaon decays. Performed the combination analysis of world data on kaon decays used to obtain the group's published value for Vus, which is widely cited as the current reference value.
• Since the end of FP6 funding, has continued independently to periodically update the combination analysis of data on Vus, including most recently at the CKM 2016 conference.
• Served as open reviewer for the 2018 edition of the Particle Data Group mini-review "Vud, Vus, the Cabibbo angle, and CKM unitarity".

NA62 at the CERN SPS (6/2005–present): Centrally involved in all aspects of NA62, a fixed-target experiment at the CERN SPS to precisely measure BR(K+ -> pi+ nu anti-nu), with

particular emphasis on the design, construction, and operation of the experiment's large-angle photon veto (LAV) system:
• Served as run coordinator during data collection with the NA48 apparatus in 2007 for the measurement of BR(K+ -> e+ nu)/BR(K+ -> mu+ nu).
• Participated in early studies of detector technologies intended for use in the LAV system. Helped to design and construct a lead/scintillating-fiber photon veto detector prototype at Frascati and to measure and compare its performance to those of a lead/scintillating-tile prototype and an assembly of lead-glass blocks in beam tests at the Frascati Beam Test Facility, developing techniques to measure electron detection inefficiencies as low as 1e-5.
• Helped to develop the final design of the LAV system, based on the reuse of the lead-glass modules from the OPAL electromagnetic barrel calorimeter.
• Coordinated the construction of the LAV detectors at Frascati throughout the entire period of activity, from fall 2008 through summer 2014. Largely responsible for the on-time delivery of the 12 detectors for use in NA62. Coordinated much of the installation of the LAV detectors.
• Contributed to the development and testing of the LAV front-end electronics.
• Assumed primary responsibility for the commissioning of the LAV system during the first NA62 run (September–December 2014). Had primary responsibility for LAV maintenance and operations, as well as start-of run setup, for annual NA62 runs from 2015 to 2017.
• Contributed to studies of the performance of the LAV detectors with reconstructed data and to the development of tools to measure and monitor the efficiency of the LAV stations.
• Served as NA62 run coordinator during runs in 2015, 2016, and 2017.
• Played a key role in early efforts to develop a vision for the evolution of the experimental program after the end of LHC Run 2.

KLEVER (2/2012–present): Coordinator of a project to design, construct, and carry out an experiment at the CERN SPS to measure BR(KL -> pi0 nu anti-nu) using a high-energy neutral secondary beam during LHC Run 4:
• Made key contributions to the preparation of the PRIN grant proposal (2010-2011 call) funding early studies for the project. During the period of funding (February 2013–February 2016), served as the effective coordinator of scientific work on the project. Developed the early simulations and established the general feasibility of the experiment. Was principal author and editor of the report summarizing the conclusions of the design study.
• As part of a broader effort to identify opportunities for future rare kaon decay experiments at CERN and to advocate to preserve options for such experiments in the design of any future high-intensity fixed-target facility, represented the project in discussions in the context of INFN's What Next meetings (flavor physics working group) and the CERN Future Circular Collider Study (working group on physics with the FCC-hh injectors).
• Currently represent the KLEVER Project in the CERN Physics Beyond Colliders future-study initiative in preparation for the 2020 update of the European Strategy on Particle Physics.
• Currently coordinating the writing of the Letter of Intent for the KLEVER Experiment to the CERN SPS/PS Experiments Committee (SPSC).
• Principal investigator for a scheduled test in the H2 beamline at CERN in August 2018 to measure pair production in metallic crystals, to obtain data for the design of the KLEVER beam-photon converter and calorimeter. Secured beam time and funding for the test from CERN and INFN.

Publications:
• Author or co-author of 208 citable papers in the INSPIRE-HEP database of high-energy physics literature (h-index = 47)

Presentations:
• Contributions at 28 international conferences and workshops
• Seminars at Columbia University, Brookhaven, University of Washington, IFAE Barcelona, and Saclay

Conference organization and professional service:
• Service as session convener or organizer at 6 international conferences, including most recently as organizer of the session on rare B, D, and K decays at CKM2016 (Mumbai, December 2016)

Professional associations and qualifications:
• 1/2014: National qualification for the role of associate professor (Abilitazione Scientifica Nazionale 2012, 02/A1, II fascia)
• 6/1995-present: Member of the American Physical Society

1.a National and international grants (as Principal Investigator)

• Principal investigator, KLEVER-AXIAL beam test of pair production in crystals, 8-15 August 2018: 18.5 kE funds awarded by INFN Commissione Nazionale Scientifica I, 1 week of beam time in SPS H2 beam line awarded by CERN.
• Scientist-in-charge, Italy node, European Commission Seventh Framework Program, 2013 Marie Curie Actions/Initial Training Networks proposal "EUROFLAVOUR", FP7-PEOPLE-2013-ITN proposal 607661, 48 months: Evaluation: 90.20%, threshold 70%.
• Participant and co-author, PRIN proposal "KLEVER", 2010Z5PKWZ (2010-2011 call), 36 months, 771 kE awarded.
• Participant and co-author, PRIN proposal "NA62", 2008TMHBWJ (2008 call), 24 months, 184 kE awarded.

1.b National and international acknowledgments

• Served as open reviewer for the 2018 edition of the Particle Data Group mini-review "Vud, Vus, the Cabibbo angle, and CKM unitarity", Oct 2017.
• Co-convener and session organizer: Rare B, D, and K decays, Ninth International Workshop on the CKM Unitarity Triangle (CKM 2016), Nov 2016.
• KLEVER project selected for inclusion in CERN Physics Beyond Colliders study group, Sep 2016. Member of Physics Beyond Colliders Conventional Beams working group, Sep 2016-present.
• Selected as CERN Scientific Associate, May 2014. Served appointment in NA62 Collaboration, Sep 2014-Nov 2015.
• National qualification for the role of associate professor, Jan 2014 (Abilitazione Scientifica Nazionale 2012, 02/A1, II fascia).
• Organizer, NA62 Physics Handbook Workshop, CERN, Dec 2009.
• Session Chair: CP and T violation, 2009 Kaon International Conference, Tsukuba, Japan, Jun 2009.
• Convener and session organizer: Flavor physics, International Workshop on e+e- Collisions from Phi to Psi (PHIPSI '08), Frascati, Italy, Apr 2008.
• Scientific secretary, Scientific Committee of the Laboratori Nazionali di Frascati, Jul 2005-Dec 2008.
• Selected as INFN Foreign Post-Doctoral Fellow, Feb 1998. Served appointment in KLOE Collaboration, INFN Laboratori Nazionali di Frascati, Nov 1998-Oct 2000.
• Member of the American Physical Society, Jun 1995-present.
• Elected to membership of Phi Beta Kappa academic honor society upon graduation magna cum laude with B.A. in Physics, Columbia University, New York, USA, May 1991.

2. Principal scientific publications of PI

1. NA62 Collaboration (Eduardo Cortina Gil, Elisa Minucci, Sergey Padolski, Plamen Petrov (Louvain U.), Bob Velghe (Louvain U. & TRIUMF), Venelin Kozhuharov (Sofiya U. & Frascati), Leandar Litov (Sofiya U.), Georgi Georgiev (Sofiya U. & Frascati), Douglas Bryman, Ji Fu (British Columbia U.), Toshio Numao (TRIUMF), Tomas Husek, Karol Kampf, Michal Zamkovsky (Charles U.), Riccardo Aliberti, Gia Khoriauli, Jonas Kunze, David Lomidze, Radoslav Marchevski, Letizia Peruzzo...(2018). Search for heavy neutral lepton production in K+ decays. PHYSICS LETTERS. SECTION B, vol. 778, p. 137-145, ISSN: 0370-2693, doi: https://doi.org/10.1016/j.physletb.2018.01.031 - **Articolo in rivista**

2. Gil EC, Albarran EM, Minucci E, Nussle G, Padolski S, Petrov P, Szilasi N, Velghe B, Georgiev G, Kozhuharov V, Litov L, Husek T, Kampf K, Zamkovsky M, Aliberti R, Geib KH, Khoriauli G, Kleinknecht K, Kunze J, Lomidze D...(2017). The beam and detector of the NA62 experiment at CERN. JOURNAL OF INSTRUMENTATION, vol. 12, ISSN: 1748-0221, doi: 10.1088/1748-0221/12/05/P05025 - **Articolo in rivista**

3. Moulson M, for the NA62-KLEVER project (2017). Prospects for an experiment to measure BR(K-L(0) -> pi(0)nu(nu)over-bar) at the CERN SPS. JOURNAL OF PHYSICS. CONFERENCE SERIES, vol. 800, ISSN: 1742-6588, doi: 10.1088/1742-6596/800/1/012037 - **Contributo in Atti di convegno**

4. Moulson M (2014). Experimental determination of Vus from kaon decays. In: Proceedings of 8th International Workshop on the CKM Unitarity Triangle (CKM 2014). - **Contributo in Atti di convegno**

5. Lazzeroni C, Romano A, Ceccucci A, Danielsson H, Falaleev V, Gatignon L, Lopez SG, Hallgren B, Maier A, Peters A, Piccini M, Riedler P, Frabetti PL, Gersabeck E, Kekelidze V, Madigozhin D, Misheva M, Molokanova N, Movchan S, Potrebenikov Y...(2013). Precision measurement of the ratio of the charged kaon leptonic decay rates. PHYSICS LETTERS. SECTION B, vol. 719, p. 326-336, ISSN: 0370-2693, doi: 10.1016/j.physletb.2013.01.037 - **Articolo in rivista**

6. Ambrosino F, Angelucci B, Antonelli A, Costantini F, D'Agostini G, Di Filippo D, Fantechi R, Gallorini S, Giudici S, Leonardi E, Mannelli I, Massarotti P, Moulson M, Napolitano M, Palladino V, Rafaelli F, Raggi M, Saracino G, Serra M, Spadaro T...(2012). The large-angle photon veto system for the NA62 experiment at the CERN SPS. JOURNAL OF PHYSICS. CONFERENCE SERIES, vol. 404, ISSN: 1742-6588, doi: 10.1088/1742-6596/404/1/012022 - **Contributo in Atti di convegno**

7. Antonelli A, Corradi G, Moulson M, Paglia C, Raggi M, Spadaro T, Tagnani D, Ambrosino F, Di Filippo D, Massarotti P, Napolitano M, Saracino G, Angelucci B, Costantini F, Fantechi R, Gallorini S, Giudici S, Mannelli I, Raffaelli F, Venditti S...(2012). The NA62 LAV front-end electronics. JOURNAL OF INSTRUMENTATION, vol. 7, ISSN: 1748-0221, doi: 10.1088/1748-0221/7/01/C01097 - **Articolo in rivista**

8. Lazzeroni C., Romano A., Ceccucci A., Danielsson H., Falaleev V., Gatignon L., Lopez S.G., Hallgren B., Maier A., Peters A., Piccini M., Riedler P., Dyulendarova M., Frabetti P.L., Kekelidze V., Madigozhin D., Marinova E., Molokanova N., Movchan S., Potrebenikov Y....(2011). Test of lepton flavor universality in K -> l nu decays. PHYSICS LETTERS. SECTION B, vol. 698, p. 105-114, ISSN: 0370-2693 - **Articolo in rivista**

9. Ambrosino F, Antonelli A, Antonelli M, Archilli F, Bencivenni G, Bini C, Bloise C, Bocchetta S, Bossi F, Branchini P, Capon G, Capussela T, Ceradini F, Ciambrone P, De Angelis A, De Lucia E, De Maria M, De Santis A, De Simone P, De Zorzi G...(2011). Precision measurement of the K-S meson lifetime with the KLOE detector. THE

EUROPEAN PHYSICAL JOURNAL. C, PARTICLES AND FIELDS, vol. 71, ISSN: 1434-6044, doi: 10.1140/epjc/s10052-011-1604-7 - **Articolo in rivista**

10. Antonelli M, Cirigliano V, Isidori G, Mescia F, Moulson M, Neufeld H, Passemar E, Palutan M, Sciascia B, Sozzi M, Wanke R, Yushchenko OP (2010). An evaluation of broken vertical bar V-us broken vertical bar and precise tests of the Standard Model from world data on leptonic and semileptonic kaon decays. THE EUROPEAN PHYSICAL JOURNAL. C, PARTICLES AND FIELDS, vol. 69, p. 399-424, ISSN: 1434-6044, doi: 10.1140/epjc/s10052-010-1406-3 - **Articolo in rivista**

11. Antonelli M, Asner DM, Bauer D, Becher T, Beneke M, Bevan AJ, Blanke M, Bloise C, Bona M, Bondar A, Bozzi C, Brod J, Buras AJ, Cabibbo N, Carbone A, Cavoto G, Cirigliano V, Ciuchini M, Coleman JP, Cronin-Hennessy DP...(2010). Flavor physics in the quark sector. PHYSICS REPORTS, vol. 494, p. 197-414, ISSN: 0370-1573, doi: 10.1016/j.physrep.2010.05.003 - **Recensione in rivista**

12. Ambrosino F, Antonelli A, Antonelli M, Archilli F, Beltrame P, Bencivenni G, Bini C, Bloise C, Bocchetta S, Bossi F, Branchini P, Campana P, Capon G, Capussela T, Ceradini F, Ciambrone P, De Lucia E, De Santis A, De Simone P, De Zorzi G...(2010). Measurement of the eta -> 3 pi(0) slope parameter alpha with the KLOE detector. PHYSICS LETTERS. SECTION B, vol. 694, p. 16-21, ISSN: 0370-2693, doi: 10.1016/j.physletb.2010.09.022 - **Articolo in rivista**

13. Ambrosino F, Antonelli A, Antonelli M, Archilli F, Bacci C, Beltrame P, Bencivenni G, Bertolucci S, Bini C, Bloise C, Bocchetta S, Bossi F, Branchini P, Campana P, Capon G, Capussela T, Ceradini F, Chi S, Chiefari G, Ciambrone P...(2009). Measurement of sigma(e(+)e(-) -> pi(+)pi(-)gamma(gamma)) and the dipion contribution to the muon anomaly with the KLOE detector. PHYSICS LETTERS. SECTION B, vol. 670, p. 285-291, ISSN: 0370-2693, doi: 10.1016/j.physletb.2008.10.060 - **Articolo in rivista**

14. Ambrosino F, Antonelli A, Antonelli M, Archilli F, Beltrame P, Bencivenni G, Bini C, Bloise C, Bocchetta S, Bossi F, Branchini P, Capon G, Capriotti D, Capussela T, Ceradini F, Ciambrone P, De Lucia E, De Santis A, De Simone P, De Zorzi G...(2009). Precise measurement of Gamma(K -> e nu(gamma))/Gamma(K -> mu nu(gamma)) and study of K -> e nu gamma. THE EUROPEAN PHYSICAL JOURNAL. C, PARTICLES AND FIELDS, vol. 64, p. 627-636, ISSN: 1434-6044, doi: 10.1140/epjc/s10052-009-1177-x - **Articolo in rivista**

15. Ambrosino F, Antonelli A, Antonelli M, Archilli F, Beltrame P, Bencivenni G, Bertolucci S, Bini C, Bloise C, Bocchetta S, Bossi F, Branchini P, Capon G, Capussela T, Ceradini F, Ciambrone P, Crucianelli F, De Lucia E, De Santis A, De Simone P...(2009). Measurement of the branching ratio and search for a CP violating asymmetry in the eta -> pi(+)pi(-)e(+)e(-)(gamma) decay at KLOE. PHYSICS LETTERS. SECTION B, vol. 675, p. 283-288, ISSN: 0370-2693, doi: 10.1016/j.physletb.2009.04.013 - **Articolo in rivista**

16. Ambrosino F, Antonelli A, Antonelli M, Archilli F, Beltrame P, Bencivenni G, Bertolucci S, Bini C, Bloise C, Bocchetta S, Bossi F, Branchini P, Capon G, Capussela T, Ceradini F, Ciambrone P, De Lucia E, De Santis A, De Simone P, De Zorzi G...(2009). A global fit to determine the pseudoscalar mixing angle and the gluonium content of the eta ' meson. JOURNAL OF HIGH ENERGY PHYSICS, ISSN: 1126-6708, doi: 10.1088/1126-6708/2009/07/105 - **Articolo in rivista**

17. M. ANTONELLI, E. DE LUCIA, P. DE SIMONE, P. FRANZINI, S. GLAZOV, E. GOUDZOVSKI, MOULSON M., V. OBRAZTSOV, M. PALUTAN, M. PICCINI, G. RUGGIERO, B. SCIASCIA, T. SPADARO, M. VELTRI, R. WANKE, A. WINHART, O. YUSHCHENKO, M. SOZZI, J. BIJNENS, V. CIRIGLIANO...(2008). Precision tests of the Standard Model with leptonic and semileptonic kaon decays. - **Altro**

18. Ambrosino F, Antonelli A, Antonelli M, Archilli F, Bacci C, Beltrame P, Bencivenni G, Bertolucci S, Bini C, Bloise C, Bocchetta S, Bossi F, Branchini P, Caloi R, Campana P, Capon G, Capussela T, Ceradini F, Cesario F, Chi S...(2008). vertical bar V-us vertical bar and lepton universality from kaon decays with the KLOE detector. JOURNAL OF HIGH ENERGY PHYSICS, ISSN: 1126-6708, doi: 10.1088/1126-6708/2008/04/059 - **Articolo in rivista**

19. Ambrosino F, Antonelli A, Antonelli M, Archilli F, Bacci C, Beltrame P, Bencivenni G, Bertolucci S, Bini C, Bloise C, Bocchetta S, Bossi F, Branchini P, Caloi R, Campana P, Capon G, Capussela T, Ceradini F, Cesario F, Chi S...(2008). Determination eta -> pi(+) pi(-) pi(0) Dlitz plot slopes and asymmetries with the KLOE detector. JOURNAL OF HIGH ENERGY PHYSICS, ISSN: 1126-6708, doi: 10.1088/1126-6708/2008/05/006 - **Articolo in rivista**

20. Ambrosino F, Antonelli A, Antonelli M, Archilli F, Beltrame P, Bencivenni G, Bertolucci S, Bini C, Bloise C, Bocchetta S, Bossi F, Branchini R, Campana P, Capon G, Capussela T, Ceradini F, Ciambrone P, Crucianelli F, De Lucia E, De Santis A...(2008). Study of the process e(+)e(-) -> omega pi(0) in the phi-meson mass region with the KLOE detector. PHYSICS LETTERS. SECTION B, vol. 669, p. 223-228, ISSN: 0370-2693, doi: 10.1016/j.physletb.2008.09.056 - **Articolo in rivista**

3. Hindex of PI (only for the scientific fields in which the use of the H-index is usually adopted)

H-Index	Source
47	INSPIRE-HEP database (SLAC)

4. Associated investigators' Curriculum Vitae

1. PETRUCCI Ferruccio Carlo

PETRUCCI FERRUCCIO CARLO CURRICULUM

Ferruccio Carlo Petrucci graduated in Physics in 1976 from the University of Pisa with a thesis in Laser Spectroscopy. Since 1983, the year in which entered as a researcher at the University of Ferrara, he has participated in various experiments in High Energy Physics at national and international laboratories, dedicated to study various aspects of fundamental physical systems such as the proton, the neutron, bound states of charm quarks, K mesons.

His experimental work in this field focused mainly on the use of detectors of charged and neutral particles, from design to testing of prototypes, construction, data analysis and hardware management during the data taking. Among the achievements the limited streamer tubes and the multiwire proportional chamber for the experiment PS170 (APPLE) at CERN, the inner drift chamber detector for E760 (Fermilab), the streamer tubes and scintillators in the experiment FENICE on ADONE, at the Frascati Laboratories of INFN.
At the same time he has always been involved in research and technological development, participating in experiments promoted by the Commission for Application Technologies of INFN and dealing with electron cooling of ion beams, laser diagnostics of electron beams, imaging of art paintings with monochromatic X-rays.
In two periods, for a total of 16 years, he has been coordinator of the research in Application Technologies, for the Ferrara unit of INFN. In the Scientific Commission of the Institute he represented the research groups in Medical Physics, Accelerator Technologies, Applied Matter Physics and Archaeometry for funding and development.

In the NA48 experiment at CERN, dedicated to the study of CP violation in the decays of K-mesons, he has collaborated on several technological aspects. First of all the optoelectronic system of quality control for the electrodes of the liquid krypton electromagnetic calorimeter and the design and management of the system of purification of the helium gas. Since 2000 he has directed the project of upgrade for the electronic readout of the wire chambers tracking system. Since 2002 it has allowed the experiment to acquire data at high rate, ending the measurement of the ratio epsilon'/ epsilon for CP violation and promoting new objectives: the study of rare decays of neutral K (NA48/1, 2000-2002) and asymmetries in the decays of charged kaons (NA48/2, 2003-2005).
He is currently responsible for the Ferrara research group in the international collaboration NA62, which aims the observation of the very rare decay of the charged K meson in pion, neutrino and antineutrino. The research grpoup has designed and realized the electronic readout of a silicon pixel beam detector (Gigatracker), capable of measuring the position and the transit time of the particles with a time resolution better than 200ps, supporting a rate at the GHz level. The experiment is successfully acquiring data on beam since 2015.
Since 2013 to 2016 he was local coordinator of the research project PRIN 2010-11, funded to study the feasibility of the experiment KLEVER, devoted to the measurement of the branching ratio of the ultra-rare decay of the neutral K meson in pion, neutrino and antineutrino. The result of this work is the basis of a possible future integration of the goal of NA62, studying the decay of neutral – instead of charged - K meson. And it is in this fashion that he is now participating to the activities to design the future KLEVER setup.

Physics applied to Cultural Heritage is a second area of activity, for which he held research funds from MIUR and INFN. In particular, his work in this area has focused on developing innovative technologies for image diagnostic of works of art.
Among these are the image spectroscopy for the conservation of works of Contemporary Art, the infrared reflectography in extended spectral range to observe the preparatory drawing in old paintings, the differential K-edge radiography to reconstruct the distribution of a chemical element in a pictorial layer.
More recently, dealing with issues of authentication of contemporary works, he proposed and successfully tested, in collaboration with the Laboratory for Cultural Heritage (LABEC) in Florence, the dating of paintings from the second half of the twentieth century with the radiocarbon method.
The rise of interest in physical methods applied to Cultural Heritage has recently created a network of activities – called INFN-CHNet - in units of INFN distributed throughout Italy and devoted to the nuclear research and applications. He is actually involved in this network, joining with other groups of scientific investigations in Italy and with the european infrastructure E-RIHS.

Concerning teaching, from 1995 to 1997 he served as coordinator for the Professional Training Course "Restoration of Works of Modern and Contemporary Art", organized in collaboration with the University of Ferrara.
He has been in charge of Experimental Physics for Cultural Heritage in the Degree Course in "Science and Technology for Cultural Heritage" during its period of activation in Ferrara, since 2001 until 2014, where he promoted and coordinated the curriculum of Diagnostics and Conservation of Works of Art.
He proposed and coordinated the Master Degree in "Conservation and Diagnostics of Works of Modern and Contemporary Art", which has been activated at the University of Ferrara since 2004/2005 up to 2009/2010.
In the Master Degree of "Science in Conservation and Diagnostics for Cultural Heritage", activated in collaboration by the Universities of Ferrara and Modena-Reggio Emilia since 2010

up to 2012, he was in charge of the integrated course of Physics Diagnostics for Cultural Heritage.
From 2003/2004 up to now he carries the teaching of Laboratory of Archaeometry, offered now for the two-year Master degree course in Physics, where students perform image diagnostics on paintings.
He is currently Associate Professor at the University of Ferrara, in charge of teaching Physics for the undergraduate Course in Computer Science.

2. MASSAROTTI Paolo
PERSONAL DATA
• Date of birth: 16 Feb 81
• Address: Department of Physics “Ettore Pancini”, Università Federico II Naples Italy
• Email: massarotti@na.infn.it
CAREER SUMMARY
• Researcher, art. 24 lett. b) 240/2010, at the University of Naples Federico II, Oct 15 - present (tenure track for associate professor position);
• Researcher, art. 24 lett. a) 240/2010, at the University of Naples Federico II, Dec 13 - Sep 15 ;
• Post-doctoral research fellow at the University of Naples Federico II, Sep 12 - Dec 13;
• Researcher, Level III (art. 23) at INFN Naples, Aug 11 – Jul 12;
• Post-doctoral research fellow at INFN Naples, Jul 09 – Jun 11;
• Post-doctoral research fellow at the University of Naples Federico II, Feb 08 – Jan 09;
• Graduate research fellow at the University of Naples Federico II, November 04 – December 07;
EDUCATIONAL AND ACADEMIC QUALIFICATION
• Associate Professor Qualification in Fundamental Interaction Experimental Physics;
• Teaching Qualification in Maths and Physics, Jul 13;
• Doctor of Philosophy, University of Naples Federico II, Dec 07;
• Laurea in Physics, magna cum laude, University of Naples Federico II, Jul 04;

RESPONSIBILITIES IN EXPERIMENTS : :
• (04-10) Leading figure of KLOE Kaon analysis group; central role in KLOE data analysis developing software tools for the whole KLOE collaboration.
• (14 - present) CHANTI detector expert for the NA62 Collaboration at CERN.
• (09-present) Development and construction of the CHANTI detector in NA62. Leading organizational role in the Front-End electronics development.
• (11-13) Co-Responsible for construction and installation of the LAV detectors in NA62 .
• (16 - present) Leading role in the development of the Cosmic Ray Stand at the Frascati laboratories of the INFN (LNF) for the validation of the MicroMegas Chambers for the New Small Wheels (NSW), composing the innermost station of the ATLAS muon forward tracking system.
PM scientific activity is focussed on both data analysis and detector design and realization since year 2004 .
He has contributed to the KLOE, NA62 and ATLAS experiments.
NA62
Since Feb 08, Dr Massarotti (PM) has been a leading member of the NA62 Collaboration. NA62 is an experiment based at the CERN North Area, the goal of which is to measure the branching ratio (BR) of the ultra-rare decay K+ to pi+nu nubar. This flavour-changing neutral current weak decay is forbidden at tree level in the SM. Its BR is expected to be on the order of ~8*10-11 and the goal of NA62 is to measure it with 10% uncertainty. Comparison of this measurement with the very precise SM prediction would confirm or exclude certain models for new physics.
PM played a key role in the design, development and simulation of a charged-particle detector system for NA62 to veto upstream inelastic interactions of the kaon beam (CHarged ANTIcounter). Six square stations make the detector with a rectangular hole for the beam passage. The detector covers a broad angular region, complementary to the Large-Angle photon Vetoes (LAVs) one, is characterized by inefficiency of the order of few per mille for charged particle and a time resolution of the order of 1 ns.
The maximum expected rate in input to the Front End Electronics (FEE) is, for the inner bars, of the order of about 1 MHz per bar. PM participated actively to the data acquisition and has been CHANTI detector expert. He also presented, at “IEEE” conference and at the 12th Pisa Meeting on Advanced Detectors in 2012, the CHANTI performances, which are in perfect agreement with the expectation.
PM had a leading role in the construction of the LAVs. The LAVs are high efficiency photon detectors aimed at vetoing events with a 0 in the final state, that reuse the lead-glass blocks from the OPAL electromagnetic calorimeter in a new configuration. Monte Carlo studies have shown that these detectors must have inefficiencies below about 104 over a large energy range. A first prototype was built in spring 09 and tested with muon and electron beams in the autumn of the same year at CERN, on the NA48 beam line. PM played a central role in these tests. From Nov 09 to May 10, PM supervised the commissioning of the OPAL lead glass modules at CERN. PM also played a central role in a test of a second prototype at CERN in summer 10. From Aug 11 until the end of 13, PM has been the LAV detectors construction co-responsible at LNF and the co-responsible of the LAV installation in the NA62 beamline at CERN.
During the first phase of the NA62 experiment, a high-statistics sample of kaon decays was collected in order to measure the ratio Rk = BR(K+ to e+ nu)/BR(K+ to mu+ nu). The SM prediction for RK is extremely precise. In 11, the results were published in Physics Letters B. PM played an important role in the study of various systematic effects as cluster shaping and background contamination that were instrumental to achieve the record precision obtained.

ATLAS
Since July 16 PM has been a member of the Atlas collaboration. The ATLAS detector is one of the two general purpose high luminosity experiments at LHC at CERN. The muon spectrometer encircles the rest of the ATLAS detector subsystems defining the ATLAS overall dimensions. The innermost muon station called Small Wheel (SW) has to be change for Run3 (2021) therefore the collaboration has decided to replace the SW with a New SW system combining smallstrip Thin Gap Chambers & resistive MicroMegas (MM) detectors in order to maintain the excellent performance of the muon system beyond Run2. The NSW requires fully efficient high rate capable MM chambers with a single plane spatial resolution better than 100 um independent of the track incidence angle and the magnetic field (B < 0.3 T). MM trapezoidal detector modules, with areas between 2 and 3 m2 are composed by 4 read-out layers, two for the reconstruction of the precision coordinate and two with stereo reading (±1.5 degrees) for the reconstruction of also the second coordinate. MM chambers are designed to provide efficiency better than 95% per single plane at rate capability up to 15 kHz/cm2, in presence of magnetic fields up to 0.3 T.
Two prototypes have been constructed at LNF (SM1 Module0 and SM1 Module0.5) and PM has a leading role in the development of the Cosmic Ray Stand at LNF and in the data analysis for the validation of the chambers.
KLOE
From Jan 04 to Dec 10, PM was a leading member of KLOE collaboration. KLOE is an experiment for the study of kaon physics based at LNF. During his studies for his Laurea and doctorate degrees, PM made substantial contributions in the following areas:
• KLOE data taking
• The precise measurement of the charged kaon lifetime (tauK)
• Determination of the CKM matrix element |Vus|
• The measurement of the BRs for the decays K+ to mu+ nu, K+ to pi0 l+ nu, and K+ to pi+ pi0 analysis; in particular, through studies of background levels and detection efficiencies
• The development of analysis tools used by the larger KLOE collaboration
For the measurement of tauK, PM developed two data analysis techniques to obtain the proper decay time distribution of the charged kaon: one from the measurement of its decay length as observed in the KLOE drift chamber and one from the measurement of its time of flight, obtained from the arrival times of its neutral decay products (pi0) in the KLOE electromagnetic calorimeter. The measurement of tauK is of fundamental importance for the determination of |Vus|. The results for both tauK and |Vus| were published in Journal of High Energy Physics. PM played a central role in the measurements of the branching ratios for K+ to mu+ nu, K+ to pi0 l+ nu and K+ to pi+ pi0, developing techniques for the reconstruction efficiencies estimation and for the background evaluation. These measurements were published in Physics Letters B and the Journal of High Energy Physics. For his substantial expertise acquired in the studies of the kaon physics since 08 PM is a collaborator of Particle Data Book (PDG).
From the expertise acquired during the collaboration with the Flavianet group, for the determination of CKM matrix element Vus, PM plays a leading role in the studies of correlation of the different results on flavour physics and of the constraints on new physics beyond the Standard Model (SM).
INTERNATIONAL CONFERENCE TALKS:
• PHIPSI13, Rome, Italy, Sep 13: “Searches for new physics at NA62”;
• FPCP13, Buzios, Brasil May 13: “Result on rare decays from NA62”;
• IEEE Anaheim, CA, USA Nov 12. Poster session: “The CHarged ANTIcounter for the NA62 Experiment at CERN”
• 12th Pisa Meeting on Advanced Detectors, Isola d'Elba, Italy, May 12. Poster session: “The large-angle photon veto system for the NA62 experiment at CERN” and “The CHarged ANTIcounter for the NA62 Experiment at CERN”
• Lake Louise Winter Institute, Alberta, Feb 11: “Searches for new physics at NA62”;
• Third Workshop on Theory, Phenomenology and Experiments in Heavy Flavour Physics, July 2010 Capri: “Searches for new physics at NA62”;
• FPCP10, Turin, review talk: “|Vus| and |Vud|”;
• International Conference on Flavour Physics 09, Hanoi: “Search of New Physics with kaon decays at NA62”;
• HQL08, Melbourne, review talk: “|Vus| determination from kaon decays”;
• Kaon07, Frascati: “KLOE measurements of the charged kaon lifetime and BR(K+ to pi+ pi 0 (g))”;
• Moriond07 , La Thuille: “Charged kaon lifetime with KLOE”;
• WIN 07, Kolkata: “KLOE results from charged kaons”.
MEMBERSHIP OF COMMITTEES
Sep 15: Flavour changing and conserving processes" (FCCP2015), Capri, Italy.
Sep 09: NA62 General Meeting 2009, Capri, Italy
Jun 08: Flavianet Physics Workshop, Capri, Italy
May 05 & Jun 07: 5th & 7th KLOE Physics Workshop, Capri, Italy
Since 2016 PM is the responsible of the International Masterclasses of Particle Physics in Naples; he is also one of the organizers of educational physics seminars at the Fondazione Idis-Citta della Scienza in Naples, one of the organisers of European Research Night in Naples and member of Scuola Politecnica e delle Scienze di Base, University of Naples Federico II, committee for FUTURO REMOTO event.

3. SOZZI Marco Stanislao
Master degree in physics in Torino 1989 - experimental high-energy physics: feasibility study of a hyperon CP decay experiment at Fermilab.
Ph.D. in physics in Torino 1993: search of the P-wave singlet state of charmonium in the E760 experiment at Fermilab.
Research in experimental particle physics, focusing on flavour physics and CP violation studies.

Design of the central trigger processor for the NA48 experiment at CERN.
Research fellow at CERN 1994-1995: design and test of the online zero-suppression system for the liquid Krypton EM calorimeter in the NA48 experiment.
Assistant professor at Scuola Normale Superiore in Pisa 1995.
Coordination of the INFN groups data analysis for the search of direct CP violation in NA48, leading to the proof of the existence of the effect after 35 years of experimental searches.
Participation in the CERN NA48/1 and NA48/2 programs since the proposal stage.
Co-convener of the analysis group for direct CP violation search in NA48/2.
Deputy spokesman of the CERN NA48/2 experiment since 2002 to its conclusion.
Paid scientific associate at CERN in 2002-2003.
INFN referee for LEP experiments, for LHC experiments computing, GRID scientific computing and COMPASS experiment.
Co-organizer and member of organizing committee of several international conferences (KAON2001, HIF2005, GPU in HEP 2014, Chiral Dynamics 2015, GPU in physics 2016).
Lecturer, organizer and scientific secretary of the international CP violation Varenna school in 2005.
Participation in the CERN NA62 ultra-rare kaon decay search experiment proposal at CERN, convener of the trigger and data aquisition working group, first proponent of use of GPUs in hard real time in low-level triggering in HEP.
Associate professor at University of Pisa since 2006.
Several teaching duties at Scuola Normale di Pisa, University of Pisa and Firenze.
Lecturing on CP violation for graduate schools at the Universities of Pisa, Firenze, Heidelberg, and at summer schools in Erice, Frascati, Zuoz.
Coordinator of the HEP program for the graduate school of physics at the University of Pisa since 2008.
Deputy head of the study council in physics in 2012.
Head of the graduate school in physics of the University of Pisa from 2012 to 2018.
Leader of the NA62 Pisa research group since 2012.
Italian representative of the NA62 experiment (60 physicists from 9 universities and INFN sections) from 2013 to 2018.
Gained eligibility to full professorship (ASN) in 2014.
Participant to funded PRIN 2006, 2008, 2010.
Author of over 130 scientific publications, over a dozen invited talks and many other conference talks.

4. MENICHETTI Ezio
Studies
Maturita' classica, Genova, 1969
Physics degree, Genova, 1974

Academic career
National grant post-degree, Genova, 1974
INFN staff, Torino, 1975-1988
Associate professor, Udine, 1988-1990
Associate professor, Torino, 1990-1999
Full professor, Torino, since 2000

Research and Teaching
INFN staff spokeman, Torino, 1979-1982
INFN Gruppo I spokeman, Torino, 1982-1984
Local spokeman, DELPHI, Torino, 1984 -1990
Local spokeman, NA48, Torino, 1992-2001
Co-Chair, Scientific Lab Committee, University of Torino, 1998-2000
Co-Chair, Physics Master program, University of Torino, 2001-2003
Chair, Physics PhD Program, University of Torino, 2002-2005
Co-Chair, Nuclear and Particle Physics Master Program, University of Torino, since 2009
Physics Representative, University Senate, Torino, 2010-2012
Member, National Committee for Academic Qualification in Nuclear and Particle Physics, 2013-2014
Corresponding Member, Accademia delle Scienze, Torino, since 2013

(a) Spectroscopy of light flavors
I started in 1975 a collaboration with a Torino group working in the field
(b)Charmonium spectroscopy

Around 1980 I started to work on an experiment at the CERN ISR (R704). The aim was the study of some charmonium states. In 1984 we completed this first generation experiment with improvements on the measurement of the masses of chi1 and chi2 and aother results. I then started to work on a second generation experiment at the Fermilab Antiproton Accumulator (E760). We collected data in several periods, mostly in 1991. This experiment has been continued with another number (E835) and is still active.
(c) Design and construction of DELPHI
I've been scientific responsible for the Torino group participating to the DELPHI experiment at LEP from 1982 to 1991.
(d) Direct CP violation: NA48
Since 1992 I'm scientific responsible for the Torino group working in NA48, aiming to detect direct CP violation in the K0L decays. The experiment has already published its first results
(e)Astroparticle Physics: AUGER
In 2000-2012 I've been a member of the AUGER Observatory project, working on the Fluorescence Detector electronics and on data analysis
(f) Ultrarare K+ Decays: NA62
Since 2012 I'm parte of the NA62 Collaboration at the CERN SPS. I'm working mostly on fast trigger systems and physics data analysis

A few indicators (Google Scholar):

All Since 2012
Cites
15357 5871
H-Index
62 34
i10-index
151 62

Skills
Main: Particle Physics, Detectors, Electronics
Others: Computing, Statistics

Interests: Energy, Outreach, Literature, Music

Teaching:
Courses taught since 1988

Electronics
Physics I
Computer Science students, Univ. di Udine, 1988-1990

Physics Lab I
Physics Experiments III
Physics students, Univ. di Torino, 1991-2001

Physics Lab II
Material Science students, Univ. di Torino, 1995-1998

Physics Foundations
Relativity Lab
Teacher Post-Degree students, 2003-2007

E&M
Electronics
Classical Mechanics
Elementary Particles I

Elementary Particles II
Relativistic Kinematics
Physics Master Program, Univ. di Torino, dal 2002

E&M
Waves, Radiation, Relativity
Material Science Bachelor Program, 2002-2010

5. Principal scientific publications of associated investigators

1. **PETRUCCI Ferruccio Carlo**

1. Batley J.R, Kalmus G., Lazzeroni C., Munday D.J., Slater M.W., Wotton S.A., Arcidiacono R., Bocquet G., Cabibbo N., Ceccucci A., Cundy D., Falaleev V., Fidecaro M., Gatignon L., Gonidec A., Kubischta W., Maier A., Massri K., Norton A., Patel M....(2017). Searches for lepton number violation and resonances in K± decays. PHYSICS LETTERS. SECTION B, vol. 769, p. 67-76, ISSN: 0370-2693, doi: 10.1016/j.physletb.2017.03.029 - **Articolo in rivista**
2. Gil E. Cortina, AlbarrÃ¡n E. MartÃ-n, Minucci E., NÃ¼ssle G., Padolski S., Petrov P., Szilasi N., Velghe B., Georgiev G., Kozhuharov V., Litov L., Husek T., Kampf K., Zamkovsky M., Aliberti R., Geib K.H., Khoriauli G., Kleinknecht K., Kunze J., Lomidze D....(2017). The beam and detector of the NA62 experiment at CERN. JOURNAL OF INSTRUMENTATION, vol. 12, p. P05025, ISSN: 1748-0221, doi: 10.1088/1748-0221/12/05/P05025 - **Articolo in rivista**
3. Lazzeroni C., Lurkin N., Romano A., The NA62 Collaboration Null, Blazek T., Ceccucci A., Danielsson H., Falaleev V., Gatignon L., Goy Lopez S., Hallgren B., Maier A., Peters A., Piccini M., Riedler P., Frabetti P.L., Gersabeck E., Kekelidze V., Madigozhin D., Misheva M....(2017). Measurement of the 0 electromagnetic transition form factor slope. PHYSICS LETTERS. SECTION B, vol. 768, p. 38-45, ISSN: 0370-2693, doi: 10.1016/j.physletb.2017.02.042 - **Articolo in rivista**
4. Lazzeroni, C., Lurkin, N., Newson, F., Romano, A., Ceccucci, A., Danielsson, H., Falaleev, V., Gatignon, L., Goy Lopez, S., Hallgren, B....(2017). Search for heavy neutrinos in K+ > mu+ nu(mu) decays. PHYSICS LETTERS. SECTION B, vol. 772, p. 712-718, ISSN: 0370-2693, doi: 10.1016/j.physletb.2017.07.055 - **Articolo in rivista**
5. Impallaria Anna, Federico Evangelisti, Ferruccio Petrucci, Flavia Tisato (2016). A new scanner for in situ digital radiography of paintings. APPLIED PHYSICS. A, MATERIALS SCIENCE & PROCESSING, vol. 122, p. 1043-1046, ISSN: 1432-0630, doi: 10.1007/s00339-016-0579-5 - **Articolo in rivista**
6. Petrucci F, Caforio L, Peccenini E, Pellicori V (2016). Radiocarbon dating of twentieth century works of art. APPLIED PHYSICS. A, MATERIALS SCIENCE & PROCESSING, vol. 122, p. 983-986, ISSN: 1432-0630, doi: 10.1007/s00339-016-0501-1 - **Articolo in rivista**
7. Batley J.R, Kalmus G., Lazzeroni C., Munday D.J., Slater M.W., Wotton S.A., Arcidiacono R., Bocquet G., Cabibbo N., Ceccucci A., Cundy D., Falaleev V., Fidecaro M., Gatignon L., Gonidec A., Kubischta W., Norton A., Maier A., Patel M., Peters A....(2015). Search for the dark photon in 0 decays. PHYSICS LETTERS. SECTION B, vol. 746, p. 178-185, ISSN: 0370-2693, doi: 10.1016/j.physletb.2015.04.068 - **Articolo in rivista**
8. Batley J.R., Kalmus G., Lazzeroni C., Munday D.J., Slater M.W., Wotton S.A., Arcidiacono R., Bocquet G., Cabibbo N., Ceccucci A., Cundy D., Falaleev V., Fidecaro M., Gatignon L., Gonidec A., Kubischta W., Norton A., Maier A., Patel M., Peters A....(2014). A new measurement of the K ± ± decay at the NA48/2 experiment. PHYSICS LETTERS. SECTION B, vol. 730, p. 141-148, ISSN: 0370-2693, doi: 10.1016/j.physletb.2014.01.038 - **Articolo in rivista**
9. C. Lazzeroni, A. Romano, A. Ceccucci, H. Danielsson, V. Falaleev, L. Gatignon, S. Goy Lopez, B. Hallgren, A. Maier, A. Peters, M. Piccini, P. Riedler, P.L. Frabetti, E. Gersabeck, V. Kekelidze, D. Madigozhin, M. Misheva, N. Molokanova, S. Movchan, Yu. Potrebenikov...(2014). Study of the K±pi± gamma gamma decay by the NA62 experiment. PHYSICS LETTERS. SECTION B, vol. 732, p. 65-74, ISSN: 0370-2693, doi: 10.1016/j.physletb.2014.03.016 - **Articolo in rivista**
10. J. R. Batley, G. Kalmus, C. Lazzeroni, D. J. Munday, M. W. Slater, S. A. Wotton, R. Arcidiacono, G. Bocquet, N. Cabibbo, A. Ceccucci, D. Cundy, V. Falaleev, M. Fidecaro, L. Gatignon, A. Gonidec, W. Kubischta, A. Norton, A. Maier, M. Patel, A. Peters...(2014)159 - **Articolo in rivista**
11. L. Caforio, M.E. Fedi, P.A. Mandò, F. Minarelli, E. Peccenini, V. Pellicori, F.C. Petrucci, P. Schwartzbaum, F. Taccetti (2014). Discovering forgeries of modern art by the 14C Bomb Peak. THE EUROPEAN PHYSICAL JOURNAL PLUS, vol. 129, p. 1-5, ISSN: 2190-5444, doi: 10.1140/epjp/i2014-14006-6 - **Articolo in rivista**
12. Rinella G. Aglieri, Ambrosino F., Angelucci B., Antonelli A., Anzivino G., Arcidiacono R., Azhinenko I., Balev S., Bendotti J., Biagioni A., Biino C., Bizzeti A., Blazek T., Blik A., Bloch-Devaux B., Bolotov V., Bonaiuto V., Britton D., Britvich G., Brook N....(2014). The kaon identification system in the NA62 experiment at CERN SPS. JOURNAL OF INSTRUMENTATION, vol. 9, p. C12048, ISSN: 1748-0221, doi: 10.1088/1748-0221/9/12/C12048 - **Articolo in rivista**
13. C. Lazzeroni, A. Romano, A. Ceccucci, H. Danielsson, V. Falaleev, L. Gatignon, S. Goy Lopez, B. Hallgren, A. Maier, A. Peters, M. Piccini, P. Riedler, P.L. Frabetti, E. Gersabeck, V. Kekelidze, D. Madigozhin, M. Misheva, N. Molokanova, S. Movchan, Yu. Potrebenikov...(2013). Precision Measurement of the Ratio of the Charged Kaon Leptonic Decay Rates. PHYSICS LETTERS. SECTION B, vol. 719, p. 326-336, ISSN: 0370-2693, doi: 10.1016/j.physletb.2013.01.037 - **Articolo in rivista**
14. J.R. Batley, G. Kalmus, C. Lazzeroni, D.J. Munday, M.W. Slater, S.A. Wotton, R. Arcidiacono, G. Bocquet, N. Cabibbo, A. Ceccucci, D. Cundy, V. Falaleev, M. Fidecaro, L. Gatignon, A. Gonidec, W. Kubischta, A. Norton, A. Maier, M. Patel, A. Peters...(2012). New measurement of the K+- to pi+ pi- e+- nu (Ke4) decay branching ratio and hadronic form factors. PHYSICS LETTERS. SECTION B, vol. 715, p. 105-115, ISSN: 0370-2693, doi: 10.1016/j.physletb.2012.07.048 - **Articolo in rivista**
15. J.R. Batley, A.J. Culling, G. Kalmus, C. Lazzeroni, D.J. Munday, M.W. Slater, S.A. Wotton, R. Arcidiacono, G. Bocquet, N. Cabibbo, A. Ceccucci, D. Cundy, V. Falaleev, M. Fidecaro, L. Gatignon, A. Gonidec, W. Kubischta, A. Norton, A. Maier, M. Patel...(2011). New measurement of the K+- >> pi+- mu+ mu- decay. PHYSICS LETTERS. SECTION B, vol. 697, p. 107-115, ISSN: 0370-2693, doi: 10.1016/j.physletb.2011.01.042 - **Articolo in rivista**
16. J.R. Batley, G. Kalmus, C. Lazzeroni, D.J. Munday, M.W. Slater, S.A. Wotton, R. Arcidiacono, G. Bocquet, N. Cabibbo, A. Ceccucci, D. Cundy, V. Falaleev, M. Fidecaro, L. Gatignon, A.

Gonidec, W. Kubischta, A. Norton, A. Maier, M. Patel, A. Peters...(2010). Precise tests of low energy QCD from Ke4 decay properties. THE EUROPEAN PHYSICAL JOURNAL. C, PARTICLES AND FIELDS, vol. 70, p. 635-657, ISSN: 1434-6044, doi: 10.1140/epjc/s10052-010-1480-6 - **Articolo in rivista**

17. M. Fiorini, V. Carassiti, A. Ceccucci, E. Cortina, A. Cotta Ramusino, G. Dellacasa, P. Jarron, J. Kaplon, A. Kluge, F. Marchetto, E. Martin, S. Martoiu, G. Mazza, M. Noy, F. Petrucci, P. Riedler, A. Rivetti, S. Tiuraniemi (2010). The NA62 Gigatracker: Detector properties and pixel read-out architectures. NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH. SECTION A, ACCELERATORS, SPECTROMETERS, DETECTORS AND ASSOCIATED EQUIPMENT, vol. 624, p. 314-316, ISSN: 0168-9002, doi: 10.1016/j.nima.2010.03.095 - **Articolo in rivista**
18. J. R. Batley, A. J. Culling, G. Kalmus, C. Lazzeroni, D. J. Munday, M. W. Slater, S. A. Wotton, R. Arcidiacono, G. Bocquet, N. Cabibbo, A. Ceccucci, D. Cundy, V. Falaleev, M. Fidecaro, L. Gatignon, A. Gonidec, W. Kubischta, A. Norton, A. Maier, M. Patel...(2009). Determination of the S-wave pi pi scattering lengths from a study of K-+/- -> pi(+/-)pi(0)pi(0) decays. THE EUROPEAN PHYSICAL JOURNAL. C, PARTICLES AND FIELDS, vol. 64, p. 589-608, ISSN: 1434-6044, doi: 10.1140/epjc/s10052-009-1171-3 - **Articolo in rivista**
19. J.R. Batley, G.E. Kalmus, C. Lazzeroni, D.J. Munday, M. Patel, M.W. Slater, S.A. Wotton, R. Arcidiacono, G. Bocquet, A. Ceccucci, D. Cundy, N. Doble, V. Falaleev, L. Gatignon, A. Gonidec, P. Grafström, W. Kubischta, I. Mikulec, A. Norton, B. Panzer-Steindel...(2009). Measurement of the polarization of the Xi0 (anti-Xi0) hyperon beam by the NA48/1 experiment. PHYSICS LETTERS. SECTION B, vol. 681, p. 406-412, ISSN: 0370-2693, doi: 10.1016/j.physletb.2009.10.054 - **Articolo in rivista**
20. J.R. Batley, A.J. Culling, G. Kalmus, C. Lazzeroni, D.J. Munday, M.W. Slater, S.A. Wotton, R. Arcidiacono, G. Bocquet, N. Cabibbo, A. Ceccucci, D. Cundy, V. Falaleev, M. Fidecaro, L. Gatignon, A. Gonidec, W. Kubischta, A. Norton, A. Maier, M. Patel...(2008). First observation and measurement of the decay K± --> pi± e+ e- gamma. PHYSICS LETTERS. SECTION B, vol. 659, p. 493-499, ISSN: 0370-2693, doi: 10.1016/j.physletb.2007.11.075 - **Articolo in rivista**

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2. **MASSAROTTI Paolo**

1. Ambrosino F., Antonelli A., Antonelli M., Archilli F., Bacci C., Beltrame P, Bencivenni G., Bertolucci S., Bini C., Bloise C., Bocchetta S., Bossi F., Branchini P, Caloi R., Campana P, Capon G., Capussela T., Ceradini F., Chi S., Chiefari G....(2008). Measurement of the charged kaon lifetime with the KLOE detector. JOURNAL OF HIGH ENERGY PHYSICS, ISSN: 1126-6708 - **Articolo in rivista**
2. Ambrosino F., Antonelli A., Antonelli M., Archilli F., Bacci C., Beltrame P, Bencivenni G., Bertolucci S., Bini C., Bloise C., Bocchetta S., Bossi F., Branchini P, Caloi R., Campana P, Capon G., Capussela T., Ceradini F., Cesario F., Chi S....(2008). |Vus| and lepton universality from kaon decays with the KLOE detector. JOURNAL OF HIGH ENERGY PHYSICS, ISSN: 1126-6708 - **Articolo in rivista**
3. Ambrosino F., Antonelli A., Antonelli M., Archilli F., Beltrame P, Bencivenni G., Bini C., Bloise C., Bocchetta S., Bossi F., Branchini P, Capon G., Capriotti D., Capussela T., Ceradini F., Ciambrone P, De Lucia E., De Santis A., De Simone P, De Zorzi G....(2009). Precise measurement of Gamma(K -> e nu(gamma))/Gamma(K -> mu nu(gamma)) and study of K -> e nu gamma. THE EUROPEAN PHYSICAL JOURNAL. C, PARTICLES AND FIELDS, vol. 64, p. 627-636, ISSN: 1434-6044, doi: 10.1140/epjc/s10052-009-1177-x - **Articolo in rivista**
4. Lazzeroni C., Romano A., Ceccucci A., Danielsson H., Falaleev V., Gatignon L., Goy Lopez S., Hallgren B., Maier A., Peters A., Piccini M., Riedler P., Frabetti P. L., Gersabeck E., Kekelidze V., Madigozhin D., Misheva M., Molokanova N., Movchan S., Potrebenikov Yu....(2013). Precision measurement of the ratio of the charged kaon leptonic decay rates. PHYSICS LETTERS. SECTION B, vol. 719, p. 326-336, ISSN: 0370-2693, doi: 10.1016/j.physletb.2013.01.037 - **Articolo in rivista**
5. Lazzeroni C., Romano A., Ceccucci A., Danielsson H., Falaleev V., Gatignon L., Lopezl S. Goy, Hallgren B., Maier A., Peters A., Piccini M., Riedler P, Dyulendarova M., Frabetti P L., Kekelidze V., Madigozhin D., Marinova E., Molokanova N., Movchan S., Potrebenikov Yu....(2011). Test of lepton flavour universality in K+ -> l(+)nu decays. PHYSICS LETTERS. SECTION B, vol. 698, p. 105-114, ISSN: 0370-2693, doi: 10.1016/j.physletb.2011.02.064 - **Articolo in rivista**
6. Ambrosino F., Antonelli A., Antonelli M., Archilli F., Bacci C., Beltrame P, Bencivenni G., Bertolucci S., Bini C., Bloise C., Bocchetta S., Bossi F., Branchini P, Caloi R., Campana P, Capon G., Capussela T., Ceradini F., Chi S., Chiefari G....(2008). Measurement of the absolute branching ratios for semileptonic K+/- decays with the KLOE detector. JOURNAL OF HIGH ENERGY PHYSICS, ISSN: 1126-6708 - **Articolo in rivista**
7. Ambrosino F., Antonelli A., Antonelli M., Archilli F., Bacci C., Beltrame P, Bencivenni G., Bertolucci S., Bini C., Bloise C., Bocchetta S., Bossi F., Branchini P, Campana P, Capon G., Capussela T., Ceradini F., Cesario F., Chi S., Chiefari G....(2008). Measurement of the branching ratio of the K(+)->pi(+)pi(0)(gamma) decay with the KLOE detector. PHYSICS LETTERS. SECTION B, vol. 666, p. 305-310, ISSN: 0370-2693, doi: 10.1016/j.physletb.2008.07.070 - **Articolo in rivista**
8. Ambrosino F., Capussela T., Filippo D. Di, Massarotti P., Mirra M., Napolitano M., Palladino V., Saracino G., Roscilli L., Vanzanella A., Corradi G., Tagnani D., Paglia U. (2016). CHANTI: a fast and efficient charged particle veto detector for the NA62 experiment at CERN. JOURNAL OF INSTRUMENTATION, vol. 11, p. P03029, ISSN: 1748-0221, doi: 10.1088/1748-0221/11/03/P03029 - **Articolo in rivista**
9. Gil, E. Cortina, Albarrán, E. Martín, Minucci, E., Nüssle, G., Padolski, S., Petrov, P., Szilasi, N., Velghe, B., Georgiev, G., Kozhuharov, V....(2017). The beam and Detector of the NA62 experiment at CERN. JOURNAL OF INSTRUMENTATION, vol. 12, p. P05025, ISSN: 1748-0221, doi: 10.1088/1748-0221/12/05/P05025 - **Articolo in rivista**
10. Ambrosino F., Antonelli A., Antonelli M., Archilli F., Bacci C., Beltrame P, Bencivenni G., Bertolucci S., Bini C., Bloise C., Bocchetta S., Bossi F., Branchini P, Campana P, Capon G., Capussela T., Ceradini F., Chi S., Chiefari G., Ciambrone P...(2009). Measurement of sigma(e(+)e(-) -> pi(+)pi(-)gamma(gamma)) and the dipion contribution to the muon anomaly with the KLOE detector. PHYSICS LETTERS. SECTION B, vol. 670, p. 285-291, ISSN: 0370-2693, doi: 10.1016/j.physletb.2008.10.060 - **Articolo in rivista**
11. Ambrosino F., Archilli F., Beltrame P, Bencivenni G., Bini C., Bloise C., Bocchetta S., Bossi F., Branchini P, Capon G., Capussela T., Ceradini F., Ciambrone P, De Lucia E., De Santis A., De Simone P, De Zorzi G., Denig A., Di Domenico A., Di Donato C....(2011). Measurement of sigma-(e(+)e(-) -> pi(+)pi(-)) from threshold to 0.85 GeV2 using initial state radiation with the KLOE detector. PHYSICS LETTERS. SECTION B, vol. 700, p. 102-110, ISSN: 0370-2693, doi: 10.1016/j.physletb.2011.04.055 - **Articolo in rivista**
12. Ambrosino F., Antonelli A., Antonelli M., Archilli F., Beltrame P, Bencivenni G., Bertolucci S., Bini C., Bloise C., Bocchetta S., Bossi F., Branchini P, Capon G., Capussela T., Ceradini F., Ciambrone P, De Lucia E., De Santis A., De Simone P, De Zorzi G....(2009). A global fit to determine the pseudoscalar mixing angle and the gluonium content of the eta ' meson. JOURNAL OF HIGH ENERGY PHYSICS, ISSN: 1126-6708, doi: 10.1088/1126-6708/2009/07/105 - **Articolo in rivista**
13. AMBROSINO, FABIO, CAPUSSELA, TIZIANA, CHIEFARI, GIOVANNI, DI DONATO, CAMILLA, A. Doria, MASSAROTTI, PAOLO, MEOLA, SABINO, NAPOLITANO, MARCO, PERFETTO, FRANCESCO, SARACINO, GIULIO (2008). Determination of eta ---> pi+ pi- pi0 Dalitz plot slopes and asymmetries with the KLOE detector.. JOURNAL OF HIGH ENERGY PHYSICS, vol. 05, p. 1-14, ISSN: 1029-8479, doi: 10.1088/1126-6708/2008/05/006 - **Articolo in rivista**
14. AMBROSINO, FABIO, A. Antonelli, M. Antonelli, F. Archilli, P. Beltrame, G. Bencivenni, S. Bertolucci, C. Bini, C. Bloise, S. Bocchetta, F. Bossi, P. Branchini, G. Capon, D. Capriotti, CAPUSSELA, TIZIANA, F. Ceradini, P. Ciambrone, E. De Lucia...(2010). CPT symmetry and quantum mechanics tests in the neutral Kaon system at KLOE. FOUNDATIONS OF

PHYSICS, vol. 40, p. 852-866, ISSN: 0015-9018, doi: 10.1007/s10701-009-9366-x - **Articolo in rivista**

15. Ambrosino F., Antonelli A., Antonelli M., Archilli F., Beltrame P, Bencivenni G., Bertolucci S., Bini C., Bloise C., Bocchetta S., Bossi F., Branchini R., Campana R., Capon G., Capussela T., Ceradini F., Ciambrone P, Crucianelli F., De Lucia E., De Santis A....(2008). Study of the process e(+)e(-) -> omega pi(0) in the phi-meson mass region with the KLOE detector. PHYSICS LETTERS. SECTION B, vol. 669, p. 223-228, ISSN: 0370-2693, doi: 10.1016/j.physletb.2008.09.056 - **Articolo in rivista**
16. Ambrosino F., Antonelli A., Antonelli M., Archilli F., Beltrame P, Bencivenni G., Bertolucci S., Bini C., Bloise C., Bocchetta S., Bossi F., Branchini P, Capon G., Capussela T., Ceradini F., Ciambrone P, Crucianelli F., De Lucia E., De Santis A., De Simone P...(2009). Measurement of the branching ratio and search for a CP violating asymmetry in the eta -> pi(+)pi(-)e(+)e(-)(gamma) decay at KLOE. PHYSICS LETTERS. SECTION B, vol. 675, p. 283-288, ISSN: 0370-2693, doi: 10.1016/j.physletb.2009.04.013 - **Articolo in rivista**
17. Ambrosino F., Antonelli A., Antonelli M., Archilli F., Beltrame P, Bencivenni G., Bini C., Bloise C., Bocchetta S., Bossi F., Branchini P, Campana P, Capon G., Capussela T., Ceradini F., Ciambrone P, De Lucia E., De Santis A., De Simone P, De Zorzi G....(2010). Measurement of the eta -> 3 pi(0) slope parameter alpha with the KLOE detector. PHYSICS LETTERS. SECTION B, vol. 694, p. 16-21, ISSN: 0370-2693, doi: 10.1016/j.physletb.2010.09.022 - **Articolo in rivista**
18. C. Lazzeroni, A. Romano, A. Ceccucci, H. Danielsson, V. Falaleev, L. Gatignon, S. G. Lopez, B. Hallgren, A. Maier, A. Peters, M. Piccini, P. Riedler, P. Frabetti, E. Gersabeck, V. Kekelidze, D. Madigozhin, M. Misheva, N. Molokanova, S. Movchan, Y. Potrebenikov...(2014). Study of the K+- --> pi+- gamma gamma decay by the NA62 experiment. PHYSICS LETTERS. SECTION B, vol. 732, p. 65-74, ISSN: 0370-2693, doi: 10.1016/j.physletb.2014.03.016 - **Articolo in rivista**
19. MASSAROTTI, PAOLO (2014). SEARCH FOR $K^+ \to \pi^+ \nu \bar\nu$ DECAYS AT NA62 EXPERIMENT AT CERN. INTERNATIONAL JOURNAL OF MODERN PHYSICS CONFERENCE SERIES, vol. 35, ISSN: 2010-1945, doi: 10.1142/S2010194514604220 - **Articolo in rivista**
20. Paolo Massarotti (2013). The Large-Angle Photon Veto System for the NA62 Experiment at CERN. In: ICHEP 2012. POS PROCEEDINGS OF SCIENCE, ISSN: 1824-8039 - **Contributo in Atti di convegno**

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3. SOZZI Marco Stanislao

1. Ammendola R., Biagioni A., Chiozzi S., Cotta Ramusino A., Di Lorenzo S., Fantechi R., Fiorini M., Frezza O., Lamanna G., Lo Cicero F., Lonardo A., Martinelli M., Neri I., Paolucci P.S., Pastorelli E., Piandani R., Pontisso L, Rossetti D., Simula F., Sozzi M....(2017). Graphical processors for HEP trigger systems. NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH. SECTION A, ACCELERATORS, SPECTROMETERS, DETECTORS AND ASSOCIATED EQUIPMENT, vol. 845, p. 612-615, ISSN: 0168-9002, doi: 10.1016/j.nima.2016.06.043 - **Articolo in rivista**
2. Gil, E. Cortina, Albarrán, E. Martín, Minucci, E., Nüssle, G., Padolski, S., Petrov, P., Szilasi, N., Velghe, B., Georgiev, G., Kozhuharov, V....(2017). The beam and detector of the NA62 experiment at CERN. JOURNAL OF INSTRUMENTATION, vol. 12, p. P05025, ISSN: 1748-0221, doi: 10.1088/1748-0221/12/05/P05025 - **Articolo in rivista**
3. Lazzeroni, C., Lurkin, N., Newson, F., Romano, A., Ceccucci, A., Danielsson, H., Falaleev, V., Gatignon, L., Goy Lopez, S., Hallgren, B....(2017). Search for heavy neutrinos in K+->pi mu decays. PHYSICS LETTERS. SECTION B, vol. 772, p. 712-718, ISSN: 0370-2693, doi: 10.1016/j.physletb.2017.07.055 - **Articolo in rivista**
4. Collaboration CERN NA48/2, Giudici S., Pierazzini G., Sozzi M., Venditti S., Costantini F. (2015). Search for the dark photon in π^0 decays. PHYSICS LETTERS. SECTION B, vol. 746, p. 178-185, ISSN: 0370-2693, doi: doi:10.1016/j.physletb.2015.04.068 - **Articolo in rivista**
5. C. Lazzeroni, A. Romano, A. Ceccucci, H. Danielsson, V. Falaleev, L. Gatignon, S. Goy Lopez, B. Hallgren, A. Maier, A. Peters, M. Piccini, P. Riedler, P.L. Frabetti, E. Gersabeck, V. Kekelidze, D. Madigozhin, M. Misheva, N. Molokanova, S. Movchan, Yu. Potrebenikov...(2014). Study of the K+- to pi+- gamma gamma decay by the NA62 experiment.. PHYSICS LETTERS. SECTION B, vol. 732, p. 65-74, ISSN: 0370-2693 - **Articolo in rivista**
6. J. R. Batley, G. Kalmus, C. Lazzeroni, D. J. Munday, M. W. Slater, S. A. Wotton, R. Arcidiacono, G. Bocquet, N. Cabibbo, A. Ceccucci, D. Cundy, V. Falaleev, M. Fidecaro, L. Gatignon, A. Gonidec, W. Kubischta, A. Norton, A. Maier, M. Patel, A. Peters...(2014)159 - **Articolo in rivista**
7. Lazzeroni, C., Romano, A., Ceccucci, A., Danielsson, H., Falaleev, V., Gatignon, L., Goy Lopez, S., Hallgren, B., Maier, A., Peters, A....(2014). Study of the K ± ± decay by the NA62 experiment. PHYSICS LETTERS. SECTION B, vol. 732, p. 65-74, ISSN: 0370-2693, doi: 10.1016/j.physletb.2014.03.016 - **Articolo in rivista**
8. C. Lazzeroni, A. Romano, A. Ceccucci, H. Danielsson, V. Falaleev, L. Gatignon, S. Goy Lopez, B. Hallgren, A. Maier, A. Peters, M. Piccini, P. Riedler, P.L. Frabetti, E. Gersabeck, V. Kekelidze, D. Madigozhin, M. Misheva, N. Molokanova, S. Movchan, Yu. Potrebenikov...(2013). Precision measurement of the ratio of the charged kaon leptonic decay rates. PHYSICS LETTERS. SECTION B, vol. 719, p. 326-336, ISSN: 0370-2693, doi: 10.1016/j.physletb.2013.01.037 - **Articolo in rivista**
9. Batley JR, Kalmus G, Lazzeroni C, Munday DJ, Slater MW, Wotton SA, Arcidiacono R, Bocquet G, Cabibbo N, Ceccucci A, Cundy D, Falaleev V, Fidecaro M, Gatignon L, Gonidec A, Kubischta W, Norton A, Maier A, Patel M, Peters A...(2012). New measurement of the K-+/- -> pi(+)pi(-)e(+/-)v (Ke4) decay branching ratio and hadronic form factors. PHYSICS LETTERS. SECTION B, vol. 715, p. 105-115, ISSN: 0370-2693, doi: 10.1016/j.physletb.2012.07.048 - **Articolo in rivista**
10. Batley JR, Kalmus G, Lazzeroni C, Munday DJ, Slater MW, Wotton SA, Arcidiacono R, Bocquet G, Cabibbo N, Ceccucci A, Cundy D, Falaleev V, Fidecaro M, Gatignon L, Gonidec A, Kubischta W, Norton A, Maier A, Patel M, Peters A...(2011). New measurement of the K(+/-) -> pi(+/-)mu(+)mu(-) decay. PHYSICS LETTERS. SECTION B, vol. 697, p. 107-115, ISSN: 0370-2693, doi: 10.1016/j.physletb.2011.01.042 - **Articolo in rivista**
11. Batley JR, Kalmus GE, Lazzeroni C, Munday DJ, Patel M, Slater MW, Wotton SA, Arcidiacono R, Bocquet G, Ceccucci A, Cundy D, Doble N, Falaleev V, Gatignon L, Gonidec A, Grafstrom R, Kubischta W, Marchetto F, Mikulec I, Norton A...(2011). Precision measurement of the ratio BR(K(S) -> pi(+)pi(-)e(+)e(-))/BR(K(L) -> pi(+)pi(-)pi(0)(D)). PHYSICS LETTERS. SECTION B, vol. 694, p. 301-309, ISSN: 0370-2693, doi: 10.1016/j.physletb.2010.10.008 - **Articolo in rivista**
12. Lazzeroni C, Romano A, Ceccucci A, Danielsson H, Falaleev V, Gatignon L, Lopezl SG, Hallgren B, Maier A, Peters A, Piccini M, Riedler P, Dyulendarova M, Frabetti PL, Kekelidze V, Madigozhin D, Marinova E, Molokanova N, Movchan S, Potrebenikov Y...(2011). Test of lepton flavour universality in K(+) -> l(+)nu decays RID F-3326-2011 RID A-6640-2010. PHYSICS LETTERS. SECTION B, vol. 698, p. 105-114, ISSN: 0370-2693, doi: 10.1016/j.physletb.2011.02.064 - **Articolo in rivista**
13. Lazzeroni C., Romano A., Ceccucci A., Danielsson H., Falaleev V., Gatignon L., Lopezl S. Goy, Hallgren B., Maier A., Peters A., Piccini M., Riedler P., Dyulendarova M., Frabetti P. L., Kekelidze V., Madigozhin D., Marinova E., Molokanova N., Movchan S., Potrebenikov Yu....(2011). Test of lepton flavour universality in K(+) -> l(+)nu decays. PHYSICS LETTERS. SECTION B, vol. 698, p. 105-114, ISSN: 0370-2693, doi: 10.1016/j.physletb.2011.02.064 - **Articolo in rivista**
14. Antonelli M, Asner DM, Bauer D, Becher T, Beneke M, Bevan AJ, Blanke M, Bloise C, Bona M, Bondar A, Bozzi C, Brod J, Buras AJ, Cabibbo N, Carbone A, Cavoto G, Cirigliano V, Ciuchini M, Coleman JP, Cronin-Hennessy DP...(2010). Flavor physics in the quark sector. PHYSICS REPORTS, vol. 494, p. 197-414, ISSN: 0370-1573, doi: 10.1016/j.physrep.2010.05.003 - **Articolo in rivista**

15. Antonelli M, Cirigliano V, Isidori G, Mescia F, Moulson M, Neufeld H, Passemar E, Palutan M, Sciascia B, SOZZI, MARCO STANISLAO, Wanke R, Yushchenko OP (2010). An evaluation of broken vertical bar V(us broken vertical bar) and precise tests of the Standard Model from world data on leptonic and semileptonic kaon decays. THE EUROPEAN PHYSICAL JOURNAL. C, PARTICLES AND FIELDS, vol. 69, p. 399-424, ISSN: 1434-6044, doi: 10.1140/epjc/s10052-010-1406-3 - **Articolo in rivista**
16. Batley J. R., Kalmus G., Lazzeroni C., Munday D. J., Slater M. W., Wotton S. A., Arcidiacono R., Bocquet G., Cabibbo N., Ceccucci A., Cundy D., Falaleev V., Fidecaro M., Gatignon L., Gonidec A., Kubischta W., Norton A., Maier A., Patel M., Peters A....(2010). Precise tests of low energy QCD from K(e4) decay properties. THE EUROPEAN PHYSICAL JOURNAL. C, PARTICLES AND FIELDS, vol. 70, p. 635-657, ISSN: 1434-6044, doi: 10.1140/epjc/s10052-010-1480-6 - **Articolo in rivista**
17. Batley JR, Kalmus G, Lazzeroni C, Munday DJ, Slater MW, Wotton SA, Arcidiacono R, Bocquet G, Cabibbo N, Ceccucci A, Cundy D, Falaleev V, Fidecaro M, Gatignon L, Gonidec A, Kubischta W, Norton A, Maier A, Patel M, Peters A...(2010). Measurement of the direct emission and interference terms and search for CP violation in the decay K(+/-) -> pi(+/-)pi(0)gamma. THE EUROPEAN PHYSICAL JOURNAL. C, PARTICLES AND FIELDS, vol. 68, p. 75-87, ISSN: 1434-6044, doi: 10.1140/epjc/s10052-010-1349-8 - **Articolo in rivista**
18. Batley J. R., Culling A. J., Kalmus G., Lazzeroni C., Munday D. J., Slater M. W., Wotton S. A., Arcidiacono R., Bocquet G., Cabibbo N., Ceccucci A., Cundy D., Falaleev V., Fidecaro M., Gatignon L., Gonidec A., Kubischta W., Norton A., Maier A., Patel M....(2009). Determination of the S-wave pi pi scattering lengths from a study of K(+/-) -> pi(+/-)pi(0)pi(0) decays. THE EUROPEAN PHYSICAL JOURNAL. C, PARTICLES AND FIELDS, vol. 64, p. 589-609, ISSN: 1434-6044, doi: 10.1140/epjc/s10052-009-1171-3 - **Articolo in rivista**
19. Batley JR, Culling AJ, Kalmus G, Lazzeroni C, Munday DJ, Slater MW, Wotton SA, Arcidiacono R, Bocquet G, Cabibbo N, Ceccucci A, Cundy D, Falaleev V, Fidecaro M, Gatignon L, Gonidec A, Kubischta W, Norton A, Maier A, Patel M...(2008). New high statistics measurement of K-e4 decay form factors and pi pi scattering phase shifts. THE EUROPEAN PHYSICAL JOURNAL. C, PARTICLES AND FIELDS, vol. 54, p. 411-423, ISSN: 1434-6044, doi: 10.1140/epjc/s10052-008-0547-0 - **Articolo in rivista**
20. SOZZI, MARCO STANISLAO (2008). Discrete Symmetries and CP Violation. p. 1-568, Oxford:Oxford University Press, ISBN: 9780199296668 - **Monografia o trattato scientifico**

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4. MENICHETTI Ezio

1. Aab, A., Abreu, P., Aglietta, M., Ahn, E. J., Al Samarai, I., Albert, J. N., Albuquerque, I. F. M., Allekotte, I., Allen, J., Allison, P....(2015). The Pierre Auger Cosmic Ray Observatory. NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH. SECTION A, ACCELERATORS, SPECTROMETERS, DETECTORS AND ASSOCIATED EQUIPMENT, vol. 798, p. 172-213, ISSN: 0168-9002, doi: 10.1016/j.nima.2015.06.058 - **Articolo in rivista**
2. A. Aab, P. Abreu, M. Aglietta, E. J. Ahn, I. Al Samarai, I. F. M. Albuquerque, I. Allekotte, J. Allen, P. Allison, A. Almela, J. Alvarez Castillo, J. Alvarez-Muñiz, R. Alves Batista, M. Ambrosio, A. Aminaei, L. Anchordoqui, S. Andringa, C. Aramo, F. Arqueros, H. Asorey...(2014). SEARCHES FOR LARGE-SCALE ANISOTROPY IN THE ARRIVAL DIRECTIONS OF COSMIC RAYS DETECTED ABOVE ENERGY OF 1019eV AT THE PIERRE AUGER OBSERVATORY AND THE TELESCOPE ARRAY. THE ASTROPHYSICAL JOURNAL, vol. 794, p. 172-186, ISSN: 1538-4357, doi: 10.1088/0004-637X/794/2/172 - **Articolo in rivista**
3. A. Aab, P. Abreu, M. Aglietta, M. Ahlers, E. J. Ahn, I. Al Samarai, I. F. M. Albuquerque, I. Allekotte, J. Allen, P. Allison, A. Almela, J. Alvarez Castillo, J. Alvarez-Muñiz, R. Alves Batista, M. Ambrosio, A. Aminaei, L. Anchordoqui, S. Andringa, C. Aramo, F. Arqueros...(2014). A TARGETED SEARCH FOR POINT SOURCES OF EeV NEUTRONS. THE ASTROPHYSICAL JOURNAL LETTERS, vol. 789, p. L34-1-L34-7, ISSN: 2041-8205, doi: 10.1088/2041-8205/789/2/L34 - **Articolo in rivista**
4. A. Aab, P. Abreu, M. Aglietta, M. Ahlers, E. J. Ahn, I. Al Samarai, I. F. M. Albuquerque, I. Allekotte, J. Allen, P. Allison, A. Almela, J. Alvarez Castillo, J. Alvarez-Muñiz, R. Alves Batista, M. Ambrosio, A. Aminaei, L. Anchordoqui, S. Andringa, C. Aramo, F. Arqueros...(2014). A SEARCH FOR POINT SOURCES OF EeV PHOTONS. THE ASTROPHYSICAL JOURNAL, vol. 789, p. 160-1-160-12, ISSN: 0004-637X, doi: 10.1088/0004-637X/789/2/160 - **Articolo in rivista**
5. A. Aab, P. Abreu, M. Aglietta, M. Ahlers, E.J. Ahn, I.F.M. Albuquerque, I. Allekotte, J. Allen, P. Allison, A. Almela, J. Alvarez Castillo, J. Alvarez-Muñiz, R. Alves Batista, M. Ambrosio, A. Aminaei, L. Anchordoqui, S. Andringa, T. Antii, C. Aramo, F. Arqueros...(2014). Origin of atmospheric aerosols at the Pierre Auger Observatory using studies of air mass trajectories in South America. ATMOSPHERIC RESEARCH, vol. 149, p. 120-135, ISSN: 0169-8095, doi: 10.1016/j.atmosres.2014.05.021 - **Articolo in rivista**
6. A. Aab, P. Abreu, M. Aglietta, M. Ahlers, E.J. Ahn, I. Al Samarai, I.F.M. Albuquerque, I. Allekotte, J. Allen, P. Allison, A. Almela, J. Alvarez Castillo, J. Alvarez-Muñiz, R. Alves Batista, M. Ambrosio, A. Aminaei, L. Anchordoqui, S. Andringa, C. Aramo, F. Arqueros...(2014). Muons in air showers at the Pierre Auger Observatory: Measurement of atmospheric production depth. PHYSICAL REVIEW D, PARTICLES, FIELDS, GRAVITATION, AND COSMOLOGY, vol. 90, p. 012012-1-012012-15, ISSN: 1550-7998, doi: 10.1103/PhysRevD.90.012012 - **Articolo in rivista**
7. A. Aab, P. Abreu, M. Aglietta, M. Ahlers, E.J. Ahn, I. Al Samarai, I.F.M. Albuquerque, I. Allekotte, J. Allen, P. Allison, A. Almela, J. Alvarez Castillo, J. Alvarez-Muñiz, R. Alves Batista, M. Ambrosio, A. Aminaei, L. Anchordoqui, S. Andringa, C. Aramo, F. Arqueros...(2014). Reconstruction of inclined air showers detected with the Pierre Auger Observatory. JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS, vol. 2014, p. 019-1-019-31, ISSN: 1475-7516, doi: 10.1088/1475-7516/2014/08/019 - **Articolo in rivista**
8. A. Aab, P. Abreu, M. Aglietta, M. Ahlers, E.J. Ahn, I.F.M. Albuquerque, I. Allekotte, J. Allen, P. Allison, A. Almela, J. Alvarez Castillo, J. Alvarez-Muñiz, R. Alves Batista, M. Ambrosio, A. Aminaei, L. Anchordoqui, S. Andringa, T. Antii, C. Aramo, F. Arqueros...(2014). Probing the radio emission from air showers with polarization measurements. PHYSICAL REVIEW D, PARTICLES, FIELDS, GRAVITATION, AND COSMOLOGY, vol. 89, p. 052002-052019, ISSN: 1550-7998, doi: 10.1103/PhysRevD.89.052002 - **Articolo in rivista**
9. J.R. Batley, G.E. Kalmus, C. Lazzeroni, D.J. Munday, M. Patel, M.W. Slater, S.A. Wotton, R. Arcidiacono, G. Bocquet, A. Ceccucci, D. Cundy, N. Doble, V. Falaleev, L. Gatignon, A. Gonidec, P. Grafström, W. Kubischta, F. Marchetto, I. Mikulec, A. Norton...(2013). Measurement of the branching ratio of the decay. PHYSICS LETTERS. SECTION B, vol. 720, p. 105-110, ISSN: 0370-2693, doi: 10.1016/j.physletb.2013.01.023 - **Articolo in rivista**
10. P. Abreu, M. Aglietta, M. Ahlers, E. J. Ahn, I. F. M. Albuquerque, D. Allard, I. Allekotte, J. Allen, P. Allison, A. Almela, J. Alvarez Castillo, J. Alvarez-Muñiz, R. Alves Batista, M. Ambrosio, A. Aminaei, L. Anchordoqui, S. Andringa, T. Antii, C. Aramo, E. Arganda...(2013). Ultrahigh Energy Neutrinos at the Pierre Auger Observatory. ADVANCES IN HIGH ENERGY PHYSICS, vol. 2013, p. 1-18, ISSN: 1687-7357, doi: 10.1155/2013/708680 - **Articolo in rivista**
11. P. Abreu, M. Aglietta, M. Ahlers, E. J. Ahn, I. F. M. Albuquerque, D. Allard, I. Allekotte, J. Allen, P. Allison, A. Almela, J. Alvarez Castillo, J. Alvarez-Muñiz, R. Alves Batista, M. Ambrosio, A. Aminaei, L. Anchordoqui, S. Andringa, T. Antii'c, C. Aramo, E. Arganda...(2013). CONSTRAINTS ON THE ORIGIN OF COSMIC RAYS ABOVE 1018eV FROM LARGE-SCALE ANISOTROPY SEARCHES IN DATA OF THE PIERRE AUGER OBSERVATORY. THE ASTROPHYSICAL JOURNAL LETTERS, vol. 762, p. L13-1-L13-8, ISSN: 2041-8205, doi: 10.1088/2041-8205/762/1/L13 - **Articolo in rivista**
12. P. Abreu, M. Aglietta, M. Ahlers, E. J. Ahn, I. F. M. Albuquerque, D. Allard, I. Allekotte, J. Allen, P. Allison, A. Almela, J. Alvarez Castillo, J. Alvarez-Muñiz, R. Alves Batista, M. Ambrosio, A. Aminaei, L. Anchordoqui, S. Andringa, T. Antii'c, C. Aramo, E. Arganda...(2013). Bounds on the density of sources of ultra-high energy cosmic rays from the Pierre Auger Observatory. JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS, vol. 2013, p. 009-1-009-18, ISSN: 1475-7516, doi: 10.1088/1475-7516/2013/05/009 - **Articolo in rivista**

13. P. Abreu, M. Aglietta, M. Ahlers, E.J. Ahn, I.F.M. Albuquerque, I. Allekotte, J. Allen, P. Allison, A. Almela, J. Alvarez Castillo, J. Alvarez-Muñiz, R. Alves Batista, M. Ambrosio, A. Aminaei, L. Anchordoqui, S. Andringa, T. Anticic, C. Aramo, F. Arqueros, H. Asorey...(2013). Techniques for measuring aerosol attenuation using the Central Laser Facility at the Pierre Auger Observatory. JOURNAL OF INSTRUMENTATION, vol. 8, p. P04009, ISSN: 1748-0221, doi: 10.1088/1748-0221/8/04/P04009 - **Articolo in rivista**
14. Pierre Auger Collaboration (Pedro Abreu (Lisbon, IST & LIP, Lisbon) et al.), E.Menichetti, A.Tonachini (2013). Bounds on the density of sources of ultra-high energy cosmic rays from the Pierre Auger Observatory. JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS, vol. 1305, p. 009-33, ISSN: 1475-7516, doi: 10.1088/1475-7516/2013/05/009 - **Articolo in rivista**
15. Pierre Auger Collaboration (Pedro Abreu (Lisbon, IST & LIP, Lisbon) et al.). E.Menichetti, A.Tonachini (2013). Interpretation of the Depths of Maximum of Extensive Air Showers Measured by the Pierre Auger Observatory. JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS, vol. 1302, p. 026-040, ISSN: 1475-7516, doi: 10.1088/1475-7516/2013/02/026 - **Articolo in rivista**
16. P. Abreu, M. Aglietta, M. Ahlers, E. J. Ahn, I. F. M., D. Allard, I. Allekotte, J. Allen, P. Allison, A. Almela, J. A. Castillo, J. Alvarez-Muniz, R. A. Batista, M. Ambrosio, A. Aminaei, L. Anchordoqui, S. Andringa, T. Antici'c, C. Aramo, E. Arganda...(2012). Search For Point-like Sources of Ultra-high Energy Neutrinos At the Pierre Auger Observatory and Improved Limit On the Diffuse Flux of Tau Neutrinos. THE ASTROPHYSICAL JOURNAL LETTERS, vol. 755, ISSN: 2041-8205, doi: 10.1088/2041-8205/755/1/L4 - **Articolo in rivista**
17. J. Abraham et al., P. Auger Collaboration (R. Bonino, R. Cester, A. Chiavassa, A. Gorgi, S. Maldera, E. Menichetti, G. Navarra, A. Tonachini) (2010). Measurement of the Depth of Maximum of Extensive Air Showers above 10(18) eV. PHYSICAL REVIEW LETTERS, vol. 104, ISSN: 0031-9007, doi: 10.1103/PhysRevLett.104.091101 - **Articolo in rivista**
18. J. Abraham, P. Auger Collaboration (R. Bonino, R. Cester, A. Chiavassa, A. Gorgi, S. Maldera, E. Menichetti, G. Navarra, A. Tonachini) (2010). Measurement of the energy spectrum of cosmic rays above 10(18) eV using the Pierre Auger Observatory. PHYSICS LETTERS. SECTION B, vol. 685, p. 239-246, ISSN: 0370-2693, doi: 10.1016/j.physletb.2010.02.013 - **Articolo in rivista**
19. J.R. Batley, G.E. Kalmus, C. Lazzeroni, D.J. Munday, M. Patel, M.W. Slater, S.A. Wotton, R. Arcidiacono, G. Bocquet, A. Ceccucci, D. Cundy, N. Doble, V. Falaleev, L. Gatignon, A. Gonidec, P. Grafstrom, W. Kubischta, F. Marchetto, I. Mikulec, A. Norton...(2010). Precision measurement of the ratio BR(KS --> pi+pi-e+e-)/BR(KL -->pi+pi-pi0D). PHYSICS LETTERS. SECTION B, vol. 694, p. 301-309, ISSN: 0370-2693 - **Articolo in rivista**
20. J.R. Batley, G.E. Kalmus, C. Lazzeroni, D.J. Munday, M. Patel, M.W. Slater, S.A. Wotton, R. Arcidiacono, G. Bocquet, A. Ceccucci, D. Cundy, N. Doble, V. Falaleev, L. Gatignon, A. Gonidec, P. Grafstrom, W. Kubischta, I. Mikulec, A. Norton, B. Panzer-Steindel...(2010). New Precise Measurements of the Xi0 and Lambda0 Decay Asymmetries. PHYSICS LETTERS. SECTION B, vol. 693, p. 241-248, ISSN: 0370-2693 - **Articolo in rivista**

6. Hindex of associated investigators (only for the scientific fields in which the use of the H-index is usually adopted)

nº	Surname Name	H-Index	Source
1.	PETRUCCI Ferruccio Carlo	41	INSPIRE
2.	MENICHETTI Ezio	62	INSPIRE
3.	SOZZI Marco Stanislao	39	INSPIRE-HEP database (SLAC)
4.	MASSAROTTI Paolo	29	INSPIRE-HEP database (SLAC)

7. Main staff involved (max 10 professors/researchers for each research unit, in addition to the PI or associated investigator), highlighting the time commitment expected

List of the Research Units

Unit 1 - MOULSON Matthew David

Personnel of the research unit

nº	Surname Name	Category	University/ Research Institution	e-mail address	Months/person expected
1.	MOULSON Matthew David	Ricercatore	Istituto Nazionale di Fisica Nucleare	matthew.moulson@lnf.infn.it	6,0
2.	BIINO Cristina	Primo ricercatore	Istituto Nazionale di Fisica Nucleare	cristina.biino@cern.ch	3,0
3.	GIANOLI Alberto	Primo tecnologo	Istituto Nazionale di Fisica Nucleare	alberto.gianoli@fe.infn.it	3,0
4.	D'AMBROSIO Giancarlo	Dirigente di ricerca	Istituto Nazionale di Fisica Nucleare	giancarlo.dambrosio@na.infn.it	3,0
5.	FILIPPI Alessandra	Primo ricercatore	Istituto Nazionale di Fisica Nucleare	alessandra.filippi@to.infn.it	3,0

Unit 2 - PETRUCCI Ferruccio Carlo

Personnel of the research unit

nº	Surname Name	Category	University/ Research Institution	e-mail address	Months/person expected
1.	PETRUCCI Ferruccio Carlo	Professore Associato confermato	Università degli Studi di FERRARA	petrucci@fe.infn.it	3,0

Unit 3 - MASSAROTTI Paolo

Personnel of the research unit

nº	Surname Name	Category	University/ Research Institution	e-mail address	Months/person expected
1.	MASSAROTTI Paolo	Ricercatore a t.d. (art. 24 c.3-b L. 240/10)	Università degli Studi di Napoli Federico II	paolo.massarotti@na.infn.it	3,0
2.	AMBROSINO Fabio	Professore Ordinario (L. 240/10)	Università degli Studi di Napoli Federico II	Fabio.Ambrosino@na.infn.it	3,0

Unit 4 - SOZZI Marco Stanislao

Personnel of the research unit

nº	Surname Name	Category	University/ Research Institution	e-mail address	Months/person expected
1.	SOZZI Marco Stanislao	Professore Associato confermato	Università di PISA	marco.sozzi@cern.ch	3,0
2.	GIUDICI Sergio	Ricercatore confermato	Università di PISA	sergio.giudici@unipi.it	3,0

Unit 5 - MENICHETTI Ezio

Personnel of the research unit

nº	Surname Name	Category	University/ Research Institution	e-mail address	Months/person expected
1.	MENICHETTI Ezio	Professore Ordinario	Università degli Studi di TORINO	menichetti@to.infn.it	3,0
2.	SOLDI Dario	Assegnista	Università degli Studi di TORINO	d.soldi89@gmail.com	6,0

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8. Major new contracts for staff specifically to recruit

nº	Associated or principal investigator	Number of contracts RTD expected	Number of research grants expected	Number of PhD expected	Predictable overall time commitment (months)
1.	MOULSON Matthew David	0	1	0	24
2.	PETRUCCI Ferruccio Carlo	0	1	0	24
3.	MASSAROTTI Paolo	0	1	0	24
4.	SOZZI Marco Stanislao	0	1	0	24
5.	MENICHETTI Ezio	0	1	0	24
	Total	**0**	**5**	**0**	**120**

9. Statement by the Principal Investigator

Con la sottomissione della presente proposta, consapevole della responsabilità civile e penale, attesto l'assenza di duplicazione degli obiettivi e dei contributi richiesti con altri progetti in corso o già conclusi

"I dati contenuti nella domanda di finanziamento sono trattati esclusivamente per lo svolgimento delle funzioni istituzionali del MIUR. Incaricato del trattamento è il CINECA - Business Unit MIUR. La consultazione è altresì riservata agli atenei e agli enti di ricerca (ciascuno per le parti di propria competenza), al MIUR - D.G. per il Coordinamento e lo Sviluppo della Ricerca - Ufficio V, al CNGR e ai CdS. Il MIUR potrà anche procedere alla diffusione dei principali dati economici e scientifici relativi ai progetti finanziati".

Date 28/03/2018 ore 21:00