FATA2023 BOOK OF ABSTRACTs (preliminary version as of 07 August 2023)
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FAst Timing Applications for Nuclear Physics and Medical Imaging
Catania-Italy, 2nd - 5th October 2023
Book of Abstract Authors in Alphabetic order
Preliminary list of speakers on July 302023

The conference will focus on the most recent developments of fast-timing techniques for applications of radiation detectors in the fields of experimental nuclear physics and medical applications, covering the following topics:

- *Scintillators and photodetectors for fast timing readout electronics for ultrafast detectors*
- *Solid-state detector technology for fast timing processing of time-stamped data*
- *Precise event-time tagging in high luminosity accelerators towards picoseconds*
- *Time-of-flight (TOF) resolution*
- *Time-of-flight positron-emission tomography (TOF-PET) for medical imaging and monitoring of hadron therapy*
- *Fluorescence microscopy techniques at including time-resolved imaging.*

Participation in the workshop by students, postdocs, technical staff and engineers is strongly encouraged. More details on the program will be given in the second circular and on the conference website: https://agenda.infn.it/e/FATA2023

List of selected speakers

1-Paolo Bianchini
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Fast-timing technology in non-linear and super-resolution microscopy.

Fast-timing technology has been implemented in non-linear and super-resolution laser scanning microscopy to improve several imaging methods. The fast or ultrafast time information point-by-point can be translated into better spatial resolution and more quantitative data about the physical processes occurring in that defined spatial position. In order to acquire such data, specialized hardware is required. Depending on the method used, single photon detectors or detector arrays are required; TCSPC or fast FPGA board or lock-in amplifiers should serve for data process and acquisition; pulsed visible laser or ultrafast femtosecond are needed to trigger the photophysical processes, which give the contrast for the image formation. The seminar will discuss about image scanning microscopy(ISM), its ability to measure fluorescence lifetime (FL)[1], and its combination with two-photon excitation fluorescence microscopy (2PEFM)[2]. The ISM exploits a spad

array to replace the confocal pinhole, and the resulting image is reconstructed by pixel reassignment. Such a method, while improving the spatial resolution, allows measuring FL at a higher signal-to-noise ratio. Moreover, the use of ultrafast femtosecond lasers for two-photon excitation opens the discussion on other non-linear contrast mechanisms, such as transient absorption. Its measure can be realized by pump-probe spectroscopy, a time-resolved method used to study dynamic processes in materials. Its implementation in a scanning microscope and the exploitation of absorption saturation allows it to bring the spatial resolution down to tens of nanometers using NIR light [3].

[1] Castello M, Tortarolo G, Buttafava M, Deguchi T, Villa F, Koho S, Pesce L, Oneto M, Pelicci S, Lanzanó L, Bianchini P, Sheppard CJR, Diaspro A, Tosi A, Vicidomini G. A robust and versatile platform for image scanning microscopy enabling super-resolution FLIM. Nat Methods. 2019 Feb;16(2):175–8.
[2] Koho SV, Slenders E, Tortarolo G, Castello M, Buttafava M, Villa F, Tcarenkova E, Ameloot M, Bianchini P, Sheppard CJR, Diaspro A, Tosi A, Vicidomini G. Two-photon image-scanning microscopy with SPAD array and blind image reconstruction. Biomed Opt Express. 2020;11(6):2905.
[3] Zanini G, Korobchevskaya K, Deguchi T, Diaspro A, Bianchini P. Label-Free Optical Nanoscopy of Single- Layer Graphene. Acs Nano. 2019 Aug 27;13(8):9673–81.

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2- Francesca Carnesecchi
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Extremely precise time resolution for charged particles: very thin LGADs and direct SiPM detection

Abstract (preliminary version)

This presentation focuses on two advancements in the field of particle detection and timing resolution.

The first topic explores the capabilities of Silicon PhotoMultipliers (SiPMs) beyond their conventional usage. While SiPMs are typically employed as photon detectors, recent investigations have unveiled their potential to directly detect charged particles. Detailed studies proved that this capability is related to the Cherenkov light emission in the protective layer above the sensor. Beam test results demonstrate a remarkable detection efficiency around 99%, and an intrinsic time resolution of approximately 20 ps. This breakthrough could enable the application of SiPMs as combined charged particle detectors in numerous fields, ranging from space

experiments to collider detectors.

The second topic is about advancements in Low Gain Avalanche Detectors (LGADs), specifically aiming to enhance their timing performance to fulfil the requirements of future-generation experiments. The discussion focuses on the performance evaluation of very thin (between 15 to 30 um) LGAD prototypes from Fondazione Bruno Kessler (FBK) and the development of the novel concept of the "double-LGAD". The thinner LGADs design has shown promising prospects for improved timing performance, while the double-LGAD concept generates a higher signal, offering advantages for the electronics and leading also to a better time resolution.

Overall, these pioneering advancements pave the way for achieving time resolutions of around 20 ps or less, setting a new standard for the field.

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3-Roberto Cardella
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The 100μm PET : an ultra high resolution small-animal PET based on monolithic pixel detectors

The 100μPET project, led by the University of Geneva, the University of Luzern, and the École Polytechnique Fédérale de Lausanne, aims at the development of a small-animal positron-emission tomography (PET) scanner with ultra-high-resolution molecular imaging capabilities. This is achieved through the use of a compact, modular stack of multiple thin layers of monolithic pixel detectors and flexible printed circuits (FPC), resulting in unprecedented scanner depth-of-interaction and volumetric granularity. Performance simulations have shown a point-spread-function of 0.15 mm, free of parallax effect, leading to a volumetric spatial resolution one to two orders of magnitude better than current PET scanners.
A 130nm BiCMOS technology has been selected to develop the ASIC, which allows for timing resolution in the order of tens of picoseconds. However, the stringent power consumption specifications for the ASIC of less than 120mW/cm2 require limiting the timing performance to 200ps at the current prototyping stage. A 2.3x3 cm2 monolithic pixel detector is currently being designed and will implement an event-driven binary readout with 100μm hexagonal pixels and integrated time-to-digital converters. Additionally, research and development on production methods have demonstrated the feasibility and reliability of the thin stack through cost-effective flip-chip bonding of the ASIC to the FPC using conductive adhesives. The recent developments in simulation, ASIC, and hardware prototyping will be presented.

4-Daniel Charlet
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Enhanced White rabbit node at the ps level

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5- Alberto Diaspro
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Microscopy at the nanoscale towards the artificial microscope

Today, the optical microscope, from super-resolved fluorescence to label-free mechanisms of contrast, is a powerful and fast device that produces real-time images with a high molecular content. This gives us unprecedented insight into the morphological and functional properties of biological cells at the nanoscale. Moreover, optical microscopy is multimodal and boosted by artificial intelligence. This makes intelligent the microscope. Super-resolved fluorescence microscopy, incorporating photochemical parameters from brightness to lifetime, and non-linear approaches are coupled to label-free polarization methods expanding the available data set. One ambitious target is the potential ability to transform a label-free interrogation of the biological sample into a molecular-rich fluorescence-based image. An interesting case study is related to understanding the visualization of chromatin organization. Here we will show the coupling of label-free Mueller matrix microscopy with fluorescence using a CNN approach.

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6-Paulo Fonte
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Resistive Plate Chambers directed towards PET scanners

Resistive Plate Chambers (RPC) are very well suited for the converter-plate gamma detection technique. Such approach, although providing a lower detection efficiency compared to the standard crystal-based technology, offers more accurate tridimensional localization of the photon interaction point, lower costs and comparable timing accuracy. In this talk we will report on the last 20 years of research towards the realization of practical RPC-PET scanners.

7-Luis Mario Fraile
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Fast Timing in Nuclear Spectroscopy experiments

Scintillators and photodetectors for fast timing are revolutionizing various research fields. Innovative scintillator crystals with excellent time response, good energy resolution, and relatively high effective Z, are highly advantageous for radioactive ion beam experiments, enabling fast-timing experiments that can accurately measure nuclear state lifetimes, even in the range down to tens of picoseconds. In such experiments, the lifetimes of nuclear levels are determined by employing fast electronic coincidences between the radiation that populates and de-excites a given nuclear level. The presentation will discuss the instrumentation, readout electronics and the digitization methods for fast-timing measurements, and it will illustrate its use in nuclear spectroscopy experiments. Examples of the capabilities of ultrafast detectors to handle high count rates, thereby improving the performance of modern preclinical PET scanners, and applications in hadrontherapy monitoring will be also provided.

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8-Giuseppe Iacobucci
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"Picosecond time stamping capabilities in fully monolithic highly granular silicon pixel detectors"

The MONOLITH H2020 ERC Advanced project aims at producing a monolithic silicon pixel ASIC with 50µm pixel pitch and picosecond-level time stamping. The two main ingredients of the project are fast and low- noise SiGe BiCMOS electronics and a novel sensor concept, the Picosecond Avalanche Detector (PicoAD). The PicoAD uses a patented multi-PN junction to engineer the electric field and produce a continuous gain layer deep in the sensor volume. The result is an ultra-fast current signal with low intrinsic jitter in a full fill factor and highly granular monolithic detector. Testbeam measurements of the proof-of-concept PicoAD prototype shows full efficiency and time resolutions of 13ps at the center of the pixel and 25ps at the pixel edge, for an average of 17ps over the pixel surface. A second monolithic prototype with improved electronics, at present produced on a 350Ωcm substrate without internal gain layer, provides 20ps time resolution. A version of this second prototype that features special PicoAD wafers is under production

9-Georgios Konstantinou
Metacrystal SA, I3M, Geneva, Switzerland

Metascintillators for TOF applications

Metascintillators, composed scintillator topologies with synergistic improvements in specifications relevant to PET and HEP experiments, have already been developed for several years. The concept of gamma interaction energy sharing and corresponding improvement has been demonstrated. Especially in the case of BGO based systems, in combination with BaF2 and organic compounds, timing and stopping power similar to LYSO:Ce has been achieved, using significantly cheaper raw materials, Currently, several different attempts are underway to further expand this, first generation heterostructure paradigm, through the integration of faster materials, such as perovskites, and photonic elements. In the same time, the theory of analysis of the pulses and application of neural networks in next generation detectors is under focus as well. We deem that this approach, due to the flexibility of combining materials with complementary characteristics, has the potential to bring detectors with 10 ps TOF resolution in the next decade, leading to significant improvement of detection capabilities and reconstructionless PET.

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10- Dario Lattuada
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ToF measurements in laser-induced hard electromagnetic background

The advent of new techniques in laser amplification triggered many laboratories to start new projects to study plasmas with temperatures and pressures close to those existing only in astrophysical sites. This has attracted the interest of the nuclear astrophysics community since it could unlock the measurement of cross-sections in an environment similar to the astrophysical ones, where the electrons and ions are mostly separated and the electron screening contribution has to be evaluated. A laser experiment is very different from a standard nuclear physics experiment with an accelerator and cold gas, liquid or solid targets. The background induced by a high-intensity high-power laser can in some cases represent a strong hindrance to the study of nuclear reactions, especially at the energies of interest for nuclear astrophysics. To overcome this difficulty, the ToF technique is used since it helps to disentangle the expected signal from the main source of laser-induced background. This is mainly due to the hard-X/gamma peak and the strong electromagnetic pulse (EMP) following the sudden ionization of the target (and the generation of a plasma). While the former can be disentangled by moving far away the detectors provided you have sufficient solid angle coverage, the latter is preventing the use of any sensitive electronics (such as spectroscopic amplifiers, complex integrated devices) sometimes even behind concrete walls. A small review of the ToF detectors commonly used to detect charged particles and neutrons coming from nuclear reactions occurring in such an environment will be given, with a special focus on the nuclear astrophysics case. Some successful results, ongoing campaigns and future projects will be discussed.

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11 Domenico Lo Presti
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Measurement of cosmic muon time of flight for background rejection

The purpose of this measurement is the correct discrimination of near-horizontal tracks. This very tiny flux suffers the noise by upward-going muons. They are particles that seem to come from below the horizontal plane before passing through the telescope so that they perfectly mimic particles that come downwards in the opposite direction and produce a wrong increase of the flux. The TOF module consists of an additional electronic board (TDC-GPX2 evaluation board) which receives the OR signal output of the MAROC3 chip in each board after a delay line, a monostable and a digital level translator. Counting th e time jitter of all elements involved in the TOF measurement chain, the time resolution is about 1 ns.

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12-Agatino Musumarra
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Combining high resolution timing and pulse-shape discrimination towards the next generation detectors for neutron capture measurements at n_TOF (CERN)

Liquid C6D6 (Benzene-d6) has been the scintillation material of choice for performing most of the neutron- capture cross section measurements at CERN n_TOF for more than 20 years. Recently a revamping of solid- state Stilbene scintillator ha s been justified by its good timing performances, no toxicity and excellent neutron-gamma discrimination by Pulse-Shape analysis. Consequently, several measurements were recently performed at the n_TOF facility at CERN to characterize its performances. We benchmarked both regular and deuterated Stilbene scintillation crystals. According with the preliminary results we are starting to develop and design a new generation of detectors with enhanced detection sensitivity and improved safety and maintenance conditions.

13-Stefano Perazzini
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State-of-the art of timing measurement with LAPPD devices

The precise determination of the time-of-arrival of particles on detectors is very important for several applications in high-energy physics (HEP) experiments, as well as in medical imaging devices like PET scanners. In the HEP sector, the increase of instantaneous luminosity foreseen at future particle colliders, poses important challenges to the detectors operating at these facilities. The realisation of devices with few tens of picoseconds of time resolution and capable to operate in high-radiation environment is deemed fundamental to deal with the increased pile-up and fully exploit the discovery potential of the next generation of experiments. The time resolution achievable by microchannel plate (MCP) photodetectors (PMT) makes these devices a very promising technological solution to face this challenge. The Large Area Picosecond PhotoDetector (LAPPD) is the largest MCP-PMT ever built, all made with inexpensive materials, hence suitable also for the instrumentation of large surfaces. Examples of recent timing-measurement applications of the LAPPD in the HEP sector will be presented.

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14-Felix Ulrich-Pur
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Low Gain Avalanche Detectors for Nuclear and Medical Physics

Silicon sensors have been used in experiments for several dozen years, mainly for the accurate measurement of the position of charged particles. However, to deal with the increasing luminosity of particle physics experiments, research and development of those sensors have recently also been focussing on precise time measurements, enabling simultaneous particle tracking with µm resolution and time-of-arrival measurement with tens of ps resolution, so-called 4D-tracking. Currently, the most promising 4D-tracking detectors are based on the Low Gain Avalanche Diode (LGAD) technology, which will be widely used in the construction/upgrades of experimental systems at high and low-energy nuclear physics frontiers such as ATLAS, CMS or HADES and also in medical applications, e.g. in ion beam therapy. Within this contribution, we will present several applications of LGAD strip sensors, which were produced at Fondazione Bruno Kessler (FBK). This includes the reaction time (T0) detector for the High Acceptance Di-Electron Spectrometer (HADES) at GSI in Darmstadt, Germany, a beam-structure monitor for the Superconducting Darmstadt LINear Accelerator (S-DLINAC) at the Technische Universität Darmstadt and an ion imaging experiment conducted at the MedAustron cancer therapy and research centre in Wiener Neustadt, Austria.

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15-Crispin Williams
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Application of TOF techniques to prostate cancer diagnosis

We have built a PET scanner consisting of two planar detectors that are placed above and below the pelvic region of the patient being scanned. We will review the imaging procedure and discuss the importance of accurate time-of-flight information.

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16- Maria Cristina Guarrera
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Time-of-Flight based diagnostics for high-energy laser-driven beams: recent experimental results at VULCAN petawatt class laser facility

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The study of high-power laser-plasma interaction as an innovative particle acceleration technique has recently gained attention from the scientific community. This acceleration scheme opens new scenarios in the framework of compact acceleration systems for both charged and uncharged particles. However, the characterization of the laser-driven beams represents a scientific and technological challenge due to their multiparticle composition, high energy spread (100%), angular distribution (up to 40°) and intensity (up to 10^{12} protons/MeV^{-1} sr^{-1}). The time-of-flight (TOF) technique based on semiconductor (e.g., silicon, silicon carbide or diamond) devices has proven to be a promising methodology to reconstruct in real time the energy spectrum of beams emitted in laser-plasma interaction. In this contribution, the experimental results obtained using a 10-um Silicon Carbide detector placed in a backward direction will be reported. The experimental run was conducted at the VULCAN facility (Rutherford Appleton Laboratory, UK) in a specific acceleration scheme optimized to reduce the proton beam divergency with a long-pulse, petawatt class laser.

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17- P. Lecoq
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Pushing the frontiers of Time-of-Flight resolution: From Hope to Practice

The future generation of radiation detectors is more and more demanding on timing performance for a wide range of applications, covering a large energy spectrum from optical photons to high energy particles produced in collider physics experiments.
There is in particular a consensus for gathering Europe's multi-disciplinary academic and industrial excellence around the ambitious challenge to develop a 10 ps TOF PET scanner (TOFPET). The goal is to reduce the radiation dose (currently 5-25 mSv for whole body PET/CT), scan time (currently > 10 minutes), and costs per patient (currently > 1000 € per scan), all by an order of magnitude. To achieve this very ambitious goal it is essential to significantly improve the performance of each component of the detection chain: light production, light transport, photodetection, readout electronics.
The possibility to reach 10 ps time-of-flight resolution at small energies, as required in PET scanners, although extremely challenging, is not limited by physical barriers.
This talk will show how progress in nanotechnologies open new perspectives for the development of meta-scintillators, a new class of multifunctional multi-intelligent scintillators. Indeed, a number of disruptive technologies, such as multifunctional heterostructures, combining the high stopping power of well know scintillators with the ultrafast photon emission resulting from the 1D, 2D, or 3D quantum confinement of the excitons in nanocrystals, photonic crystals, photonic fibers, as well as new concepts of 3D digital SiPM structures, open the way to new radiation detector concepts with unprecedented performance.
A first generation of metascintillators will be presented (Fig. 1), allowing an improvement by a factor of 2 in time-of-flight resolution (and therefore in PET equivalent sensitivity) as compared to the state-of-the art. Perspectives for an ultimate

gain of 20 (time-of-flight resolution of 10 ps) will be discussed.

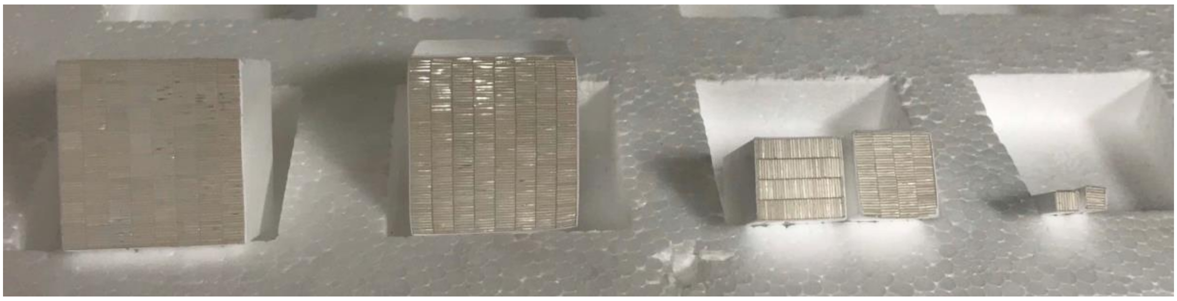

Fig.1: First generation of metascintillators showing: right, 2 LYSO/EJ232 metapixels 3x3x25mm, middle: two 4 x 4 matrices of metapixels, left: 2 8 x 8 matrices of metapixels.

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18-Nunzia Martorana
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FraISe: a new opportunity at INFN-LNS in Catania

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At the Laboratori Nazionali del Sud of INFN (INFN-LNS) the construction of the FraISe (Fragment In- flight Separator) facility is underway. The facility will enable, using the in-flight fragmentation method, to deliver light and medium mass Radioactive Ion Beams (RIBs) in the Fermi energy domain, with intensities of 10^3-10^7 pps [1-5]. FraISe will be a highly competitive facility allowing to further exploring the nuclear physics knowledge, also in uncharted area of the nuclide chart. A key aspect for the RIBs delivering are the beam tuning and the transport, indeed appropriate diagnostics and tagging devices are demanded in a facility using a fragment separator. The diagnostics and tagging systems for the FraISe facility have to operate also in radioactively harsh environments. Moreover, with such systems several features of RIBs, such as the event-by-event composition of the cocktail beam, point-to-point measurement of the cocktail intensity, relative composition, 2D profile, and to some extent angular distribution and trajectory information, have to be measured. In these years, a diagnostics system and a tagging device, especially designed for the CHIMERA multidetector beam line, have been developed. Such systems are based on the SiC technology in order to sustain the intensities achievable with FraISe. Furthermore, relevant timing features for the determination of the RIBs energy by TOF and RIBs composition by the ΔE-TOF method are necessary. For this reason, the diagnostics and tagging devices are also equipped with an optimized fast frontend electronics [6]. In this contribution, we discuss the recent results on the FraISe facility, with a particular focus on the diagnostics and tagging devices.

[1] Russotto P. et al., Jour. of Phys. Conf. Ser., 1014 (2018) 012016 and references therein. [2] Russo A.D. et al., NIM B, 463 (2020) 418.
[3] Martorana N.S., Il Nuovo Cimento 44 C (2021) 1.
[4] Martorana N.S. et al., Il Nuovo Cimento 45 C (2022) 63. [5] Martorana N.S. et al., Frontiers in Physics, 10 (2022).
[6] Altana C. et al., IEEE Nuclear Science Symposium and Medical Imaging Conference 390 (NSS/MIC), 1–4 (2021).

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19. Giada Petringa
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Silicon Carbide detectors for short-pulsed, highly intense beams generated in laser-plasma interaction

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Over the last decades, the interest toward innovative particle acceleration techniques, alternative to conventional methods, has led to a growing effort in the study of high-power laser-plasma interactions as sources of a varied range of particles. Ultra-short multi-megaelectronvolt laser-accelerated ions, if well controlled, could provide a promising alternative tool for dose delivery during radiobiological irradiations. In this framework, the development of novel instrumentation aimed at measuring with good accuracy ion beam characteristics, such as energy distribution, flux, and shot-to-shot reproducibility, represents a crucial step toward obtaining controlled beams, exploitable for applications. Recenlty Silicon carbide (or SiC) detectors have become invaluable tools to detect charged particles produced by laser-plasma interaction. With their unique properties, including wide bandgap, high radiation tolerance, fast response times, and high sensitivity, SiC detectors enable accurate beam diagnostics, profiling, time-resolved measurements, and dosimetry. In this work, the characteristics of the new generation of SiC adopted with laser-driven proton beams will be described. New solutions for the energy spectra, beam profiling and relative dosimetry will be also discussed.

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20- Michela Marafini
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Time Of flight Plastic Scintillators: new fluorophores for timing detectors

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Organic plastic scintillators are largely exploited for fast timing detectors thanks to their short scintillation time with respect to inorganic crystals. Plastic scintillators are cheap to produce, light and easy to manipulate (any standard mechanical workshop can handle the cutting, polishing, etc.). Nowadays, fastest plastic scintillators available on the market are EJ- 232 (Eljen Technology) and BC-422 (Saint Gobain) with a rise time of 350 ps, a decay time of 1.6 ns and a pulse width of 1.3 ns. The timing and light output performances can be exploited in several application (from fundamental particle physics with time of flight and dE/dx detectors up to medical application, i.e. dosimetry). New fluorophores have been produced with the aim of realising very fast scintillating detectors and are now covered by a patent. TOPs samples (Time Of flight Plastic Scintillators) that have been produced show very fast time response. Very high concentrations of primary dopant are achievable (30% and more) and up to now the

best performances are obtained with concentration of 14%. The performance achieved with TOPS samples are extremely promising: a time resolution improvement from 10 up to 35% with respect to the EJ-232 has been demonstrated. In addition, an increase of light output has been obtained for all samples with a consequent potential improvement in energy resolution measurements of a factor up to 35%. Nowadays, 3D printers are more and more employed in detector R&D. We demonstrate that it is possible to exploit the resin material as solvent and to incorporate the scintillator inside the resin. Prototype samples of scintillator dissolved in liquid resin have been polymerised by UV. Irradiation with MIP hallows to conclude that the energy loss (dE/dx) of the muon is clearly contributing to the scintillation response with its typical landau shape.
In order to obtain a plastic scintillator in witch low energy photons (about 100 keV) interact via photoelectric effect it is possible to incorporate Hi-Z elements in the plastic scintillator. The TOPs scintillators can be enriched with Hi-Z elements (first test with Er and Bi): the produced samples show promising results. We demonstrate the feasibility of such a strategy enriching the 2N sample with Bismuth pivalate in a concentration ranging from 1 up to 4%.

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21-Paolo Russotto
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TOF Methods and performances in high segmented multidetector " (co-operative work of INFN CHIRONE experiment)

Fast timing applications in nuclear physics are useful for charge and mass identification using either time of flight or pulse shape methods. Typical performances obtained with the multi-detectors CHIMERA and FARCOS will be shown.

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22-Massimiliano Scisciò
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Fast time-resolved optical and X imaging in laser-matter experiments for nuclear physics and imaging applications

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The interaction of high-power (GW level and higher) laser pulses (from nanoseconds, down to femtoseconds regimes) with matter is exploited for numerous applications, which include particle acceleration [1], laboratory astrophysics [2] and inertial confinement fusion (ICF) [3]. In these fields, , numerous laser systems have been developed over the last decades, implementing laser pulses interacting with solid targets at intensities that, for some applications, even exceed 1020 W/cm2. The interaction drives the generation of a plasma (with temperatures up to the keV level) over a timespan of the same order of magnitude of the laser pulse. These plasmas represent a source of radiation and accelerated particles that can be exploited for imaging techniques at fast time scales. These include, for instance, X-ray contact microscopy for biological samples [4] or high-brightness electron beams for radiographic applications [5]. Moreover, several diagnostic techniques have been developed for a precise characterization of the temporal evolution of the plasma parameters (such as temperature, density and expansion velocity, shockwave velocity), investigating events on the picosecond range, which is the typical time-scale of laser-driven nuclear fusion experiments, where typically nanosecond laser pulses are used. Exploiting the radiation emission of the plasma in the X-ray and visible spectrum, allows obtaining time-dependent images of the plasma profile evolution with a ps resolution, by implementing acquisition systems driven by fast signals, and synchronised with the main laser pulse. Indeed, the development and implementation of these so-called streak-camera based techniques has become a trending topic.

At the laser facility ABC of the ENEA research center of Frascati, which delivers laser pulses with 3 ns duration and up to 100 J energy, several diagnostics for sub-nanosecond measurements are implemented. Shadowgraphy and interferometry of the generated plasma are performed within a sub-nanosecond timeframe. A time-gated multi-channel plate is capable of retrieving X-ray measurements with a resolution in the range of 100 ps. Moreover, a X-ray streak camera (10 ps resolution) and a streak camera for visible light (1 ps resolution) are implemented. These diagnostics are used for ps-resolution imaging of the plasma evolution and time ps-resolved visible spectrometry [6]. They allow investigating the plasma properties on this timescale, representing a crucial tool in various types of experiments. These include applications in the field of laser-driven nuclear fusion, such as laser-driven p-11B reactions, nuclear laboratory astrophysics, and experiments where novel target types and materials for ICF applications are studied, such as so-called foam targets as potential candidates for absorber- ablators.

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State-of-the-art of Time-of-Flight spectrometers used in fission, quasi- fission and multinucleon transfer experiments for the study of heavy and superheavy elements

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Abstract
Fission, quasi-fission and multinucleon transfer reactions in heavy ion collisions at energies around the Coulomb barrier are types of two-body reactions. The observables of main importance are the primary masses of the products and their total kinetic energy. Given the energy and mass respective ranges, the Time-Of-Flight (TOF) method is the detection method of choice because it can guarantee mass and energy resolution of few mass units and around 10 MeV, respectively.
A Time-Of-Flight (TOF) spectrometer is a tool to measure velocities and directions of motion of travelling particles. Usually this is accomplished by using a detector that gives a signal when the particle passes through, the Start detector, followed, at a certain fixed distance, by the Stop detector that gives a signal when the particle hits it. The set of Start and Stop detectors is usually called a TOF arm. In the most advanced spectrometers, the Start detector has a reduced size and can stand high particle rates, while the Stop detector is position sensitive at the scope of measuring, with a fair accuracy, the length of the flight path and the angle of motion with respect to the beam direction. The Start detector is usually not-position sensitive, and the particles do not punch through the Stop detector.
One of the most productive TOF spectrometer is based on the CORSET project [1] which consist of 2 arms, each one containing a Start and a Stop detector. Only the Stop detectors are position sensitive. The time of flight and the position of the fragments in each respective arm along with the two-body kinematics allows the reconstruction of the mass and kinetic energies of the primary fragments. The Start and Stop detectors use a system of microchannel plates to achieve a fast time resolution (~150 ps). It is possible to reach a mass resolution up to 2-4 amu with a flight path of 20 cm.
In the presentation, we will discuss the features of the CORSET spectrometer, and a new implementation of the TOF method, the TOSCA project [2]. This latter is based on a unit which can measure the position of the traveling fragments without stopping them and is equipped with digital electronics. A possible implementation of the TOSCA units in a new type of spectrometer that can also measure the charge

of the ions will be presented as well.

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ToF diamond detector for fast diagnostic in laser driven and fusion plasma experiments.

The detection of radiation emission in laser induced plasma experiments is a powerful method for getting information on the physics of laser-matter interaction. Time-of-flight (TOF) measurements are an effective method to obtain spectra of particles accelerated from laser- generated plasmas. To this respect, diamond TOF detectors are very attractive due to their interesting features like fast signal collection time, signal proportional to the energy deposited by the incident radiation, blindness to visible radiation, radiation hardness and high signal to noise ratio.

TOF detectors based on high quality chemical vapour deposition (CVD) single crystal diamond, in two different configurations i.e. planar and transverse configuration, were fabricated at "Tor Vergata" University of Rome laboratories. A systematic investigation of the main physical properties affecting the diamonds response was carried out, aimed at developing novel diamond detectors specifically designed to measure particles with about 200 ps time precision. Each diamond detector was characterized by using 5.5 MeV alpha particles source and a broad band preamplifier. These CVD diamond detectors were also successfully employed to monitor plasma products generated by high power laser in several experiments performed at INFN-FLAME laser facility, Prague Asterix Laser System (PALS), VEGA 3 laser system.

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Time-of-flight technique in the search of new particles at the SND@LHC experiment

SND@LHC is a compact and stand-alone experiment that performed the first collider neutrino observation at the LHC. The detector, located 480 m from the ATLAS interaction point, is composed of a target region, followed downstream by a hadronic calorimeter and a muon identification system. The target region is instrumented with five walls of emulsion cloud chambers, each followed by a scintillating fiber (SciFi) tracker plane, whose function is to assign a timestamp to the reconstructed events. The physics programme of the SND@LHC exper- iment mainly focuses on measuring neutrinos, but the detector is also capable of performing direct searches for Feebly Interacting Particles. The background from neutrino interactions can be rejected by making a time-of-flight (TOF) measurement. The read-out electronics, based on the TOFPET2 ASIC, has been optimised to meet the stringent time resolution requirements to perform these studies. After an overview of the SND@LHC detector, the talk will focus on the read-out electronics, in particular on the timing measurements, and on the characterisation of their performance, measured both in the laboratory and from collision data.

Provisory to be confirmed:

26-Emanuele-Vincenzo-Pagano

(provisory, to be confirmed) ***Timing-performances of EJ276: standard and green versions.***