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Book of Abstracts

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3D CFD Simulations of LOVA in STARDUST-U Facility

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An Analysis of Generation, Evolution and Self-organization of RF-Excited Trapped Plasmas

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An analysis of generation, evolution and self-organization of RF-excited trapped plasmas

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The dynamics of the flow in magnetized non-neutral plasmas is dominated by the diocotron (Kelvin-Helmholtz) instability, which leads to features like turbulence and self-organization and at the same time yields manipulation opportunities through resonant interaction with external perturbations. Crucial factors in the dynamics and equilibrium of the trapped plasma are the initial conditions and the possible presence of multiple charged species, both of which may be related to the generation

technique, and therefore the evolution of initially quiescent particle distributions has generally been investigated. Both the dynamics and the possible final equilibrium states are dramatically altered when the plasma is generated by means of a strong external forcing leading to residual-gas ionization and continuous production and loss of particles from the confinement region. The measurement of the relevant plasma features, such as density, transverse distribution and temperature is characterized during the evolution of the system using an array of diagnostics that includes both destructive and non-destructive techniques. Measurement and analysis show how the specific features of this forced evolution and the resulting interplay of phenomena occurring over different time scales concur to establish a much more complicated plasma dynamics, characterized by the formation of coherent structures and non-axisymmetric final states that show unexpected robustness properties against common sources of instability.

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An innovative Bifocal Metrology System for Aerospace Application

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In this presentation an innovative space metrology system which objective is to measure the mutual arrangement between two spacecrafts is descripted. It is a simple and robust system that makes possible relative attitude measurements between 2 satellites in formation flying with coarse and fine accuracies. Generally, in formation flying mission it's necessary to have a satellite attitude control whose accuracy depends on their relative distance. The proposed metrology is based on an innovative optical projective system embedded on satellite 1 and a target composed by several light sources mounted on satellite 2. Optical system concurrently projects on a CCD two images of the target and from relative position of the light sources on the CCD image plane it's possible to detect position and attitude of the S2. Basic element of innovation of this versatile metrology concept is the possibility to work on a very large S/Cs range distance (~10m-15 Km) and to determinate the relative attitude and position of two spacecrafts on all six degree of freedom in a very simple and fast way.

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BAND-GEM Detectors for Loki@ESS

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Characterization of Proton & Ion Beam Profiles from Laser Ultra-thin Foil Interactions

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Cloud Technologies in High-Energy Physics Data Processing

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In the last decade, cloud computing has overtaken grid computing as a paradigm of distributed data storage and processing systems at the largest scales. The top commercial cloud providers today operate distributed systems at a significantly larger scale than even the biggest high-energy physics (HEP) collaborations. Some of the cloud computing innovations (such as object storage, infrastructure-as-a-service, or NoSQL databases) have been successfully adopted by HEP in preparation for upcoming data sets at the exabyte scale. Other innovations, such as the Hadoop data analytics system, are not easily applicable to HEP data sets, which might come as a surprise. An exciting field of current research is focused on how the needs of scientific data processing workflows differ from industrial needs, and how we can ensure that our academic distributed systems stay at the technology forefront.

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Conceptual Design of a Neutron Diagnostic for 2-D Deuterium Power Density Map Reconstruction in MITICA

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Density Measurement of Hydrogen Plasma by Optical and Acoustic Methods

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Detection of Alimentary Frauds by Laser Spectroscopy

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Detectors for Neutron Spactroscopy Scattering Science

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Development and High Temperature Testing by 14 MeV neutron irradiation of Single Crystal Diamond Detectors

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Development of a Digital Method for Neutron-gamma Discrimination Based on Matched Filtering

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Diagnosing the ICF Targets

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Diagnosing transient plasma status: from solar atmosphere to tokamak divertor

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The emission of the solar upper atmosphere reflects time-dependent and non-equilibrium effects due to plasma dynamics (e.g. flares, solar transition region). Simplified models which imply zero density approach (coronal picture) and ionisation equilibrium are often adopted in the analysis of the observed spectra.
However, in dynamic plasmas, the ionisation states are not relaxed to local thermal conditions. Additionally, at chromosphere/transition region boundary, the higher densities modify the atomic populations through redistribution and the recombination and ionisation rate coefficients are affected by step-wise processes.
The present work addresses such issues using the Generalised Collisional-Radiative (GCR) theory, as implemented in the Atomic Data and Analysis Structure (ADAS), together with the most accurate atomic data available.
This approach has enabled the extension of diagnostic techniques, such as line ratios and emission measure, to the investigation of low temperature/high density layers of the solar atmosphere, with validation by recent observations, leading to a fresh methodology for the detection and assessment of non-equilibrium processes in the solar upper atmosphere.
These techniques are introduced for the analysis of a flare observed using the Ultraviolet Spectrometer and Polarimeter (UVSP), on-board the Solar Maximum Mission (SMM), and for their diagnostic potential in support of the Interface Region Imaging Spectrograph (IRIS) and the Spectral Imaging of the Coronal Environment (SPICE), on-board the forthcoming space borne satellite Solar Orbiter.
It also strongly exploits the interdisciplinary links between astrophysical and laboratory (such as tokamak devices) plasmas, sharing the development of the common modelling for the time-dependent ionisation study, which is applied to the interpretation of the data from B2-SOLPS simulations in the context of MAST Super-X divertor upgrade. The derived atomic data allow equivalent prediction in non-stationary transport regimes and transients of both the solar atmosphere and tokamak divertors, except that the tokamak evolution is about one thousand times faster.

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Diagnostic Techniques and Technologies for next JET D-T Campaigns with a view on ITER and DEMO

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Diagnostic measurements and technologies at the STAR electron-photon collider

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Diagnostics for JET DT2 Experiments

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Dielectric and Conductive Probe Measurements of Electromagnetic Pulses from Interaction of Nanosecond ABC Laser with Targets

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Digital Pulse Processing for Nuclear Research, Security and Applications

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Digital Pulse Processing for Nuclear Research, Security and Applications

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Digital sampling technique has become common in many applications as homeland security and nuclear medicine as well as in research fields of nuclear and particle physics. Digital sampling devices can represent multichannel oscilloscopes, but at the same time they can implement algorithms, traditionally operated by analog devices, in Field Programmable Gate Arrays (FPGAs). The success of the digital sampling devices is linked to the ability of their algorithms to be adapted to changing experimental conditions, experimental system upgrades and to operate data reduction through programmable on-board operation. Applications and observed performances of CAEN digital acquisition devices are going to be presented.

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Dr

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JET next D-T campaign is presently scheduled for the year 2019. The main scientific objectives include the assessment of the isotopic effects on various plasma aspects: mainly on confinement, on the threshold to access the H mode and on ELM behaviour. From a technical point of view, the total yield of the entire D-T phase is expected to be 1.7 1021 neutrons, about a factor of six higher than the previous main D-T campaign on JET, DTE1. Therefore the radiation field will be quite relevant for next step devices, since the neutron flux at the first wall (~1016n/cm2s), for example, will be comparable to the one in ITER behind the blanket.
In terms of diagnostics developments, for many years JET diagnostics have been upgraded in order to provide adequate support for the scientific exploitation of a D-T campaign. The main efforts have concentrated on improving three main aspects of JET measuring capability: 1) the quality of the measurements to support the plasma physics programme 2) the diagnostic for the fusion products

3) diagnostic technologies for ITER and DEMO.
In terms of general diagnostic capability, compared to the previous DTE1, JET diagnostics have a much better spatial and temporal resolution of both the ion and electron fluid (about one order of magnitude improvement for each parameter). The consistency of the various independent measurements of the same parameters has also increased significantly; the three independent measurements of the electron temperature, for example, agree now within 5%. Moreover, solutions are being addressed to operate some cameras, both visible and IR, even during the full D-T phase to provide imaging of the plasma and the first wall. Various upgrades of neutral particle analysis are being considered, mainly to measure the isotopic composition.
With regard to the fusion products, JET now can deploy a consistent set of techniques to measure the neutron yield and neutron spectra and to diagnose the fast particles. A full calibration of the neutron diagnostics with a 14 MeV source is being prepared, after the recent very successful calibration for the 2.45 MeV neutrons. Vertical and horizontal lines of sight are foreseen for neutron and gamma spectrometry, in order to better determine the thermal neutron yield and to separate the trapped and passing components of the alphas. Various gamma ray spectrometers are being developed to cover all the various operational scenarios, from trace tritium to 50-50 D-T operation. The redistribution of the alphas will be measured with the gamma ray cameras, recently upgraded with full digital electronics; new detectors are being considered to bring the time resolution of the system in the ten of ms range. The lost alphas will also be diagnosed with improved spatial and temporal resolution, using Faraday cups and a scintillator probe.
From a technological perspective, the D-T campaign will provide a unique opportunity to test ITER and DEMO relevant technologies. From radiation hard detectors, for example Hall probes, to neutron absorbers and to shielding concepts, the potential of various solutions in a realistic 14 MeV radiation field will be assessed. The effects of neutrons and gamma on ancillary technologies and systems, such as fibre optics and electronics circuits, are also expected to be sufficiently high to derive useful information about the competitive advantage of various alternatives.

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Driving Earth Observation Open Science and Innovation in the Digital Age.

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Dual-Frequency Single-Beam Polarimetry for Plasma Internal Magnetic Field Measurements

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Electronic Solar Compass for High Precision Orientation on any Planet

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Electronic solar compass for high precision orientation on any planet

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A compact fully automatic electronic solar compass has been developed at the ENEA Frascati laboratories. The compass is inspired to "camera obscura" sundials like those inside churches. Sun ephemerides are calculated using a approximate but effective analytical solution of Kepler's equations where the Earth (or other planets) orbit main parameters are introduced. The instrument is light, cheap and it reaches an accuracy of 1 arcminute. Some examples of application of the device as well as the possibility to use it on Mars will be presented.

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Fast Rise Time IR Detectors for Lepton Storage Rings

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Fast rise time IR detectors for lepton storage rings

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GEM Detectors for WEST and Potential Application for Heavy Impurity Transport Studies

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GEM Detectors for WEST and Potential Application for Heavy Impurity Transport Studies

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GEM detectors for WEST and potential application for heavy impurity transport studies

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In Tokamaks, plasma emits as a volumetric Soft-X-Ray (SXR) source. Emitted X-rays can give very useful information about plasma stability, shape and impurity content. In the particular case of tokamaks equipped with metallic walls, mainly Tungsten, the interplay between particle transport and MagnetoHydroDynamic (MHD) activity might lead to impurities accumulation and finally to sudden plasma termination called disruption. Studying such phenomena is thus essential if stationary discharges are to be achieved.

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IR Diagnostics for Fusion Reactors

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IR Diagnostics on Fusion Reactors

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ITER perspective on fusion reactor diagnostics - A spectroscopic view

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The ITER tokamak requires diagnostics that on the one hand have a high sensitivity, high spatial and temporal resolution and a high dynamic range, while on the other hand are robust enough to survive in a harsh environment.

In recent years significant progress has been made in addressing critical challenges to the diagnostic development. This presentation uses the spectroscopic diagnostics of ITER to highlight these challenges and the proposed solutions:

- First mirror protection and cleaning: First mirror in ITER are subject to a significant particle flux from the plasma, leading to erosion of and deposition on the mirror. R&D is progressing on techniques to reduce the plasma flux (shutters, custom geometries & baffles, gas puffing …) and to recover the optical properties of damaged mirrors.
- Nuclear confinement: ITER is a nuclear device and its vacuum vessel also provides the primary nuclear confinement. In order to extract the spectroscopy signals from the plasma, while ensuring all (safety) requirements on the confinement, several optical, mechanical, fluid and electrical feedthroughs that are nuclear grade and at the same time optimized for diagnostic use are under development. Also for vacuum spectroscopy systems, vacuum extensions, fulfilling the nuclear requirements are being assessed.
- Radiation mitigation strategy for optical and electronic components: At full power DT operation ITER will produce significant neutron and gamma fluxes, causing a significant radiation load on the components of spectroscopy systems located close to the plasma. The expected effects on optical and electronic components are being assessed and strategies to mitigate the impact of radiation on the performance of the spectroscopic diagnostics are developed.
- High resolution/sensitivity detection: Due to the 3 items mentioned above, the signal reaching the actual spectrometer/detector can be significantly attenuated. Spectrometer/detection systems are, therefore developed that aim at a high throughput and detection sensitivity while keeping a high spectral resolving power.
- Calibration strategies: Access to the ITER vessel is severely limited. Techniques are investigated allow both 'off-line' and in-situ calibration of wavelength and intensity. This includes recent developments in X-ray sources (compact EBIT), (quasi-)real time calibration, exploitation of the full spectral information et cetera.
  This contribution presents an overview of recent achievements in the above mentioned topical areas.

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Importance of Energy-Angular Resolution in Top-Hat Electrostatic Analysers Measurements

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Invisible Marking System by Extreme Ultraviolet Radiation: the New Frontier for Anti-counterfeiting Tags

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LIBS Application to Deposited Layers Diagnostics in Fusion Machines

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LIBS application to deposited layers diagnostics in fusion machines

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Laser Induced Breakdown Spectroscopy (LIBS) is nowadays a well established tool for qualitative, semiquantitative and quantitative analyses of surfaces, with micro-destructive characteristics and capabilities for stratigraphy. LIBS is an appealing technique compared with many other types of elemental analysis thanks to the set up versatility facilitating non-invasive and remote analyses, as well as suitability to diagnostics in harsh environments. LIBS capabilities have been tested for the determination of the atomic composition of multilayered samples simulating the tiles of plasma facing components in the next generation fusion machines such as ITER [1]. Experiments were carried on in a test chamber designed and realized in order to optimize the characteristics of a LIBS system working in vacuum and remotely [2], which simulated the in situ operation needed for monitoring the erosion and re-deposition phenomena occurring on the inner walls of a fusion device. The effects of time delay and laser fluence on LIBS sensitivity at reduced pressure were examined, looking for operational conditions suitable to analytical applications, both as surface characterization and stratigraphic profiles. The quantitative analysis of some atomic species in the superficial layer has been carried out using a Calibration Free (CF) approach in the time window where Local Thermal Equilibrium (LTE) was assumed for an LIBS analysis. Results obtained on ITER-like tiles where D atoms were implanted demonstrated a performance suitable to determine D concentration within the accuracy needed for the specific in situ application.
First experiments on FTU have demonstrated the remote application of the LIBS technique to detect major surface components also in the presence of intense magnetic fields.
Double pulse experiments, carried out in cooperation with the Institute of Plasma Physics and Laser Microfusion of Warsaw, allowed to increase the detection sensitivity in order to detect hydrogen isotopes at concentration of the order of 1%.

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LIDAR Sensing for Enviromental Science

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Laser Sensing of Explosives, IEDs and Precursors

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Laser-Accelerated Ions and Electrons at LMJ/PETAL

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Last Developments in Tomographic Reconstructions for the Exact Sciences

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In thermonuclear plasmas, emission tomography use integrated measurements along lines of sight (LOS) to determine the two-dimensional (2-D) spatial distribution of the volume emission intensity. The technique can be applied to gamma-ray, neutron, soft and hard X-ray emissions. The measurements are line integral data obtained by arrays of collimated detectors looking through the plasma along different LOSs at different orientations. Due to the availability of only a limited number views and to the coarse sampling of the LOS, the tomographic inversion is a limited data set problem. In order to compensate for the lack of experimental data additional a priori information that is usually incorporated in the objective function. Successful approaches in JET are based on different statistical

principles (like e.g. minimum Fisher information, maximum likelihood) and on constraints which imposes smoothness of the reconstructed distributions along the magnetic profiles.
The problem of evaluating the errors associated with the reconstructed emissivity profile is a still open one. Recently a method for the numerical evaluation of the statistical properties of the uncertainties in reconstructions has been developed. It has been used first for gamma and neutron emissivity reconstruction and further applications to other diagnostics are currently under development.
Apart from the noisy data, the final reconstructed image quality also depends on the constraints imposed for the compensation of the restrictive measuring geometry. The occurrence of specific induced artefacts has been assessed in order to avoid wrong interpretations of the results.
In specific experimental conditions, the availability of LOSs is restricted to a single view. In this case an explicit reconstruction of the emissivity profile is no longer possible. However, machine learning classification methods can be used in order to derive the type of the distribution [1-2]. In the present approach, following an idea introduced in [3], the classification is developed using the theory of belief functions which provide the support to fuse the results of independent clustering and supervised classification. The results of the learning in supervised classification depend on the method and on the parameters chosen. Moreover the learning process is particularly difficult when few or imprecise learning data is available. The unsupervised classification is more complex due to the absence of class labels. The synergy of supervised and unsupervised classification provide improved results for the case of JET gamma tomography using one view (measurements provided only by the vertical camera – case specific to DT campaigns) when using a one-vs-all SVM as supervised classifier and KNN as the unsupervised clustering algorithm. The information fusion based on the belief function framework allows to represent the uncertainty of the results of the clustering and supervised classification and to combine the results managing the conflict.

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Machine Learning for Scientific Applications

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Machine learning for scientific applications

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ABSTRACT
At present, a major problem in many scientific fields is not the lack of data but the amount of stored data (that includes waveforms and video-movies). All the data are of no value without mechanisms to efficiently and effectively extract information and knowledge from them. Data mining is the scientific discipline to deal with this. The main distinguishing characteristic of data mining is its "data

driven" nature, as opposed to other methods that are often "model driven". In statistics, researches frequently try to find the smallest amount of data that gives sufficiently confident estimates. In data mining, we intend to use the opposite approach, namely, we are interested in building a model that is not too complex but at the same time describes the entire database.
Data mining techniques use machine learning. The formulation of a learning problem is rather broad. It encompasses many specific disciplines but this introductory talk will only consider the ones related to pattern recognition (SVM, neural networks, clustering and combination of classifiers) and regression estimation (SVR). Concepts and methodologies will be presented. Also, different ways of estimating the accuracy and reliability of the predictions will be mentioned (Bayes classifiers, logistic regression, conformal predictors, Venn predictors and ridge regression confidence machines). Finally, general ideas about advanced techniques (active learning) and specific applications to nuclear fusion will be shown.

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Measurement of RF-excited non-neutral plasmas in Penning-Malmberg traps

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Magnetized non-neutral plasmas confined in electro-magnetostatic traps represent a somewhat simplified system with respect to quasi-neutral plasmas such as those found in high-pressure discharges or fusion machines. At the same time these plasmas retain many physical properties (Kelvin-Helmholtz instabilities, transport, turbulence) of the latter systems while offering enhanced confinement and diagnostic opportunities. In particular, the interpretation and modelling of physical phenomena in these plasmas is made easier by the choice of clean (single-species), quiescent initial conditions. On the contrary, very different dynamics and equilibrium states take place when this condition does not hold, for instance when the plasma is generated by means of a strong external forcing leading to residual-gas ionization. The presence of radio-frequency (RF) excitation and of multiple charged species greatly affects the existence and the path to an equilibrium state, and at the same time the identification of the role of the various phenomena taking place is made much more difficult. As a consequence, the support of extensive experimental measurement is of paramount importance in order to support a correct modelling of the whole system evolution. We discuss the integration of a systematic measurement campaign based on optical and electrostatic diagnostics of plasma properties (charge, density profile and energy) allowing us to track the evolution and most peculiar features of RF-generated and continuously excited trapped plasmas.

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Measurements of Fluctuations in Tokamak Plasmas

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(Conference Title: Measurements of Fluctuations in Tokamak Plasmas)
Optical Imaging Measurements of Turbulence and Instabilities in Tokamak Plasmas*
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Abstract:

Magnetically confined fusion-grade plasmas exhibit a wide range of macroscopic and microscopic instabilities that strongly impact their performance, particle and energy confinement, and stability. The combination of large density and temperature gradients, populations of multiple species of thermal and energetic particles, and magnetic geometry drive instabilities that result in turbulence and magneto-hydrodynamic instabilities over a range of scales. Characterizing, understanding, predicting, and controlling turbulence and its resulting transport is of central importance to fundamental plasma physics and is critically important to the development of fusion energy. Because of the high temperatures typically encountered in tokamak plasmas (T ≤ ~ 10 keV, ~100,000,000 K), remote sensing technologies are typically required to measure the parametric behavior, spatiotemporal characteristics, and complex dynamics and interactions of these instabilities. Active and passive optical, microwave and beam-based techniques have therefore been developed and exploited to diagnose plasma instabilities. We focus here on measurements of density and temperature fluctuations utilizing optical emissions from a hydrogenic neutral beam (~1-3 MW, E~30-45 keV/amu) that is injected to heat, fuel, rotate and drive current in toroidal plasmas. Via appropriate viewing geometry with respect to the neutral beam, magnetic flux surfaces and field lines, high spatial resolution measurements of low-wavenumber, ion gyroscale instabilities can be obtained. Beam Emission Spectroscopy (BES) and Ultra-Fast Charge Exchange Recombination Spectroscopy UF-CHERS) diagnostics have been developed to measure density and ion temperature, respectively. BES measures Balmer-alpha (n=3-2) photons emitted from collisionally excited neutral beam atoms. UF-CHERS observes Doppler-broadened charge exchange emission from intrinsic carbon impurity ions (CVI, n=8-7). Critical diagnostic requirements include achieving adequate spatial resolution as well as high photon flux, which insures that photon noise dominates electronic noise and also maximizes sensitivity to low-amplitude fluctuation signals; normalized fluctuation amplitudes are typically ñ/n<1% in the core regions of high-performance plasmas with frequencies f<1 MHz. Sufficient SNR is achieved with high throughput and high-transmission optical systems, high-quantum-efficiency PIN photodiode or APD detectors, specialized low-noise, high-gain preamplifiers and high-transmission narrow band interference filters (BES) or a prism-coupled volume phase holographic transmission grating (UF-CHERS). Measurement capabilities include identification of turbulence and energetic particle mode characteristics and evolution, equilibrium and high-frequency flows, turbulence imaging, turbulence and flow dynamics across transport bifurcations, and parametric dependence of turbulence on key plasma parameters such as rotation and magnetic shear, normalized plasma pressure, and electron-to-ion temperature ratio. Measurements are compared with nonlinear simulations that are used to predict plasma transport behavior in next-generation burning plasma experiments. Developmental ideas for future optical diagnostic concepts, such as employing Lyman-alpha based emission to achieve higher signal-to-noise and improved spatial resolution, will be introduced.

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Neutron Spectroscopy for Fusion Experiments

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New Analysis Methods to Push the Boundaries of Diagnostic Techniques in the Environmental Sciences

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New Technique for the Measurement of Electron Temperature in Fusion Reactor Plasmas

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On Determining the Prediction Limits of Mathematical Models for Time Series

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On Determining the Prediction Limits of Mathematical Models for Time Series

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Prediction is one of the main objectives of scientific analysis. Prediction in this sense refers to both modelling and forecasting. The determination of the limits of predictability is an important issue of both theoretical and practical relevance. In the case of modelling time series, reached a certain level in performance in either modelling or prediction, it is often important to assess whether all the information available in the data has been exploited or whether there are still margins for improvement of the tools being developed. In this paper, a new information theoretic approach is proposed to address this issue and quantify the quality of the models and/or predictions. The excellent properties of the developed indicators have been proved with the help of a systematic series of numerical tests

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Optical Imaging Measurements of Turbulence and Instabilities in Tokamak Plasmas

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Perspective of Diagnostics for Fusion Reactors Seen from ITER Side

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Perspective of diagnostics for fusion reactors seen from ITER side

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Perspectives of Quantum Light: from Quantum Computer to Future Quantum Communications

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Perspectives of Quantum Light: from Quantum Computer to Future Quantum Communications

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The main objective of quantum information consists of understanding the quantum nature of information and learning how to process it by using physical systems operating under the laws of quantum mechanics. In this perspective, completely new schemes of information transfer and processing, enabling new forms of communication and enhancing the computation and simulation power, are currently developed, with a beneficial impact in the design of new scientific strategies.
Among the different platforms quantum photonics represents an excellent experimental test bench for various concepts introduced within the framework of quantum information theory. However the realization of interferometric optical schemes of increasing complexity requires the introduction of integrated waveguide technology to achieve the desired scalability, stability and miniaturization of the devices.
In this talk, after a brief introduction on the fundamental concepts of quantum information, I will present the main results obtained by our group with the use of integrated quantum circuits.

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Perspectives of Quantum Light: from Quantum Computer to Future Quantum Communications

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Photon Pulse Characterization of FERMI Free Electron Laser

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Photon pulse characterization at FERMI Free Electron Laser

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The advent of X-ray Free Electron Lasers (FEL) has opened a new era for exploring the fundamental laws of matter. These machines combine the exceptional properties of conventional lasers (ultra-short, brilliant, coherent, and transform limited pulses) and synchrotrons (short and selectable wavelengths, different polarizations), allowing to probe the ultra-fast dynamics of atoms and molecules in simple and complex systems at a nano-scale level. Among the FELs built and put in operation worldwide in the last years, FERMI (Trieste - Italy) represents the only EUV/Soft X-Ray FEL user facility that takes advantage of the High Gain Harmonic Generation scheme. In this scheme, an external EUV "seeding" laser is used to manipulate the electron bunch so to end up with an FEL emission that inherits the stability and coherence properties of the seed laser itself. In this way FERMI is capable of generating coherent ultra-bright and ultra-short photon pulses that can also present full polarization (linear horizontal or vertical, circular right or left.
In order to optimize the machine and let the users know the detailed parameters of the FEL radiation, a dedicated set of diagnostics is installed along the photon beam transport system. In particular, every pulse is characterized online and shot-to-shot for what concerns its intensity, spatial/angular distribution and position, and spectral content. Moreover, it is possible to determine the polarization, coherence, and pulse length of the FEL emission by means of more elaborate diagnostic tools used in dedicated time slots.
In this presentation the FERMI FEL emission process as well as the diagnostics used to characterize the properties of the different pulses will be presented and discussed.

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Photon pulse characterization of the FERMI free electron laser

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Photonics for Next Generation Data Centers

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Positron Emission Tomography: State of the Art and Future Developments

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Recent Advances in Optical Communications for Physics

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We review our most recent results in Optical Communications that can be applied to research in Physics, covering mostly high eenergy physics and medical physics.

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Recent Advances in Biomedical Optoacoustic Tomography"

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Recent Advances in Optical Communications for Physics

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Recent Development in the Thomson Parabola Spectrometer Diagnostic for Laser-Drivern Multi-Species Ion Sources

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Recent Progress in Diagnostics Development for Laser Driven Fast and Epithermal Neutrons

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Recent developments in the Thomson Parabola Spectrometer diagnostic for laser-driven multi-species ion sources

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Ongoing developments in laser-driven ion acceleration, in synergy with the currently available/upcoming multi-Petawatt laser facilities around the world, would foster in a near future the frontier of ion energies to multi-100 MeV range. Development of diagnostics to cope with such high-energy, multi-species ion sources is highly warranted and timely. Thomson Parabola Spectrometers (TPS) [1] have been widely used for spectral characterization of such ion sources. Although the TPS has the unique ability of dispersing ions simultaneously depending on their energy and charge to mass ratios (Z/A), it has several intrinsic limitations, such as (i) inability to discriminate between ions with same Z/A, for instance between D+ and C6+ ions while using deuterated plastic targets to study bulk acceleration, (ii) low resolution and overlapping of ion traces at high energies, (iii) single line of sight measurement, typically of extremely small solid angle (nSr-□Sr). A review of recent (progressive) developments on the TPS diagnostic to deal with these shortcomings will be presented, such as (i) using differential filtering techniques [2] to retrieve spectra of ion species with the same Z/A ratio, (ii) extended, trapezoidal electric plates to achieve high energy-resolution at high energies without sacrificing the lower energy part of the spectrum [3,4], and further development into a novel multi-pinhole TPS design, that would allow angularly resolved, complete spectral characterization of the multi-species beam.

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Recent progress in diagnostics development for laser driven fast and epithermal neutrons

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Abstract:
Neutrons generated using intense laser driven ion beams has recently received a great deal of attention. Intense lasers can produce 10s of MeV protons in a small divergence cone by Target Normal Sheath Acceleration (TNSA) mechanism, which is highly efficient in producing fast neutrons via fusion reaction with low mass atomic nuclei. Employing neutron converter in a close proximity to the ion source, a beamed neutron flux can be obtained [1] which is highly suitable for a range

of application, such as neutron therapy [2], material testing [3]. Laser driven short neutron bursts can also be efficiently moderated to thermal and epithermal region for a wide range of applications, such as imaging [4], nuclear resonance spectroscopy [5], Boron neutron capture therapy [6] etc. A review of recent developments in neutron diagnostics made by our group will be presented. Plastic scintillators in a time-of-flight arrangement are most widely used spectrometers for fast neutrons. Absolute calibration of three types of plastic scintillators (such as EJ232Q, BC422Q and EJ410) in a time-of-flight arrangement using laser driven neutrons will be presented, which was obtained against gamma insensitive, absolutely calibrated bubble detector spectrometer fielded in-situ [7]. High flux of Epithermal neutron were produced using a compact moderator in an recent experiment at Rutherford Appleton laboratory employing 100 TW Vulcan. Spectral and spatial profiles of the epithermal neutrons were measured respectively by 3He proportional counters and Kodak LR films backed by boron nitride sheet. The epithermal neutrons flux measured by the both diagnostics are in agreement, which is comparable to the state-of-art epithermal flux currently delivered at the sample locations in many large-scale spallation facilities.

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Reproduction and Modeling of Vacuum Failures Inside STARDUST-U

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Results and Diagnostic Technologies from the U.S. National Ignition Facility

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The National Ignition Facility (NIF) at the Lawrence Livermore National Laboratory (LLNL) is the world's largest and most energetic laser system. The NIF is built to create very extreme states of matter - temperatures more than 100 million K and pressures more than 100 billion atmospheres - conditions emulating those found in the interiors of stars and planets. One of the main NIF campaigns is focused on demonstrating thermonuclear burn in the laboratory by laser inertial fusion.

Rapid progress is being made, with recent experiments demonstrating fuel gains > 1 (more fusion energy generated than delivered to the fuel) and significant alpha heating. The diagnostic suite is an impressive one – with over 60 instruments simultaneously recording x-rays, gamma rays, optical signals and neutrons to explore the physics of inertial fusion. We will discuss these diagnostic technologies and the accompanying target platforms that have made these advances possible.

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Results and Diagnostic Technologies at U.S.A. National Ignition Facility

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Results and Diagnostic Technologies at U.S.A. National Ignition Facility

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Runaway Electron Diagnostics in FTU

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Runaway Electron Diagnostics in FTU

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Self-Phase Modulation Effects as Laser Produced Plasma diagnostics

Author: Danilo Giulietti[1]

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Self-Phase Modulation Effects as Laser Produced Plasma diagnostics

Author: Danilo Giulietti[1]

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High intensity laser radiation propagating in a plasma suffers deep changes concerning both its spatial and spectral distribution. These changes can give information about the kind of the developed interaction. In particular the Self Phase Modulation (SPM) of the impinging laser radiation is currently used to evidence fast variation of the electron plasma density, produced for example by the target ionization or poderomotive forces. The SPM effects dramatically increase as the laser pulse decreases and this is the reason for why they have to be specially considered in the experiments in which femtosecond laser pulses are used.

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Self-phase Modulation as Diagnostic in Laser Produced Plasmas

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SiC Detectors for Radiation Sources Characterization and Fast Plasma Diagnostics

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Spectroscopic Measurements of Plasma Emission Light for Plasma-based Acceleration Experiments

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Spectroscopy as a key diagnostic tool in astrophysics

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Stand off optical systems for chemical detection and identification tool to improve public security

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Nowadays the intentional diffusion in air (both in open and closed environments) of chemical and biological contaminants presents a dramatic risk for the health of the public worldwide. The needs of a high-tech network composed by diagnostics, software, decision support systems and cyber security tools are urging all the stakeholders (military, public, research & academic entities), who are working on the subject, to develop innovative solutions to face this problem. The Quantum Electronics and Plasma Physics (QEP) Research Group is working since the 1960s on the development of laser-based technologies for the stand-off detection of contaminants in the atmosphere. Actually, four demonstrators have been developed (two LIDAR-based and two DIAL-based) and have been deployed in experimental campaigns during 2015. These systems have the demonstrated capability to detect and/or identify chemical substances in different environmental conditions. All the apparatuses developed will be presented together with a critical analysis of the data collected.

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Stochastic Calibration of Fast Sampling Air Quality Multisensory Systems

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Support Vector Regression for first Analysis of Time Series

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In the last years, new and more sophisticated measurements have been at the basis of the major progress in various disciplines related to the environment, such as remote sensing and thermonuclear fusion. To maximize the effectiveness of the measurements, new data analysis techniques are required. First data processing tasks, such as filtering and fitting, are of primary importance, since they can have a strong influence on the rest of the analysis. Even if Support Vector Regression is a method devised and refined at the end of the 90s, a systematic comparison with more traditional non parametric regression methods has never been reported. In this paper, a series of systematic tests is described, which indicates how SVR is a very competitive method of non-parametric regression that can usefully complement and often outperform more consolidated approaches. The performance of Support Vector Regression as a method of filtering is investigated first, comparing it with the most popular alternative techniques. Then Support Vector Regression is applied to the problem of non-parametric regression to analyse Lidar surveys for the environments measurement of particulate matter due to wildfires. The proposed approach has given very positive results and provides new perspectives to the interpretation of the data.

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Swarm - Europe's Magnetic Field and Geospace Explorer Mission

Recent Advances in Plasma Diagnostic / 137

THz Diagnostics for Art Conservation at the ENEA Center of Frascati

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THz Plasma Diagnostics: an Evolution from FIR and Millimeter > Waves Historical Applications

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THz Plasma Diagnostics: an Evolution from FIR and Millimeter Waves historical Applications

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THz diagnostics for art conservation at the ENEA center of Frascati

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The electromagnetic radiation, in the range from IR to X-rays, is widely used in the field of art conservation and diagnostics. In the last few years a new interest was devoted to the longer wavelengths, in the so called "THz region" of the spectrum, due to the peculiar characteristics of the radiation in this spectral range, that make it ideal for applications in this field [1]: it's low photon energy and its ability to penetrate dielectric materials. This high penetration capabilities were used to demonstrate the possibility to detect artwork hidden under layers of other dielectric materials [2, 3, 4]. Making use of phase-sensitive techniques it is also possible to get information on the optical properties of the materials under study and to obtain images that include spectroscopic information about the sample [5].

The realization of new radiation sources in this region was the key to develop new techniques to be applied to the field of art conservation. New technologies were able to fill the so called "THz gap" with both free electron source and laser drive sources. At present a wide choice of THz radiation source are available to researchers. A certain number of such sources are at present available at the THz laboratories at ENEA-Frascati and they were used to develop imaging systems for mural paintings in the framework of the Italy-Japan bilateral project "THz-ARTE" [6].
The main applications developed in this project will be shown, including a new 3D scanning system developed for mural painting, tested on a real "fresco on tavella" by Alessandro Gherardini.

ACKNOWLEDGMENTS
We gratefully acknowledge the "Ministero degli Affari Esteri e della Cooperazione internazionale" for funding the THz-ARTE project and the Museum of San Marco, Florence, for having allowed the access and measurements on Gherardini's painting .

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TOF Diagnostique of Tin Resonant Laser Photoionization in SPES Laser Offline Laboratory

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TRANSLATING 3D OPTOACOUSTIC TOMOGRAPHY: FROM PRE-CLINICAL RESERACH TO CLINICAL TRIALS

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This lecture will discuss development and translation of optoacoustic imaging from the first works that set the basic principles of the technology to the first in vivo images in small animals, to the most recent advances in diagnostic imaging of breast cancer. We also present the design features and technical parameters of the optoacoustic imaging systems required for clinically viable devices. Finally we will present our vision of the future medical imaging modalities and their applications in the main stream medicine.

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Target Technology Used in U.S.A. inertial Fusion Program

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Target Technology Used in U.S.A. inertial Fusion Program

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Terahertz and infrared radiation in III Generation synchrotron machines and Free Electron Laser: from the production to the use for spectroscopy and diagnostic

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The free-electron laser FLASH2: Challenges for photon diagnostics and beamline design

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FLASH2, a major extension of the soft X-ray free-electron laser FLASH at DESY, turns FLASH into a multi-user FEL facility. First lasing of FLASH2, this new undulator line driven additionally by the FLASH linear accelerator, was achieved in August 2014 with simultaneous user operation at FLASH1. The wide wavelength range of FLASH spans from approximately 4.2 - 60 nm in the fundamental and down to below 1 nm in the 5th harmonic with pulse energies of up to several hundred µJ and pulse lengths in the tens to hundreds of femtoseconds range. While of high interest to users, these pulse parameters pose great challenges from the photon diagnostics and beamline instrumentation point of view. Online diagnostics for beam intensity, position, wavelength, wave front, and pulse length, which are mostly pulse resolved, have been developed at FLASH1 and have now been optimized for FLASH2. The new FLASH2 experimental hall offers space for up to six experimental end stations, some of which will be installed permanently. Pump-probe facilities for XUV-XUV, XUV-optical and XUV-THz experiments will complete the FLASH2 user facility.

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The free-electron laser Flash2: Challenges for photon diagnostics and beamline design

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Tomographic Capabilities of the new GEM based SXR diagnostic of WEST

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The tokamak WEST (Tungsten Environment in Steady-State Tokamak) will start operating by the end of 2016 as a test bed for the ITER divertor components in long pulse operation. In this context, radiative cooling of heavy impurities like tungsten (W) in the Soft X-ray (SXR) range [0.1 keV; 15 keV] is a critical issue for the plasma core performances [1]. Thus reliable tools are required to monitor the local impurity density and avoid W accumulation.

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Tomographic Capabilities of the new GEM based SXR diagnostic of WEST

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Waste Processing

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Waste processing: new near infrared technologies for material identification and selection

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The awareness of environmental issues on a global scale increases the opportunities for waste handling companies. Recovery is set to become all the more important in areas such as waste selection, minerals processing, electronic scrap, metal and plastic recycling, refuse and the food industry. Effective recycling relies on effective sorting. Sorting is a single element of the waste disposal/recovery process, but it is a vital part. The big players in the sorting market are pushing for the creation of new technologies to cope with literally any type of waste. This has led to the presence of a wide range of sorting application on the market today. The new emerging technologies rely on the use of sensors to achieve high level of efficiency. New technologies based on hyperspectral imaging are entering the market because of the new possibilities they offer for the classification of materials. They can satisfy the increased level of quality of recycled products complying with specific standards determined by industrial applications. Near Infrared (NIR) spectra of materials contain information regarding their chemical composition and molecular structure. These features can be used to distinguish different types of material within an undifferentiated sample for industrial purposes. NIR spectroscopy offers

a unique combination of speed, simplicity of sample preparation, easy usage, non-destructiveness and good reproducibility.
After an overview of spectroscopic and analytical techniques used for the recognition of different materials, I will speak of a new method based on the NIR spectral images developed for the identification of different classes of materials present in wood waste. We have investigated the spectrum of a wide sample of materials as plastics, ceramics, tiles, woods, laminates in the range 1100 - 2500 nm. We found those features that characterized the different classes of materials and searched for those spectral regions able to distinguish them. We identified the spectral bands potentially most effective in the discrimination process and we defined different indices able to distinguish among different materials. The developed classification method shows that the near infrared spectral analysis can be used as an efficient technique to identify different objects, facilitating rapid and accurate separation process. We present the approach and the first results of the new identification and selection process.

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X-ray Polarimetry and perspectives in high energy astrophysics

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