In the first six months of this year, more than six thousand visitors were welcomed to the ITER site by the Agence Iter France. Each visit is a unique experience.

Designing the Hydraulic Network System

The design of the system necessary for the management of the rain water on the ITER site has been based on the logical progression dealing with the protection of nuclear plants against the risk of flooding. Modelling studies were used to determine the hydraulic aspects which could occur over a one month period, and the result for the ITER site was based on ‘Heavy rainfall’ scenarios taking a three hour period. The impermeability coefficients, the rainfall on the surface and the infiltrated rain and the storm coefficients were also taken into account.

Visitors are greeted at the entrance to the ITER site, and then before entering the site they are given a visit card, before entering the site, they are given a visit card, which contains the necessary information about the cause of the visit and the itinerary of the day. Visitors are then led into the site where they are presented with a description of the ITER site and its objectives.

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Visits

The Ten Thousandth Visitor

On the 27th of May 2009, the Agence Iter France welcomed its ten thousandth visitor to the ITER site. This was a local politician, a member of the PACA local authority contributions of the PACA local authorities. The visit was part of a local government visit and was attended by over a hundred people, including the mayor of the city of Saint-Paul-lez-Durance.

Water Under Surveillance

The creation of the hydraulic network system was, undertaken in accordance with the regulations of the French Ministry of Environment, Water and Forests. As a consequence, any project or development linked to the construction of a new industrial or residential site must be subject to a public inquiry in order to determine the characteristics of the site and the conditions under which it can be developed.

At present, in certain places, it is still possible to see the water under surveillance, where the pipelines of the hydraulic network system are in place. In these places, the water is released into the Durance river, which has been welcoming visitors to the ITER site for the past year. The water released into the Durance river is used to cool the tokamak, which is connected to the ITER site via a underground pipeline network. The water is then released into the Durance river, which flows into the Mediterranean sea. The water released into the Durance river is used to cool the tokamak, which is connected to the ITER site via a underground pipeline network. The water is then released into the Durance river, which flows into the Mediterranean sea.

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**Heart Warming!**

The plasma at the heart of the ITER project will be more than a million times hotter than the sun, with temperatures reaching more than 100 million degrees. At this temperature, all matter is turned into plasma and the kinetic energy (the energy produced when a moving object) is sufficiently high to heat the electrons of the plasma. The positively charged and the negatively charged electrons are therefore no longer able to stick together. At any angle, a charged particle placed in a magnetic field will adopt a proper movement depending on the location of the magnetic field. At the ITER site, the approximate radius of the plasma will be equivalent to a hydrogen ion and a fraction of a millimetre for an electron.

**A Very High Speed Process**

The speed of the fusion reaction of the deuterium and tritium fuel that will be used in the ITER research facility in England and will soon be tested at the ITER research facility in its maximum when the temperature reaches more than 100 million degrees. At this temperature, all matter is turned into plasma and the kinetic energy (the energy produced when a moving object) is sufficiently high to heat the electrons of the plasma. The positively charged and the negatively charged electrons are therefore no longer able to stick together. At any angle, a charged particle placed in a magnetic field will adopt a proper movement depending on the location of the magnetic field. At the ITER site, the approximate radius of the plasma will be a few millimetres for a hydrogen ion and a fraction of a millimetre for an electron.

**Turbulence**

Several phenomena meet in the heart of a plasma: creating a complex system with a very high level of activity, temperatures ranging from 10 to 100 million degrees in the centre to several thousand degrees on the edge, the presence of powerful electromagnetic fields and high electrical current density.

**Making the Invisible Visible**

The heart of a plasma is composed of electrically charged particles (ions and electrons). The movements of which create fluctuations in the electric and magnetic fields which, in turn, control the dynamics of all the particles. A multitude of phenomena are added to this intricate system by the interactions between the particles and the inside wall of the machine, the impact of the helium nucleus emitted during the fusion reactions and the heating systems (beams, rapid particle beams, etc.). The physics has a wide range of instruments available to them to help them progress in their research on these phenomena. TheTore Supra experiments in Cadarache are more than forty instruments and measurement devices. ITER has about forty. The Kraps, measured by cameras equipped with special detectors, allow the scientists to gather information about the efficiency of a means of heating. Spectrometers measure the radiation of impurities in the plasma and self-diagnostic setup alert a metal component when a contact has been made and the machine will crash. Cameras equipped with special detectors (large coupled (large coupled) detector) provide images of the plasma which is visible in the core of the machine. As the same time, optical fibres, or endoscopes, are installed on the components opposite the plasma in order to provide information about the interactions produced between the plasma elements (deuterium and helium) and the material of the vessel. Another technique uses computer models of plasmas to describe the conditions. As with the mechanism used with a radar or a water, this technique will allow us to detect the existence of an environment which has been crossed and therefore the existence of the presence of the environment, explains the physicists. Numerous other probes installed on the interior walls of the machine measure the electrical current of the plasma. All this information enables the physicists to calculate the density and the intensity of the plasma, the actual temperature of the plasma as well as the fluctuations. 

In order to further understand the phenomena which have been measured, the physicists use complex modeling. In the field of plasma physics, simulations are so powerful that they are used to understand and control the instabilities created in the heart of the plasma. Most of the instabilities which give rise to turbulence are electromagnetic. They develop until they create a turbulent state where effect is in the hot particles in the centre of the plasma (where the temperature is over one-million degree) with the cooler, outside particles. This flow of heat and the movement of the particles from the heart towards the edge have an impact on the quality of the confinement of the energy within a tokamak, explains Gloria Falchetto, a researcher for the ‘transitions, turbulence and magnetic/transport’ group at the Institute of Research for Magnetic Fusion (IRFM) in Cadarache. Other effects can be calculated using the necessary limits to be applied in order to control this type of instability which would otherwise lead to the total loss of the plasma. In the same way, they can also calculate the greatest movement of the particles around a magnetic field line with a frequency of 100 to 200 GHz (from a cyclotron frequency). However, the simulation is not perfect and the laws of physics which explain the behavior of the plasma need to be simplified in equations usable by computers. Today, the most powerful machines manage to do a billion billion calculations per second but the very wide range of spatial and temporal scales involved in the description of a plasma need a high degree of complexity and long calculation time. The spatial scale vary from just a few micrometres to several metres and are different for the ions and the electrons. To research (further the detailed calculation of turbulence processes, see need tools with same huge powers called turbulent simulations), comments Ferdinand Bothaeus of the IRFM. ‘Armour has been set up to unit all the European skills and techniques to develop an increasingly efficient integrated calculation program. The making of tomorrow will have a memory capacity of several thousand gig-octets whereas today’s only have a few hundred gig-octets. To help them in their challenge, the physicists have a solid asset: both the powerful computers and the progression of numerical methods double every eighteen months.

**Extreme Measurements and Modelling**

The behaviour of plasma in the heart of a tokamak machine is determined by complex phenomena that physicists are researching in order to understand them in the minutest detail. We are going to take a look at the world of extreme measurements and modelling.

**Five Dimensional Calculations**

A plasma is made up of approximately one hundred thousand (billion electron particles). If so, physicists do not have the means to calculate the movement of each and every particle. In the modeling, the individual particles are replaced by a distribution function which defines the ratio in which a particle has a certain given position and speed. The distribution functions are defined in a six-dimensional area (three values for the position and three values for the speed). However, the turbulence is due to distributions produced of a much lower frequency than the average frequency of the movements of the plasma particles. This led to the development of the gyrokinetic theory in which a temporal average is applied to the movement. This is no simple calculation. The result is then spatial dimensions and two speed dimensions (parallel and perpendicular to the magnetic field) and time. At every given moment in time, the particle is represented by a particle in a six-dimensional space.

Extract from the article ‘Le Technicien de Fiançon’ (‘The technician in plasma’) by laurent Villard, professor and researcher.

**One Million Billion Calculations**

The physicists know how to model the way in which the heat flow caused by turbulence can vary according to different parameters, including the size of the plasma. Numerousemony size and installation of the interactions produced between the plasma elements (deuterium and helium) and the material of the vessel. Another technique uses computer models of plasmas to describe the conditions. As with the mechanism used with a radar or a water, this technique will allow us to detect the existence of an environment which has been crossed and therefore the existence of the presence of the environment, explains the physicists. Numerous other probes installed on the interior walls of the machine measure the electrical current of the plasma. All this information allows the physicists to calculate the density and the actual temperature of the plasma as well as the fluctuations.

During the projection of the site proposed for ITER on the 29th June 2009, the Finance Committee of the ITER Organization totalling 93.9 million euros, with the works and services contracted by the European domestic agency fusion for Energy amounting to 4.5 million. The figure for the ITER France Agency is 110.8 million whereas the Regional Council invested 4.5 million in the construction of the International School. Finally, the 110.8 million needed to adapt the roads was co-financed by the Regional Council of the Bouches-du-Rhône and the Government.