NUCLEAR ENERGY
THE BETTER ENERGY

July 2020 | Issue 2

Highlights

Tokamak
Size Comparison

WOMEN IN NUCLEAR SCIENCE

Meet our Team

THIS ISSUE'S SPECIAL ARTICLE

ITER- A ROADWAY TO NEW ENERGY

Image Courtesy: ITER.org

Letter from the Founder

This is a special edition for various reasons. First and foremost, we are celebrating reaching over 600 followers on our social media channels. These numbers (along with likes, comments and shares) keep our team motivated to bring you the most updated and striking features of Nuclear Energy and help you appreciate our perception of the better energy.

This issue also marks our entry into the realm of nuclear fusion. We will introduce you to ITER – the first ever device being built on earth that aims to tame the enormous amount of energy released post fusion process and use it to provide electricity. Although it currently sounds a lot like science fiction, it really is so much more than that. Thirty five countries have come together to make this a reality and solve the planet's impending energy crisis. Using colorful figures and some fundamental concepts, ITER – A roadway to new energy, will bring boundless fusion energy to light your living rooms.

Furthermore, through this issue we have tried to expand our reaches within the Nuclear Science community by exploring the lives and research of some extraordinary women in this field. Being a woman in science myself, I realized how important it was for my team to connect with young girls out there who, at this very moment, might be dreaming of becoming a scientist when they grow up. Women in Nuclear Science will give a message that is both loud and clear – Is it difficult? Yes. Is it impossible? No.

We have also used this issue as an opportunity to introduce to our readers four new members who have recently joined our team and taken up various tasks to help run this initiative as efficiently as possible.

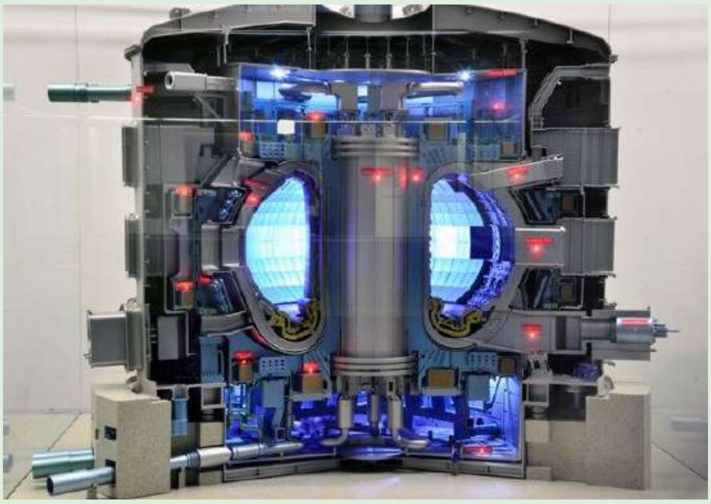
Finally, thanks to all our readers who made the first issue of this magazine successful. We sincerely hope that you all find the second issue equally interesting. Happy Reading!

Nirupama Sensharma
Founder

ITER- A ROADWAY TO NEW ENERGY

- Nilormi Das

Energy demand will skyrocket in the near future under the combined pressure of population growth, urbanization and expanding access to energy. Amidst such a scenario of energy crisis, imagine charging your favorite gadgets using the same source which powers the protective suit of Iron Man. But, what's the source!? He uses power transmitted by a device which imitates the only star of our solar system, the Sun, in principle. Yes, you read it right! An artificial Sun!
Let's explore the path of such a device capable of producing boundless energy that fuels the stars in reality on human soil.



Small 1:50-scale model of ITER Tokamak manufactured by See & See Power Tech, Seoul, South Korea

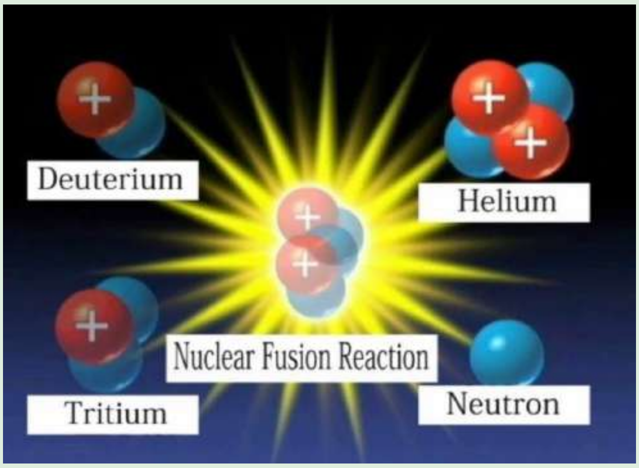
ITER, an acronym for the International Thermonuclear Experimental Reactor (in Latin, it means "the way"), based on a similar reaction mechanism as that of the sun. It is by virtue of this process two atoms of hydrogen result into an atom of helium along with the release of energy. This phenomenon is termed as Nuclear Fusion.
ITER being a product of the culmination of decades of fusion research carried out on hundreds of devices across the globe is the world's first experimental fusion research reactor to produce net energy is under construction in St. Paul lez Durance, located in the southern part of France. This initiative is going to be the next level evolution of nuclear energy capable of producing emissions-free electricity.

This international joint experiment in fusion is a collaborative venture of seven of its member states (China, European Union (EU), India, Japan, South Korea, Russian Federation and USA) to prove the feasibility of nuclear fusion as a future source of energy. Initially, the idea of this surreal multination multiple-hands project was proposed in 1985. Altogether 35 nations are cooperating in this project. The gigantically capacious area of ITER spreads over an area of 180 hectares (~ 445 acre) accommodating 39 buildings and about 2000 on-site workers. The facility will be operational in 2025.

ITER~ Mechanism with a glitch!

In nuclear fusion, two different heavier isotopes of hydrogen — deuterium and tritium are squashed to give one helium atom and a very energetic neutron (~14MeV). Harnessing this released energy in an efficient way will result in controlled nuclear fusion.

This mechanism is to be followed in the ITER experimental facility. This reaction mechanism will be carried out within a donut-shaped device, called Tokamak (a Russian acronym meaning "*toroidal chamber with magnetic coils*"). Initially, torus-shaped tokamaks were developed by Soviet Union and later on adopted by most fusion research facilities throughout the world.



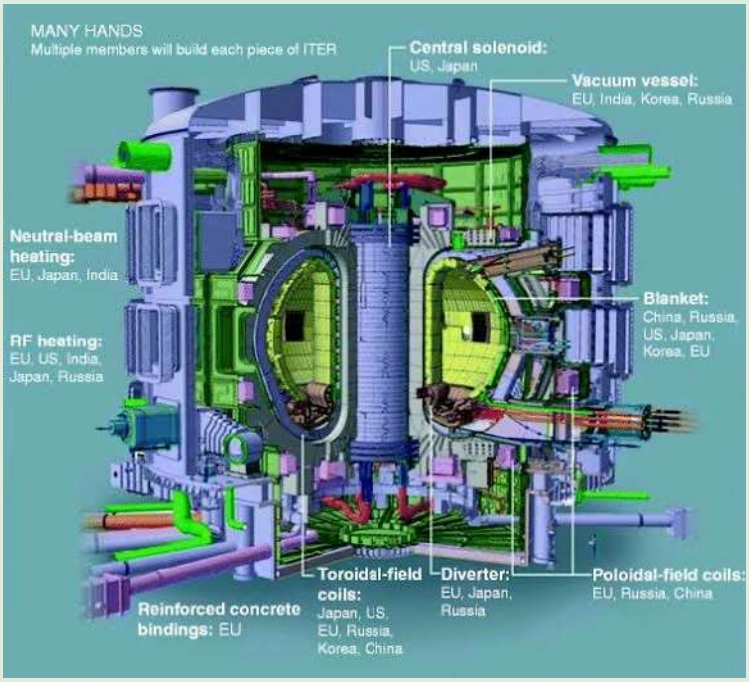
Formation of alpha-particle (4He2) and 14-MeV neutron as a result of D-T Fusion Reaction.

Two positive nuclei, deuterium (D) and tritium (T) despite being like fuse..How!? In the core of the Sun, the huge gravitational pressure amidst very high temperature (~ 15 million C) allows the fusion reactions to proceed. As an effect of these high pressures and temperatures, the fourth state of matter, Plasma is achieved inside the Sun. Whereas, in ITER temperatures of the order of 150 million C is required to achieve a controlled fusion reaction. The reaction will take place inside the tokamak preventing the device wall from such high temperature with the help of magnetic fields. To simply visualize, consider a magnetically confined bottle, inside which plasma has been formed as a result of high temperature and pressure, permitting the fusion reactions to proceed.

Basic Primary Components of ITER

- Tokamak - Device capable of harnessing the energy produced due to fusion.
- Magnets - Initiate, confine, shape and control plasma magnetically. Superconducting strands of niobium-tin or niobium titanium mixed with copper are used for the huge, high performance, technically challenging magnet system of ITER facility. The magnet system includes the Toroidal Field (TF) System, the Poloidal Field (PF) System and the Central Solenoid.

- Vacuum Vessel - Steel container which houses the fusion reaction.
- Blanket - Shields the vacuum vessel and external components from high energy neutrons produced as a result of fusion.
- Divertor - Extracts out the heat and waste produced due to fusion reaction preventing plasma contamination and minimizing damage.
- Cryostat - Stainless steel vacuum pressure chamber with an objective to enclose the vacuum vessel and provide a high vacuum, ultra-cool environment to the vacuum vessel and the superconducting magnet.



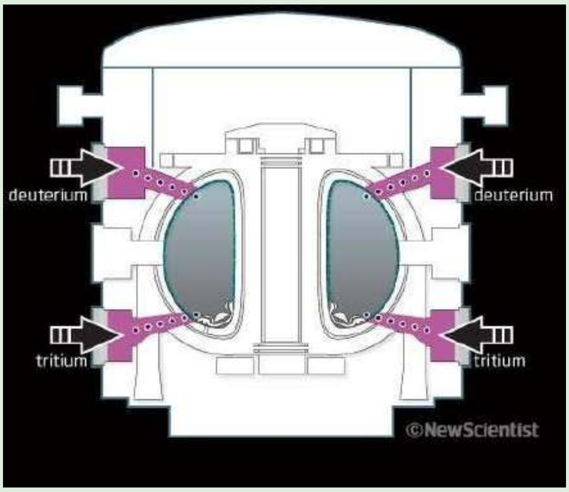
Schematic of ITER-components contribution by the member nations.

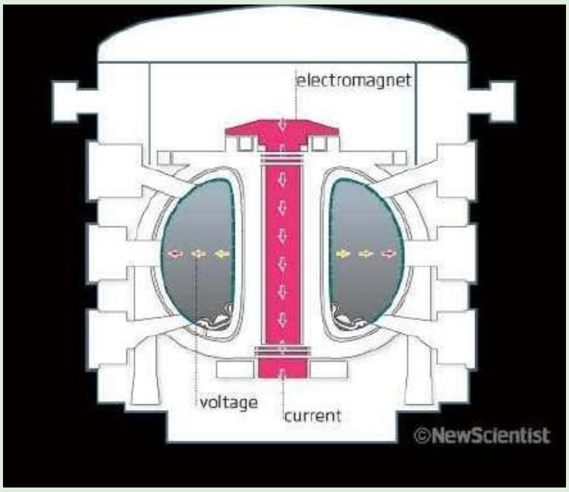
Source of Reaction Components

The parent component of the nuclear fusion reaction can be extracted from the anomalous element of nature, Water. Yes, deuterium, the heavy hydrogen can be easily extracted from seawater. Though the second source, tritium has limited abundance worldwide but the huge fat tummy of ITER facility is capable of reproducing aka "breed" the heaviest form of hydrogen using self-sustaining tritium breeding modules.

Working Principle

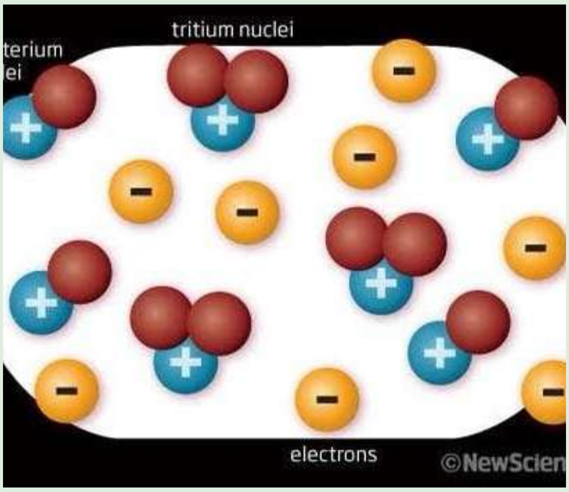
1. In tokamak, gaseous deuterium (D) and tritium (T) are injected in the form of puffs.

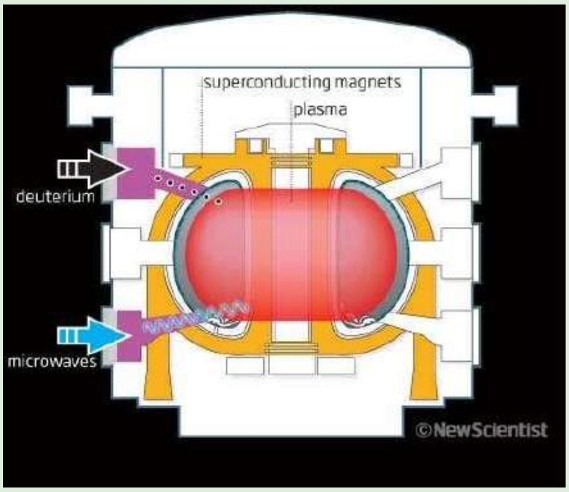




2. Across the gas, voltage is produced as a result of electricity flow through the electromagnet.

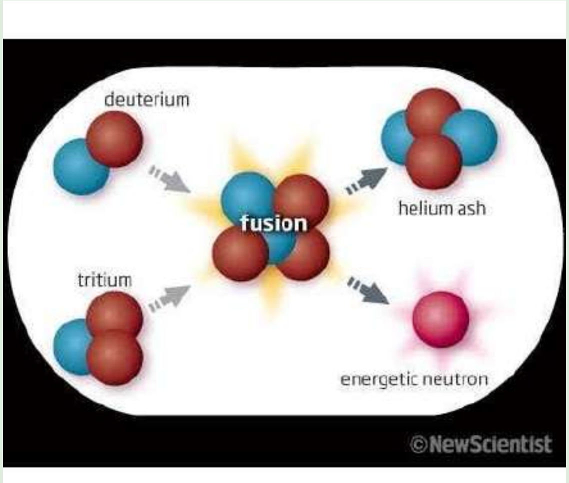
3. As an effect of voltage, electrons of D and T get ripped off and turn into charged ions, resulting in formation of a soupy kind of thing containing particles called Plasma, the 4th state of matter.

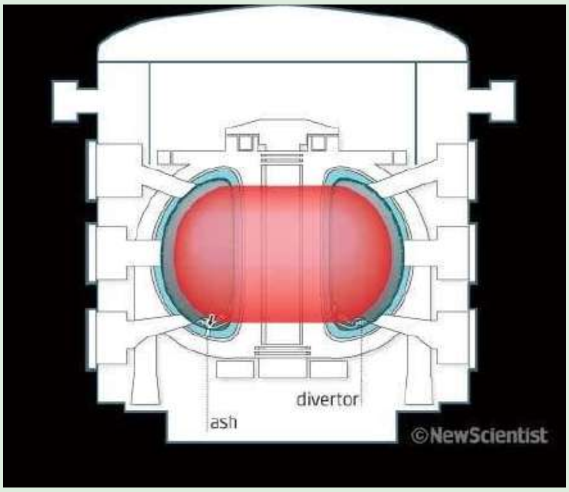




4. Plasma is magnetically confined inside the vacuum vessel by the resultant field created by an array of superconducting magnetic coils. The magnetic coils serve the purpose of current generation as well as plasma confinement due to which plasma gets heated to a not-so-fusion-feasible temperature of 10 million degree celsius.

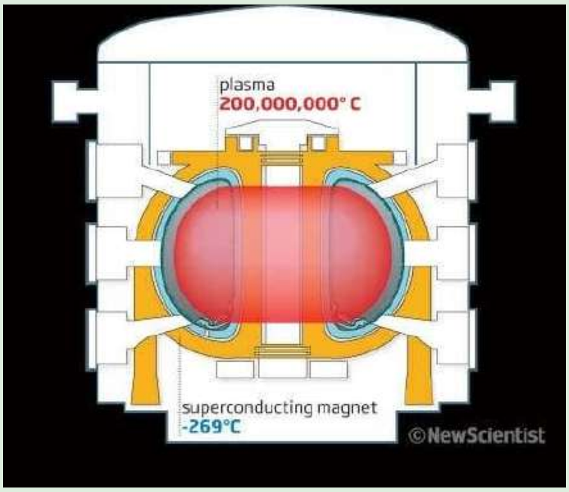
5. To raise the temperature upto 100 - 200 million degree celsius, radio and microwaves are fired into the plasma and high-energy beams of D-atoms, which is enough for nuclear fusion to occur.

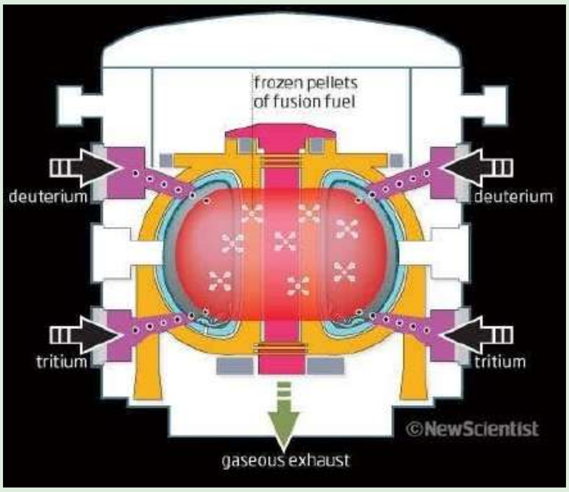




6. As a result of fusion, Helium and high-energy neutrons are produced that keep the plasma hot by depositing their energy before they are forced out through the divertor as "ashes".

7. The tiles on the plasma-facing components get bombarded and heated by neutrons and other particles. In near future, this heat will be harnessed to produce electricity.





8. To continue the reaction process, plasma must be continuously refuelled with D and T.

ITER in a nutshell

Magnitudinal Features of ITER

- ITER machine Weight: 23,000 tons (equivalent to 3 Eiffel towers)
- Output energy ~ 50 times the input energy (For Input = 50MW, Output = 500MW)
- Temperature: 150 million degree celsius (10 times that of Sun's core)
- Tokamak's Dimension: 30 m * 30m m (h*w)
- Plasma: 6.2 metre (Radius), 840 m^3 (Volume)
- Magnet System Weight: 10,000 tonnes
- Combined Magnetic Energy: 51 GJ (gigajoules)
- Vacuum Vessel: 19.4 m (Outer Diameter), 11.4 m (Height), ~5200 tonnes (Weight)
- Blanket Module: 440 modules, 1 m * 1.5 m (dimension), 4.6 tonnes each (Weight)
- Cryostat Weight: 3800 tonnes

Advantages

- CO_2 free energy.
- No long-lived radioactive waste.
- No harmful emission.
- Zero possibility of a nuclear catastrophe (no meltdown like Chernobyl).

Latest Progress

- On July 3, 2020 TF Coil #13 partner of TF #12, also procured by Japan reached the ITER site.
- On June 30, 2020 ITER-India along with industrial partner Larsen & Toubro flagged-off the accomplishment of an industrial milestone of Cryostat manufacturing.
- On June 26, 400-tonne magnet Poloidal Field Coil, procured and manufactured by Europe and China respectively arrived on site.
- On May 28, 2020 Cryostat Base section - 10 metre tall, ~1250 tons, an Indian contribution was installed at the tokamak pit.
- On April 25, 2020 TF Coil #12, procured by Japan, reached the site.

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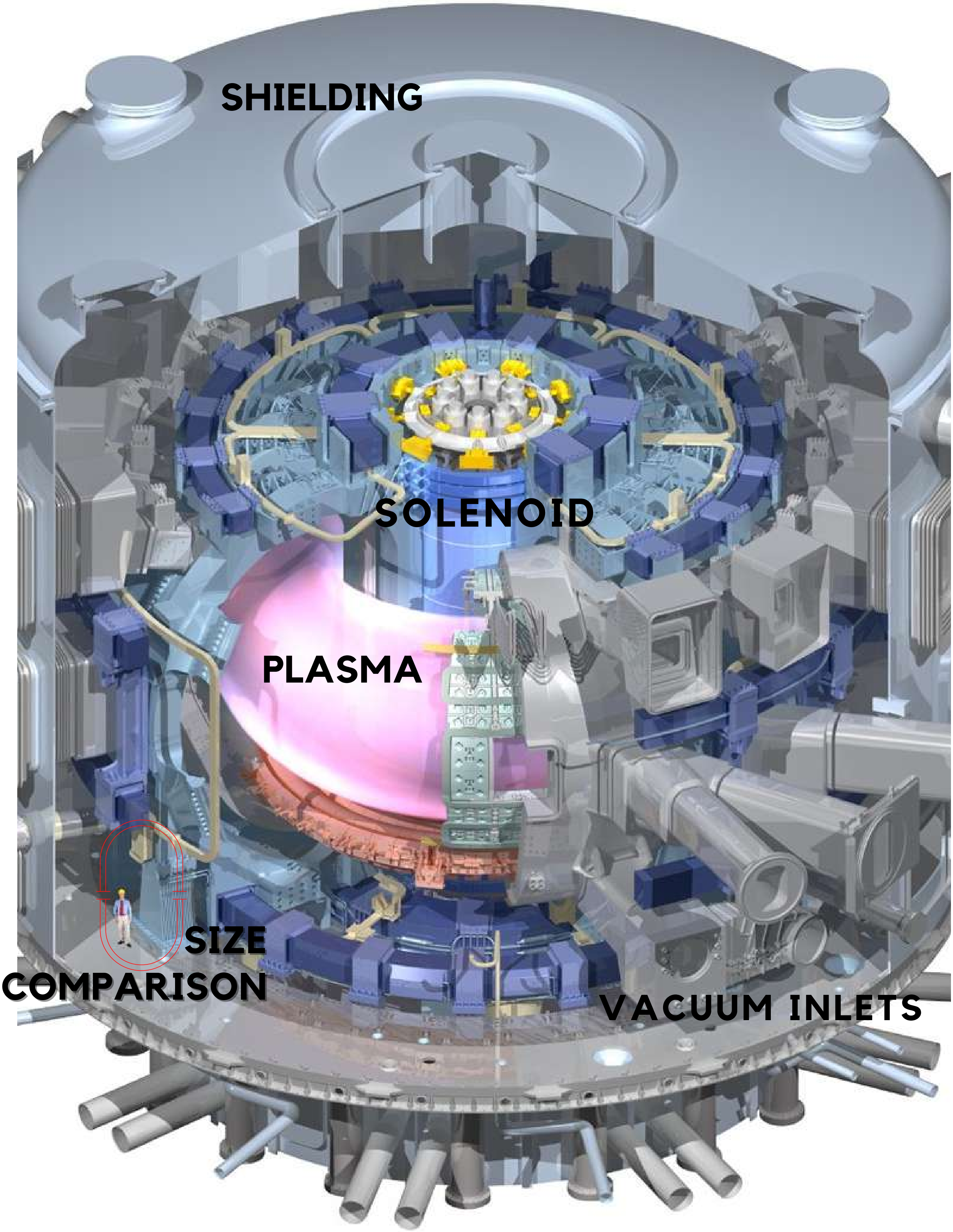
3. https://encrypted-tbn0.gstatic.com/images?q=tbn%3AANd9GcTXaPAWtUsOMMsHb7IPBmdhLcpD_n5VcXnV9w&usqp=CAU

TOKAMAK SIZE COMPARISON



Women in Nuclear Science

***"Are you sure this is the right field for you?"** is a question that women like us often get asked. Women like us, meaning women trying to enter male-dominated careers. Since time immemorial, our society has created a demarcation between careers that can be pursued by men and those that are suitable for women. Although time and again women have proved otherwise, the stigma still prevails. Being a woman nuclear physicist, I have often been asked if I am smart enough, brave enough and intelligent enough to compete with other well-established male colleagues of mine. Surprisingly, these questions do not require a bold yes or no answer. These questions are best answered by actions that speak louder than all words. This feature is dedicated to all women who have, at some point of their life, been asked such questions. Below are some extraordinary women who have made a career in Nuclear Science and have vowed to never stop.*

Kelly A. Chipps is a staff member and former Liane B. Russell Fellow working in the Experimental Nuclear Astrophysics group of the Physics Division at Oak Ridge National Laboratory, and current lead of the Jet Experiments in Nuclear Structure and Astrophysics (JENSA) project. She holds a Ph.D. in applied physics from the Colorado School of Mines and a bachelor's degree in engineering physics.

" As a woman in nuclear science, I do find that I am occasionally the only woman in the room. But I have seen positive changes over the years, both in the numbers of women and LGBT+ individuals in my field, and also in the awareness of colleagues that we need to be open to different backgrounds and viewpoints and cognizant of our own potential for bias. Finding the right mentor is tremendously important – nobody's perfect, but there are many bright and supportive mentors out there who want to help you to succeed, whatever that means to you."

Erika Holmbeck has recently earned her PhD in Nuclear Astrophysics from the University of Notre Dame. She is now a Postdoctoral Researcher at the Rochester Institute of Technology.

" My tie to nuclear physics is through astrophysics; I study how the Universe creates the heaviest elements through key nuclear mechanisms, notably the rapid neutron-capture process. My theory-intensive research utilizes measurements made in nuclear laboratories and occasionally takes me to telescopes to observe stars. Collaboration and communication are key in this field. Whether it be building accelerators or telescopes, it cannot be done alone. More importantly, it is essential to find the right research group to work with. Don't be afraid to ask questions, and remember that making mistakes is part of the learning process ".

Magali Zabeigo has been working as a Research Engineer in France for almost 24 years now. Her career has been a succession of paths that she has chosen to follow. It started with spending a year of her PhD at the University of Wisconsin, Madison, eventually leading to her current position at CEA Cadarache in the South of France.

" I work in the domain of Severe Accident in Nuclear Reactors, a very rich domain that tackles several fields of physics and chemistry. At CEA, I have been involved in modelling and development of physics softwares that are used by engineers and researchers around the world.Developing such a code means understanding the physics, implementing appropriate equations (debugging), validating models, training users and designing experiments. I am also a mother who, at CEA, was given the opportunity to be a researcher while taking care of my family. As a researcher, one's main mission is to learn. Research becomes what you make out of it, you are the only person who can propel yourself forward in a gratifying direction by injecting energy and ideas and by seizing the opportunities that cross your path ".

Laura Leay is a Nuclear Scientist and Research Manager at the University of Manchester in the UK. She leads a research group that helps inform national policy on managing radioactive waste safely. She is also a Science Writer and works as an Expert Advisor (secondee) at the Department for Business, Energy and Industrial Strategy (BEIS).

" My experience of working in the UK, both as an academic and in industry, has been very positive. Many people I have met have been very supportive and have actively helped me develop my career. There are lots of very interesting scientific and engineering challenges and, once you get involved in a particular project, you quickly find that there's an incredible amount of detail involved. It can sometimes become easy to be overwhelmed by these details so it's important to find focus and choose an area of the industry that you find most fascinating ".

Farheen Naqvi is a Research Scientist in the Department of Nuclear science and engineering at the Massachusetts Institute of Technology. Originally from India, she has obtained her PhD in Nuclear Physics from the University of Cologne in Germany. She also has multiple Postdoc experiences from Yale University, Michigan State University and University of Notre Dame.

" Working in the field of nuclear security and policy is a dream which I envisioned as a young masters student at the University of Delhi in India. More than a decade and several research labs later, I got to work on what I have always wanted to. My background in nuclear structure and nuclear astrophysics gives a multidimensional perspective to solve problems in this relatively more technical field. My advice for the young students would be to think big, work hard and never hesitate to diversify your knowledge pool ".

Aakanksha Saxena is a Diagnostic Integration Engineer at the ITER Organization. She started with a Bachelor of Applied Science (B.A.Sc.) degree from Delhi University, followed by a Masters in Nuclear Engineering from Université Paris Sud. She did her PhD at CEA where she worked on Sodium-cooled Fast Reactors (SFR).

" I have been working in the nuclear industry for nearly 10 years now and it has been an absolutely amazing experience. I started with my Ph.D in CEA and then joined, first of a kind, ITER project. I enjoy going to work every day for solving new challenges, meet new people, and learn different things. My message to the budding scientists and engineers is to follow your heart and motivation. I can tell you that time will challenge your decisions and when it does, your motivation will help you to fight those difficult times. Hard work, determination and motivation towards solving the ever-growing energy crisis is my mantra that gets me going every day and I love it!"

Narimane Boulefred is a Commissioning engineer for Nuclear waste handling and process systems within the OLkiluoto 3 project in Finland. Prior to this, she has worked as a Nuclear Engineer at Orano, France and studied the dismantling scenarios of CEA nuclear sites.

" I've been fortunate to work immediately after graduating from my Nuclear energy masters in two fields at opposite ends of a Nuclear power plant life span : Decommissioning and commissi - -oning. I currently manage maintenance work, testing activities and operations of waste process systems of EPR while ensuring the safety of the plant and the personnel. I enjoy working under deadlines, with budget and commercial outcomes. I advise young students to unravel their working style as early as possible and find out whether they would enjoy a research environment or a marketing and executive leading career to avoid future disappointments in career misplacement."

Meet the Team

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Meet our new members...

Nilormi Das is from Kolkata, India and is a B.Tech + M.Tech in Nuclear Science and Technology from Amity University, Noida with keen interests in plasma physics and controlled fusion. She is experienced in both nuclear fission and fusion processes with research exposures in nuclear electronics, detector fabrication and simulation and neutronics. Her vast experience has enabled her to be a part of various exhibitions and outreach programs targeting science education for the general public. She has volunteered as a Content writer for Nuclear Energy - The Better Energy and would take over as our Nuclear Fusion expert.

Vivek Patel is a PhD student at Bergische Universitaet Wuppertal, Germany. He is working on instrumentation of Ring Imaging Cherenkov (RICH) Detector system at GSI, Darmstadt, Germany. His interest in science outreach programs has led him to be actively involved in various popularization activities and career counselling for students who want to pursue careers in science and related fields. He has a four years teaching experience from India and that has enabled him to understand the issues many students face while pursuing a career in science. Vivek has volunteed for Nuclear Energy - The Better Energy to help our members get insights into various job opportunities and career prospects in science.

Dhaval Gadariya holds a joint European MS in Nuclear Fusion and Engineering Physics and is a Gold Medalist from the Applied Physics department of SVNIT, Surat. He is a PhD scholar at the Laboratorio Nacional de Fusión at CIEMAT, Madrid, working on development of disruption predictors for fusion reactors. His principal interests lie in the popularization of knowledge on Nuclear Fusion and energy and talent acquisition.Dhaval has joined Nuclear Energy - The Better Energy as a Content writer.

Ashabari Majumdar is a PhD candidate in Nuclear Physics at the University of Notre Dame. Her research involves actinide target preparation and neutron-induced fission reactions.
She is enthusiastic about communicating science to the public and creating awareness. She has been involved with various outreach events at the local community level. She has joined Nuclear Energy - The Better Energy as a content writer and hopes to be empowered by connecting with the society on a global scale.

New initiatives and more

Our goal with Nuclear Energy - The better Energy is to spread awareness about various aspects of nuclear energy and its importance and applications in day to day life. We try to do this through various initiatives such as articles, blogs, interviews with associated scientists, etc.
As an added feature, we will now include a section on "opportunities" in the field of nuclear and related sciences. The main idea here would be to motivate and introduce students and young adults to various job/academic opportunities. We hope to serve as a platform for those looking to shape their career in the field of nuclear science.
Please feel free to reach out to us if you have any questions about nuclear energy and we will be happy to help you. You can reach us via:

nuclear-energy-the-better-energy

nuclear-energy-the-better-energy

Website: https://thebetterenergy.net/