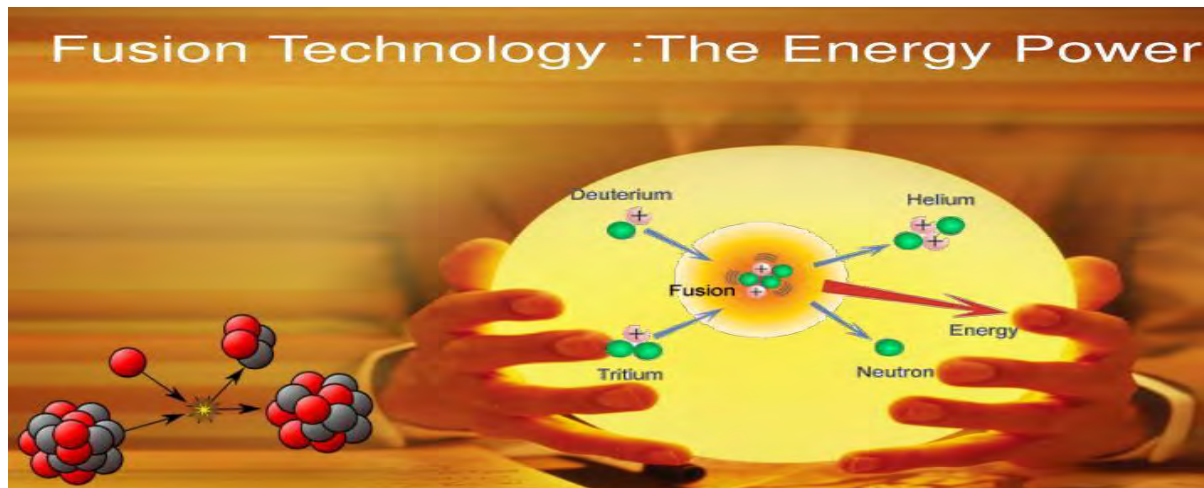


ADVANCED GENERATION HYBRID TYPE PUSHER D-T FUSION PLASMA FUELED ROCKET MODELING



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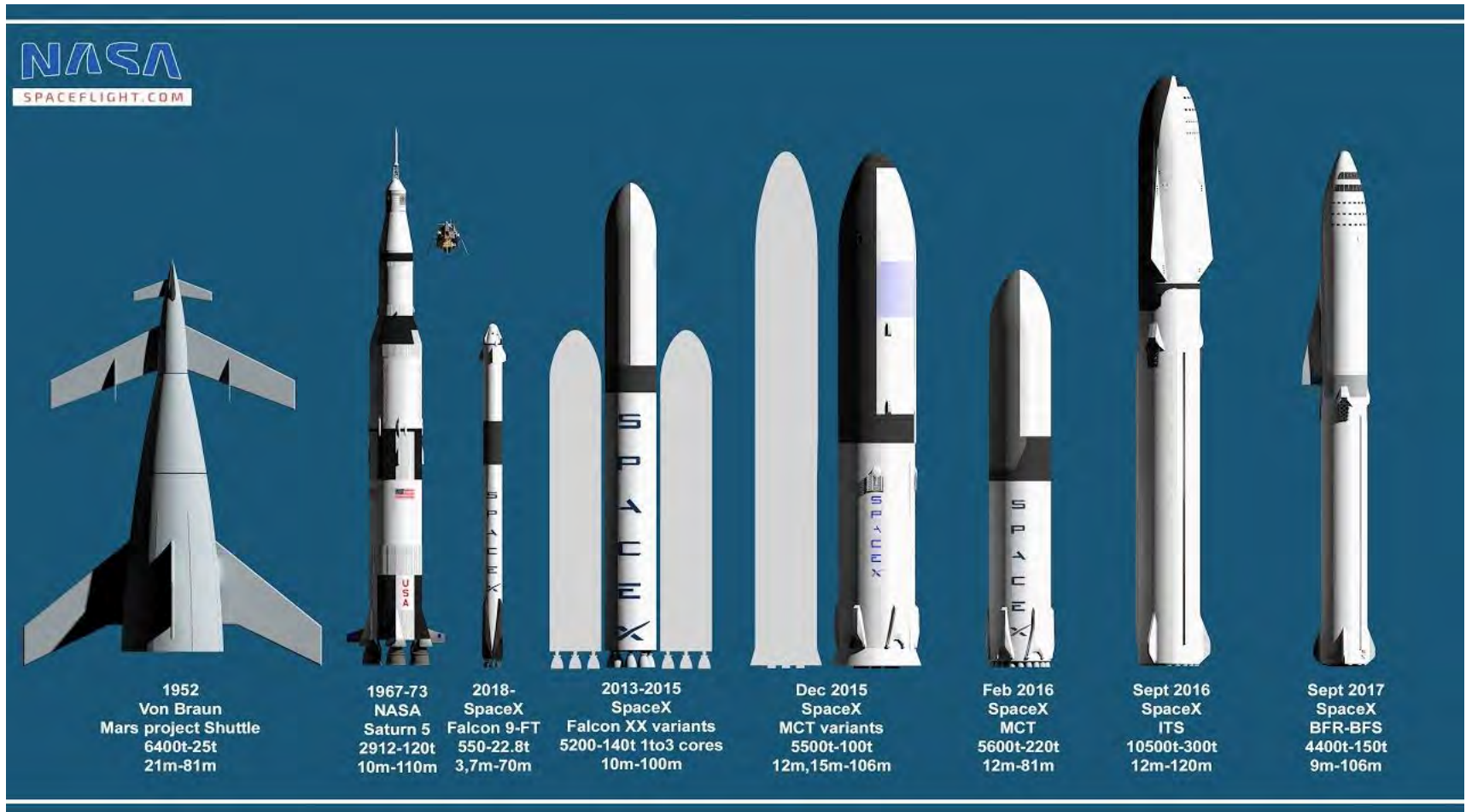
introduction

- In General, The Fusion-fission (Hybrid) Is A Combination Of The Fusion And Fission Processes. In This concept, The Fusion Plasma Is Surrounded With A Blanket Made Of The Fertile Materials To Convert Them Into Fissile Materials By Transmutation Through The Capture Of The High Yield Fusion Neutrons.
- The Advanced Fusion Energy Program Will Be A Critical Mission That Captures The Imagination By Developing An Exotic Product That Can Dominate The Global Market For Future Generations.
- .

introduction

- In This Study ,This System With D-t Fuel Is A Magnetically Printed Controlled Design With Smaller Lighter Magnetic Restraint That Is More Effective With The Mcnp-5x Nuclear Modeling. In Addition, It May Be Possible To Develop Continuously In The Future With New Mathematical Theory And Simulation To Prevent Plasma Imbalances.
- Nuclear Fusion is the energy-producing process taking place in the core of the Sun and stars.
- The core temperature of the Sun is about 15 million °C. At these temperatures hydrogen nuclei fuse to give Helium and Energy. The energy sustains life on Earth via sunlight

NASA's rocket models from 1952 to 2017



Blanket (including first wall)

Blanket Functions:

A. Power Extraction

- Convert kinetic energy of neutrons and secondary gamma-rays into heat
- Absorb plasma radiation on the first wall
- Extract the heat (at high temperature, for energy conversion)

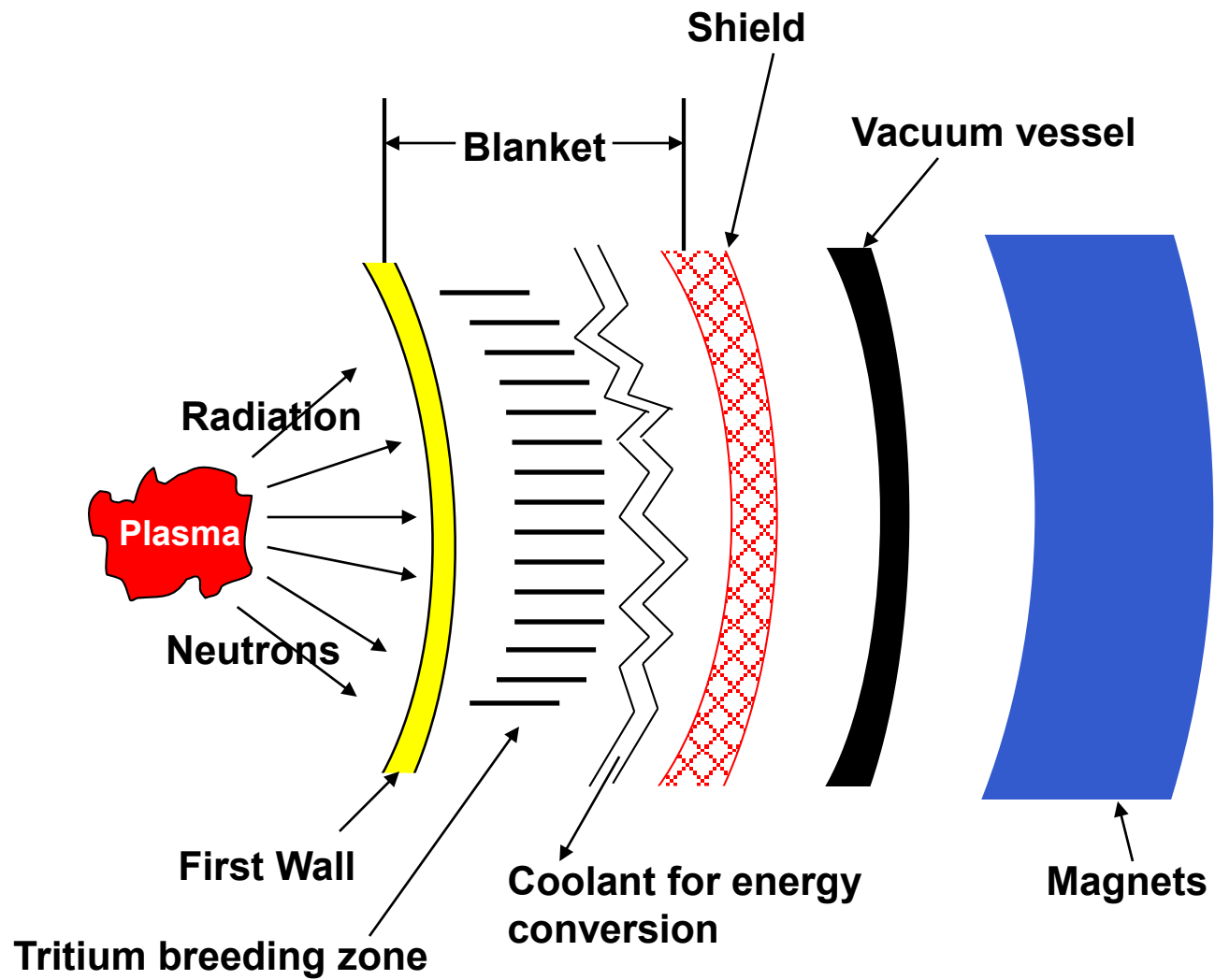
B. Tritium Breeding

- Tritium breeding, extraction, and control
- Must have lithium in some form for tritium breeding

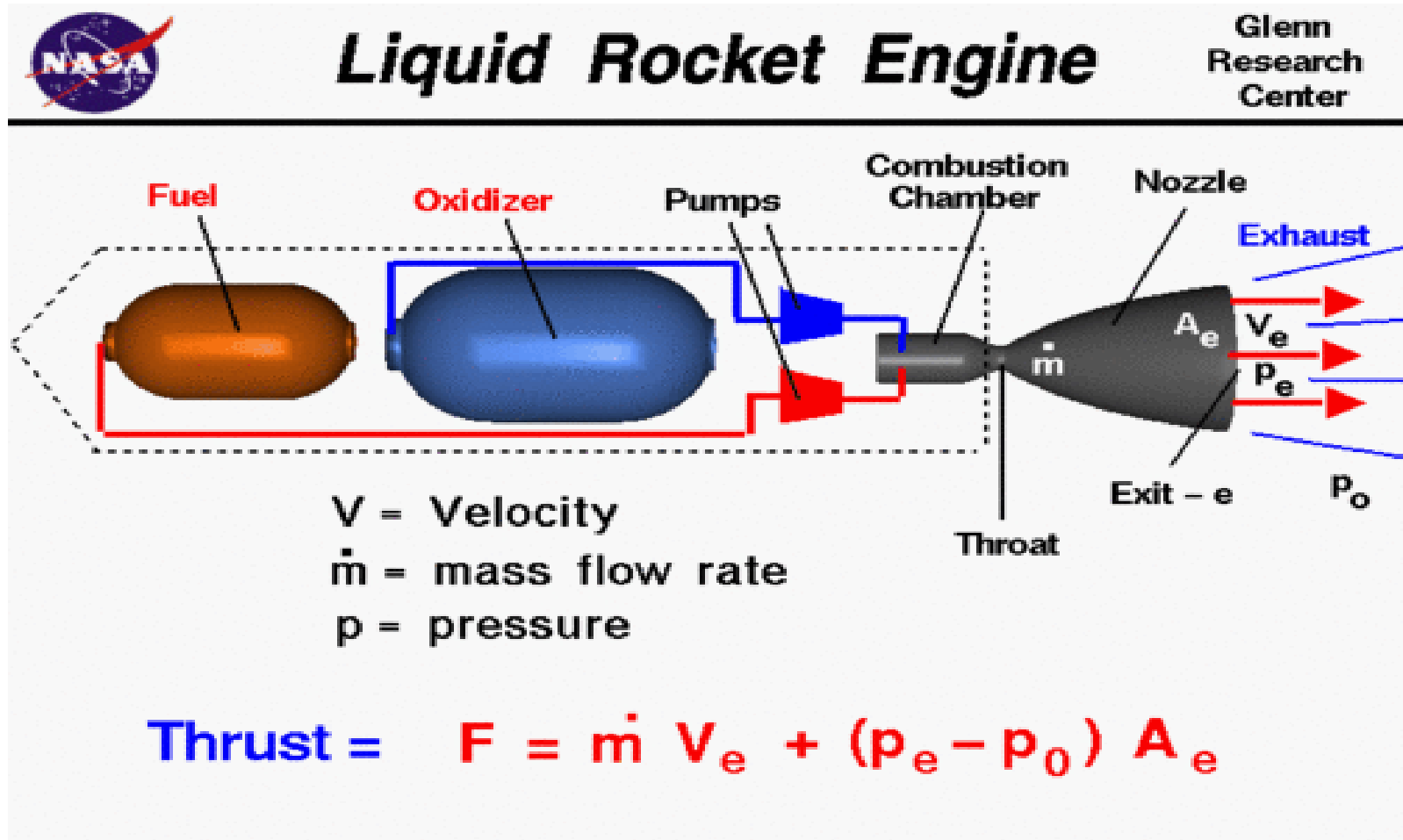
C. Physical Boundary for the Plasma

- Physical boundary surrounding the plasma, inside the vacuum vessel
- Provide access for plasma heating, fueling
- Must be compatible with plasma operation
- Innovative blanket concepts can improve plasma stability and confinement

D. Radiation Shielding of the Vacuum Vessel

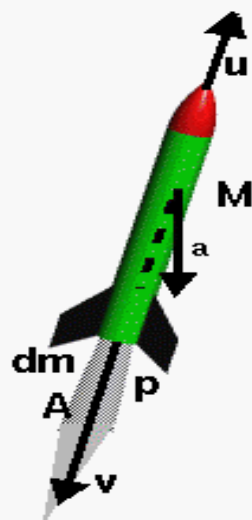


Liquid alternatif working lithium





Ideal Rocket Equation



M = instantaneous mass of rocket

u = velocity of rocket

v = exhaust velocity

A = exhaust area

p = exhaust pressure

p_0 = atmospheric pressure

In time increment dt , exhausted mass = dm $dm = \dot{m} dt$

Change in momentum of system = $M du - dm v$

Force on system = $(p - p_0) A - M g \cos a$ (neglect drag)

Change in momentum = Impulse = Force dt

$$M du - dm v = [(p - p_0) A - M g \cos a] dt$$

$$M du = [(p - p_0) A + \dot{m} v] dt \quad (\text{neglect weight})$$

$$V_{eq} = \text{equivalent exhaust velocity} = \frac{(p - p_0) A}{\dot{m}} + v$$

$$M du = V_{eq} \dot{m} dt = -V_{eq} dM$$

$$du = -V_{eq} \frac{dM}{M}$$

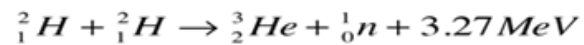
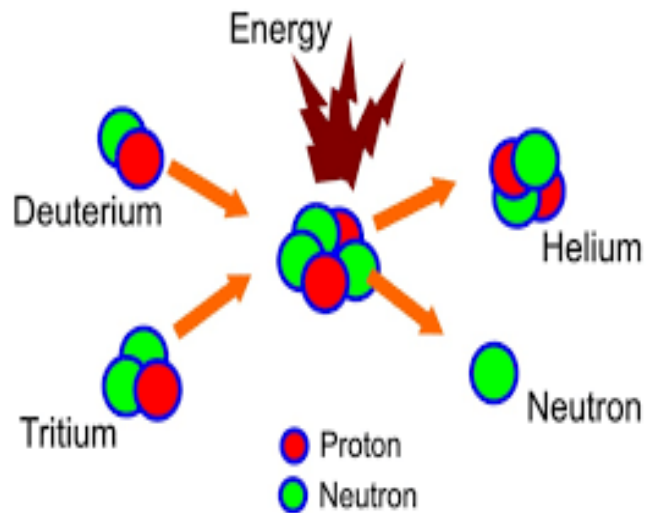
$$\Delta u = -V_{eq} \ln(M) \Big|_{mf}^{me}$$

$$MR = \text{propellant mass ratio} = \frac{mf}{me}$$

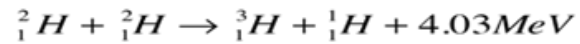
$$\Delta u = V_{eq} \ln \left(\frac{mf}{me} \right) = V_{eq} \ln MR = I_{sp} g_0 \ln MR$$

- A fusion D-T rocket is a simulation design for a fusion-powered rocket capable of providing efficient and long-range acceleration in space without the need for a large fuel source. However, this system is a larger and more complex model.
- Also, a potentially advantageous option is possible. The instant availability of the system hybrid type (fission + fusion) energy, the scope of this study, as part of a subcritical working spacecraft to be replaced traditional electric drive arrangement that can contain high power plasma. It is possible to transform it into a production / acceleration structure.

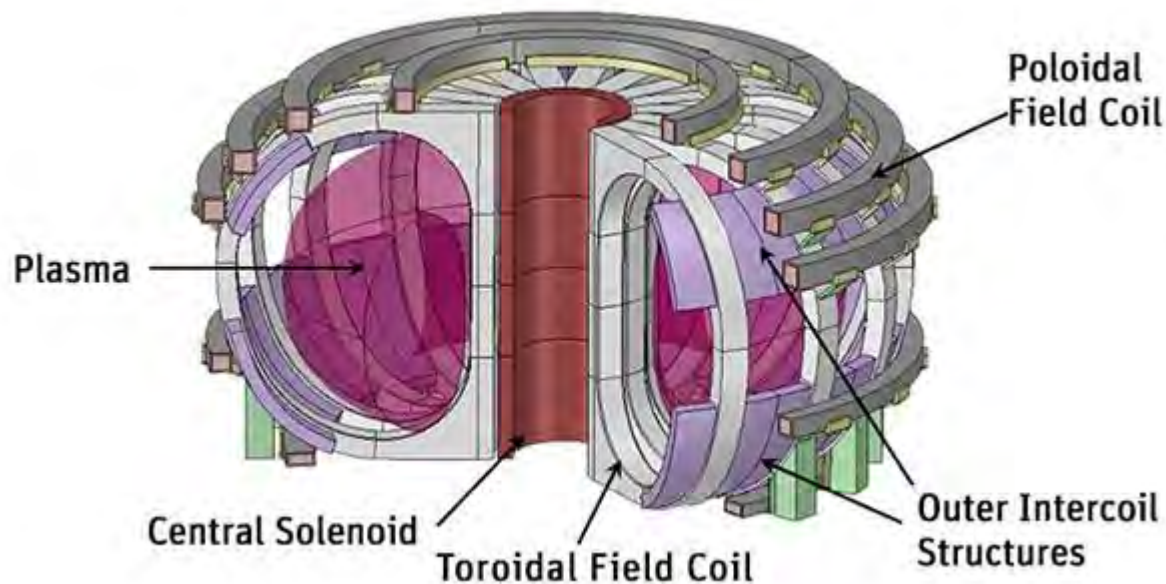
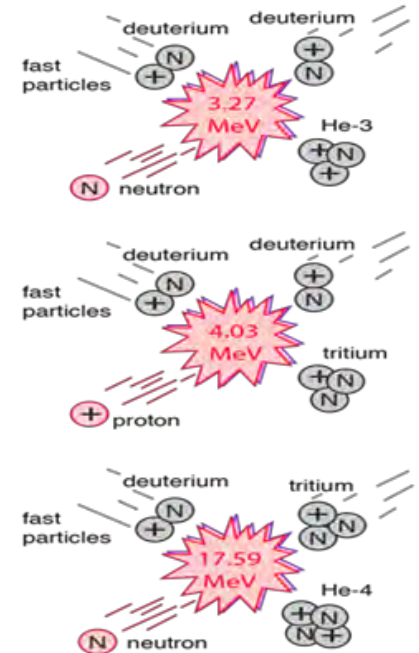
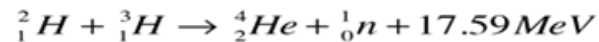
- Controlled nuclear advanced hybrid reactor thinking, almost few grooves of radioactive fallout compared to conventional fission reactors have unlimited fuel reserves and are pre-programmed by developed states. Of course, many tests for commercialization and continuity of D-T fuel is essential.
- In this study, MHD balance is discussed in terms of radiation heat transfer conditions, current driving and nuclear performance. In addition, the turbulence model and Monte Carlo (MC) simulation program, which expanded to an incompressible Mhd flow, used. The MHD model is the propagation of fluid dynamics into electrically conductive liquids, such as plasmas, by including the effects of electromagnetic forces.



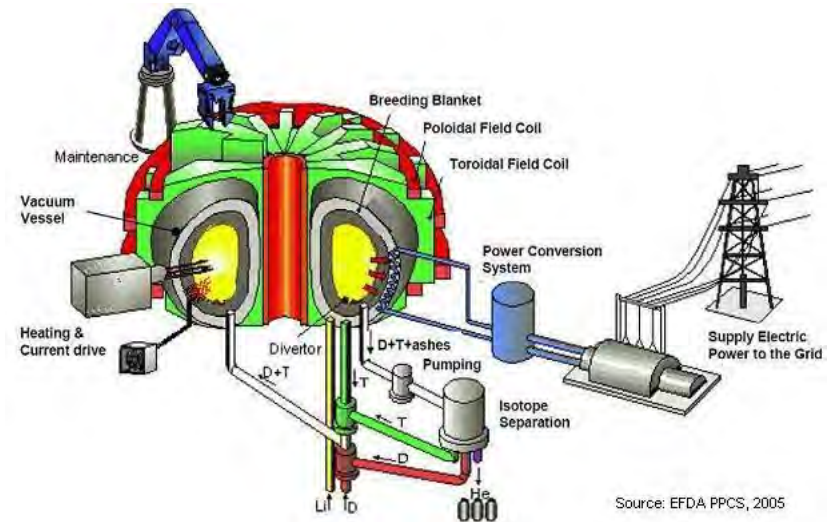
**Deuterium-deuterium
Fusion**

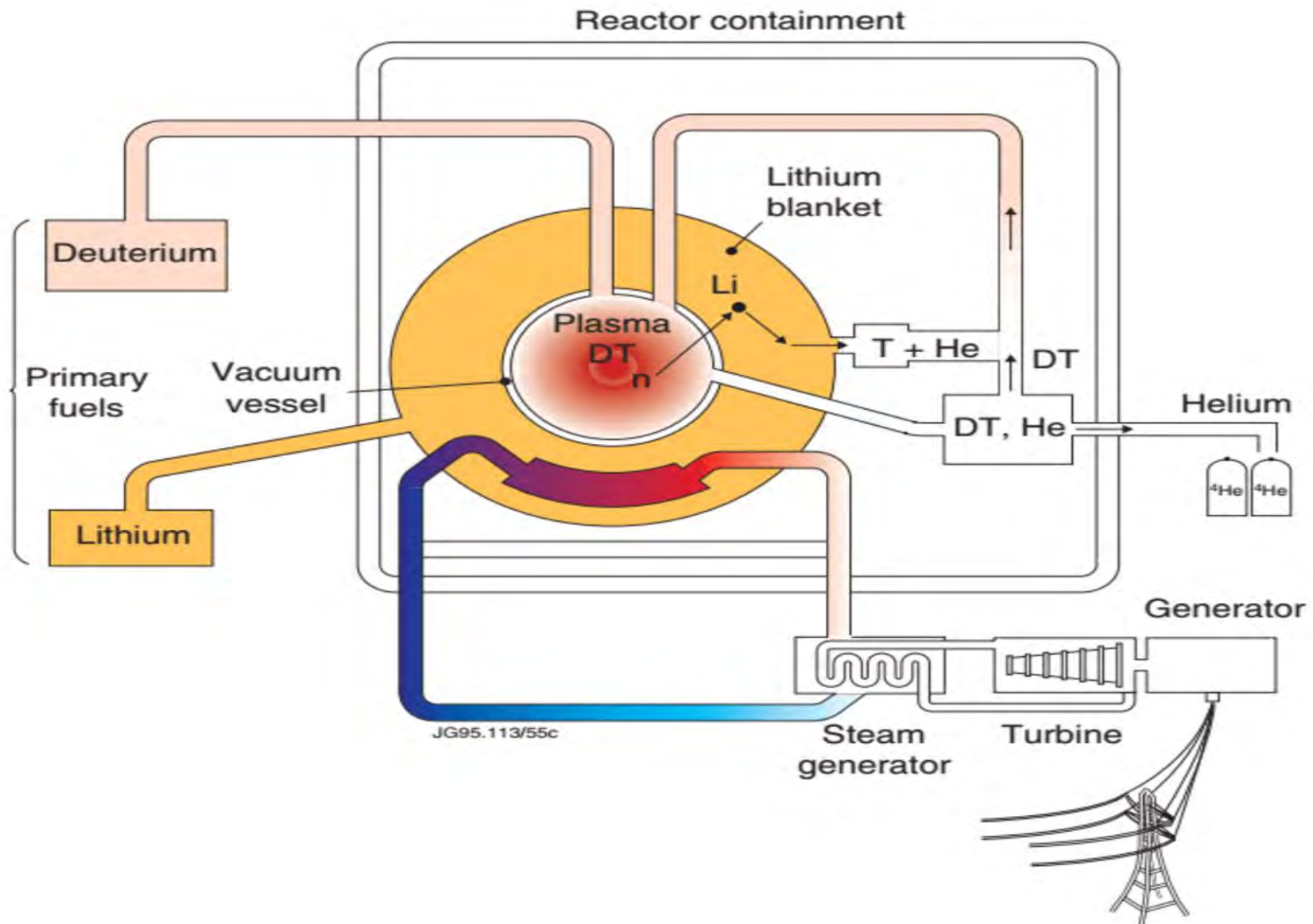


**Deuterium-tritium
Fusion**



Electricity generation in the near future in an advanced fusion power plant

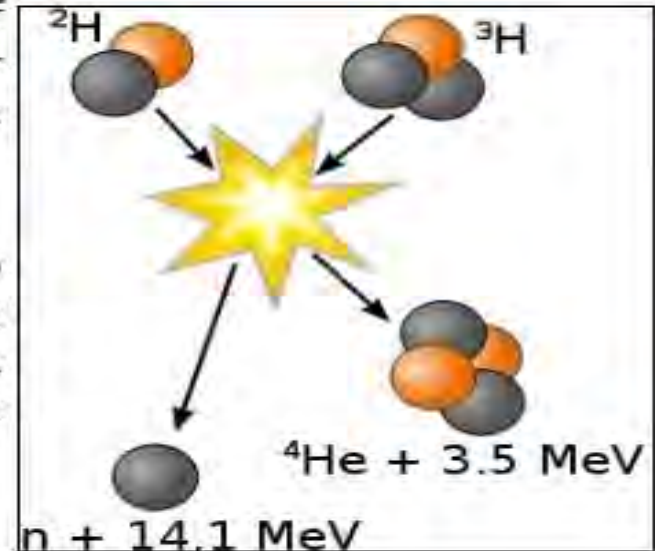
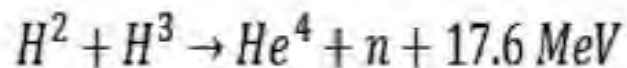




Fusion Reactions

Nuclear Fusion (brief)

- ▶ Nuclear fusion involves joining of smaller nuclei to form a larger nucleus and giving out a large amount of energy in the reaction.
- ▶ In the picture alongside, two isotopes of hydrogen, deuterium and tritium, combine to form a helium atom, releasing a neutron and a large amount of energy.



Fusion Reactions

- **Deuterium** – from *water*
(0.02% of all hydrogen is *heavy hydrogen* or *deuterium*)
- **Tritium** – from *lithium*
(a light metal common in the Earth's crust)



Deuterium + Lithium \rightarrow Helium + Energy

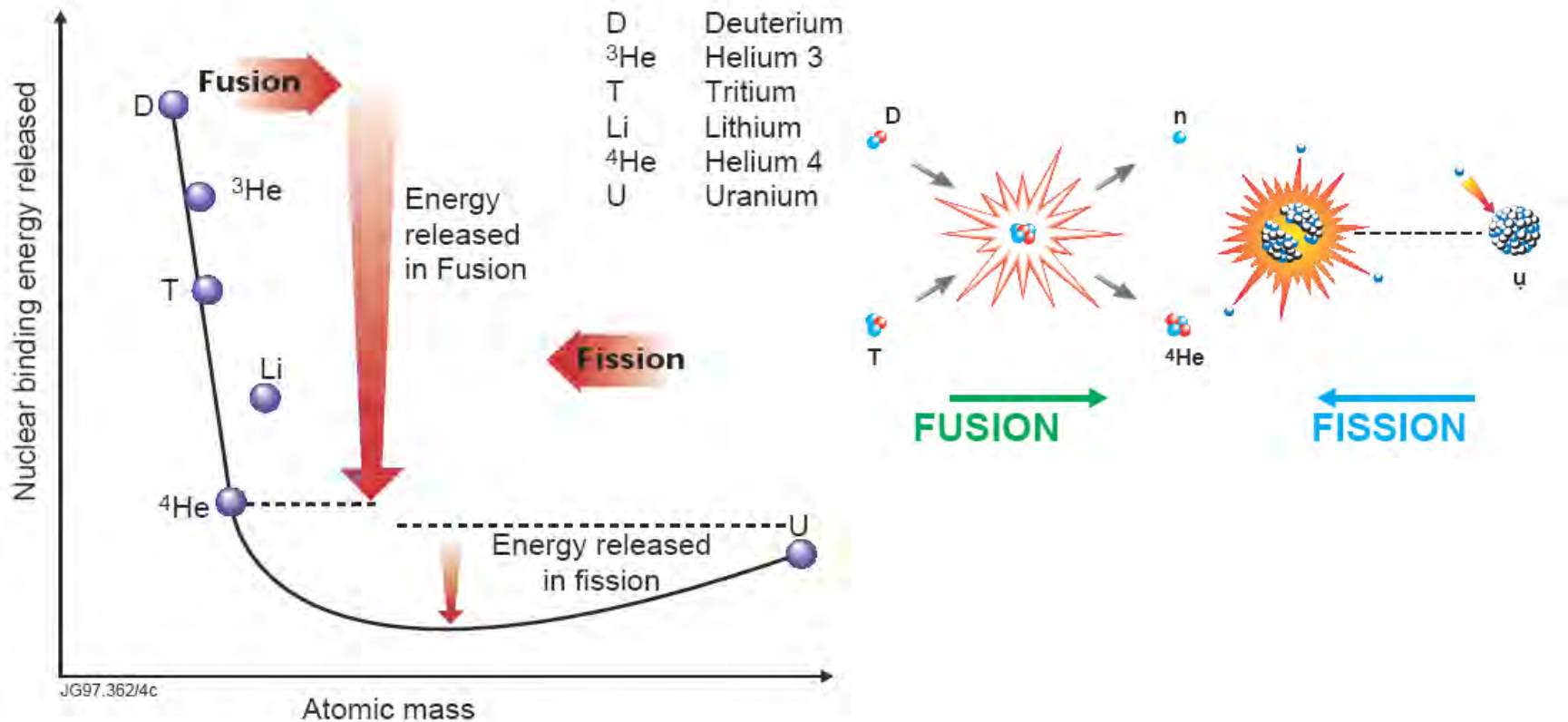
Tritium production



This *fusion cycle* (which has the fastest reaction rate) is of interest for *Energy Production*

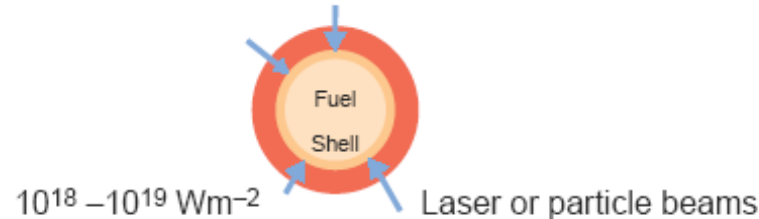
Energy Released by Nuclear Fusion and Fission

- Fusion reactions** release much higher energies than **Fission reactions**



Inertial Confinement

- Laser implosion of small (3mm diameter) solid deuterium–tritium pellets produces fusion conditions
- **Pressure generation**



100 million atmosphere plasma envelope formed

- **Compression**
Fuel is compressed by rocket-like blow off
200,000 million atmospheres in core
- **Ignition and burn**

- Peak com for extrer
- Core is heated and 'spark ignition' occurs

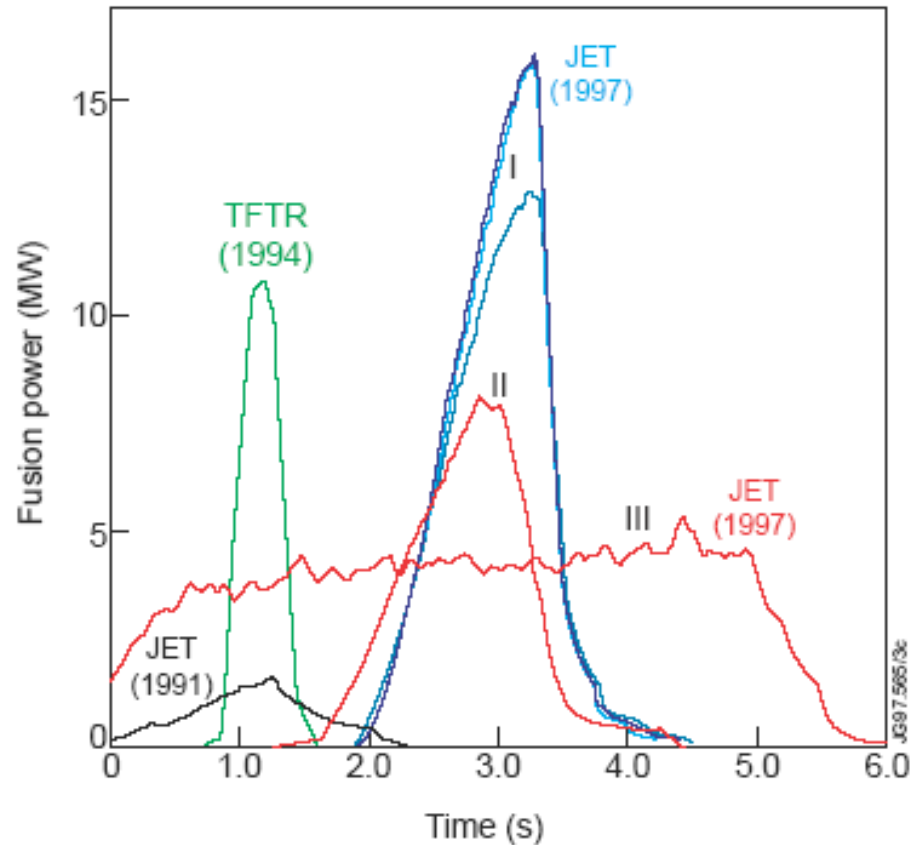
50M°C / 10^4 tonne
per m^{-3} in core



$$\tau_E \sim R/4c_s$$

s liquid density

Fusion Power Development



The diagram encompasses :

- Two pulses with 10% T in D in JET in 1991;
- A result from the D-T studies on TFTR (1993 to 1997);
- High fusion power and quasi-steady-state fusion power from the >200 pulses with >40% T in D in the JET D-T experiments of 1997.

Nuclear Reactions and Tokamak

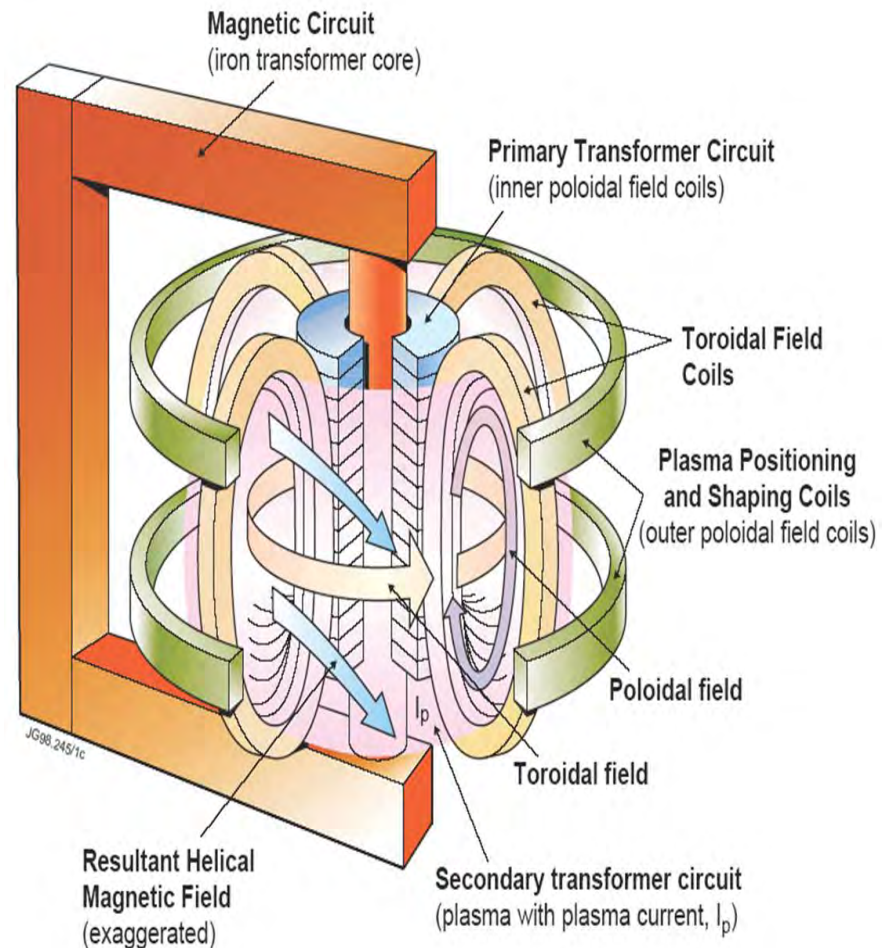
- *Light nuclei* (hydrogen, helium) release energy when they fuse (Nuclear Fusion).
- The product nuclei weigh less than the parent nuclei

Programmatic

- Demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes.

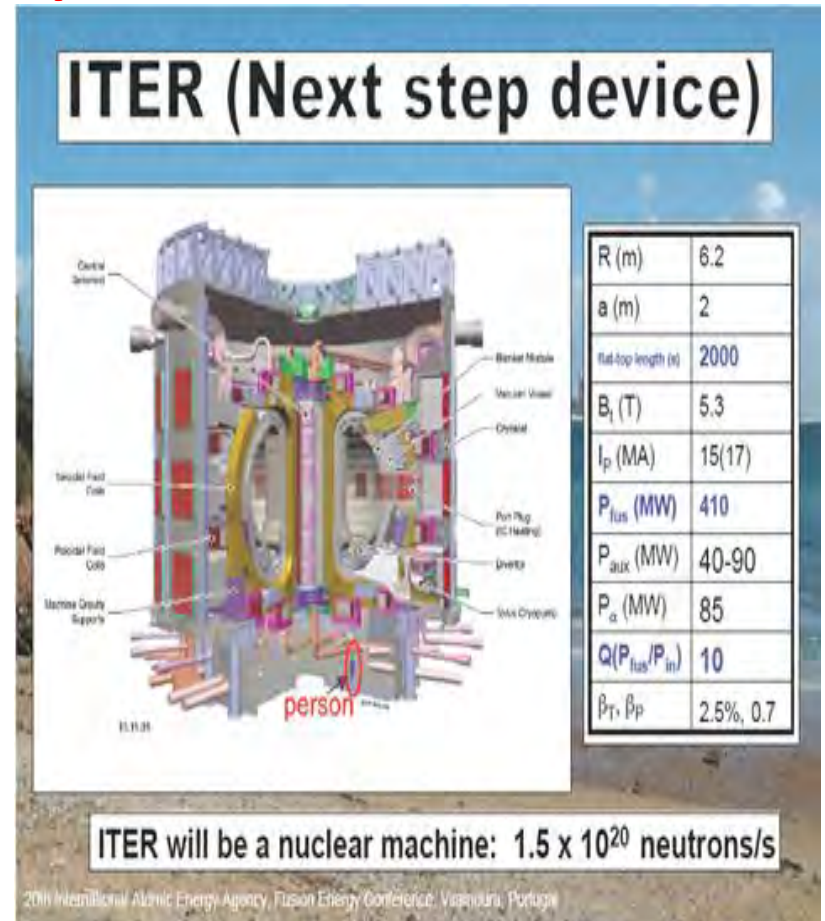
Technical

- Demonstrate extended burn of DT plasmas, with steady state as the ultimate goal.
- Integrate and test all essential fusion power reactor technologies and components.
- Demonstrate safety and environmental acceptability of fusion.
- Heavy nuclei (Uranium) release energy when they split (Nuclear Fission)
- The product nuclei weigh less than the original nucleus



ITER(international Thermonuclear Experimental Reactor)

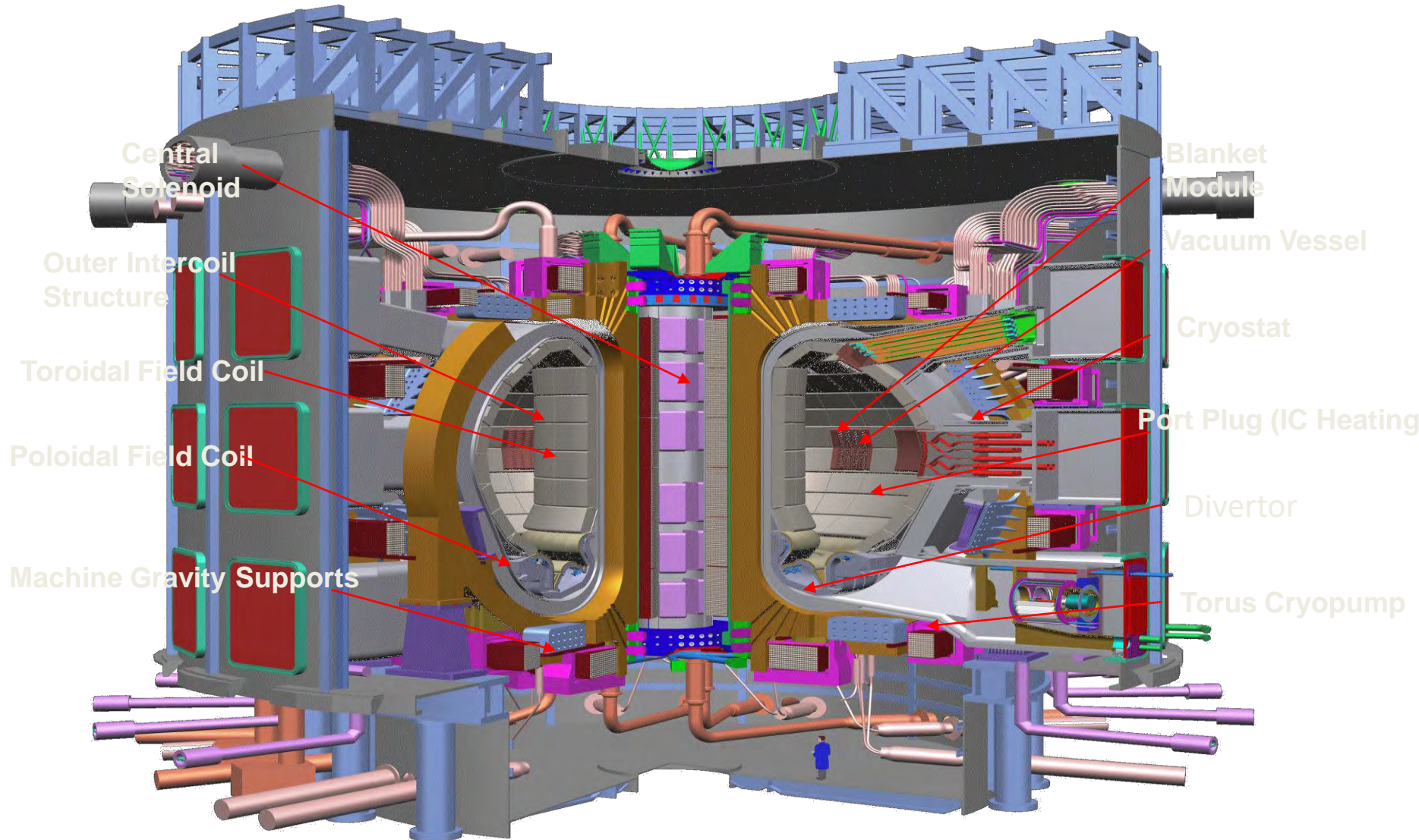
- In southern France, 35 nations are collaborating to build the world's largest tokamak, a magnetic fusion device that has been designed to prove the feasibility of fusion as a large-scale and carbon-free source of energy based on the same principle that powers our Sun and stars.
- The experimental campaign that will be carried out at ITER is crucial to advancing fusion science and preparing the way for the fusion power plants of tomorrow.
- Thousands of engineers and scientists have contributed to the design of ITER since the idea for an international joint experiment in fusion was first launched in 1985. The ITER Members—China, the European Union, India, Japan, Korea, Russia and the United States—are now engaged in a 35-year collaboration to build and operate the ITER experimental device, and together bring fusion to the point where a demonstration fusion reactor can be designed.



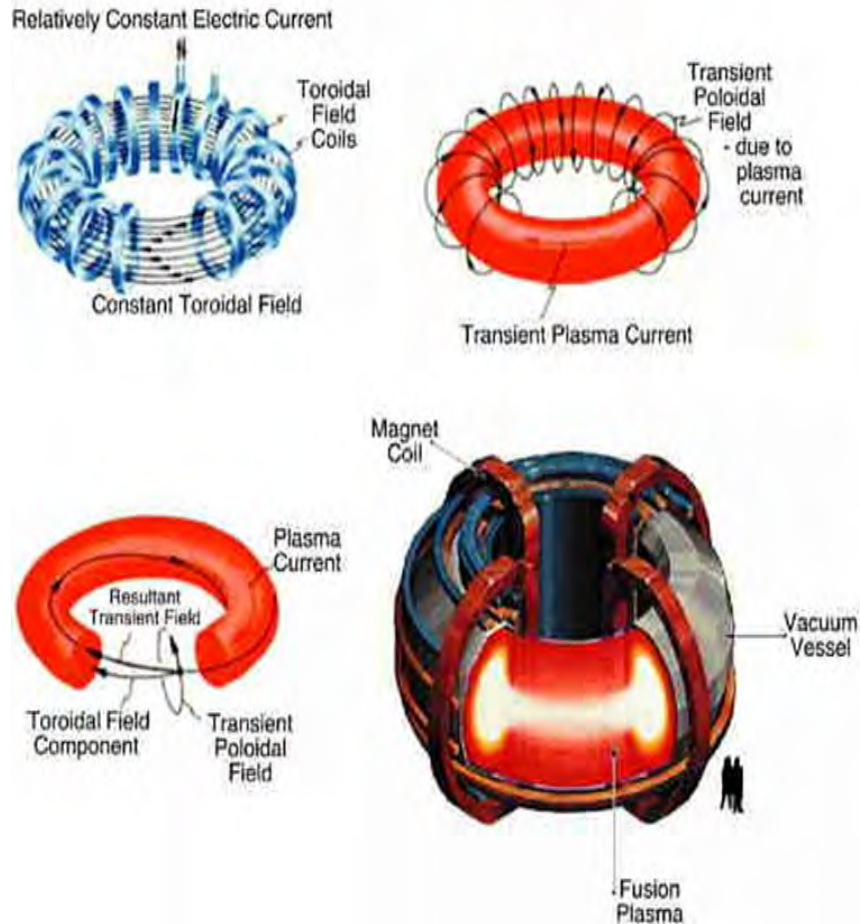
ITER Parameters

Total fusion power	500 MW (700MW)
Q = fusion power/auxiliary heating power	≥ 10 (inductive)
Average neutron wall loading	0.57 MW/m ² (0.8 MW/m ²)
Plasma inductive burn time	≥ 300 s
Plasma major radius	6.2 m
Plasma minor radius	2.0 m
Plasma current (inductive, I_p)	15 MA (17.4 MA)
Vertical elongation @95% flux surface/separatrix	1.70/1.85
Triangularity @95% flux surface/separatrix	0.33/0.49
Safety factor @95% flux surface	3.0
Toroidal field @ 6.2 m radius	5.3 T
Plasma volume	837 m ³
Plasma surface	678 m ²
Installed auxiliary heating/current drive power	73 MW (100 MW)

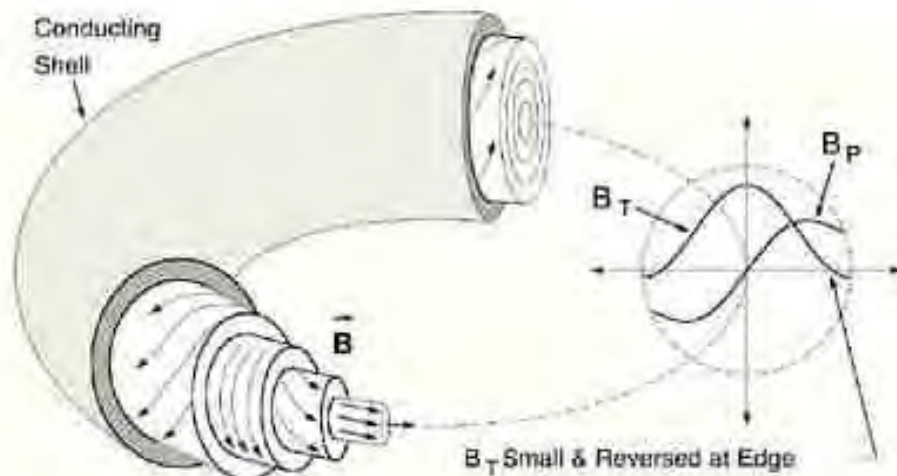
ITER Design - Main Features



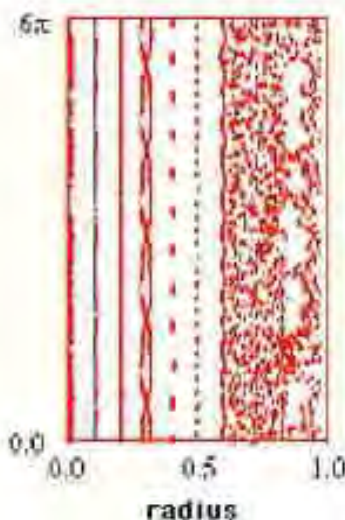
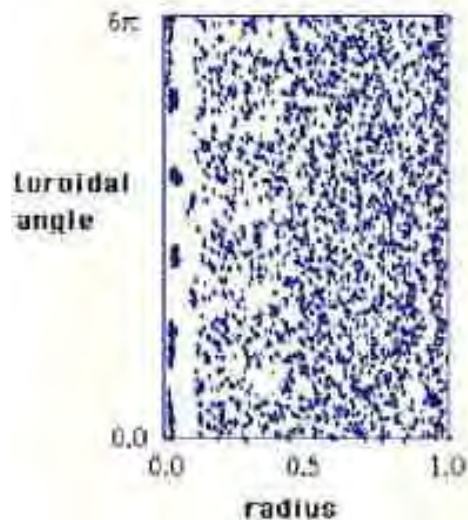
The Tokamak Configuration



The components of the tokamak confinement configuration, one of the more advanced plasma confinement concepts. It uses a strong toroidal field created by external field coils (top left) to stabilize the plasma while using a poloidal field created by a toroidal plasma current to confine the particles (upper right). The final configuration depends on the interaction of these fields (bottom left) and includes a large vacuum vessel to isolate the hot plasma from the surrounding environment (bottom right; people shown for scale).



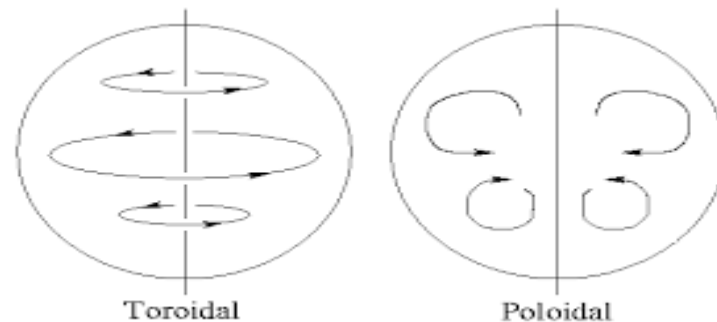
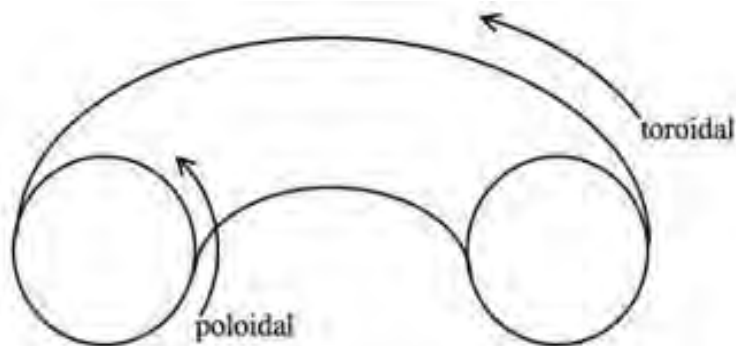
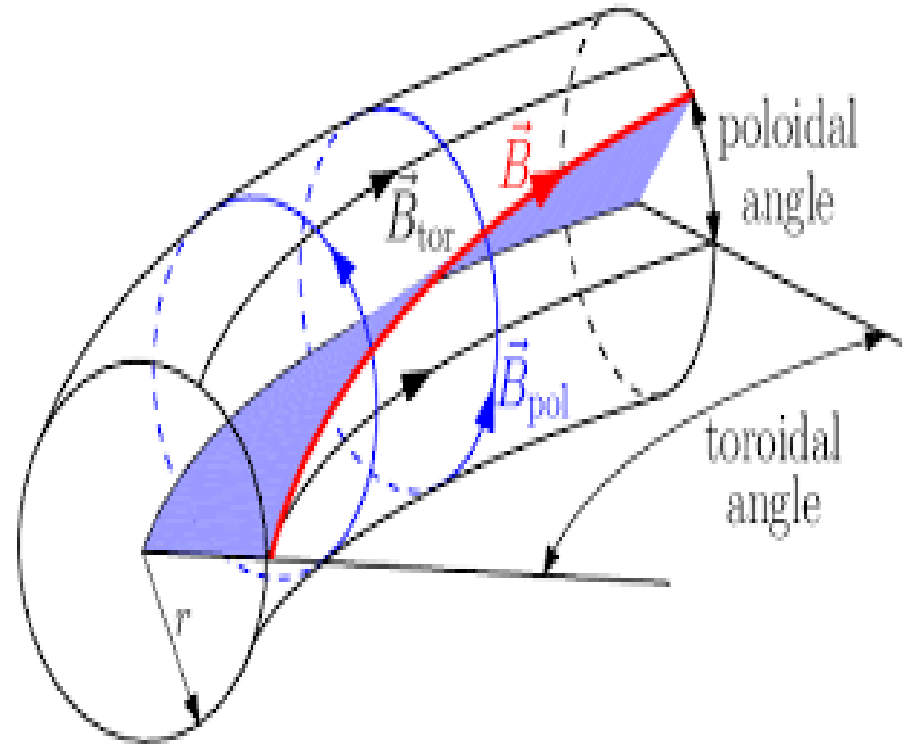
Magnetic Field Structure of the RFP



A magnetic confinement concept such as the reversed-field pinch (RFP) (top) is a relatively self-organizing configuration that is subject to turbulent magnetic field structures. The magnetic topology includes a reversal of the toroidal field inside the plasma owing to plasma currents. Under normal inductive current drive, the magnetic field lines can readily become chaotic, as indicated by a puncture plot of the field lines as they traverse a poloidal plane (bottom left). With finer control of the plasma currents, well-defined flux surfaces are restored (bottom right). NOTE: B_T , toroidal magnetic field; B_P , poloidal magnetic field.

Toroidal Equilibrium and Radial Pressure Balance

- : Basic Problem of Toroidal Equilibrium
- 1. Radial pressure balance
- 2. Toroidal force balance
- Radial Pressure Balance
- 1. The largest forces are usually associated with radial pressure balance
- 2. The magnetic field must confine the plasma radially so it is isolated from the vacuum chamber.
- 3. There are several ways to do this using toroidal and/or poloidal fields. This is not very difficult to accomplish.
- Toroidal Force Balance
- 1. Smaller forces are also present associated with unavoidable outward toroidal expansion forces



Fusion Nuclear Technology (FNT)

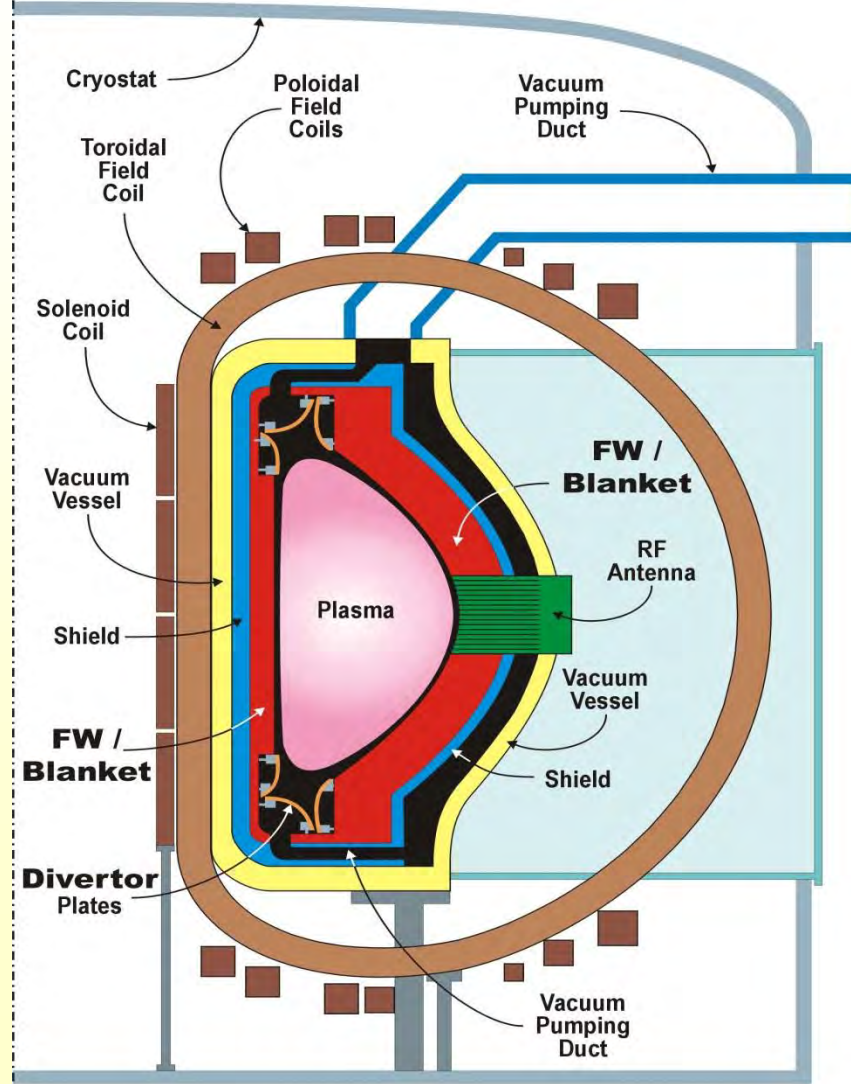
Fusion Power & Fuel Cycle Technology

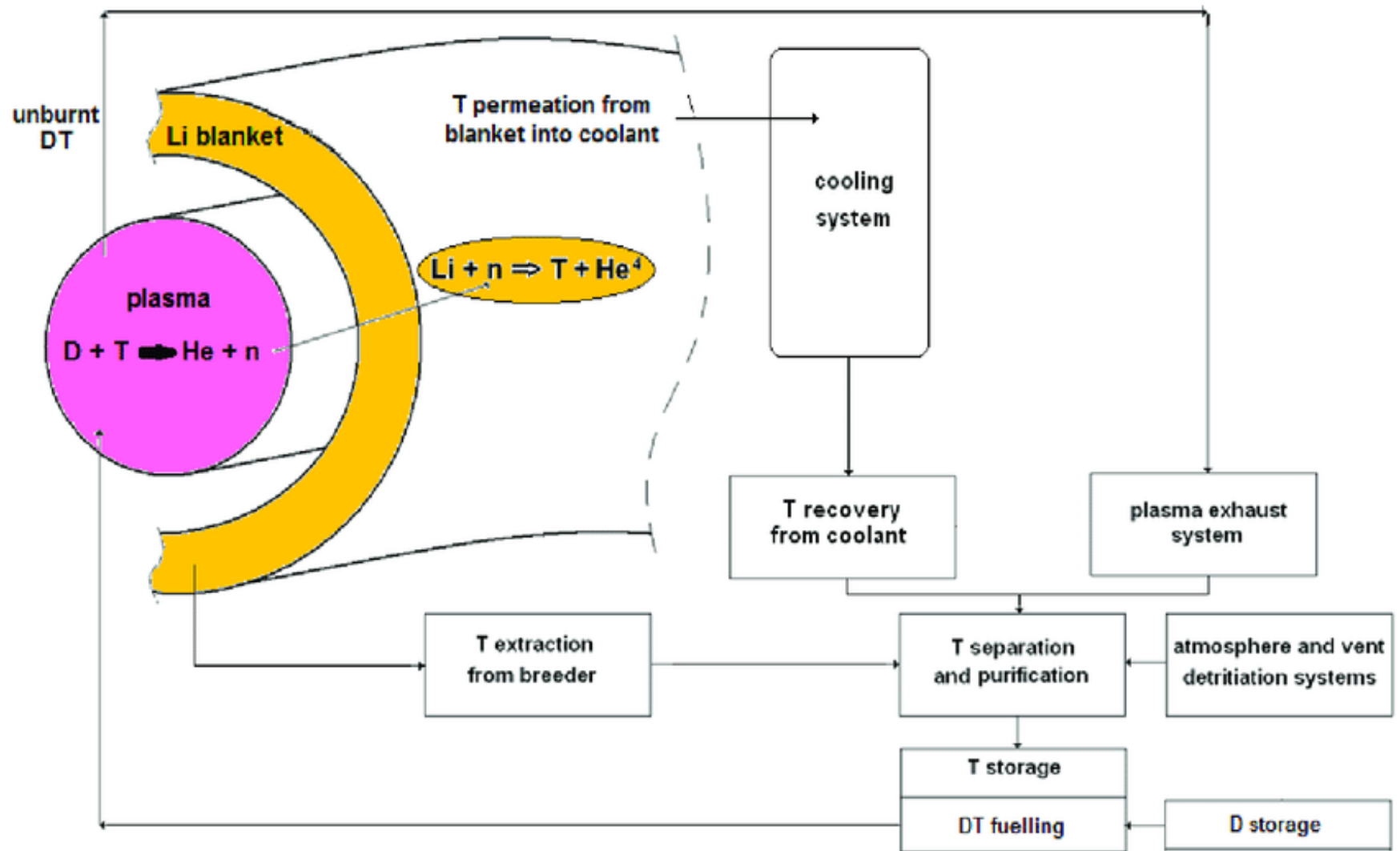
FNT Components from the edge of the Plasma to TF Coils (Reactor “Core”)

1. Blanket Components
2. Plasma Interactive and High Heat Flux Components
 - a. divertor, limiter
 - b. rf antennas, launchers, wave guides, etc.
3. Vacuum Vessel & Shield Components

Other Components affected by the Nuclear Environment

4. Tritium Processing Systems
5. Instrumentation and Control Systems
6. Remote Maintenance Components
7. Heat Transport and Power Conversion Systems





Blanket Materials

1. Tritium Breeding Material (Lithium in some form)

Liquid: Li, LiPb (^{83}Pb ^{17}Li), lithium-containing molten salts

Solid: Li_2O , Li_4SiO_4 , Li_2TiO_3 , Li_2ZrO_3

2. Neutron Multiplier (for most blanket concepts)

Beryllium (Be, Be_{12}Ti)

Lead (in LiPb)

3. Coolant

– Li, LiPb – Molten Salt – Helium – Water

4. Structural Material

- Ferritic Steel (accepted worldwide as the reference for DEMO)
- Long-term: Vanadium alloy (compatible only with Li), and SiC/SiC

5. MHD insulators (for concepts with self-cooled liquid metals)

6. Thermal insulators (only in some concepts with dual coolants)

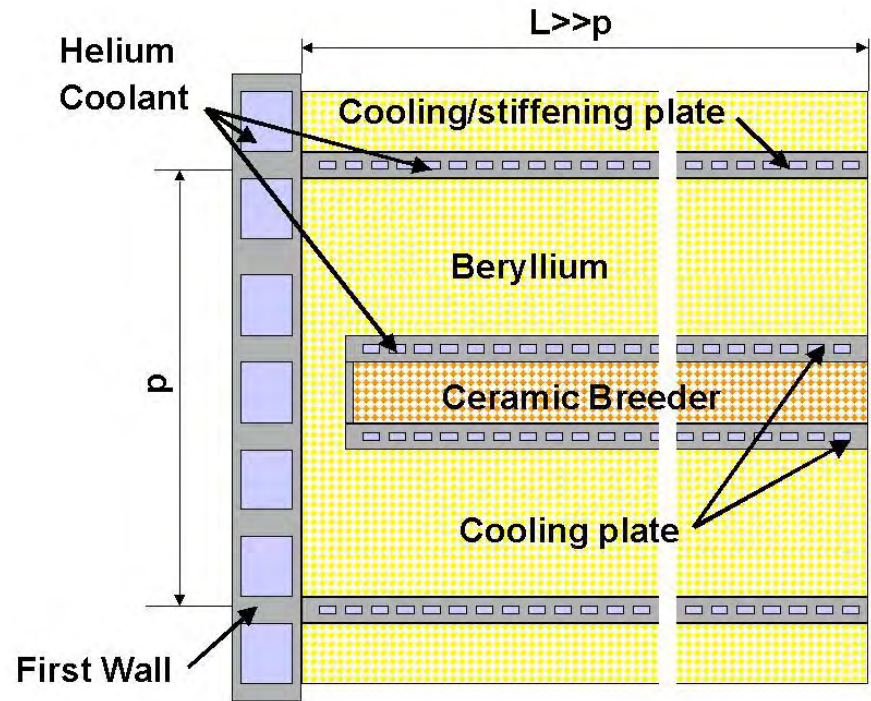
7. Tritium Permeation Barriers (in some concepts)

8. Neutron Attenuators and Reflectors

A Helium-Cooled Li-Ceramic Breeder Concept: Example

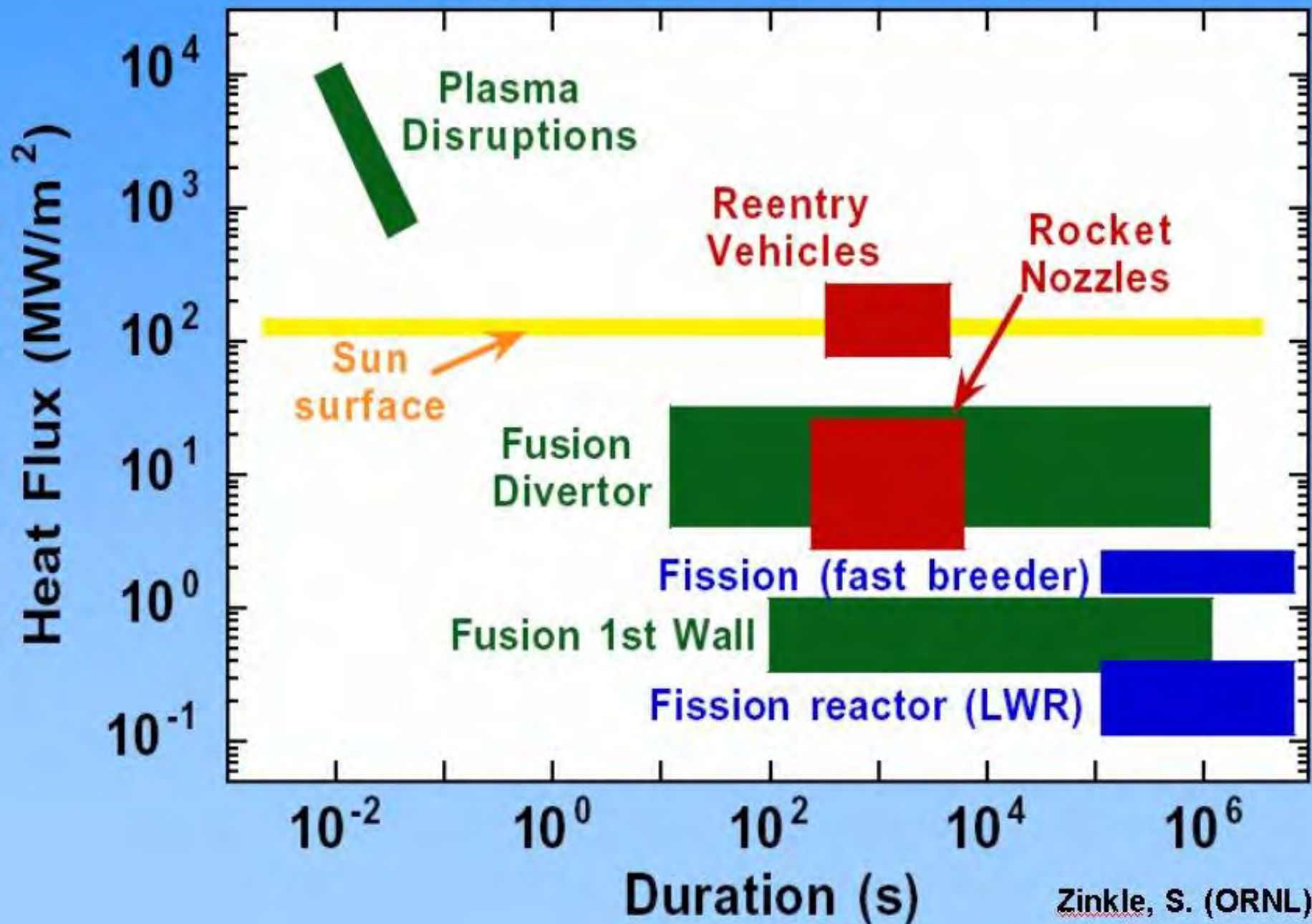
Material Functions

- **Beryllium** (pebble bed) for neutron multiplication
- **Ceramic breeder** (Li_4SiO_4 , Li_2TiO_3 , Li_2O , etc.) for tritium breeding
- **Helium purge** (low pressure) to remove tritium through the “interconnected porosity” in ceramic breeder
- **High pressure Helium** cooling in structure (ferritic steel)

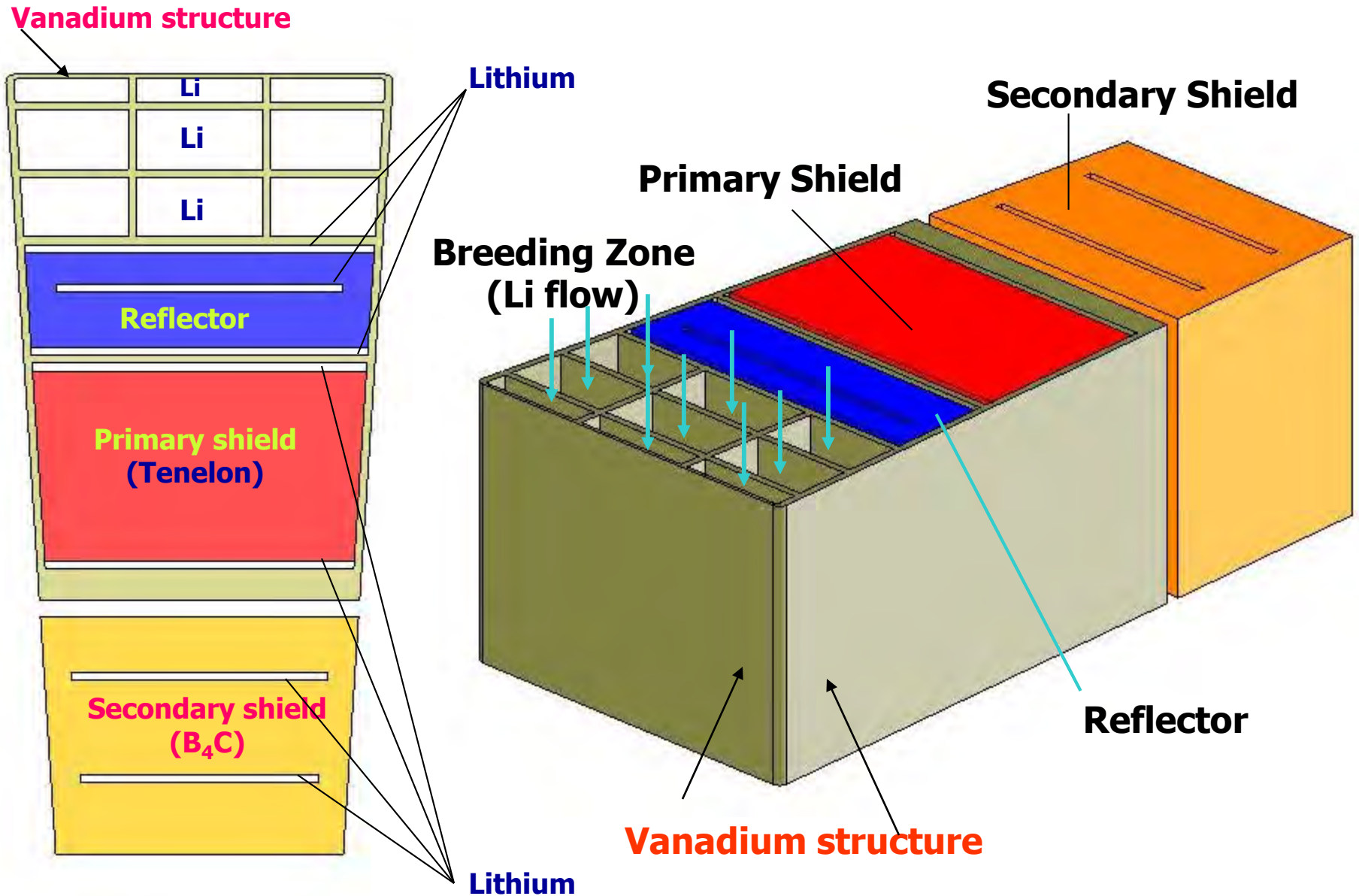


Several configurations exist (e.g. wall parallel or “head on” breeder/Be arrangements)

Comparison of Heat Fluxes



Li/Vanadium Blanket Concept



Flows of electrically conducting coolants will experience complicated magnetohydrodynamic (MHD) effects

What is magnetohydrodynamics (MHD)?

- Motion of a conductor in a magnetic field produces an EMF that can **induce current** in the liquid. This must be added to Ohm's law:

$$\mathbf{j} = \sigma(\mathbf{E} + \mathbf{V} \times \mathbf{B})$$

- Any induced current in the liquid results in an additional **body force** in the liquid that usually opposes the motion. This body force must be included in the Navier-Stokes equation of motion:

$$\frac{\partial \mathbf{V}}{\partial t} + (\mathbf{V} \cdot \nabla) \mathbf{V} = -\frac{1}{\rho} \nabla p + \nu \nabla^2 \mathbf{V} + \mathbf{g} + \frac{1}{\rho} \mathbf{j} \times \mathbf{B}$$

- For **liquid metal coolant**, this body force can have dramatic impact on the flow: e.g. **enormous MHD drag**, highly distorted velocity profiles, non-uniform flow distribution, modified or suppressed turbulent fluctuations

Ideal MHD Equations (one version)

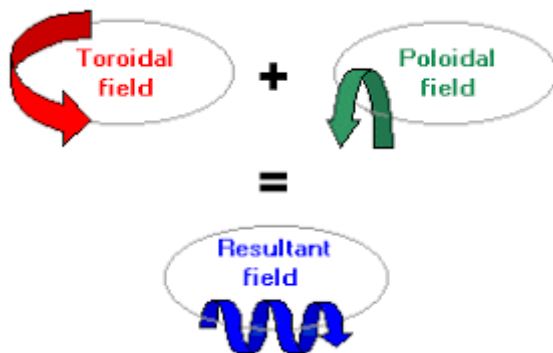
Fluid Equations

$$\begin{aligned}\frac{\partial \rho}{\partial t} &= -\nabla \cdot (\rho \mathbf{v}) \\ \frac{\partial \rho \mathbf{v}}{\partial t} &= -\nabla \cdot (\rho \mathbf{v} \mathbf{v} + p \mathbf{I}) + \mathbf{j} \times \mathbf{B} \\ \frac{\partial e}{\partial t} &= -\nabla \cdot [(e + p) \mathbf{v}] + \mathbf{j} \cdot \mathbf{E} \\ e &= \frac{1}{2} \rho v^2 + \frac{p}{\gamma - 1}\end{aligned}$$

Maxwell's Equations

$$\begin{aligned}\frac{\partial \mathbf{B}}{\partial t} &= -\nabla \times \mathbf{E} \\ \mu_0 \mathbf{j} &= \nabla \times \mathbf{B} \\ \nabla \cdot \mathbf{B} &= 0\end{aligned}$$

Ohm's Law $\mathbf{0} = \mathbf{E} + \mathbf{v} \times \mathbf{B}$



Derivation of MHD equations

Derivation 4.1 Starting from Ampere's Law, Faraday's Law and Ohm's Law, derive the Induction Equation

$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \times (\mathbf{v} \times \mathbf{B}) + \eta \nabla^2 \mathbf{B},$$

where $\eta = 1/(\mu_0 \sigma)$

- Note that conductivity σ is caused by collisions between ions and electrons and so is temperature-dependent (see Chapter 2). We use

$$\sigma = 7 \times 10^4 T^{3/2} \text{ mho m}^{-1} \text{ (or } \Omega^{-1} \text{ m}^{-1}) \text{ - where } T \text{ in K}$$

(but in derivation above we assume σ is constant)

- The equation of motion or **momentum equation** is

$$\rho \frac{d\mathbf{v}}{dt} = -\nabla p + \mathbf{j} \times \mathbf{B} + \rho \mathbf{g}$$

- The RHS is total force per unit volume: pressure gradients, Lorentz force and gravity. (Other forces such as viscous drag could also be included). Using Ampere's law, note

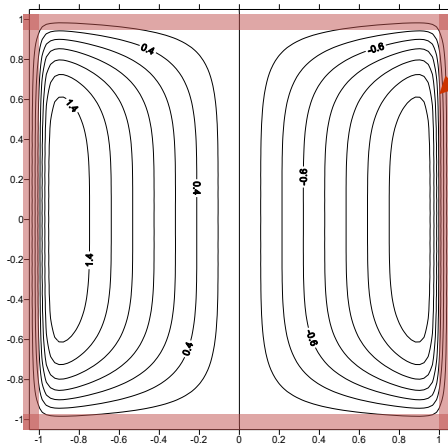
$$\mathbf{j} \times \mathbf{B} = (1/\mu_0)(\nabla \times \mathbf{B}) \times \mathbf{B}$$

- The LHS is the mass (per unit volume) multiplied by the acceleration seen by a moving fluid element – this is given by a convective derivative

$$\frac{d\mathbf{v}}{dt} = \left(\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v} \right)$$

Large MHD drag results in large MHD pressure drop

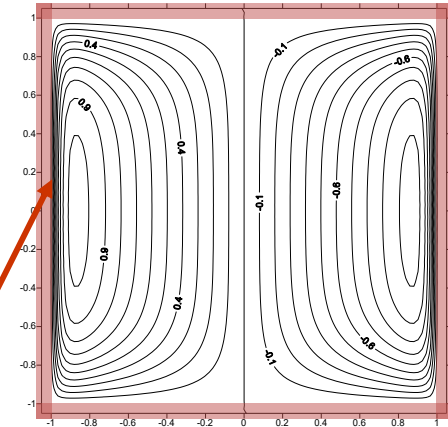
Conducting walls



Lines of current enter the low resistance wall – leads to very high induced current and high pressure drop

All current must close in the liquid near the wall – net drag from $\mathbf{j} \times \mathbf{B}$ force is zero

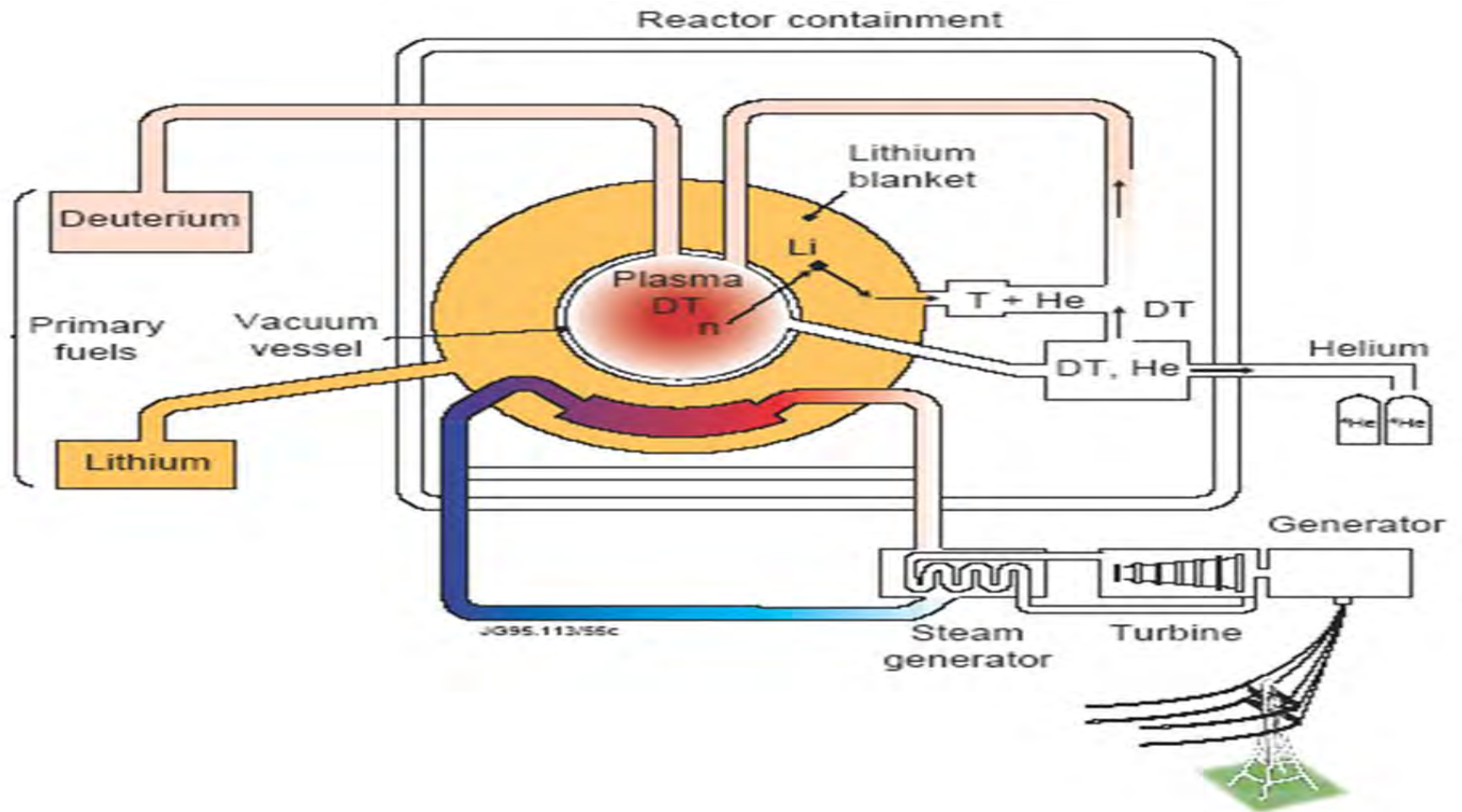
Insulated wall



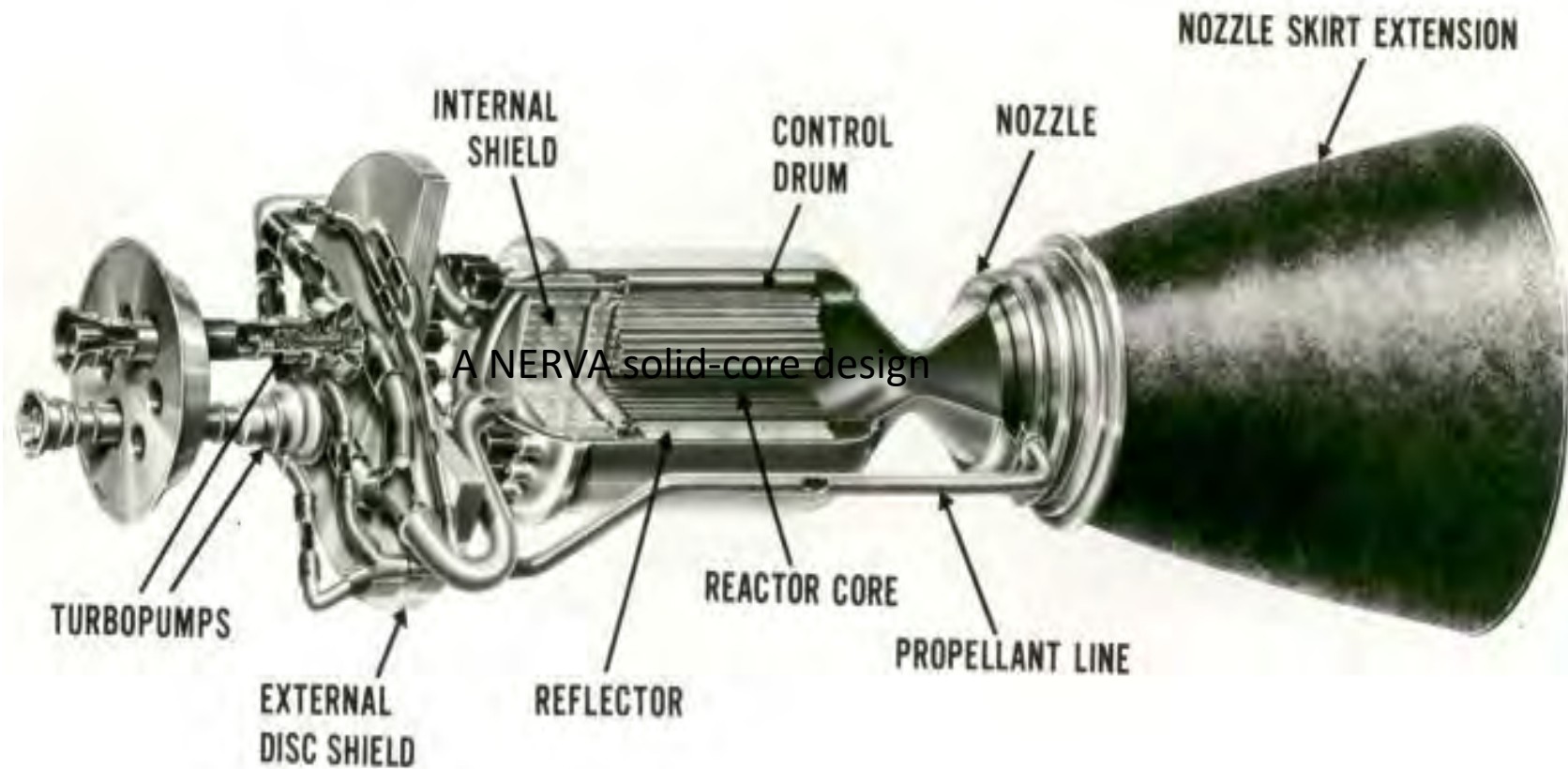
- Net $\mathbf{j} \times \mathbf{B}$ body force $\nabla p = c \sigma V B^2$ where $c = (t_w \sigma_w) / (a \sigma)$
- For high magnetic field and high speed (self-cooled LM concepts in inboard region) the pressure drop is large
- The resulting stresses on the wall exceed the allowable stress for candidate structural materials
- Perfect insulators make the net MHD body force zero
- But insulator coating crack tolerance is very low ($\sim 10^{-7}$).
 - It appears impossible to develop practical insulators under fusion environment conditions with large temperature, stress, and radiation gradients
- Self-healing coatings have been proposed but none has yet been found (research is on-going)

- The system can provide a lighter and more compact alternative based on fusion energy, just as the field can be analyzed like a fusion engine based on an inverted configuration. Developed states, scientists, and great entrepreneurs have constantly accelerated their advanced research projects agency into nuclear-powered spacecraft and rockets to gain the upper hand for future generations

Fusion Power Station Schematic

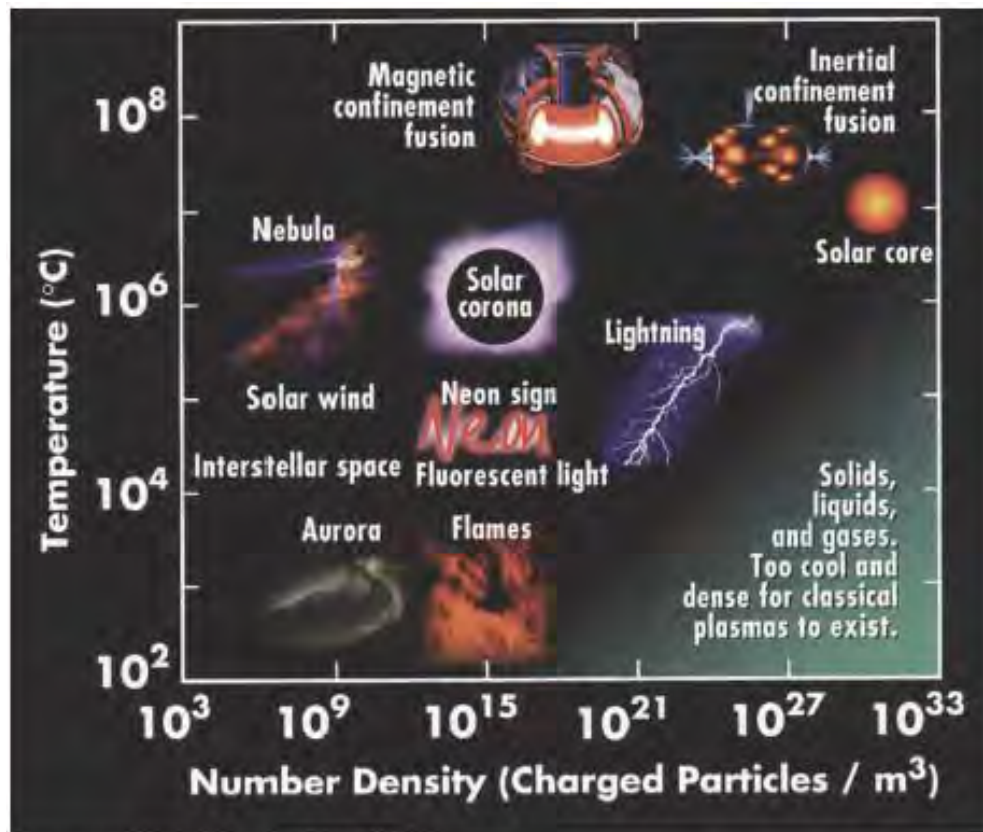


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Plasmas

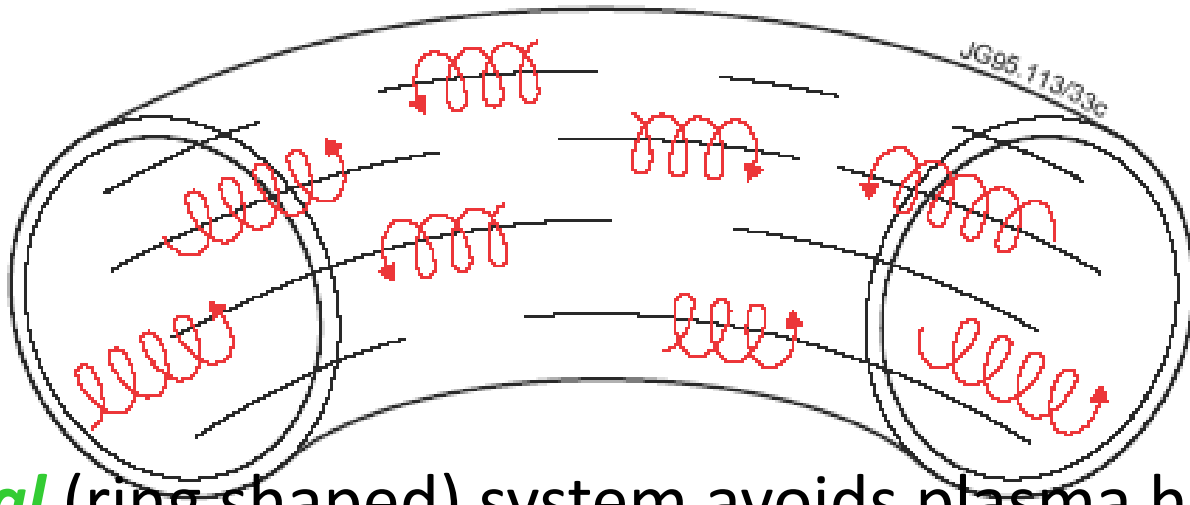
- A **Plasma** is an ionised gas. A mixture of **positive ions** and **negative electrons** with overall **charge neutrality**
- Plasmas constitute the 4th state of matter, obtained at temperatures in excess of 100,000 degrees
- Plasmas conduct **electricity** and **heat**



- A fusion rocket is a theoretical design for a fusion-propelled rocket that could provide efficient, long-term acceleration into space without the need to carry a large supply of fuel.
- The design is based on developing fusion energy technology beyond current capabilities and building rockets much larger and more complex than any current spacecraft. A smaller and lighter fusion reactor may be possible in the future when more sophisticated methods are devised to control magnetic confinement and prevent plasma instabilities.

Magnetic Confinement

- **Magnetic fields** cause charged particles to spiral around field lines. Plasma particles are lost to the vessel walls only by relatively slow diffusion **across** the field lines



- **Toroidal** (ring shaped) system avoids plasma hitting the end of the container
- The most successful Magnetic Confinement device is the **TOKAMAK** (Russian for '**Toroidal Magnetic Chamber**')

How Large a Device?

- For fusion power to ignite a plasma:
 - There has to be *sufficient density* of deuterium and tritium ions (n_i);
 - The reacting ions have to be *hot enough* (T_i);
 - The *energy* from the fusion α 's must be *confined for long enough* (τ_E).

τ_E increases with the square of the device size
– a large machine is needed.

- The *fusion triple product* ($n_i T_i \tau_E$) and the *ion temperature* (T_i) must both be large enough (below a certain temperature the fusion reaction probability is too small)

pressure ($n_i T_i$) ≥ 2 atmospheres

confinement time > 5 seconds

plasma ion temperature ≈ 100 - 200 Million $^{\circ}\text{C}$

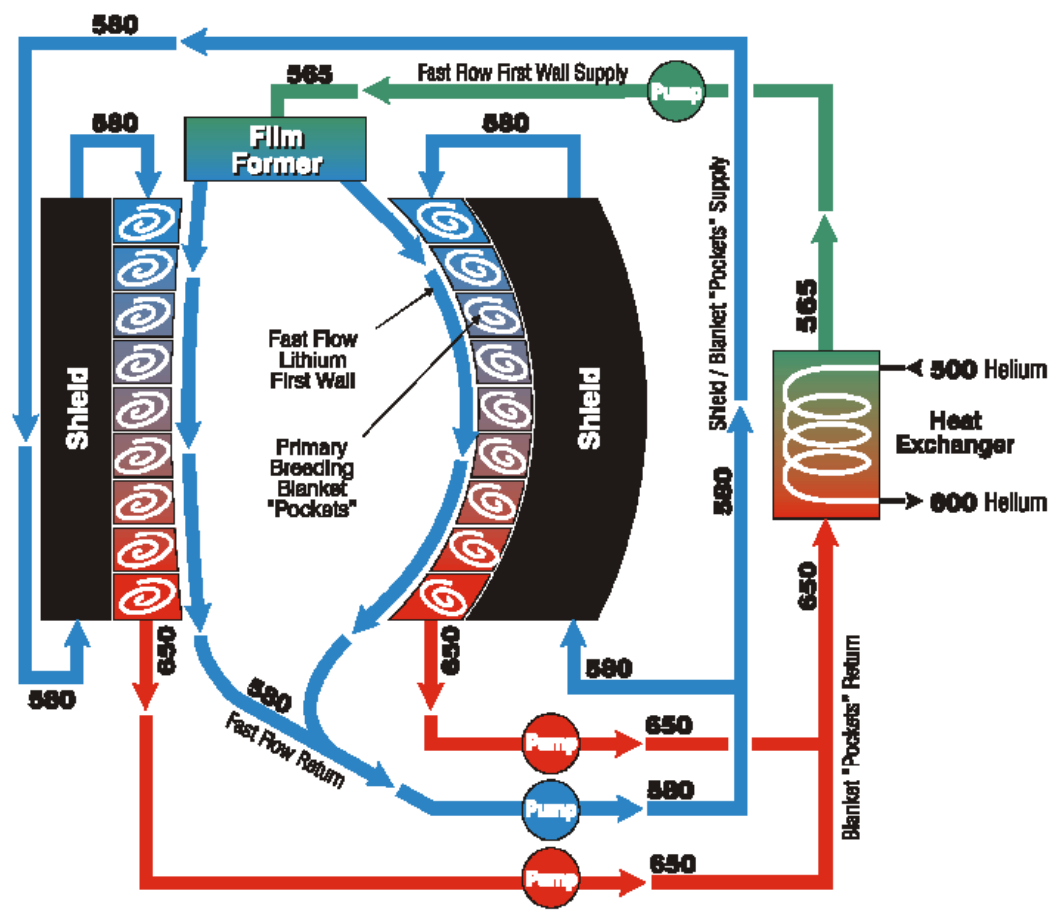
- Inertial fusion could provide a lighter and more compact alternative, as well as a fusion engine [1] based on a field inversion configuration. Nuclear fusion pulse propulsion is an approach to using nuclear fusion energy to provide rocket propulsion.
- The most important advantage of thermonuclear fusion for space flights can be a very large specific fuel, and the most important disadvantage is the large mass of the reactor. However, a thermonuclear rocket produces less radiation than a fission rocket, a reduction in mass is necessary for shielding.

- We argue that it is essential for the fusion energy program to identify an imagination-capturing critical mission by developing a unique product which could command the marketplace. We lay out the logic that this product is a fusion rocket engine, to enable a rapid response capable of deflecting an incoming comet, to prevent its impact on the plane.

DESIGN FOR D-T BY MCNP-4 CODE

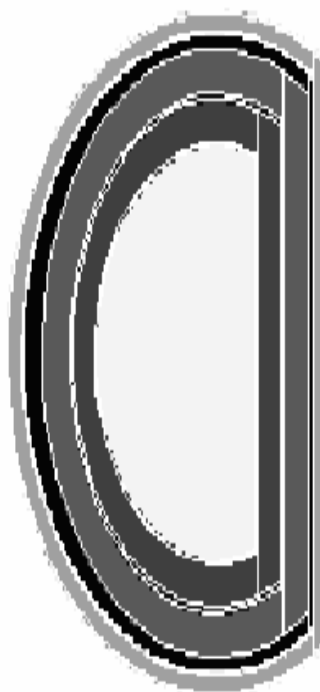
- Nowadays, the complexity in the nature of the industrial problems unfortunately makes analytical solution impossible. The nature of problems becomes complicated and the number of integrated systems increases very fast with the technological developments.
- On contrary to the analytical approaches, simulation models are more successful in modeling and solution of complicated problems. It is easier to follow the interactions between the variables in simulation designs.
- But, it requires too much computer usage. It is aimed to get numerical results by applying the data collected from the reel system to the model developed on the computer. By evaluating and interpreting the results, some estimates are done for system performance criterions. By using simulation models the worst condition scenarios can also be investigated.

- Calling the simulation technique as Monte-Carlo technique was done by Von Neumann and Ulam, and first applications was carried out in neutron diffusion problems. Monte-Carlo technique is randomly number selection technique from one or more probabilistic distribution in a special trial or simulation study.
- The method was then adopted easily for solution of much more complicated and non-statistical problems such as integrodifferential evaluation problems. Some authors suggested classification of the method for using only for sampling works of variance reduction techniques. However, the usage of the method nowadays is generally in selection of values randomly from the probabilistic distributions.

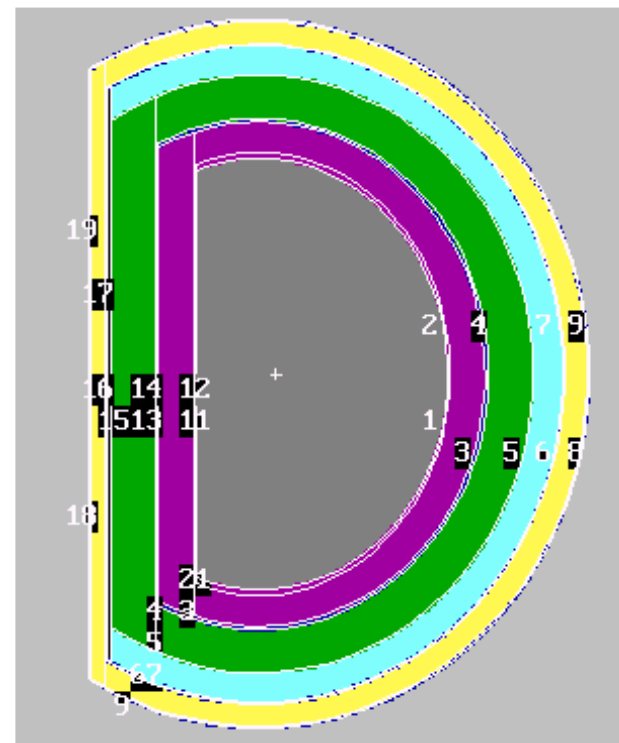
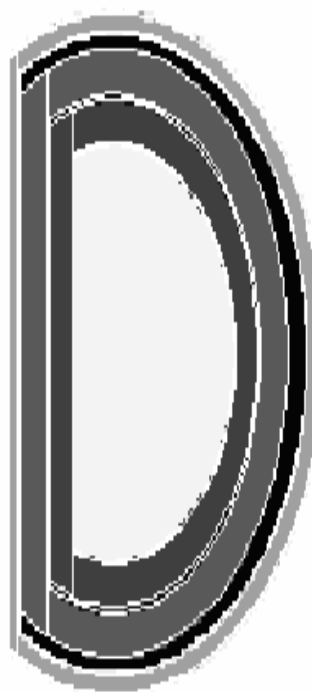




Cross-sectional 2D View Of D-T Fusion Plasma Fueled Rocket Modeling Designed in MCNP-5x with Cell and Surface Numbers



+



Neutron Spectrum Used In The Calculations

- Following modeling, plasma was designed as neutron source that the inner surface of first liquid wall exposed to neutrons homogeneously and the calculations were conducted with the fusion neutron spectrum shown in Figure.
- The total tritium production amount per source neutron (TBR) in first liquid wall, blanket and shield zones was calculated with respect to the enrichment of Li-6 in the Flibe. For all Li-6 enrichments, TBR meets the requirement of $TBR > 1.05$ which is necessary for self-sufficient fusion reactor.
- For a self-sustaining fusion reactor, a $TBR > 1.05$ will be required. The TBR values have been calculated in the range between 1.153 and 1.295 for natural Li-6 and 90% Li-6 enrichment, respectively. While the TBR value increases with Li-6 enrichment, the best performance TBR value of 1.295 is achieved with 90% Li-6.

FW/MHD Stability Flow Approach

- In D-T Fusion Plasma Fueled Rocket Modeling studies, Navier-Stokes and Maxwell equations were used to analyze the effects of various fluids (flin, Lithium and Sn-Li).
- For the modeling of magnetohydrodynamics (MHD), studies have been carried out to determine the effect of the plasma aspect ratio, elongation, pressure and flow profiles and the position of the curved fixing wall.
- Plasma flow and pressure profiles are determined to provide a high stable β and large, well aligned boot current at the same time. between the boot current profile and the desired MHD constant current profile.
- Plasma geometry plays an important role in MHD stability as well as overall power plant design. Aspect variations showed the well-known trend that b increases as the aspect ratio decreases, but current propulsion power also increased. we offer many advantages such as replacing the first liquid wall with thick liquids, high fusion power density, high control reliability and usability, and low failure reduced radioactive waste quantities and increased build a life.

In D-T Fusion Plasma Fueled Rocket Modeling studies, Hydrodynamics Properties Working

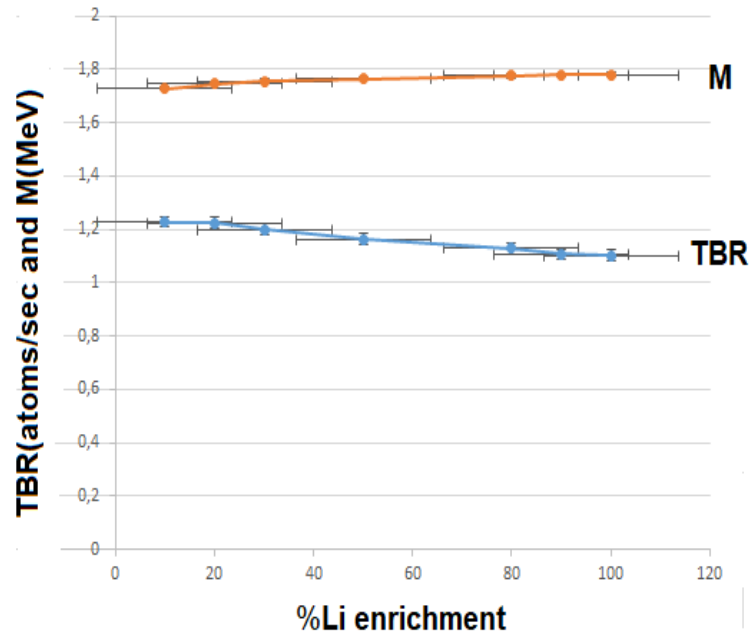
Property	Unit	FliBe (550 C°)	Lithium (500C°)	Tin-Lithium (500C°)
composition	Mole *A	66%LiF, 34%BeF2	100% Li	80% Sn, 20% Li
melting point	K	733	459	599
density	Kg/m ³	2011	485	6800
dynamic viscosity	Kg/m.s	0.0116	0.32x10 ⁻¹	1.2x10 ⁻³
electrical cond.	l/12m	184	2.83x10 ⁶	1.67x10 ⁶
thermal cond.	W/m.K	1.06	49.6	33.44
specific heat	J/Kg.K	2380	4170	317
surface tension	N/m ²	0.2	0.35	0.53
liquid thickness	ln	0.45	0.40	0.40
liquid velocity	m/s	8.1	10	10
channel 1/2 width	t	0.68	0.57	0.07
flow length	m	8	8	8
toroidal field	T	8	8	8
radial field	T	0.2	0.2	0.2
radius of curvature	m	6.7	6.7	6.7

- In the figure-5 per source neutron, local tritium breeding ratio TBR (atoms /Sec) and M (MeV) states of energy multiplication coefficient change versus % ^6Li can be seen. In graphic, it is clear that enriching the Li result in a significant decrease in the TBR and a negligible increase M. The local TBR and M values are shown for outboard and inboard regions. The overall TBR and M depend on the neutron coverage fractions (NCF) of regions surrounding the plasma and the blanket thickness in each region. The relative NCF for the inboard and outboard regions varies significantly with the aspect ratio. The Tritium breeding ratio (TBR) would be given, $\text{TBR} = \text{Tbr}_6 + \text{Tbr}_7$; where, respectively; Tbr 6 and Tbr 7 on Li_6 and Li_7 depended. The Tritium breeding ratio (TBR) can be given as follows;
- $$\text{Tbr}_6 = \iint \phi \cdot \sum n_i \sigma_i T dE \cdot dV \text{ and } \text{Tbr}_7 = \iint \phi \cdot \sum (n_i, n'_i) \sigma_i T dE \cdot dV \quad (3)$$
- Another important neutronic parameter is the energy impact factor M. It is defined ratio of the ratio total energy deposited in the systems to the incident neutron kinetic energy. The energy produced in (D, T) reactor should be as high as possible than this energy produced by plasma

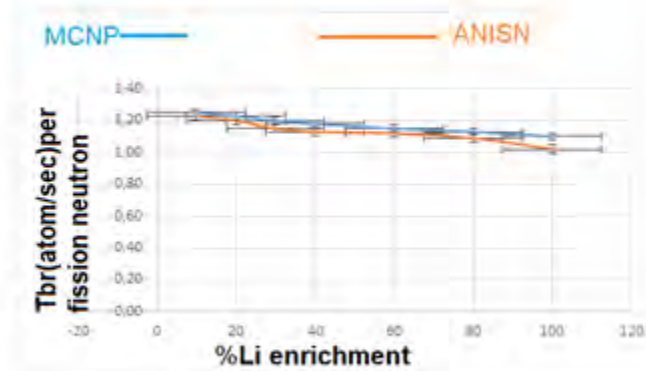
- In D-T Fueled Rocket Modeling studies fusion reactor has a fusion power of 2170 MW and an energy multiplication of $M = 1.2$. This produces a total power of ~ 2600 MW. Due to the low fission rates found in the fusion zone, the energy ratio is somewhat low .
- Energy multiplication factor (M) can be given as follows;

$$\begin{aligned}
 \text{➤ } M = 1 + \left\{ \frac{200 * \beta}{14.1} + 0.34 * (Tbr_6) + 0.175 * (Tbr_7) \right\} \text{ and } & \langle \beta \rangle = \\
 \iint \phi * \Sigma_F * dE * dV & \quad (4)
 \end{aligned}$$

Local TBR and M Exchange Versus of % Li



Compare of MCNP5X and ANISN Simulation



➤ **Result and discussion**

- In the present study the attempts has been made to estimate the influence of the concrete aggregates on the shielding parameters for three type of ordinary, serpentine and steel magnetite concrete by Monte Carlo N-Particle (MCNP) transport code.
- MCNP calculations havebeen performed in order to obtain the leakage of neutrons, photons and electrons from dry shield
- The D-T Fusion process offers the promise of virtually unlimited energy source from cheap abundant fuels;No atmospheric pollution of greenhouse and acid rain gases;Low radioactive burden from waste for future generations.Tremendous Progress has been achieved over the past decades in plasma physics and fusion technology.
- Fusion R&D involves many challenging areas of physics and technologies and is carried out through extensive international collaboration.

Result and discussion

- **Based on the advanced hybrid type (fission + fusion) reaction, the D-T type advanced rocket model will be able to provide efficiency and long-term acceleration in space without the need to carry large-mass fuels.**
- **In addition, in the very near future, space vehicles, spaceships, space stations, rocket systems will be designed with safe and convenient fusion type energy to other**

Result and discussion

- **The future of manned space exploration and space development is critical, with the creation of a much more efficient propulsion architecture for intraspace transportation.**
- **A very convincing reason to explore the viability of nuclear power in a rocket is the energy density gain of nuclear fuel compared to the energy of chemical combustion.**
- **The fusion propelled rocket (FDR) represents a revolutionary approach to powered fusion propulsion. The source releases its energy directly to the propellant without the need to convert it into electricity.**
- **It uses a solid lithium propellant that does not require a significant tank weight. The propellant is quickly**

**THANK YOU FOR LISTENING TO ME CAREFULLY
AND CAREFULLY**