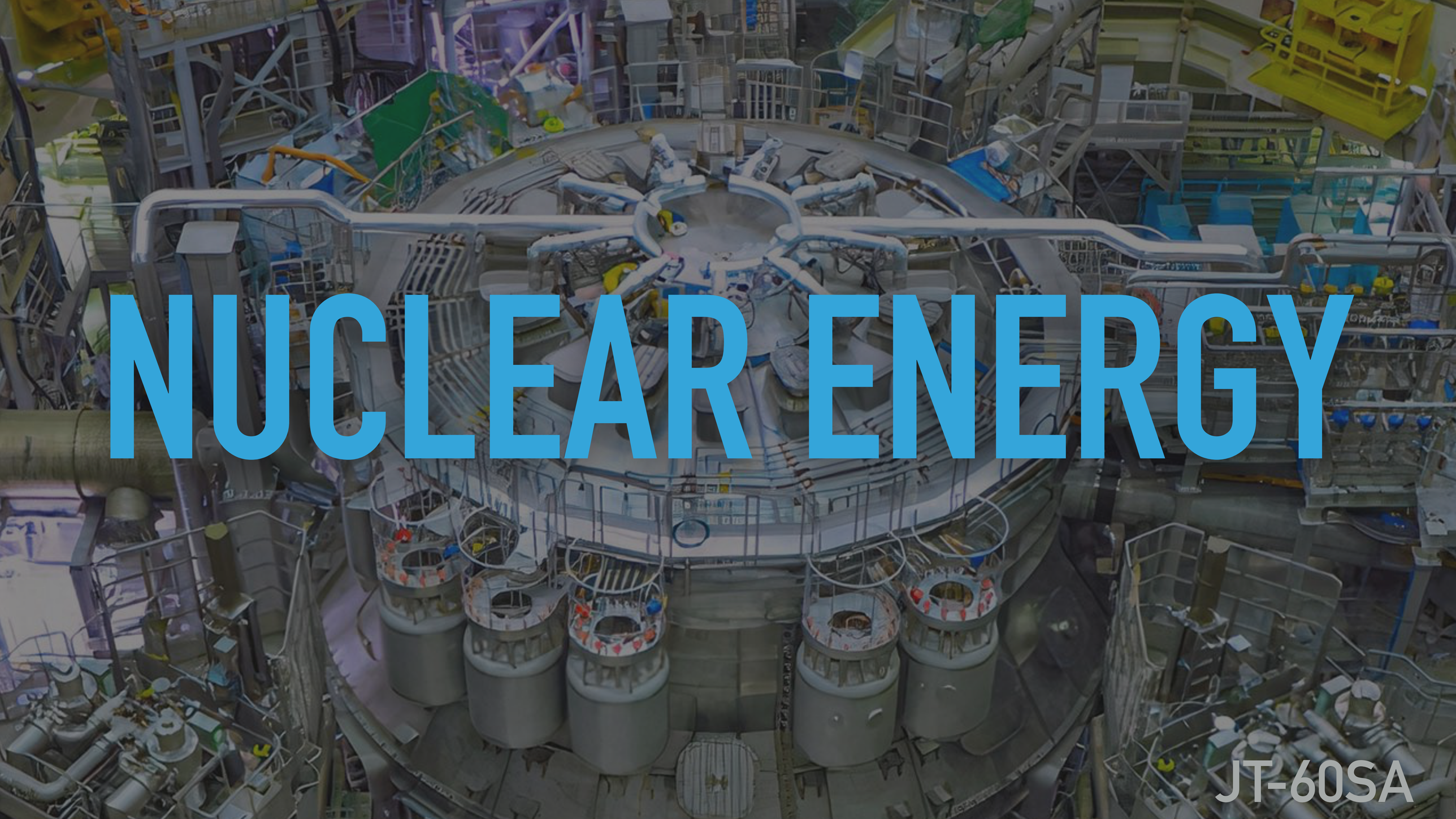
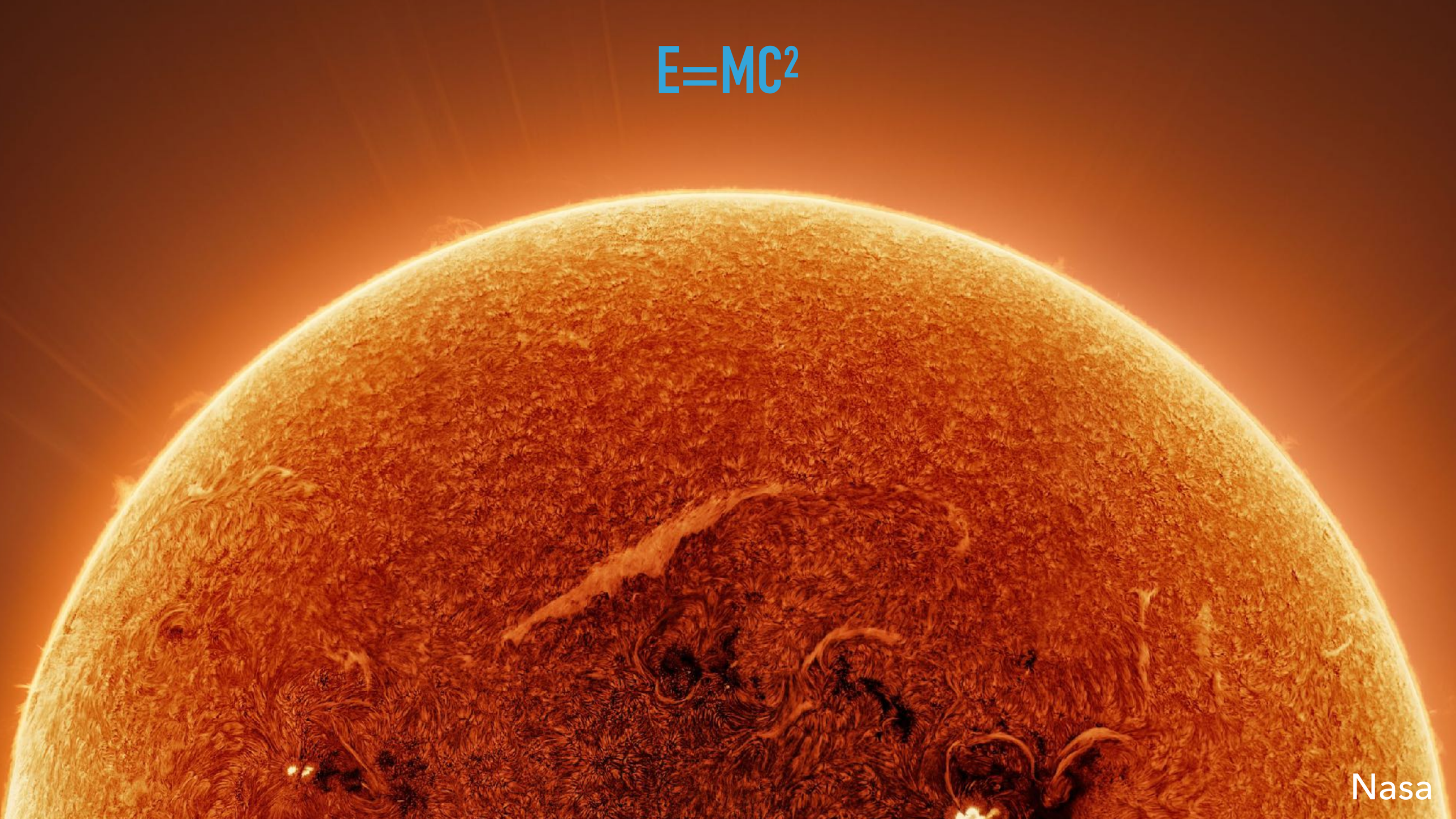

NUCLEAR ENERGY
JT-60SA

$E=MC^2$

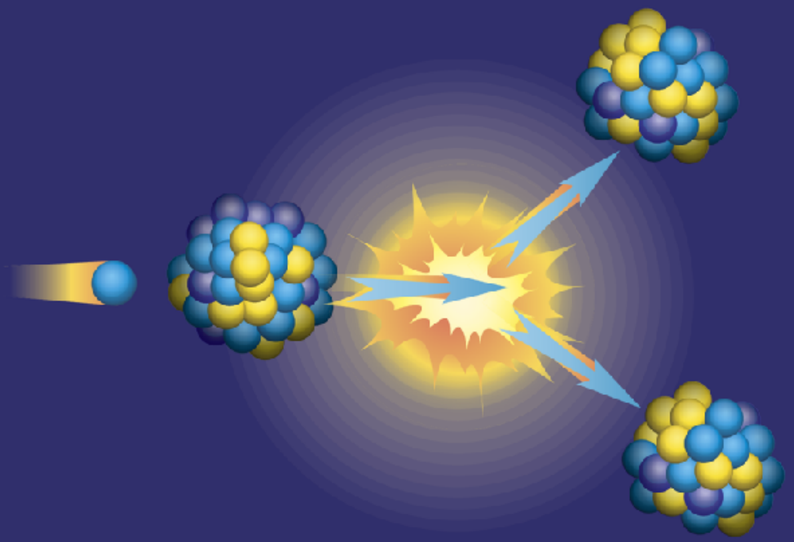


Nasa

Fission vs. Fusion

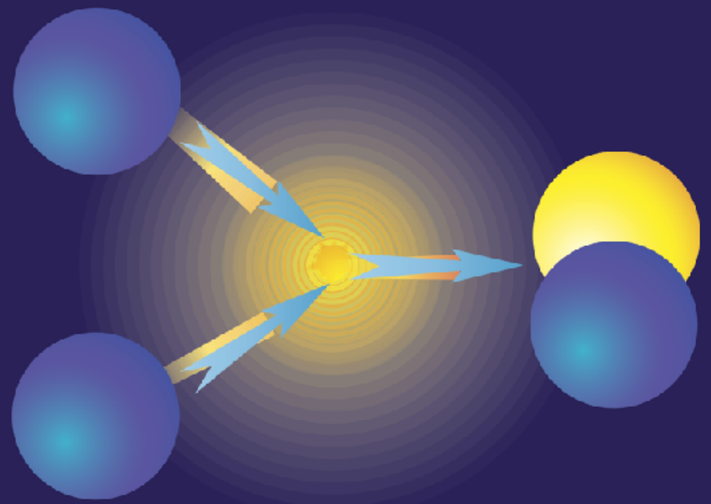
Physical processes that produce energy from atoms

FISSION



Splits a larger atom into 2 or more smaller ones.

FUSION



Joins 2 or more lighter atoms into a larger one.

energy.gov

A GUIDE TO DIFFERENT TYPES OF RADIATION

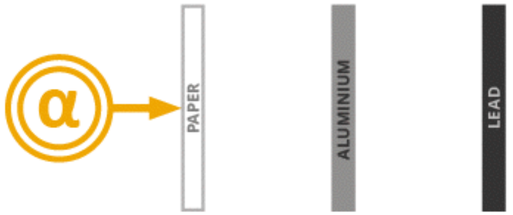
Ionising radiation commonly comes in three different forms: alpha, beta, and gamma radiation. Each of these has a differing composition, and they also differ in their penetration, ionisation ability, and uses. This graphic summarises each type in turn.

α ALPHA

2 protons & 2 neutrons

IONISATION ABILITY: ☢ ☢ ☢

HOW PENETRATING? ☢ ☢ ☢



USES

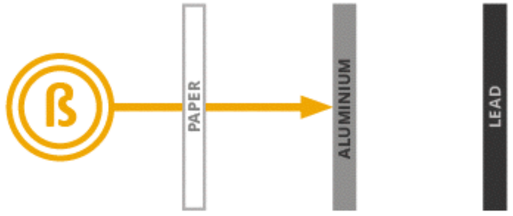
Many smoke detectors contain americium-241, which releases alpha radiation and helps detect smoke. Alpha radiation-emitting elements have also been used to power some heart pacemakers and some space probes, including the Mars Curiosity Rover.

β BETA

High energy electron

IONISATION ABILITY: ☢ ☢ ☢

HOW PENETRATING? ☢ ☢ ☢



USES

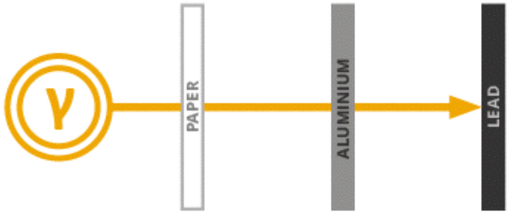
Beta-radiation emitters can be used as tracers in medicine to image inside the body, and have also been used in cancer treatment. In industry, they have been used to find leaks in underground pipes, and to gauge the thickness of materials during manufacture.

γ GAMMA

High energy EM radiation

IONISATION ABILITY: ☢ ☢ ☢

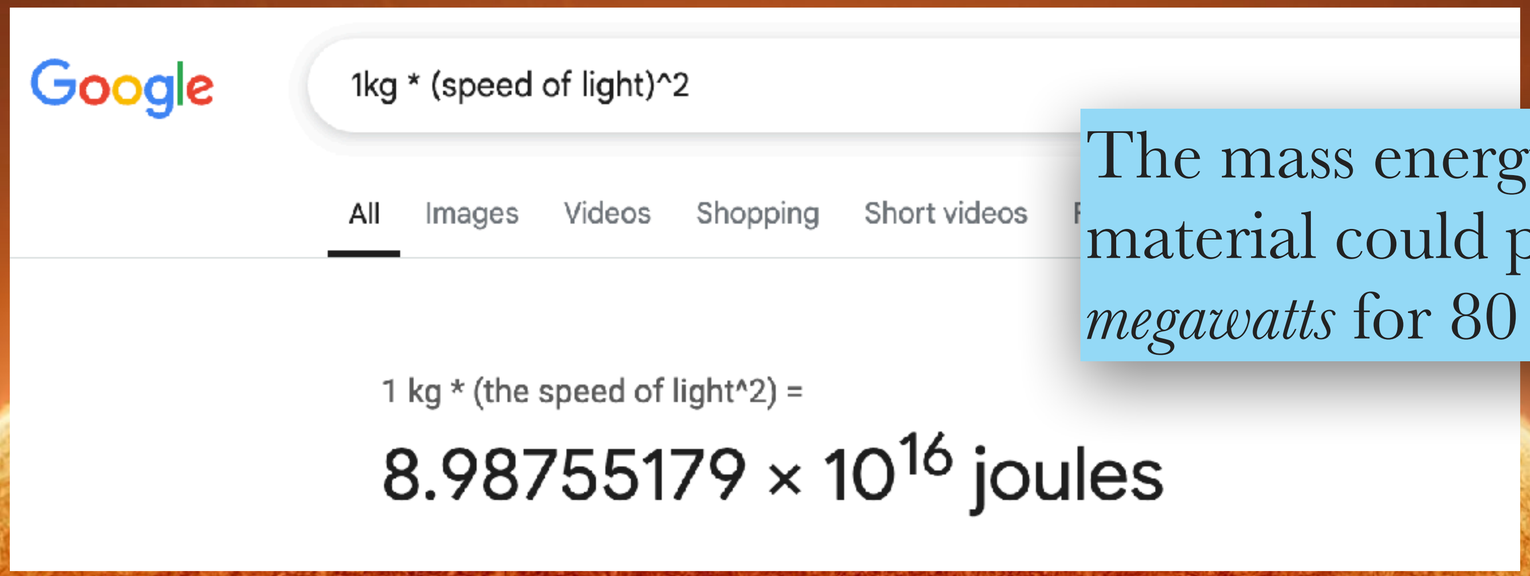
HOW PENETRATING? ☢ ☢ ☢



USES

Gamma radiation is used to help sterilise medical equipment, and can also help sterilise packaged foods. Gamma ray detection is used by a number of telescopes to produce images. They have also been used in cancer treatment to help kill cancer cells.

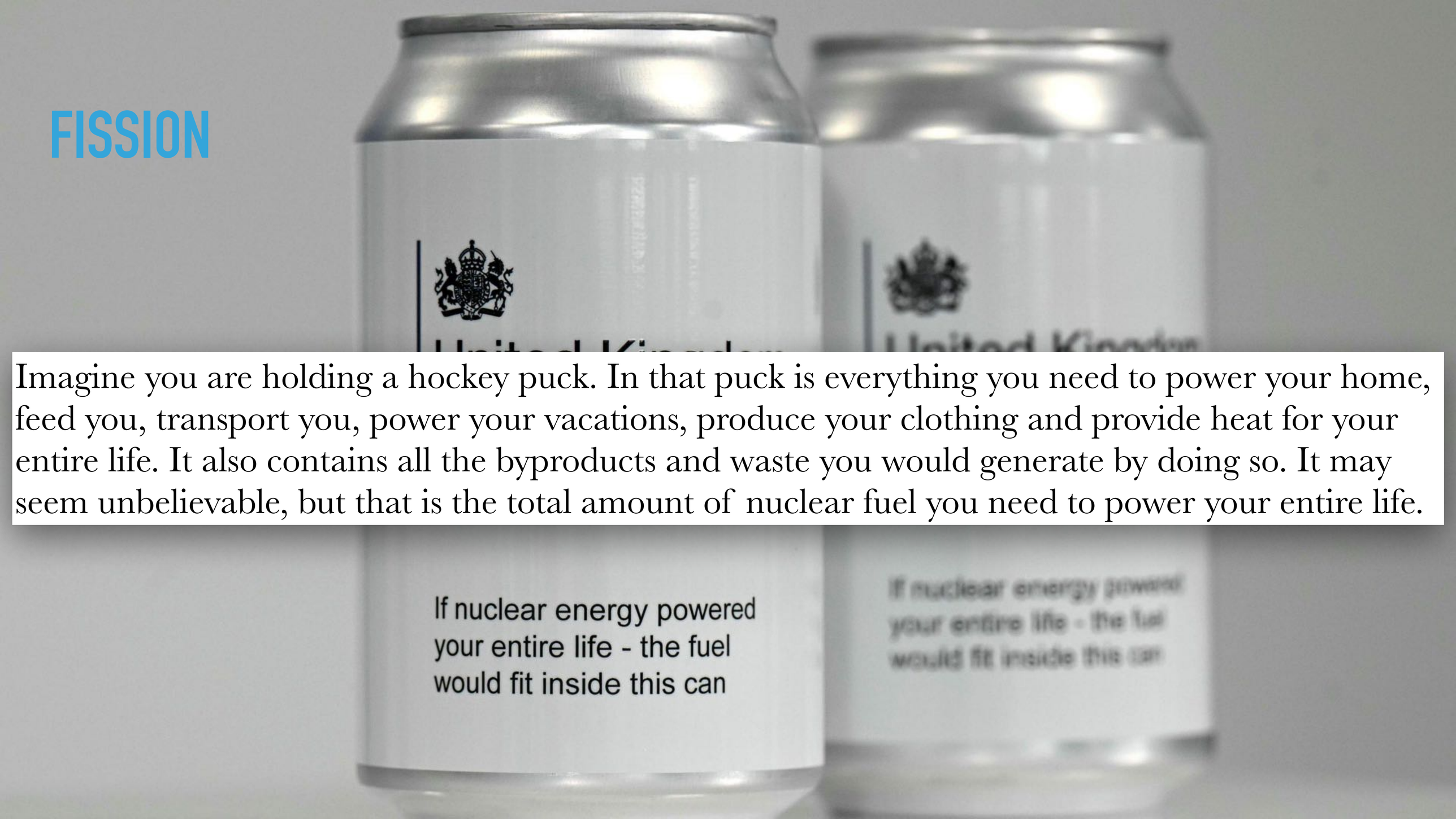
$E=MC^2$



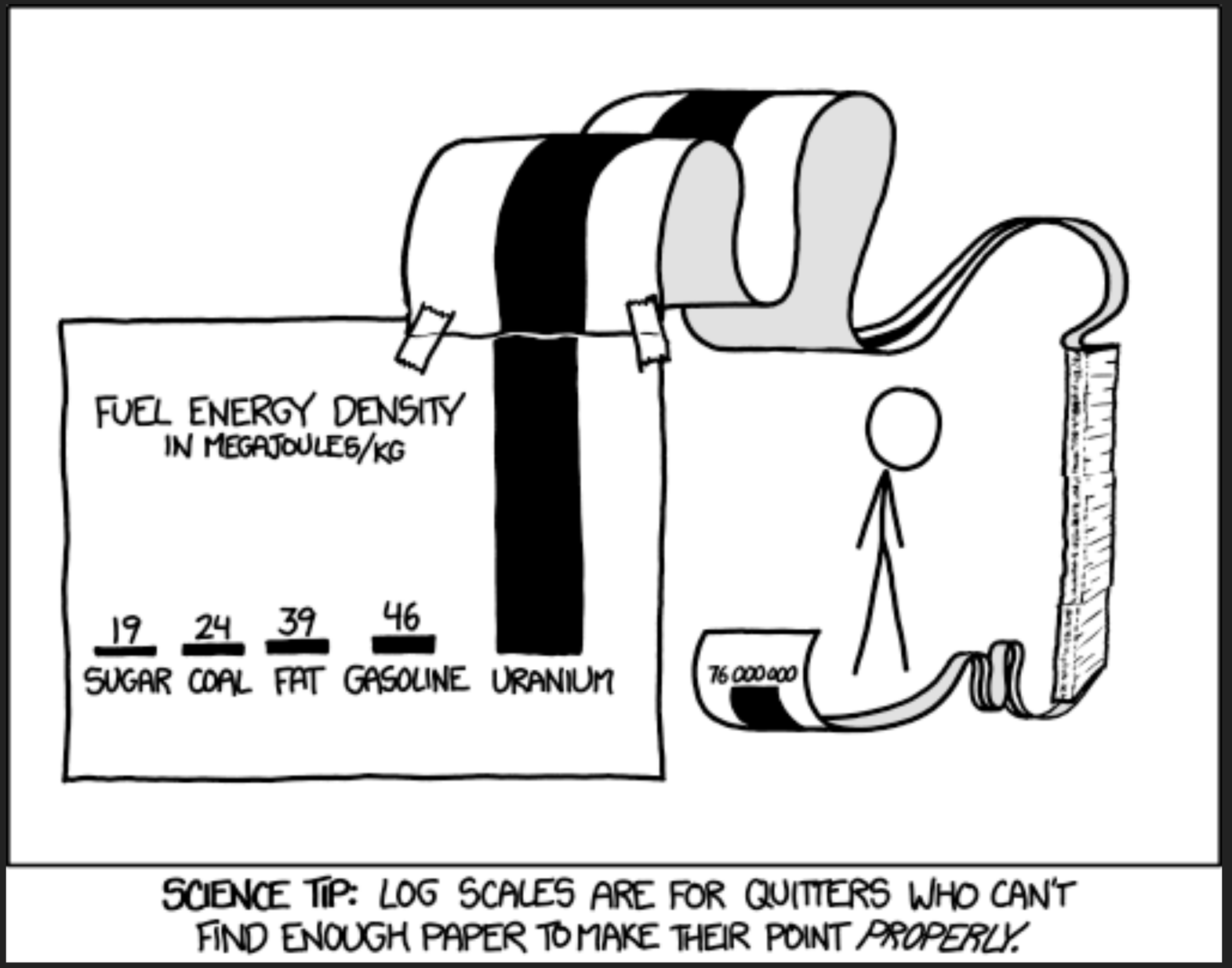
The mass energy of 1kg of material could provide 35 *megawatts* for 80 years.

Nasa

FISSION



Imagine you are holding a hockey puck. In that puck is everything you need to power your home, feed you, transport you, power your vacations, produce your clothing and provide heat for your entire life. It also contains all the byproducts and waste you would generate by doing so. It may seem unbelievable, but that is the total amount of nuclear fuel you need to power your entire life.



SCIENCE TIP: LOG SCALES ARE FOR QUITTERS WHO CAN'T FIND ENOUGH PAPER TO MAKE THEIR POINT *PROPERLY.*

https://xkcd.com/1162/

OKLO, GABON

Natural nuclear reaction site, 1.7B years ago

Duke Energy

Albert Einstein
Old Grove Rd.
Nassau Point
Peconic, Long Island

August 2nd, 1939

F.D. Roosevelt,
President of the United States,
White House
Washington, D.C.

Sir:

Some recent work b
municated to me in manus
ium may be turned into a
mediate future. Certain
to call for watchfulness
of the Administration. I
to your attention the fo

In the course of t
through the work of Joli
America - that it may be
in a large mass of urani
ities of new radium-like
almost certain that this could be achieved in the immediate future.

This new phenomenon would also lead to the construction of bombs, and it is conceivable - though much less certain - that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air.

This new phenomenon would also lead to the construction of bombs, and it is conceivable - though much less certain - that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air.

The United States has only very poor ores of uranium in moderate quantities. There is some good ore in Canada and the former Czechoslovakia, while the most important source of uranium is Belgian Congo.

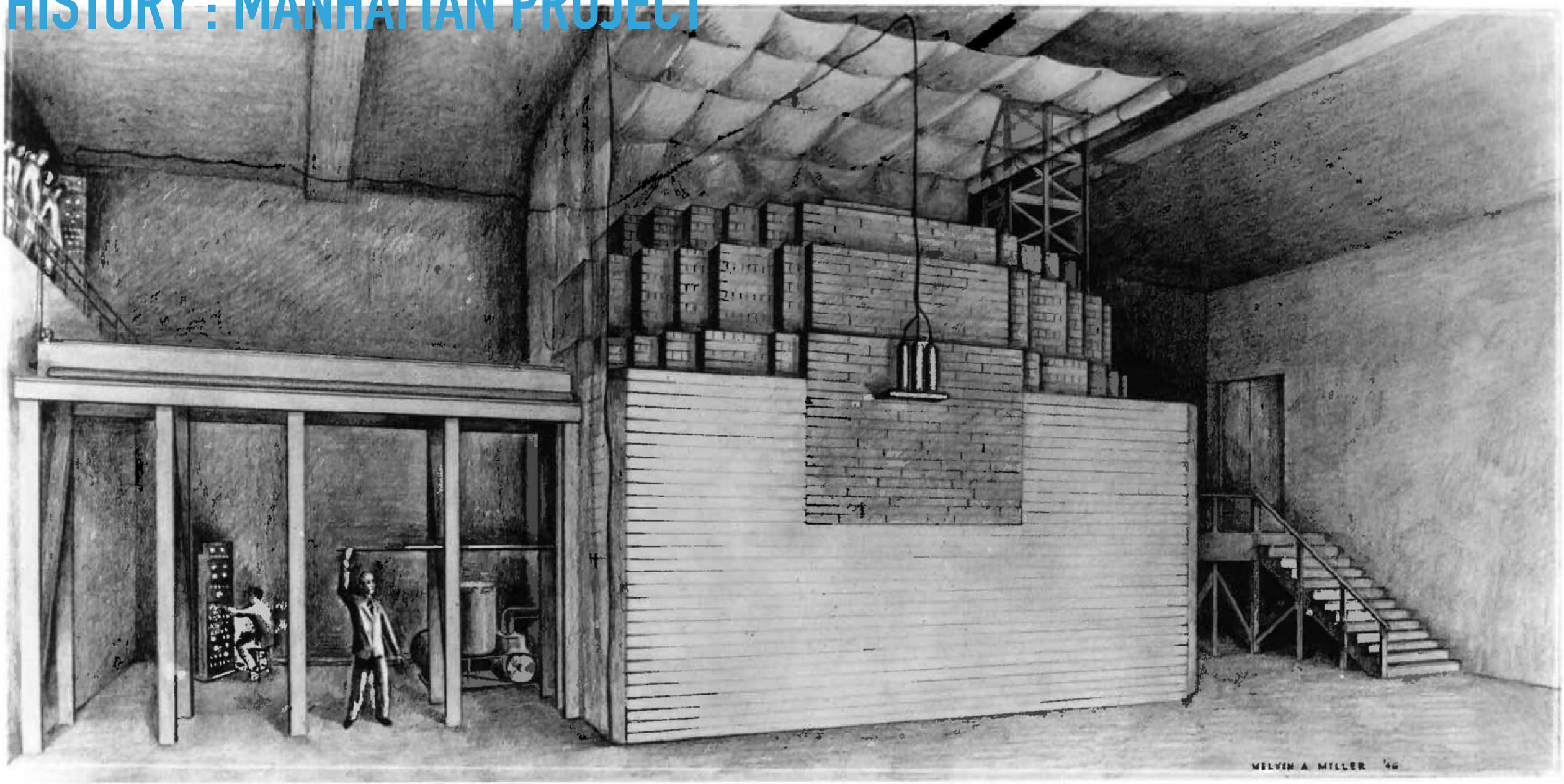
In view of this situation you may think it desirable to have some permanent contact maintained between the Administration and the group

on,

I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such early action might perhaps be understood on the ground that the son of the German Under-Secretary of State, von Weizsäcker, is attached to the Kaiser-Wilhelm-Institut in Berlin where some of the American work on uranium is now being repeated.

Yours very truly,
A. Einstein
(Albert Einstein)

HISTORY : MANHATTAN PROJECT



Chicago Pile I (CP-I), World's First Reactor

HISTORY : MANHATTAN PROJECT
DEMON CORE

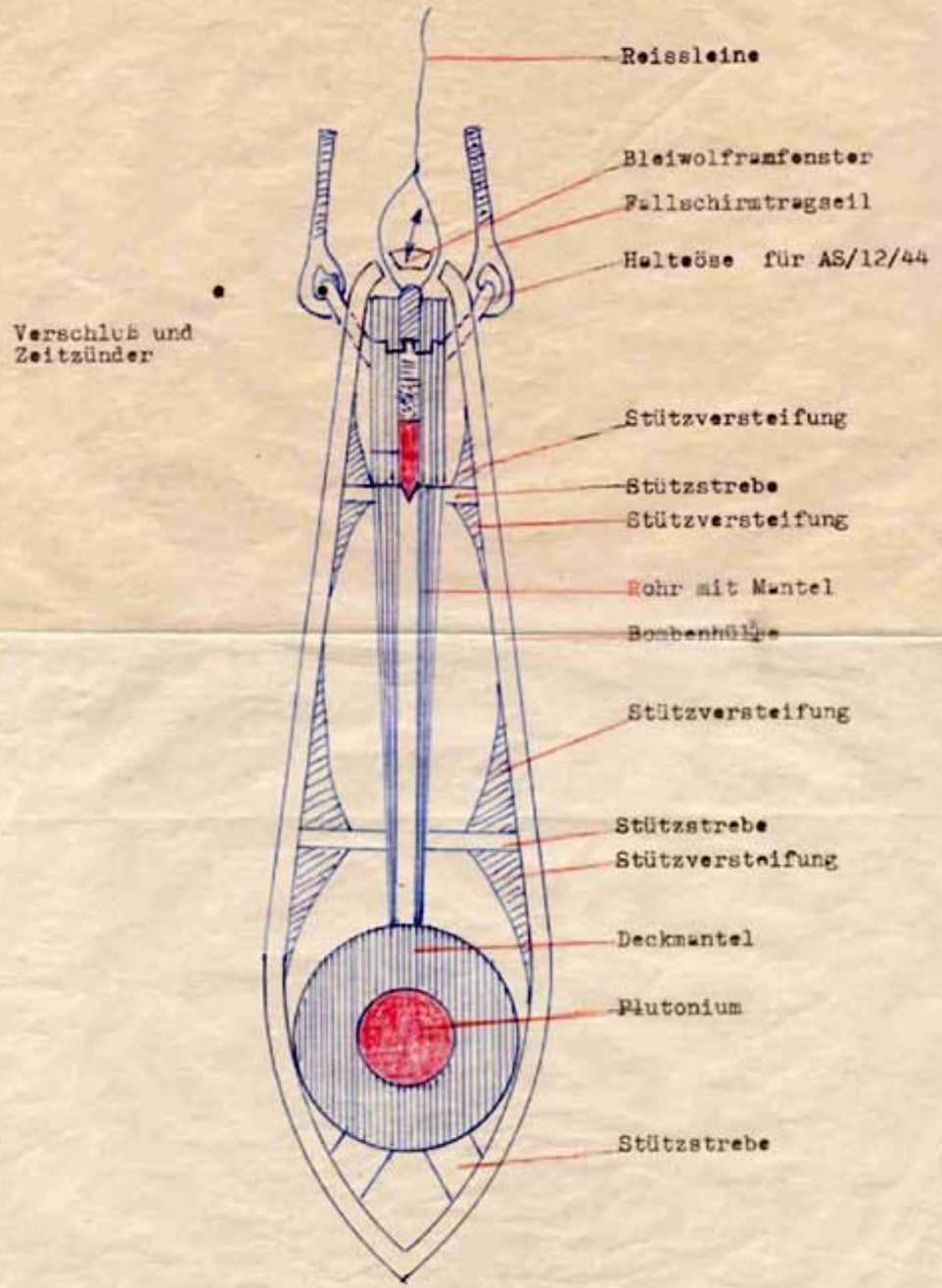
Louis Slotin

https://www.nps.gov/

https://arsmagine.com/others/the-demon-core/

URANBOMBE TYPE II

SCIZZE 1



AUGUST 6, 1945

HIROSHIMA

“LITTLE BOY”

90,000–166,000 DEAD

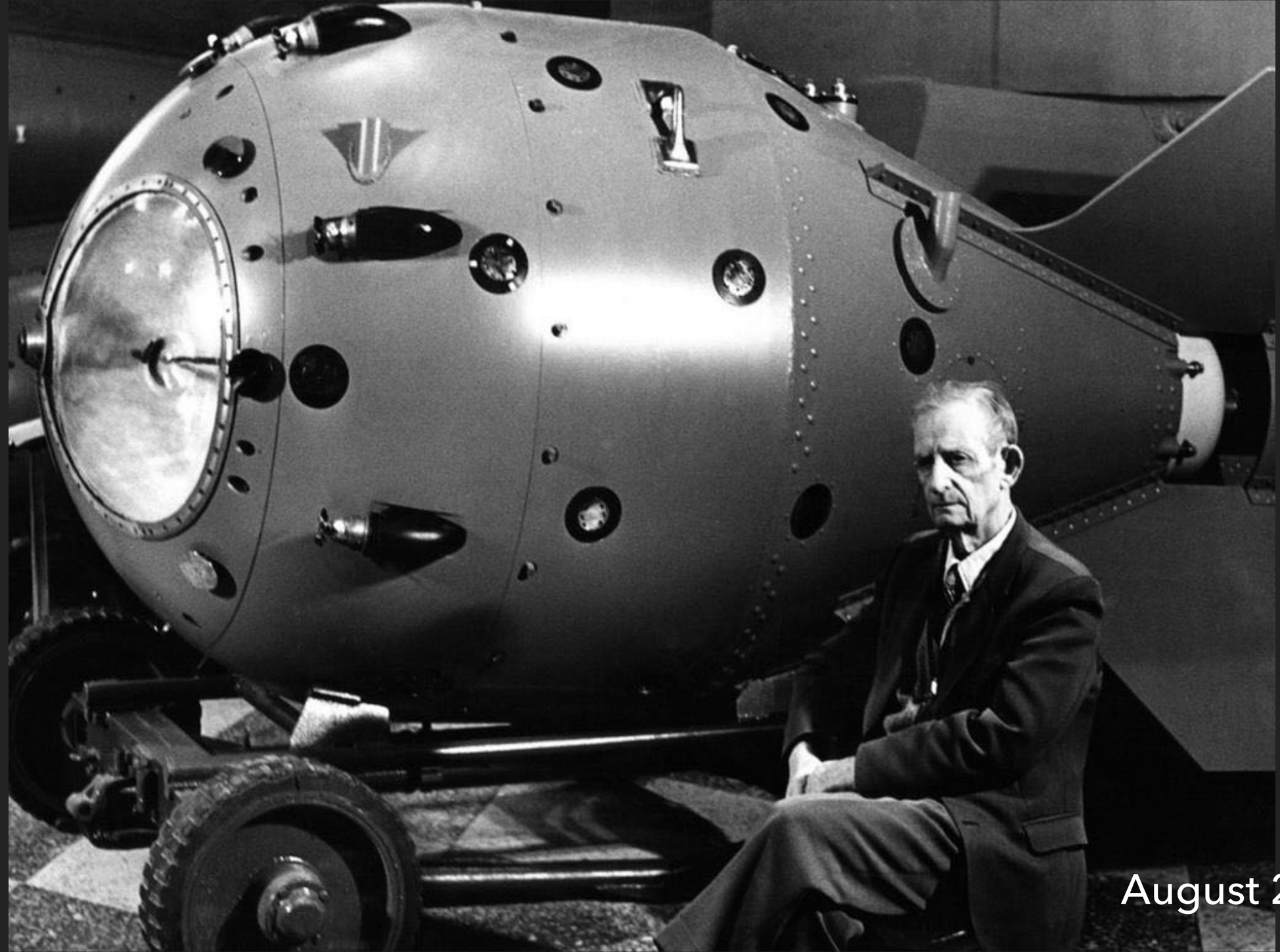
AUGUST 9, 1945

NAGASAKI

“FAT MAN”

60,000–80,000 DEAD

РДС-1



August 29, 1949

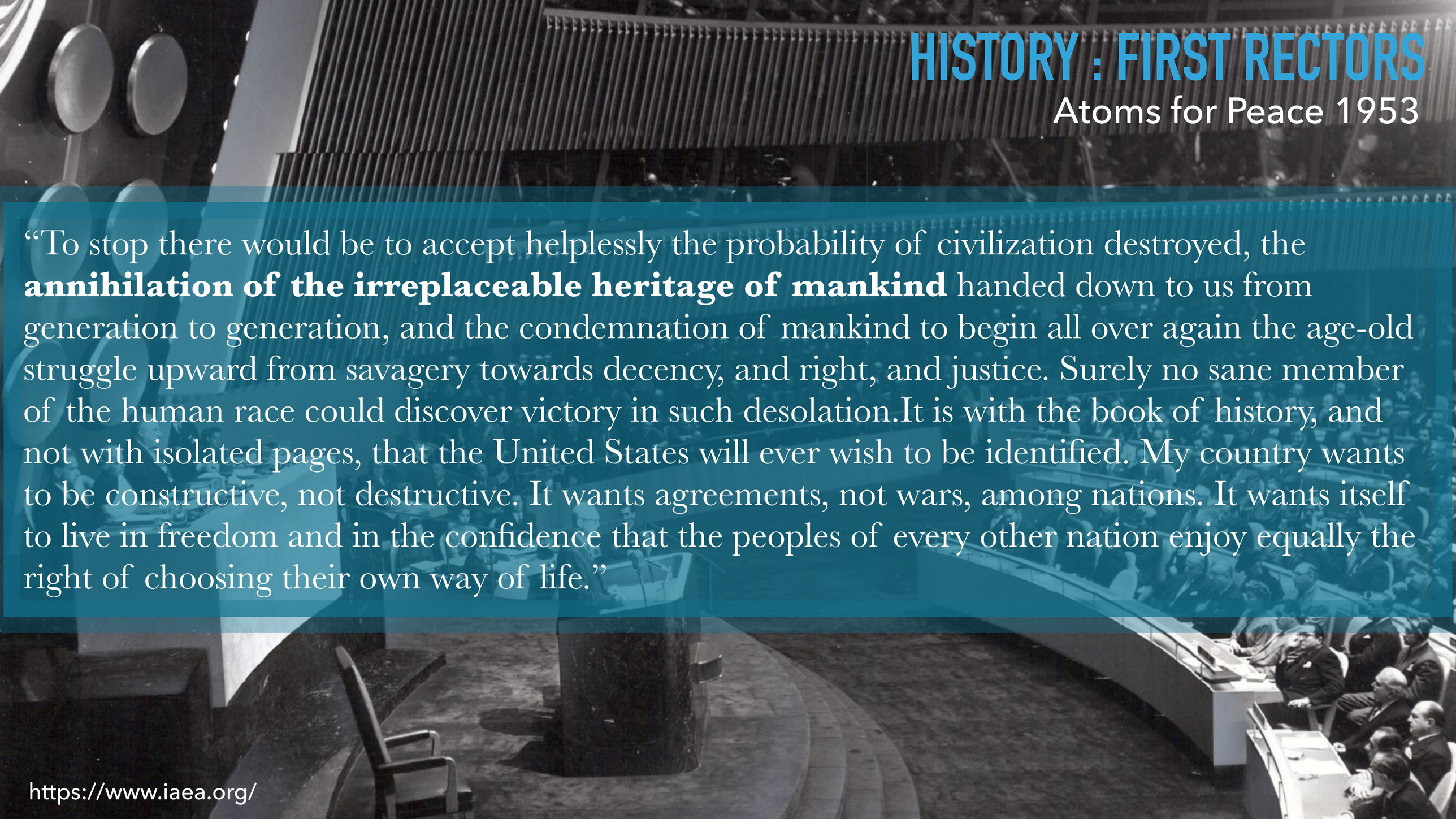
HISTORY : FIRST RECTORS

1951 - Arco, Idaho

https://www.travelobscura.com/

HISTORY : FIRST RECTORS

Atoms for Peace 1953



"To stop there would be to accept helplessly the probability of civilization destroyed, the **annihilation of the irreplaceable heritage of mankind** handed down to us from generation to generation, and the condemnation of mankind to begin all over again the age-old struggle upward from savagery towards decency, and right, and justice. Surely no sane member of the human race could discover victory in such desolation.It is with the book of history, and not with isolated pages, that the United States will ever wish to be identified. My country wants to be constructive, not destructive. It wants agreements, not wars, among nations. It wants itself to live in freedom and in the confidence that the peoples of every other nation enjoy equally the right of choosing their own way of life."

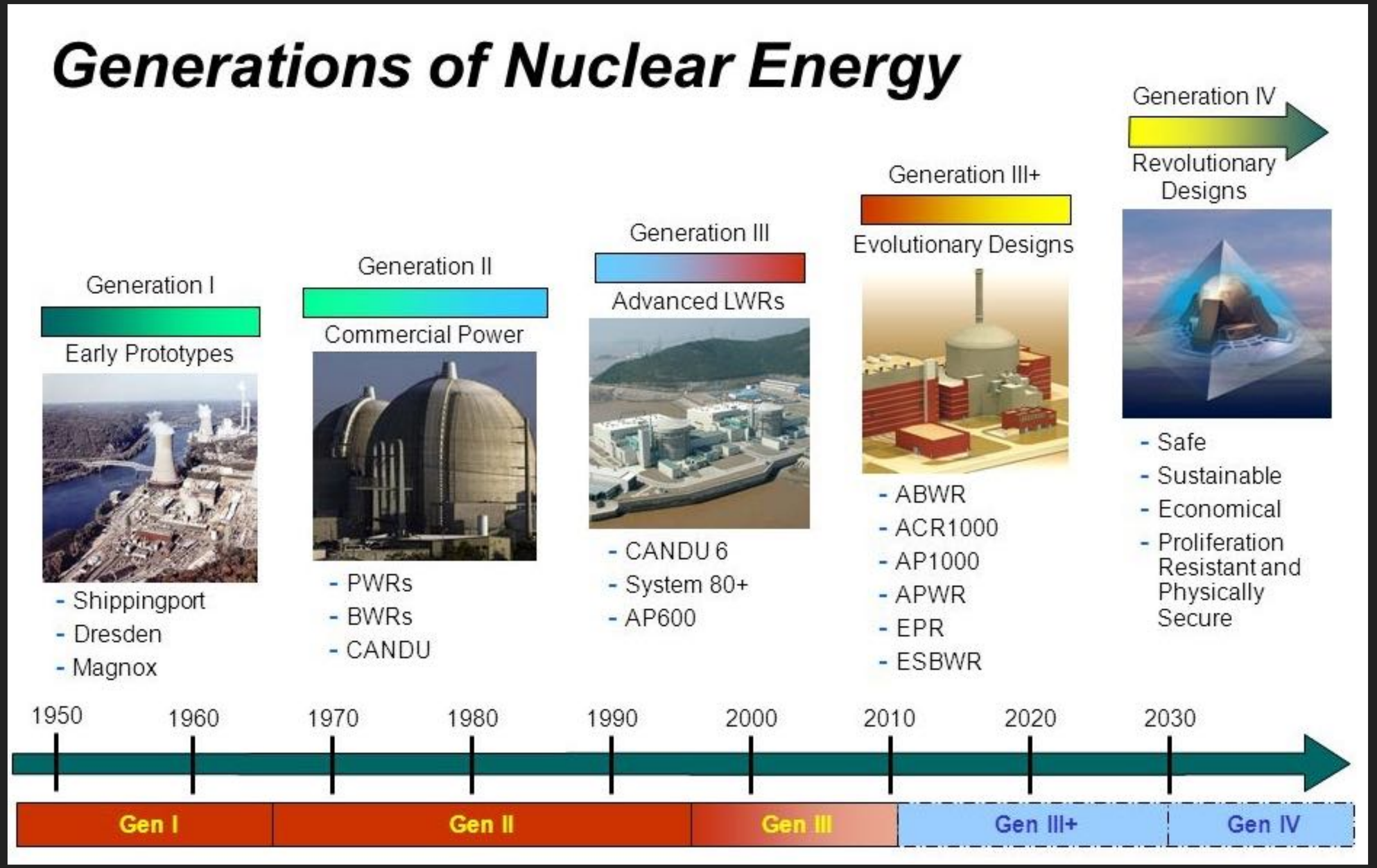
https://www.iaea.org/

"For space science, like nuclear science and all technology, **has no conscience of its own.** Whether it will become a force for good or ill depends on man, and only if the United States occupies a position of pre-eminence can we help decide **whether this new ocean will be a sea of peace or a new terrifying theater of war.**"

JFK 1962 "Address at Rice University on the Nation's Space Effort"

ASIDE: SUBMARINES, AIRCRAFT CARRIERS

GEN 1/2/3 REACTORS



ACCIDENTS

3Mile Island

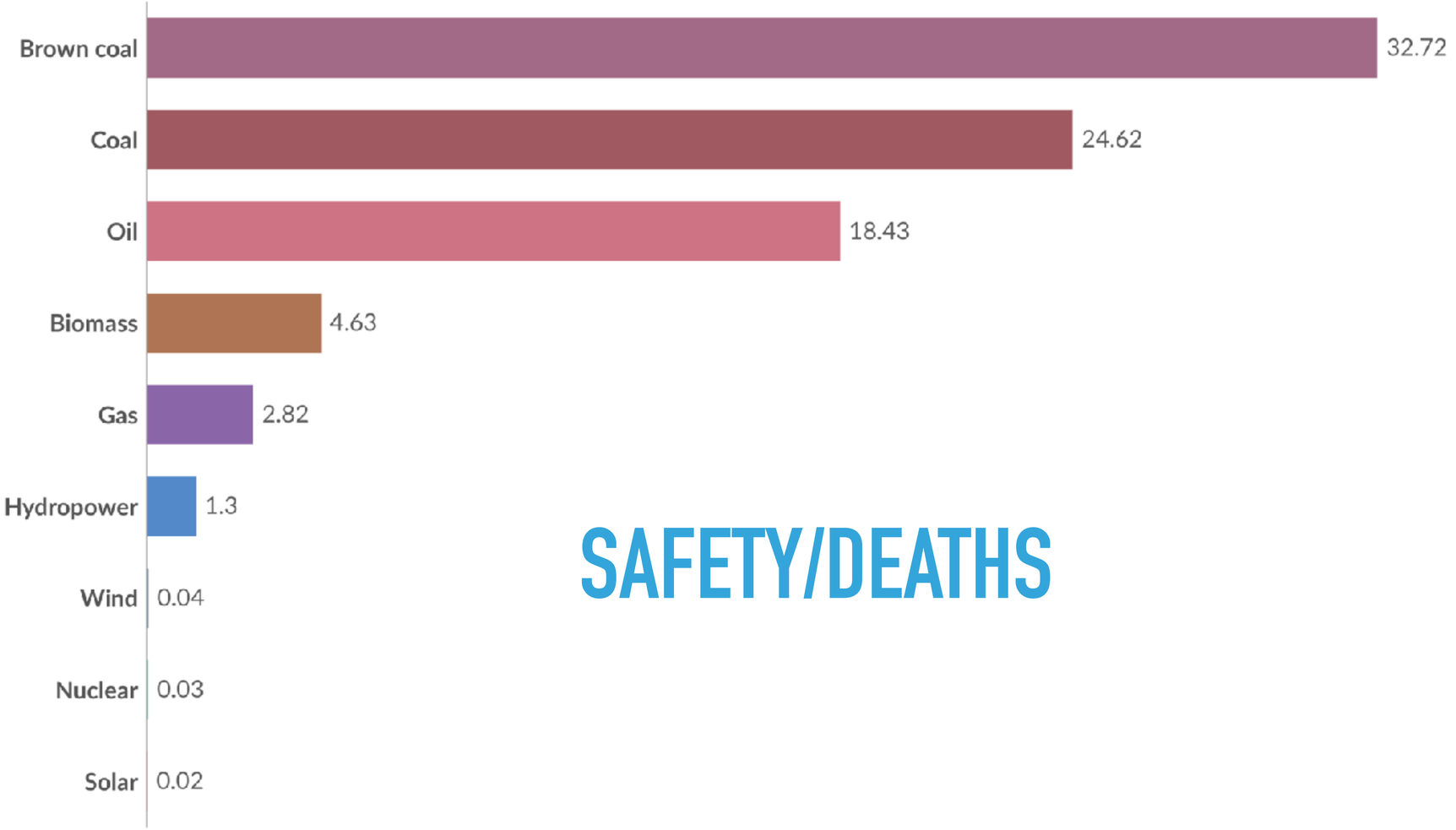
Chernobyl

Fukushima

Death rates per unit of electricity production

Our World in Data

Death rates are measured based on deaths from accidents and air pollution per terawatt-hour[1] of electricity.

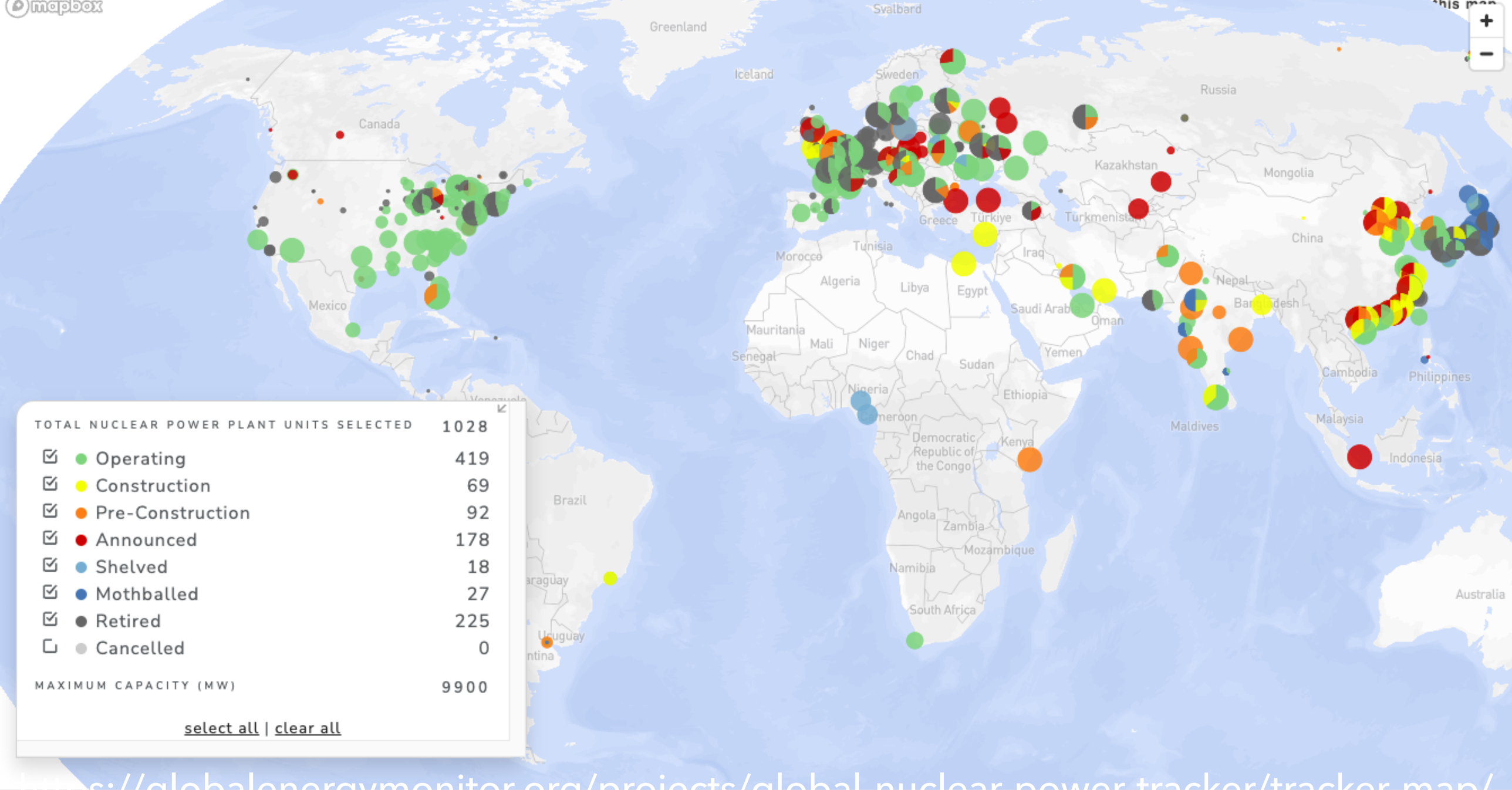


SAFETY/DEATHS

Data source: Markandya & Wilkinson (2007); Sovacool et al. (2016); UNSCEAR (2008; & 2018)

OurWorldinData.org/energy | CC BY

1. Watt-hour: A watt-hour is the energy delivered by one watt of power for one hour. Since one watt is equivalent to one joule per second, a watt-hour is equivalent to 3600 joules of energy. Metric prefixes are used for multiples of the unit, usually: - kilowatt-hours (kWh), or a thousand watt-hours. - Megawatt-hours (MWh), or a million watt-hours. - Gigawatt-hours (GWh), or a billion watt-hours. - Terawatt-hours (TWh), or a trillion watt-hours.



https://globalenergymonitor.org/projects/global-nuclear-power-tracker/tracker-map/

URANIUM MINING

Edward Burtynsky,

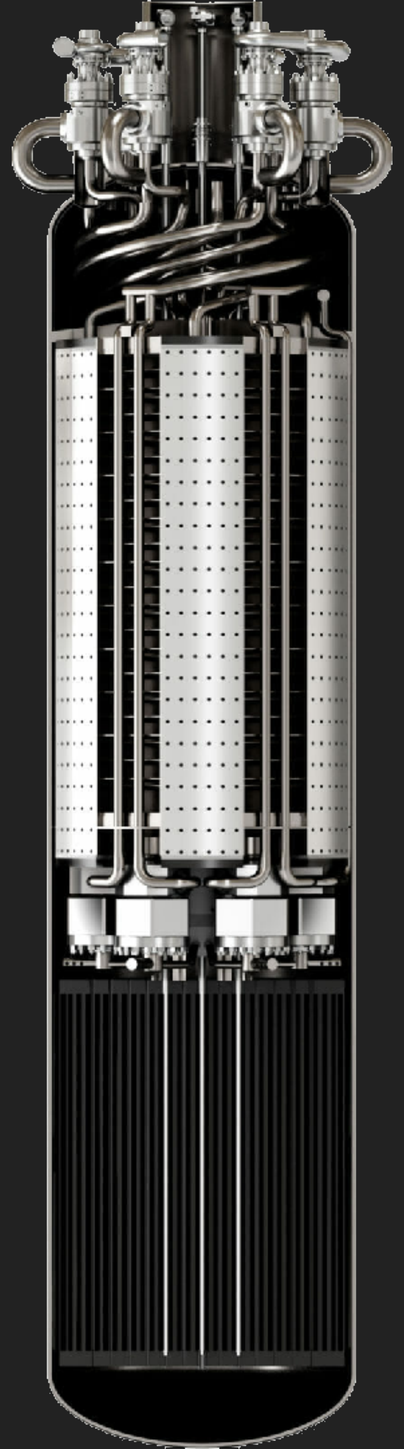
Uranium Tailings #13,

Husab Uranium Mine, Namibia, 2018

URANIUM MINING

GEN 4 REACTORS

Reactor at Shidaowan plant in China’s eastern Shandong province



GEN 4 REACTORS

Terrestrial Energy ISMR

SMALL MODULAR REACTORS

Small modular reactors (SMRs) are one of the latest innovations in producing nuclear energy. With a simplified, compact design and relative low-cost production methods, innovators hope to deploy them more readily.

SMRS

SMALL:

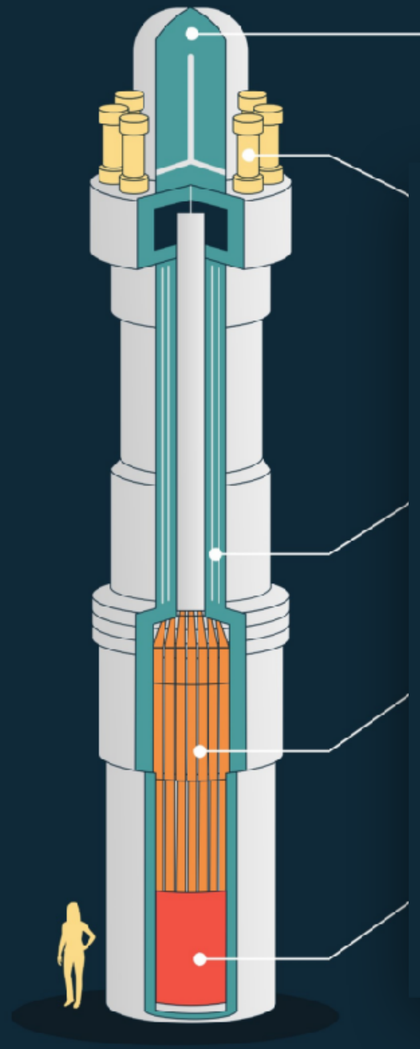
SMRs are designed to be in the range of 1 to 300 megawatts, roughly one third of the gigawatt scale of traditional nuclear reactors

MODULAR:

SMRs can be manufactured in a factory and transported to the site, making them easier to deploy and potentially reducing construction costs

REACTOR:

Like all nuclear reactors today, SMRs harness nuclear fission to generate heat to produce energy



PRESSURIZER

Maintains a stable pressure within the primary coolant loop to prevent boiling and ensures that the coolant remains in a liquid state to improve efficiency and safety

conversion system

Source: U.S. Department of Energy

The Main SMR Types

Light Water Reactors

High Temperature Gas Cooled Reactors

Molten Salt Reactors

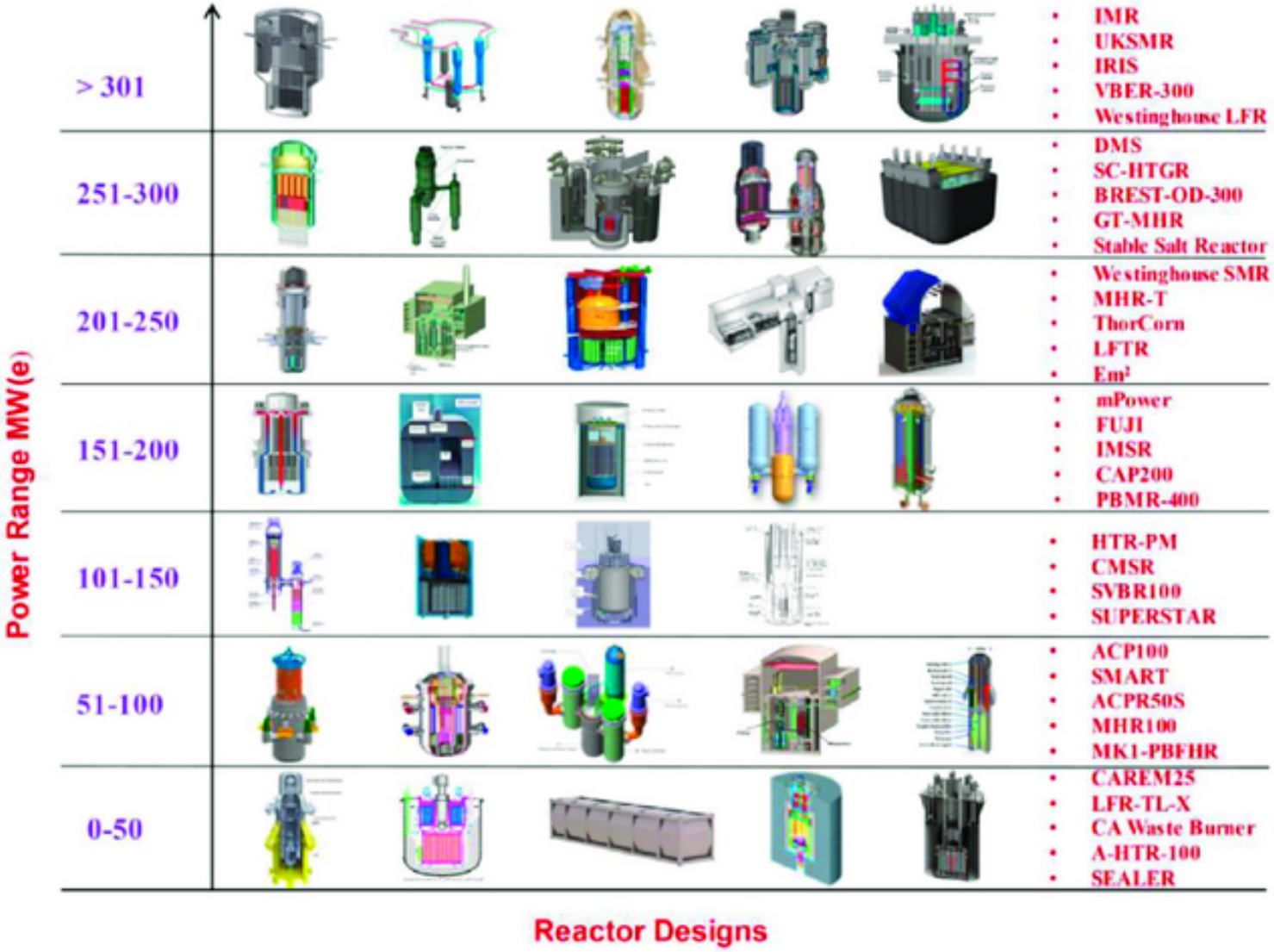
Fast Neutron Reactors

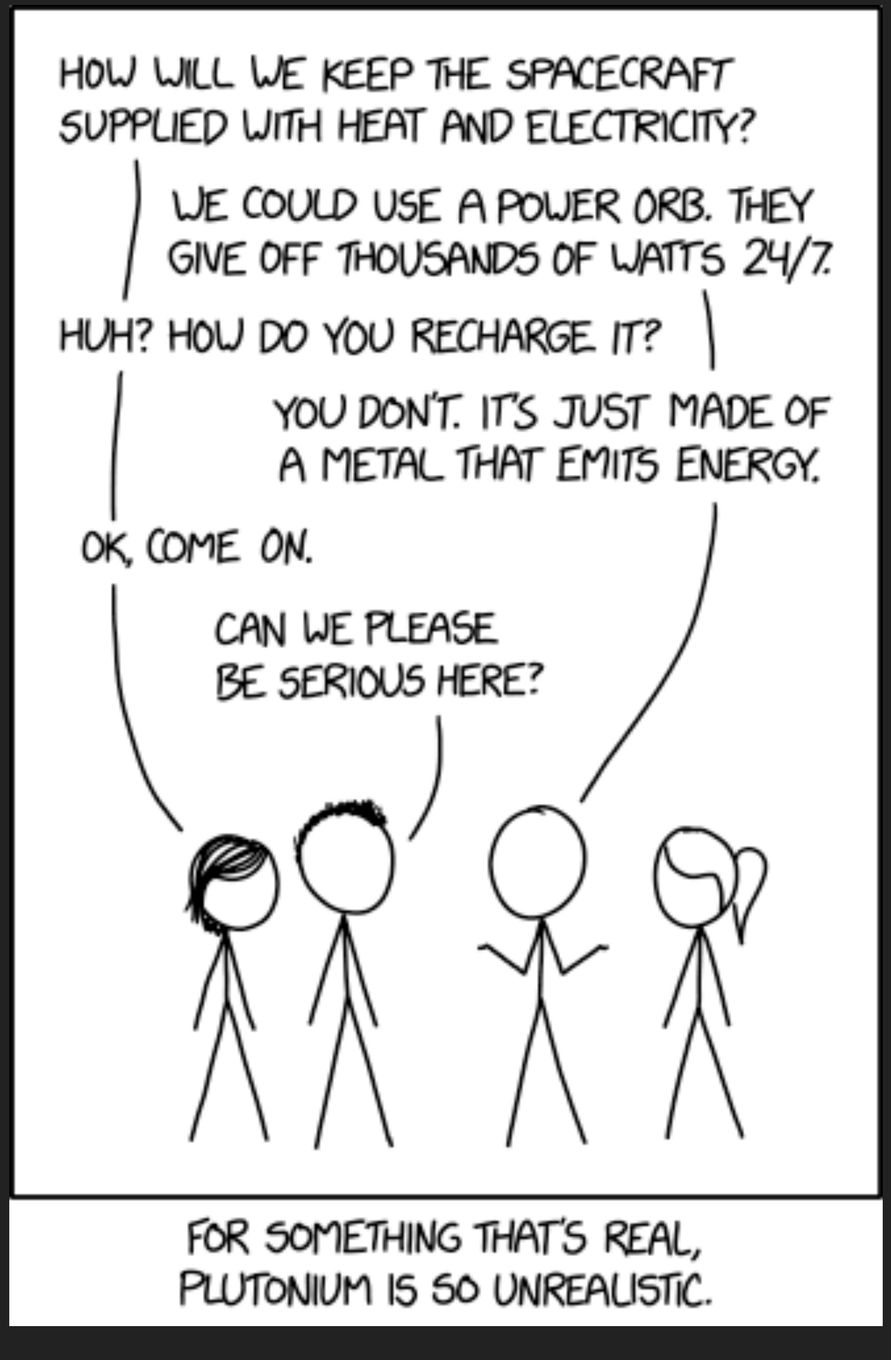
By using smaller, mass manufactured designs, SMRs can provide additional benefits in terms of **safety**, **cost**, and **flexibility** in nuclear power generation.

Sources:
https://smrroadmap.ca/
https://www.eralberta.ca/media-releases/government-of-alberta-and-emissions-reduction-alberta-commit-7-million-for-cenovus-to-study-the-use-of-small-modular-nuclear-reactors-in-the-oil-sands/
https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs
https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors.aspx
https://www.oecd-nea.org/jcms/pl_26297/the-nea-small-modular-reactor-smr-strategy
https://www.energy.gov/ne/articles/infographic-small-modular-reactors

ENERGY minute

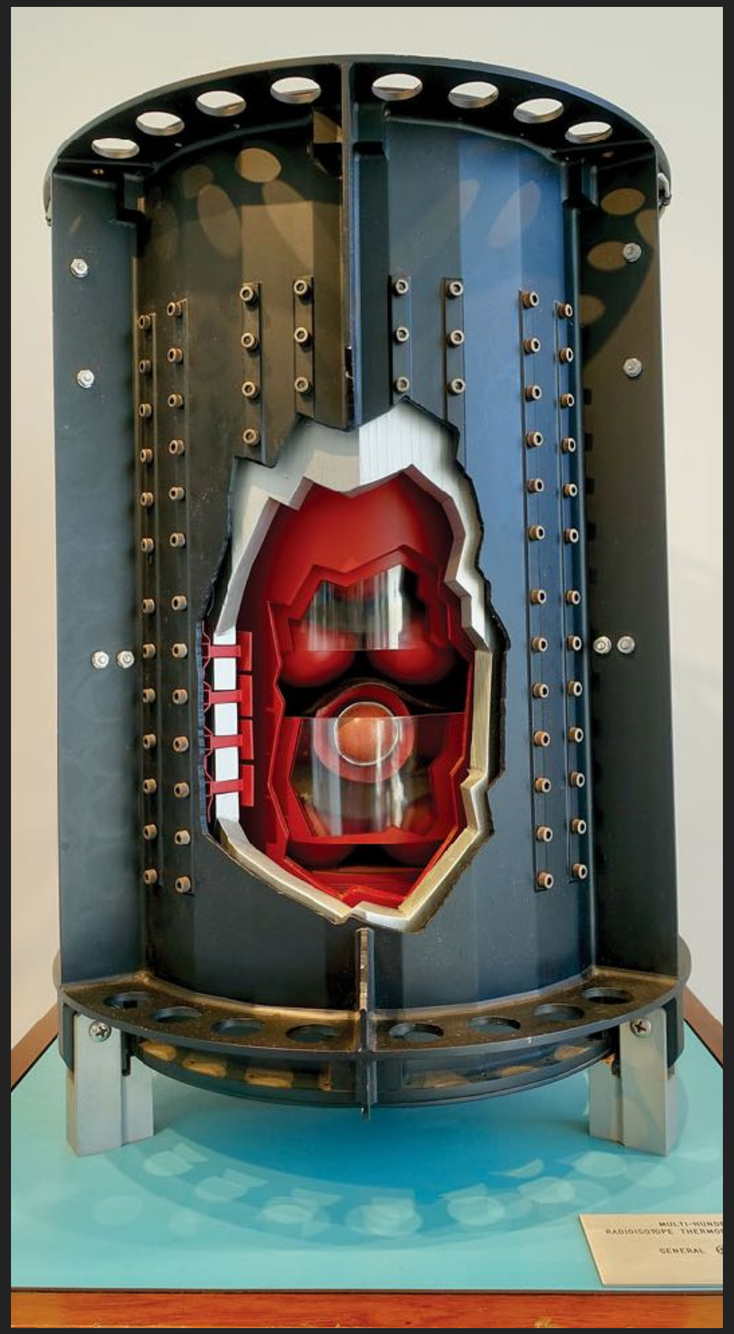
SMRS

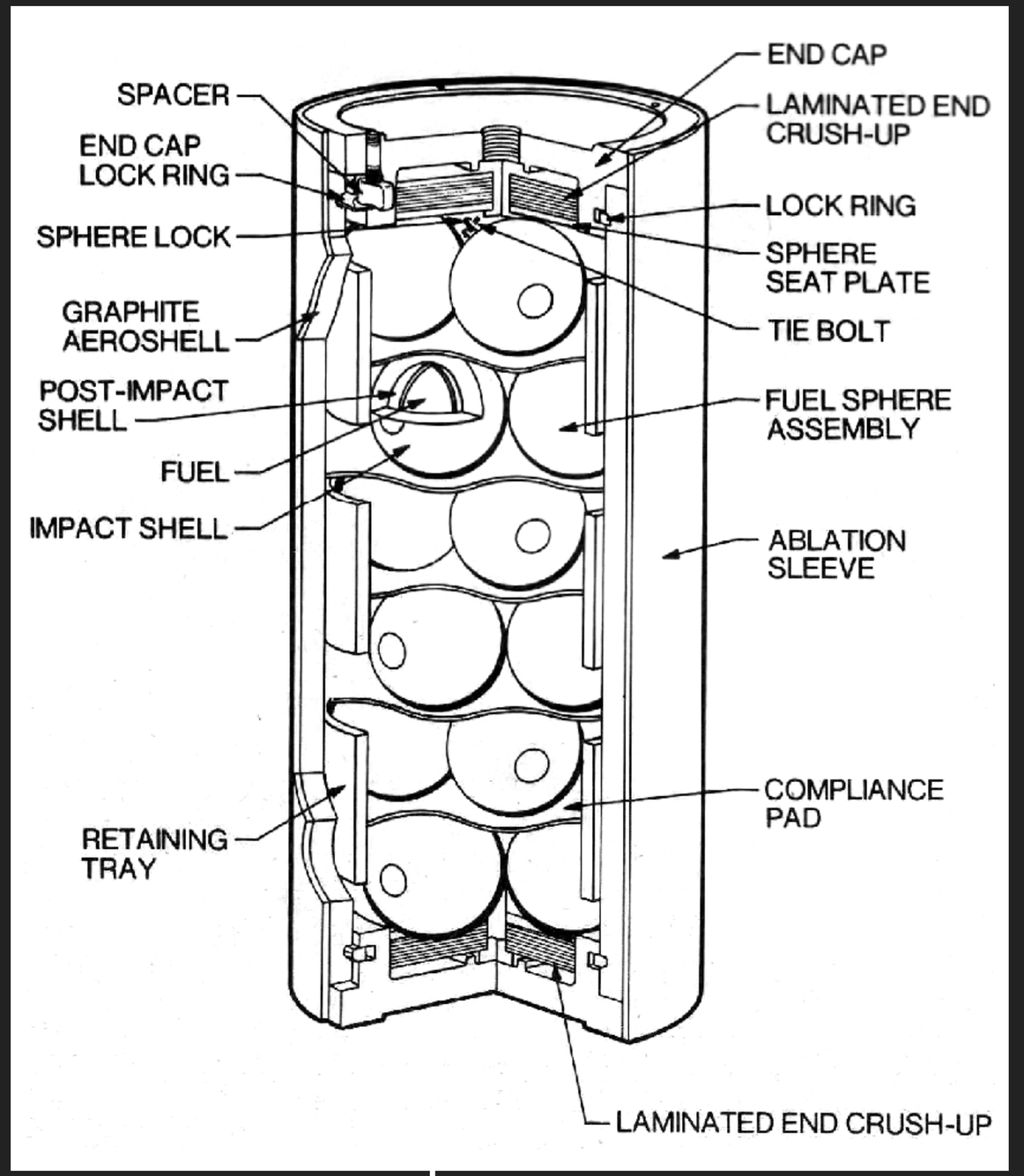

Power Range MW(e)
> 301
251-300
201-250
151-200
101-150
51-100
0-50
Reactor Designs
IMR
UKSMR
IRIS
VBER-300
Westinghouse LFR
DMS
SC-HTGR
BREST-OD-300
GT-MHR
Stable Salt Reactor
Westinghouse SMR
MHR-T
ThorCorn
LFTR
Em³
mPower
FUJI
IMSR
CAP200
PBMR-400
HTR-PM
CMSR
SVBR100
SUPERSTAR
ACP100
SMART
ACPR50S
MHR100
MK1-PBFHR
CAREM25
LFR-TL-X
CA Waste Burner
A-HTR-100
SEALER



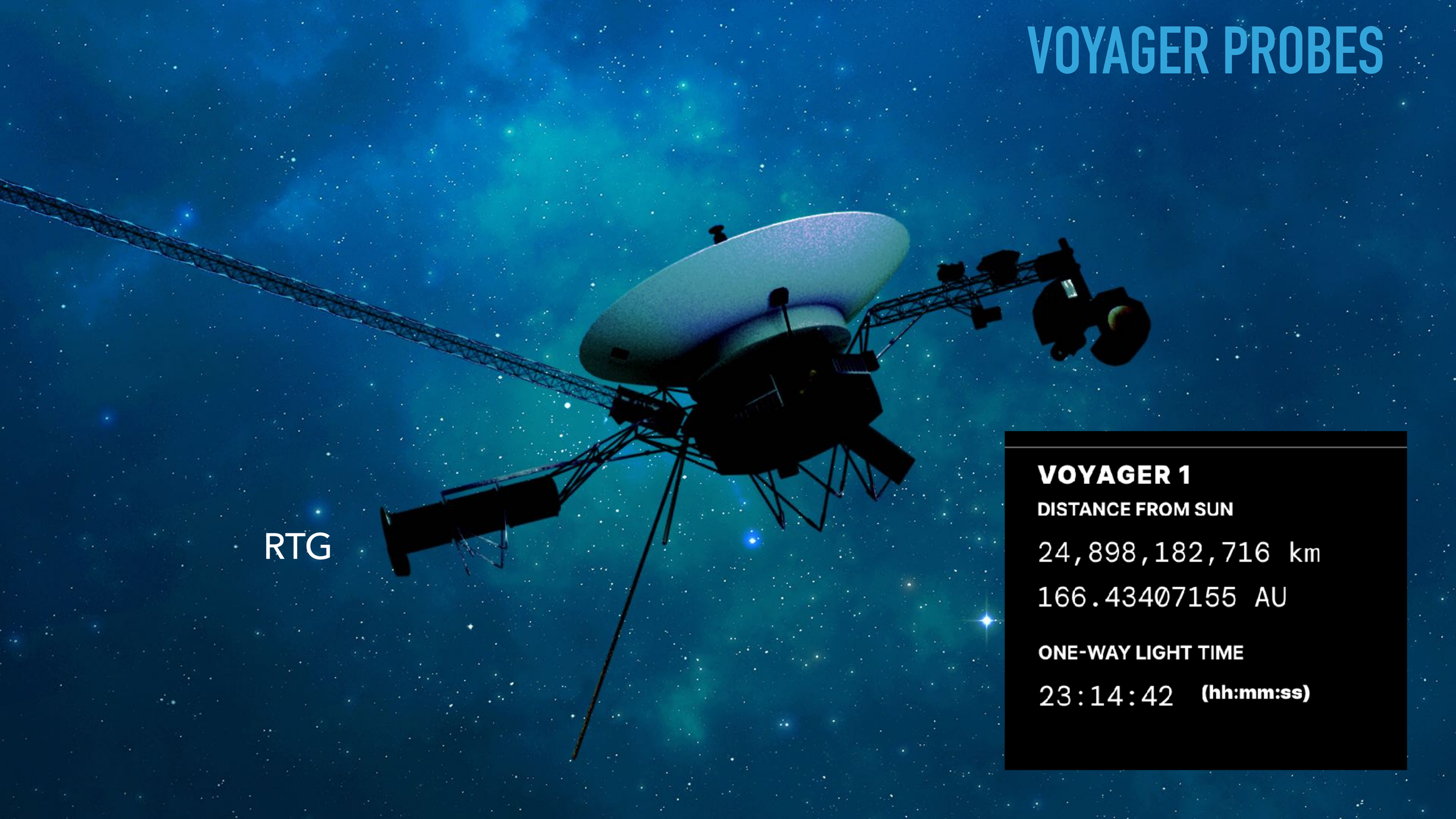
https://xkcd.com/2115/


HOW WILL WE KEEP THE SPACECRAFT SUPPLIED WITH HEAT AND ELECTRICITY?
WE COULD USE A POWER ORB. THEY GIVE OFF THOUSANDS OF WATTS 24/7.
HUH? HOW DO YOU RECHARGE IT?
YOU DON'T. IT'S JUST MADE OF A METAL THAT EMITS ENERGY.
OK, COME ON.
CAN WE PLEASE BE SERIOUS HERE?
FOR SOMETHING THAT'S REAL, PLUTONIUM IS SO UNREALISTIC.




END CAP
SPACER
LAMINATED END CRUSH-UP
END CAP LOCK RING
LOCK RING
SPHERE LOCK
SPHERE SEAT PLATE
TIE BOLT
GRAPHITE AEROSHELL
POST-IMPACT SHELL
FUEL SPHERE ASSEMBLY
FUEL
IMPACT SHELL
ABLATION SLEEVE
COMPLIANCE PAD
RETAINING TRAY
LAMINATED END CRUSH-UP

VOYAGER PROBES



VOYAGER 1

DISTANCE FROM SUN

24,898,182,716 km

166.43407155 AU

ONE-WAY LIGHT TIME

23:14:42 **(hh:mm:ss)**

CURIOSITY & PERSEVERANCE ROVERS

FUSION

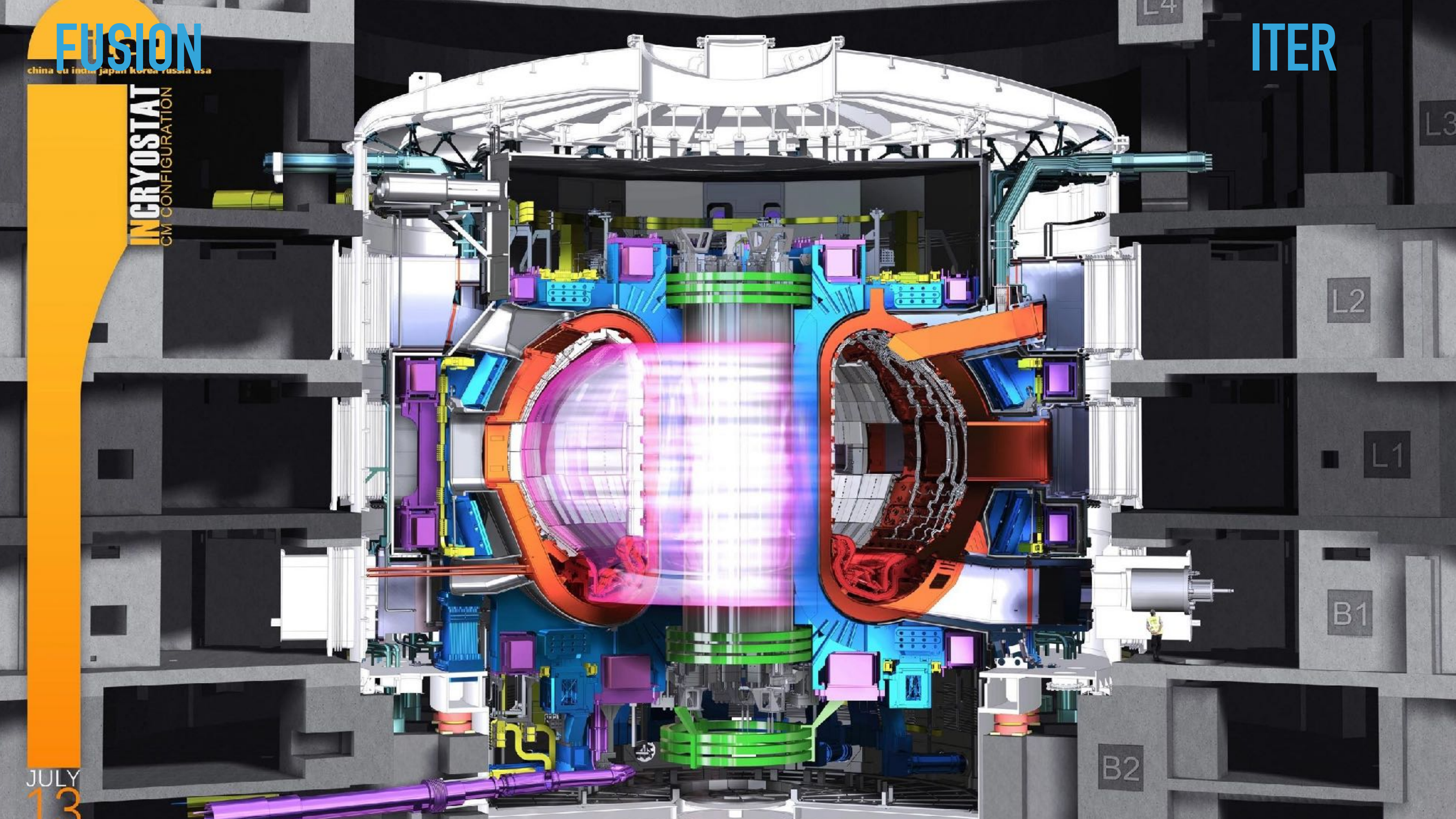
FUSION

china eu india japan korea russia usa

ITER

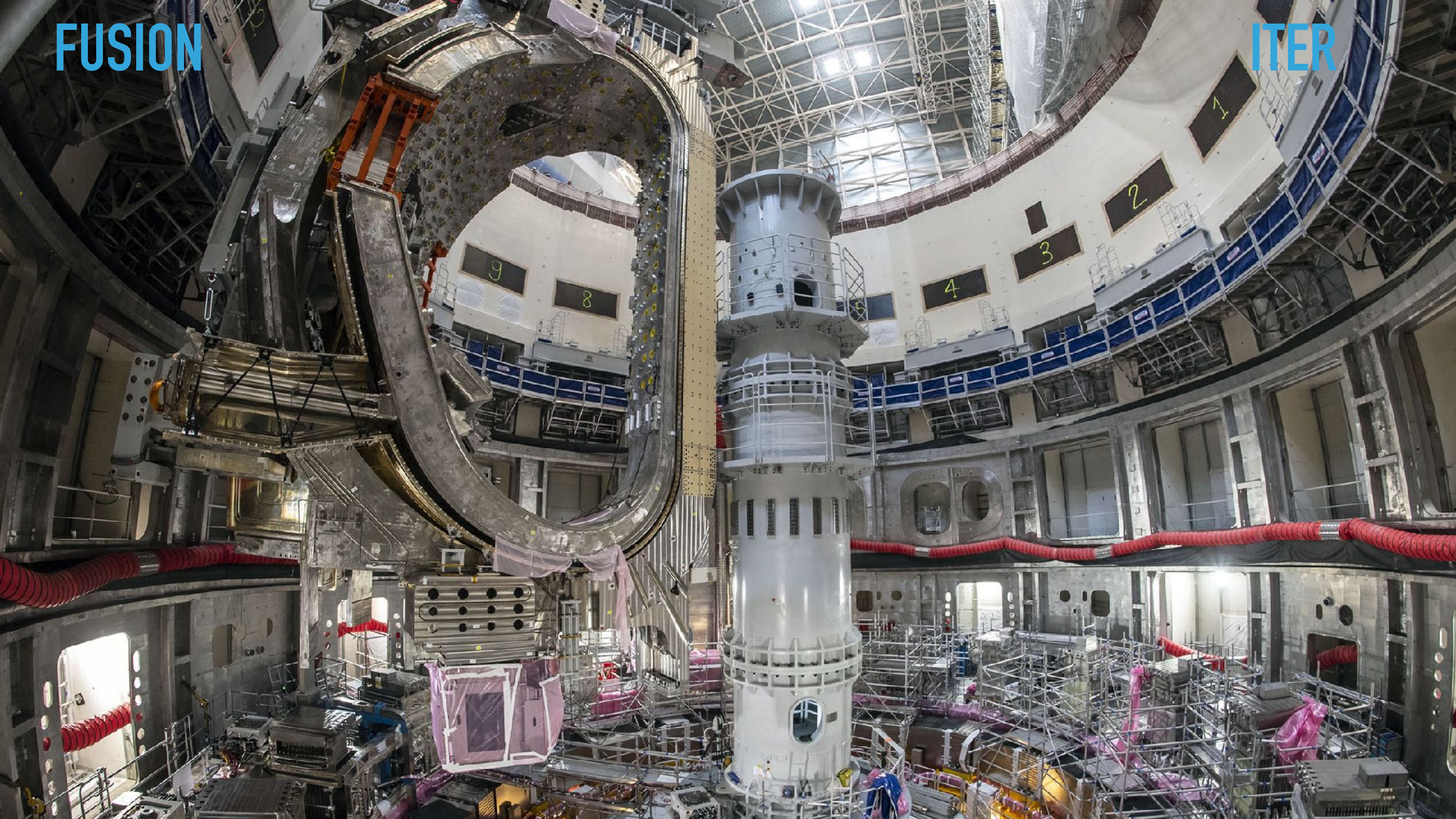
CRYOSTAT

CM CONFIGURATION

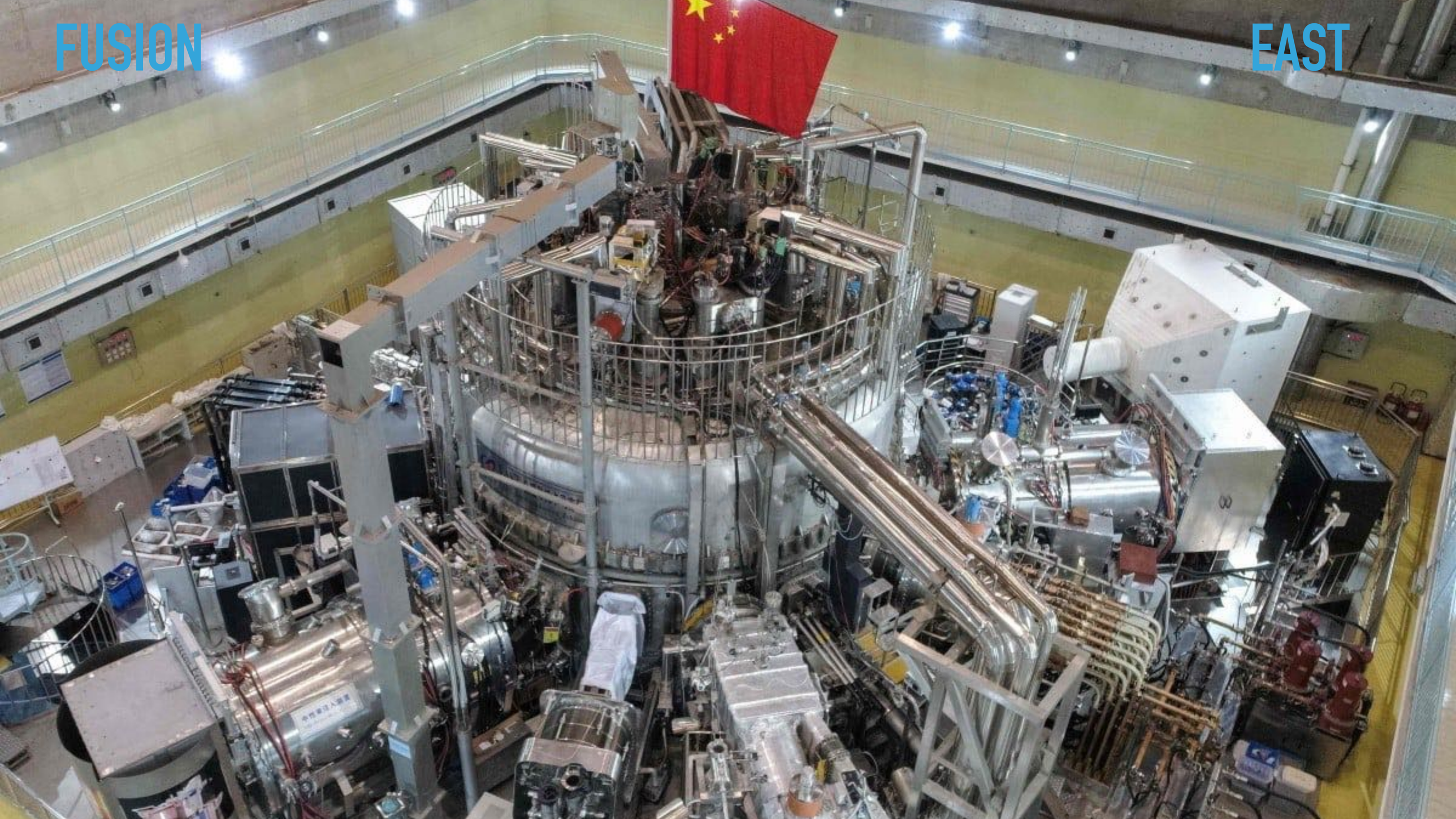


JULY

13


9
8
5
4
3
2
1


FUSION
ITER


FUSION
EAST


FUSION
NIL

FUSION

NIL

FUSION

NIL