



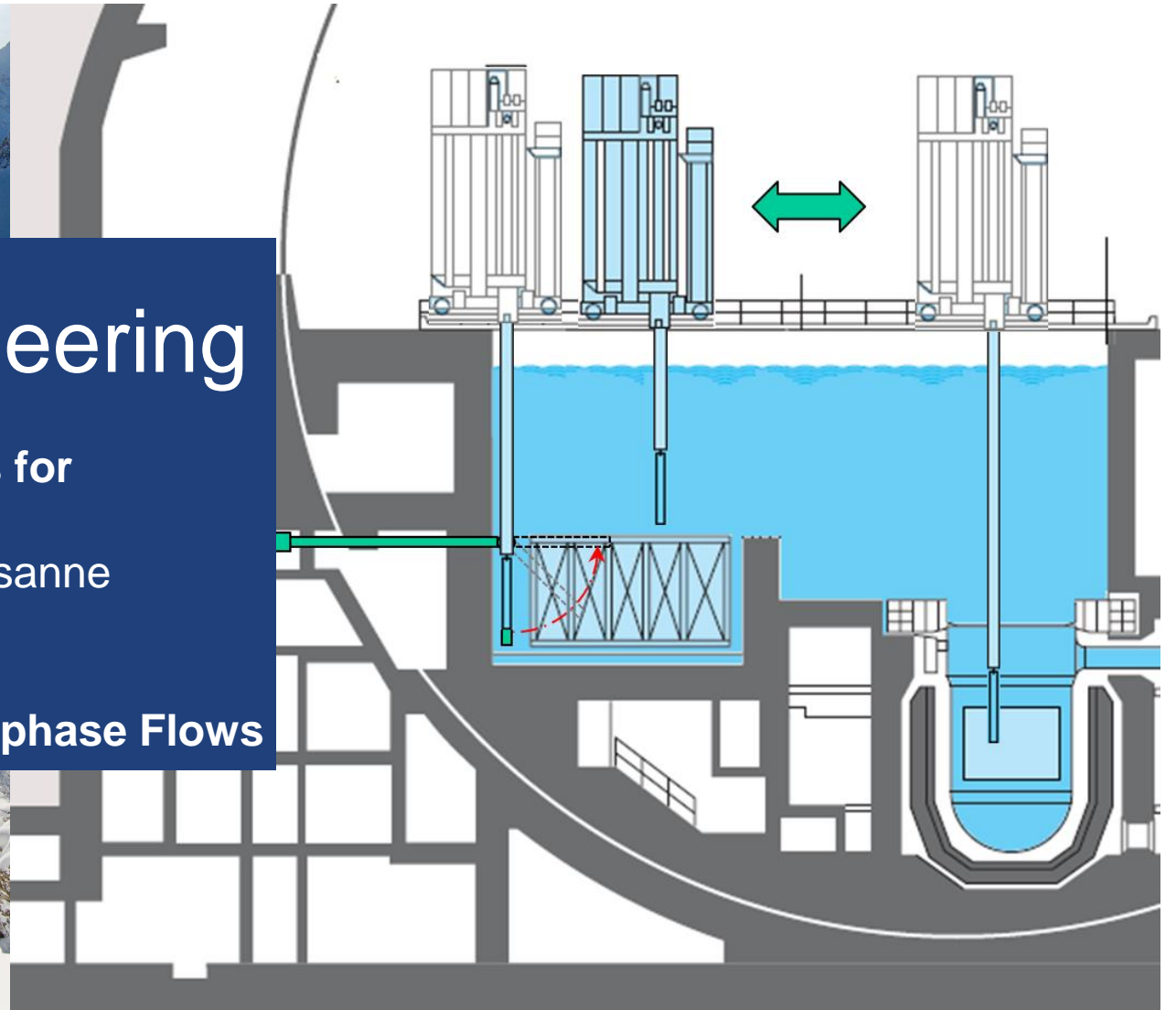
MSc in Nuclear Engineering

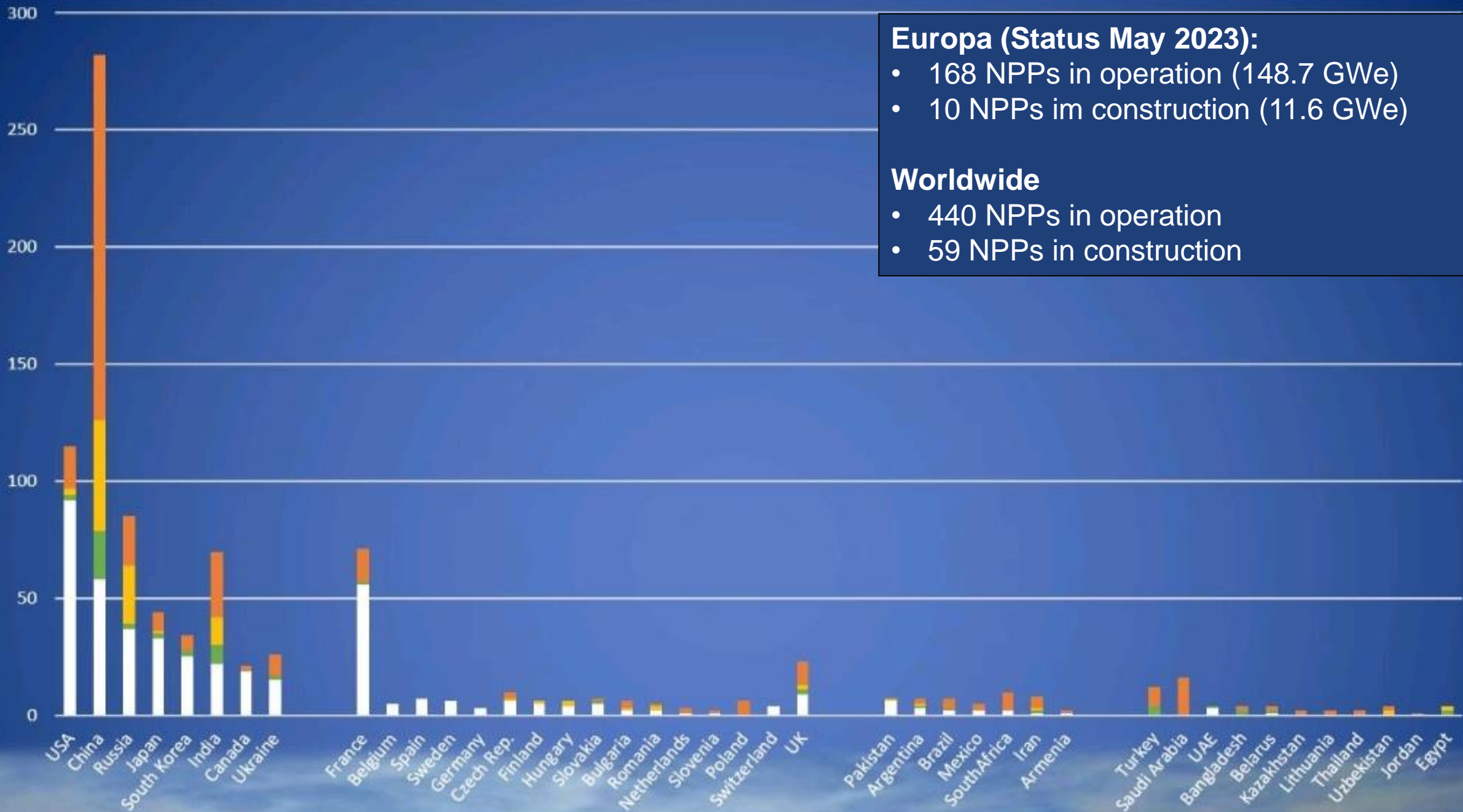
Unleash benefits of nuclear technologies for humanity

A joint program of ETH Zurich and EFP Lausanne

Prof. Annalisa Manera

Laboratory of Nuclear Systems and Multiphase Flows





Europa (Status May 2023):

- 168 NPPs in operation (148.7 GWe)
- 10 NPPs im construction (11.6 GWe)

Worldwide

- 440 NPPs in operation
- 59 NPPs in construction

source: WNA (world-nuclear.org) January 2023

■ Fleet ■ Construction ■ Planned ■ Program

Decision-making phase

Countries considering nuclear power without having made a final decision

33 countries already use nuclear energy

Kernkraftwerke in Bau



Kernkraftwerke projektiert



Zurzeit keine Kernkraftwerke in Bau



29 stay with it



11 start with it

Kernkraftwerke in Bau



Kernkraftwerke projektiert



4 stop with nuclear (?)

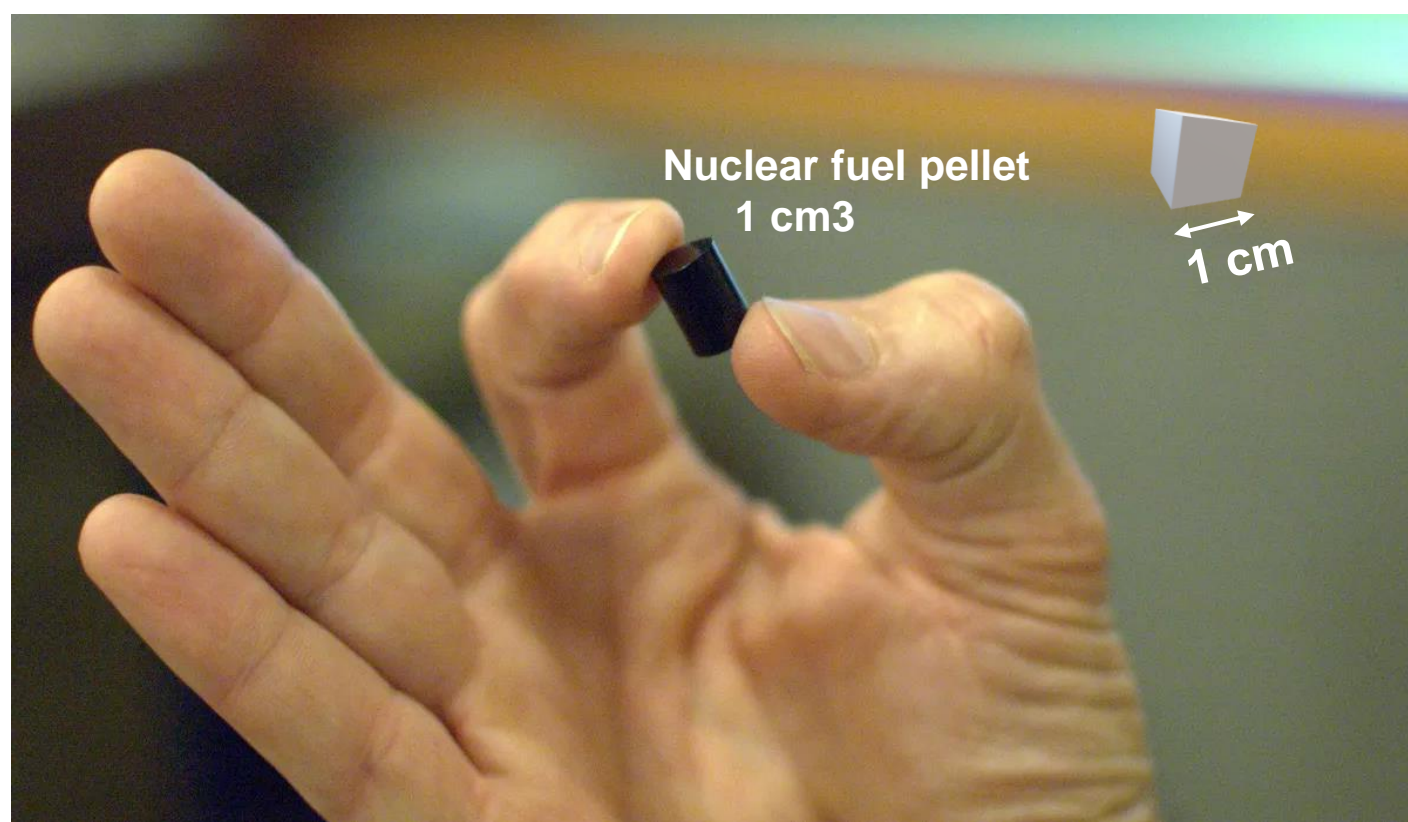
befristete Laufzeiten



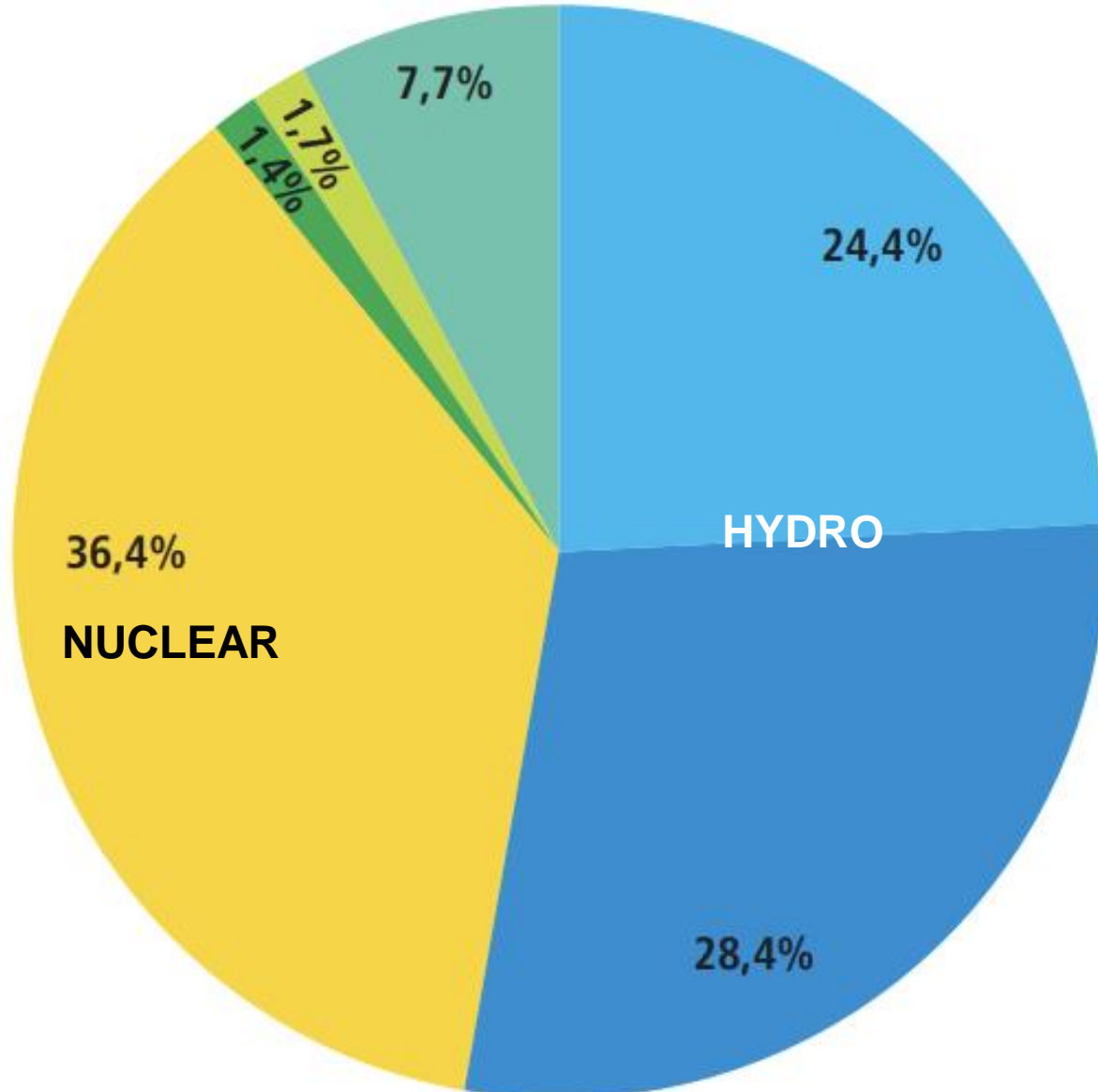
unbefristete Laufzeiten



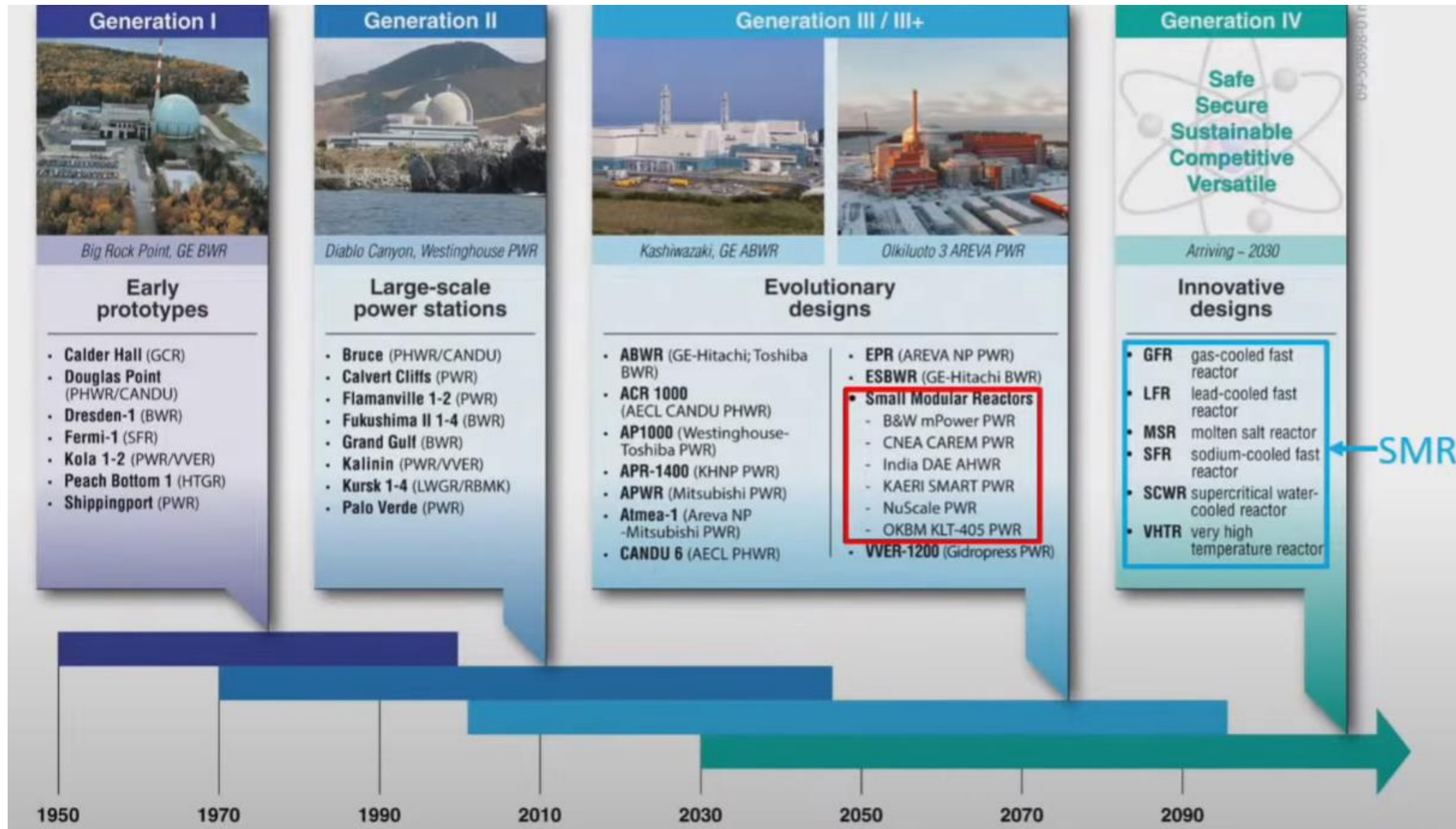
Why nuclear engineering?



Electricity Production in Switzerland - 2022



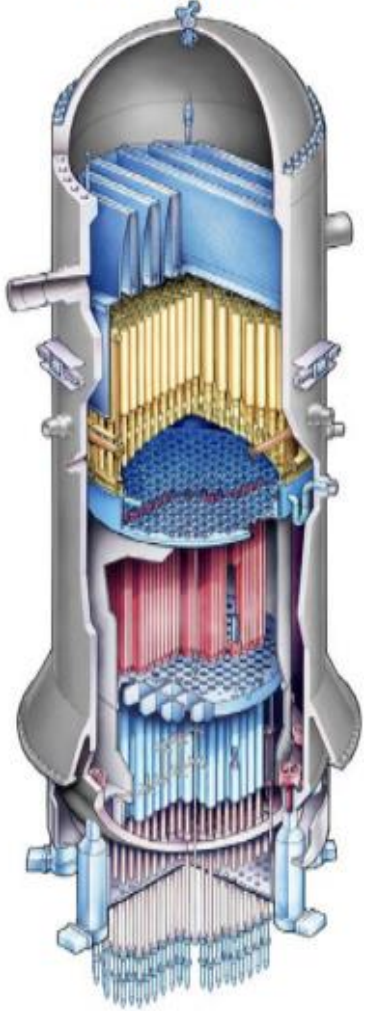
Why nuclear engineering? FISSION REACTORS / NUCLEAR POWER



SMR

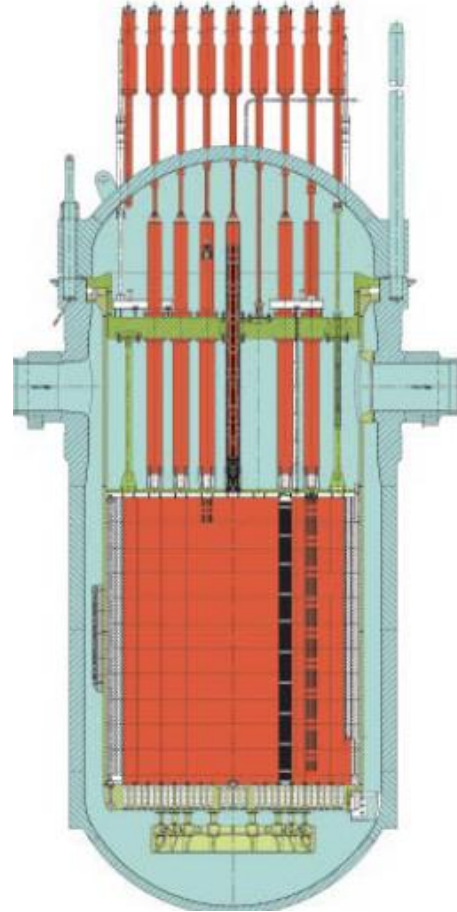
Large Gen-III/III+ NPPs on the market and already in operation (examples)

ABWR



Op: 4 (Japan)
Constr: 2 (Japan)

EPR



Op: 3 (China, Finland)
Constr: 2 (UK)

AP1000



Op: 5 (China, USA)
Constr: 1 (USA)

APR-1400



Op: 6 (S.Korea, UAE)
Constr: 4 (S. Korea, UAE)

Not only for electricity production



Remote
mining
operations



Industrial
process
heat



District
heating



Remote
communities



Hydrogen
Generation



Marine
Shipping



Critical
Infrastructure
Installations

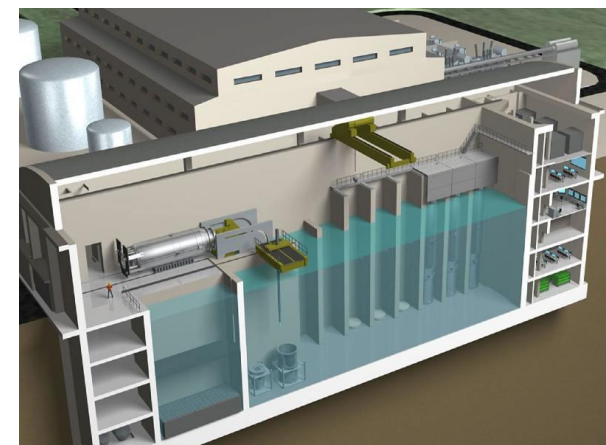


Disaster
relief

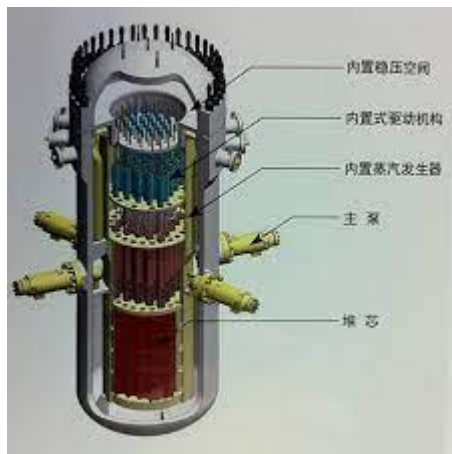


Research
Reactors

SMRs – Small Modular Reactors



NuSCALE (6x77 MW), for Utah, by 2029



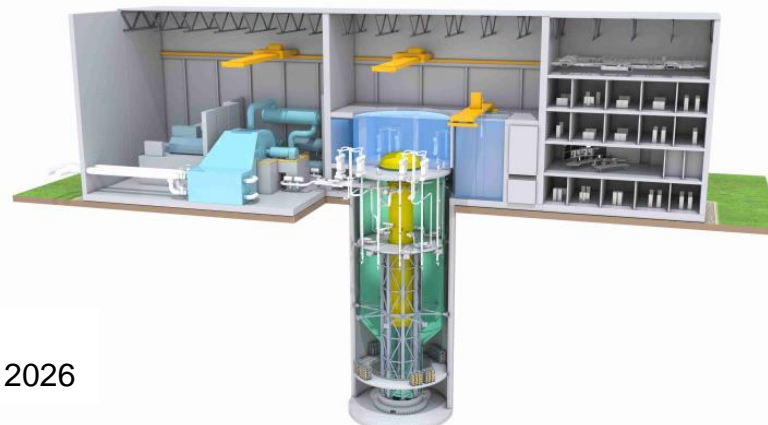
ACP 100, in construction (China)



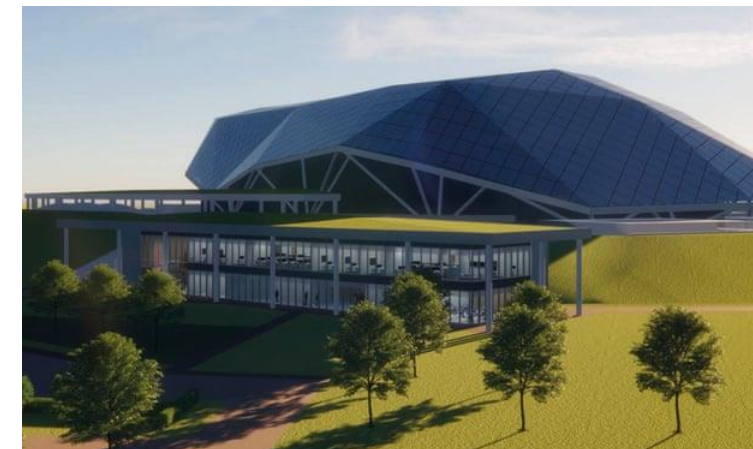
X-energy (USA)
DOW, construction to start in 2026



NUWARD (EdF/Technicatome), 170 MW, ab 2030



BWRX-300 (GE/Hitachi) für
Ontario Power, operation by 2028



UK SMR (Rolls Royce), 443 MW, by 2030

SMART (Korea), 100 MW



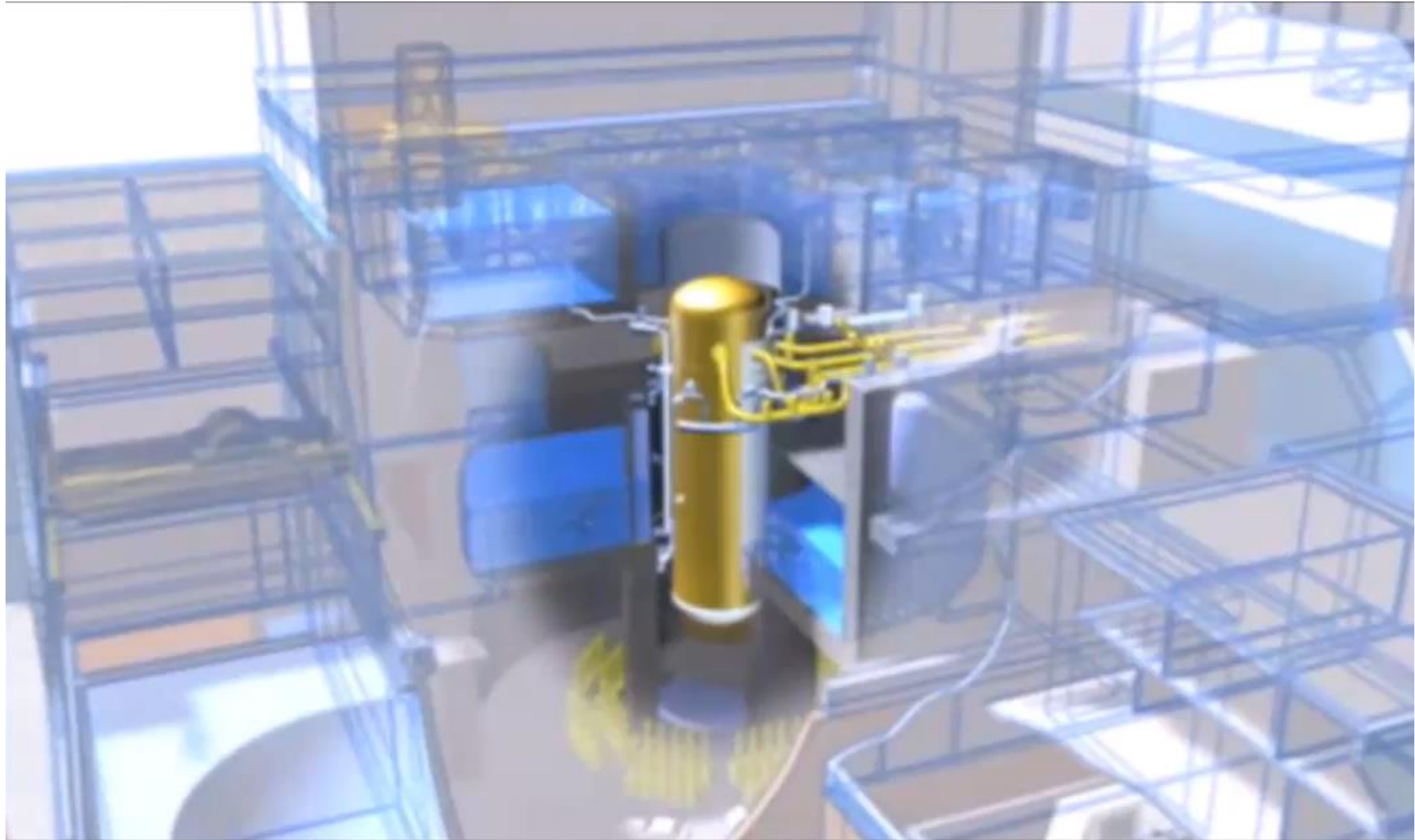
Several SMRs to be completed by 2030

They are all hiring at all levels (BSc, MSc, PhD)

Strong shortage of nuclear engineers!!!!

Also in Switzerland...

Passive Safety
systems



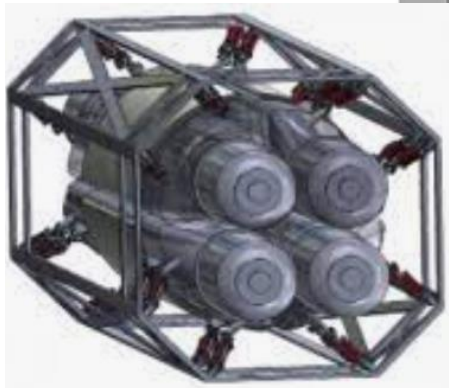
Why nuclear engineering? MICROREACTORS FOR REMOTE AREAS



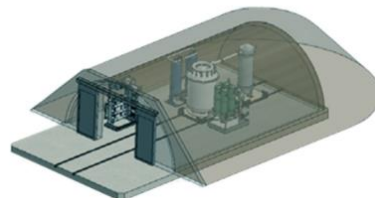
OKLO



HOLOGEN

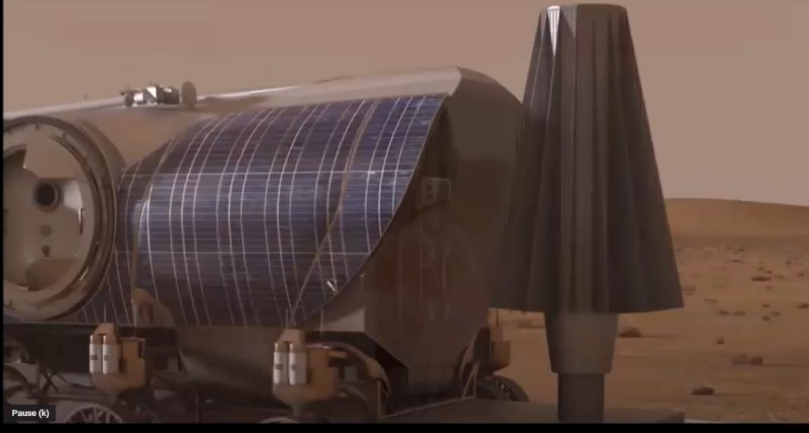
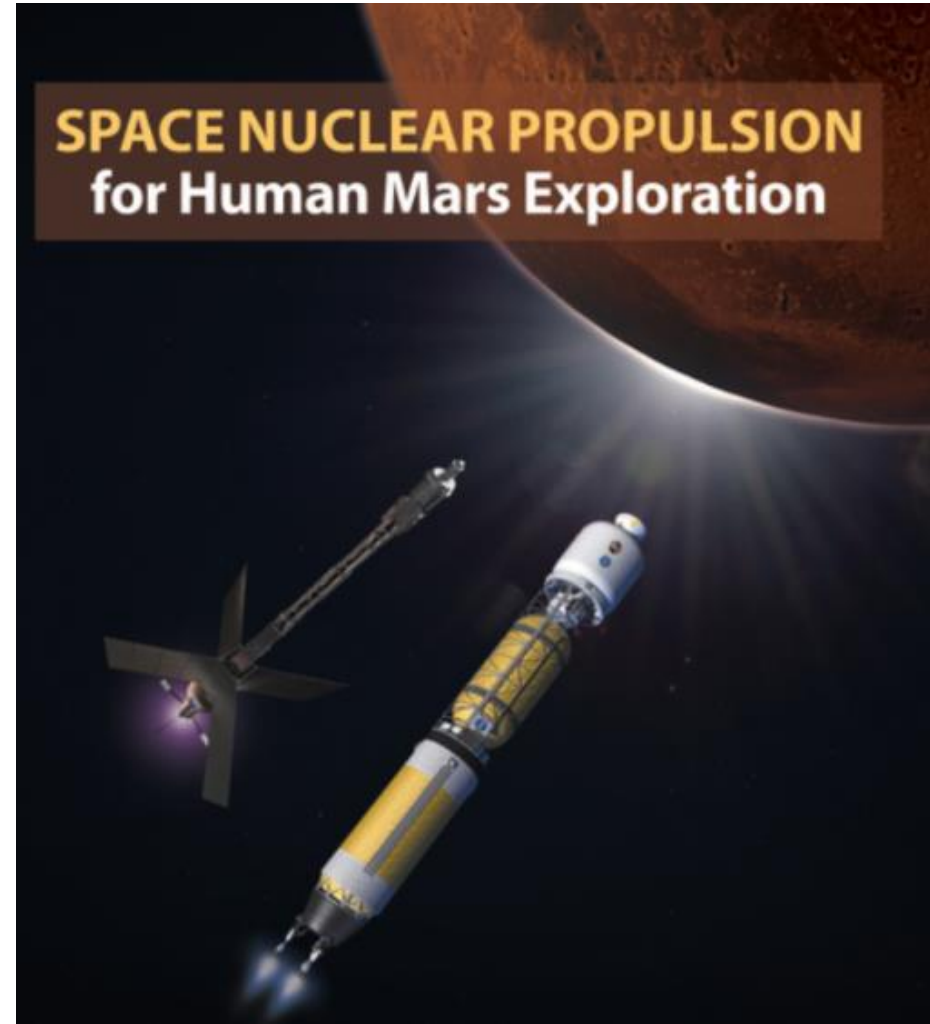


BWXT

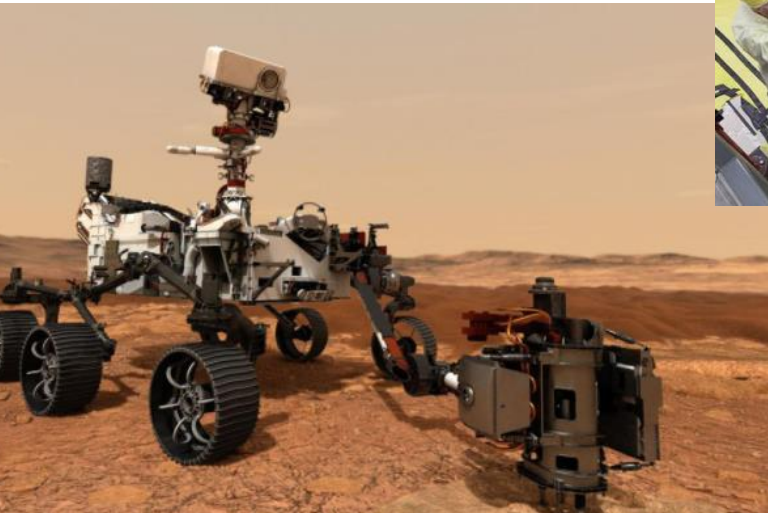


**AGGRESSIVE NUCLEAR PROPULSION R&D EFFORT
NEEDED TO SEND HUMANS TO MARS IN 2039**

**Nuclear Propulsion Could Help Get Humans to
Mars Faster**



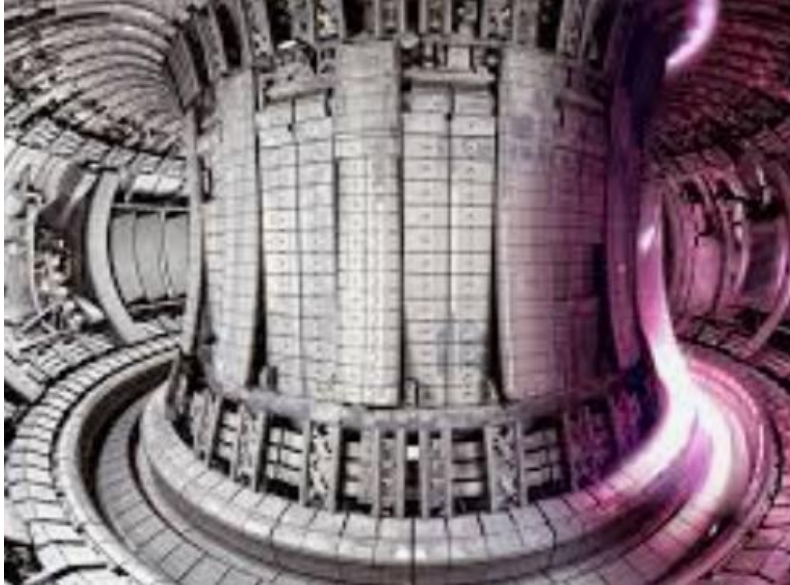
**KILOPOWER REACTOR / NASA
with technology from Los Alamos**



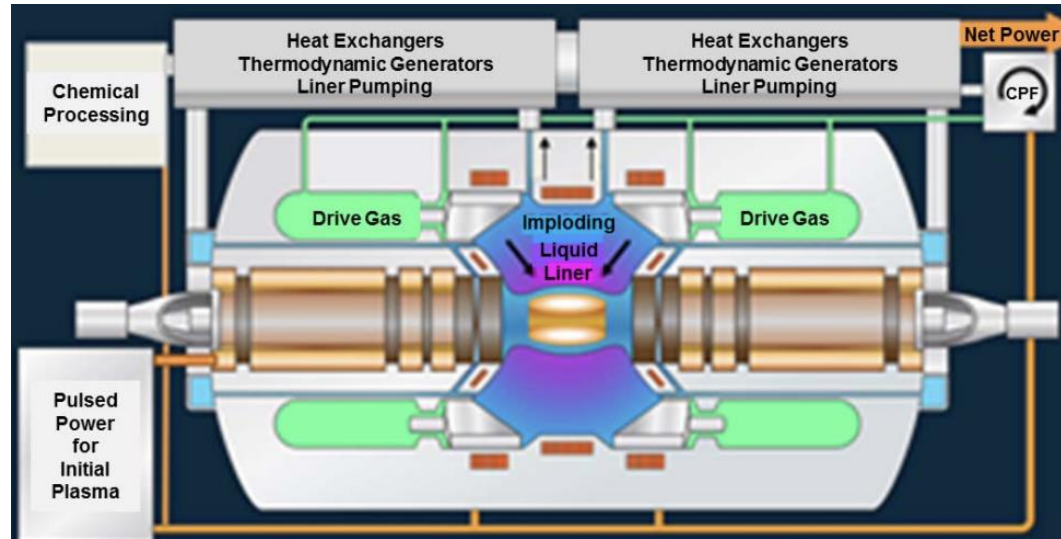
**Perseverance rover will run on nuclear power
RTG (Radioisotope thermoelectric generator)
will provide power for the rover for about 14 years**

Why nuclear engineering? FUSION POWER

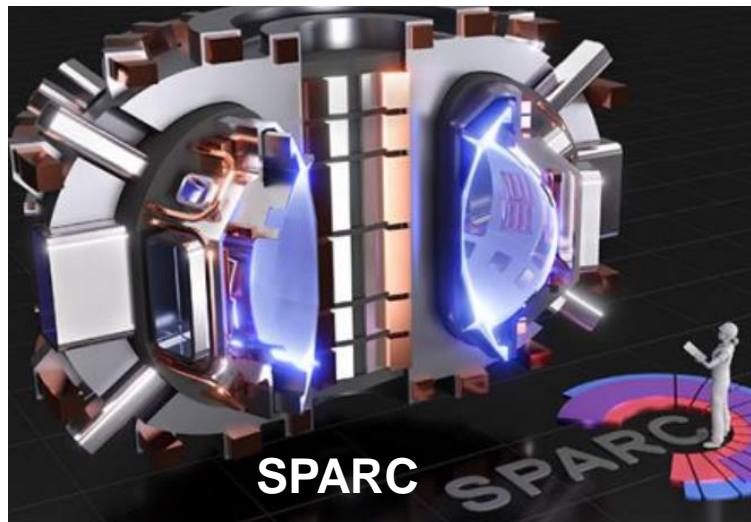
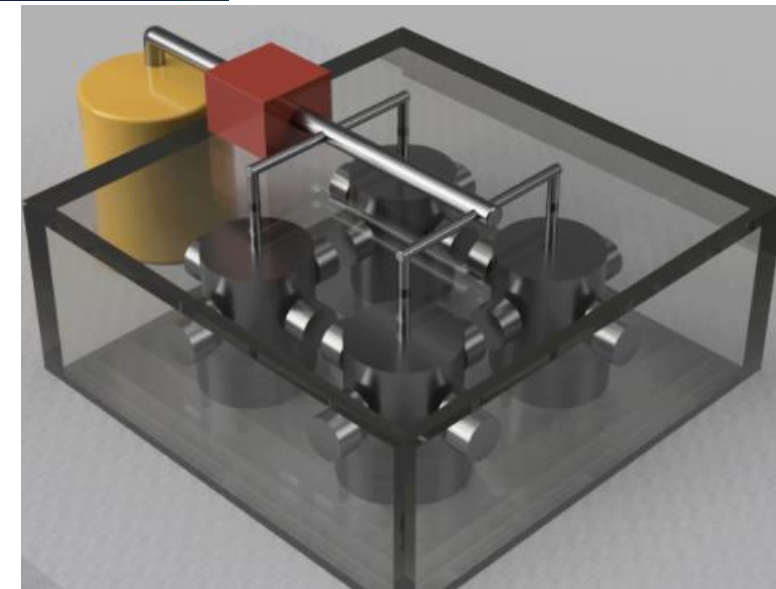
ITER / International effort



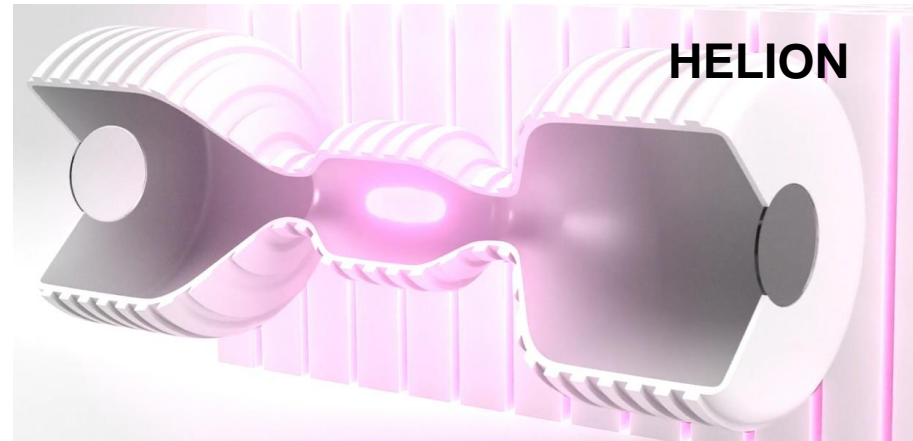
GENERAL FUSION



MIFGEN



SPARC



HELION

DMAVT

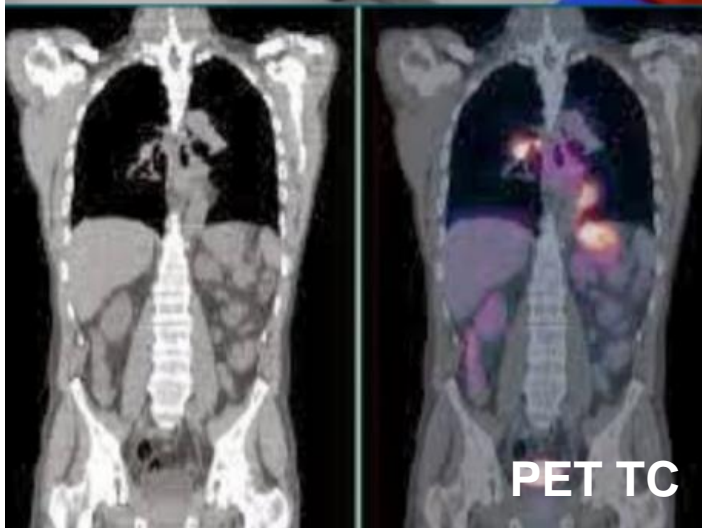
Nuclear engineers are experts in the interactions between **ionizing radiation** and matter, **nuclear imaging** instrumentation and **radiation dosimetry**.

- ❑ Therapeutic and diagnostic applications of radionuclides (except those used in sealed sources for therapeutic purposes)
- ❑ Equipment associated with their production, use, measurement and evaluation
- ❑ Quality of images resulting from their production and use
- ❑ Medical health physics associated with this subfield

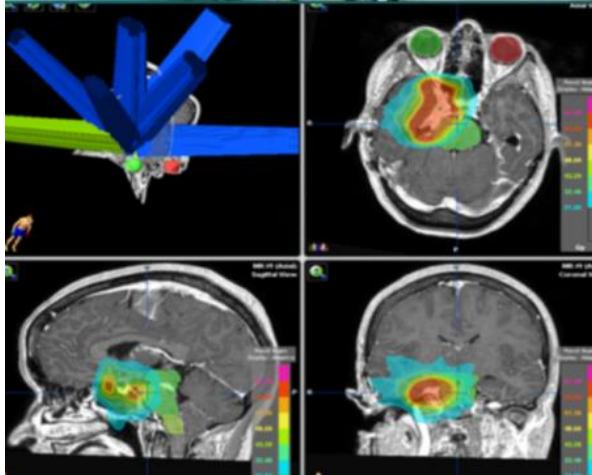
Imaging



Radiotherapy



PET TC

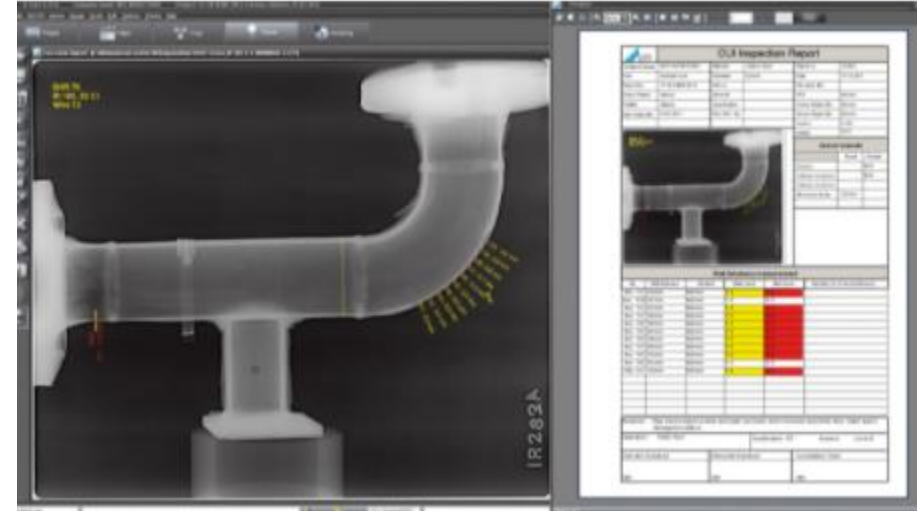
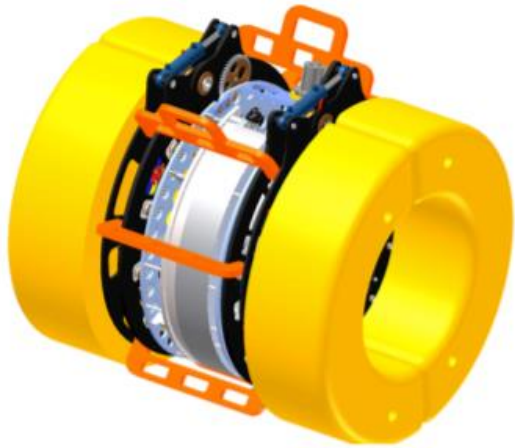


Irradiation plan design

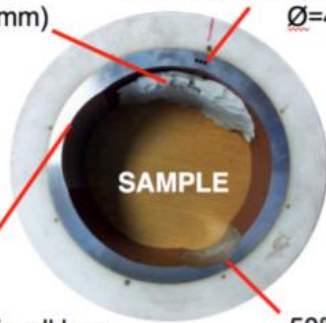


INDUSTRIAL RADIOGRAPHY

TOMOGRAPHIC IMAGING FOR UNDERWATER OIL/GAS PIPELINES



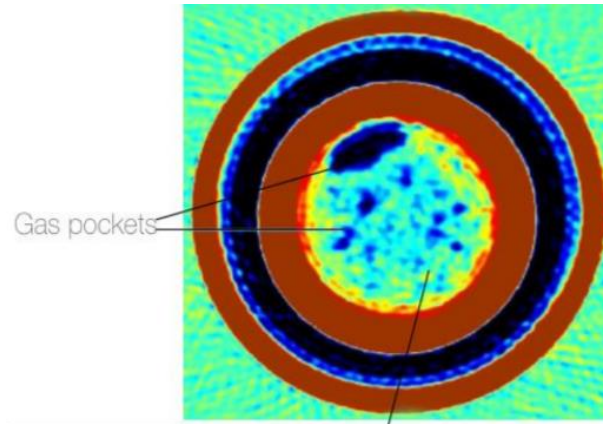
Deposits (~15-20mm)
Buried defects (3 holes $\varnothing=4\text{mm}$)



SAMPLE

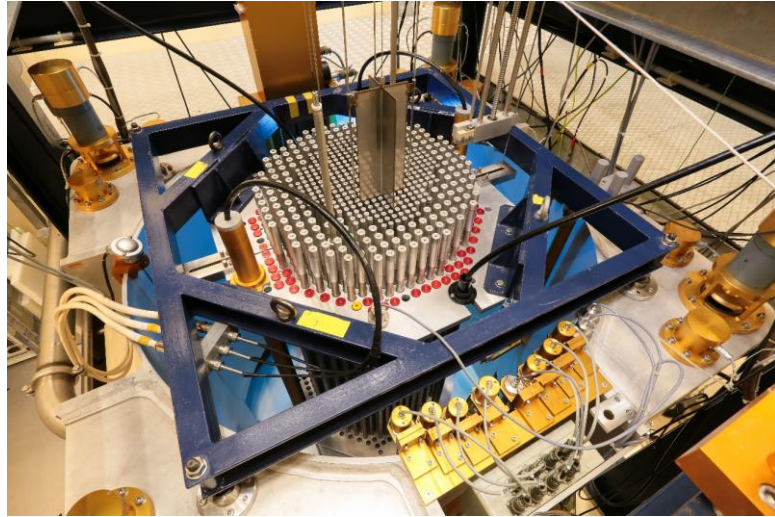
25% Erosion/ wall loss

50% Erosion/ wall loss

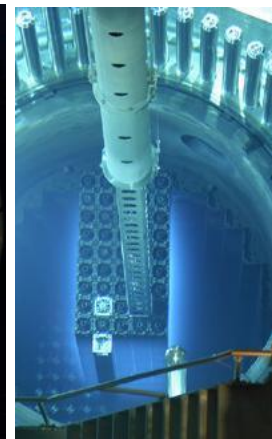
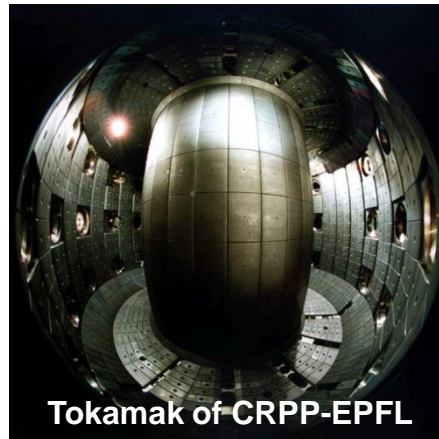


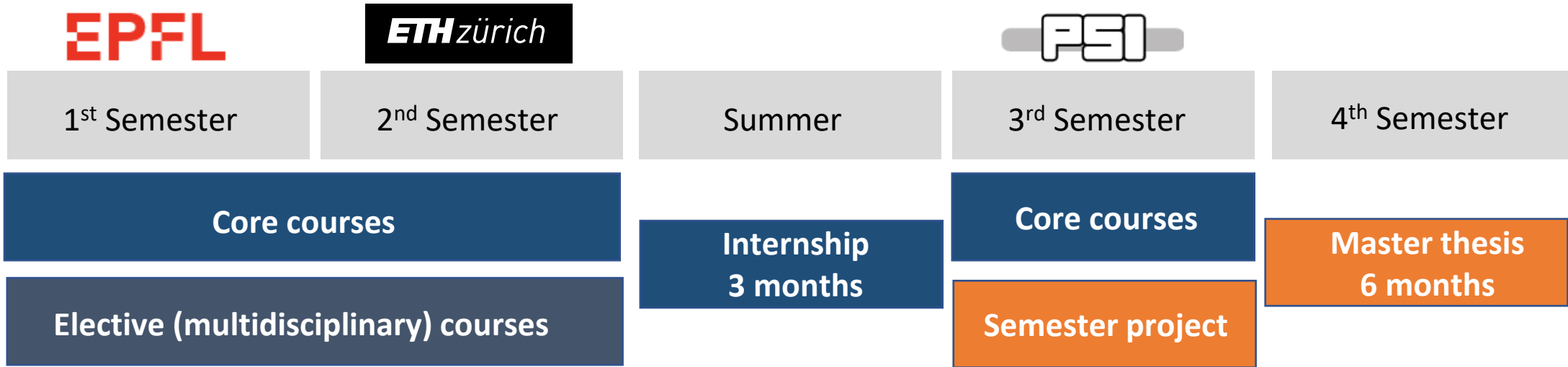
Asphaltene @1.2g/cc

ETH zürich 4 Semesters (120 credits)



- ❑ Fission technology as energy source (nuclear power plants)
- ❑ Neutronics
- ❑ Thermo-hydraulics and fluid-dynamics
- ❑ Nuclear safety, efficiency, environmental aspects
- ❑ Fusion reactors and plasma physics
- ❑ Nuclear Medicine, Research and industry beyond nuclear power plants
- ❑ Fuel cycle from Uranium mines to disposal
- ❑ Integration of nuclear power plants in the energy system, synergy with other energy technologies





Praktikumsplattform

www.nuklearforum.ch/de/praktikumsplattform

The Swiss Nuclear Engineering Master Program

How is the Nuclear Engr. Master organized?

EPFL

1st Semester



ENSI
Eidgenössisches Nuklearsicherheitsinspektorat

PAUL SCHERRER INSTITUT



nagra
aus verantwortung

BKW®



ZWILAG

Kernkraftwerk Gösgen

apollo+
nuclear

ALPIQ

AFRY
AF PÖVRY



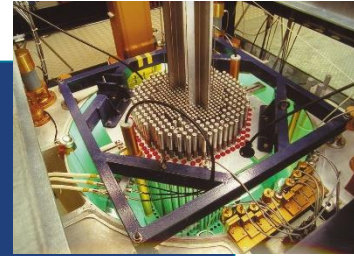
Kernkraftwerk
Leibstadt

0 20 40 km
0 20 40 mi



❑ 1st Semester, EPF Lausanne

Focus: Reactor physics, Neutron Transport, Radiation Biology and dosimetry, Plasma physics (fusion)



❑ 2nd Semester, ETH Zürich

Focus: Reactor technology, Nuclear fuel, Nuclear Safety, Thermo-hydraulics and fluid-dynamics, Material Science, Nuclear Medicine

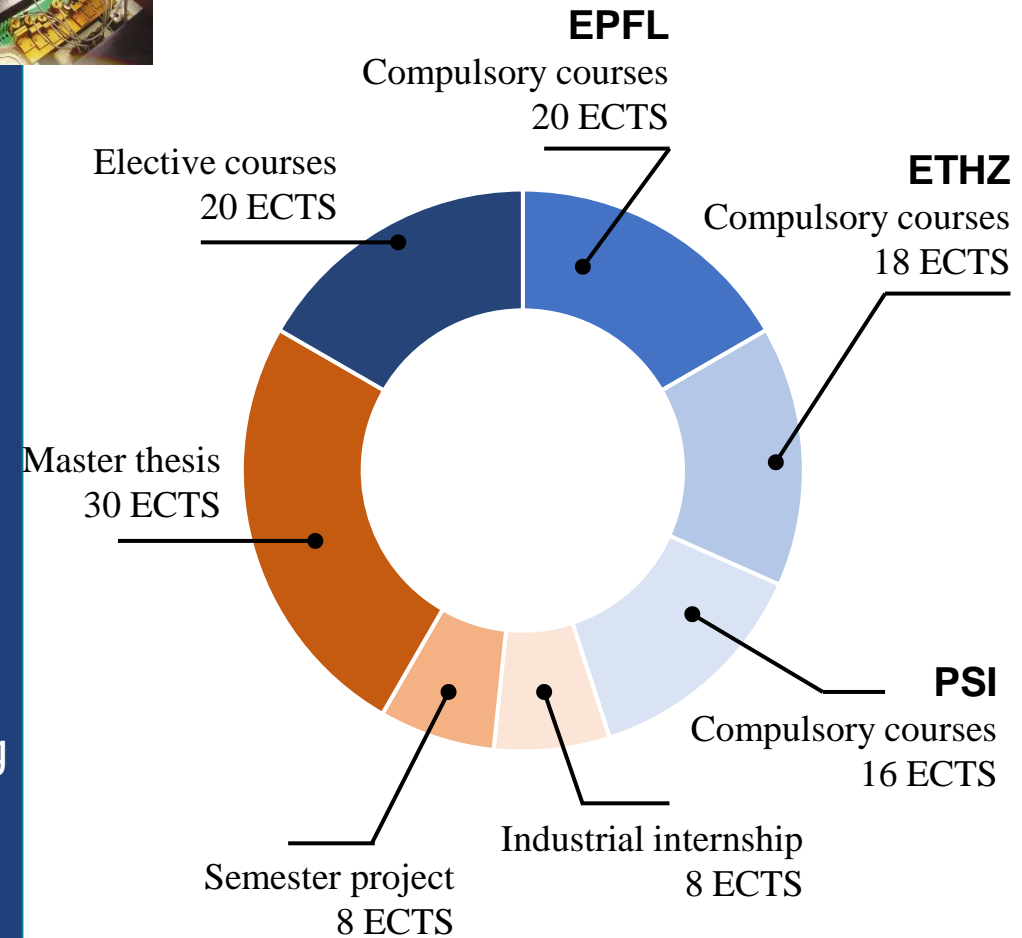
Placeholder for 3 months industrial internship

❑ 3rd Semester, Paul Scherrer Institut / ETH Zürich

Focus: Research (Semester project), Deepening in Material science, Severe accidents, Decommissioning and waste disposal

❑ 4th Semester, PSI / ETH Zürich / EPF Lausanne / Extern

Focus: Research => Master thesis

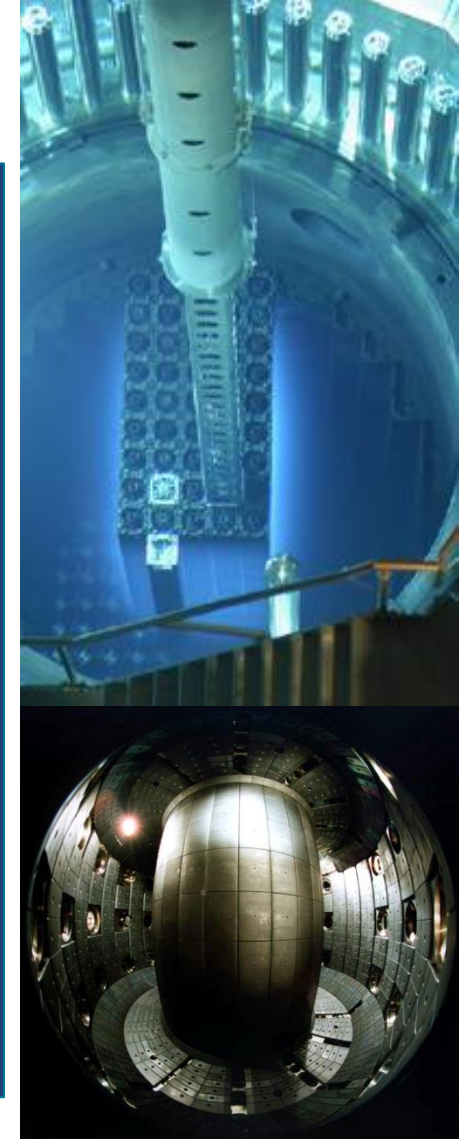


□ SPECIALIZATIONS

- Fission reactors and NPPs
 - Thermal-hydraulics
 - Neutronics
- Plasma physics and Fusion Reactors
- Medical Physics
- Energy Systems
- Materials
- Particle Physics and Detection
- Computational Methods

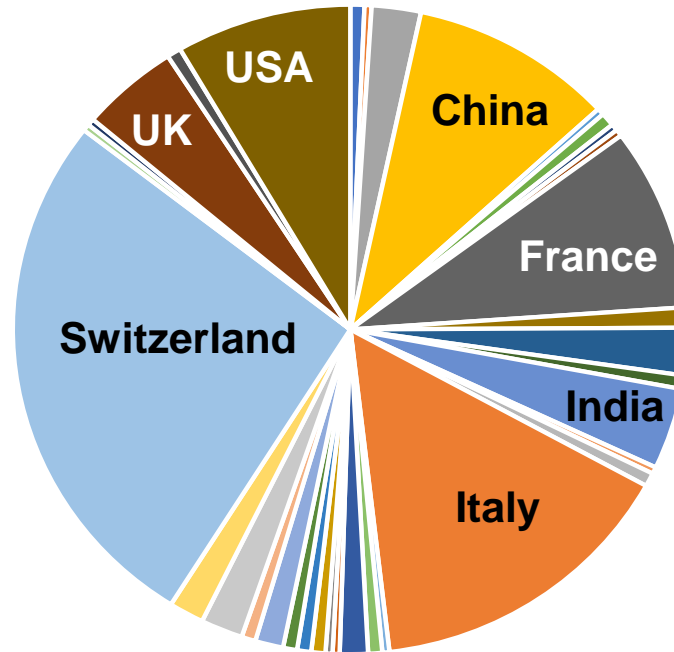
Motivations

- ❑ More interesting, versatile and innovative than some people think!
- ❑ Very high energy density of nuclear fuel – Advantage (great effect from small amounts of substance)
- ❑ Nuclear energy supports the energy transition as a powerful, environmentally friendly competitor to coal, oil and gas
- ❑ Reduced storage requirements for renewables thanks to the ability to plan generation
- ❑ Nuclear methods open up a multitude of non-invasive measurement and diagnostic procedures in technology and medicine
- ❑ Strong therapy option for the most serious illnesses
- ❑ Enjoy internationality of the nuclear community and your study mates!
- ❑ High level of multidisciplinary opens a broad range of carrier possibilities



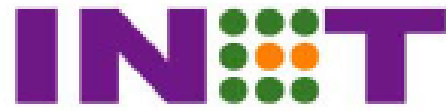
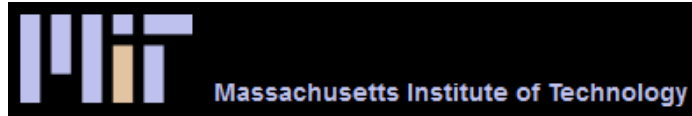
Where are the students who apply come from (country of Bachelor degree)

Applications 2013 - 2022 (Bachelor country) - 297 students



- | | | | | | | |
|---------------|-----------|-----------|-------------|------------------|---------------|--------------|
| ■ Belgium | ■ Brasil | ■ Canada | ■ China | ■ Czech Republic | ■ Egypt | ■ Estland |
| ■ Equator | ■ France | ■ Germany | ■ Greece | ■ HongKong | ■ India | ■ Indonesia |
| ■ Irland | ■ Italy | ■ Japan | ■ Lebanon | ■ Mexico | ■ Netherlands | ■ New Zeland |
| ■ Pakistan | ■ Russia | ■ Serbia | ■ Singapore | ■ South Africa | ■ South Korea | ■ Spain |
| ■ Switzerland | ■ Tunisia | ■ UAE | ■ UK | ■ Ukraine | ■ USA | |

ETH zürich International Collaborations



MSc Students visiting Hotlab at PSI

Prof. Annalisa Manera
Director of Nuclear
Engineering MSc Program
maneraa@ethz.ch

Laboratory of Nuclear Systems
and Multiphase Flows
ETH-Zurich
ML K 13
Sonneggstrasse 3
8092 Zürich

Apply at
www.master-nuclear.ch

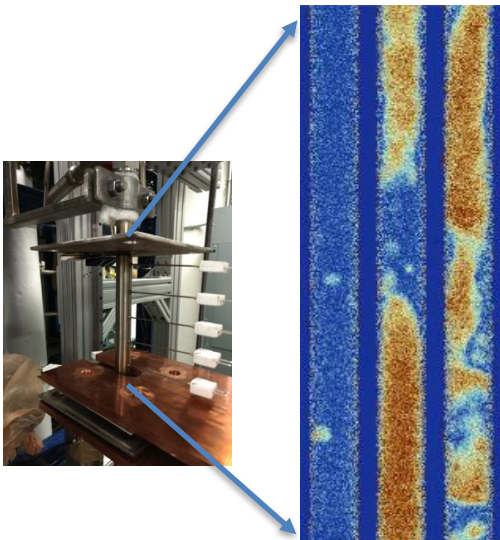


Nuclear Systems and Multiphase Flows Lab

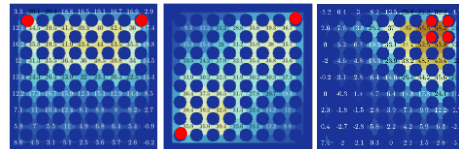
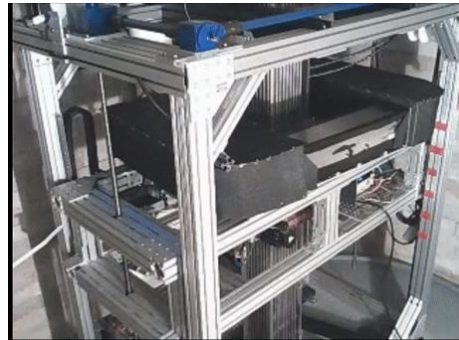
High-resolution experiments for single- and multiphase flows, advanced instrumentation, computational fluid-dynamics.



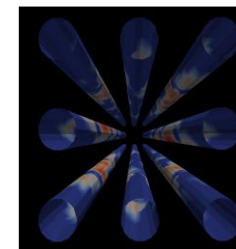
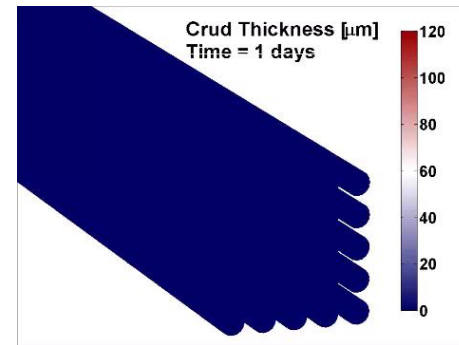
Prof. Annalisa Manera



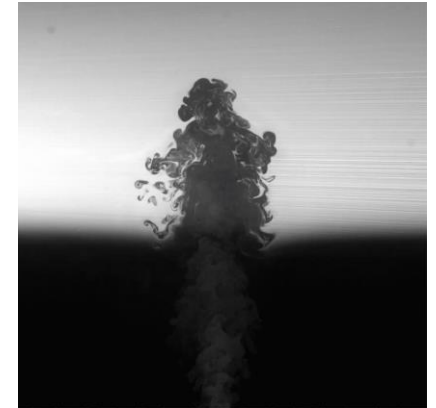
Xray radiography of Steam-water flow at 75 bar



Void-fraction distribution in a fuel bundle using γ -tomography



CFD/chemistry multiphysics simulations of CRUD deposition on nuclear fuel



Buoyant jets in stratified environments using PIV + Refractive-index matching

Applications: nuclear power plants (LWRs, microreactors, advanced reactors) fluid-dynamics processes, imaging