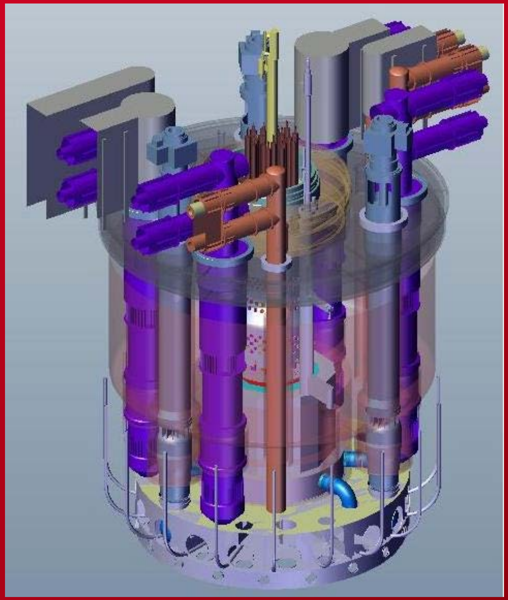
DE LA RECHERCHE À L'INDUSTRIE



www.cea.fr

International Symposium on Present Status and Future Perspective for Reducing of Radioactive Wastes

Concept and Future Perspective on **ASTRID** project in France

Sylvestre PIVET

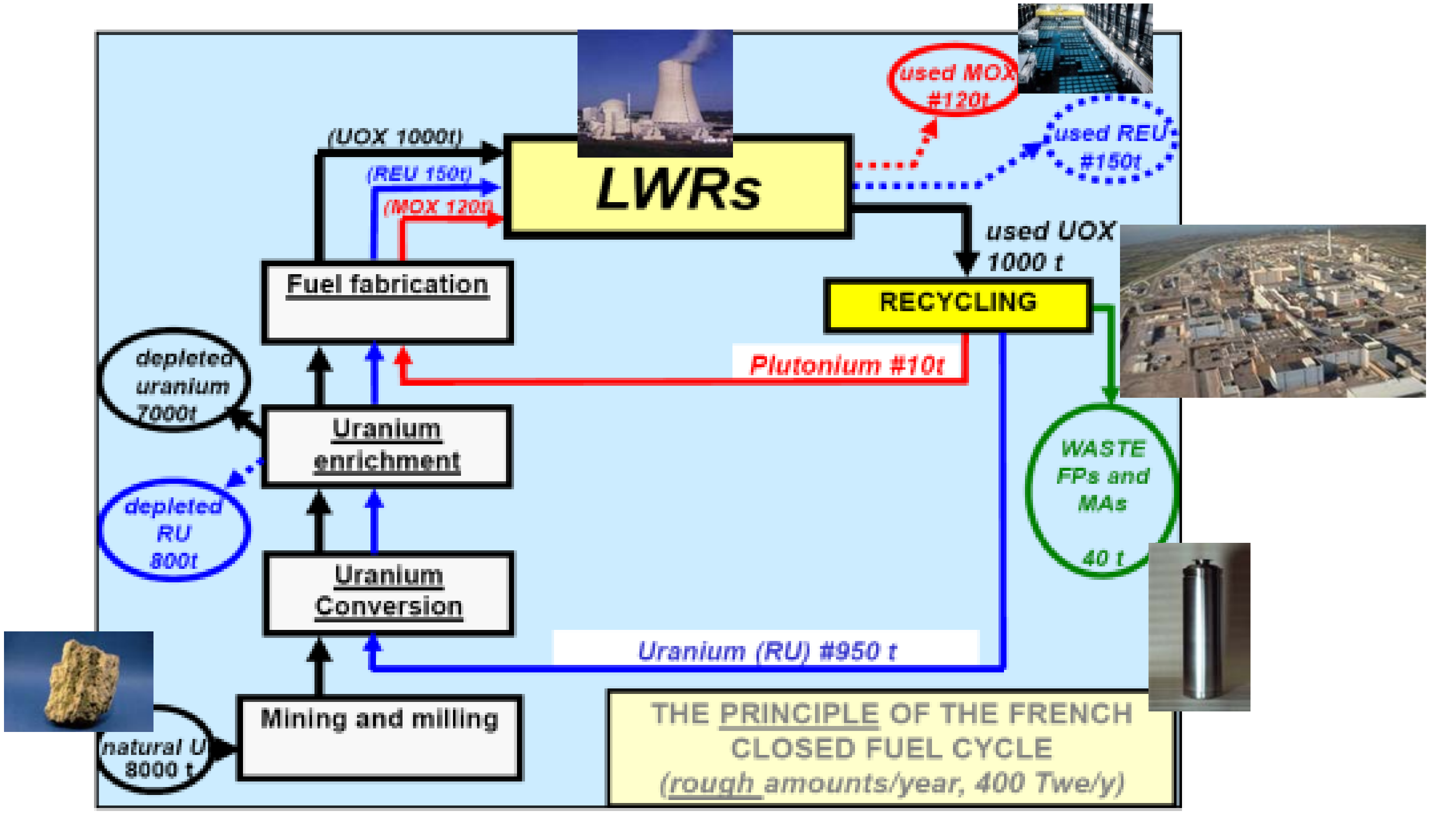
CEA, Nuclear Energy Division
Direction of Innovation and Nuclear Support Division

17 FEBRUARY 2016

The French frame of long-term Radioactive Waste Management

- The 2006 Act

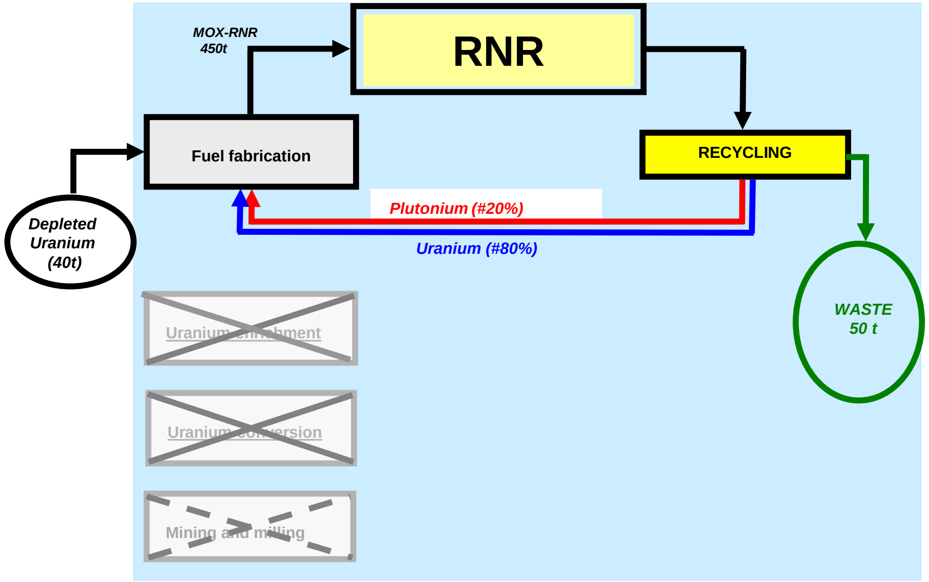
- Principles :
  - Recycling to decrease waste amount & harmfulness



  - Geological repository : the reference option for ultimate waste management.

Fast reactors at the heart of the CEA research

- For the longer term: comprehensive closed fuel cycle
- Excellent use of uranium resources
- Contribution to the management of long-lived radioactive waste



Sodium-cooled fast reactors

Astrid program

Gas-cooled fast reactors

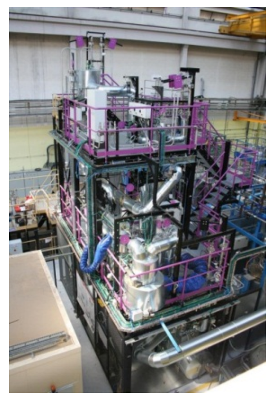
For the longer term

The Astrid project: perimeter

ASTRID design studies

Core fabrication workshop

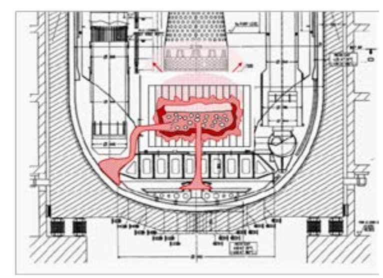
- MOX fuel
- A few tons per year



Full scale component testing

- Large test sodium loops
- Refurbishment of zero power reactor MASURCA

Severe accidents experimental program



R&D

The ASTRID Project

Technological demonstration reactor (a step before a First Of A Kind)

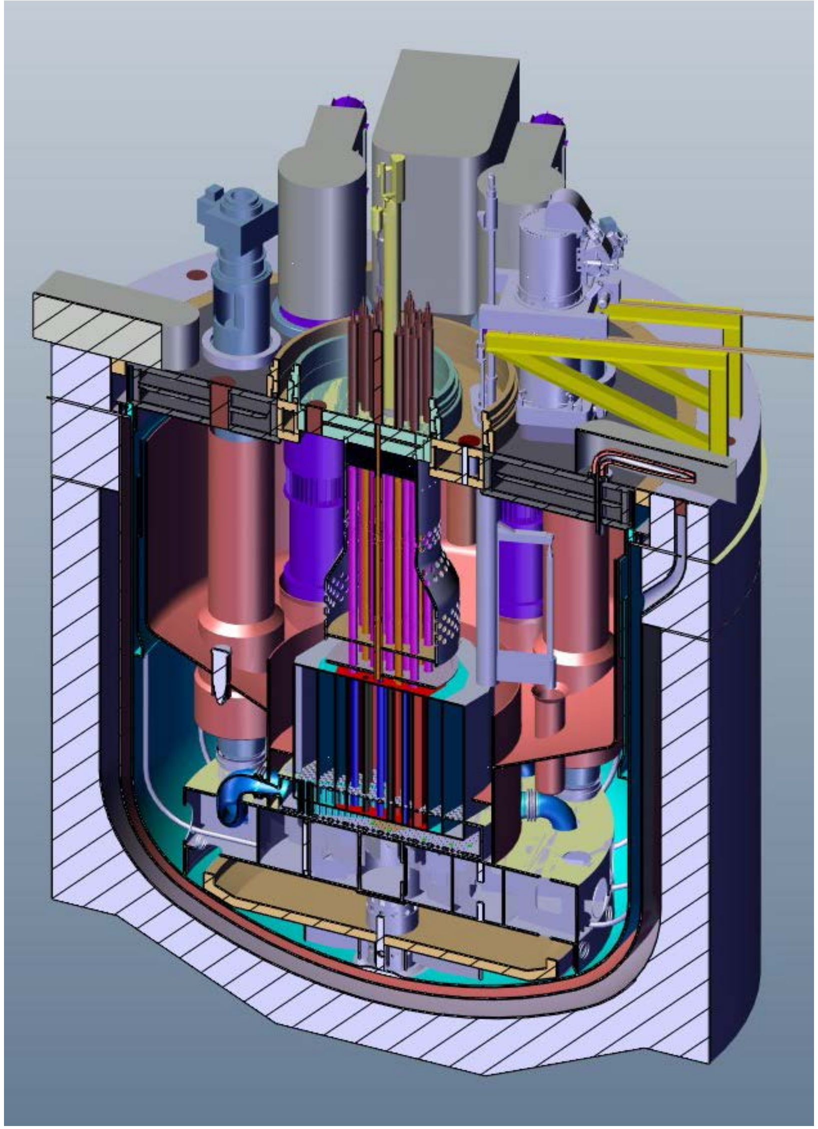
- Integrating French and international SFRs feedback
- A GEN IV system
  - Safety
  - Durability
  - Operability
  - Non proliferation warranty
- Irradiation services and options test

14 industrial Partners have joined the astrid Project

CEA/Nuclear Energy Division is in charge of the ASTRID project

Bilateral industrial partnerships cover main design engineering batches

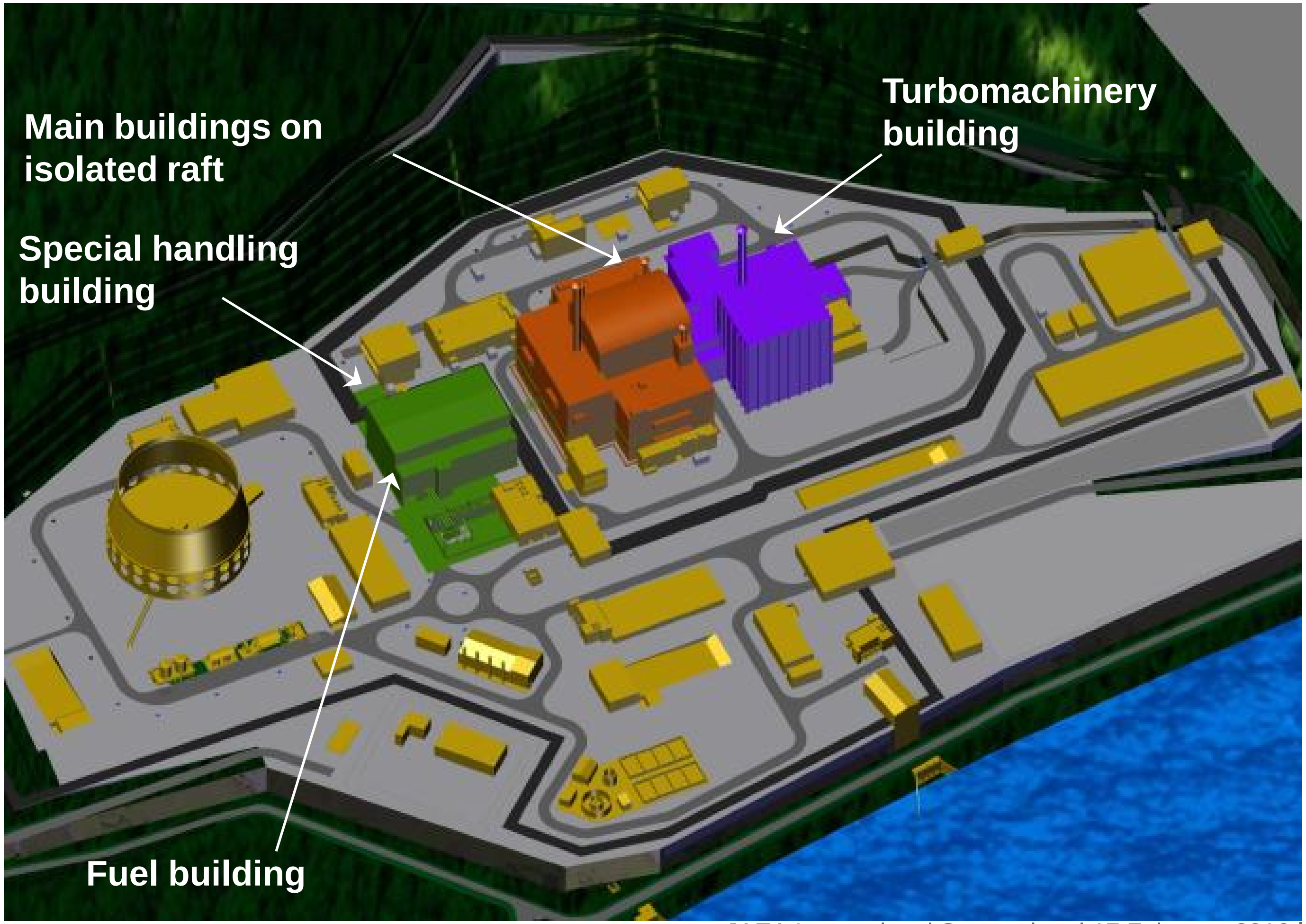
Astrid main technical choices



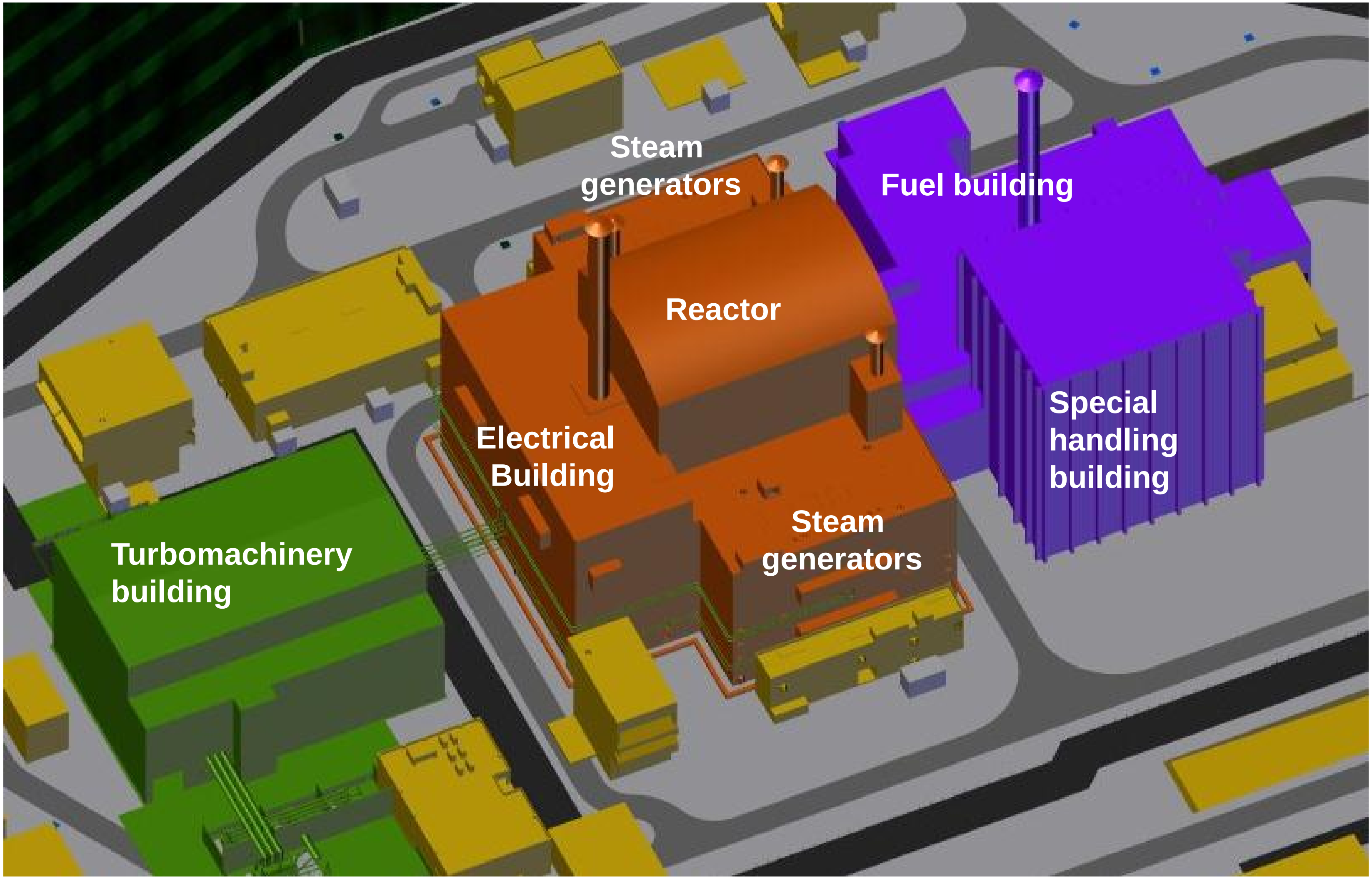
- 1500 thMW - ~600 eMW
- Oxide fuel UO2-PuO2.
  New reactor core design
- Core catcher integrated into the reactor vessel to catch molten core debris
- Inerting and early leak detection systems which greatly reduce the risk of sodium fires
- Integration of in-service inspection requirements into the reactor design
- Multiple, redundant decay heat removal systems.
- Experimental capabilities: to contribute to the qualification of transmutation, fertile or burner subassemblies

Reactor site studies and infrastructures implementation

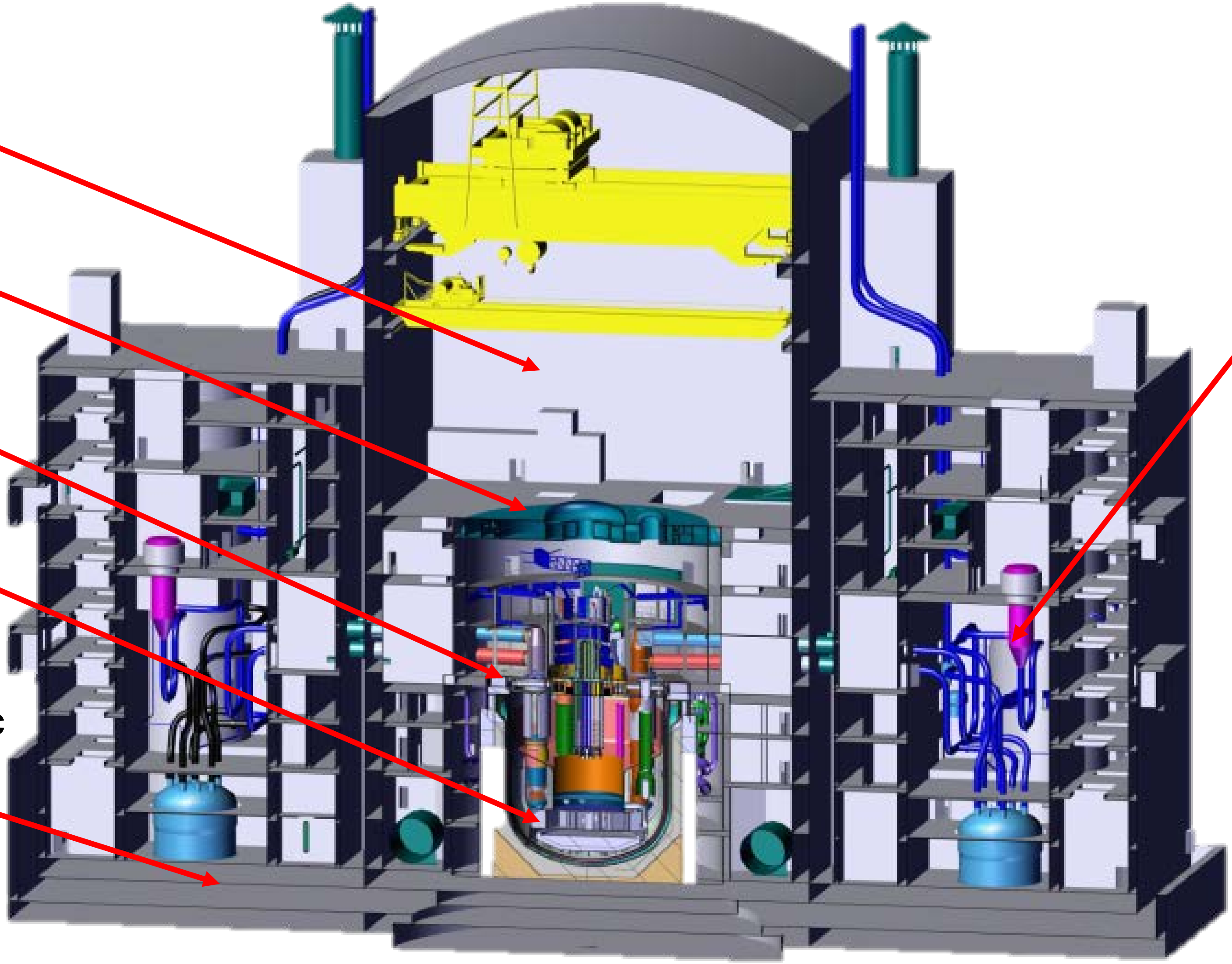
- A one geographical level platform
- An optimization work on the balance of plant



Reactor site studies and infrastructures implementation



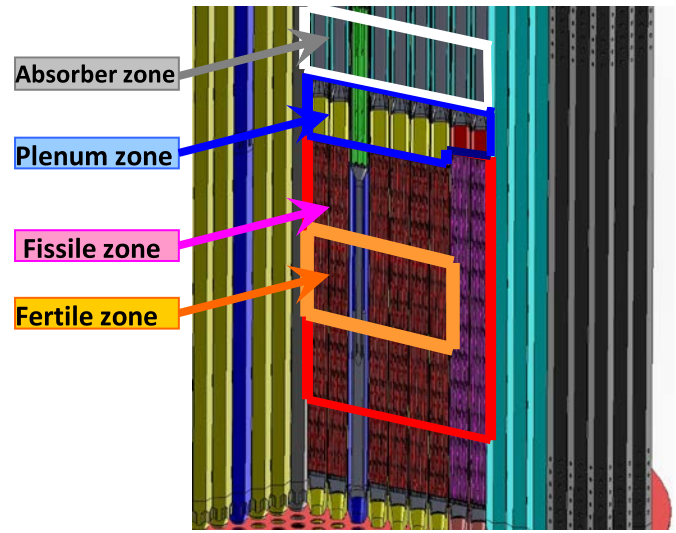
Reactor building



Confirmation of a low sodium void core (CFV)

Enhanced Core safety in case of all protection systems failures

« CFV » = no power increase in case of coolant loss *(CEA-AREVA-EDF patent)*



Low Sodium Void Worth Core

Objectives :

- Reduced reactivity loss
- Negative sodium void worth
- Favorable behavior in non protected transients

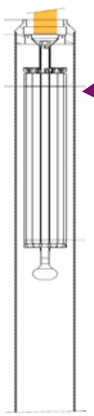
Phenix experiments post-irradiation examinations

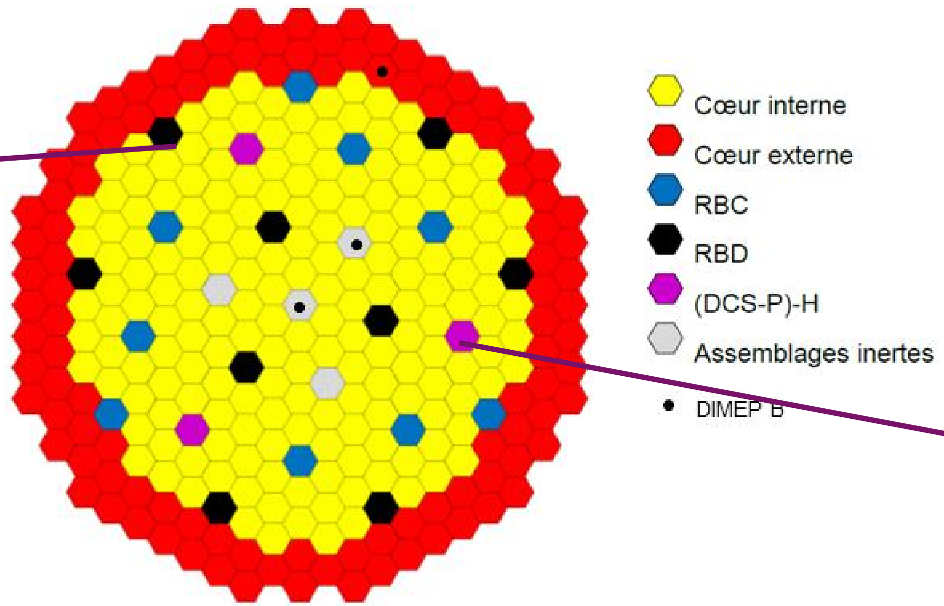
ASTRID mock-up in Masurca ZPR

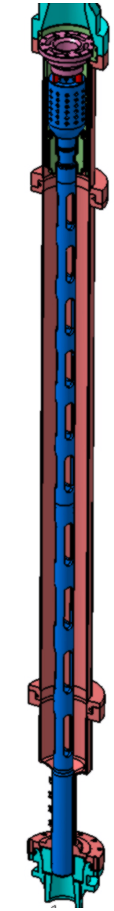
Reactivity control system and its complementary safety devices

- All the rods are used for reactor operation: control rods and diversified rods.
- Addition of complementary diversified safety devices : hydraulics ones and Curie point thermal ones.

Curie point electro magnet

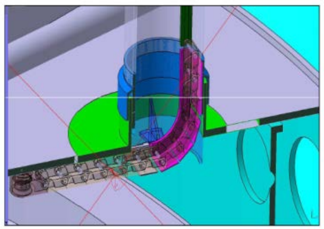


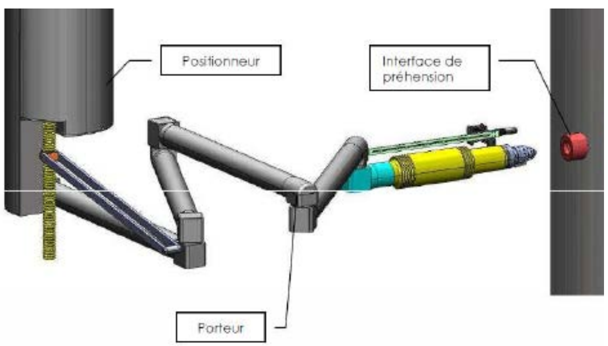




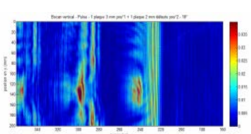
In service inspection and repair

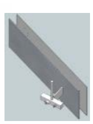
Carrier development



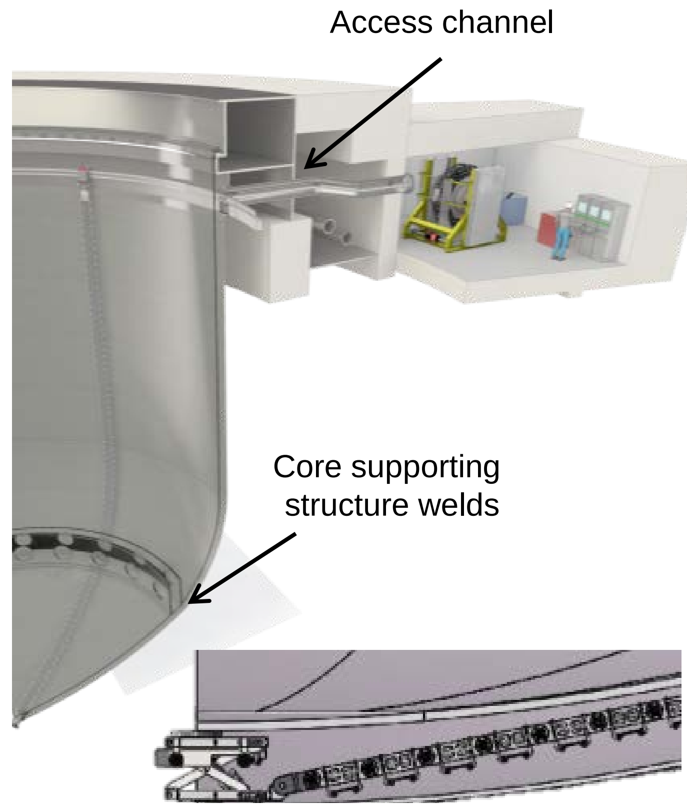


Sensor development



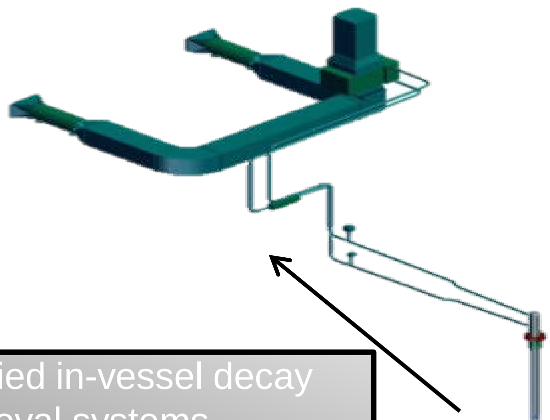


Main vessel inspection

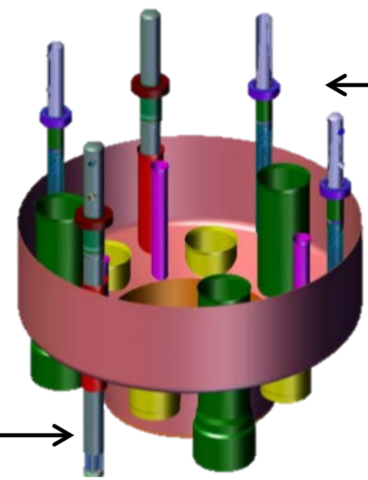


Pushing chain with inspection trolley

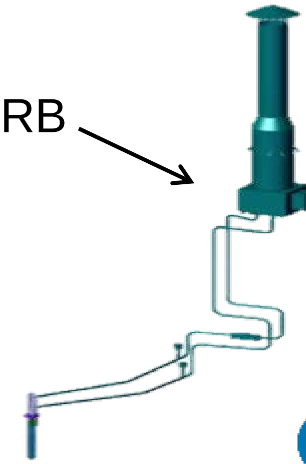
Diversified decay heat removal systems



RRA



RRB



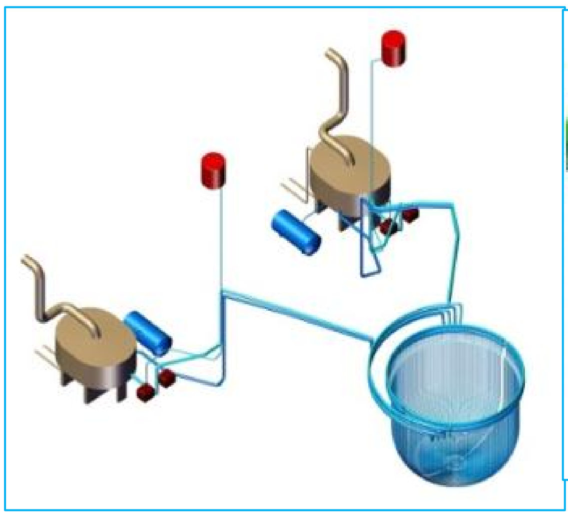
2 diversified in-vessel decay heat removal systems
- Na coolant
- Air heat sink

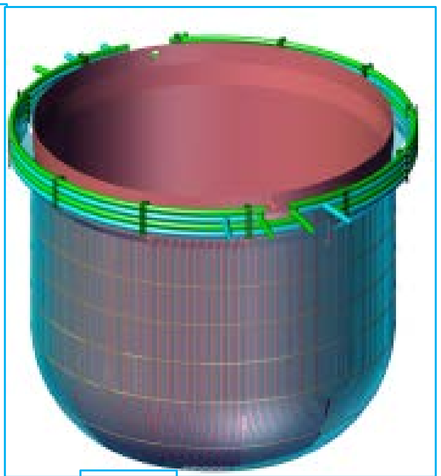
AREVA

JAEA

MFBR Systems, Inc.

MITSUBISHI HEAVY INDUSTRIES, LTD.





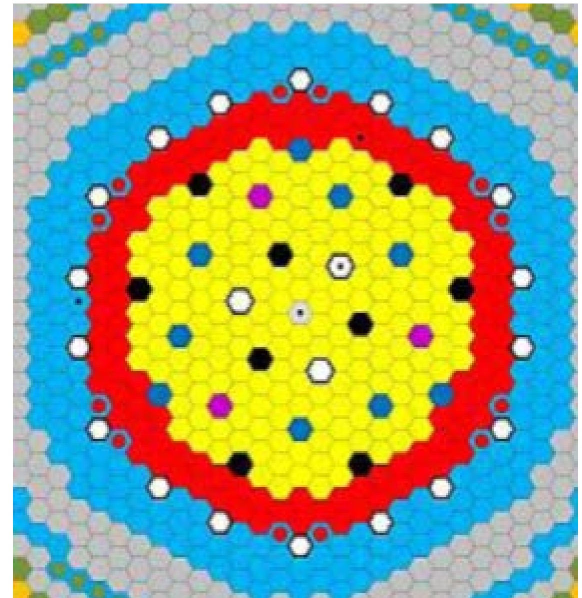
RRC

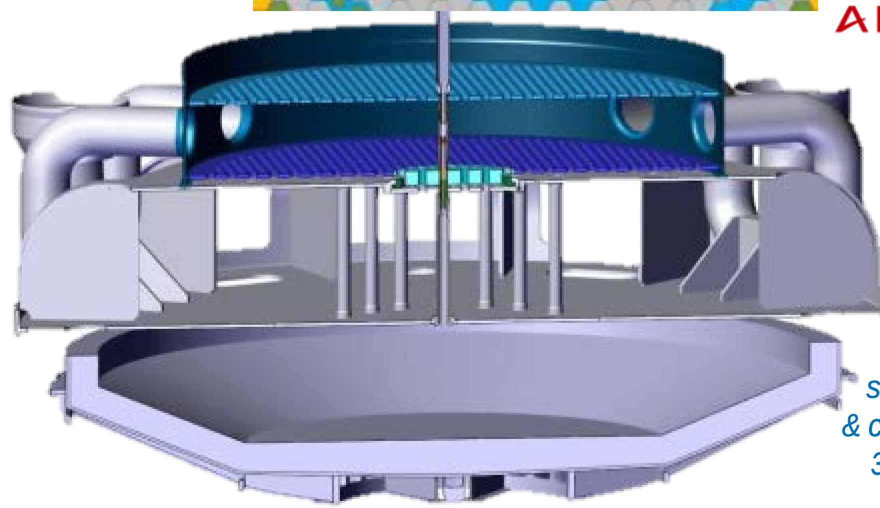
Third heat removal system through reactor vessels for severe accidental conditions
- Oil coolant
- Water heat sink

In-core complementary safety devices for severe accidents mitigation

- CFV core equipped with 21 devices for corium dispersion

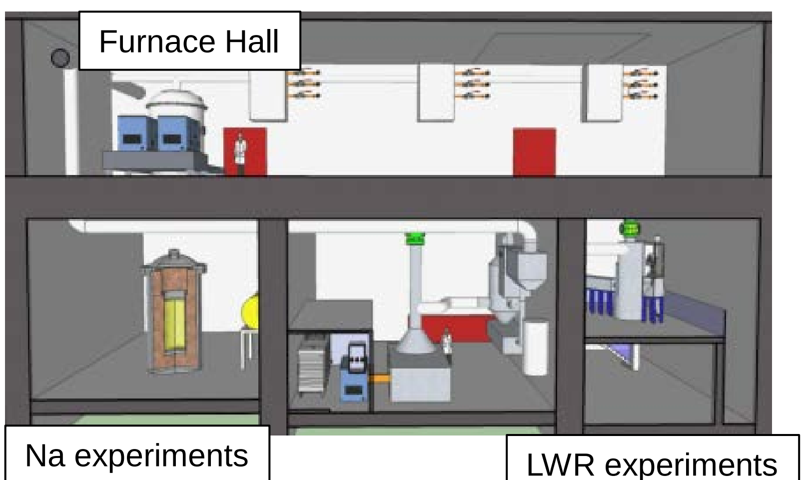
- Objectives:
  - Reduce re-criticality risk
  - Avoid melting propagation to the internal storage
  - Minimize impact on core performances





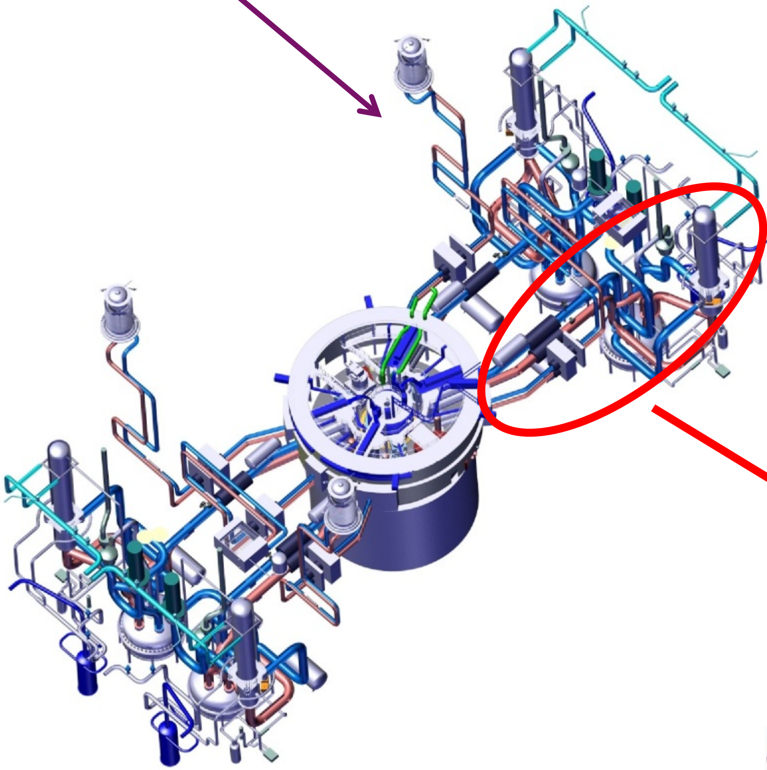
Diagrid, strongback & core catcher 3D Mockup

Foreseen Plinius2 facility – CEA Cadarache



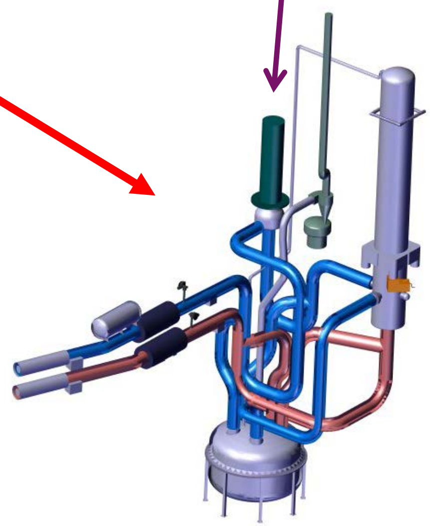
Secondary loops main options
(steam water PCS option)

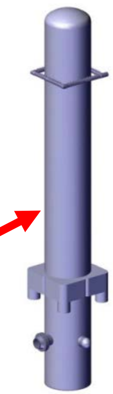
4 loops secondary circuits



375 MW helicoïdal Steam Generator

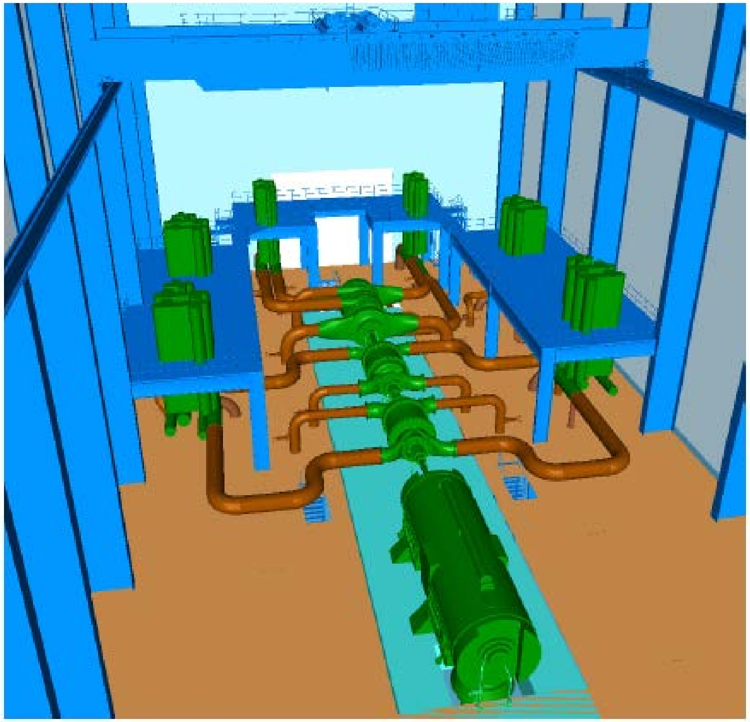
Electro Magnetic pump



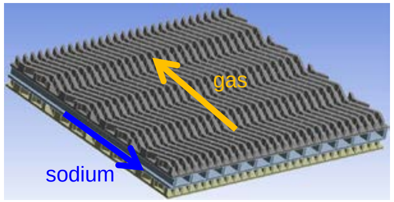


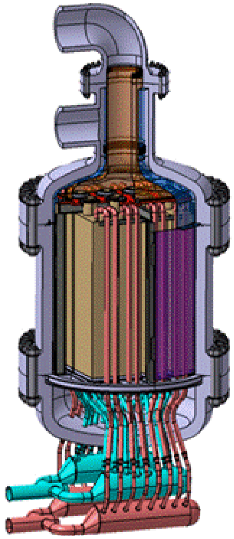
GAS power conversion system: an option under study

- Brayton gas cycle : 180 bar of Nitrogen at 515°C
- 37% efficiency
- Operation and safety analysis have been performed
- No show-stopper identified at that point

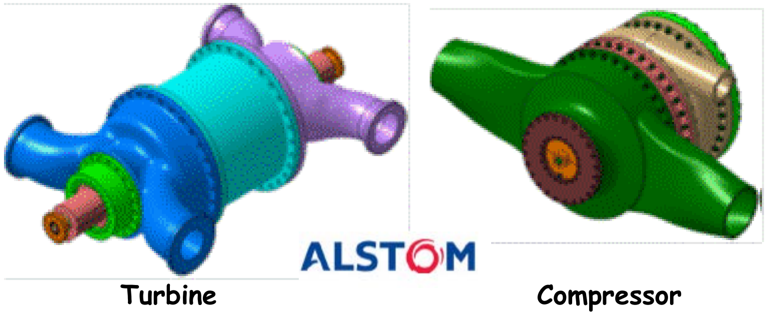


Compact sodium gaz heat exchanger

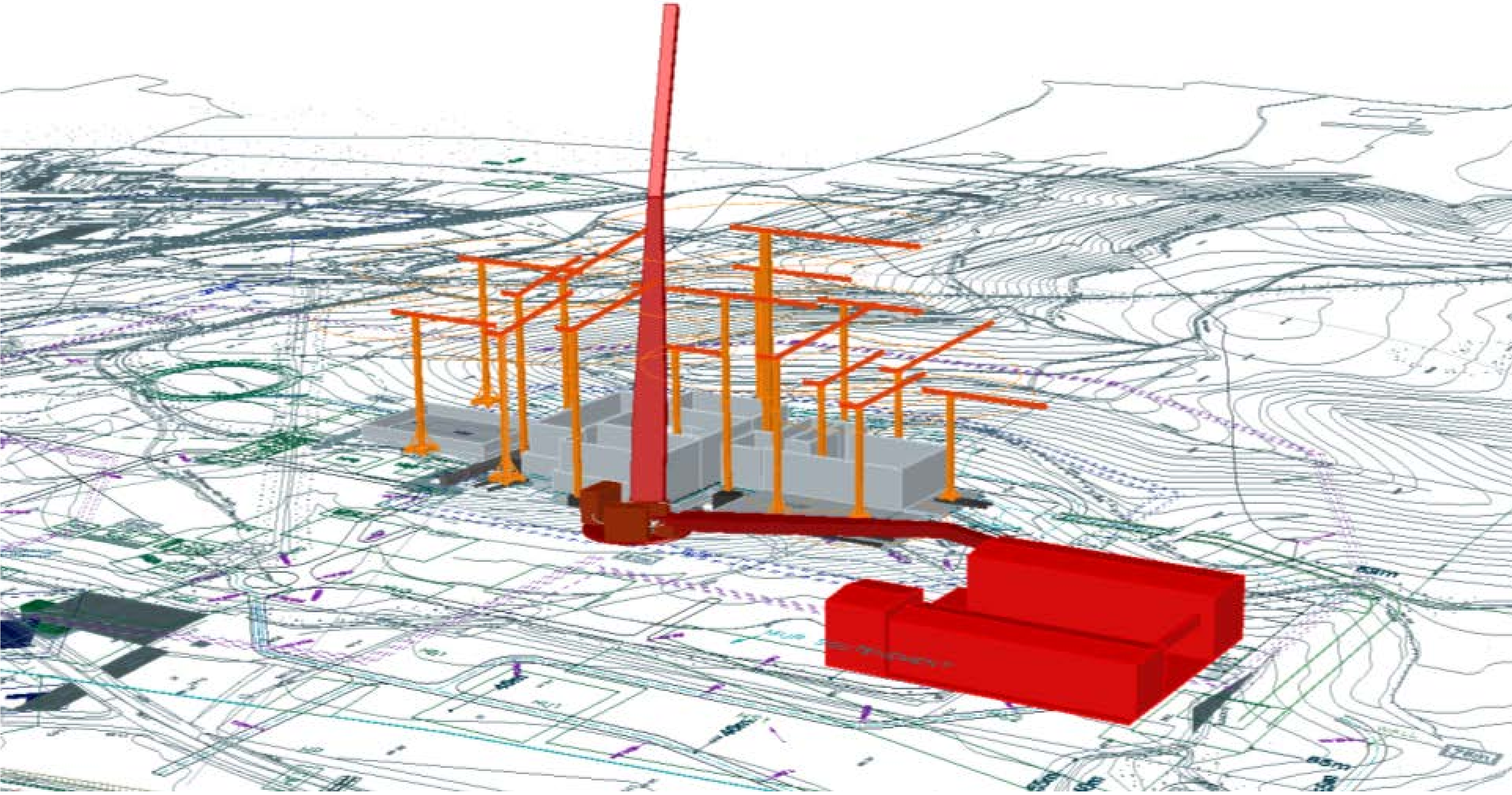




Turbomachinery



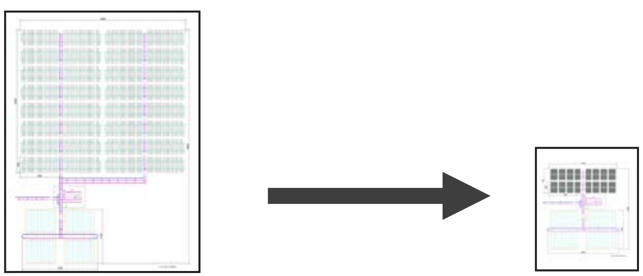
Constructability studies



Transmutation of minor actinides

- Americium has been identified as a first target for a possible separation and transmutation strategy with the goal of reducing the long term harmfulness of ultimate waste.

- A substantial impact on the on the high-level waste disposal surface area required



Without transmutation *transmutation AM*

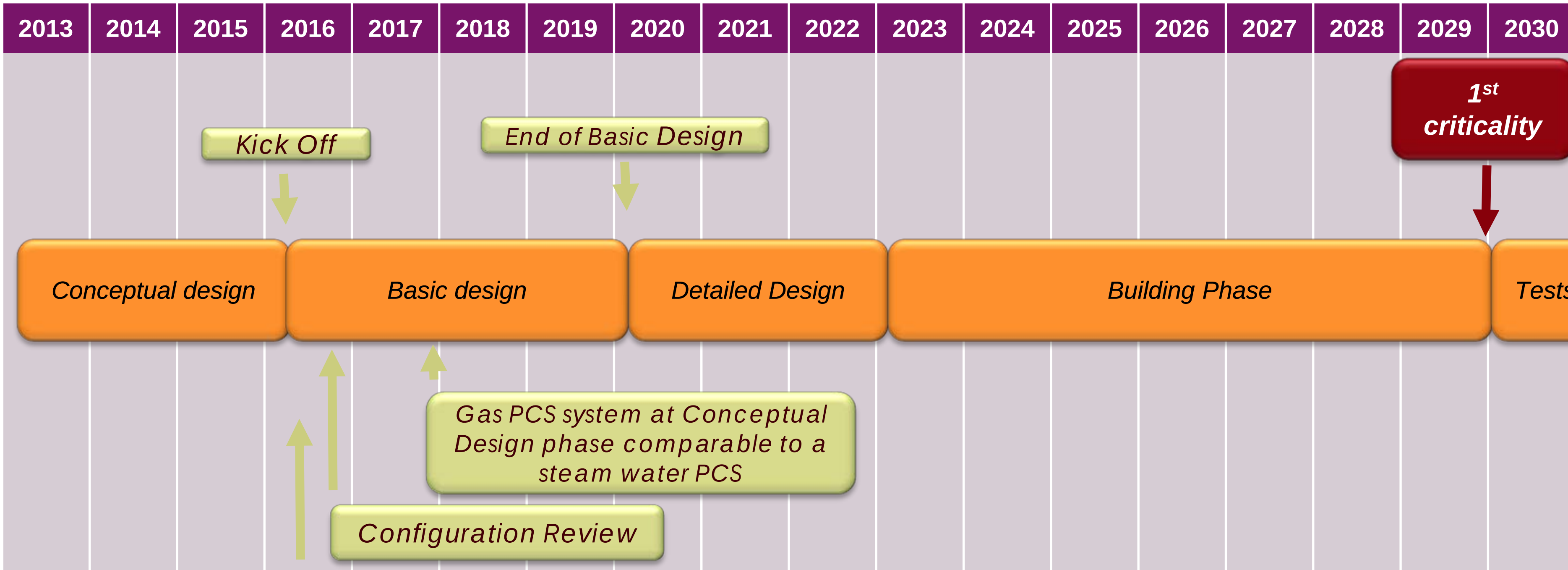
Contribution to intrinsic harmfulness

After 30 years ***After 300 years*** ***After 1000 years***

R&D studies

- Recycling B_4C

Planning of astrid project *(under discussion)*



Confirmation or re-consideration of some options

- *Opportunities raised by the gas PCS*
- *Operability fuel handling optimization, internal storage vs external storage*
- *General lay out, buildings optimization, constructability and realization planning*
- *Mechanical integrity and lifetime of large components*
- *Decay heat removal and mitigation strategy, safety devices*
- *ASTRID frontend/backend fuel cycle*

Cost, safety and operability are the drivers

Thank you for your attention