
INVAP

CNEN
Comissão Nacional de Energia Nuclear

AMAZUL
Amazônia Azul Tecnologias de Defesa S.A.

INVAP

Proyecto RMB

Reator Multipropósito Brasileiro

Background

2013: Basic Engineering
INVAP's scope: Reactor systems (a.k.a. Nuclear island)
Execution term: 1 year (june 2013/ june 2014)

2017: Detail Engineering
INVAP' scope: Reactor systems (a.k.a. Nuclear island)
Execution term: 2 years (december 2017/ december 2019)
+ 4 month revision-approval.

Conventional systems(e.g. Architecture, Services) by AMAZUL

Background

RMB

- Based on OPAL reactor
- 30 MW
- Moly production
- Loop for fuel testing
- Pneumatic rabbits
- Silicon irradiation
- Cold Neutron Source
- Neutron Beams

RA10

- Based on OPAL reactor
- 30 MW
- Moly production
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Two similar designs tailored to specific requirements

Outcome

Documentation to support:

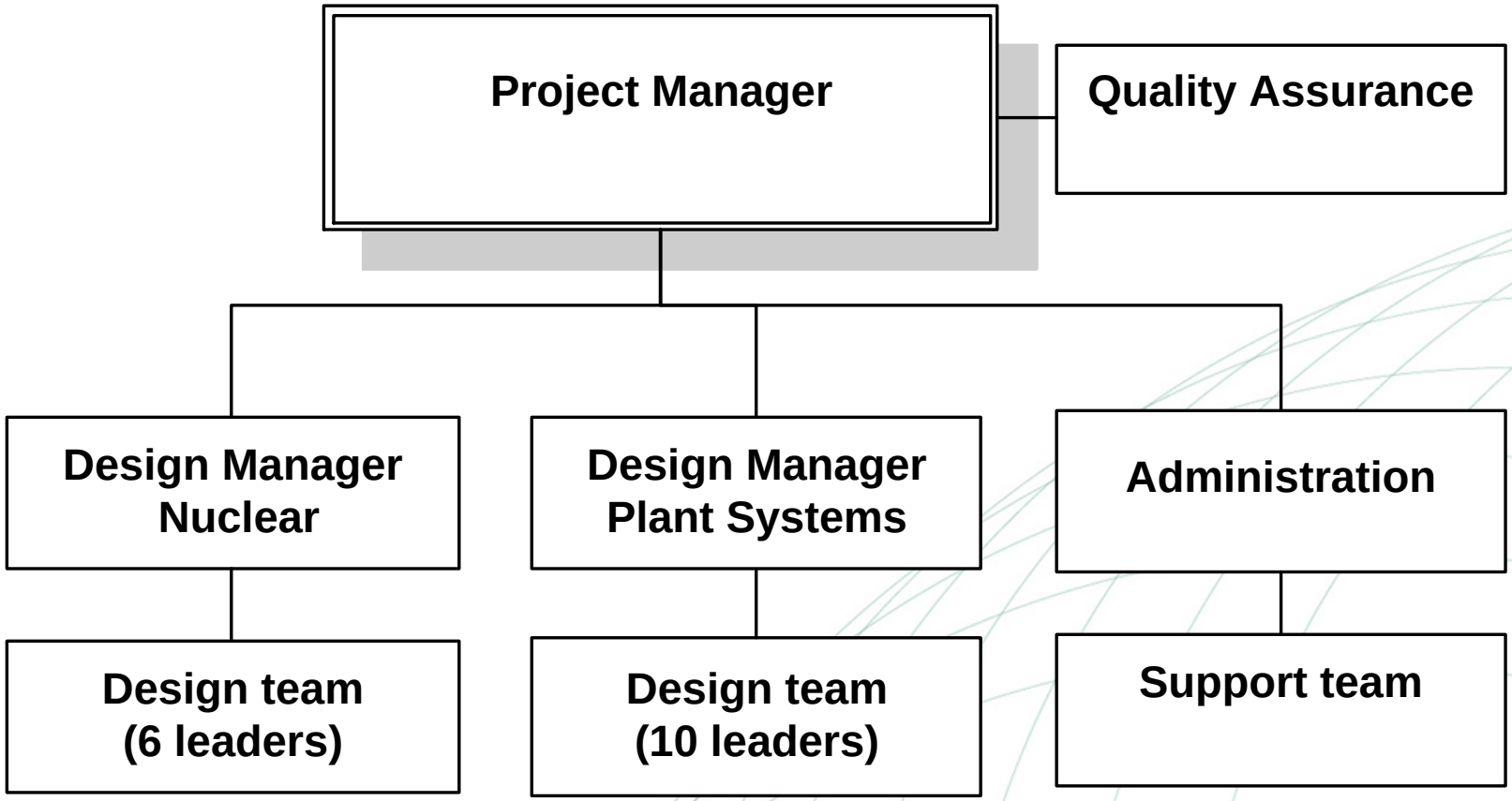
- Fabrication of components
- Purchasing of commercial-grade items
- Installation of components/systems
- FSAR

Typical set of documents

- Diagrams
- Drawings
- Calculation reports
- Descriptive reports
- Technical specs

Design integrated with the engineering developed by AMAZUL.

Organizational chart



Design Teams

NUCLEAR

- Neutronics
- Thermal-hydraulics
- Shielding
- Safety / Licensing
- I&C- Radiation Monitoring
- I&C- Nucleonic Instrumentation

PLANT SYSTEMS

- Mechanical
- Piping
- Process
- Electricity
- Ventilation (HVAC)
- I&C-Plant Instrumentation
- I&C- Control & Monitoring
- I&C- Reactor Protection
- Communications
- Integration / Lay-out

Organization of the works

55 Work Packages (WP)

Design Teams:

2 Design Managers
16 Design Leaders (Senior Engineers)
100 Designers (2018)
150 Designers (2019)

Product:

5000 documents
3D Model (Reactor Building, integrating both: INVAP and AMAZUL systems)

Integration INVAP/AMAZUL

Integration of equipment and components, building architecture in a consolidated 3D model.

Management of systems input/output data and requirements.

Collaboration and exchange of expertise/experience, e.g.:

- AMAZUL-INVAP:
  - Compliance of local standards and norms
  - Selection of commercial-grade items
- INVAP- AMAZUL:
  - Advising on designs in similar reactors

Integration INVAP-AMAZUL

METHOD

- CNEN leads and coordinates
- Working as a unique Team
- Design Leaders (counterparts) in each design discipline
- Periodic communications, revision/analysis of documents.

PROBLEMS

- Language
- Customs and habits
- Local standards
- Compatibility of design tools (software, e.g. Bentley-PDMS)
- Design criteria
- Scope of works (battery limits, design “gaps”)

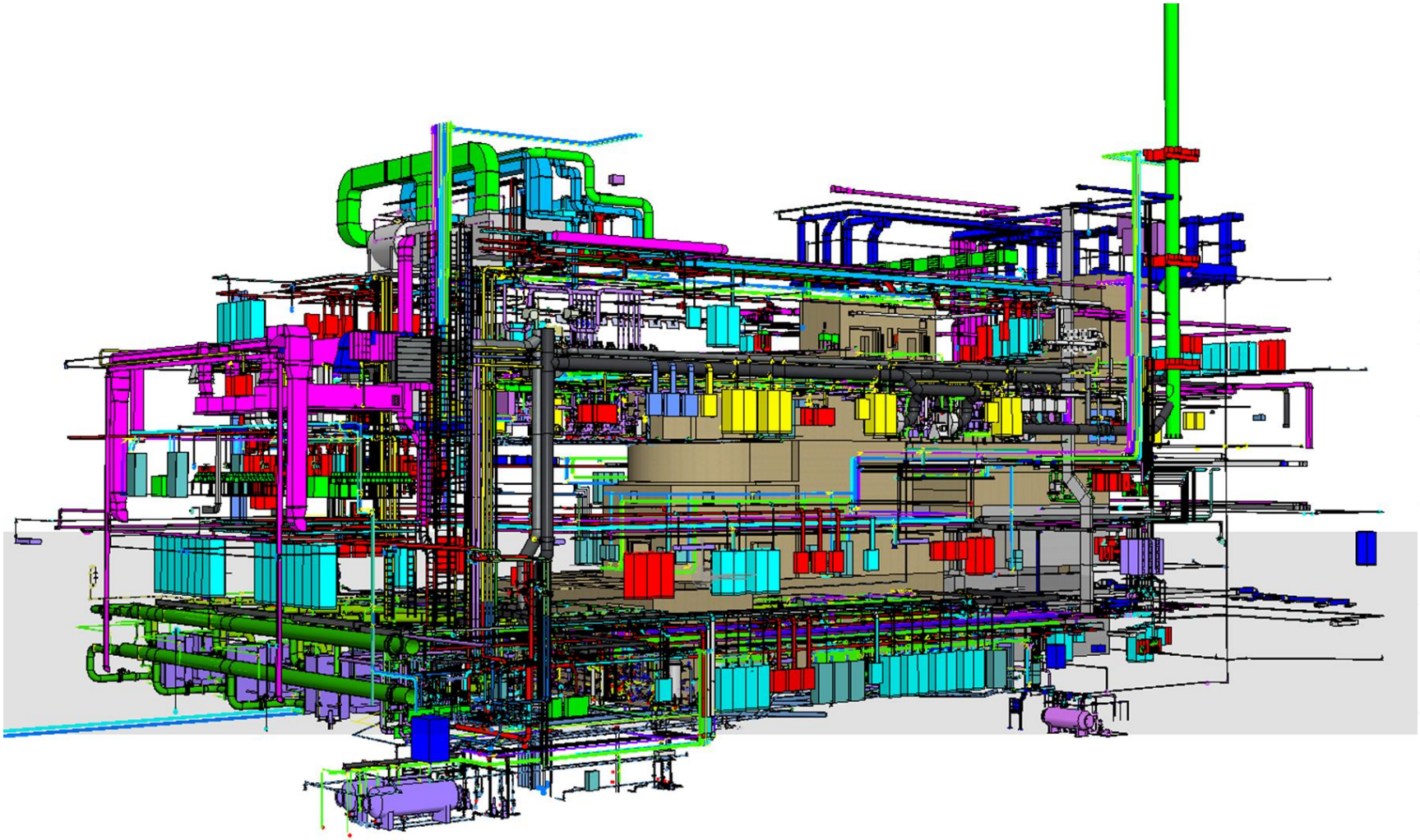
RMB

3D MODEL

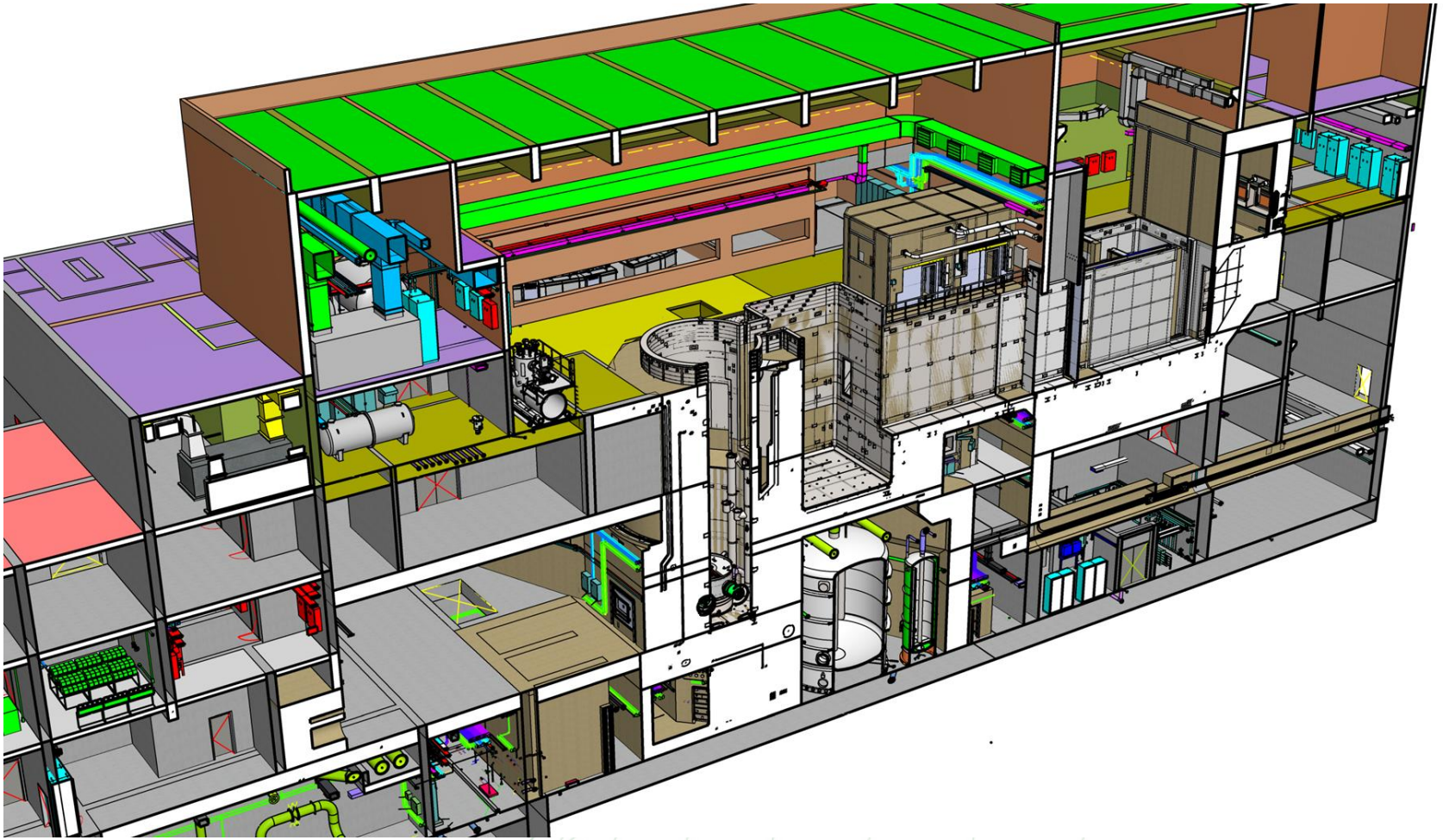
3-D Model

- Integrates designs from INVAP and AMAZUL
- INVAP leads the works
- Tool:
  - Bentley® system
    - OpenBuildings
    - Raceway & Cable Management (BRCM)
    - AutoPLANT_Modeler
    - OpenPlant PID
    - OpenPlant Modeler
    - AutoPIPE
    - OpenPLANT Isometrics Management
    - OpenPlant Support Engineering
  - Solidworks

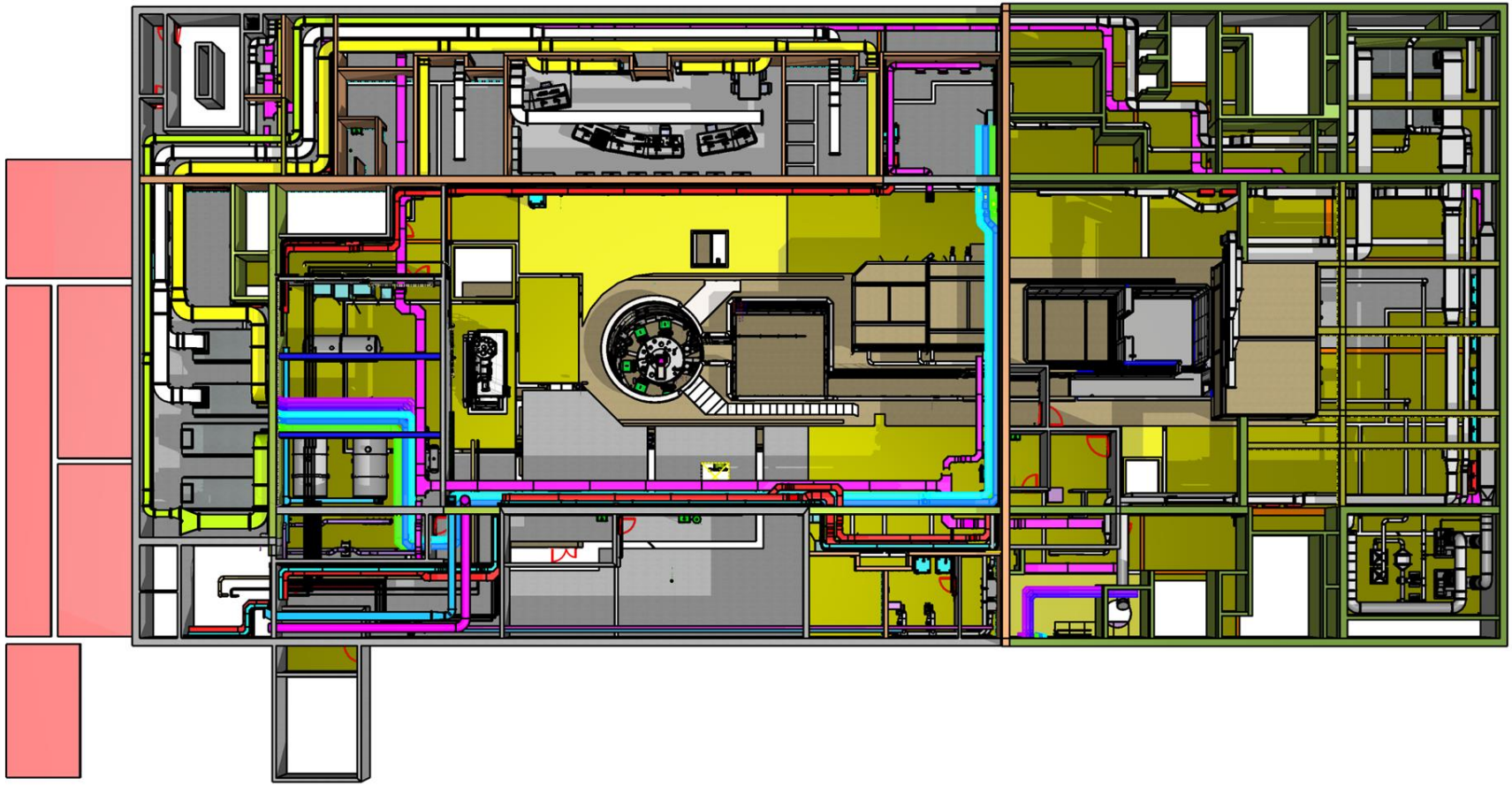
3D Model- view



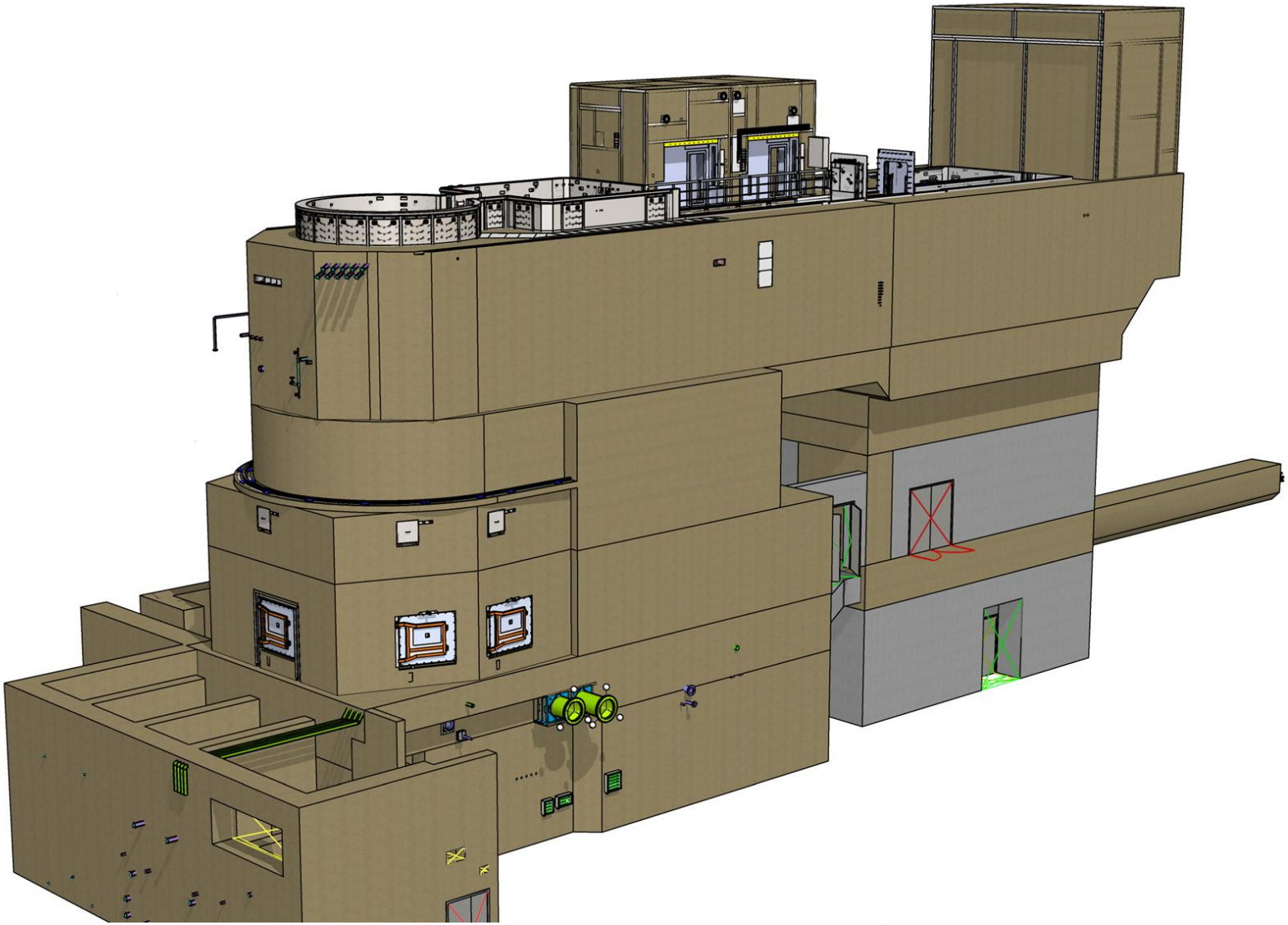
3D model- section view



3 D model- Plan view

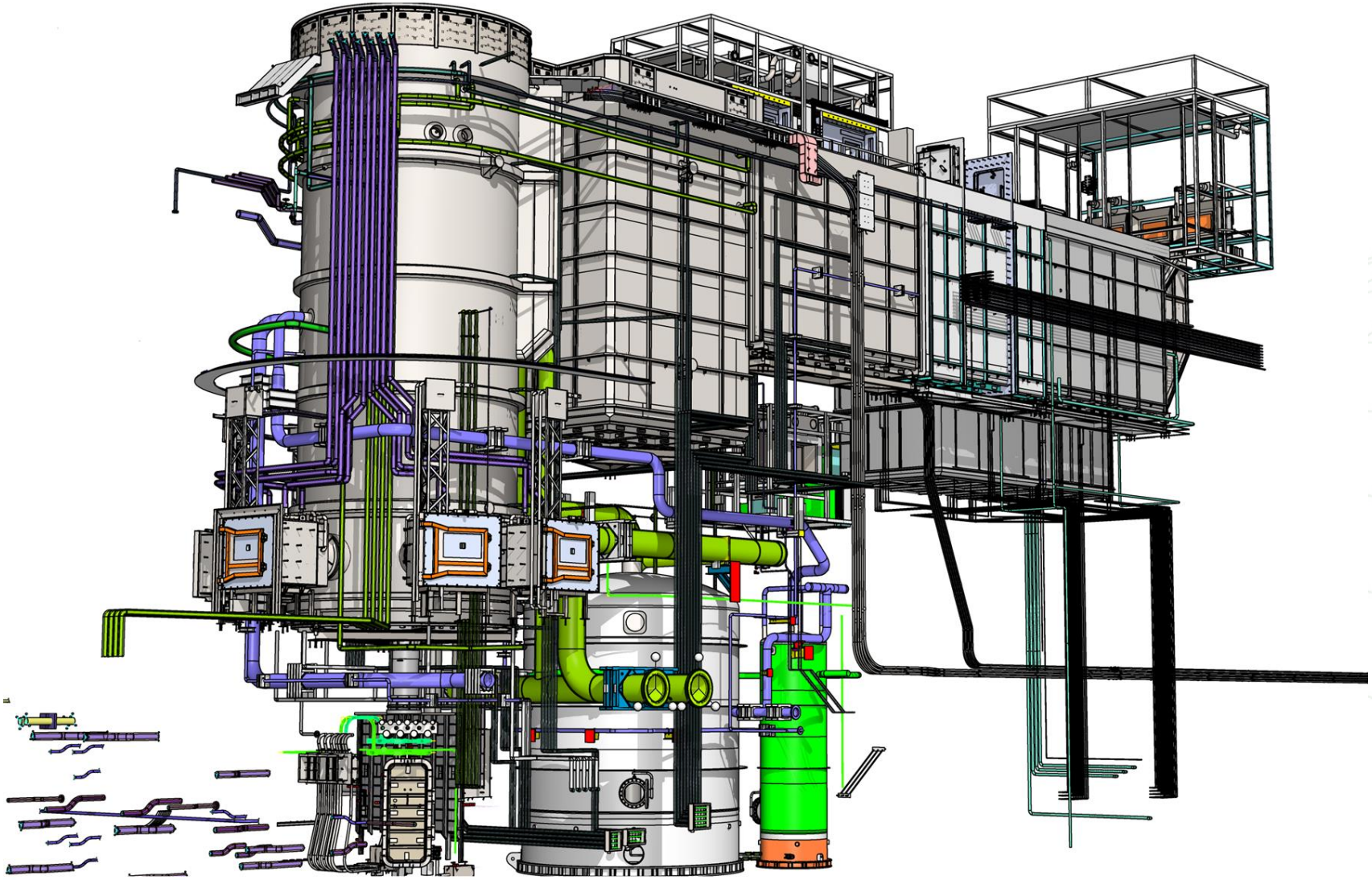


3D model- Reactor block- view



3D model- Reactor block- Section view

POOLS, HOT CELLS, DECAY TANKS



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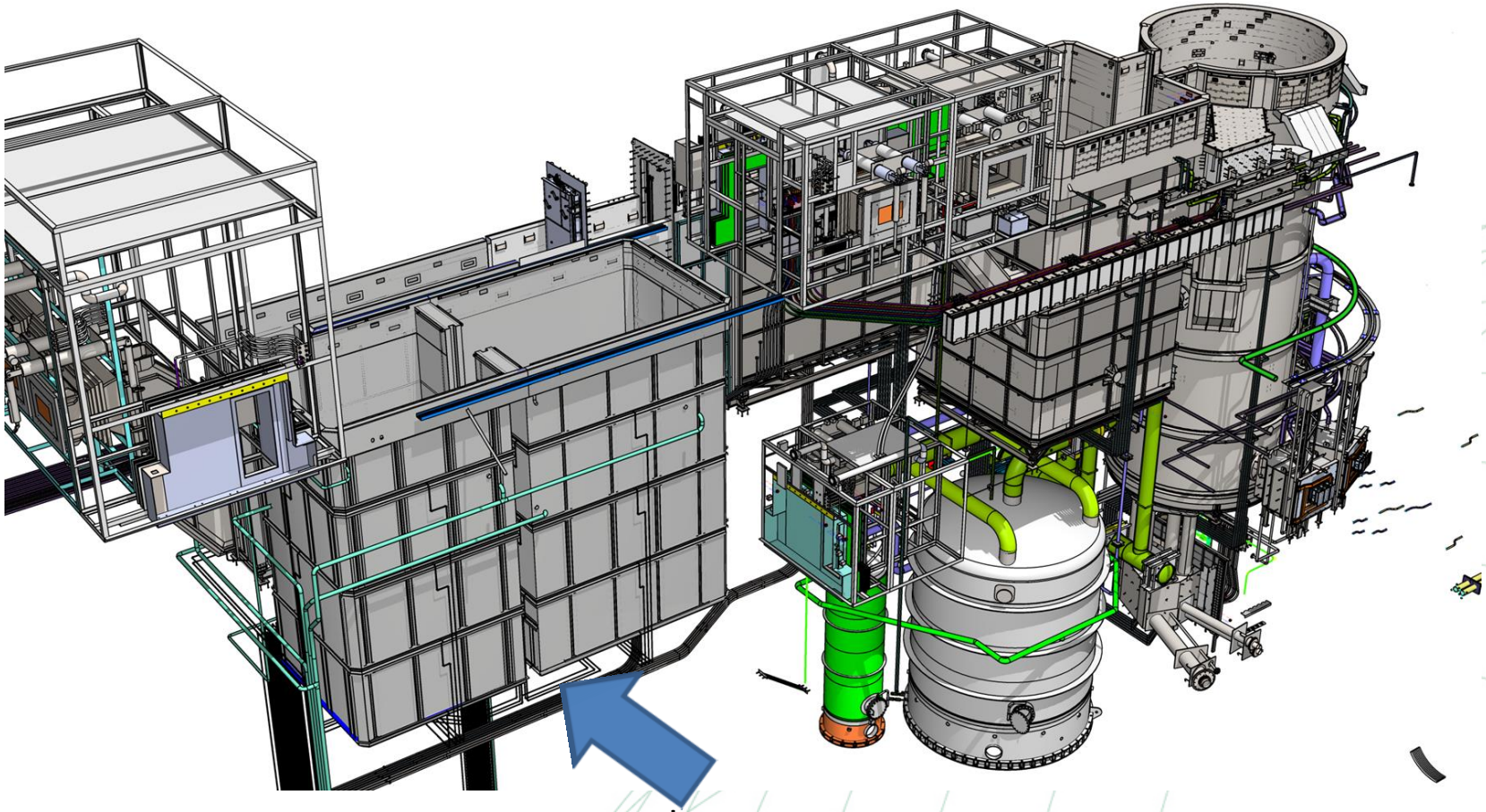
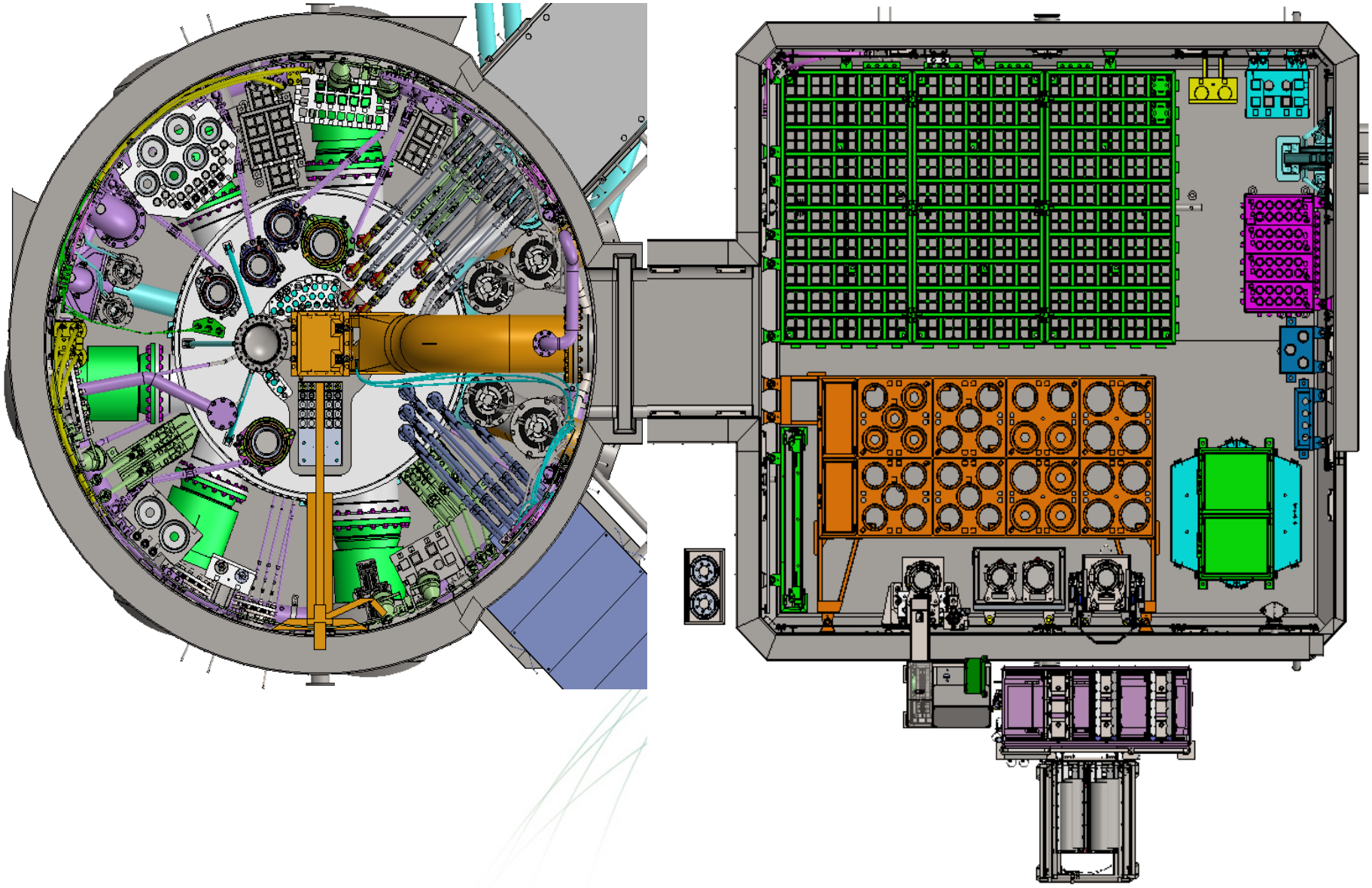
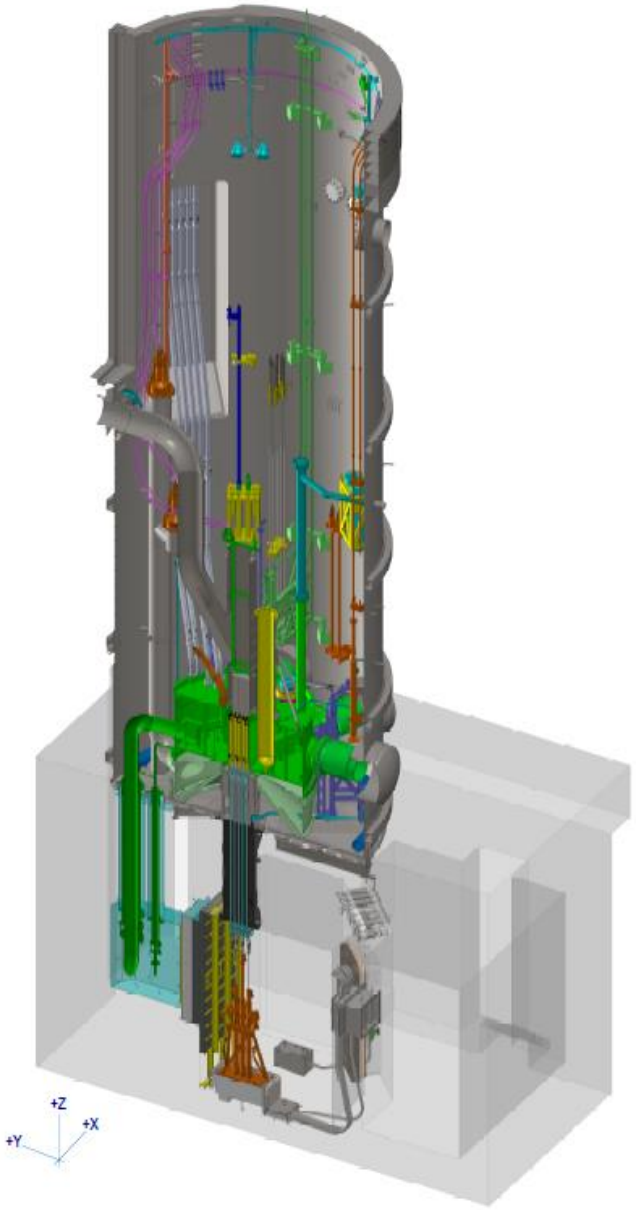


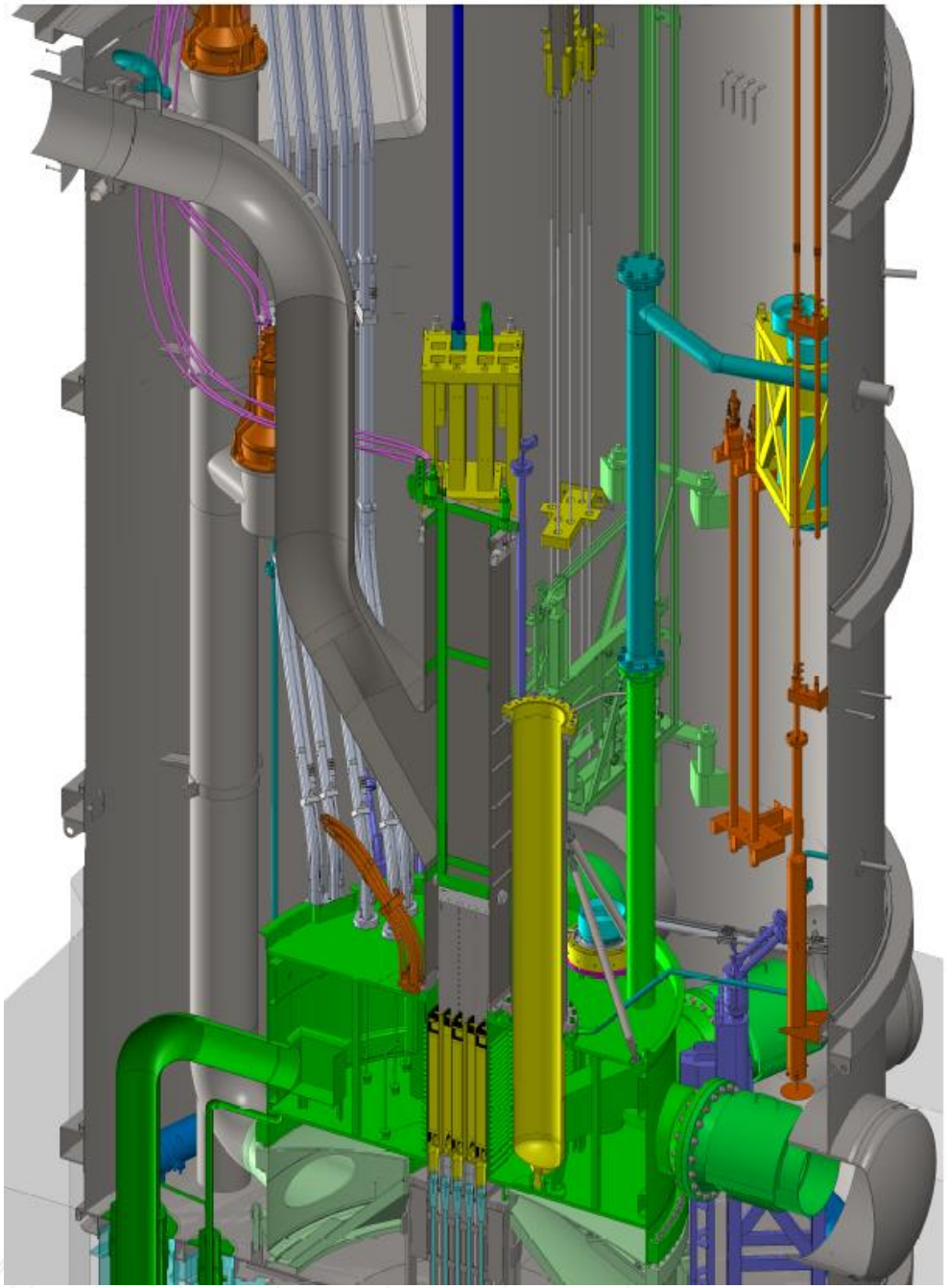
by AMAZUL

N01- POOLS PLAN VIEW

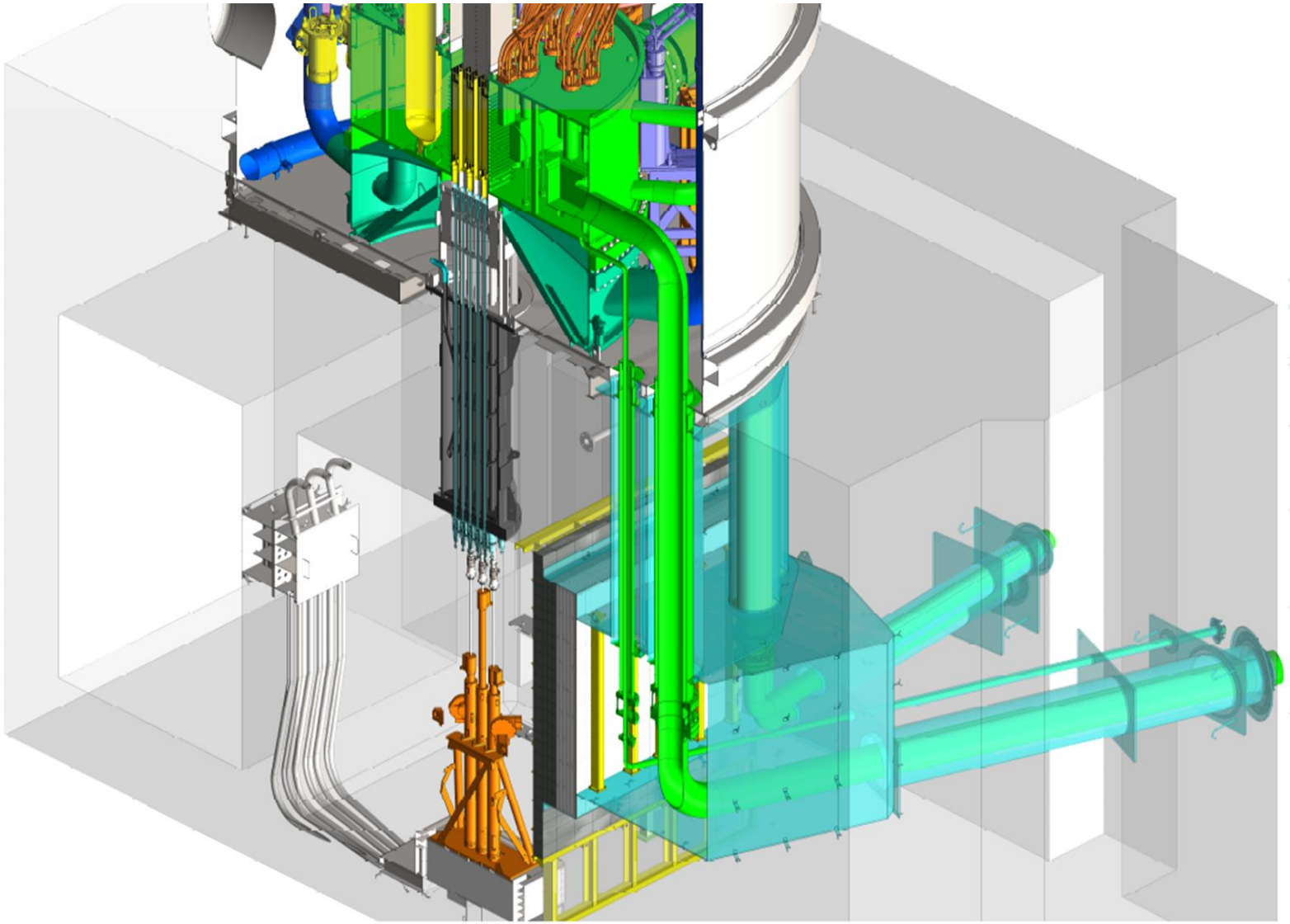


REACTOR POOL-SECTION





HEAVY WATER CIRCUIT-
CONTROL RODS MECHANISM



MAIN CONTROL ROOM

EMERGENCY CONTROL ROOM

Thank you.

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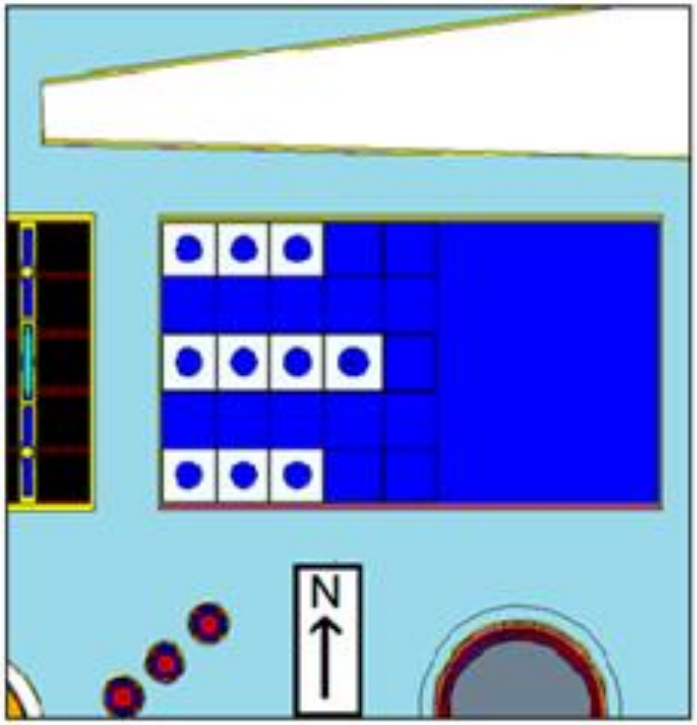
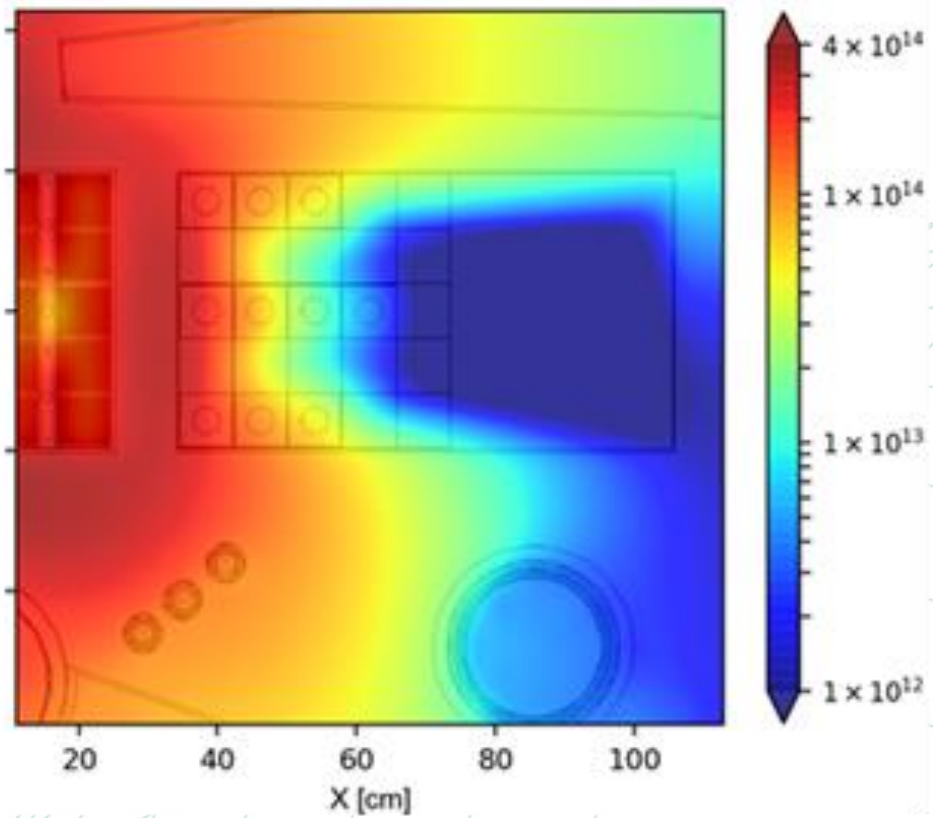
RMB

NUCLEONICS

Neutronic design- FIF





MCNP model

Thermal neutron flux [n cm-2 s-1]

RMB

SAFETY & LICENSING

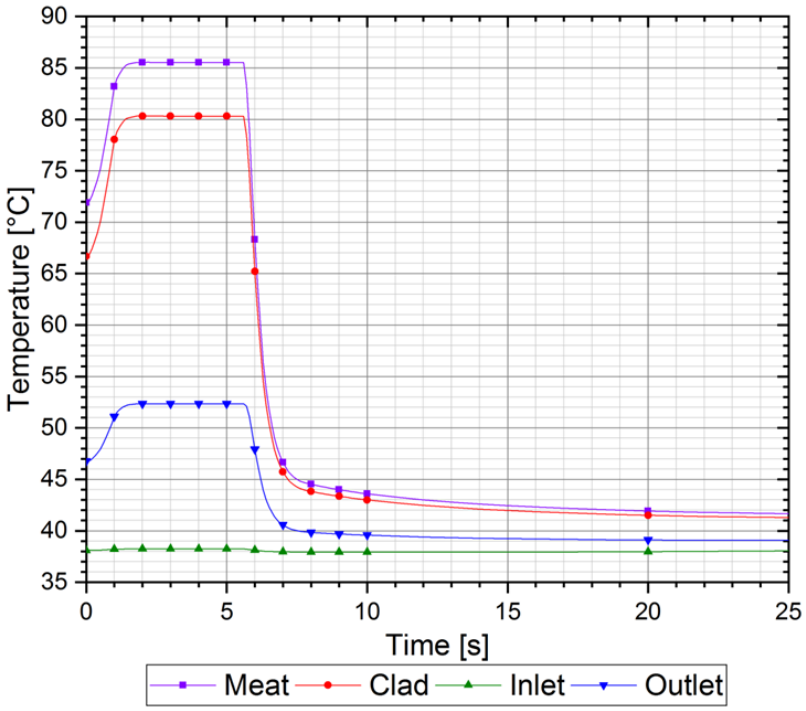
FSAR and Support to Licensing

- Chapter 02: Safety Objectives and Engineering Design Requirements
- Chapter 05: The Reactor
- Chapter 06: Research Reactor Cooling Systems and Connected Systems
- Chapter 07: Engineered Safety Features
- Chapter 08: Instrumentation and Control Systems
- Chapter 11: Reactor Utilization (partial)
- Chapter 12: Operational Radiological Safety (partial)
- Chapter 15: Commissioning
- Chapter 16: Safety Analysis
- Chapter 17: Operational Limits and Conditions (partial scope to INVAP responsibilities)
- Chapter 18: Management Systems (partial)
- Chapter 19: Decommissioning

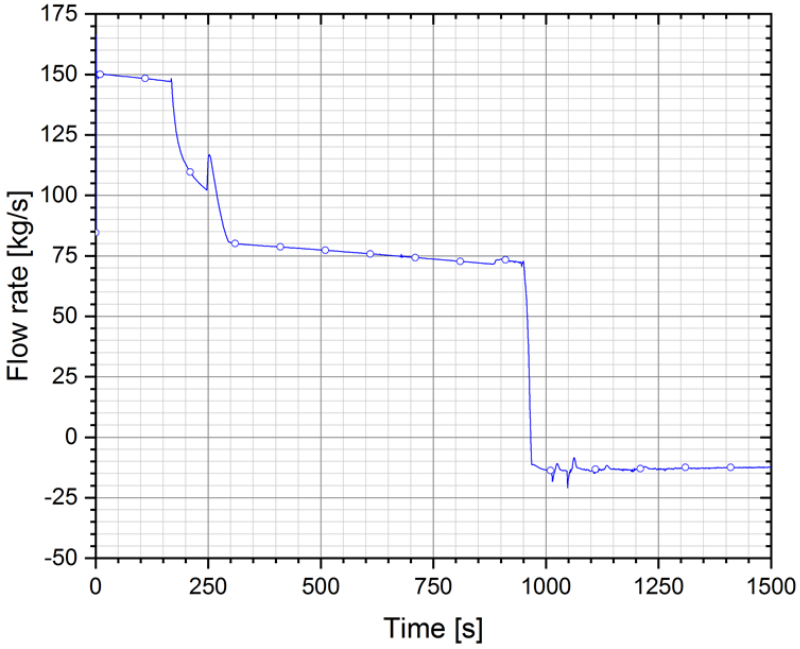
Chapter 16: Safety Analysis

- LOCA (Loss of Coolant Accident)
- LOFA (Loss of Flow Accident)
- LOHS (Loss of Heat Sink)
- LOEP (Loss of Electric Power Supply)
- RIA (Reactivity Insertion Accident)

Chapter 16: Safety Analysis



Average channel temperatures - LOCA (Pump Shaft Seizure)



Mass flow rate through riser's top - LOCA (Pump Shaft Seizure)