Recent Activities and Development of GIF-LFR-SSC

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on behalf of
GIF – LFR – pSSC

The 23rd International Conference on Nuclear Engineering (ICONE 23)
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SUMMARY

GIF-LFR REFERENCE SYSTEMS

STATUS OF MAIN ACTIVITIES of LFR-pSSC

New members of LFR pSSC

LFR STATUS - MoU Countries

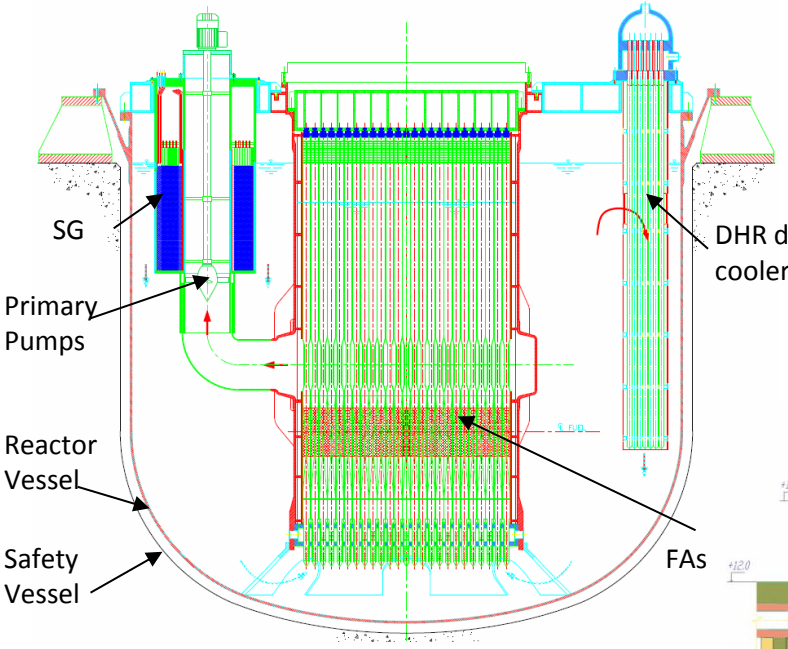
JAPAN
RUSSIAN FEDERATION
EURATOM

Three reference systems:

ELFR (600 MWe), BREST (300 MWe) and SSTAR (small size)

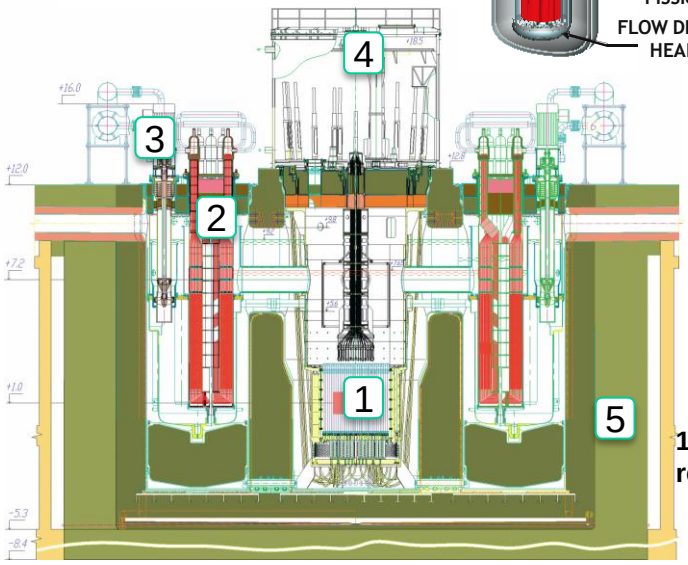
Members (MoU) of provisional System Steering Committee: EU, RUSSIA, JAPAN

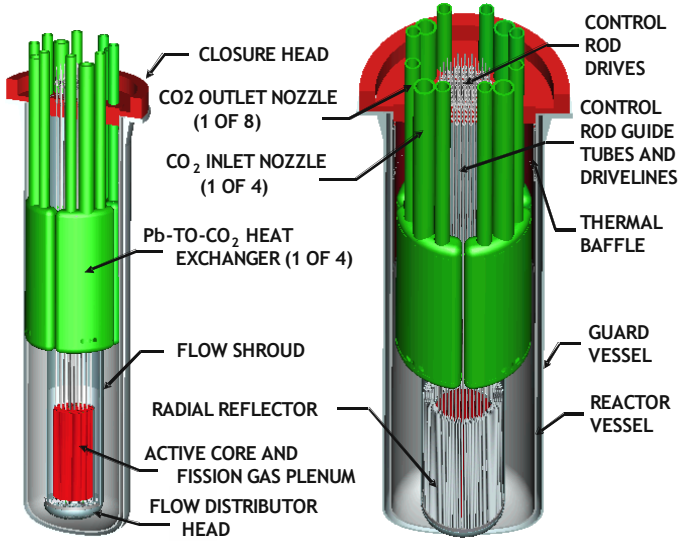
Observers of pSSC activities: US, Korea, China



ELFR

BREST





SSTAR

1 Core, 2 steam generator, 3 Pump, 4 refueling machine, 5 Reactor Vault

Status of the main activities: ***SRP, White Paper,SDC, ToR***

- **SYSTEM RESEARCH PLAN:**
  Substantial revision started mid 2012.
  Final SSC draft issued December 2014
  Report sent to Expert Group.
- **LFR White Paper on safety**: White paper based on ALFRED (used as an example of LFR design with application of ISAM) reviewed by EG and **completed** . **White Paper already published on GIF web-site by RSWG**
- **LFR – Safety Design Criteria**:
  LFR - SDC developed on the basis of SFR - SDC.
  Still working on that, first draft availability: summer 2015
- Draft for the **"Terms of reference for GIF system safety assessment"** prepared
  It will be discussed at the RSWG meeting in Petten on June 9-10 2015
- NEXT LFR-SSC meeting in Seoul (Korea) 24-26 May 2015

New members of LFR pSSC

- **RUSSIAN FEDERATION**

  Valery Smirnov (NIKIET) replaced by **Andrei Moissev** (NIKIET)

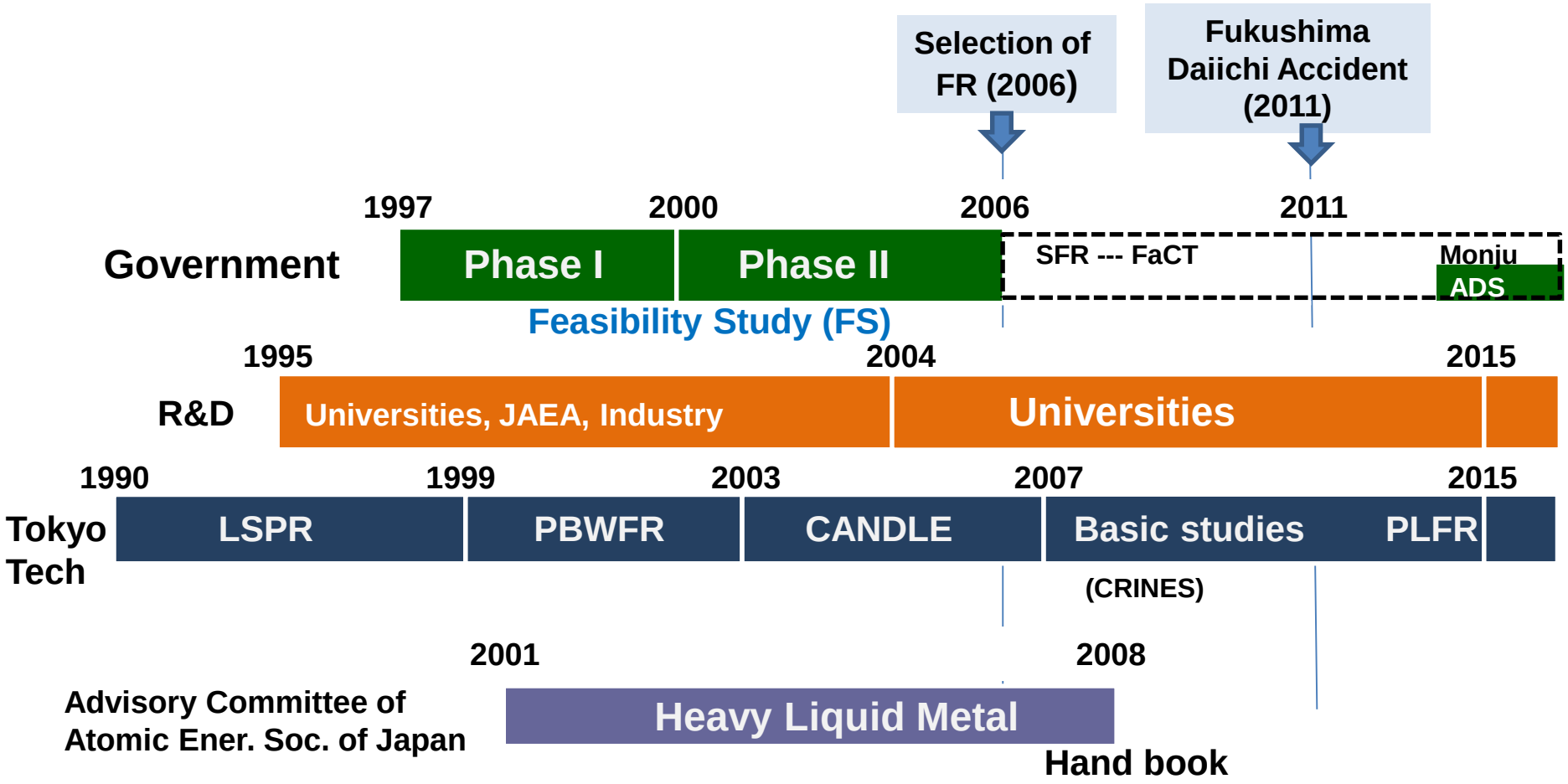
- **EURATOM**

  Didier Haas (JRC) replaced by **Kamil Tuček** (JRC)

The LFR-pSSC participants expressed their gratitude for the work performed by Valery and Didier and the friendly relationship established.

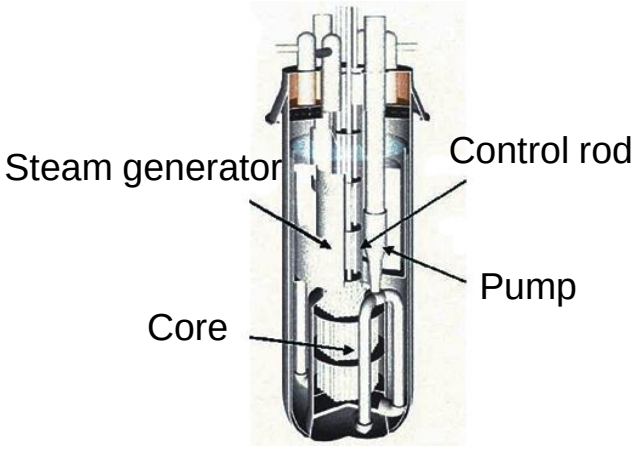
A warm welcome in the group to Andrei and Kamil

JAPAN



CRINES: Center for Res. into Innovative Nucl. System
FS: Feasibility Study on Commer. FR Cycle Sys.
FaCT: FR Cycle System Tech. Dev. Project
LSPR, PBWFR, PLFR: LFR concepts
CANDLE: Type of burning

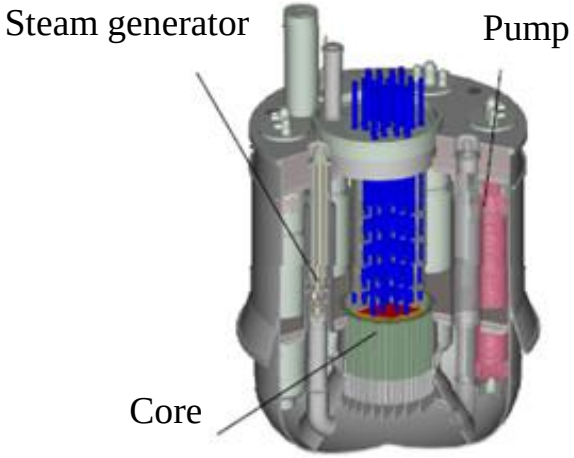
Concepts of LFR



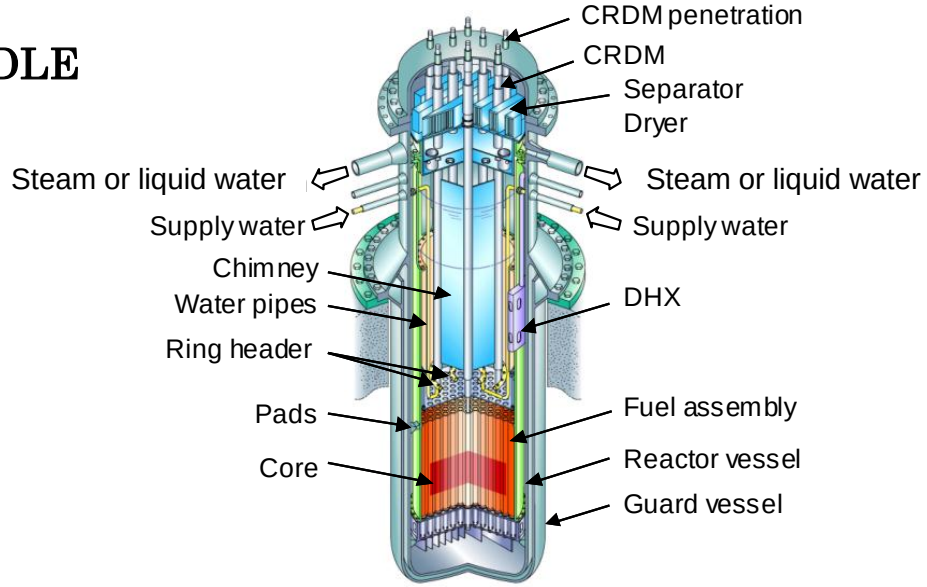
Long Life Core / Simple / Portable / CANDLE
(LSPR, 50MWe, Tokyo Tech)

Innovativeness

- Portable
- Long life core/ CANDLE burning
- Direct contact of LBE and water



Medium Size (750MWe, JNC/JAPC)



Direct Contact / Long Life Core
(PBWFR / PLFR, 150MWe, Tokyo Tech)

Investigations at Tokyo Tech

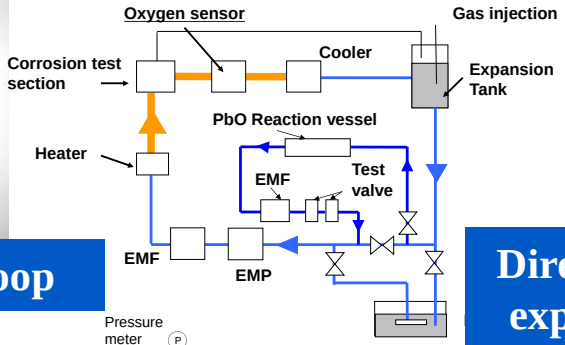
Although in Japan activities on LFR are limited, some basic studies have been carried out at Tokyo Institute of Technology.

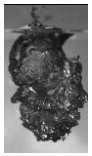
- **Designs**:
  - Nuclear design: Low void reactivity, Long life core, CANDLE burn (High burnup without recycling)
  - Thermal-hydraulic and structural design
  - Plant design
  - Safety analysis (UTOP, ULOF, ULOHS)
- **Thermal-hydraulic tests**: LBE natural circulation, Water-LBE direct contact (Violent boiling, Two-phase flow, Water leak from SG), LBE mist flow and electro-static precipitation, Magneto-hydrodynamic and supersonic flow meters
- **Material tests**: Corrosion-resistant material (Al/Si-added steels, AlFe-alloy-coated steels, ceramics, refractory metals), Effect of stresses, cold-works and welding on steel corrosion, Erosion phenomena
- **Po test**: Po removability, Filtration
- **Oxygen control tests**: Oxygen sensor, Oxygen control with gas and PbO
- **LBE property test**: Diffusivity of impurities, etc.
- **Analytical studies**: Core calculation, Thermal-hydraulics, MD simulation

Experimental facility and Analysis at Tokyo Tech

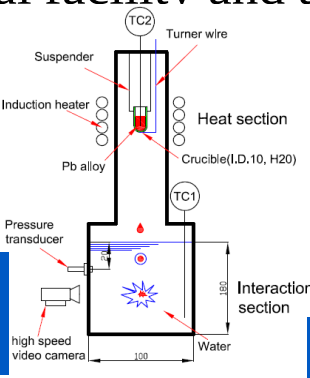
Activities also carried out using the experimental facilitv and analytical tools.

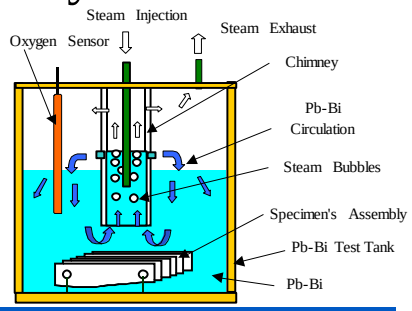
Corrosion test loop



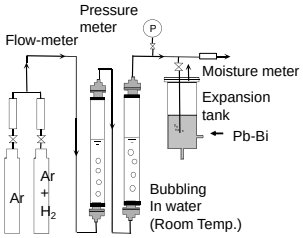


Direct- contact explosion test

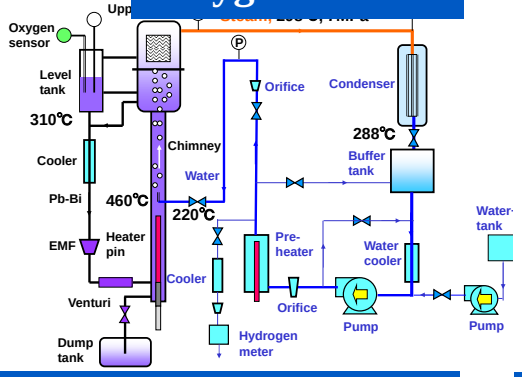




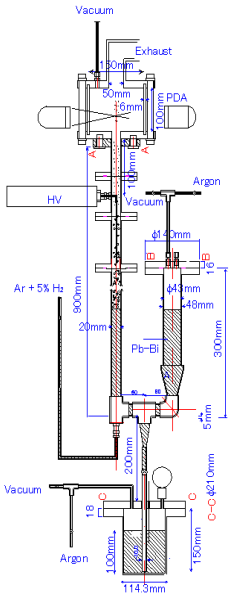
Corrosion and oxygen control test



Oxygen control

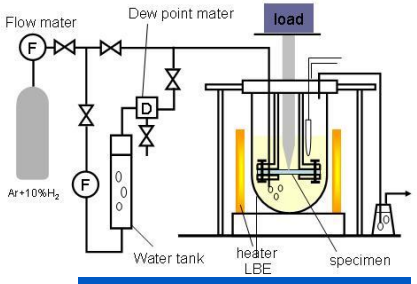


Direct-contact boiling flow loop

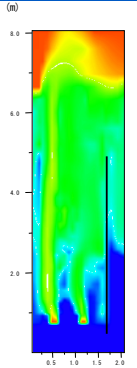


LBE mist test

Surface coating

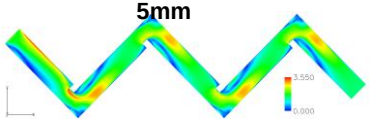


Stress and corrosintest



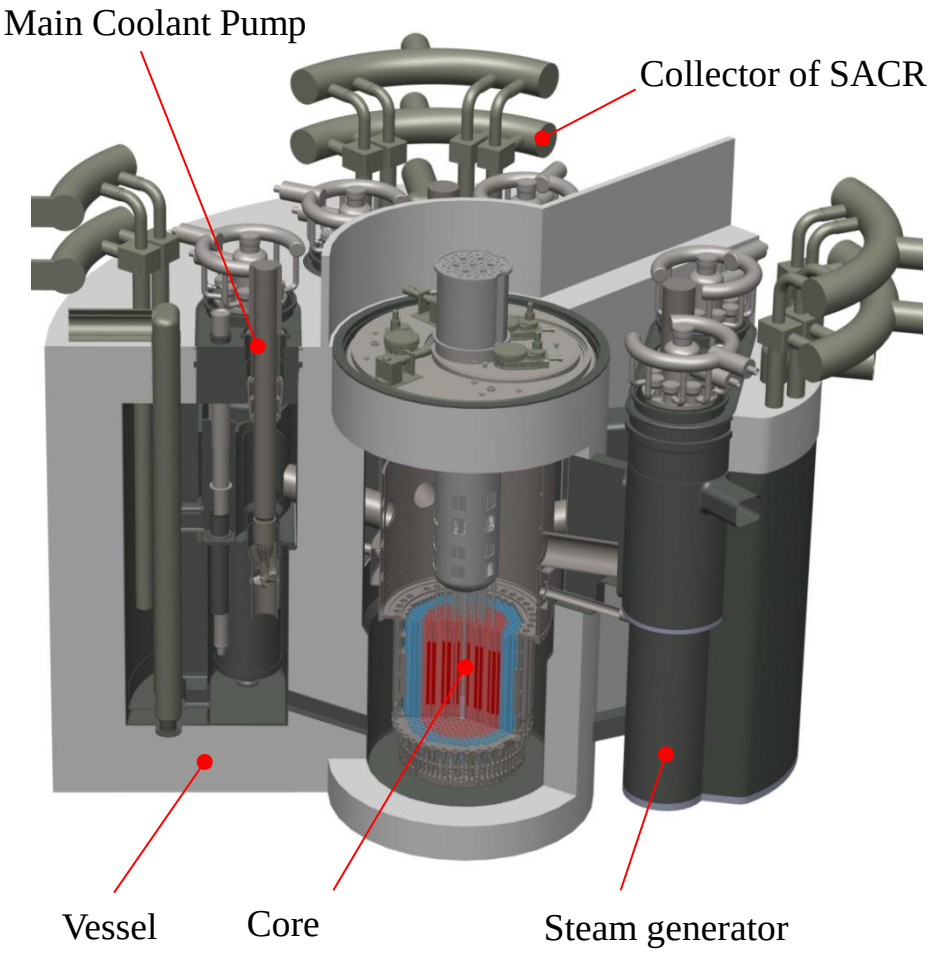
Void fraction in chimney

Chevron dryer



Two-phase and mist flow analysis

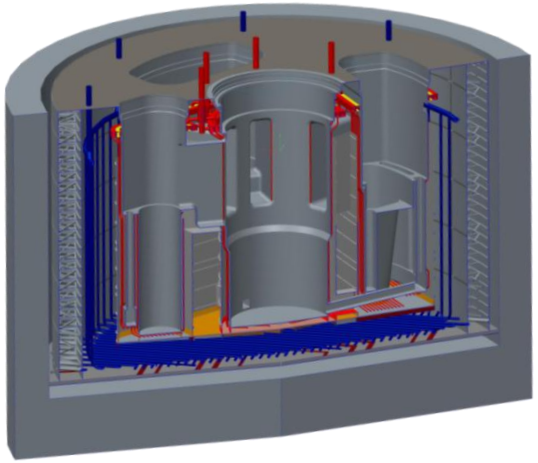
BREST-OD-300: key components and technical characteristics



Thermal power, MW	700
Electric power, MW	300
Steam production rate, no less than, t/hour	1480
Coolant of the first contour	Lead
Gas pressure above the lead level: - exceed, MPa - maximal, MPa	 0,003-0,008 0,02
Average temperature of the lead coolant on the active zone entry/ exit, °C	420/540
Average temperature of the water coolant on the steam generator entry/ exit, °C	340/505
Loop number	4
FA number in the active zone	169
Core height, mm	1100
Fuel load, t	20,6
Fuel campaign, years	5
Burn-up of unloaded fuel (maximum/ average), % HM.	9,0/5,5

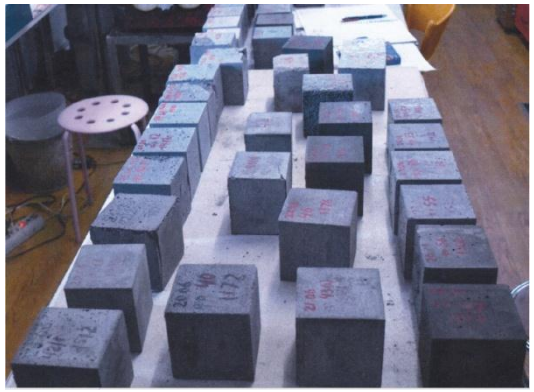
Computational and experimental substantiation of reactor vessel

The vessel



The vessel bottom mockup

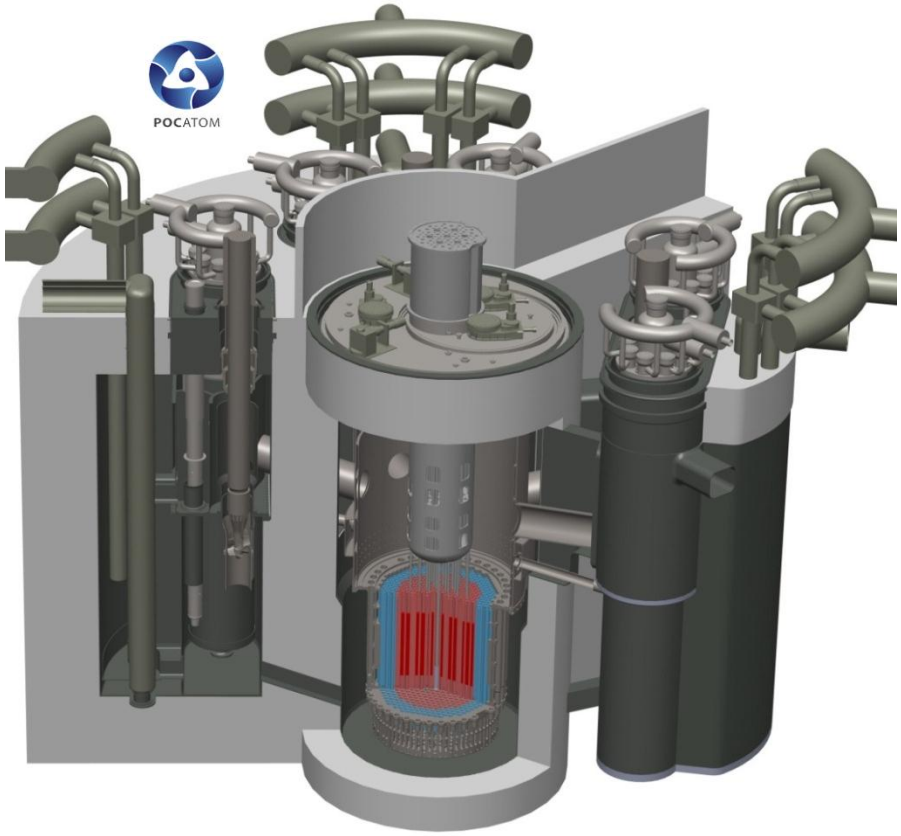
The concrete species



Results: Carried out tests on short-term mechanical properties of the concrete, developed methods of basic strength and thermal computations, mounted a mockup of the vessel bottom, determined recommendations on the drying modes

Coming results: Mechanical (including after irradiation) and thermophysical properties of the selected concrete compounds, determination of thermal conductivity coefficients in the concrete filler, experimental determination of temperature profile for verification of computational methods, development of mounting, filling and drying technologies for the reactor vessel

RUSSIAN FEDERATION



BREST - OD - 300 SCHEDULE:

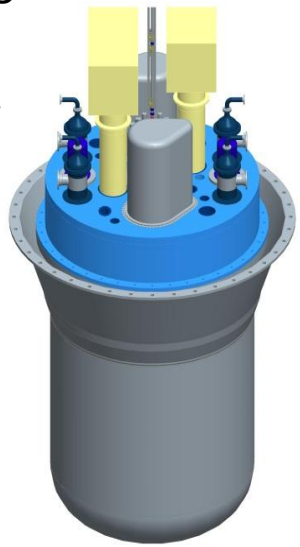
Design finalization	**2014**
License approval	**2015**
Start construction	**2016**
Commissioning	**2020-2022**

THE MYRRHA - FEED CONTRACT - FROM OCTOBER 7, 2013

FEED – Front End Engineering and Design

Consortium: *Areva TA (leader) – France, Ansaldo Nucleare S.p.A. – Italy, Empresario Agrupados – Spain, Grontmji Industries - Belgium.*

Contents: *technical design of the infrastructure except for: Primary System, Accelerator, Spent Fuel Building, Remote Handling*



EXAMPLES OF SYSTEMS INCLUDED IN FEED:

SCS, RVACS, Cover Gas, LBE conditioning , Pressure Relief etc.

Safety, integration and lay-out included in the FEED scope

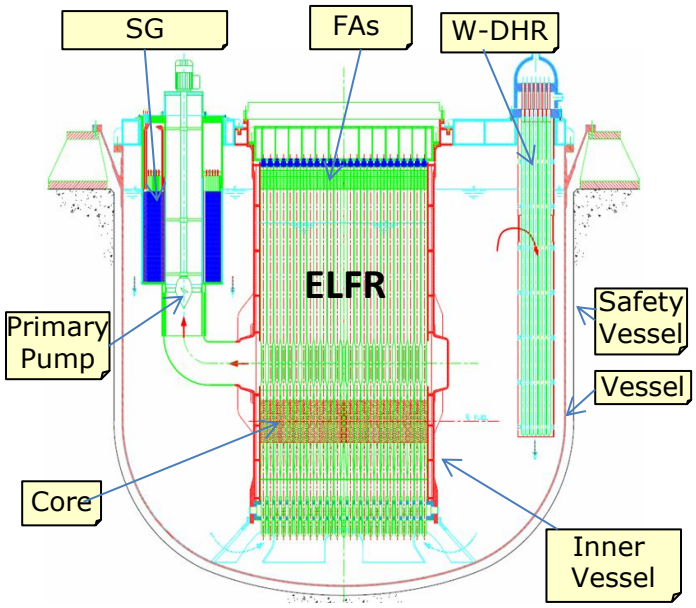
MYRRHA 2015 activities:

- ***Design review of MYRRHA primary side (first half of 2015 by SCK)***
- ***Investigation on introduction of IHX double tube (minimize SGTR)***
- ***Second phase of FEED expected to start September 2015***

Status of activities in Europe

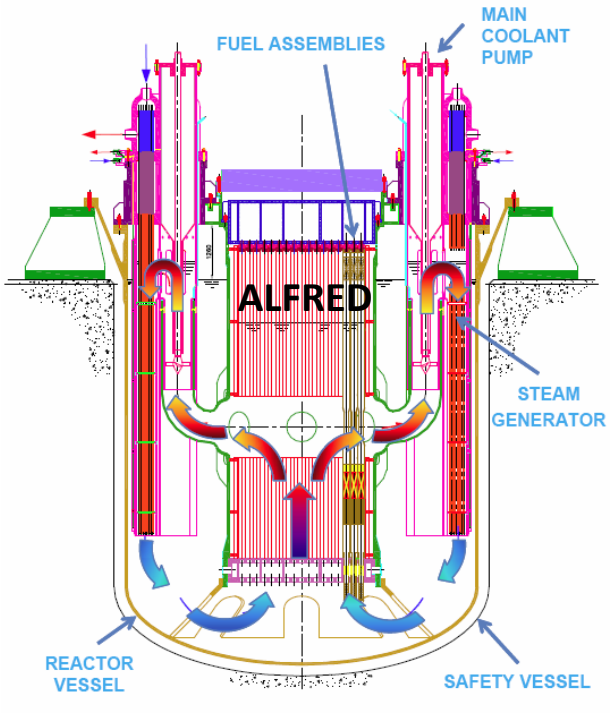
EURATOM FP7 LEADER Project (April 2010 – September 2013) generated ELFR and ALFRED Conceptual designs: **ELFR as the reference Industrial plant - ALFRED as LFR Demonstrator**

ELFR is one of the reference Systems of GIF-LFR activities



Power: ***1500 MWth (630 MWe)***
Primary cycle : ***400-480 °C***
Secondary cycle ***335-450 °C 18MPa***

ALFRED CONSORTIUM signed in December 2013 ACTIVITIES MAINLY ON ALFRED



Power: ***300 MWth (125 MWe)***

EURATOM - ALFRED and FALCON

Consortium (FALCON) signed on December 18th 2013 by:
Ansaldo Nucleare, ENEA and RATEN-ICN
Reference site for construction is in Mioveni (Romania).

EU Organizations are invited to join FALCON through a technical cooperation agreement (MoA).
For the MoA the interested organization can:
Contact one of the FALCON members
Agree on a technical activities program
Sign the MoA with the FALCON member
All contributions are expected to be of an in-kind nature.
The aim is to constitute a network of organizations interested in the LFR technology development and, as a closer goal, committed to ALFRED construction.

MoA STATUS:
CRS4 (Sardinia - Italy) MOA SIGNED
NRG (Petten, The Netherlands) MoA final text agreed
SRS (Rome, Italy) - MOA SIGNED
IIT (Milan, Italy) - activity Agreed – under signature
KIT (Karlsruhe, Germany - MOA SIGNED
CIRTEN (Consortium of Universities, Italy) – MOA SIGNED
GRS (TSO, Germany) – contacts on going
SYMLOG (France) - MOA SIGNED

FALCON NEW MEMBER:

CV-REZ joined FALCON Dec. 2014 and is now a full member of the consortium

LEADER – BREST Cooperation Agreement

On May 2014 a Cooperation Agreement (CooA) has been signed between Ansaldo Nucleare, coordinator of LEADER project, and OJSC NIKIET, coordinator of BREST project.

The CooA is based on the exchange of information between the two projects on 7 basic topics:

COORDINATION AGREEMENT for BILATERAL COORDINATED PARALLEL PROJECTS COLLABORATION on EURATOM/ ROSATOM *"DEVELOPMENT OF FAST REACTORS COOLED BY LEAD"*	СОГЛАШЕНИЕ О КООРДИНАЦИИ ДВУСТОРОННЕГО СОТРУДНИЧЕСТВА ЕВРАТОМ/ РОСАТОМ ПО СКООРДИНИРОВАННЫМ ПАРАЛЛЕЛЬНЫМ ПРОЕКТАМ по теме *«РАЗРАБОТКА БЫСТРОГО РЕАКТОРА, ОХЛАЖДАЕМОГО СВИНЦОМ»*

Topic 1. **<u>Conceptual design</u> of lead cooled fast reactors at various power sizes and purposes**
Topic 2. **Approaches and methods of ensuring nuclear safety**
Topic 3. **Computational and exp. studies of neutron and physical characteristics of the LFR**
Topic 4. **Computer and exp. study of thermal and hydraulic characteristics of elements of the active core, steam generator and circulating flow pattern in the whole reactor**
Topic 5. **Investigation on available materials compatible with lead coolant and possible approaches for corrosion control/reduction**
Topic 6: **long term behavior of NFC highlighting advantages and environmental impacts**
Topic 7: **<u>Education and training:</u> Provide a framework to grow the skills of the young generation of engineers and scientist on lead cooled fast reactor technology as well as scientific aspects.**

The CooA consist of a number of meetings dedicated to information exchange among experts.
A support action for the European partners has been presented to the last H2020 call on Sept. 2014.
Some formal steps needs yet to be finalized: **First meeting expected in September 2015.**

Thank you for your attention

16th LFR SSC Meeting Hefei – China December 10-12 2014