Seminarium Zakładu Energetyki Jądrowej i Analiz Środowiskowych

# Demonstrator ALLEGRO – koncepcja, portfel projektów, roadmapa

Anna Przybyszewska

**Materiały wykorzystane w niniejszym dokumencie pochodzą z prezentacji dotyczących projektu demonstratora ALLEGRO, autorstwa**:

- **A.Vasile (CEA)**
- **B. Hatala, R. Zajac. P. Derilek (VUJE)**
- **L. Belovsky (UJV)**
- **A. Horvath, J. Gado (MTA EK)**

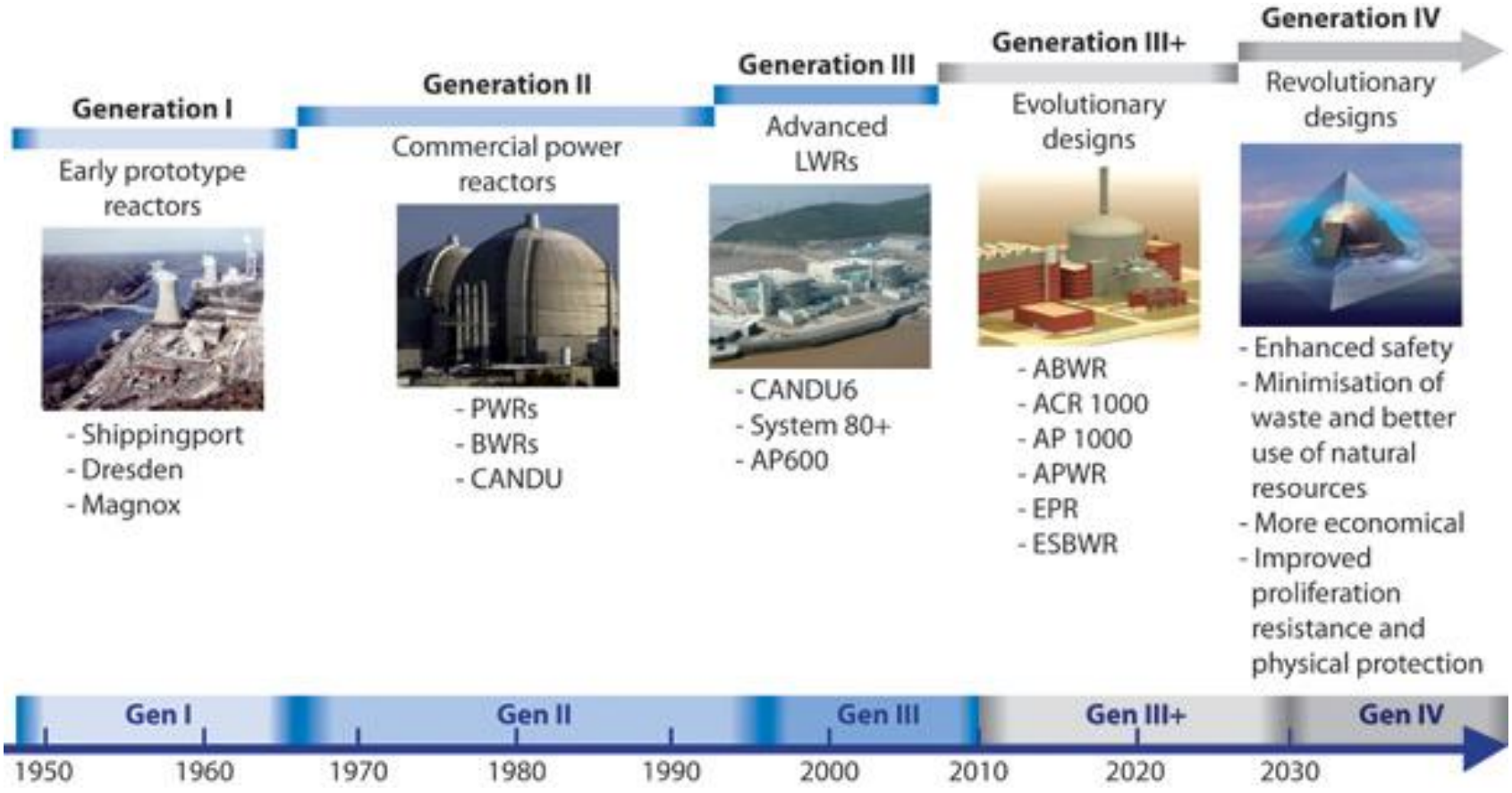
**Slajdy dotyczące projektu VINCO oraz V4G4 przygotował Ł. Kurpaska (NCBJ).**

# Plan Prezentacji

1. Koncepcja reaktora ALLEGRO
2. Portfel projektów ALLEGRO
3. Roadmapa ALLEGRO

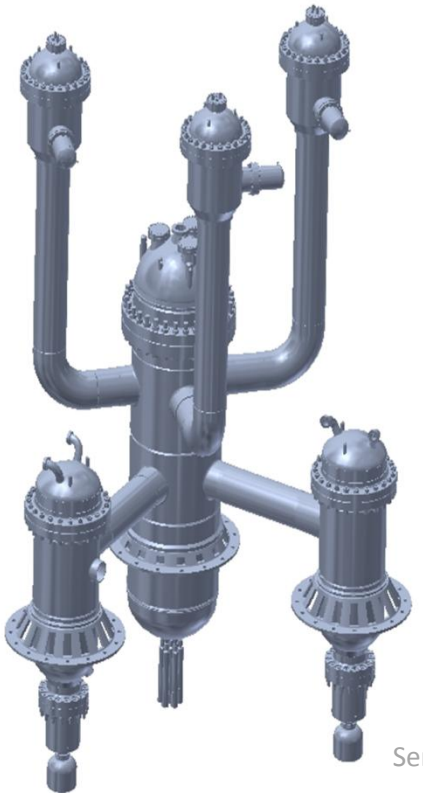
# 1. Koncepcja reaktora demonstracyjnego ALLEGRO

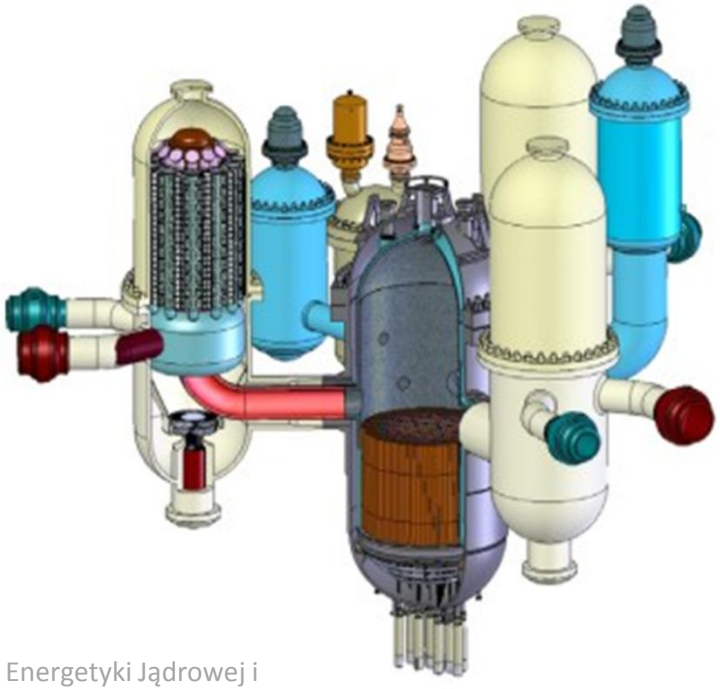
# Evolution of Nuclear Energy Systems



# Development of Gas Cooled Fast Reactor Technology

**ALLEGRO** → **GFR 2400**



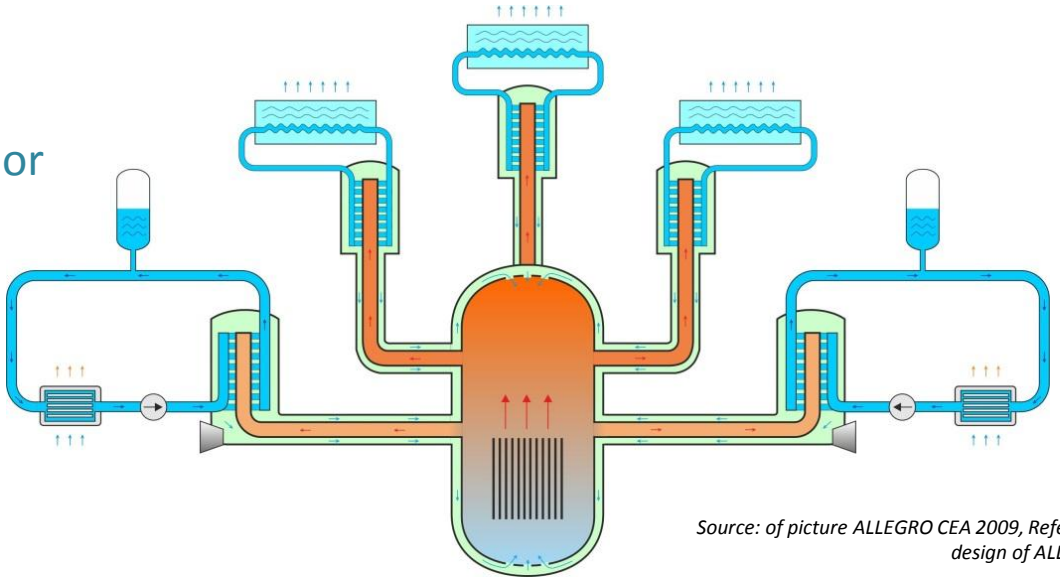


# ALLEGRO

**Proving the concept GFR Gen-IV:**

- demonstration of the high-temperature helium technology;
- demonstration ability of reactor to conversion of fuel and transmutation of actinides;
- demonstration of heat production for industrial end-users.

Reference design:
- power: 50-75 MWt,
- single or double primary loop (He or He-N),
- secondary steam-water circuit



*Source: of picture ALLEGRO CEA 2009, Reference design of ALLEGRO*

# History of ALLEGRO concepts (2002-2015)

| ETDR CEA 2007 50 MWt | | ALLEGRO CEA 2009 75 MWt | | ALLEGRO CEA 2010 75 MWt | | ALLEGRO V4G4 <75 MWt | |
|---|---|---|---|---|---|---|---|
| I. circuit | II. circuit | I. | II. | I. | II. | I. | II. |
| He | water | He | water | He | He | He | N2-He (?) |
| 260/ 560 °C | 130/ 197 °C | 260/ 530 °C | 127/ 197 °C | 260/ 530 °C | 135/ 466 °C | 260/ ~530 °C | ? |
| 480/ 850 °C | 130/ 197 °C | 400/ 800 °C | 127/ 197 °C | ? | ? | 400/~800 °C | ? |

- ETDR CEA 2008 (FP6 GCFR STREP)
- ALLEGRO CEA 2009 (FP7 GoFastR)
- ALLEGRO CEA 2010 (Patented innovative option)

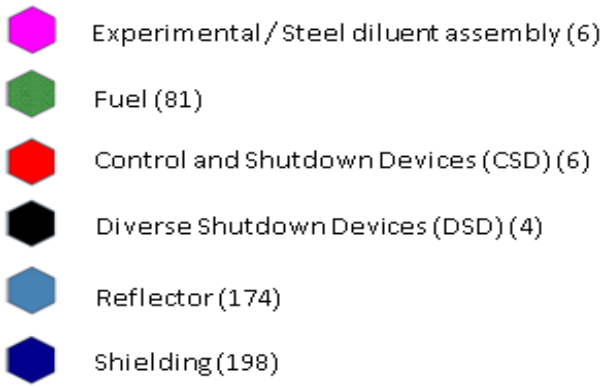
} **CEA + EURATOM**

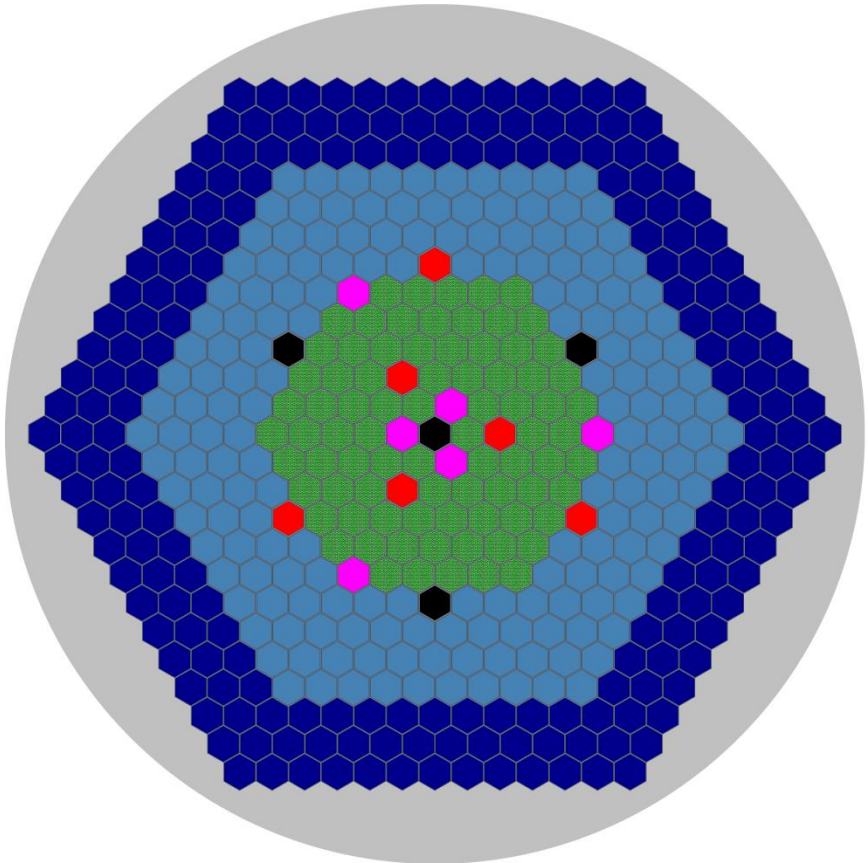
- ALLEGRO V4G4 20xx (…)

# Main characteristic of the ALLEGRO core

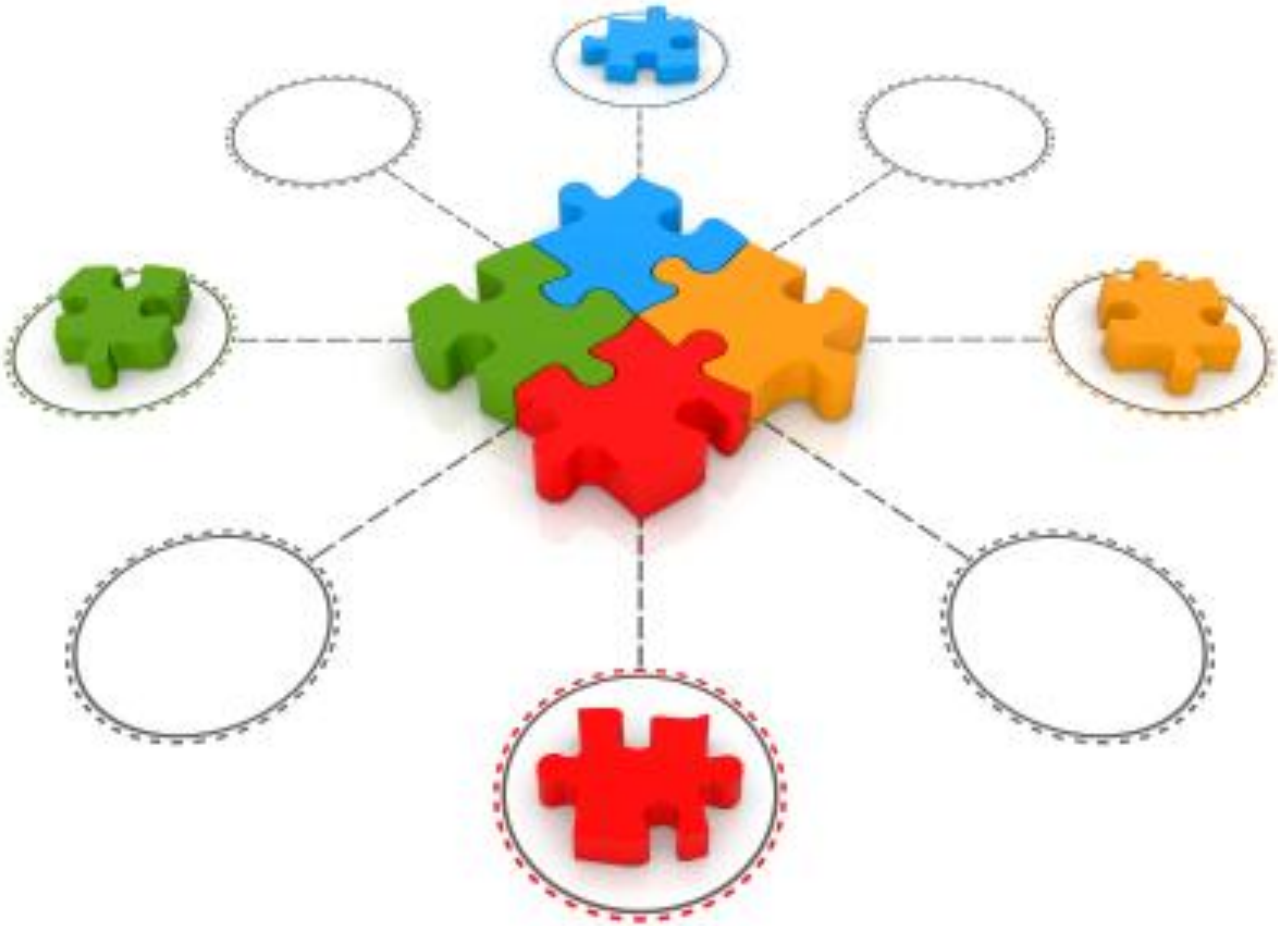
The reactor shall be operated with two different cores: The starting MOX core will serve to test the operation of the gas cooled fast reactor with well established fuel.
The second core using the ceramic fuel will serve for testing the new fuel design.

| | MOX Core | Ceramic Core |
|---|---|---|
| Core power | 75 MWth | |
| Coolant pressure | 7 MPa | |
| Primary mass flow rate | 53 kg/s | 36 kg/s |
| Core inlet temperature | 260 °C | 400 °C |
| Core outlet temperature | **560 °C** | **850 °C** |



# 2. Portfel projektów ALLEGRO



# EURATOM Projects

**FP5 GCFR (2000-2002) – EC contribution 0.25 M€**

•Review of experience in gas reactors, formulation of future R&D

**FP6 GCFR-STREP (2005-2009) – EC 2 M€**

•600 MWt case (plate fuel & direct He Brayton cycle) abandoned after first year

•Continued were GFR2400 (direct, indirect) & its demonstrator (ETDR, ALLEGRO)

**FP7 ADRIANA (2010-2011) – CSA, EC 0.99 M€**

•Mapping of existing & required experimental infrastructure for SFR, LFR & GFR research

**FP7 GoFastR (2010-2013) – CP-FP, EC 3 M€**

•Design & Safety of GFR2400 and its demonstrator ALLEGRO

**FP7 ALLIANCE (2012-2015) – CSA, EC 0.86 M€**

•Support of the ALLEGRO Preparatory phase

**FP7 ESNIIplus (2013-2017) – CP&CSA, EC 6.45 M€ (GFR only partially)**

•Preparing ESNII for HORIZON 2020

# National projects on GFR/ALLEGRO related projects

## CEA: Till 2009-10 (or 2013 respectively)

## Czech Republic (V4G4): ÚJV & CV Řež

Technology Agency of the Czech Republic (TACR): ~2.37 MEUR (2012-2019): Helium technologies, Code validation, Safety analyses

## Slovak republic (V4G4): VUJE (Trnava)

Structural funds through national Operational programs: Approved ~2.9 MEUR (2015): Support of the ALLEGRO project

## Hungary (V4G4): MTAEK (Budapest)

Government funding: Expected ~2.5 MEUR (2016-19): Support of the ALLEGRO project

# ALLEGRO Related EU Projects

**ESNII Plus**

9/2013 – 8/2017

Coordinator: CEA (A. Vasile – C. Wahide)

Activity on ALLEGRO: Core optimization

**ALLIANCE**

10/2012 – 9/2015

Coordinator: MTA EK (A. Horvath), CEA contributes (C. Wahide – A. Vasile)

Activity on ALLEGRO: R&D Roadmap

**VINCO**

9/2015 – 9/2018

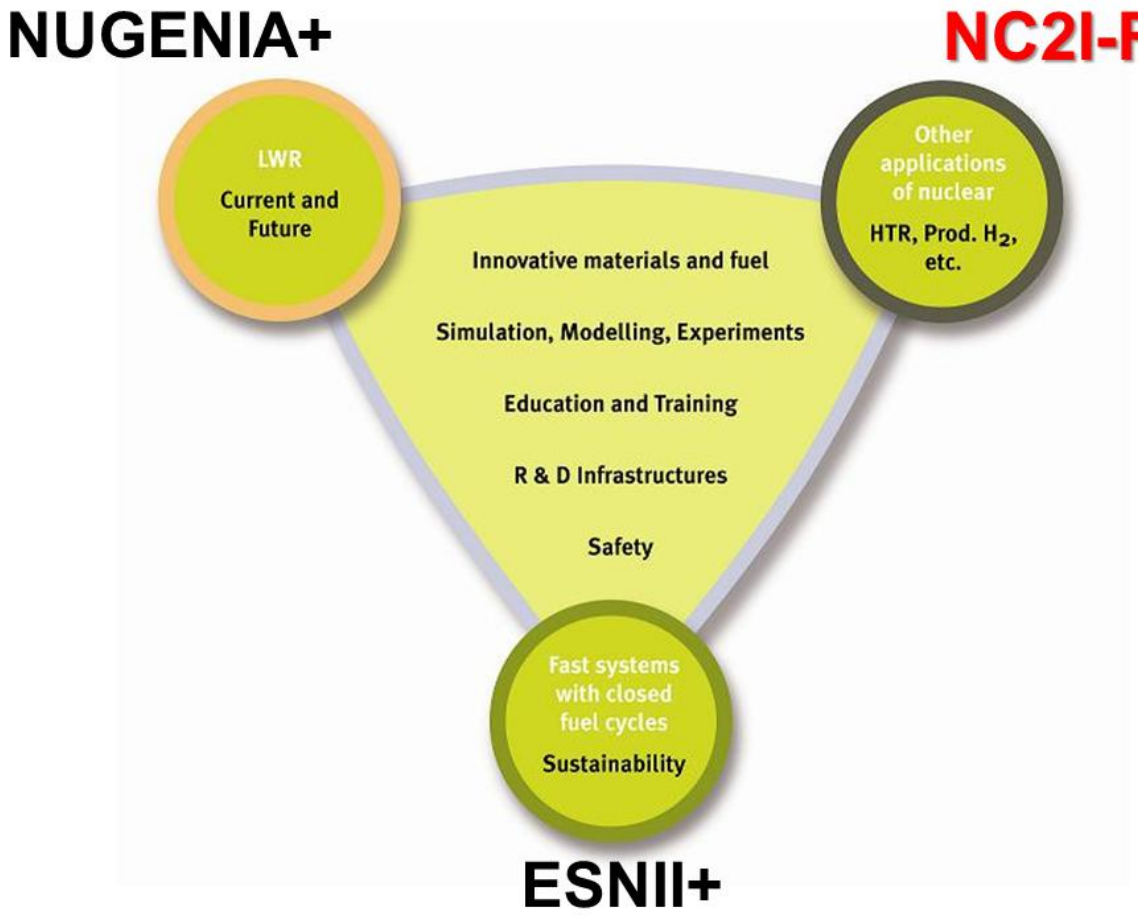
Coordinator NCBJ (J. Jagielski), CEA contributes (C. Wahide – A. Vasile)

Activity on ALLEGRO:

- Use of Structural funds to finance R&D
- -Benchmarking on core and reactor systemCoordination with other EU projects and international forums (GIF, IAEA)
- Education & Training and Communication

# Three pillars of the SNETP vision

**SNETP = Sustainable Nuclear Energy Technology Platform**



ESNII
European Sustainable Nuclear Industry Initiative

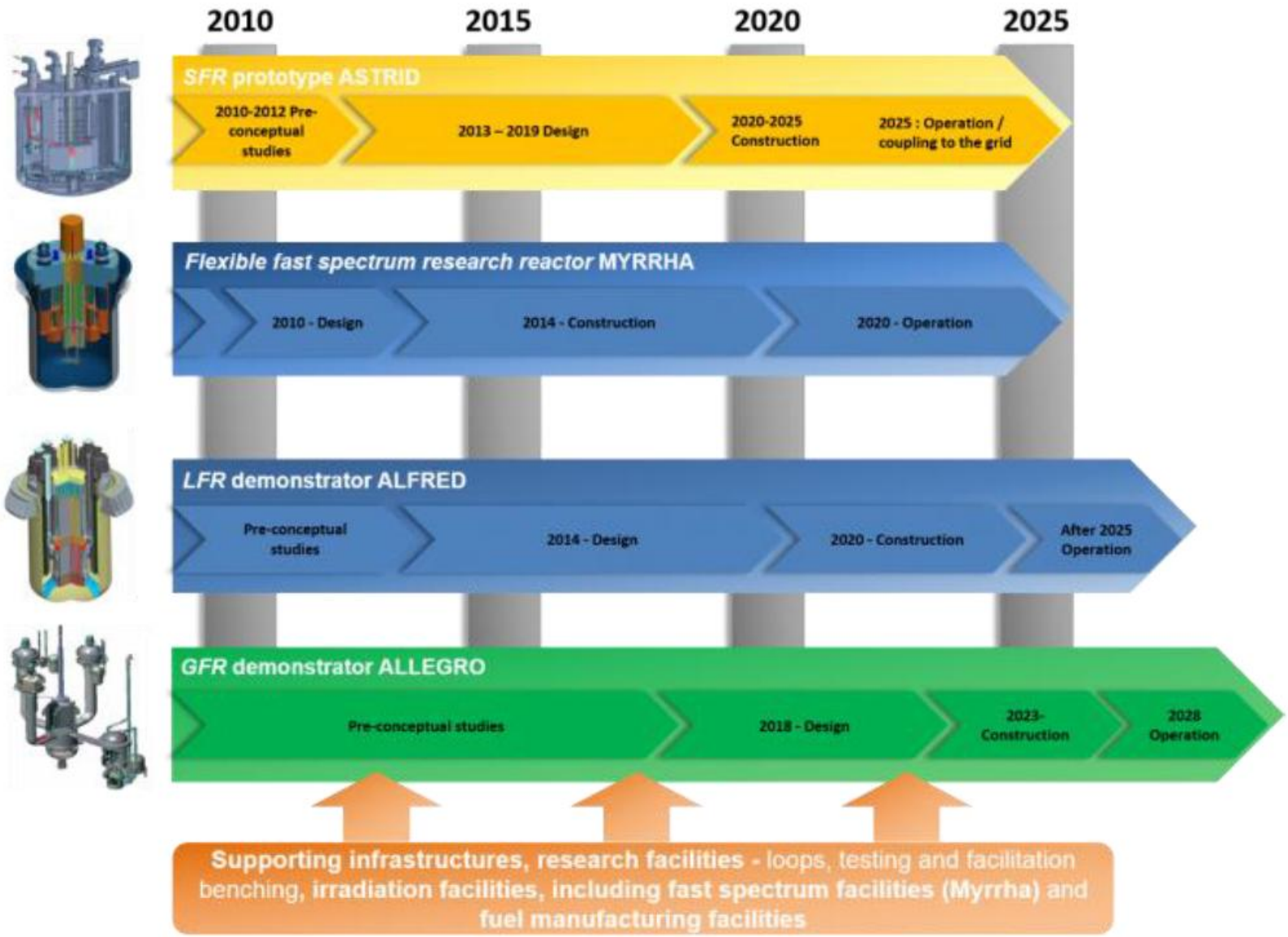
Develop a **strategic approach for FRs in Europe** in support of the European Sustainable Nuclear Industrial Initiative (ESNII) within the SET-Plan.

Prepare **ESNII structuration and deployment strategy including legal, administrative, financial and governance**, for the Horizon 2020 period, with a vision to 2050.

Implement European coordinated **crosscutting R&D** on **Reactor Safety** for the next generation of nuclear installations.

# ESNII credible and prioritized implementation plan

SNETP
Sustainable Nuclear Energy Technology Platform

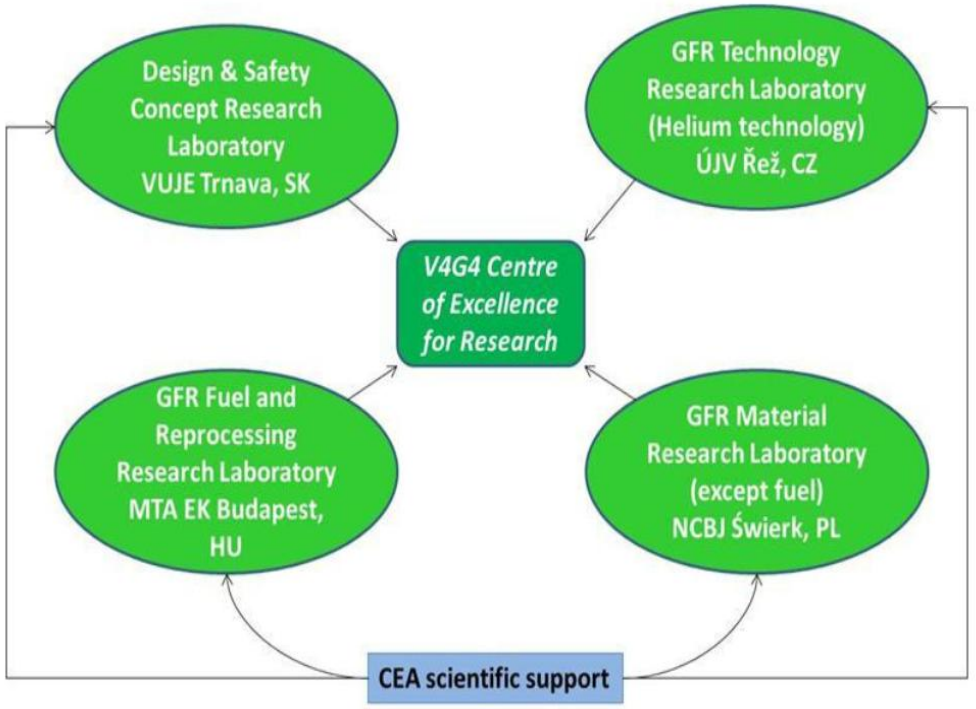


# ESNII program

| | SFR | LFR | | GFR |
|---|---|---|---|---|
| Demonstrator | ASTRID | ALFRED | MYRRHA | ALLEGRO |
| Nominal power | 1500 MWth<br>600 MWe | 300 MWth<br>125 MWe | 100 MWth<br>0 MWe | < 75 MWth/<br>0 MWe |
| Primary layout | Pool | Pool | Pool | Loop |
| Coolant | Sodium | Lead | LBE | Helium |
| Fuel | MOX | MOX | MOX | MOX/UOX/<br>Ceramic |
| Site | France | Romania | Belgium | Slovakia |
| Construction start | 2020 | 2027 | 2022 | > 2030 |

# Visegrad 4 countries for Generation 4 reactors

The involved nuclear research institutes agreed in 2013 to establish the V4G4 (Visegrad 4 countries for Generation 4 reactors) legal entity for organizing the research and design activities and to facilitate
the financing of the project using European and National Funds.



# VINCO

## Visegrad Initiative for Nuclear Cooperation

VINCO project represents the next stage of capacity building in nuclear technologies in Central European countries. Participating countries defined already their specializations: helium technology in Czech Republic, design and safety analyses in Slovakia, fuel studies in Hungary and material research in Poland. Having such expertise, the joint development of Gen IV nuclear technologies with the special emphasis on gas-cooled reactors is fully possible.

# VINCO - Participants

- NCBJ – National Centre for Nuclear Research, Świerk
- UJV – UJV Řež, Řež
- CVR – Research Centre, Řež
- VUJE - Nuclear Power Plant Research Institute, Trnava
- MTAEK - Centre for Energy Research, Budapest
- CEA - Alternative Energies and Atomic Energy Commission, Gif-sur-Yvette

# VINCO: work package breakdown & leaders

Project Coordinator – *NCBJ:* ***Jacek Jagielski***

WP1 - Project Management – *NCBJ:* ***Łukasz Kurpaska***

WP2 - The use of structural funds for financing of research infrastructure in nuclear technologies – *UJV:* ***Lubor Žežula***

WP3 - Mutual learning exercises and design studies for ALLEGRO demonstrator – *VUJE:* ***Petr Dařílek***

WP4 - Coordination of V4G4 Activities and Strategic planning – *MTAEK:* ***Akos Horvath,***

WP5 - Education and Training, Mobility of Researchers – *NCBJ:* ***Ludwik Dobrzyński***

WP6 - Dissemination of Results for Awareness-raising and Communication – CVR, ***Jana Kalivodova***

# 3. ALLEGRO Roadmap

# ALLEGRO Roadmap

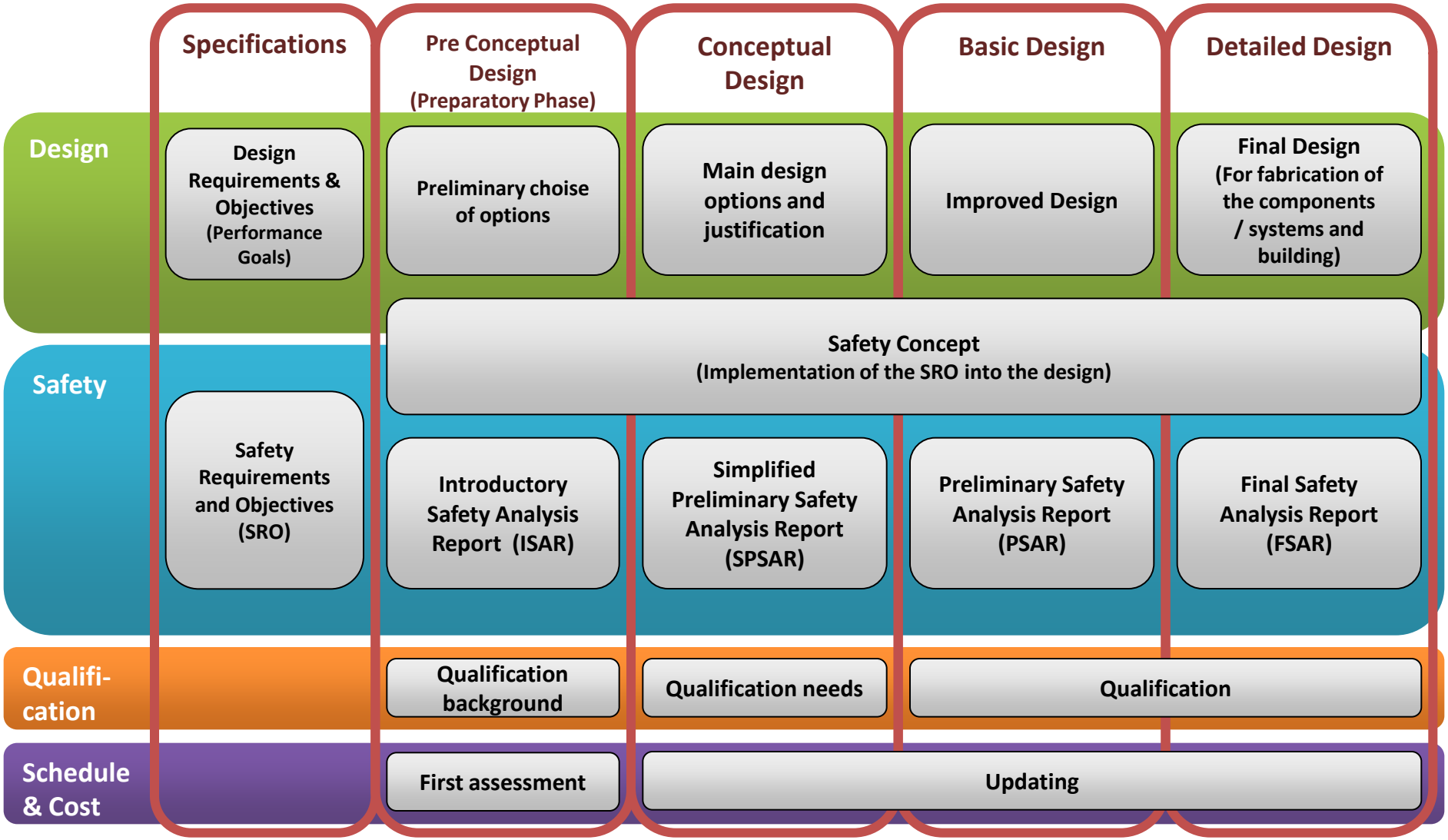
Roadmap was done by the V4G4 members and CEA

# ALLEGRO Roadmap

**The work was divided in the following areas:**

1) Whole Project Activities including Specifications (Design and Safety), Business Plan and legal issues, System integration and assessment, and Siting and Licensing
2) Reactor system
3) Core
4) Systems, Structures and Components
5) Gas management
6) Instrumentation and Control
7) Safety

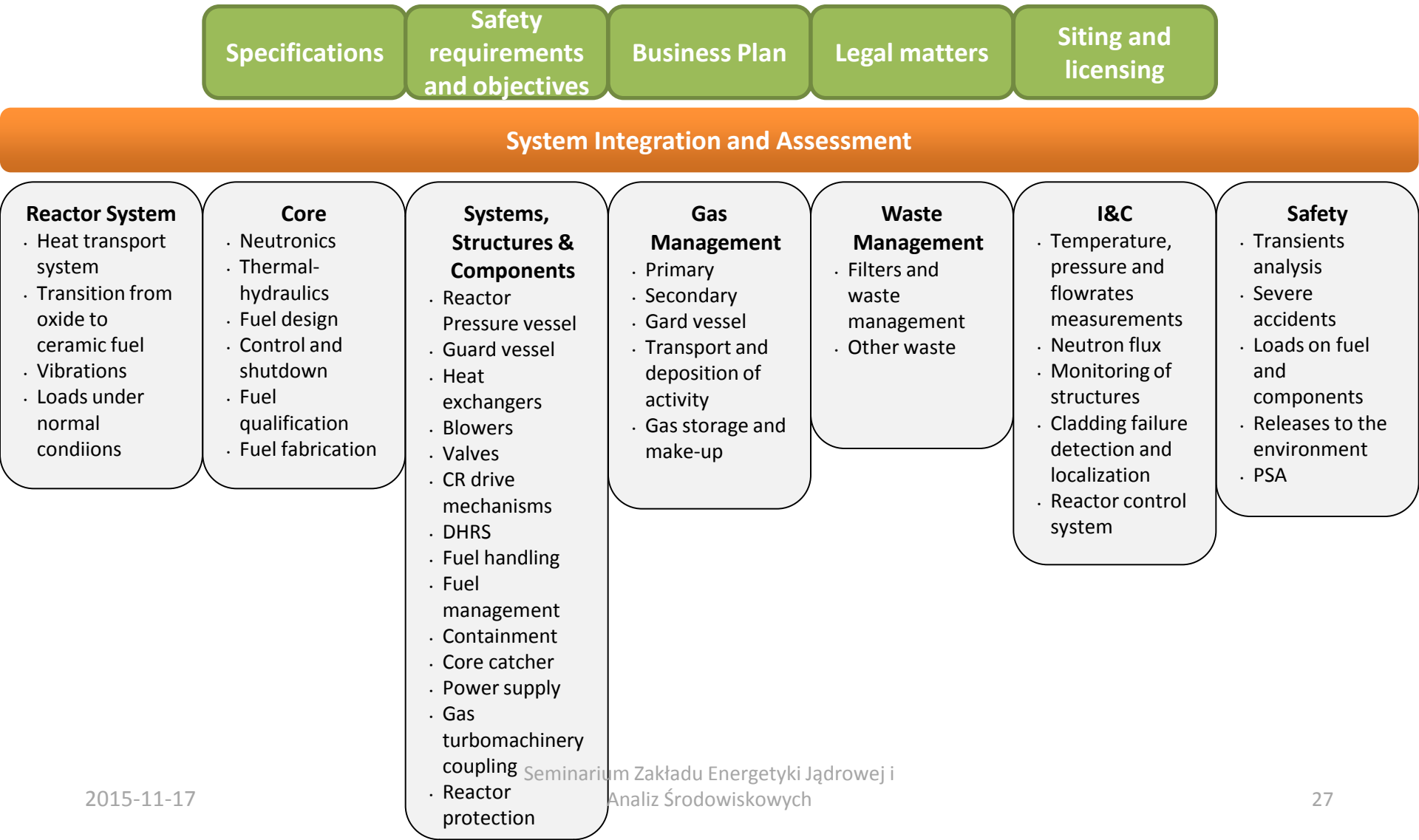
# Phases of the ALLEGRO project



# ALLEGRO Roadmap

Each area is described by the tasks with definitions:
- Title
- Leader of the task and other contributors
- Objectives of the task depending on the phase of the project
- Technical description
- Level to be reached at the end of various phases
- Tools to be used to perform the task
- Input data
- Time schedule
- Manpower
- Investments

# Structure of Roadmap



# Finalization of Roadmap

- *The ALLEGRO Design and Safety Roadmap* was presented to Steering Committee held in Bratislava, January 27 - 28, 2015).
- Last meeting on the finalization of the Roadmap: Trnava, 10 - 11 March 2015.
- Definition of all tasks completed and contributions defined.
- Final version submitted to the previous  Steering Committee on June 4, 2015.

001
April 2015
Rev. 0

# ALLEGRO

## Design and Safety Roadmap

B. Hatala, P. Darilek, R. Zajac - VUJE
L. Belovsky, P. Vacha, P. Hajek - UJV
K. Rózycki, A. Przybyszewska - NCBJ
J. Gadó, A. Kereszturi, Z. Hozer, I. Toth, G. Mayer - MTA EK
A. Vasile - CEA

**V4G4 Centre of Excellence**

# Summary of The Distribution of Tasks

Leader ●

Contributor ○

| Area | Tasks | VUJE | UJV | MTAEK | NCBJ |
|---|---|---|---|---|---|
| Whole Project activities | Design specifications and objectives | ● | ● | ● | ● |
| | Safety requirements & Objectives | ● | ● | ● | ● |
| | Business Plan | ● | ● | ● | ● |
| | Legal matters | ● | ● | ● | ● |
| | System Integration & Assessment | ● | ● | ● | ● |
| | Siting & Licensing | ● | | ○ | ○ |
| Reactor system | Heat transport systems | ● | ○ | ○ | ○ |
| | Transition from start-up to ceramic core | ● | ○ | ○ | ○ |
| | Assessment of vibrations | ● | | | |
| | Loads on fuel & components in normal operation | ● | | | |

# Summary of The Distribution of Tasks

| Area | | Tasks | VUJE | UJV | MTAEK | NCBJ |
|---|---|---|---|---|---|---|
| Core (1/2) | Neutronics | Review of existing studies | ● | ○ | ○ | |
| | | Calculation of the stat up core | ○ | ○ | ● | ○ |
| | | Design of the experimental ceramic S/As | | ○ | ● | |
| | | Transition cores | ○ | ○ | ● | ○ |
| | | Gamma heating of structures | | | | ● |
| | | Radiological protection | | | | ● |
| | Core and subassembly thermalhydraulics | Core thermalhydraulics optimization | ○ | ○ | ● | ○ |
| | | Fuel bundle thermalhydraulics | ○ | ○ | | ○ |
| | S/A and fuel rod design | Fuel rod thermomechanical behavior (UOX and ceramic) | | | ● | |
| | | Fuel S/A design | | ○ | ● | |

# Summary of The Distribution of Tasks

| Area | | Tasks | VUJE | UJV | MTAEK | NCBJ |
|---|---|---|---|---|---|---|
| Core (2/2) | Control and shutdown S/A design | Absorbers rod design & behaviour | ○ | | ● | |
| | | Control subassembly design & behaviour | ○ | | ● | |
| | | Additional shutdown system | | | | ● |
| | Qualification of the fuel | Specification of the required qualification for the fuel | | ○ | ● | |
| | | Qualification dossier of the start-up core | | | ● | |
| | Fuel fabrication | Fuel specifications for the fabrication | | | ● | |
| | | Fabrication of the start-up core | | | ● | |

# Summary of The Distribution of Tasks

| Area | | Tasks | VUJE | UJV | MTAEK | NCBJ |
|---|---|---|---|---|---|---|
| Systems, Structures & Components (1/3) | Reactor Pressure Vessel (RPV) | RPV layout | ○ | ● | | ○ |
| | | Thermalhydraulics | ○ | ● | | ○ |
| | | Internals | ● | ○ | | |
| | | Thermal insulation of primary, secondary and DHRS circuits | ● | | | |
| | | RPV and primary circuit seals | | | | ● |
| | | Structural materials inside the RPV | | | | ● |
| | Gard Vessel | Layout | ● | ○ | | ○ |
| | | Cooling of the RPV and heat removal from the GV atmosphere | ● | ○ | | ○ |
| | | GV structures | ● | | | |

# Summary of The Distribution of Tasks

| Area | | Tasks | VUJE | UJV | MTAEK | NCBJ |
|---|---|---|---|---|---|---|
| Systems, Structures & Components (2/3) | Heat exchangers | Main HX | ● | | | |
| | | DHR HX | ● | | | |
| | | Gard vessel HX | ● | | | |
| | Blowers | Primary circuit blowers | | ● | | |
| | | Secondary circuit blowers | | ● | | |
| | | DHRS blowers | | ● | | |
| | Valves | Main isolation valves | ● | | | |
| | | DHR valves | ● | | | |
| | | Safety valves | ● | | | |
| | Control rod drive mechanisms | | ○ | | | ● |
| | DHRS | Design in nominal conditions | ○ | ● | ○ | ○ |
| | | Experimental testing | ○ | ● | | |
| | | Gas injection system | | ● | ○ | |

# Summary of The Distribution of Tasks

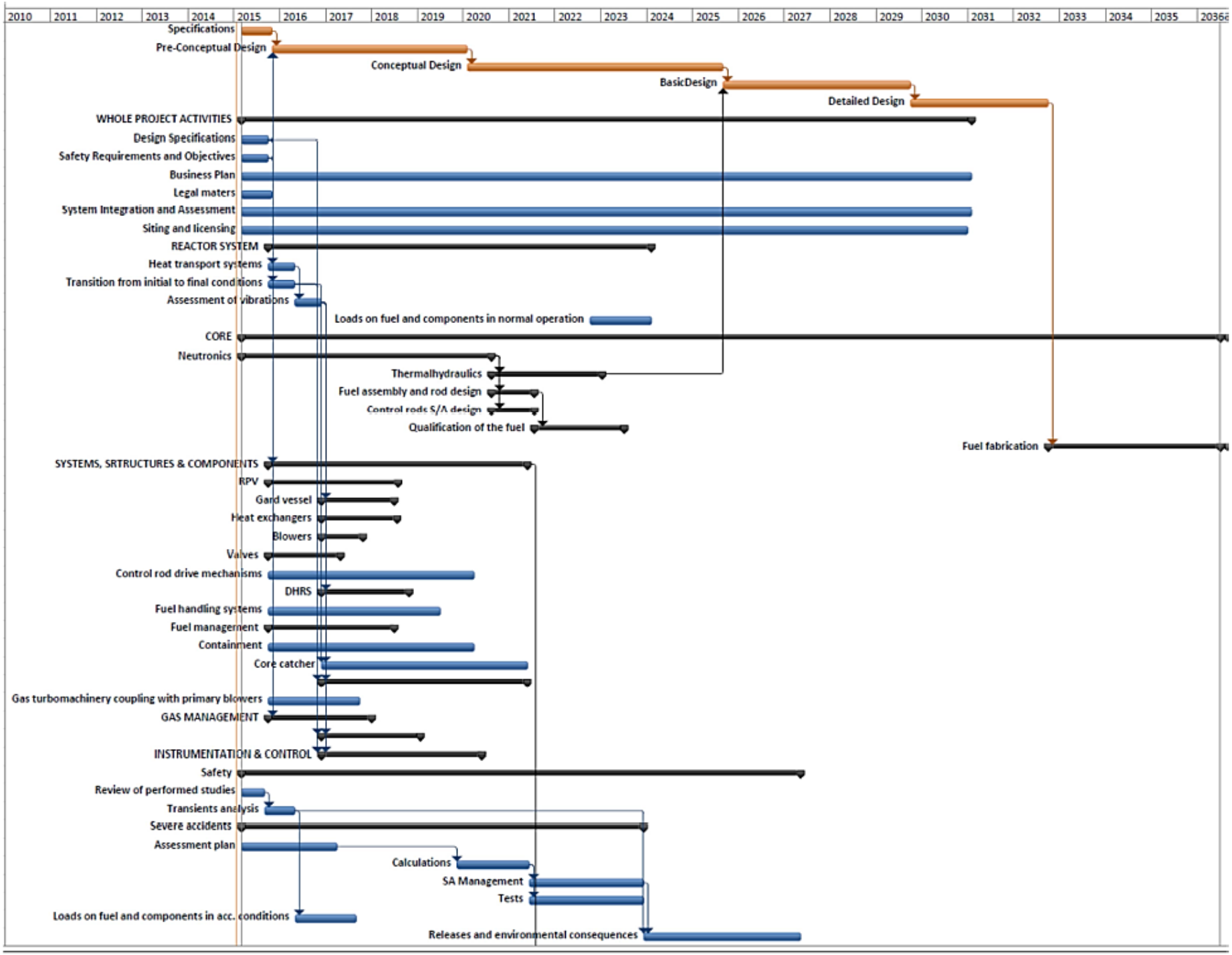
| Area | | Tasks | VUJE | UJV | MTAEK | NCBJ |
|---|---|---|---|---|---|---|
| Systems, Structures & Components (3/3) | Fuel handling systems | | ● | | | ○ |
| | Fuel management | Fresh fuel storage and transfer | ● | | | |
| | | Spent fuel transfer & storage | ● | | | |
| | Containment | | ● | | | |
| | Core catcher | | ○ | ● | | |
| | Power supply systems | Normal power supply | ● | | | |
| | | Emergency power supply | ● | | | |
| | | Battery back-up for accident management | ○ | ● | ○ | |
| | Gas turbomachinery coupling with primary blowers | | ● | | | |
| | Reactor protection system | | ○ | | ● | |

# Summary of The Distribution of Tasks

| Area | Tasks | VUJE | UJV | MTAEK | NCBJ |
|---|---|---|---|---|---|
| Gas management | Primary He quality | | ● | | ○ |
| | Secondary gas quality | | ● | | ○ |
| | GV atmosphere management | | ● | | ○ |
| | Transport and deposition of activity | | ● | | ○ |
| | Gas storage and make-up | | ● | | ○ |
| Waste management | Filters and waste management | | ● | | ○ |
| | Other waste management | | ● | | ○ |
| Instrumentation & control | Core outlet temperature, pressure, flowrate and determination of heat balance | ● | | ○ | ○ |
| | Neutron flux measurements | ○ | | ○ | ○ |
| | Monitoring of the reactor atmosphere, cladding failure detection and localization systems | | | ○ | ○ |
| | Reactor control system | ● | | ○ | |

# Summary of The Distribution of Tasks

| Area | | Tasks | VUJE | UJV | MTAEK | NCBJ |
|---|---|---|---|---|---|---|
| Safety | Review of existing analysis of transients | | ○ | ○ | ● | ○ |
| | System transient analysis: DC and DEC (in particular LOCA + Blackout) | | ○ | ● | ● | ● |
| | Severe accidents | Assessment plan | ○ | ● | ○ | ○ |
| | | Calculations | ○ | ● | ○ | |
| | | Management | ○ | ● | ○ | ○ |
| | | Tests | | | | |
| | Loads on fuel and components in accidental conditions | | | ○ | ○ | |
| | Releases and environmental consequences | | | ○ | ○ | |
| | PSA | | ○ | ● | ○ | ○ |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Specifications
Pre-Conceptual Design
Conceptual Design
BasicDesign
Detailed Design
WHOLE PROJECT ACTIVITIES
Design Specifications
Safety Requirements and Objectives
Business Plan
Legal maters
System Integration and Assessment
Siting and licensing
REACTOR SYSTEM
Heat transport systems
Transition from initial to final conditions
Assessment of vibrations
Loads on fuel and components in normal operation
CORE
Neutronics
Thermalhydraulics
Fuel assembly and rod design
Control rods S/A design
Qualification of the fuel
Fuel fabrication
SYSTEMS, SRTRUCTURES & COMPONENTS
RPV
Gard vessel
Heat exchangers
Blowers
Valves
Control rod drive mechanisms
DHRS
Fuel handling systems
Fuel management
Containment
Core catcher
Gas turbomachinery coupling with primary blowers
GAS MANAGEMENT
INSTRUMENTATION & CONTROL
Safety
Review of performed studies
Transients analysis
Severe accidents
Assessment plan
Calculations
SA Management
Tests
Loads on fuel and components in acc. conditions
Releases and environmental consequences

# Resume of Roadmap

What was done?

- Structure defined
- 80 tasks identified
- 77 description defined and contributors identified
- 3 tasks description and contributors pending
- About 400 person x year needed
  for the pre conceptual design and concept design

What's next?

Optimize the structure (could be done later)
Identify contributors for some tasks
Include additional tasks
Progress on rules for availability of codes, data, documents
Roadmap refining and updating (living document)


WHO?
WHAT?
HOW?
WHERE?
WHY?
?