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Serpent Code Using in ALLEGRO Project

**4th Annual Serpent User
Group Meeting**

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***Department of Nuclear Design
and Fuel Management***

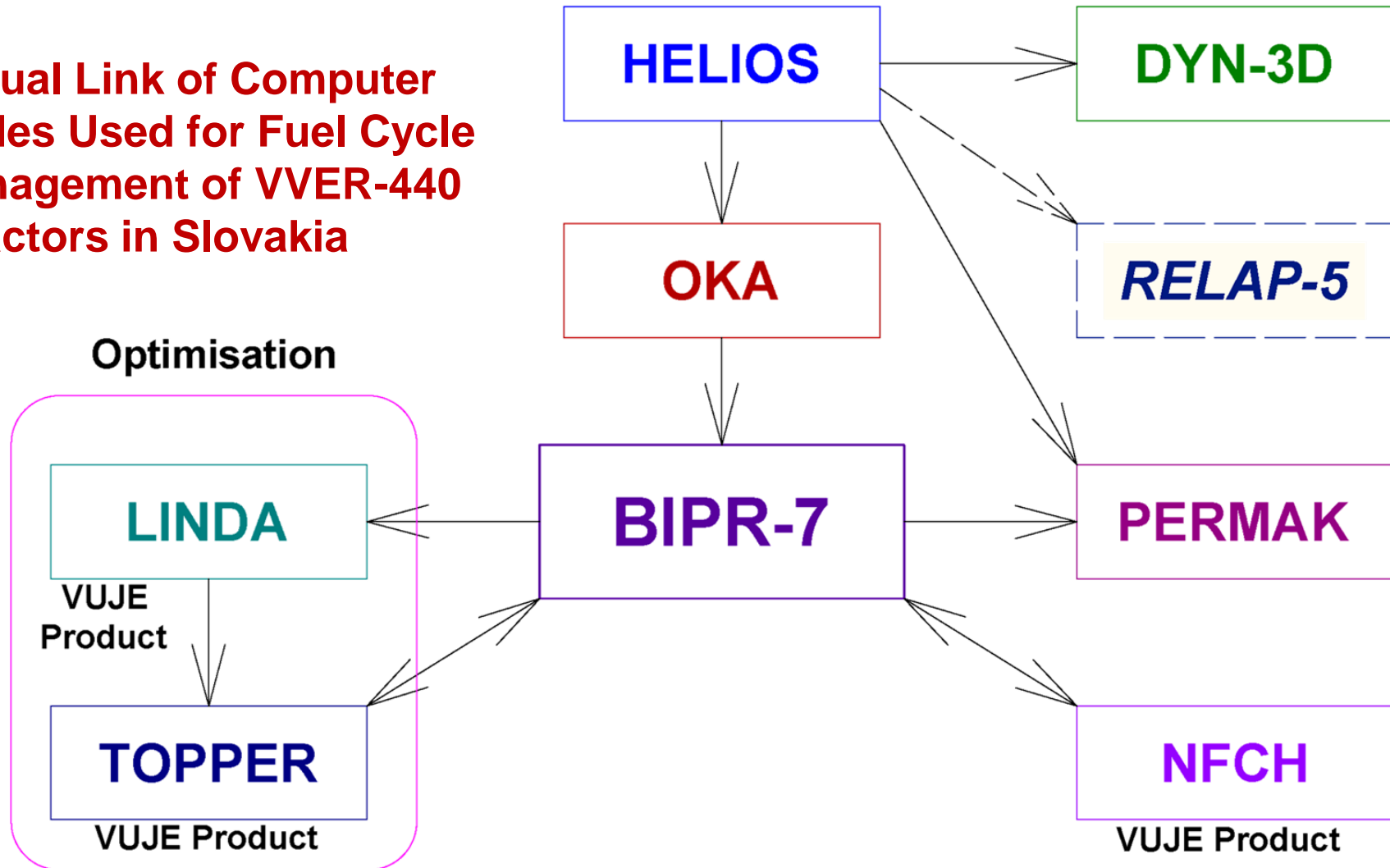
**University of Cambridge
Cambridge, 17th – 19th September 2014**



- Short Overview of the Department of Nuclear Design and Fuel Management
- Description of ALLEGRO Project
- Description of ALIANCE Project
- V4G4 – Centre of Excellence
- Combination of SERPENT and DYN
- Some Results Comparison of SERPENT, HELIOS and TRITON
- Summary

Computer codes system for VVER-440 neutronics calculations

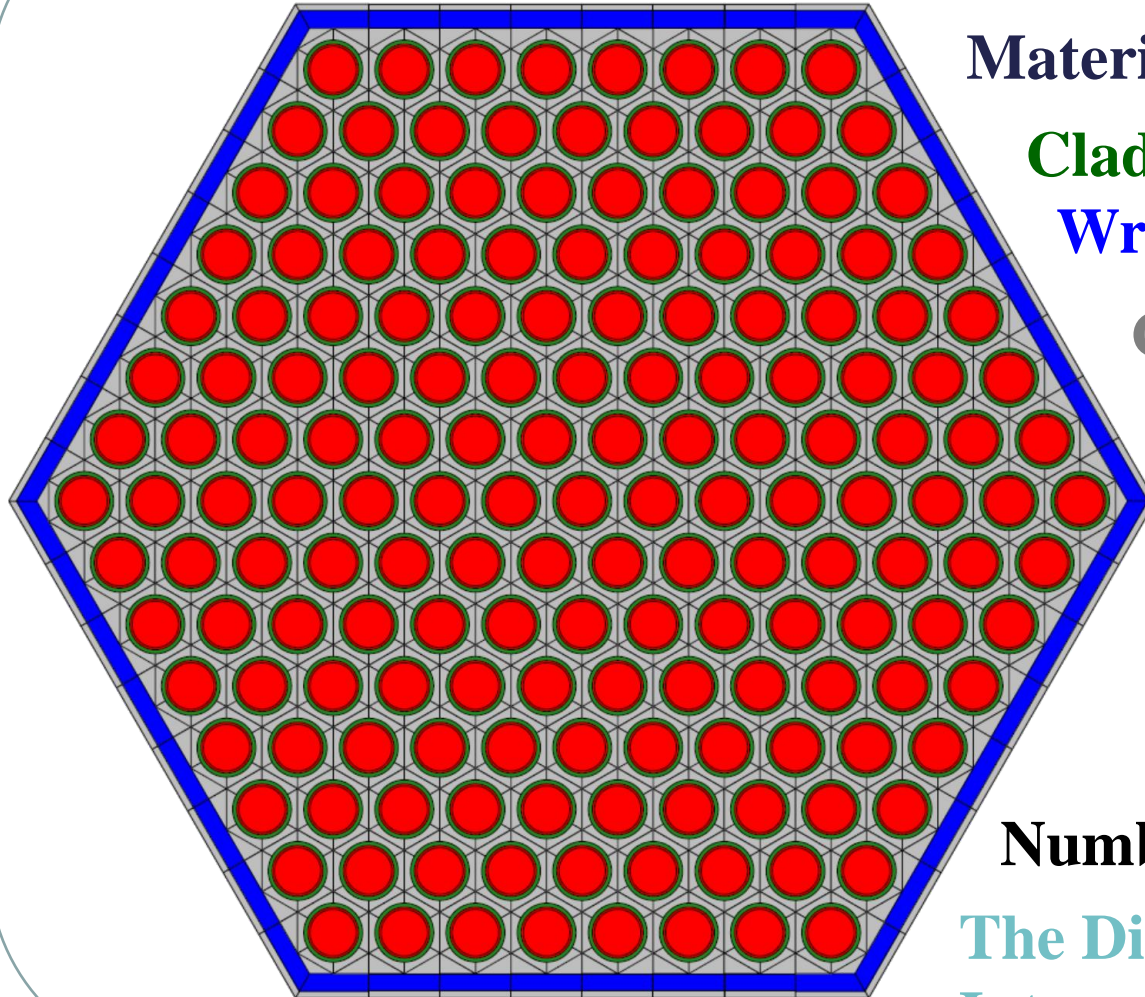
Mutual Link of Computer Codes Used for Fuel Cycle Management of VVER-440 Reactors in Slovakia



- **ALLEGRO** is low power GFR reactor without electricity generation, dedicated to demonstration of helium cooled high temperature fast reactor technology.
- Development and verification of refractory fuel and verification of reliable removal of decay heat after shut down with loss of pressure are of special interests.



Cross Section of MOX Starting Sub-Assembly



Materials:

Cladding/

Wrapper Tube: 15-15 Ti Steel

Coolant: He-4

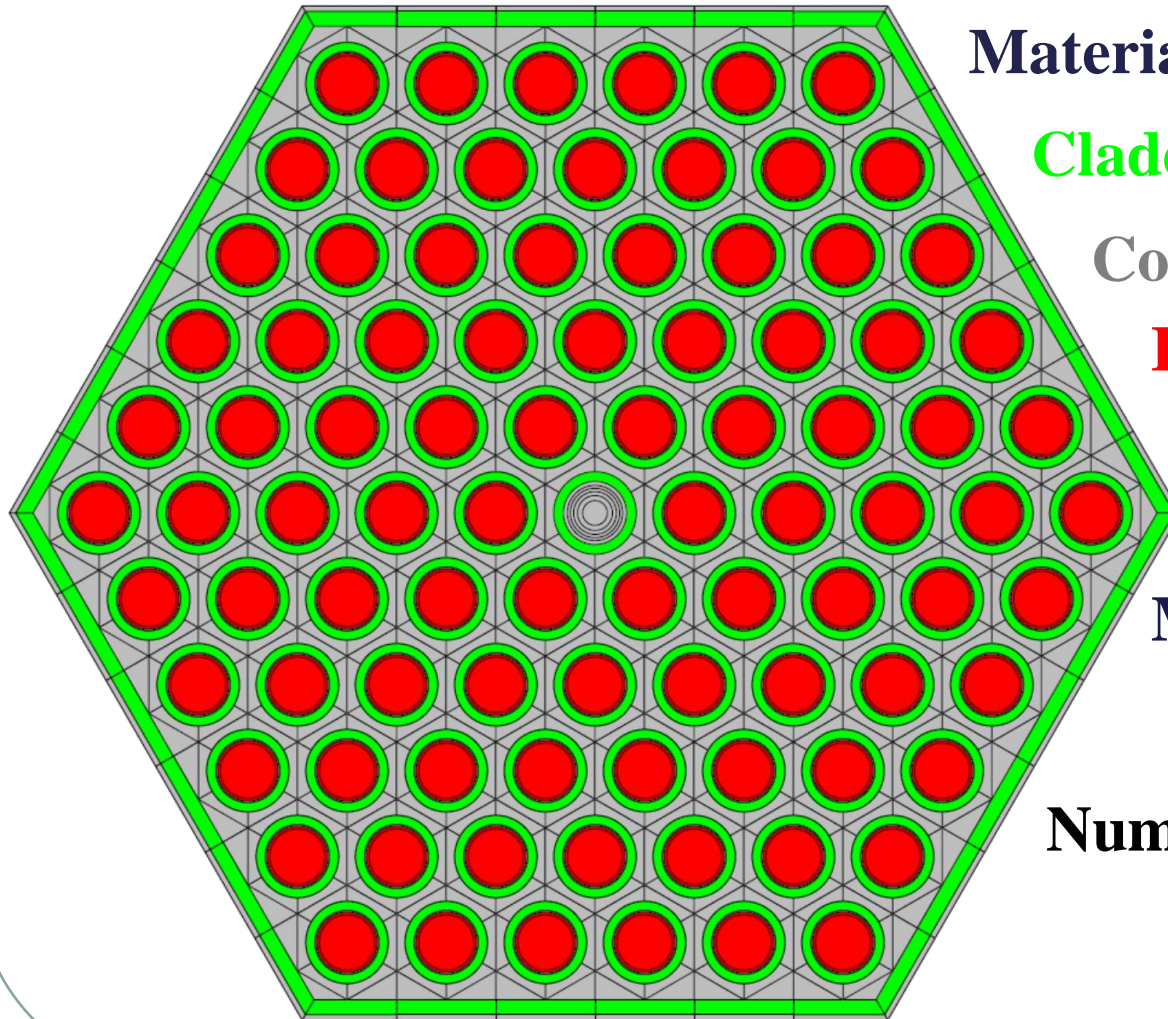
Fuel: PuO₂ (MOX)
24 % Pu

Model: Sub-Assembly in
Infinite Lattice and
in Super-Cell

Number of Pins: 169

The Distance Wire was
Integrated into the Cladding

Ceramic Pin Sub-Assembly



Materials:

Cladding/Wrapper Tube: SiC

Coolant: He-4

Fuel: UPuC

27.5 % Pu

**Model: Sub-Assembly in
Infinite Lattice**

Number of Fuel Pins: 90

Project Acronym: ALLIANCE

Project full title: Preparation of ALLEGRO – Implementing Advanced Nuclear Fuel Cycle in Central Europe

Duration: 36 months

Work packages:

Project management (WP 1)

Roadmap of ALLEGRO demonstrator (WP 2) (WP leader-VUJE)

ALLEGRO design and safety concept (WP 3) (WP leader-VUJE)

Experimental support to design work (WP 4)

Safety and licensing (WP 5)

Dissemination (WP 6)

Integrated management of ALLEGRO (WP 7)

Participants: MTA EK (Hungary), UJV (Czech Republic), VUJE (Slovakia), CEA (France), INBK (Germany), IRSN (France), NCBJ (Poland), BME (Hungary), CVR (Czech Republic)

- **2005: French government strategy: Priority to SFR + GFR/VHTR**
 - Project of a commercial GFR 2400 MW_{th}: Fuel to be developed
 - GFR demonstrator ALLEGRO 75 MW_{th} - *concept developed by CEA*
 - Assess the **GFRs technological feasibility** and test components
 - Test the GFR ceramic (carbide mixed) fuel
- **2009: Modification of the French government strategy**
 - Resources redirected to SFR only
 - GFR: only fuel (R&D) and safety
- **2010: ALLEGRO consortium**
 - GFR demonstrator ALLEGRO – F(CEA) → CZ, HU, SK + PL(2012)
 - Joint preparatory work started in the Central Europe under CEA scientific support

2013: Establishment of V4G4 Centre of Excellence (July 18, 2013)

- The Centre of Excellence for GFR studies was formed among the Central European members
(HU – MTA EK, SK – VUJE, a.s., CZ – UJV and PL - NCBJ)
- The four legs of the Centre:

ALLEGRO consortium



Fuel research (HU)

Design and safety (SK)

Helium technology (CZ)

Industrial use of high parametric heat (PL)

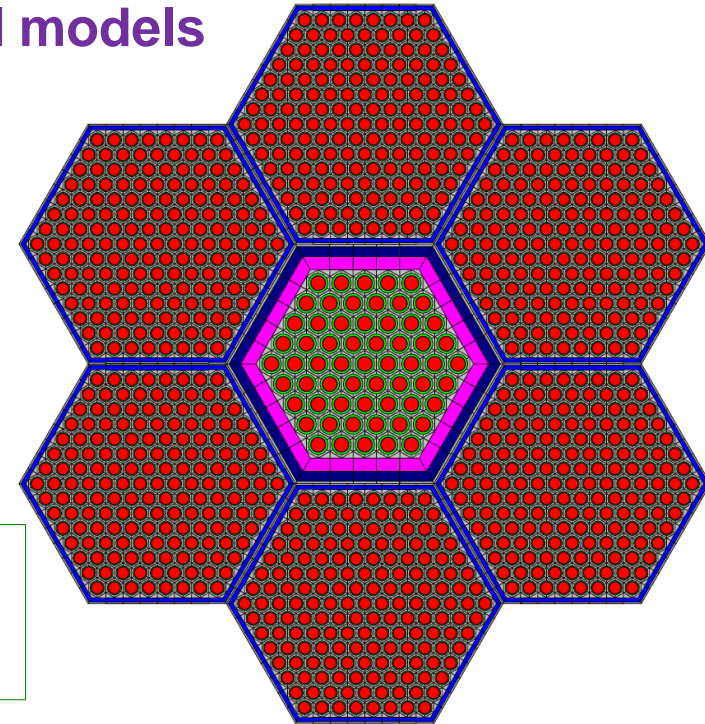
Objectives:

- 3D Burnup calculations of ALLEGRO fuel assemblies in infinite lattice
- **Optimisation of control assemblies in ALLEGRO core**
- **Generation of 2D ALLEGRO few-group constants for DYN**
 - Fuel assemblies: generated in infinite assembly lattice calculations
 - Control assemblies: generated in super-cell models

NJOY 99.161++

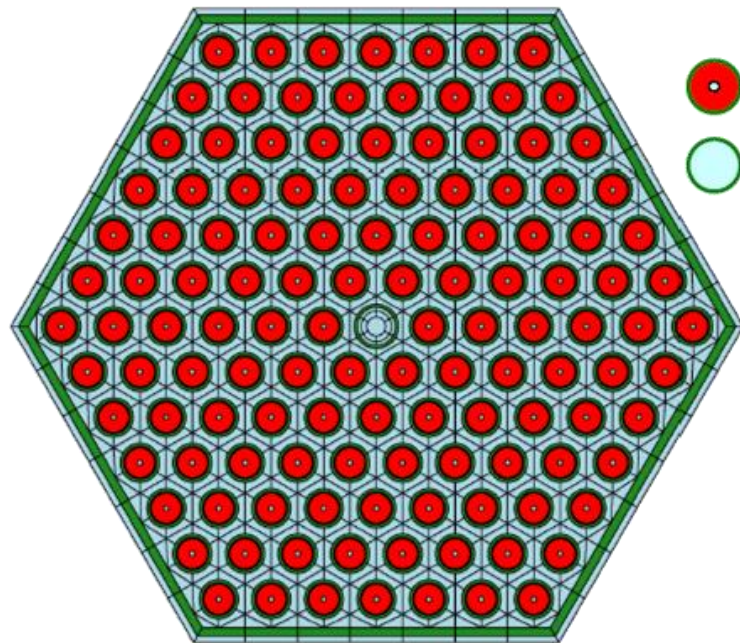
SERPENT 2

DYN

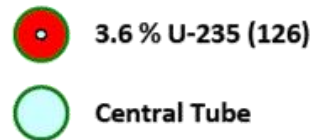


Comparison of the Codes

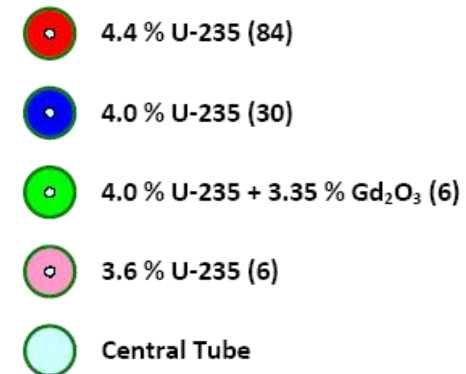
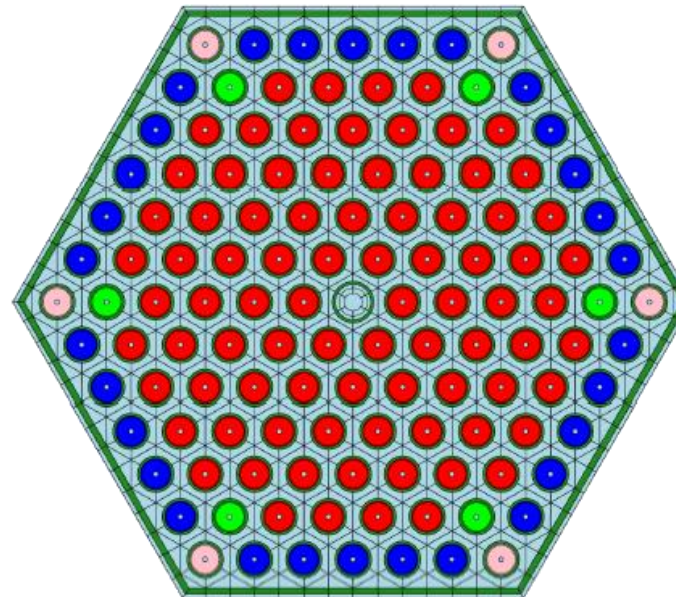
- Used Codes: **SERPENT 1.1.19**, **HELIOS 2.1.1** and **Triton (SACLE 6.1.2)**
- Subject of calculation: **2D calculation of VVER-440 assemblies in infinite lattice with enrichment 3.6 % U-235 and Gd2 4.25 % U-235 + 3.35 Gd₂O₃**



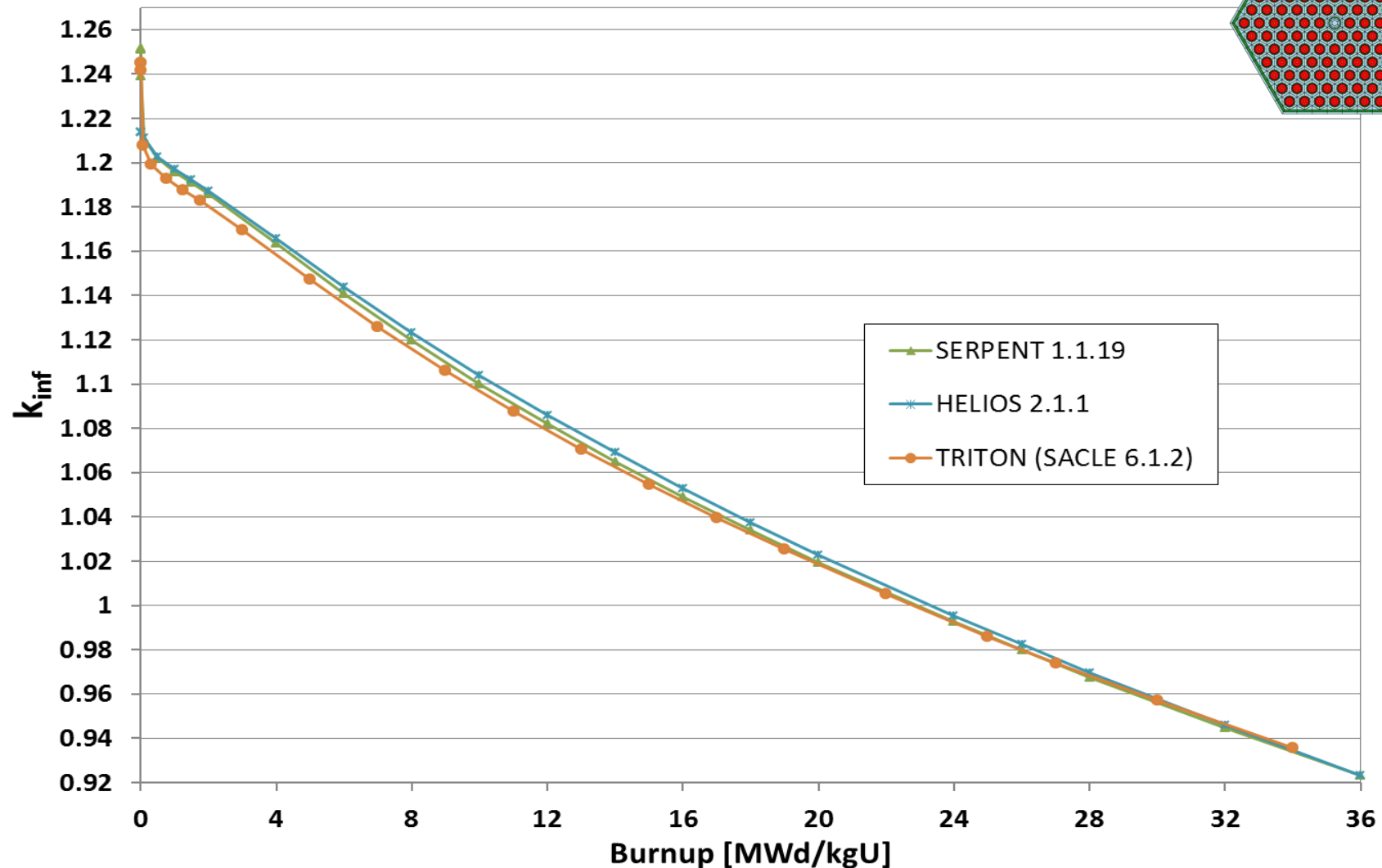
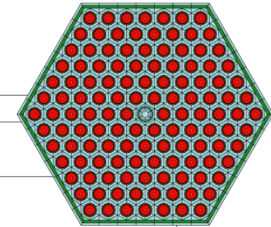
VVER-440 assembly
3.6 % U-235

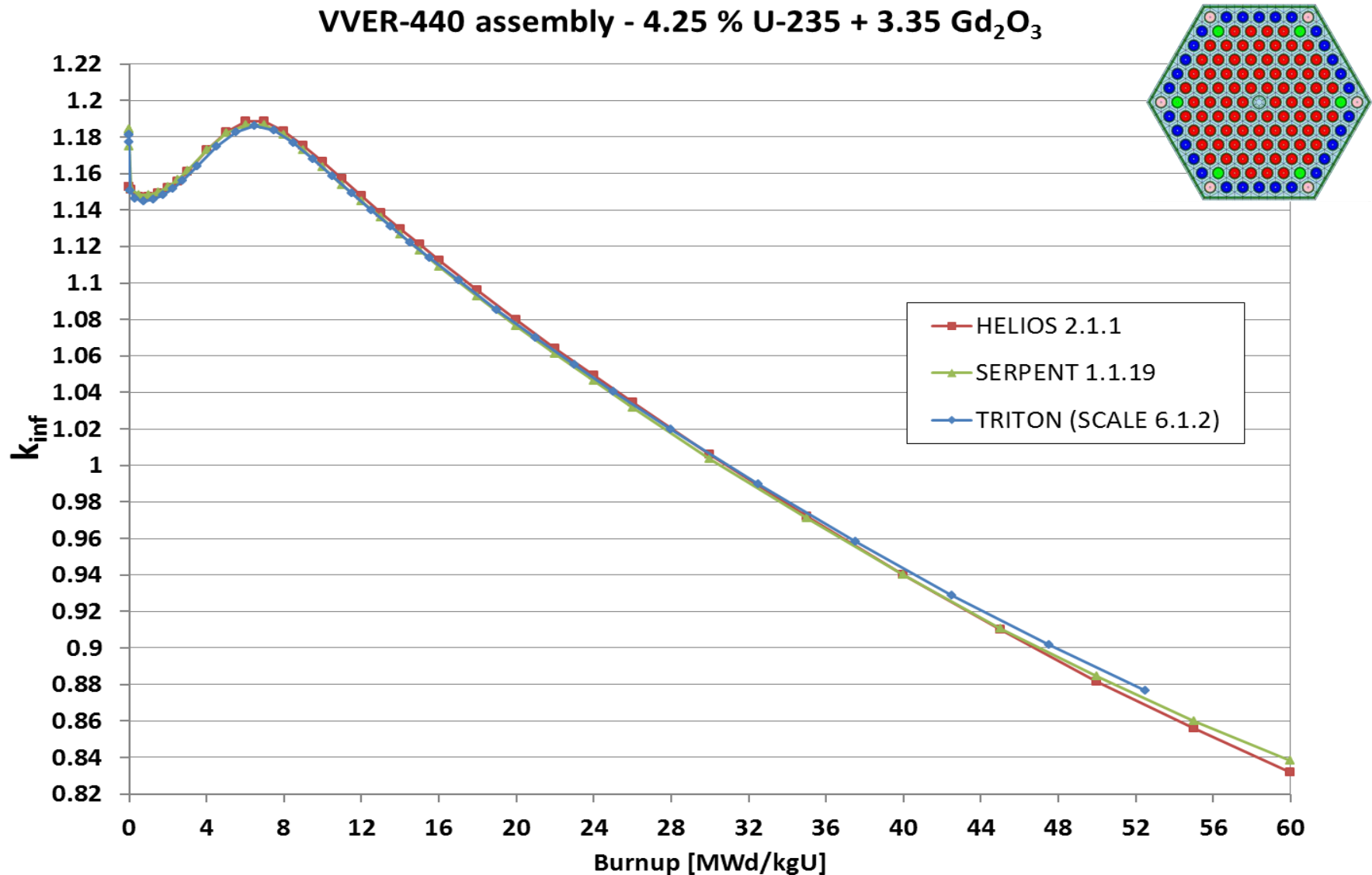


Gd2 VVER-440 assembly
4.25 % U-235 + 3.35 % Gd₂O₃



VVER-440 assembly - 3.6 % U-235





Summary / Conclusion

- ALLEGRO is 75 MW_{th} demonstrator of GFR technology without electricity production
- Important milestone – establishment of V4G4 Centre of Excellence
 - The role of Slovakia: Design and safety concept
- Good agreement of three codes:
SERPENT 1.1.19, HELIOS 2.1.1 and TRITON (SCALE 6.1.2)
- Near future: Comparison of SERPENT vs. VVER-440 experimental values (nuclide concentration, burnup)
- Main aim of our department:
Generation of 2D ALLEGRO few-group constants for DYN