GFR R&D PROGRAME IN V4 COUNTRIES

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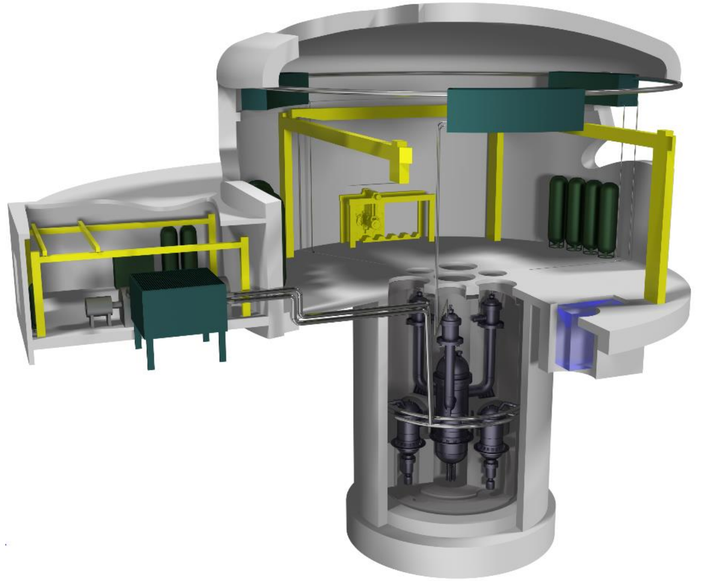
Skupina ÚJV
LIDÉ | INOVACE | TECHNOLOGIE

CONTENT

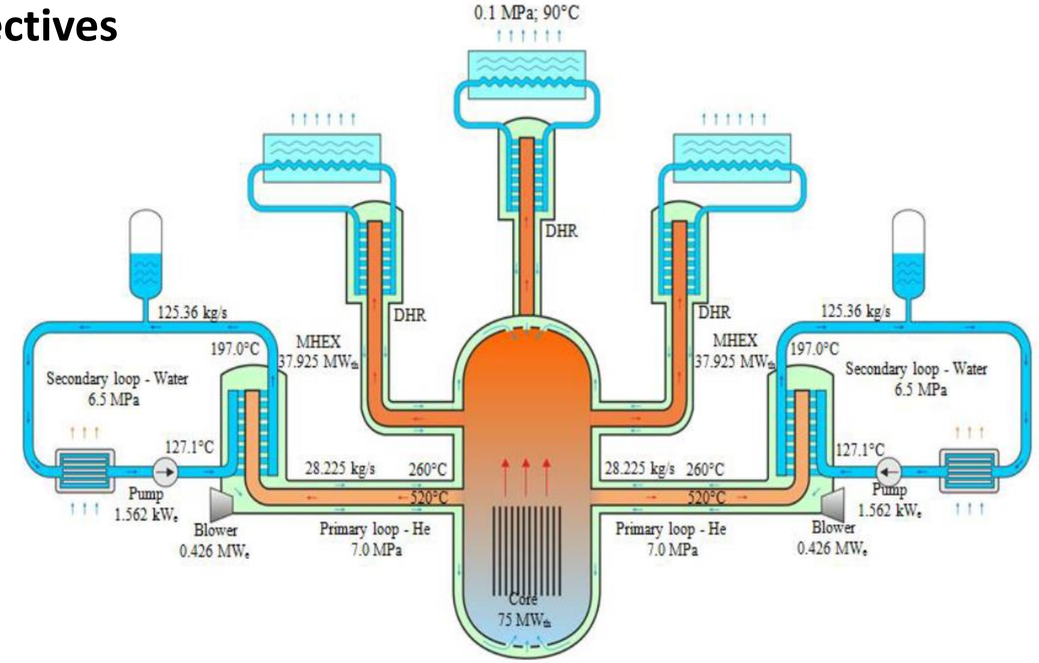
- GFR demonstrator ALLEGRO
- HeFASTo concept
- Ongoing national and International R&D on GFR in Europe

ALLEGRO – DESIGN OVERVIEW

- **Two consecutive core configurations**
  - Driver core – MOX/UO_2 pin-type fuel in steel cladding, experimental positions for fuel qualification
  - Refractory core – (U,Pu)C pin-type fuel in SiC-SiCf cladding <- GFR reference fuel
- **Target core outlet temperature 850°C**
- **Power density up to 100 MW/m³**
- **Focus on fully passive safety to meet GENIV objectives**



ALLEGRO main characteristics	
Nominal Power (thermal)	75 MW
Driver core fuel/cladding	MOX(UO2) / 15-15ti Steel
Experimental fuel/cladding	UPuC / Sic-Sicf
Fuel enrichment	35% (MOX) / 19.5% (UO2)
Power density	100 MWth/m3
Primary coolant	He
Primary pressure	7 MPa
Driver core in/out temperature	260°C / 530°C
Experimental fuel in/out T	400°C / 850°C



THE ALLEGRO PROJECT TEAM

- **International collaboration**
  - V4G4 CoE – 6 organizations from 5 countries (CZ,HU, SK,PL + FR)
  - Increasing numbers of officially collaborating organizations
- **V4G4 Centre of Excellence**
- **Full members (alphabetically):**

Centre for Energy Research, Hungary

National Centre for Nuclear Research, Poland

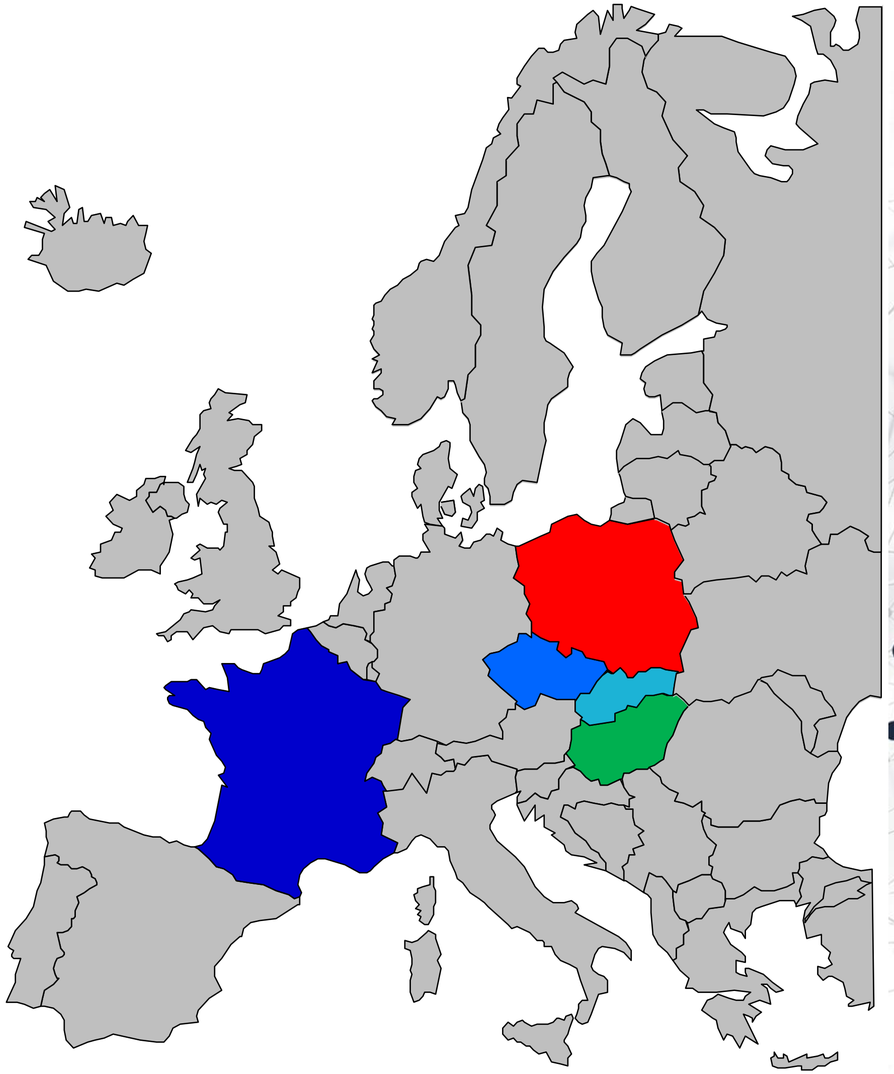
ÚJV Řež, a.s., Czech Republic

VUJE, a s., Slovakia

- **Associated members (alphabetically)**

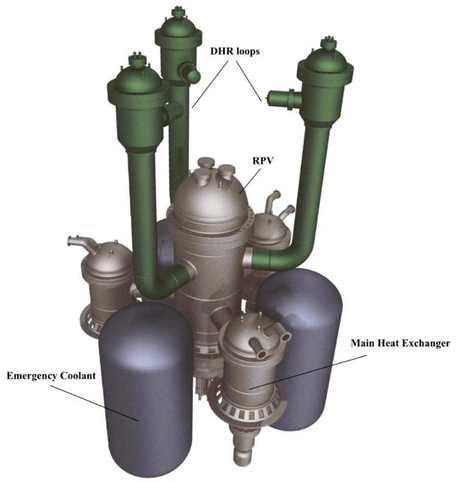
Alternative Energies and Atomic Energy Commission, France

Research Centre Řež, Czech Republic



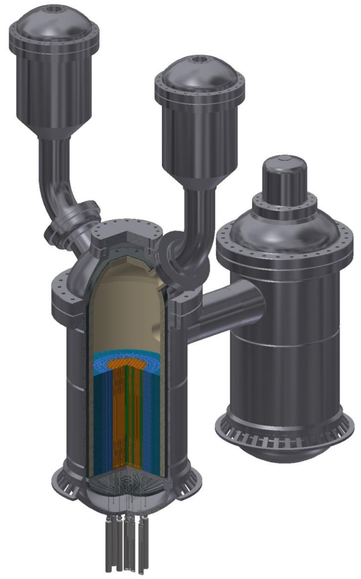
ALLEGRO – MAIN GOALS

- **ALLEGRO should achieve:**
  - Demonstration of viability of the GFR technology
  - Proof of concept – ability to deliver high-potential heat while remaining safe and reliable
  - Testbed– qualification of materials and technologies in prototypical conditions
- **Ultimate goal – Qualification of the GFR technology for commercial application**



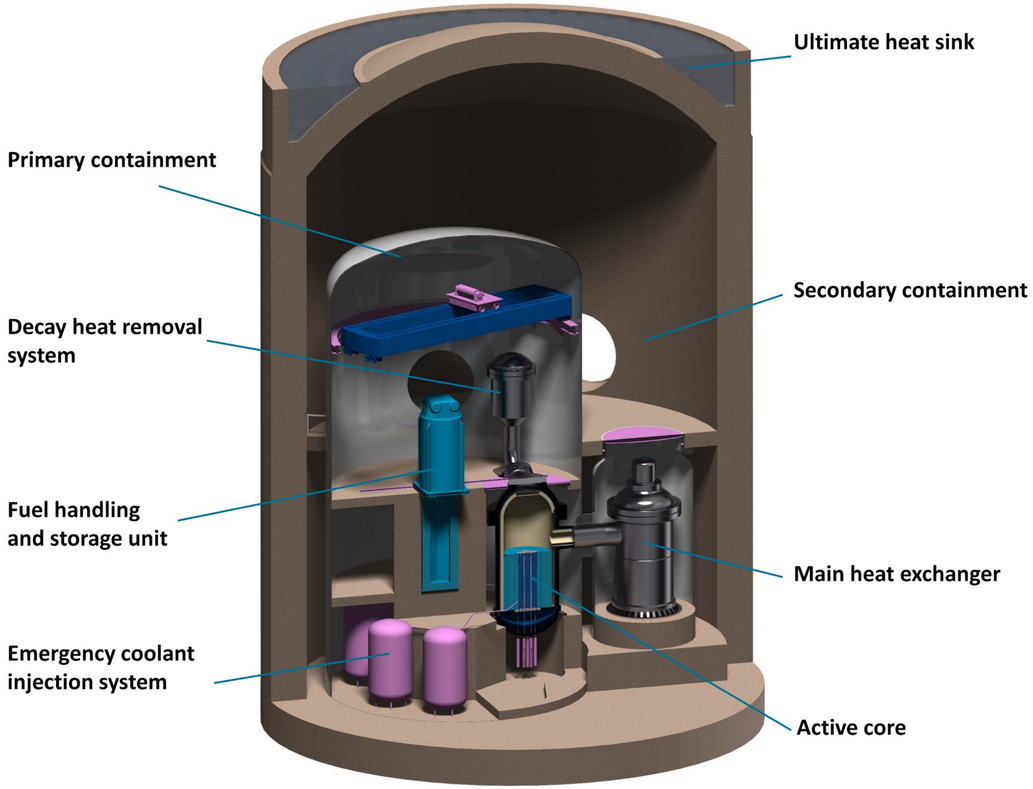
ALLEGRO

Commercial GFR



HeFASTo - GOALS AND BASIS OF DESIGN

- **The main goal of the HeFASTo is to bring a modern, feasible and attractive concept of commercially applicable GFR**
  - Modular construction
  - Relatively small size of a unit
  - Based on solutions developed for ALLEGRO as the GFR demonstrator
- **Focus on maximum possible levels of versatility and utilization of the inherent properties:**
  - Fast reactor -> breeding allows for excellent fuel economics, potential to use reprocessed (recycled) fuel
  - High-temperature -> Utilization of the heat in industrial processes as well as electricity production
- **Comply with the most stringent requirements of GENIV Reactors**
  - Fully passive safety
  - Proliferation issues are treated by development of a unique configuration of the active core, limiting fuel handling



HeFASTo – MAIN PARAMETERS

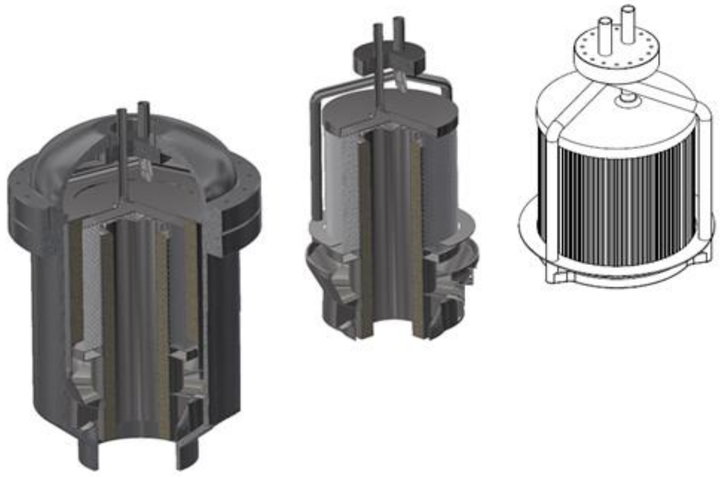
Main Features of HeFASTo

- Core outlet temperature 900°C
- Placed partially underground – only 18m above ground
- 5 years of operation without the need for fuel handling
- Ability to used reprocessed fuel

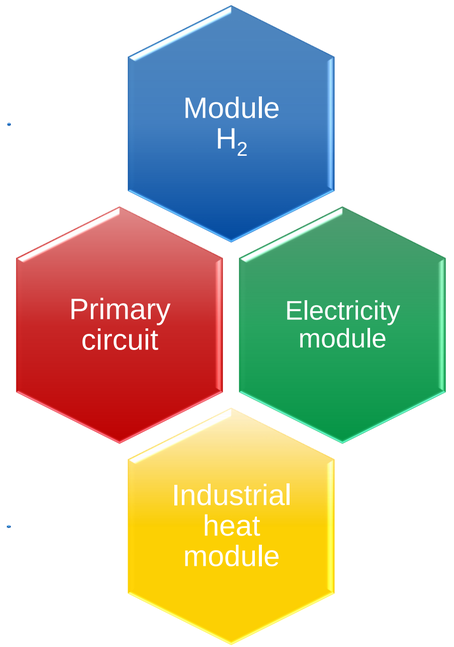
Parameter	Value	Unit
Thermal power	200	MWth
Core inlet/outlet temperature	450 / 900	°C
Primary coolant	He	-
Primary pressure	7,5	MPa
Secondary coolant	N2+He	-
Secondary pressure	8,0	MPa
Fuel	UC or(U,Pu)C	-
Fuel enrichment	UC - 19,5 (U,PU)C - 30	%
Operation time without outage	5	years
Load factor	>95	%

HeFASTo – MODULARITY

- **Focus on simplification of construction, repairs and transport**
  - Minimalization of welds done on the construction site
  - Diameters of all main components suitable for transport via railway or road
  - Emphasis on easy repairs of main components – replacable modules



- **Secondary circuit**
  - **Options for combination of three different power conversion modules:**
    - Hydrogen production module – high-temperature electrolysis
    - Electricity production module – combined cycle (44 % efficiency)
    - Direct heat supply for chemical industry (850°C at the customer side)



CURRENT GFR R&D PRIORITIES

- **GFR R&D priorities summarized in a document ALLEGRO R&D Roadmap**
  - Living document prepared by V4G4 CoE
  - Selected priorities listed below

Topical area	Key particular issues	Cross-cutting R&D synergies with
The core	Fuel composition selection	Other fast reactor technologies (sodium in particular)
	Fuel thermal-mechanics behavior	
	Core Safety	
Systems and components	Valves	VHTRs
	Sealing	
	Heat exchangers	
	Reactivity control systems	Other fast reactor technologies
Materials	Core materials – cladding, reflector, shielding	Other fast reactor technologies
	Structural materials of primary circuit	VHTRs
	Structural materials for the containment	VHTRs
Safety and reliability	Philisophy of passive safety	GENIII+ reactors
	Severe accident prevention and management	SFR
Thermal-hydraulics	Natural convection	Operating/operated gas-cooled reactors
Helium-related technologies	Coolant purification	(V)HTRs

SAFE-G PROJECT (H2020)

- **Recieved funding from the Euratom H2020 programme NFRP-2019-2020-6**
- **Full name:**
  - Safety of GFRs through innovative materials, technologies and processes
- **Consortium:**
  - 15 organizations from 7 European countries + Japan

    VUJE(SK), STUBA(SK), UJV Rez(CZ), CVR(CZ), CTU(CZ), EK(HU), BME(HU), CEA(FR), NCBJ(PL), Cambridge U.(UK), AMRC(UK), WOOD(UK), BriVaTech(GER), Kyoto U.(JAP), Evalion(CZ)
- **Total budget: 4.5M€**
- **Duration: October 2020 – September 2024**
- **Work packages:**
  - Core design and safety
  - Innovative materials and technologies
  - Decay heat removal
  - Results integration, standardization and codes
  - Education and training

GFR/ALLEGRO R&D PROJECTS IN CZECHIA

- **Ongoing national R&D projects that include GFR/ALLEGRO:**
  - 9 ongoing projects in Czechia, one European project
  - 5 successfully finished

Name	Duration	Main goal	Total budget (M€)
NOVA	2018-2022	Development of sacrificial materials for core catchers of GFRs	0.7
REDEAL	2018-2024	Testing of construction materials in gaseous environments at extreme conditions (high temperature, corrosive environments)	1.3
MKM	2018-2024	Development of a new class of Zr based alloys and high entropy alloys with optimized properties for Nuclear industry	1.7
ALLEGRO	2018-2025	Design and testing of key systems and components for ALLEGRO	1.9
SODOMAHe	2019-2025	Stability and resistance of materials for high-temperature helium-cooled reactors	2.8
MATPRO	2020-2024	Development of "better concrete" for extreme conditions	0.7
KOBRA	2020-2023	Development of a passive safety systems for GFRs/VHTRs based on prolongation of primary compressor rundown by utilization of decay heat	1.3
PMATF	2020-2023	Methods for the characterization, testing, and qualification of irradiated samples of ATF materials	1.6
VELEMLOK	2022-2025	Development and testing of very-high temperature materials and prototyping of components	1.2
			Total: 13.2

COOPERATION ON THE PROJECTS

- **Czech Republic has solid capabilities in developing cutting-edge nuclear technologies**
  - Close cooperation of R&D companies, academia and the nuclear supply chain
  - Capability to develop a reactor project from the pre-conceptual phase to manufacturing of the components

No.	Abbreviation	Name	Type of organization
1	ATEKO	-	Manufacturer/Supplier
2	CTU	Czech Technical University in Prague	University
3	CU	Charles University	University
4	CVR	Research Center Rez	R&D Organization
5	SKP	Doosan Skoda Power	Manufacturer/Supplier
6	IIC CAS	Institute of Inorganic Chemistry, CZ Academy of Sciences	Academia
7	IT CAS	Institute of Thermomechanics, CZ Academy of Sciences	Academia
8	MICO	Moravian Industrial Company	Supplier
9	Skoda JS	Skoda Nuclear Engineering	Supplier/research organization
10	SVUM	- (former National Institute of Material Research)	Private R&D Organization
11	TUL	Technical University Liberec	University
12	UCT	University of Chemical Technology in Prague	University
13	UJV	- (Former Nuclear Research Institute)	Private R&D Organization
14	UJP	- (former National Institute of Nuclear Fuels)	Private R&D Organization
15	UWB	University of West Bohemia in Pilsen	University

GFR R&D PROJECTS -> R&D PROGRAM

- **New projects are formulated based on a wider picture of both the finished and ongoing activities**
- Utilization of synergies, newly acquired know-how, new knowledge
- **Several R&D topics developed into more complex R&D programs**
  - **Development of components and systems**
    - Projects ALLEGRO, NOVA and MATPRO – development of systems and components accompanied by targeted material development
  - **Development, construction and operation of electrically heated GFR Mockup**
    - S-ALLEGRO facility in Pilsen, Czech Republic. Developed by CVR, ATEKO and UJV Rez, in operation since 2020
    - STU helium loop in Trnava, in operation since 2019
  - **Material research and development**
    - Projects SODOMAHe, REDEAL and MKM in synergy, Obtained knowledge being utilized in design of components for the GFR
  - **Helium technologies**
    - Consecutive projects TEQUILA, CIPERA, and REGNET dealing with coolant purification and helium sealing, each with increasing level of detailed and enlarged scope, utilizing the HTHL facility in Rez

S-ALLEGRO MOCKUP AND STU HELIUM LOOP

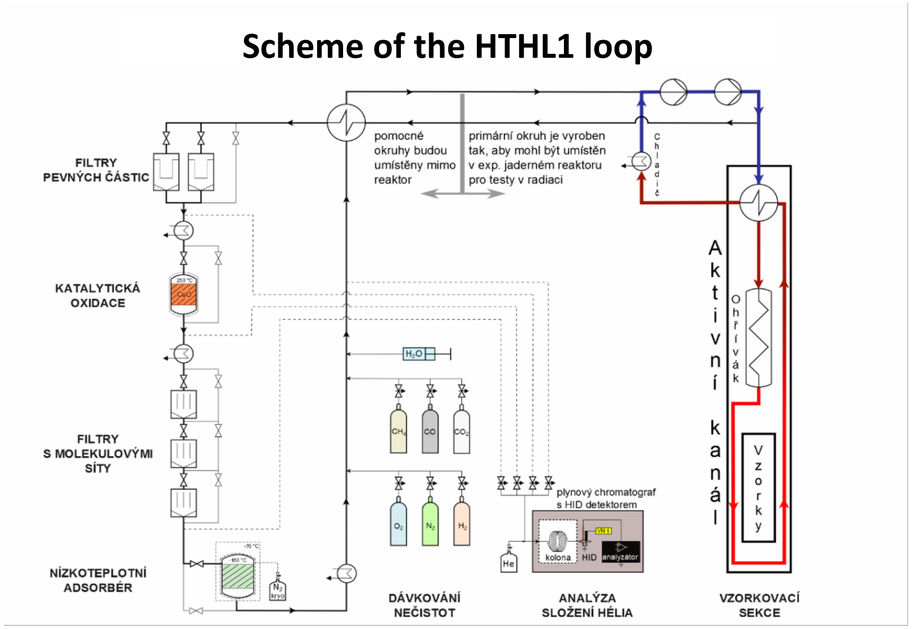
- **S-ALLEGRO**
  - Located in Pilsen, Czech Republic
  - Integral facility, electrically heated mock-up of ALLEGRO in 1/75 scale
  - Helium at 7 MPa, max. outlet T 850°C, max. power 1 MW
  - Available for both thermal-hydraulics experiments and out-of-pile testing of scaled-down components

- **STU helium loop**
  - Located in Trnava, Slovakia
  - He loop for studying natural circulation cooling
  - Helium at 7 MPa, max. outlet T 520°C, max power 220 kW

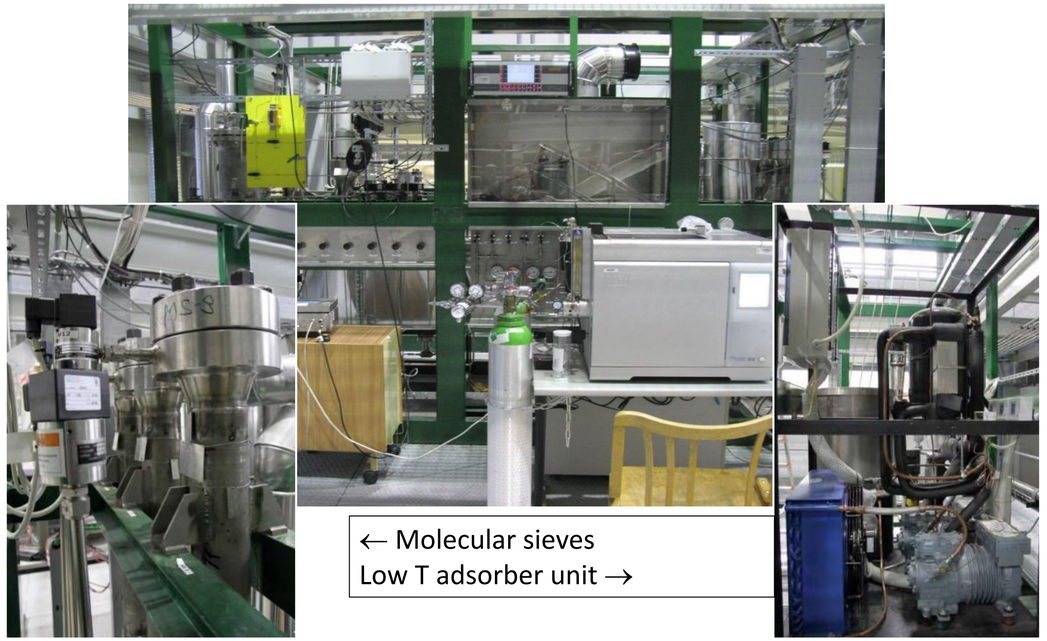
HELIUM TECHNOLOGIES R&D

- **Test-facilities for separation of impurities/gases from gaseous media**
- **Performance of Helium purification unit in the HTHL1 loop (CV Rez)**
  - Purification unit (H2, CO, CO2, CH4): Mech. filters, Room-T mol. sieves, CuO bed 250 °C, Adsorber -70 °C
  - Doping unit & Analytical unit (Gas chromatograph & optical hygrometer)
  - Out-off pile training facility

Scheme of the HTHL1 loop



View of the HTHL1 loop purification unit



← Molecular sieves
Low T adsorber unit →

Thank you for your attention!

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