Conclusions

Session 4: **Targets and Coupling experiments**

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About coupling experiments

• **Frédéric Mellier** in his « *overview of the achieved coupling experiments on zero power facilities* » has shown:

The interest of zero (or low) power experiments thanks to their

- flexibility (modular mock-up)
- the absence of thermal effects and fuel burn-up
- the rather simplicity of execution

He made a **review of the experiments performed since 1995** in the world

Status of Accelerator Driven Systems Research and Technology Development

About coupling experiments

Country	Project	Period	Facility	Operator	Type of facility	Core	Neutron source
Belarus	Yalina-Thermal	2000 - 2005	YALINA	JIPNR	Subcritical assembly (keff < 0,98)	Thermal	252Cf, Am-Be, D-D/D-T generator (NG-12-1)
	Yalina-Booster	2005 - 2008				Fast/Thermal	
Belgium	GUINEVERE, FREYA	2006 - 2016	VENUS-F	SCK	Zero power critical assembly	Fast	Am-Be, D-D/D-T generator (GENEPI 3C)
Brazil	-	2014	IPEN-MB-01	IPEN	Zero power critical assembly	Thermal	Am-Be
China	NBRPC	2005 -	VENUS-1	CIAE	Subcritical assembly (keff < 0,98)	Fast/Thermal	^{252}Cf, Am-Be, D-D/D-T generator (CIAE PNG)
France	MUSE-1	1995	MASURCA	CEA	Zero power critical assembly	Fast	^{252}Cf
	MUSE-2	1996					^{252}Cf
	MUSE-3	1998					D-T generator (Sodern Genie 26)
	MUSE-4	1999 - 2004					D-D/D-T generator (GENEPI 1)
India	-	2013 -	PURMINA BRAHMMA	BARC	Subcritical assembly (keff ~ 0,85 - 0,9)	Thermal	D-D/D-T generator (CIA PNG)
Italy	TRADE phase I (RACE-T)	2004 - 2006	ENEA RC-1	ENEA	TRIGA (1 MW MarkII)	Thermal	^{252}Cf
							Commercial D-T generator
Japan	FCA XX1-1	2001	FCA	JAEA	Zero power critical assembly	Fast	^{252}Cf + W test zone
Japan	KART, Lab project	2002 -	KUCA	KURRI	Zero power critical assembly	Thermal	D-D/D-Tgenerator
							100 MeV protons / W target
USA	RACE	2004 - 2007	ISU subcritical assembly	ISU-IAC, UNLV, UT, TAMU	Subcritical assembly (keff ~0,90)	Thermal	20-25 MeV electrons (LINAC) + W-Cu target
			UT NETL		TRIGA (1 MW Mark II)	Thermal	

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The **interest of zero (or low) power experiments** thanks to their

- flexibility (modular mock-up)
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He made a **review of the experiments performed since 1995** in the world => **strong impact of the FEAT experiment at CERN (1994)**

He focused on a few **major experimental programmes** MUSE, GUINEVERE/FREYA, YALINA, KUCA and their outcomes. **These experiments address(ed) mainly two kinds of needs**:

About coupling experiments

- **licensing a power facility to be constructed**: this was clearly presented by **Peter Baeten** in his talk about « *The GUINEVERE facility and associated experiment programs and outputs* »

He showed how the **pre-licensing and design of MYRRHA require to address some dedicated focus points** among which:

- sub-criticicality monitoring and control
- validation of nuclear data and neutronic codes

Since 2011 the GUINEVERE facility VENUS-F + GENEPI-3C **has hosted** experimental programmes **dedicated to these specific focus points** (**GUINEVERE, FREYA, MYRTE**)

➔ **Successful approach**: answers are there: **current to flux monitoring and absolute reactivity measurements during beam interruptions have been validated in representative conditions of MYRRHA**

About coupling experiments

• **a wide range of parametric measurements very usefull for benchmarking**: perfectly illustrated by **Song Hyun Kim** in « *Experimental benchmarks on Accelerator Driven System at Kyoto University Critical Assembly* »

Many published experiments were performed at the KUCA (Kyoto University Critical Assembly) facility :

- with two types of neutron source: 14 MeV (DT source) and spallation (100 MeV protons on a W target)
- core loaded with U5, Th232

Experiments with Minor Actinides, Pb-Bi, … foreseen

➔ **Both approaches improve the amount of available data useful for lead or lead-bismuth ADS feasibility studies or design or licensing**

About coupling experiments

• The talk by **Chao Liu** about « *Development Strategy & Progress of China LEAd-based Reactor (CLEAR)* » has confirmed that in any case:

If a country has defined a roadmap to develop innovative nuclear systems such as ADSs, with an intermediate power system (as CLEAR-I) **it will have to go through building experimental facilities**:

- **for technology**: validation of reactor components (CLEAR-S, lead alloy cooled system = non nuclear)
- **for neutronics**: physical test in reactor (CLEAR-0): sub-critical reactor + neutron source

➔ **Maybe several experiments look similar to your eyes BUT we have to keep in mind that experience gained at such test facilities cannot be bypassed. If one wants to build reactor, one has to design, to build, to measure, to model, to operate mock-ups, zero-power reactor, to build up one's own expertise.**

About Targets

• **Three talks to illustrate the different activities** around « targets »:

• **A completed experiment which successfully operated a spallation target prototype**: **Michael Wohlmuther** presented us « *MegaPIE and its post-irradiation examination* ».

The PIE brought **many results about the LBE itself and about the T91 window.** Today **we can take advantage of all the experience gained thanks to the MEGAPIE** experiment.

• **A spallation source under construction dedicated to « neutrons for science »** presented by **Rikard Linander** « *The ESS target design and beam raster system* ».

The target is **not designed for an ADS** but interesting issues concerning the accelerator-target interface are beeing addressed.

About Targets

• **Three talks to illustrate the different activities** around « targets »:

• **An ADS beam- spallation target interface under design: Takanori Sugawara** has presented the « *Beam window design for ADS systems in JAEA* ».

The introduction of 3 SAR (subcriticality adjustment rods) into the core of the 800 MW ADS under design allows the reduction of the maximum beam intensity to 10 mA. **In such condition a window can be envisaged.** Different analyses were performed and presented regarding to burn-up, particle transport, thermo-hydraulics, material structure, **supporting the feasibility of a window for the beam-target coupling**.

• At last, **Karel Samec** has presented « *A high power targets for an ADS* » : **taking into account all the experience gained from MEGAPIE and the EURISOL international projects, a new design for a high power target is proposed.**

Status of Accelerator Driven Systems Research and Technology Development

As a conclusion

- No doubts that we have got **many inputs to manage the two interface issues**:

  - beam/target

  - target or source/ reactor

- On both topics **experiments have brought some crucial answers** so that…

- We are **on the way to be able to build a more powerful ADS** (than a simple mock-up).

- Whatever ADSs would be developped for, **their feasibility issue, on target and coupling side, has made strong progress.**

- **Thanks again to all the speakers.**