Intersemester course			
Nuclear data			Contact hours: Assignment hours: Self-study hours:
Coordinator:EC-JRC-IRMM		EQF 7	3 ECTS
Upon completion of this course, participants will be able to:			
Learning outcomes	Knowledge	Outline the importance of neutron induced reactions for nuclear (energy) applications	
		Compare neutron sources and particle and radiation detection techniques	
		Explain nuclear data production by neutron activation and time-of-flight measurements	
		Compare nuclear data libraries	
		Apply nuclear data to nuclear reactor model calculations	
		Analyse the effect of nucear data on reactor parameters	
		Understand the basic uncertainty propagation principles	
	Skills	Conduct particle and radiation detection measurements	
		Conduct cross section measurements	
		Conduct nuclear system model calculation	
		Manage uncertainty propagation and sensitivity analysis	
	Competences	Be aware of the importance of nuclear data for nuclear (energy) applications	
Education method			
Face to face lectures, classroom and lab exercises, technical visits			
Assessment method			
	Continuous assessment		
Pre-requisites and mandatory literature			
DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Vol I (1993) GUM: Guide to the Expression of Uncertainty in Measurement (BIPM)			

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Topics

		GENTLE Partner	hours
1	**Nuclear physics for nuclear energy applications**	**(IRMM)**	**6,5**
	Importance of neutrons for nuclear applications	Lecture	1
	Neutron induced reactions and nuclear reaction models	Lecture	1
	Neutron sources	Lecture	1
	Nuclear detection techniques	Lecture	1,5
	Gamma-ray detection	Practice	2
2	**Production and use of nuclear data for neutron induced reactions**	**(IRMM)**	**6,5**
	Neutron activation measurements	Lecture	1
	Time-of-flight cross section measurements	Lecture	1,5
	Production and characterization of samples	Lecture	1
	Measurements at GELINA	Practice	1
	Exercise on analysis of cross section data	Exercise	3
3	**Nuclear data tools**	**(UPM)**	**3**
	Nuclear data format used worldwide	Lecture	1
	Nuclear data libraries	Lecture	1
	Processing of nuclear data	Exercise	1
4	**Introduction to the evaluation of uncertainties**	**(IRMM)**	**3,5**
	Evaluation of measurement of uncertainties	Lecture	1
	Adjusting to experimental data	Lecture	0,5
	Exercises	Exercise	1,5
5	**Nuclear reactor calculations**	**(SCK-CEN)**	**6,5**
	Introduction to nuclear reactors		1
	Deterministic neutron transport methods		1
	Monte Carlo based neutron transport methods		1
	Build a simplified model of BR1		2
	Analyse the effect of nuclear data on keff and reaction rates		1,5
6	**Methodologies for nuclear data uncertainty propagation in reactor calculations**	**(UPM)**	**6,5**
	Sensitivity-uncertainty (S/U) methodology		1
	Comparison of Monte Carlo and S/U methodology		1
	Examples of S/U applications for reactor systems		1
	Comparison of Monte Carlo and S/U in case of Beta decay		1,5
	Application to the BR1 reactor model		2

References

G.F. Knoll, Radiation Detection and Measurement, Wiley (2000)
P. Schillebeeckx et al., Nuclear Data Sheets 113, 3054 (2012)
DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Vol II (1993)

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D.G. Cacucci, Sensitivity and Uncertainty Analysis Theory, Chapman and Hall/CRC (2003)
http://www-nds.iaea.org (IAEA Nuclear Data Services)
http://www.oecd-nea.org/dbdata (OECD/NEA Data Bank services)
http://www.oecd-nea.org/janis (JANIS4.0 Java-based Nuclear Data Information System)

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Main lecturers	
photo	*Oscar Cabellos de Francisco (UPM)* *Oscar Cabellos obtained a Master in Mechanical and Power Engineering at the Polytechnical University of Madrid (UPM) in 1993. He got his PhD at UPM in 1998 and became member of the Institute of Nuclear Fusion in 1998. Since 2001 he is Associate Professor (Nuclear Physics and Nuclear Reactor Physics) in the Department of Nuclear Engineering (DIN). He is working at DIN in cross-section processing (consultant of OECD/NEA Data Bank), uncertainty and sensitivity analysis in activation and criticality calculations (member of UAM/NEA Data Bank working group and co-author of ACAB code).*
photo	*Jan Heyse (EC-JRC-IRMM)* *Jan Heyse holds a master in engineering (physics) and obtained his PhD at the university of Ghent in 2002, studying nuclear interaction at intermediate energies at the AGOR cyclotron at KVI in Groningen. He started his carreer at the EC-JRC-IRMM in Geel where he was involved in spontaneous and neutron induced fission measurements. From 2006 until 2010 he participated in the MYRRHA project as a researcher and project engineer of the Reactor Technology Research group of the Anvanced Nuclear Systems institute at SCK-CEN. Since 2010 he is again working at EC-JRC-IRMM where he is involved in neutron induced cross section measurements at the TOF-facility*
photo	*Peter Schillebeeckx (EC-JRC-IRMM)* *Peter Schillebeeckx obtained his PhD at the university of Ghent in 1988. He started his professional carrier at the Institute Lau Langevin where he was scientific responsible for gamma-ray spectrometers installed at the high flux reactors. In 1989 he joined the EC-JRC at Ispra. At the JRC Ispra he was scientific responsible for the development of measurement techniques for the Non Destructive Assay (NDA) of nuclear material based on active and passive neutron assay, gamma spectroscopy and calorimetry. Since 2001 he is working at the JRC IRMM in Geel where he is the scientific responsible for measurements at the TOF-facility GELINA with an emphasis on capture and total cross section measurements in the resonance region.*
photo	*Peter Siegler (EC-JRC-IRMM)* *P. Siegler obtained his PhD at the University Darmstadt, Germany in 1994 working on nuclear fission at the former CBNM (now IRMM) of the European Commission. In 1995 he joined the Japan Atomic Energy Research Institute in Tokai-mura on a fellowship in the Nuclear Data Center. In 1996 he started his work at the EC-JRC-IRMM in Geel on neutron transmission measurements at the TOF-facility GELINA. Since 2012 he is the technical responsible for the TOF-facility GELINA.*
photo	*Gert Van den Eynde (SCK-CEN)* *Gert Van den Eynde holds degrees of master in engineering (computer science) from Katholieke Universiteit Leuven, master in nuclear engineering from Université Libre de Bruxelles and obtained his PhD in the field of nuclear reactor physics at the Université Libre de Bruxelles in 2005. He has been a member of the MYRRHA Team at SCK•CEN since 1998 where he contributed to the neutronic reactor core design of MYRRHA*

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	Since 2006 he is head of the Nuclear Systems Physics group which deals with the neutronic analysis and safety analysis of various nuclear systems, among which MYRRHA, GUINEVERE and BR1. He is also a member of the SCK•CEN Academy and is responsible for the courses in the domain of nuclear reactor technology.	