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WORK PLAN FOR IMPROVING THE DARWIN2.3
DEPLETED MATERIAL BALANCE CALCULATION
CONCERNING SOME IMPORTANT ISOTOPES FOR
FUEL CYCLE

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- DARWIN2.3: reference package for fuel cycle applications – developed by CEA\DEN and its industrial partners
- Based on APOLLO2 / ERANOS2 for LWR / SFR deterministic neutron transport calculation, and DARWIN/PEPIN2 for depletion calculation
- Experimentally validated thanks to a large database of Post-Irradiation Experiment (UOX/MOX PWR, UOX BWR, MOX SFR)
- Points out some important nuclides for the fuel cycle for which the depletion calculation could be improved. Some isotopes have no available experimental validation

Post-Irradiation Experiment (PIE) : fuel pellet dissolution + chemical analysis



ATALANTE hot cell

Source: International conference
“ATALANTE 2016” record on cea.fr

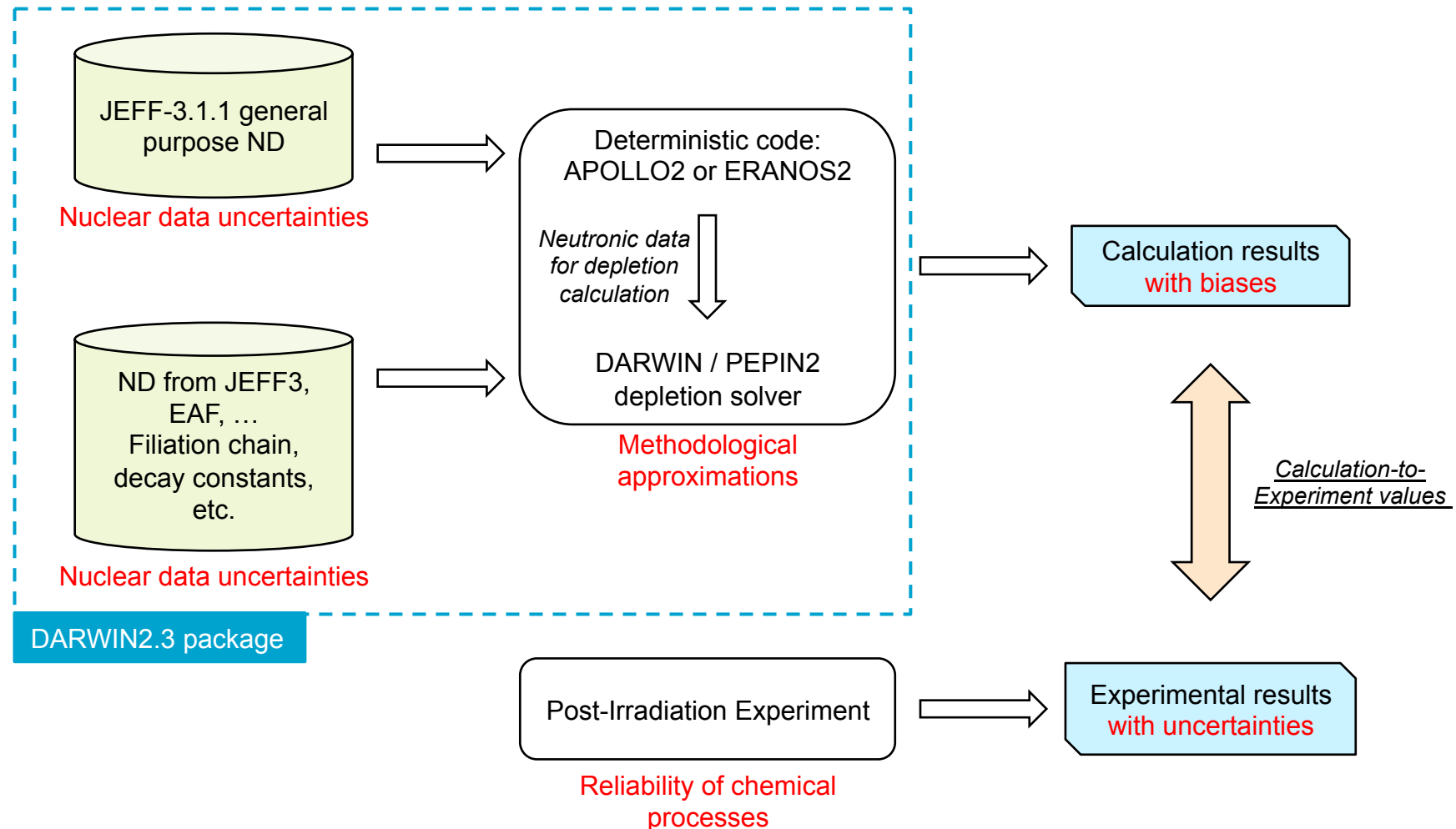
EXAMPLES OF NUCLIDES OF INTEREST

PWR	Burn-up (GWj/t)	244Cm/238U		154Eu/238U		137Cs/238U	
		(C-E)/E (in %)	σ (in %)	(C-E)/E (in %)	σ (in %)	(C-E)/E (in %)	σ (in %)
UOX Bugey Fessenheim 3.1% 235U	20			0.6	4.0	-3.5	2.1
	25					-5.4	2.0
	40	-6.8	6.7	6.3	3.8	-7.1	2.1
	50	-5.4	6.0			-4.7	2.0
	60					-5.6	2.3

Source: Experimental validation of the DARWIN2.3 package for fuel cycle applications, San-Felice et al., Nuclear Technology, 184, 2013

- Results from the experimental validation report for 3 important isotopes for fuel cycle
- Global tendency for UOX PWR calculation for these isotopes:
 - 244Cm: -6% \pm 6%
 - 154Eu: +6% \pm 2%
 - 137Cs: -4% \pm 2%

SOURCES OF BIASES AND UNCERTAINTIES



Verification Validation Uncertainty Quantification process to quantify the biases and uncertainties of a calculation package [?] Relies on precise methodologies to estimate (and reduce) methodological biases and improve nuclear data (use of the CONRAD code, developed at CEA)

■ **DARWIN2.3 methodological biases:**

- Recent advances in TRIPOLI4® enables carrying out depletion calculation
- Benchmark DARWIN2.3 / TRIPOLI4® to have an order of magnitude of modelling biases initiated

■ **Extension of the DARWIN2.3 experimental validation:**

- Some important nuclides for the fuel cycle have no available experimental validation (^{14}C , ^{36}Cl , ^{85}Kr , ...)
- Feasibility study of the CARMINA experimental program undertaken (CARbon Measurement for Induced Neutron Activation)

■ **Nuclear data improvement:**

- Assimilation of integral experiments results to reduce uncertainties and provide covariance matrixes
- example: ^{137}Cs systematically underestimated in UOX fuel