The French criticality CRISTAL package has many pertinent features [1]. One of them is the possibility to use now a Perturbation algorithm (so called MORET ‘Perturbation’ or MP) based on the Correlated Sampling Method (CSM) [2]. It allows to calculate easily and without more calculation time, the $K_{eff}$ of a benchmark and the effect (in $K_{eff}$ difference) of small perturbation on the data, especially atom densities and mixture concentration.

The calculation results of MP are validated by two kinds of comparisons:
1/ numerical comparison: $K_{eff}$ differences obtained by deterministic codes (APOLLO 2 2 Sn) or perturbation results obtained by Monte Carlo reference codes such as TRIPOLI4.2 or MCNP 4C,
2/ experimental comparison.

Numerical Validation
The same variation is put in a calculation case. For MORET 4, TRIPOLI4.2 or MCNP 4C, the same geometrical model is used. For Apollo 2 Sn, the 3D geometry is described in an equivalent 2D geometry, which gives a $K_{eff}$ near that obtained by Monte Carlo codes.

Experimental Validation
IRSN has a large data base of experiments made in Saclay and Valduc [3]. Recent Fission Products experiments are very accurate [4] (refer to this publication for the description and some results). In particular, experiments in the same driver array configurations and the same fission product solution only differ by this fission product mixture in the central tank. Thus the difference in water height $\Delta H$, which is the sub-critical approach parameter, is correlated to $K_{eff}$ difference. With the relationship $\Delta K/\Delta H$ for the experiments, it is easy to obtain the value $\Delta K$ of the perturbation resulting of changing a mixture by another one of the same fission product. An example is given thereafter with the 2811 and 2809 experiments performed with Cs solution with difference height $\Delta H = 29.83$ mm:
2811: Cs Concentration = 129,885 g/l, Acidity $H^+$ = 0.014N HNO$_3$, density $\rho = 1.1383$ g/cm$^3$,
2809: Cs Concentration = 76,286 g/l, Acidity $H^+$ = 0.014N HNO$_3$, density $\rho = 1.0809$ g/cm$^3$,
In the range of criticality height, $\Delta K/\Delta H = 20.31 \times 10^{-5}$ for 2811 and 22.57 $\times 10^{-5}$ for 2809.
Thus, $\Delta K$ experimental is between 606 and 673 $\times 10^{-5}$ while MORET Perturbation gives 656 or 689 $\times 10^{-5}$ depending on what is the mixture used for perturbation. The agreement is quite fair.

Systematic comparisons of experimental and calculated perturbations are going on with other cases (solution mixtures of same or different FP) in the same driver array (respectively 23x23-25, 23x25-25 and 25x25-25).

REFERENCES