FISSION PRODUCTS CREDIT FOR PWR MOX BURNUP CREDIT IMPLEMENTATION

L. JUTIER, S. EVO

IRSN (France)

E. GUILLOU, G. GRASSI

AREVA (France)

Faire avancer la sûreté nucléaire
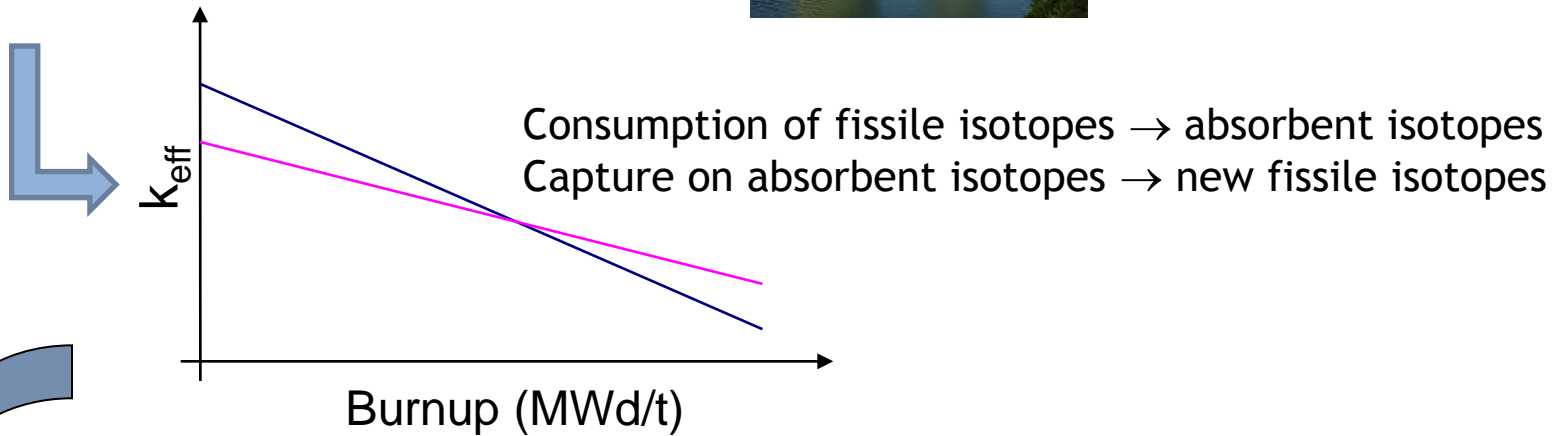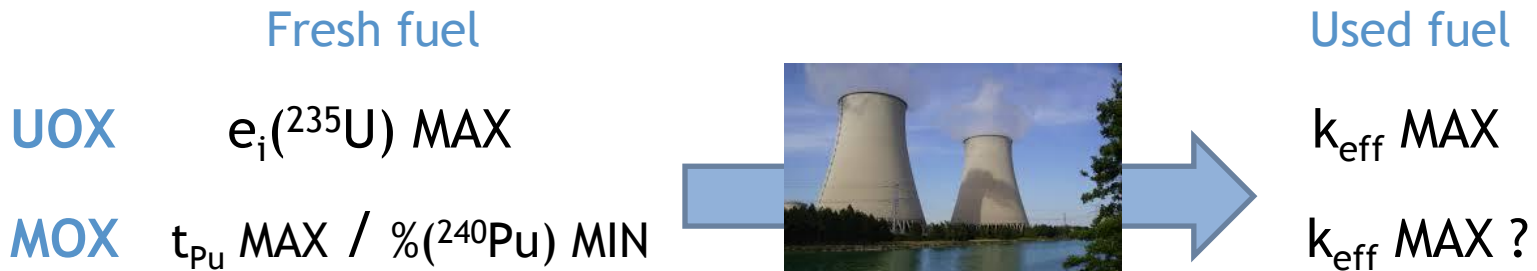
IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

OVERVIEW

▌ PWR MOX Burnup Credit context

▌ MOX fuel compositions database

▌ Calculation method and models

▌ Evolution of the fission products contribution to the reactivity decrease

▌ Fission products credit estimation

▌ Conclusion

PWR MOX Burnup Credit context

Fresh fuel   Used fuel

UOX $e_i(^{235}U)$ MAX k_{eff} MAX

MOX t_{Pu} MAX / $\%(^{240}Pu)$ MIN k_{eff} MAX ?

Consumption of fissile isotopes $\rightarrow$ absorbent isotopes
Capture on absorbent isotopes $\rightarrow$ new fissile isotopes

(y-axis: k_{eff} ; x-axis: Burnup (MWd/t))

Method to define a bounding plutonium vector for the fresh fuel that gives, after irradiation, the most reactive composition, whatever the irradiation history.   *J. Raby et al.* ICNC 2007
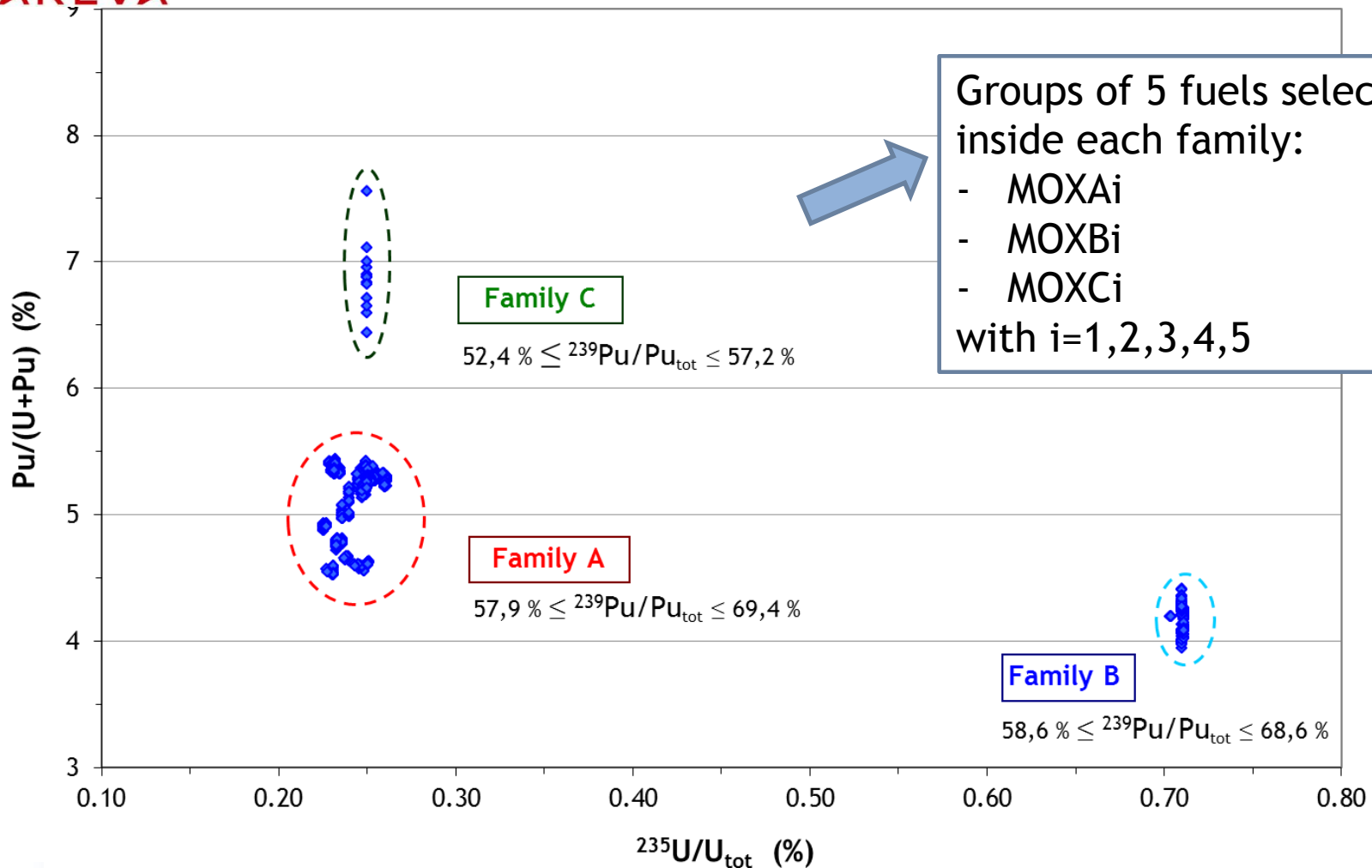
↗ **Goal = explore an alternative to the definition of a bounding plutonium vector for PWR MOX fuel for BUC implementation.**

MOX fuel compositions database

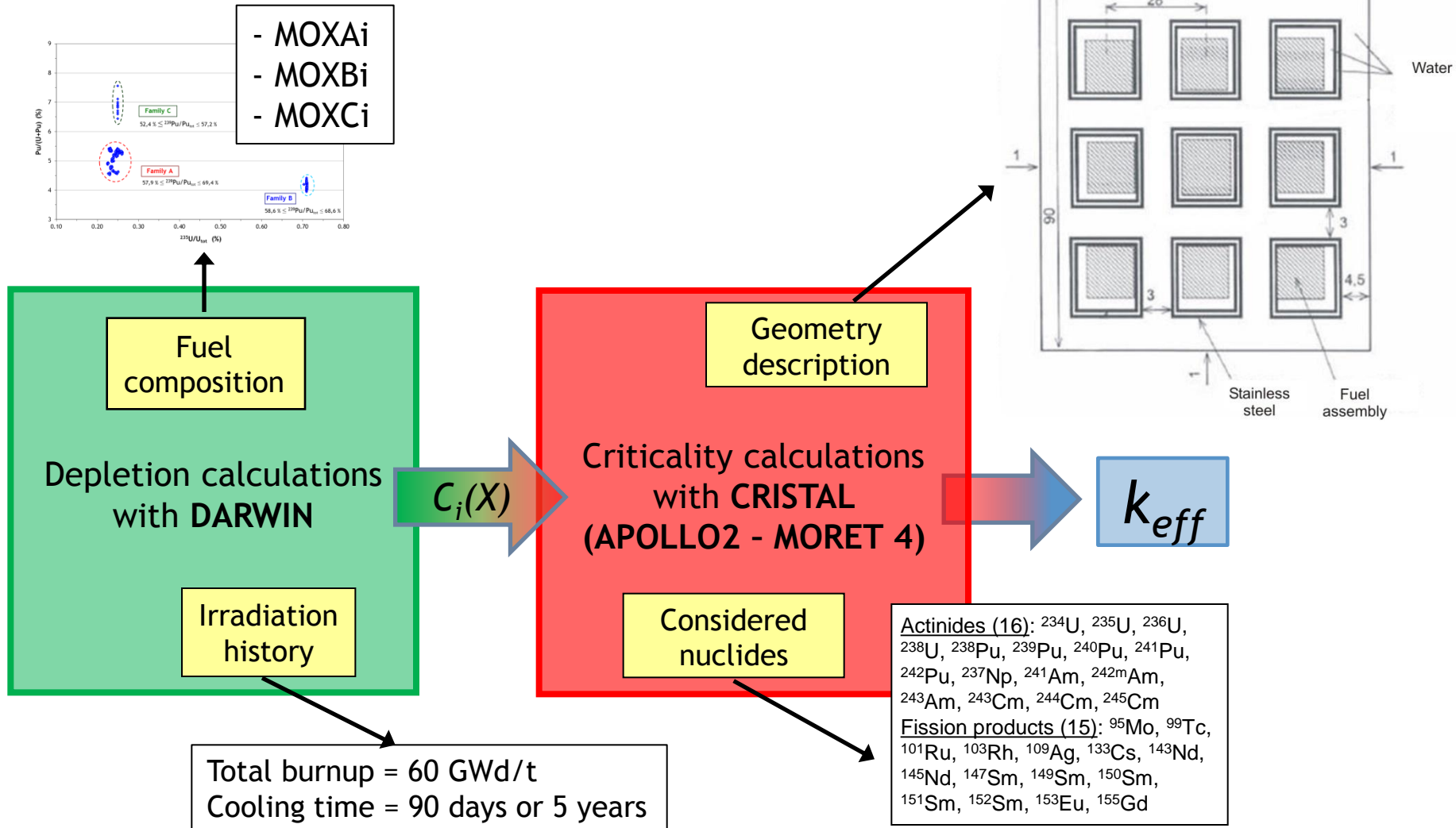↗ **AREVA** **database of PWR MOX fuel produced in France**

Groups of 5 fuels selected inside each family:
- MOXAi
- MOXBi
- MOXCi

with i=1,2,3,4,5

Family C

$52{,}4\,\% \leq {}^{239}Pu/Pu_{tot} \leq 57{,}2\,\%$

Family A

$57{,}9\,\% \leq {}^{239}Pu/Pu_{tot} \leq 69{,}4\,\%$

Family B

$58{,}6\,\% \leq {}^{239}Pu/Pu_{tot} \leq 68{,}6\,\%$

Pu/(U+Pu) (%)

${}^{235}U/U_{tot}$ (%)

Calculation method and models

- MOXAi
- MOXBi
- MOXCi

Fuel composition

Depletion calculations with DARWIN

$C_i(X)$

Geometry description

Criticality calculations with CRISTAL (APOLLO2 – MORET 4)

k_{eff}

Irradiation history

Considered nuclides

Total burnup = 60 GWd/t
Cooling time = 90 days or 5 years

Actinides (16): ^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{237}Np, ^{241}Am, ^{242m}Am, ^{243}Am, ^{243}Cm, ^{244}Cm, ^{245}Cm
Fission products (15): ^{95}Mo, ^{99}Tc, ^{101}Ru, ^{103}Rh, ^{109}Ag, ^{133}Cs, ^{143}Nd, ^{145}Nd, ^{147}Sm, ^{149}Sm, ^{150}Sm, ^{151}Sm, ^{152}Sm, ^{153}Eu, ^{155}Gd

Evolution of the fission products contribution to the reactivity decrease

↗ **Definitions**

2 criticality calculations performed:
- ✓ 1 with actinides (A)
- ✓ 1 with actinides and fission products (A+FP)

▌Actinides reactivity worth

$$\Delta k_{eff}^{\ BU}(A) = k_{eff}^{\ BU=0}(A) - k_{eff}^{\ BU}(A) \quad \times 10^5 \ \text{(pcm)}$$

▌Fission products reactivity worth

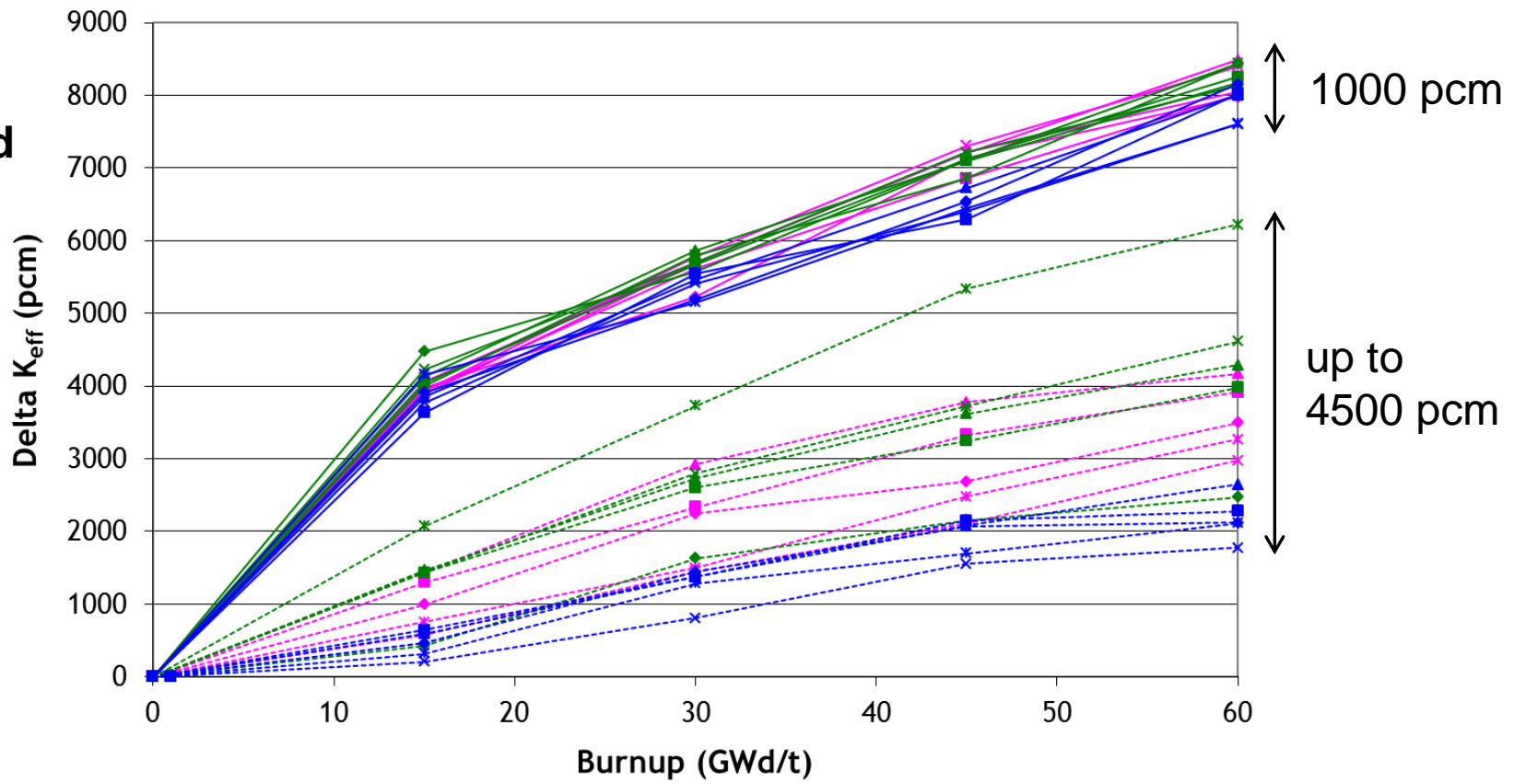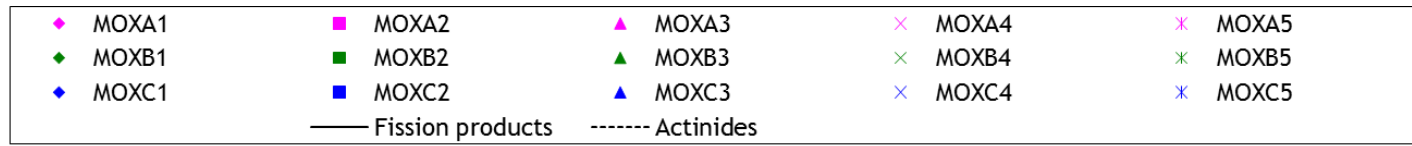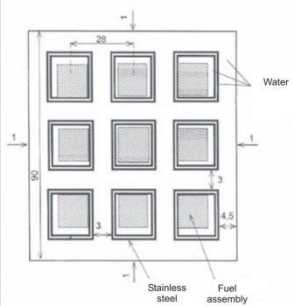$$\Delta k_{eff}^{\ BU}(FP) = k_{eff}^{\ BU}(A) - k_{eff}^{\ BU}(A+FP) \quad \times 10^5 \ \text{(pcm)}$$

Evolution of the fission products contribution to the reactivity decrease

↗ **Results**
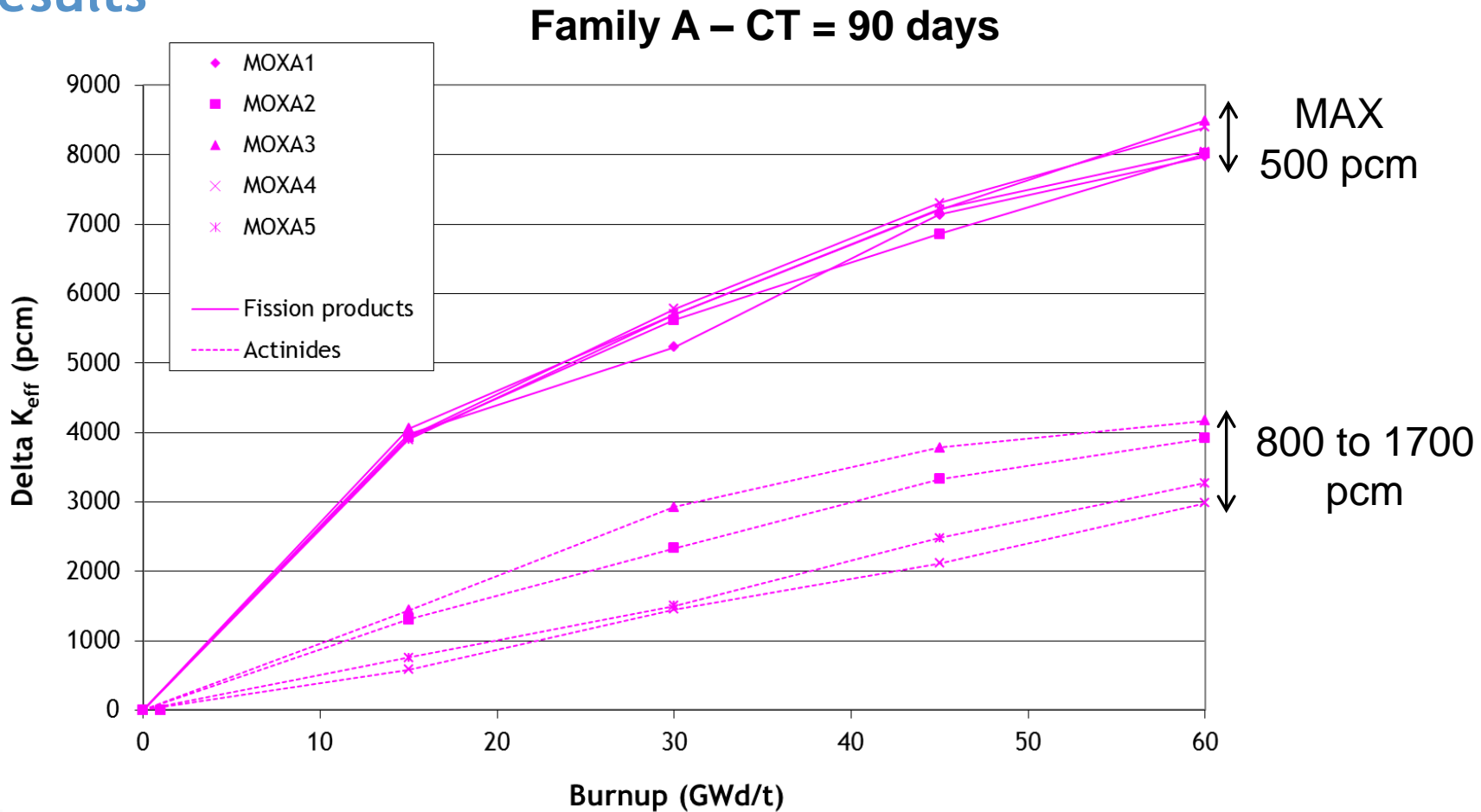
Family A – CT = 90 days

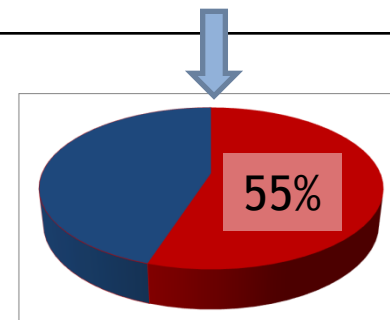# Evolution of the fission products contribution to the reactivity decrease

Evolution of the fission products contribution to the reactivity decrease
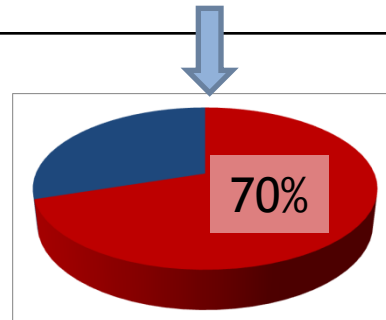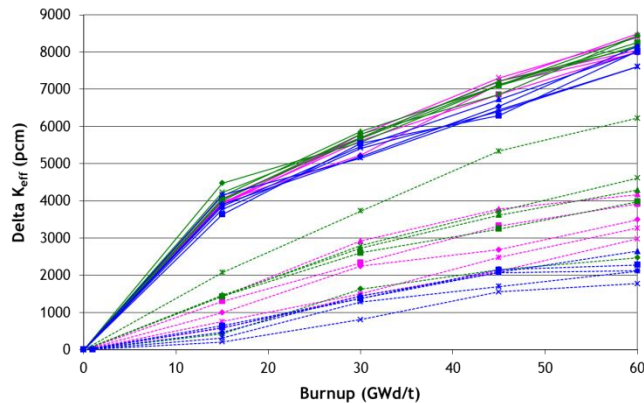
↗ **Influence of cooling time**

Family A – CT = 5 years
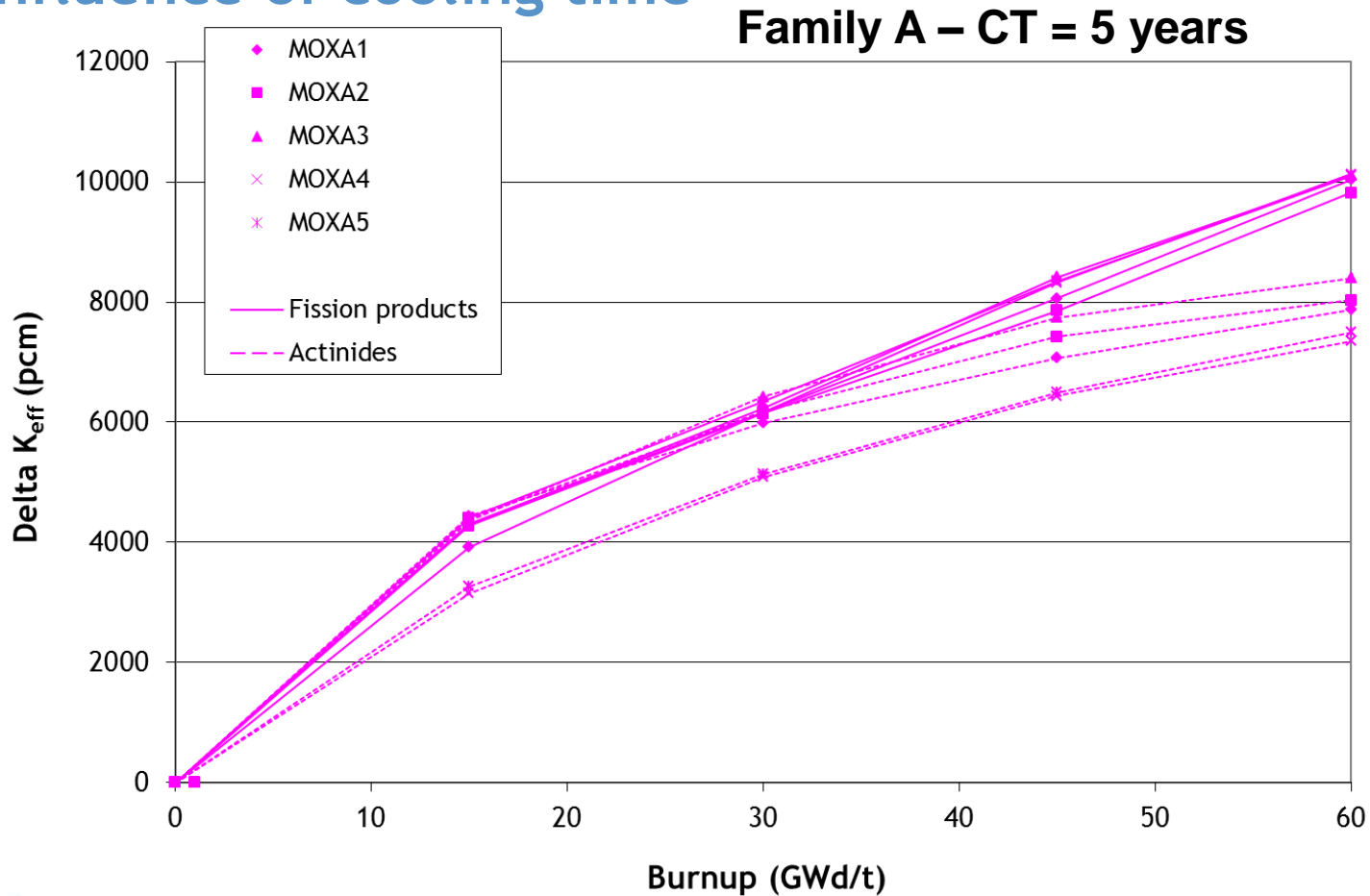
Fission products credit estimation

Fission products credit ×10^5 (pcm)	CT = 90 days	CT = 5 years
BU = 45 GWd/t	7000	8000
BU = 60 GWd/t	8000	10000

Total credit

 70%

 55%

Conclusion

Total credit

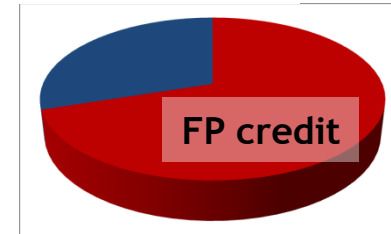FP credit

+

↗ **Fission products contribution to the reactivity decrease could be predicted without calculation by using an abacus.**

⚠ Depends on the geometric configuration

Biases need to be estimated to take into account the nuclear data validation as well as the codes validation