A global and flexible model for Sodium-cooled Fast Reactors in electro-nuclear scenarios

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A global and flexible model

- SFRs common in scenarios and strategies for the future of nuclear energy
- SFRs always use reprocessing

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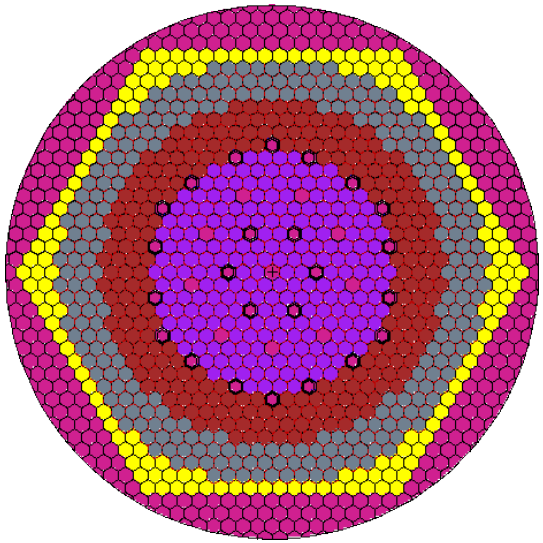
- No consensus on design / Several different designs used
- One model for each design would be impractical

$\Rightarrow$ single, physics-based, flexible model able to represent a wide range of designs.

A model based on the ESFR

What kind of possibilities we want to include inside our new model?



Based on ESFR (European Sodium Fast Reactor)

Add flexibility to the concept

- burners & breeders : $FIR \in [0.8; 1.6]$
- variable power : $P \in [900; 6500] MWth$

Able to simulate a wide range of SFR concepts

Right level of precision in simulations

We base our model on physics-based simulations made with SMURE
When we simulate the reactor, we do approximations.
What effect on the precision? Which ones are acceptable?

Approximation	k	Inventory EOC
Assembly Model	++	++
Homogeneous	$\sim$	0
Total multi-group	0	+
multi-group w/o U8	0	0
Time steps' nb	0	0
R zones' nb	0	+
Stat	0	0

Right level of precision in simulations

What design and fuel parameter have influence on the results?
Can we neglect the influence of some of parameter and don't sample in their direction?

Parameter	k	Breeder/Burner	Power
$< \%Pu >$	++	++	0
$\%Pu_{out} / < \%Pu >$	++	0	0
R (m)	+	+	++
H (m)	+	+	++
Blanket rings	0	++	0
Control Rods	++	0	0

Building of a Training Base

Training base size limits :

- Range of simulable designs
- Max precision of models trained on it (Multilayer Perceptron)

$\Rightarrow$

- To get good precision in numerical interpolation : 1500 random points with LHS
- 1500 Simulations with SMURE : 45 000 *h.proc*

Creating a database is long, using a wide range one save calculation time

Full core to punctual mono-energetic model

Physics-based simulations have several evolving cells (c) with different behaviours.

Numerical model train on punctual one energy group values. + Only fission, capture and (n,2n) XS are taken into account.

For each isotope we calculated average punctual one-group values :

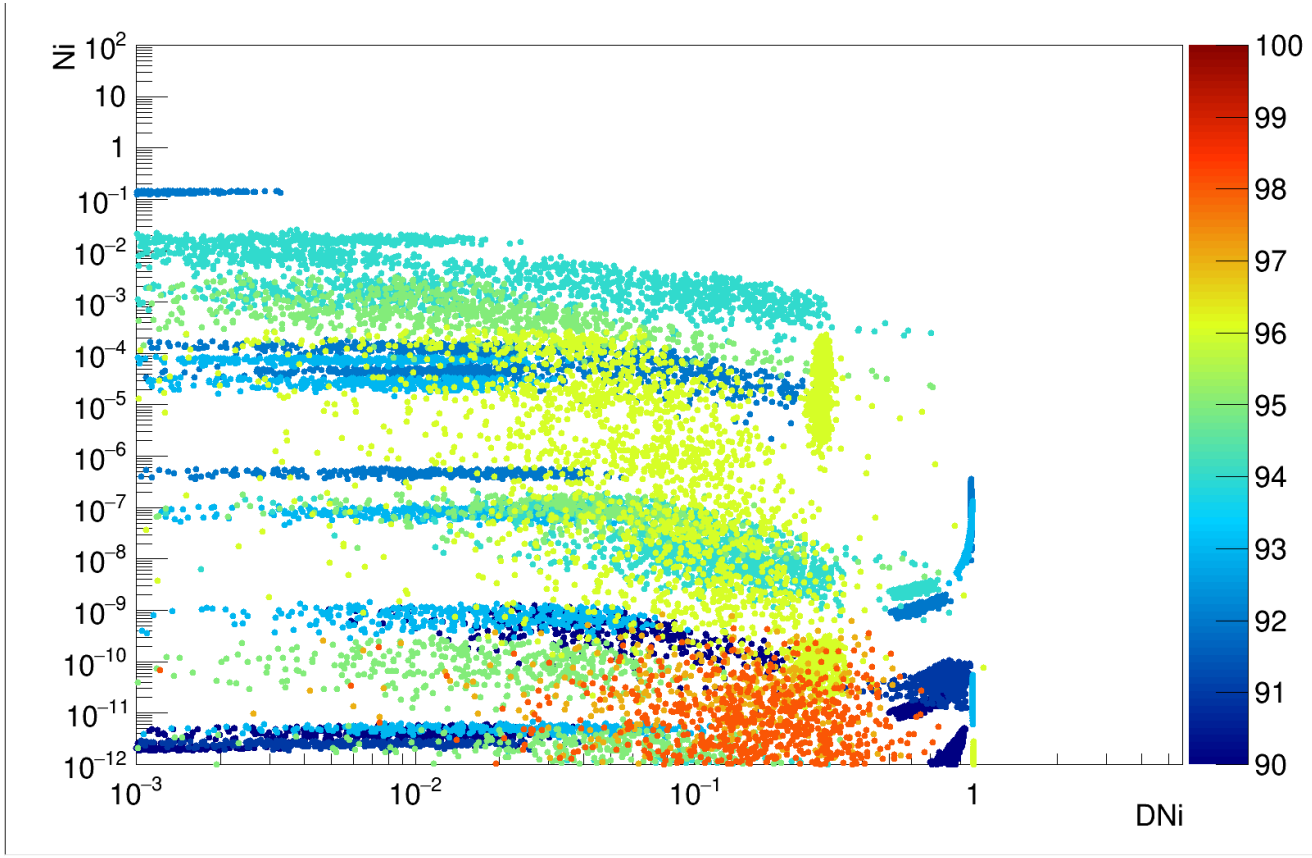
Inv $N_{tot} = \sum_c N_c$

Flux $\phi_{tot} = \sum_c \frac{\phi_c V_c}{V_{tot}}$

XS $RR_{tot} = \sum_c RR_c \Rightarrow \sigma_{tot} = \sum_c \frac{N_c \sigma_c \phi_c}{V_{tot}}$

Evaluation of precision in context of scenario

Recalculation of inventories using fitted XS :



Error on ^{238}Pu and ^{242}Pu 20% $\Rightarrow$ Far higher that design specific models.

Why these big errors? Physics approximations or over-simplifications?

Conclusions

Our flexible wide range SFR model has errors :

- due to approximations in the physics-based simulation,
- due to sampling of the parameters,
- due to conversion of physics-based model results for training purposes
- due to simplifications in the model in the fuel cycle code.

$\Rightarrow$ currently higher errors than existing models.

But the computation time saved by a global model is huge.

- Are these bigger errors worth the gain in time ?
- Is it possible to decrease these errors via changes in models?