Computational Nuclear Engineering Research Group

MODEL vs RECIPE

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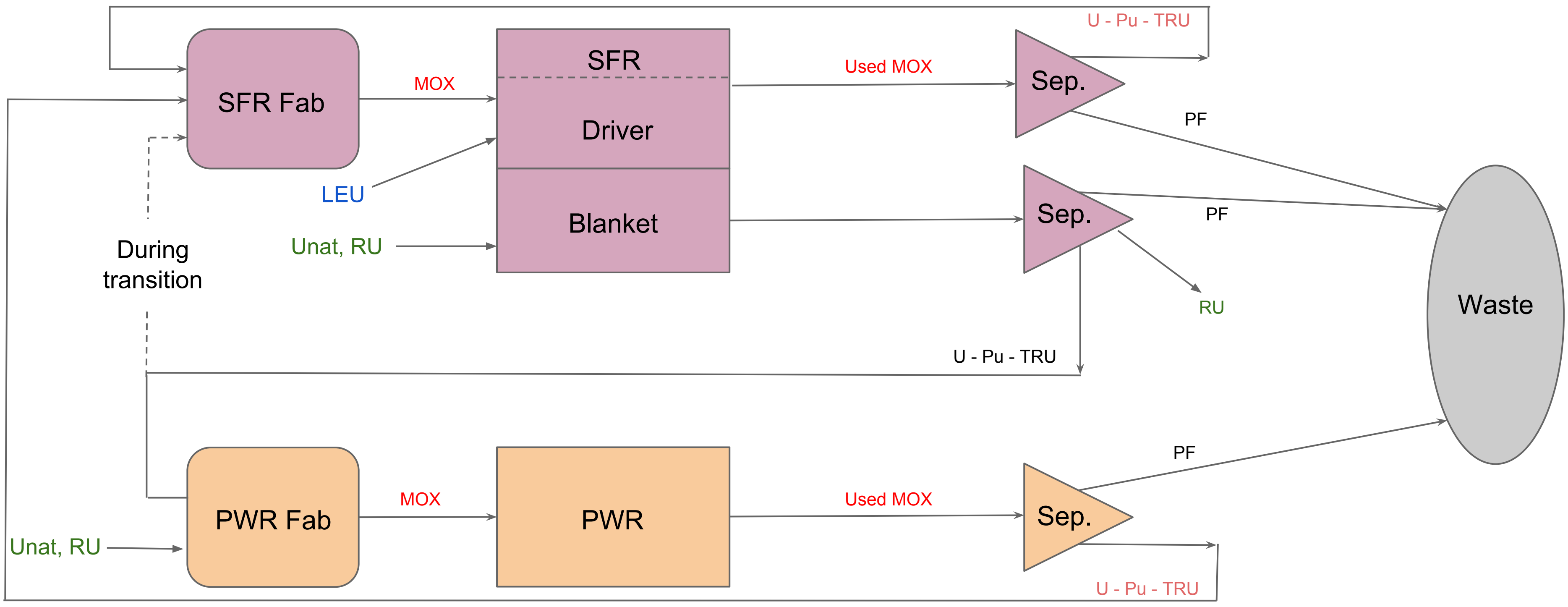
TECHNICAL WORKSHOP ON FUEL CYCLE SIMULATION
2017/07

Fuel Cycle: based on EG30



Simulation Option

"RECIPE"

- Decay: no
- Fuel compositions:
  - PWR: 1 recipe [1]
  - Blanket in/out:1 recipe [1]
  - SFR 5 pass transition recipes [1]
- Fuel fabrication: fixed fractions [1]
- Separation efficiency 0.98
- P(PWR)/P(SFR) = 0.213

[1] T. Fei et al., private communication. Argonne National Laboratory (2017).

Simulator: CYCLUS

"MODEL"

- Decay: yes/no (2 simulations)
- Fuel composition:
  - PWR: model + depletion
  - Blanket in/out:1 recipe
  - SFR: model + depletion
- Fuel fabrication: models
- Separation efficiency 0.98
- P(PWR)/P(SFR) = 0.213

Neural network based Models,:

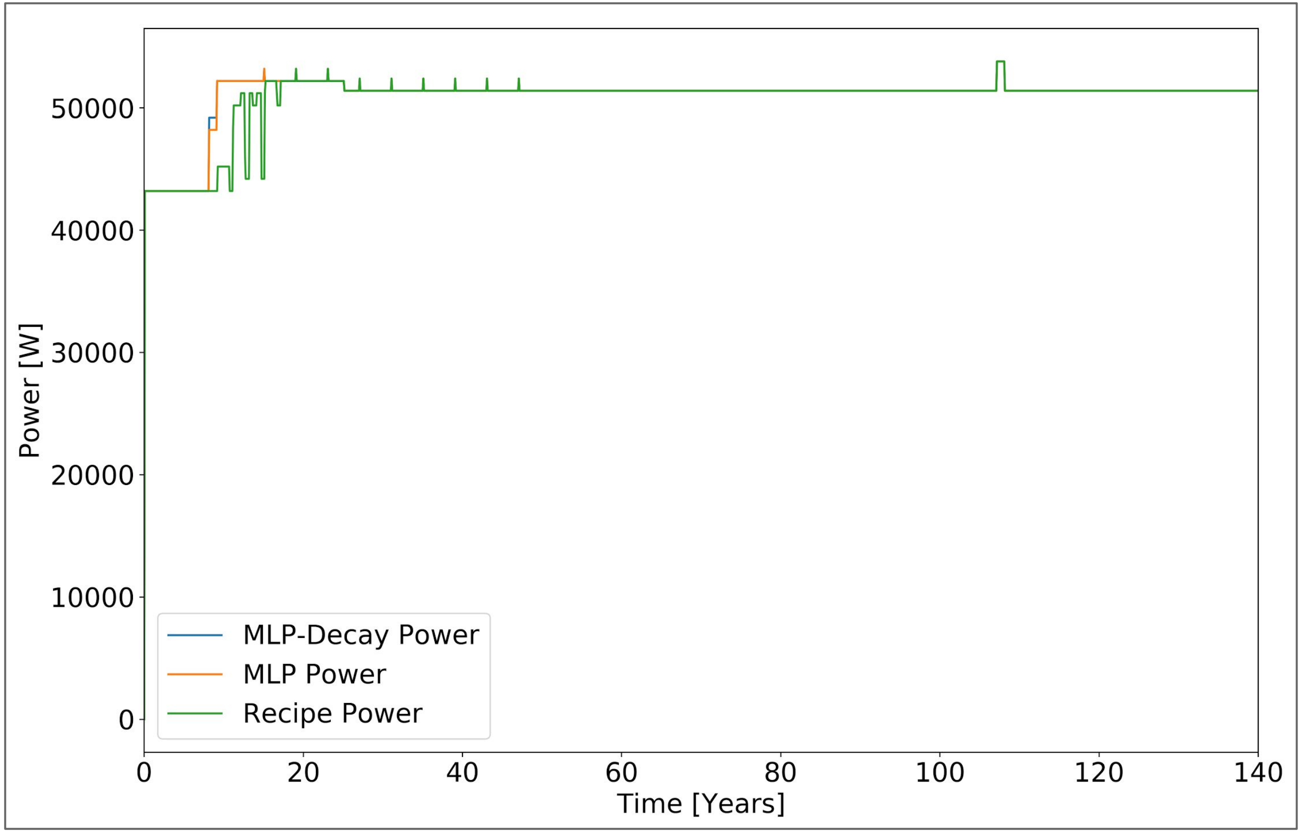
- Cross section as f(t)
- k_{inf} as f(t):
  - + Linear reactivity model/k_{inf} BoC
  - + $k_{threshold}$ (1.034 PWR/ 1.06 FBR)

B. Leniau, et al., "A neural network approach for burn-up calculation and its application to the dynamic fuel cycle code CLASS," Annals of Nuclear Energy, 81, (2015).

B. Leniau, et al., "Generation of FBR-Na physics models for the nuclear fuel cycle code CLASS", PHYSOR 2016, USA

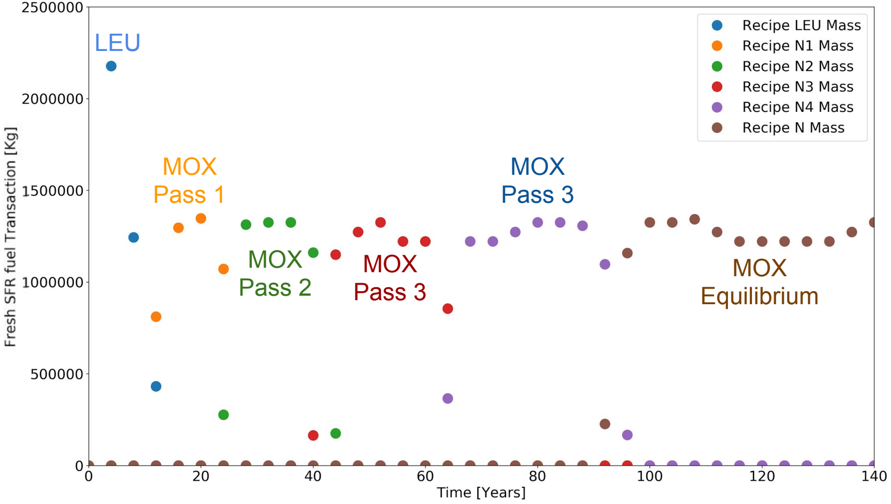
Thermal Power

- Lack of blanket TRU before 20y
- Overlap between decommission and start of reactors



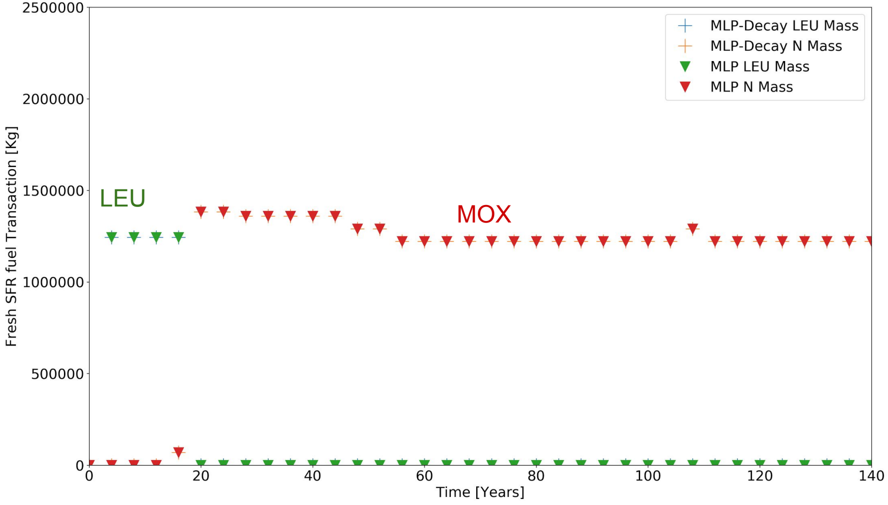
SFR - Driver Batches

RECIPE calculation



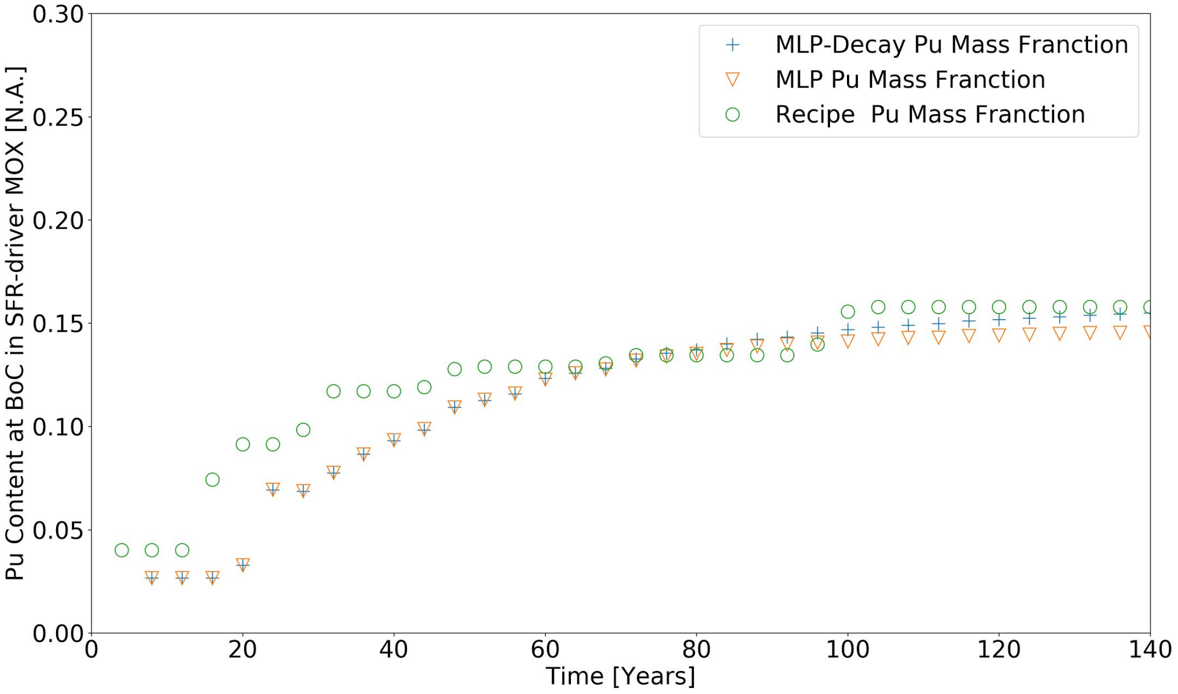
5 recipes pass: 5 differents Separation/fabrication loops

MODEL calculation



1 model : 1 Separation/fabrication loop

BoC: SFR fresh driver fuel composition



- Recipe: 6 different steps
- Model: smooth transition

- Overall lower Pu content in Model calculations, seems to reach the same equilibrium

-> fixing $k_{inf}(t=0)$ fix the Pu content

Material Used by SFR Driver Fuel Fab

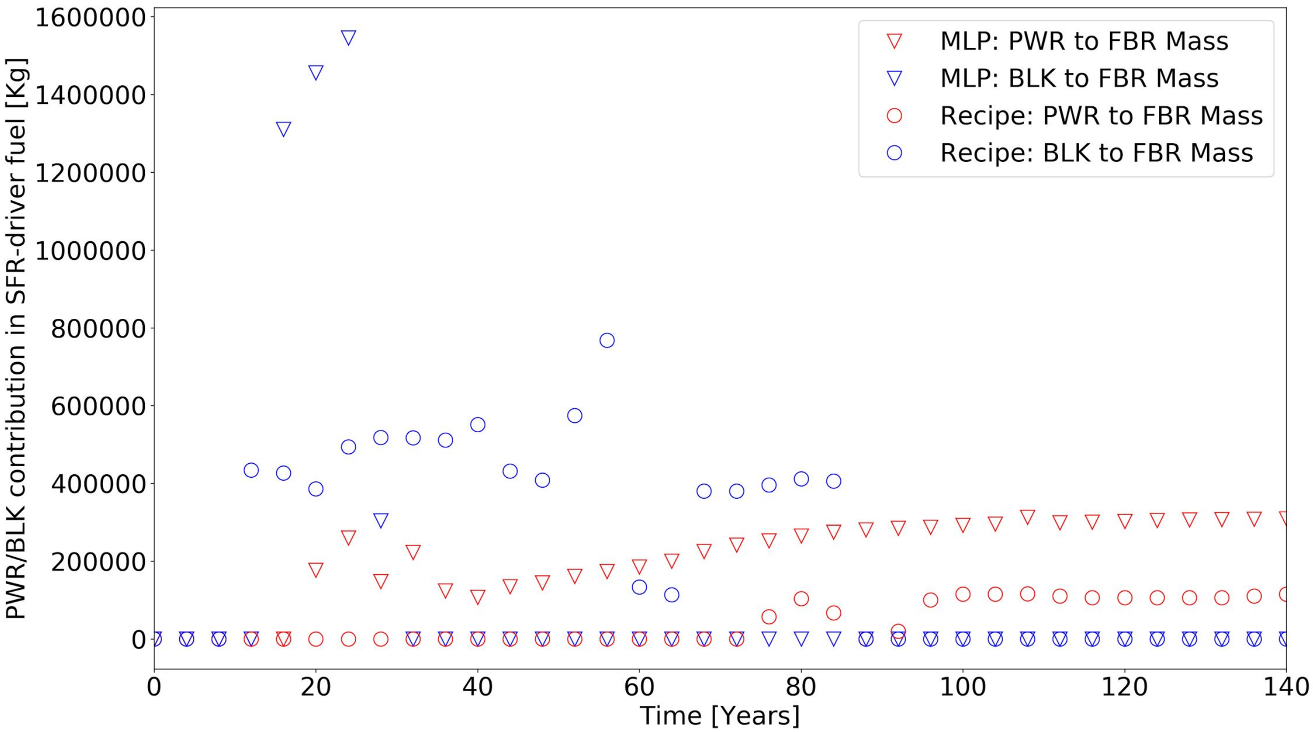
BLANKET-TRU required:

- Recipe: 85y
- Model: 30y

Transition to PWR-TRU:

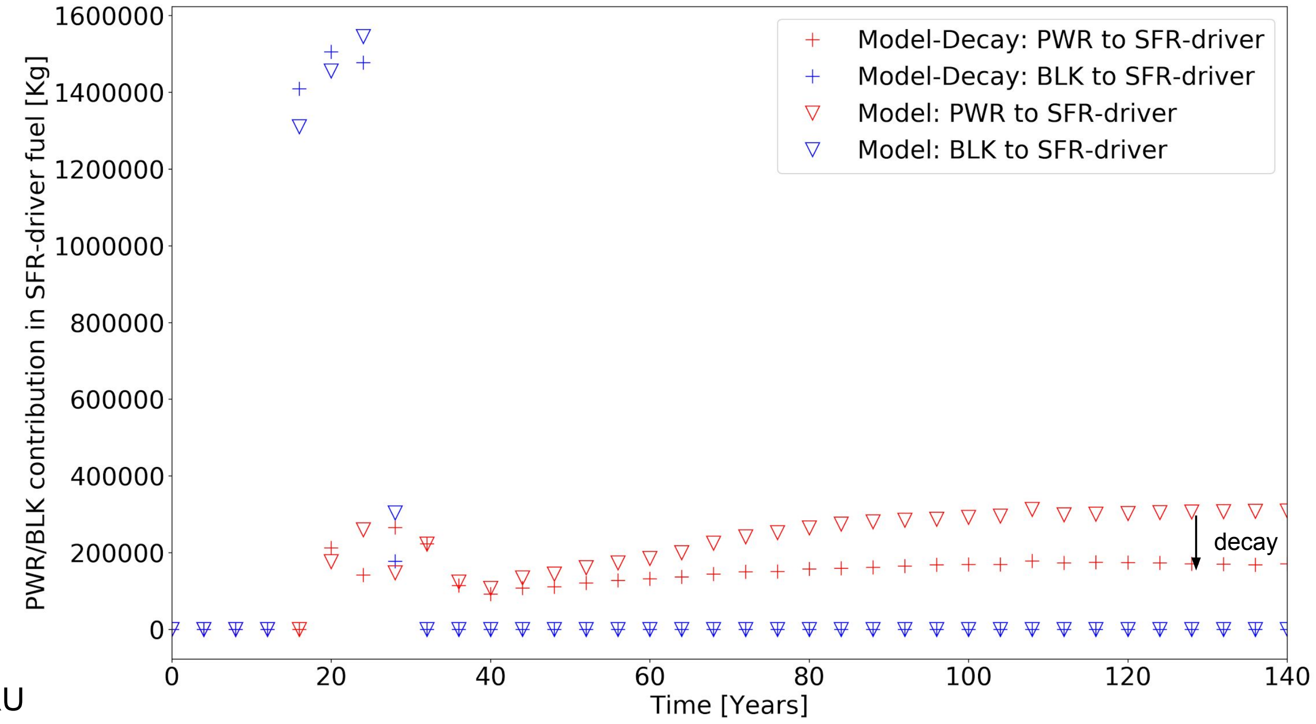
- Recipe: 90y
- Model: 35y

1. Recipe vs no-decay



Material Used by SFR Driver Fuel Fab

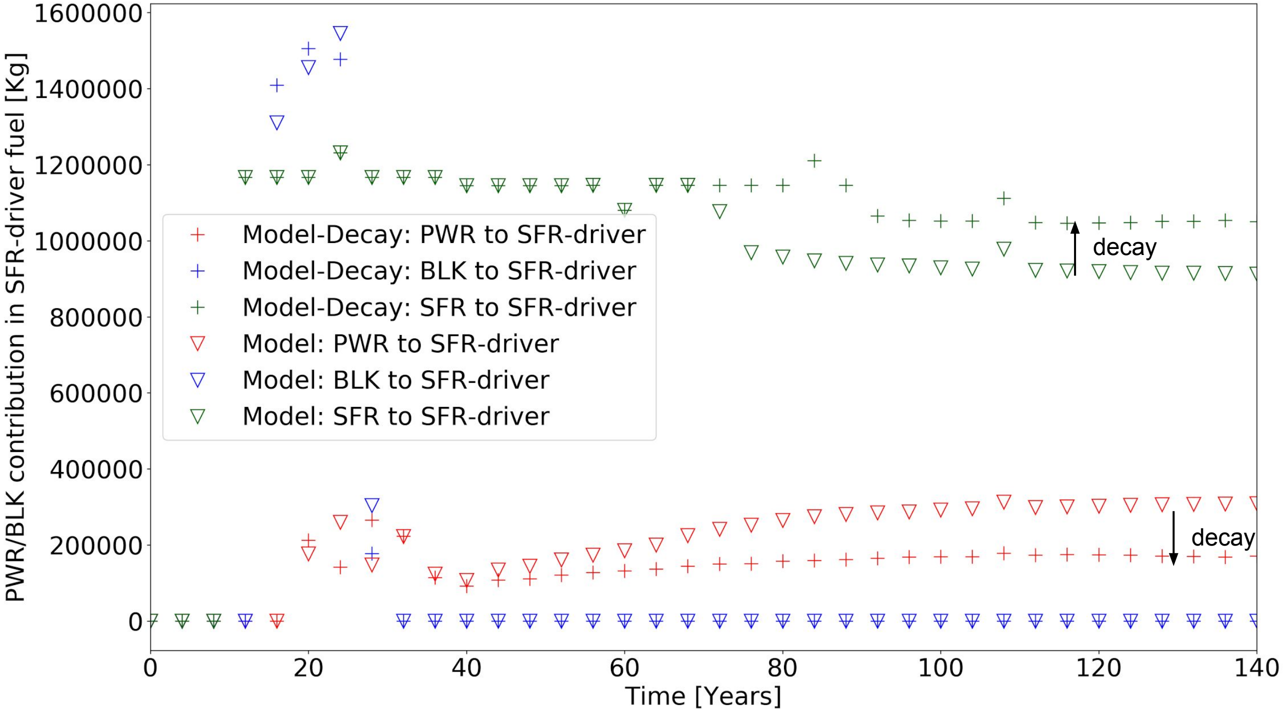
Model: decay vs no-decay



Decay reduce the need in PWR-TRU

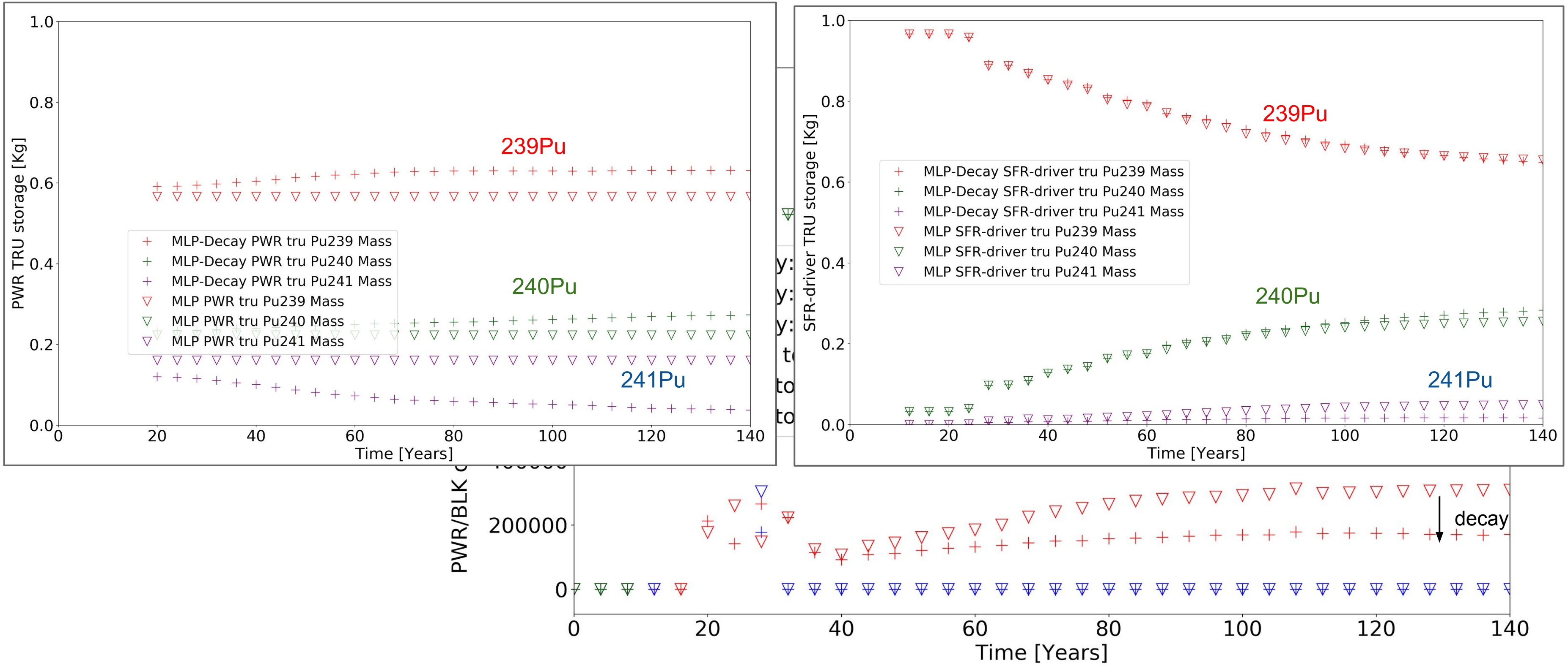
Material Used by SFR Driver Fuel Fab

Model: decay vs no-decay

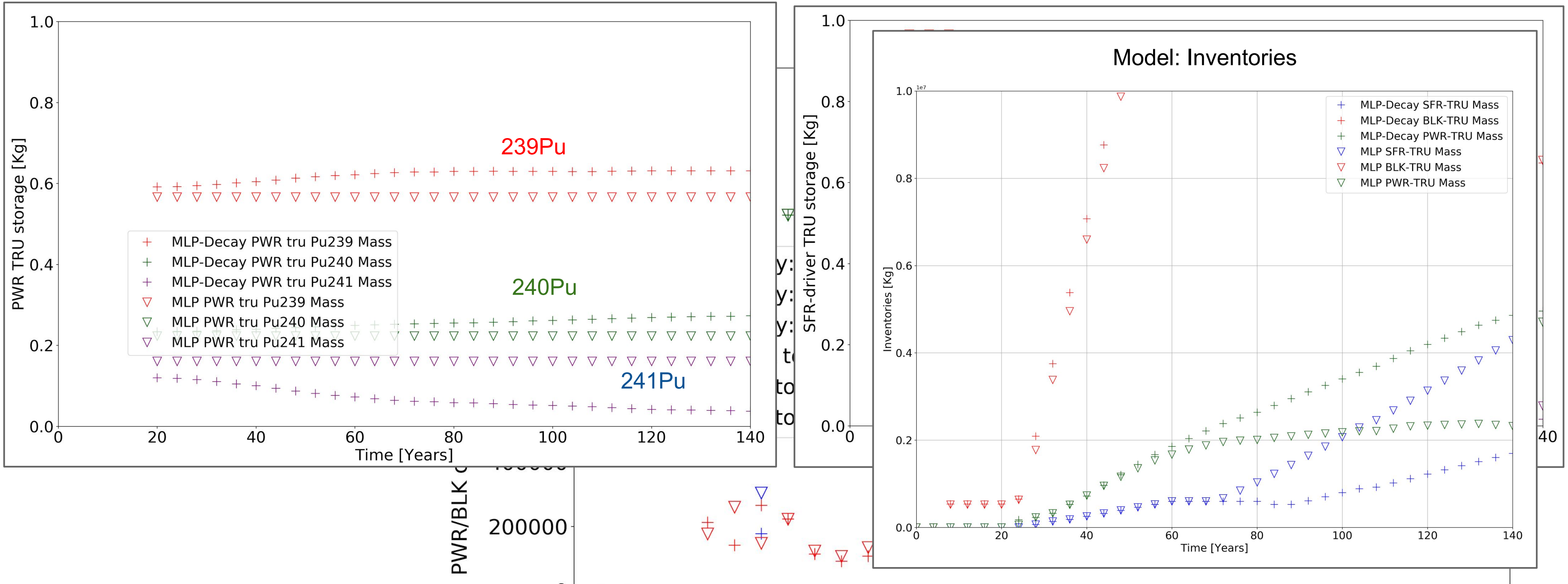


Decay reduce the need in PWR-TRU

PWR/SFR-driver inventories: Pu composition

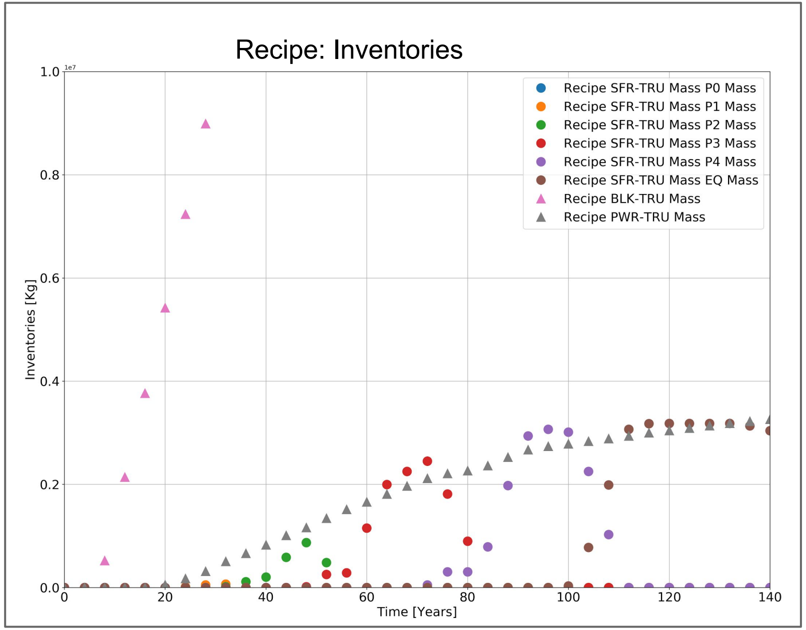


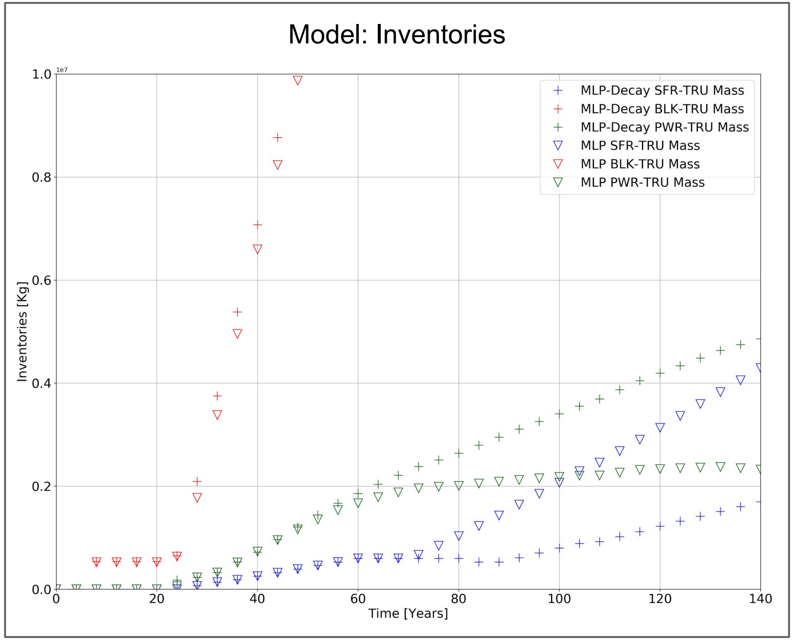
PWR/SFR-driver inventories: Pu composition



As we need use less PWR-TRU, it stay longer in storage...

Inventories





- Limited amount of used inventories,
- Well designed cycle

- Pile-up of SFR / PWR - TRU
- Faster transition (from blanket to PWR)

Conclusion

Recipe:

- Well designed fuel cycle
- Can miss the decay effect (unexpected pill-up…)

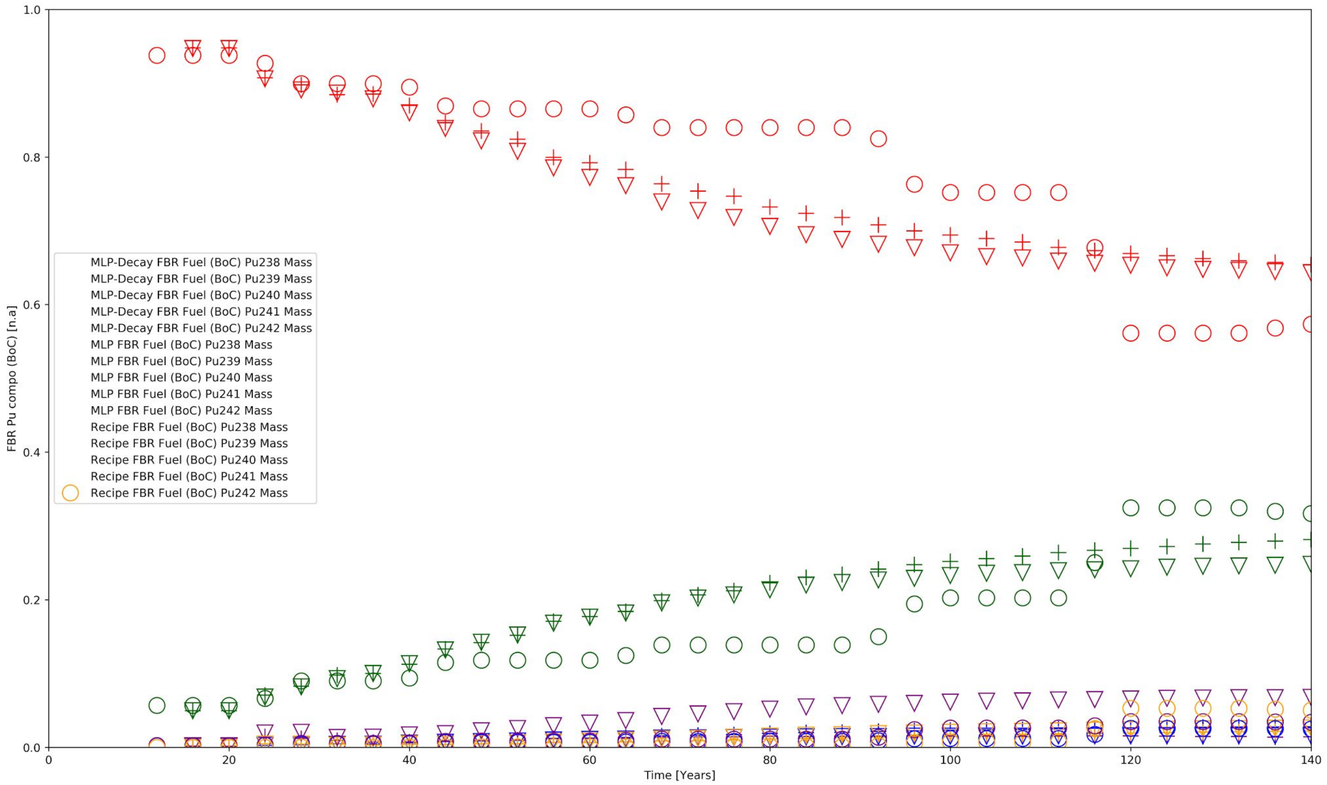
> Complex modeling choices up-front
> Approximation during the fuel cycle (limited decay effect…)

Model:

- Follows/tracks decay effect
- Less control on the fuel cycle (decisions made by the models)

> Up-front approximation: build a simplified model
> “Accurate” isotopic follow-up

Is the best modeling option depending on the study ?


1.0
0.8
0.6
0.4
0.2
0.0
FBR Pu compo (BoC) [n.a]
0
20
40
60
80
100
120
140
Time [Years]
MLP-Decay FBR Fuel (BoC) Pu238 Mass
MLP-Decay FBR Fuel (BoC) Pu239 Mass
MLP-Decay FBR Fuel (BoC) Pu240 Mass
MLP-Decay FBR Fuel (BoC) Pu241 Mass
MLP-Decay FBR Fuel (BoC) Pu242 Mass
MLP FBR Fuel (BoC) Pu238 Mass
MLP FBR Fuel (BoC) Pu239 Mass
MLP FBR Fuel (BoC) Pu240 Mass
MLP FBR Fuel (BoC) Pu241 Mass
MLP FBR Fuel (BoC) Pu242 Mass
Recipe FBR Fuel (BoC) Pu238 Mass
Recipe FBR Fuel (BoC) Pu239 Mass
Recipe FBR Fuel (BoC) Pu240 Mass
Recipe FBR Fuel (BoC) Pu241 Mass
Recipe FBR Fuel (BoC) Pu242 Mass