



Creating synthetic State declarations using Cyclus

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Introduction and Mission Relevance

Mission:

Improve data science techniques to process declarations to the IAEA

- Automate and improve efficiency of flagging inconsistencies

Challenge:

Real or realistic State Declarations not available to R&D community

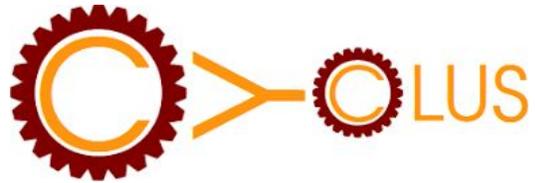
Objective:

Produce synthetic State Declarations

- Safeguards community could use for developing new analytical algorithms



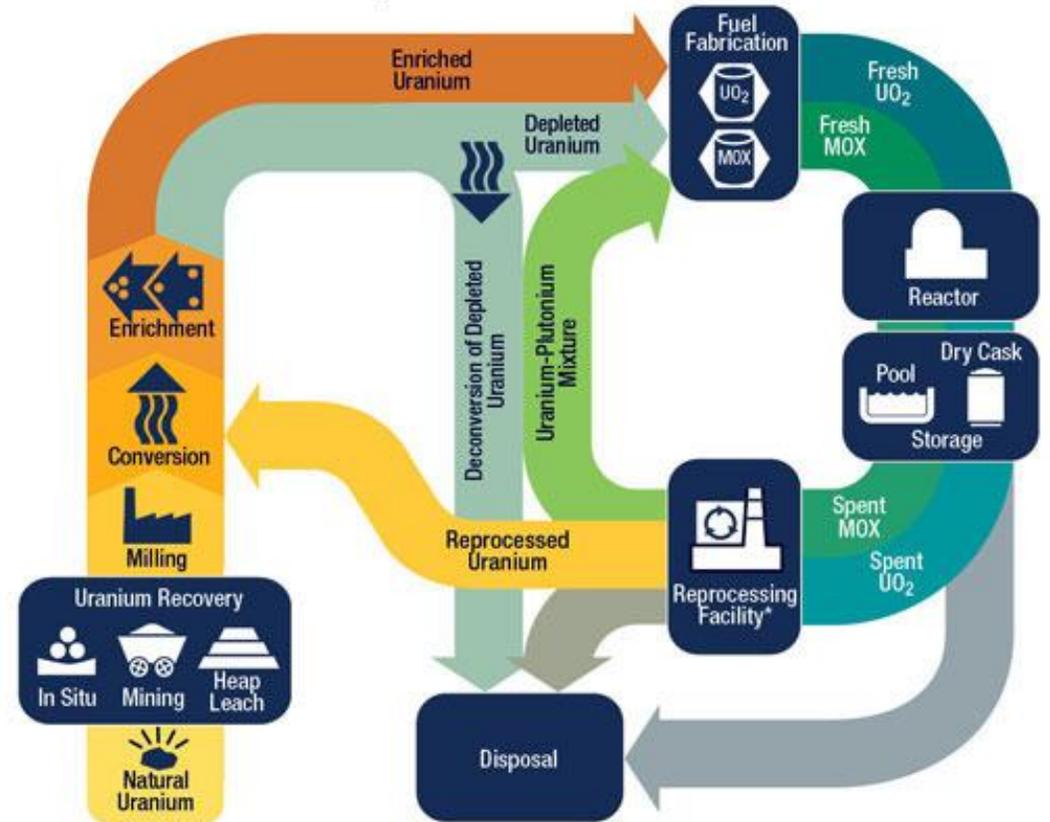
Technical Approach



- Is Cyclus the right tool?
- Can Cyclus adequately model the entire nuclear fuel cycle?

Built models of the fuel cycle with collaborators to determine applicability of Cyclus

The Nuclear Fuel Cycle



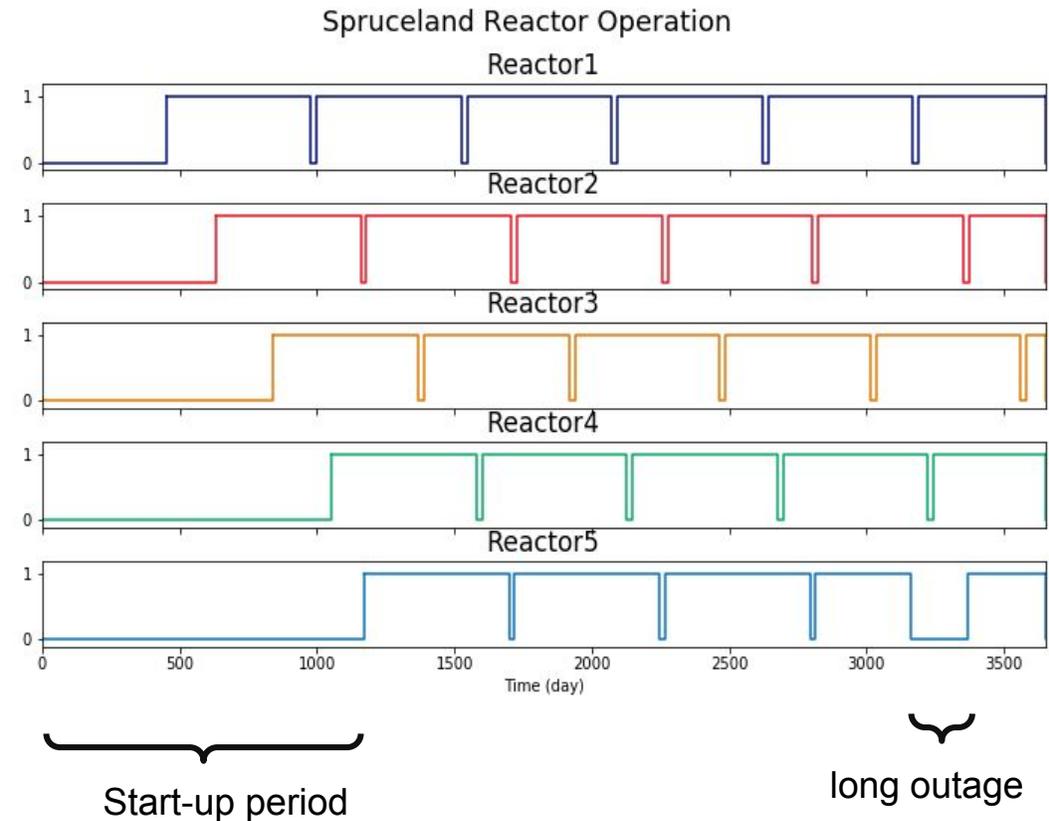
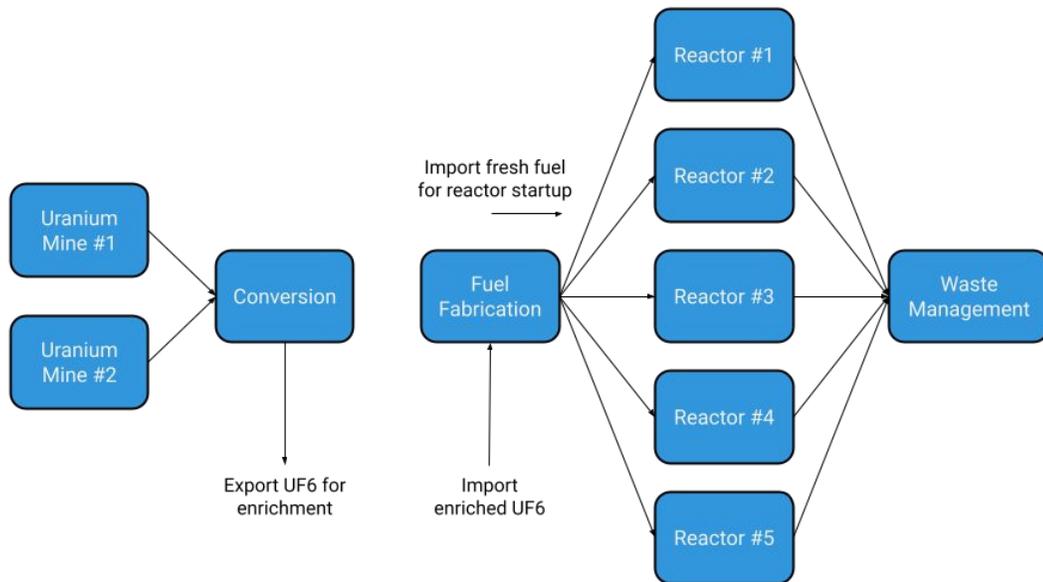
* Reprocessing of spent nuclear fuel, including mixed-oxide (MOX) fuel, is not practiced in the United States.
Note: The NRC has no regulatory role in mining uranium.

As of January 2019



Fictitious Case Study

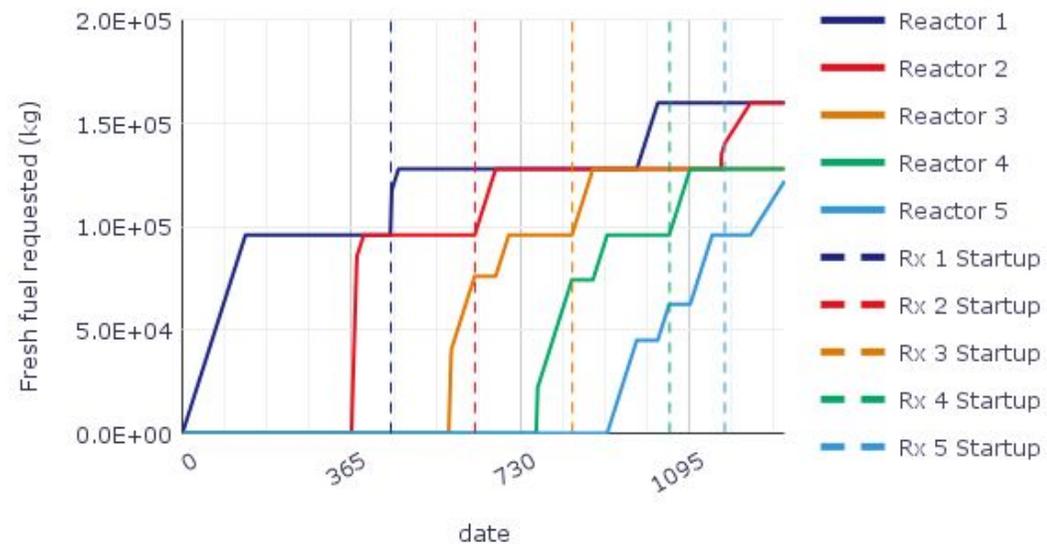
- Five AP-1000-style reactors started up over a ~four year period
- No domestic enrichment
 - must export UF6 and import enriched material



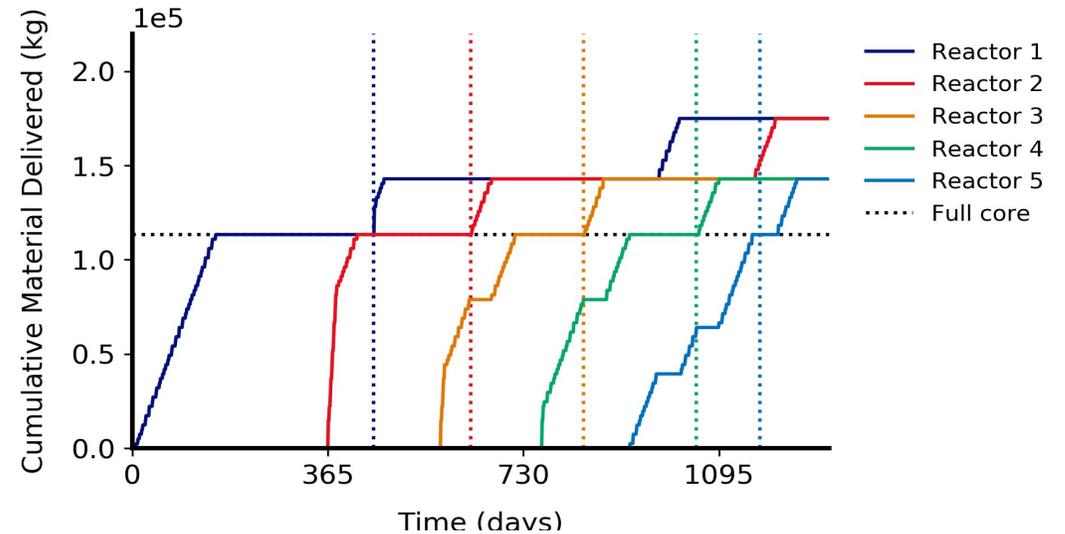
Fresh fuel supplied to reactors

- Given production constraints (kg/day) and limits on imports, Cyclus model performs exactly as expected

Expected cumulative fresh fuel supplied during startup

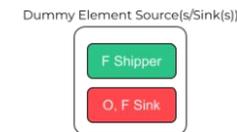
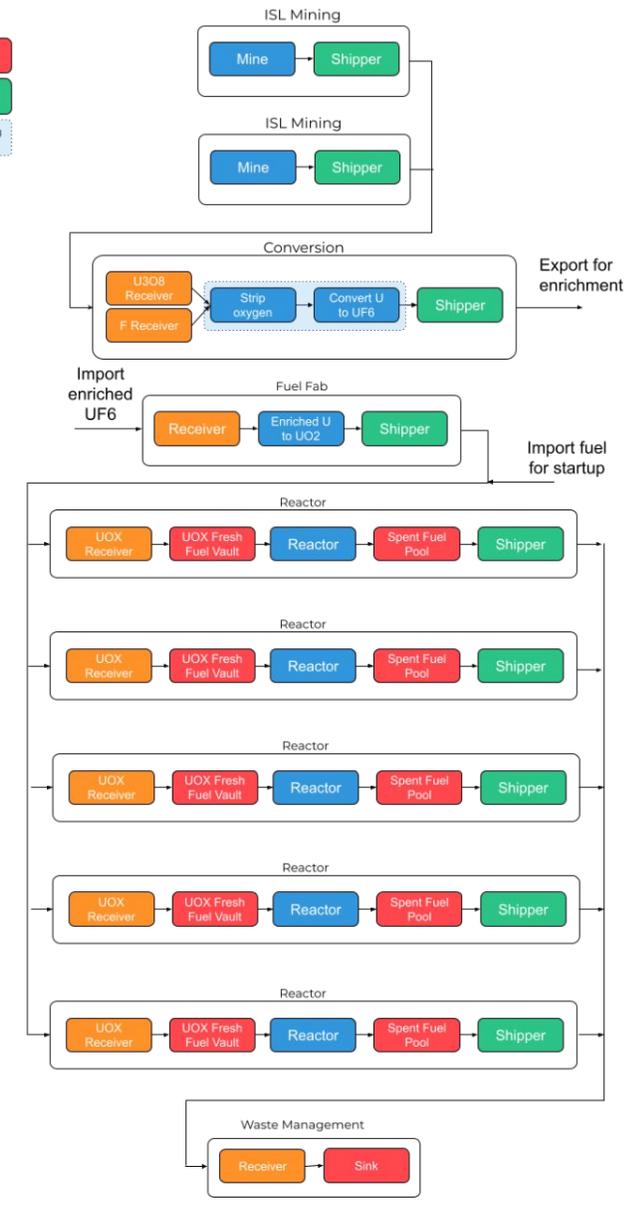
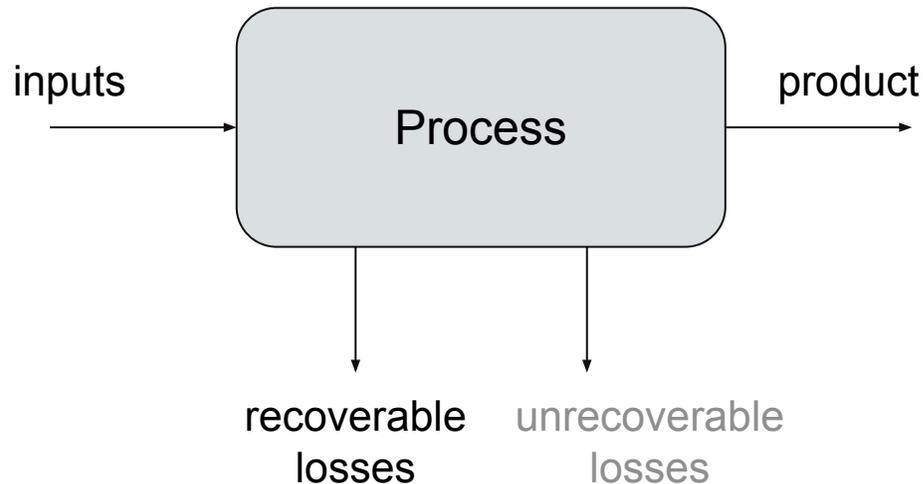


Cumulative Fresh Fuel Received During Reactor Startup Period



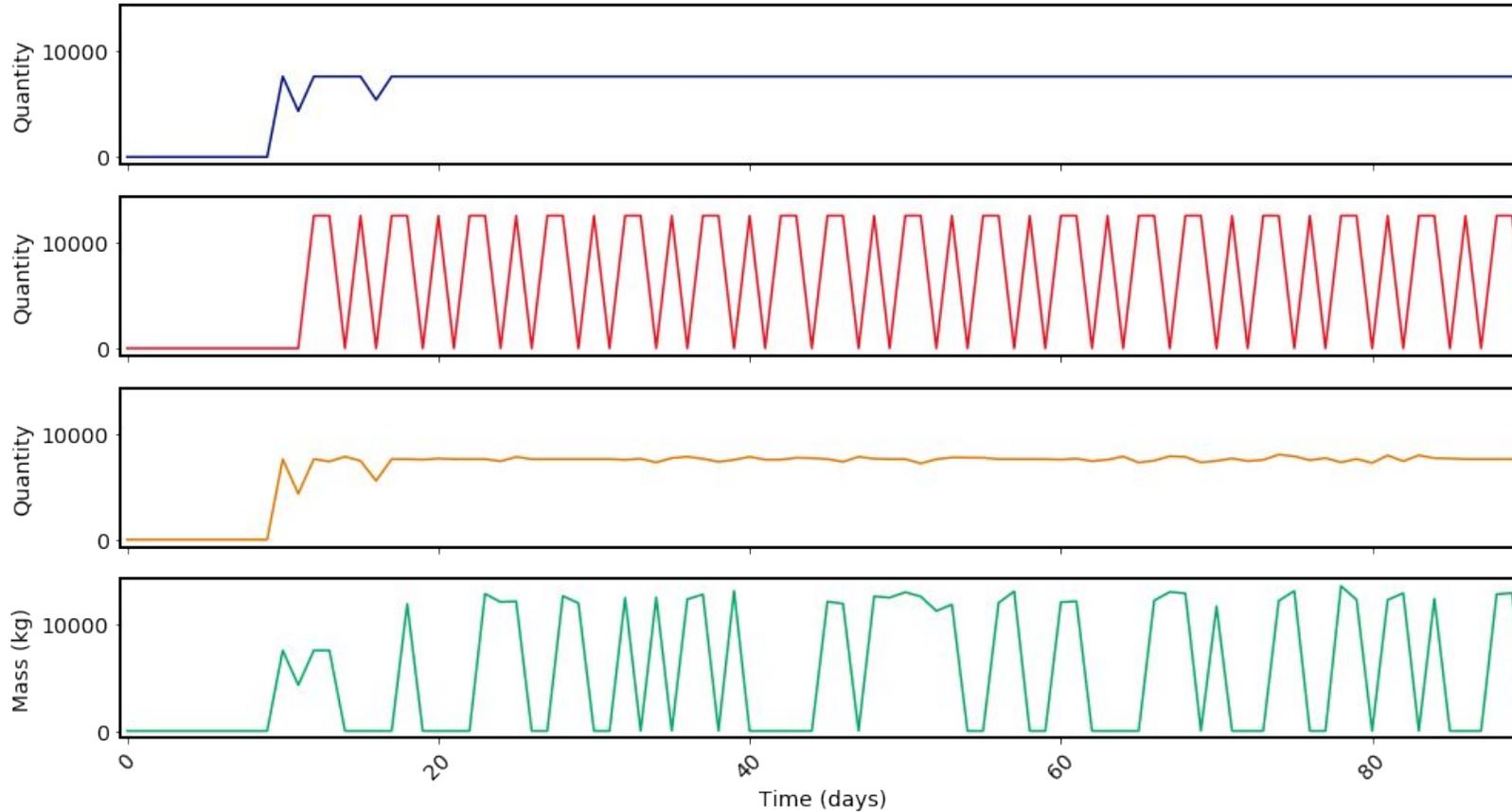
Adapting Cyclus to safeguards

- Facilities have multiple material balance areas (MBA)
- Safeguards style data recorded per MBA for each facility
- can be tracked at facility or MBA level



Moving towards “realistic” material movement

Spruceland UF6 exported



Regular export

Material exported in realistic quantities
(integer quantities of “1 truck worth”)

Constant request with random demand
(Gaussian)

Realistic export with random demand
(Gaussian)

MTV Impact

- Previous work developed out of internship at Los Alamos (thanks to consortium)
- Long-term collaboration with LANL
- Built network from MTV workshops and 2019 MTV fuel cycle facility modeling workshop at UW
 - Internship offers from labs



Conclusion & Expected Impact

- Follow-up grant was funded
 - Cyclus modeling essential to project success
- Converting Cyclus simulation information into the recording and reporting procedures defined by the IAEA (Code 10)
- Adding new features to Cyclus

INVENTORY CHANGE REPORT (ICR) FORM R.01.1/c																		
COUNTRY Neptune										PERIOD COVERED BY REPORT FROM 141201 TO 141231								
FACILITY NND-										REPORT NO. 15								
MATERIAL BALANCE AREA NND1										PAGE NO. 1 OF 1 PAGES		SIGNATURE						
ENTRY NO.	CONTINUATION	DATE OF INVENTORY CHANGE	MBA/COUNTRY		TYPE OF INVENTORY CHANGE	RMP CODE	NAME OR NUMBER OF BATCH	NUMBER OF ITEMS IN BATCH	MATERIAL DESCRIPTION	ELEMENT	ACCOUNTANCY DATA			ISOTOPE CODE	MEASUR BASIS	CONCISE NOTE	CORRECTION TO	
			FROM	TO							WEIGHT OF ELBMENT	UNIT kg/g	WEIGHT OF FISSILE ISOTOPES (URANIUM ONLY) (g)				REPORT NO.	ENTRY NO.
1		141215	NN-B	NND1	RD	3	045C8	1	BQ1G	E	163257	G	1306	G	N			2
2	C	141215	NN-B	NND1	RD	3	045C8	0	BQ1G	P	1498	G		N				2
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001:0I/NP/15#002:1/1#003:20142331#006:DanielJackson#010:I
#015:20141201/20141231#207:NND-#307:NND1#309N#370:NN-B#40
7:3#411:RD#412:20141215#430:BQ1G#446:045C8#469:N#470:1#63
0:163257G#1306G#710:1498G#
```

Code 10 statement indicates a transfer of 163257 grams uncontained enriched U in oxide form with 1498 grams of plutonium from MBA NN-B to MBA NND1 on December 15, 2014.

Future developments to Cyclus

- Current cyclus agents are not “smart”
 - When a fresh fuel vault empties, it immediately requests more material
 - Contracts
- Transportation
 - Added shipment quantity
 - No time/distance handling yet
- Noise
 - Most cyclus agents are “perfect”
 - material never lost or gained to the simulation

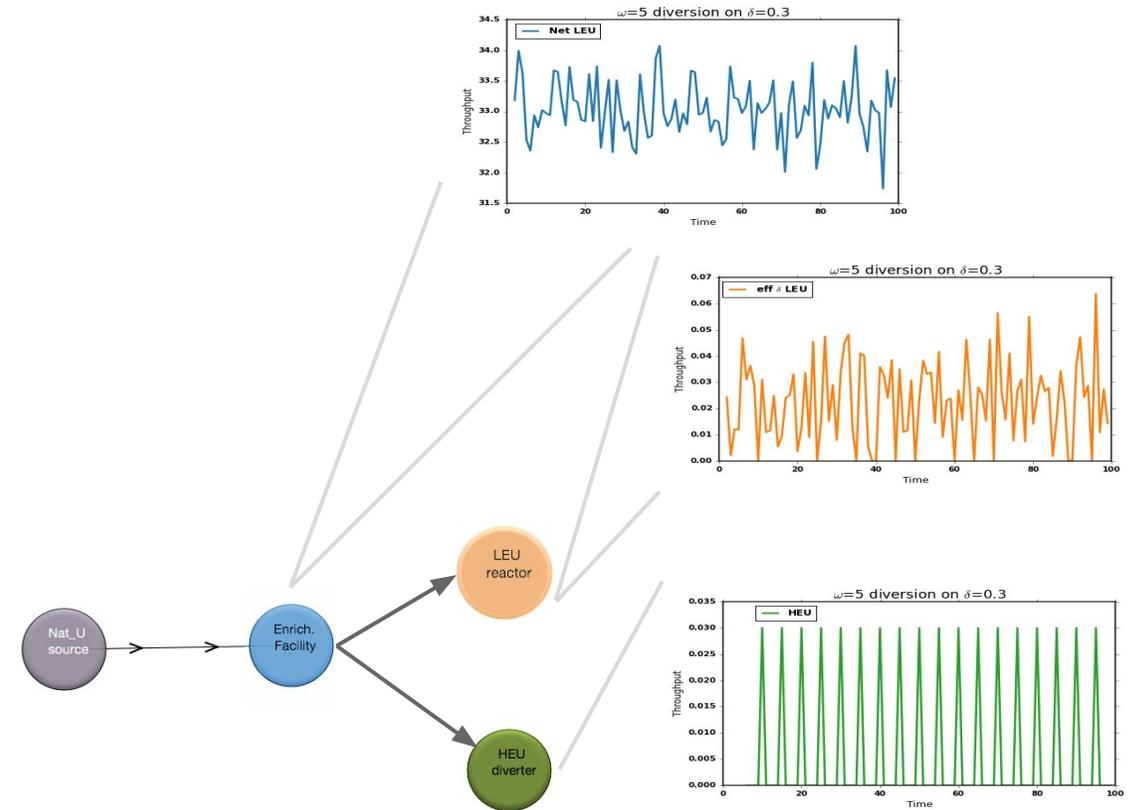


diagram: Cyclus development team

Acknowledgements



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