Advanced Nuclear Fuel Cycle Code Simulator with a Full Graphical interface

Błażej Chmielarz, Wacław Gudowski, Torbjörn Bäck, Karen Atabekjan, Alan Tkaczyk

E-mail contacts:

Blazej Chmielarz blazejc@kth.se

Waclaw Gudowski waclaw@kth.se

Overview

- 1. Introduction
- 2. Technical features
- 3. GUI
- 4. Status
- 5. Future plans

Introduction

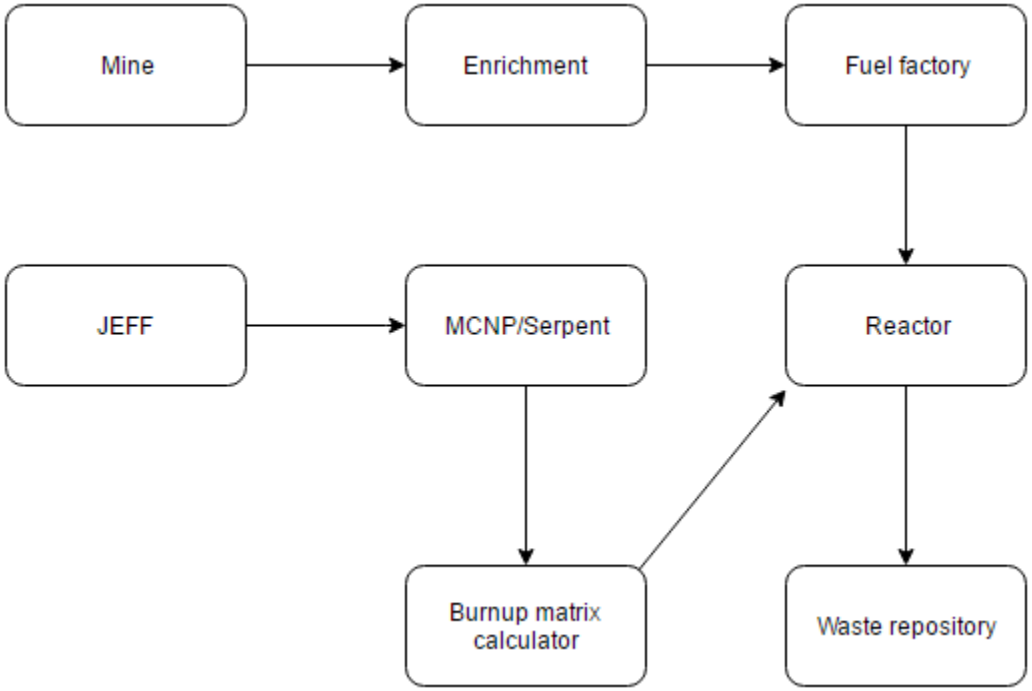
The idea behind the program:

- Easy to use
- With a GUI
- Short runtime
- Open-source
- Learning and educating tool

Technical features

- Developed for Linux
- Written in C++
- Requires Boost, Grace and gtkmm 2.4

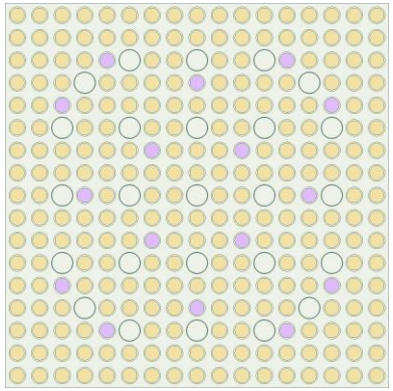
Technical features



Technical features

Solution method

- Burnup matrix, flux specific, 1307 nuclides
- Reactor timesteps: 1 day, 5 days, 30 days, 1 year
- Today´s status:
  - Includes today one PWR and one BWR design
  - Fixed flux (10^{14} for PWR and $5*10^{13}$) for BWR



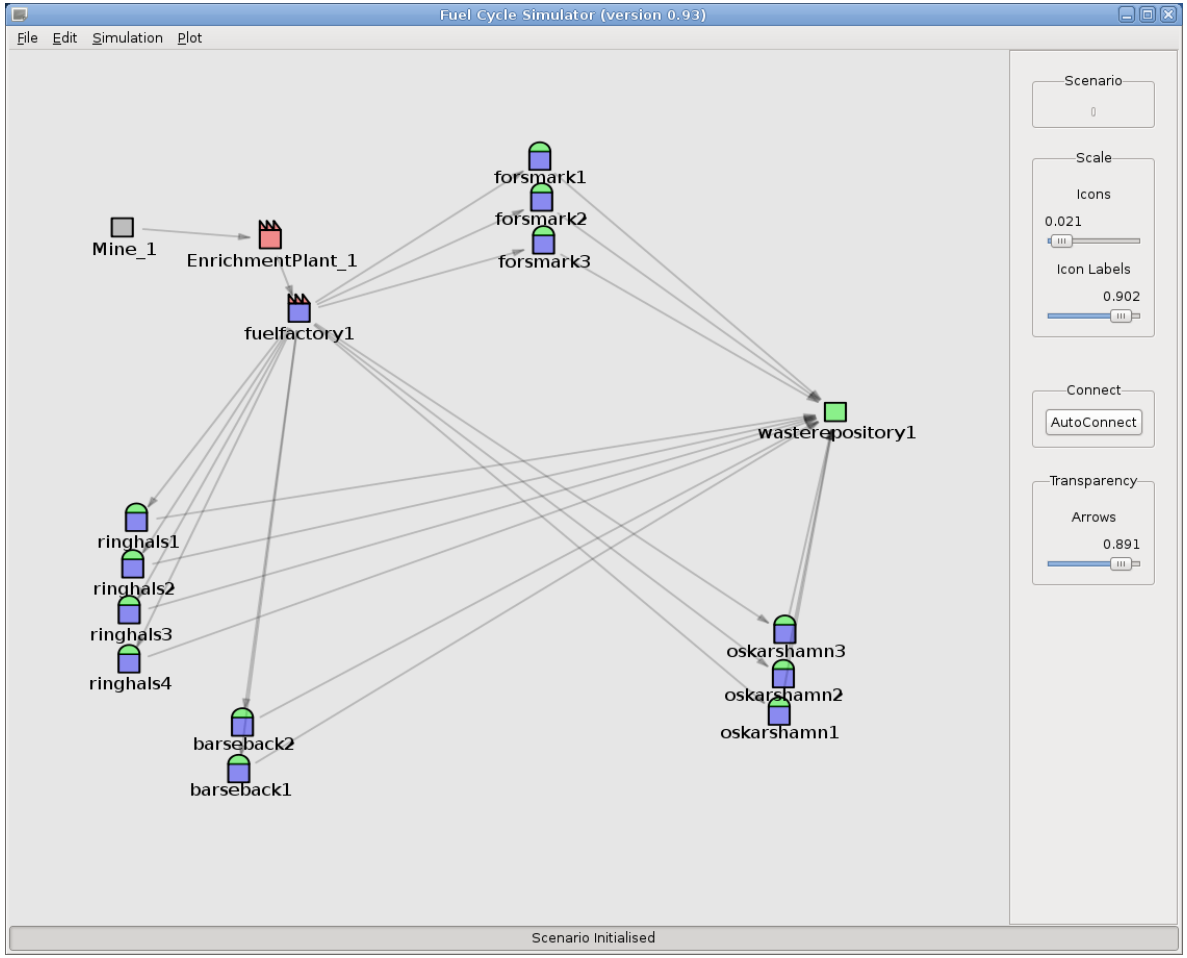
Technical features

Input

- Scenario file

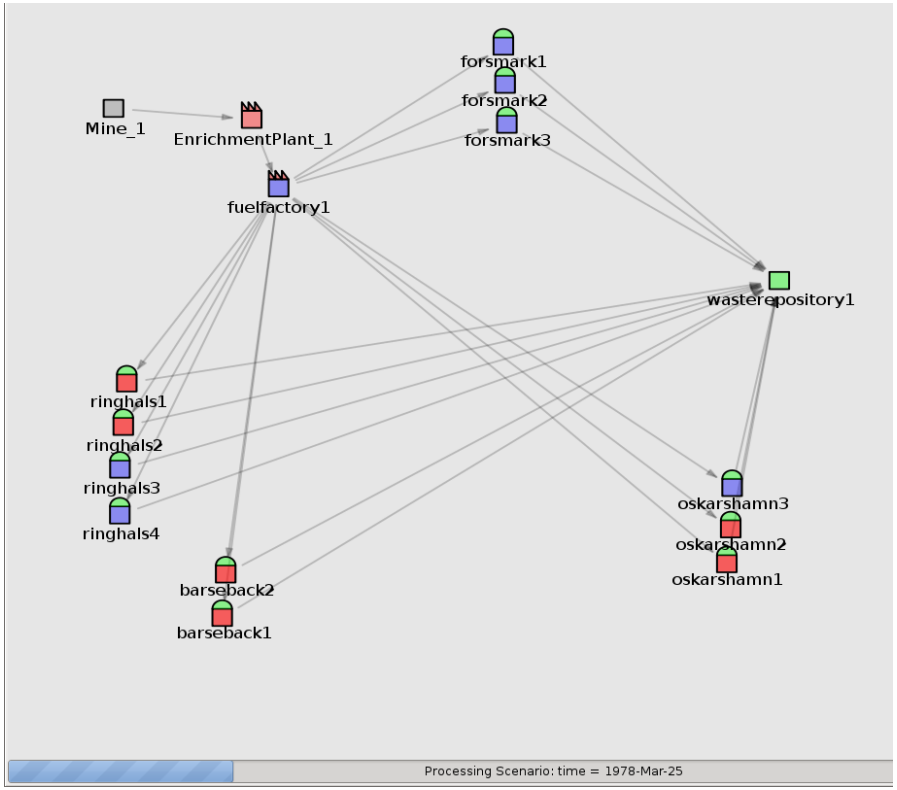
```
start simulation 1970-Jan-01
stop simulation 3000-Jan-01
time step 360
reactor time step 30
facility size 0.021
label size 0.902
arrow transparency 0.891

%============== Objects =======================

fuelfactory
name fuelfactory1
GUIposX 0.29
GUIposY 0.3
startdate 1900-Jan-01
stopdate 2500-Jan-01
fuelprovider EnrichmentPlant_1
fuelreceiver forsmark1
fuelreceiver forsmark2
fuelreceiver forsmark3
fuelreceiver oskarshamn1
fuelreceiver oskarshamn2
fuelreceiver oskarshamn3
fuelreceiver ringhals1
fuelreceiver ringhals2
fuelreceiver ringhals3
fuelreceiver ringhals4
fuelreceiver barseback1
fuelreceiver barseback2

reactor
power 968
number_of_fuel_batches 4
fuel_cycle_time 360
total_fuel_mass 100000
type LWR
```

GUI


Fuel Cycle Simulator (version 0.93)
File
Edit
Simulation
Plot
Scenario
Scale
Icons
0.021
Icon Labels
0.902
Connect
AutoConnect
Transparency
Arrows
0.891
forsmark1
forsmark2
forsmark3
Mine_1
EnrichmentPlant_1
fuelfactory1
wasterepository1
ringhals1
ringhals2
ringhals3
ringhals4
barseback2
barseback1
oskarshamn3
oskarshamn2
oskarshamn1
Scenario Initialised

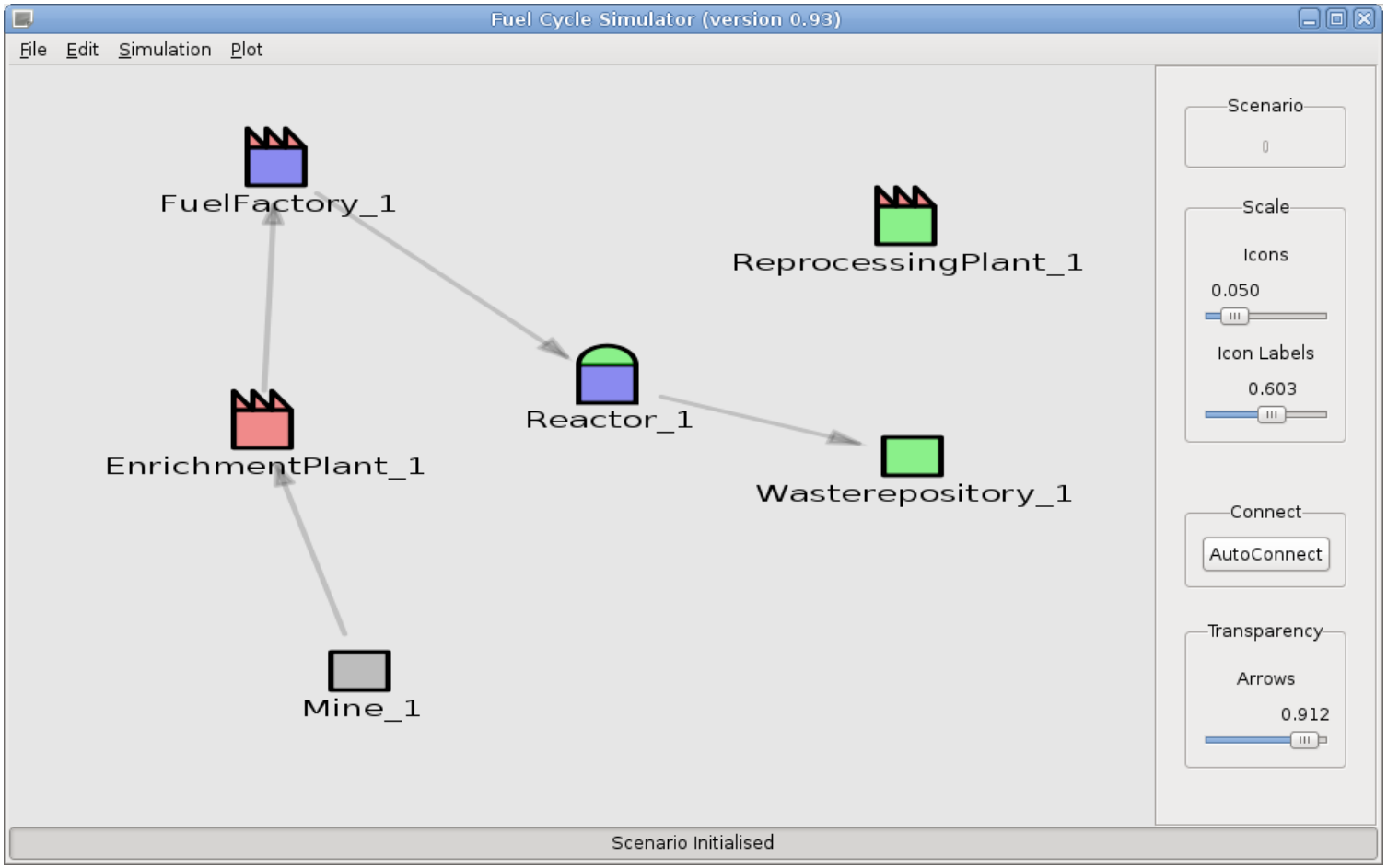
GUI

Reactors change color when they start operating in the scenario



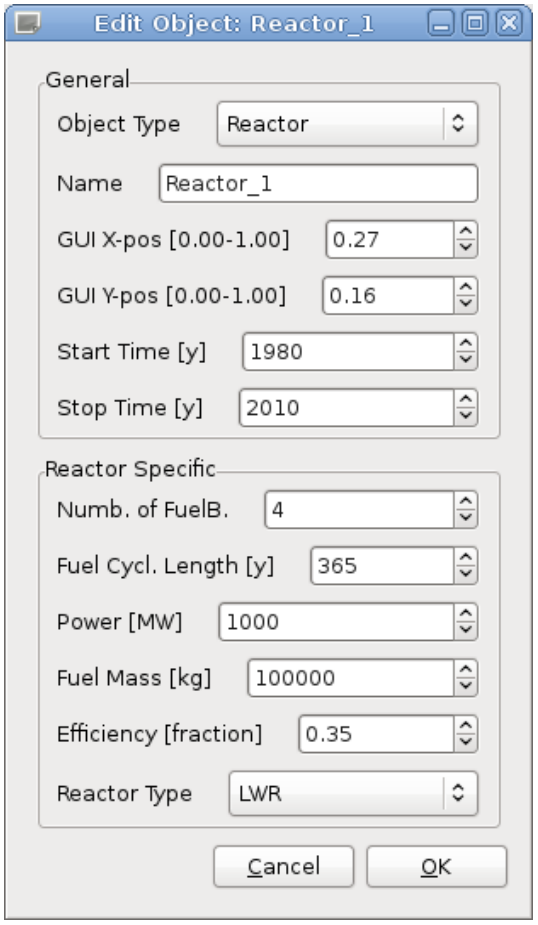
GUI

‘New scenario’

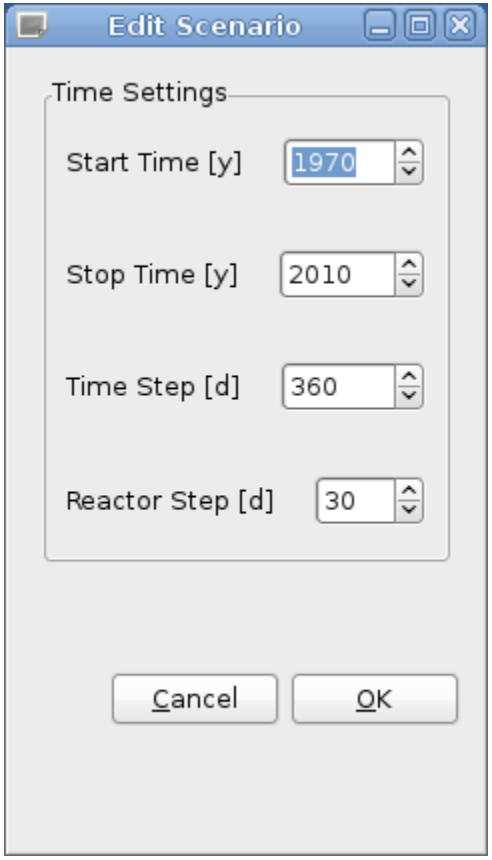


GUI

‘Edit Reactor’

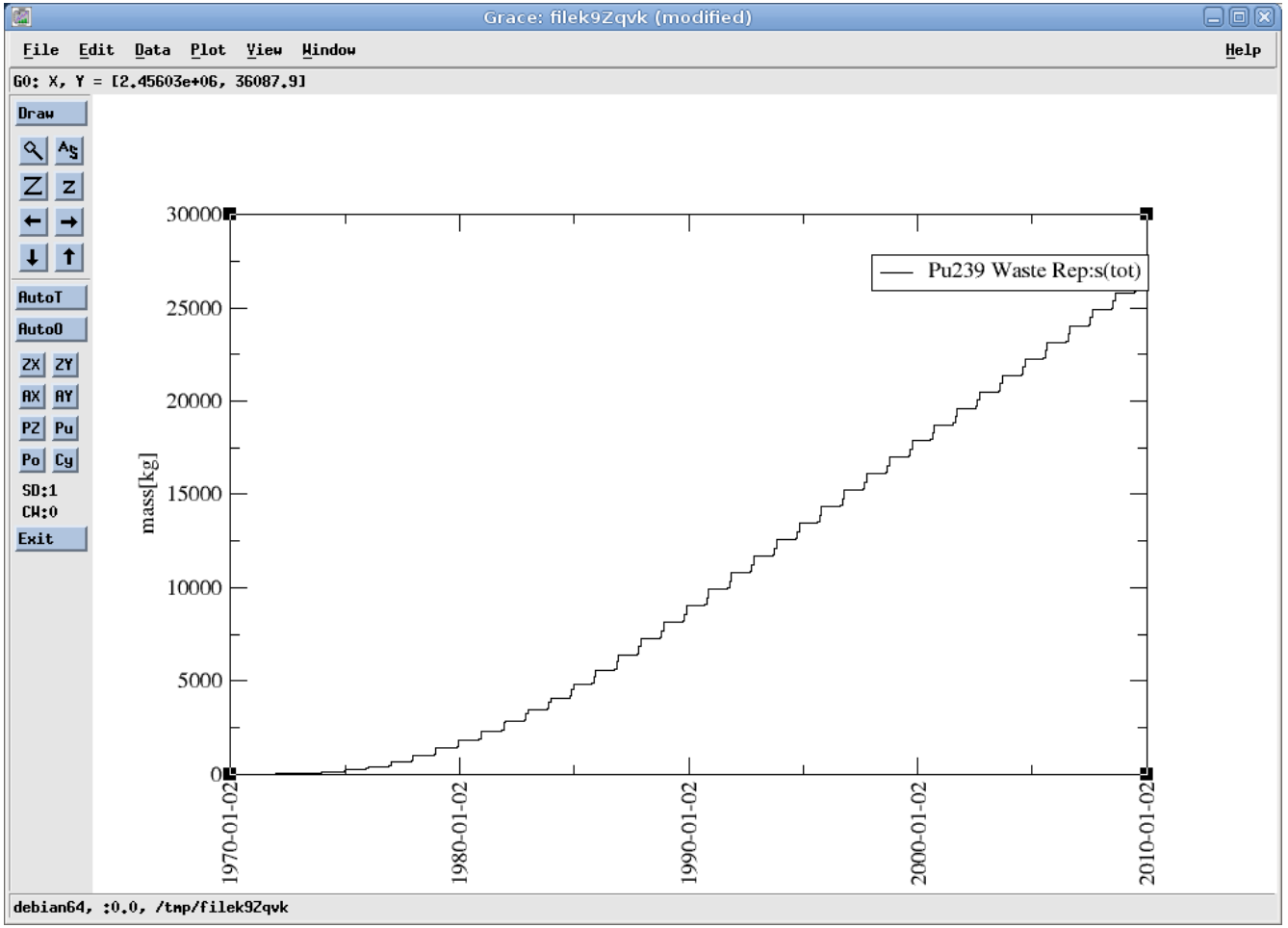


‘Edit Scenario‘



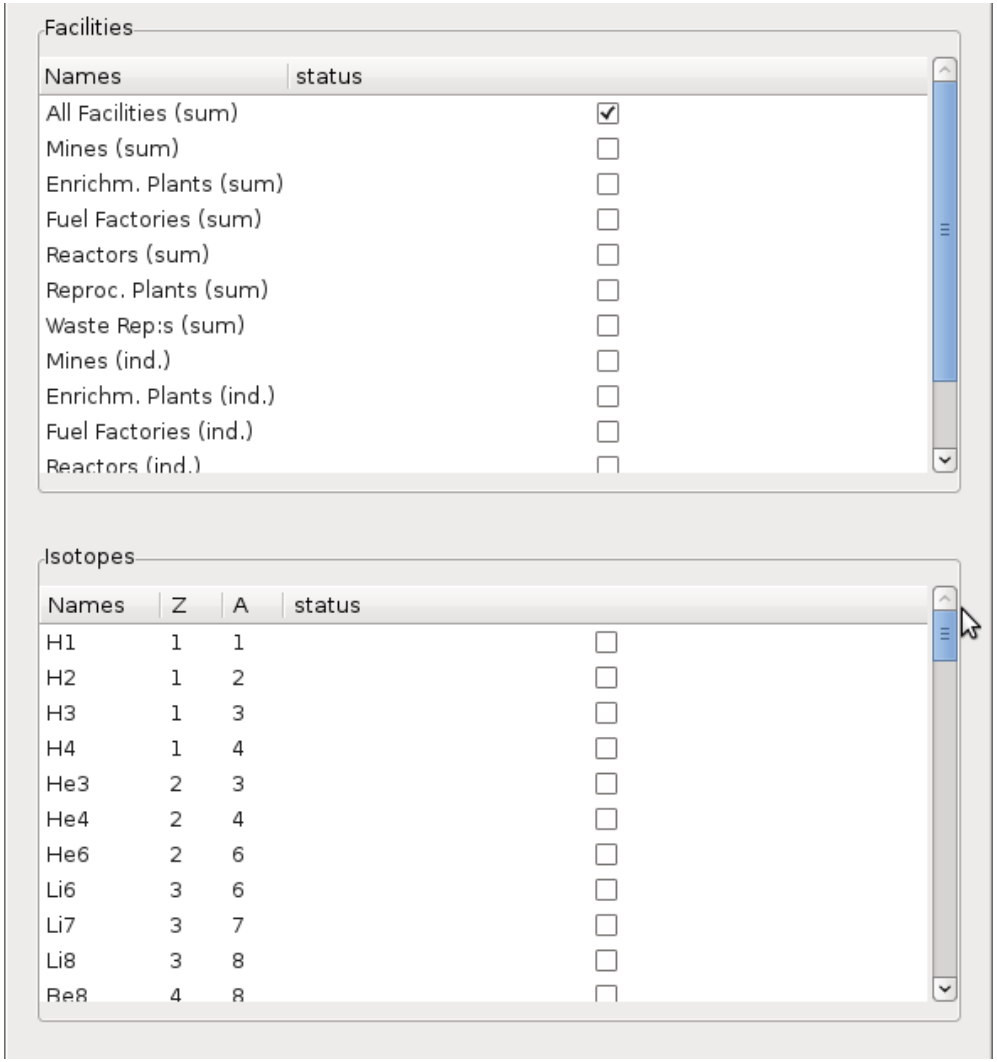
GUI

‘Plot’


Grace: filek9Zqvk (modified)
File Edit Data Plot View Window Help
G0: X, Y = [2.45603e+06, 36087.9]
Draw
AutoT
AutoO
ZX ZY
AX AY
PZ Pu
Po Cy
SD:1
CW:0
Exit
Pu239 Waste Rep:s(tot)
mass[kg]
30000
25000
20000
15000
10000
5000
0
1970-01-02
1980-01-02
1990-01-02
2000-01-02
2010-01-02
debian64, :0.0, /tmp/filek9Zqvk

GUI

‘Plot’


Facilities
Names
status
All Facilities (sum)
Mines (sum)
Enrichm. Plants (sum)
Fuel Factories (sum)
Reactors (sum)
Reproc. Plants (sum)
Waste Rep:s (sum)
Mines (ind.)
Enrichm. Plants (ind.)
Fuel Factories (ind.)
Reactors (ind.)
Isotopes
Names
Z
A
status
H1 1 1
H2 1 2
H3 1 3
H4 1 4
He3 2 3
He4 2 4
He6 2 6
Li6 3 6
Li7 3 7
Li8 3 8
Be8 4 8

Status

- Functional
  - No reprocessing, no MOX cycles implemented
  - Short runtime (under 5 minutes)
  - Instantaneous processing/infinite storage
- Accepts MCNP output for calculation of burnup matrix
- Can be compiled on new Linux systems
- Data is exported only to Grace, Open-sourcce plotting tool
- Not validated against other codes

Future plans

- Validation of a simple model with results from other codes
- Implementation of new reactor designs using cross sections from Serpent output
  - In spirit of Open-source
  - Requires further validation
  - In development

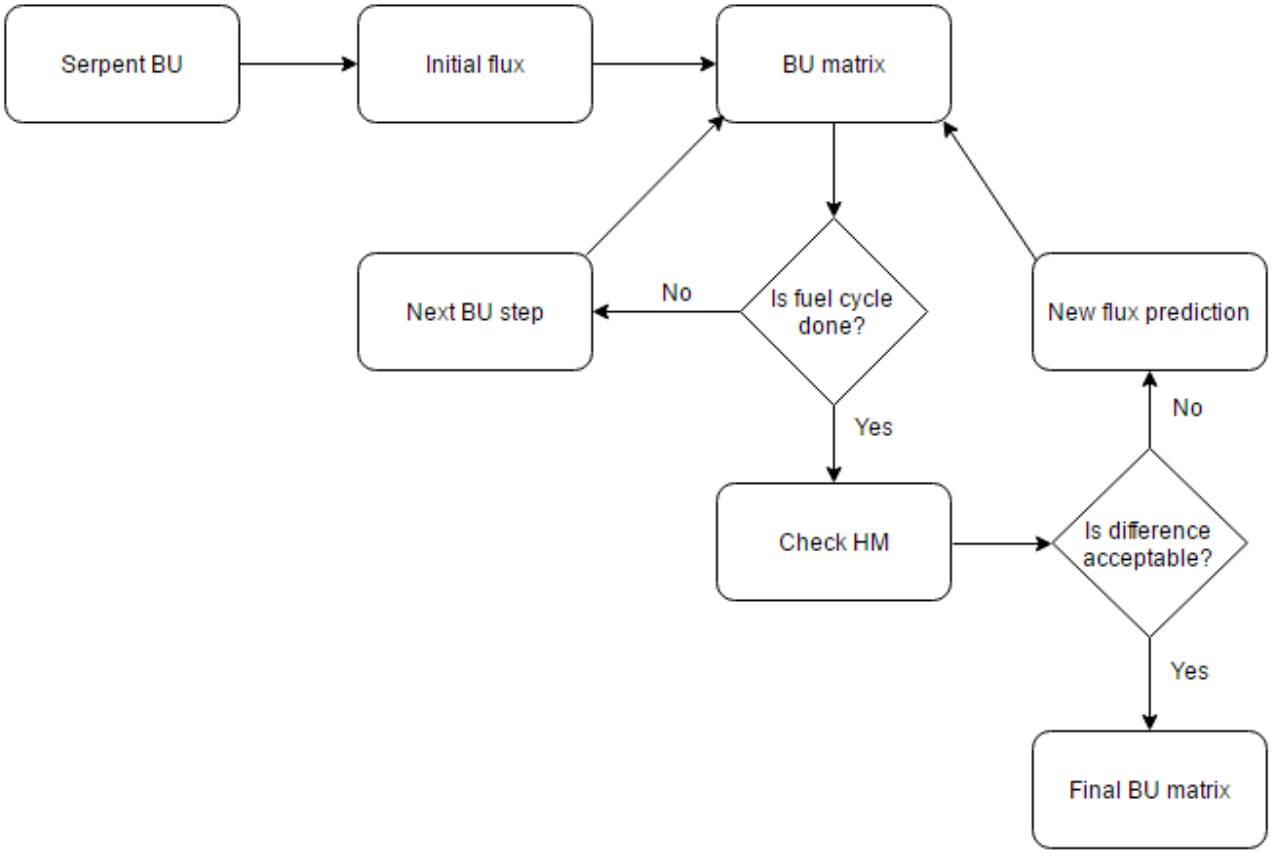
Future plans

- Introduction of breeder reactors and ADS
  - Requires validation of reprocessing and of breeding

Future plans

- Accurate calculation of flux using mass balance:
  - In order to find accurate BU matrix
  - Using $E = \Delta mc^2$ flux can be determined
  - $E = E_{radiation} + E_{fission}$
  - $E_{fission} = \#_{fission} \times E_{1\ fission}$
  - $\#_{fission} = f(t, l, m, \phi, \eta, f, P_{NL})$
  - $E_{radiation} \approx 7\%$

Future plans – flux calculation



Future plans – flux calculation

- Problems:
  - $E_{reactor} = E_{radiation} + E_{fission} - E_{loss}$
  - $E_{loss} = E_{heat} + E_{radiation}$
  - $E_{radiation} \neq const$
  - Requires iteration of calculating a burnup matrix which includes all possible nuclides, computationally expensive
  - In development

Acknowledgment

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Thank you for your attention

Questions?