EBIT Simulation Software & ULE HPGe Update

Jon Ringuette
Colorado School of Mines

EBIT Simulation code

- Initial code sourced from Rene's LISP code
- Translated into Python3 code
- Allow for command line operation
- Use of configuration files
- Can simulate changing beam energy

What is calculated?

- **Current Density**
- **Ionization Rates**
- **Radiative Reionization rates**
- **Charge Exchange rates**

```lisp
(let* ((species (iter (for q from 46 to 51)
      (collect (list (format nil "Sb ~a+" q) 0 q))))
       (result (make-array (list (length species)) :initial-element '())))
  (labels ((add-pop (time arr)
       (iter
         (for (label s q) in species)
         (for i first 0 then (1+ i))
         (setf (aref result i) (append (aref result i)
               (list (list time (aref arr s q))))))))
    (calc-charge-populations  (list
             (make-species :z 51 :a 129 :initial-sci-population 1d0))
            :probe-every 0.01d0
            :probe-fn #'add-pop
            :breeding-time 30d0
            :beam-energy 26000d0
            :pressure 1d-10
            :beam-current .02d0
            :rk-params (make-rkstep-params :desired-accuracy-per-charge-state 1d-7)
            :beam-radius 90e-4)
    (mgl-gnuplot:with-session ()
      (mgl-gnuplot:command "reset")
     (mgl-gnuplot:command "set term pdf color enchanged dashed")

      ;(mgl-gnuplot:command "set terminal x11 color enhanced dashed")
      (mgl-gnuplot:command "set xlabel 'breeding time [ms]'")
      (mgl-gnuplot:command "set logscale x")
      (mgl-gnuplot:command "set xrange [2000:20000]")
      (mgl-gnuplot:command "set yrange [0:.4]")

      (mgl-gnuplot:command "set ylabel 'population'")
      (mgl-gnuplot:command "set samples 1000000")
      (mgl-gnuplot:command "set title 'I_e = 2A, V_e = 26kV, r_e = 90um, p_{H}= 1e-10T")
      (mgl-gnuplot:command "set output '/Users/wintermute/for_kyle/46-51-26kev.pdf'")

      (mgl-gnuplot:plot*
       (iter
         (for s in species)
         (for i first 0 then (1+ i))
         (collect
             (mgl-gnuplot:data* (aref result i)
               (format nil "using ($1*1000):2 with lines title '~a' lw 4 dashtype ~a"  (first s) (1+ (third s)))))))
      (mgl-gnuplot:command "unset output"))))
```

```
# You must choose either matplotlib for a graph or csv for a.. well.. csv file..
outputType = matplotlib
outputFileName = mygraph.png

#outputType = csv
#outputFileName = mycsv.csv


[matPlotLib]
# Using these you can specify the xmin and xmax (time) for graphing so you can kind of zoom in or ignore parts same for yaxi
population
#graphXMinTime = 2
#graphXMaxTime = 3
#graphYMinPop = 0.1
#graphYMaxPop = 0.25


[Run]
# For any species listed on this line there must be a corresponding entry for it below with z, nucleons, etc..
# It was easier to program this way AND you don't have to comment out species you want to keep!
# I hope you have a non-frustrating day!

# speciesList should be comma separated
speciesList = Sb51, Fe55

#This will be the order it runs the beams, note it runs these sequentially
beamList = BeamAndTrap, BeamAndTrap2

#this doesn't exist yet..
autoOptimizer = off
optimizeChargeState = 49

[BeamAndTrap]
beamEnergy = 60000
breedingTime = 2.5
probeEvery = 0.001
ionEbeamOverlap = 1.0
beamCurrent = .02
beamRadius = 90.0e-4
pressure = 1e-11
ionTemperature = 100.0

# ONLY THE BEAM ENERGY AND BREEDING TIME ARE ADJUSTED IN SUBSEQUENT ENTRIES, the rest are dummy parameters for anything besi
beam in beamList
[BeamAndTrap2]
beamEnergy = 1000
breedingTime = 3


[Sb51]
z = 51
nucleons = 129
chargeStates = 39, 40, 41, 42, 43
populationPercent = 1.0
```

How to run it

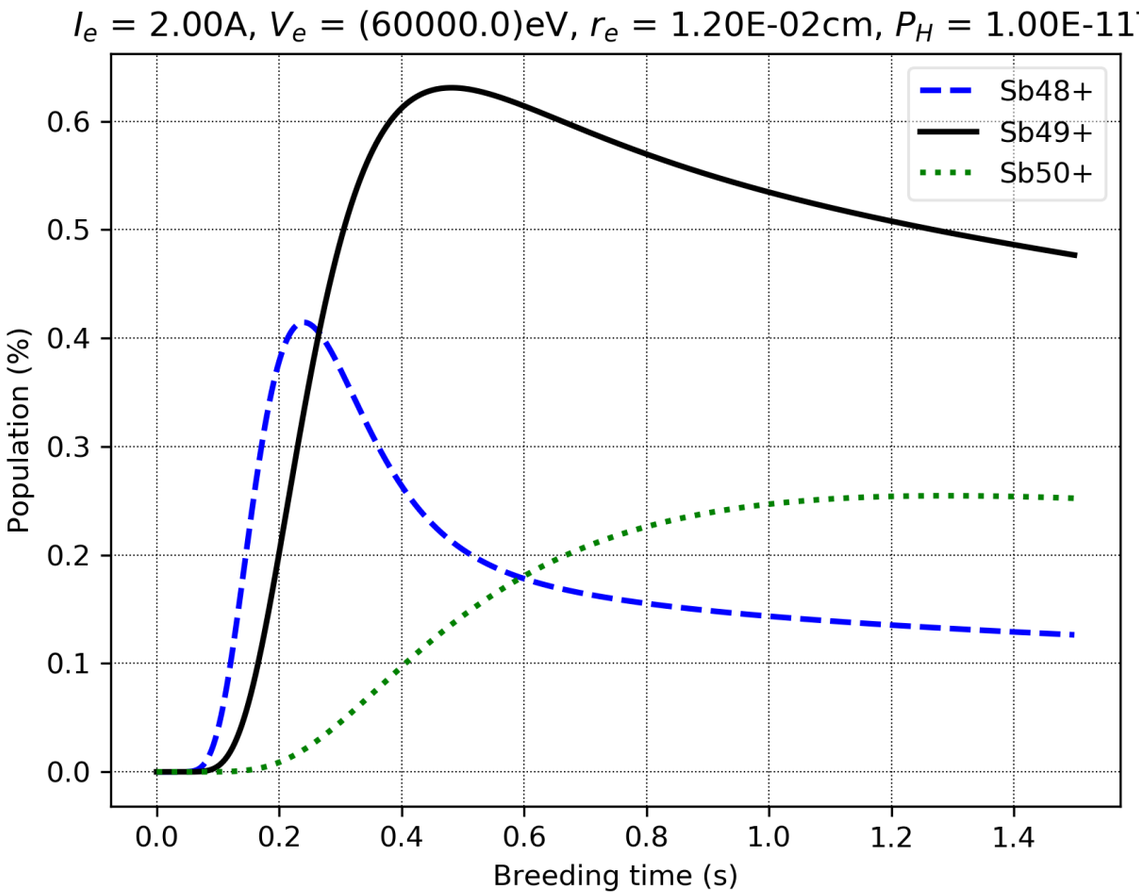
```
wintermute@csm-wl-dhcp-192-152 ~/D/S/M/R/n/ebitsim>
pypy3 ebitsim.py --configFile NeLikeSb_noramp.cfg
Running simulation! ....
Simulating using beam energy 6650.0
Simulating Species : 51
Writing graph to : NeLikeSb_noramp.png
wintermute@csm-wl-dhcp-192-152 ~/D/S/M/R/n/ebitsim>
```

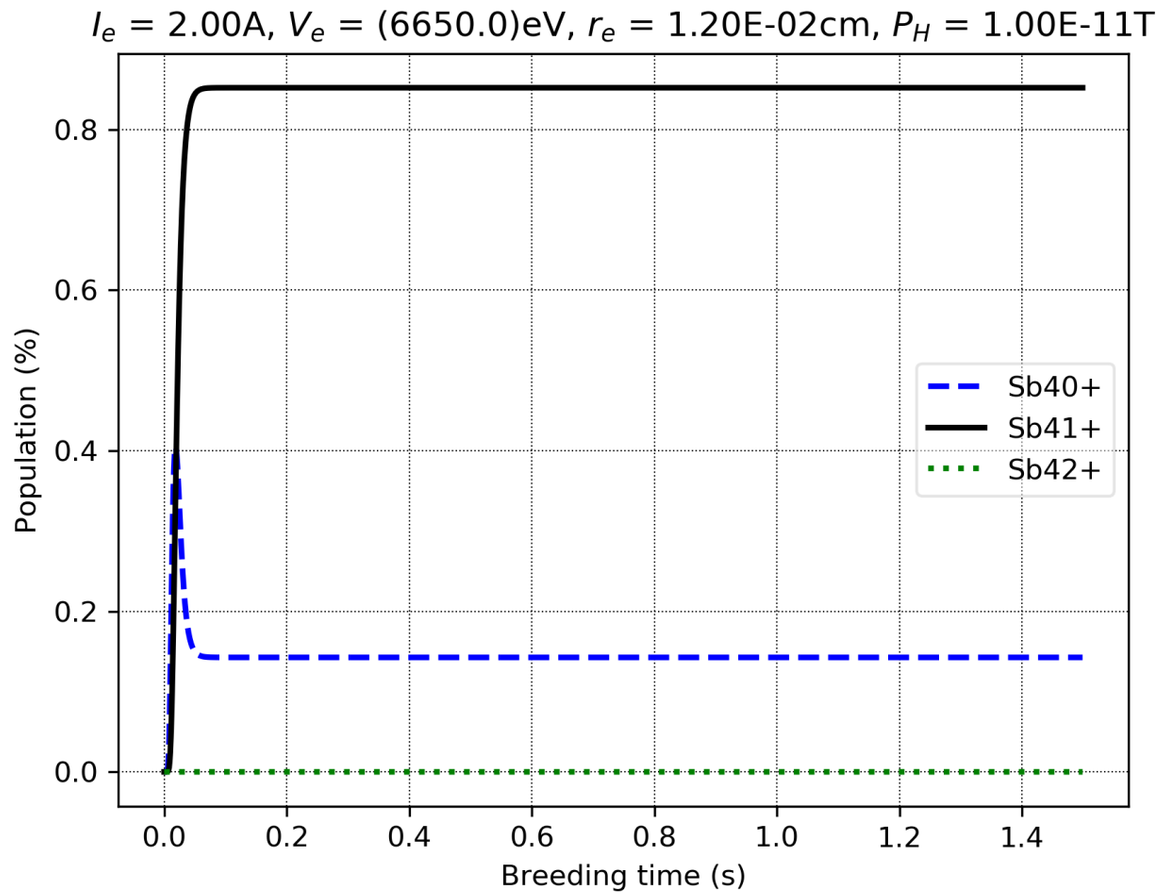
```
wintermute@csm-wl-dhcp-192-152 ~/D/S/M/R/n/ebitsim>
pypy3 ebitsim.py -z 51 -a 129 --chargeStates 39 40 41 42 43 --beamEnergy=10000.0 --breedingT
ime=2.5 --outputFile=BE10_I0.02_SB51_39_43.png
Running simulation! ....
Simulating using beam energy 10000.0
Simulating Species : 51
Writing graph to : BE10_I0.02_SB51_39_43.png
wintermute@csm-wl-dhcp-192-152 ~/D/S/M/R/n/ebitsim>
```

- **Can export PNG graph or CSV file**

Charge Breeding Simulations

Antimony - 129Sb

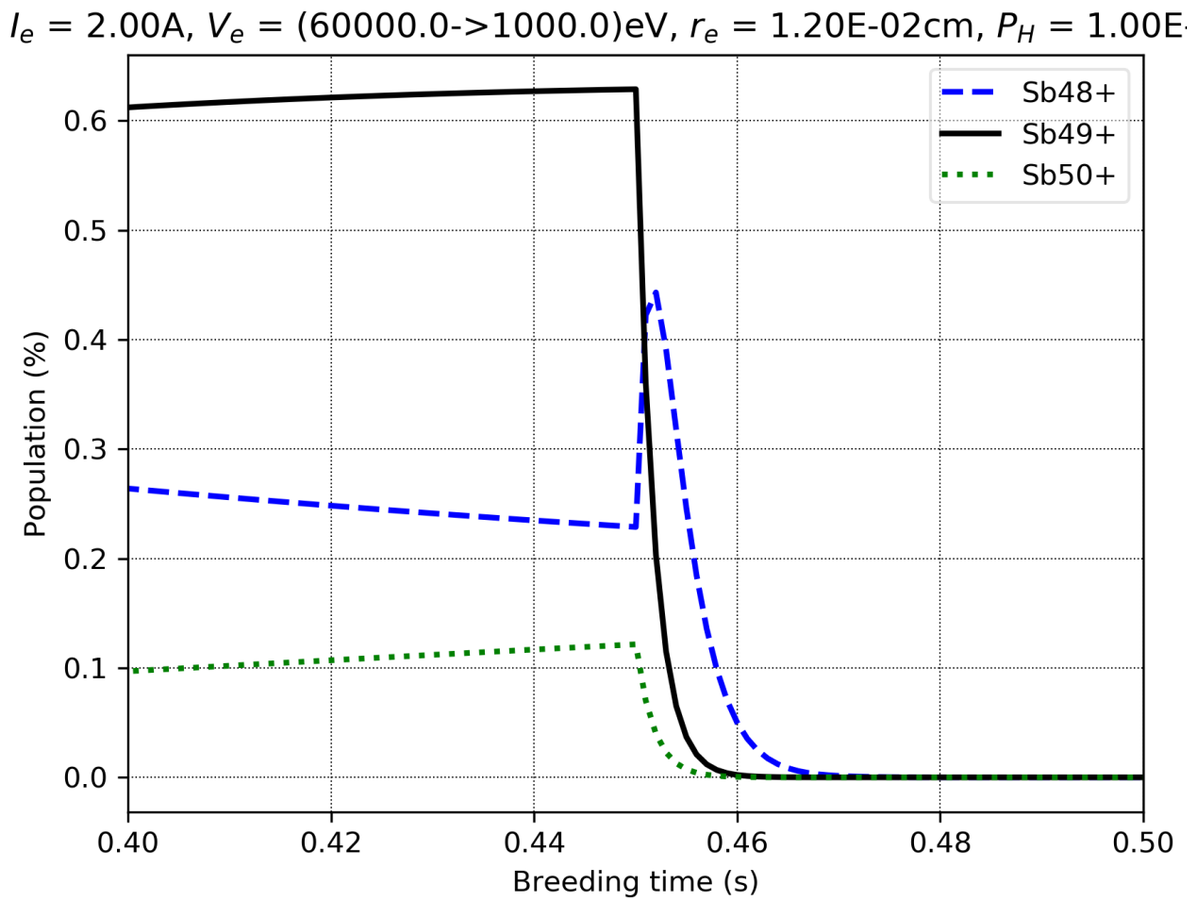


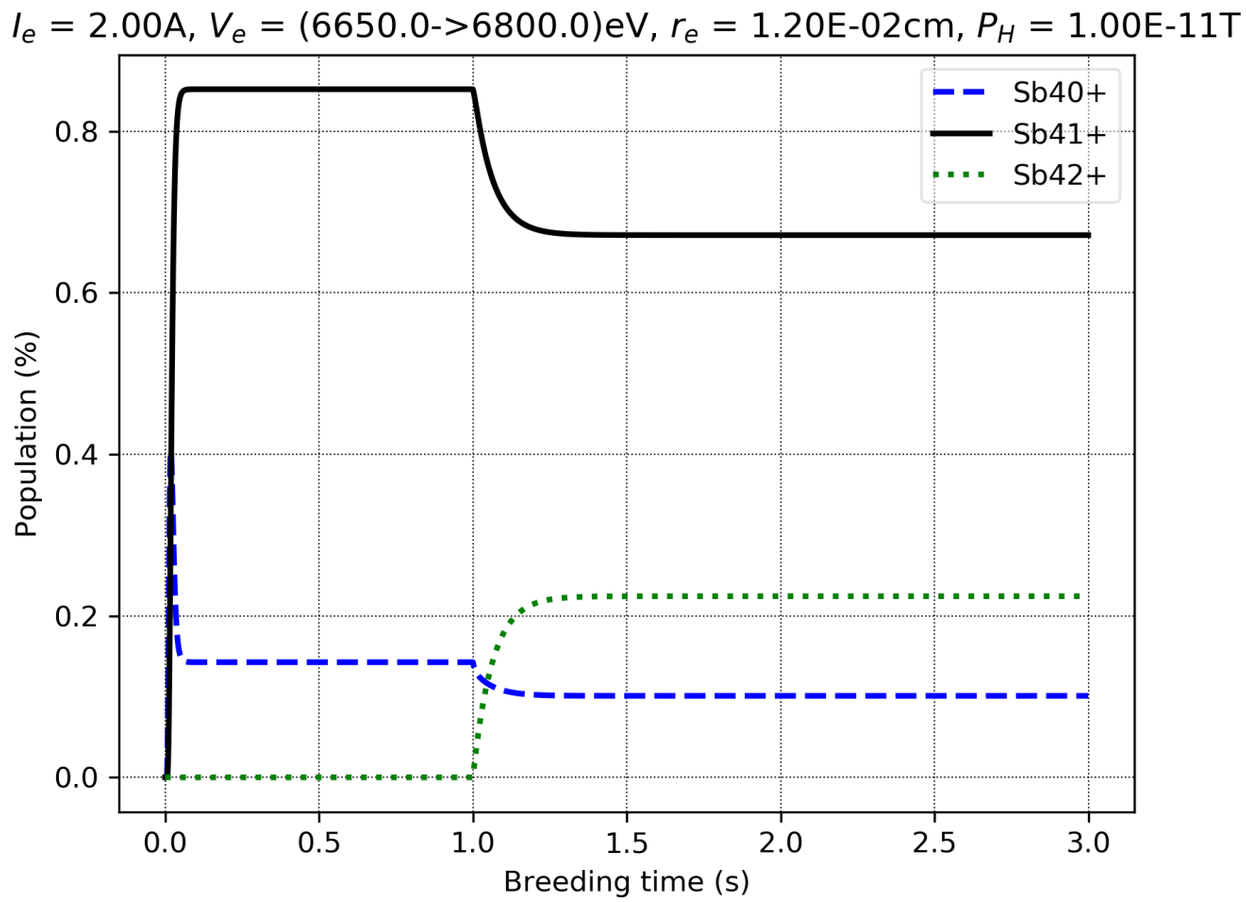


Charge breeding for the He-like (left) and Ne-like (right) cases

Simulation of charge breeding w/ ebeam ramping

Antimony - 129Sb





He-like (left) - Ne-like (right)

Where to get it?

https://github.com/mineselectroweakgroup/ebitsim

Whats left to do?

- **Auto tune beam for optimal charge breeding**
- **Compare results to experiment for beam energy changes**

****Please let me know if you have something you would like to see it capable of doing!**

ULE Update