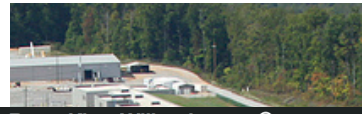
An overview of the McStas tools

Presenter: Peter Willendrup

mcgui - pl vs py versions



python File Simulation Help — 58% Tue 09:52 Peter Kjær Willendrup

mcgui-py

Instrument:

Run... Plot

/Users/pkwi/tmp/BNL_H8_2.instr Open... Edit

Messages:

```
Ki = 2.662 Angs-1 Energy = 14.69 meV

Velocity = 1676 m/s, lambda = 2.36 Angs
[BNL_H8] Initialize

Save [BNL_H8]
Detector: D0_Source_I=0.00316938 D0_Source_ERR=1.39492e-05 D0_Source_N=51624 "D0_Source.psd"
Detector: D1_SC1_Out_I=0.0204218 D1_SC1_Out_ERR=3.53957e-05 D1_SC1_Out_N=334732
"D1_SC1_Out.psd"
Detector: D2_A4_I=0.0137398 D2_A4_ERR=2.90361e-05 D2_A4_N=225525 "D2_A4.psd"
Detector: D4_SC2_In_I=0.00154949 D4_SC2_In_ERR=3.0833e-06 D4_SC2_In_N=256010 "D4_SC2_In.psd"
Detector: D5_SC2_Out_I=0.0012141 D5_SC2_Out_ERR=2.72906e-06 D5_SC2_Out_N=201984
"D5_SC2_Out.psd"
Detector: D7_SC3_In_I=1.22624e-07 D7_SC3_In_ERR=2.22874e-10 D7_SC3_In_N=331552 "D7_SC3_In.psd"
Detector: D8_SC3_Out_I=2.34805e-08 D8_SC3_Out_ERR=9.80451e-11 D8_SC3_Out_N=62774
"D8_SC3_Out.psd"
Detector: D10_SC4_In_I=1.20956e-09 D10_SC4_In_ERR=7.04081e-12 D10_SC4_In_N=32387 "D10_SC4_In.psd"
Detector: He3H_I=9.20884e-10 He3H_ERR=6.14589e-12 He3H_N=24690 "He3.psd"

Finally [BNL_H8:/Users/pkwi/tmp/BNL_H8_2.instr_20161602_095206]. Time: 2 [s]
simulation done
```

McStas: BNL_H8.instr

File Simulation neutron site Tools Help (McDoc)

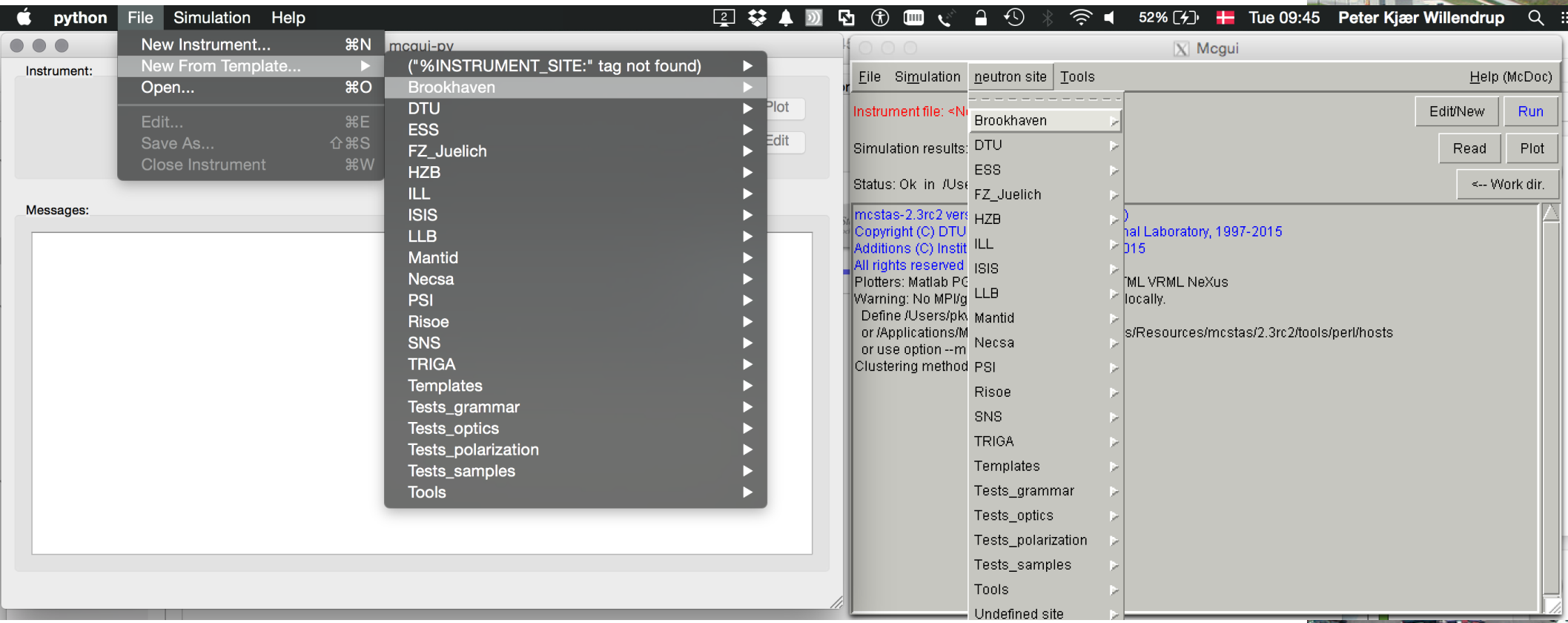
Instrument file: BNL_H8.instr Edit/New Run

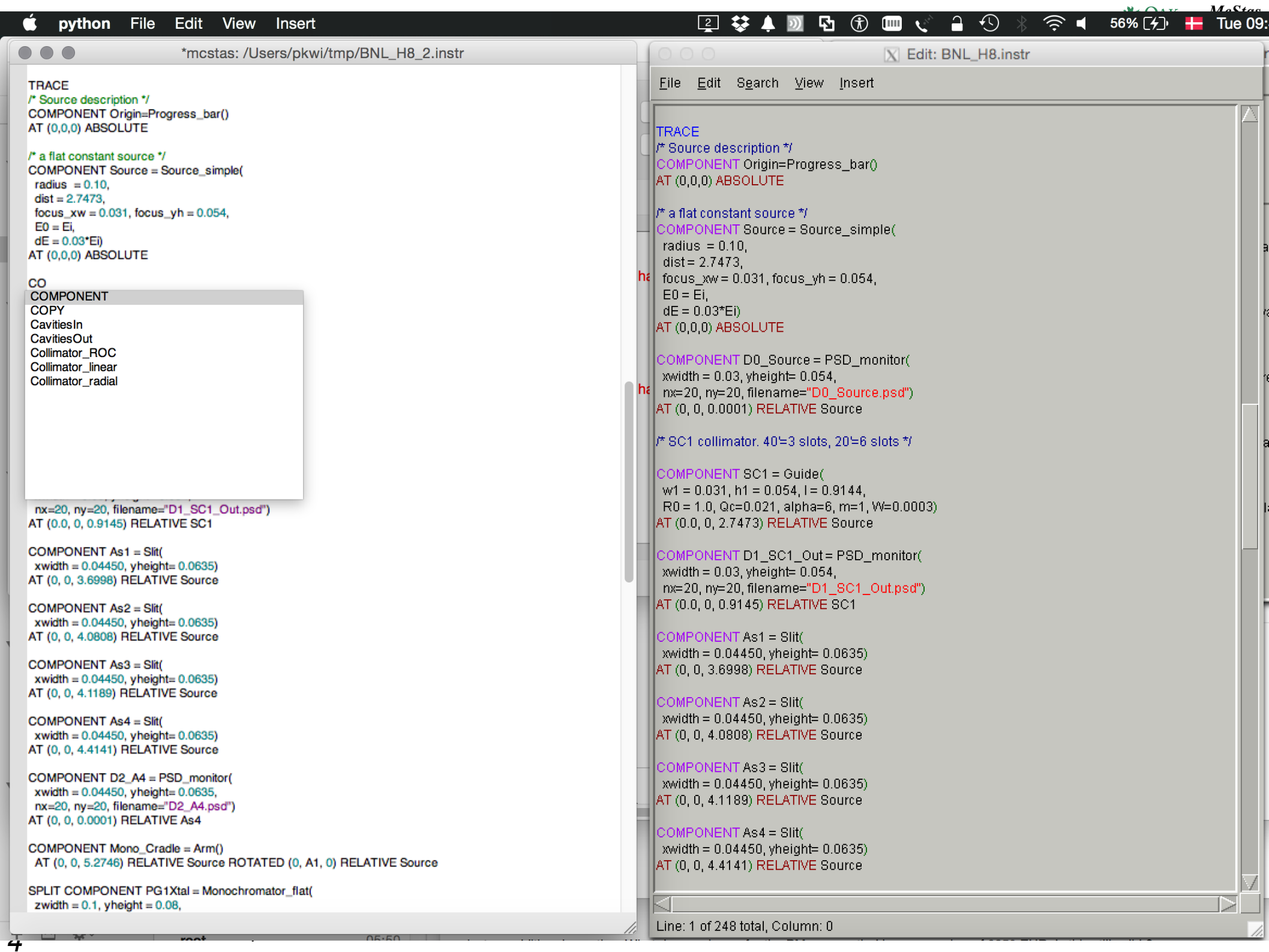
Simulation results: ./BNL_H8_20160216_095201/mccode.sim Read Plot

Status: Done in /Users/pkwi/tmp <-- Work dir.

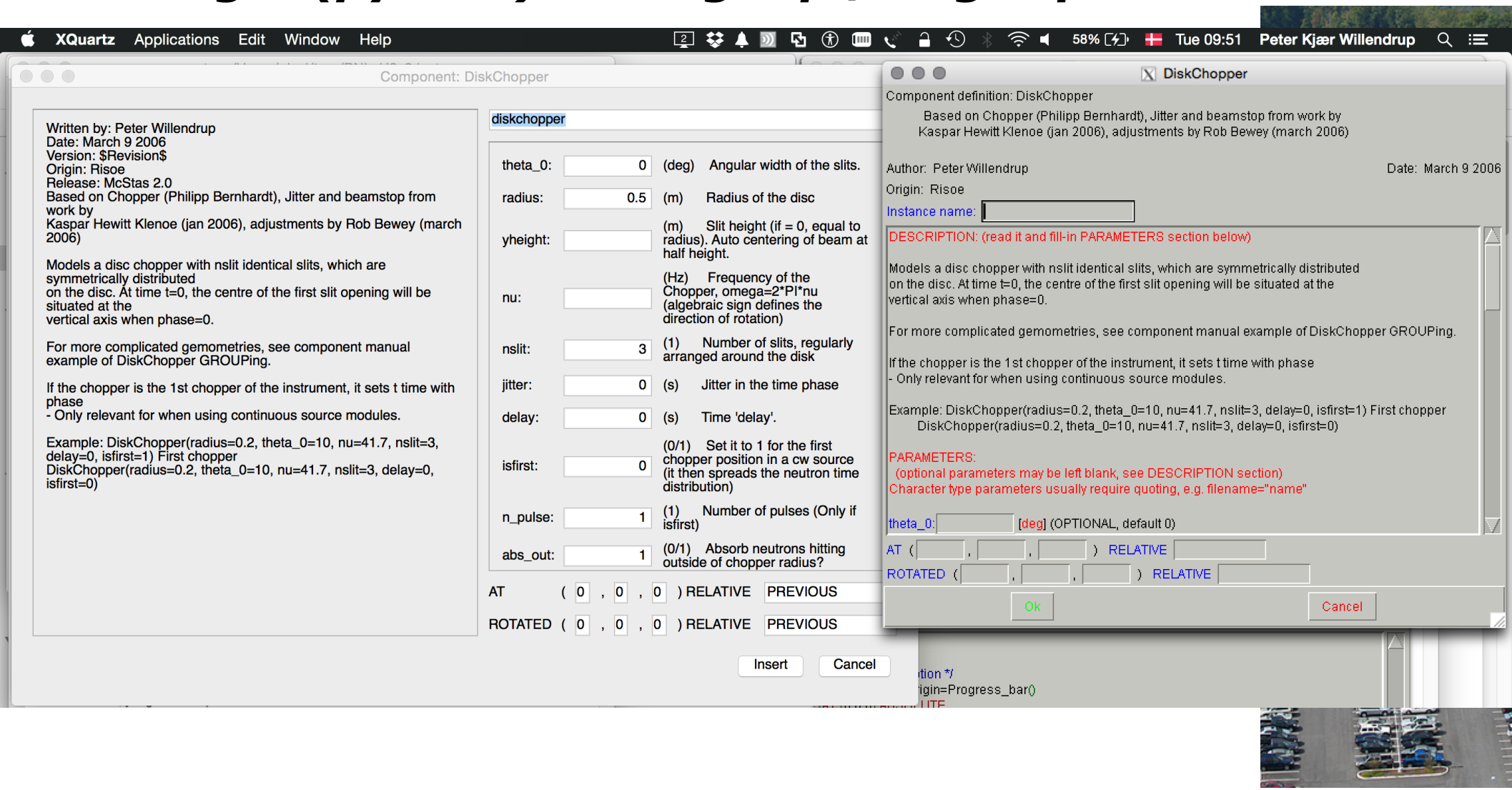
```
[BNL_H8] Initialize
Instrument:  BNL_H8 on localhost.
Monochromator : DM = 3.3539
A1 = 20.60, A2 = 41.20 (deg)
Ki = 2.662 Angs-1 Energy = 14.69 meV
Velocity = 1676 m/s, lambda = 2.36 Angs
[BNL_H8] Initialize

Save [BNL_H8]
Detector: D0_Source_I=0.00315673 D0_Source_ERR=1.39213e-05 D0_Source_N=51418 "D0_Source.psd"
Detector: D1_SC1_Out_I=0.0203765 D1_SC1_Out_ERR=3.53562e-05 D1_SC1_Out_N=334036 "D1_SC1_Out.p
sd"
Detector: D2_A4_I=0.0137207 D2_A4_ERR=2.90158e-05 D2_A4_N=225266 "D2_A4.psd"
Detector: D4_SC2_In_I=0.0015422 D4_SC2_In_ERR=3.07604e-06 D4_SC2_In_N=254980 "D4_SC2_In.psd"
Detector: D5_SC2_Out_I=0.00120838 D5_SC2_Out_ERR=2.72265e-06 D5_SC2_Out_N=201359 "D5_SC2_Out.
psd"
Detector: D7_SC3_In_I=1.23504e-07 D7_SC3_In_ERR=2.23683e-10 D7_SC3_In_N=335623 "D7_SC3_In.psd"
Detector: D8_SC3_Out_I=2.37352e-08 D8_SC3_Out_ERR=9.85107e-11 D8_SC3_Out_N=63985 "D8_SC3_Out.p
sd"
Detector: D10_SC4_In_I=1.23657e-09 D10_SC4_In_ERR=7.12662e-12 D10_SC4_In_N=33283 "D10_SC4_In.ps
d"
Detector: He3H_I=9.46184e-10 He3H_ERR=6.22804e-12 He3H_N=25556 "He3.psd"

Finally [BNL_H8:./BNL_H8_20160216_095201]. Time: 1 [s]
```

mcgui (python) vs mcgui.pl/mcgui-pl

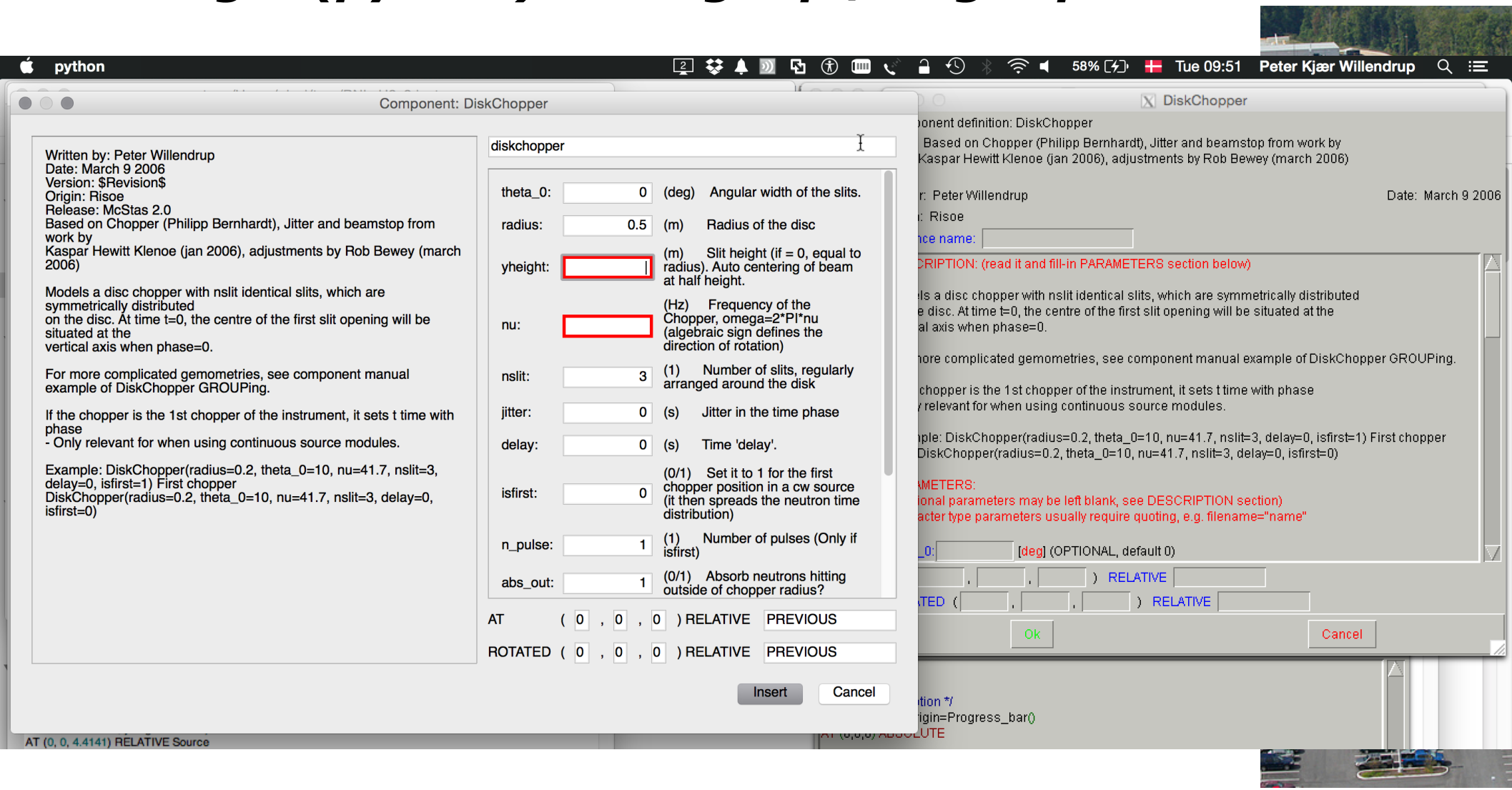



python File Edit View Insert
56% Tue 09:
*mcstas: /Users/pkwi/tmp/BNL_H8_2.instr
TRACE
/* Source description */
COMPONENT Origin=Progress_bar()
AT (0,0,0) ABSOLUTE
/* a flat constant source */
COMPONENT Source = Source_simple(
radius = 0.10,
dist = 2.7473,
focus_xw = 0.031, focus_yh = 0.054,
E0 = Ei,
dE = 0.03*Ei)
AT (0,0,0) ABSOLUTE
CO
COMPONENT
COPY
CavitiesIn
CavitiesOut
Collimator_ROC
Collimator_linear
Collimator_radial
nx=20, ny=20, filename="D1_SC1_Out.psd")
AT (0.0, 0, 0.9145) RELATIVE SC1
COMPONENT As1 = Slit(
xwidth = 0.04450, yheight= 0.0635)
AT (0, 0, 3.6998) RELATIVE Source
COMPONENT As2 = Slit(
xwidth = 0.04450, yheight= 0.0635)
AT (0, 0, 4.0808) RELATIVE Source
COMPONENT As3 = Slit(
xwidth = 0.04450, yheight= 0.0635)
AT (0, 0, 4.1189) RELATIVE Source
COMPONENT As4 = Slit(
xwidth = 0.04450, yheight= 0.0635)
AT (0, 0, 4.4141) RELATIVE Source
COMPONENT D2_A4 = PSD_monitor(
xwidth = 0.04450, yheight= 0.0635,
nx=20, ny=20, filename="D2_A4.psd")
AT (0, 0, 0.0001) RELATIVE As4
COMPONENT Mono_Cradle = Arm()
AT (0, 0, 5.2746) RELATIVE Source ROTATED (0, A1, 0) RELATIVE Source
SPLIT COMPONENT PG1Xtal = Monochromator_flat(
zwidth = 0.1, yheight = 0.08,
Edit: BNL_H8.instr
File Edit Search View Insert
TRACE
/* Source description */
COMPONENT Origin=Progress_bar()
AT (0,0,0) ABSOLUTE
/* a flat constant source */
COMPONENT Source = Source_simple(
radius = 0.10,
dist = 2.7473,
focus_xw = 0.031, focus_yh = 0.054,
E0 = Ei,
dE = 0.03*Ei)
AT (0,0,0) ABSOLUTE
COMPONENT D0_Source = PSD_monitor(
xwidth = 0.03, yheight= 0.054,
nx=20, ny=20, filename="D0_Source.psd")
AT (0, 0, 0.0001) RELATIVE Source
/* SC1 collimator. 40'=3 slots, 20'=6 slots */
COMPONENT SC1 = Guide(
w1 = 0.031, h1 = 0.054, l = 0.9144,
R0 = 1.0, Qc=0.021, alpha=6, m=1, W=0.0003)
AT (0.0, 0, 2.7473) RELATIVE Source
COMPONENT D1_SC1_Out = PSD_monitor(
xwidth = 0.03, yheight= 0.054,
nx=20, ny=20, filename="D1_SC1_Out.psd")
AT (0.0, 0, 0.9145) RELATIVE SC1
COMPONENT As1 = Slit(
xwidth = 0.04450, yheight= 0.0635)
AT (0, 0, 3.6998) RELATIVE Source
COMPONENT As2 = Slit(
xwidth = 0.04450, yheight= 0.0635)
AT (0, 0, 4.0808) RELATIVE Source
COMPONENT As3 = Slit(
xwidth = 0.04450, yheight= 0.0635)
AT (0, 0, 4.1189) RELATIVE Source
COMPONENT As4 = Slit(
xwidth = 0.04450, yheight= 0.0635)
AT (0, 0, 4.4141) RELATIVE Source
Line: 1 of 248 total, Column: 0

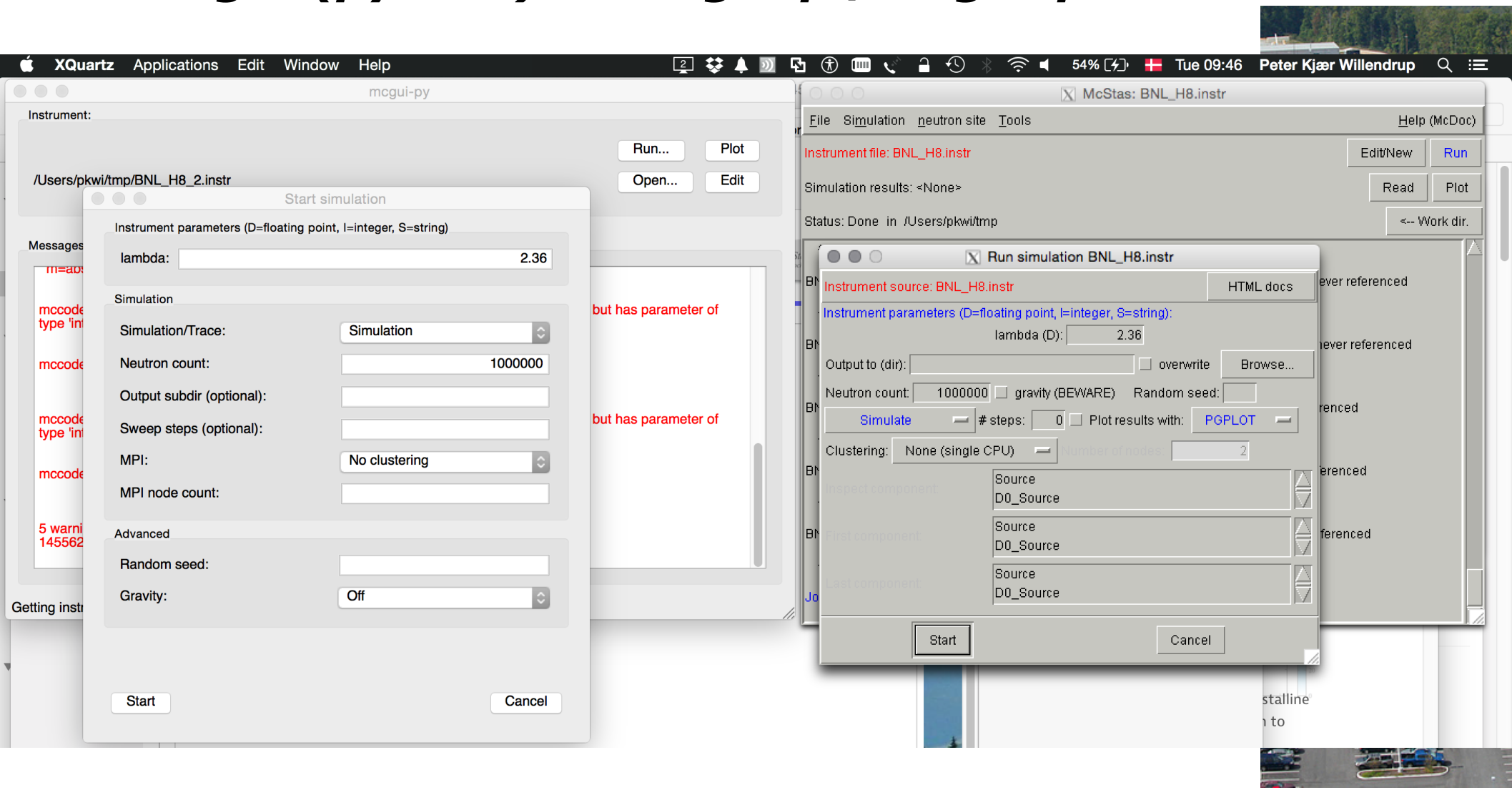
mcgui (python) vs mcgui.pl/mcgui-pl



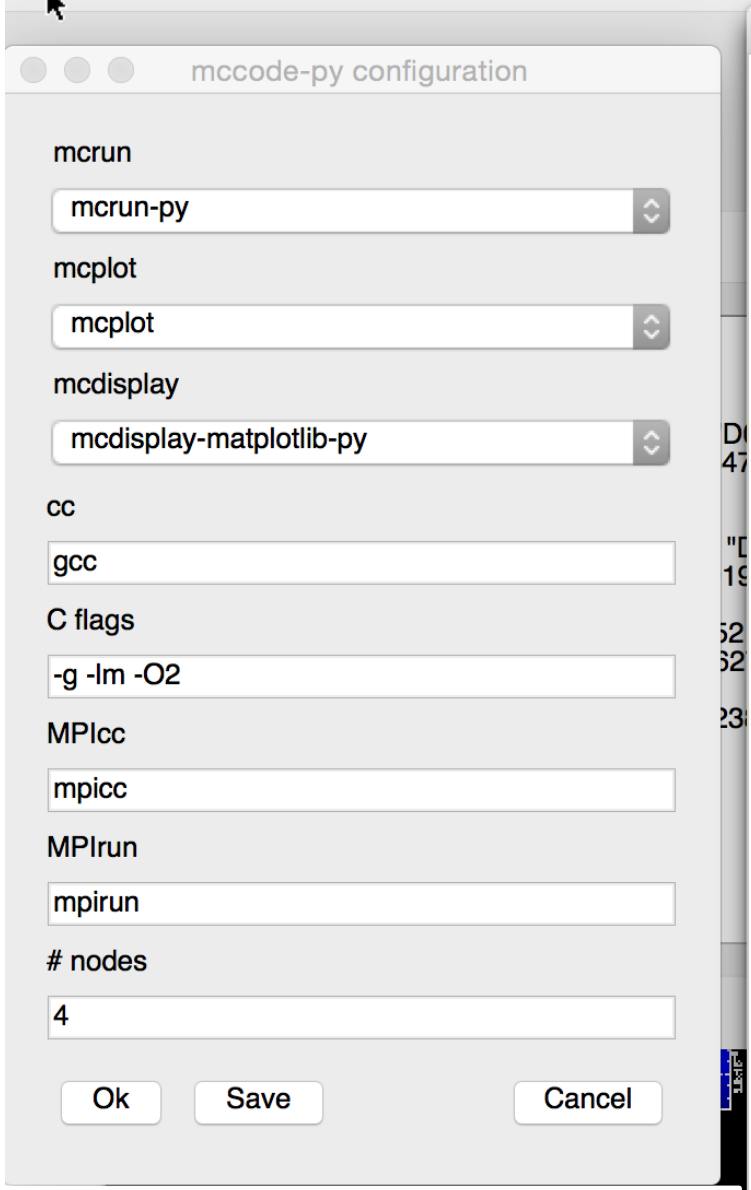
mcgui (python) vs mcgui.pl/mcgui-pl



mcgui (python) vs mcgui.pl/mcgui-pl



mcgui



October 2018

mcrun (py) vs. mcrun.pl/mcrun-pl version

October 2018

tmp — pkwi@pkwi-mbp15: ~/tmp — bash — 88×50

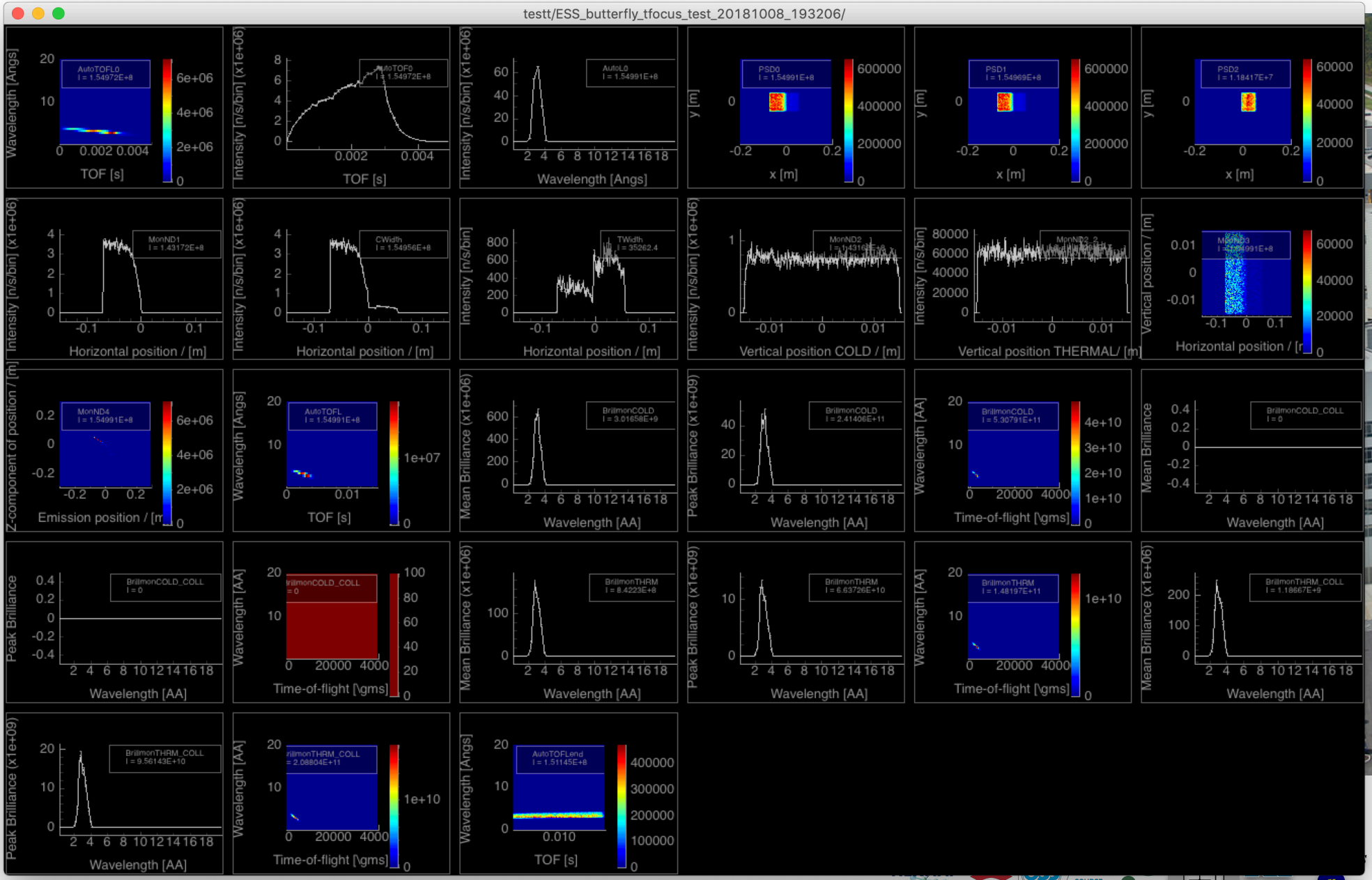
```
XQuartzScreenSnapz004.png
pkwi@pkwi-mbp15:~/Pictures$ open XQuartzScreenSnapz00*
pkwi@pkwi-mbp15:~/Pictures$ cd
pkwi@pkwi-mbp15:~$ cd tmp/
pkwi@pkwi-mbp15:~/tmp$ mcrun-py --help
Usage: mcrun.py [-cpnN] Instr [-sndftgahi] params={val|min,max|min,guess,max}...

Options:
  --version             show program's version number and exit
  -h, --help            show this help message and exit

  mcrun options:
    -c, --force-compile
                        force rebuilding of instrument
    -p FILE, --param=FILE
                        read parameters from file FILE
    -N NP, --numpoints=NP
                        set number of scan points
    -L, --list          use a fixed list of points for linear scanning
    -M, --multi         run a multi-dimensional scan
    --mpi=NB_CPU        spread simulation over NB_CPU machines using MPI
    --machines=FILE     read machine names from FILE (MPI/grid)
    --slave=HOST        execute simulation on distant HOST (SSH grid)
    --optimise=COMP     Add COMP to the list of monitors to maximise
                        (optimisation criteria, requires Math::Amoeba)
    --optimise-all      Maximise all monitors
    --optimise-prec=PREC
                        relative requested accuracy of criteria (default:
                        1e-3)
    --optimise-file=FILE
                        store optimisation results in FILE (defaults to:
                        "mcstas.dat")
    --test              execute McStas self-test and generate report
    --no-cflags         disable optimising compiler flags for faster
                        compilation
    --verbose           enable verbose output

  Instrument options:
    -s SEED, --seed=SEED
                        set random seed (must be: SEED != 0)
    -n COUNT, --ncount=COUNT
                        set number of neutrons to simulate
    -t, --trace         enable trace of neutron through instrument
    -g, --gravitation   enable gravitation for all trajectories
    -d DIR, --dir=DIR   put all data files in directory DIR
    --format=FORMAT     output data files using format FORMAT (format list
                        obtained from <instr>.out -h)
    --no-output-files   Do not write any data files
    -i, --info          Detailed instrument information
pkwi@pkwi-mbp15:~/tmp$
```

tmp — pkwi@pkwi-mbp15: ~/tmp — bash — 103×49

```
pkwi@pkwi-mbp15:~/tmp$ mcrun --help
mcrun: reading local mcstas configuration from /Users/pkwi/.mcstas/mccode_config.perl
/usr/local/bin/mcrun: reading local mcstas configuration from /Users/pkwi/.mcstas/mccode_config.perl
*** No directory given - placing data in _20160216_095914 ***
"Usage: mcrun [-cpnN] Instr [-sndftgahi] params={val|min,max|min,guess,max}
mcrun options:
   -c        --force-compile  Force rebuilding of instrument.
   -p FILE   --param=FILE     Read parameters from file FILE.
   -n COUNT  --ncount=COUNT   Set number of neutrons to simulate.
   -N NP     --numpoints=NP   Set number of scan points.
             --grid=NB_CPU    Spawn simulations to multiple machine/cores grid.
             --multi=NB_CPU     see the documentation for more info.
   --mpi     --mpi=NB_CPU     Spread simulation over NB_CPU machines using MPI
   --machines=MACHINES        Read machine names from file MACHINES (MPI/grid)
   --slave=HOST               Execute simulation on distant HOST (SSH grid)
   --optim=COMP               Add COMP to the list of monitors to maximize
                                (optimization criteria, requires Math::Amoeba)
   --optim                    Maximize all monitors
   --optim-prec=PREC          Relative requested accuracy of criteria (1e-3)
   --optim-file=FILENAME      Defines filename for storing optim results.
                                (Defaults to "mcoptim_XXXX.dat")
   --test                     Execute McStas selftest and generate report
   --no-cflags                Does not use CFLAGS for faster compilation
  Instr options:
   -s SEED   --seed=SEED      Set random seed (must be != 0)
   -n COUNT  --ncount=COUNT   Set number of neutrons to simulate.
   -d DIR    --dir=DIR        Put all data files in directory DIR.
   -f FILE   --file=FILE      Put all data in a single file.
   -t        --trace          Enable trace of neutron through instrument.
   -g        --gravitation    Enable gravitation for all trajectories.
   -a        --data-only      Do not put any headers in the data files.
   --no-output-files          Do not write any data files.
   -h        --help           Show help message.
   -i        --info           Detailed instrument information.
   --format=FORMAT            Output data files using format FORMAT.
                              (format list obtained from <instr>.out -h)
"This program both runs mcstas with Instr and the C compiler to build an
independent simulation program. The following environment variables may be
specified for building the instrument:
  MCSTAS        Location of the McStas and component library
                  (/Applications/McStas-2.3rc2.app/Contents/Resources/mcstas/2.3rc2).
  MCSTAS_CC     Name of the C compiler              (cc)
  MCSTAS_CFLAGS Options for compilation             (-lm -g -O2 -L/usr/local/lib -lNeXus -DUSE_NEXUS )
  MCSTAS_FORMAT Default FORMAT to use for data files (PGPLOT)
SEE ALSO: mcstas, mcdoc, mcplot, mcdisplay, mcgui, mcresplot, mcstas2vitess
DOC:      Please visit http://www.mcstas.org/
** No instrument definition name given

pkwi@pkwi-mbp15:~/tmp$
```

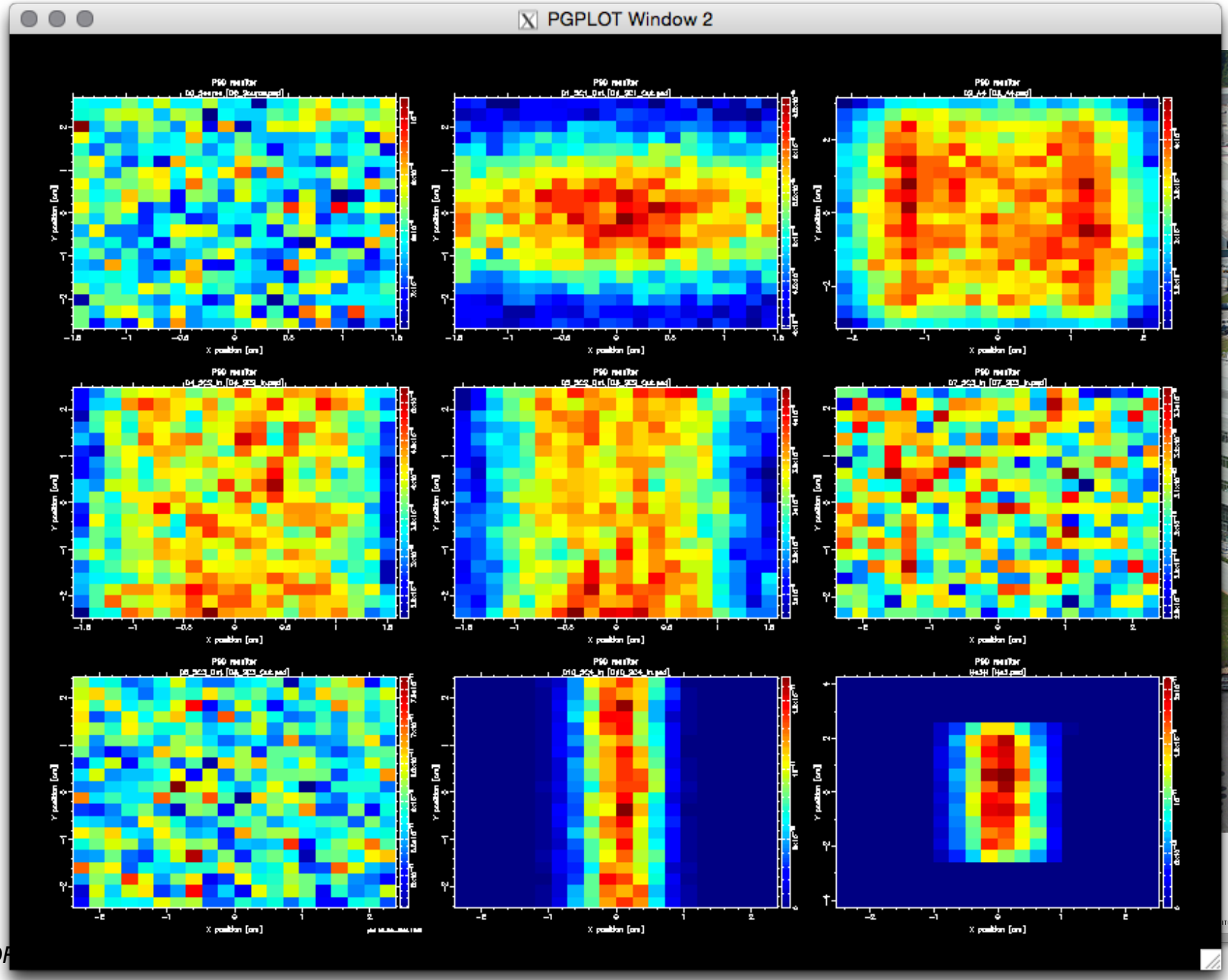
mcplot /mcplot-pyqtgraph (python)

October 2018

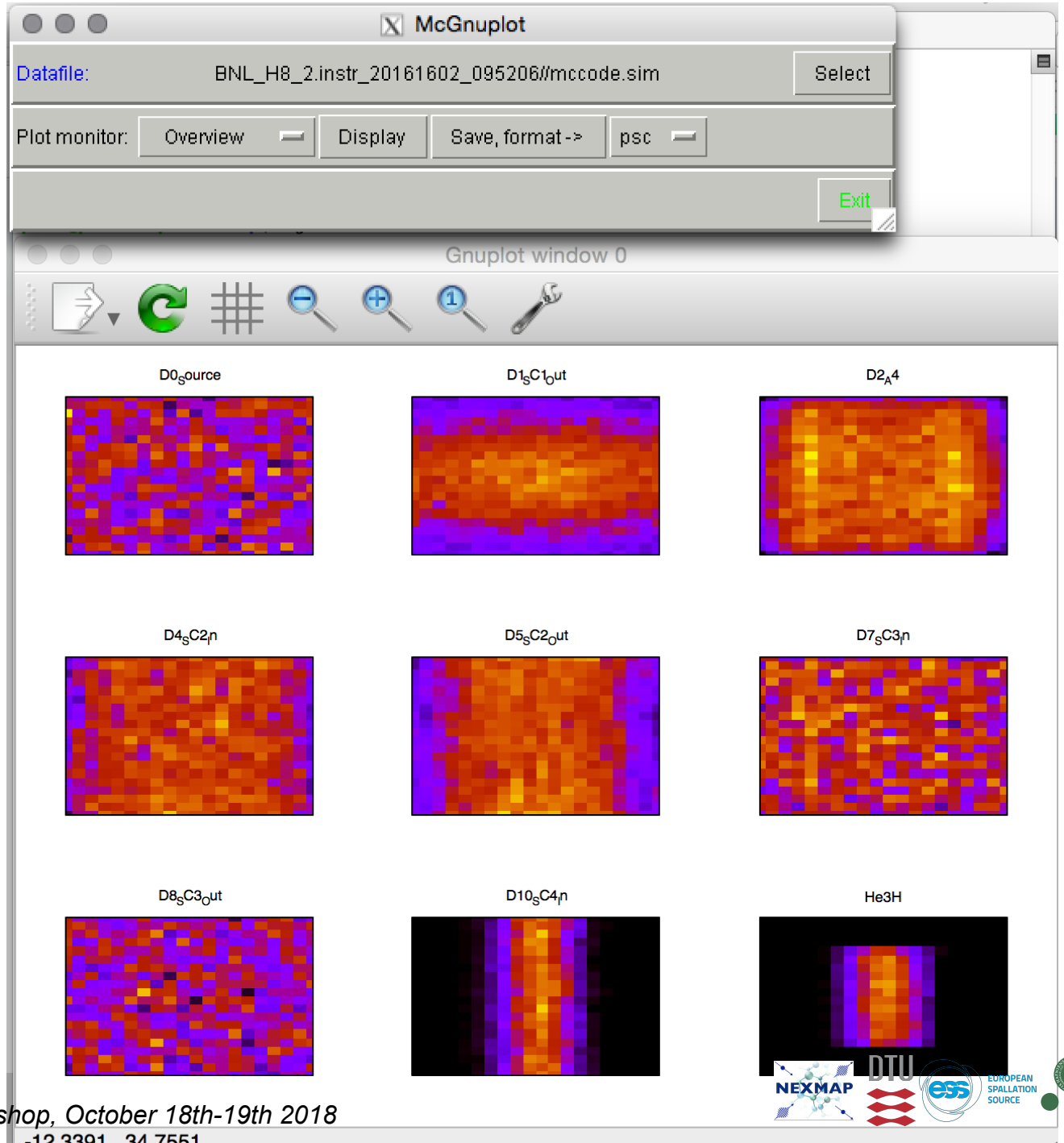


mcplot.pl/mcplot-pl (--format=PGPLOT)

October 2018

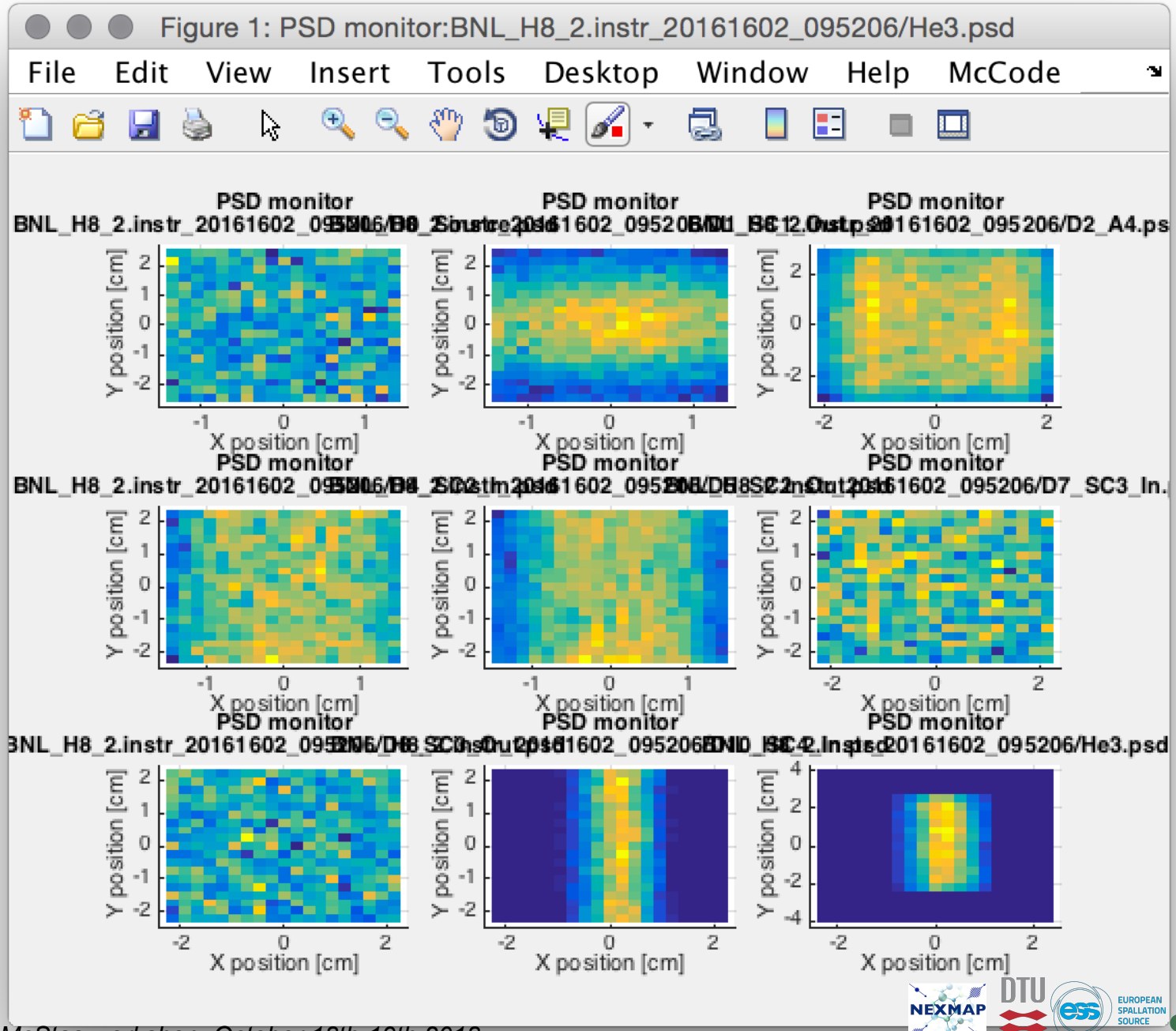


mcplot.pl/mcplot-pl --format=Gnuplot



mcplot.pl/mcplot-pl —format=Matlab

October 2018

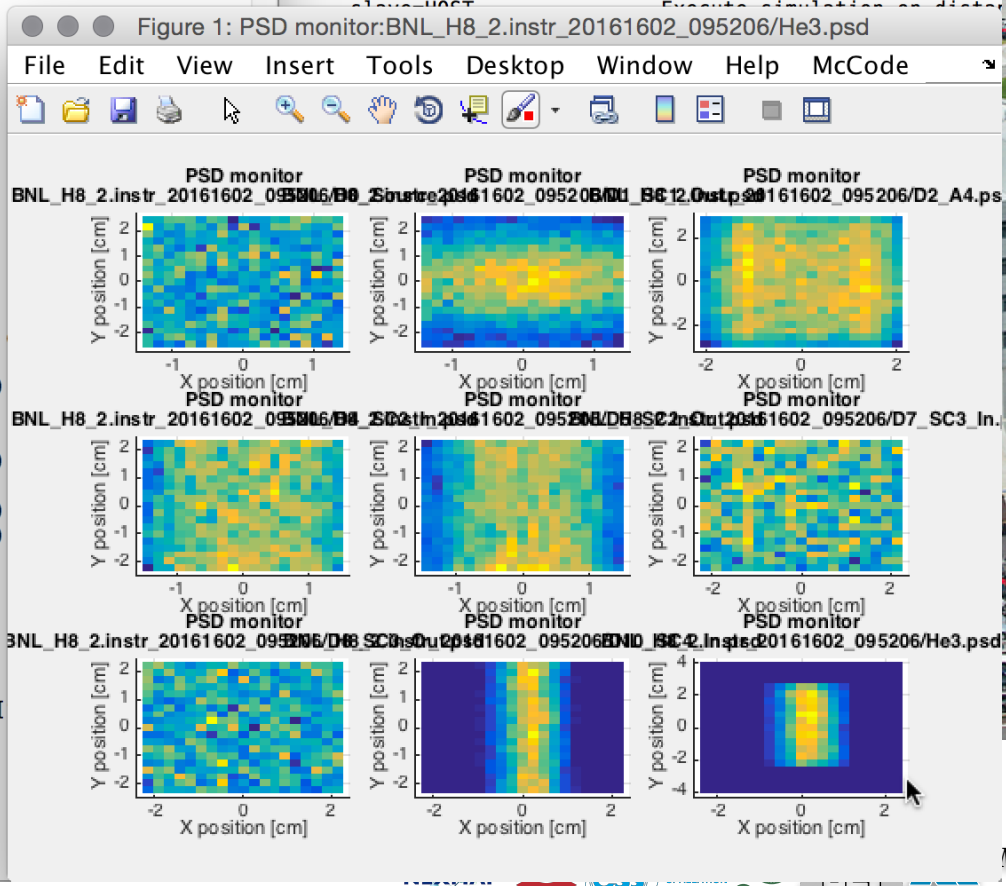


mcplot-matlab (Unix only)

October 2018

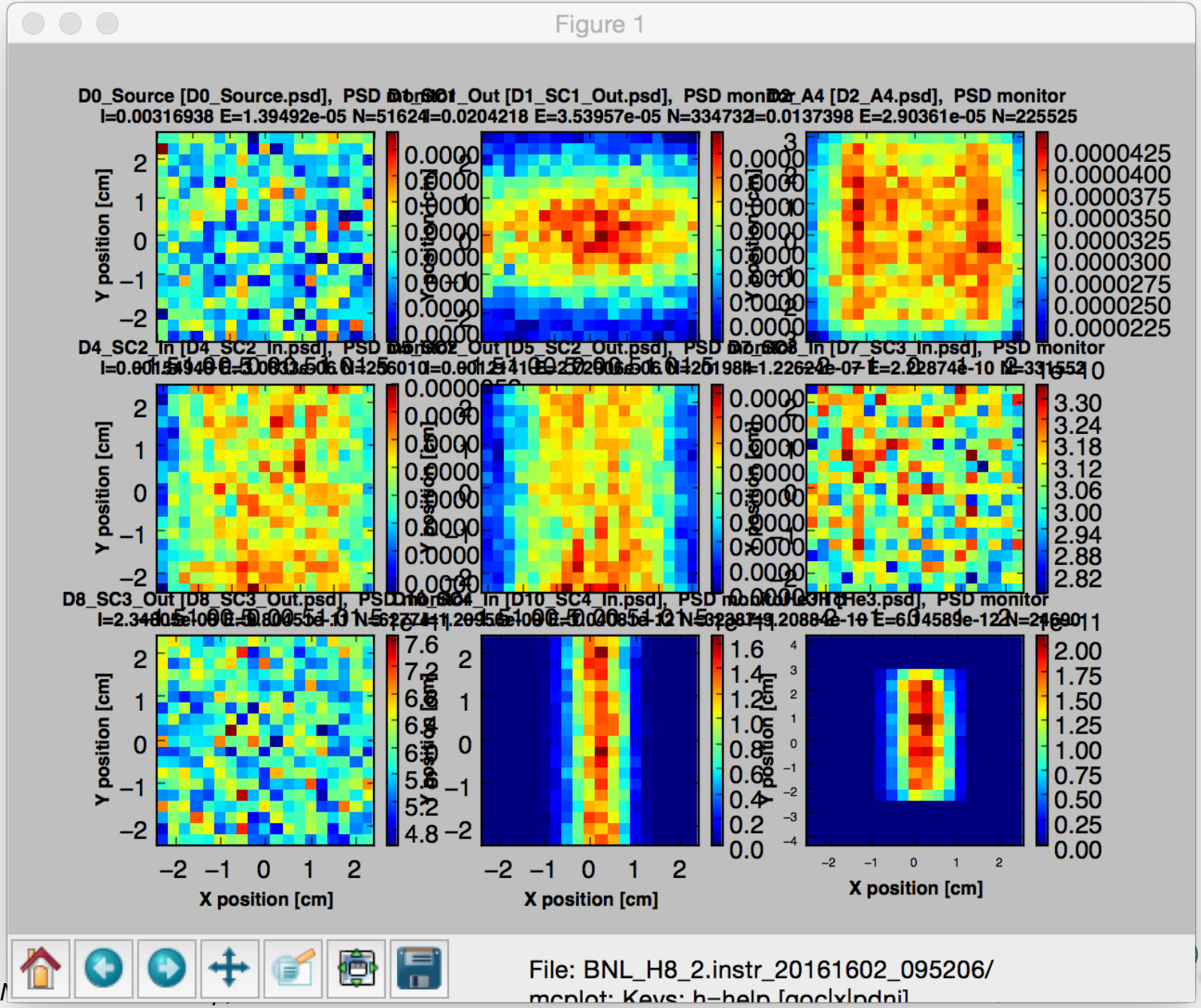
```
tmp — pkwi@pkwi-mbp15: ~/tmp — MATLAB — 88×50
/usr/local/bin/mcplot: reading local mcstas configuration from /Users/pkwi/.mcstas/mccod
e_config.perl
Click on a plot for full-window view.
Press key for hardcopy (in graphics window), 'Q' to quit
  'P' BW postscript
  'C' color postscript
  'N' PNG file
  'M' PPM file
  'G' GIF file
  'L' Toggle log10 plotting mode
  'T' Toggle contour plotting mode
  'Q' quit
^C
pkwi@pkwi-mbp15:~/tmp$ mcplot-mat BNL_H8_2.instr_20161602_095206/
mcplot-matlab         mcplot-matplotlib-py
pkwi@pkwi-mbp15:~/tmp$ mcplot-mat BNL_H8_2.instr_20161602_095206/
mcplot-matlab         mcplot-matplotlib-py
pkwi@pkwi-mbp15:~/tmp$ mcplot-matlab BNL_H8_2.instr_20161602_095206/

                            < M A T L A B (R) >
                  Copyright 1984-2014 The MathWorks, Inc.
                   R2014b (8.4.0.150421) 64-bit (maci64)
                              September 15, 2014


To get started, type one of these: helpwin, helpdesk, or demo.
For product information, visit www.mathworks.com.

Loading BNL_H8_2.instr_20161602_095206/mccode.sim (McCode simulation
Loading BNL_H8_2.instr_20161602_095206/D0_Source.psd (McCode format)
Loading BNL_H8_2.instr_20161602_095206/D1_SC1_Out.psd (McCode format)
Loading BNL_H8_2.instr_20161602_095206/D2_A4.psd (McCode format)
Loading BNL_H8_2.instr_20161602_095206/D4_SC2_In.psd (McCode format)
Loading BNL_H8_2.instr_20161602_095206/D5_SC2_Out.psd (McCode format)
Loading BNL_H8_2.instr_20161602_095206/D7_SC3_In.psd (McCode format)
Loading BNL_H8_2.instr_20161602_095206/D8_SC3_Out.psd (McCode format)
Loading BNL_H8_2.instr_20161602_095206/D10_SC4_In.psd (McCode format)
Loading BNL_H8_2.instr_20161602_095206/He3.psd (McCode format)

ans =

  Columns 1 through 5

    [1x1 struct]    [1x1 struct]    [1x1 struct]    [1x1 struct]    [

  Columns 6 through 9

    [1x1 struct]    [1x1 struct]    [1x1 struct]    [1x1 struct]

>>
```

```
tmp — pkwi@pkwi-mbp15: ~/t
pkwi@pkwi-mbp15:~/tmp$ mcrun --help
mcrun: reading local mcstas configuration from /Users/pkwi
/usr/local/bin/mcrun: reading local mcstas configuration
*** No directory given - placing data in _20160216_095914
"Usage: mcrun [-cpnN] Instr [-sndftgahi] params={val|min,r
mcrun options:
   -c          --force-compile  Force rebuilding of instrume
   -p FILE     --param=FILE     Read parameters from file FI
   -n COUNT    --ncount=COUNT   Set number of neutrons to si
   -N NP       --numpoints=NP   Set number of scan points.
               --grid=NB_CPU    Spawn simulations to multipl
               --multi=NB_CPU     see the documentation for
   --mpi       --mpi=NB_CPU     Spread simulation over NB_CP
   --machines=MACHINES          Read machine names from file
```

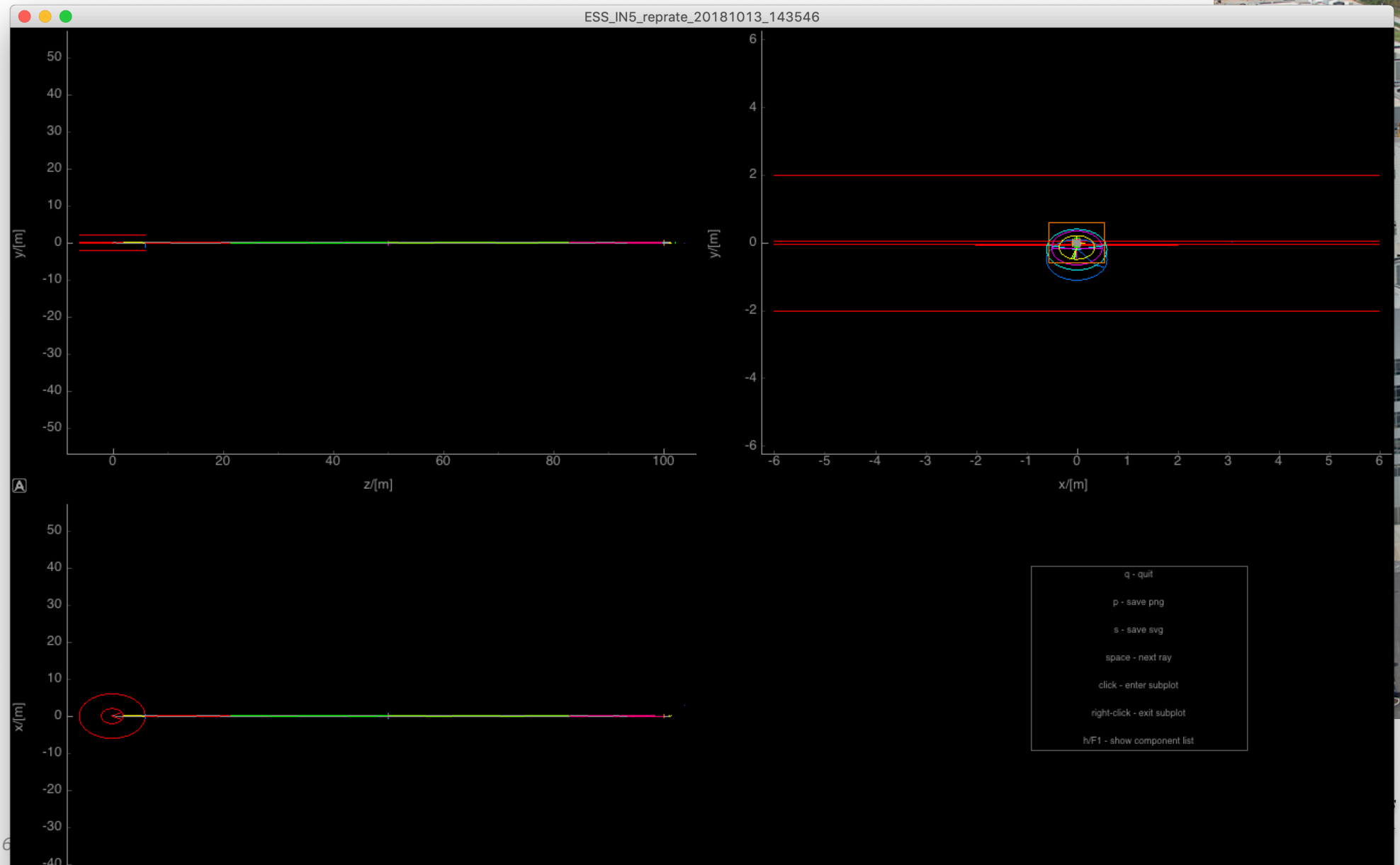


mcplot-matplotlib (python)

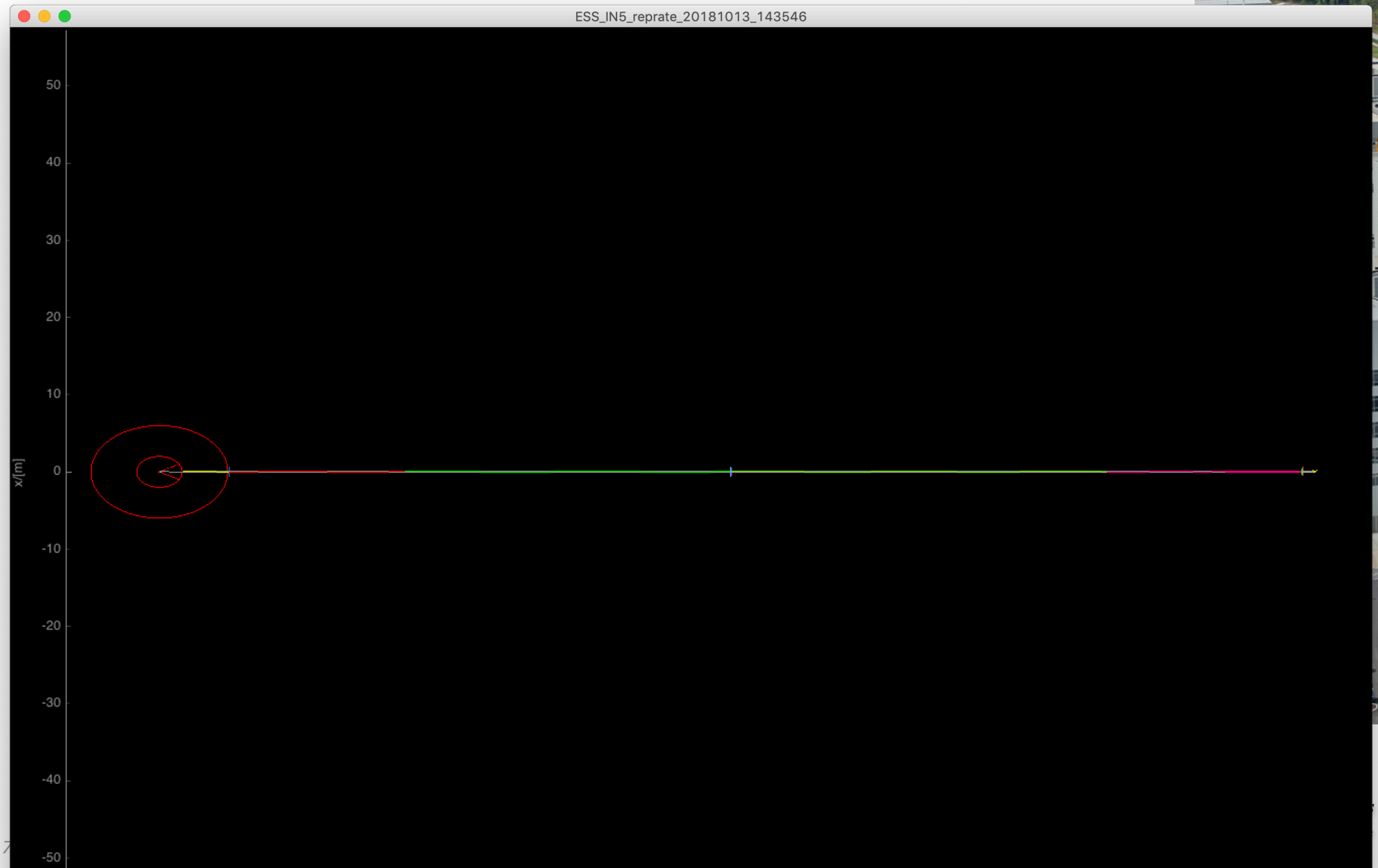
October 2018



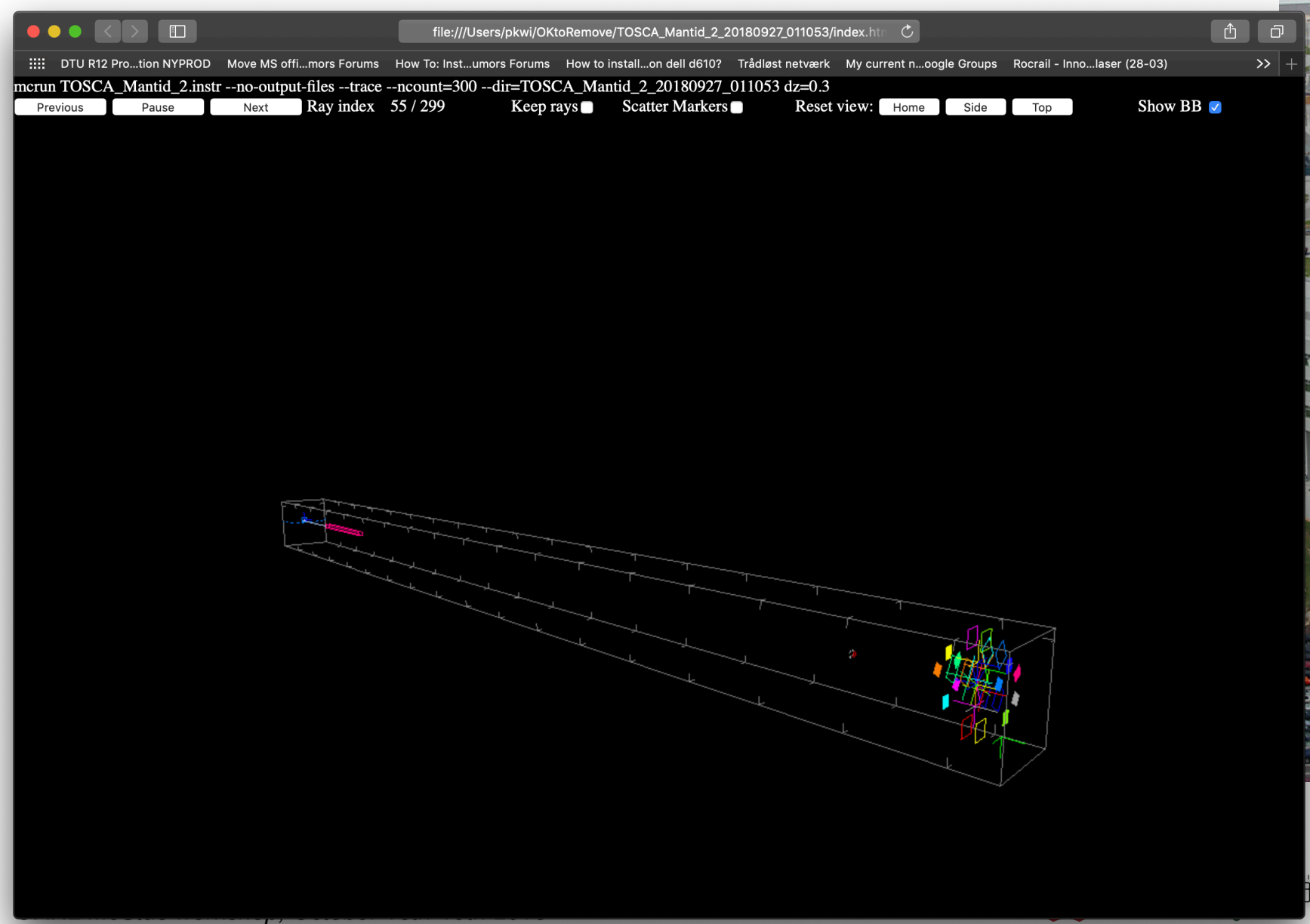
mcdisplay / mcdisplay-pyqtgraph (python)



mcdisplay / mcdisplay-pyqtgraph (python)



mcdisplay-webgl (python)



mcdisplay.pl / mcdisplay-pl

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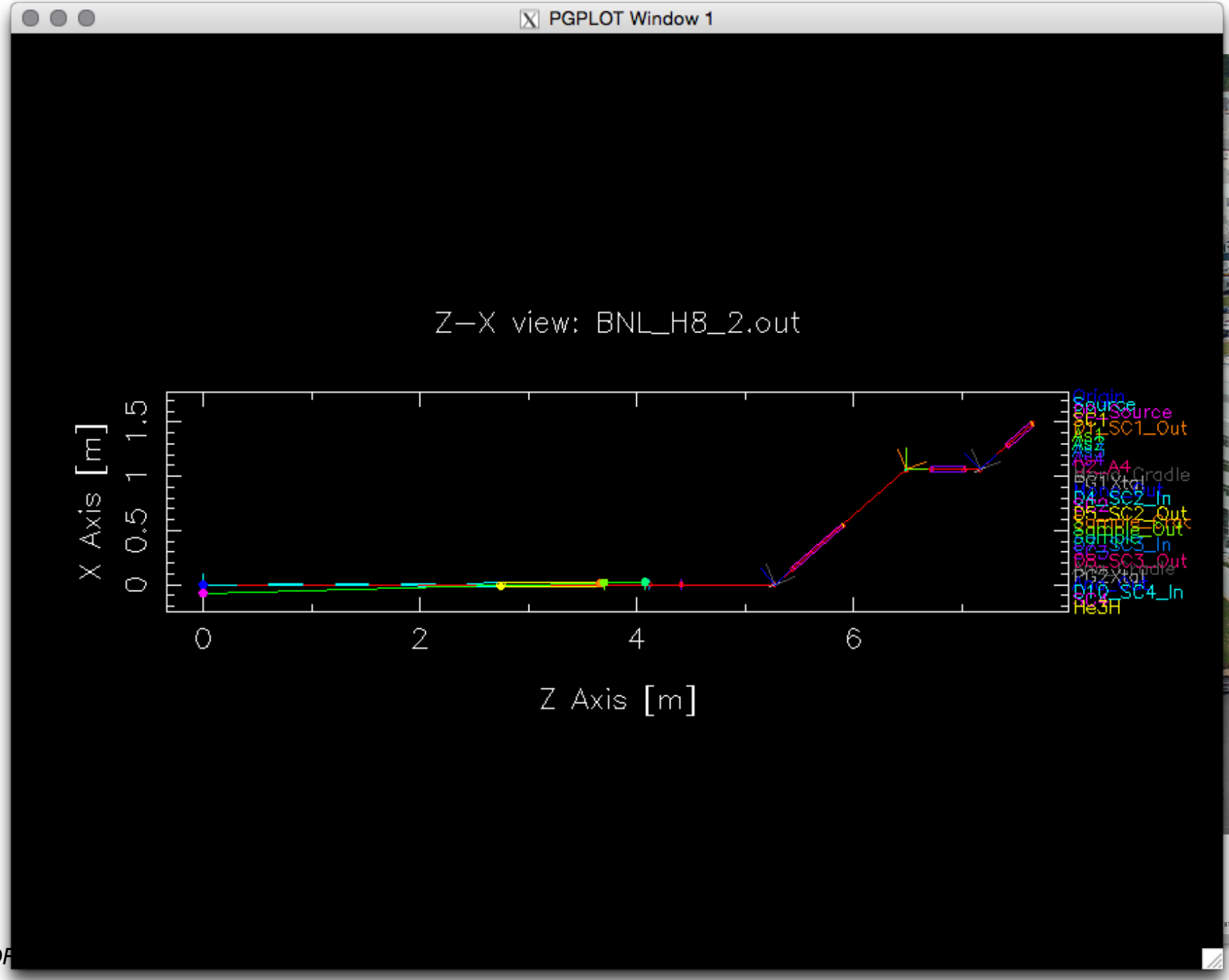
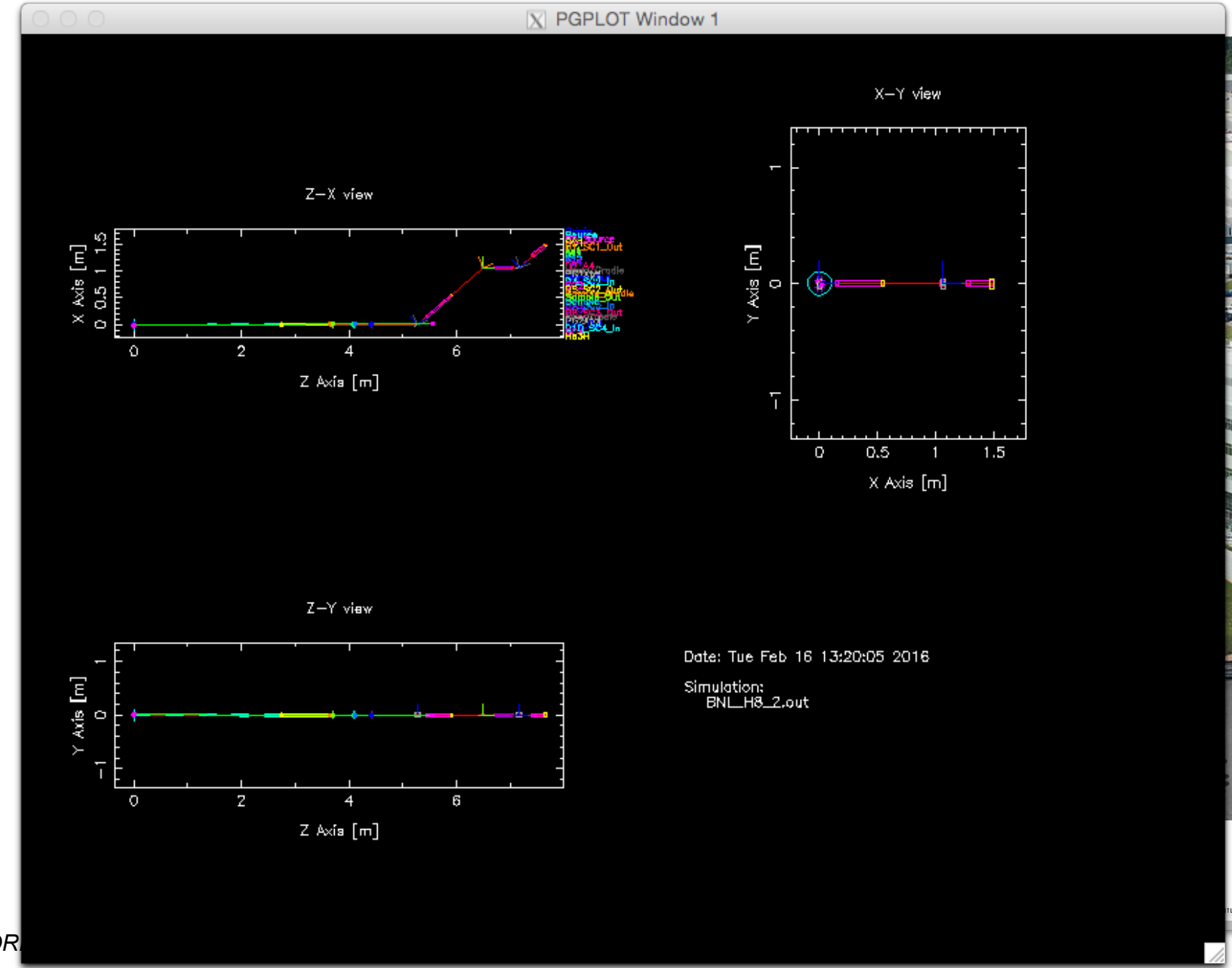


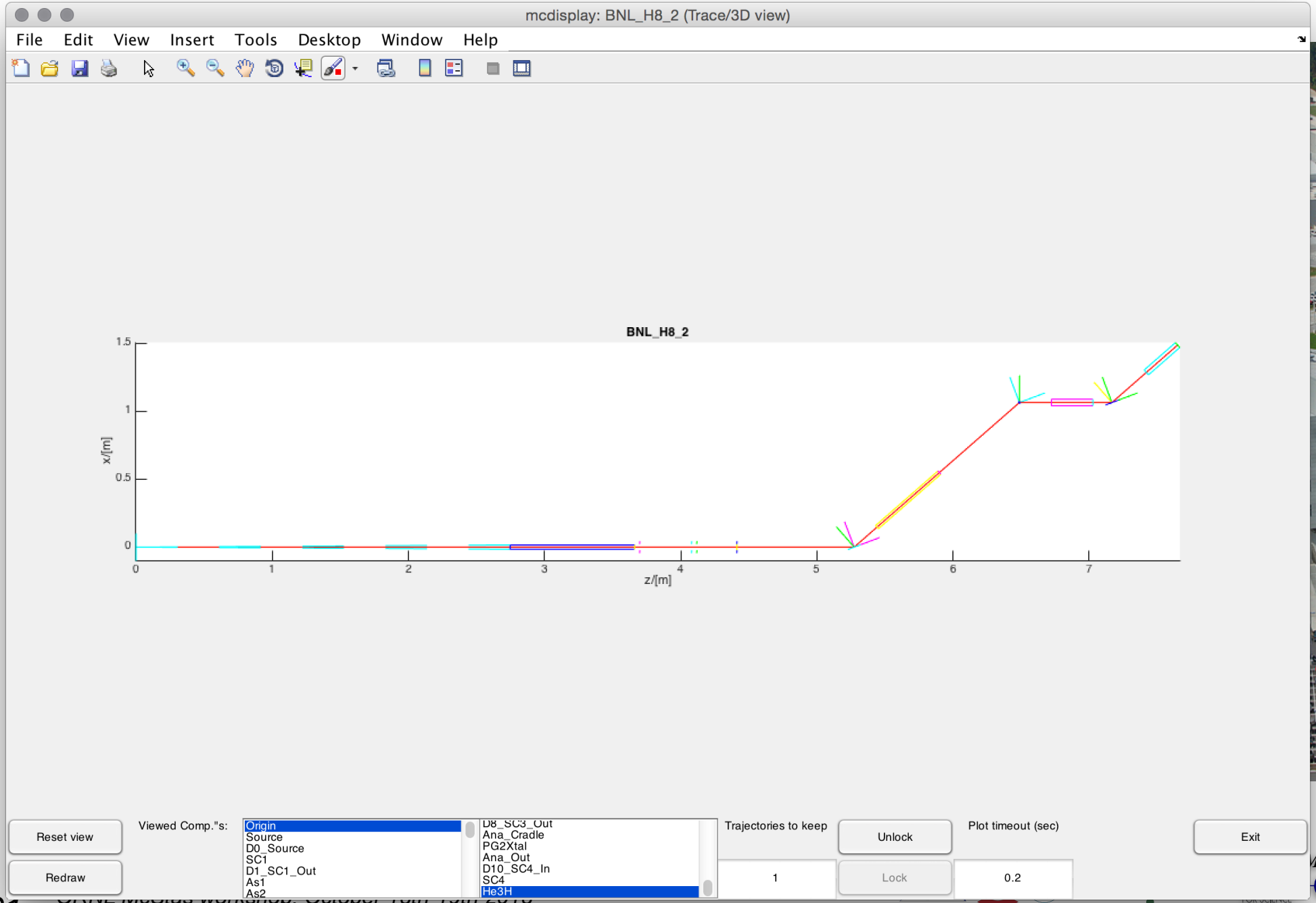
mcdisplay.pl / mcdisplay-pl with -mm

October 2018



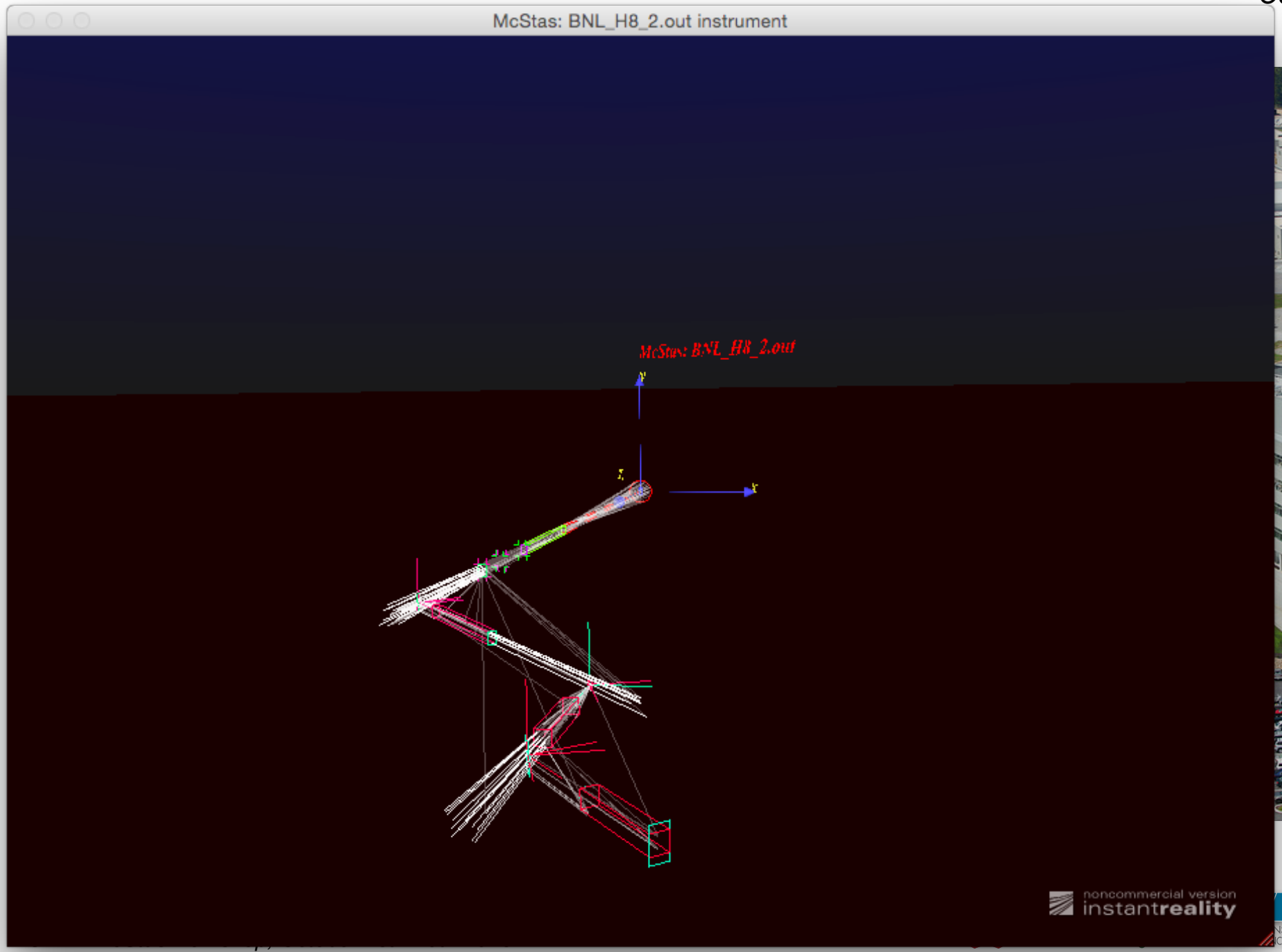
mcdisplay.pl / mcdisplay-pl --format=Matlab

October 2018



mcdisplay.pl / mcdisplay-pl --format=VRML

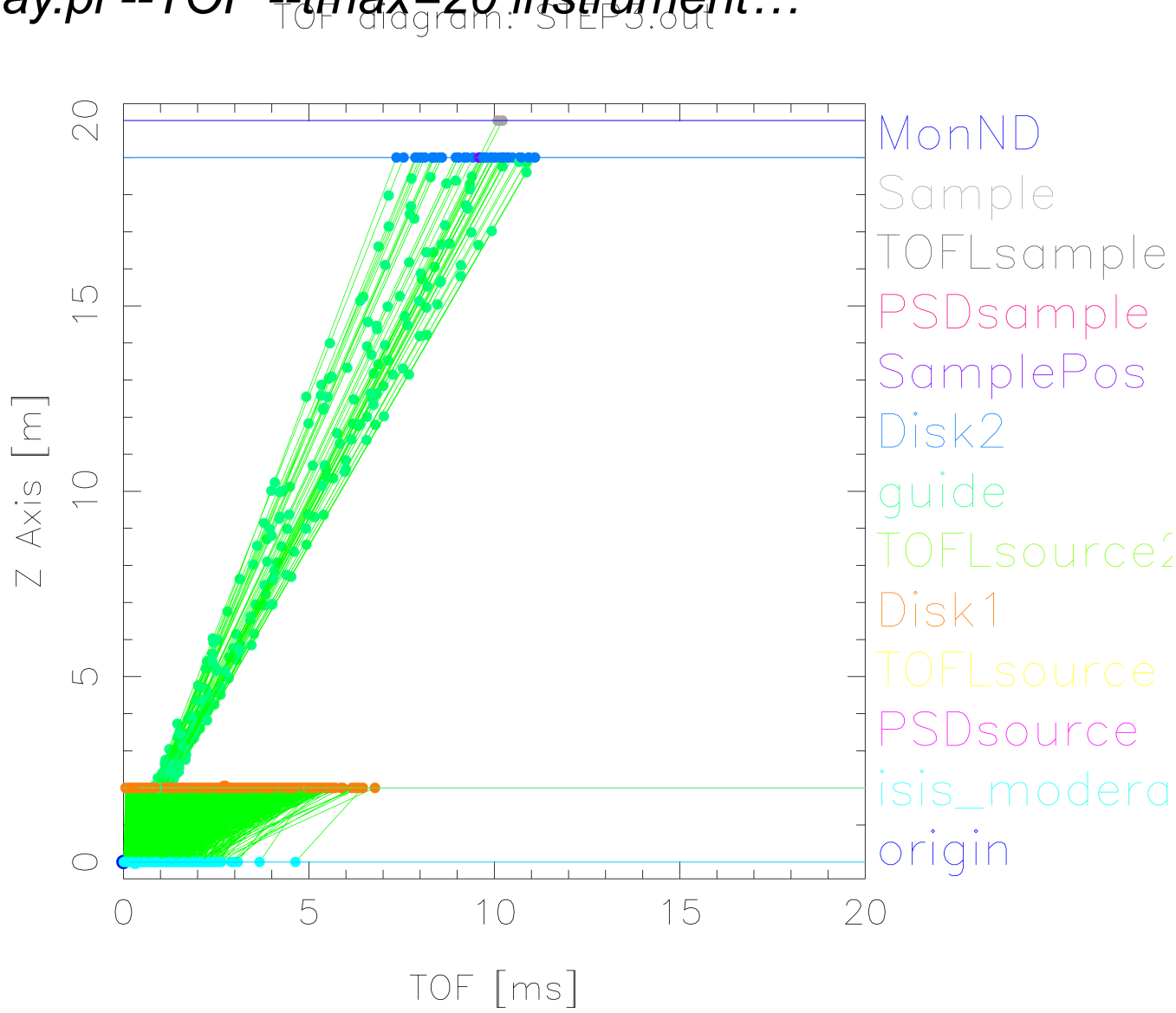
October 2018



TOF diagram util based on mcdisplay

October 2018

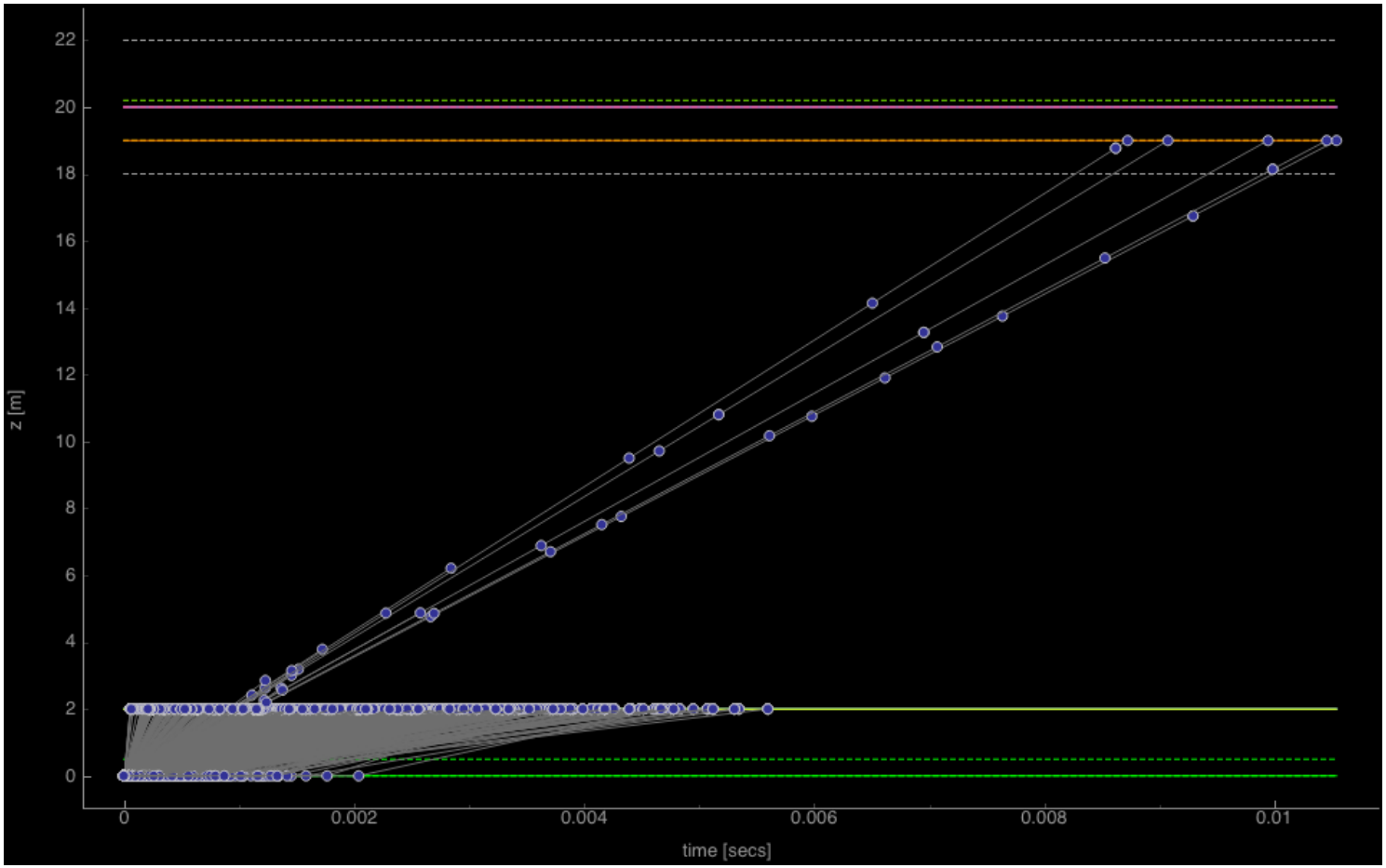
- *mcdisplay.pl --TOF --tmax=20 instrument…*



TOF diagram util based on mcdisplay

October 2018

- *mcdisplay-pyqtgraph --TOF instr*



Useful links / docs

- http://mcstas.org/links

McStas Overview of web resources for McStas

Get the code, report bugs etc.

- McStas website
- McStas mailinglist subscription (Please enrol!)
- McStas Facebook page (Please follow us!)
- McStas downloads
- McStas+McXtrace GitHub
- McStas+McXtrace issues + bug reporting

Neutron scattering + McStas e-learning

- e-neutrons website (free enrolment)

Tutorials, howto's, docs

- How McStas works - in 2 minutes
- Tutorial: Build a SANS
- Tutorial: Build a diffractometer (outdated in certain parts)
- McStas user manual - **Better use `mcdoc -m` in the terminal!**
- McStas component manual - **Better use `mcdoc -c` in the terminal!**
- McStas component docs - **Better use `mcdoc` in the terminal!**
- McStas sample model functionality matrix (not fully up to date)
- McStas and McXtrace GitHub wiki - tutorials, guides and more

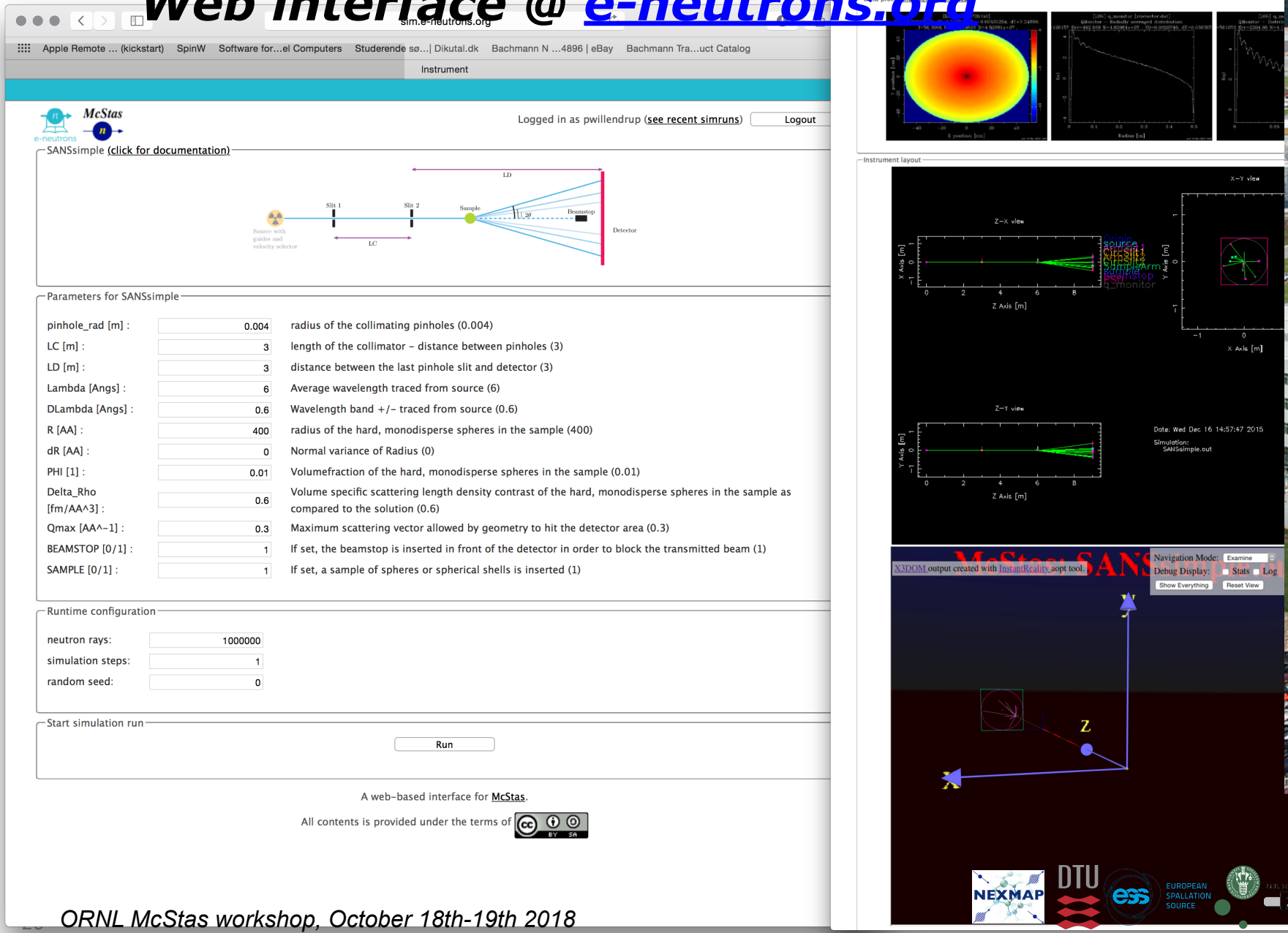
- https://github.com/McStasMcXtrace/McCode/wiki

Documentation on the McCode tools

- User documentation for the 2017- Python tool set'
- mcrun variants - table overview
- mcplot variants - table overview
- mcdisplay variants - table overview

Web interface @ e-neutrons.org

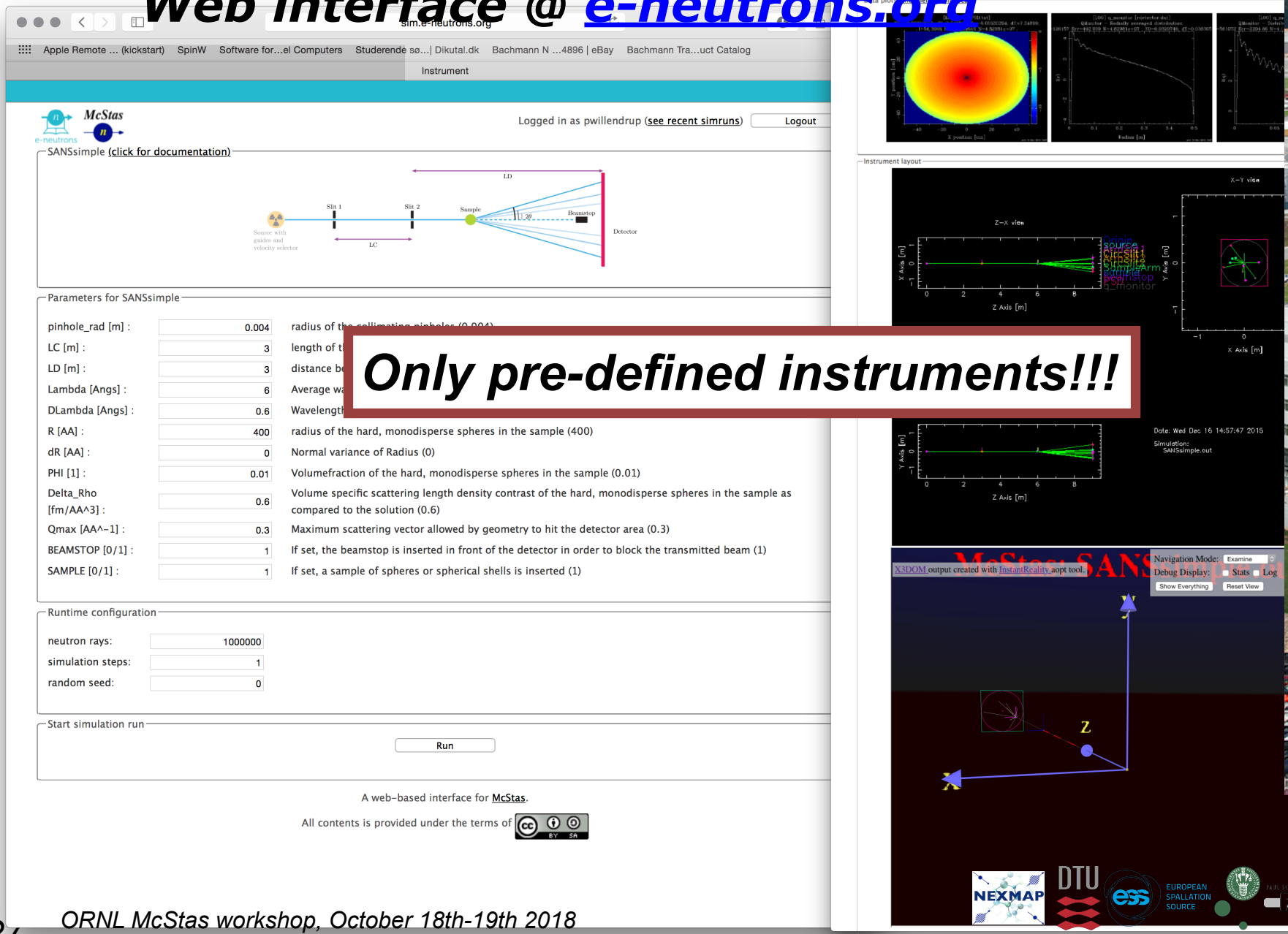
October 2018



Web interface @ e-neutrons.org

Only pre-defined instruments!!!

October 2018



We

e-neutrons.org

Apple Remote ... (kickstart) SpinW Software for...el Computers Studerende sø...| Dikutal.dk Bachmann N ...4896 | eBay Bachmann Tra...uct Catalog

e-neutrons

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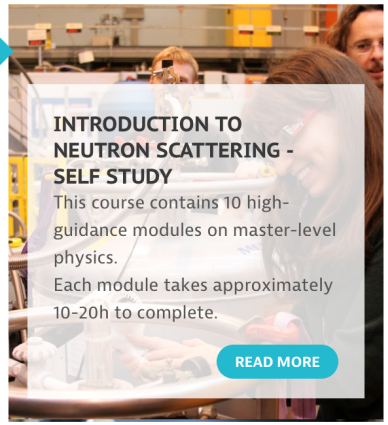
Username pwillendru Password •••••••• Login

Courses

Introduction to Neutron Scattering
High-guidance self study

Introduction to Neutron Scattering
Open course for blended learning

Muon Spin Spectroscopy
A course on a complementary technique to neutron scattering

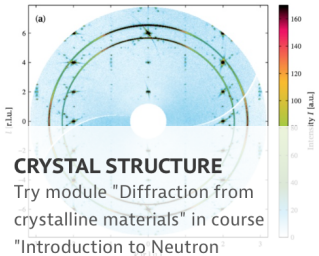


Science cases

Finding crystal structure
Chemistry of materials

Characterising liposomes in suspension
Life sciences

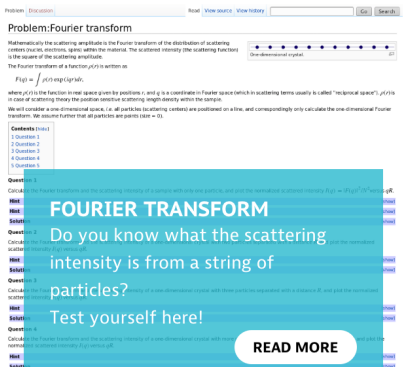
Characterising magnetic order
Magnetic and electronic phenomena



CRYSTAL STRUCTURE
Try module "Diffraction from crystalline materials" in course "Introduction to Neutron Scattering"

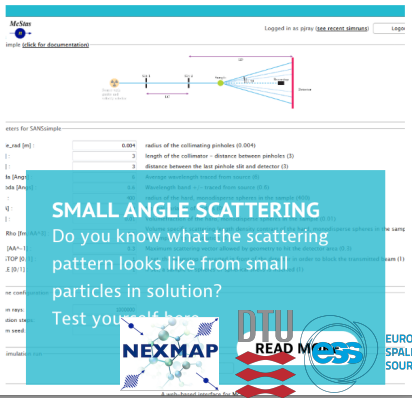
READ MORE

Exercise taster



Quiz taster

Simulation taster



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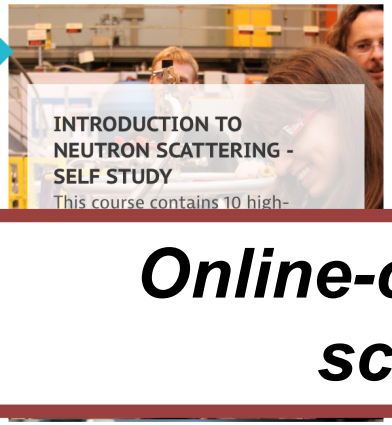

Science cases

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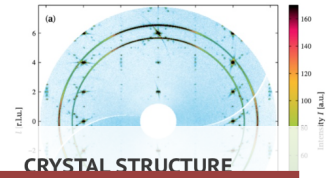
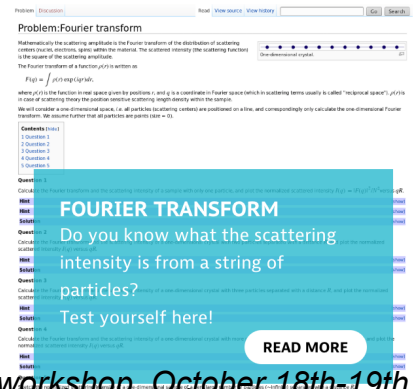


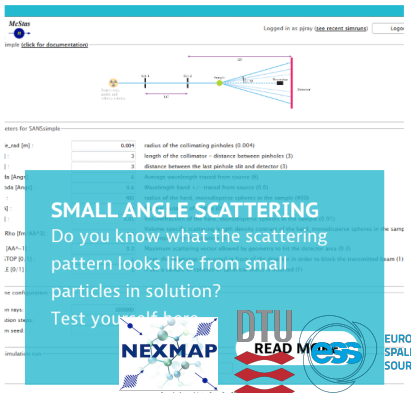
Online-course on neutron scattering available!

Exercise taster



Quiz taster

Simulation taster



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The available selection of courses is visible at this Moodle page. The list below uses the "short" naming convention for courses, i.e.

- ns-intro="Introduction to neutron scattering"
- ns-intro-selfstudy="Introduction to neutron scattering – self study"
- musr="Introduction to muon spin resonance"

Please fill in the form, indicating your personal data and requested courses.

If you have an account already and want to change your password, please visit our Password change service

Please avoid special characters like the Danish æ,ø and å in this prototype

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First Name:

Last Name:

Email:

Requested username:

intro-ns-selfstudy

intro-ns

musr

Submit

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Please avoid special charact

Free subscription!!

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First Name:

Last Name:

Email:

Requested username:

intro-ns-selfstudy

intro-ns

musr

Submit

6 McStas various utils

October 2018

- *Hidden gems and useful little things…*
- *+ Disclaimers and tips for the next couple of days…*

cif2hkl

- *Util for generating McStas style "laz/lau" reflection lists from CIF file*
- *Based on CrysFML from the ILL (FullProf)*
- *Compile for your system from https://github.com/McStasMcXtrace/McCode/tree/master/tools/other/cif2hkl*
- *(May also get included in McStas 2.4)*

iFit optimiser (http://ifit.mccode.org)

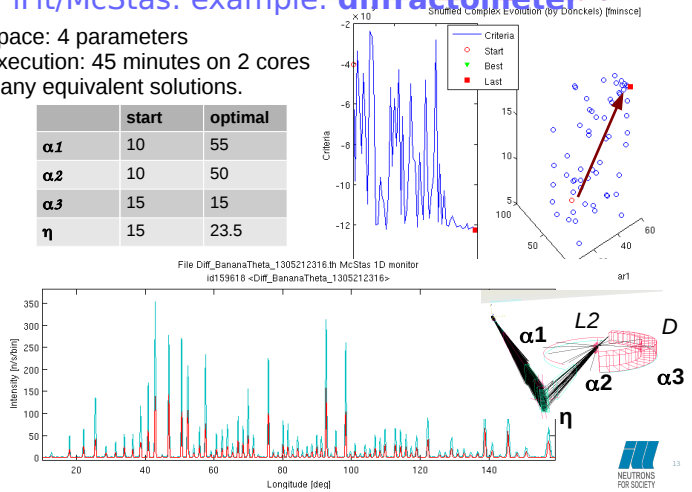
October 2018

- *General data / optimisation framework*
- *~ Modern "spec_nd"*
- *Matlab based, but does not require matlab (binary distribution also)*
- *Reads and plots McStas*
- *Can run McStas as a "cost function", varying instrument parameters*

iFit/McStas: example: **diffractometer**

Space: 4 parameters
Execution: 45 minutes on 2 cores
Many equivalent solutions.

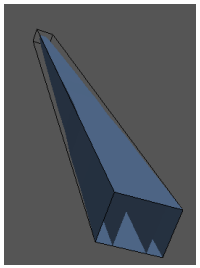
	start	optimal
α1	10	55
α2	10	50
α3	15	15
η	15	23.5

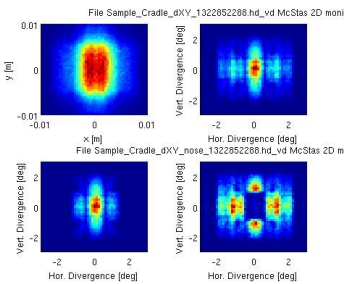


iFit/McStas: example: **IN22 nose**

Gain a factor 3 in flux for 50 k€.

- No need to use high *m* coating for top/bottom → m=4
- *m=6* to *m=5* only reduces flux by 1%.
- Nose 87 cm long. Profile is not fully parabolic.





Cluster utility scripts

October 2018

- *mcsub cluster scripts*

```
./mcsub_slurm.pl
Usage: ./mcsub_slurm.pl [options] [mcrun params]
 -h        --help             Show this help
 -rN       --runtime=N        Specify maximum runtime (hours) [default 1]
 -qQNAME   --queue=QNAME      Specify wanted SLURM queue [default 'express']
 -e<mail>  --email=<mail>     Specify address to notify in reg. sim status [default none]
           --nodes=NUM        Specify wanted number of nodes [default 1]
           --name=NAME        Specify slurm job name [default
"McSub_<USERNAME>_<TIMESTAMP>"]


After running ./mcsub_slurm.pl NAME.batch is ready for submission using the sbatch command
```

- *Takes a "mcrun commandline"*
- *Writes batch file "template" for use with PBS or slurm cluster queue systems*
- *https://github.com/McStasMcXtrace/McCode/tree/master/tools/cluster-scripts*

Vitess - compatibility

- *Utility script for converting Vitess reflectivity files for use with McStas* (https://github.com/McStasMcXtrace/McCode/blob/master/tools/other/Refl_Vitess2McStas.sh)

- *mcstas2vitess generates Vitess module + tcl snippet from McStas component (poor docs, will improve)*

Next: Time for exercises

Forming groups

- ***Suggestion for Thursday-Friday exercises:***
  - *Often sitting with a colleague is helpful*
  - *Form teams of two people for the exercises*
  - *Try to gather complementary knowledge by teaming up with someone from a different work area*

Next: Exercises

Disclaimers

- ***We will likely find new and intersting bugs as we move along… :-)***

- ***Programme is flexible - don't get frustrated if we lag behind, we will either adapt or catch up later!***

- ***Much of the teaching material is new / adapted, so there may be inconsistencies / confusion in some parts… :-)***