Practical Sessions 1 and 2: First Simulations and Analysis

The SIXTE Team – Remeis Observatory

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ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

WFI ATHENA

IFU ATHENA X-ray Integral Field Unit

Set up → Does everything work?

- Installed SIMPUT and SIXTE and XSPEC (→ HEASoft)?

0.1 Set environment variable

.bashrc

```
export SIMPUT=simputdir
export SIXTE=sixtedir
. $SIXTE/bin/sixte-install.sh
```

.cshrc

```
setenv SIMPUT=simputdir
setenv SIXTE=sixtedir
source $SIXTE/bin/sixte-install.sh
```

SciServer

```
source $HOME/workspace/Storage/sixte/sixte_volume/sixte_setup.sh
```

Set up → Does everything work?

0.2 Test SIMPUT, SIXTE and XSPEC

```
plist simputfile

plist runsixt

xspec
```

Part 1: Preparing Input → `simputfile`

1.1 Run `plist simputfile` (or look into manual: sect. 10.2.2)

1.2 Which parameters do you think we should change for . . .

name of source	
source position	
source flux	
energy	
logarithmic energy grid & number of bins	
define xspec file	

Part 1: Preparing Input → `simputfile`

1.3 Write shell script to create a simputfile (→ manual sect. 10.2.2):

name of source	`Src_Name=`*name*`.fits`
source position	`Ra=0.0, Dec=0.0`
source flux	`srcFlux=2.137e-11`
energy	`Elow=0.1, Eup=15, Emin=2, Emax=10`
logarithmic energy grid & number of bins	`logEgrid=yes, Nbins=1000`
define xspec file	`XSPECFile=`*name*`.xcm`

Part 1: Preparing Input → xspec

- Source needs spectrum → create spectrum with xspec

1.4 If you use the SciServer → Create folder in:
`/$HOME/workspace/Storage/`*`username`*`/persistent/`*`name_of_folder`*

1.5 Go there!

1.6 Now start by typing `xspec` into terminal

```
model          phabs*pegpwrlw
nH>            0.2
PhoIndex>      2.05
eMin>          2
eMax>          10
norm>          21.6
```

→ See manual for name of xspec file and further advice (section 10.2.2)

1.7 run `simputfile`

Part 1: Preparing Input → `simputfile` shell script

Solution `simputfile` shell script:

```
#!/bin/sh
base=mcrab

$SIXTE/bin/simputfile          \
    Simput=${base}.fits        \
    Src_Name=first             \
    RA=0.0 Dec=0.0             \
    srcFlux=2.137e-11          \
    Elow=0.1 Eup=15            \
    Nbins=1000                 \
    logEgrid=yes               \
    Emin=2 Emax=10             \
    XSPECFile=${base}.xcm      \
    clobber=yes
```

Part 2: Running the Simulation → `runsixt`

2.1 Which parameters do you think we should change for . . .

Path to .xml file	
Simput Catalog	
telescope pointing	
exposure time	
output file	
prefix for output file	

Hint: run `plist runsixt`

Part 2: Running the Simulation → `runsixt`

2.2 Write a shell script and run a simulation for one large chip of the WFI

2.3 Run a second simulation with an offset pointing of the source

Path to .xml file	`XMLFile=`*`xmlfile`*
Simput Catalog	`Simput=`*`name.fits`*
telescope pointing	`Ra=0.0, Dec=0.0`
exposure time	`Exposure=1000`
output file	`EvtFile=`*`name.fits`*
prefix for output file	`Prefix=`*`name`*

Hint: Run `plist runsixt`

Hint: xmldir=`$SIXTE/share/sixte/instruments/athena-wfi/wfi_wo_filter_B4C`

Hint: Take a look into the manual, section 10.2.4

Part 2: Running the Simulation → runsixt

Solution runsixt shell script:

```
#!/bin/sh
base=mcrab
xmldir=#xmldir
xml=${xmldir}/ld_wfi_ff_large.xml

$SIXTE/bin/runsixt                      \
     XMLFile=${xml}                     \
     RA=0.000 Dec=0.000                 \
     Prefix=sim_                        \
     Simput=${base}.fits                \
     EvtFile=evt_${base}.fits           \
     Exposure=1000
```

Part 3: Analysing the Simulation $\rightarrow$ FTOOLS

3.1 Take a look at the structure of the event file.

- Use `fstruct` and `fv` or `fdump`
- Speculate on the meaning of the individual columns in the event file

3.2 Check if the Event File contains a significant fraction of pile-up

- What do the individual rows mean?

Hint: Take a look into the manual (sect. 10.2.5) for details

Part 3: Analysing the Simulation → `imgev`

3.3 Generate an image of the event file using imgev

3.4 What do the different parameters mean?

→ Manual, section 10.2.5

Part 3: Analysing the Simulation → imgev

Solution imgev shell script:

```
#!/bin/sh

$SIXTE/bin/imgev                                                \
    EvtFile=sim_evt_mcrab.fits                                  \
    Image=img_mcrab.fits                                        \
    CoordinateSystem=0 Projection=TAN                           \
    NAXIS1=512 NAXIS2=512                                       \
    CUNIT1=deg CUNIT2=deg                                       \
    CRVAL1=0.0 CRVAL2=0.0                                       \
    CRPIX1=256.5 CRPIX2=256.5                                   \
    CDELT1=-6.207043e-04 CDELT2=-6.207043e-04                   \
    history=true clobber=yes
```

Part 3: Analysing the Simulation → `makespec`

- Point source → quite boring. So, spectral shape:

3.5 Generate a spectrum using makespec

Hint: Use same xmldir as before

Hint: Manual, sect. 10.2.5

3.6 Use XSPEC **on your own machine** to plot the spectrum

→ If working on SciServer: download spectrum from SciServer

→ Take a look into the manual, section 10.2.5

Part 3: Analysing the Simulation → makespec

Solution makespec shell script:

```
#!/bin/sh
xmldir=#xmldir

$SIXTE/bin/makespec                                                    \
    EvtFile=sim_evt_mcrab.fits                                         \
    Spectrum=spec_mcrab.pha                                            \
    EventFilter=                                                       \
      "(RA>359.95 || RA<0.05) && Dec>-0.05 && Dec<+0.05"               \
    RSPPath=${xmldir}                                                  \
    clobber=yes
```

Part 3: Analysing the Simulation → `makelc`

- Generate a lightcurve
- What's important for a lightcurve to define?
  → Duration
  → Time resolution
- Ways to define a lightcurve:
  - ASCII
    → Energy dependent → time and flux
    → Stochastic through power spectrum → frequency and power
  - Lorentzians and zero-centered low frequency QPO

→ More informations: Manual section 10.3.1

Part 3: Analysing the Simulation → `makelc`

- Ways to define a lightcurve:
  - ASCII → **Energy dependent** → **time and flux**

3.7 Create a simput file with a TIMING extension

- Parameter for Date → value is 55000
- Include lightcurve → `/sixtedata/tutorial/inputs/Practical_2`

or `https://www.sternwarte.uni-erlangen.de/research/sixte/downloads/example_lightcurve.dat`

3.8 Run the simulation → `runsixt`

3.9 Produce the light curve → `makelc`

→ Eventfile
→ Lightcurve
→ Duration (in s) → 1000.0
→ Time resolution (in s) → 1.0

3.10 Analyze the light curve → `fplot`

→ Manual, section 10.3.1

Part 3: Analysing the Simulation → `makelc`

Solution `makelc` shell script:

```
#!/bin/sh
base=mcrab_lightcurve

$SIXTE/bin/makelc                    \
     EvtFile=sim_evt_${base}.fits    \
     Lightcurve=sim_${base}.lc       \
     length=1000.0                   \
     dt=1.0
```