

How to use 3D model of 2011, Jun. 22 M6.5 flare (18:05:32 UT)

By Natsuha Kuroda

New Jersey Institute of Technology, Nov. 2017

Supplemental document to Kuroda et al. (2017)

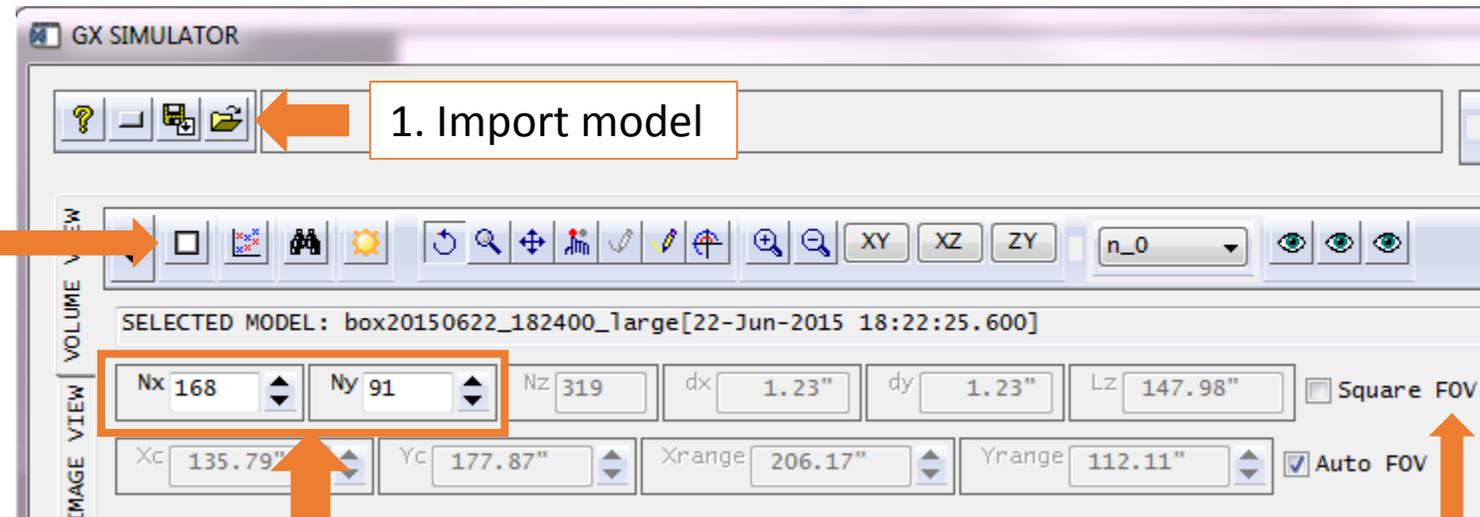
Introduction

- This documentation explains how to reproduce the model results introduced in the paper *“Three-dimensional forward-fit modeling of the hard X-ray and the microwave emissions of the 2015-06-22 M6.5 flare”* by Kuroda et al. (2017). Please cite this paper when using this model.
- This model is to be used in the 3D multi-wavelength simulator ***GX Simulator***, of which the details of how to use the interface is introduced at https://web.njit.edu/~gnita/gx_simulator_help/.
- This model is a “customized” model which uses the externally-defined magnetic field model specifically prepared for this flare analysis (a non-linear force-free field model, see Section 2.1 of the paper).

1. Model preparation

- First, import the model (*2015-jun-22-M6.5_180532.gxm*) and compute the rendering grid. The default grid size is set to be $(dx, dy) = (1.23'', 1.23'')$ which is equal to the resolution of the externally-defined magnetic field model (the best choice). However, one can increase the grid size to reduce the computation time by setting (N_x, N_y) to some fractions of the original values. For example, setting $(N_x, N_y) = (168, 91)/4 \sim (42, 23)$ can reduce the grid computation time by a factor of ~ 15 .

3. Press  then  to compute the rendering grid.



2. Change these to change the grid size to the desired values

*Uncheck if checked

2. HXR result reproduction (Section 4.1, Figure 6 and 8)

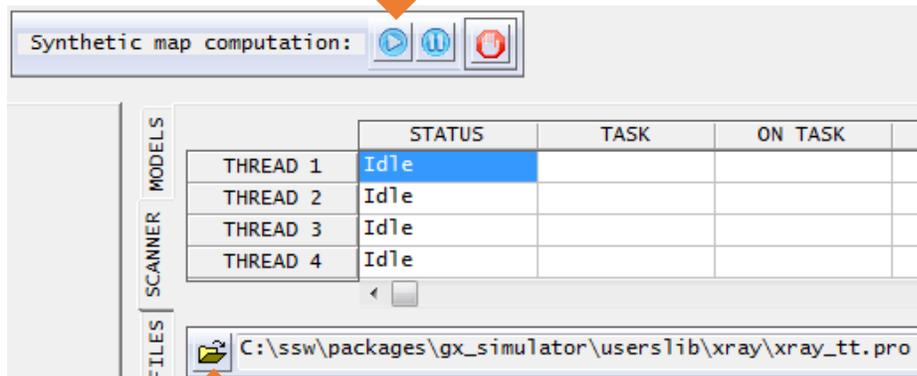
- First, upload the provided X-ray computation routine (*xray_tt.pro*) and begin computation. One can upload the reference spectrum file (*ref_rhessi_180532_nonnegative.ref*) and compare it to the model as the emission is computed. The computed model spectrum can be retrieved by saving the spectrum to the local folder and using the following commands in IDL:

```
restore, 'hxr_spectrum.sav'
```

```
energies = objxy->get_xdata()
```

```
counts = objxy->get_ydata()
```

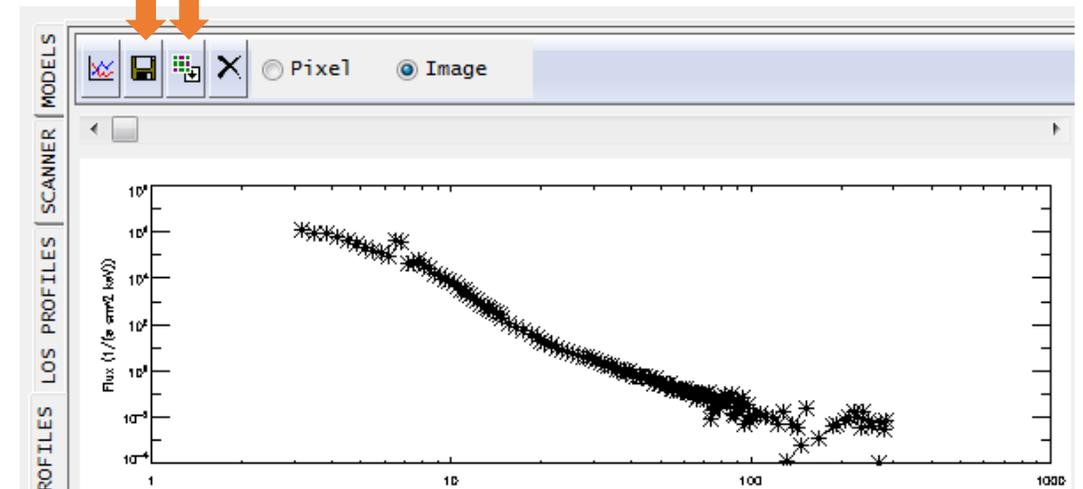
5. Start computation



4. Upload the computation routine

7. Save the spectrum to the local folder

6. Upload the reference spectrum file

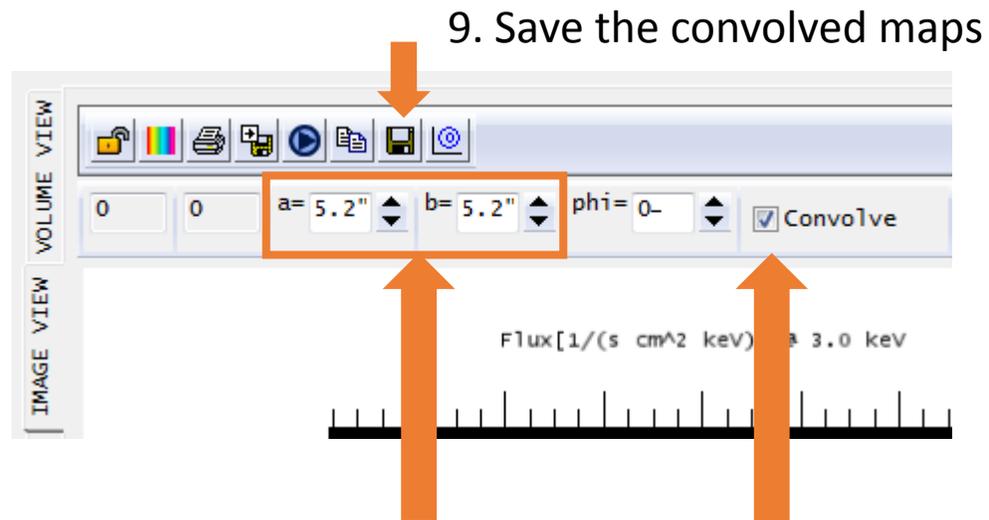


2. HXR result reproduction (Section 4.1, Figure 6 and 8)

- For the images, convolve the pixelated model images by PSF defined by the parameters $(a,b) = 5.2$ in the IMAGE VIEW. Save the convolved maps, and combine the images within the energy ranges of the observation by using the provided *xray_channelize.pro*. The combined images are stored as an object, which can be retrieved in IDL with the following commands:

```
restore, 'xray_integrated.map'
```

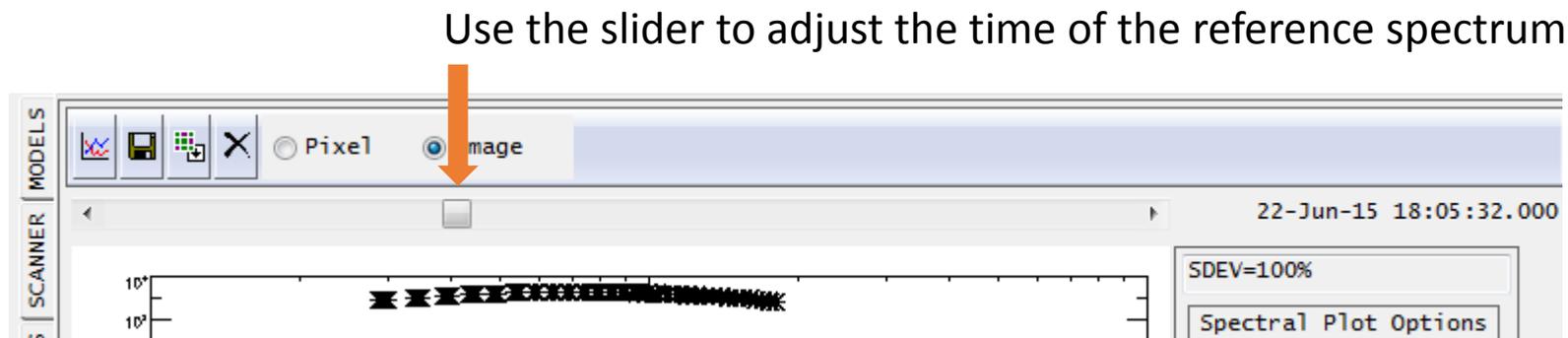
```
hxr_map = map->get(0, /map) ;index = 0 for the first energy range (6-12 keV)
```



8. Set these values (corresponds to FWHM $\sim 6.79''$) and convolve

3. MW result reproduction (Section 4.2, Figure 9)

- For the spectrum, one can follow the same directions given in slides #4. For MW, use one of the radio emission computation routines available in `\gx_simulator\userslib\radio_flaring`. One can load the reference spectrum file `2015-06-22_EOVSA_nonzero.ref`, and use the top slider to adjust the time of the spectrum to be 18:05:32 UT.
- For the relative visibility, please contact Natsuha Kuroda for further details.



4. Notes

1. In order to reproduce the spectrum from each flux tube separately, one must eliminate all other unwanted flux tubes. It is also recommended that after reducing the model to one flux tube, one should recompute the rendering grid by following the slide #3, to reset the voxel ownership determined by nT pressure in each voxel.
2. For HXR, one may initially find that 20-35 keV and 50-75 keV images are not reproduced as presented in the paper. This is due to the overlapping of some of the loops that interferes with the simulator's voxel ownership implementation (Section 4.2). The correct images can be reproduced if one eliminates the "thermal-only" loop (Flux Tube 3).
3. If one wishes to use *.ref* files in IDL command lines, one can do so by simply using *restore* command. For HXR, either `ref.y[* ,0]` or `ref[* ,1]` can be used. For MW, one must add `ref.y[* ,0,*]` and `ref.y[* ,1,*]`.