

# Practical 2 – The Energetic Universe

Athena School — June 2022, Toulouse

# Introduction

The simulations in this session will focus on using the **Athena WFI** and **X-IFU** to observe sources in the Energetic Universe science theme.

We will be looking at a **survey of AGN and galaxy clusters** and at a **bright low-mass X-ray binary**.

**As a general note:** in each folder, there are also instructions in a `README.txt` file.

# Part 1: Survey

You can find the scripts in the `day2_survey` folder in the simulation package.

As a first step, we need to get our SIMPUTs. For this, run the **two scripts in the `simput` subdirectory**. They will download and extract three tarballs which contain large SIMPUT catalogs generated at INAF, Bologna, found under `http://www.bo.astro.it/~gilli/mock.html`

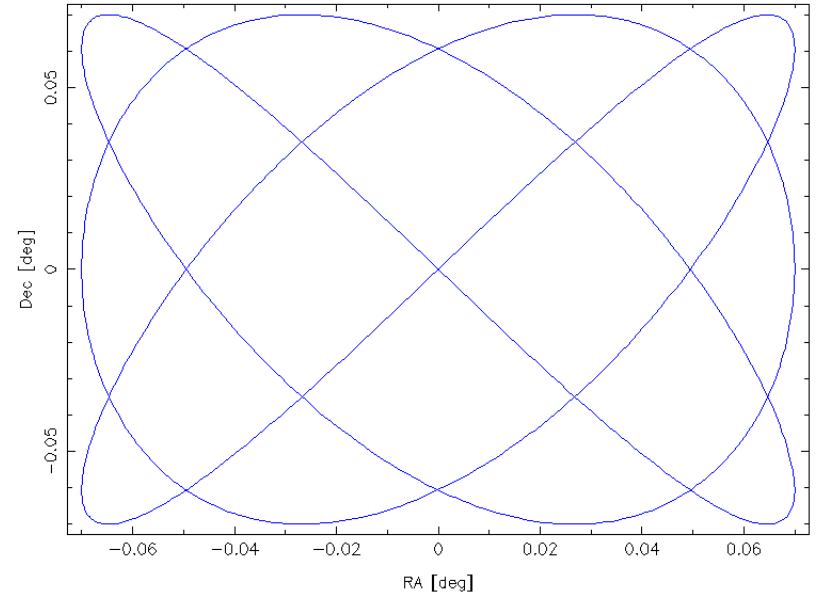
Once this is done, **run the simulation via `3_sim_survey.sh`**.

While the simulation is running, look at the SIMPUT files – these files contain a large amount of sources! The `g07_a100deg2_sixte` files contain, for instance, **5 million** AGN in an area of 100 square degrees, with **more than 1000 distinct spectra!**

# Part 1: Survey

Looking at the simulation script, we do one extra step: **generating an attitude file**

This file is used as input for `athenawfisim`, and causes the telescopes pointing to vary in a **Lissajous pattern** during the observation, in order to cover the chip gaps of the WFI.



Once the simulations are done, you should have a **survey image** and **exposure map** in the `img` subdirectory. **Plot them!**

These maps can then be used to run, e.g., **source detection algorithms**, but this is beyond the scope of this session.

# Part 1: Survey

If time allows, you can do some of the following further steps:

- **Correct the output image** for exposure using the exposure map.
- Rerun the survey with 100 ks exposure or more – the 10 ks used here are quite short.
- Extract some **source spectra**! Note that you need to take into account the individual **source exposures** for correct flux estimation!  
To use ds9 regions, don't forget to use `radec2xy`!

## Part 2: Bright Source

You can find the scripts in the `day2_bright` folder in the simulation package.

In this exercise, we simulate a very bright source, the **low-mass X-ray binary GRO J1655-40**.

The SIMPUT is already generated, the spectrum is a `diskbb + powerlaw` with **galactic and system-intrinsic wind absorption lines**.

First, simply **observe the source with both X-IFU and WFI** using the `run_xifu.sh` and `run_wfi.sh` scripts.

These scripts also generate spectra. **Plot them!** What do they look like? (Additionally, look at the X-IFU event file. **How many counts does it have?**)

## Part 2: Bright Source

The spectra will have **hardly any counts**.

This is not due to the source being dim or a short exposure – the source is so bright that the **detectors can not handle the count rates!** Very few of the detected events are so-called **valid events**, from which an energy can be reconstructed.

In order to still observe bright sources, the Athena instruments have two options:

- Additional **photon absorbing filters**
- Observing in **defocused mode**

For extremely bright sources, the WFI also has the so-called **fast-chip**, which has a **faster readout time** and **is defocused by default**.

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You can enable these options with the **OPT variable** in the `run_xifu.sh` and `run_wfi.sh` scripts. For the fast chip, there is the `run_wfi_fast.sh` script. Try them out and plot the spectra. **Compare the spectra with the different options!**

For the defocused options: Create images from the eventfiles using `imgev` or `fv`. What do they look like?