

# Practical 1 – The Hot Universe

Athena School — June 2022, Toulouse

# Introduction

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

We will be looking at a **galaxy cluster** and at **WHIM line absorption in a Gamma Ray burst**.

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

# Part 1: Galaxy Cluster

You can find the scripts in the `day1_cluster` folder in the simulation package.

As a first step, **run the simulation via `2_run_sim.sh`**. This is a 100 ks simulation, so it takes some time to run.

While the simulation is running, look at the SIMPUT file – this is a **multi-source SIMPUT**, made up of several **images** with their own **spectra**!

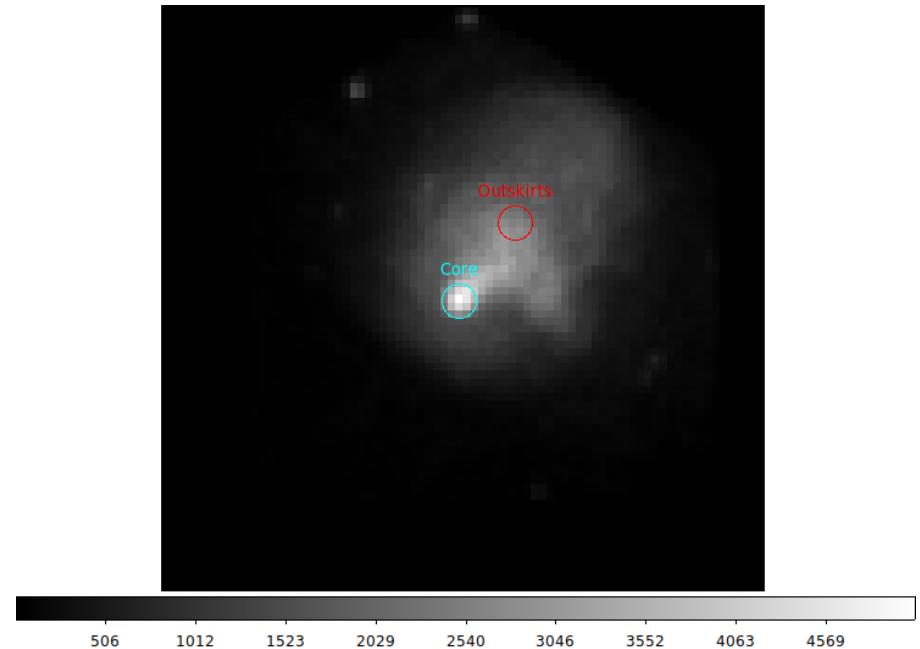
Each image corresponds to a **particular source region with constant spectral parameters**. When they are all combined, we have the full source!

# Part 1: Galaxy Cluster

Once the simulation is done, create an image with the corresponding script (`3_make_img.sh`)

When viewed in e.g. `ds9`, you will get something like this:

We can then define **regions** for our spectral extraction.



To extract spectra, either define and save your own regions, or use the provided core and outskirts region files.

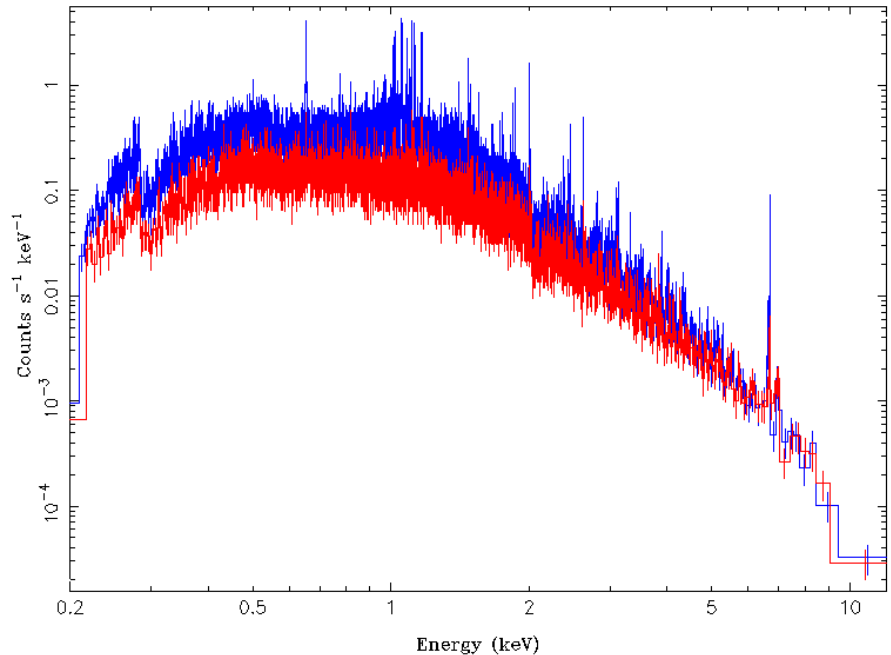
# Part 1: Galaxy Cluster

Once you've defined your regions, run the extraction script `4_extract_spectra.sh` (If you've defined your own regions, you need to edit the `EventFilter` key accordingly)

Then, plot the spectra in your favourite program. Here is an example, color coded as before:

Note the increased line emission in the core region.

Optionally: Fit both spectra with an `phabs*apec` model!



## Part 2: WHIM Absorption

You can find the scripts in the `day1_whim` folder in the simulation package.

As a first step, **run the simulation via `run_xifu.sh`**. The SIMPUT was generated by Sarah Walsh from University College Dublin.

While the simulation is running, look at the SIMPUT file – this is a point source with a TIMING column – the source has **timing behavior!**

Looking at the LIGHTCURVE extension, the source has an exponential decay. It models a **Gamma Ray Burst (GRB) with WHIM absorption lines** (c.f. the SPECTRUM extension)

## Part 2: WHIM Absorption

The `run_xifu.sh` script also generates a **spectrum and a light curve** – plot them!

For the spectrum, examine the region between 0.3 and 0.8 keV. You can also try and fit the spectrum and identify the absorption lines.

### Optional:

This GRB is, especially at the beginning, **rather bright**. We will see in more detail in the next session how to handle bright sources – as a first attempt, rerun `run_xifu.sh`, changing the script's OPT parameter.

Make an image of both the **old and new eventfile** to see what changed, and compare the spectra!