Streamlining Galaxy Cluster X-ray Analysis with XGA and DAXA

An introduction to the software, and some initial results

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Introducing XGA and DAXA

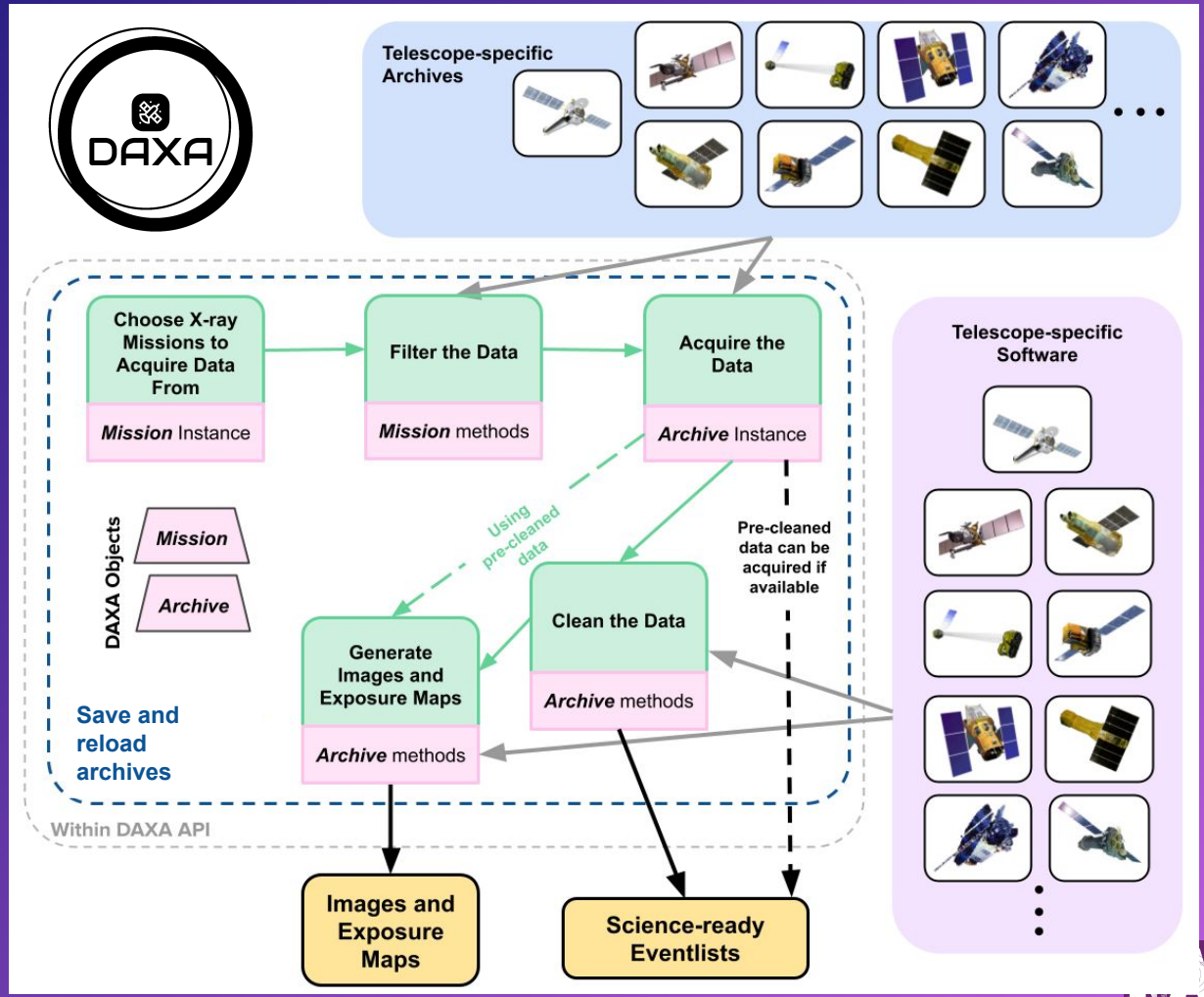
- Big thank you to David Turner
- XGA and DAXA are both:
  - Open source Python modules
  - Fully documented
  - Provide a consistent interface for interaction with telescope specific software
- For completely transparent and reproducible science
- Making X-ray astronomy accessible to non-experts

Introducing XGA and DAXA

Acquiring and Cleaning

Generation and Analysis

Multi-mission dataset


DAXA
Telescope-specific Archives
Choose X-ray Missions to Acquire Data From
Mission Instance
Filter the Data
Mission methods
Acquire the Data
Archive Instance
Telescope-specific Software
DAXA Objects
Mission
Archive
Using pre-cleaned data
Pre-cleaned data can be acquired if available
Clean the Data
Archive methods
Generate Images and Exposure Maps
Archive methods
Save and reload archives
Within DAXA API
Images and Exposure Maps
Science-ready Eventlists

DAXA - Democratising Archival X-ray Astronomy


```
import daxa
from daxa.mission import XMMPointed, Chandra, NuSTARPointed
from astropy.coordinates import SkyCoord
```

```
# Coordinates for a source we want to acquire data for
gx_coords = SkyCoord(186.6565, -62.7704, frame='fk5', unit=deg)

# X-ray missions we want data from
xt = XMMPointed()
nt = NuSTARPointed()
ct = Chandra()
```

```
nt.filter_on_positions(gx_coords, Quantity(30, 'arcmin'))
ct.filter_on_positions(gx_coords, Quantity(30, 'arcmin'))
xt.filter_on_positions(gx_coords, Quantity(30, 'arcmin'))
```

Searching for observations at a position in the sky by XMM, NuStar, and Chandra

XGA - X-ray: Generate and Analyse

	Declare a Source (or Sample)	→ Generate Products from Source	→ Analyse Products
User Interface (Python)	***Upon initial setup:*** *Provide science ready archive of eventlists* *Optionally provide region files* Instantiate a Source object using the source's coordinates	Generate: • Images • Exposure Maps • Ratemaps • Spectra • Lightcurves View and Plot products	• Count rates • Fit models to spectra • Temperature and luminosities • Gas density, surface brightness, and hydrostatic mass profiles And more!

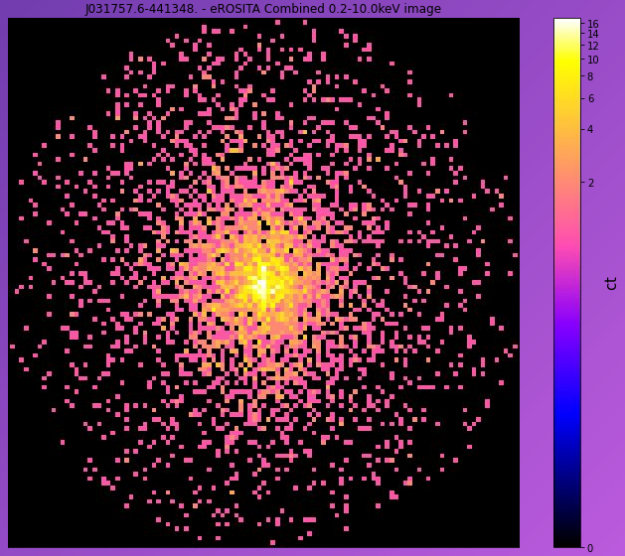
XGA - X-ray: Generate and Analyse


```
from astropy.units import Quantity

import xga
from xga.sources import GalaxyCluster
from xga.generate.esass.phot import evtool_image
from xga.xspec import single_temp_apec
```

```
src = GalaxyCluster(49.49, -44.23, 0.11,
                    r500=Quantity(500, 'kpc'),
                    search_distance={'erosita': Quantity(3.6, 'deg')})
```

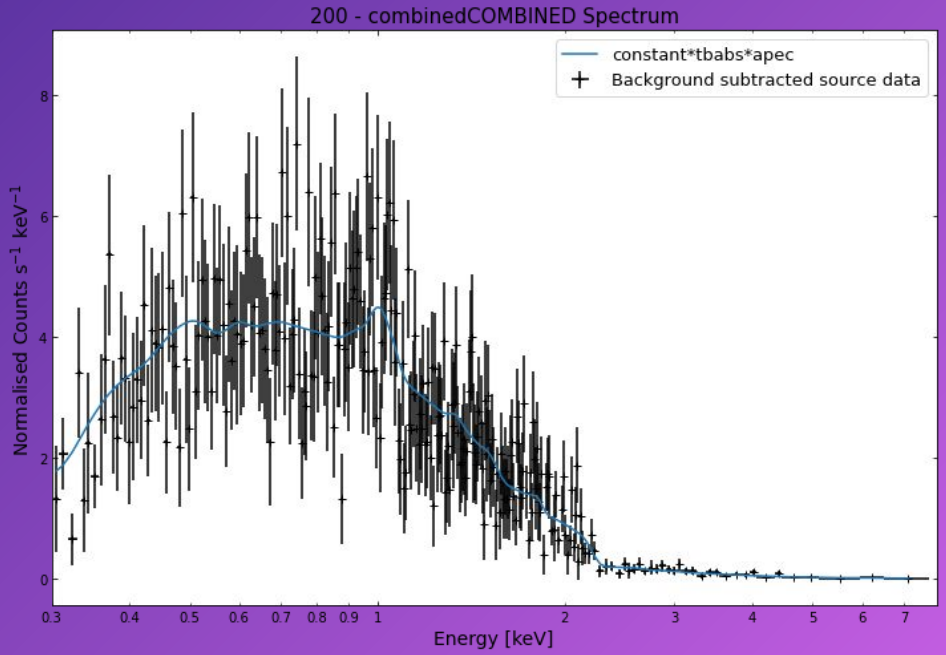
```
evtool_image(src, combine_obs=True)
```




```
im = src.get_combined_images(telescope='erosita')
mask = src.get_custom_mask(src.r500, remove_interlopers=False, telescope='erosita')
im.view(mask=mask, zoom_in=True)
```

XGA - X-ray: Generate and Analyse

```
single_temp_apec(src, 'r500', stacked_spectra=True)
```

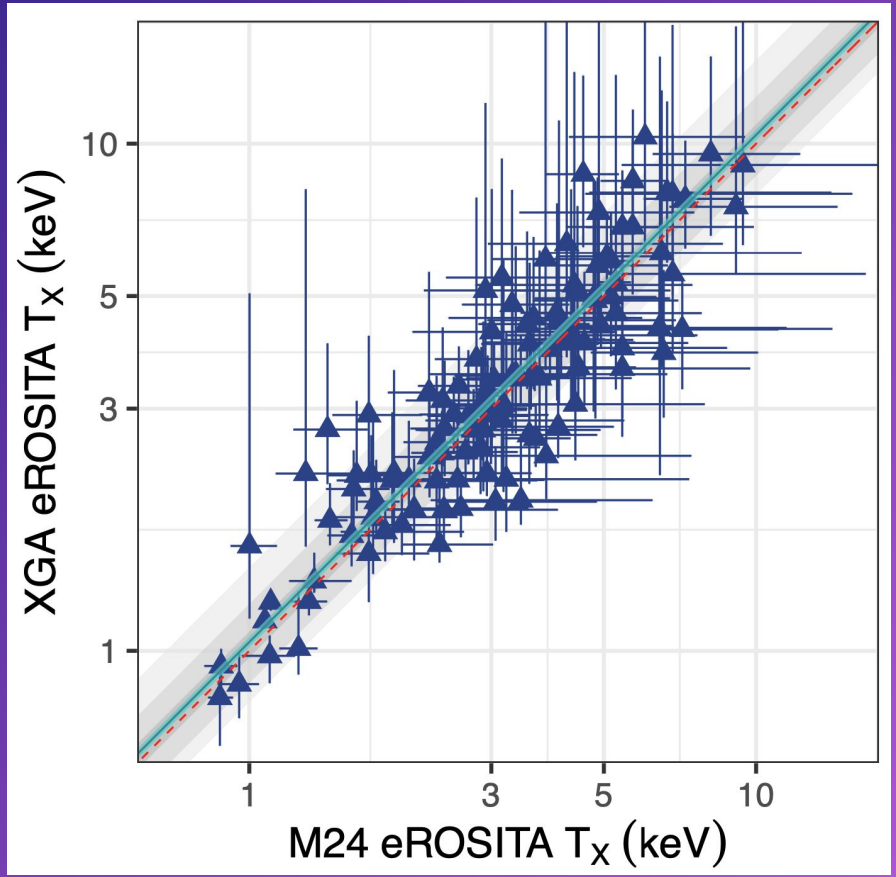



```
src.get_temperature('r500', 'erosita')
```

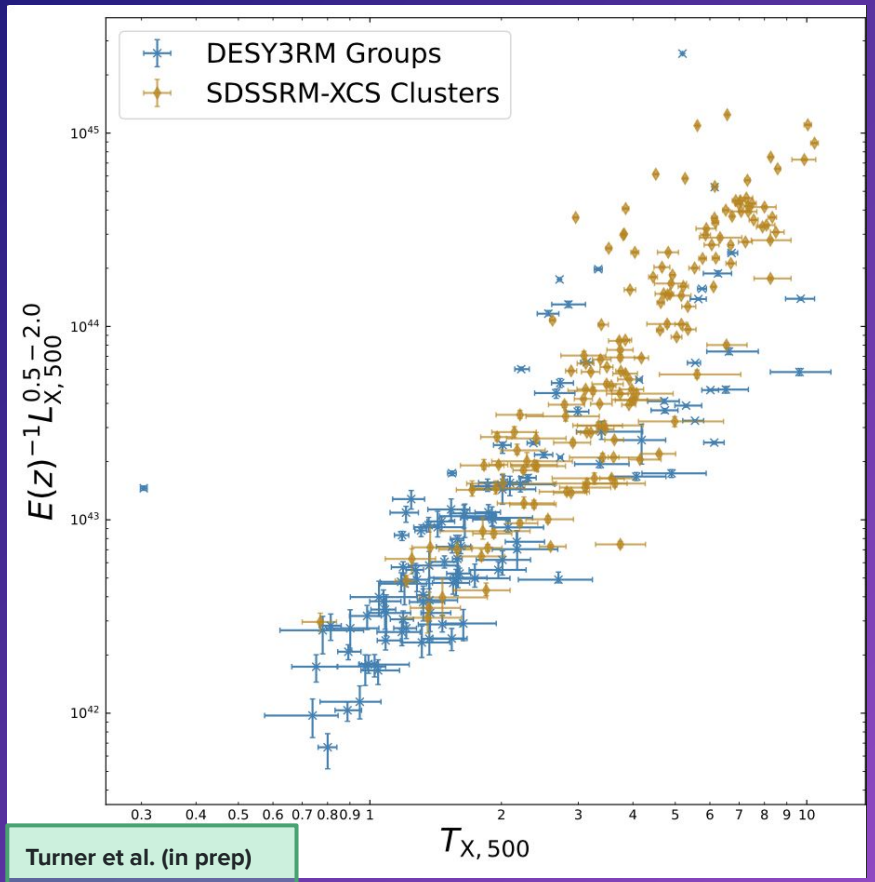
[4.05107, 0.37065881, 0.44978493] keV

```
src.get_combined_spectra('r500', telescope='erosita').view()
```

XGA - X-ray: Generate and Analyse



XGA - X-ray: Generate and Analyse



Turner et al. (in prep)

- DES Y3 redMaPPer selected clusters richness ≤ 20
- These tend to get discounted
- XMM measured Luminosities and Temperatures
- Relation seems to agree with previous cluster sample

Future Plans

- ❑ Add NuSTAR and Chandra
- ❑ Docker environment
- ❑ Version 1 release

- ❑ Add data cleaning for other telescopes

- ❑ Comparison of XMM and eROSITA measured luminosities and temperatures for DES Y3 redMaPPer clusters

  - Pilling et al. (in prep)

Visit https://github.com/DavidT3 for the repositories, and links to tutorials.

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