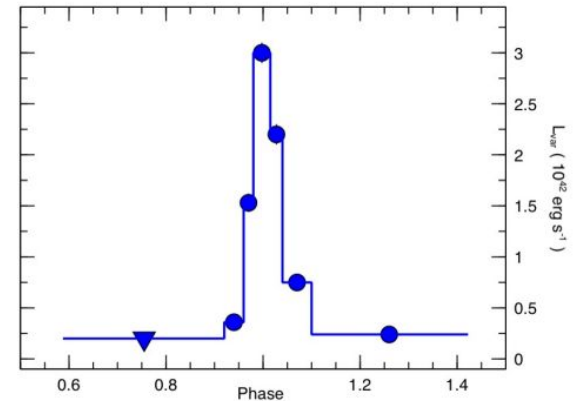
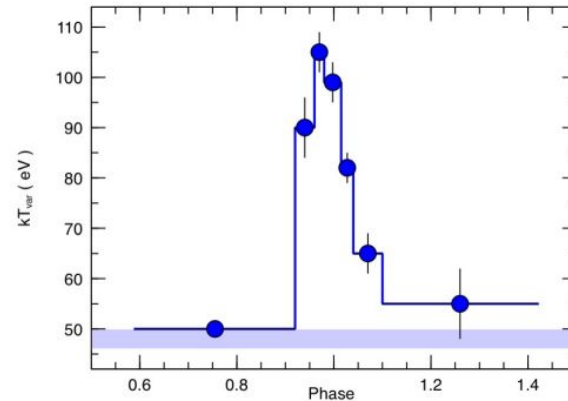
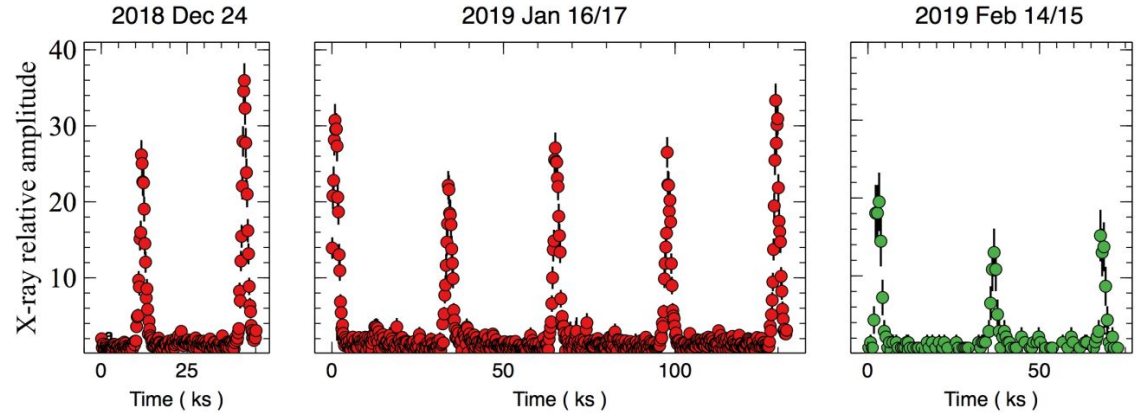


Spectral and timing analysis of eRO-QPE3

Example: GSN 069

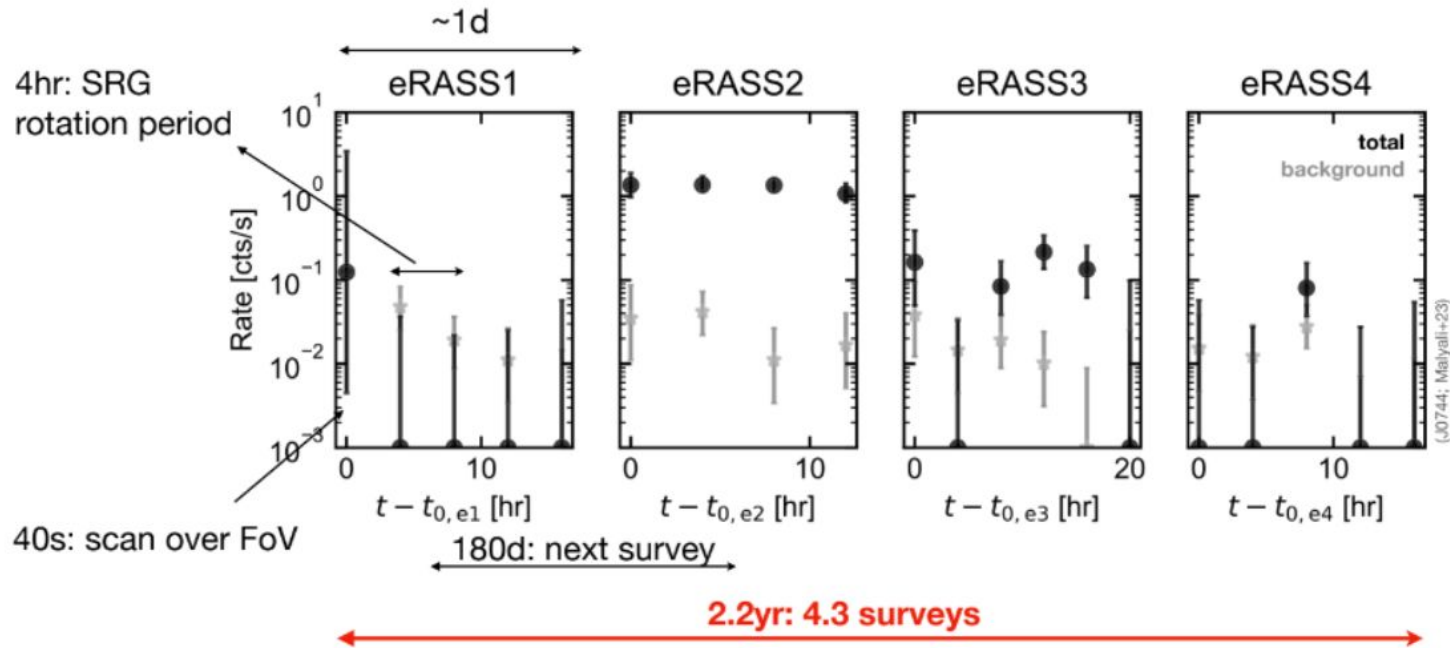
- First QPE discovered (Miniutti+19)
- Temperature evolution during QPE: hotter when brighter behavior



Can we look for similar behavior in eROSITA?

What timescales is eROSITA sensitive to?

The eROSITA scanning strategy:

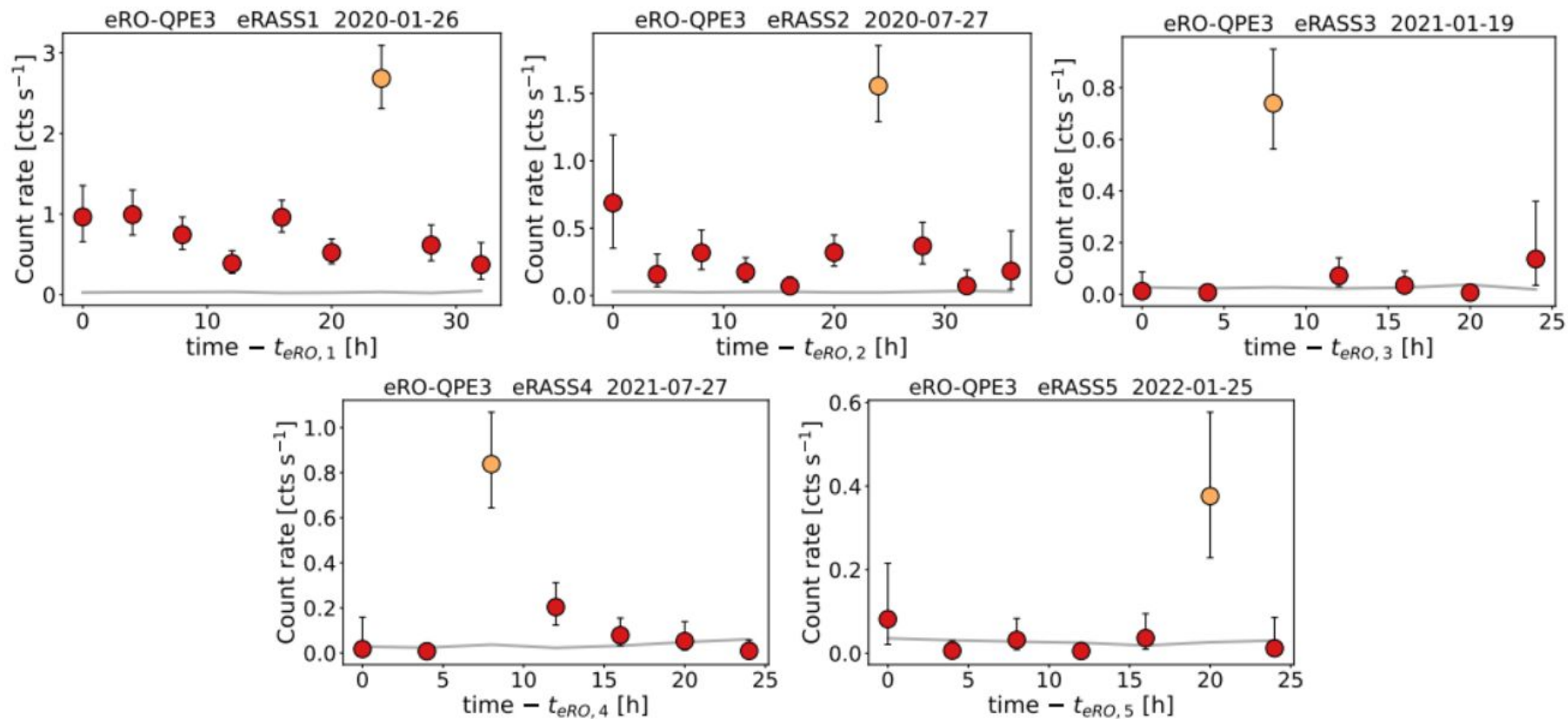


Adapted from A. Rau, A. Malyali

eRO-QPE3:

The more the merrier: *SRG*/eROSITA discovers two further galaxies showing X-ray quasi-periodic eruptions

R. Arcodia^{*1,2}, Z. Liu², A. Merloni², A. Malyali², A. Rau², J. Chakraborty¹, A. Goodwin³, D. Buckley⁴, J. Brink⁴, M. Gromadzki⁵, Z. Arzoumanian⁶, J. Buchner², E. Kara¹, K. Nandra², G. Ponti^{7,2}, M. Salvato², G. Anderson³, P. Baldini², I. Grotova², M. Krumpke⁸, C. Maitra², J. C. A. Miller-Jones³, M. E. Ramos-Ceja²



Step 1:

- Get the **skytile events** and **image** for eRO-QPE3 from the DR1 page

Hints:

- this is a very famous source (SIMBAD should resolve this)

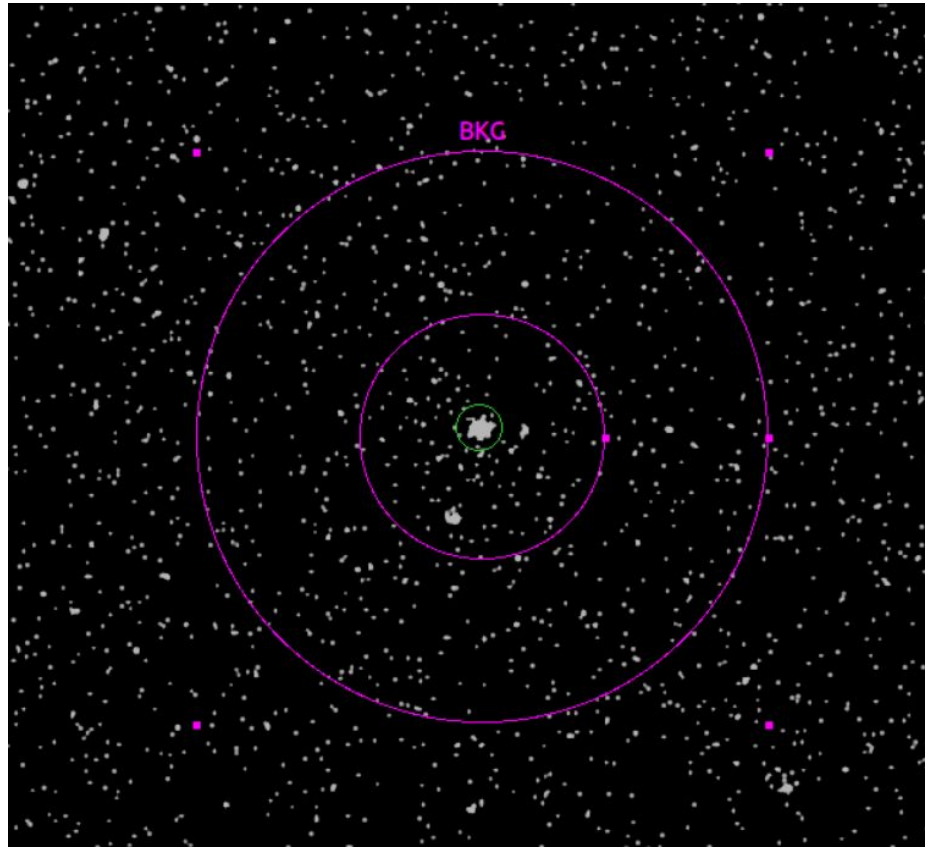
https://erosita.mpe.mpg.de/dr1/erodat/skyview/skytile_search/

- Both events and images can be found under the EXP directory

Step 2:

Visualize the **image with DS9**.

- To find the source:
 - Play with the scale: under scale select 'log' and '99%'
 - Convolve with a smoothing kernel: analysis -> smooth
 - Define a region and input the coordinates: edit -> region
 - Drag your cursor on the image to define a circular region
 - Double click and input the source region coordinates
 - Select an appropriate radius size (any ideas?)
 - You can remove smoothing for this, to have a true representation of event locations.
- Save source region as src.reg in CIAO / WCS format: region -> save region
- Delete region and create an annulus region: region -> shape -> annulus
- Define a large background region and save it as bkg.reg
- **Watchout for nearby sources!**



Step 3:

Extraction of the lightcurve with srctool

- Initialize Heasoft and eSASS

```
srctool eventfiles="./em01_211120_020_EventList_c010.fits" \  
  srccoord="icrs;210.2222 -28.7665" \  
  prefix="eROQPE3_" \  
  todo="?" \  
  insts="1 2 3 4 6" \  
  srcreg="src.reg" \  
  backreg="bkg.reg" \  
  exttype="POINT" \  
  lctype="REGULAR-" \  
  lcpars='10' \  
  lcemin="0.2 2.3" \  
  lcemax=" 2.3 5" \  
  psftype="2D_PSF" \  
  flagsel="0" \  
  clobber="yes" \  
  gtitype="GTI" \  
  writeinsts="8"
```

the fractional exposure parameter is very important for accurate count rate estimation!

```
srctool eventfiles="./em01_211120_020_EventList_c010.fits" \  
  srccoord="icrs;210.2222 -28.7665" \  
  prefix="eROQPE3_" \  
  todo="LC LCCORR" \  
  insts="1 2 3 4 6" \  
  srcreg="src.reg" \  
  backreg="bkg.reg" \  
  exttype="POINT" \  
  lctype="REGULAR-" \  
  lcpars='10' \  
  lcemin="0.2 2.3" \  
  lcemax=" 2.3 5" \  
  psftype="2D_PSF" \  
  flagsel="0" \  
  clobber="yes" \  
  gtitype="GT1" \  
  writeinsts="8"
```

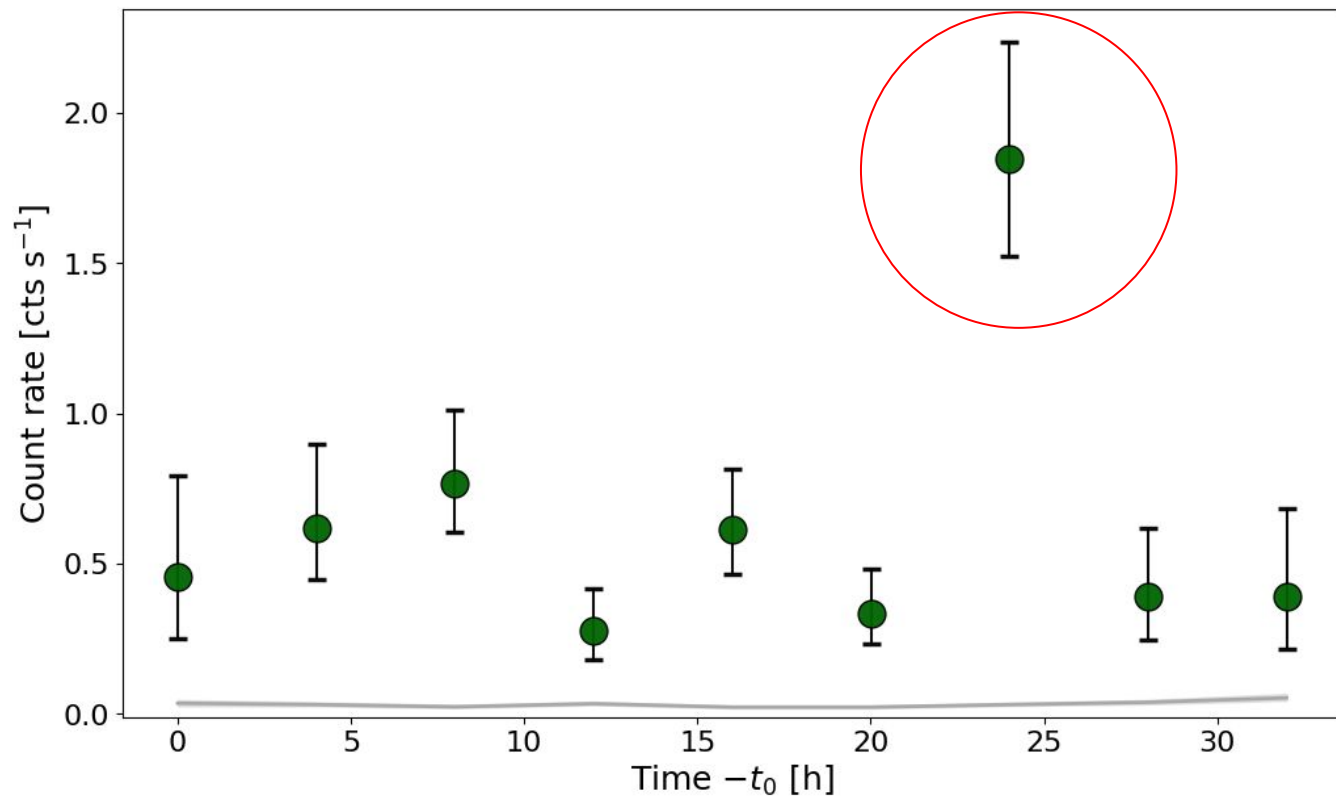
Step 4:

Plot the light-curve with

<https://github.com/rarcodia/eRebin>

You can find the plots in the folder images

```
python3 Rebin_eROday.py -names eROQPE3_020_LightCurve_00001.fits -indir ./ -outdir ./
```



Step 5:

Let's extract spectra from the quiescence and from the QPE candidate. We need to split the events into different “good” time intervals (GTI)

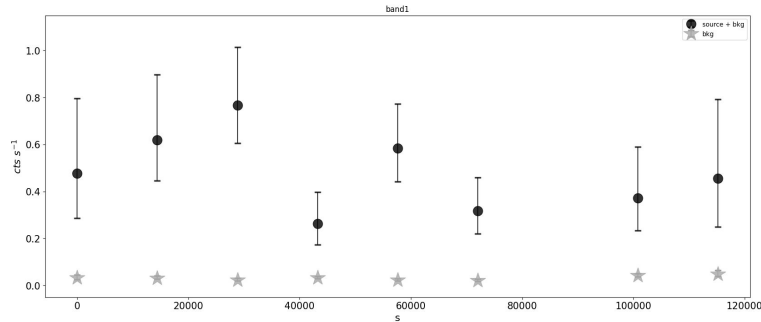
- To identify GTI you could look at the lightcurve. I have already provided them for you.
- We will use evtool
https://erosita.mpe.mpg.de/dr1/eSASS4DR1/eSASS4DR1_tasks/evtool_doc.html
- You can either provide a fits GTI file:
 - `evtool eventfiles="./em01_211120_020_EventList_c010.fits.gz" outfile="quiescence.fits" gti="gti_file_qui.fits"`
- Or just a TSTART and TSTOP:
 - `evtool eventfiles="./em01_211120_020_EventList_c010.fits.gz" outfile="QPE.fits" gti='633415227.333 633422427.333'`

Step 6:

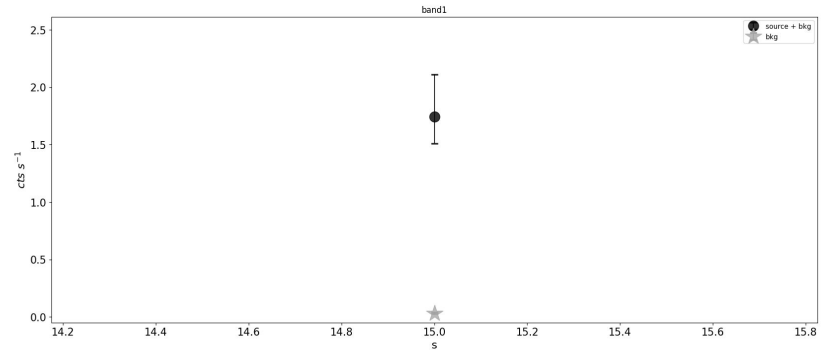
Now extract Spectra Light Curves RMF and ARF with SRCTOOL from your new eventfiles.

Do your light-curves look like this?

Quiescence



QPE



Let's see if we find a harder when brighter behavior
with Zsofi's analysis!


```
srctool eventfiles="/quiescence.fits" \  
  srccoord="icrs;210.2222 -28.7665" \  
  prefix="quiescence_" \  
  todo="LC LCCORR SPEC ARF RMF" \  
  insts="1 2 3 4 6" \  
  srcreg="src.reg" \  
  backreg="bkg.reg" \  
  exttype="POINT" \  
  lctype="REGULAR-" \  
  lcpars="10" \  
  lcemin="0.2 2.3" \  
  lcemax="2.3 5" \  
  psftype="2D_PSF" \  
  flagsel="8" \  
  clobber="yes" \  
  gitype="GTI" \  
  writeinsts="0"
```

```
srctool eventfiles="/QPE.fits" \  
  srccoord="icrs;210.2222 -28.7665" \  
  prefix="qpe_" \  
  todo="LC LCCORR SPEC ARF RMF" \  
  insts="1 2 3 4 6" \  
  srcreg="src.reg" \  
  backreg="bkg.reg" \  
  exttype="POINT" \  
  lctype="REGULAR-" \  
  lcpars="10" \  
  lcemin="0.2 2.3" \  
  lcemax="2.3 5" \  
  psftype="2D_PSF" \  
  flagsel="0" \  
  clobber="yes" \  
  gitype="GTI" \  
  writeinsts="8"
```