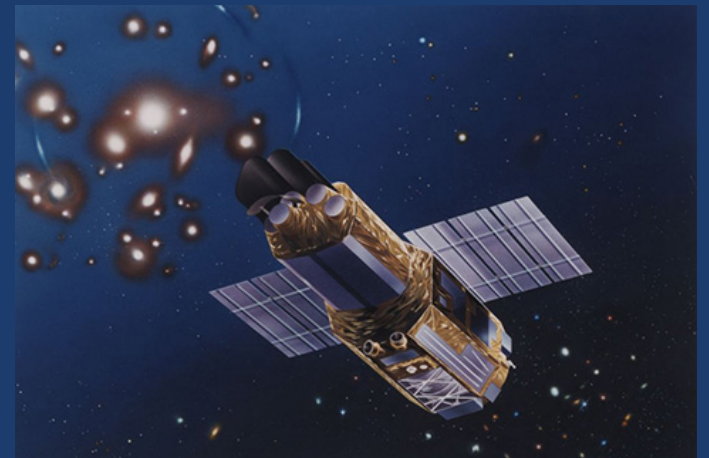




# Other Instruments

J. Wilms, T. Dauser, P. Peille



# Gendetsim

Generalized model for pixel-based detectors: **gendetsim**

Parameters:

```
1  ImpactList = impacts.fits      impact list input file
2      RawData = raw.fits         raw data output file
3      Mission = SRG              mission name: Chandra, GRAVITAS, IXO,
      ATHENA, SRG, XMM
4  Instrument = eROSITA           instrument name
5      Mode = none                instrument mode (including filter)
6  (XMLFile = none)              XML input file with detector
      definition (overwrites Mission, Instrument, and Mode)
7  (MJDREF = 55000.0)            reference Modified Julian Date
8  (TSTART = 0.0)               start time (s)
9  Exposure = 1000.0             simulated exposure time (s)
10     (Seed = -1)                seed for random number generator (-1:
      initialize with system time)
11     (chatter = 3)              verbosity
12     (clobber = no)             overwrite output files if exist?
13     (history = true)           write a history block with program
      parameters to each FITS file?
```

**XMLFile**: generalized language allowing to model most pixel-based detectors

## Example: CCDs for Arcus

Example: CCDs for ARCUS project

Start with field of view and imaging information:

```
1 <?xml version="1.0"?>
2 <!-- ARCUS Gratings CCD -->
3 <instrument type="ARCUS">
4   <telescope>
5     <fov diameter="0.5"/>
6   </telescope>
```

More complicated instruments also have a PSF definition for the imaging.

## Example: CCDs for Arcus

Detector specification:

General pixel information (for imaging):

```
8 <detector>
9
10 <dimensions xwidth="2048" ywidth="1024"/>
11
12 <pixelborder x="0." y="0."/>
13 <wcs xrpix="0.0" yrpix="0.0"
14     xrval="0.0" yrval="0.0"
15     xdelt="1" ydelt="1">
```

## Example: CCDs for Arcus

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General pixel information (for imaging):

```
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10 <dimensions xwidth="2048" ywidth="1024"/>
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14     xrval="0.0" yrval="0.0"
15     xdelt="1" ydelt="1">
```

Detection process: use RMF and ARF (generated externally):

```
17 <rmf filename="arcus_ccd.rmf"/>
18 <arf filename="arcus_diagonal.arf"/>
```

## Example: CCDs for Arcus

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General pixel information (for imaging):

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8 <detector>
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10 <dimensions xwidth="2048" ywidth="1024"/>
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15     xdelt="1" ydelt="1">
```

Detection process: use RMF and ARF (generated externally):

```
17 <rmf filename="arcus_ccd.rmf"/>
18 <arf filename="arcus_diagonal.arf"/>
```

Charge cloud and digitization information:

```
19 <cte value="1"/>
20 <split type="exponential" par1="0.355"/>
21
22 <threshold_readout_lo_keV value="100.e-3"/>
23 <threshold_event_lo_keV value="0.1"/>
24 <threshold_split_lo_keV value="0.01"/>
```

## Example: CCDs for Arcus

Detector specification (cont'd):

Reading out a pixel detector:

```
26 <readout mode="time">
27   <wait time="0.1"/>
28   <loop start="0" end="1023" increment="1" variable="$i">
29     <readoutline lineindex="0" readoutindex="$i"/>
30     <lineshift/>
31     <wait time="9.76562e-6"/>
32   </loop>
33   <newframe/>
34
35 </readout>
```

That's it:

```
36 </detector>
37 </instrument>
```

## Example: CCDs for Arcus

Modification: binning in  $y$ -direction:

Reading out a pixel detector:

```
26 <readout mode="time">
27   <wait time="0.1"/>
28   <!-- read out 1023 rows in 10ms, binning 16 rows at a time -->
29   <!-- NB: 9.76562e-6 = 10ms/1024 -->
30   <loop start="0" end="1023" increment="16" variable="$i">
31     <loop start="0" end="15" increment="1">
32       <lineshift/>
33       <wait time="9.76562e-6"/>
34     </loop>
35     <readoutline lineindex="0" readoutindex="$i"/>
36   </loop>
37   <newframe/>
38
39 </readout>
```



## Suzaku

A more complex example: *Suzaku* burst mode:

1. **Wait** for  $8\text{ s} - b$
2. flush whole CCD w/charge  
injection, takes 156 ms
3. **expose** for  $b\text{ s}$
4. read into framestore w/o charge  
injection (25 ms)

# Suzaku

A more complex example: *Suzaku* burst mode:

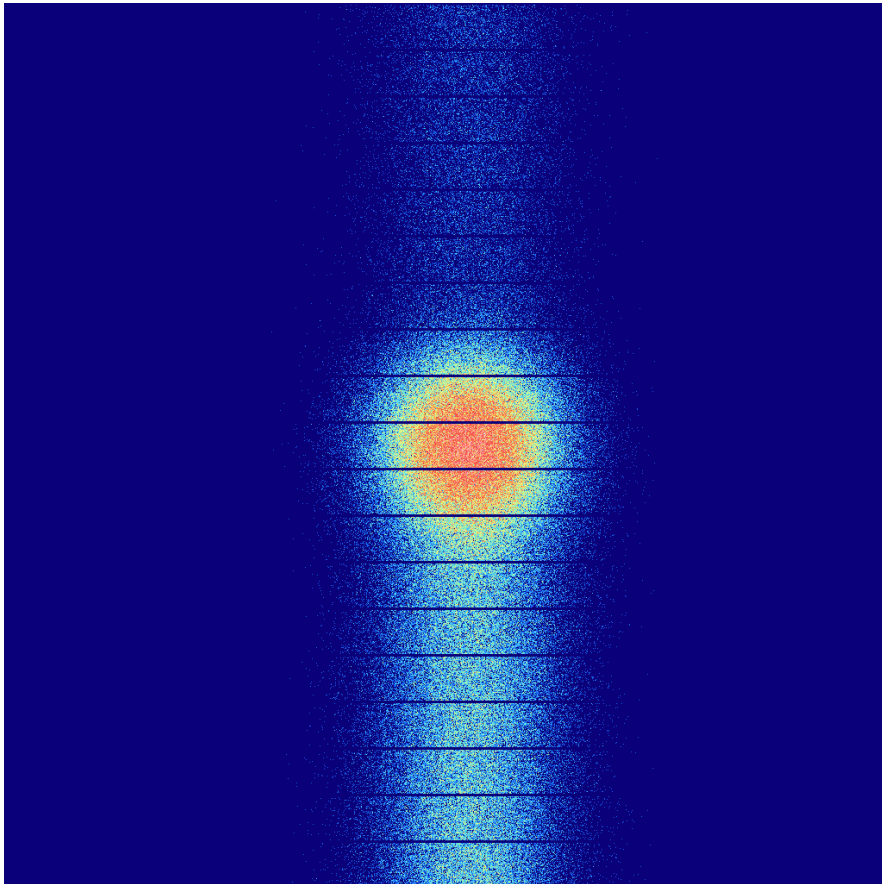
1. **Wait** for 8 s –  $b$
2. flush whole CCD w/charge injection, takes 156 ms
3. **expose** for  $b$  s
4. read into framestore w/o charge injection (25 ms)

Example:  $b = 0.94$  s

```
1 <readout mode="time">
2   <wait time="7.906"/>
3   <loop start="0" end="1023"
4     increment="1">
5     <clearline lineindex="0"/>
6     <lineshift/>
7     <wait time="0.000152"/>
8   </loop>
9   <wait time="0.094"/>
10  <loop start="0" end="1023"
11    increment="1" variable="$i
12      ">
13    <readoutline lineindex="0"
14      readoutindex="$i
15      "/>
16    <lineshift/>
17    <wait time="0.0000244"/>
18  </loop>
19  <newframe/>
20 </readout>
```

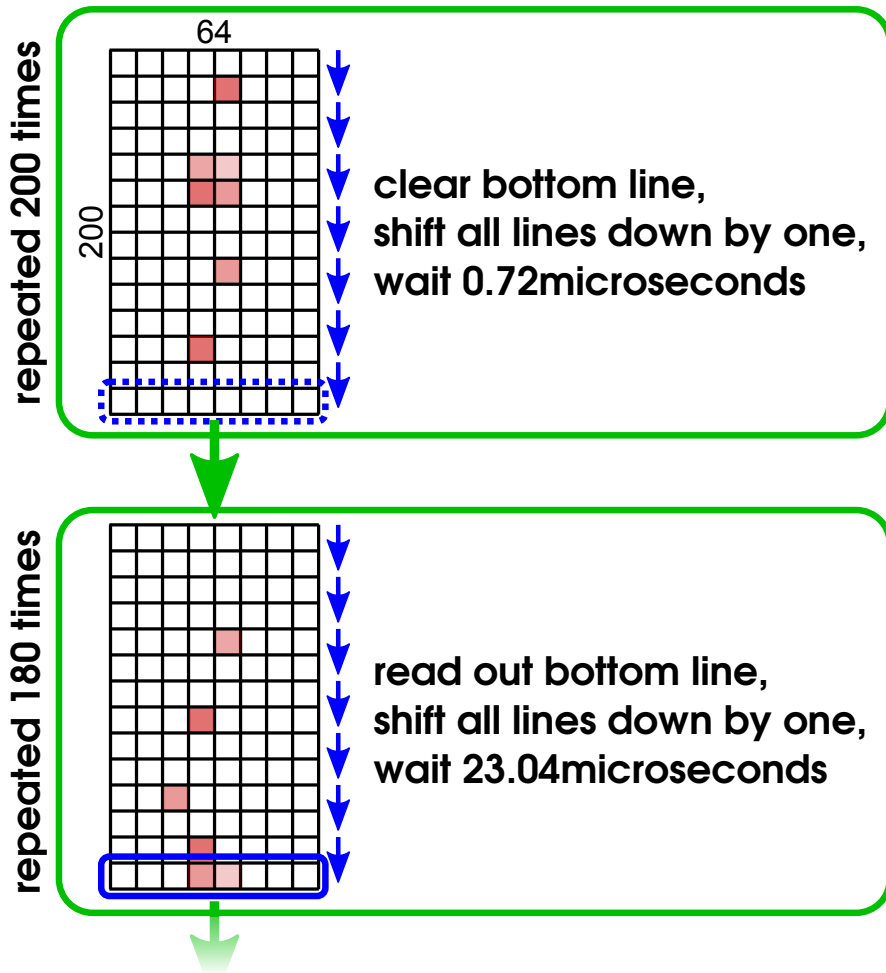
# Suzaku

A more complex example: *Suzaku* burst mode:



```
1 <readout mode="time">
2   <wait time="7.906"/>
3   <loop start="0" end="1023"
4     increment="1">
5     <clearline lineindex="0"/>
6     <lineshift/>
7     <wait time="0.000152"/>
8   </loop>
9   <wait time="0.094"/>
10  <loop start="0" end="1023"
11    increment="1" variable="$i
12      ">
13    <readoutline lineindex="0"
14      readoutindex="$i
15        "/>
16    <lineshift/>
17    <wait time="0.0000244"/>
18  </loop>
19  <newframe/>
20 </readout>
```

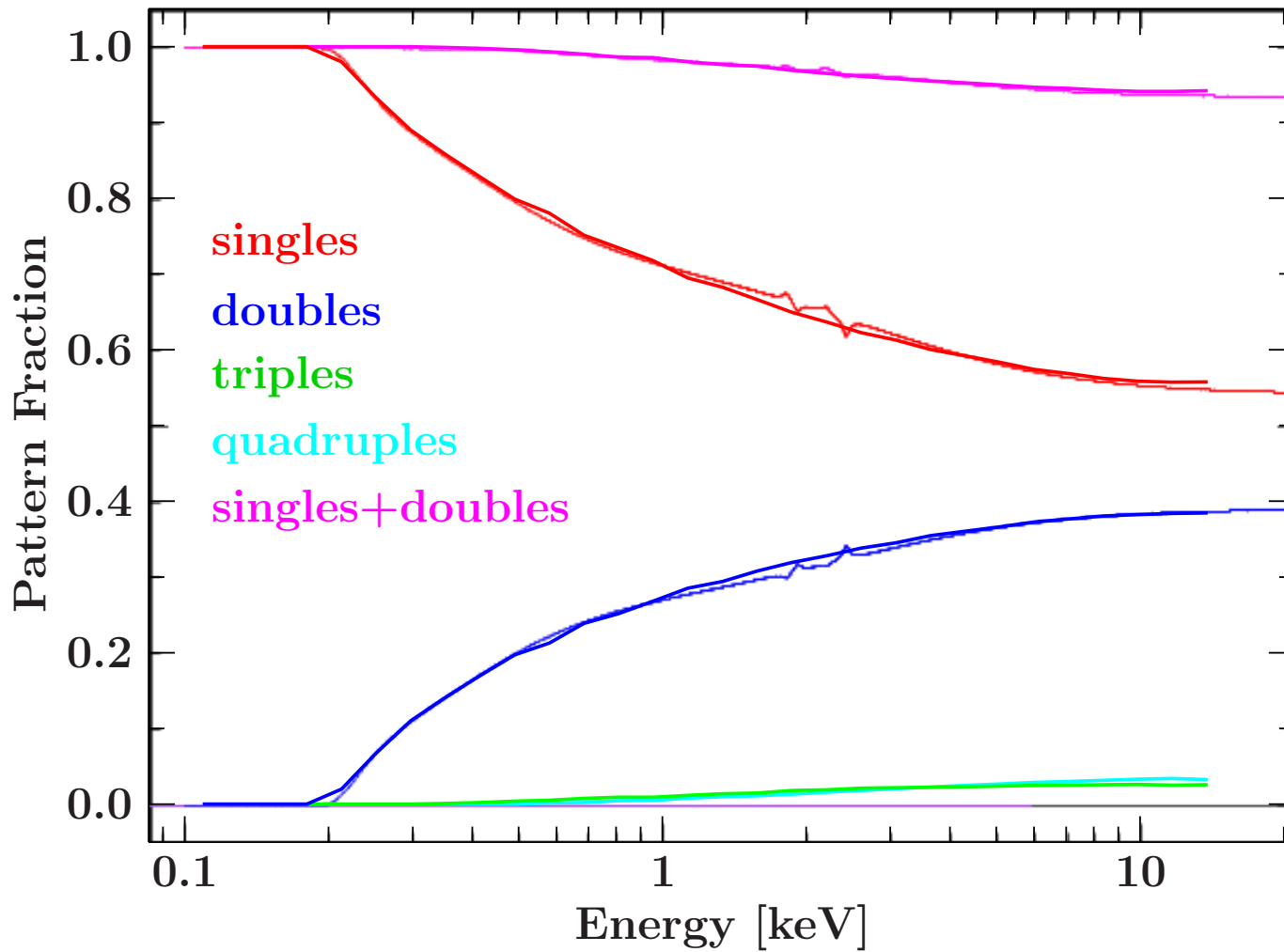
# XMM-Newton



```
<readout mode="time">  
  <loop start="0" end="199" increment="1">  
    <clearline lineindex="0"/>  
    <lineshift/>  
    <wait time="0.72e-6"/>  
  </loop>  
  <loop start="0" end="179" increment="1"  
    variable="$i">  
    <readoutline lineindex="0"  
      readoutindex="$i"/>  
    <newframe/>  
    <lineshift/>  
    <wait time="23.04e-6"/>  
  </loop>  
</readout>
```

Verification: XMM-Newton EPIC-pn (example: burst mode readout)

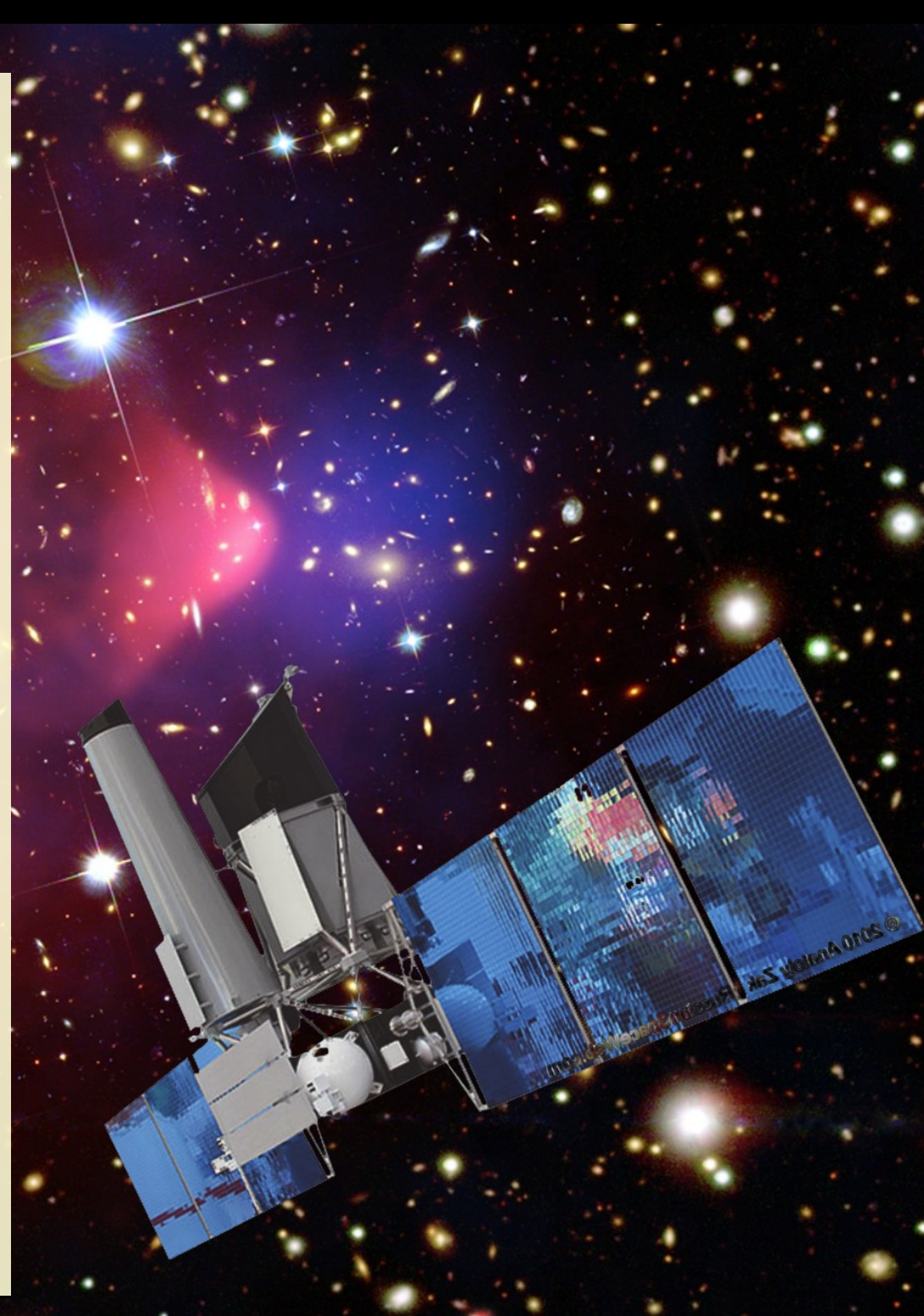
# XMM-Newton



Charge cloud model in XMM-Newton EPIC-pn:  
smooth lines: calibrated model, ragged lines: simulation

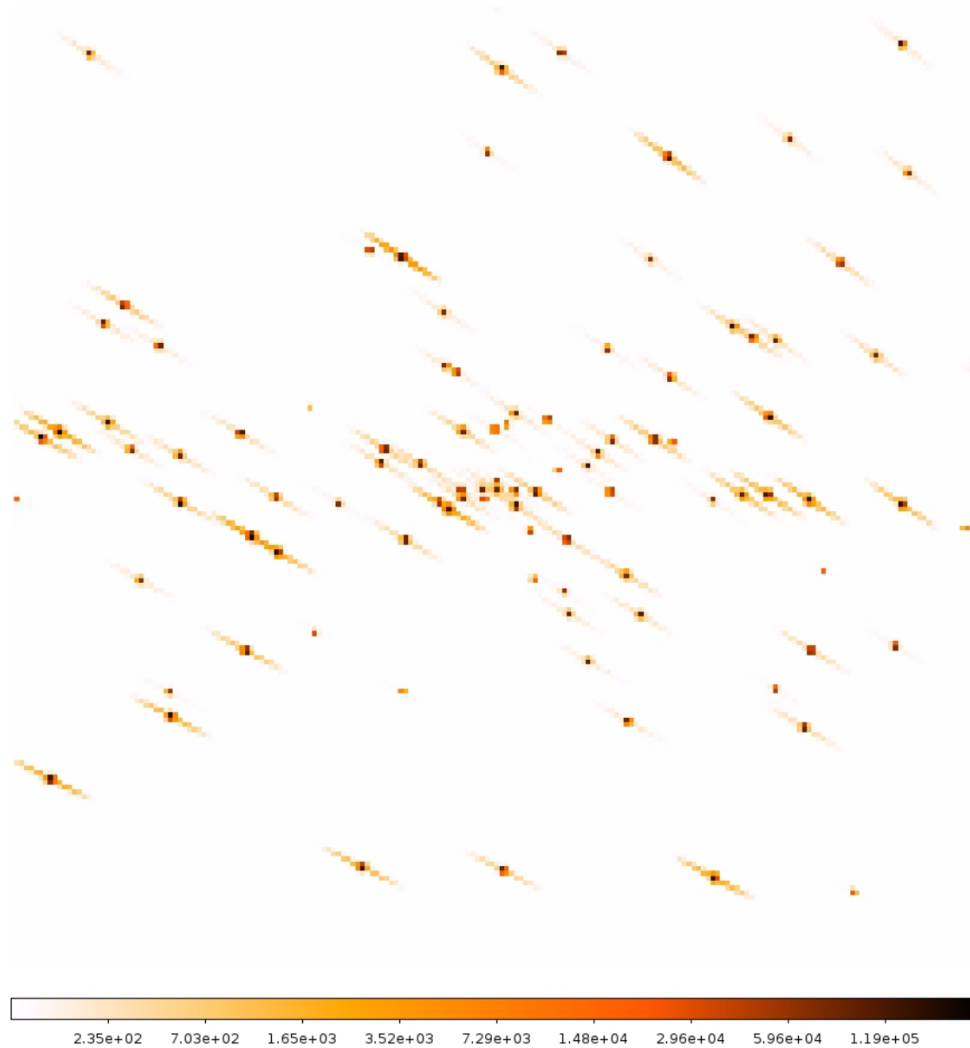
## eROSITA:

- **Slew survey**, attitude!
- Simulation needed for 7 telescopes/detectors
- Frame store readout
- **Simulation tools:**
  - erosim: simulate survey
  - ero\_vis: determine visibility of X-ray sources from attitude
  - ero\_rawevents, ero\_calevents: convert simulator output to internal eROSITA SASS formats
- Also have tool to produce telemetry stream (and FITS from telemetry) – available upon request





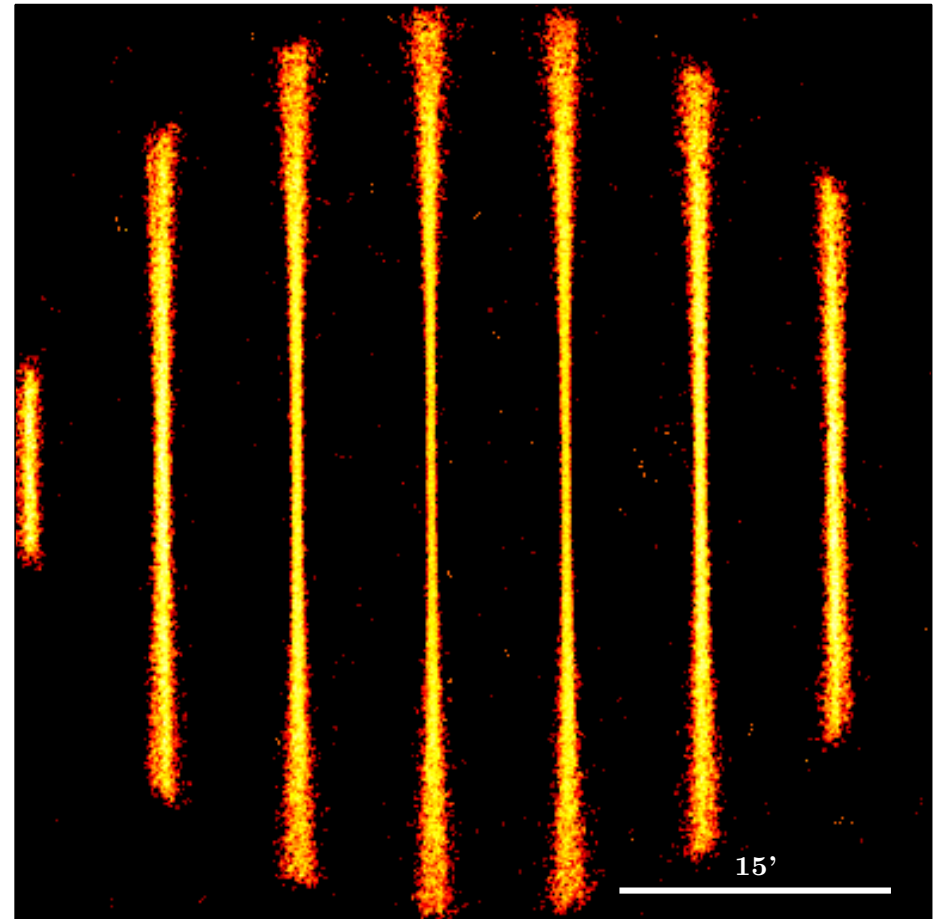
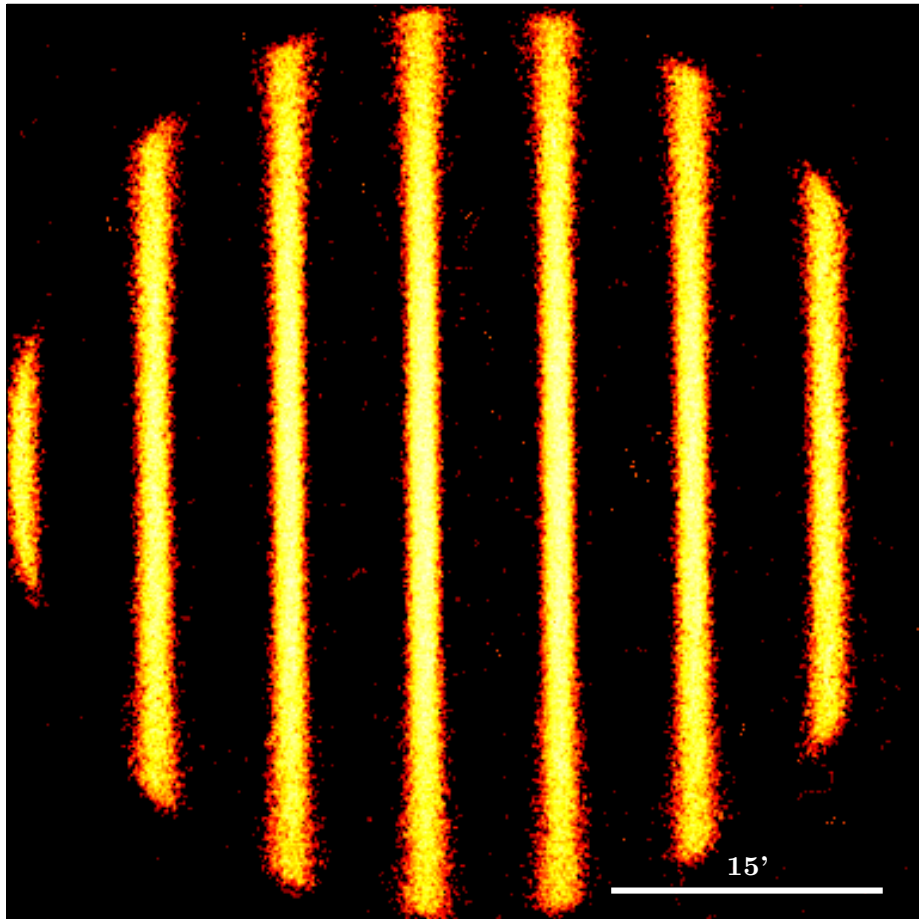
# Galactic Center



Inner 20° × 20° of the Galaxy

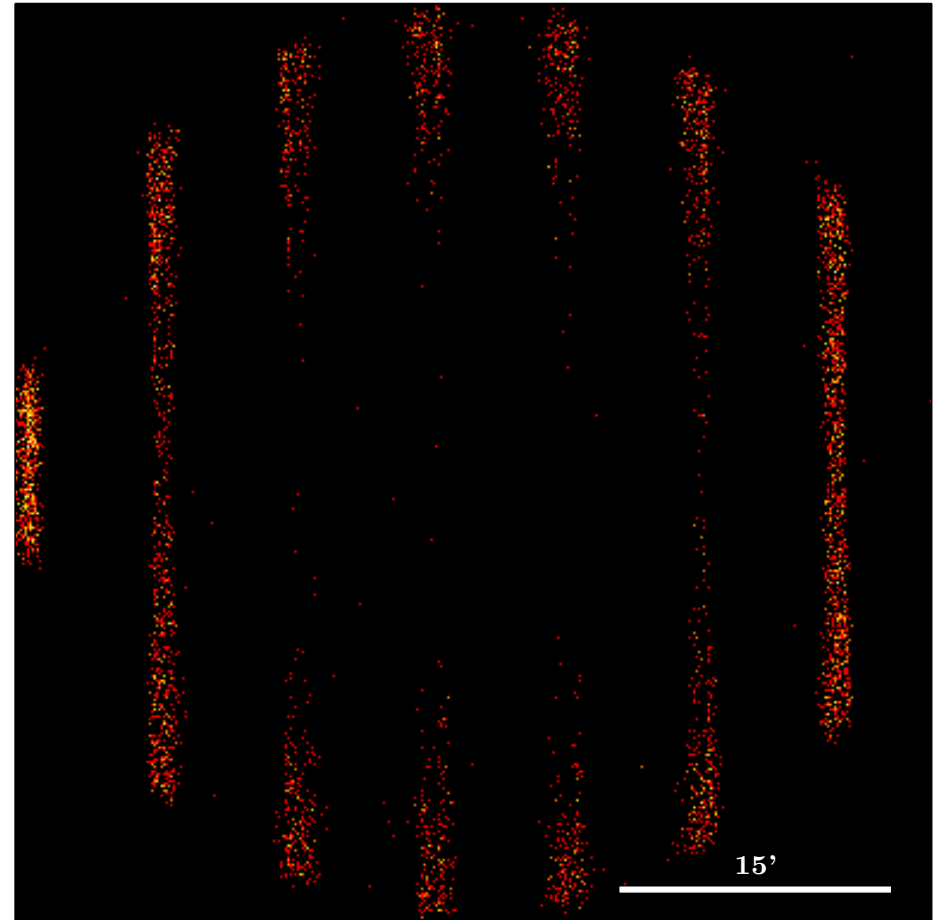
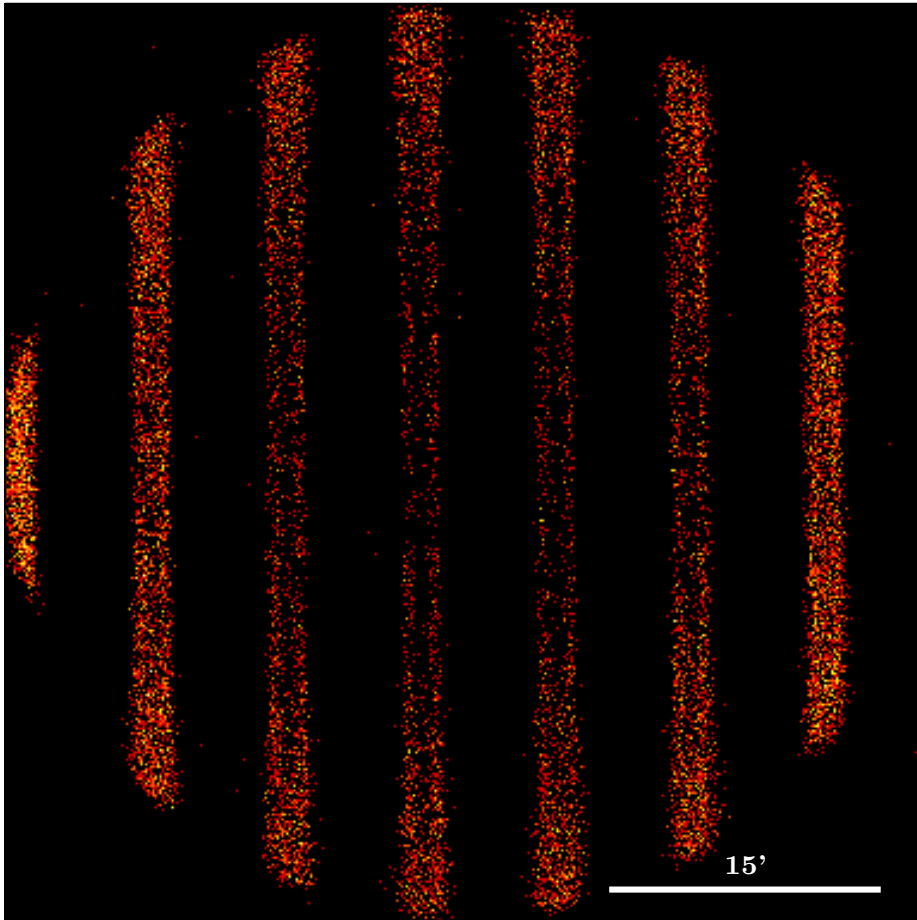


## PSF effects



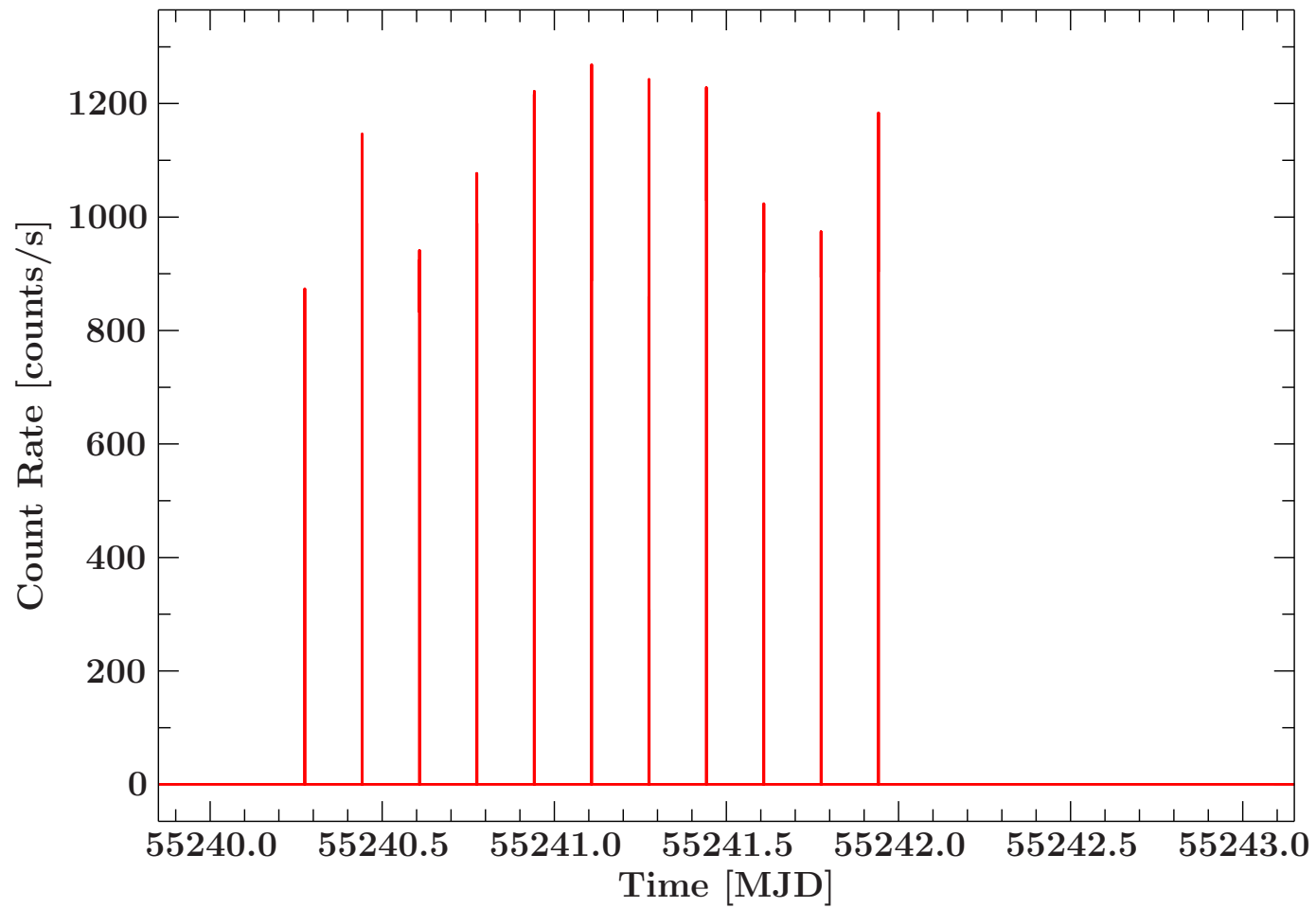
slew observation over the Crab and Vela X-1 (all evts)

## PSF effects

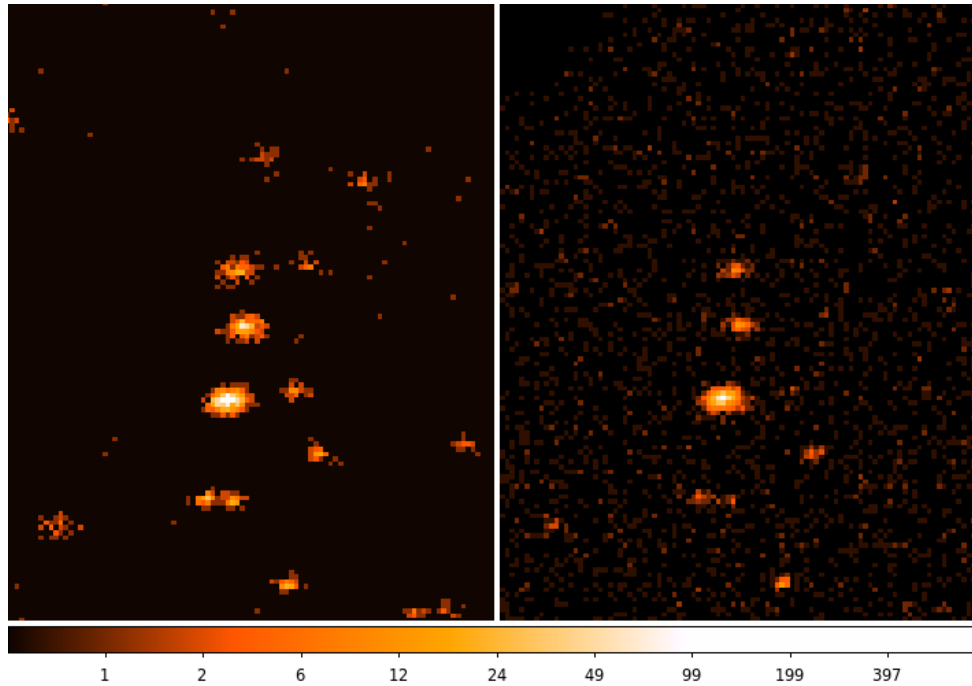


slew observation over the Crab and Vela X-1 (good evts only)

# PSF effects



Daily light curve of Cyg X-1



CDFS: Simulation

Observation

Courtesy Hans Moritz Günther (MIT)

*Chandra*: As of MARX 5.3, MARX can work with SIMPUT files

<http://space.mit.edu/cxc/marx/>

MARX parameters: `SourceType=SIMPUT S-SIMPUT-Source=CDFS_cat_giacconi.fits`

`S-SIMPUT-Library=/path/to/libsimput.so`

The simulator `simx` for Suzaku, XMM-Newton, Hitomi, Athena can also read and write SIMPUT  
simplified detector model, no variability