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Hitomi hackathon

Part 2: Walk-through of Hitomi data analysis

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Purpose

Target Audience:
Heasoft user with no experience of Hitomi analysis

Goal:
Data reduction and spectral fitting of the Perseus cluster in the simplest way

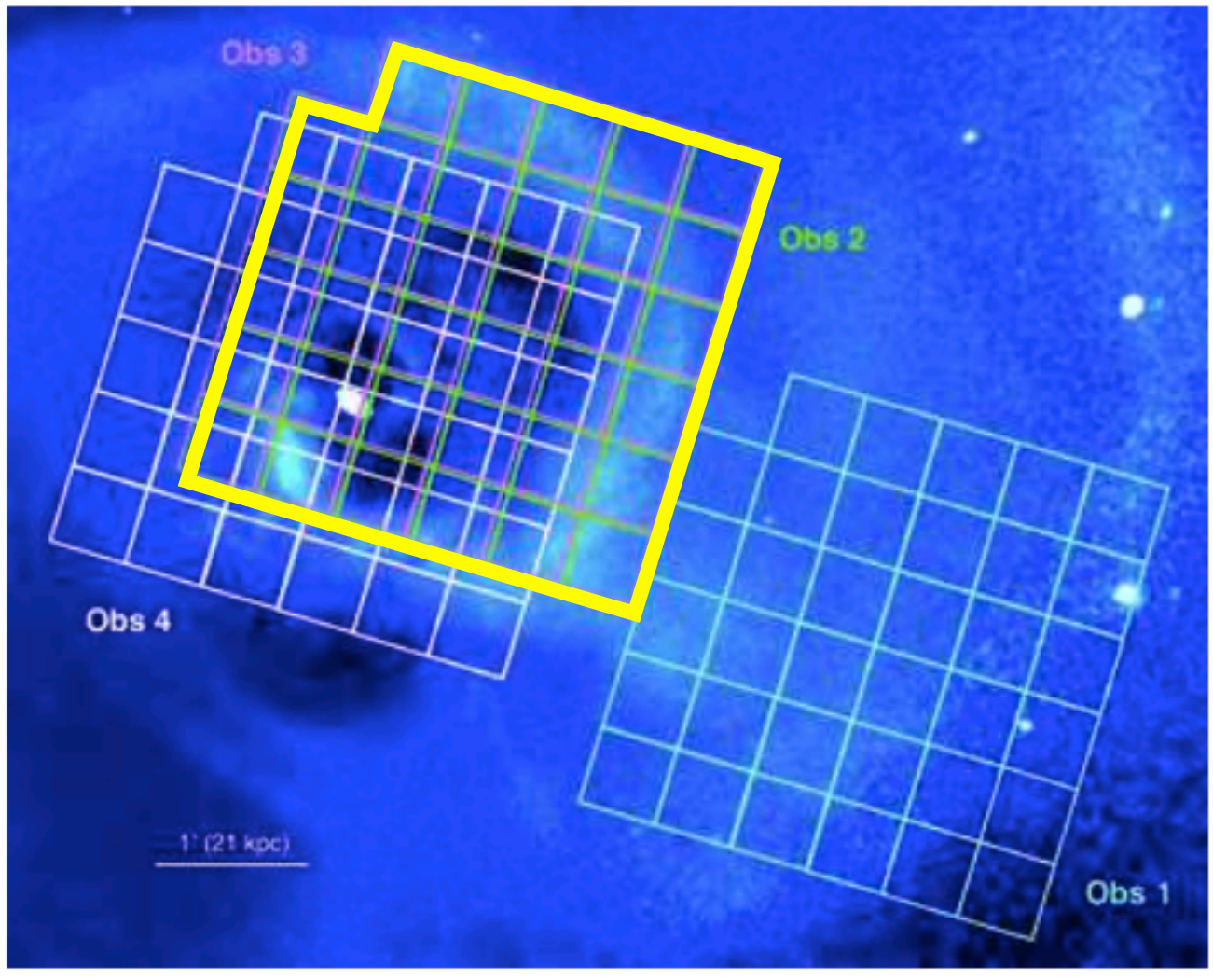
Reference:
Hitomi documents, including Step-by-Step Guide (https://heasarc.gsfc.nasa.gov/docs/hitomi/analysis/)

Setting

Heasoft: v6.25

CALDB: latest (2018 Feb 12)

Data: Perseus cluster (ID:10040030)



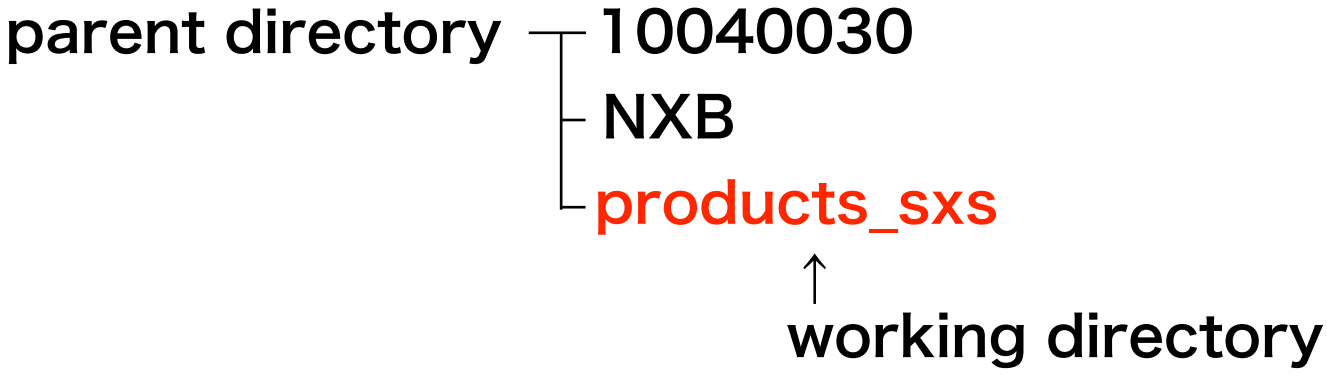
(Hitomi collaboration 2016)

0. Download

data
wget -q -nH --no-check-certificate --cut-dirs=5 -r -l0 -c -N -np -R 'index*' -erobots=off --retr-symlinks https://heasarc.gsfc.nasa.gov/FTP/hitomi/data/obs/1//100040030/sxs/
wget -q -nH --no-check-certificate --cut-dirs=5 -r -l0 -c -N -np -R 'index*' -erobots=off --retr-symlinks https://heasarc.gsfc.nasa.gov/FTP/hitomi/data/obs/1//100040030/auxil/

NXB files
mkdir NXB
cd NXB
wget https://darts.jaxa.jp/pub/hitomi/data/nxb_20170510/ah_sxs_nxbafmar4_20140101v001.evt.gz
wget https://darts.jaxa.jp/pub/hitomi/data/nxb_20170510/ah_gen_nxbehk_20140101v002.fits.gz
cd ..

1. Screening

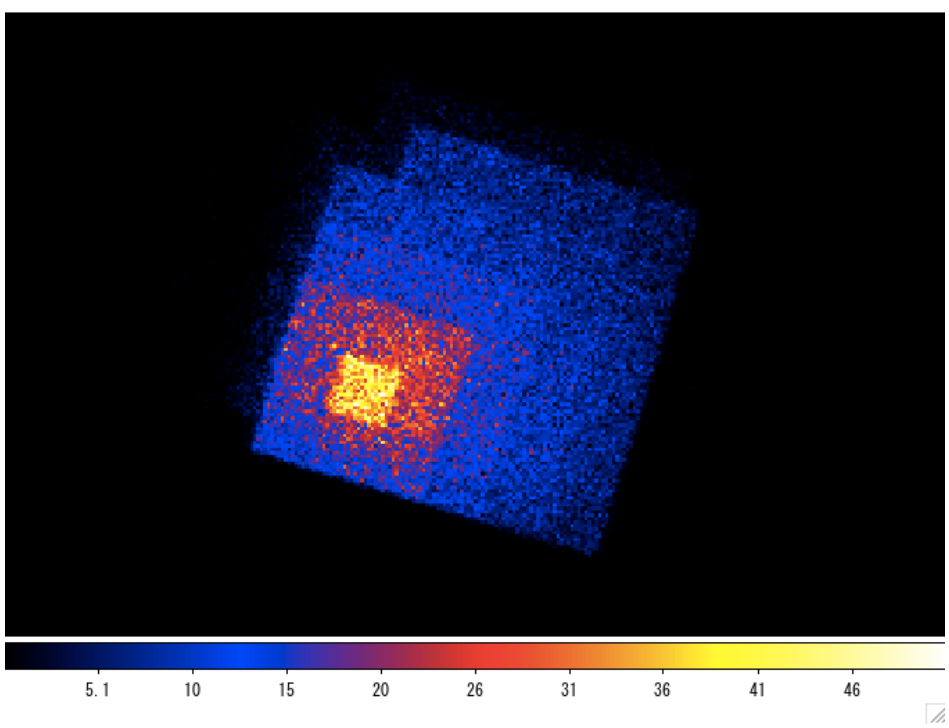



```
mkdir products_sxs
cd products_sxs

ftselect infile='../100040030/sxs/event_cl/
ah100040030sxs_p0px1010_cl.evt.gz[events]' \
outfile=ah100040030sxs_p0px1010_cl2.evt \
expression="(PI>=400)&&((RISE_TIME>=40&&RISE_TIME<=60
&&ITYPE<4)||(ITYPE==4))&&STATUS[4]==b0"
```

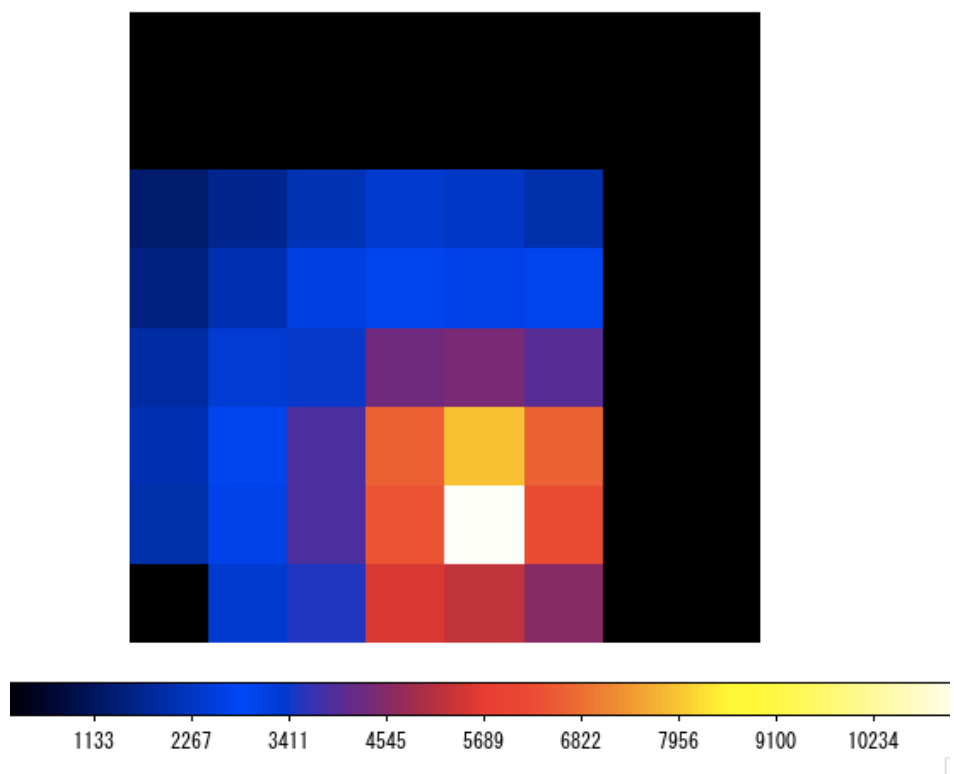
2. Extract image

(2.1) extract image
xselect
xsel
read events ah100040030sxs_p0px1010_cl2.evt
./
yes
extract image
save image ah100040030sxs_p0px1010_cl2_sky.img
set xyname detx dety
extract image
save image ah100040030sxs_p0px1010_cl2_det.img
exit
no

sky image



detector image

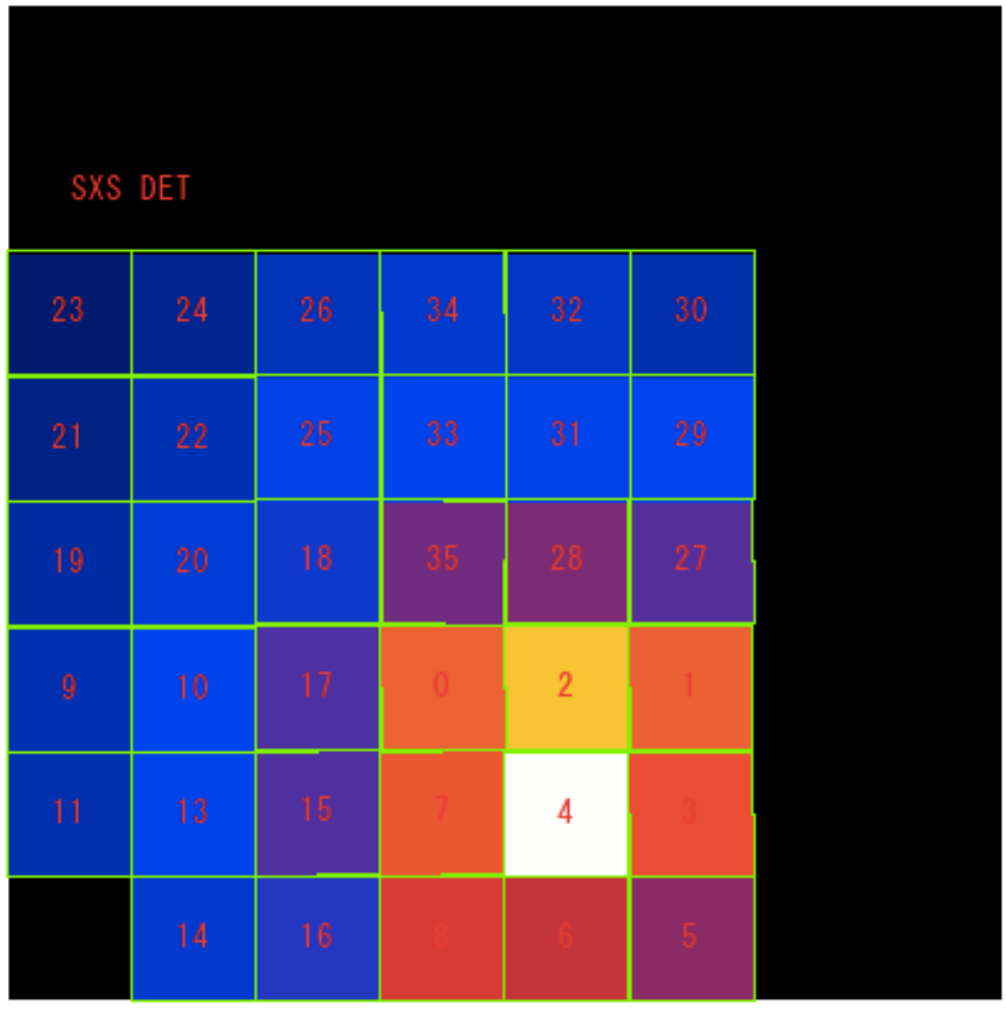


2. Extract image

(2.2) region files
fkeyprint ah100040030sxs_p0px1010_cl2.evt+1 RA_NOM
fkeyprint ah100040030sxs_p0px1010_cl2.evt+1 DEC_NOM
fkeyprint ah100040030sxs_p0px1010_cl2.evt+1 PA_NOM

ra=49.9324156058081
dec=41.520131055133 2
roll=-106.936048924
ahmkregion instrume=SXS ra=${ra} dec=${dec} roll=${roll}

ds9 ah100040030sxs_p0px1010_cl2_det.img -region file SXS.DET.box.reg -region file SXS.DET.text.reg -zoom to fit -cmap b &

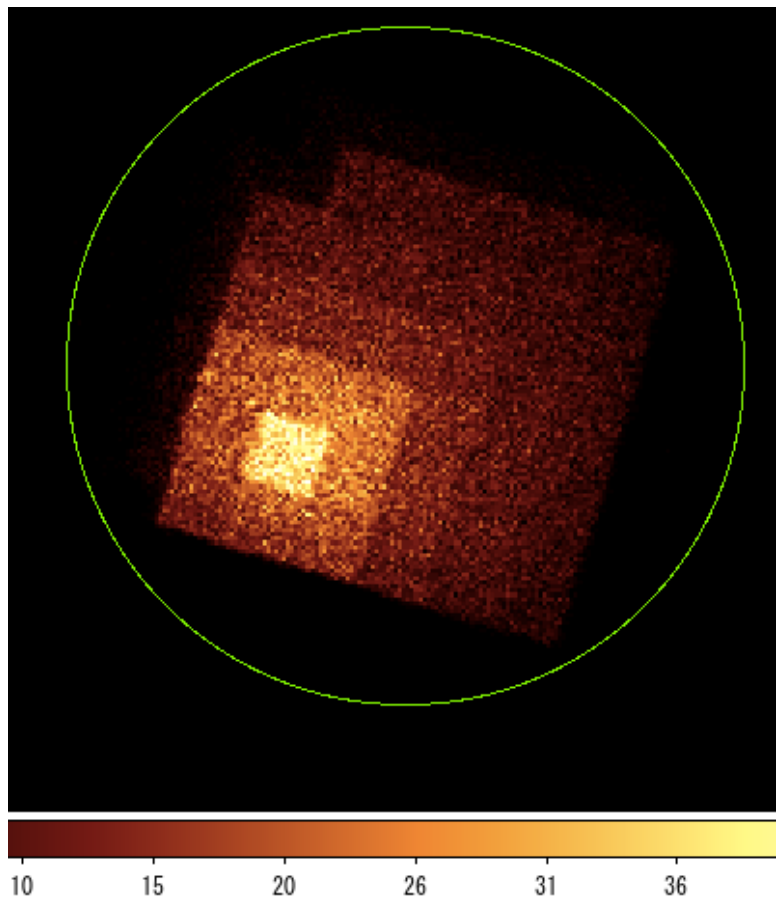


2. Extract image

```
coordpnt "3.5,3.5" outfile=none telescop=HITOMI
instrume=SXS ra=${ra} dec=${dec} roll=${roll} startsys=det
stopsys=radec
## coordpnt: OUTX OUTY=   49.93350633    41.52159242

ra_center=49.93350633
dec_center=41.52159242
cat << EOF >! perseus_offset_sky.reg
fk5
circle(${ra_center},${dec_center},150.0")
EOF
```

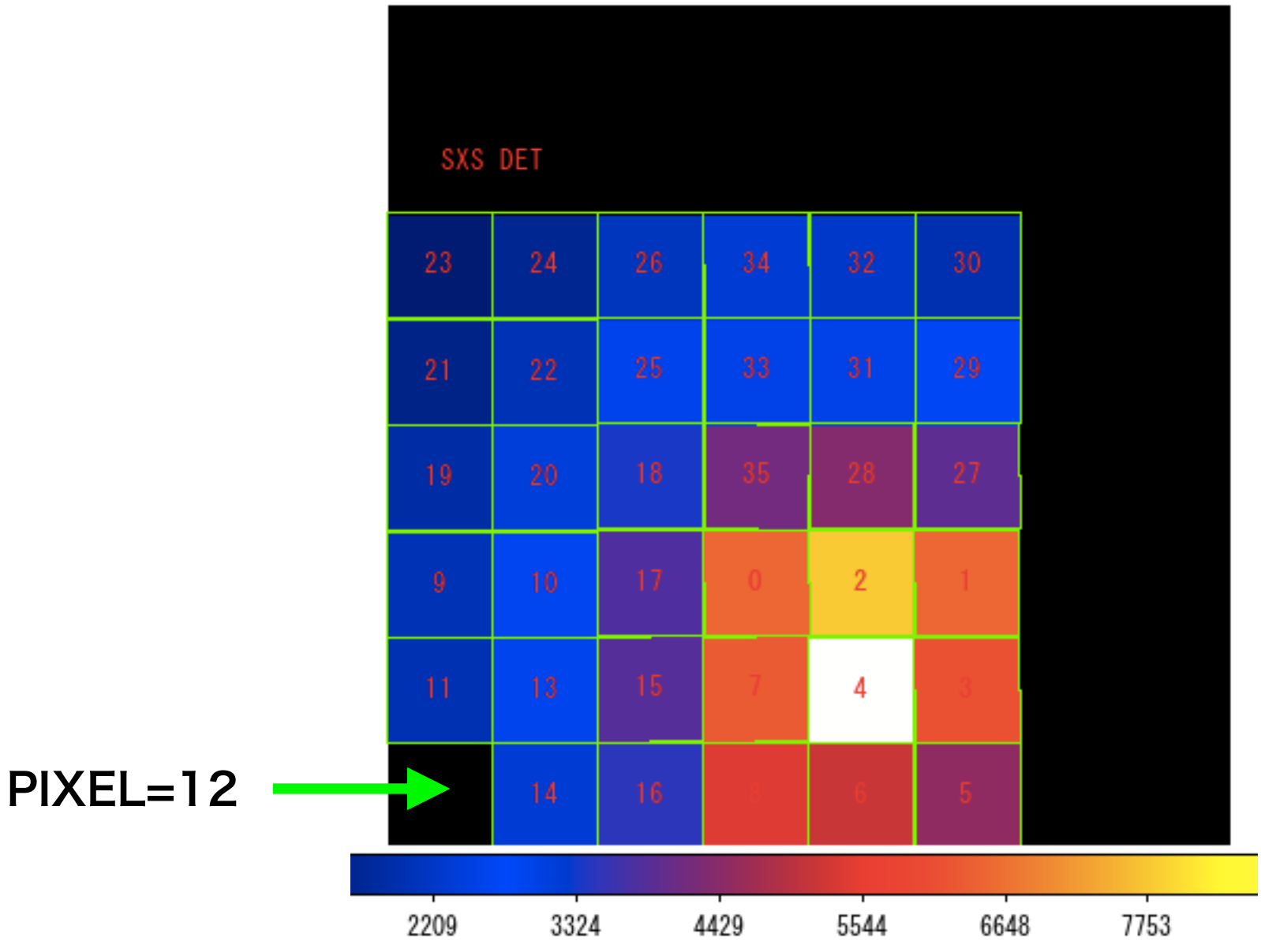
check the image

ds9 ah100040030sxs_p0px1010_cl2_sky.img -region file perseus_offset_sky.reg -cmap bb &



3. Full-array data

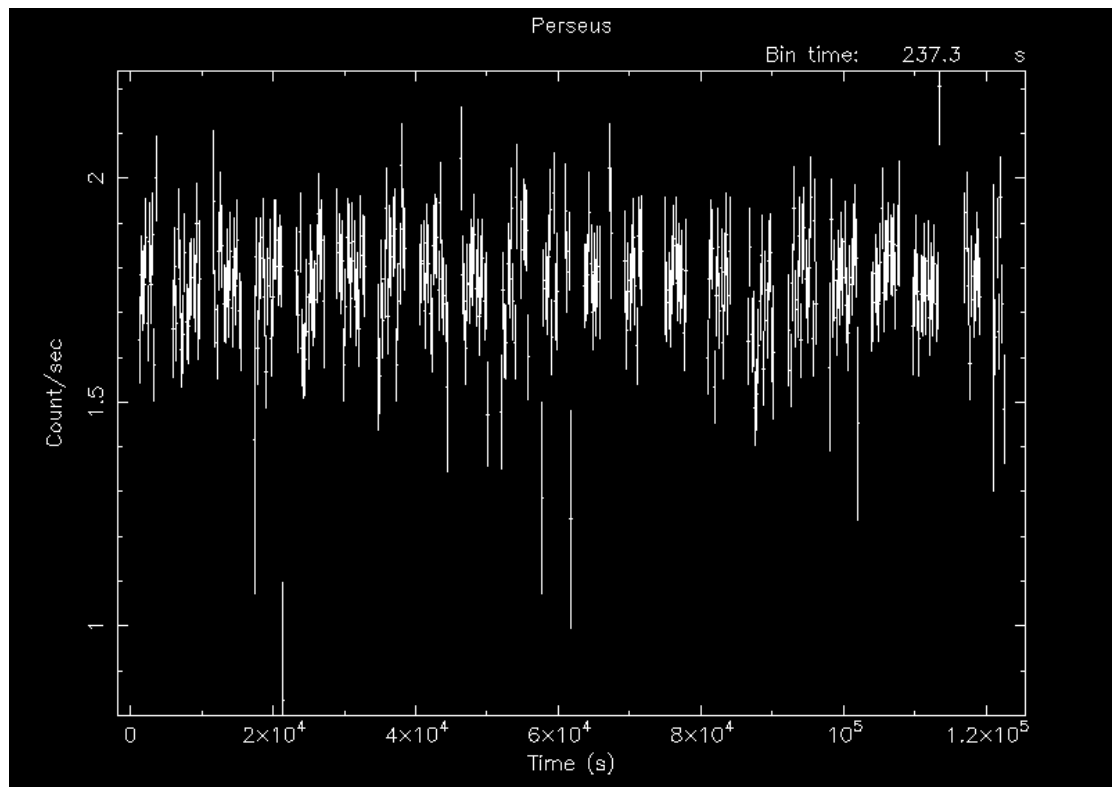
```
sxsregext infile=ah100040030sxs_p0px1010_cl2.evt \
regmode=RADEC region=./perseus_offset_sky.reg \
resolist=0 outroot=ah100040030sxs_detreg \
outexp=ah100040030sxs.expo \
ehkfile=../100040030/auxil/ah100040030.ehk.gz \
delta=20 numphi=1 clobber=yes

## check image
ds9 ah100040030sxs_detreg.img -region file
SXS.DET.box.reg -region file SXS.DET.text.reg -zoom to fit -
cmap b &
```



PIXEL=12

3. Full-array data

check light curve
lcurve
1
ah100040030sxs_detreg.lc
-
INDEF
INDEF
default
yes
/XW
quit



extract spectra
xselect
xsel
read events ah100040030sxs_p0px1010_cl2.evt
./
yes
filter column "PIXEL=0:11,13:35"
filter GRADE "0:0"
extract spectrum
save spectrum ah100040030sxs_p0px1010_cl2_HP.pi
exit
no

4. NXB spectrum

```
sxsnxbgen infile=ah100040030sxs_p0px1010_cl2.evt \
ehkfile=../100040030/auxil/ah100040030.ehk.gz
regfile=NONE \
innxbfile=../NXB/ah_sxs_nxbafmar4_20140101v001.evt.gz \
innxbehk=../NXB/ah_gen_nxbehk_20140101v002.fits.gz \
outpifile=ah100040030sxsnxb_cl2.pi pixels="-" \
cleanup=yes chatter=3 clobber=yes mode=hl \
logfile=ah100040030sxsnxb_cl2.log \
sortbin=0,4,5,6,7,8,9,10,11,12,13,99 \
expr="PI>=400&&RISE_TIME>=40&&RISE_TIME<=60&&ITYPE
<4&&STATUS[4]==b0"

fthedit ah100040030sxsnxb_cl2.pi+1 BACKSCAL add
1.000000E+00
```

5. Response files

(5.1) RMF file

```
sxsmkrmf infile=ah100040030sxs_p0px1010_cl2.evt \
outfile=ah100040030_sxs_cl2_HP_small.rmf resolist=0 \
regmode=det regionfile=ah100040030sxs_detreg.reg \
whichrmf=m
```

(5.2) recalculate exposure map

```
ahexpmap ehkfile=../100040030/auxil/ah100040030.ehk.gz \
gtifile=ah100040030sxs_p0px1010_cl2.evt instrume=SXS
badimgfile=NONE \
pixgtifile=../100040030/sxs/event_uf/
ah100040030sxs_px1010_exp.gti.gz \
outfile=ah100040030sxs_p0px1010.expo
outmaptype=EXPOSURE \
delta=20.0 numphi=1 stopsys=SKY instmap=CALDB \
qefile=CALDB contamifile=CALDB vigfile=CALDB \
obffile=CALDB fwfile=CALDB gvfile=CALDB maskcalsrc=yes \
fwtype=DEFAULT specmode=MONO \
specfile=spec.fits specform=FITS energy=1.5 \
evperchan=DEFAULT abund=1 cols=0 covfac=1 \
clobber=yes chatter=1 \
logfile=make_expo_ah100040030sxs_p0px1010.log
```

5. Response files

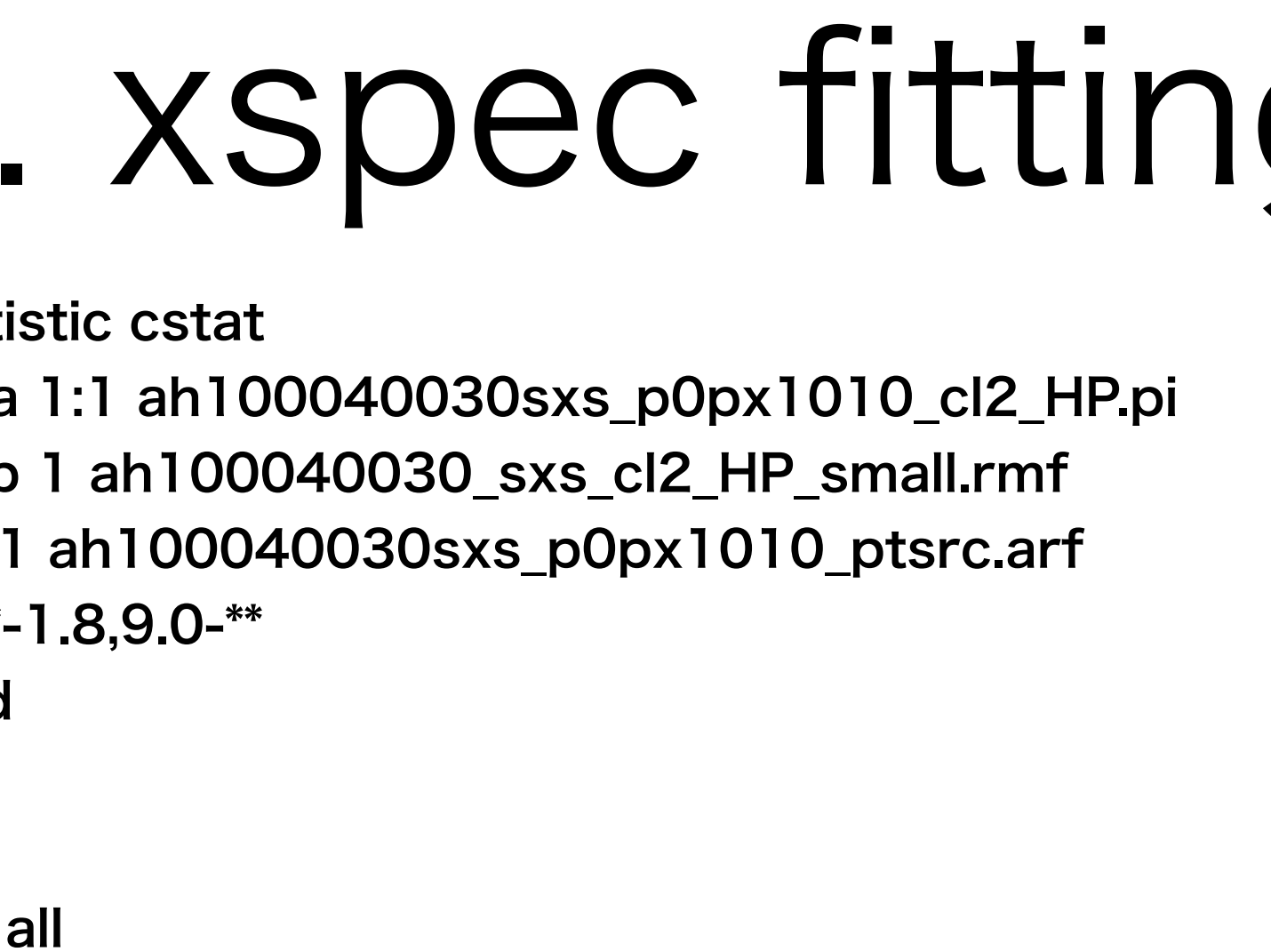
(5.3) arf file
NOTE: this script assumes that the target is point source.
You should read the "step by step guide" and the published paper (e.g. Hitomi collaboration 2018, PASJ, 70, 9)

```
aharfgen  \
xrtevtfile=raytrace_ah100040030sxs_p0px1010_ptsrc.fits \
source_ra=49.9507 source_dec=41.5128 telescop=HITOMI \
instrume=SXS emapfile=ah100040030sxs_p0px1010.expo \
regmode=DET regionfile=ah100040030sxs_detreg.reg \
sourcetype=POINT \
rmffile=ah100040030_sxs_cl2_HP_small.rmf \
erange="0.5 17.0 0 0" \
outfile=ah100040030sxs_p0px1010_ptsrc.arf \
numphoton=300000 minphoton=1 teldeffile=CALDB \
qefile=CALDB contamifile=CALDB obffile=CALDB \
fwfile=CALDB gatevalvefile=CALDB \
onaxisffile=CALDB onaxiscfile=CALDB mirrorfile=CALDB \
obstructfile=CALDB frontreffile=CALDB backreffile=CALDB \
pcolreffile=CALDB scatterfile=CALDB auxtransfile=NONE \
mode=h clobber=yes seed=7 \
logfile=make_arf_ah100040030sxs_p0px1010_ptsrc.log
```

6. xspec fitting

```
statistic cstat
data 1:1 ah100040030sxs_p0px1010_cl2_HP.pi
resp 1 ah100040030_sxs_cl2_HP_small.rmf
arf 1 ah100040030sxs_p0px1010_ptsrc.arf
ig **-1.8,9.0-**
pl ld

ipl
win all
log x off
r x 6.4 6.7
r y 1e-2 5
```

Model: Tbabs*(bapec+pegpwrlw)



Enjoy Hitomi Analysis!