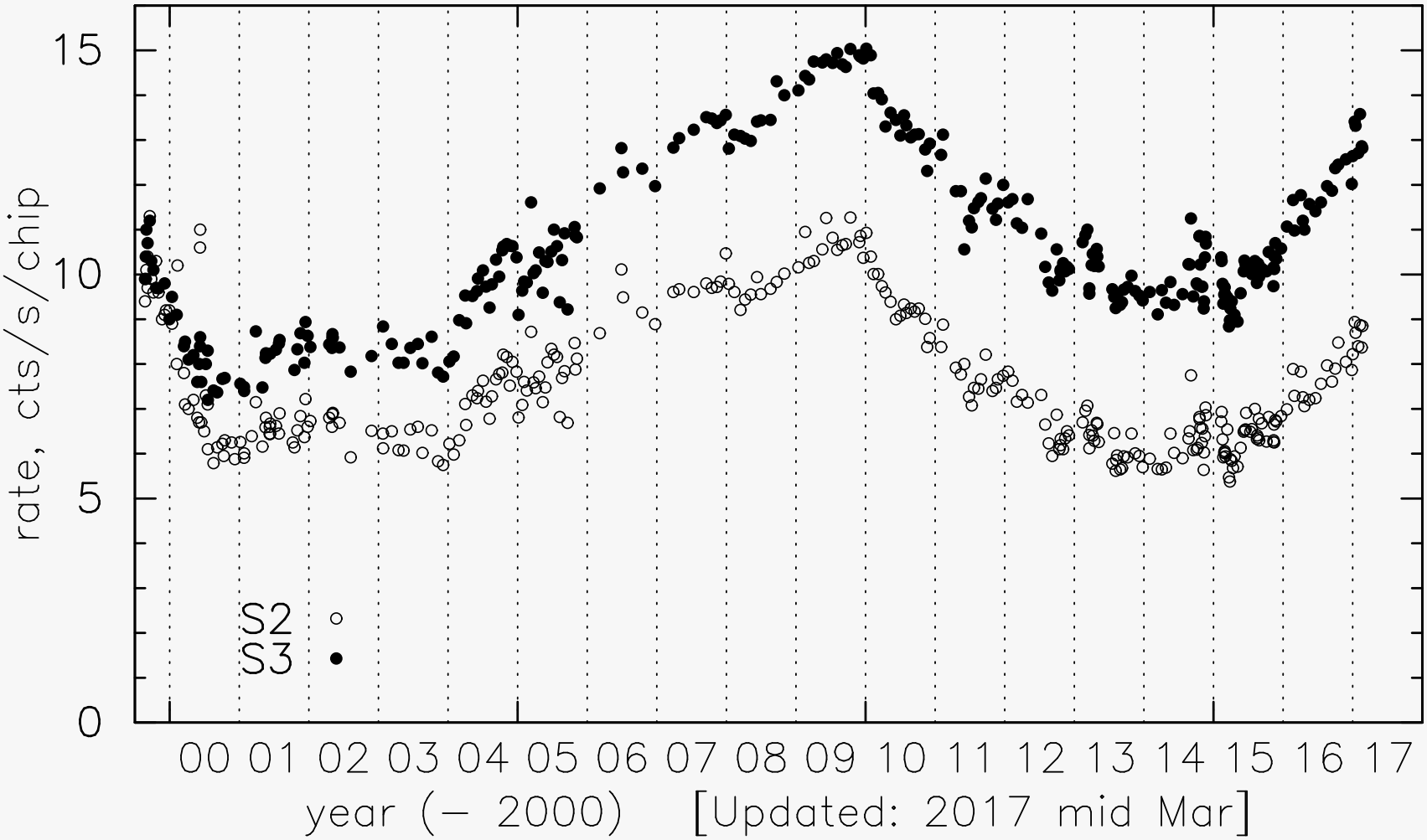
Chandra ACIS Background

Terrance J. Gaetz

Chandra X-ray Center/Smithsonian Astrophysical Observatory

IACHEC 2017

ACIS Quiescent Background Rates (all grades)



Background Periods

"Blank sky" (sources-removed) Background:

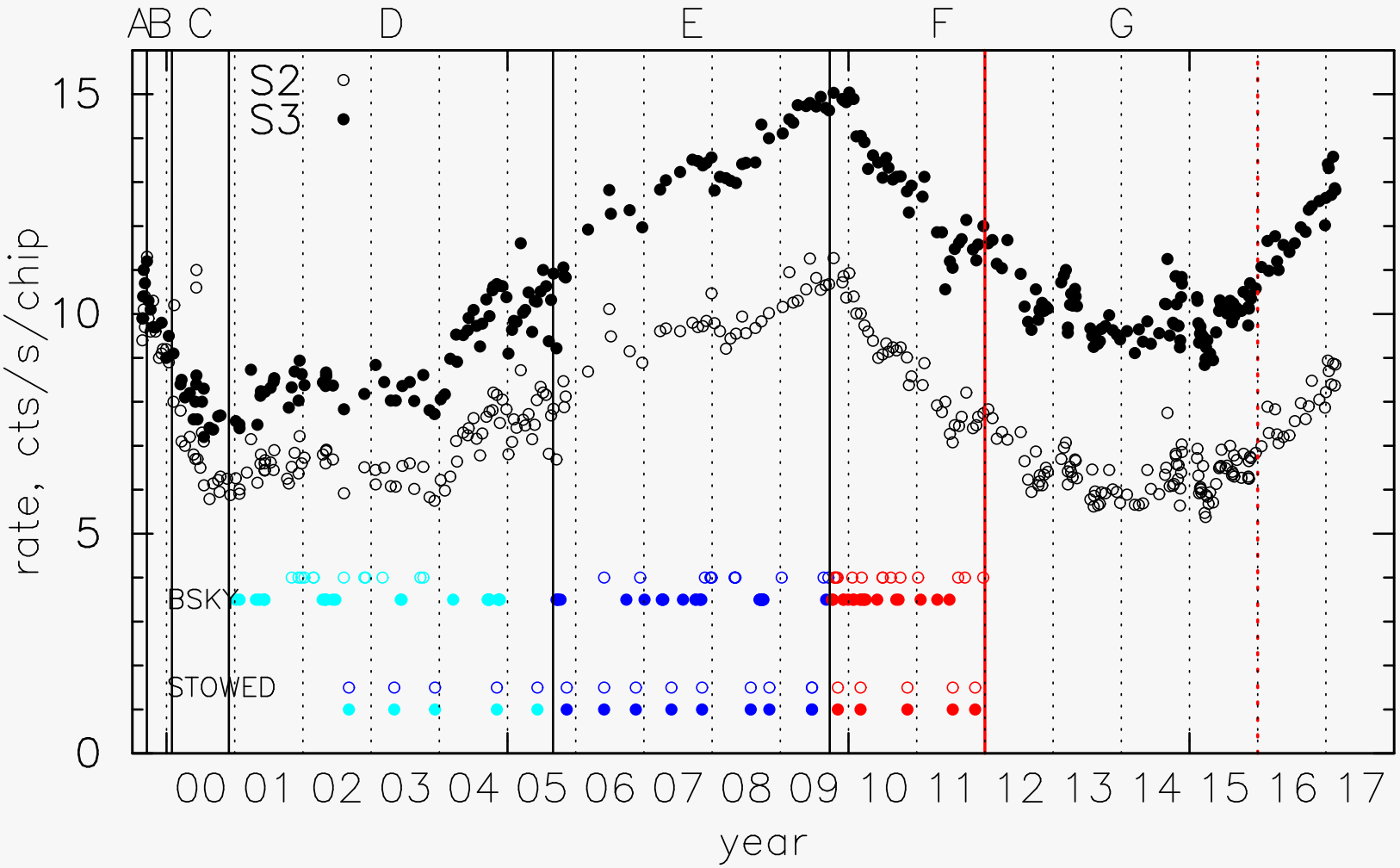
	Date	Description
A	First Light to 1999-09-16	∼-100C: FI chip CTI rapidly increasing
B	1999-09-17 to 2000-01-28	-110C: BG rate declined slowly
C	2000-01-29 to 2000-11-30	-120C: BG further declined (∼15%)
D	2000-12-01 to 2005-08-31	-120C: BG picks up; include VF data
E	2005-09-01 to 2009-09-21	-120C: BG climbs, peaks
F	2009-09-21 to 2011-12-31	-120C: BG peaked, declines

Background Periods

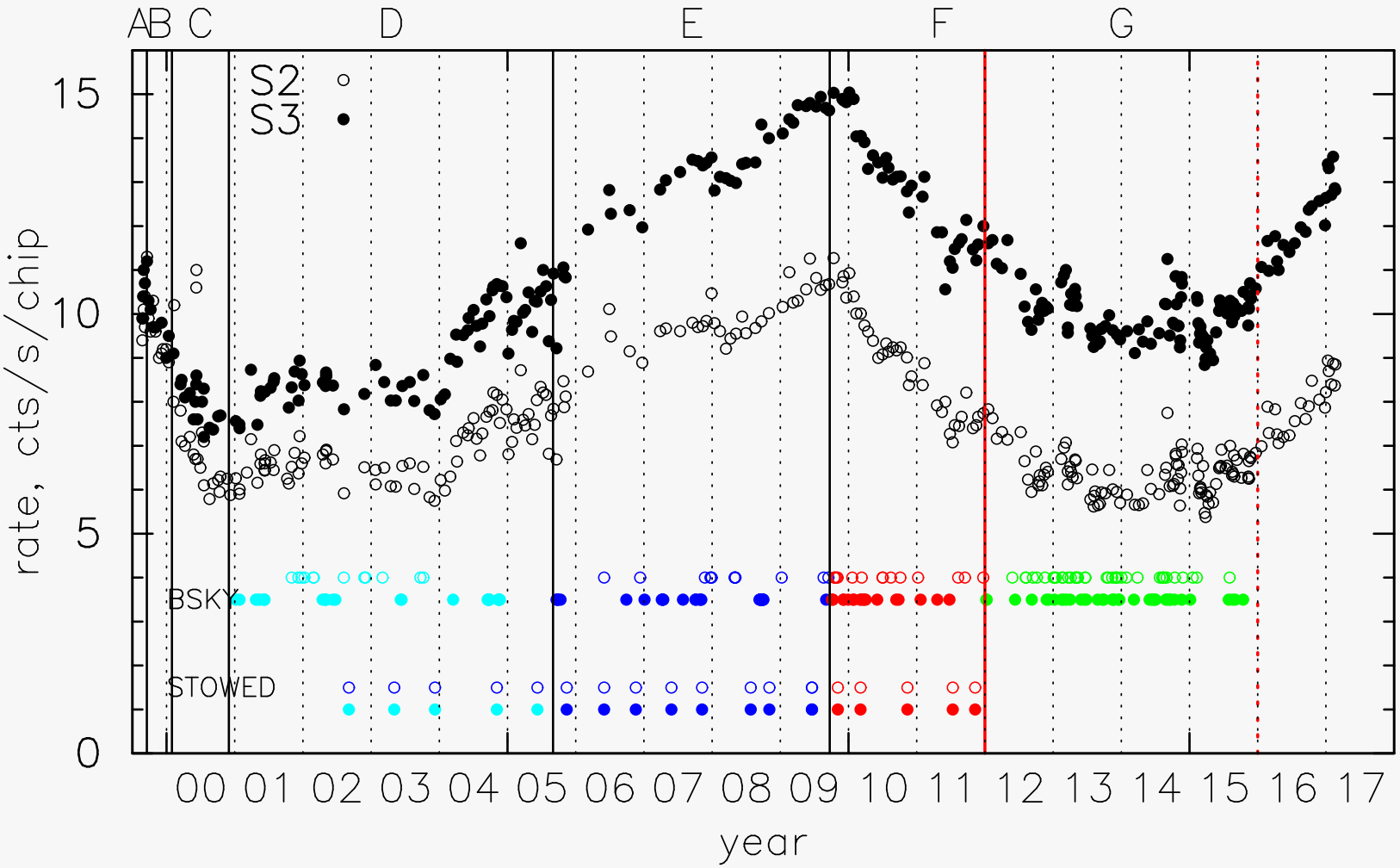
"Blank sky" (sources-removed) Background:

	Date	Description
A	First Light to 1999-09-16	∼-100C: FI chip CTI rapidly increasing
B	1999-09-17 to 2000-01-28	-110C: BG rate declined slowly
C	2000-01-29 to 2000-11-30	-120C: BG further declined (∼15%)
D	2000-12-01 to 2005-08-31	-120C: BG picks up; include VF data
E	2005-09-01 to 2009-09-21	-120C: BG climbs, peaks
F	2009-09-21 to 2011-12-31	-120C: BG peaked, declines
G	2012-01-01 to 2015-12-31	-120C: BG flattens, starts to pick up

ACIS Quiescent Background Rates (all grades)



ACIS Quiescent Background Rates (all grades)



Generation of the Blank Sky Backgrounds

ObsID selection:

- only `VFAINT` mode observations
- ACIS-I aimpoint: at least I0, I1, I2, I3 on
  ACIS-S aimpoint: at least S2, S3 on
- standard adu limits
- `EXPOSURE` $\geq$ 30 ks
- $|b_{ii}| \geq 20^{\circ}$
- RASS R4+R5$<$ 200

New Issues

- more observations with elevated focal plane temp (part or all of the observation)
  - use observations with Focal Plane temperature within a few degrees of -120 C (“do no harm”)
  - TBD: study whether high focal plane temperature affects background
- more deep pointings (or multiple visits with the same pointing/role)
  - “burns in” the sources - harder to fill in excluded source regions using other other observations
  - Avoid deep pointings with same pointing and roll, or use only a fraction of the data (cuts down on amount of usable data)
- thermal limitations: less data for additional chips
  - period G: still respectable I2 and I3 background for S aimpoint
  - not enough S3 data for I aimpoint ⇒ no new background for that combination

New Issues

- more observations with elevated focal plane temp (part or all of the observation)
  - use observations with Focal Plane temperature within a few degrees of -120 C (“do no harm”)
  - TBD: study whether high focal plane temperature affects background
- more deep pointings (or multiple visits with the same pointing/role)
  - “burns in” the sources - harder to fill in excluded source regions using other other observations
  - Avoid deep pointings with same pointing and roll, or use only a fraction of the data (cuts down on amount of usable data)
- thermal limitations: less data for additional chips
  - period G: still respectable I2 and I3 background for S aimpoint
  - not enough S3 data for I aimpoint ⇒ no new background for that combination

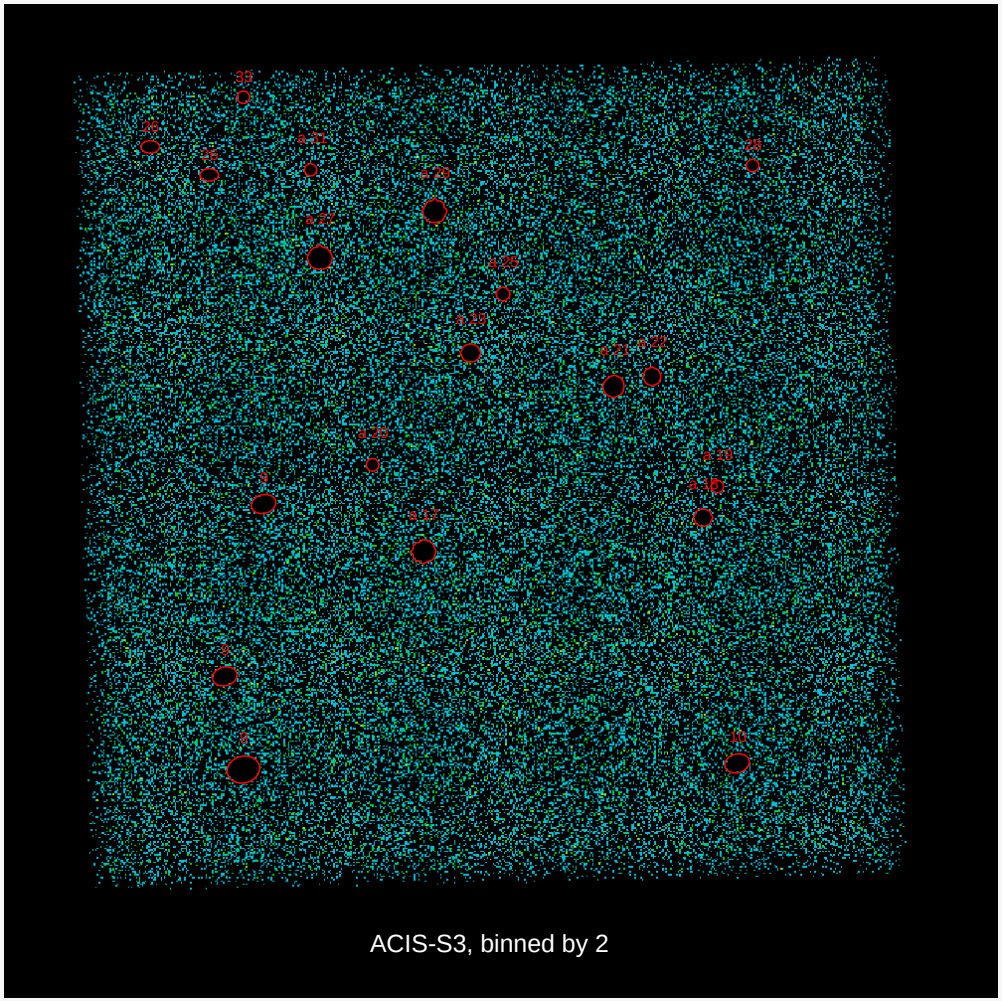
New Issues

- more observations with elevated focal plane temp (part or all of the observation)
  - use observations with Focal Plane temperature within a few degrees of -120 C (“do no harm”)
  - TBD: study whether high focal plane temperature affects background
- more deep pointings (or multiple visits with the same pointing/role)
  - “burns in” the sources - harder to fill in excluded source regions using other other observations
  - Avoid deep pointings with same pointing and roll, or use only a fraction of the data (cuts down on amount of usable data)
- thermal limitations: less data for additional chips
  - period G: still respectable I2 and I3 background for S aimpoint
  - not enough S3 data for I aimpoint $\Rightarrow$ no new background for that combination

Generation of the Blank Sky Backgrounds

Procedure

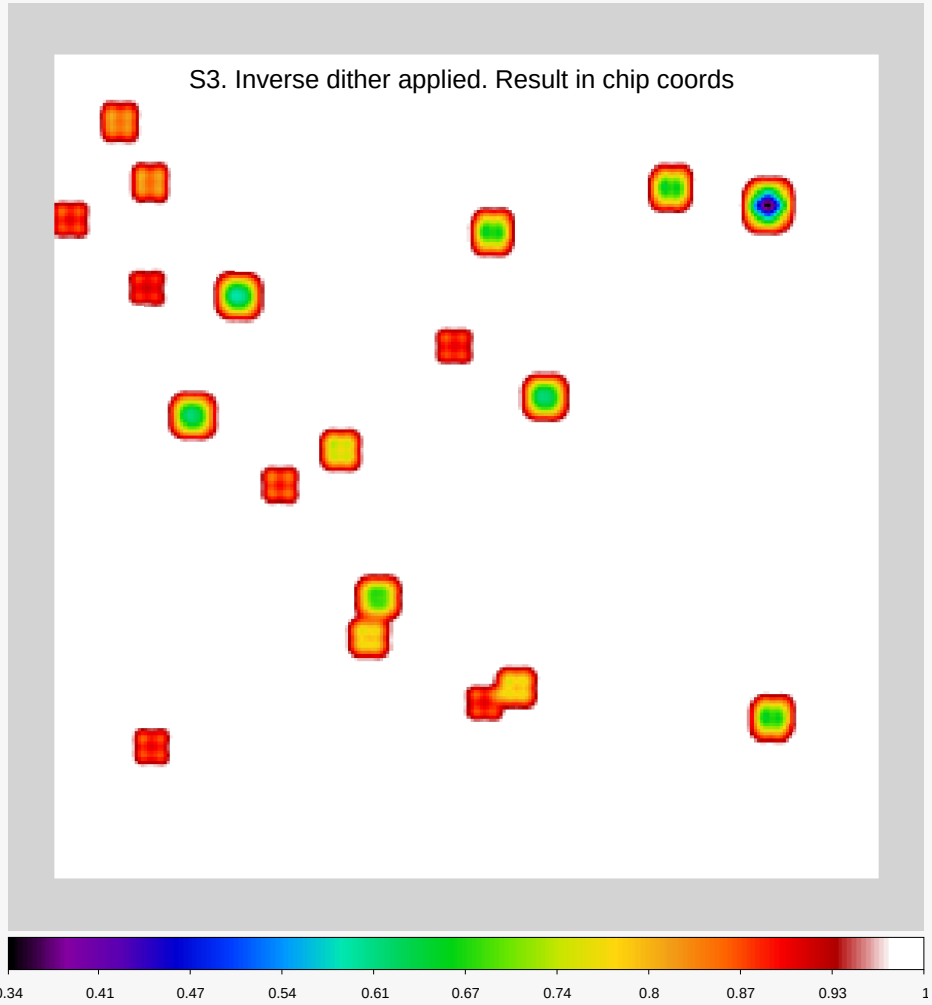
- locate sources and diffuse emission (partially automated)
- sources punched from event list (using source regions)



Generation of the Blank Sky Backgrounds

Procedure (cont.)

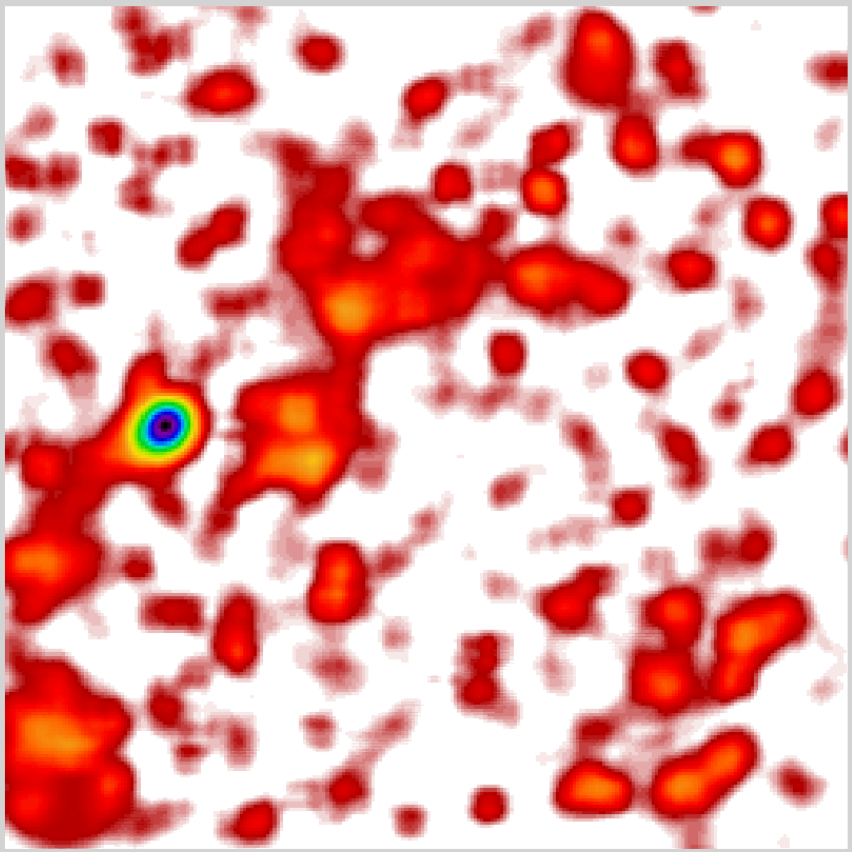
- make source mask in chip coords (apply inverse dither to source regions)



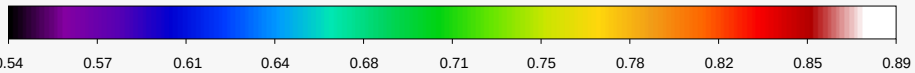
Generation of the Blank Sky Backgrounds

Procedure (cont.)

- combine source masks for each chip (source mask for S3 in chip coordinates)



S3, summed mask regions (chip coords)



Generation of the Blank Sky Backgrounds

Procedure (cont.)

- select a culling level based on source mask:
  - randomly remove events; retained events based on culling level and source mask
  - new effective source mask flat (or depressions up to $\sim$ 10%)
  - if depressions remain, fill in the holes randomly using nearby data with similar `chipx`, `chipy`
- remove CALDB bad columns/pixels (which may have been filled in by previous step)
- sort events by `chipx`, `chipy`
- remove columns: `time`, `tdetx`, `tdety`, `pha_ro`
- previous steps mangled the header; restore file structure

Generation of the Blank Sky Backgrounds

Procedure (cont.)

- select a culling level based on source mask:
  - randomly remove events; retained events based on culling level and source mask
  - new effective source mask flat (or depressions up to $\sim$ 10%)
  - if depressions remain, fill in the holes randomly using nearby data with similar `chipx`, `chipy`
- remove CALDB bad columns/pixels (which may have been filled in by previous step)
- sort events by `chipx`, `chipy`
- remove columns: `time`, `tdetx`, `tdety`, `pha_ro`
- previous steps mangled the header; restore file structure

Generation of the Blank Sky Backgrounds

Procedure (cont.)

- select a culling level based on source mask:
  - randomly remove events; retained events based on culling level and source mask
  - new effective source mask flat (or depressions up to $\sim$ 10%)
  - if depressions remain, fill in the holes randomly using nearby data with similar `chipx`, `chipy`
- remove CALDB bad columns/pixels (which may have been filled in by previous step)
- sort events by `chipx`, `chipy`
- remove columns: `time`, `tdetx`, `tdety`, `pha_ro`
- previous steps mangled the header: restore file structure

Generation of the Blank Sky Backgrounds

Procedure (cont.)

- select a culling level based on source mask:
  - randomly remove events; retained events based on culling level and source mask
  - new effective source mask flat (or depressions up to $\sim$ 10%)
  - if depressions remain, fill in the holes randomly using nearby data with similar `chipx`, `chipy`
- remove CALDB bad columns/pixels (which may have been filled in by previous step)
- sort events by `chipx`, `chipy`
- remove columns: `time`, `tdetx`, `tdety`, `pha_ro`
- previous steps mangled the header: restore file structure

Generation of the Blank Sky Backgrounds

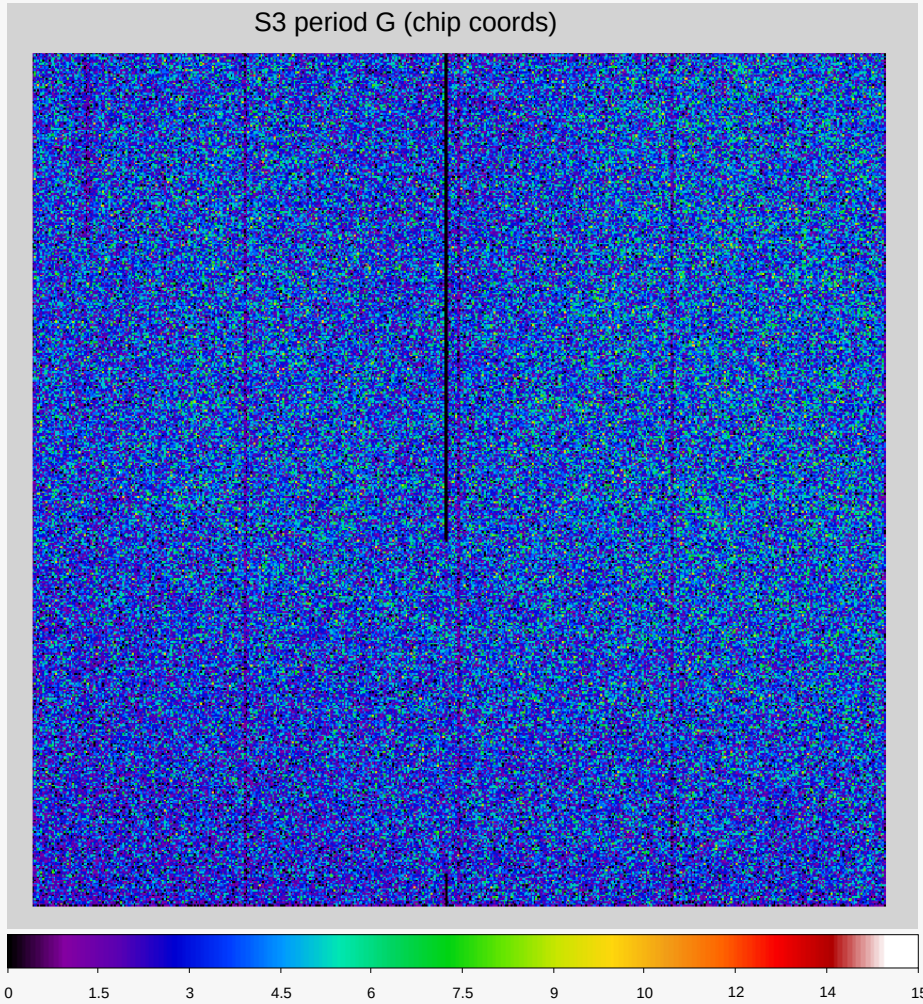
Procedure (cont.)

- select a culling level based on source mask:
  - randomly remove events; retained events based on culling level and source mask
  - new effective source mask flat (or depressions up to $\sim$ 10%)
  - if depressions remain, fill in the holes randomly using nearby data with similar `chipx`, `chipy`
- remove CALDB bad columns/pixels (which may have been filled in by previous step)
- sort events by `chipx`, `chipy`
- remove columns: `time`, `tdetx`, `tdety`, `pha_ro`
- previous steps mangled the header: restore file structure

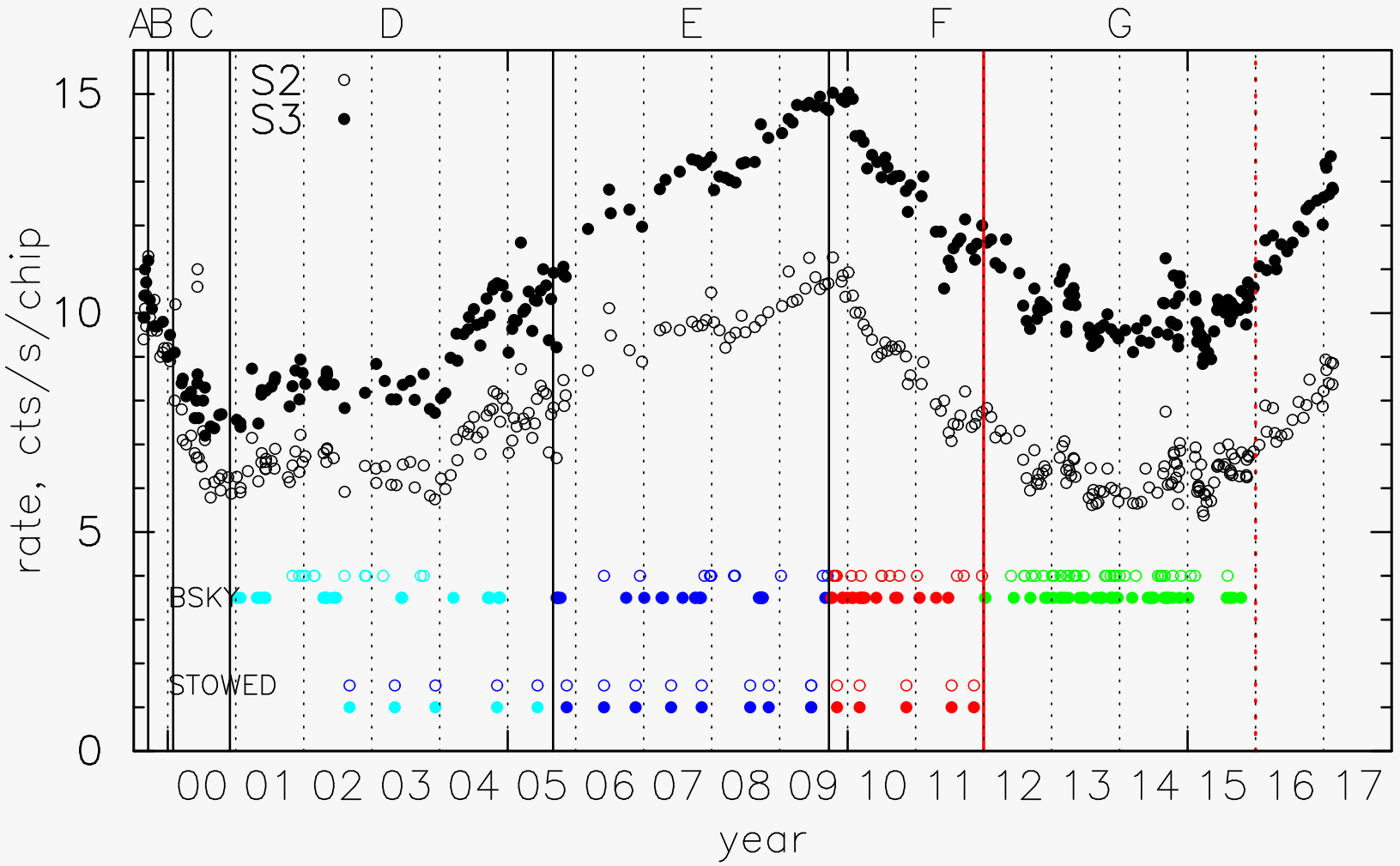
Generation of the Blank Sky Backgrounds

Procedure (cont.)

- Resulting S3 sky background (chip coordinates)



Sky Background Epochs



Period G Exposure times

aimpoint	ccd	exposure
ACIS-I	I0	$\sim$ 1 Ms
ACIS-I	I1	$\sim$ 1 Ms
ACIS-I	I2	$\sim$ 1 Ms
ACIS-I	I3	$\sim$ 1 Ms
ACIS-I	S2	$\sim$ 350 ks

aimpoint	ccd	exposure
ACIS-S	S1	$\sim$ 600 ks
ACIS-S	S2	$\sim$ 900 ks
ACIS-S	S3	$\sim$ 900 ks
ACIS-S	S4	$\sim$ 900 ks
ACIS-S	I2	$\sim$ 600 ks
ACIS-S	I3	$\sim$ 900 ks

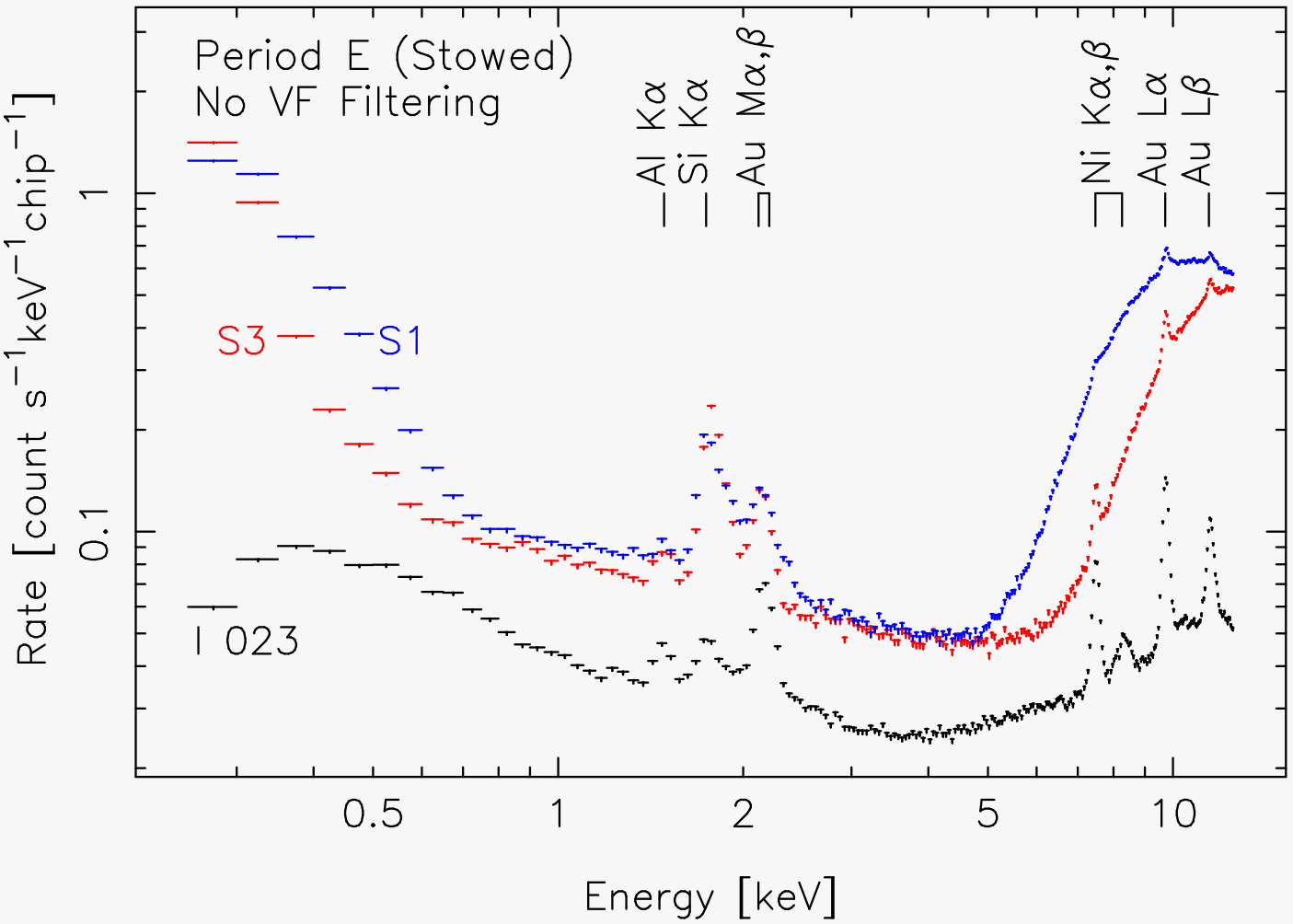
- Subject to revision during V&V of the backgrounds

Summary

- new blank sky background covering 2012 to 2015 in preparation
- finalizing V&V of the data, examine spectra, etc.
- released for CALDB testing imminent

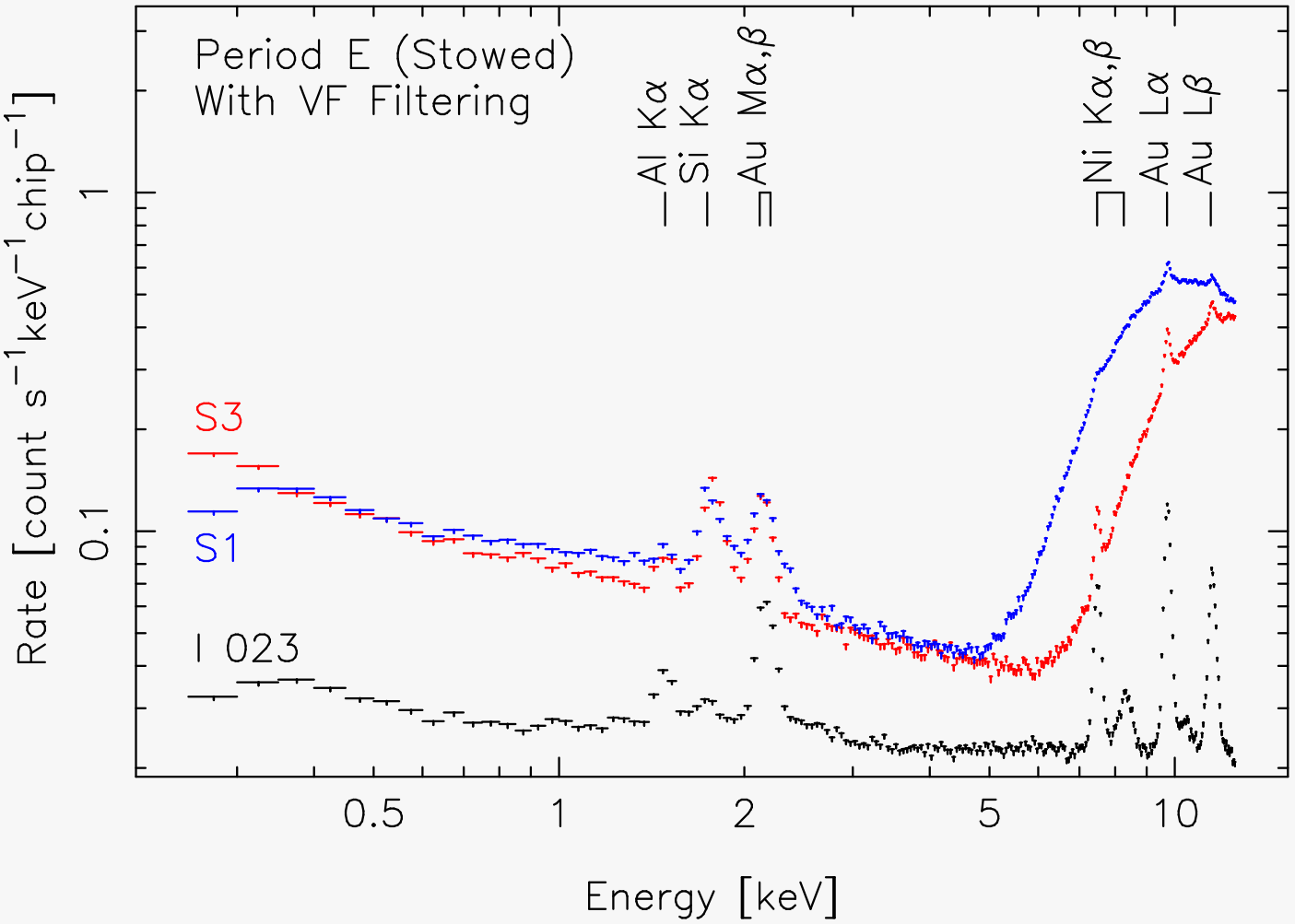
Background Features (ACIS “stowed”)

- particle-induced background (continuum)
- fluorescent lines



Background Features (ACIS “stowed”)

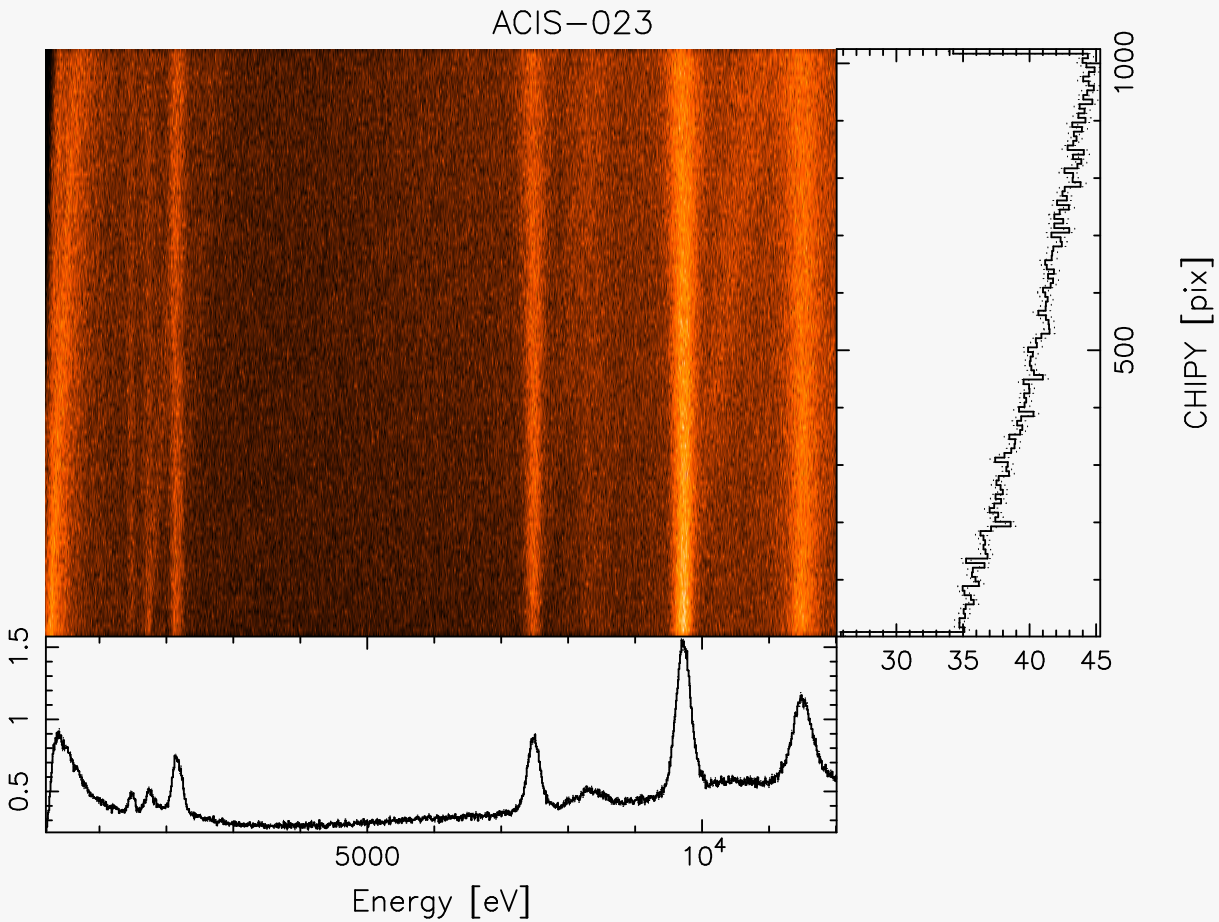
- particle-induced background (continuum)
- fluorescent lines



Background Spatial/Spectral Variation (ACIS “stowed”)

FI Chips – I0, I2, I3

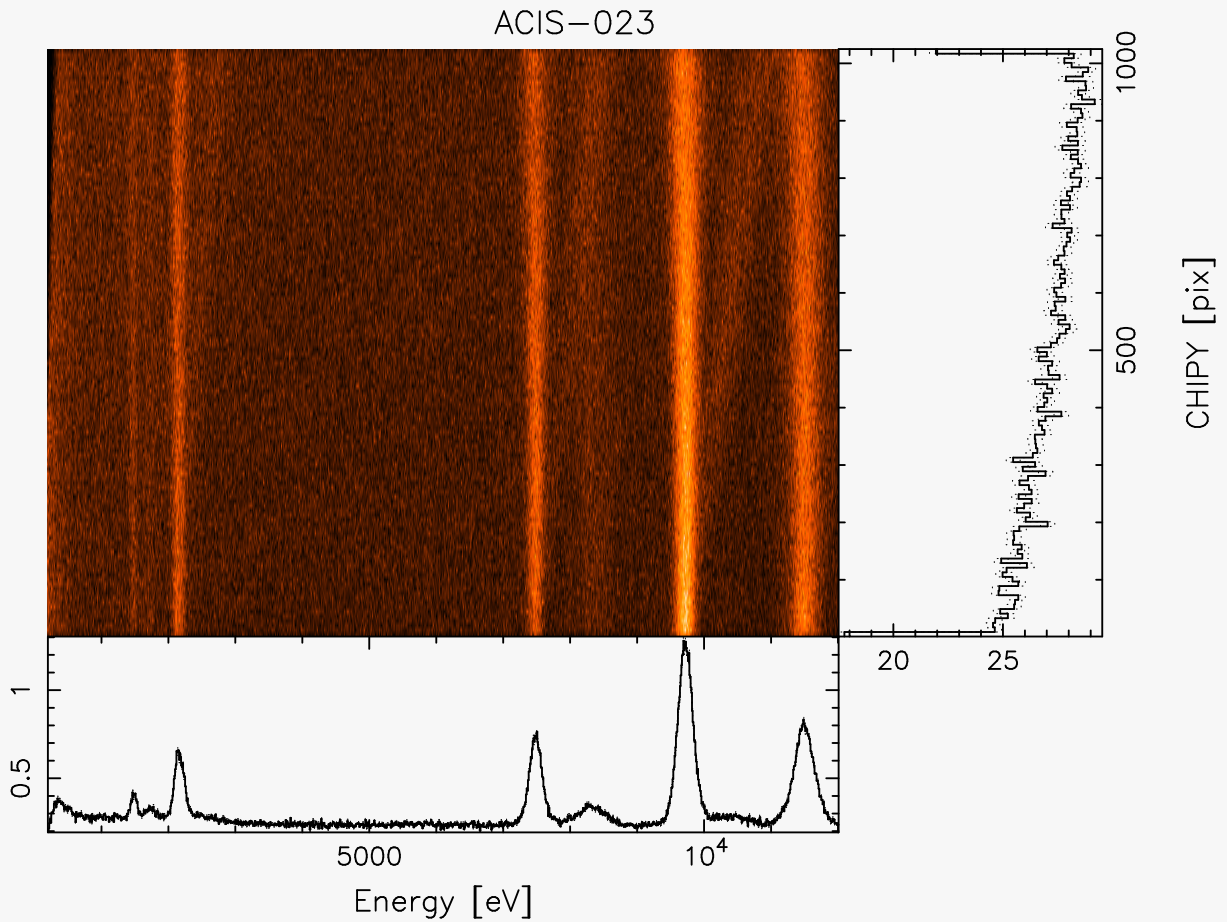
ACIS-I023 Background Spectrum: `chipy` Variation (no VF cleaning)



Background Spatial/Spectral Variation (ACIS “stowed”)

FI Chips – I0, I2, I3

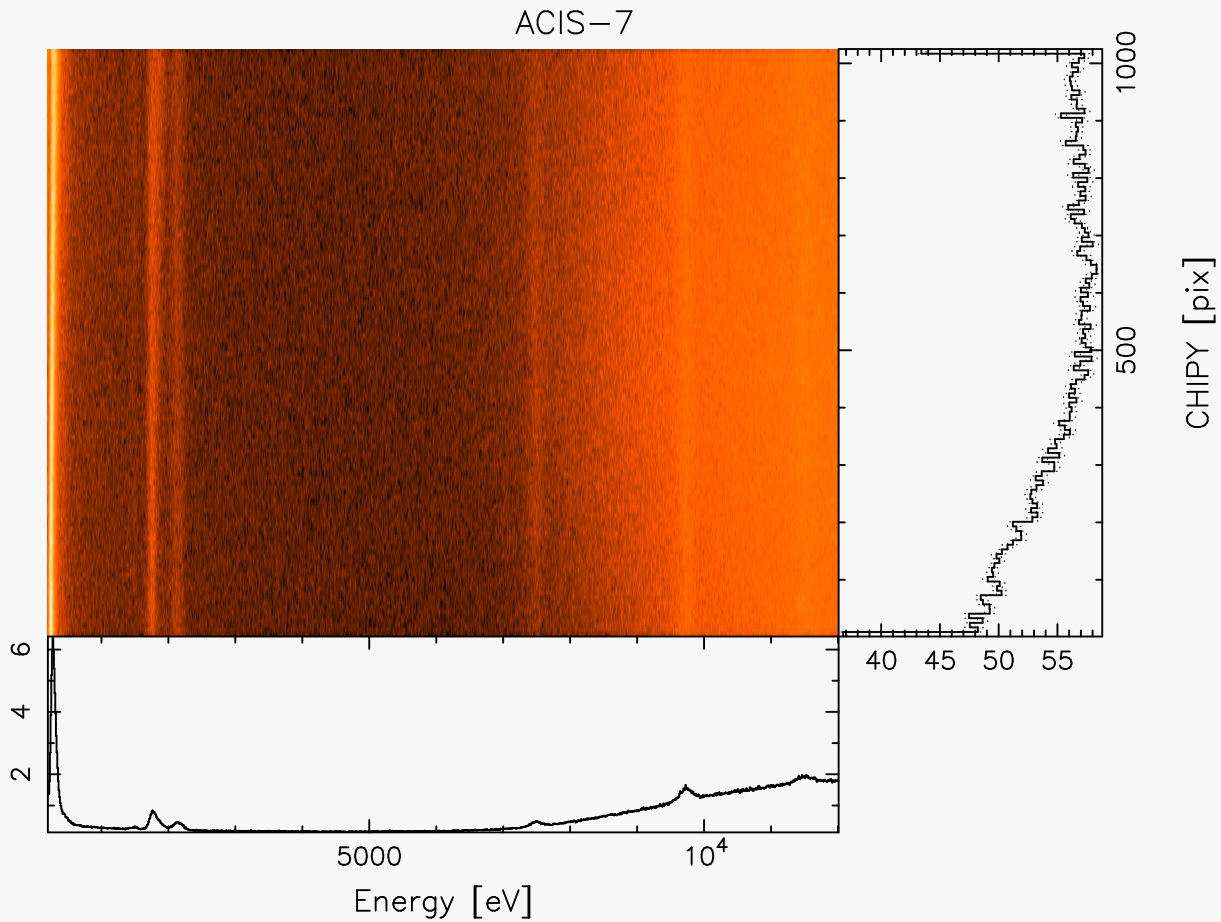
ACIS-I023 Background Spectrum: `chipy` Variation (with VF cleaning)



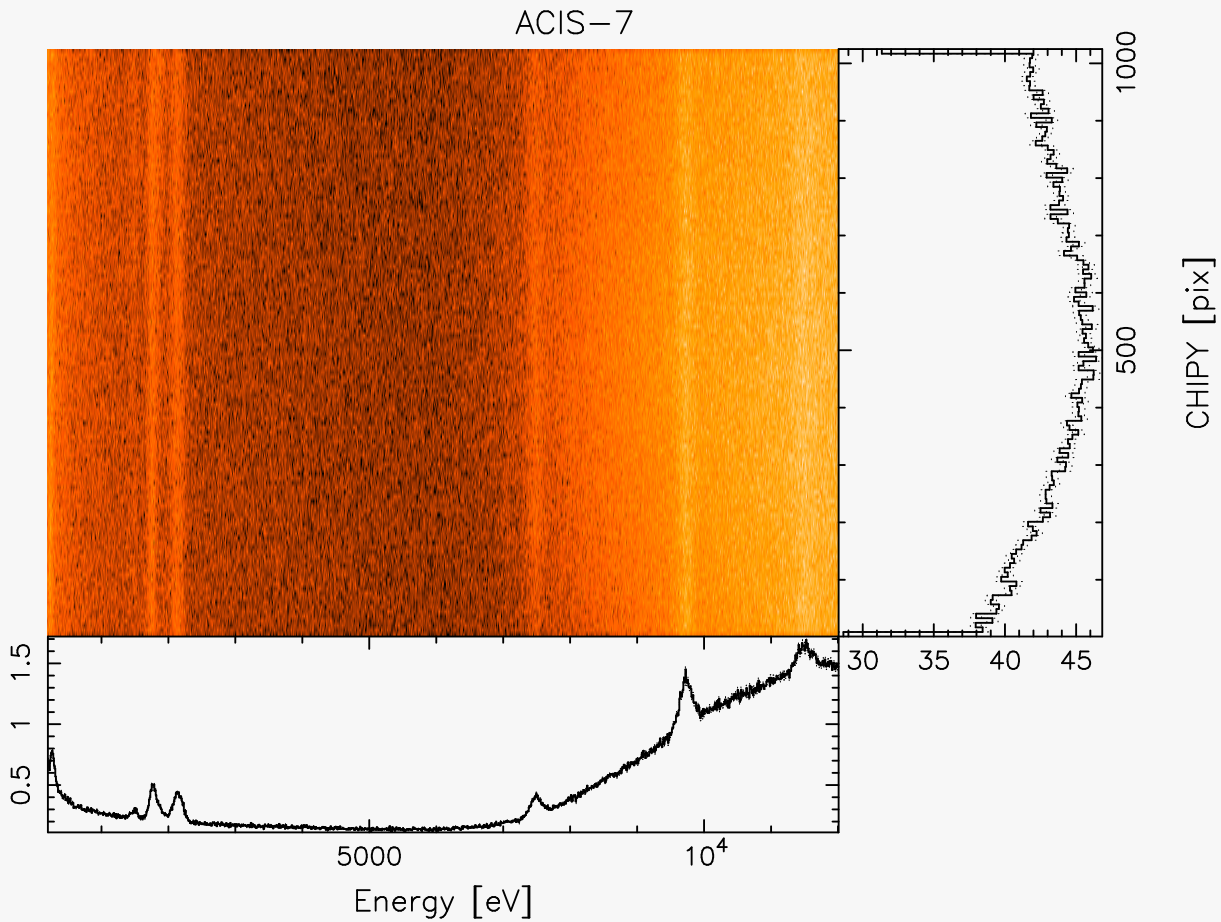
Background Spatial/Spectral Variation (ACIS “stowed”)

BI Chip – S3

ACIS-S3 Background Spectrum: `chipy` Variation (no VF cleaning)



Background Spatial/Spectral Variation (ACIS “stowed”)

BI Chip – S3

ACIS-S3 Background Spectrum: `chipy` Variation (with VF cleaning)