Chandra ACIS-I3 Gain Droop

Terry Gaetz

Chandra X-ray Center/Smithsonian Astrophysical Observatory

IACHEC 2018

ACIS-I3 Mid-Chip “gain droop”

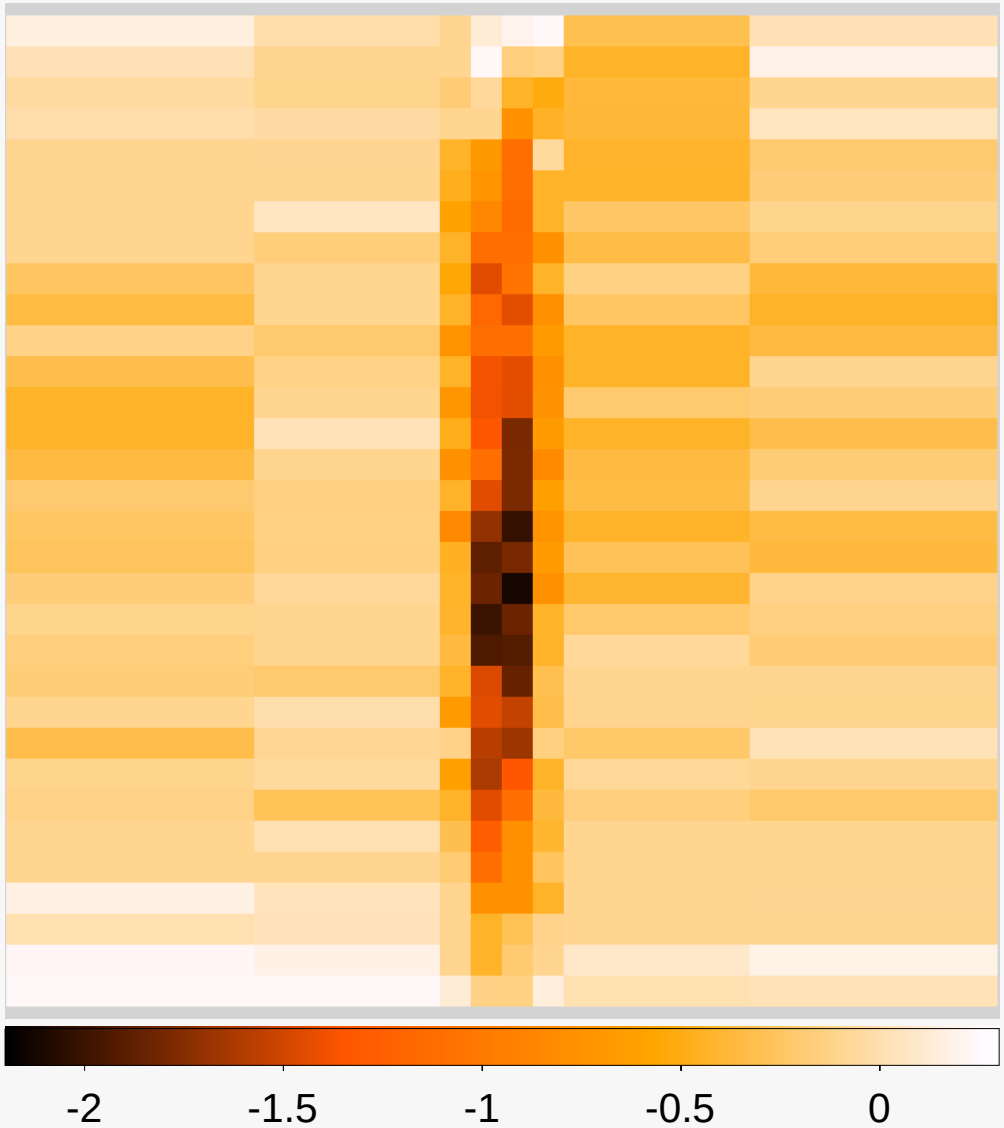
- The issue:
  slightly reduced FI chip gain near the node1/node 2 boundary:
  `chipx` 512-513

- RMF constructed from a matched pair of cal files:
  `p2_resp`, `detgain`

- initial `p2_resp`, `detgain` for FI chips:
  Δ`chipx`=256, Δ`chipy`=32 “tiles”
  - “gain droop” effect diluted and masked
- gain droop noticed with `tgain` work (N. Durham)
  calibrated on finer grid
- `tgain` deltas are from `detgain`;
  fix problem by fixing `detgain`

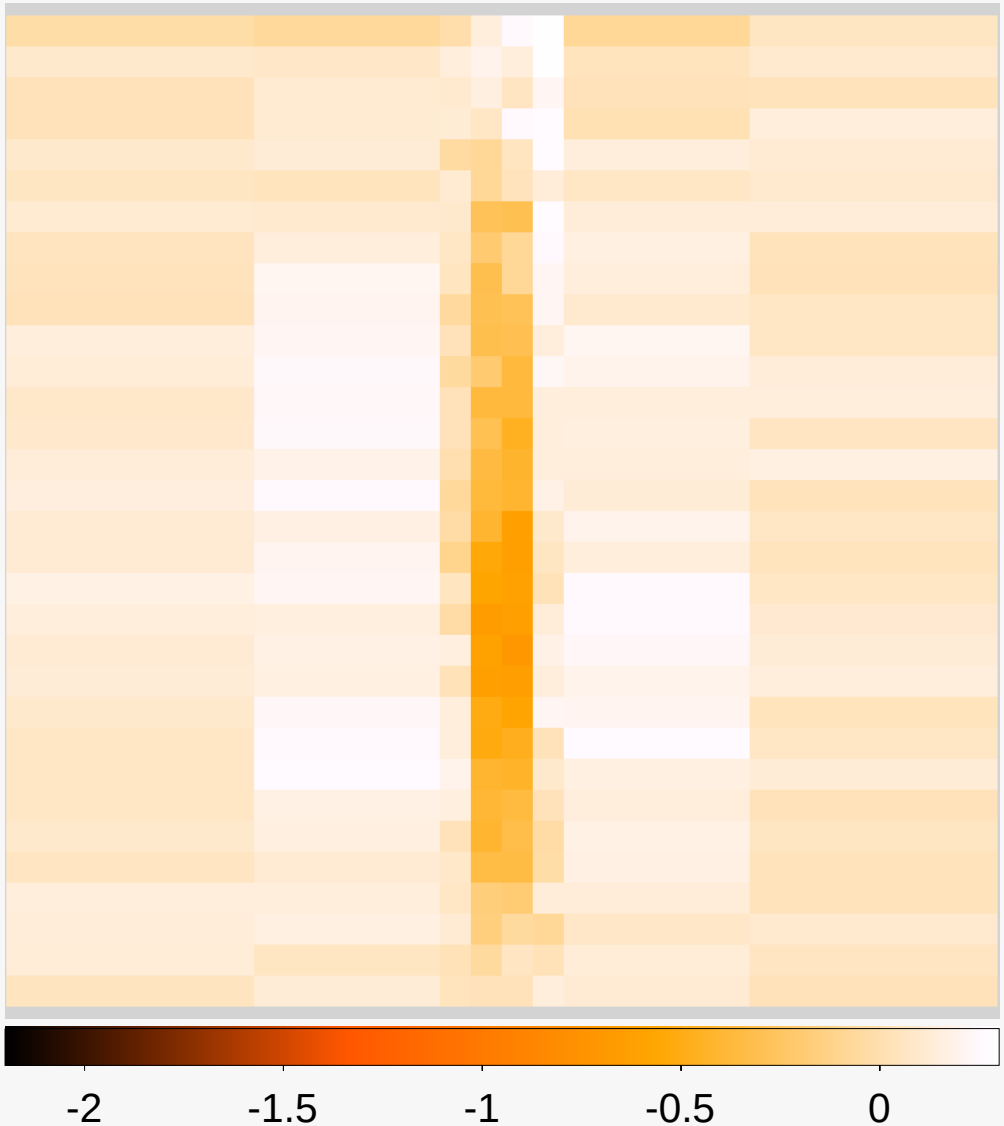
ACIS-I3 Mid-Chip “gain droop” (w/ CALDB gain, resp)

Epoch 1, -120.19 C to -119.19 C
ACIS-I3, Al-Kα (1.486 keV)



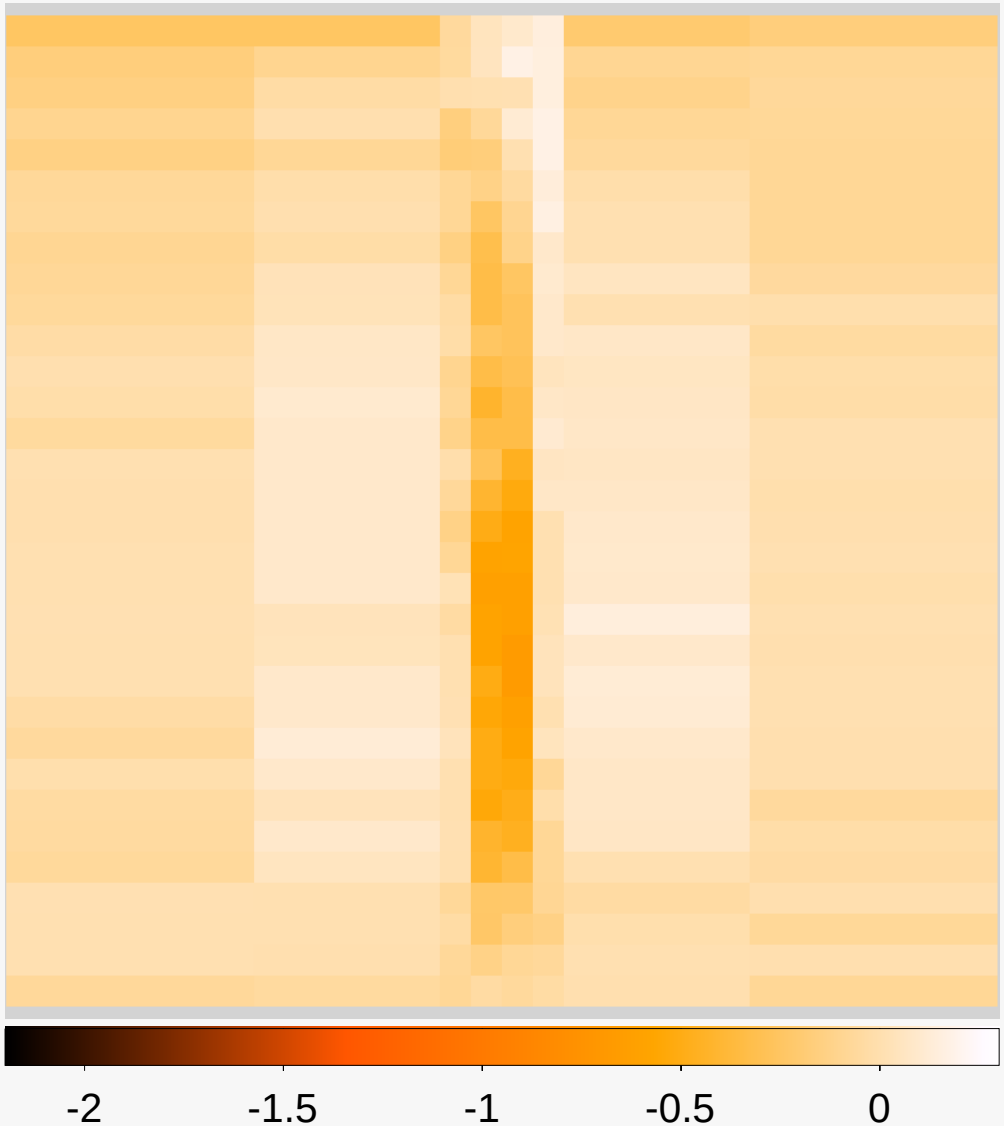
ACIS-I3 Mid-Chip “gain droop” (w/ CALDB gain, resp)

Epoch 1, -120.19 C to -119.19 C
ACIS-I3, Ti-Kα (4.509 keV)



ACIS-I3 Mid-Chip “gain droop” (w/ CALDB gain, resp)

Epoch 1, -120.19 C to -119.19 C
ACIS-I3, Mn-Kα (5.895 keV)



Mitigation Approach

The ACIS-I3 RMF is constructed from:

- `p2_resp`: ideal CCD response + CTI broadening
- `detgain`: relates `PHA` to energy
- Currently, tiles with $\Delta\texttt{chipx} = 256, \Delta\texttt{chipy} = 32$
- fixed (approx. logarithmic) `PHA` grid for each tile, energies vary slightly from tile to tile (gain)

Refine ACIS-I3 tiling:

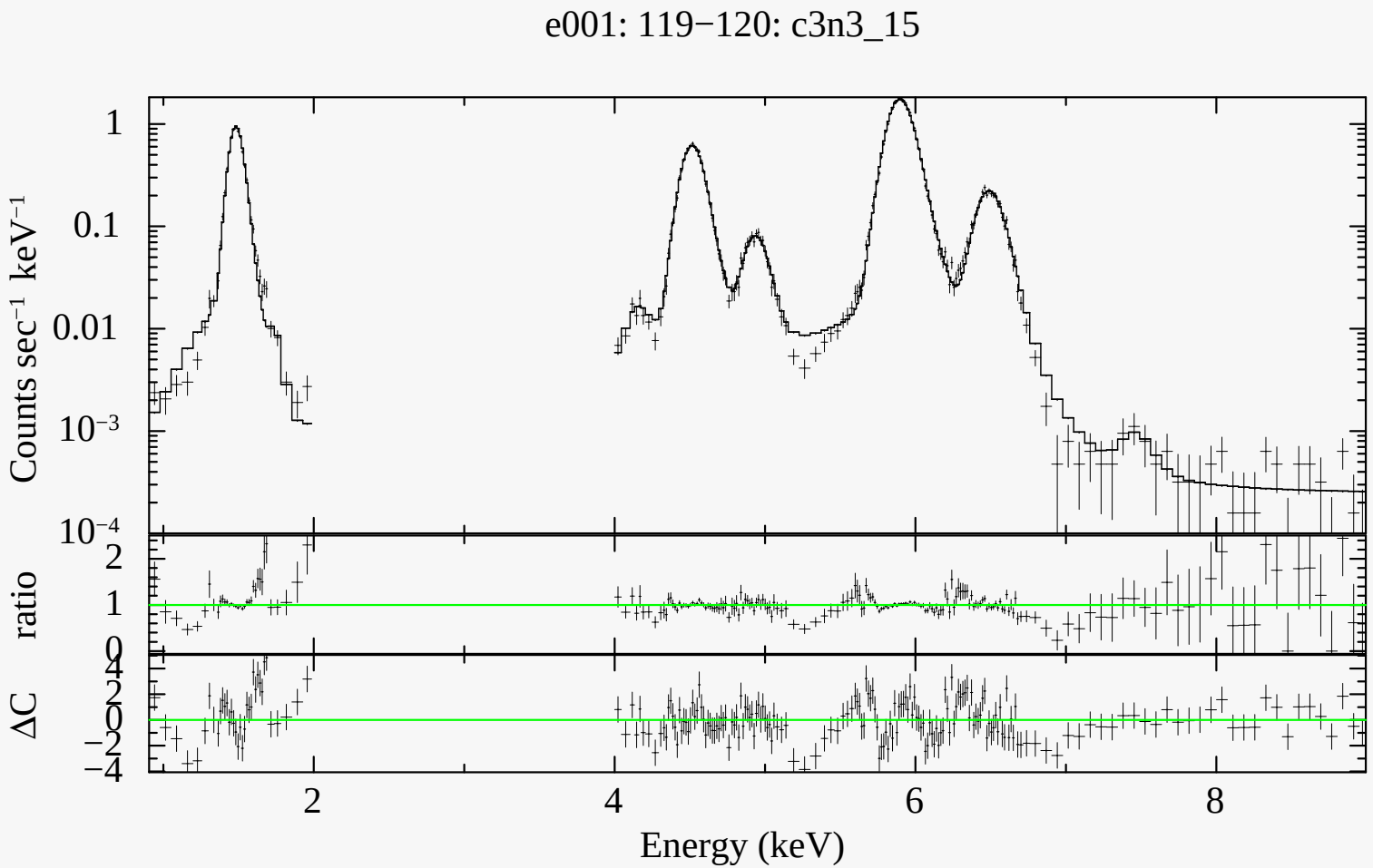
- Change to $\Delta\texttt{chipx} = 256, 192, 32, 32, 32, 32, 192, 256$

Do fits to ECS data

- based on Epoch 1 External CaI Source (ECS) data
- fit for energies of Al-Kα, Ti-Kα, Mn-Kα ($\sim$1.5, 4.5, 5.9 keV)
- "modify gains", remake RMFs, refit and iterate (until done. . .)

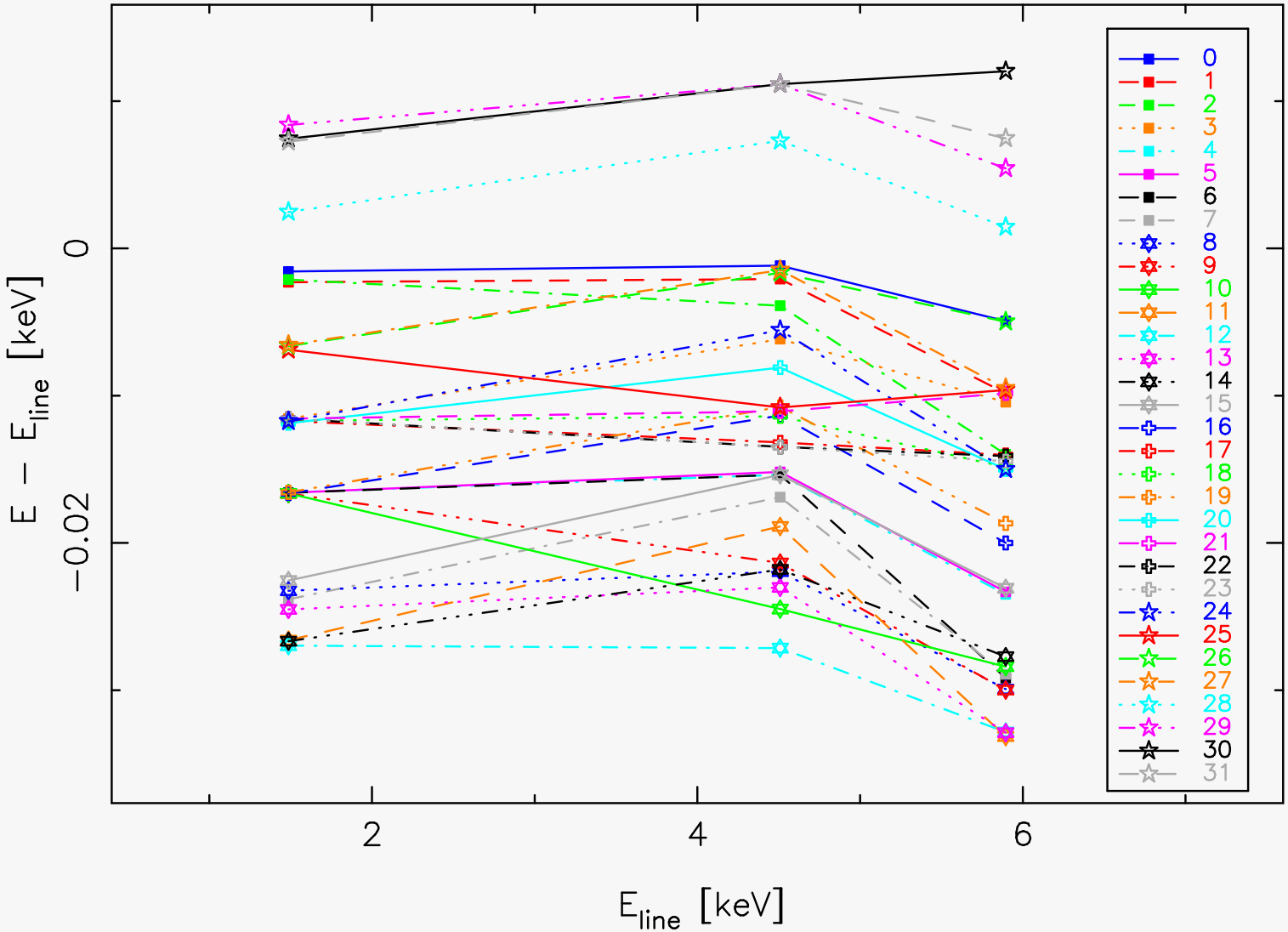
Example Fit to External Calibration Source (ECS)

Epoch 1, -120.19 to -119.19: rows middle
I3, node 3 32 rows



$\Delta E = E - E_{\text{line}}$ vs. E_{line}

ACIS-I3, Epoch 1, -120.19 to -119.19: chipx: 481-512, Δchipy = 32



Mitigation Approach

For each tile: 3 energies (Al-Kα, Ti-Kα, Mn-Kα)

- need to extend over the full range, $\sim$ 0.2-12 keV.
  - try a linear fit to $\Delta E \equiv E - E_{line}$
- $E < 1.5\,\mathrm{kev}$ or $> 5.9\,\mathrm{keV}$
  - for now, keep flat at Al-K value (low E) and Mn K value (high E)

Summary

- ACIS FI chip mid-chip gain droop is significant
- A mitigation approach has been developed and is being tested
  - refine response and gain tiling
  - fit for Al-Kα, Ti-Kα, Mn-Kα for early ECS data
  - fit linear function to ΔE for the three line energies
  - apply ΔE corrections to `detgain` and test
  - iterate if necessary