Overview of ACIS Bakeout

Executive Summary

The CXC is not currently considering a Bakeout because:

- **RISK:** There are unknown risks for damaging the ACIS filter (potential loss of instrument). Concepts for ground tests to characterize the risk currently do not provide the information that we would need to proceed with a Bakeout at an acceptable risk level.
- **EFFECTIVENESS:** Simulations of the outcome of a Bakeout are highly uncertain, ranging from an increase in the contamination layer to no significant change to a significant reduction in the layer
- **BENEFIT:** Although the benefit to low energy science is clear, observations above 2.0 keV are unaffected by the contamination layer. There is not a consensus in the Chandra Users community that a Bakeout is worth the risk.
- **FUTURE IMPACT:** Data within the last year indicate the accumulation rate of the contaminant has decreased. The contaminant at the center of S3 is accumulating significantly slower than predicted by the N0010 contamination model and the contaminant at the center of I3 has not increased in the last 6 months within the uncertainties.

Contamination and Bakeout Studies

Characterization of the Contamination Layer:

Herman Marshall (MIT), Akos Bogdan(SAO), & Paul Plucinsky (SAO)

2018, 'The complicated evolution of the ACIS contamination layer over the mission life of the Chandra X-ray Observatory', Plucinsky et al., SPIE, 10699

2016,'The evolution of the ACIS contamination layer over the 16-year mission of the Chandra X-ray Observatory', Plucinsky et al., SPIE, 9905

2004,'An evaluation of a bake-out of the ACIS instrument on the Chandra X-Ray Observatory', Plucinsky et al., SPIE, 5488

2004,'Composition of the Chandra ACIS contaminant', Marshall et al., SPIE, 5165

Contamination Migration Studies:

Steve O'Dell, Doug Swartz (NASA/MSFC), and Neil Tice (LMA/MIT)

2017,'Modeling contamination migration on the Chandra X-ray Observatory IV', O'Dell et al., SPIE, 10397

2015,'Modeling contamination migration on the Chandra X-ray Observatory III', O'Dell et al., SPIE, 9601

2013,'Modeling contamination migration on the Chandra X-ray Observatory II', O'Dell et al., SPIE, 8859

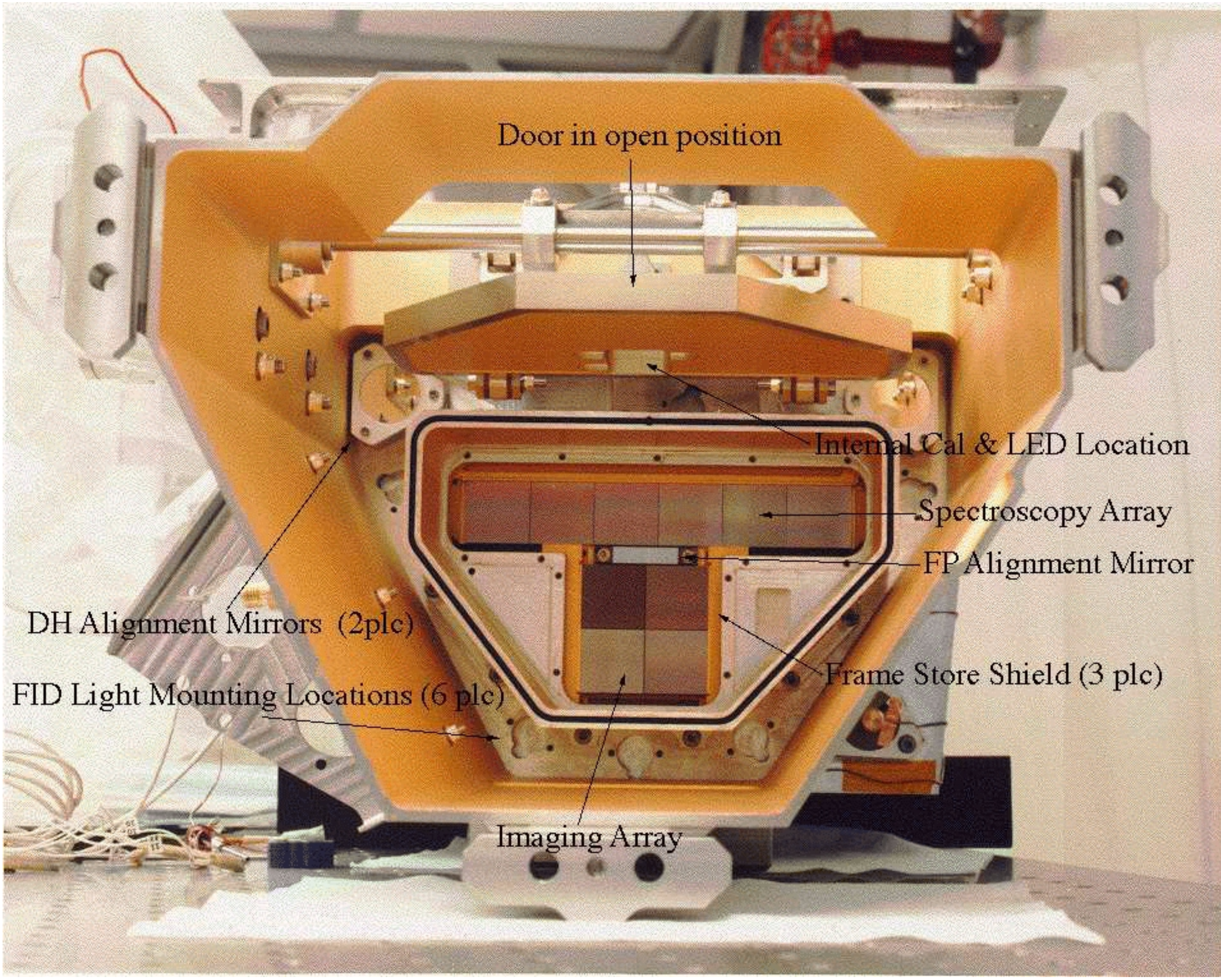
2005,'Modeling contamination migration on the Chandra X-ray Observatory', O'Dell et al., SPIE, 5898

Many Other Contributors to this Effort:

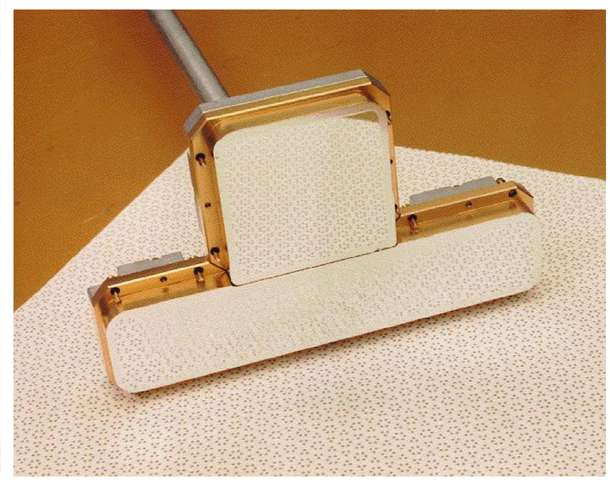
Alexey Vikhlinin, Dan Schwartz, Richard Edgar, Gregg Germain, John ZuHone (SAO), Catherine Grant, Mark Bautz, Norbert Schulz, Peter Ford, Bob Goeke, Corentin Monmeyran (MIT)

ACIS Collimator & Camera Body

ACIS Engineering unit



ACIS Filters



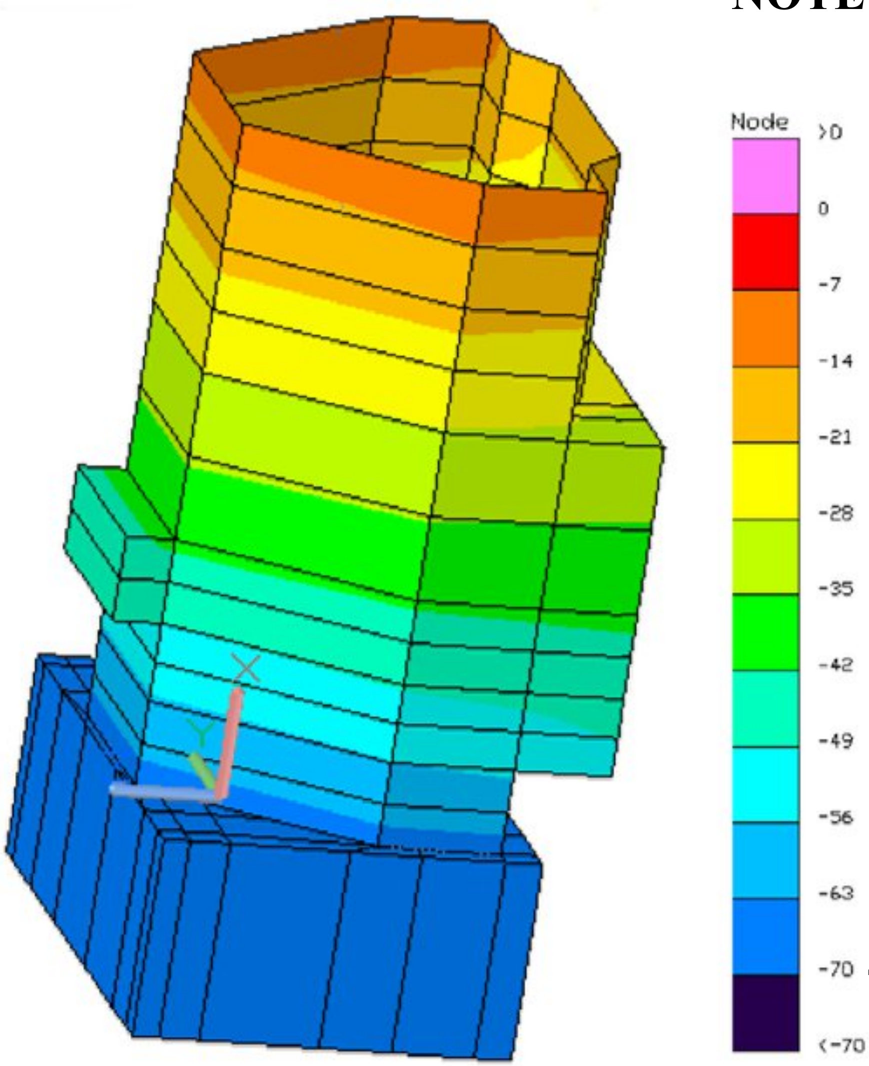
Collimator and Camera Body Temperatures

Tice (LMA)
O'Dell & Swartz (MSFC)

Normal Operations

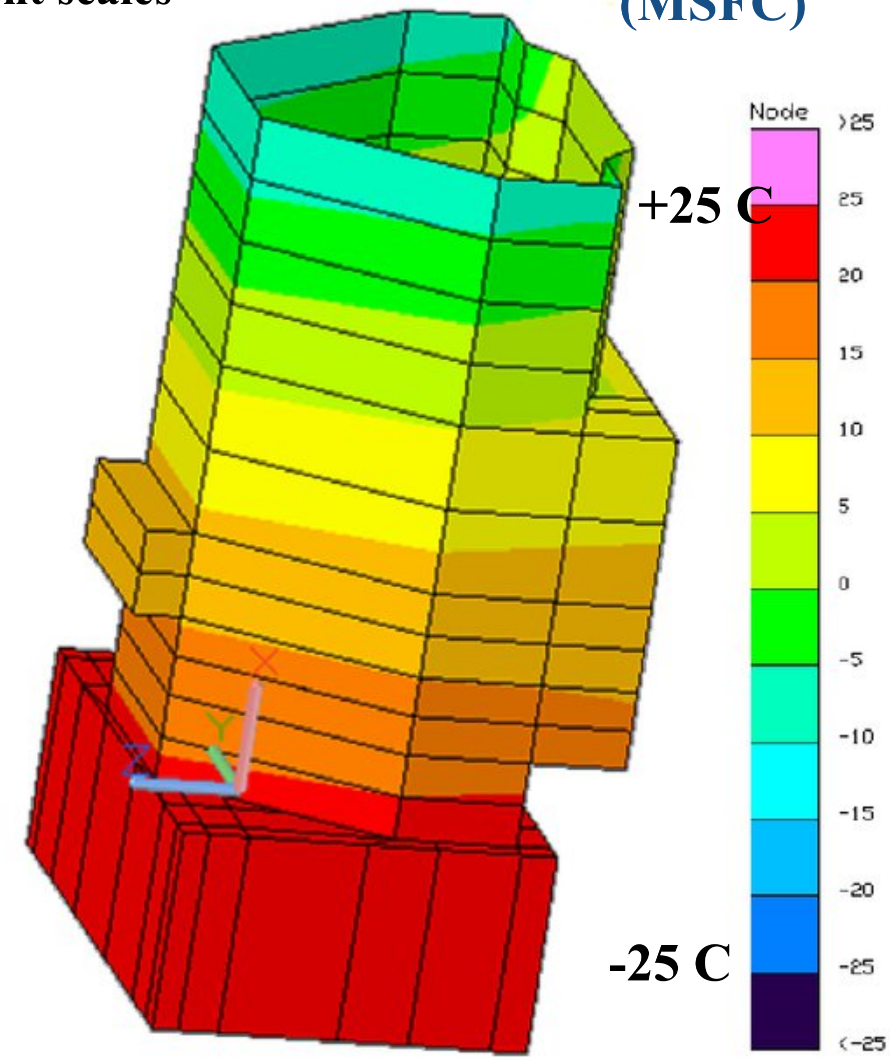
Bakeout

NOTE: different scales



0 C

-70 C



+25 C

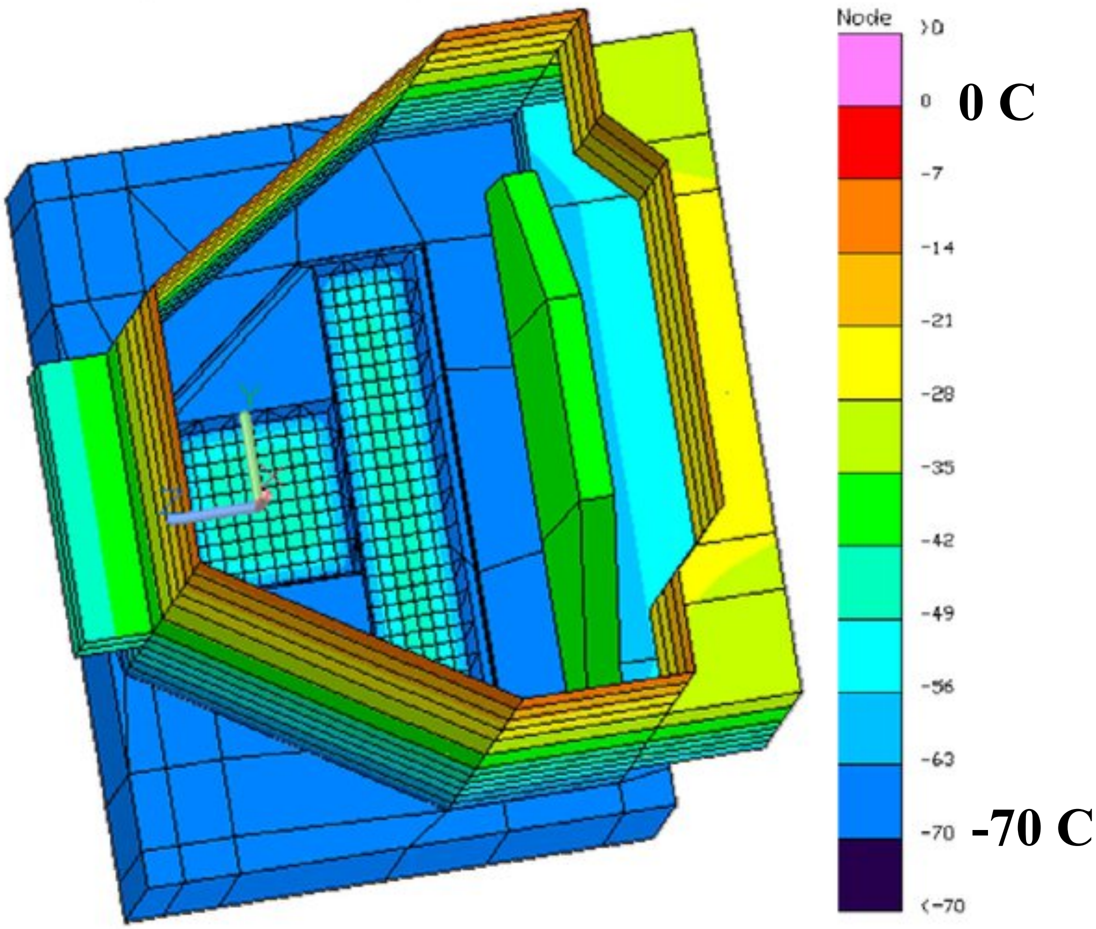
-25 C

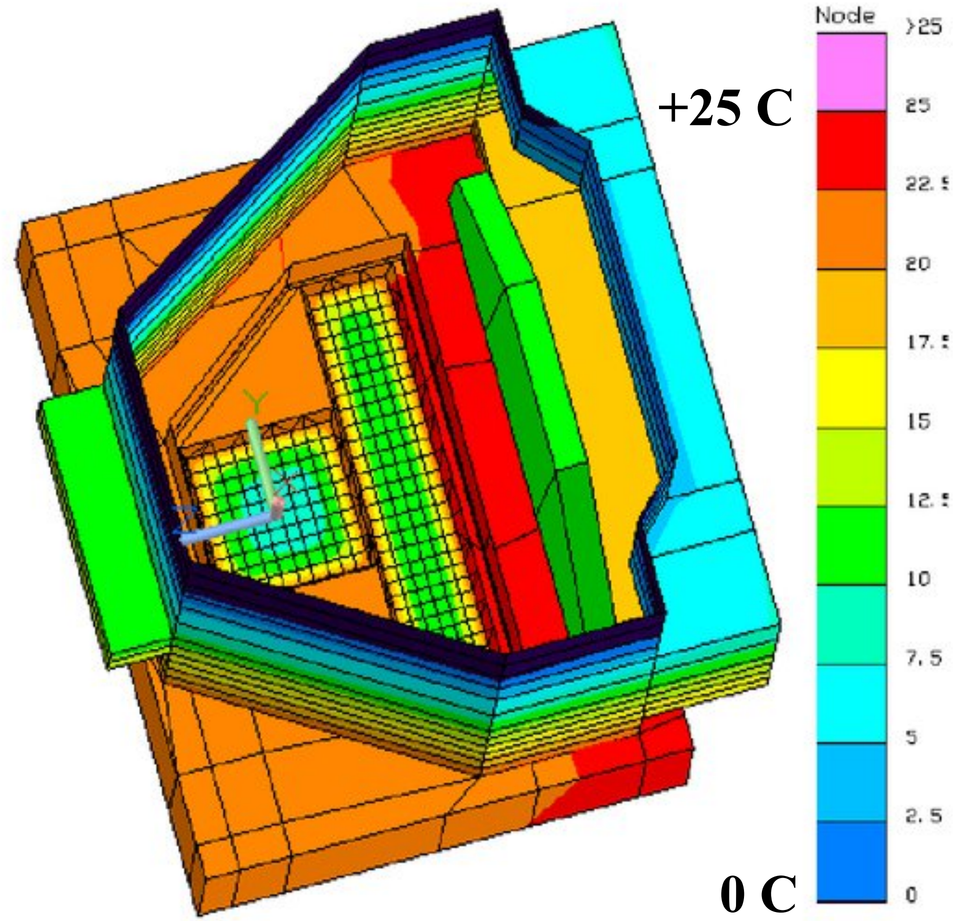
Filter Temperatures

Tice (LMA)
O'Dell & Swartz (MSFC)

Normal Operations **Bakeout**

NOTE: different scales





Simulation Results

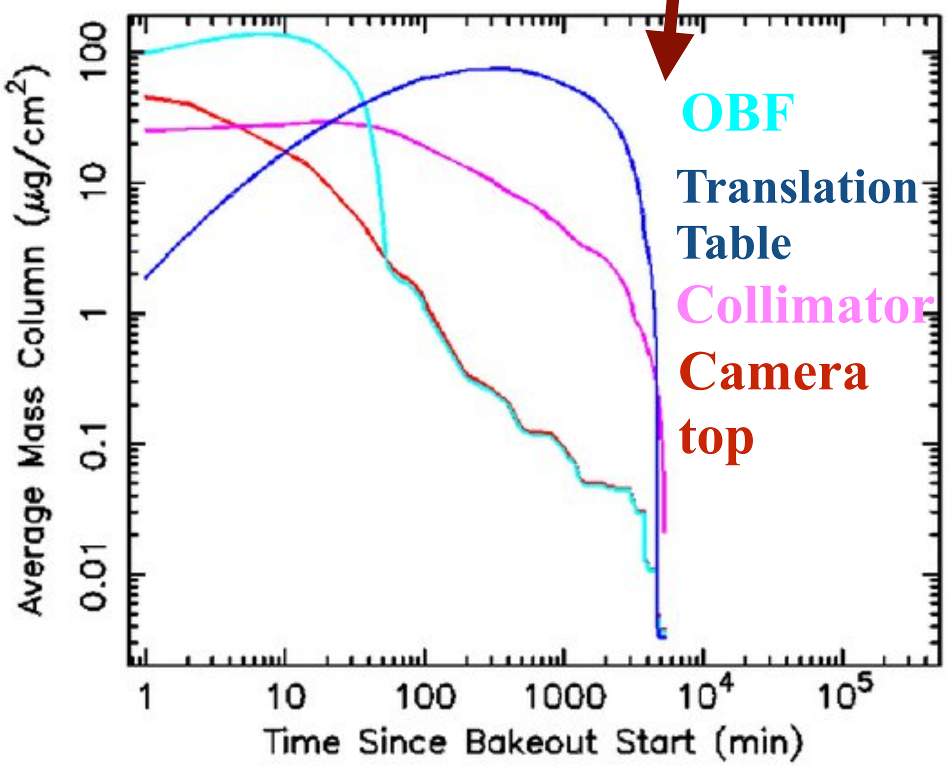
O'Dell & Swartz 2017 (MSFC)

- The ACIS contaminant is most likely composed of multiple materials
- Mass vaporization rates of the contaminants are not known
- Simulations below assume the vaporization rate of octadecane (medium volatility) and dioctyl phthalate (low volatility)
- amount of heating time for a 'successful' is dramatically different for the different simulations

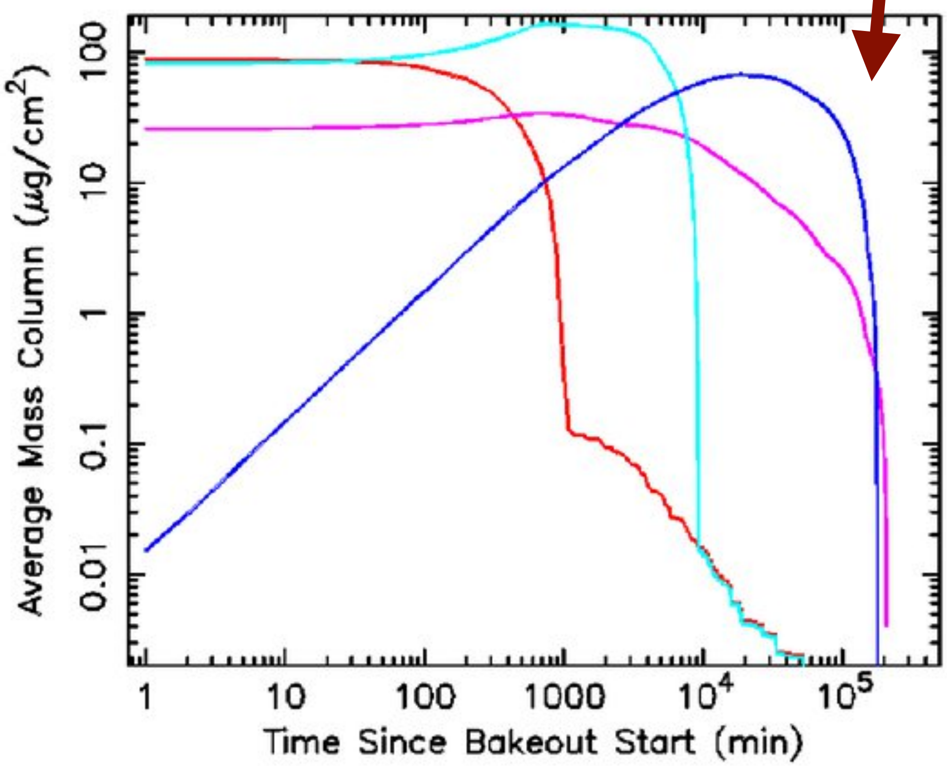
3.6e5 s

1.2e7 s
20 weeks

Medium Volatility



Low Volatility



Consequences of a Bakeout

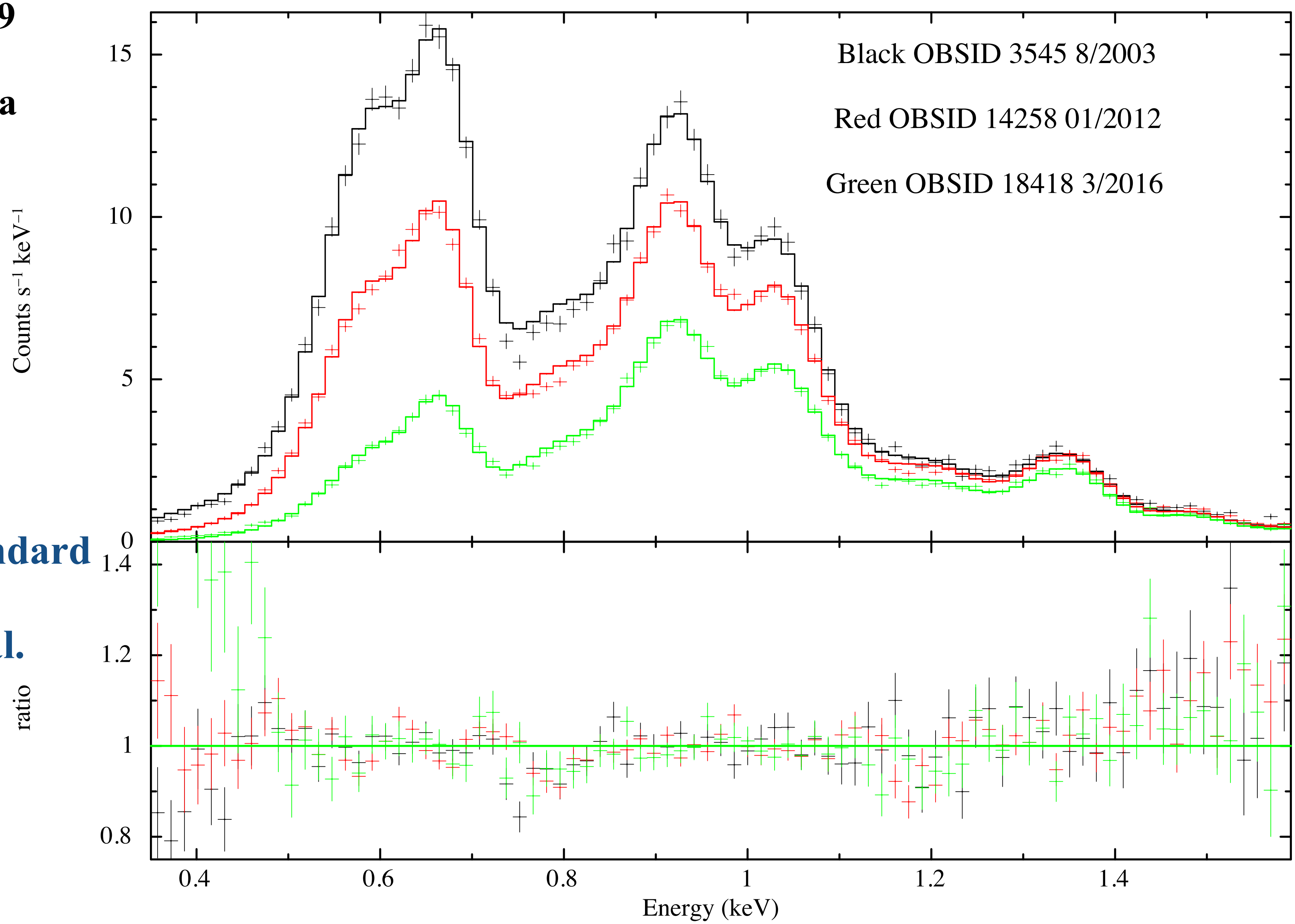
- The Bakeout itself would take significant time, conservatively 1-2 orbits
- The recalibration effort would take considerable time. A quick assessment of the outcome could be done in 1-2 orbits but a full recalibration would require about a million seconds of calibration time
- It is likely the uncertainty in the new calibration products would be larger than they are in the current calibration products
- Another open question is how quickly the contaminant would redeposit on the filters. More calibration observations to monitor and characterize the re-accumulation of the contaminant might be necessary if the contaminant is depositing quickly and in unexpected ways.

Impact on Soft Sources

ACIS-S S3

1 E0102.2-7219 supernova remnant with a soft spectrum. ~90% of the area at the energy of the O VIII Ly-α (0.654 keV) has been lost.

IACHEC standard model Plucinsky et al. 2017 A&A, 597, A35

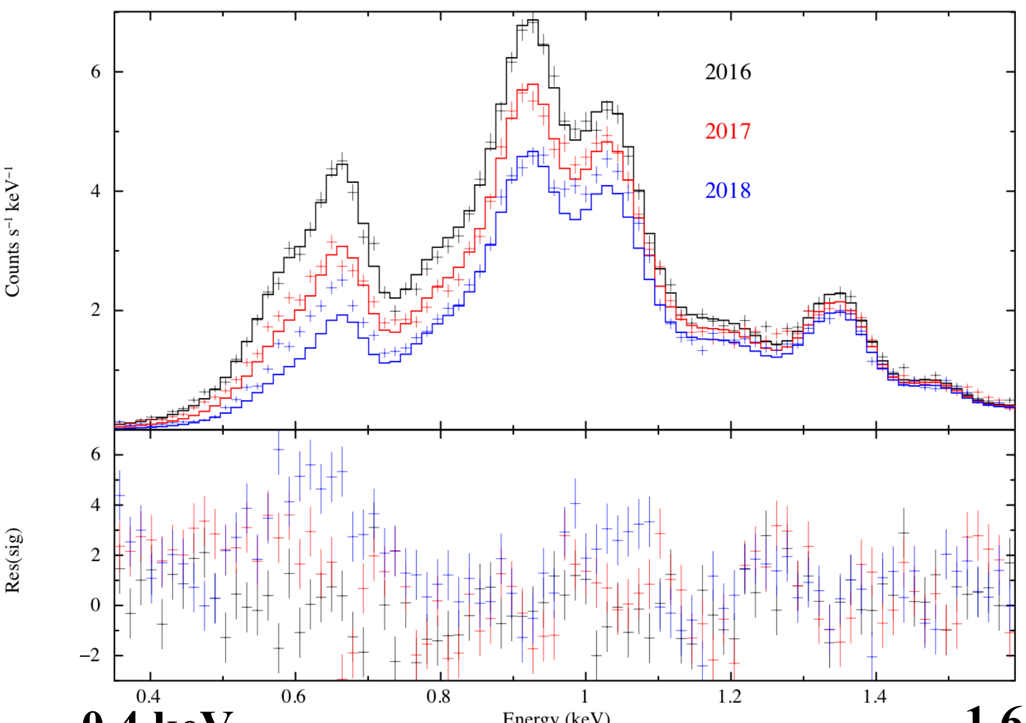


Dramatically Different Behavior from 2016-2018

- **IACHEC model was fit to the 2016 data and then frozen to compare to the 2017 and 2018 data using the N0010 contamination model**
- **If the N0010 contamination model were correct, the 2017 and 2018 data would be well fitted by the model**
- **It is clear the N0010 contamination model over-predicts the contamination on S3 and by a large amount on I3**
- **N0011 contamination model released on 28 June 2018, improved ACIS-I contamination model**

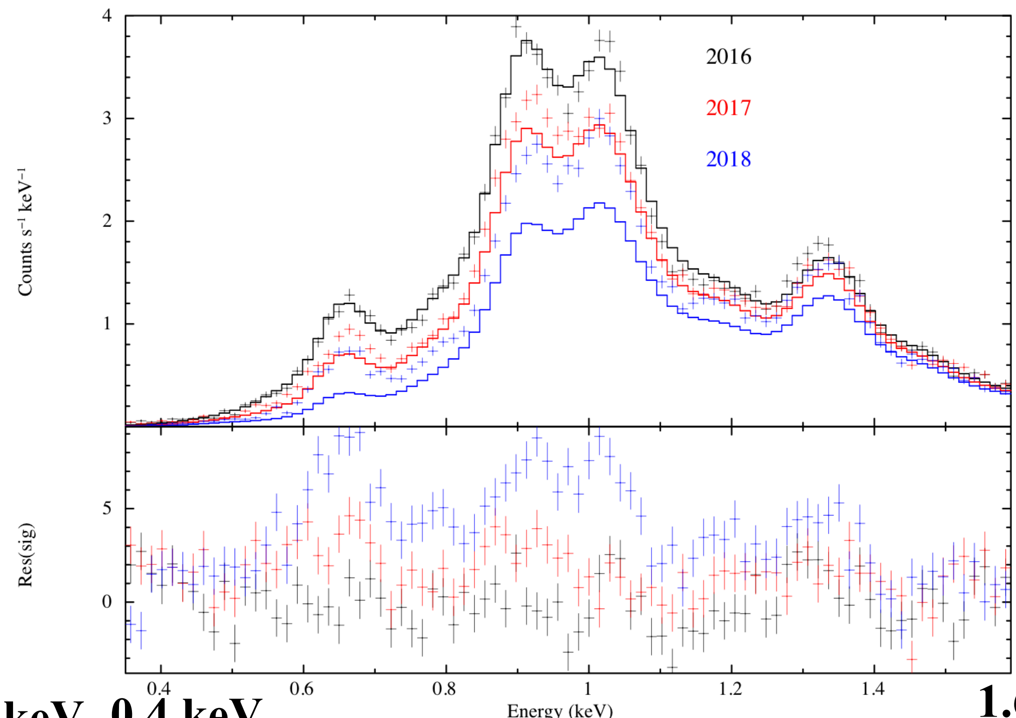
2016 Model compared to 2017 & 2018 data

ACIS-S S3 aimpoint



0.4 keV **1.6 keV**

ACIS-I I3 aimpoint

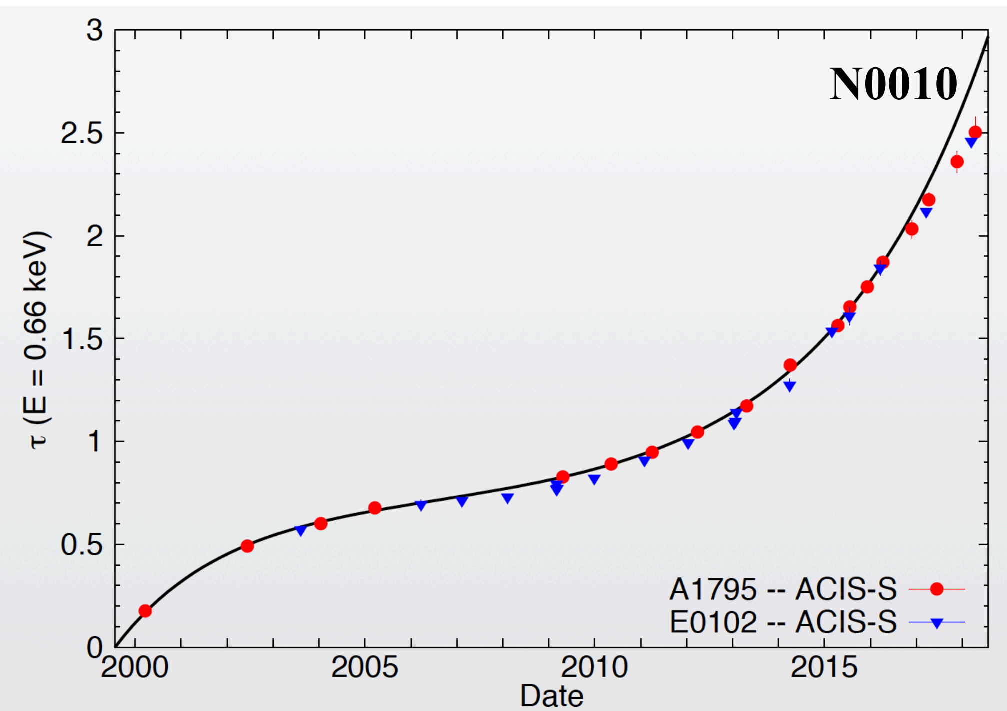


0.4 keV **1.6**

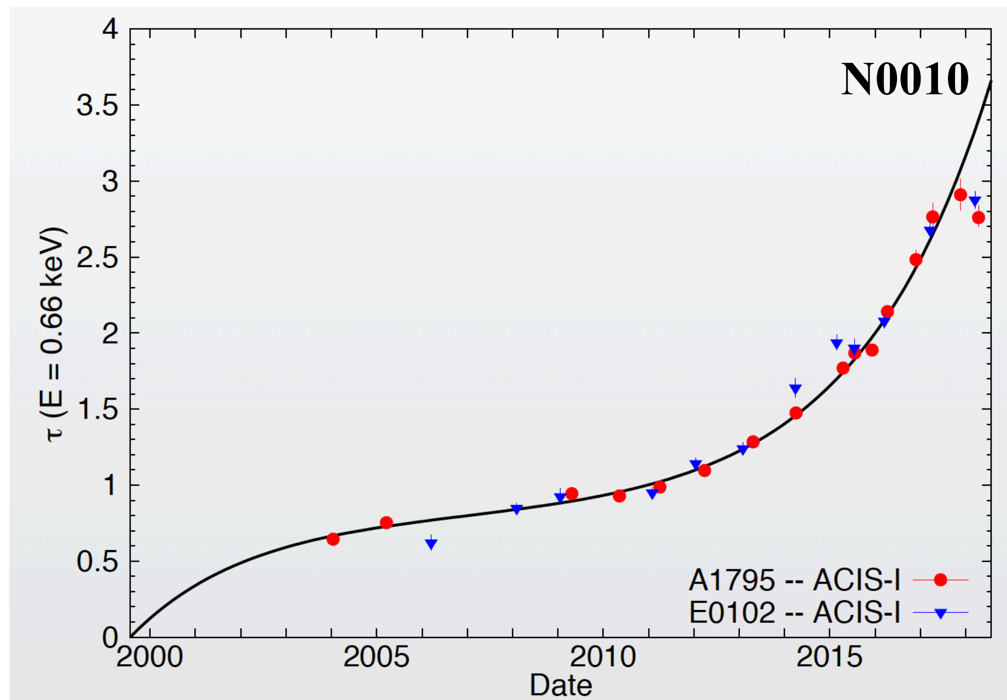
Accumulation of the Contaminant *Bogdan (SAO)*

- A1795 is observed ~6 months and E0102 is observed annually
- Optical depth at 0.66 keV is determined by fitting C, O, & F edges to the data
- ACIS-S S3 aimpoint shows a significant decrease in the accumulation rate compared to the N0010 model
- ACIS-I I3 aimpoint also shows a decrease but the A1795 data in the last 6 months are consistent with no accumulation
- accumulation rate == deposition rate - [vaporization rate + surface migration rate], we do not know if the deposition rate has decreased or the vaporization rate has increased or both

ACIS-S S3 aimpoint



ACIS-I I3 aimpoint



OBF Temperature Distribution

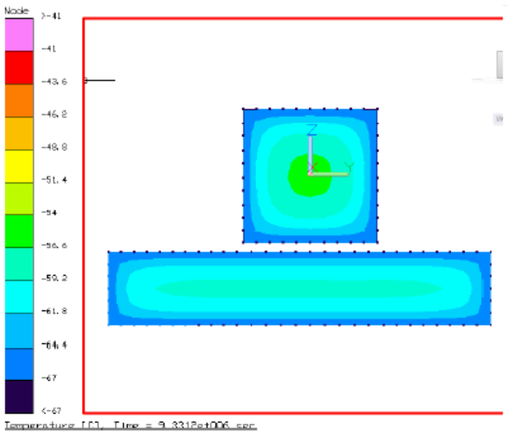
Tice (LMA/MIT)

- Temperature distribution on filters changes as the contaminant accumulates. The center of the ACIS-I filter is *always* warmer than the center of the ACIS-S filter

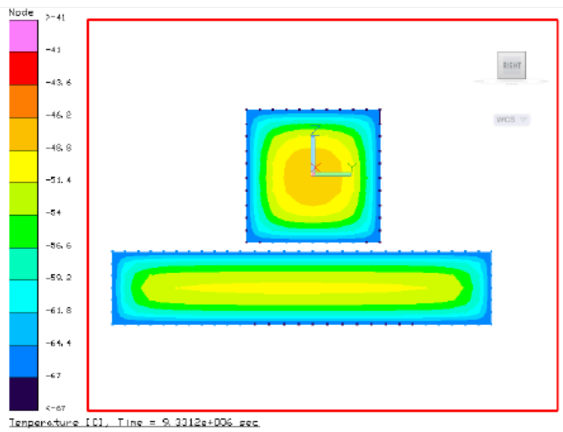
-41 C

-51.4 C

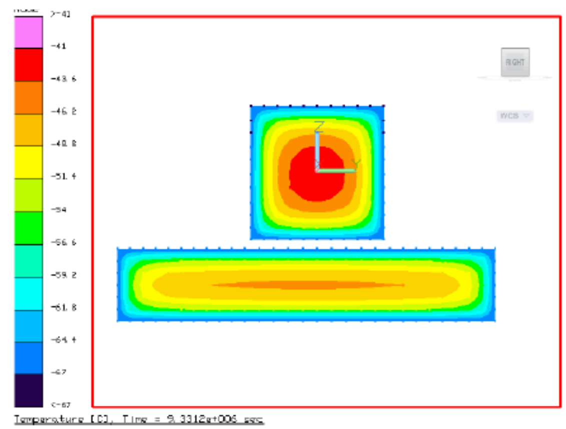
-67 C



e=0.05 Tmax= -55.8 C



e=0.10 Tmax= -46.5 C



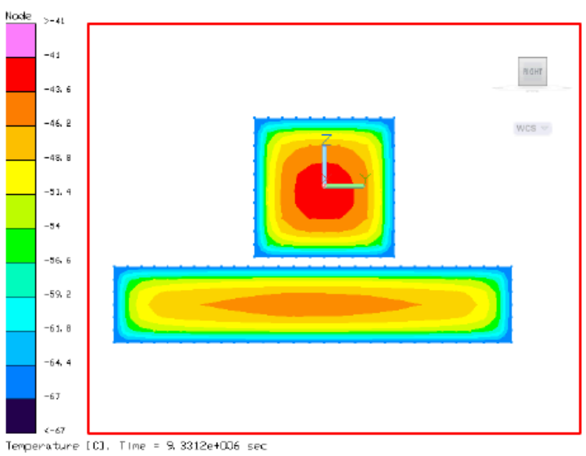
e=0.20 Tmax= -41.7 C

-41 C

e = emittance

-51.4 C

-67 C

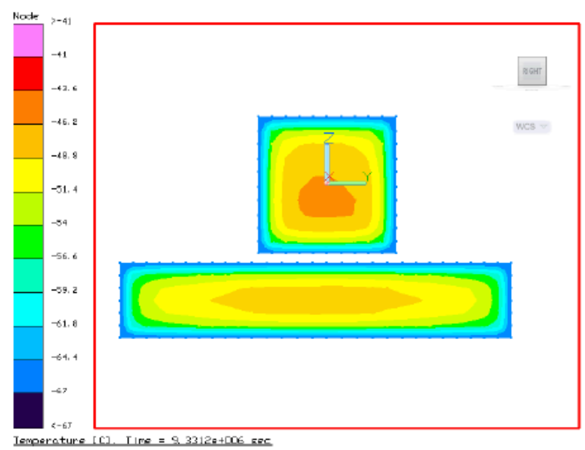


e=0.40 Tmax= -42.3 C

-41 C

-51.4 C

-67 C



e=0.80 Tmax= -45.6 C

27

Summary

- Oversubscription rate for Chandra proposals remains high, 5.7 for Cycle 20
- Proposers continue to select ACIS over HRC by a large margin (95% of approved Cycle 20 targets select ACIS)
- Senior Review ranks the Chandra program highly in terms of quality of science
- There is no consensus in the Chandra Users community that Bakeout is worth the risk
- Recent data indicate a significant decrease in the accumulation rate of the contaminant, it is not clear what will happen in the future

Given this situation, it would be challenging to convince the project to accept the risk associated with a Bakeout.