Evolution of the contamination layer on the Chandra ACIS optical blocking filter

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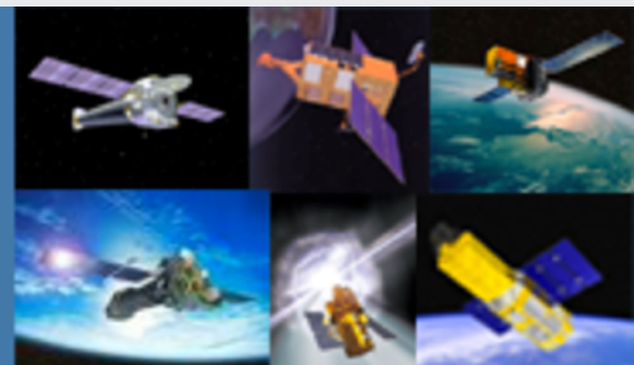
IACHEC

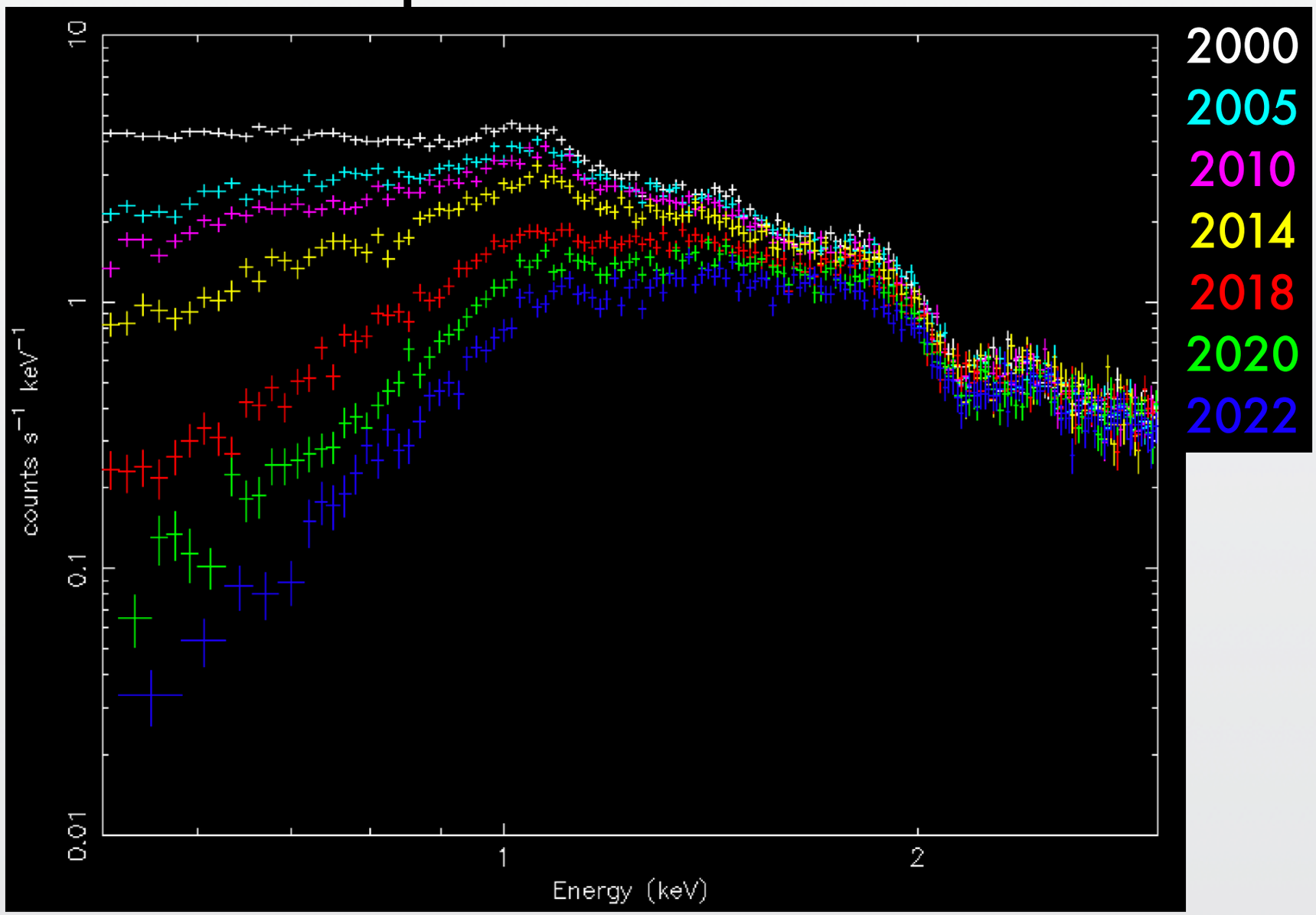
International Astronomical Consortium for High Energy Calibration



Contaminant on the OBF

- Molecular contaminant on the ACIS optical blocking filter
- Absorption from Carbon, Oxygen, Fluorine

ACIS-S spectra of Abell 1795



Monitoring the contaminant

Multi-prong approach to monitor the buildup of the contaminant

- Abell 1795
  - time dependence
  - spatial structure
  - covers ACIS-S and ACIS-I
- Blazars (e.g. Mkn 421)
  - time dependence
  - spatial structure
  - chemical composition
  - covers ACIS-S
- E0102
  - independent verification of contamination models
- ECS data
  - time dependence
  - spatial structure
  - covers ACIS-S and ACIS-I
  - fading due to its 2.7 years half-life

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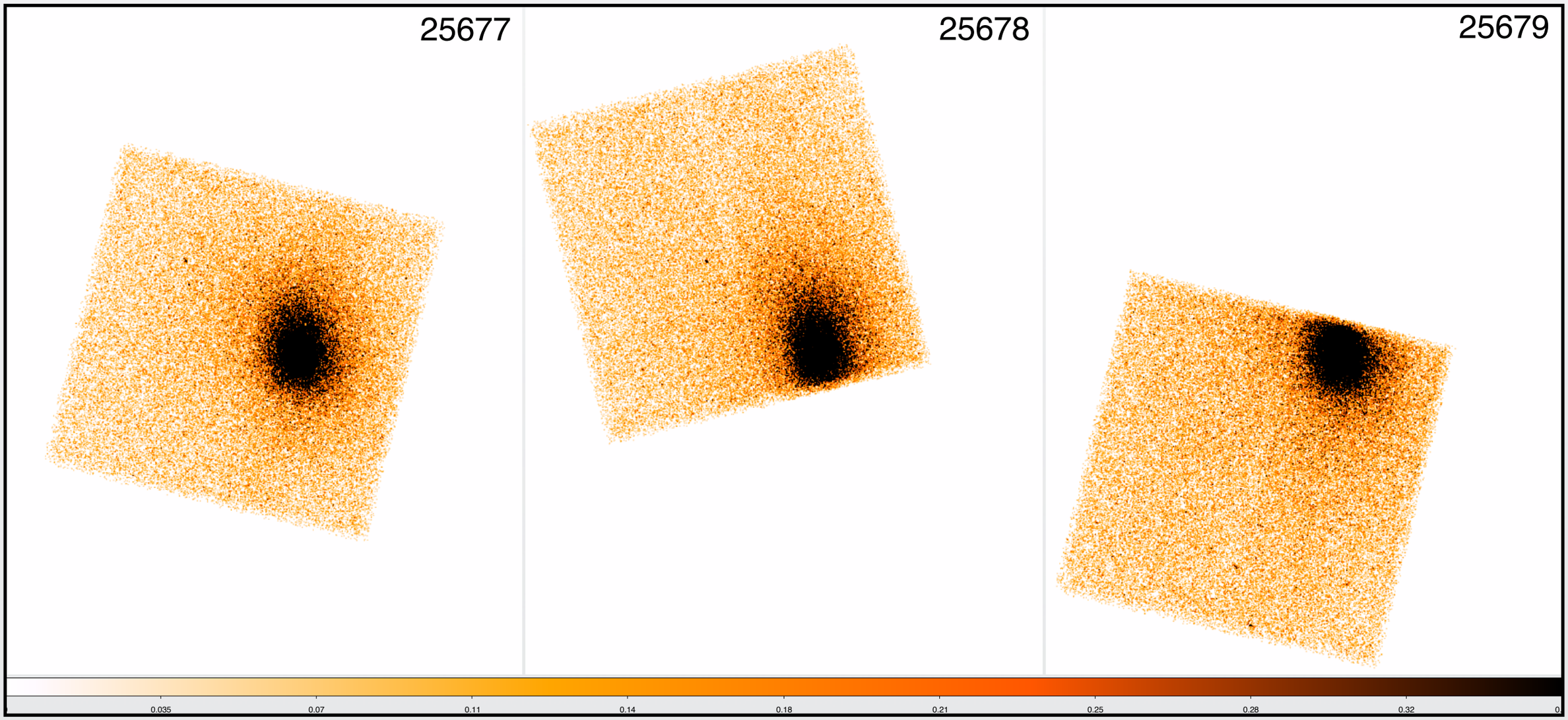
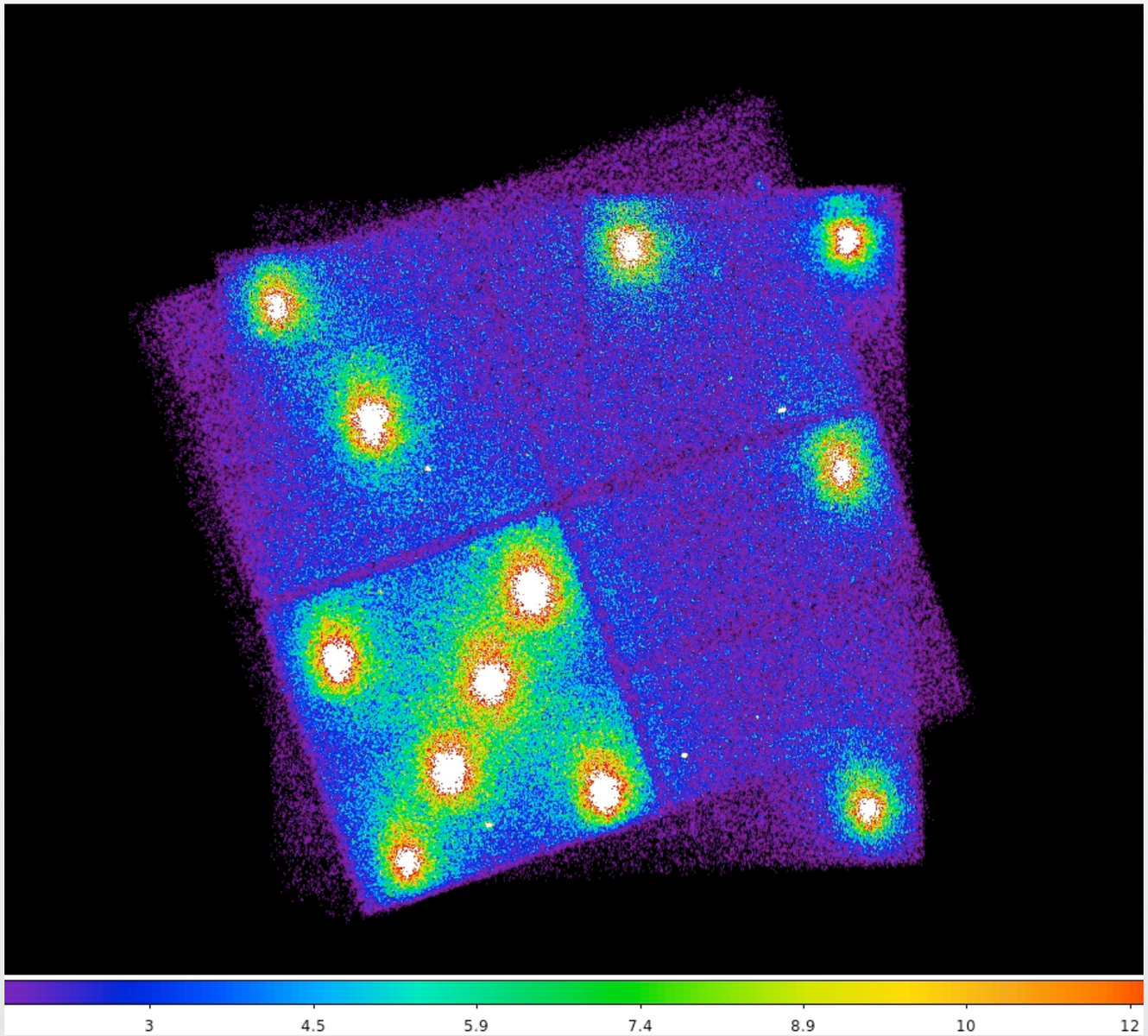
ACIS observations of A1795

- Raster scan with ACIS-S and ACIS-I once every year
- 3 pointings with ACIS-S
- 8 pointings with ACIS-I (alternated)
- Monitor the aimpoint every 6 months



ACIS-I observations of A1795

- Raster scan with ACIS-S and ACIS-I once every year
- 3 pointings with ACIS-S
- 8 pointings with ACIS-I (alternated)
- Monitor the aimpoint every 6 months

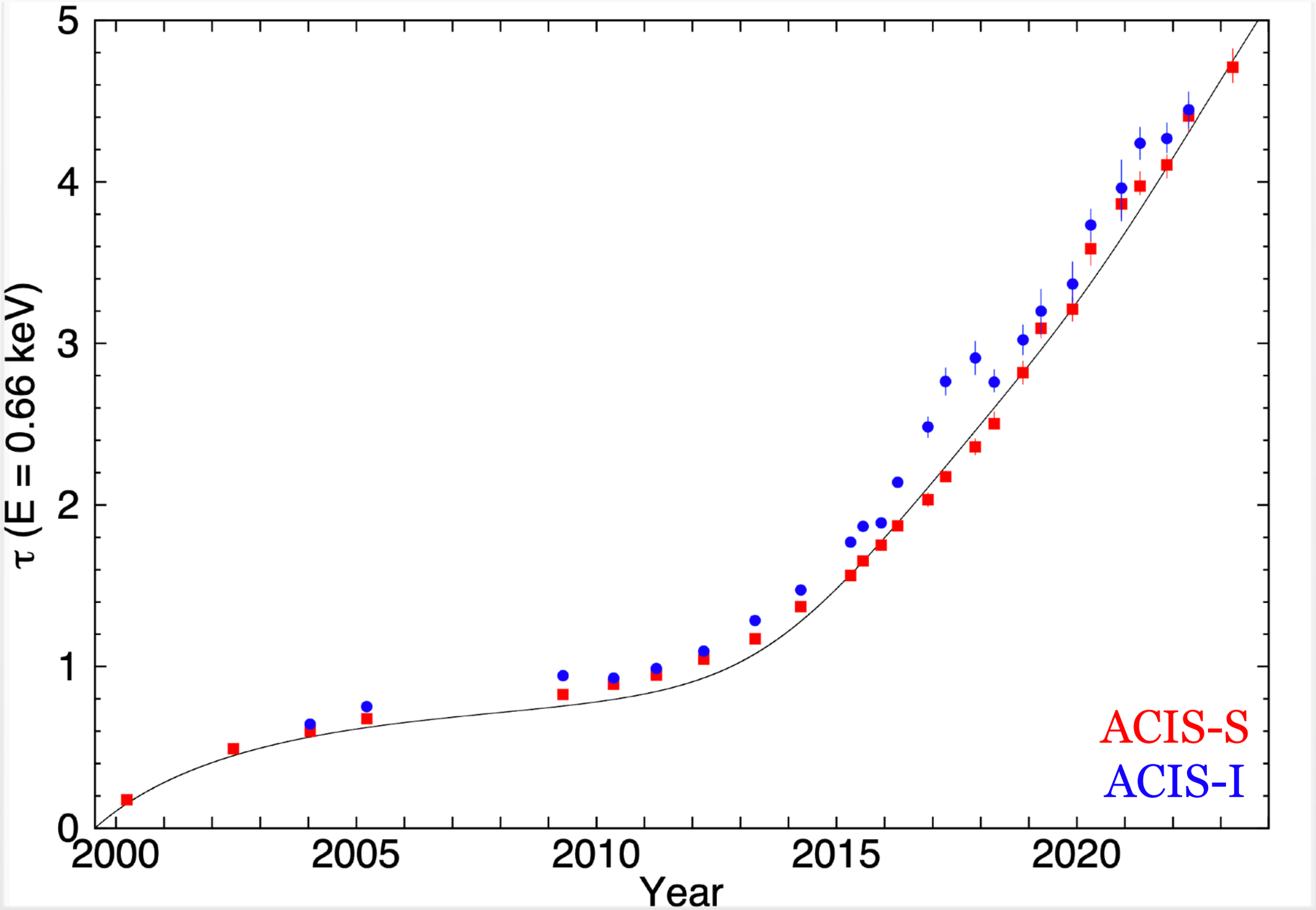


Measuring the contaminant at the center of the OBF

- Uniform data analysis procedure

- Computing the time dependence:
  - point sources excluded
  - spectral characteristics of Obs ID 494 (December 1999) used as reference by extracting circular region with 65″ radius centered on A1795
  - spectrum described with Galactic column density, APEC models, and ACIS contamination with fixed O/C and F/C ratios
  - For subsequent observations the spectra of the same 65″ circular region is extracted with the contamination correction turned off
  - The follow-up spectra are fit with best fit spectrum obtained from Obs ID 494 and additional ACIS contamination
  - Simultaneous fitting if observations are split

Time dependence of contaminant in the center of ACIS-S and ACIS-I



Conclusions on the time dependence of the contaminant in the center

- Accumulation of the molecular contamination on the OBF continues
- Optical depth of contaminant is $\tau = 4.7$, implying that <1% of photons pass through the OBF at 0.66 keV
- The level of contaminant is comparable on ACIS-I and ACIS-S since 2018
- Contamination model (N0015) released in November 2022 provides an accurate correction

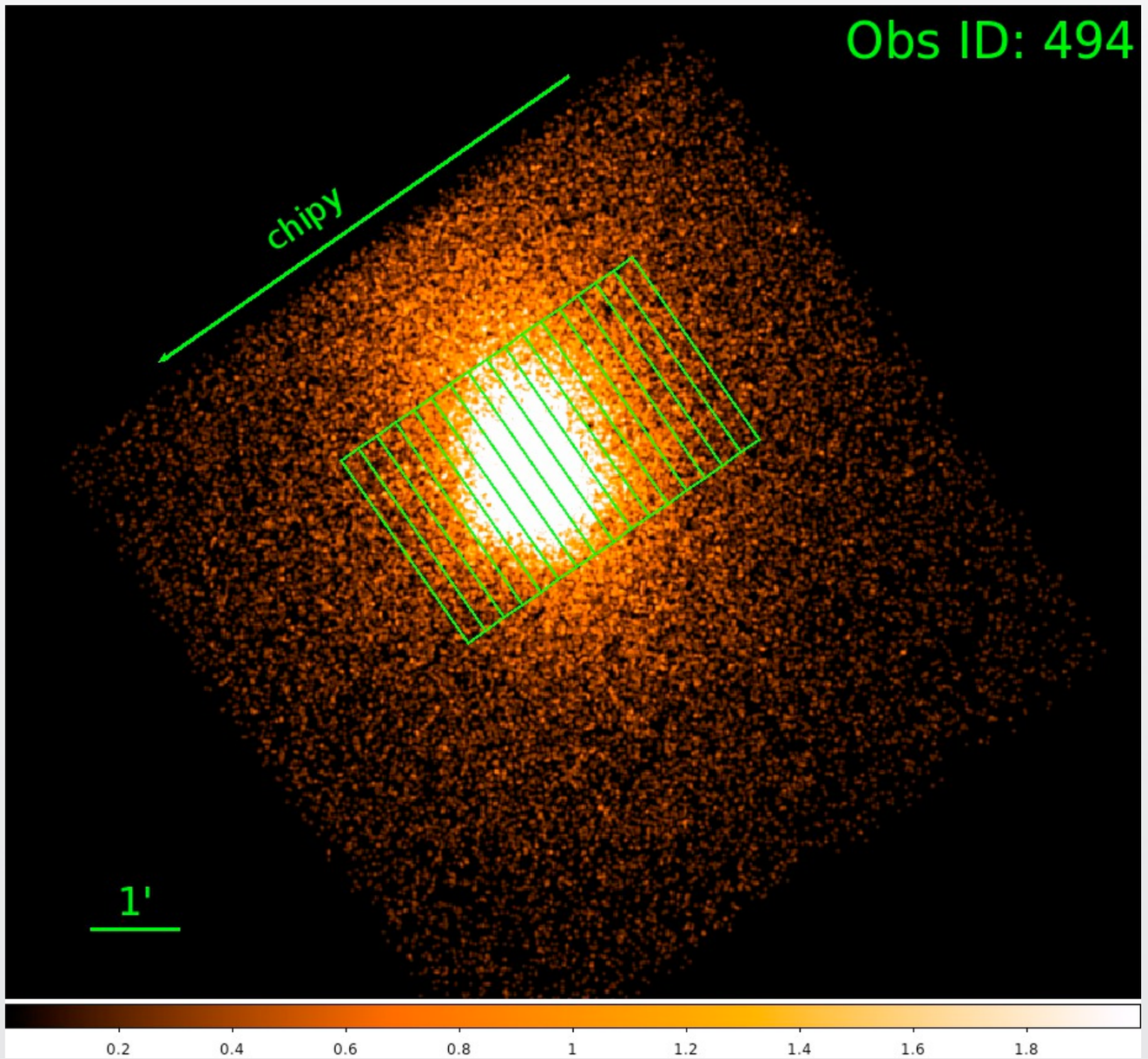
Spatial structure of the contaminant

- Each observation is 20-25 ks
- Uniform data analysis procedure

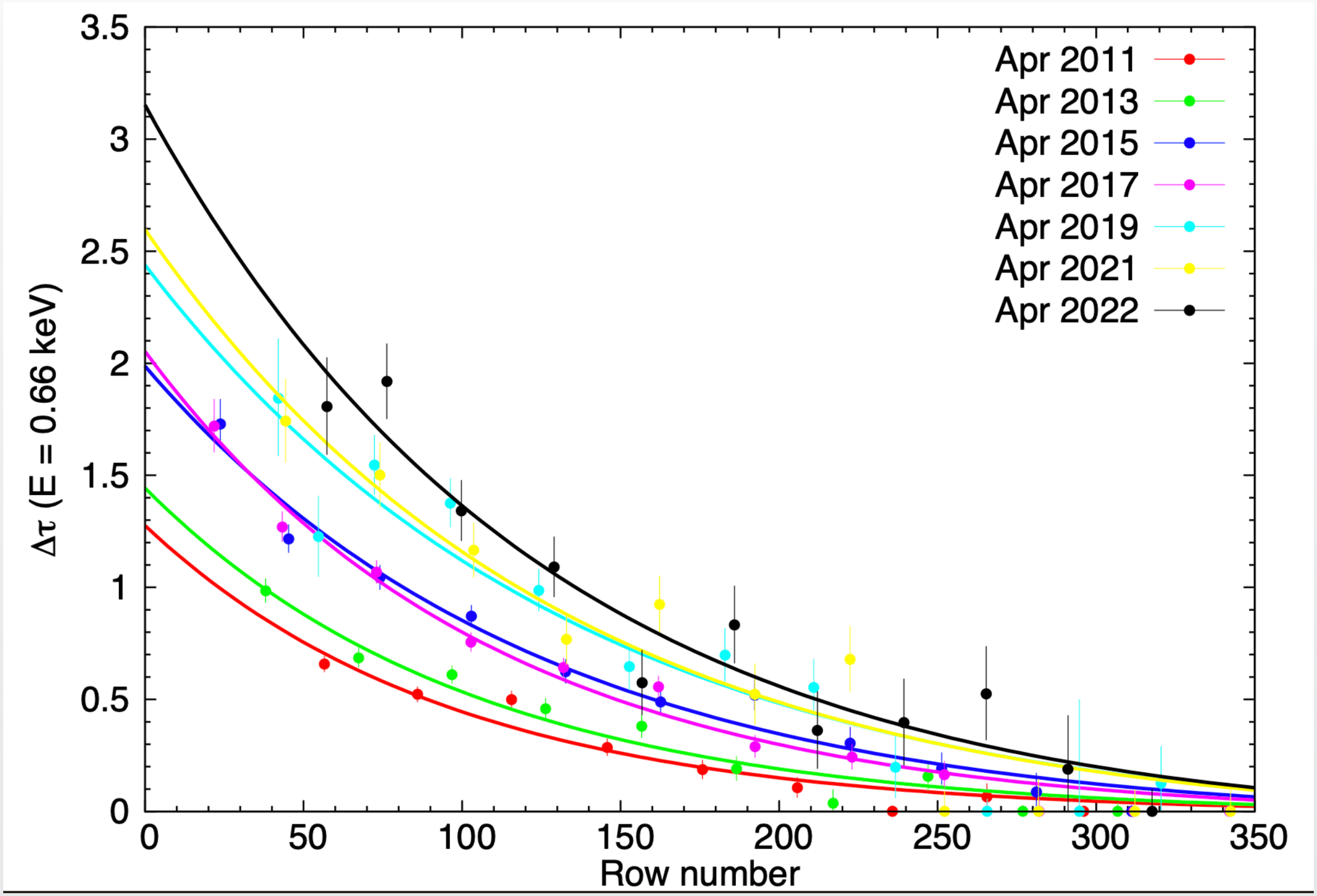
- Computing the shape of the spatial structure:
  - point sources excluded
  - for each epoch a grid is defined centered on the center of A1795 extending along y direction of the detector
  - Spectra for each regions is extracted and ARFs are generated with the contamination correction turned off
  - For regions in the top/bottom chipy regions the extra contamination relative to the center is determined by extracting the spectrum in the same region and adding an extra contamination component
  - spectra are described with Galactic column density, single temperature APEC model, and ACIS contamination models with fixed O/C and F/C ratios

Spatial structure of the contaminant

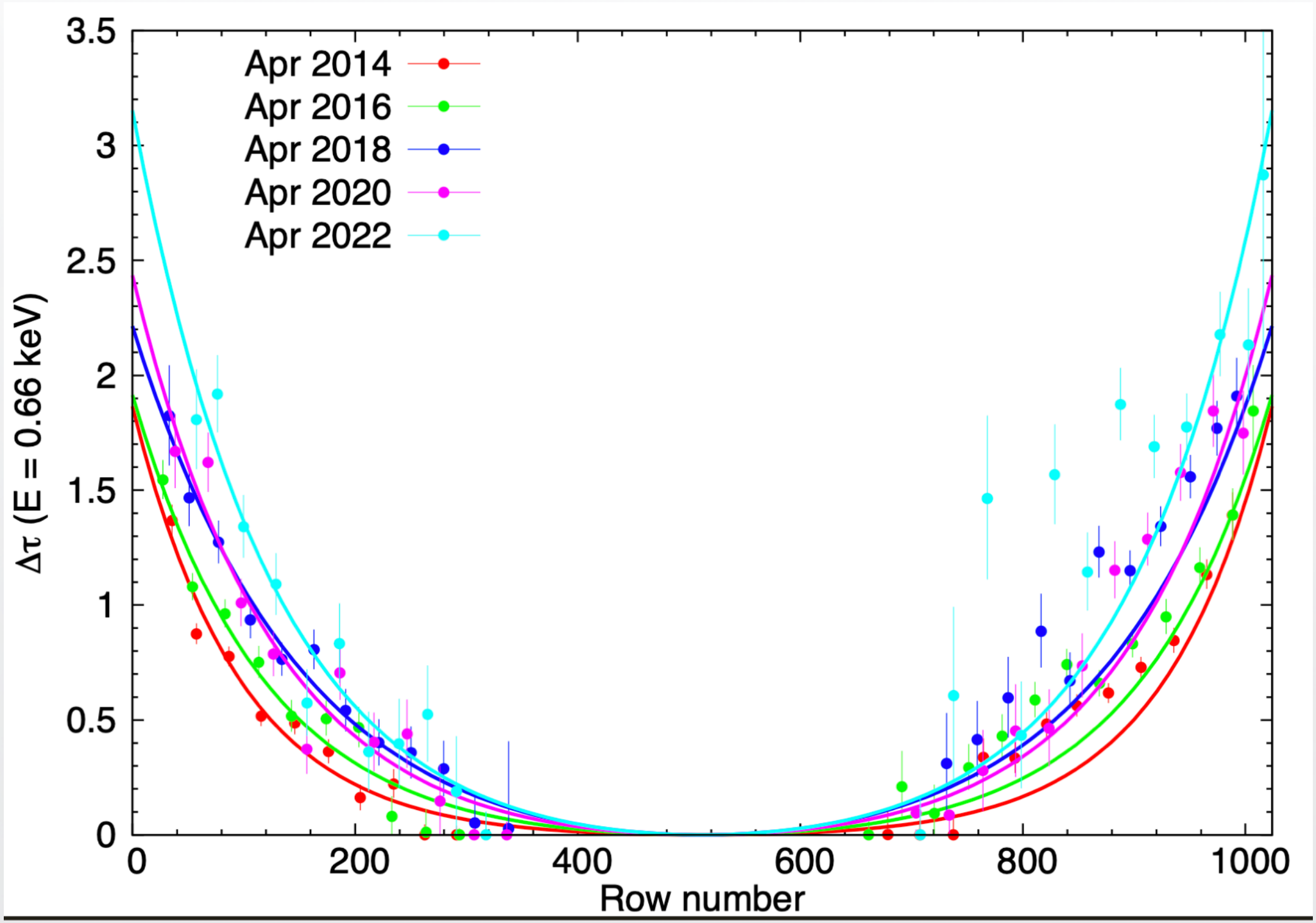
- Raster scan with ACIS-S and ACIS-I once every year
- 3 pointings with ACIS-S
- 8 pointings with ACIS-I



Shape of the spatial structure of the contaminant on ACIS-S

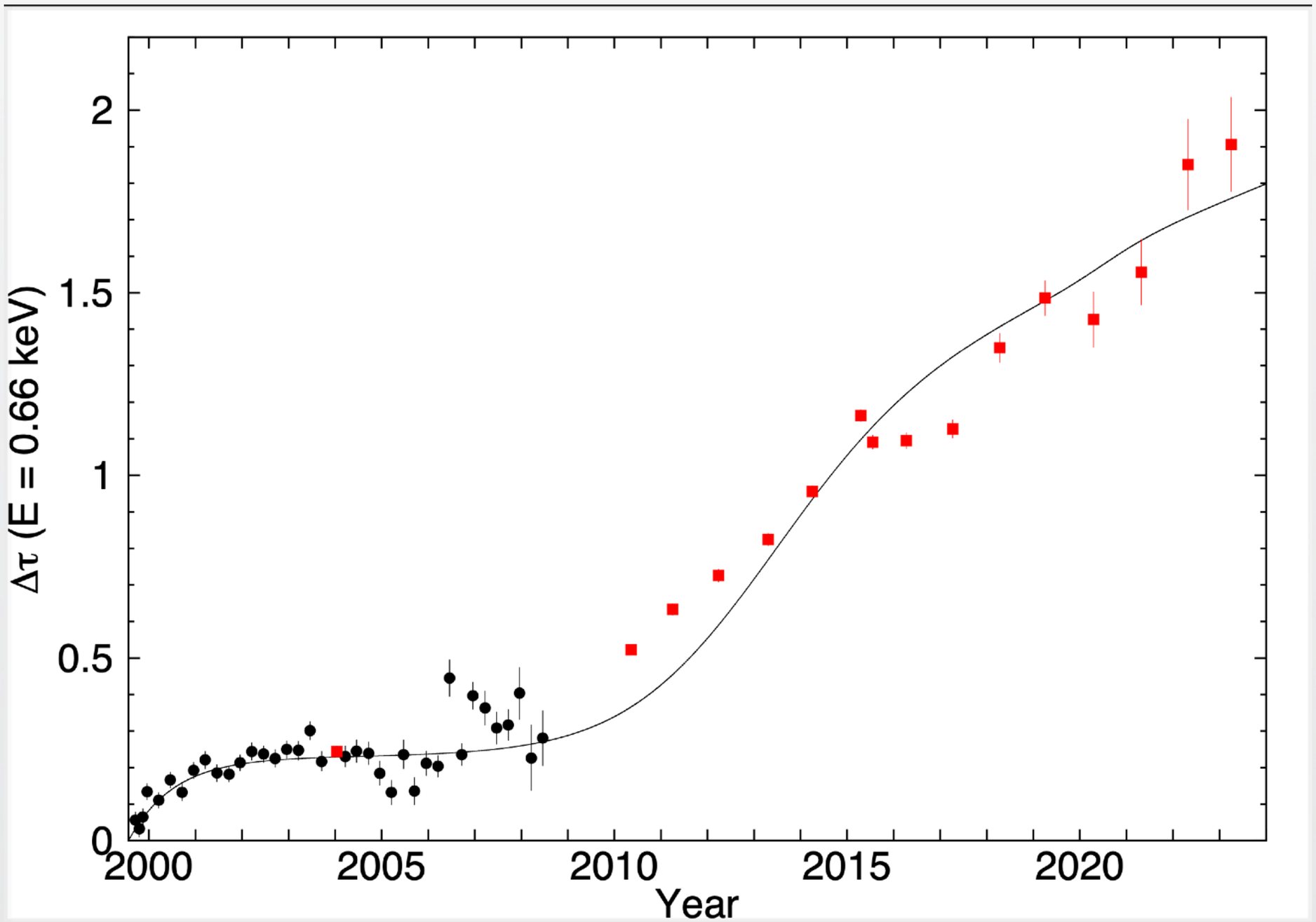


Shape of the spatial structure of the contaminant on ACIS-S



Edge-to-center difference using A1795 data

- Optical depth at y=64 relative to the center at E=0.66 keV
- ECS data up to 2008
- ACIS-S3 of Abell 1795 beyond 2008



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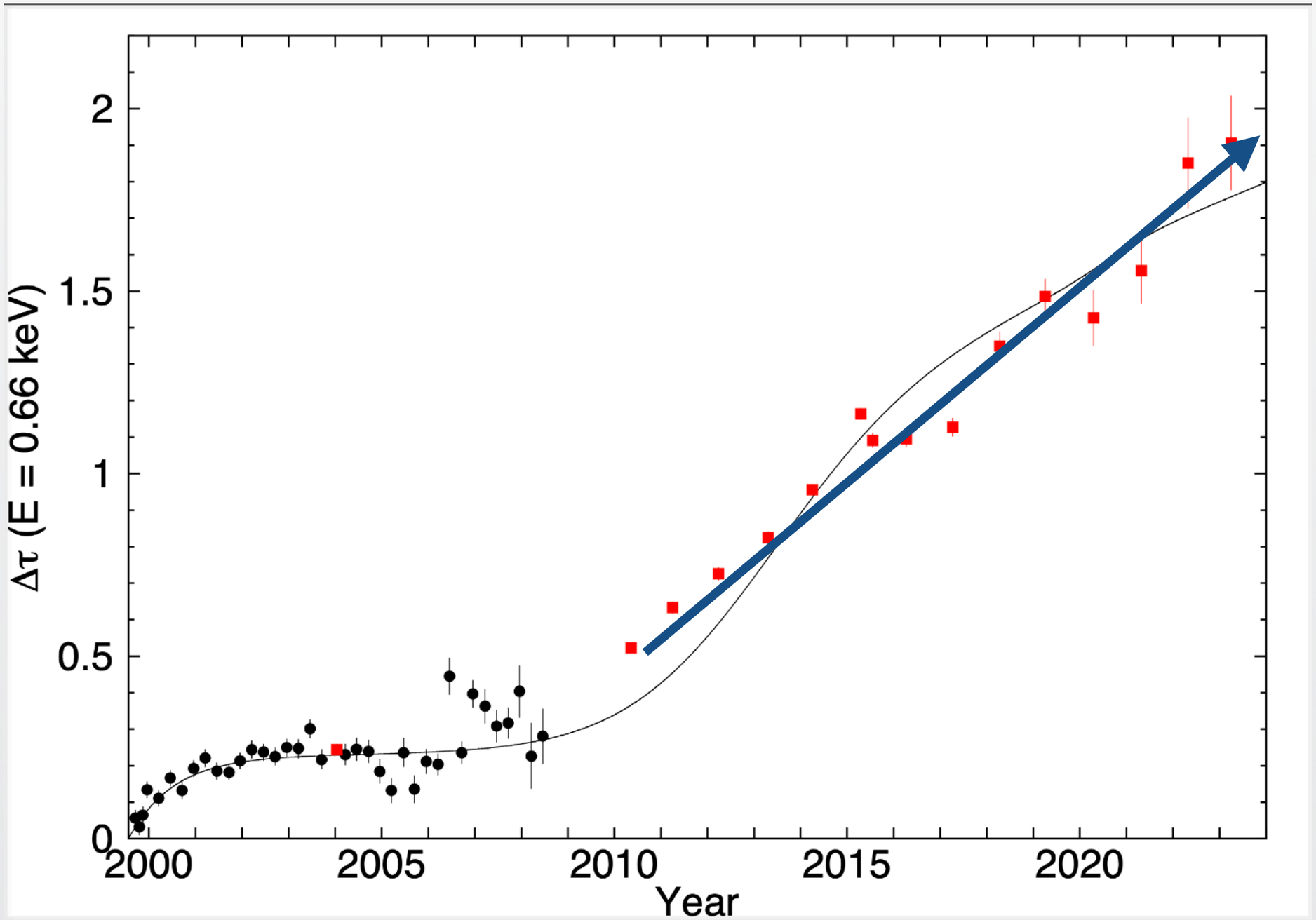
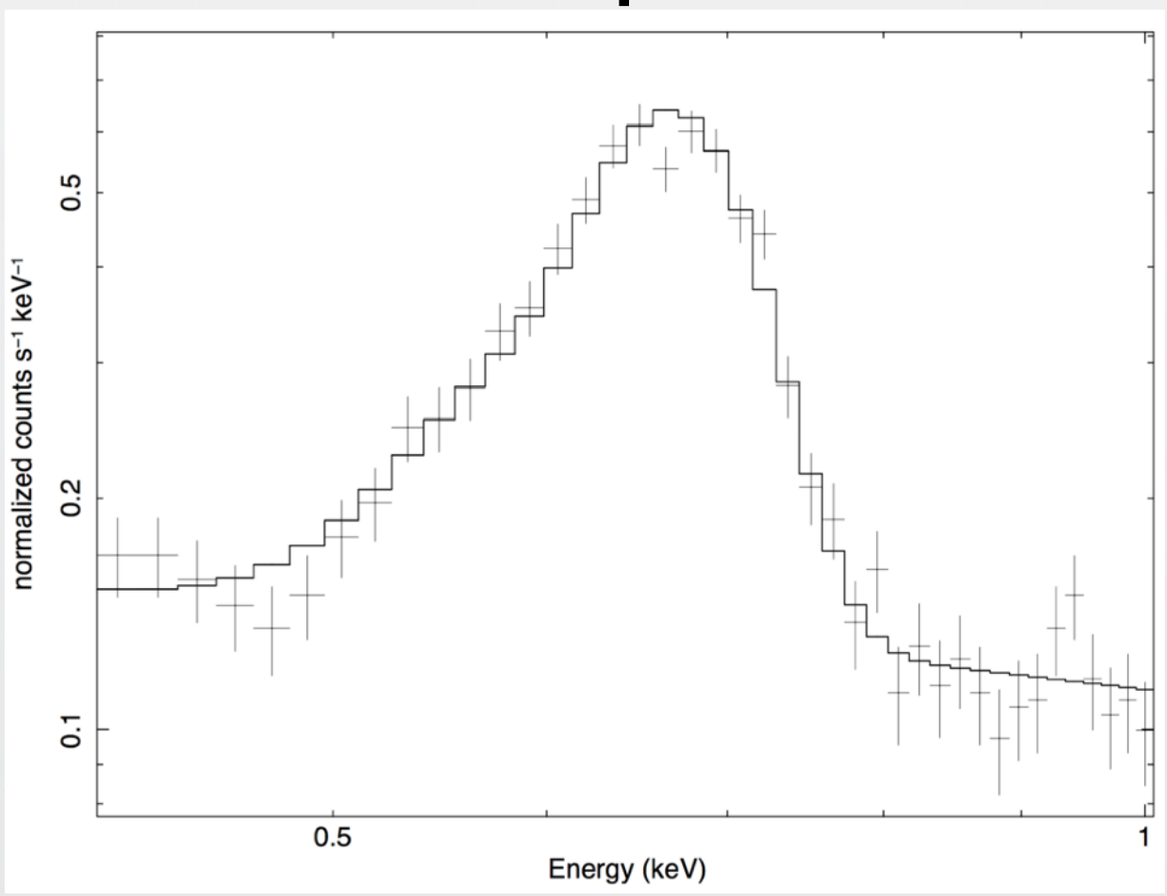


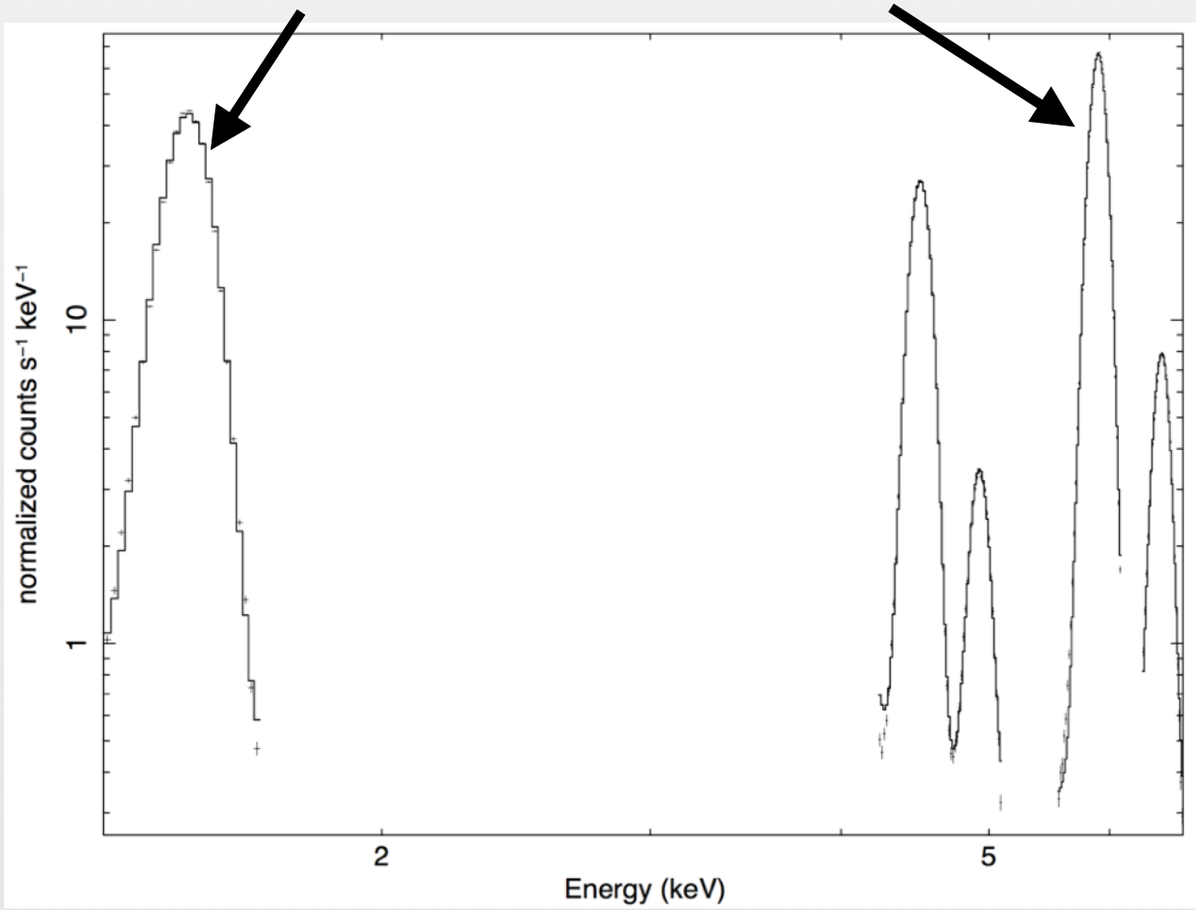
ECS observations

- ECS data can be used to measure the contaminant on the OBF
- Measure flux ratio of the L-complex to Mn-Kα lines
- Convert $f_L/f_{Mn\text{-}K\alpha}$ ratio to optical depth

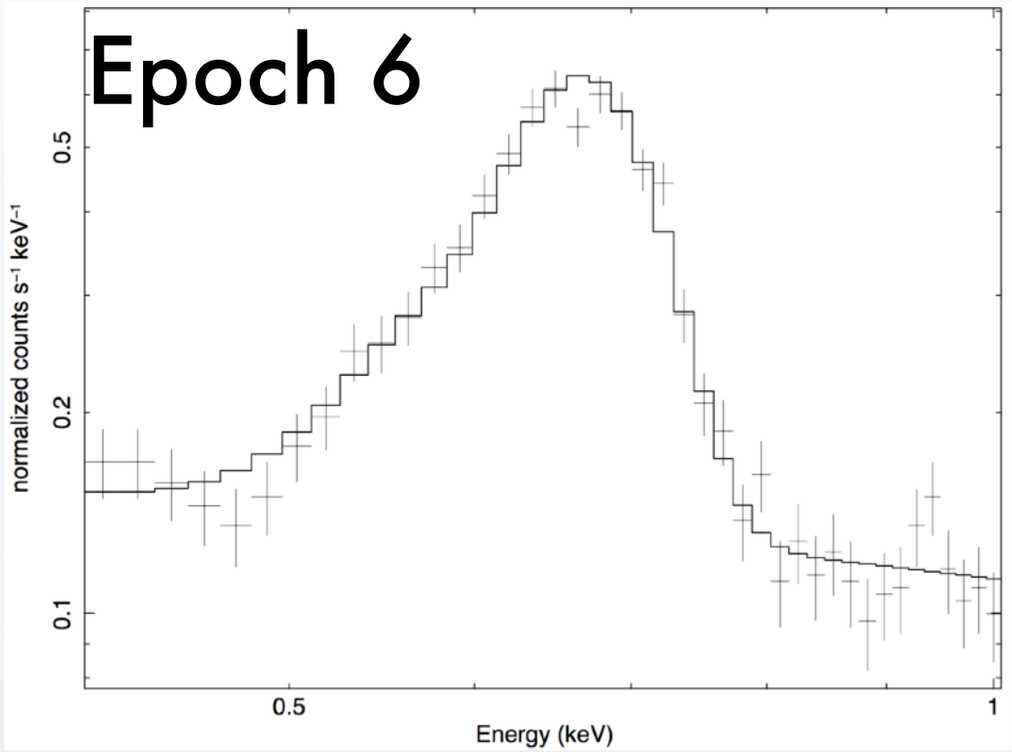
L-complex

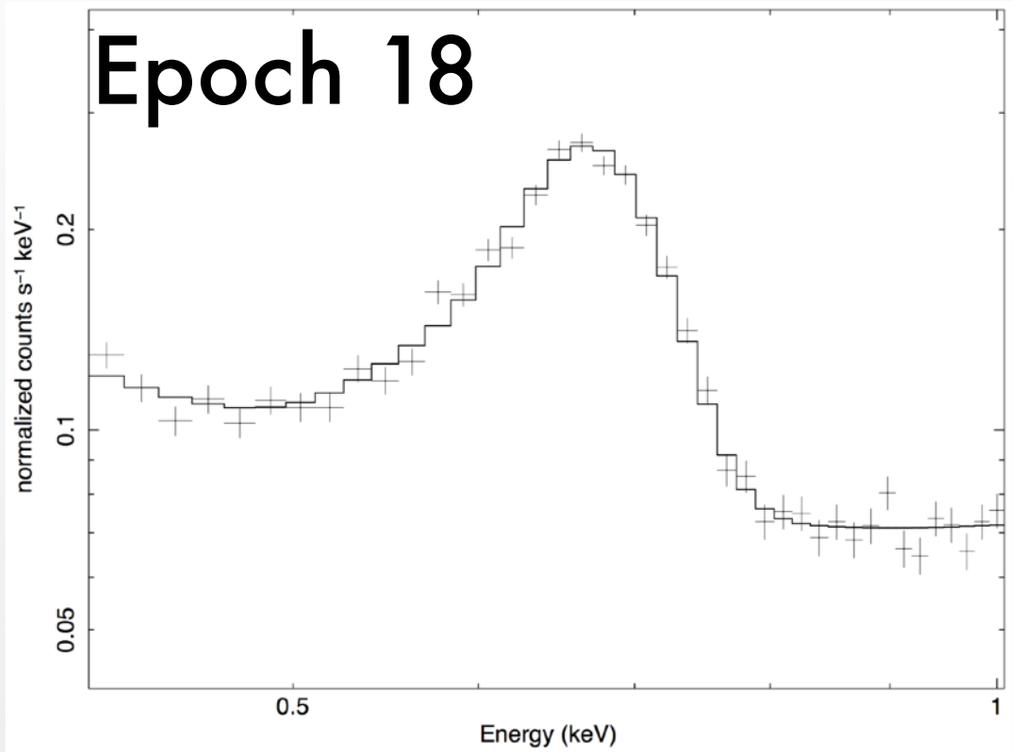


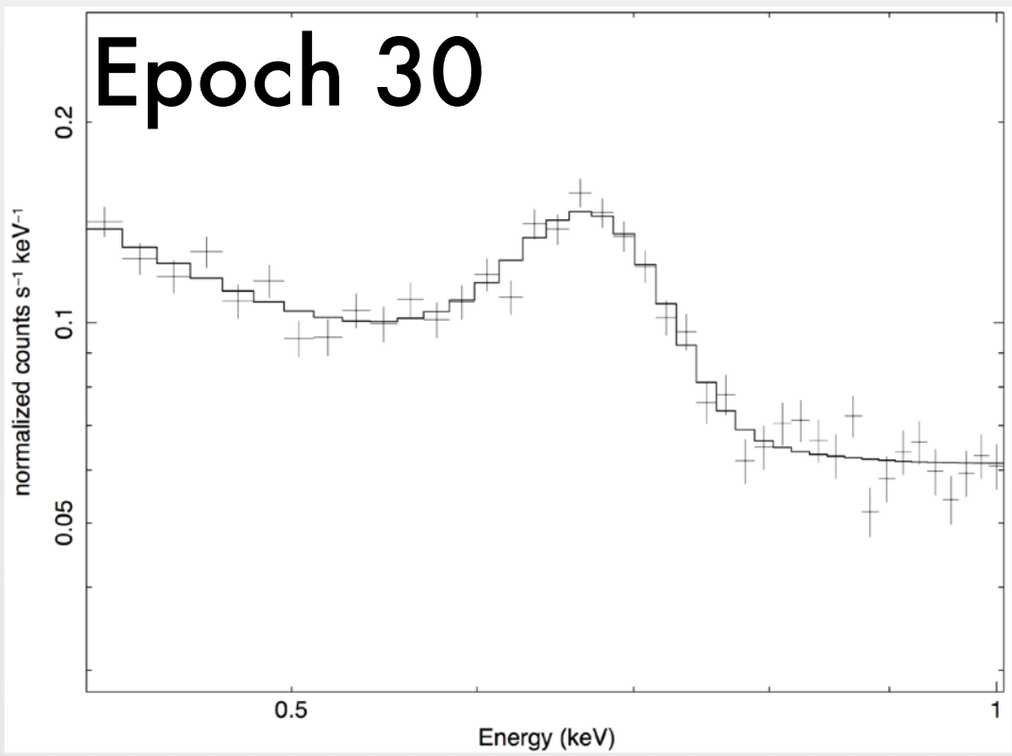
Al-Kα line Mn-Kα line

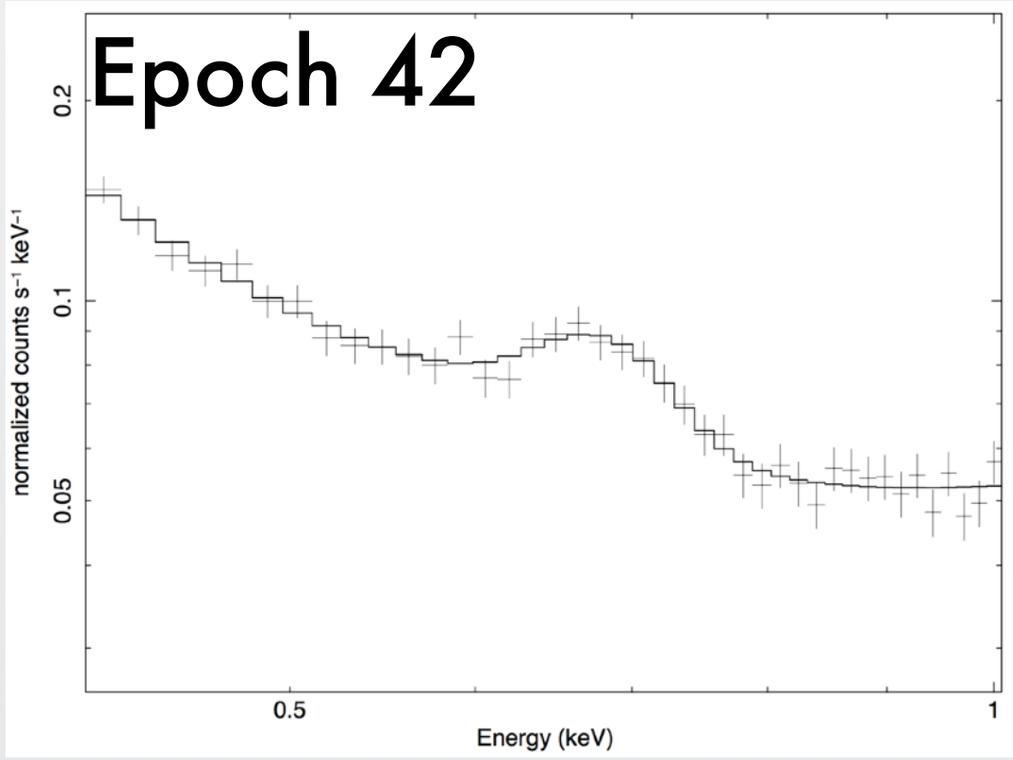


Weakening L-complex in S3



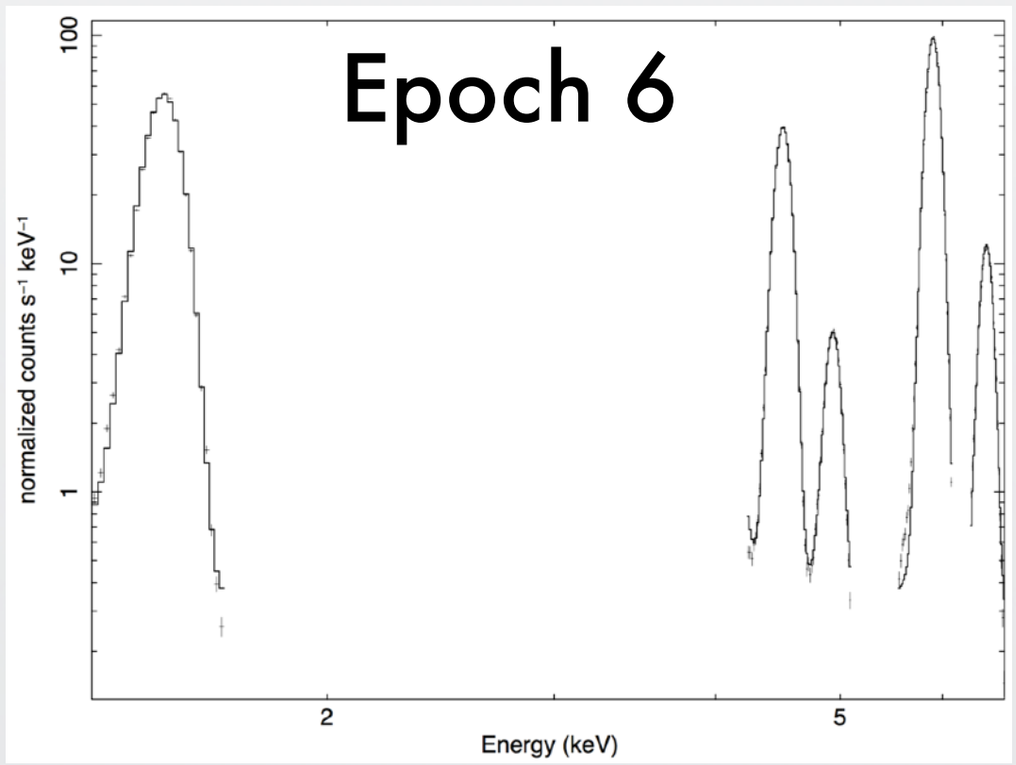


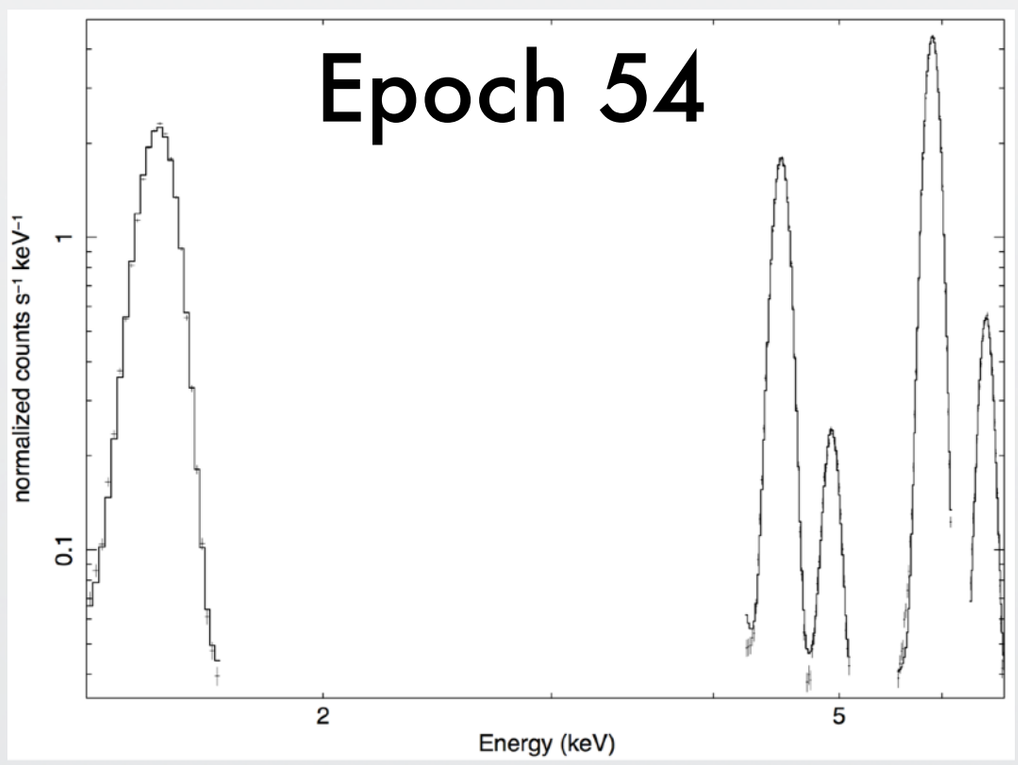




Al-Kα can be used to study the contamination

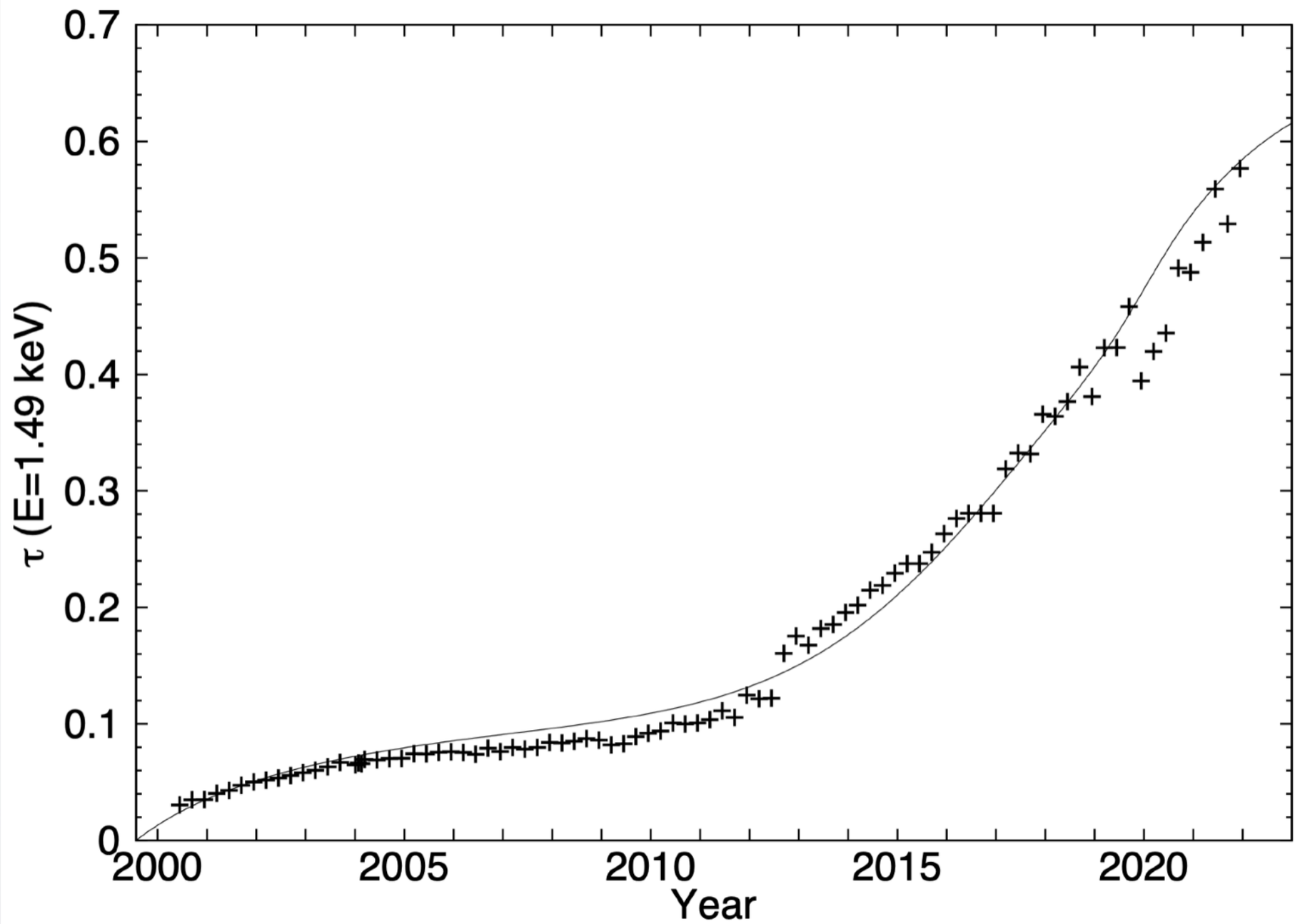
- Flux in L-complex decreases, statistical and systematic uncertainty increase
- After 2005 L-complex cannot be used to compute accurate (<5%) optical depths
- However Al-Kα and Mn-Kα is strong and can be used to measure optical depths





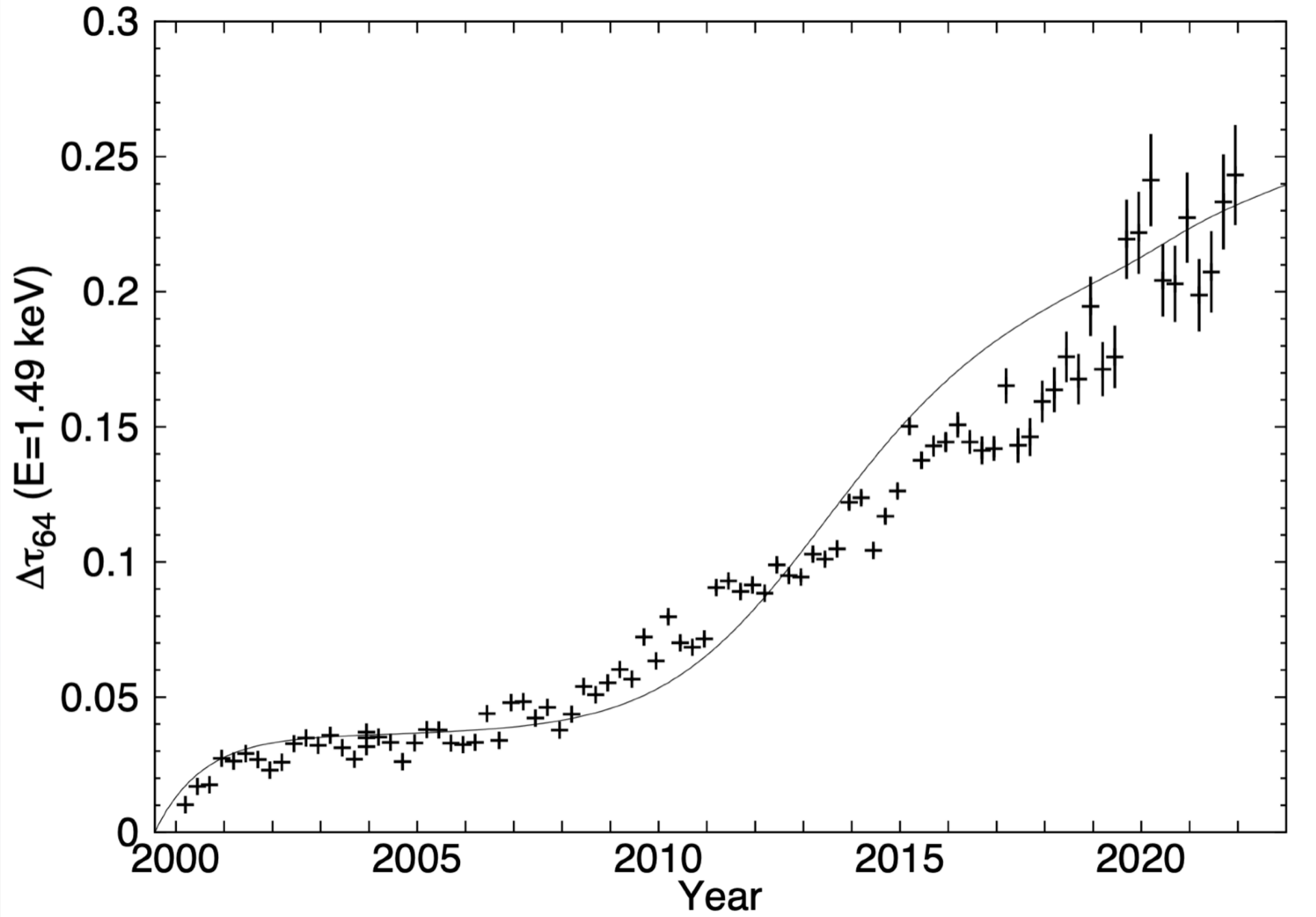
Evolution of the contaminant using ECS data

- Ratio of Al Ka to Mn Ka line is used to derive the optical depths
- Plot shows evolution of the optical depths at the center at E=1.49 keV



Edge-to-center difference using ECS data

- Ratio of Al Kα to Mn Kα line is used to derive the optical depths
- Plot shows optical depths relative to the center at E=1.49 keV



Conclusions on the spatial structure of the contaminant

1. The spatial structure of the contaminant can be described with an exponential model that is similar albeit slightly broader than before 2014
2. A linear model may provide an appropriate fit to the data at late epochs
3. ECS data (E=1.49 keV) can be used to characterize the contaminant
4. N0015 contamination model provides accurate correction