

Re-analysis of 3.5 keV Excess

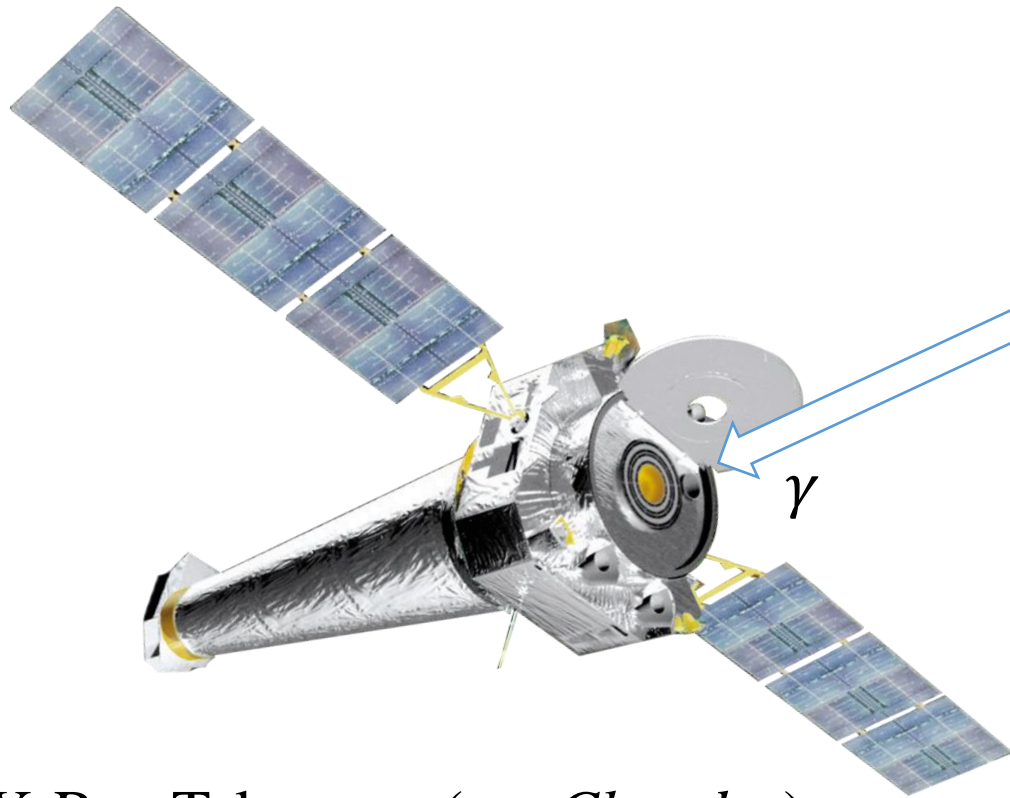
Yujin Park

Christopher Dessert, Joshua Foster, Benjamin Safdi

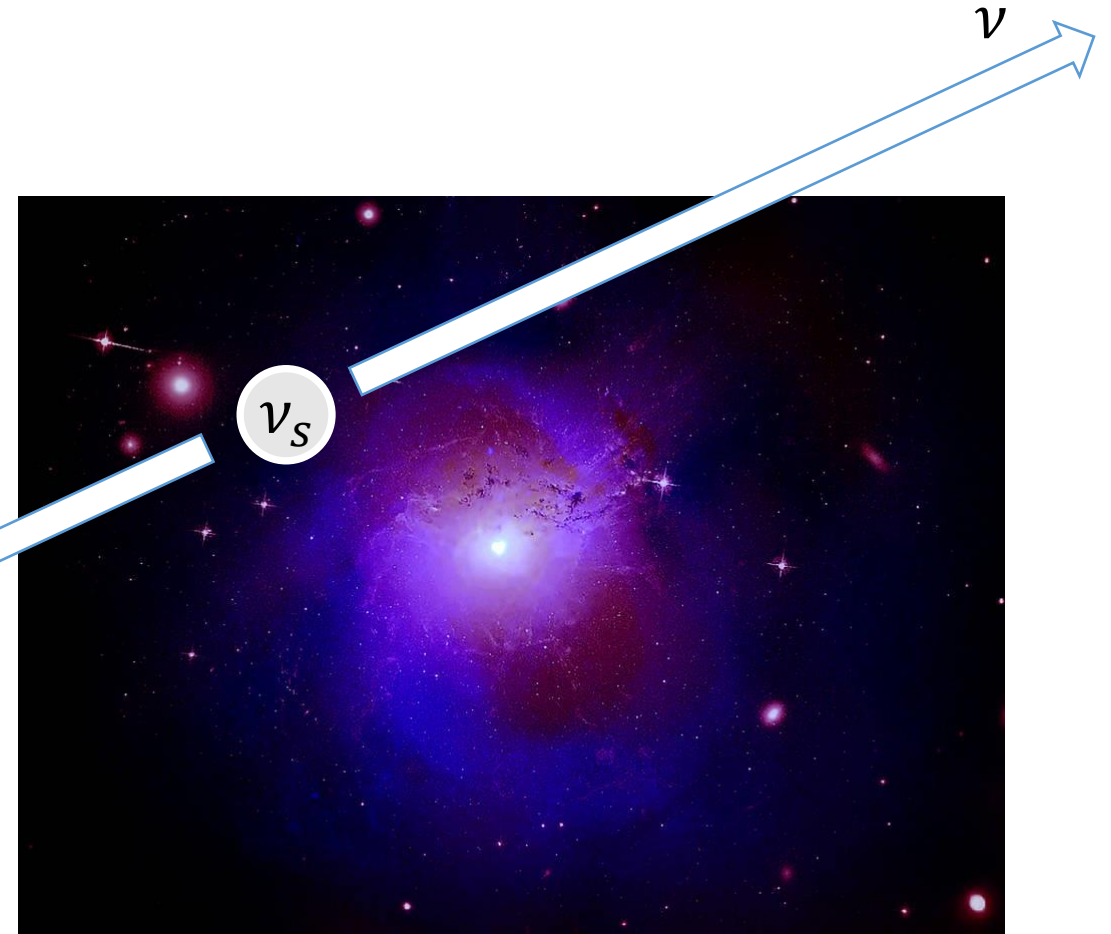
University of California, Berkeley

ICHEP 2022 07.08.2022

Dark Matter Evidence

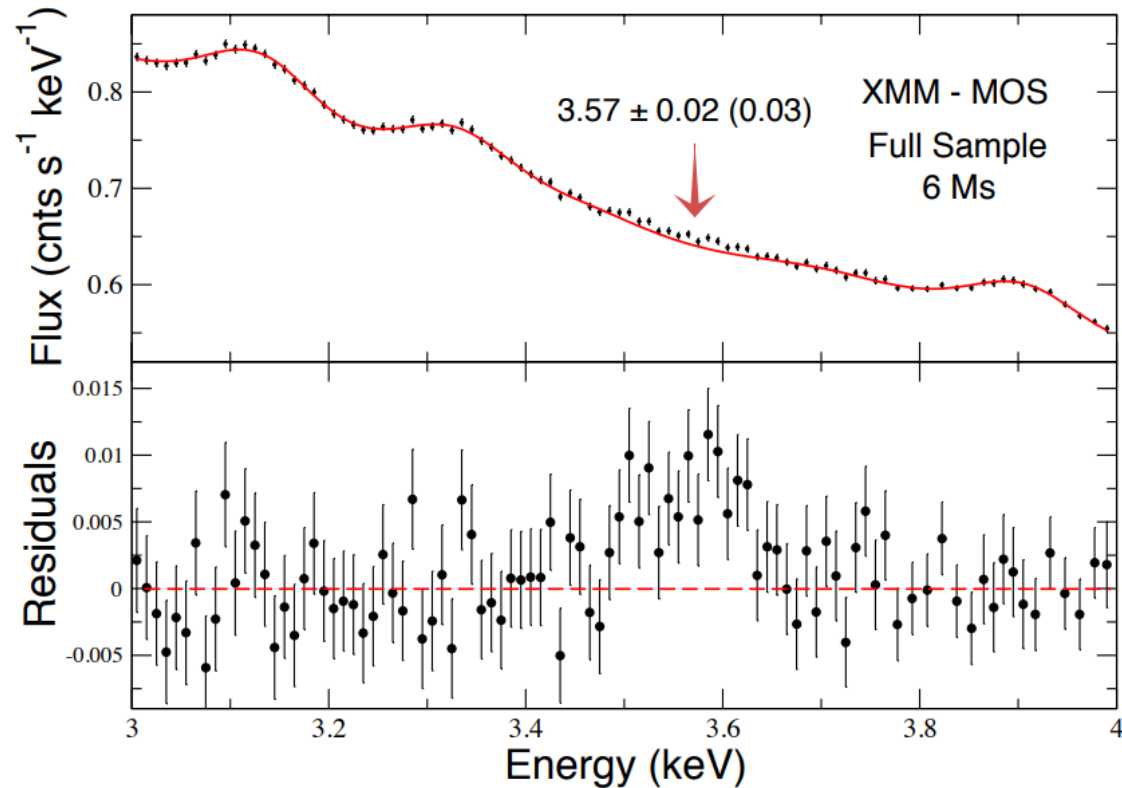


X-Ray Telescope (ex. *Chandra*)

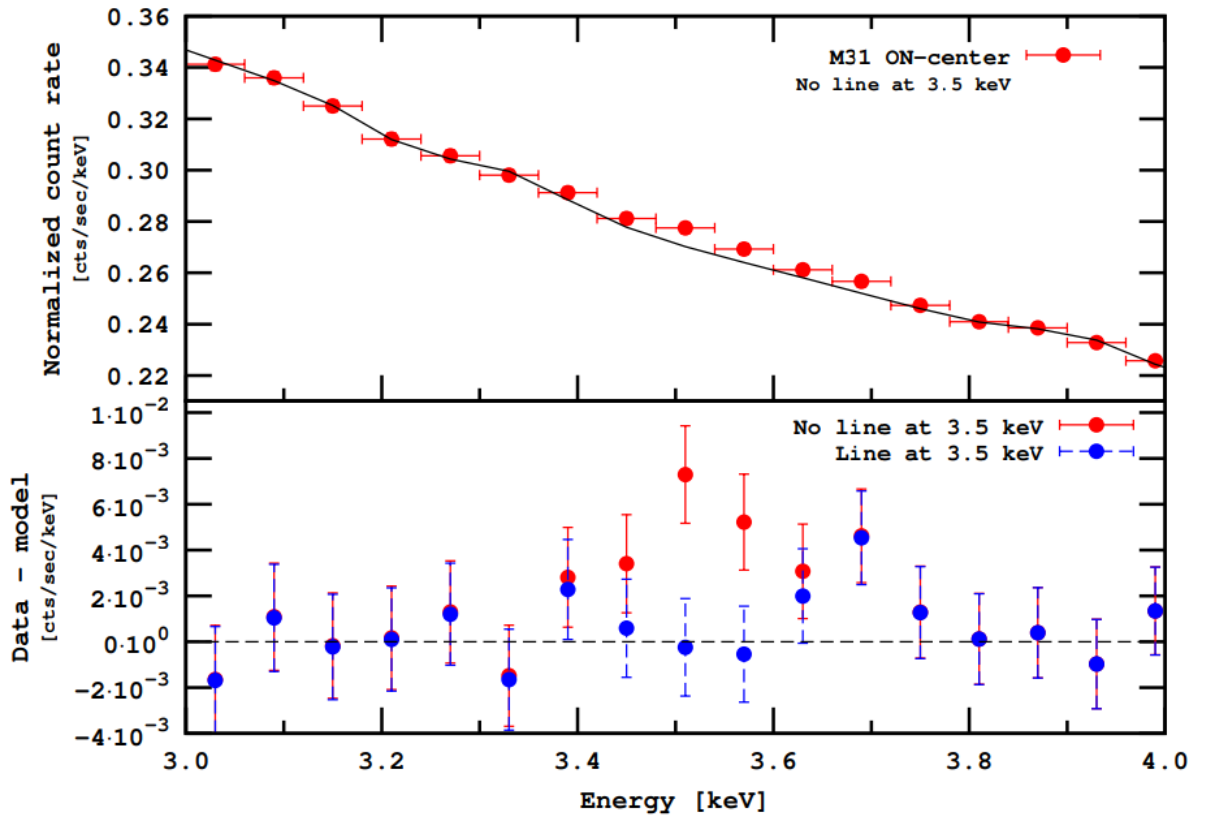


Perseus Cluster

Back in 2014...



Esra Bulbul et al. arXiv:1402.2301

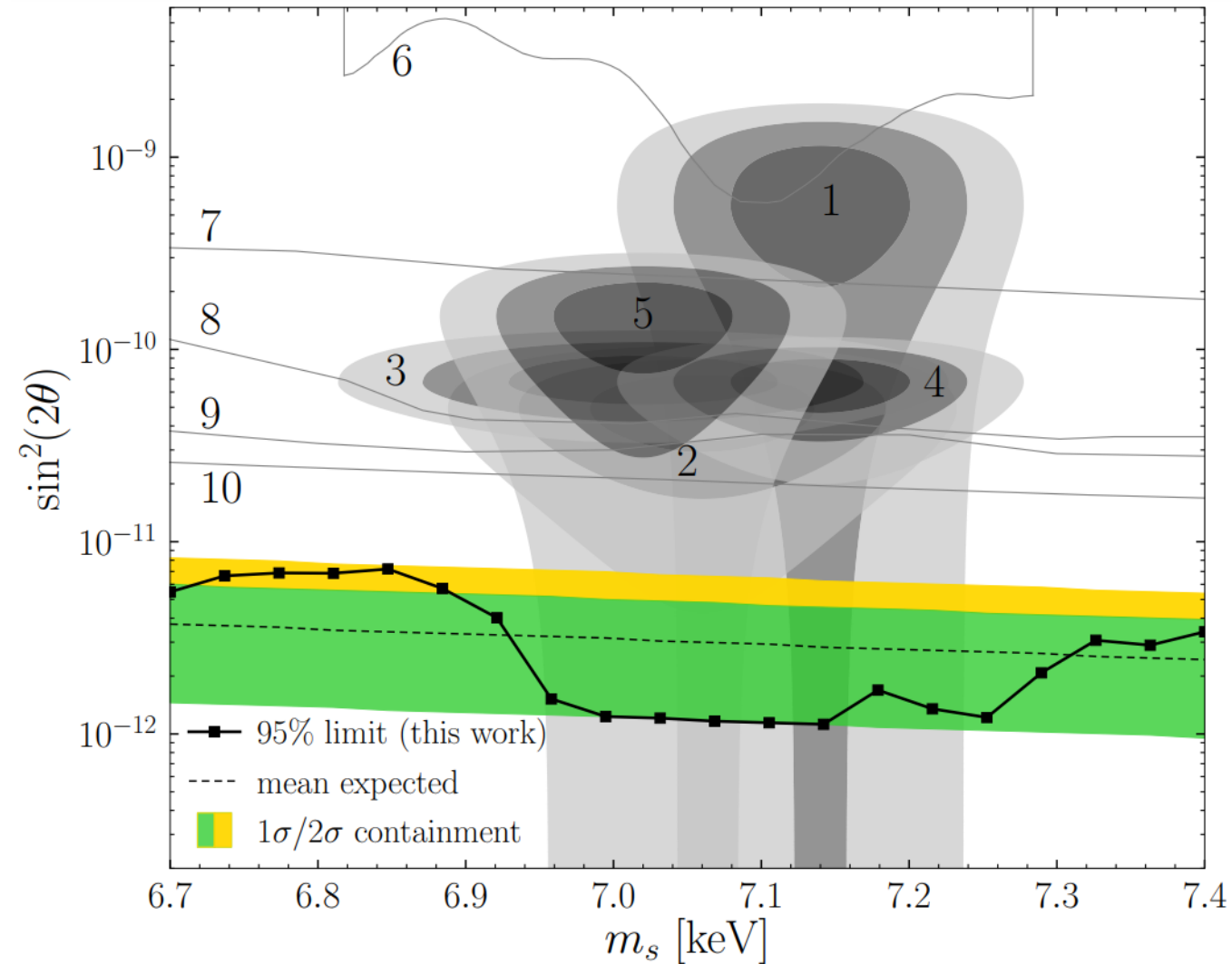


Alexey Boyarsky et al. arXiv:1402.4119

- Excess discovered near the energy of 3.5 keV

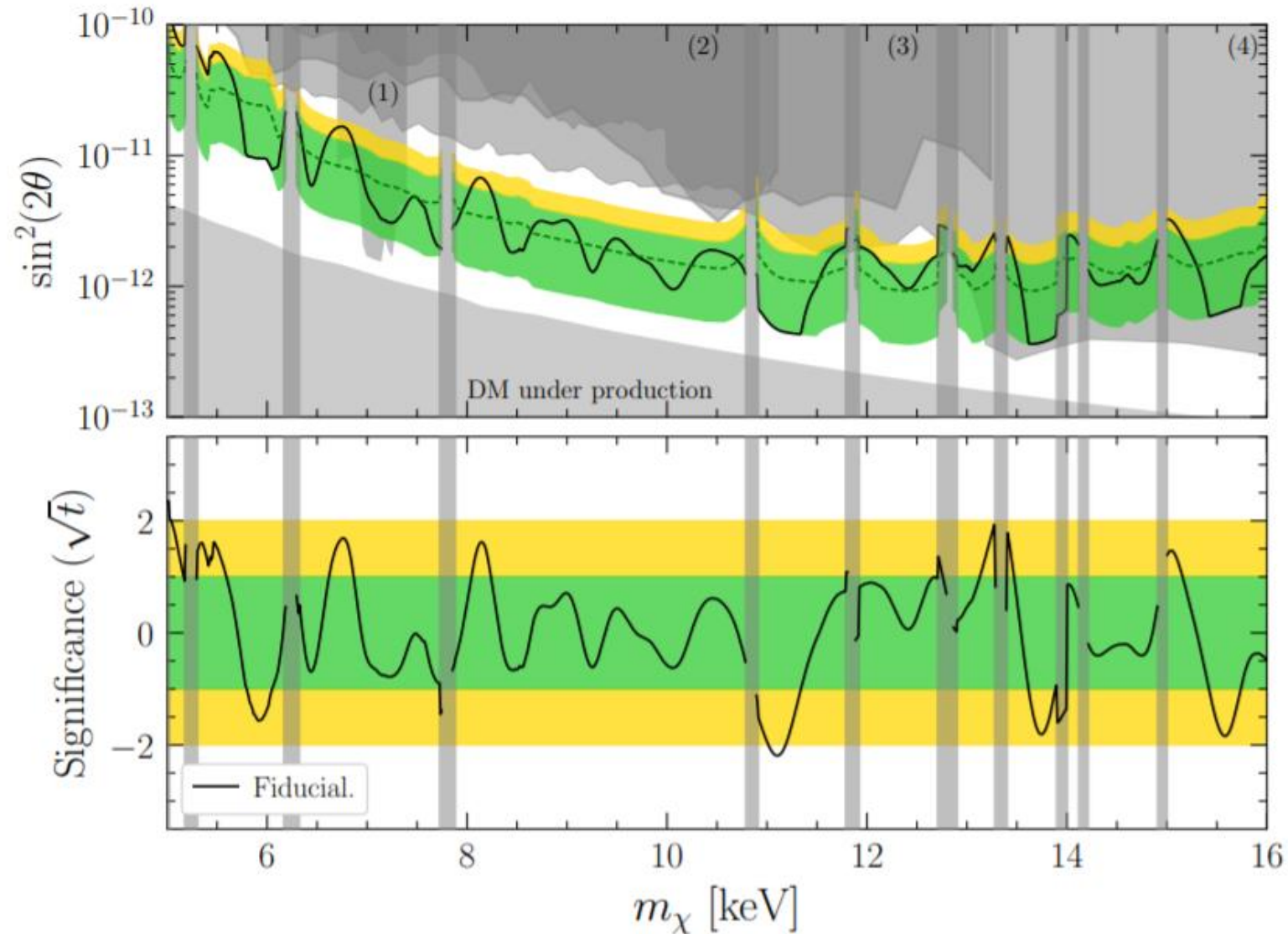
However...

- Dark matter interpretation ruled out by Dessert et al. arXiv:1812.06976



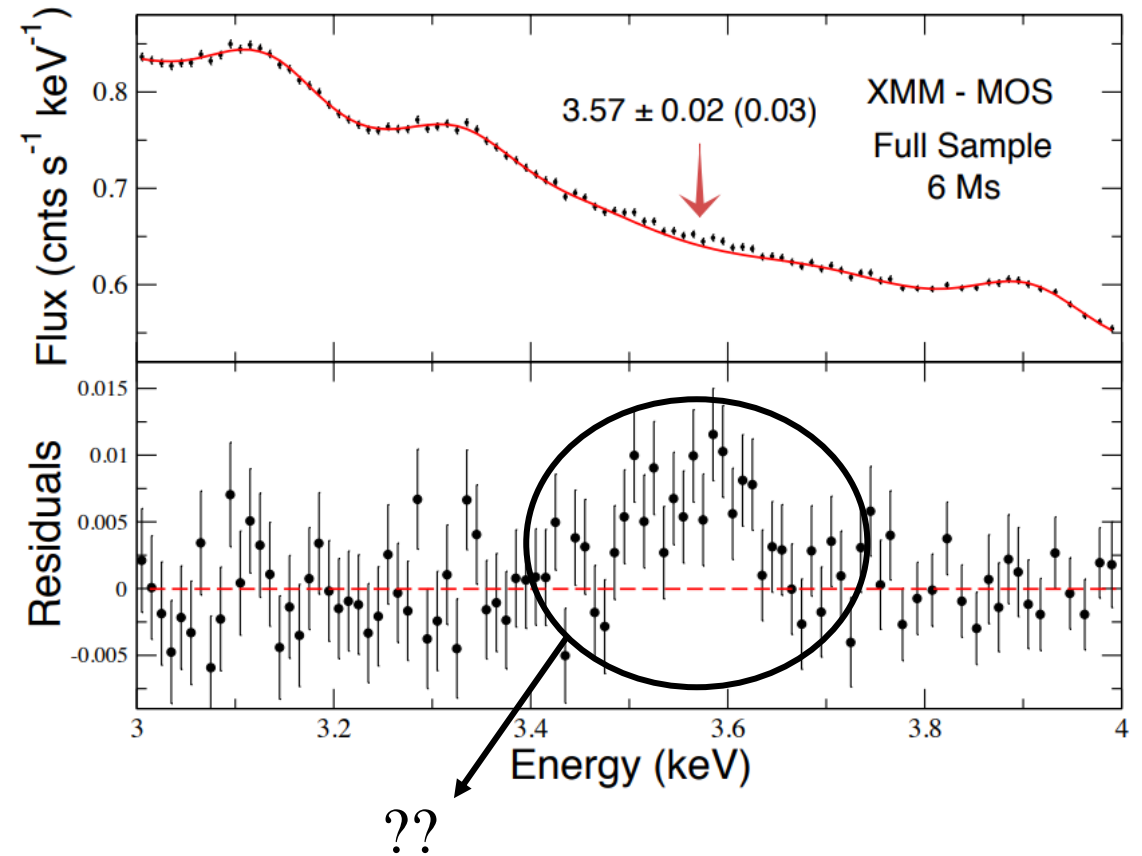
However...

- Also ruled out by Foster et al. 2102.02207



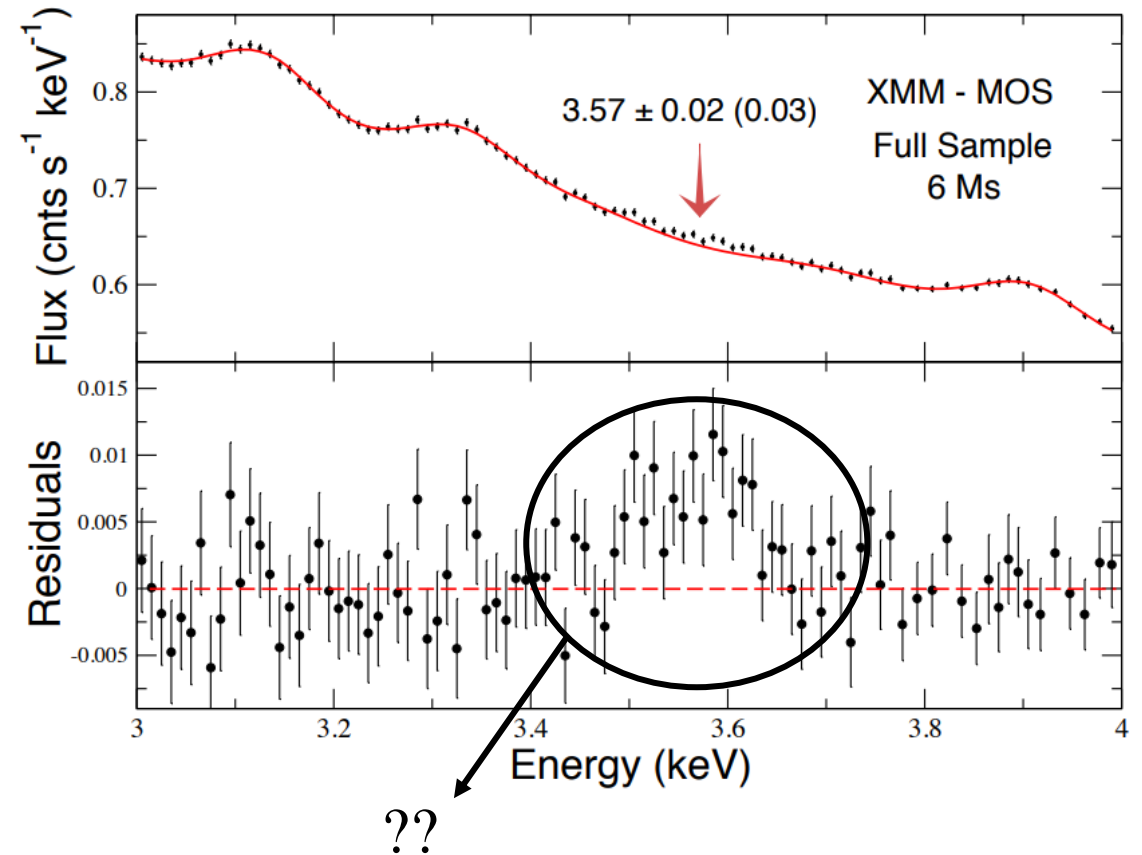
What is the 3.5 keV Excess?

- Where is this excess from?
- Possible explanations
 - Unresolved astrophysical lines
 - K XVIII lines at 3.48 and 3.52 keV
 - S XVI charge exchange at 3.5 keV
 - Mismodeling

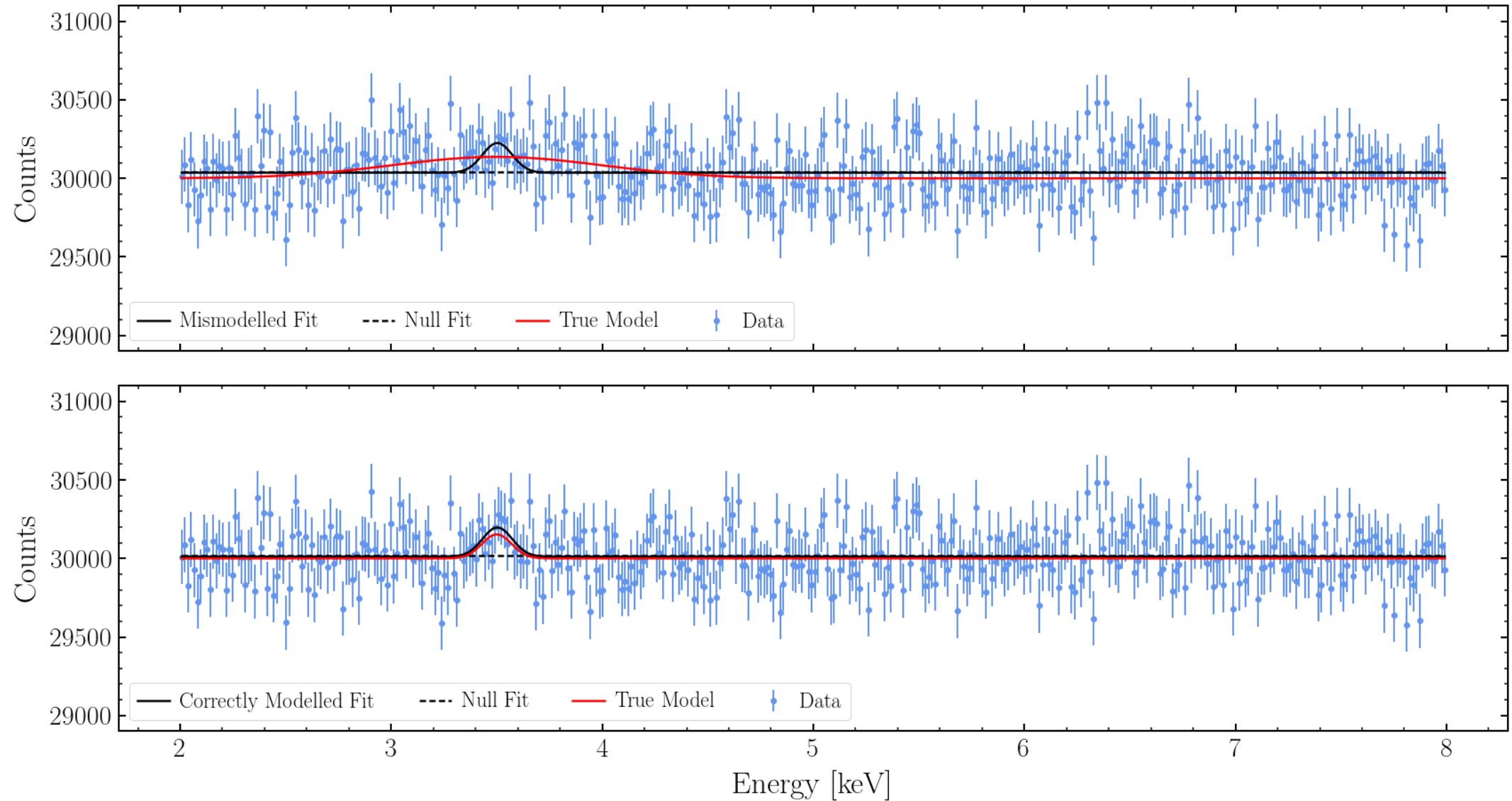


What is the 3.5 keV Excess?

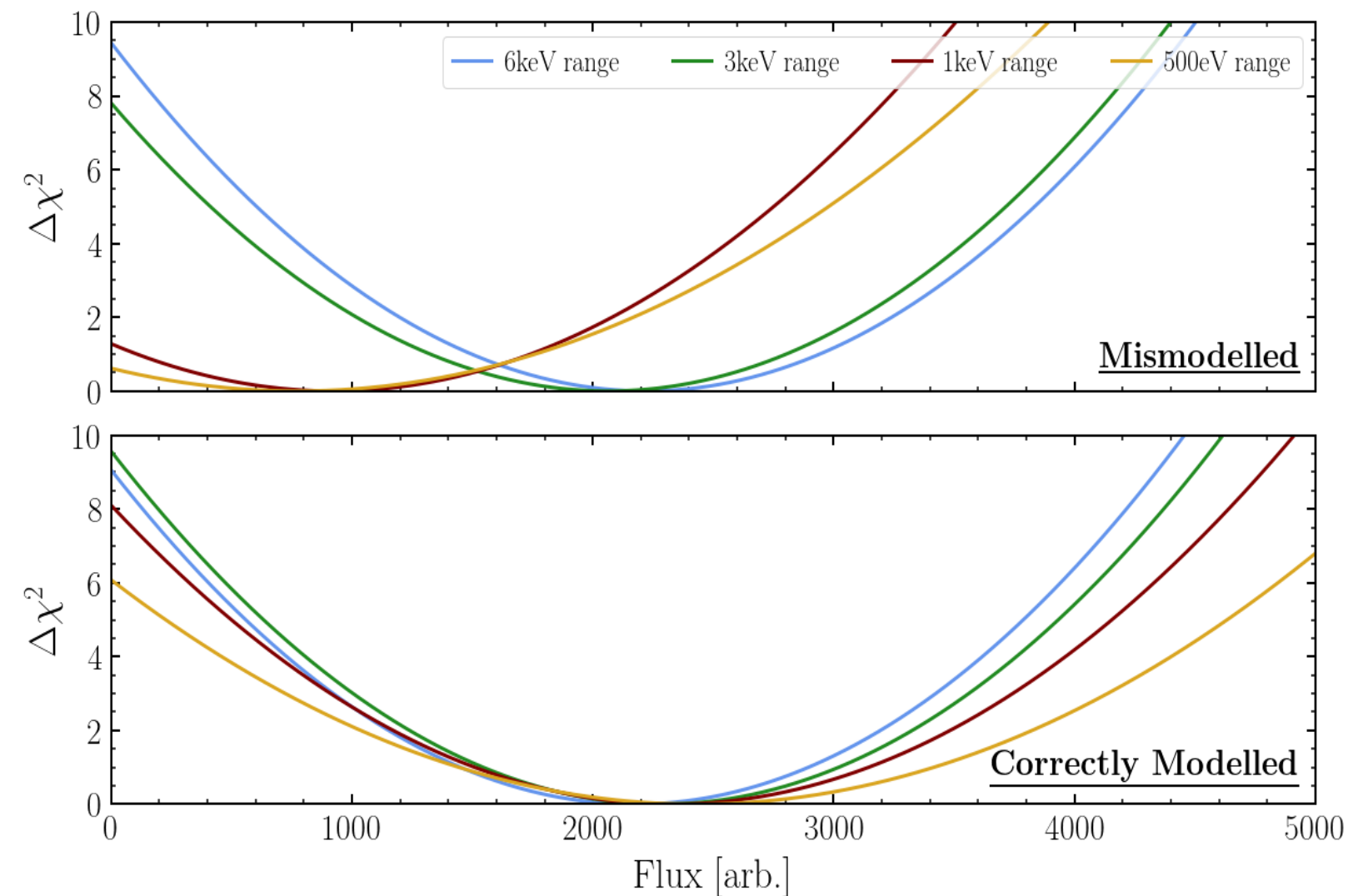
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Effects of mismodeling – Toy model

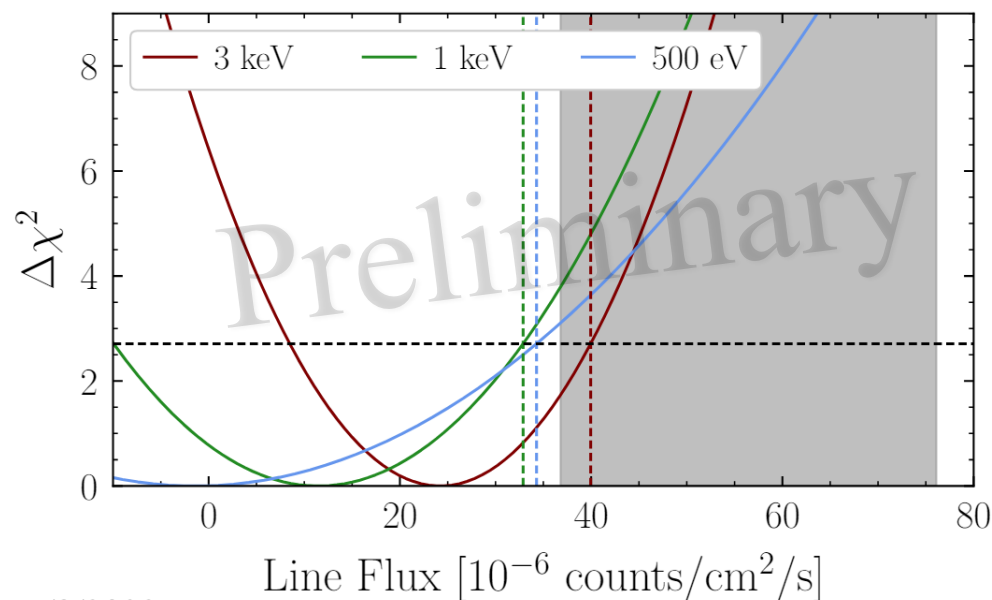
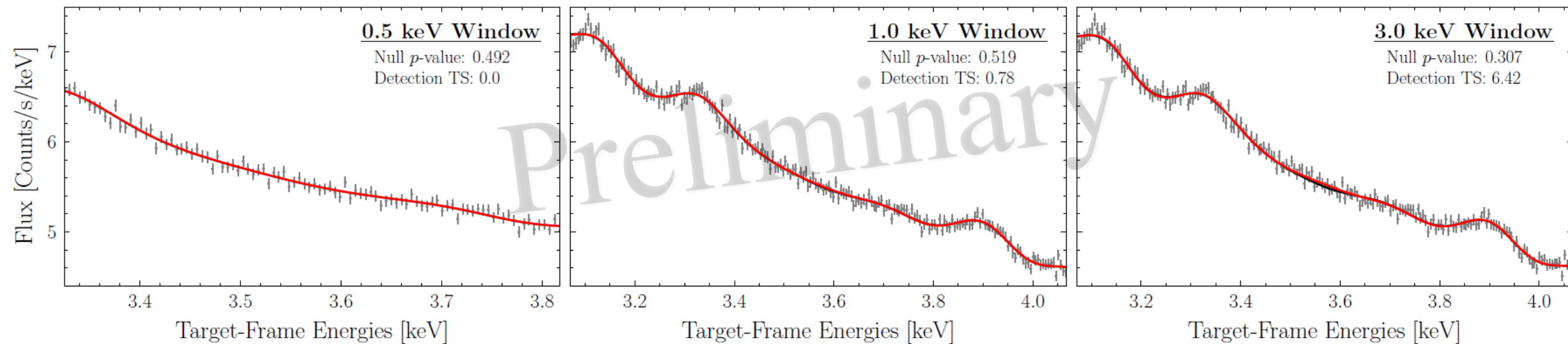


Results from the toy model



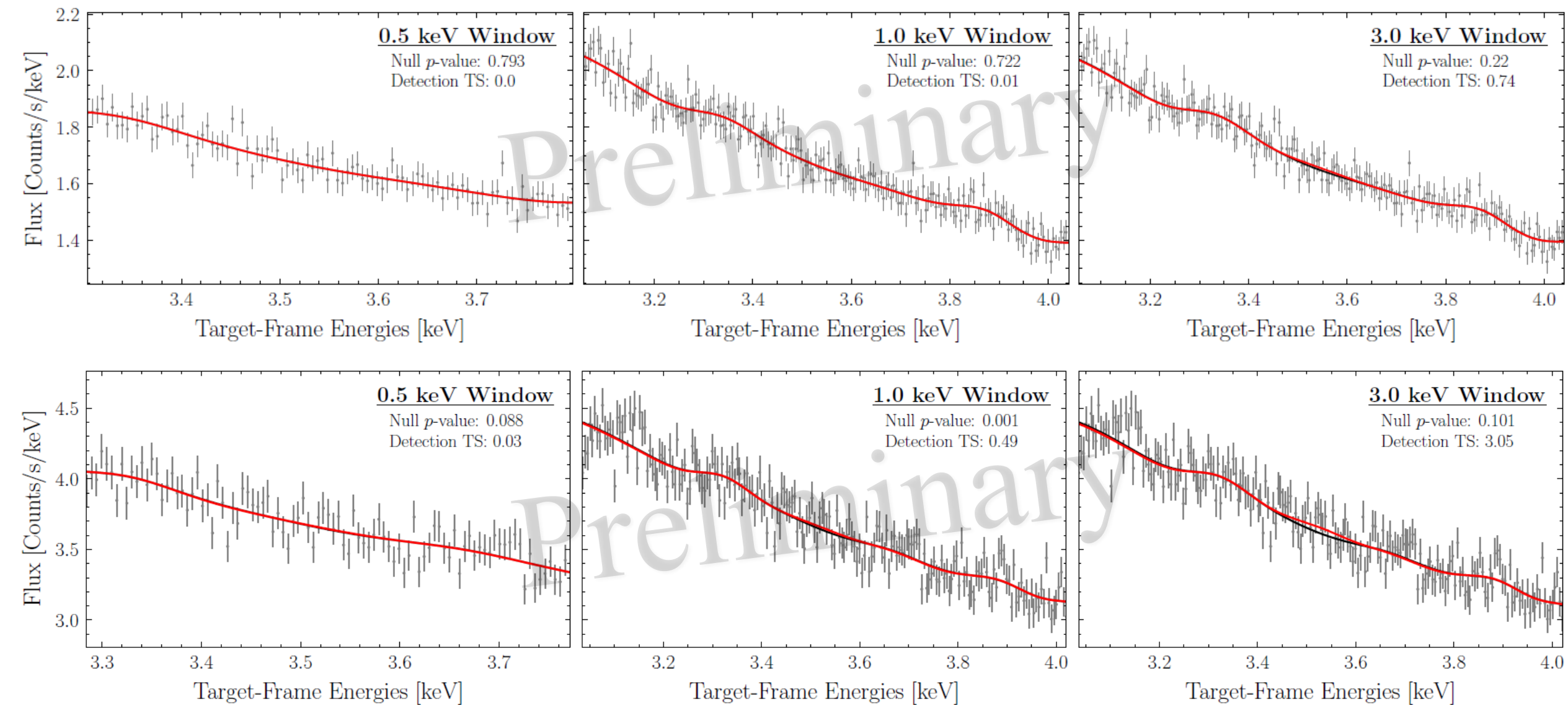
- Things to note:
 - Best-fit flux inconsistent in mismodelled example
 - $\Delta\chi^2$ decreases significantly with mismodeling

On physical observations – Perseus, *MOS*

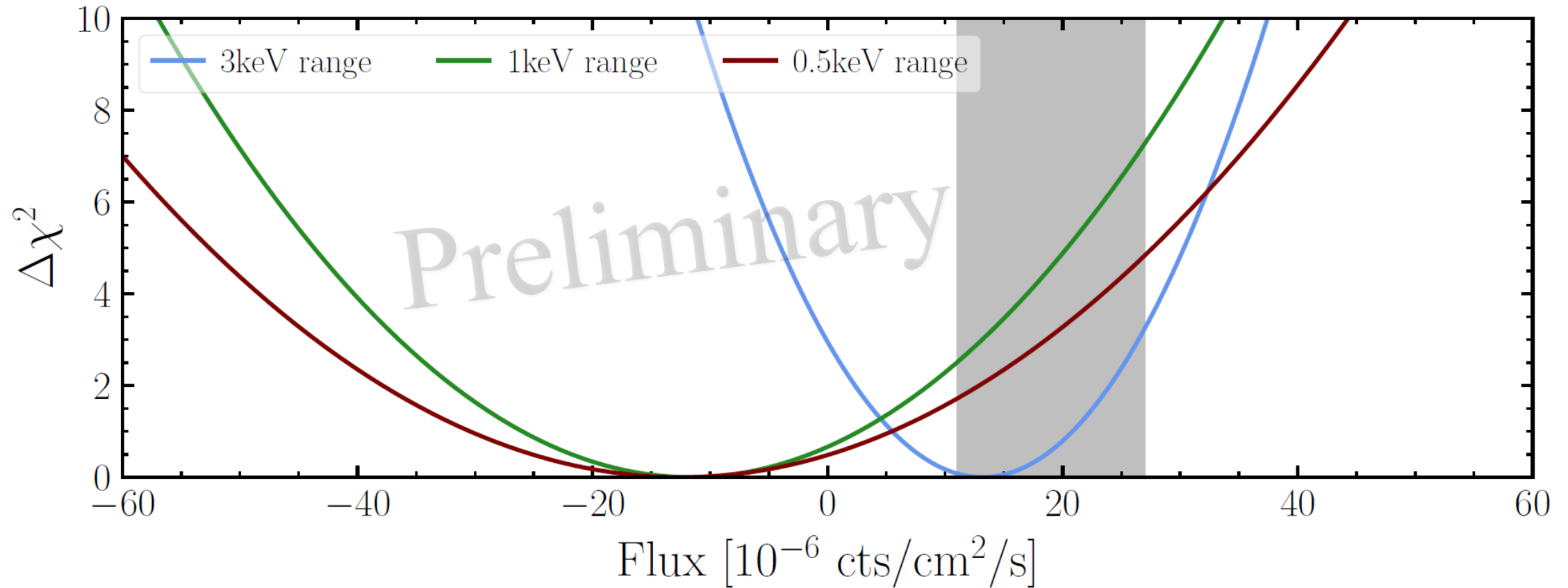


- Did not recover the same signal
- Found better minimum than presented by Bulbul et al.

Coma (top), Ophiucus (bottom)



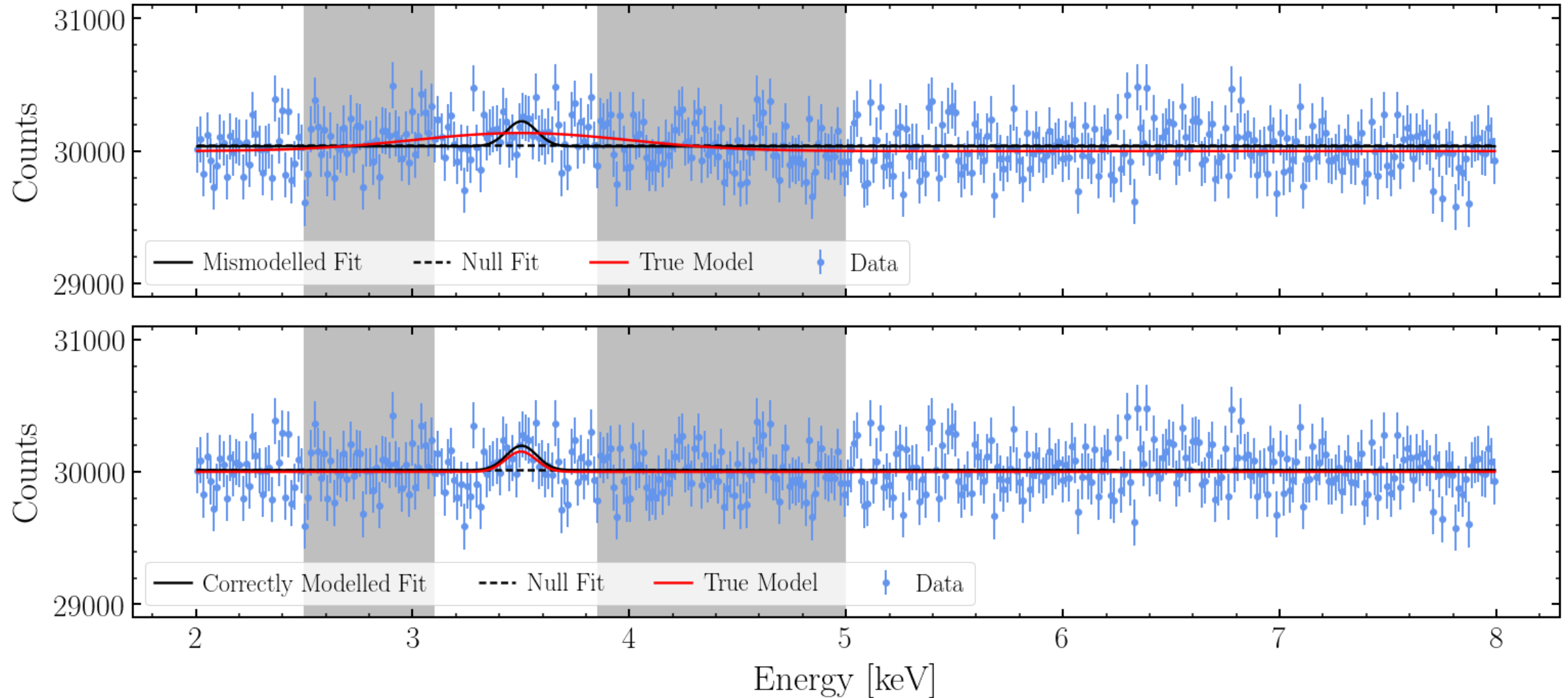
On physical observations – Perseus, *Chandra*



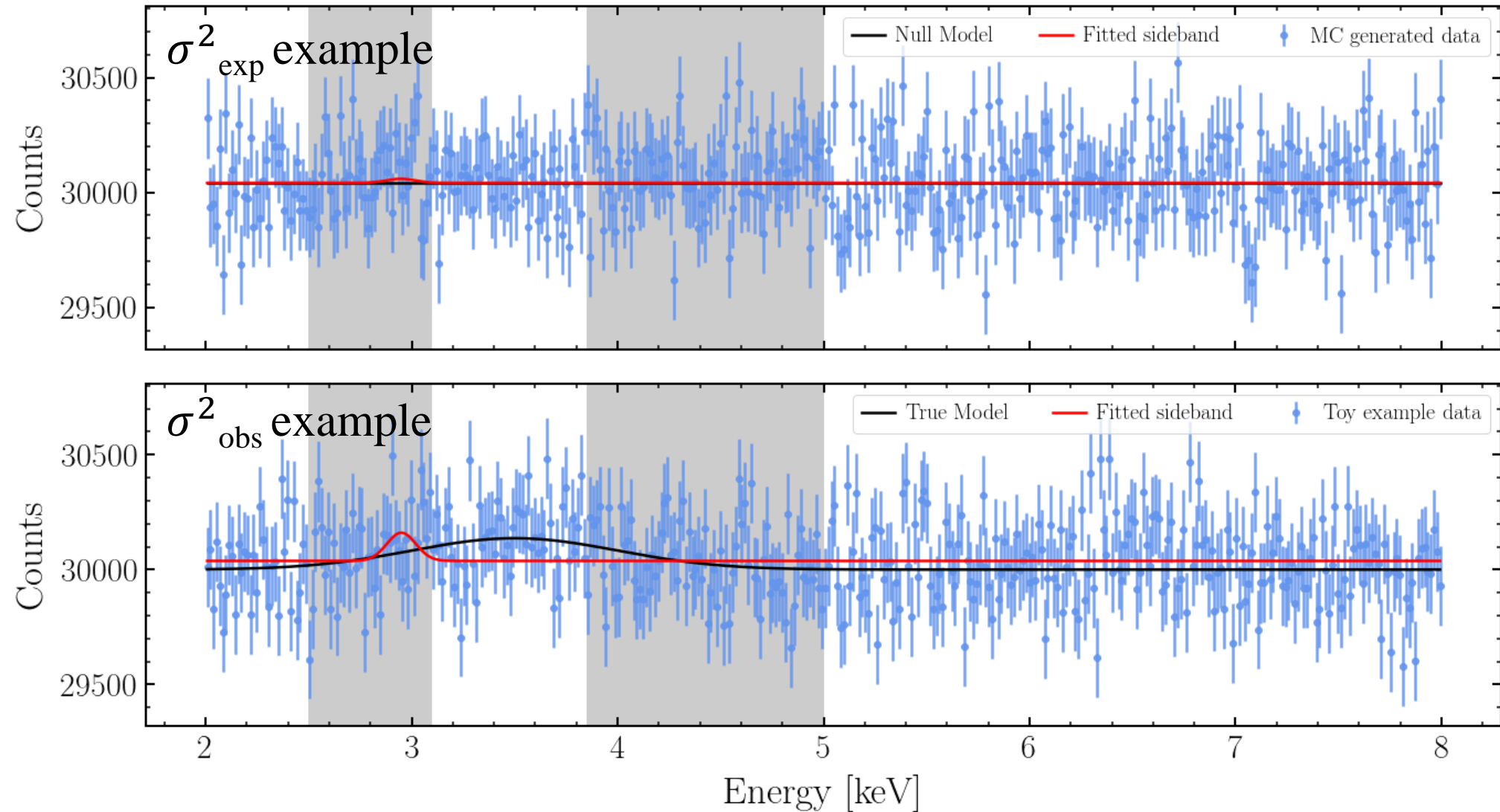
- Signal recovered in the range presented in [1402.2301]
- But inconsistent in different ranges of analysis

Additional analysis – “Spurious” signal test

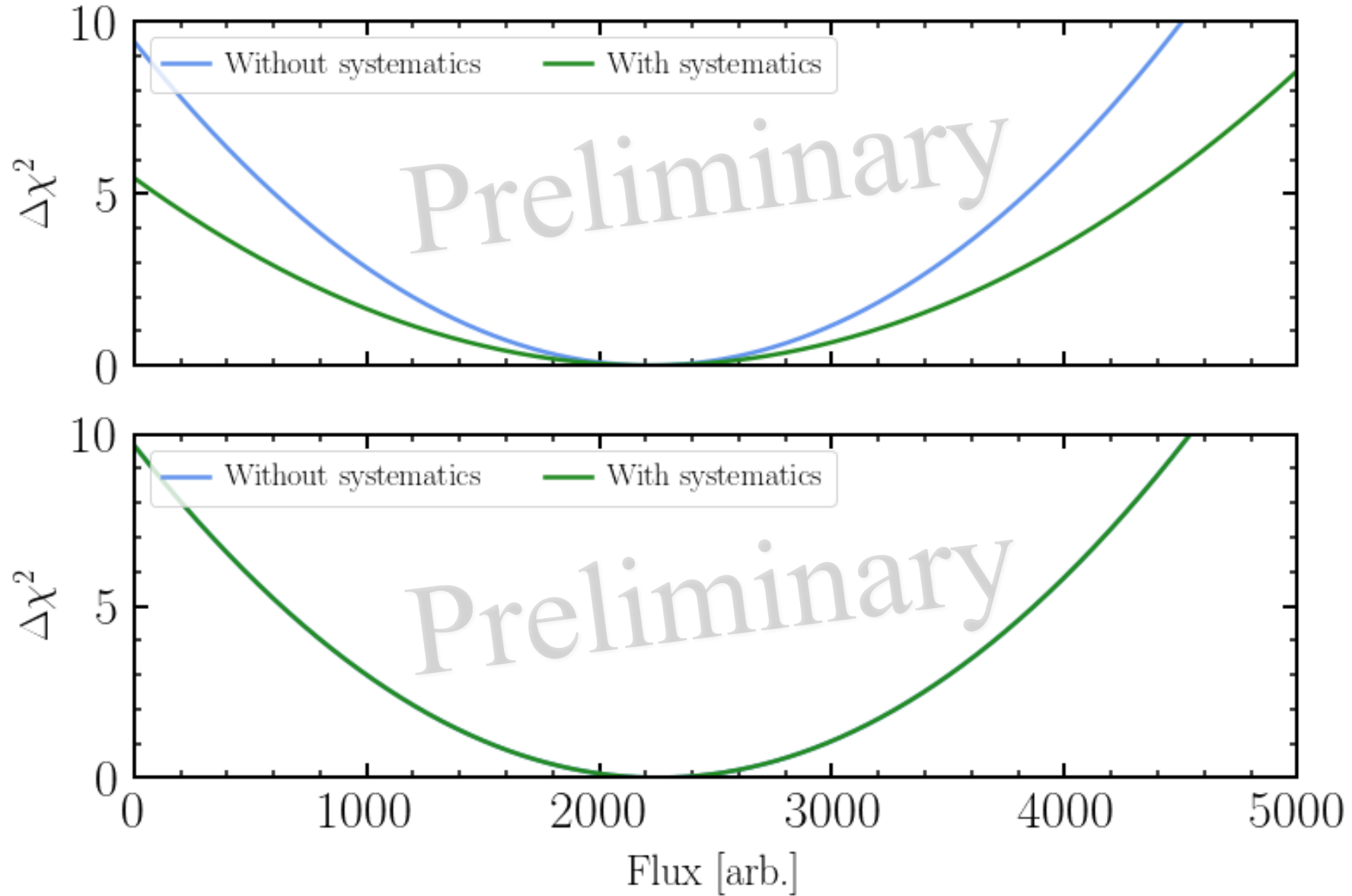
$$\sigma_{\text{spur},m}^2 = \max \left[0, \text{Var} \left[\{\sin^2(2\theta)\}_m \right]_{\text{observed}} - \text{Var} \left[\{\sin^2(2\theta)\}_m \right]_{\text{expected}} \right]$$



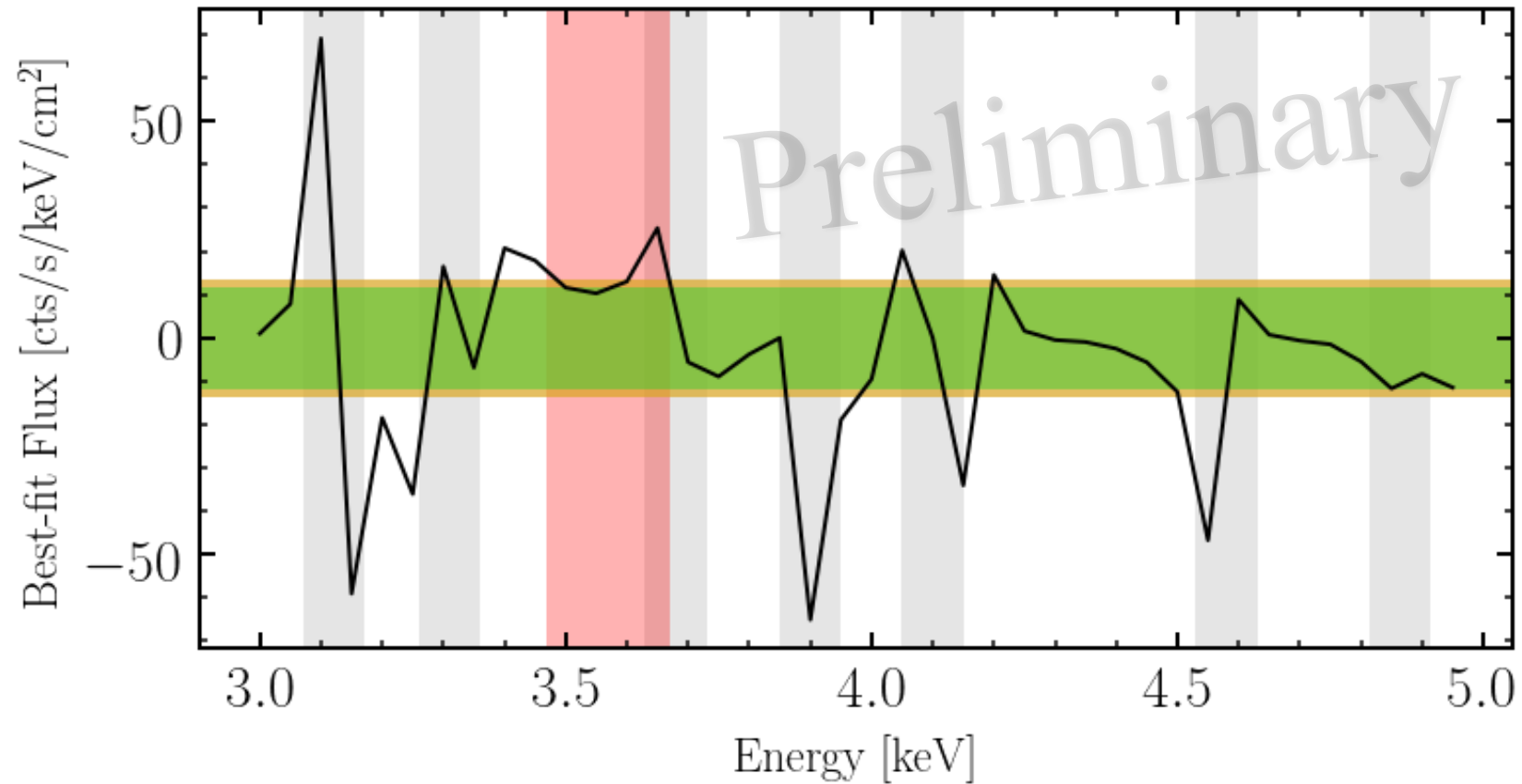
Additional analysis – “Spurious” signal test



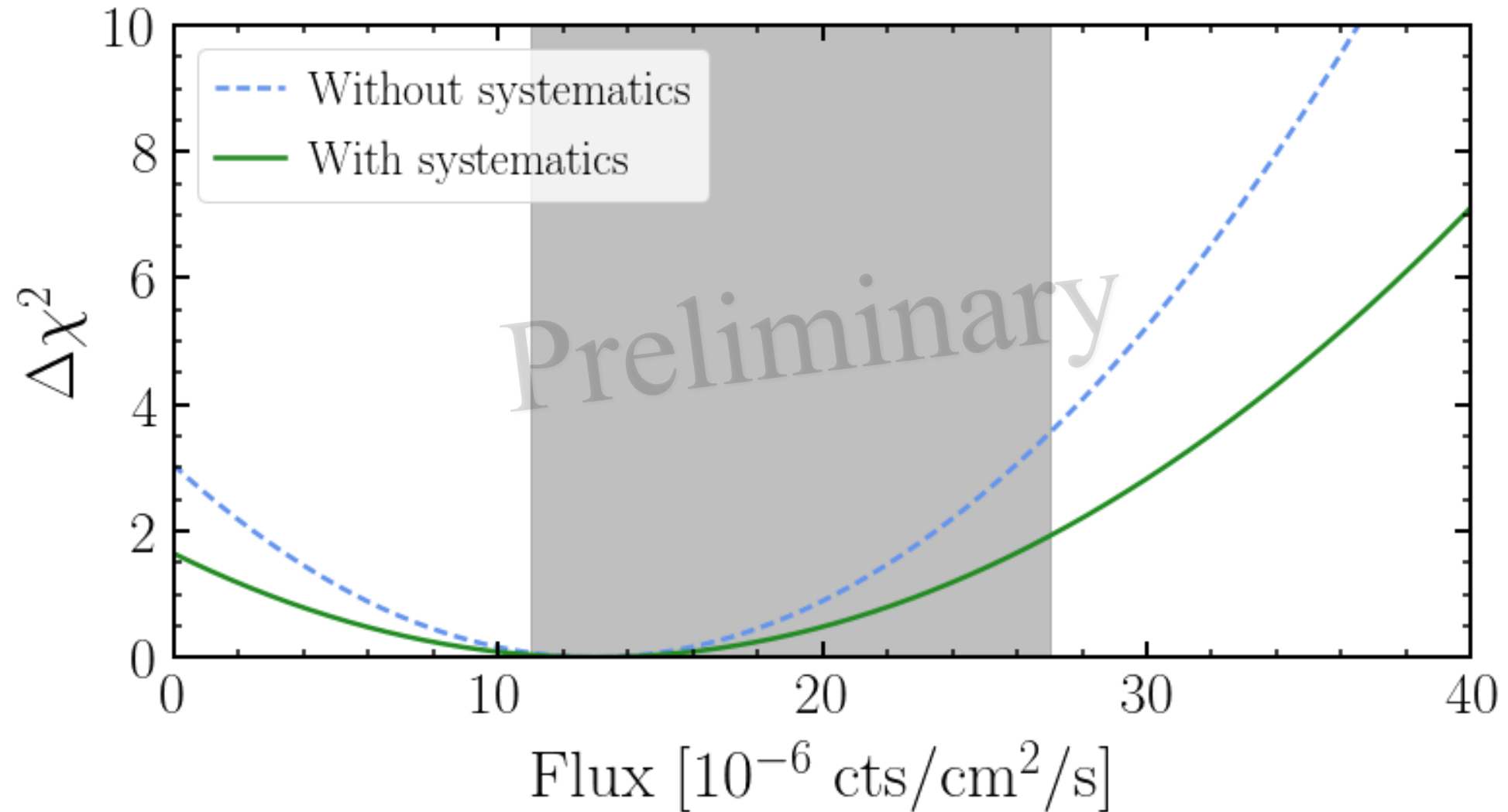
Spurious signal test result



On physical observation – Perseus, *Chandra*



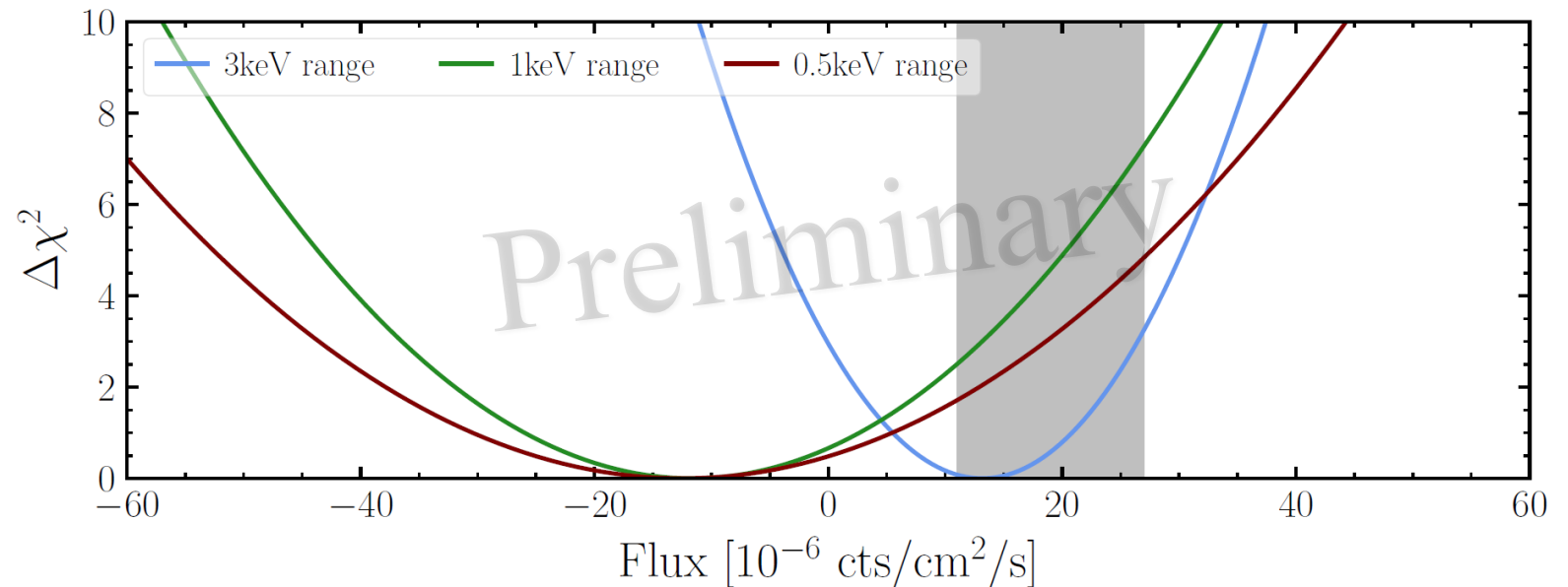
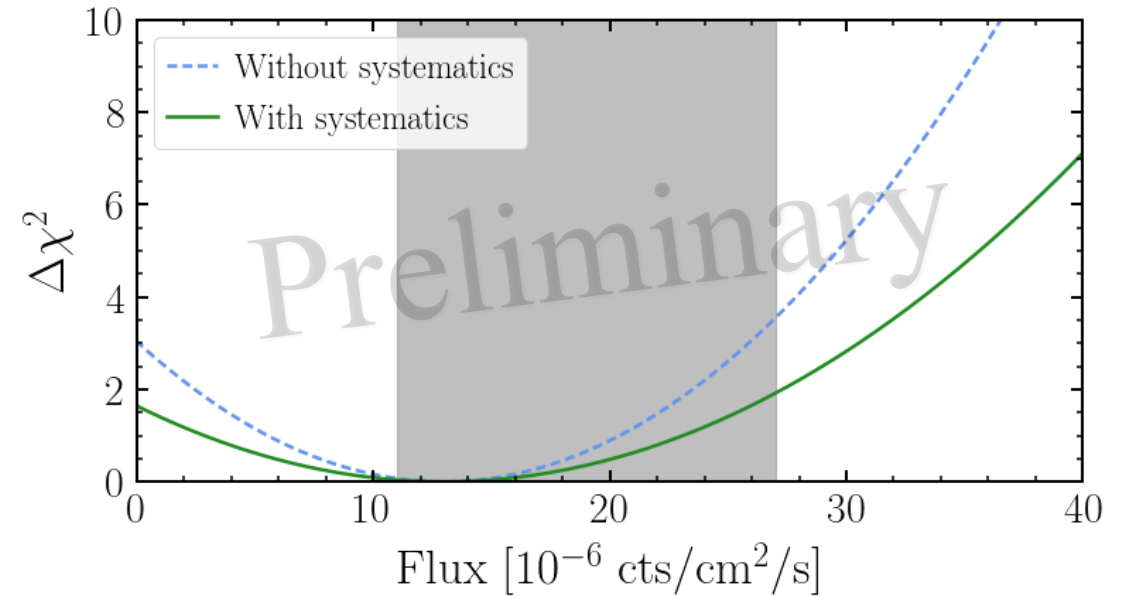
On physical observation – Perseus, *Chandra*



Revisiting 3.5 keV Result

- Observe evidence suggesting mismodeling effects of the data
- Better minimum found with use of more sophisticated optimizer
- Finalizing the analysis and additional spurious signal analysis

Perseus



Thank you!