

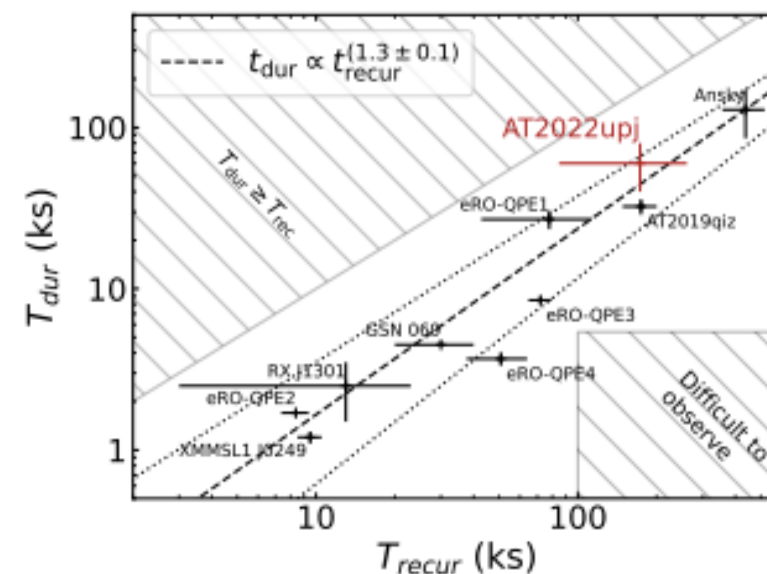
Tatra Astro Summit 2025

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Spectral signatures of quasiperiodic outflows
in galactic nuclei

Quasi-Periodic Eruptions

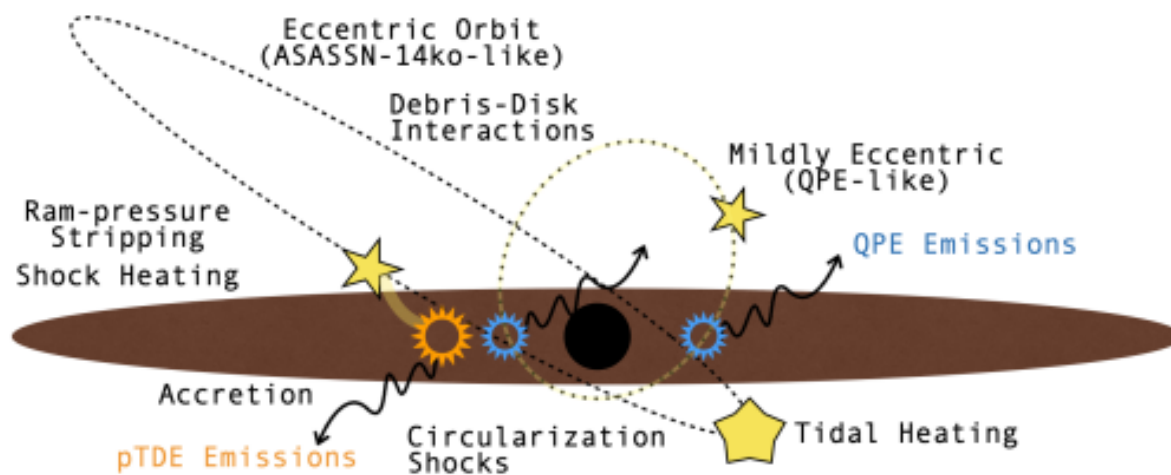
- Recurring, bright, soft X-ray bursts observed in the nuclei of galaxies
- Periods: hours to a week
- Possible new probe of SMBH physics
- Possible mechanisms:
 - Accretion disk instabilities (Miniutti+21, Sniegowska+22, Middleton+25)
 - SMBH + orbiter (EMRIs, TDE-linked scenarios; King 20, Sukova+21, Linial+Metzger 23, Franchini+23, Vurm+25)



Hernández-García+25

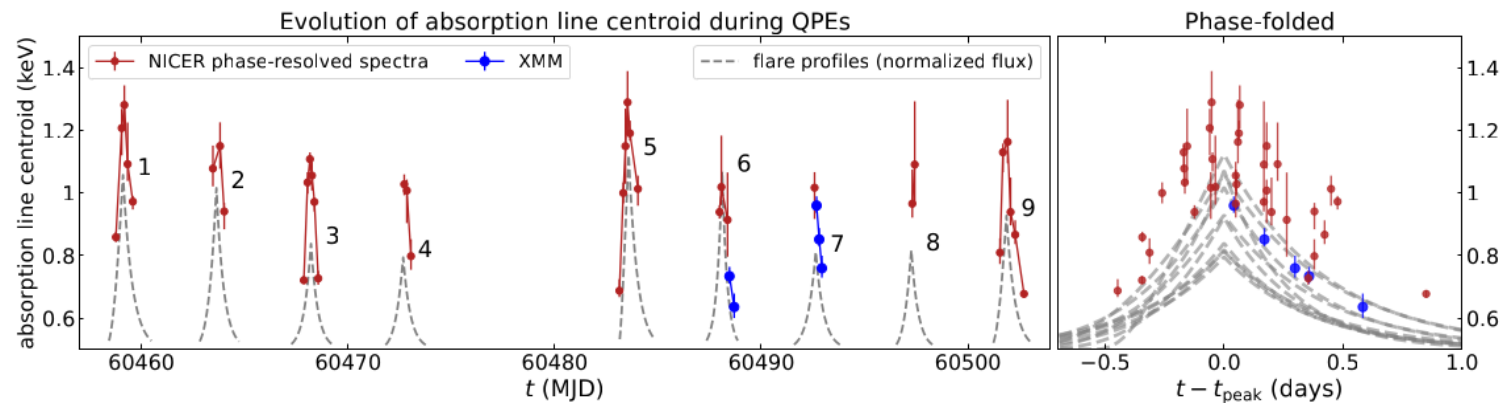
Project Goal

- Collision -> heating, shocks -> expanding flow -> cooling
- Does the collision picture explain the time-dependent spectral features observed?



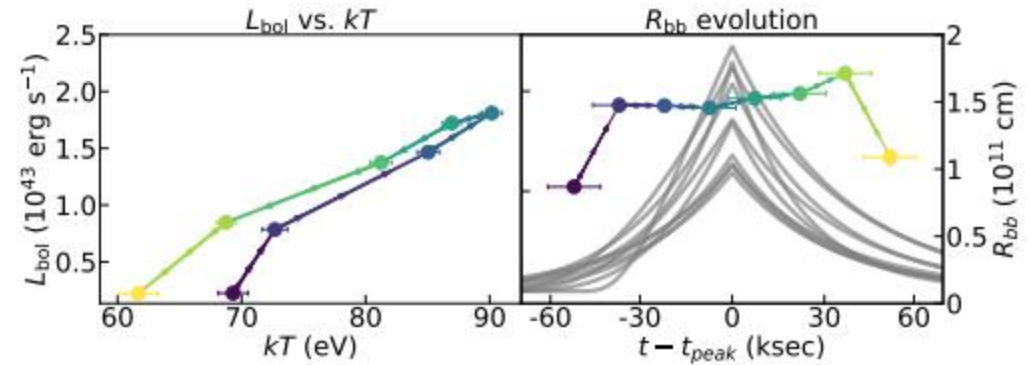
Object Selection

- ZTF19acnskyy ("Ansky"): first QPE with high-resolution, high S/N spectra
- Shows absorption lines clearly
- Only dataset so far that allows testing physical models of ionization and expansion in detail



Observational Puzzle

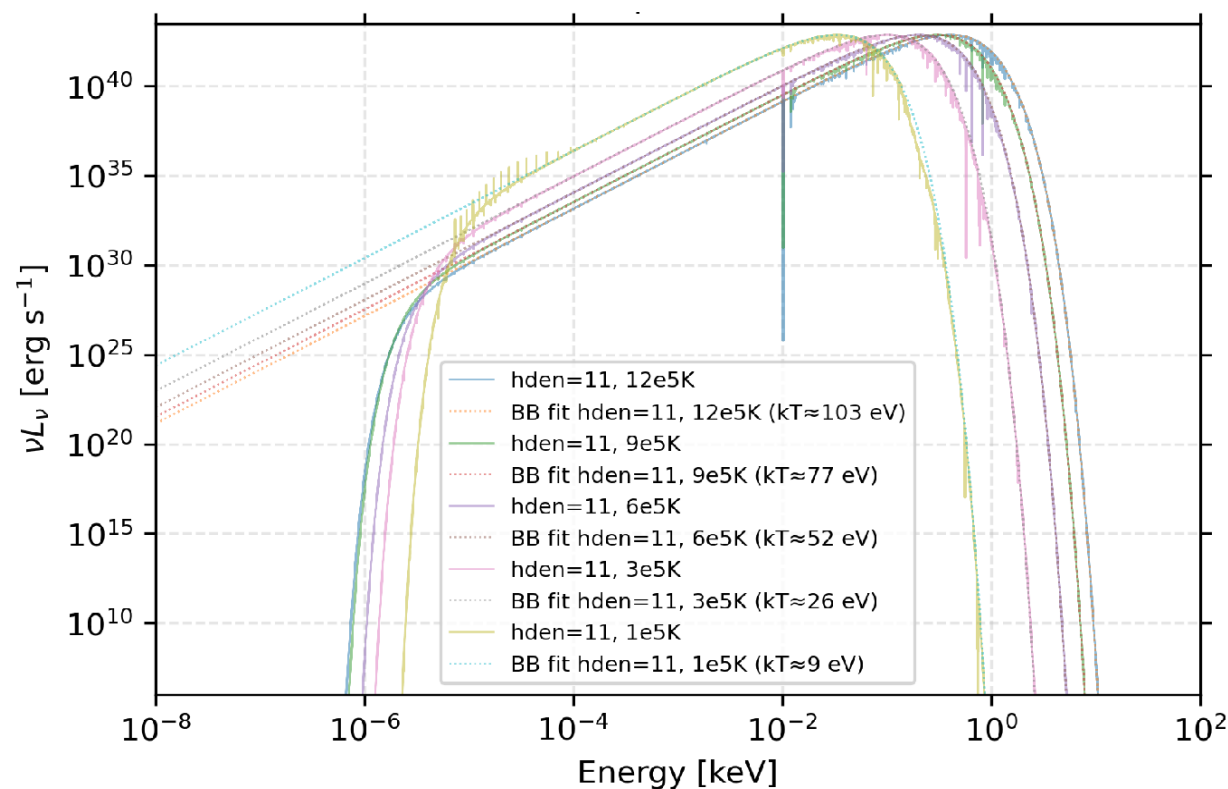
- Strong absorption/emission line variability – lines deepest/broadest at peak
- Rapid ionization changes during bursts
- Evolution consistent with expanding, recombining plasma



Plan

- Build a self-consistent physical model of QPE spectra using CLOUDY
- Capture time-dependent ionization and expansion
- Test the homologous expansion scenario
- Reproduce key observational diagnostics:
 - Evolution of absorption line depths and widths
 - Comparison of pre/during/post burst states
- Direct comparison to Ansky spectra

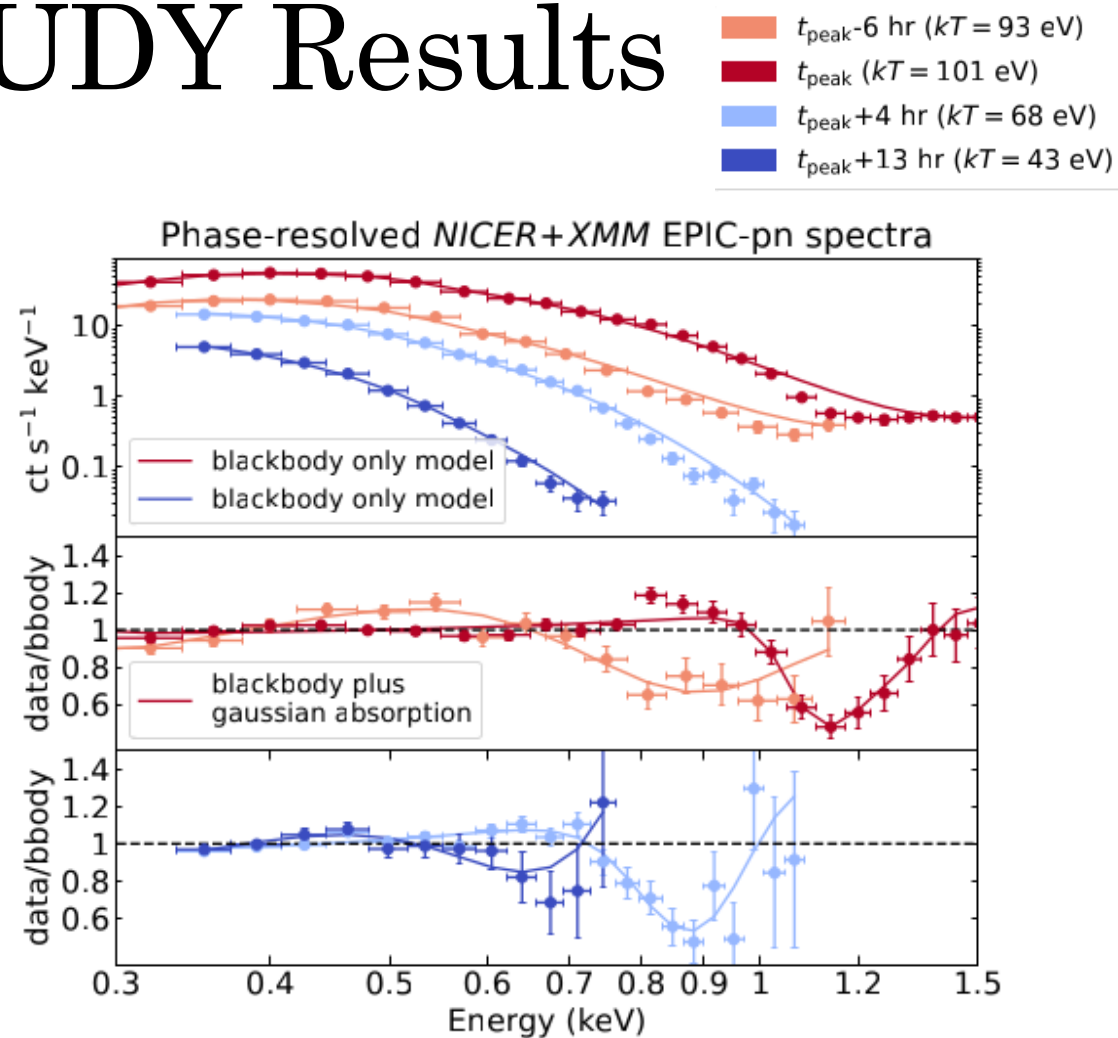
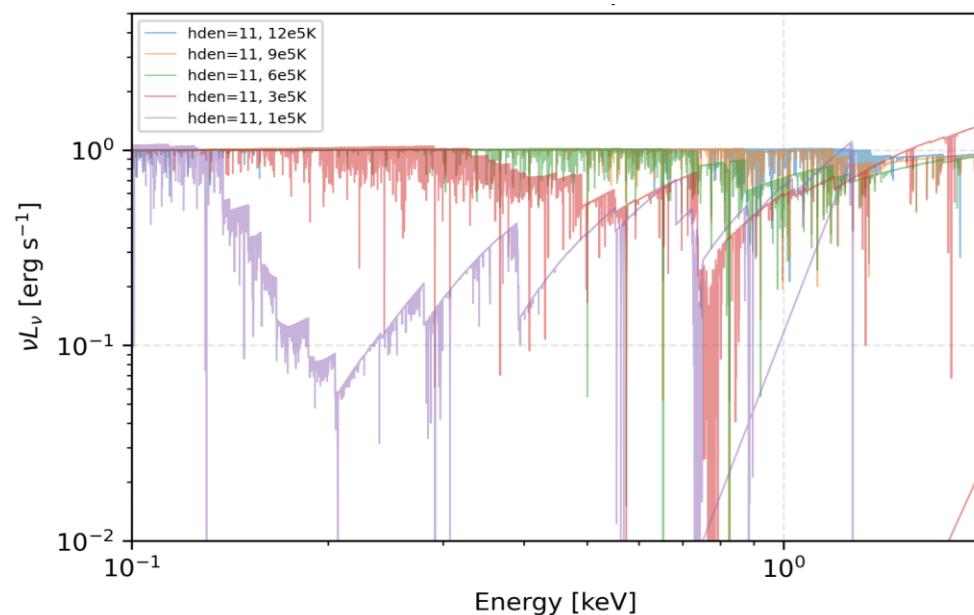
Preliminary CLOUDY Results



- Varying local density: higher n, lower L
- Changing column density: optical depth
- Changing temperature of ionizing source: spectrum expansion to higher/lower energies

Preliminary CLOUDY Results

- Typical values: 10^5 K, 10^{14} cm 3 , 10^{11} cm $^{-3}$



Future Steps

- Build a grid of models covering density, turbulence, geometry...
- Comparison with XMM-Newton data of Ansky:
 - line depth vs time evolution during a burst
 - line width vs centroid correlations
 - RGS spectrum with O/N features
- Forecast for ULTRASAT/QUVik detectability – or how to best link to future observations?
- Use line evolution to constrain geometry/kinematics – What can that tell us about the possible origins of QPEs?