The Deep Chandra Campaign to Observe the JWST North Ecliptic Pole Time Domain Field

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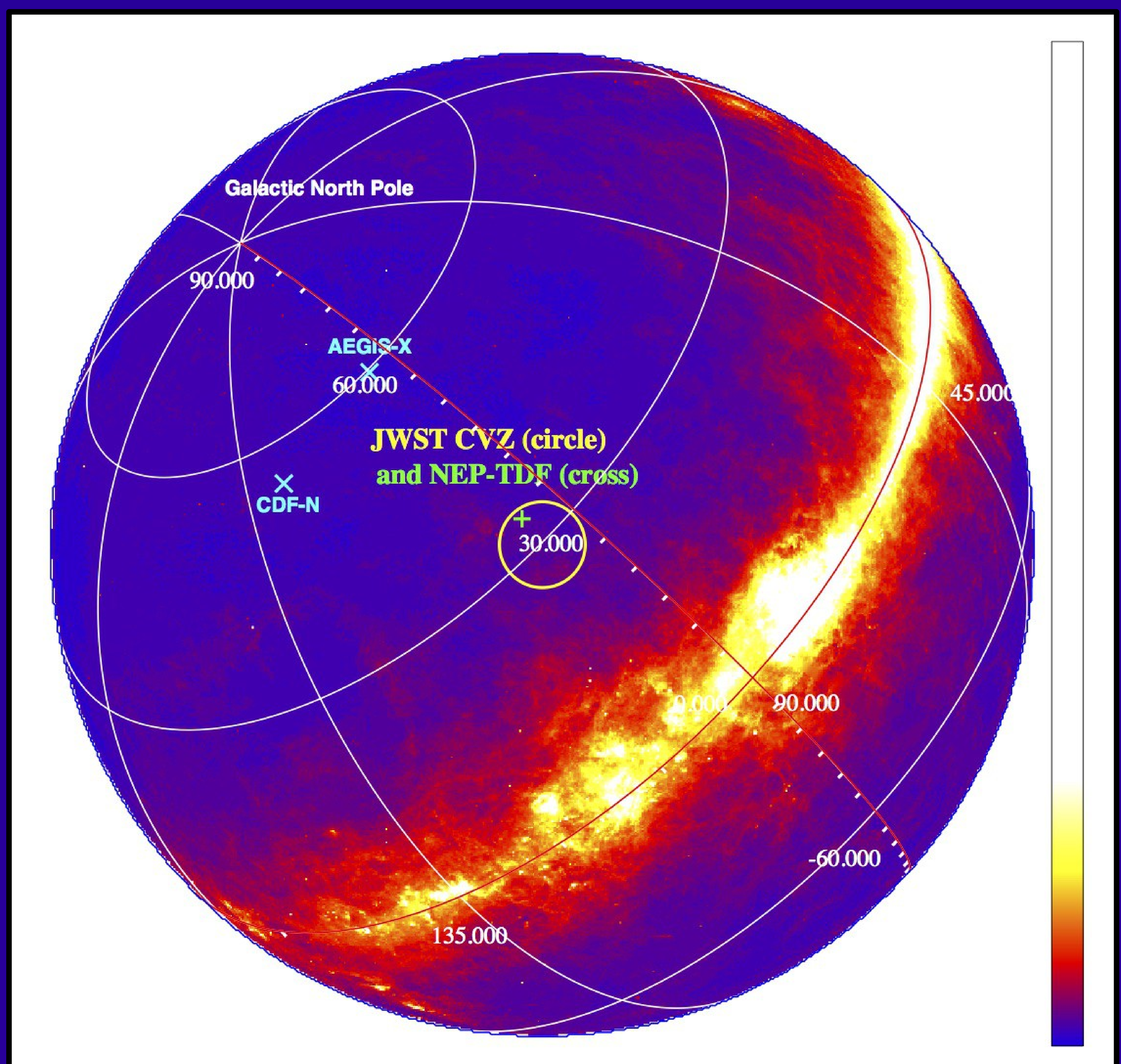
What is JWST-NEP-TDF?



The James Webb North Ecliptic Pole Deep Time Domain Field (**JWST-NEP-TDF**) is a Guaranteed Time Observer (GTO) field planned for observation shortly after JWST launch (PI Windhorst; GTO 1176). Thanks to its position in the JWST continuous viewing zone (CVZ), its low infrared background and lack of bright interloper objects, JWST-NEP-TDF is the very best field for time domain astronomy that takes advantage of JWST's ability to probe large cosmic lookback times. We anticipate these qualities will also make the deepest possible JWST co-adds due to repeat visits over the mission.

X-Ray Synergy with Chandra

Only Chandra has the angular resolution and faint-source sensitivity to match JWST. We are in the process of a multi-cycle campaign to develop JWST-NEP-TDF in X-rays with Chandra/ACIS-I. We have recently completed the first **300 ks** (Cycle 19; PI Maksym) within the past month. By the end of 2019 (Cycle 20; PI Maksym), we anticipate a total of **540 ks**.

Deep observations now will set a baseline for follow-up of X-ray counterparts to JWST-detected transients. At very high redshifts, rest-frame UV will be observed in O/IR. These may include:

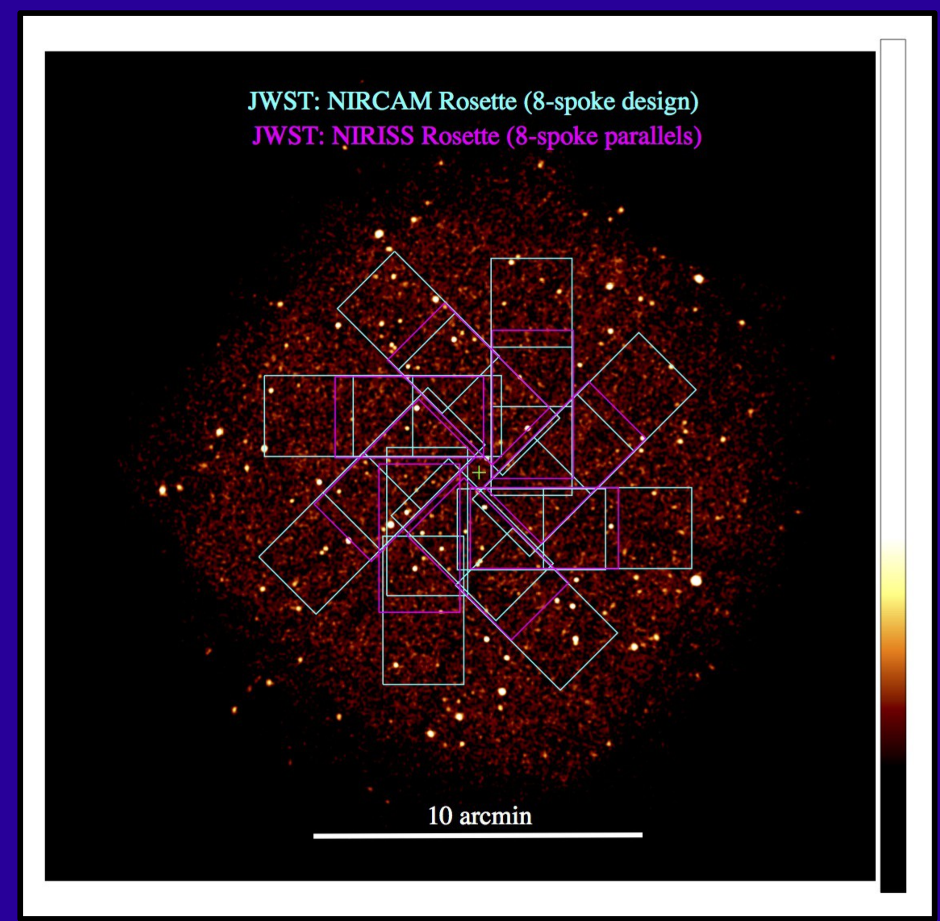
TDEs – Superluminous supernovae – NS-NS mergers – Pair production supernovae
High-*z* AGN Variability – Changing Look Quasars

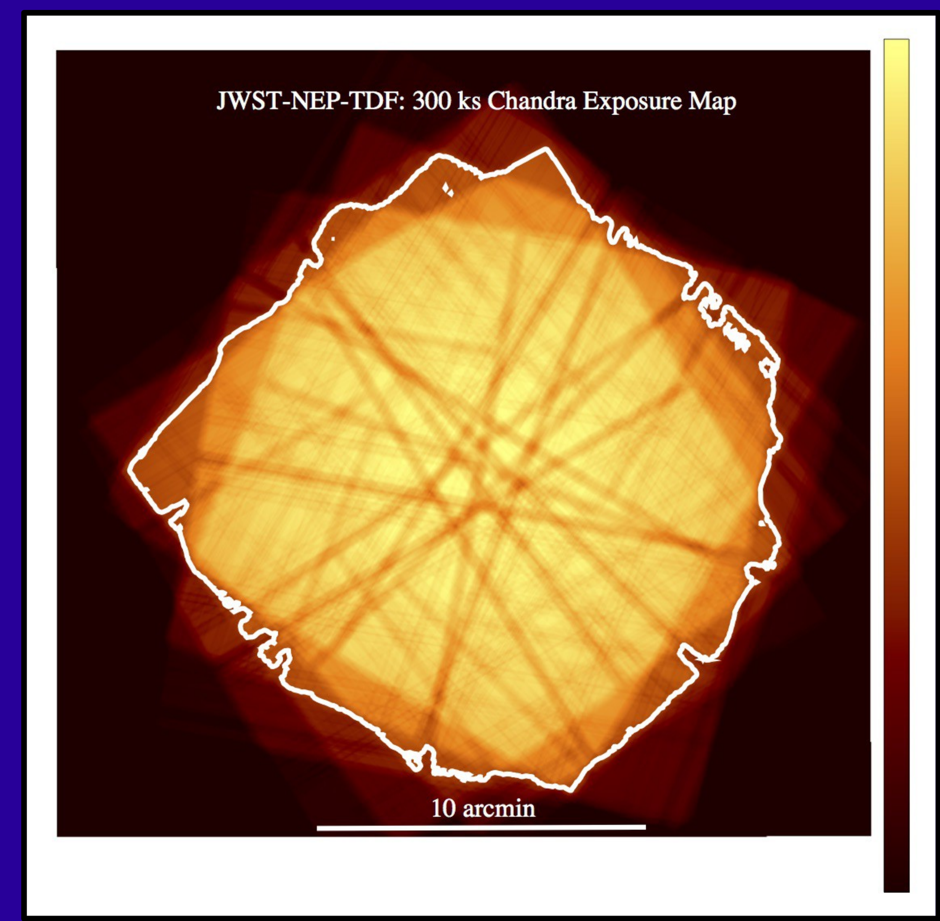
JWST can expect to find *all* counterparts to Chandra-detected X-ray sources, enabling fully complete stacking analysis of the unresolved X-ray background.

Other deep Chandra fields (e.g. CDF-S, CDF-S, AEGIS-X) can expect visits by JWST, but will be limited by severe JWST visibility constraints.

These data will be matched by a deep multiwavelength dataset including HST (see Poster #363.14, Jansen et al), as well as LBT/LBC, Subaru/HSC, VLA, VLBI, IRAM and more.

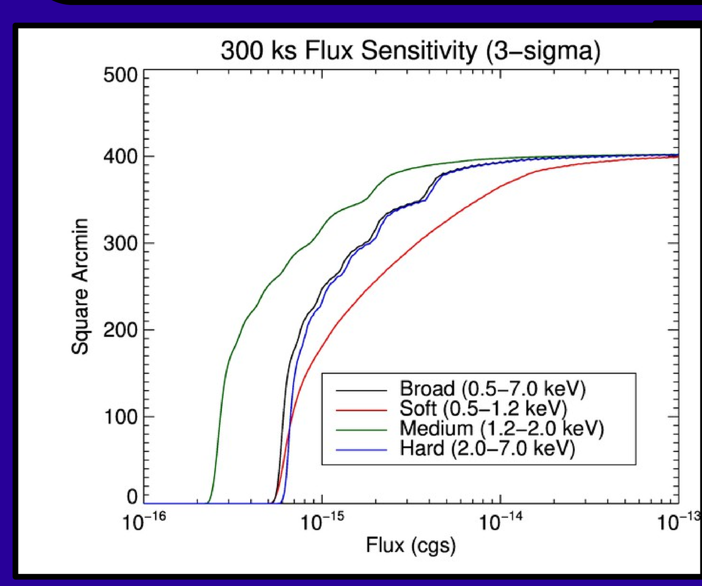
JWST-NEP-TDF/Chandra The First 300 ks

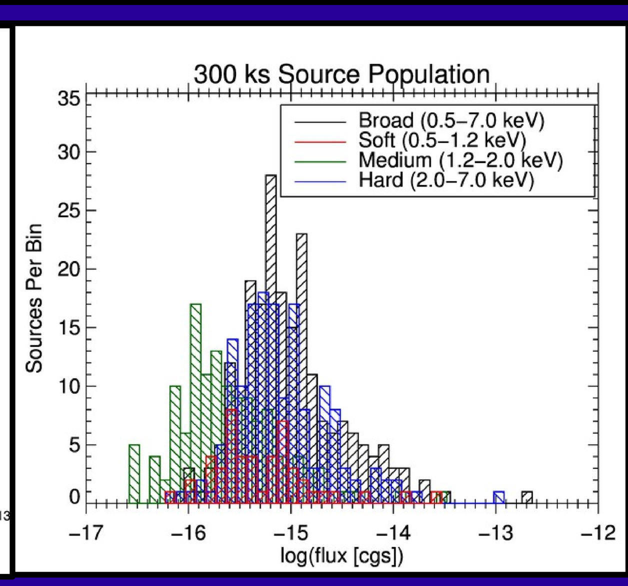


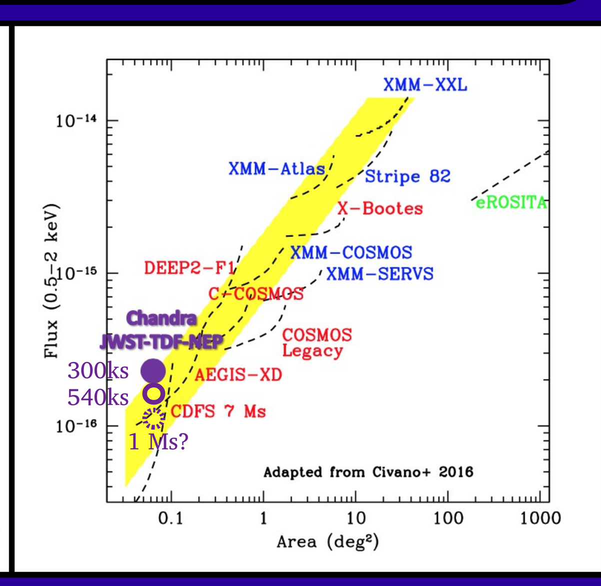


Above, Left: Comparison of the first 300ks of Chandra with one possible 8-spoke rosette configuration for JWST. Due to its position in the CVZ, JWST NIRCAM photometric images can be constructed with parallel NIRISS slitless spectroscopy overlapping previous epochs at 180° roll. Currently 4 deep spokes are planned at 90° angles (GTO 1176; ~46 hrs), plus a shallower 45° offset spoke (GTO 1255; PI Milam). With modest adjustments for roll, the ACIS-I FOV is well-matched to the planned JWST rosette.

Above, Right: Exposure map for the co-added 300ks of Chandra/ACIS-I. White contours indicate exposure levels at 50% of the maximum value, which includes all regions of reduced exposure due to (dithered) chip gaps.





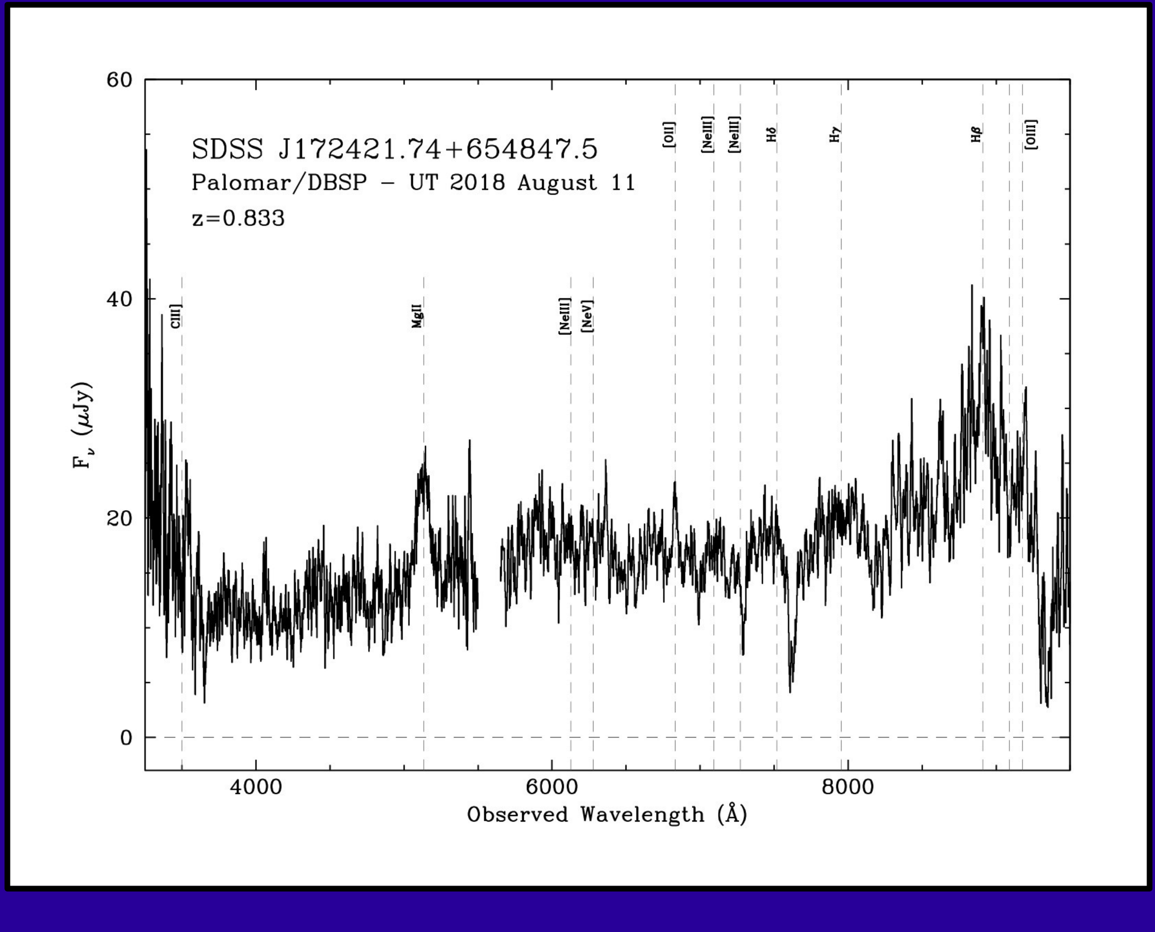


Above, Left: Flux sensitivity curves for Chandra Source Catalog (CSC) standard bands show that JWST-NEP-TDF/Chandra reaches ~few x 10^{-16} erg s^{-1} cm^{-2} across most of the field.

Above, Center: We have detected [218, 49, 134, 158] sources independently in the [broad, soft, medium, hard] bands, of which [145, 21, 67, 1] have $>3\sigma$ significance. When the catalogs are merged, we expect almost all sources to have broad-band counterparts.

Above, Right: Field depth and area compared to other surveys. Increasing depth to ~1 Ms will make JWST-NEP-TDF/Chandra competitive with AEGIS-X, set optimal baseline limits for anticipated monitoring variability, and provide an optimal counterpart to the deepest-possible JWST field.

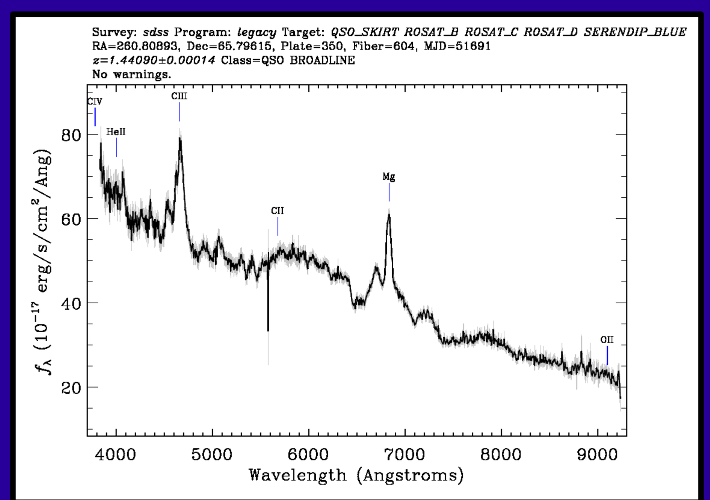
A Bright X-ray Transient!

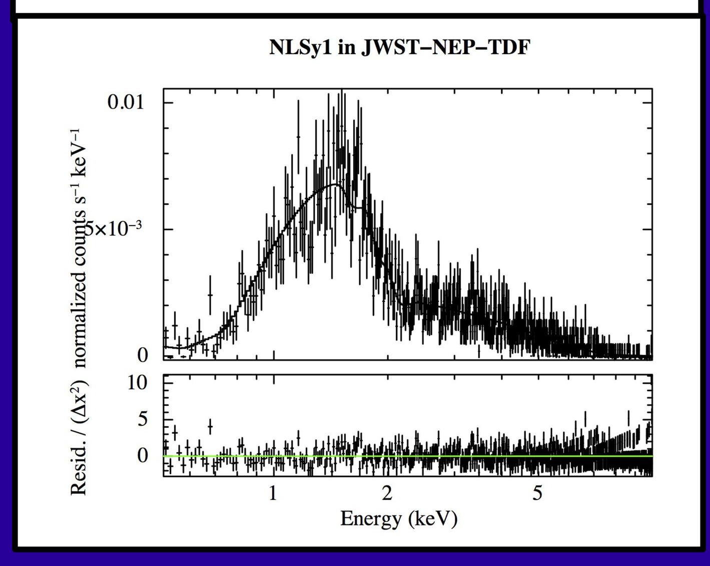


We have identified our first X-ray flare near the periphery of the field. In <3 months, a source increasedin F_X by x7, from ~2×10^{43} erg/s to ~1.4×10^{44} erg/s. This is comparable to what is seen in Changing Look Quasars (though unfortunately no pre-flare optical spectroscopy is available). Post-flare Palomar spectroscopy shows the optical counterpart is consistent with a bright AGN at $z=0.833$. There is evidence for complex intervening Balmer absorption in the line of sight. Analysis of ground-based optical and Swift UV follow-up is ongoing.

See ATel#11906 and ATel#12049 for further details.

Jet Emission from an Iron-Loud NLSy1/FSRQ





The brightest X-ray source in the JWST-NEP-TDF is a NLSy1/FSRQ. At ~0.012 ct/s, we observe ~3000 counts total, or ~560 counts per 50-ks epoch. The prominent rest-UV iron complexes suggest a high accretion rate (see SDSS spectrum, left). The optical spectrum has broad sub-structure which suggests possibly strong outflows or a binary system.

The composite X-ray spectrum is well-fit to a power law ($\Gamma=1.56$), which may vary by ~2σ between epochs (Γ~1.3-1.8). It is consistent with pure jet emission, as might be expected from an FSRQ.

XMM-Newton is needed to study spectral variability. The spectrum is hard enough to suggest the NLSy1/FSRQ is easily detectable by NuSTAR, even out to ~70 keV (rest frame).

References:

Jansen & Windhorst, 2018, PASP, 130, 994, 124001
Maksym et al, ATel #11906
Civano et al, ATel #12049

This work has been supported by Chandra grant G08-19119X