Constraining the AGN torus at cosmic noon

Using high-resolution **JWST imaging** and **simultaneous SED fitting**

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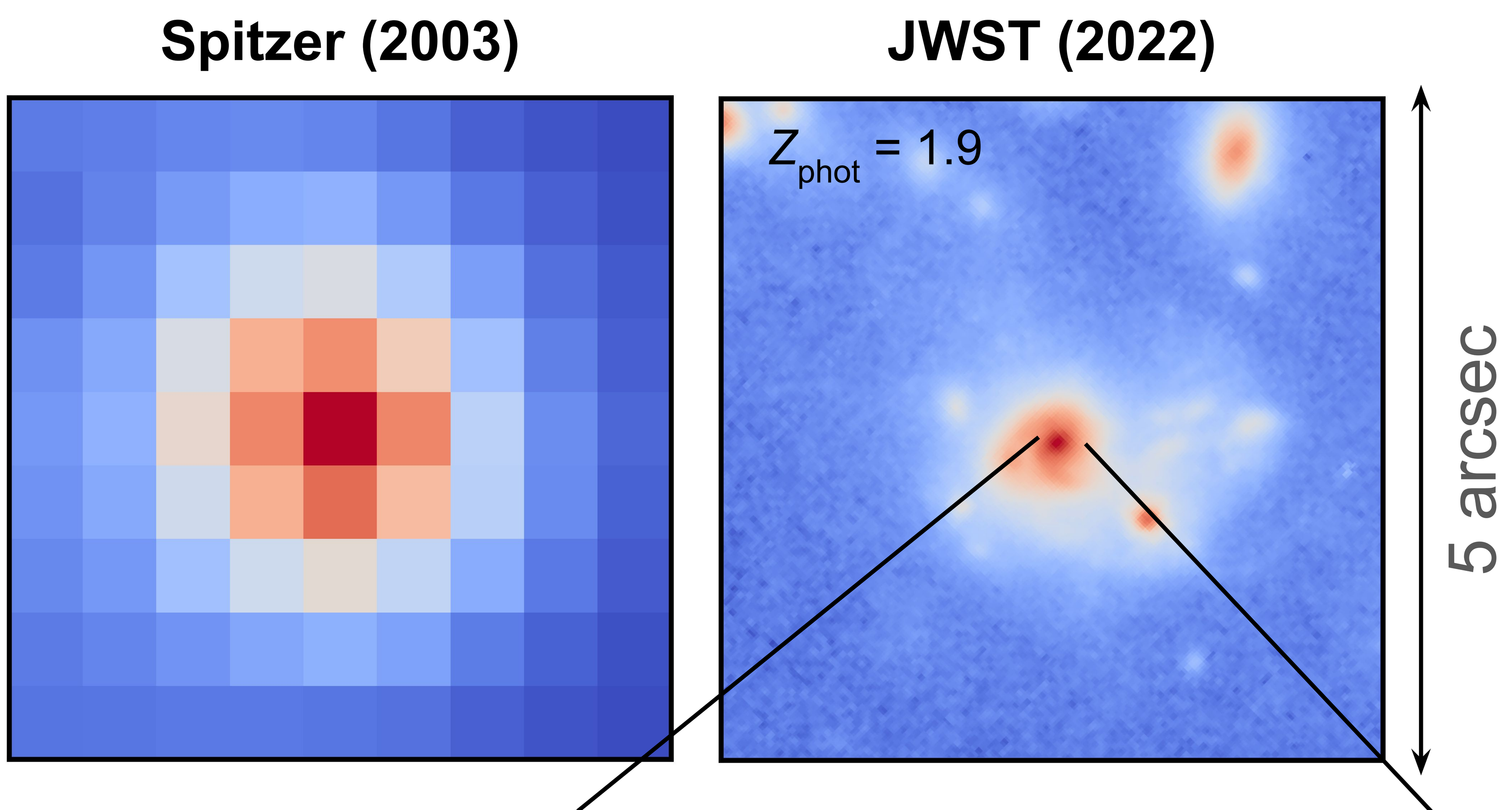
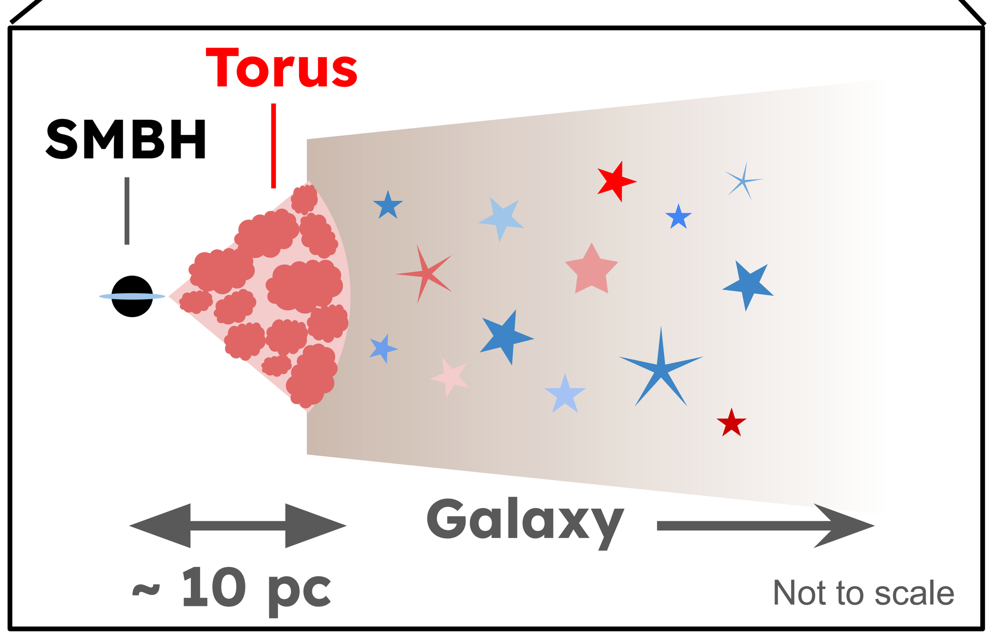


Figure 1: High-resolution JWST imaging in the IR (top right) enables, for the first time, the removal of most host galaxy contamination in faint AGN at z ~ 2, allowing more accurate estimates of IR emission from the central AGN torus (schematic on the right).



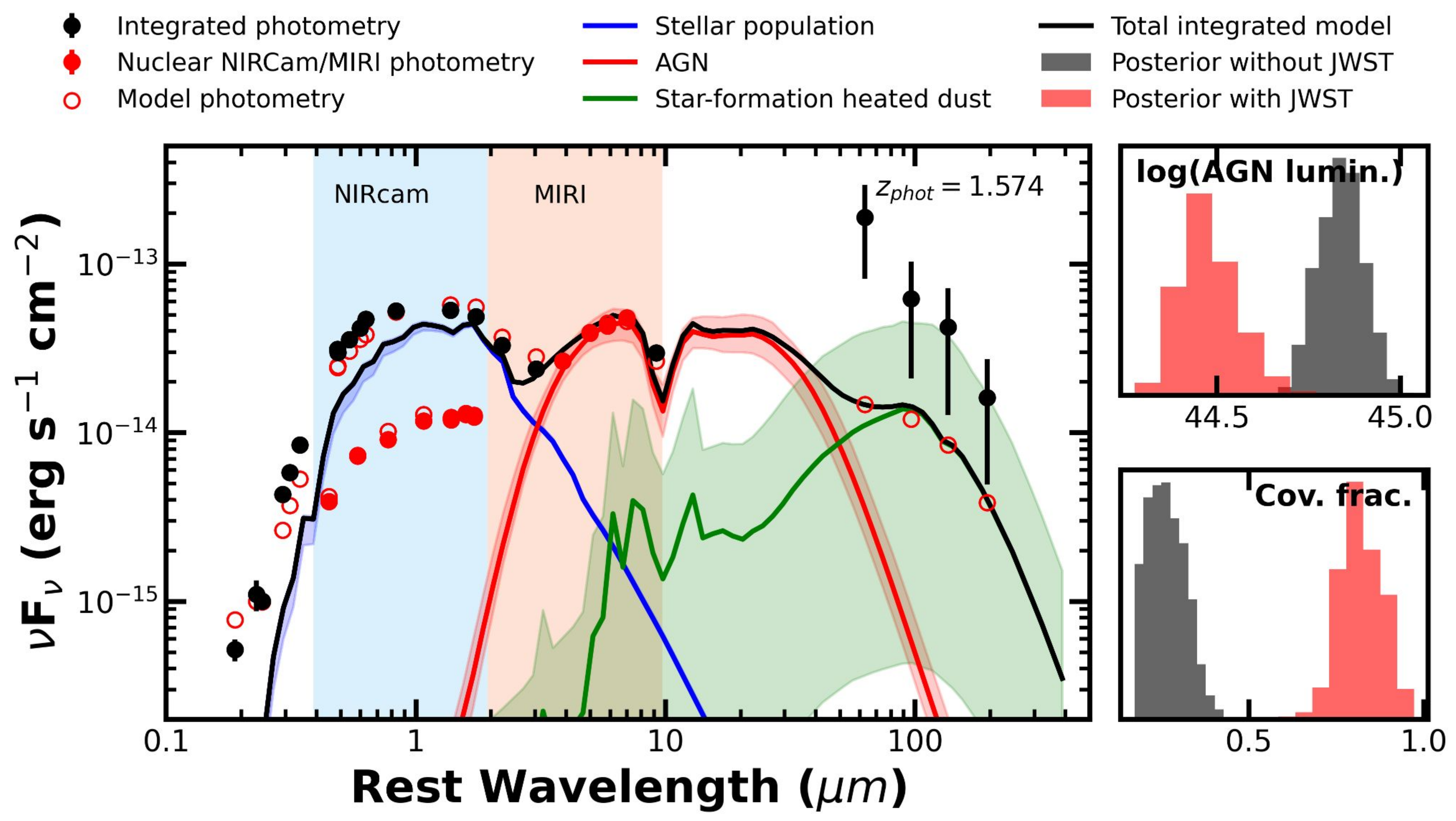


Figure 2: An example SED fit for one of our sources (left) and the posterior distribution of two key AGN parameters (right). The right panels highlight significant differences in posterior values when JWST data (solid red points in left panel) is included, compared to fits without it. Similar differences or improved uncertainties are observed for most sources with JWST photometry.

Do the AGN tori evolve with cosmic time?

The AGN torus is an obscuring structure (~10 pc) of dust and gas surrounding the accretion disc. It is a **bridge between the host galaxy and the material feeding the SMBH**, and thus an important ingredient in our understanding of AGN. The dust and gas in the **host galaxies have evolved significantly** since cosmic noon (z~2). Therefore, it stands to reason that the AGN tori might have **co-evolved** with host properties. **JWST infrared imaging** now allows, for the first time, the separation of host contamination from torus dust and accretion disc emission (Figure 1). We use this new data to **constrain torus parameters at cosmic noon**.

Sample selection

We selected 66 **X-ray sources** with L(2–10 keV) > 10^{43} from the 100 arcmin^2 region of EGS with multi-band infra-red imaging from the **JWST CEERS** program. These sources also have archival **UV to FIR data from the CANDELS and HELP** surveys. Our final sample includes **sources within the redshift range 0.7 < z < 3.5**.

AGN modelling & SED fitting

We construct a set of two SEDs: (i) **UV to FIR photometry integrated over the entire galaxy**, and (ii) **near- and mid-IR photometry of only the nuclear region from JWST**. These SEDs are **fit simultaneously** using a three-component model. The AGN component is shared between the two, while the galaxy component is scaled for the nuclear SED relative to the integrated galaxy SED. This approach ensures a **self-consistent modeling of emission across different physical scales**.

The model has **14 free parameters from 3 components**: (i) stellar emission from a population of given age with a decaying star formation rate (Bruzual and Charlot 03), (ii) AGN emission based on a **two-phase clumpy torus model SKIRTOR** (Stalevski+12, 16), and (iii) galaxy dust illuminated by star-formation (Dale+14).

We use the **Bayesian SED fitting code FortesFit** (Rosario, 19), which allows flexible incorporation of SED models, the exact SEDs specified by the suite of filter bands, priors on all parameters, and fitting using the nested sampling algorithm through Multinest.

Key results

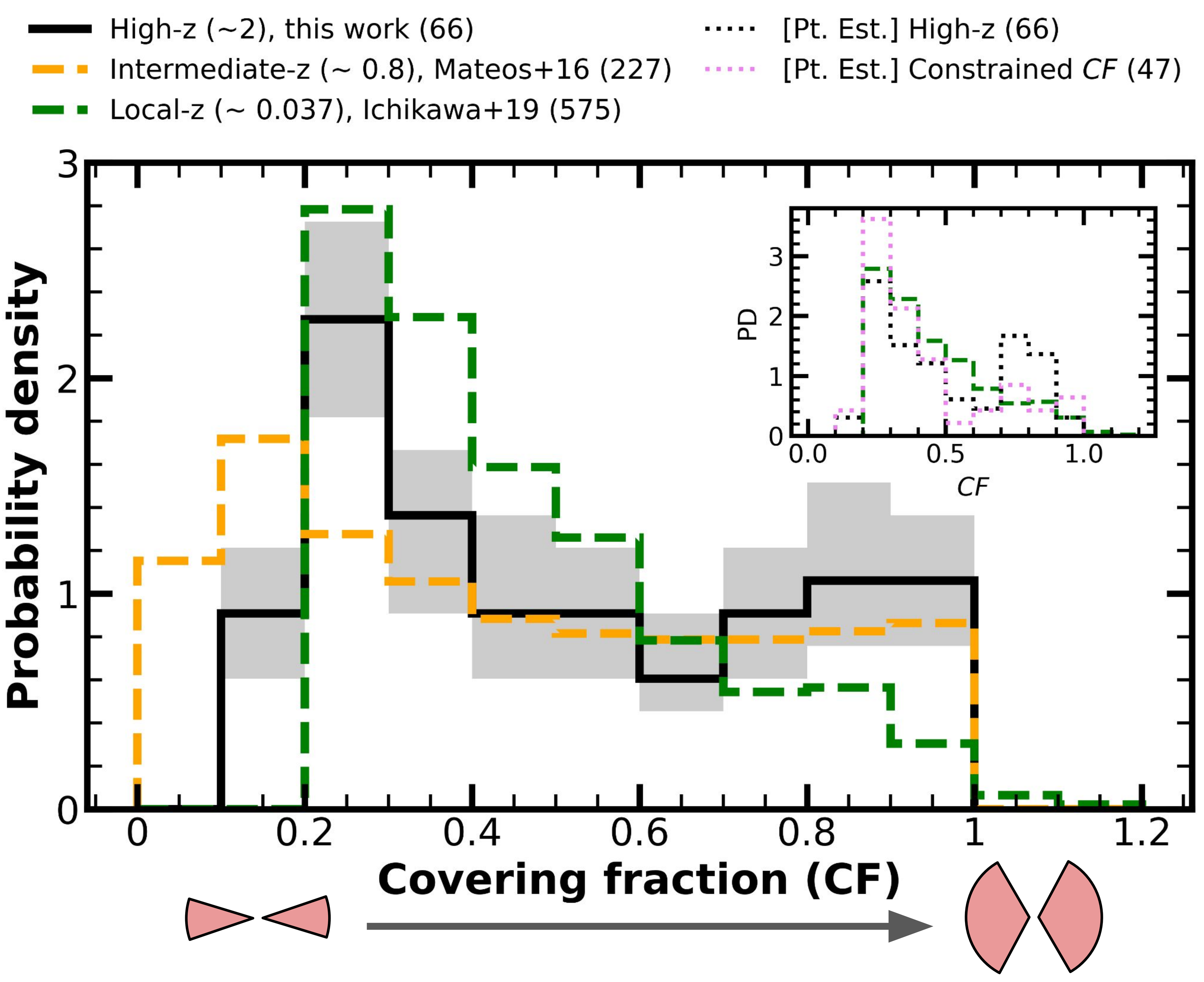


Figure 3: CF distribution for similarly selected AGN samples at different redshifts, showing potential signs of evolution. These differences largely vanish when the full uncertainties in individual CF measurements are excluded, referred here as point estimate (inset).

- Our simultaneous SED fitting framework **significantly improves the constraints** on the AGN torus using **novel JWST imaging**.
- For the first time, we determine the **CF distribution of an AGN sample at cosmic noon** (z~2) comparable with **equally luminous AGN in the nearby Universe**.
- We find that the CF distribution of these two populations is **consistent with each other**, suggesting a **lack of evolution** in AGN tori despite strong evolution in AGN host properties (eg. Rosario+12).
- We find that the inference of population level properties can be significantly driven by factors like **choice of model, incorporating uncertainties from SED fitting, and choice of priors**.
- If unaccounted for, these factors can lead to **population statistics that may be interpreted as signs of evolution** in AGN tori.
- We are applying these SED fitting techniques to a **larger sample of AGN in COSMOS-Web** using different selection methods.

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