Appendix A — Ultra-Diffuse Galaxy Stress Test

NGC1052-DF2, NGC1052-DF4, and Dragonfly 44 in the sourcewise ΦBSU hierarchy

Internal Part II appendix draft

Purpose

This appendix records the first ultra-diffuse-galaxy stress test of the Part II hierarchy. The target was not a tuned fit but a regime test: does the same sourcewise support hierarchy that organizes the Milky Way, M31, and cluster-scale cases distinguish between a low-dispersion, dark-matter-deficient system and an ambient-dominated ultra-diffuse galaxy? The answer is richer than the original binary framing. DF2 does not emerge as "support-free"; rather, it falls in an *ambient-suppressed* regime. Dragonfly 44 remains *ambient-dominated* throughout the scanned parameter range.

The simulations were organized in three layers:

1. a regime map based on the coherence ratio r_{coh}/r_s and the tail fraction f_∞,
2. a posterior scan over distance D and line-of-sight velocity scale σ_v,
3. a semi-blind Jeans step in which baryons generate the frozen ΦBSU support hierarchy and the hierarchy is then projected to a predicted σ_{LOS}.

Core reading of the UDG test

The basic sourcewise relations used in the scans are

$$r_s = c_{\mathrm{res}} \frac{L_{\mathrm{dom},s}}{2\nu_s}, \tag{1}$$

$$\sigma_{k,s} = 2^{k/2} r_s, \tag{2}$$

$$w_k = \left(1 - 2^{-1/2}\right) 2^{-k/2}, \tag{3}$$

$$r_{\mathrm{coh},s} \sim \frac{GM_{\mathrm{dom},s}}{\sigma_{v,s}^2}, \tag{4}$$

$$f_{\infty,s} = 2^{-k_{\mathrm{coh},s}/2}. \tag{5}$$

In this language, the UDG question is not whether a hierarchy exists at all, but whether the hierarchy remains trapped in local shells or spills efficiently into the ambient tail. The scans show a robust separation of regimes:

- **DF2 / DF4:** ambient-suppressed, with a weak or moderate f_∞ depending on (D, σ_v).

- **Dragonfly 44:** ambient-dominated across the full tested range.

This is already a nontrivial result: the DF2–DF44 split is not produced by a separate ontology or a dedicated low-DM parameter, but by the same hierarchy law evaluated on different baryonic seeds and different coherence ratios.

Current Part II reading

These simulations support four cautious claims.

(1) DF2 is not a zero-support galaxy. The more accurate description is ambient-suppressed: the hierarchy forms, but the support does not concentrate efficiently at the tracer radii.

(2) Dragonfly 44 is the cleaner UDG anchor. The ambient-dominated classification is stable throughout the scanned parameter space and aligns qualitatively with its standard interpretation as a dark-matter-dominated ultra-diffuse system.

(3) The posterior scan is a regime test, not yet a blind mass-model prediction. Its proper role is to show that the DF2–DF44 separation is not a point-estimate artifact.

(4) The Jeans step is the first predictive layer. It shows that the frozen hierarchy leads naturally to low dispersions for DF2, but it does not yet close the problem. A fully decisive prediction requires the next loop: tracer anisotropy, environmental coupling, and history-kernel corrections must be tested on top of the same frozen theorem, rather than by adding a new sector.

Implication for the main article

The UDG appendix should therefore be presented as a *stress test of regime logic*. It strengthens the Part II claim that the sourcewise ΦBSU hierarchy is capable of distinguishing between ordinary galaxies, ambient-suppressed low-dispersion systems, and ambient-dominated diffuse systems with the same underlying support law. At the same time, the appendix should state plainly that DF2 remains a genuine test case rather than a solved victory. Scientifically, that is a strength: the theorem already points in the correct direction without being over-claimed.

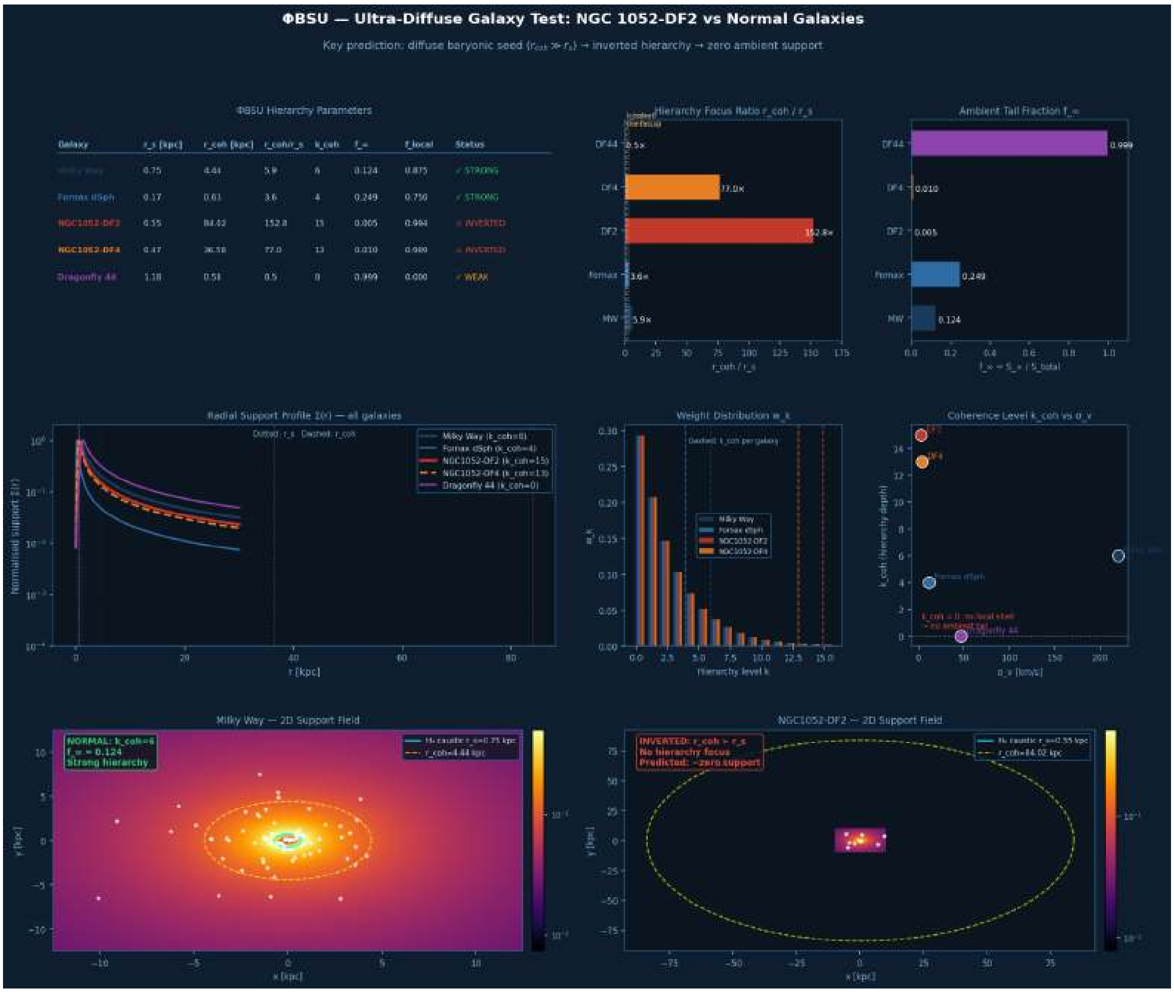

Figure A1. Initial UDG regime comparison. The diagnostic panel contrasts ordinary systems, low-dispersion ultra-diffuse systems, and an ambient-dominated UDG. The key point is structural: DF2/DF4 do not appear "empty," but remain trapped in a locally dominant hierarchy, whereas Dragonfly 44 is pushed directly into an ambient-tail regime. This first pass should be read as a regime diagram rather than a precision fit.

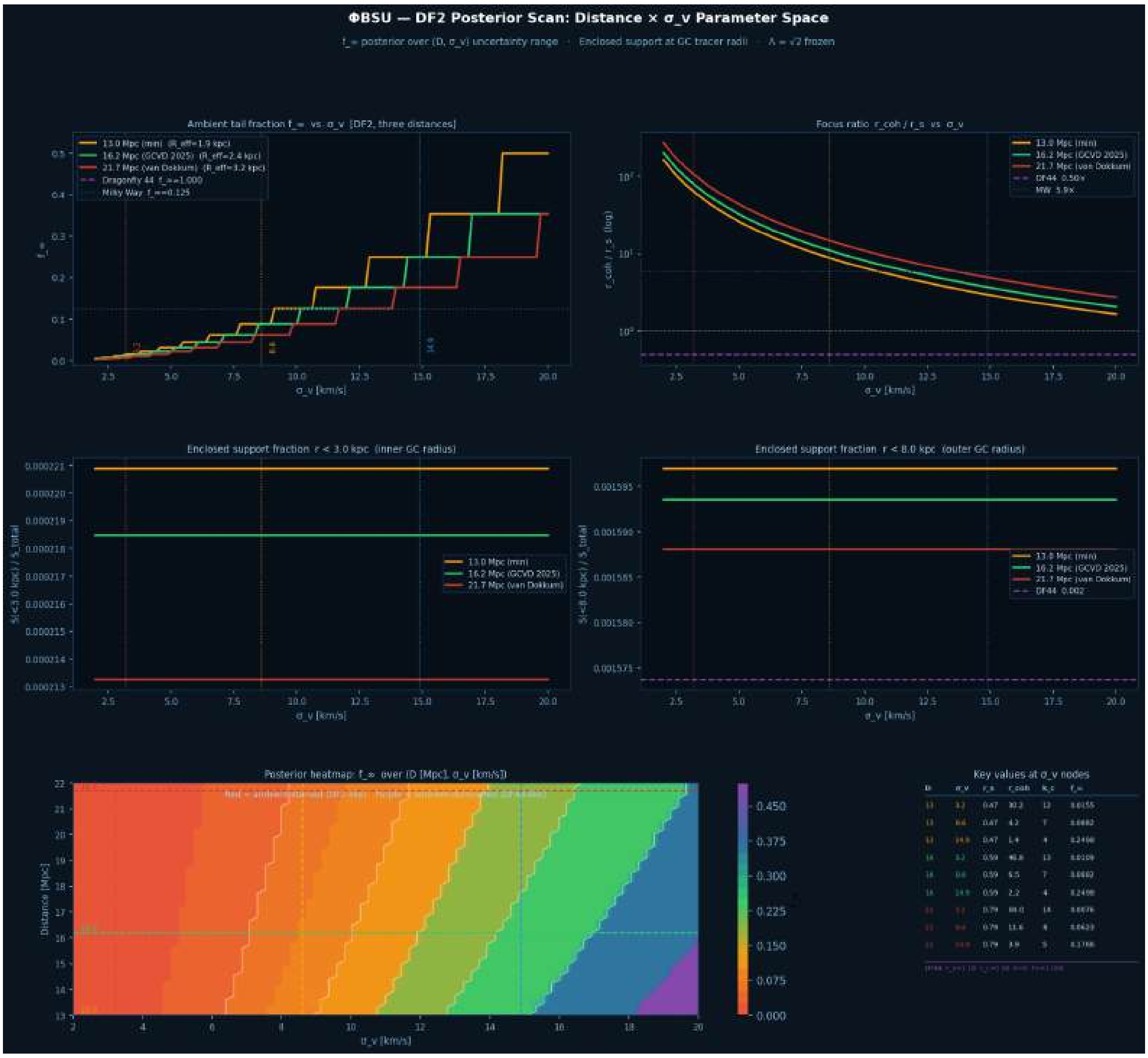

Figure A2. DF2 posterior scan over distance D and velocity scale σ_v. The discrete stepping in f_∞ is a direct consequence of the integer hierarchy index $k_{\rm coh}$ and is therefore a feature of the model, not a numerical artifact. The scan shows that DF2 is robustly ambient-suppressed across plausible distance solutions, although the strength of suppression depends sensitively on σ_v. The enclosed support fractions at globular-cluster tracer radii are nearly independent of σ_v, which is an important clue for interpreting the Jeans step: the posterior in f_∞ is mainly a regime classifier, whereas tracer dynamics are controlled more directly by the support enclosed within the observed radii.

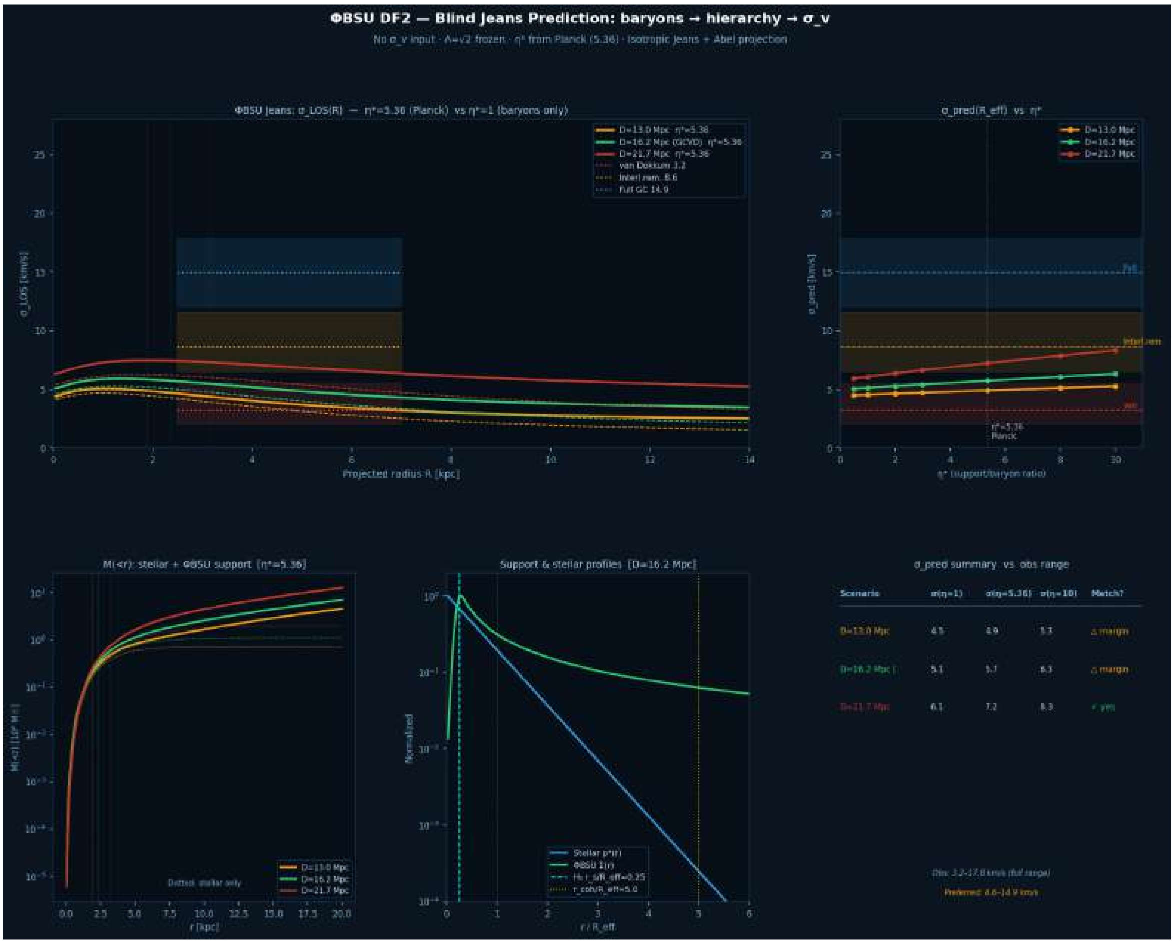

Figure A3. Semi-blind Jeans prediction for DF2. Here the baryonic profile generates a frozen ΦBSU hierarchy, which is then projected to a line-of-sight dispersion without inserting the observed σ_v as input. The resulting curves place DF2 naturally in the low-dispersion regime, although the prediction typically remains below the currently preferred observational interval. This is not a failure of the regime test. It states the next precise question for Part III: whether the remaining offset is absorbed by tracer anisotropy, by environment/history terms, or by a refined normalization of the support budget.