

IMPLEMENTATION CHECKLIST

UDEL recoil signature — operational procedure

BY

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A step-by-step operational checklist for running the minimal first test on the Hydra–Centaurus / Great Attractor basin using Cosmicflows-4. Each step has a defined output.

1 Define the target clearly

Pick one basin only for the first pass: Hydra–Centaurus / classical Great Attractor direction. Do not try to solve the whole multi-basin universe yet. A recent 2026 study argues the classical Great Attractor is not one dynamically dominant object — which makes it even more important to phrase this as a basin test, not a 'single monster object' test.

***Output of this step:** A one-line basin definition: sky region, approximate radial range, whether Norma is included or excluded in your working mask.*

2 Gather the first dataset

Use Cosmicflows-4 as the first working catalog. It compiles distances for 55,877 galaxies assembled into 38,065 groups, and it is explicitly intended to support peculiar-velocity inference. Plan a later comparison with the DESI Peculiar Velocity Survey.

***Output of this step:** One working table with: RA, Dec, redshift, distance, distance uncertainty, and group ID if available.*

3 Build the basin mask

Create a sky-and-distance selection for galaxies likely associated with the target basin. For the first pass, use: an angular cone or polygon around the Hydra–Centaurus direction, minimum and maximum distance cuts, and an optional exclusion of obviously unrelated foreground clutter. Do not over-engineer the mask yet.

***Output of this step:** A boolean selection in_basin in $\{0,1\}$ for each galaxy.*

4 Split into 3 shells

Use three radial shells only: near, middle, far. The goal is not high resolution — the goal is to see whether the basin appears to strengthen toward low redshift. Choose shell boundaries so each shell has enough objects to be statistically usable. Peculiar-velocity data stability matters more than elegant binning.

Output of this step: A shell label k in $\{1, 2, 3\}$ for each selected galaxy.

5 Compute the first observable

For each galaxy, estimate the line-of-sight peculiar velocity: $v_{pec,||} = v_{obs} - H(z_i) * d_i$. Write down exactly which background $H(z)$ you use — Planck-like LambdaCDM or a low- z approximation. Do not leave that ambiguous.

Output of this step: A column $v_{pec,||}$ with uncertainty if you can propagate it.

6 Make the first sanity plots

Before any reconstruction, generate these three plots: (A) peculiar velocity vs distance inside the basin mask; (B) sky map of radial peculiar velocities, colored by sign and magnitude; (C) histogram of peculiar velocities by shell. These first plots are not proof, but they immediately tell you whether the mask, shelling, or signal is coherent.

Output of this step: 3 quick diagnostic figures.

7 Reconstruct a smoothed flow field

Move from radial values to a smoothed basin picture. A practical first pass can use smoothing/interpolation in 3D or a simpler radial-cone approach. Define the smoothed velocity field $v(x)$, then compute convergence via divergence: $\Theta(x) = \text{grad} * v(x)$, where $\Theta < 0$ means attractor-like convergence.

Output of this step: One convergence map per shell.

8 Define the core basin metric

For each shell k , compute the basin-depth statistic: $A_k = -\langle B, k \rangle$. This is the main test statistic. Larger A_k = deeper or stronger basin. First key check: does $A_1 > A_2 > A_3$, or

does the near shell look systematically deeper than expected?

Output of this step: A 3-number summary: A_1, A_2, A_3 with uncertainties if possible.

9 Add a basin-center check

For each shell, find the point of strongest convergence $x_{\{c,k\}}$. Then compare $\Delta x_{\{c,k\}} = x_{\{c,k\}} - x_{\{c,1\}}$. If the basin center jumps around wildly across shells, the reconstruction may be unstable or the target may not be one coherent structure.

Output of this step: A table of basin centers by shell.

10 Add a mass-comparison layer

Estimate a rough flow-inferred pull vs mass-inferred pull. Define a placeholder ratio: $R_k = P_k(\text{flow}) / P_k(\text{mass})$. $R_k \approx 1$ means mapped mass explains pull. $R_k > 1$ means flow suggests stronger pull. Do not oversell this step early — the first version can be rough.

Output of this step: One rough pull-to-mass ratio per shell.

11 Compare against the standard expectation

You need a null, even if simple. Assume standard growth: no recoil, ordinary structure growth, no cross-layer mass reinforcement. Ask: is the observed shell trend unusual? Is the basin too deep at low redshift? Is the pull-to-mass ratio unexpectedly high? Later, use mock catalogs or published growth expectations for a stronger null.

Output of this step: A simple residual summary: $\Delta A_k = A_k(\text{obs}) - A_k(\text{LambdaCDM-like})$.

12 Define the early success criteria

The test is worth pursuing further if any of these appear: (1) late-time shell deepening stronger than standard expectation; (2) a coherent convergence center across shells with excess low- z strength; (3) a pull-to-mass ratio that trends upward toward low redshift; (4) the same pattern repeating in a second basin.

13 Define the early kill criteria

Stop or heavily downgrade the idea if: shell-to-shell deepening is fully ordinary within errors; the basin center is unstable and reconstruction looks noisy; pull-to-mass mismatch disappears under basic controls; the apparent signal is obviously caused by distance errors or selection effects. That does not kill UDEL as a whole — it only kills this specific proof path.

14 Best Practical Order of Work

1. Cosmicflows-4 ingest
 2. Basin mask
 3. Three shells
 4. Peculiar velocity calculation
 5. First sanity plots
 6. Smoothed convergence map
 7. Basin depth A_k
 8. Basin-center stability
 9. Rough pull-to-mass comparison
 10. Only then decide whether DESI PV should be brought in as a second-stage cross-check
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15 The One-Sentence Mission Statement

Use Cosmicflows-4 to measure whether the Hydra–Centaurus / Great Attractor basin deepens toward low redshift more than standard structure growth predicts, and whether its flow-inferred pull begins to exceed what mapped mass reasonably supports.