CBU/UU NEUTRINO CRACKER — Module 64 Proof Bundle - Evan Wesley x Vivi The Physics Slayer!

A self-contained mathematical summary of v38–v64

Executive Summary

Across modules v38–v64 we established, quantified, and cross-stressed a minimal parametric picture that reconciles the observed (toy/profiling-based) *delta-scan* responses with systematic-correlation hypotheses. The key outcomes are:

1. **Correlation-only is mathematically impossible** to reach the observed targets d_t (v38,v40–v42): even with fully correlated blocks, the ceiling is $\Delta\chi^2_{\rm on} = 15.1748$, while all targets are $d_t \ll \Delta\chi^2_{\rm on}$.
2. A **Reality Bridge** model—an extra damping factor $\beta \in (0,1)$ layered on top of correlated blocks and controlled by a robust-loss fraction $\alpha_{\rm L} \in [0,1]$—*does* close all targets simultaneously.
3. With a single baseline damping $\beta_{\rm base} = 0.829$ (product of mechanism factors) the per-target robust fractions
$$\alpha_{\rm L}(t) = 1 - \frac{d_t}{\Delta\chi^2_{\rm on}\,\beta_{\rm base}}$$
reproduce the four targets to within sub-percent rounding.
4. A **single global** $\alpha_{\rm L}$ cannot match four distinct d_t simultaneously if channel totals are preserved; the minimal bounded-drift solution requires an $\mathcal{O}(0.56)$ fractional capacity band.
5. **Mode asymmetry** (different β for ν vs $\bar{\nu}$) is highly degenerate: as long as the *totals* per channel are conserved, a wide range of $\Delta\beta = \beta_\nu - \beta_{\bar{\nu}}$ is feasible and orthogonal to the core closure.

1 Anchors, Notation, and Targets

Let

$$\Delta\chi^2_{\rm off} = 29.4931, \qquad \Delta\chi^2_{\rm on} = 15.1748, \qquad \beta_{\rm base} = 0.829. \tag{1}$$

These "off"/"on" anchors come from the block-correlation stress (v43–v46). The four target combined point-tests (ALL channels at $\delta \in \{192^\circ, 198^\circ\}$) are

$$d_{\rm v38} = 3.9150, \quad d_{\rm v40} = 1.2918, \quad d_{\rm v41} = 1.0980, \quad d_{\rm v42} = 1.2383. \tag{2}$$

Unless otherwise noted, all $\Delta\chi^2$ are for the combined four-channel sum.

2 Correlation-Only No-Go (v45–v46)

Define a correlation fraction $f \in [0,1]$ and correlation-only interpolation

$$\Delta\chi^2_{\rm corr}(f) = (1-f)\,\Delta\chi^2_{\rm off} + f\,\Delta\chi^2_{\rm on}, \qquad f \in [0,1]. \tag{3}$$

Then $\Delta\chi^2_{\rm corr} \in [\Delta\chi^2_{\rm on}, \Delta\chi^2_{\rm off}]$ with *minimum* $\Delta\chi^2_{\rm on}$ at $f = 1$. For any target d the correlation-only feasibility requires $d \geq \Delta\chi^2_{\rm on}$. But each observed $d_t < \Delta\chi^2_{\rm on}$, so no f can satisfy $\Delta\chi^2_{\rm corr}(f) = d_t$.

Therefore, correlation-only is impossible. A convenient diagnostic is the (unphysical) $f_{\mathrm{corr\,only}}$ one would need if $\beta \equiv 1$:

$$f_{\mathrm{corr\,only}}(d) = \frac{d - \Delta\chi^2_{\mathrm{off}}}{\Delta\chi^2_{\mathrm{on}} - \Delta\chi^2_{\mathrm{off}}} \notin [0,1] \quad \text{for } d < \Delta\chi^2_{\mathrm{on}}. \tag{4}$$

Numerically (v46): $f_{\mathrm{corr\,only}} \in \{1.786,\ 1.970,\ 1.983,\ 1.973\}$ for v38,v40,v41,v42 respectively; all are outside $[0,1]$.

3 Reality Bridge Model (v47–v55)

We introduce an extra damping factor $\beta \in (0,1]$ beyond block correlation and parameterize the *robust* fraction $\alpha_{\mathrm{L}} \in [0,1]$ such that

$$\Delta\chi^2(d \,|\, \alpha_{\mathrm{L}}) = \Delta\chi^2_{\mathrm{on}}\, \beta_{\mathrm{base}}\, (1 - \alpha_{\mathrm{L}}). \tag{5}$$

Given a target d_t, the required robust fraction is

$$\alpha_{\mathrm{L}}(t) = 1 - \frac{d_t}{\Delta\chi^2_{\mathrm{on}}\, \beta_{\mathrm{base}}}. \tag{6}$$

With $\beta_{\mathrm{base}} = 0.829$ and $\Delta\chi^2_{\mathrm{on}} = 15.1748$ this yields

Tag	d_t	$\frac{d_t}{\Delta\chi^2_{\mathrm{on}}\beta_{\mathrm{base}}}$	α_{L}	$\beta_{\mathrm{tot}} = \beta_{\mathrm{base}}(1-\alpha_{\mathrm{L}})$
v38	3.9150	0.3110	0.6890	0.2580
v40	1.2918	0.1030	0.8970	0.0851
v41	1.0980	0.0870	0.9130	0.0724
v42	1.2383	0.0981	0.9019	0.0816

The closure check $\Delta\chi^2 = \Delta\chi^2_{\mathrm{on}}\, \beta_{\mathrm{tot}}$ reproduces all four targets within rounding (v48–v49).

Mechanistic Decomposition. One convenient factorization is $\beta_{\mathrm{tot}} = \beta_{\mathrm{ms}}\, \beta_{\mathrm{res}}\, (1 - \alpha_{\mathrm{L}})$, where multi-scale ($\beta_{\mathrm{ms}}$) and resolution ($\beta_{\mathrm{res}}$) pieces combine into $\beta_{\mathrm{base}} = \beta_{\mathrm{ms}}\beta_{\mathrm{res}} = 0.829$ (v47–v48). The precise split is not unique; what matters is the product.

4 Mode Asymmetry (v56–v59)

Let channel totals be preserved but allow different β for ν and $\bar{\nu}$. Define channel weights S^c_ν and $S^c_{\bar{\nu}}$ with $S^c_\nu + S^c_{\bar{\nu}} = \Delta\chi^2_{\mathrm{on}}{}^{c}$ and per-channel constraint

$$S^c_\nu\, \beta^c_\nu + S^c_{\bar{\nu}}\, \beta^c_{\bar{\nu}} = \beta_{\mathrm{base}}\, \Delta\chi^2_{\mathrm{on}}{}^{c}. \tag{7}$$

Let $\Delta\beta^c \equiv \beta^c_\nu - \beta^c_{\bar{\nu}}$. Solving (7) with $\beta \in [0,1]$ gives a channel-wise feasible interval for $\Delta\beta^c$. Intersecting the four channels (v59) produces a *global* window

$$\Delta\beta \in [-0.2736,\ +0.2631], \tag{8}$$

within which all channels satisfy (7). Because Eq. (7) conserves each channel's total, the Reality Bridge closure (5) is unaffected by the split: $\alpha_{\mathrm{L}}(t)$ is unchanged for any common $\Delta\beta$ in (8).

5 Single-α_L Impossibility and Bounded-Drift Feasibility (v60–v62)

If one enforces a *single* α_L for all tags and also preserves totals, Eq. (5) implies a single common prediction

$$d_\mathrm{common} = \Delta\chi^2_\mathrm{on}\,\beta_\mathrm{base}\,(1-\alpha_\mathrm{L}), \tag{9}$$

which cannot equal four distinct d_t simultaneously (v60). Minimizing the L2 error gives $(1-\alpha_\mathrm{L}) = \big(\sum_t d_t\big)/(4\Delta\chi^2_\mathrm{on}\beta_\mathrm{base})$ and leaves nonzero residuals.

Relaxing with a symmetric multiplicative drift $s_t \in [1-\varepsilon, 1+\varepsilon]$ per target, the feasibility condition for a given ε is the overlap of intervals

$$X \equiv (1-\alpha_\mathrm{L}) \in \bigcap_t \left[\frac{d_t}{\mathcal{C}(1+\varepsilon)}, \frac{d_t}{\mathcal{C}(1-\varepsilon)}\right], \qquad \mathcal{C} \equiv \Delta\chi^2_\mathrm{on}\,\beta_\mathrm{base}. \tag{10}$$

The minimal feasible half-width is $\varepsilon^* \approx 0.562$ with a consistent choice $X^* = 0.199256$ ($\alpha^*_\mathrm{L} = 0.800744$), yielding drifts s_t that exactly reconstruct each d_t (v61–v62). Numerically,

$$s_\mathrm{v38} = 1.561861, \qquad s_\mathrm{v40} = 0.515354, \qquad s_\mathrm{v41} = 0.438039, \qquad s_\mathrm{v42} = 0.494011. \tag{11}$$

6 Per-Channel and Per-Bin Extensions (v51–v53)

Decomposing into channels c and bins b with on-anchors $\Delta\chi^2_\mathrm{on}{}^{c,b}$,

$$d = \sum_{c,b} \Delta\chi^2_\mathrm{on}{}^{c,b}\,\beta_\mathrm{base}\,(1-\alpha_\mathrm{L})\,s_{c,b}. \tag{12}$$

Stress-tests with independent $\pm 20\%$ jitters on $\Delta\chi^2_\mathrm{on}{}^{c,b}$ show 100% feasibility for recovering the same α_L per tag, with small ($\mathcal{O}(10^{-3})$) scatter in the required α_L (v51–v53).

7 Robust Priors and Curvature (v41–v42, v54)

We modeled robust profiling by a convex blend of Gaussian and Laplace penalties. For a generic pull x,

$$\rho(x;\alpha) = (1-\alpha)\,\frac{x^2}{\sigma^2} + \alpha\,\frac{|x|}{b}, \qquad \alpha \in [0,1]. \tag{13}$$

Increasing α (more Laplace) modestly increases the point-test $\Delta\chi^2$ and improves outlier resilience (v42). The δ-curvature per channel is well approximated by

$$\Delta\chi^2_c(\delta) = k_c\,(\delta - 195^\circ)^2, \tag{14}$$

with $(k_\mathrm{CRUST\_NO}, k_\mathrm{MANTLE\_NO}, k_\mathrm{CRUST\_IO}, k_\mathrm{MANTLE\_IO}) \approx (0.029311, 0.039344, 0.033222, 0.041300)$, reproducing v40 checkpoints at $\delta = 192^\circ, 195^\circ, 198^\circ$.

8 Leverage and ROI (v39, v55)

Toy leverage studies indicate that (for modest changes) $\Delta\chi^2$ grows roughly linearly with exposure r and approximately inversely with per-bin shape systematics. The most effective single levers were reducing shape systematics (e.g., 5% → 1%) followed by exposure gains, consistent across channels.

Conclusions

- The *No-Go* proof eliminates correlation-only explanations for the observed depths d_t.
- The *Reality Bridge* with a common β_{base} and per-target $\alpha_{\text{L}}(t)$ closes all targets and remains robust under outlier stress and mode asymmetry that conserves channel totals.
- A single α_{L} can be made compatible only with substantial ($\sim$56%) symmetric capacity drift, tightly quantified by the bounded-drift construction.
- Per-bin/channel decompositions and robust blends do not upset these statements; they clarify how budgets redistribute without altering the required global damping picture.

Numerical Appendix

Anchors and Targets

Quantity	Symbol	Value
Off-corr anchor	$\Delta\chi^2_{\text{off}}$	29.4931
On-corr anchor	$\Delta\chi^2_{\text{on}}$	15.1748
Baseline damping	β_{base}	0.829
Capacity	$\mathcal{C} = \Delta\chi^2_{\text{on}}\beta_{\text{base}}$	12.5799
Targets	d_t	{3.9150, 1.2918, 1.0980, 1.2383}

Derived Quantities

Tag	α_{L}	$1-\alpha_{\text{L}}$	β_{tot}	d_{pred}
v38	0.689	0.311	0.2580	3.915
v40	0.897	0.103	0.0851	1.292
v41	0.913	0.087	0.0724	1.098
v42	0.902	0.098	0.0816	1.238

Note: All numerical values match the print-first module outputs (v38–v64) up to rounding in the last displayed digit.