The Standard Model Convention and Normalisation Audit in VERSF

▲ Programme Milestone — Quantitative Normalisation Series Gate QN-2 / Standard Model Convention and Normalisation Closure

Locking gauge, field, charge, Higgs, Yukawa, mixing, phase, dimensional, and renormalisation conventions before quantitative Standard Model derivations

Keith Taylor VERSF Theoretical Physics Programme — Quantitative Normalisation Series Tier A convention-stability gate paper, QN-2

General Reader Summary

A physical theory can be right in substance and wrong in numbers because its conventions move.

QN-1 closed one such danger for VERSF: the symbol κ had appeared in several related but non-identical roles. QN-1 showed that these appearances could be reconciled only after the symbol was typed by role, exponent level, dimensional status, and convention. The lesson was simple:

A number is not physical until the convention slot it occupies is fixed.

The Standard Model has the same problem at a larger scale.

Before VERSF can attempt quantitative Standard Model derivations — masses, couplings, mixings, charges, hierarchy factors, electroweak scales, Yukawa suppressions, CKM/PMNS angles, or gravitational-response bridges — it must lock a much larger convention ledger. Otherwise, later results could be changed by silent shifts in:

- hypercharge normalisation;
- generator trace normalisation;
- the sign of the covariant derivative;
- the definition of electric charge;
- the Higgs vacuum normalisation;
- the distinction between v and $v/\sqrt{2}$;
- whether a Yukawa coefficient or a fermion mass is being predicted;
- whether a coupling is g', g_1, α_Y, or GUT-normalised α_1;
- whether a mass is pole, running, bare, or threshold-matched;
- whether a mixing matrix is V, $V^\dagger$, $U_e^\dagger U_\nu$, or $U_\nu^\dagger U_e$;
- whether a phase is physical or removable by field redefinition;
- whether a VERSF localization exponent is amplitude-level or probability-level;
- whether a dimensional scale is being confused with a dimensionless exponent.

This paper imposes the required discipline. Its central point is:

The Standard Model inside VERSF must be represented by a typed convention ledger. Gauge charges, field normalisations, Higgs normalisations, Yukawa maps, mixing matrices, phase conventions, renormalisation schemes, and VERSF localization quantities are not interchangeable merely because they appear in the same formula chain.

The paper does **not** derive the Standard Model. It does **not** derive the values of masses or couplings. It does **not** claim that the VERSF commitment scale ξ is the electroweak scale. It does **not** claim that any Standard Model parameter is now predicted.

It proves something narrower and necessary:

Once the Standard Model convention ledger is fixed, every legitimate change of convention preserves the same physical record. If a claimed convention change alters a charge, mass ratio, coupling, mixing angle, anomaly condition, hierarchy exponent, or response coefficient, then it is not a convention change; it is an error, an approximation with an uncarried correction, or an open bridge debt.

In one sentence:

QN-2 closes Standard Model convention drift in VERSF: before any later quantitative gate may claim a mass, coupling, hierarchy, charge, or mixing result, it must state the representation, normalisation, scale, scheme, basis, phase, dimensional, and VERSF-localisation conventions under which that result is meaningful.

Contents

Abstract

VERSF aims to connect finite commitment structure, localization laws, closure censuses, completion densities, gap scales, and response coefficients to quantitative Standard Model data. Such a programme is vulnerable unless its conventions are fixed before numerical predictions are claimed.

QN-1 closed the κ-localization convention problem by replacing bare κ with a typed ledger of localization stiffness, probability exponent, reciprocal compliance, channel-log weight, gap scale, and response coupling. QN-2 generalises the same discipline to the Standard Model as a whole.

The Standard Model contains many convention-sensitive structures: gauge-group representation labels, generator normalisations, hypercharge normalisation, covariant-derivative sign, electroweak mixing orientation, Higgs vacuum normalisation, Yukawa-to-mass conversion, flavour-basis choices, CKM and PMNS phase placement, anomaly bookkeeping, running versus pole masses, scheme-dependent couplings, GUT-normalised versus electroweak-normalised U(1) couplings, and dimensional restoration of $\hbar$, c, ξ, v, and response scales.

This paper defines a Standard Model convention ledger

$\mathfrak{L}\_SM = (\mathfrak{S}, \mathfrak{G}, \mathfrak{T}, \mathfrak{D}, \mathfrak{Y}, \mathcal{H}, \mathfrak{F}, \mathfrak{M}, \mathfrak{R}, \mathfrak{B})$,

where the entries specify continuum and spinor convention, gauge algebra and representations, generator and trace normalisation, covariant derivative, hypercharge and electric-charge convention, Higgs and vacuum normalisation, flavour and Yukawa convention, mixing and phase convention, renormalisation convention, and the VERSF interface.

The physical datum is not any bare convention-dependent symbol. It is the Standard Model record projection

$\Pi\_rec(\mathfrak{L}\_SM)$,

the collection of convention-invariant terminal consequences: charge assignments, representation content, anomaly cancellation, S-matrix elements, pole observables, properly scheme-labelled running quantities, mass ratios under stated schemes, mixing invariants, CP invariants, decay rates, cross sections, and VERSF record consequences.

A convention transformation is valid if and only if it preserves this physical record projection after all symbols are translated. Valid transformations compose and invert. Therefore no chain of valid convention transformations can alter a physical prediction.

QN-2 fixes a canonical Standard Model ledger for later VERSF quantitative gates:

$G\_SM^\wedge local = SU(3)\_c \times SU(2)\_L \times U(1)\_Y$

at the local Lie-algebra level; fundamental generators are normalised by

$Tr(T^a T^b) = ½ \delta^{ab}$;

the electric charge operator is

$Q = T_3^L + Y/2$;

the Higgs doublet has

$H = (H^+, H^0)^T$, $Y\_H = +1$, $\langle H^0 \rangle = v/\sqrt{2}$;

the canonical tree-level mass relations are

$m\_W = gv/2$, $m\_Z = (v/2)\cdot\sqrt{(g^2 + g'^2)}$, $m\_f = y\_f\, v/\sqrt{2}$;

the electroweak scale is anchored operationally by the Fermi constant,

$v = (\sqrt{2}\ G\_F)^\wedge(-1/2) \approx 246.22$ GeV;

and $g_1 = \sqrt{(5/3)}\cdot g'$ is reserved for GUT-normalised hypercharge, never silently substituted for g'.

The theorem proves that later VERSF gates may change notation, basis, phase convention, or normalisation only by explicit maps preserving Π_rec. If a claimed convention change alters a charge, anomaly condition, mass, coupling, mixing invariant, hierarchy exponent, or dimensional response coefficient, then it is not a convention change but a physical discrepancy, hidden approximation, or open bridge debt.

QN-2 therefore closes the Standard Model convention-normalisation gate. It does not complete the derivation of the Standard Model. It makes such derivations auditable.

---

0. Inheritance, Notation, and Firewalls

0.1 Inherited commitments

QN-2 inherits the following commitments.

I1 — QN-1 convention discipline. Bare symbols are not physical. A coefficient is meaningful only after its role, level, exponent variable, dimensional status, and observable projection have been fixed.

I2 — κ-ledger inheritance. The QN-1 κ-ledger remains active. In particular:

$\kappa\star = 8/3$

is the canonical localization-stiffness representative;

$c\star = \kappa\star^{-1} = 3/8$

is reciprocal compliance;

$\lambda_{14} = \ln 14$

is a channel-log weight, not equal to 8/3;

$m\star = \sqrt{(\kappa\star/2)} \cdot \xi^{-1}$

is an inverse-length gap scale; and κ_eff is a dimensional response coupling unless bridged.

I3 — Finite commitment scale. VERSF retains the finite commitment scale ξ, with associated dimensional scales such as ξ^{-1}, $\hbar c/\xi$, and ξ/c. QN-2 does not identify these with Standard Model scales without a bridge theorem.

I4 — Physical-sector discipline. Gauge redundancy, adjoint residue, ghosts, basis artifacts, unphysical phases, and convention-only signs do not count as physical predictions.

I5 — Minimal Standard Model boundary. Unless explicitly stated, the Standard Model ledger refers to the minimal chiral Standard Model with one Higgs doublet and no right-handed neutrino. Neutrino-mass extensions may be audited by QN-2, but they must be typed as extensions.

I6 — Quantitative gates require scheme and scale. Masses, Yukawas, gauge couplings, quartic couplings, and running parameters are not numerical predictions unless the renormalisation scheme, scale, threshold convention, and comparison object are stated.

I7 — VERSF bridge discipline. No VERSF quantity may be identified with a Standard Model quantity merely by dimensional similarity, numerical closeness, or symbolic resemblance. Bridges require explicit maps, domains, mechanisms, and error control.

0.2 Standing notation

The local Standard Model gauge algebra is written

$$\mathfrak{g}_{SM} = \mathfrak{su}(3)_c \oplus \mathfrak{su}(2)_L \oplus \mathfrak{u}(1)_Y.$$

The local gauge group is written

$$G_{SM}^{local} = SU(3)_c \times SU(2)_L \times U(1)_Y.$$

A possible global quotient — for example by a discrete subgroup $\mathbb{Z}_n$ — is not assumed unless a later topological or line-operator gate requires it. Local perturbative Standard Model normalisation is fixed independently of that global choice.

The canonical electric-charge convention is

$$Q = T_3^L + Y/2.$$

The canonical Higgs convention is

$$H = (H^+, H^0)^T,\ Y_H = +1,\ \langle H \rangle = (1/\sqrt{2})\cdot(0, v)^T.$$

The canonical electroweak coupling convention is

$$e = g \sin\theta_W = g' \cos\theta_W,\ \tan\theta_W = g'/g.$$

The GUT-normalised hypercharge coupling, when used, is

$$g_1 = \sqrt{(5/3)} \cdot g',\ \alpha_1 = (5/3) \cdot \alpha_Y.$$

It is not interchangeable with g' or α_Y without this conversion.

0.3 Firewalls

This paper does **not** claim:

- that VERSF has derived all Standard Model parameters;
- that the value of v follows from ξ;
- that the Higgs sector has been replaced by VERSF closure alone;
- that the three fermion generations have been derived here;
- that Yukawa matrices have been predicted here;
- that CKM or PMNS values have been derived here;
- that g' and g_1 are the same coupling;
- that v and $v/\sqrt{2}$ are interchangeable;
- that pole masses and running masses are interchangeable;
- that the SU(3) Casimir $C_F = 4/3$ is the same object as the VERSF gap coefficient $g_\kappa = 4/3$;
- that $U(1)_Y$ normalisation can be changed without changing the coupling convention;
- that a field redefinition is physically meaningful unless its record projection is stated;
- that a convention theorem is a parameter derivation.

It proves a narrower and necessary result:

Once the Standard Model ledger is fixed, any later VERSF numerical claim can be audited for convention stability. If the prediction changes under a valid convention transformation, it was not a prediction.

0′. Predictive-Content Ledger

Object	Prior risk	QN-2 status
Bare Standard Model convention	implicit	disallowed
Gauge algebra	assumed	fixed locally as $\mathfrak{su}(3)_c \oplus \mathfrak{su}(2)_L \oplus \mathfrak{u}(1)_Y$
Global gauge quotient	often ignored	typed as separate topological choice
Generator normalisation	variable	fixed by $\mathrm{Tr}(T^a T^b) = \frac{1}{2}\delta^{ab}$ in fundamentals
Hypercharge convention	vulnerable	fixed by $Q = T_3^L + Y/2$
GUT-normalised U(1)	frequently conflated	separated: $g_1 = \sqrt{(5/3)}\cdot g'$
Covariant-derivative sign	convention-sensitive	fixed and tracked
γ^5/ε orientation	implicit	fixed in $\mathfrak{S}$
Field-strength sign	convention-sensitive	fixed by [D, D] commutator

Object	Prior risk	QN-2 status
R_ξ gauge parameter vs VERSF ξ	symbol collision	firewalled
Higgs doublet orientation	sign/order-sensitive	fixed as $H = (H^+, H^0)^T$, Y_H = +1
Higgs VEV	v vs v/√2 drift	fixed by $\langle H^0 \rangle = v/\sqrt{2}$
Electroweak scale	ambiguous referent	anchored by v = (√2 G_F)^(−1/2)
Fermion masses	Yukawa/mass ambiguity	fixed by m_f = y_f v/√2 after diagonalisation
CKM convention	V vs V† risk	fixed by charged-current slot
PMNS convention	extension-dependent	typed; active only with neutrino-mass extension
Physical phases	removable/physical confusion	separated by rephasing invariants (J, θ̄)
Running couplings	scheme/scale drift	scheme and scale required
Pole masses	conflated with running masses	separated
Weak angle	multiple definitions in circulation	on-shell, $\overline{MS}$, effective typed as distinct
VERSF κ-ledger	inherited	remains active
ξ, v, m⋆, κ_eff	dimensional confusion risk	separated unless bridged
Casimir 4/3 vs VERSF 4/3	numerical collision	typed as distinct
Later quantitative gates	convention-vulnerable	must inherit QN-2 ledger

---

1. Purpose, Claim Level, and Named Premises

1.1 The question

The Standard Model contains many numerical and symbolic quantities whose values depend on convention unless the convention is stated.

For example,

$Q = T_3 + Y/2$ and $Q = T_3 + Y$

are both used in the literature, with different definitions of Y. The physics is the same only if the coupling and charge normalisation are translated.

Similarly,

$m\_f = y\_f\, v/\sqrt{2}$ and $m\_f = y\_f\, v_{174}$

are the same only if $v_{174} = v/\sqrt{2} \approx 174$ GeV. Without that statement, a factor of √2 can enter a mass prediction.

Likewise,

$g_1 = \sqrt{(5/3)} \cdot g'$

is not a new electroweak coupling but a GUT-normalised version of hypercharge. A coupling prediction can shift by 5/3 if this is confused.

QN-2 asks:

Can VERSF lock the Standard Model convention ledger tightly enough that later quantitative gates cannot move numbers by changing notation?

The answer is yes, but only by treating every convention-sensitive object as typed.

1.2 Claim level

Claim level: QN-2 Standard Model convention-stability and normalisation-audit theorem.

Epistemic grade: Conditional technical closure.

QN-2 does not derive Standard Model parameter values. It proves that later derivations must be convention-stable and gives the ledger by which they are audited.

1.3 Named premises

Premise SMN-1 — Physical record projection

The physical content of a Standard Model/VERSF calculation is not a bare Lagrangian symbol. It is the record projection

$\Pi\_rec(\mathfrak{L}\_SM)$,

the set of convention-invariant consequences: charges, representation content, anomaly status, S-matrix elements, pole observables, scheme-labelled running parameters, mass ratios under stated conventions, mixing invariants, CP invariants, transition probabilities, decay rates, cross sections, and VERSF terminal-record consequences.

Falsifier: a claimed convention change alters Π_rec.

Premise SMN-2 — Standard Model convention ledger

A Standard Model convention ledger is a tuple

$\mathfrak{L}$_SM = ($\mathfrak{S}$, $\mathfrak{G}$, $\mathfrak{T}$, $\mathfrak{D}$, $\mathfrak{Y}$, $\mathfrak{H}$, $\mathfrak{F}$, $\mathfrak{M}$, $\mathfrak{R}$, $\mathfrak{V}$),

where:

- $\mathfrak{S}$ specifies continuum, metric, spinor, chirality, and unit conventions;
- $\mathfrak{G}$ specifies gauge algebra, representation labels, and possible global quotient;
- $\mathfrak{T}$ specifies generator and trace normalisation;
- $\mathfrak{D}$ specifies covariant-derivative sign and coupling placement;
- $\mathfrak{Y}$ specifies hypercharge and electric-charge convention;
- $\mathfrak{H}$ specifies Higgs doublet, potential, vacuum, and electroweak orientation;
- $\mathfrak{F}$ specifies fermion, Yukawa, and mass conventions;
- $\mathfrak{M}$ specifies mixing, basis, and phase conventions;
- $\mathfrak{R}$ specifies renormalisation scheme, scale, and threshold convention;
- $\mathfrak{V}$ specifies the VERSF interface: ξ, κ-ledger, channel weights, gap scales, and response couplings.

A Standard Model calculation is incomplete unless its active entries are stated or inherited.

Falsifier: a quantitative derivation depends on an unstated ledger entry.

Premise SMN-3 — Canonical local gauge convention

QN-2 adopts the local Standard Model gauge algebra

$\mathfrak{g}$_SM = $\mathfrak{su}$(3)_c ⊕ $\mathfrak{su}$(2)_L ⊕ $\mathfrak{u}$(1)_Y.

Global quotient data are typed separately and may not be silently used to alter local charge or coupling normalisation.

Falsifier: local gauge normalisation is changed by invoking a global quotient without an explicit topological bridge.

Premise SMN-4 — Generator normalisation

For fundamental generators,

$T\_c^a = \lambda^a/2$, $T\_L^i = \sigma^i/2$,

with

$\mathrm{Tr}(T^a T^b) = ½\, \delta^{ab}$.

Casimirs and Dynkin indices are meaningful only under this normalisation or an explicitly converted one.

Falsifier: a Casimir, trace factor, or beta-function coefficient is used under a different generator normalisation without conversion.

Premise SMN-5 — Electric-charge and hypercharge convention

QN-2 adopts

$Q = T_3^L + Y/2$.

The canonical one-generation field assignments are:

Field	Representation	Hypercharge
$Q_L = (u_L, d_L)^T$	(3, 2)	+1/3
u_R	(3, 1)	+4/3
d_R	(3, 1)	−2/3
$L_L = (\nu_L, e_L)^T$	(1, 2)	−1
e_R	(1, 1)	−2
$H = (H^+, H^0)^T$	(1, 2)	+1

Right-handed neutrinos are absent unless an extension is declared.

Falsifier: a charge, Yukawa term, anomaly condition, or electroweak relation is computed using a different hypercharge convention without translating Y and g′.

Premise SMN-6 — Covariant derivative convention

QN-2 uses

$D_\mu = \partial_\mu + i\, g_s\, G^a_\mu\, T_c^a + i\, g\, W^i_\mu\, T_L^i + i\, g' \,(Y/2)\, B_\mu$.

Then the photon coupling is

$D_\mu \supset i\, e\, Q\, A_\mu$,

with

$A_\mu = \sin\theta_W \cdot W^3_\mu + \cos\theta_W \cdot B_\mu$, $Z_\mu = \cos\theta_W \cdot W^3_\mu - \sin\theta_W \cdot B_\mu$,

and

$e = g \sin\theta_W = g' \cos\theta_W$.

Changing the sign convention for D_μ is permitted only if all gauge-field and charge signs are translated consistently.

Falsifier: an electroweak sign, weak charge, or charged-current orientation changes under a claimed convention shift.

Premise SMN-7 — Higgs and vacuum convention

The Higgs doublet is

$H = (H^+, H^0)^T$, $Y\_H = +1$,

with

$\langle H\rangle = (1/\sqrt{2}) \cdot (0, v)^T$.

The canonical tree-level mass relations are

$m\_W = gv/2$, $m\_Z = (v/2)\cdot\sqrt{(g^2 + g'^2)}$, $m\_f = y\_f v/\sqrt{2}$.

The scale v is anchored operationally by the Fermi constant: $v = (\sqrt{2}\ G\_F)^{(-1/2)}$. If the reduced electroweak scale $v\_red = v/\sqrt{2}$ is used, it must be named explicitly.

Falsifier: a later derivation mixes v and $v/\sqrt{2}$ without conversion, or invokes "the electroweak scale" without a target object.

Premise SMN-8 — Yukawa and flavour convention

The canonical Yukawa terms are

$\mathscr{L}\_Y = -\ \bar{Q}\_L\ Y\_d\ H\ d\_R - \bar{Q}\_L\ Y\_u\ \tilde{H}\ u\_R - \bar{L}\_L\ Y\_e\ H\ e\_R + h.c.,$

where

$\tilde{H} = i\sigma^2 H^*$.

After electroweak symmetry breaking,

$M\_f = (v/\sqrt{2}) \cdot Y\_f$.

Physical fermion masses are singular values of M_f, subject to the stated renormalisation convention.

Falsifier: a Yukawa eigenvalue, mass eigenvalue, hierarchy exponent, or VERSF suppression factor is compared without specifying whether it maps to Y_f, M_f, a pole mass, or a running mass.

Premise SMN-9 — Mixing and phase convention

QN-2 defines the CKM matrix by the charged-current slot

$$\mathscr{L}_{CC} = (g/\sqrt{2}) \cdot \bar{u}_L \gamma^\mu V_{CKM} d_L W^+_\mu + \text{h.c.},$$

with

$$V_{CKM} = U_{uL}^\dagger U_{dL}.$$

If neutrino masses are introduced, QN-2 defines

$$U_{PMNS} = U_{eL}^\dagger U_{\nu L}$$

under the standard charged-current convention. Phase placement is conventional; physical CP violation must be expressed through rephasing-invariant quantities — the Jarlskog invariant J, the strong-CP combination $\bar{\theta} = \theta + \arg\det(Y_u Y_d)$, or explicitly named phase conventions.

Falsifier: a prediction changes under rephasing, basis rotation, or replacing V by V† without a stated convention map.

Premise SMN-10 — Renormalisation convention

Gauge couplings, Yukawa couplings, quartic couplings, running masses, and mixing parameters are functions of renormalisation scheme and scale. A numerical comparison must state

(scheme, μ, thresholds, matching, observable).

Pole masses, running masses, bare masses, and threshold-matched masses are different objects.

Falsifier: a numerical Standard Model/VERSF comparison omits scheme and scale where they matter.

Premise SMN-11 — VERSF bridge admissibility

A claimed bridge from a VERSF quantity to a Standard Model quantity must supply:

1. dimensional map;
2. representation slot;
3. convention ledger entries;
4. physical mechanism;
5. domain of validity;
6. error control;
7. observable projection.

Numerical closeness is not a bridge.

Falsifier: a VERSF-to-Standard-Model identification lacks any of these components.

2. The Standard Model Convention-Drift Problem

2.1 Why this gate is necessary

The Standard Model is unusually compact, but its notation is not unique. Different communities use different but equivalent conventions. That is harmless when all translations are known. It becomes dangerous when a derivation uses convention-dependent numbers as though they were physical.

A few examples are enough.

Hypercharge drift

Some authors use

$Q = T_3 + Y/2$,

while others use

$Q = T_3 + Y$.

A lepton doublet then has $Y = -1$ in the first convention and $Y = -1/2$ in the second. Both are fine. Mixing them is fatal.

Higgs-scale drift

With

$\langle H^0 \rangle = v/\sqrt{2}$,

fermion masses satisfy

$m_f = y_f v/\sqrt{2}$.

If instead one writes $v_{red} = v/\sqrt{2} \approx 174$ GeV, then

$m_f = y_f v_{red}$.

The same physics has two notations. A silent switch changes Yukawa predictions by $\sqrt{2}$.

U(1) coupling drift

The electroweak hypercharge coupling is g'. The GUT-normalised coupling is

$g_1 = \sqrt{(5/3)} \cdot g'$.

Confusing α_1 with α_Y changes a coupling comparison by 5/3.

Weak-angle drift

The symbol $\sin^2\theta_W$ refers, in different contexts, to the on-shell definition $\sin^2\theta_W = 1 - m_W^2/m_Z^2$, the $\overline{MS}$ running quantity $\hat{s}^2(\mu)$, or the effective leptonic mixing angle $\sin^2\theta_{eff}$ extracted from Z-pole asymmetries. These differ at the level of ~0.008 — far larger than modern experimental precision. A “prediction of the weak angle” without a definition is not a prediction.

Mixing-matrix drift

A CKM convention may place

$V_{CKM} = U_{uL}^\dagger U_{dL}$

or its adjoint in a charged current depending on field ordering. Physical probabilities are unaffected only if the convention is carried consistently.

VERSF exponent drift

A VERSF localization exponent may refer to amplitude, probability density, compliance, channel-log suppression, gap scale, or response coupling. QN-1 closed this for κ. QN-2 prevents the same drift from reappearing inside Standard Model derivations.

2.2 The four possible outcomes

Given two Standard-Model-like or VERSF-like quantities, exactly four legitimate cases exist.

Case 1 — Same physical object, different convention

Example:

$Q = T_3 + Y/2$ versus $Q = T_3 + Y'$, $Y' = Y/2$.

The physics is identical after translating Y and the U(1) coupling.

Case 2 — Exact composite under an inherited construction

Example:

$m\_f = y\_f\ v/\sqrt{2}$.

A Yukawa eigenvalue and a fermion mass are not the same object, but the relation is exact once the Higgs convention is fixed.

Case 3 — Related quantities with a bridge pending

Example: a VERSF completion-density exponent and a Standard Model Yukawa hierarchy. They may be related, but only a bridge theorem can establish the map.

Case 4 — Different objects, no identification proposed

Example: the SU(3) Casimir $C\_F = 4/3$ and the VERSF gap coefficient $g\_\kappa = 4/3$. They are numerically equal but live in different ledgers. No identification follows.

2.3 Rule

A Standard Model symbol inside VERSF is never accepted as physical until its ledger slot is fixed.

Acceptable later notation includes

$g\_s, g, g', g_1, \alpha\_s, \alpha_2, \alpha\_Y, \alpha_1$,

but only with the active normalisation stated.

Acceptable mass notation includes

$m\_f\text{^}pole, m\_f\text{^}\bar{M}\bar{S}(\mu), y\_f(\mu), M\_f = (v/\sqrt{2})\cdot Y\_f$,

but not an untyped "mass prediction."

Acceptable VERSF notation includes

$\kappa\star, c\star, \lambda_{14}, m\star, \kappa\_eff$,

but not bare κ.

---

3. The Physical Record Invariant

3.1 The invariant is the record projection

A convention is a representation of physics. It is not the physics itself.

Define the physical record projection

$\Pi\_rec(\mathfrak{L}\_SM)$

as the set of physical consequences after gauge redundancy, basis redundancy, phase redundancy, unit convention, and notation convention have been removed.

It **includes**:

- electric charges;
- colour and weak representation content;
- allowed gauge-invariant interaction terms;
- anomaly cancellation;
- pole masses;
- properly scheme-labelled running masses and couplings;
- S-matrix elements;
- decay rates;
- cross sections;
- mixing probabilities;
- rephasing-invariant CP measures (J, $\bar{\theta}$);
- ratio-type observables such as $\rho = m\_W^2/(m\_Z^2 \cos^2\theta\_W)$ under a stated scheme;
- terminal-record consequences in VERSF.

It **excludes**:

- field labels;
- unphysical phases;
- basis choices;
- sign choices removable by field redefinition;
- gauge-fixing artifacts;
- generator normalisation before coupling conversion;
- bare symbols without scheme and scale;
- convention-dependent intermediate coefficients.

3.2 Definition — valid Standard Model convention transformation

A transformation

$\mathfrak{L}\_SM^{(1)} \longrightarrow \mathfrak{L}\_SM^{(2)}$

is **valid** if and only if

$\Pi\_rec(\mathfrak{L}\_SM^{(1)}) = \Pi\_rec(\mathfrak{L}\_SM^{(2)})$

after all fields, couplings, generators, charges, phases, masses, and schemes have been translated.

This is the Standard Model analogue of QN-1's invariant log-attenuation.

Two readings must not be confused. A **passive** transformation relabels the same physical configuration in new symbols; it is always a candidate convention transformation. An **active** transformation changes the physical configuration itself; it is never a convention transformation, however similar the formulas may look. The record projection distinguishes the two: a passive transformation preserves Π_rec by construction; an active one generally does not.

3.3 Lemma 1 — Record invariance

Lemma 1. A claimed convention transformation is physically valid if and only if it preserves the physical record projection.

Proof. By definition, a convention transformation changes representation, notation, basis, normalisation, or phase placement while preserving the underlying physical predictions. If the record projection changes, then some observable or scheme-labelled comparison object has changed; the transformation was not a convention transformation but a change of theory, an approximation, or an error. Conversely, if all record consequences are preserved after translation, the two ledgers are convention-equivalent. ■

3.4 Lemma 2 — Valid convention transformations form a groupoid

Lemma 2. Standard Model convention transformations form a groupoid on the space of convention ledgers.

Proof. Identity transformations preserve the record projection. If a transformation preserves Π_rec, its inverse translation also preserves Π_rec. If two transformations each preserve Π_rec, their composition preserves Π_rec. Therefore valid transformations compose and invert, with identities, on the objects 𝔏_SM. ■

3.5 Corollary — no convention chain can change a prediction

If a later VERSF calculation begins in one convention and ends in another, the prediction must be identical after translation. If it is not, one of the conversions was invalid. Because valid transformations form a groupoid, invalidity cannot hide in the composition: at least one individual step fails the record test, and the audit consists of locating it.

4. The Canonical Standard Model Ledger

QN-2 fixes the following canonical ledger for later VERSF papers.

4.1 Continuum and spinor ledger

Natural units are used unless dimensions are being restored:

$\hbar = c = 1$.

Metric convention on the emergent 4-manifold:

$\eta_{\mu\nu} = \mathrm{diag}(+, -, -, -)$.

Dirac adjoint:

$\bar{\psi} = \psi^\dagger \gamma^0$.

Chirality projectors:

$P_L = (1 - \gamma^5)/2$, $P_R = (1 + \gamma^5)/2$.

The weak group $SU(2)_L$ acts on left-chiral doublets.

γ^5 convention:

$\gamma^5 = i \gamma^0 \gamma^1 \gamma^2 \gamma^3$, $(\gamma^5)^2 = 1$, $\mathrm{Tr}(\gamma^5 \gamma^\mu \gamma^\nu \gamma^\rho \gamma^\sigma) = -4i\, \varepsilon^{\mu\nu\rho\sigma}$.

Orientation convention:

$\varepsilon^{0123} = +1$ (hence $\varepsilon_{0123} = -1$ under $\eta = \mathrm{diag}(+,-,-,-)$).

Field-strength convention: for each gauge factor, $F_{\mu\nu}$ is defined by the commutator of the declared covariant derivative,

$[D_\mu, D_\nu] = i g F^a_{\mu\nu} T^a$,

so that

$F^a_{\mu\nu} = \partial_\mu A^a_\nu - \partial_\nu A^a_\mu - g f^{abc} A^b_\mu A^c_\nu$,

with structure constants fixed by $[T^a, T^b] = i f^{abc} T^c$ under the declared trace normalisation.

Changing the γ^5 sign or the ε orientation flips the meaning of “left-chiral,” the sign of the θ-term, and the sign of J; such changes — like any change of metric or gamma-matrix convention — are valid only with full translation of all chirality-, ε-, sign-, and phase-sensitive quantities in kinetic, mass, and interaction terms.

4.2 Gauge ledger

Local gauge algebra:

$\mathfrak{su}(3)_c \oplus \mathfrak{su}(2)_L \oplus \mathfrak{u}(1)_Y$.

Canonical local group notation:

$SU(3)_c \times SU(2)_L \times U(1)_Y$.

Global quotient data are held separate.

4.3 Generator ledger

Fundamental generators:

$T_c^a = \lambda^a/2$, $T_L^i = \sigma^i/2$.

Trace normalisation:

$\mathrm{Tr}(T^a T^b) = \frac{1}{2} \delta^{ab}$.

Gauge kinetic terms:

$\mathscr{L}_{gauge} = -\frac{1}{4} G^a_{\mu\nu} G^{a\mu\nu} - \frac{1}{4} W^i_{\mu\nu} W^{i\mu\nu} - \frac{1}{4} B_{\mu\nu} B^{\mu\nu}$.

4.4 Charge ledger

Electric charge:

$Q = T_3^L + Y/2$,

with the canonical hypercharge table of Premise SMN-5.

4.5 Higgs ledger

$H = (H^+, H^0)^T$, $Y_H = +1$, $\langle H \rangle = (1/\sqrt{2})\cdot(0, v)^T$.

Potential convention:

$V(H) = -\mu_H^2 H^\dagger H + \lambda (H^\dagger H)^2$.

At tree level:

$v^2 = \mu_H^2/\lambda$, $m_h^2 = 2\lambda v^2$.

Operational anchor:

$v = (\sqrt{2}\, G_F)^{-1/2} \approx 246.22$ GeV.

4.6 Yukawa ledger

$\mathscr{L}_Y = -\bar{Q}_L Y_d H d_R - \bar{Q}_L Y_u \tilde{H} u_R - \bar{L}_L Y_e H e_R + \text{h.c.}$

Mass matrices:

$M_f = (v/\sqrt{2}) \cdot Y_f$.

4.7 Mixing ledger

$V_{CKM} = U_{uL}^\dagger U_{dL}$.

If neutrinos are massive:

$U_{PMNS} = U_{eL}^\dagger U_{\nu L}$.

Physical mixing predictions must be given as matrix-element magnitudes, angles under a stated parameterisation, rephasing-invariant CP quantities, or transition probabilities.

4.8 Renormalisation ledger

Every running object must be labelled

$X^{\mathcal{S}}(\mu)$,

where $\mathcal{S}$ is the scheme and μ the scale. Examples:

$g_s^{\overline{MS}}(\mu)$, $y_t^{\overline{MS}}(\mu)$, $m_b^{\overline{MS}}(\mu)$.

Pole masses are labelled separately:

m_f^{pole}.

4.9 VERSF interface ledger

The active VERSF quantities are

ξ, $\kappa\star$, $c\star$, λ_{14}, $m\star$, κ_eff,

with their QN-1 meanings retained. No Standard Model quantity is identified with any of these unless a bridge theorem is supplied.

---

5. Gauge Group, Generator, and Trace Normalisation

5.1 Local algebra versus global group

The local perturbative Standard Model depends on the Lie algebra and representation action. A global quotient can matter for line operators, monopoles, global charge quantisation, and topological sectors. It is therefore not meaningless. But it is a separate ledger entry.

QN-2 fixes the local algebra and defers the global quotient unless explicitly invoked.

5.2 Lemma 3 — Generator rescaling is not physical if the coupling is rescaled

Lemma 3. Let a gauge interaction enter through

$g\ A^a\_\mu\ T^a$.

If the generator is rescaled

$T'^a = a\ T^a$,

then the same interaction is obtained by

$g' = g/a$.

Thus g and T^a separately are convention-dependent; the product g T^a is the invariant interaction object once the gauge-field normalisation is fixed.

Proof.

$g'\ A^a\_\mu\ T'^a = (g/a)\ A^a\_\mu\ (a\ T^a) = g\ A^a\_\mu\ T^a$.

The interaction is unchanged. In the nonabelian case, the rescaling $T^a \to aT^a$ also rescales the structure constants via the commutator; consistency of the $-\frac{1}{4}FF$ kinetic term and the cubic and quartic self-couplings is enforced by the declared trace normalisation, which fixes both f^{abc} and the coupling simultaneously. ■

5.3 Trace normalisation fixes the coupling convention

The kinetic term and trace convention together fix the meaning of the coupling. Once QN-2 declares

$Tr(T^a T^b) = ½ δ^{ab}$,

then g_s, g, and g′ have their canonical meanings, and the standard values of the Casimirs and Dynkin indices follow:

C_F(SU(3)) = 4/3, C_A(SU(3)) = 3, T(fund) = 1/2.

Beta-function coefficients quoted under any other trace normalisation must be converted before use.

5.4 Casimir firewall

Under the canonical SU(3) fundamental normalisation,

C_F^SU(3) = 4/3.

Under the QN-1 VERSF gap convention,

g_κ = 4/3.

These numbers are equal. They are not the same object. The first is a group-theoretic Casimir in colour representation theory. The second is a VERSF half-stiffness gap coefficient inherited from the localization ledger.

Rule: numerical equality of rational constants across different ledgers has no physical force without a bridge theorem.

---

6. Hypercharge, Electric Charge, and Electroweak Orientation

6.1 The canonical charge relation

QN-2 fixes

$Q = T_3^L + Y/2$.

This gives:

- u_L: $T_3 = +1/2$, $Y = +1/3$, so $Q = +2/3$;
- d_L: $T_3 = -1/2$, $Y = +1/3$, so $Q = -1/3$;
- ν_L: $T_3 = +1/2$, $Y = -1$, so $Q = 0$;
- e_L: $T_3 = -1/2$, $Y = -1$, so $Q = -1$;
- H^+: $T_3 = +1/2$, $Y = +1$, so $Q = +1$;
- H^0: $T_3 = -1/2$, $Y = +1$, so $Q = 0$.

6.2 Alternative hypercharge convention

If another paper uses

$Q = T_3^L + Y'$,

then

$Y' = Y/2$,

and the covariant derivative must become

$D_\mu = \partial_\mu + i g' Y' B_\mu$

rather than

$D_\mu = \partial_\mu + i g' (Y/2) B_\mu$.

The invariant object is $g'Y/2 = g'Y'$.

6.3 Lemma 4 — Hypercharge normalisation equivalence

Lemma 4. The conventions $Q = T_3 + Y/2$ and $Q = T_3 + Y'$ are physically equivalent if and only if $Y' = Y/2$ and the U(1) coupling is placed consistently so that the operator multiplying B_μ is unchanged.

Proof. The physical electromagnetic charge and hypercharge gauge interaction depend on the operator multiplying the gauge field. If $Y' = Y/2$, then $g'Y/2 = g'Y'$; all charges and interactions match. If this relation is not imposed, electric charges or B_μ interactions change, so the record projection changes. ■

6.4 Electroweak mixing orientation

QN-2 fixes

$A_\mu = s_W W^3_\mu + c_W B_\mu$, $Z_\mu = c_W W^3_\mu - s_W B_\mu$,

where $s_W = \sin \theta_W$ and $c_W = \cos \theta_W$. The inverse relations are

$W^3_\mu = s_W A_\mu + c_W Z_\mu$, $B_\mu = c_W A_\mu - s_W Z_\mu$.

This ensures the photon couples to eQ. A sign-flipped Z convention is allowed only if all Z-couplings are sign-flipped consistently.

6.5 The weak angle is not one number

Beyond tree level the phrase "the weak mixing angle" refers to distinct objects:

- **on-shell:** $\sin^2\theta_W \equiv 1 - m_W^2/m_Z^2$, defined to all orders by pole masses;
- **$\overline{\text{MS}}$:** $\hat{s}^2(\mu)$, a running scheme parameter;
- **effective:** $\sin^2\theta_{eff}$, extracted from Z-pole asymmetries.

These agree at tree level and differ radiatively by amounts far exceeding experimental precision. Any later VERSF claim about the weak angle must name which object is predicted.

---

7. Field, Kinetic, and Dimensional Normalisation

7.1 Canonical kinetic terms

The canonical field normalisation is fixed by

$\mathscr{L}_{kin} = -\frac{1}{4} G^a_{\mu\nu} G^{a\mu\nu} - \frac{1}{4} W^i_{\mu\nu} W^{i\mu\nu} - \frac{1}{4} B_{\mu\nu} B^{\mu\nu} + \Sigma_\psi \bar{\psi} i\gamma^\mu D_\mu \psi + (D_\mu H)^\dagger(D^\mu H)$.

A field rescaling changes coefficients elsewhere. Therefore field normalisation is part of the ledger.

7.2 Lemma 5 — Field rescaling is not a physical prediction

Lemma 5. A constant field rescaling changes Lagrangian coefficients but not physical predictions, provided the kinetic term is recanonicalised and all couplings are transformed accordingly.

Proof. Let $\varphi' = a\varphi$. The kinetic term scales by a^{-2} when written in φ'. Restoring canonical kinetic normalisation forces corresponding changes in interaction coefficients. S-matrix elements computed after canonicalisation are unchanged, so the rescaling is a convention transformation, not a physical prediction. ■

7.3 Dimensional ledger

In natural units,

$[\varphi] = 1$, $[\psi] = 3/2$, $[A_\mu] = 1$, $[g] = [y_f] = [\lambda] = 0$, $[v] = [m] = 1$.

VERSF introduces ξ, with

$[\xi] = -1$

in mass units, and

$[\xi^{-1}] = 1$.

Thus:

- $\kappa\star$ is dimensionless;
- $m\star \sim \xi^{-1}$ has mass dimension one;
- $\hbar c/\xi$ is an energy scale;
- κ_{eff} is dimensional unless explicitly nondimensionalised.

7.4 Dimensional firewall

A dimensionless coefficient cannot equal a dimensional scale. Therefore

$\kappa\star \neq m\star$, $\kappa\star \neq v$, $m\star \neq v$

unless a dimensional bridge specifies units, mechanism, and observable relation.

---

8. Higgs, Vacuum, and Mass Normalisation

8.1 The Higgs vacuum

QN-2 fixes

$\langle H\rangle = (1/\sqrt{2})\cdot(0, v)^T$.

The neutral fluctuation may be written in unitary gauge as

$H(x) = (1/\sqrt{2})\cdot(0, v + h(x))^T$.

The phase of the vacuum has been rotated to zero by an $SU(2)_L \times U(1)_Y$ transformation, and $v > 0$ is chosen; the reality and positivity of v are themselves ledger entries, and are required for $\bar{\theta} = \theta + \arg\det(Y_u Y_d)$ to equal $\theta + \arg\det(M_u M_d)$.

8.2 Gauge-boson masses

From $(D_\mu H)^\dagger(D^\mu H)$:

$m_W = gv/2$, $m_Z = (v/2)\cdot\sqrt{g^2 + g'^2}$, $m_\gamma = 0$.

8.3 Weak angle relation

$\cos\theta_W = g/\sqrt{g^2 + g'^2}$, $\sin\theta_W = g'/\sqrt{g^2 + g'^2}$.

Then, at tree level,

$m_W = m_Z \cos\theta_W$,

equivalently

$\rho \equiv m_W^2/(m_Z^2 \cos^2\theta_W) = 1$.

The relation $\rho = 1$ is a record-invariant statement of custodial structure at tree level; beyond tree level, ρ becomes scheme-sensitive and must be labelled. Radiative corrections and measured effective weak angles require the renormalisation ledger of §11.

8.4 Higgs potential

Using

$V(H) = -\mu_H^2 H^\dagger H + \lambda(H^\dagger H)^2$,

the minimum satisfies

$v^2 = \mu_H^2/\lambda$,

and the Higgs mass is

$m_h^2 = 2\lambda v^2$.

Alternative potential normalisations — for example $\lambda(H^\dagger H)^2/2$, or $+\mu^2$ with an inverted sign convention — are allowed only with conversion.

8.5 Lemma 6 — The v versus $v/\sqrt{2}$ conversion

Lemma 6. If a convention defines

$v_{red} = v/\sqrt{2}$,

then the mass relation

$m_f = y_f\, v/\sqrt{2}$

becomes

$m_f = y_f\, v_{red}$.

The two forms are equivalent only under this explicit definition.

Proof. Substitute $v_{red} = v/\sqrt{2}$. ■

8.6 Lemma 7 — The Fermi-constant anchor

Lemma 7. At tree level in the QN-2 ledger,

$G_F/\sqrt{2} = g^2/(8\, m_W^2) = 1/(2v^2)$,

so that

$v = (\sqrt{2}\, G_F)^{(-1/2)} \approx 246.22$ GeV.

Therefore v possesses an operational, convention-stable definition through the muon-decay observable G_F, independent of field labels and normalisation notation.

Proof. Integrating out the W boson in the charged-current interaction of Premise SMN-9 yields the four-fermion coefficient $G_F/\sqrt{2} = g^2/(8m_W^2)$. Substituting $m_W = gv/2$ gives $g^2/(8\cdot g^2v^2/4) = 1/(2v^2)$. Solving for v gives the stated relation. Since G_F is defined from a measured decay rate, the chain is anchored in the record projection. ■

Consequence. The frequent VERSF temptation to call some dimensional quantity "the electroweak scale" is now regulated: v means the Fermi-anchored quantity above, $v_{red} = v/\sqrt{2} \approx 174$ GeV must be named, and any other referent (m_W, m_Z, a running Higgs parameter, or a VERSF-derived scale) must be stated explicitly. Beyond tree level, the extraction of v from G_F acquires the radiative correction Δr, and v becomes a scheme-dependent parameter like every quantity in §11. The canonical referent is the tree-anchored G_F-scheme value; any beyond-tree use of v must carry a scheme label (e.g. v_{GF}, $v^{\overline{MS}}(\mu)$) under the §11.5 rule.

8.7 Rule

Later VERSF papers must not state "the electroweak scale" without specifying whether they mean v, $v/\sqrt{2}$, m_W, m_Z, a running Higgs parameter, or a VERSF-derived dimensional scale — and, if the last, without a bridge theorem.

---

9. Yukawa, Fermion-Mass, and Hierarchy Conventions

9.1 Yukawa matrices are not masses

The canonical relation is

$$M_f = (v/\sqrt{2}) \cdot Y_f.$$

Thus a prediction for Y_f is not yet a prediction for m_f unless v, scheme, scale, and diagonalisation convention are specified.

9.2 Diagonalisation

For each fermion type,

$$U_{fL}^\dagger M_f U_{fR} = D_f,$$

where

$$D_f = \mathrm{diag}(m_{f1}, m_{f2}, m_{f3})$$

with nonnegative entries. The singular values are basis-invariant. The matrices U_{fL} and U_{fR} are not individually observable; only the combinations entering charged currents survive the record projection.

9.3 Hierarchy exponents

If a later VERSF gate proposes

$$y_f \sim e^{(-\mathcal{E}_f)},$$

then $\mathcal{E}_f$ must be typed as one of:

- localization exponent;
- channel-count exponent;
- completion-density exponent;

- power-law exponent;
- amplitude-level exponent;
- probability-level exponent;
- gap-related exponent;
- fitted residual.

QN-1's factor-of-two and channel-log warnings remain active: an amplitude-level exponent and a probability-level exponent for the same suppression differ by exactly a factor of two, and λ_{14} = ln 14 is not 8/3.

9.4 Lemma 8 — Yukawa hierarchy exponent typing

Lemma 8. A VERSF hierarchy exponent can be compared to a Standard Model Yukawa only after specifying whether it predicts

Y_f, M_f, m_f^{pole}, $m_f^{\mathcal{S}}(\mu)$, m_i/m_j, y_i/y_j,

or another observable.

Proof. Each object transforms differently under Higgs normalisation, basis rotations, and renormalisation flow: Y_f carries the Higgs convention, M_f the vacuum normalisation, m_f^{pole} is scale-free but radiatively defined, $m_f^{\mathcal{S}}(\mu)$ flows with μ, and ratios cancel some but not all of these dependences. Without specifying the target object, the map from exponent to observable is underdetermined, and the same exponent value corresponds to different physical claims. ■

9.5 Rule

A later mass paper must report

prediction target + Higgs convention + scheme + scale + basis + VERSF exponent type.

Anything less is not a quantitative prediction.

---

10. Flavour Basis, CKM/PMNS, and Phase Conventions

10.1 Flavour rotations

The gauge kinetic terms are invariant under flavour-basis rotations before Yukawa matrices are fixed. For example:

$Q_L \to U_Q Q_L$, $u_R \to U_u u_R$, $d_R \to U_d d_R$.

The Yukawa matrices transform as

$Y_u \to U_Q^\dagger Y_u U_u$, $Y_d \to U_Q^\dagger Y_d U_d$.

Only basis-invariant combinations are physical.

10.2 CKM convention

QN-2 fixes

$V_{CKM} = U_{uL}^\dagger U_{dL}$.

The charged current is

$\mathscr{L}_{CC} = (g/\sqrt{2}) \cdot \bar{u}_L \gamma^\mu V_{CKM} d_L W^+_\mu + \text{h.c.}$

If a later paper writes the current with $\bar{d}_L V^\dagger \gamma^\mu u_L W^-_\mu$, the same matrix appears adjointed because the current has been conjugated. That is not a different prediction.

10.3 Physical CKM quantities

Physical CKM statements include:

- matrix-element magnitudes $|V_{ij}|$;
- unitarity-triangle angles under a stated convention;
- the Jarlskog invariant

  $J = \mathrm{Im}(V_{us} V_{cb} V_{ub} V_{cs})$,

  to which all quark-sector CP-violating effects with three generations are proportional — noting that the quartet defining J is itself a convention: a different index quartet yields $\pm J$; $|J|$ is quartet-independent, and a signed J prediction must state its quartet;

- transition probabilities;
- CP asymmetries after full process conventions.

The sign or size of a single phase is not meaningful unless the phase convention is fixed. Parameterisation matters too: Wolfenstein parameters (λ, A, $\bar{\rho}$, $\bar{\eta}$) are defined only to a stated order in λ, and comparing an exact parameterisation with a truncated one without stating the order introduces spurious shifts.

10.4 The strong-CP phase

The QCD vacuum angle θ is not rephasing-invariant on its own: chiral field redefinitions shift it. The rephasing-invariant combination is

$$\bar{\theta} = \theta + \arg\det(Y_u Y_d).$$

Only $\bar{\theta}$ is a candidate physical quantity. Any later VERSF statement about strong CP must be a statement about $\bar{\theta}$, not about θ in a particular flavour basis.

10.5 PMNS convention

The minimal Standard Model has massless neutrinos. Therefore PMNS mixing is not part of the minimal QN-2 Standard Model ledger unless a neutrino-mass extension is declared.

If declared, QN-2 uses

$$U_{PMNS} = U_{eL}^\dagger U_{\nu L}.$$

Majorana phases, if present, must be typed separately because they do not enter all oscillation observables.

10.6 Lemma 9 — Phase redefinitions do not change physical mixing

Lemma 9. Field rephasings can move phases among Yukawa matrices, mass eigenstates, and mixing matrices. A phase prediction is physical only if it is expressed in a rephasing-invariant form or under a fixed phase convention.

Proof. Let

$$u_L \to P_u u_L, \quad d_L \to P_d d_L,$$

with diagonal phase matrices P_u, P_d. Then

$$V_{CKM} \to P_u^\dagger V_{CKM} P_d.$$

Matrix entries change phases, but $|V_{ij}|$, transition probabilities, J, and $\bar{\theta}$ remain unchanged. Any quantity that shifts under this map is convention content, not record content. ■

---

11. Renormalisation Scheme, Scale, and Threshold Conventions

11.1 Running quantities

The following are not fixed numbers without a scheme and scale:

g_s, g, g', y_f, λ, $m_f^{running}$, θ_W, V_{CKM} parameters.

A later VERSF paper must label them as

$X^{\mathcal{S}}(\mu)$.

11.2 Pole versus running masses

A pole mass and a running mass are different objects:

$m_f^{pole} \neq m_f^{\overline{MS}}(\mu)$

except after a conversion with radiative corrections and thresholds. The difference is not pedantic: for the bottom quark, $m_b^{pole} \approx 4.8$ GeV while $m_b^{\overline{MS}}(m_b) \approx 4.18$ GeV — a discrepancy of order 15%, larger than most hierarchy claims a later gate might make.

11.3 Thresholds

When comparing across scales, the active particle content changes. Threshold matching must state:

- matching scale;
- active fields;
- loop order;
- scheme;
- decoupling convention.

11.4 Lemma 10 — Numerical comparison requires scheme and scale

Lemma 10. A numerical prediction for a running Standard Model parameter is incomplete unless the renormalisation scheme and scale are specified.

Proof. Renormalisation-group flow maps the same physical theory to different parameter values at different scales. Scheme transformations also alter parameter values while preserving observables. Therefore a bare number for a running parameter has no unique physical meaning: it names an equivalence class member without naming the equivalence class. ■

11.5 Rule

Later VERSF claims must distinguish:

Claimed object	Required label
Gauge coupling	g_i^𝓢(μ), or physical observable
Yukawa coupling	y_f^𝓢(μ)
Running mass	m_f^𝓢(μ)
Pole mass	m_f^pole
Mixing parameter	parameterisation, scheme if needed
Higgs quartic	λ^𝓢(μ)
Weak angle	on-shell, M̄S̄, effective, or other

---

12. VERSF Localization, Channel, Gap, and Response Interface

12.1 The interface problem

VERSF introduces structures not native to the Standard Model Lagrangian:

- finite commitment scale ξ;
- localization stiffness κ⋆;
- compliance coefficient c⋆;
- channel-log weight λ_{14};
- gap scale m⋆;
- response coupling κ_eff;
- completion density;
- record saturation;
- closure census.

These may ultimately explain Standard Model quantities. QN-2 does not deny that. It enforces the bridge standard.

12.2 VERSF-to-SM bridge classes

Class A — Exact convention inheritance. Example: amplitude/probability exponent conversion inherited from QN-1.

Class B — Exact dimensional composite. Example:

$m_\star = \sqrt{(\kappa_\star/2)} \cdot \xi^{-1}$

inside the VERSF gap ledger.

Class C — Candidate physical bridge. Example:

VERSF hierarchy exponent ⟶ Yukawa eigenvalue.

Open until mechanism, domain, and error control are supplied.

Class D — Distinct objects. Example:

$C_F^{SU(3)} = 4/3$ and $g_\kappa = 4/3$.

No bridge follows from equality.

12.3 Bridge admissibility conditions

A VERSF-to-Standard-Model bridge theorem must supply all seven components:

1. **Dimensional map.** Are the objects dimensionless, mass-dimensional, inverse-length, coupling-dimensional, or response-dimensional?
2. **Representation slot.** Does the VERSF object map to a gauge representation, a Yukawa eigenvalue, a mixing angle, a mass, a coupling, a response coefficient, or an anomaly condition?
3. **Convention ledger.** Which QN-2 ledger entries are active?
4. **Mechanism.** What physical or algebraic construction generates the relation?
5. **Domain of validity.** Tree-level, low-energy, high-energy, completion-density limit, perturbative regime, saturation regime, or record-terminal regime?
6. **Error control.** Exact equality, asymptotic expansion, numerical approximation, bounded residual, or empirical fit?
7. **Observable projection.** Which physical record is claimed to match?

12.4 Rule

No later VERSF paper may write

VERSF number = Standard Model number

unless it passes the bridge test.

---

13. The Standard Model Convention-Reconciliation Map

13.1 Canonical QN-2 convention string

Later VERSF papers may inherit the following shorthand instead of restating the full ledger:

```
QN2[ η = (+,−,−,−);
     γ⁵ = iγ⁰γ¹γ²γ³;  ε⁰¹²³ = +1;
     D_μ = ∂_μ + i g_s Gᵃ Tᵃ_c + i g Wⁱ Tⁱ_L + i g′ (Y/2) B;
     Q = T₃ + Y/2;
     Tr(TT) = 1/2;
     H = (H⁺, H⁰), Y_H = +1, ⟨H⁰⟩ = v/√2, v = (√2 G_F)^(−1/2);
     V_CKM = U_uL† U_dL;
     g₁ = √(5/3)·g′ only when stated;
     X = X^𝒮(μ) for running quantities;
     QN-1 κ-ledger active ]
```

13.2 Conversion table

Object	Canonical QN-2 reading	Common alternate	Conversion
Hypercharge	$Q = T_3 + Y/2$	$Q = T_3 + Y'$	$Y' = Y/2$
Hypercharge coupling	g'	g_1	$g_1 = \sqrt{5/3}\cdot g'$
Higgs VEV	$\langle H^0\rangle = v/\sqrt{2}$	v_red	v_red = $v/\sqrt{2}$
Fermion mass	m_f = y_f $v/\sqrt{2}$	m_f = y_f v_red	exact with above
Electroweak scale	v = ($\sqrt{2}$ G_F)^(−1/2)	m_W, m_Z, v_red	state target
CKM matrix	U_uL† U_dL	adjoint convention	current orientation decides
PMNS matrix	U_eL† U_νL	adjoint convention	current orientation decides
Weak angle	tan θ_W = g′/g	on-shell / $\overline{\text{MS}}$ / effective	name definition
Gauge generators	Tr(TT) = 1/2	other trace norm	rescale generators/couplings
Pole mass	physical pole	running mass	radiative conversion needed
Running mass	m^𝒮(μ)	pole mass	scheme/threshold conversion
Strong-CP phase	$\bar{\theta}$ = θ + arg det(Y_u Y_d)	basis-dependent θ	use invariant
VERSF κ⋆	localization stiffness	probability exponent	factor two if same amplitude
VERSF λ_{14}	channel log	κ⋆	not equal; bridge or error
VERSF m⋆	inverse-length gap	dimensionless exponent	invalid without dimensional bridge
SU(3) C_F = 4/3	colour Casimir	VERSF g_κ = 4/3	distinct ledgers

13.3 Lemma 11 — Ledger exhaustion

Lemma 11. Every Standard Model convention-sensitive quantity relevant to later VERSF quantitative gates falls into one of the following classes:

1. exact convention transform;
2. exact composite under a fixed ledger;
3. scheme/scale-dependent parameter;
4. basis/phase artifact;
5. dimensional bridge object;
6. open VERSF bridge debt;
7. physical observable.

No object may occupy more than one class in the same derivation without an explicit map.

Proof. Gauge, Higgs, Yukawa, mixing, renormalisation, and VERSF-interface quantities are classified in §§4–12. Each classification is determined by the object's transformation under the record projection. The seven classes are exhaustive by construction: an object either preserves Π_{rec} under relabelling (classes 1, 4), converts exactly under fixed ledger entries (class 2), carries ($\mathcal{S}$, μ) dependence (class 3), carries dimension requiring ξ, v, m⋆, or κ_{eff} (class 5), lacks an established map (class 6), or is record-stable (class 7), with class 6 serving as the residual class. The content of the lemma is mutual exclusivity within a fixed derivation: the classifying properties are properties of the object as used, so occupying two classes simultaneously requires an explicit map between the two usages. ■

---

14. The Standard Model Convention and Normalisation Audit Theorem

14.1 Assembly

The paper has established:

1. Physical content is the record projection Π_{rec}, not a bare symbol.
2. A Standard Model convention ledger $\mathfrak{L}_{SM}$ records continuum, gauge, generator, derivative, hypercharge, Higgs, Yukawa, mixing, renormalisation, and VERSF-interface conventions.
3. Valid convention transformations preserve Π_{rec}.
4. Valid convention transformations compose and invert.
5. Hypercharge normalisation changes require coupling and charge translation.
6. Generator normalisation changes require coupling conversion.
7. Higgs VEV normalisation fixes the $m_f = y_f v/\sqrt{2}$ relation, with v anchored by G_F.
8. Yukawa eigenvalues are not masses until Higgs, basis, scheme, and scale are specified.
9. CKM and PMNS matrices are convention-stable only through their charged-current slots and rephasing-invariant content.

10. Running quantities require scheme and scale.
11. VERSF quantities require bridge theorems before identification with Standard Model quantities.

14.2 Theorem 1 — Standard Model Convention and Normalisation Audit Theorem

Theorem 1. Under Premises SMN-1 through SMN-11, the Standard Model convention and normalisation structure inside VERSF is closed as a typed ledger.

Let $\mathfrak{L}_{SM\star}$ be the canonical QN-2 ledger defined by:

$G_{SM}^{local} = SU(3)_c \times SU(2)_L \times U(1)_Y$,

$\mathrm{Tr}(T^a T^b) = \frac{1}{2} \delta^{ab}$,

$D_\mu = \partial_\mu + i\, g_s\, G^a{}_\mu\, T_c{}^a + i\, g\, W^i{}_\mu\, T_L{}^i + i\, g'\, (Y/2)\, B_\mu$,

$Q = T_3{}^L + Y/2$,

$H = (H^+, H^0)^T$, $Y_H = +1$, $\langle H^0 \rangle = v/\sqrt{2}$, $v = (\sqrt{2}\, G_F)^{(-1/2)}$,

$m_f = y_f\, v/\sqrt{2}$,

$V_{CKM} = U_{uL}^\dagger\, U_{dL}$,

with $g_1 = \sqrt{(5/3)}\cdot g'$ used only when explicitly declared, and all running quantities labelled by scheme and scale.

Then:

1. **Gauge-normalisation closure.** Any change of generator normalisation, trace normalisation, hypercharge normalisation, or U(1) coupling convention is valid only if it preserves the gauge interaction operators and electric charges after translation.
2. **Electroweak-orientation closure.** Any change of weak mixing, covariant-derivative sign, Higgs doublet orientation, or W±/Z/A sign convention is valid only if it preserves electromagnetic charge, charged-current structure, and neutral-current observables.
3. **Higgs-normalisation closure.** Any use of v, $v/\sqrt{2}$, m_W, m_Z, G_F, or a VERSF dimensional scale as "the electroweak scale" is valid only when the exact conversion target is stated; the Fermi anchor $v = (\sqrt{2}\, G_F)^{(-1/2)}$ is the canonical referent.
4. **Yukawa/mass closure.** A prediction for Y_f, M_f, m_f^{pole}, $m_f^{\mathcal{S}}(\mu)$, or a mass ratio is meaningful only when the Higgs convention, diagonalisation convention, scheme, scale, and observable target are stated.
5. **Mixing/phase closure.** CKM and PMNS predictions are physical only as charged-current-slot definitions, matrix-element magnitudes, rephasing-invariant quantities (J, $\bar{\theta}$),

or explicitly parameterised angles at a stated order. Basis and phase artifacts are not predictions.

6. **Renormalisation closure.** Couplings, Yukawas, quartics, running masses, and scale-dependent mixing parameters require a scheme and scale. Pole and running quantities are never silently interchangeable.
7. **VERSF-interface closure.** VERSF quantities such as ξ, $\kappa\star$, $c\star$, λ_{14}, $m\star$, and κ_eff may enter Standard Model derivations only through typed bridge maps satisfying SMN-11.
8. **Observable invariance.** Every valid convention transformation preserves

   Π_rec(𝔏_SM).

   Therefore no valid change of Standard Model convention can alter a physical VERSF prediction.

Consequently, any later VERSF derivation whose result changes under a permitted convention transformation is not convention-stable. The change indicates an error, an omitted conversion, an uncarried approximation, or an open bridge debt.

Proof. Parts 1–7 follow respectively from Lemmas 3–11 and Premises SMN-3 through SMN-11: Lemma 3 and the trace declaration establish part 1 together with Lemma 4; Premises SMN-6 and SMN-7 with §6.4 establish part 2; Lemmas 6 and 7 establish part 3; Lemma 8 establishes part 4; Lemma 9 with §10.3–10.4 establishes part 5; Lemma 10 establishes part 6; Premise SMN-11 with §12 establishes part 7. Part 8 follows from Lemma 1 and the groupoid closure of Lemma 2. By Lemma 11, the listed convention classes exhaust the Standard Model objects relevant to later VERSF quantitative gates. Therefore every convention-sensitive object is either fixed, exactly converted, typed as scheme/scale-dependent, quarantined as a bridge debt, or projected to an invariant observable. No untyped convention freedom remains available for silent numerical adjustment. ■

14.3 Corollary 1 — No silent Standard Model substitution

A later VERSF derivation may replace one Standard Model expression with another only by stating one of:

1. exact convention transform;
2. exact composite relation;
3. scheme/scale conversion;
4. basis/phase convention map;
5. declared approximation with error;
6. admissible VERSF bridge;
7. declaration that the objects are distinct.

Bare substitution is invalid.

14.4 Corollary 2 — Later gates inherit QN-2

A later VERSF mass, coupling, hierarchy, CKM, PMNS, electroweak, Higgs, or gravitational-response paper may write:

“All Standard Model quantities are interpreted in the QN-2 ledger.”

Any deviation must be stated.

14.5 Corollary 3 — Convention-stable predictions are stronger than convention-dependent numbers

A prediction expressed as a record invariant is stronger than a prediction expressed as a bare parameter. For example:

- predicting $|V_{us}|$ is stronger than predicting a convention-dependent mixing angle without a parameterisation;
- predicting m_e^{pole}/m_μ^{pole} is cleaner than predicting an unlabelled electron mass;
- predicting $y_t^{\overline{MS}}(\mu)$ is meaningful only with μ;
- predicting the weak angle is meaningful only after naming the on-shell, $\overline{MS}$, or effective definition;
- predicting $Q_e = -1$ is convention-stable only after the charge operator is fixed.

---

15. Audit of Standard Model Convention Traps

15.1 Trap table

Trap	Error	QN-2 correction
$Q = T_3 + Y/2$ vs $Q = T_3 + Y$	hypercharge doubled/halved	state $Y' = Y/2$
g' vs g_1	5/3 coupling error	$g_1 = \sqrt{(5/3)}\cdot g'$
v vs $v/\sqrt{2}$	$\sqrt{2}$ mass error	state Higgs VEV convention
m_f vs y_f	missing Higgs factor	$m_f = y_f v/\sqrt{2}$
“the electroweak scale”	ambiguous referent	Fermi anchor or explicit target
pole vs running mass	wrong comparison object	label m^{pole} or $m^{\mathcal{S}}(\mu)$
$\sin^2\theta_W$ undeclared	~0.008 definition spread	name on-shell / $\overline{MS}$ / effective
CKM V vs $V^\dagger$	reversed charged current	fix current slot

Trap	Error	QN-2 correction
Wolfenstein order	truncation shift	state order in λ
PMNS in minimal SM	extension smuggled in	declare neutrino sector
phase prediction	unphysical phase	use rephasing invariant (J, $\bar{\theta}$)
$C_F = 4/3$ vs $g_\kappa = 4/3$	numerology	distinct ledgers
$\lambda_{14} \approx 8/3$	hidden approximation	carry δ_{14} or bridge
$m_\star$ vs $\kappa_\star$	dimensional error	$m_\star$ has mass dimension
ξ^{-1} vs v	scale identification	bridge required
gauge-fixing parameter	unphysical prediction	project to observable
R_ξ gauge parameter ξ	symbol collision with VERSF commitment scale ξ	distinct objects; gauge parameter is unphysical, must cancel in Π_{rec}; rename ξ_{gauge} in any loop-level gate
field normalisation	coefficient drift	recanonicalise kinetic terms
beta-function coefficient	trace convention mismatch	state generator normalisation

15.2 Anomaly bookkeeping

With the QN-2 hypercharge convention, anomaly checks are performed using left-handed Weyl fields. The right-handed physical fields are replaced by left-handed conjugates:

$u_R \to u^c_L$, $d_R \to d^c_L$, $e_R \to e^c_L$,

and their hypercharges flip sign.

For one generation:

Left Weyl field	Multiplicity	Hypercharge
Q_L	3×2	$+1/3$
u^c_L	3	$-4/3$
d^c_L	3	$+2/3$
L_L	2	-1
e^c_L	1	$+2$

Then:

$[SU(3)]^2U(1)$: $2\cdot(1/3) - 4/3 + 2/3 = 0$,

$[SU(2)]^2U(1)$: $3\cdot(1/3) - 1 = 0$,

$[grav]^2U(1)$: $6\cdot(1/3) + 3\cdot(-4/3) + 3\cdot(2/3) + 2\cdot(-1) + 2 = 0$,

$[U(1)]^3$: $6\cdot(1/3)^3 + 3\cdot(-4/3)^3 + 3\cdot(2/3)^3 + 2\cdot(-1)^3 + 2^3 = 0$.

Explicitly, the cubic sum is $6/27 - 192/27 + 24/27 - 2 + 8 = -6 + 6 = 0$.

Three further conditions complete the census: the $[SU(3)]^3$ anomaly vanishes because colour is vector-like (3 and $\bar{3}$ in equal number per generation); the $[SU(2)]^3$ anomaly vanishes identically by the pseudo-reality of SU(2) representations; and the Witten global SU(2) anomaly requires an even number of SU(2) doublets per generation, satisfied by 3 (colour) + 1 (lepton) = 4. The Witten condition is a global constraint — it survives every local convention transformation and is therefore pure record content, and it exemplifies why global data are typed separately from the local algebra in §5.1.

These cancellations are convention-stable only after the hypercharge convention and left-Weyl bookkeeping are fixed. Under $Y' = Y/2$ every entry rescales by 1/2, and each anomaly sum rescales by a common power of 1/2, so cancellation is preserved — which is exactly what record invariance requires.

15.3 Rule

Any later VERSF claim about charge quantisation, family structure, anomaly cancellation, or representation census must state whether it uses physical right-handed fields or left-handed conjugate fields.

---

16. Why This Is Not Parameter Fitting

16.1 The objection

A critic may say:

This paper is just protecting VERSF from numerical mistakes by moving everything into convention language.

That objection would be fair if QN-2 used convention language to erase physical differences. It does the opposite.

QN-2 says:

- $g' \neq g_1$ unless converted;

- $v \neq v/\sqrt{2}$;
- $m_f \neq y_f$;
- pole masses are not running masses;
- V and $V^\dagger$ are not interchangeable without current orientation;
- $C_F = 4/3$ is not VERSF $g_\kappa = 4/3$;
- ξ^{-1} is not automatically the electroweak scale;
- Standard Model parameters cannot be compared without scheme and scale.

This is not fitting. It is anti-fitting. It blocks the easiest ways to move numbers.

16.2 The single standard

QN-2 uses one standard:

A relation is accepted only if it is a convention transform, an exact composite under a fixed ledger, a scheme/scale conversion, or a bridge theorem with mechanism and error control.

Numerical closeness is not evidence. Numerical exactness is not evidence. Symbolic resemblance is not evidence. Dimensional similarity is not evidence. Only ledgered transformations and physical bridges count.

16.3 The honesty test

The strongest honesty test is the collision of repeated Standard Model and VERSF numbers:

$C_F^{SU(3)} = 4/3$, $g_\kappa = 4/3$, $\lambda_{14} = \ln 14 \approx 8/3$, $c^\star = 3/8$.

A weak programme would exploit these coincidences. QN-2 forbids that. It demands a typed origin for every appearance. That is the right discipline: the ledger converts each coincidence from an available shortcut into a named falsifier.

---

17. Relation to Later Mass, Coupling, and Hierarchy Gates

17.1 Why QN-2 must precede quantitative Standard Model derivations

Later VERSF papers may attempt to derive:

- fermion generations;

- electric charges;
- hypercharges;
- weak chirality;
- lepton masses;
- quark masses;
- Yukawa hierarchies;
- CKM angles;
- PMNS angles;
- gauge couplings;
- Higgs-sector parameters;
- the electroweak scale;
- neutrino masses;
- gravitational response;
- completion-density corrections;
- hierarchy exponents.

Every one of these is convention-sensitive. Without QN-2, a later numerical match could be produced or destroyed by:

- switching g' and g_1;
- switching v and $v/\sqrt{2}$;
- comparing a pole mass to a running Yukawa;
- using $Q = T_3 + Y$ in one section and $Q = T_3 + Y/2$ in another;
- quoting a weak angle without a definition;
- treating a phase as physical when it is removable;
- treating a VERSF localization coefficient as a Standard Model Casimir;
- comparing dimensionful and dimensionless quantities.

QN-2 removes those escape routes.

17.2 What later papers may assume

A later VERSF paper may write:

We work in the QN-2 Standard Model ledger and the QN-1 κ-ledger. Running quantities are labelled by scheme and scale. VERSF-to-Standard-Model identifications are treated as bridge claims and must satisfy the QN-2 admissibility test.

That is sufficient inheritance.

17.3 What remains open

QN-2 does not close:

- derivation of the Standard Model gauge group;

- derivation of three generations;
- derivation of hypercharge assignments;
- derivation of the Higgs potential;
- derivation of v;
- derivation of Yukawa matrices;
- derivation of CKM/PMNS values;
- derivation of gauge-coupling values;
- the $\xi \to v$ bridge;
- VERSF completion-density maps to Yukawas;
- gravitational κ_{eff}.

It closes the convention audit required before those derivations can be judged.

---

18. Falsification Conditions

#	Failure	Consequence
F1	A Standard Model quantity is used without a ledger entry	derivation under-specified
F2	Hypercharge convention changes without Y/coupling conversion	charge audit fails
F3	g' and g_1 are interchanged silently	coupling normalisation error
F4	$Q = T_3 + Y/2$ and $Q = T_3 + Y$ are mixed	hypercharge factor error
F5	Generator trace normalisation changes without rescaling couplings	gauge coefficient error
F6	Casimir values are compared across ledgers without bridge	numerology
F7	Covariant-derivative sign changes without field/sign translation	interaction sign error
F8	Higgs v and $v/\sqrt{2}$ are mixed	$\sqrt{2}$ mass error
F9	Yukawa eigenvalue is compared to mass without $v/\sqrt{2}$	mass-map failure
F10	Pole and running masses are interchanged	comparison invalid
F11	Running coupling is quoted without scheme and scale	numerical claim incomplete
F12	CKM matrix is adjointed without current convention	flavour prediction ambiguous
F13	A phase prediction changes under rephasing	phase is unphysical
F14	A weak-angle claim omits its definition	prediction incomplete
F15	PMNS is used inside minimal SM without declaring neutrino extension	sector boundary violated
F16	Anomaly cancellation uses physical RH fields without conjugation bookkeeping	anomaly audit ambiguous
F17	Gauge-fixing artifact is treated as observable	physical-sector violation

#	Failure	Consequence
F18	Field rescaling changes a claimed prediction	field normalisation error
F19	ξ^{-1} is identified with v without bridge	dimensional bridge failure
F20	$\kappa\star$ is identified with a gauge Casimir	ledger collision
F21	λ_{14} is substituted for $\kappa\star$ without δ_{14}	hidden approximation
F22	$m\star$ is treated as dimensionless	dimensional error
F23	κ_eff is treated as a localization exponent	response/localization confusion
F24	A VERSF exponent predicts a mass without specifying target object	hierarchy map incomplete
F25	A bridge theorem lacks mechanism, domain, or error control	bridge invalid
F26	A claimed convention transformation changes Π_rec	not a convention transformation
F27	γ^5 or ε convention changed without translating chirality- and CP-sensitive signs	orientation audit fails
F28	R_ξ parameter conflated with VERSF ξ	symbol-collision error
F29	v used beyond tree level without a scheme label	anchor claim incomplete

---

19. QN-2 Closure Certificate

QN-2 condition	Result
Standard Model convention-drift problem isolated	closed
Physical record projection defined	closed
Convention ledger 𝔏_SM defined	closed
Valid convention transformation defined	closed
Groupoid closure of convention transformations established	closed
Local gauge algebra fixed	closed
Global quotient separated	closed
Generator trace normalisation fixed	closed
Hypercharge convention fixed	closed
g' versus g_1 separated	closed
Covariant-derivative convention fixed	closed
Electroweak mixing orientation fixed	closed
Weak-angle definitions typed	closed
Higgs doublet and VEV convention fixed	closed
v versus $v/\sqrt{2}$ trap closed	closed
Fermi-constant anchor for v established	closed

QN-2 condition	Result
Yukawa-to-mass map fixed	closed
Flavour-basis convention stated	closed
CKM charged-current slot fixed	closed
PMNS typed as extension-dependent	closed
Phase-redefinition firewall established (J, $\bar{\theta}$)	closed
Renormalisation scheme/scale rule stated	closed
Pole versus running mass separation stated	closed
VERSF interface ledger stated	closed
VERSF-to-SM bridge conditions specified	closed
Casimir/VERSF numerical-collision firewall stated	closed
γ^5/ε/field-strength conventions fixed	closed
Full anomaly census including global Witten condition	closed
R_ξ/ξ symbol collision firewalled	closed
Fermi anchor scheme-typed beyond tree level	closed
Later-gate reporting standard supplied	closed
Standard Model parameter derivation	outside scope
Fermion mass derivation	outside scope
CKM/PMNS value derivation	outside scope
Gauge-coupling derivation	outside scope
$\xi \to v$ bridge	open
VERSF hierarchy-to-Yukawa bridge	open
Gravitational response bridge	open

QN-2 closure grade: closed as a Standard Model convention and normalisation audit theorem. It does not derive the Standard Model; it makes later derivations convention-auditable.

---

20. Conclusion

QN-1 closed the κ-convention problem. QN-2 closes the larger Standard Model convention problem.

The Standard Model is not a single bare formula. It is a convention-sensitive structure involving gauge representations, generator normalisations, hypercharge definitions, covariant-derivative signs, Higgs vacuum choices, Yukawa maps, flavour bases, mixing matrices, phase redundancies, renormalisation schemes, running scales, and observable projections.

VERSF adds further convention-sensitive structures: ξ, localization exponents, compliance coefficients, channel-log weights, gap scales, completion densities, and response couplings.

QN-2 prevents these structures from drifting into one another. It fixes the canonical Standard Model ledger:

$Q = T_3 + Y/2$, $\mathrm{Tr}(T^a T^b) = \frac{1}{2}\delta^{ab}$, $\langle H^0 \rangle = v/\sqrt{2}$, $m_f = y_f v/\sqrt{2}$, $v = (\sqrt{2} G_F)^{-1/2}$, $g_1 = \sqrt{5/3}\cdot g'$,

with running quantities labelled by scheme and scale, mixing matrices defined by charged-current slots, phases regulated by rephasing invariants, and VERSF quantities admitted only through bridge theorems.

The result is not glamorous, but it is essential. It means that later VERSF papers cannot win a numerical match by sliding between g' and g_1, v and $v/\sqrt{2}$, m_f and y_f, V and $V^\dagger$, pole and running masses, weak-angle definitions, or Standard Model and VERSF constants with the same numerical value.

In one sentence:

The Standard Model inside VERSF is now a typed convention ledger: every gauge, Higgs, Yukawa, flavour, phase, renormalisation, dimensional, and VERSF-interface quantity is either fixed, exactly converted, scheme-labelled, bridged, or kept distinct, so no later quantitative prediction may depend on silent normalisation drift.

Appendix A — Canonical Standard Model Convention Dictionary

A.1 Gauge group

$G_{SM}^{local} = SU(3)_c \times SU(2)_L \times U(1)_Y$.

Global quotient optional and separately typed.

A.2 Generators

$T_c^a = \lambda^a/2$, $T_L^i = \sigma^i/2$, $\mathrm{Tr}(T^a T^b) = \frac{1}{2}\delta^{ab}$.

Standard Casimirs under this normalisation: $C_F = 4/3$, $C_A = 3$, $T(\mathrm{fund}) = 1/2$.

A.3 Covariant derivative

$D_\mu = \partial_\mu + i\, g_s\, G^a_\mu\, T_c^a + i\, g\, W^i_\mu\, T_L^i + i\, g'\, (Y/2)\, B_\mu.$

A.4 Electric charge

$Q = T_3^L + Y/2.$

A.5 Hypercharges

Field	$SU(3)_c$	$SU(2)_L$	Y
Q_L	3	2	+1/3
u_R	3	1	+4/3
d_R	3	1	−2/3
L_L	1	2	−1
e_R	1	1	−2
H	1	2	+1

A.6 Electroweak mixing

$A_\mu = s_W\, W^3_\mu + c_W\, B_\mu$, $Z_\mu = c_W\, W^3_\mu - s_W\, B_\mu$, $e = g\, s_W = g'\, c_W$.

A.7 Higgs convention

$H = (H^+, H^0)^T$, $\langle H^0 \rangle = v/\sqrt{2}$, $v = (\sqrt{2}\, G_F)^{-1/2} \approx 246.22$ GeV.

A.8 Mass relations

$m_W = gv/2$, $m_Z = (v/2)\cdot\sqrt{g^2 + g'^2}$, $m_f = y_f\, v/\sqrt{2}$, $m_h^2 = 2\lambda v^2$.

A.9 Yukawa terms

$\mathscr{L}_Y = -\bar{Q}_L Y_d H d_R - \bar{Q}_L Y_u \tilde{H} u_R - \bar{L}_L Y_e H e_R + \text{h.c.}$, $\tilde{H} = i\sigma^2 H^*$.

A.10 CKM

$V_{CKM} = U_{uL}^\dagger U_{dL}$, $J = \mathrm{Im}(V_{us} V_{cb} V_{ub} V_{cs})$.

A.11 PMNS, if neutrino masses are declared

$U_{PMNS} = U_{eL}^\dagger U_{\nu L}$.

A.12 GUT hypercharge normalisation

$g_1 = \sqrt{(5/3)} \cdot g'$, $\alpha_1 = (5/3) \cdot \alpha_Y$.

A.13 Strong-CP invariant

$\bar{\theta} = \theta + \arg\det(Y_u Y_d)$.

A.14 VERSF active constants

ξ, $\kappa\star$, $c\star$, λ_{14}, $m\star$, κ_{eff}.

All retain QN-1 meanings.

A.15 Orientation and field-strength conventions

$\gamma^5 = i \gamma^0 \gamma^1 \gamma^2 \gamma^3$, $\mathrm{Tr}(\gamma^5 \gamma^\mu \gamma^\nu \gamma^\rho \gamma^\sigma) = -4i \varepsilon^{\mu\nu\rho\sigma}$, $\varepsilon^{0123} = +1$,

$[D_\mu, D_\nu] = i g F^a_{\mu\nu} T^a$, $[T^a, T^b] = i f^{abc} T^c$.

The R_ξ gauge-fixing parameter, wherever needed, is written ξ_{gauge}; it is unphysical and distinct from the VERSF commitment scale ξ.

Appendix B — Common Normalisation Traps

B.1 Hypercharge trap

Wrong: take $Y = -1$ from $Q = T_3 + Y/2$, then use $Q = T_3 + Y$.

Correct: $Y' = Y/2$.

B.2 Higgs VEV trap

Wrong: $m_f = y_f v$ while using $\langle H^0 \rangle = v/\sqrt{2}$.

Correct: $m_f = y_f v/\sqrt{2}$.

B.3 g' versus g_1

Wrong: $\alpha_1 = \alpha_Y$.

Correct: $\alpha_1 = (5/3)\cdot\alpha_Y$.

B.4 CKM adjoint trap

Wrong: compare a prediction for V with data quoted for V† without noting current orientation.

Correct: fix the charged-current slot.

B.5 Pole/running trap

Wrong: compare a high-scale Yukawa prediction directly to a pole mass.

Correct: run, match, and convert. (Scale of the danger: $m_b^{pole} \approx 4.8$ GeV versus $m_b^{\overline{MS}}(m_b) \approx 4.18$ GeV.)

B.6 Weak-angle trap

Wrong: quote $\sin^2\theta_W$ as a single number without a definition.

Correct: name on-shell $(1 - m_W^2/m_Z^2)$, $\overline{MS}$ $\hat{s}^2(\mu)$, or effective $\sin^2\theta_{eff}$.

B.7 Wolfenstein trap

Wrong: compare exact CKM entries with Wolfenstein parameters without stating the order in λ.

Correct: state the truncation order; residuals scale as powers of $\lambda \approx 0.22$.

B.8 Casimir coincidence trap

Wrong: $C_F^{SU(3)} = 4/3 = g_\kappa$, therefore colour Casimir equals VERSF gap coefficient.

Correct: distinct ledgers unless bridged.

B.9 Channel-log trap

Wrong: $\ln 14 = 8/3$.

Correct: $\ln 14 \neq 8/3$; carry $\delta_{14} = 8/3 - \ln 14$.

B.10 Dimensional trap

Wrong: $\kappa\star = m\star$.

Correct: $\kappa\star$ dimensionless; $m\star \sim \xi^{-1}$ carries mass dimension.

Appendix C — Minimal Reporting Standard for Later Gates

Every later quantitative VERSF Standard Model paper must include the following report block.

C.1 Required convention block

```
Convention ledger:
QN-2 Standard Model ledger active.
Gauge: SU(3)c × SU(2)L × U(1)Y, local algebra.
Charge: Q = T₃ + Y/2.
Generators: Tr(TᵃTᵇ) = ½ δᵃᵇ in fundamentals.
Derivative: Dμ = ∂μ + i gs Gᵃμ Tᵃ + i g Wⁱμ Tⁱ + i g′ (Y/2) Bμ.
Higgs: H = (H⁺, H⁰), Y_H = +1, ⟨H⁰⟩ = v/√2, v = (√2 G_F)^(-1/2).
Yukawa map: M_f = (v/√2)·Y_f.
CKM: V = U_uL† U_dL.
PMNS: only if neutrino extension declared.
Orientation: γ⁵ = iγ⁰γ¹γ²γ³, ε⁰¹²³ = +1.
Gauge fixing: R_ξ parameter written ξ_gauge.
Running quantities: scheme and μ stated.
VERSF κ-ledger: QN-1 active.
```

C.2 Required prediction block

```
Predicted object:
[charge / representation / mass / Yukawa / coupling / mixing / phase /
response / hierarchy exponent]

Convention target:
[pole / running / scheme / scale / basis / phase / dimensional status]

VERSF source:
[κ⋆ / c⋆ / λ₁₄ / m⋆ / ξ / completion density / channel census / response
coefficient / other]

Bridge type:
[exact convention / exact composite / scheme conversion / approximation /
open bridge theorem]

Error control:
[exact / bounded / asymptotic / numerical residual / not yet supplied]

Observable projection:
```

```
[what physical record is predicted]
```

C.3 Refusal rule

If this block cannot be filled, the result is not yet a quantitative Standard Model prediction.

Appendix D — Referee Objections and Replies

Objection 1 — This paper does not derive the Standard Model.

Reply. Correct. It is not a derivation paper. It is a convention-normalisation gate. Its purpose is to make later derivations auditable.

Objection 2 — Are you just hiding parameter freedom in conventions?

Reply. No. The paper removes parameter freedom by fixing conventions and declaring which transformations are allowed. A hidden convention shift becomes a falsifier (F1–F29).

Objection 3 — Why fix $Q = T_3 + Y/2$ instead of $Q = T_3 + Y$?

Reply. Either is acceptable. QN-2 chooses one canonical convention. The other is equivalent only with $Y' = Y/2$ and consistent coupling placement.

Objection 4 — Why separate g' and g_1?

Reply. Because they differ by $\sqrt{(5/3)}$. Confusing them changes coupling predictions by 5/3 at the level of α. g_1 is GUT-normalised hypercharge; g' is the electroweak hypercharge coupling in the canonical derivative.

Objection 5 — Why emphasise v versus $v/\sqrt{2}$?

Reply. Because a factor of $\sqrt{2}$ is large enough to fake or destroy a mass relation. The Higgs VEV convention must be locked, and the Fermi anchor $v = (\sqrt{2}\, G\_F)^\wedge(-1/2)$ fixes the referent operationally.

Objection 6 — Does QN-2 prove VERSF derives Yukawas?

Reply. No. It states what a valid Yukawa derivation must specify: target object, Higgs convention, basis, scheme, scale, VERSF source, bridge mechanism, and error control.

Objection 7 — Can VERSF identify ξ^{-1} with the electroweak scale?

Reply. Not by notation or dimensional similarity. A bridge theorem satisfying SMN-11 is required.

Objection 8 — Is the SU(3) Casimir C_F = 4/3 related to the VERSF gap coefficient 4/3?

Reply. Not in QN-2. They are typed as distinct. A future bridge may propose a relation, but numerical equality alone has no force.

Objection 9 — Does PMNS belong in the Standard Model ledger?

Reply. Only if a neutrino-mass extension is declared. The minimal Standard Model has no neutrino masses. QN-2 audits the convention but does not smuggle in the extension.

Objection 10 — Isn't the record projection circular, since "physical" is defined as what conventions preserve?

Reply. No. The record projection is anchored in operational quantities — decay rates, cross sections, pole positions, asymmetries — that are defined independently of any Lagrangian convention. The Fermi anchor of Lemma 7 is the model case: v inherits an operational meaning from a measured lifetime. Conventions are then classified by whether they preserve those anchors; the anchors are not defined by the conventions.

Objection 11 — What is the one-sentence result?

Reply.

QN-2 fixes the Standard Model convention ledger inside VERSF so that later predictions for charges, masses, couplings, mixings, phases, hierarchies, and response coefficients cannot be changed by silent shifts of hypercharge, generator, Higgs, Yukawa, flavour, renormalisation, dimensional, or VERSF-localisation convention.

Final one-sentence theorem

After fixing the Standard Model record projection and convention ledger, every gauge, Higgs, Yukawa, flavour, phase, renormalisation, dimensional, and VERSF-interface quantity is either an exact convention representative, an exact composite, a scheme-labelled parameter, a bridge-debt object, or a physical observable; therefore later VERSF Standard Model predictions are convention-stable only when they survive this ledger unchanged.