Paper 020

Formal Verification of Falsification Protocols for Frontier Physics Experiments

From narrative controls to machine-checkable laboratory obligations

JMP0X1B Research Group

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Abstract

JMP0X1B papers repeatedly require pressure ladders, polarity pairs, shielding controls, blind runs, null bounds, and artifact ledgers. This paper proposes a formal verification layer for such protocols. Experimental obligations are expressed as state machines and temporal properties: no claim may be emitted before calibration, blinding, control coverage, safety gates, and ledger closure have occurred. The language target is JMP0X1B, with TLA-style specifications as an external reference.

Status. Draft manuscript for review and revision. This paper is not an empirical claim of new physics or field-ready technology. It is a structured proposal, theory note, protocol, or application architecture intended to be auditable, falsifiable, and publishable with source.

Contents

1 Problem

Laboratory protocols are usually written in prose. Prose is flexible, but it permits missing controls, skipped calibration, and retroactive analysis choices. The problem is to make the logical structure of a falsification protocol explicit enough to be checked before, during, and after a run.

2 Model

A protocol is a transition system over states such as design, calibration, blind assignment, run, analysis, unblinding, review, and release. Safety and scientific obligations are temporal invariants. Evidence artifacts are preconditions for transitions.

$$\Box(\text{ClaimReleased} \Rightarrow \text{Calibrated} \wedge \text{ControlsCovered} \wedge \text{LedgerClosed} \wedge \text{Reviewed}).$$

$$\Diamond\text{ErratumAllowed}, \qquad \Box(\text{DataAmended} \Rightarrow \text{RevisionLinked}).$$

3 Claims

1. **Claim 1.** A frontier-physics protocol should be model-checkable at the level of obligations even when the physics model is speculative.
2. **Claim 2.** Temporal gates can prevent premature anomaly claims without slowing down null publication.
3. **Claim 3.** Formal protocols make independent replication easier because missing controls become explicit failure states.
4. **Claim 4.** The same machinery can govern technology qualification papers and software/hardware release workflows.

4 Evidence Plan

The paper verifies three sample protocols: UHV capacitor nulls, coated-wire materials replication, and microwave cavity closure. For each, the model checker should find injected violations such as skipped calibration, unblinding before analysis lock, or claim release without ledger closure. A successful result is a small library of reusable protocol patterns.

5 JMP0X1B Implementation Surface

JMP0X1B should expose protocol states, transition guards, artifact requirements, and reviewer signatures. A small translator can emit TLA-style specs or run a native checker when the toolchain matures.

Illustrative JMP0X1B-style contract

```
protocol CapacitorNull {
    state Designed -> Calibrated requires photon_reference && leakage_dummy
    state Calibrated -> Blinded requires analysis_plan.committed
```

```
    state Blinded -> Released requires controls.coverage >= required && ledger.closed && revie
    invariant no_claim_before_release
}
```

6 Release And Review Plan

Release formal specs, counterexample traces, protocol templates, and mapping documents from prose paper requirements to machine-checkable obligations.

7 Open Questions

- What fragment of temporal logic is enough for laboratory protocols?
- How should human judgment be represented without pretending it is deterministic?
- Can protocol failures be published as useful errata?
- What native JMP0X1B syntax should be adopted for protocol declarations?

8 Conclusion

Formal verification does not prove the physics. It proves that the experiment followed the declared path before interpreting the result. For speculative research, that distinction is essential.

References

References

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