From station data to corrected flux: an integrated analysis and simulation framework for miniTRASGO

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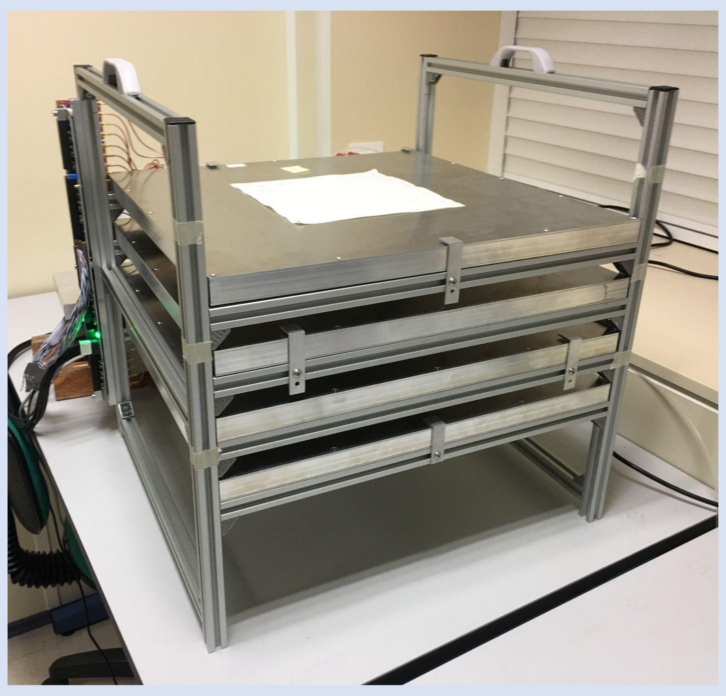
Motivation



miniTRASGO [1,2] is a compact multigap RPC-based [3] cosmic-ray telescope with timing and tracking capability. The detector concept and first monitoring results have already been reported; the present work addresses the reproducible simulation and analysis layer.

The measured trigger rate depends on detector geometry, plane efficiencies, trigger logic, live time, reconstruction selections, atmospheric conditions, and data-quality effects.

Figure 1. Left. The miniTRASGO in commissioning configuration.

The objective is to connect simulation, reconstruction, quality control, and correction in a common framework that transforms measured and simulated station data into corrected detector observables.

Digital twin structure

Detector and flux configuration → **Muon generation** → **Plane crossings** → **RPC and strip response** → **Readout and trigger response** → **Station-format simulated data**

- **Detector and flux configuration:** A parameter mesh defines controlled detector states. Scanned quantities include incident flux, plane efficiencies, angular distribution, and trigger configuration.
- **Muon generation:** Events are generated with known truth information: event time, entry position, zenith angle, azimuth angle, and input flux normalization.
- **Plane crossings:** Generated tracks are propagated to the RPC stack. For each plane, the simulation stores the crossing position and crossing time.
- **RPC and strip response:** Plane crossings are converted into detector signals. The model includes plane efficiency, charge generation, strip induction, charge sharing, and strip multiplicity.
- **Readout and trigger response:** Strip signals are converted into DAQ-level observables, including front/back timing, signal propagation, electronics thresholds, timing jitter, trigger logic, and DAQ smearing.
- **Station-format simulated data:** Accepted events are written as station-format simulated files. The output preserves an analysis-compatible event format, simulation truth, configuration metadata, and parameter-mesh identity.

Common analysis chain

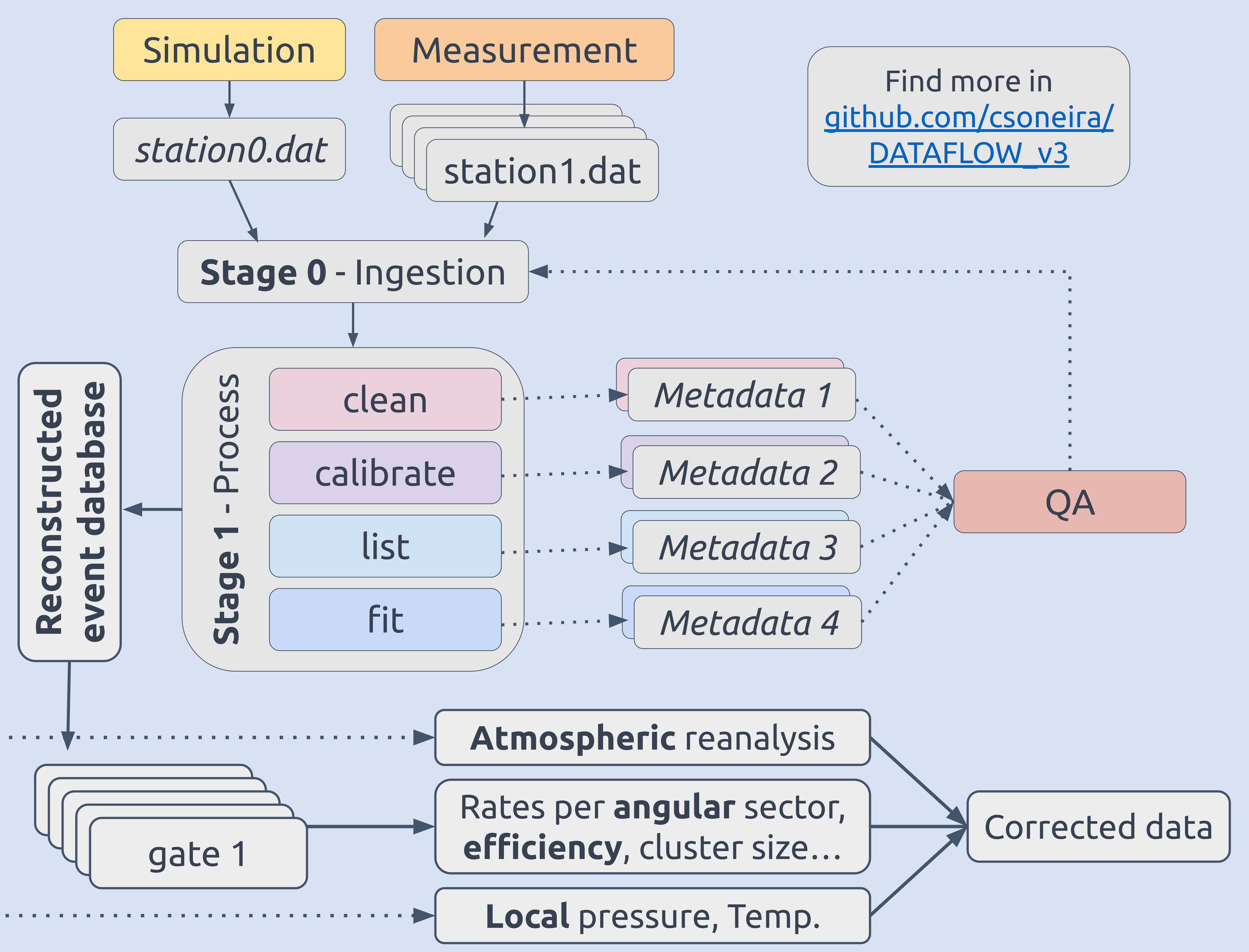


Figure 2. Common analysis chain for measured and simulated station data. Station-format files are ingested, cleaned, calibrated, reconstructed, and quality-checked to produce event databases.

Real vs simulated closure

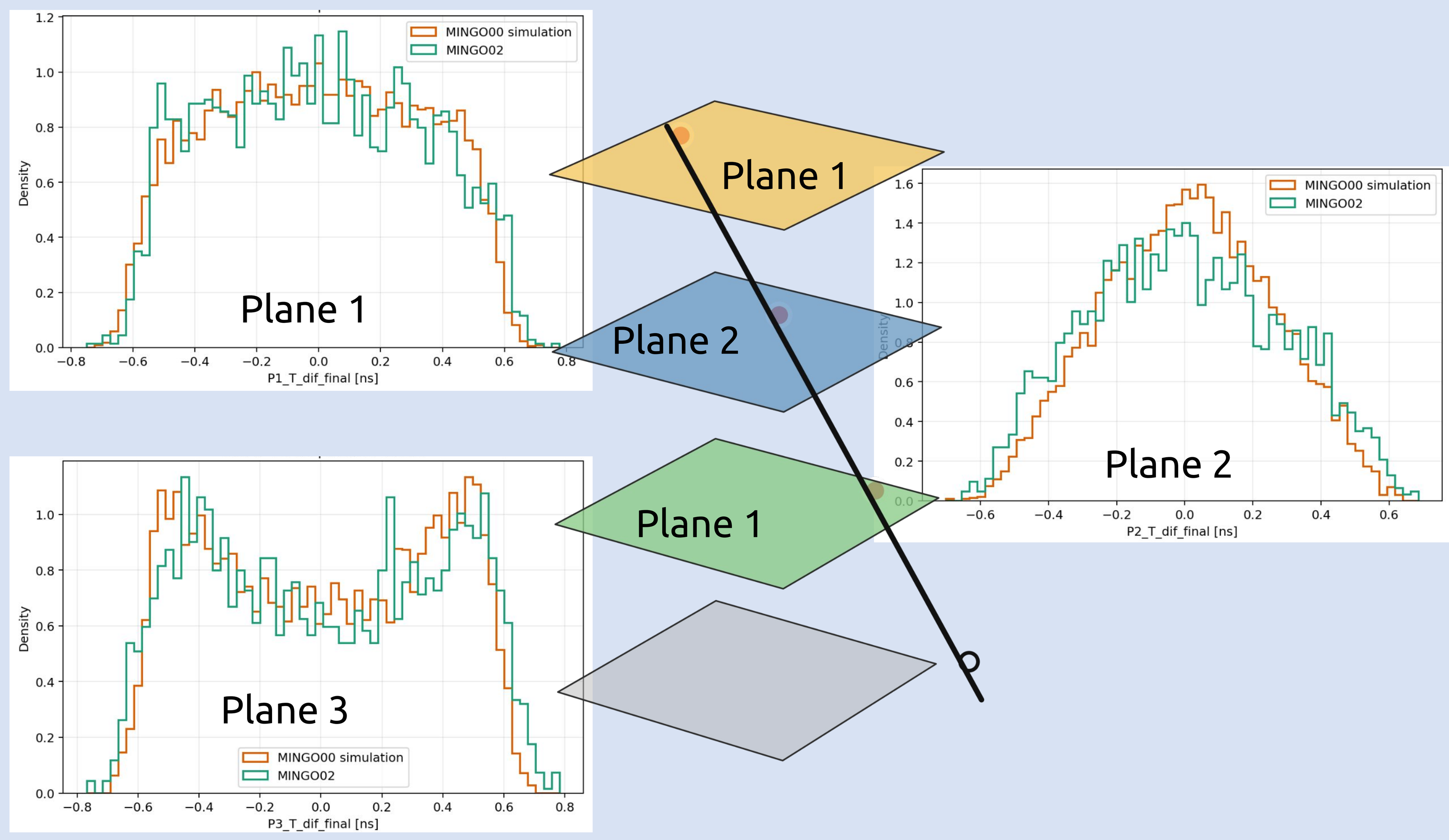


Figure 3. Real/simulation comparison for plane combination 123. MINGO02 data (**green**) are compared with the efficiency-matched MINGO00 simulation (**orange**). The selected parameters are z = [0, 145, 290, 435] mm, $I(\theta) \propto \cos^{1.647}(\theta)$, Flux = 1.868 cts/min/cm², and trigger combinations ['12', '13', '23', '34'].

Simulation-derived detector-response correction

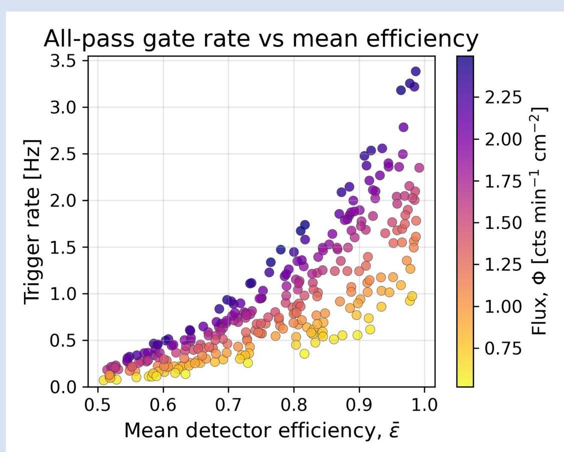
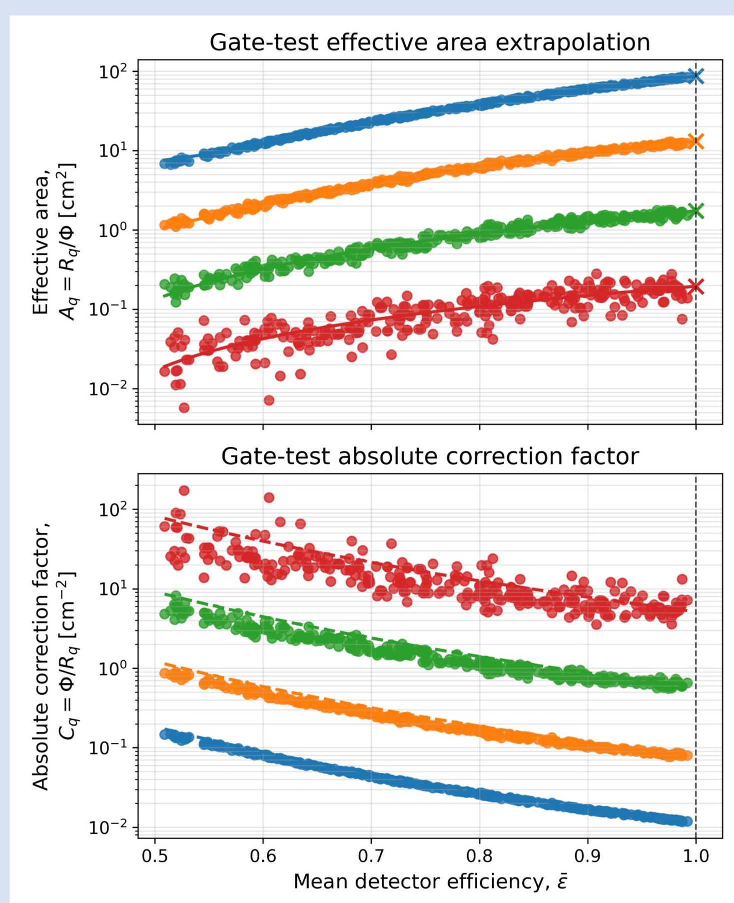
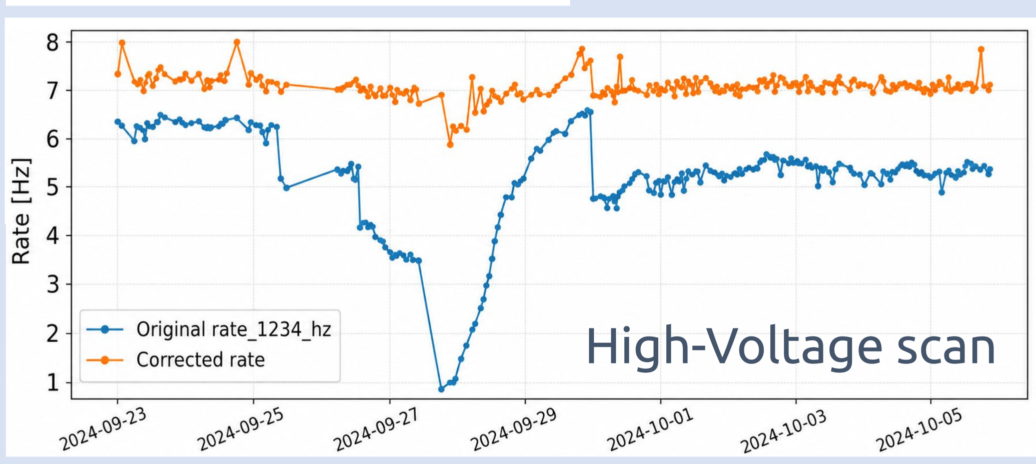


Fig.4. Left. Trigger rate in the digital twin as a function of flux and efficiency. **Right.** Correction factors for increasing charge thresholds. **Bottom.** Application to a real data HV scan.





Acknowledgments

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References

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