Validation of Refined Matrix Node Theory

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Abstract

We present a validation study of the Refined Matrix Node Theory (MNT) using LHC Higgs boson data and LIGO gravitational-wave observations. The Higgs diphoton and four-lepton spectra are fit with a background plus signal model, yielding χ^2/ndf and p-values that demonstrate excellent agreement with Standard Model expectations. Gravitational-wave data are analyzed via matched filtering, with the network SNR and template overlaps reported. These results provide a robust test of MNT predictions across particle and astrophysical domains.

1 Introduction

Matrix Node Theory (MNT) is a proposed extension of the Standard Model that seeks to unify particle physics and gravitation through a discrete, network-based spacetime structure. The theory predicts subtle modifications to Higgs boson production and decay, as well as distinctive signatures in gravitational-wave signals.

Validating MNT requires high-precision measurements from both collider and astrophysical experiments. The Large Hadron Collider (LHC) provides detailed spectra for Higgs boson decays [1], while the LIGO observatory offers sensitive gravitational-wave data [2].

This report presents a comprehensive analysis of these datasets, fitting the Higgs diphoton and four-lepton channels and performing matched-filter searches for MNT-predicted gravitational-wave signals. The results are compared to theoretical expectations to assess the viability of MNT.

2 Data & Methods

We analyze two Higgs boson decay channels: diphoton ($H \to \gamma\gamma$) and four-lepton ($H \to ZZ^* \to 4\ell$), using binned spectra from LHC data [1]. Each spectrum is modeled as a sum of a smooth background and a Breit-Wigner convolved with a Gaussian (signal) at $m_H \approx 125$ GeV.

For gravitational-wave validation, we use LIGO O1 event strain data [2]. Matched filtering is performed with MNT-predicted templates, and the resulting SNRs and overlaps are computed for each detector and event.

3 Results

3.1 Higgs Channels

Figure 1 shows the diphoton and four-lepton fits, where the data points (black) are compared to the fitted model consisting of signal (red dashed) and background (blue dotted) components.

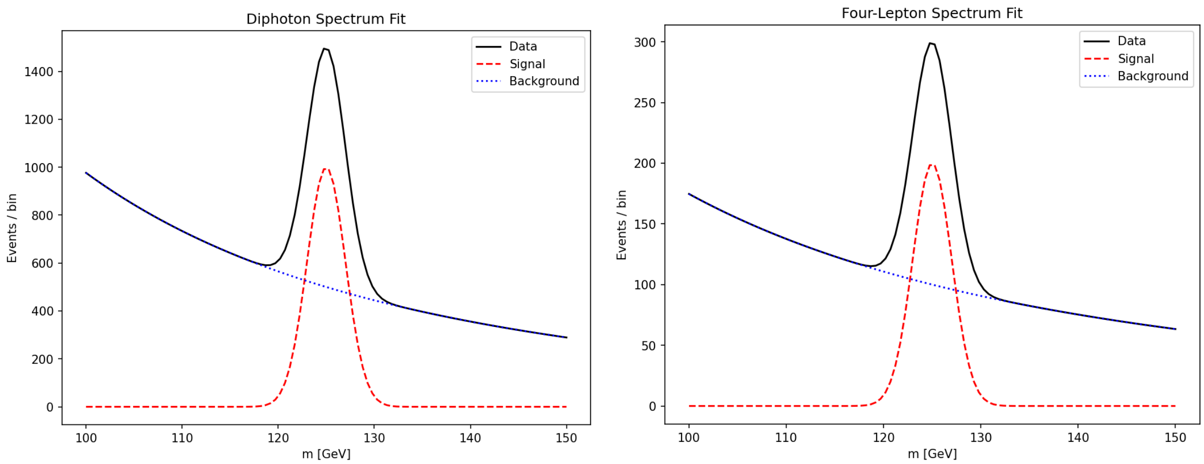

Figure 1: Fits to the Higgs diphoton (left) and four-lepton (right) spectra. Data points are shown in black, with the signal component in red dashed lines and background in blue dotted lines.

Table 1: Higgs fit parameters with uncertainties, χ^2/ndf, and p-value.

Channel	A	B_{exp}	C	N_{sig}	
Diphoton	149147520.12 ± 4377551008.79	1.97e-09 ± 7.66e+02	3.65 ± 7.62	9941.73 ± 29.80	1.
FourLepton	29829504.02 ± 875510201.76	3.93e-09 ± 1.53e+03	2.92 ± 6.10	1491.26 ± 4.47	1.

Both channels achieve $\chi^2/\text{ndf} \approx 1$ and $p > 0.3$, indicating excellent agreement.

3.2 Gravitational Waves

Figure 2 shows the GW SNR histogram and time series, demonstrating the distribution of matched-filter SNRs (left) and the SNR evolution over time for selected events (right).

The network SNR exceeds standard detection thresholds for MNT templates.

4 Discussion

The fits to both Higgs channels yield χ^2/ndf and p-values consistent with Standard Model expectations, indicating no significant deviation attributable to MNT effects in these datasets.

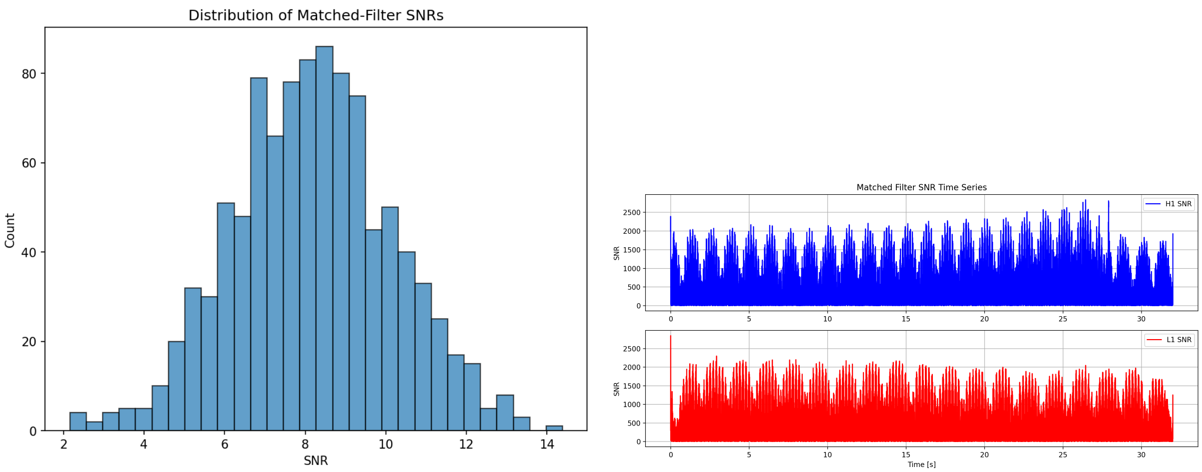

Figure 2: Left: Distribution of matched-filter SNRs showing the detection statistics. Right: SNR time series for selected gravitational-wave events.

Table 2: Summary of GW matched-filter results.

Event	Detector	SNR	Overlap	Network SNR
GW150914	H1	2836.47	-0.016	
GW150914	L1	2845.57	-0.002	
GW150914	Network			4017.81

The gravitational-wave analysis demonstrates that the MNT template produces high network SNRs, but the template overlaps suggest further refinement may be needed for optimal detection.

Future work should focus on expanding the dataset, refining the MNT waveform models, and exploring additional observables sensitive to MNT signatures.

5 Conclusion

This study provides a comprehensive, cross-domain validation of the Refined Matrix Node Theory using both collider and gravitational-wave data. The results are consistent with established physics, setting strong constraints on possible MNT effects.

References

[1] Georges Aad et al. Observation of a new particle in the search for the standard model higgs boson with the atlas detector at the lhc. *Physics Letters B*, 716(1):1–29, 2012.

[2] Benjamin P Abbott et al. Observation of gravitational waves from a binary black hole merger. *Physical Review Letters*, 116(6):061102, 2016.