



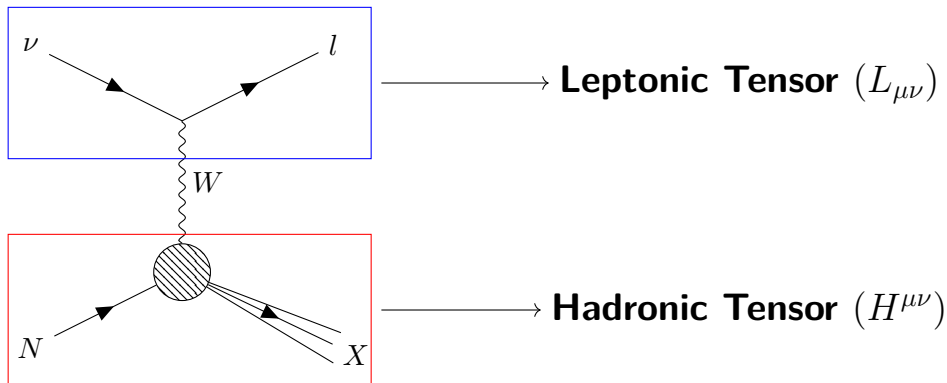
Automating the Leptonic Tensor Update

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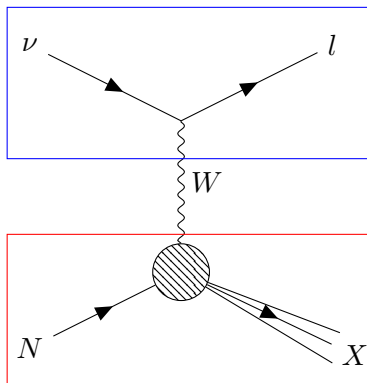
In Collaboration with Diego Lopez Gutierrez (Undergrad at MacAlester College)

11 February 2021

Leptonic and Hadronic Tensor



Leptonic and Hadronic Tensor

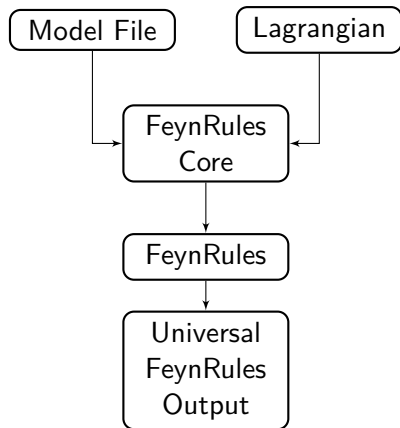


Notes:

- Leptonic tensor only contains perturbative physics.
- Can use LHC tools to calculate Leptonic tensor
- Hadronic tensor is difficult, but event generators have these calculations implemented already.

FeynRules and UFO

- *Mathematica* Program
- Takes model file and Lagrangian as input
- Calculates the Feynman rules
- Outputs in Universal FeynRules Output (UFO) format



[[arXiv:0806.4194](#), [arXiv:1108.2040](#), [arXiv:1310.1921](#)]

Recursive Matrix Element Generation

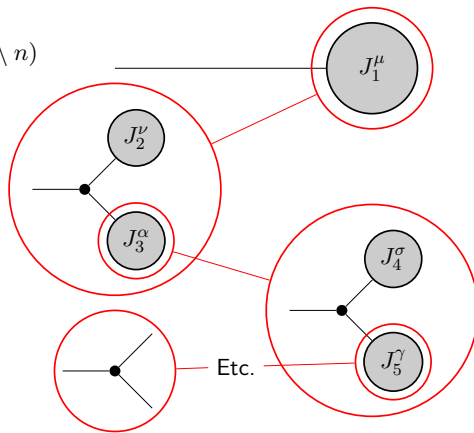
$$\mathcal{J}_\alpha(\rho) = P_\alpha(\rho) \sum_{\mathcal{V}_\alpha^{\alpha_1, \alpha_2}} \sum_{\mathcal{P}_2(\rho)} \mathcal{S}(\pi_1, \pi_2) V_\alpha^{\alpha_1, \alpha_2}(\rho_1, \rho_2) \mathcal{J}_{\alpha_1}(\rho_1) \mathcal{J}_{\alpha_2}(\rho_2)$$

$$\mathcal{A}(\rho) = \mathcal{J}_{\alpha_n}(n) \frac{1}{P_{\bar{\alpha}_n}(\rho \setminus n)} \mathcal{J}_{\bar{\alpha}}(\rho \setminus n)$$

Brend's-Giele Recursion

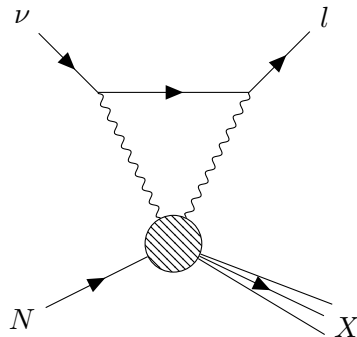
- Reuse parts of calculation
- Most efficient for high multiplicity
- Reduces computation from $\mathcal{O}(n!)$ to $\mathcal{O}(a^n)$

[Nucl. Phys. B306(1988), 759]

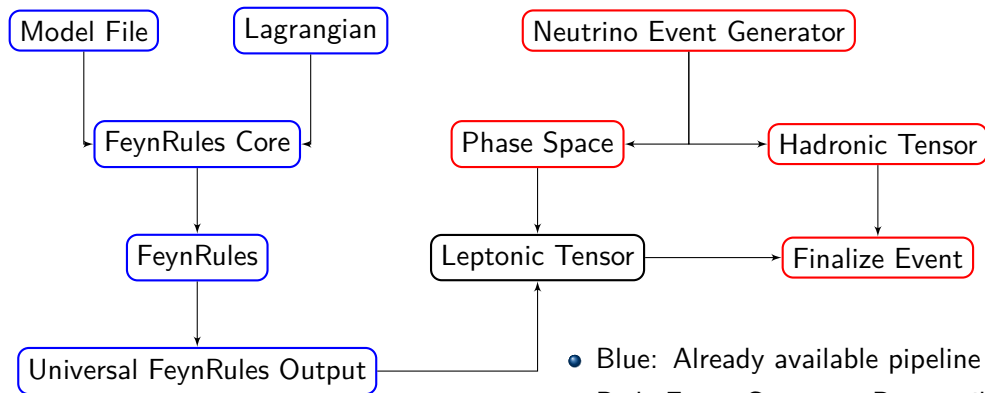


Leptonic and Hadronic Tensor: Possible issues

- Which part is responsible for phase space generation
- Handling of g_L and g_R (g_V and g_A) for nuclear side
- Can't handle multiple boson exchanges
- More issues will probably arise



Future / Proposed Interface



- Blue: Already available pipeline
- Red: Event Generator Responsibility

Conclusions

- BSM important for the next generation neutrino experiments
- Requires automating theory calculations
- Take advantage of LHC tools
- Proposal for separation of responsibilities