FERMILAB-POSTER-21-058-STUDENT-T

Automatic Leptonic Tensor Generation for Beyond the Standard Model Theories

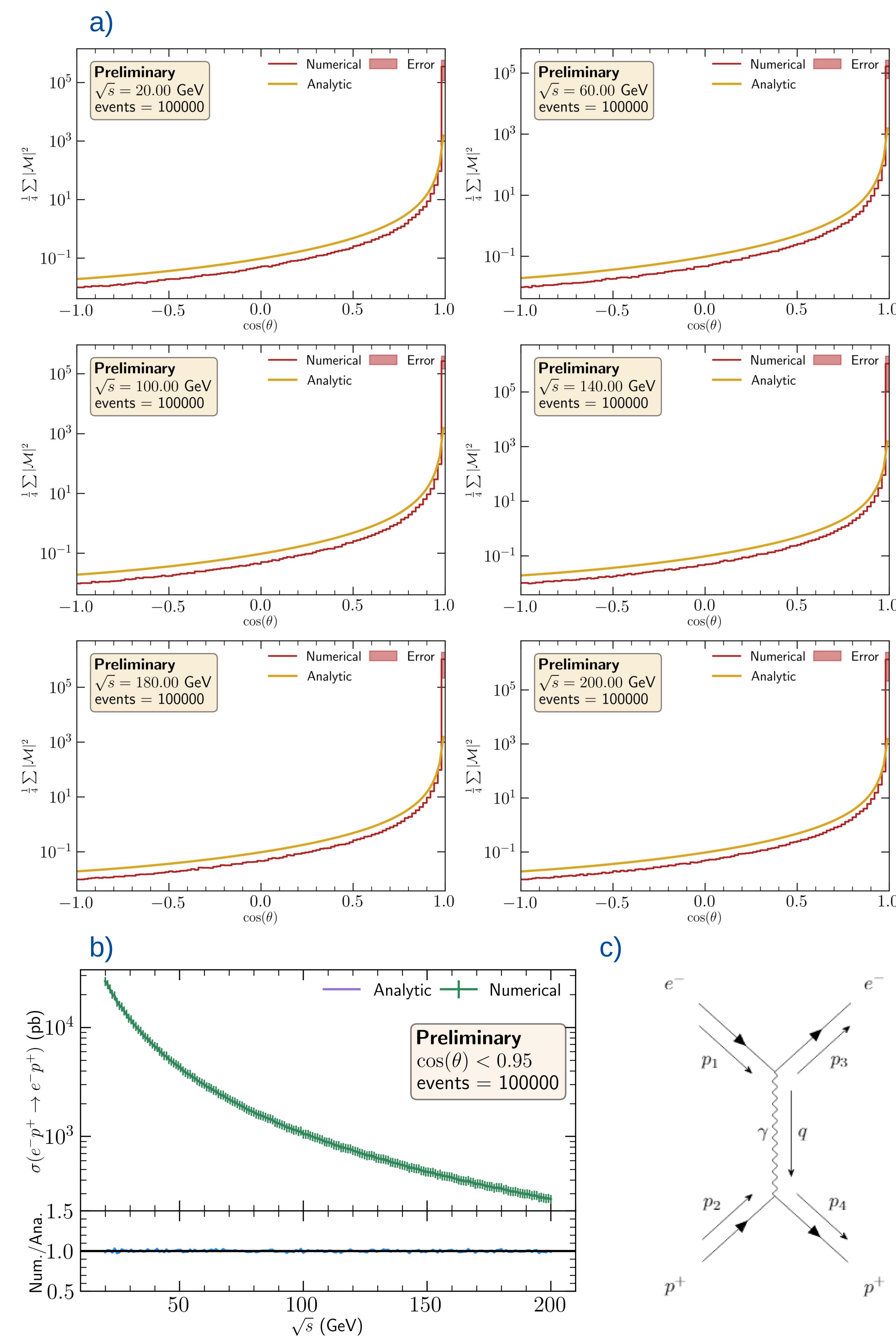
Diego Lopez Gutierrez[1,2], Joshua Isaacson[2] — [1]Macalester College, [2] Theoretical Physics Department,

Introduction

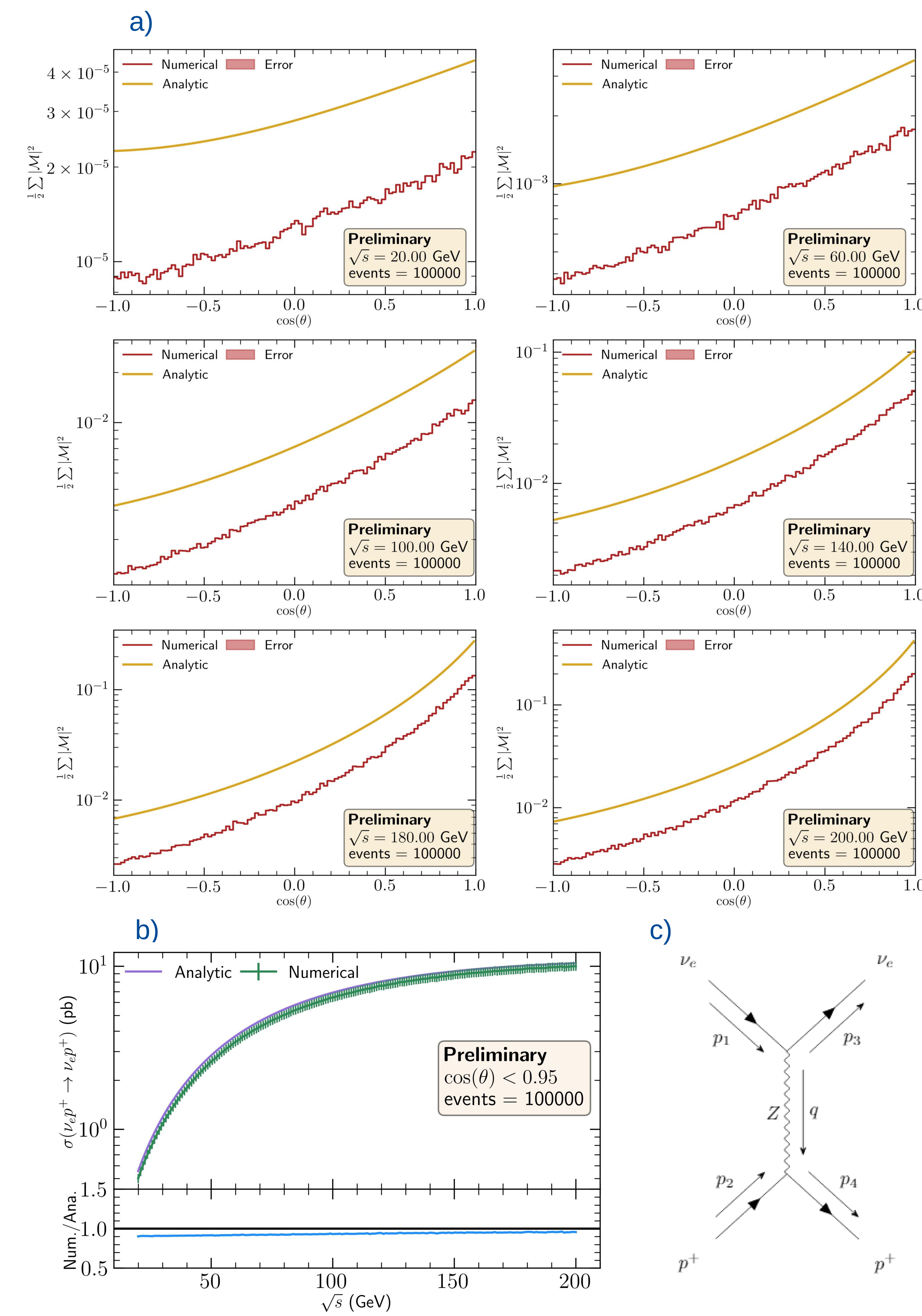
- Tons of data (DUNE, T2HK, etc.)
- Testing of (neutrino) BSM theories:
  - Manually: time-consuming, prone to errors, infeasible.
- Automatic:
  - Separate $|M|^2$ into hadronic and leptonic tensors.
  - Focus on BSM physics within $L_{\mu\nu}$.
  - Event generators provide $H^{\mu\nu}$.
  - Easily interfaced to several generators.
- Novel program to automatically calculate leptonic tensors of neutrino BSM theories:
  - Requires only BSM Lagrangian.
  - Can be easily interfaced to several neutrino event generators.

Methods

- Based on COMIX generator from Sherpa.
- Universal FeynRules Output (UFO) files:
  - Contains all information about BSM theory.
  - Agnostic of *a priori* assumptions, flexible, output in Python modules.
- Berends-Giele recursive algorithm:
  - Recursive build up of Feynman diagrams.
  - Recycling of diagrams' components within processes. Highly-efficient.
- Multichannel phase space integration:
  - Need to validate results.
  - $\sigma \propto \int d\Pi_n |M|^2 \rightarrow$ Monte Carlo integration.
  - Integration divided in k channels with prob. distribution $g_i(\Pi_n)$ and probability $\alpha_i, i = 1, \ldots, k$.
  - Optimization of α_i reduces variance.



.Fig. 1. Panel a): Analytic and computational $\frac{1}{4}|M|^2$ vs. $\cos(\theta)$ for $e^-p^+ \rightarrow e^-p^+$ for $E_{CM} = \{20, 60, 100, 140, 180, 200\}$ GeV. Panel b): Analytic and computational σ vs. E_{CM} for $e^-p^+ \rightarrow e^-p^+$ for a range $[20, 200]$ (GeV). Panel c) Feynman diagram for $e^-p^+ \rightarrow e^-p^+$.



.Fig. 2. Panel a): Analytic and computational $\frac{1}{4}|M|^2$ vs. $\cos(\theta)$ for $\nu_e p^+ \rightarrow \nu_e p^+$ for $E_{CM} = \{20, 60, 100, 140, 180, 200\}$ GeV. Panel b): Analytic and computational σ vs. E_{CM} for $\nu_e p^+ \rightarrow \nu_e p^+$ for a range $[20, 200]$ (GeV). Panel c) Feynman diagram for $\nu_e p^+ \rightarrow \nu_e p^+$.

Preliminary Results and Conclusion

- Validation results of two SM processes: $e^-p^+ \rightarrow e^-p^+$ and $\nu_e p^+ \rightarrow \nu_e p^+$.
- Using $L_{\mu\nu}$ from code, we plotted $|M|^2$ vs. $\cos(\theta)$ for six $E_{CM} = \{20.0,\ 60.0,\ 100.0,\ 140.0,\ 180.0,\ 200.0\}$ (GeV) as well as σ vs. E_{CM}.
- Correct off factors of calculations. Test more complex SM processes as well as BSM models

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.