SBS Collaboration Meeting

Summary | Thesis Overview | Current State of Things | Looking Ahead

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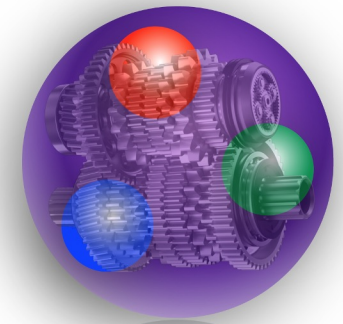
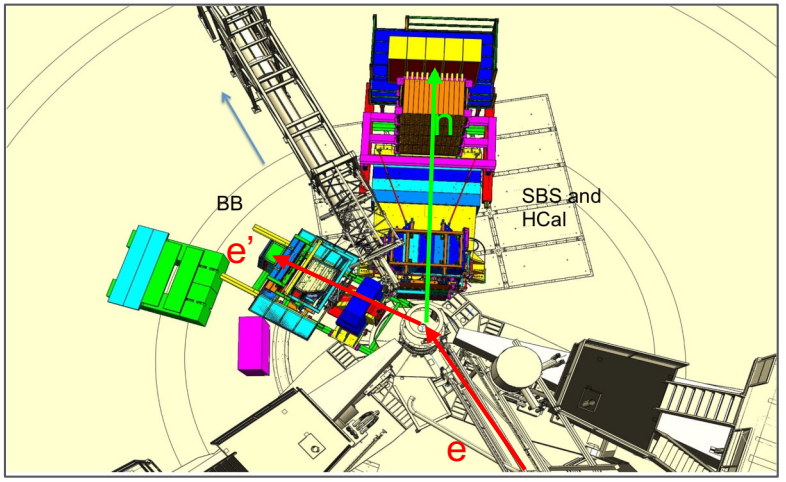
Summary

- Advisor: Nilanga Liyanage
- Sub-system: GEM detectors
- Thesis experiment:
  - nTPE (*E12-20-010*)
- Analysis:
  - Calibrations
  - Simulation
  - Physics extraction
- Thesis writing in-progress
- Expected graduation: Spring 2024





Thesis Overview

nTPE (***n**eutron **T**wo-**P**hoton **E**xchange*): measurement of the two-photon exchange contribution to the electron-neutron elastic scattering cross-section. Extract the electric form factor of the neutron, using the "ratio method".

Measurement at a single $Q^2 = 4.5\ (^{GeV}/_{c})^2$ point, and two beam energies corresponding to two scattering angles and two correlated epsilon values:

$\boldsymbol{SBS8}$: $E_1 \approx 6\ GeV, \theta_1 = 26.5^o, \epsilon_1 \approx 0.6$ $\boldsymbol{SBS9}$: $E_2 \approx 4GeV, \theta_2 = 49.0^o, \epsilon_2 \approx 0.8$

From Observables:

Ratio of Quasi-elastic Yields, $R_{QE} = \frac{N_{e,e'n}}{N_{e,e'p}}$

Pure Elastic Yields, $R_{corr} = \frac{\sigma_{en}}{\sigma_{ep}} = R_{QE} f_{corr}$

Correction factor, $f_{corr} = (f_{efficiency})(f_{nuclear})(f_{radiative})(f_{fermi})$

$$G_M^n \approx \sqrt{\left[R_{corr}\left(\frac{\sigma^p_{Mott}}{\sigma^n_{Mott}}\right)\left(\frac{1+\tau_n}{1+\tau_p}\right)\left(\frac{\tau_p}{\epsilon_p}G^2_{M,p}\right)\right]\left(\frac{\epsilon_n}{\tau_n}\right)}$$

$$A = \frac{R_{Corr,\epsilon_1}}{R_{Corr,\epsilon_2}} = \underbrace{\frac{R_{Mott,\epsilon_1}}{R_{Mott,\epsilon_2}}\frac{(1+\epsilon_1 S^p)}{(1+\epsilon_2 S^p)}}_{\text{Define as B}}\frac{(1+\epsilon_1 S^n)}{(1+\epsilon_2 S^n)} \rightarrow A = B\frac{(1+\epsilon_1 S^n)}{(1+\epsilon_2 S^n)}$$

$S^p = \frac{\sigma_L^p}{\sigma_T^p}$ & $S^n = \frac{\sigma_L^n}{\sigma_T^n}$ } L: Longitudinal, T: Translational

$\frac{\sigma_L}{\sigma_T} \equiv Rosenbluth\ slope\ related\ to\ \frac{G_E}{G_M}\ (in\ OPE)$

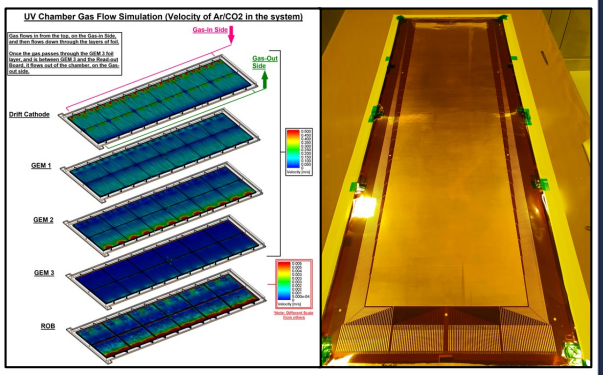
Small range of ϵ & small slopes: $A \approx B|1 + \Delta\epsilon S^n|$ $where$ $\Delta\epsilon = \epsilon_1 - \epsilon_2$

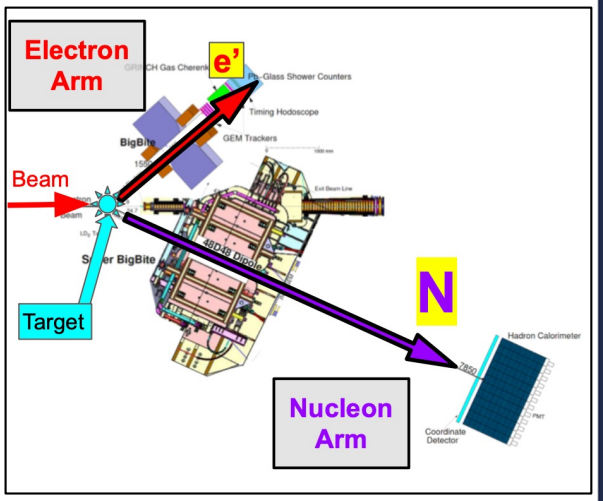
$S^n = \frac{A-B}{B\Delta\epsilon}$ **sum** of the **slope due to** $\frac{G_E^n}{G_M^n}$ and the **TPE contribution**

$A = \frac{R_{corr,\epsilon_1}}{R_{corr,\epsilon_2}}$ $B = \frac{R_{Mott,\epsilon_1}}{R_{Mott,\epsilon_2}}\frac{(1+\epsilon_1 S^p)}{(1+\epsilon_2 S^p)}$ $S^p = \frac{\sigma_L^p}{\sigma_T^p}$ $S^n = \frac{\sigma_L^n}{\sigma_T^n}$

Thesis Overview

- Thesis completion ~ 30% - Intro, Foundations, GEMs
- Sub-detector focus: GEMs
  - UV GEM R&D: physical/electrical design, prototyping, gas flow design/simulations, testing, tooling, et cetera…
  - GEM initialization and commissioning
  - Crosstalk analysis
  - ….
- Physics
  - Presentation of precursory preliminary results
  - GMn extraction along the way *(??)*
  - TPE contribution from the S^n extraction
  - …
- Defense in Spring 2024
  - Complete majority of thesis by end of/early next year
  - Leaves room for revisions, additions, etc…



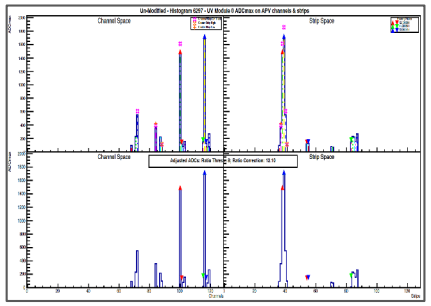


Current State of Things: Analytical Foci

Data Calibrations

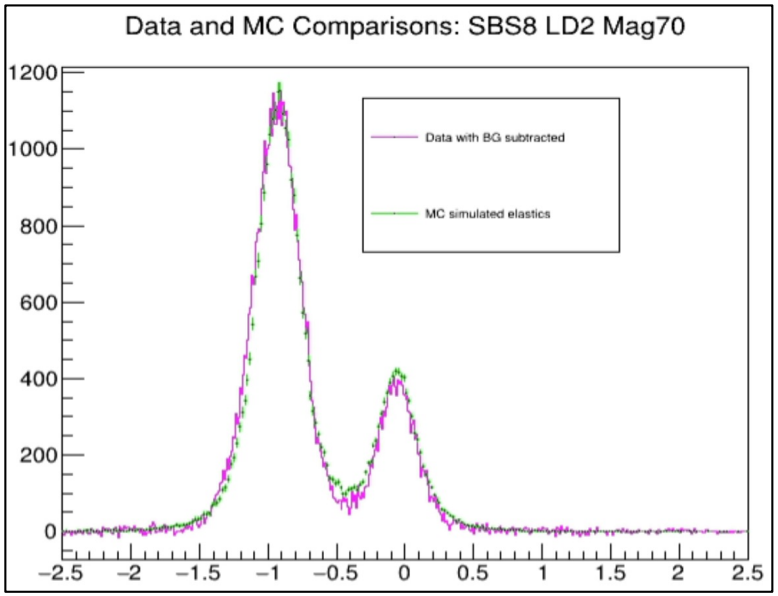
- Mainly in the form of GEM Crosstalk
  - Not being implemented
  - Better suited for higher rates

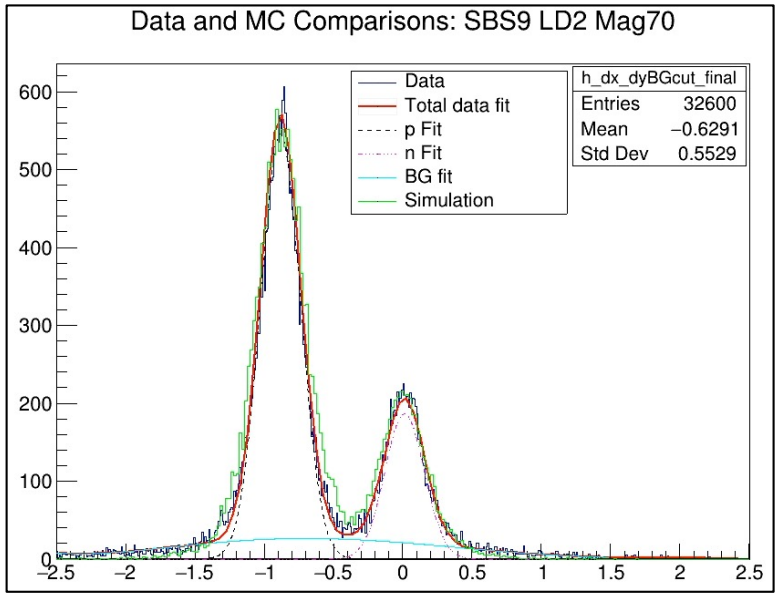
Crosstalk Event Viewer



MC calibrations

MC & Data “tuning” for SBS8 & SBS9



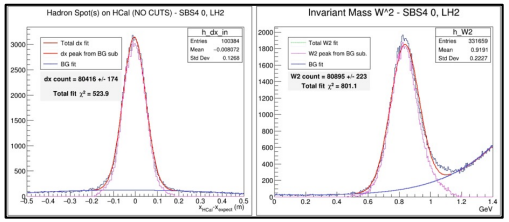


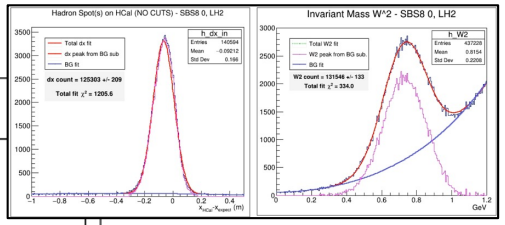
Current State of Things: Analytical Foci

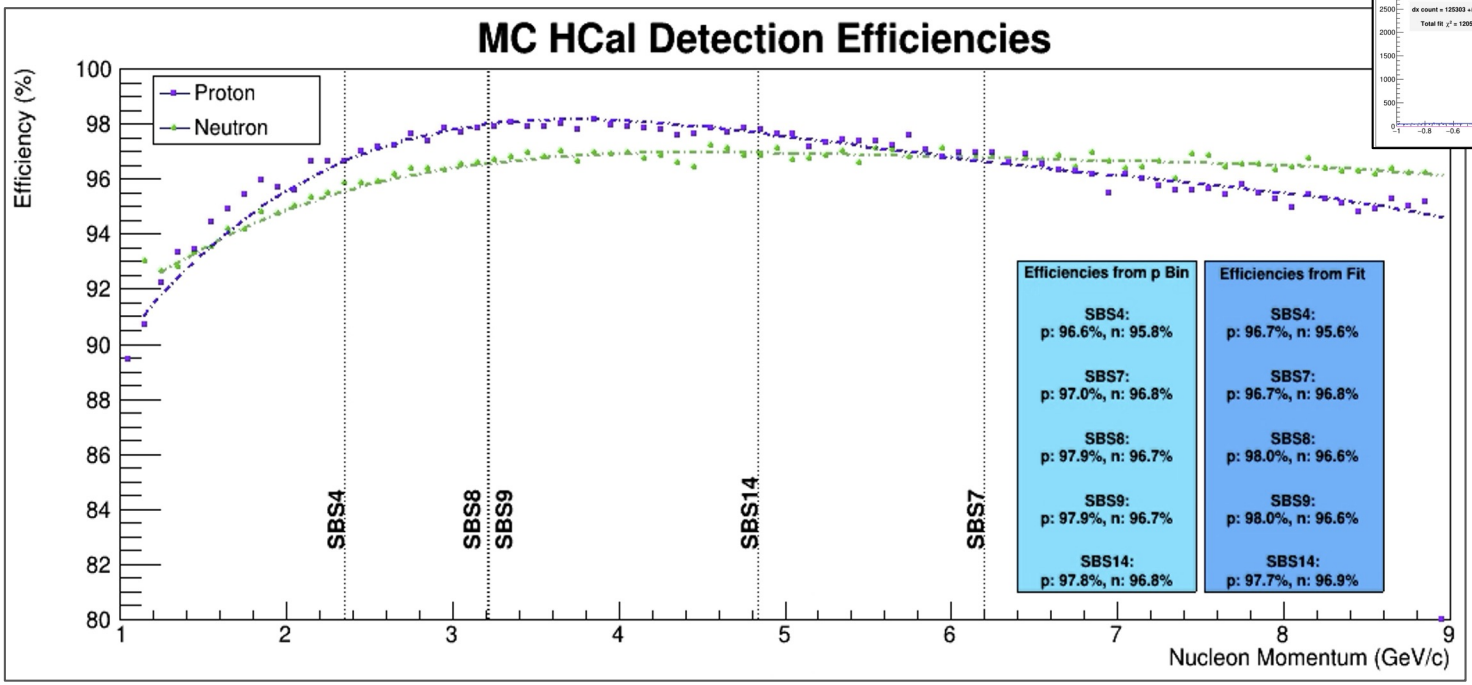
HCal Detection Efficiencies

SBS4 Data → **97.3766%** +/- 3.37492%
SBS8 Data → **96.3466%** +/- 1.89023%
SBS9 Data → In-progress

SBS4 MC → **96.6%**
SBS4 MC → **97.9%**
SBS9 MC → **98.0%**

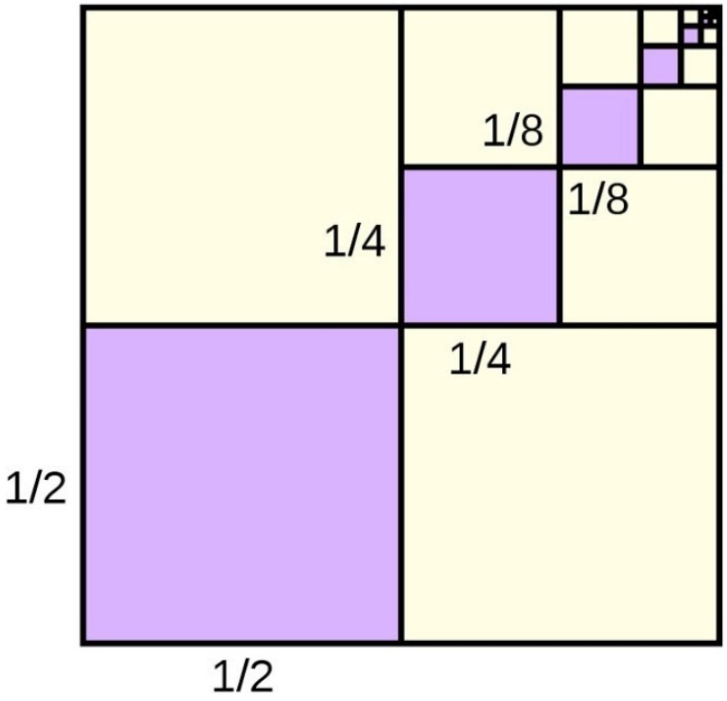






Looking Ahead

- To-do list…



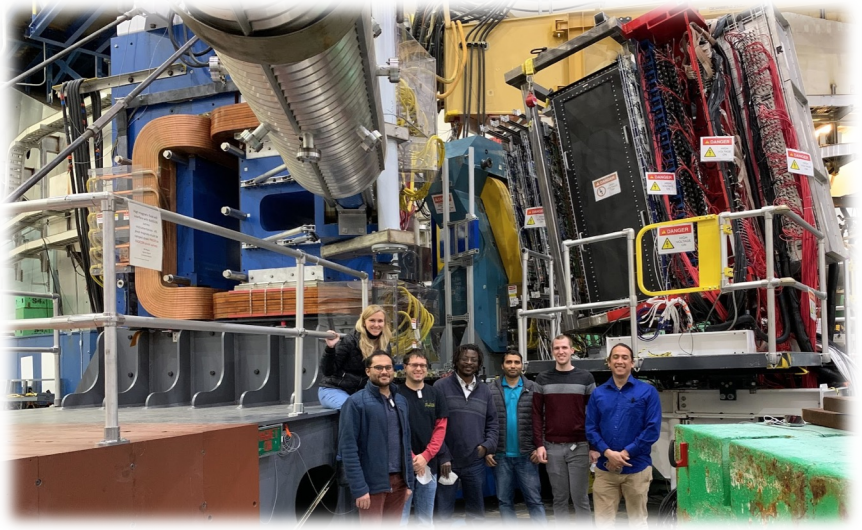
$$\sum_{n=1}^{\infty} \frac{1}{2^n} = \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \cdots$$

Looking Ahead

- That series actually converges… to 1… not so lucky….
- Replay simulations (recent updates and additions)
- Calibrations on MC (revisions already needed and more required after re-replay anyhow)
- Re-tune
- Script/machinery to extract GMn and TPE
- Error propagation mechanisms
- Complete writing of non-results-related thesis
  - Experimental set-up (All {sub} systems)
  - Analysis flow

Summary

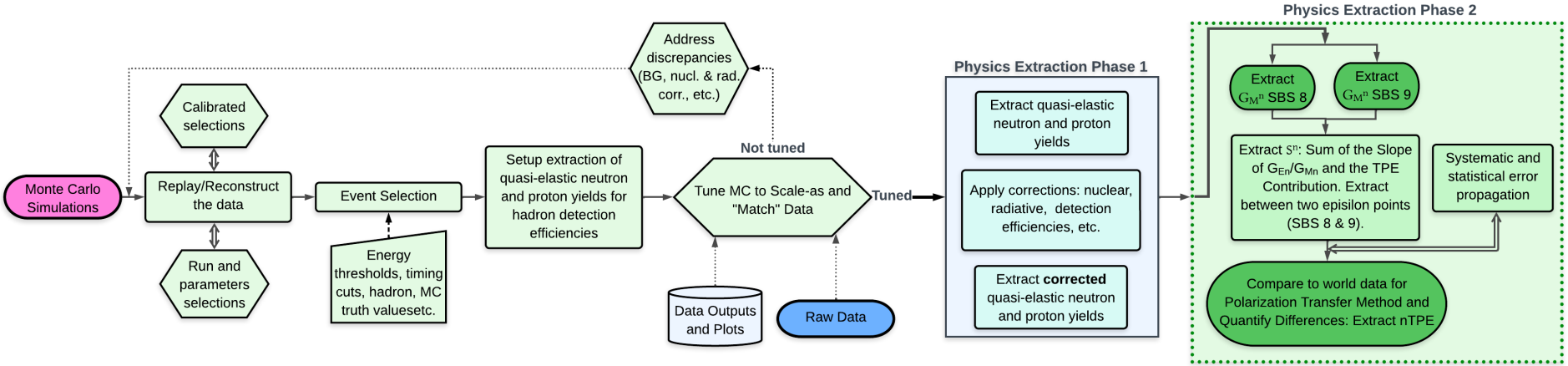
- Analysis
  - Hiccups from recent move and recent breakdown of cue/farm setup
  - Rebuild/replay simulations → Repeat Efficiencies → Tuning → Yields → Extractions → Error → Results *{Pass 1, 2 as available}*
  - Need machinery for physics extractions… plan of attack in place
  - Goal for physics extraction: Fall 2023
- Writing of thesis (~30% complete)
- Expected graduation: Spring 2024



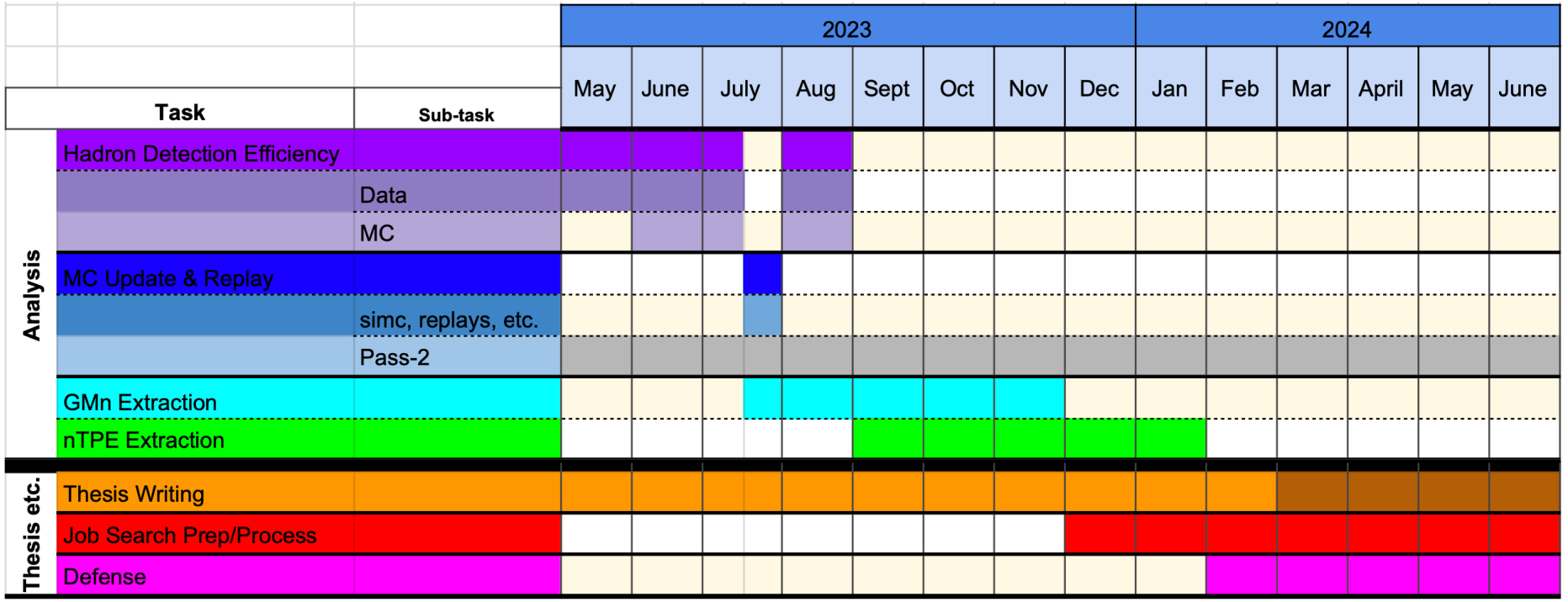
Presentation Complete.
Thank you.

Questions?

BACKUP SLIDES


Address discrepancies (BG, nucl. & rad. corr., etc.)
Calibrated selections
Monte Carlo Simulations
Replay/Reconstruct the data
Run and parameters selections
Event Selection
Energy thresholds, timing cuts, hadron, MC truth valuesetc.
Setup extraction of quasi-elastic neutron and proton yields for hadron detection efficiencies
Not tuned
Tune MC to Scale-as and "Match" Data
Tuned
Data Outputs and Plots
Raw Data
Physics Extraction Phase 1
Extract quasi-elastic neutron and proton yields
Apply corrections: nuclear, radiative, detection efficiencies, etc.
Extract corrected quasi-elastic neutron and proton yields
Physics Extraction Phase 2
Extract G_M^n SBS 8
Extract G_M^n SBS 9
Extract S^n: Sum of the Slope of G_{En}/G_{Mn} and the TPE Contribution. Extract between two episilon points (SBS 8 & 9).
Systematic and statistical error propagation
Compare to world data for Polarization Transfer Method and Quantify Differences: Extract nTPE

Timeline & Schedule

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