GMn/nTPE Analysis Progress

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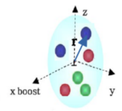
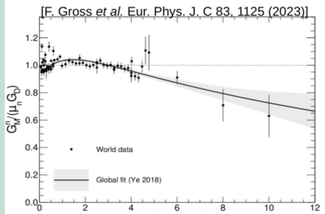
Purpose of G_M^n/nTPE

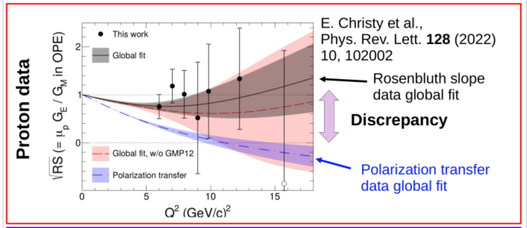
- Nucleons composite objects:
  - proton: μ_p = 2.79 μ_N
  - neutron: μ_n = -1.91 μ_N
- **Form factors ≡ charge distribution**



- Elastic scattering: $\left(\frac{d\sigma}{d\Omega}\right)_{eN\to eN} = \frac{\sigma_{Mott}}{\epsilon(1+\tau)}\left[\tau G_M^2(Q^2) + \epsilon G_E^2(Q^2)\right]$, $\tau = Q^2/|4M_N|$
  Magnetic FF — Electric FF
- G_M^n: scarce data at high Q^2;

[F. Gross *et al.* Eur. Phys. J. C 83, 1125 (2023)]



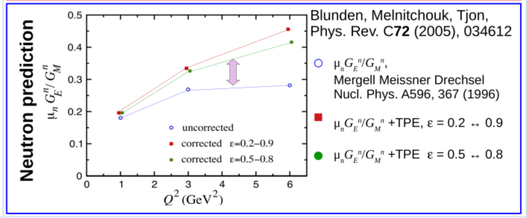


E. Christy et al., Phys. Rev. Lett. **128** (2022) 10, 102002

Rosenbluth slope data global fit

Discrepancy

Polarization transfer data global fit



Blunden, Melnitchouk, Tjon, Phys. Rev. C**72** (2005), 034612

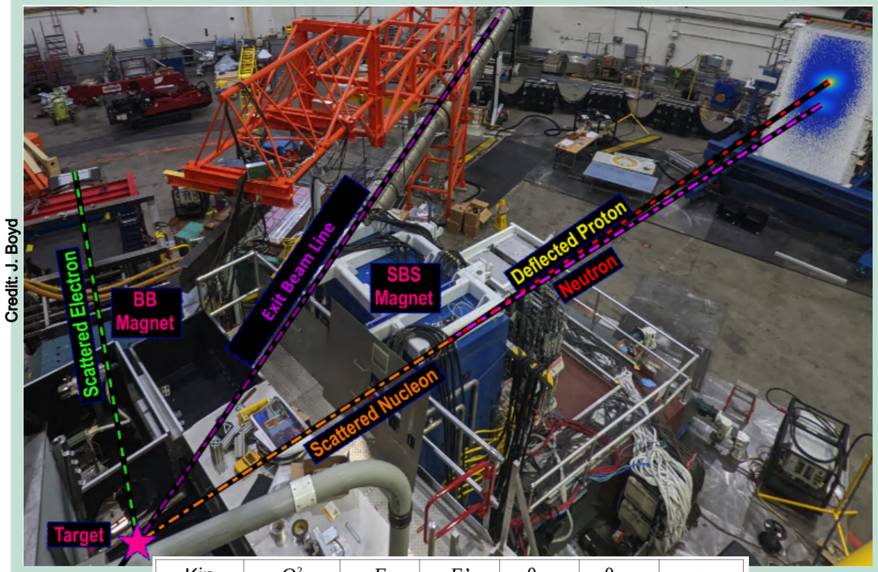
$\mu_n G_E^n/G_M^n$, Mergell Meissner Drechsel Nucl. Phys. A596, 367 (1996)

$\mu_n G_E^n/G_M^n$ +TPE, ε = 0.2 ↔ 0.9

$\mu_n G_E^n/G_M^n$ +TPE ε = 0.5 ↔ 0.8

Experimental setup

Credit: J. Boyd

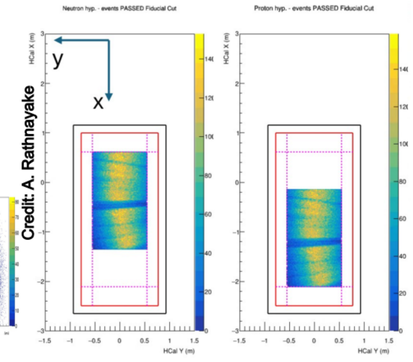


Kin	Q^2 (GeV/c)^2	E (GeV)	E' (GeV)	θ_{BB} (deg)	θ_{SBS} (deg)	ε
SBS4	3.01	3.728	2.129	36.0	31.9	0.721
SBS7	10.0	7.906	2.588	40.9	15.9	0.492
SBS11	13.50	9.860	2.676	41.9	12.8	0.437
SBS14	7.52	5.965	1.965	47.2	17.3	0.456
SBS8	4.51	5.965	3.565	26.5	29.9	0.797
SBS9	4.50	4.015	1.618	49.0	22.5	0.512

nTPE

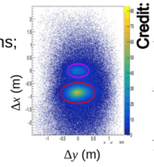
Selection/Extraction of neutron/proton ratios

- **Electron selection**
  - Track selection:
    - Optical + χ^2 cut;
    - $n_{hits} \geq 3$;
    - $|v_z| \geq 8$ cm;
  - BigBite calorimeter selection:
    - $E_{PS} \geq 0.2$ GeV;
    - $E_{PS}+E_{SH} \geq$;
  - Fiducial selection=>
  - Exclusive: 0.6<W^2<1.20 GeV^2
- **Fiducial selection**
  - Remove events with proton or neutron out of HCal;
  - Eliminates systematics due to *n/p* acceptance;



Credit: A. Rathnayake

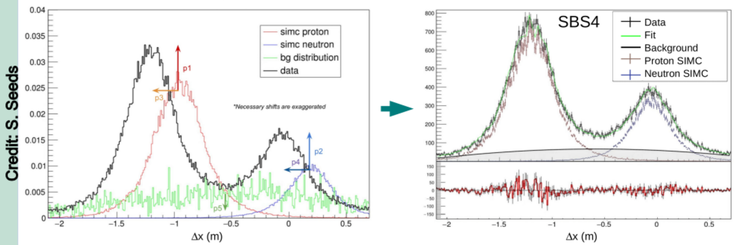
- **Nucleon selection**
  - $E_{HCal} \geq 0.1$ GeV;
  - time t_{HCAL}-t_{Shower} ns;
  - "Spot" cut;



Cross section ratios σ_{en} / σ_{ep} with Monte Carlo:

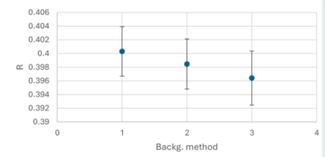
- Monte Carlo D(ee'n), D(ee'p) from SIMC:
  - Includes radiative corrections
  - Includes nuclear momentum
- Adjustment of MC samples to data:
  - Correction of σ_{en}, σ_{ep}

Credit: S. Seeds

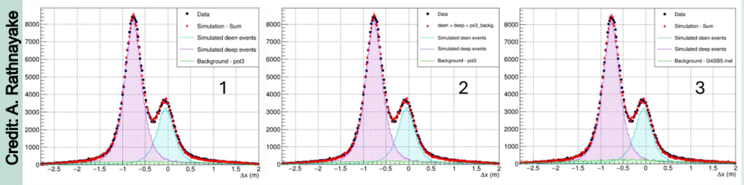


Systematics studies

- **Inelastic background subtraction:**
  - 1: Combined fit *en*+*ep* +background of data Δx
  - 2: Data background (HCal antiselection);
  - 3: MC (Christy-Bosted) generated background
- $R_{n/p}$ consistent within 1%

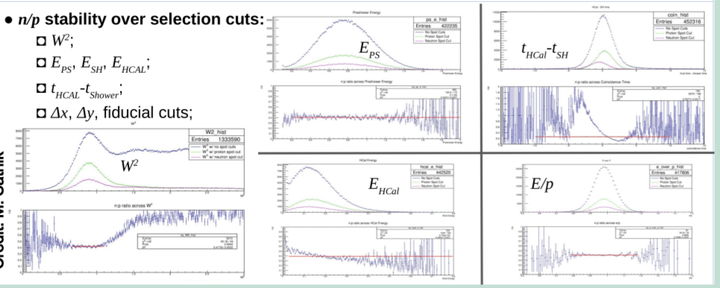


Credit: A. Rathnayake



- ***n/p* stability over selection cuts:**
  - W^2;
  - E_{PS}, E_{SH}, E_{HCAL};
  - t_{HCAL}-t_{Shower};
  - Δx, Δy, fiducial cuts;

Credit: M. Satnik

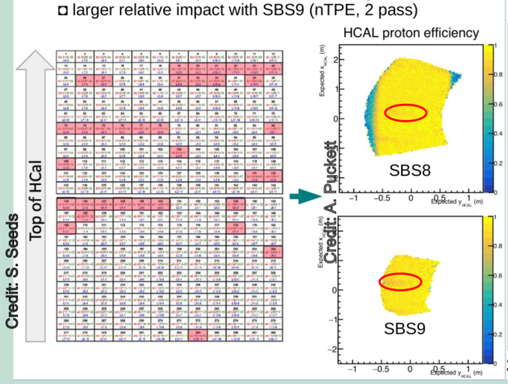


Analysis challenges

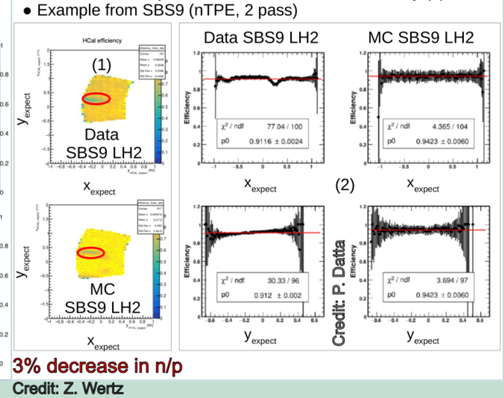
HCal non-uniformity issue

- Several HCal modules with low performance
  - Induces local drops of detection efficiency
  - larger relative impact with SBS9 (nTPE, 2 pass)

Credit: S. Seeds



- Addressing HCal non-uniformity:
  - Adjust HCal MC gains to reproduce data non-uniformity (1);
  - Correct MC yield with relative MC/data efficiency (2);
- Example from SBS9 (nTPE, 2 pass)

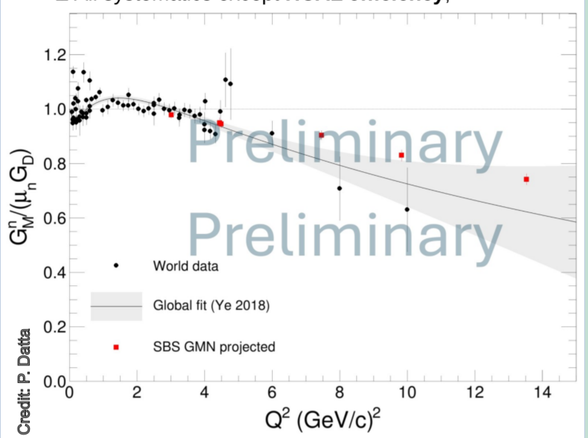


3% decrease in n/p

Credit: Z. Wertz

Preliminary results

- **Preliminary G_M^n results:**
  - Uncertainties include statistics;
  - All systematics except **HCAL efficiency**;



NTPE results under scrutiny due to very high sensitivity to HCal non uinformity issue