

GMN/NTPE Analysis Update

Eric Fuchey

William & Mary

SBS weekly meeting, August 21st 2024



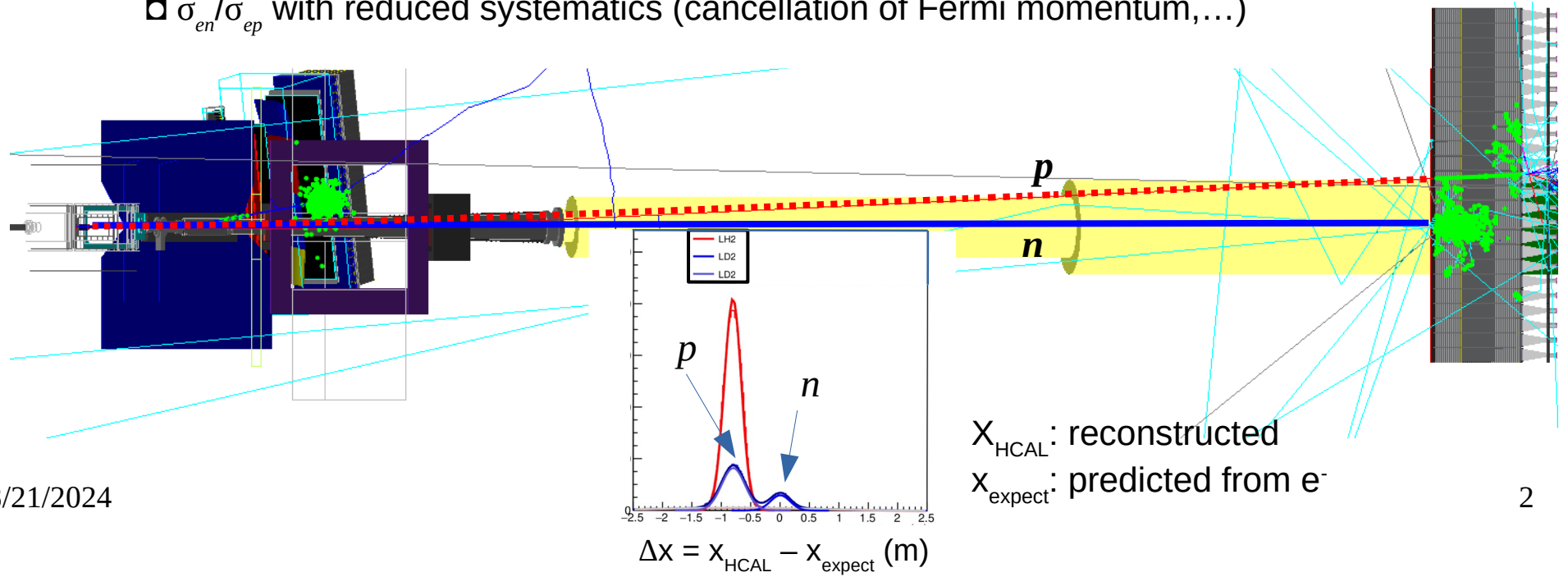
WILLIAM & MARY

CHARTERED 1693



Reminder: GMN/NTPE

- GMN: E12-09-019 (A. Camsonne, B. Quinn, B. Wojteskowski)
 - simultaneous en/ep measurement on D_2
 - Separation of p and n with SBS
 - σ_{en}/σ_{ep} with reduced systematics (cancellation of Fermi momentum,...)



08/21/2024

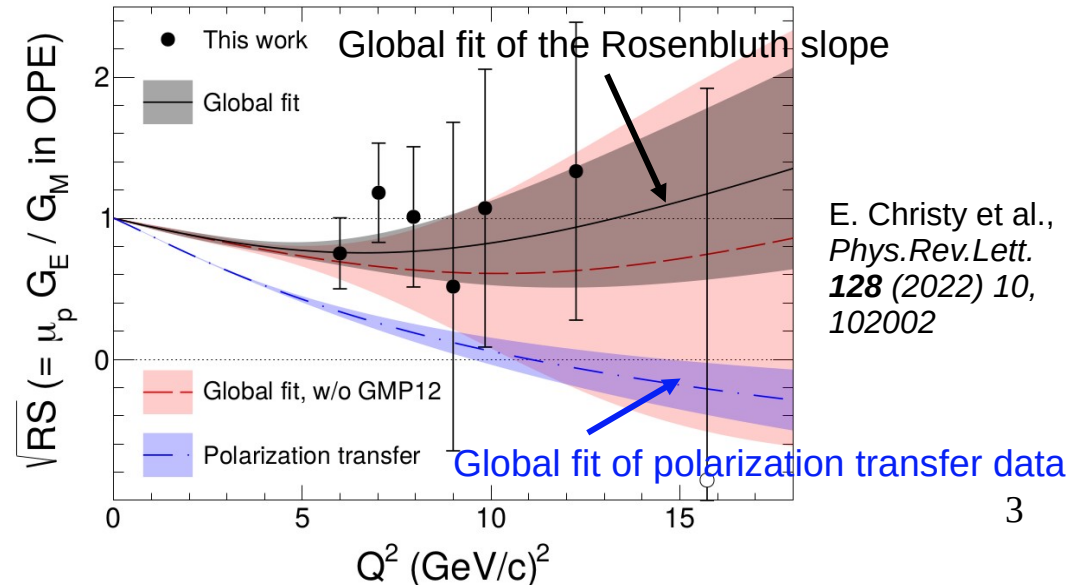
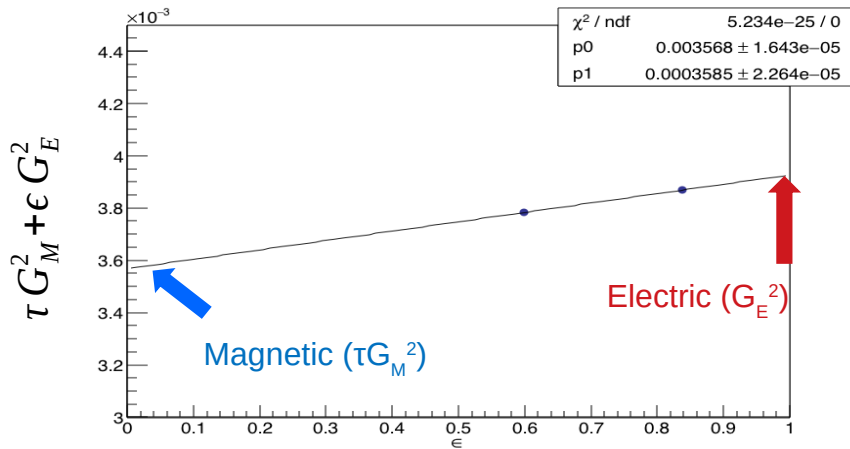
Reminder: GMN/NTPE

- NTPE: E12-20-010 (E.F., S. Alsalmi, B. Wojteskhowski)

- measurement of σ_{en}/σ_{ep} at two beam energies, $Q^2 = 4.5 \text{ GeV}^2$

- neutron Rosenbluth slope;

- NTPE = Discrepancy between neutron Rosenbluth slope and polarization data



Status as of February 21st

Since *last update*:

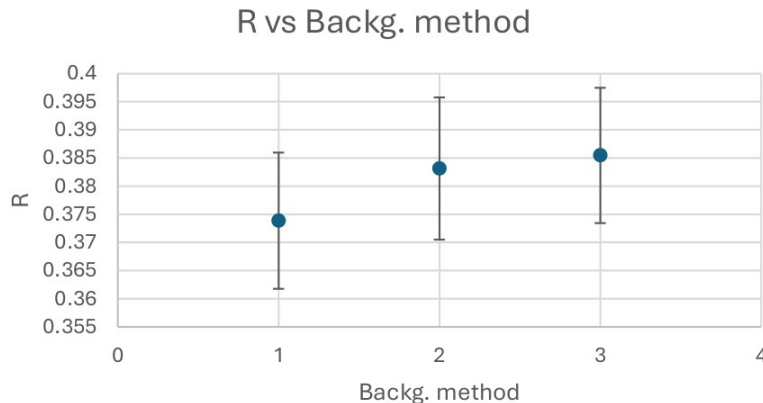
- Method of evaluation of n/p ratio established;
- Method of extraction of physics from n/p provided;
- Pass 2 data ready;
- Pending items as of February 21st:
 - estimation of systematics from inelastic background;
 - estimation of n/p stability over selection cuts;
 - account for HCAL non-uniformity; estimation of systematics;
 - extraction of observables with all systematic uncertainties;

Subtraction of inelastic background

- Three methods for inelastic background estimation/subtraction:
 - 1) Combined fit quasi-elastic(gauss) + inelastic (pol2) of the Δx distribution;
 - 2) Estimation of background with anti-selection of nucleon (out-of-time)
 - 3) Inelastic MC generation with Christy-Bosted model;

SBS7, analysis credit [A. Rathnayake](#):
Induced systematic uncertainty $\sim 0.9\%$

SBS14, analysis credit [P. Datta](#):
Induced systematic uncertainty $\sim 1.2\%$
SBS11: 3.5% (not shown here)



p Cross-section from: Ye et al, 2017
GEn from: Ye et al, 2017

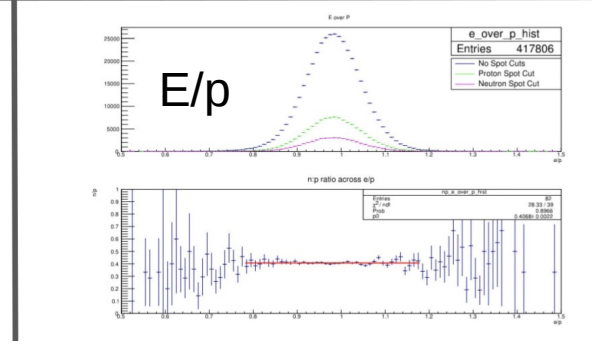
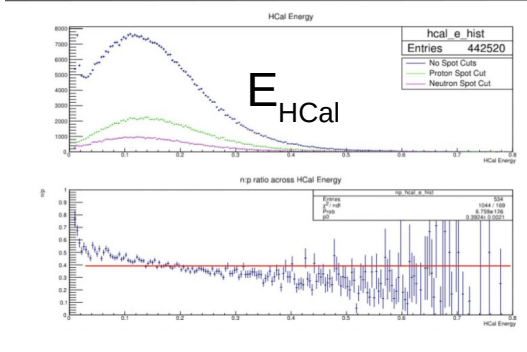
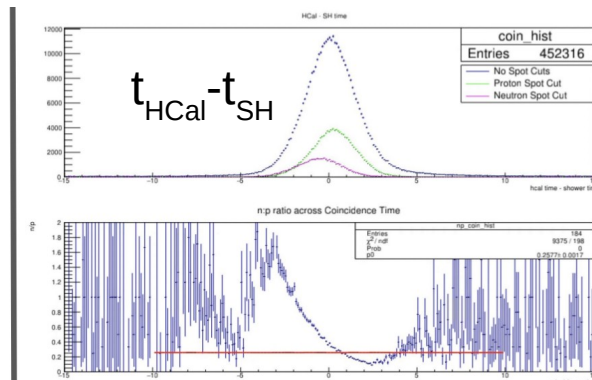
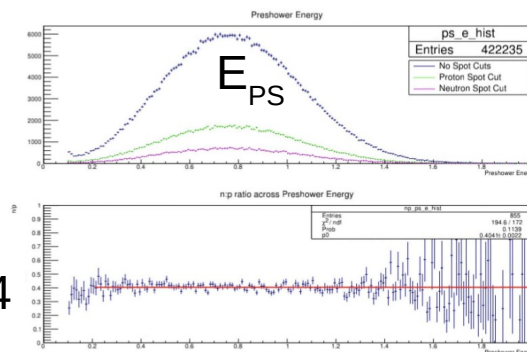
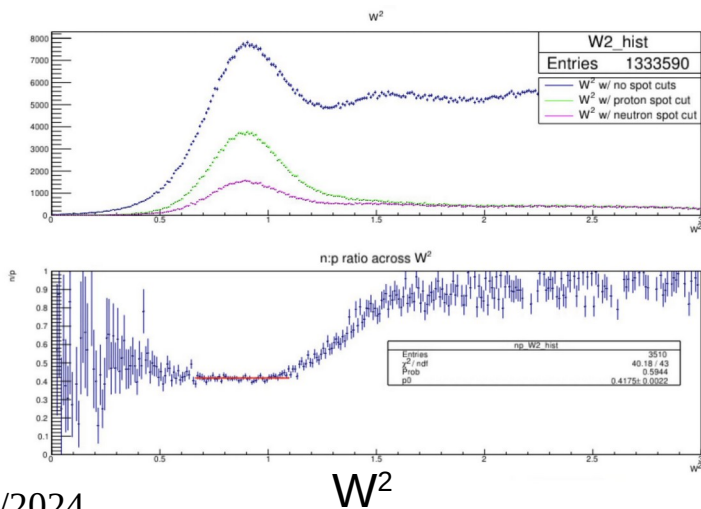
1. R w/ MC bg. : 1.095 +/- 0.010 -> GMn/muGD : **0.8968**
2. R w/ data bg : 1.108 +/- 0.010 -> GMn/muGD : **0.9022**
3. R w/ poly. bg. : 1.112 +/- 0.010 -> GMn/muGD : **0.9039**

n/p ratio stability over selection cuts

- n/p ratio stability over several cuts:

- W^2 ;
- E_{PS} , E_{SH} , E_{HCAL} ;
- $t_{HCAL} - t_{Shower}$;
- Δx , Δy ;
- fiducial cuts;

- Analysis credit: [M. Satnik](#) SBS4



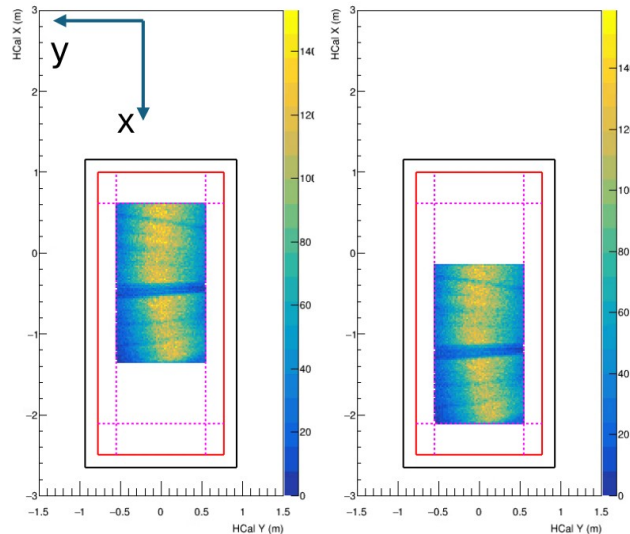
n/p ratio stability over selection cuts

- n/p ratio stability over several cuts:

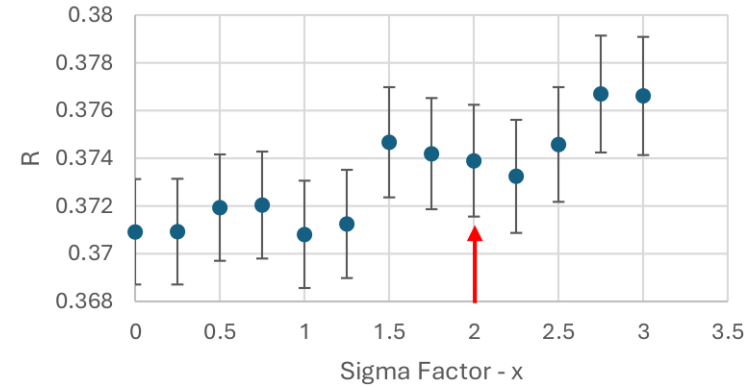
- W^2 ;
- E_{PS}, E_{SH}, E_{HCAL} ;
- $t_{HCAL} - t_{Shower}$;
- $\Delta x, \Delta y$;
- fiducial cuts;

- Analysis credit: [A. Rathnayake](#) SBS7

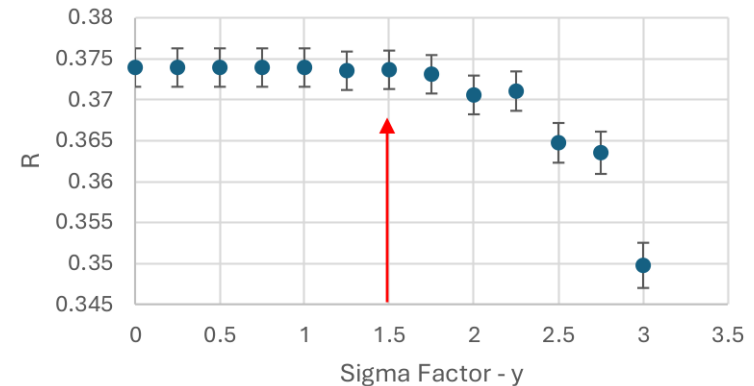
Neutron hyp. - events PASSED Fiducial Cut Proton hyp. - events PASSED Fiducial Cut



R vs Sigma factor x



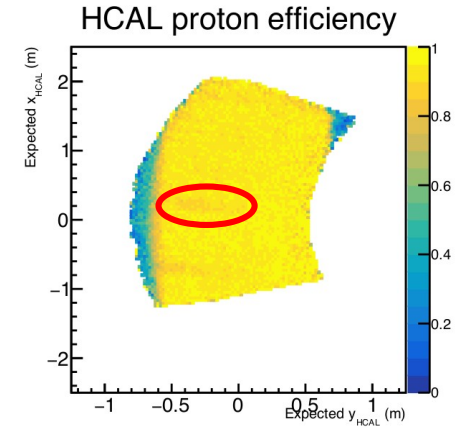
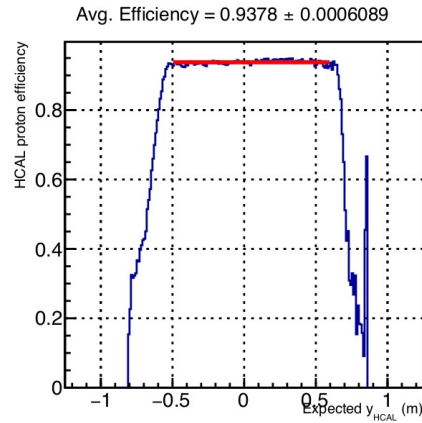
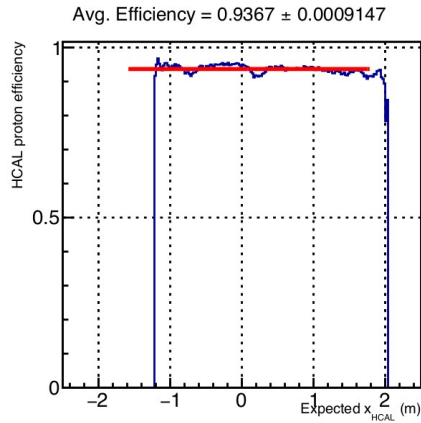
R vs sigma factor y



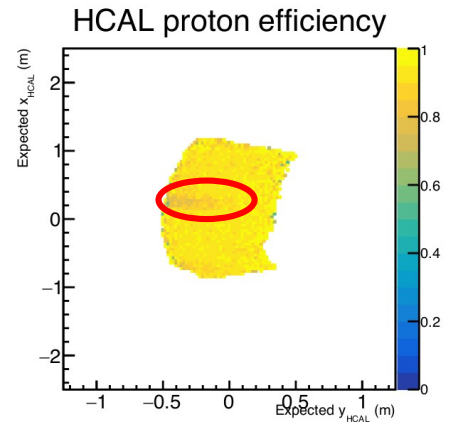
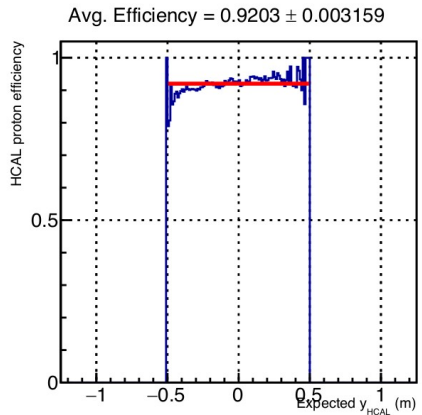
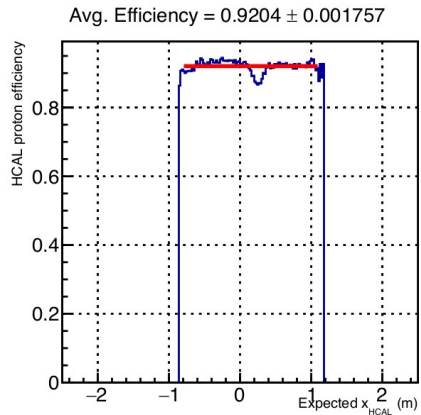
HCAL efficiency non-uniformity

- Efficiency uniformity estimated with data (plots/analysis credit: [A. Puckett](#))

SBS8



SBS9



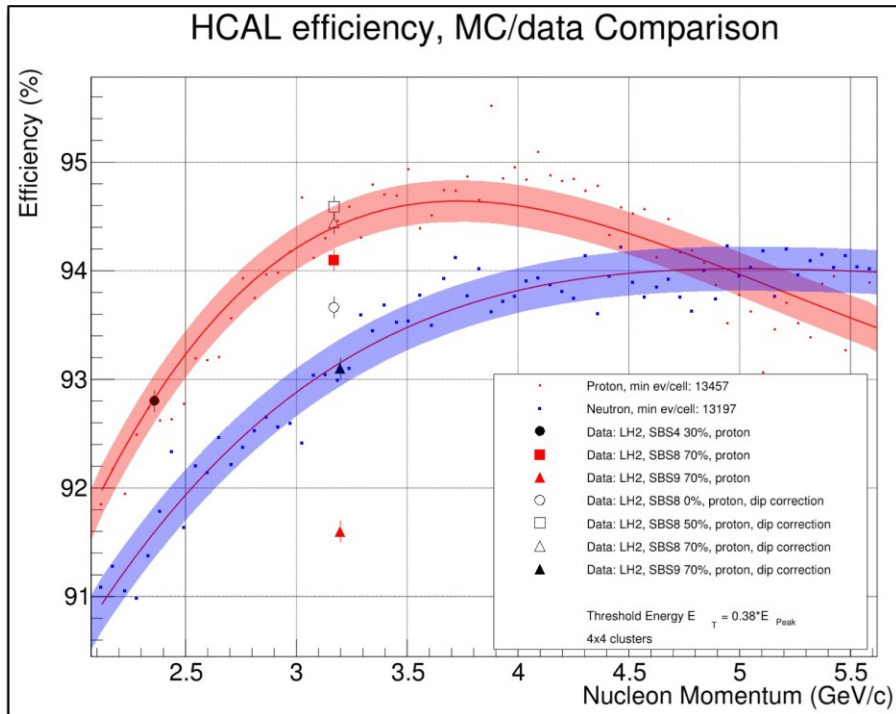
Dip in efficiency:
more impact
on SBS9
than SBS8

08/21/2024

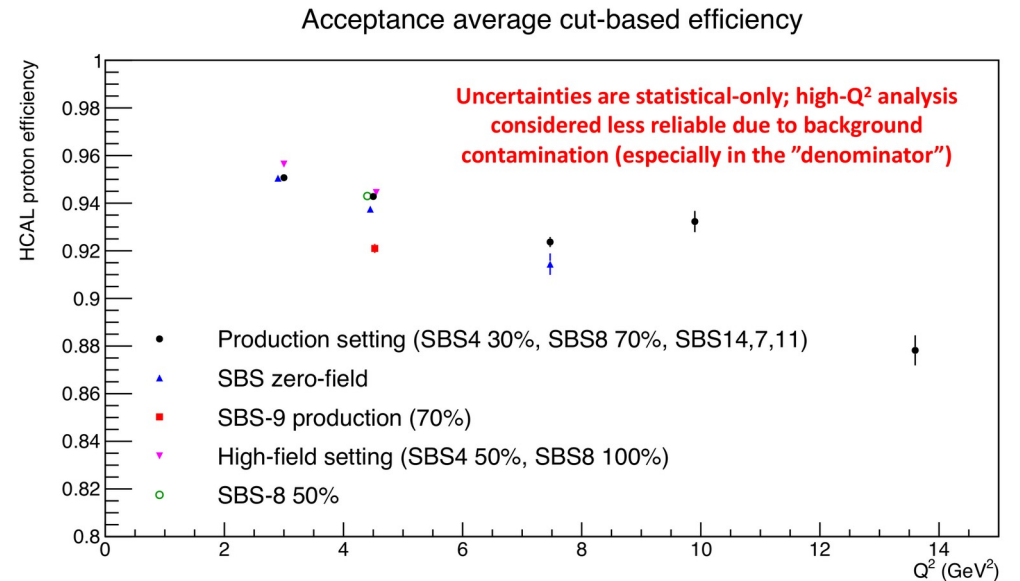
HCAL efficiency non-uniformity

- Impact on HCal global detection efficiency:

Analysis credit: [S. Seeds](#)



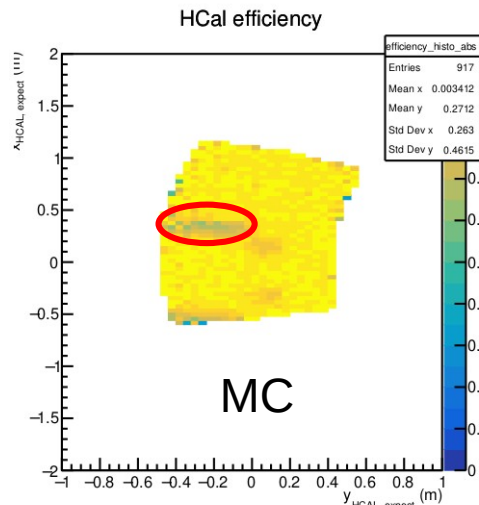
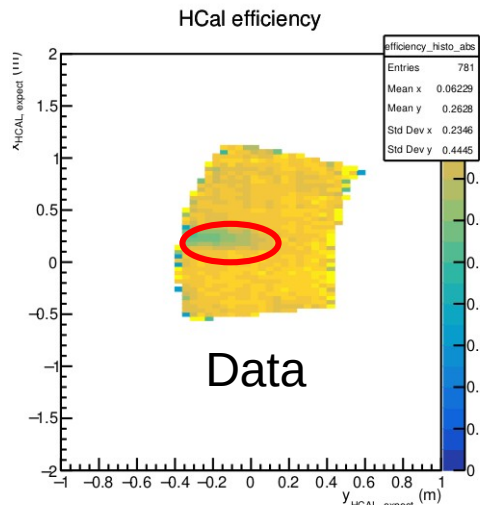
Analysis credit: [A. Puckett](#)



HCAL efficiency non-uniformity

- Attempt to reproduce non-uniformity with MC [1]:

- HCAL gain in MC digitization: 10^6 ;
- Setting gains for red blocks on map: 10^3 ;
- Efficiency on LH₂, SBS9 (independent analysis):



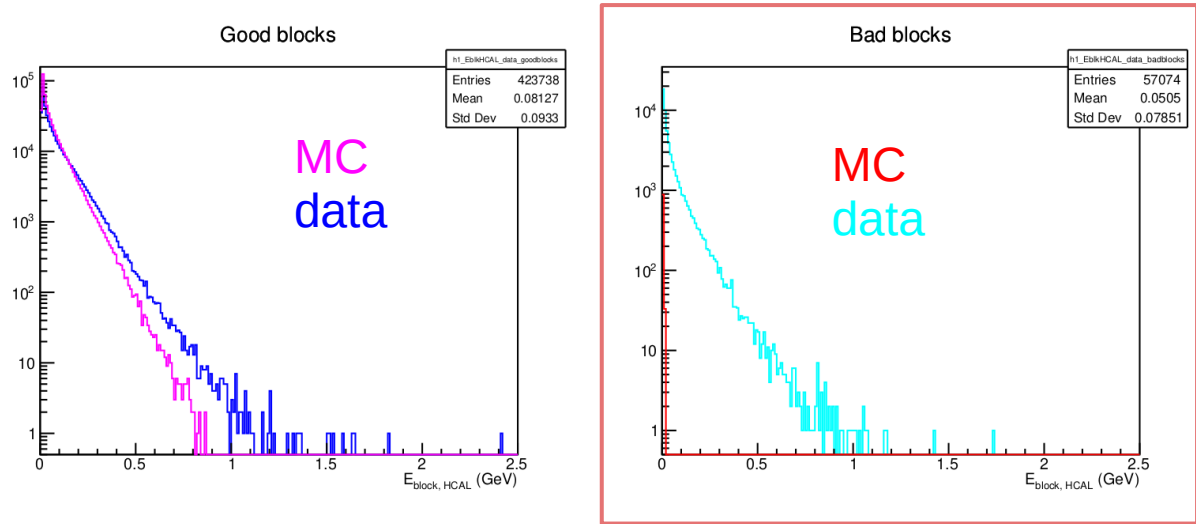
Top of HCAL

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81	82	83	84
85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108
109	110	111	112	113	114	115	116	117	118	119	120
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133	134	135	136	137	138	139	140	141	142	143	144
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193	194	195	196	197	198	199	200	201	202	203	204
205	206	207	208	209	210	211	212	213	214	215	216
217	218	219	220	221	222	223	224	225	226	227	228
229	230	231	232	233	234	235	236	237	238	239	240
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253	254	255	256	257	258	259	260	261	262	263	264
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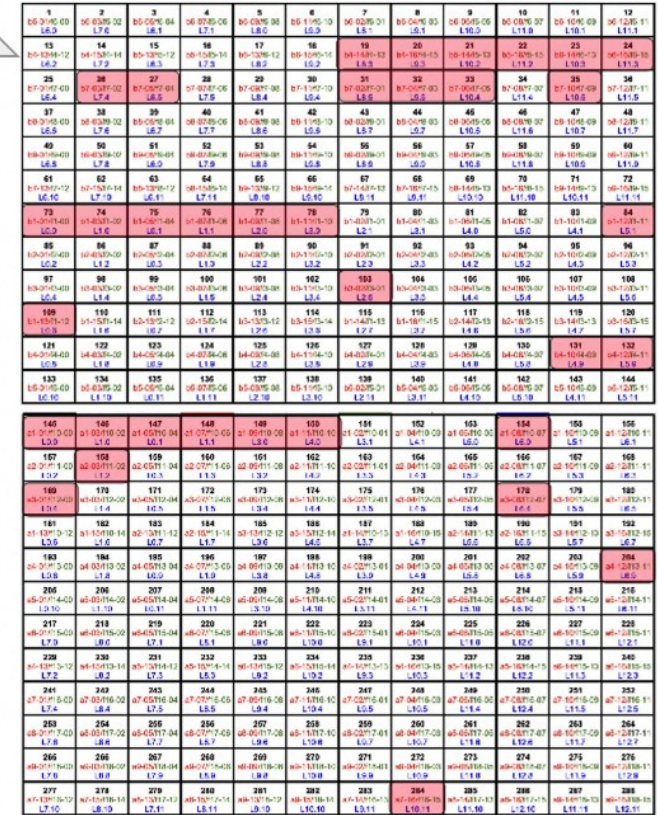
HCAL efficiency non-uniformity

- Attempt to reproduce non-uniformity with MC [1]:

- HCAL gain in MC digitization: 10^6 ;
- Setting gains for red blocks on map: 10^3 ;
- Energy deposit in blocks data Vs MC => needs tuning

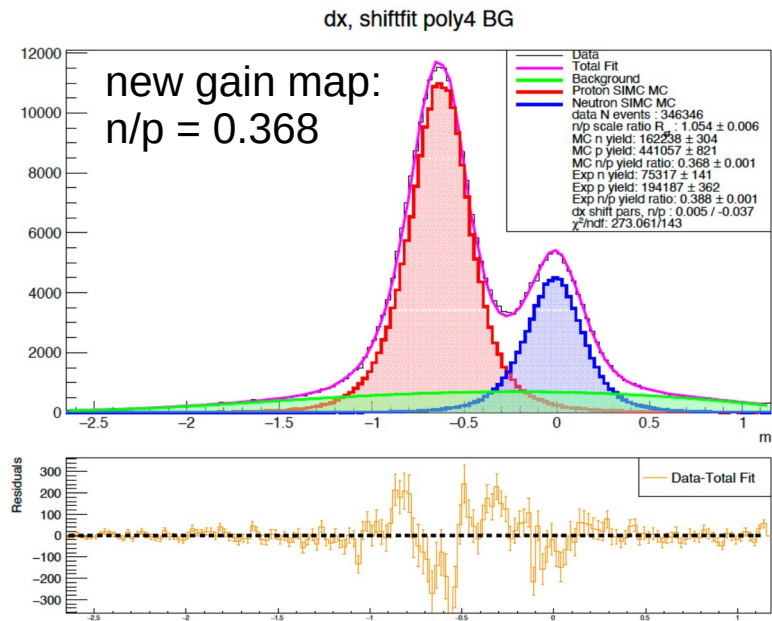
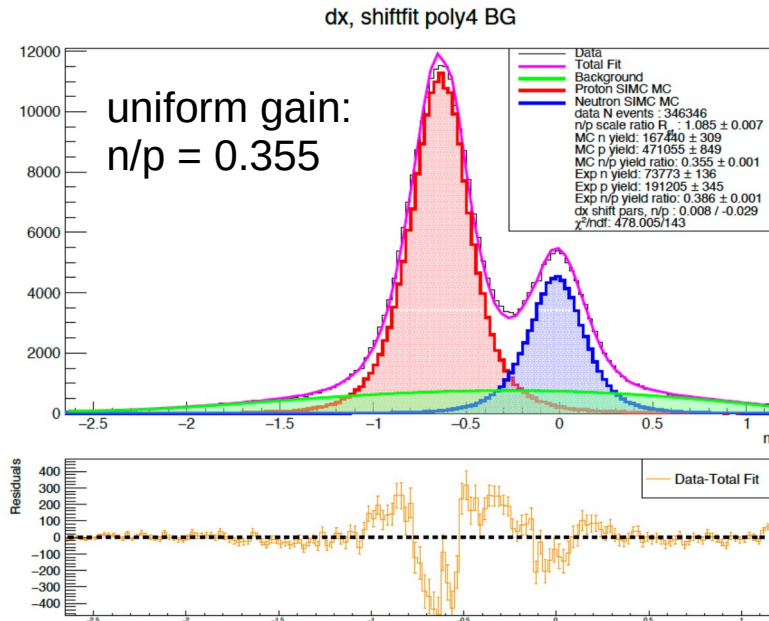


Top of HCAL



HCAL efficiency non-uniformity

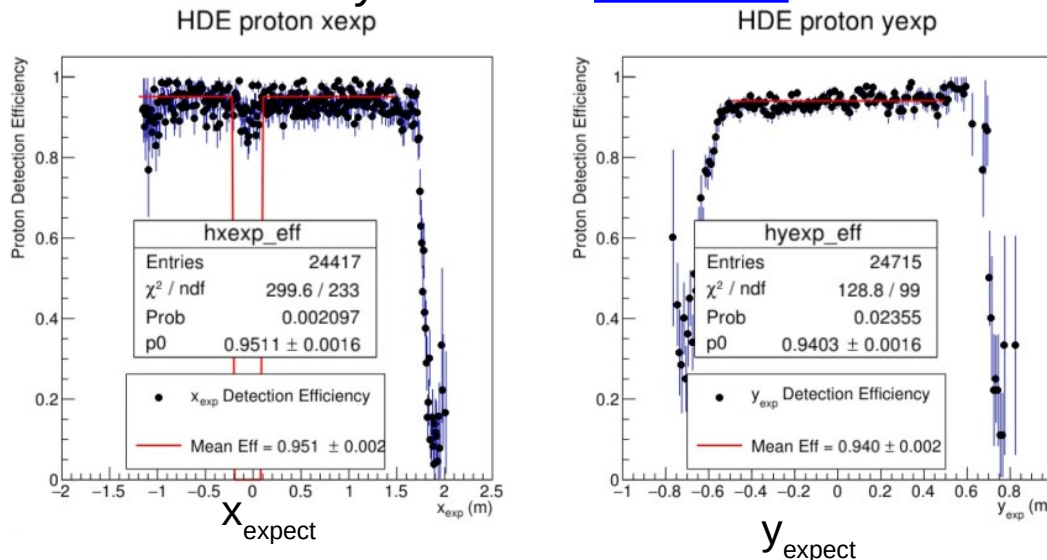
- Attempt to reproduce non-uniformity with MC:
 - Comparison between n/p ratios with new gain map vs uniform gain;
 - Analysis credit [Z. Wertz](#): 3% increase in n/p ratio for SBS8, 50% SBS field;
 - **In progress** (other setting give results that remain to be understood);



HCal efficiency non-uniformity

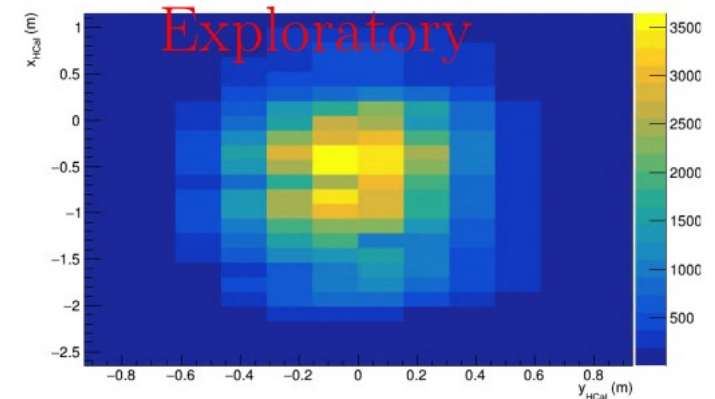
- Alternate method to work around HCal efficiency non-uniformity:
Reweight MC events with HCal non-uniformity map;
 - Map efficiency along x_{expect} , y_{expect} ;
 - weight MC with relative variation efficiency according to x_{expect} , y_{expect} map;
 - ◆ used by John for his analysis

Analysis credit: [S. Seeds](#)



Analysis credit: J. Boyd

Simulaton: HCal block hits - SBS9, 70%, LD2

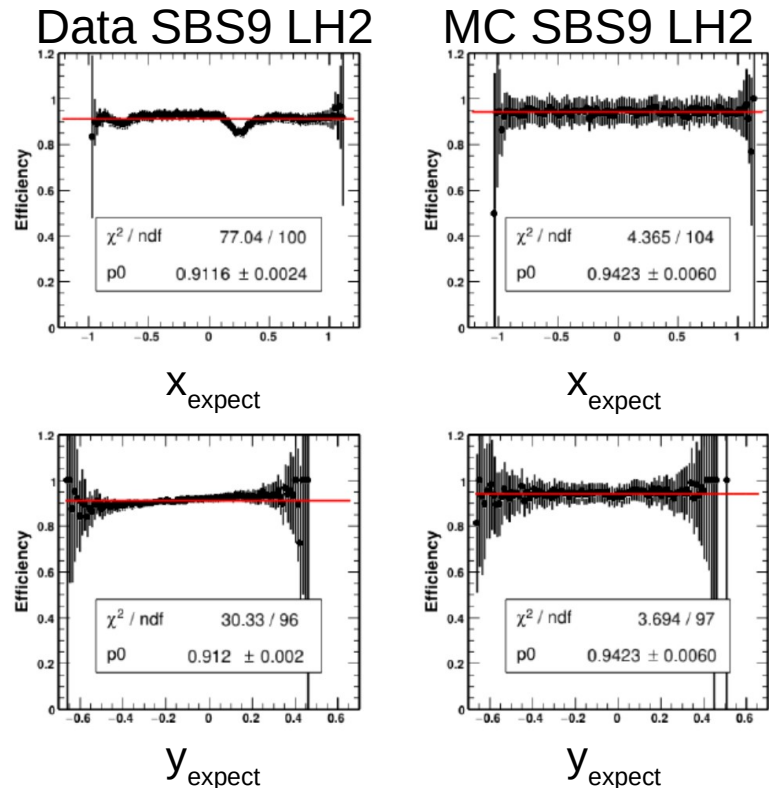


HCAL efficiency non-uniformity

- Alternate method to work around HCal efficiency non-uniformity:
Reweight MC events with HCal non-uniformity map;

- Map efficiency along x_{expect} , y_{expect} ;
- weight MC with relative efficiency variation
- Improvement:
 - ◆ Apply same efficiency analysis for data, MC;
 - ◆ use ratio of $\eta_{\text{data}}/\eta_{\text{MC}}$;
 - ◆ has yet to be deployed in analysis;

Analysis credit: P. Datta



GMN/NTPE results

- GMN (all students):
 - most advanced analysis include statistics and systematics
except HCal detection efficiency
 - GMN will still benefit from a refined correction of HCal non-uniformity
- NTPE: (John, Sebastian, Zeke)
 - Existing analyses very preliminary and need independent cross checks
 - use very coarse corrections for HCal non-uniformity map
 - Result featured in John's thesis may change with a more refined correction of HCal non-uniformity;

Summary

- Progress:
 - Inelastic background subtraction nailed down (~1%-3% systematic induced);
 - Systematic studies of n/p stability;
- Getting to integrate the HCal non-uniformity in the analysis (in progress):
 - using MC including non-uniformity effects;
 - reweighting MC events with HCal non-uniformity map;
- Next steps:
 - Converge on HCal non-uniformity corrected analysis
 - Evaluate and propagate systematic;
 - Prepare publication;

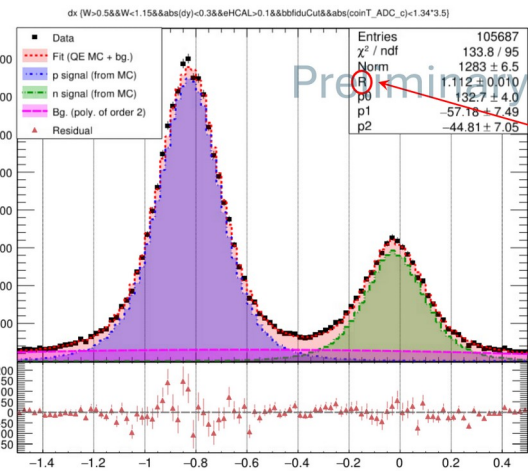
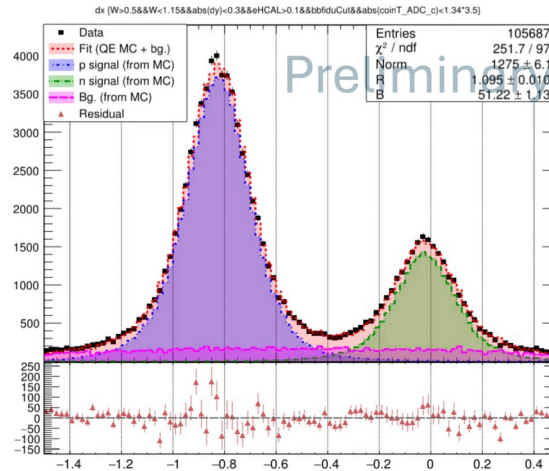
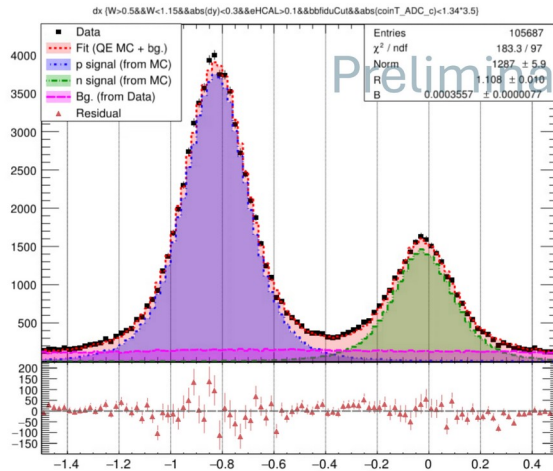
Students status

- John, Sebastian, Nathaniel, recently graduated (Congrats!);
- Anu, Provakar to graduate within 2-4 weeks;
- Maria, Zeke to graduate within the next 3-6 months;
- A few students may continue the analysis as post-docs;

Back up

Subtraction of inelastic background

- Three methods for inelastic background estimation/subtraction:
 - SBS14, analysis credit [P. Datta](#) => induced systematic uncertainty ~1.2%



(SBS7 ~ 1.5%)
(SBS11 ~ 3.5%)

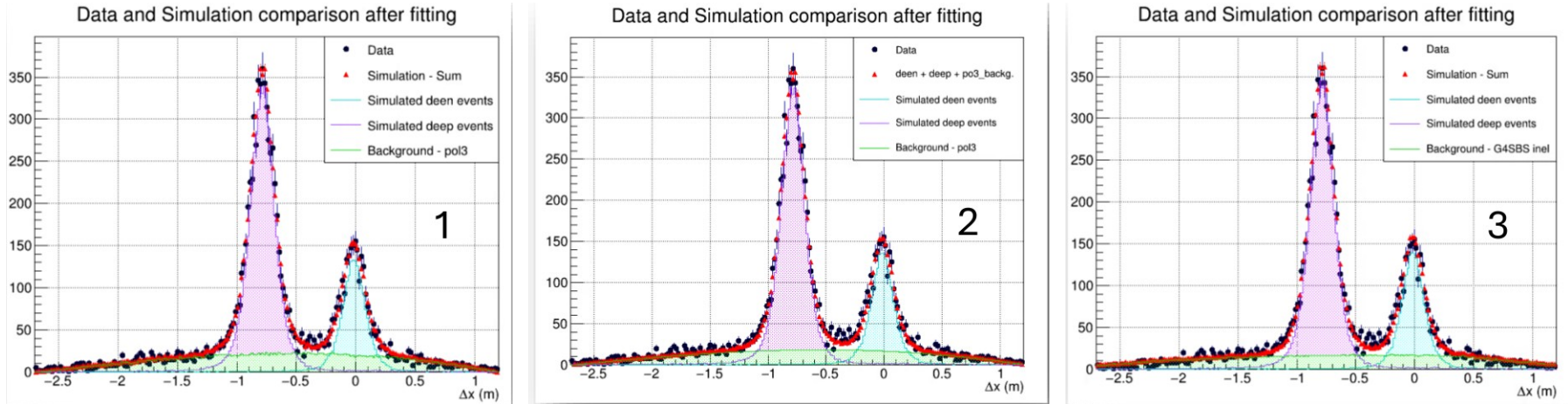
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Std. Dev.: 0.0037

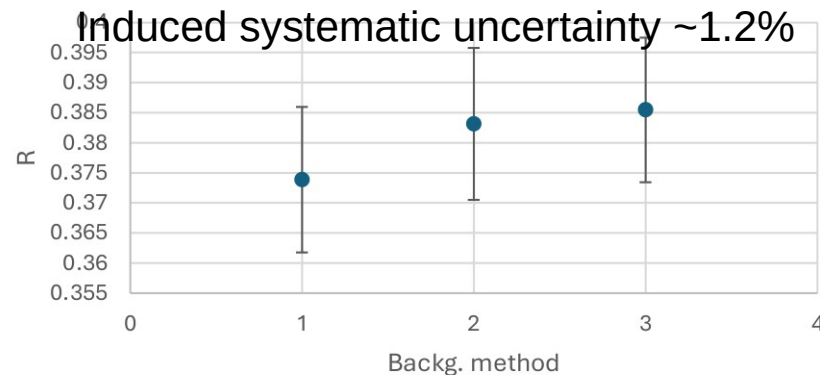
Subtraction of inelastic background

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R vs Backg. method

(SBS4 <0.5%)

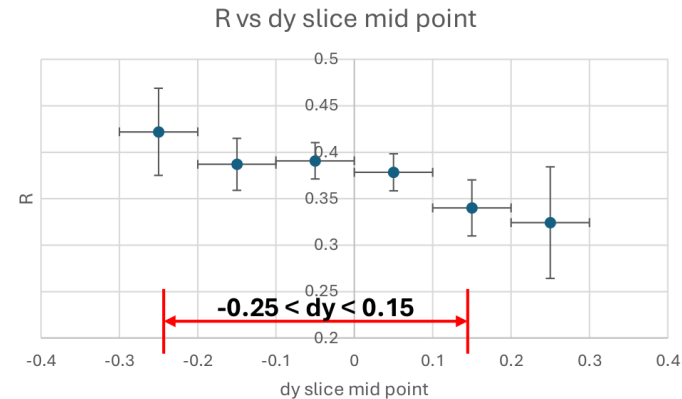
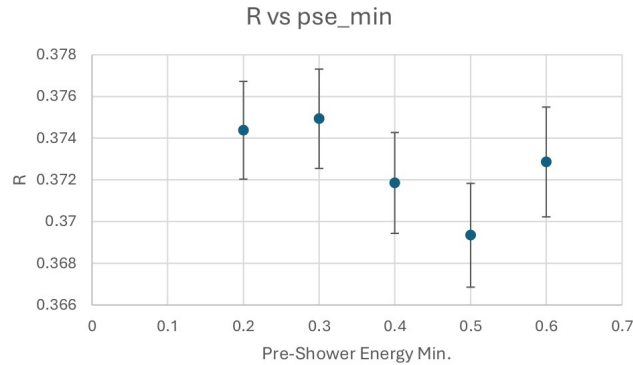
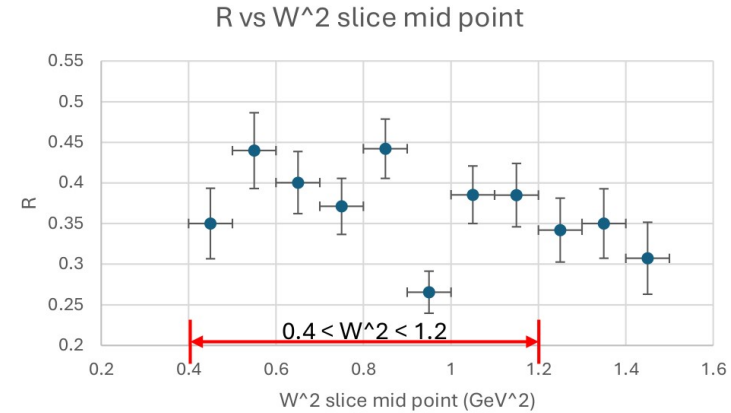


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 - For SBS9: 10% increase in n/p ratio (analysis credit [Z. Wertz](#));

