Forward Neutron Production at MIPP Experiment

analysis status report

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neutron analysis

Motivation

- There is only one experiment with neutron production from p+p at 158 GeV/c (NA49)
- HARP reaches only 15 GeV and does not measure neutrons
- MIPP covers variety of targets and beam momenta
- Proton Radiography
- Test, provide input to neutron production in Monte Carlos

Analysis outline

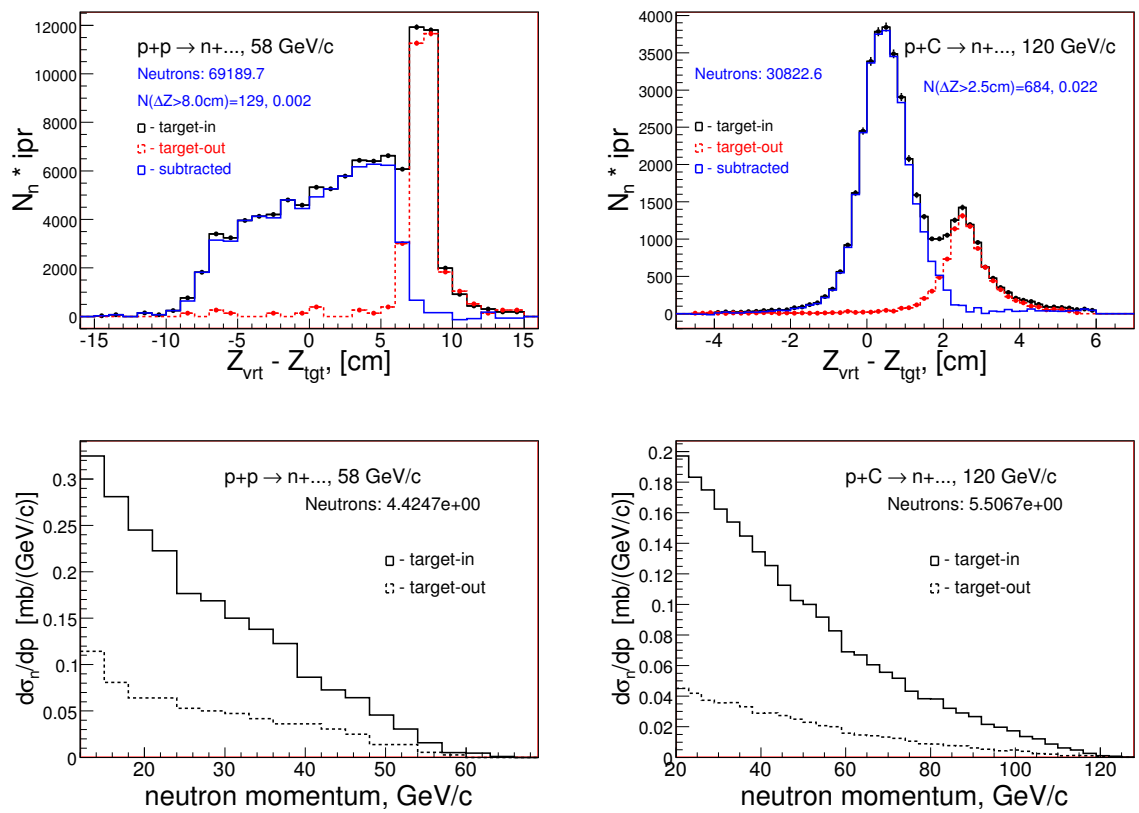
- Event selection (good run, good beam track)
- Neutron selection
- Trigger efficiency
- Acceptance, selection efficiency
- Backgrounds
- Systematic uncertainties (not covered)
- Neutron cross section (preliminary)

Measured neutron spectra (uncorrected)

$$\sigma_n = \frac{N_n(t_{in}) - N_n(t_{out})}{N_{beam}} \times \frac{1}{A} \times \frac{1}{n_t} \times \frac{1}{bs} \times 10^4, \text{ mb/(GeV/c)}$$

- E_n = E_{hcal} - $E_{trks,hcal}$ (if)
- p_n(min) = 12(20) GeV/c for p_{beam} = 58(120) GeV/c
- $\theta_n(max) \approx$ 23 mrad

64155 target, p_b	N_n	σ_n, mb
H_2, 58 GeV/c	69190	4.42 $\pm$ 0.07
Be, 58 GeV/c	3618	3.83 $\pm$ 0.25
C, 58 GeV/c	27363	3.10 $\pm$ 0.08
Bi, 58 GeV/c	14749	0.85 $\pm$ 0.02
U, 58 GeV/c	25588	0.70 $\pm$ 0.01
Be, 120 GeV/c	53087	6.25 $\pm$ 0.02
C, 120 GeV/c	30823	5.51 $\pm$ 0.03
Bi, 120 GeV/c	34180	1.56 $\pm$ 0.01



Top: the interaction vertex positions for H_2 (left) and C (right) targets.

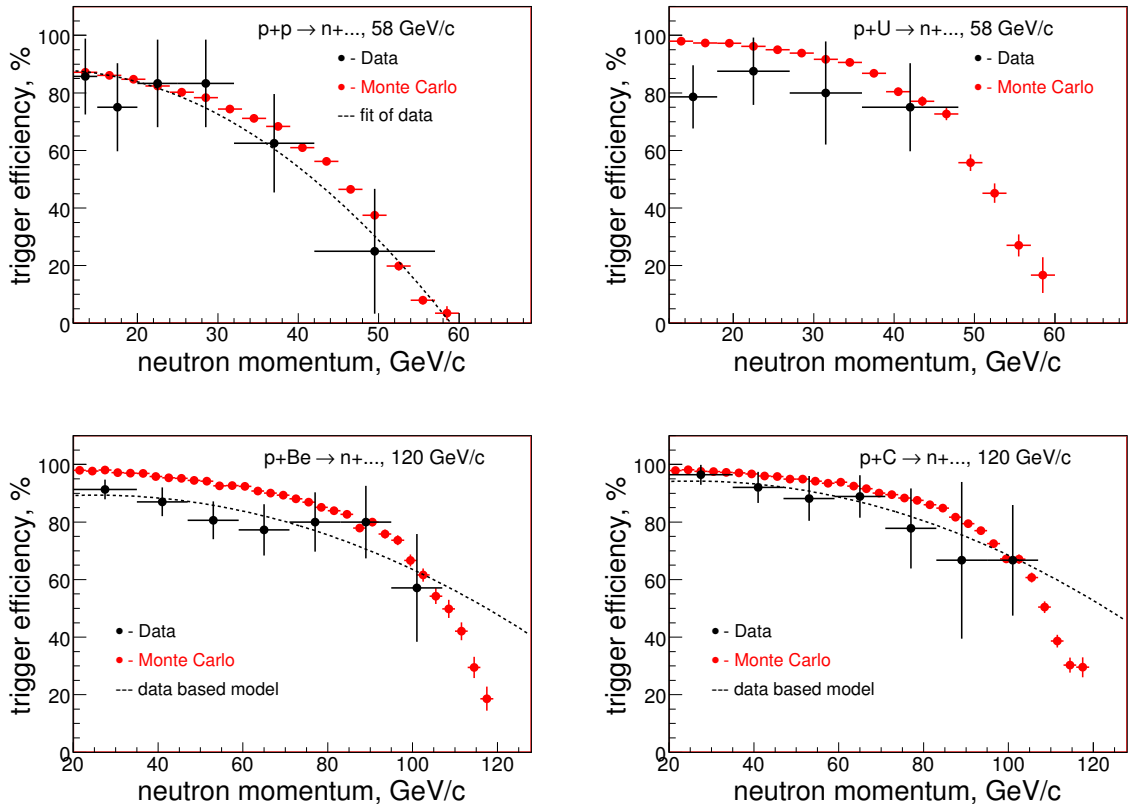
Bottom: the uncorrected cross section $d\sigma_n/dp$ as a function of the neutron momentum for H_2 (left) and C (right) targets.

Trigger efficiency

- Use unbiased beam triggers
- Select neutrons
- See if trigger fires

target, p_b	ϵ_{trig}(data)	ϵ_{trig}(mc)
H_2, 58 GeV/c	0.72±0.07	0.75
Be, 58 GeV/c	1.00±?	0.82
C, 58 GeV/c	0.80±0.18	0.85
Bi, 58 GeV/c	0.57±0.19	0.91
U, 58 GeV/c	0.80±0.07	0.91
Be, 120 GeV/c	0.84±0.03	0.92
C, 120 GeV/c	0.89±0.03	0.93
Bi, 120 GeV/c	0.76±0.03	0.97

MC results are based on FLUKA and GEANT simulation.



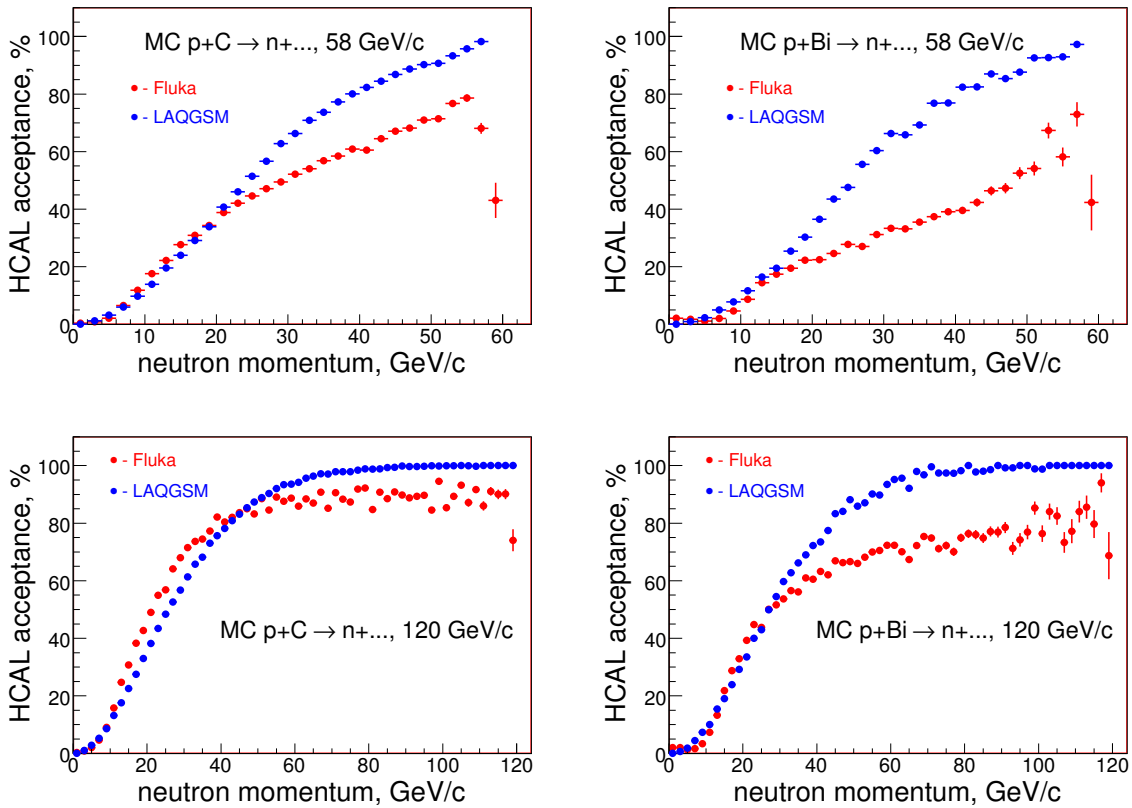
Top: the trigger efficiency as a function of the neutron momentum for H_2 (left) and U (right) targets.

Bottom: the trigger efficiency as the function of the neutron momentum for Be (left) and C (right) targets.

Calorimeter acceptance, total cut efficiency

- Use MC simulation, trigger is on
- a_{hcal}=$N_n(hcal)/N_n(gen)$
- ϵ_{nsel}=$a_{hcal} \times \epsilon_{n-reco}$

target, p_b	a_{hcal}	ϵ_{nsel}
H_2, 58 GeV/c	0.51	0.43
Be, 58 GeV/c	0.46	0.39
C, 58 GeV/c	0.44	0.37
Bi, 58 GeV/c	0.26	0.22
U, 58 GeV/c	0.26	0.22
Be, 120 GeV/c	0.81	0.71
C, 120 GeV/c	0.79	0.71
Bi, 120 GeV/c	0.61	0.55



Top: the calorimeter acceptance as a function of the neutron momentum for C (left) and Bi (right) targets at 58 GeV/c beam momentum.

Bottom: the calorimeter acceptance as a function of the neutron momentum for C (left) and Bi (right) targets at 120 GeV/c beam momentum.

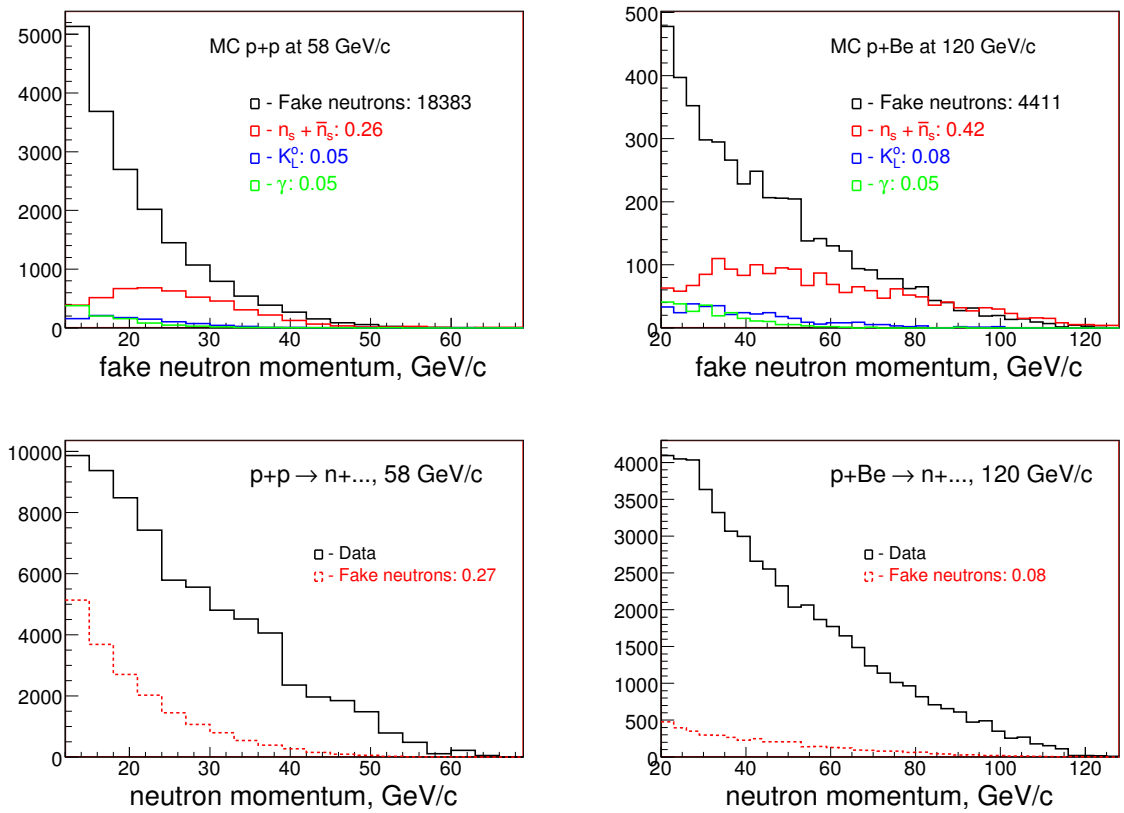
NOTE: Studies with LAQGSM approach are in progress.

Backgrounds

Sources: un/mis-reconstructed tracks and neutrals: K_L^o, n_s, γ

- Use MC events with no neutrons
- Select neutrons same way as in data
- What will pass is the background
- Apply normalization

target, p_b	Backgr.	Fraction
H_2, 58 GeV/c	18383	0.27
Be, 58 GeV/c	271	0.07
C, 58 GeV/c	2038	0.07
Bi, 58 GeV/c	676	0.05
U, 58 GeV/c	1594	0.06
Be, 120 GeV/c	4411	0.08
C, 120 GeV/c	2223	0.07
Bi, 120 GeV/c	2014	0.06



Top: the background spectrum with the neutrals superimposed for H_2 (left) and Be (right) targets.

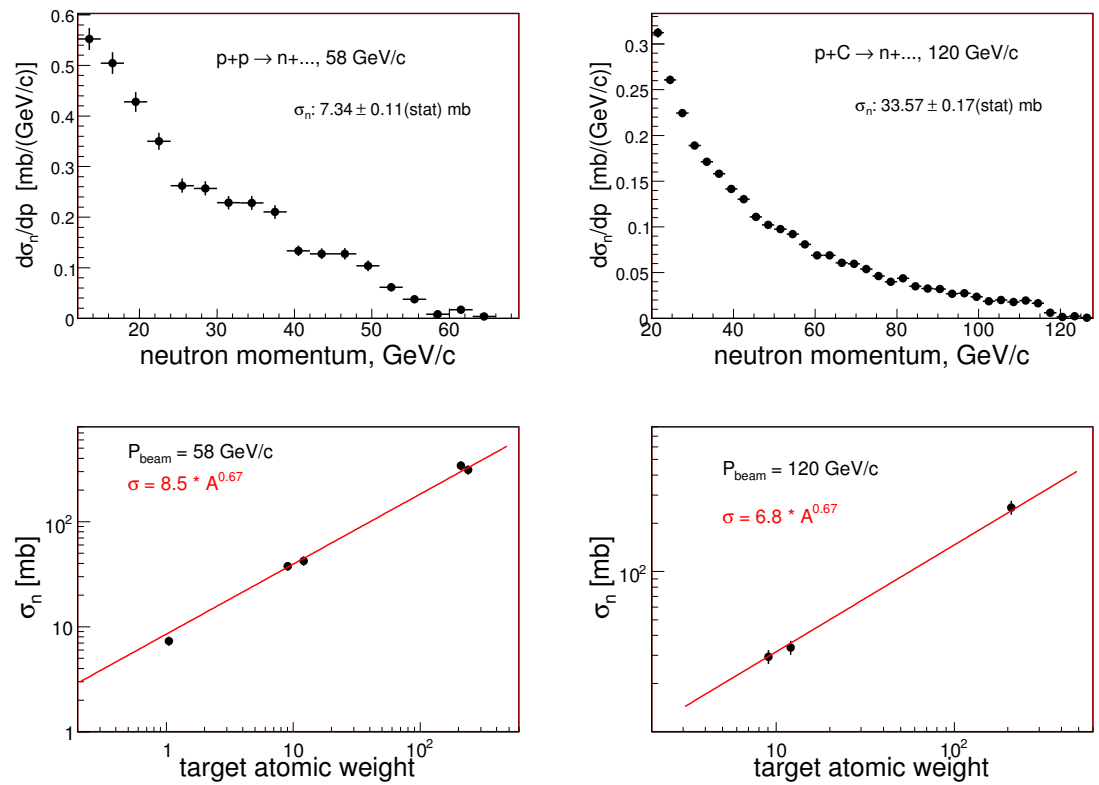
Bottom: the neutron spectrum (data) with the total background superimposed for H_2 (left) and Be (right) targets.

Results are based on FLUKA and GEANT simulation.

Neutron cross section results (preliminary)

$$\sigma_n = \frac{N_n(t_{in}) - N_n(t_{out}) - N_n(backgr)}{N_{beam} \times \epsilon_{trig} \times \epsilon_{nsel}} \times \frac{1}{A} \times \frac{1}{n_t} \times \frac{1}{bs} \times 10^4, \text{ mb/(GeV/c)}$$

target, p_b	σ_n, mb
H_2, 58 GeV/c	7.3 ± 0.1
Be, 58 GeV/c	37.7 ± 2.4
C, 58 GeV/c	42.3 ± 1.1
Bi, 58 GeV/c	341.4 ± 8.4
U, 58 GeV/c	311.3 ± 4.6
Be, 120 GeV/c	29.4 ± 0.1
C, 120 GeV/c	33.6 ± 0.2
Bi, 120 GeV/c	251.0 ± 1.0

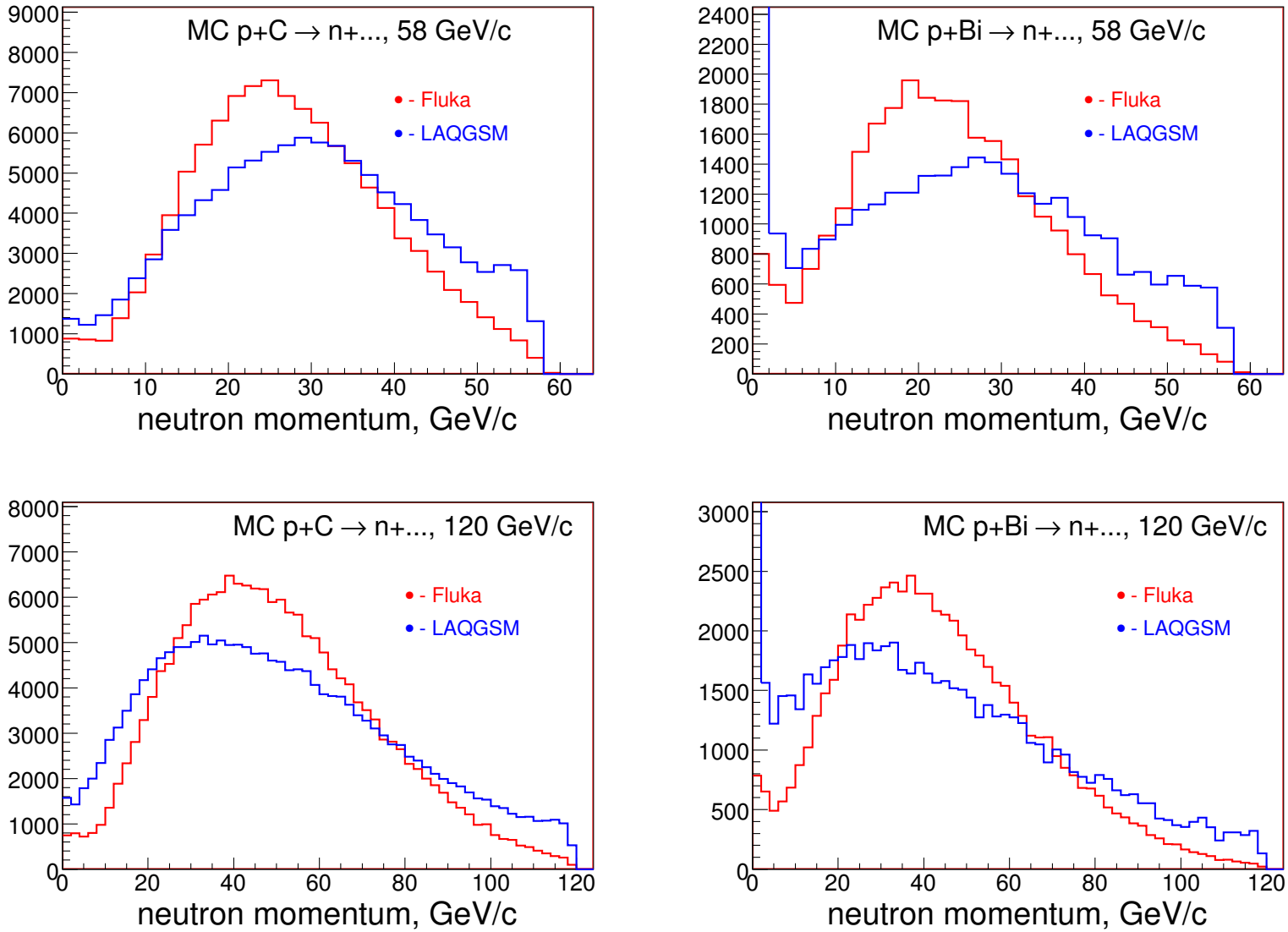


Top: the resulting $d\sigma_n/dp$ for H_2 (left) and C (right) targets.

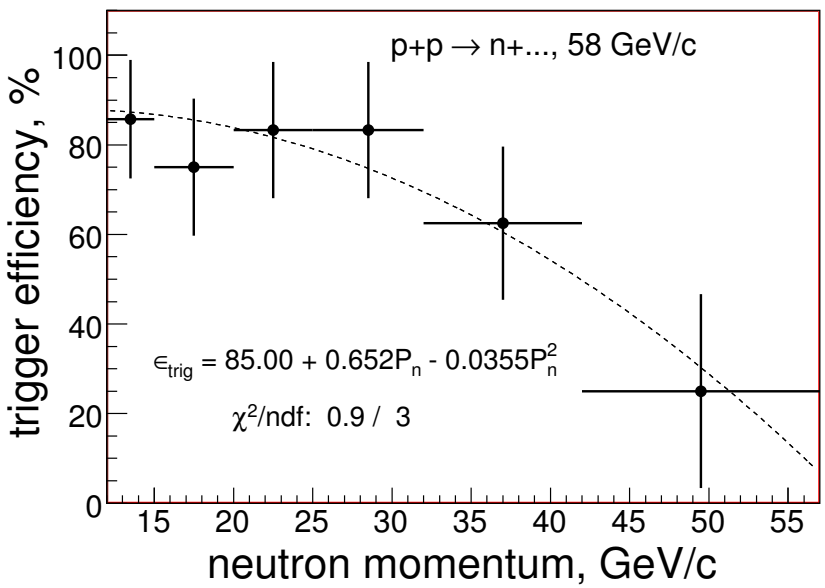
Bottom: the resulting σ_n as a function of target atomic weight for 58 GeV/c (left) and 120 GeV/c (right) beam momentum, respectively.

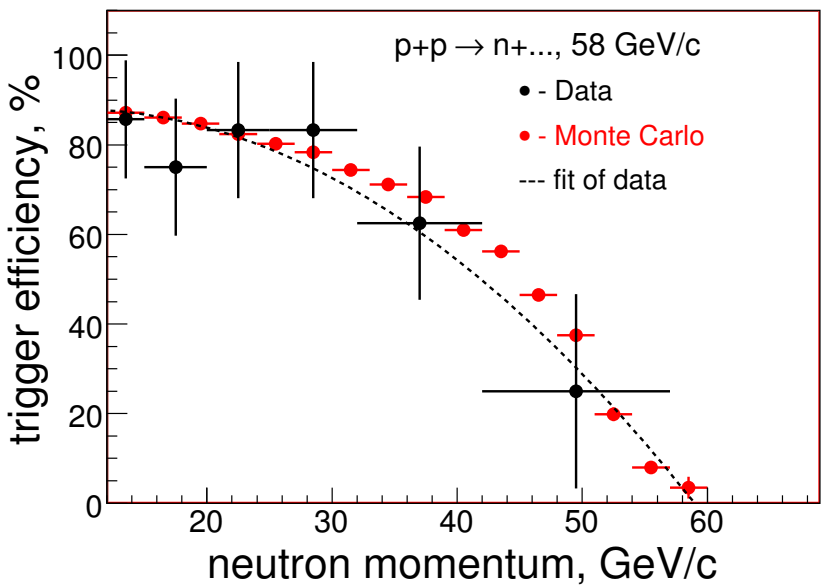
Back-up plots

neutron production (within HCAL): Fluka vs LAQGSM

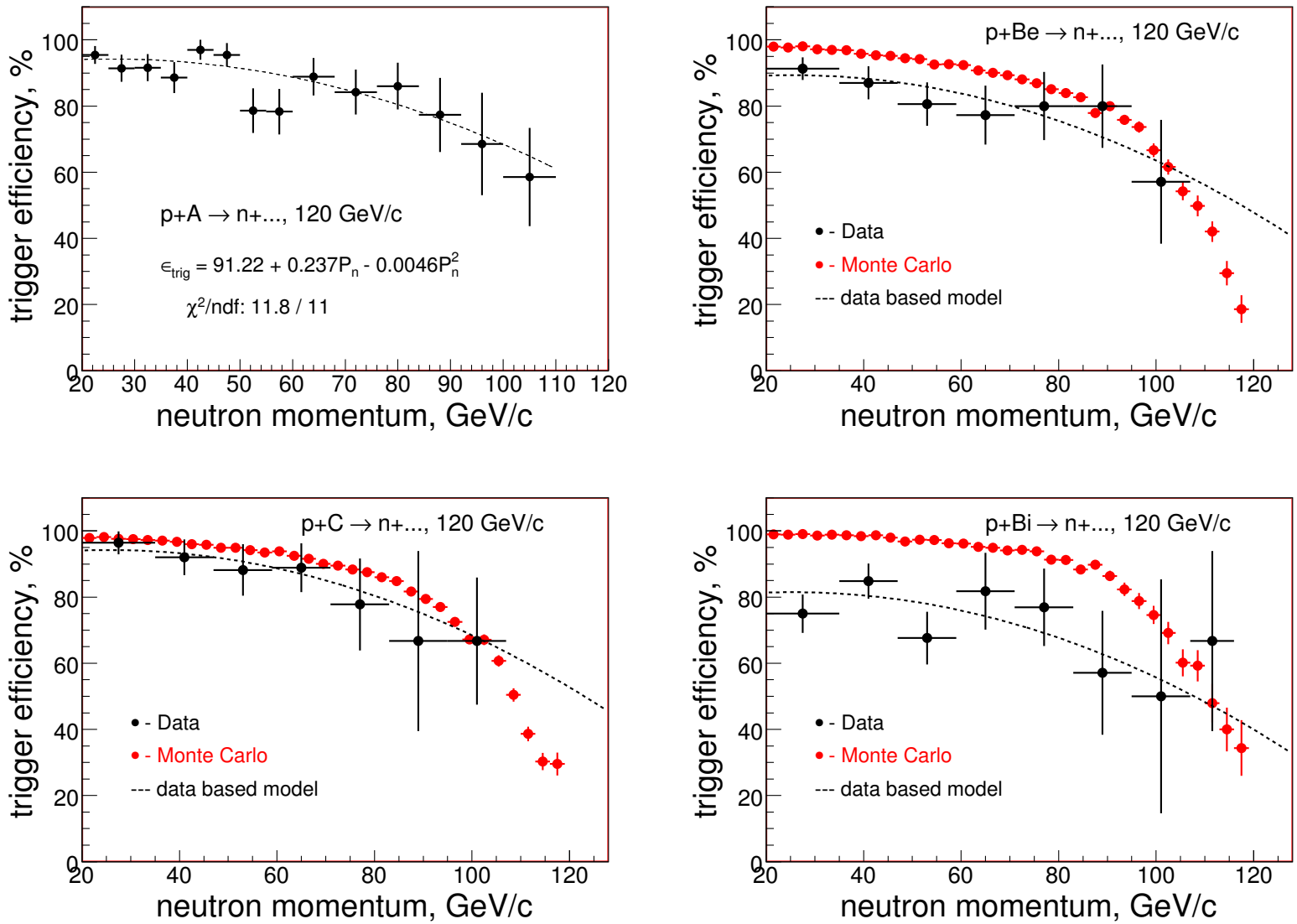
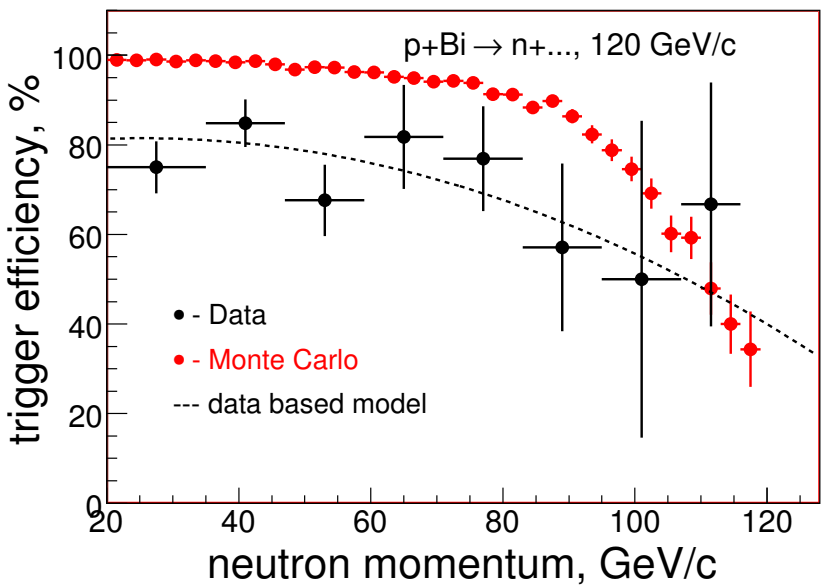
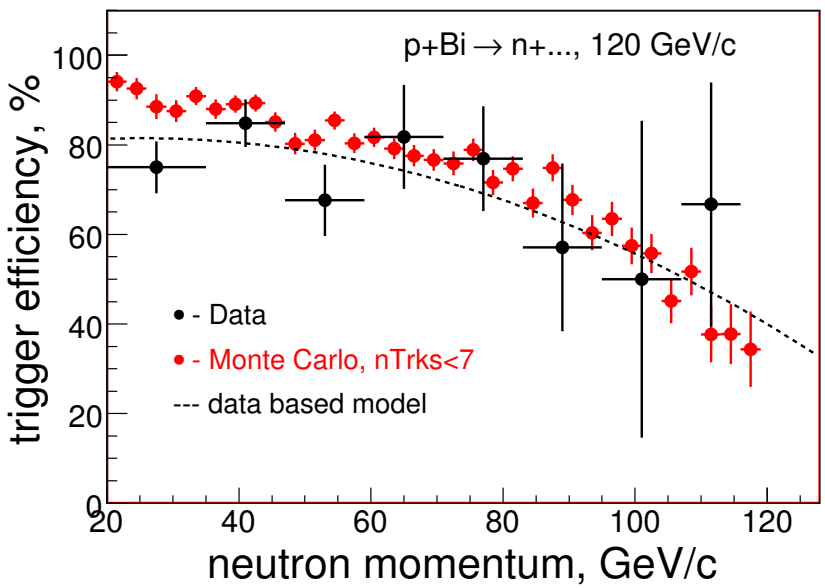


trigger efficiency: LH2 target at 58 GeV/c





trigger efficiency update, continue



trigger efficiency update, continue