^{3}He Cross-Section Summary

E12-06-121

Murchhana Roy

Raw Cross-section Extraction: (Section 7.5)

$$\sigma_{raw}(E',\theta) = \frac{\text{Yield}_{cor}(E',\theta)}{L * A * \Delta\Omega * \Delta E'}$$

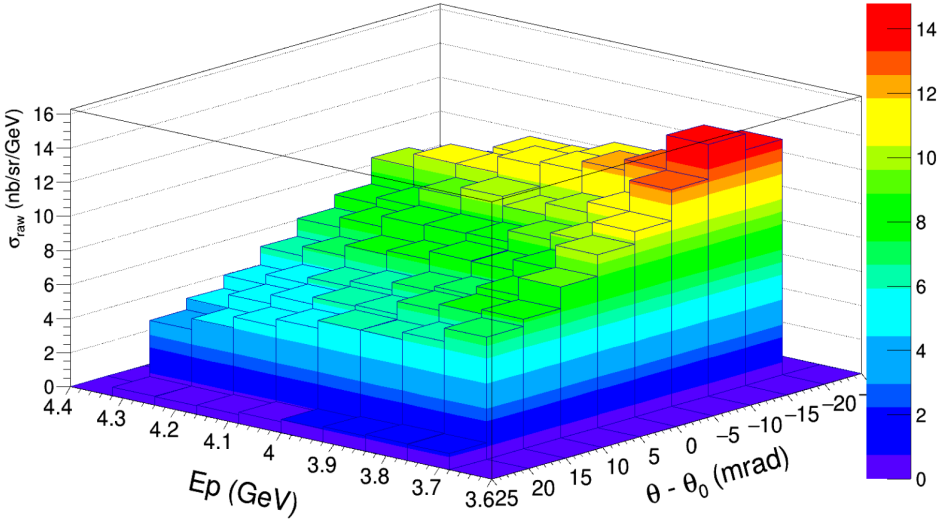
$$\text{Yield}_{cor}(E',\theta) = \frac{\text{Yield}(E',\theta)}{\varepsilon_{cal} * \varepsilon_{cheren} * \varepsilon_{tr} * \varepsilon_{trig} * livetime}$$

$L = \eta_{tar} * l_{tar} * Q_{tot} / |e|$ (integrated luminosity)

$\Delta\Omega$= solid angle generated per (E',θ) bin

$\Delta E'$= momentum acceptance per (E',θ) bin

$A(E',\theta) = N_{detected}(E',\theta)/N_{thrown}(E',\theta)$ (**section 7.4.7**)



HMS Kin-C (20°, -4.0 GeV/c)

Cuts used:

- -9<z<9 (cm)
- -8<δ<8 (%)
- -0.04<xp<0.04 (rad)
- -0.02<yp<0.02 (rad)
- PID Cuts: 0.2<E/P<2 (calorimeter), npe>1 (Cherenkov)

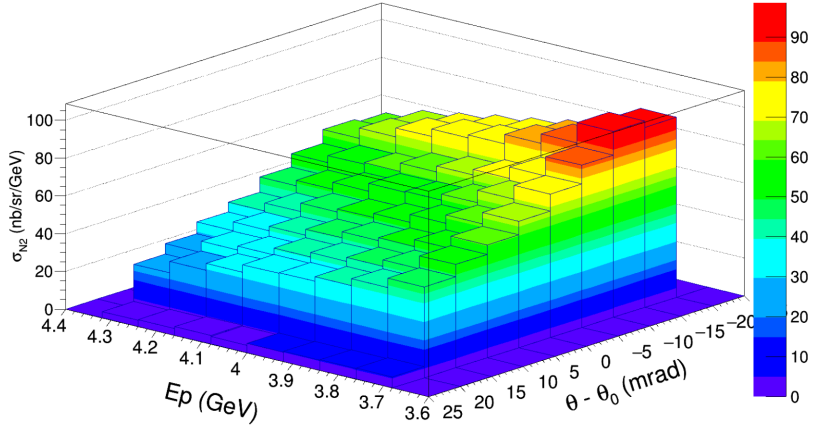
Cross-section Extraction: N_2 subtraction (section 7.5.1)

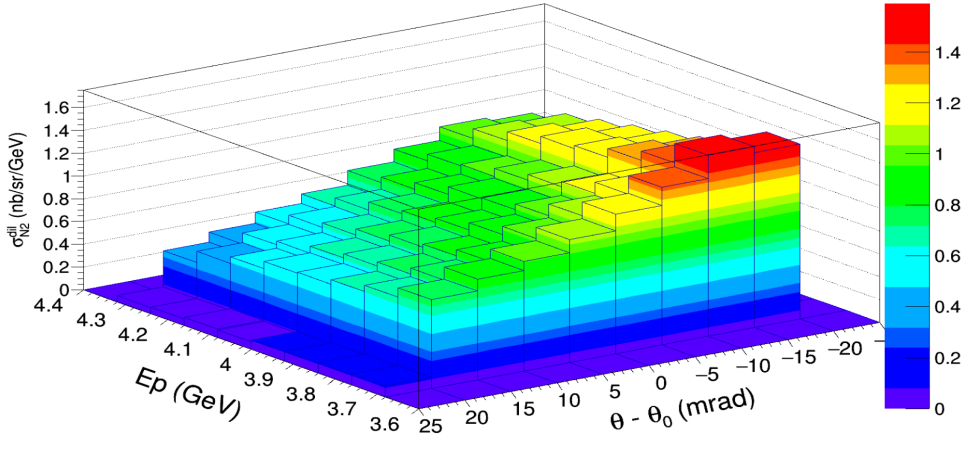
Production Cell
$\eta_{N2} = 0.13$ amg
$\eta_{He3} = 7.76$ amg

$$\sigma_{rad}(E', \theta) = \sigma_{raw}(E', \theta) - \sigma_{N2}^{dil}(E', \theta)$$

$$= \frac{\eta_{N2} * \sigma_{N2}}{\eta_{N2} + \eta_{He3}}$$

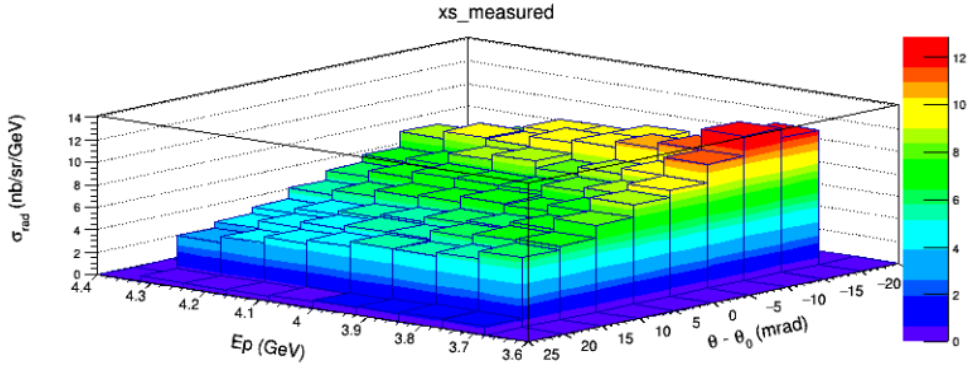
N_2 reference cell data





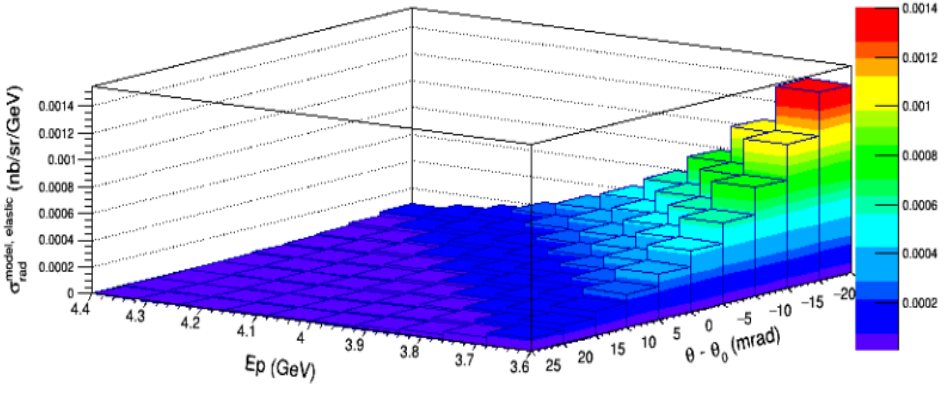
Max N_2 dilution ~15%

N_2 subtracted xsection: σ_{rad}

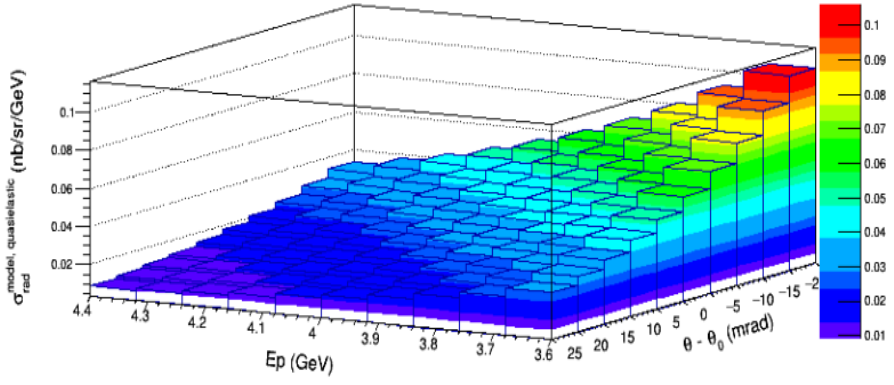


Cross-section Extraction: Radiative Correction (section 7.5.2)

$$\sigma_{\mathrm{Born}} = \left(\sigma_{rad} - \sigma_{rad}^{elastic,\,model} - \sigma_{rad}^{quasielastic,\,model}\right) * \frac{\sigma_{\mathrm{Born}}^{model}}{\sigma_{rad}^{inelastic,\,model}}$$



Max elastic contribution 0.2%

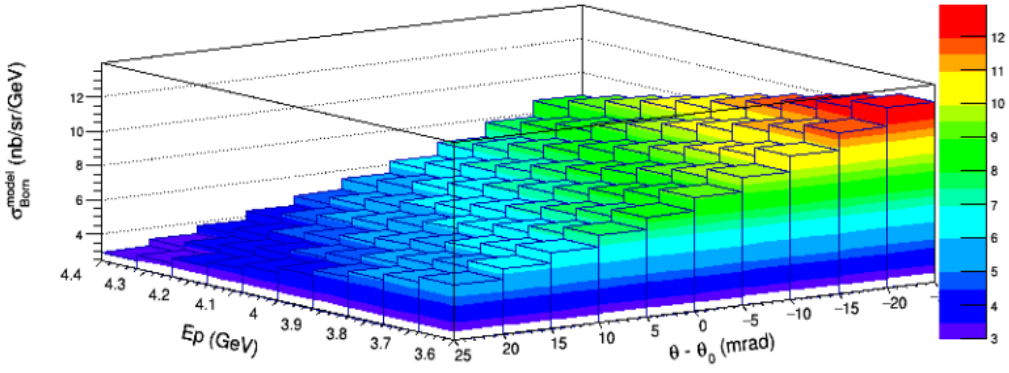


Max quasi-elastic contribution 2.5%

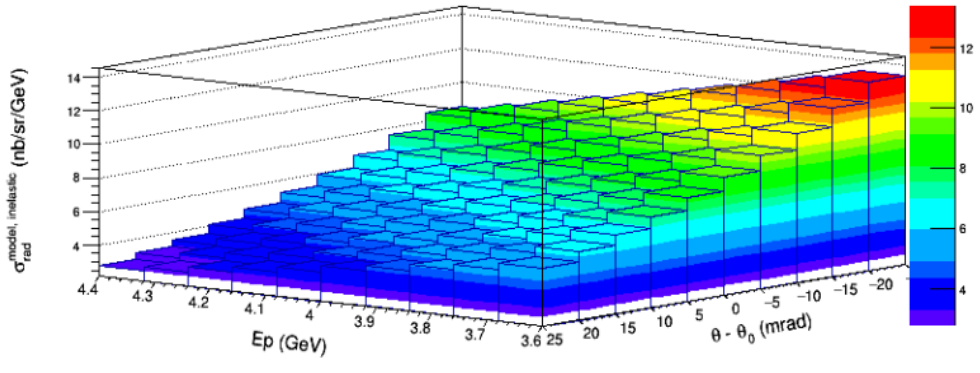
Cross-section Extraction: Radiative Correction

$$\sigma_{\text{Born}} = \left(\sigma_{rad} - \sigma_{rad}^{elastic,\,model} - \sigma_{rad}^{quasielastic,\,model}\right) * \frac{\sigma_{\text{Born}}^{model}}{\sigma_{rad}^{inelastic,\,model}}$$

$\sigma_{\text{Born}}^{\text{Model}}$

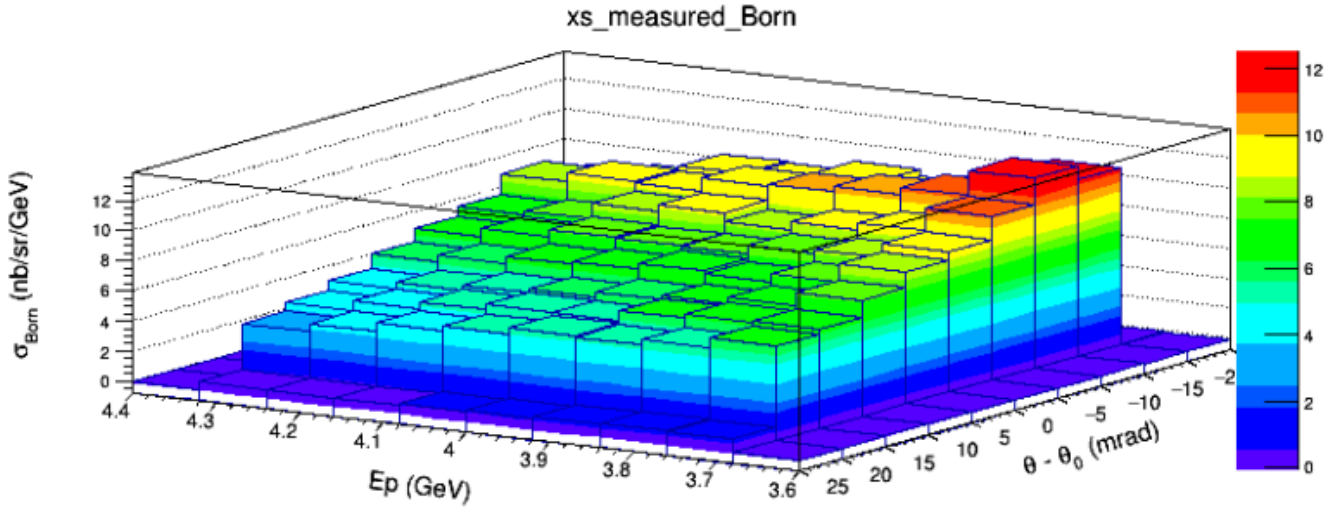


$\sigma_{\text{Inelastic}}^{\text{Model}}$



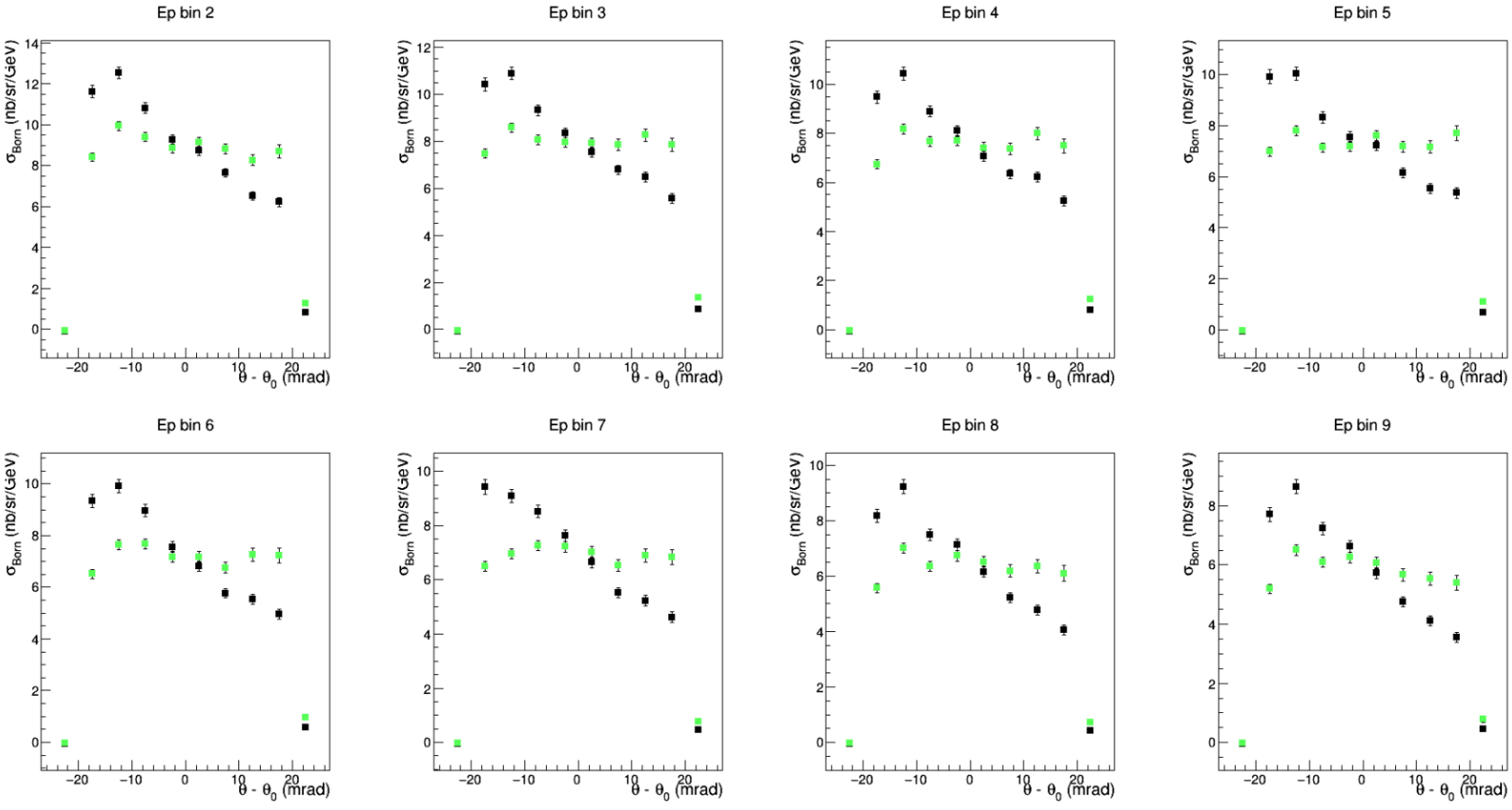
Cross-section Extraction: Radiative Correction

$$\sigma_{\mathrm{Born}} = \left(\sigma_{rad} - \sigma_{rad}^{elastic,\,model} - \sigma_{rad}^{quasielastic,\,model}\right) * \frac{\sigma_{\mathrm{Born}}^{model}}{\sigma_{rad}^{inelastic,\,model}}$$



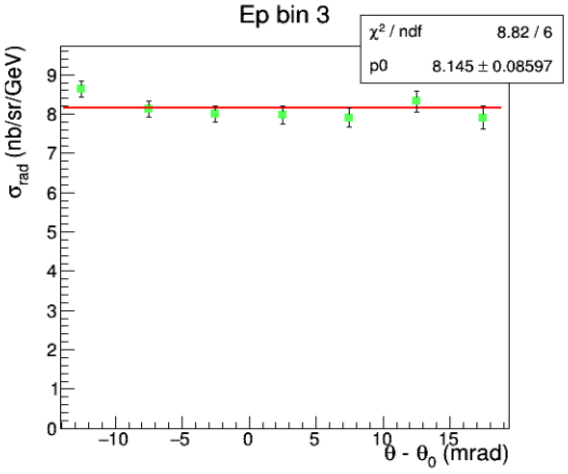
Cross-section Extraction: Bin-centering corrections (section 7.5.3)

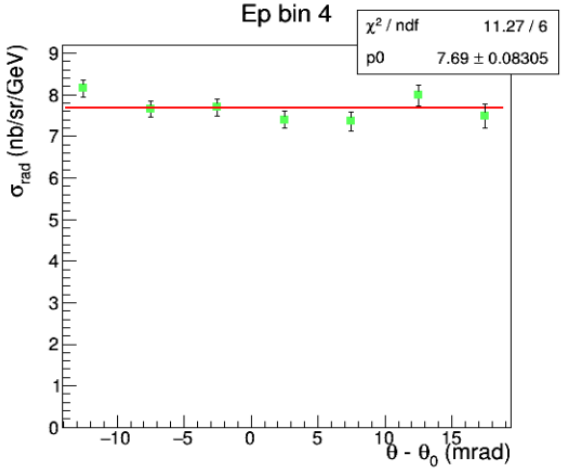
$$[\sigma_{\mathrm{Born/rad}}(\theta_0)]_{\mathrm{BC,\,i}} = \sigma_{\mathrm{Born/rad}}(\theta_i) * \frac{\sigma_{\mathrm{Born/rad}}^{model}(\theta_0)}{\sigma_{\mathrm{Born/rad}}^{model}(\theta_i)}$$

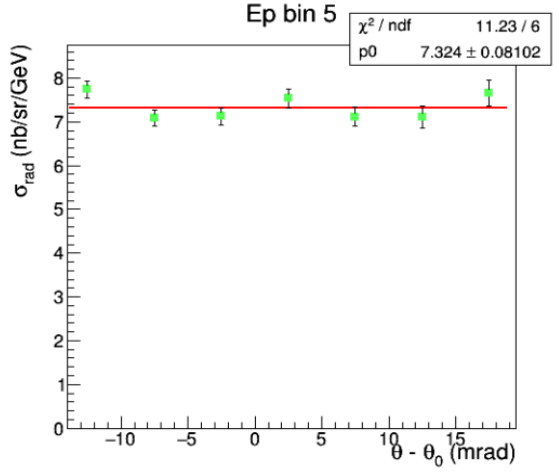


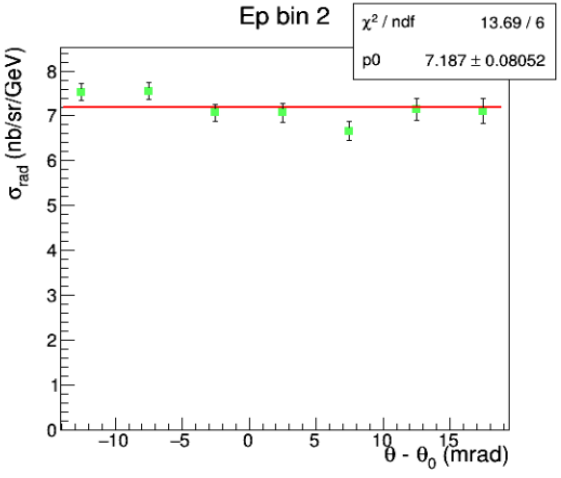
Cross-section Extraction: Bin-centering corrections

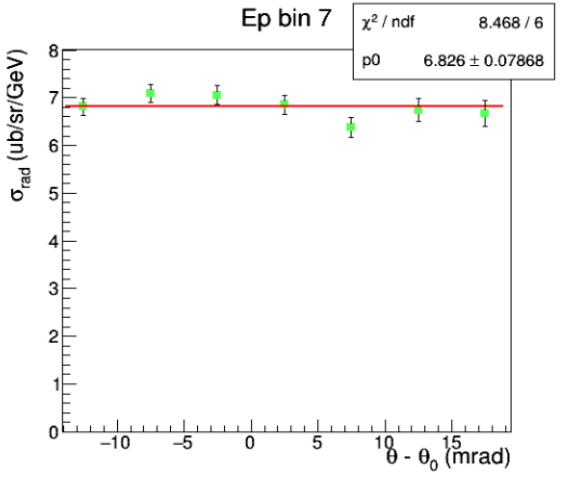
$$[\sigma_{\mathrm{Born/rad}}(\theta_0)]_{\mathrm{BC,\,i}} = \sigma_{\mathrm{Born/rad}}(\theta_i) * \frac{\sigma_{\mathrm{Born/rad}}^{model}(\theta_0)}{\sigma_{\mathrm{Born/rad}}^{model}(\theta_i)}$$

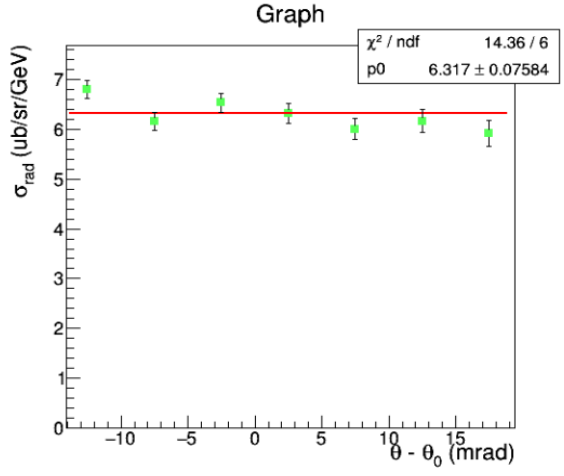






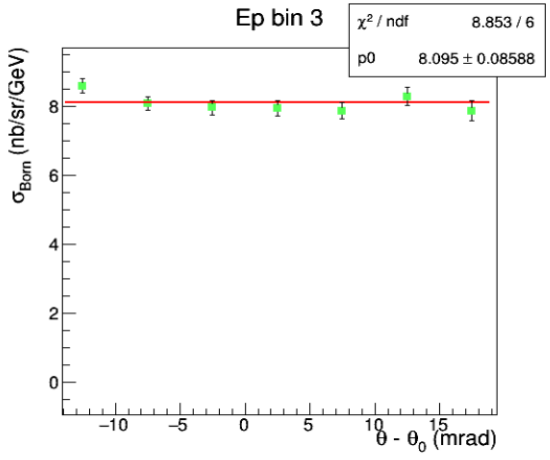


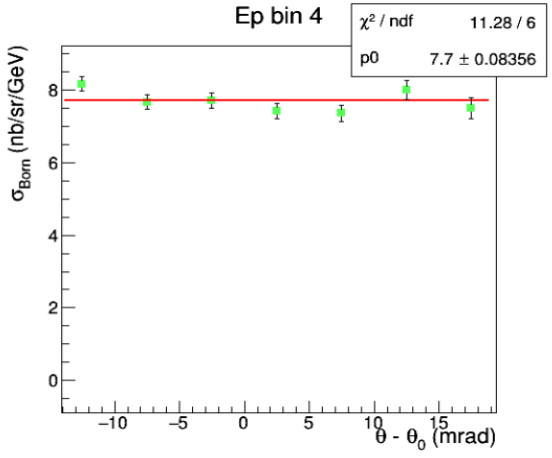


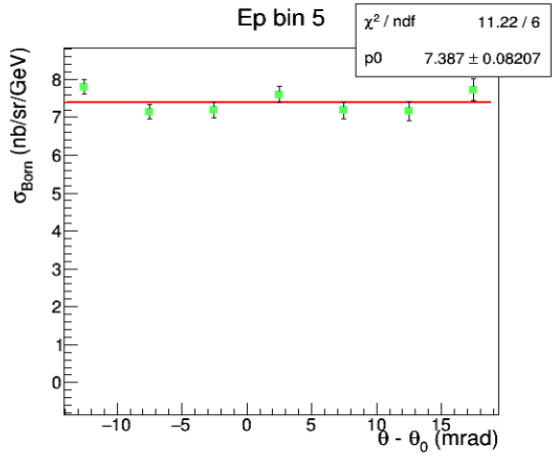


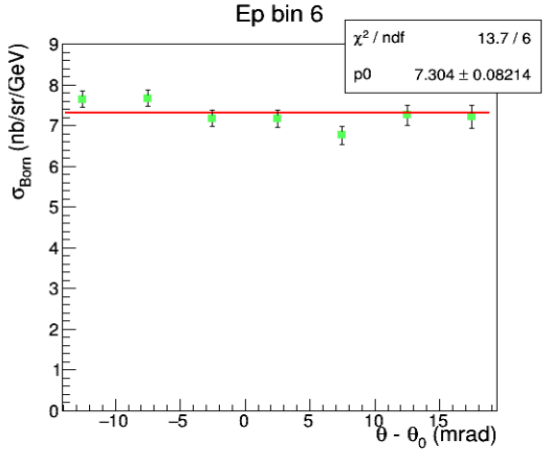
Cross-section Extraction: Bin-centering corrections

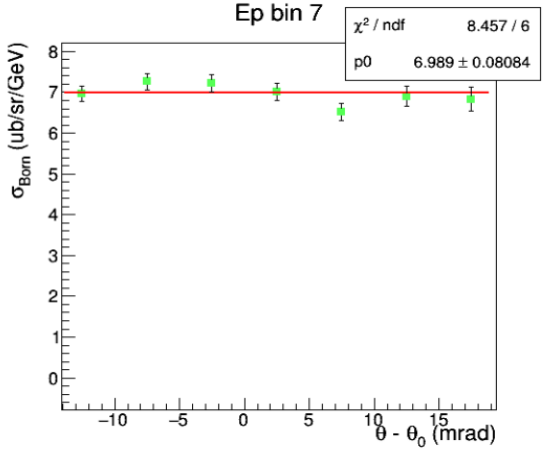
$$[\sigma_{\mathrm{Born/rad}}(\theta_0)]_{\mathrm{BC,\,i}} = \sigma_{\mathrm{Born/rad}}(\theta_i) * \frac{\sigma_{\mathrm{Born/rad}}^{model}(\theta_0)}{\sigma_{\mathrm{Born/rad}}^{model}(\theta_i)}$$

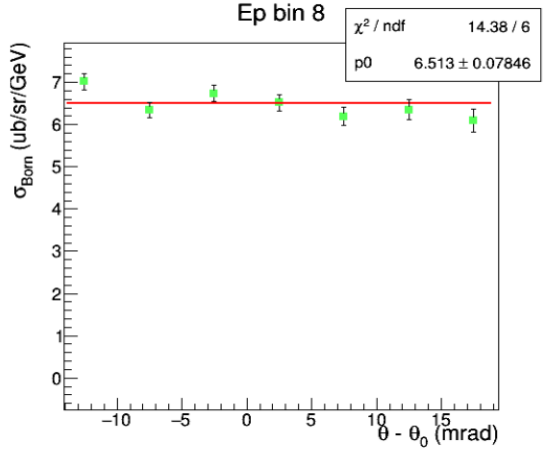




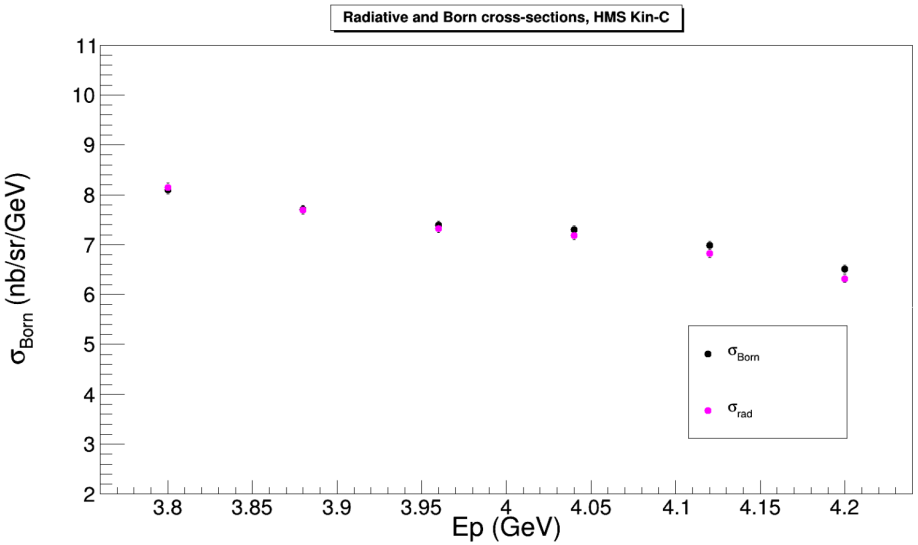


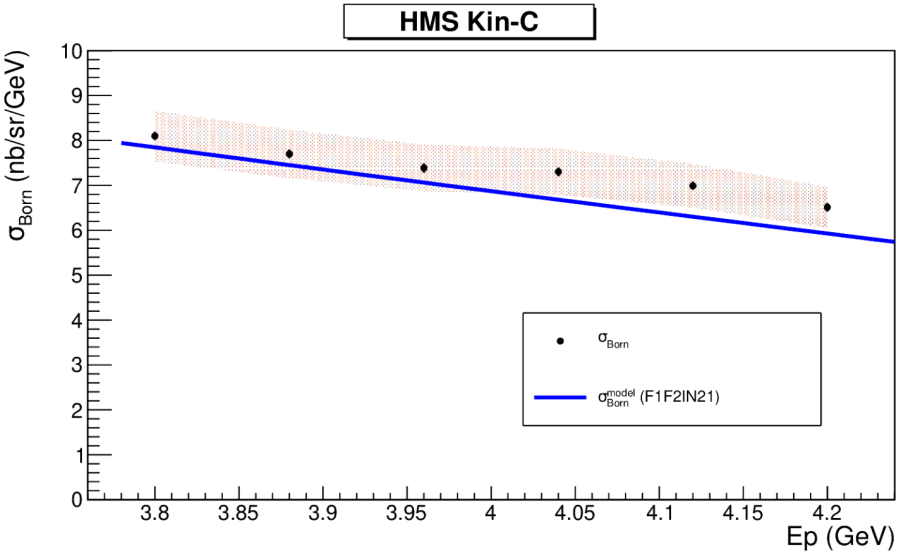






Cross-section Extraction: Rad and Born



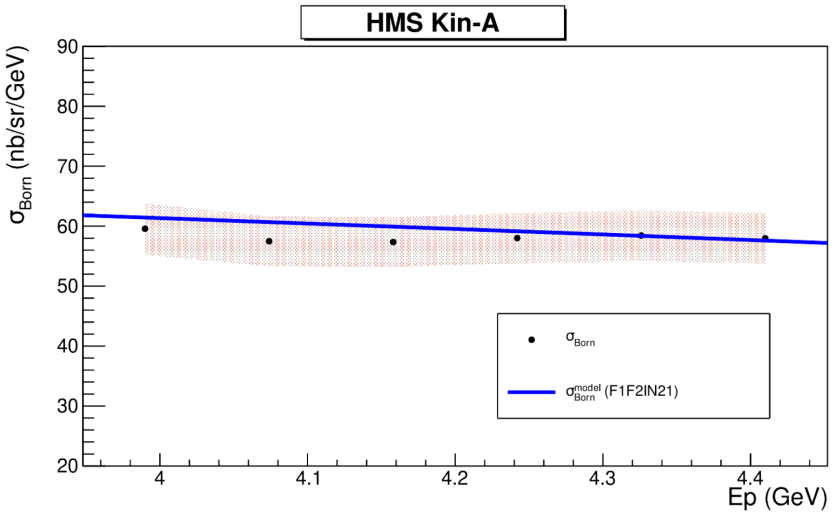


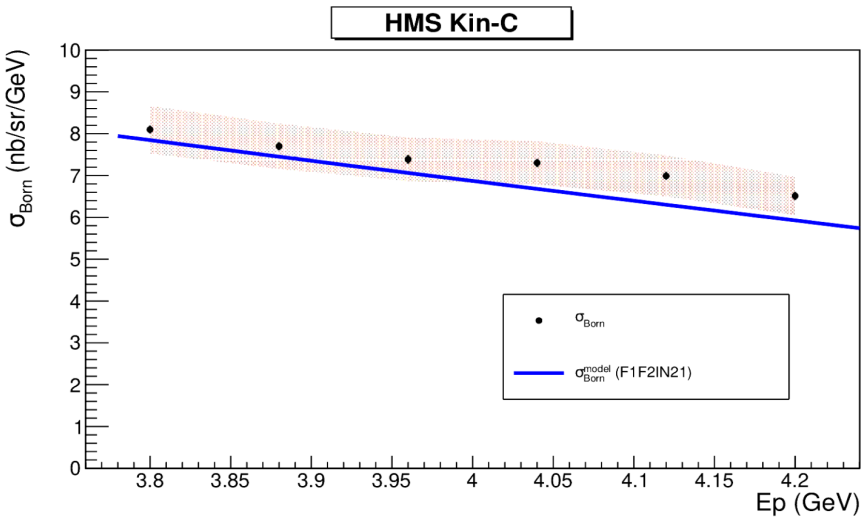
Systematic Errors: **(section 7.5.4)**

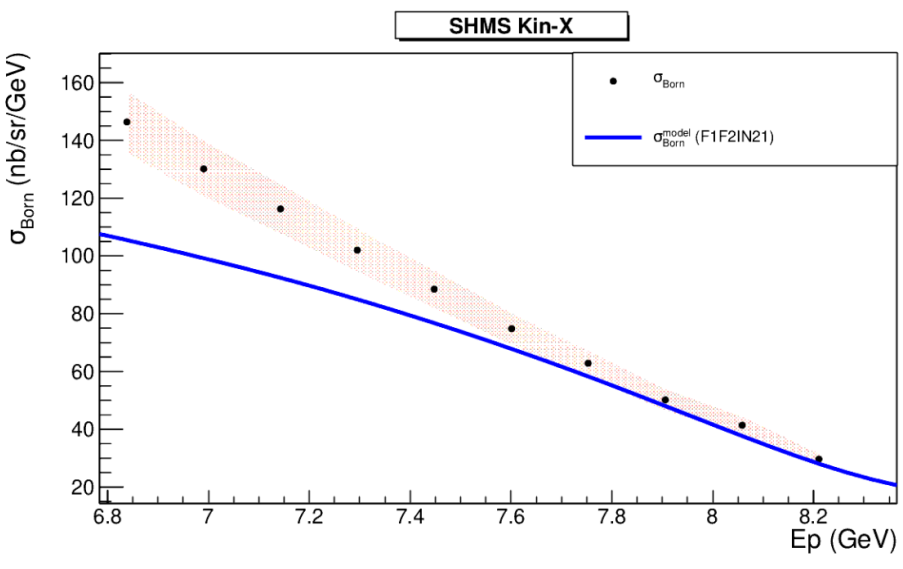
Quantity	Relative systematic error
Cut efficiencies	3%
Point-to-point errors from the calorimeter and Cherenkov efficiencies	0.02%
Beam charge	1%
Target density	2%
Spectrometer acceptance	4.5%
N2 dilution	0.3%
Radiative correction	4%

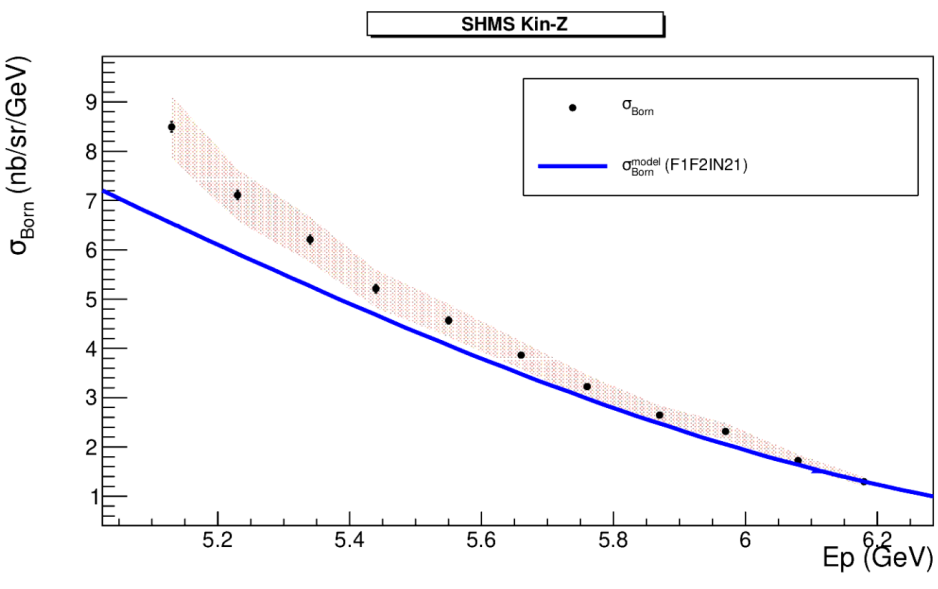
Cross-section Extraction: HMS, SHMS

Tabulated results in Appendix E









^{3}He Cross-section Extraction: Future Work

1. Finalize systematic errors in target density, radiative correction (systematic study by varying the material thicknesses etc) and acceptance (need to check the absolute error, I used an upper bound based on relative acceptance error study).

2. HMS Kin-B, limited DIS runs and they have very short livetime reported (<=60%).

3. SHMS xsections and radiative corrections need to be verified.

4. Bill suggested to change the #bins in rc-externals -> might resolve the quasi elastic distribution issue?

5. Verify these xsections using the other method: MC ratio method.

6. Link to my dissertation: https://uknowledge.uky.edu/physastron_etds/92/

Paths to all my analysis codes:

Reference time Cut analysis:
/group/c-polhe3/Users/murchhana/d2n_2020/Ref_time_analysis

Cherenkov analysis:
1. Time window: /group/c-polhe3/Users/murchhana/d2n_2020/Detector_time_window_cuts/cherenkov
2. Calibration: /group/c-polhe3/Users/murchhana/d2n_2020/cherenkov_calibration

Acceptance analysis:
1. 2D acceptances: /group/c-polhe3/Users/murchhana/d2n_2020/mc_simulation/acceptance/multidimentional_acceptance_hms(shms).C
2. 1D delta acceptance for different xp, yp cuts:
/group/c-polhe3/Users/murchhana/d2n_2020/mc_simulation/acceptance/acc_plots_mc_single_arm_hms(shms).C
3. Acceptance uncertainty analysis:
/group/c-polhe3/Users/murchhana/d2n_2020/mc_simulation/acceptance/acceptance_uncertainty_study/plot_hms(shms)_target_rc_yield_weighted.C

Paths to all my analysis codes:

Xsection extraction:

1. Raw acceptance corrected cross sections as a function of E',θ:
/group/c-polhe3/Users/murchhana/d2n_2020/mc_simulation/acceptance/xs_extraction/xs_hms(shms)_data_theta.C
2. N2 background estimation:
/group/c-polhe3/Users/murchhana/d2n_2020/mc_simulation/acceptance/xs_extraction/xs_hms(shms)_N2.C
3. Born xsection:
/group/c-polhe3/Users/murchhana/d2n_2020/mc_simulation/acceptance/xs_extraction/xs_hms(shms)_data_theta_unradiating.C

Runlist used for xsection extraction:

1.DIS he3 runs: /group/c-polhe3/Users/murchhana/d2n_2020/mc_simulation/acceptance/xs_extraction/runlist/HMS(SHMS)_runlist/hms(shms)_d2n_kinA(B,C)_runlist_good.csv
2. N2 runs:
polhe3/Users/murchhana/d2n_2020/mc_simulation/acceptance/xs_extraction/runlist/HMS(SHMS)_runlist/hms(shms)_d2n_kinA(B,C)_runlist_N2.csv

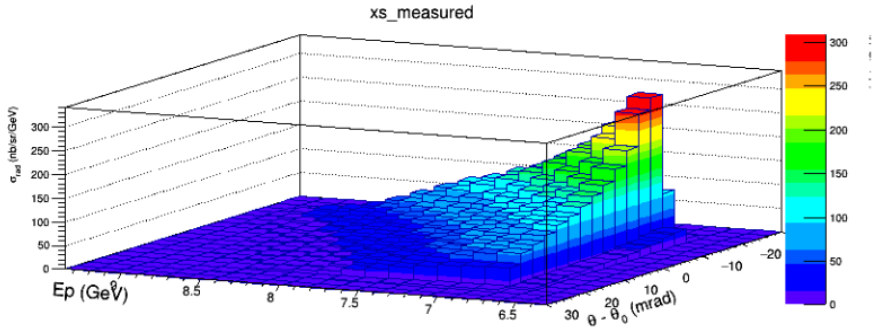
Paths to all my analysis codes:

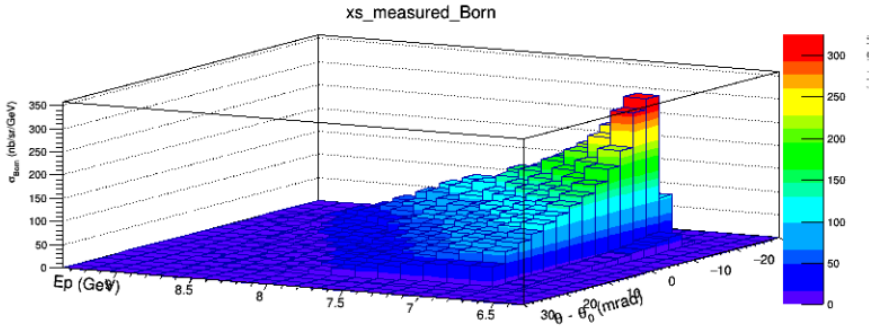
MC Simulations:
/group/c-polhe3/Users/murchhana/mc-single-arm/worksim/comparison/new_simulation_20M_tight_cut , Readme file

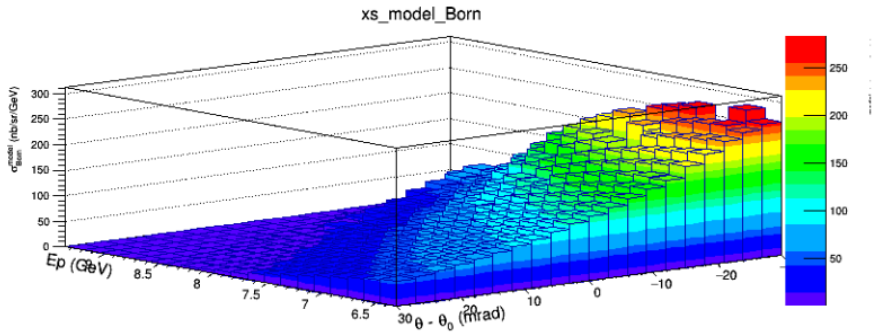
Rc-externals output:
/group/c-polhe3/Users/murchhana/rc-externals/output/externals

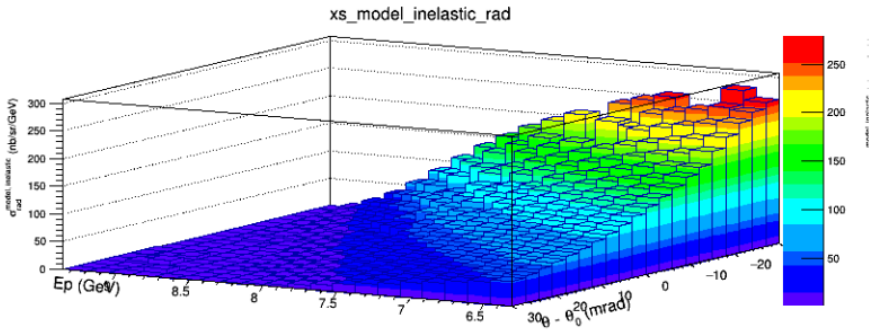
Main working directory:
/group/c-polhe3/Users/murchhana

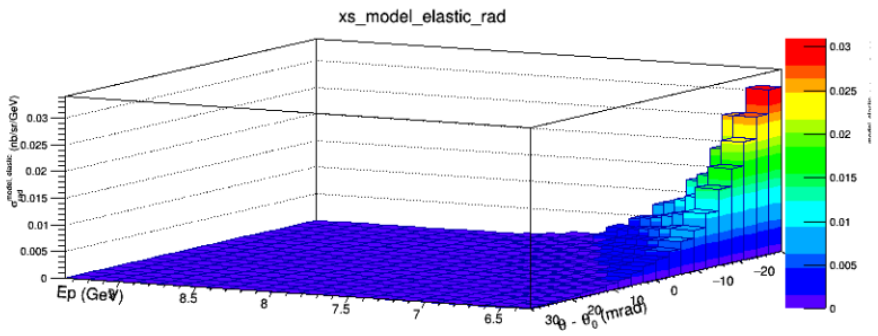
SHMS Kin-X

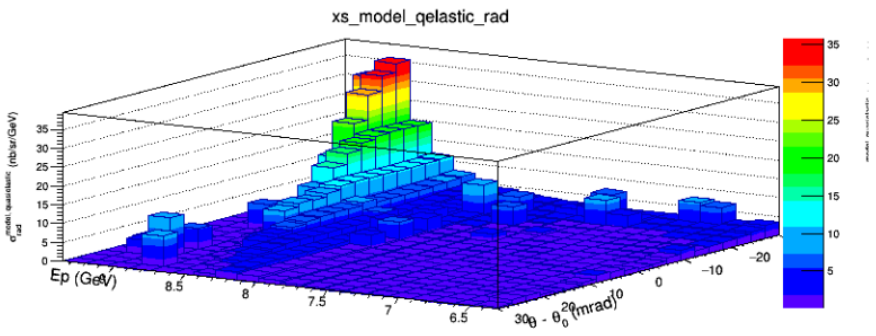

xs_measured
Ep (GeV)
θ - θ0 (mrad)


xs_measured_Born
Ep (GeV)
θ - θ0 (mrad)

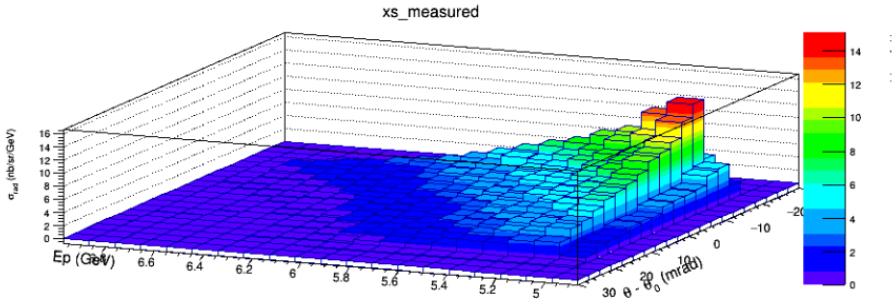

xs_model_Born
Ep (GeV)
θ - θ0 (mrad)

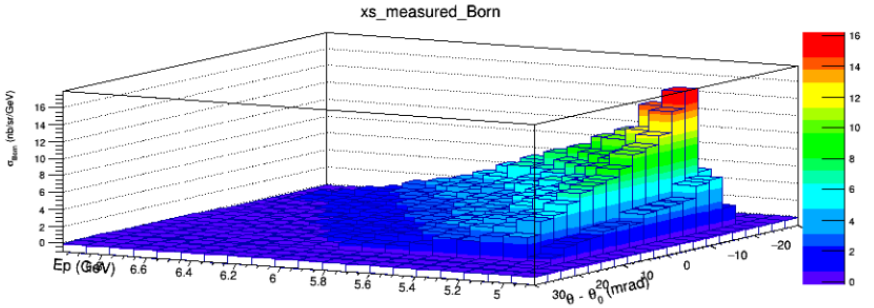

xs_model_inelastic_rad
Ep (GeV)
θ - θ0 (mrad)

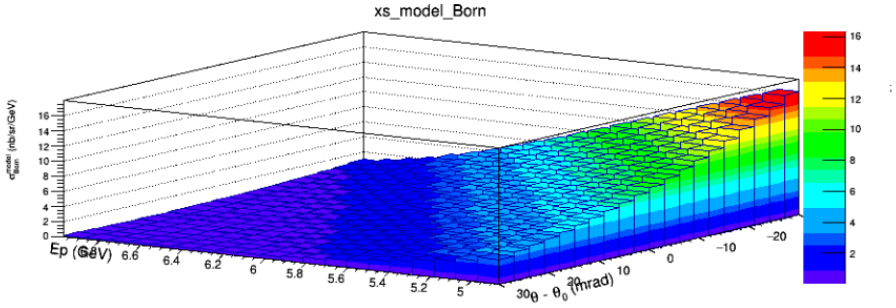

xs_model_elastic_rad
Ep (GeV)
θ - θ0 (mrad)

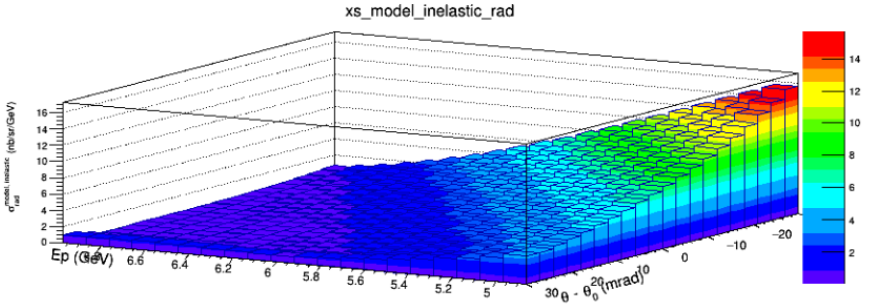

xs_model_qelastic_rad
Ep (GeV)
θ - θ0 (mrad)

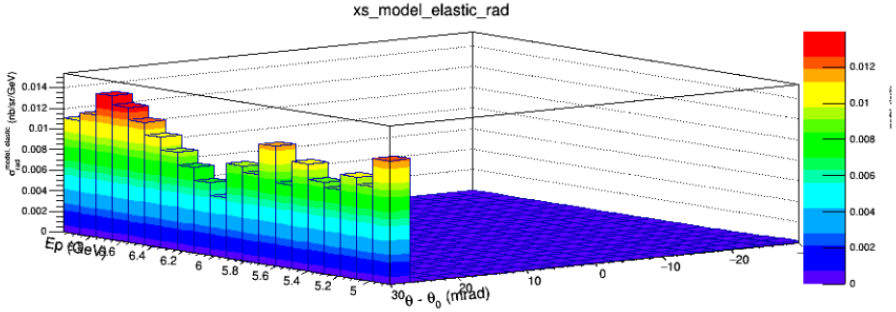
SHMS Kin-Z


xs_measured
Ep (GeV)
θ - θ0 (mrad)


xs_measured_Born
Ep (GeV)
θ - θ0 (mrad)


xs_model_Born
Ep (GeV)
θ - θ0 (mrad)


xs_model_inelastic_rad
Ep (GeV)
θ - θ0 (mrad)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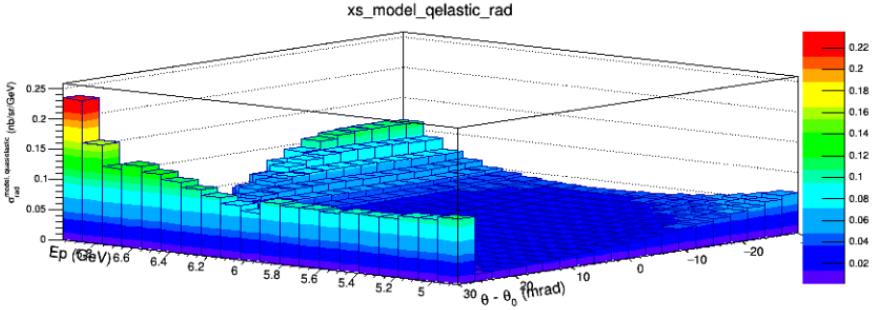
Ep (GeV)
θ - θ0 (mrad)


xs_model_qelastic_rad
Ep (GeV)
θ - θ0 (mrad)