π^0 cross-section analysis

DVCS collaboration meeting

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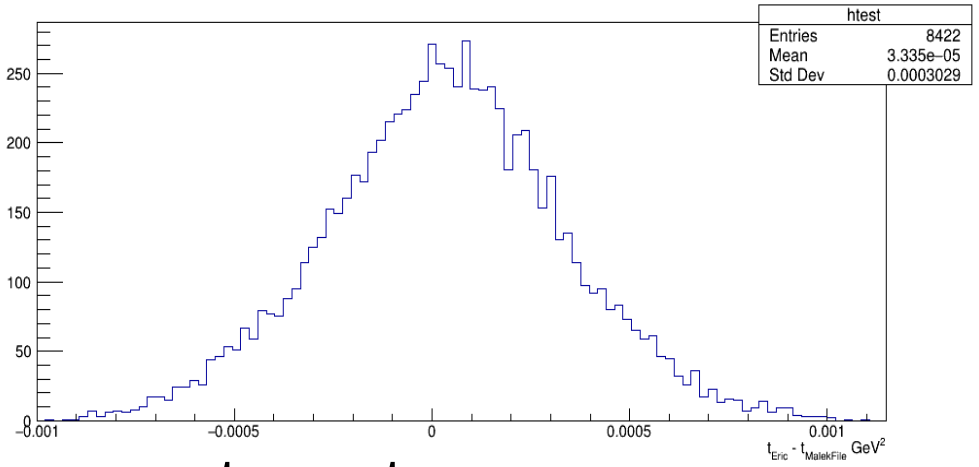
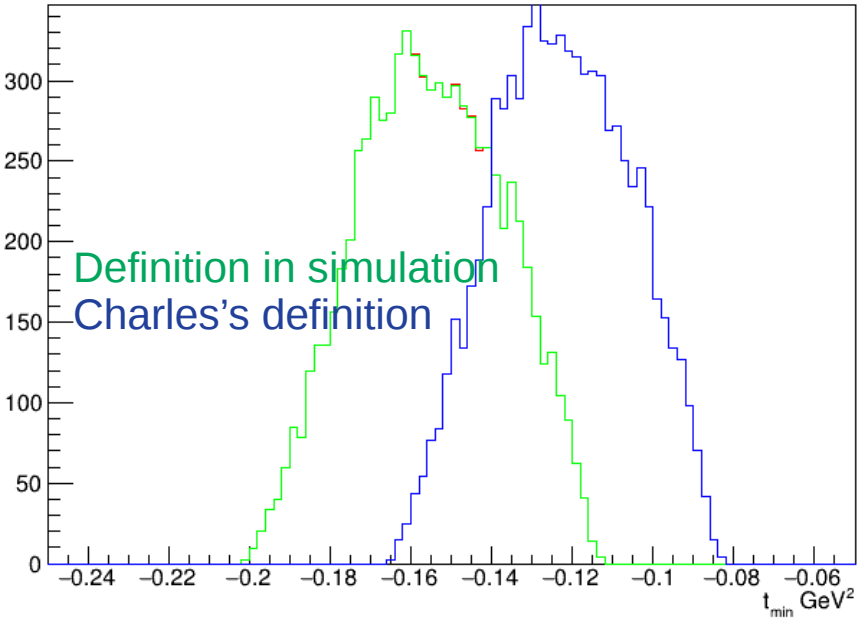
Feb 01, 2020

t and t_{min}
Eric definition vs one in Malek's File



$t_{Eric} - t_{Malek's\ File}$

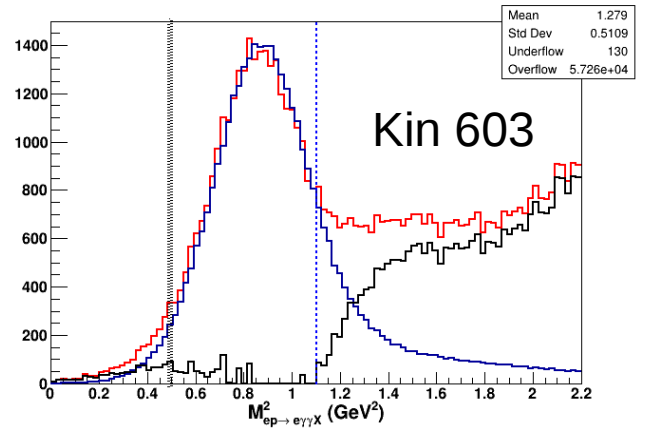


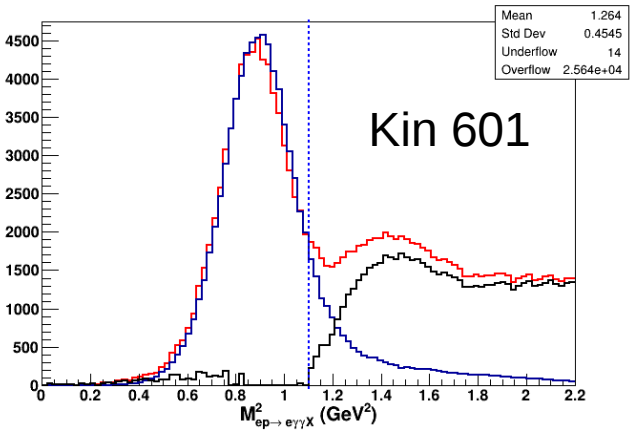
t_{min} and t redefined during analysis

t : Difference between Malek's file and "t" I computed (using Eric's definition) is below "t" resolution (Good in t)

t_{min} : Simulation has some other definition than what Charles's suggested (ELOG 585)

Smearing the simulation





Unphysical events ($(M^2 < 0)$)

- Kin 601 => 0.02 %
- Kin 603 => 0.5%

$$\begin{bmatrix} q_x \\ q_y \\ q_z \\ E \end{bmatrix} \to Gaus\left(\mu, \frac{\sigma}{\sqrt{E}}\right) \begin{bmatrix} q_x \\ q_y \\ q_z \\ E \end{bmatrix}$$

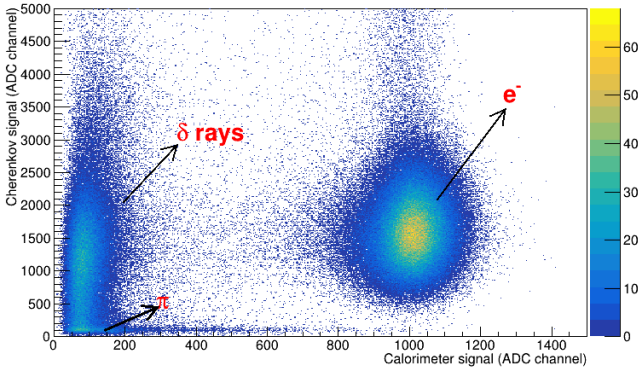
$$\begin{bmatrix} q_x \\ q_y \\ q_z \\ E \end{bmatrix} \to Gaus(0, \theta) \begin{bmatrix} q_x \\ q_y \\ q_z \\ E \end{bmatrix}$$

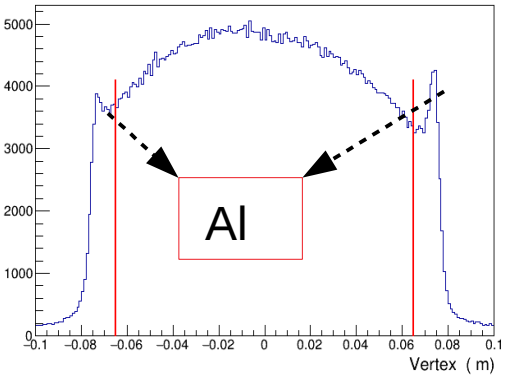
Done is two steps:

1) First determine μ and σ (keeping theta at nominal value)
2) Second fix μ and σ and then smear θ

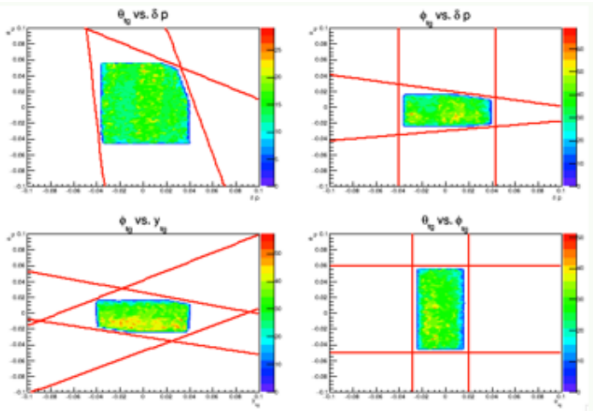
Electron selection

PID

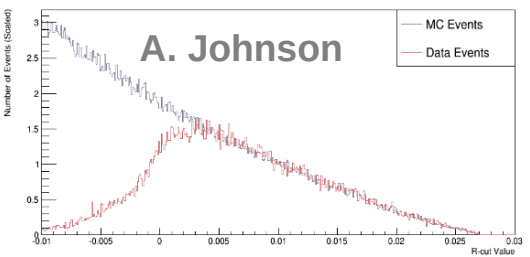




Acceptance



- PID [H.Rashad]
  - Cherenkov => (>150 channel)
  - Pion rejector =>(pr1/w1>200) && (pr1/w1 + pr2/w2)>600

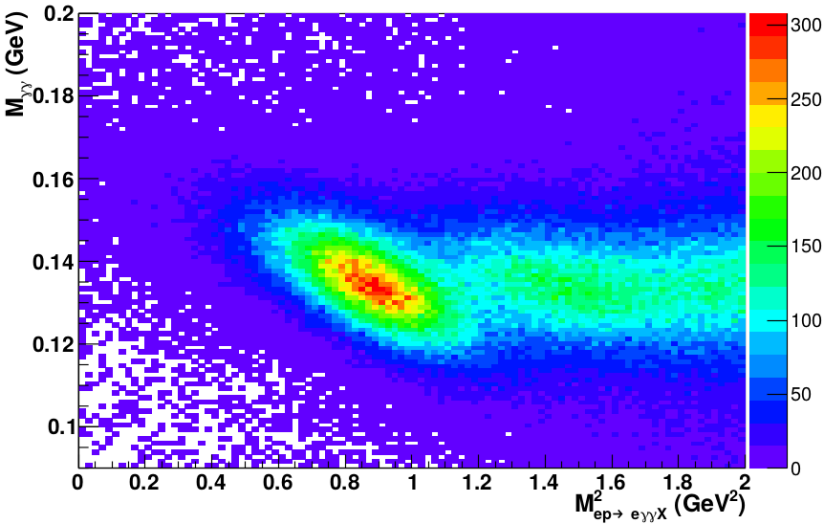


- Acceptance R-cut [A. Johnson]
- Vertex[-6.5 cm, 6.5 cm]
- Single track [4S0M + 3S1M] [H.Rashad]

Correction for dead time, tracking efficiency, and trigger efficiencies are well in place

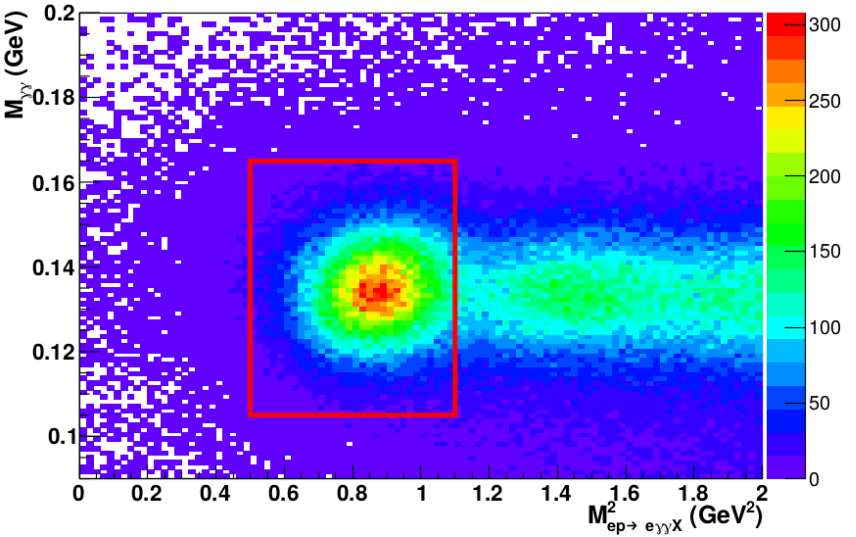
π^0 event selection

Correlation between missing mass and invariant mass



$ep \to e'p'\pi^0$

$\pi^0 \to \gamma\gamma$



$$M^2_{ep\to e'\gamma\gamma X} = (e + p - e' - \gamma_1 - \gamma_2)^2$$

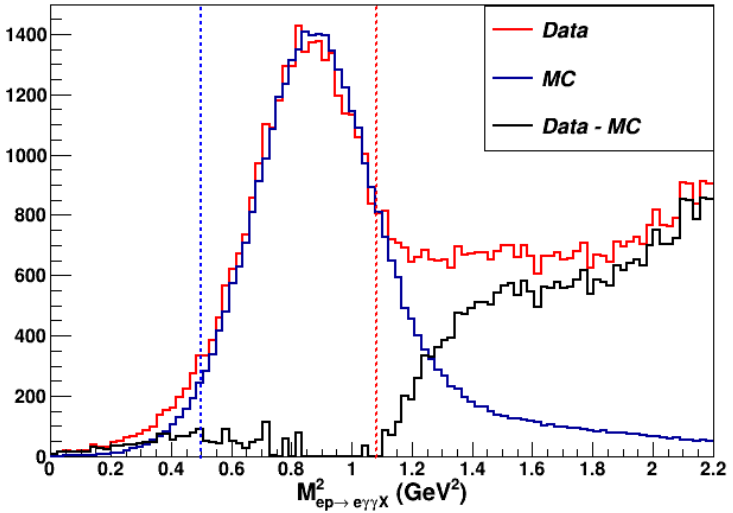
$$M_X^2 = M_X^2|_{raw} + Corr \cdot \left(m_{\gamma_1\gamma_2} - m_{\pi^0}\right)$$

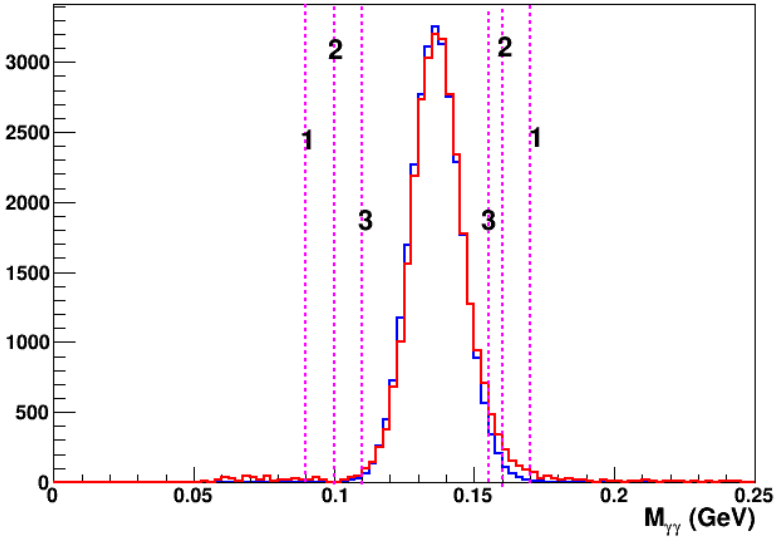
$$Corr = \frac{2}{m_{\pi^0}}\left(m_{\pi^0}^2 - 2\sqrt{2}\left(\nu + M_p - q\cos\theta_{\pi\gamma^*}\right)\frac{E_1E_2}{E_1+E_2}\right)$$

Corr:
Kin 601=> -13.7 GeV
Kin 603 => -17.6 Gev

M. Mazouz (https://hallaweb.jlab.org/dvcslog/Pion/131

Exclusivity cuts





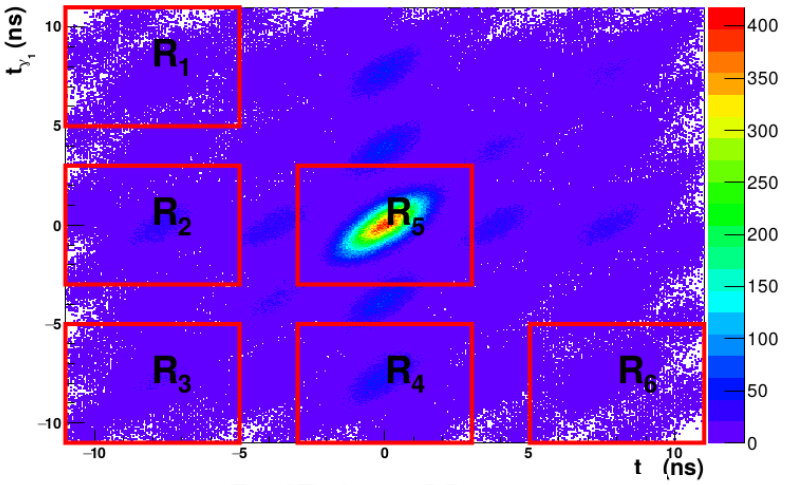
Kinematic	$M_x^2\ (GeV^2)$	$M_{\gamma_1\gamma_2}$ (GeV)
601	[0.3, 1.08]	[0.10, 0.16]
603	[0.5, 1.08]	[0.10, 0.16]

ep ⟶ e'p'π^0 X => well below to eliminate the SIDIS contamination

π^0 event selection
Accidental subtraction

N_{acc}

$e^- \gamma_1 \gamma_2$



$$R_5 = N_{ccc} + N_{acc} + N_{cca} + N_{cac} + N_{aaa}$$

$$N^{ACC} = R_3 + (R_2 + R_4) - (R_1 + R_6)$$

Clustering window	Accidental	Section	Description
[-3, 3]	$N_{ccc} + N^{ACC}$	R_5	$\|t_{\gamma_1}\| <= 3$ and $\|t_{\gamma_2}\| <=3$
[-11, -5]	$N_{acc} + N_{aaa}$	R_3	$\|t_{\gamma_1} + 8\| <= 3$ and $\|t_{\gamma_2} + 8\| <=3$
[-11, -5] and [-3, 3]	$N_{cca} + N_{cac} + 2\,N_{aaa}$	$R_2 + R_4$	$\|t_{\gamma_1}\| <= 3$ and $\|t_{\gamma_2} + 8\| <=3$
[-11, -5] and [5, 11]	$2\,N_{aaa}$	$R_1 + R_6$	$\|t_{\gamma_1} + 8\| <= 3$ and $\|t_{\gamma_2} - 8\| <=2$

$$R_1(R_6) = N_{aaa}$$

$$R_2 = N_{cca} + N_{aaa}$$

$$R_3 = N_{acc} + N_{aaa}$$

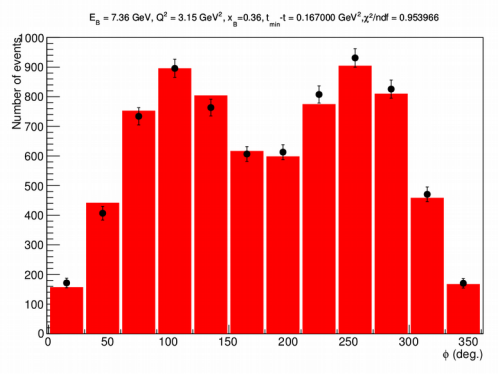
$$R_4 = N_{cac} + N_{aaa}$$

Cross-section extraction formalism (π^0 production)

$$\frac{d^4\sigma}{dQ^2 dx_B dt d\phi} = \frac{1}{2\pi}\Gamma_\gamma(Q^2, x_B, E)\left[\frac{d\sigma_T}{dt} + \epsilon\frac{d\sigma_L}{dt} + \sqrt{2\epsilon(1+\epsilon)}\frac{d\sigma_{TL}}{dt}\cos(\phi) + \epsilon\frac{d\sigma_{TT}}{dt}\cos(2\phi) + h\sqrt{2\epsilon(1-\epsilon)}\frac{d\sigma_{TL'}}{dt}\sin(\phi)\right]$$

$$\chi^2 = \sum_{r=0}^{N}\left(\frac{N_r^{exp} - N_r^{MC}}{\sigma_r^{exp}}\right)^2 \qquad N_r^{MC} = \sum_{v=0}^{V}\sum_{n=0}^{N} K_{rv}^n X_v^n \qquad K_{rv}^n = \sum_{i\epsilon r\cap v}\Gamma_n(E, Q^2, x_B, \phi)\frac{\Gamma_{MC}^i}{N_{gen}}$$

$$\overline{X}^n = \sum_{v'=1}^{V}\sum_{n'=1}^{N}[A^{-1}]_{v,v'}^{n,n'} \cdot B_{v'}^{n'}$$

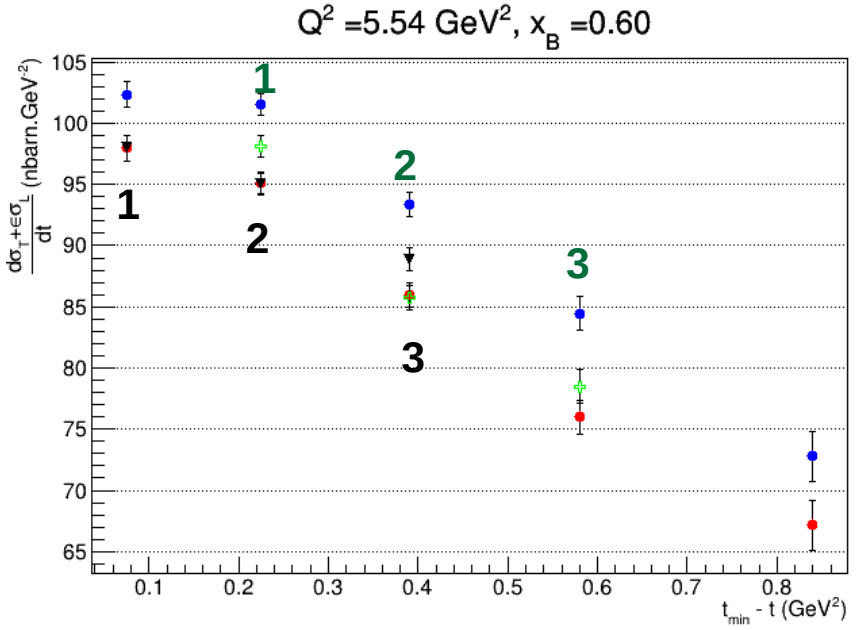


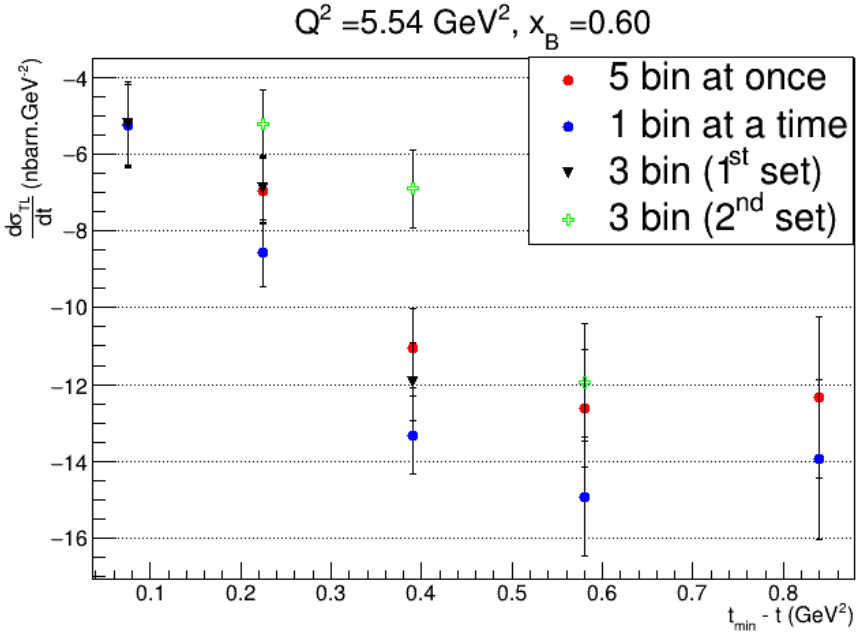
K_{rv} : Bin migration probability

σ^{exp} : Error in data (accidental subtraction considered)

For helicity dependent term $N_r^{exp} = N^+ - N^-$

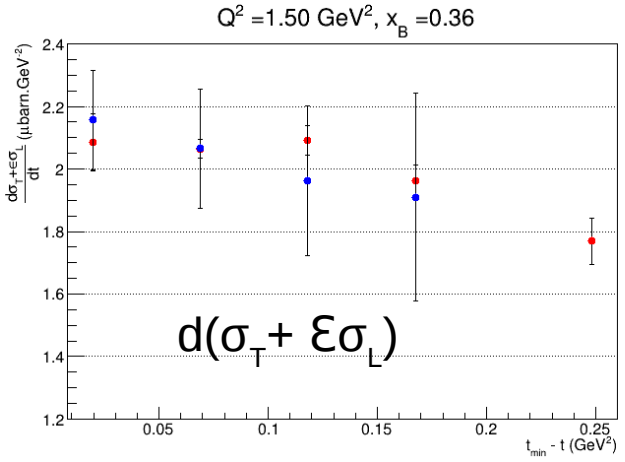
Cross section with different t' bin size
Kin 601 (E0=8.52 GeV)

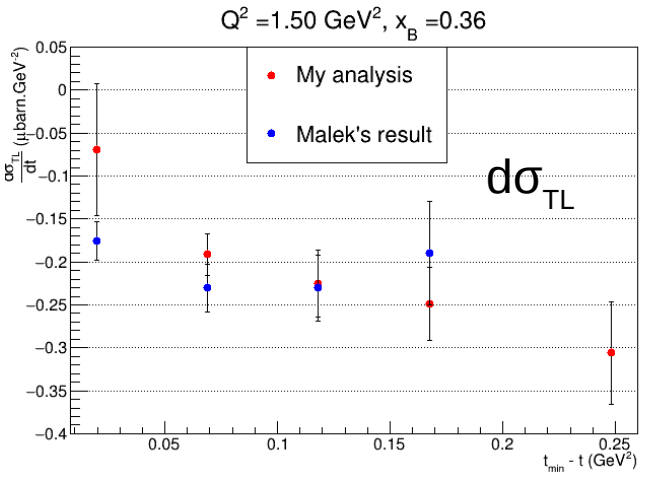


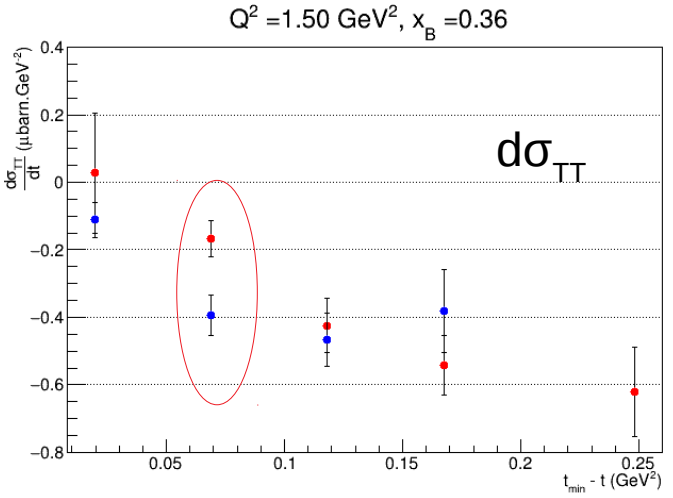


- 5 t' bin analysis is equivalent to 3 bin analysis and looking at middle bin (to account the bin migration)
- Migration is preferentially in one direction

Cross-section parameters
Kin1High Malek's Data(E0=5.55 GeV)





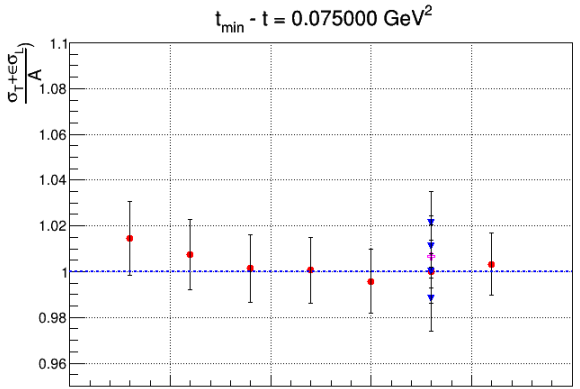


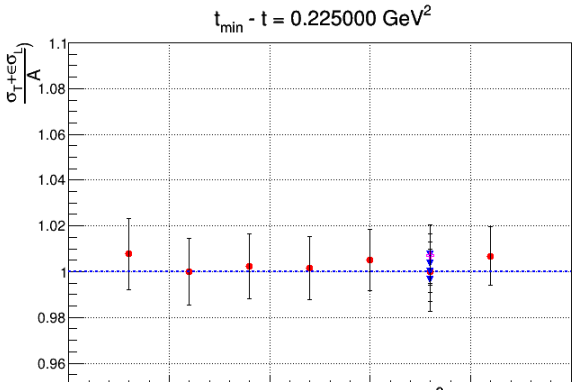
- My code for cross-section can reproduce Malek's result within statistical uncertainty

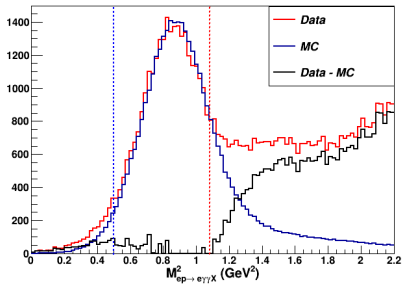
Systematic study
Kin 601/603

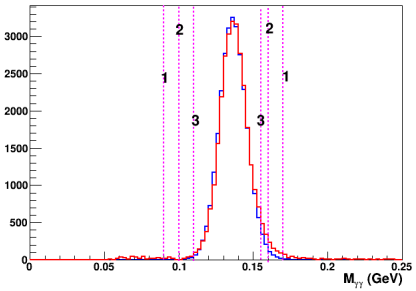
1) Exclusive cuts
2) Clustering threshold
3) Photon E cut
4) Virtual radiative correction (approximation for DVCS)
5) Correction from 3 clustering
6) May be comparison with G.R Goldstein, J.O Hernandez S. Liuti

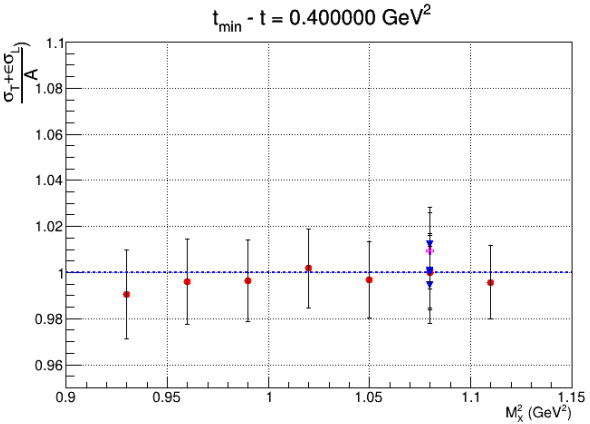
Systematic study (Exclusive cut)
Kin 603

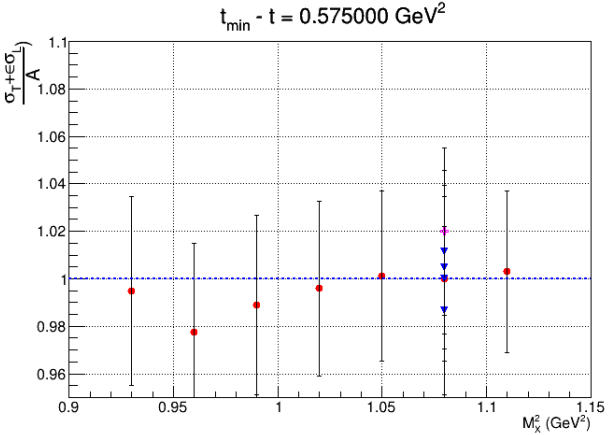


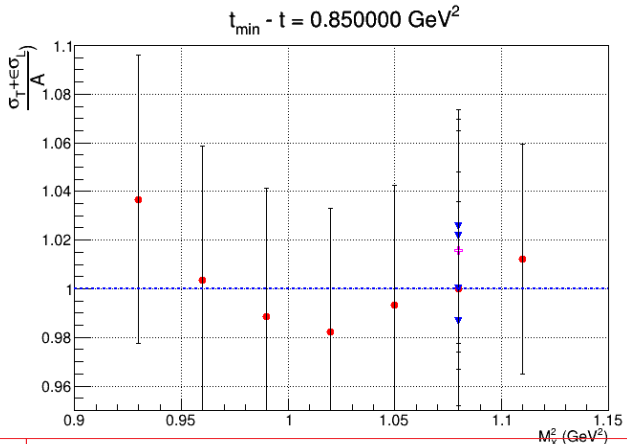










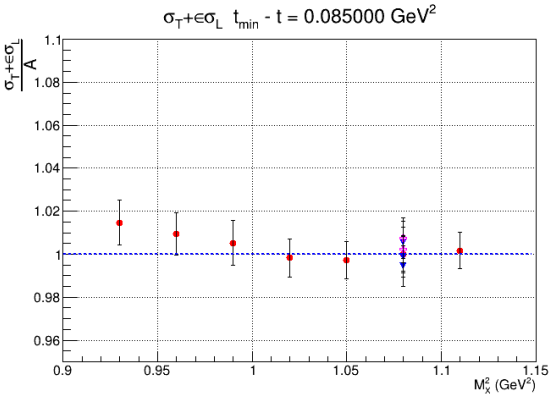


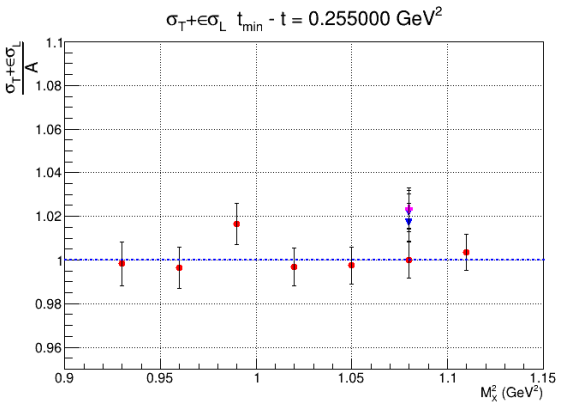
Minv fixed at “2” (3σ)
M² low end fixed
M² high end at different position

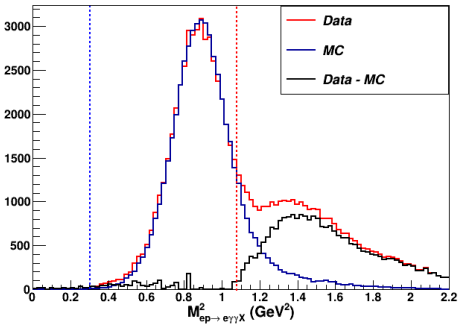
Minv fixed at “2” (3σ)
M² high end fixed
M² low end at different position

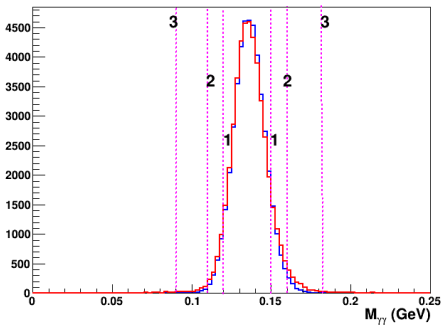
M² fixed
Minv at different spot “1” and “3”

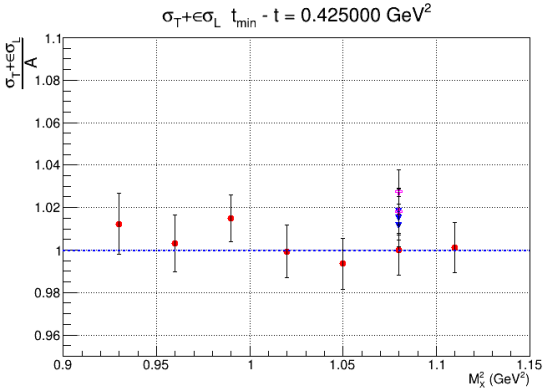
Systematic study (Exclusive cut)
Kin 601

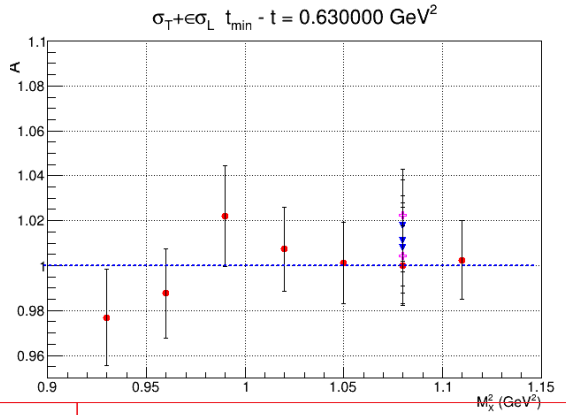


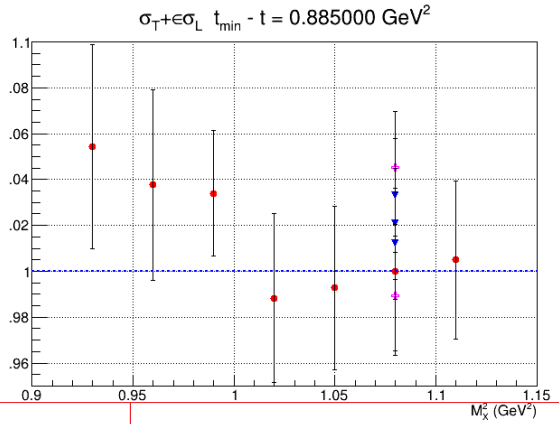










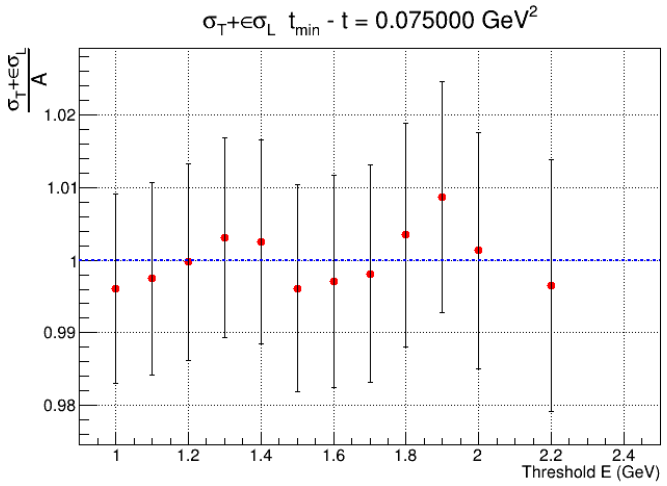


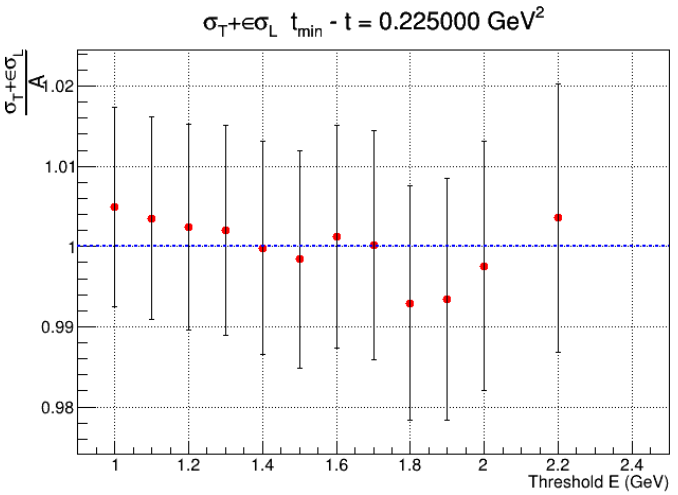
Minv fixed at “2” (2σ)
M² low end fixed
M² high end at different position

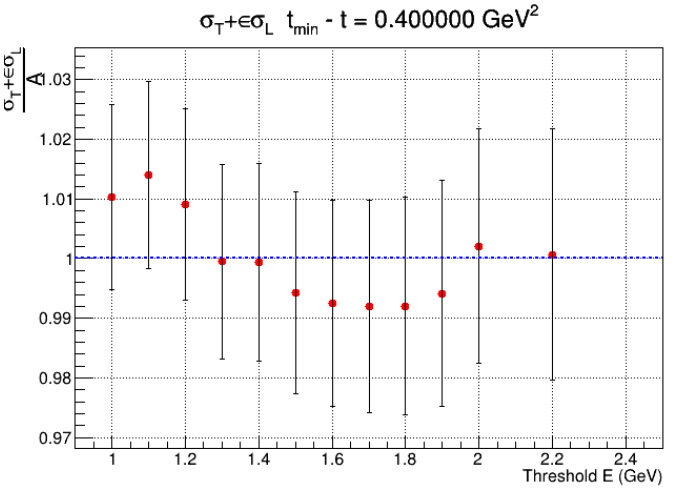
Minv fixed at “2” (2σ)
M² high end fixed
M² low end at different position

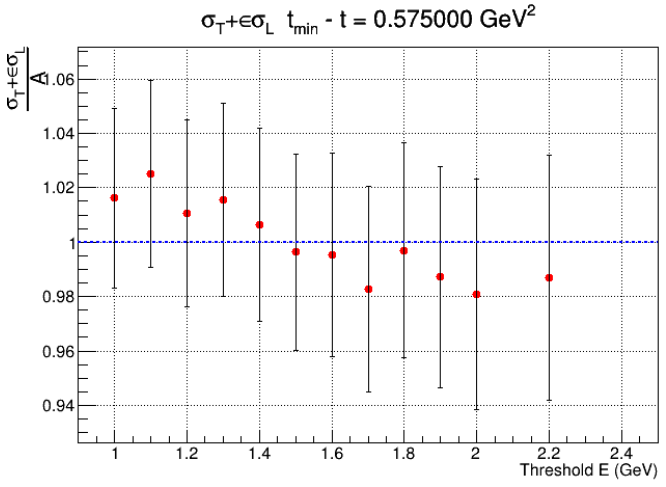
M² fixed
Minv at different spot “1” and “3”

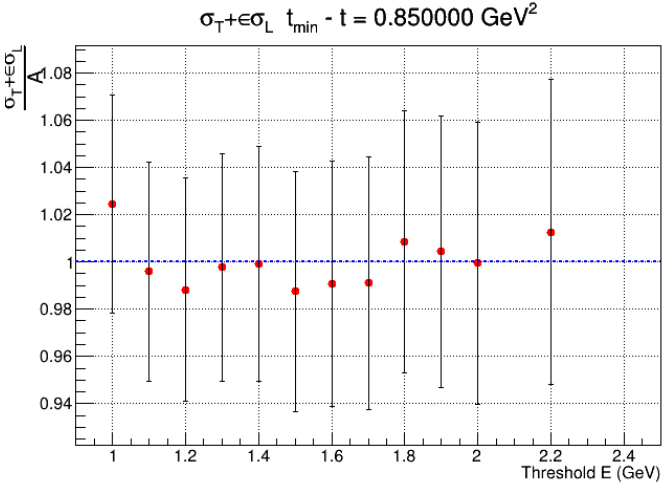
Systematic study (cut on photons E)
Kin 603











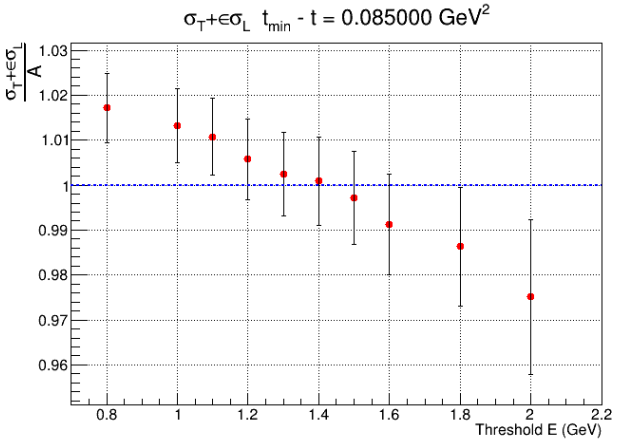
Cut

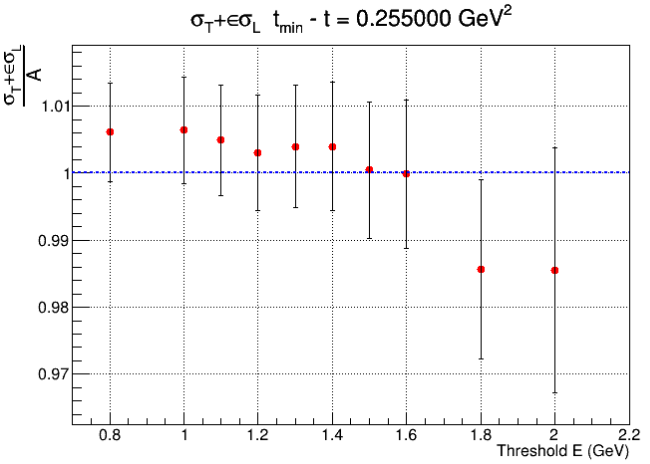
- both photon > Threshold E

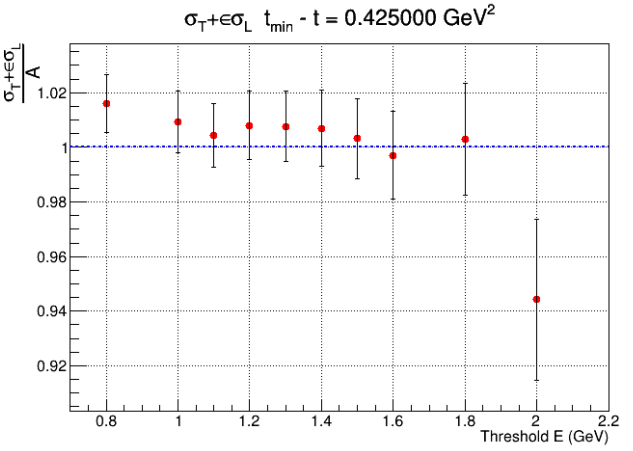
➔ Only $\sigma_T + \varepsilon\sigma_L$ is sensitive

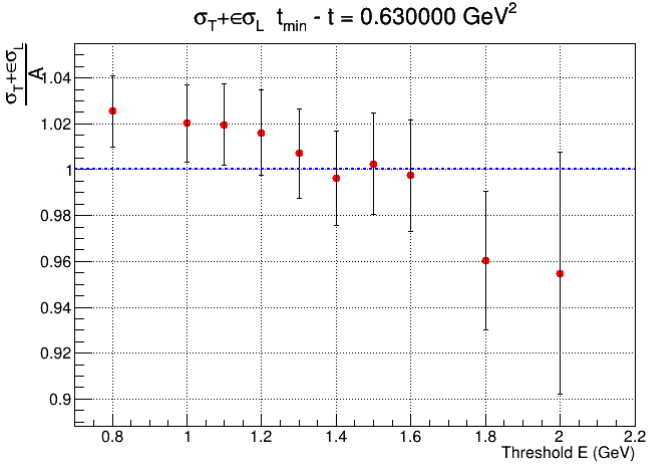
➔ Cross-section is consistent w.r.t E cut

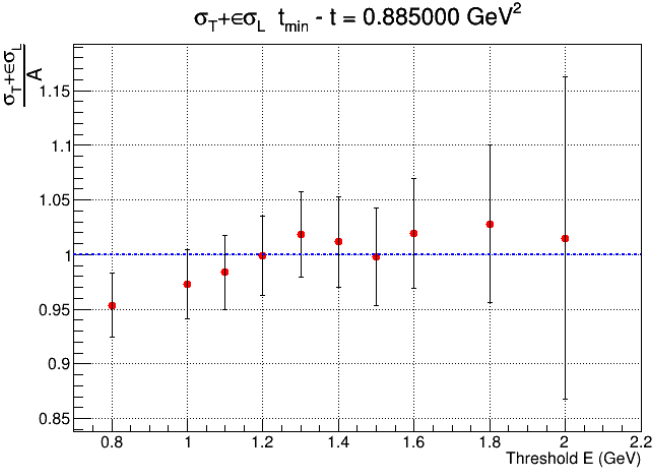
Systematic study (cut on photons E)
Kin 601







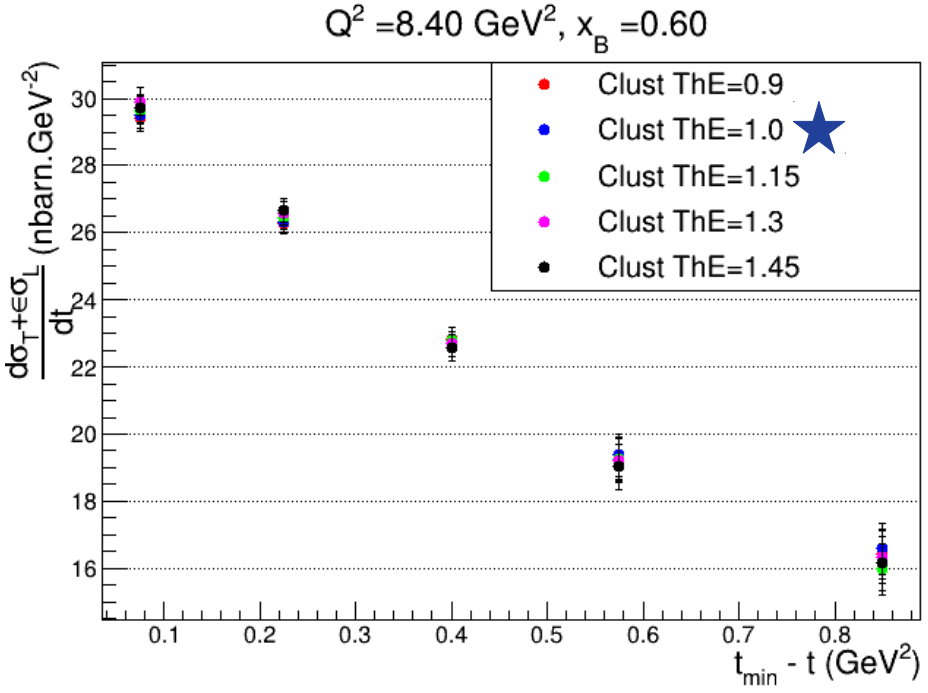


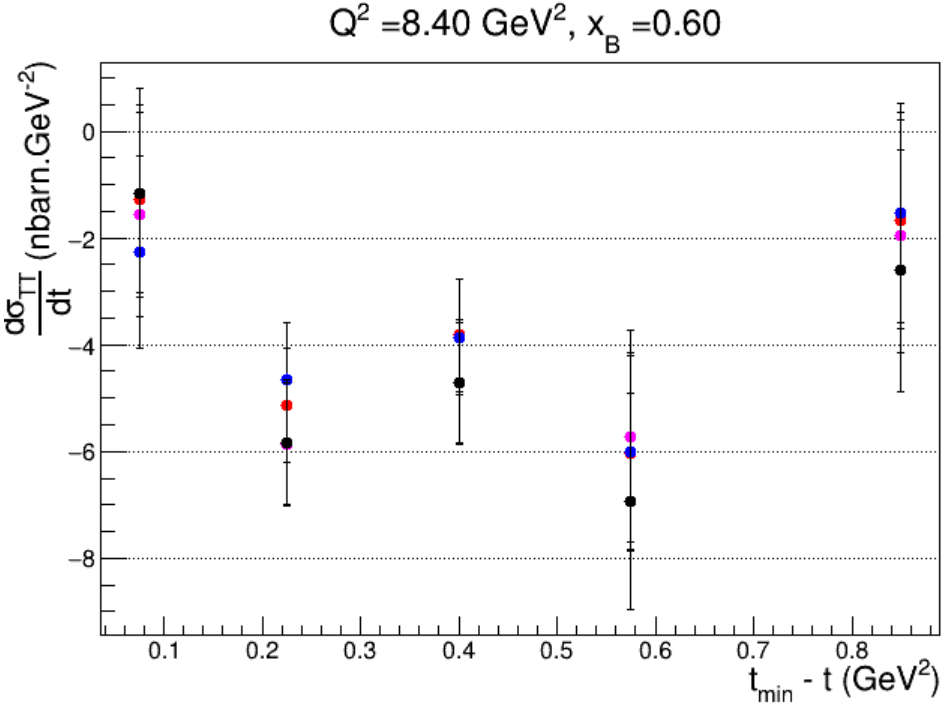


Cut

- both photon > Threshold E
- ➔ Only $\sigma_T + \epsilon\sigma_L$ is sensitive
- ➔ Systematic up to 4%
- ➔ No reasonable explanation through variation in kinematic variables (Q^2, xB Γ,..)

Systematic study (Clustering threshold)
Kin 603



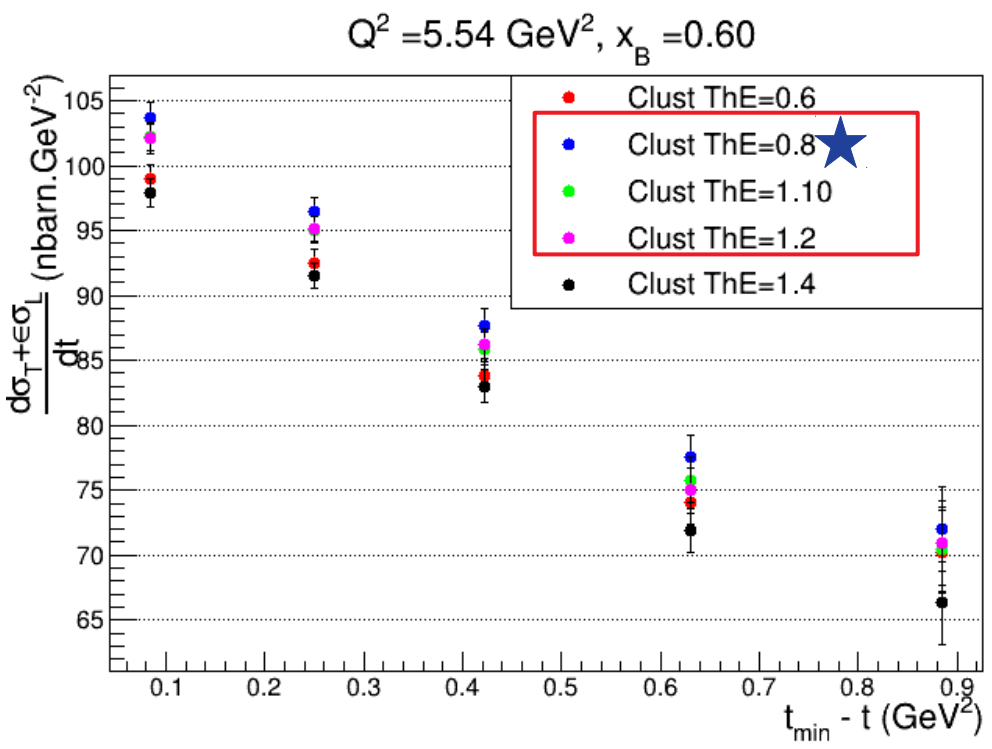


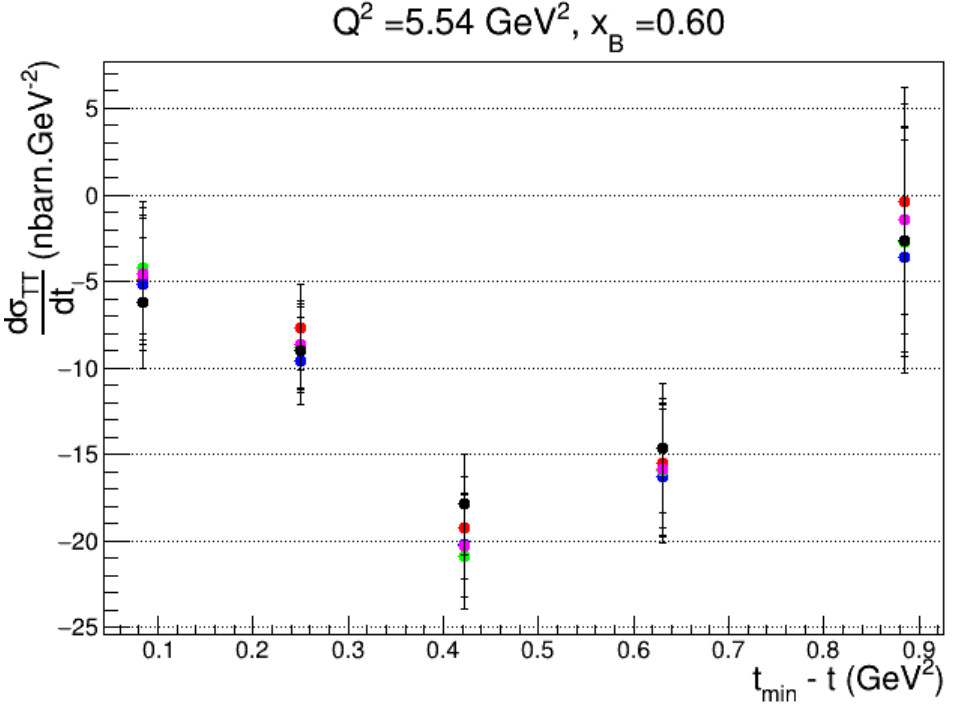
Cuts on photon E:

- **$E_1 = E_2$ > Clustering Threshold (No any cut on photon E in analysis)**

- **Cross-section results are in good agreement**

Systematic study (Clustering threshold)
Kin 601

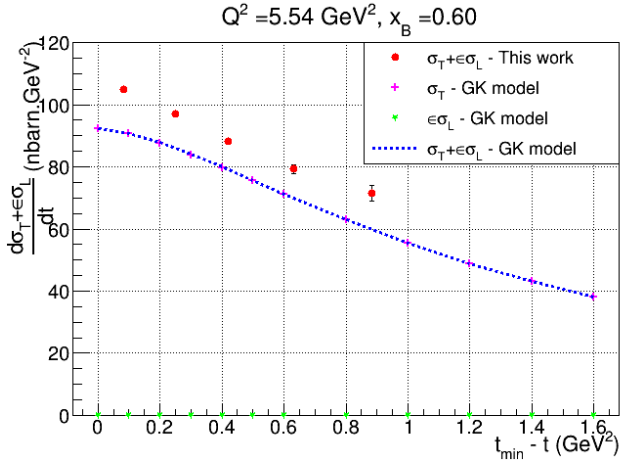


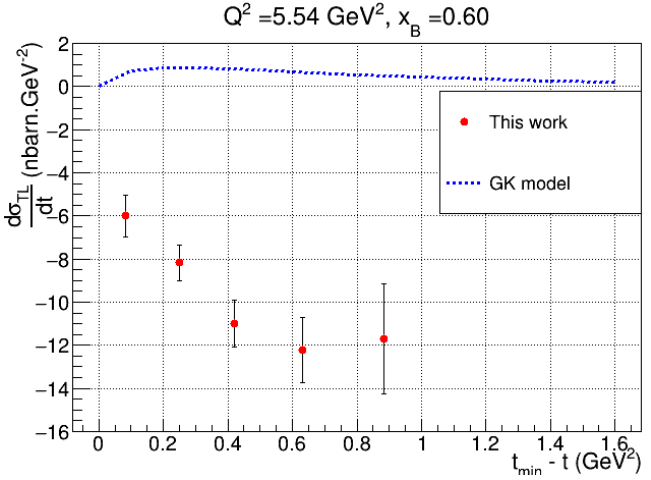


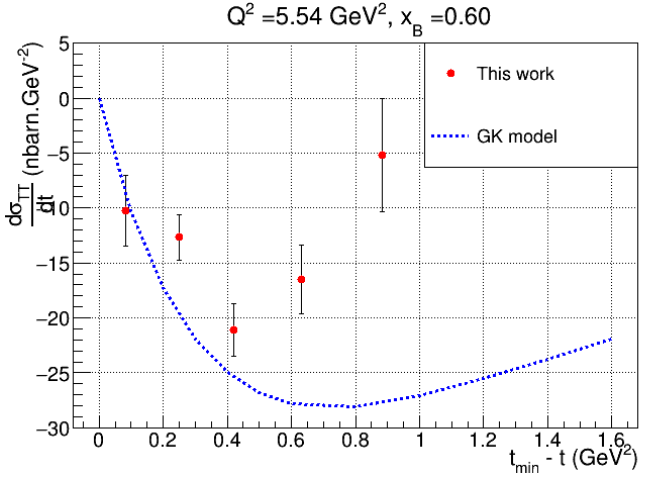
Cuts on photon E:

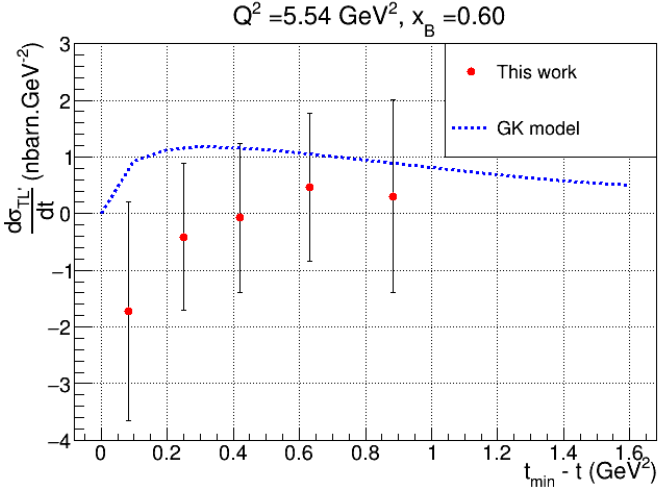
$E_1 = E_2 > 1.5$ GeV (Additional cut on photon E > Clustering threshold)

Cross-section parameters
Kin 601 (E0=8.52 GeV)



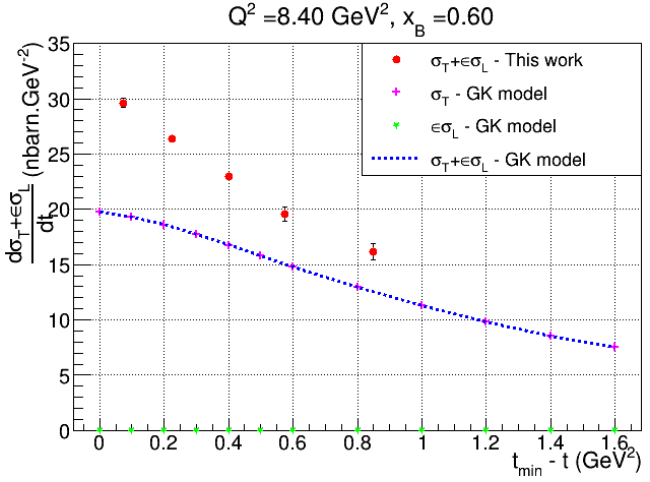


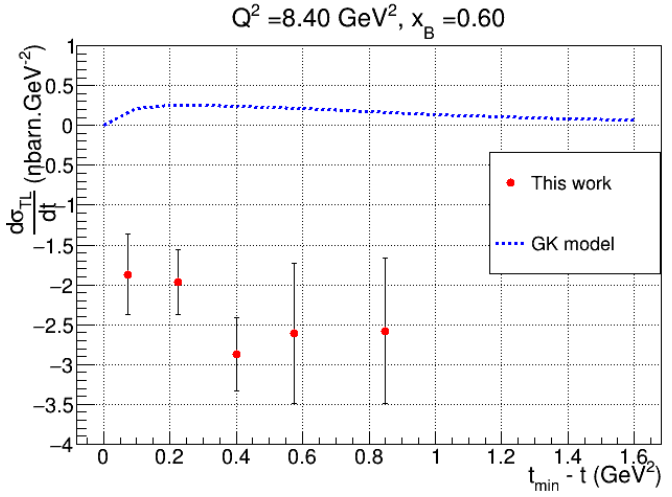


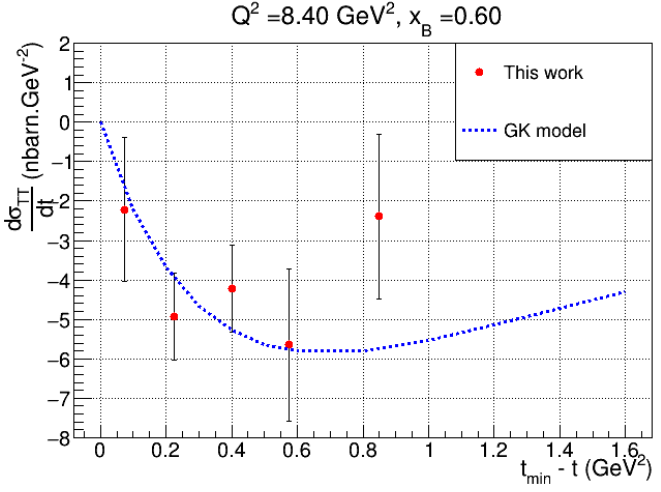


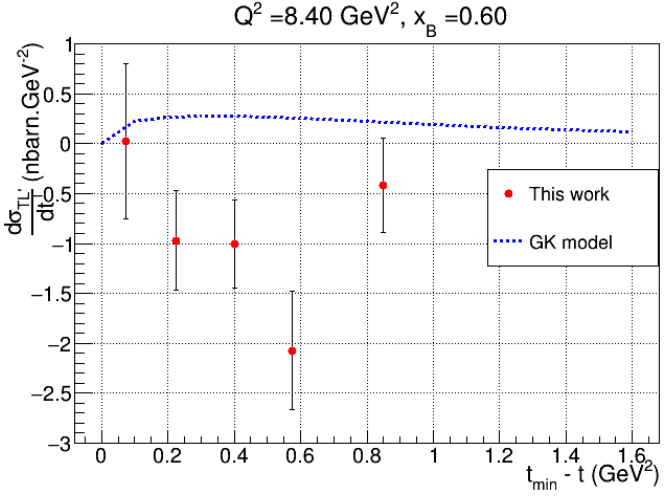
- Model used data at small xB and t
- σ_L from model is consistent to zero

Cross-section parameters
Kin 603 (E0=10.59 GeV)









- The interference term σ_{LT} suggest σ_L is larger
- These data will improve the parametrization of the GPDs

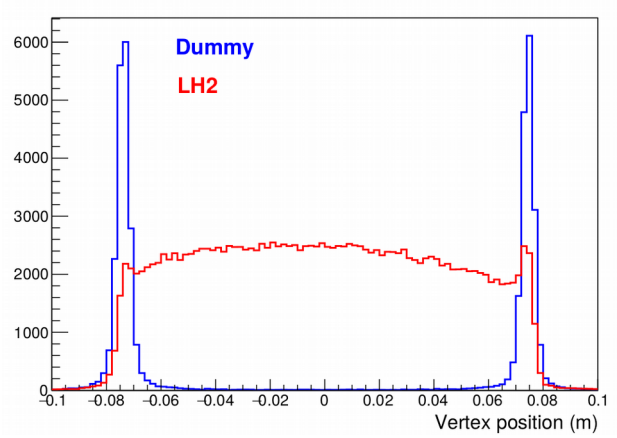
Error budget

Kin	Run period	E_{beam} (GeV)	P_0 (GeV)	θ_{HRS} (deg)	Q1 status	$(\sigma_M/\sigma_D)_{OU}$	$(\sigma_M/\sigma_D)_E$	$(\sigma_M/\sigma_D)_A$	**Average**
481	Sp '16	4.48	1.48	37.14	Unsat.	1.03	1.06	1.00	1.03
361	F '14	7.38	2.71	22.83	Unsat.	0.95	0.97	0.99	0.97
362	F '16	8.52	3.19	20.98	SOS (1%)	1.04	1.06	1.06	1.05
363	F'16	10.62	3.99	18.67	SOS (7%)	1.04	1.07	1.06	1.06
601	F '16	8.52	3.59	24.56	SOS (4%)	1.01	1.06	1.06	1.04
603	F '16	10.62	3.15	29.00	SOS (1%)	0.98	1.02	1.03	1.01
482	Sp '16	8.82	3.996	26.27	detuned	1.06	--	1.06	1.06
483	Sp '16	8.82	2.920	26.27	detuned	1.06	--	1.09	1.06
484	Sp '16	10.97	3.360	24.92	detuned	1.09	--	1.09	1.09
Average						**1.03±0.04**	**1.04±0.04**	**1.05±0.03**	**1.04±0.04**

Source	Contribution
DIS (e^-)	4%
Exclusive cuts	0.5%
Threshold E cut and clustering	0 + 0 (603) Point to point up to 4% each (601)
Trigger loss (seen in DIS)	?
Beam Polarization	1%

- 4% systematic in DIS = {PID, R-Function, Luminosity, Solid angle, trigger+tracking efficiency, virtual radiative correction}
- 4 % deviation from world data
  - ➔ May not effect DVCS trigger

THANK YOU !


Dummy
LH2
6000
5000
4000
3000
2000
1000
0
−0.1
−0.08
−0.06
−0.04
−0.02
0
0.02
0.04
0.06
0.08
0.1
Vertex position (m)