

Prompt photons + jet in DIS

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Physics overview

- Kinematics:

- $Q^2 = -q^2$ – virtuality

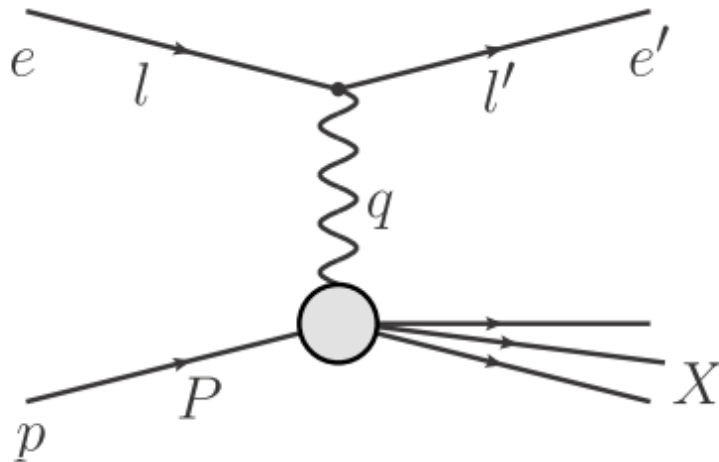
- $y = \frac{P \cdot q}{P \cdot l}$ – inelasticity

- $x = \frac{Q^2}{2P \cdot q}$ – longitudinal momentum fraction carried by the incoming parton

Electrons/Positrons: 27.5 GeV

Protons: 920 GeV (820 GeV until 1998)

luminosity of $\approx 374 \text{ pb}^{-1}$



Data

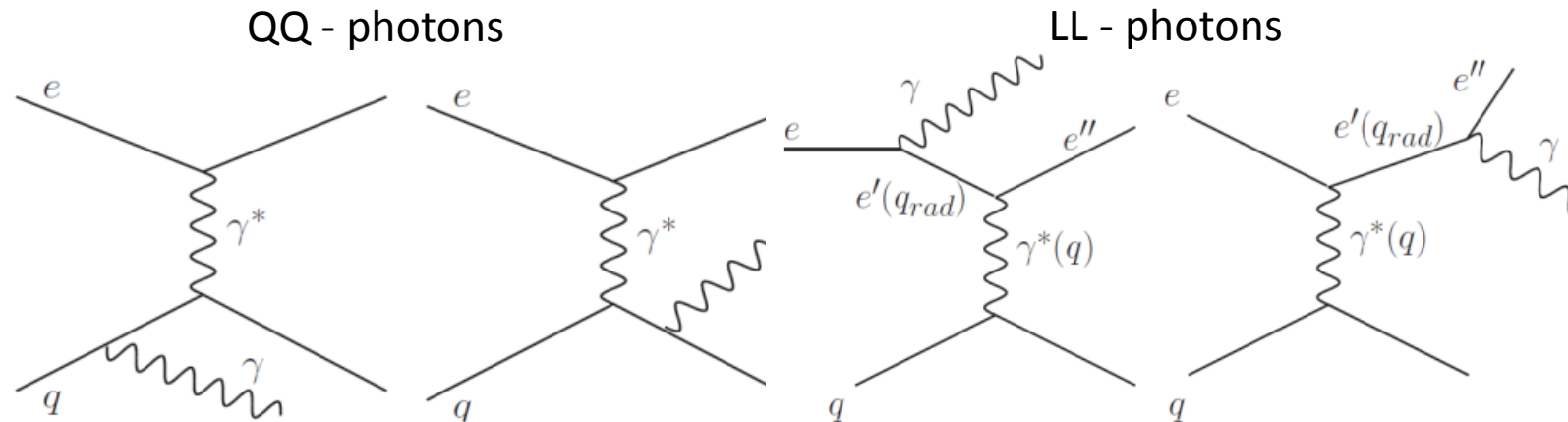
- 0405e, 06e, 0607p

MC

- PYTHIA (signal)
- ARIADNE (background)

Prompt photons

- Photons which are produced promptly in the collision, **before the quarks and gluons have had time to form hadrons, and well before those hadrons decay**
- High transverse energy final state photons (E_T^γ)
- Isolated state:
 - no tracks within $\Delta R(\eta, \varphi) = 0.2$ cone around the photon candidate
 - photon candidate has at least 90% of the reconstructed jet energy



prompt photons are emitted from a quark as part of a QCD process (QQ photons)

photon is radiated from an incoming or outgoing lepton (LL photons)

Observables to study

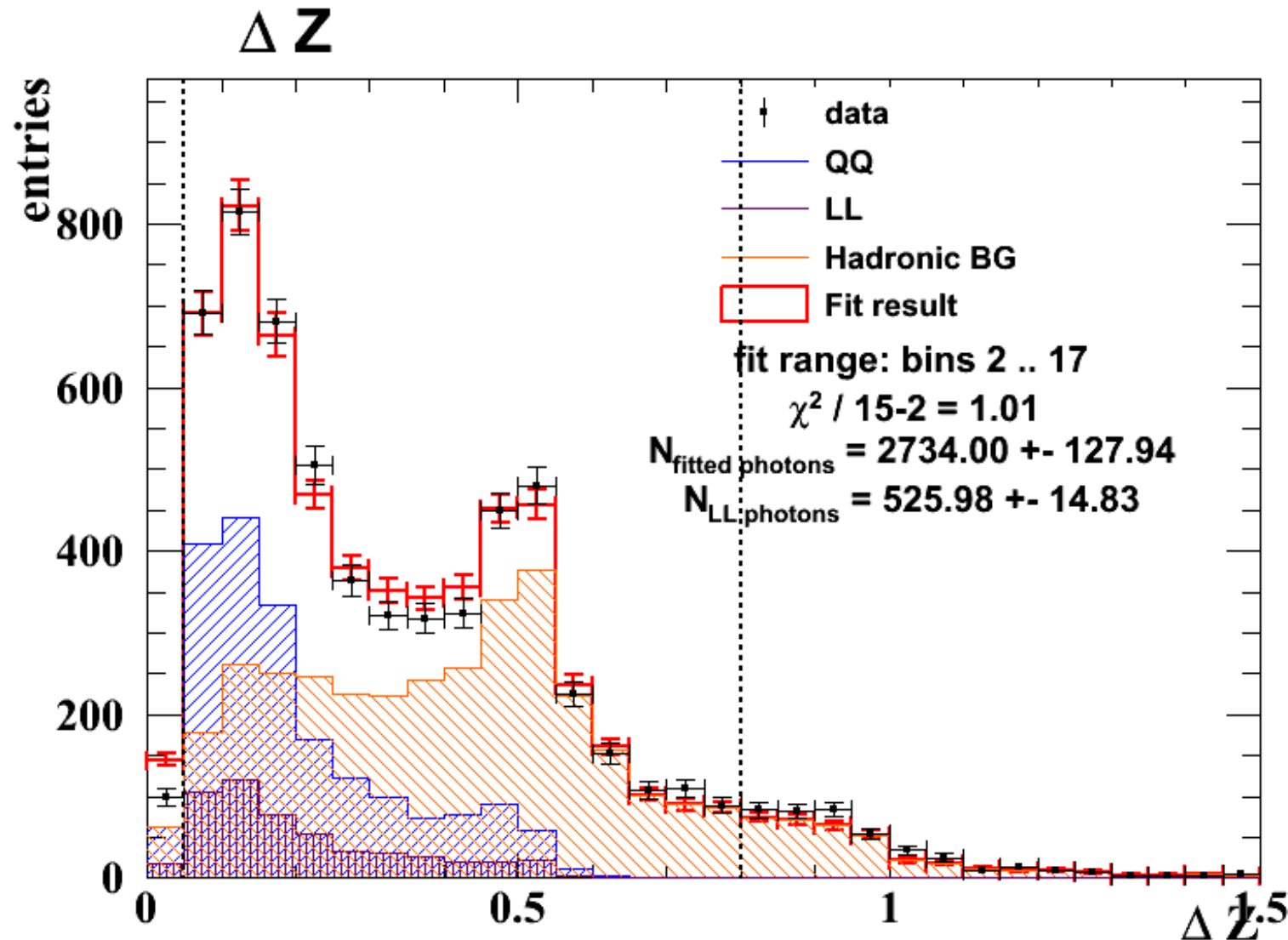
$$\begin{aligned} \bullet x_\gamma &= \frac{\sum_{jet,\gamma}(E-p_z)}{2y_{Bj}E_e} & \bullet \Delta\eta_{\gamma,jet} &= \eta_{jet} - \eta_\gamma & \bullet \Delta\eta_{\gamma,e} &= \eta_e - \eta_\gamma \\ \bullet x_p &= \frac{\sum_{jet,\gamma}(E+p_z)}{2E_p} & \bullet \Delta\varphi_{\gamma,jet} &= \varphi_{jet} - \varphi_\gamma & \bullet \Delta\varphi_{e,\gamma} &= \varphi_e - \varphi_\gamma \end{aligned}$$

Similar kind of analysis was previously done for photoproduction ($Q^2 < 1$).

What was done:

- Moved to new fitting region – excluding the first bin from the fit
- Corrected signal shape
- Studied new ways of doing the fit
- Recalculated and compared new cross sections

Signal extraction



Energy-weighted mean width of the electromagnetic shower(cluster) in calorimeter relative to its centroid:

$$\delta Z = \frac{\sum_{zufo} |z_i - z_{cluster}| \cdot E_i}{l_{cell} \sum E_i}$$

Studied fits

- A bin by bin $\min\chi^2$ -fitting procedures is done. The minimized functions:

1. $\text{Data} - \text{Photons}_{MC} * a - \text{Background}_{MC} * (1 - a)$

2. $\text{Data} - LL_{MC} - QQ_{MC} * a - \text{Background}_{MC} * (1 - a)$ ← used before

3. $\text{Data} - QQ_{MC} * a - \text{Background}_{MC} * (1 - a)$

4. $\text{Data} - QQ_{MC} * a - \text{Background}'_{MC} * (1 - a)$

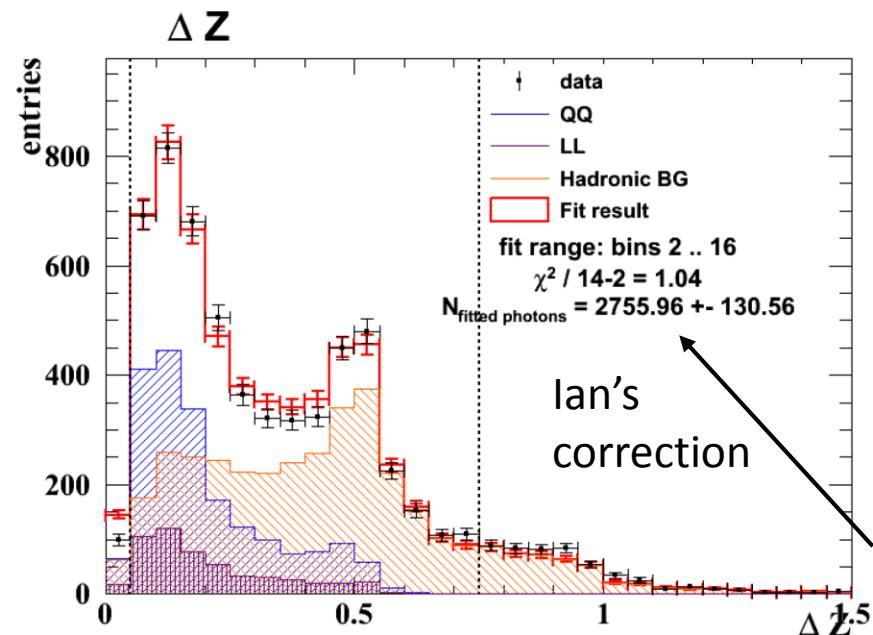
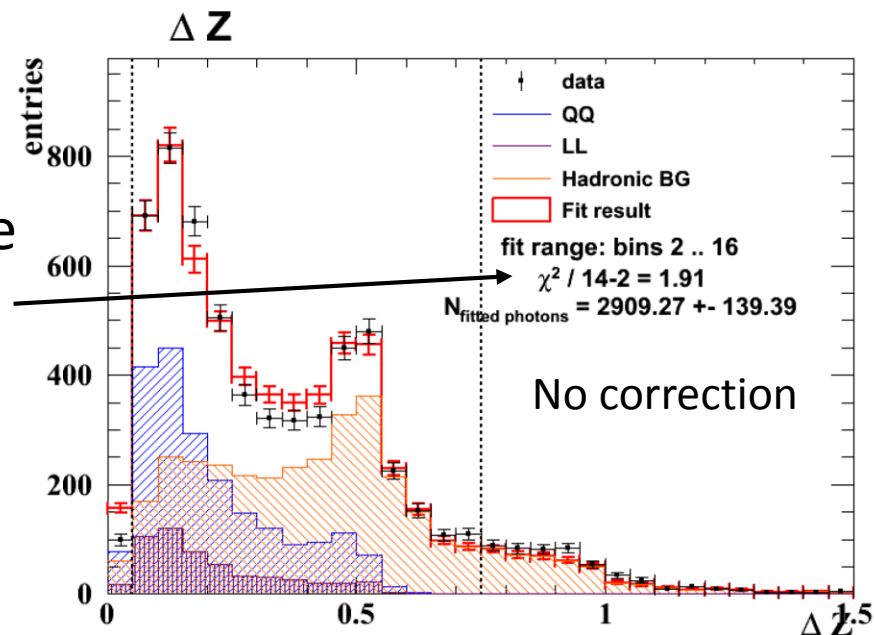
- Number of fitted photons is defined:

- $N = a * N_{data, full} * \frac{N_{sg, full}}{N_{sg, fitted}} + N_{LL, full}$ ← for (1) and (2)

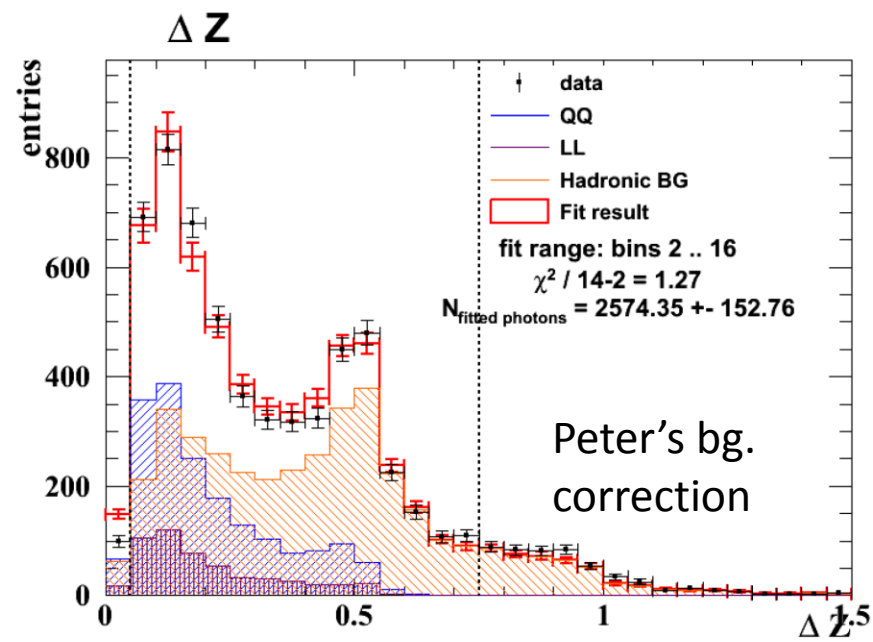
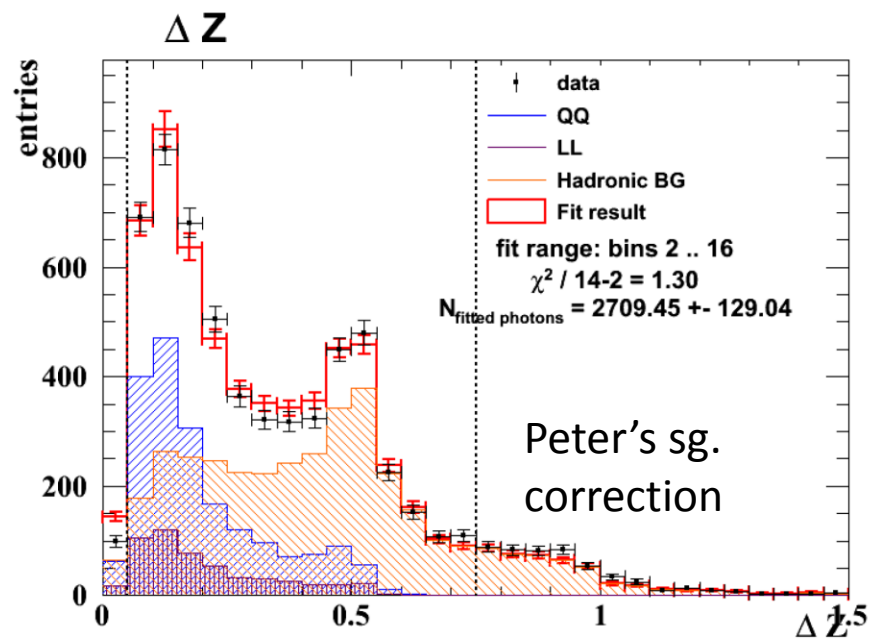
- $N = a * N_{data, full} * \frac{N_{sg, full}}{N_{sg, fitted}}$ ← for (3) and (4)

$$\text{for data} = \text{LL}' + \text{QQ}' * a + \text{bg}' * (1 - a)$$

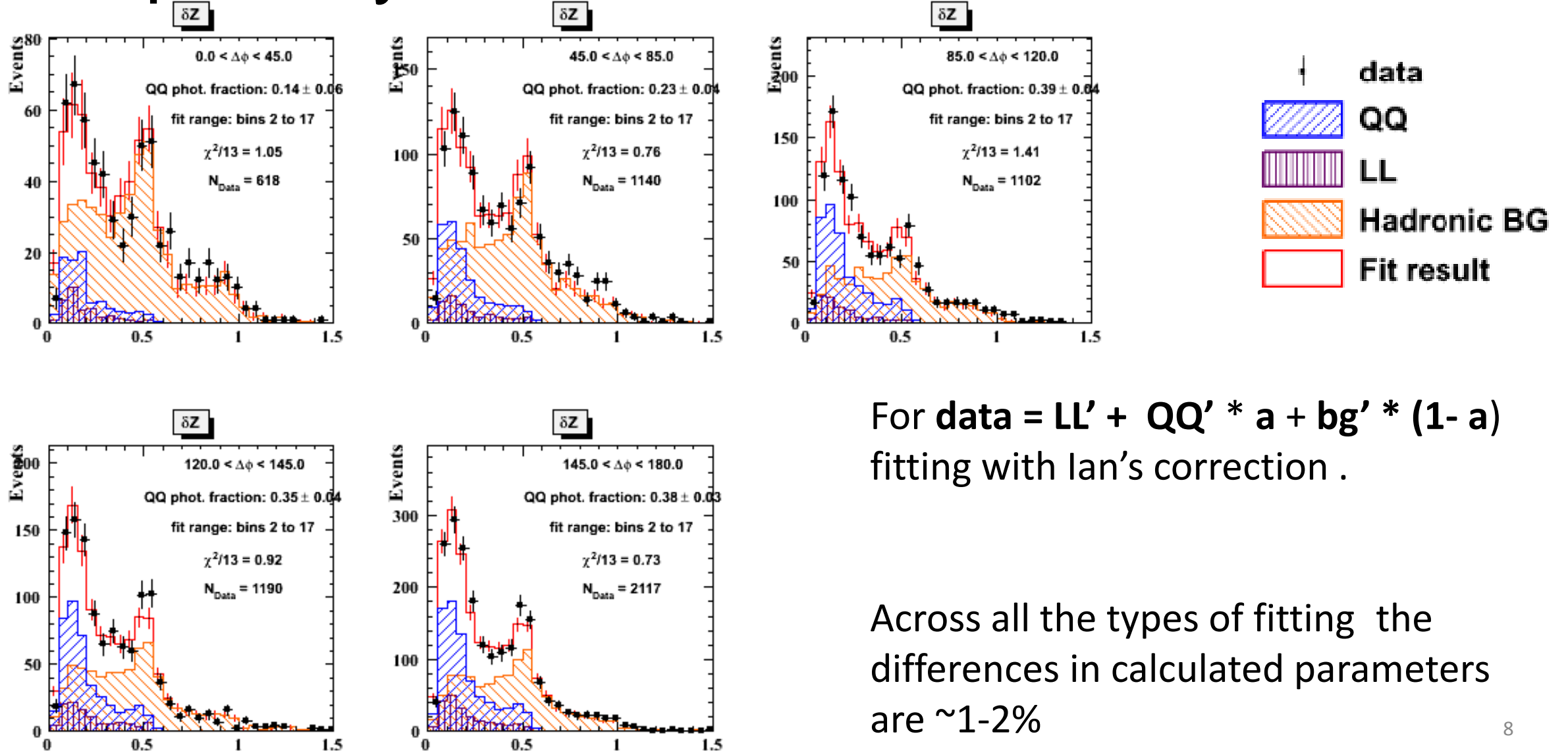
Usage of the correction overall makes the fit better



Changing the fitting region gave us overall ~+5% to number of fitted photons



$\Delta\phi$ bin-by-bin fit

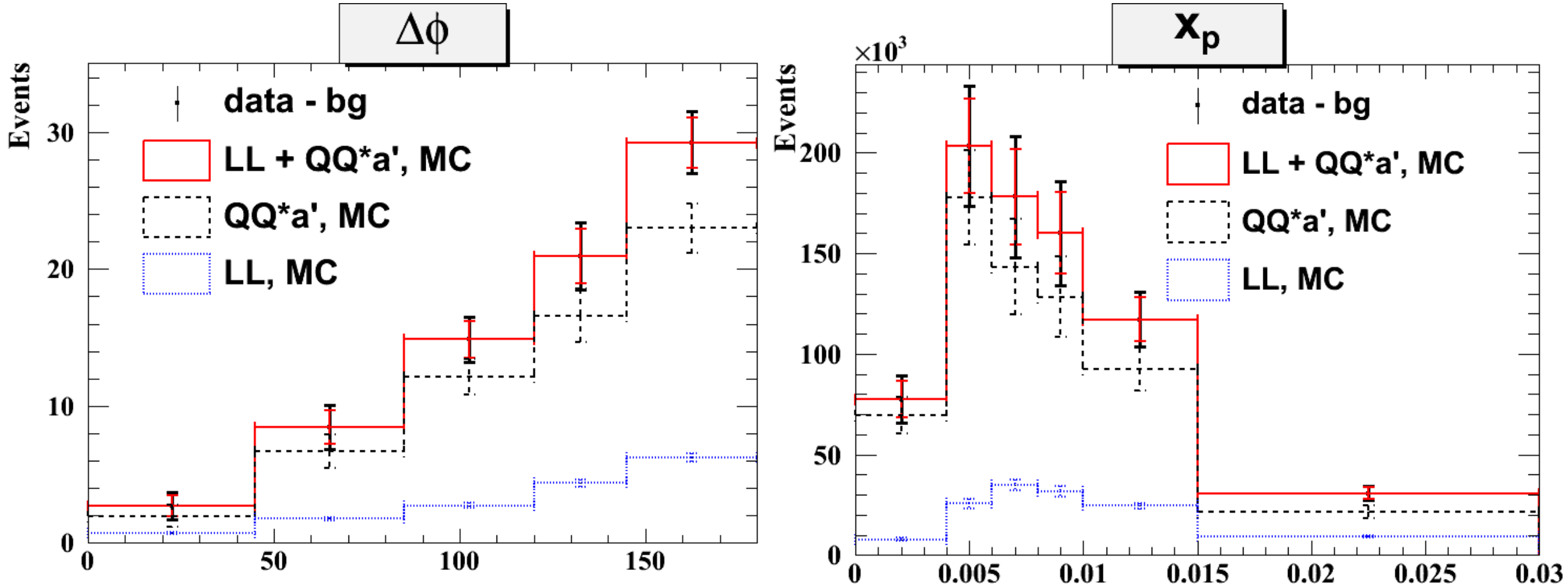


For $\text{data} = \text{LL}' + \text{QQ}' * a + \text{bg}' * (1 - a)$
fitting with Ian's correction .

Across all the types of fitting the
differences in calculated parameters
are $\sim 1\text{-}2\%$

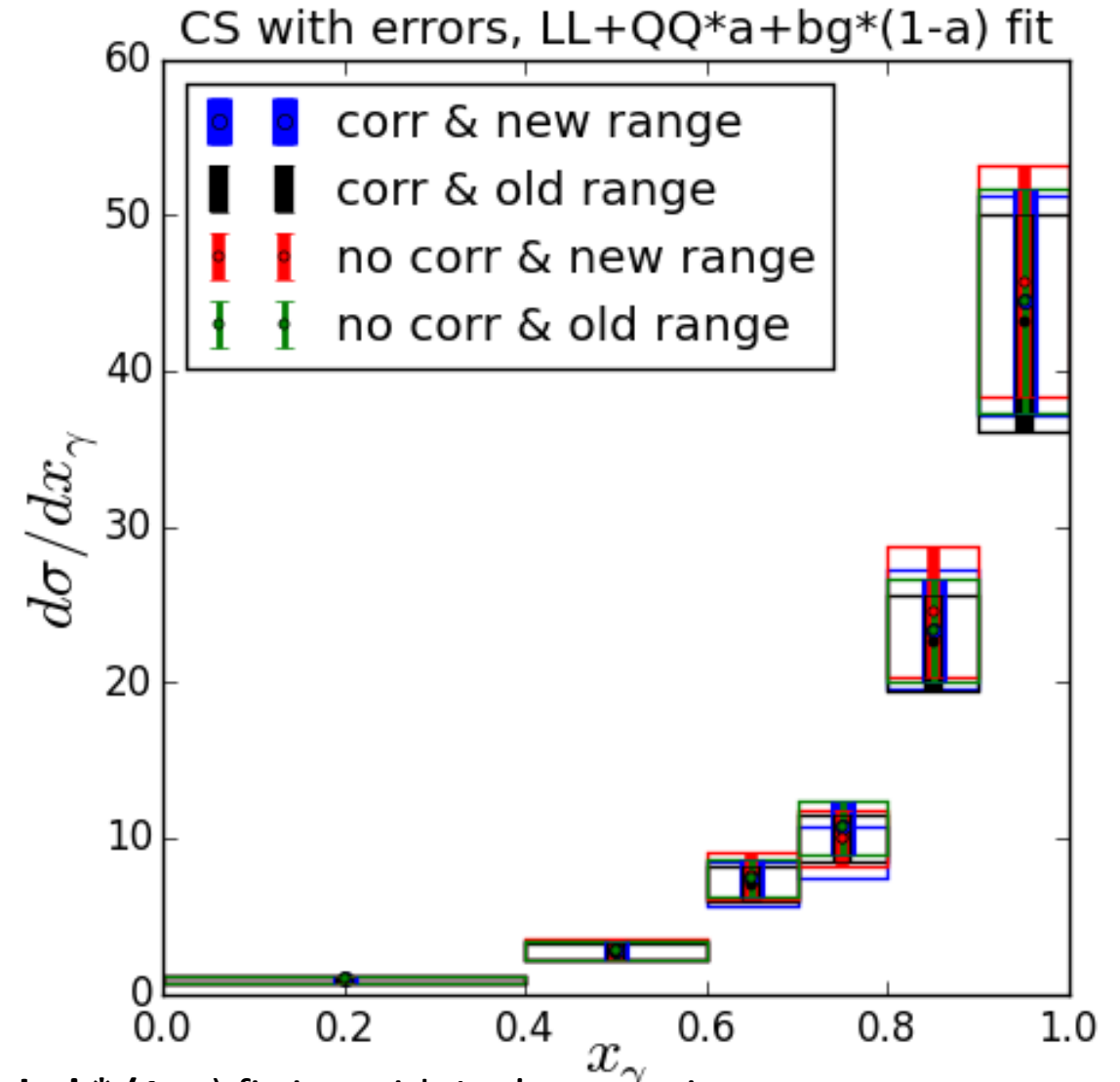
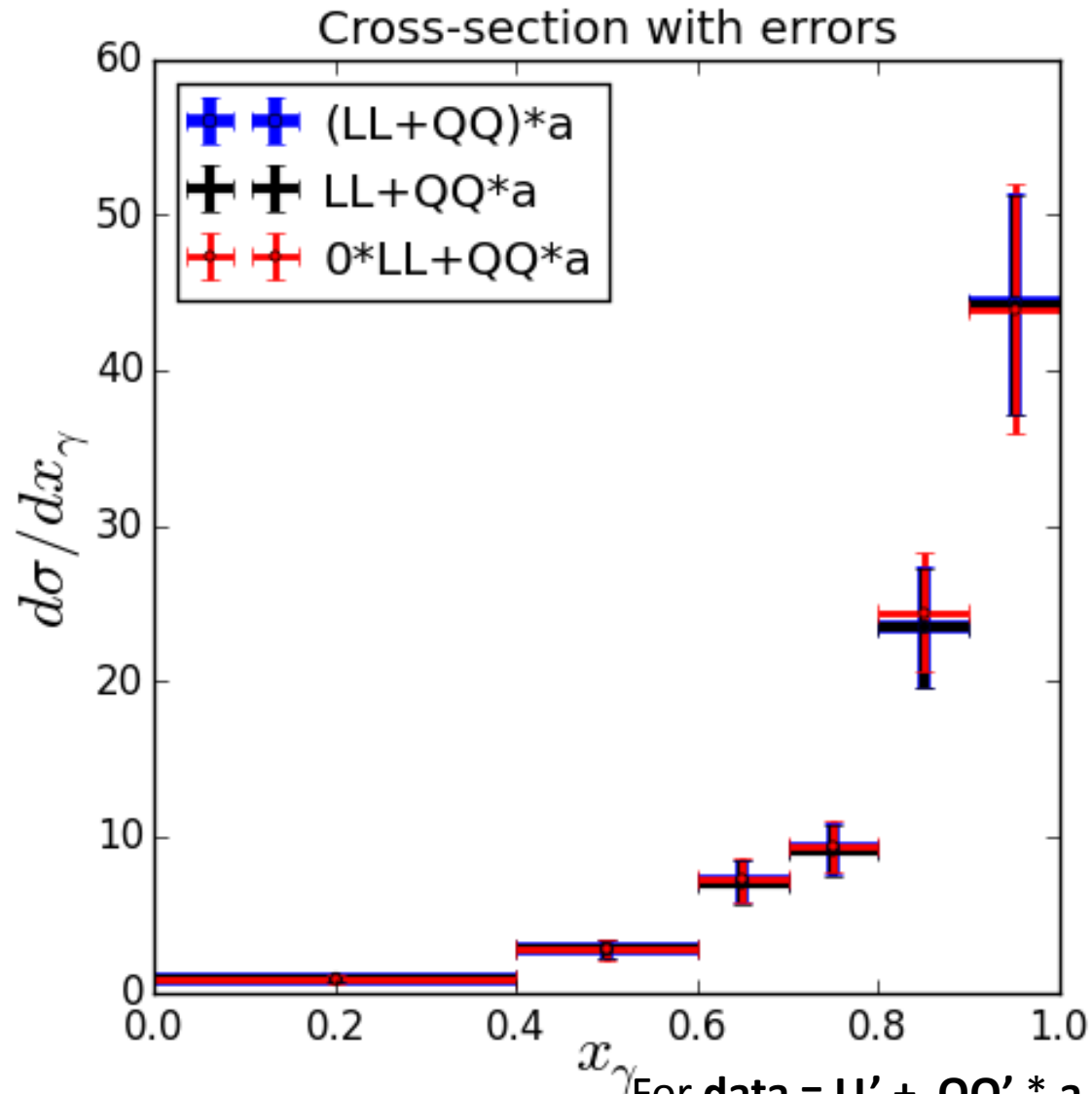
Control plots

All the procedures showed good description of data



For $\text{data} = \text{LL}' + \text{QQ}' * a + \text{bg}' * (1 - a)$ fitting with Ian's correction .

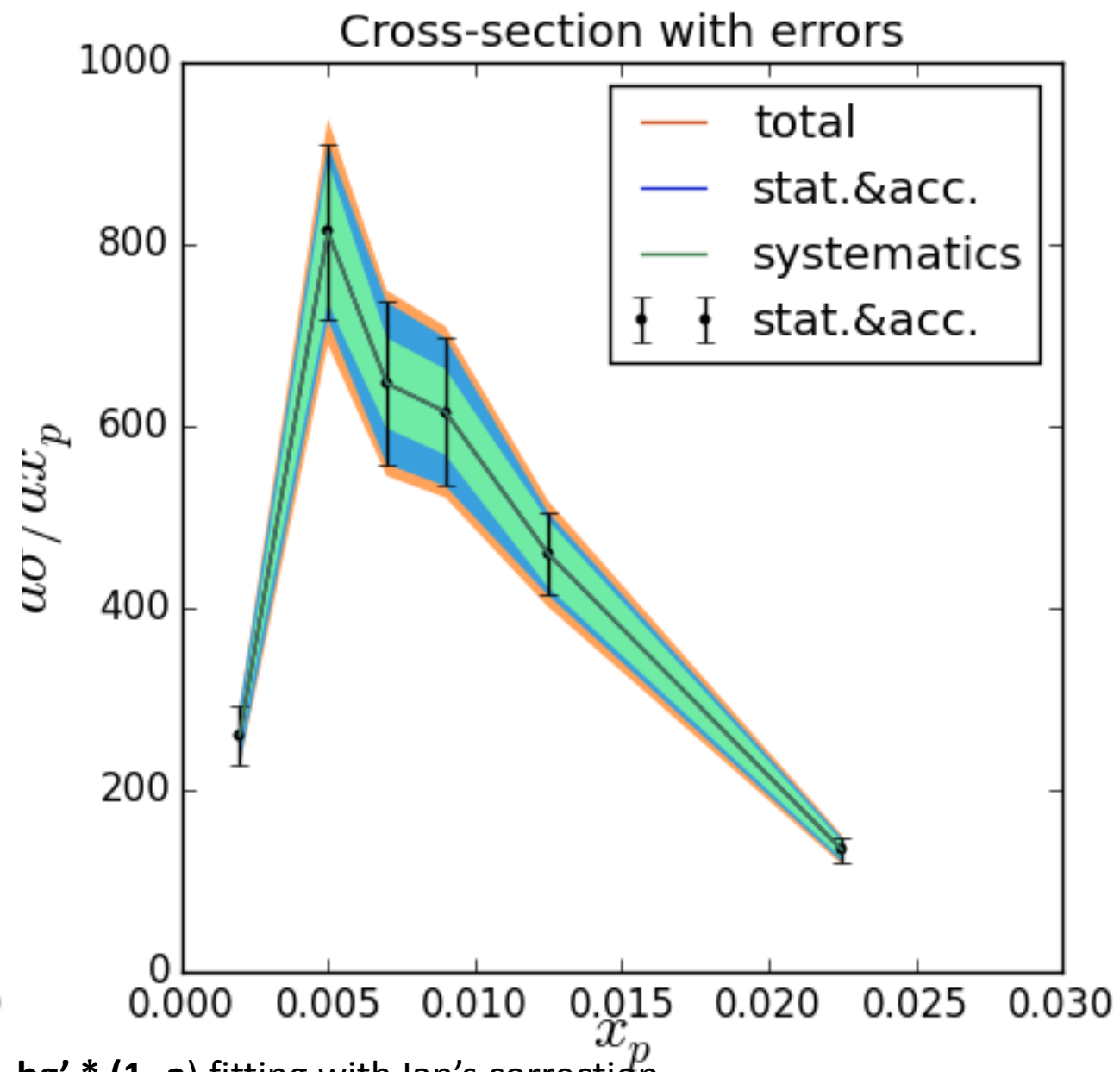
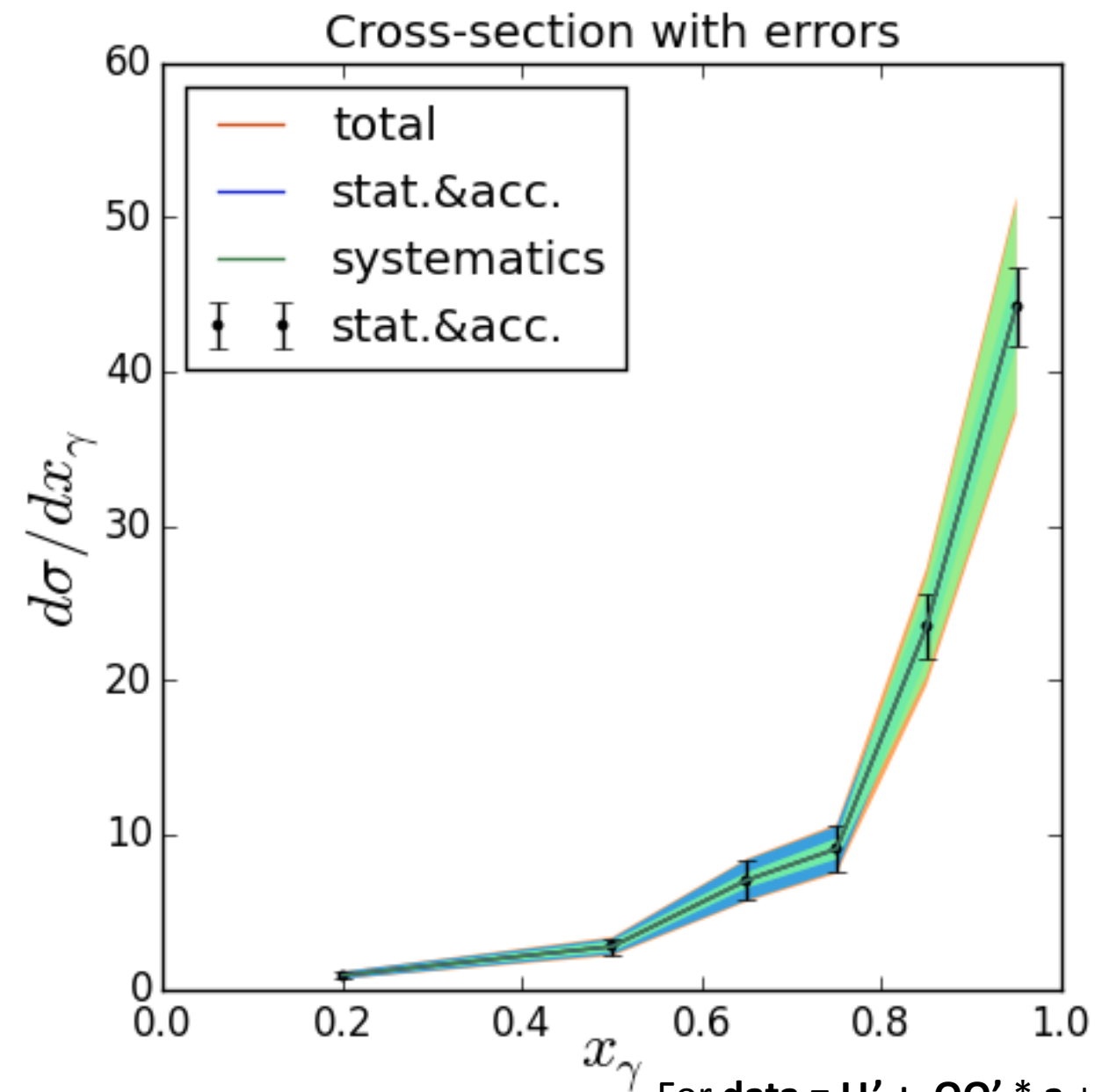
Comparison of fits



For **data** = $LL' + QQ' * a + bg' * (1-a)$ fitting with Ian's correction .

x_γ

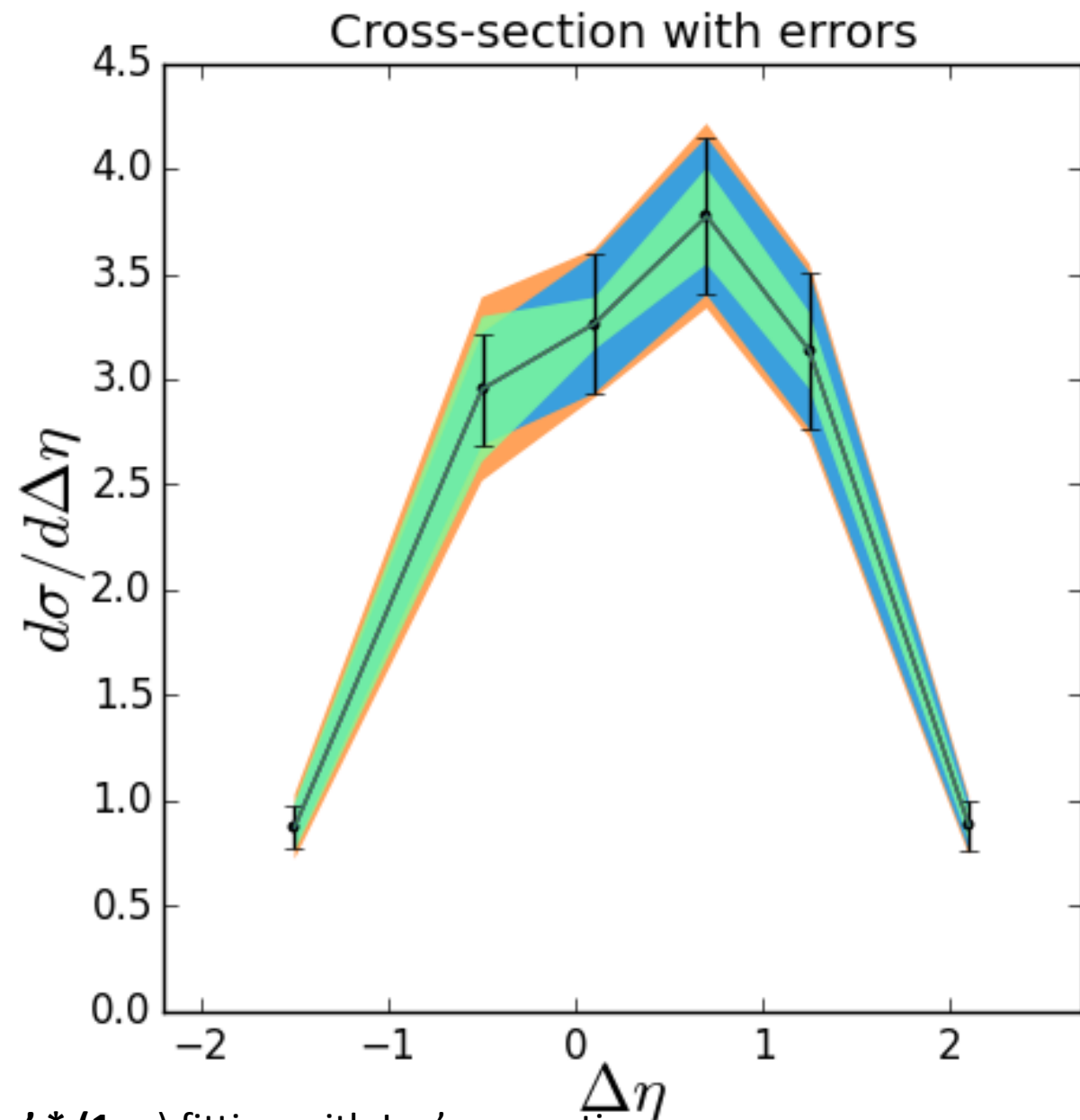
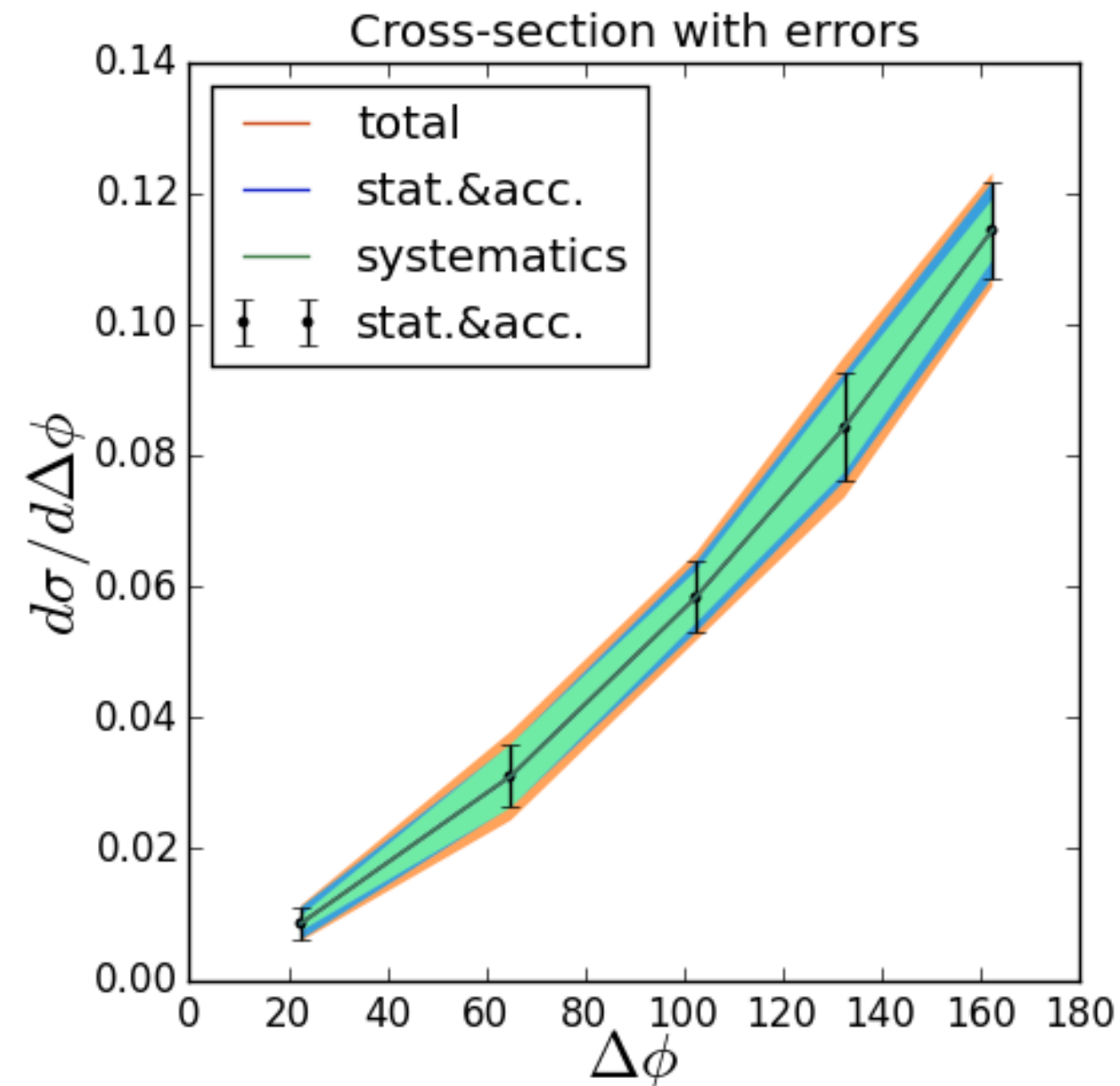
Cross sections

 x_p 

For **data = LL' + QQ' * a + bg' * (1- a)** fitting with Ian's correction .

$\Delta\phi$

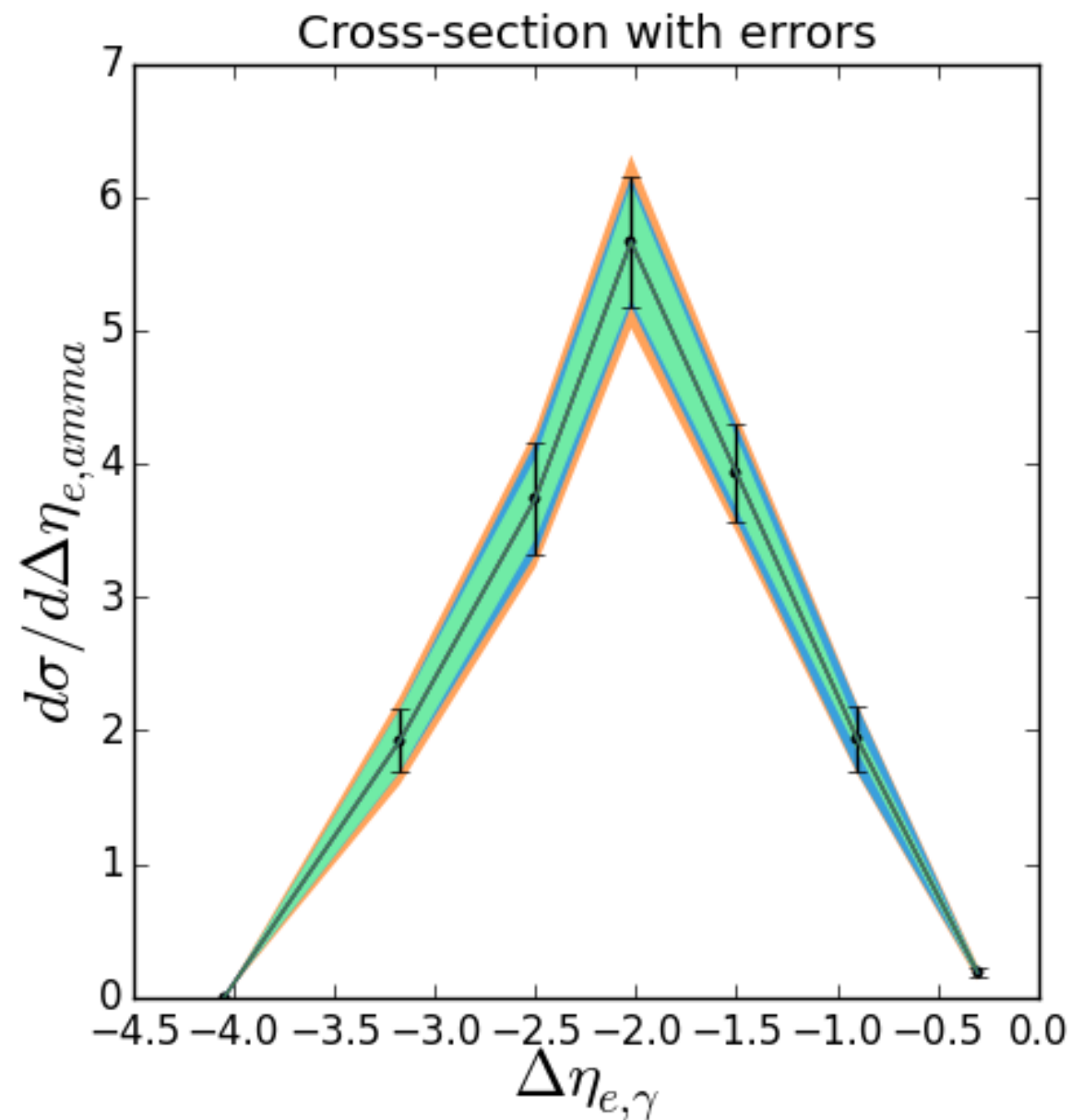
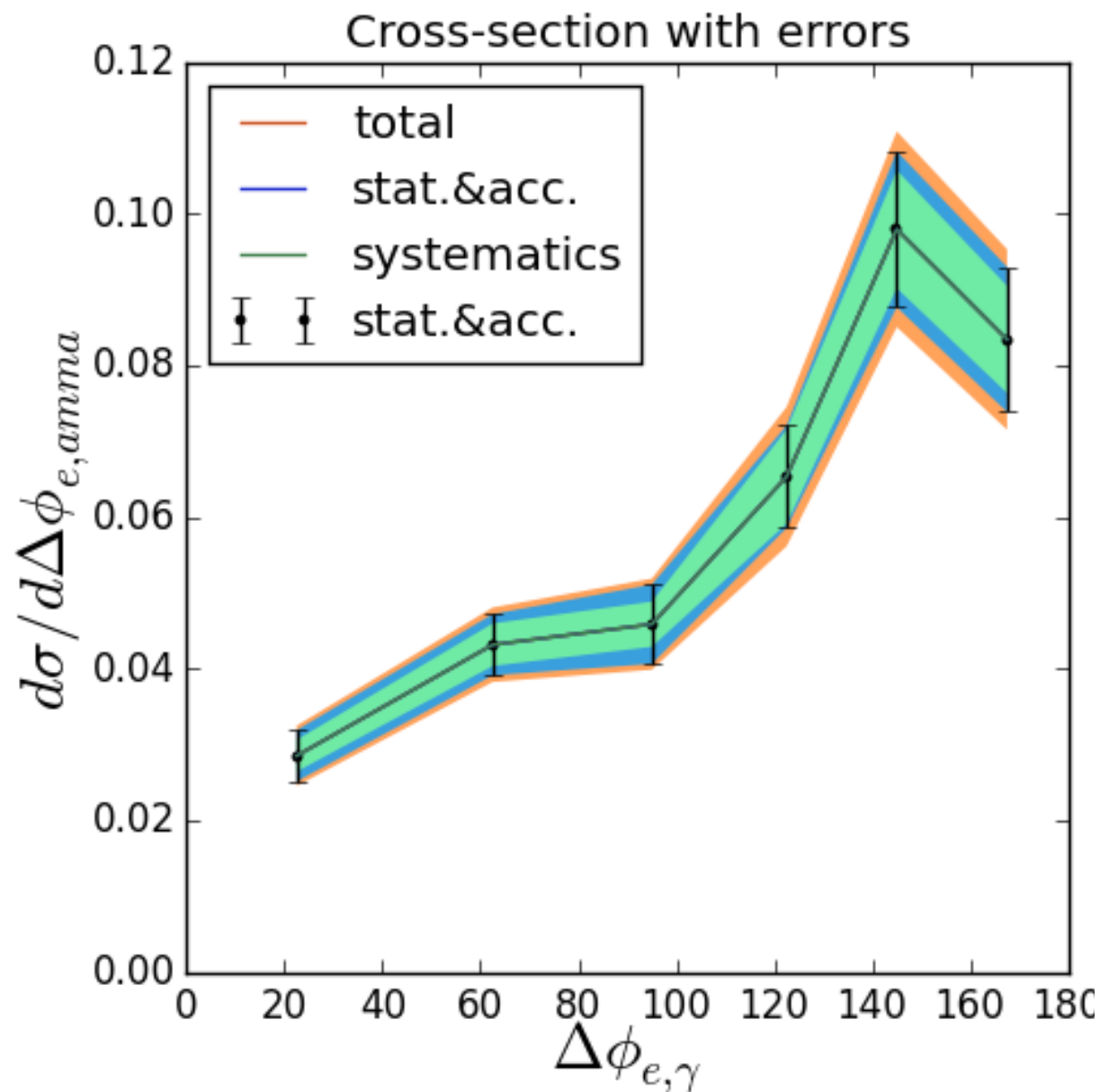
Cross sections

 $\Delta\eta$ 

For **data = LL' + QQ' * a + bg' * (1- a)** fitting with Ian's correction.

$\Delta\varphi_{e,\gamma}$

Cross sections

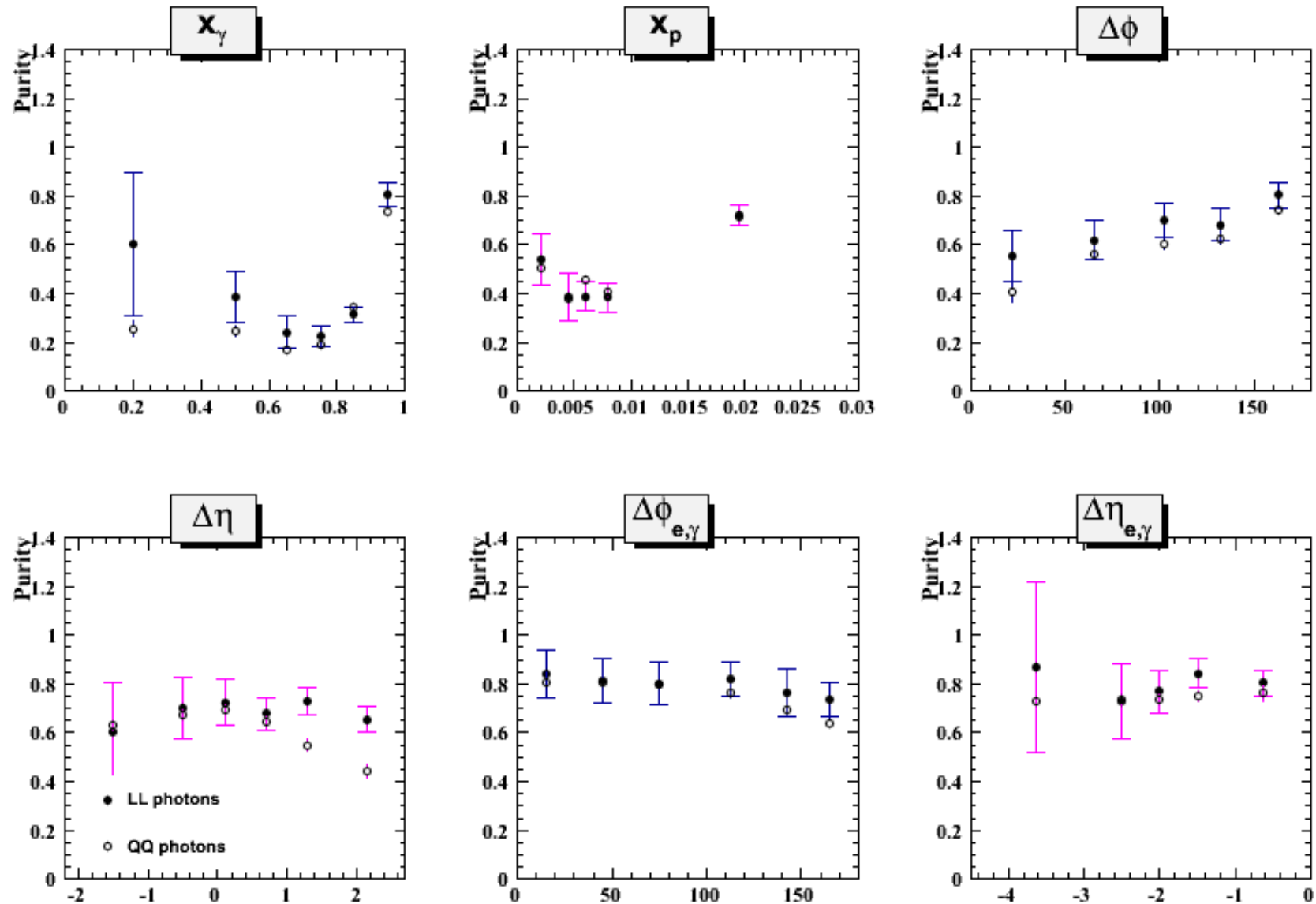
 $\Delta\eta_{e,\gamma}$ 

For **data = LL' + QQ' * a + bg' * (1- a)** fitting with lan's correction.

Conclusions

- We analyzed various fitting procedures.
- Defined analysis method. It is compatible with one used in the previous researches.
- Next is to compare results with theoretical models.

is defined as the relation of found with
Appendix.Purity – detector level cuts photons to actual



Appendix. Cross sections

- For a given observable Y , the production cross section:

$$\frac{d\sigma}{dY} = \frac{A_{QQ} \cdot N(\gamma_{QQ})}{\mathcal{L} \cdot \Delta Y} + \frac{d\sigma_{LL}^{MC}}{dY}$$

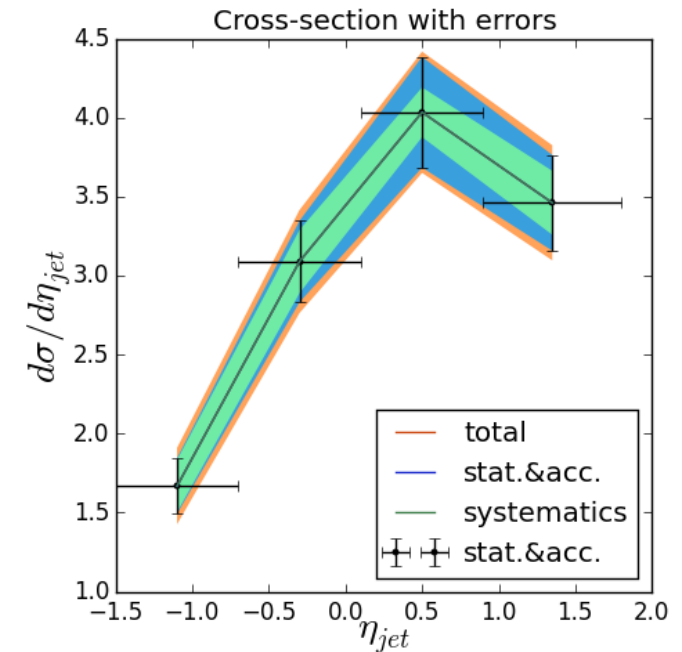
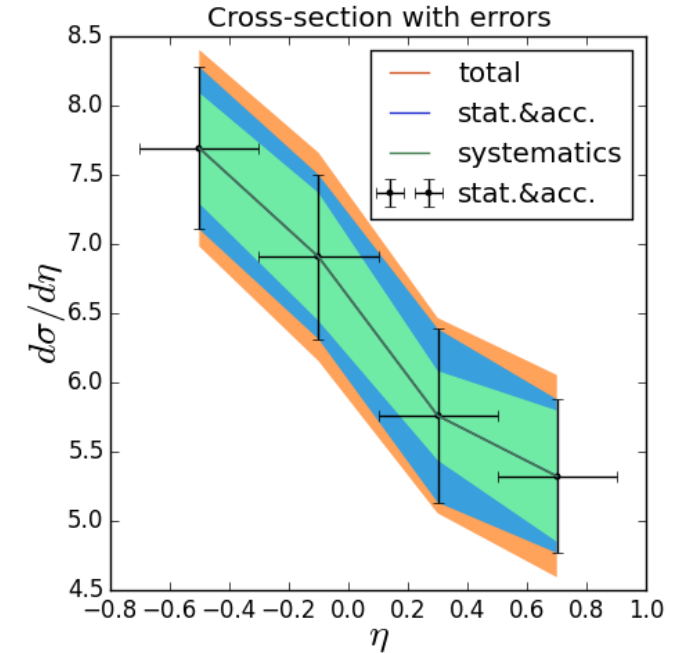
$N(\gamma_{QQ})$ - number of QQ photons extracted from the fit,

ΔY - bin width,

\mathcal{L} - total integrated luminosity,

σ_{LL}^{MC} - cross section for LL photons

- $A_{QQ} = \frac{N_{detector\ level}}{N_{true\ level}}$ - acceptance correction for QQ photons



Appendix. Fitting procedure

- For the control plots the next procedures was applied for each bin in terms of new variables separately:
 - LL_{MC} and $background_{MC}$ are scaled to the level of data luminosity
 - QQ_{MC} is scaled to the number of photons candidates in data sample after subtraction of predicted LL photons.
 - $Background_{MC}$ was scaled to number of photon candidates in data.
 - A bin by bin $min\chi^2$ -fitting procedures is done. The minimized function:
$$Data - Photons_{MC} * a - Background_{MC} * (1 - a)$$
, where a – fitting parameter,
 $Photons_{MC}$ – LL_{MC} and QQ_{MC} photons (scaled to the number of photon candidates in data before the fitting procedure)
- a – illustrates the prompt photons fraction in data photon candidates sample

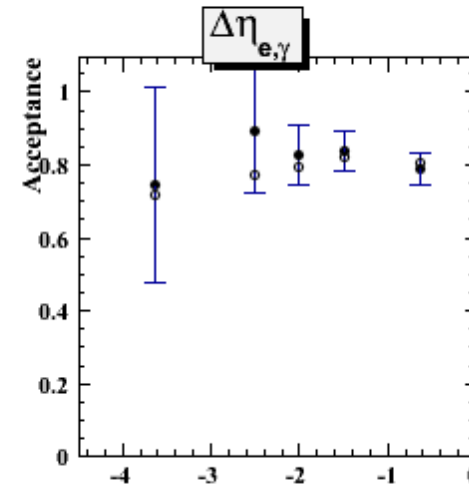
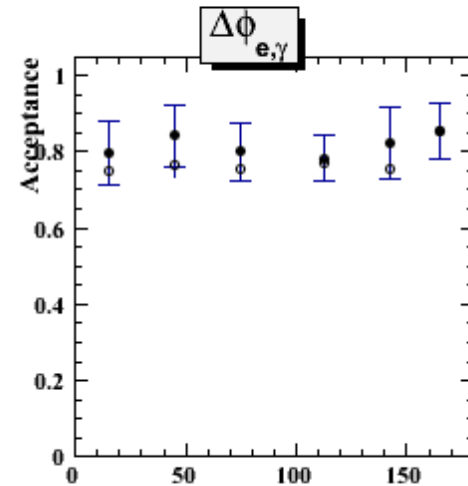
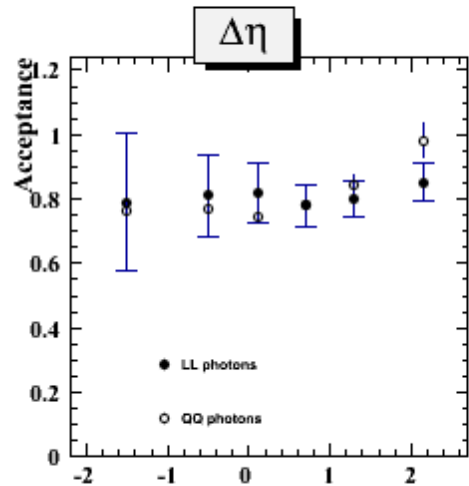
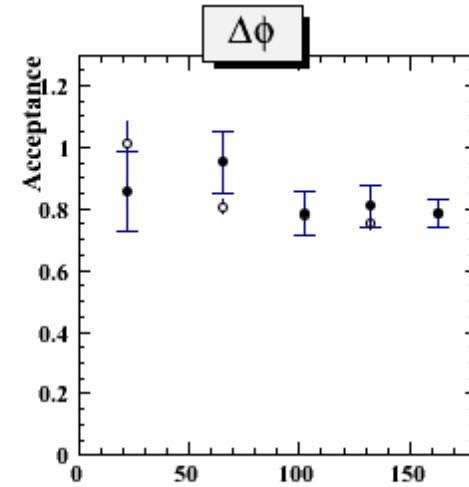
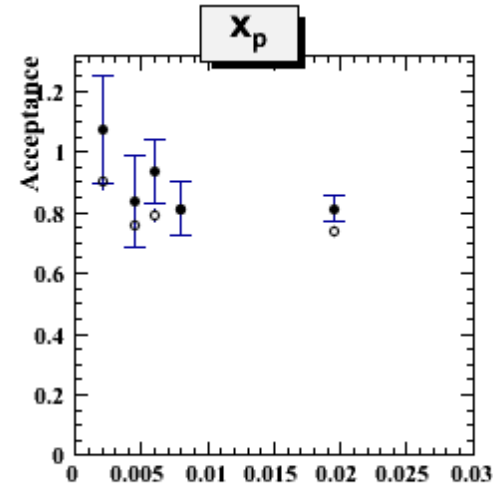
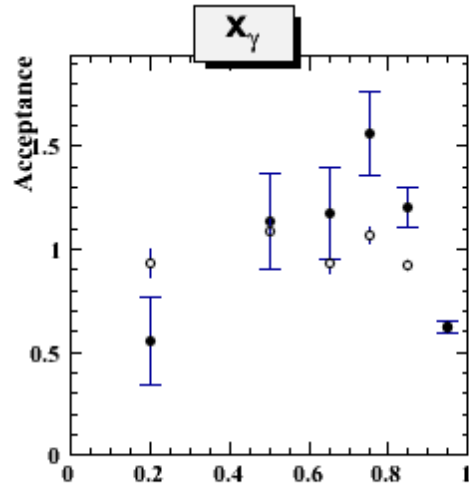
Appendix.Event selection

- DIS selection
 - $10 < Q_{el}^2 < 350 \text{ GeV}^2$
 - Electron cuts:
 - $E_{e,corr} > 10 \text{ GeV}$
 - $140^\circ < \theta_{el} < 180^\circ$
 - $|X| < 14.8, \text{ cm}$
 - $|Y| < 14.8, \text{ cm}$
- Prompt photon selection
 - $4 < E_T^\gamma < 15, \text{ GeV}$
 - $-0.7 < \eta_\gamma < 0.9$
 - $E_\gamma \div E_{jet \text{ with } \gamma} > 0.9$
 - $\Delta R < 0.2$ – no tracks
 - $E_{EMC} \div (E_{EMC} + E_{HAC})$
- Jet selection (zufos used)
 - $E_T^{jet} > 2.5, \text{ GeV}$
 - $-1.5 < \eta_{jet} < 1.8$
 - Use jet with $E_{T,max}^{jet}$
- Cleaning
 - Triggers
 - SPP02 for 0405e
 - SPP09 for 06e, 0607p
 - $|Z_{vtx}| < 40, \text{ cm}$
 - $35 < E - p_z < 65, \text{ GeV}$
 - Number of vertex tracks not in RCAL > 1

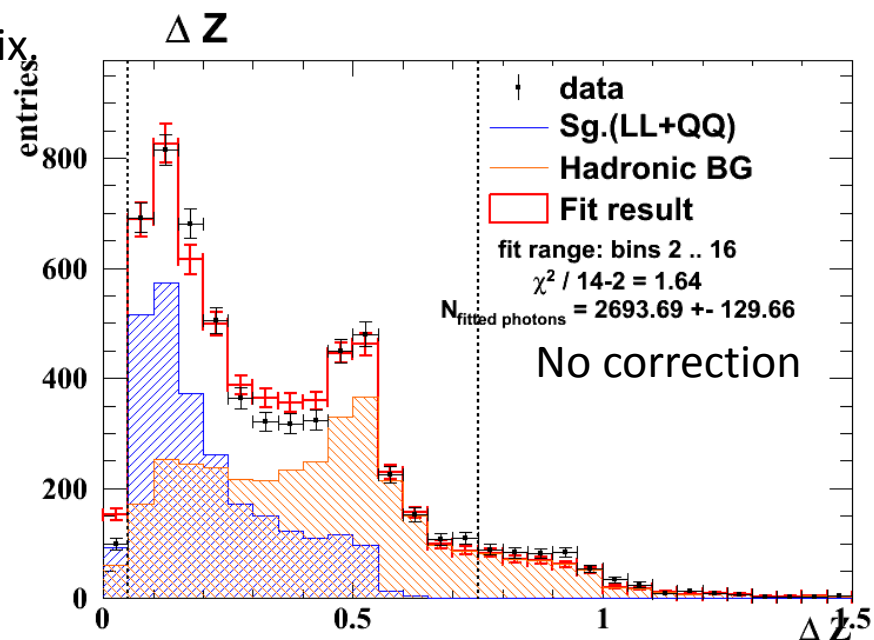
Appendix.

Acceptance

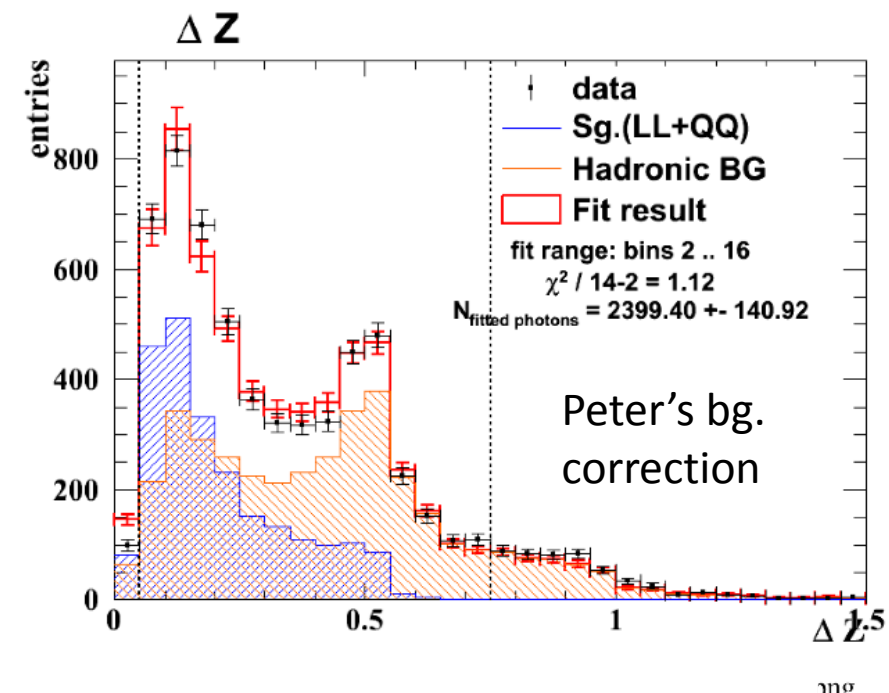
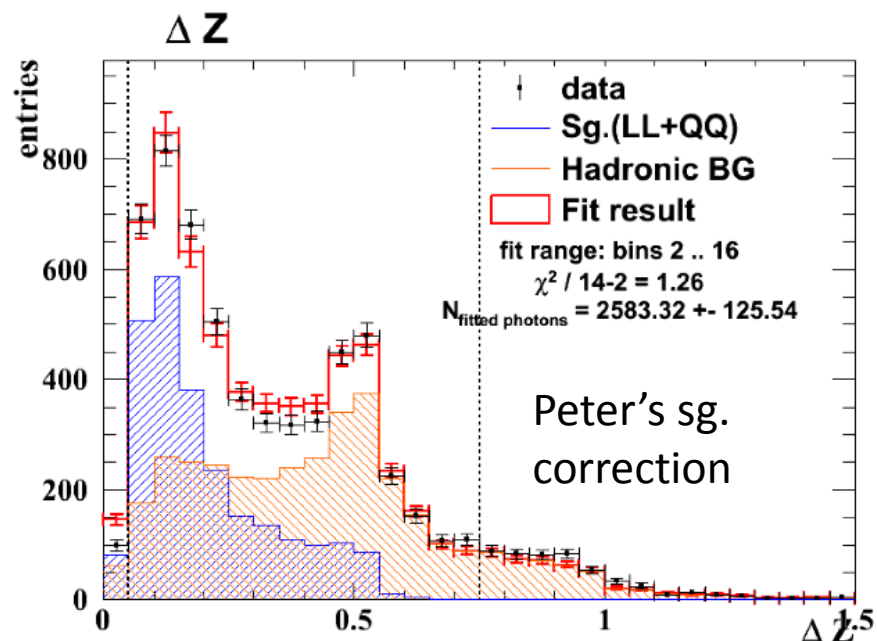
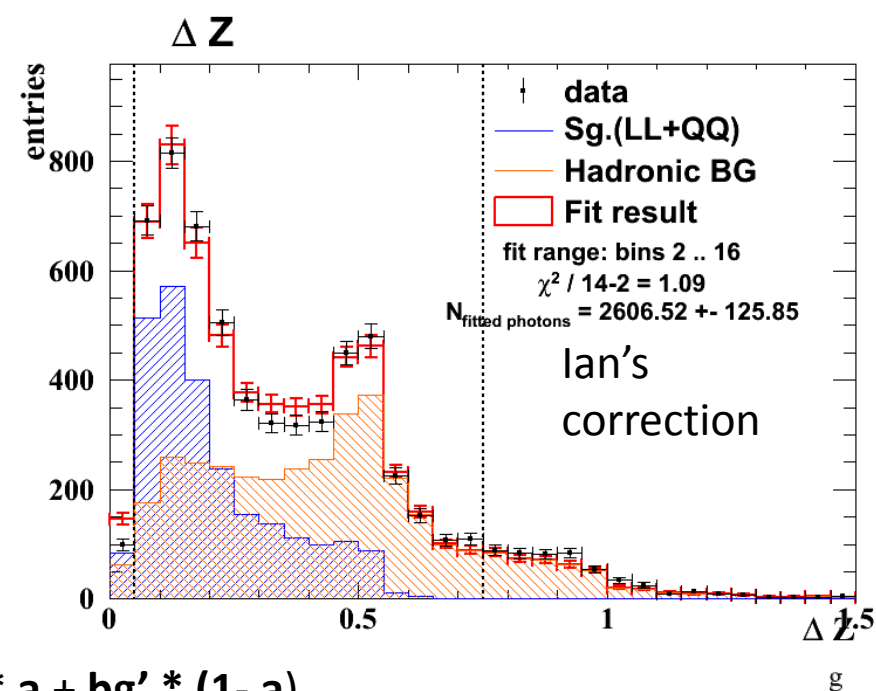
$Acc = \frac{N_{detector\ level}}{N_{true\ level}}$ acceptance can be calculated as the relation of corresponding histograms scaled to data luminosity



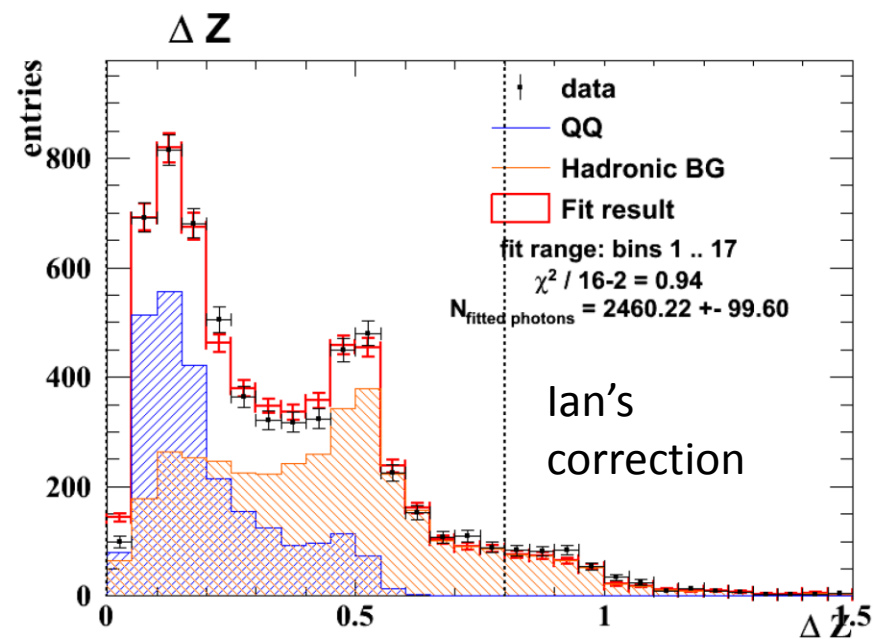
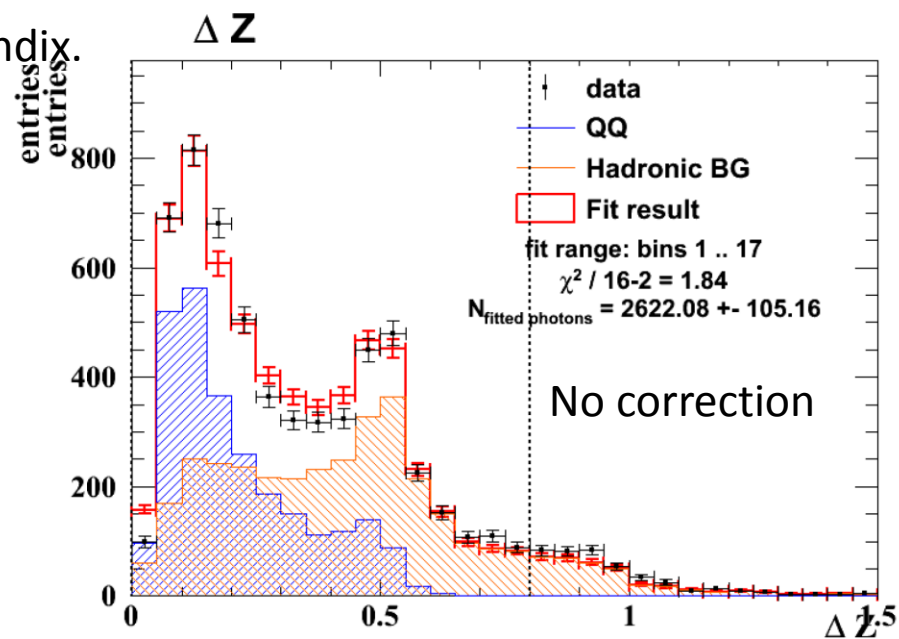
Appendix



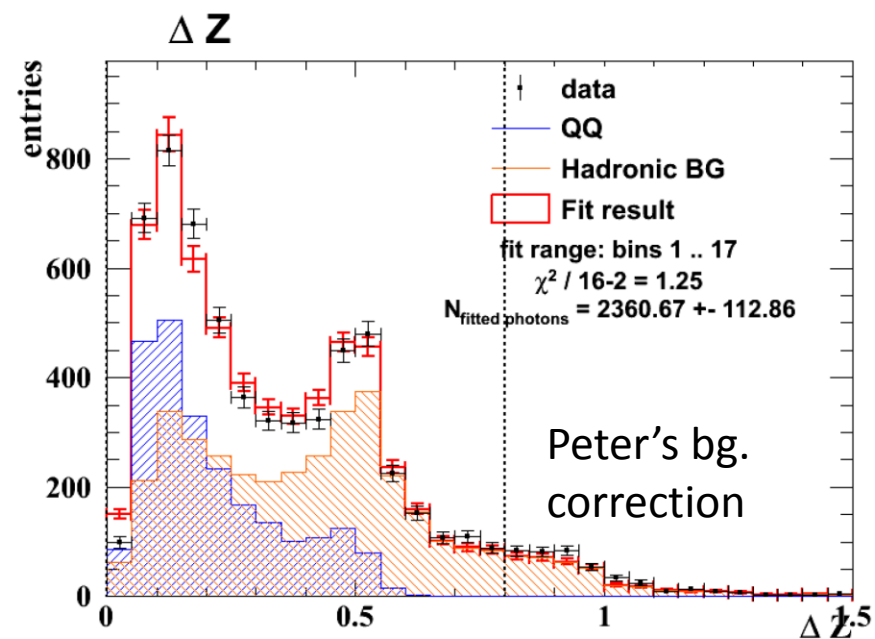
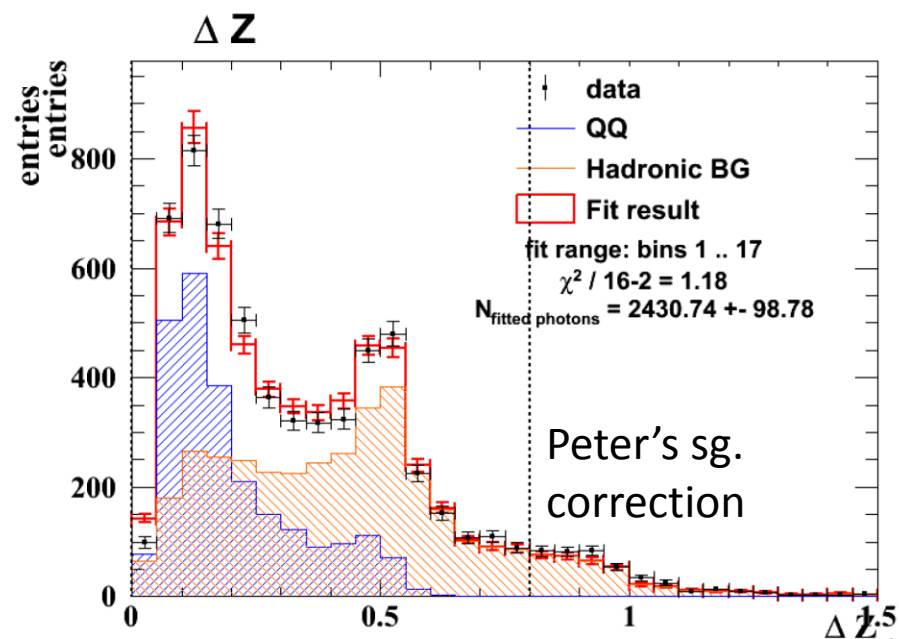
$$\text{data} = \text{photons} * a + \text{bg}' * (1 - a)$$



Appendix.

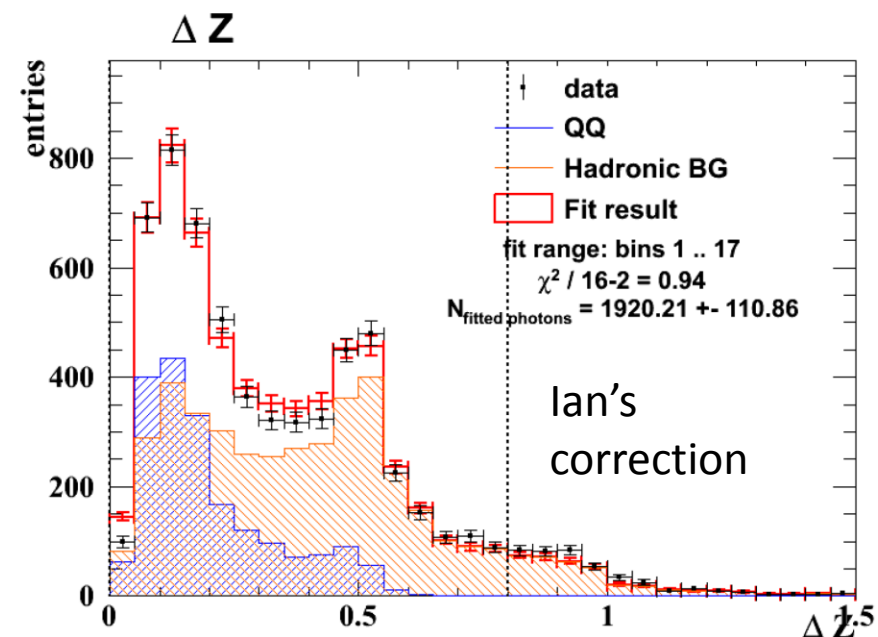
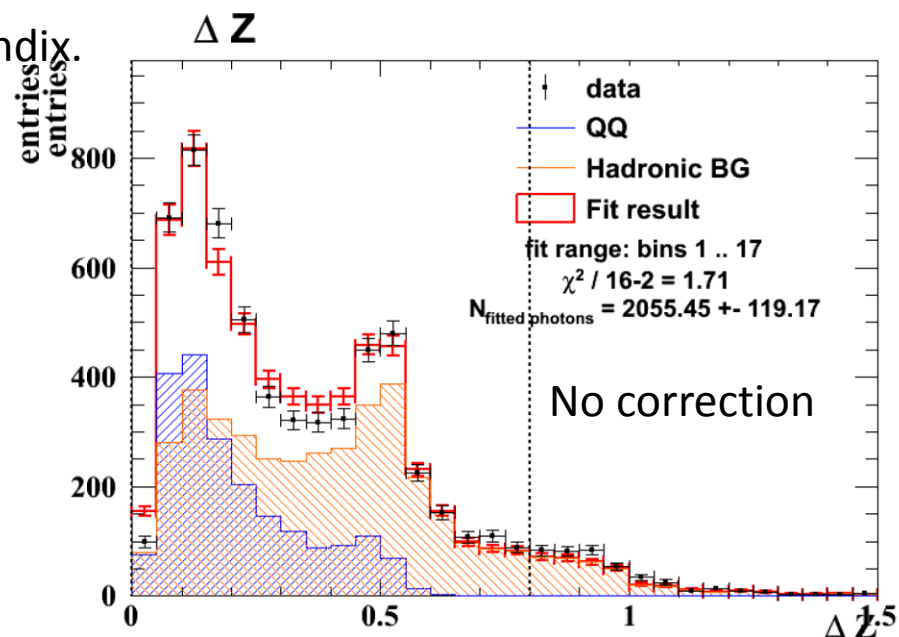


$$\text{data} = \text{QQ}' * a + \text{bg}' * (1 - a)$$

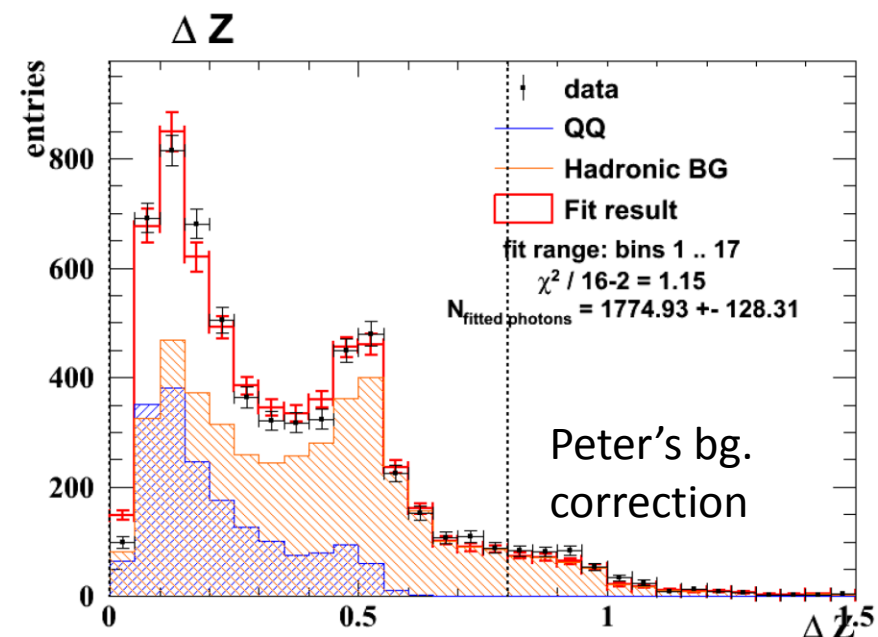
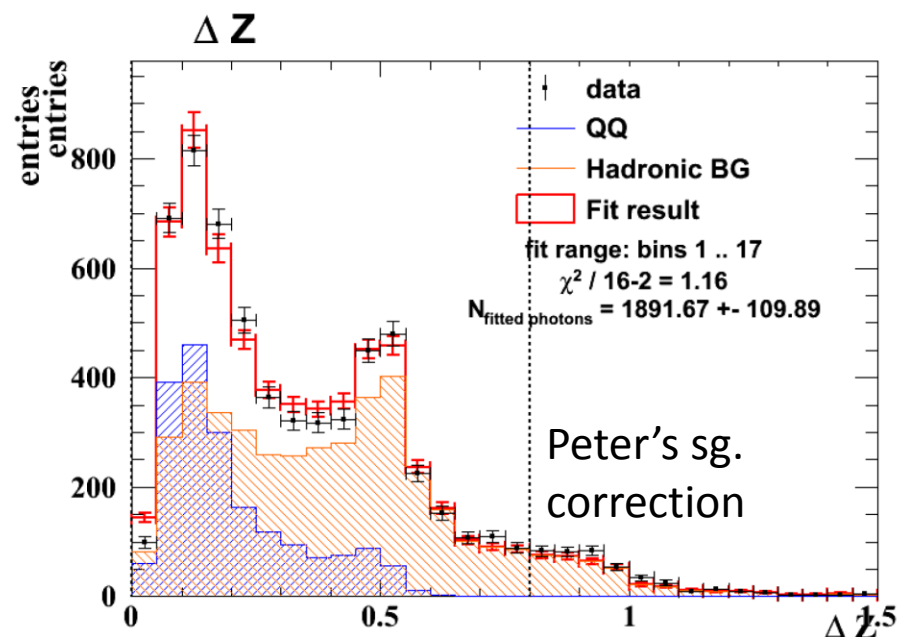


qqlum_new = 1,6

Appendix.



$$\text{data} = \text{QQ}' * a + \text{bg}'' * (1 - a)$$

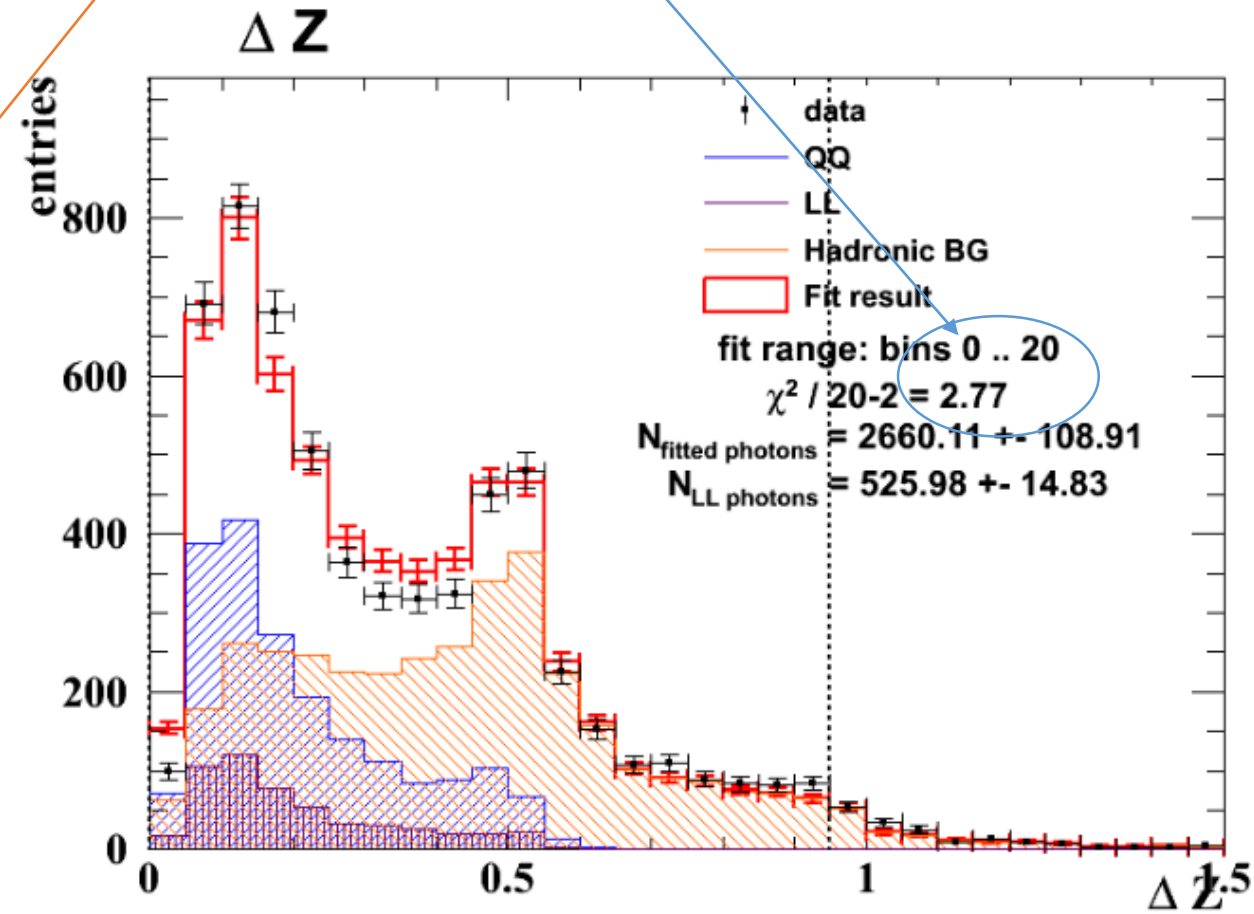
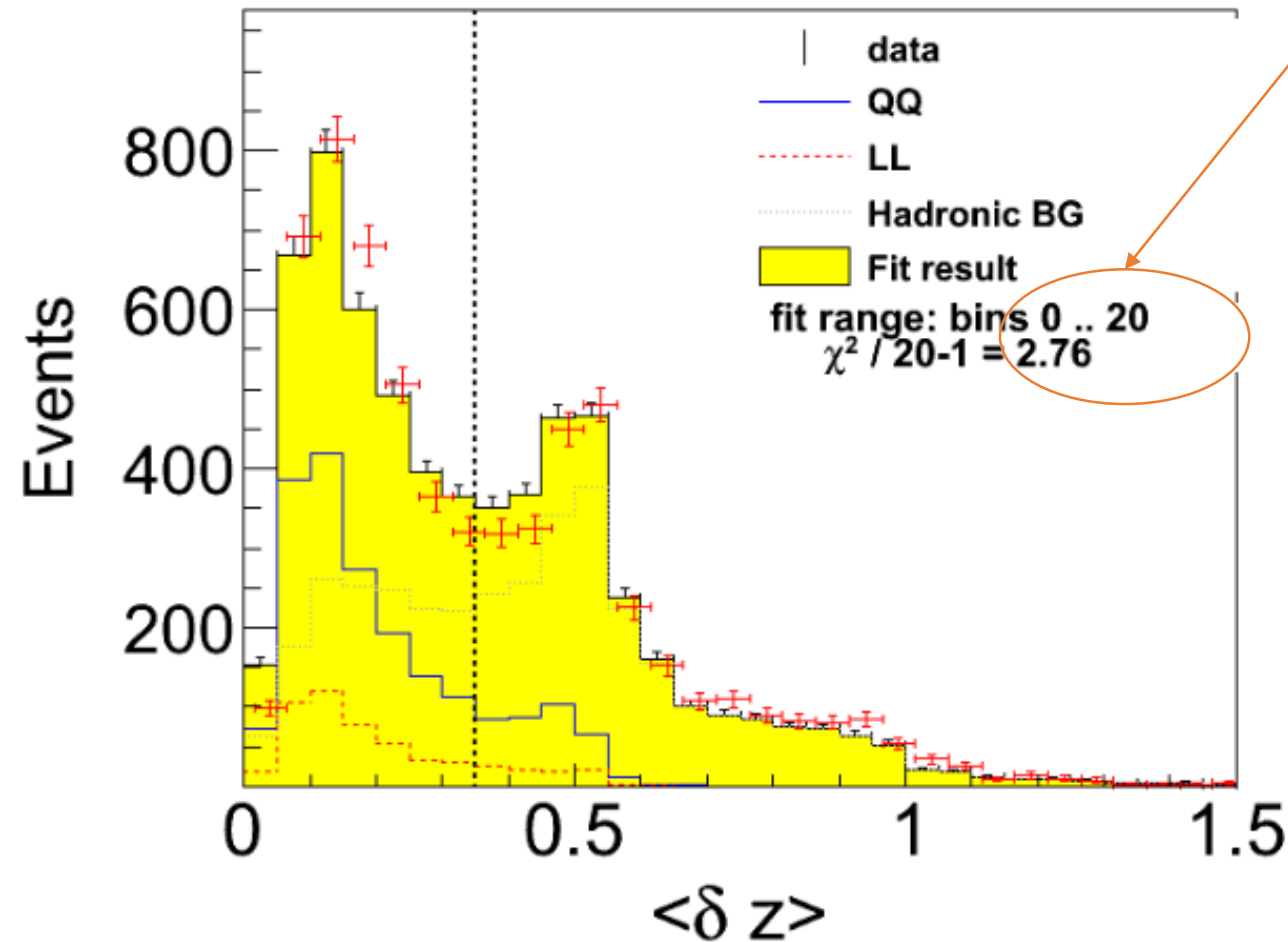


Comparison to old results

for **data** = **LL'** + **QQ'** * **a** + **bg'** * (**1- a**)

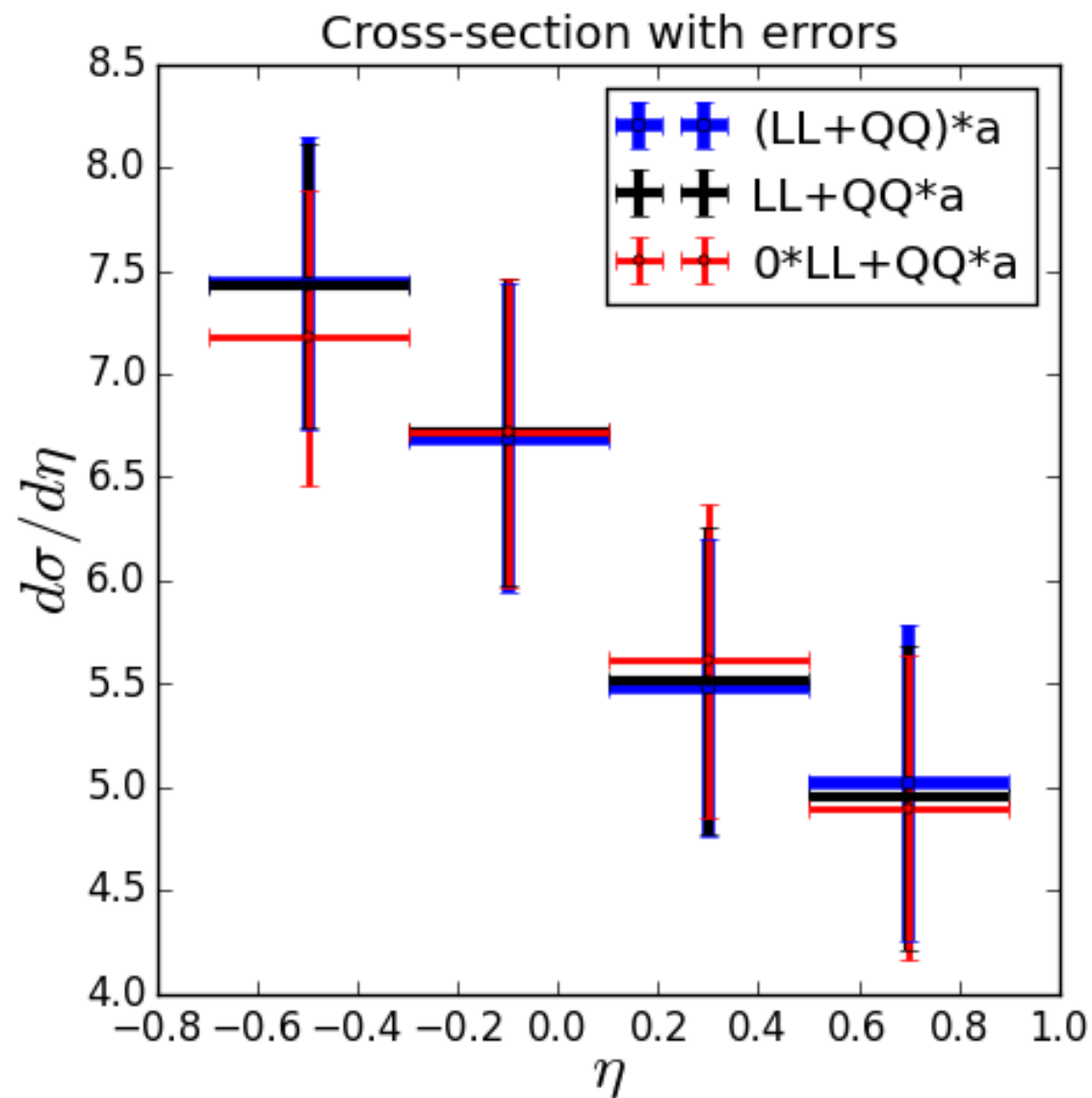
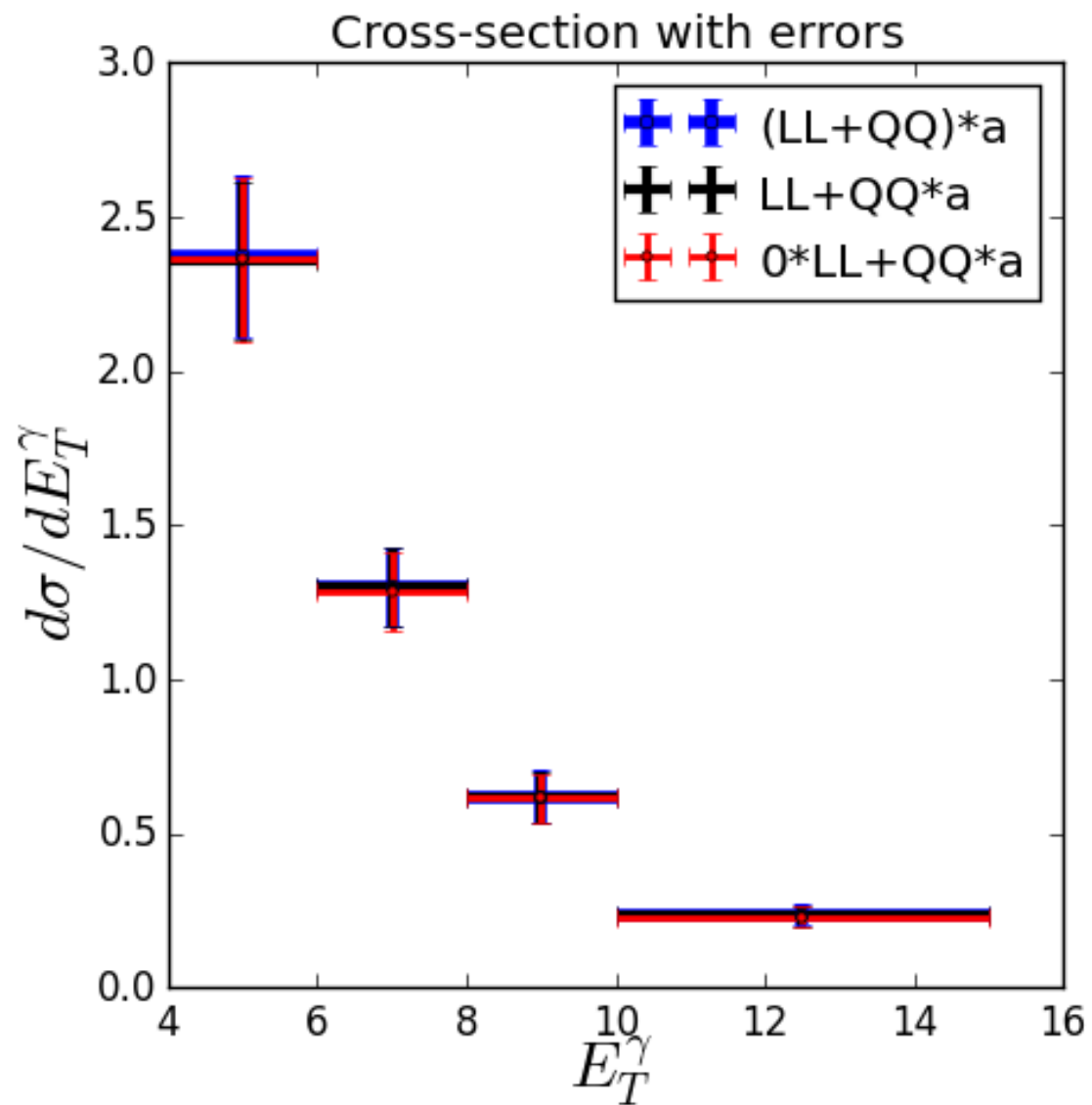
The range is 0 – 20

The chi-squared 2.76

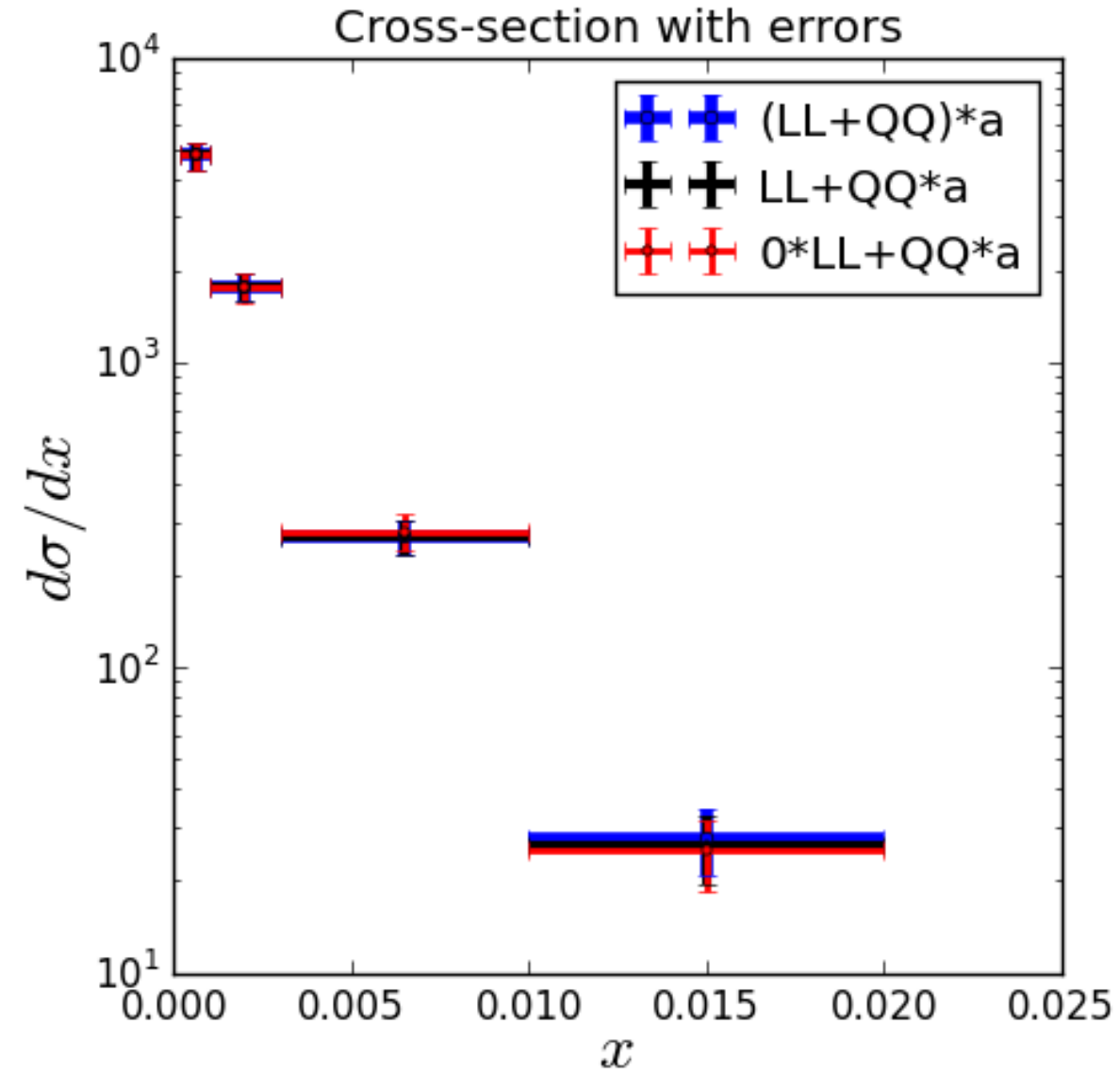
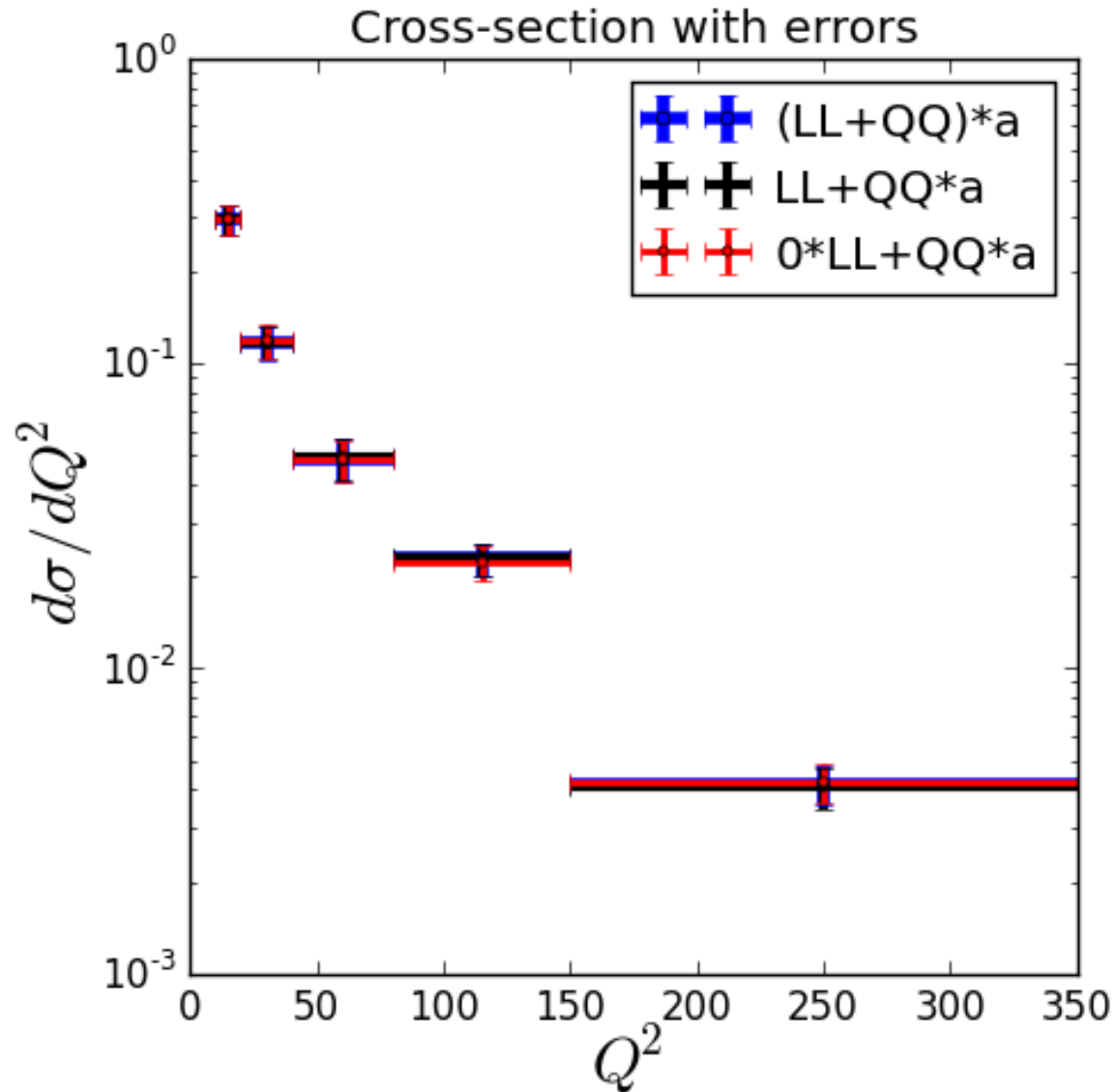


Appendix.

Comparison of fits

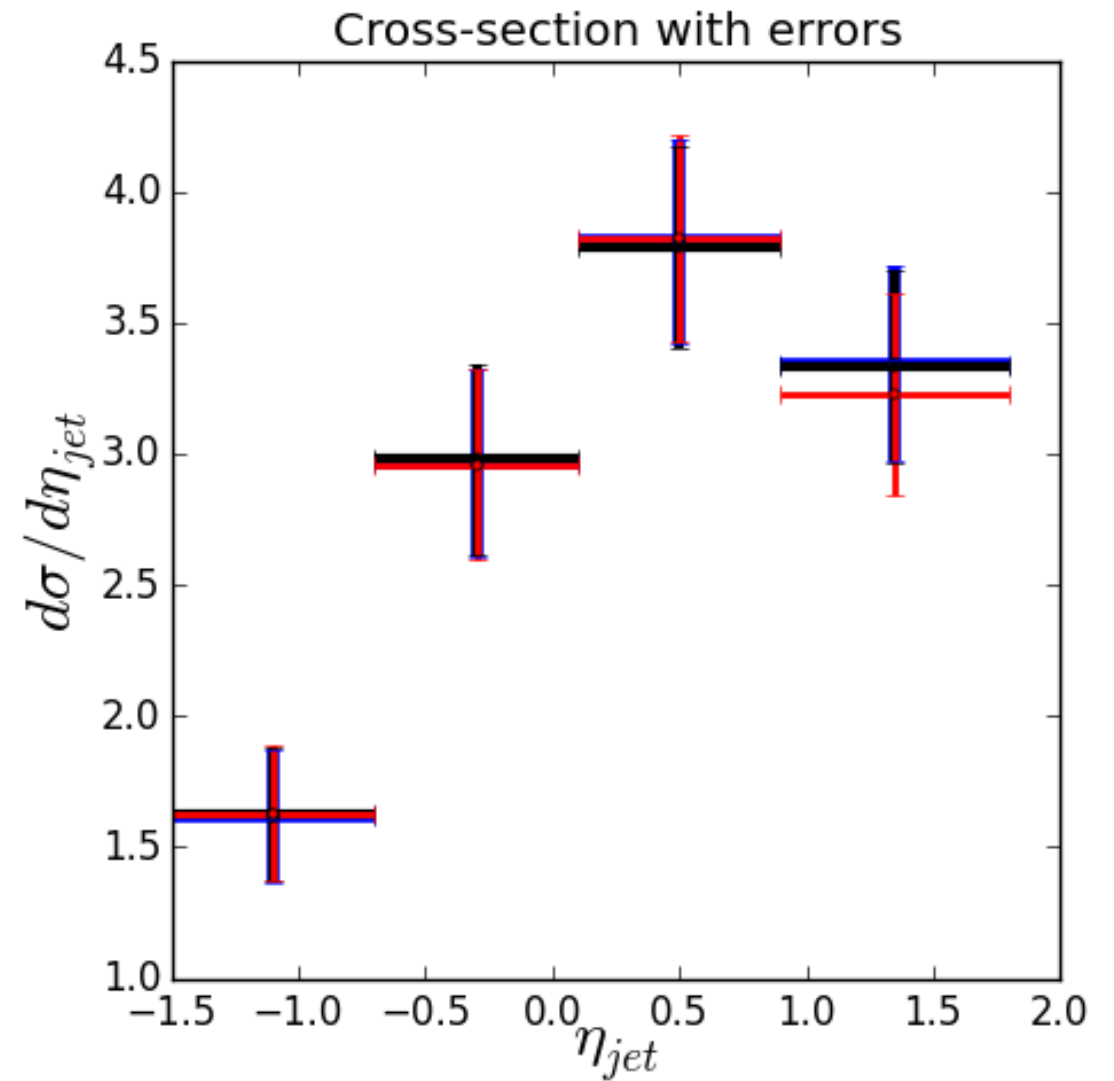
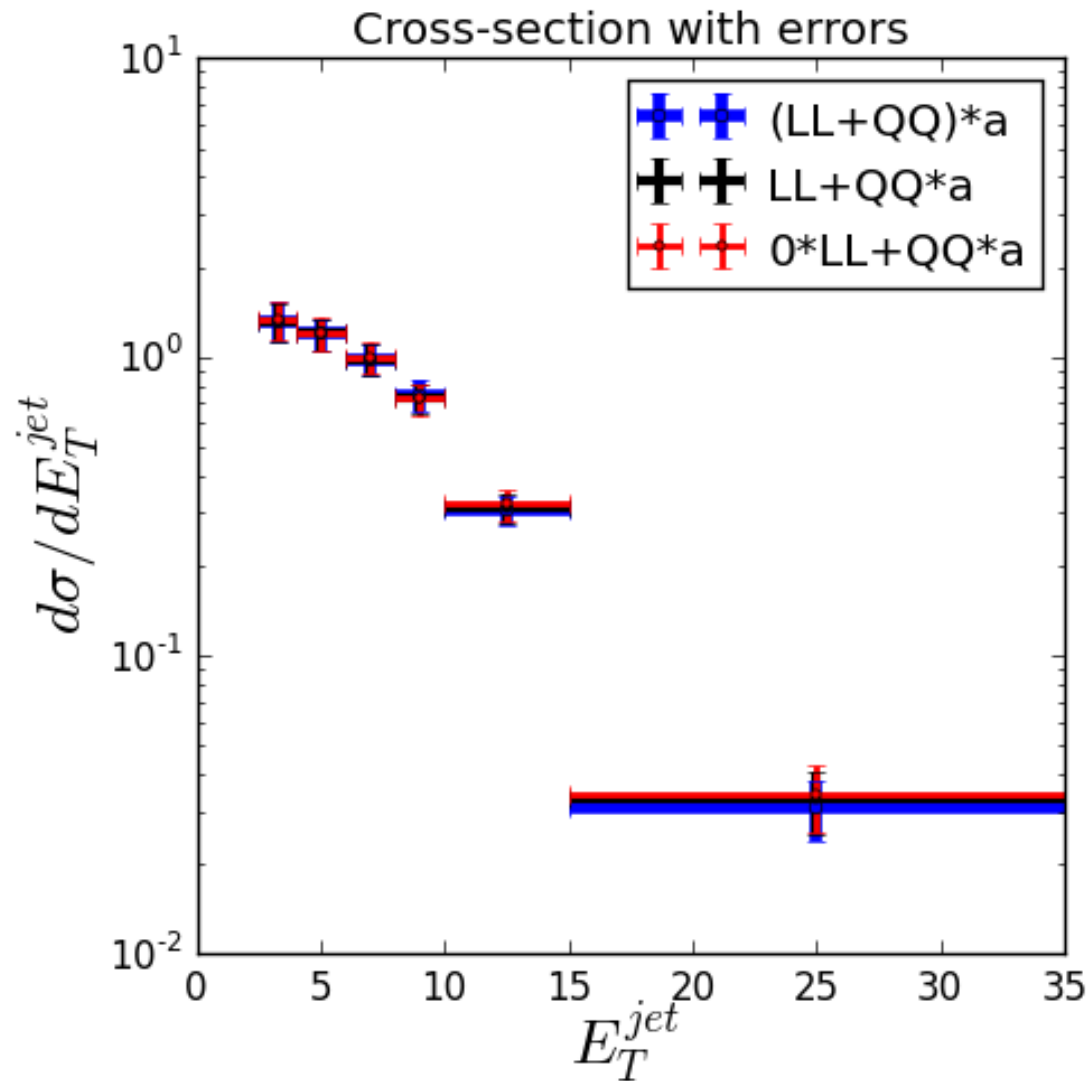


Comparison of fits



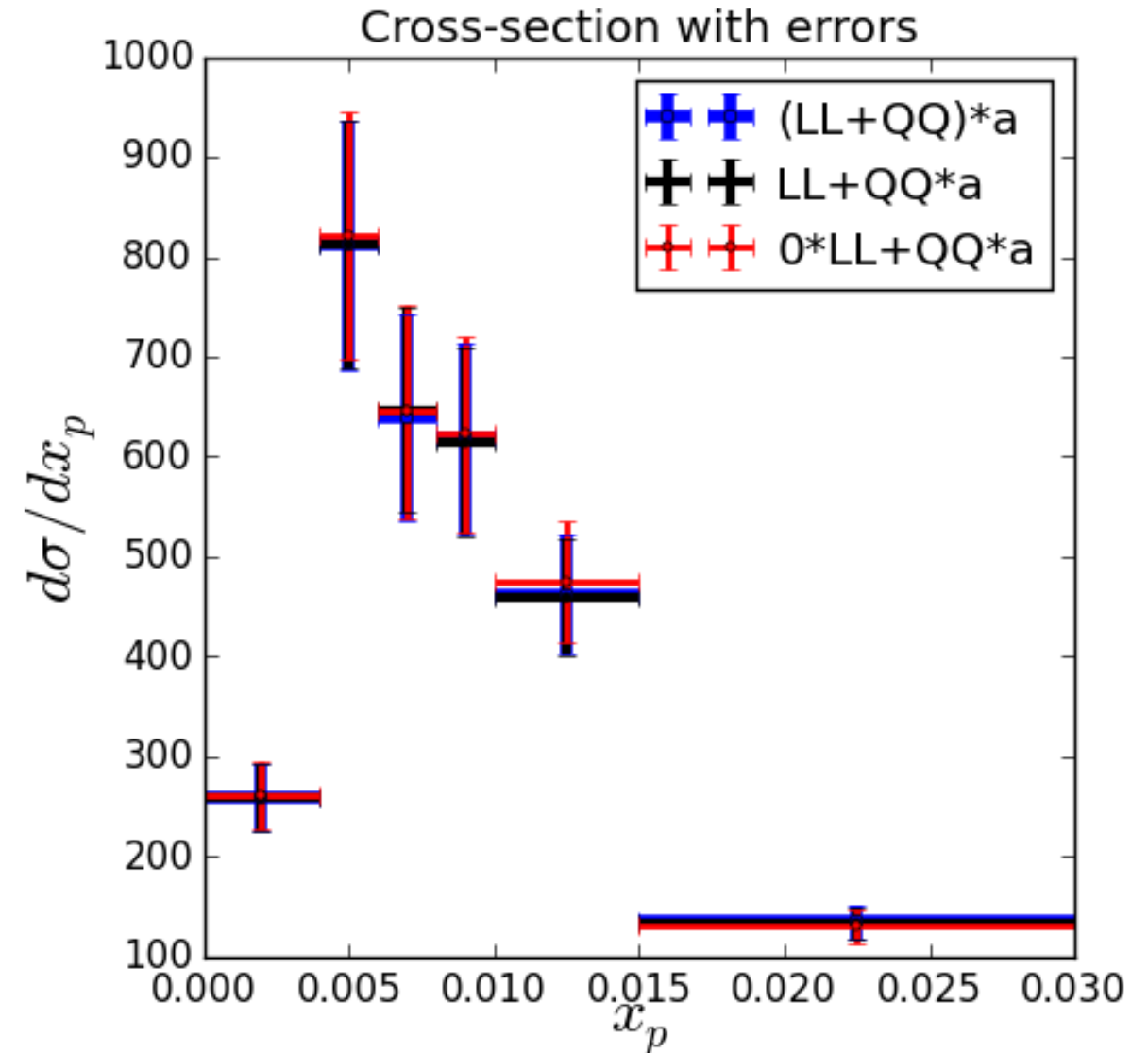
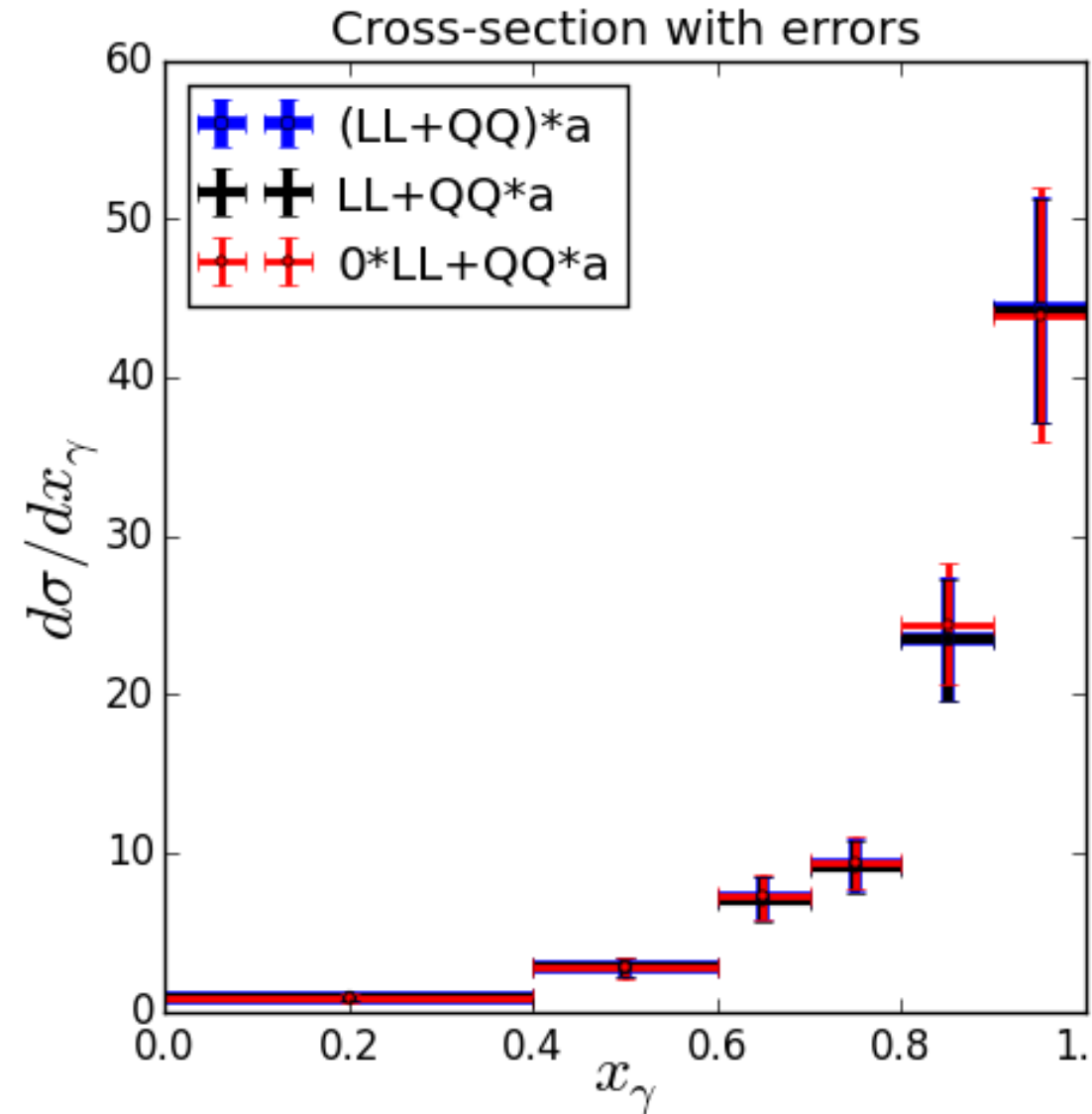
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Comparison of fits

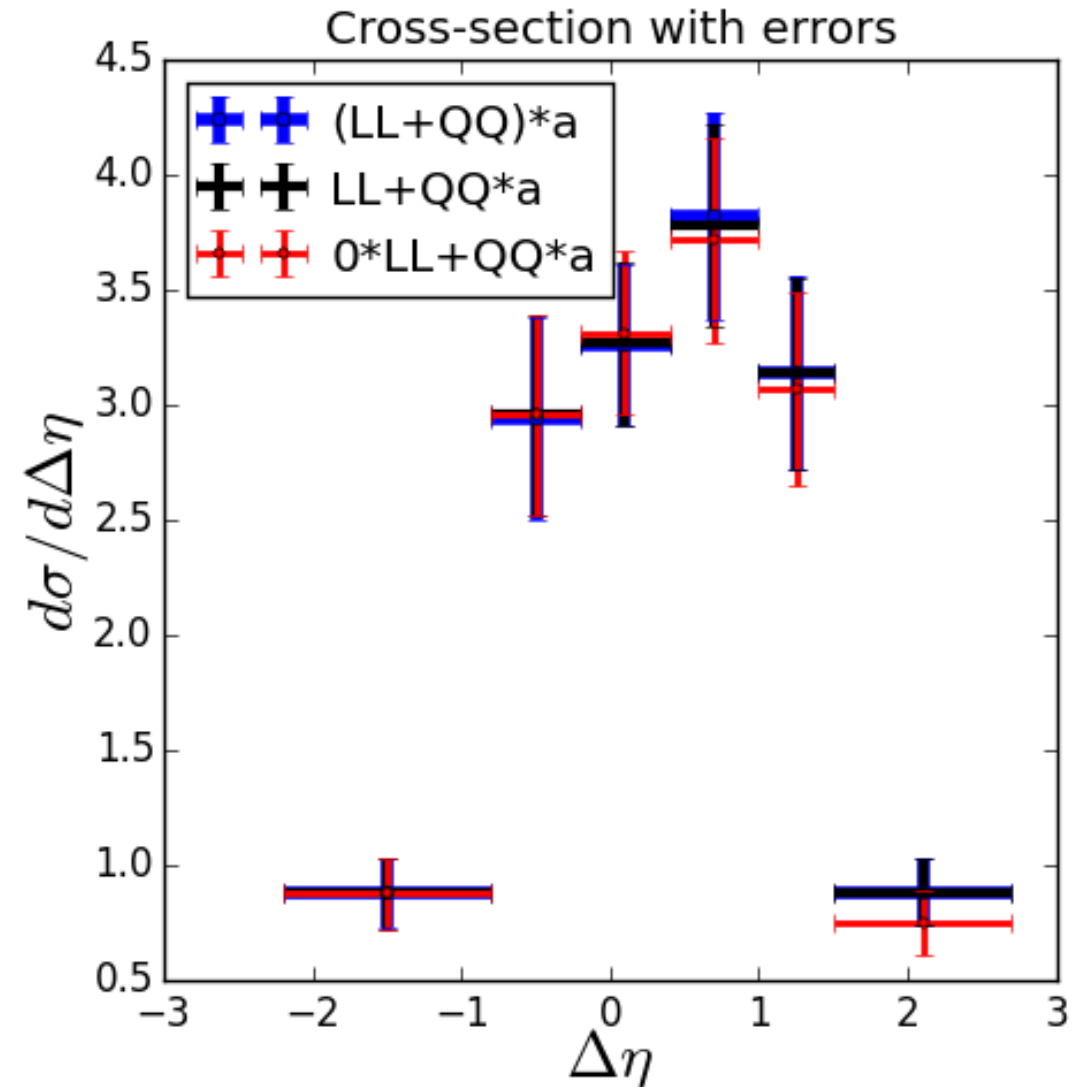
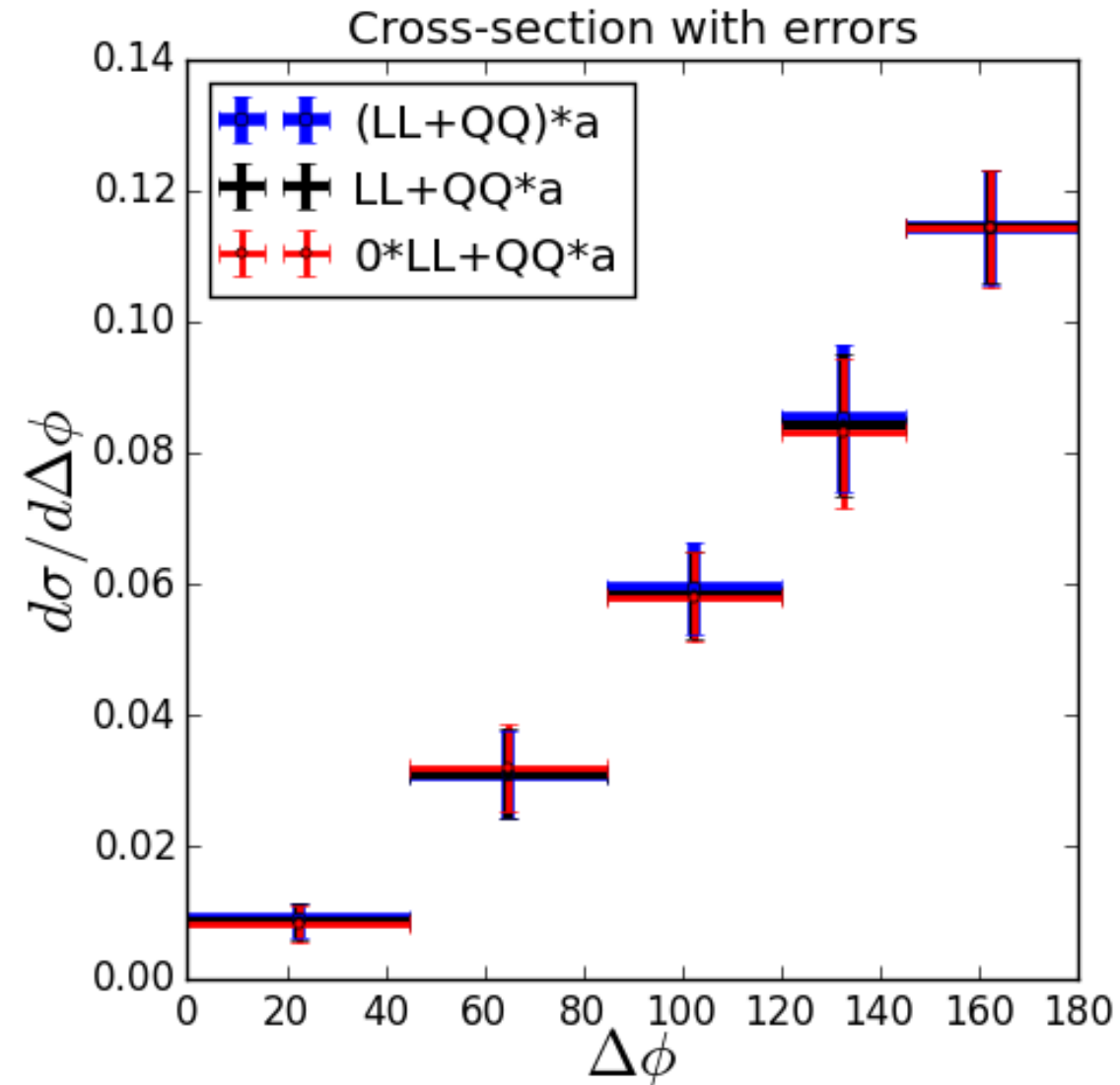


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Comparison of fits

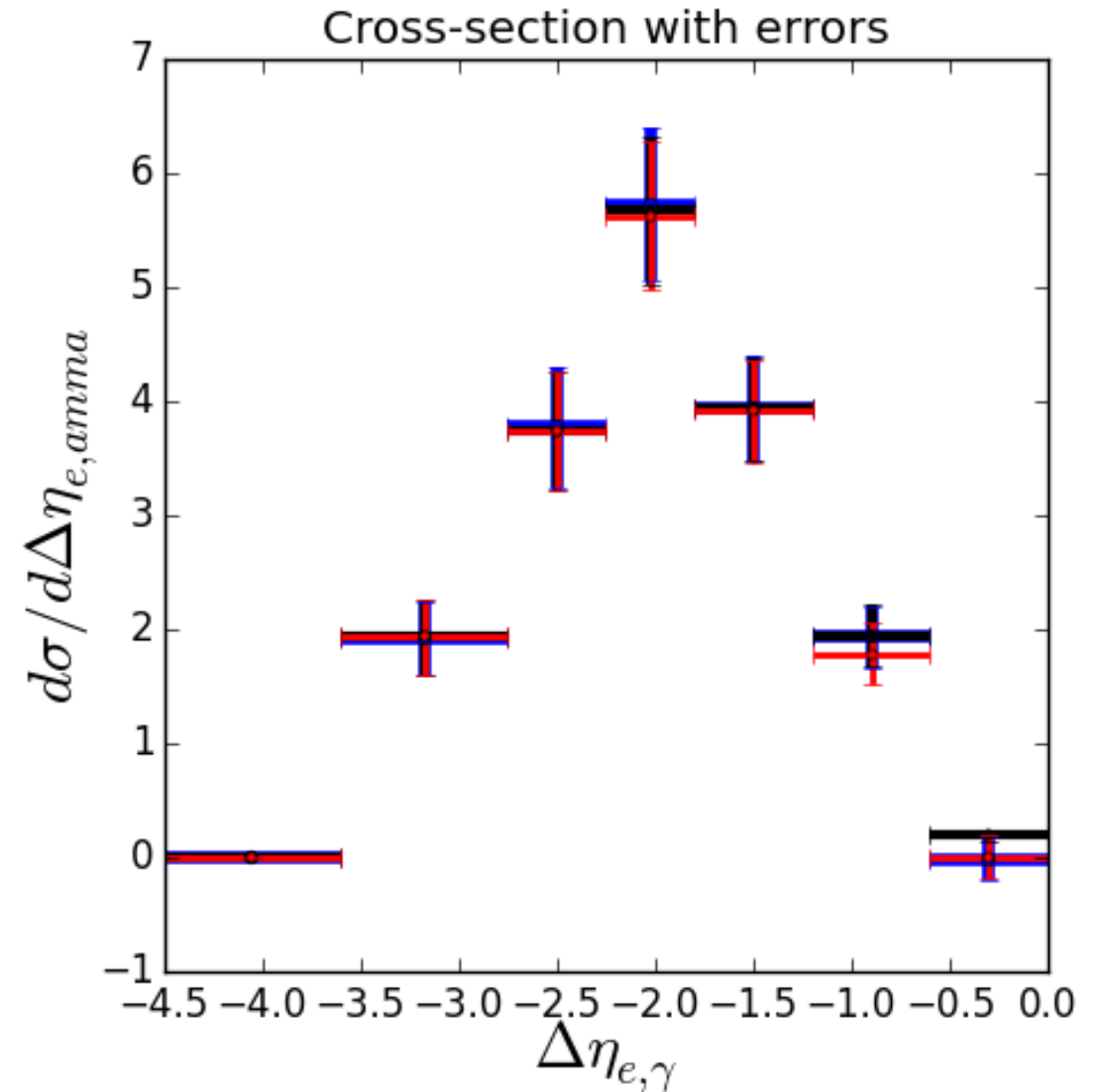
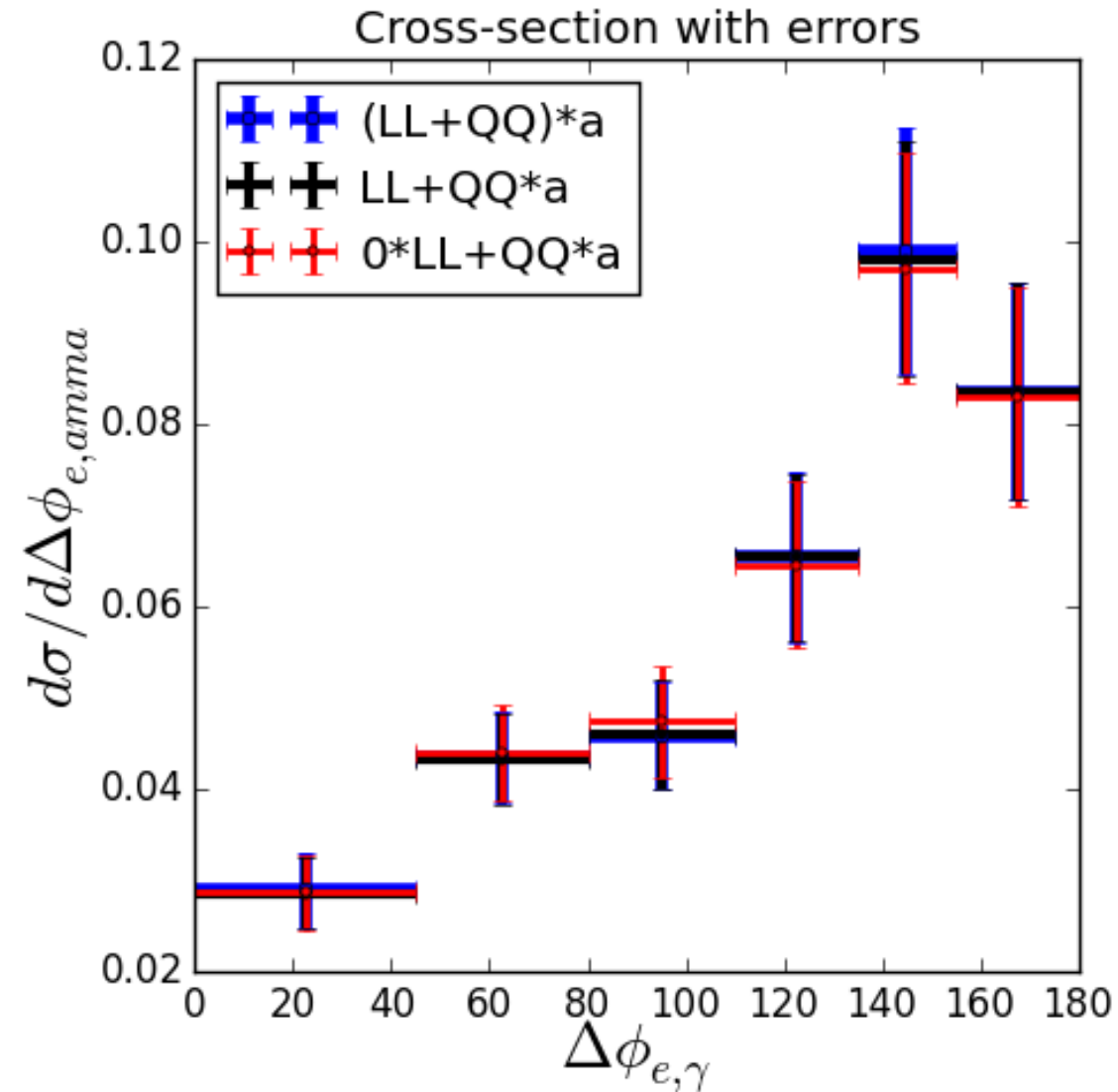


Comparison of fits

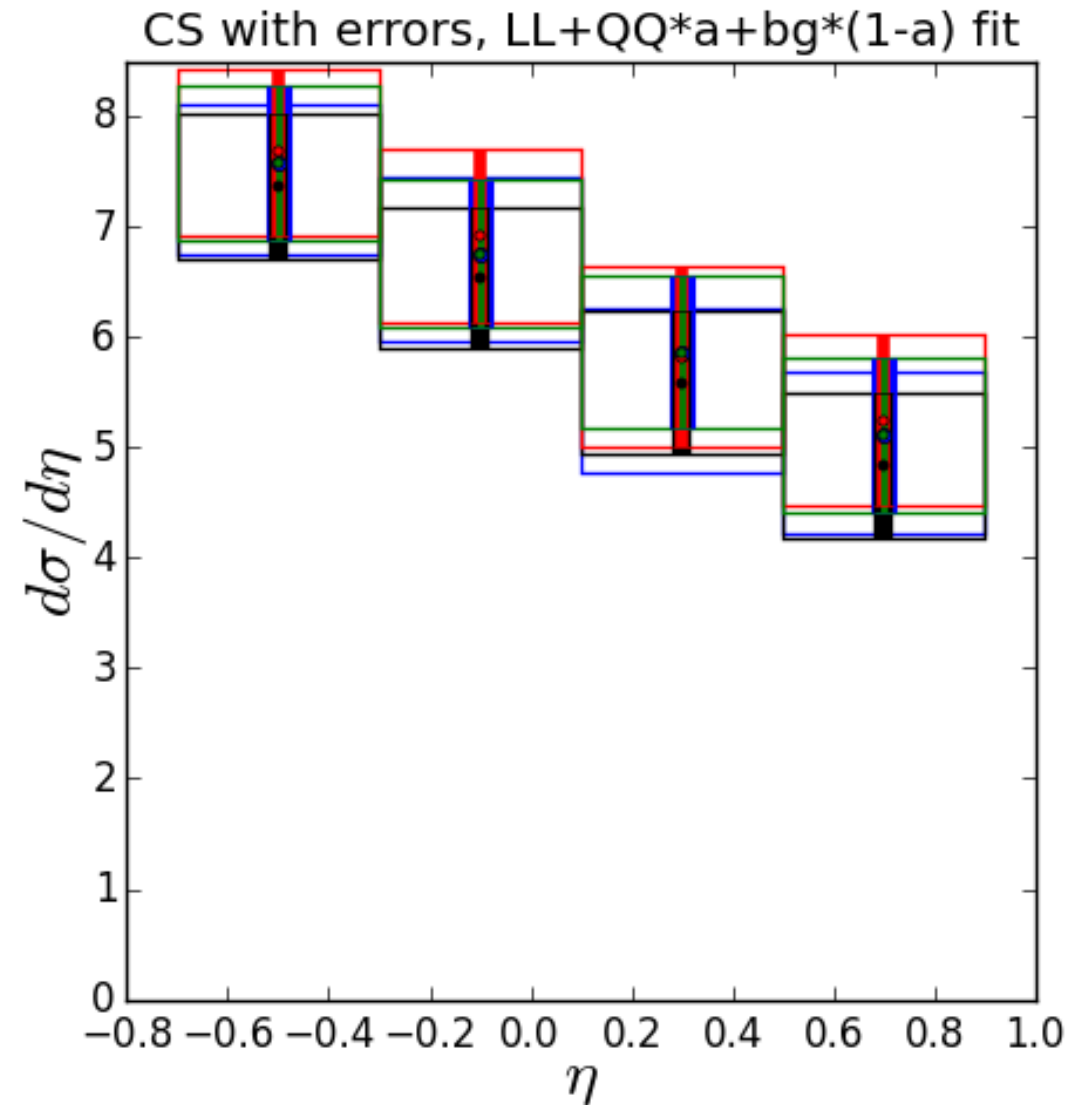
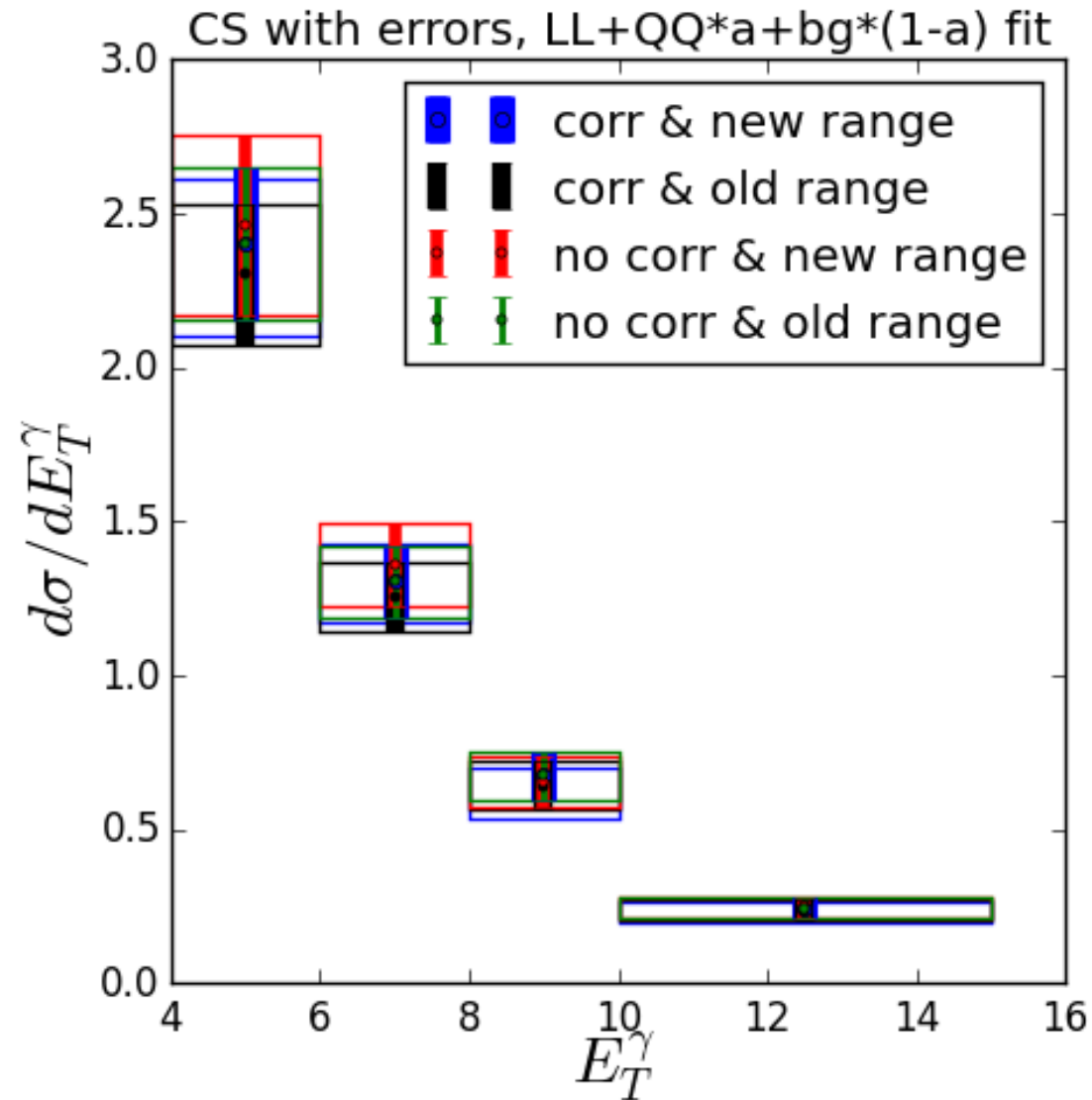


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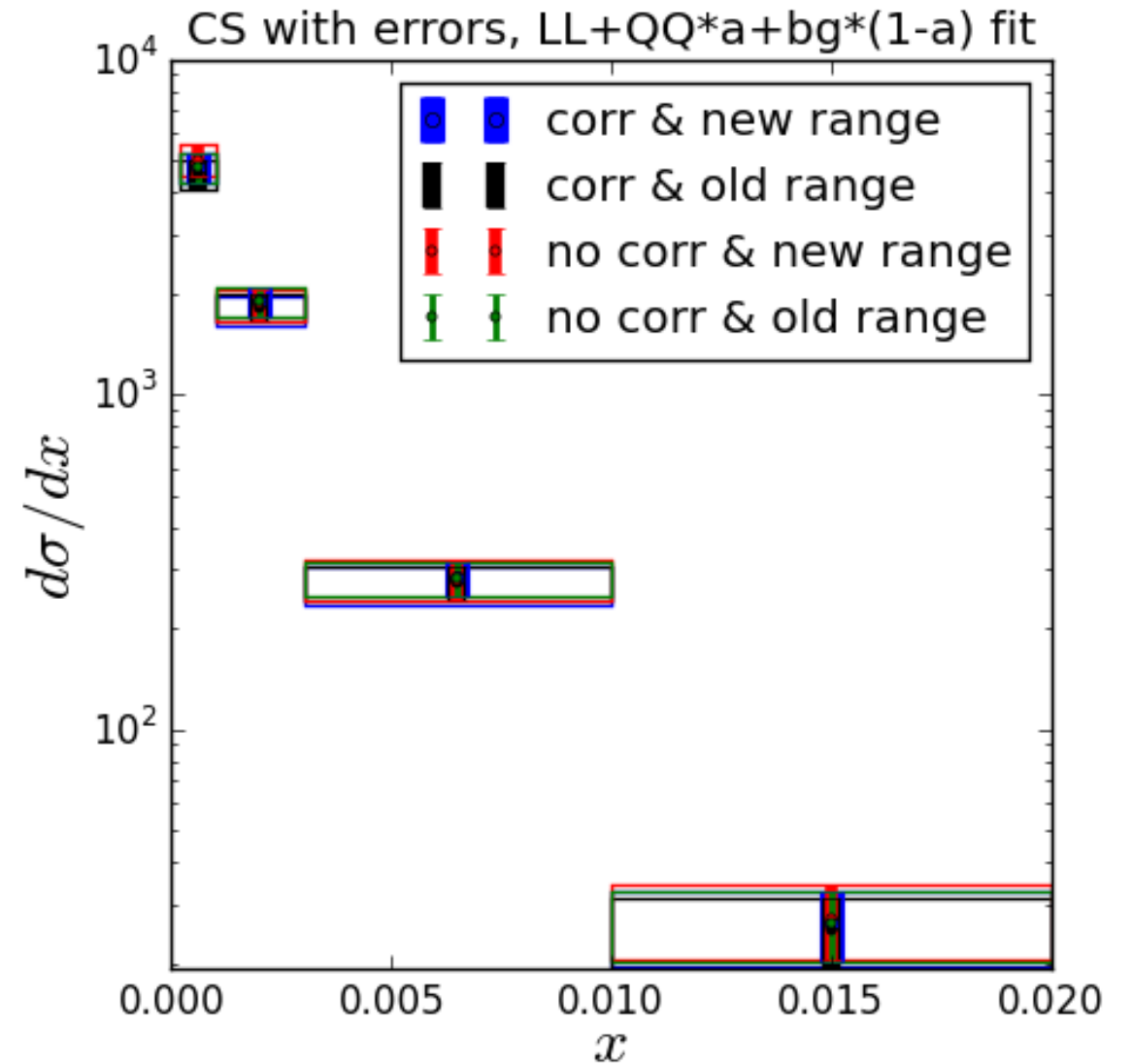
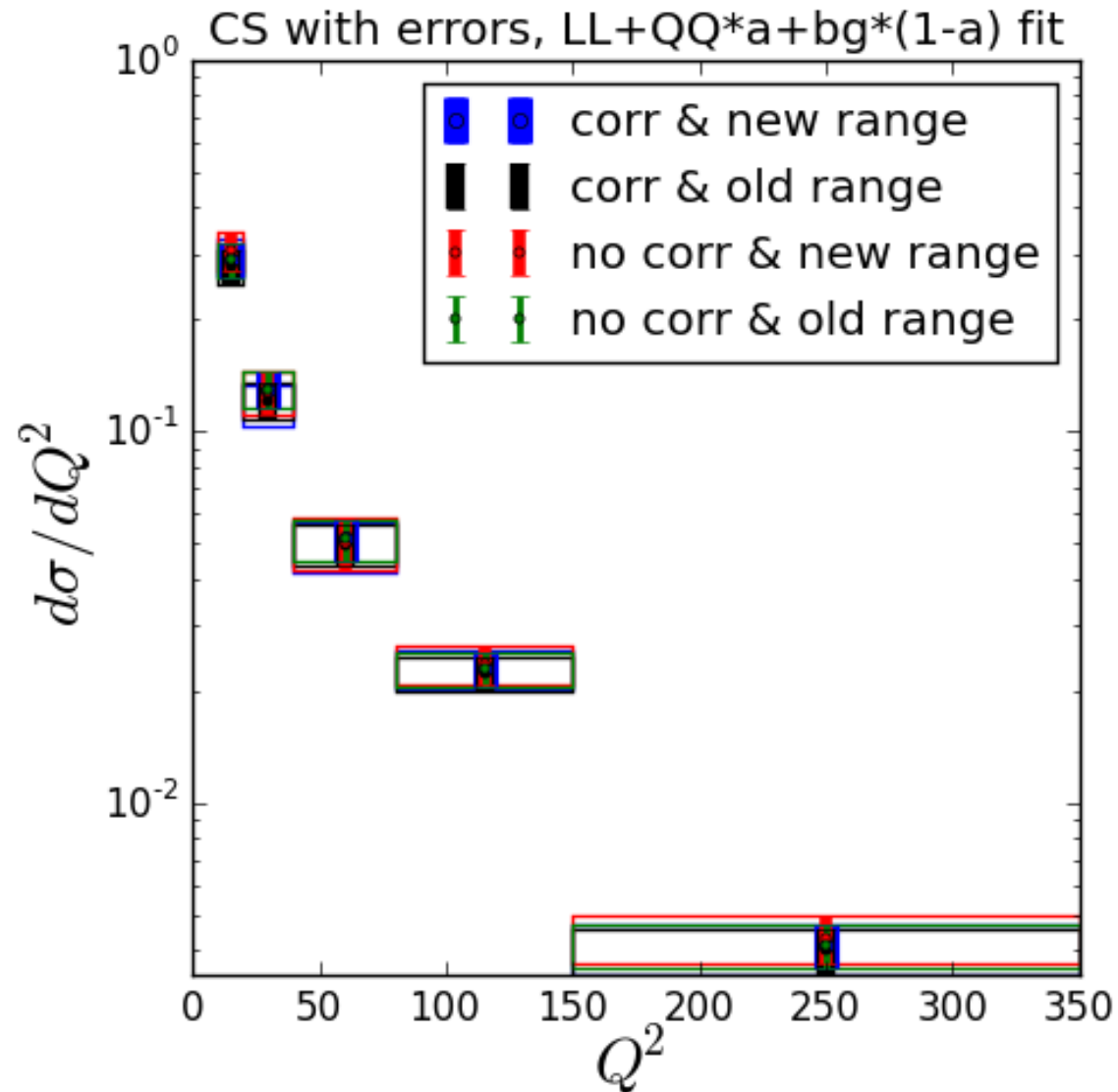
Comparison of fits



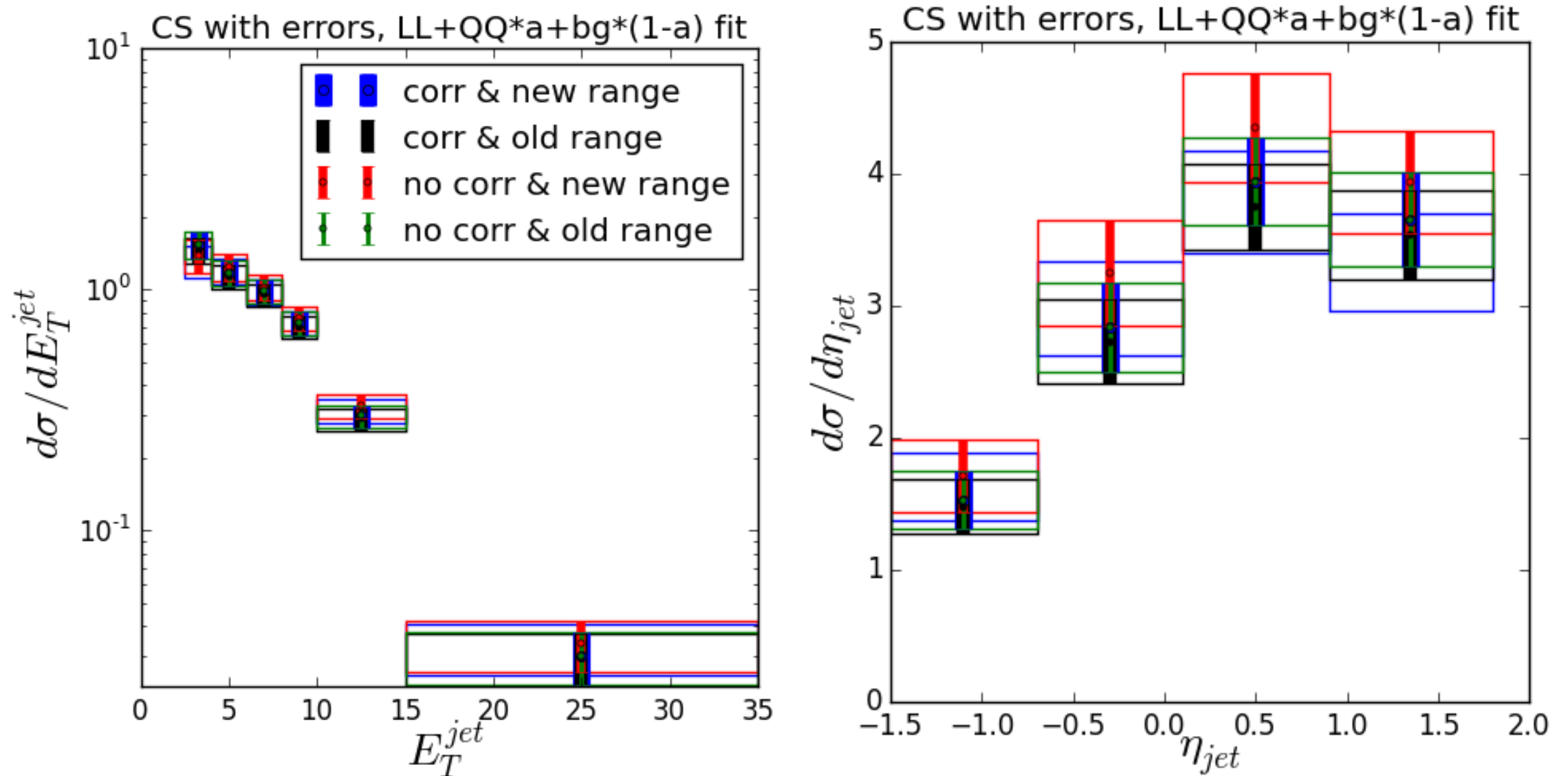
Corrections and new range effects



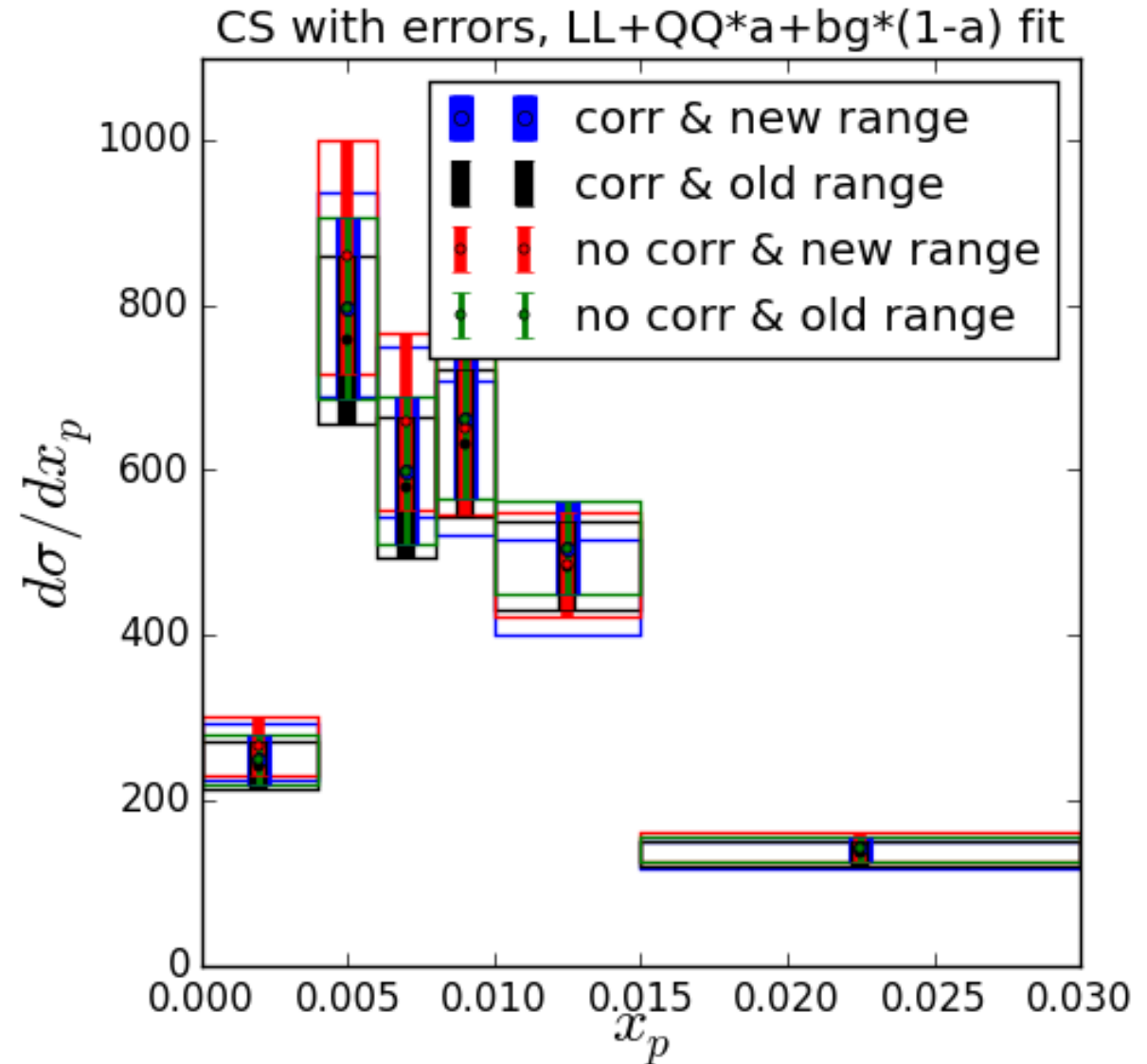
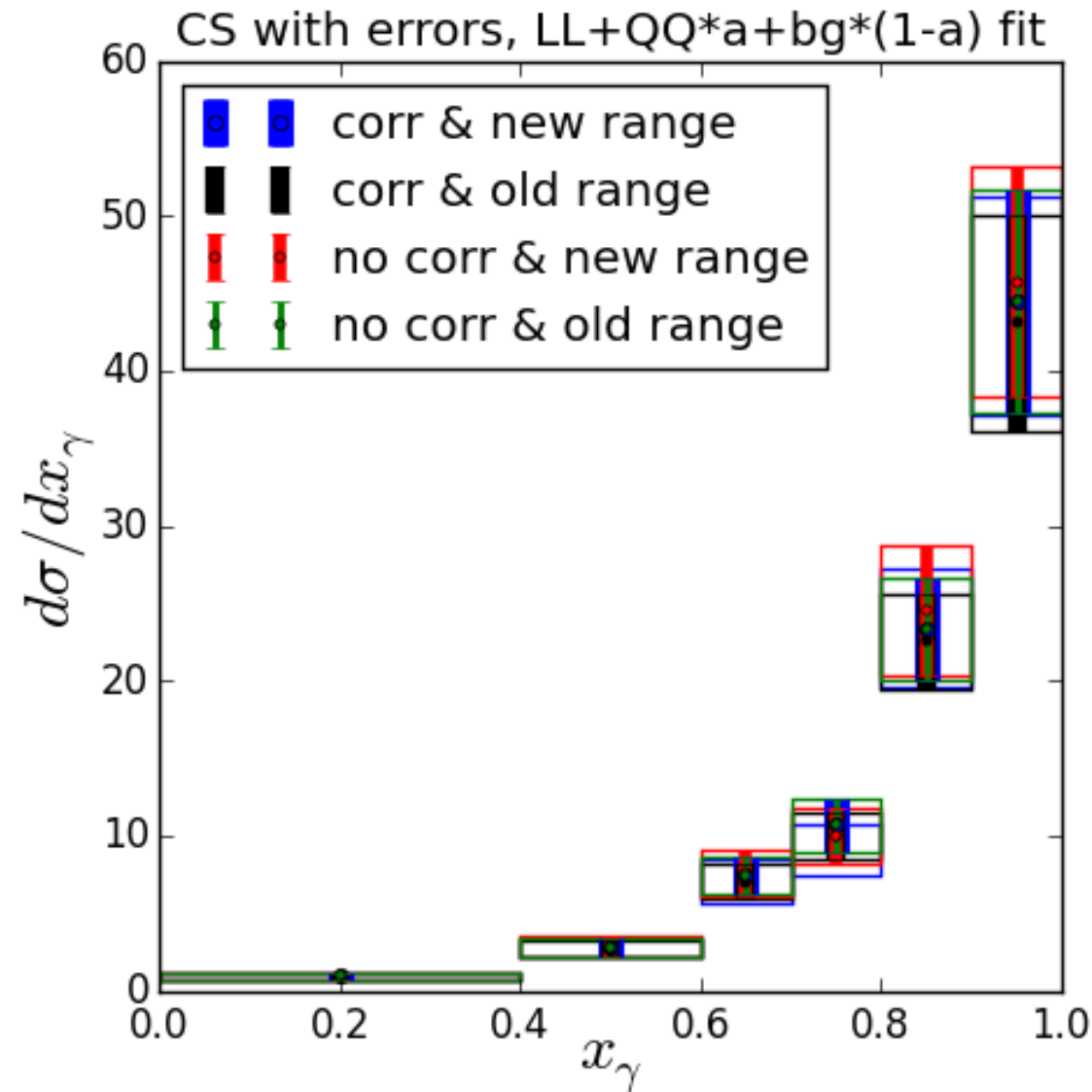
Corrections and new range effects



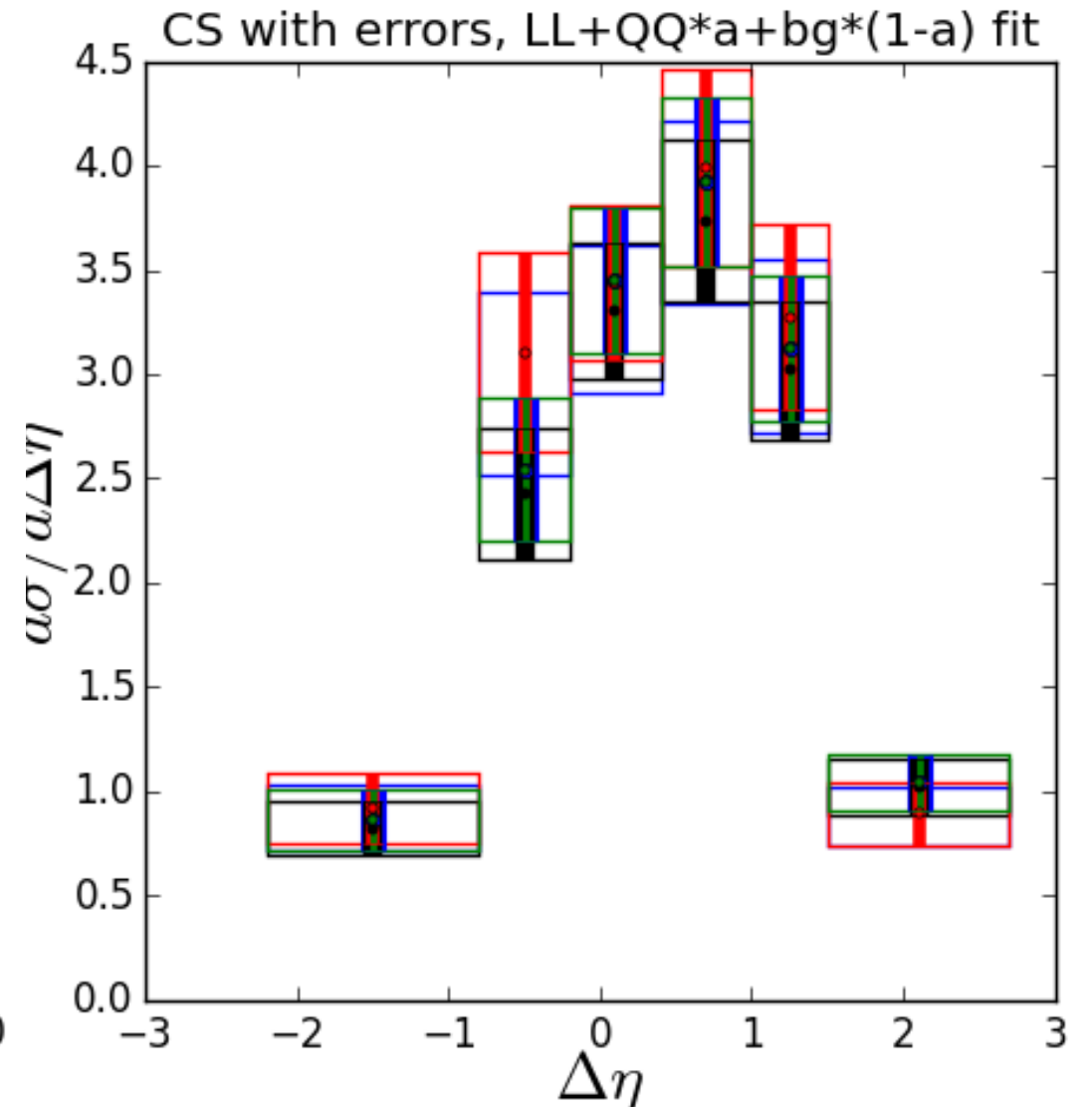
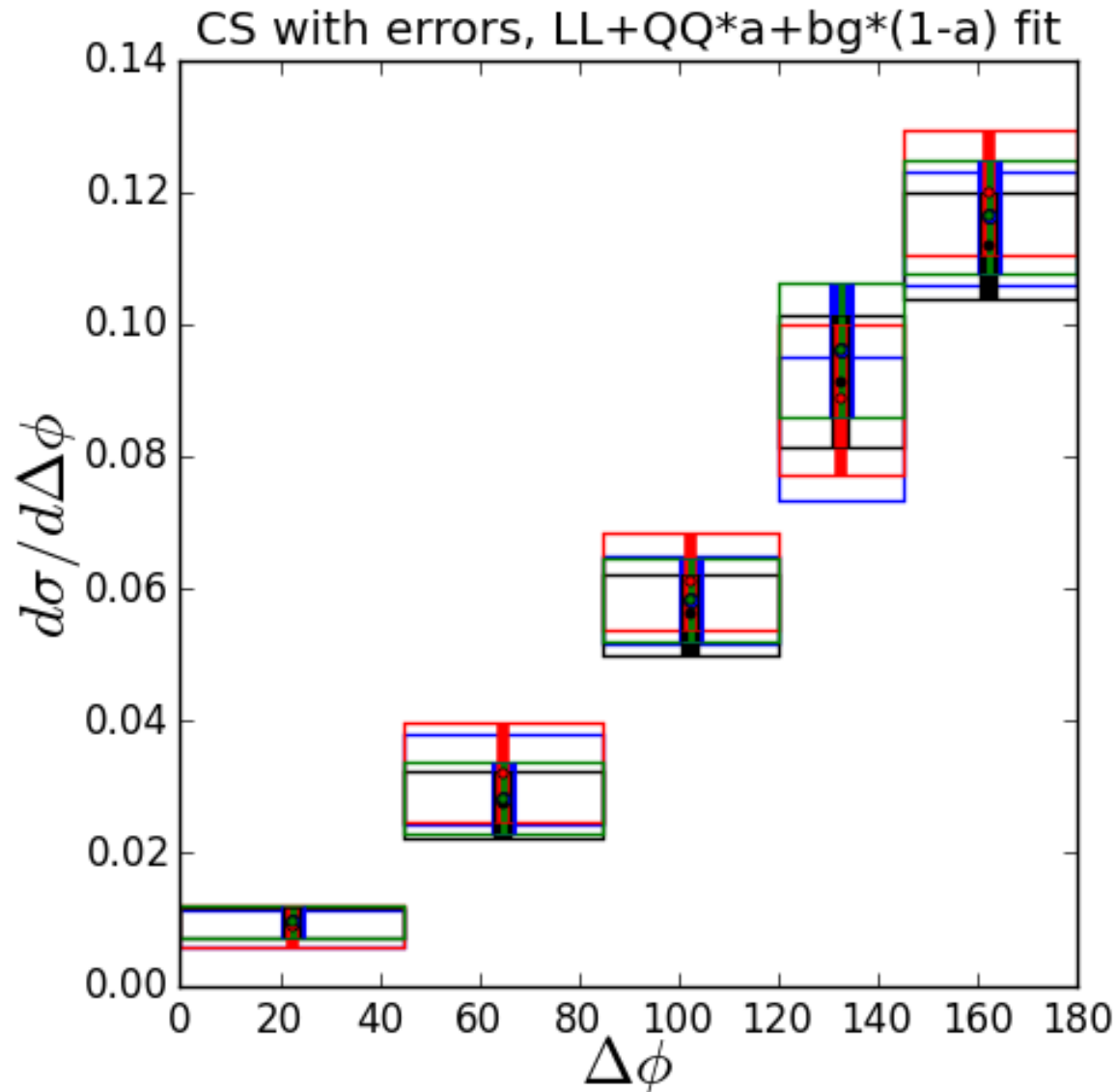
Corrections and new range effects



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Corrections and new range effects

