Update on the feasibility studies of a measurement of Transition Distribution Amplitudes with $\overline{\text{P}}$ANDA

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Electromagnetic Processes
June 24th, 2013

Outline

Transition Distribution Ampliltudes approach: reaction $\bar{p}p \to \gamma^\star \pi^0 \to e^+e^+\pi^0$

$\bar{p}p \to \gamma^\star \pi^0 \to e^+e^+\pi^0$ admits QCD collinear factorisation in terms of Distribution Amplitudes and Transition Distribution Amplitudes at

- Hard scale: high momentum transfer
- Low transversal momentum for the π^0

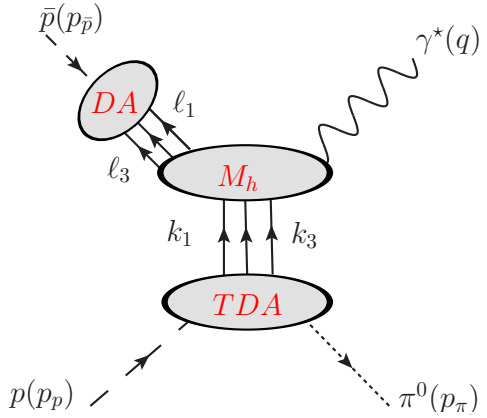
TDA:

- New non-perturbative objects
- Fourier transform of a Matrix Element of a three-quark light-cone local operator
- Transition between a proton and a pion
- Information about the π-cloud in the proton

In CM of $\overline{\text{P}}$ANDA

π^0 backward $\to$ emmited by p

π^0 forward $\to$ emmited by $\bar{p}$



$\bar{p}p \to e^+e^-\pi^0$

Validity of QCD factorization and access to TDAs?

measuring the cross section of $\bar{p}p \to e^+e^-\pi^0$ at different s values

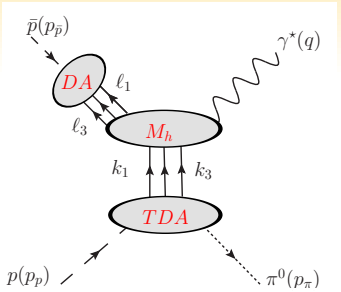
$\to$ kinematics accesible by $\overline{\text{P}}$ANDA

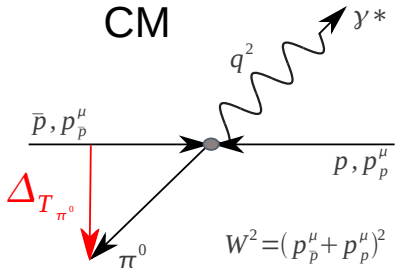
Studies based on: J. P. Lansberg et al., Phys Rev D 76, 111502(R) (2007)

Simulation of $\bar{p}p \to e^+e^-\pi^0$ and $\bar{p}p \to \pi^+\pi^-\pi^0$

Signal: $\bar{p}p \to e^+e^-\pi^0$

- W^2=5 GeV^2 and 10 GeV^2 (W^2=s)
- π^0 Forward and Backward
  $\to$ 4 simulations
- $\frac{d\sigma}{dq^2}$ calculated for π-transverse momentum $\Delta_{T_{\pi^0}} = 0$,
- extrapolated over a $\Delta_{T_{\pi^0}} < 0.5$ GeV and $[q^2_{min}, q^2_{max}]$[1]

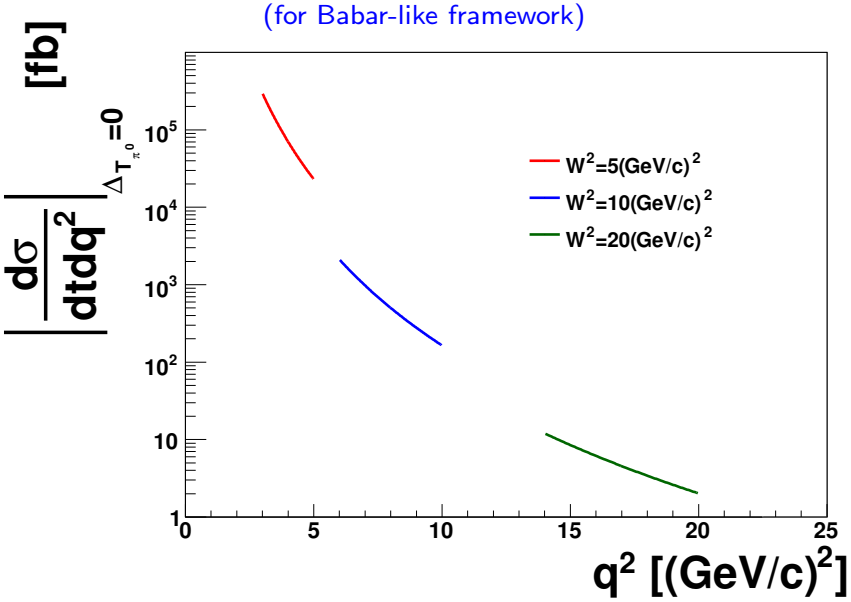




[1] Values for q^2_{min} and q^2_{max} are shown later in slide 6

Input for the Event Generator

(for Babar-like framework)

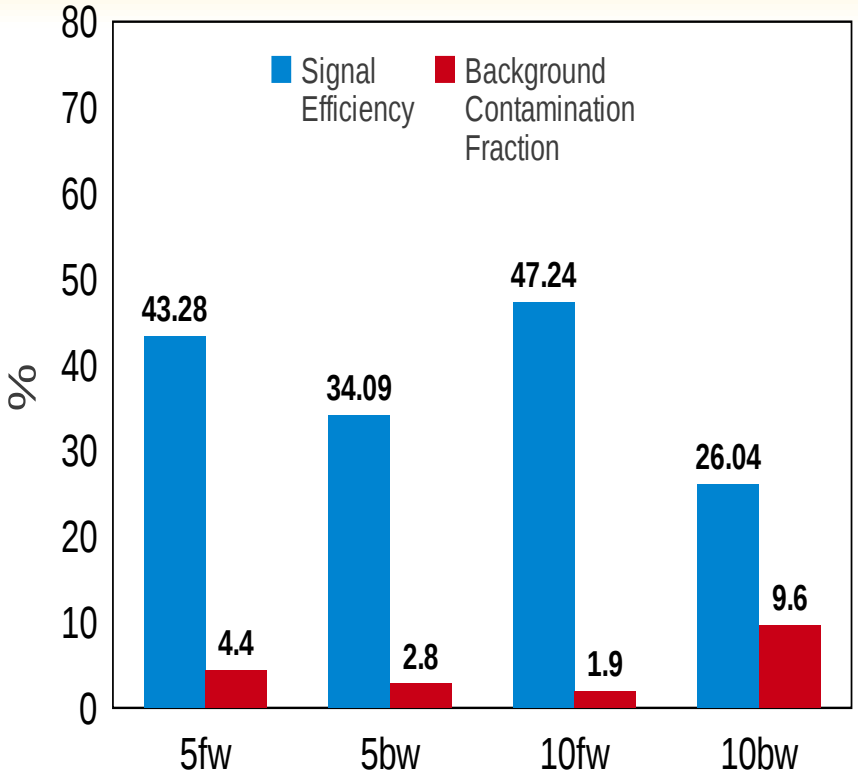


Background: $\bar{p}p \to \pi^+\pi^-\pi^0$

- No data
- The same angular distribution as the signal
- Cosidered to be 10^6 times higher

Last Report

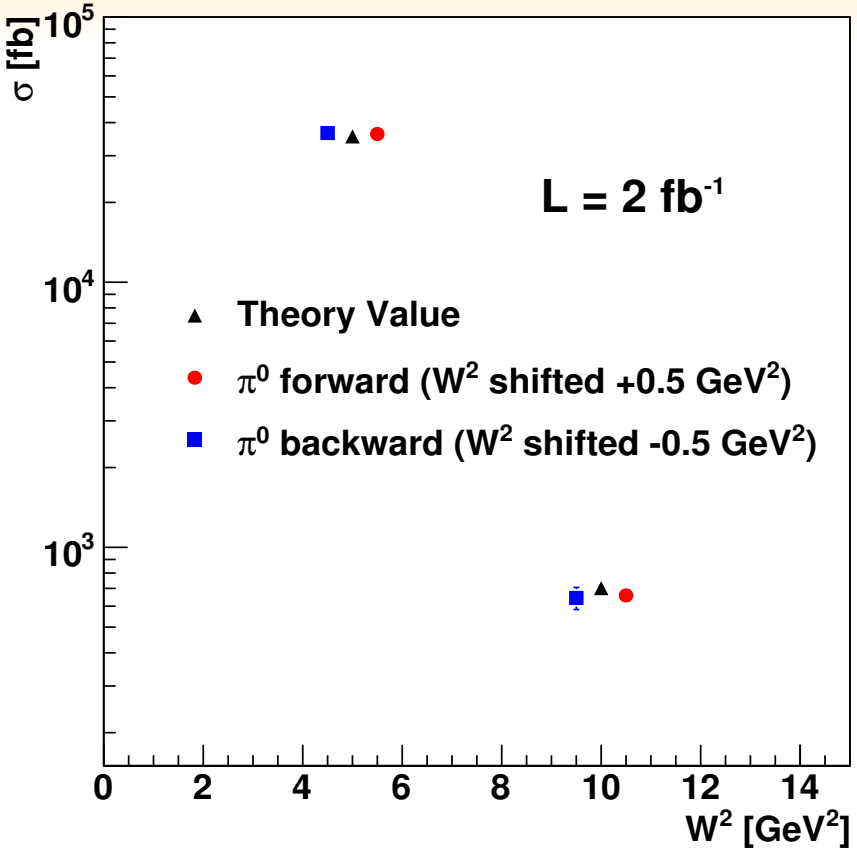
(M.C. Mora Espí, Panda Meeting - EMP session, Dez 2012)



W^2 and π^0 direction

Global Background Suppression: 10^8

NEW: Background Suppression Study bin per bin



Previously: σ_{Sg} calculated in an unphysical $\Delta_{T_{\pi^0}}$ → Rate overestimation

NEW: Signal simulation with correct σ_{Sg} calculation and rate

Reaction reconstruction

Event selection: Combinations of $\pi^0 + e^+ + e^-$ candidates per event

- Particle identification cuts (PID):
  - Different cuts on the particle identification probability
- Kinematical fit:
  - Cuts on the confidence level for a track fit with π or e hypothesis

Kinematic region selection

- q^2 cuts in the region in which the cross section is integrated

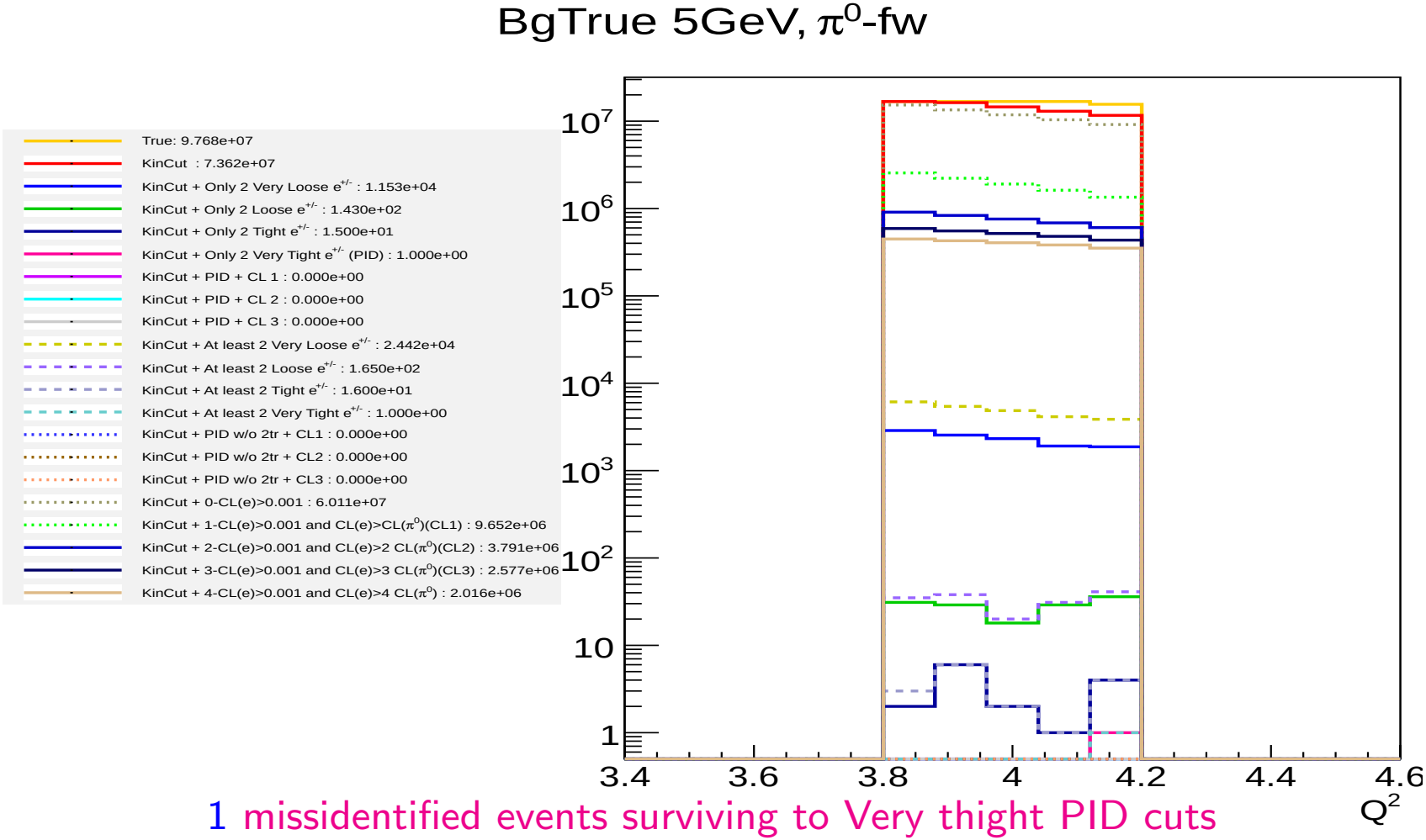
	$W^2 = 5\,\mathrm{GeV}^2$	$W^2 = 10\,\mathrm{GeV}^2$
Simulation limits	$3.61 < q^2 < 5.29$	$5.76 < q^2 < 9.18$
Analysis limits	$3.8 < q^2 < 4.2$	$7.00 < q^2 < 8.00$
Expected Statistics	~ 4014	~ 250

- $|cos\theta_{\pi^0}| > 0.85 \Rightarrow \Delta T_{\pi^0} < 0.5\,\mathrm{GeV}$ (QCD factorisation)

Effect of the cuts on the Background at $W^2 = 5$ GeV/c^2, π^0 forward

For $W^2 = 5$ GeV/c^2, π^0 forward: $9.77 \cdot 10^7$ events between $[q_{min}, q_{max}]$

10^8 events between $[q_{min}, q_{max}]$ in each case



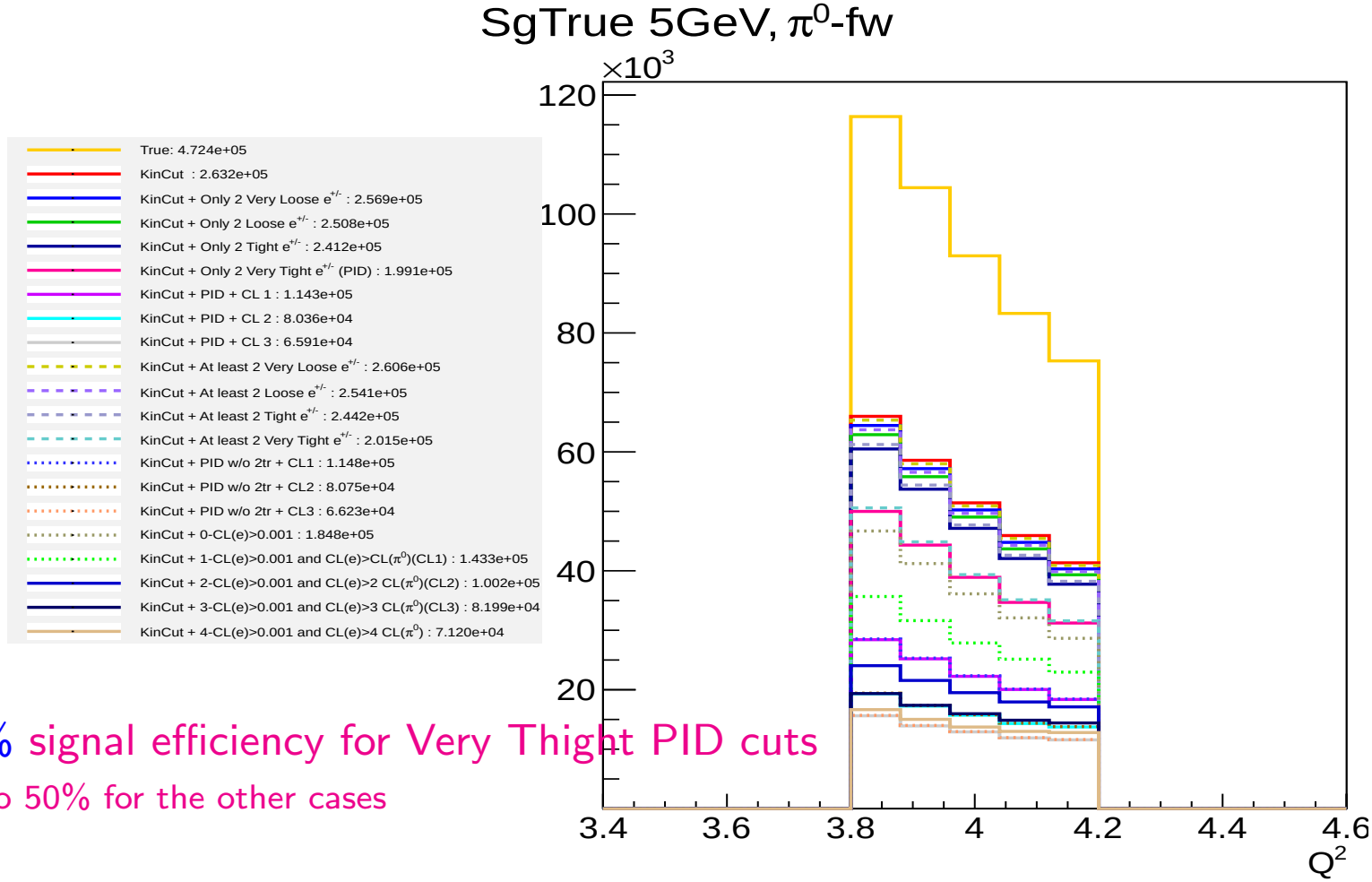
1 missidentified events surviving to Very thight PID cuts

0 or maximum 1 missidentified Bg events for the other cases

Effect of the cuts on the Signal at $W^2 = 5$ GeV/c^2, π^0 forward

10^6 events for Efficiency Studies

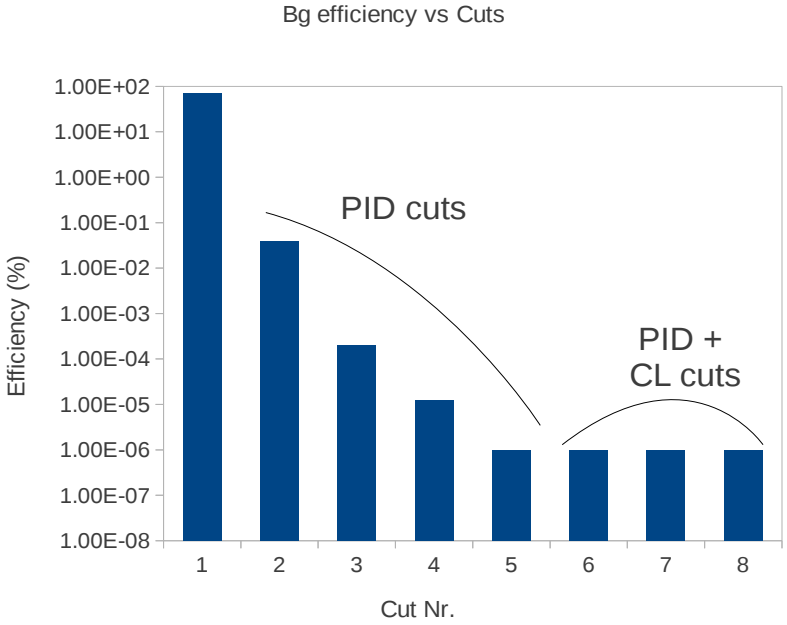
285 simulated events between $[q_{min}, q_{max}]$ at $W^2 = 5\,\text{GeV}^2$
4143 simulated events between $[q_{min}, q_{max}]$ at $W^2 = 10\,\text{GeV}^2$
For the analysis: Based on σ calculation and $\mathcal{L} = 2\,\text{fb}^{-1}$

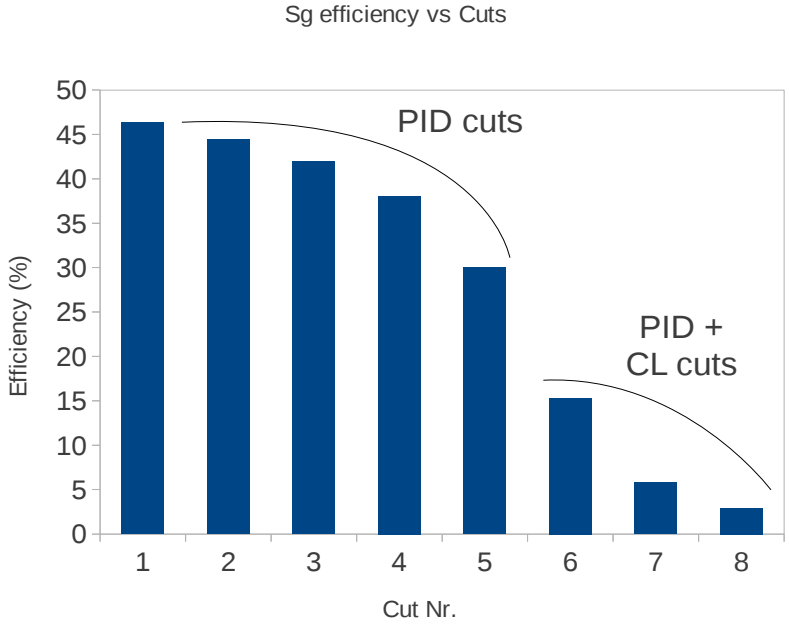


20% signal efficiency for Very Thight PID cuts

up to 50% for the other cases

Efficiency and Signal Significance





The confidence level cuts suppress a lot of Signal and do not help with the background suppression

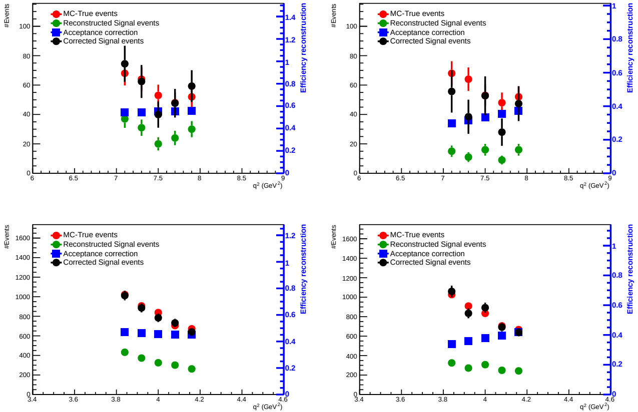
Maximum Signal Significance $\left(S_{Sg} = \frac{N_{Sg}}{N_{Sg}+N_{Bg}}\right)$ used to select the best cut

Best Cut $\rightarrow$ PID+q^2 cuts: Only 2 Very Loose $e^{+/-} + q^2_{min} < q^2 < q^2_{max}$

Bg Suppression: 10^8 Signal efficiency: 20 - 50 %

Measurement of σ and comparison with the Theory

Carl Zeiss Stiftung



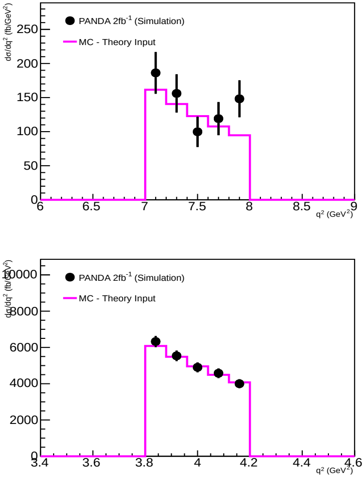
Only Signal Statistical Errors included (!!!)

A measurement of σ is feasible with $\overline{\mathrm{P}}$ANDA

at $W^2 = 5\,\mathrm{GeV}^2$ and $W^2 = 10\,\mathrm{GeV}^2$

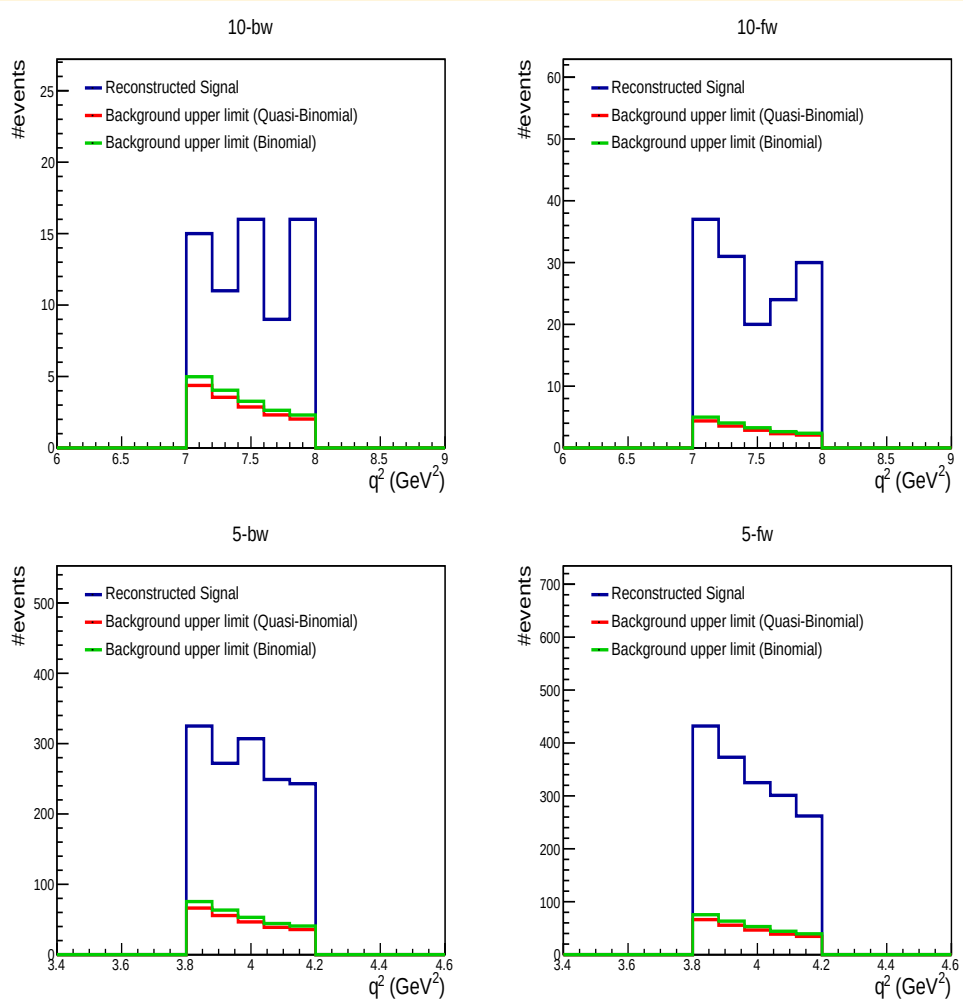
Cross Section

Carl Zeiss Stiftung



The Signal errors have to be modified to take into account the background contamination

Background vs. Reconstructed Signal



Upper limit for Background contamination

for 0 or 1 missidentified events in the simulation

$$N_{Bg} = \epsilon_{Bg}(10^6 \cdot \sigma_{Sg}^{Theo})\mathcal{L}$$

Two approaches for ϵ

Quasi-Binomial[2] with 1σ CL (67.3%)

$$\epsilon_{Bg} = \frac{Reco+1}{True+2} \pm \sqrt{\frac{(Reco+1)(Reco+2)}{(True+2)(True+3)} - \frac{(Reco+1)^2}{(True+2)^2}}$$

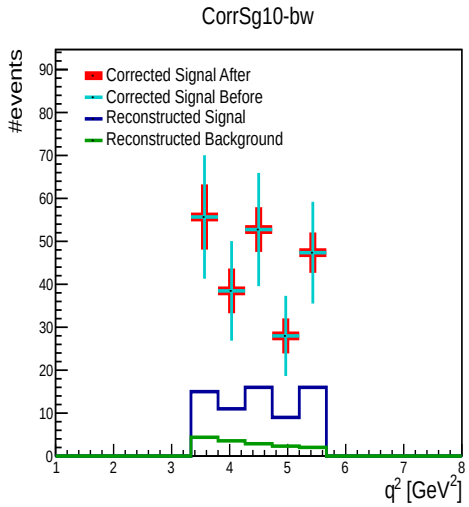
Binomial with 1σ CL (68%)

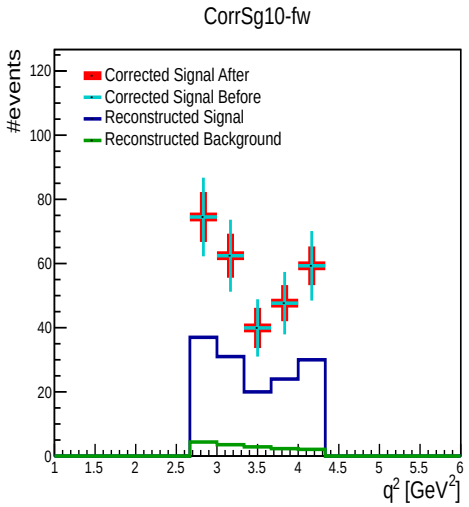
$$\epsilon_{Bg} = -\frac{1}{True}\log CL \pm ?$$

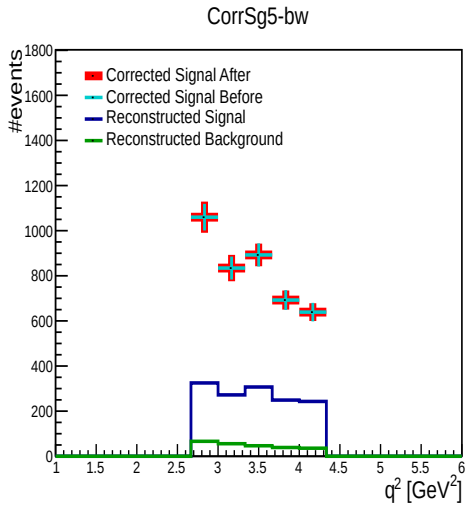
[2] T. Ullrich and Z. Xu,

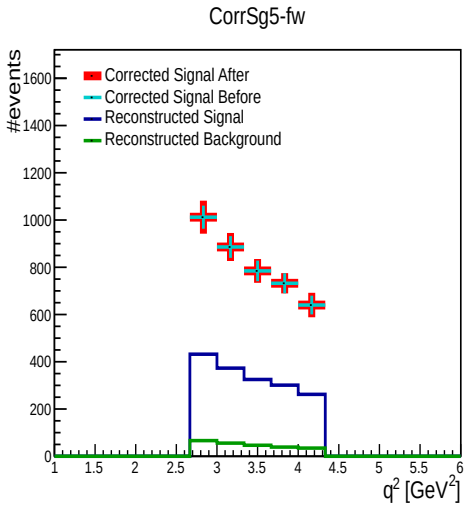
arXiv:physics/0701199v1, 17 Jan 2007

Error in the determination of the Cross Section









Error propagation

$$N_{Sg} = N - N_{Bg}$$

$$(\Delta N_{Sg})^2 = (\Delta N)^2 + (\Delta N_{Bg})^2$$

$$\left(\frac{\Delta N_{Bg}}{N_{Bg}}\right)^2 = \left(\frac{\Delta \epsilon_{Bg}}{\epsilon_{Bg}}\right)^2 + \left(\frac{\Delta \sigma_{Bg}}{\sigma_{Bg}}\right)^2$$

$\Rightarrow$ Why do we get smaller errors after the error propagation calculation?

UNDER INVESTIGATION

Conclusion and Outlook

- The error performed in the calculation of σ_{Sg} has been corrected
- A second analysis for the measurement of $\bar{p}p \rightarrow e^+e^-\pi^0$ $\overline{\text{P}}$ANDA with in the TDA approach is done with improved statistics for signal and background
- A global background rejection of 10^8 is achievable in all cases keeping the signal efficiency above 20%

- The background contamination bin per bin is under study
- The error in the determination of σ_{Sg} is under investigation
- A measurement of the TDA is feasible with $\overline{\text{P}}$ANDA

Thank you