Simulation and analyis of $\bar{p}p \rightarrow e^+e^-\pi^0$ using the TDA approach

with the BaBar-like software

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Computing Session

Outline

Physical processes

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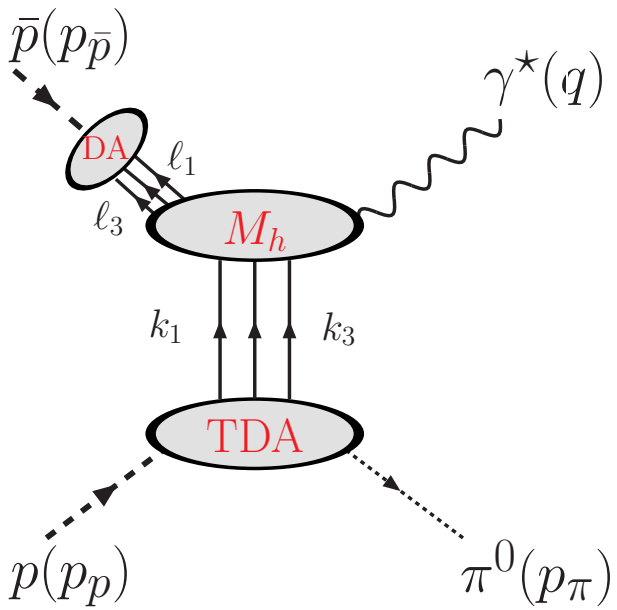
TDA'S APPROACH[1]:



- Study the validity of TDA's: Measuring the cross section of ($\bar{p}p \to e^+e^-\pi^0$) and comparing it with the theory.
- Approach valid at high energies.
- Event generator developed for Babar-like framework.
- Main background process is $\bar{p}p \to \pi^+\pi^-\pi^0$.

[1] J. P. Lansberg et al., Phys Rev D 76, 111502(R) (2007)

Simulation characteristics

- Signal ($\bar{p}p \rightarrow e^+e^-\pi^0$)[2]:
  - W^2=5 GeV^2 and 10 GeV^2 (W^2=s)
  - π^0 Forward and Backward
    $\rightarrow$ 4 simulations
  - Theoretical cross section calculated for $\Delta_{T_{\pi^0}} = 0$...
  - ... integrating over a $\Delta_{T_{\pi^0}} < 0.5$ GeV
- Background ($\bar{p}p \rightarrow \pi^+\pi^-\pi^0$):
  - $\pi^+\pi^-\pi^0$ the same angular distribution as the signal.
  - We assume a background cross section 10^6 times higher than signal

[2] Based on J.P. Lansberg Phys Rev D 76, 111502(R) (2007)

Number of true events simulated

	Reaction	$W^2(\,\mathrm{GeV}^2)$	π^0	N_{events}
Background suppression	$\pi^+\pi^-\pi^0$	5	forward	$\approx 10^8$
	$\pi^+\pi^-\pi^0$	5	backward	$\approx 10^8$
	$\pi^+\pi^-\pi^0$	10	forward	$\approx 10^8$
	$\pi^+\pi^-\pi^0$	10	backward	$\approx 10^8$
Efficiency studies	$e^+e^-\pi^0$	5	forward	$\approx 10^6$
	$e^+e^-\pi^0$	5	backward	$\approx 10^6$
	$e^+e^-\pi^0$	10	forward	$\approx 10^6$
	$e^+e^-\pi^0$	10	backward	$\approx 10^6$
Expected statistics	$e^+e^-\pi^0$	5	forward	150 000
	$e^+e^-\pi^0$	5	backward	150 000
	$e^+e^-\pi^0$	10	forward	6 000
	$e^+e^-\pi^0$	10	backward	6 000

Analysis Steps

- Simulation
- Best cuts selection
- Signal/Noise ratio
- Analysis w/o Background contamination
- Analysis with Background contamination
- Error Analysis

Analysis process

- Event selection: Combinations of $\pi^0 + e^+ + e^-$ candidates per event
  - Particle identification cuts (PID):
    - Only 2 tracks (+ and -) and very loose electrons (+ and -) per event
    - Only 2 tracks (+ and -) and loose electrons (+ and -) per event
    - Only 2 tracks (+ and -) and tight electrons (+ and -) per event
    - Only 2 tracks (+ and -) and very tight electrons (+ and -) per event
    - At least 2 tracks (+ and -) with 2 very loose electrons (+ and -) per event
    - At least 2 tracks (+ and -) with 2 loose electrons (+ and -) per event
    - At least 2 tracks (+ and -) with 2 tight electrons (+ and -) per event
    - At least 2 tracks (+ and -) with 2 very tight electrons (+ and -) per event
  - Kinematic fit cuts - Confidence level (CL):
    - $\mathrm{CL}(e^{+/-}) > 0.001$
    - $\mathrm{CL}(e^{+/-}) > 0.001$ and $\mathrm{CL}(e^{+/-}) > \mathrm{CL}(\pi^{+/-})$
    - $\mathrm{CL}(e^{+/-}) > 0.001$ and $\mathrm{CL}(e^{+/-}) > 2 \cdot \mathrm{CL}(\pi^{+/-})$
    - $\mathrm{CL}(e^{+/-}) > 0.001$ and $\mathrm{CL}(e^{+/-}) > 3 \cdot \mathrm{CL}(\pi^{+/-})$
  - Combinations of PID and CL cuts.

- Kinematic region selection (Only for analysis):
  - Q^2 cuts in the region in which the cross section is integrated
  - $\Delta_{T_{\pi^0}} < 0.5\,\mathrm{GeV}$

Best Cut Selection

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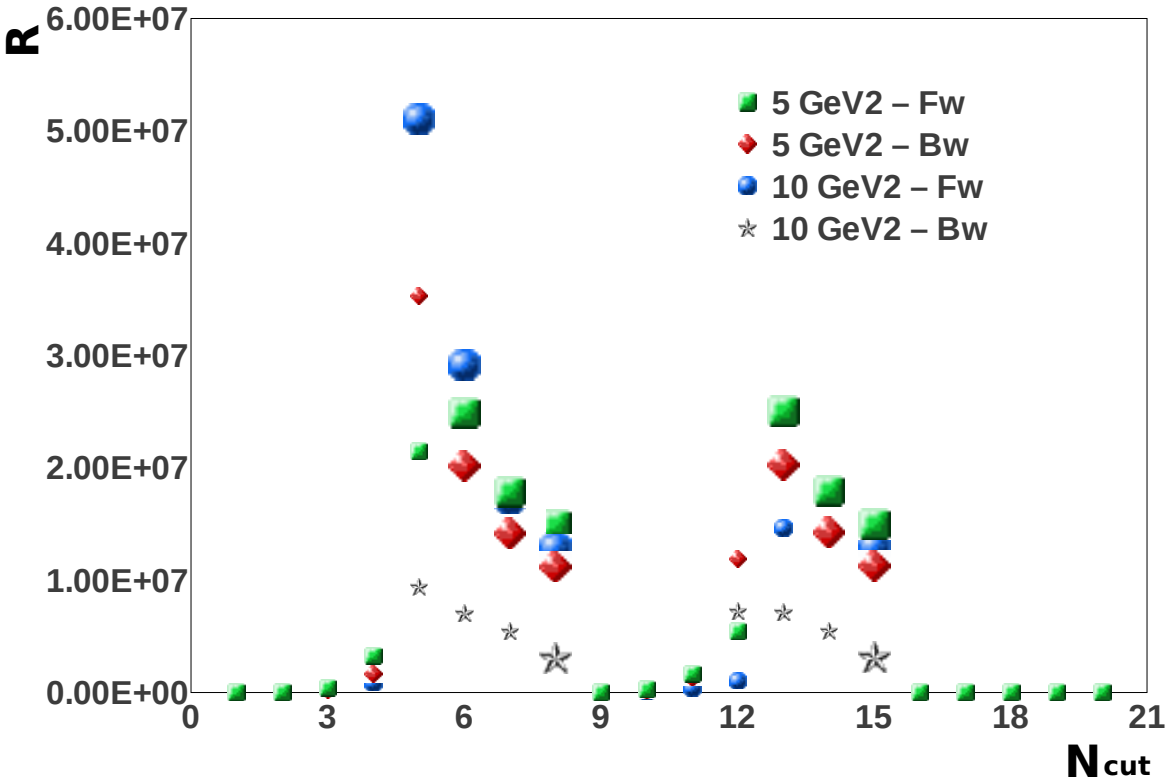
$$\mathrm{Eff}_{Bg} = \frac{N^{Bg}_{Cut}}{N^{Bg}_{True}} \qquad \mathrm{Eff}_{Sg} = \frac{N^{Sg}_{Cut}}{N^{Sg}_{True}} \qquad R = \frac{\mathrm{Eff}_{Sg}}{\mathrm{Eff}_{Bg}}$$



Best cut: $N_{cut} = 5$: Only 2 tracks (+ and -) and very tight electrons (+ and -) per event

Background contamination fraction

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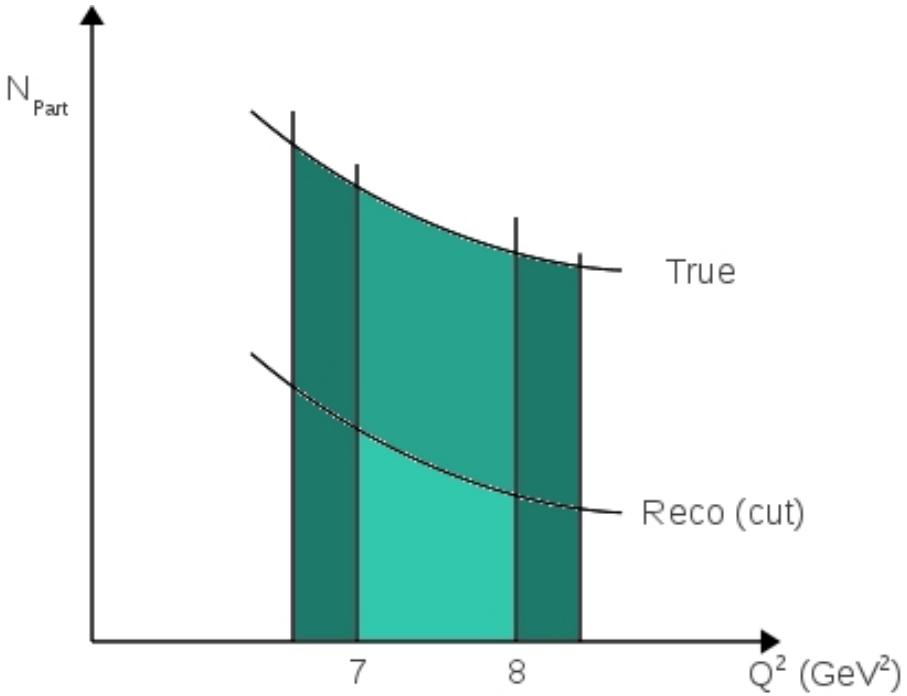
W^2	Forward		Backward	
	Signal	Background	Signal	Background
	Expected number of true events (Calculated)			
	N^{Sg}_{True}	N^{Bg}_{True}	N^{Sg}_{True}	N^{Bg}_{True}
5	150000	$1.5 \cdot 10^{11}$	150000	$1.5 \cdot 10^{11}$
10	6000	$6 \cdot 10^{9}$	6000	$6 \cdot 10^{9}$
	Efficiencies [%] (From Simulations with high statistics)			
	Eff_{Sg}	Eff_{Bg}	Eff_{Sg}	Eff_{Bg}
5	43.3	$2 \cdot 10^{-6}$	34.1	$9.7 \cdot 10^{-7}$
10	47.2	$9.3 \cdot 10-7$	26.0	$2.8 \cdot 20^{-6}$
	Reconstructed events after efficiencies (True·Efficiency)			
	N^{Sg}_{Reco}	N^{Bg}_{Reco}	N^{Sg}_{Reco}	N^{Bg}_{Reco}
5	64916	3023	51134	1449
10	2834	55	1562	166

Background Contamination [%] ($\frac{N^{Bg}_{Reco}}{N^{Bg}_{Reco}+N^{Sg}_{Reco}}$)		
	$Cont_{Bg,\,Fw}$	$Cont_{Bg,\,Bw}$
5	4.4	2.8
10	1.9	9.6

Kinematical region cuts

	$W^2 = 5\,\mathrm{GeV}^2$	$W^2 = 10\,\mathrm{GeV}^2$
Simulation limits	$3.61 < Q^2 < 5.29$	$5.76 < Q^2 < 9.18$
Analysis limits	$3.8 < Q^2 < 4.2$	$7.00 < Q^2 < 8.00$



$$\mathrm{Corr} = \frac{\mathrm{Reco}[7,8]}{\mathrm{True}[7,8]}$$

Analysis without taking background contamination into account

SELECTION CUT:

Only 2 tracks (+ and -) and very tight electrons (+ and -) per event

KINEMATIC REGION SELECTION:

$3.8 < Q^2 < 4.2$ at $W^2 = 5\,\mathrm{GeV}^2$;

$7.00 < Q^2 < 8.00$ at $W^2 = 10\,\mathrm{GeV}^2$

Simulation	$N_{True\ \mathrm{w/o}\ Bg}$	$N_{Reconstructed\ \mathrm{w/o}\ Bg}$	$N_{Corrected\ \mathrm{w/o}\ Bg}$
5 GeV - fw	72263 $\pm$269	30661 $\pm$ 175	72732 $\pm$ 459
5 GeV - bw	72405 $\pm$269	25386 $\pm$ 159	73164 $\pm$ 517
10 GeV - fw	1336 $\pm$37	662 $\pm$ 26	1319 $\pm$ 52
10 GeV - bw	1313 $\pm$ 36	394 $\pm$ 20	1312 $\pm$ 66

Analysis taking background contamination fraction into account

$$N_{Reconstructed} = N_{Background\ fraction} + N_{Reconstructed\ \text{w/o}\ Bg}$$

Simulation	$N_{Reconstructed}$	$N_{Signal\ fraction}$	$\epsilon_{rel}(N_{Signal\ fraction})[\%]$
5fw	31967.2 ± 178.8	30544 ± 172.7	0.57
5bw	26066.8 ± 161.5	25348 ± 158.1	0.62
10fw	674.4 ± 26.0	661 ± 25.5	3.9
10bw	428.5 ± 20.7	387 ± 19.0	4.9
		$N_{Corrected}$	$\epsilon_{rel}(N_{Corrected})[\%]$
5fw		72454.3 ± 453.1	0.63
5bw		73054.5 ± 513.9	0.70
10fw		1317.1 ± 51.2	3.9
10bw		1288.5 ± 63.4	4.9

Conclusions and Outlook

- First approximation analysis for the measurement of $\bar{p}p \rightarrow e^+e^-\pi^0$ in the TDA approach is done.
- Error calculation takes into account only statistic errors. Numbers to be checked.
- A reasonable measurement of the cross section could be done in all cases. First sight on TDA approach validity.

- A new event generator for signal is needed (π^0 not only at $\Delta_{T_{\pi^0}} = 0$ but $\Delta_{T_{\pi^0}} < 0.5$).
- Cross section of background in the same kinematic region is unknown.
- A new event generator for background is needed.