Protocol

Nicolas Heimann

nicolas.heimann@studium.uni-hamburg.de

Jesse Hinrichsen

jesse.hinrichsen@studium.uni-hamburg.de

Universität Hamburg

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Zusammenfassung

An abstract...

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1 Introcution

2 Identifying events

Quantities for events:
Ctrk(Sump): Energy of charged traces
Ctrk(N): Number of charged traces
Ecal(SumE): Energy in electronic-kalorimeter
Hcal(SumE): Energy in hadronic-kalorimeter

Quantities					
Run	Event	Ctrk(Sump)	Ctrk(N)	Ecal(SumE)	Hcal(SumE)
00	ELECTRONS	AF	AFG	004	00
00	MUONS	AF	AFG	004	00
00	TAUS	AF	AFG	004	00
00	HADRONS	AF	AFG	004	00

3 Statistical analysis of Z^0 decay channels

3.1 Decay width and cross-section

Using equation (2.12) we calculate following decay width of the Z-boson into fermions and (2.14) for cross-section at peak.

Decay width for different channels	
Channel	Decay width
$\Gamma_l = \Gamma_e = \Gamma_\mu = \Gamma\tau$	85.9 MeV
Γ_ν	165.9 MeV
$\Gamma_u = \Gamma_c$	301.5 MeV
$\Gamma_d = \Gamma_s = \Gamma_b$	381.4 MeV
Γ_Z	2502.7 MeV
Γ_{hadr}	1747.3 MeV
Γ_{lept}[1]	257.8 MeV
Γ_{neutr}	497.6 MeV

Partial cross-section at peak	
σ_{lept}	5.35 KeV^{-2}
σ_{neutr}	10.32 KeV^{-2}
$\sigma_{u,c}$	18.76 KeV^{-2}
$\sigma_{d,s,c}$	23.73 KeV^{-2}

3.2 Estimating change of Z^0 decay width for additional channels

Decay width of Z^0 for additional channels		
Added channel	Z^0 width	relative increase
Lepton	2.589 GeV	3.5 %
Neutrino	2.669 GeV	6.6 %
u-Quark	2.804 GeV	12 %
d-Quark	2.884 GeV	15.2 %

3.3 Differential cross-section

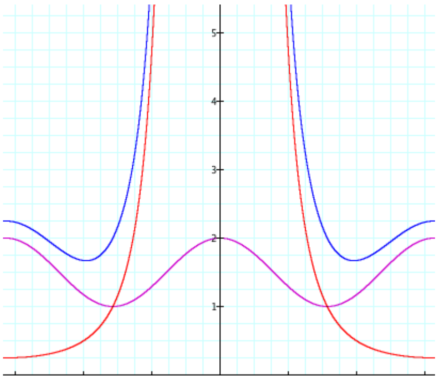

Abbildung 1: Differential cross-section on Θ qualitatively. Red: t-channel, violet: s-channel, blue: s-channel + t-channel

For s-channel: $\frac{d\sigma}{d\Omega} \propto 1 + \cos^2\Theta$ (for big $Theta$)
For t-channel: $\frac{d\sigma}{d\Omega} \propto (1 - \cos\Theta)^{-2}$ (for small $Theta$)

3.4 Forward-Backward Asymmetry

Based on equation (2.18)

Forward-Bckward asymmetry			
$\sqrt{s}$ / $\sin^2(\theta_W)$	0.21	0.23	0.25
89.225 GeV	0.547	0.321	0.285
91.225 GeV	0.530	0.407	0.284
93.225 GeV	0.515	0.480	0.284

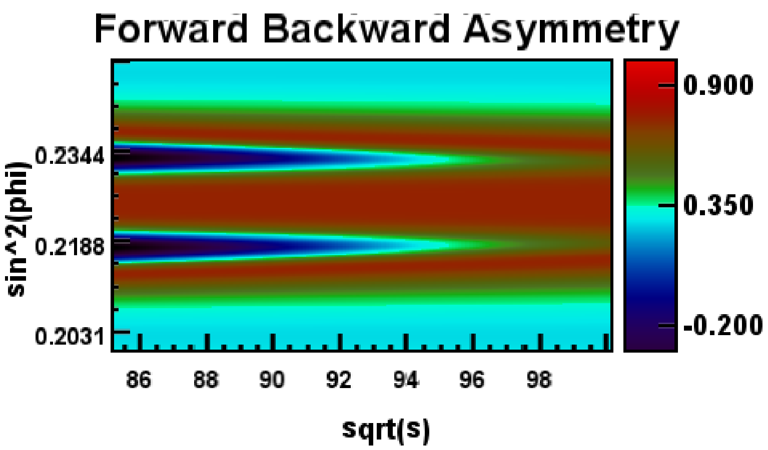

Abbildung 2: Forward-Bckward asymmetry

4 Analyzing Data

4.1 Pure Events

For the e^+, e^- detection we have to apply a cut for the $-0.71 \leq \cos(\theta) \leq 0.65$ and $-0.925 \leq \cos(\theta) \leq -0.85$ due to a problem in the detector.

4.1.1 Z->e^+, e^-

- All energy in Ecal
- None in Hcal
- 2 charged traces
- Momentum of charged traces around Z_M

4.1.2 Z->μ^+, μ^-

- None in Ecal
- Very little in Hcal
- 2 charged traces
- Momentum of charged traces around Z_M
- For $\cos(\theta) leq - 0.7$ and $\cos(\theta) geq 0.7$ the slope for differential cross-section is not as expected. Thus cut it.

4.1.3 Z->τ^+, τ^-

asd

4.2 Seperating t-channel for e^+e^-

We are looking for a cut to remove all t-channel events. Therefore we define

$$\frac{T}{T+S} \leq 0.05 \tag{1}$$

where $T = a(1 - \cos\theta)^{-2}$ and $S = b(1 + \cos^2\theta)$. And write

$$\frac{dN}{d\cos\theta} = \frac{a}{(1-\cos\theta)^2} + b(1 + \cos^2\theta) \tag{2}$$

Integrate $\cos\theta$

$$\int dN = \frac{a}{1-\cos\theta} + b\left(\cos\theta + \frac{1}{3}\cos^3\theta\right) \tag{3}$$

We obtain detector errors outside $cos\theta \in [-0.7, 0.7]$. To solve the equation for a and b we create 2 equations by split around $\cos\theta = 0$.

$$\begin{aligned} 11786 &= a(\frac{1}{1-0.7} - 1) + b(0,7 + \frac{1}{3}0.7^3) \\ 9620 &= a(1 - \frac{1}{1+0.7}) + b(0,7 + \frac{1}{3}0.7^3) \end{aligned} \tag{4}$$

So we get

$$\begin{aligned} 11786 &= (2 + \frac{1}{3})a + 0,813433b \\ 9620 &= 0,4117647a + 0,813433b \end{aligned} \tag{5}$$

So $a = 1127,2$ and $b = 9155,857$. We want $\frac{T}{T+S} \leq 0.05$ so we need to solve

$$\frac{a}{(1-\cos\theta)^2}\frac{1}{\frac{a}{(1-\cos\theta)^2} + b(1+\cos^2\theta))} \leq 0.05 \iff \cos\theta \leq -0.188342 \tag{6}$$

To get true number of s-channel events we now integrate over the whole interval

$$N_s = b\int_{-1}^{1} d\cos\theta(1 + \cos^2\theta) = \frac{8}{3}b = 24413 \tag{7}$$

4.3 Create efficiency matrix

We create efficiency matrix where each element is given by

$$\epsilon = \frac{N_{cut}}{N_{true}} \tag{8}$$

Thus performing the cuts to data set XX we could create the following matrix

$$\epsilon = \begin{pmatrix} 2.86 \cdot 10^{-01} & 1.0 \cdot 10^{-05} & 0 & 0 \\ 0 & 9.18 \cdot 10^{-01} & 5.77 \cdot 10^{-03} & 0 \\ 3.03 \cdot 10^{-03} & 9.13 \cdot 10^{-03} & 7.93 \cdot 10^{-01} & 4.05 \cdot 10^{-03} \\ 1.02 \cdot 10^{-03} & 0 & 1.2 \cdot 10^{-02} & 9.95 \cdot 10^{-01} \end{pmatrix} \tag{9}$$

To find filter background and find N_{true} we need to solve the following equation

$$N_{obs} = \epsilon N_{true} \tag{10}$$

Multiply left side with inverse efficiency matrix we get

$$\epsilon^{-1} N_{obs} = N_{true} \tag{11}$$

with inverse efficiency matrix

$$\epsilon^{-1} = \begin{pmatrix} 3.5 & -3.81 \cdot 10^{-05} & 2.77 \cdot 10^{-07} & -1.13 \cdot 10^{-09} \\ 8.39 \cdot 10^{-05} & 1.09 & -7.92 \cdot 10^{-03} & 3.23 \cdot 10^{-05} \\ -1.33 \cdot 10^{-02} & -1.25 \cdot 10^{-02} & 1.26 & -5.13 \cdot 10^{-03} \\ -3.43 \cdot 10^{-03} & 1.51 \cdot 10^{-04} & -1.52 \cdot 10^{-02} & 1.01 \end{pmatrix} \tag{12}$$

The error of efficiency matrix is given by

$$\Delta\epsilon = \sqrt{\frac{\epsilon(1-\epsilon)}{N}} \tag{13}$$

Using $\epsilon\Delta\epsilon^{-1} + \Delta\epsilon\epsilon^{-1} = 0$ we get error for inverse efficiency matrix:

$$\Delta\epsilon^{-1} = -\epsilon^{-1}\Delta\epsilon\epsilon^{-1} = \begin{pmatrix} -3.55 \cdot 10^{-02} & 4.24 \cdot 10^{-07} & 1.08 \cdot 10^{-08} & -9.96 \cdot 10^{-11} \\ 1.43 \cdot 10^{-05} & -1.06 \cdot 10^{-03} & -3.9 \cdot 10^{-04} & 3.18 \cdot 10^{-06} \\ -1.6 \cdot 10^{-03} & -3.78 \cdot 10^{-04} & -2.21 \cdot 10^{-03} & -2.43 \cdot 10^{-04} \\ -6.42 \cdot 10^{-04} & 9.57 \cdot 10^{-06} & -4.77 \cdot 10^{-04} & -1.97 \cdot 10^{-04} \end{pmatrix} \tag{14}$$

Apply the filters we used within monte carlo simulation we could find the total number of observed events for each $\sqrt{s} \in \{...\}$:

$$N_{obs} = \begin{pmatrix} 2.0 \cdot 10^{+01} & 9.0 \cdot 10^{+01} & 1.0 \cdot 10^{+02} & 2.0 \cdot 10^{+03} \\ 8.0 \cdot 10^{+01} & 3.0 \cdot 10^{+02} & 3.0 \cdot 10^{+02} & 7.0 \cdot 10^{+03} \\ 9.0 \cdot 10^{+01} & 4.0 \cdot 10^{+02} & 3.0 \cdot 10^{+02} & 9.0 \cdot 10^{+03} \\ 6.0 \cdot 10^{+02} & 3.0 \cdot 10^{+03} & 2.0 \cdot 10^{+03} & 7.0 \cdot 10^{+04} \\ 1.0 \cdot 10^{+02} & 6.0 \cdot 10^{+02} & 5.0 \cdot 10^{+02} & 1.0 \cdot 10^{+04} \\ 4.0 \cdot 10^{+01} & 3.0 \cdot 10^{+02} & 3.0 \cdot 10^{+02} & 6.0 \cdot 10^{+03} \\ 6.0 \cdot 10^{+01} & 3.0 \cdot 10^{+02} & 3.0 \cdot 10^{+02} & 7.0 \cdot 10^{+03} \end{pmatrix} \tag{15}$$

Thus we get using inverse efficiency matrix

$$N_{true} = (\epsilon^{-1} N_{obs}^T)^T = \begin{pmatrix} 6.995 \cdot 10^{+01} & 1.006 \cdot 10^{+02} & 1.08 \cdot 10^{+02} & 2.512 \cdot 10^{+03} \\ 2.833 \cdot 10^{+02} & 3.053 \cdot 10^{+02} & 2.966 \cdot 10^{+02} & 6.682 \cdot 10^{+03} \\ 3.183 \cdot 10^{+02} & 4.214 \cdot 10^{+02} & 3.838 \cdot 10^{+02} & 8.812 \cdot 10^{+03} \\ 2.207 \cdot 10^{+03} & 3.12 \cdot 10^{+03} & 2.635 \cdot 10^{+03} & 6.718 \cdot 10^{+04} \\ 3.987 \cdot 10^{+02} & 6.252 \cdot 10^{+02} & 5.346 \cdot 10^{+02} & 1.306 \cdot 10^{+04} \\ 1.294 \cdot 10^{+02} & 2.847 \cdot 10^{+02} & 2.805 \cdot 10^{+02} & 6.287 \cdot 10^{+03} \\ 1.959 \cdot 10^{+02} & 3.163 \cdot 10^{+02} & 2.812 \cdot 10^{+02} & 7.016 \cdot 10^{+03} \end{pmatrix} \tag{16}$$

with error of

$$\Delta N_{true} = \begin{pmatrix} -7.095 \cdot 10^{-01} & -1.284 \cdot 10^{-01} & -8.901 \cdot 10^{-01} & -5.511 \cdot 10^{-01} \\ -2.873 & -3.809 \cdot 10^{-01} & -2.443 & -1.487 \\ -3.228 & -5.185 \cdot 10^{-01} & -3.19 & -1.948 \\ -2.238 \cdot 10^{+01} & -3.771 & -2.367 \cdot 10^{+01} & -1.47 \cdot 10^{+01} \\ -4.044 & -7.586 \cdot 10^{-01} & -4.633 & -2.861 \\ -1.313 & -3.568 \cdot 10^{-01} & -2.236 & -1.375 \\ -1.987 & -3.866 \cdot 10^{-01} & -2.463 & -1.531 \end{pmatrix} \tag{17}$$

Next we calculate crossection by using equation (S-3.3):

$$\frac{dN}{dt} = \mathcal{L}\sigma \tag{18}$$

Using the following matrix for Strahlungskorrektur from table 5.5

$$\Lambda = \begin{pmatrix} 9.0 \cdot 10^{-02} & 9.0 \cdot 10^{-02} & 9.0 \cdot 10^{-02} & 2.0 \\ 2.0 \cdot 10^{-01} & 2.0 \cdot 10^{-01} & 2.0 \cdot 10^{-01} & 4.3 \\ 3.6 \cdot 10^{-01} & 3.6 \cdot 10^{-01} & 3.6 \cdot 10^{-01} & 7.7 \\ 5.2 \cdot 10^{-01} & 5.2 \cdot 10^{-01} & 5.2 \cdot 10^{-01} & 1.08 \cdot 10^{+01} \\ 2.2 \cdot 10^{-01} & 2.2 \cdot 10^{-01} & 2.2 \cdot 10^{-01} & 4.7 \\ -1.0 \cdot 10^{-02} & -1.0 \cdot 10^{-02} & -1.0 \cdot 10^{-02} & -2.0 \cdot 10^{-01} \\ -8.0 \cdot 10^{-02} & -8.0 \cdot 10^{-02} & -8.0 \cdot 10^{-02} & -1.6 \end{pmatrix} \tag{19}$$

And the following Luminosities given by table 5.6:

$$\mathcal{L}dt = \begin{pmatrix} 4.6398 \cdot 10^{+02} \\ 6.6752 \cdot 10^{+02} \\ 4.8676 \cdot 10^{+02} \\ 2.2466 \cdot 10^{+03} \\ 5.3591 \cdot 10^{+02} \\ 4.506 \cdot 10^{+02} \\ 7.097 \cdot 10^{+02} \end{pmatrix} \tag{20}$$

We calculate the crossection for each element $\sigma_{ij} = N_{true,ij}/(\mathcal{L}dt)_i - \Lambda_{ij}$:

$$\sigma = \begin{pmatrix} 1.33105 \cdot 10^{-01} & 2.9044 \cdot 10^{-01} & 2.99061 \cdot 10^{-01} & 7.38817 \\ 3.21344 \cdot 10^{-01} & 6.22457 \cdot 10^{-01} & 5.98488 \cdot 10^{-01} & 1.42622 \cdot 10^{+01} \\ 5.46949 \cdot 10^{-01} & 1.15915 & 1.06876 & 2.57169 \cdot 10^{+01} \\ 8.00873 \cdot 10^{-01} & 1.80151 & 1.58741 & 4.05623 \cdot 10^{+01} \\ 4.32723 \cdot 10^{-01} & 1.29668 & 1.12314 & 2.89486 \cdot 10^{+01} \\ 7.21127 \cdot 10^{-02} & 5.73666 \cdot 10^{-01} & 5.47035 \cdot 10^{-01} & 1.36859 \cdot 10^{+01} \\ -1.0932 \cdot 10^{-03} & 3.31443 \cdot 10^{-01} & 2.79308 \cdot 10^{-01} & 8.23799 \end{pmatrix} \tag{21}$$

The error of crossection in eq (18) is given by

$$\Delta\sigma = \sqrt{\left(\frac{\partial \sigma}{\partial N_{True}} \Delta N_{True}\right)^2 + \left(\frac{\partial \sigma}{\partial (\mathcal{L}dt)} \Delta \mathcal{L}dt\right)^2} = \sqrt{\left(\frac{1}{\mathcal{L}dt} \Delta N_{True}\right)^2 + \left(-\frac{N_{True}}{(\mathcal{L}dt)^2} \Delta \mathcal{L}dt\right)^2} \tag{22}$$

Where the error of $\mathcal{L}dt$ is given by

$$\Delta\mathcal{L}dt = \pm \begin{pmatrix} 4.249604 \\ 5.691792 \\ 4.454466 \\ 16.43293 \\ 4.848926 \\ 4.276552 \\ 6.104764 \end{pmatrix} [nb^{-1}] \tag{23}$$

Finally we get

$$\Delta\sigma = \begin{pmatrix} 2.0603 \cdot 10^{-03} & 2.0057 \cdot 10^{-03} & 2.8681 \cdot 10^{-03} & 4.96 \cdot 10^{-02} \\ 5.6236 \cdot 10^{-03} & 3.9419 \cdot 10^{-03} & 5.2671 \cdot 10^{-03} & 8.5376 \cdot 10^{-02} \\ 8.9322 \cdot 10^{-03} & 7.9929 \cdot 10^{-03} & 9.747 \cdot 10^{-03} & 1.6571 \cdot 10^{-01} \\ 1.2284 \cdot 10^{-02} & 1.0296 \cdot 10^{-02} & 1.3589 \cdot 10^{-02} & 2.1885 \cdot 10^{-01} \\ 1.0112 \cdot 10^{-02} & 1.065 \cdot 10^{-02} & 1.2499 \cdot 10^{-02} & 2.2052 \cdot 10^{-01} \\ 3.9891 \cdot 10^{-03} & 6.0496 \cdot 10^{-03} & 7.716 \cdot 10^{-03} & 1.3245 \cdot 10^{-01} \\ 3.6702 \cdot 10^{-03} & 3.8727 \cdot 10^{-03} & 4.8643 \cdot 10^{-03} & 8.506 \cdot 10^{-02} \end{pmatrix} \tag{24}$$