Everything Very Preliminary!

Differential Decay Rate

$$\begin{aligned}\frac{\mathrm{d}^3\Gamma}{\mathrm{d}v{\cdot}q\,\mathrm{d}q^2\,\mathrm{d}\cos\theta} =& \frac{G_F^2|V_{cb}|^2}{8\pi^3}\sqrt{v{\cdot}q^2-q2}\big[2q^2W_1(v{\cdot}q,q^2)\\ &+[(v{\cdot}q)^2-q^2][1-\cos^2\theta]W_2(v{\cdot}q,q^2)\\ &-2q^2\sqrt{v{\cdot}q^2-q^2}\cos\theta W_3(v\cdot q,q^2)\big]\theta(q^2)\theta((v{\cdot}q)^2-q^2)\end{aligned}$$

How Power Corrections enter

- Optical Theorem

$$W_i^{(n)} = \frac{1}{m_b^n} f(v{\cdot}q, q^2, \mathrm{HQE})\ \delta^{(n)}(m_b^2 - 2m_b v{\cdot}q + q^2 - mc^2 + i\epsilon)$$

- Lepton energy cut

$$\theta(v{\cdot}q - z\sqrt{v{\cdot}q^2 - q^2} - 2E_{\mathrm{cut}})$$

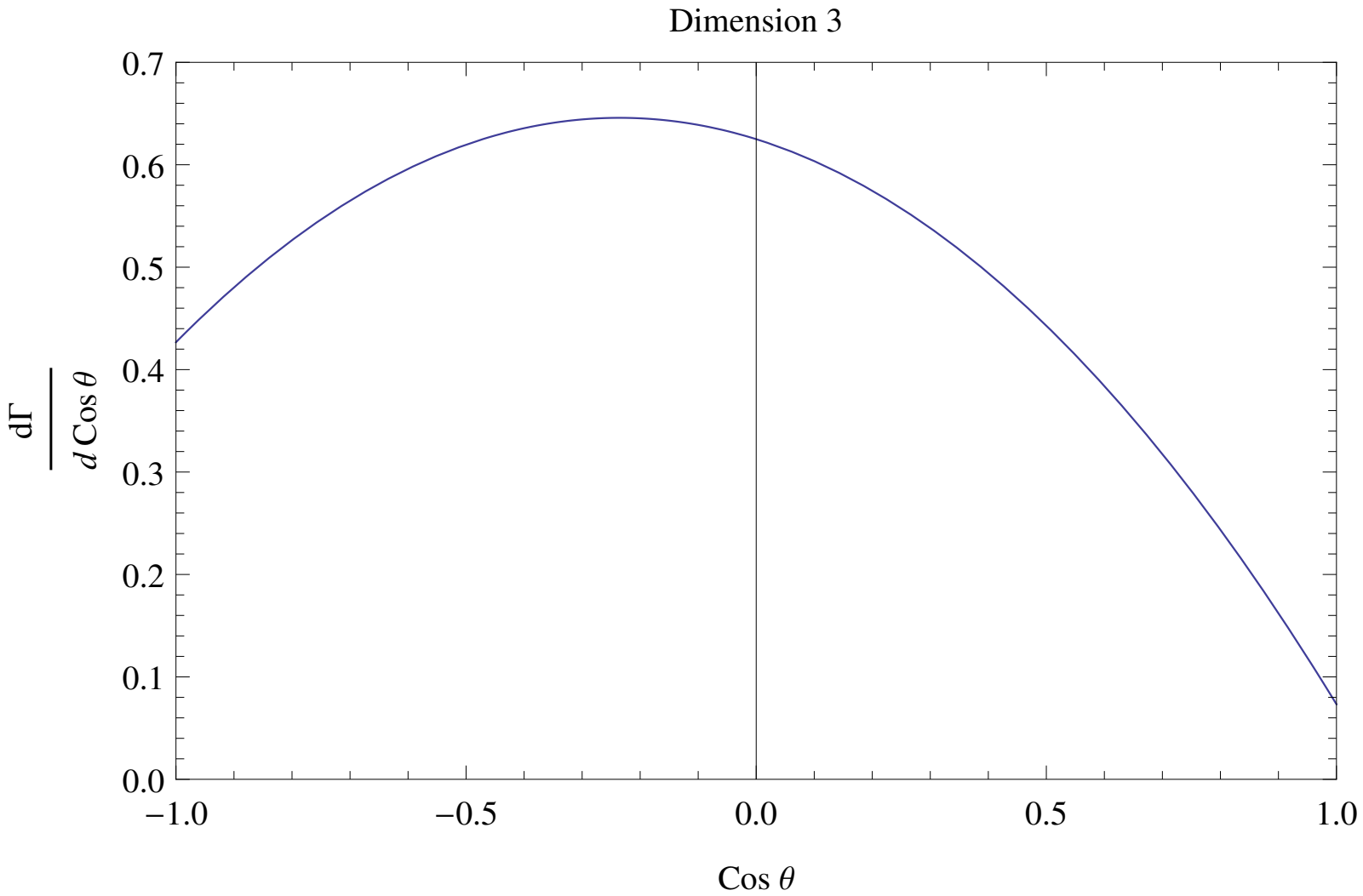
- Forward Backward Asymmetry

$$\mathrm{AFB} = -\frac{1}{m_b^5 + \ldots} \int \mathrm{d}q^2 \mathrm{d}v{\cdot}q q^2 [v{\cdot}q^2 - q^2] \; W_3(v{\cdot}q, q^2) \; \theta(q^2)\theta((v{\cdot}q)^2 - q^2)$$

- Moments without energy cut gives only a factor!

Numerical Results

$$\begin{aligned}
\Gamma &\approx \frac{G_F^2 |V_{cb}|^2 m_b^5}{192\pi^3}[0.607 - 0.014\mu_\pi^2 - 0.057\mu_g^2] \\
\langle E_\ell \rangle &\approx 1.399 + 0.033\mu_\pi^2 - 0.078\mu_G^2 \\
\langle (E_\ell - \langle E_\ell \rangle)^2 \rangle &\approx 0.18 + 0.042\mu_\pi^2 - 0.024\mu_G^2 \\
\langle M_x^2 \rangle &\approx 4.571 - 0.657\mu_\pi^2 + 0.447\mu_G^2 \\
\langle (M_x^2 - \langle M_x^2 \rangle)^2 \rangle &\approx 0.189 + 4.508\mu_\pi^2 - 0.235\mu_G^2 \\
\mathrm{AFB} &\approx -0.177 + 0.017\mu_\pi^2 + 0.059\mu_G^2
\end{aligned}$$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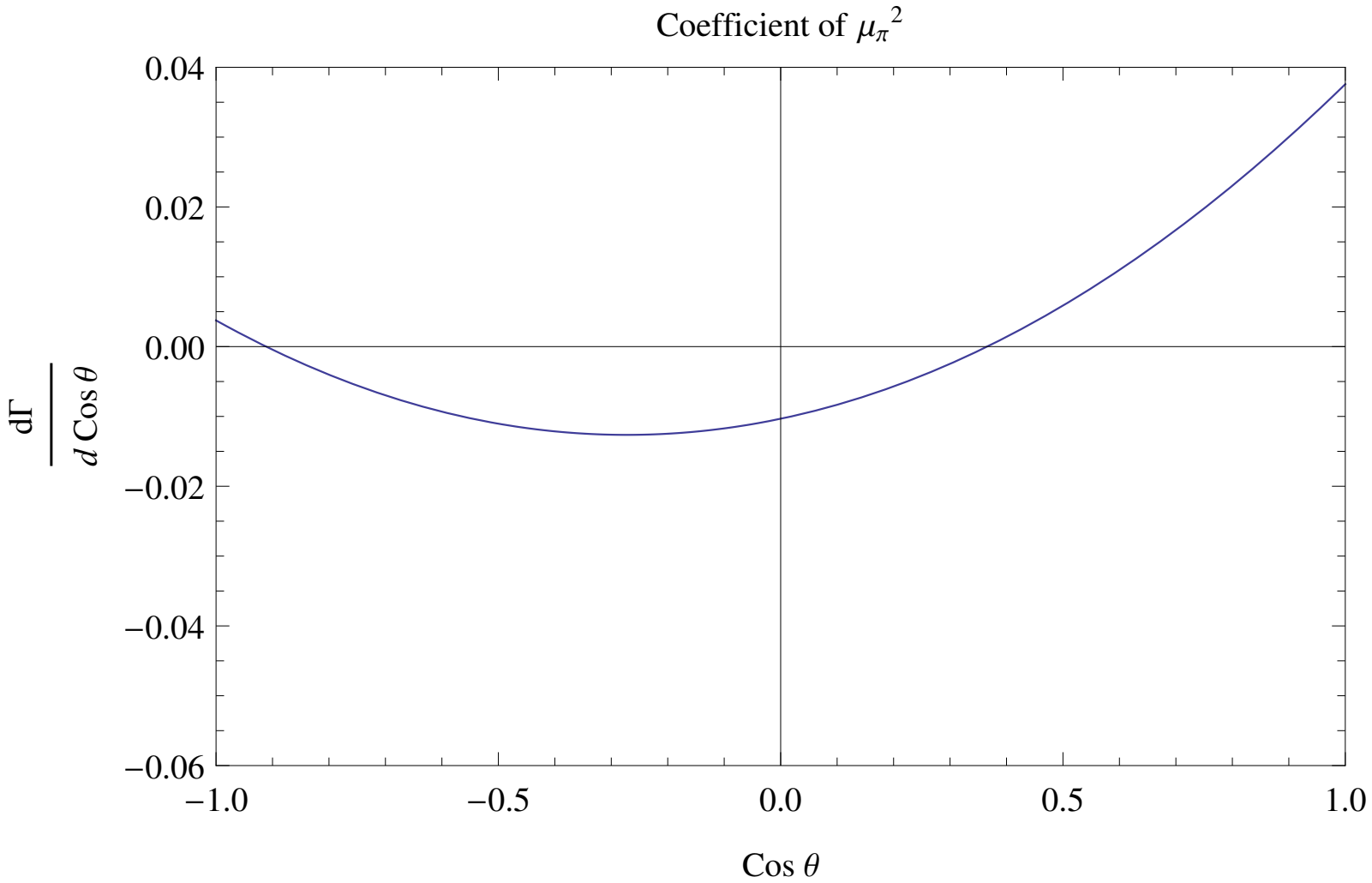
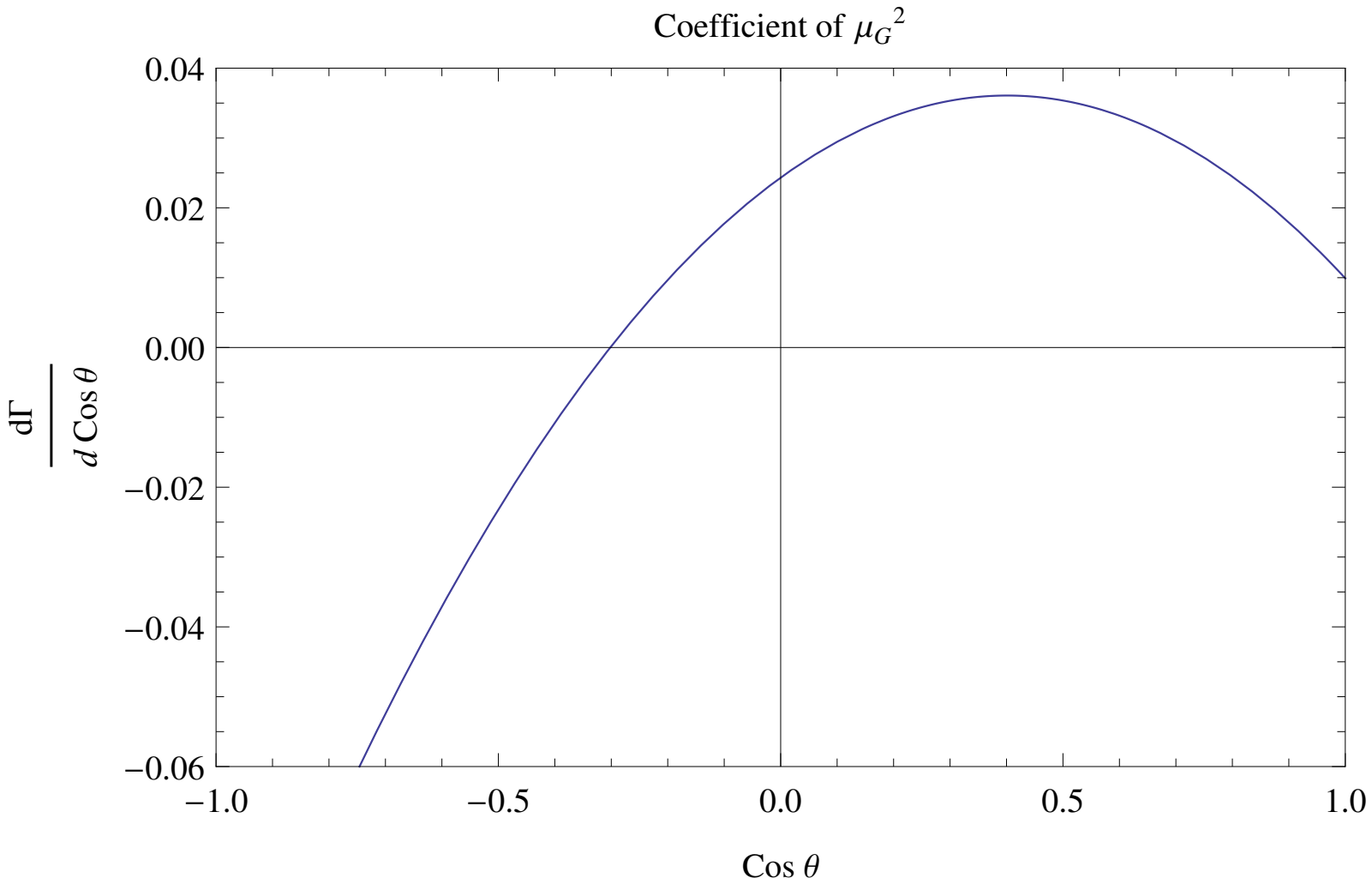
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
−1.0
−0.5
0.0
0.5
1.0
dΓ / d Cos θ
Cos θ


Coefficient of $\mu_\pi{}^2$
0.04
0.02
0.00
−0.02
−0.04
−0.06
−1.0
−0.5
0.0
0.5
1.0
$\frac{d\Gamma}{d\,\mathrm{Cos}\,\theta}$
Cos θ


Coefficient of $\mu_G{}^2$
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0.02
0.00
−0.02
−0.04
−0.06
−1.0
−0.5
0.0
0.5
1.0
$\frac{d\Gamma}{d\,\mathrm{Cos}\,\theta}$
Cos θ