DETERMINING THE HIGGS SPIN AND PARITY USING GLUON POLARIZATION

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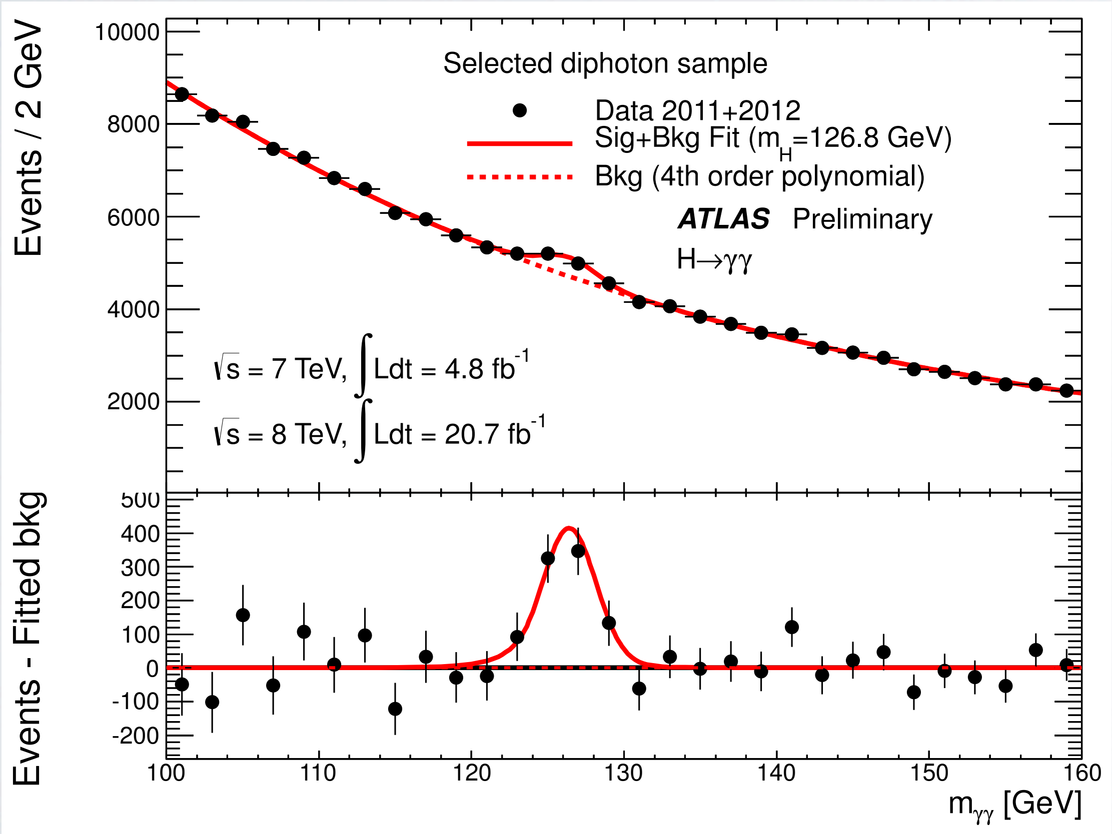
HIGGS J^P DETERMINATION

	postive parity	negative parity
spin-0	0^+	0^-
spin-1	✗	✗
spin-2	2^+_m 2^+_h $2^+_{h'}$ $2^+_{h''}$	2^-_h

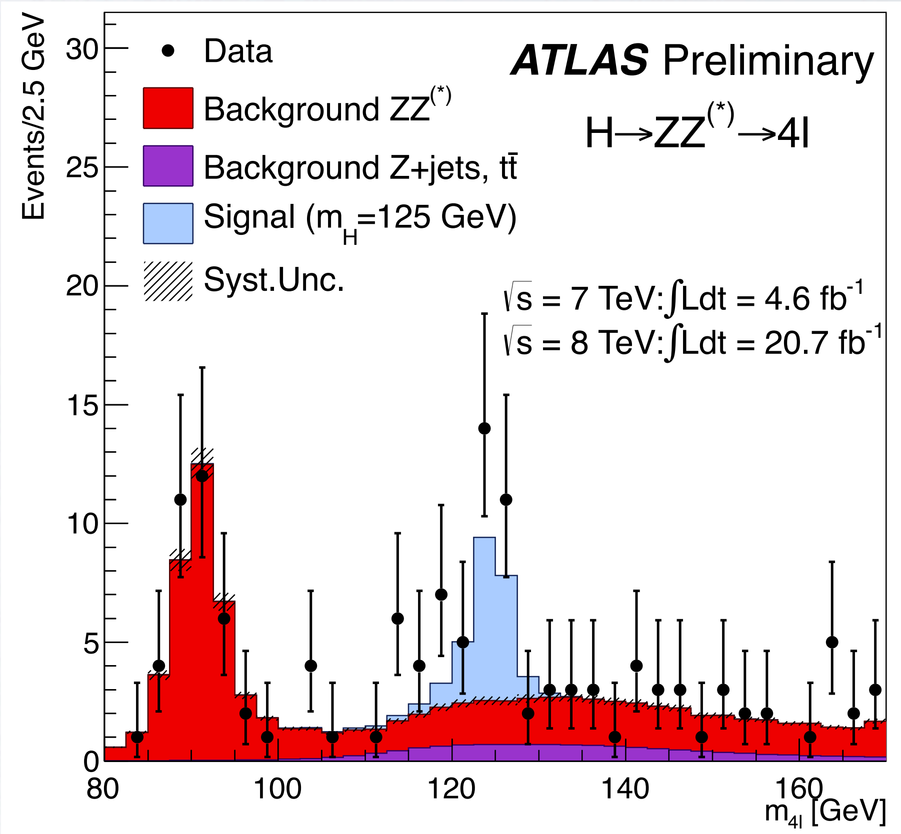
HIGGS J^P DETERMINATION

di-photon



ATLAS-CONF-2013-012

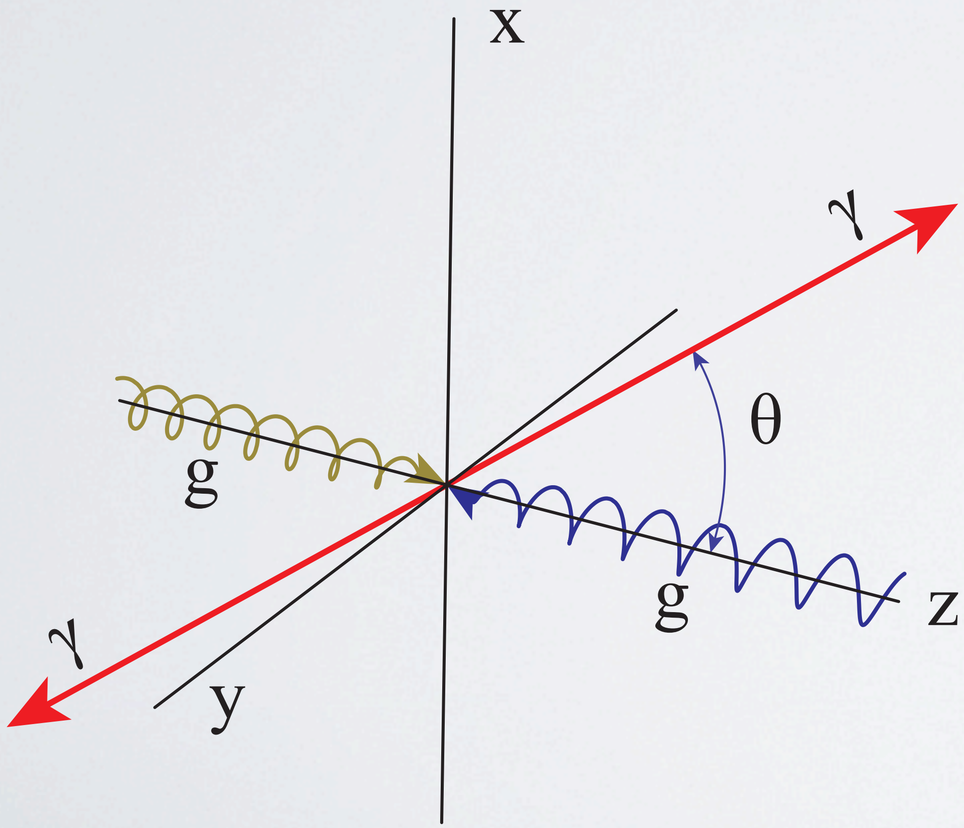
$ZZ^* \to 4l$



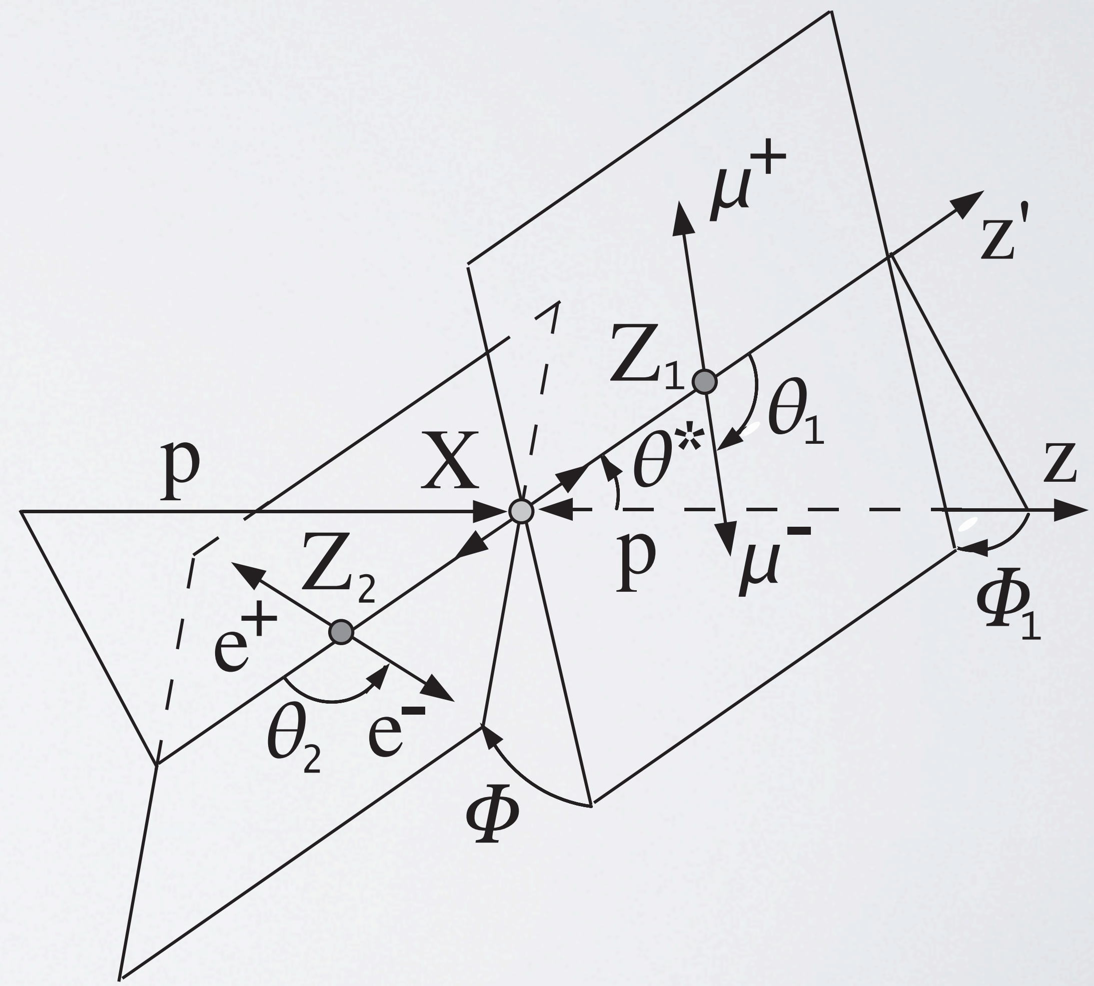
ATLAS-CONF-2013-013

HIGGS J^P DETERMINATION

di-photon



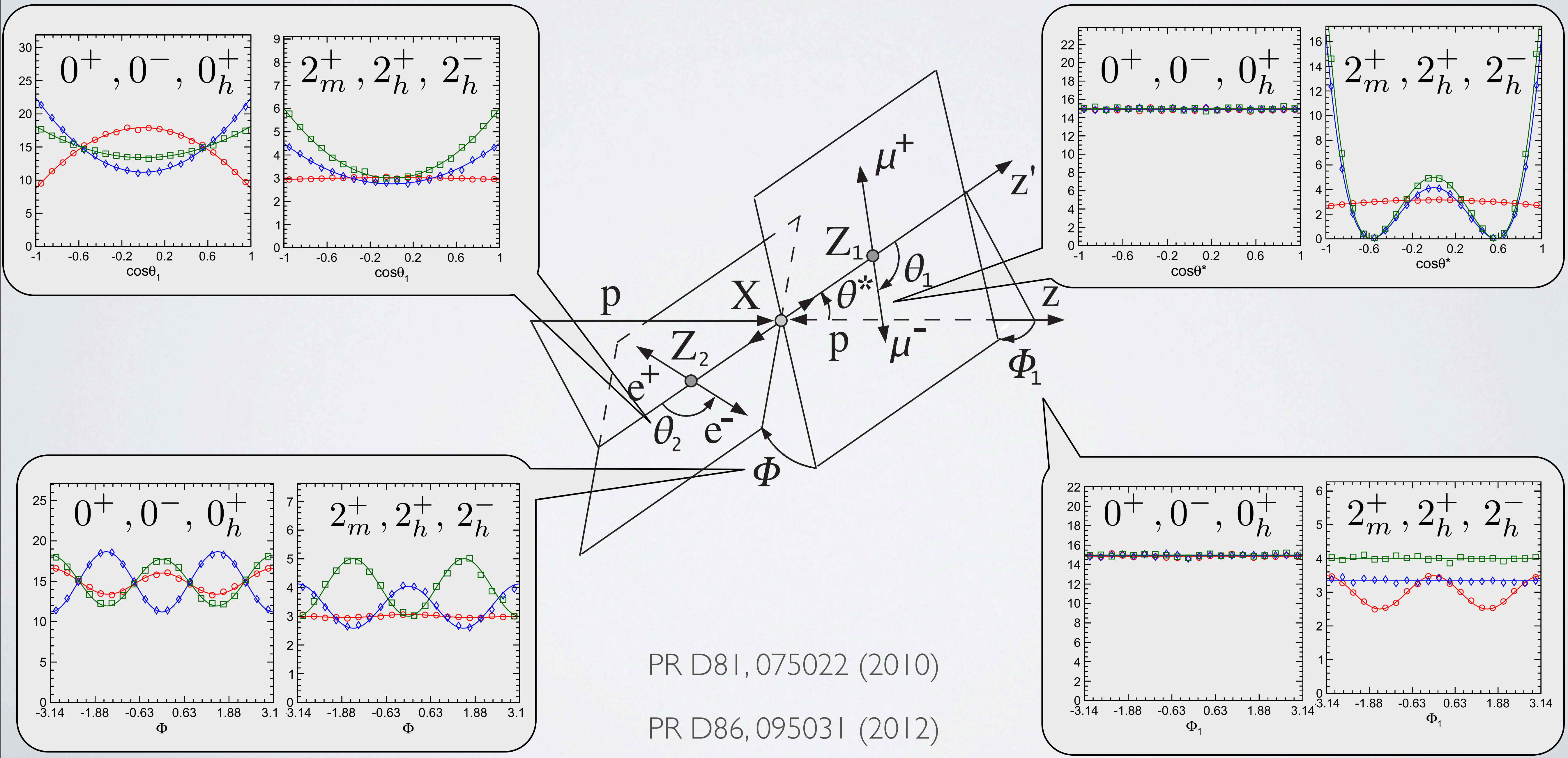
$ZZ^* \rightarrow 4l$



PR D81, 075022 (2010)

HIGGS J^P DETERMINATION

$ZZ^* \rightarrow 4l$

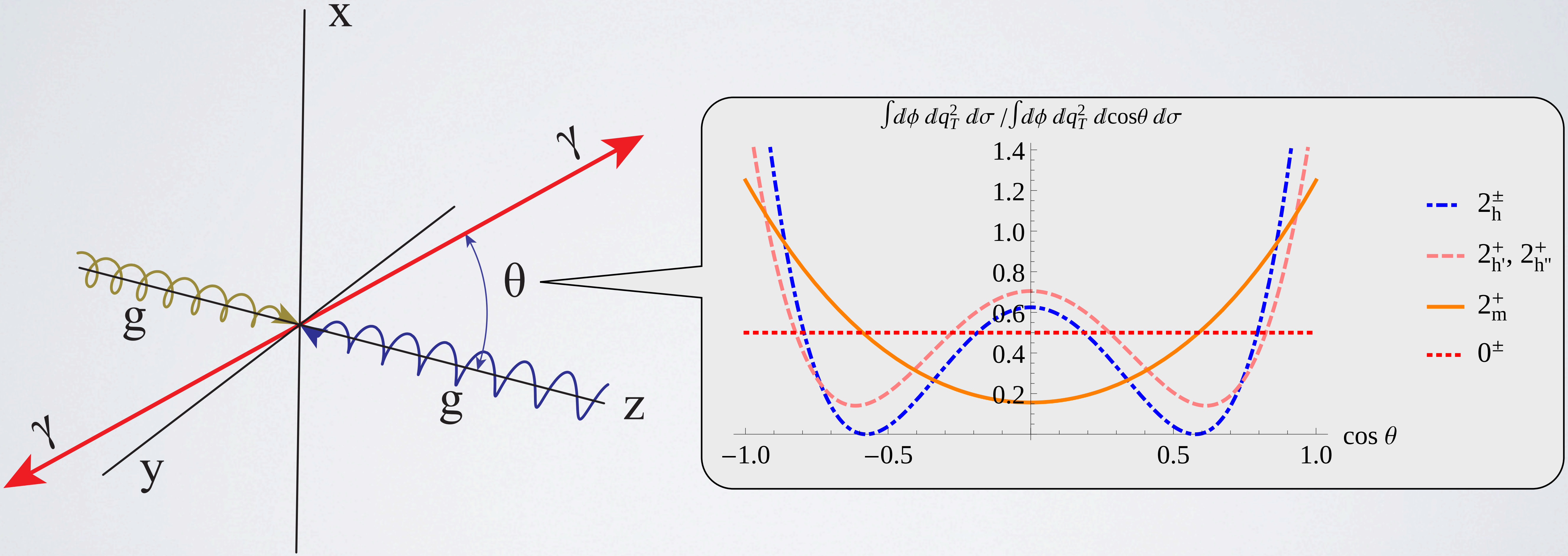


PR D81, 075022 (2010)

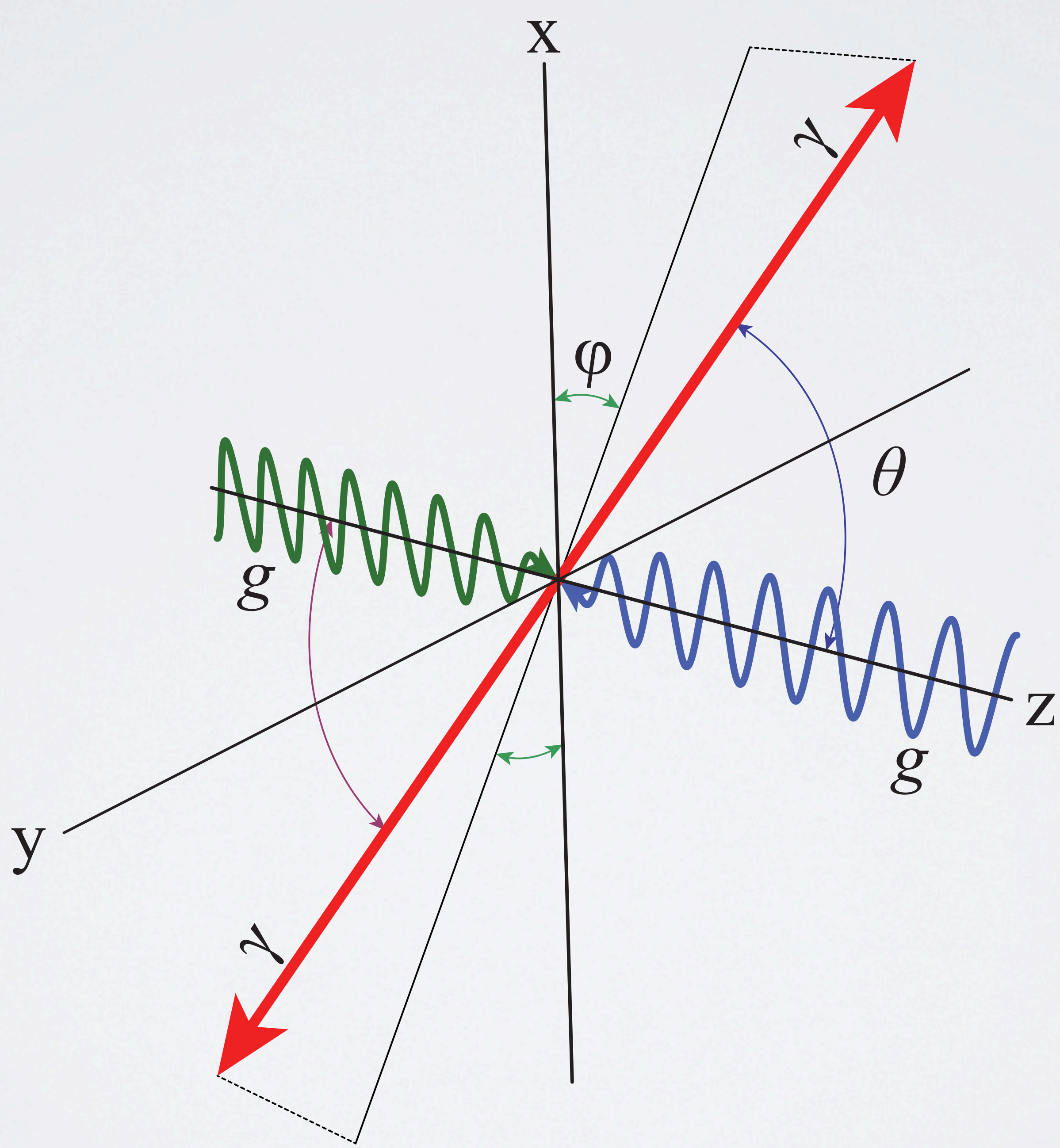
PR D86, 095031 (2012)

HIGGS J^{P} DETERMINATION

di-photon



WITH GLUON POLARIZATION

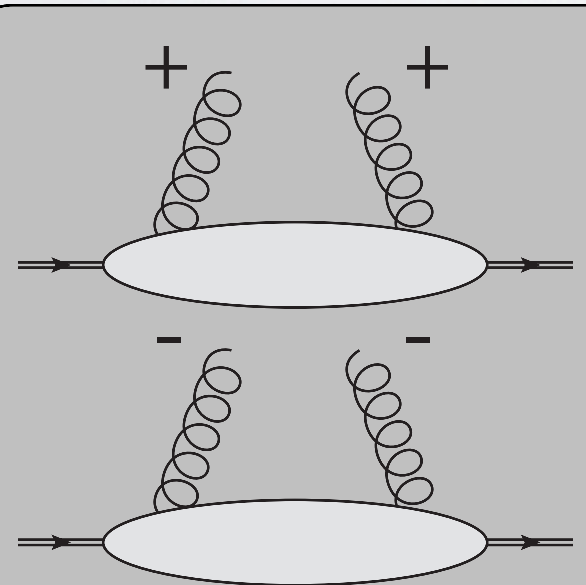


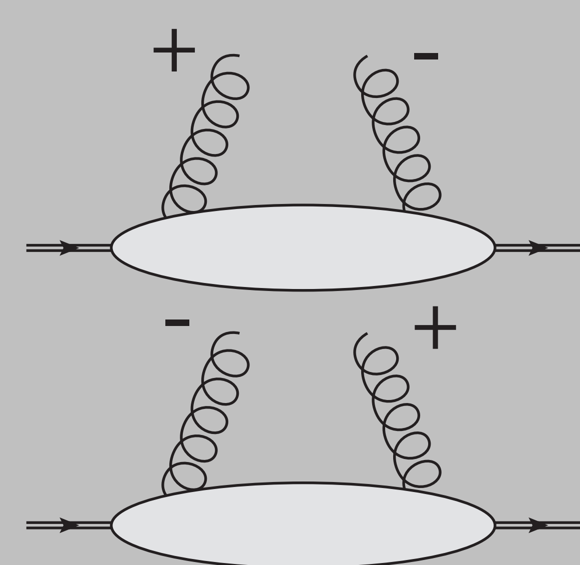
TMD FACTORIZATION

$$\frac{\mathrm{d}\sigma}{\mathrm{d}^4q\mathrm{d}\Omega} \propto \int \mathrm{d}^2\boldsymbol{p}_T \mathrm{d}^2\boldsymbol{k}_T \delta^2(\boldsymbol{p}_T + \boldsymbol{k}_T - \boldsymbol{q}_T)\mathcal{M}_{\mu\rho\kappa\lambda}\left(\mathcal{M}_{\nu\sigma}{}^{\kappa\lambda}\right)^* \Phi_g^{\mu\nu}(x_1, \boldsymbol{p}_T, \zeta_1, \mu)\, \Phi_g^{\rho\sigma}(x_2, \boldsymbol{k}_T, \zeta_2, \mu), \quad (1)$$

$$\Phi_g^{\mu\nu}(x, \boldsymbol{p}_T, \zeta, \mu) \equiv 2\int \frac{\mathrm{d}(\xi\cdot P)\,\mathrm{d}^2\xi_T}{(xP\cdot n)^2(2\pi)^3} e^{i(xP+p_T)\cdot\xi} \mathrm{Tr}_c\left[\langle P|F^{n\nu}(0)\,\mathcal{U}_{[0,\xi]}^{n[-]}\,F^{n\mu}(\xi)\,\mathcal{U}_{[\xi,0]}^{n[-]}|P\rangle\right]_{\xi\cdot P'=0}$$

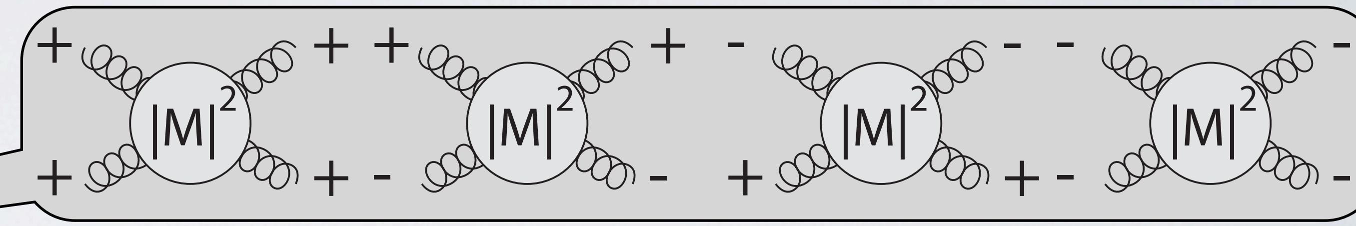
$$= -\frac{1}{2x}\left\{g_T^{\mu\nu} f_1^g - \left(\frac{p_T^\mu p_T^\nu}{M_p^2} + g_T^{\mu\nu}\frac{\boldsymbol{p}_T^2}{2M_p^2}\right)h_1^{\perp\, g}\right\} + \mathrm{HT}, \quad (2)$$

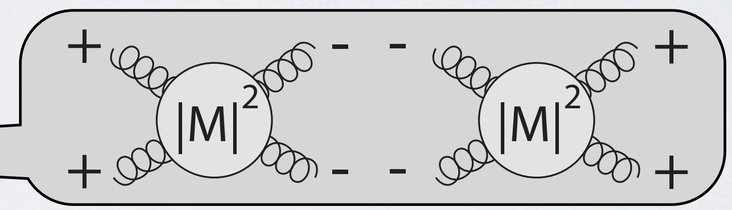


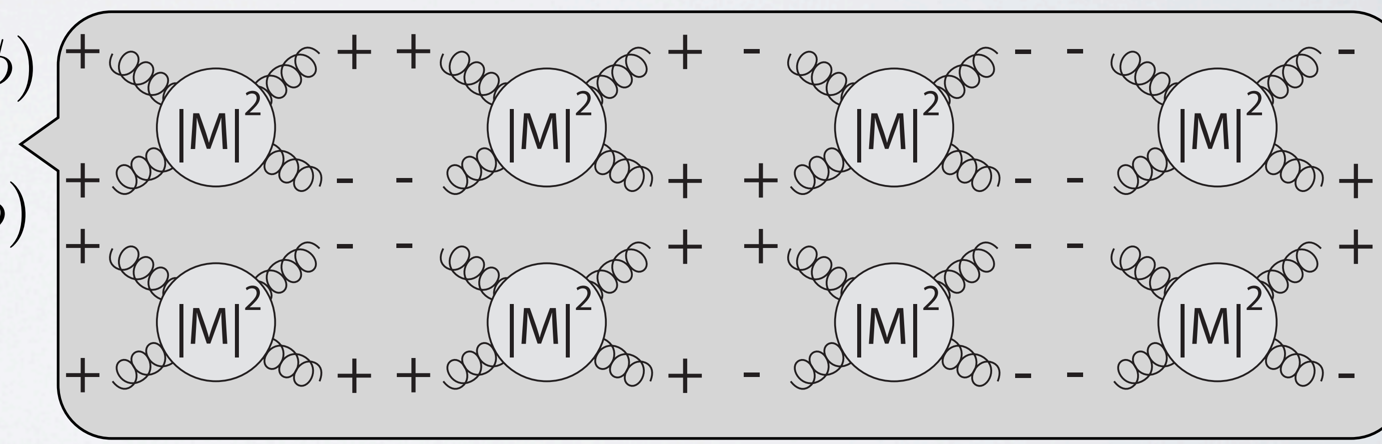


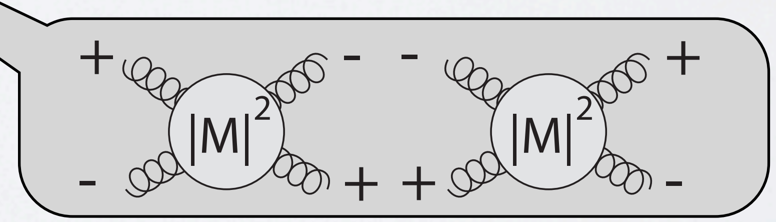
GENERAL STRUCTURE

$$
\begin{aligned}
&\frac{\mathrm{d}\sigma}{\mathrm{d}^4 q \mathrm{d}\Omega} \propto \\
&F_1(Q,\theta)\,\mathcal{C}\left[f_1^g f_1^g\right] \\
&+F_2(Q,\theta)\,\mathcal{C}\left[w_2\, h_1^{\perp g} h_1^{\perp g}\right] \\
&+F_3(Q,\theta)\,\mathcal{C}\left[w_3 f_1^g h_1^{\perp g} + (x_1 \leftrightarrow x_2)\right]\cos(2\phi) \\
&+F_3'(Q,\theta)\,\mathcal{C}\left[w_3 f_1^g h_1^{\perp g} - (x_1 \leftrightarrow x_2)\right]\sin(2\phi) \\
&+F_4(Q,\theta)\,\mathcal{C}\left[w_4\, h_1^{\perp g} h_1^{\perp g}\right]\cos(4\phi) \\
&+\mathcal{O}\left(\frac{q_T}{Q}\right),
\end{aligned}
$$

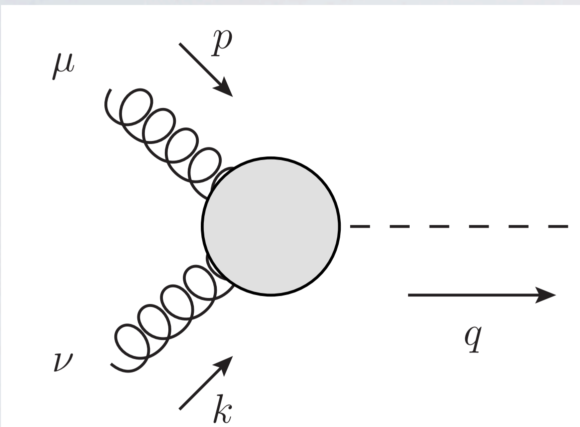




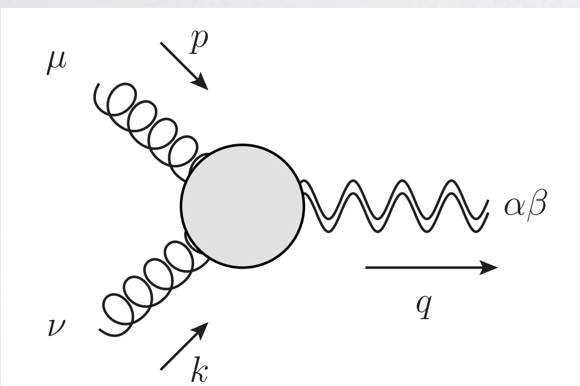




PARTONIC AMPLITUDES



$$= a_1\, q^2 g^{\mu\nu} + a_3\, \epsilon^{pk\mu\nu}$$

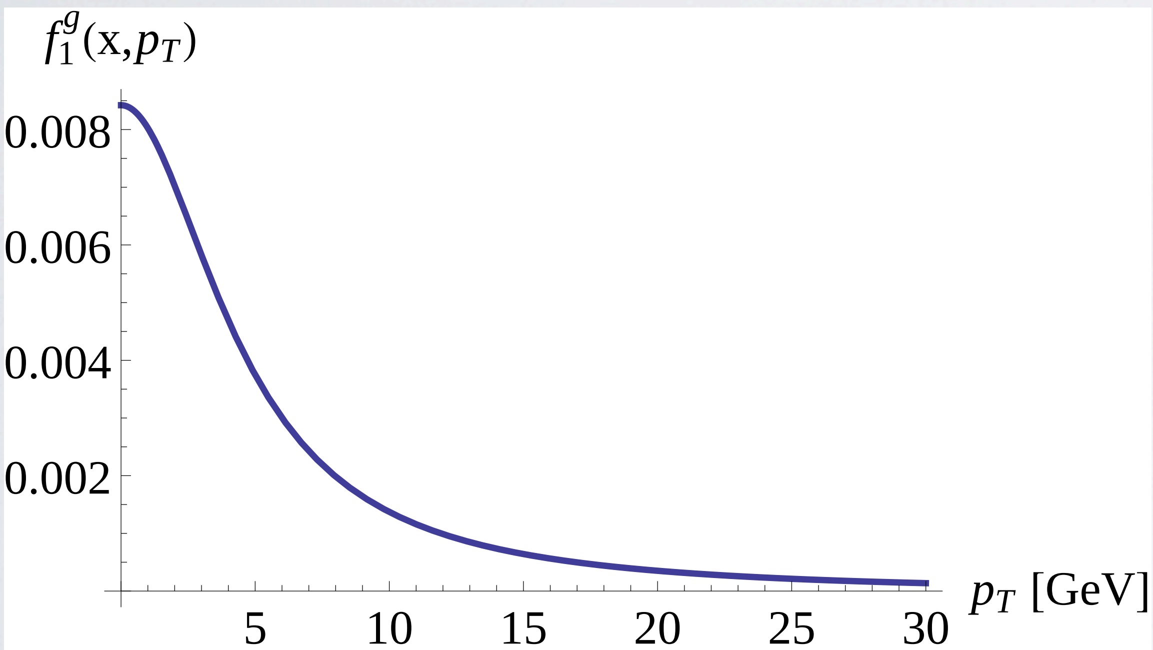


$$= \frac{1}{2} c_1\, q^2 g^{\mu\alpha} g^{\nu\beta} + \left[c_2\, q^2 g^{\mu\nu} + c_5\, \epsilon^{pk\mu\nu}\right] \frac{(p-k)^\alpha (p-k)^\beta}{q^2}$$

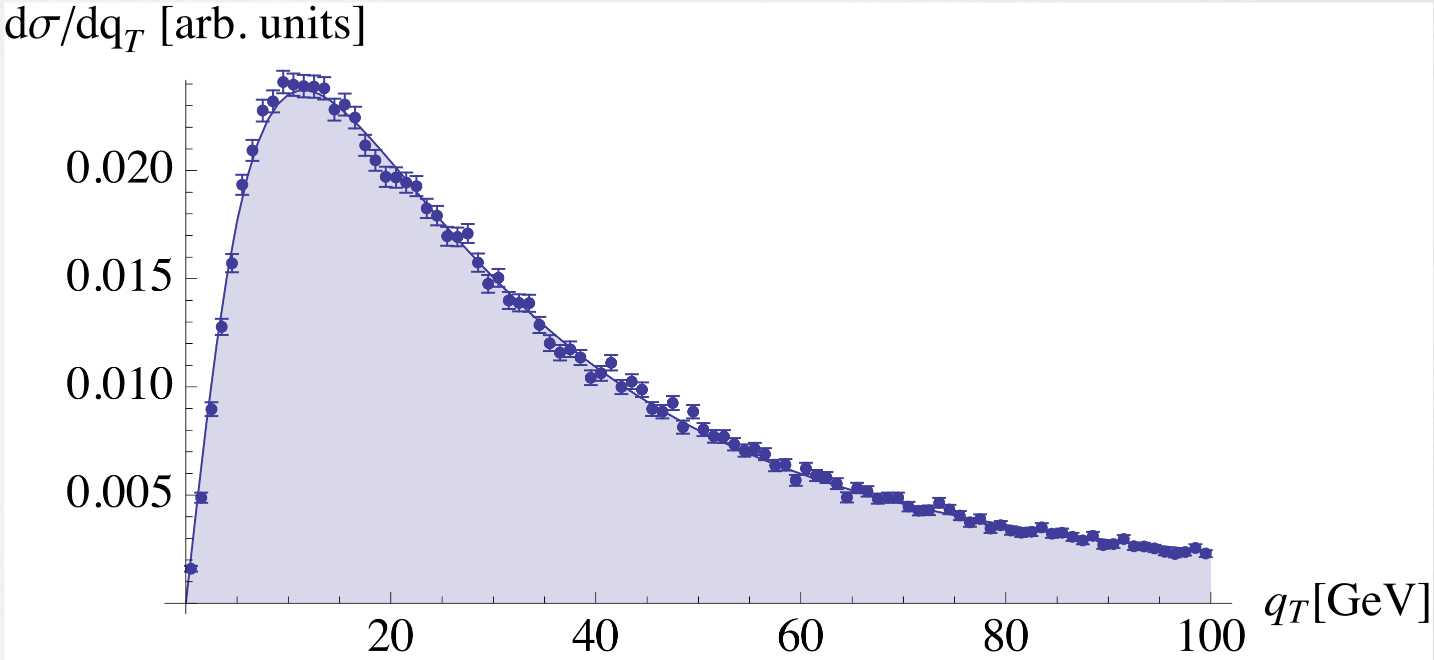
scenario	0^+	0^-	2^+_m	2^+_h	$2^+_{h'}$	$2^+_{h''}$	2^-_h
a_1	1	0	-	-	-	-	-
a_3	0	1	-	-	-	-	-
c_1	-	-	1	0	1	1	0
c_2	-	-	$-\frac{1}{4}$	1	1	$-\frac{3}{2}$	0
c_5	-	-	0	0	0	0	1

UNPOLARIZED DISTRIBUTION

$$f_1^g(x, \boldsymbol{p}_T^2, \frac{3}{2}\sqrt{s}, M_h) = \frac{A_0\, M_0^2}{M_0^2 + \boldsymbol{p}_T^2} \exp\left[-\frac{\boldsymbol{p}_T^2}{a\boldsymbol{p}_T^2 + 2\sigma^2}\right]$$



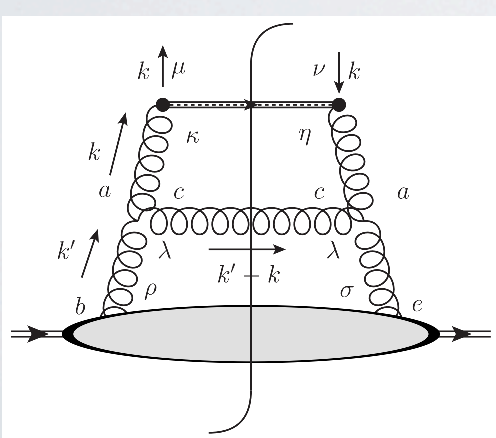
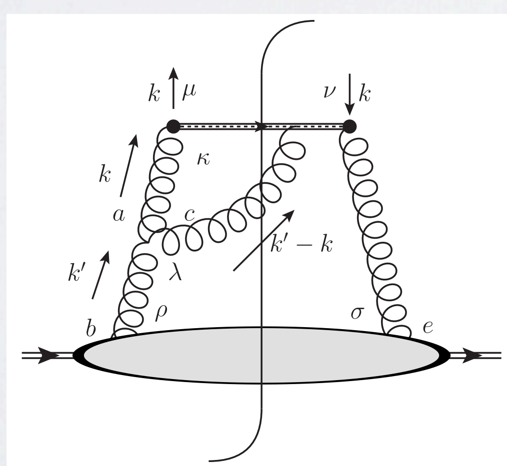
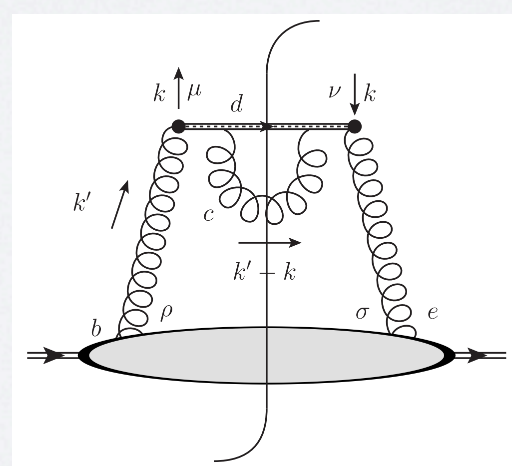
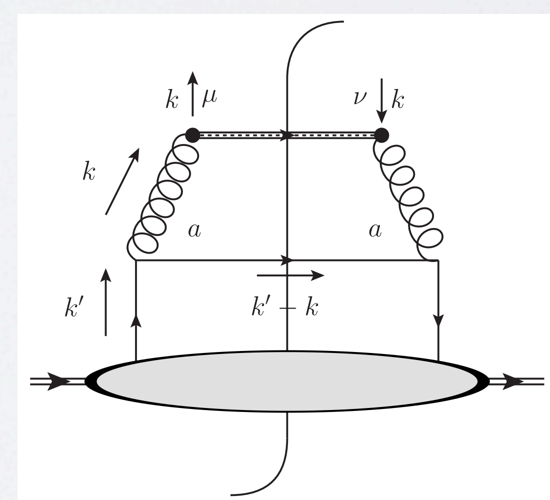
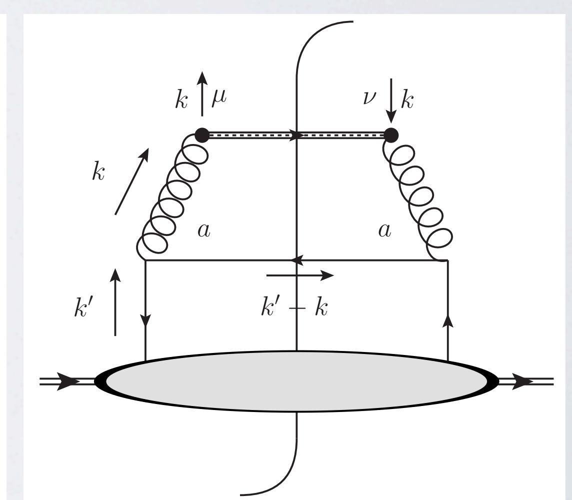
$$\mathcal{C}[w\, f\, g] \equiv \int d^2\boldsymbol{p}_T \int d^2\boldsymbol{k}_T\, \delta^2(\boldsymbol{p}_T + \boldsymbol{k}_T - \boldsymbol{q}_T)$$
$$w(\boldsymbol{p}_T, \boldsymbol{k}_T)\, f(x_1, \boldsymbol{p}_T^2)\, g(x_2, \boldsymbol{k}_T^2)$$



POLARIZED DISTRIBUTION

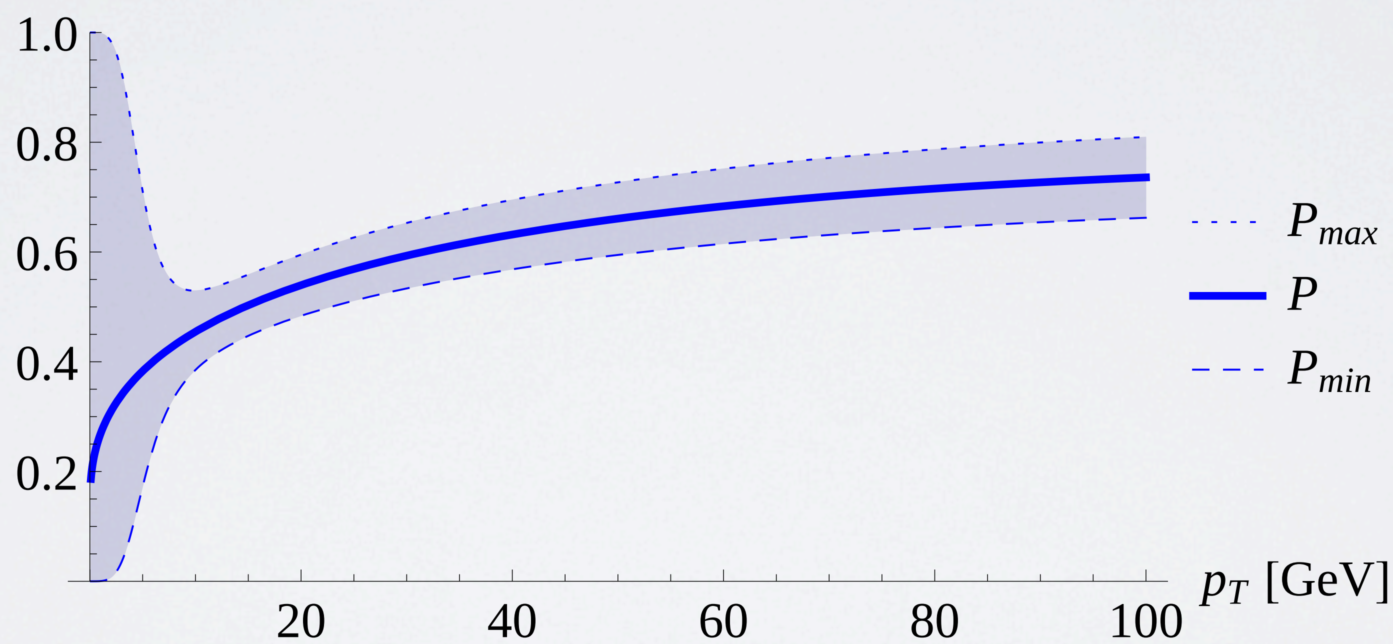
$$h_1^{\perp g}(x, \boldsymbol{p}_T, \zeta, \mu) = \mathcal{P}(x, \boldsymbol{p}_T^2, \zeta) \frac{2M_p^2}{\boldsymbol{p}_T^2} f_1^g(x, \boldsymbol{p}_T, \zeta, \mu),$$

$$\Phi^{\mu\nu}(x, \boldsymbol{k}_T) = \frac{\int \mathrm{d}(\xi \cdot P)\mathrm{d}^2\xi_T}{(k \cdot n)^2(2\pi)^3} e^{ik\cdot\xi} 2\mathrm{Tr}_c \langle P \big| F^{n\nu}(0)\mathcal{U}^{[-]}_{[0,\xi]} F^{n\mu}(\xi)\mathcal{U}^{[-]}_{[\xi,0]} \big| P \rangle.$$

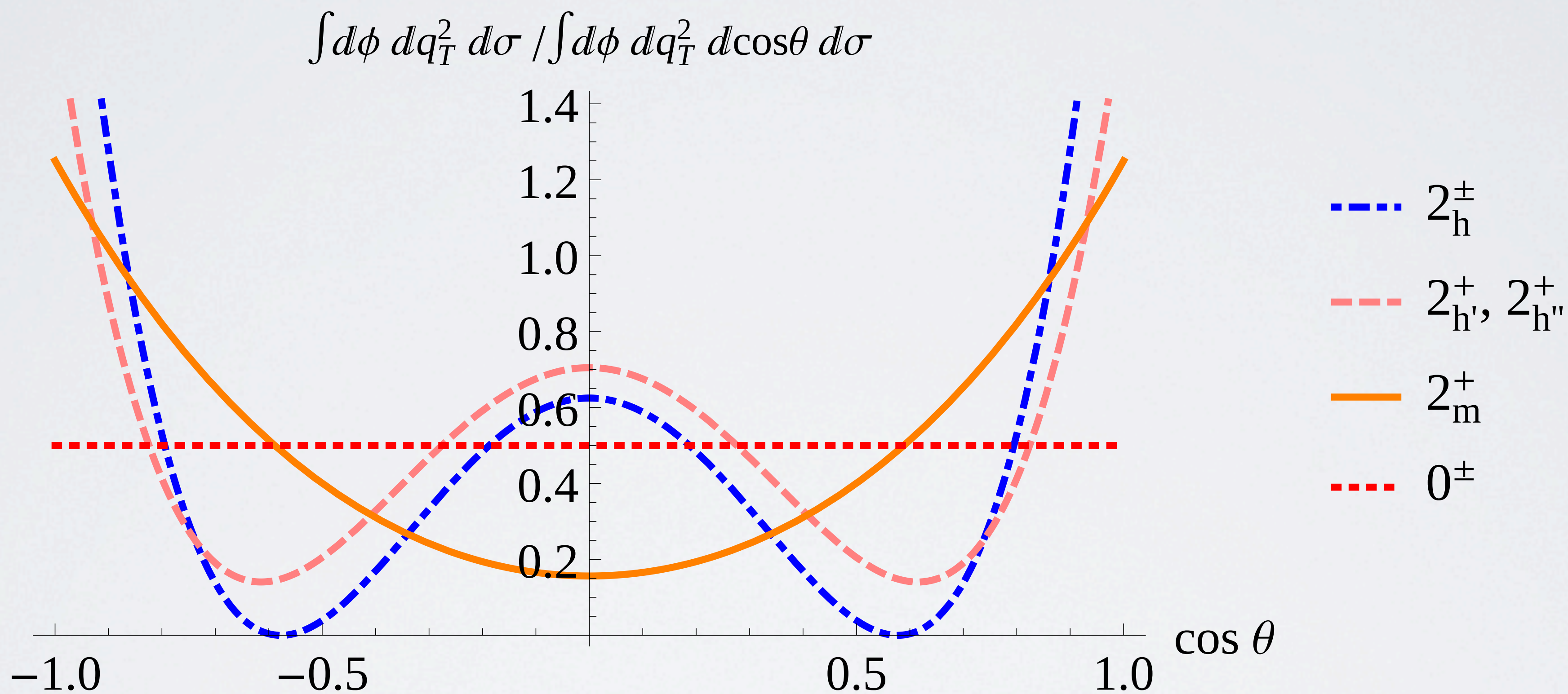
DEGREE OF POLARIZATION

$$h_1^{\perp g}(x, \boldsymbol{p}_T, \zeta, \mu) = \mathcal{P}(x, \boldsymbol{p}_T^2, \zeta) \frac{2M_p^2}{\boldsymbol{p}_T^2} f_1^g(x, \boldsymbol{p}_T, \zeta, \mu),$$

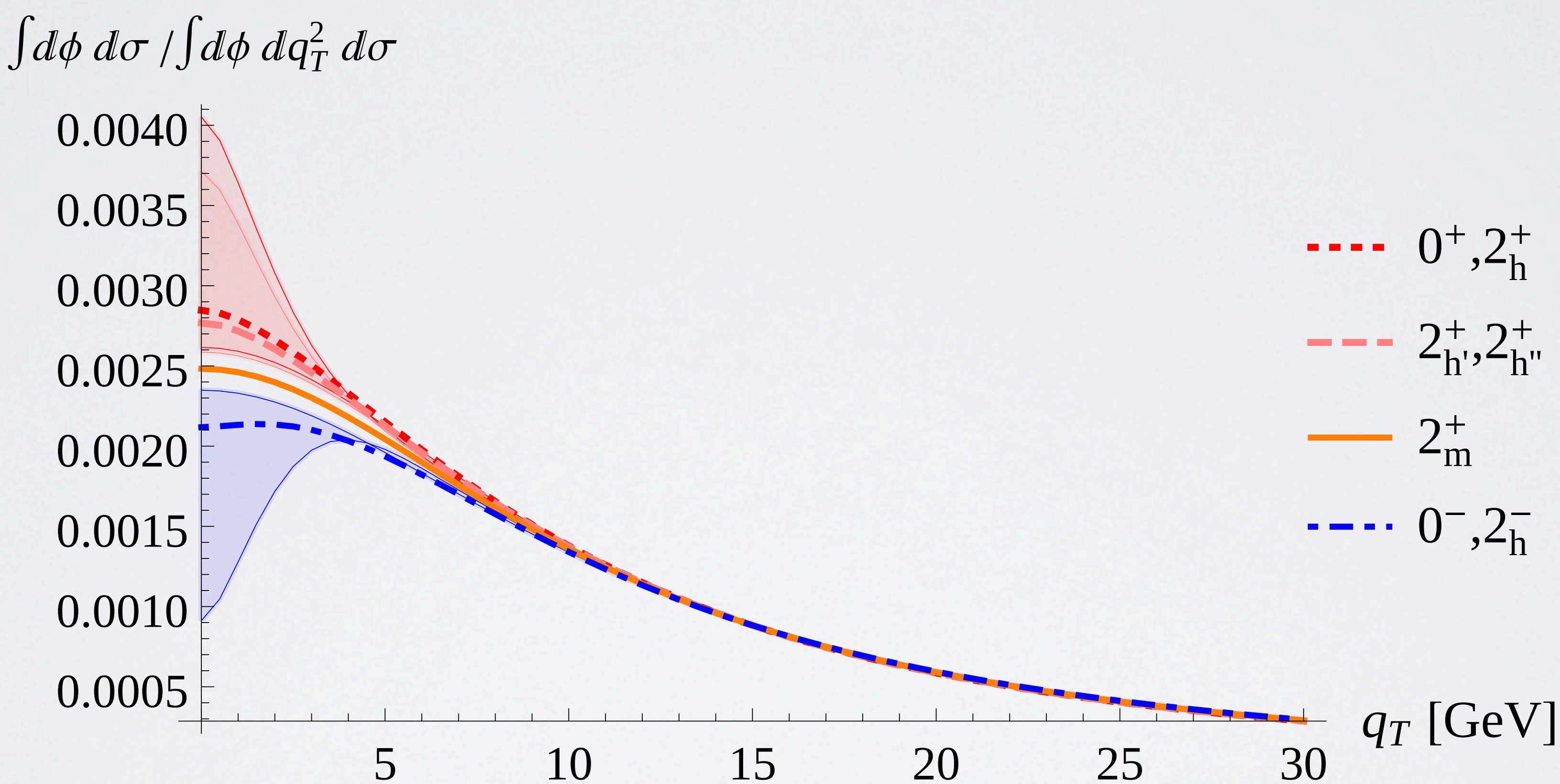


CGC model predicts full polarization at small x:
A. Metz and J. Zhou, Phys. Rev. D 84, 051503 (2011)

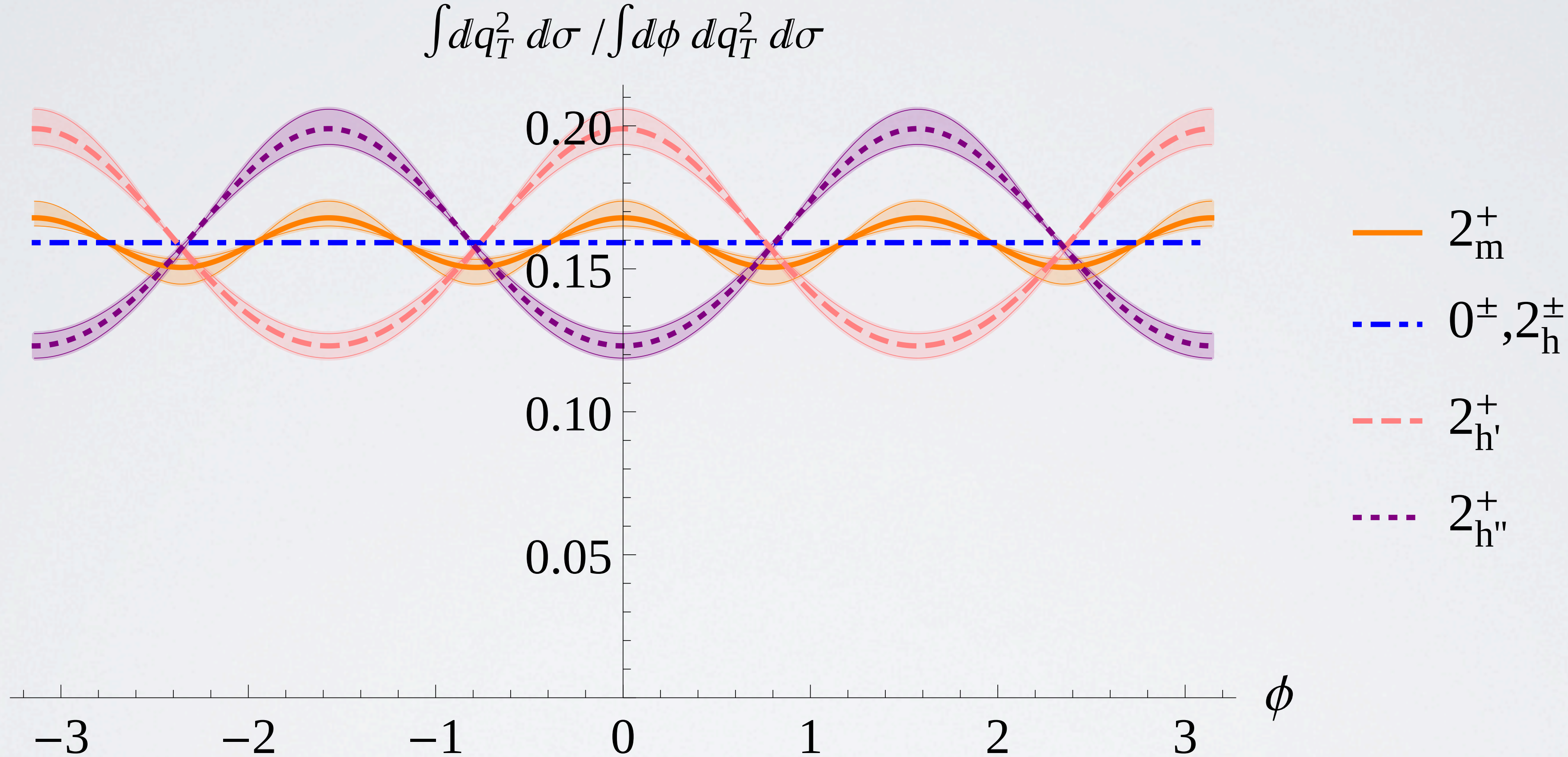
COSθ DISTRIBUTION



TRANSVERSE MOMENTUM DISTRIBUTION



Φ DISTRIBUTION



REMARKS

- gg->box->$\gamma\gamma$ background also φ dependent
- same can be done in the H->ZZ* channel

CONCLUSIONS

- gluon polarization modifies both q_T and ϕ distribution
- q_T distribution modification different for positive/negative parity states
- ϕ distribution modification different for spin-2/spin-0
- ϕ distribution modification different for the various spin-2 coupling scenarios

more info:
arXiv:1304.2654