On Photonic Observables in W-Pair Production

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Outline:

- **Introduction.**
- **Differences in Photonic Distributions between YFSWW and RacoonWW.**
- **Non-leading EW Corrections to Photon Observables in YFSWW.**
- **Conclusions.**

People:

S. JADACH, W. PŁACZEK, M. SKRZYPEK, B.F.L. WARD, Z. WĄS

Programs	Papers
KoralW:	Comput. Phys. Commun. **94** (1996) 215
	Phys. Lett. **B372** (1996) 289;
	Comput. Phys. Commun. **119** (1999) 272
	Comput. Phys. Commun. **125** (2000) 8
	Comput. Phys. Commun. **140** (2001) 475
YFSWW3:	Phys. Rev. **D54** (1996) 5434
	Phys. Lett. **B417** (1998) 326
	Phys. Rev. **D61** (2000) 113010
	Comput. Phys. Commun. **140** (2001) 432
	Phys. Lett. **B523** (2001) 117
	CERN-TH/2000-337, hep-ph/0007012
	$\longrightarrow$ submitted to Phys. Rev. **D**
	CERN-TH/2001-274, January 2002
	$\longrightarrow$ to be submitted to Phys. Lett. **B**

$\longrightarrow$ **Programs available at:**

`http://cern.ch/placzek`

Standard Perturbative Approach:

Order	Loops/Real-Photons
$\mathcal{O}(\alpha^0)$	**0/0**
$\mathcal{O}(\alpha^1)$	**1/0** $+$ **0/1**
$\mathcal{O}(\alpha^2)$	**2/0** $+$ **1/1** $+$ **0/2**
...	...

$\Rightarrow$ At $\mathcal{O}(\alpha^1)$ Only Tree-level Single-Photon Observables

$\Rightarrow$ Radiative Corrections to Single-Photon Observables appear at $\mathcal{O}(\alpha^2)$ and h.o.

RacoonWW (A. Denner et al.):

- **Main Event Generation Mode:**
  $\longrightarrow$ **Single-Photon Observables at Tree Level**
- **Special (dedicated) 1γ Mode:**
  $\longrightarrow$ **Single-Photon Observables with $\mathcal{O}(\alpha^3)$ LL ISR Corrections (through QED Structure Functions)**

Exclusive Yennie-Frautschi-Suura Exponentiation:

$$\sigma = \sum_{n=0}^{\infty} \frac{1}{n!} \int \prod_{j=1}^{4} \frac{d^3 q_j}{q_j^0} \left\{ \prod_{i=1}^{n} \frac{d^3 k_i}{k_i^0} \tilde{S}(\{p\},\{q\},k_i) \Theta\left(\frac{2k_i^0}{\sqrt{s}} - \epsilon \right) \right\}$$
$$\times \delta^{(4)} \left(p_1 + p_2 - \sum_{j=1}^{4} q_i - \sum_{j=1}^{n} k_i \right) \; e^{Y(\{p\},\{q\};\epsilon)}$$
$$\times \left[\bar{\beta}_0^{(m)}(\{p\},\{q\}) + \sum_{i=1}^{n} \frac{\bar{\beta}_1^{(m)}(\{p\},\{q\},k_i)}{\tilde{S}(\{p\},\{q\},k_i)} + \ldots \right],$$

where

$\tilde{S}(\{p\},\{q\},k)$ — Soft-Photon Radiation Factor

$Y(\{p\},\{q\};\epsilon)$ — YFS Infrared (IR) FormFactor

$\bar{\beta}_n^{(m)}(\ldots)$ — $\mathcal{O}(\alpha^m)$ Non-IR YFS Residuals for n Real Photons

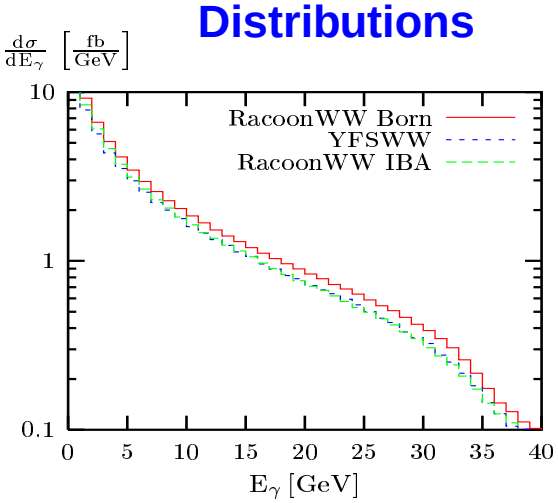
- Each Event with Infinite Number of Radiative Photons (most integrated over)
- Correct IR limit
- Perturbative Non-IR Corrections included Multiplicatively: For Any Number of Photons (Exact in Soft-Photon Limit)

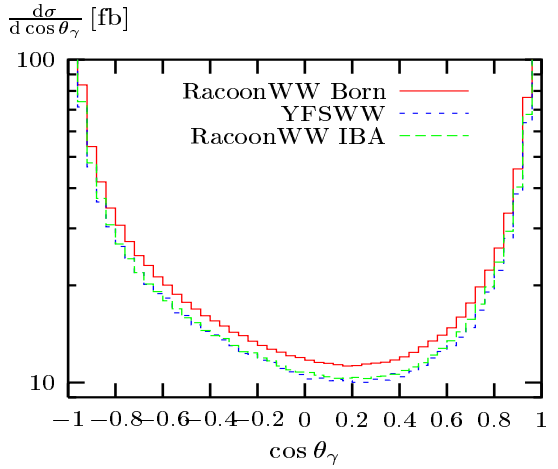
$\Rightarrow$ **Single-Photon Observables in YFSWW:**

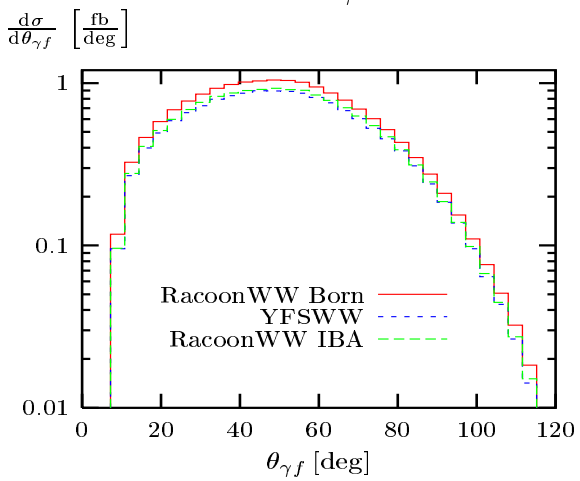
$*$ $\mathcal{O}(\alpha^2)$ LL ISR Corrections

$*$ Approximate $\mathcal{O}(\alpha^1)$ Non-Leading (NL) EW Corrections

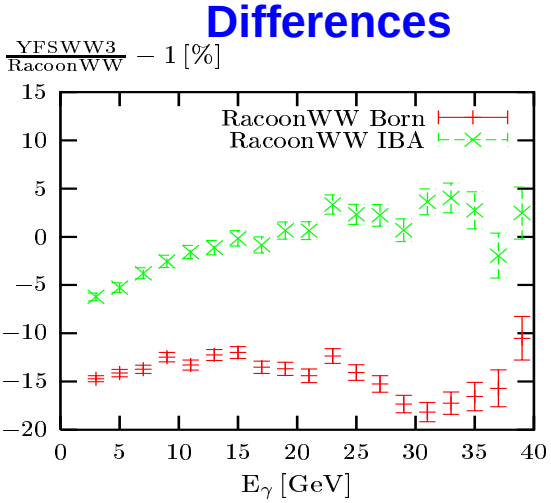
Distributions

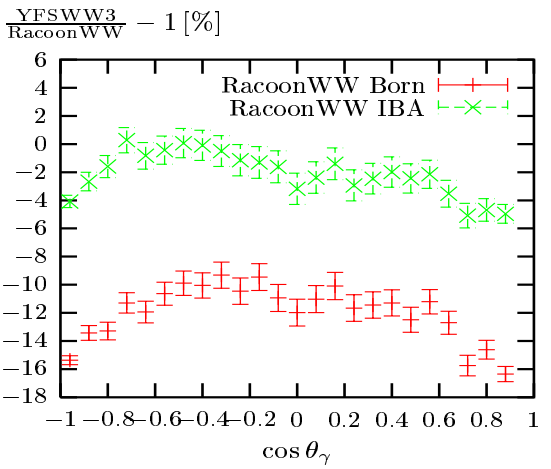


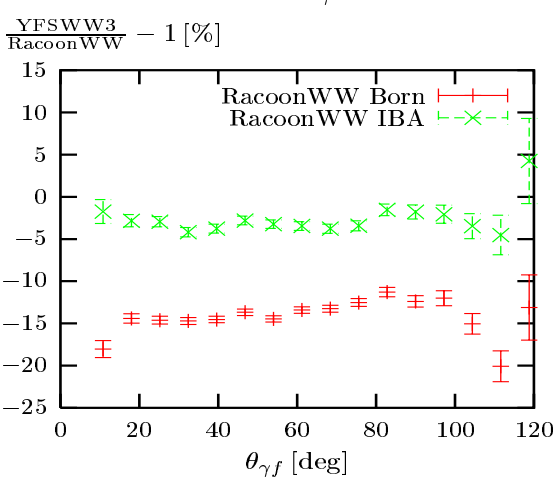




Differences







A. Denner et al., hep-ph0104057

$+$ **2000 LEP2MC Workshop** $\longrightarrow$ Differences $\mathbf{10–20\%}$

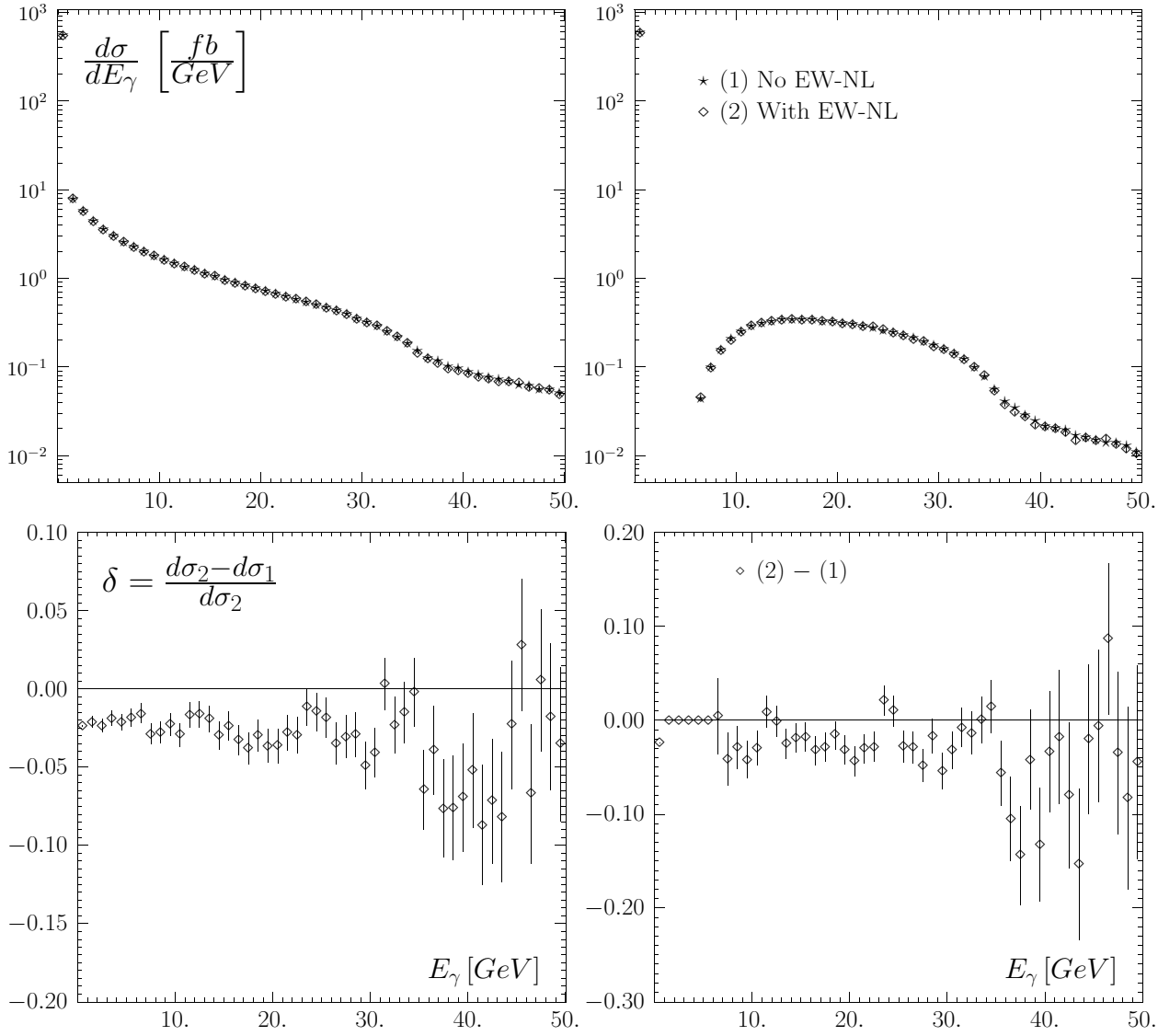
$\times$ **ISR-Corrected RacoonWW** $\longrightarrow$ Differences $\leq \mathbf{5\%}$

YFSWW Below **RacoonWW**

YFSWW: Effect of $\mathcal{O}(\alpha^1)$ NL EW Corr.

$$e^+e^- \longrightarrow W^+W^- \longrightarrow u\bar{d}\mu^-\bar{\nu}_\mu$$

CALO5 **CALO25**



E_γ @ $\sqrt{s} = 200$ GeV

$\Rightarrow$ **NL EW Corrections:** $\sim -2.5\%$ **shift**

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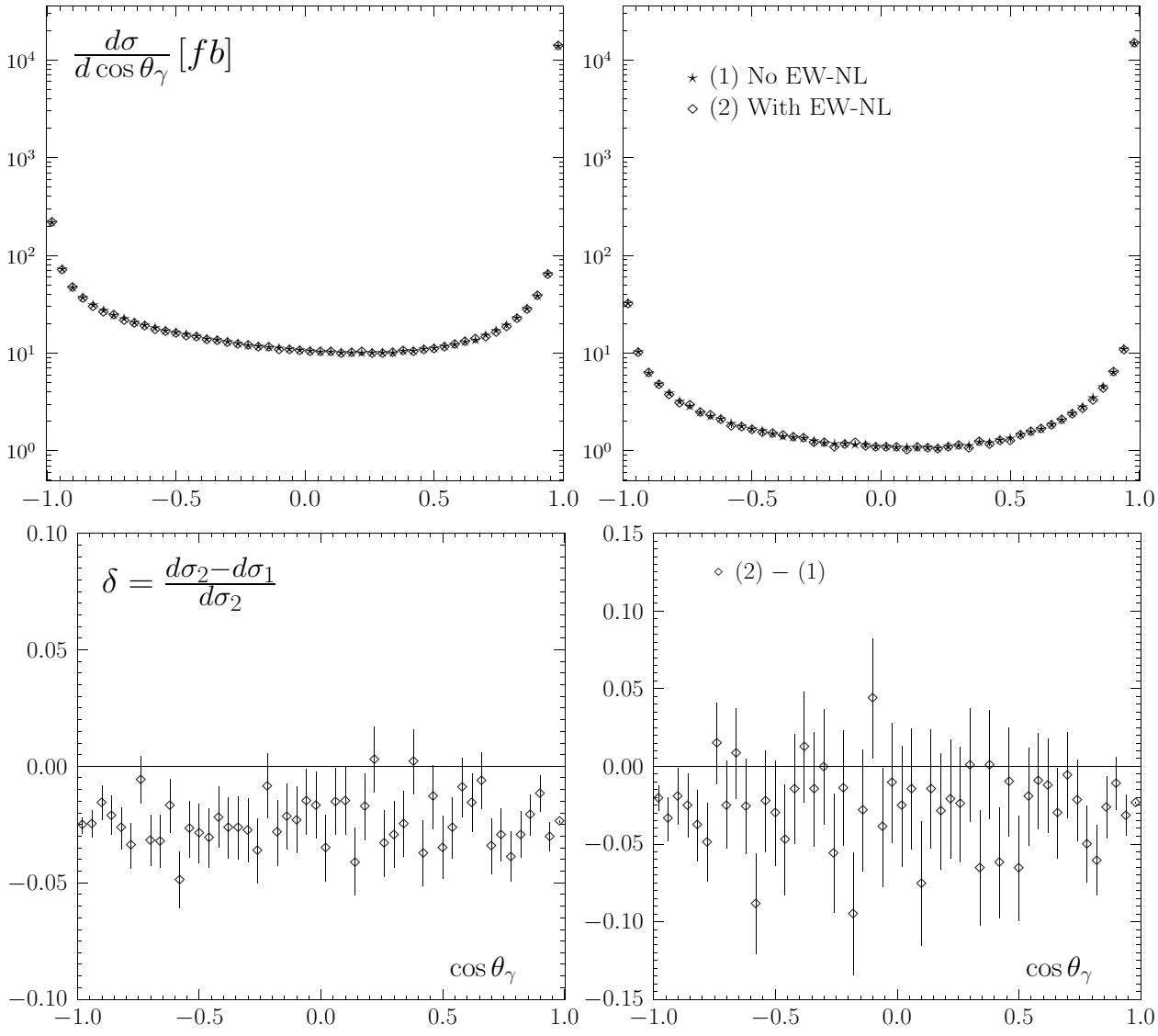

$\cos\theta_\gamma$ @ $\sqrt{s} = 200$ GeV

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YFSWW: Effect of $\mathcal{O}(\alpha^1)$ NL EW Corr.

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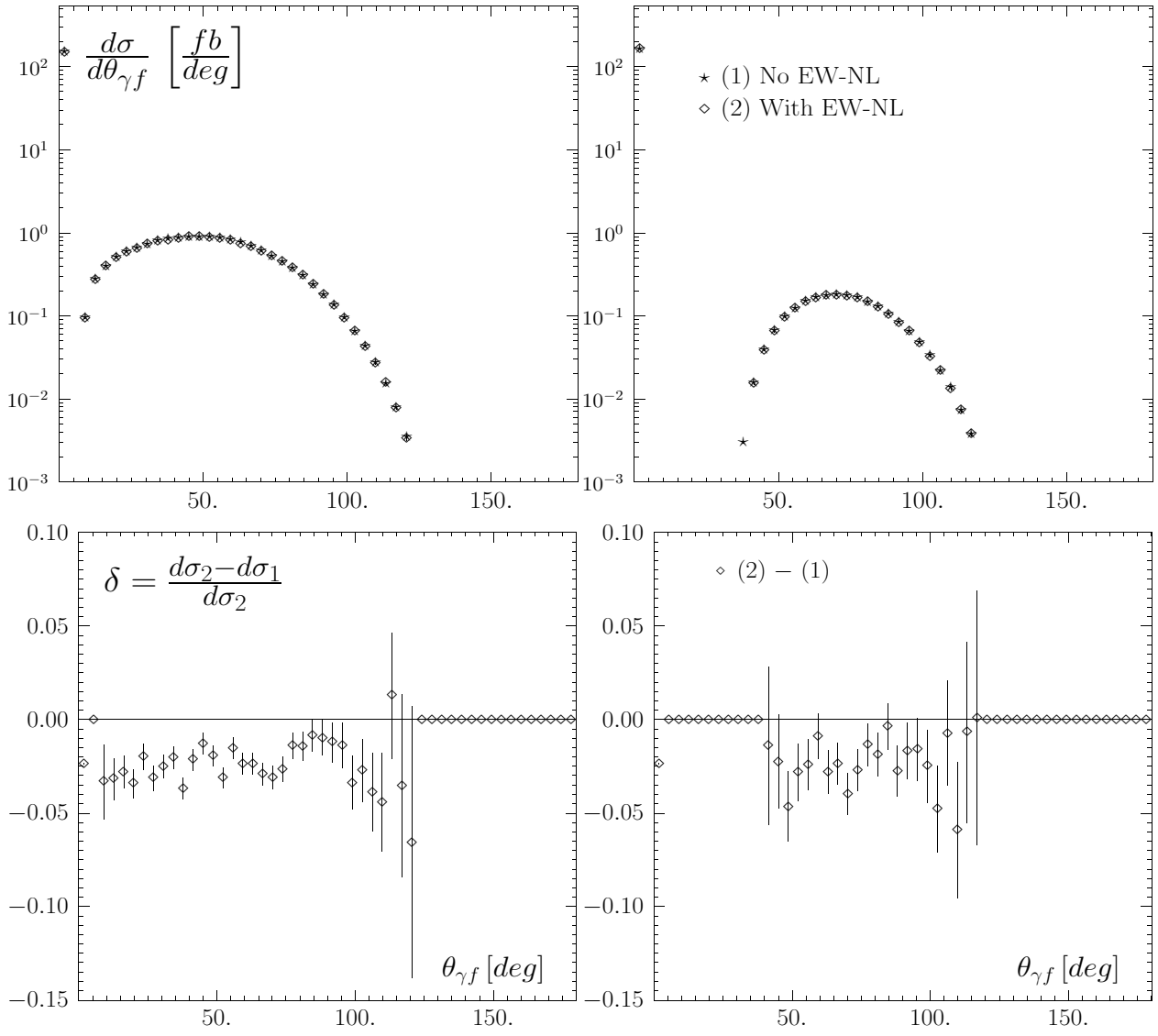

$\theta_{\gamma f}$ @ $\sqrt{s} = 200$ GeV

$\Rightarrow$ **NL EW Corrections:** $\sim -2.5\%$ **shift**

Conclusions

- **Differences in Single-Photon Distributions:**

	YFSWW Main Mode
RacoonWW: Main Mode	10–20%
RacoonWW: 1γ Mode with ISR	$\leq 5\%$

- **At $\mathbf{E_{CM} = 200}$ GeV $\mathcal{O}(\alpha^1)$ NL EW Corrections for Single-Photon Distributions in YFSWW $\rightarrow$ Shift of $\sim -2.5\%$**

  $\Rightarrow$ **For 1γ Distributions with ISR Corrections Only:**

  YFSWW and RacoonWW Agree to $\sim 2\%$

- **At $\mathbf{E_{CM} = 500}$ GeV $\mathcal{O}(\alpha^1)$ NL EW Corrections in YFSWW induce a Shift for Single-Photon Distributions of ~ 5–10%**

- **Hopefully, Direct Comparisons of Recent Versions of the Two Programs Will be Done Soon!**

NOTE: The above NL Correction is Not the Full $\mathcal{O}(\alpha^1)$ to Single-Photon Observables, but its Part – Probably Substantial