

# New Developments in Electroweak Calculations

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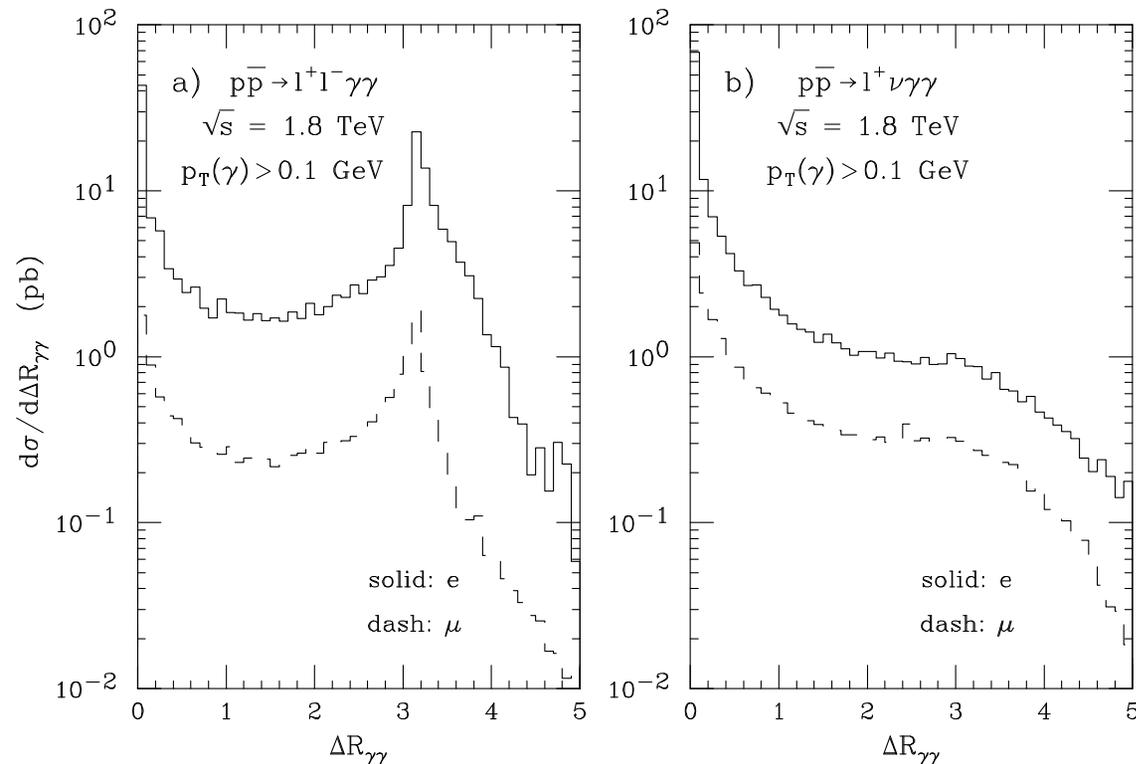
- final state photon radiation shifts  $W$  mass by  $\mathcal{O}(100)$  MeV:
  - ☞ need to worry about multiple final state photon radiation in  $W$  and  $Z$  production
  - ☞ effect should be more pronounced in  $Z$  case since both final state leptons radiate
- recent papers:
  - UB, Stelzer, PRD 61, 073007 (2000)
  - Jadach, Placzek, Eur. Phys. J. **C29**, 325 (2003)
  - Montagna et al., hep-ph/0303102

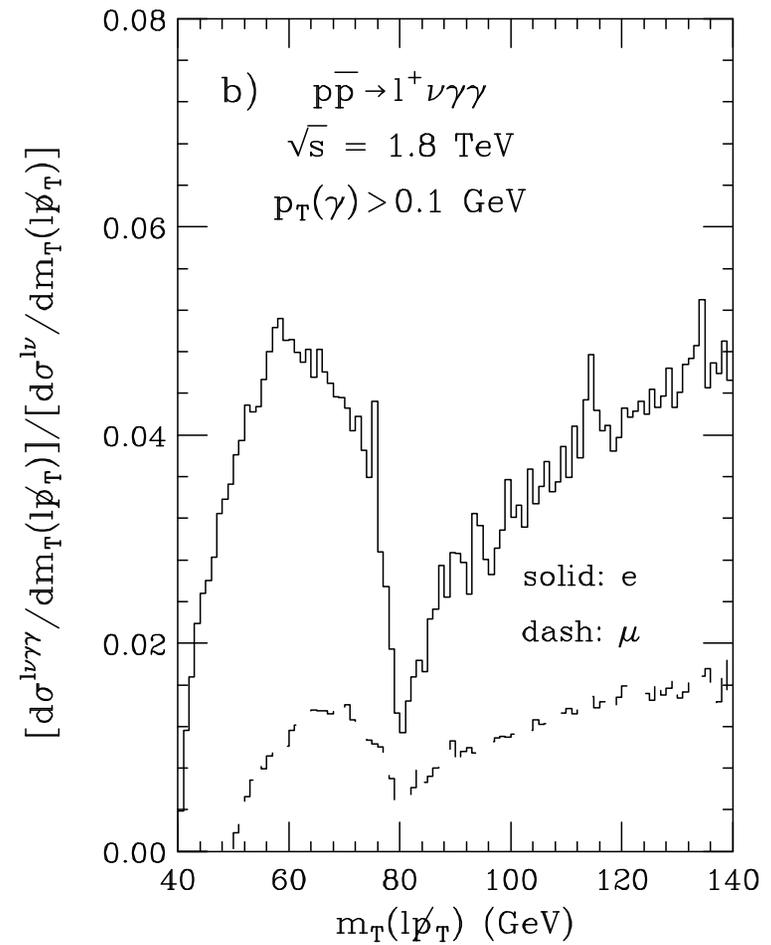
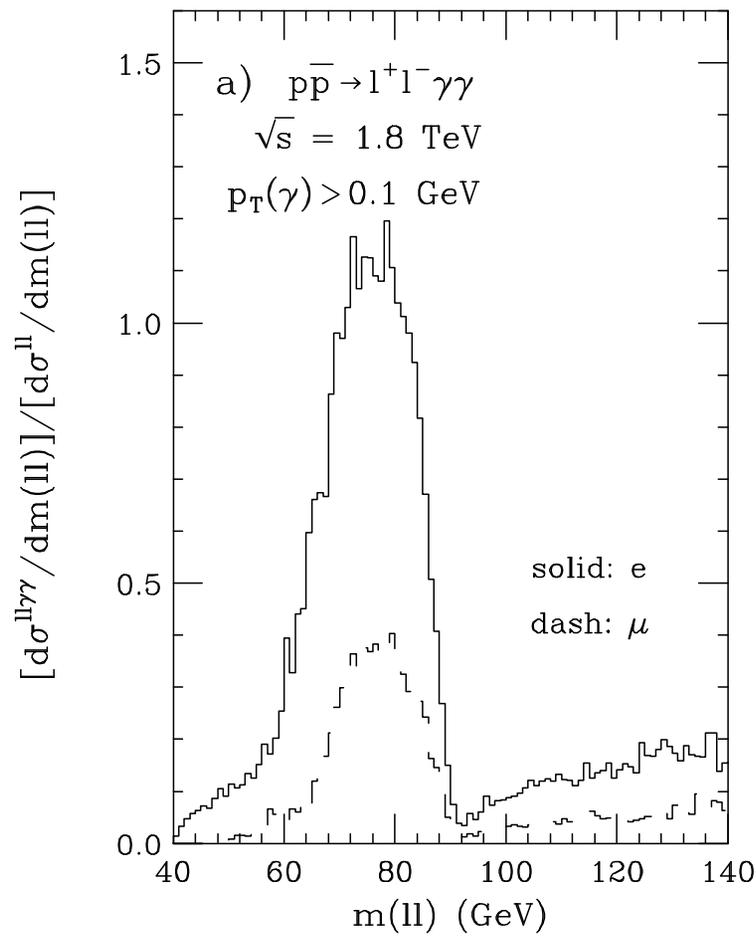
- first steps to address this question:

☞ explicit matrix element calculation of  $l\nu\gamma\gamma$  and  $l^+l^-\gamma\gamma$  production (UB, T. Stelzer)

→ valid for small and large angle brem (in contrast to Photos)

→ and photon  $p_T$ 's as small as 100 MeV





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- remarks:

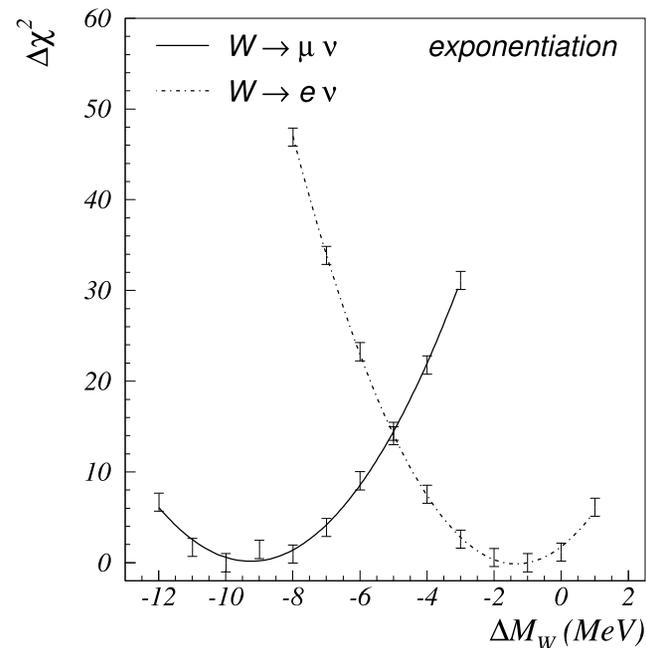
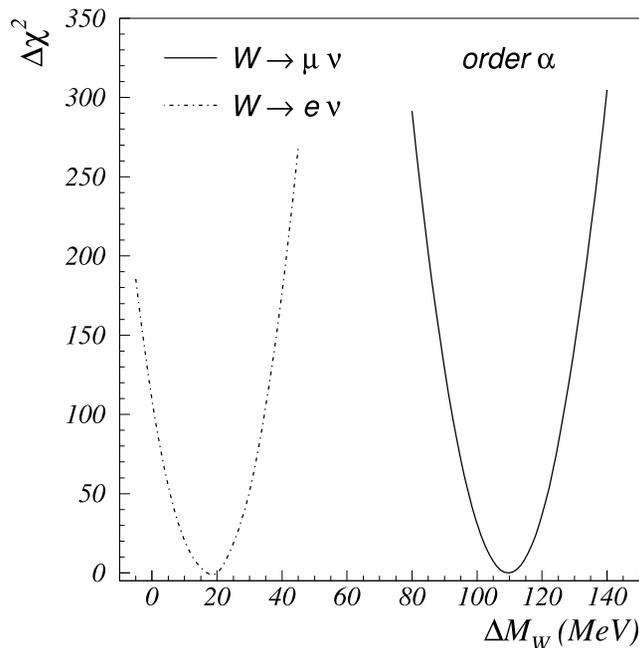
- ☞ no lepton id requirements included

- ☞ need to include soft and virtual corrections

- ☞ better: resum final state photon radiation to all orders

- Montagna et al. (hep-ph/0303102):
  - ☞ calculate higher order real and virtual corrections using QED structure function approach
  - ☞ currently only for  $W$  production,
  - ☞ and only final state corrections are incorporated (reasonable approximation for higher order photonic corrections)
  - ☞ procedure used is **not** gauge invariant
  - ☞ however, terms violating gauge invariance are numerically small ( $< 0.1\%$ )
- Montagna et al. calculated shift in  $M_W$  using simplified detector model:
  - combine  $e$  and  $\gamma$  momenta for  $\Delta R(e, \gamma) < 0.2$
  - reject  $\mu$  events if  $E_\gamma > 2$  GeV and  $\Delta R(\mu, \gamma) < 0.2$

👉 result:



👉 shift of  $M_W$  caused by multi-photon radiation is about **10%** of that caused by one photon radiation

👉 **Note:** absolute value of shift caused by  $\mathcal{O}(\alpha)$  corrections smaller than value observed by CDF/DØ, due to simplified detector model

- Jadach, Placzek:

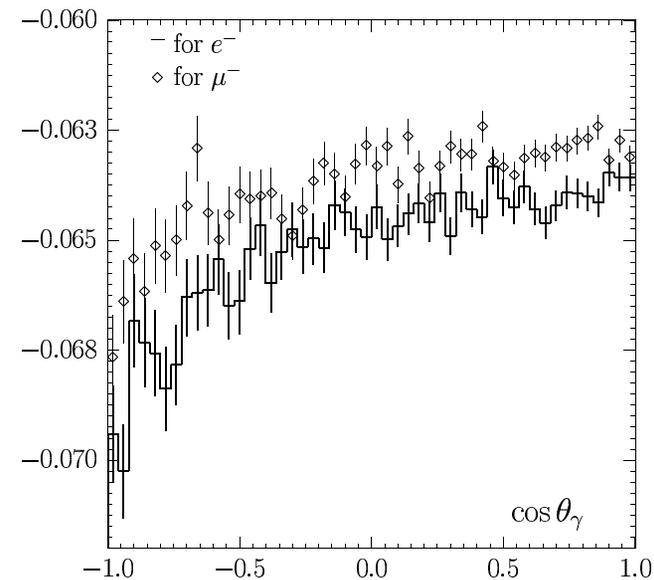
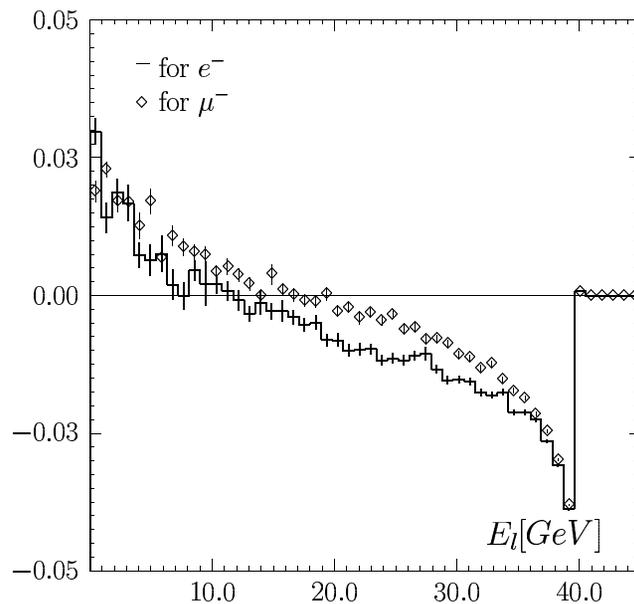
- ☞ use YFS exclusive exponentiation

- ☞ currently only at parton level and for  $W$  production

- ☞ procedure used is gauge invariant

- ☞ sample parton level results:

- ☞ vertical axis:  $\delta = (d\sigma_{YFS} - d\sigma_{\mathcal{O}(\alpha)})/d\sigma_{YFS}$



- ☞ corrections are sizable
- ☞ lepton id requirements are included
- near term plans:
  - ☞ implement final state multiphoton effects in WGRAD / ZGRAD following the approach used by Jadach and Placzek
  - ☞ work with Resbos' nians on unified  $W/Z$  generator
  - ☞ include resummation of electroweak Sudakov logs (important at large invariant/transverse masses)