QED for CDF *W* mass measurement

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Second *W* mass workshop
Fermilab

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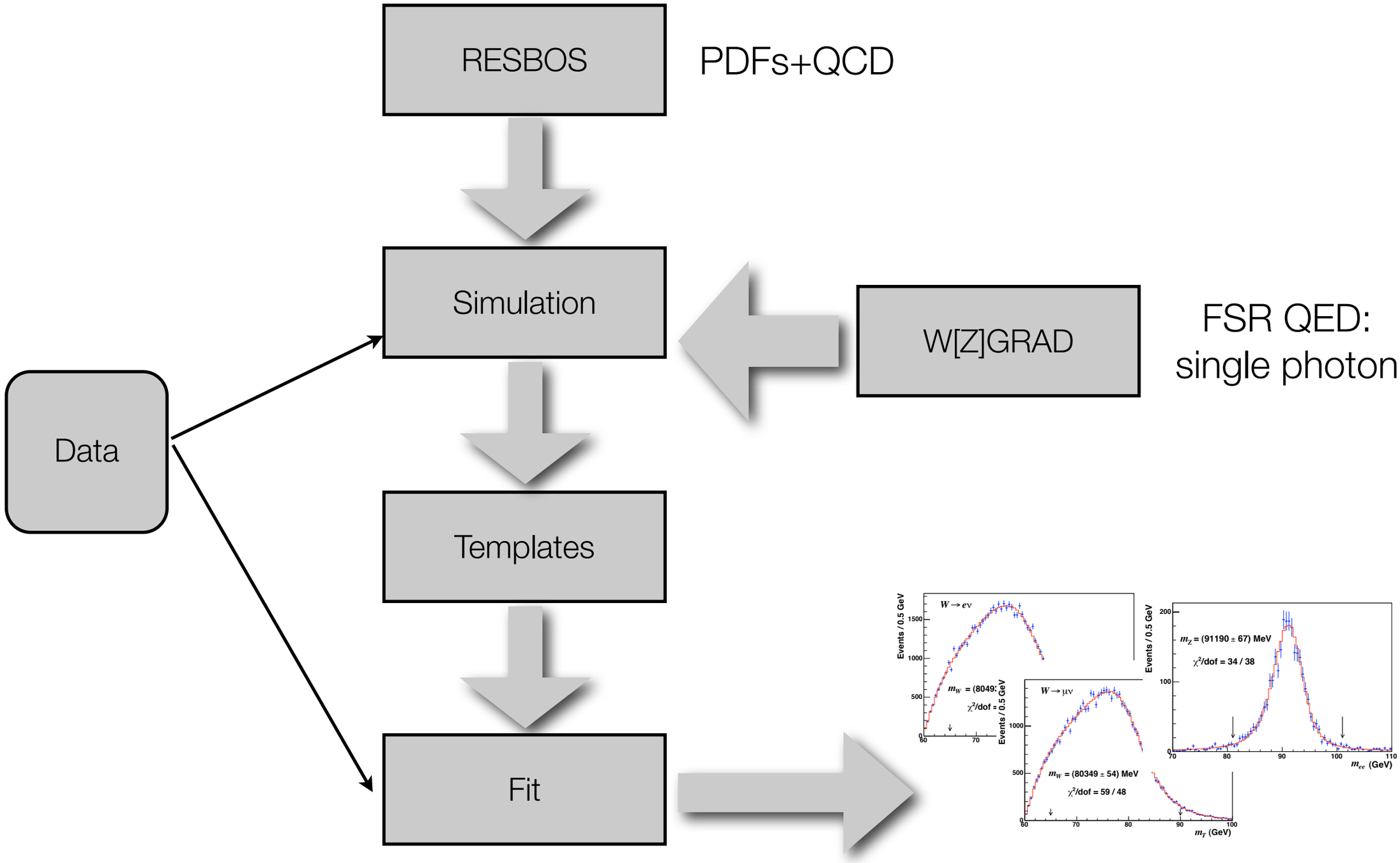
“Method 1”

- Used in 200 pb^{-1} measurement at CDF



Old result

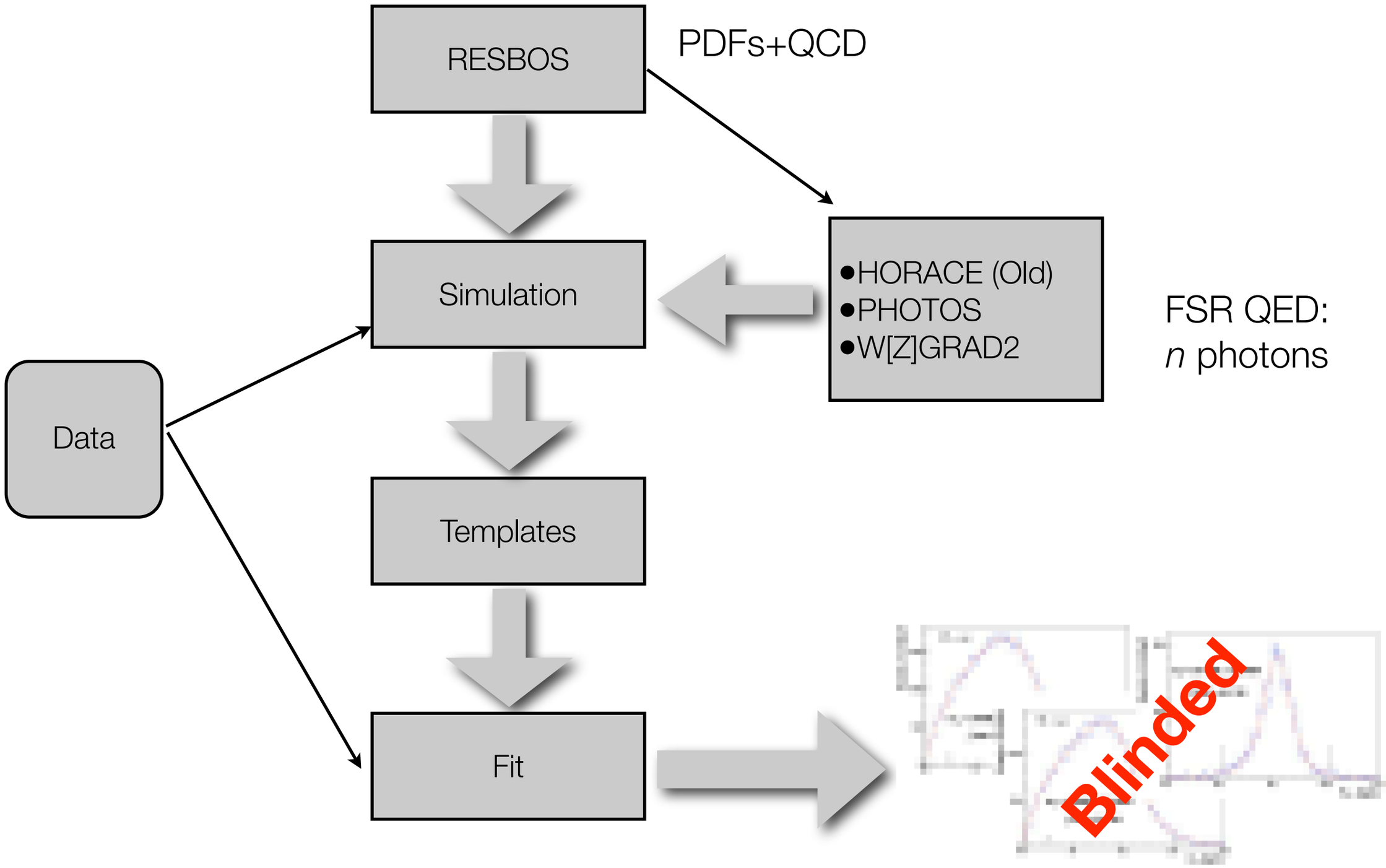
Systematic Uncertainties (GeV/c^2): m_T fit

Source	$W \to \mu\nu$	$W \to e\nu$	Common
Lepton Scale	17	30	17
Lepton Resolution	3	9	0
Lepton Efficiency	1	3	0
Lepton Tower Removal	5	8	5
Recoil Energy Scale	9	9	9
Recoil Energy Resolution	7	7	7
Backgrounds	9	8	0
PDFs	11	11	11
W Boson p_T	3	3	3
Photon Radiation	12	11	11
Statistical	54	48	0
Total	60	62	26

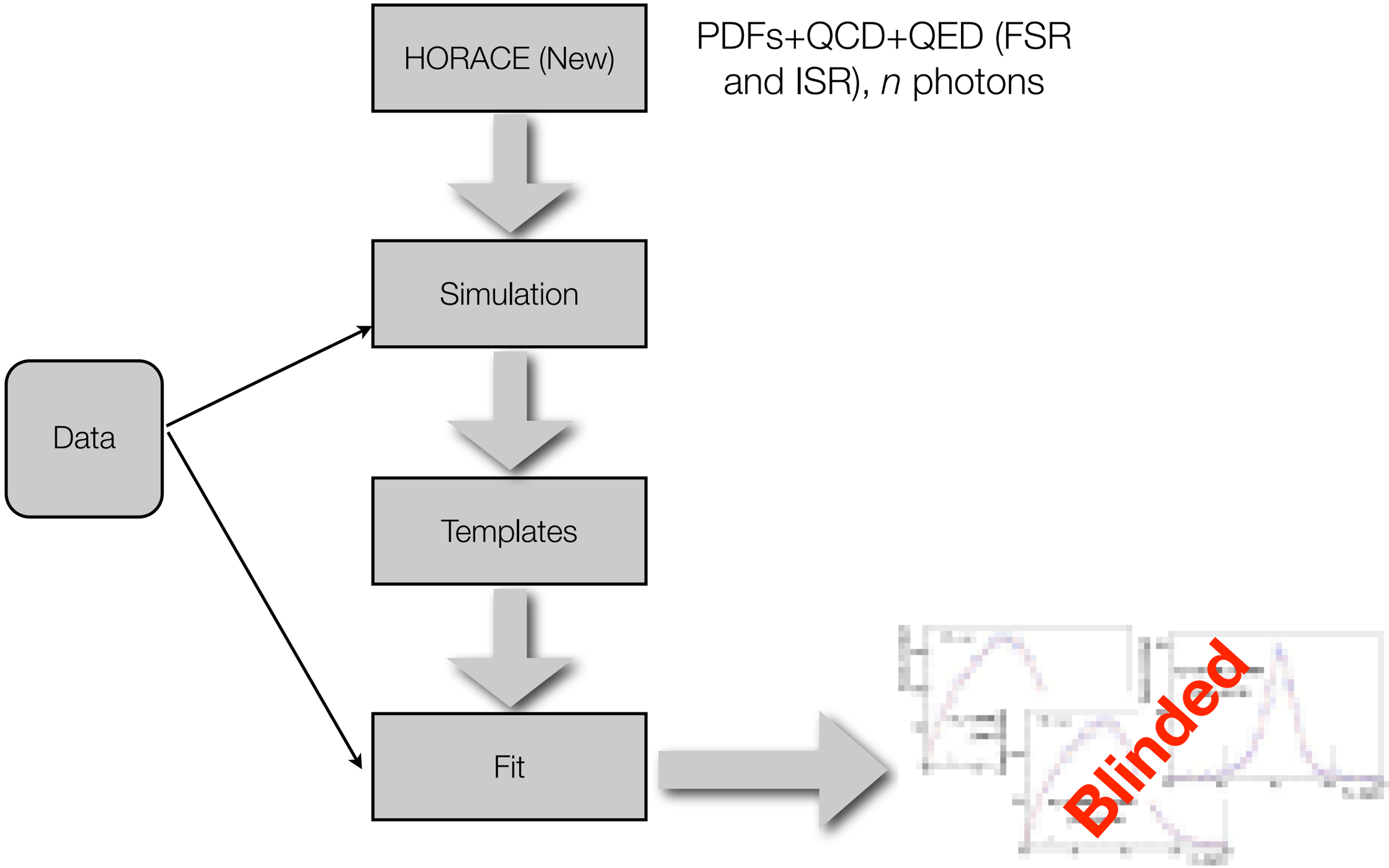
Fit	$\delta m_{W,Z}(\mu)$ (MeV)	$\delta m_{W,Z}(e)$ (MeV)
m_T	−158	−138
p_T	−206	−186
$\not{p}_T$	−77	−59
m_{ll}	−196	−215

- ISR and interference negligible to within 5 MeV
  - Take 5 MeV error
- Cut off y at 10^{-4}
  - $y = E_{photon}/E_{lepton}$
- Sample 1-photon events from WGRAD (y,dR)

“Method 1” v2


RESBOS
PDFs+QCD
Simulation
●HORACE (Old)
●PHOTOS
●W[Z]GRAD2
FSR QED:
n photons
Data
Templates
Fit
Blinded

Method 2


HORACE (New)
PDFs+QCD+QED (FSR and ISR), *n* photons
Simulation
Data
Templates
Fit
Blinded

Comparing generators

- Showing HORACE (old), PHOTOS, and (where applicable) old WGRAD
  - Need to run new WGRAD (includes LL)

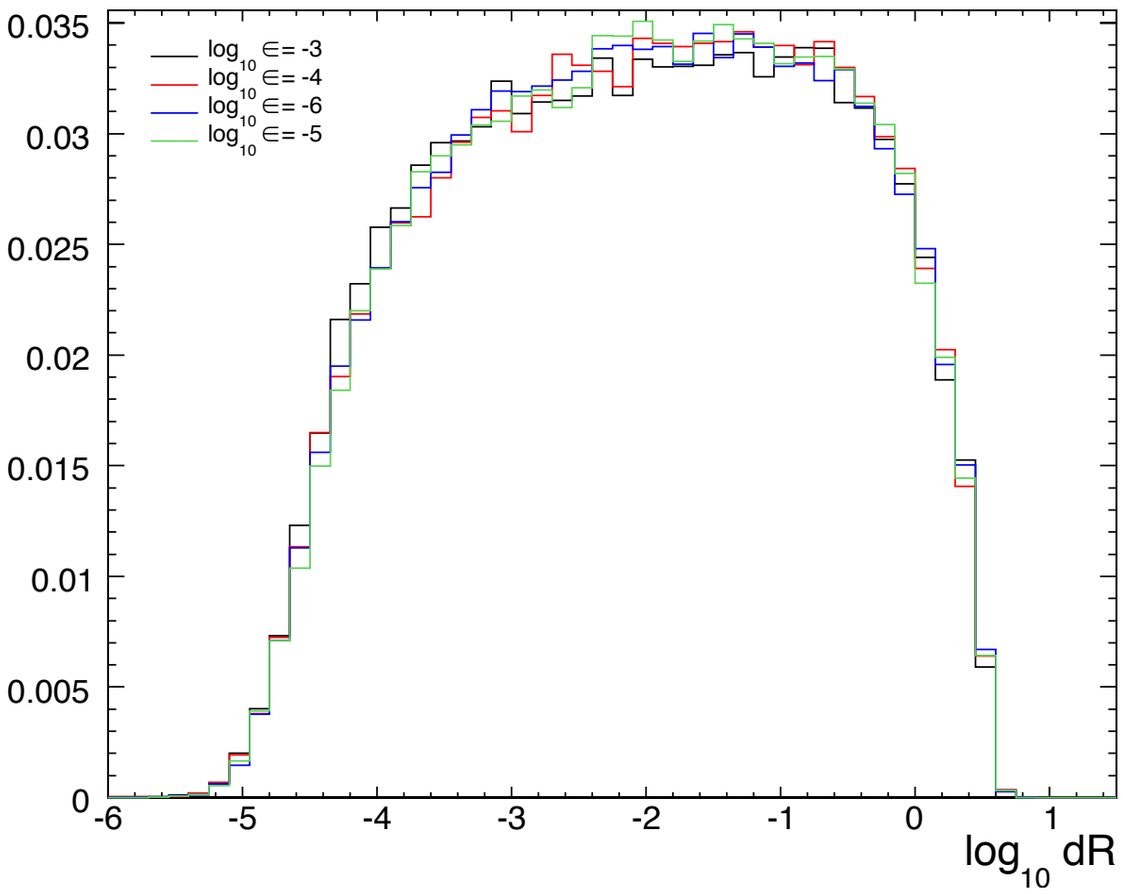
$$y = \frac{\sum E_\gamma}{\sum E_\gamma + E_\ell} \qquad dR^2 = (\Delta\eta)^2 + (\Delta\phi)^2$$

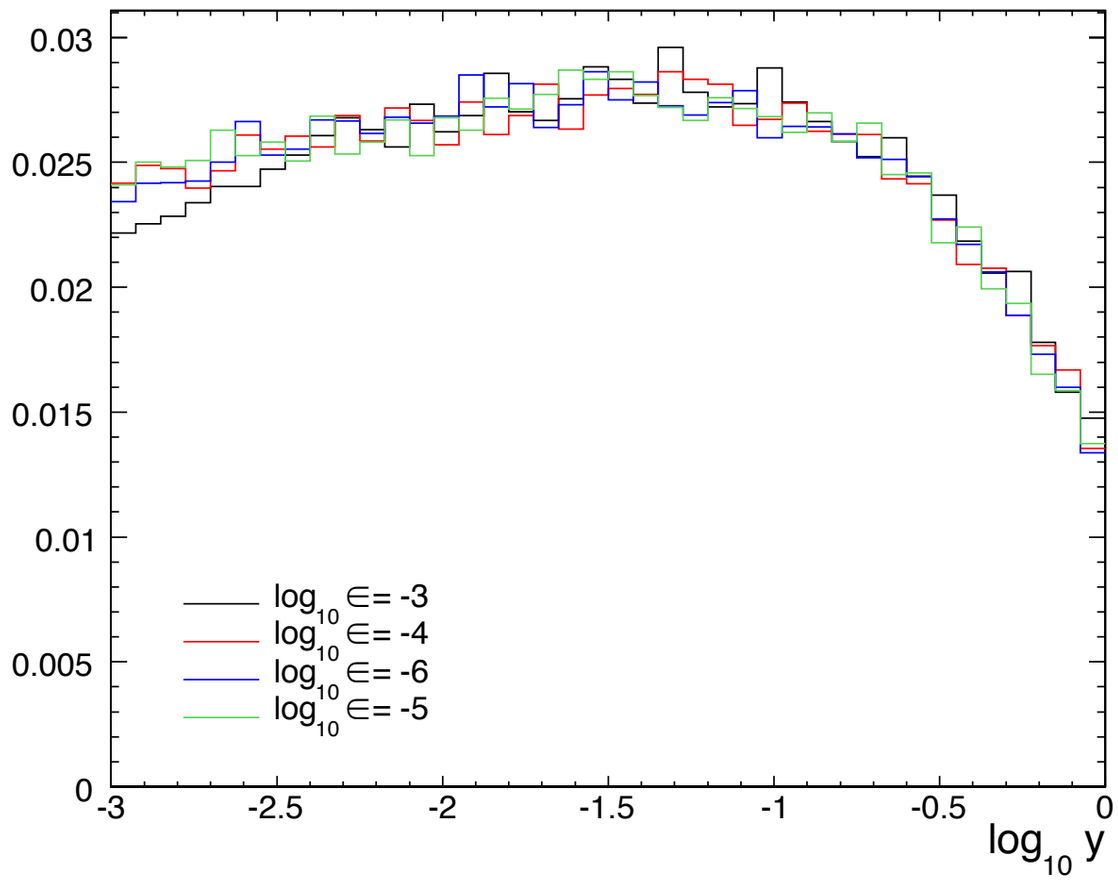
- Angles are between vector sum of photons and post-FSR lepton

- Soft separator of $\varepsilon=10^{-4}$ except when otherwise specified
- Radiation is FSR only
- Cuts placed on leptons before radiation
  - $p_T>23$ GeV
  - $|\eta|<1.0$

- PHOTOS has exponentiation on

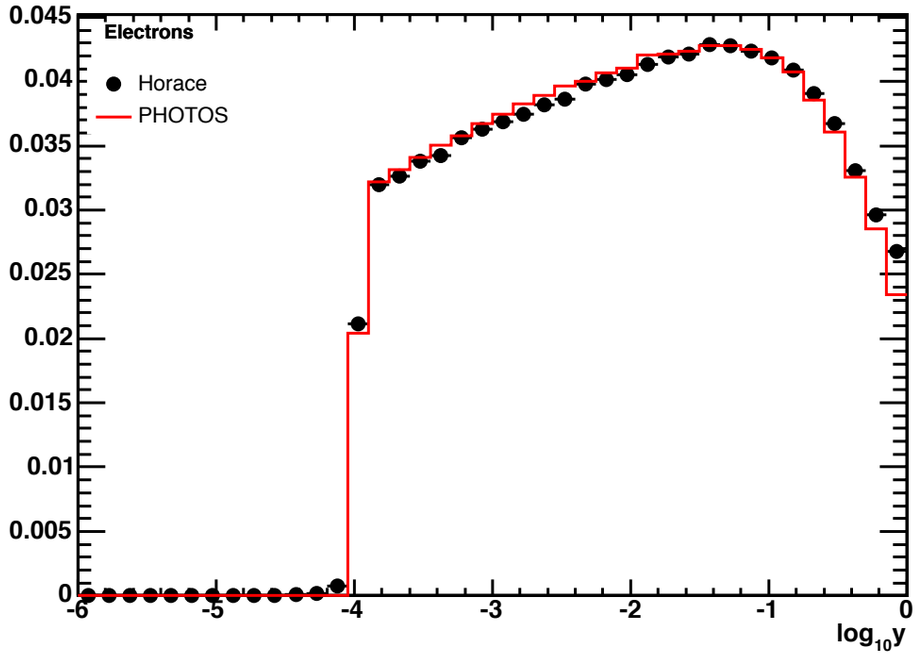
Cutoff comparison for PHOTOS

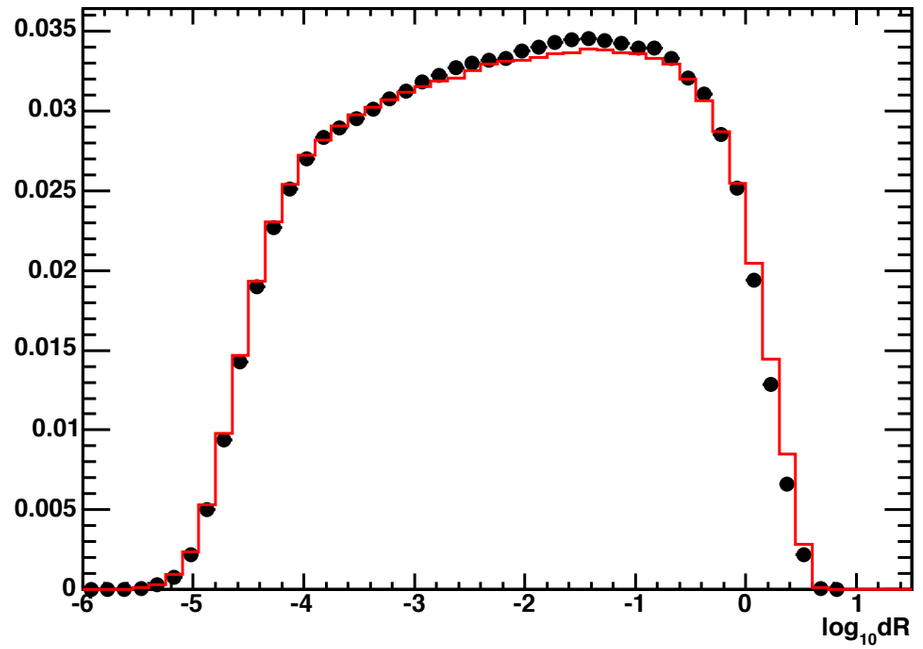


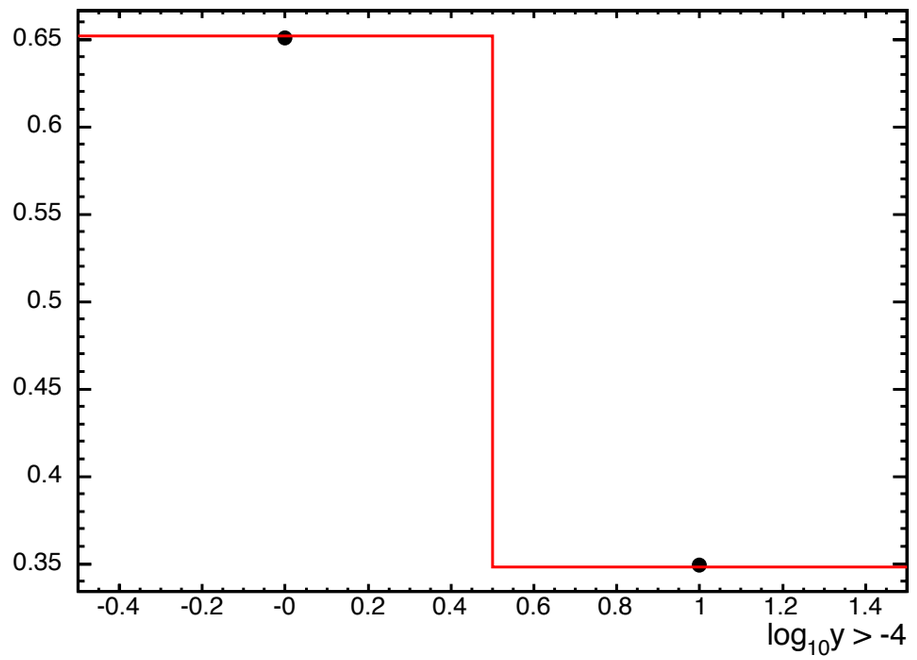


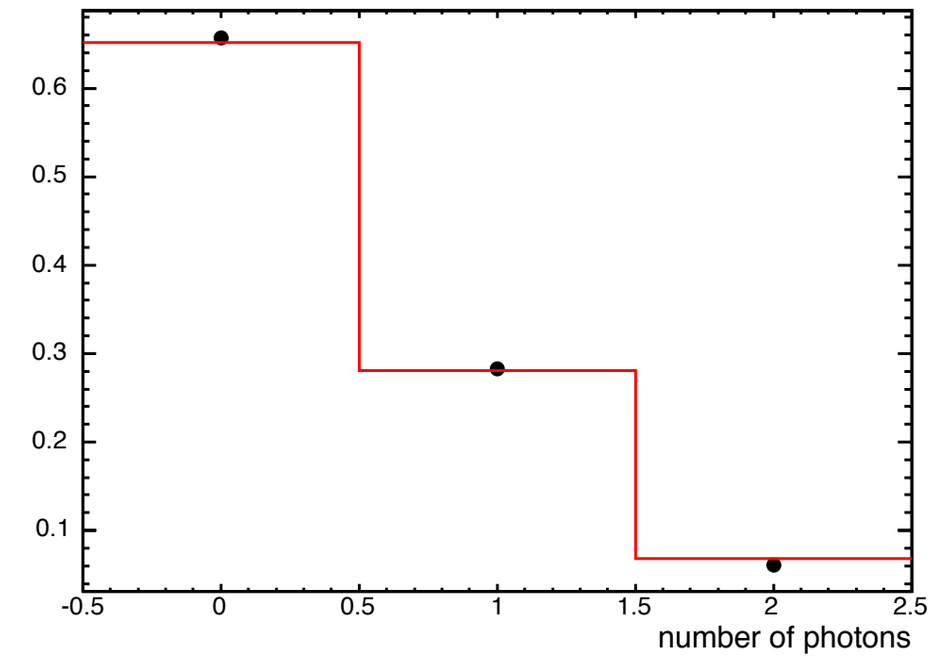
- These plots made with relatively low statistics (10^7 events)
- PHOTOS authors state lowest cutoff without exponentiation to be 10^{-2} and 10^{-7} with.

Comparison with Horace: all electrons

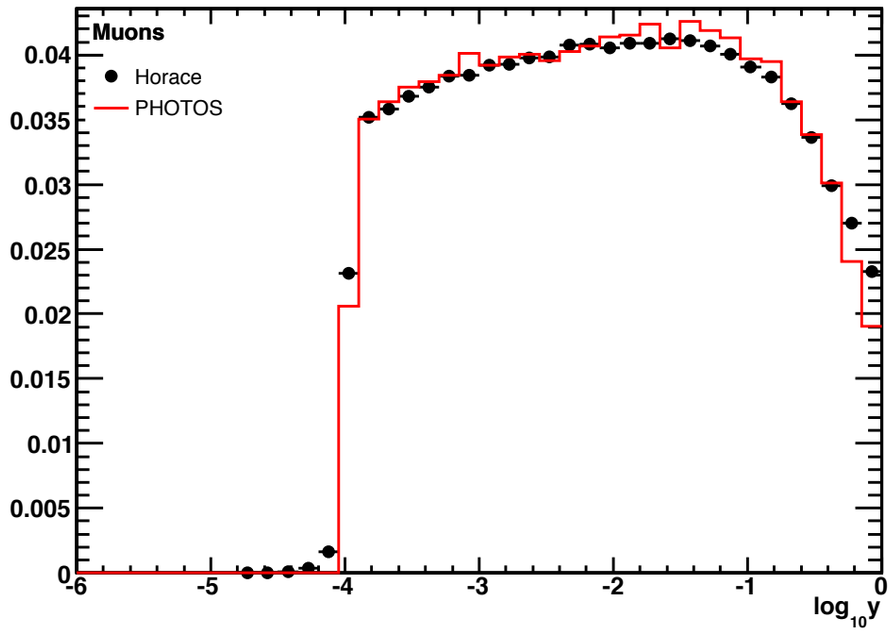


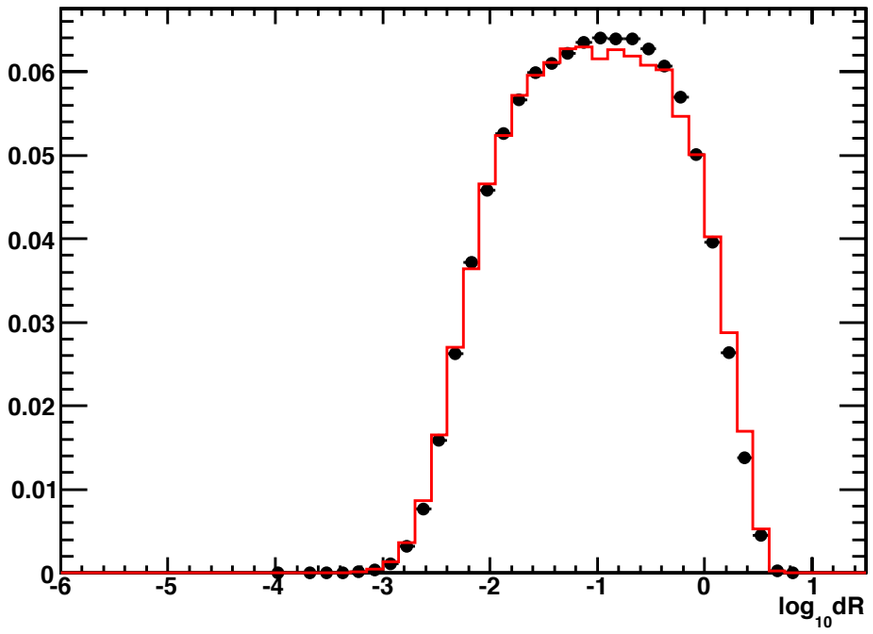


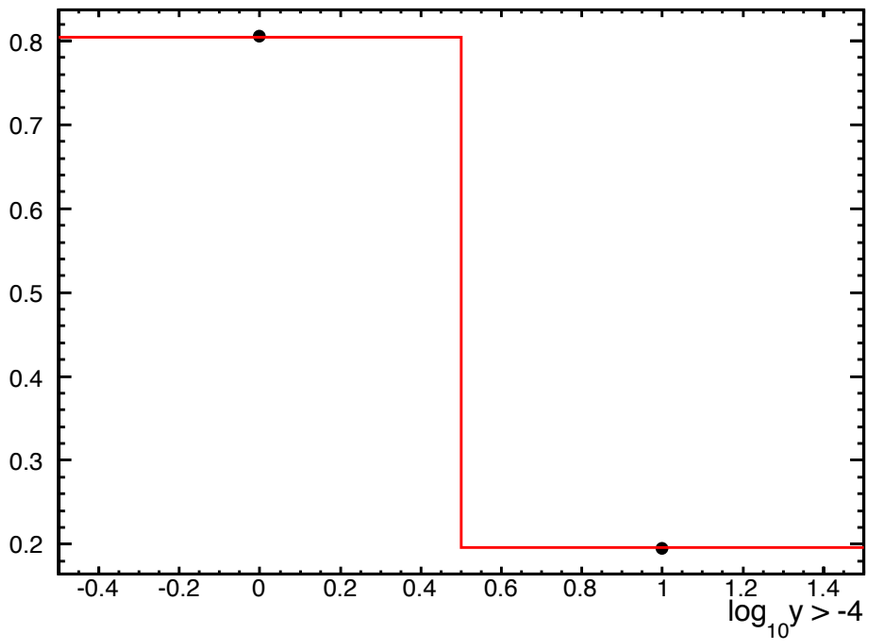




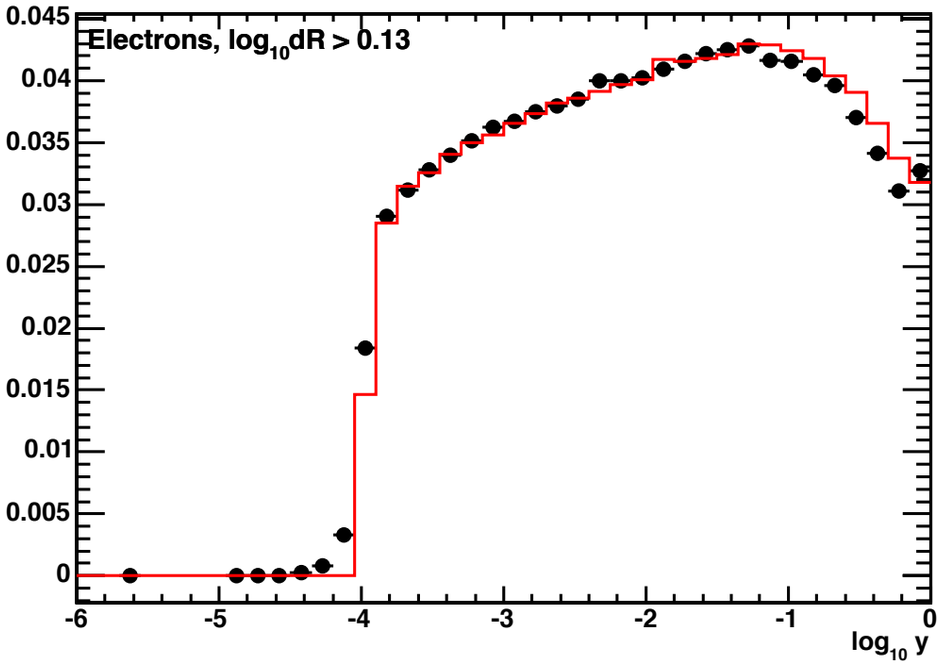
Comparison with Horace: all muons

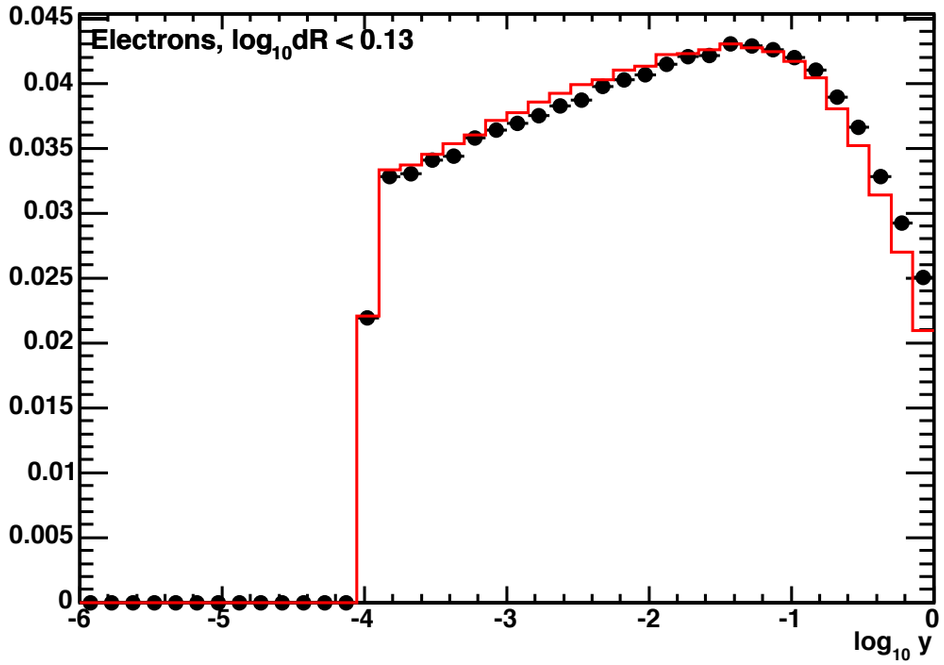


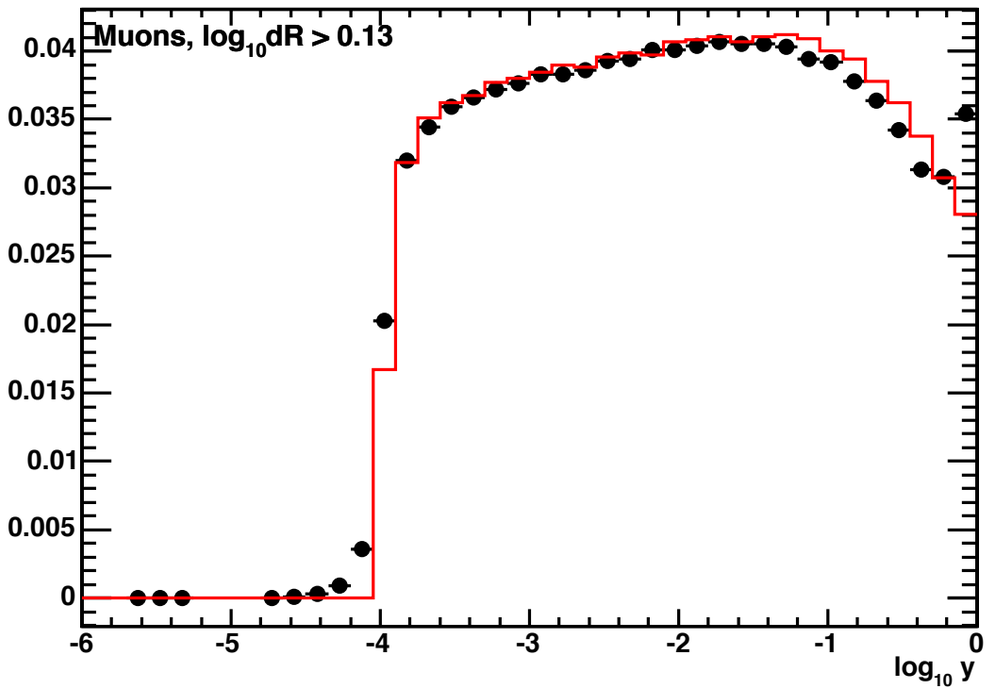


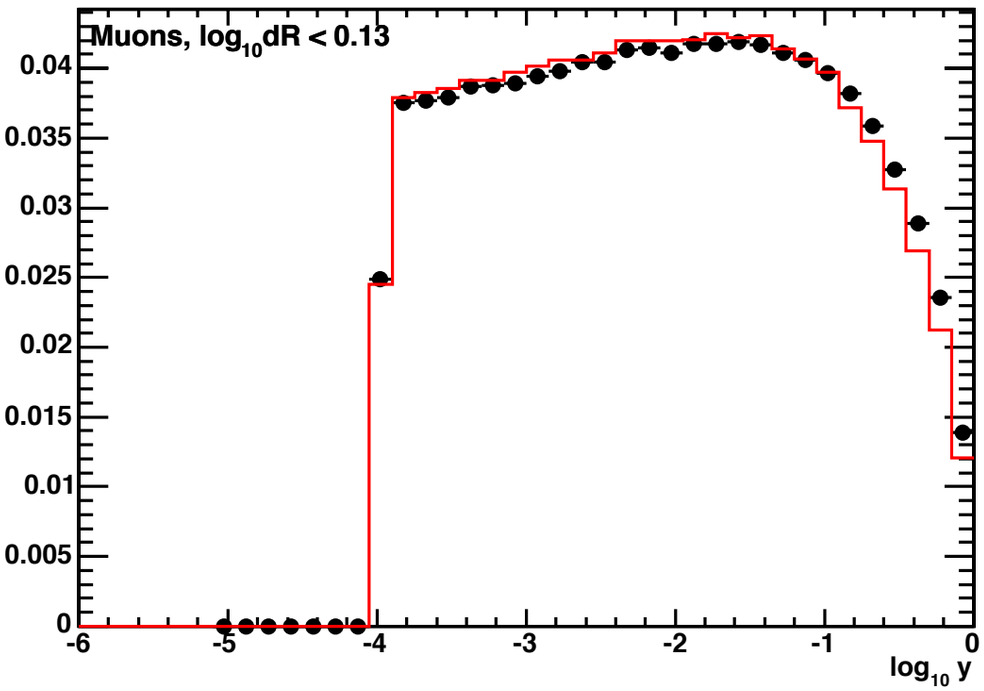


dR > 0.13 and dR < 0.13

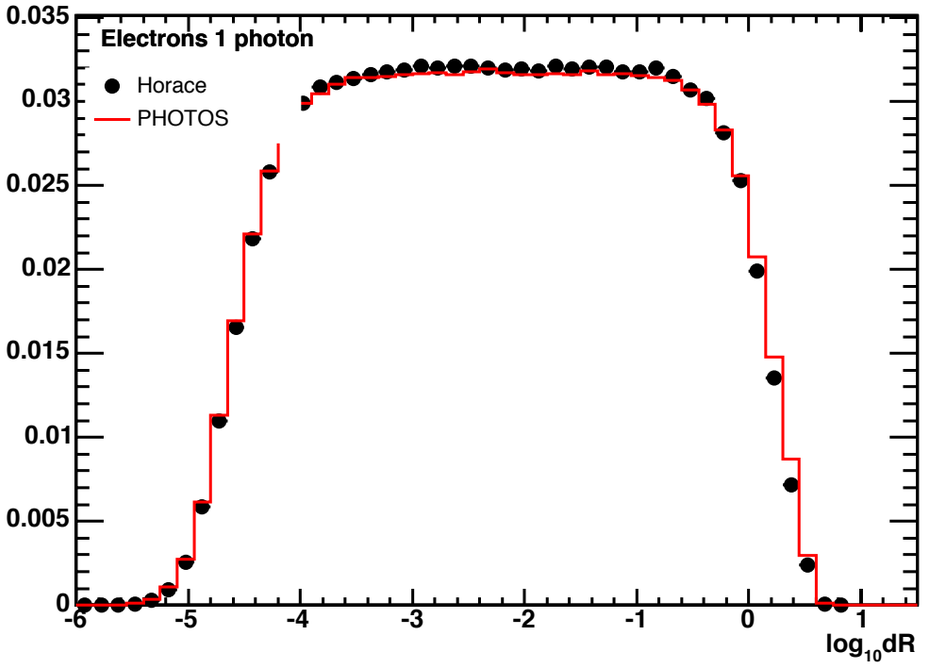


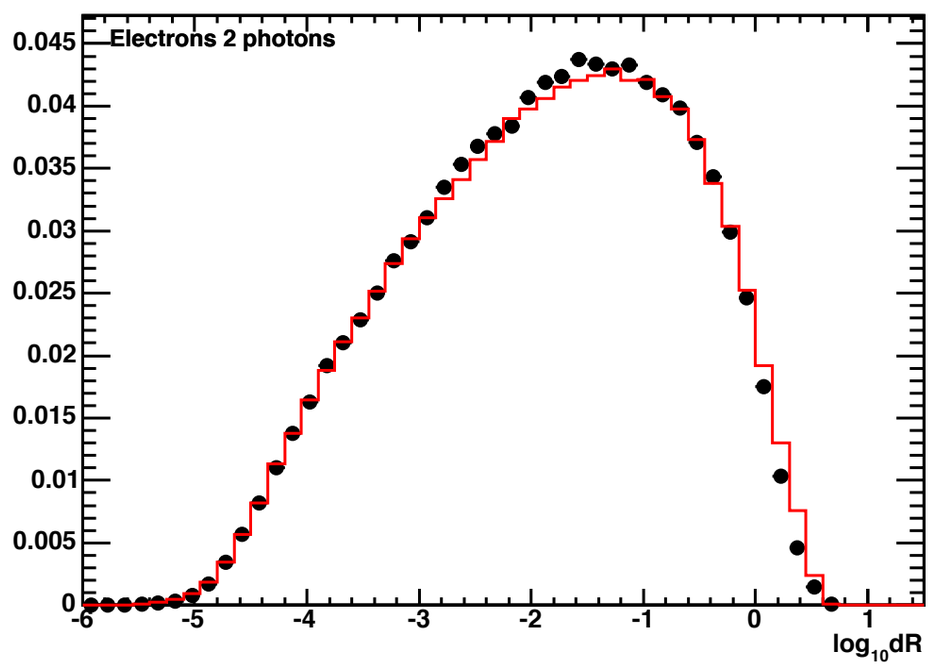


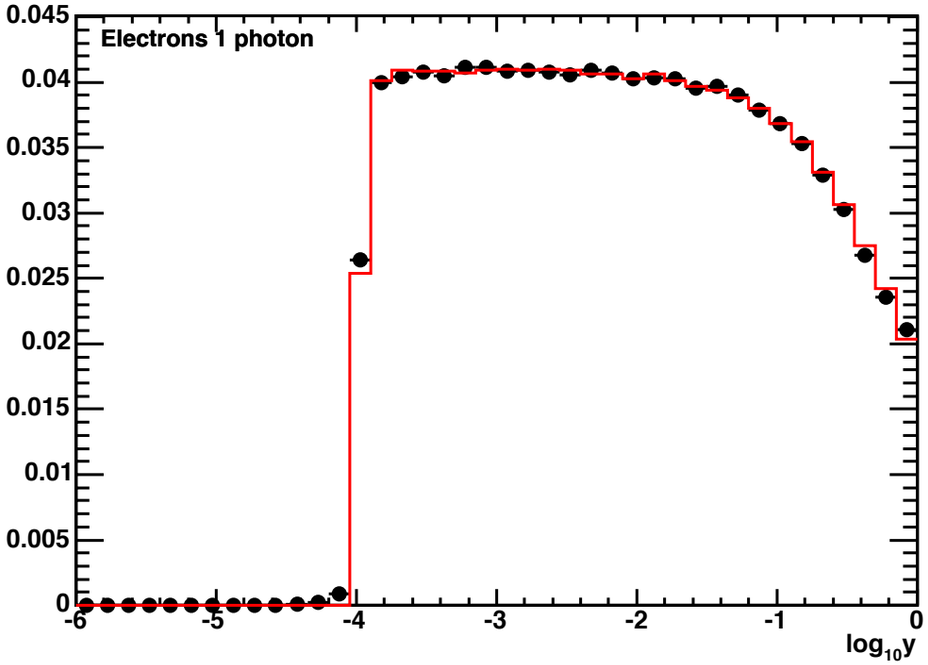


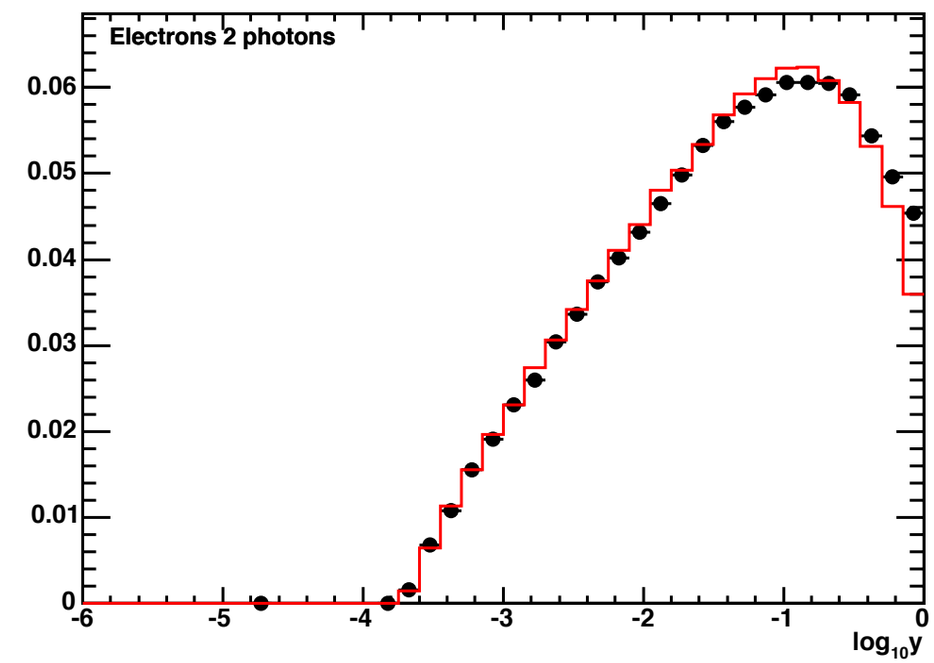


One and two photon events: electrons

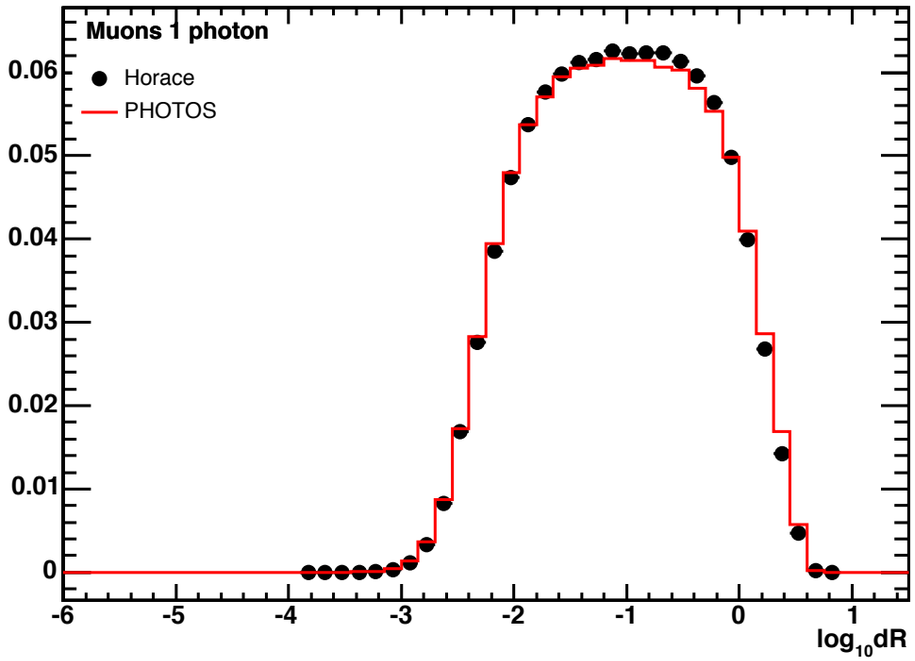


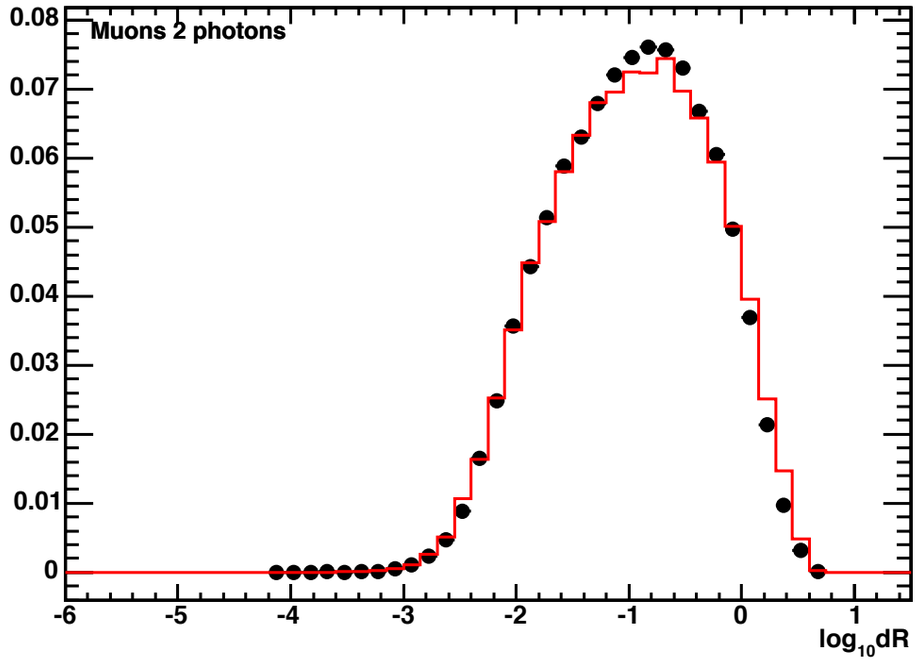


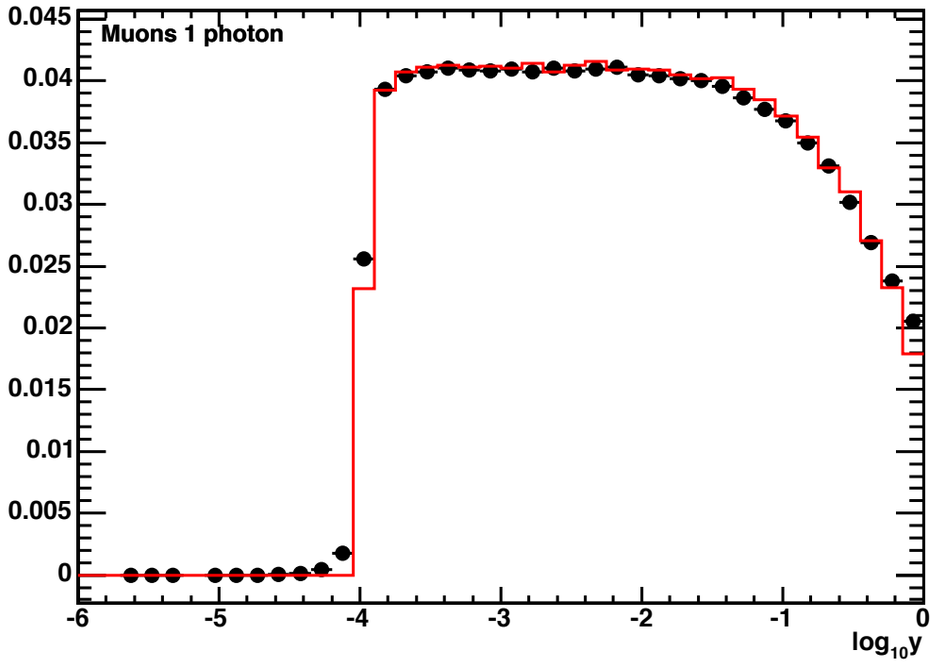


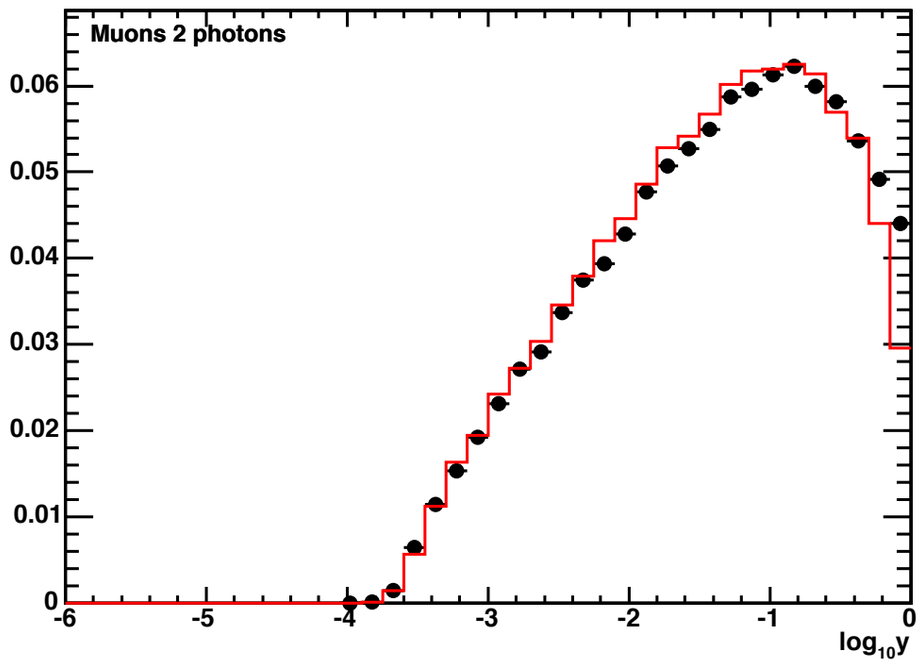


One and two-photon events: muons

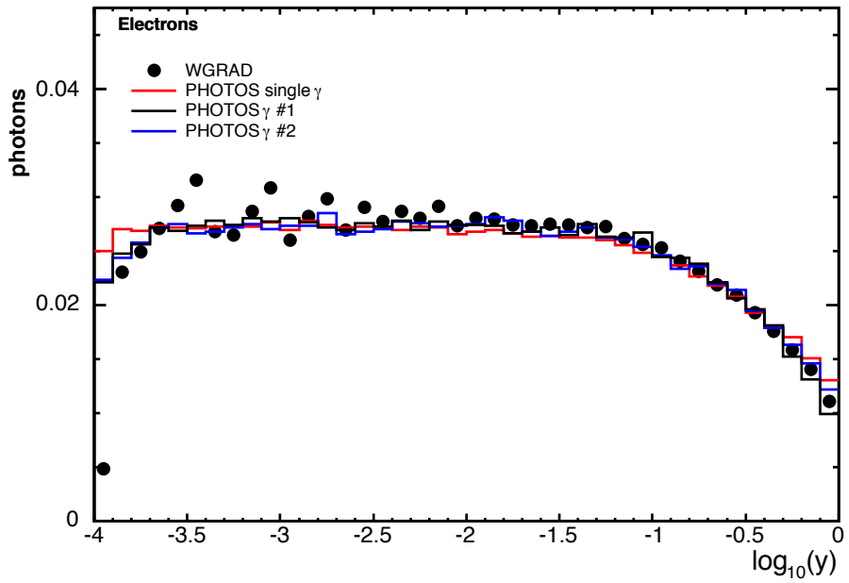


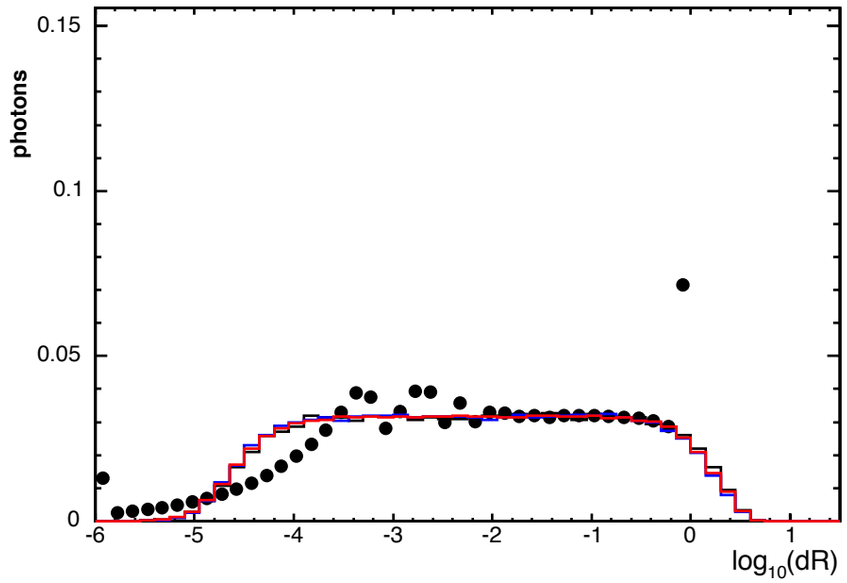


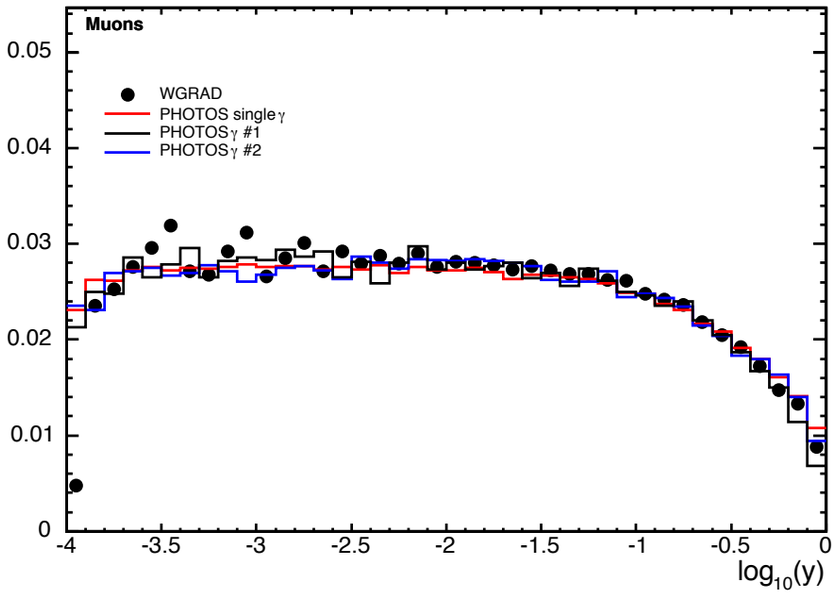


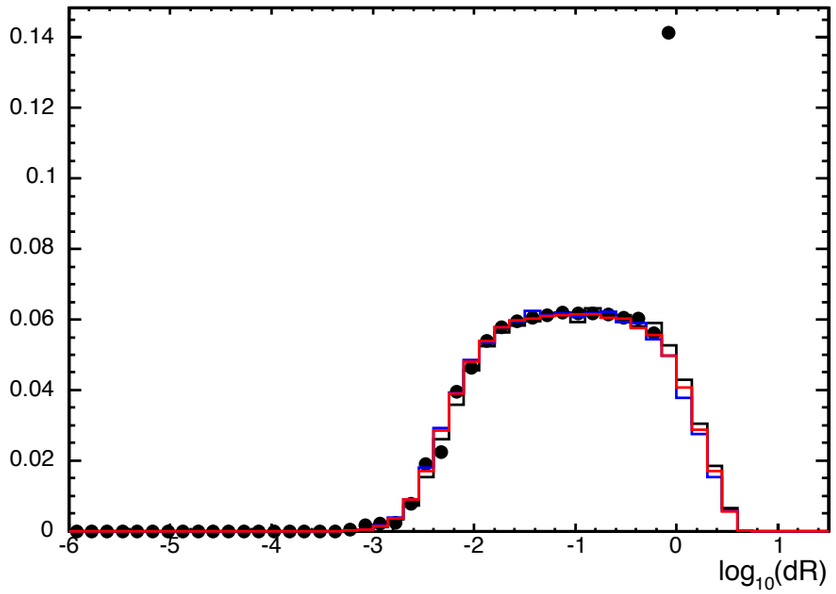


Individual photons









- Comparing individual photons in PHOTOS events to WGRAD
  - No qualitative difference between first and second photons in PHOTOS

Conclusions

- FSR spectrums from WGRAD, Old HORACE and PHOTOS are similar
- Energy spectrums of individual photons from PHOTOS very similar
  - Can independently model rate of multi-photon emission and sample single photons for kinematics (*q.e.d.*)
- Questions/comments/suggestions?