中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

ATLAS EXPERIMENT

2023.01-04研究生考核

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2023/04/23

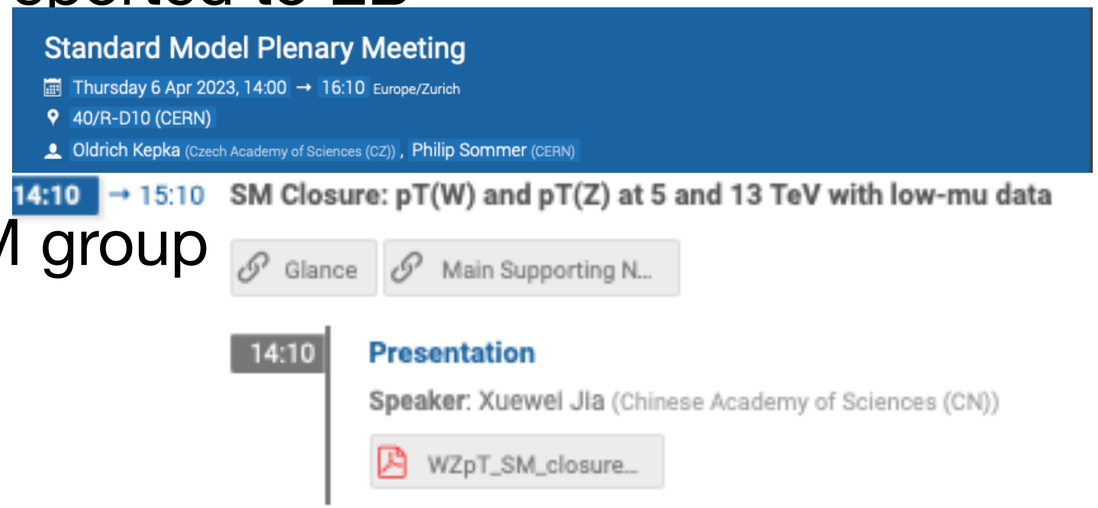
Outline

- Analysis
  - Low-μ W Z pT measurement at 5 and 13 TeV
  - Low-μ W mass measurement at 5 and 13 TeV

Low-μ W Z pT measurement

Status:

- Last EB meeting in Jan.
  - Answer to the comments from EB
- SM closure in Mar.
  - Remained pT uT compatibility issue solved, reported to EB
  - Updated everything to the latest version
  - Answer to questions and comments from SM group
- SM Approved, paper draft also sent to EB

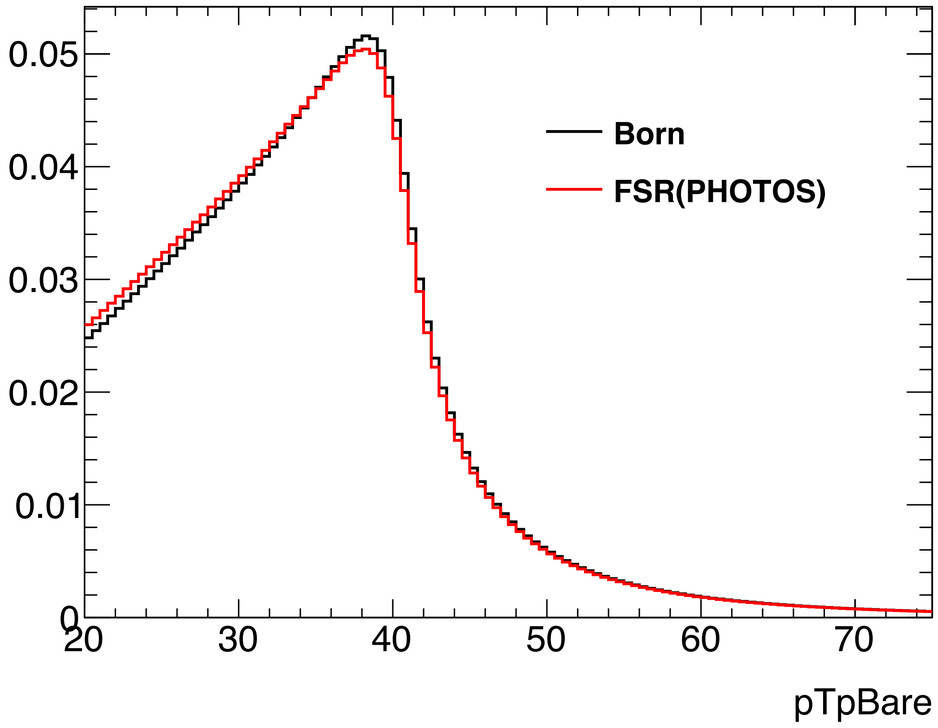


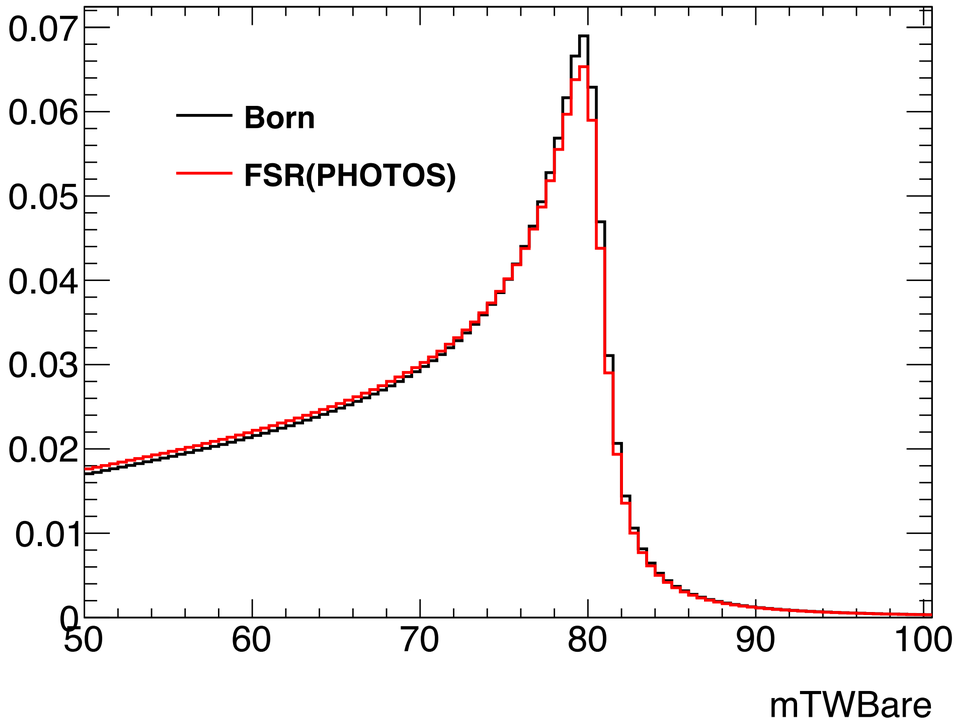
Low-μ W mass measurement

- Present NLO EW corrections effect on W mass measurement @Precision Drell-Yan measurements workshop(https://indico.cern.ch/event/1234311/?view=standard)

$O(\alpha)$ EW corrections effect on w mass

- Baseline: PHOTOS FSR, Pythia parton shower ISR
- Missing EW calculation: Fermion-pair emission, **ISR FSR interference, genuine weak corrections (QED+EW correction)**





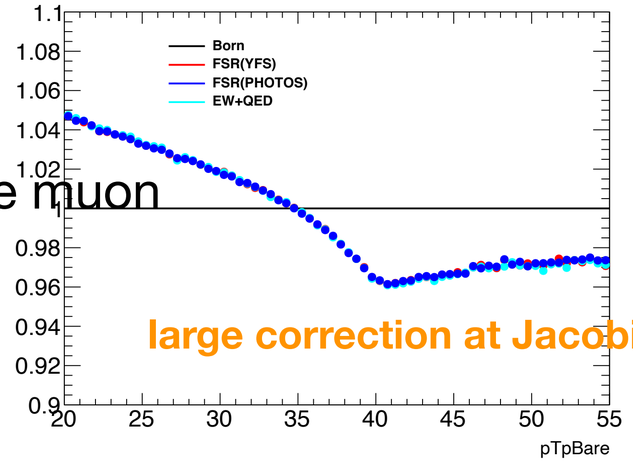
Correction effect on kinematics

1 000 000 000 events G_μ scheme

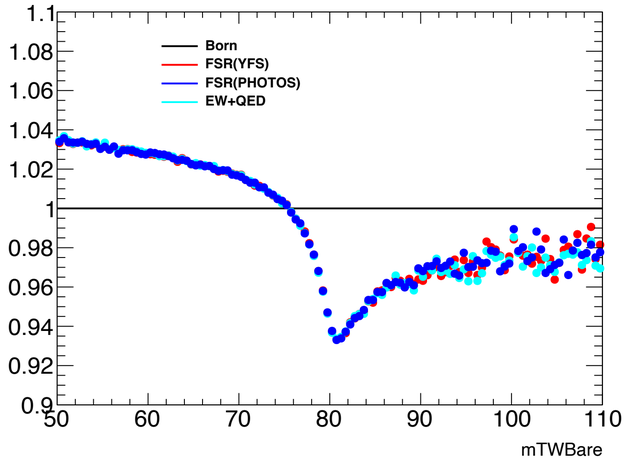
Ratio to born level

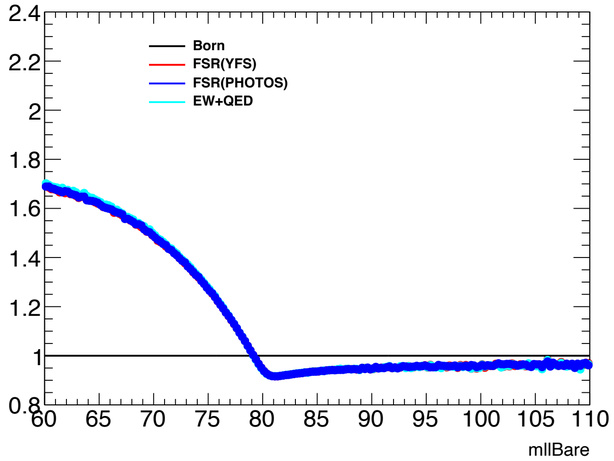
13 TeV $W^+ \to \mu\nu$

Bare muon



large correction at Jacobian peak

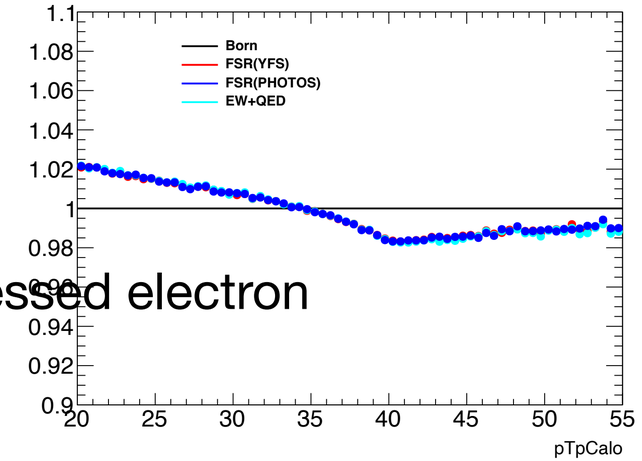


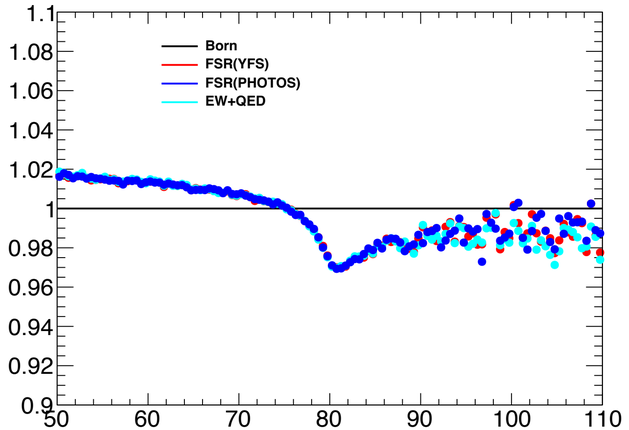


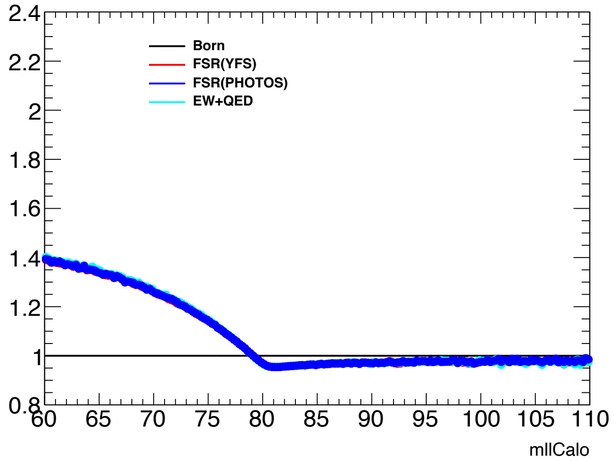
Ratio to born level

13 TeV $W^+ \to e\nu$

Dressed electron







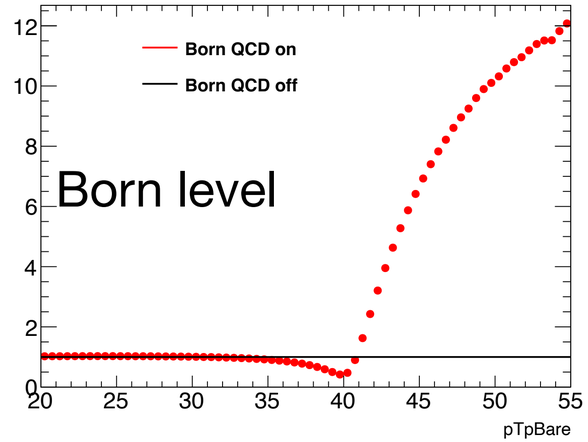
FSR correction dominates full EW correction

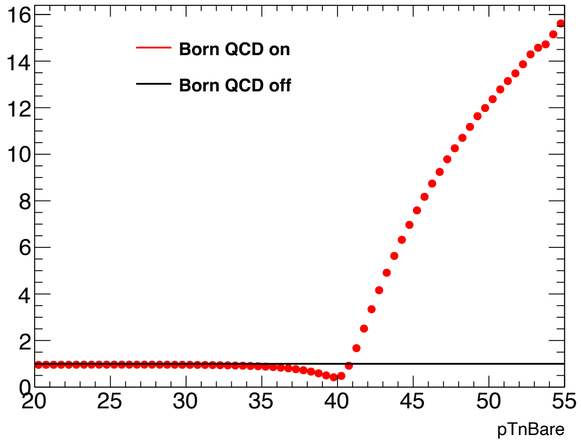
Initial QCD parton shower on and off

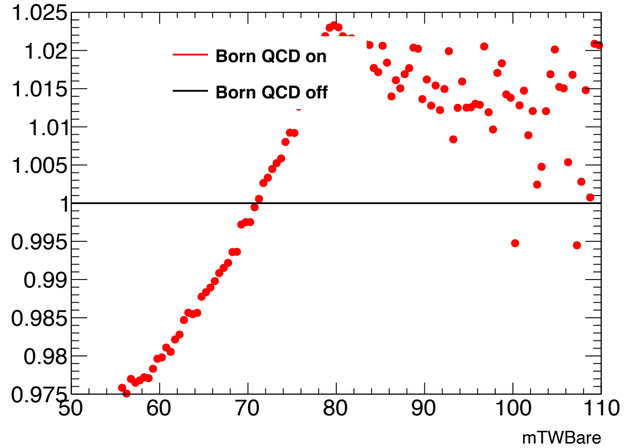
13 TeV $W^+ \to \mu\nu$

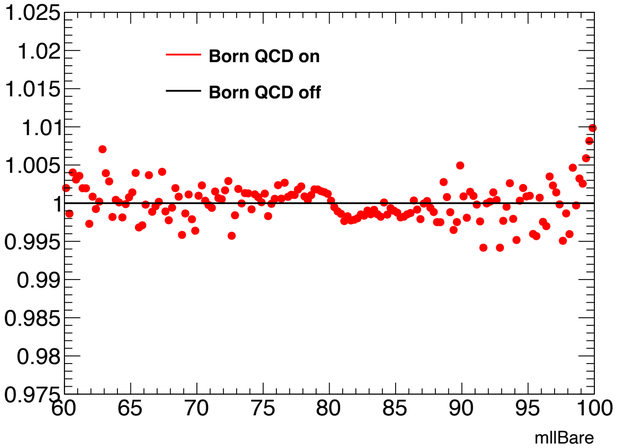
Kinematic change when switch on initial state QCD parton shower

done by Pythia



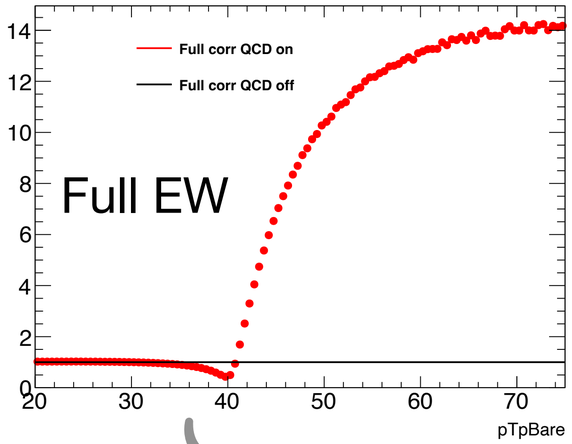


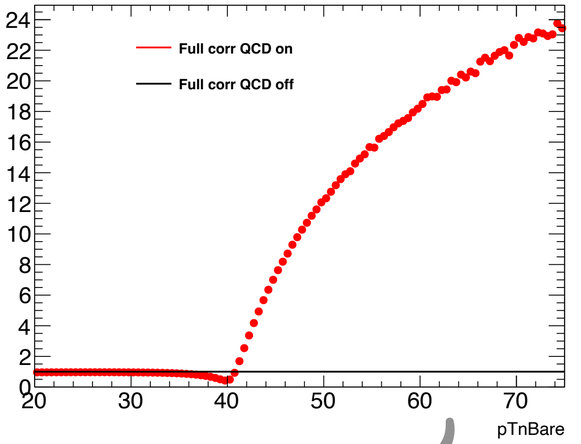


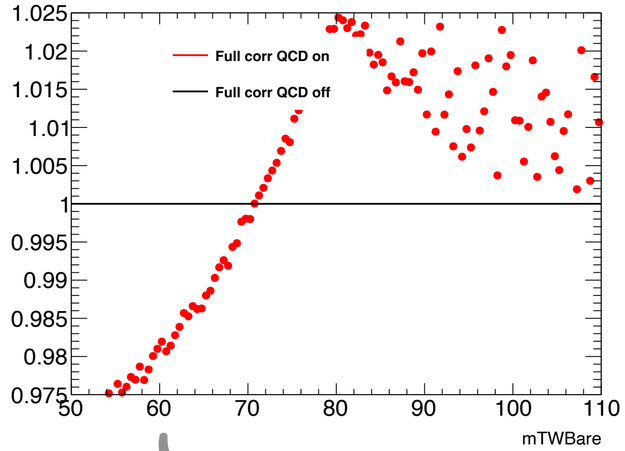


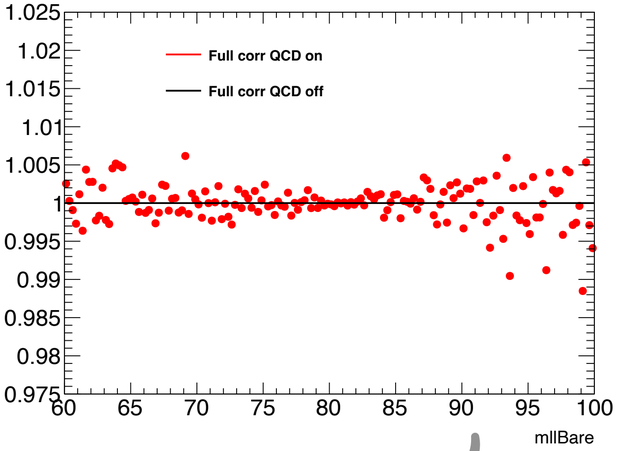
Sensitive to WpT

Not sensitive to WpT





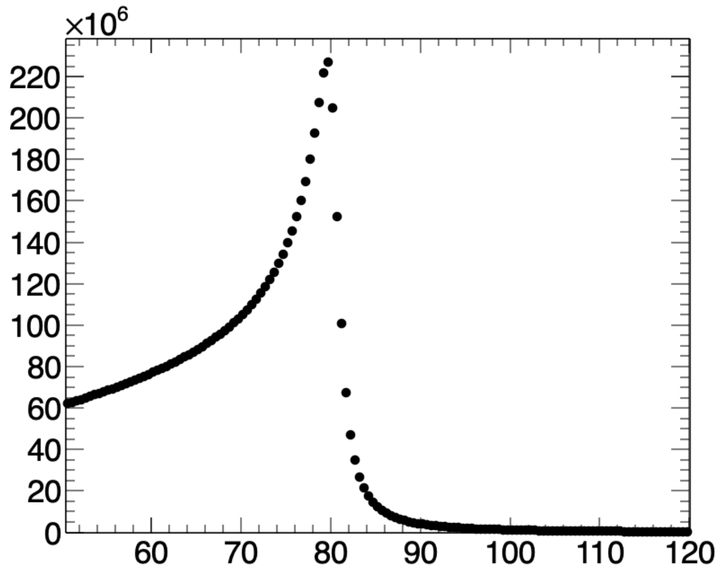




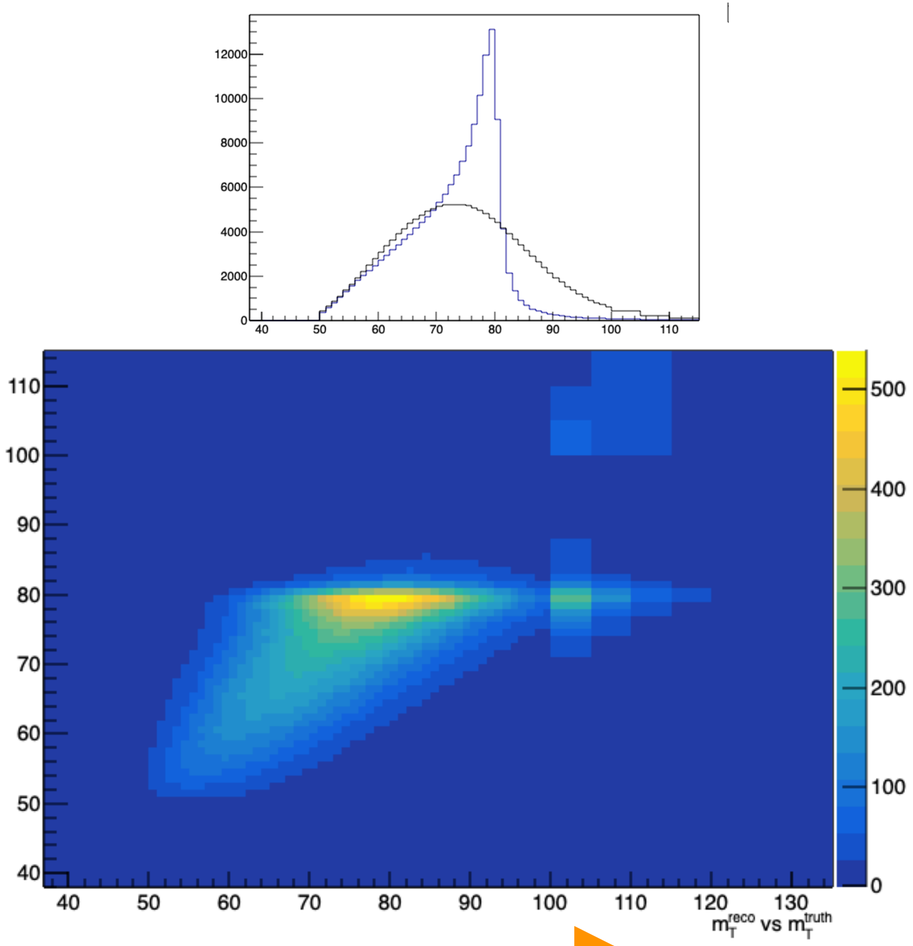
Large effect

Small effect

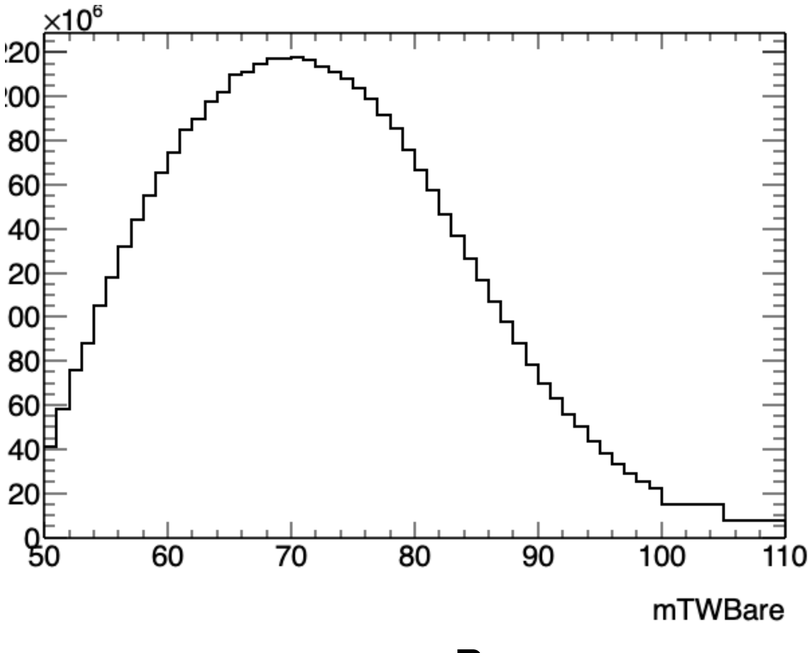
From truth level to reco level



Truth (full phase space)

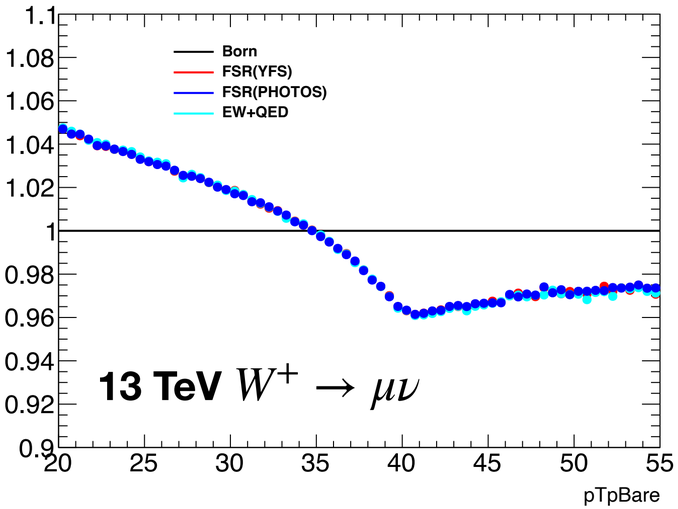


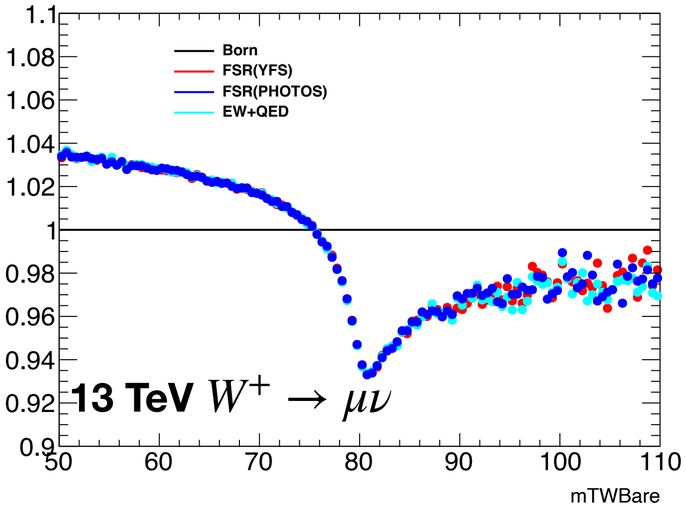
Migration matrix (no truth cut)
PowhegPythia



Reco

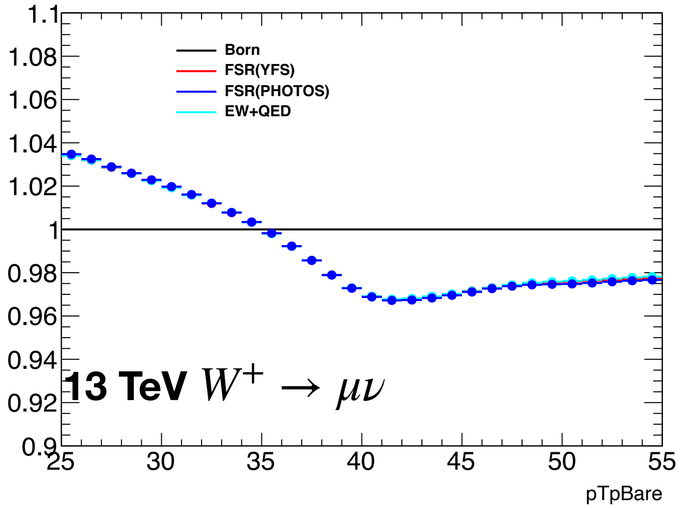
From truth level to reco level

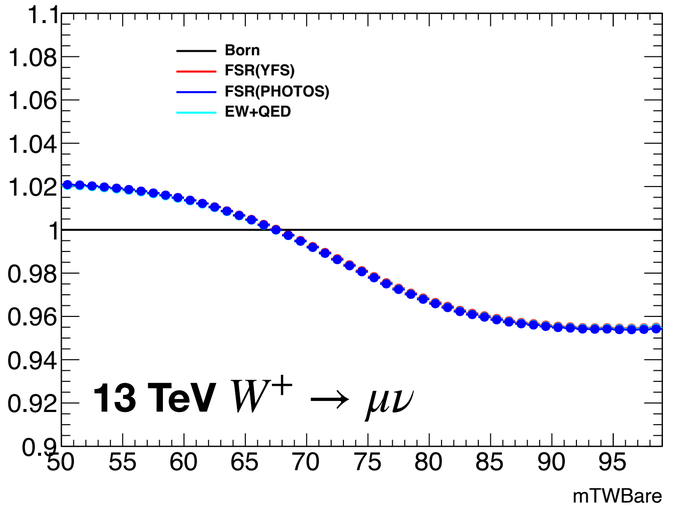




Correction at truth level

Migration matrix





Correction at reco level

Preliminary estimation of effect on m_W measurement

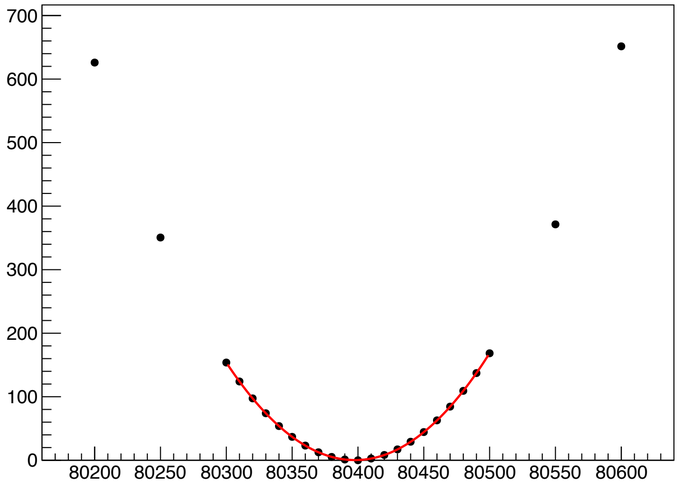
- ***Rough estimation*** with template fit
- Template fit:
  - Generate template with different W mass (reweighted from one mass point)
  - Calculate Chi2 with data, interpolate with parabola to find minimum

1. Generate template in [80200,80600] MeV
2. Use one template, corrected with the full EW correction as pseudo-data

   Correct with ratio *Full_electroweak/FSR* only at truth level/reco level
3. Perform template fit

$$\chi^2 = \sum_i^n \frac{(n_t - n_{data})^2}{\sigma_t^2 + \sigma_{data}^2}$$

(uncorrelated, over estimated)



Preliminary estimation of effect on m_W measurement

Channel	Reco level correction IS QCD on	Truth level correction IS QCD on	Reco level correction IS QCD off	Truth level correction IS QCD off
5 TeV W+ ->ev	-4.29	-2.45	-4.21	-5.30
5 TeV W- ->ev	-3.36	1.06	-4.45	-7.48
5 TeV W+ ->uv	-3.70	-6.51	-4.54	-4.31
5 TeV W- ->uv	-2.38	1.32	-4.69	-6.10
13 TeV W+ ->ev	-3.57	-8.93	-5.50	-11.33
13 TeV W- ->ev	-1.31	0.85	-5.07	-8.37
13 TeV W+ ->uv	-3.52	-9.81	-5.90	-8.93
13 TeV W- ->uv	-3.05	-5.53	-5.28	-9.38

mT

pseudo data: 80400 MeV

Summary and prospects

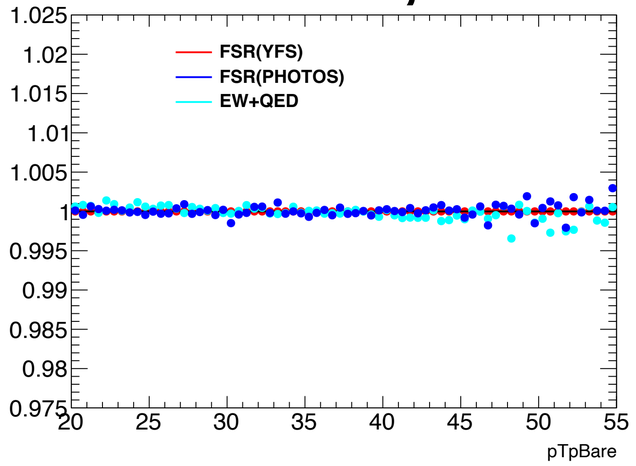
- $O(\alpha)$ electroweak corrections dominated by the FSR correction, impact of missing corrections are shown
- QCD initial state parton shower has visible effect on lepton pT spectrum since lepton pT very sensitive WpT, also reflected in fit estimation
- Effect of the full EW correction estimated with simple inclusive template fit
  - ~ 5 MeV contribution to the uncertainty for future low-μ mW @ 5 and 13 TeV
  - W+ and W-, electron and muon compatible
  - Reco level and generator level corrections close
- To optimize:
  - Compare and validate Powheg-EW and winhac
  - Estimate final uncertainty for mW measurement with PLH fit
  - ……

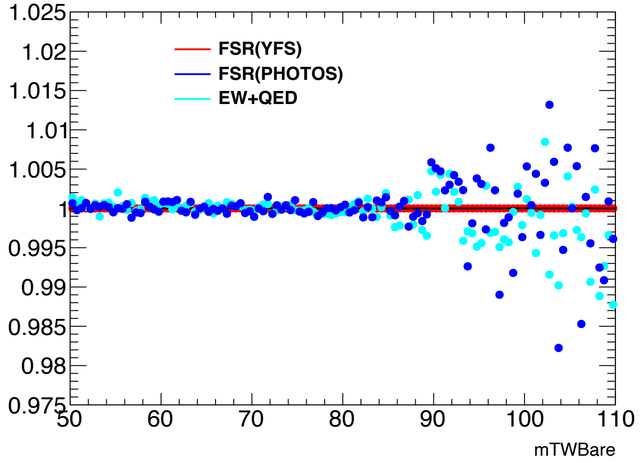
Back-up

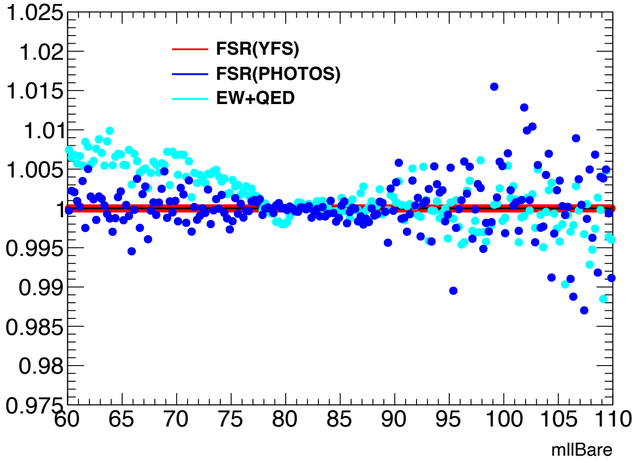
Initial QCD parton shower on and off

13 TeV $W^+ \to \mu\nu$ QCD on

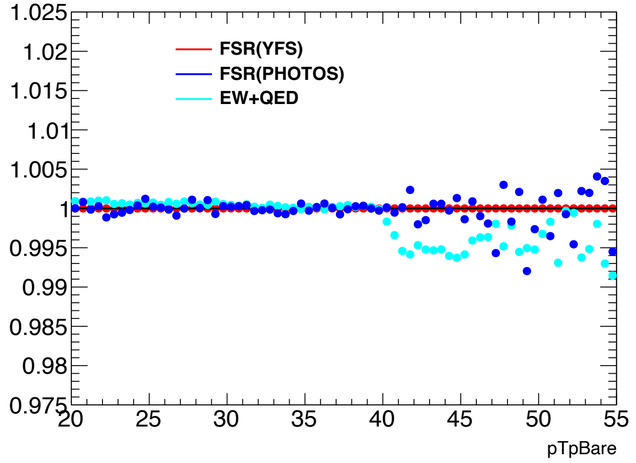
Beyond FSR correction behavior analogous

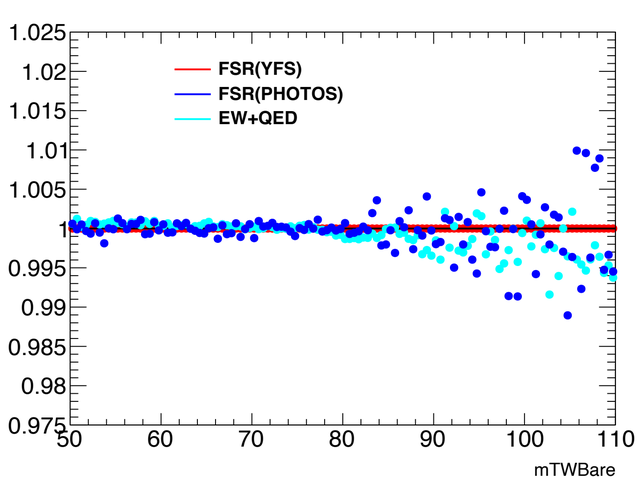


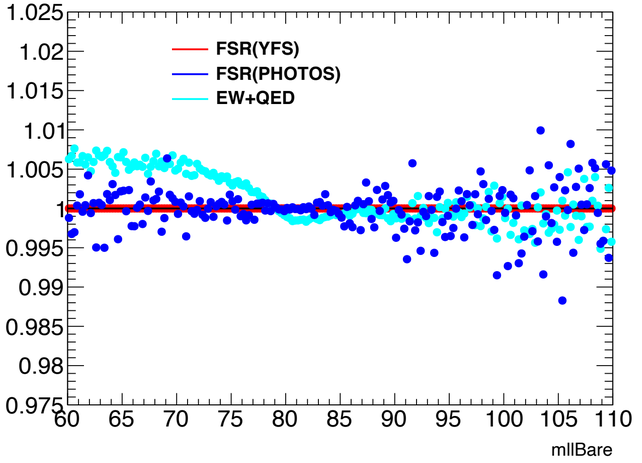




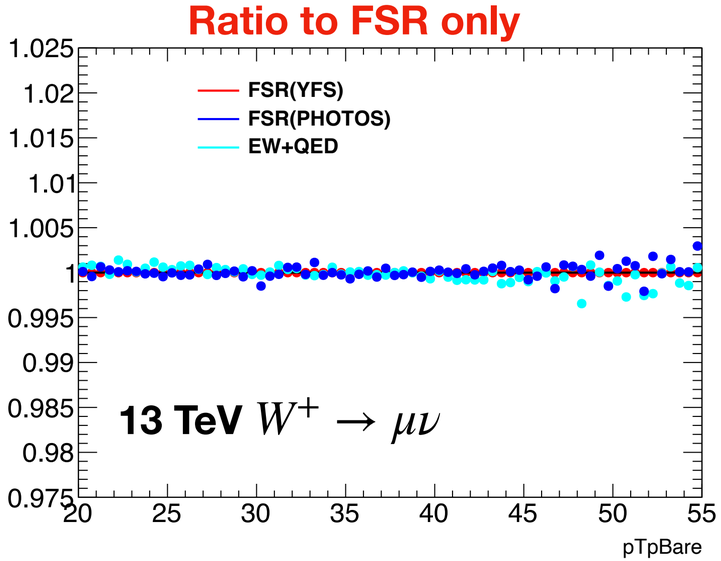
13 TeV $W^+ \to \mu\nu$ QCD off

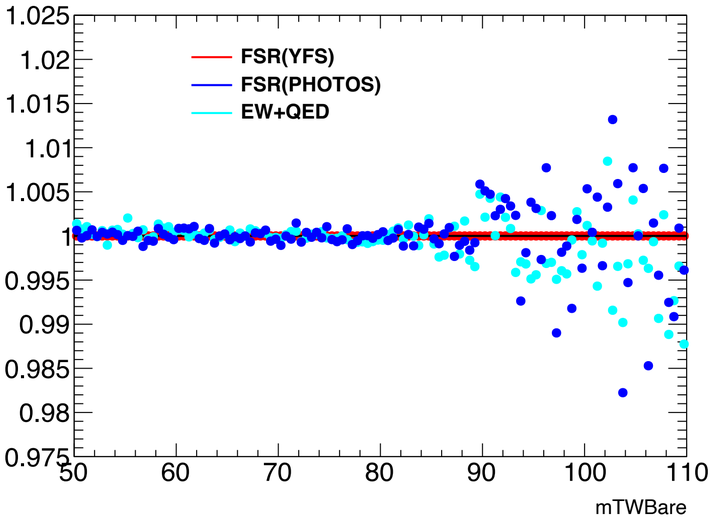




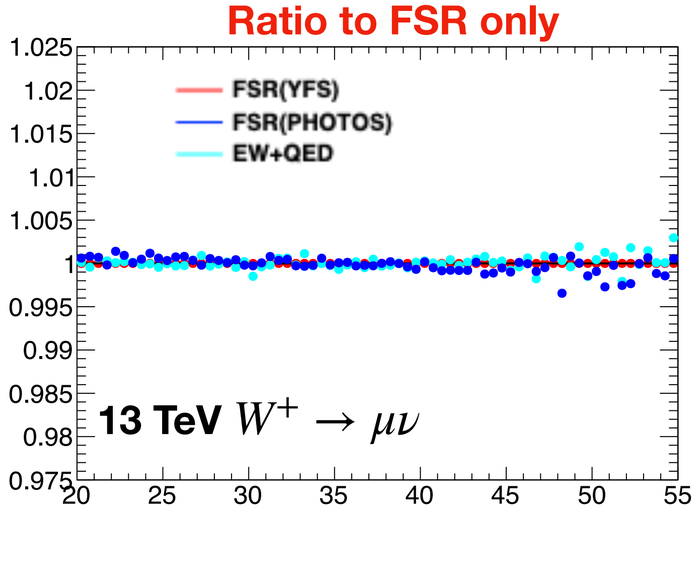


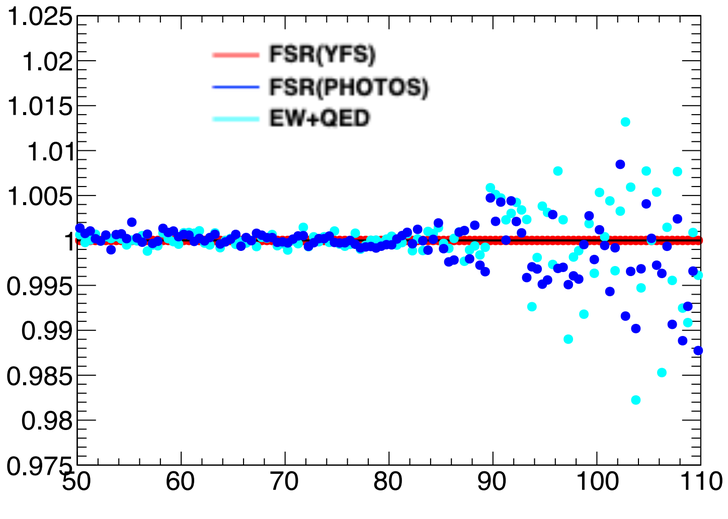
From truth level to reco level





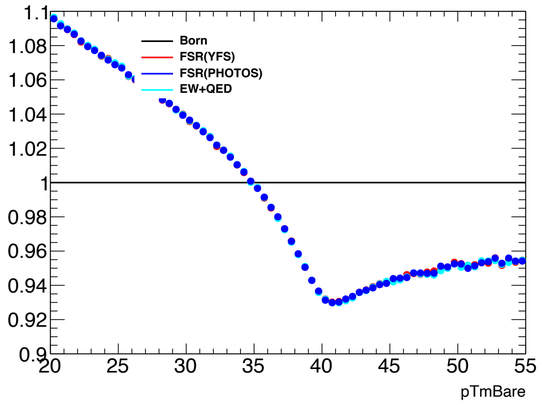
Remained EW correction at truth level

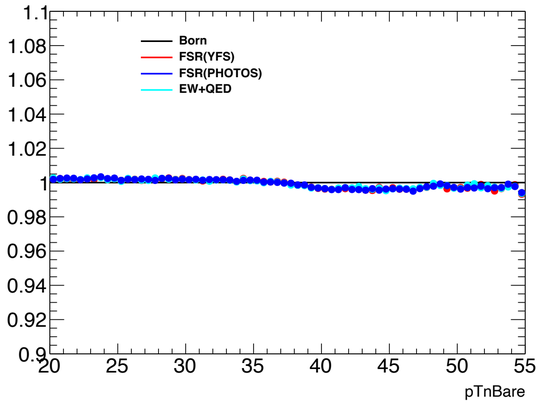


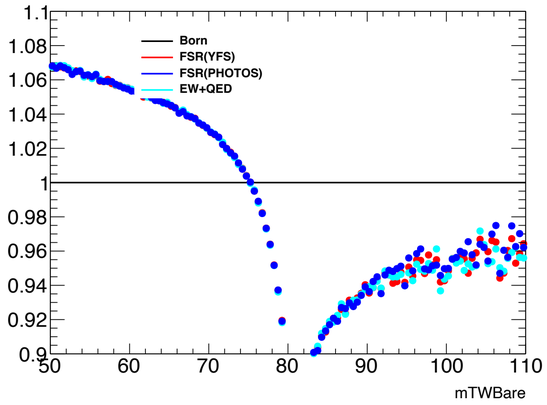


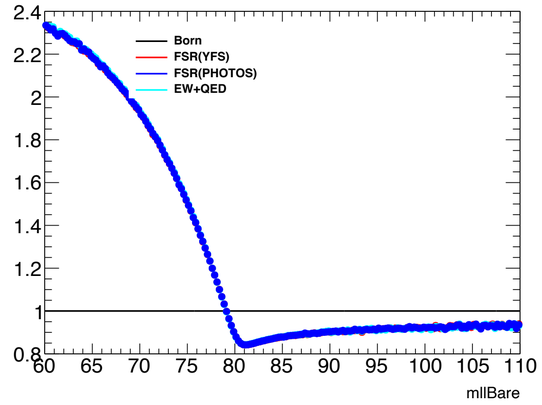
at reco level

Correction effect on kinematics

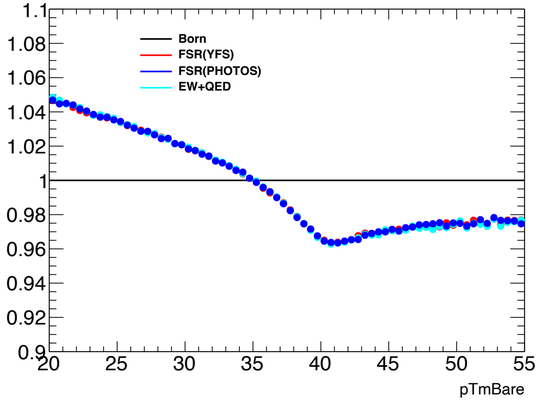


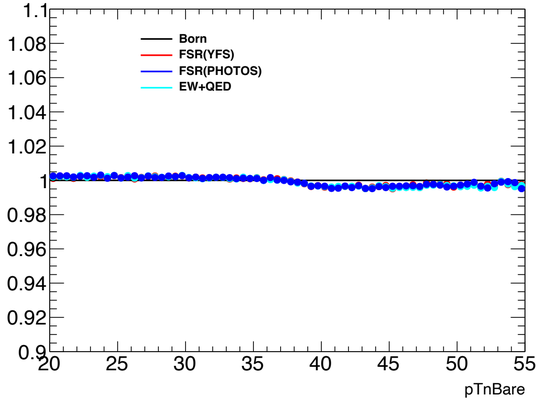


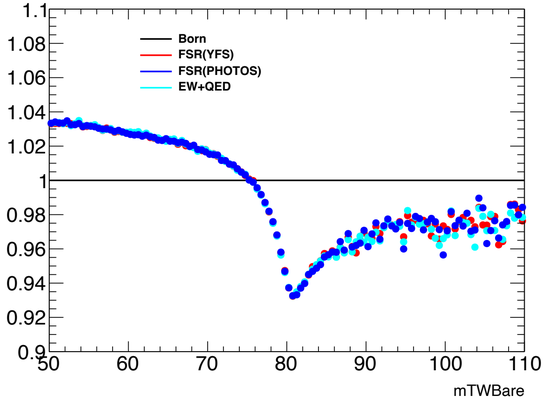


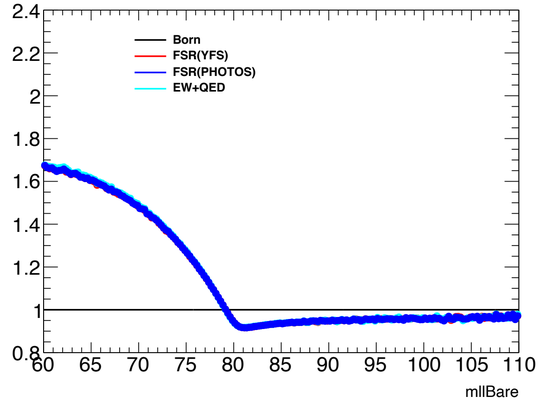


13 TeV $W^- \to \mu\nu$



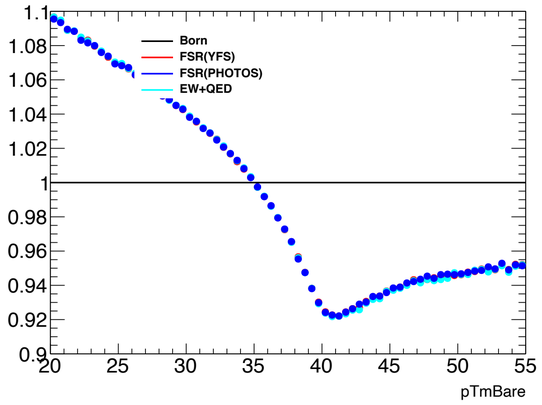


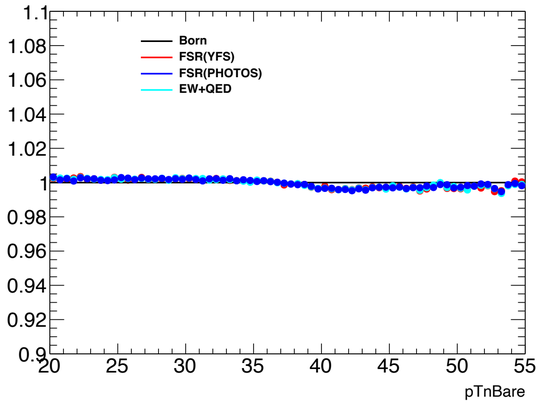


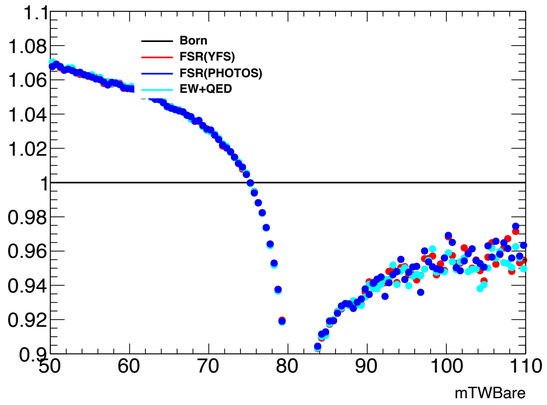


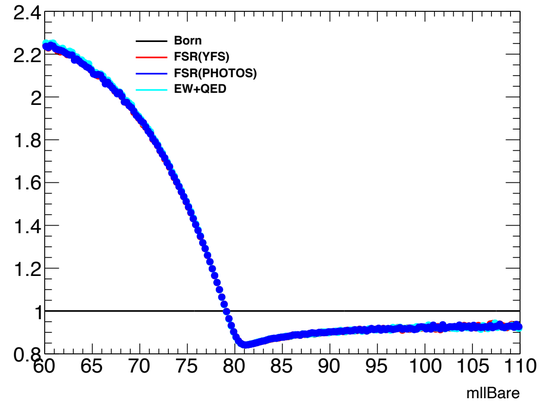
13 TeV $W^- \to e\nu$

Correction effect on kinematics

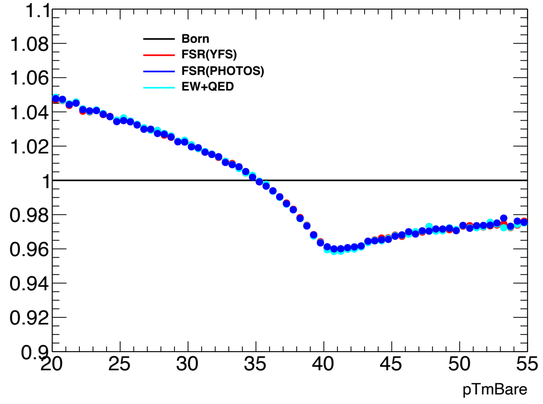


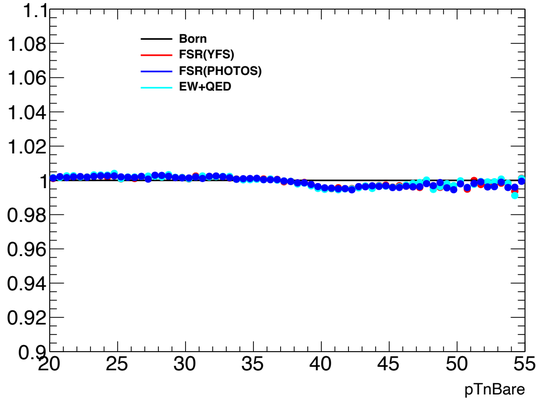


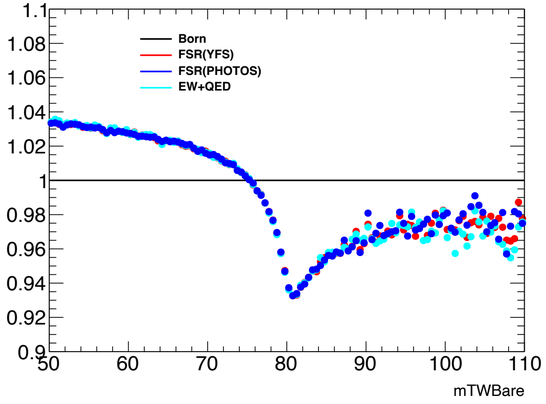


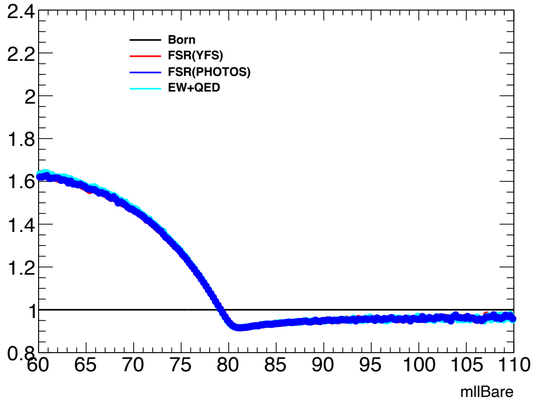


5 TeV $W^- \to \mu\nu$







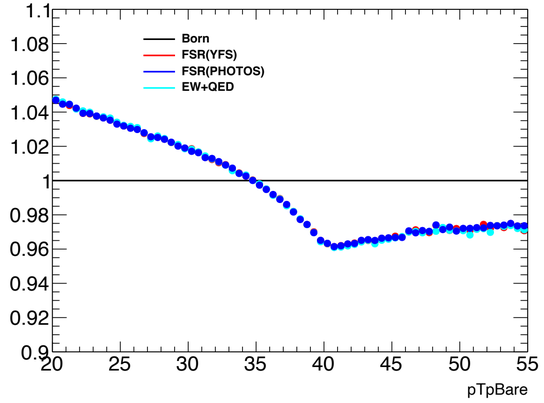


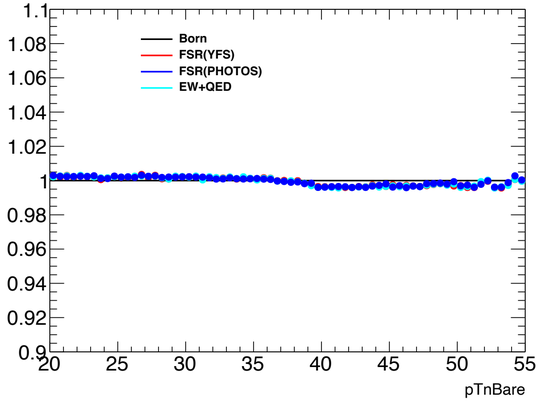
5 TeV $W^- \to e\nu$

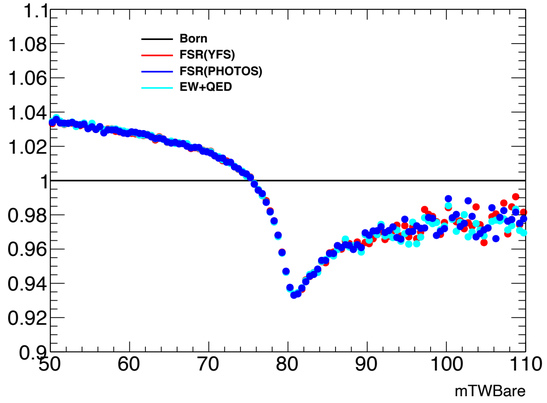
Initial QCD parton shower on and off

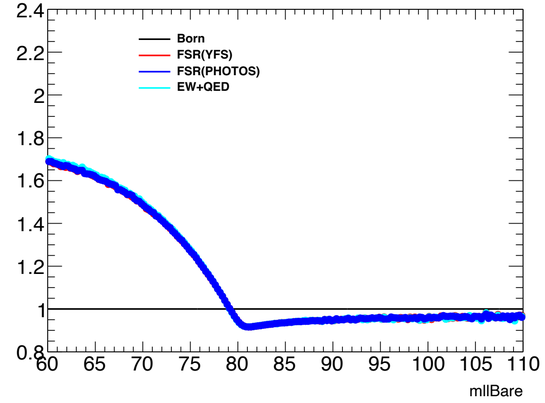
13 TeV $W^+ \to \mu\nu$ QCD on

EW correction change when switch on QCD parton shower





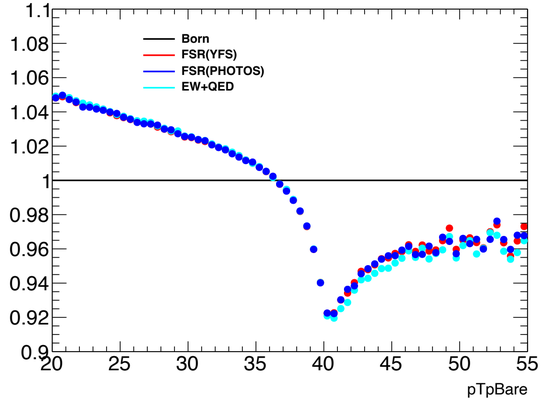


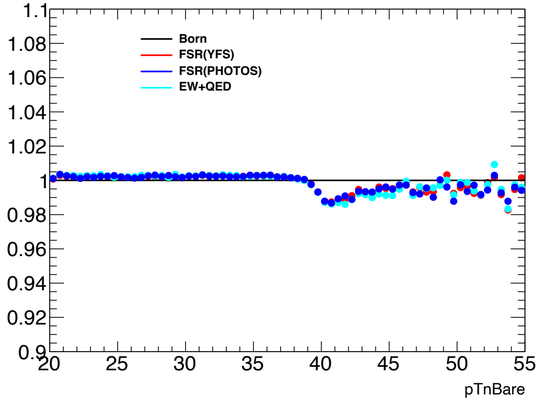


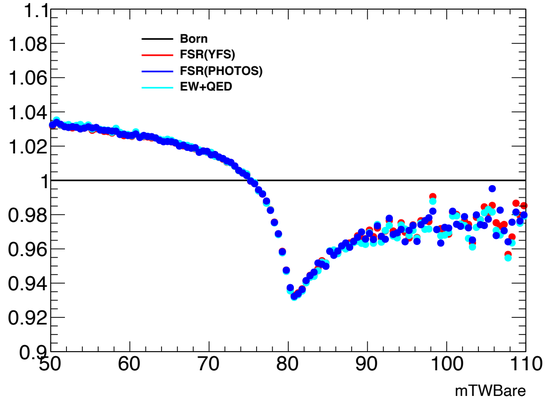
13 TeV $W^+ \to \mu\nu$ QCD off

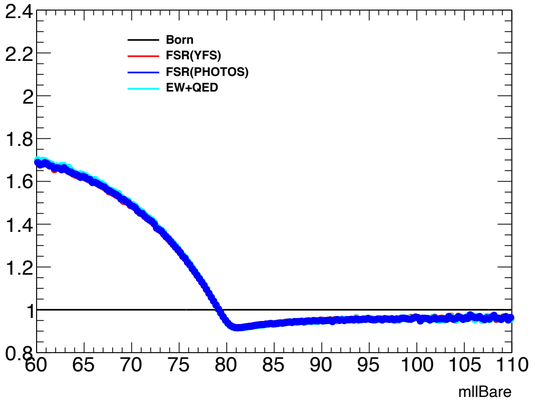
Sensitive to WpT

Not sensitive to WpT









Visible effect

Very small effect

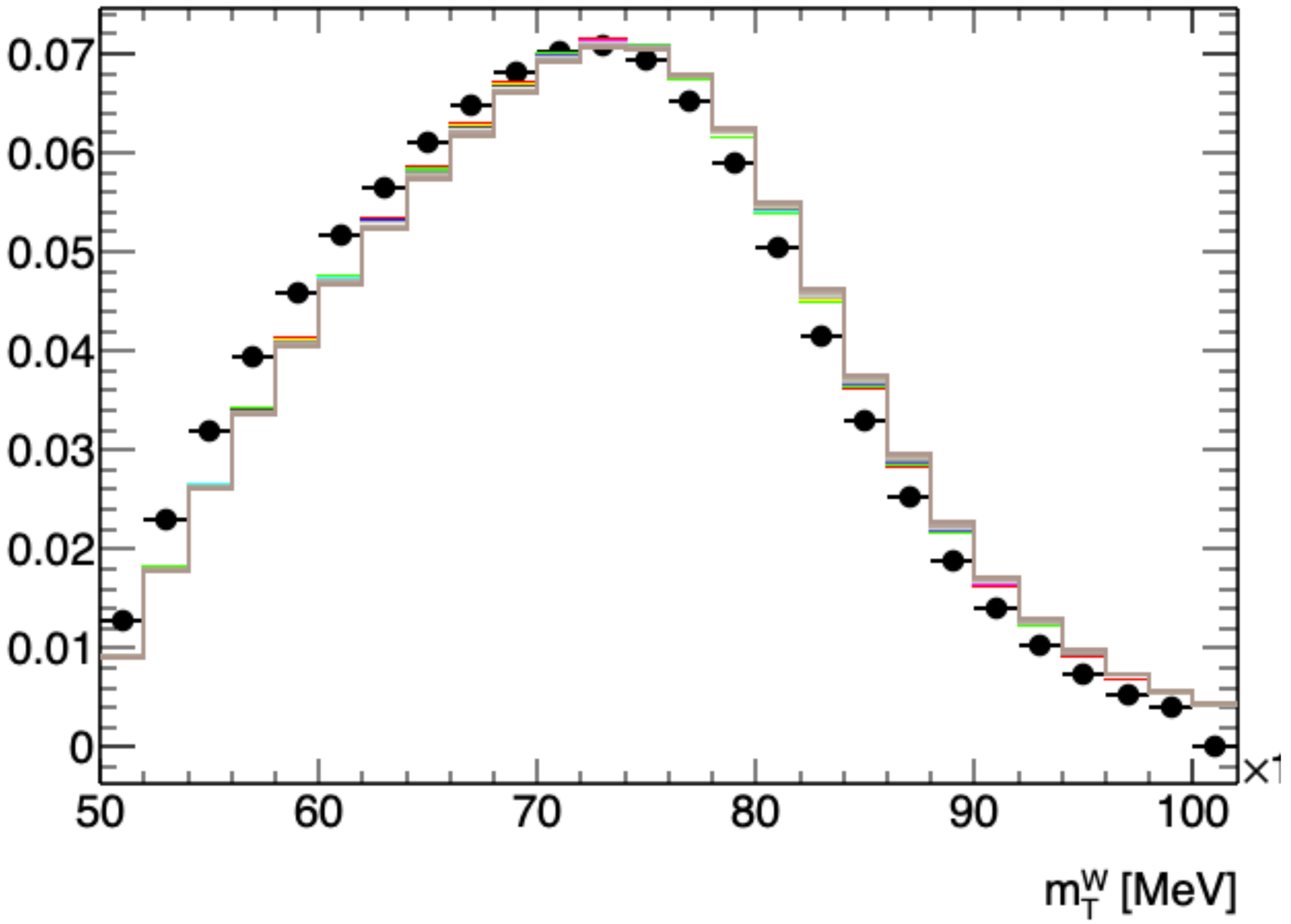
Preliminary estimation of effect on m_W measurement

Channel	Reco level correction IS QCD on	Truth level correction IS QCD on	Reco level correction IS QCD off	Truth level correction IS QCD off
5 TeV W+ ->ev	-6.63	-7.23	-14.79	-21.48
5 TeV W- ->ev	-5.50	-5.04	-14.99	-20.40
5 TeV W+ ->uv	-6.11	-7.60	-13.36	-20.76
5 TeV W- ->uv	-3.69	-2.53	-11.99	-15.58
13 TeV W+ ->ev	-5.98	-7.33	-22.56	-30.76
13 TeV W- ->ev	-4.24	-4.52	-22.71	-32.84
13 TeV W+ ->uv	-4.39	-1.95	-20.88	-29.13
13 TeV W- ->uv	-4.74	-4.01	-22.44	-31.27

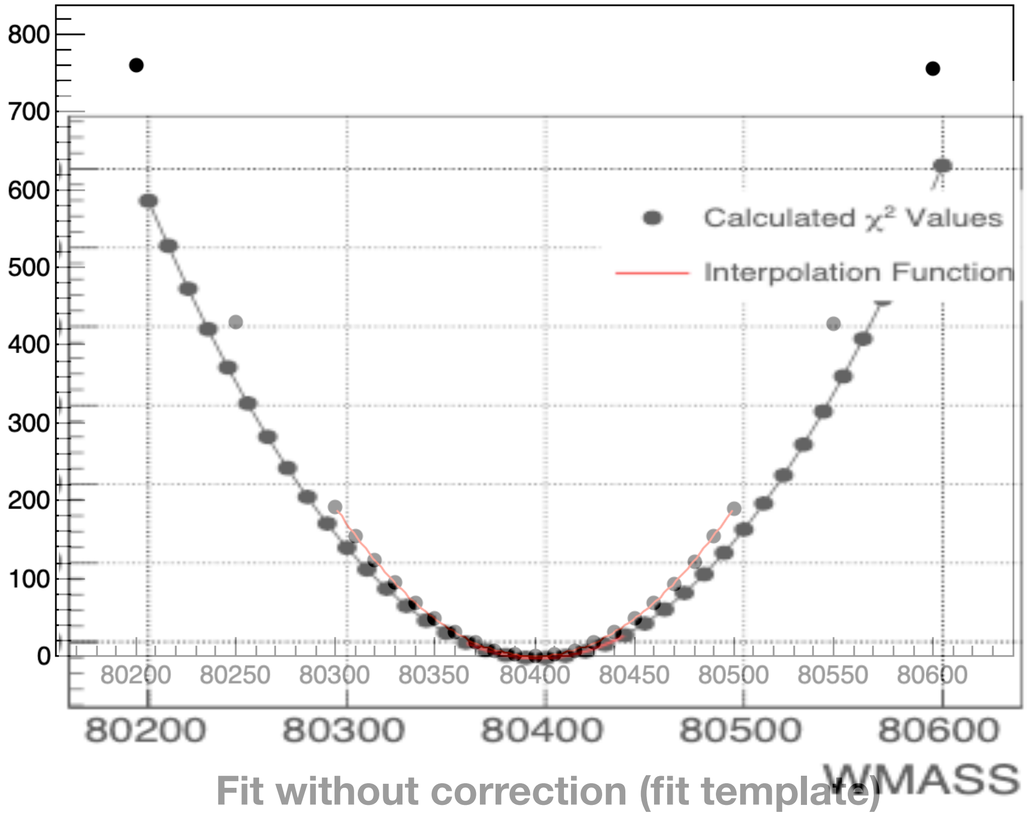
Lepton pT

Sensitive to WpT

pseudo data: 80400 MeV

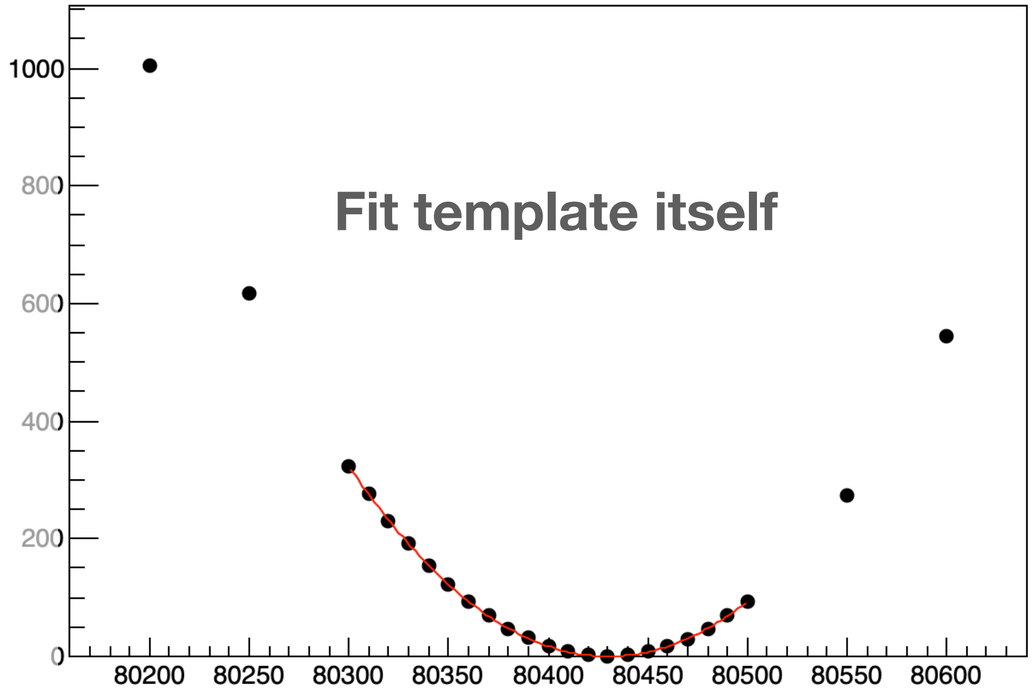

0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
50
60
70
80
90
100
m_T^W [MeV]

Preliminary estimation of effect on m_W measurement



Fit without correction (fit template)

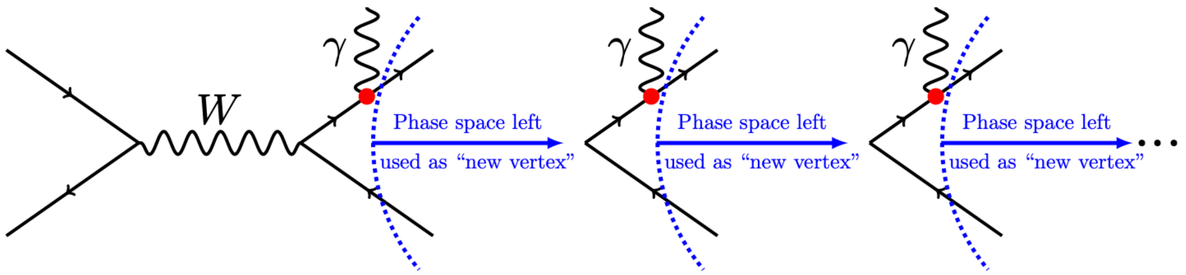
80400–>80400.1 +/- 7.2



Fit without correction (fit template)

80430–>80430.1 +/- 7.2

- PHOTOS: afterburner, NLO ME



- YFS:

$$\sigma^{tot}_{\rm YFS} = \sum_{n=0}^{\infty} \int \frac{d^3q_l}{q_l^0}\frac{d^3q_\nu}{q_\nu^0}\rho_n^{(1)}(p_1,p_2,q_1,q_2,k_1,\ldots,k_n),$$

$$\rho_n^{(1)} = e^{Y(Q,q_l;k_s)}\,\frac{1}{n!}\prod_{i=1}^{n}\frac{d^3k_i}{k_i^0}\tilde{S}(Q,q_l,k_i)\theta(k_i^0-k_s)\,\delta^{(4)}\left(p_1+p_2-q_l-q_\nu-\sum^{n}k_i\right)$$

$$\times\left[\bar{\beta}_0^{(1)}(p_1,p_2,q_l,q_\nu)+\sum_{i=1}^{n}\frac{\bar{\beta}_1^{(1)}(p_1,p_2,q_l,q_\nu,k_i)}{\tilde{S}(Q,q_l,k_i)}\right].$$