Electroweak and subleading corrections in $t\bar{t}$ + jets production

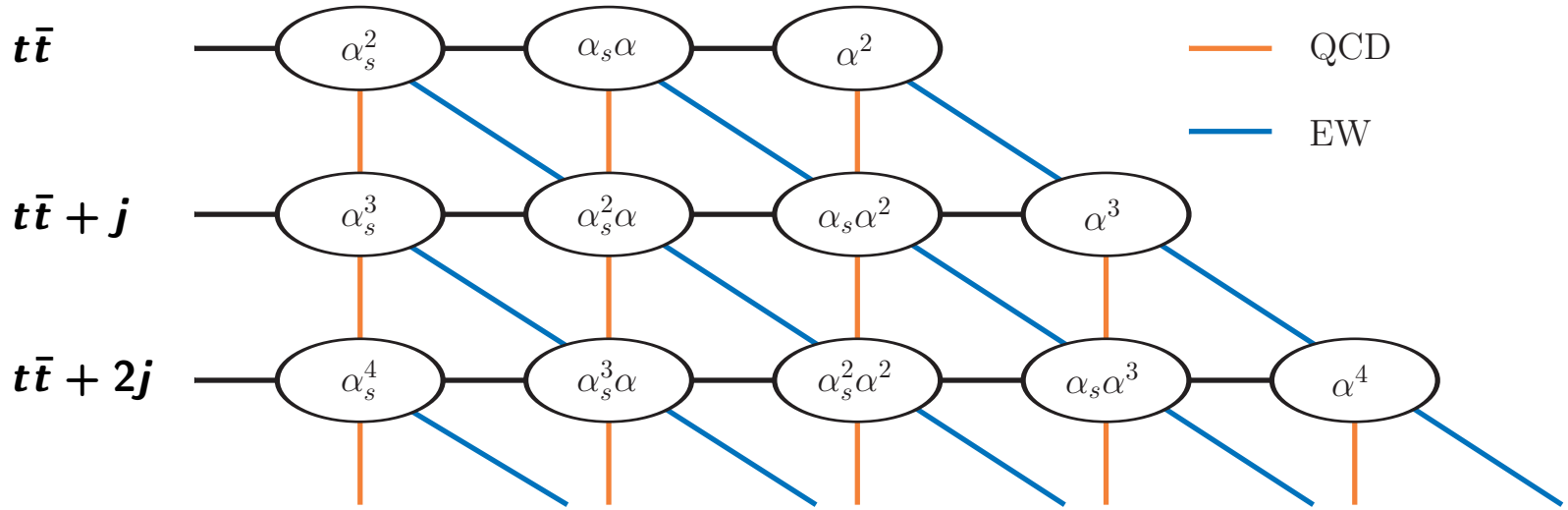
Marek Schönherr

LHC Top WG Meeting

16 May 2018

Anatomy of $t\bar{t}$ + jets production

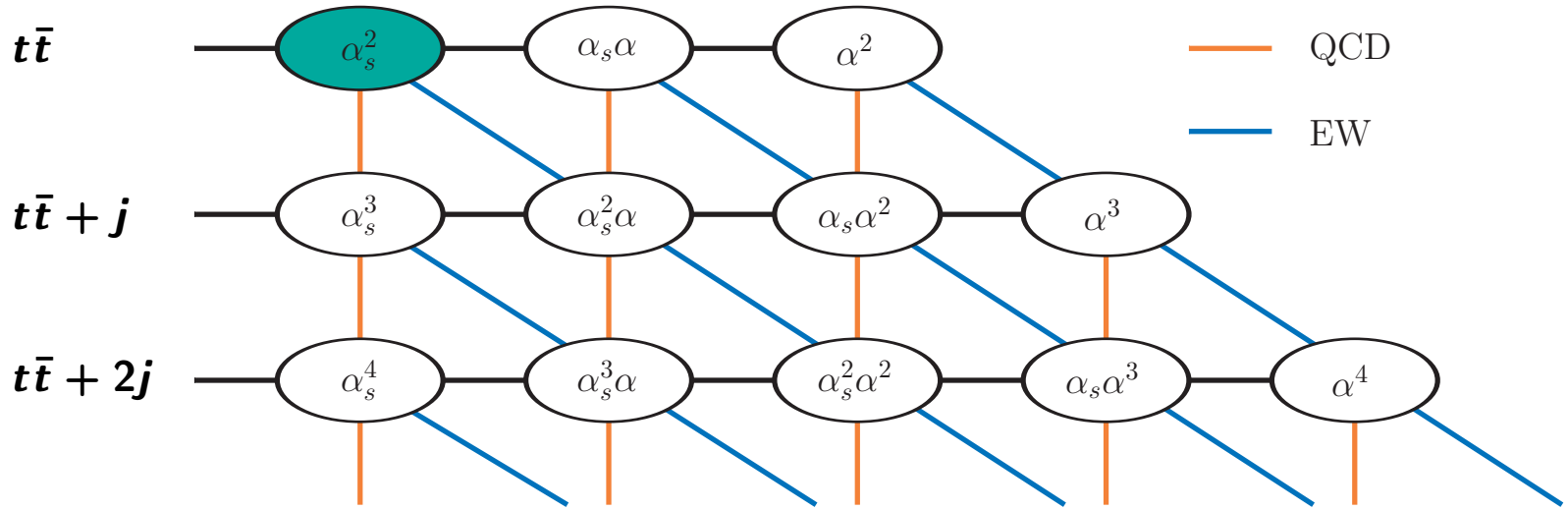
tree-level configuration



	$t\bar{t}$	$t\bar{t}+j$
LO	$\mathcal{O}(\alpha_s^2)$	$\mathcal{O}(\alpha_s^3)$
subLO	$\mathcal{O}(\alpha_s\alpha)$, $\mathcal{O}(\alpha^2)$	$\mathcal{O}(\alpha_s^2\alpha)$, $\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$
NLO QCD	$\mathcal{O}(\alpha_s^3)$	$\mathcal{O}(\alpha_s^4)$
NLO EW	$\mathcal{O}(\alpha_s^2\alpha)$	$\mathcal{O}(\alpha_s^3\alpha)$
all NLO	$\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$	$\mathcal{O}(\alpha_s^2\alpha^2)$, $\mathcal{O}(\alpha_s\alpha^3)$, $\mathcal{O}(\alpha^4)$

Anatomy of $t\bar{t}$ + jets production

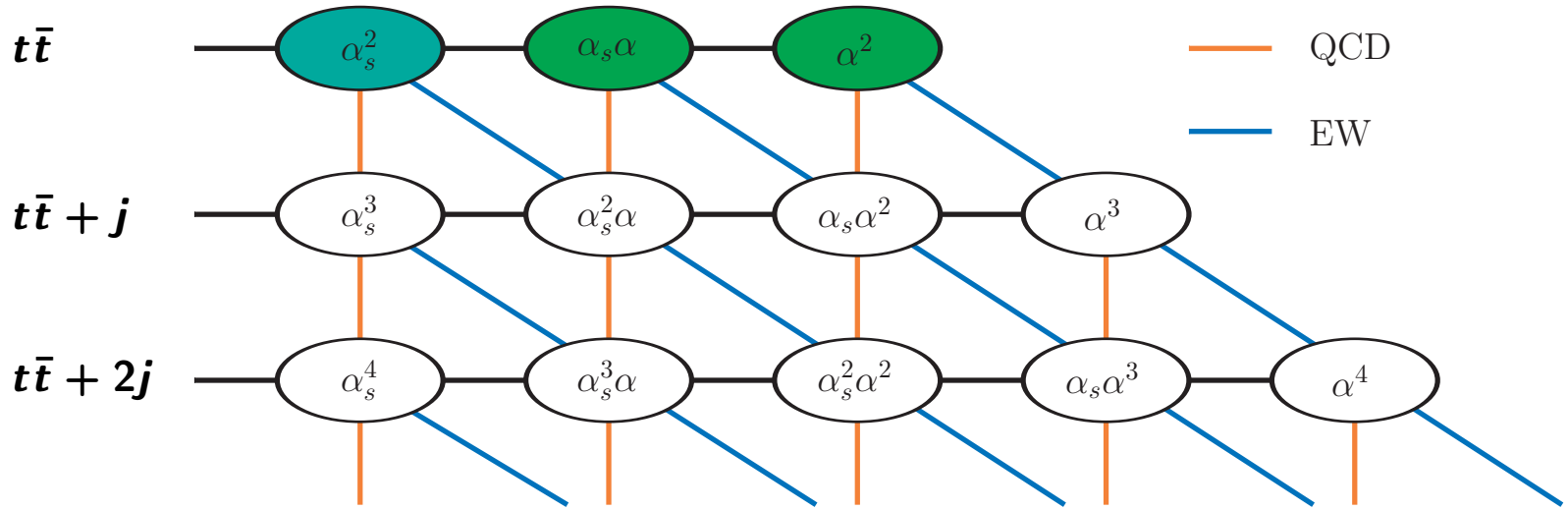
tree-level configuration



	$t\bar{t}$	$t\bar{t}+j$
LO	$\mathcal{O}(\alpha_s^2)$	$\mathcal{O}(\alpha_s^3)$
subLO	$\mathcal{O}(\alpha_s\alpha)$, $\mathcal{O}(\alpha^2)$	$\mathcal{O}(\alpha_s^2\alpha)$, $\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$
NLO QCD	$\mathcal{O}(\alpha_s^3)$	$\mathcal{O}(\alpha_s^4)$
NLO EW	$\mathcal{O}(\alpha_s^2\alpha)$	$\mathcal{O}(\alpha_s^3\alpha)$
all NLO	$\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$	$\mathcal{O}(\alpha_s^2\alpha^2)$, $\mathcal{O}(\alpha_s\alpha^3)$, $\mathcal{O}(\alpha^4)$

Anatomy of $t\bar{t}$ + jets production

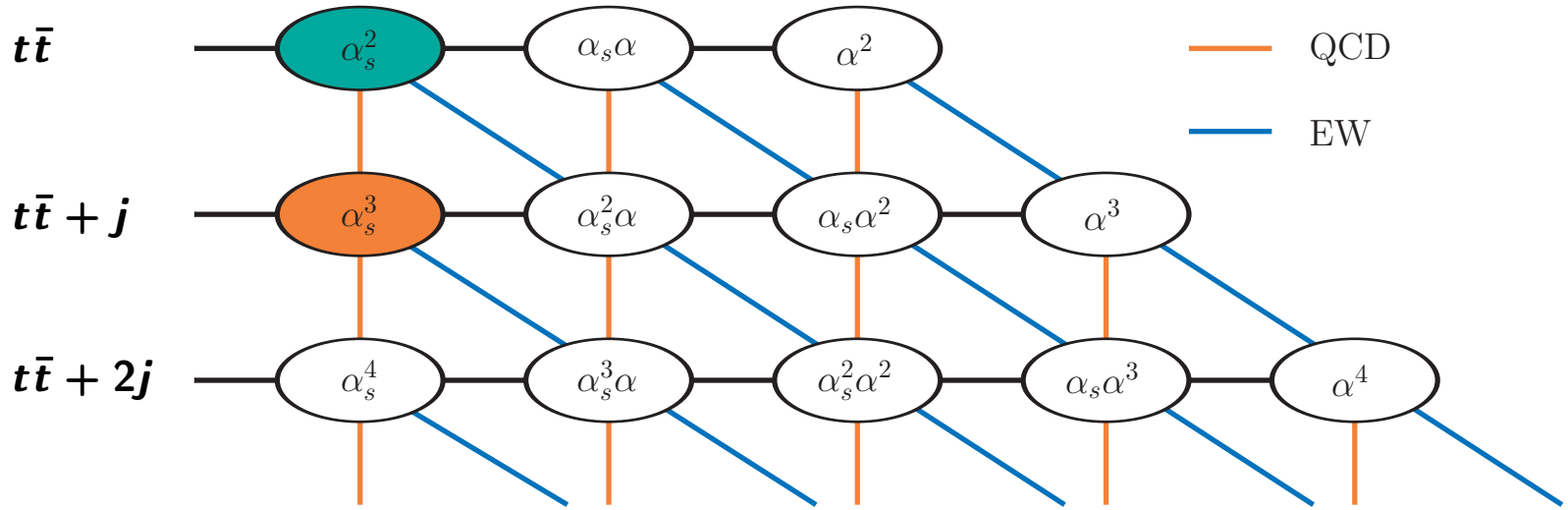
tree-level configuration



	$t\bar{t}$	$t\bar{t}+j$
LO	$\mathcal{O}(\alpha_s^2)$	$\mathcal{O}(\alpha_s^3)$
subLO	$\mathcal{O}(\alpha_s\alpha)$, $\mathcal{O}(\alpha^2)$	$\mathcal{O}(\alpha_s^2\alpha)$, $\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$
NLO QCD	$\mathcal{O}(\alpha_s^3)$	$\mathcal{O}(\alpha_s^4)$
NLO EW	$\mathcal{O}(\alpha_s^2\alpha)$	$\mathcal{O}(\alpha_s^3\alpha)$
all NLO	$\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$	$\mathcal{O}(\alpha_s^2\alpha^2)$, $\mathcal{O}(\alpha_s\alpha^3)$, $\mathcal{O}(\alpha^4)$

Anatomy of $t\bar{t}$ + jets production

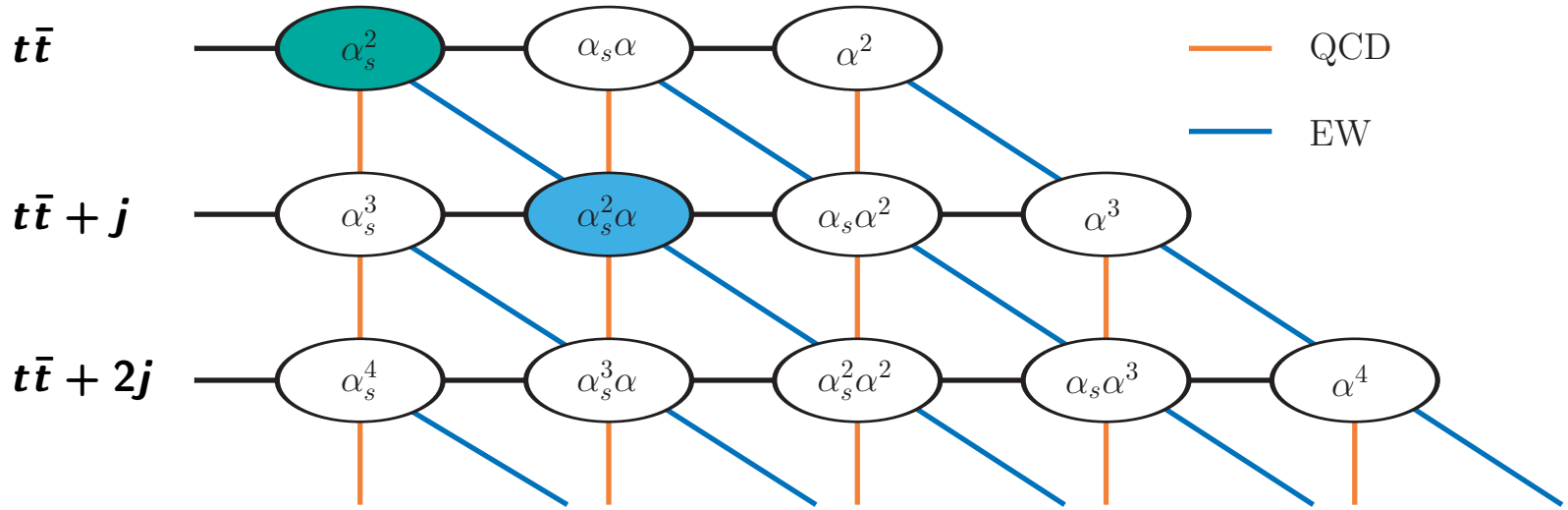
tree-level configuration



	$t\bar{t}$	$t\bar{t}+j$
LO	$\mathcal{O}(\alpha_s^2)$	$\mathcal{O}(\alpha_s^3)$
subLO	$\mathcal{O}(\alpha_s\alpha)$, $\mathcal{O}(\alpha^2)$	$\mathcal{O}(\alpha_s^2\alpha)$, $\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$
NLO QCD	$\mathcal{O}(\alpha_s^3)$	$\mathcal{O}(\alpha_s^4)$
NLO EW	$\mathcal{O}(\alpha_s^2\alpha)$	$\mathcal{O}(\alpha_s^3\alpha)$
all NLO	$\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$	$\mathcal{O}(\alpha_s^2\alpha^2)$, $\mathcal{O}(\alpha_s\alpha^3)$, $\mathcal{O}(\alpha^4)$

Anatomy of $t\bar{t}$ + jets production

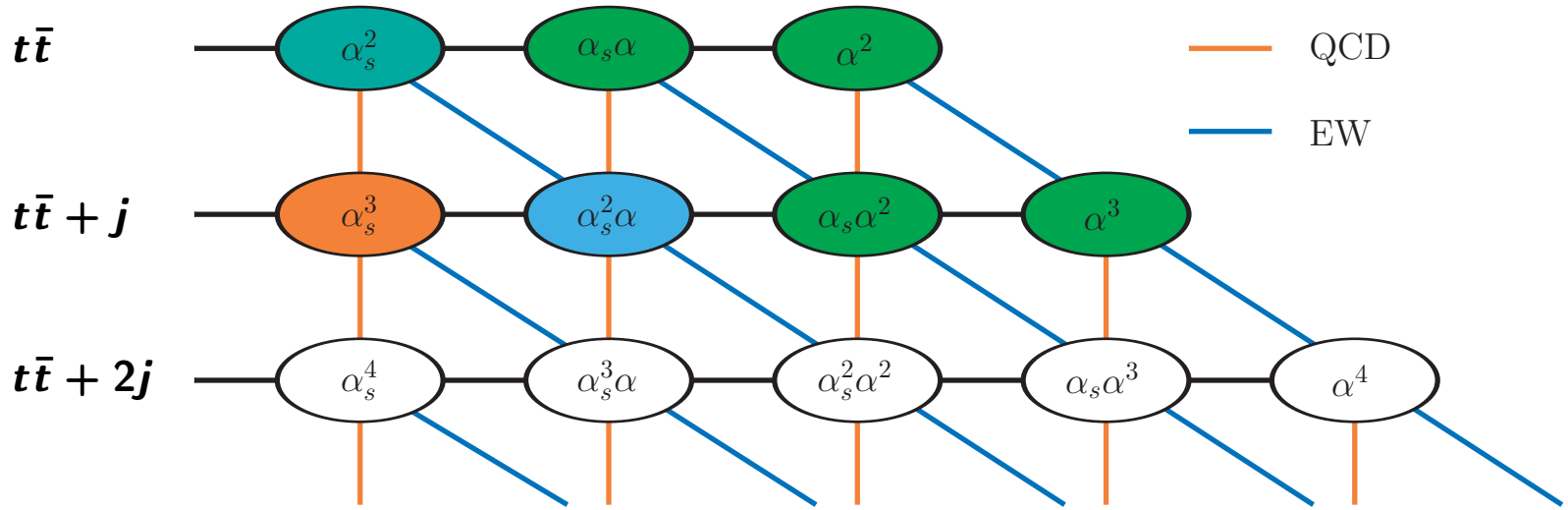
tree-level configuration



	$t\bar{t}$	$t\bar{t}+j$
LO	$\mathcal{O}(\alpha_s^2)$	$\mathcal{O}(\alpha_s^3)$
subLO	$\mathcal{O}(\alpha_s\alpha)$, $\mathcal{O}(\alpha^2)$	$\mathcal{O}(\alpha_s^2\alpha)$, $\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$
NLO QCD	$\mathcal{O}(\alpha_s^3)$	$\mathcal{O}(\alpha_s^4)$
NLO EW	$\mathcal{O}(\alpha_s^2\alpha)$	$\mathcal{O}(\alpha_s^3\alpha)$
all NLO	$\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$	$\mathcal{O}(\alpha_s^2\alpha^2)$, $\mathcal{O}(\alpha_s\alpha^3)$, $\mathcal{O}(\alpha^4)$

Anatomy of $t\bar{t}$ + jets production

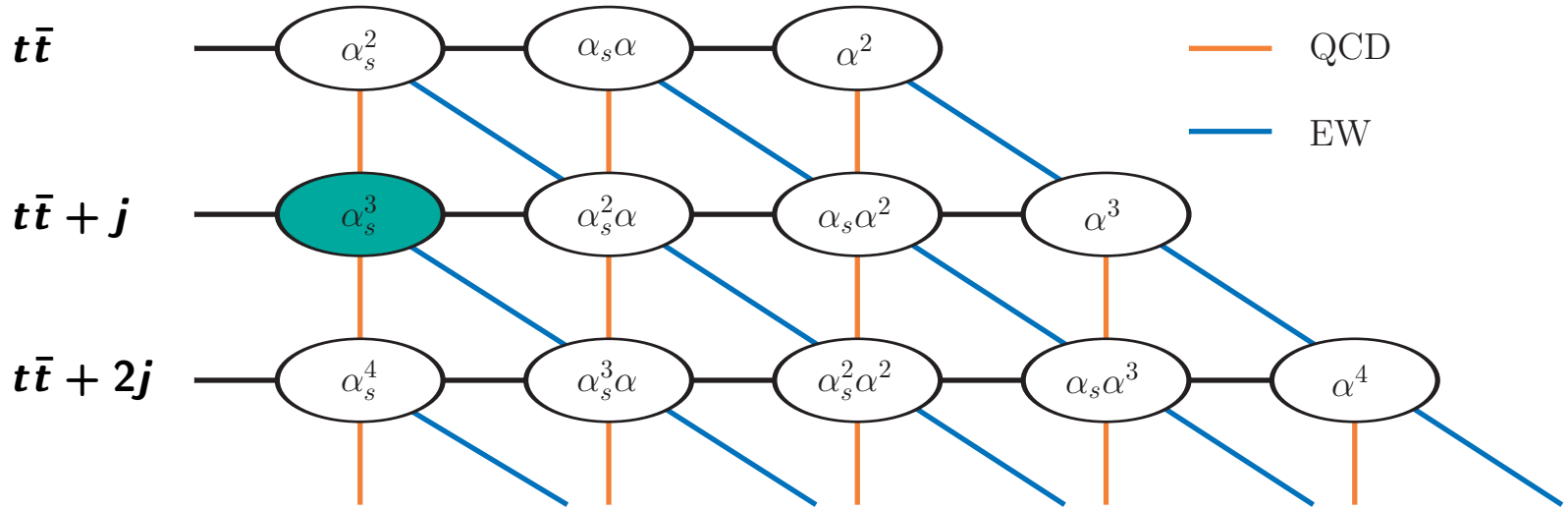
tree-level configuration



	$t\bar{t}$	$t\bar{t}+j$
LO	$\mathcal{O}(\alpha_s^2)$	$\mathcal{O}(\alpha_s^3)$
subLO	$\mathcal{O}(\alpha_s\alpha)$, $\mathcal{O}(\alpha^2)$	$\mathcal{O}(\alpha_s^2\alpha)$, $\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$
NLO QCD	$\mathcal{O}(\alpha_s^3)$	$\mathcal{O}(\alpha_s^4)$
NLO EW	$\mathcal{O}(\alpha_s^2\alpha)$	$\mathcal{O}(\alpha_s^3\alpha)$
all NLO	$\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$	$\mathcal{O}(\alpha_s^2\alpha^2)$, $\mathcal{O}(\alpha_s\alpha^3)$, $\mathcal{O}(\alpha^4)$

Anatomy of $t\bar{t}$ + jets production

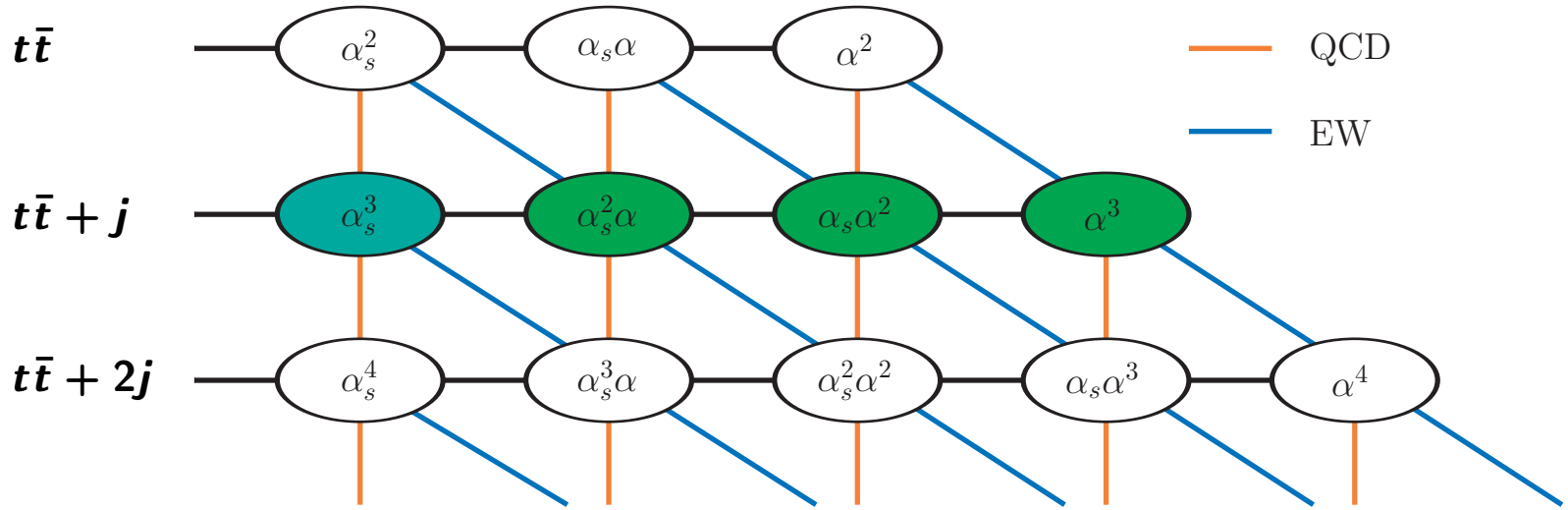
tree-level configuration



	$t\bar{t}$	$t\bar{t}+j$
LO	$\mathcal{O}(\alpha_s^2)$	$\mathcal{O}(\alpha_s^3)$
subLO	$\mathcal{O}(\alpha_s\alpha)$, $\mathcal{O}(\alpha^2)$	$\mathcal{O}(\alpha_s^2\alpha)$, $\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$
NLO QCD	$\mathcal{O}(\alpha_s^3)$	$\mathcal{O}(\alpha_s^4)$
NLO EW	$\mathcal{O}(\alpha_s^2\alpha)$	$\mathcal{O}(\alpha_s^3\alpha)$
all NLO	$\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$	$\mathcal{O}(\alpha_s^2\alpha^2)$, $\mathcal{O}(\alpha_s\alpha^3)$, $\mathcal{O}(\alpha^4)$

Anatomy of $t\bar{t}$ + jets production

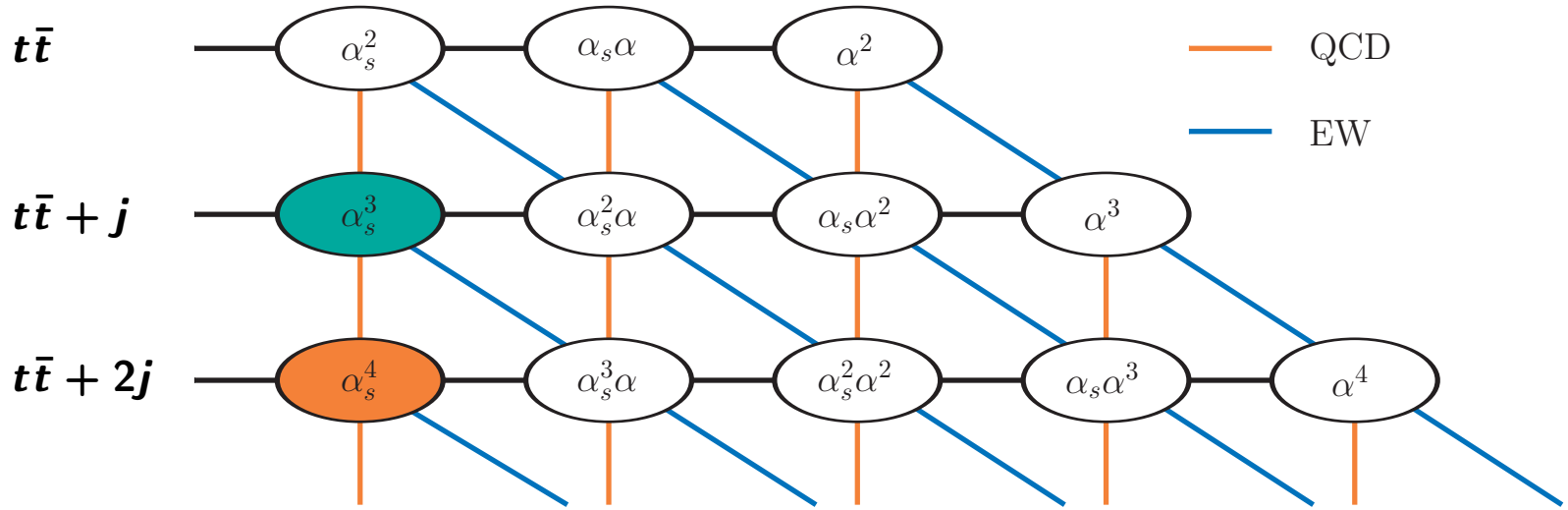
tree-level configuration



	$t\bar{t}$	$t\bar{t}+j$
LO	$\mathcal{O}(\alpha_s^2)$	$\mathcal{O}(\alpha_s^3)$
subLO	$\mathcal{O}(\alpha_s\alpha)$, $\mathcal{O}(\alpha^2)$	$\mathcal{O}(\alpha_s^2\alpha)$, $\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$
NLO QCD	$\mathcal{O}(\alpha_s^3)$	$\mathcal{O}(\alpha_s^4)$
NLO EW	$\mathcal{O}(\alpha_s^2\alpha)$	$\mathcal{O}(\alpha_s^3\alpha)$
all NLO	$\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$	$\mathcal{O}(\alpha_s^2\alpha^2)$, $\mathcal{O}(\alpha_s\alpha^3)$, $\mathcal{O}(\alpha^4)$

Anatomy of $t\bar{t}$ + jets production

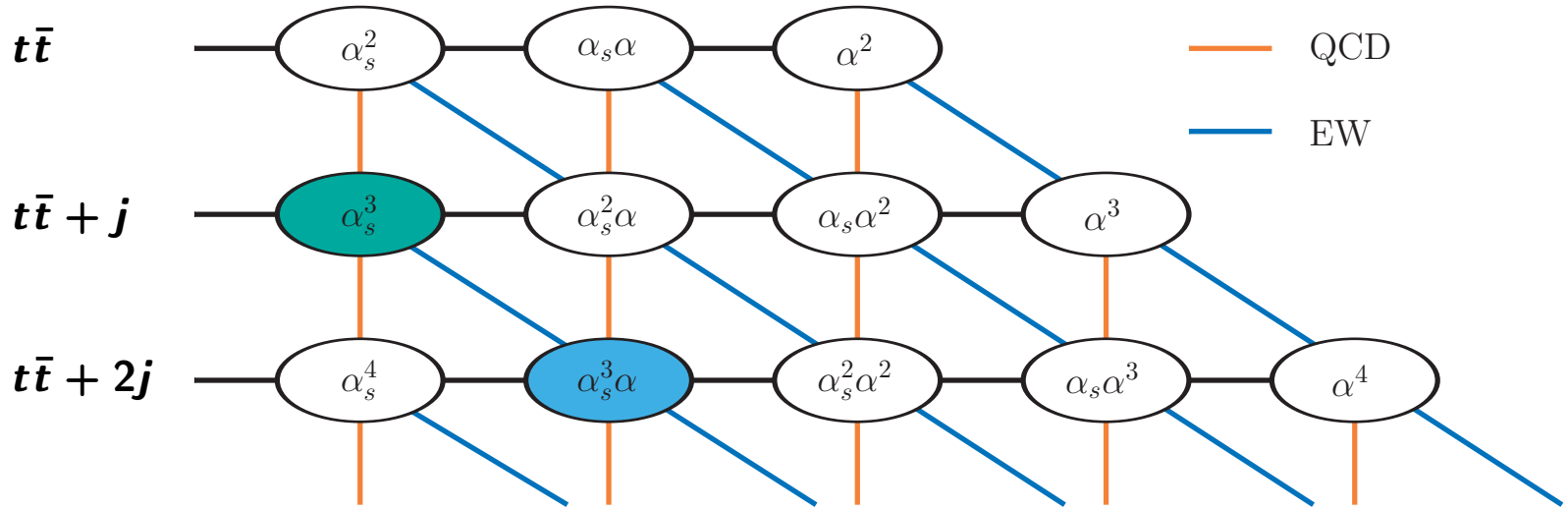
tree-level configuration



	$t\bar{t}$	$t\bar{t}+j$
LO	$\mathcal{O}(\alpha_s^2)$	$\mathcal{O}(\alpha_s^3)$
subLO	$\mathcal{O}(\alpha_s\alpha)$, $\mathcal{O}(\alpha^2)$	$\mathcal{O}(\alpha_s^2\alpha)$, $\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$
NLO QCD	$\mathcal{O}(\alpha_s^3)$	$\mathcal{O}(\alpha_s^4)$
NLO EW	$\mathcal{O}(\alpha_s^2\alpha)$	$\mathcal{O}(\alpha_s^3\alpha)$
all NLO	$\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$	$\mathcal{O}(\alpha_s^2\alpha^2)$, $\mathcal{O}(\alpha_s\alpha^3)$, $\mathcal{O}(\alpha^4)$

Anatomy of $t\bar{t}$ + jets production

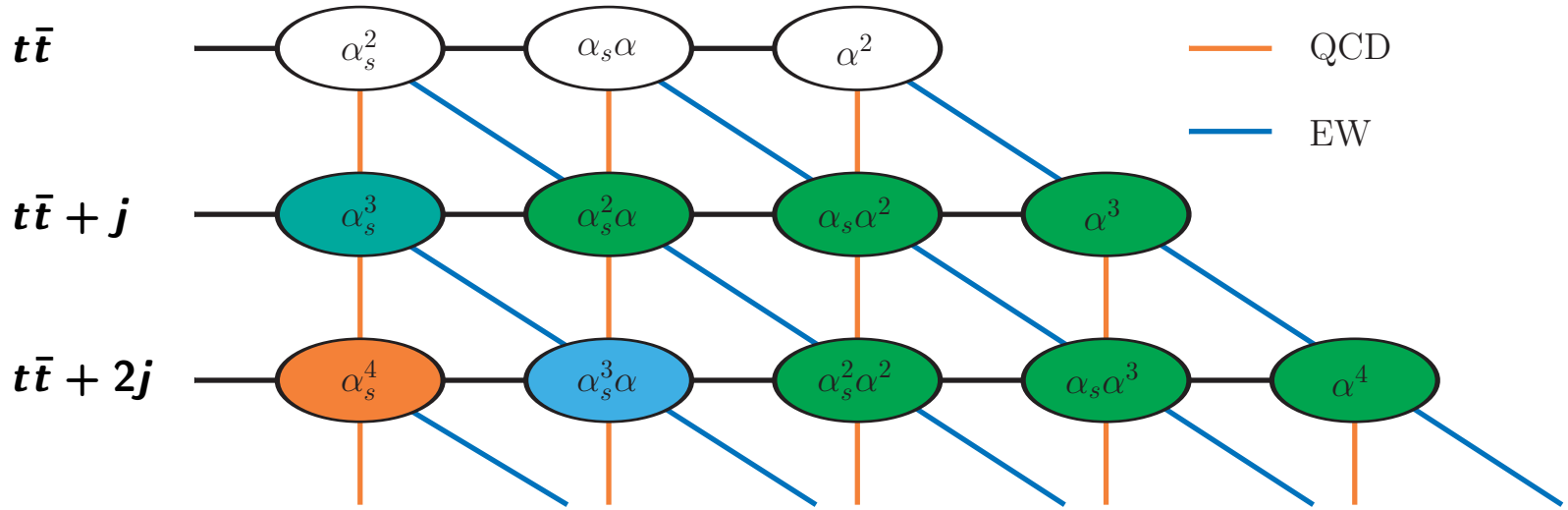
tree-level configuration



	$t\bar{t}$	$t\bar{t}+j$
LO	$\mathcal{O}(\alpha_s^2)$	$\mathcal{O}(\alpha_s^3)$
subLO	$\mathcal{O}(\alpha_s\alpha)$, $\mathcal{O}(\alpha^2)$	$\mathcal{O}(\alpha_s^2\alpha)$, $\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$
NLO QCD	$\mathcal{O}(\alpha_s^3)$	$\mathcal{O}(\alpha_s^4)$
NLO EW	$\mathcal{O}(\alpha_s^2\alpha)$	$\mathcal{O}(\alpha_s^3\alpha)$
all NLO	$\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$	$\mathcal{O}(\alpha_s^2\alpha^2)$, $\mathcal{O}(\alpha_s\alpha^3)$, $\mathcal{O}(\alpha^4)$

Anatomy of $t\bar{t}$ + jets production

tree-level configuration



	$t\bar{t}$	$t\bar{t}+j$
LO	$\mathcal{O}(\alpha_s^2)$	$\mathcal{O}(\alpha_s^3)$
subLO	$\mathcal{O}(\alpha_s\alpha)$, $\mathcal{O}(\alpha^2)$	$\mathcal{O}(\alpha_s^2\alpha)$, $\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$
NLO QCD	$\mathcal{O}(\alpha_s^3)$	$\mathcal{O}(\alpha_s^4)$
NLO EW	$\mathcal{O}(\alpha_s^2\alpha)$	$\mathcal{O}(\alpha_s^3\alpha)$
all NLO	$\mathcal{O}(\alpha_s\alpha^2)$, $\mathcal{O}(\alpha^3)$	$\mathcal{O}(\alpha_s^2\alpha^2)$, $\mathcal{O}(\alpha_s\alpha^3)$, $\mathcal{O}(\alpha^4)$

Available calculations – fixed order

$t\bar{t}$

- NNLO QCD & NLO EW (including all subleading orders)

Czakon et.al. arXiv:1705.04105

$t\bar{t} + j$

- NLO QCD & NLO EW (including all subleading orders)

Dittmaier, Uwer, Weinzierl hep-ph/0703120; Gütschow, Lindert, MS arXiv:1803.00950

$t\bar{t} + 2j$

- NLO QCD

Bevilacqua et.al. arXiv:1108.2851

$t\bar{t} + 3j$

- NLO QCD

Höche, Maierhöfer, Moretti, Pozzorini, Siegert arXiv:1607.06934

Contributions with external photons

Process with external photons only in subleading orders

Initial state photons

- photon initiated processes
  $\rightarrow$ dominated by $g\gamma \rightarrow t\bar{t}$
  $\lesssim 1\%$ of incl. xs
- less important at higher collider energies as PDFs then probed at smaller x

$\Rightarrow$ effects generally not important

Pagani, Tsinikos, Zaro arXiv:1606.01915

Final state photons

- QED bremsstrahlung
  $\rightarrow$ always present
  $\rightarrow$ important only in leptonic decays
- γ may be reconstructed as jet if not explicitly rejected
  $\rightarrow$ highly analysis dependent
  $\rightarrow$ small effect ($< 1\%$)

Available calculations – particle level

NLOPs

- POWHEG, MC@NLO @ NLO QCD for $t\bar{t}$, $t\bar{t}+j$

Frixione, Nason, Webber hep-ph/0305252
Frixione, Nason, Ridolfi arXiv:0707.3088
Kardos, Papadopoulos, Trocsanyi arXiv:1101.2672
Alioli, Moch, Uwer arXiv:1110.5251

Multijet merged

- FxFx $t\bar{t}+0,1,2j$ @ NLO QCD

Frederix, Frixione arXiv:1209.6215

- MEPS@NLO $t\bar{t}+0,1,2j$ @ NLO QCD $+3,4j$ @ LO

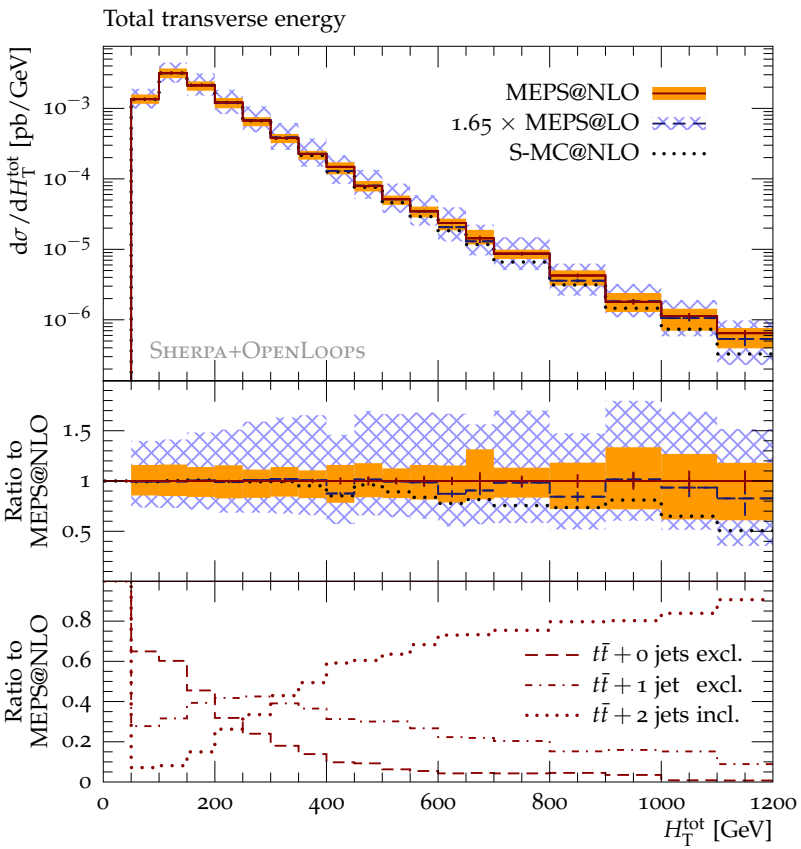
Höche, Krauss, Maierhöfer, Pozzorini, MS, Siegert arXiv:1402.6293

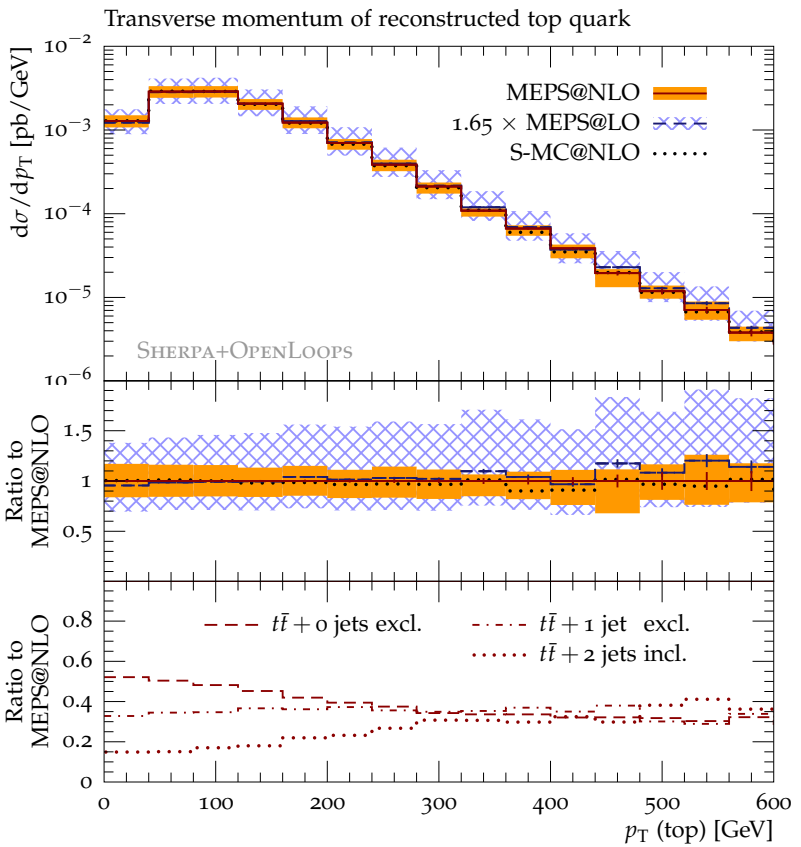
MEPS@NLO $t\bar{t}+0,1j$ @ NLO QCD+EW_{virt} $+2,3,4j$ @ LO

Gütschow, Lindert, MS arXiv:1803.00950

Multijet merged $t\bar{t}$+jets

Höche, Krauss, Maierhöfer, Pozzorini, MS, Siegert arXiv:1401.7971





Setup

SHERPA+OPENLOOPS

- uses automated framework for general NLO calculations in SHERPA
  tree-level matrix elements, dipole subtraction,
  phase space integration, process management

  MS arXiv:1712.07975
- virtual corrections from OPENLOOPS

  Cascioli, Maierhöfer, Pozzorini arXiv:1111.5206

Parameters

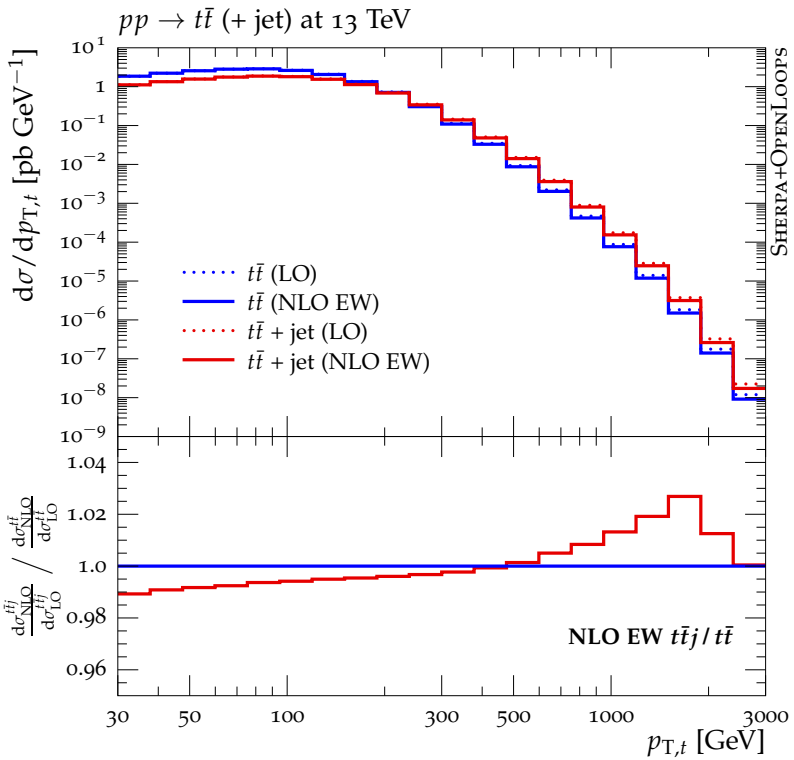
- $\mu_{R/F} = \frac{1}{2}\left(E_{\mathrm{T}}^{t} + E_{\mathrm{T}}^{\bar{t}}\right)$ in fixed-order calculation

  CKKW scale with $\mu_{\mathrm{core}} = \frac{1}{2}\left(\frac{1}{\hat{s}} + \frac{1}{m_t^2-\hat{t}} + \frac{1}{m_t^2-\hat{u}}\right)^{-\frac{1}{2}}$ in MEPS@NLO
- NNPDF3.0nnlo $\alpha_s = 0.118$, neglect γ-induced
- spin-correlated top decays, default tune for underlying event and hadronisation in data comparison

Setup

- SHERPA+OPENLOOPS:
  - $pp \to V + 0, 1, 2(, 3)$ jets — FCC report, arXiv:1607.01831; EW report arXiv:1606.02330; LH'15 arXiv:1605.04692; Kallweit,Lindert,Maierhöfer,Pozzorini,MS arXiv:1412.5157, arXiv:1511.08692
  - $pp \to Zj / pp \to \gamma j$ ratio — LH'15 arXiv:1605.04692; Kallweit,Lindert,Maierhöfer,Pozzorini,MS arXiv:1505.05704
  - $pp \to \gamma/\ell\ell/\ell\nu/\nu\nu + j$ — Lindert et.al arXiv:1705.04664
  - $pp \to Vh$ — FCC report, arXiv:1607.01831
  - $pp \to 2\ell 2\nu$ — Kallweit,Lindert,Pozzorini,MS, arXiv:1705.00598
  - $pp \to t\bar{t}/t\bar{t}j$ — Gütschow, Lindert, MS arXiv:1803.00950
  - $pp \to t\bar{t}h$ — LH'15 arXiv:1605.04692
- SHERPA+GOSAM
  - $pp \to \gamma\gamma + 0, 1, 2$ jets — Chiesa et.al. arXiv:1706.09022
  - $pp \to \gamma\gamma\gamma \,/\, \gamma\gamma\ell\nu \,/\, \gamma\gamma\ell\ell$ — Greiner, MS arXiv:1710.11514
  - $pp \to \gamma\gamma b\bar{b}$ — Greiner, MS in prep.
- SHERPA+RECOLA
  - $pp \to V + 0, 1, 2$ j, $pp \to 4\ell$, $pp \to t\bar{t}h$ — Biedermann et.al. arXiv:1704.05783

Top pair production in association with jets

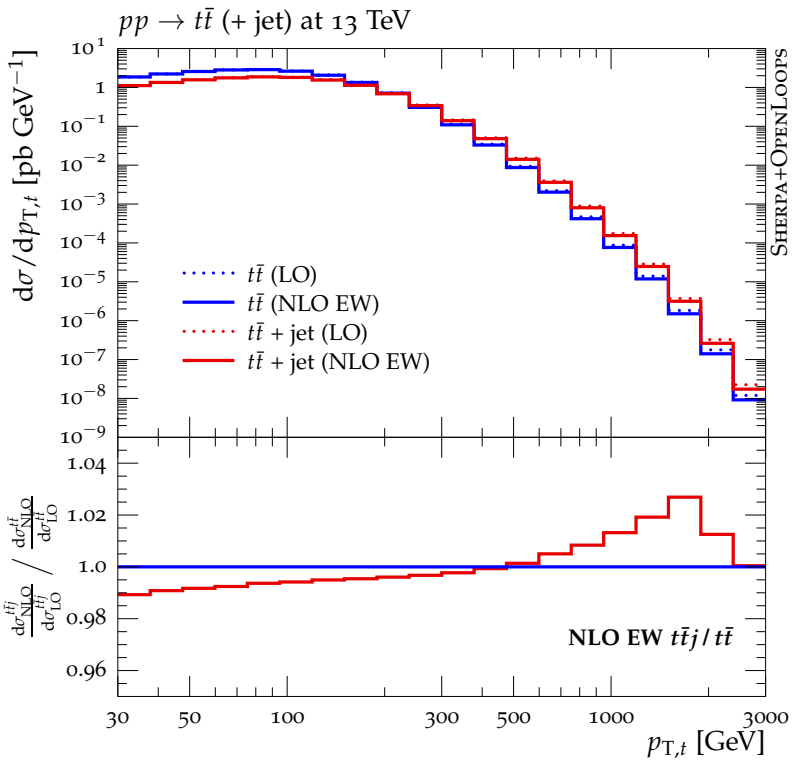


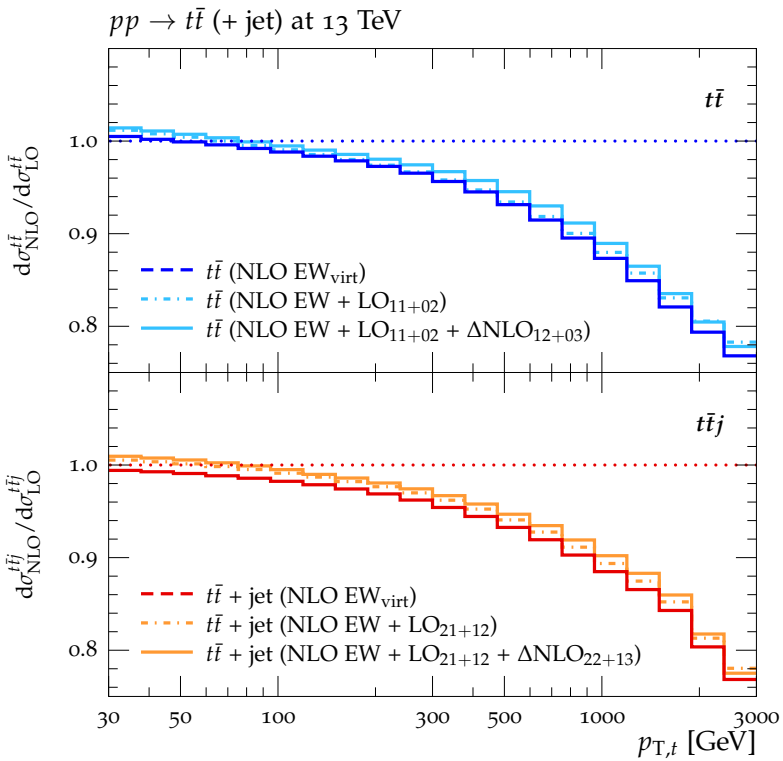
Gütschow, Lindert, MS arXiv:1803.00950

- $pp \to t\bar{t}$
  - LO: $\mathcal{O}(\alpha_s^2)$, $\mathcal{O}(\alpha_s\alpha)$, $\mathcal{O}(\alpha^2)$
  - include NLO corrections to subleading orders
- $pp \to t\bar{t}j$
  - LO: $\mathcal{O}(\alpha_s^3)$, $\mathcal{O}(\alpha_s^2\alpha)$, $\mathcal{O}(\alpha_s\alpha^2)$, $[\mathcal{O}(\alpha^3)]$
  - include NLO corrections to subleading orders

Top pair production in association with jets

Gütschow, Lindert, MS arXiv:1803.00950

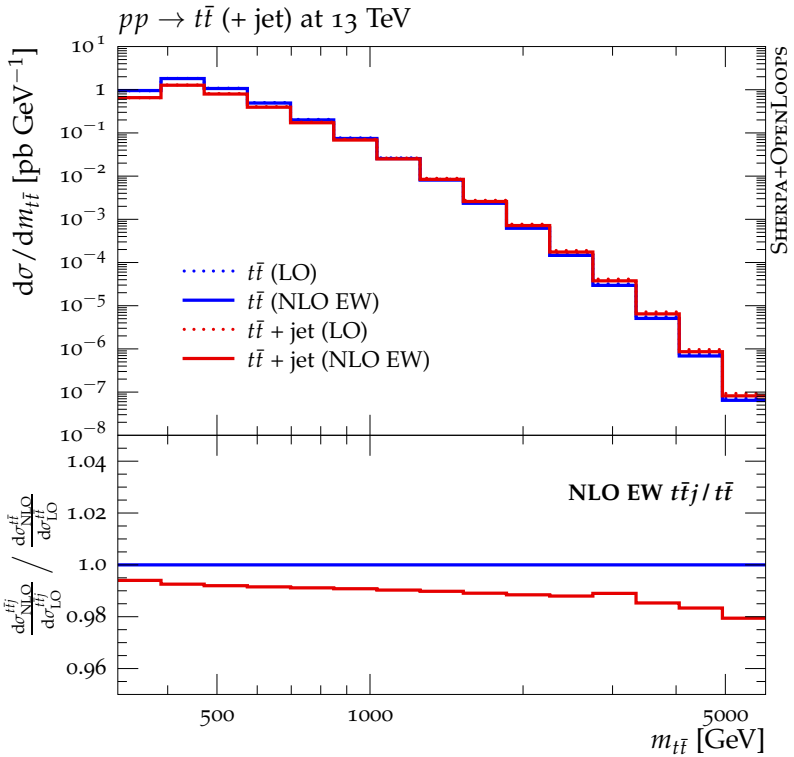


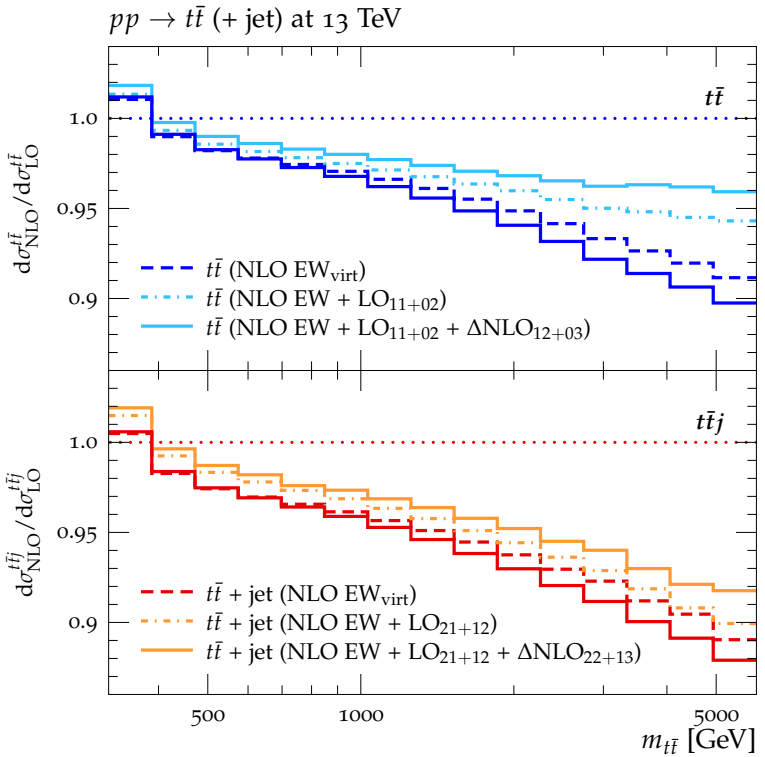


NLO EW factorises from additional jet activity

Top pair production in association with jets

Gütschow, Lindert, MS arXiv:1803.00950

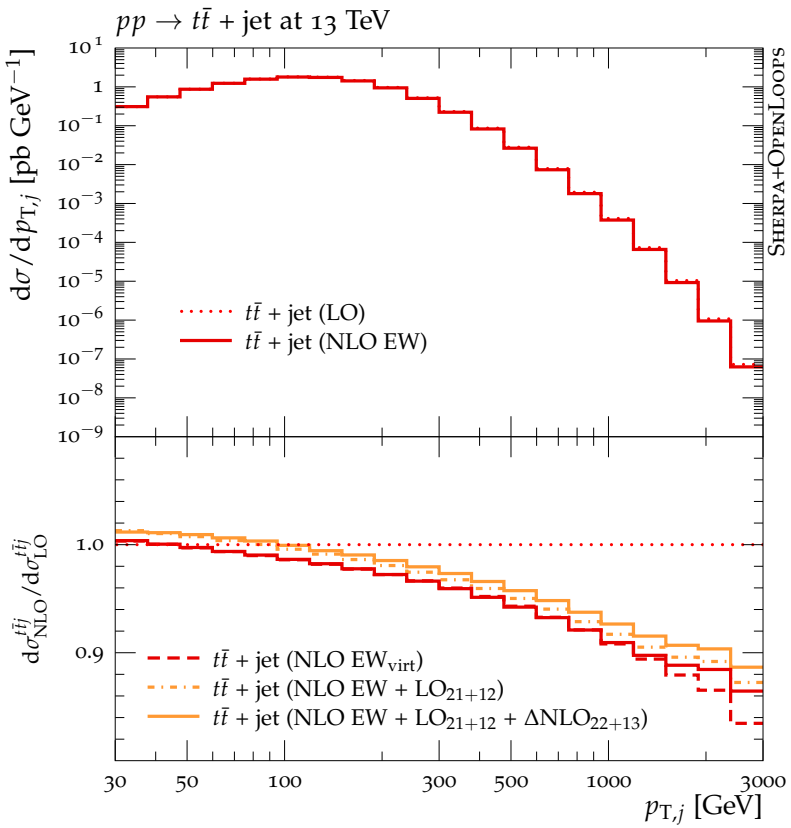




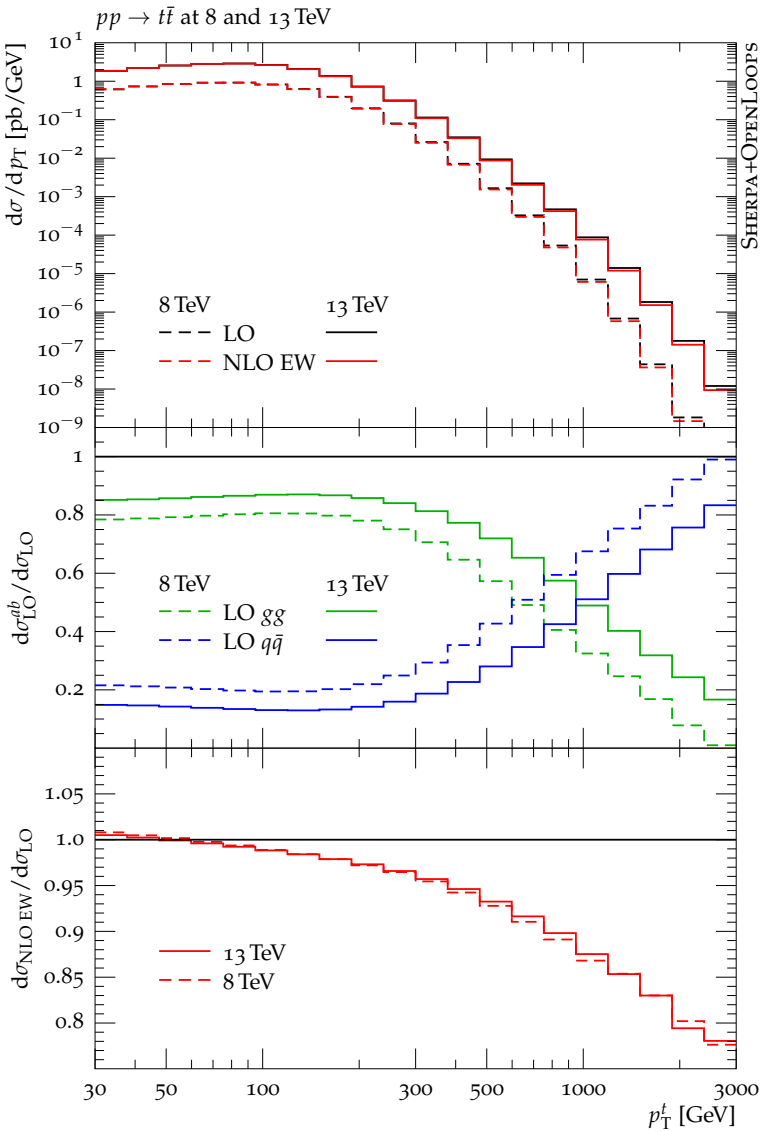
subleading orders important

Top pair production in association with jets

Gütschow, Lindert, MS arXiv:1803.00950



NLO EW corrections to $t\bar{t}$ at 8 and 13 TeV

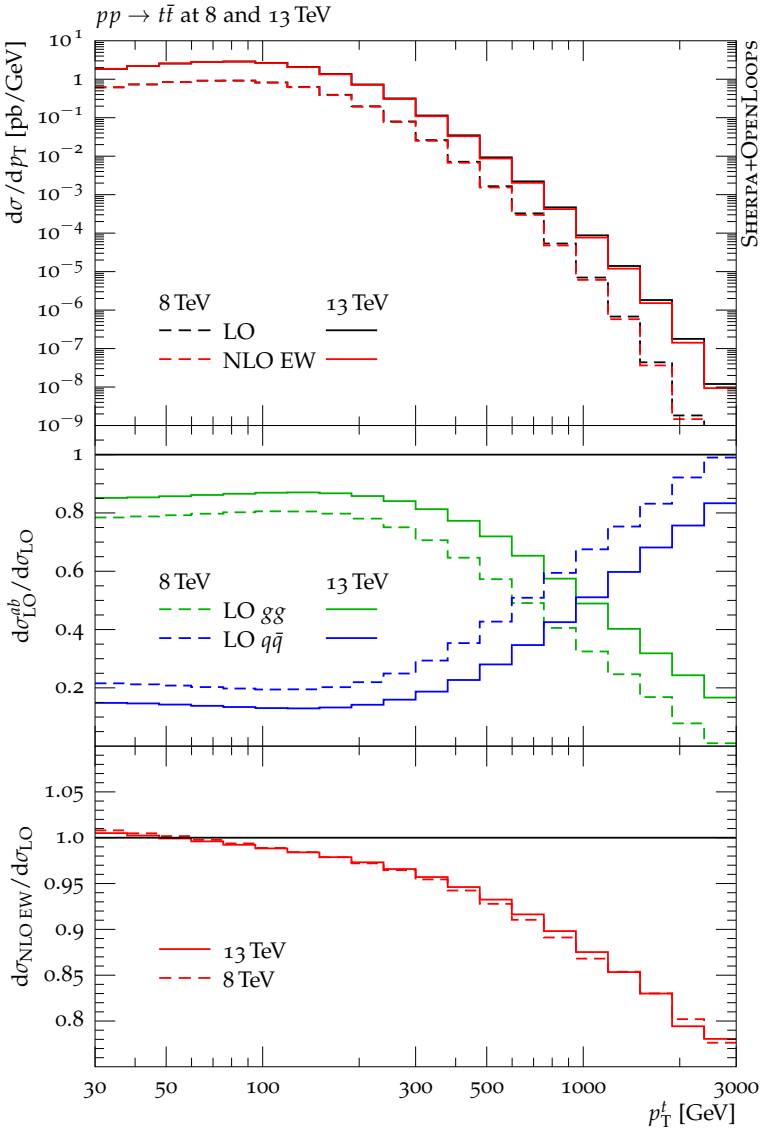


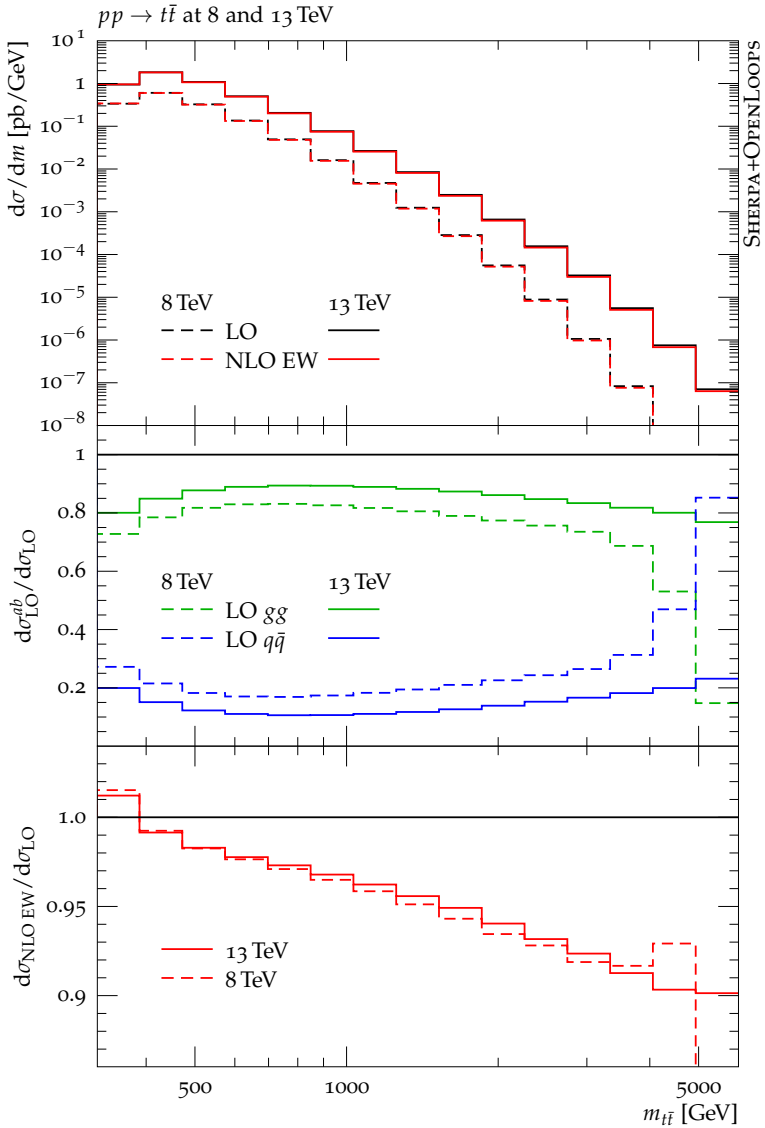
- gg channel receives smaller EW corrections in Sudakov limit than $q\bar{q}$ channel, at 1 TeV:

$$\delta^{q\bar{q}}_{\text{EW,sud}} \approx 1.5\,\delta^{gg}_{\text{EW,sud}}$$

- composition of total from gg vs $q\bar{q}$ channels changes
  $\to$ NLO EW correction changes
  $\to$ effect still small

NLO EW corrections to $t\bar{t}$ at 8 and 13 TeV





Electroweak corrections in particle-level event generation

- incorporate approximate electroweak corrections in SHERPA's NLO QCD multijet merging (MEPS@NLO)
- modify MC@NLO $\overline{\mathrm{B}}$-function to include NLO EW virtual corrections and integrated approx. real corrections

$$\overline{\mathrm{B}}_{n,\mathrm{QCD+EW_{virt}}}(\Phi_n) = \overline{\mathrm{B}}_{n,\mathrm{QCD}}(\Phi_n) + \mathrm{V}_{n,\mathrm{EW}}(\Phi_n) + \mathrm{I}_{n,\mathrm{EW}}(\Phi_n) + \mathrm{B}_{n,\mathrm{mix}}(\Phi_n)$$

- real QED radiation can be recovered through standard tools (parton shower, YFS resummation)
- simple stand-in for proper QCD+EW matching and merging
  $\rightarrow$ validated at fixed order, found to be reliable, diff. $\lesssim 5\%$ for observables not driven by real radiation

Electroweak corrections in particle-level event generation

- incorporate approximate electroweak corrections in SHERPA's NLO QCD multijet merging (MEPS@NLO)
- modify MC@NLO $\overline{\mathrm{B}}$-function to include NLO EW virtual corrections and integrated approx. real corrections

$$\overline{\mathrm{B}}_{n,\mathrm{QCD+EW_{virt}}}(\Phi_n) = \overline{\mathrm{B}}_{n,\mathrm{QCD}}(\Phi_n) + \mathrm{V}_{n,\mathrm{EW}}(\Phi_n) + \mathrm{I}_{n,\mathrm{EW}}(\Phi_n) + \mathrm{B}_{n,\mathrm{mix}}(\Phi_n)$$

exact virtual contribution

- real QED radiation can be recovered through standard tools (parton shower, YFS resummation)
- simple stand-in for proper QCD+EW matching and merging
  → validated at fixed order, found to be reliable,
  diff. $\lesssim 5\%$ for observables not driven by real radiation

Electroweak corrections in particle-level event generation

- incorporate approximate electroweak corrections in SHERPA's NLO QCD multijet merging (MEPS@NLO)
- modify MC@NLO $\overline{\mathrm{B}}$-function to include NLO EW virtual corrections and integrated approx. real corrections

$$\overline{\mathrm{B}}_{n,\mathrm{QCD+EW_{virt}}}(\Phi_n) = \overline{\mathrm{B}}_{n,\mathrm{QCD}}(\Phi_n) + \mathrm{V}_{n,\mathrm{EW}}(\Phi_n) + \mathrm{I}_{n,\mathrm{EW}}(\Phi_n) + \mathrm{B}_{n,\mathrm{mix}}(\Phi_n)$$

exact virtual contribution

approximate integrated real contribution

- real QED radiation can be recovered through standard tools (parton shower, YFS resummation)
- simple stand-in for proper QCD+EW matching and merging
  → validated at fixed order, found to be reliable,
  diff. $\lesssim 5\%$ for observables not driven by real radiation

Electroweak corrections in particle-level event generation

- incorporate approximate electroweak corrections in SHERPA's NLO QCD multijet merging (MEPS@NLO)
- modify MC@NLO $\overline{\mathrm{B}}$-function to include NLO EW virtual corrections and integrated approx. real corrections

optionally include subleading Born

$$\overline{\mathrm{B}}_{n,\mathrm{QCD+EW_{virt}}}(\Phi_n) = \overline{\mathrm{B}}_{n,\mathrm{QCD}}(\Phi_n) + \mathrm{V}_{n,\mathrm{EW}}(\Phi_n) + \mathrm{I}_{n,\mathrm{EW}}(\Phi_n) + \mathrm{B}_{n,\mathrm{mix}}(\Phi_n)$$

exact virtual contribution

approximate integrated real contribution

- real QED radiation can be recovered through standard tools (parton shower, YFS resummation)
- simple stand-in for proper QCD+EW matching and merging
  → validated at fixed order, found to be reliable,
  diff. $\lesssim 5\%$ for observables not driven by real radiation

Electroweak corrections in particle-level event generation

- incorporate approximate electroweak corrections in SHERPA's NLO QCD multijet merging (MEPS@NLO)
- modify MC@NLO $\overline{\mathrm{B}}$-function to include NLO EW virtual corrections and integrated approx. real corrections

optionally include subleading Born

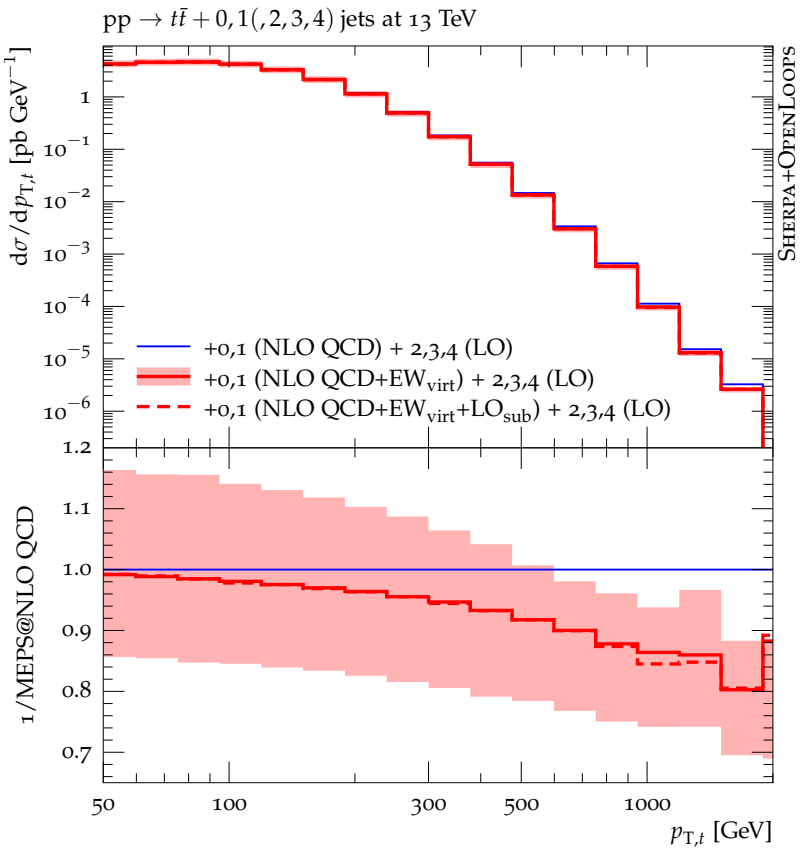
$$\overline{\mathrm{B}}_{n,\mathrm{QCD+EW_{virt}}}(\Phi_n) = \overline{\mathrm{B}}_{n,\mathrm{QCD}}(\Phi_n) + \mathrm{V}_{n,\mathrm{EW}}(\Phi_n) + \mathrm{I}_{n,\mathrm{EW}}(\Phi_n) + \mathrm{B}_{n,\mathrm{mix}}(\Phi_n)$$

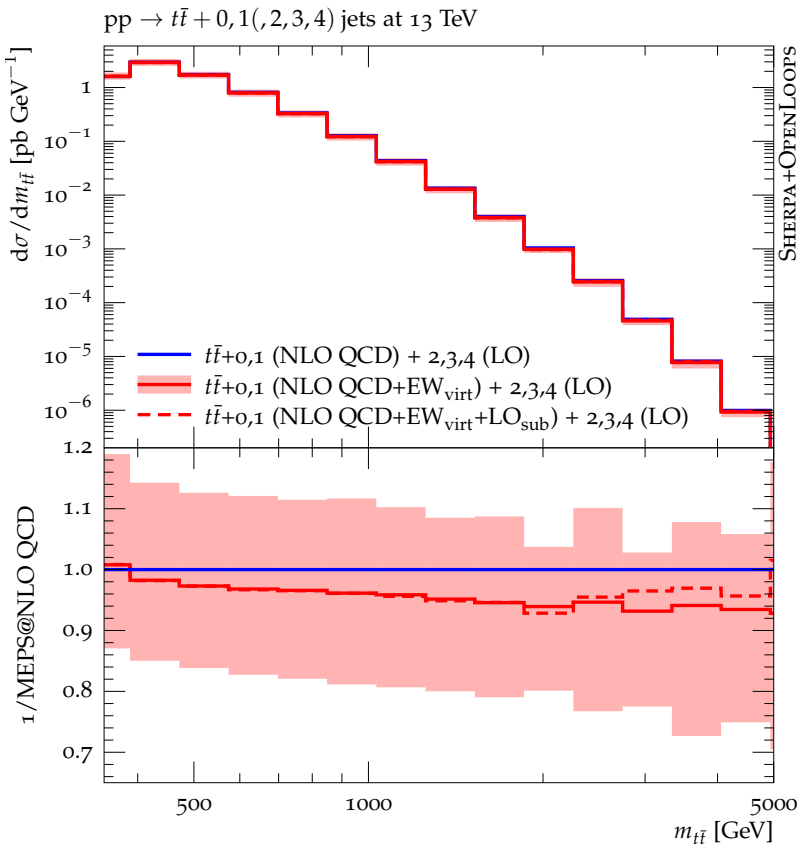
exact virtual contribution

approximate integrated real contribution

- real QED radiation can be recovered through standard tools (parton shower, YFS resummation)
- simple stand-in for proper QCD+EW matching and merging
  $\rightarrow$ validated at fixed order, found to be reliable,
  diff. $\lesssim 5\%$ for observables not driven by real radiation

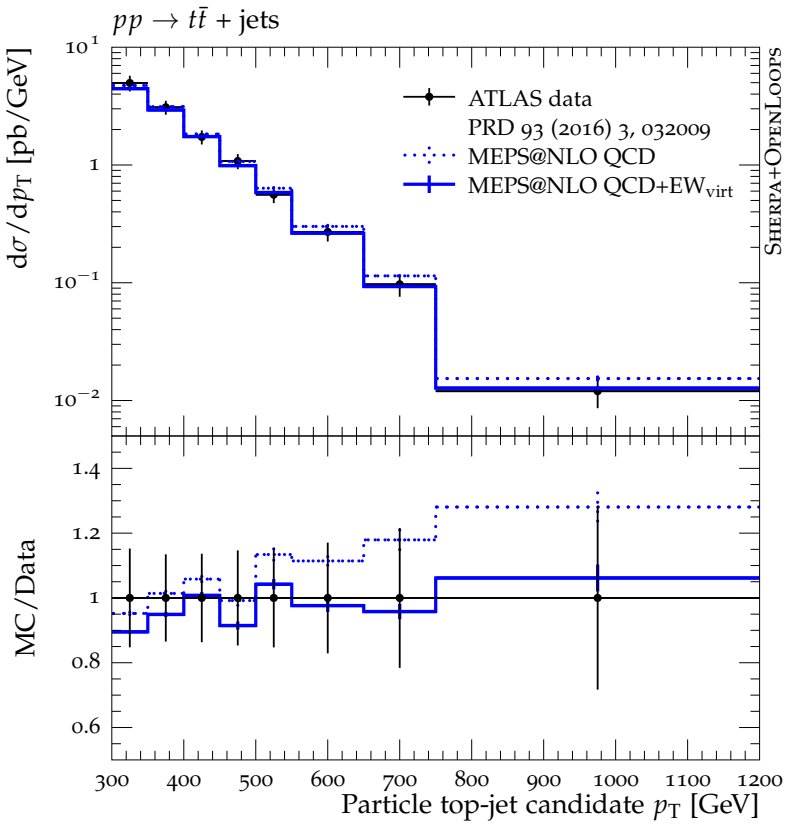
Results: $t\bar{t}$ + jets





reproduces well the corrections seen at fixed-order

Results: $t\bar{t}$ + jets at high p_T



Gütschow, Lindert, MS arXiv:1803.00950

- $pp \to t\bar{t} + 0, 1j$@NLO $+ 2, 3, 4j$@LO
- additional LO multiplicities inherit electroweak corrections through MENLOPS differential K-factor

  Höche, Krauss, MS, Siegert arXiv:1009.1127
- improved description of data

Conclusions

- $t\bar{t}$ and $t\bar{t}+j$ now known at NLO for all contributing orders $\mathcal{O}(\alpha_s^n \alpha^m)$
- inclusion of approximate EW corrections in MEPS@NLO available including important contributions from subleading orders
- improves data description for boosted top quarks already at 8 TeV
- publically available in SHERPA-2.2.5

http://sherpa.hepforge.org

Thank you for your attention!