An NLO+PS generator for top-pair and Wt* production

$$*pp \rightarrow e^+ \nu_e \mu^- \bar{\nu}_\mu b\bar{b} + X$$

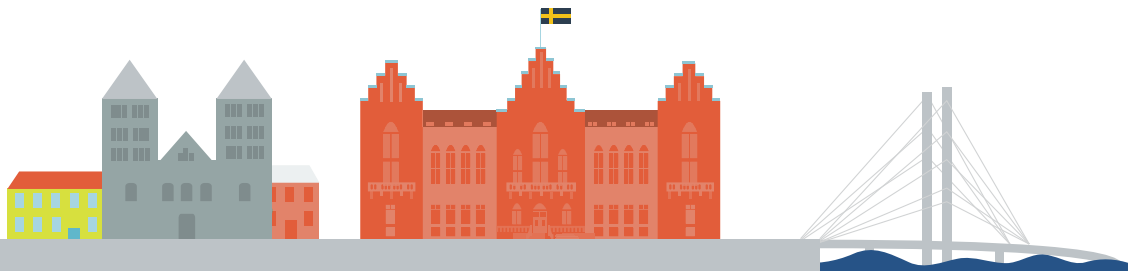**Tomáš Ježo**

Università di Milano-Bicocca
INFN, Sezione di Milano-Bicocca

In collaboration with:
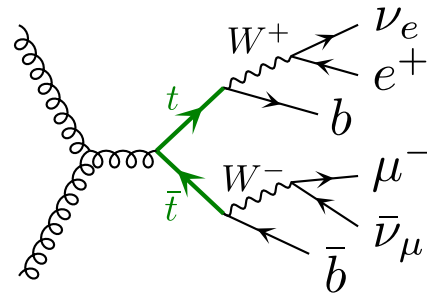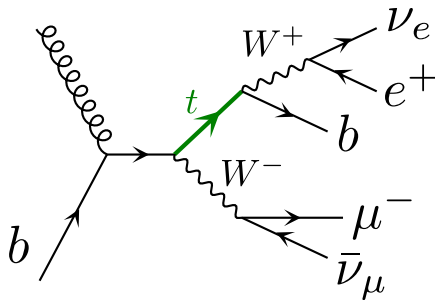*J. Lindert, P. Nason, C. Oleari and S. Pozzorini*

LHCP

14 June 2016

UNIVERSITA' DEGLI STUDI DI MILANO

BICOCCA

Introduction

▶ Production of top-pair and associated W t; top decaying leptonically

   ▷ 5F scheme, @LO

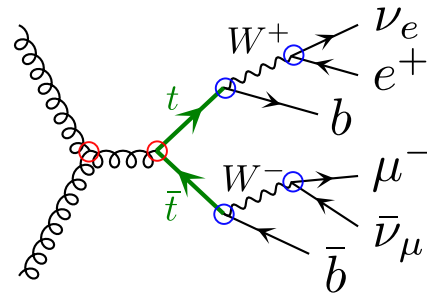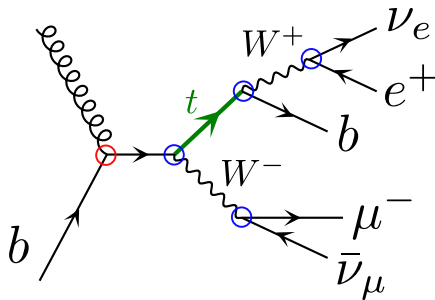
   ▷ different processes
  - ◆ different final state
  - ◆ different power of α_S

Introduction

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Introduction

- ▶ Production of top-pair and associated Wt; top decaying leptonically
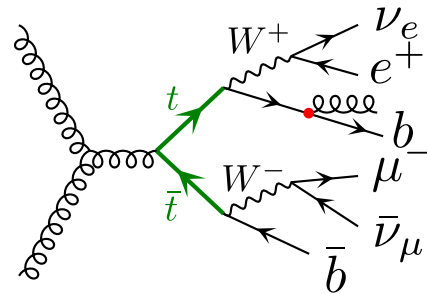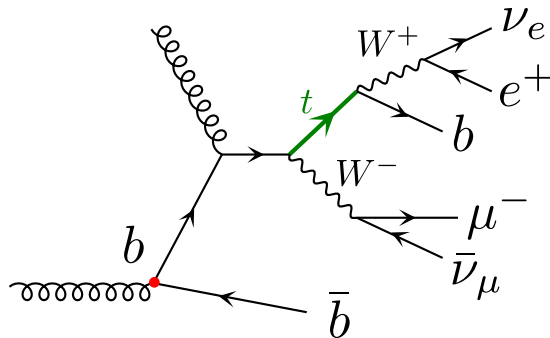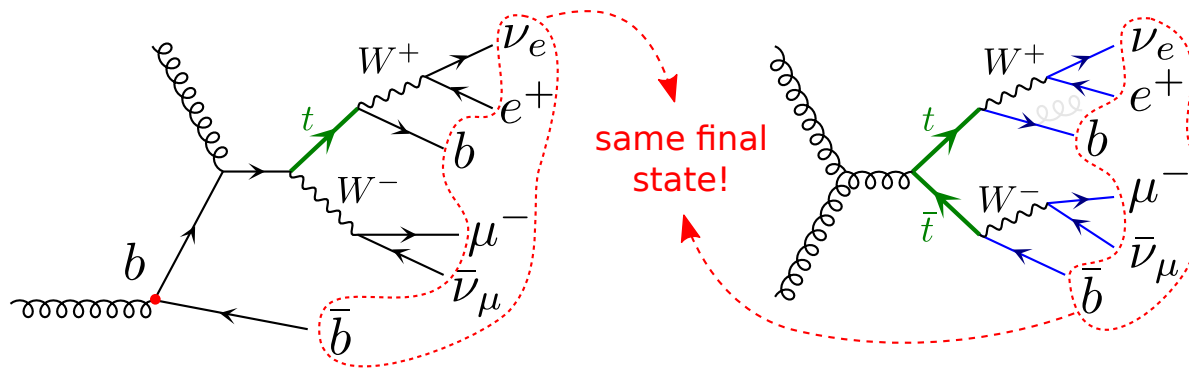
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Introduction

► Production of top-pair and associated Wt; top decaying leptonically

    ▷ 5F scheme, Wt @NLO, top-pair @LO
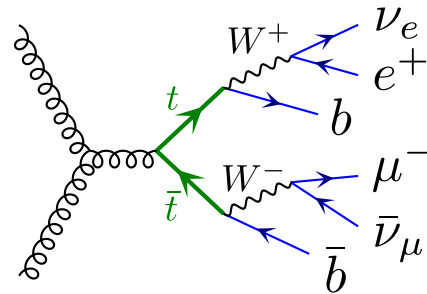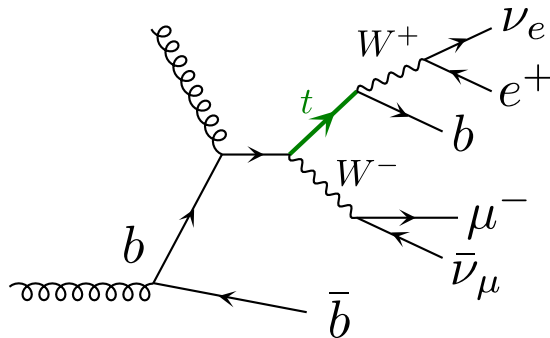

    ▷ same processes
        ◆ real correction to Wt production includes top-pair topology

Introduction

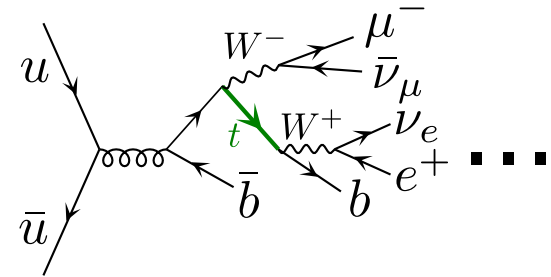▶ Production of top-pair and associated Wt; top decaying leptonically

  ▷ 4F scheme, @LO

  ▷ same processes
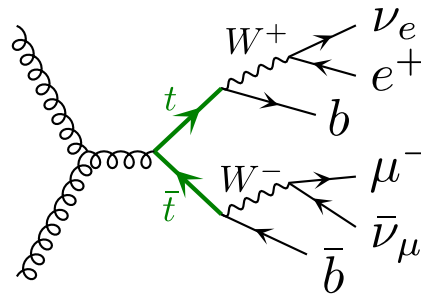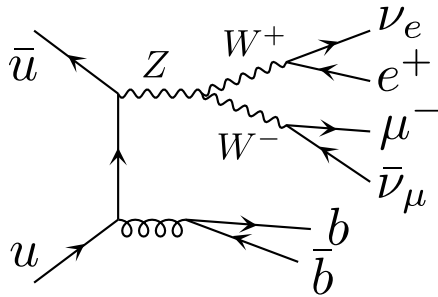   ◆ constitutes unified treatment for Wt and top-pair production

Generator details

► Process
  ▷ $pp \rightarrow e^+ \nu_e \mu^- \bar{\nu}_\mu b\bar{b}$ at NLO QCD

  ▷ Born, real and virtual matrix elements by `OpenLoops`
  ▷ 4F scheme
    ◆ Unified description of top-pair and Wt production
    ◆ Effects of b-quark mass included
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- ▶ NLO+PS generator
  - ▷ Resonance aware FKS subtraction & NLO+PS matching

NOW preserves the mass of the resonance

Generator details

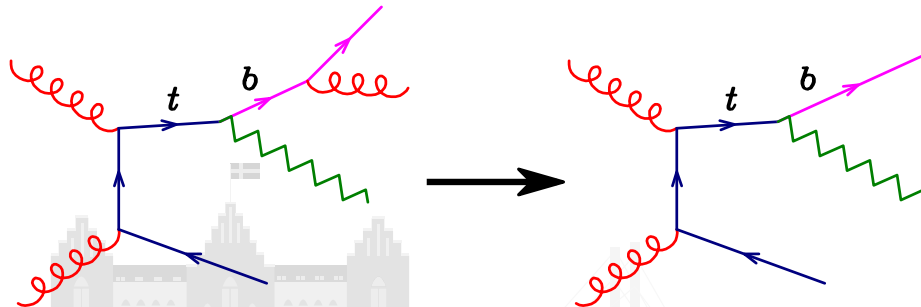- ► Process
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- ► NLO+PS generator
  - ▷ Resonance aware FKS subtraction & NLO+PS matching
  - ▷ **New version of** `POWHEG BOX`: `POWHEG BOX RES`

- ► Shower Monte Carlo
  - ▷ `Pythia8`: interface beyond LH standard required
  - ▷ `Herwig7`: work in progress
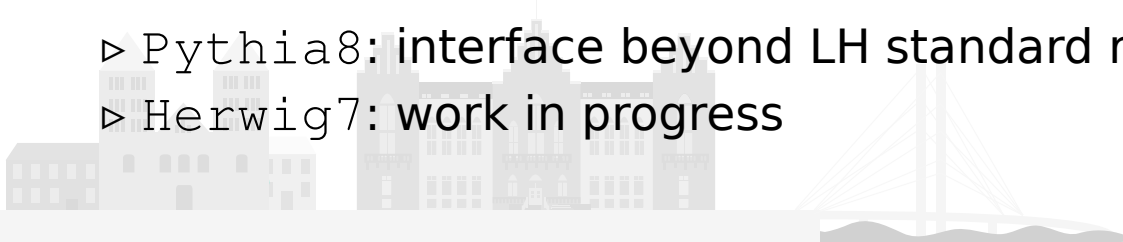
Resonance "awareness"

- **NLO**
  - ▷ Counterterm kinematics does not preserve the mass of the resonance, spoiling IR cancellation
- **NLO+PS**
  - ▷ Real and underlying Born kinematics not on-shell at the same time when calculating the Sudakov form factor, potentially distorting the shape of radiation observables
- **PS**
  - ▷ Information about the resonance structure of the event not passed on to PS (not available), leading to the mass of the resonance not being preserved when reshuffling momenta

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Can we require that the mass of the resonances is preserved?
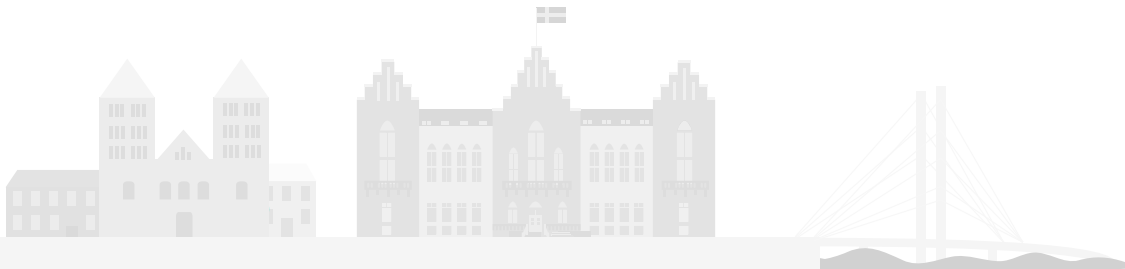
Resonance "awareness"

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- **NLO+PS**
  - ▷ Trivial once the integration is separated (see above)
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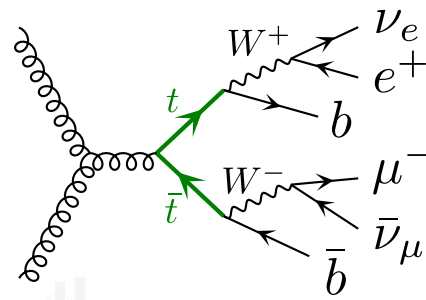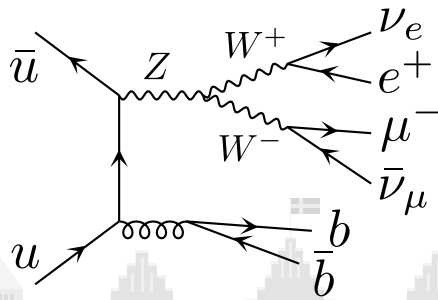- **NLO+PS**
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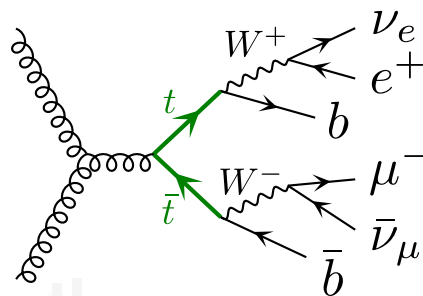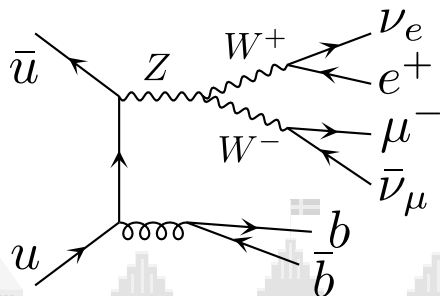- **NLO+PS**
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- Alternative solution in

  [Frederix, Frixione, Papanastasiou, Prestel, Torrielli 2016]

Results

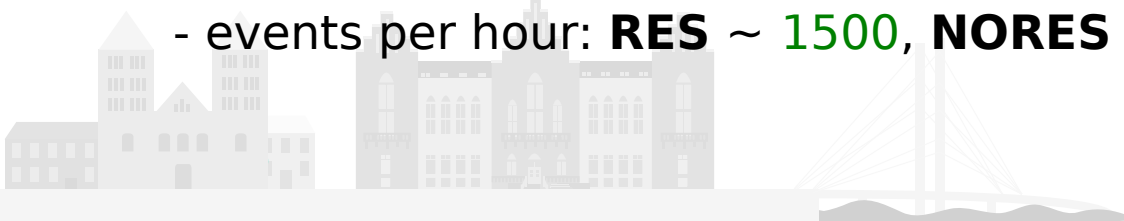▶ Study efficiency improvement with resonance treatment

  ▷ NLO:
- stage 1: `ncalls=80k, itmx=2`
- stage 2: `ncalls=100k, itmx=4`
- ncores: `64`
- xsec rel. accuracy: **RES** = 0.11%, **NORES** = 0.79%/0.29%

  ▷ efficiency of generation of radiation:
- vetos per event: **RES** ~ 750, **NORES** ~ 15 000
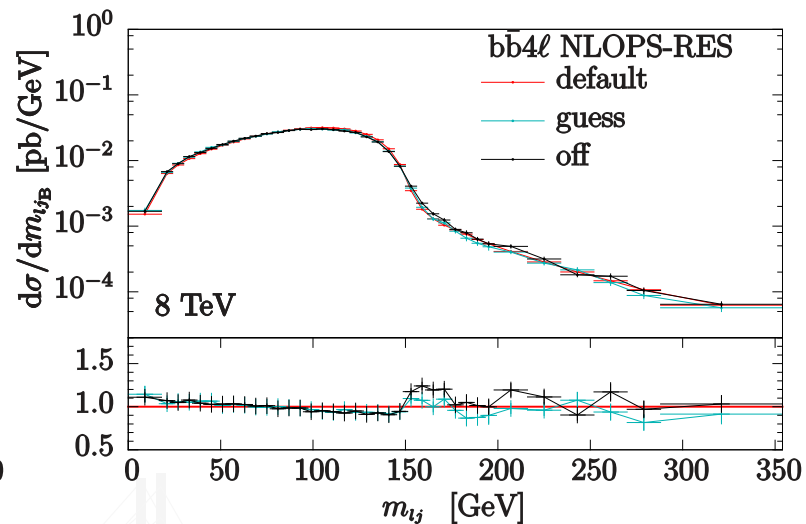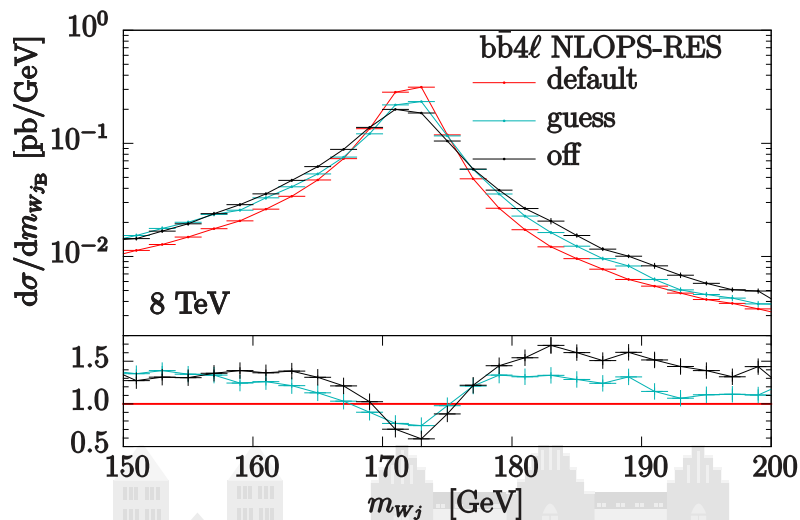
  ▷ speed of event generation:
- events per hour: **RES** ~ 1500, **NORES** ~ 200

Results

► Study impact of the resonance treatment:

  ▷ default: resonant treatment on, hardest emission from resonance & hardest emission from the production
  ▷ guess: resonant treatment off, resonance structure "guessed"
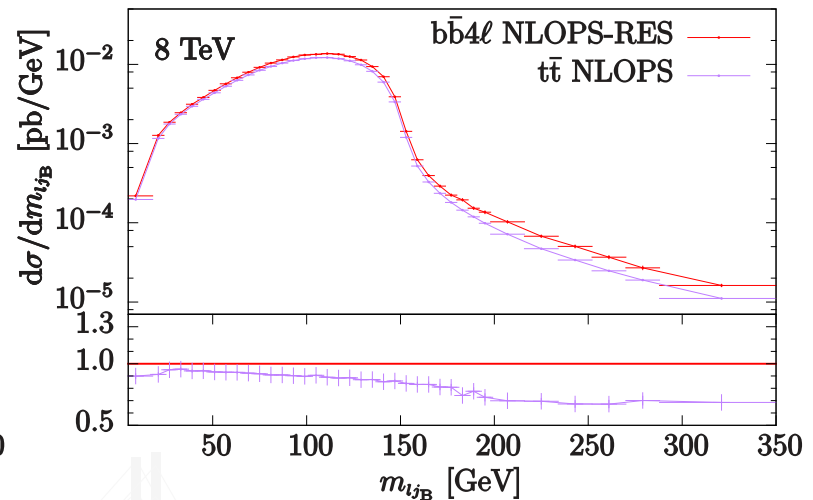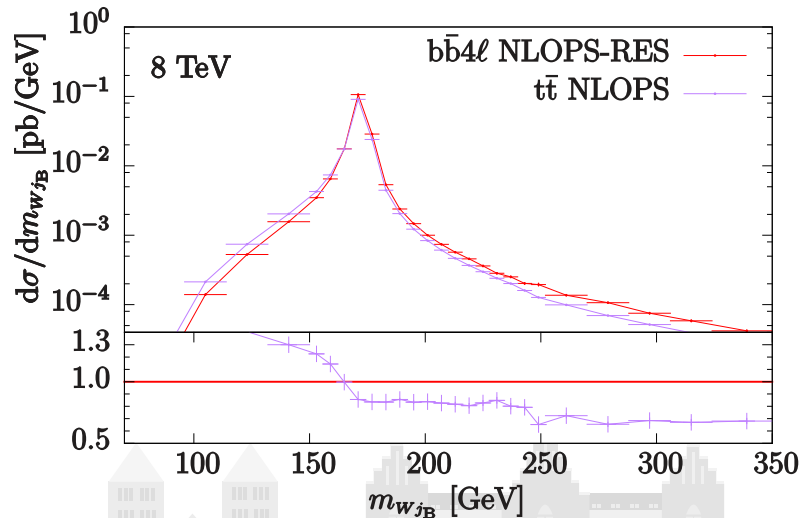 ▷ off: resonant treatment off

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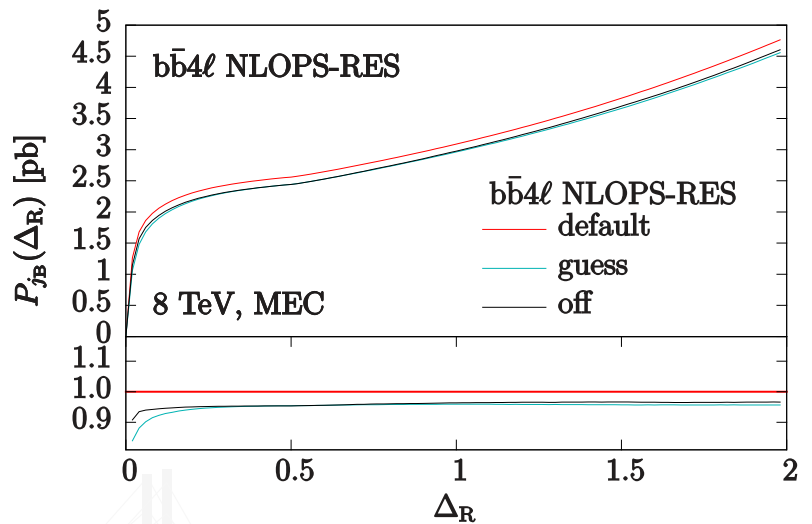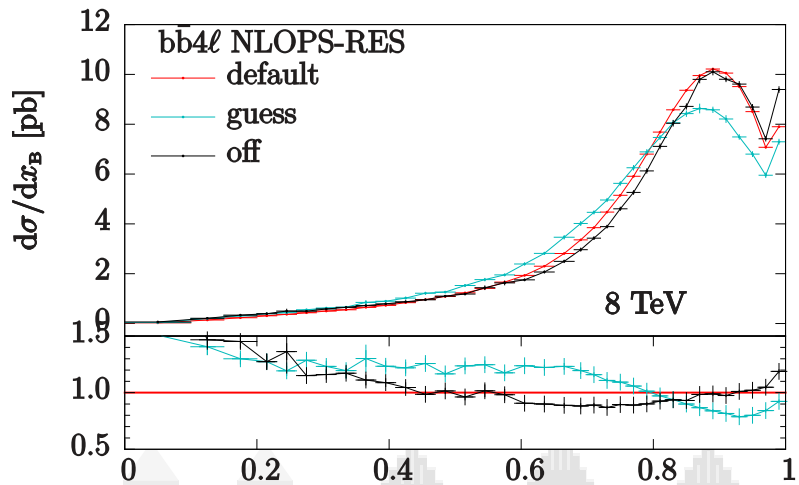
Results

► Compare against older generators:
  ▷ $b\bar{b}4\ell$: resonant treatment on, hardest emission from resonance & hardest emission from the production
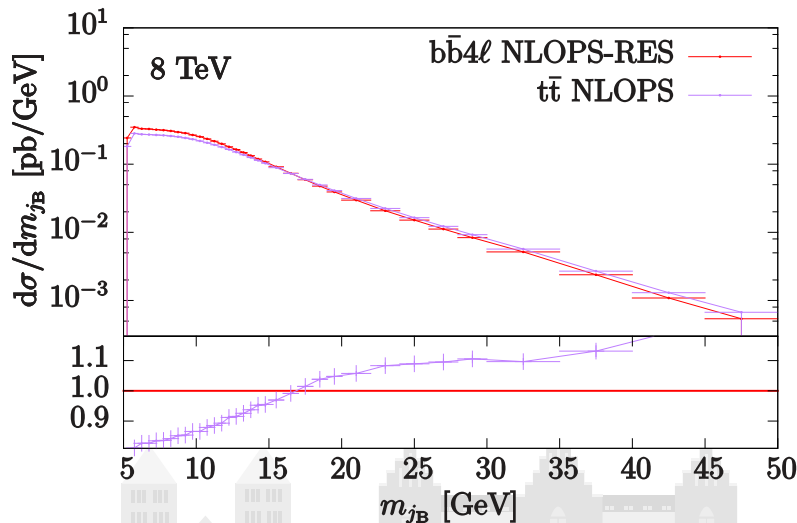 ▷ $t\bar{t}$: `hvq`, top-pair production at NLO, top decay at LO

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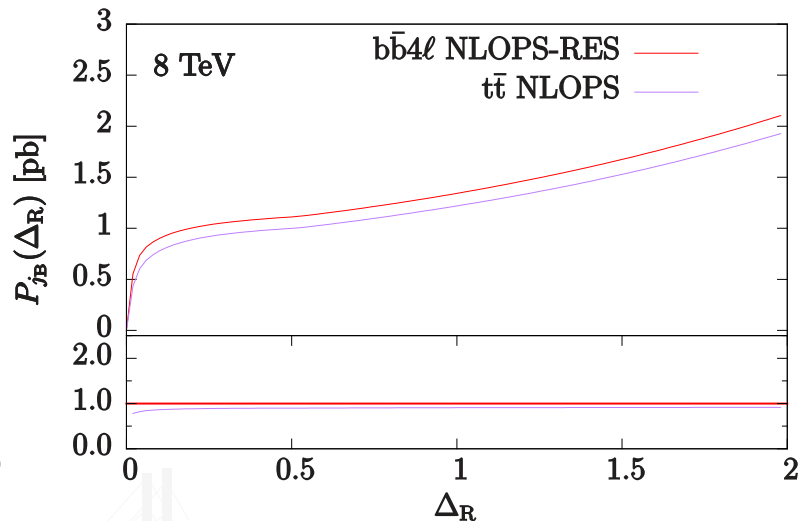
Results

▶ Investigate cross section as a function of $p_{\mathrm{T,jet}}^{\mathrm{thr}}$ in exclusive jet bins *njn*b with *n*={0,1,2} (we require eactly *n* b-tagged jets)
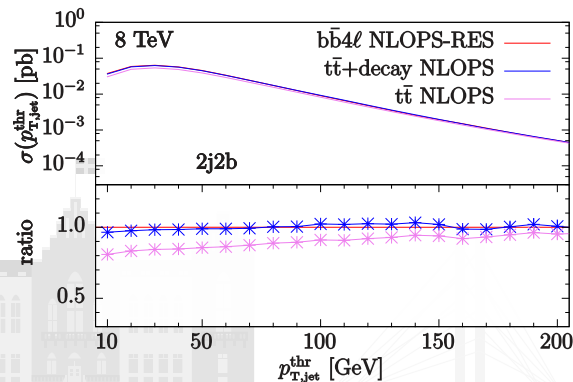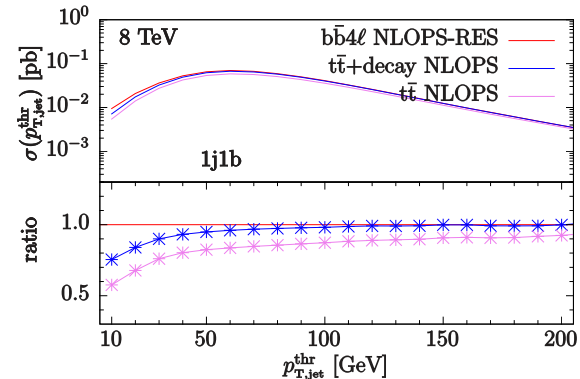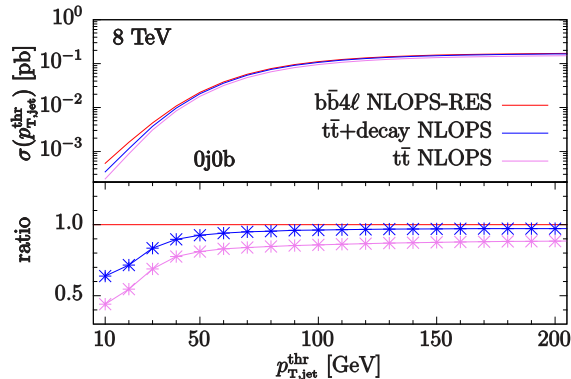
Summary

- ▶ We implement
  - ▷ $pp \rightarrow e^+ \nu_e \mu^- \bar{\nu}_\mu b \bar{b}$ at NLO QCD
  - ▷ Born, real and virtual matrix elements by `OpenLoops`
  - ▷ 4F scheme
    - ◆ Unified description of top-pair and Wt production
    - ◆ Effects of b-quark mass included
    - ◆ Phase space with unresolved b-quarks accessible
- ▶ In `POWHEG BOX RES:` resonance aware NLO+PS generator
- ▶ Code available upon request

- ▶ First results
  - ▷ Impact of the resonance treatment on radiation observables very important
  - ▷ Considerable efficiency gain when resonance treatment switched on