MadWeight 5

MEM with ISR correction

Olivier Mattelaer
University of Illinois at Urbana Champaign

P. Artoisenet, V. Lemaitre, F. Maltoni, OM: JHEP1012:068
P.Artoisent, OM: In preparation
J.Alwall, A. Freytas, OM: PRD83:074010

Outline

- MadWeight5
  - ➡ Basic idea of the phase space integration
  - ➡ Improvement/ new features of MadWeight5
- MEM with ISR correction
  - ➡ Motivation
  - ➡ Method
  - ➡ Higgs mass measurement

Text

MADWEIGHT 5

Text

Matrix Element Re-weighting

How to evaluate those weights?

$$\mathcal{P}(\boldsymbol{p}^{vis}|\alpha) = \frac{1}{\sigma_\alpha} \int d\Phi dx_1 dx_2 |M_\alpha(\boldsymbol{p})|^2 W(\boldsymbol{p}, \boldsymbol{p}^{vis})$$

Text

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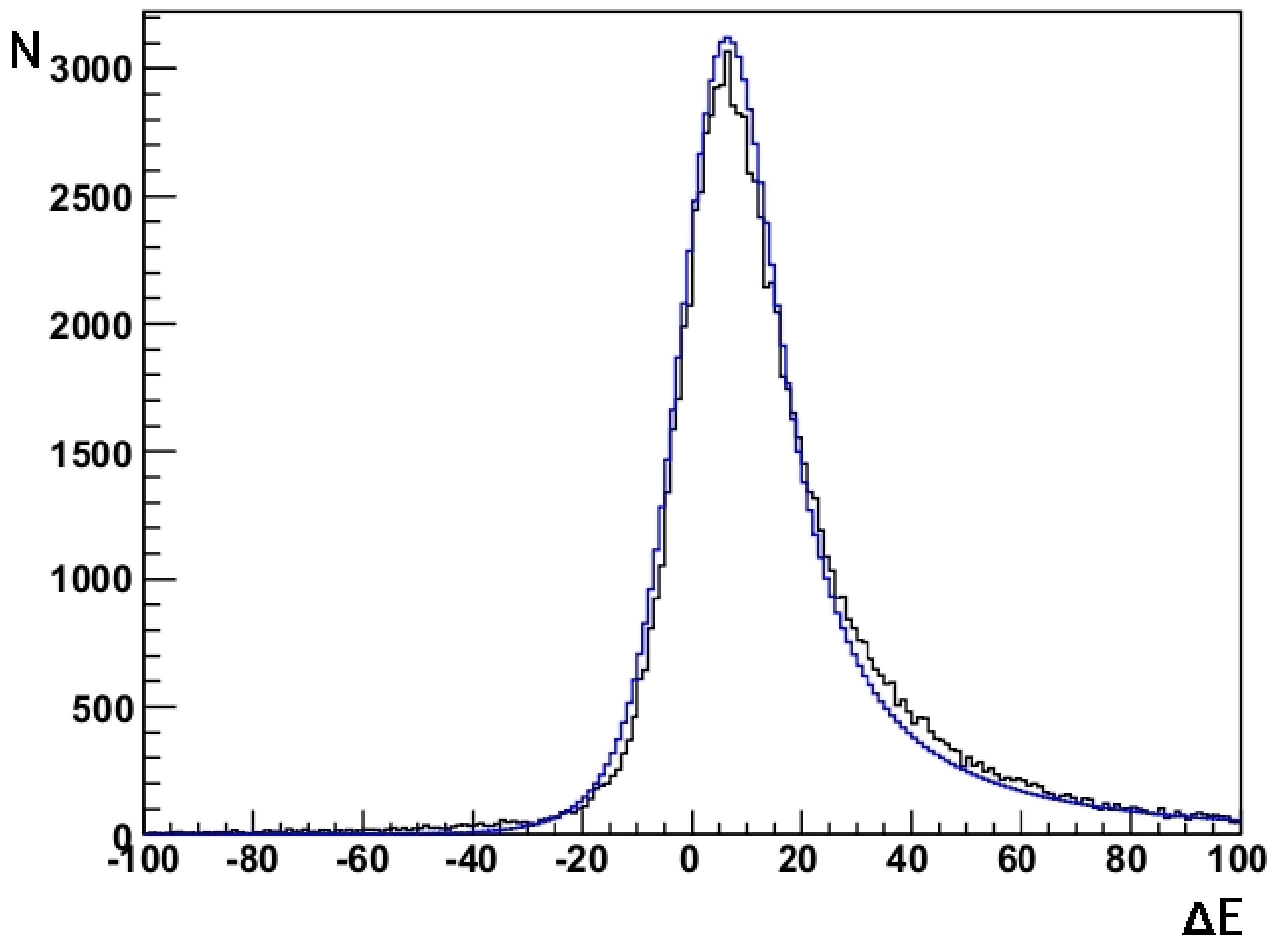

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Text

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- Need a specific integrator: MadWeight

Text

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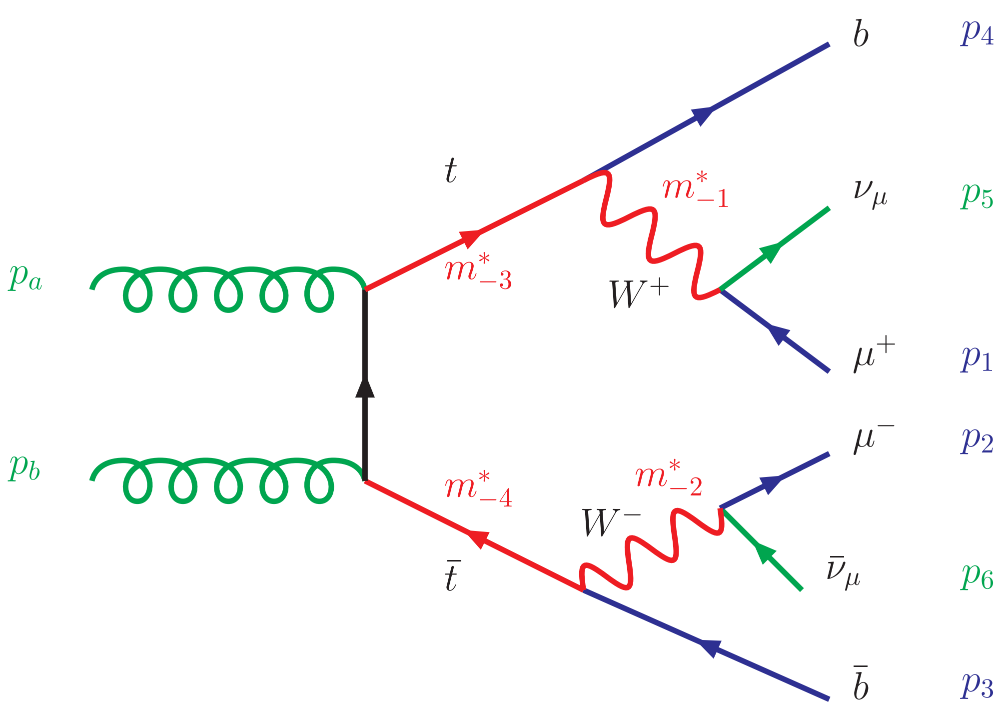
- Use of matrix-element generator: MadGraph 5
- Need a specific integrator: MadWeight 5

Text

MADWEIGHT

- First Example: di-leptonic top quark pair



- degrees of freedom 16
  - 2: pdf
  - 3 x 6: final states
  - -4: energy-momentum conservation
- peaks 16
  - 4: Breit-Wigner
  - 3 x 4: visible particles

Text

MADWEIGHT

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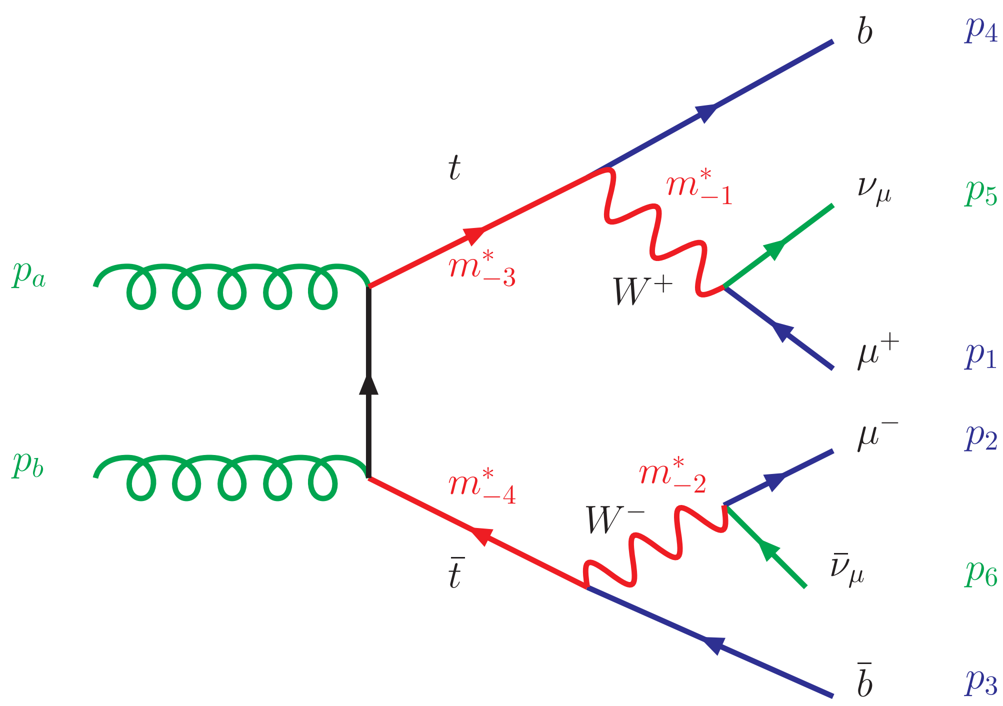

- degrees of freedom 16
- peaks 16

→ All peaks aligned

Text

MADWEIGHT

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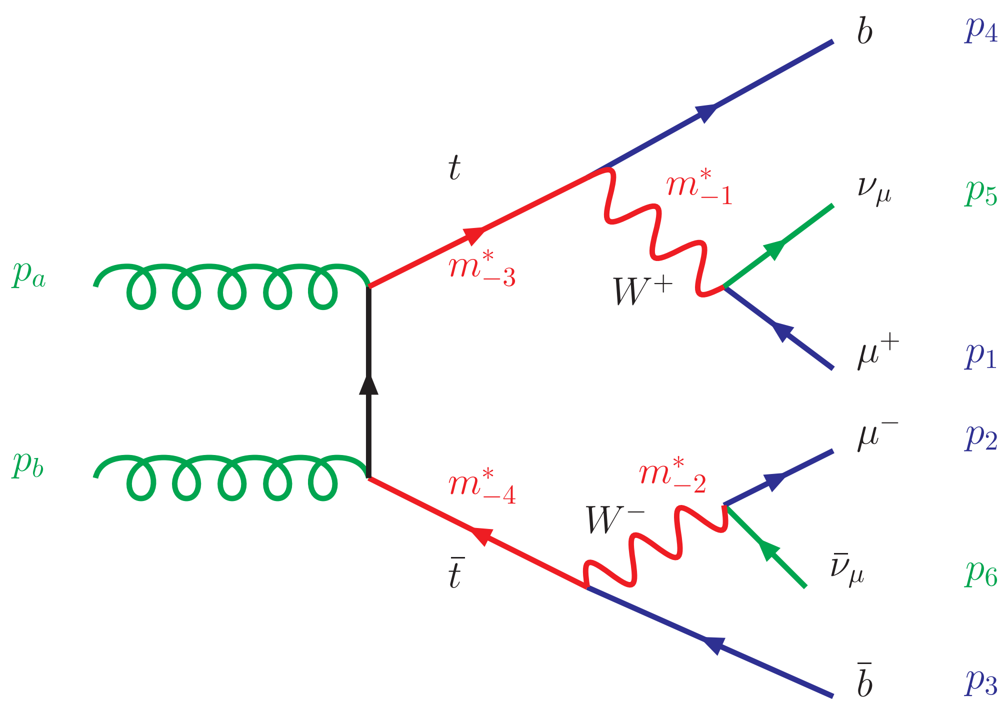

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→ All peaks aligned

$$d\phi = \prod_{i=1}^{4} \frac{d^3 p_i}{(2\pi)^3 2E_i} \prod_{i=5}^{6} \frac{d^3 p_i}{(2\pi)^3 2E_i} dx_1 dx_2 \delta^4 \left(p_a + p_b - \sum_j p_j \right)$$

Text

MADWEIGHT

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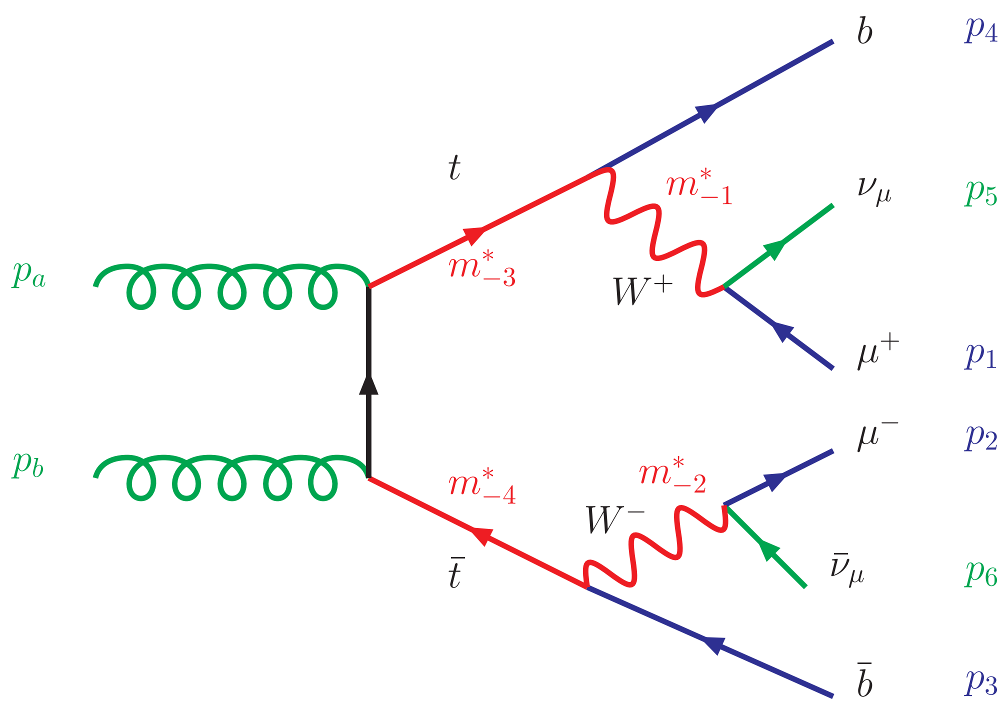

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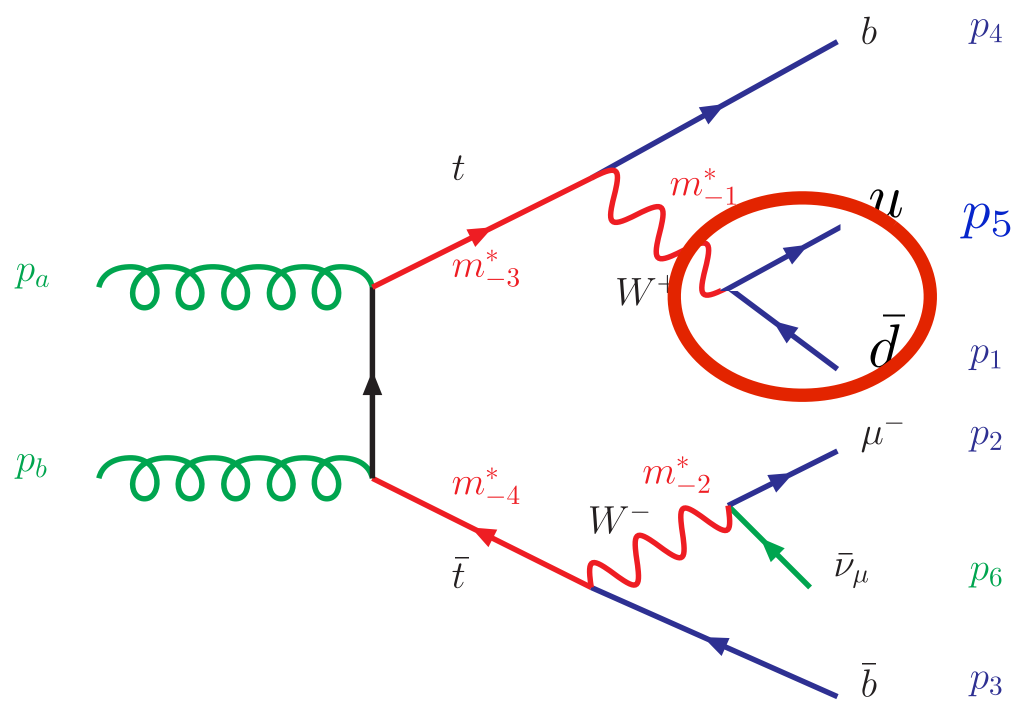
Pass to →

$$d\phi = \prod_{i=1}^{4} d\theta_i d\phi_i d|\boldsymbol{p}_i| \prod_{j=1}^{4} dm^{*2}_{-j} \times J$$

Text

MADWEIGHT

- Second Example: semi-leptonic top quark pair

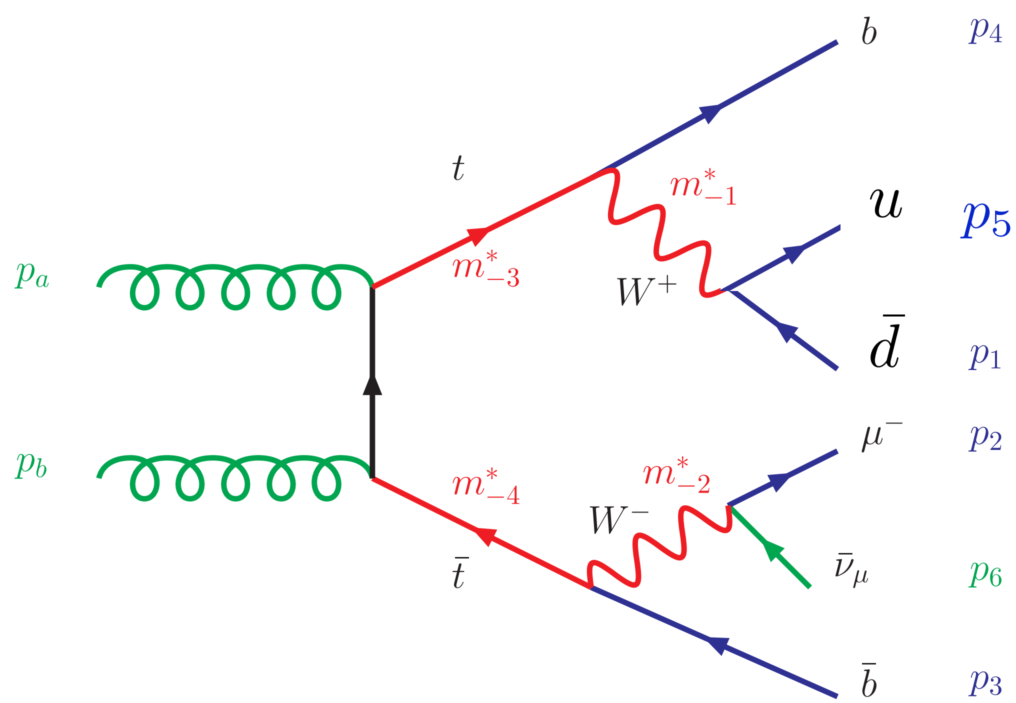


- degrees of freedom 16
- peaks 19

Text

MADWEIGHT

- Second Example: semi-leptonic top quark pair



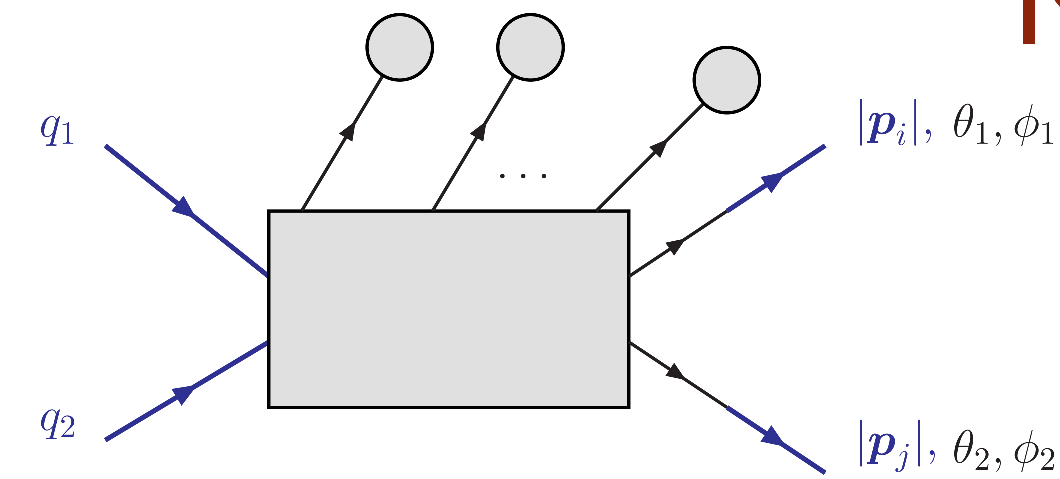
- degrees of freedom 16
- peaks 19

→ 3 peaks unaligned

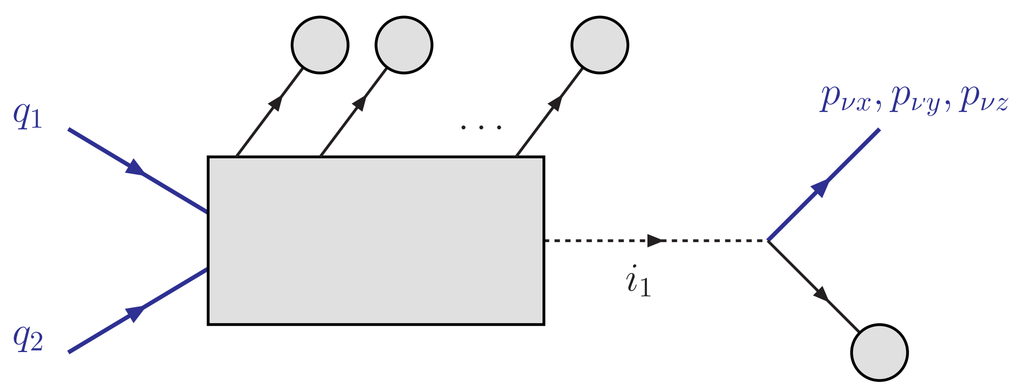
→ Multi-channel

Text

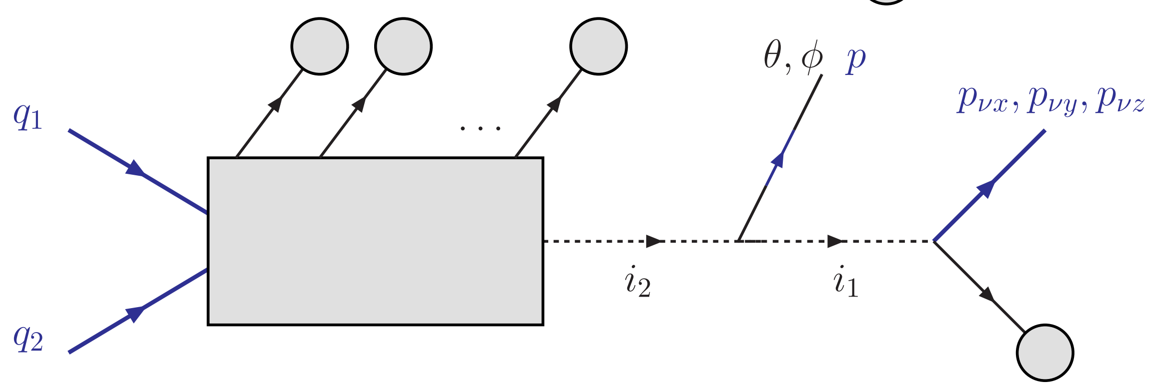
MadWeight



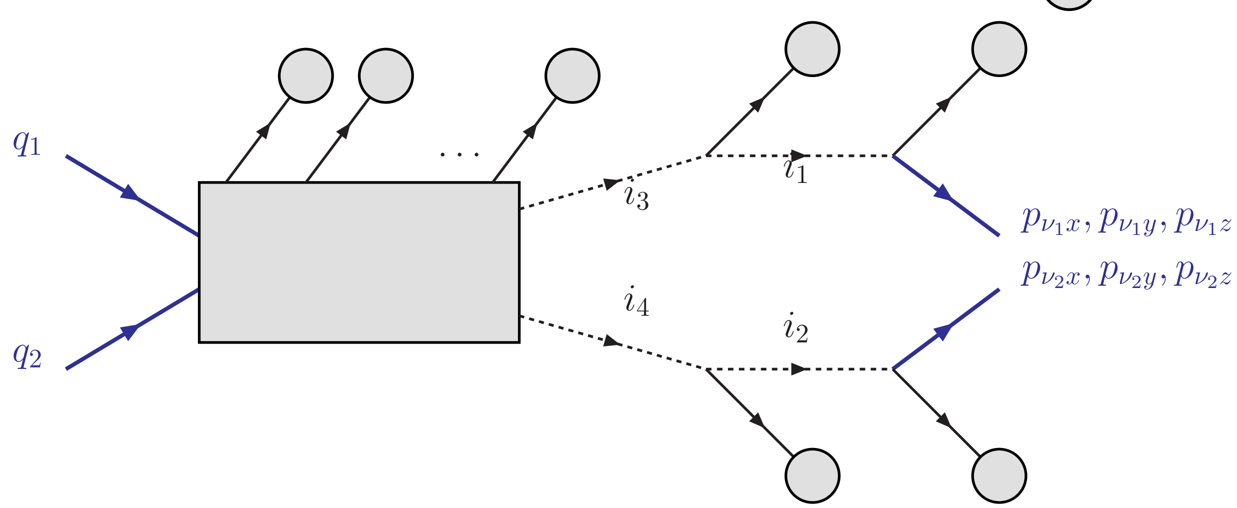
fully hadronic / leptonic process



W production

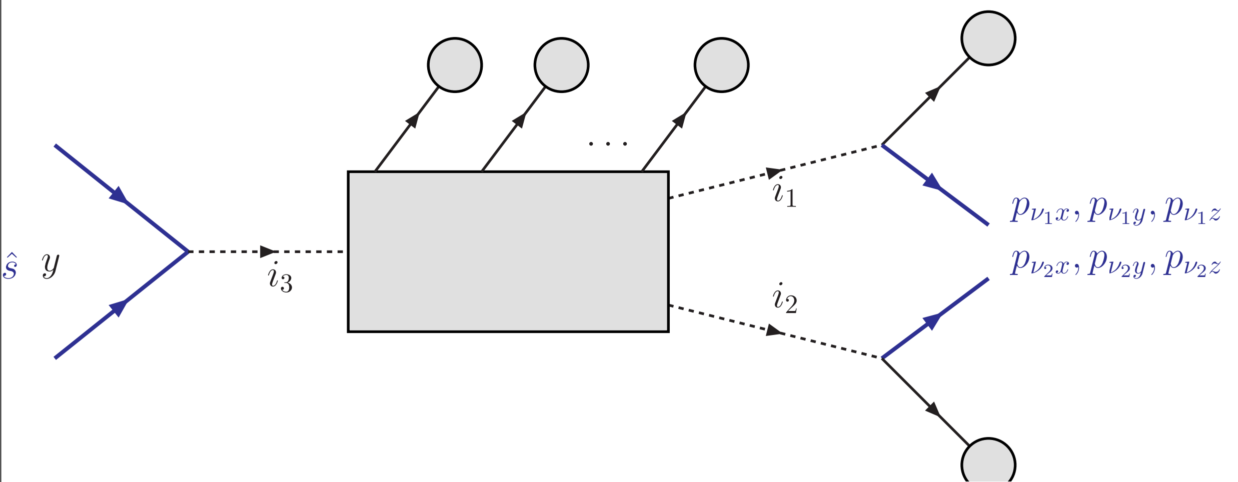


semi-leptonic top quark pair

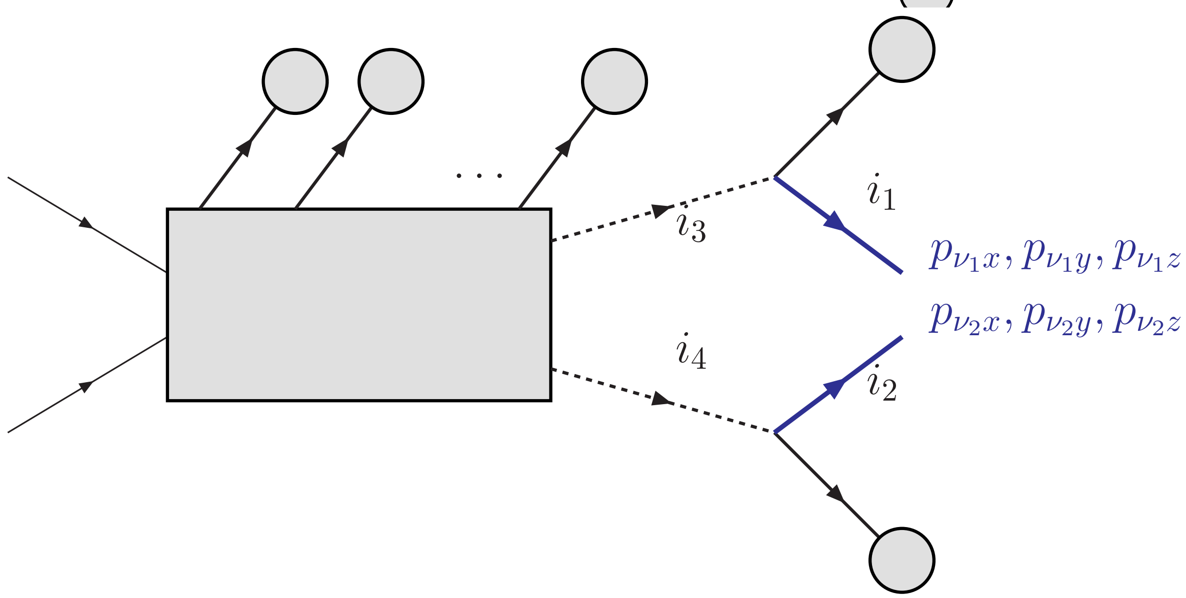


Fully leptonic top quark pair

MadWeight



Higss production decaying in W



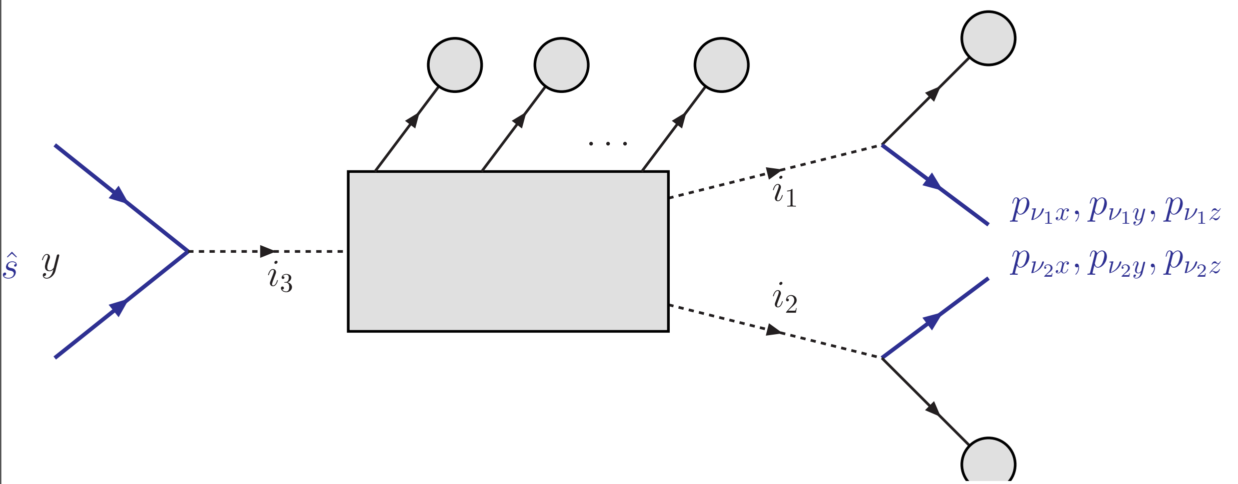
Class F

W+ W- production

Text

Wednesday, May 29, 13

MadWeight



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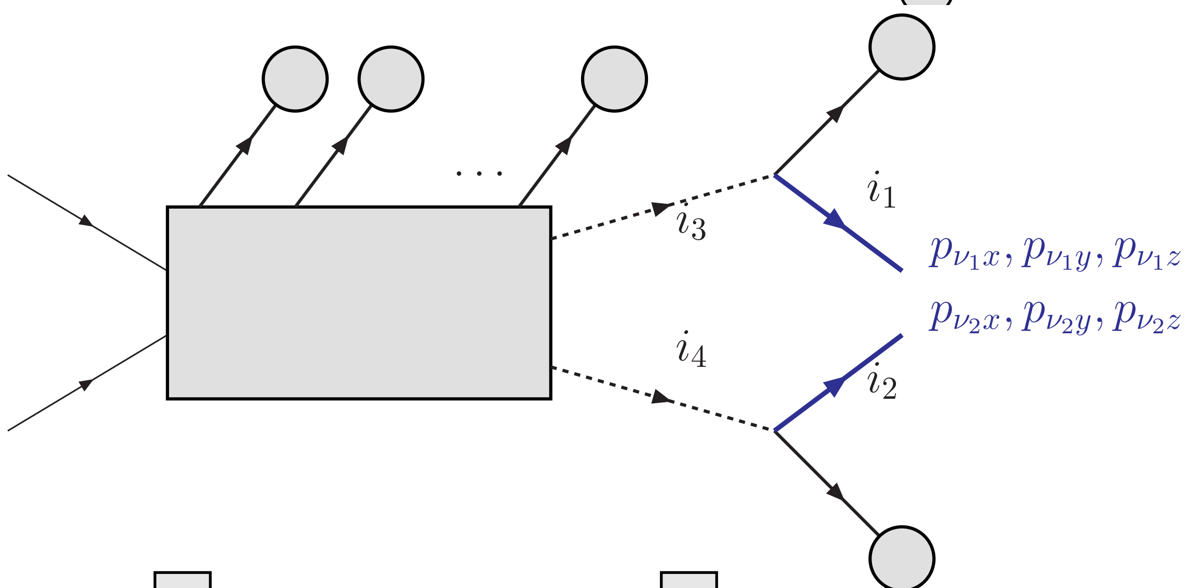
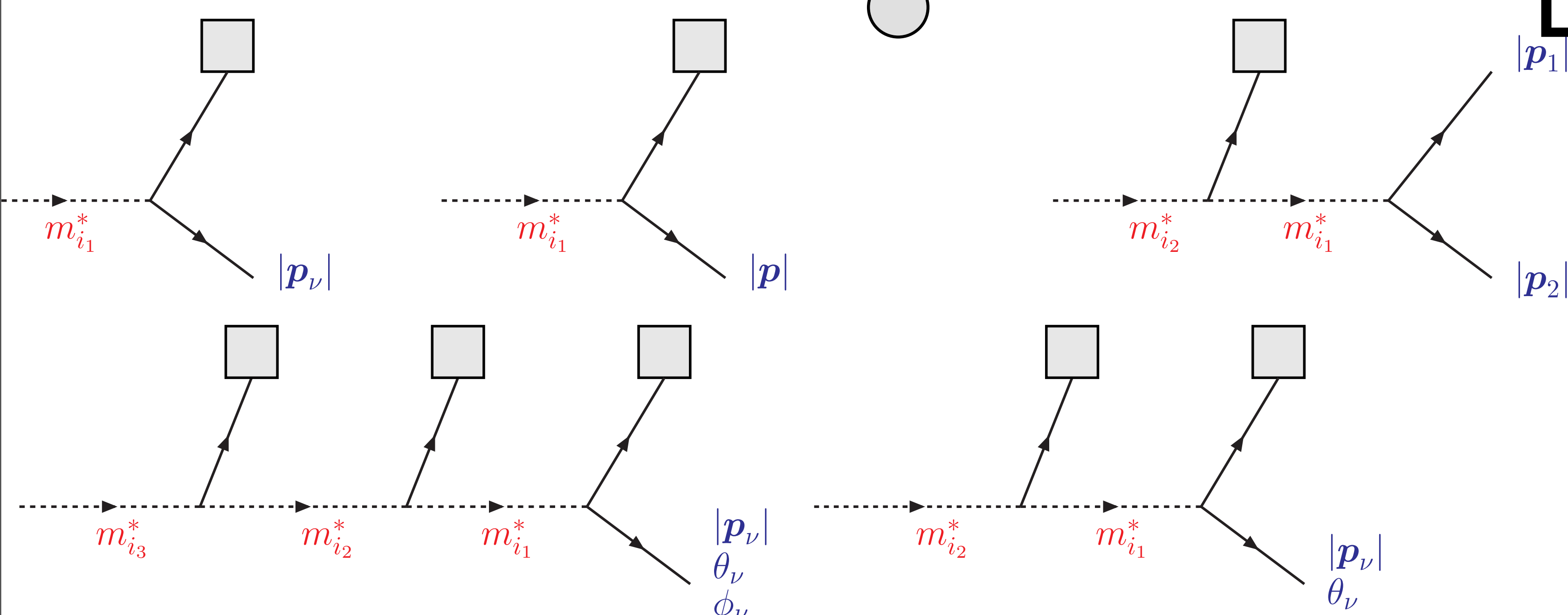


W+ W- production



Lot of possibility to have more complex process

+1 W

+1 Z

+ ...

```
##************************************************************************##
##                              TF JET                                    ##
##************************************************************************##
<block name='jet'>   #name can be anything
<info> doubel gaussian with parameter depending of the energy </info>
<particles> u,d,s,c,b,g </particles>
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<width_type> large </width_type>
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MadWeight5 Improvement

- Use MG5 idea of Subprocess merging

MW4 SubProcesses

- g g > t t~
- u u~ > t t~
- u~ u > t t~
- d d~ > t t~
- d~ d > t t~

MW5 SubProcesses

- p p > t t~

5 Integrals to perform

Text

1 Integral to perform

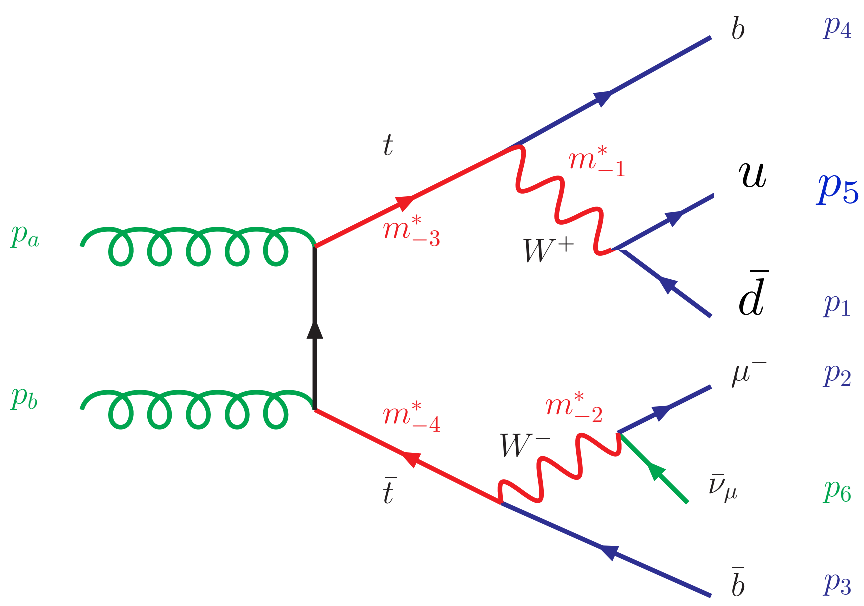
MadWeight5 Improvement

- Narrow width approximation
  - ➡ Reduce the dimension of the Phase-Space
  - ➡ Be careful:
    - ✦ The matrix-element AND the transfer function should be flat enough.
    - ✦ This reduces the discrimination power.
  - ➡ In MW5, all particles with a width lower than a given value will be integrated in this approximation.
    - ✦ default value: 0.1
    - ✦ So by default only for the Higgs

Text

MadWeight5 Improvement

- Treatment of permutations



0		12	3587							
1	1	0.935	5.230	83.80	0.00	1.0	0.0	0.00	0.0	0.0
2	4	-0.161	1.878	85.60	9.66	7.0	0.0	1.10	0.0	0.0
3	4	-0.223	5.295	45.64	5.43	3.0	0.0	0.30	0.0	0.0
4	4	0.695	2.208	37.99	7.68	8.0	0.0	3.63	0.0	0.0
5	4	1.164	3.357	49.01	6.95	13.0	0.0	2.66	0.0	0.0
6	6	0.000	6.035	39.48	0.00	0.0	0.0	0.00	0.0	0.0

MW4: one integral per permutation
MW5: Monte-Carlo over the permutation

process	tf	permutation	Sum/MonteCarlo
tt semi leptonic	delta	24	7.5
tt semi leptonic	gauss	24	2
tt di leptonic	gauss	2	0.6
w+ j j	delta	2	1.5
tth (semi lept)	gauss	720	20

MadWeight5 Improvement

- Better choices of PS parameterization
- Pre-defined grid for the transfer functions
- Smarter refine function between channel of integration
- New interface (scriptable edition of the cards)
- New cluster support
  - ➡ Creation of the directory on the flight
  - ➡ Submission by packet / support of multicore
- New output format (xml)
- Full support of BSM physics (via UFO/ALOHA)
- ISR support

Text

Speed Benchmark Comparison

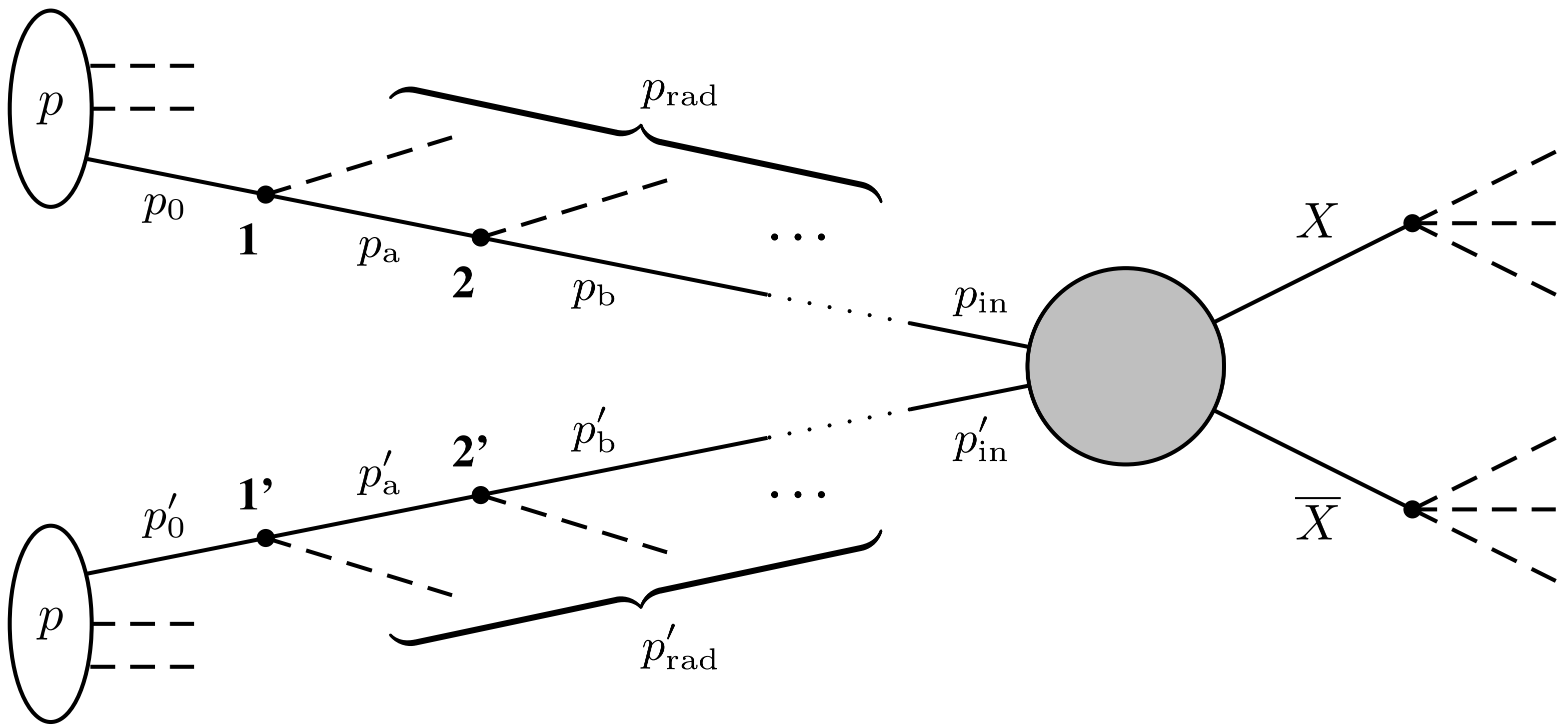
process	perm	MW4	MW5
tt semi lept	24	1h16	71s
tt fully lept	2	46s	14s
tth semi lept	720	> 2 days	43min
tth semi lept	48	> 3h	11min
tth fully lept	24	>1h	1min
h> w+ w- > 1lept	2	59s	<5s
h> w+ w- > 2lept	1	8s	<5s
z b b	24	39m	18s
zh	24	43m	<5s

running on 1core of a Intel core i7 2.3Ghz

MEM with radiation

Text

MEM with radiation



- Those radiations are important
  - ➡ ttj is 50% at LHC
  - ➡ The topics pop outs in talks a couple of times
- 3 Main idea (both were mention yesterday)
  - ➡ Transfer boost
  - ➡ MLM
  - ➡ NLO

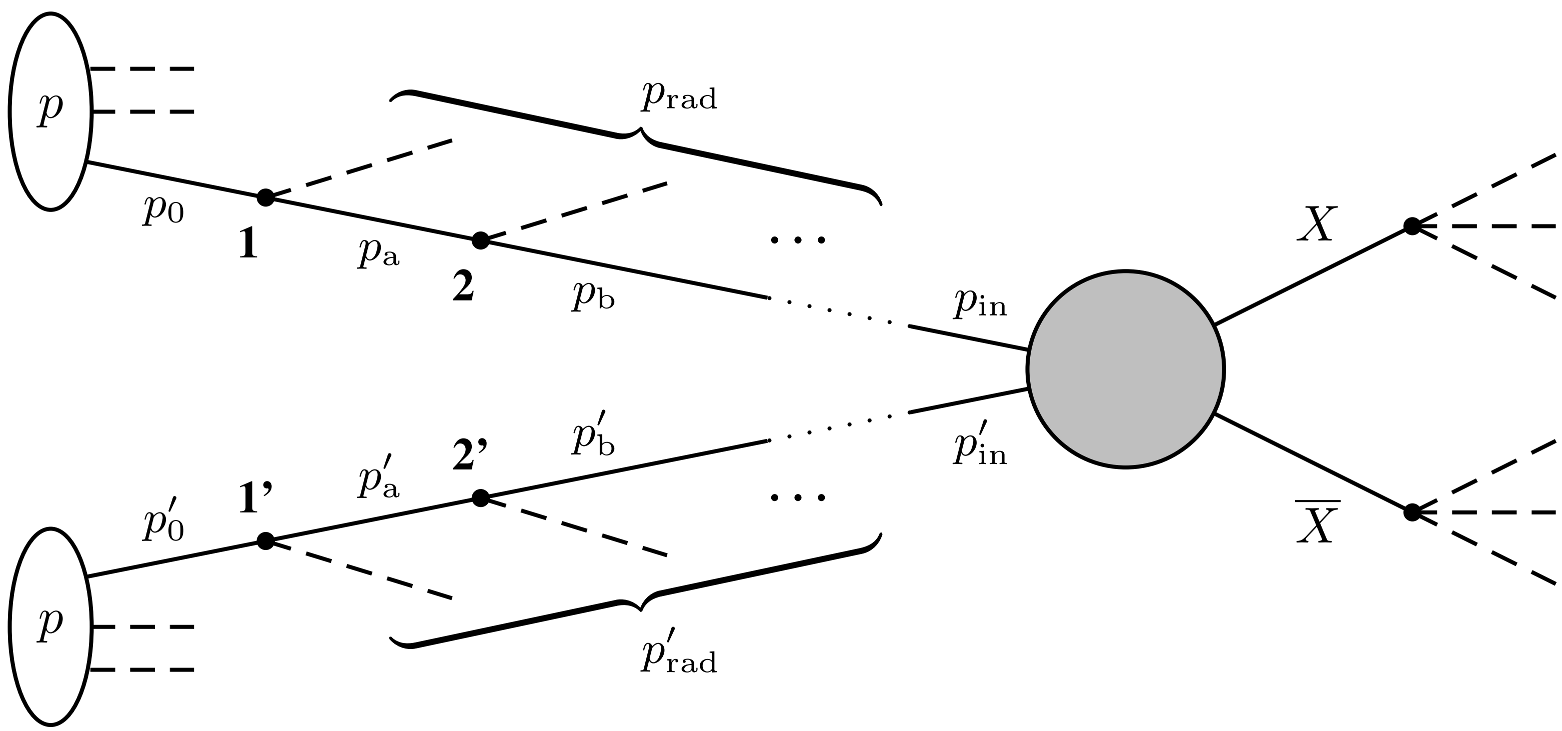
Text

My point of view

- MLM
  - ➡ Having one more jets at the matrix element level is roughly 10 times slower.
    - number of permutations (assignment jet-parton)
    - complexity of the integrand
    - dimension of the phase-space
  - ➡ The radiation problem still occurs (at least for the inclusive sample)
- NLO
  - ➡ Speed of the virtual
  - ➡ Only valid for one additional jet

Text

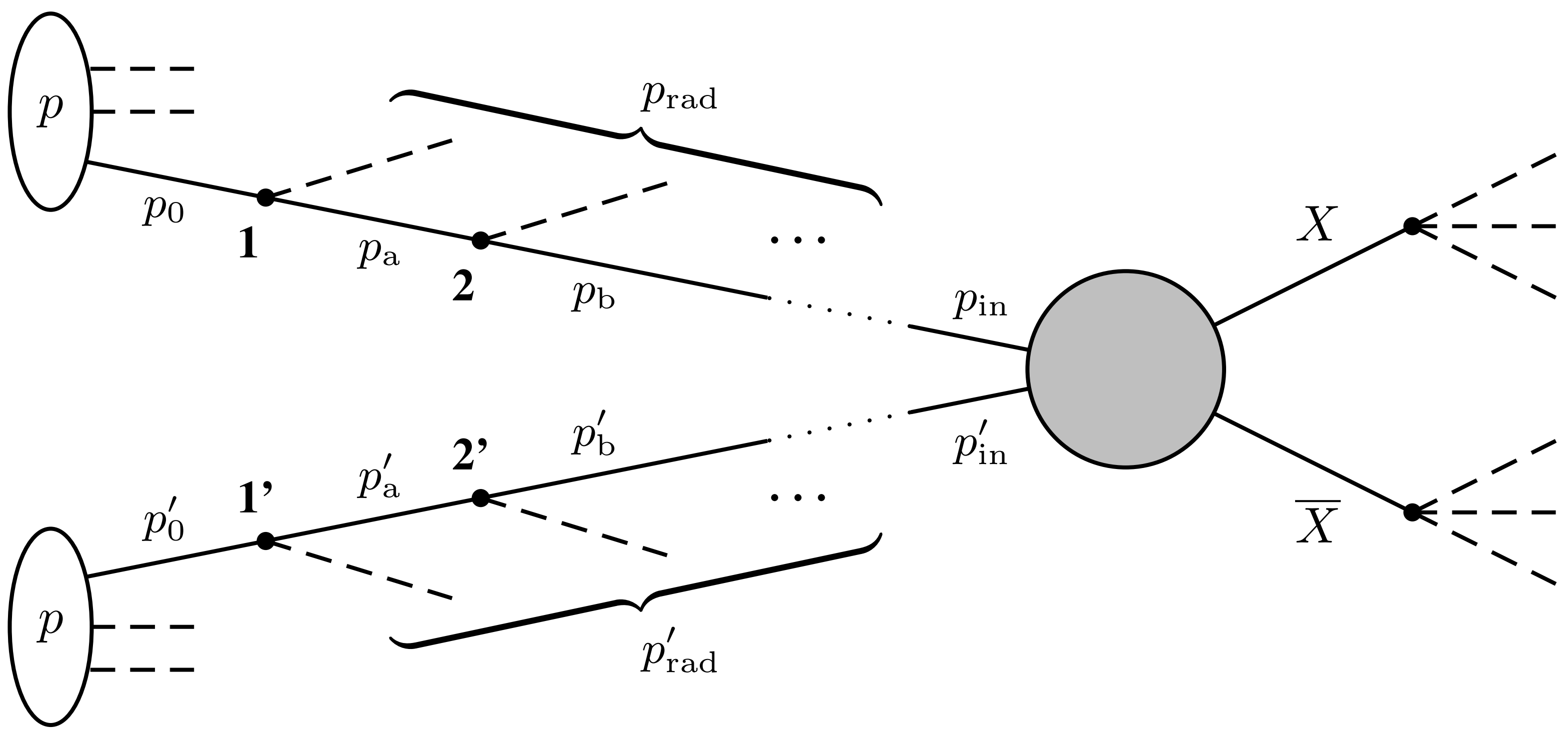
Radiations



- ISR
  - ➡ Main Effect is to induce a transverse boost.
  - ➡ Different PDF
- FSR
  - ➡ Need to be parameterize in the TF
  - ➡ Having a one parton evolving in two jets TF
  - ➡ Reasonable with MC over permutation

Text

Radiations



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  - ➡ Different PDF

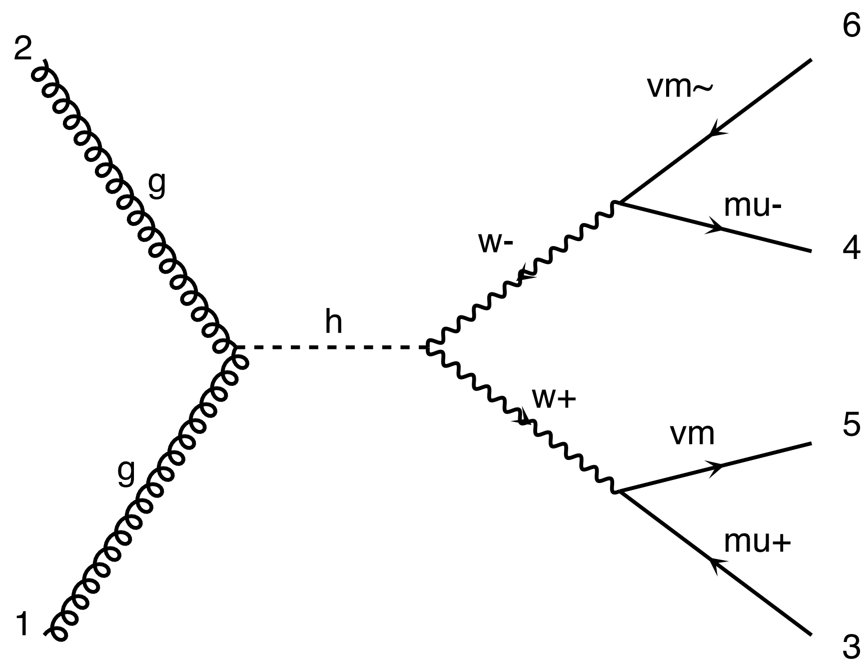
Here I will focus on ISR

Text

- FSR
  - ➡ Need to be parameterize in the TF
  - ➡ Having a one parton evolving in two jets TF
  - ➡ Reasonable with MC over permutation

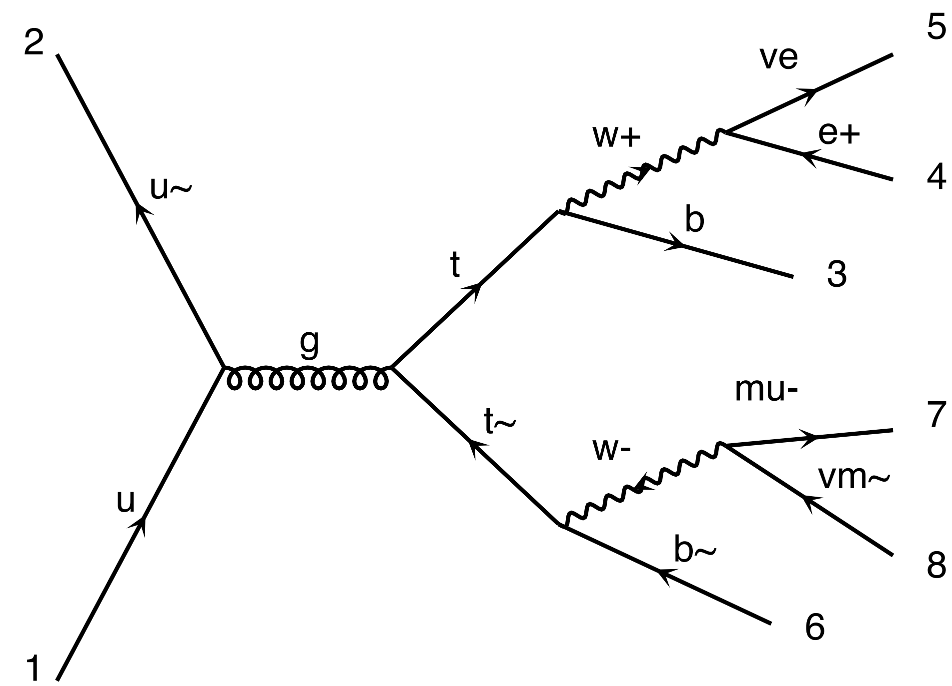
Choices of variables

Higgs production



- Higgs Mass
  - ➡ s-channel
- No FSR

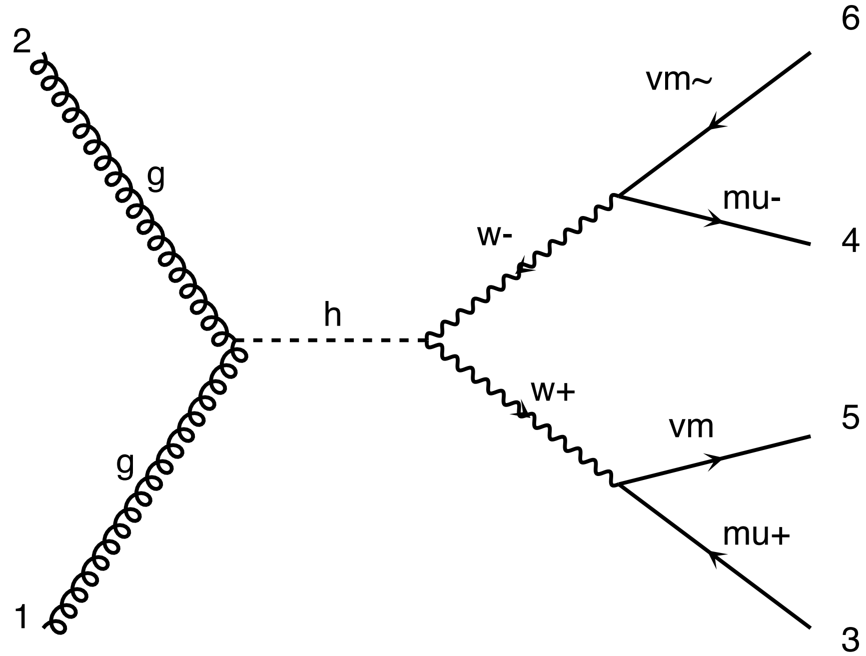
top pair production



- top Mass
- presence of FSR

Text

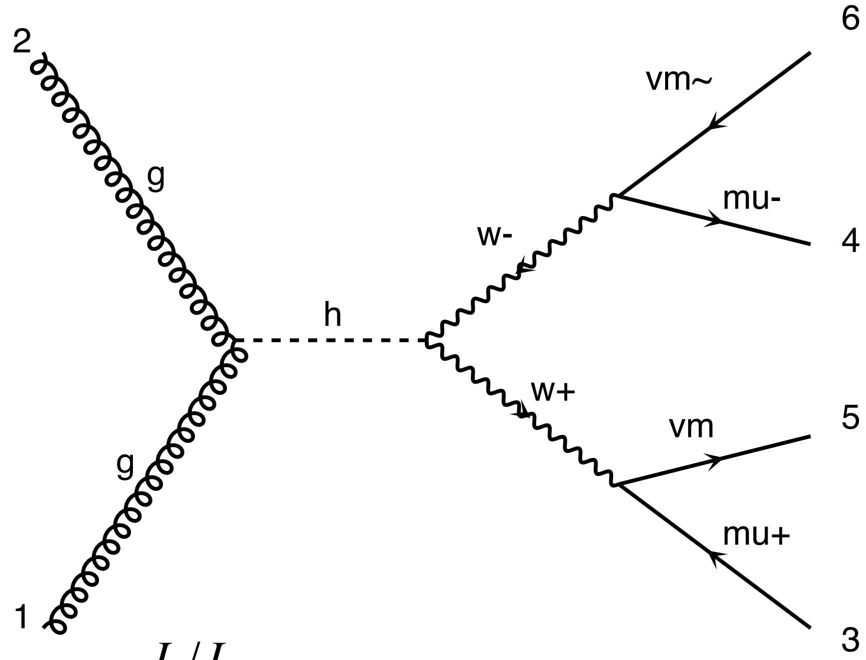
Initial State Radiation



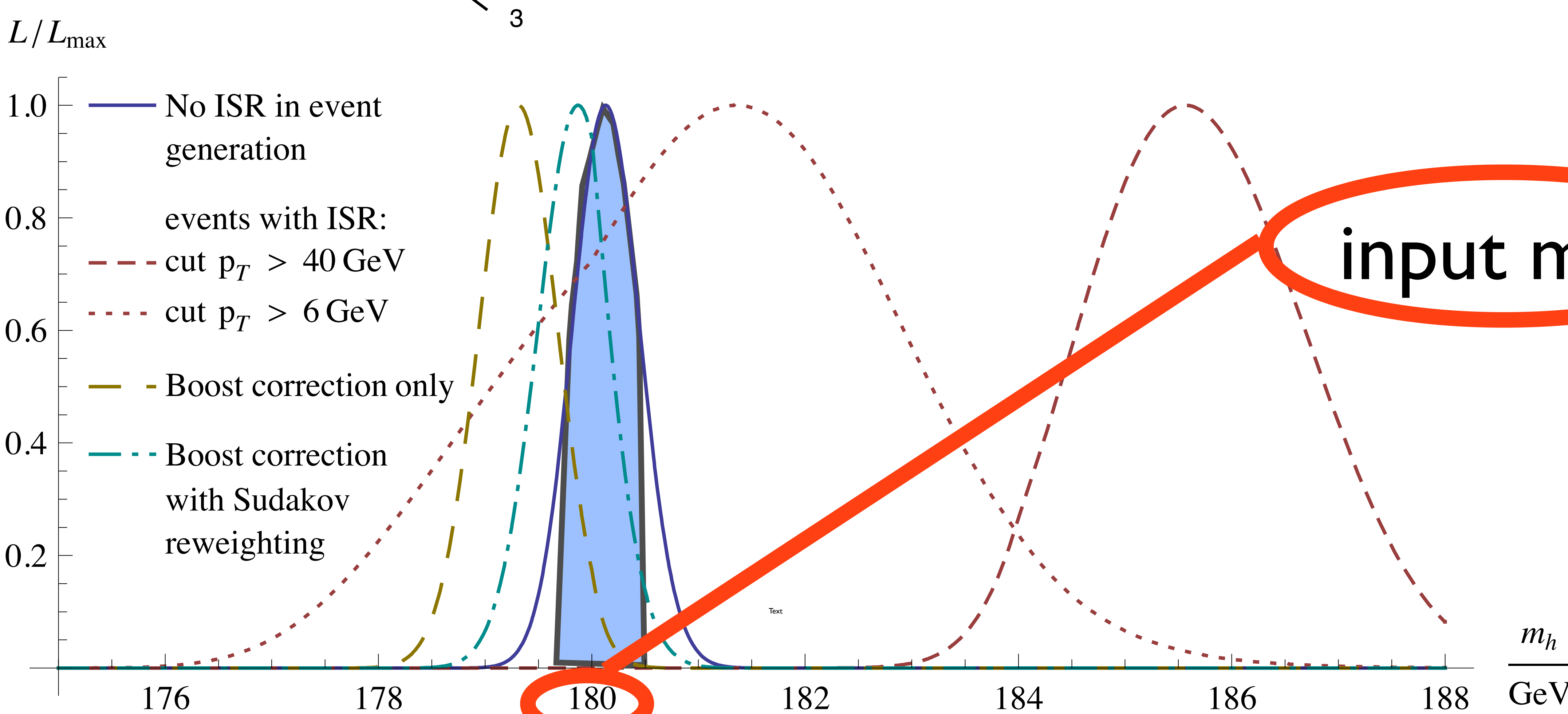
- Study the ISR on Higgs production at LHC (14 TeV) at parton level (no hadronization)

Text

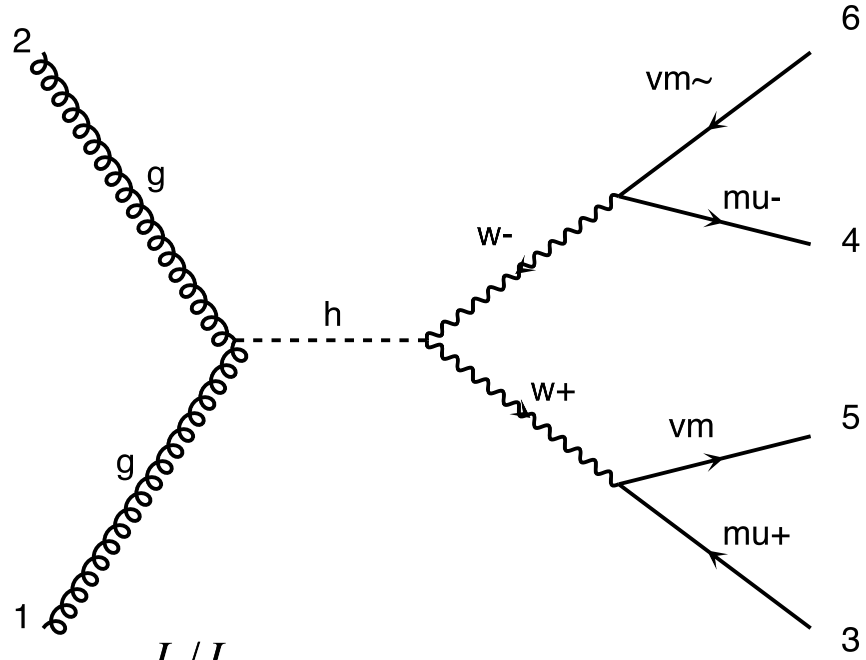
Initial State Radiation



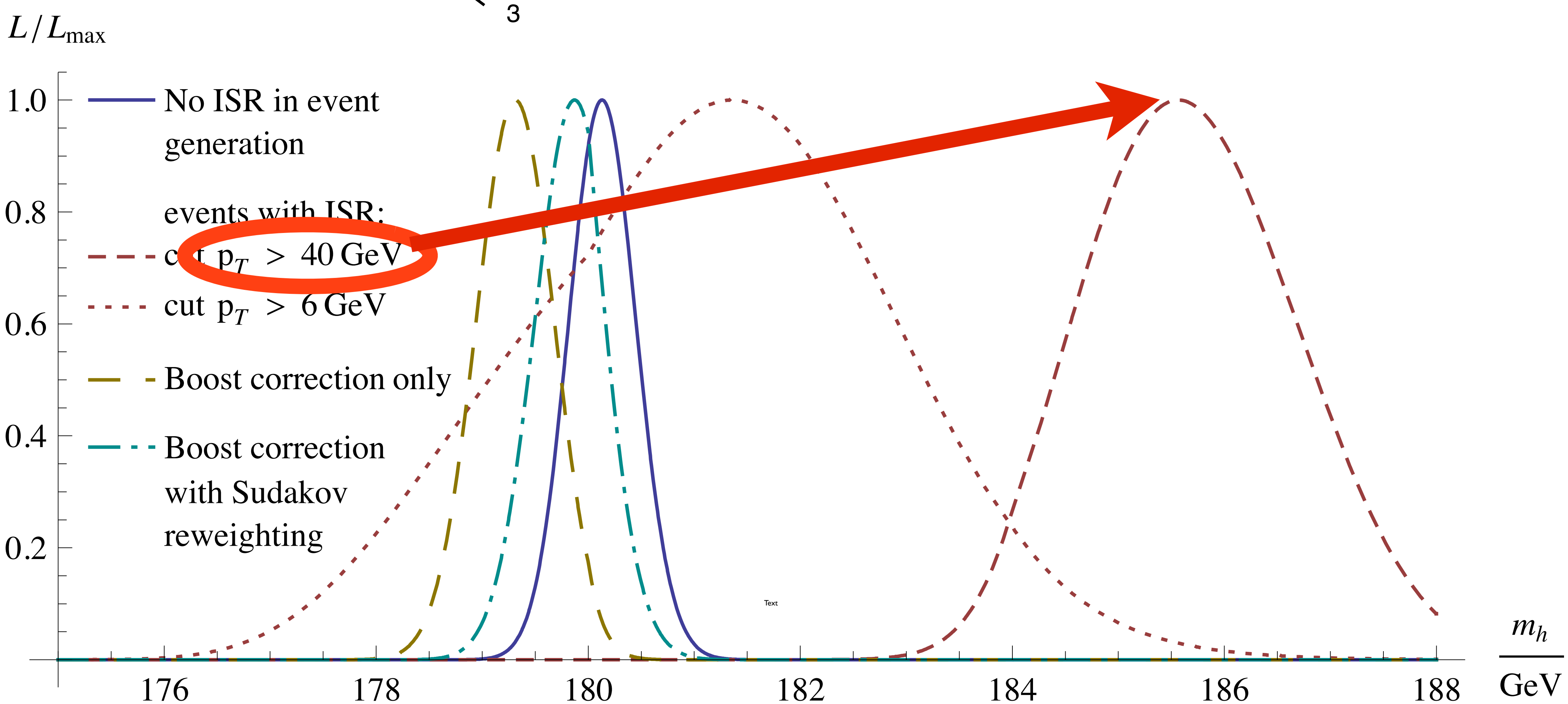
- Study the ISR on Higgs production at LHC (14 TeV) at parton level (no hadronization)
- No ISR → No Bias



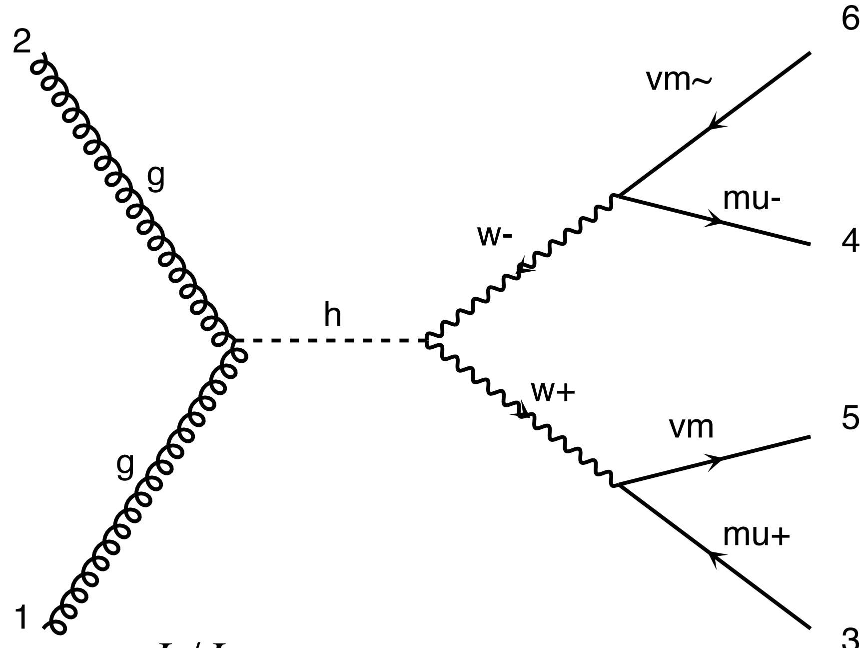
Initial State Radiation



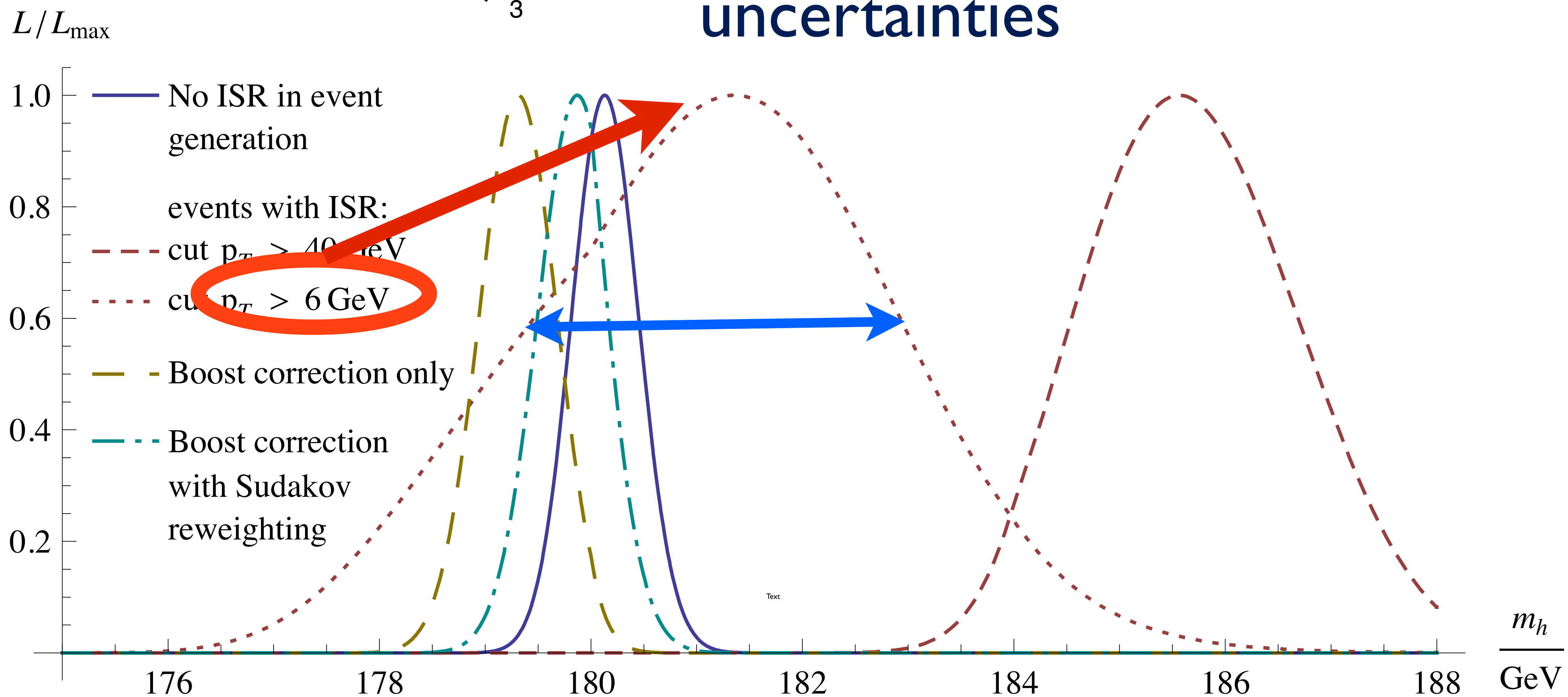
- Study the ISR on Higgs production at LHC (14 TeV) at parton level (no hadronization)
- Large Veto → Large bias



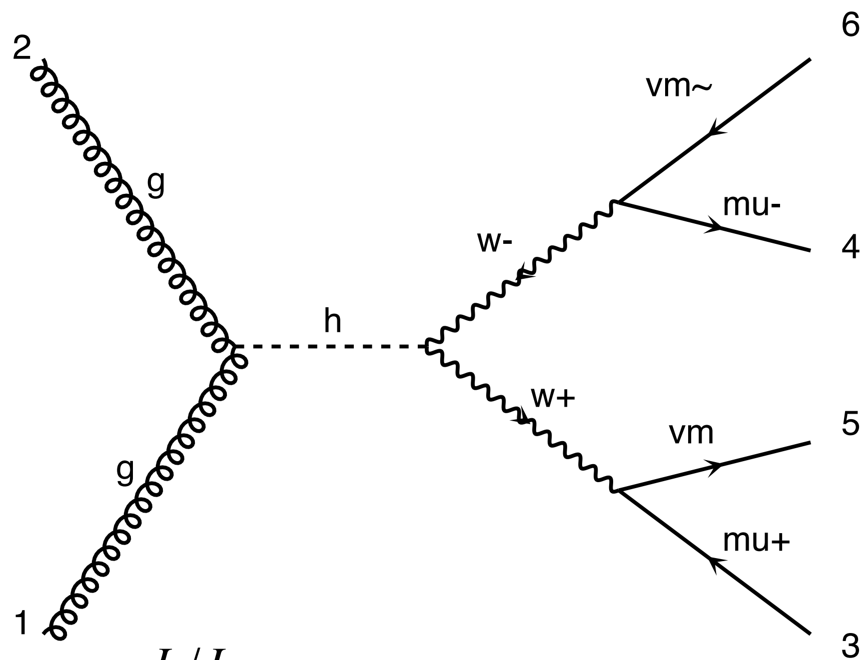
Initial State Radiation



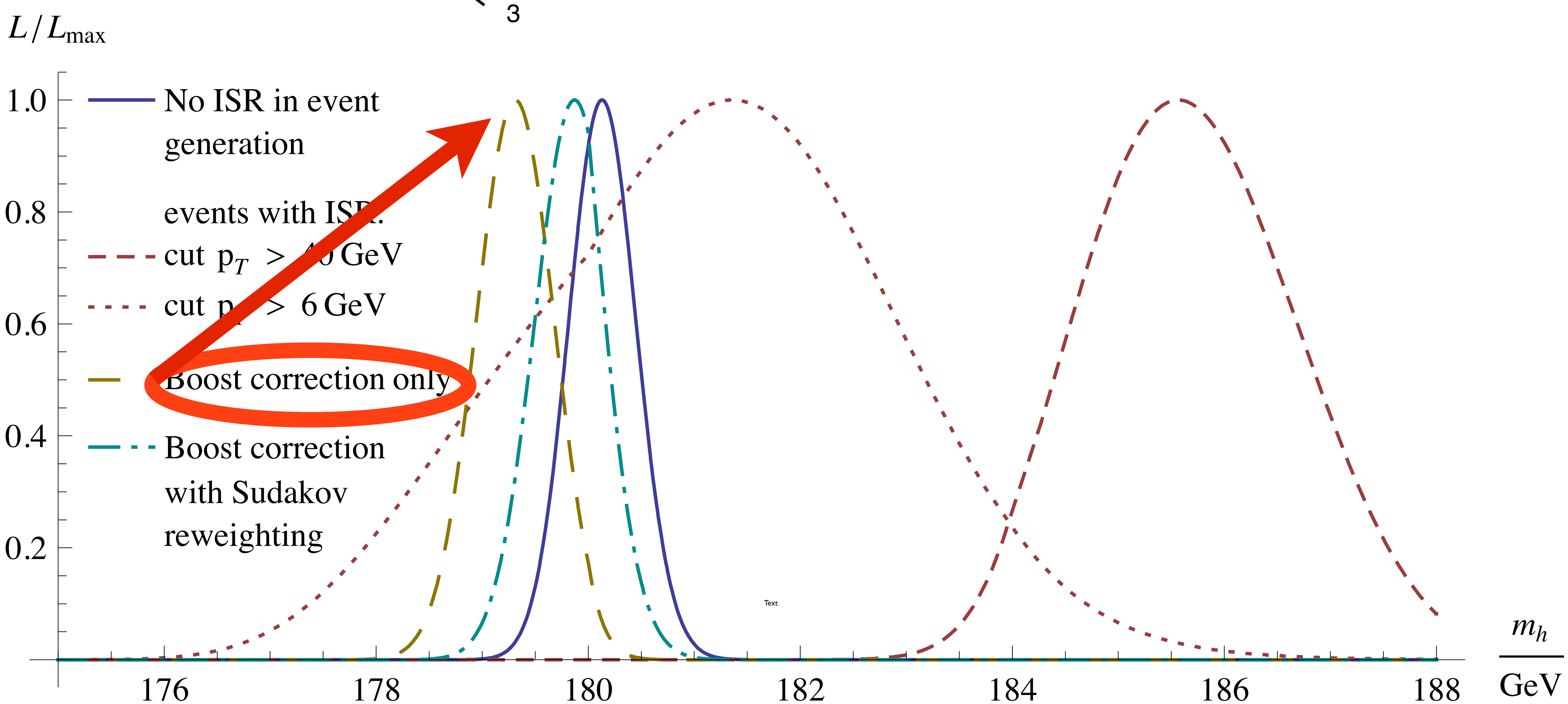
- Study the ISR on Higgs production at LHC (14 TeV) at parton level (no hadronization)
- smaller veto → smaller bias but larger statistical uncertainties



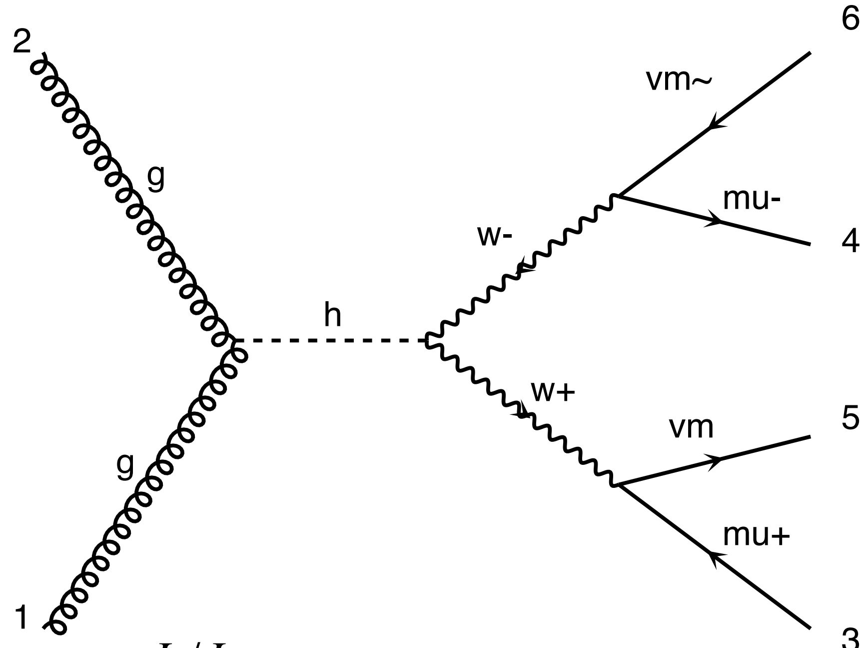
Initial State Radiation



- Study the ISR on Higgs production at LHC (14 TeV) at parton level (no hadronization)
- Use the ISR to boost the momenta ➜ small bias/error

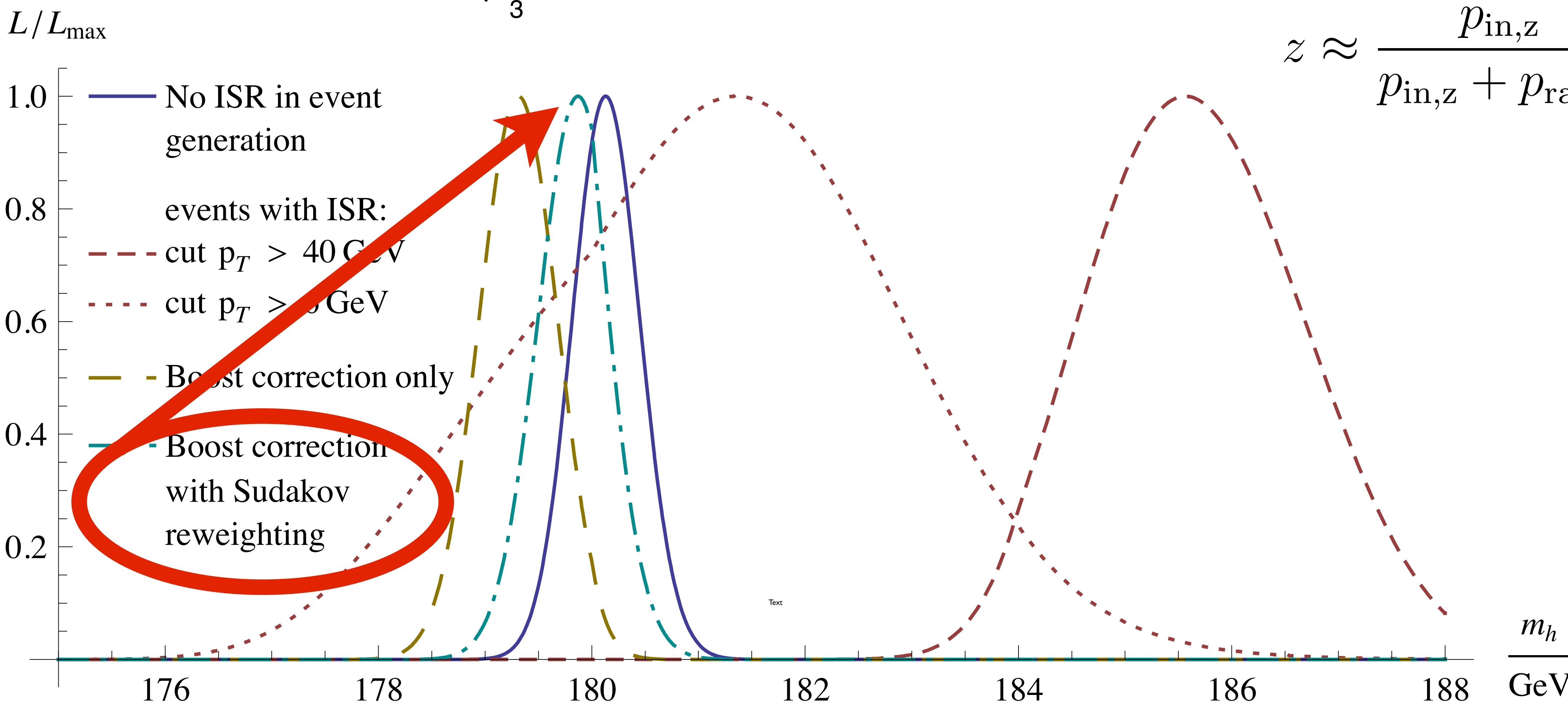


Initial State Radiation



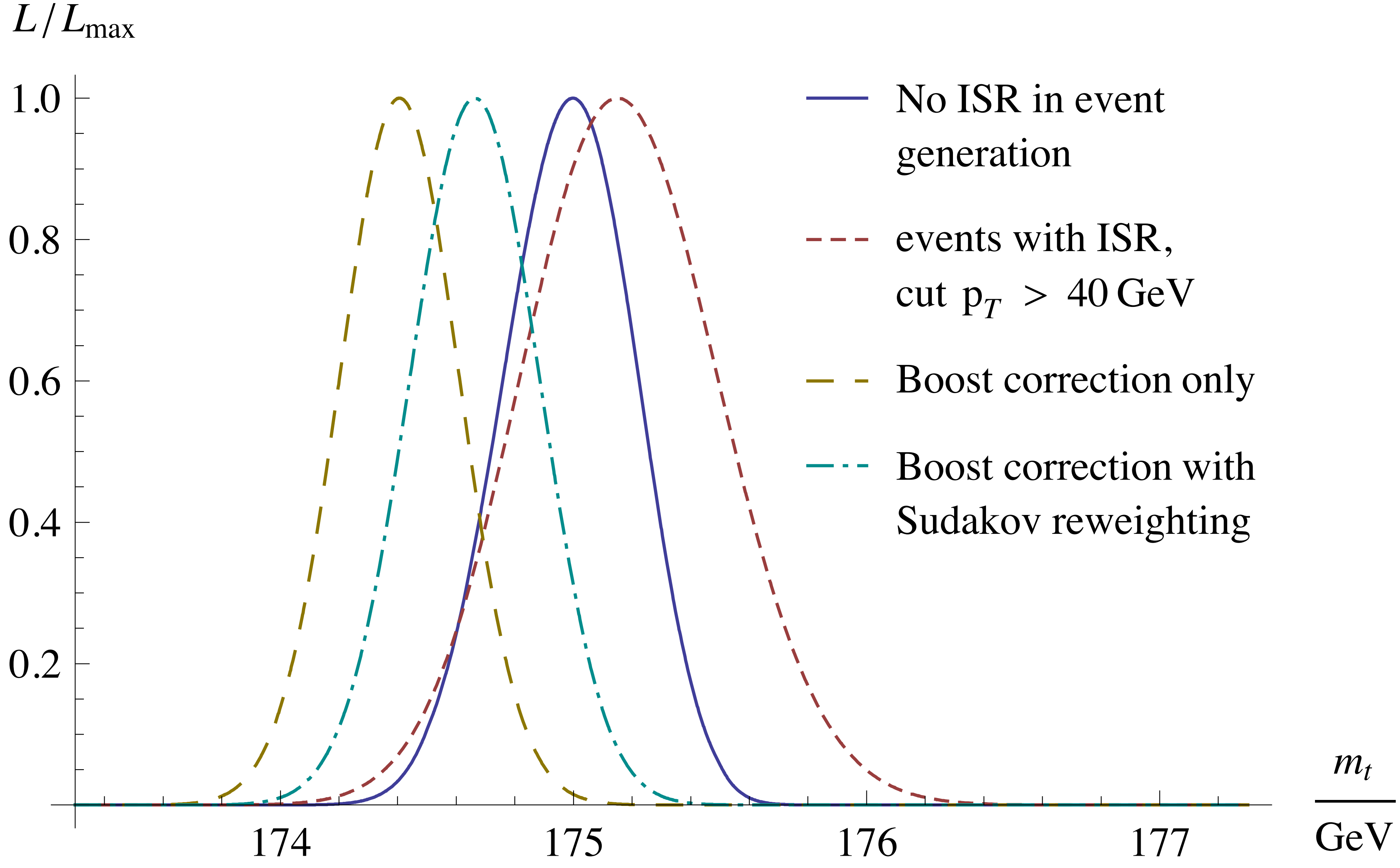
- Study the ISR on Higgs production at LHC (14 TeV) at parton level (no hadronization)
- Add the Sudakov Factor
  → No significative bias

$$z \approx \frac{p_{\text{in,z}}}{p_{\text{in,z}} + p_{\text{rad,z}}},$$



Initial State Radiation

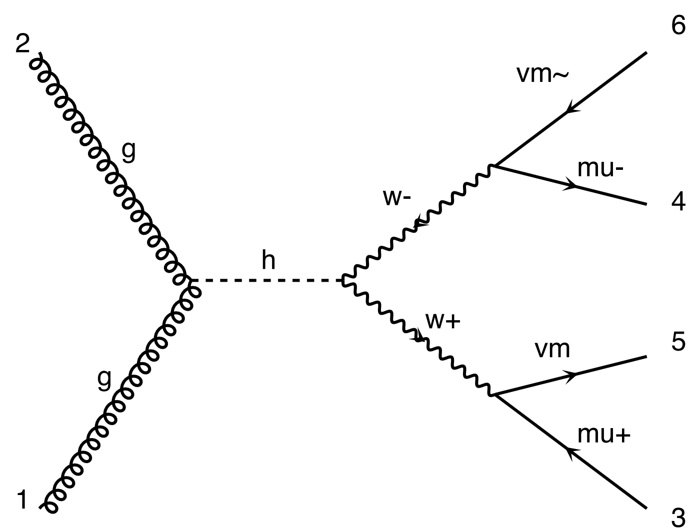
- Parton Level for top pair production



➡ Less sensitivity

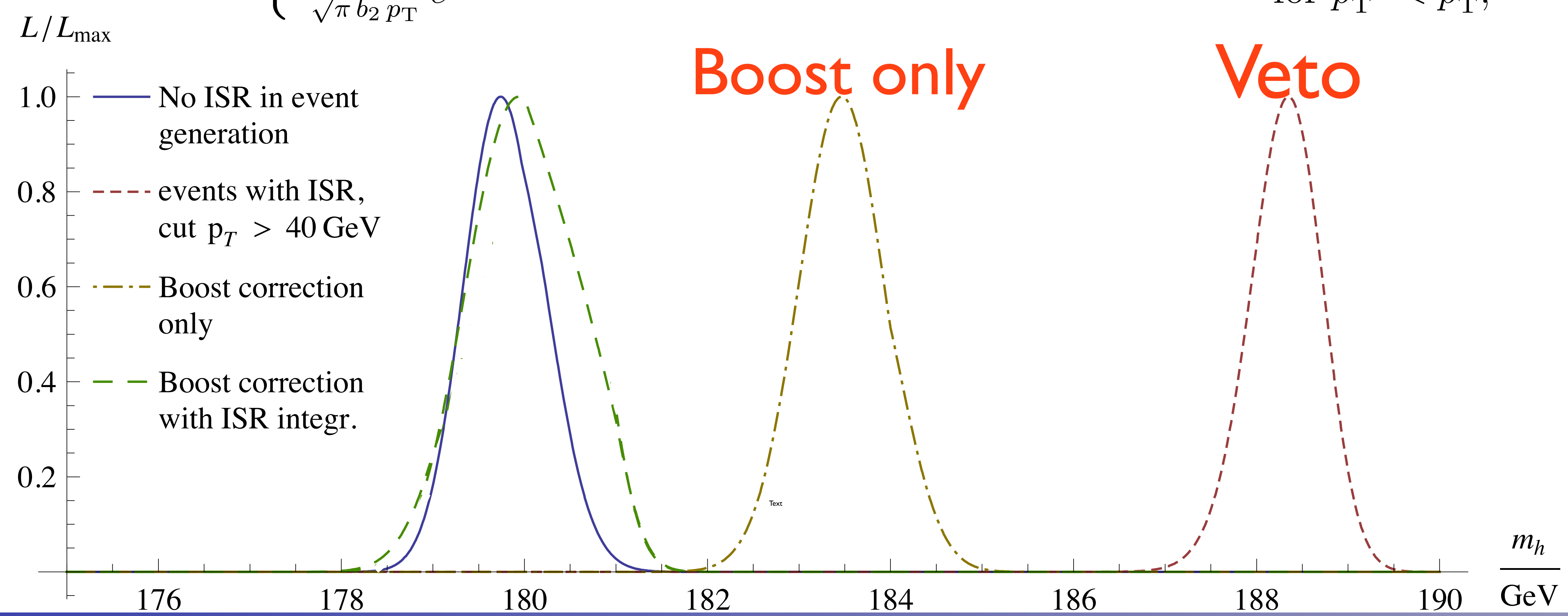
Text

Initial State Radiation

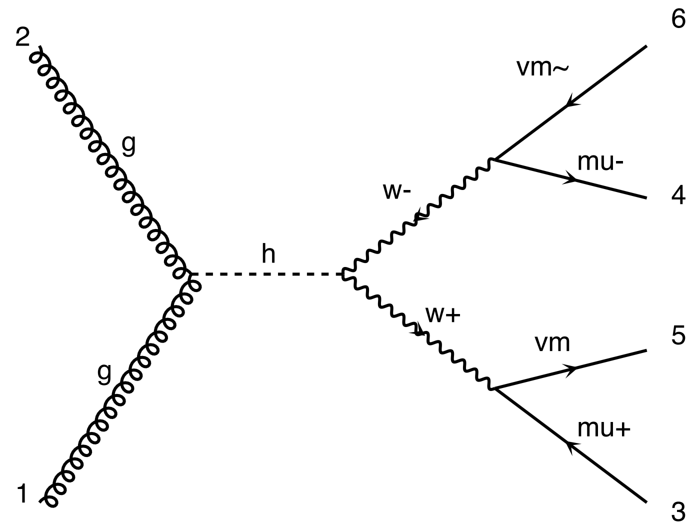


- Study the ISR on Higgs production at LHC (14 TeV) at detector level (simulation includes pile-up)

$$W_{\rm ISR}(p_{\rm T}, p_{\rm T}^{\rm vis}) = \begin{cases} \frac{1}{\sqrt{2\pi}(a_2+a_3a_5)}\left[e^{-(p_{\rm T}-p_{\rm T}^{\rm vis}-a_1)^2/(2a_2^2)} + a_3\, e^{-(p_{\rm T}-p_{\rm T}^{\rm vis}-a_4)^2/(2a_5^2)}\right], & \text{for } p_{\rm T}^{\rm vis} > p_{\rm T}^0, \\ \frac{1}{\sqrt{\pi}\, b_2\, p_{\rm T}}\, e^{-(\log(p_{\rm T})-b_1)^2/(2b_2^2)} & \text{for } p_{\rm T}^{\rm vis} < p_{\rm T}^0, \end{cases}$$

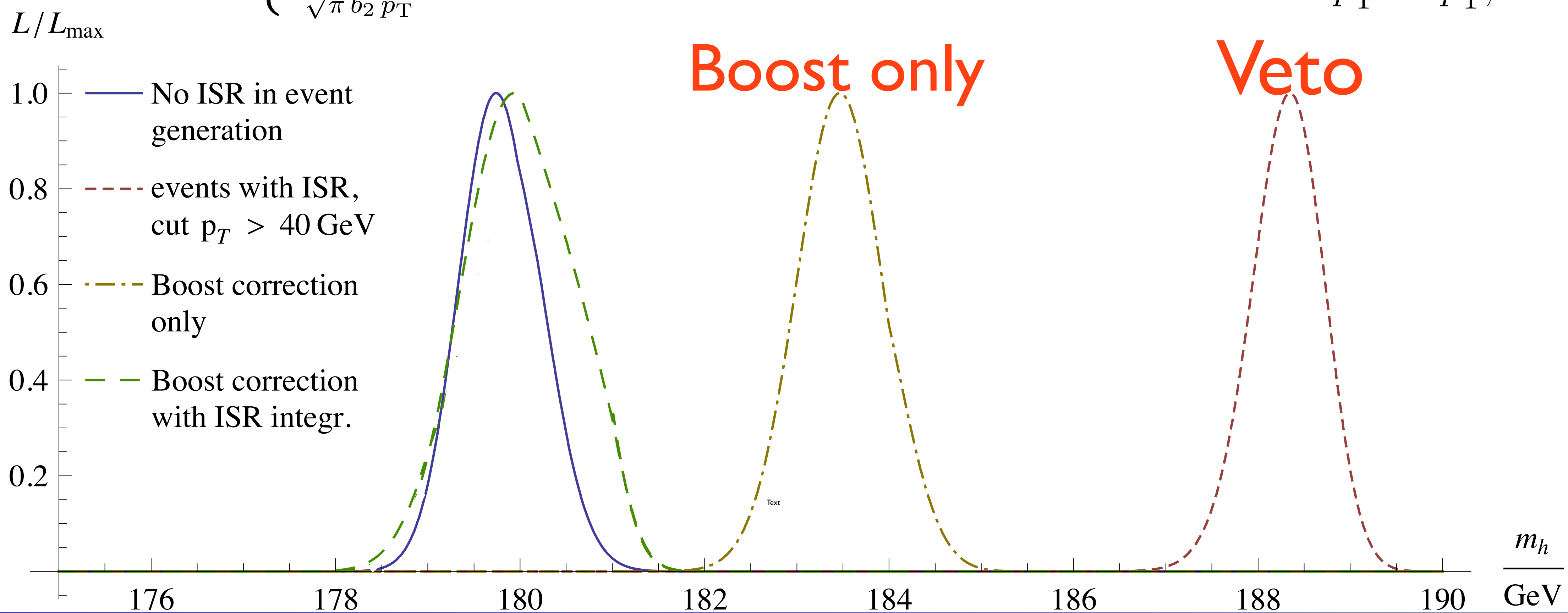


Initial State Radiation



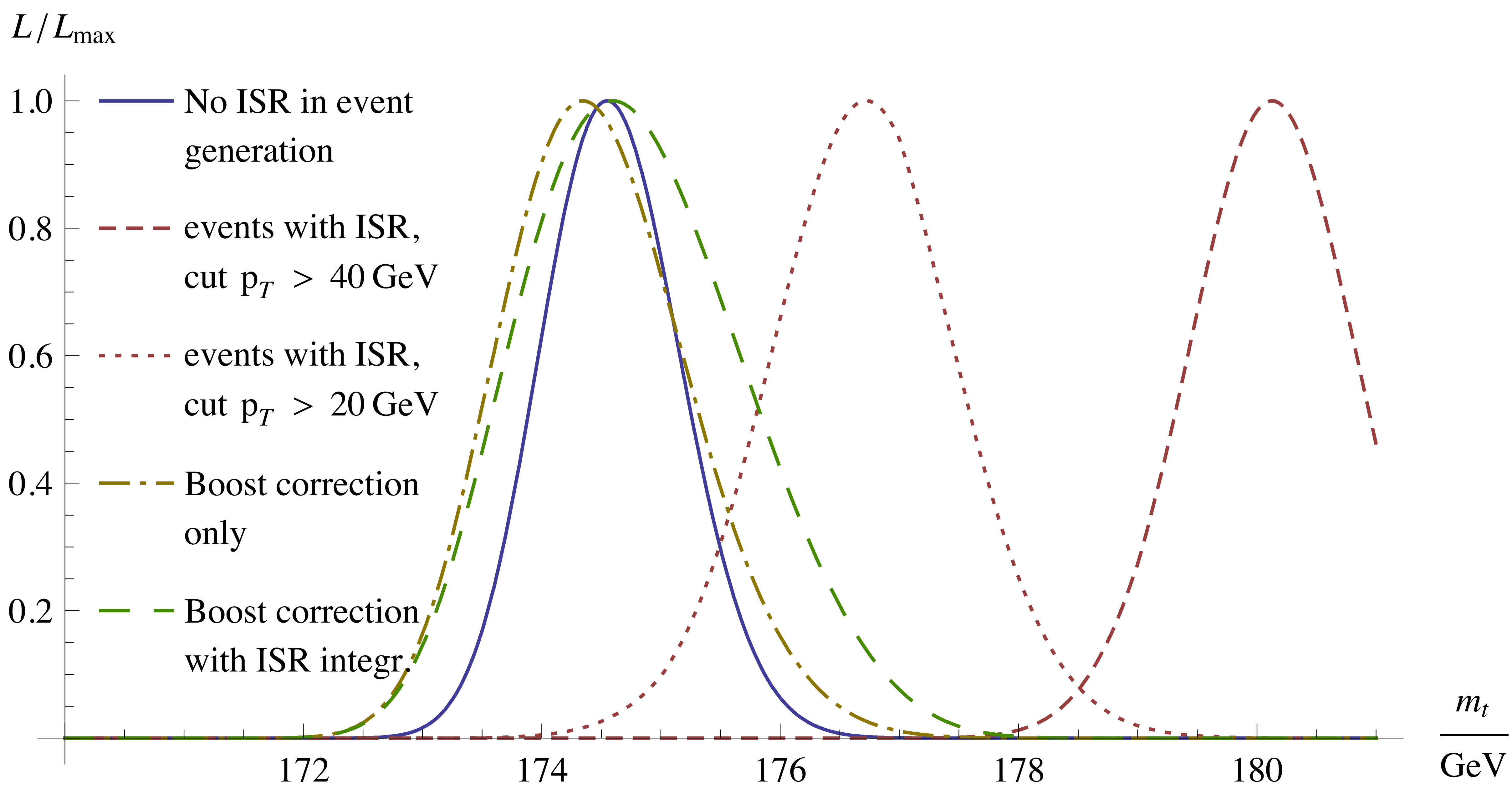
- Study the ISR on Higgs production at LHC (14 TeV) at detector level (simulation includes pile-up)
- Introduce ISR transfer functions

$$W_{\rm ISR}(p_{\rm T}, p_{\rm T}^{\rm vis}) = \begin{cases} \frac{1}{\sqrt{2\pi}(a_2+a_3 a_5)} \left[e^{-(p_{\rm T}-p_{\rm T}^{\rm vis}-a_1)^2/(2a_2^2)} + a_3\, e^{-(p_{\rm T}-p_{\rm T}^{\rm vis}-a_4)^2/(2a_5^2)} \right], & \text{for } p_{\rm T}^{\rm vis} > p_{\rm T}^0, \\ \frac{1}{\sqrt{\pi}\, b_2\, p_{\rm T}}\, e^{-(\log(p_{\rm T})-b_1)^2/(2b_2^2)} & \text{for } p_{\rm T}^{\rm vis} < p_{\rm T}^0, \end{cases}$$



Initial State Radiation

- Reconstructed Level for top pair production



Conclusion

- MadWeight5 will be released soon
  - ➡ with nicer interface / cluster support
  - ➡ with huge speed improvement
  - ➡ with ISR support
- Radiation problem
  - ➡ MLM/NLO slower method
  - ➡ Transverse boost is working
  - ➡ Need transfer function on the boost

Text