MadWeight Tutorial

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CP3

J. Alwall, A. Freytas, OM: PRD83:074010
P.Artoisenet, V.Lemaître, F. Maltoni, OM: JHEP 1012:068

Matrix Element Re-weighting

- Associate to each experimental event characterised by $\boldsymbol{p}^{vis}$, the probability $\mathcal{P}(\boldsymbol{p}^{vis}|\alpha)$ to be produced and observed following a theoretical assumption α

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- $W(\boldsymbol{p}, \boldsymbol{p}^{vis})$ is the transfer function
- $\int d\Phi dx_1 dx_2$ is the phase-space integral
- σ_α^{vis} is the cross-section (after cuts)

Matrix Element Method

- Most common and Important use is to combine those in a Likelihood

$$L(\alpha) = \prod_{i=1}^{N} \mathcal{P}(\boldsymbol{p}_i^{vis}|\alpha)$$

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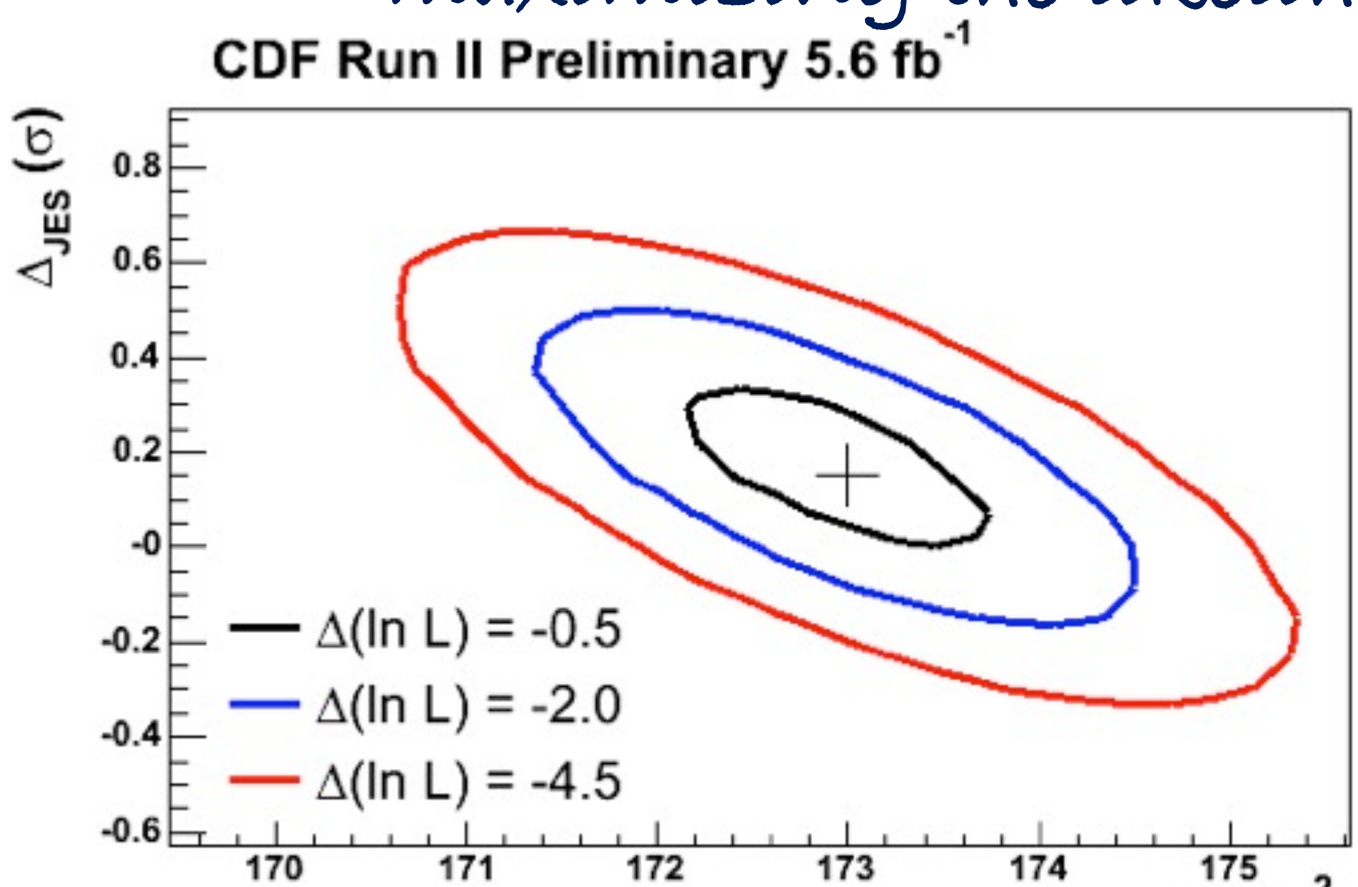

Semi-leptonic decay

$$m_{top} = 173.0 \pm 1.2\text{GeV}$$

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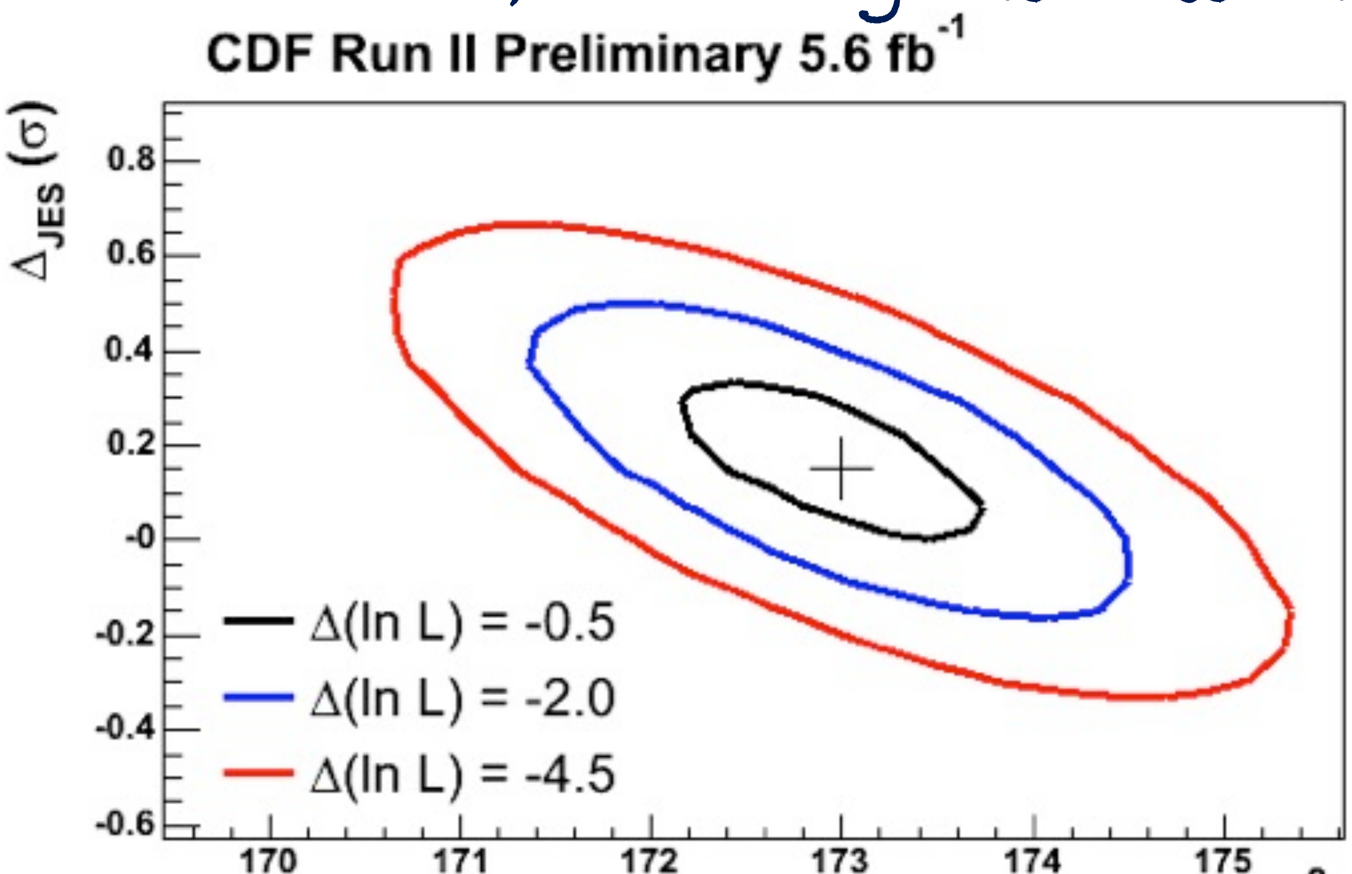

Semi-leptonic decay

$$m_{top} = 173.0 \pm 1.2\text{GeV}$$

Also use for

- Higgs Exclusion
- single top cross observation

CRITICS OF THE METHOD

- The Likelihood methods builds the BEST discriminating variable
- Fully Model dependant
- Pure LO approximation
- Transfer Function approximation
  - Factorize for each parton
  - Not valid for hard radiation
- Strong sensitivity in analysis cut
- Computing time ($N_{event} * N_{th}$ integrals)

Matrix Element Re-weighting

How to evaluate those weights?

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

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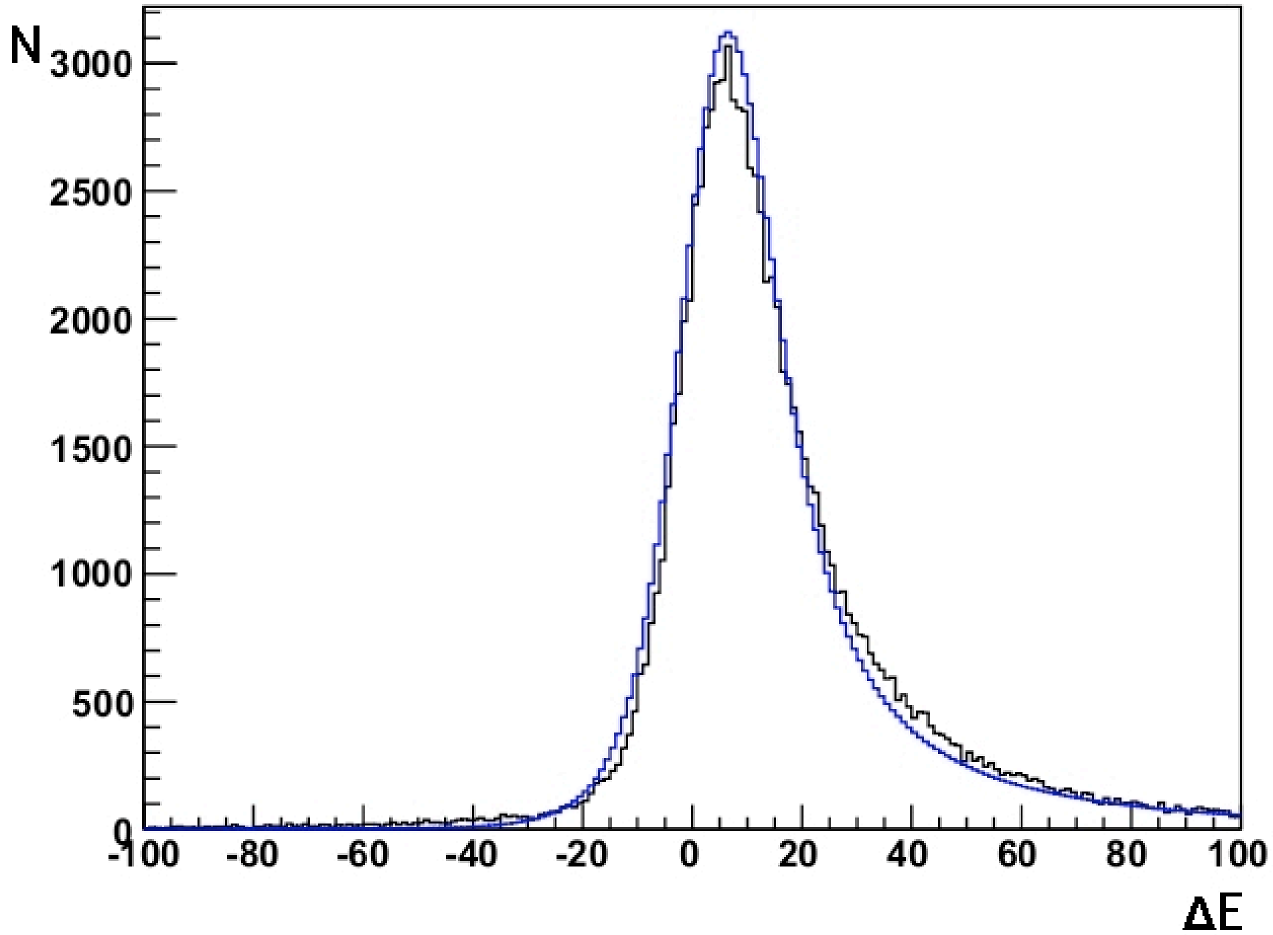

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- Need a specific integrator: MadWeight

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Difficult point: Numerical Integration

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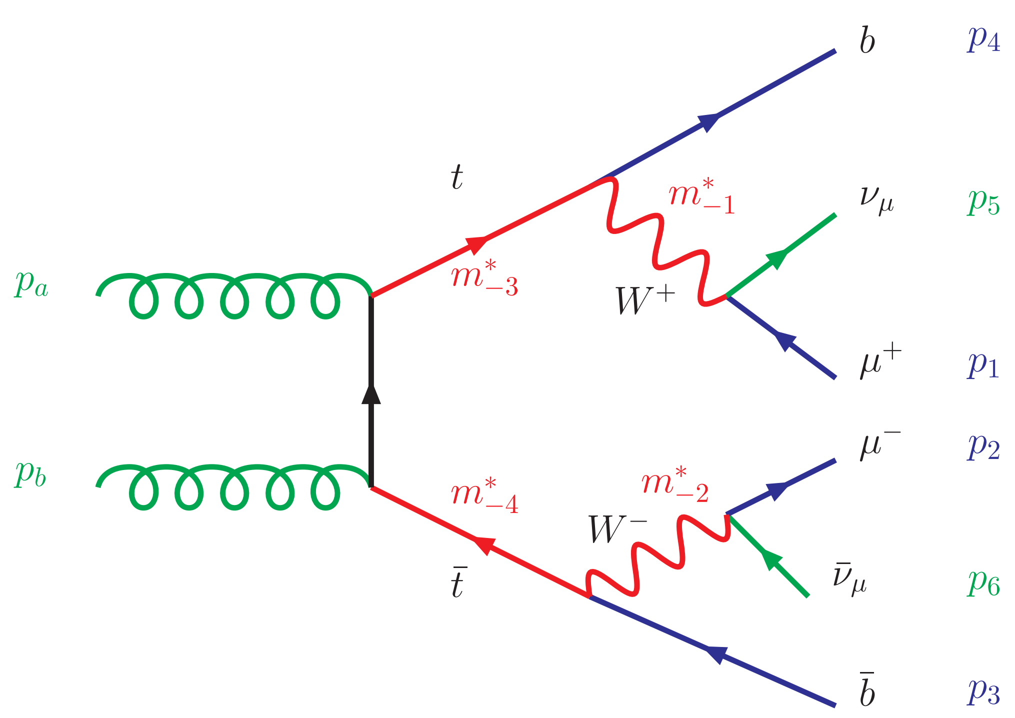
- Presence of sharp functions
  - Breit-Wigner
  - TF linked to angular observables

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

MADWEIGHT

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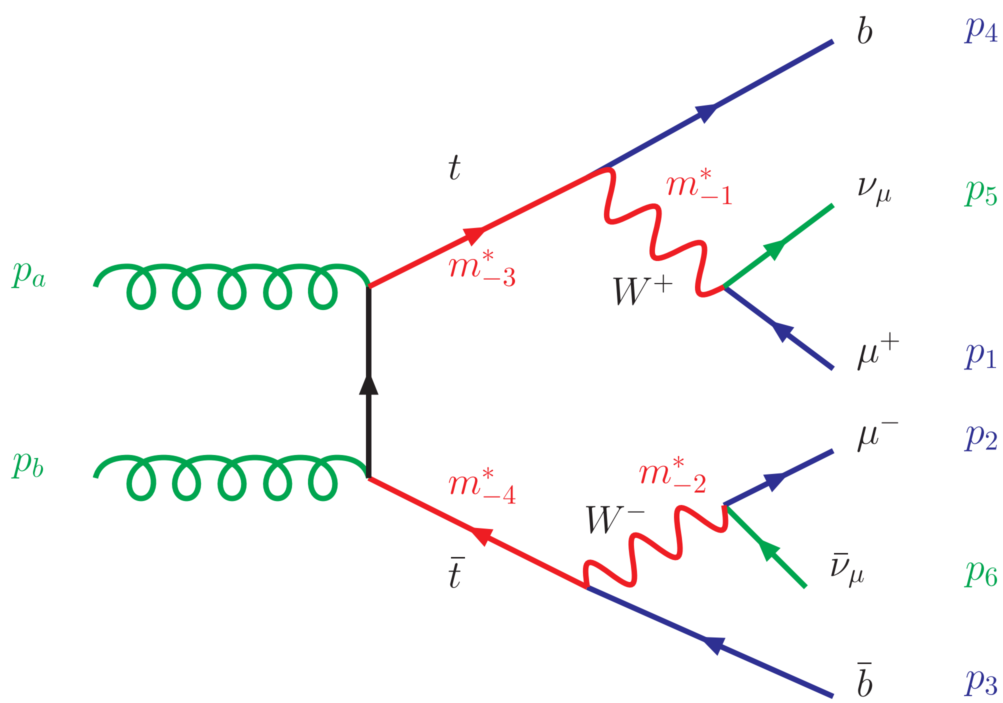

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→ All peaks aligned

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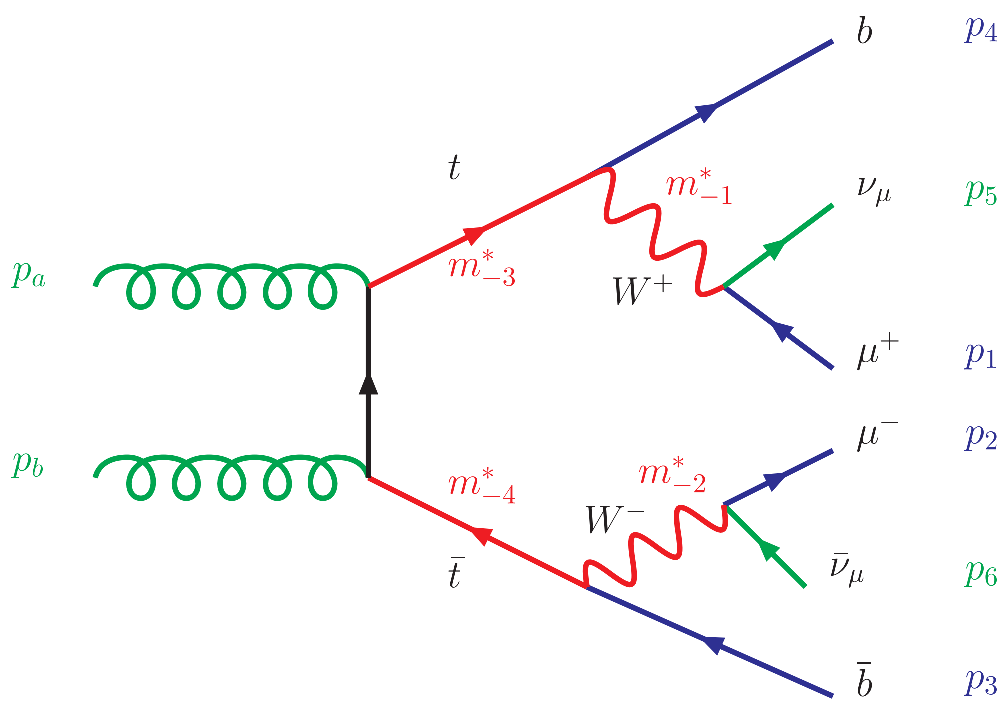

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$$d\phi = \prod_{i=1}^{4} \frac{d^3 p_i}{(2\pi)^3 2E_i} \prod_{i=5}^{6} \frac{d^3 p_i}{(2\pi)^3 2E_i} dx_1 dx_2 \delta^4 \left(p_a + p_b - \sum_j p_j \right)$$

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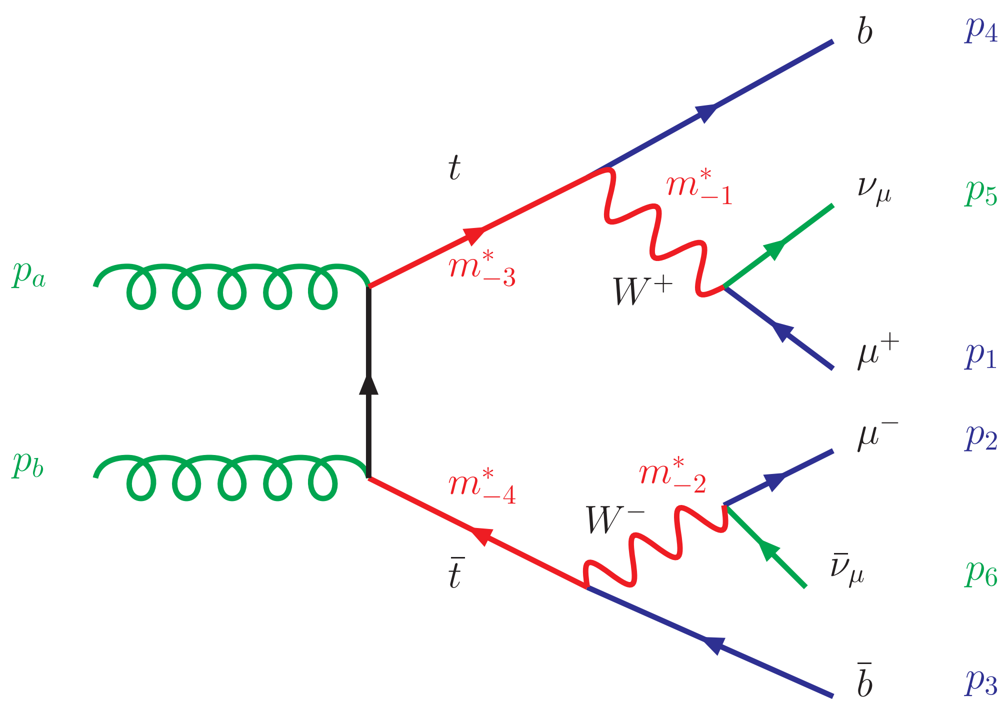

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Pass to →

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

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MADWEIGHT

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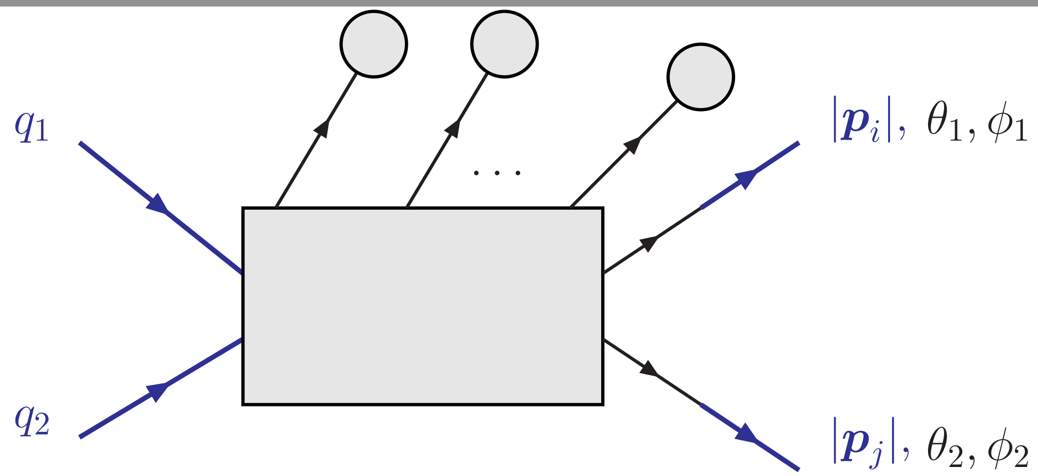
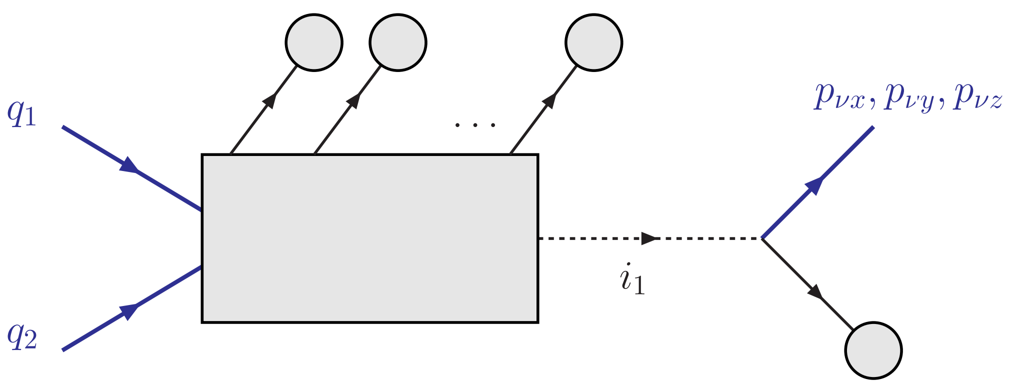
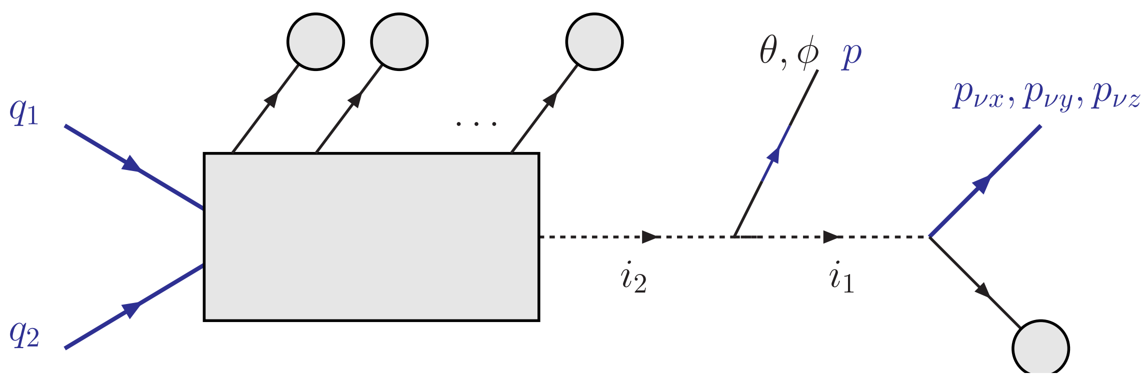
MadWeight



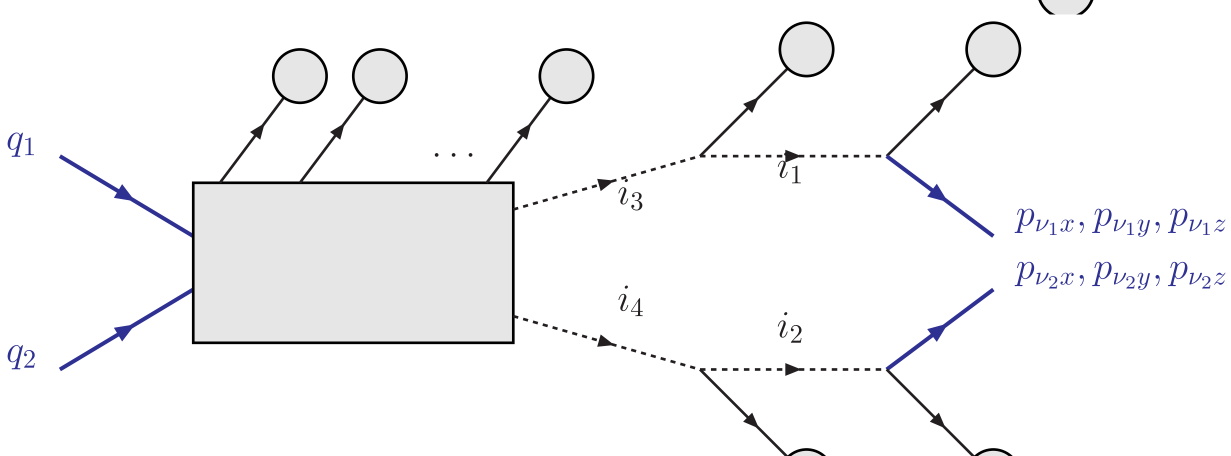
fully hadronic / leptonic process



W production

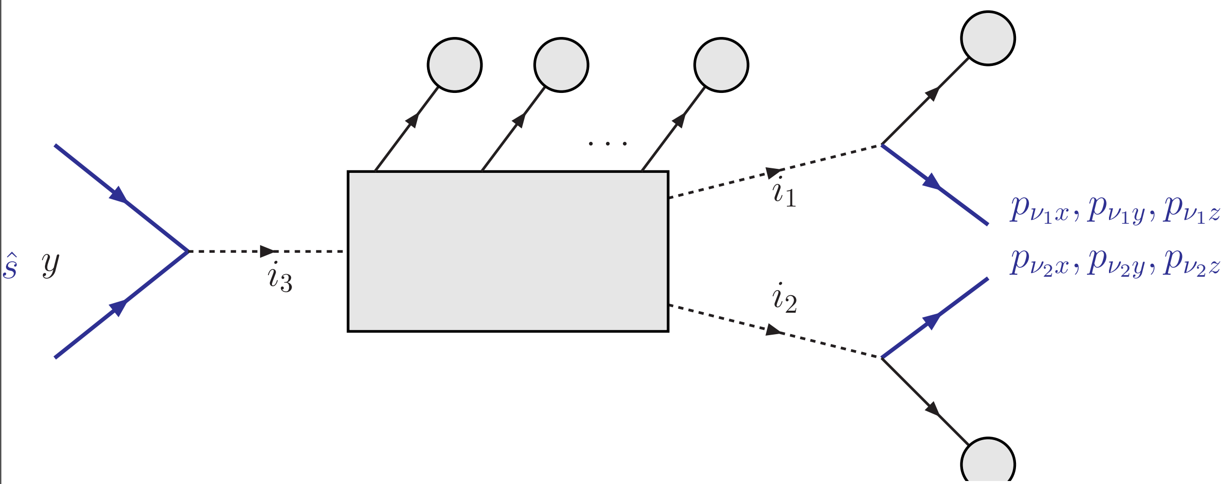


semi-leptonic top quark pair

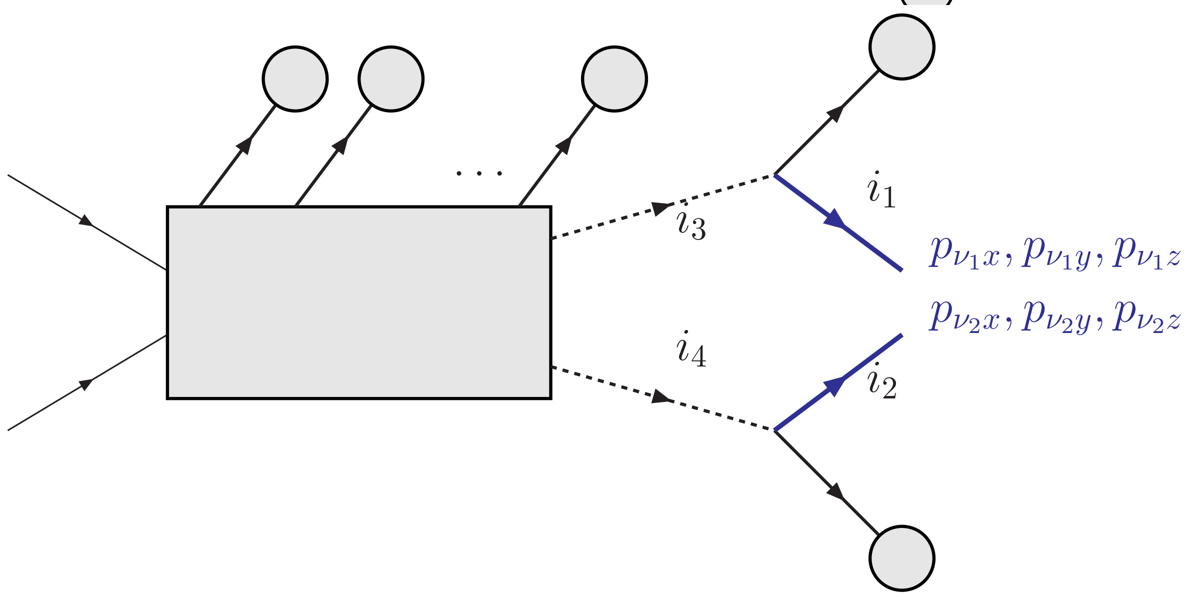


Fully leptonic top quark pair

MadWeight



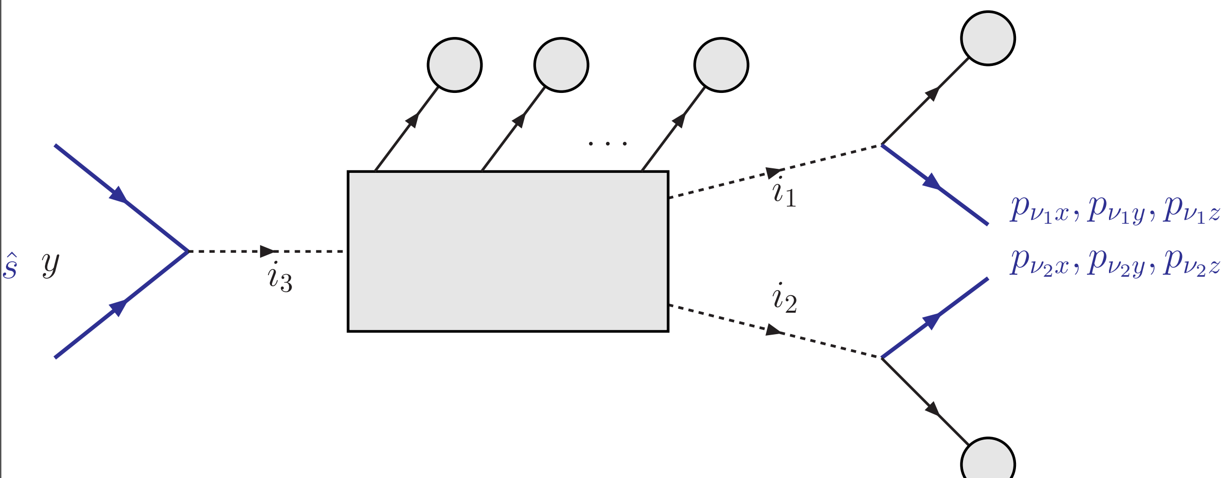
Higss production decaying in W



Class F

W+ W- production

MadWeight



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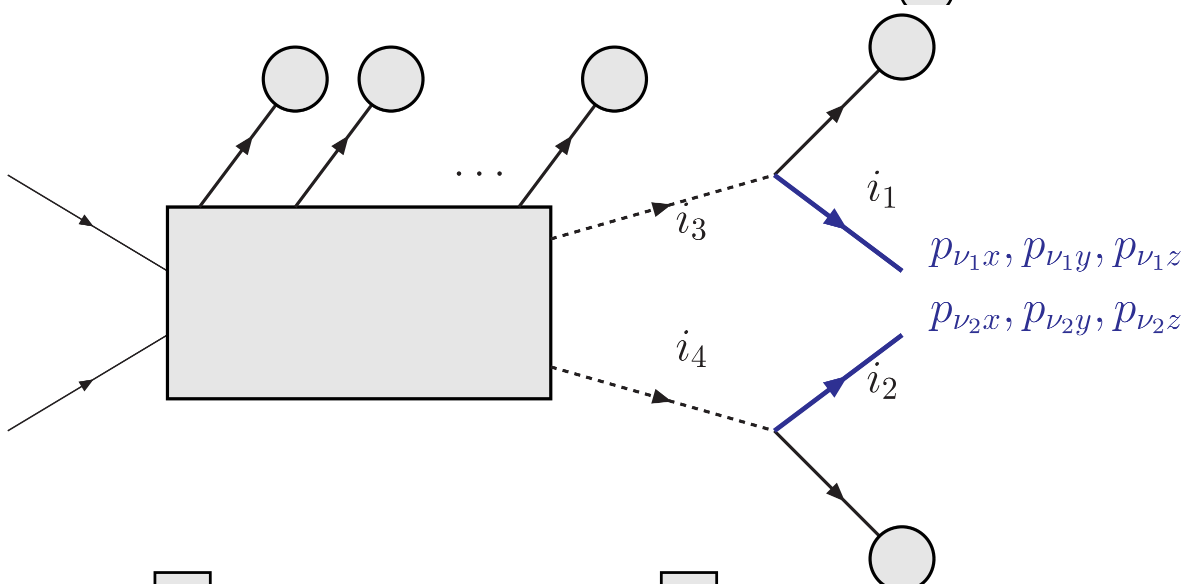

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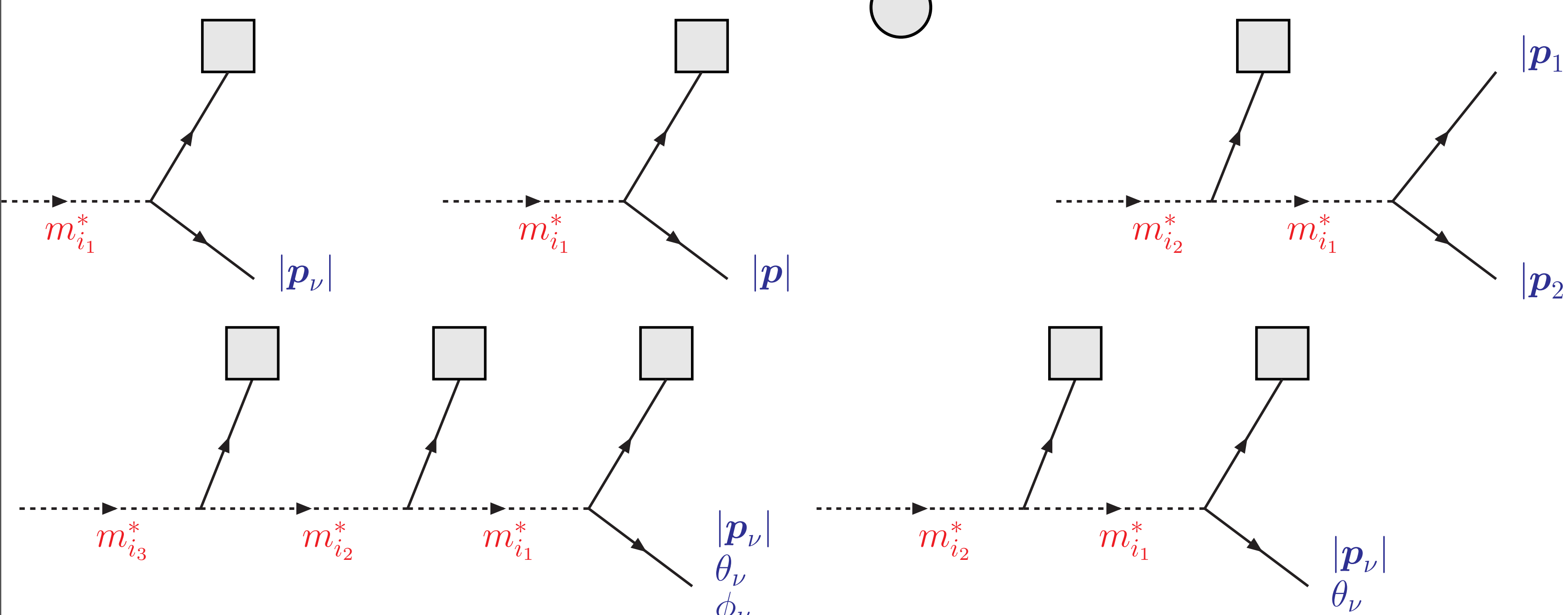

Lot of possibility to have more complex process

+1 W

+1 Z

+ ...

Demo

Terminal — bash — bash

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```

Steps

- cp -r Template MY_FIRST_MW
- ./bin/PasstoMadWeight
- edit Cards/proc_card.dat
- ./bin/newprocess
- edit Cards/transfer_card.dat
- edit Cards/MadWeight_card.dat
- edit Cards/run_card.dat
- edit Cards/param_card.dat
- Put events in LHCO format as Events/input.lhco
- ./bin/madweight.py

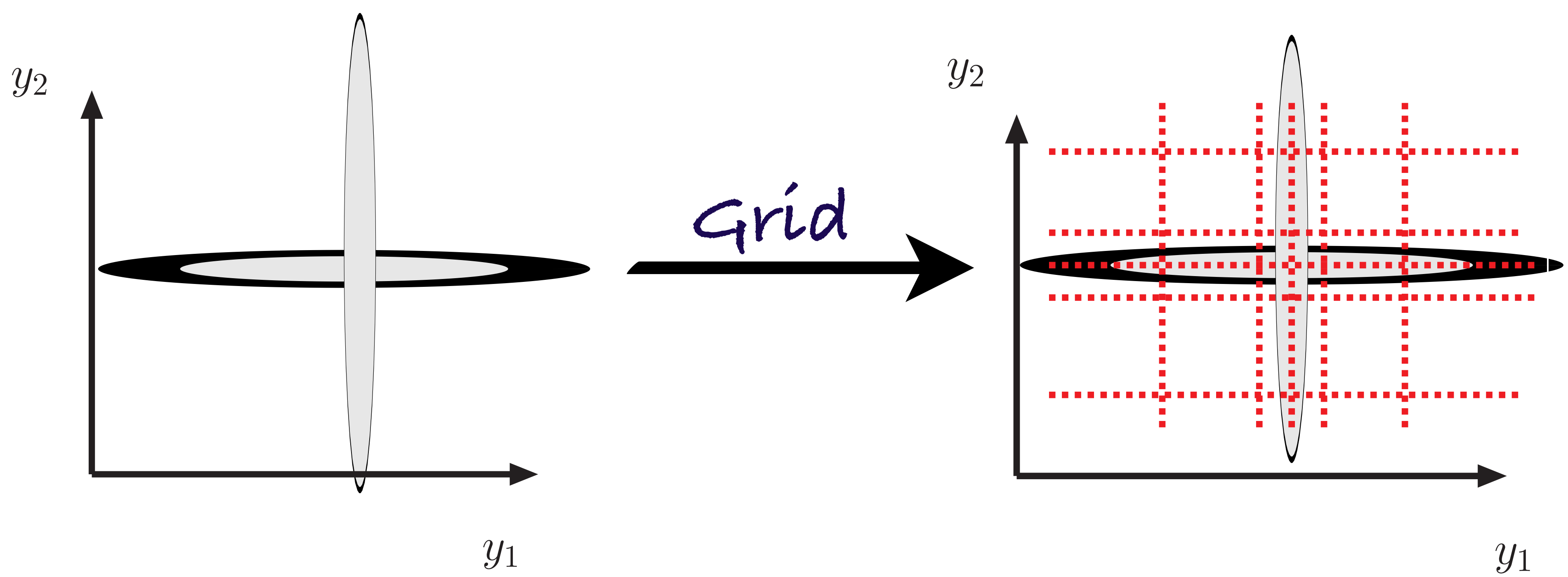
Important point

- a lhe/lhco converter exists on the wiki
- for the proc_card the decay chain syntax IS REQUIRED

- Goal: measure the W mass first for event at parton level.
- When this is done, include pythia/PGS (tuned on CMS) and reproduce the results.

Monte-Carlo Integration

- The choice of the parameterisation has a strong impact on the efficiency



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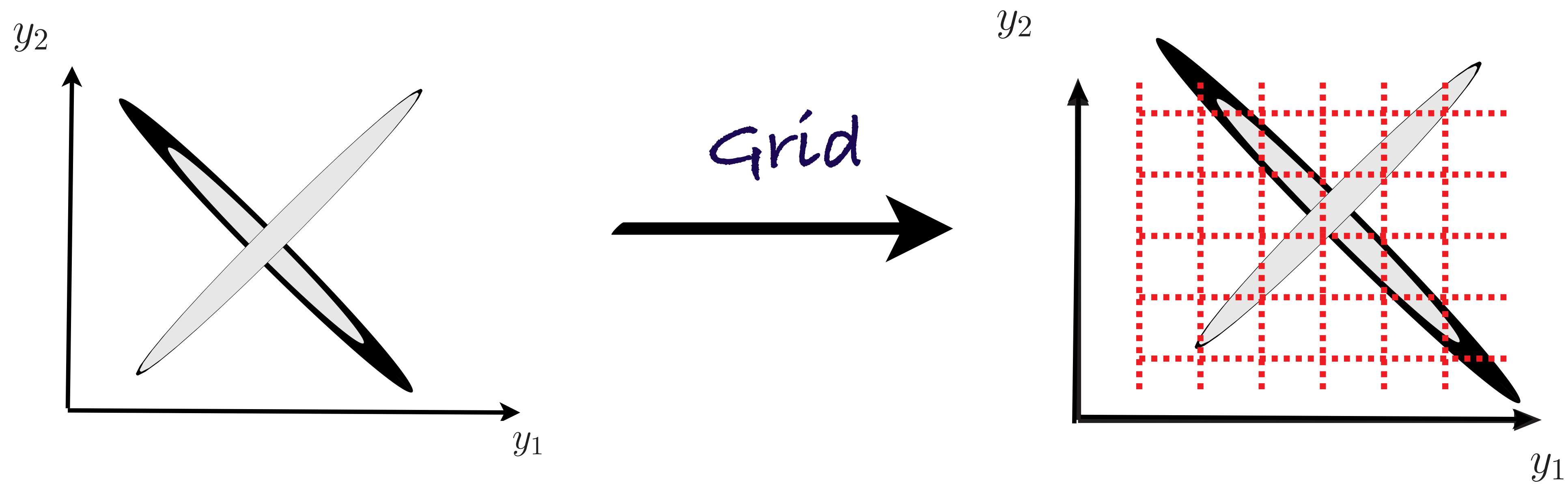

- The adaptive Monte-Carlo Techniques picks points everywhere
  → The integral converges slowly

Monte-Carlo Integration

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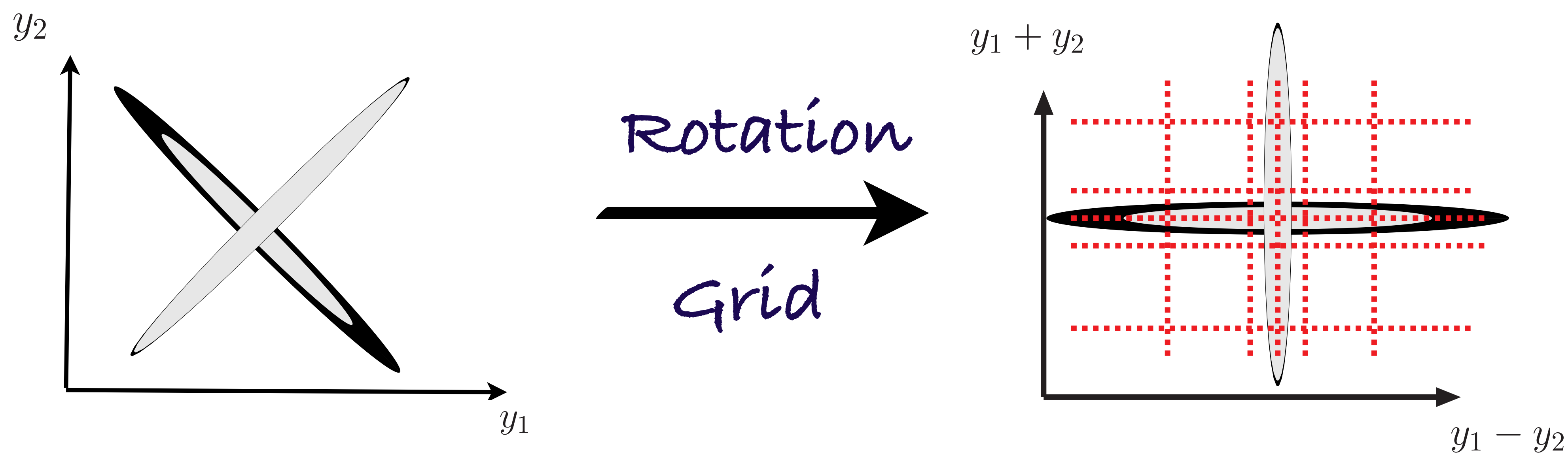

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