ALOHA

- Compute those Function Analytically
- Code in Python
- Can handle
  - ➡ all spin up to 2
  - ➡ custom propagator
  - ➡ Majorana (but in 4 fermion operator)
  - ➡ Any dimensional operator
- Only use in MadGraph5_aMC@NLO
- Plan to have similar tools for the other generator

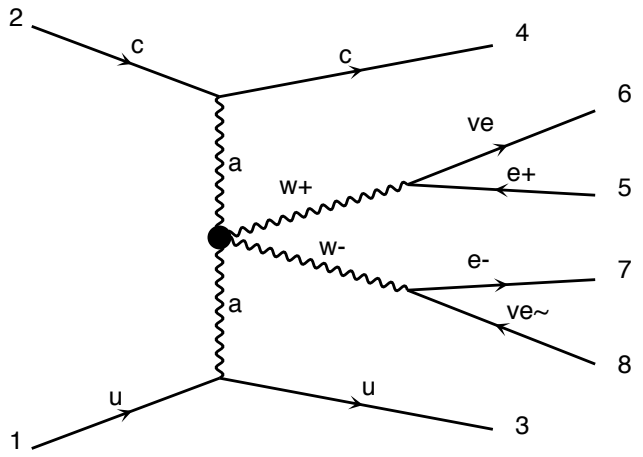
To Remember

- Numerical computation faster than analytical computation
- We are able to compute matrix-elment
  - ➡ for large number of final state
  - ➡ for any BSM theory
  - ➡ actually also for loop

BSM: decay

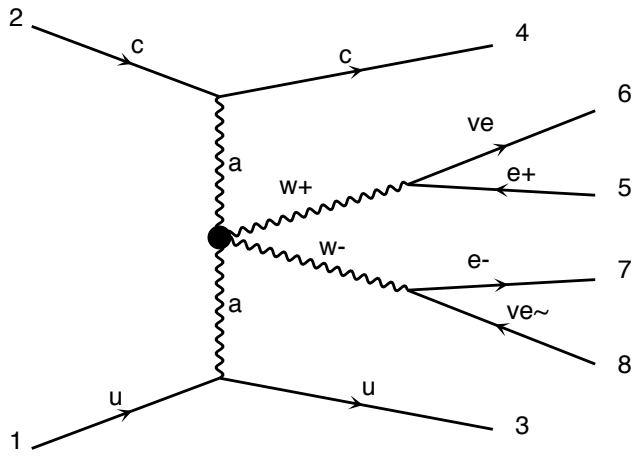
Decay

Resonant Diagram

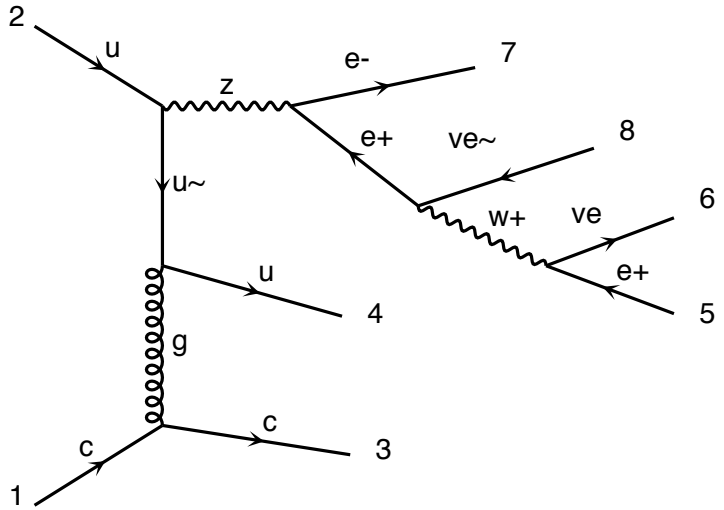


Decay

Resonant Diagram



Non Resonant Diagram



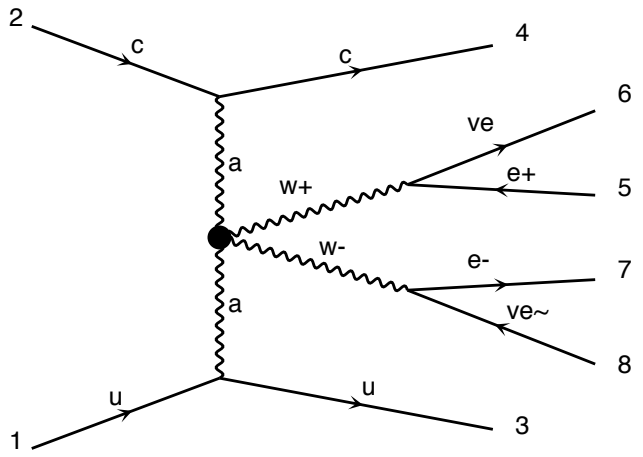
Problem

- Process complicated to have the full process

➡Including off-shell contribution

Decay

Resonant Diagram



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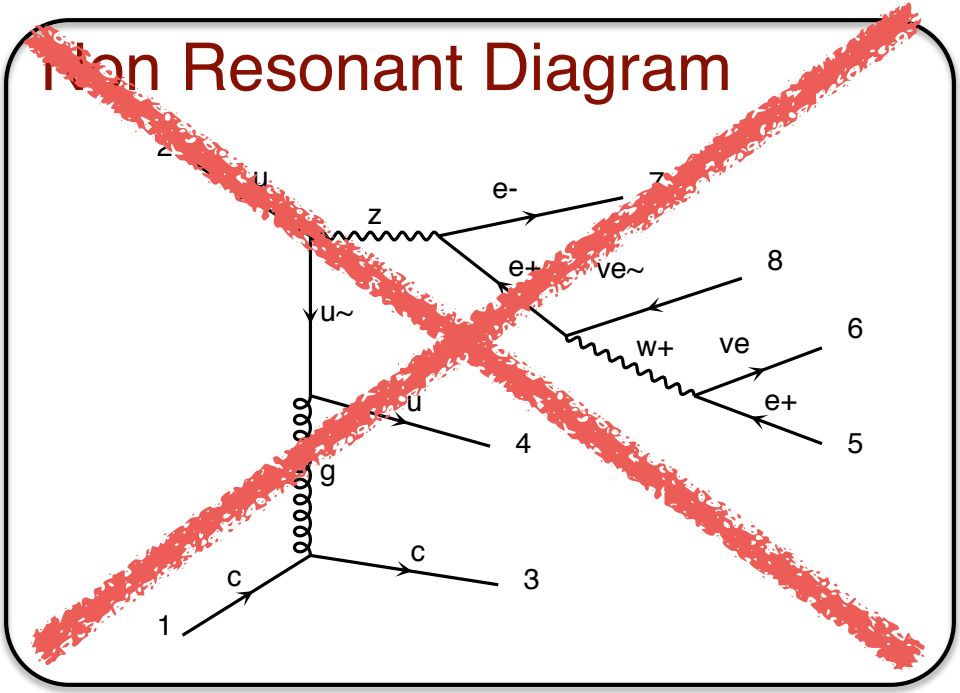

Problem

- Process complicated to have the full process

➡Including off-shell contribution

Solution

- Only keep on-shell contribution

Narrow-Width Approx.

Theory

$$\int dq^2 \left| \frac{1}{q^2 - M^2 - iM\Gamma} \right|^2 \approx \frac{\pi}{M\Gamma} \delta(q^2 - M^2)$$

$$\sigma_{full} = \sigma_{prod} * (BR + \mathcal{O}(\frac{\Gamma}{M}))$$

Comment

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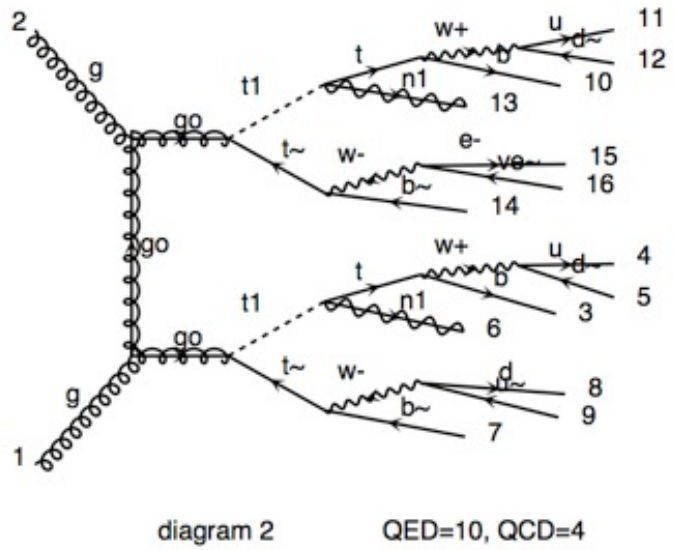
Comment

- This is an Approximation!
- This force the particle to be on-shell!
  - Recover by re-introducing the Breit-wigner up-to a cut-off

Decay chain

- p p > t t~ w+, (t > w+ b, w+ > l+ vl), \
  (t~ > w- b~, w- > j j), \
  w+ > l+ vl



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decay chains possible to simulate
directly in MadGraph!

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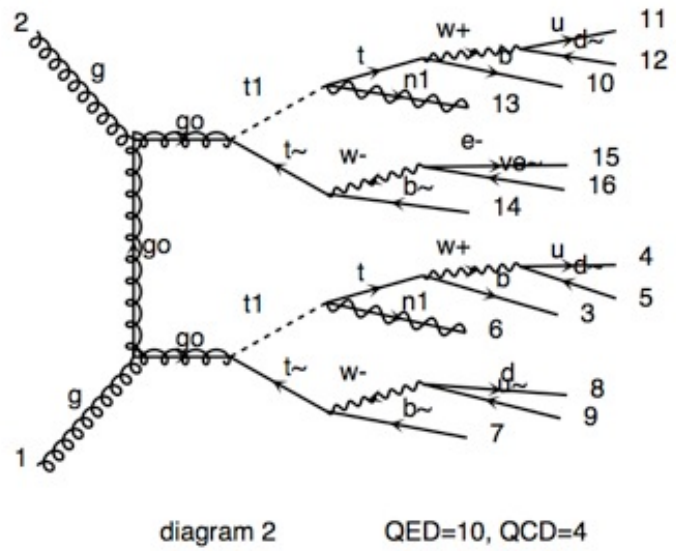
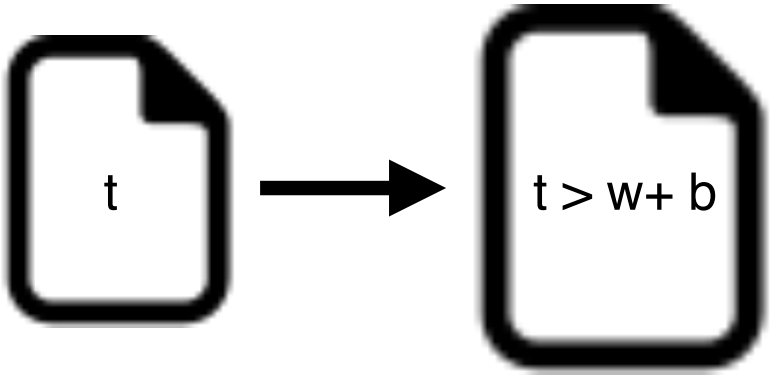


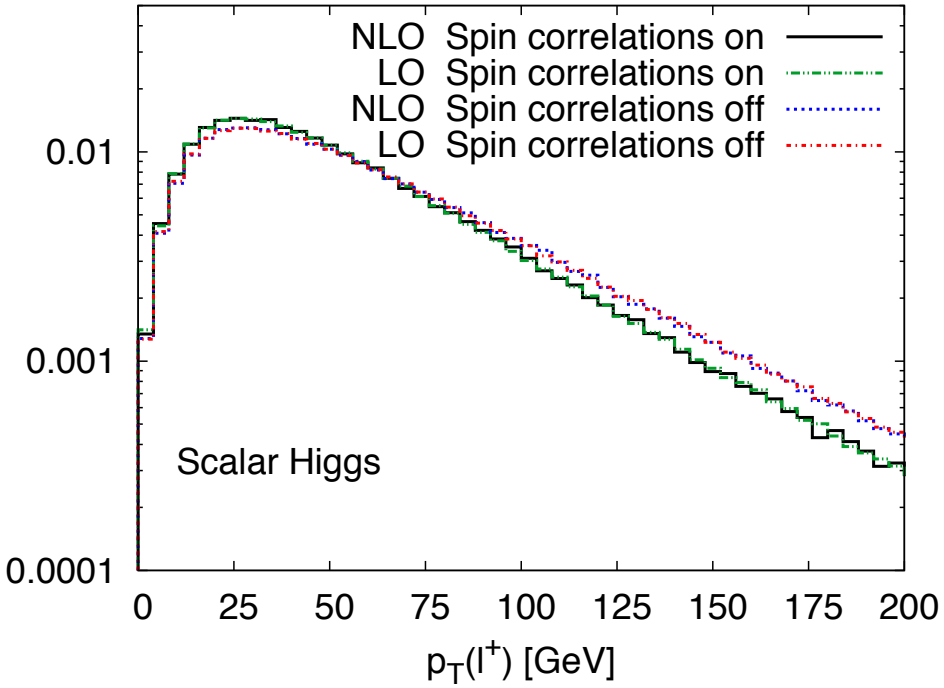
very long
decay chains possible to simulate
directly in MadGraph!

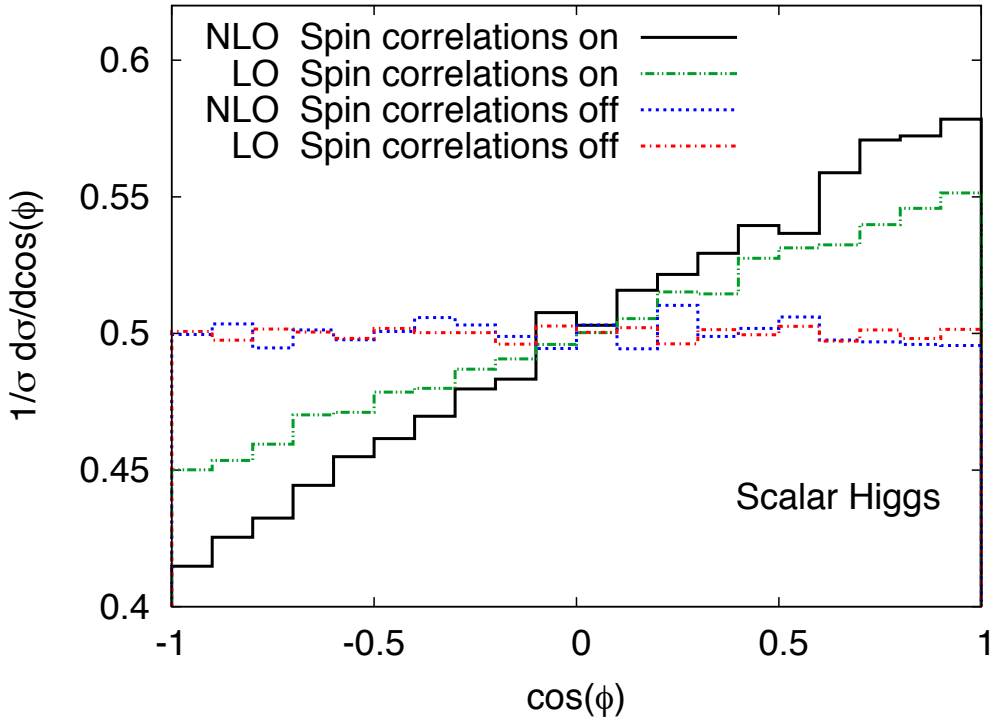
- Full spin-correlation
- Off-shell effects (up to cut-off)
- NWA not used for the cross-section

MadSpin

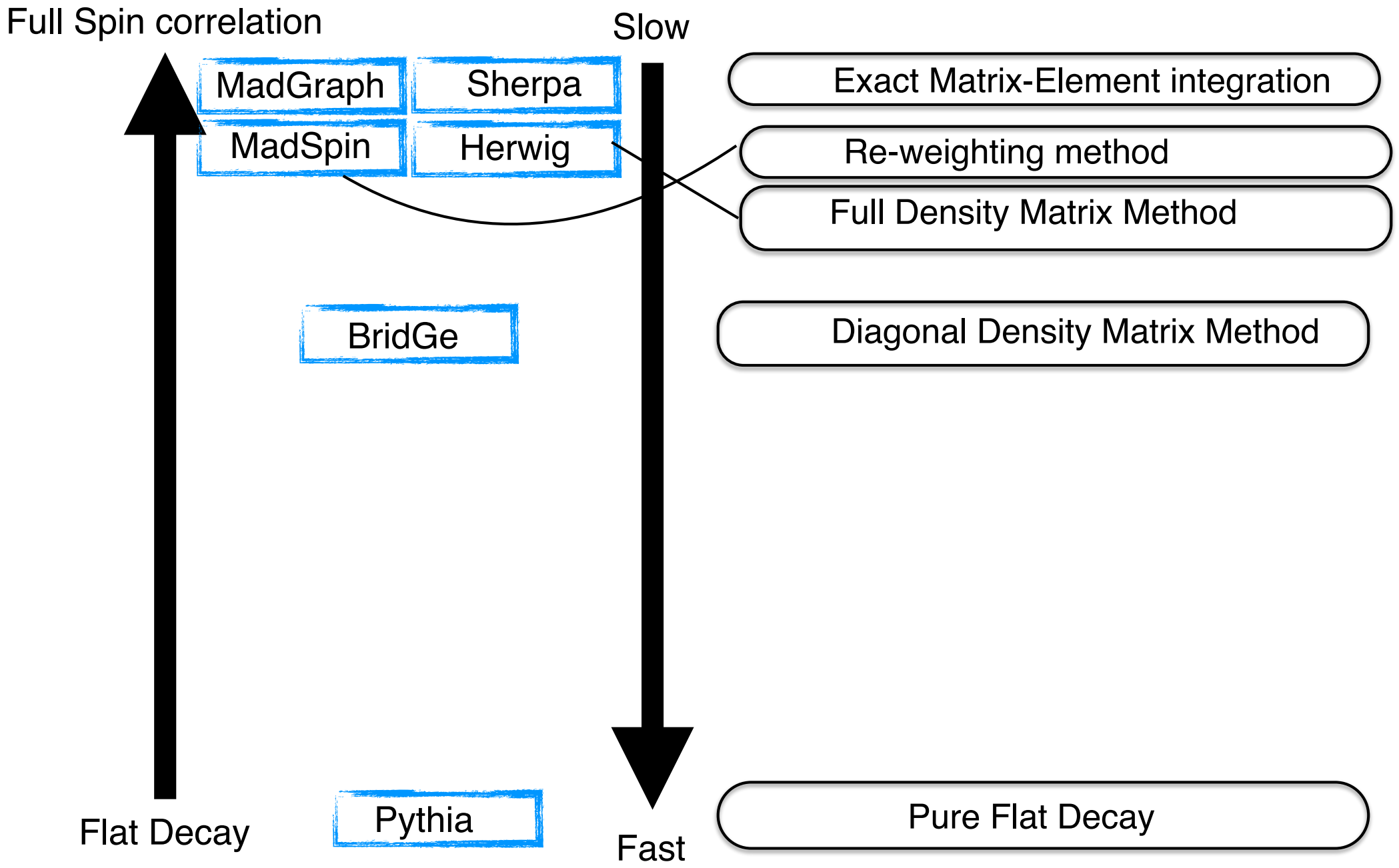
Decay as post-processing
- Independently of event generation
- But same accuracy (spin-correlation)
- Use NWA for cross-section







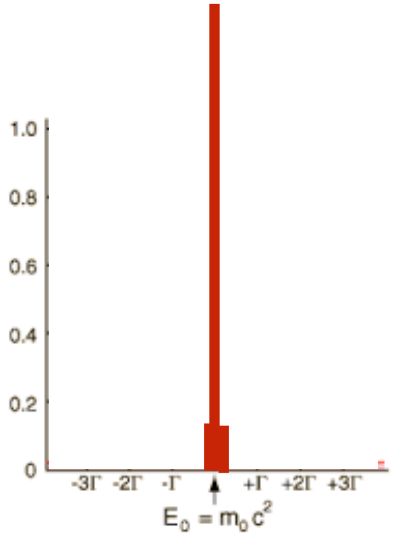
Spin-correlation



Very small width

$$\Gamma < 10^{-8} M$$

- Slows down the code
- Can lead to numerical instability



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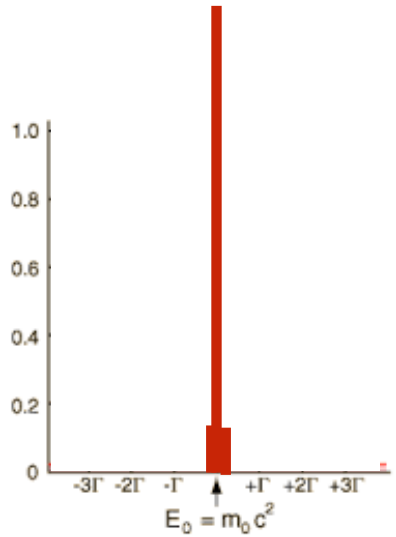
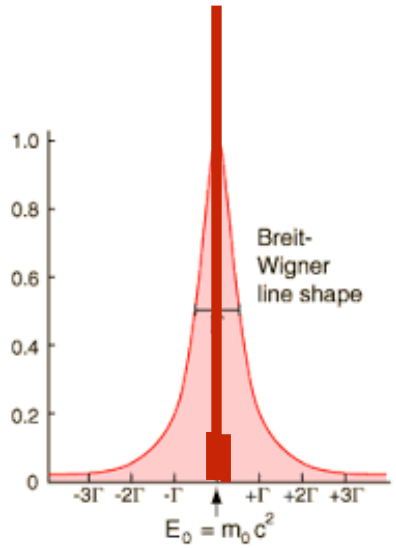


Solution

- Use a Fake-Width for the evaluation of the matrix-element
- Correct cross-section according to NWA formula $\frac{\Gamma_{fake}}{\Gamma_{true}}$



To Remember

- BSM only occurs at High Energy
  - ➡ But need correct understanding of the Low Energy to simulate events
- Matrix-Element evaluation
  - ➡ Numeric method faster than analytical one
- Narrow-width approximation
  - ➡ Know/check your hyppothesis
  - ➡ Careful about the width