Higgs Sector Spectroscopy

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Mainz
Germany

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  - Bound states?
  - Simplify: Just Higgs and W/Z

The Higgs sector as a gauge theory

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$$L = -\frac{1}{4} W^a_{\mu\nu} W^{\mu\nu}_a$$

$$W^a_{\mu\nu} = \partial_\mu W^a_\nu - \partial_\nu W^a_\mu$$

- Ws W^a_μ

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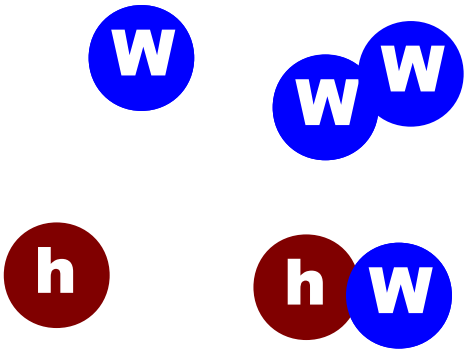

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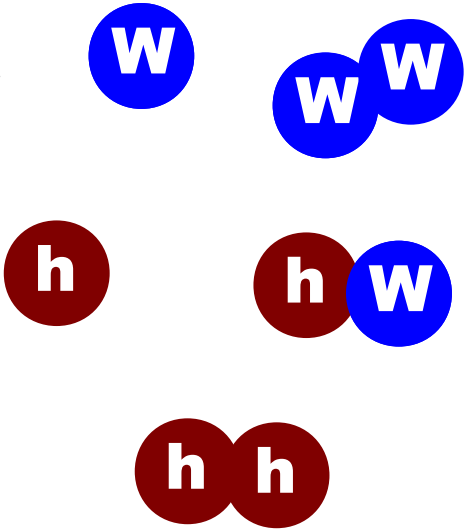

- Ws W^a_μ
- Higgs h_i
- No QED: Ws and Zs are degenerate
- Couplings g, v, λ and some numbers f^{abc} and t_a^{ij}

Symmetries

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- Local SU(2) gauge symmetry
  - Invariant under arbitrary gauge transformations $\phi^a(x)$

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- Global SU(2) Higgs flavor symmetry
  - Acts as right-transformation on the Higgs field only

$$W^a_\mu \to W^a_\mu \qquad h_i \to h_i + a^{ij} h_j + b^{ij} h_j^*$$

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- Non-perturbative: Simulate Higgs+W [Maas'12]

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- Non-perturbative: Simulate Higgs+W [Maas'12]
  - Physical W/Higgs mass ratio
    - Good comparison to perturbation theory
    - Error at least of order W-Z mass splitting
  - Close to the transition to QCD-like behavior
- Different (bare) parameters: Talk of Mark Wurtz
  - Also good agreement to standard model

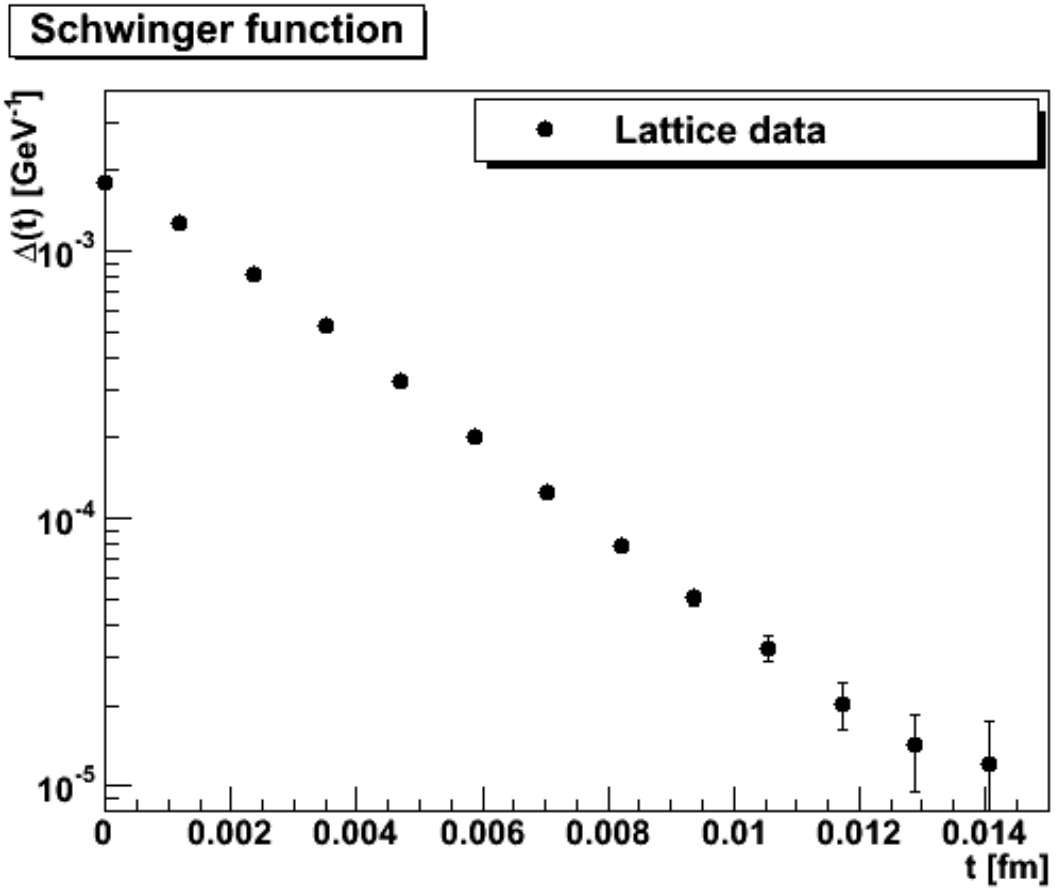
W boson

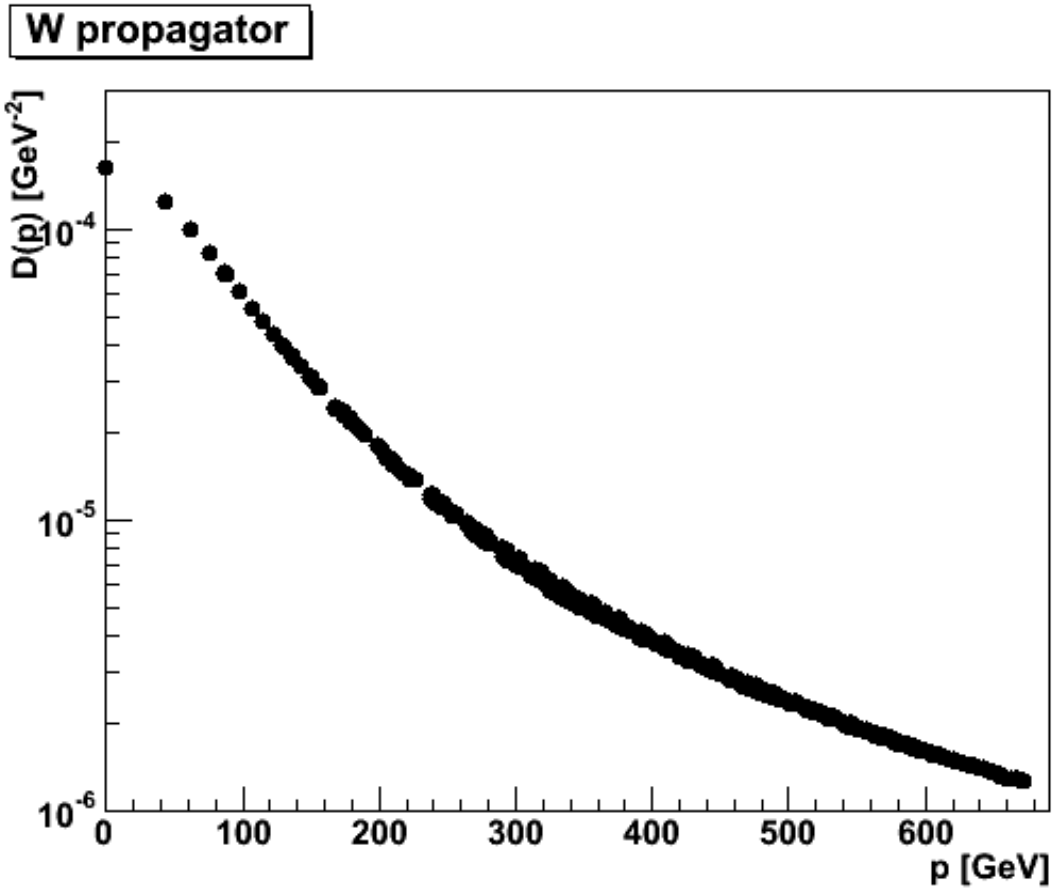
[Maas'11,'12]

- Renormalization scheme with
  $D(\mu)=1/(\mu^2+(80.375\,GeV)^2)\wedge\mu=80.375\,GeV$

W boson

[Maas'11,'12]





- Renormalization scheme with
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- Massive-like propagator
- Dynamical mass generation

W boson

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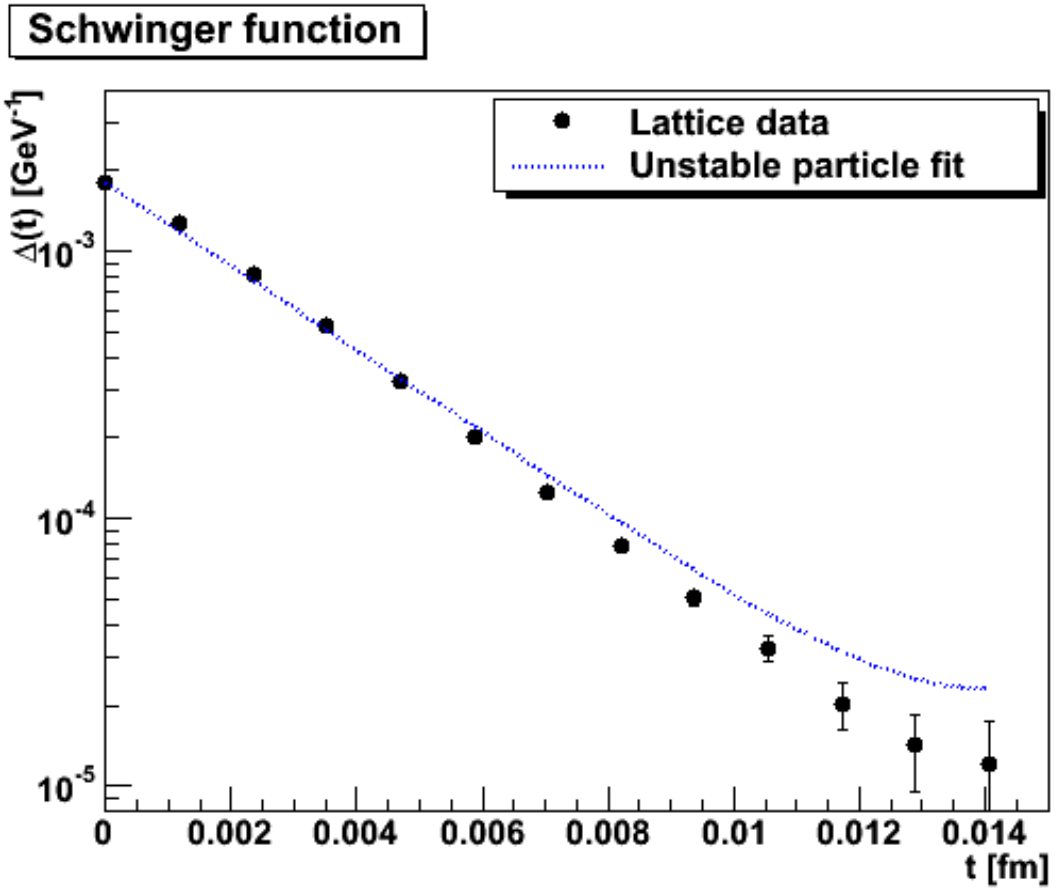

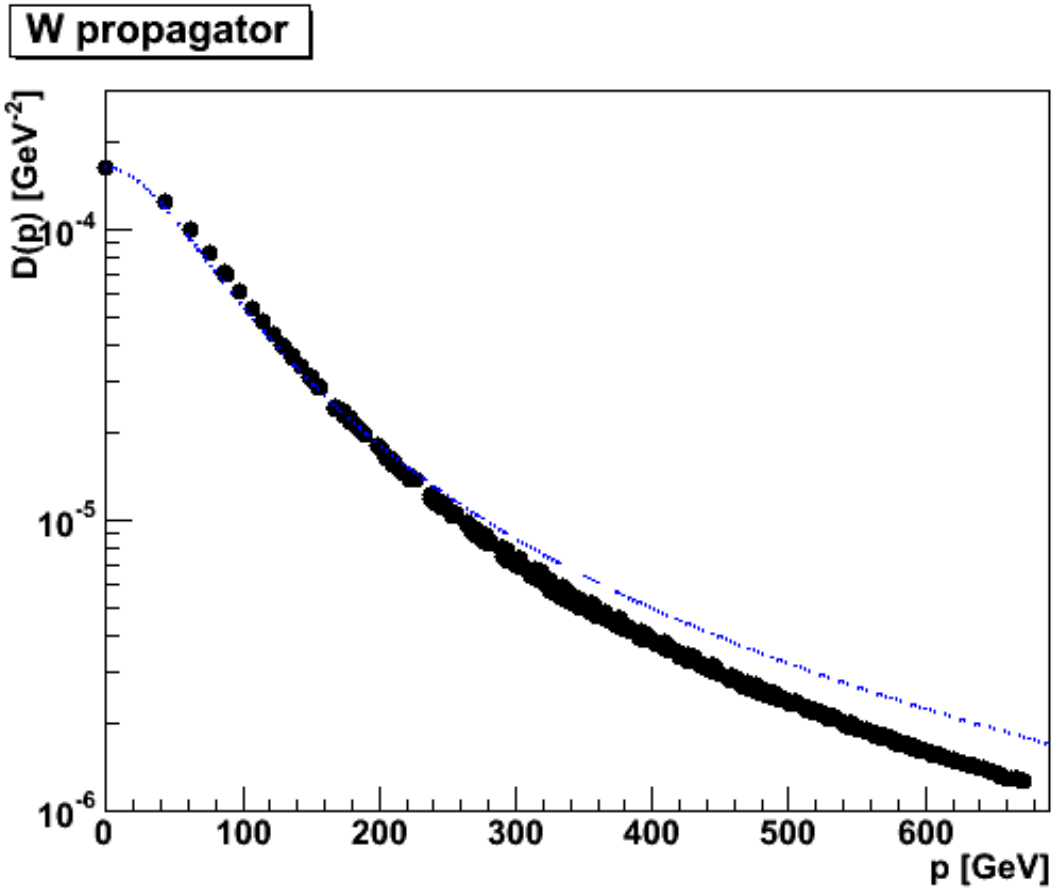

Fit type	Mass	Remark
Unstable	71.8(1) GeV	Width: 2.1(4) GeV

W boson

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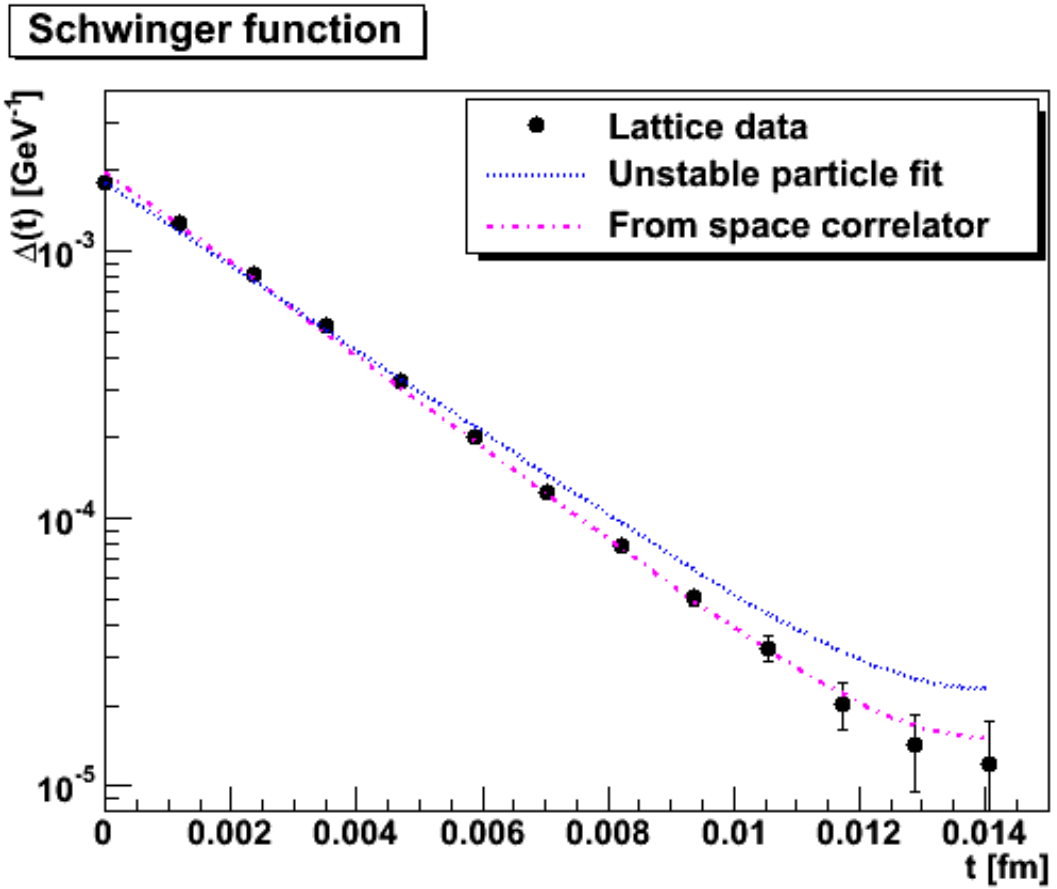

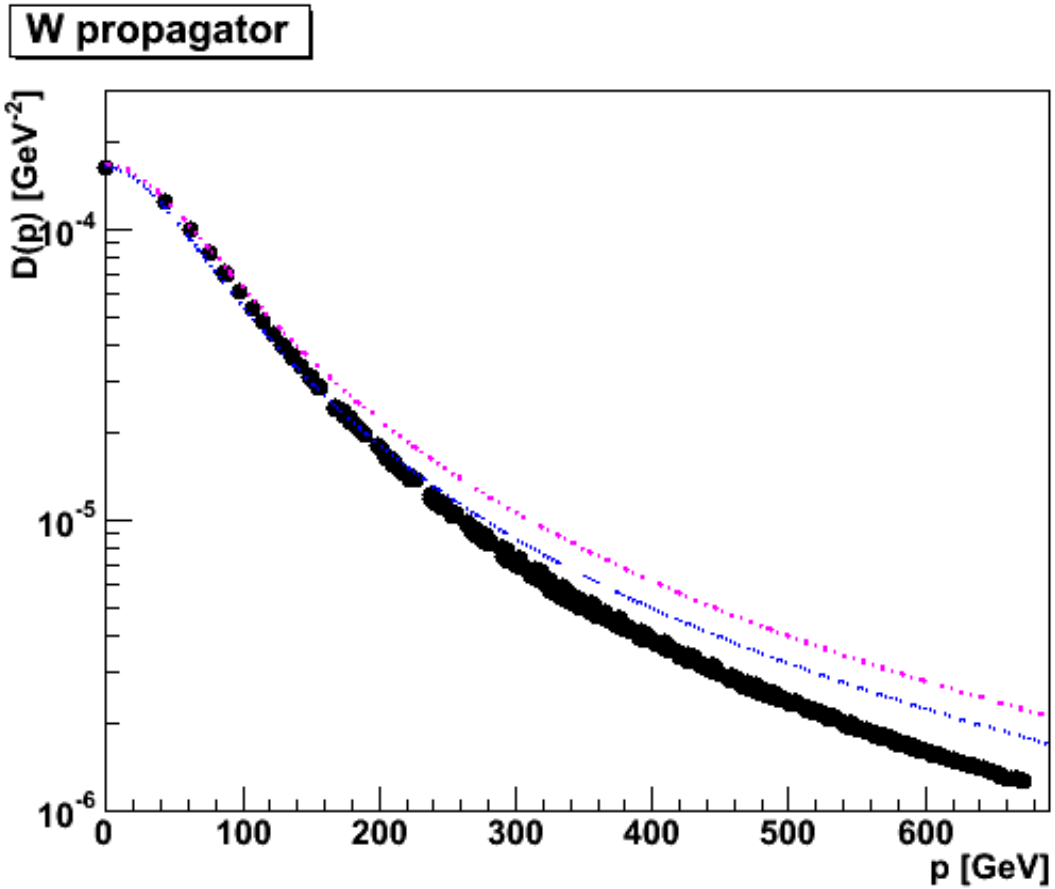

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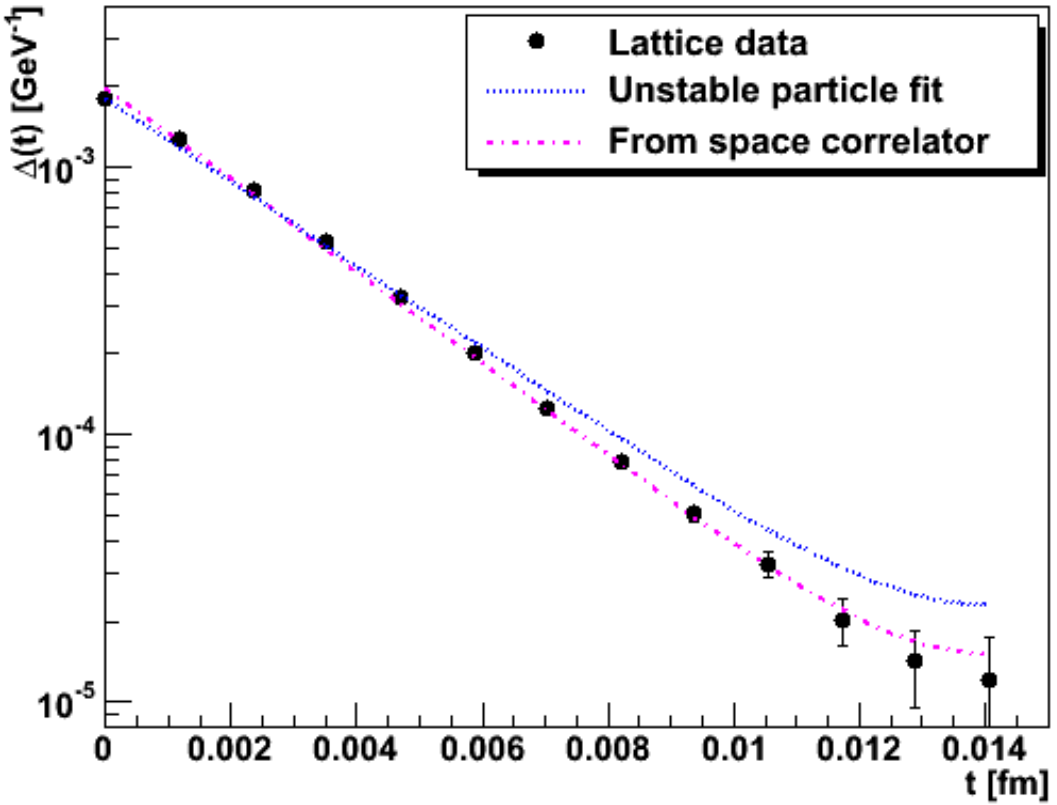
Configuration space	79(4) GeV	

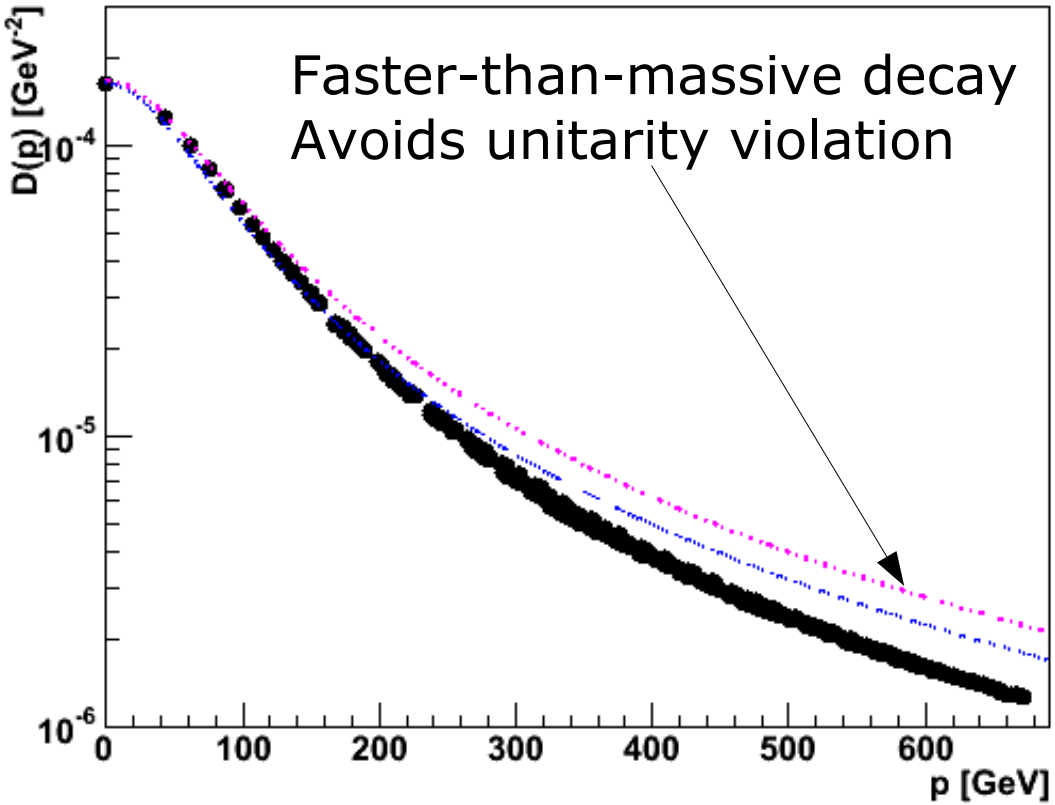
W boson

[Maas'11,'12]

Schwinger function



W propagator



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Higgs boson

[Maas'11,'12]

- Renormalization scheme with

$$D(\mu) = D^{tl}(\mu)$$
$$D(\mu)' = D^{tl}(\mu)'$$
$$D^{tl}(p) = 1/(p^2 + (123\,GeV)^2)$$
$$\mu = 123\,GeV$$

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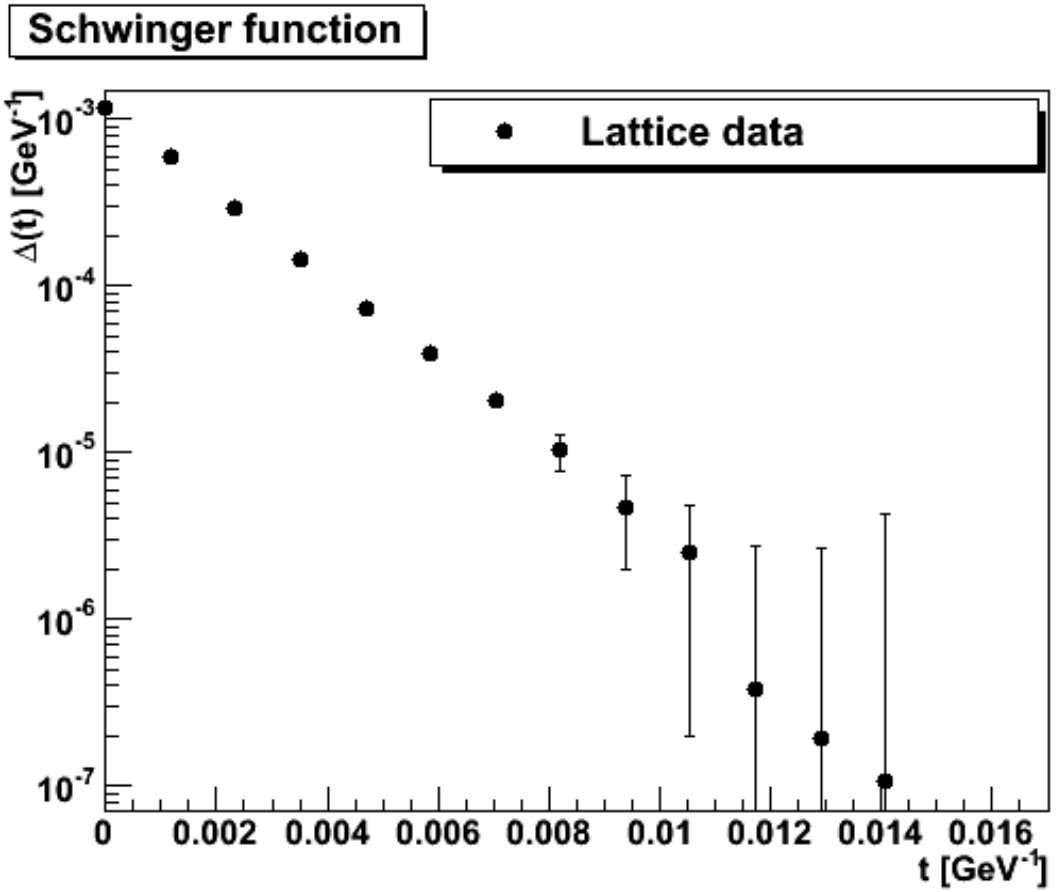
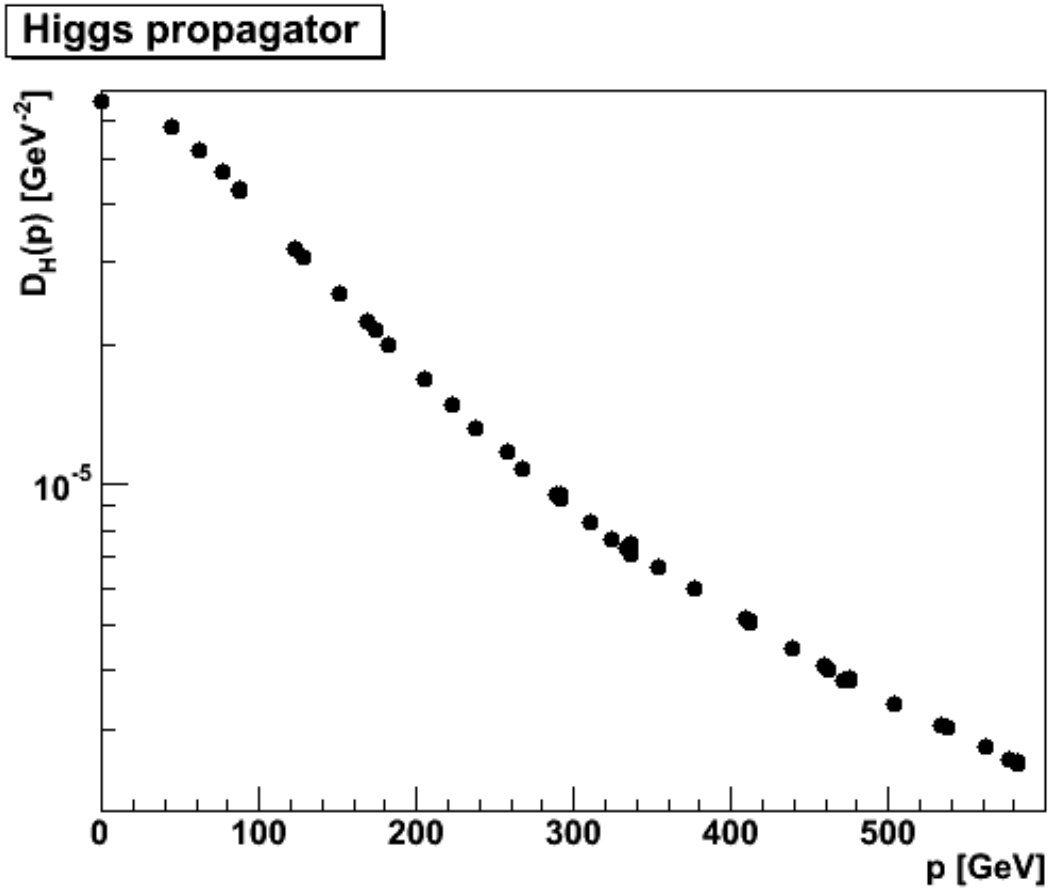


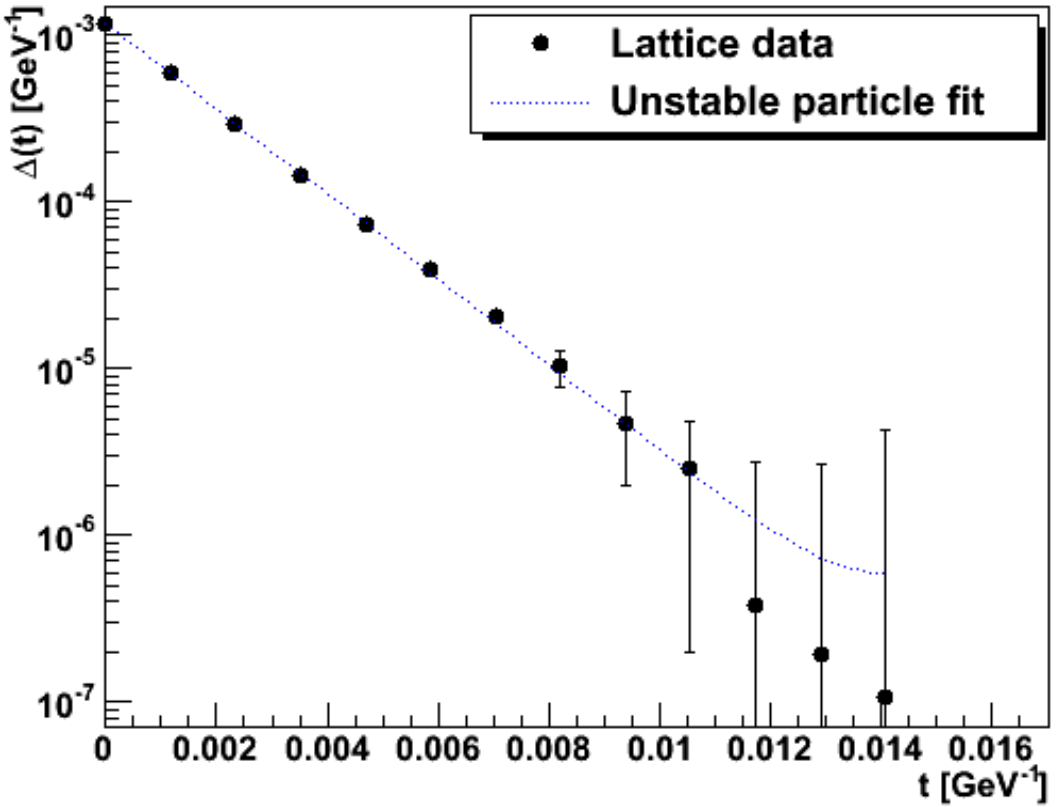


- Normal propagator – normal mass

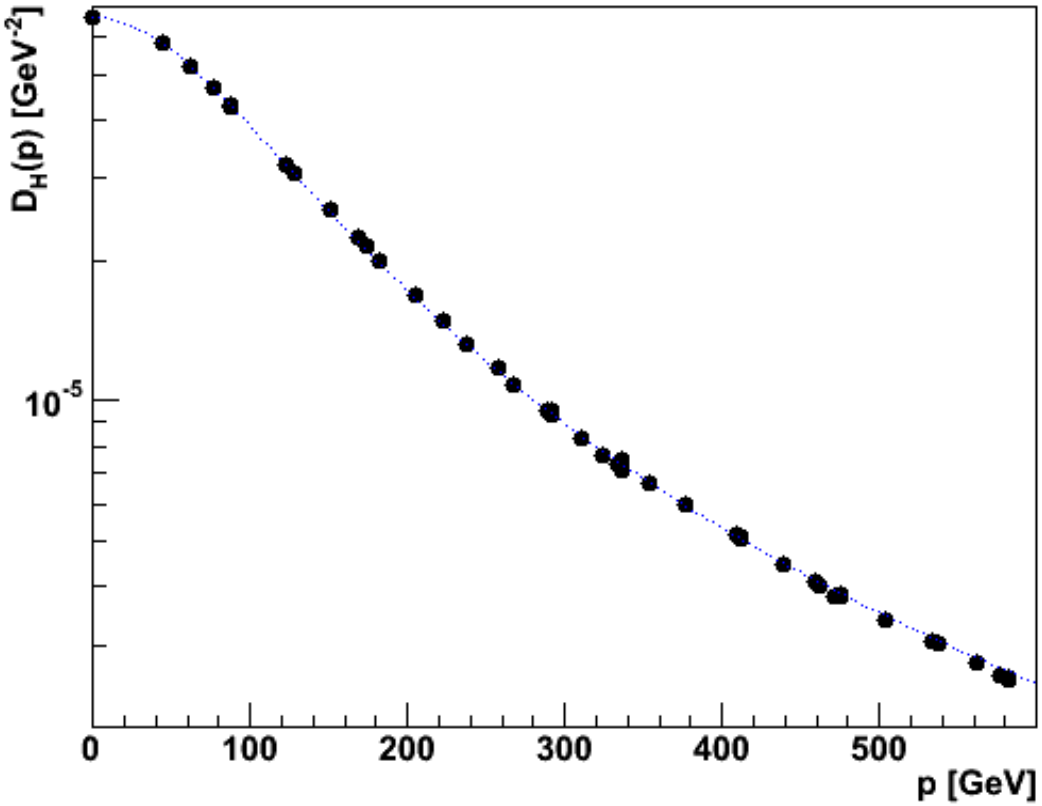
Higgs boson

[Maas'11,'12]

Schwinger function



Higgs propagator

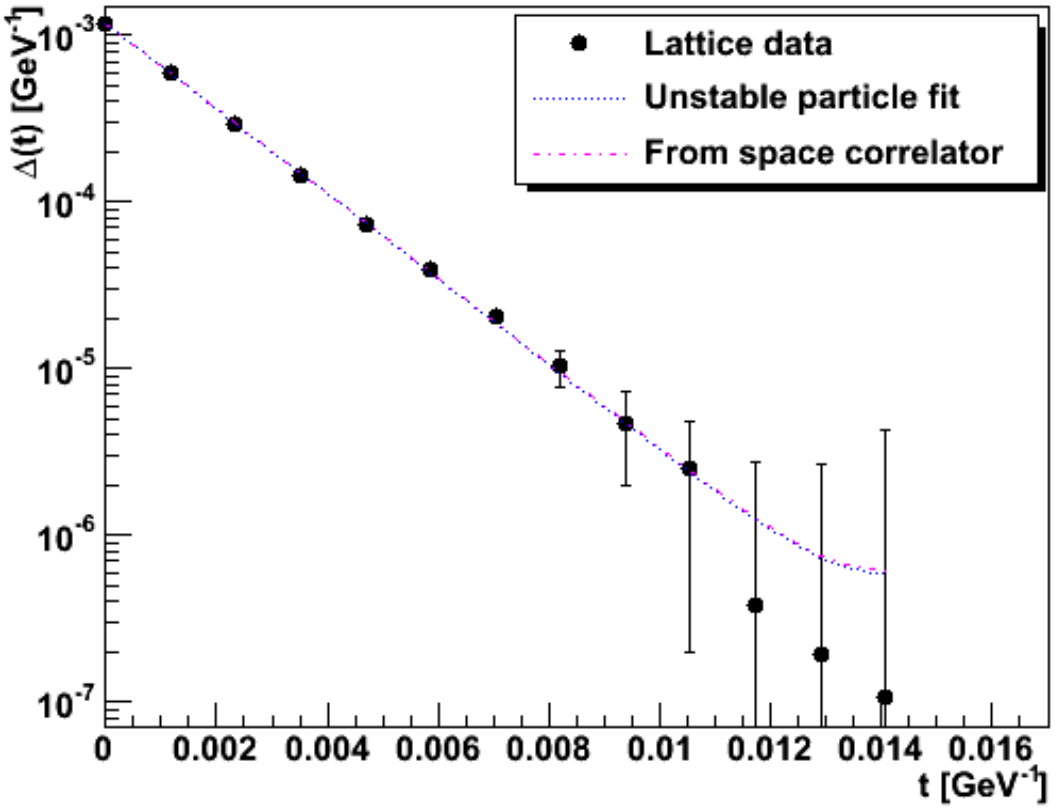


Fit type	Pole mass	Remark
Unstable	119(2) GeV	Width 1(1) GeV

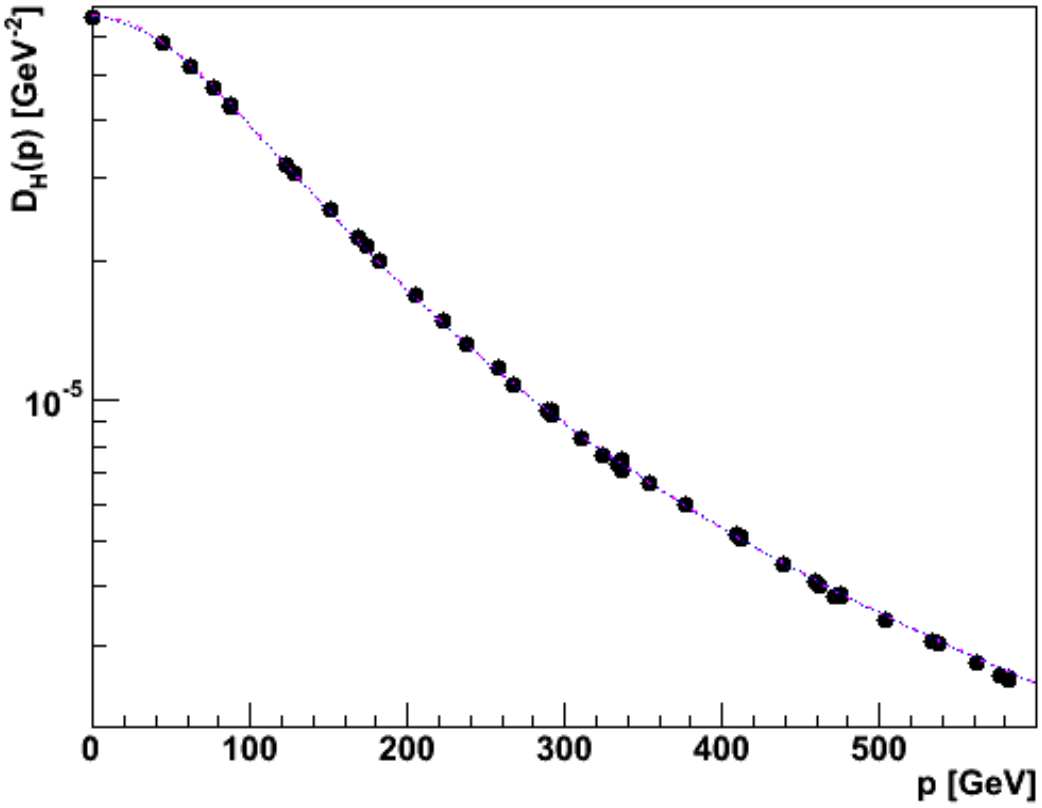
Higgs boson

[Maas'11,'12]

Schwinger function



Higgs propagator



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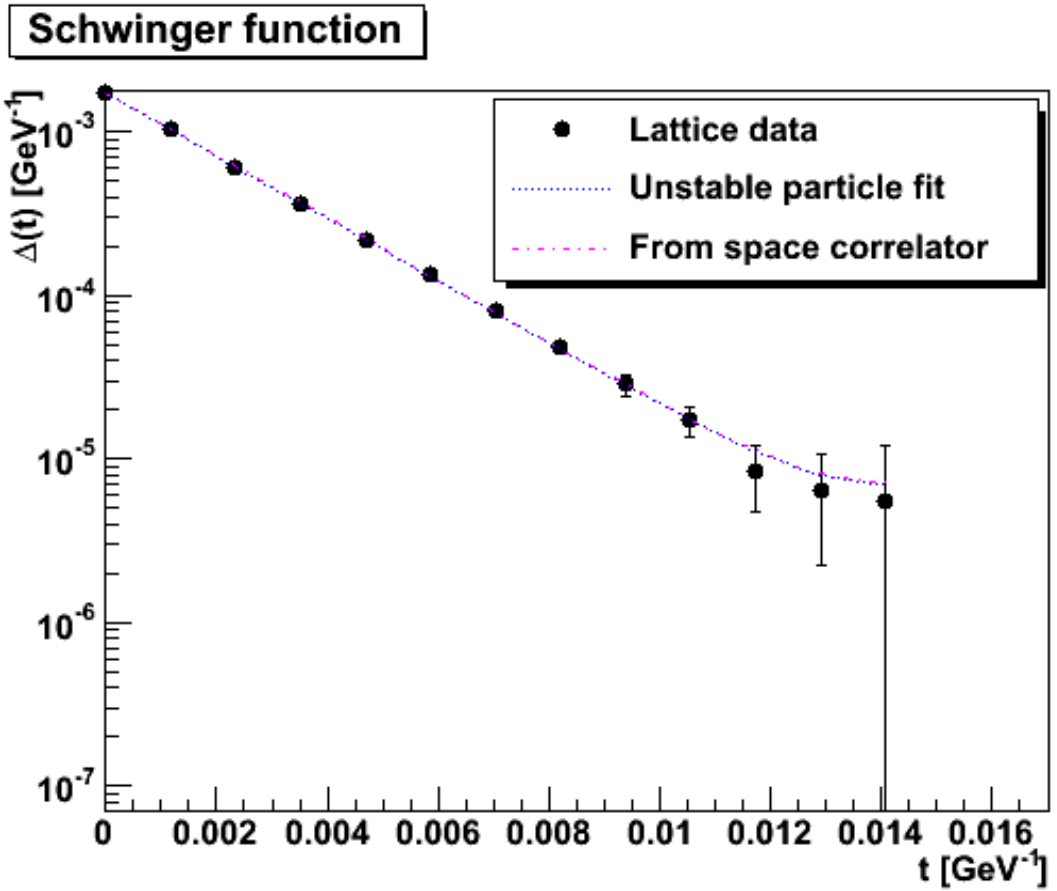
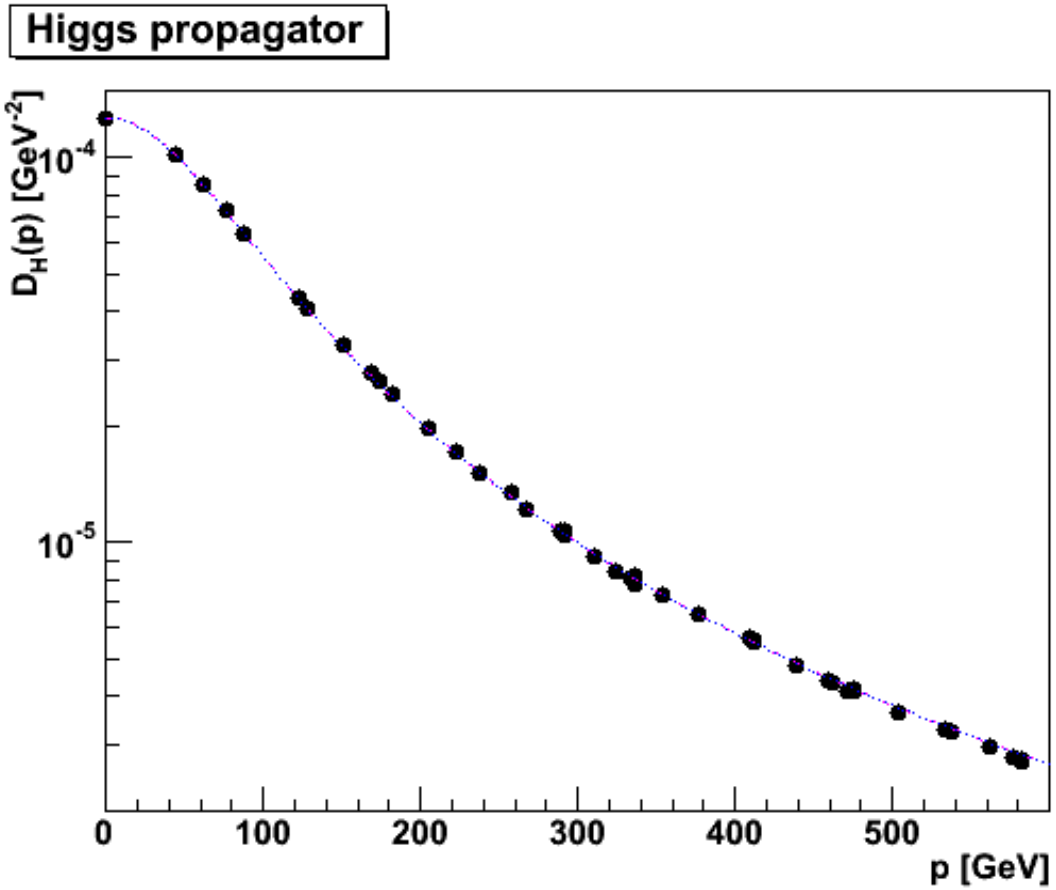
Unstable	119(2) GeV	Width 1(1) GeV
Configuration space	118(1) GeV	

Scheme dependent!

[Maas'11,'12]





Fit type	Pole mass	Remark
Unstable	86(1) GeV	Width 1(1) GeV
Configuration space	87(1) GeV	

- Different renormalization scheme with mass 90 GeV

Physical states

[Fröhlich et al.'80,
't Hooft'80,
Bank et al.'79]

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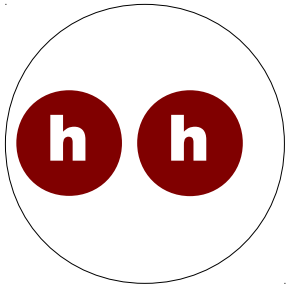

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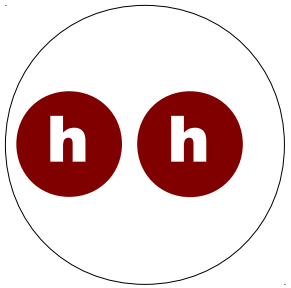

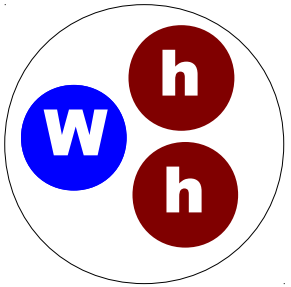

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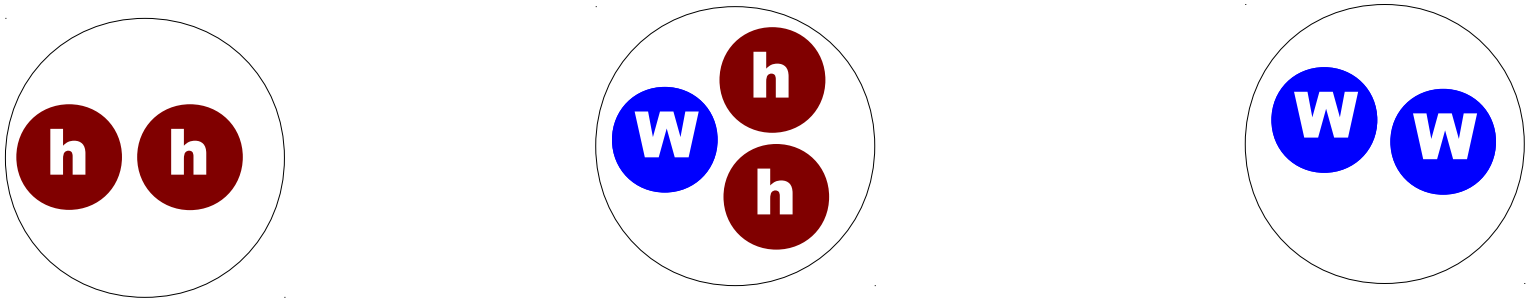

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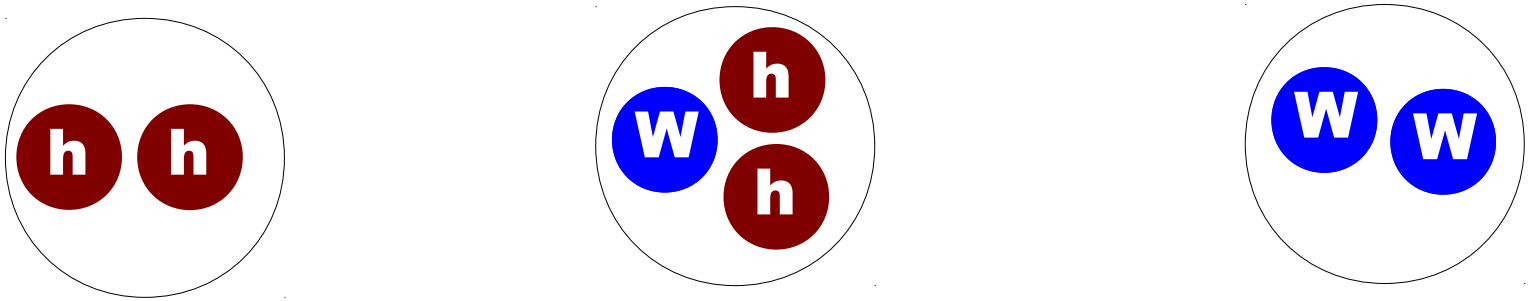
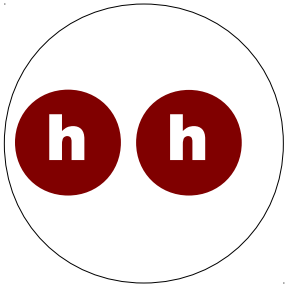


- Lattice literature: Higgs, W, Gaugeball

Higgsonium

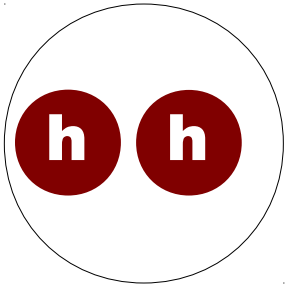
[Maas'12,Maas et al.'12]



- Simpelst 0^{++} bound state $h^{+}(x)h(x)$

Higgsonium

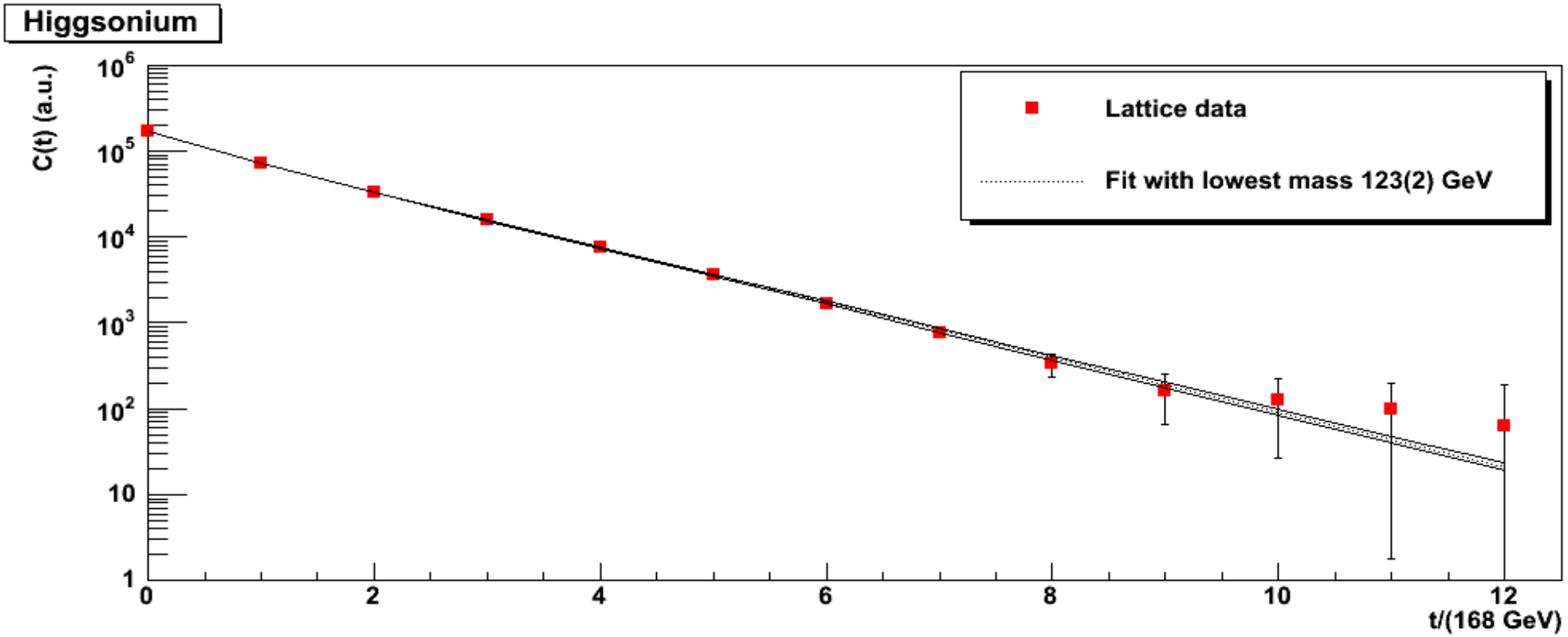
[Maas'12,Maas et al.'12]



- Simpelst 0^{++} bound state $h^{+}(x)h(x)$
  - Same quantum numbers as the Higgs
    - No weak or flavor charge

Higgsonium

[Maas'12,Maas et al.'12]



- Simpelst 0^{++} bound state $h^+(x)h(x)$
  - Same quantum numbers as the Higgs
    - No weak or flavor charge
  - Mass is about 123 GeV

Mass relation - Higgs

- Higgsonium: 123 GeV

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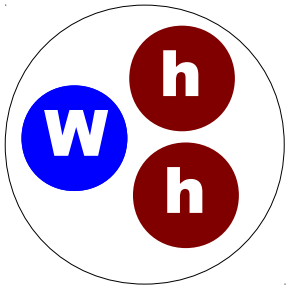
Isovector-vector state

[Maas'12,Maas et al.'12]



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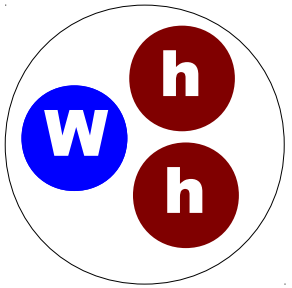

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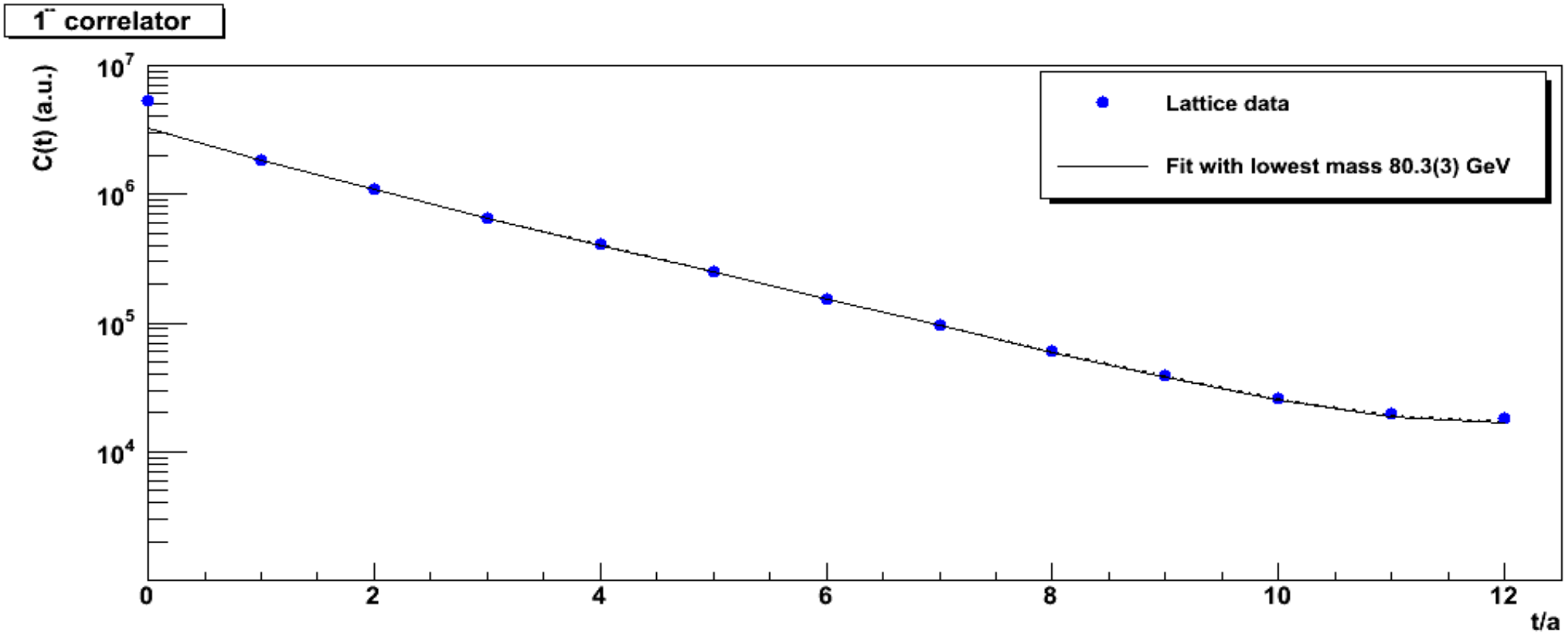

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[Fröhlich et al.'80
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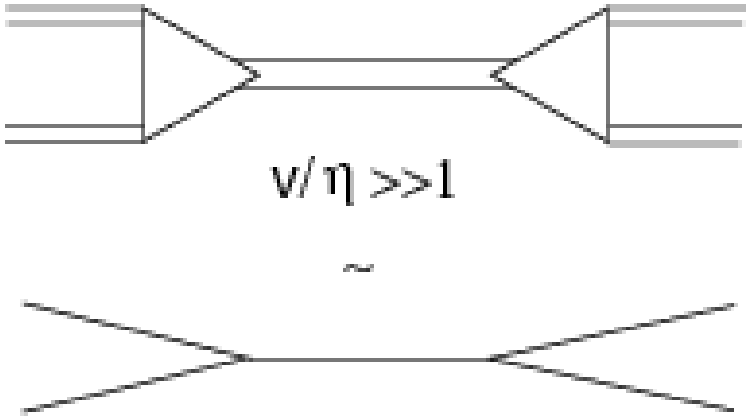

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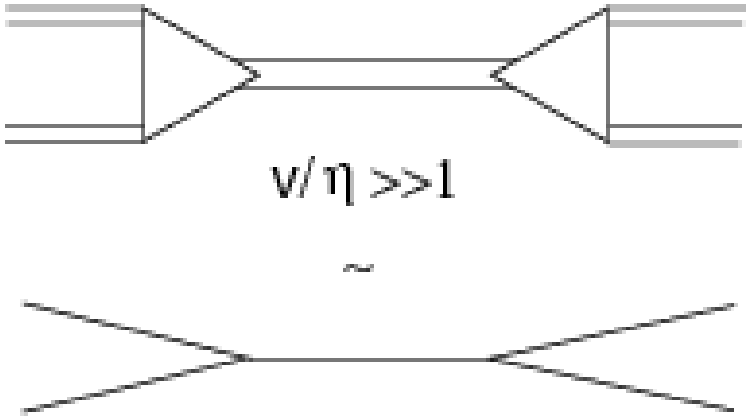

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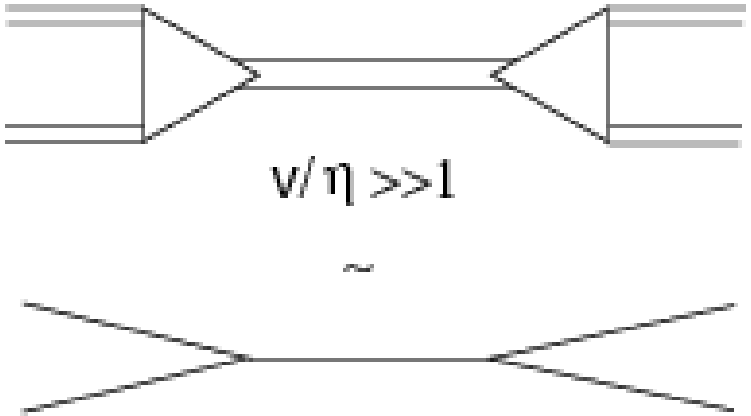

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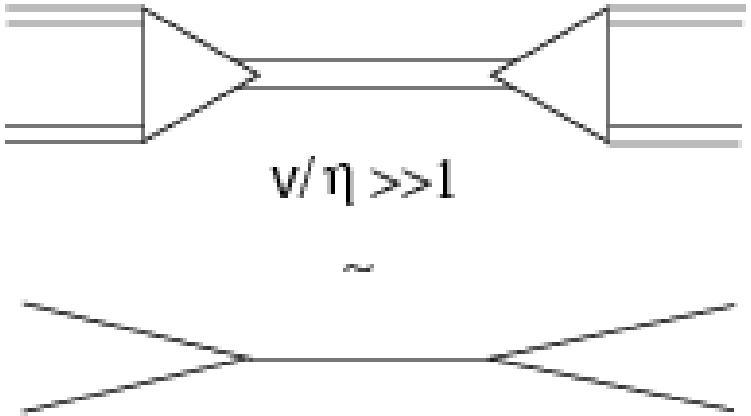

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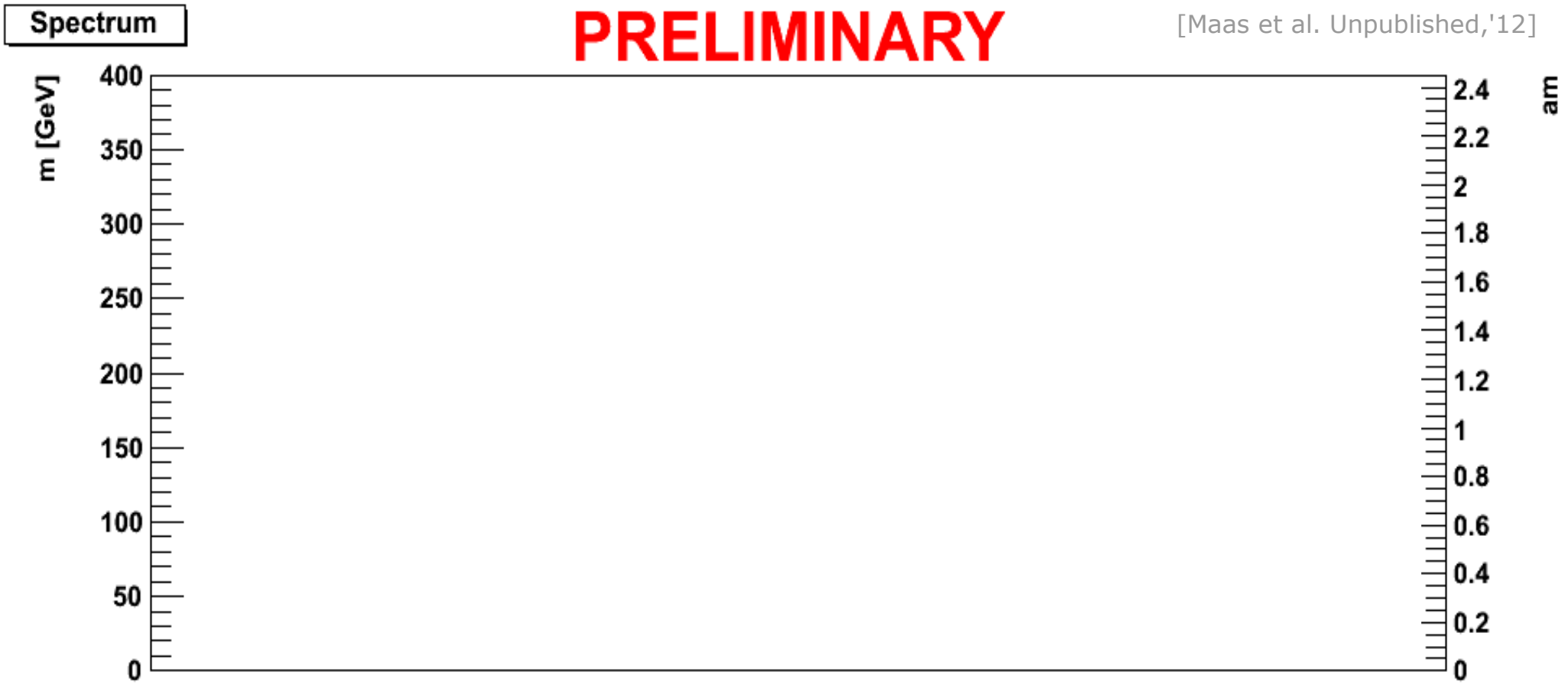

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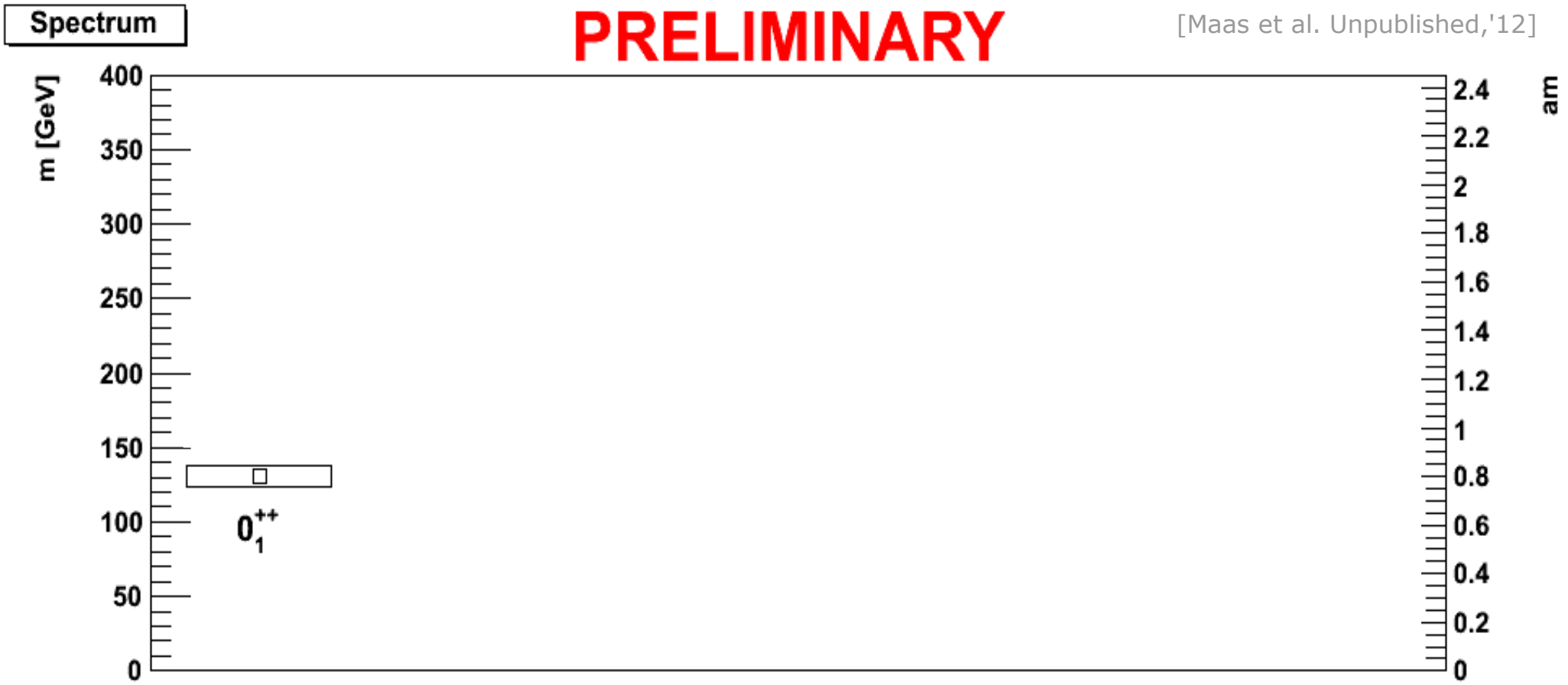

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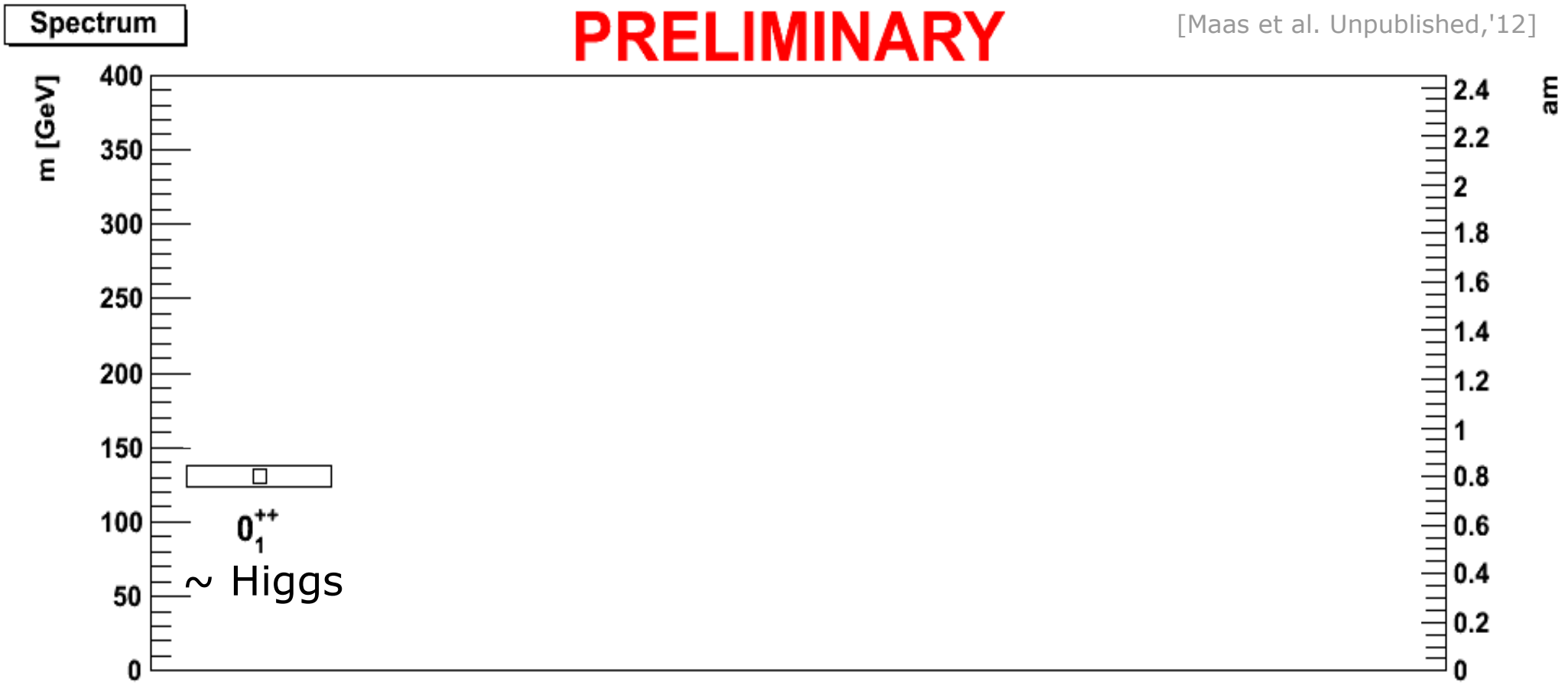

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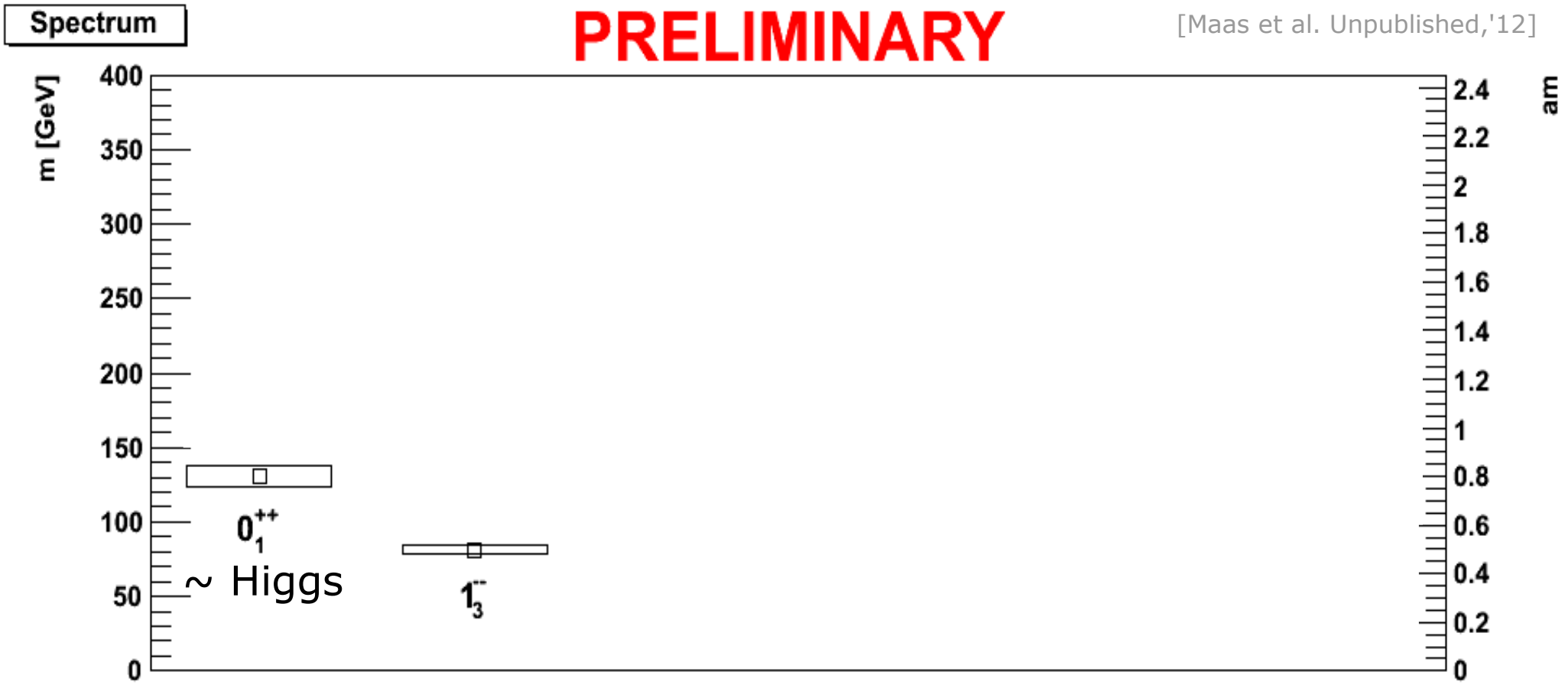

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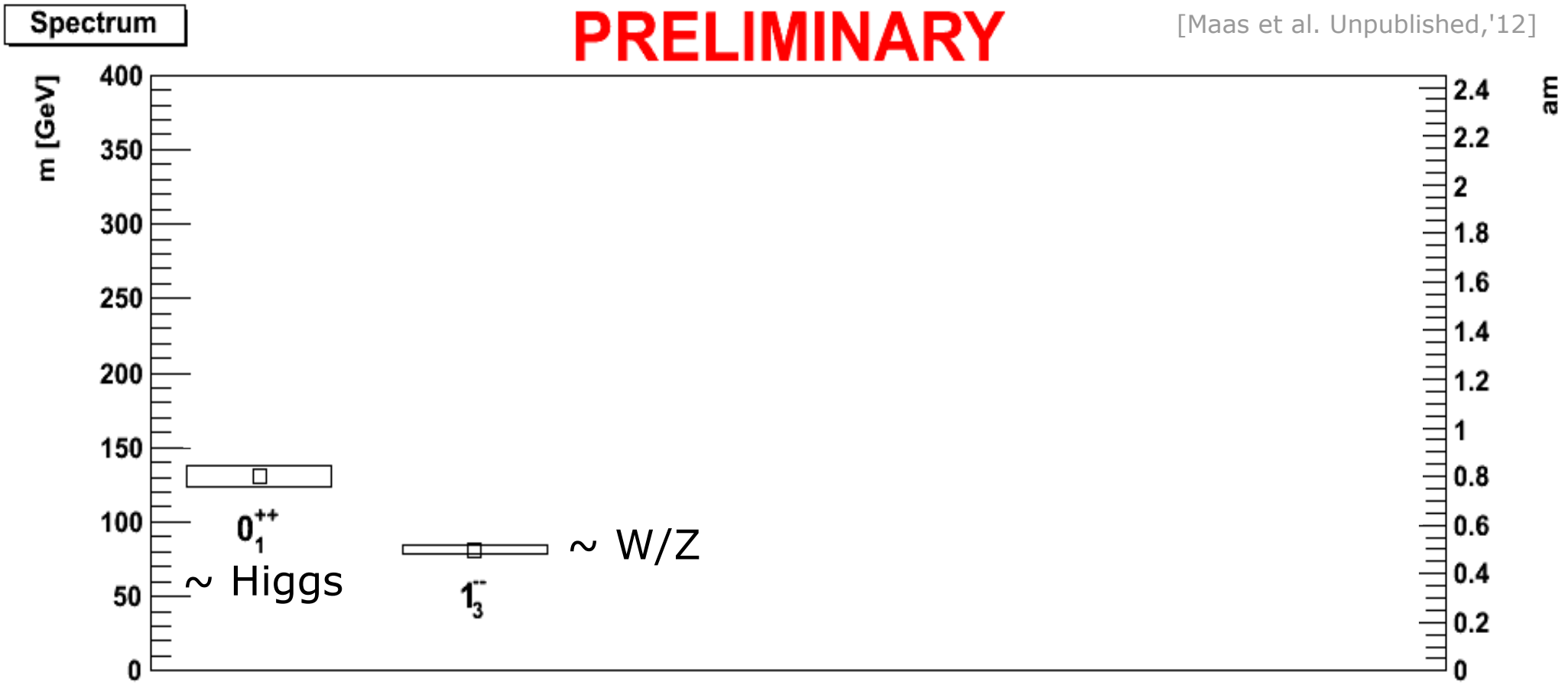

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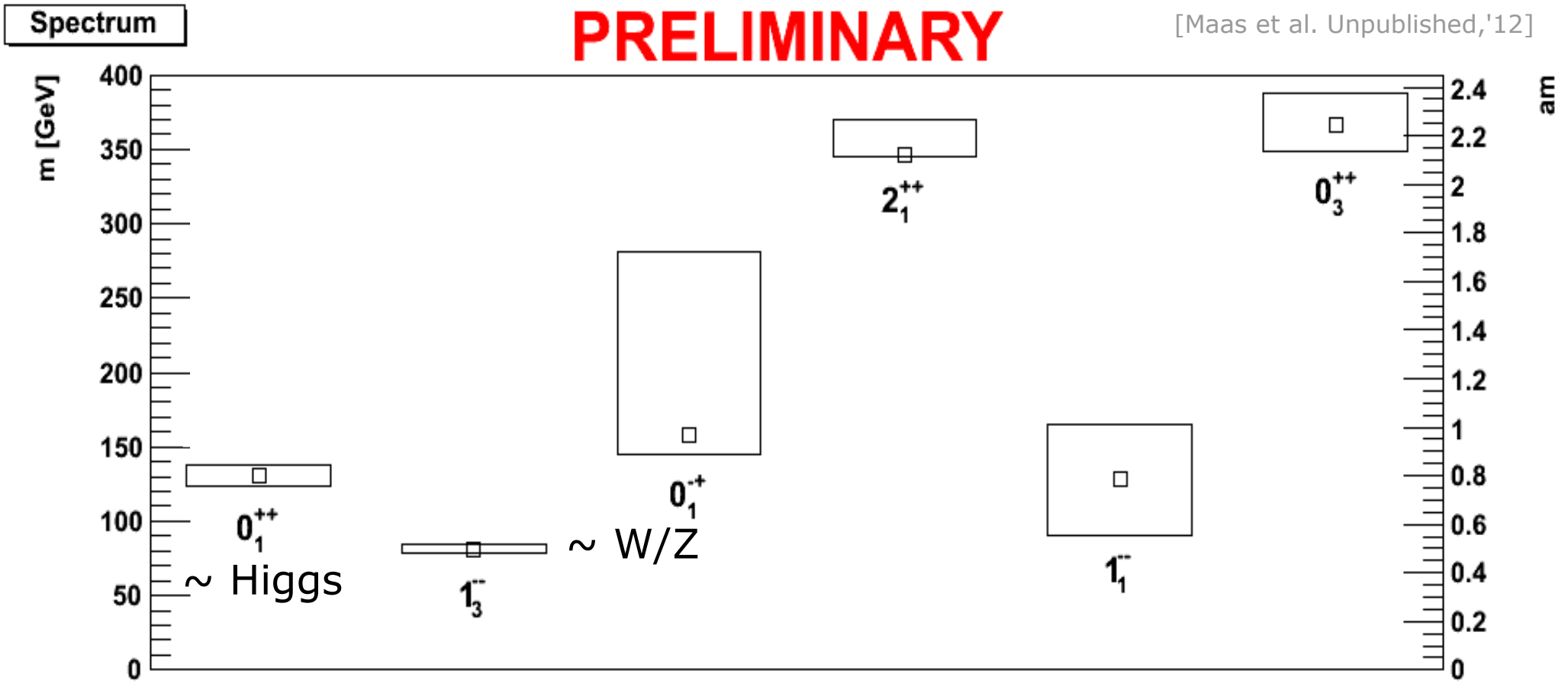

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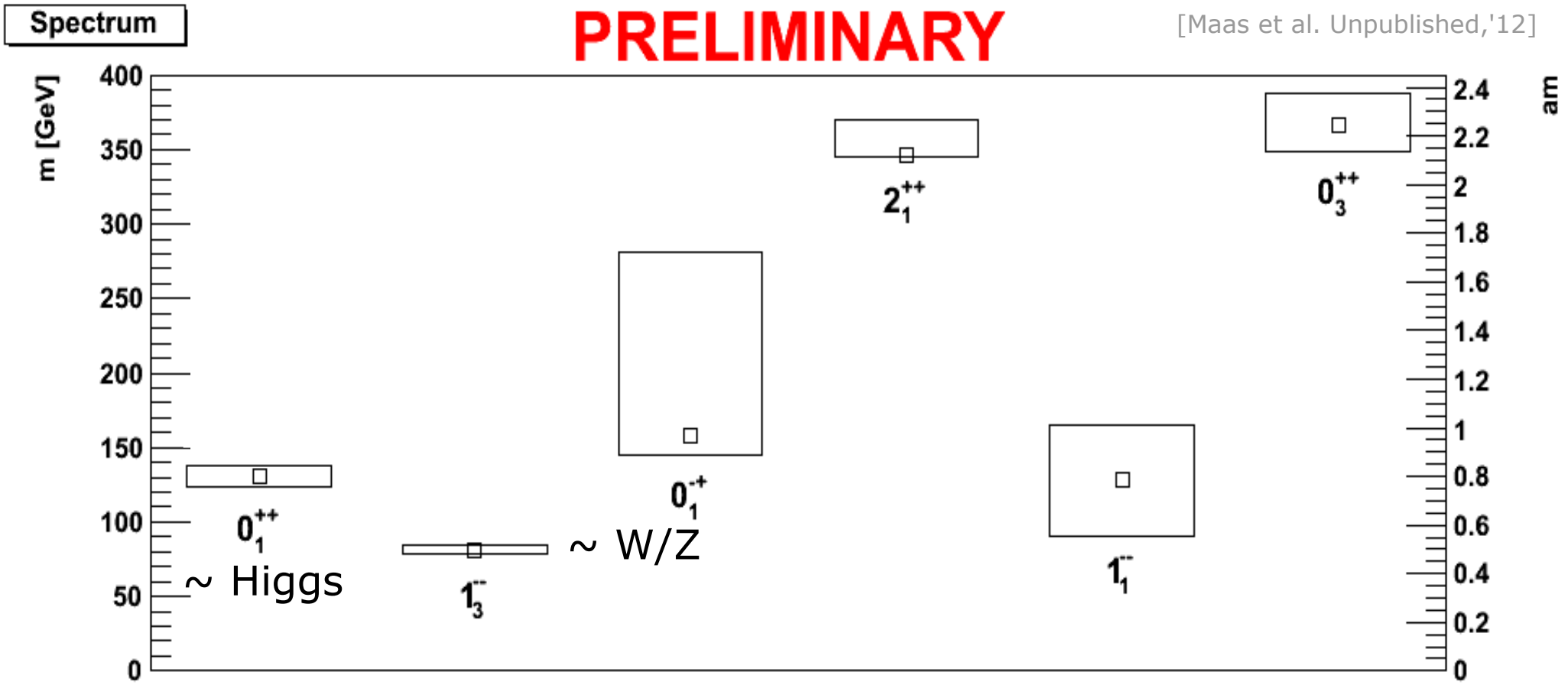

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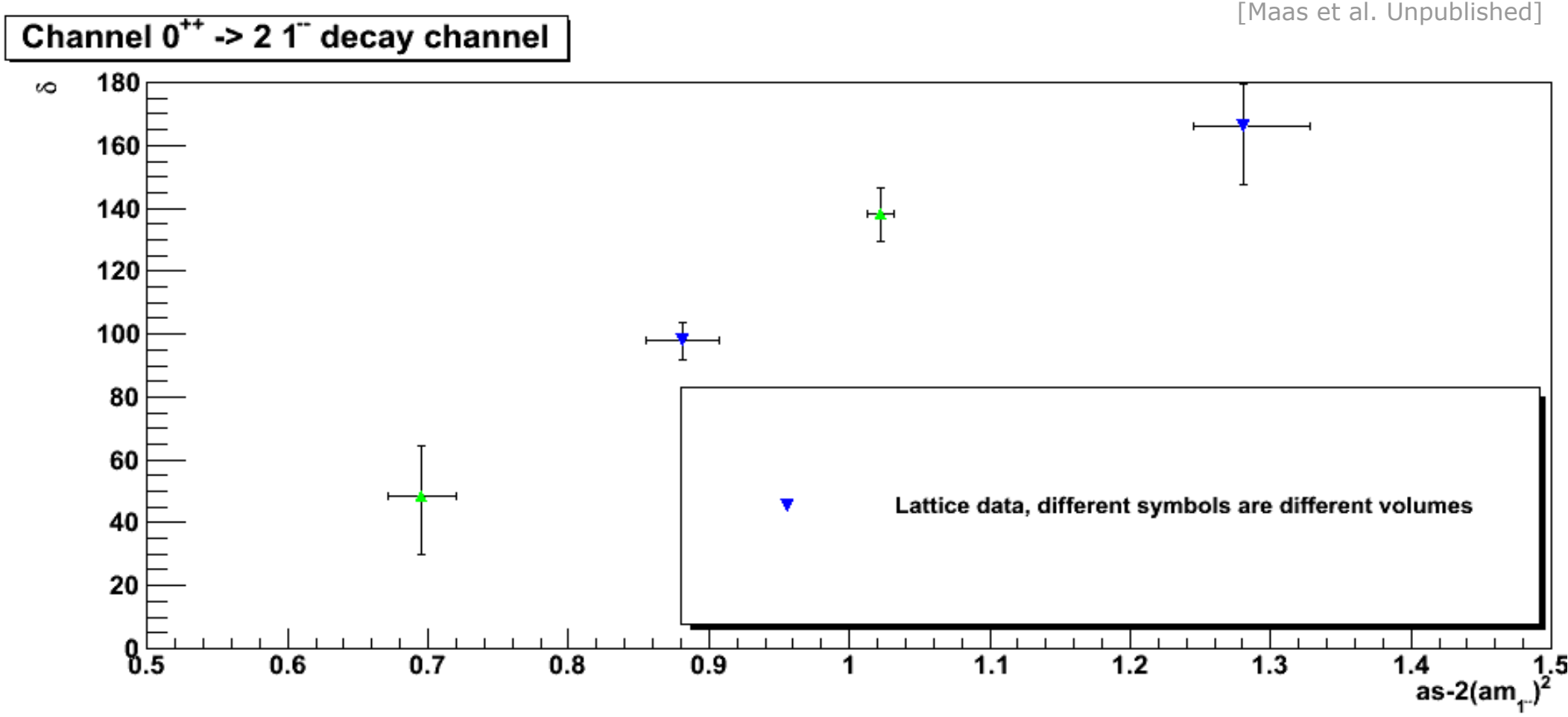

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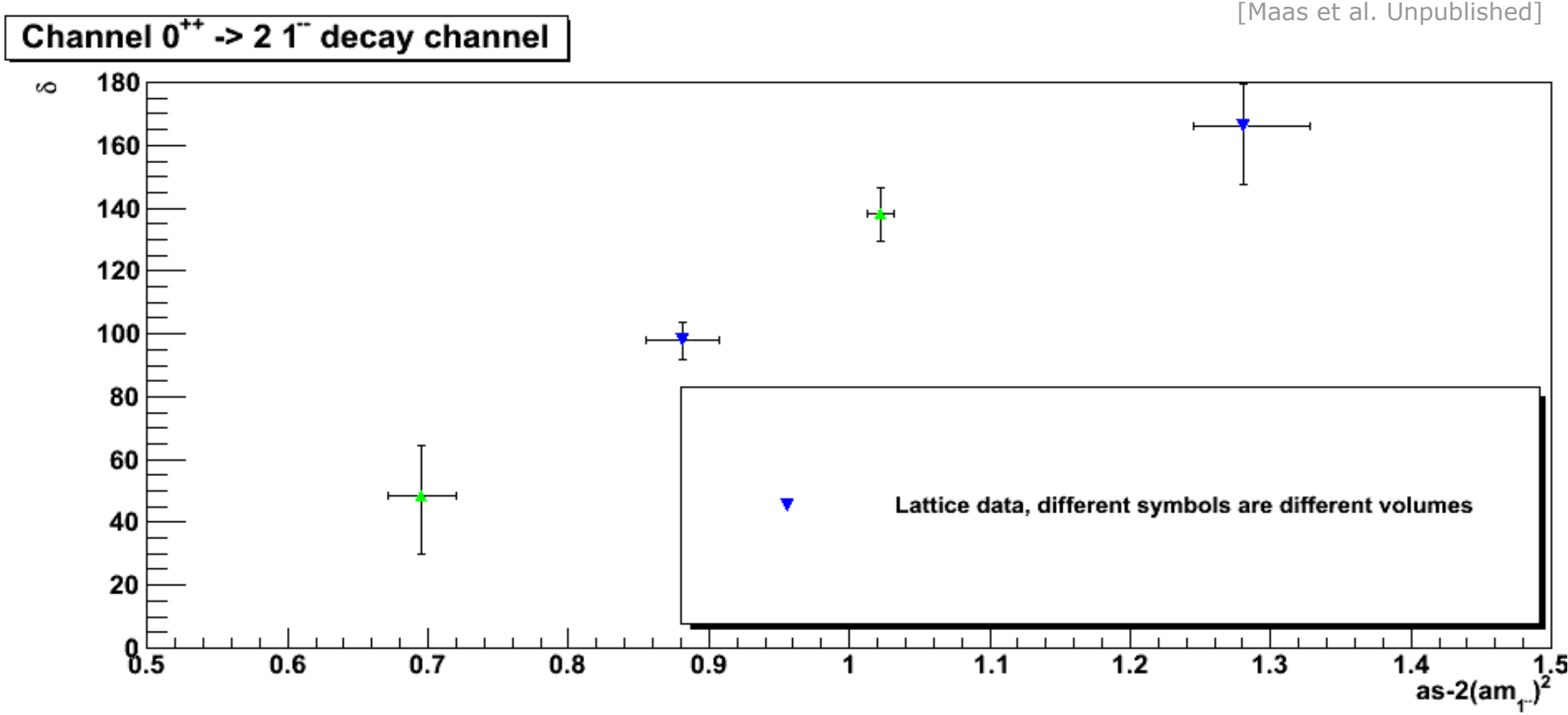

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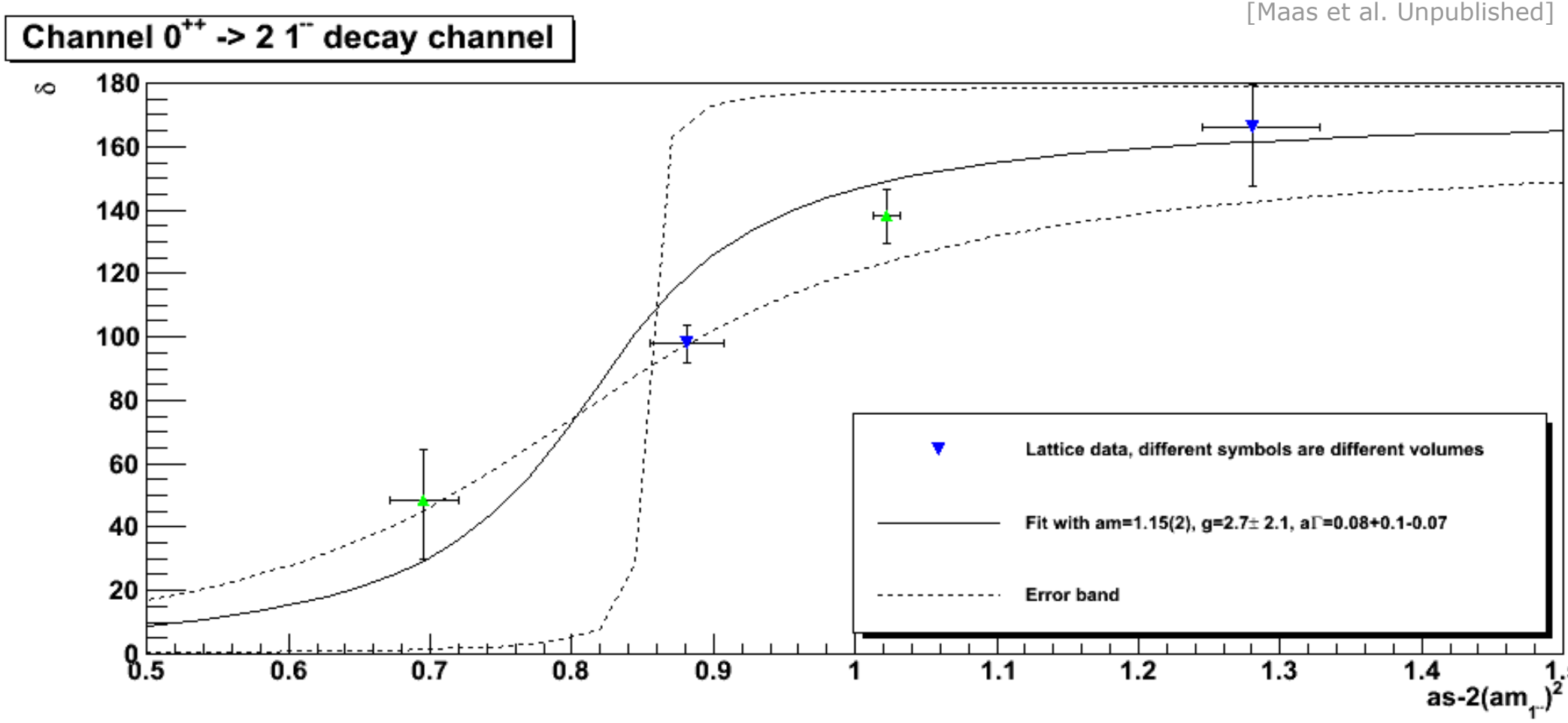

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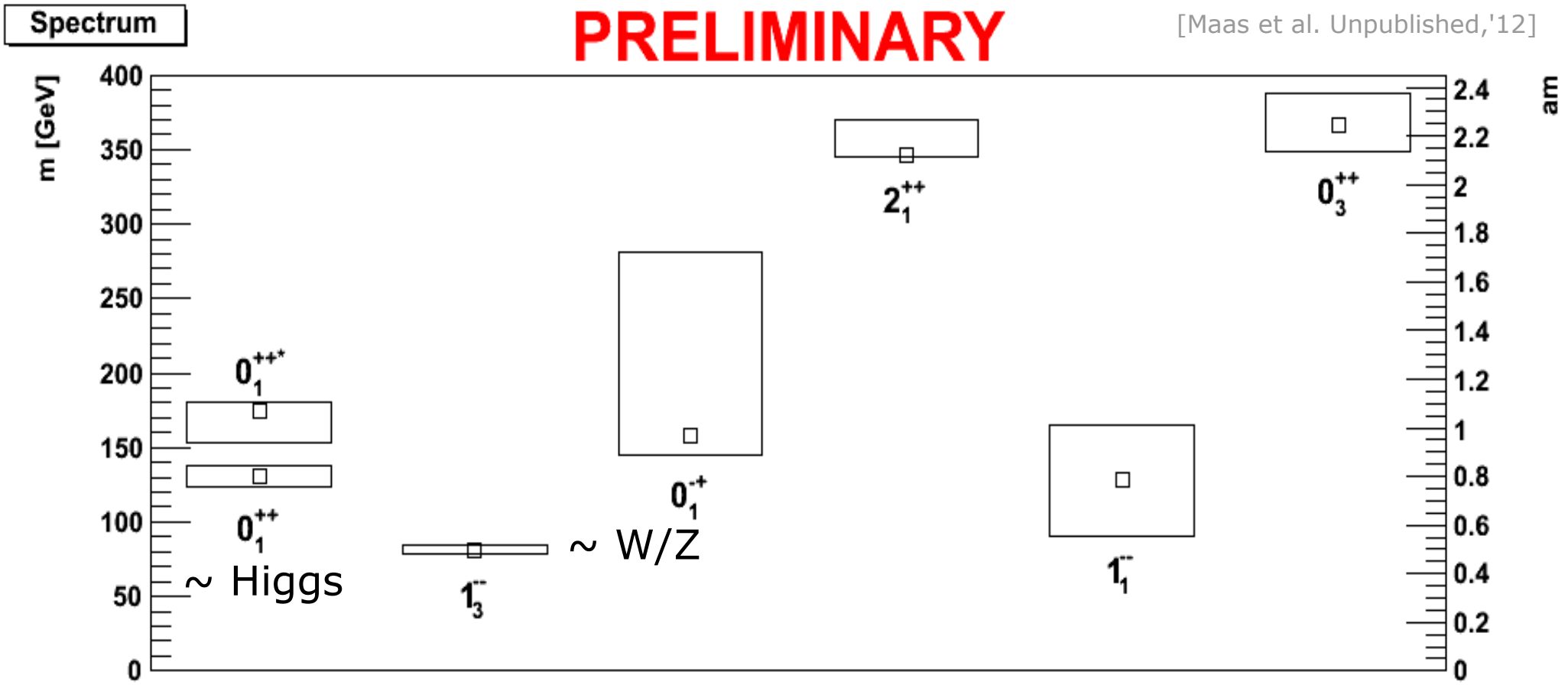

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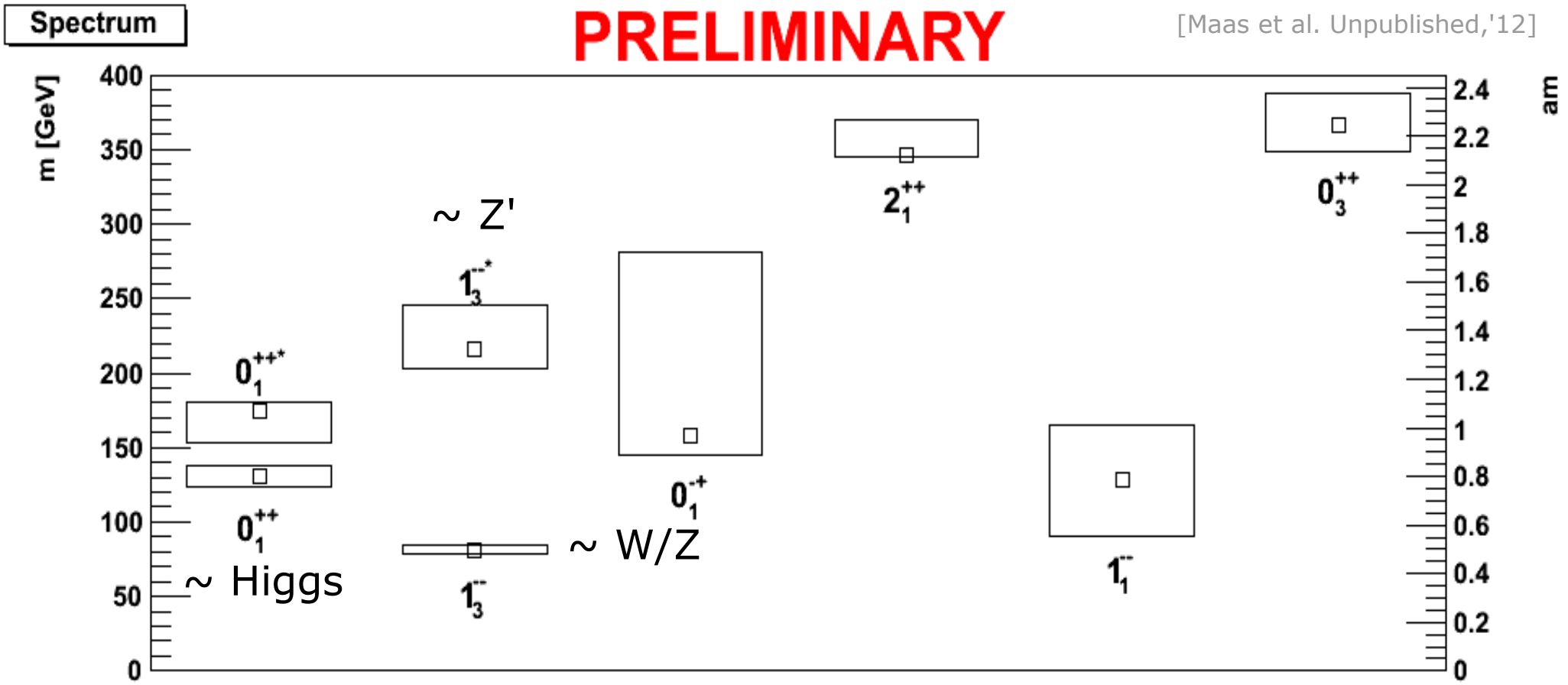

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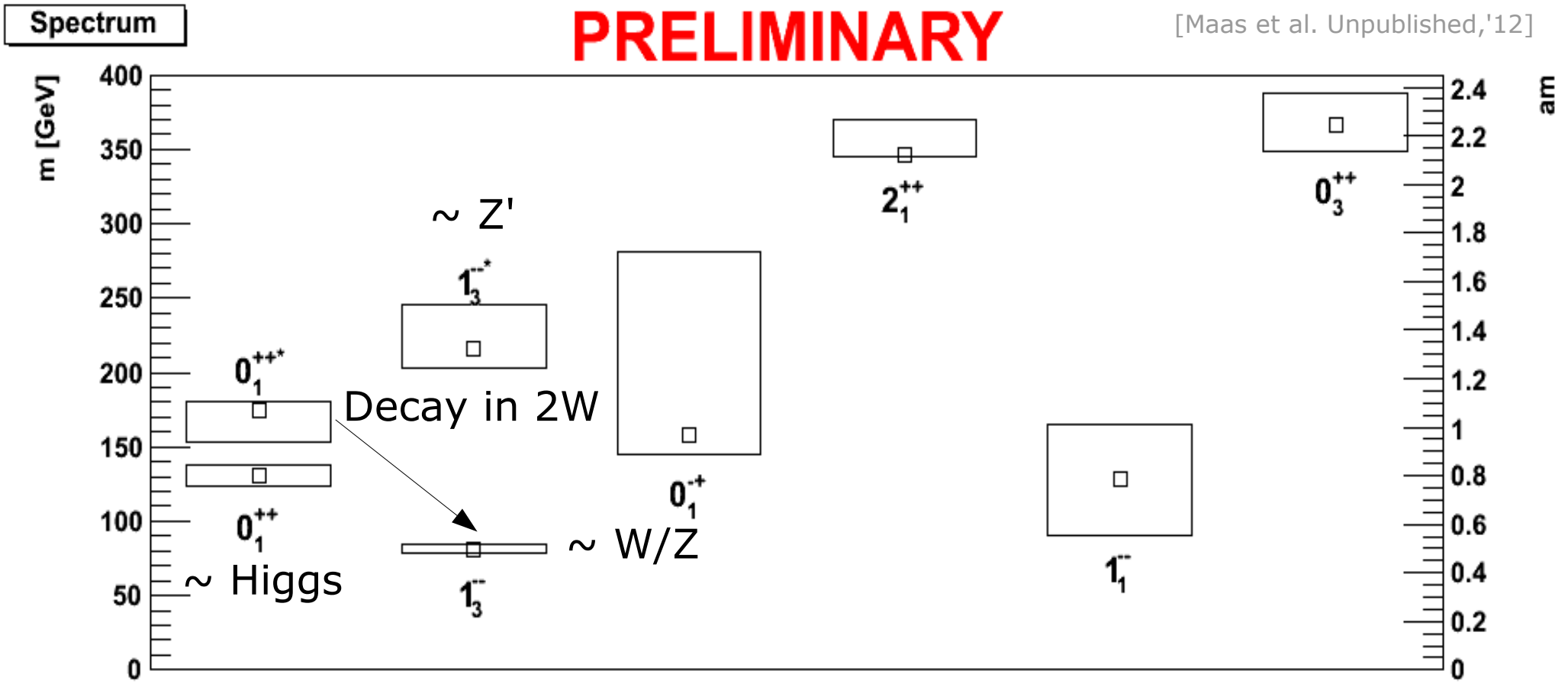

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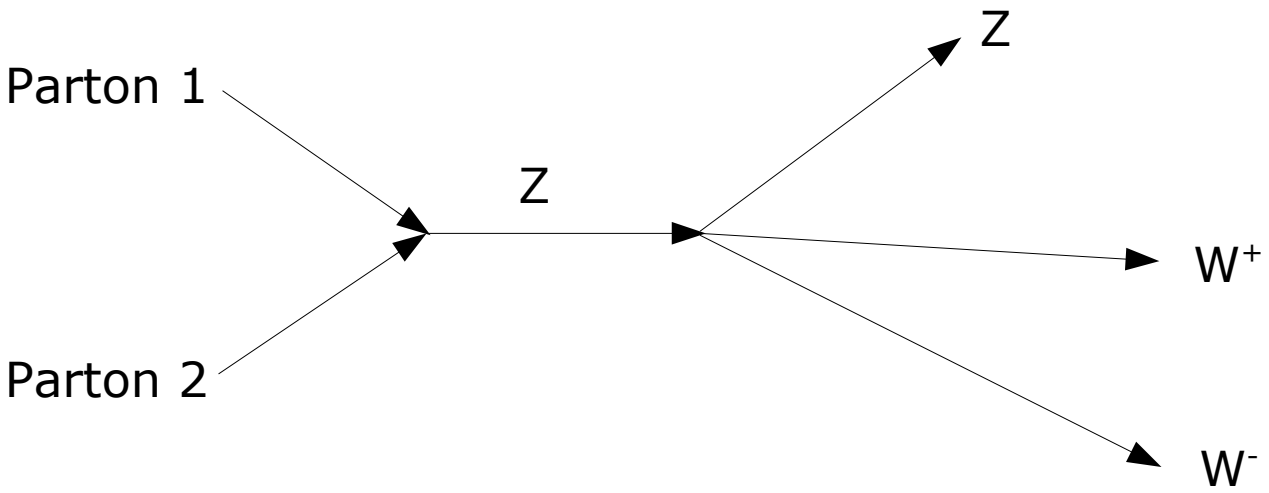

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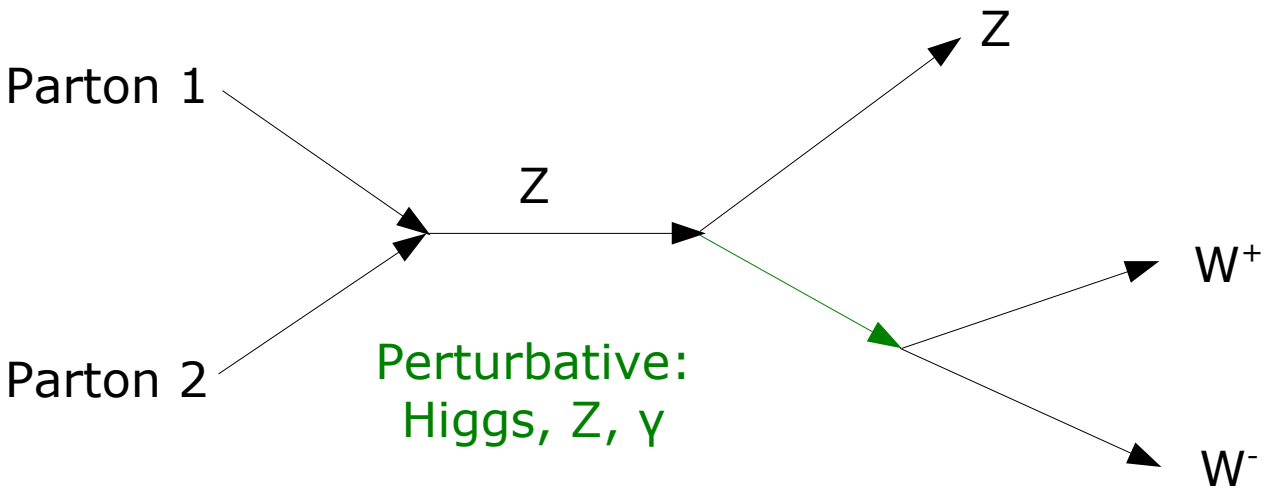

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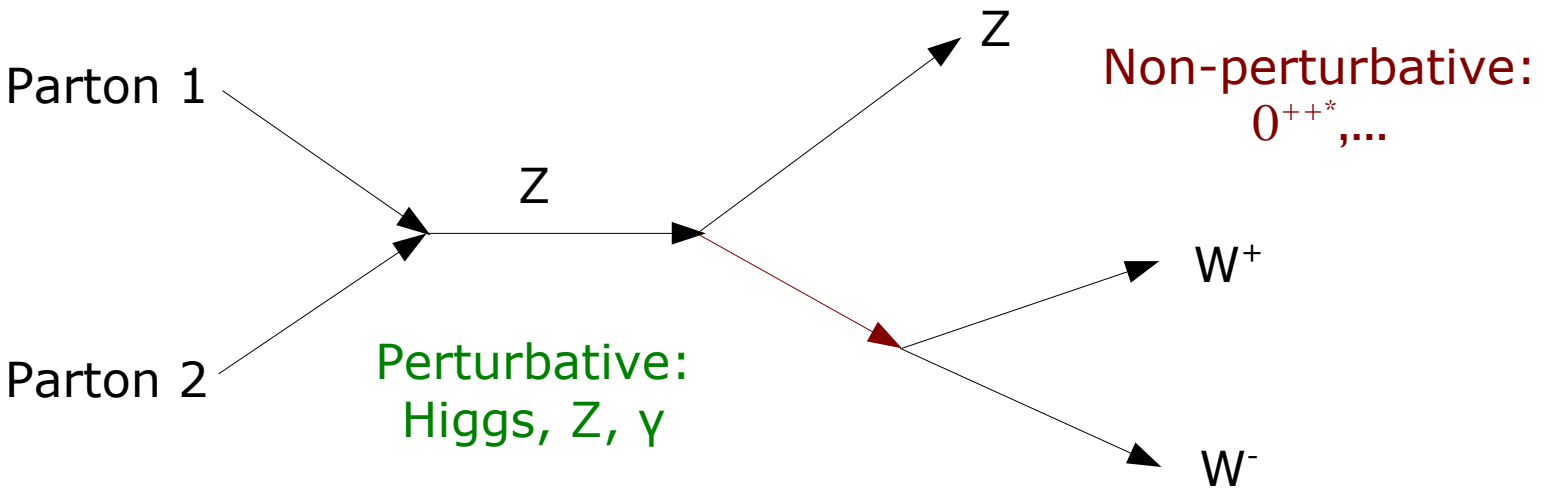

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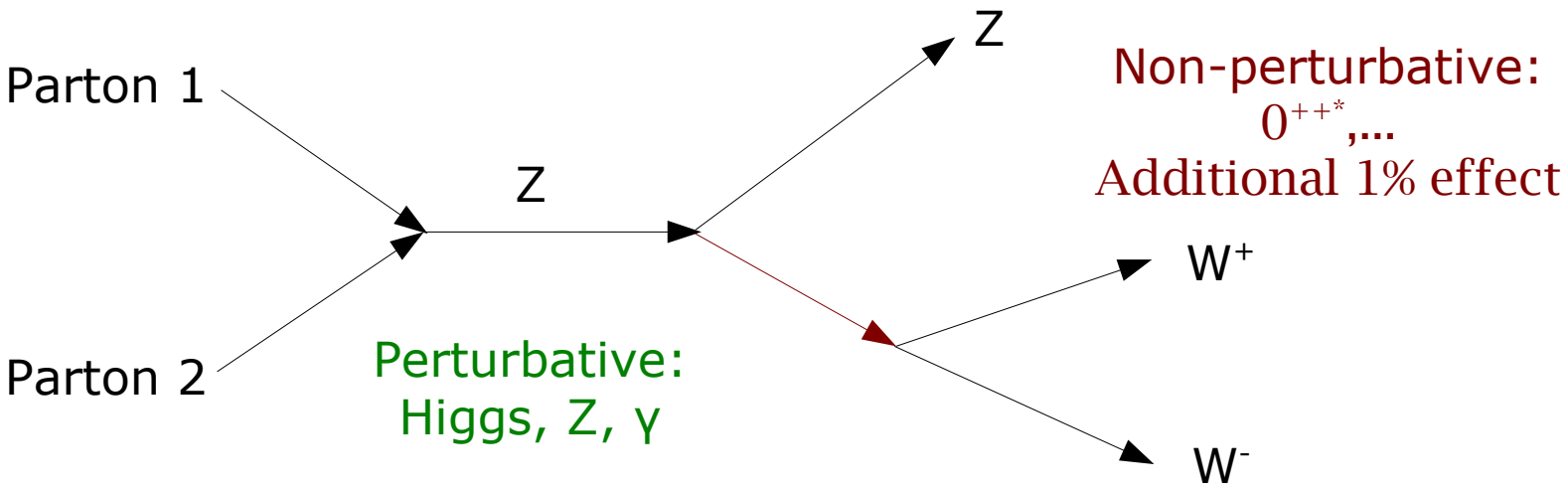

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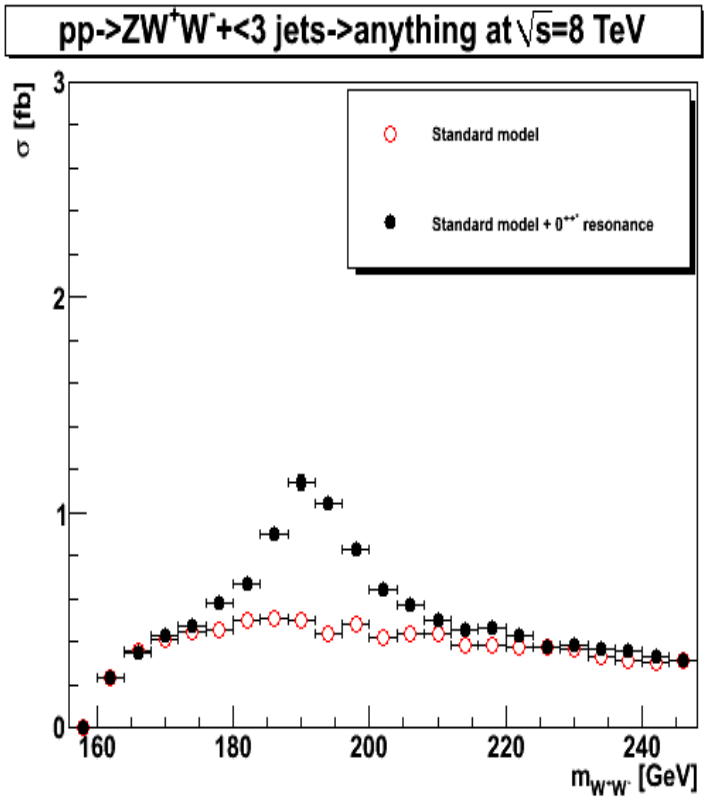

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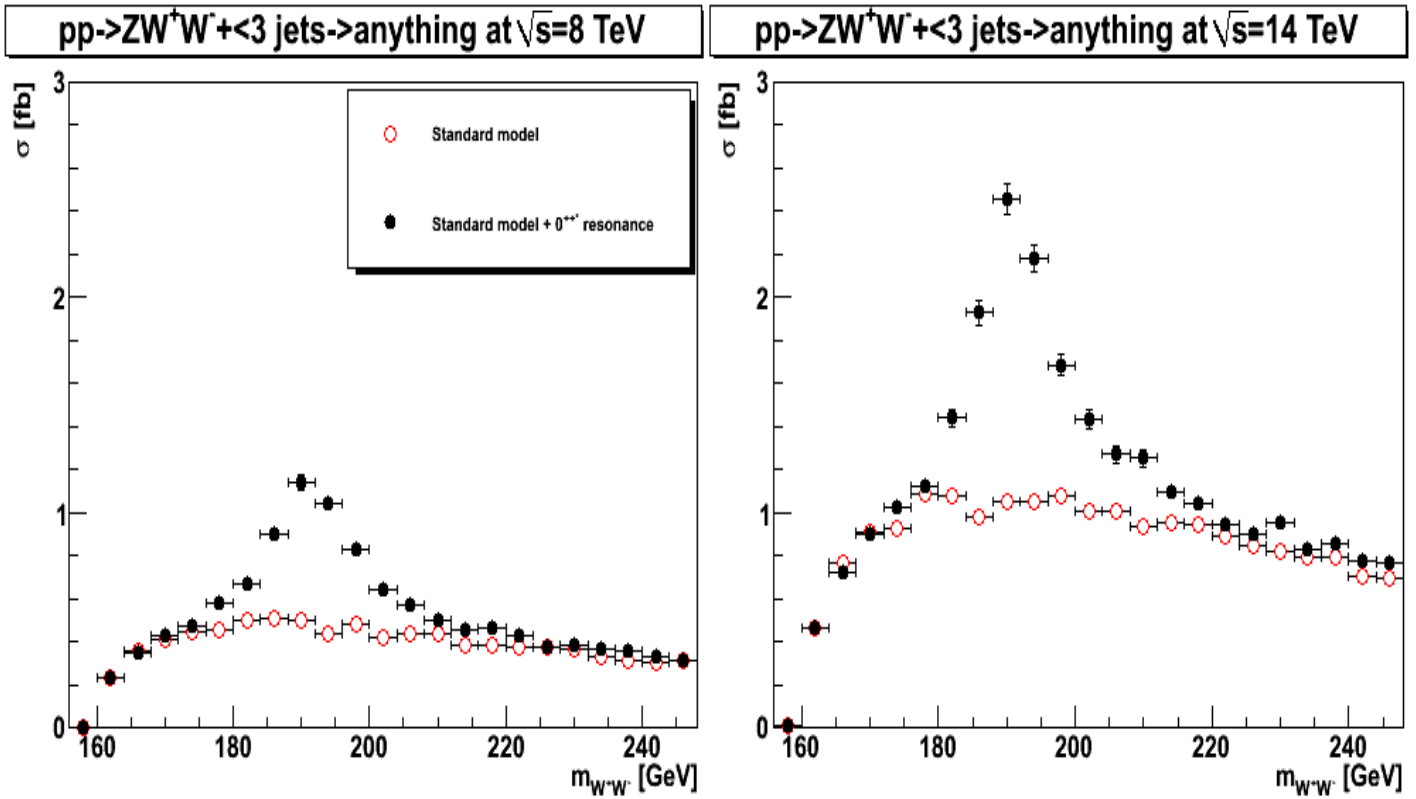

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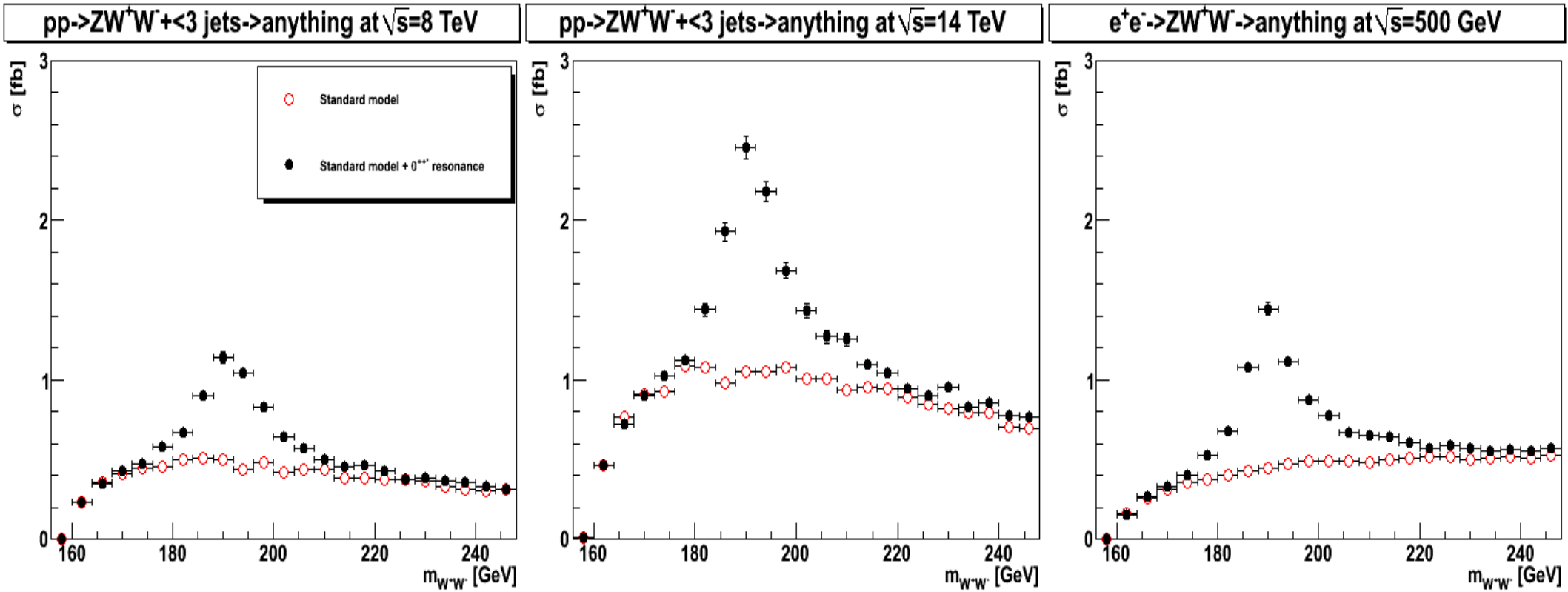

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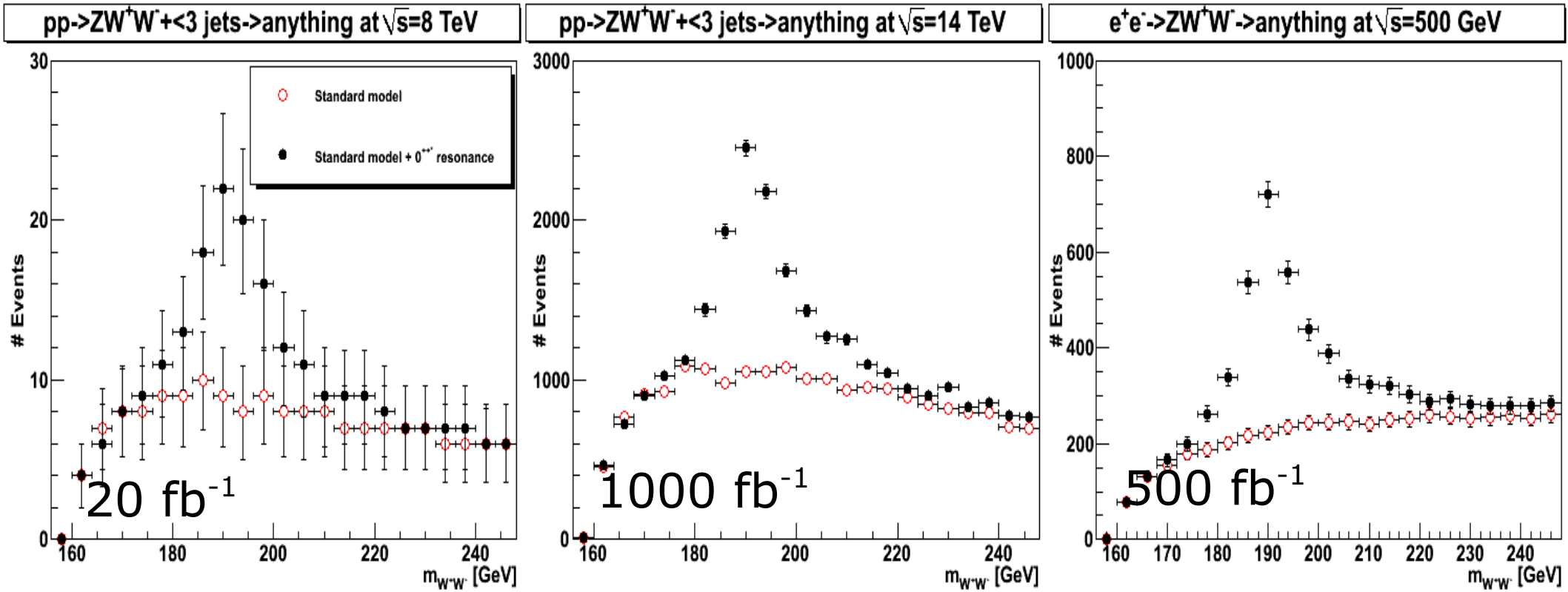

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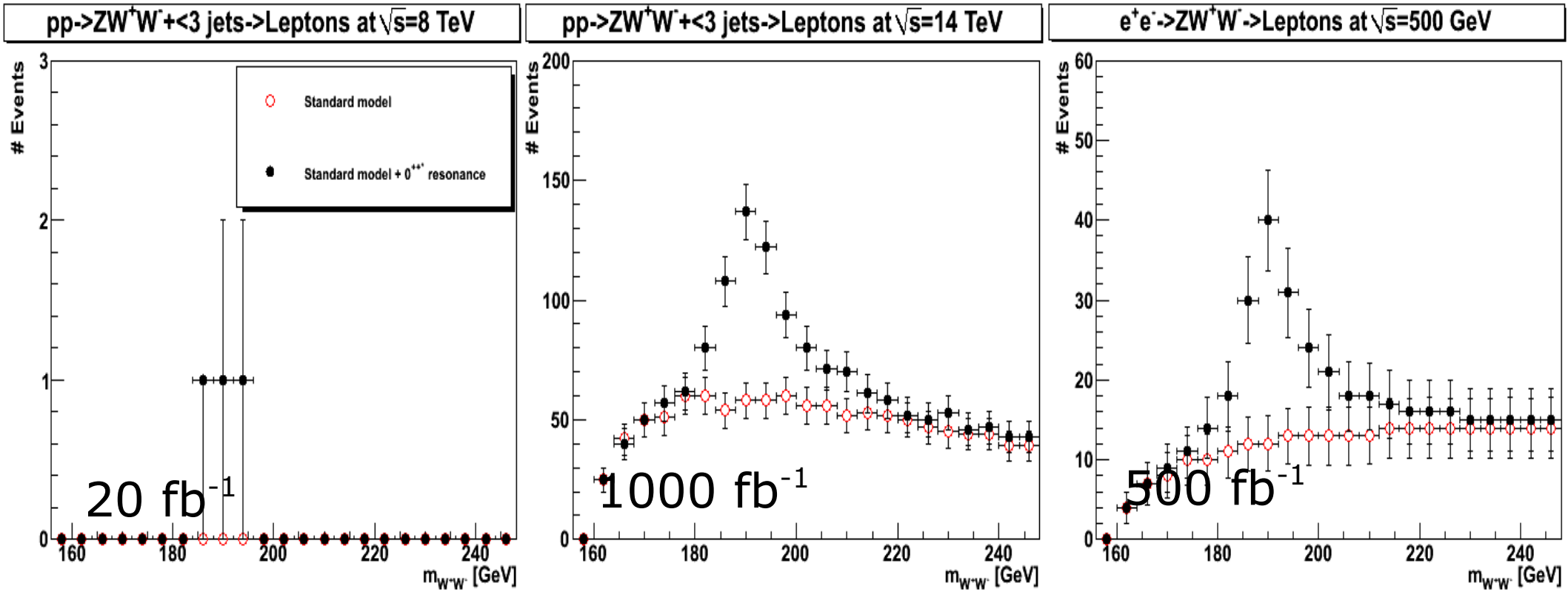

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- Non-perturbatively interesting even for a light Higgs

Summary

- Higgs sector with light Higgs successfully described by perturbation theory around classical physics
- Bound-state/elementary state duality
  - Highly relativistic bound states
    - Unusual structure
  - Physical interpretation of resonances in cross sections
  - New excitations of bound states?
    - Could be background for new physics searches
    - Possibly accessible at LHC/ILC
- Non-perturbatively interesting even for a light Higgs
- Interesting, alternative parameters: Talk by Wurtz