MadGraph Tutorial

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I. Plan of this tutorial

- Install MadGraph 5
- Generate events.
- Scan in mass

Install MadGraph 5!

- https://launchpad.net/madgraph5
  - ➡ 1.5.10
  - ➡ 2.0.0.beta3 -> (NLO available !)
- untar it (tar -xzpvf TUTO_model.tgz)
- launch it ($ ./bin/mg5)
- learn it!
  - ➡ Type tutorial and follow instructions

Where to find help?

- Ask me !
- Use the command "help" / "help XXX"
  - ➡ "help" tell you the next command that you need to do.
- Launchpad:
  - ➡ https://answers.launchpad.net/madgraph5
  - ➡ FAQ: https://answers.launchpad.net/madgraph5/+faqs

What are those cards?

- param_card: model parameters
- run_card: beam/run parameters and cuts
  - ➡ https://answers.launchpad.net/madgraph5/+faq/2014

Check list

- How do you change
  - ➡ top mass
  - ➡ top width
  - ➡ W mass
  - ➡ beam energy
  - ➡ pt cut on the lepton
  - ➡ pdf

Exercise I : Syntax

- What's the meaning of the order QED/QCD
- What's the difference between
  - ➡ p p > t t~
  - ➡ p p > t t~ QED=2
  - ➡ p p > t t~ QED=0

Exercise II: Syntax

- Generate the cross-section and the distribution (invariant mass) for
  - ➡ p p > e+ e-
  - ➡ p p > z, z > e+ e-
  - ➡ p p > e+ e- $ z
  - ➡ p p > e+ e- / z

Hint : To have automatic distributions:
mg5> install MadAnalysis

Exercise III: scripting

- Look at the cross-section for the previous process for 3 different mass points.
  - ➡ hint: you can edit the param_card/run_card via the "set" command [After the launch]
  - ➡ hint: All command [including answer to question] can be put in a file.

Let's start

Exercises

1. Follow the tutorial
2. Understand the cards
3. compare (diagram and cross-section)
   - ➡ p p > t t~
   - ➡ p p > t t~ QED=0
   - ➡ p p > t t~ QED=2
4. compare (distributions)
   - ➡ p p > e+ e-
   - ➡ p p > z, z > e+ e-
   - ➡ p p > e+ e- $ z
   - ➡ p p > e+ e- / z
5. compute the cross-section
   - ➡ for Mtop between 160 to 180 GeV
   - ➡ No scripting!

Solution

Exercise 1 : Syntax

- What's the meaning of the order QED/QCD
- What's the difference between
  - ➡ p p > t t~
  - ➡ p p > t t~ QED=2
  - ➡ p p > t t~ QED=0

Solution I : Syntax

- What's the meaning of the order QED/QCD
  - ➡ By default MG5 takes the lowest order in QED!
  - ➡ p p > t t~ => p p > t t~ QED=0
  - ➡ p p > t t~ QED=2
    - ✦ additional diagrams (photon/z exchange)

p p > t t~

Cross section (pb)
555 ± 0.84

p p > t t~ QED=2

Cross section (pb)
555.8 ± 0.91

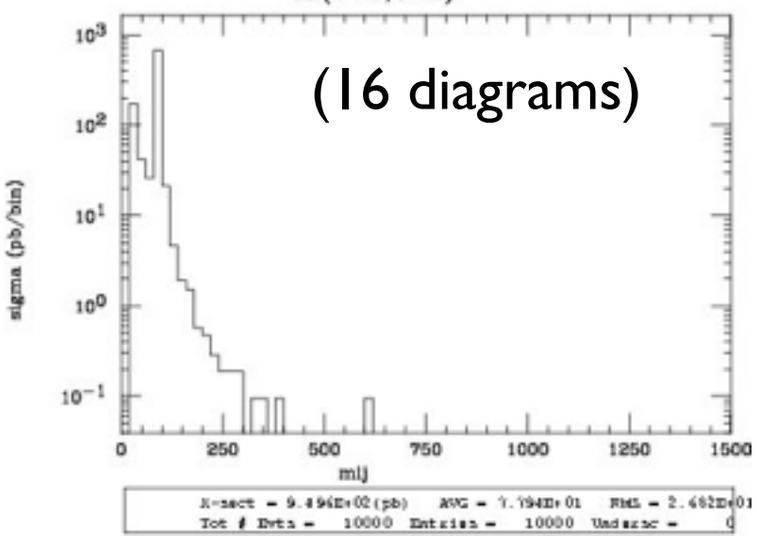
No significant QED contribution

Exercise II: Syntax

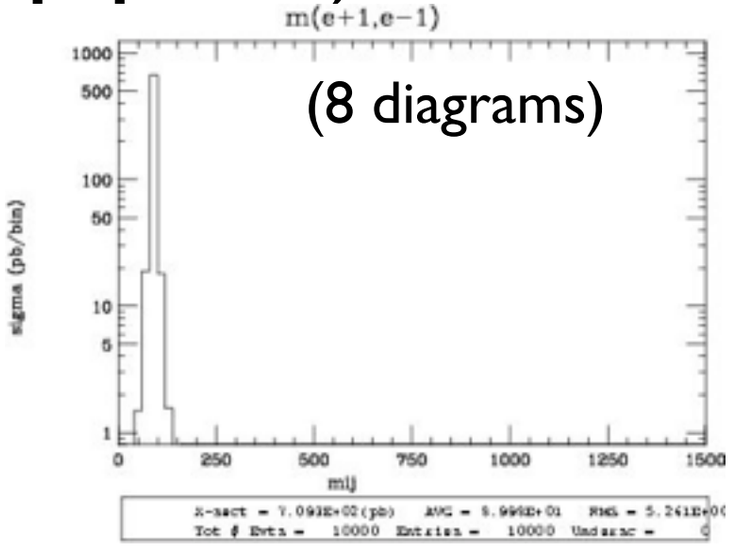
- Generate the cross-section and the distribution (invariant mass) for
  - ➡ p p > e+ e-
  - ➡ p p > z, z > e+ e-
  - ➡ p p > e+ e- $ z
  - ➡ p p > e+ e- / z

Hint : To have automatic distributions:
mg5> install MadAnalysis

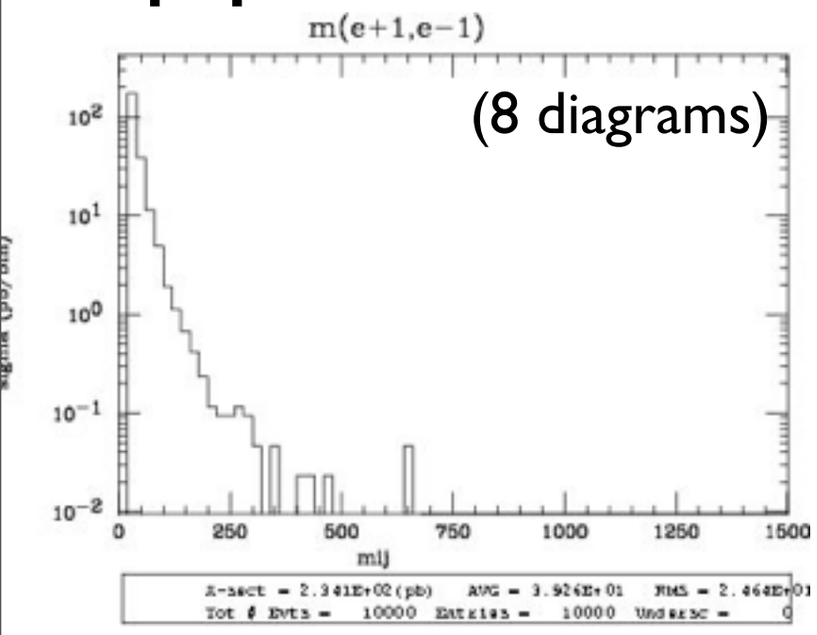
p p > e+ e-



p p >z , z > e+ e-

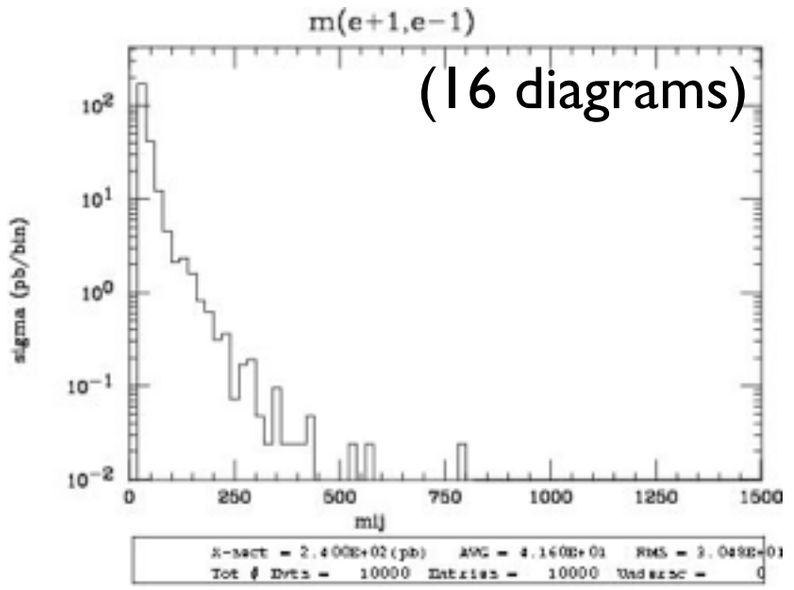


p p > e+ e- /z



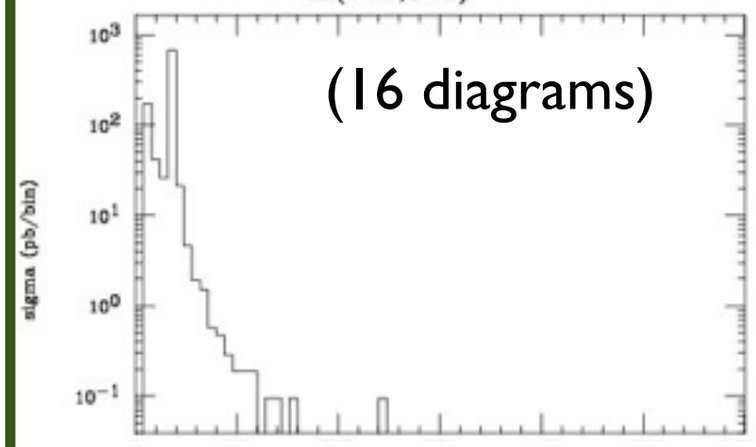
No Z

p p > e+ e- $ z



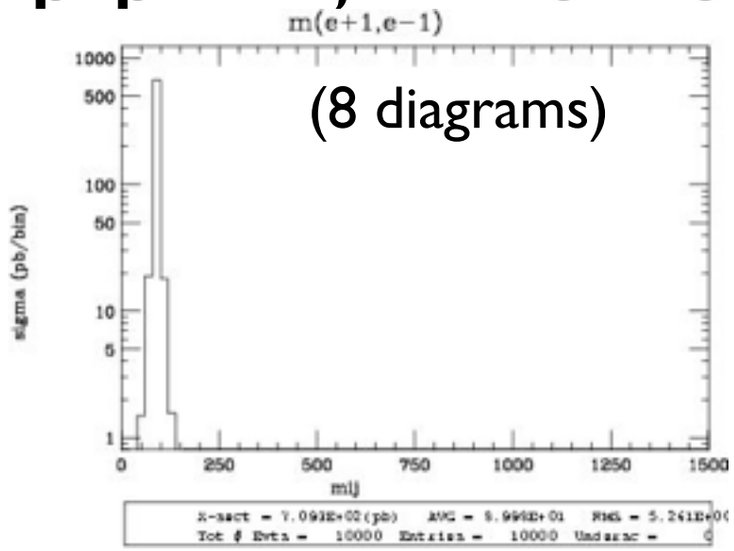
Z- onshell veto

p p > e+ e-

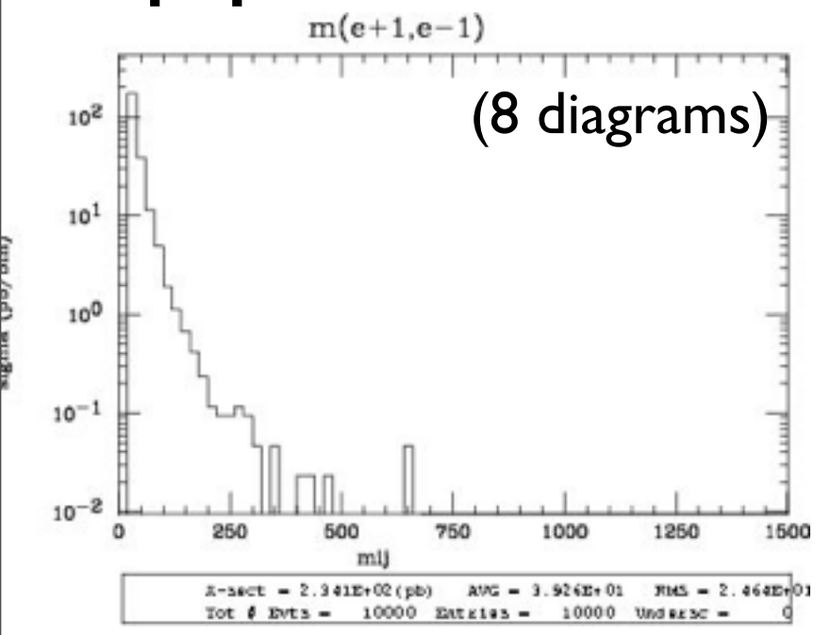


Correct Distribution

p p >z , z > e+ e-

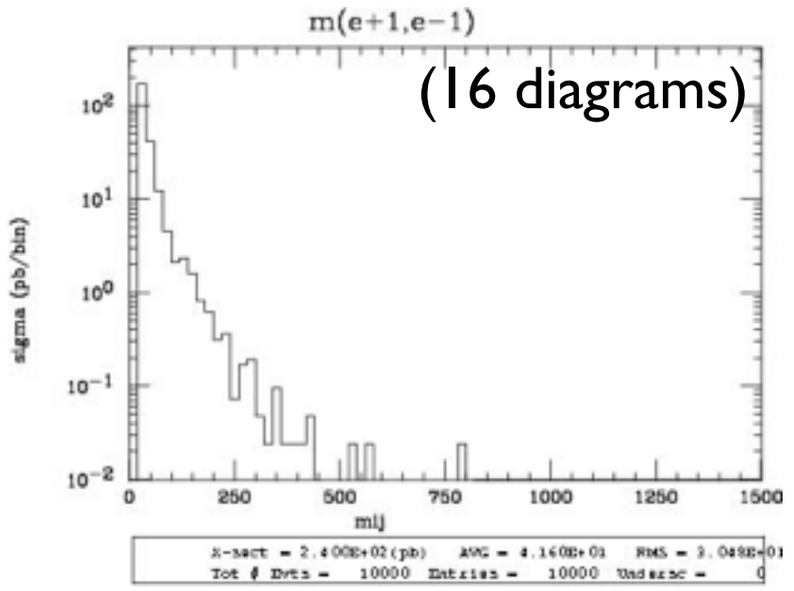


p p > e+ e- /z



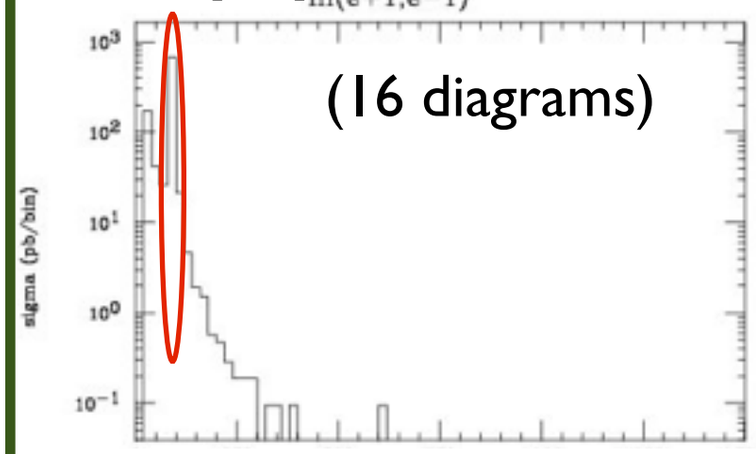
No Z

p p > e+ e- $ z



Z- onshell veto

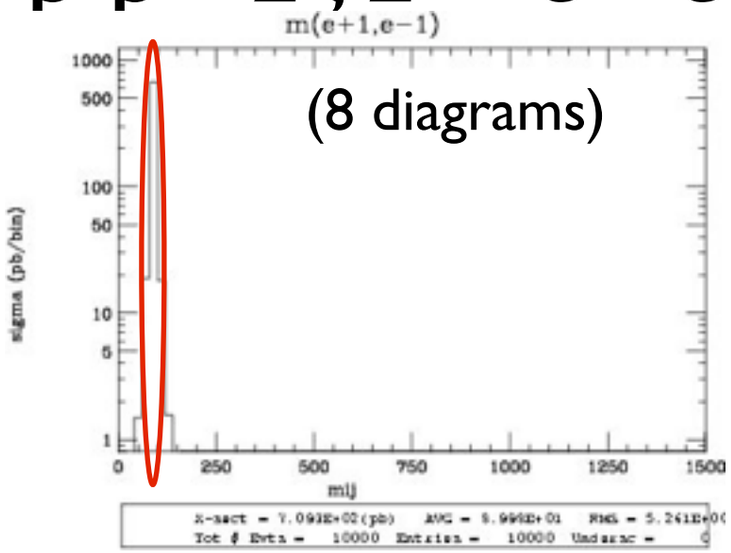
p p > e+ e-



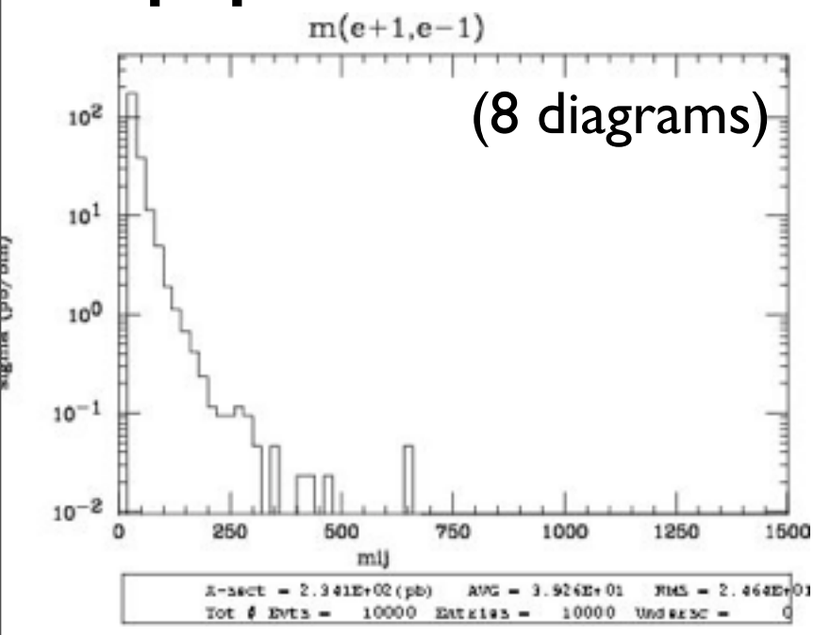
Correct Distribution

Z Peak

p p >z , z > e+ e-



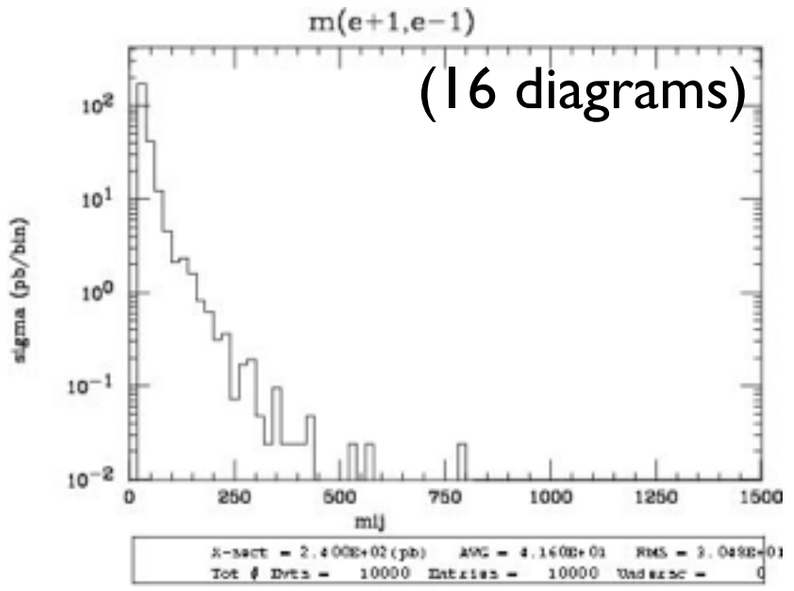
p p > e+ e- /z



No Z

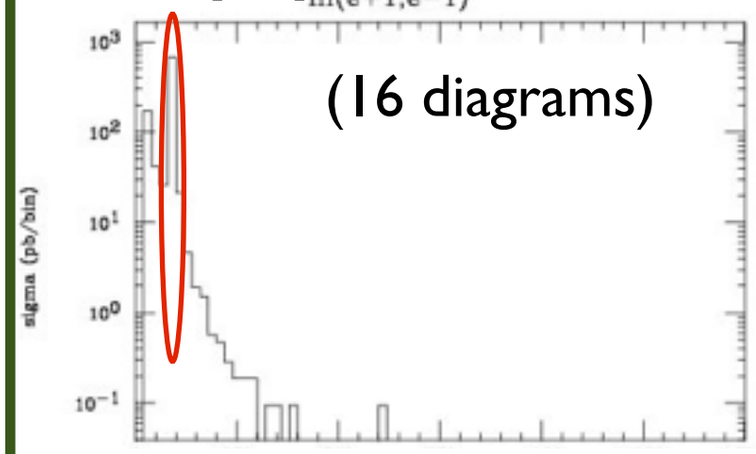
NO Z Peak

p p > e+ e- $ z



Z- onshell veto

p p > e+ e-



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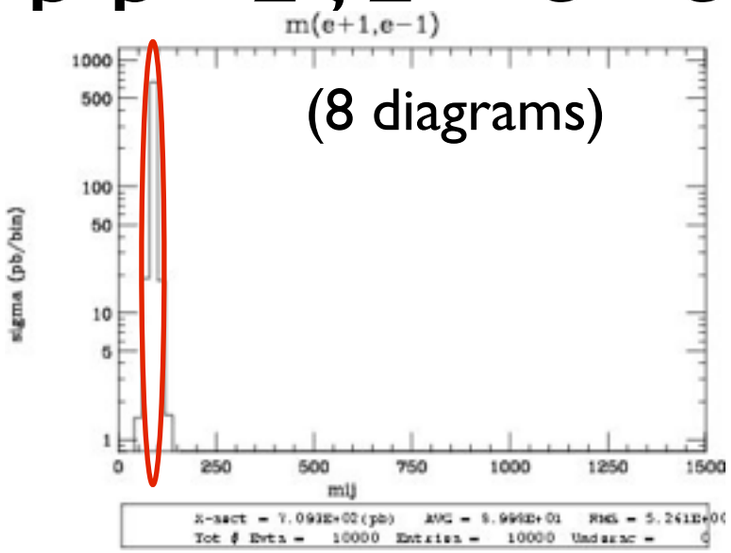
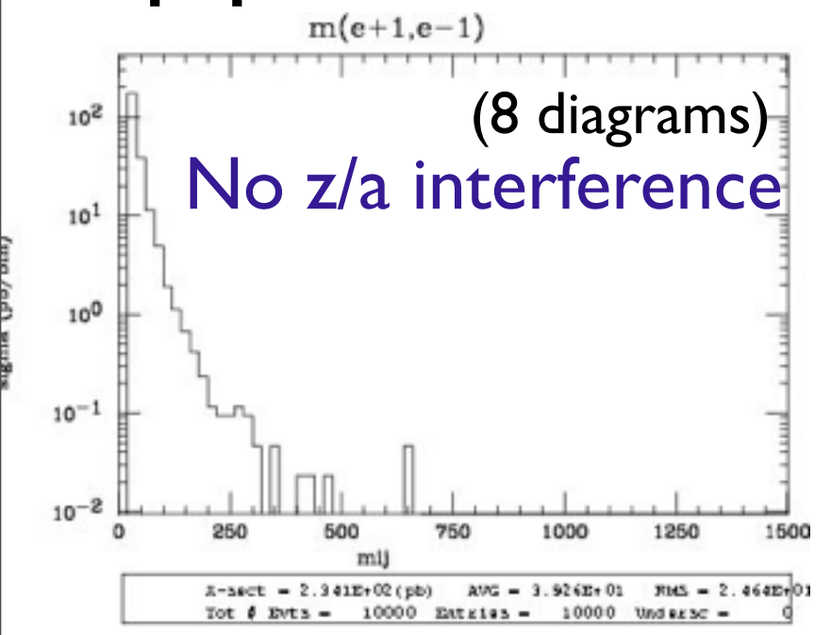


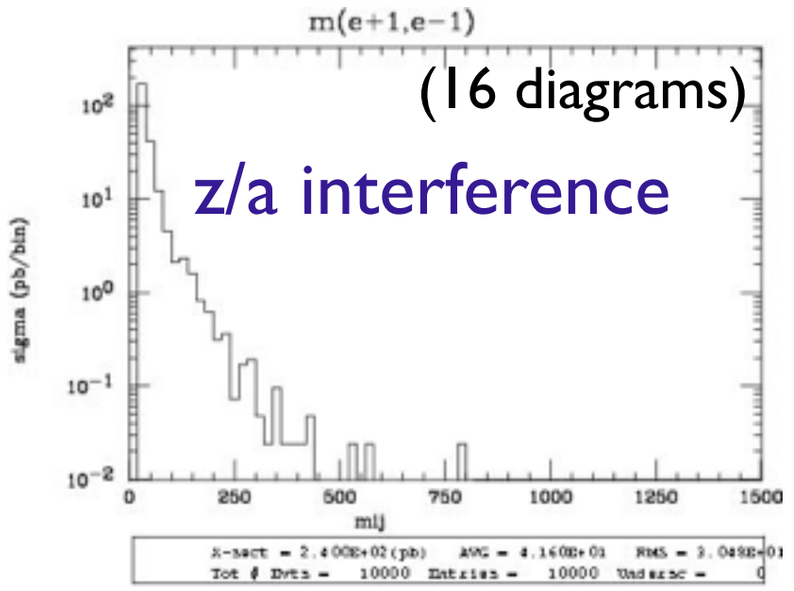
p p > e+ e- /z



No Z

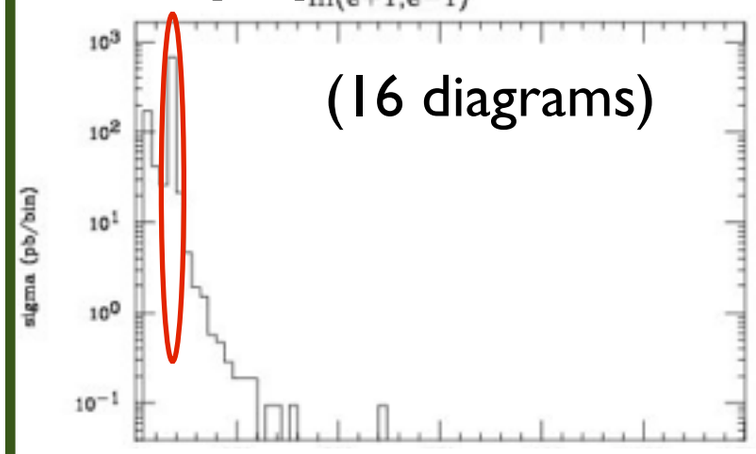
NO Z Peak

p p > e+ e- $ z



Z- onshell veto

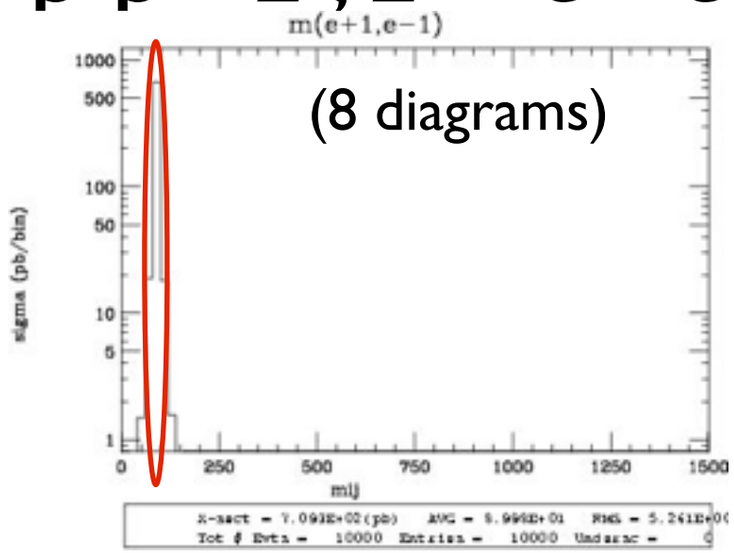
p p > e+ e-



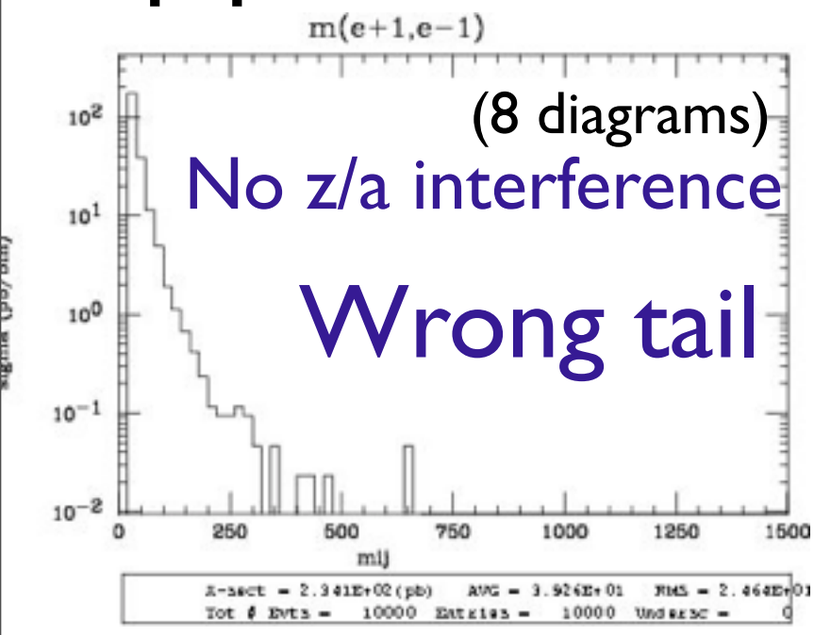
Correct Distribution

Z Peak

p p >z , z > e+ e-



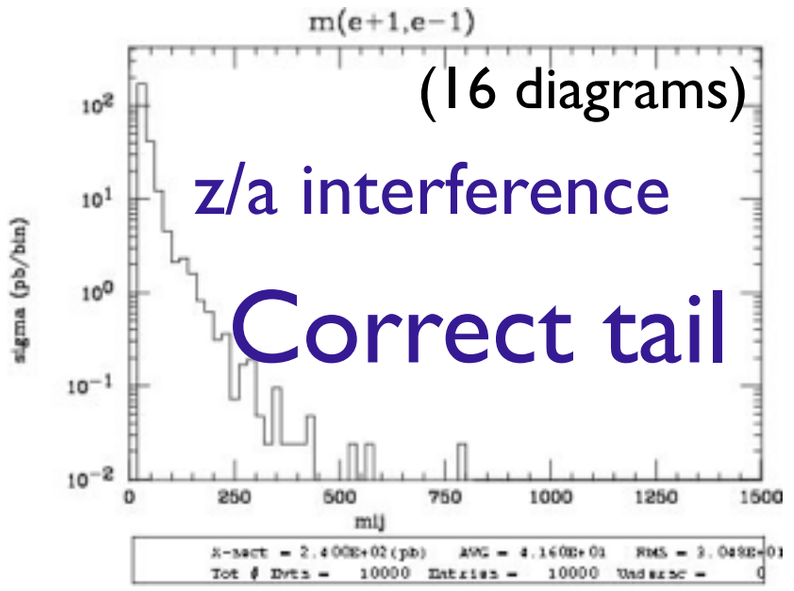
p p > e+ e- /z



No Z

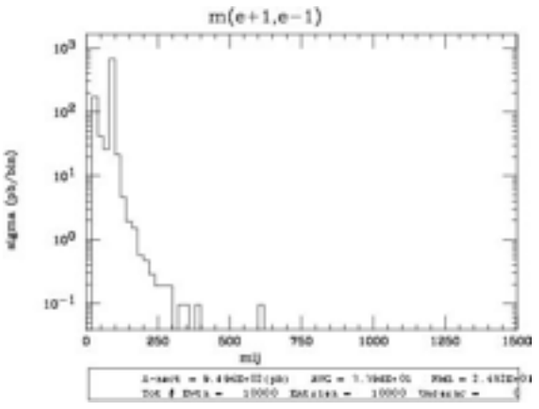
NO Z Peak

p p > e+ e- $ z



Z- onshell veto

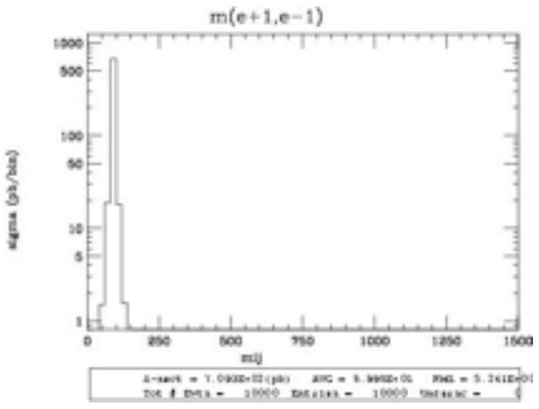
p p > e+ e-



(16 diagrams)

=

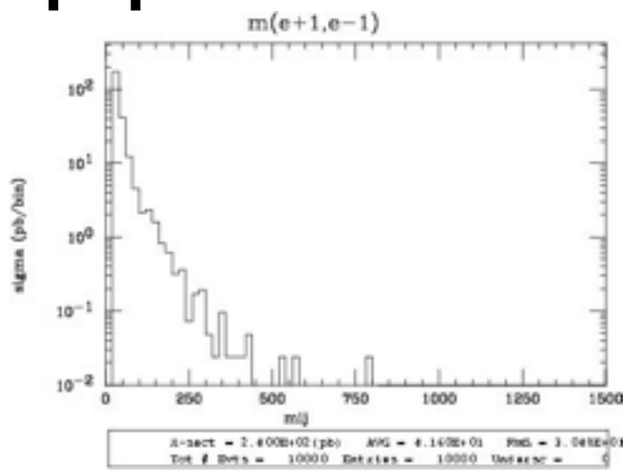
p p >z , z > e+ e-



(8 diagrams)

+

p p > e+ e- $ z



(16 diagrams)

Onshell cut: BW_cut

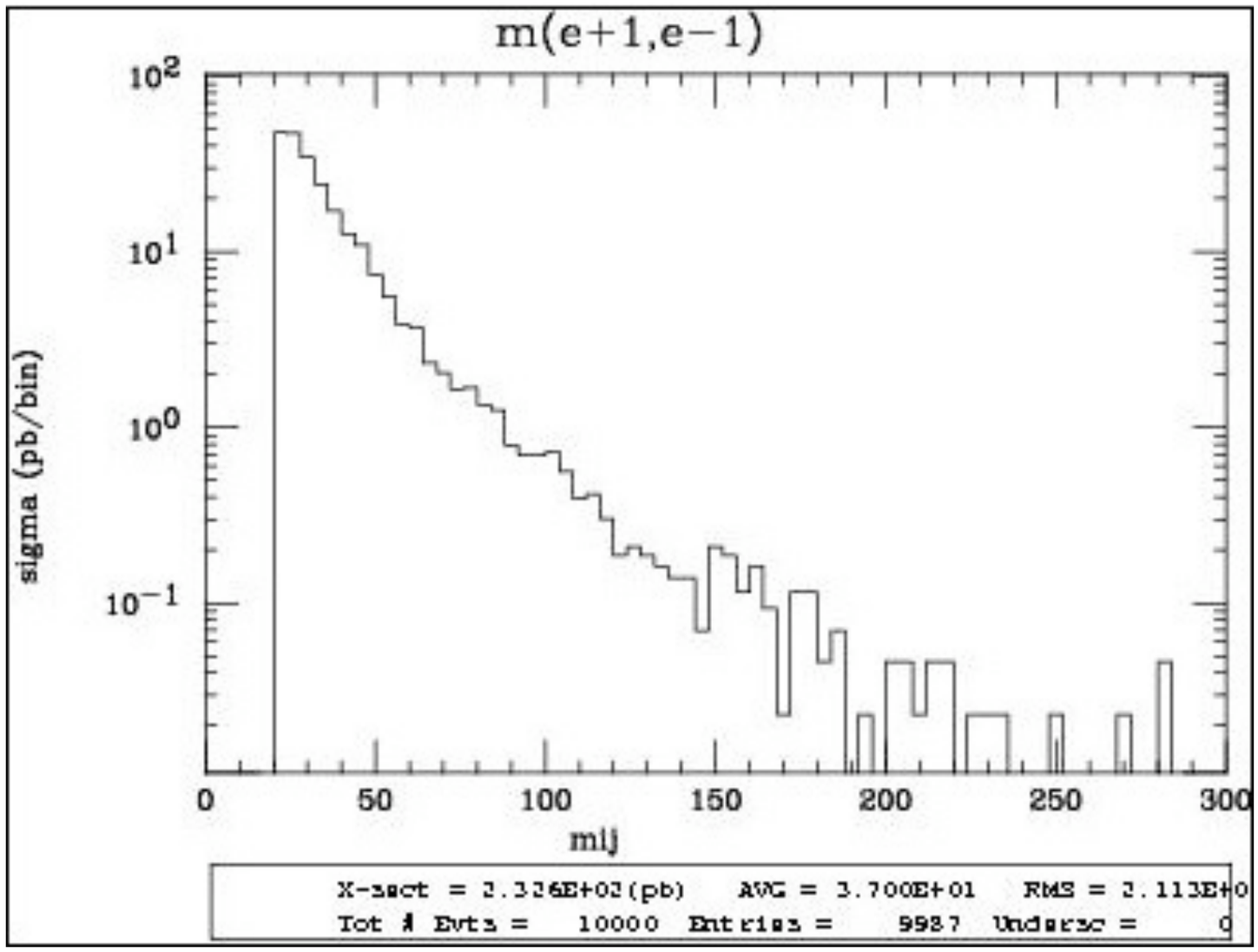
$$|M^* - M| < BW_{cut} * \Gamma$$

- The Physical distribution is (very close to) exact sum of the two other one.
- The "$" forbids the Z to be onshell but the photon invariant mass can be at MZ.
- The "/" is to be avoid if possible since this leads to violation of gauge invariance.

WARNING

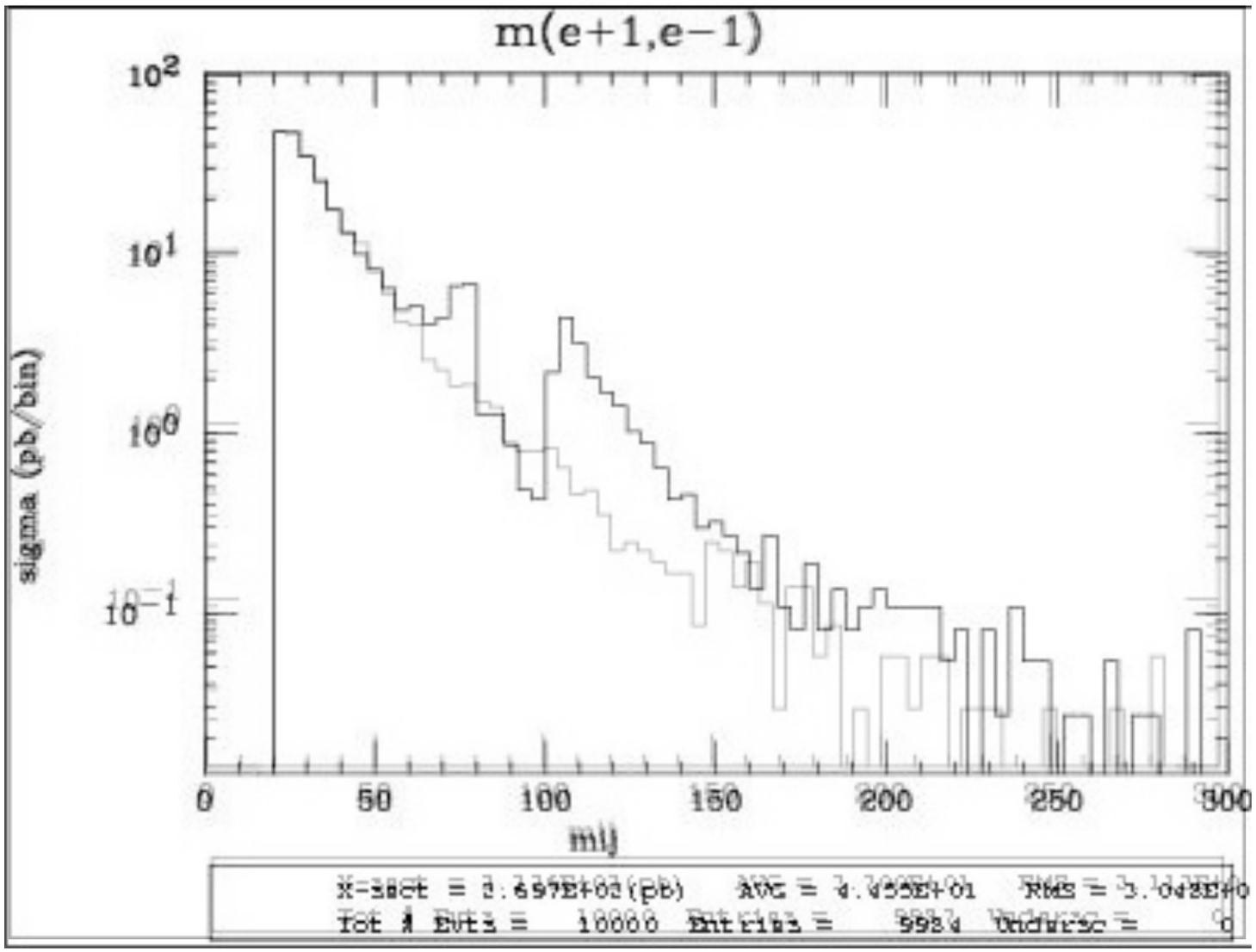
- NEXT SLIDE is generated with bw_cut =5
- This is TOO SMALL to have a physical meaning (15 the default value used in previous plot is better)
- This was done to illustrate more in detail how the "$" syntax works.

p p > e+ e- / Z


m(e+1,e−1)
sigma (pb/bin)
10^2
10^1
10^0
10^{-1}
0
50
100
150
200
250
300
mij
X-sect = 2.326E+02(pb) AVG = 3.700E+01 RMS = 2.113E+0
Tot # Evts = 10000 Entries = 9987 Underflo = 0

p p > e+ e- / Z

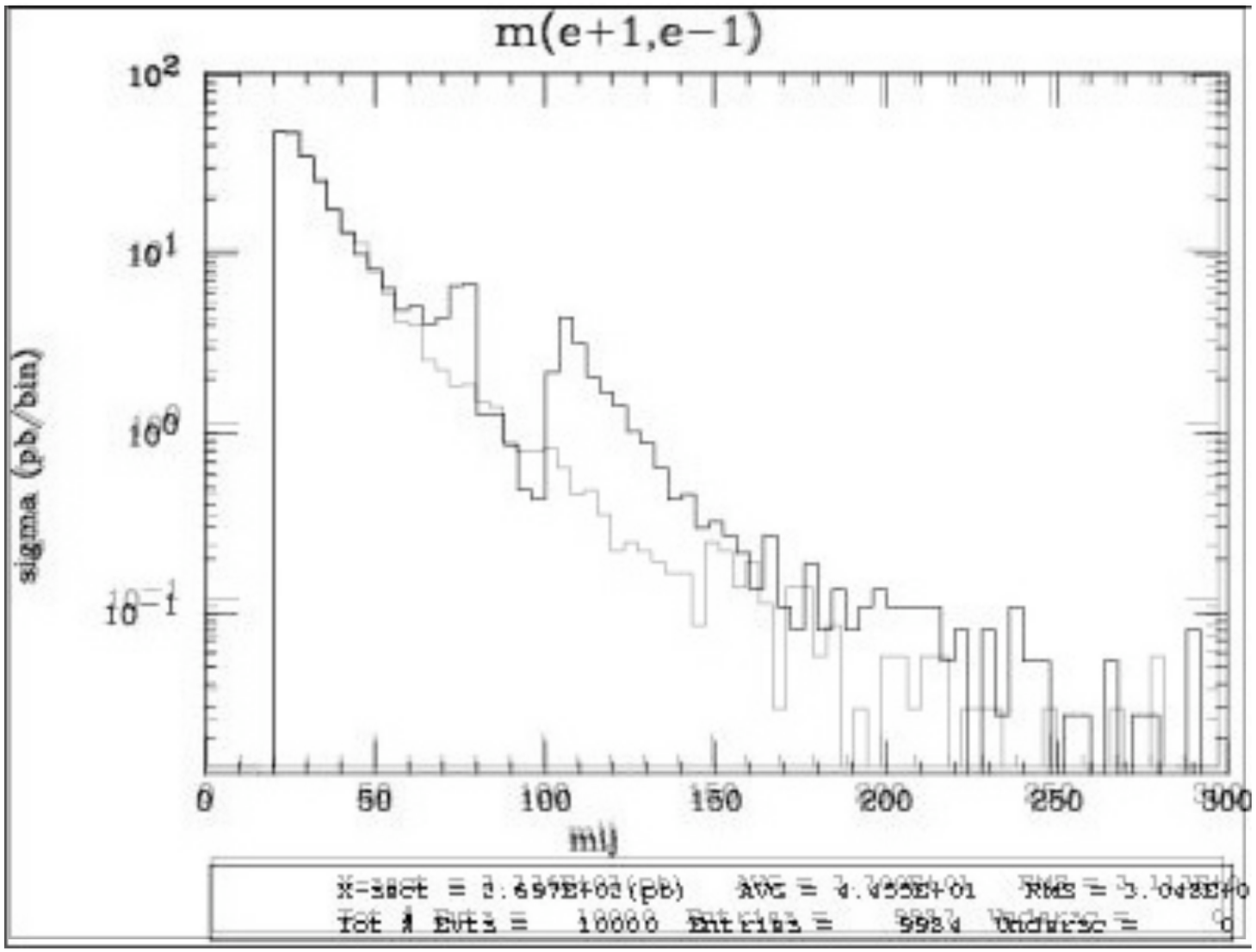
adding p p > e+ e- $ Z



See previous slide warning

p p > e+ e- / Z

adding p p > e+ e- $ Z

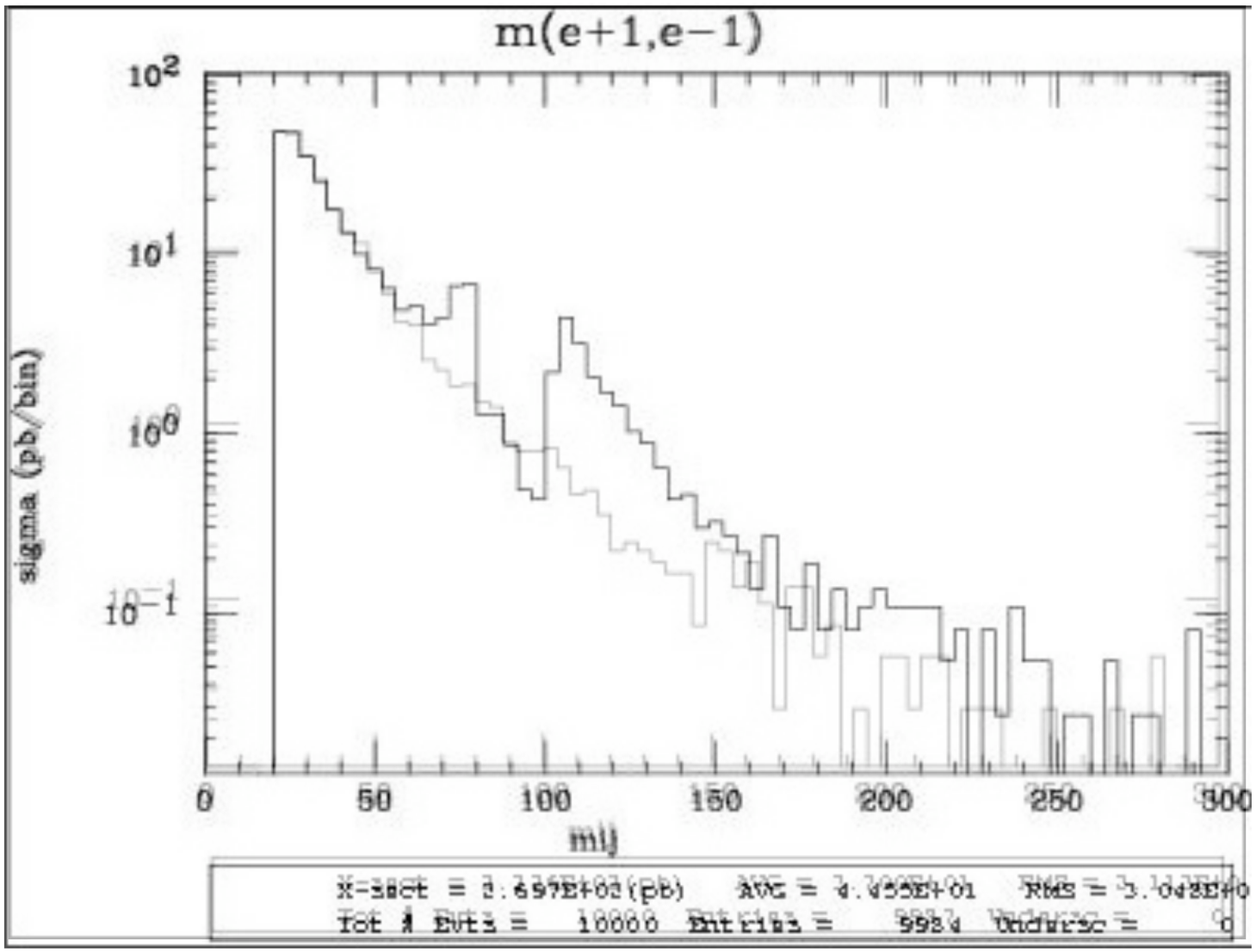


- Z onshell veto

See previous slide warning

p p > e+ e- / Z

adding p p > e+ e- $ Z

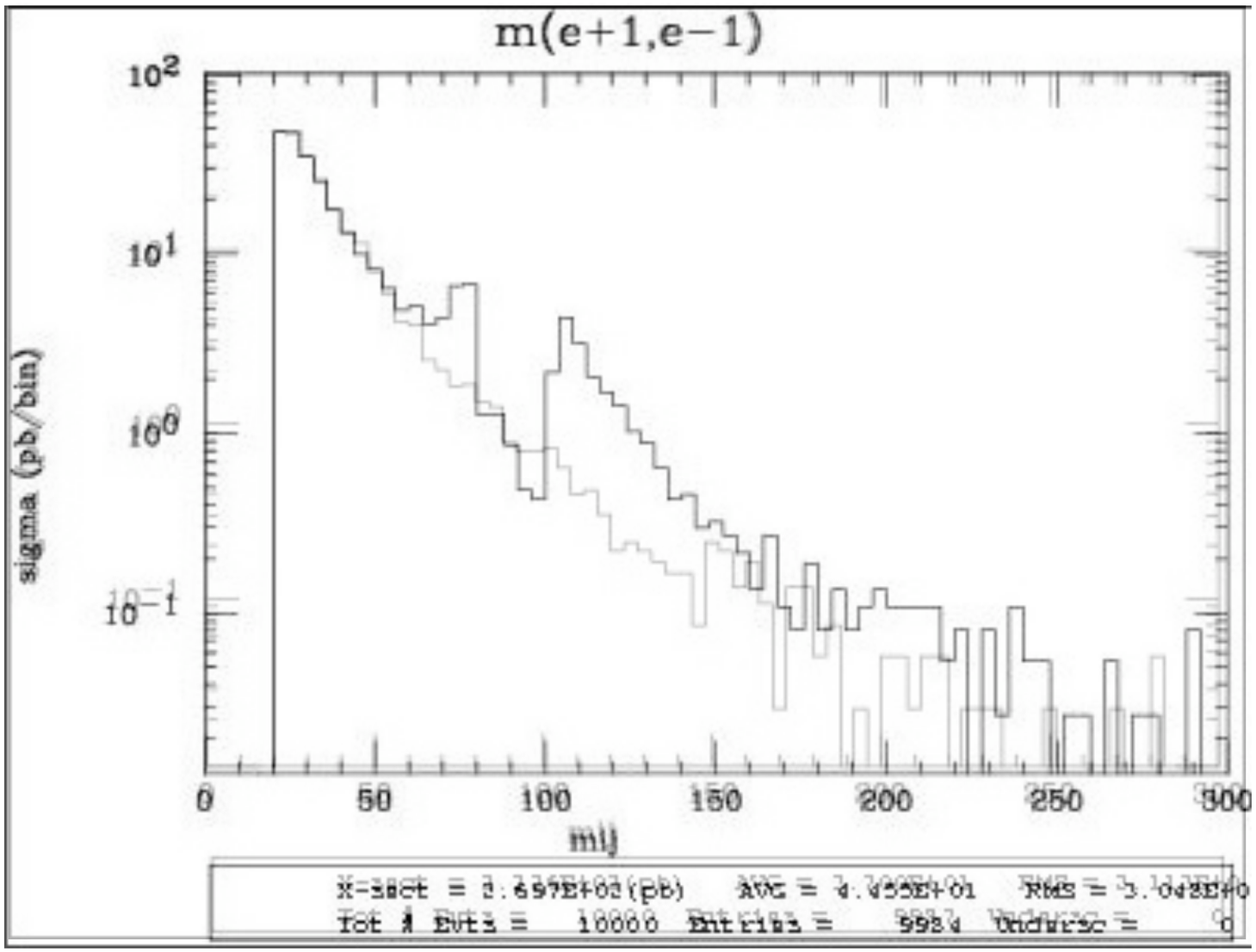


- Z onshell veto
- In veto area only photon contribution

See previous slide warning

p p > e+ e- / Z

adding p p > e+ e- $ Z

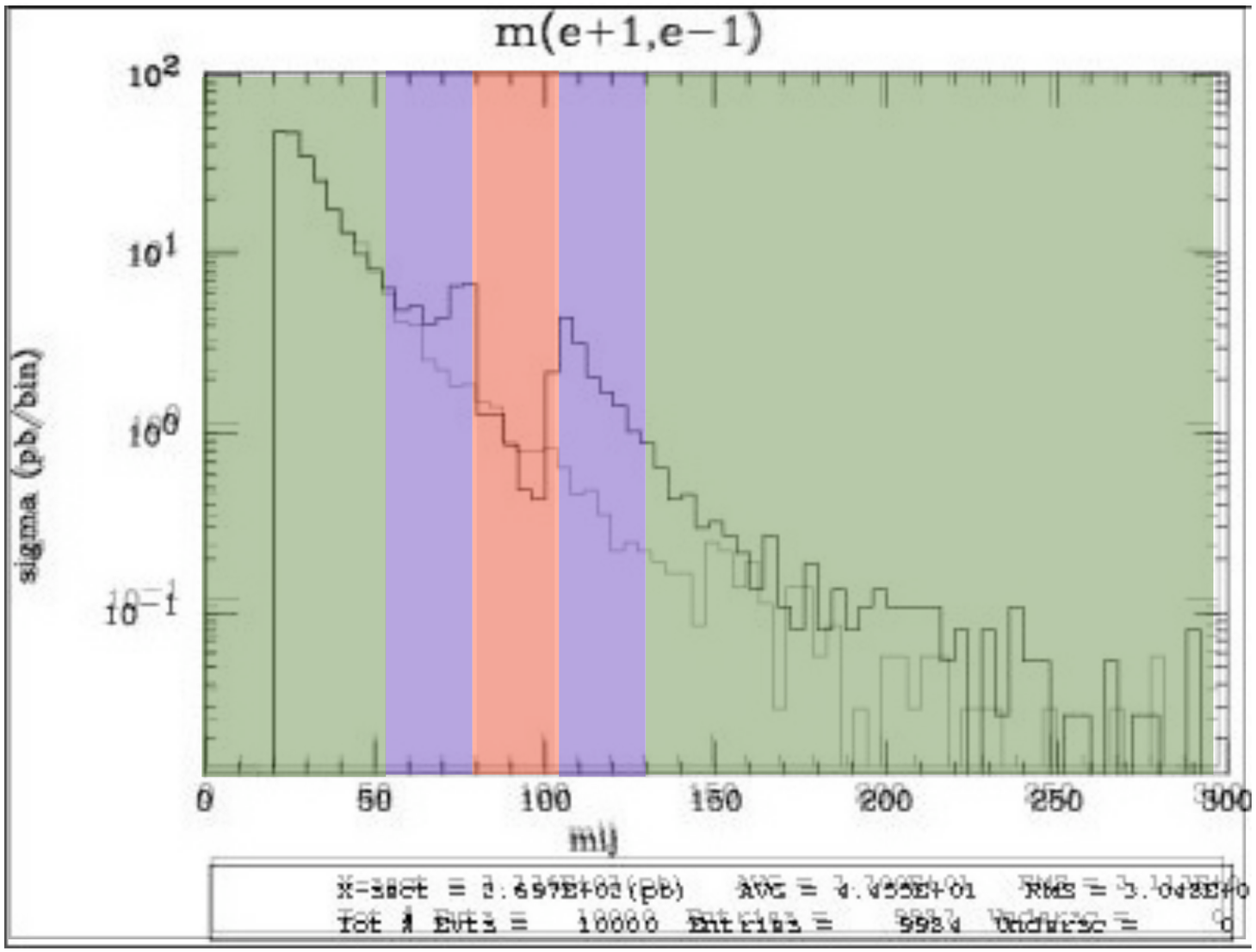


- Z onshell veto
- In veto area only photon contribution
- area sensitive to z-peak

See previous slide warning

p p > e+ e- / Z

adding p p > e+ e- $ Z



- Z onshell veto
- In veto area only photon contribution
- area sensitive to z-peak
- very off-shell Z, the difference between the curve is due to interference which are need to be KEPT in simulation.

5 times width area

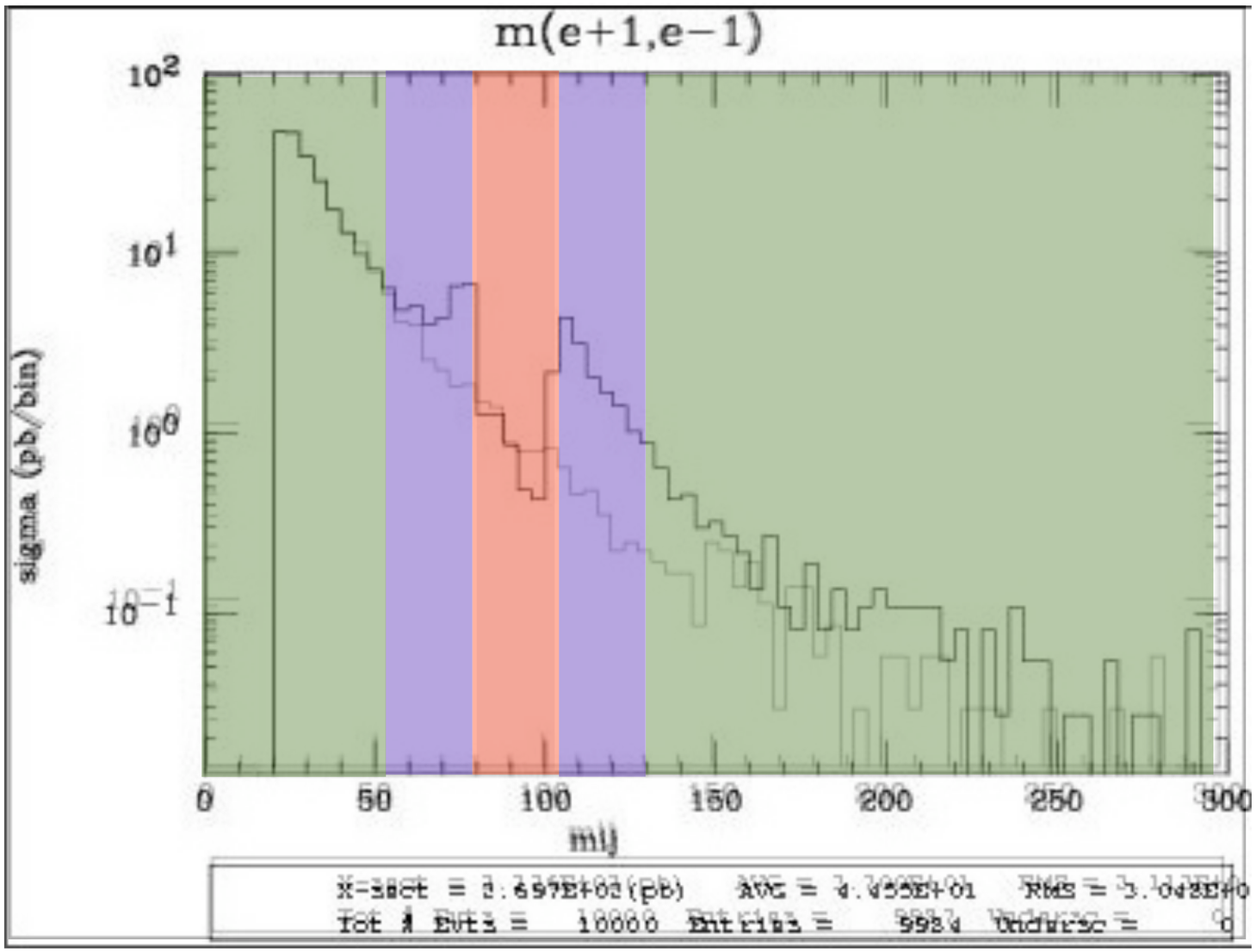
15 times width area

>15 times width area

See previous slide warning

p p > e+ e- / Z

adding p p > e+ e- $ Z



- Z onshell veto
- In veto area only photon contribution
- area sensitive to z-peak
- very off-shell Z, the difference between the curve is due to interference which are need to be KEPT in simulation.

5 times width area

15 times width area

>15 times width area

The "$" can be use to split the sample in BG/SG area

- Syntax Like
  - ➡ p p > z > e+ e- (ask one S-channel z)
  - ➡ p p > e+ e- / z (forbids any z)
  - ➡ p p > e+ e- $$ z (forbids any z in s-channel)
- ARE NOT GAUGE INVARIANT !
- forgets diagram interference.
- can provides un-physical distributions.

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Avoid Those as much as possible!

- Syntax Like
  - ➡ p p > z > e+ e- (ask one S-channel z)
  - ➡ p p > e+ e- / z (forbids any z)
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- ARE NOT GAUGE INVARIANT !
- forgets diagram interference.
- can provides un-physical distributions.

Avoid Those as much as possible!

check physical meaning and gauge/Lorentz invariance if you do.

- Syntax like
  - p p > z, z > e+ e- (on-shell z decaying)
  - p p > e+ e- $ z (forbids s-channel z to be on-shell)
- Are linked to cut $|M^* - M| < BW_{cut} * \Gamma$
- Are more safer to use
- Prefer those syntax to the previous slides one

Exercise III: scripting

- Look at the cross-section for the previous process for 3 different mass points.
  - ➡ hint: you can edit the param_card/run_card via the "set" command [After the launch]
  - ➡ hint: All command [including answer to question] can be put in a file.

Exercise III: scripting

- File content:

```
import model sm
generate p p > t t~
output
launch
set mt 160
set wt Auto
done
launch
set mt 165
set wt Auto
launch
set mt 170
set wt Auto
launch
set mt 175
set wt Auto
launch
set mt 180
set wt Auto
launch
set mt 185
set wt Auto
```

- Run it by:
  - ./bin/mg5 PATH
  - (smarter than ./bin/mg5 < PATH)