Events' structure at 100 TeV: a first look

Future Hadron Colliders, informal meeting #2

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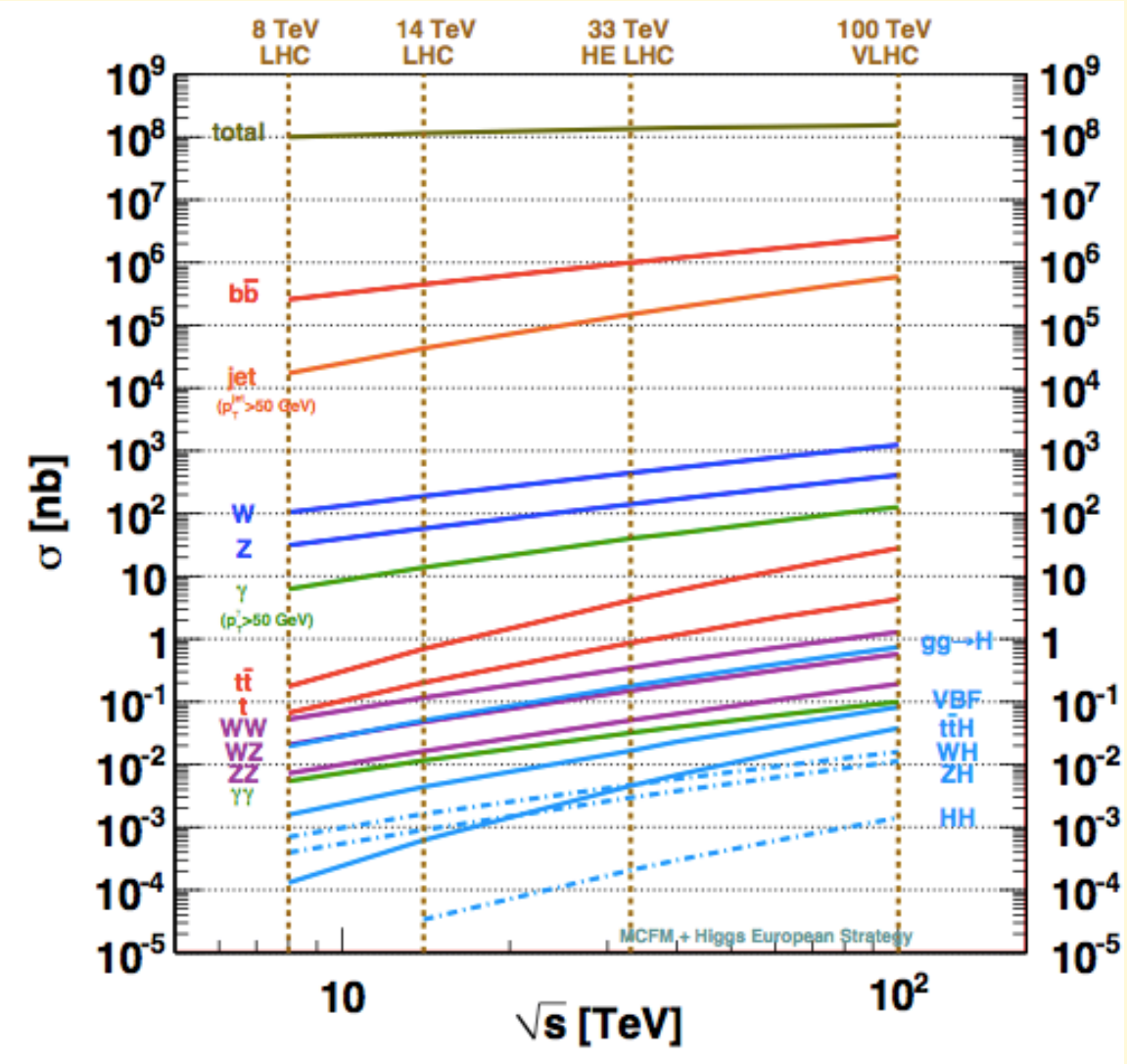
Introduction

- Ref to Snowmass study
- jet rates:
  - high pt reach
  - low-pt to saturate sigma total
  - structure of MB events ?
- W production: lepton distributions, acceptances. W pt spectrum
  - associated production of jets and W's
  - multi-W rates (3,4,5, ... ?)
- Top quarks:
  - lepton and b acceptance vs pt, eta
  - top pt and mtt spectra
- WW and HH in VBF: jet spectra, rates vs m(WW), m(HH)
- tt H production, high pt(top)
- PDF: future talk by Juan

Relevant Snowmass docs

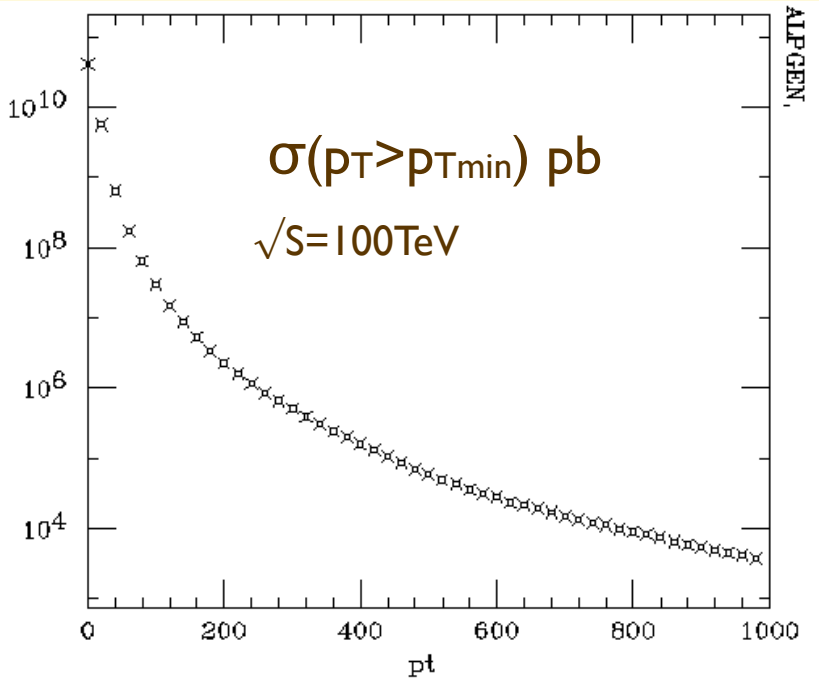
- Methods and Results for Standard Model Event Generation at sqrt{s} = 14 TeV, 33 TeV and 100 TeV Proton Colliders http://arxiv.org/abs/1308.1636v2
- Report of the Snowmass 2013 energy frontier QCD working group, http://arxiv.org/abs/1310.5189v1

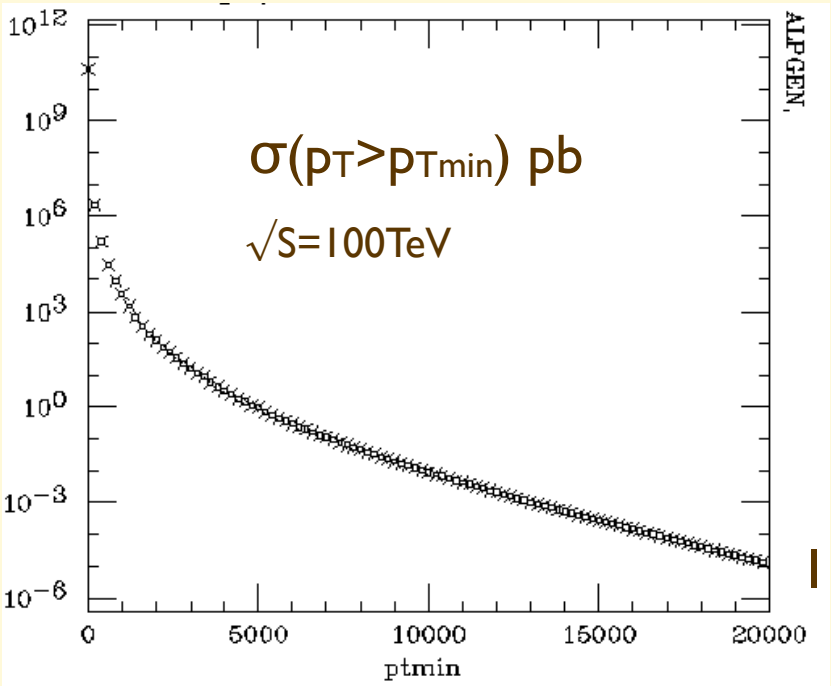


Inclusive jets

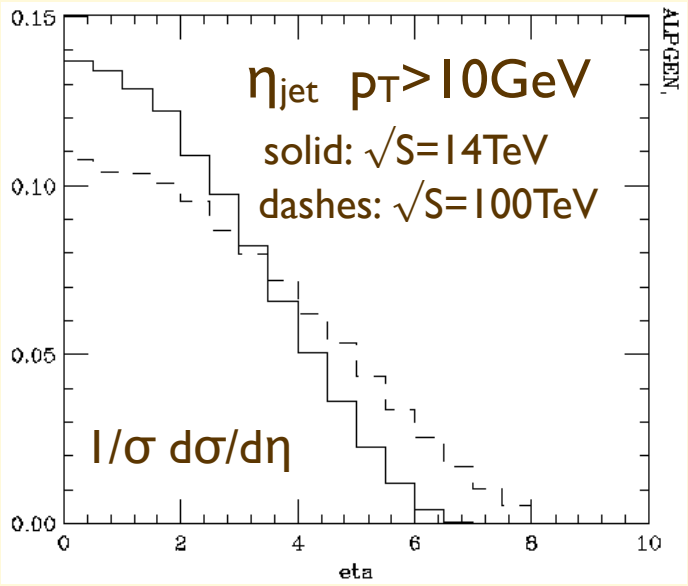
$\sigma(pt > 5\ GeV) = 240\ mb \sim 2 \times \sigma_{TOT}(pp)$

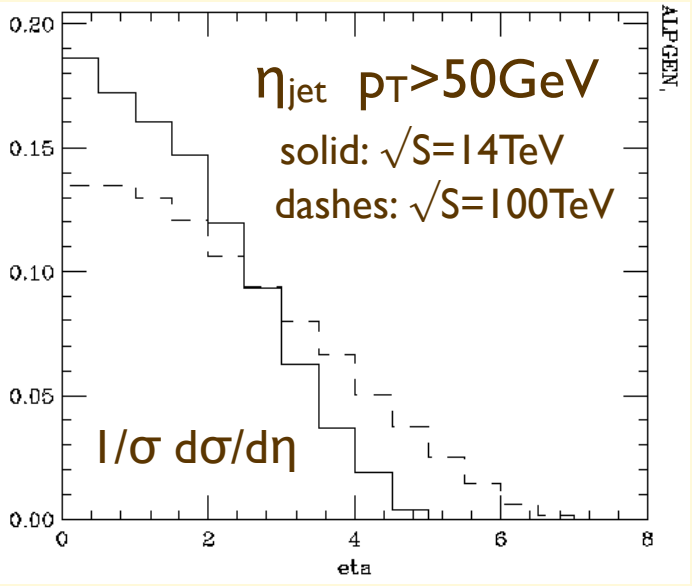
$\sigma(pt > 10\ GeV) = 40\ mb \sim 1/3 \times \sigma_{TOT}(pp)$

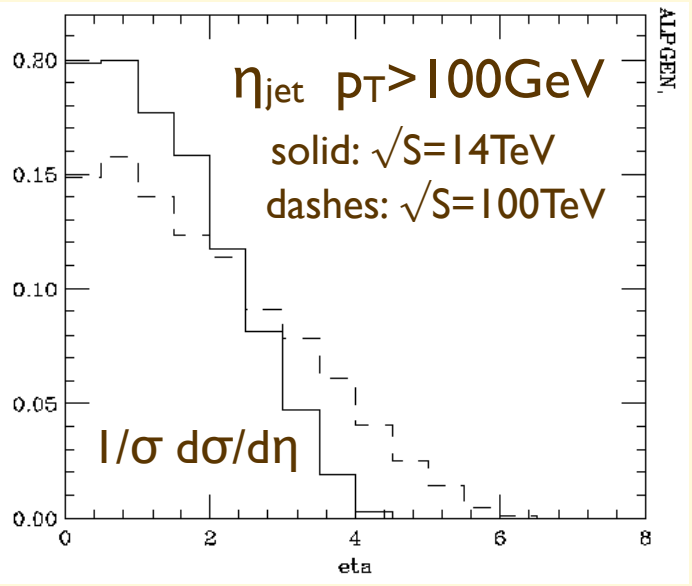




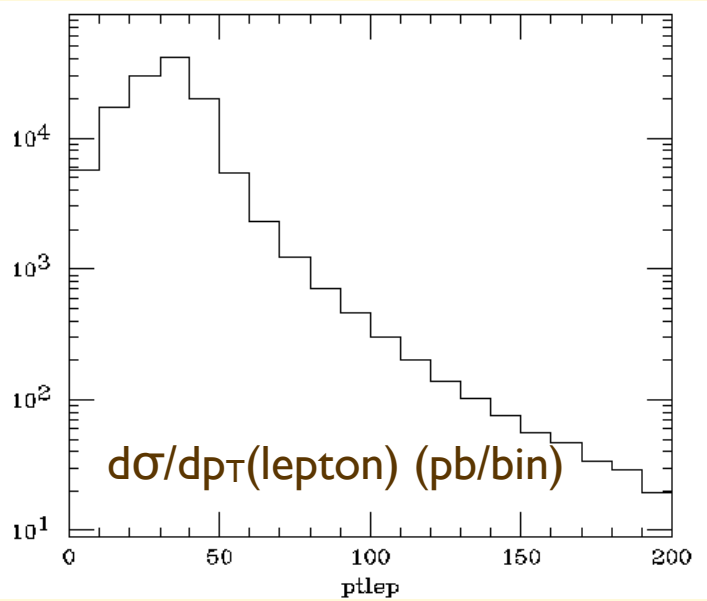
1 event/100fb^{-1}

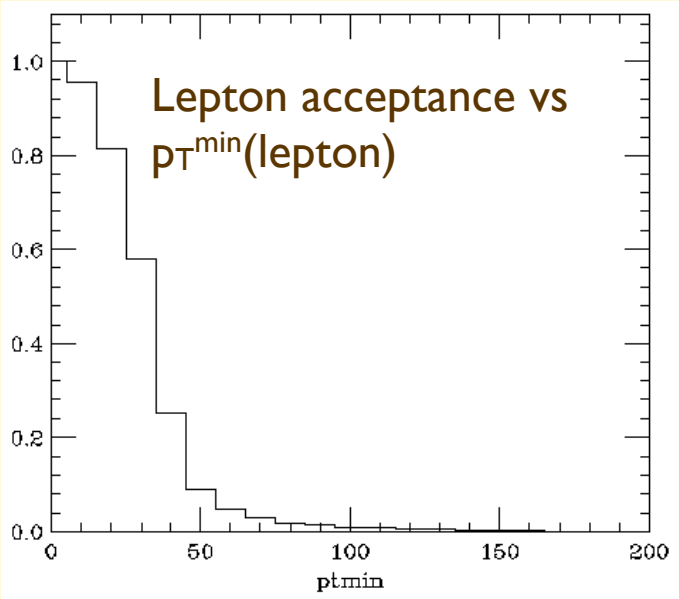


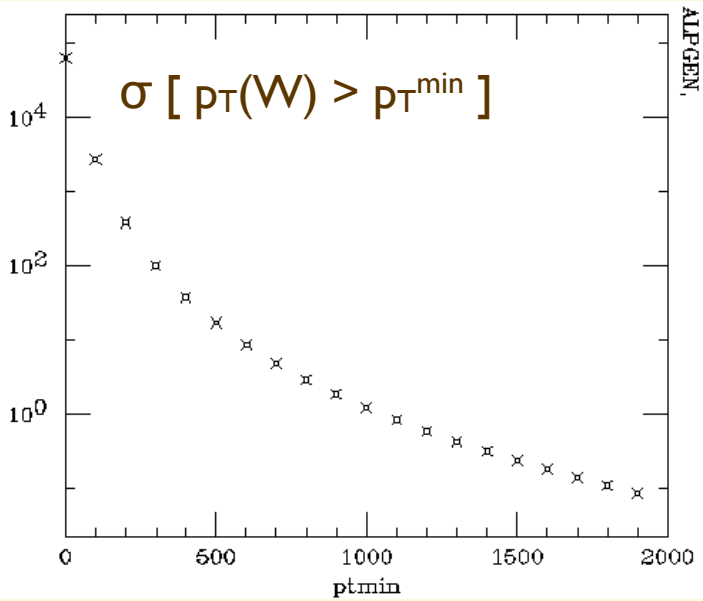


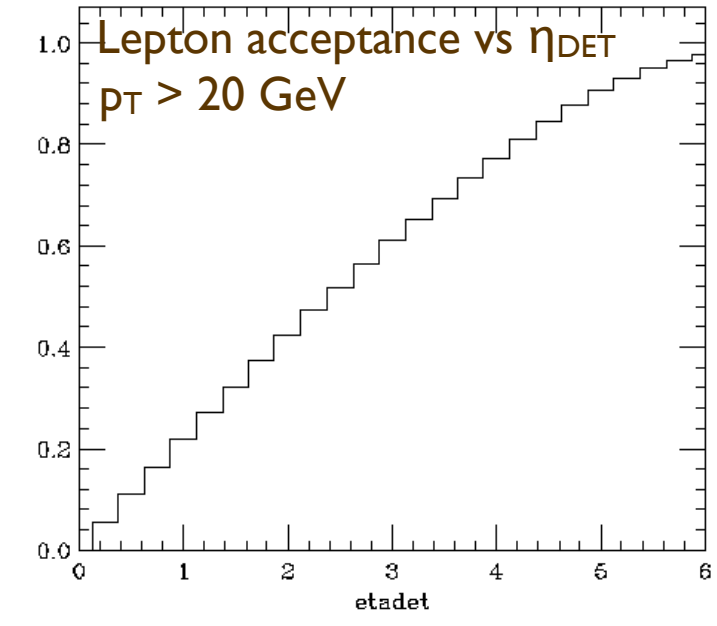


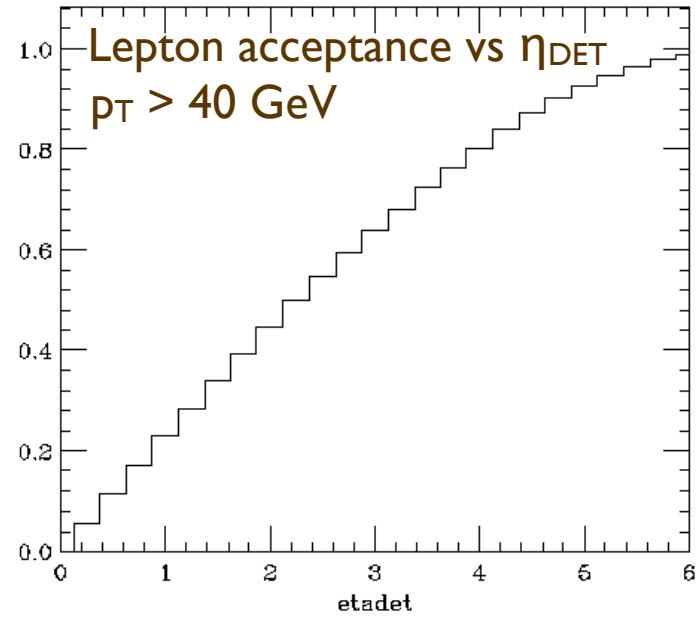
Inclusive W production



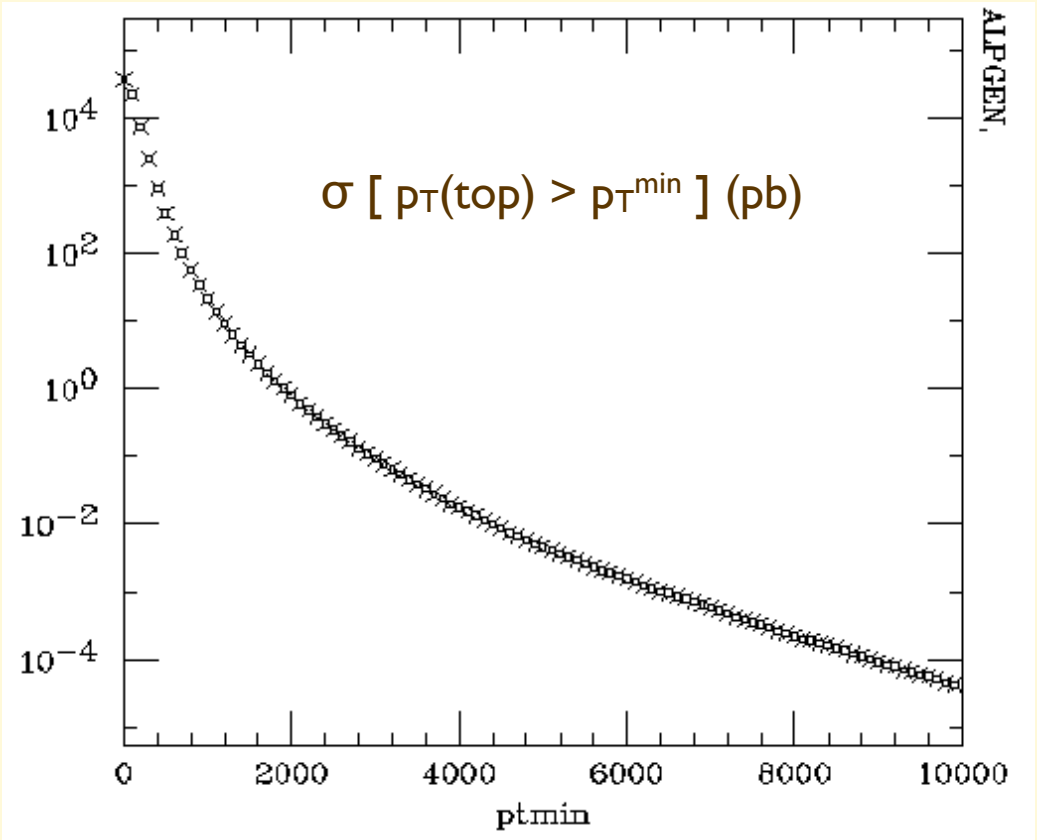


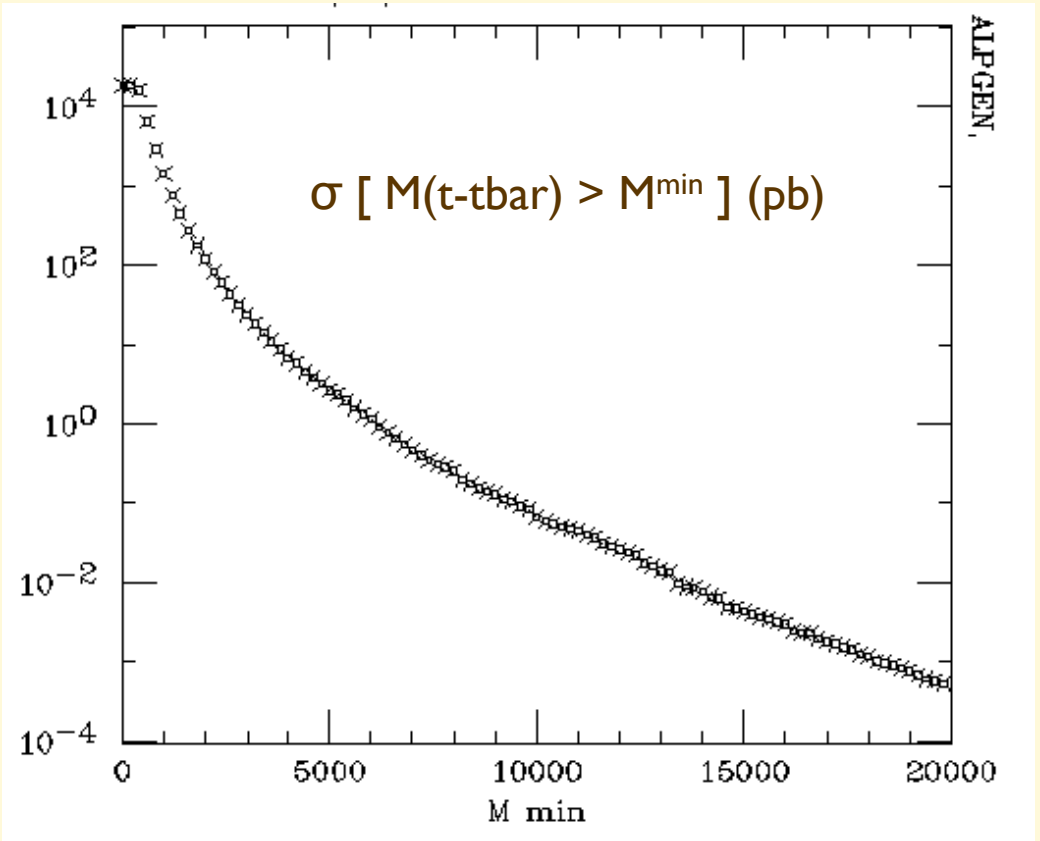




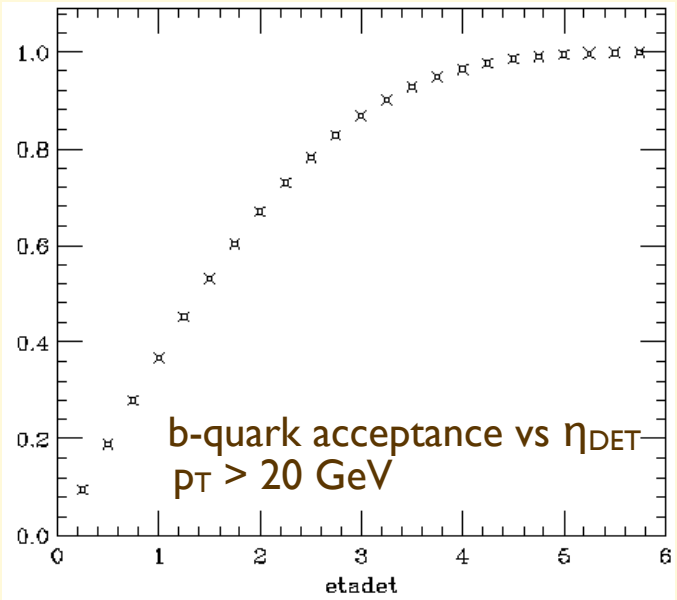


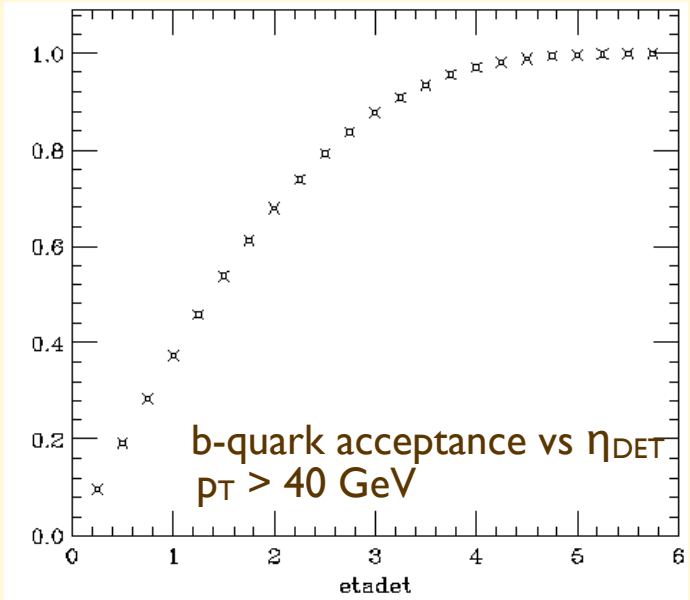
Inclusive t-tbar production: cross sections

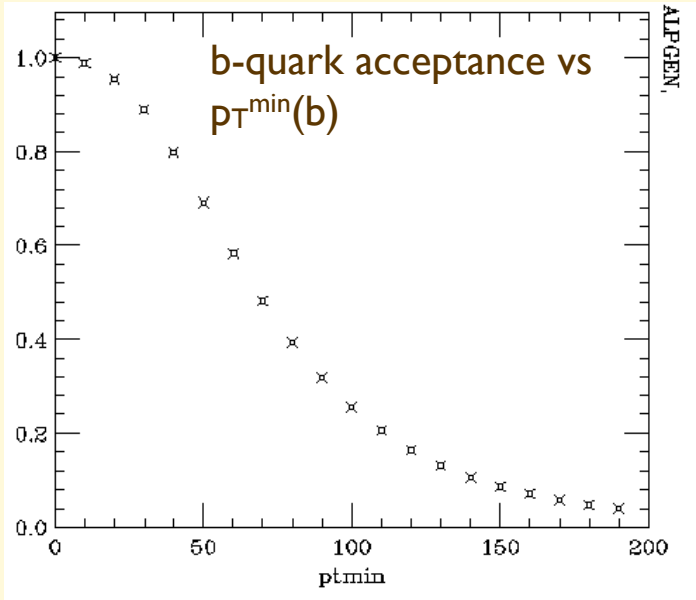


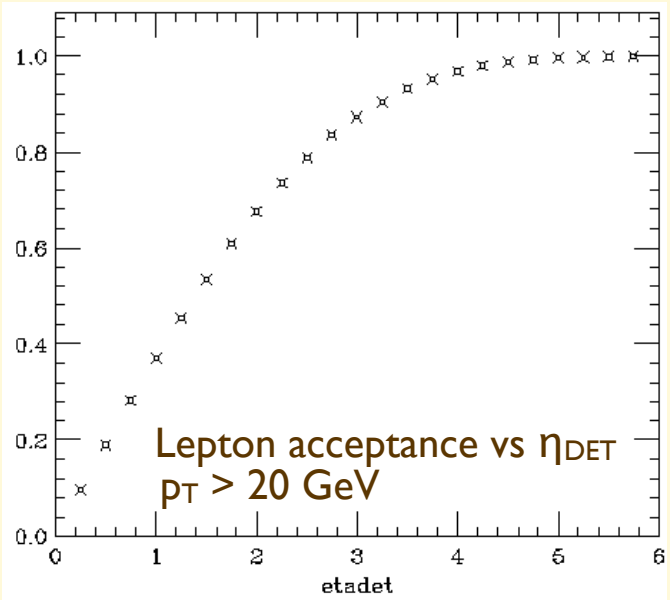


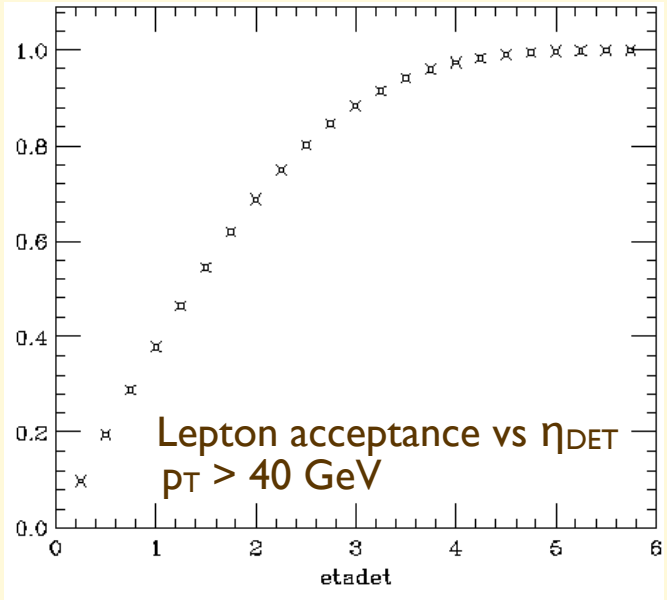
Inclusive t-tbar production: lepton and b-quark acceptances

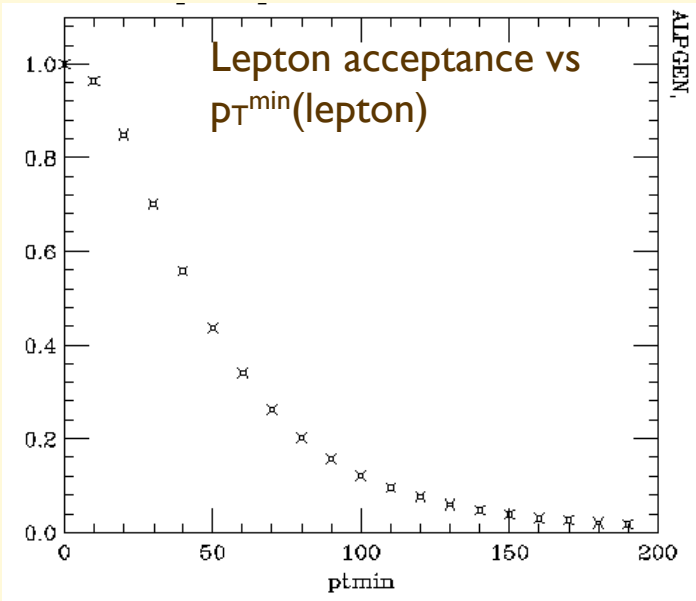






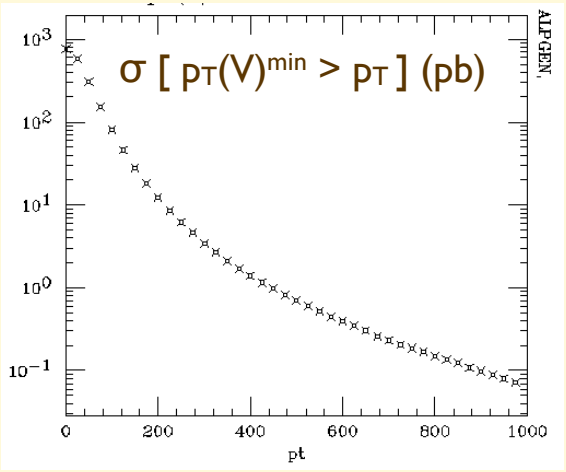




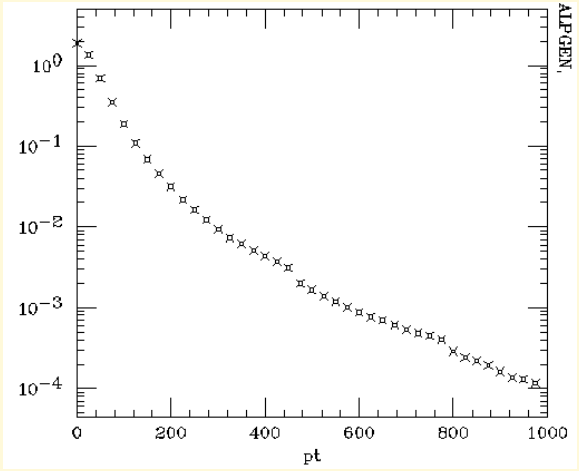


Multi-gauge boson production (no BR included)

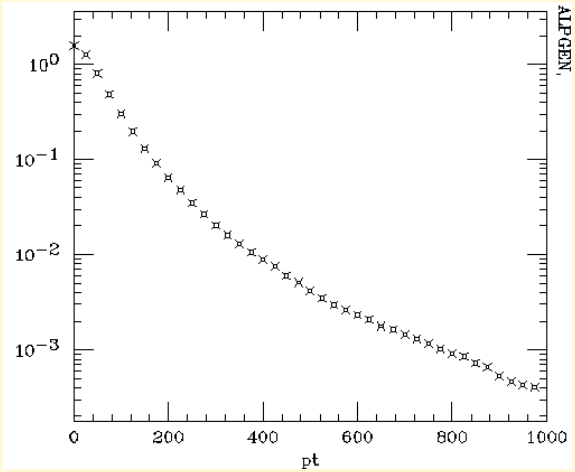
WW σ=770 pb

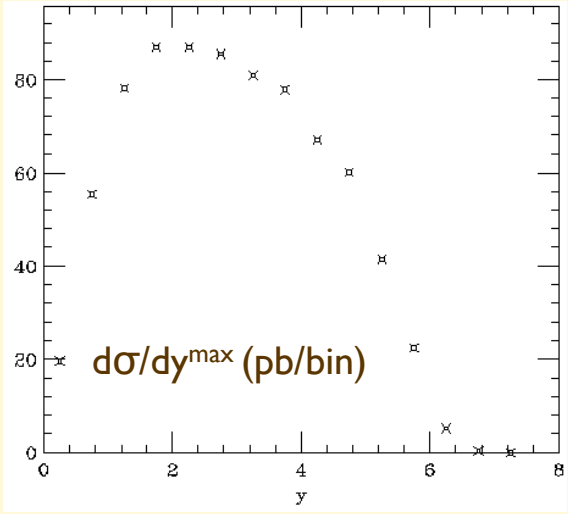


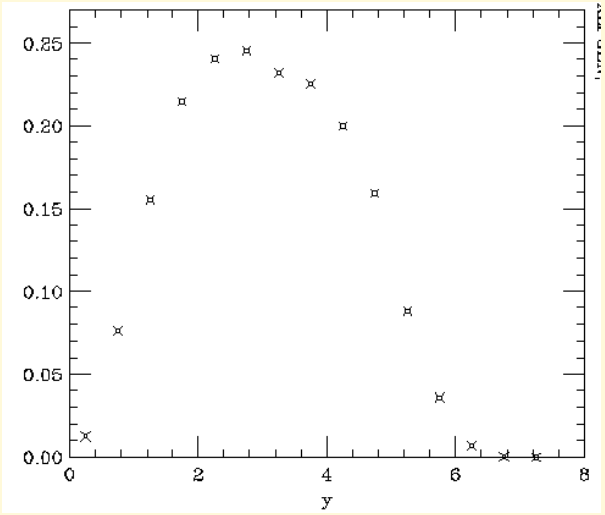
WWW σ= 2 pb

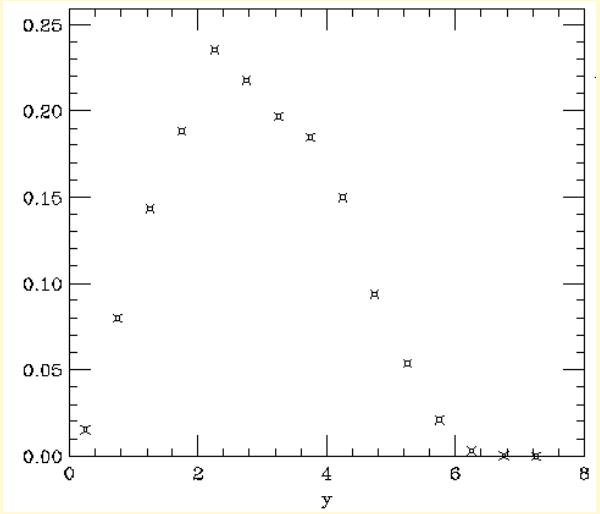


WWZ σ= 1.6 pb



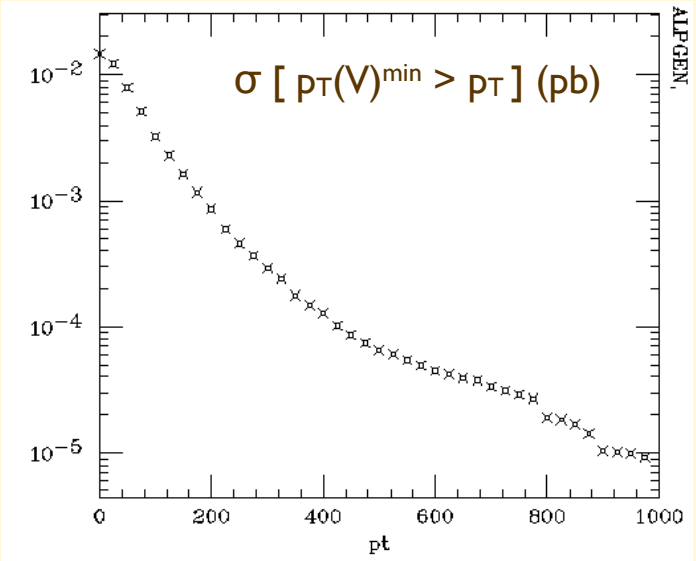


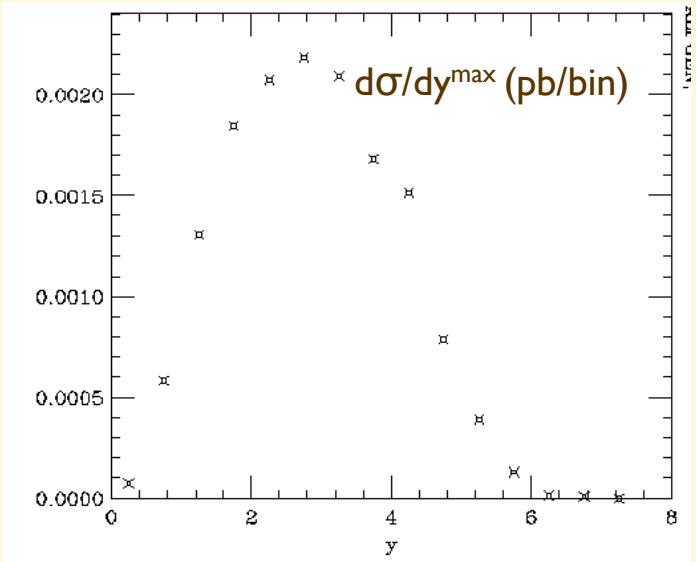




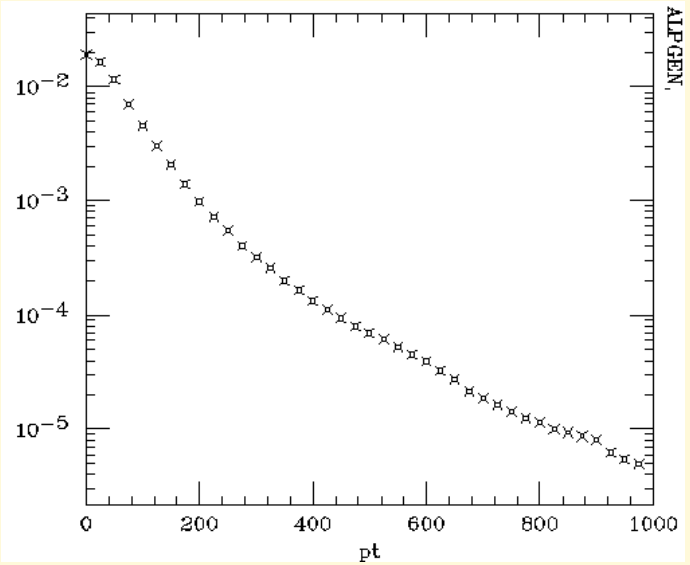
Multi-gauge boson production (no BR included)

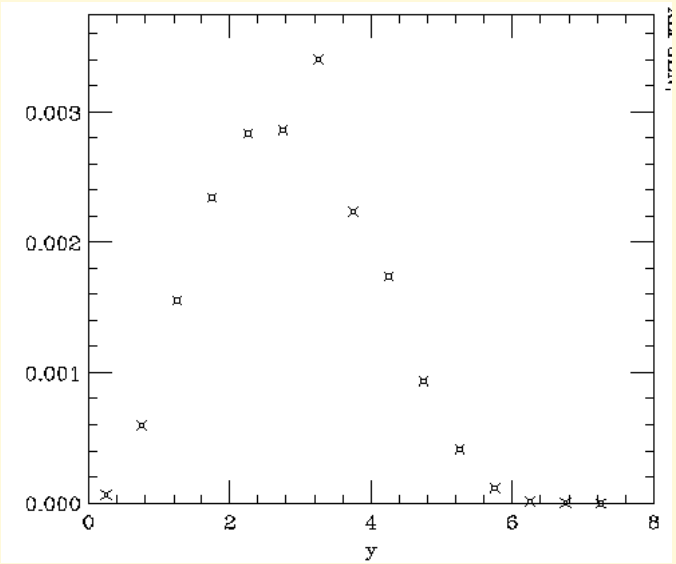
WWWW σ= 15 fb





WWWZ σ= 20 fb





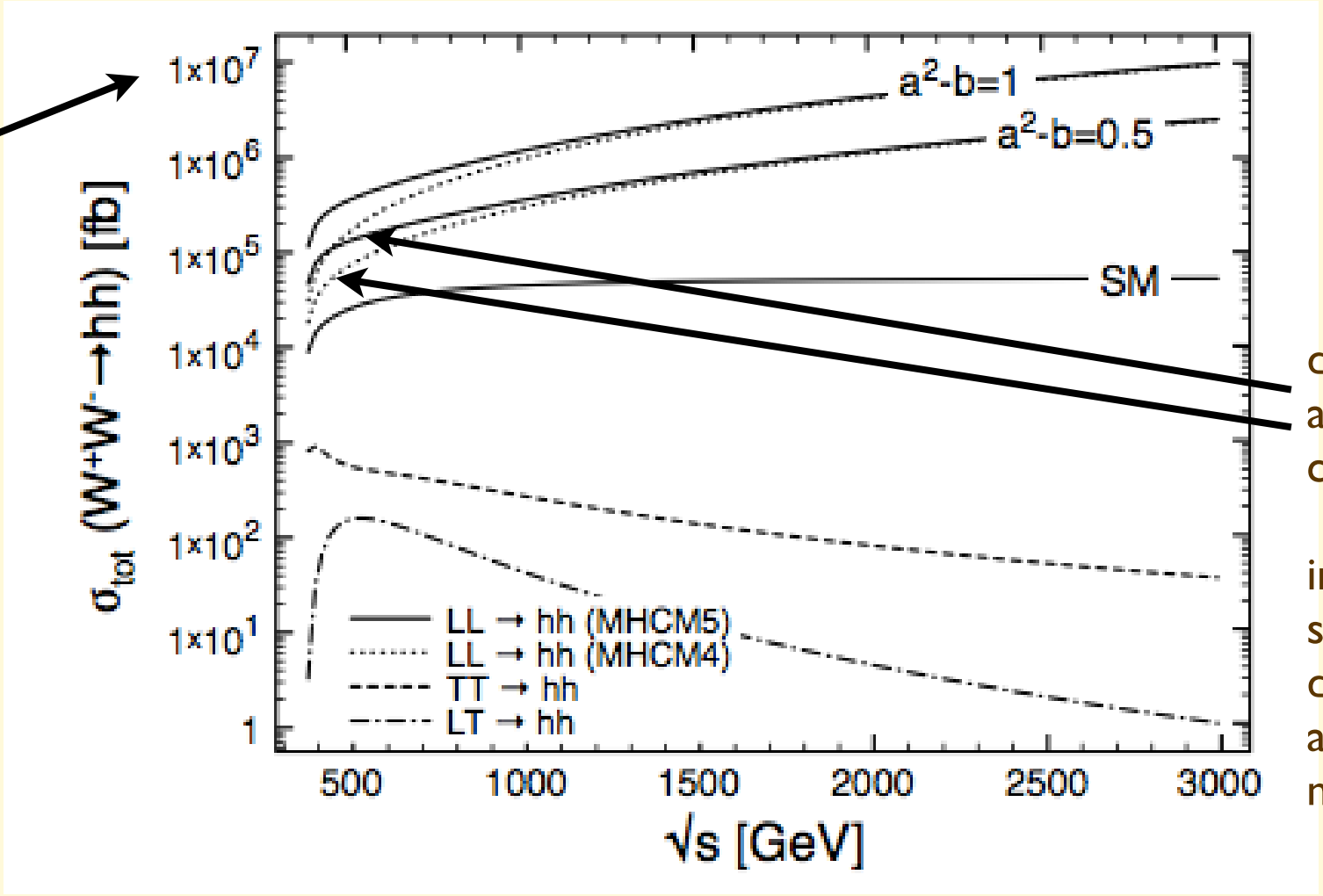
High-energy WW->WW,HH scattering

In more detail:

$$\frac{d\sigma_{LL\to LL}/dt}{d\sigma_{TT\to TT}/dt}|_{90^o} = \frac{(1-a^2)^2}{2304}\frac{s^2}{M_W^4} \qquad \frac{d\sigma_{LL\to hh}/dt}{d\sigma_{TT\to hh}/dt} = \frac{2s^2}{g^4v^4}\frac{(b-a^2)^2}{(a^4+(b-a^2)^2)}$$

Example: WW→HH

R.Contino et al, arXiv:1002.1011v2

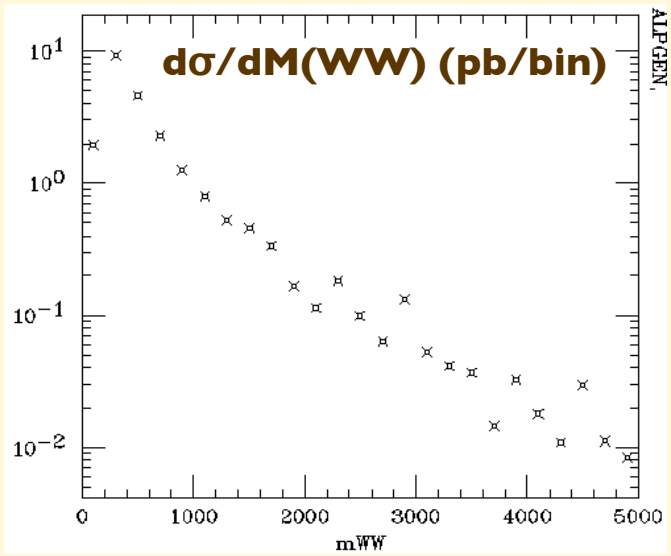


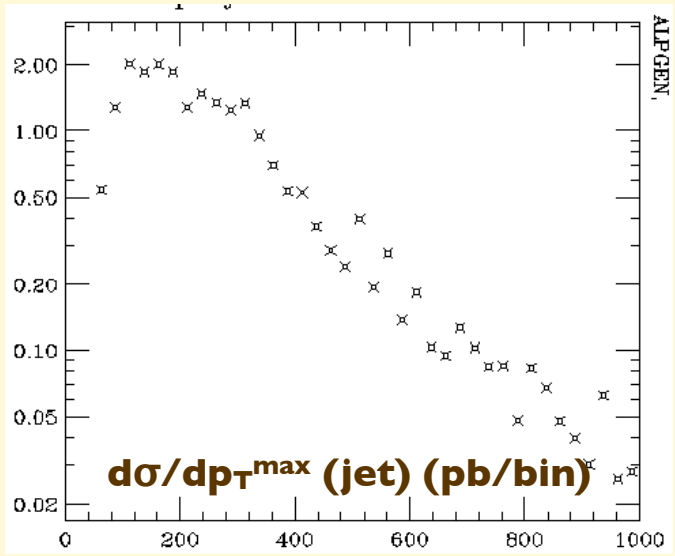
partonic cross sections

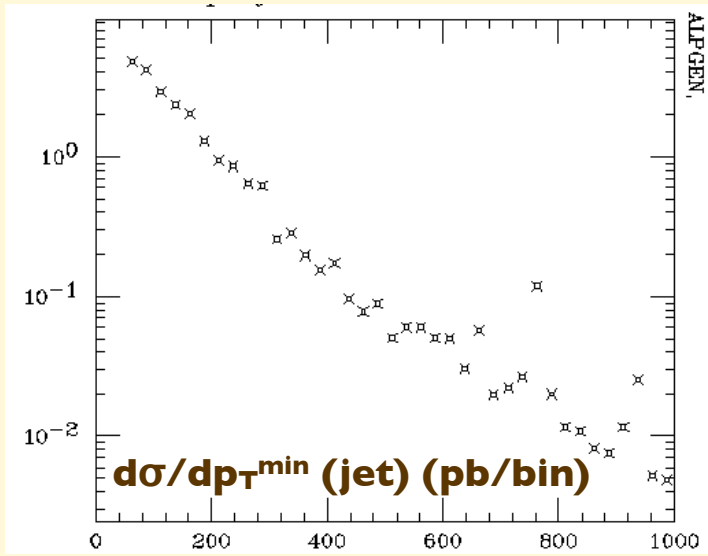
different anomalous HHH couplings:

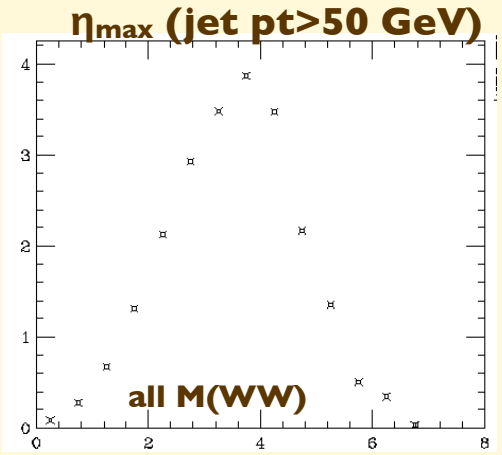
invariant mass spectrum of HH discriminates among BSM models

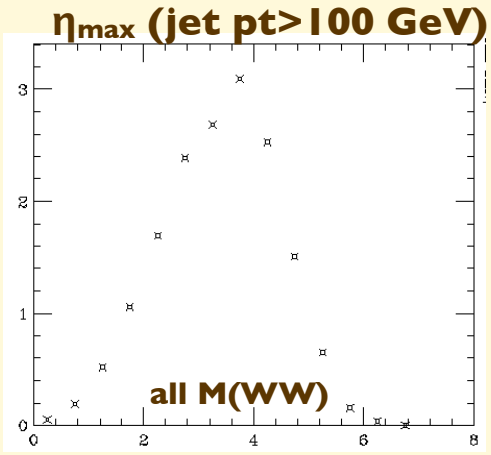
High-mass WW VBF production. p_T^{jet}> 50 GeV

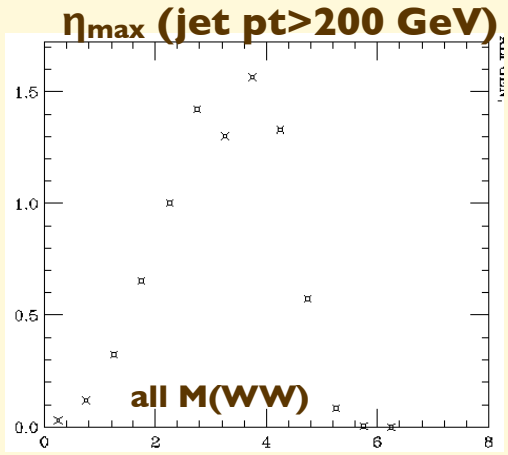


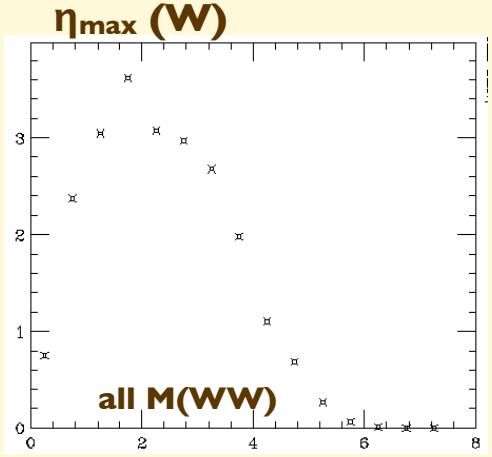


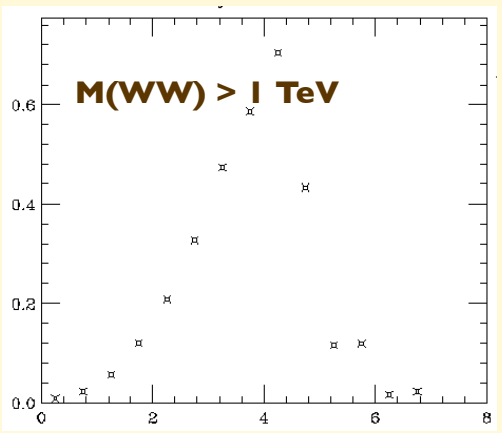


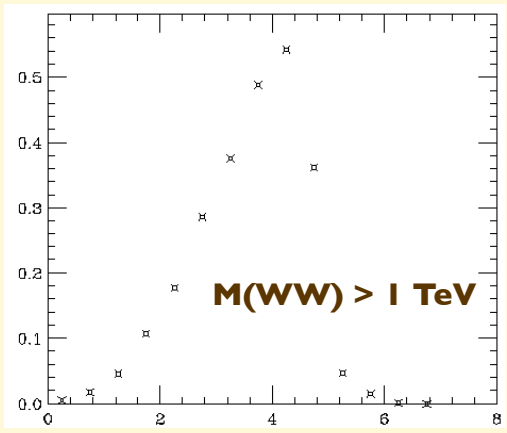


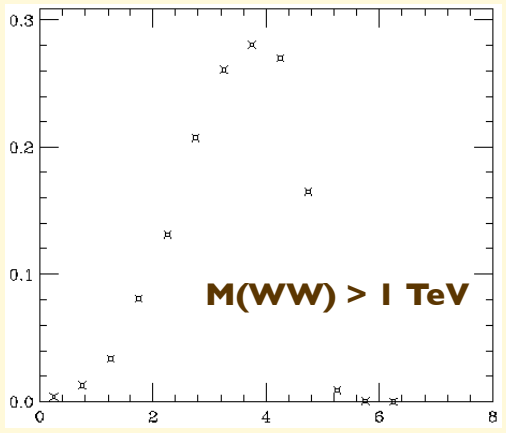


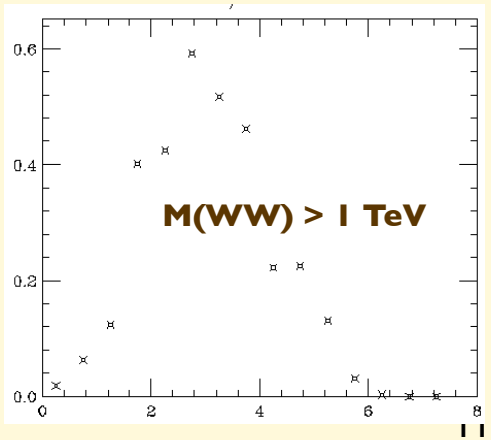




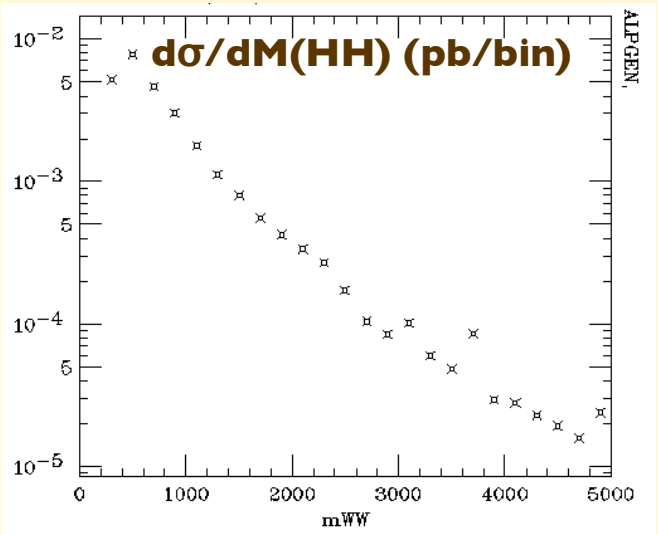


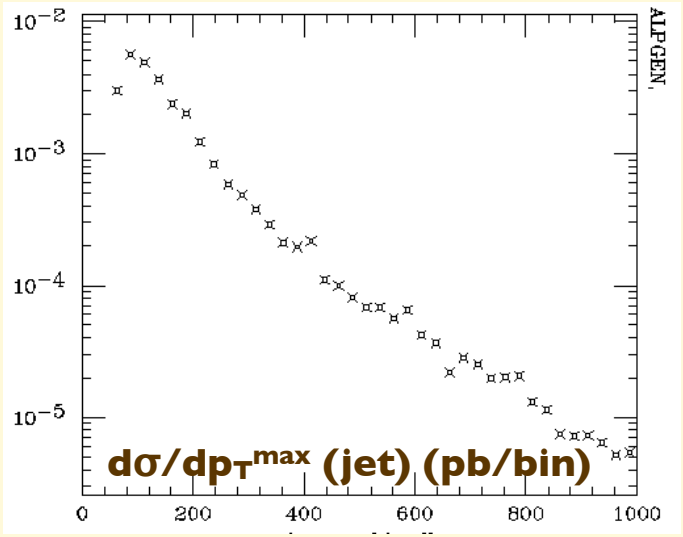


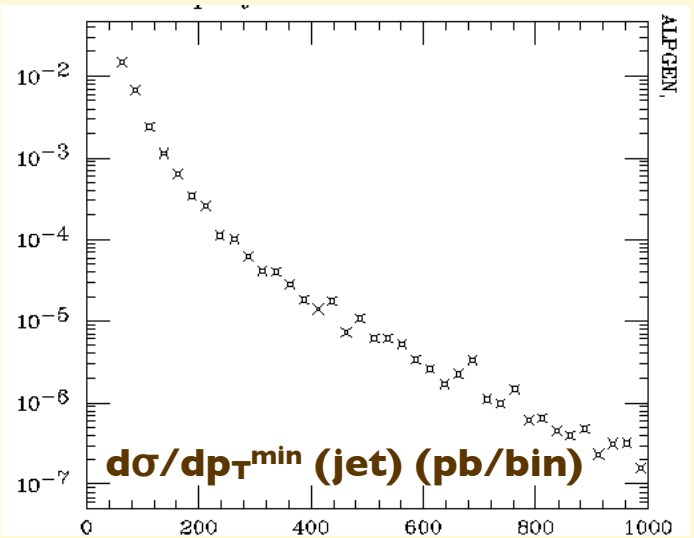




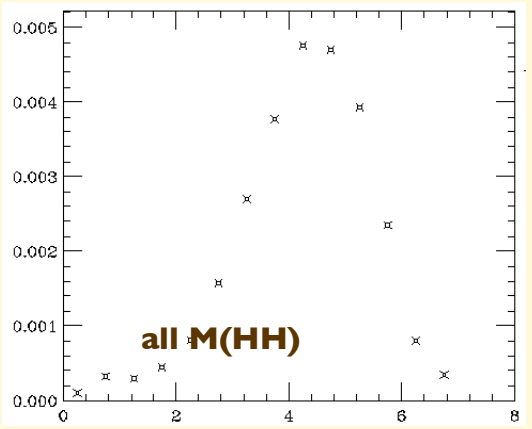
High-mass HH VBF production. p_T^{jet}> 50 GeV



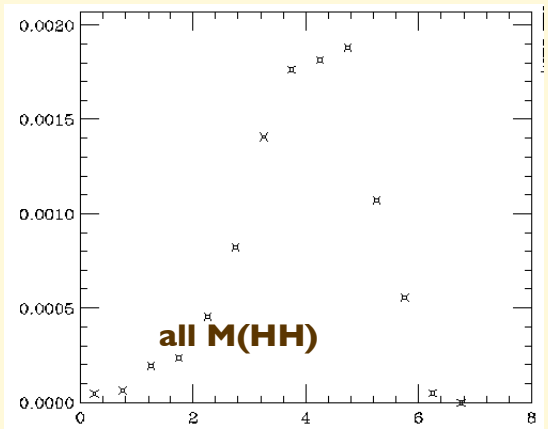




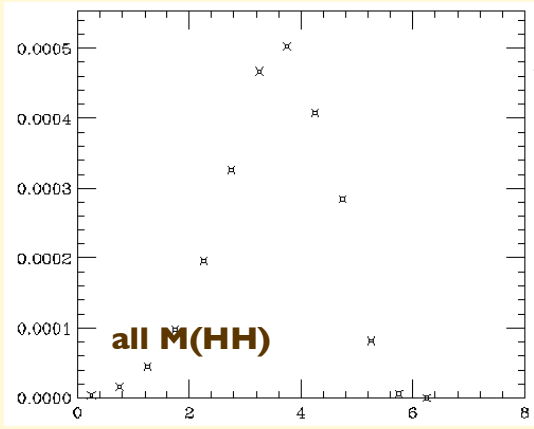
η_{max} (jet pt>50 GeV)



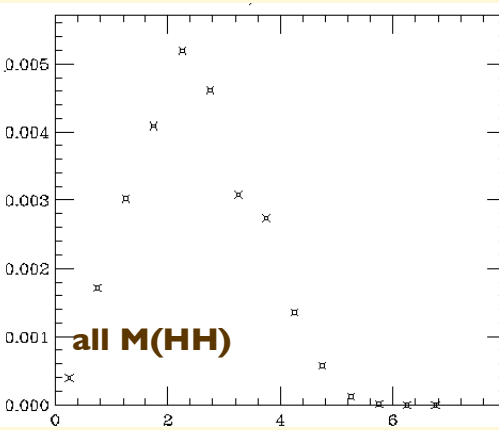
η_{max} (jet pt>100 GeV)

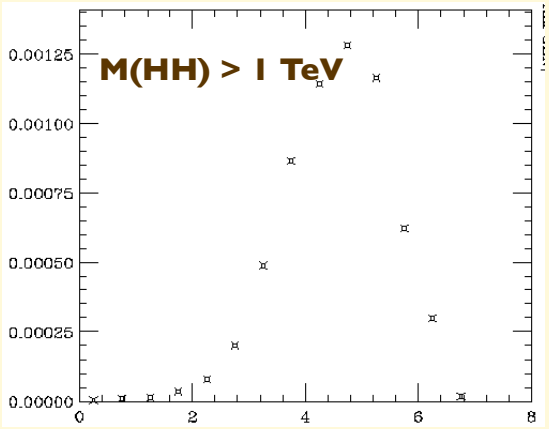


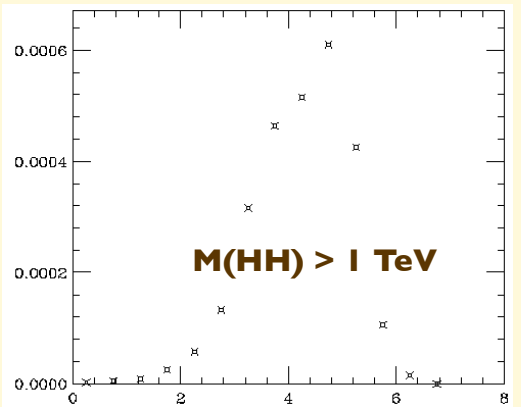
η_{max} (jet pt>200 GeV)

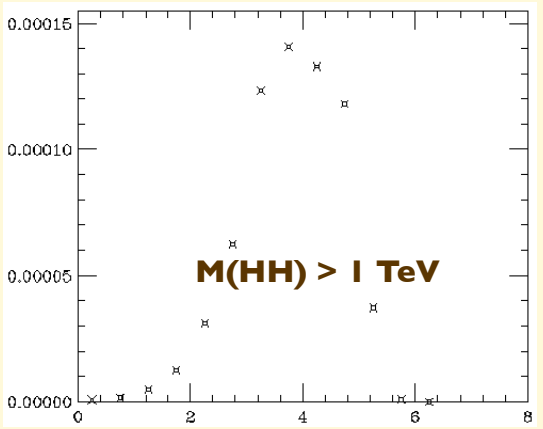


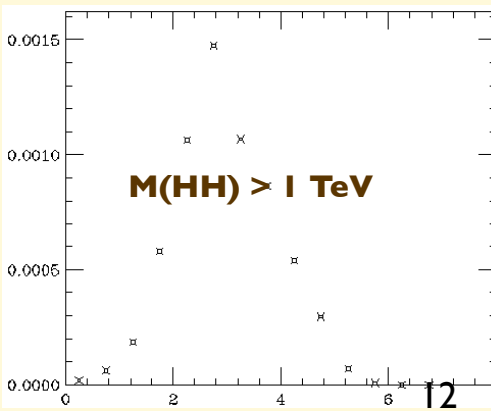
η_{max} (H)











Higgs rates at high energy

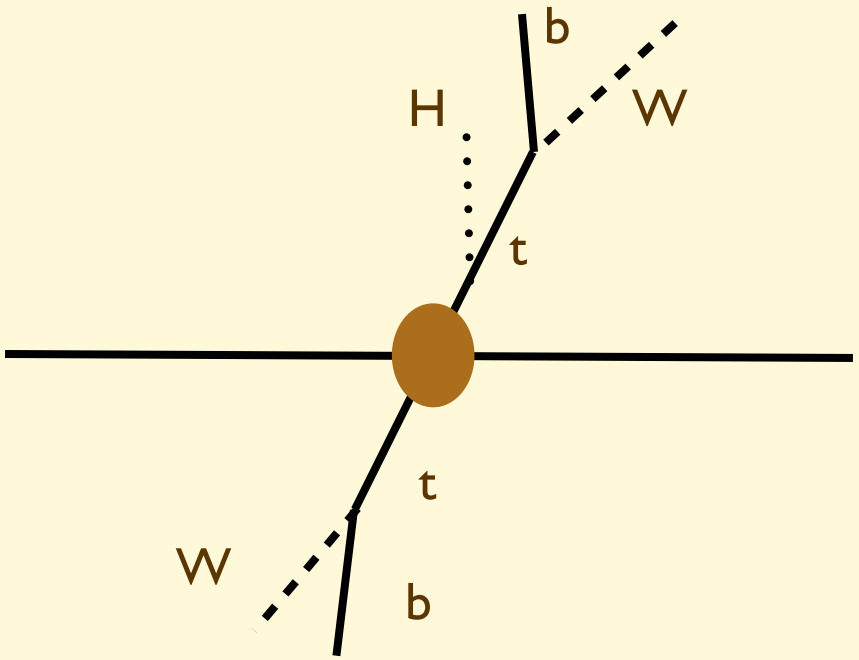
NLO rates **R(E)** = σ(E TeV)/σ(14 TeV)

	σ(14 TeV)	R(33)	R(40)	R(60)	R(80)	R(100)
ggH	50.4 pb	3.5	4.6	7.8	11.2	14.7
VBF	4.40 pb	3.8	5.2	9.3	13.6	18.6
WH	1.63 pb	2.9	3.6	5.7	7.7	9.7
ZH	0.90 pb	3.3	4.2	6.8	9.6	12.5
ttH	0.62 pb	7.3	11	24	41	61
HH	33.8 fb	6.1	8.8	18	29	42

In several cases, the gains in terms of "useful" rate are much bigger.

E.g. when we are interested in the large-invariant mass behaviour of the final states.

Example: ttH at large pt(top)



- Reduced backgrounds
- Reduced combinatorics

⇒ more reliable measurement of y_{top}

pp→ttH	**14 TeV**	**33 TeV** (33/14)	**60 TeV** (60/14)	**100 TeV** (100/14)
σ_{TOT}	0.4 pb	2.8 pb (x 7)	9.7 pb (x 24)	25 pb (x 60)
$\sigma(p_T^{top} > 0.5\ TeV)$	1.6 fb	26 fb (x 16)	120 fb (x 75)	400 fb (x 250)

(LO rates)

ttH production