Anatomy of top production and decay, and impact on m_{top} measurement

LHC top WG meeting
CERN, July 19 2012

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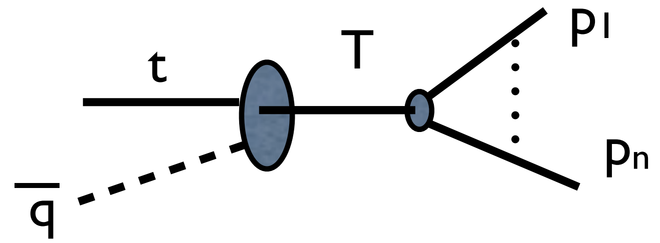
Definition of m_{top}

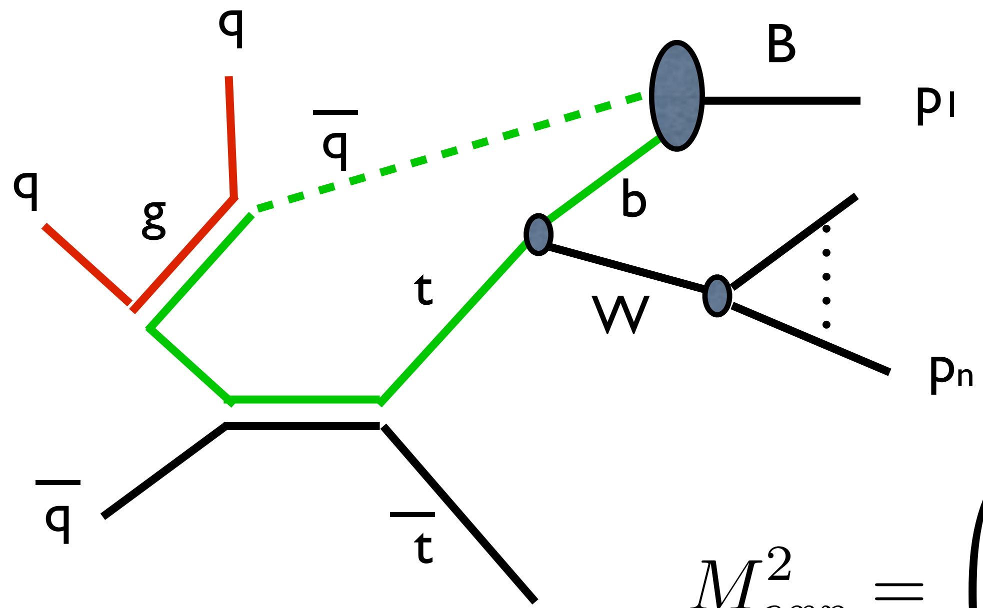
If Γ_{top} were < 1 GeV, top would hadronize before decaying. Same as b-quark



$$m_T^2 = \left(\sum_{i=1,\ldots,n} p_i \right)^2$$

$m_t = F_{lattice/potential\ models}(m_T, \alpha_{QCD})$

But Γ_{top} is > 1 GeV, top decays before hadronizing. Extra antiquarks must be added to the top-quark decay final state in order to produce the physical state whose mass will be measured



$$M_{exp}^2 = \left(\sum_{i=1,\ldots,n} p_i \right)^2$$

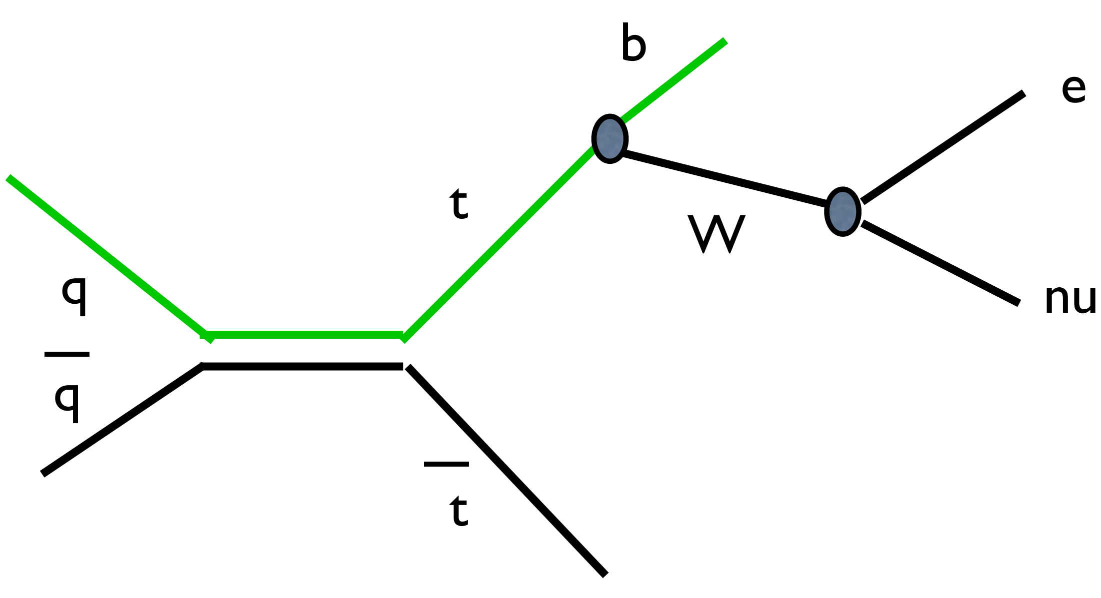
As a result, M_{exp} is not equal to m^{pole}_{top}, and will vary in each event, depending on the way the event has evolved.

The top mass extracted in hadron collisions is not well defined below a precision of $O(\Gamma_{top})\sim$ 1 GeV

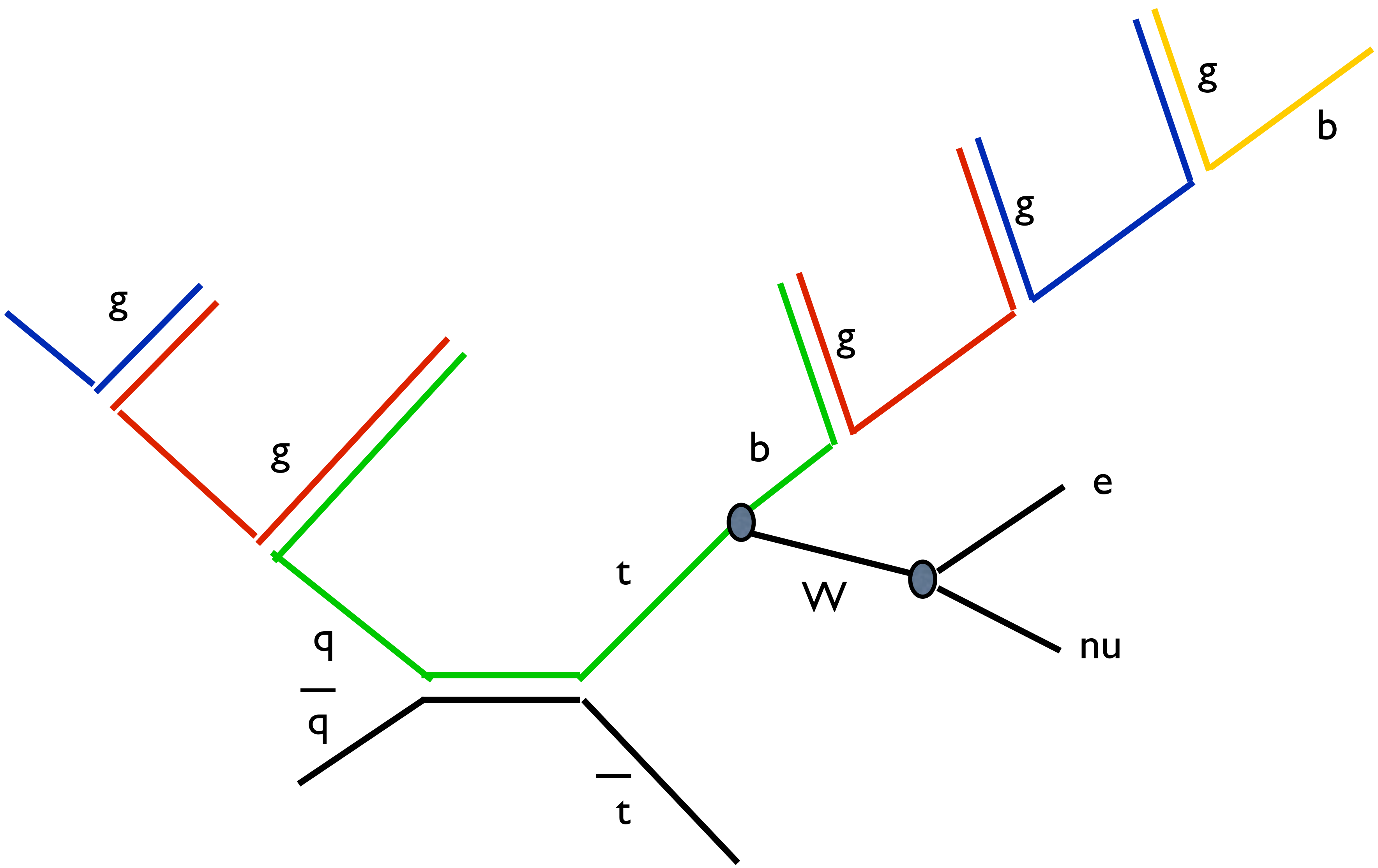
Goal:

- correctly quantify the systematic uncertainty
- identify observables that allow to validate the theoretical modeling of hadronization in top decays
- identify observables less sensitive to these effects

1. Hard Process



1. Hard Process
2. Shower evolution



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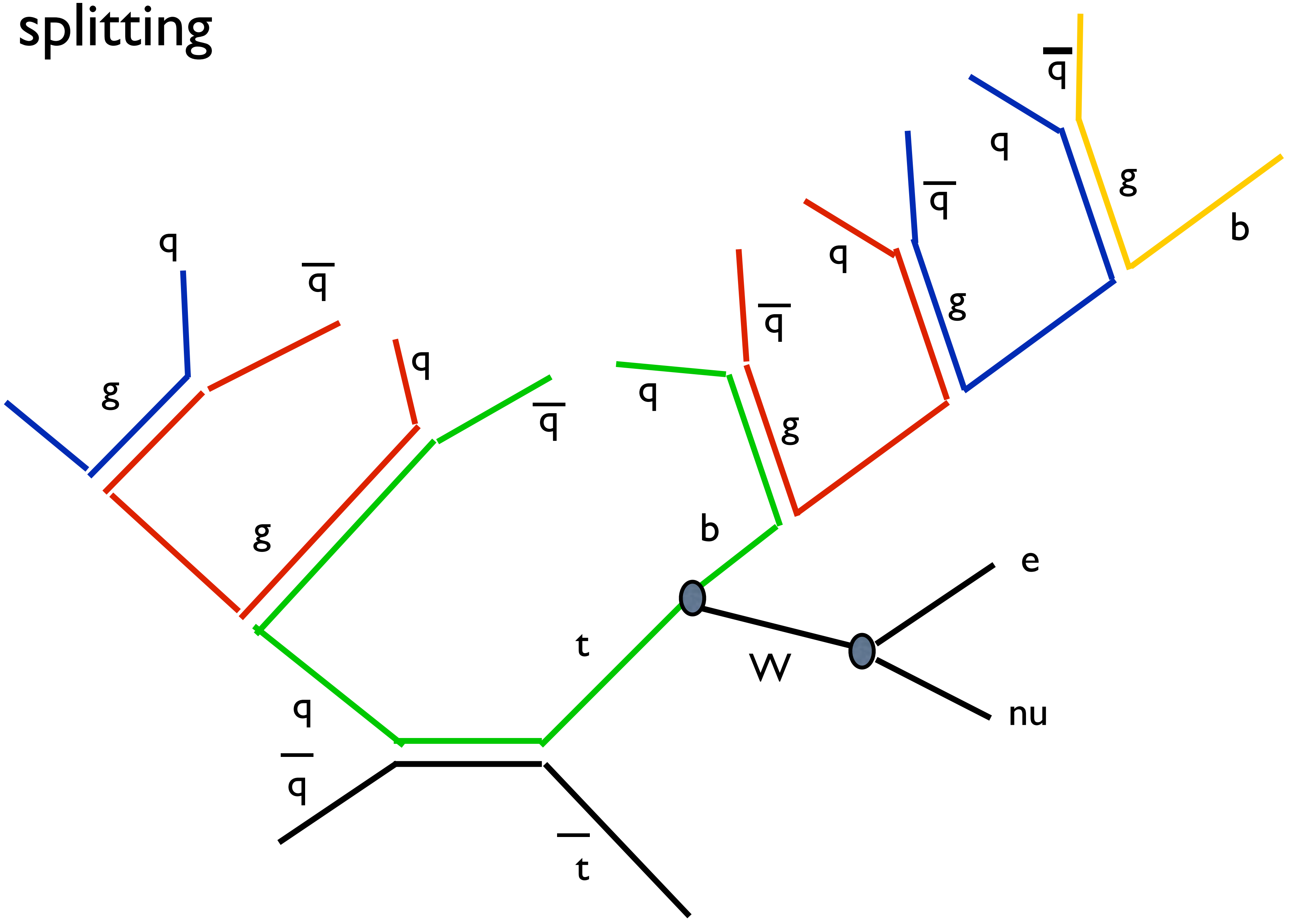

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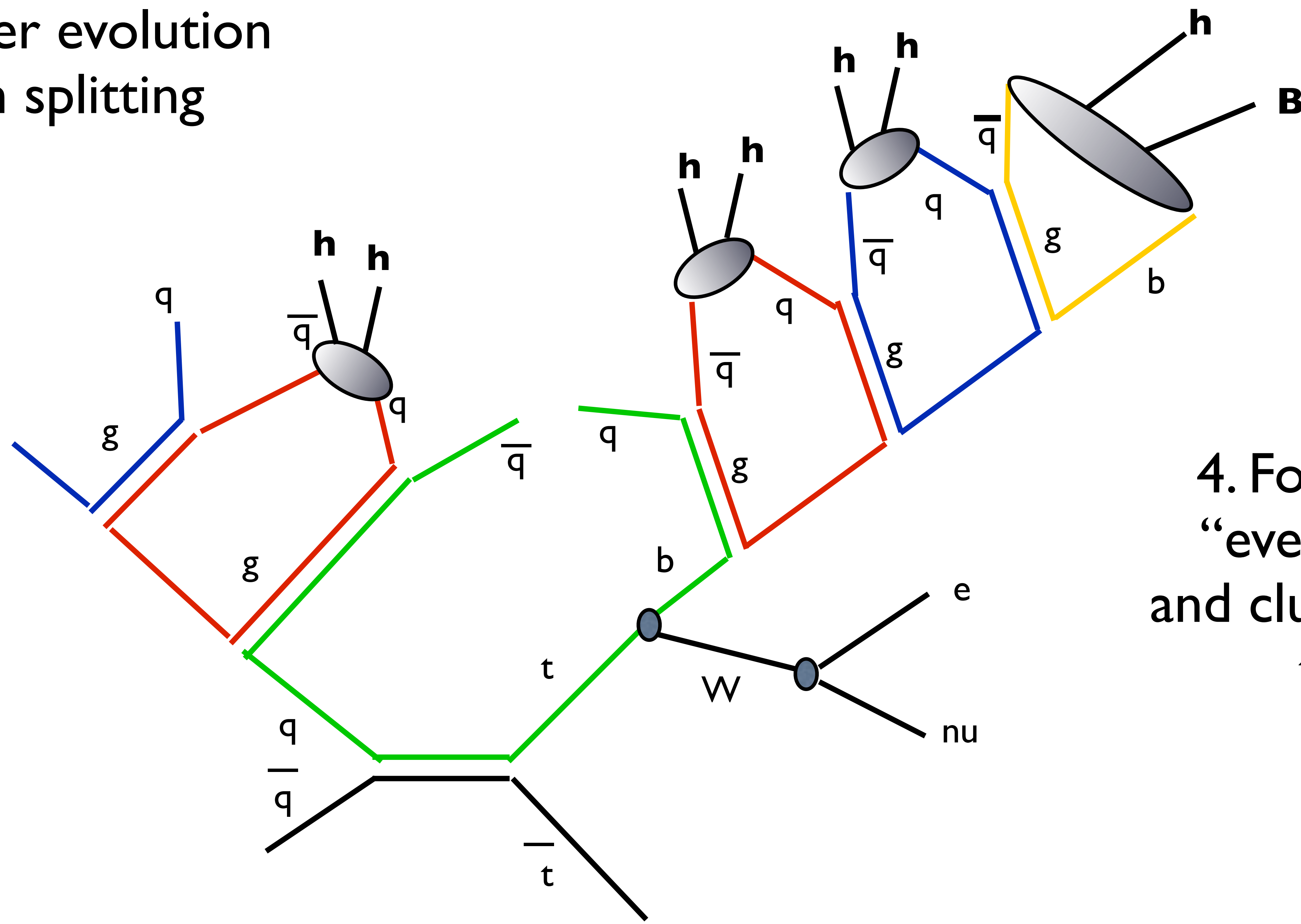

4. Formation of "even" clusters and cluster decay to hadrons

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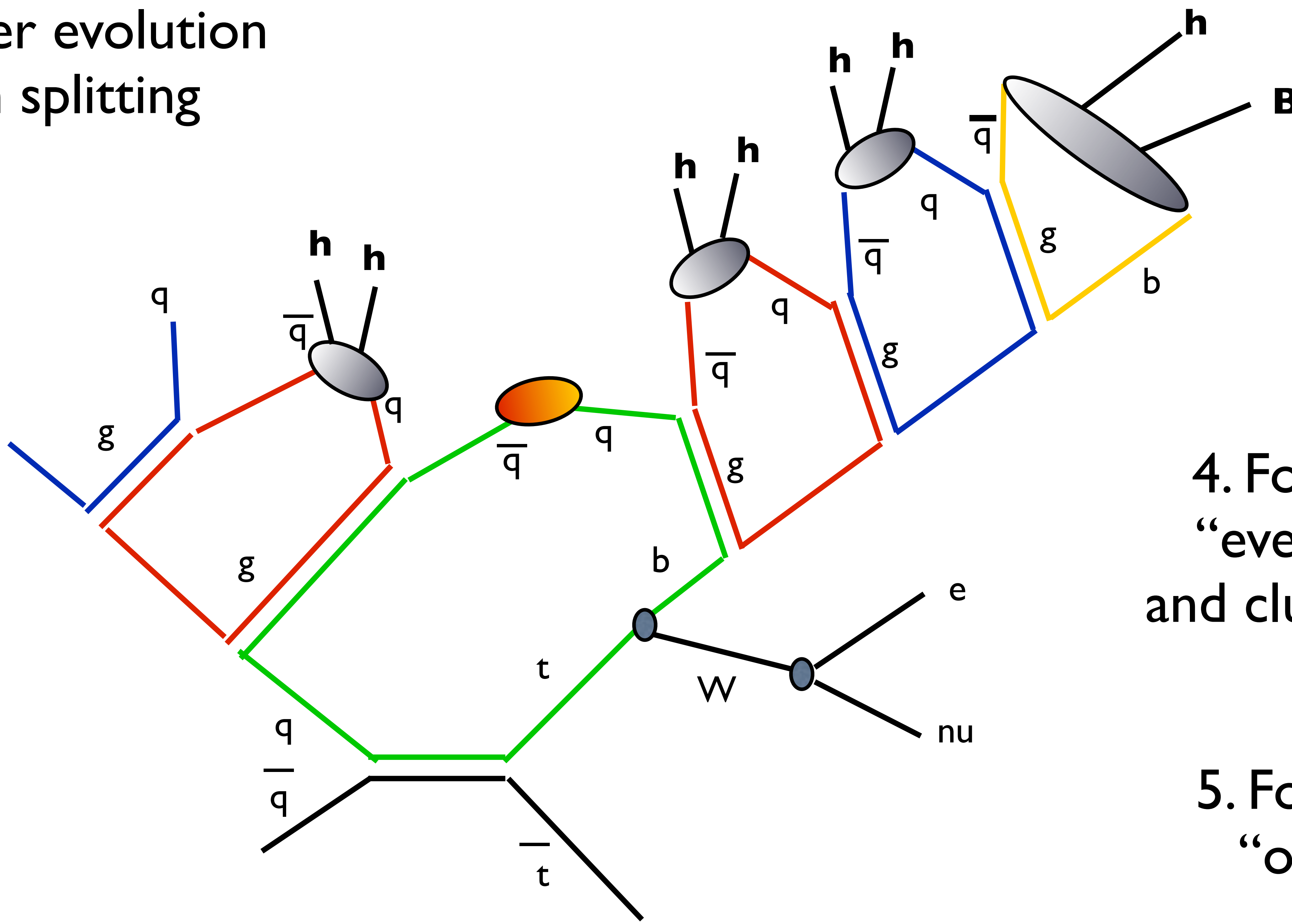

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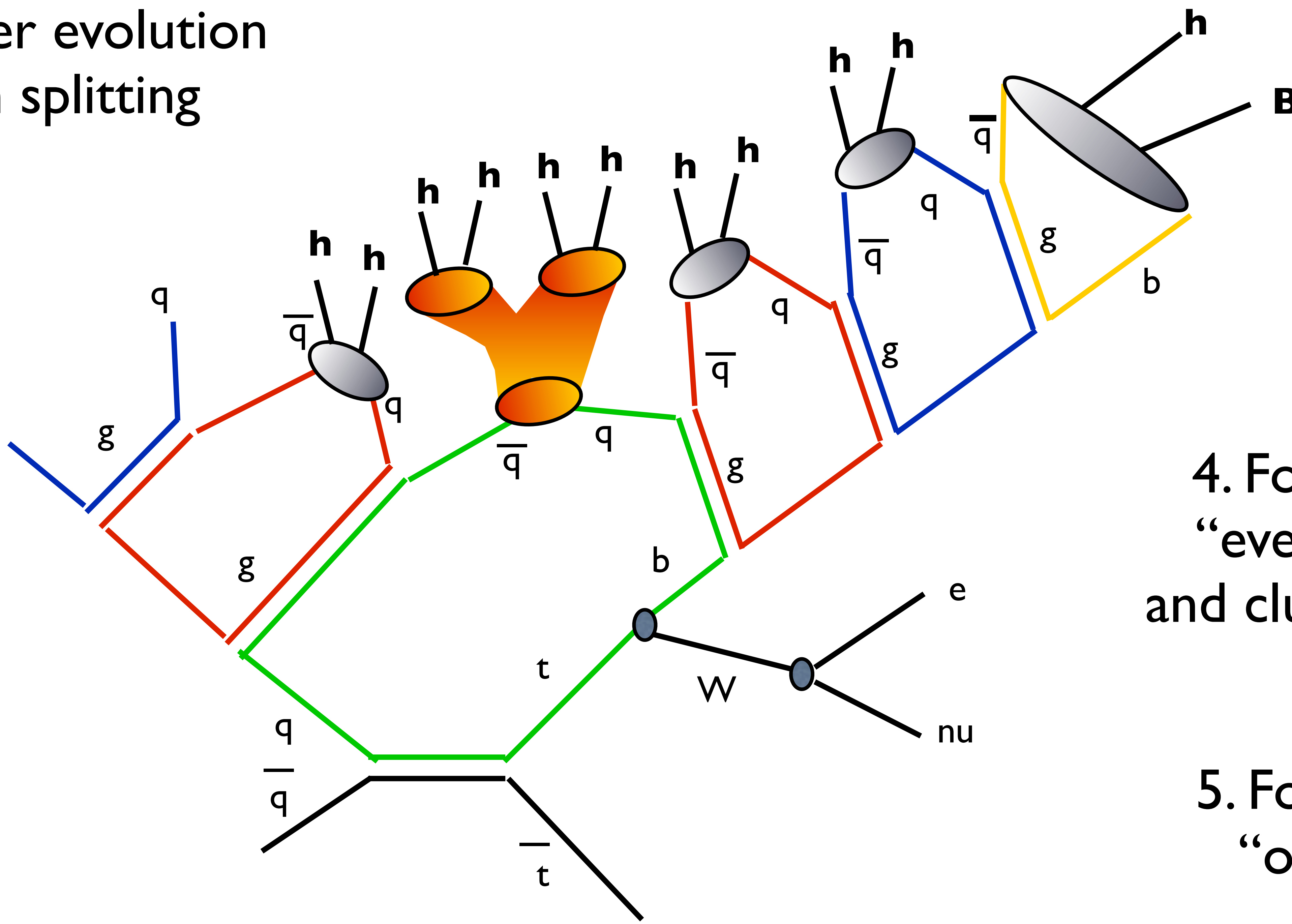

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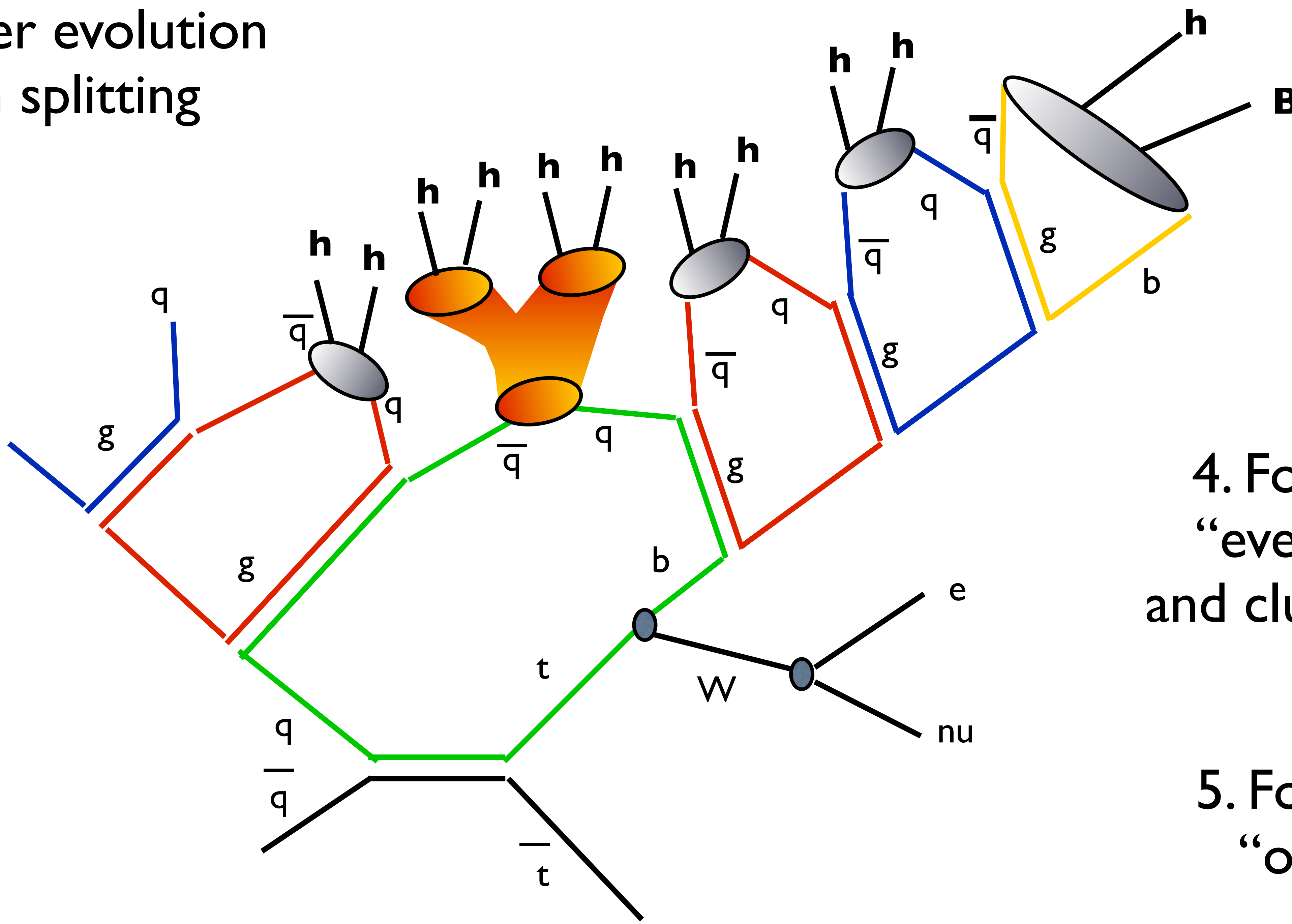

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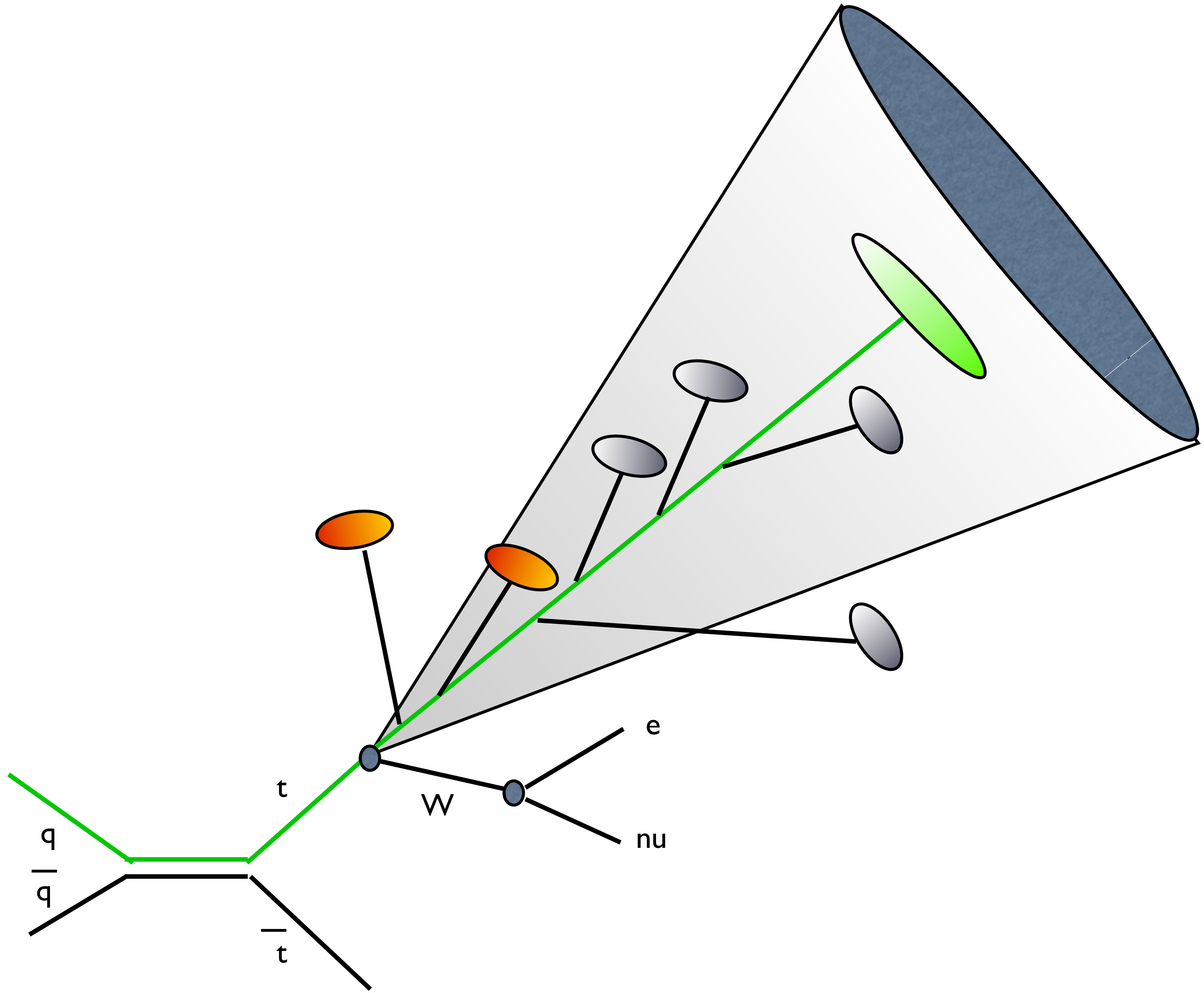
e
t
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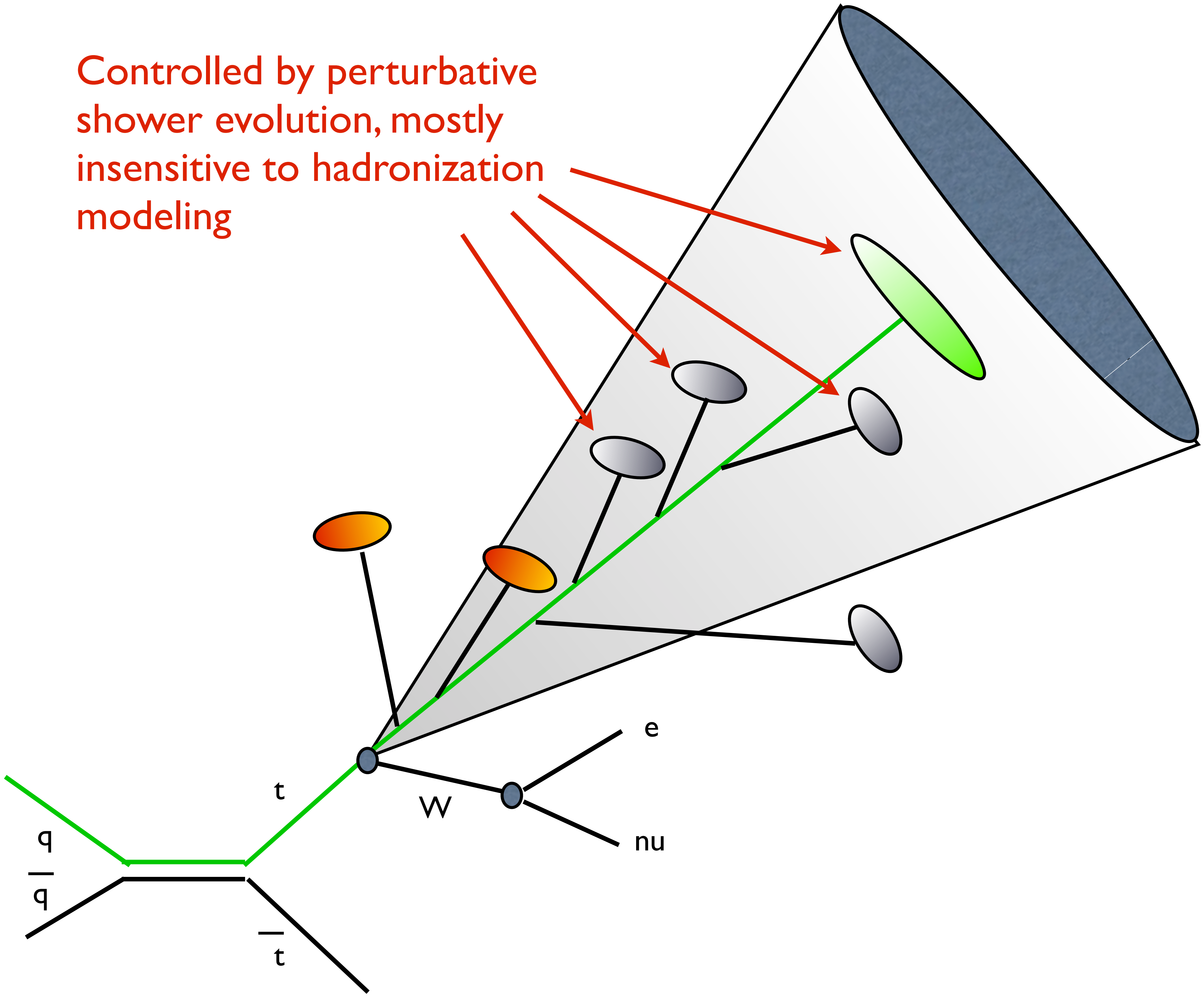
Controlled by perturbative shower evolution, mostly insensitive to hadronization modeling
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W
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nu
q
q̄
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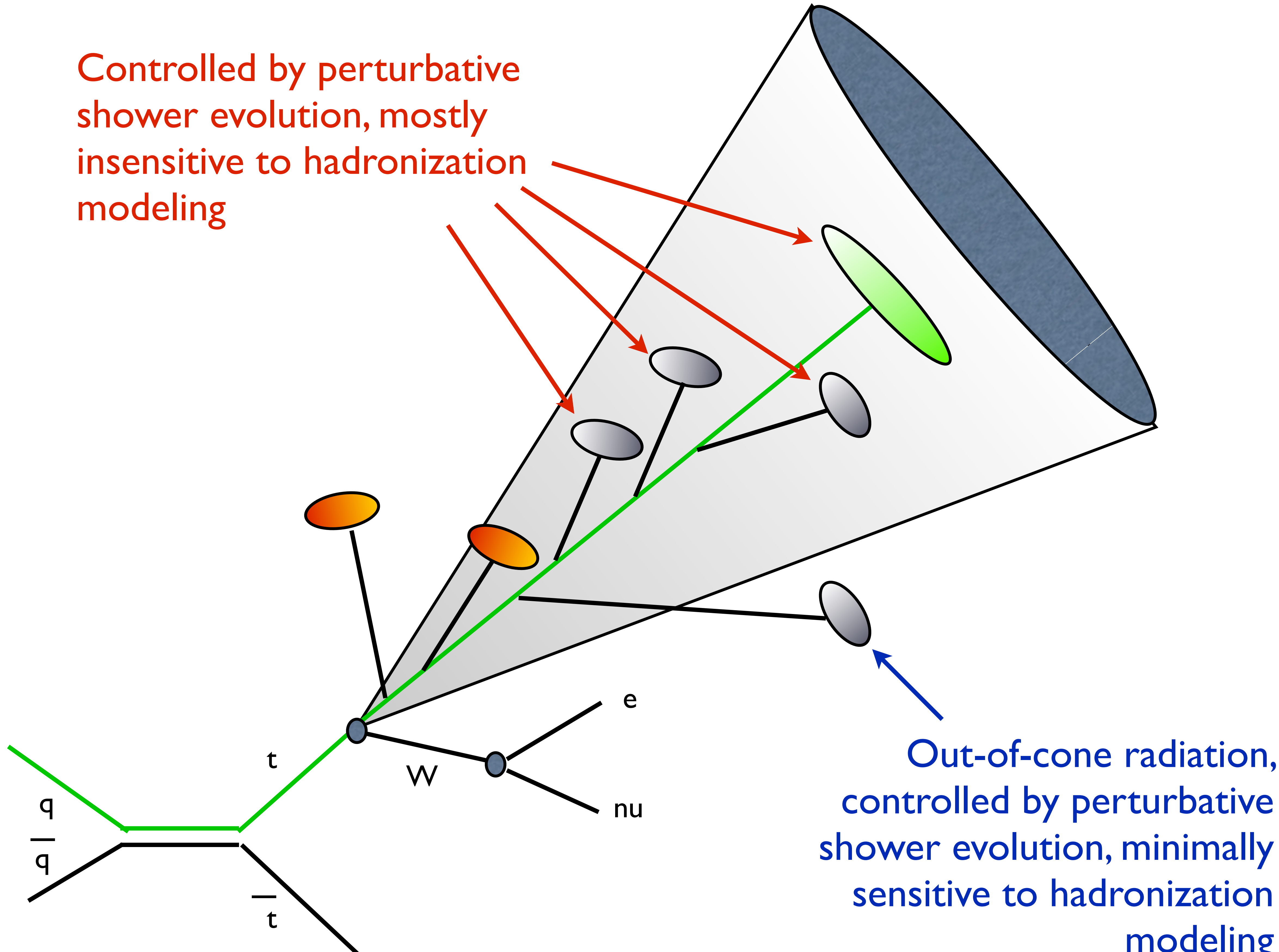

Controlled by perturbative shower evolution, mostly insensitive to hadronization modeling
e
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nu
q
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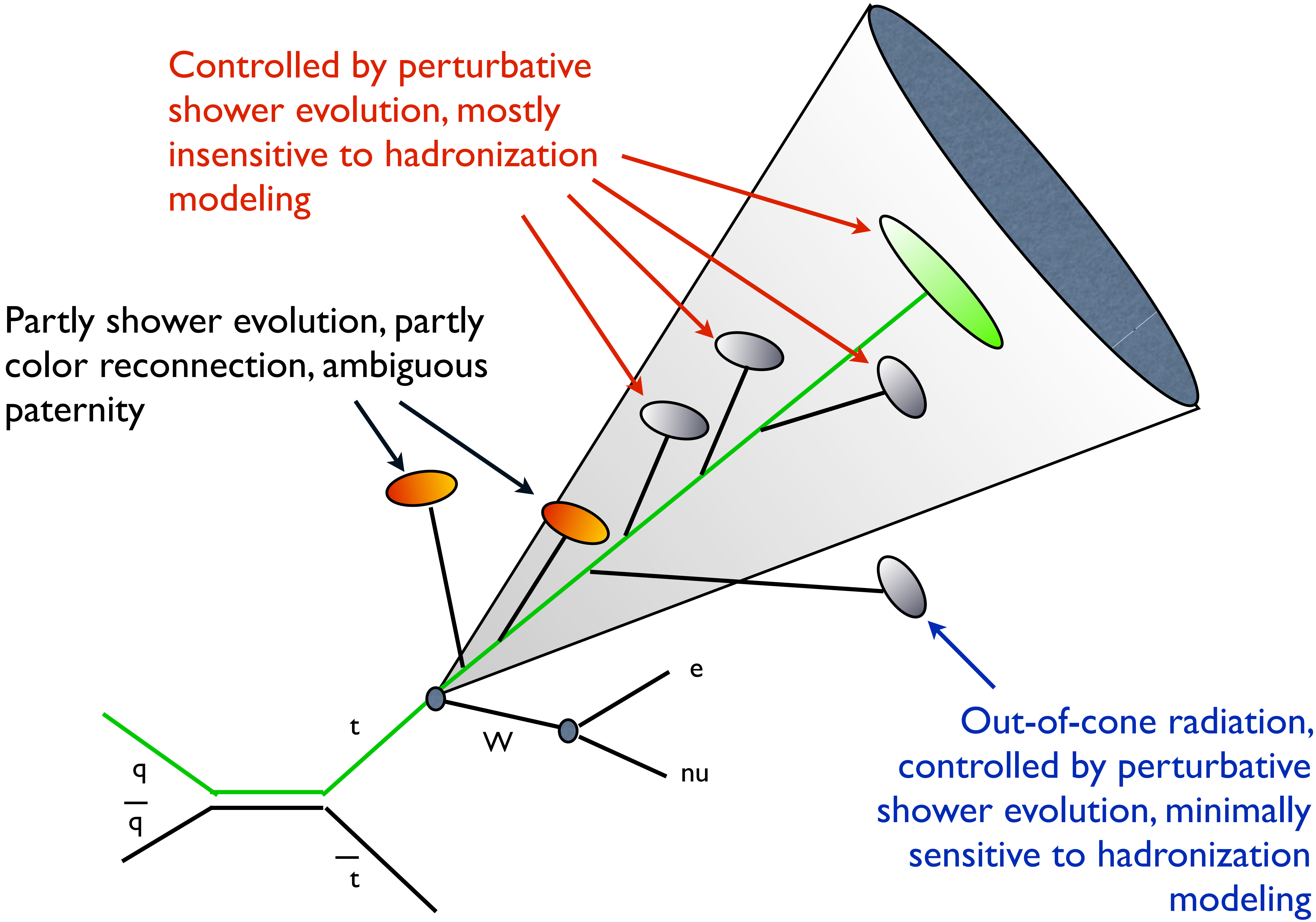
Out-of-cone radiation, controlled by perturbative shower evolution, minimally sensitive to hadronization modeling


Controlled by perturbative shower evolution, mostly insensitive to hadronization modeling
Partly shower evolution, partly color reconnection, ambiguous paternity
Out-of-cone radiation, controlled by perturbative shower evolution, minimally sensitive to hadronization modeling
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m_{top}^2 "=" $(p_W + p_{b\text{-}jet})^2$

"=" : this relation defines a template distribution, whose shape depends on m_{top}^{MC}

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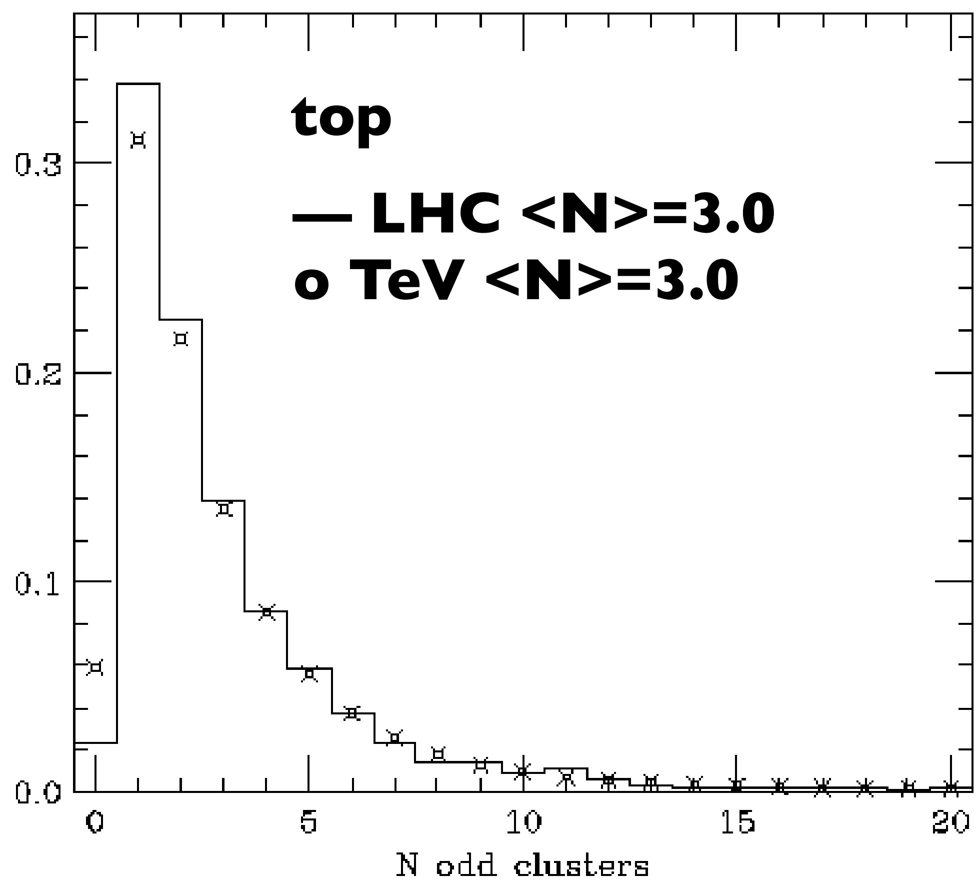
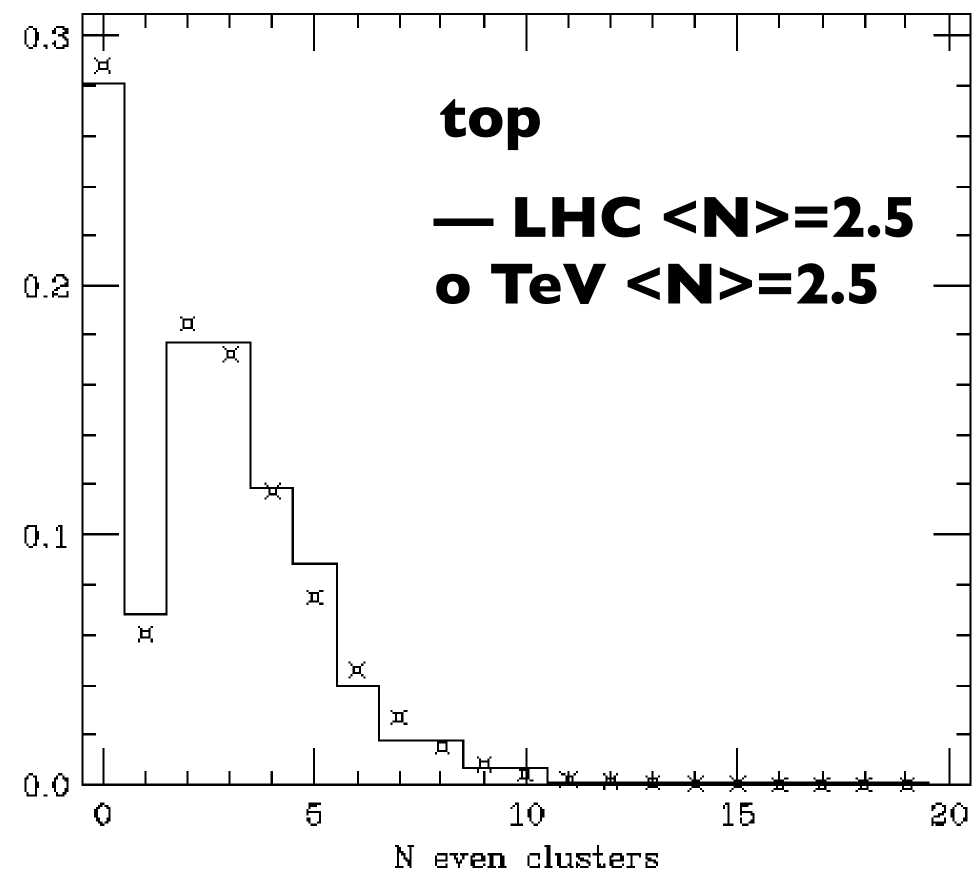
Notation:

$m_{top}(E+O)$: include both even and odd clusters
$m_{top}(E)$: include only even

Cluster multiplicities





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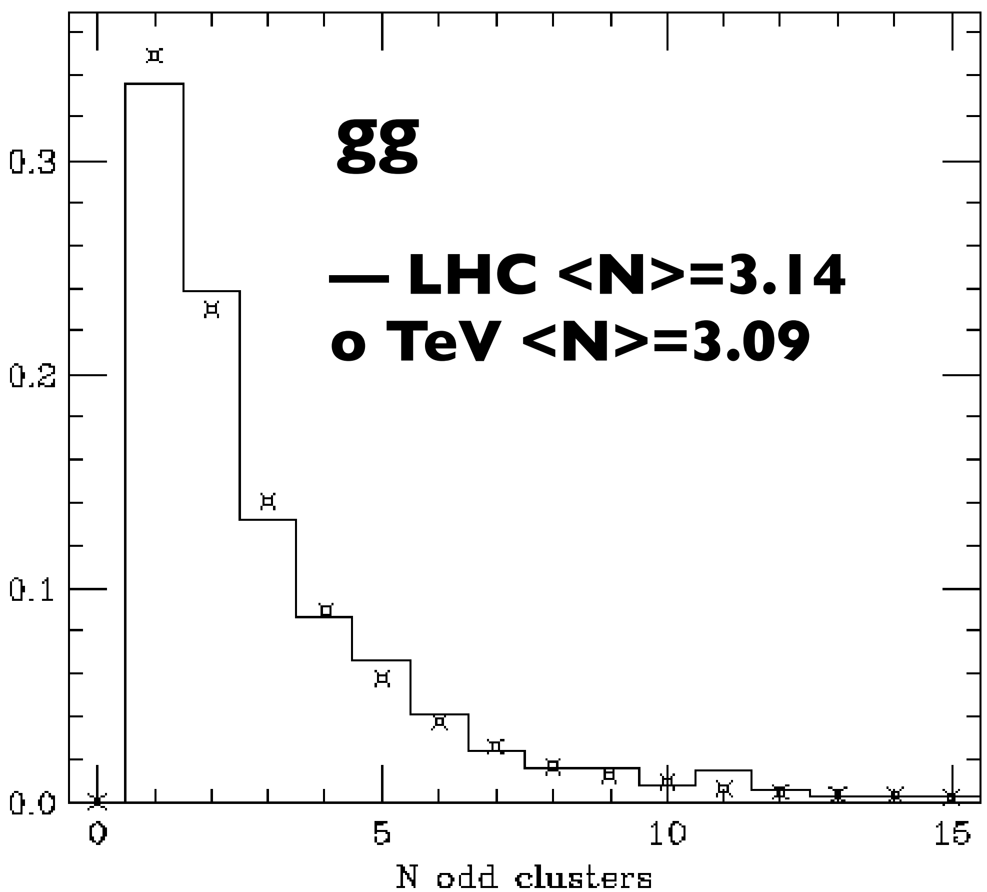
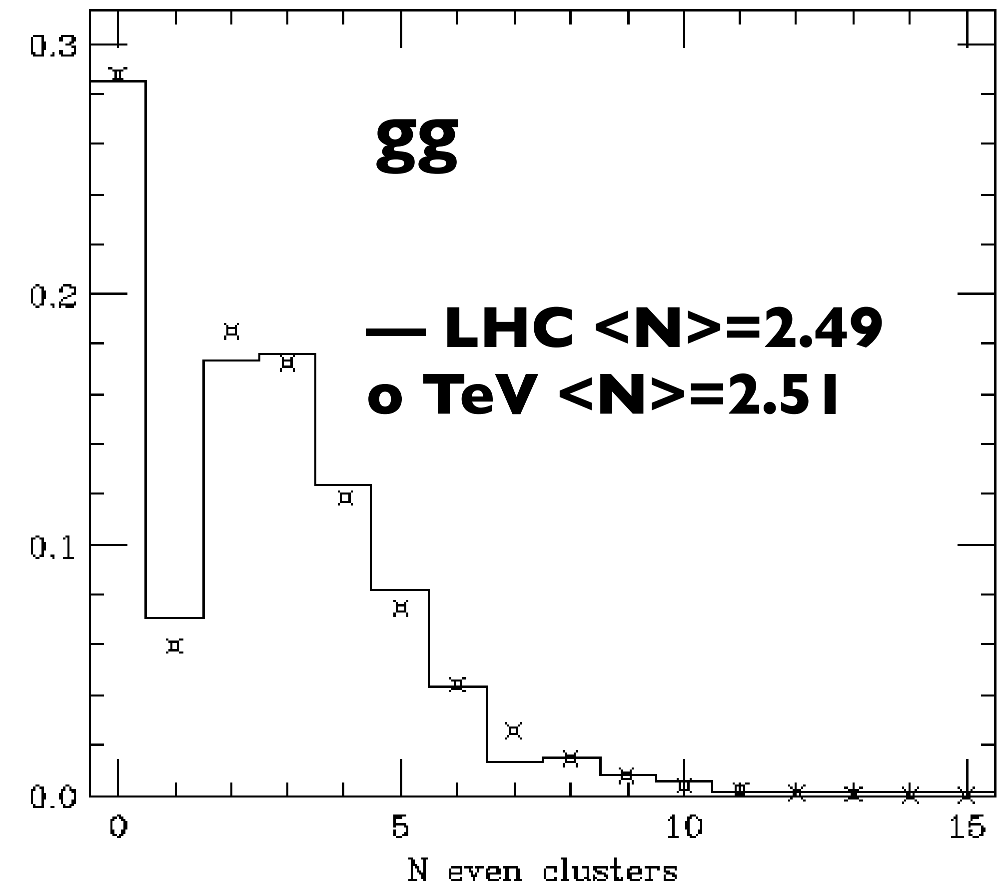
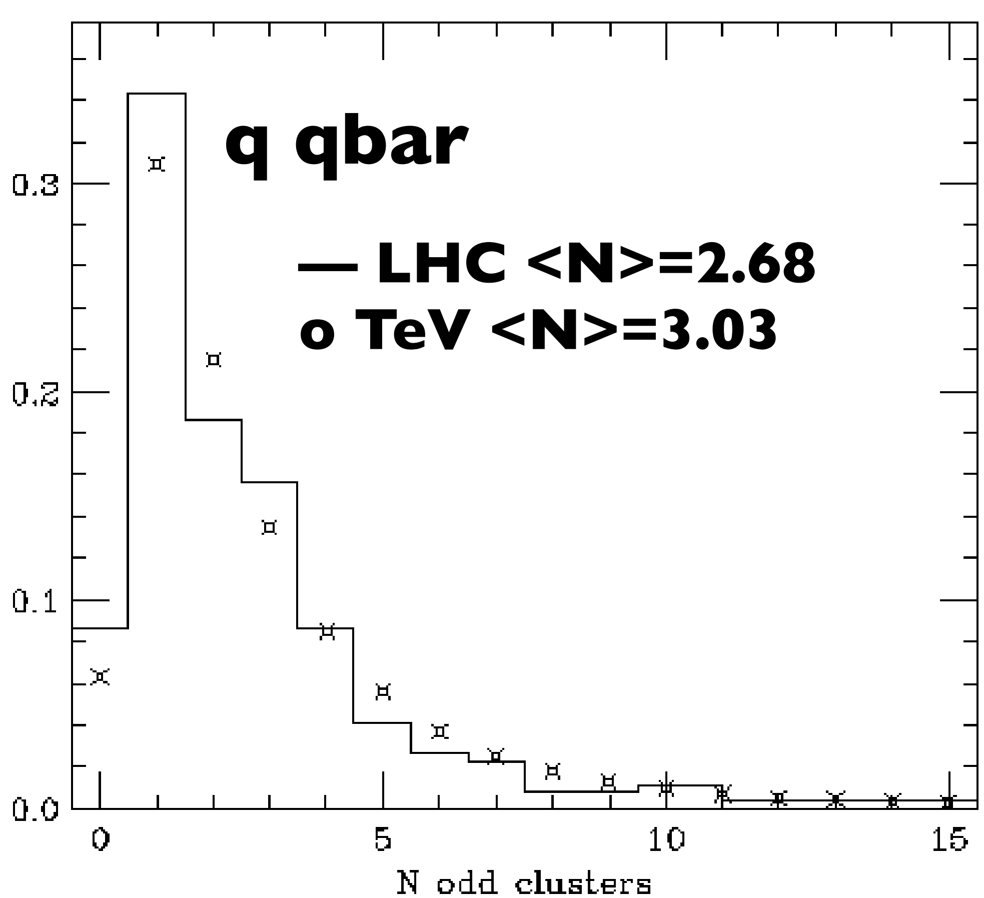
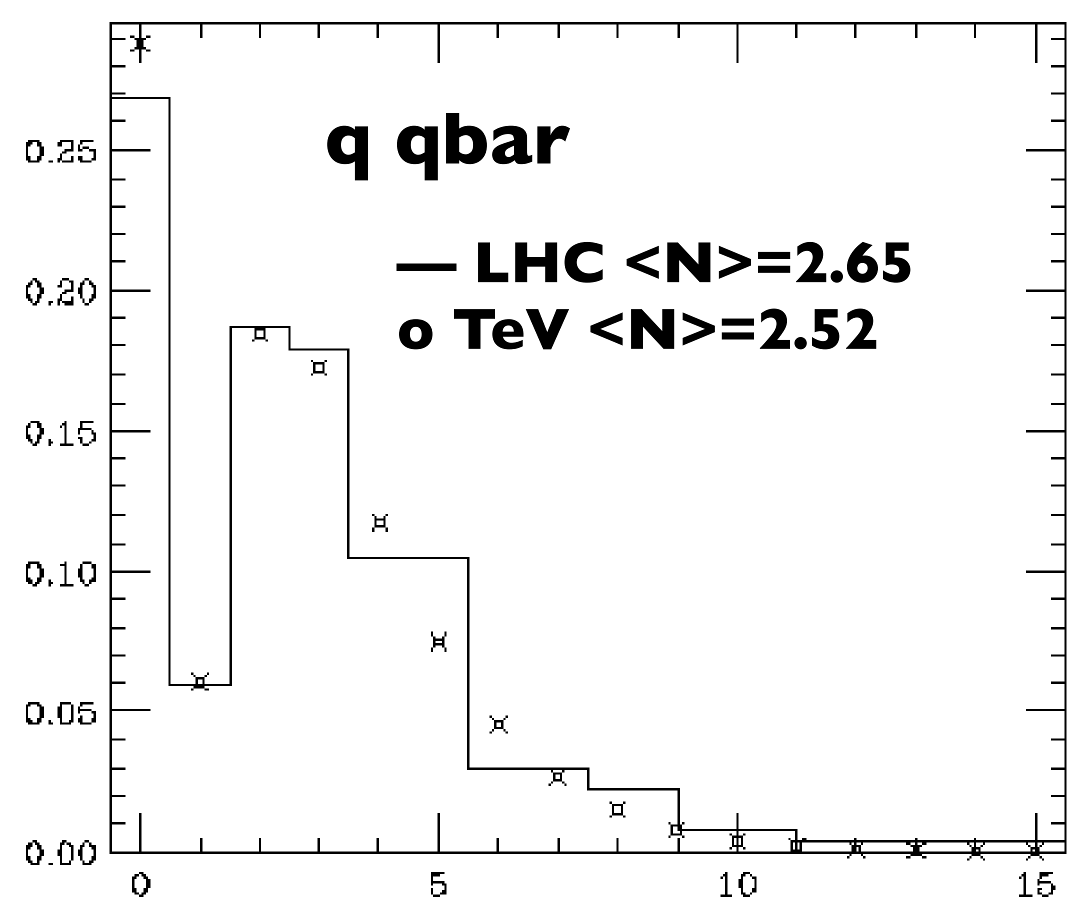


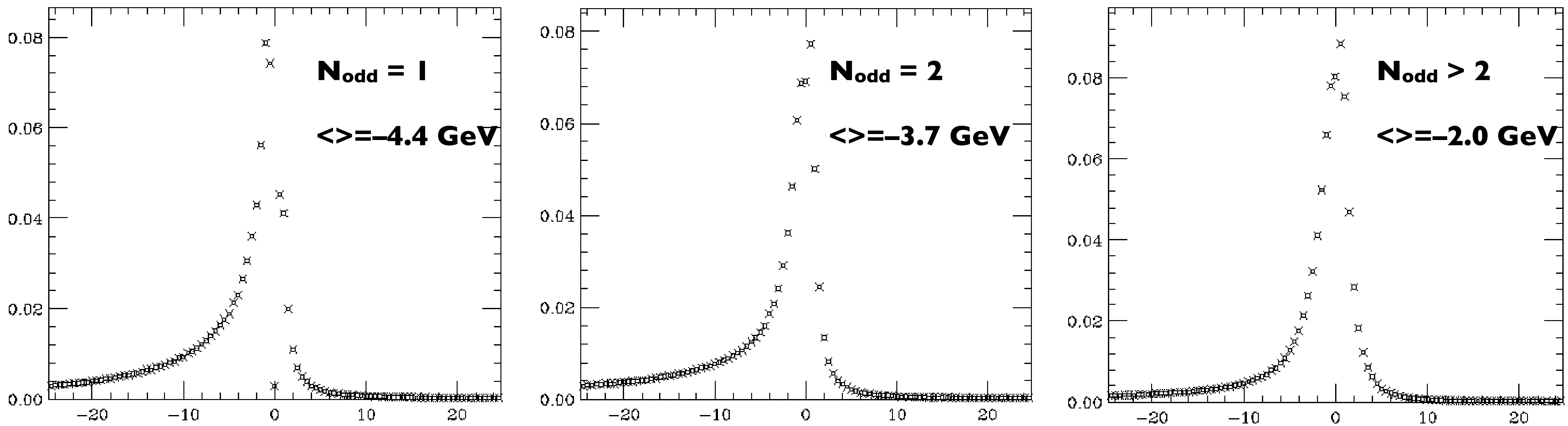




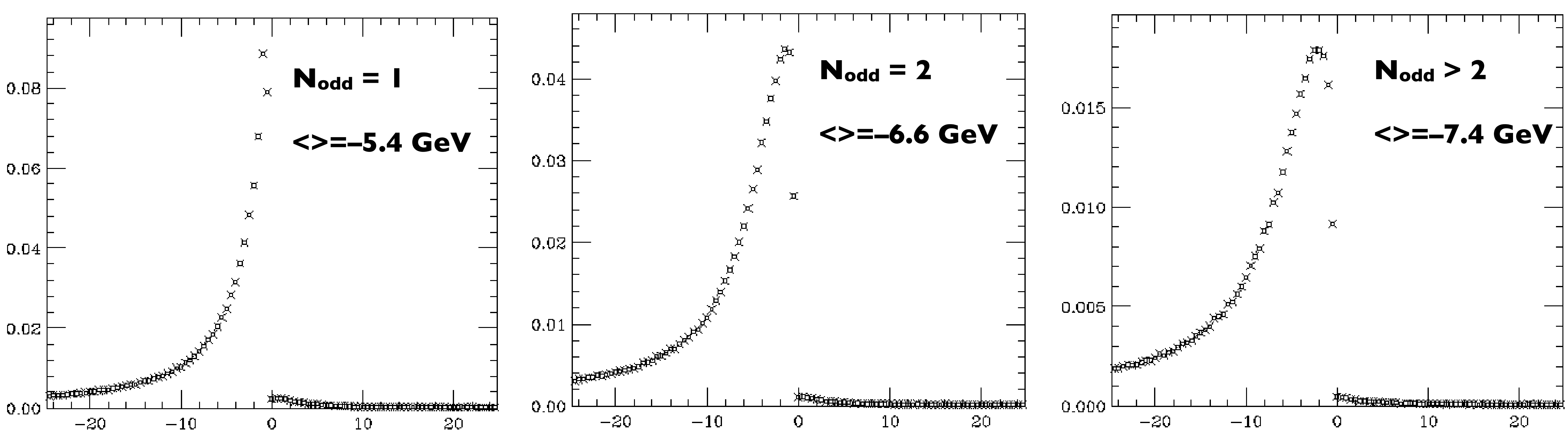


m_{top} vs cluster multiplicities

m_{top}(E+O) – 172.5



m_{top}(E) – 172.5



m_{top} vs initial state

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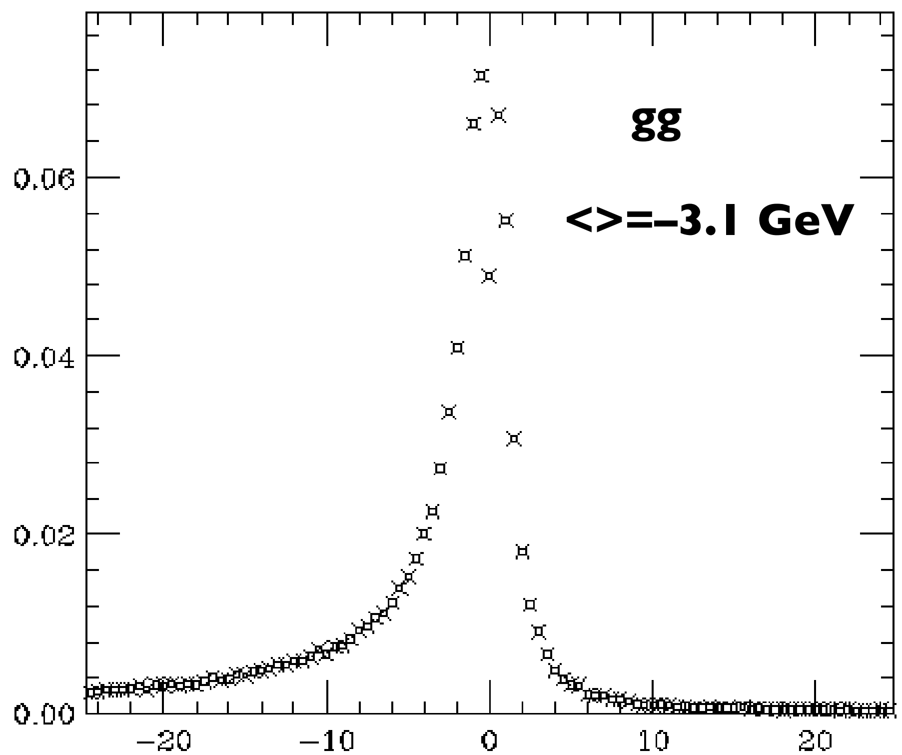
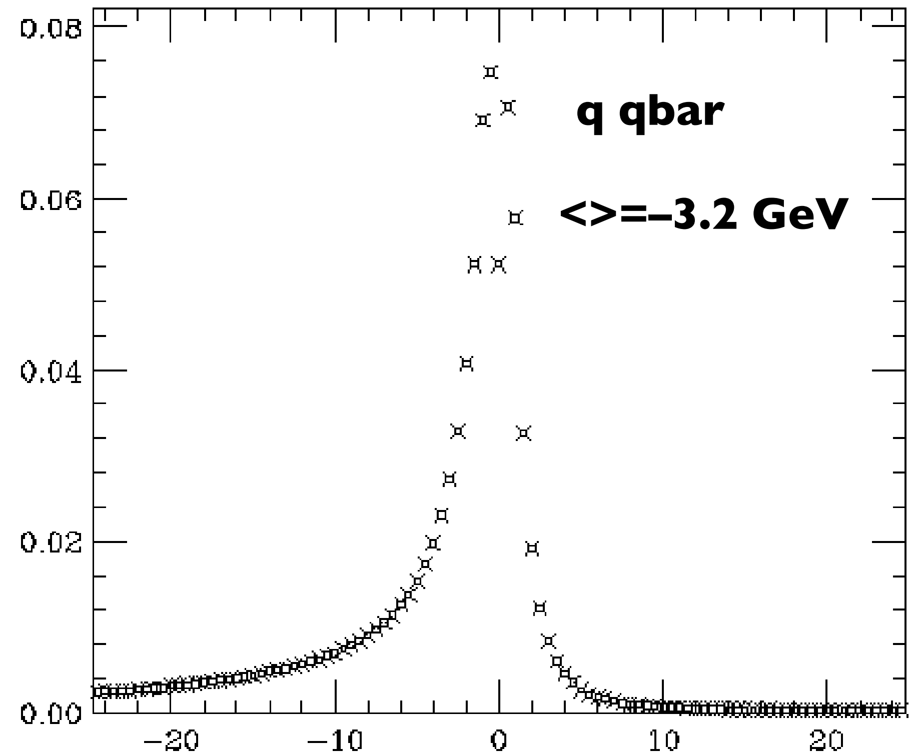
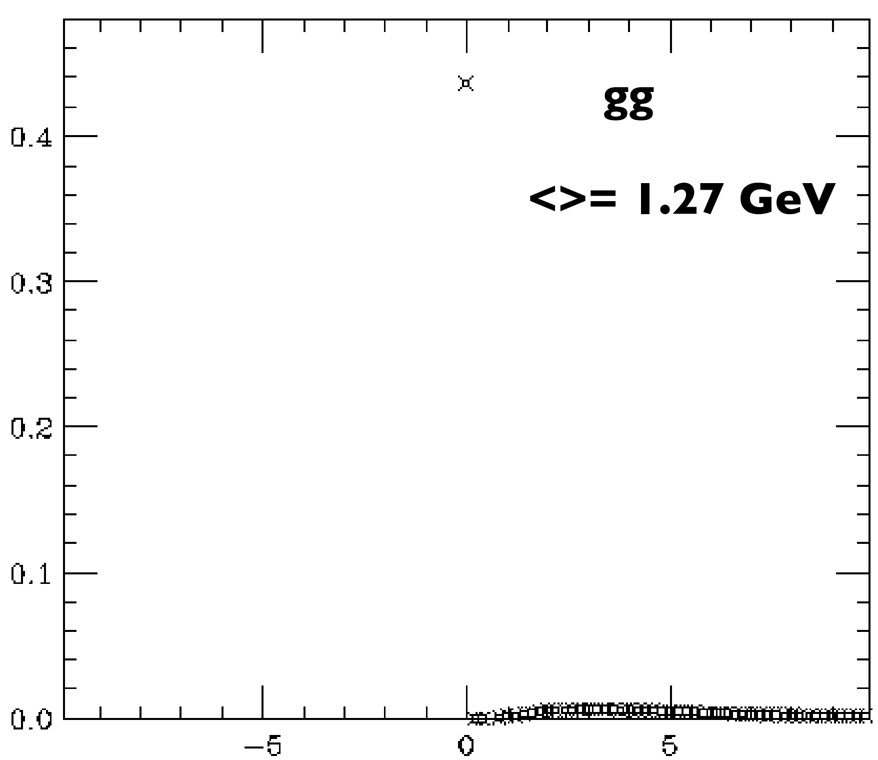
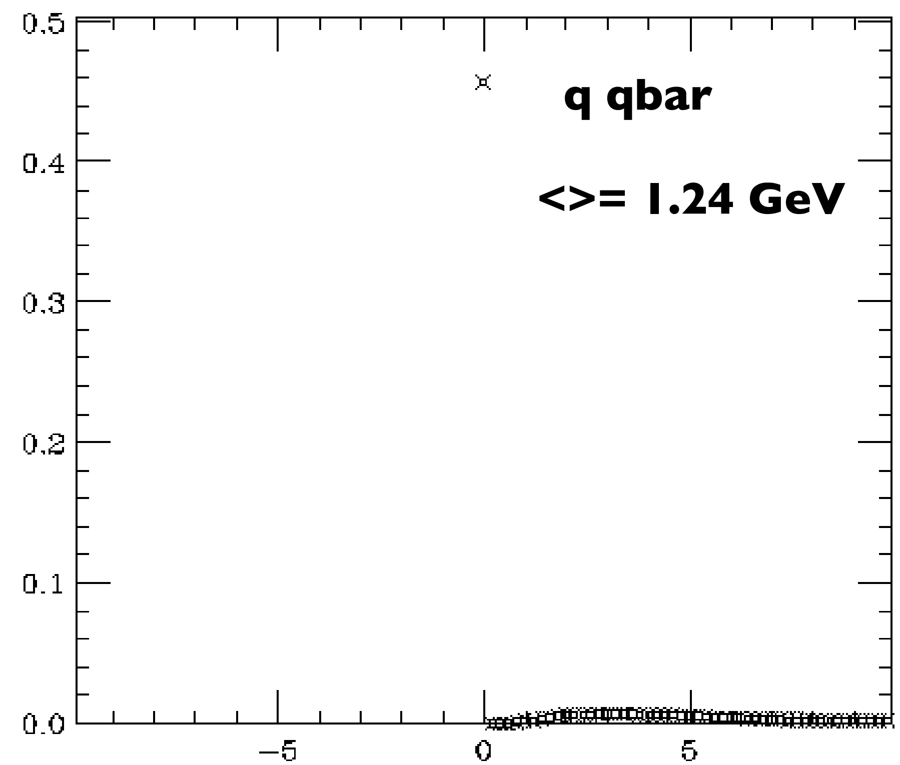




m_{top}(E+O) – m_{top}(E)

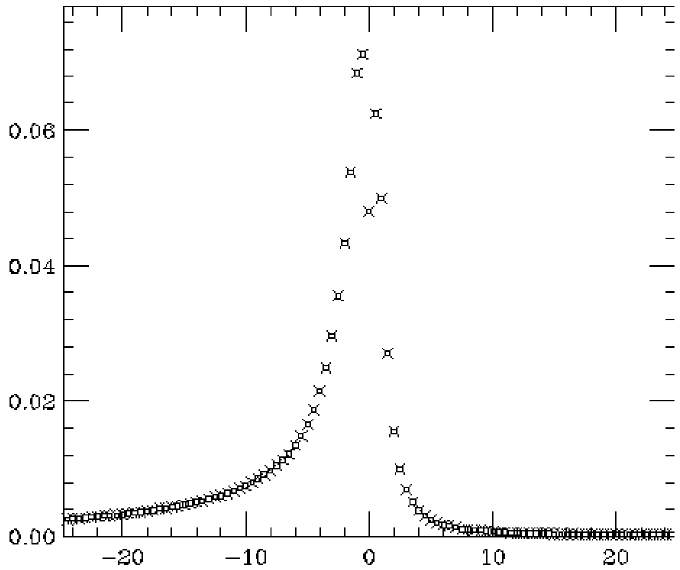




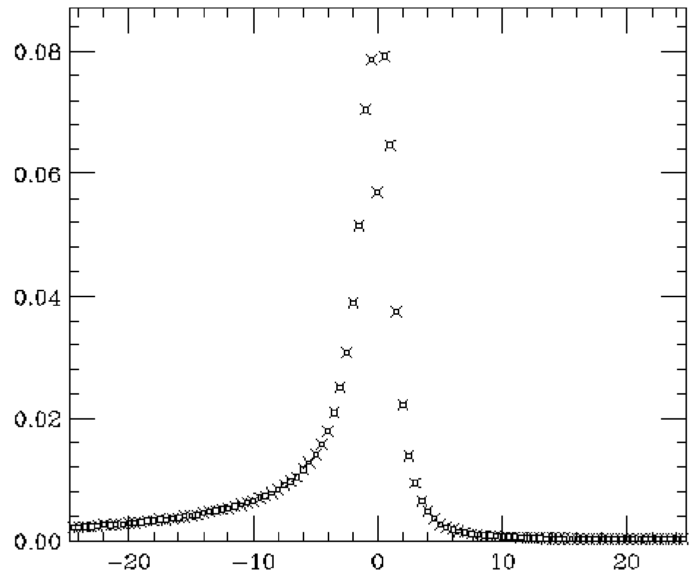
m_{top} vs pt(top)

m_{top}(E+O) – 172.5

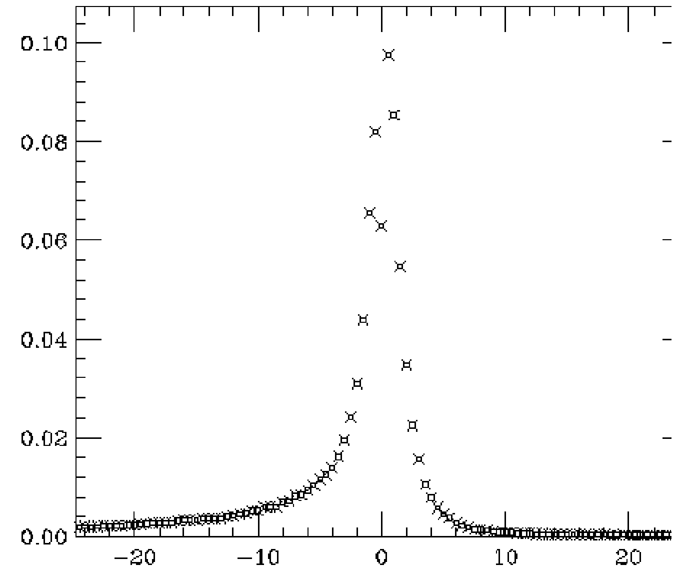
pt<100 GeV <>=–3.5 GeV



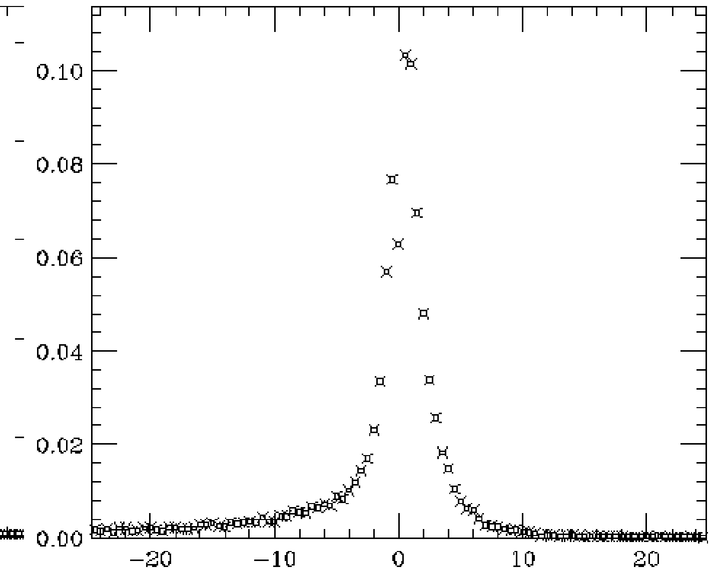
100<pt<200 <>=–2.8 GeV



200<pt<300 <>= –1.95 GeV

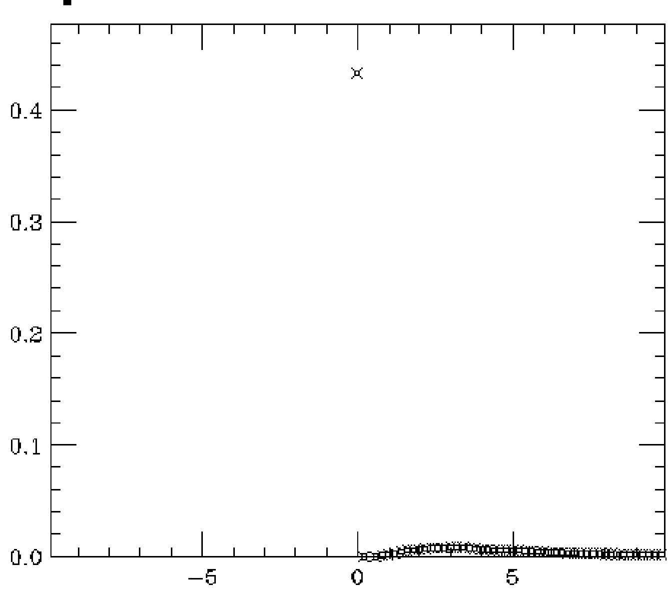


pt>300 <>= –0.98 GeV

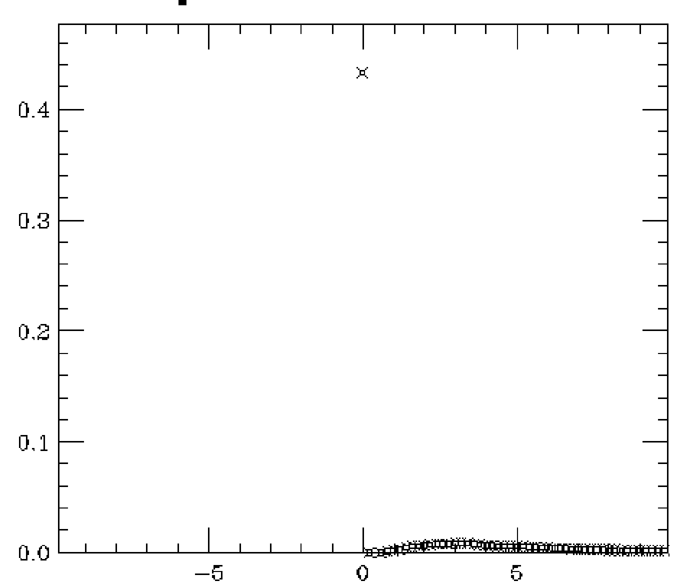


m_{top}(E+O) – m_{top}(E)

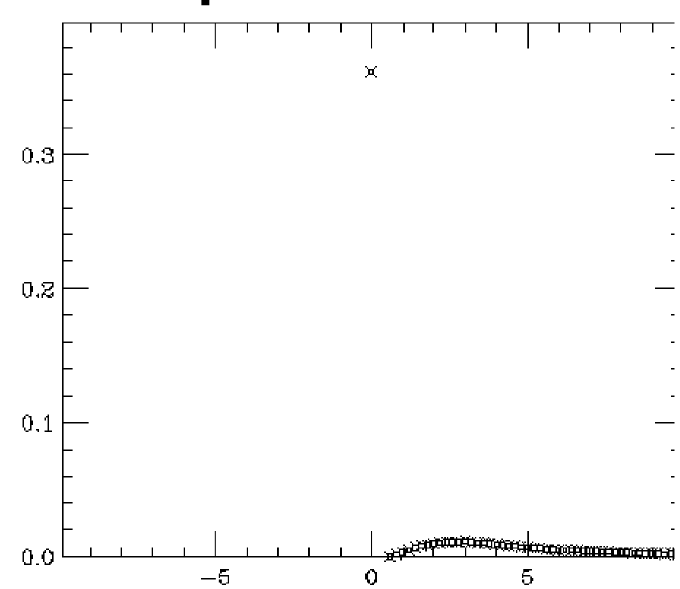
pt<100 GeV <>= 1.08 GeV



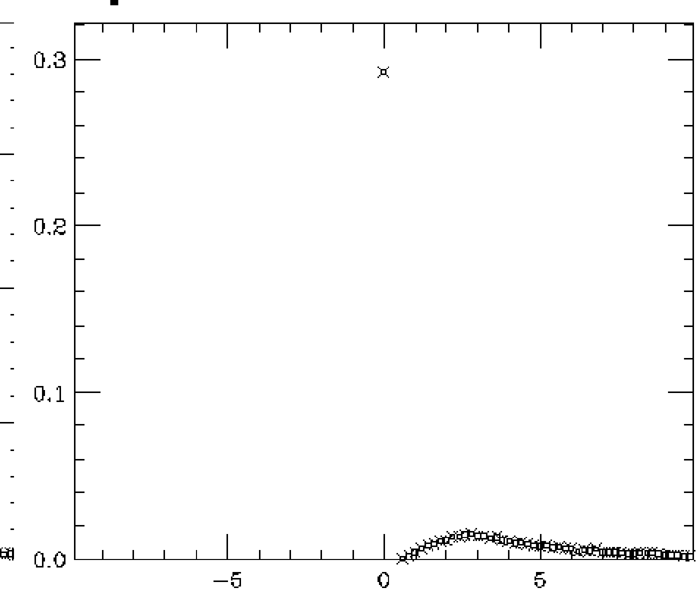
100<pt<200 <>= 1.38 GeV



200<pt<300 <>= 1.83 GeV



pt>300 <>= 2.24 GeV



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- Compare these findings with a MC study under the assumption of a hadronized top (lifetime > 1/GeV). See next page ....

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- Let the top quark hadronize in the MC, before it decays.
  - model the top hadron decay (e.g. using the spectator model)
  - compare mtop measured on this MC sample (m^{MC}_H), to mtop measured on a standard sample with top decaying before hadronization (m^{MC}_Q)
  - The top-meson mass m_T is a well defined quantity, which can be theoretically related to the top quark pole or MSbar masses.
  - If the analysis shows that $m^{MC}_H = m^{MC}_Q + \Delta m$, it is legitimate to argue that $m_T = m^{exp}_Q + \Delta m$, where m^{exp}_Q is the experimentally determined mass. From m_T one can then extract, e.g., m_t^{pole}

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- Test whether m_T is independent of the analysis chosen to extract mtop

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- Measure mtop:
  - as a function of pt(top)
  - as a function of η(b-jet)
  - separately for top and tbar
  - varying the jet algorithm to define the b-jet (e.g. use larger cones, to vary the dependence on the amount of energy associated to "odd" clusters)