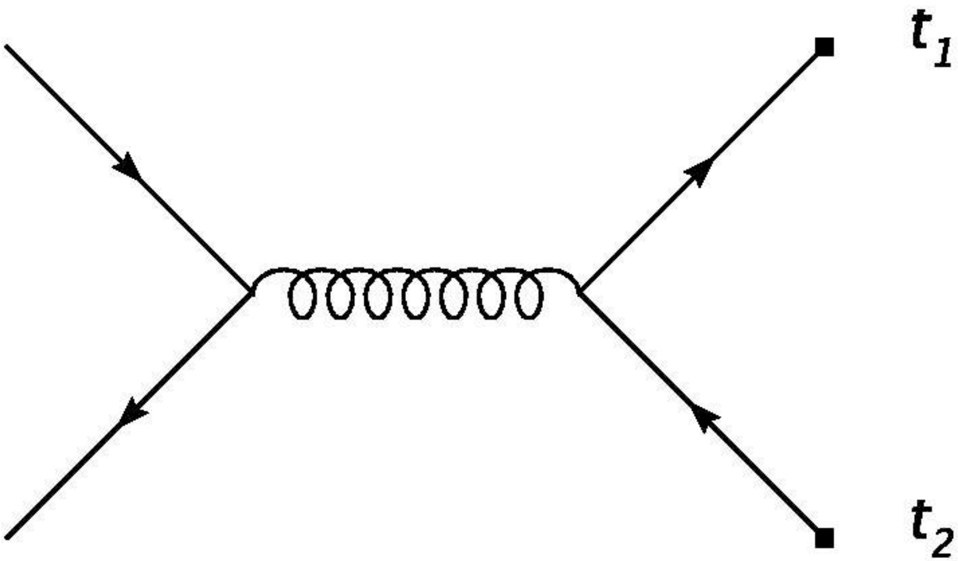
Breit-Wigners for masses of each top

$$1 = \int \delta(m^2 - m_R^2)\, dm^2 \to \int \frac{1}{\pi} \frac{m_R \Gamma_R}{(m^2 - m_R^2)^2 + m_R^2 \Gamma_R^2}\, dm^2$$



PDG

S-matrix approach to the Z

While practically all experimental analyses of LEP/SLC data have followed the 'Breit-Wigner' approach described above, an alternative S-matrix-based analysis is also possible. The Z, like all unstable particles, is associated with a complex pole in the S matrix. The pole position is process independent and gauge invariant. The mass, $\overline{M}_Z$, and width, $\overline{\Gamma}_Z$, can be defined in terms of the pole in the energy plane via [11–14]

$$\bar{s} = \overline{M}_Z^2 - i\overline{M}_Z\overline{\Gamma}_Z$$

leading to the relations

$$\overline{M}_Z = M_Z/\sqrt{1+\Gamma_Z^2/M_Z^2} \approx M_Z - 34.1 \text{ MeV}$$

$$\overline{\Gamma}_Z = \Gamma_Z/\sqrt{1+\Gamma_Z^2/M_Z^2} \approx \Gamma_Z - 0.9 \text{ MeV} .$$

~ 100 MeV

Some authors [15] choose to define the Z mass and width via

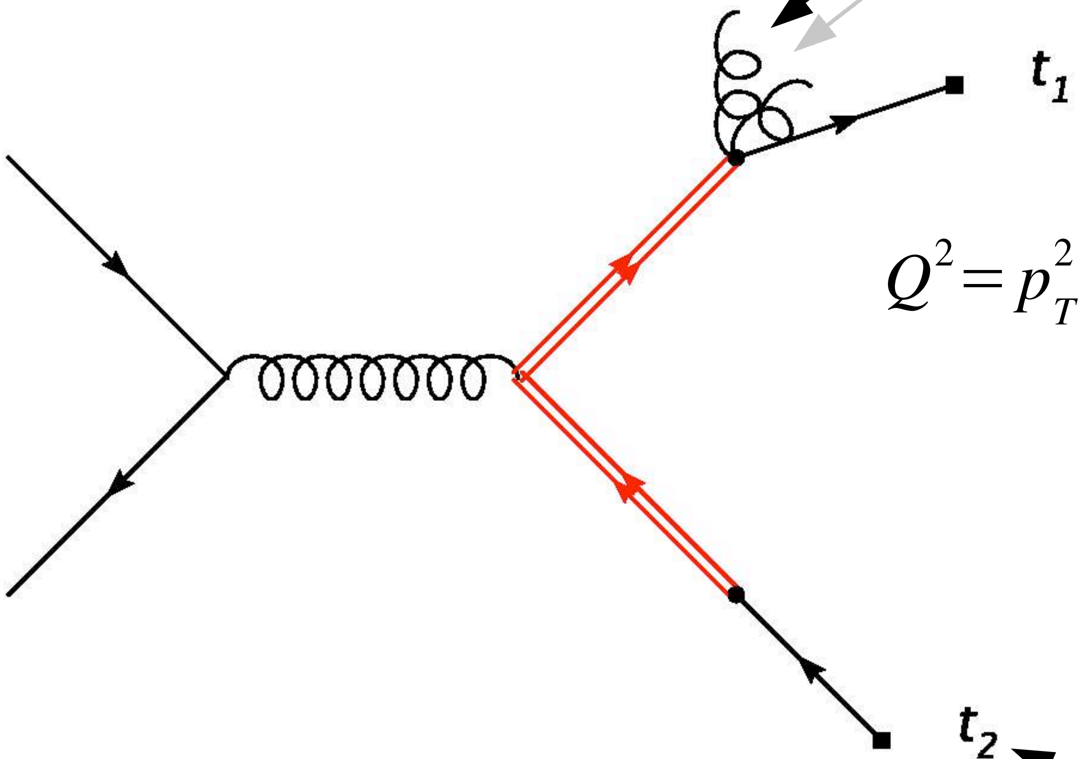
$$\bar{s} = (\overline{M}_Z - \frac{i}{2}\overline{\Gamma}_Z)^2$$

which yields $\overline{M}_Z \approx M_Z - 26$ MeV, $\overline{\Gamma}_Z \approx \Gamma_Z - 1.2$ MeV.

$$\beta_{34}(\hat{s}, \overline{m}^2, \overline{m}^2) = \beta_{34}(\hat{s}, m_3^2, m_4^2) \quad \Rightarrow \quad \overline{m}^2 = \frac{m_3^2 + m_4^2}{2} - \frac{(m_3^2 - m_4^2)^2}{4\hat{s}} .$$

Adjust kinematics in equal mass formulae

Showering
of the top
before decay

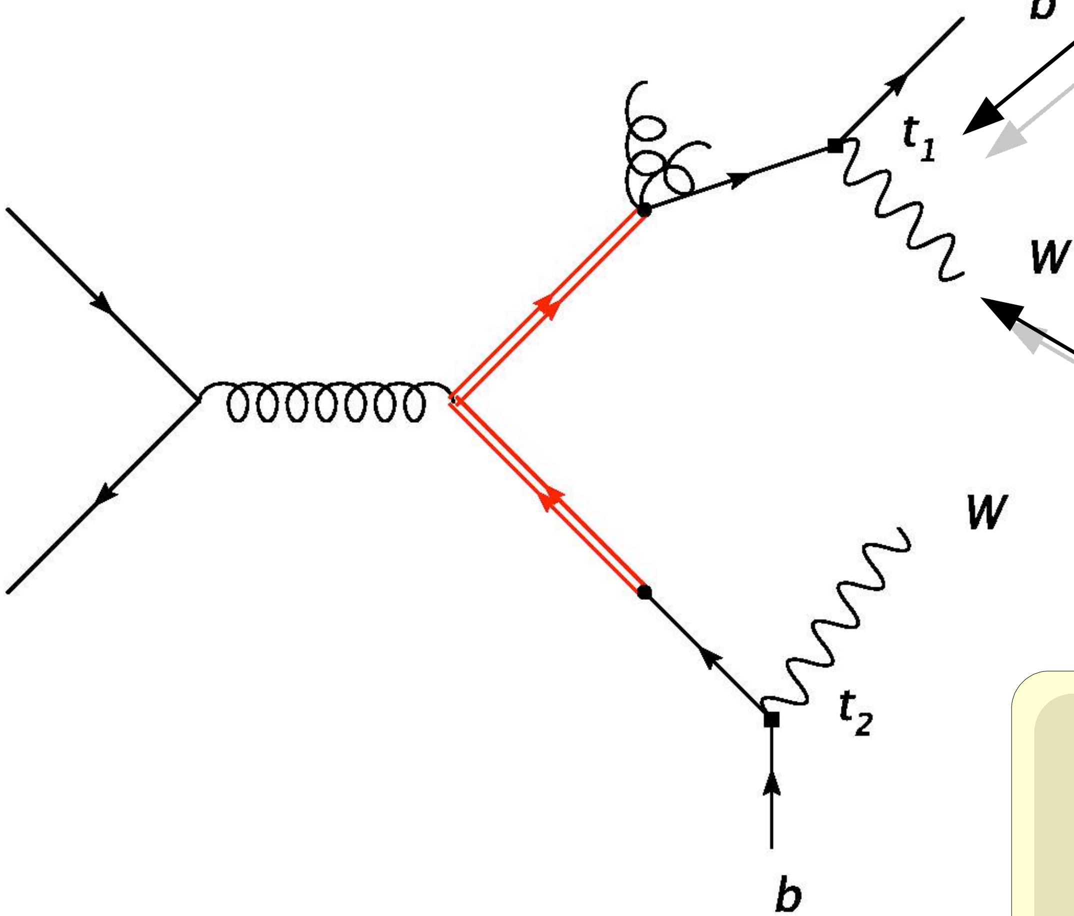


$$Q^2 = p_T^2 + m_t^2$$

Recoils
against partner
radiation

Changes kinematics
of top pair

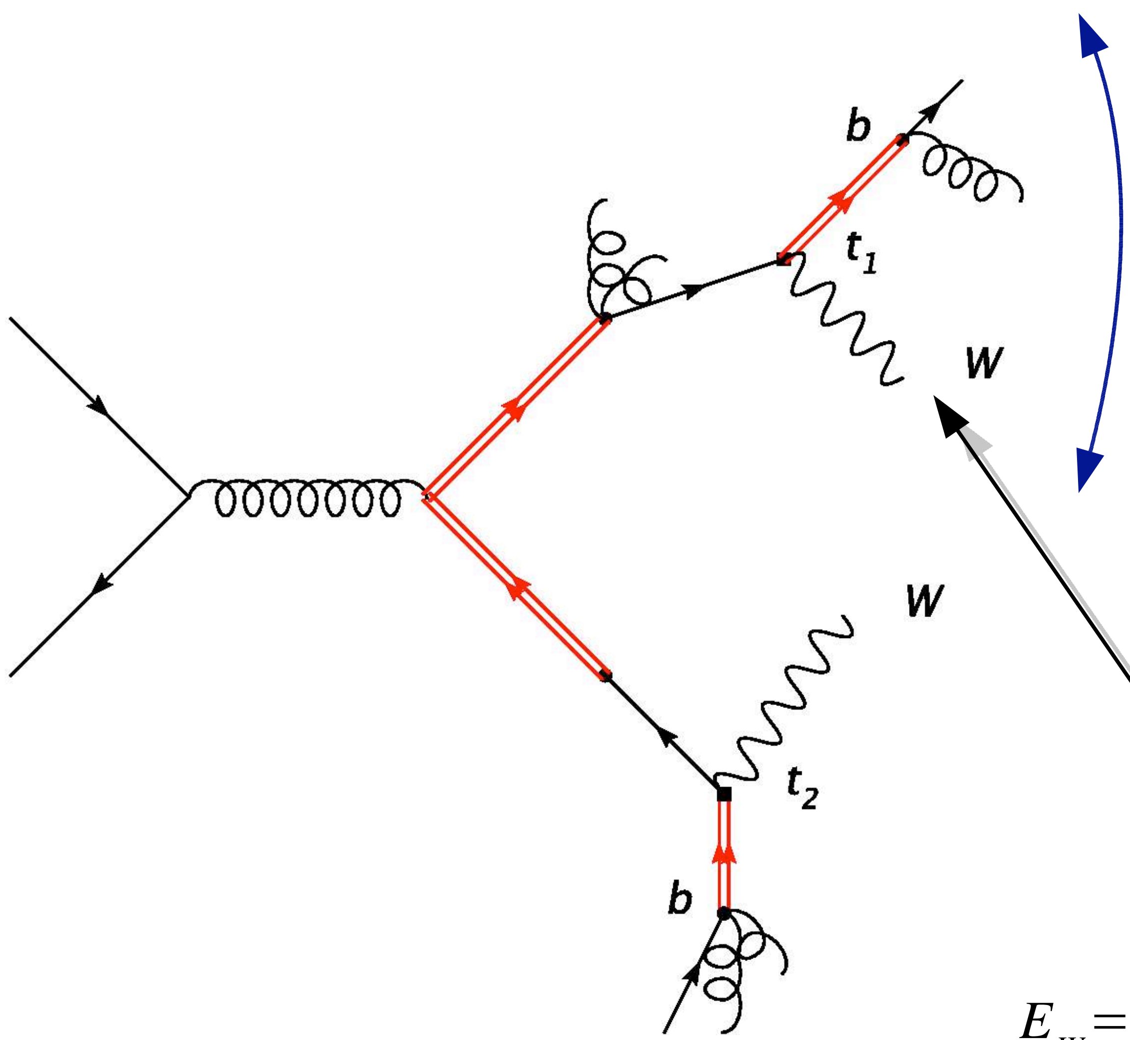
$$E_{t2} = \frac{s + m_{t2}^2 - m_{t1}^2}{2\sqrt{s}}$$



Top decays including NLO gluon radiation

W decays including NLO gluon radiation

No top-top spin correlations (HERWIG, yes)



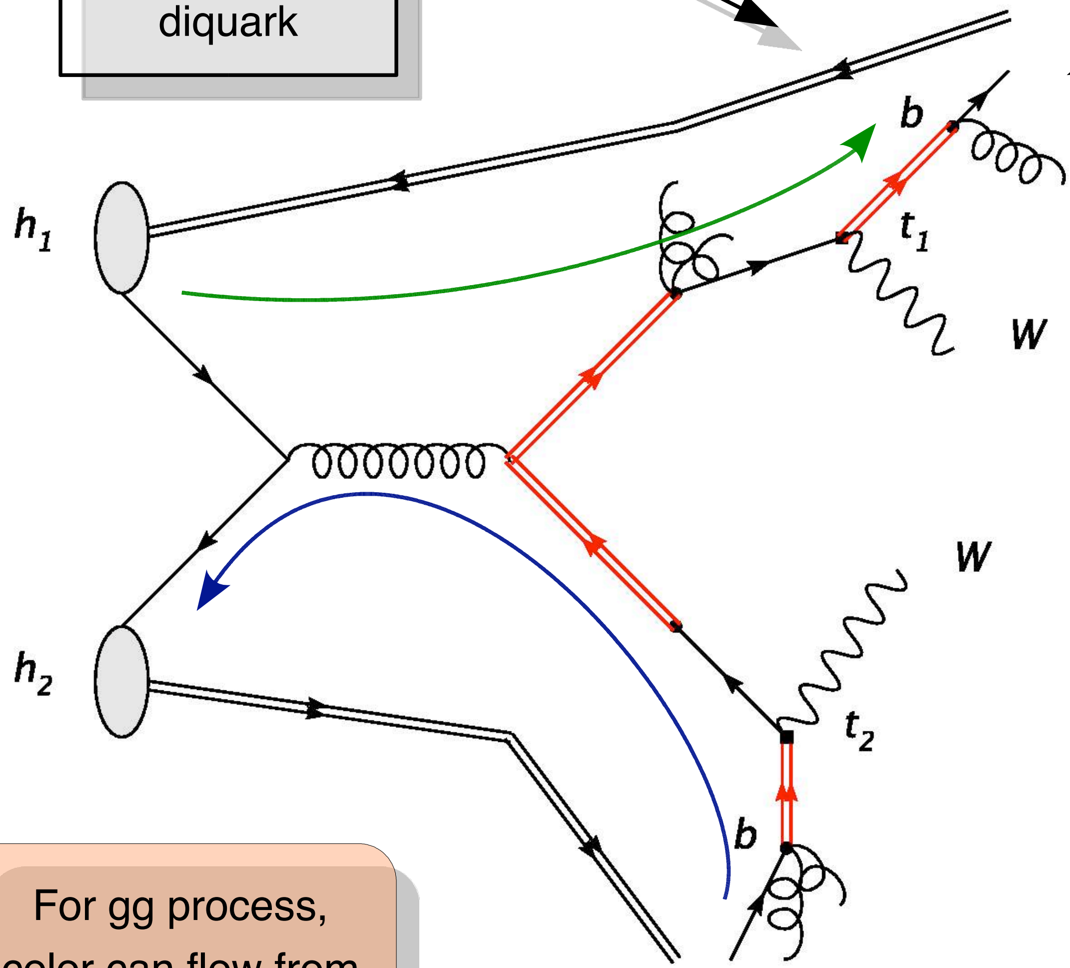
Top Mass conserved in the final state shower

W recoils against the b shower

$$E_W = \frac{m_t^2 + M_W^2 - m_{bg}^2}{2\,m_t}$$

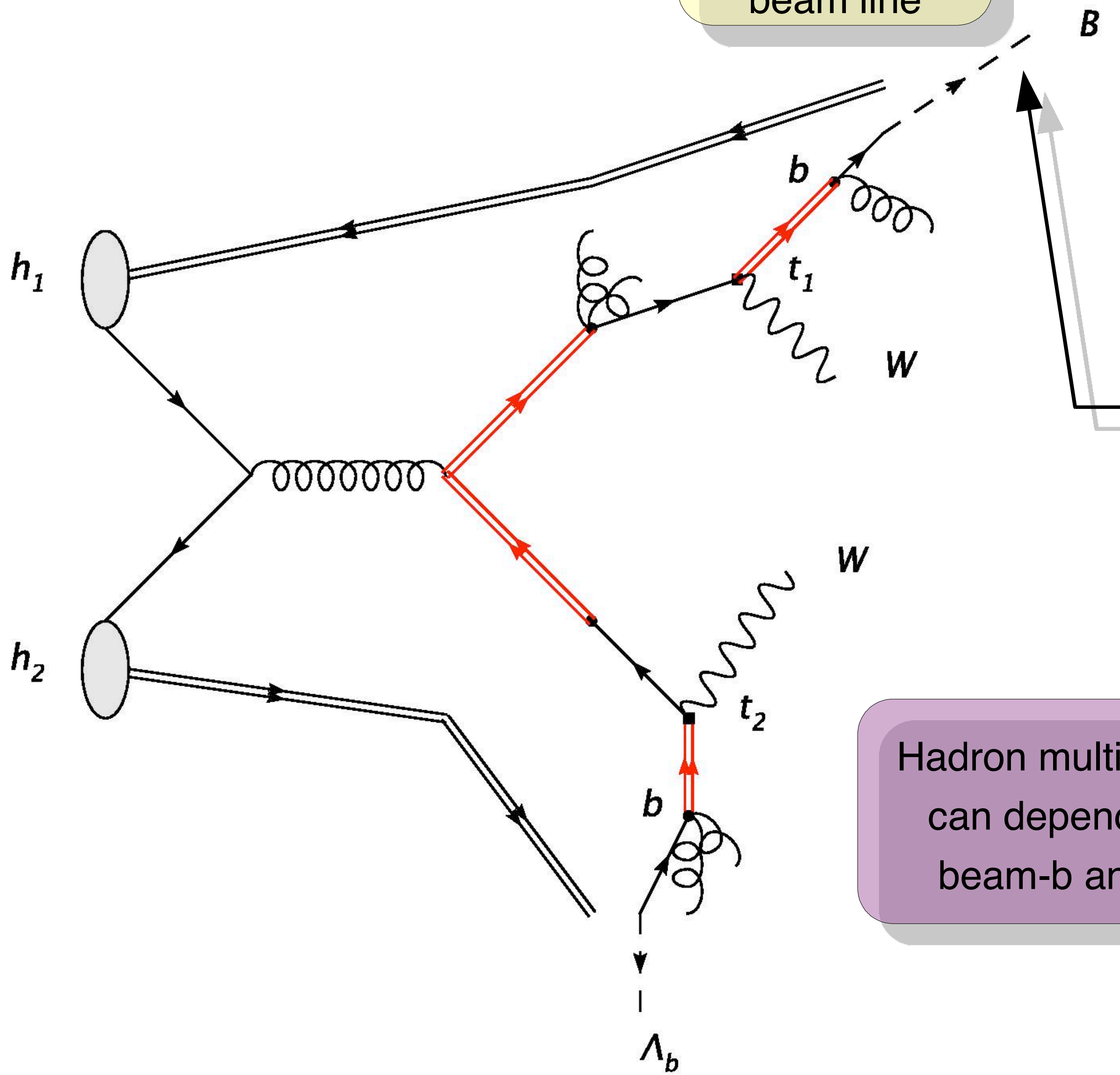
Remnant does NOT have to be simple diquark

b quark color connected to remnant with gluons as kinks on string



For gg process, color can flow from OTHER beam

String can pull b towards beam line

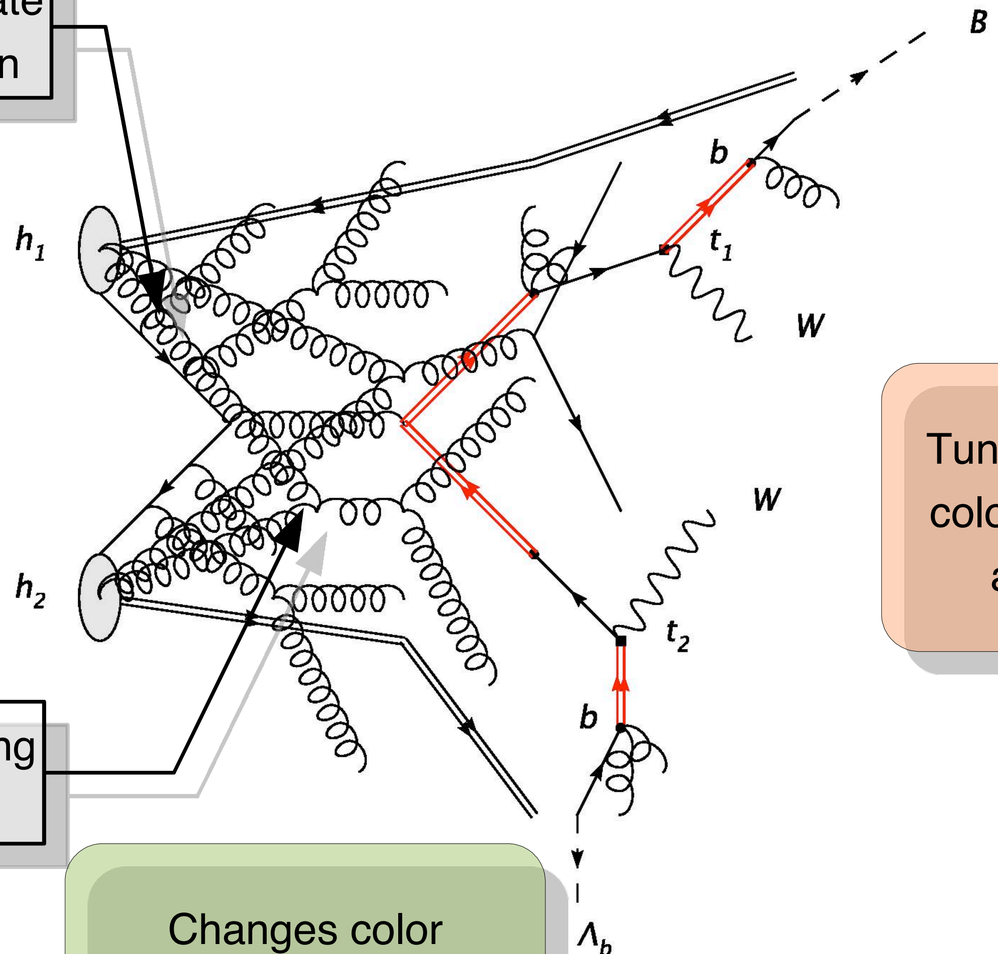


Hadron momentum comes from string fragmentation with a given f(z) (which one?)

Hadron multiplicity can depend on beam-b angle

Initial State radiation

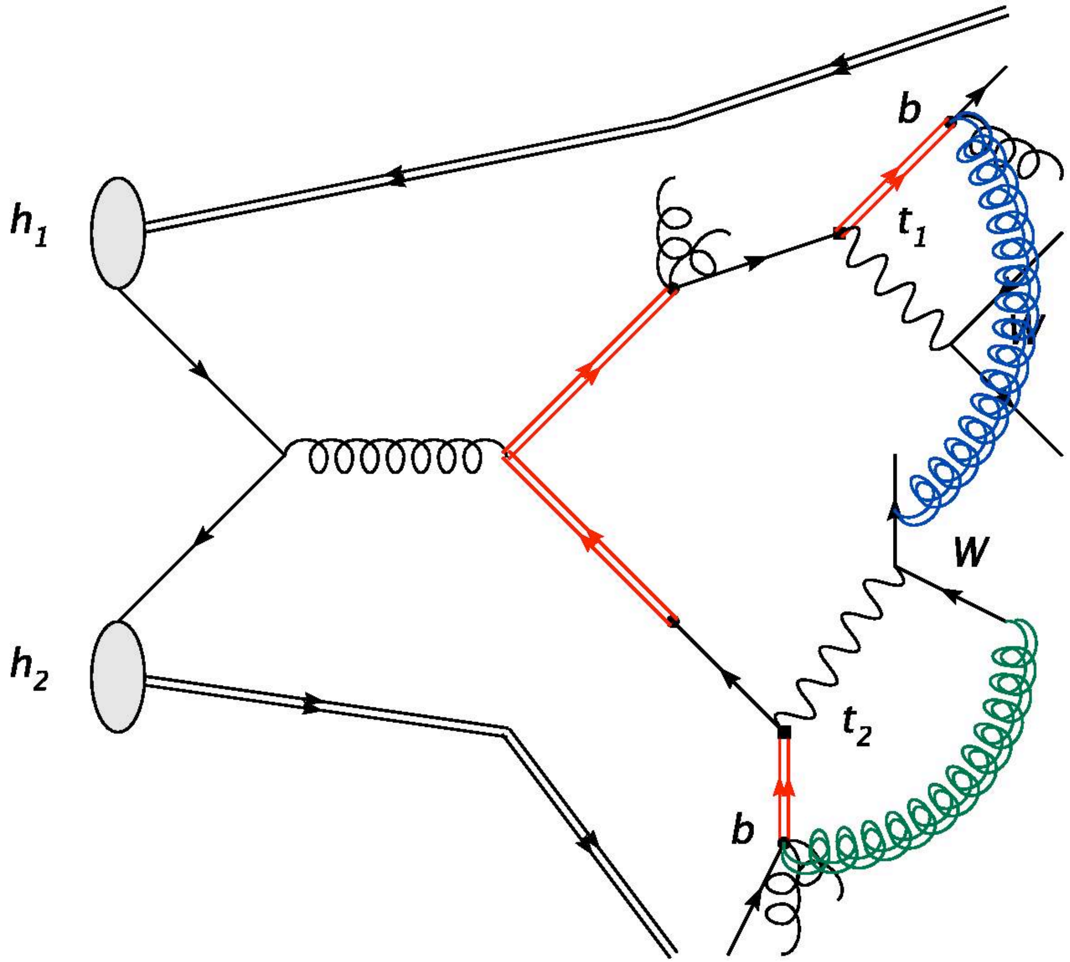
Causes confusion in top mass reconstruction



Tune A showed that color re-connections are important

Underlying Event

Changes color connections, hence fragmentation



Color Recombinations affect fragmentation, momentum of reconstructed objects

Leading Systematic in W mass @ LEP ~ 100 MeV

Magnitude of effect in hadronic environment not well known

Uncertainties on M_W

- ALEPH and L3 final results
- OPAL: final (since Sum05)
- DELPHI: prel.

Final LEP Energy Calib.: reduced uncertainty on E_b

New 4q reco: reduce FSI effect

4q weight from 16% (9% bef Sum05) to 23% (δM_W^{stat} (no syst) ~21 MeV, now 26 MeV→use most of 4q stat power)

NEW! Main Sum05 → Winter 2006

Source	Systematic Error on M_W (MeV)		
	qqlν	qqqq	Combined
QED(ISR/FSR,etc)	9	5	8
Hadronisation	14	20	15
Detector Syst.	14	8	10
LEP Beam Energy	9 (14)	9 (11)	9
Colour Reconnection	-	31 (49)	7
Bose-Einstein Corr.	-	13 (22)	3
Other	3	11	4
Total Systematic	22 (28)	43 (63)	24 (28)
Statistical	31	43 (48)	26 (27)
Overall	38 (42)	61 (79)	35 (39)

O: EPJ C45 307 (2006) L:EPJ C45 569 (2006) A: submitted to EPJC

Final State Interactions

- $1/\Gamma_W$~0.1 fm << l_{had}~1 fm →two (colour singlet) with significant space-time overlap→ possible interaction of final products
- Effect not simulated in Monte Carlo→ possible

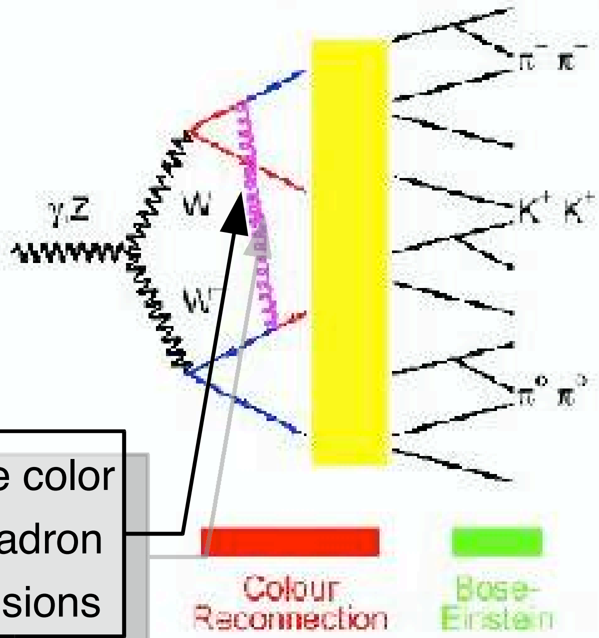
???

mass/width bias only in qqqq channel

Colour Reconnection

- Colour cross-talk between Ws: bias in qqqq but not qqlν .

more color in hadron collisions



Bose-Einstein Corrrelations

- QM interference → Momentum space correlation of bosons pairs from **different** W (inter-W) decays: **bias qqqq only**
- Established in Z^0 decays

Colour Reconnection

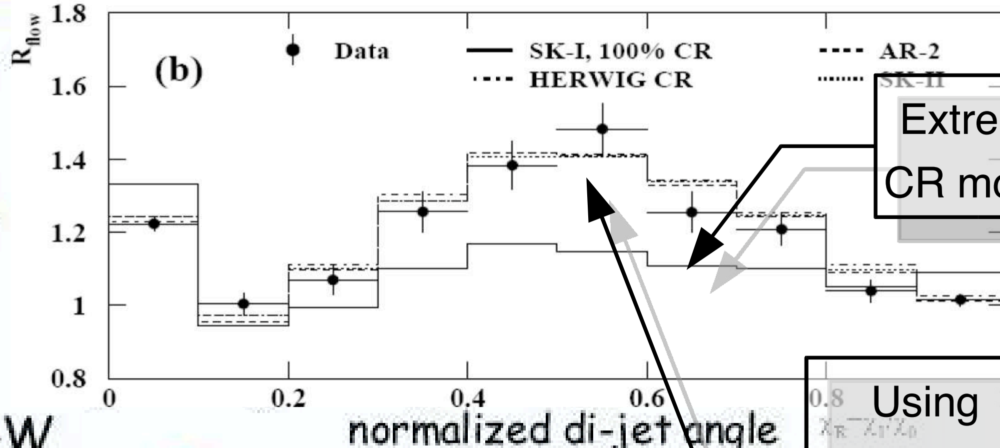
$\delta M_W, \delta\Gamma_W$ = largest (CR - no CR) shift in different models

Model	δM_W^{4q}(MeV)
Herwig	~40
Ariadne	~ 60
SKI	up to 200

p_{rec} = CR prob← CR strength

Particle Flow technique

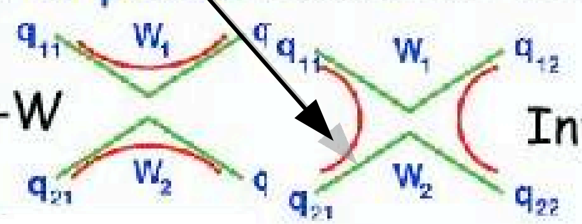
OPAL final PF study



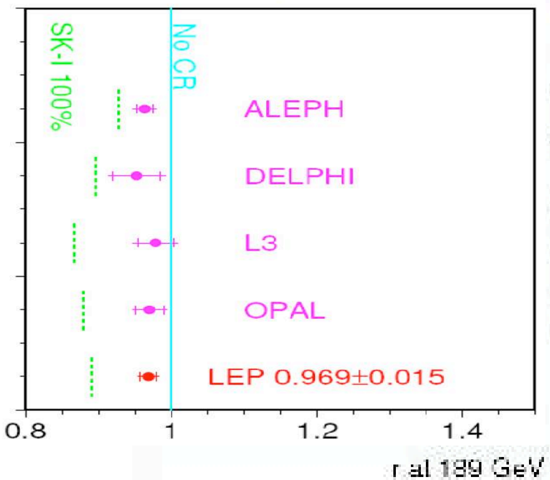
Extreme CR model

Find Observable for CR

Measure ratio of particle densities in intra- and inter-W planes : sensitive to CR



Using DATA to study CR



r=R(Data)/R(MCnoCR)
all prel, final OPAL and L3 not included

Preliminary LEP PF analysis 68% CL upper limit on CR strength in SKI model (p_{rec}< 56%)→ Data Driven δM_W for SKI

Final Step
Desensitize analysis to CR effects

Future: need A,D final results for final comb

Combine Experiments

ntres de Moriond (La Thuile) Standard Model at LEP - F. Spano' 14

MSTP(115) :

(D=0) (C) choice of colour rearrangement scenario for process 25, pair production, when both 's decay hadronically. (Also works for process 22, production, except when the 's are allowed to fluctuate to very small masses.)

= 0 : no reconnection.

= 1 : scenario I, reconnection inspired by a type I superconductor, with the reconnection probability related to the overlap volume in space and time between the and strings. Related parameters are found in PARP(115) - PARP(119), with PARP(117) of special interest.

= 2 : scenario II, reconnection inspired by a type II superconductor, with reconnection possible when two string cores cross. Related parameter in PARP(115).

= 3 : scenario II', as model II but with the additional requirement that a reconnection will only occur if the total string length is reduced by it.

= 5 : the GH scenario, where the reconnection can occur that reduces the total string length (measure) most. PARP(120) gives the fraction of such event where a reconnection is actually made; since almost all events could allow a reconnection that would reduce the string length, PARP(120) is almost the same as the reconnection probability.

= 11 : the intermediate scenario, where a reconnection is made at the `origin' of events, based on the subdivision of all radiation of a system as coming either from the or the . PARP(120) gives the assumed probability that a reconnection will occur. A somewhat simpleminded model, but not quite unrealistic.

= 12 : the instantaneous scenario, where a reconnection is allowed to occur before the parton showers, and showering is performed inside the reconnected systems with maximum virtuality set by the mass of the reconnected systems. PARP(120) gives the assumed probability that a reconnection will occur. Is completely unrealistic, but useful as an extreme example with very large effects.

Colour Reconnection (cont)

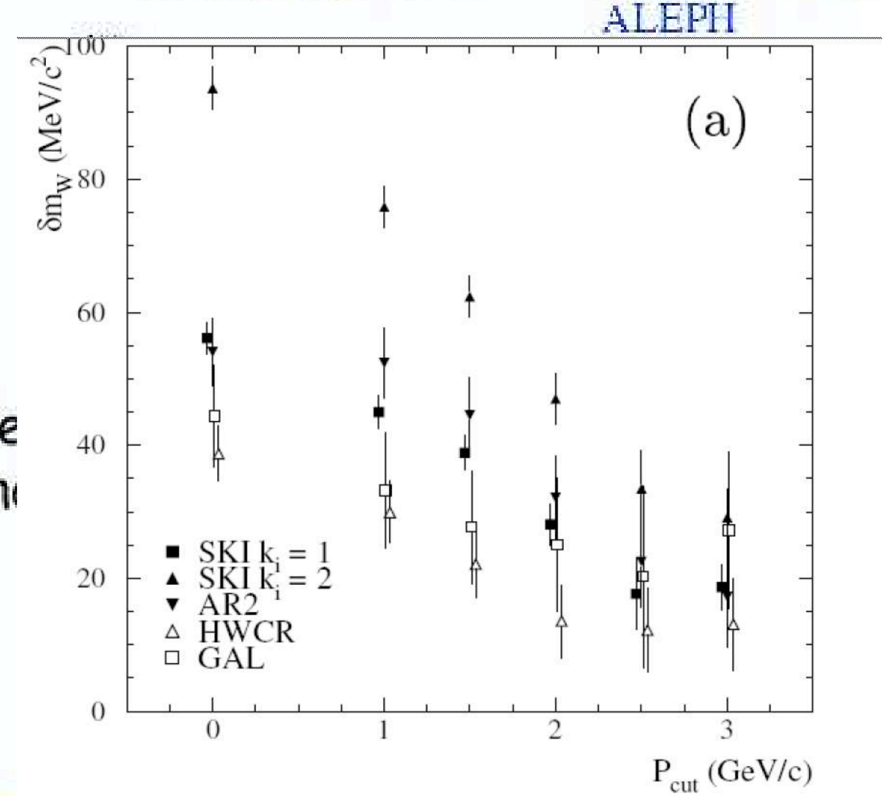
CR affects mostly soft particles between jets ⇒ changes jet direction

Re-calculate jet dir. from particles:

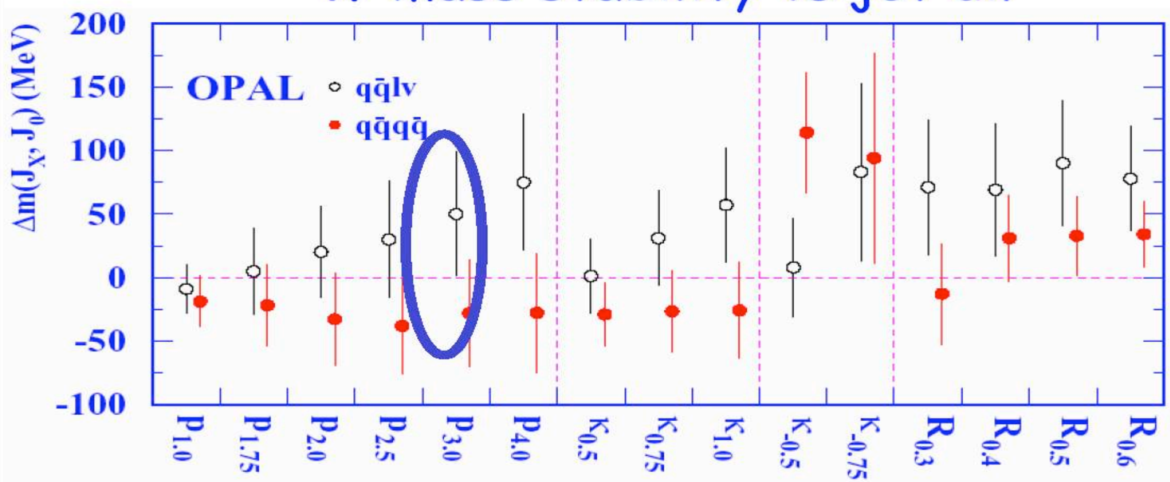
1. with momentum P larger than P_{thr}
2. by weighted momentum vector sum (weight = $|P|^{\kappa}$)
3. within cone of radius R

Use P_{thr}(GeV)=3 (A),2.5(O),2(L) for M_w (be stat-syst compr). Γ_W is obtained with stan analysis (O,A) or using P_{thr} (L).

W mass biases vs momentum cut



W mass stability vs jet dir



δM_W^{stat} :worse by 15-35%

δM_W^{had} :worse by ~ 30-100 %

δM_W^{CR} :reduced by factor 2-3

Total δM_W improves: 79 MeV→ 61 MeV

Difference between Breit-Wigner and Pole-mass small ~ 100 MeV

Gluons from top radiation E ~ 1.5 GeV ??? MeV

b fragmentation not necessarily the same as @ LEP ??? MeV

Magnitude of color re-connections needs to be studied

Experiments need to provide people for even simple studies