Colour Reconnection in WW events

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- $WW \rightarrow qqQQ$ events collected at LEP2
- Colour Reconnection effect at LEP2
- Model dependent measurement(s)
- Preliminary conclusions

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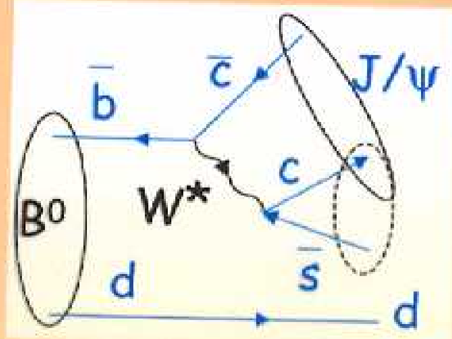
Colour Reconnection

Known example :

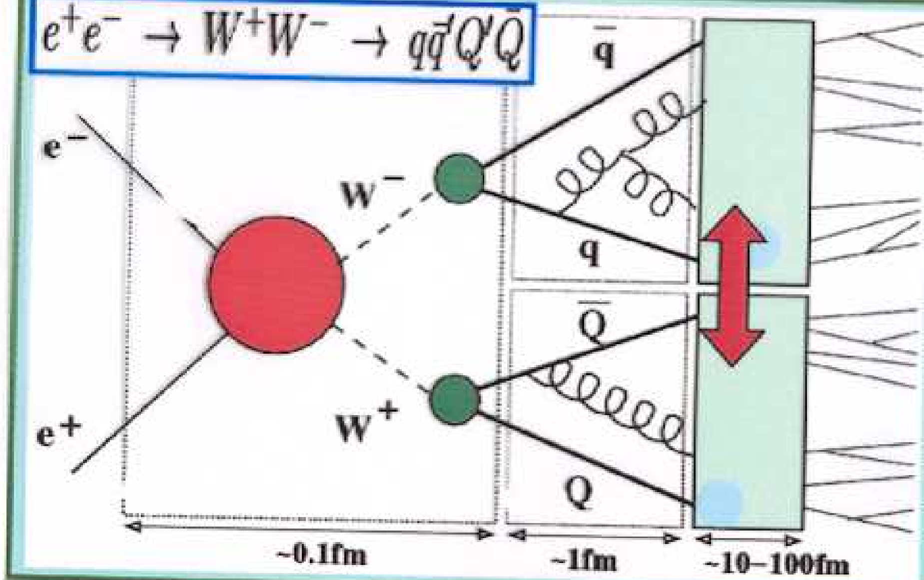
hadronic decay of B mesons

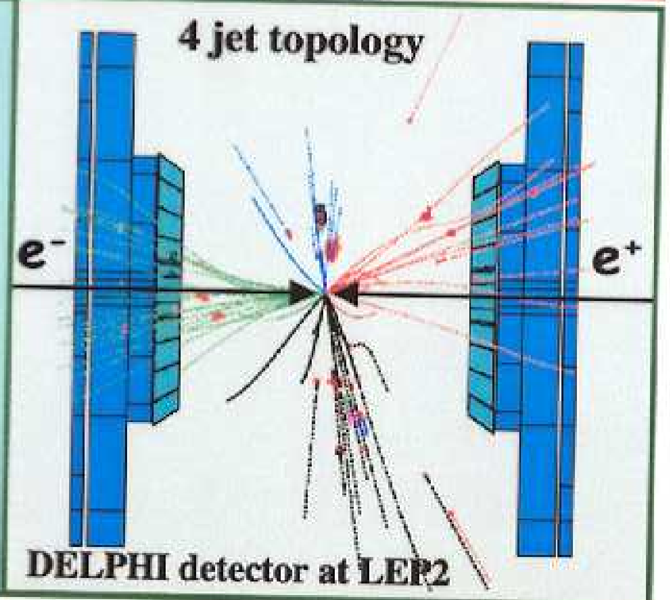
$B \to J/\Psi + X$

BR.exp ~1%
BR.fullCR ~3-5%
BR.noCR ~0.3-0.5%



G.Gustafson, U.Petterson and P.Zerwas, Phys.Lett. B209 (1988) 90





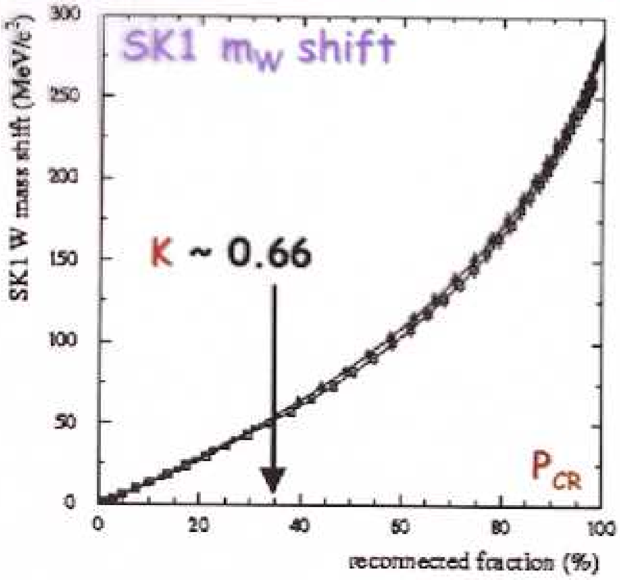
Main interest :

- Probe the interaction of two fragmenting strings
- Causes largest systematic error on W-mass

Simulating the CR effect

CR implemented in existing fragmentation models :

- PYTHIA : string reconfiguration if they overlap or cross in space-time
  - SK1 (lateral flux tube) : via event string overlap O : $P_{CR} = 1-\exp(-\kappa \cdot O)$
  - SK2 (vortex line with core) : reconnection if cores cross
  - SK2' : SK2 + only if string length is reduced
- ARIADNE : rearrangement of colour dipoles to reduce the string length (mass)
  - AR2 : only after soft gluon radiation ($E_g < \Gamma_W$)
  - AR3 : allowed everywhere (also in pertubative phase)
- HERWIG : rearrangement of colour dipoles changing the size of the clusters



Latest preliminary predictions for the W-mass
- ***PYTHIA (SK1) ~ 50 MeV/c²***
- ***ARIADNE (AR2) ~ 70 MeV /c²***
- ***HERWIG ~ 40 MeV/c²***

Statistical uncertainty (LEP2) ~ 30 MeV /c²

For each model one can study the effect on the structure of the WW events with Monte Carlo simulation and compare it with data.

Most sensitive observables

→ design an observable sensitive to for example K (SK1)

New!

Particle flow

Design an observable to measure a possible enhancement of particles in the inter-W regions...

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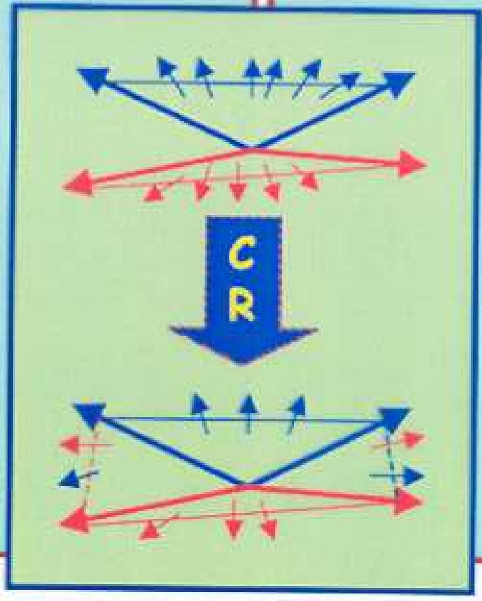
simply count particles
(background sensitive)

sensitivity ~ 2.7 σ
(for full SK1)

Eff. ~ 12%, Pur. ~ 87%



W-mass measurements

CR is an important systematic uncertainty on m_W measured in WW → qqqq events, but we designed another m_W estimator which does not have this feature...

↓

jet kinematics of the event
(background insensitive)

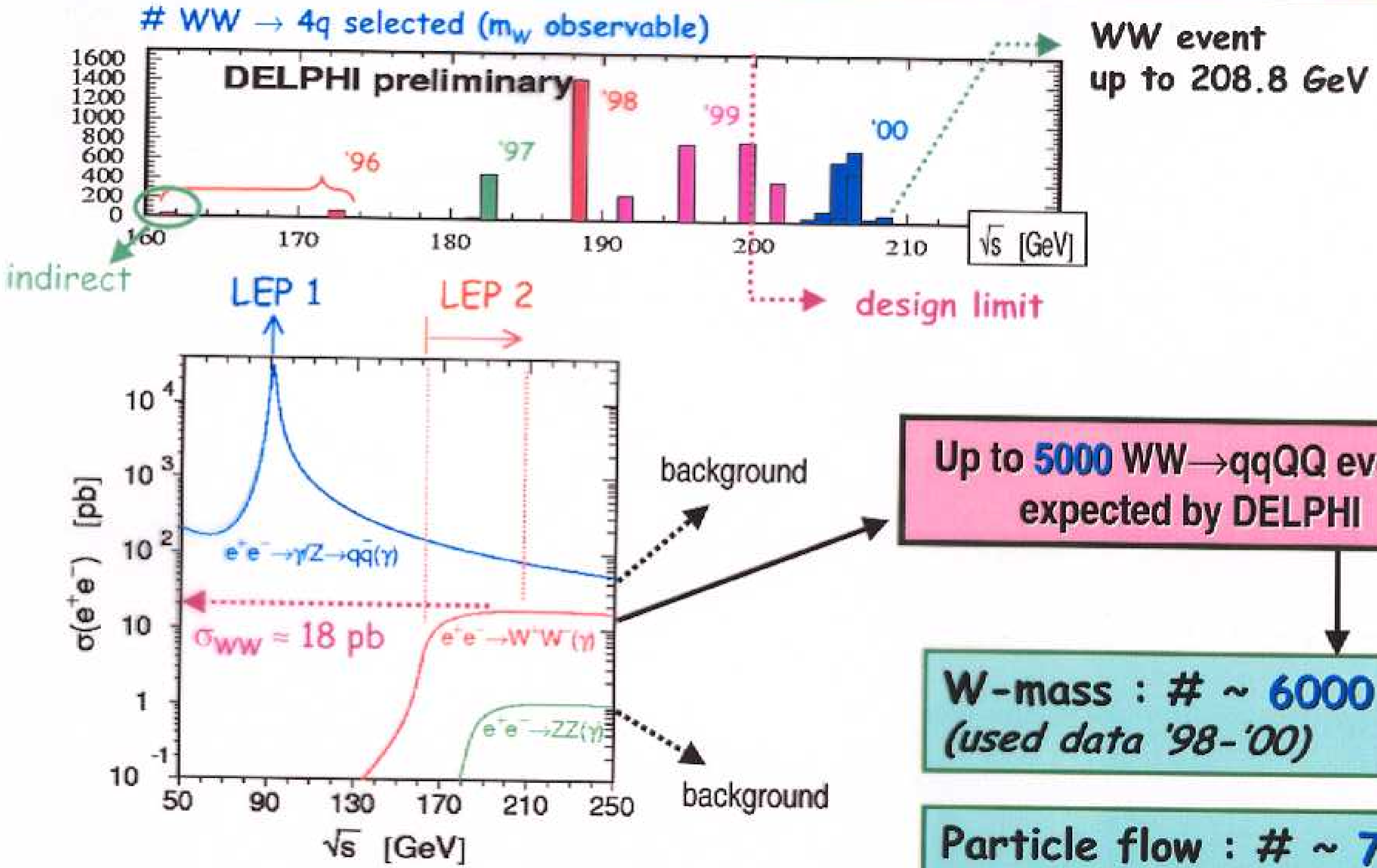
sensitivity ~ 4.3 σ
(for full SK1)

Eff. ~ 90%, Pur. ~ 71%

The correlation between both observables was found to be negligibly small

...all results are preliminary

Achievements of LEP2



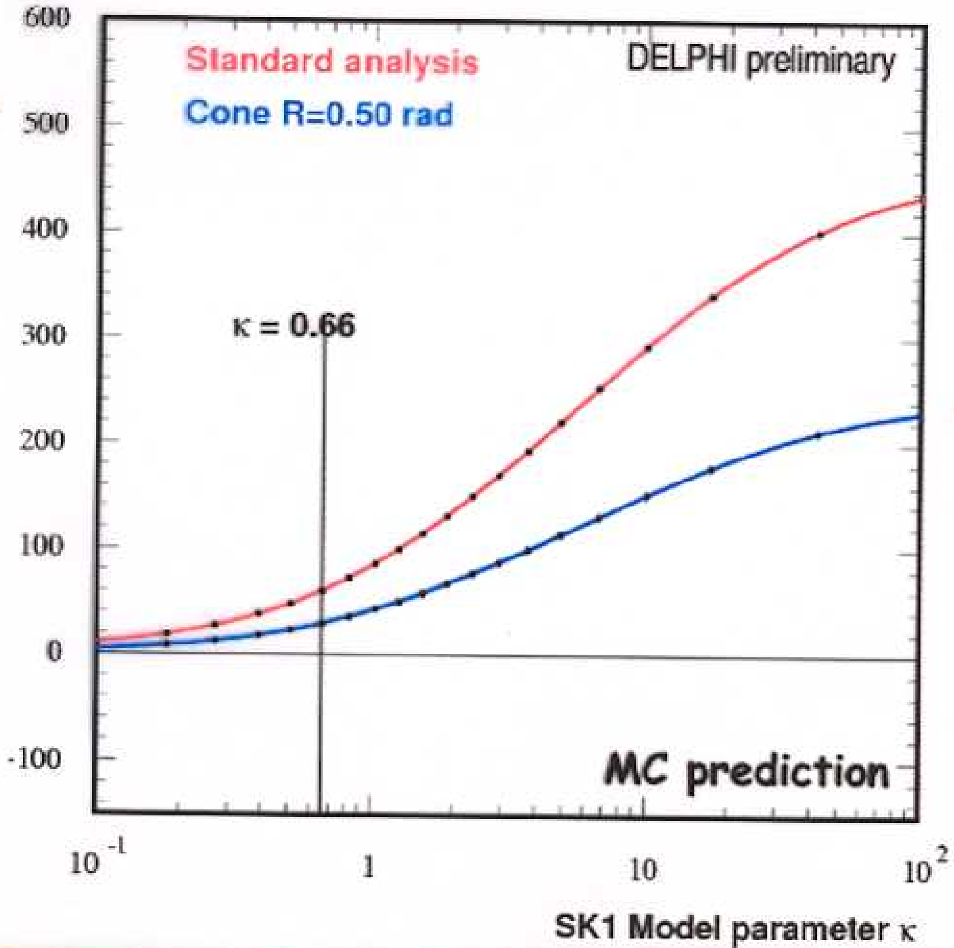
Up to **5000** WW→qqQQ events expected by DELPHI

W-mass : # ~ 6000
(used data '98-'00)

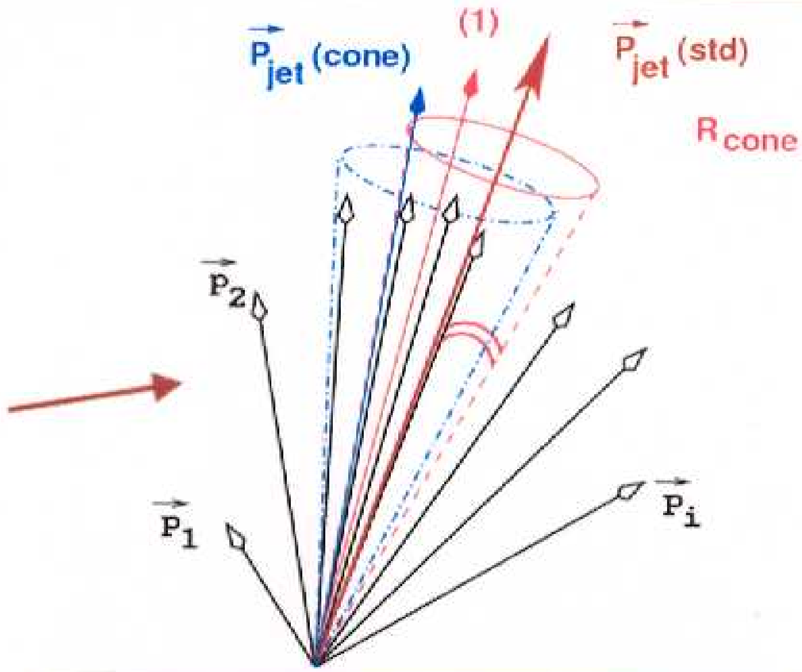
Particle flow : # ~ 720
(used data '97-'00)

W-mass observables

Influence on W mass estimator (MeV/c^2) for different values of κ (SK1)



Correlation between W mass estimators ~ 83 %
⇒ uncertainty on the difference is small

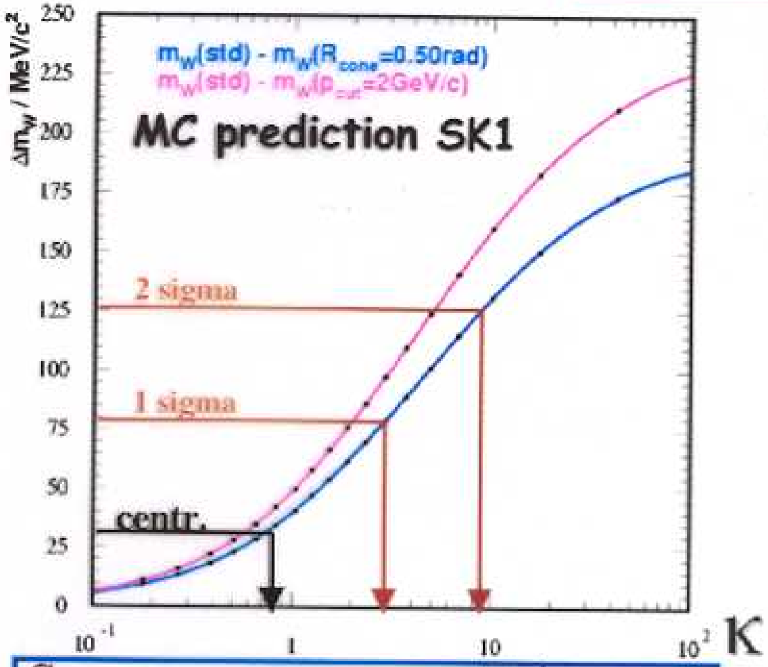


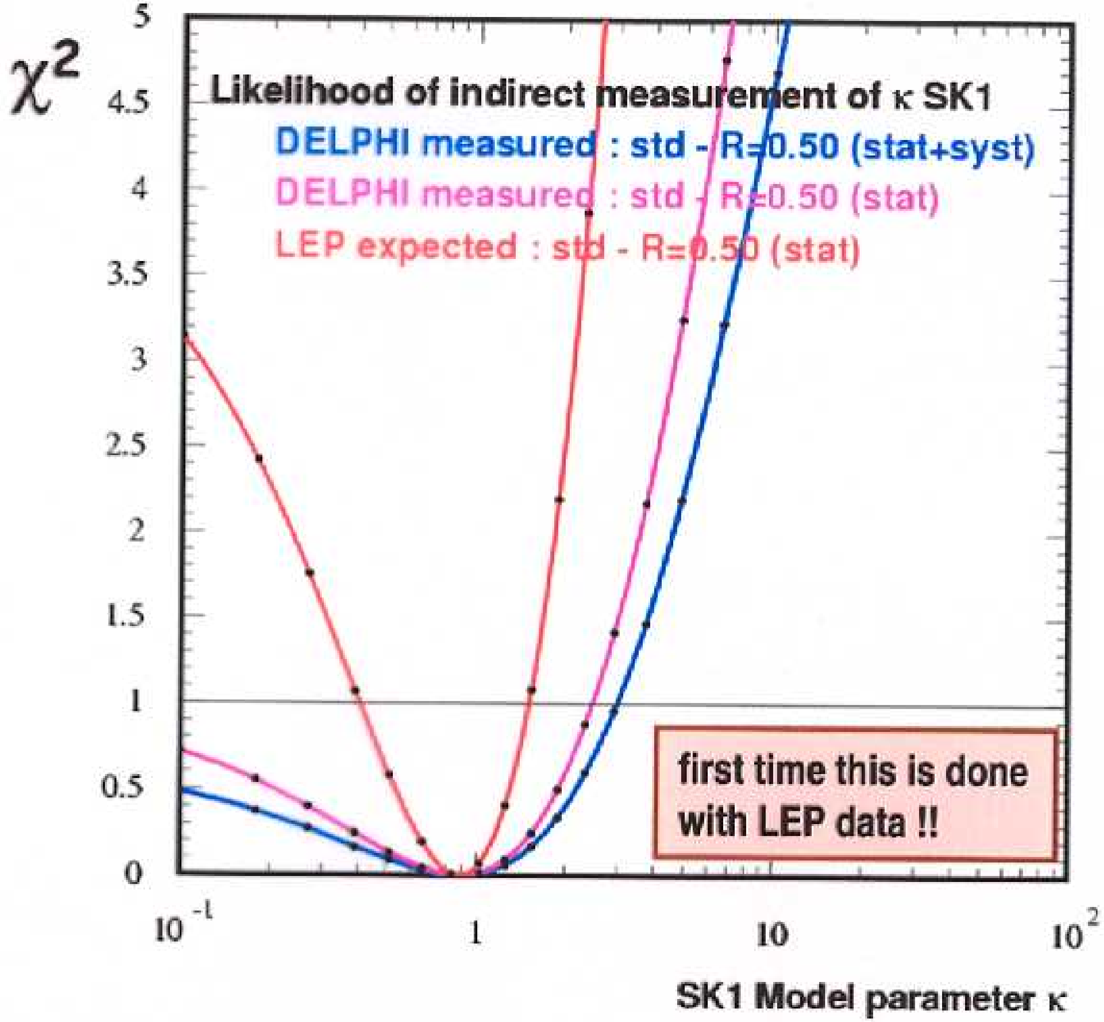
m_W is assumed to be unknown but it must be invariant for different estimators

⇓

m_W(std)-m_W(cone) from MC as function of κ

Data @189-209 : $\Delta m_W(\text{std}, R_{cone} = 0.5\,\text{rad}) = 36 \pm 36 \pm 25\ \text{MeV}/c^2$





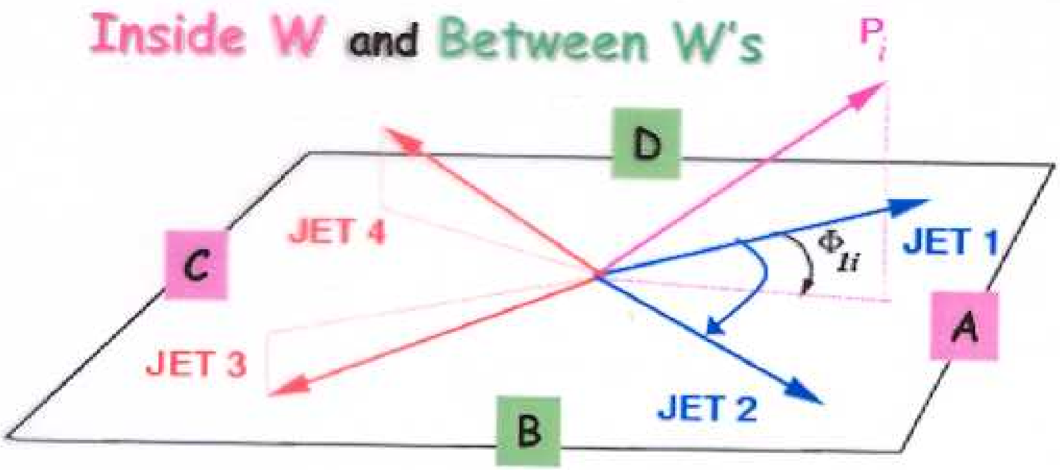
Source	MeV/c²
Fragmentation	10
$\sqrt{s}$ dependence $\oplus$ bck.	10
Energy flow in jet	11
BEI-BEA	8
BEO-BEI	16

Monte Carlo prediction if there is Colour Reconnection

ARIADNE : $\Delta m_W(\text{std}, R_{cone} = 0.5\,\text{rad}) = 3 \pm 5\ \text{MeV}/c^2$ → different behaviour

HERWIG : $\Delta m_W(\text{std}, R_{cone} = 0.5\,\text{rad}) = 23 \pm 6\ \text{MeV}/c^2$.

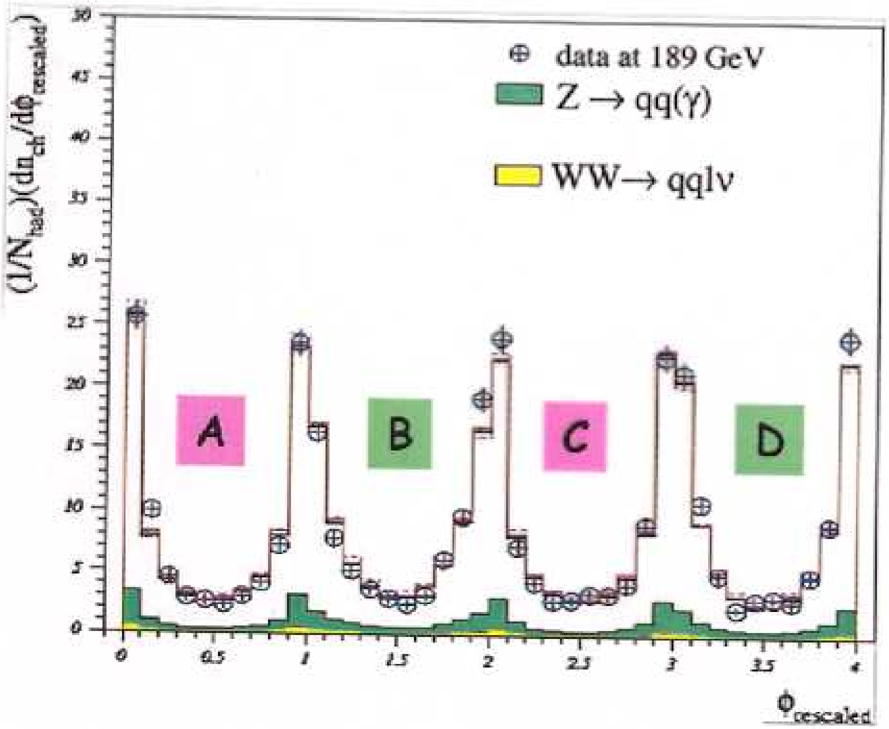
Particle flow observable

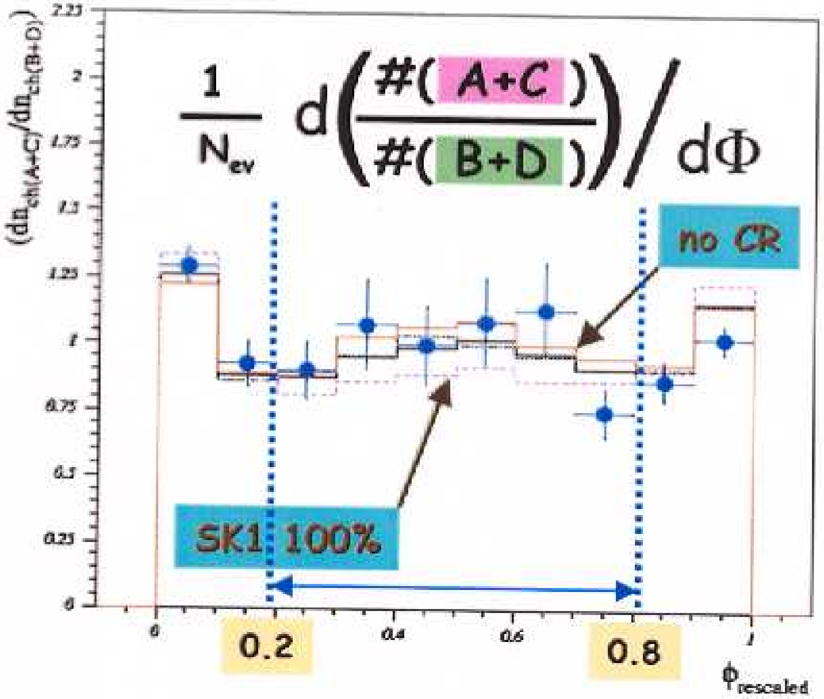


Project all charged particles P_i in the plane (jet 1, jet 2)

Rescale the angles to have an equal amount of phase-space between the jets :

$\Phi_{J,i} \rightarrow \Phi_{J,i} \cdot (1/\Phi_{JK})$





Preliminary results

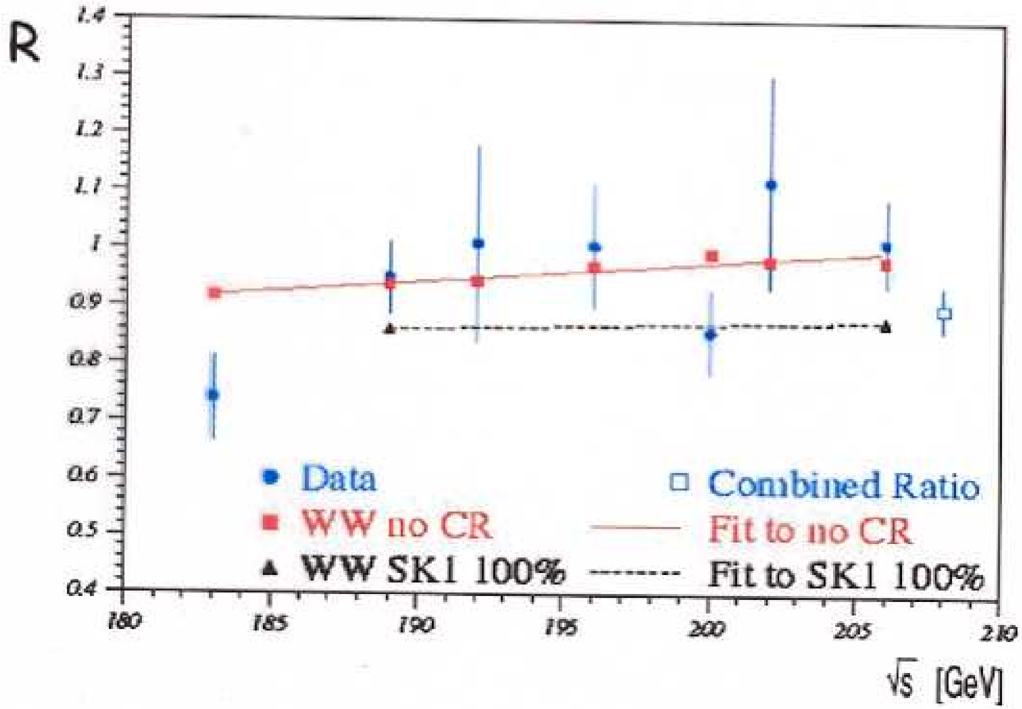
$$R = \frac{\int_{0.2}^{0.8} \frac{1}{N_{ev}} \frac{dn}{d\Phi} d\Phi (\text{regions A+C})}{\int_{0.2}^{0.8} \frac{1}{N_{ev}} \frac{dn}{d\Phi} d\Phi (\text{regions B+D})}$$

In the systematic error, were considered:

- Bose-Einstein effects (2%)
- Fragmentation modelling (1%)
- Background subtraction/modelling (0.5%)
- Generators/Tunings (0.3%)

Data @183-209 : $\langle R_{189} \rangle = 0.900 \pm 0.031 \pm 0.021$

(extrapolated to 189 GeV)



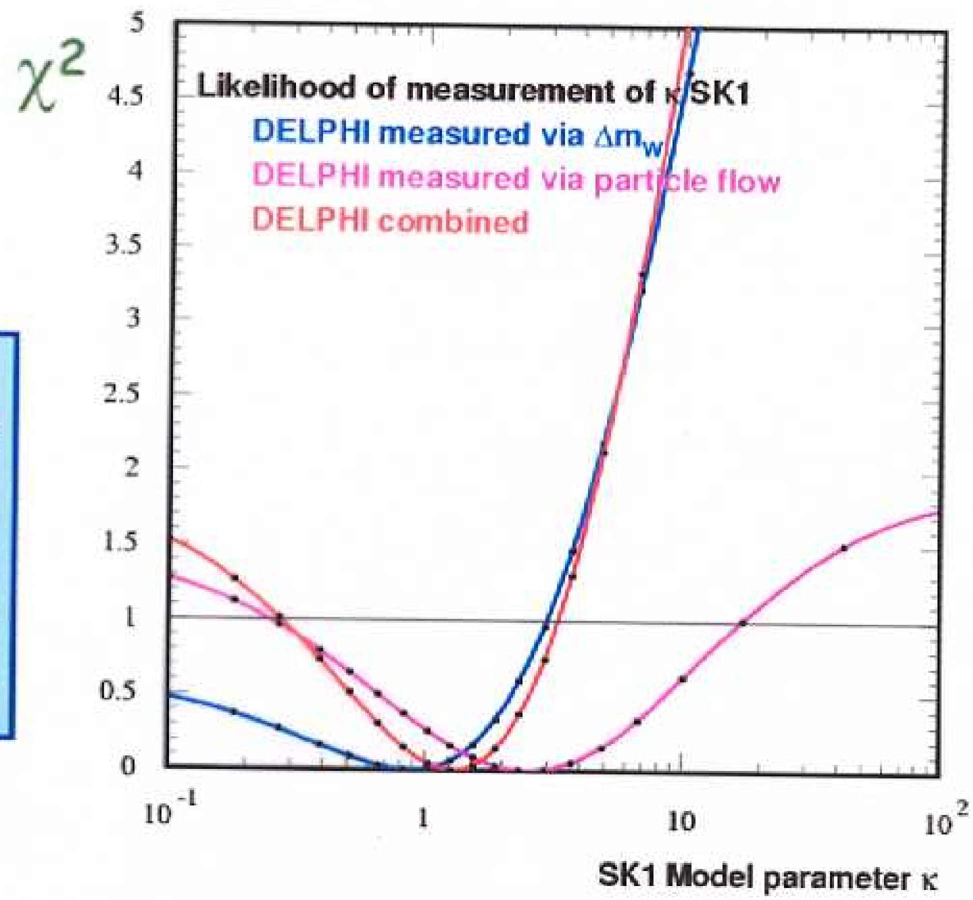
Monte Carlo prediction :

MC Sample	R
JETSET no CR	0.944 ± 0.004
SK1 100%	0.846 ± 0.004
ARIADNE no CR	0.953 ± 0.004
ARIADNE AR2	0.955 ± 0.004
HERWIG no CR	0.967 ± 0.004
HERWIG 1/9 CR	0.965 ± 0.004

Combination SK1

no correlation assumed between the two measurements (good approximation)

68% CL for κ	68% CL for P_{CR}
[0.3 , 3.3]	[14% , 75%]
central value 1.3	central value 44%



Conclusion

- Colour reconnection models are investigated in $WW \rightarrow qqQQ$ events
- Two uncorrelated observables are designed :
  - ⌘ Integrating the particle flow between jets (R)
  - ⌘ Using the kinematics of the jets (Δm_W[std,cone])
- Preliminary results prefer a small amount of Colour Reconnection
  (also the LEP combined measurement, cfr. talk of Nigel Watson)
- The observables are not sensitive to the ARIADNE model !?

Therefore one cannot decrease the systematic uncertainty on m_W

More work needed on ARIADNE !!

Preliminary shift on the W-mass

- *PYTHIA (SK1) ~ 50 MeV/c^2*
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