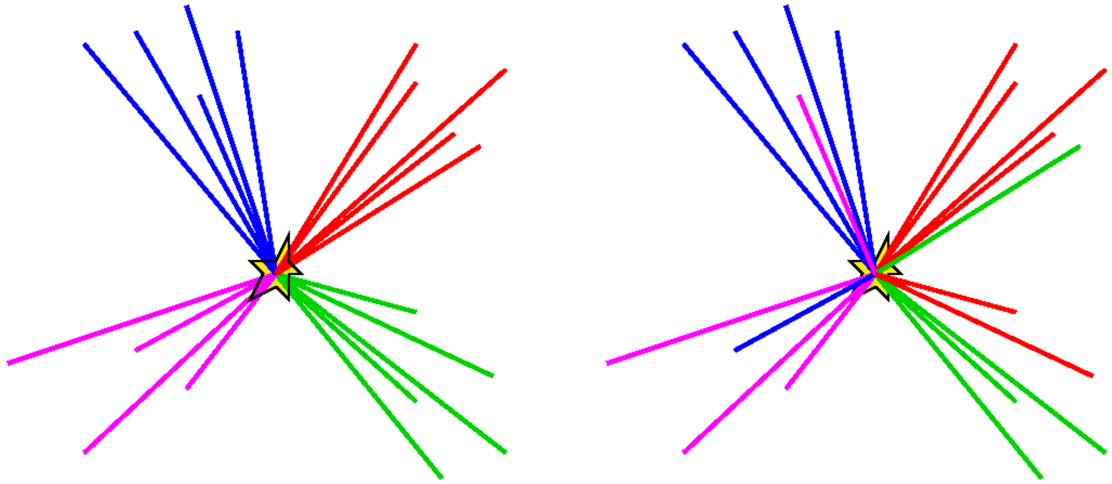
XXXVII. Rencontres de Moriond 19.03.2002

W Mass and its Uncertainty from Modelling the Hadronic Final State at LEP



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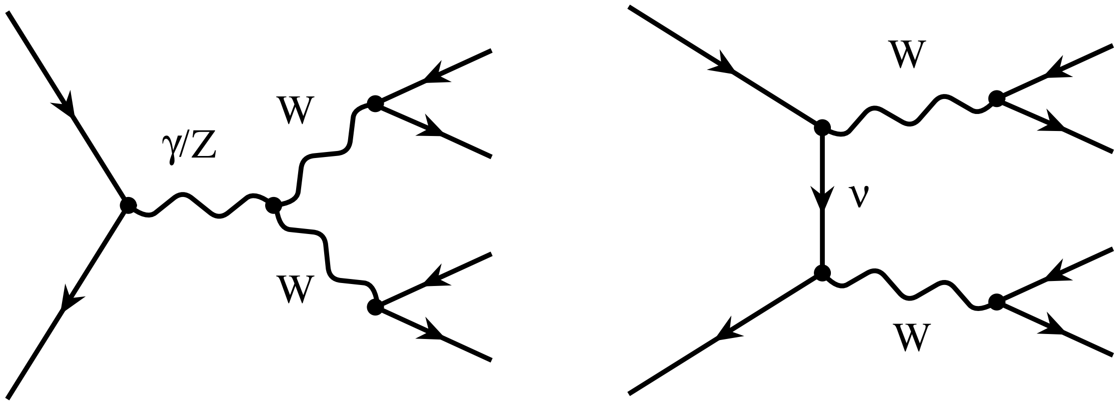
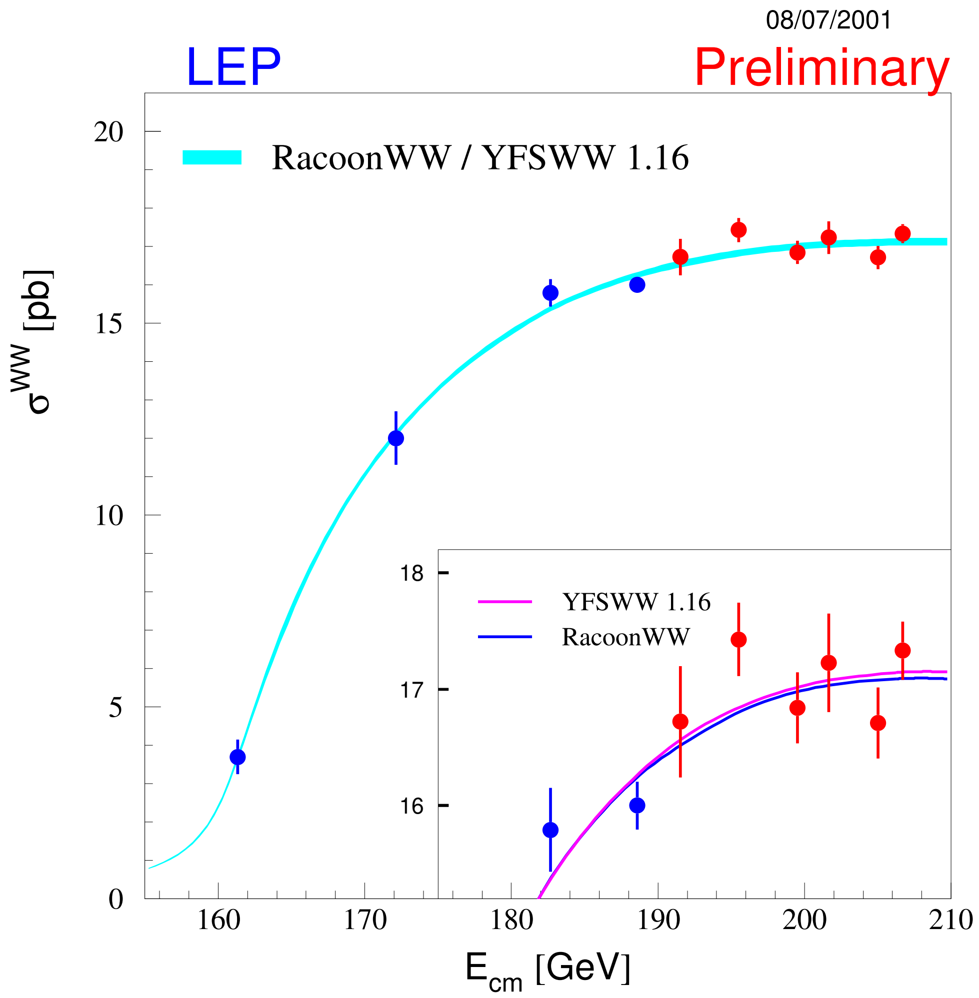
Outline



- WW Production at LEP
- WW Final States
- W Mass Determination and Systematics
- Colour Reconnection
- Hadronization
- Summary & Outlook

Note: All LEP averages are preliminary:
CERN-EP/2001-098 (hep-ex/0112021)

WW Production at LEP 2



LEP 2 1996–2000

$$E_{\mathrm{cms}} = 161 \ldots 209\,\mathrm{GeV}$$

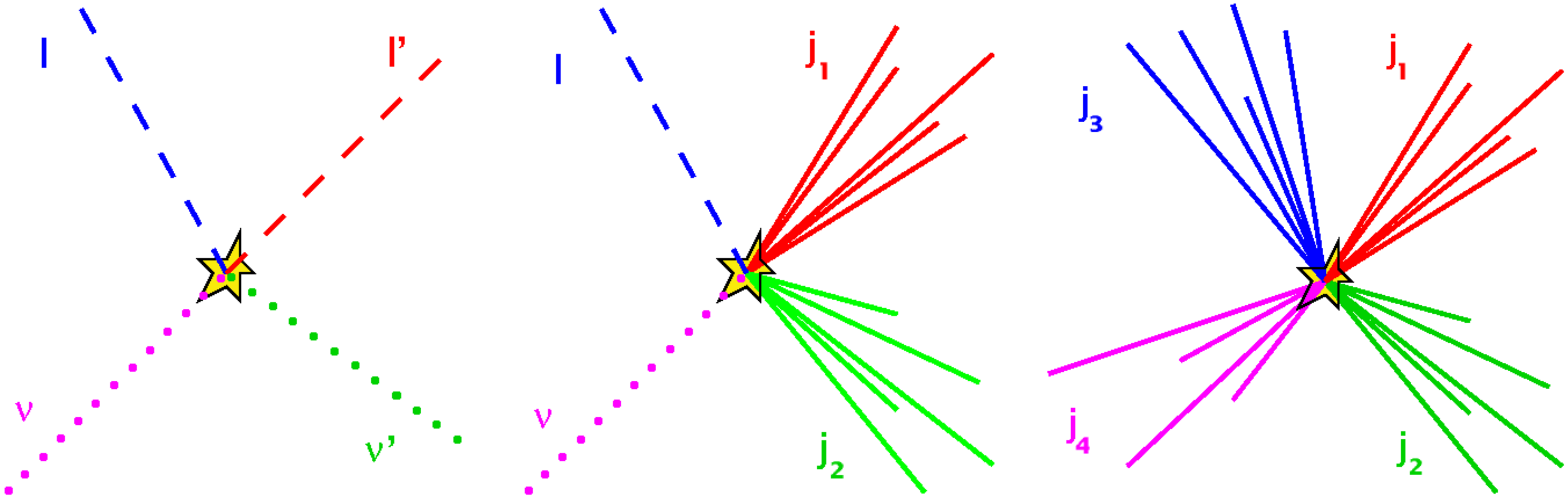
$$\mathcal{L} \approx 700\,\mathrm{pb}^{-1}/\mathrm{exp.}$$

$$\approx 10000\,WW's/\mathrm{exp.}$$

Included:

σ^{WW}	ADLO	full data set
M_W	ADL	full data set
	O	1996–1999

WW Final States



$2\,l^{\pm}$, $\geq 2\nu$

BR	$=$	11%
Eff.	$\approx$	$78\%\,(60\%)$
Pur.	$\approx$	$92\%\,(74\%)$

$\tau!$

Low Statistics

2 Jets, $1\,l^{\pm}$, $\geq 1\,\nu$

BR	$=$	44%
Eff.	$\approx$	87%
Pur.	$\approx$	91%

Hadronization

4 Jets

BR	$=$	45%
Eff.	$\approx$	86%
Pur.	$\approx$	78%

Jet-Jet $\longleftrightarrow$ W Ambiguity

Hadronization $+$ FSI

Direct W Mass Reconstruction

Not possible for $l\nu l\nu$:

$\Rightarrow$ Par. fits of e.g. E_{lepton} using MC

General Procedure for $qqqq$, $ql\nu$:

- Reconstruct 4/5 or 2 jets and no or one charged lepton
- Determine invariant jet-jet masses (2 M_W's per $qqqq$ event, choose or weight jet combination)

But: Poor jet energies $\frac{\Delta E}{E} \approx 20\%$

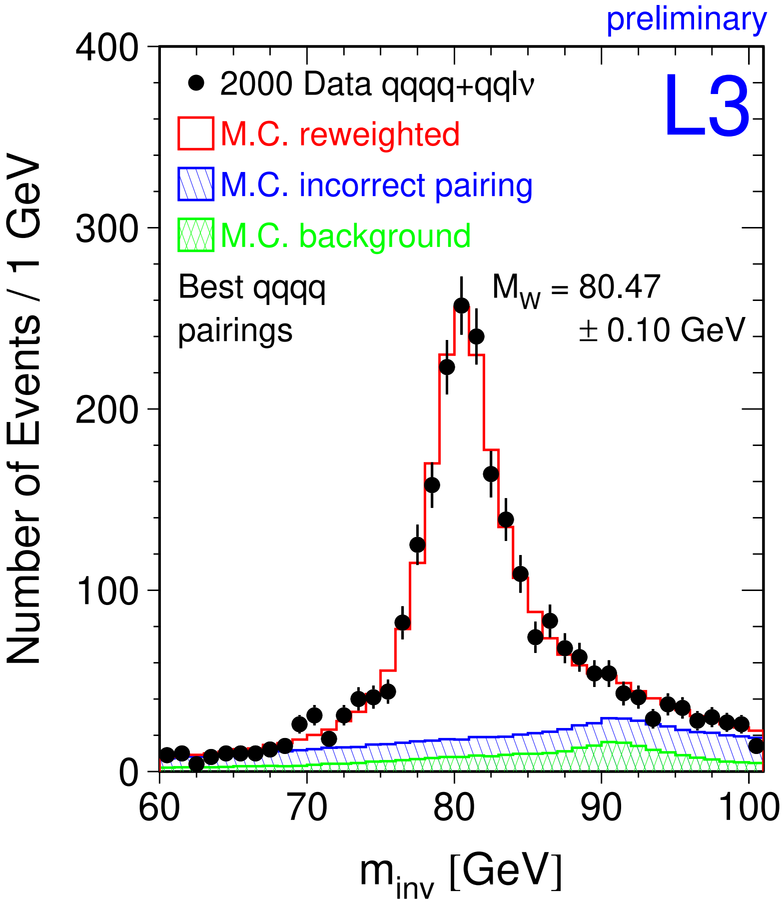
$\Rightarrow$ Constrained Fits:

4C: $\sum (E, \vec{p}) = (\sqrt{s}, \vec{0})$
1C: $M_{W+} = M_{W-}$

$\Rightarrow$ $5C$ fit for $qqqq$

$2C$ fit for $qqe\nu, qq\mu\nu$

$1C$ fit for $qq\tau\nu$ (E_τ not measured)



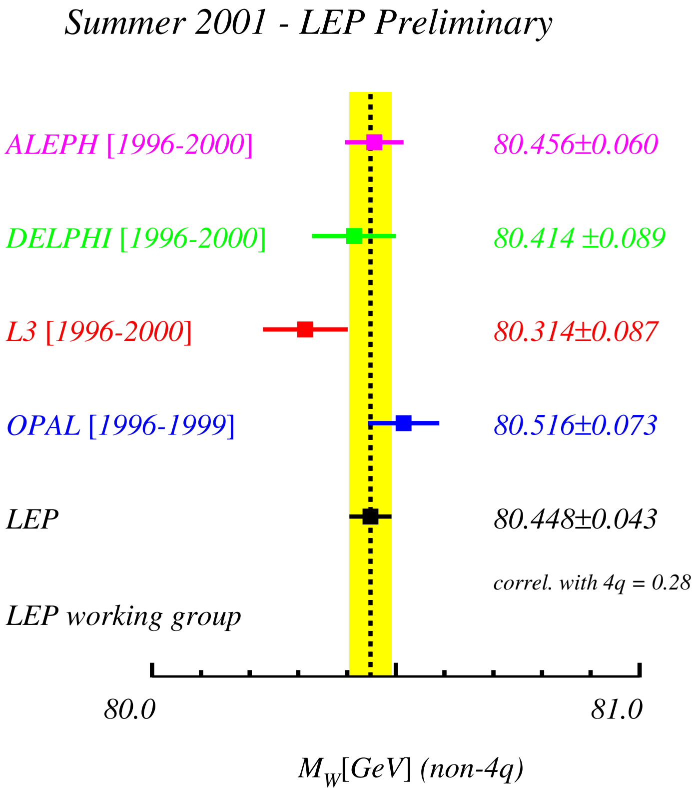
Systematic Uncertainties

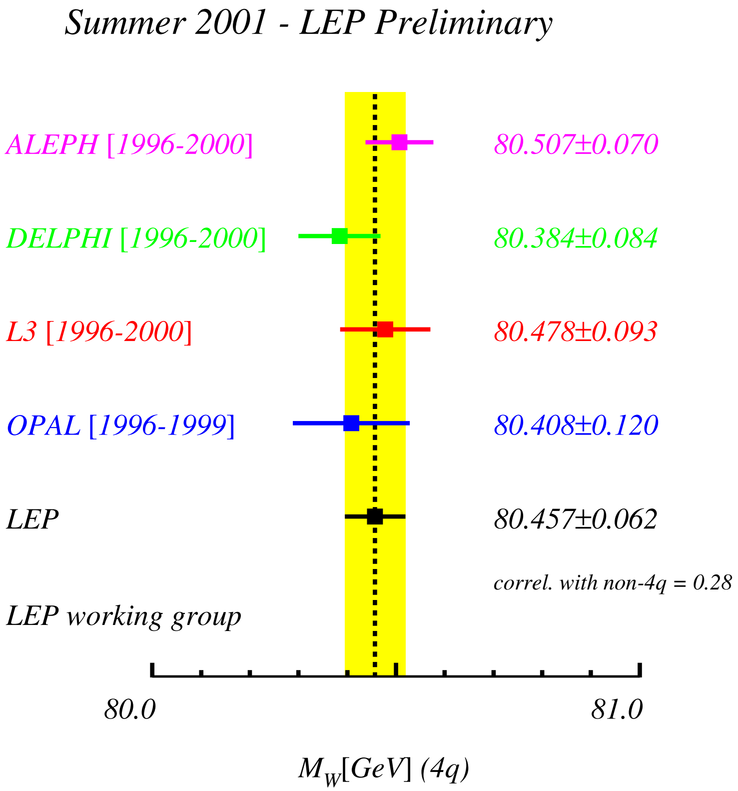
	$\Delta M_W/\mathrm{MeV}$			
Data	O final	LEP ADLO Preliminary		
	$l\nu l\nu$	$qql\nu$	$qqqq$	Combined
LEP Beam Energy	11	17	17	17
ISR/FSR	7	8	9	8
Detector Systematics	115	12	8	10
Hadronization	-	19	17	17
Colour Reconnection	-	-	40	11
Bose-Einstein Correlations	-	-	25	7
Other	52	4	4	3
Total Systematic	127	29	54	30
Statistical	410	33	30	26
Total	430	44	62	40

Statistical weights: $qql\nu$ channel: 45%, $qqqq$ channel: 55%

Total weights : $qql\nu$ channel: 73%, $qqqq$ channel: 27%!

Preliminary W Mass Measurements from LEP

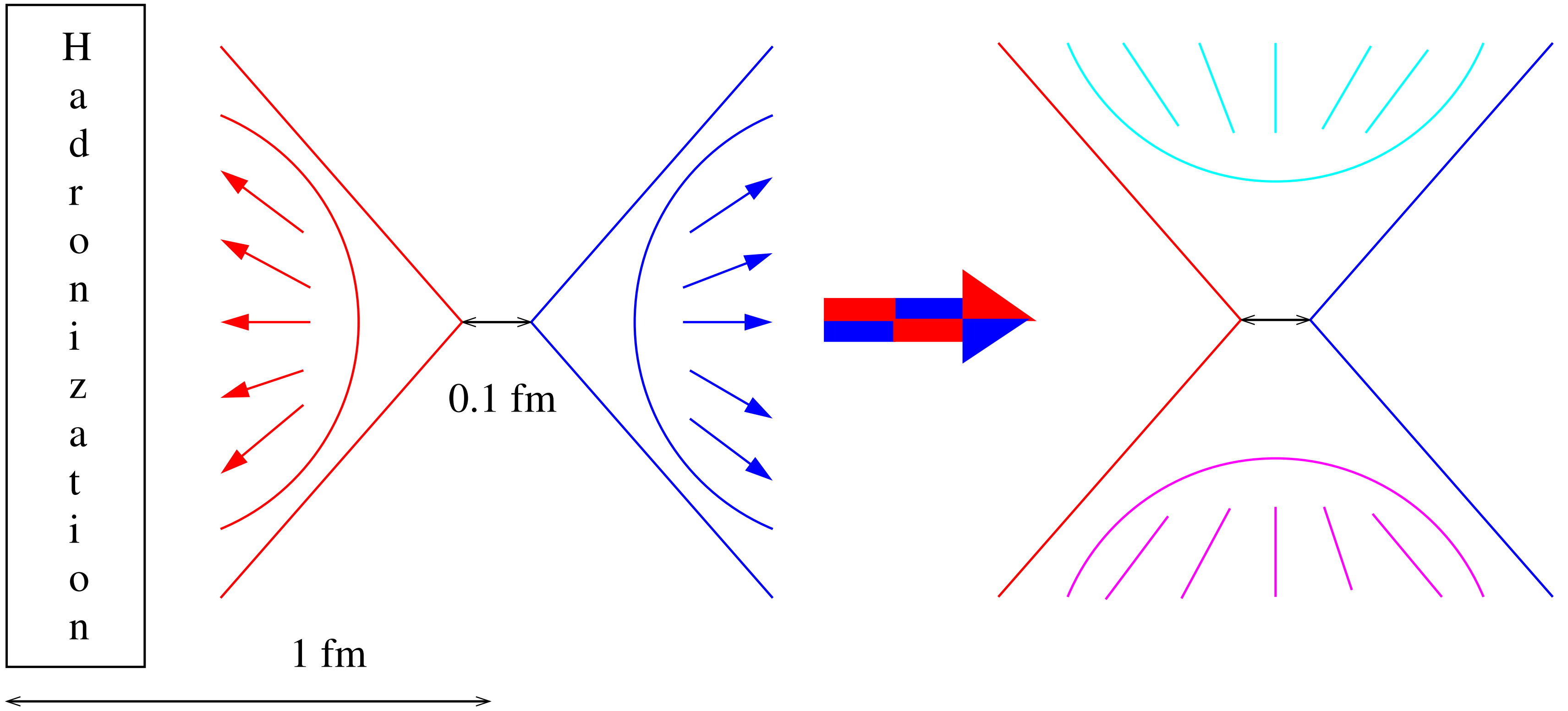




$$M_W^{non-4q} = (80.448 \pm 0.043)\,\mathrm{GeV} \qquad M_W^{4q} = (80.457 \pm 0.062)\,\mathrm{GeV}$$

$$\Delta M_W(qqqq - ql\nu) = (+9 \pm 44)\,\mathrm{MeV}$$

Colour Reconnection

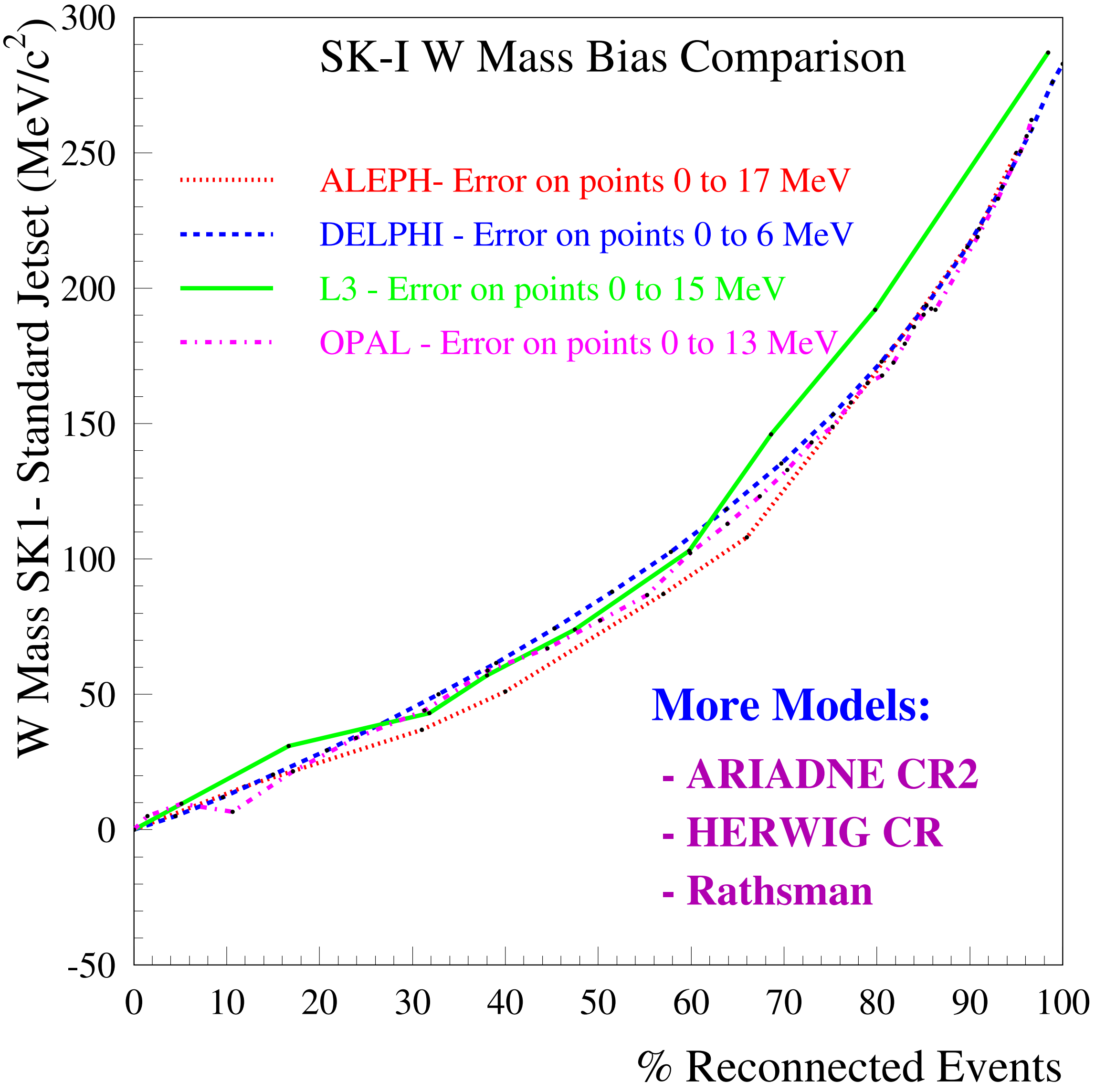


CR via hard gluons in pQCD suppressed: $\Delta M_W \approx \mathcal{O}(1\,\mathrm{MeV})$

But could be large in parton cascade! $\longrightarrow$ Phenomenological Models used:

(LEP Combination: $\Delta M_W = 40\,\mathrm{MeV}$) ADLO: $\Delta M_W \approx 30 \ldots 66\,\mathrm{MeV}$

Mass Bias Sensitivity Crosscheck



Common generator files by ALEPH

$\longrightarrow$ 150k events simulated for each detector

$\Rightarrow$ Similar Sensitivity to SK I

Observable Effects of Colour Reconnection

CR reduces 'string tension' and mixes up the colour singlet from each W!

$\Rightarrow$ More activity between jets of different W's

$\Rightarrow$ No indep. hadronization, ambiguous assignment of particles to either W

'Observable' Effects:

- Unfortunately: Reconstructed W Mass!!!
- Interjet Particle Distributions
- Smaller Multiplicities (Beware: HERWIG CR $\nearrow$)

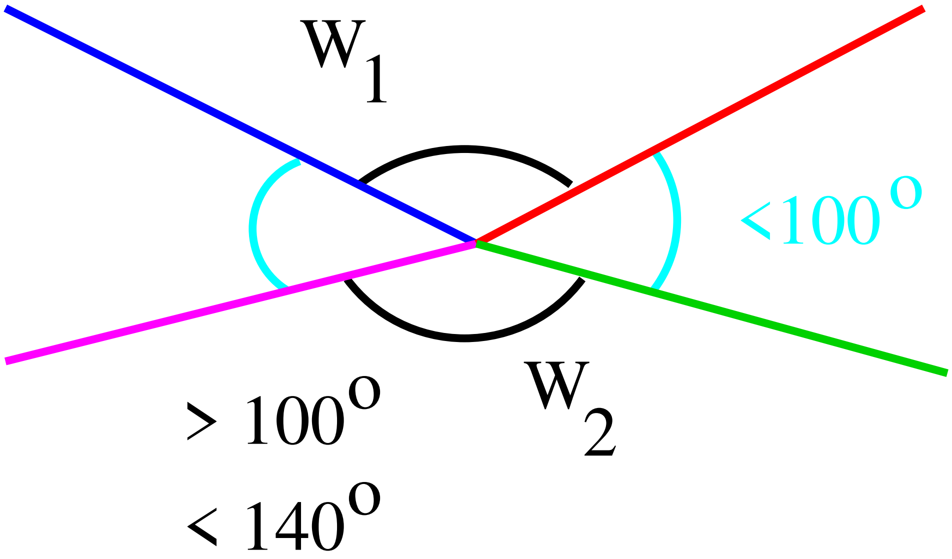
	$\sqrt{s}/$ GeV	$\langle n_{\mathrm{ch}} \rangle_{4\mathrm{q}}$	$\langle n_{\mathrm{ch}} \rangle_{2\mathrm{q}}$	$\delta \langle n_{\mathrm{ch}} \rangle = 4q - 2 \cdot 2q$
A	183-202	$35.75 \pm 0.13 \pm 0.52$	$17.41 \pm 0.12 \pm 0.15$	$0.93 \pm 0.27 \pm 0.29$
D	183-189	$38.78 \pm 0.29 \pm 0.29$	$19.57 \pm 0.26 \pm 0.23$	$-0.32 \pm 0.60 \pm 0.54$
L	183-202	$37.90 \pm 0.14 \pm 0.41$	$19.09 \pm 0.11 \pm 0.21$	$-0.29 \pm 0.26 \pm 0.30$
O	183-189	$38.51 \pm 0.22 \pm 0.33$	$19.25 \pm 0.16 \pm 0.16$	$0.06 \pm 0.39 \pm 0.32$

A: not corrected for selection biases and low momenta

$\Rightarrow$ No sensitivity here!

Interjet Particle Flow 1

Idea from L3: Look for low momentum particle (or energy) flow inbetween jets and compare interjet regions for same and different W's.



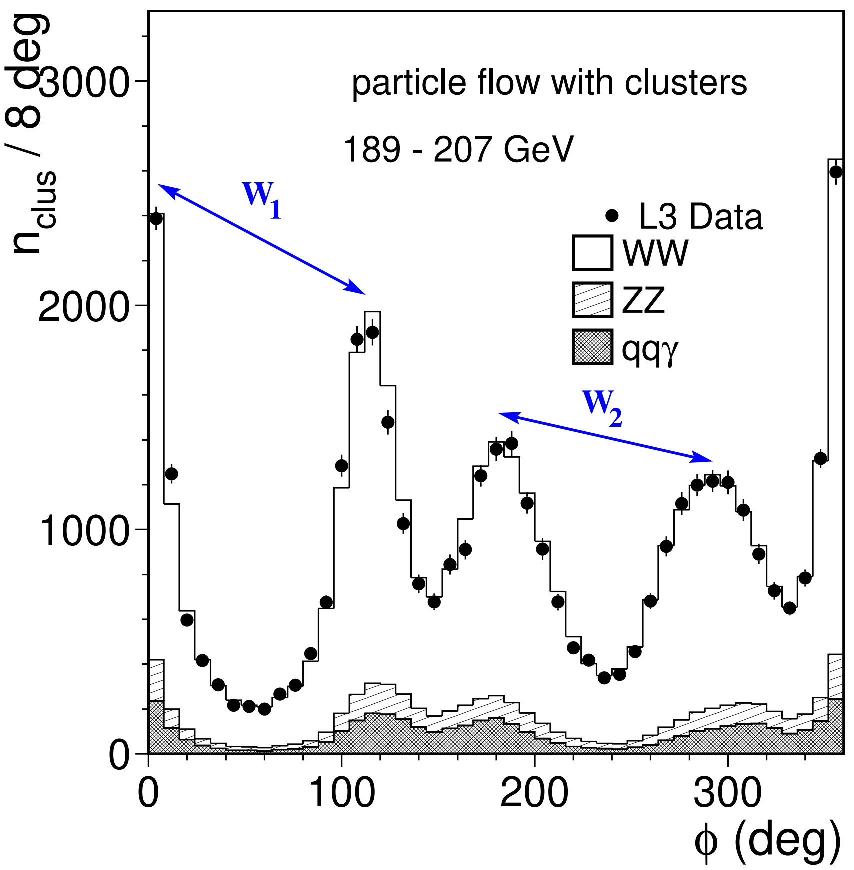
Additional selection criteria („Angular“, used by D & L):

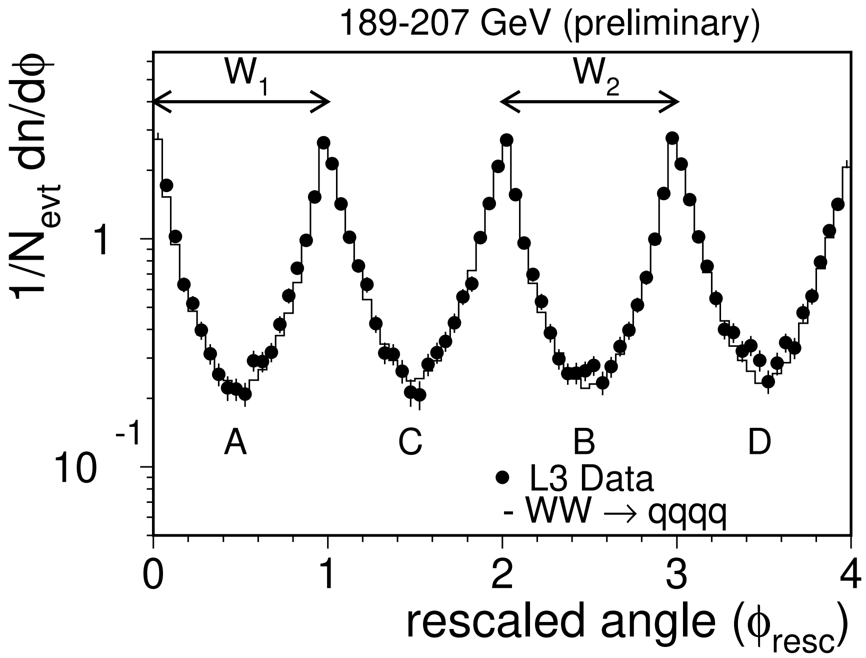
- 2 larger jet-jet angles: $> 100^\circ$, $< 140^\circ$ and not adjacent
- 2 smaller jet-jet angles: $< 100^\circ$

$\Rightarrow$:

- Clean topology, 91% correct jet pairings
- Low efficiency of $\approx$ 12%

Interjet Particle Flow 2

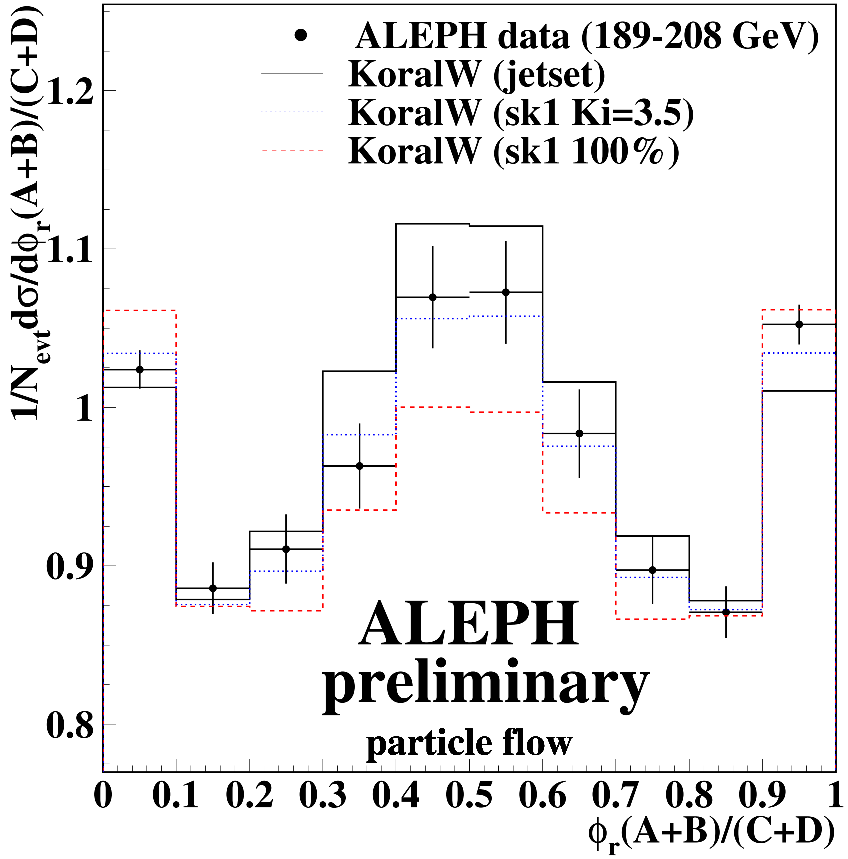




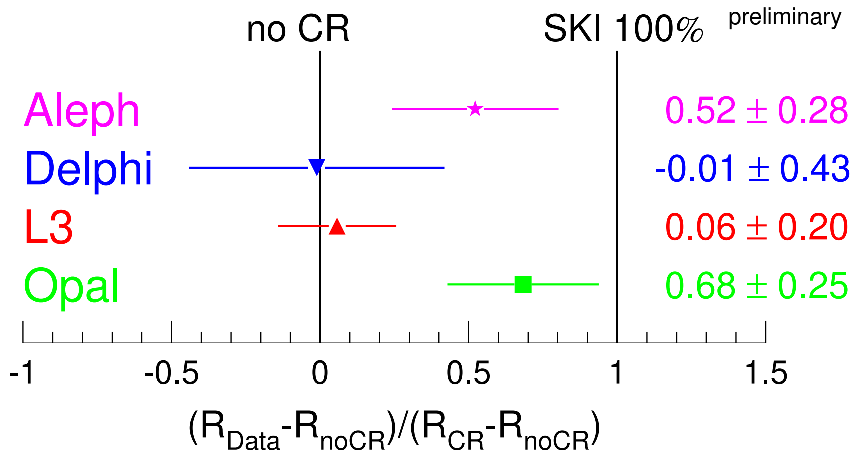
- Project onto jet 1-jet 2 plane

- Rescale interjet angles
- Account for aplanarity

Ratio of Interjet Particle Flows



$$R_N = \frac{\int_{0.2}^{0.8} \frac{1}{N}\cdot\frac{dn}{d\Phi_r}(\mathrm{intra})\,d\Phi'_r}{\int_{0.2}^{0.8} \frac{1}{N}\cdot\frac{dn}{d\Phi_r}(\mathrm{inter})\,d\Phi'_r}$$



⇒ Extreme SK I 100% disfavored

CR possible up to 80%

No clear conclusion, yet.

Need all data & LEP combination.

LEP Combination Plans

Combine R_N measurements, but . . .

Different analysis strategies:

- AO: Standard W mass selection
- DL: Angular selection

$\Rightarrow$ Normalization to MC necessary

Large COMMON MC samples are in production!

$\Rightarrow$ More to follow soon ...

Hadronization

- Assessment of uncertainty:
  - ADLO: Comp. of JETSET, ARIADNE, HERWIG

- Problems:
  - Largest systematic for $qql\nu$
  - Common for $qql\nu$ and $qqqq$
  - ADLO estimates for ΔM_W differ: $15 \ldots 30\,\mathrm{MeV}$

  $\Rightarrow$ Correlations between channels? Experiments?
  - What consequences have diff. MC tunings?

Summary & Outlook

- LEP combined:

$$M_W = (80.450 \pm 0.039)\,\mathrm{GeV}$$

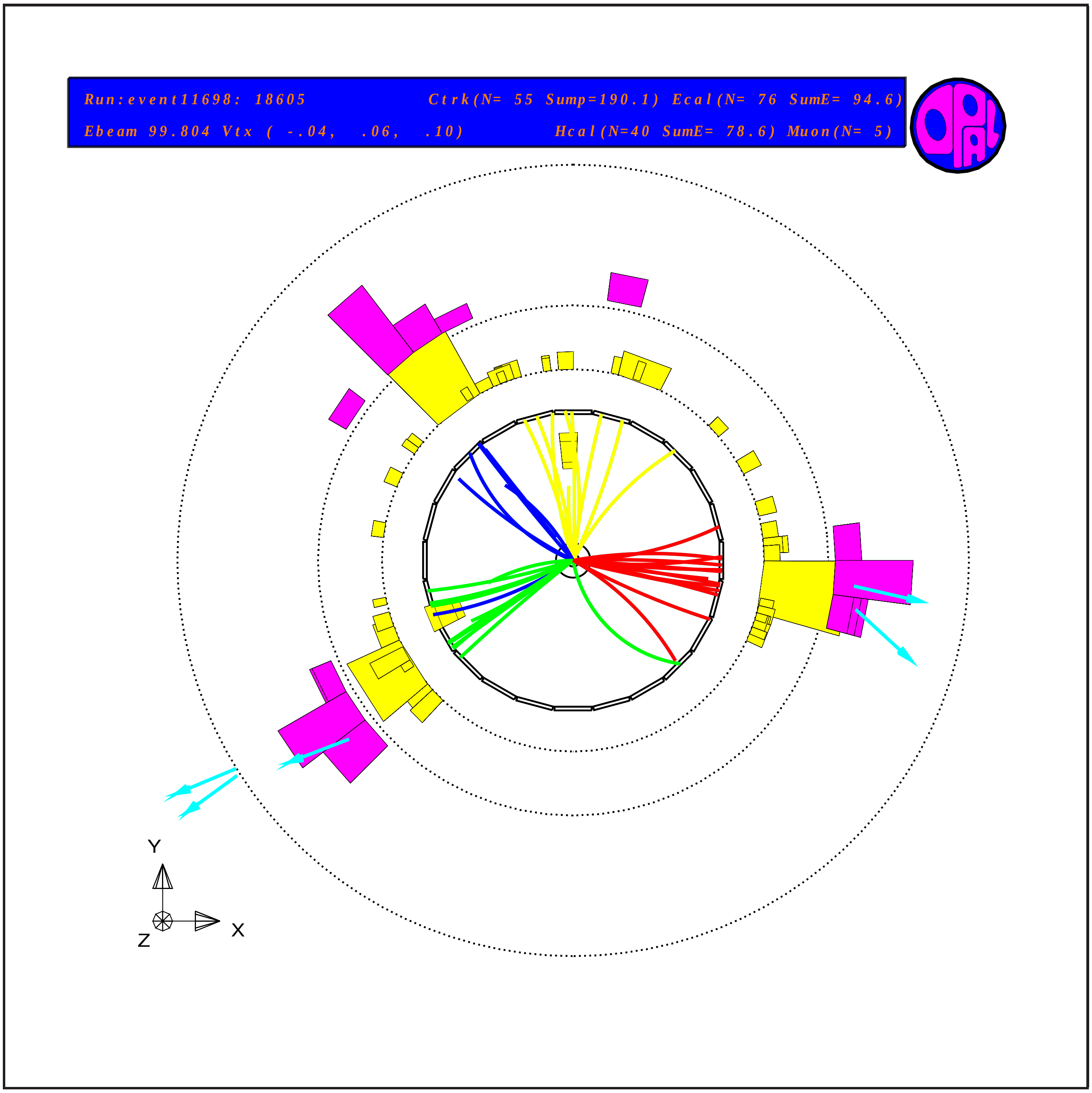
- Hadronization:
  - Some problems solved
  - $\Rightarrow$ Improved understanding and consistency for ADLO
  - Still more checks to do with new files!

- Colour Reconnection:
  - LEP wide combination of particle flows in progress

- Not mentioned:
  - DO: (U)MLBZ - Boosted Z's to mimick WW events
  - Desensitization of M_W measurement:
    - Other jet algorithms (Cone)
    - Exclude/deweight low momentum particles

    Under study!
  - Bose-Einstein Correlations? $\Rightarrow$ next talk

OPAL 4-Jet Event



Comparison to other Measurements