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WW CROSS SECTIONS AND W BRANCHING RATIOS

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On behalf the LEP collaborations

OUTLINE

* W Pair production at LEP
* W selections
* WW cross sections
* W Branching ratios
* Measurements of $|V_{cs}|$
* Conclusions

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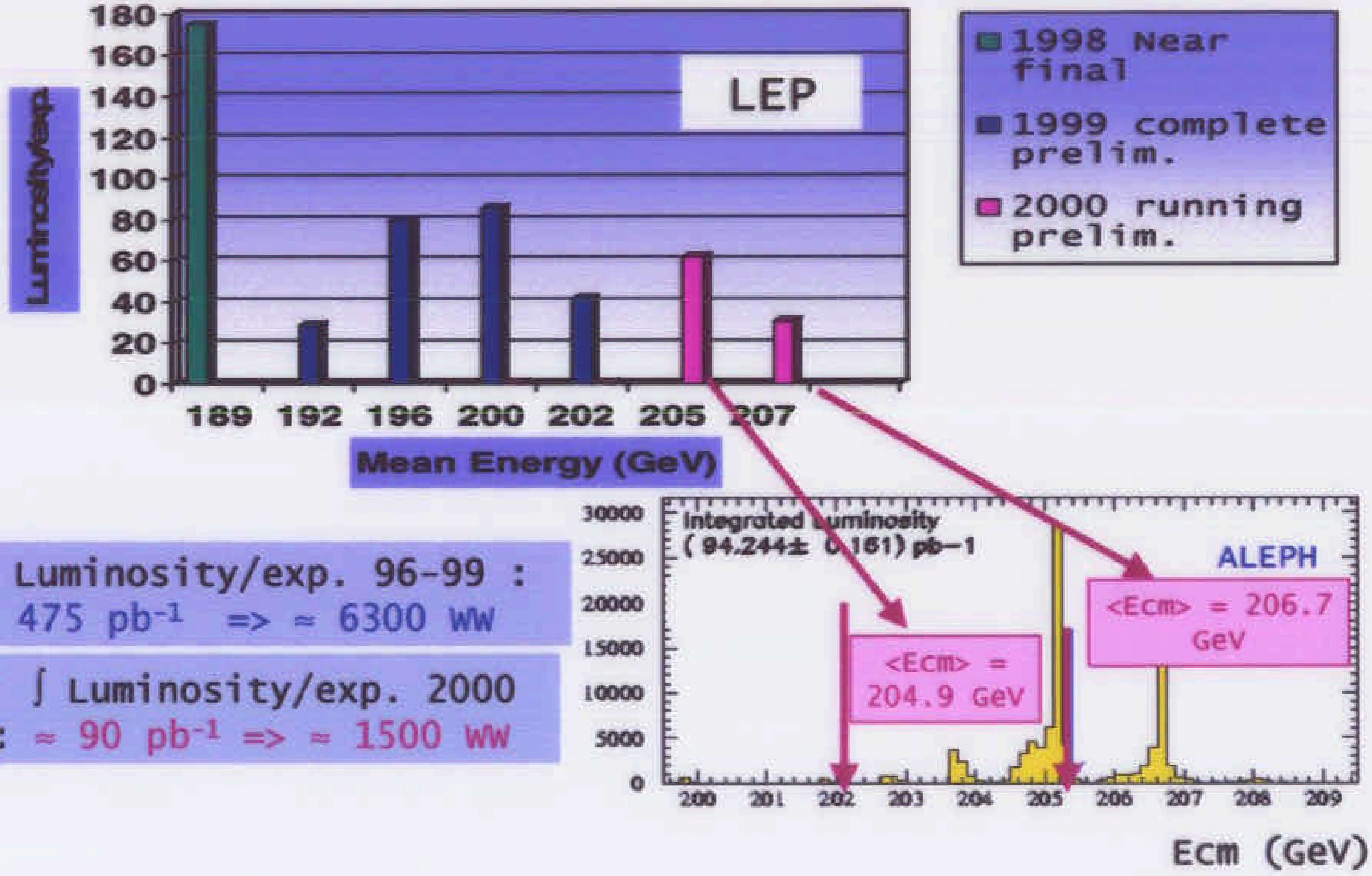
LEP DATA collected / experiment



∫ Luminosity/exp. 96-99 : 475 pb^{-1} => ≈ 6300 WW

∫ Luminosity/exp. 2000 : ≈ 90 pb^{-1} => ≈ 1500 WW

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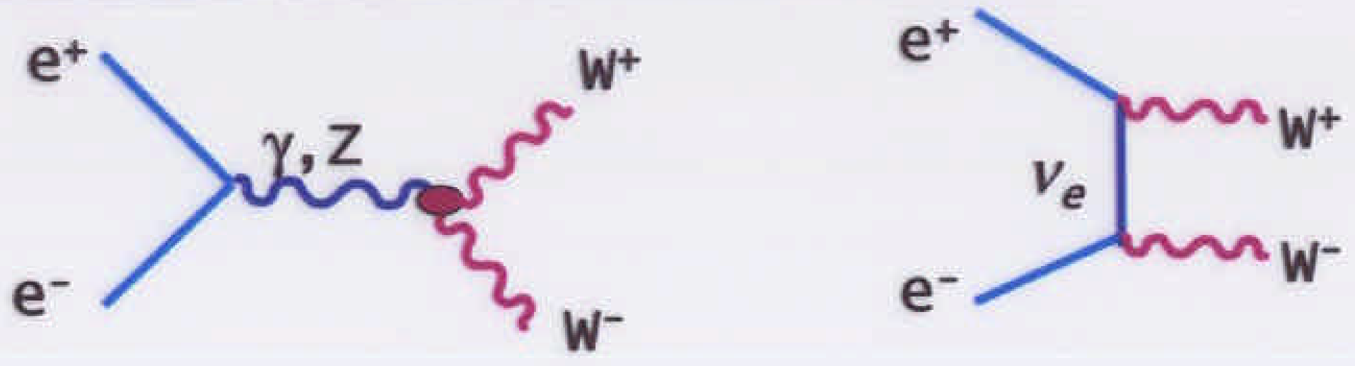
WW PRODUCTION AT LEP

- WW are pair created mainly through 3 diagrams at Born level (CC03):



- Measurements of CC03 cross sections, are corrected for 4-fermion diagram interference.

- WW belongs to the more general CC 4-fermion final states:

WW -> ffff → qqqq(46%), qqlν(44%), lνlν(11%) with l= e,μ,τ

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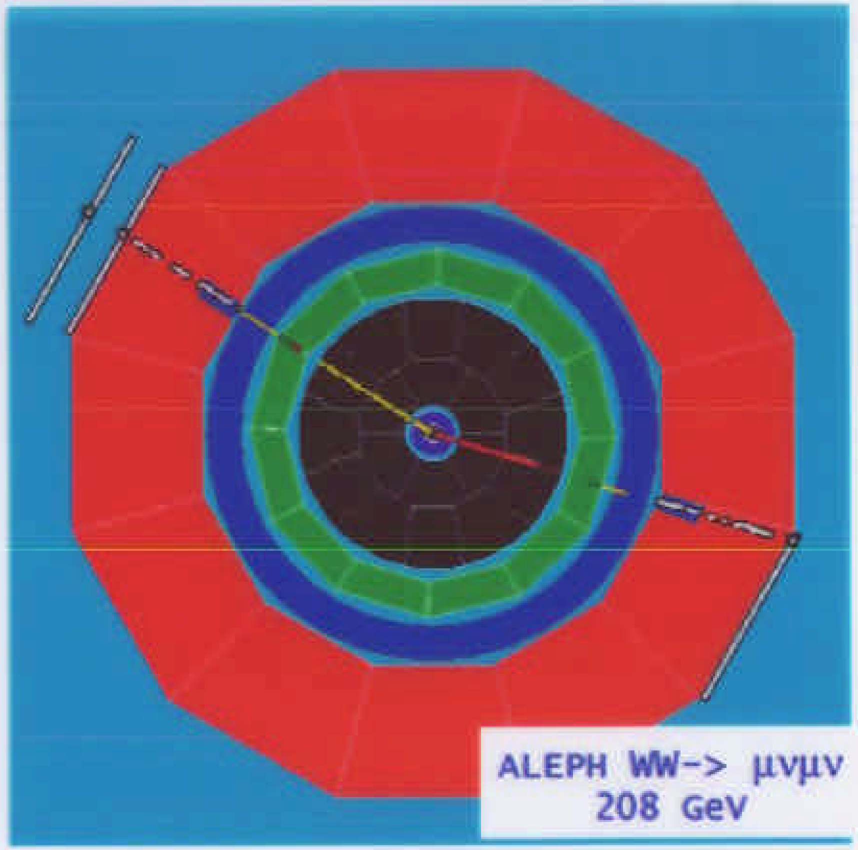
WW SELECTIONS

WW -> lνlν l=e,μ,τ
(11%)

OPAL WW-> eνeν
208.7 GeV



ALEPH WW-> μνμν
208 GeV

- Characteristics
- 2 acoplanar leptons
- missing energy

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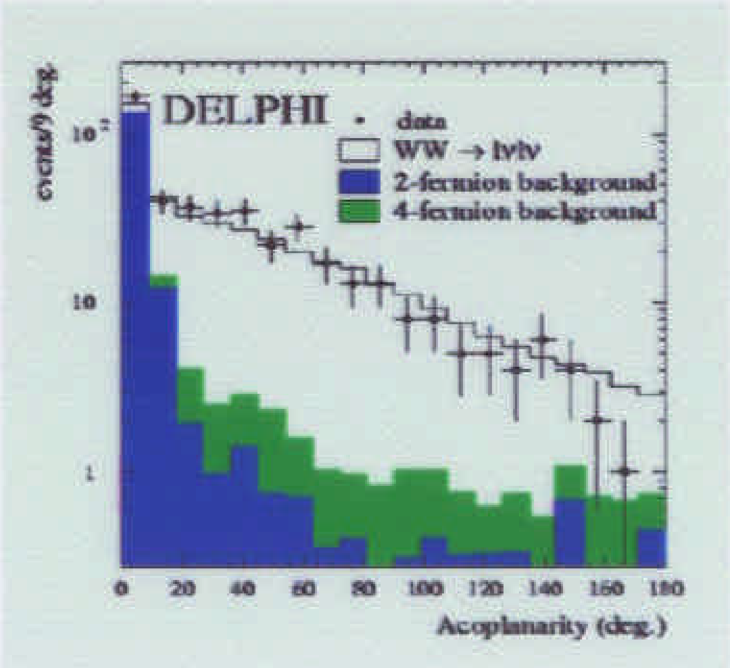
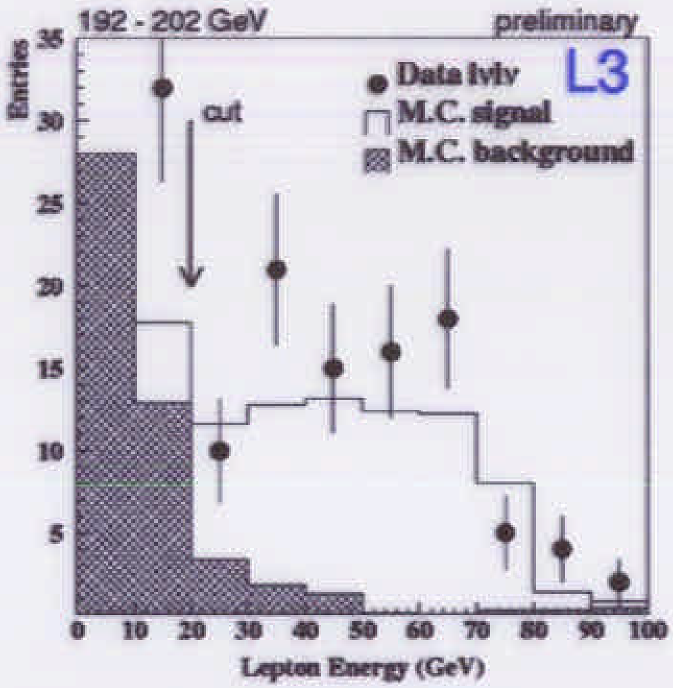
WW SELECTIONS

WW -> lνlν l=e,μ,τ

- Selections

Cut based analyses:
Acoplanarity, lepton momentum, missing energy





Typical efficiencies 60-80 %
background level 150 fb
WW cross section level 2 pb

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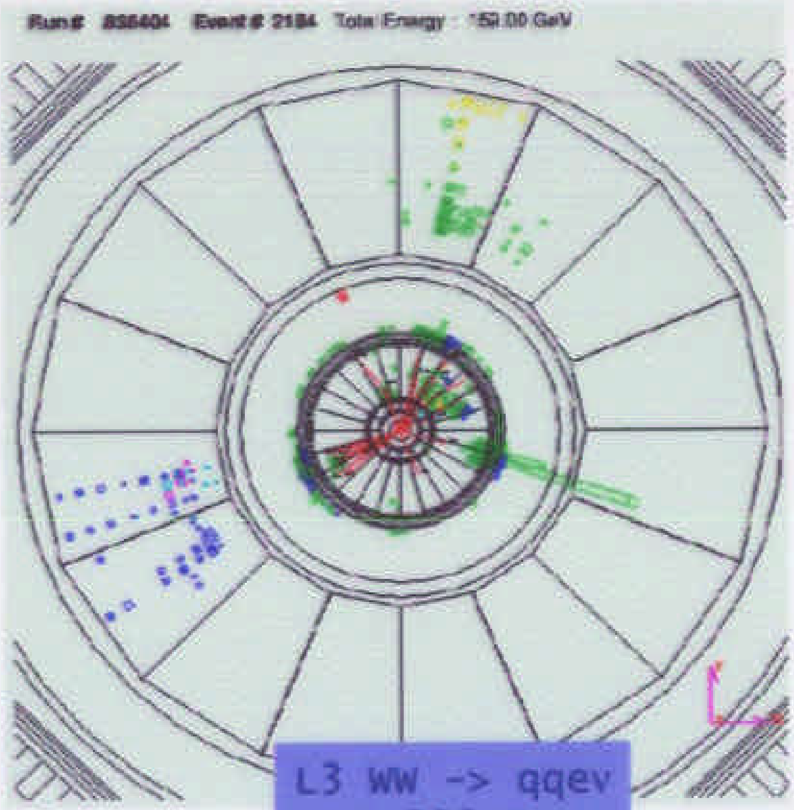
WW SELECTIONS

WW -> qqlν l=e,μ,τ (44%)

- **Characteristics**
- 2 hadronic jets
- missing energy
- isolated lepton or low multiplicity jet for τ

ALEPH WW -> qqτν at 205 GeV



L3 WW -> qqeν at 206 GeV

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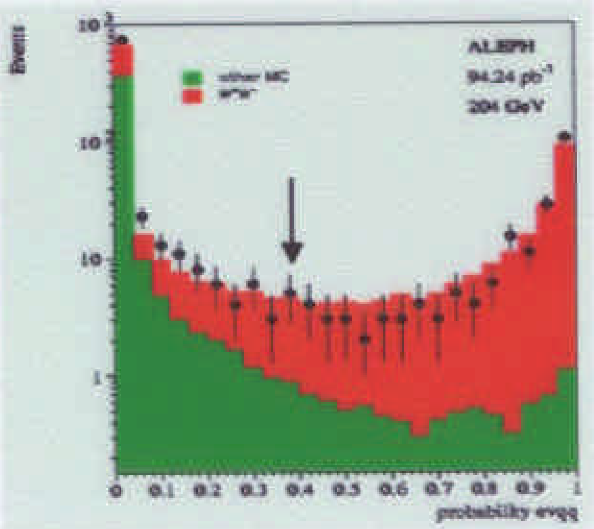
WW SELECTIONS

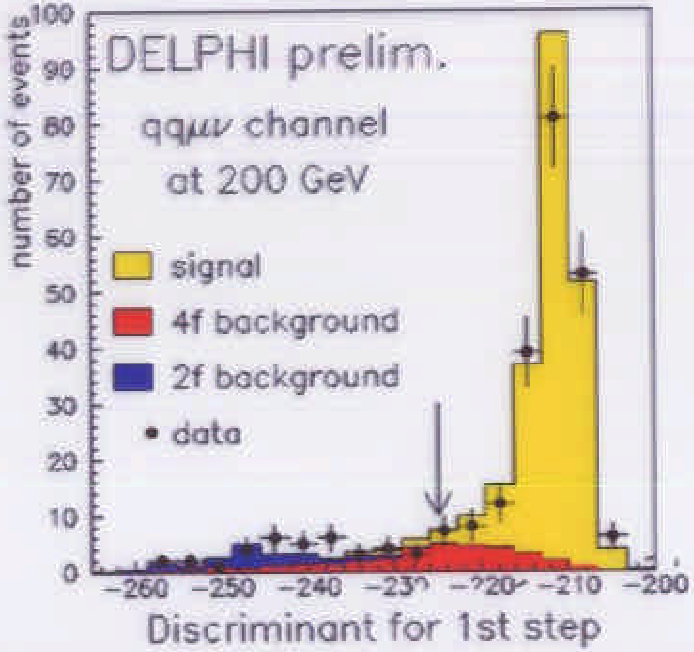
WW -> qqlν l=e,μ,τ

- Selections

Cut based analyses and/or probabilities/likelihood

- based on E_{lepton}, isolation criteria
- τ jet identification





Typical efficiencies e/μ 85 %
τ 60 %
background level e/μ 100 fb
τ 200 fb
WW cross sections level 3 pb each channel

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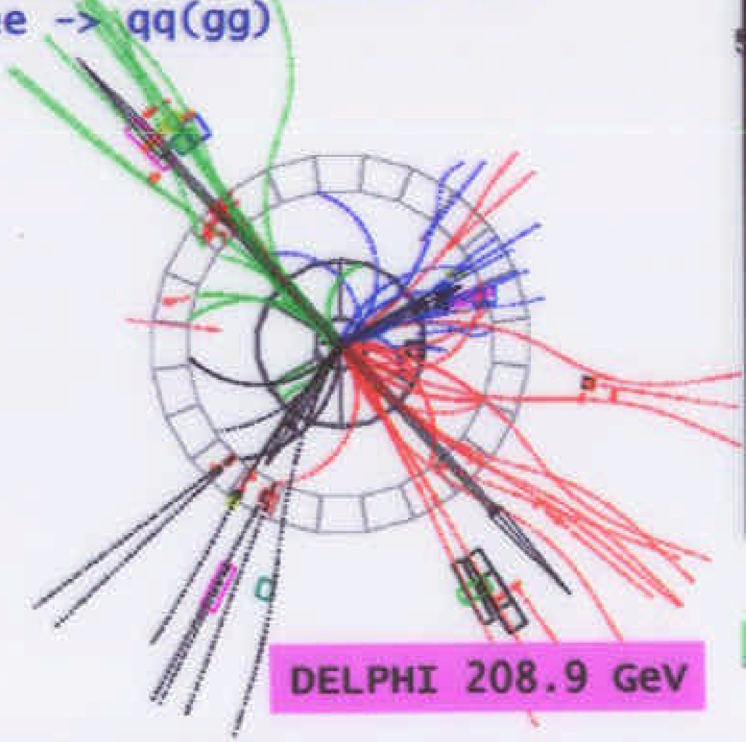
WW SELECTIONS

WW -> qqqq (46%)

•Characteristics
•4 hadronic jets
•No missing energy
•Huge QCD back.(100 pb)
ee -> qq(gg)



DELPHI 208.9 GeV

OPAL 208.4 GeV

WW SELECTIONS

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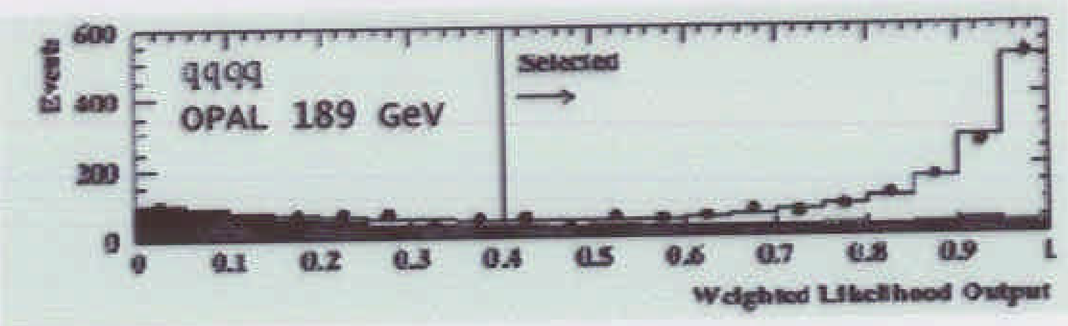
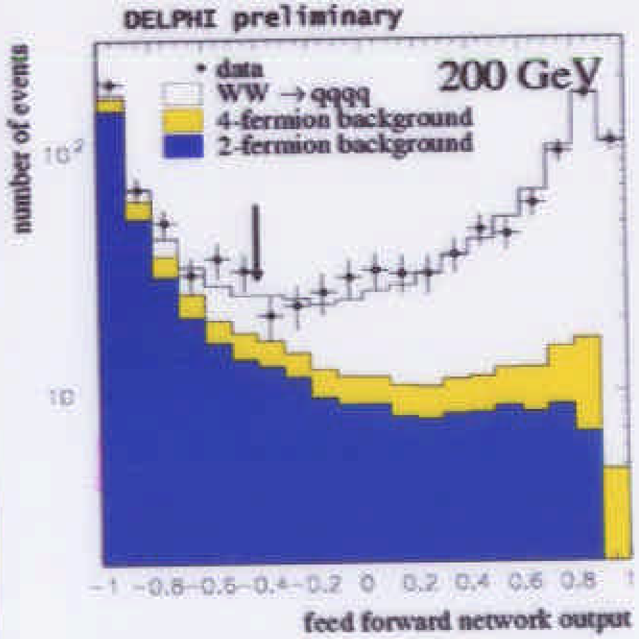
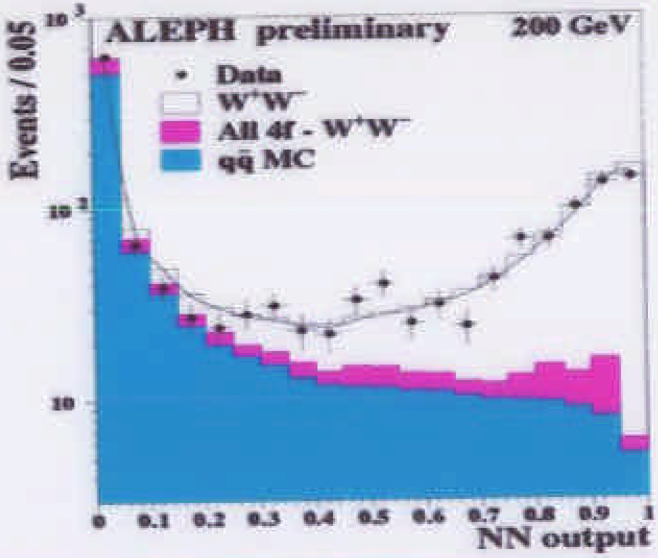
WW -> qqqq

- **Selections**
  Neural Networks,
  Likelihood analyses







Typical efficiencies 90 %
background level 2 pb
WW cross section level 8 pb

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WW CROSS - SECTIONS

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WW CROSS SECTIONS

Extraction of the cc03 cross sections/channel:

Maximum likelihood fit between the number of observed events and the number of expected events

$$L=\prod_i P(N_i^{obs},N_i^{exp}) \quad \text{with} \quad N_i^{exp}=l*\sum_j \varepsilon_{ij}\sigma_j+N_i^{bkg}$$

Luminosity (l) — Efficiency matrix (ε_{ij}) — Background +cc03-4f corr (N_i^{bkg})

Extraction of the total cross section and branching ratio

$$\sigma_j=b_j*\sigma_{WW}$$

$$b_j=\begin{cases} Br(W\rightarrow q\bar{q})^2 & j=q\bar{q}q\bar{q} \\ 2\cdot Br(W\rightarrow q\bar{q})\cdot Br(W\rightarrow l\nu) & j=q\bar{q}l\nu \\ Br(W\rightarrow l\nu)^2 & j=l\nu l\nu \\ 2\cdot Br(W\rightarrow l\nu)Br(W\rightarrow l\nu') & j=l\nu l\nu' \end{cases}$$

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WW CROSS SECTIONS

Exp /E (GeV)	σ_{WW} (pb) 189	192	196	200	202	205	207
A	15.71 ±0.38	17.23 ±0.91	17.00 ±0.57	16.98 ±0.56	16.16 ±0.76	16.70 ±0.64	17.01 ±0.88
D	15.83 ±0.43	16.90 ±1.02	17.86 ±0.63	17.35 ±0.60	17.67 ±0.84	18.81 ±0.80	16.50 ±1.05
L	16.20 ±0.46	16.39 ±0.93	16.67 ±0.60	16.94 ±0.62	16.95 ±0.88	17.70 ±0.86	17.20 ±1.03
O	16.30 ±0.38	16.60 ±0.98	18.59 ±0.74	16.32 ±0.66	18.48 ±0.91	15.84 ±0.71	15.96 ±0.96
LEP	16.00 ±0.21	16.79 ±0.48	17.39 ±0.31	16.93 ±0.30	17.20 ±0.42	17.11 ±0.37	16.68 ±0.49

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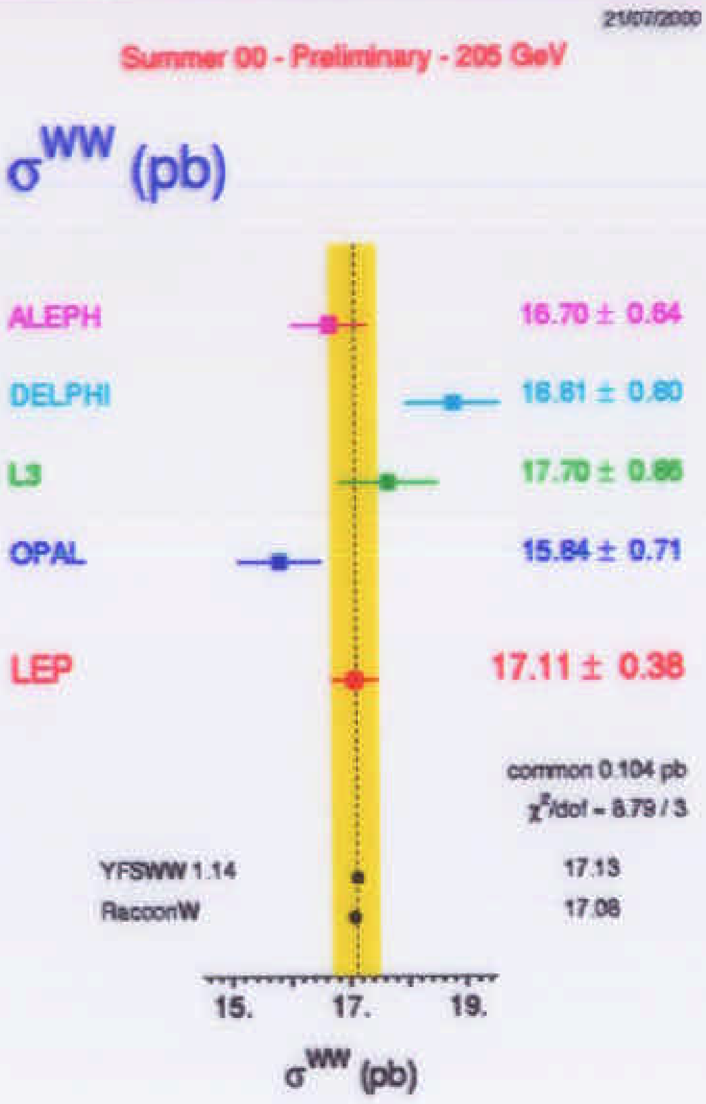
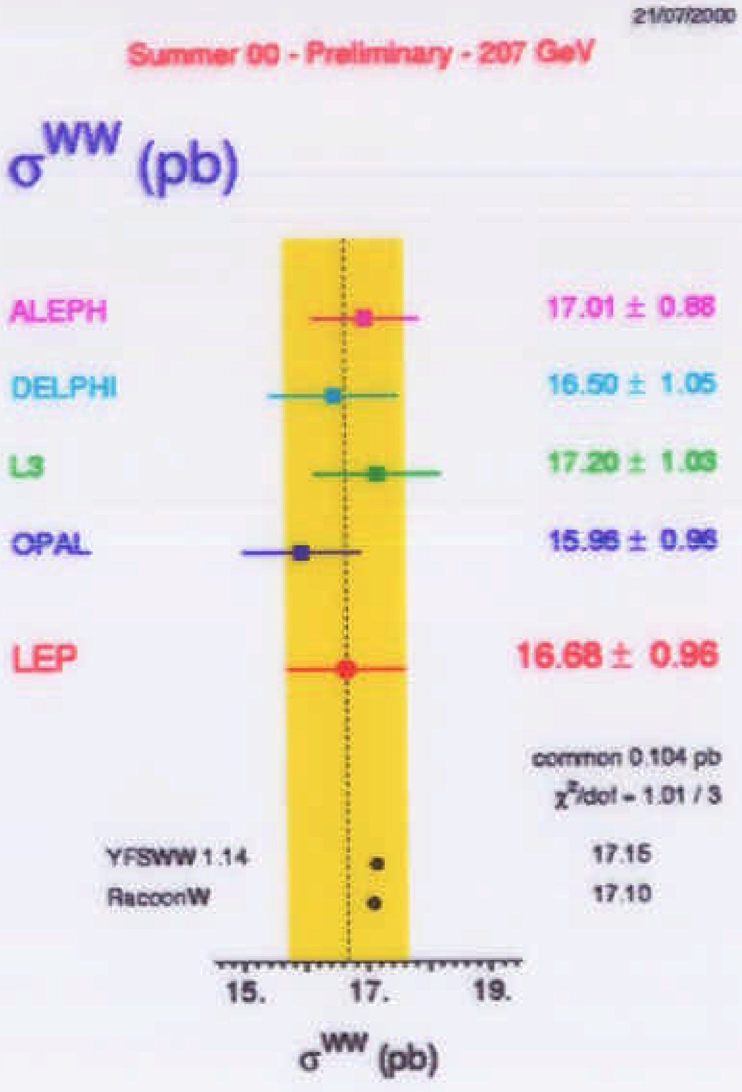
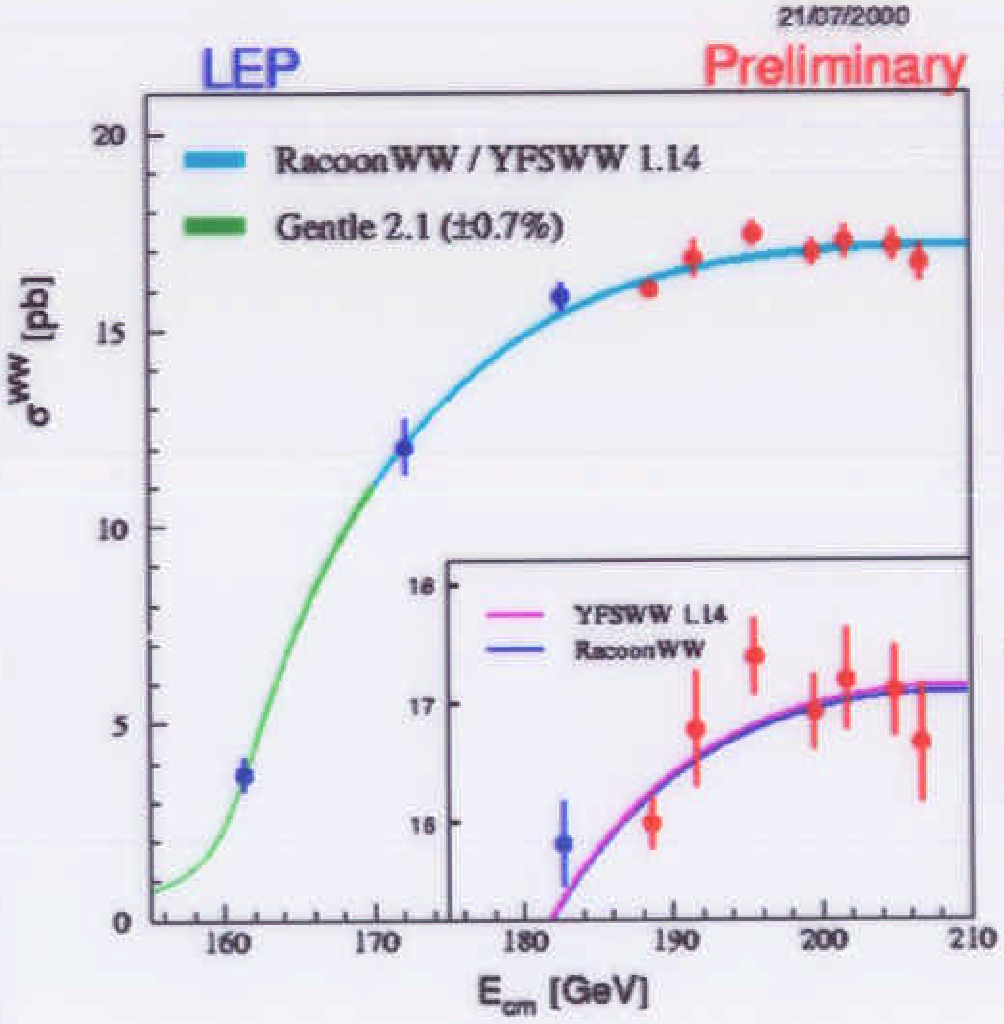
WW CROSS SECTIONS





WW CROSS SECTIONS



Theoretical improvements:

- New models with DPA calculation (RacoonWW and YFSWW)
  Error =f(Ecm,Mw) 0.4%-0.7%
- New Gentle 2.1
  Error 2% -> 0.7%
  (only due to ISR)

Better agreement with experimental values

Ref: RacoonWW: hep-ph/0006307
YFSWW 1.14: UTHEP 00-0101
for details see hep-ph/0005309
and ref in

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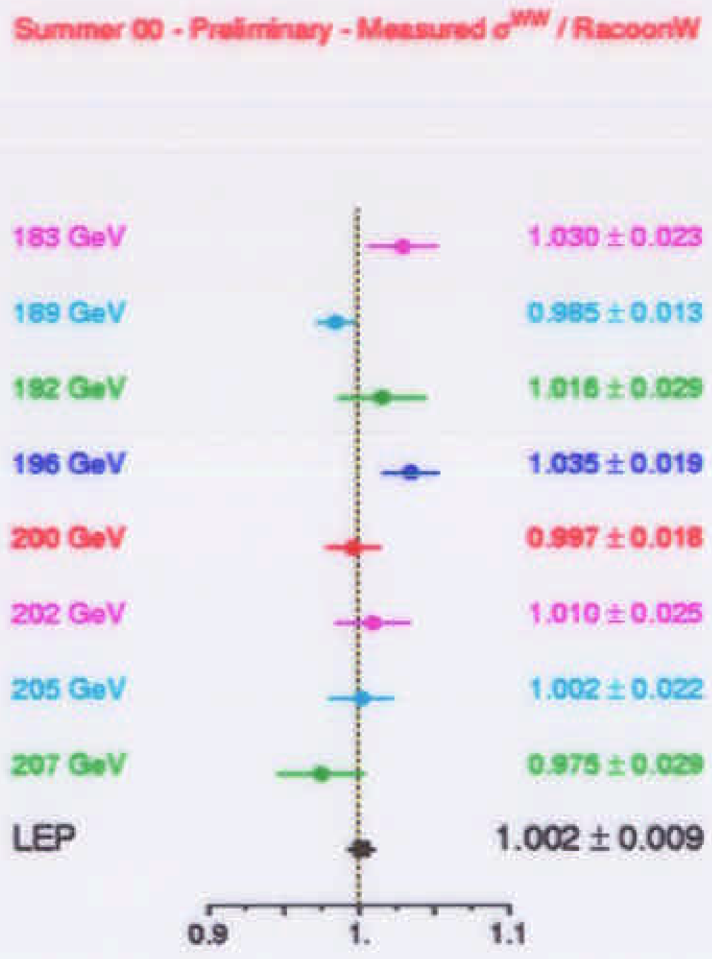
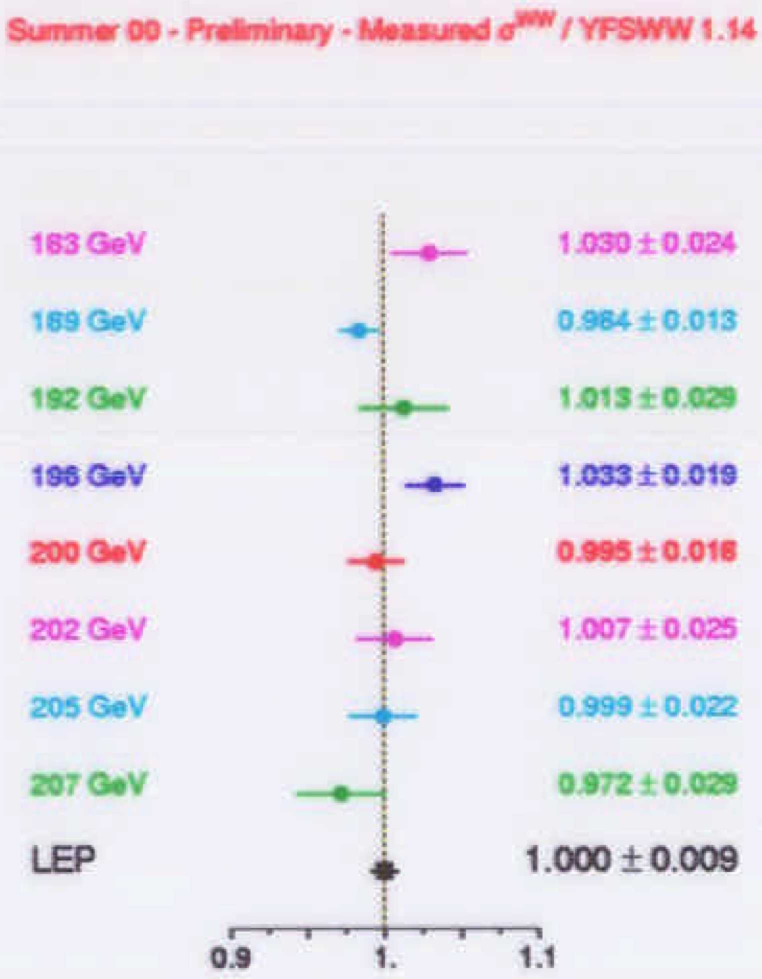
WW CROSS SECTIONS





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Branching fractions

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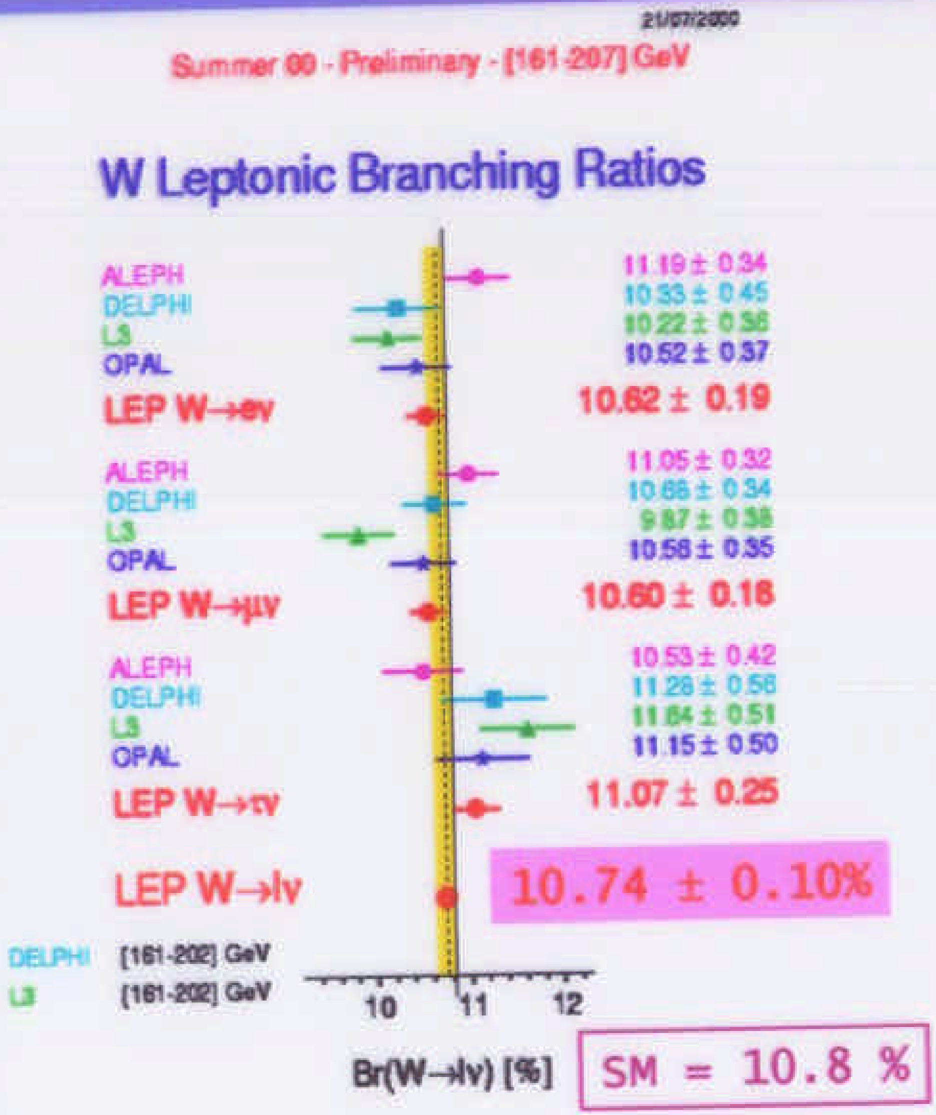
WW Branching Fractions



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$|V_{cs}|$ Measurement

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$|V_{cs}|$ MEASUREMENT

Indirect Measurement from Br(W -> qq)

$$\frac{Br(W \to q\bar{q})}{1-Br(W \to q\bar{q})} = \left(1+\frac{\alpha_s}{\pi}\right) \sum_{i=u,c;j=d,s,b} |V_{ij}|$$

Using
- The LEP Br(W -> qq)
- world average of V_{qq}
- $\alpha_s(M_w^2) = 0.121 \pm 0.002$

$|V_{cs}| = 0.989 \pm 0.016$

(without assuming unitarity)

Direct measurement from charm content in W decays

$$R_c = \frac{\Gamma(W \to cX)}{\Gamma(W \to qq)} = \frac{|V_{cd}|^2 + |V_{cs}|^2 + |V_{cb}|^2}{\sum_{i=u,c;j=d,s,b} |V_{ij}|^2}$$