Results from the OPAL Collaboration at $\sqrt{s}$ = 161 GeV

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Analyses performed with integrated luminosity $\simeq\ 10.3$ pb^{-1}

OUTLINE

- 2-fermions
- QCD, jets in $\gamma\gamma$
- $\mathrm{W^+W^-}$ (M_W and TGC)
- 4-fermions
- 4-jet studies
- Searches: $\tilde{\chi}_1^\pm$, $\tilde{\chi}^0$, $\tilde{\ell}^\pm$, $\tilde{\mathrm{t}}$, $\tilde{\mathrm{b}}$, $L^\pm$, L°, ℓ^*, H$^\circ$

2-fermion Production

- Select hadrons $\mathrm{q\bar{q}}(\gamma)$, charged leptons $\ell^+\ell^-(\gamma)$,
  photons $\nu\bar{\nu}(\gamma)$

- Effective CM energy, s', from observed γ and kinematic fit
  (0–2 missing γ)

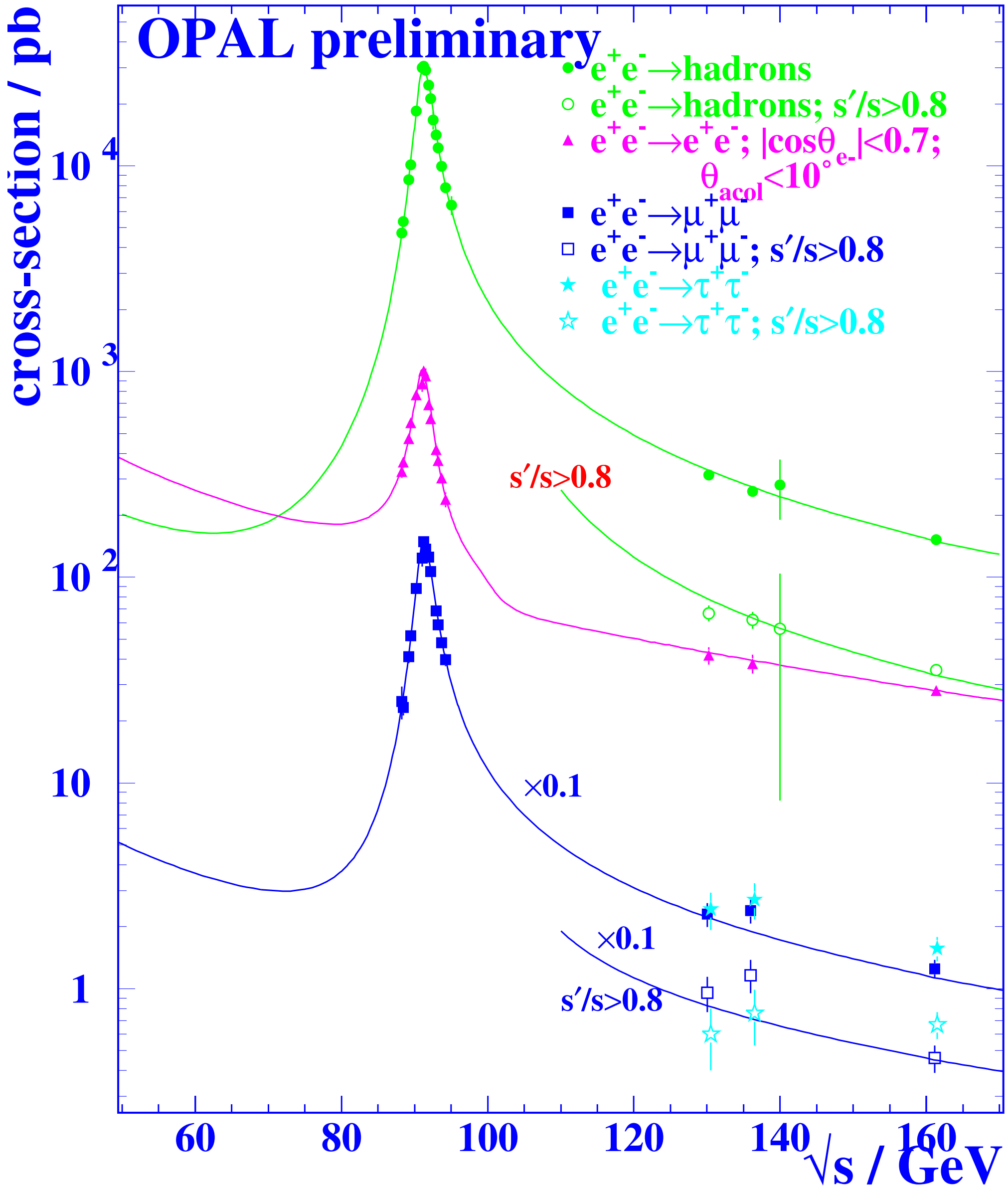
- Measure
  - inclusive σ $(s'/s > 0.01)$
  - non-radiative σ $(s'/s > 0.8)$

2 fermions	σ (pb)	σ^{SM} (pb)
Hadrons $(s'/s > 0.01)$	152±4±2	149
Hadrons $(s'/s > 0.8)$	35.3±2.0±0.7	33.2
$\mathrm{e^+e^-}(\lvert\cos\theta_{e^-}\rvert < 0.7)$	28.1±1.7±0.2	28.1
$\mathrm{e^+e^-}(\lvert\cos\theta\rvert < 0.96)$	435±7±6	424
$\mu^+\mu^-(s'/s > 0.01)$	12.5±1.2±0.5	11.3
$\mu^+\mu^-(s'/s > 0.8)$	4.6±0.7±0.2	4.5
$\tau^+\tau^-(s'/s > 0.01)$	15.7±2.0±0.7	11.3
$\tau^+\tau^-(s'/s > 0.8)$	6.7±1.0±0.3	4.5

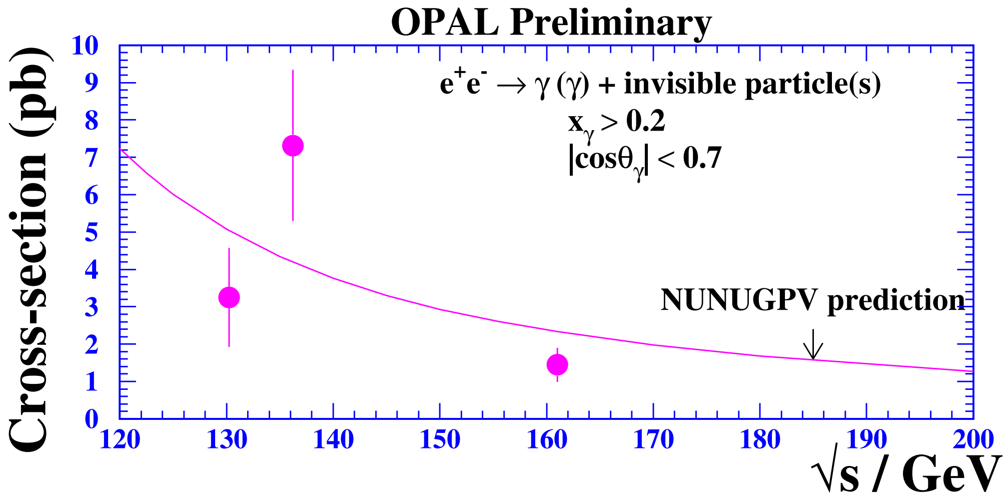
- Electrons $\theta_{\mathrm{acol}} < 10^\circ$

- Data consistent with Standard Model

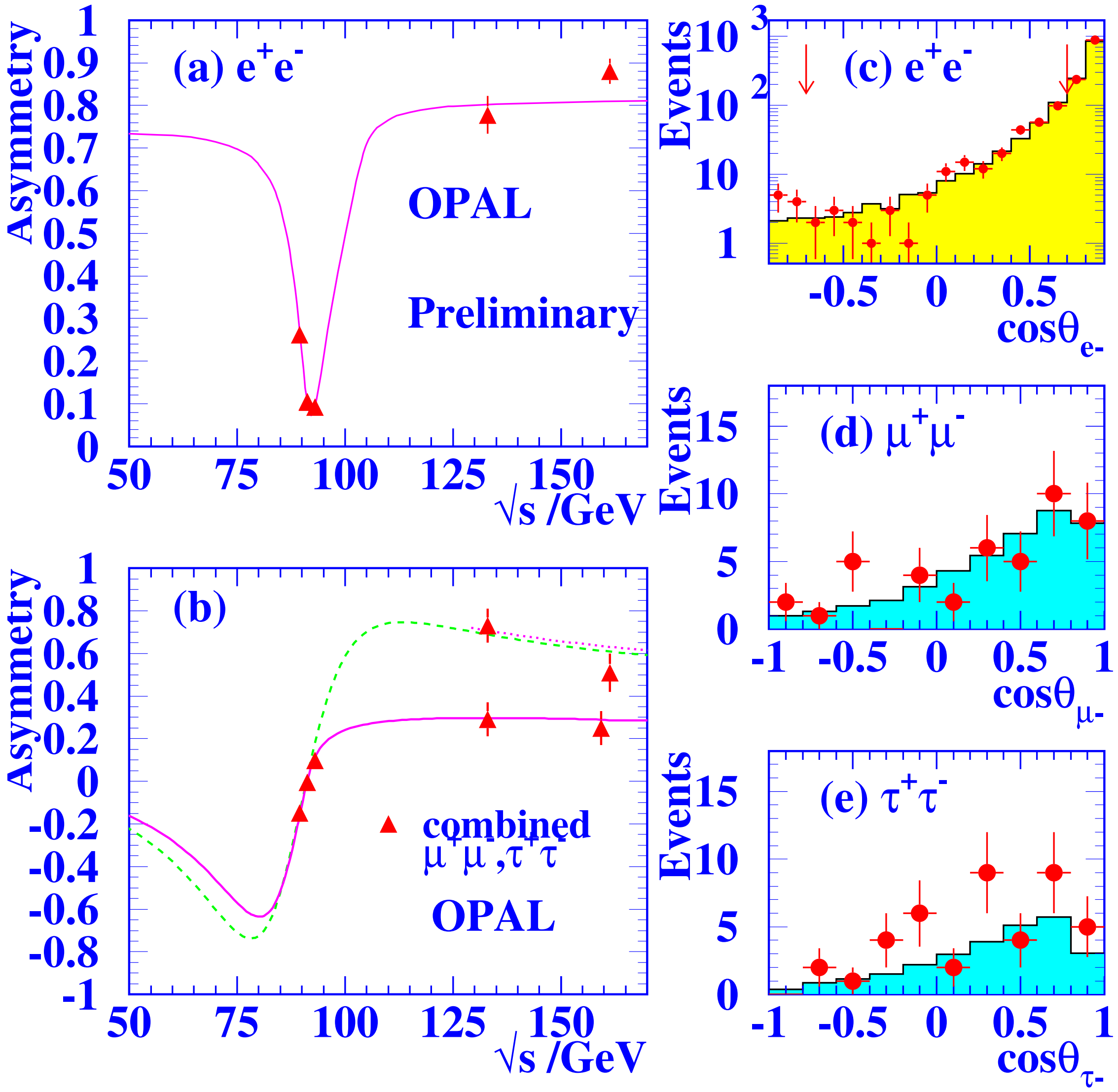
$\sqrt{s}$ Dependence of σ



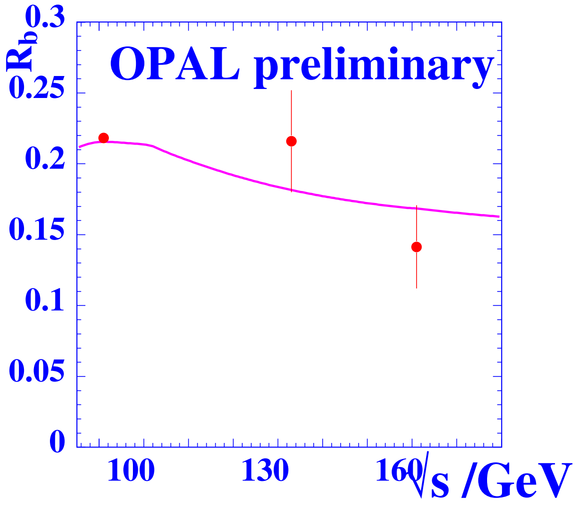
Agree with SM predictions, ZFITTER, ALIBABA



$\sqrt{s}$ Dependence of Asymmetries



$\sqrt{s}$ Dependence of R_b

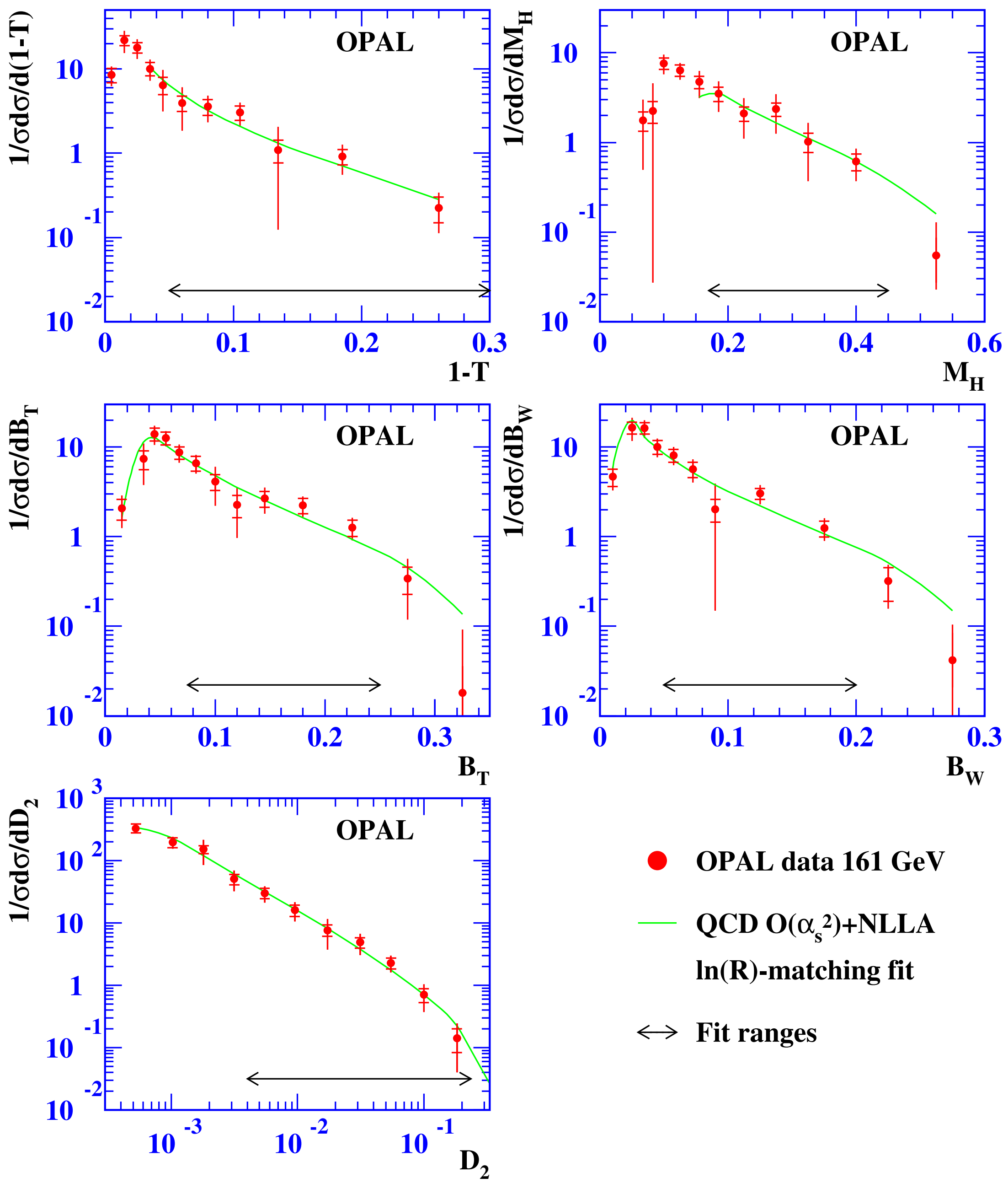


QCD

Select 307 events, $\sqrt{s}-\sqrt{s'} < 10$ GeV, $\sim 6\%$ 4-fermions

Correct to hadron level, $E_{ISR} < 1$ GeV, remove WW

Preliminary

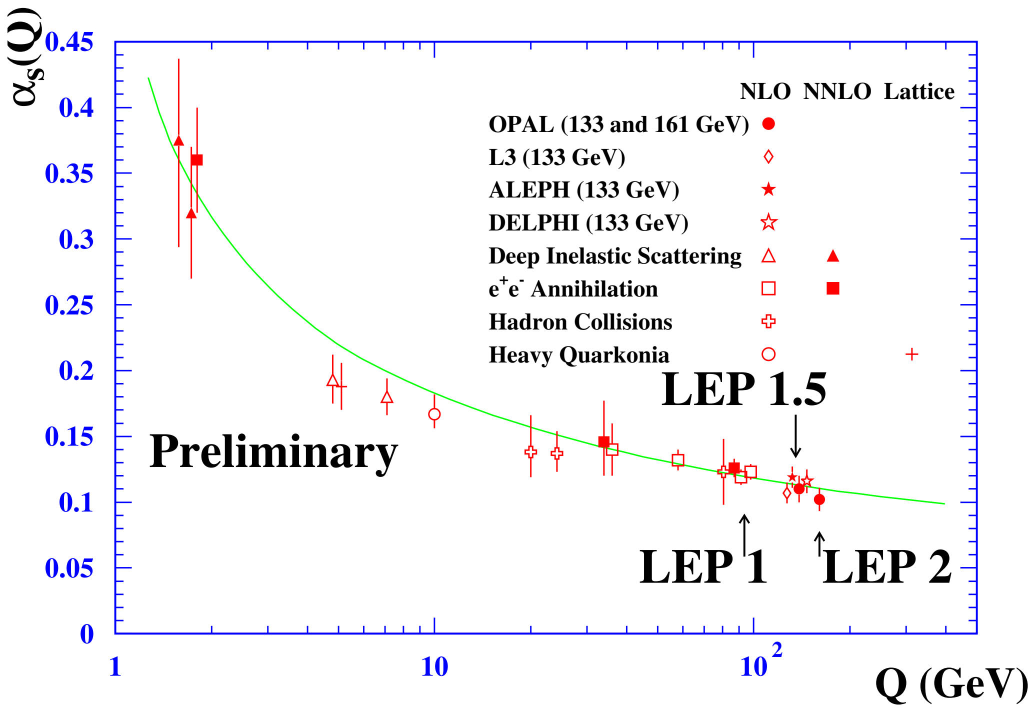


$$\boxed{\alpha_s(161\mathrm{GeV}) = 0.102 \pm 0.005(\mathrm{stat.}) \pm 0.007(\mathrm{syst.})}$$

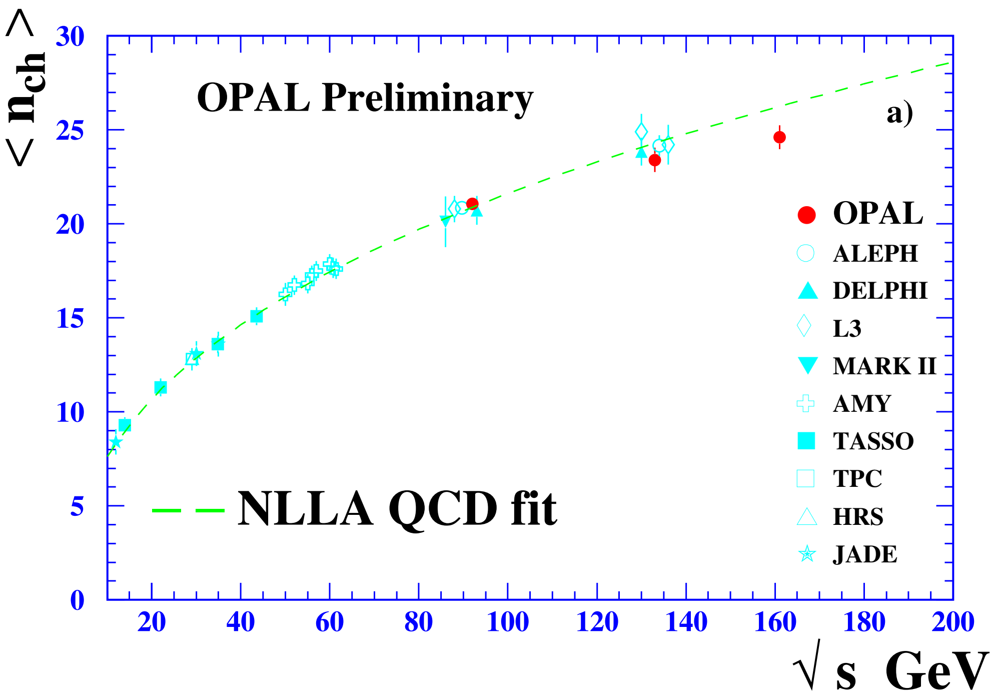
in $\mathcal{O}(\alpha_s^2)$ + NLLA QCD

Energy Evolution

α_s



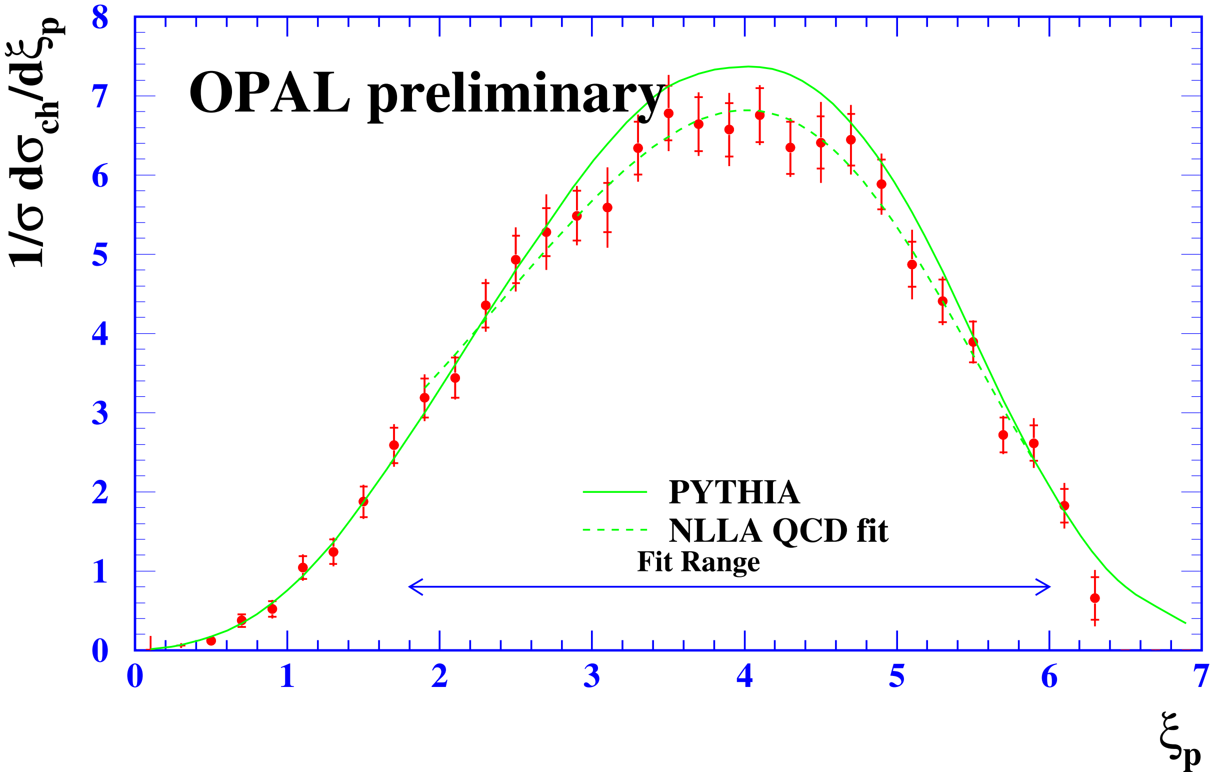
N_{ch}

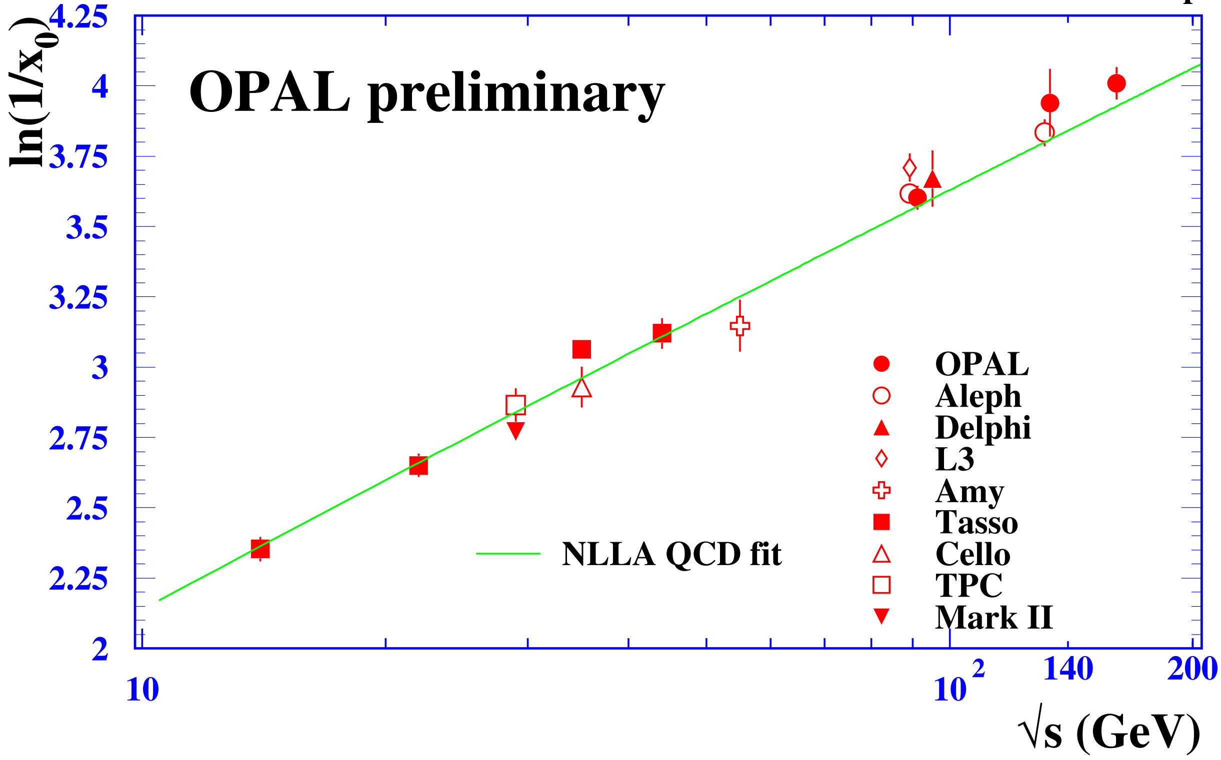


$$< N_{ch} >= 24.6 \pm 0.4(\mathrm{stat.}) \pm 0.5(\mathrm{syst.})$$

$$R_2 = 1.058 \pm 0.008 \pm 0.007$$

Fragmentation Function

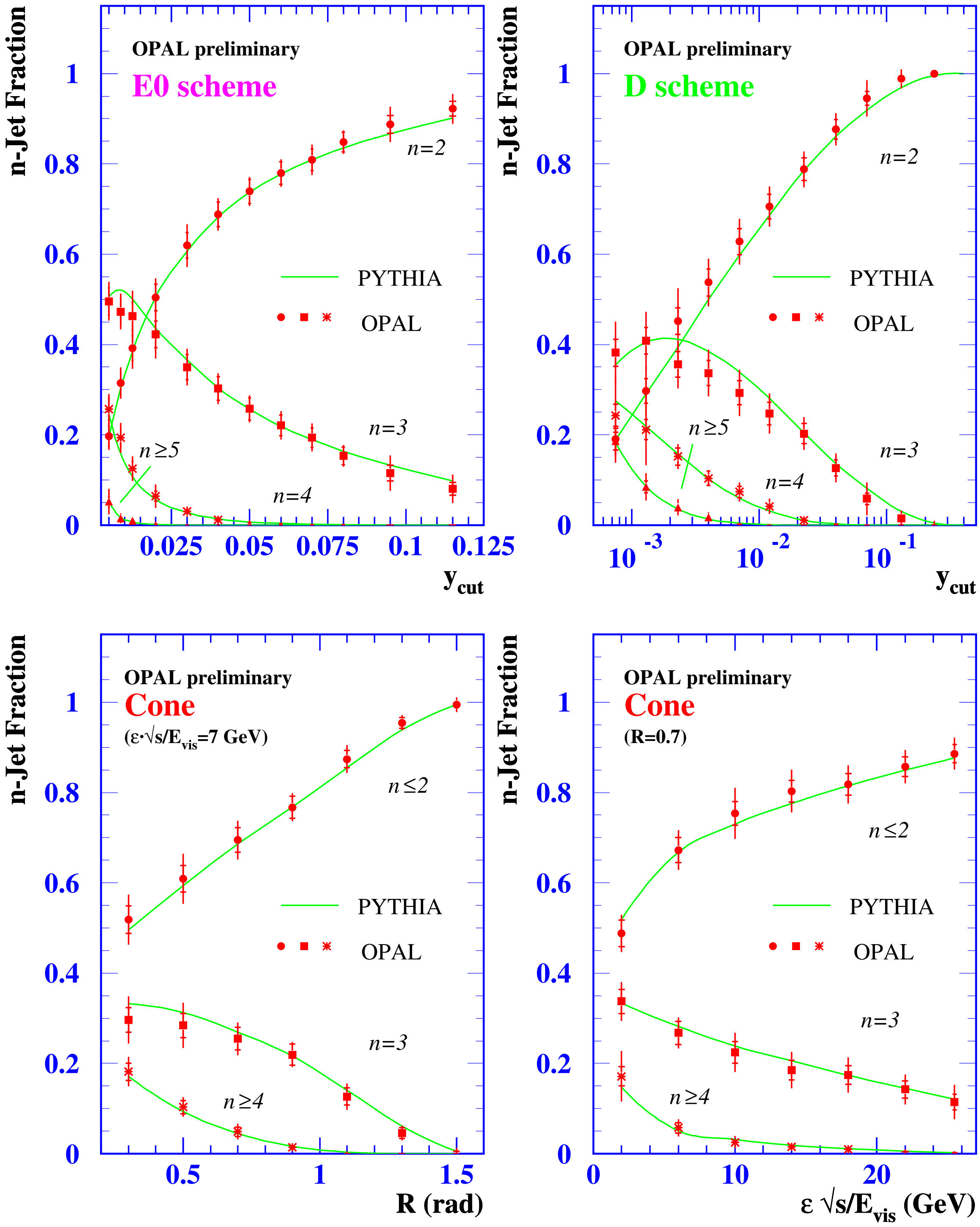




Evolution of peak position predicted by NLLA QCD

$$\xi_0 = 4.01 \pm 0.04(\text{stat.}) \pm 0.04(\text{syst.})$$

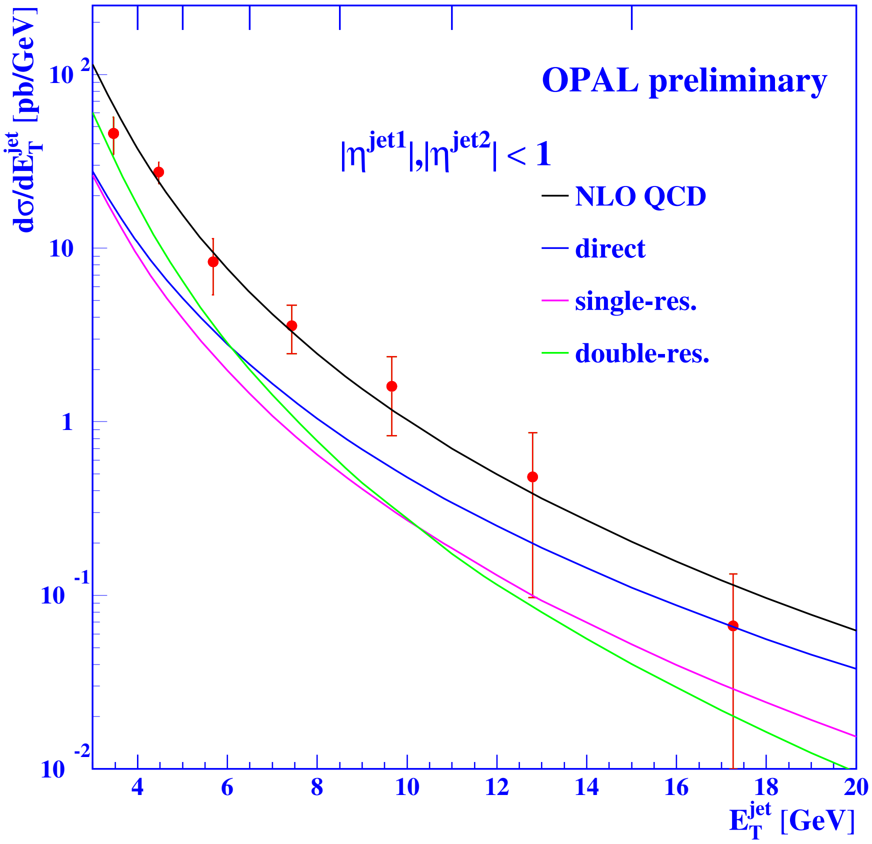
Jet Rates



- Measured for JADE E0, Durham and cone schemes
- All jet fractions described by QCD MC (bins correlated)

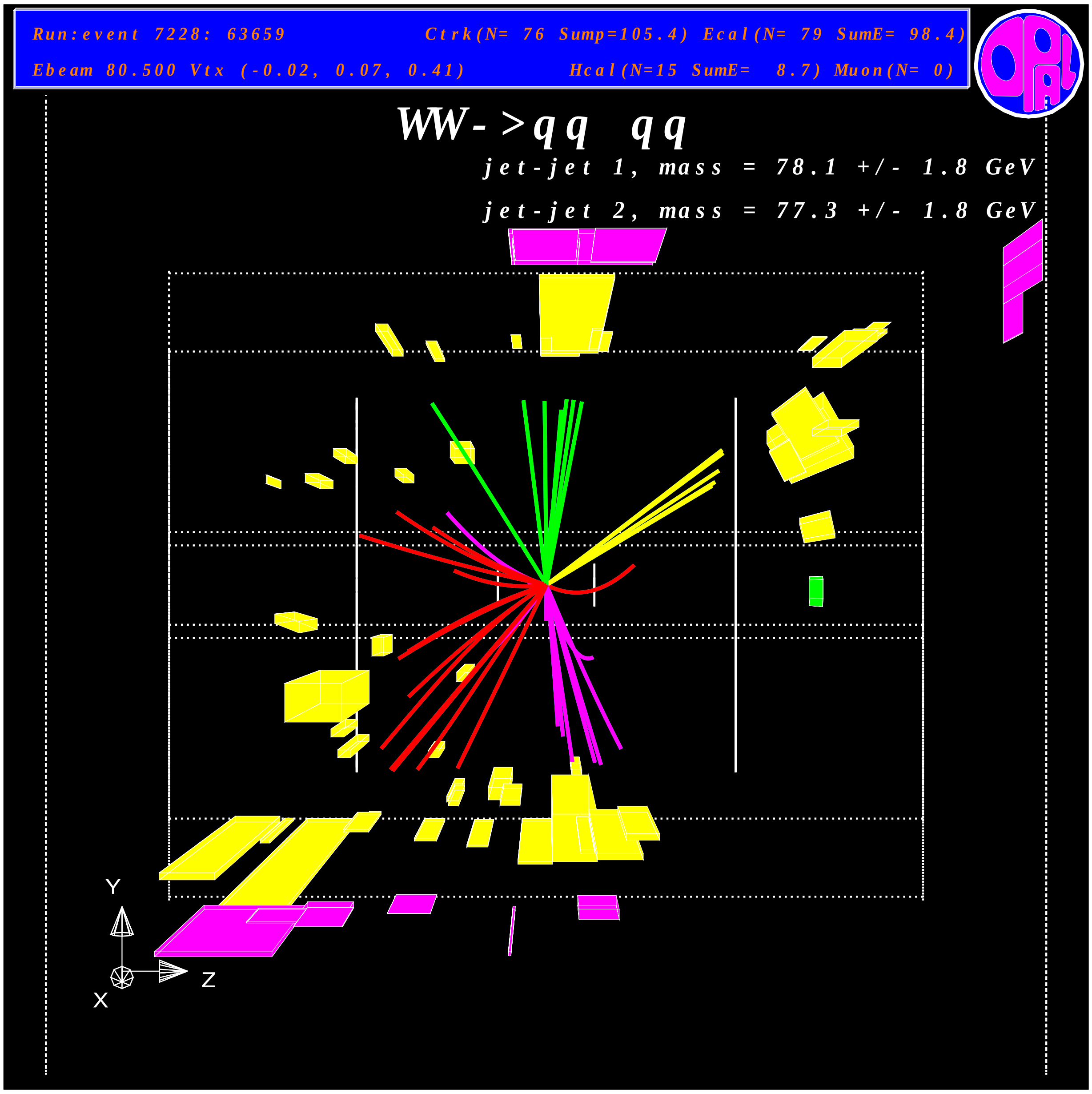
Jets In $\gamma\gamma$ Collisions

- Anti-tagged e$^\pm$, $Q^2 \approx 0$
  $\Longrightarrow$ quasi-real.
- Invariant mass $W > 3$ GeV,
  low visible energy
- Unfold data $\Longrightarrow$ inclusive 1-, 2-jet production



- Extend E_T range to ~ 16 GeV
- Agrees with NLO QCD [Kleinwort+Kramer]
- Prediction $\Rightarrow$ direct process dominates, $E_T \gtrsim 7$ GeV

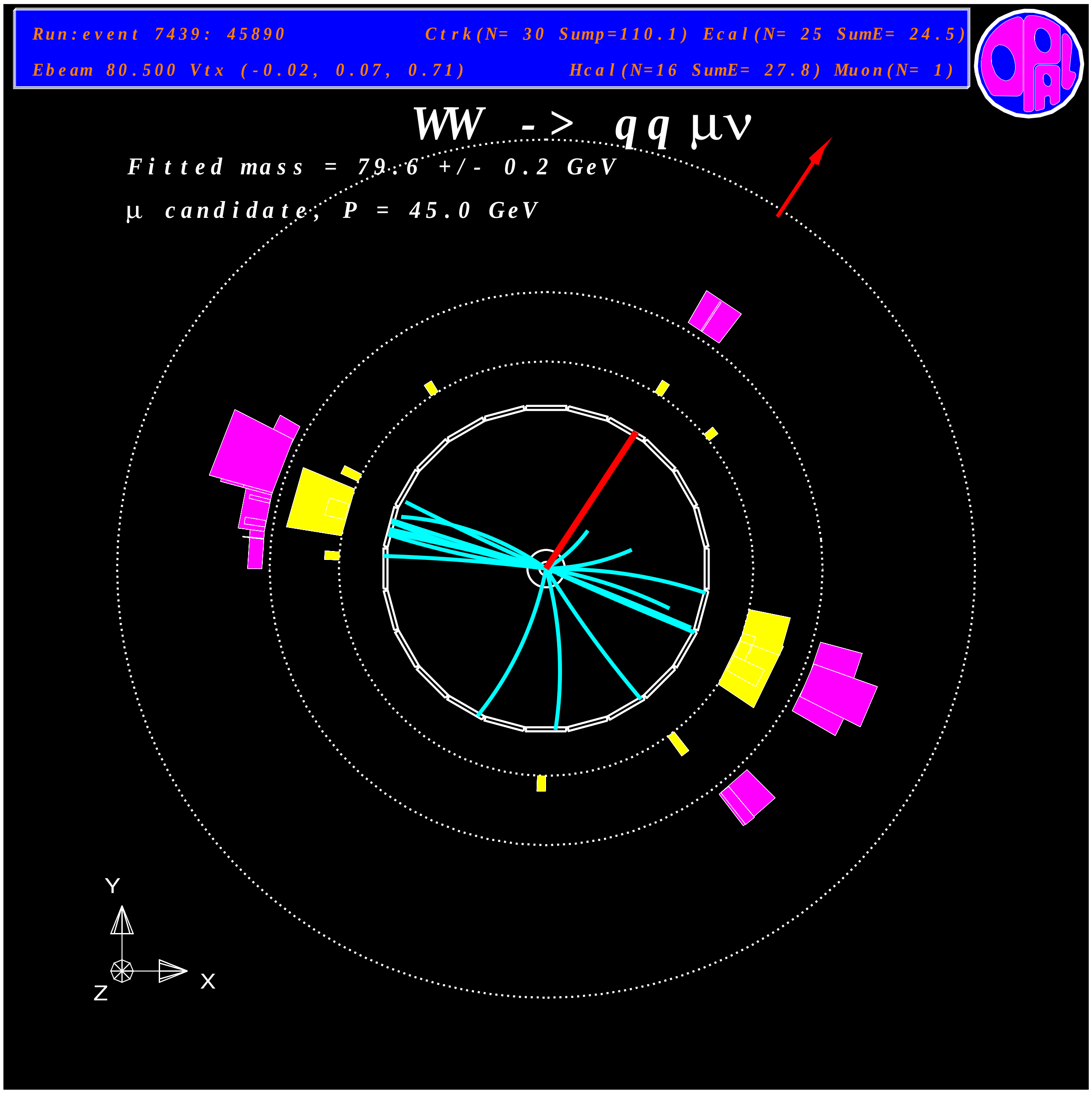
$W^+W^- \to q\bar{q}q\bar{q}$ Event Selection



4 hadronic jets, high multiplicity, large visible energy

- 4-jet like: $y_{34} > 0.01$, no hard ISR γ
- Kinematic fit with $E, \vec{p}$ conservation, $M_{W_1} = M_{W_2}$
  very loose cuts on $P_{\rm fit}(\chi^2)$, $M_{\rm fit}$

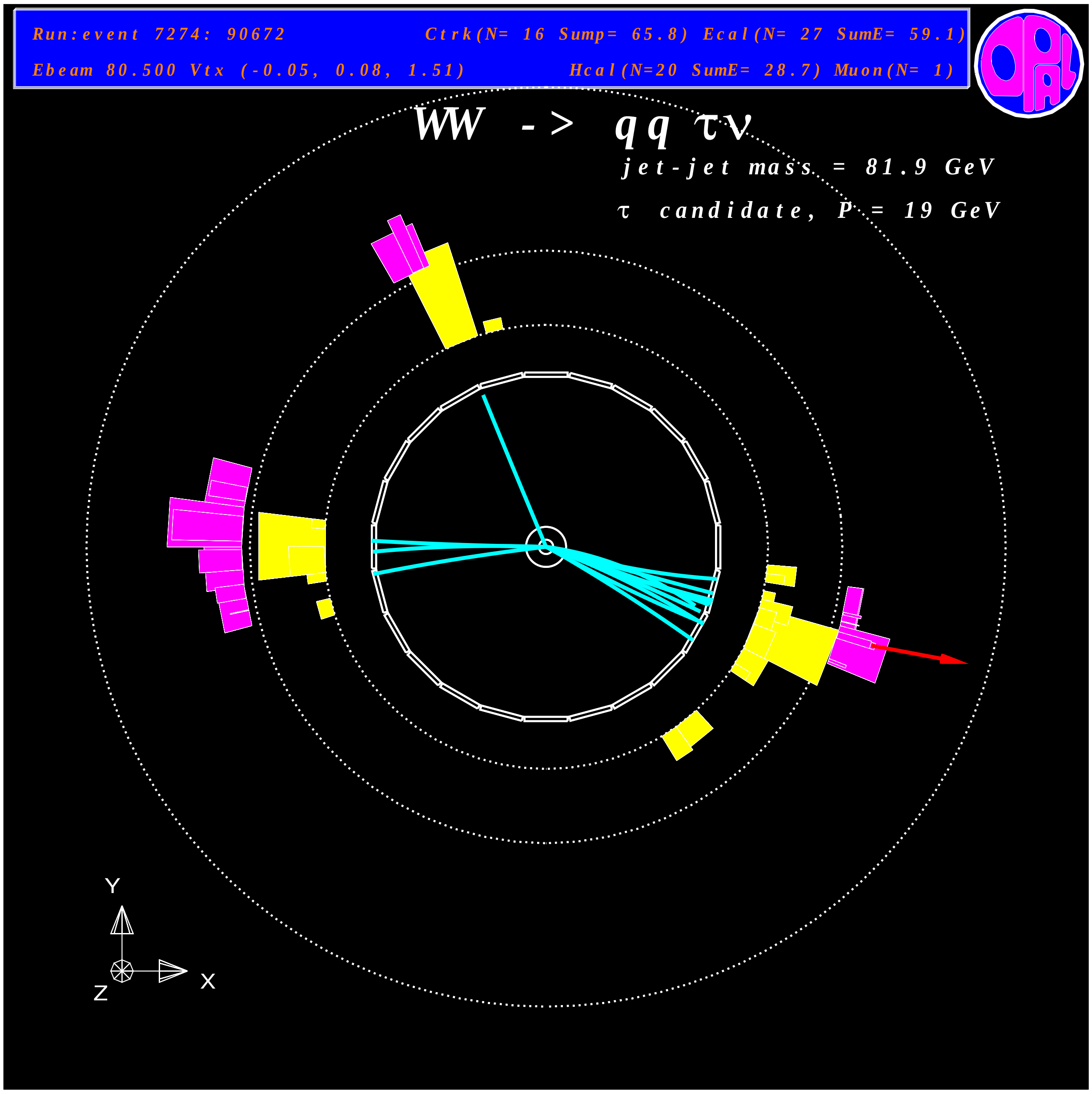
$W^+W^-\rightarrow q\bar{q}\ell\overline{\nu}_\ell$ Event Selection



2 hadronic jets, energetic $\ell^{\pm}$, missing momentum

- Isolated, high momentum e or μ
- 3-jet like: $y_{23} > 0.005$, no hard ISR γ
- significant missing P, $\sum p_T$, not forward

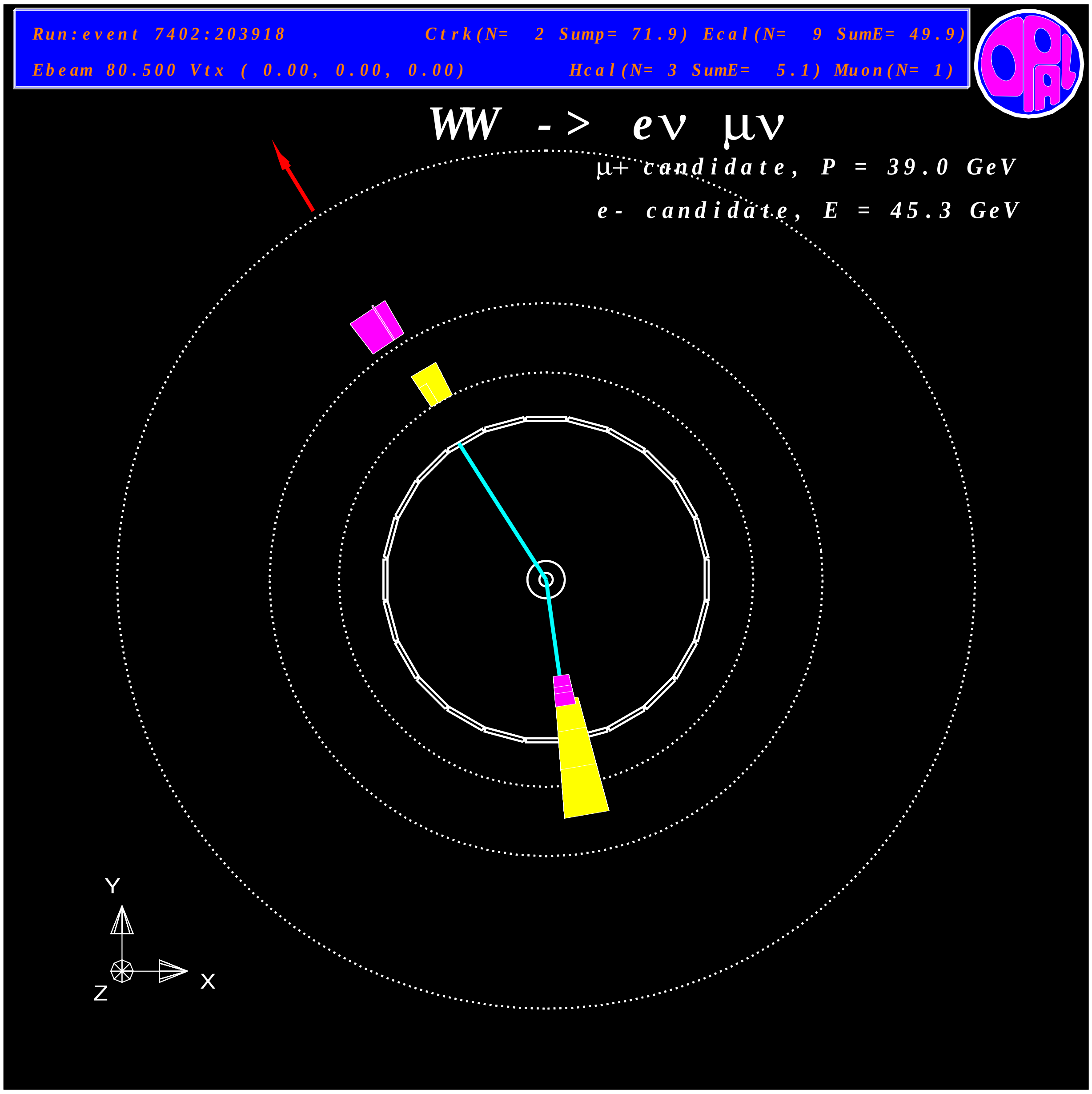
$W^+W^- \to q\bar{q}\tau\bar{\nu}_\tau$ Event Selection



3 jets (1 from τ), missing momentum

- most back-to-back jets $\Rightarrow$ q,$\bar{\text{q}}$
- τ jet isolated, 1 or 3 tracks in 10° cone.
- Other cuts similar to e, μ

$W^+W^- \to \ell^- \overline{\nu}_\ell \ell'^+ \nu_{\ell'}$ Event Selection



2 acoplanar "jets", low multiplicity, missing momentum

- Kinematic cuts on $\sum p_T$, $E_{\rm jet}\ldots$specific to final state (ee, $\mu\mu$, $\tau\tau$, eμ, eτ, $\mu\tau$)
- 2 charged, ≤ 1 neutral cone jets, allows $\ell^- \overline{\nu}_\ell \ell'^+ \nu_{\ell'} (\gamma)$
- veto forward $\mu^\pm$, net charge, ISR γ

W^+W^- Selection Summary

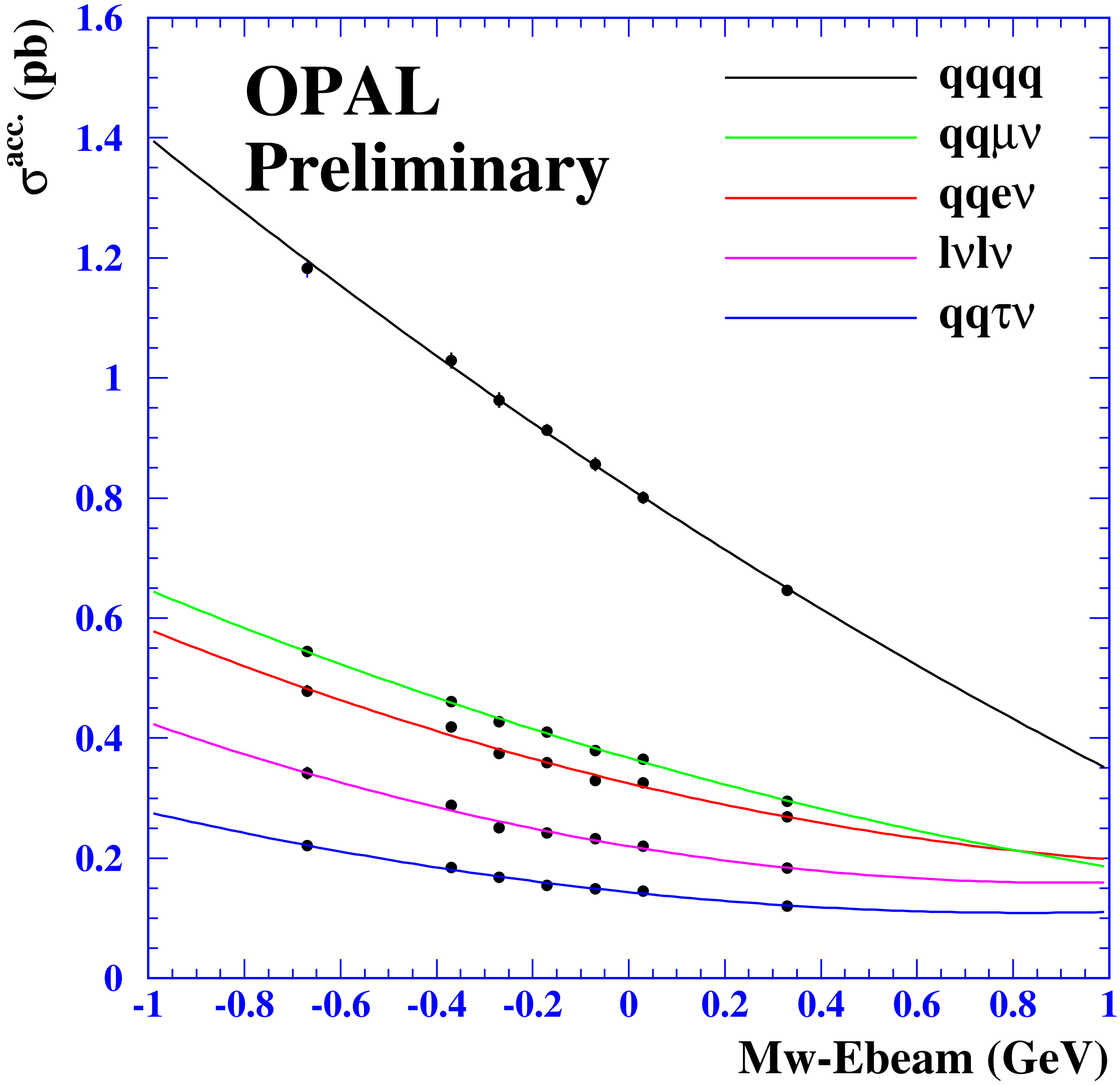
Event selection efficient for all W^+W^- decay modes

Channel	ε (%)	Expected signal	Expected bgnd.	Expected total	Obs.
$q\bar{q}q\bar{q}$	57	9.6	3.4	13.0 ± 1.1	14
$q\bar{q}e\bar{\nu}_e$	71	3.9	0.2	4.1 ± 0.5	3
$q\bar{q}\mu\bar{\nu}_\mu$	77	4.2	0.2	4.5 ± 0.5	2
$q\bar{q}\tau\bar{\nu}_\tau$	42	2.3	1.0	3.2 ± 0.4	7
$\ell\bar{\nu}_\ell\bar{\ell}\nu_\ell$	65	2.6	0.2	2.8 ± 0.3	2
Total	61	22.6	5.0	27.6 ± 2.5	28

- Δ (Expected signal) mostly $\Delta M_W \oplus \Delta E_{\mathrm{beam}} \sim 10\%$
- Results are preliminary

W Mass Measurement

- Interference $\mathrm{W}^+\mathrm{W}^- \leftrightarrow$ other 4-fermion states
- Predict M_W dependence of σ^{acc}, ε, background, using grc4f $+$ detector simulation



- Max. $\mathcal{L}$ fit, channel by channel, incl. correlations
- Systematics by repeated MC trials

$$M_\mathrm{W} = 80.40^{+0.44}_{-0.41}(\mathrm{stat.})\ ^{+0.09}_{-0.10}(\mathrm{syst.})\ \pm 0.10\ (\mathrm{LEP})$$

W^+W^- Cross-section Measurement

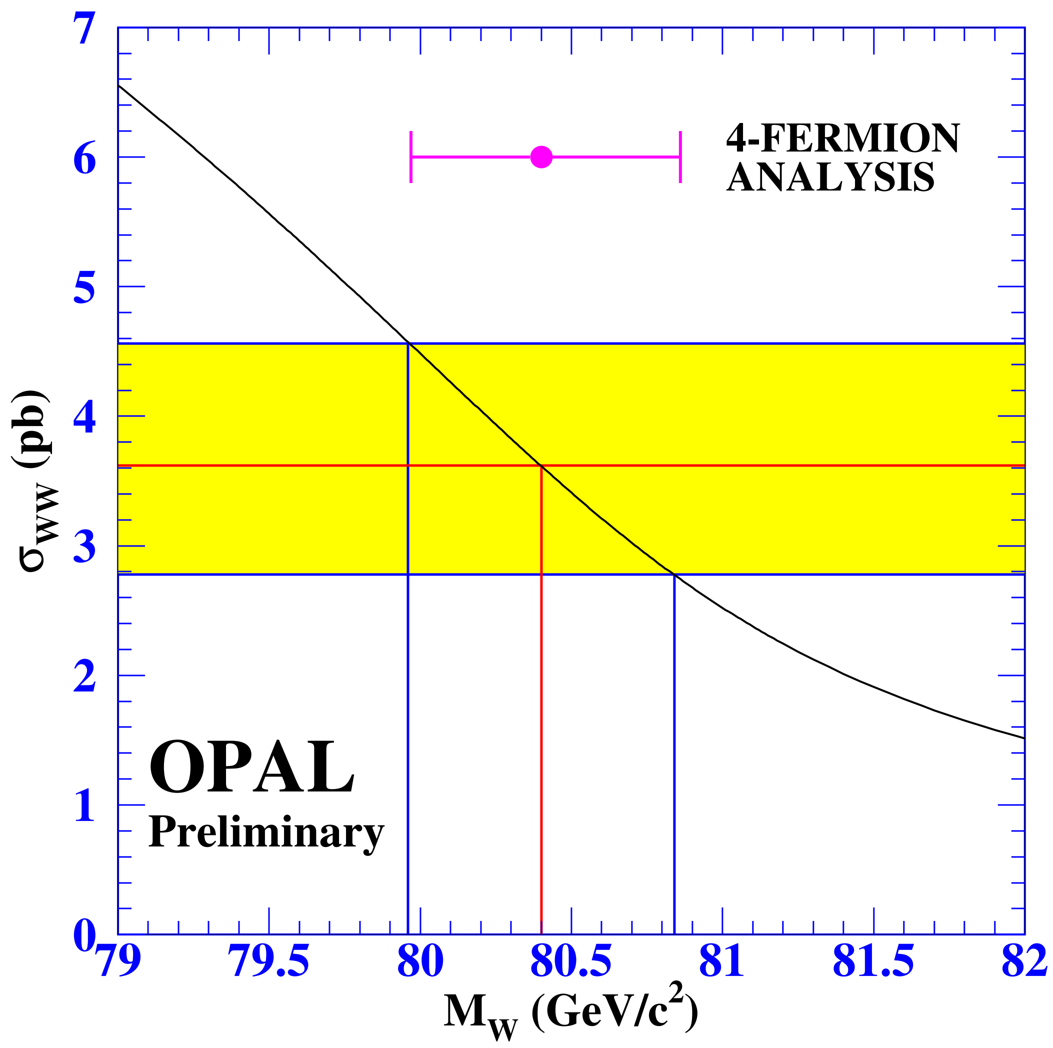
Direct measurement of W^+W^- production cross-section

- Max. $\mathcal{L}$ fit, channel by channel, incl. correlations

Assumptions:

- Subtract non-W^+W^- processes
- Absorb interference into background

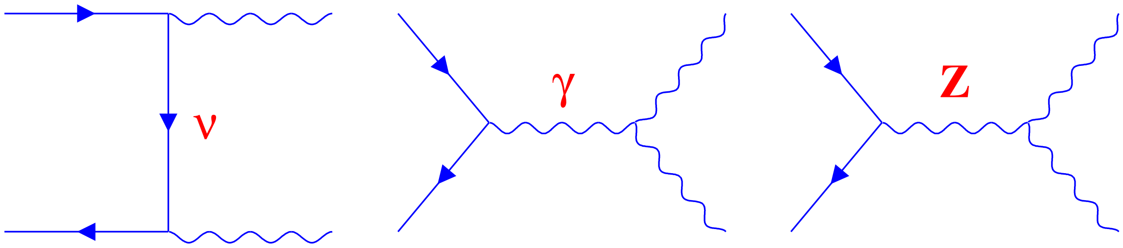
$$\sigma_{WW} = 3.62^{+0.93}_{-0.82}(\mathrm{stat.}) \pm 0.16(\mathrm{syst.})\ \mathrm{pb}$$ CC03



σ_{WW} + GENTLE $\Rightarrow$ consistent M_W.

Triple Gauge Boson Couplings

- Couplings affect total cross-section and
  angular distributions
- $e^+e^- \rightarrow W^+W^-$ diagrams:



$WW\gamma$ vertex	WWZ vertex
2 coupling constants	7 coupling constants
x_γ, y_γ	δ_Z, x_Z, y_Z etc.

- Anomalous couplings zero in SM
- Highest sensitivity in $W\phi$ model: free parameter $\alpha_{W\phi}$
- Efficiency depends on $\alpha_{W\phi}$

  $\Longrightarrow$ compare number of events
- Expected number of events derived from MC samples:
  - $W\phi$ model
  - $\alpha_{W\phi} = 0, \pm 1, \pm 2$
  - full detector simulation
- Include systematics in prediction

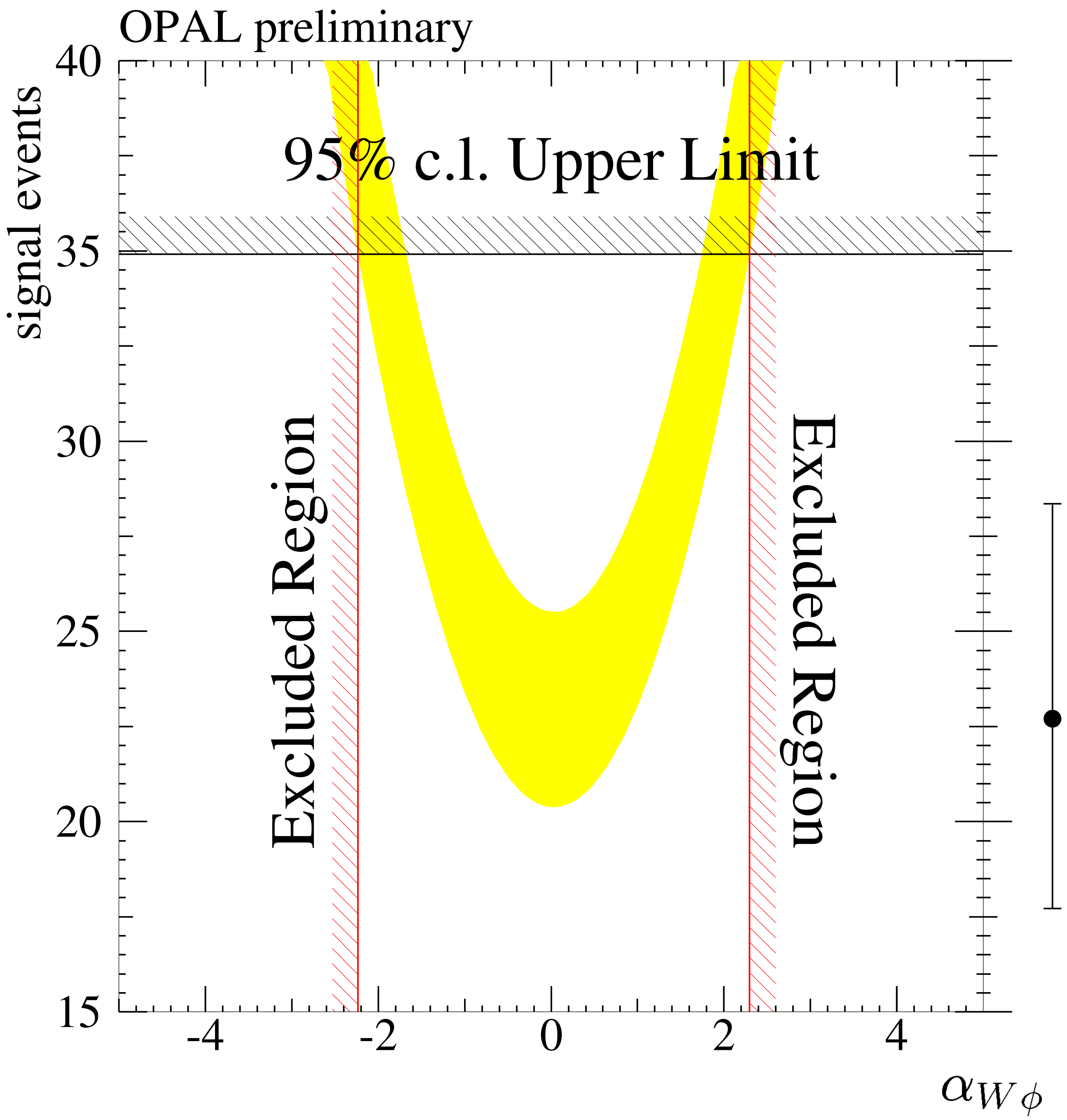
TGC from total event yield

- Observe 28 W^+W^- candidates, + expected background

  $\Rightarrow$ N(signal) < 34.9 @ 95% c.l.

- Compare with expectation, including systematics.

$\boxed{-2.2 < \alpha_{W\phi} < 2.3}$ @ 95% c.l.



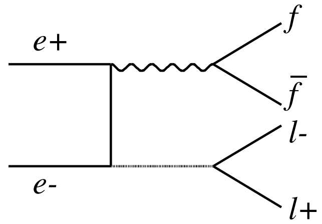
Neutral Current 4-fermion Processes

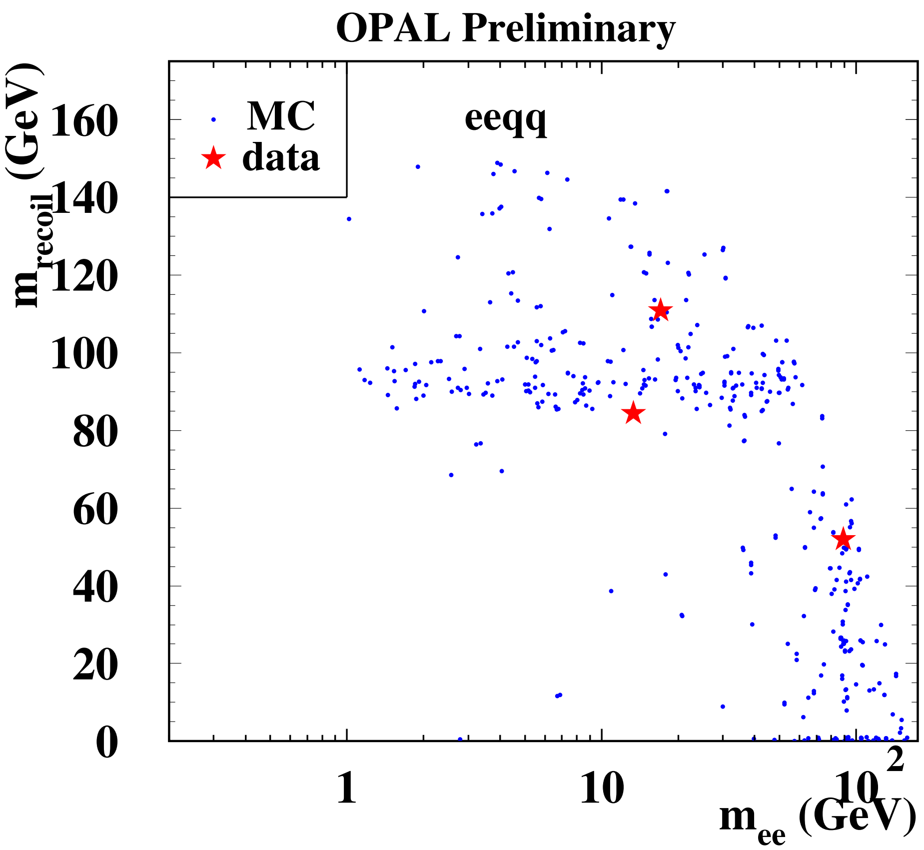
PLB **376**(1996)376 $\Rightarrow$ 'Excess' of $\ell^+\ell^-\mathrm{q\bar{q}}$ at LEP1.5

- Isolated charged leptons, all $\ell^\pm$ flavours
- Extend to low multiplicity 4-fermions ($\sim \ell^+\ell^-\ell'^+\ell'^-$)
- Repeat analysis of $\ell^+\ell^-$-jet(-jet), search for $\ell = \tau$
- Complete MC study of signal, background, $\mathrm{e^+e^-f\bar{f}}$, ...

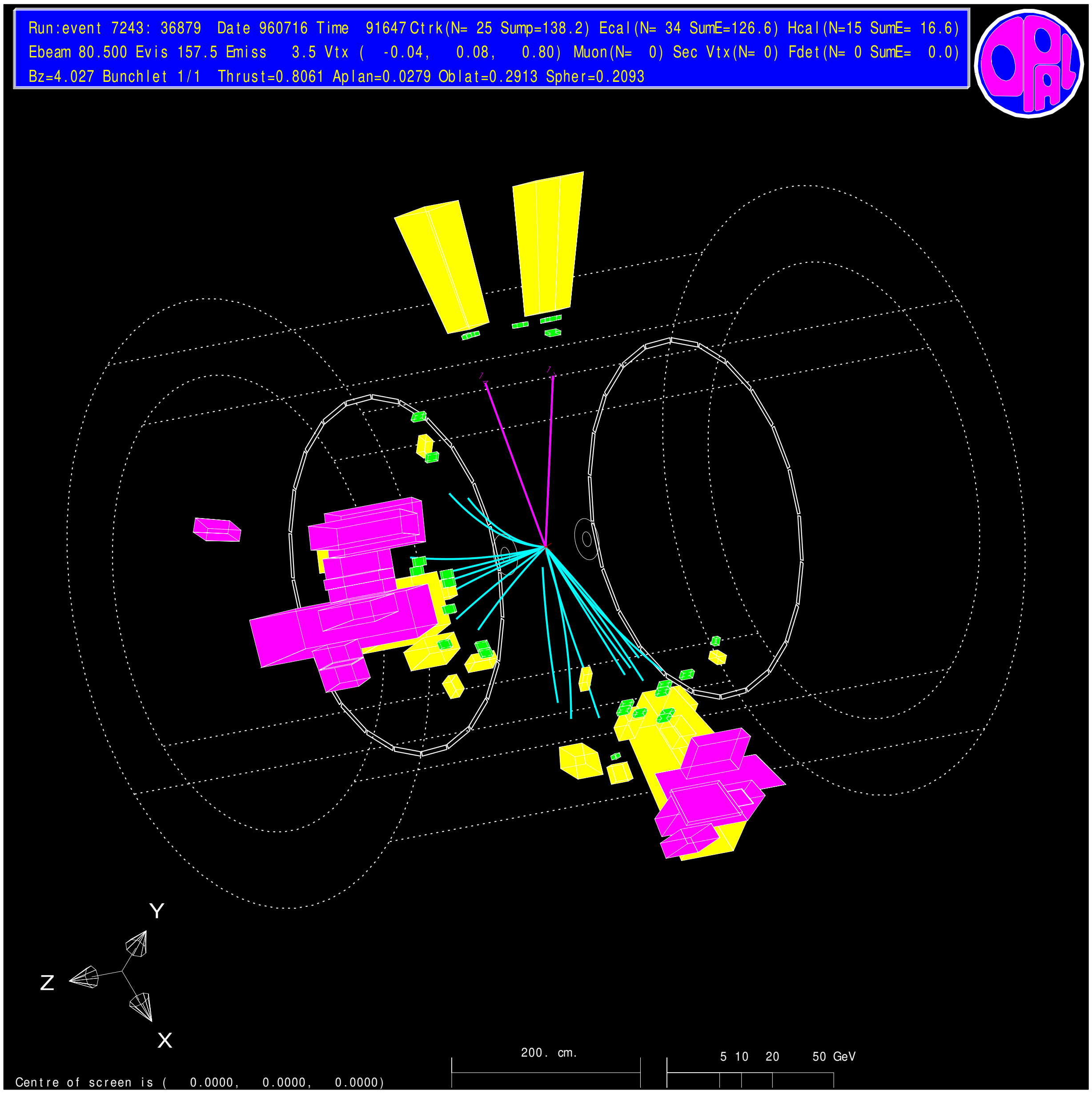
Observe 3 high multiplicity events, expect 1.7 ± 0.3 (all $\ell^\pm$)
4 low 2.0 ± 0.2

conversion dominates $\ell^+\ell^-\mathrm{q\bar{q}}$
recoil mass $\sim M_{\mathrm{Z^0}}$





$e^+e^-q\bar{q}$ 4-fermion Candidate



- $m(e^+e^-) = 13.0 \pm 0.6$ GeV
- $m(q\bar{q}) = 84.6 \pm 2.4$ GeV

Low Multiplicity 4-fermion Study

	LEP1.5	161 GeV	sum
Expected	$1.6^{+0.2}_{-0.1}$	2.5 ± 0.3	4.1 ± 0.3
Observed	2	4	6
Probability	47.9%	25.5%	23.2%

High Multiplicity 4-fermion Study

Channel	LEP1.5	161 GeV	sum
$e^+e^-q\bar{q}$ exp.	0.7 ± 0.1	0.8 ± 0.1	1.6 ± 0.3
observed	1	3	4
$\mu^+\mu^-q\bar{q}$ exp.	0.6 ± 0.1	0.9 ± 0.2	1.5 ± 0.2
observed	5	0	5
$\ell^+\ell^-q\bar{q}$ exp.	1.3 ± 0.2	1.7 ± 0.3	3.1 ± 0.5
observed	6	3	9
Probability	0.3%	25.5%	0.6%

- Doubled total expected number of events
- No increase in significance of LEP1.5 ‘excess’

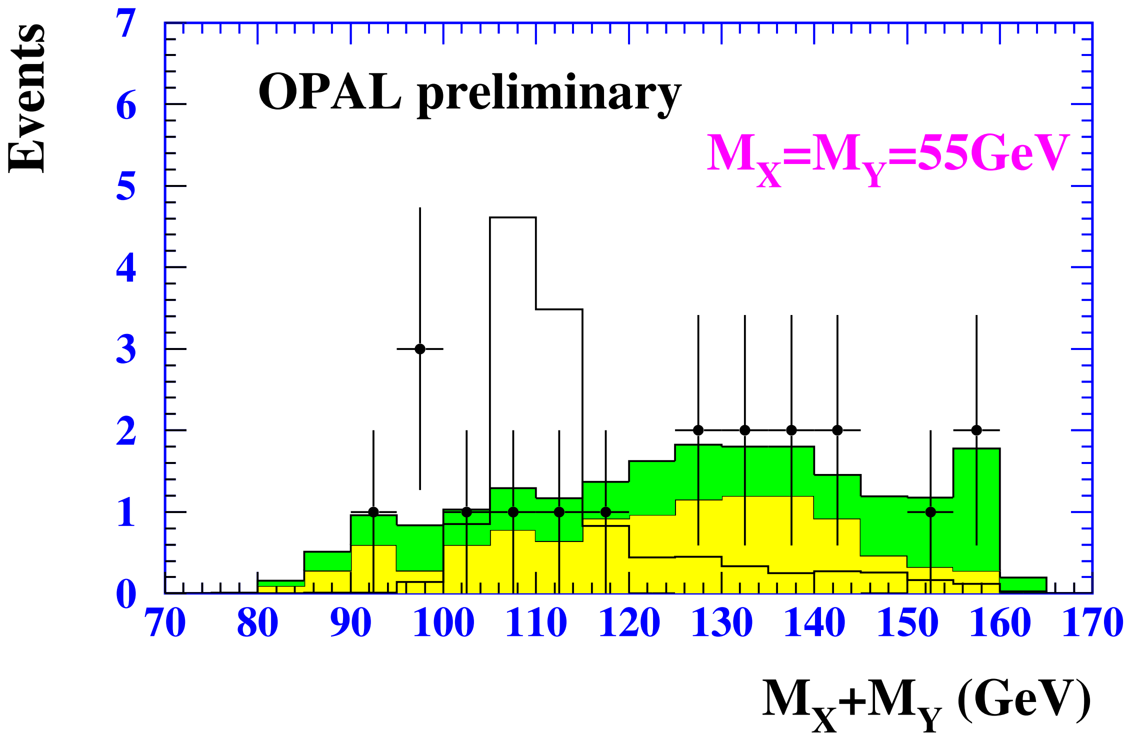
Anomalous 4-jet Production

- Hadronic events, $\sqrt{s'} > 135$ GeV
- 4 jets, $y_{34}^{D} > 0.008$, or $y_{34}^{JADE} > 0.022$
- Kinematic fit, improve δM
- Spherical event shapes, T, C-parameter
- Signal $h^{\circ} A^{\circ}$ (HZHA), grid of $M = M_X + M_Y$, ΔM
- $\varepsilon \sim 20$–50%, incl. M cuts, ε lower for M small, or ΔM large

Many cross-checks, good agreement between data and MC e.g.

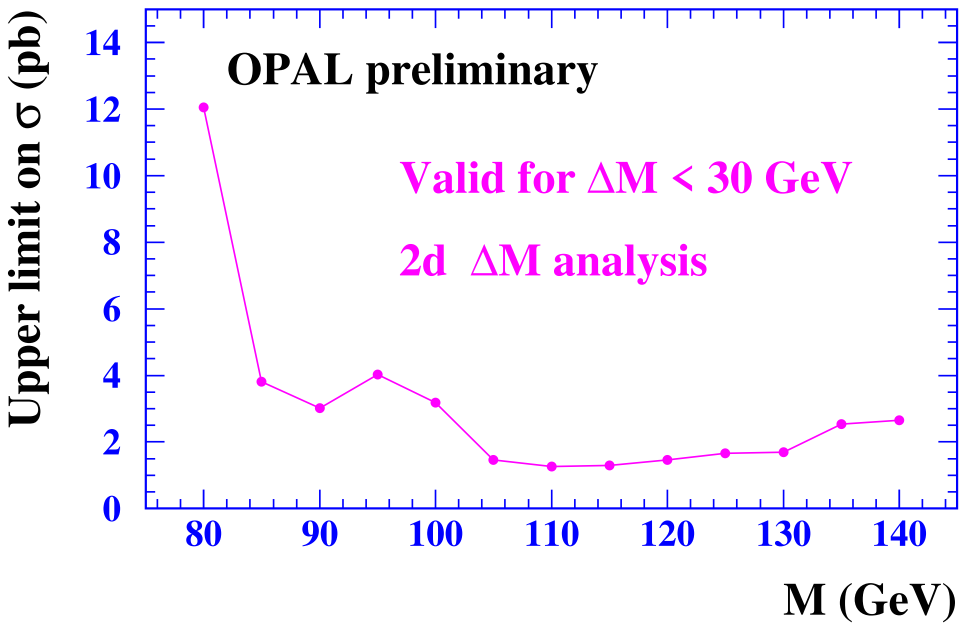
- change jet finding
- remove event shape cuts
- emulate ALEPH analysis
- remove mass cuts

Cross-Section Upper Limits



Select 19 events, SM $\Rightarrow 20.2 \pm 2.6$

For $M = 110 \pm 6$ GeV select 3, SM $\Rightarrow$ 3.0 ± 0.4

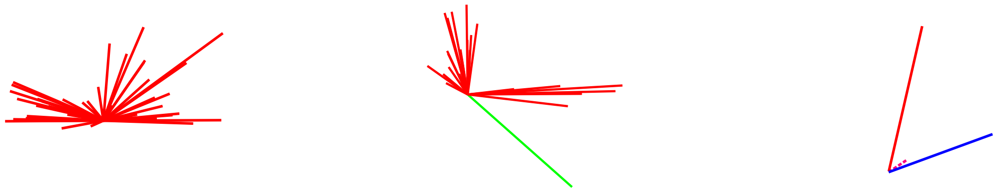


Using bins of $M \pm 6$ GeV, for $M = 110$ GeV

$\boxed{\sigma_{XY} < 1.5 \text{ pb}, \sqrt{s} = 161 \text{ GeV}}$ @ 95% c.l.

Chargino/Neutralino Search

Acoplanar 'jets' + missing energy



> 4 tracks	> 4 tracks	≤ 4 tracks
no isolated $\ell^{\pm}$	$\geq$ 1 isolated $\ell^{\pm}$	dominant, ΔM small
$\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}^0$	$\sim \tilde{\chi}_1^{\pm}$ only	$\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}^0$

- MC grid ~ 100 mass pairs $(\tilde{\chi}_1^{\pm},\tilde{\chi}_1^0)$, $(\tilde{\chi}_2^0,\tilde{\chi}_1^0)$
- Signal efficiency varies with M, ΔM, typically

$\tilde{\chi}_1^+\tilde{\chi}_1^-$ $\varepsilon \sim 40$–60%, 10–20% for $\Delta M = 5$ GeV

$\tilde{\chi}_2^0\tilde{\chi}_1^0$ $\varepsilon \sim 20$–40%, 5–20% for $\Delta M = 5$ GeV

Select 2 candidates, expect 0.7 ± 0.2 background

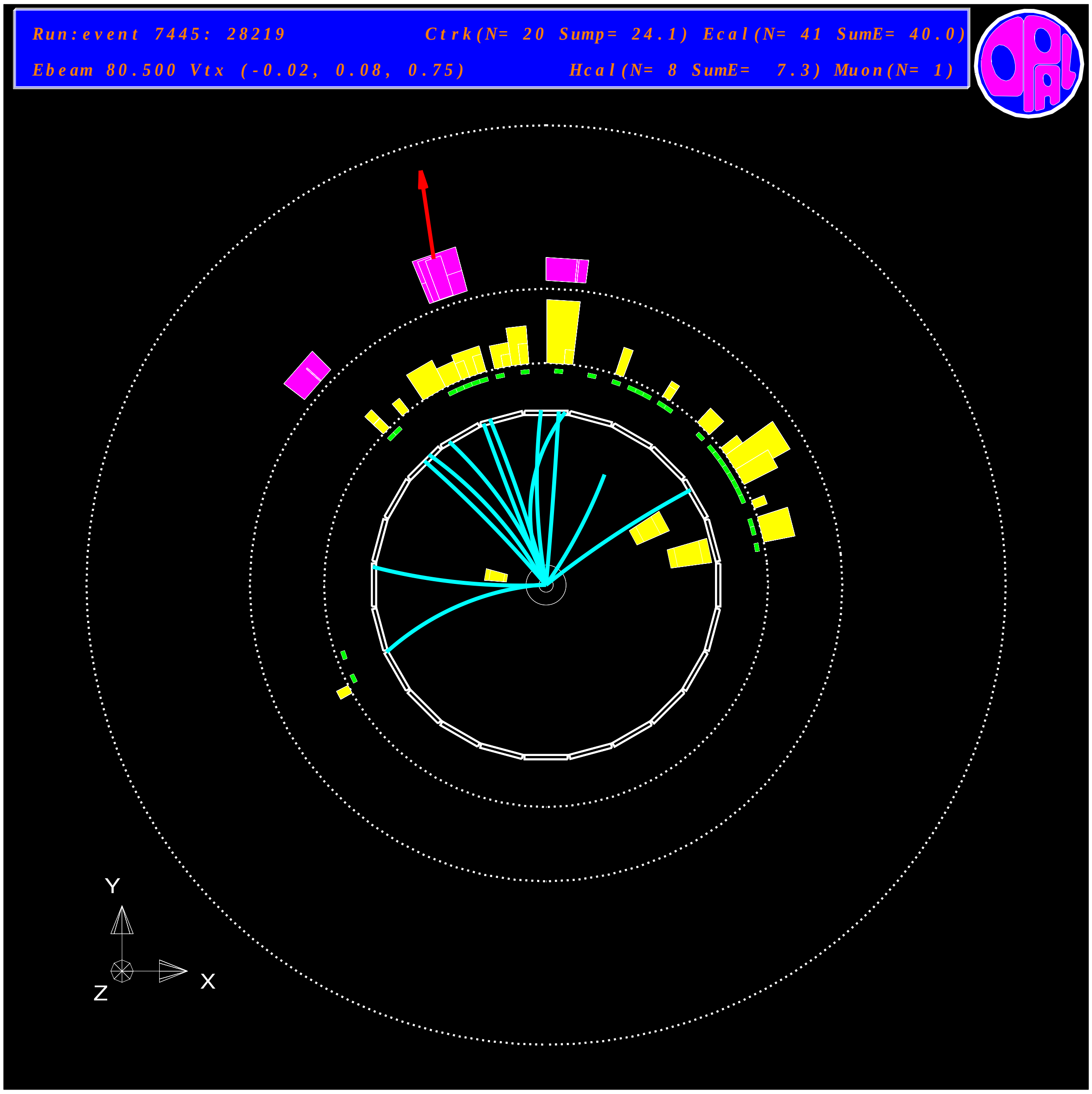
Systematics on modelling, mass interpolation, backgrounds

Mass (GeV)	$\tan\beta = 1.5$		$\tan\beta = 35$	
	Min. m_0	m_0=1 TeV	Min. m_0	m_0=1 TeV
$m_{\tilde{\chi}_1^{\pm}}$	62.0	78.5	66.5	78.8
$m_{\tilde{\chi}_1^0}$	12.0	30.3	35.8	41.3
$m_{\tilde{\chi}_2^0}$	45.3	51.9	67.2	80.0
$m_{\tilde{\chi}_3^0}$	86.3	94.3	112.5	112.5

Lower limits at 95% c.l.

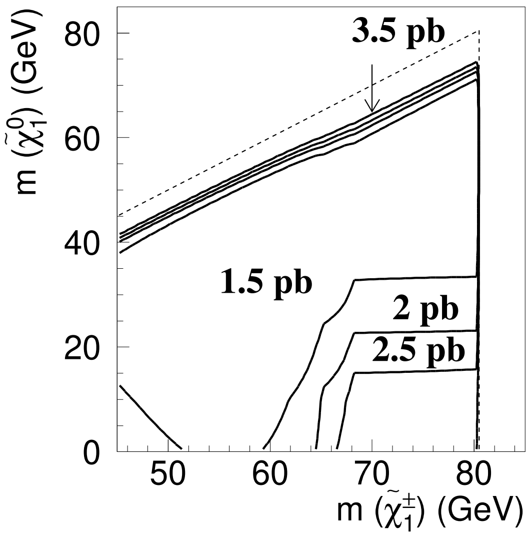
Submitted to Phys. Lett.

$\tilde{\chi}_1^{\pm}, \tilde{\chi}_1^0$ Candidate

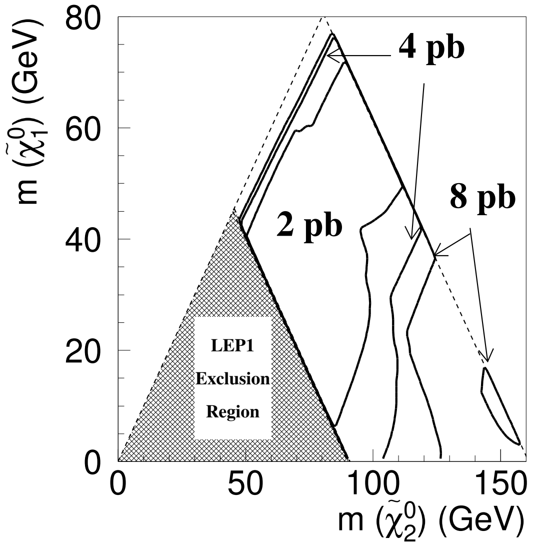


- Recoil mass $= 99$ GeV, visible energy $= 55$ GeV
- Missing transverse momentum $= 39$ GeV
- Also selected as: $\mathrm{L}^+\mathrm{L}^-, \tilde{\mathrm{t}} \rightarrow \mathrm{b}\ell^+\tilde{\nu}, \ldots$

Cross-section Limits

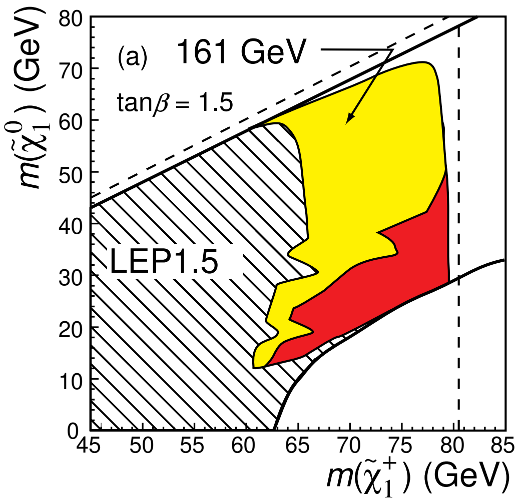


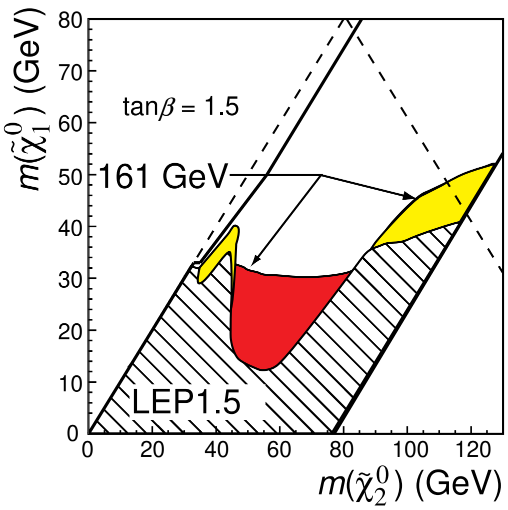
$\tilde{\chi}^\pm_1 \to \tilde{\chi}^0_1 W^\pm$ 100%



$\tilde{\chi}^0_2 \to \tilde{\chi}^0_1 W^\pm$ 100%

MSSM Mass Limits





$m(\tilde{\chi}^\pm_1) > 78.5$ GeV	$m_0 > 1$ TeV
$m(\tilde{\chi}^\pm_1) > 62.0$ GeV	m_0 minimal

@ 95% c.l.

assuming $\Delta M > 10$ GeV, $\tan\beta = 1.5$

Charged Slepton Search

Acoplanar, acollinear $\ell^+\ell^-$ + missing energy

- Topology $\sim \mathrm{W}^+\mathrm{W}^- \to \ell^-\overline{\nu}_\ell \ell'^+ \nu_{\ell'}$, low ΔM $\tilde{\chi}_1^\pm$ $\tilde{\chi}_1^0$
- Large ΔM $\longrightarrow$ large visible E, missing momentum + v.v.
- Dominant background $\mathrm{W}^+\mathrm{W}^-$ $\longrightarrow$ leptons, require:

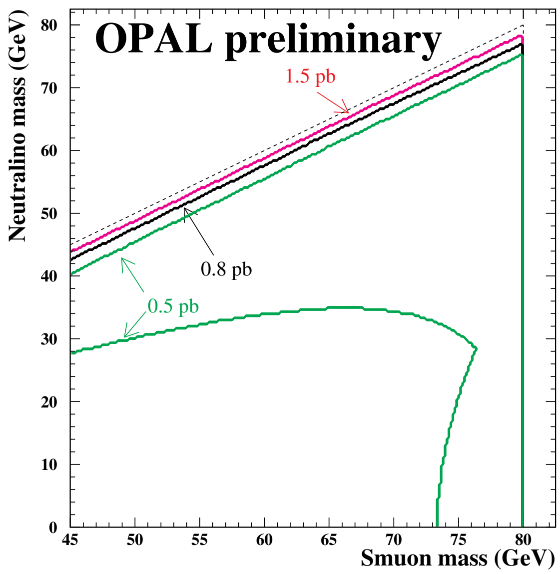
  large ΔM same flavour ℓ^+ and ℓ^-

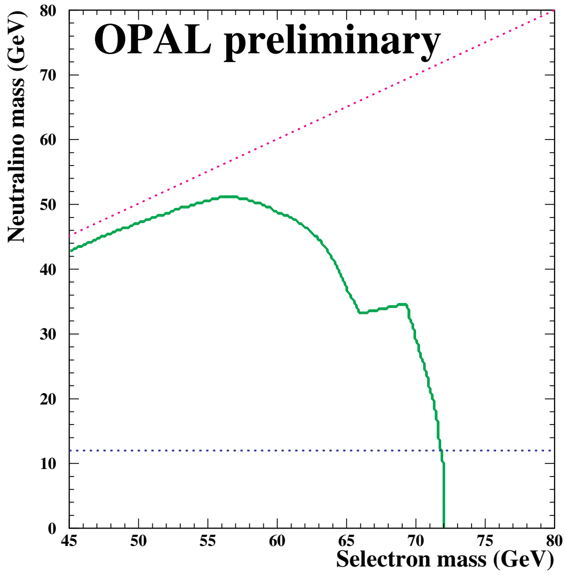
  small ΔM low momentum $\ell^\pm$

  $\varepsilon(\tilde{\tau})$ lower

- For $\tilde{\mathrm{e}}$, $\tilde{\mu}$ $\varepsilon \sim 60$–80%, 25–45% for $\Delta M = 3$ GeV

Select 5 candidates, expect 3.3 ± 0.2 background





m($\tilde{\mathrm{e}}$) > 71.8 GeV

m($\tilde{\mu}$) > 52.0 GeV

@ 95% c.l.

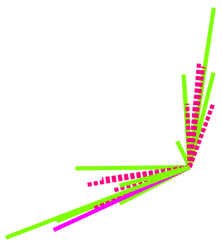
$m(\tilde{\chi}_1^0) = 12$ GeV

$\tilde{\mathrm{e}}$ only: $\mu = -200$ GeV, $\tan\beta = 1.5$

$\tilde{\rm t}$, $\tilde{\rm b}$ Search

- $m_t \sim 170 \Rightarrow \tilde{\rm t}$ may be light!
- Mixing between mass and L+R states, defined by

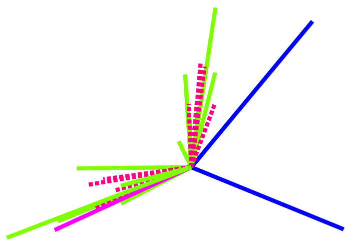
$$\tilde{\rm t}_1 = \tilde{\rm t}_{\rm L} \cos\theta_{\tilde{\rm t}} + \tilde{\rm t}_{\rm R} \sin\theta_{\tilde{\rm t}}$$



2 acoplanar jets

$\tilde{\rm t} \to {\rm c}\tilde{\chi}^0_1$

$\tilde{\rm b} \to {\rm b}\tilde{\chi}^0_1$



2 acoplanar jets + 2 $\ell^\pm$

$\tilde{\rm t} \to {\rm b}\ell^+\tilde{\nu}$ dominant if

$m(\tilde{\rm t}) > m(b) + m(\tilde{\nu})$

- Search for missing energy

Signal efficiency varies with M, ΔM, typically

$\tilde{q} \to q'\tilde{\chi}^0_1$ $\varepsilon \sim 40$–60%, $\sim 25\%$ for $\Delta M = 5$ GeV

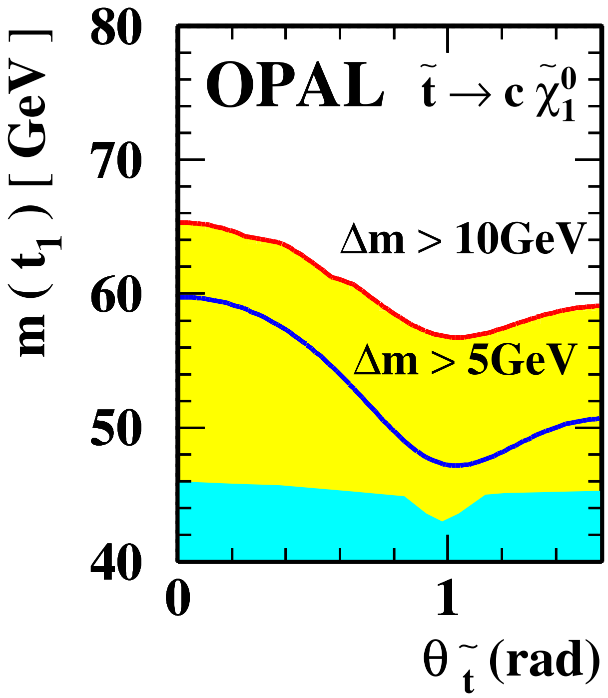
$\tilde{\rm t} \to {\rm b}\ell^+\tilde{\nu}$ $\varepsilon \sim 30$–55%, ~ 5–20% for $\Delta M > 10$ GeV

Combine with all LEP1.5 data

Select 0 $\tilde{q} \to q'\tilde{\chi}^0_1$ candidate, expect 0.9 ± 0.2 background

Select 1 $\tilde{\rm t} \to {\rm b}\ell^+\tilde{\nu}$ candidate, expect 0.6 ± 0.2 background

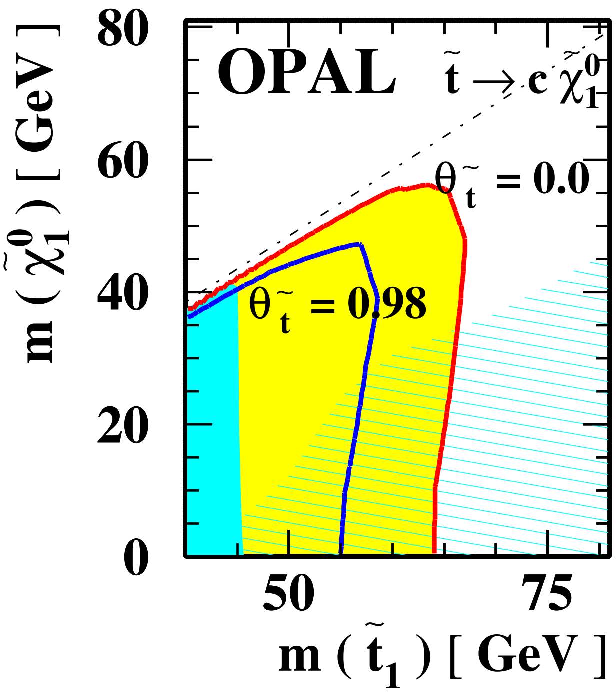
Mixing and Mass Limits



For $\tilde{t} \to c\tilde{\chi}_1^0$

$\Longleftarrow$ LEP1

All $\tilde{t}$, $\tilde{b}$ results from combined 161 GeV + LEP1.5 data



Submitted to Phys. Lett., CERN-PPE/96-133

$m(\tilde{t}) > 58.7$ GeV,	$\theta_{\tilde{t}} < \pi/4$
$m(\tilde{b}) > 60.6$ GeV,	$\theta_{\tilde{b}} = 0$

@ 95% c.l.

assuming $\Delta M > 10$ GeV

Unstable Heavy Lepton Search

- $\mathrm{L^0\overline{L^0}} \to \mathrm{WW} + 2$ charged ℓ
- $\mathrm{L^+L^-} \to \mathrm{W^+W^-} + 2\,\nu,\ \nu = \nu_\mathrm{L}$ or ν_ℓ
  (flavour mixing)
- LEP1 $\Rightarrow m(\nu_\mathrm{L}) > 37$ GeV $\Longrightarrow$ large missing energy
- No assumption of $\ell^\pm$ charge correlation (Majorana, Dirac)
- Analysis sensitive to all $\mathrm{W^\pm}$ decay modes, lepton flavours

$\boxed{\mathrm{L^0\overline{L^0}}}$ $\varepsilon \sim 25$–50%, $m(\mathrm{L^0}) = 50$–75 GeV

- observed 0 event, expected background 0.5

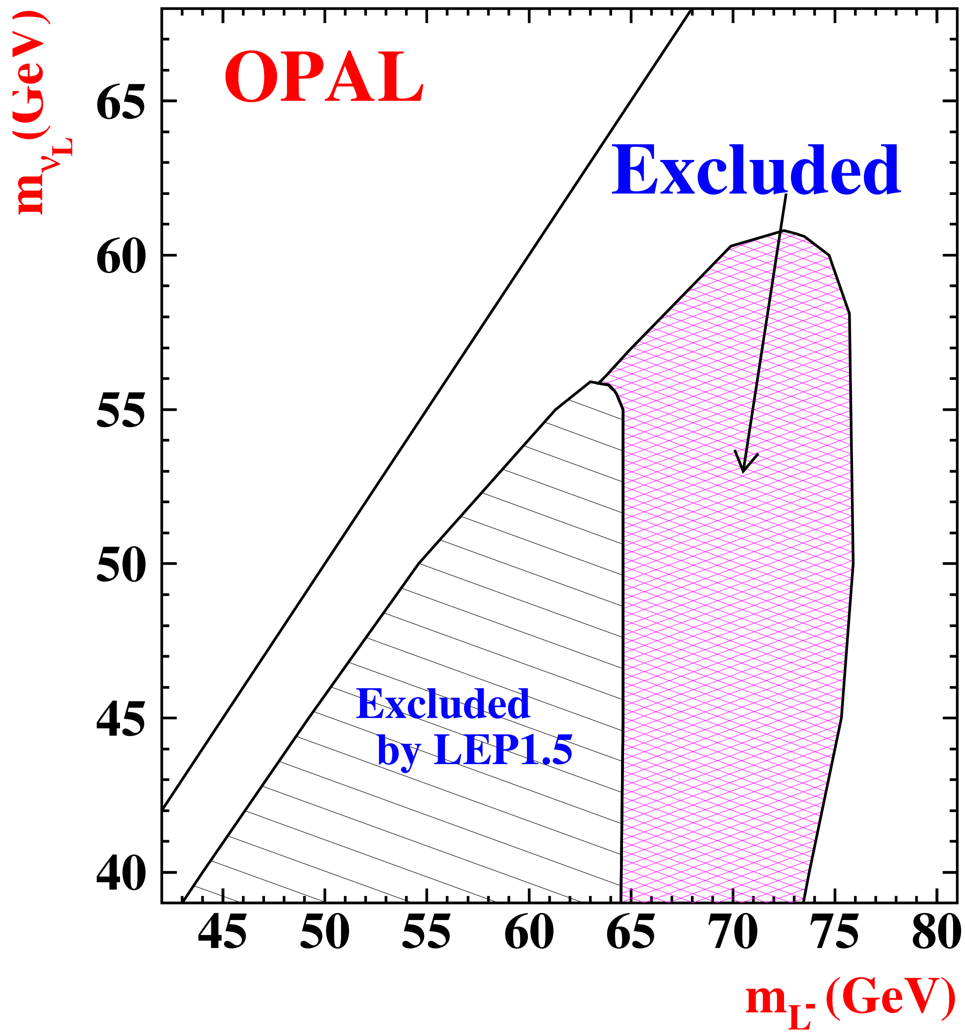
$\boxed{\mathrm{L^+L^-}, \nu \text{ heavy}}$ $\varepsilon \sim 10$–35%, $\Delta M = 5$–30 GeV

- observed 2 events, expected background 0.4

$\boxed{\mathrm{L^+L^-}, \nu \text{ light}}$ $\varepsilon \sim 20$–25%, $m(\mathrm{L^\pm}) = 60$–80 GeV

- observed 0 event, expected background 0.7

Mass limits



Event topology		161 GeV + LEP1.5
$L^0\overline{L^0} \to eW^*eW^*$	Dirac Majorana	69.3 GeV 59.5 GeV
$L^0\overline{L^0} \to \mu W^*\mu W^*$	Dirac Majorana	72.0 GeV 60.5 GeV
$L^0\overline{L^0} \to \tau W^*\tau W^*$	Dirac Majorana	66.0 GeV 55.7 GeV
$L^- \to \nu_L W^*$		73.6 GeV
$L^- \to \nu_\ell W^*$		76.7 GeV

Excited Leptons

Motivated by compositeness, scale Λ, couplings f, f'

Studied production topologies $\ell^*\ell^*$ and $\ell^*\ell$, with decays:

$$\left.\begin{array}{l} \ell^{*\pm} \rightarrow \ell^{\pm}\gamma \\ \nu^* \rightarrow \ell^{\pm}W^{\mp} \end{array}\right\} \text{for coupling } f = f'$$

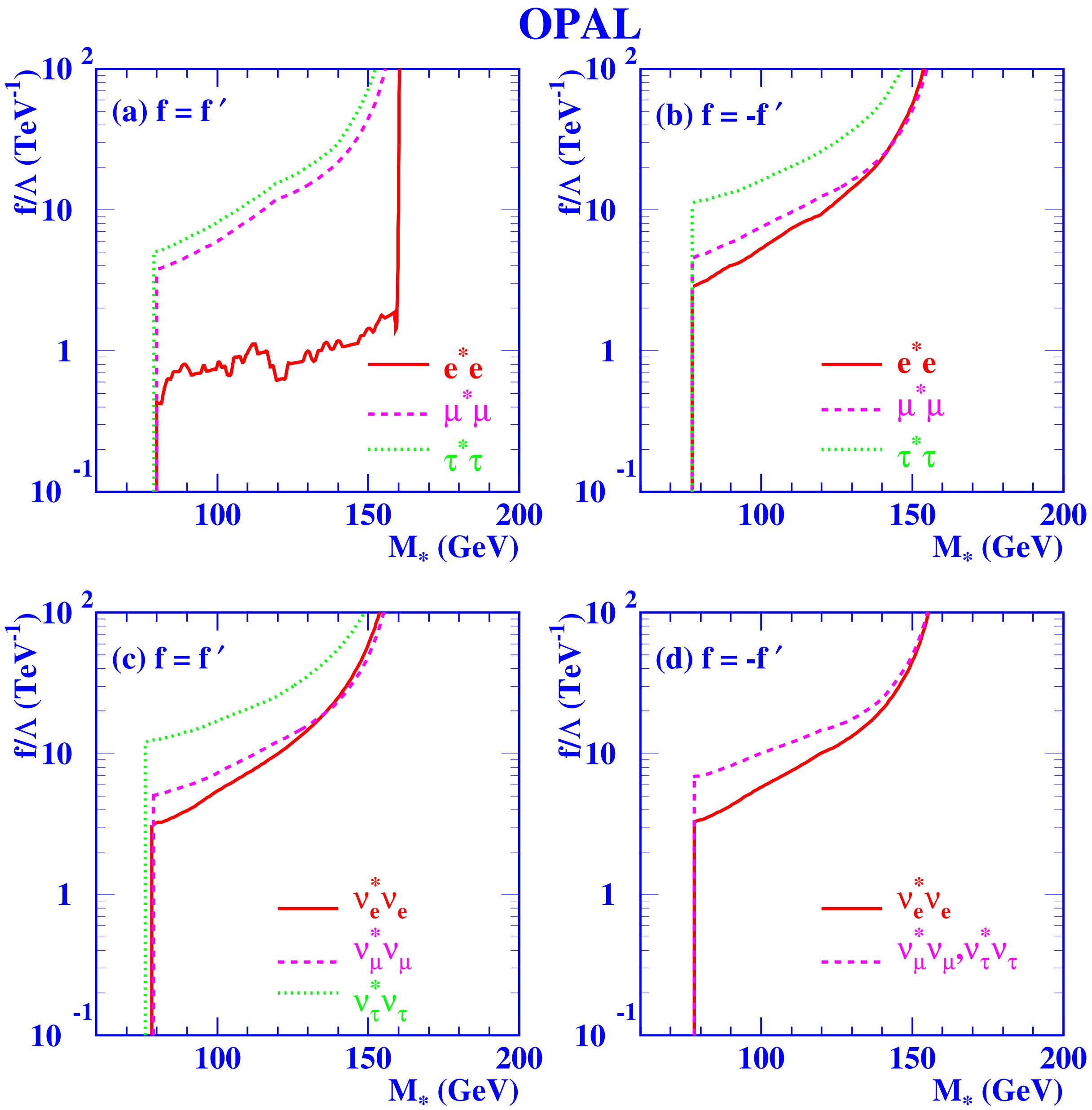
$$\left.\begin{array}{l} \ell^{*\pm} \rightarrow \ell^{\pm}W^{\pm} \\ \nu^* \rightarrow \nu^{\pm}\gamma \end{array}\right\} \text{for coupling } f = -f'$$

- photonic decays of $\nu^*\nu^*$, $\nu^*\nu$, as for SM $\nu\nu\gamma(\gamma)$
- charged decays of $\ell^*\ell^*$, identical to L^+L^- and $L^0\overline{L^0}$

$\varepsilon \sim 20$–25%, candidates consistent with SM expectation

Flavour	Decays	Coupling	161 GeV
e^*	Photonic	$f = f'$	79.9
μ^*	Photonic	$f = f'$	80.0
τ^*	Photonic	$f = f'$	79.1
e^*	Charged	$f = -f'$	77.1
μ^*	Charged	$f = -f'$	77.1
τ^*	Charged	$f = -f'$	77.1
ν_e^*	Charged	$f = f'$	78.3
ν_μ^*	Charged	$f = f'$	78.9
ν_τ^*	Charged	$f = f'$	76.2
ν_e^*	Photonic	$f = -f'$	77.8
ν_μ^*	Photonic	$f = -f'$	77.8
ν_τ^*	Photonic	$f = -f'$	77.8

Upper Limits for Coupling/Compositeness Scale



- All limits @ 95% c.l., different choice of couplings
- Structure in e*, $f = f'$ due to observed candidates
- Limits for e* stronger due to t-channel process

Standard Model Higgs Scalar Search

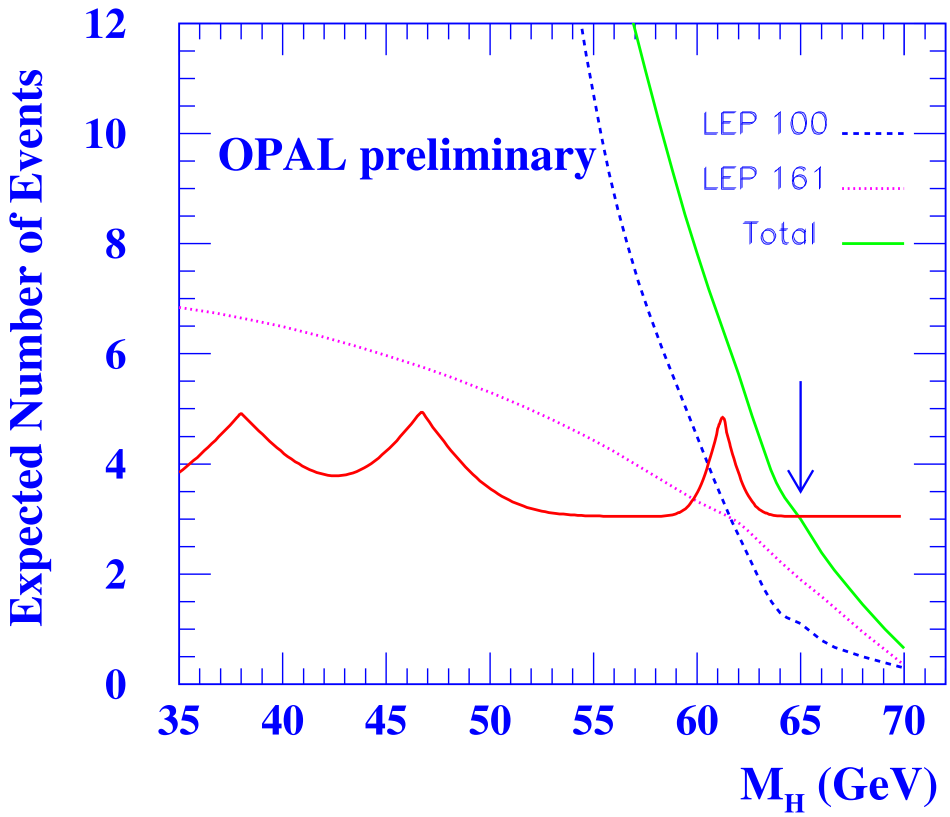
Sensitive to all relevant decay channels

- 4-jets $\varepsilon \sim 23\%$
- 2-jets + missing energy $\varepsilon \sim 47\%$
- 2-jets + $\tau^+\tau^-$ $\varepsilon \sim 20\%$
- 2-jets + $\ell^+\ell^-$ (ℓ =e,μ) $\varepsilon \sim 65\%$

Efficiencies correspond to case $m(H^\circ) > 65.0$ GeV

Total expected background 1.9 ± 0.1 events

No new candidates observed



$\boxed{m(H^\circ) > 65.0 \text{ GeV}}$ @ 95% c.l.

OPAL Summary

- Measured 2-fermion cross-sections and asymmetries
- Measured QCD event shapes,

$$\alpha_s(161\mathrm{GeV}) = 0.102 \pm 0.005 \pm 0.007 \quad \text{(prel.)}$$

- Measured $\gamma\gamma$ jet rates
- Observed $\mathrm{W}^+\mathrm{W}^-$ production! Preliminary results:

$$\sigma_{\mathrm{WW}} = 3.62^{+0.93}_{-0.82} \pm 0.16 \text{ pb}$$

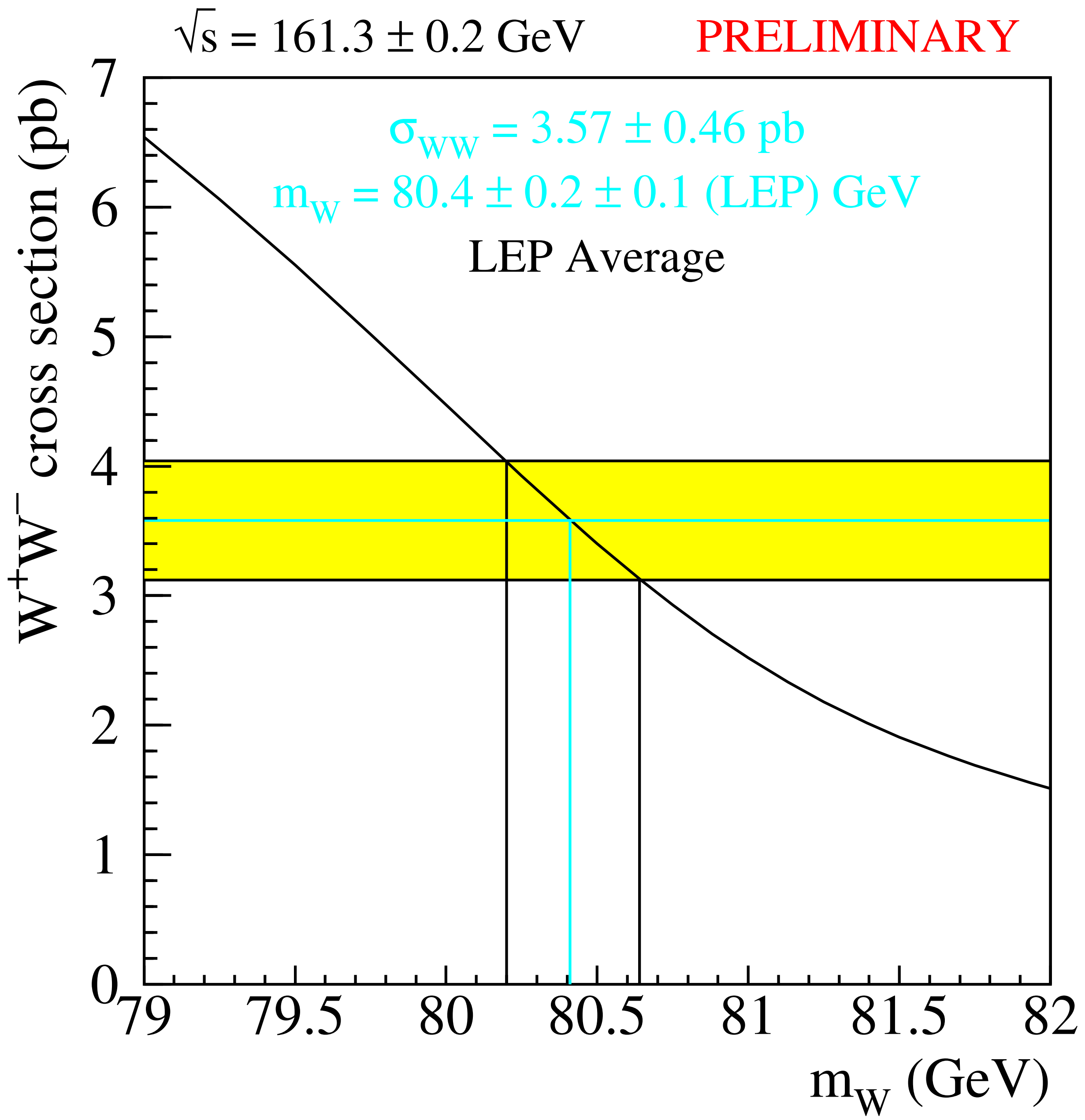
$$M_{\mathrm{W}} = 80.40^{+0.44}_{-0.41}\,{}^{+0.09}_{-0.10} \pm 0.10 \ (\mathrm{LEP}) \text{ GeV}$$

$$-2.2 < \alpha_{W\phi} < 2.3 \qquad @\ 95\% \text{ c.l.}$$

- Studied other 4-fermion processes, no excess observed
- Searches for: $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}^0$, $\tilde{\ell}^{\pm}$, $\tilde{\mathrm{t}}$, $\tilde{\mathrm{b}}$, $L^{\pm}$, L°, ℓ^*, H°
- No evidence for new physics, as yet
- Thanks to LEP/SL for more data at another, higher energy!

LEP Combined W Mass Measurement

Obtain M_{W} by averaging σ_{WW} from all LEP experiments



LEPC 8 Oct 96
LEP EW Working Group