Physics Results

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On behalf of the L3 collaboration

CERN Seminar
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Outline

- Measurements
  - ▷ 2-Photon Physics
  - ▷ QCD
  - ▷ Fermion Pair Production
  - ▷ Boson Production
  - ▷ W mass
- Searches
  - ▷ Anomalous Bosonic Couplings
  - ▷ Susy
  - ▷ Exotica
  - ▷ Higgses

Luminosity above the Z resonance $\approx 700\ \mathrm{pb}^{-1}$
$\approx 217\ \mathrm{pb}^{-1}$ AD 2000

!Mostly preliminary results!

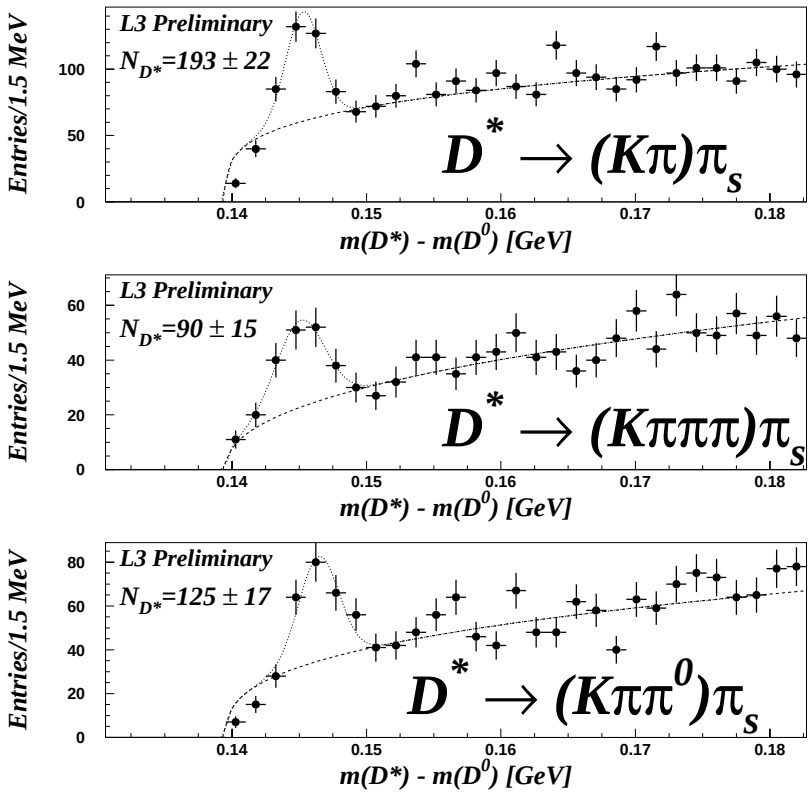
Analysis of 183-209 GeV data:

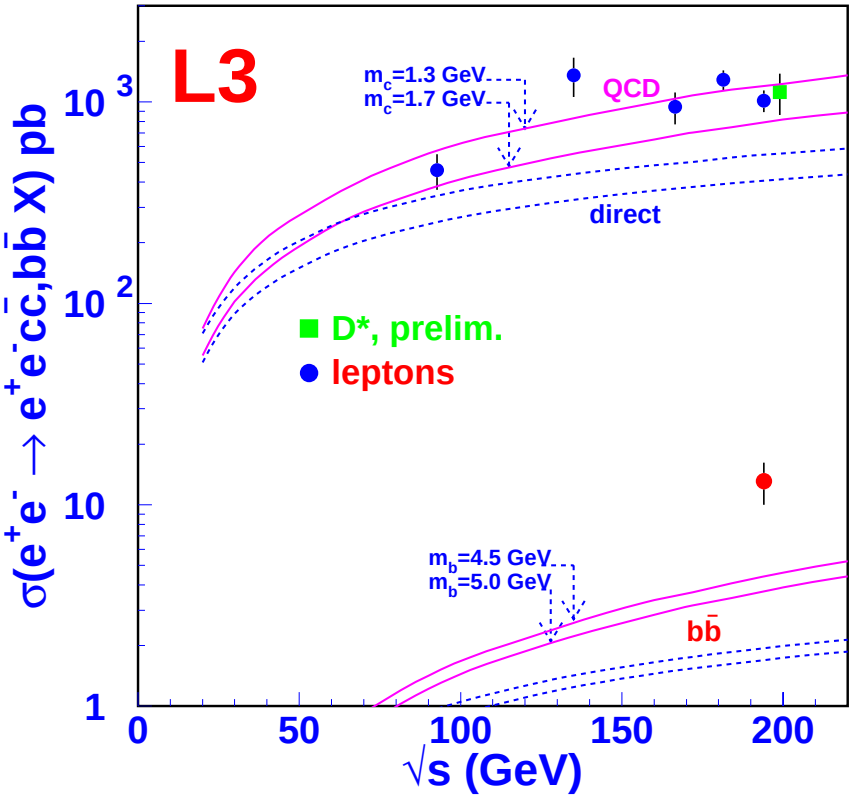
$$e^+e^- \to e^+e^-\gamma\gamma \to e^+e^- D^* + X$$

$$D^{*\pm} \to D^0\pi^\pm_{slow}$$

$$D^0 \to K^\pm\pi^\mp$$
$$K^\pm\pi^\mp\pi^+\pi^-$$
$$K^\pm\pi^\mp\pi^0$$

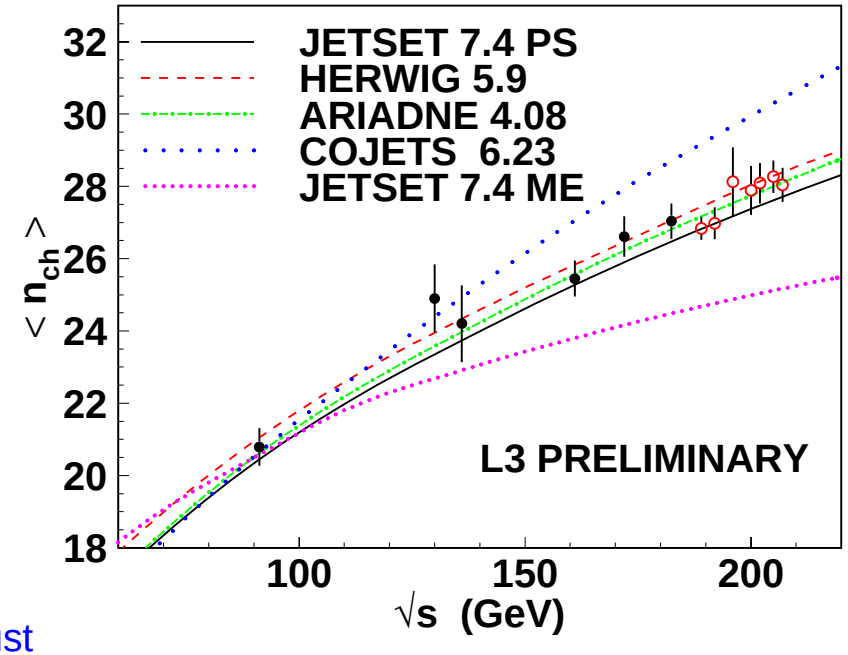
Data of 1997-2000



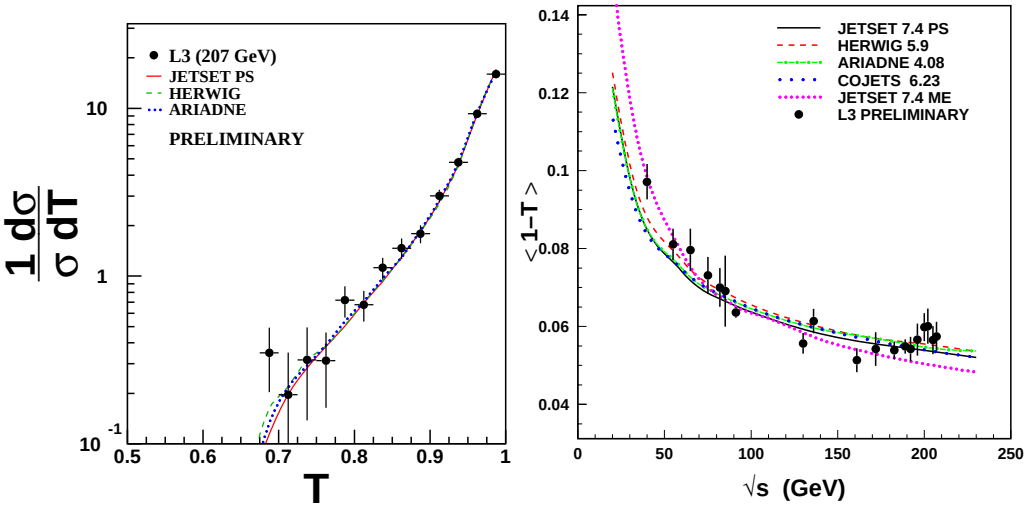


- Charm production in good agreement with QCD
- Beauty production 3 times higher than expected

Charge multiplicity



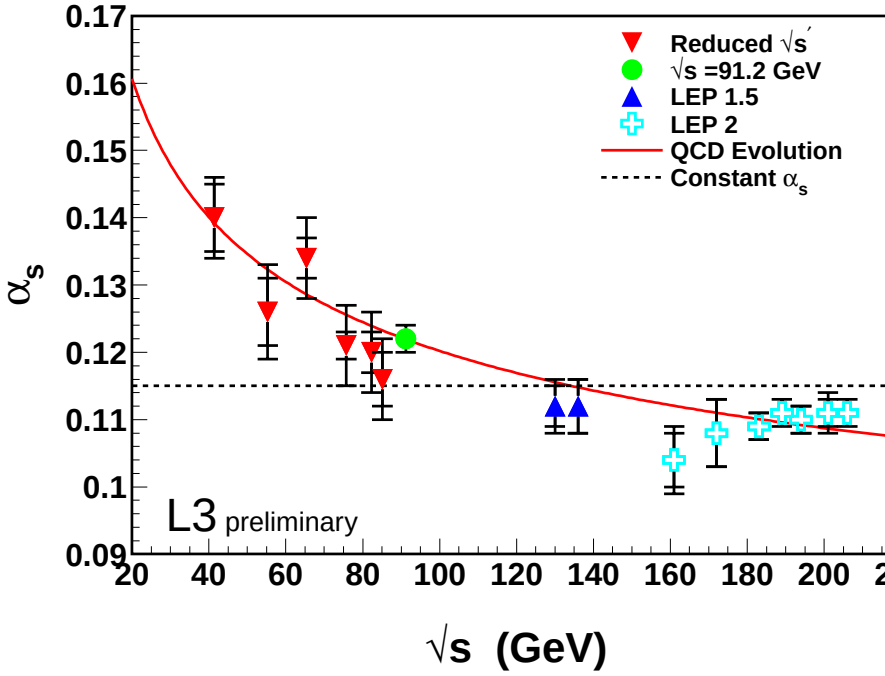
Thrust



QCD Models with parton shower describe data well

Running α_S from event shape variables.

QCD fits to $\mathcal{O}(\alpha_s^2)$ with resummed LO and NLO terms



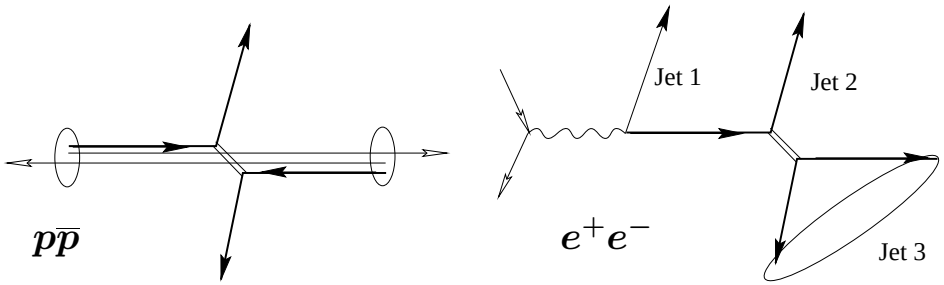
From year 2000 data:

$\alpha_S(206\ \text{GeV}) = 0.1111 \pm 0.0022(\text{exp}) \pm 0.0056($

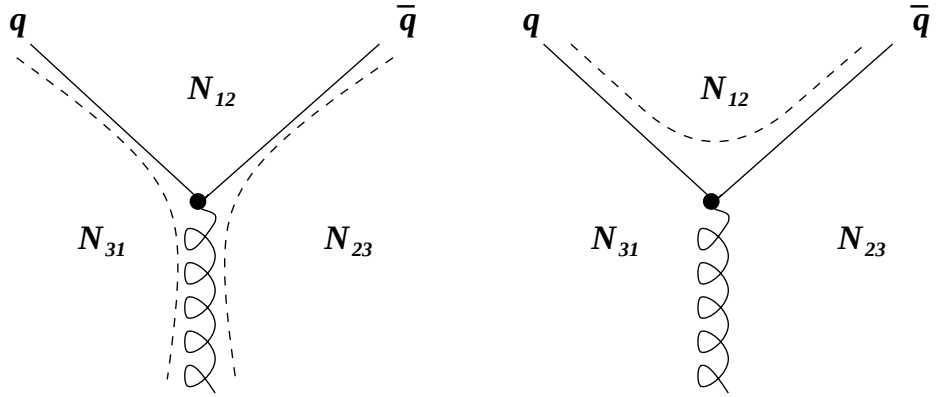
From hadronic event shapes using all data:

$\alpha_S(M_Z) = 0.1219 \pm 0.0011(\text{exp}) \pm 0.0059$

- Observation of large rapidity gaps in $p\bar{p}$ and ep collisions
- Search for colour singlet exchange in hadronic Z decays



- Study "Mercedes star" 3-jet events with tagged gluon jet
- 2,000 events out of 2,000,000 from 94/95 Z-pole data



colour octet colour singlet

Colour flow:

→ More particles (N)

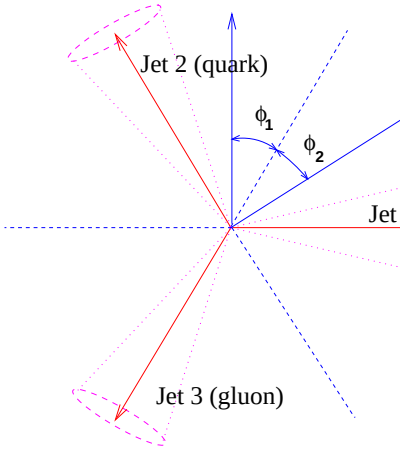
→ Smaller angular separation

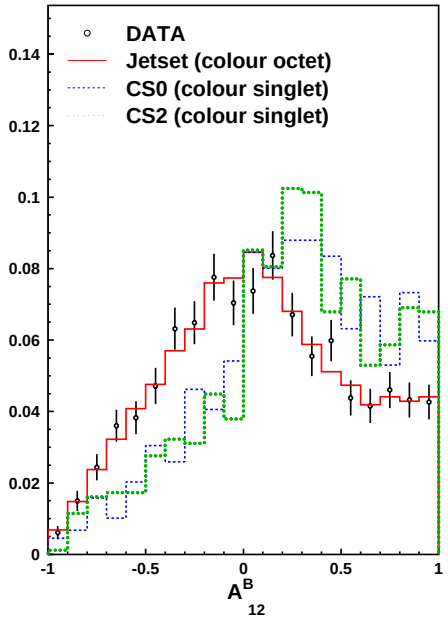
Define asymmetries in the particle flow:

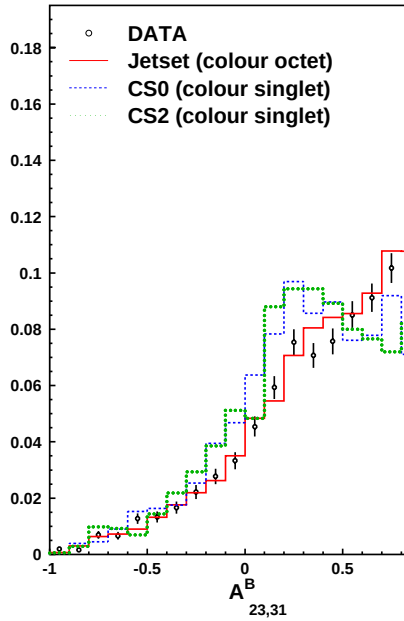
Angle from the bisector in GAP between jets 1 and 2:
$B_{12} = \mathrm{Min}(\phi_1, \phi_2)$

Angular Asymmetry for bisector angle in GAP 12:
$A^B_{12} = \frac{-B_{12}+B_{23}+B_{31}}{B_{12}+B_{23}+B_{31}}$

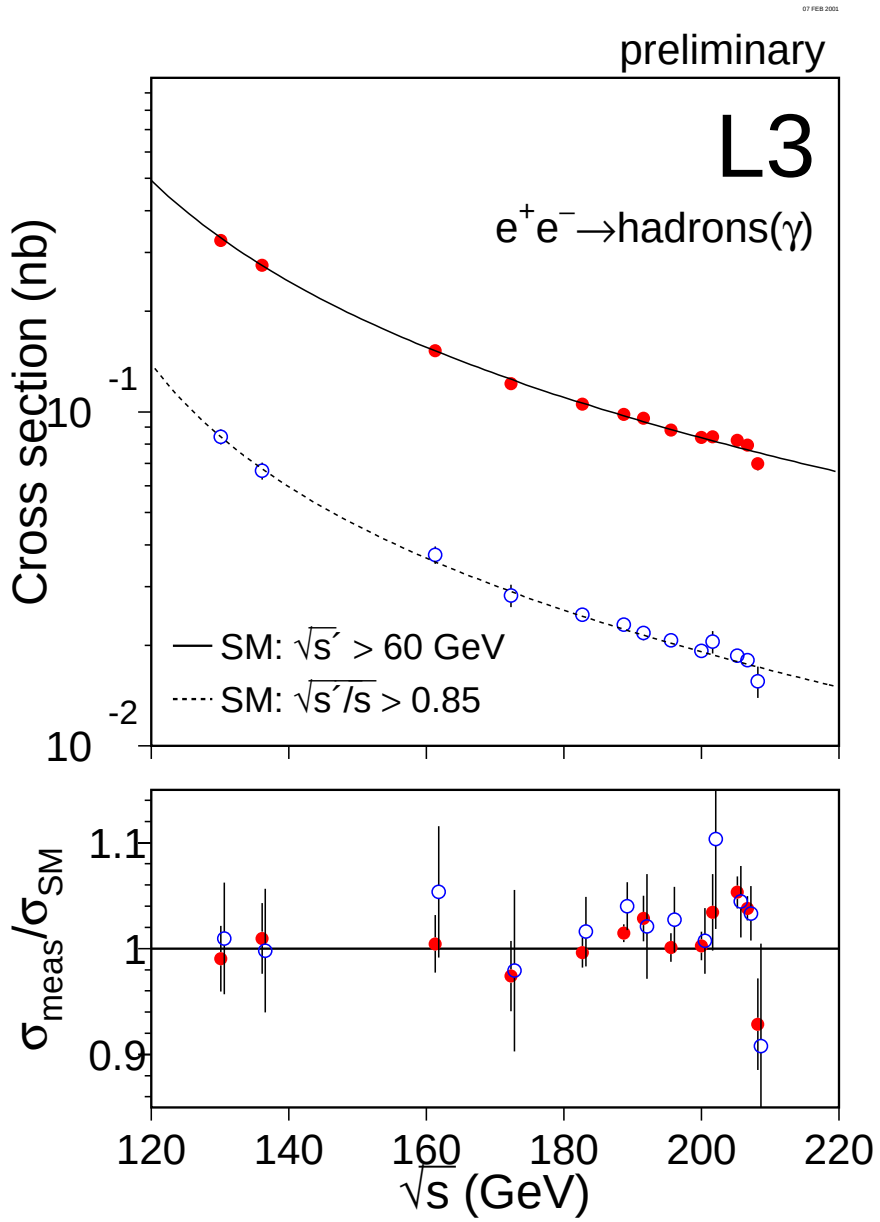
Similarly, define A^B_{23} and A^B_{31}



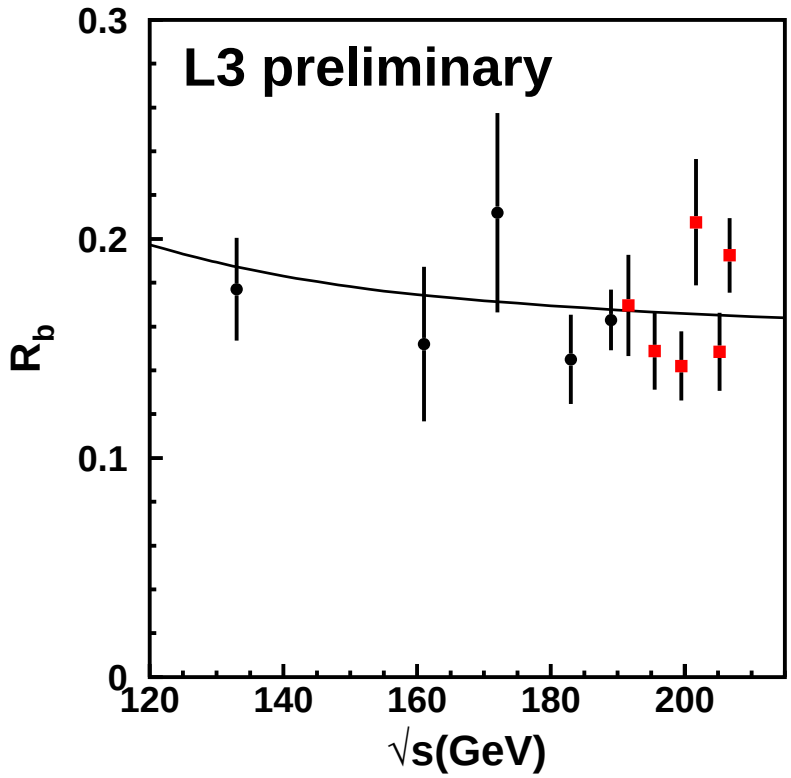


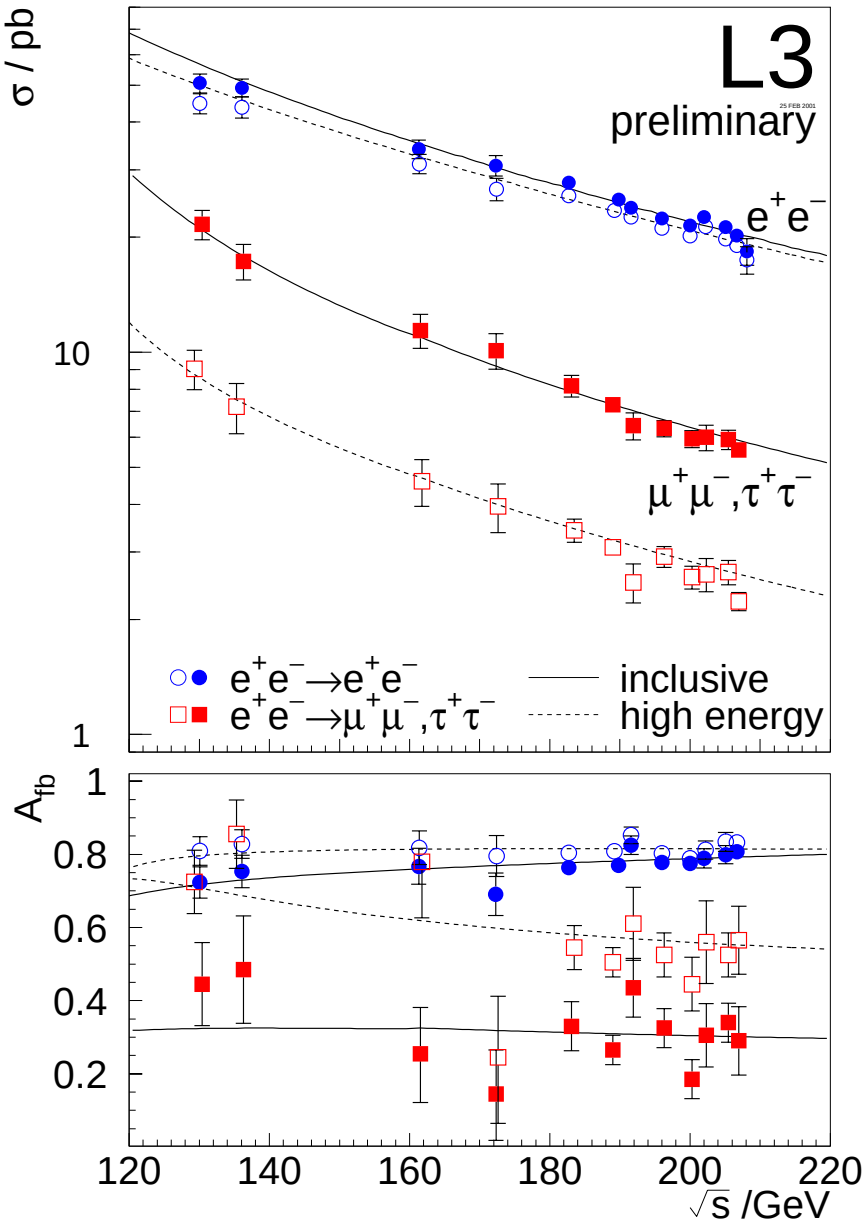


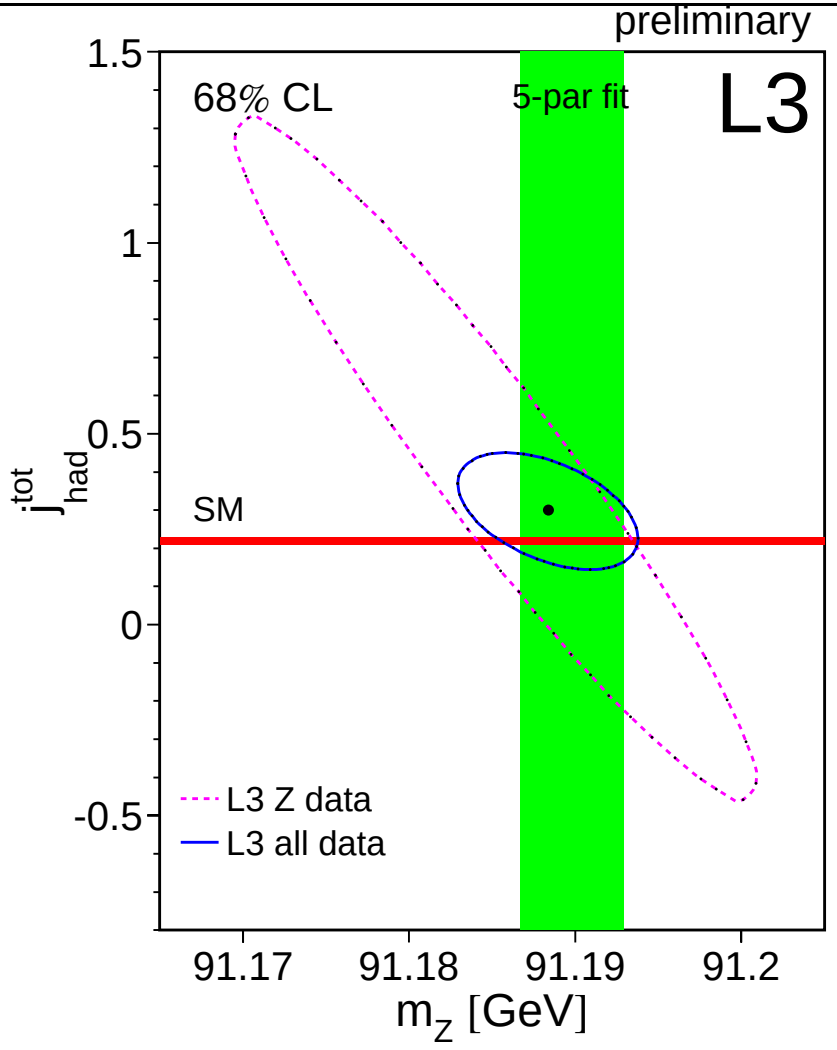
Fraction of colour singlet exchange $<$ 12% (95%C
$\approx$ 10% expected from $p\bar{p}$ and ep



Measure $R_b = \sigma(b\bar{b})/\sigma(q\bar{q})$ for $\sqrt{s'/s} > 0.85$:

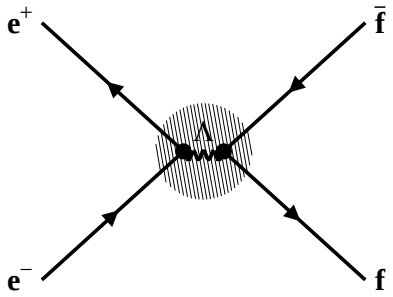


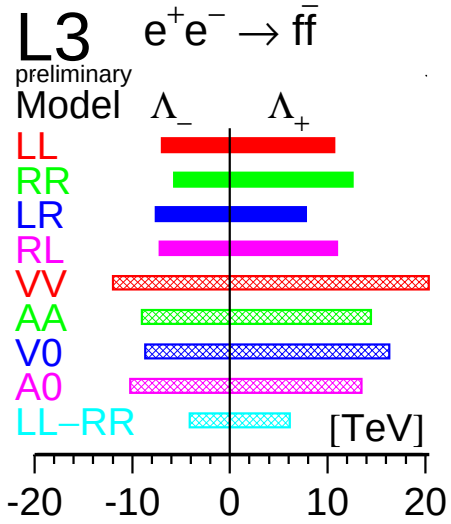




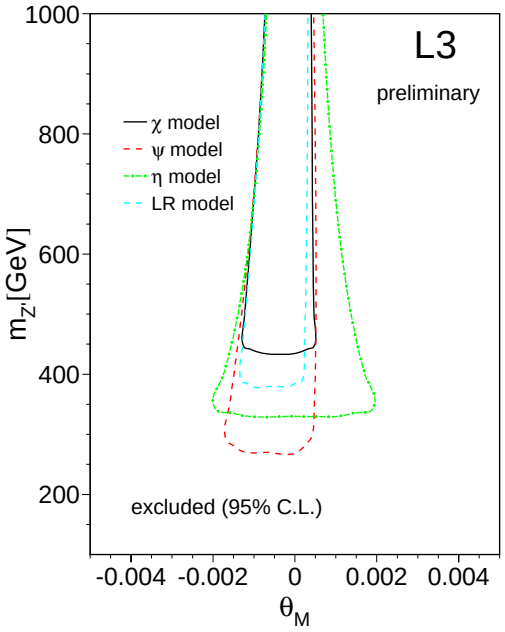
	j^{tot}_{had}	M_Z[MeV]	co
L3 Z data	0.44 ± 0.59	$91\,185.2 \pm 3.1 \pm 9.8$	-0.
L3 → 209GeV	0.30 ± 0.10	$91\,188.4 \pm 3.1 \pm 1.8$	-0.
L3 standard fit	0.22 fixed	$91\,189.5 \pm 3.1$	

Contact interactions:



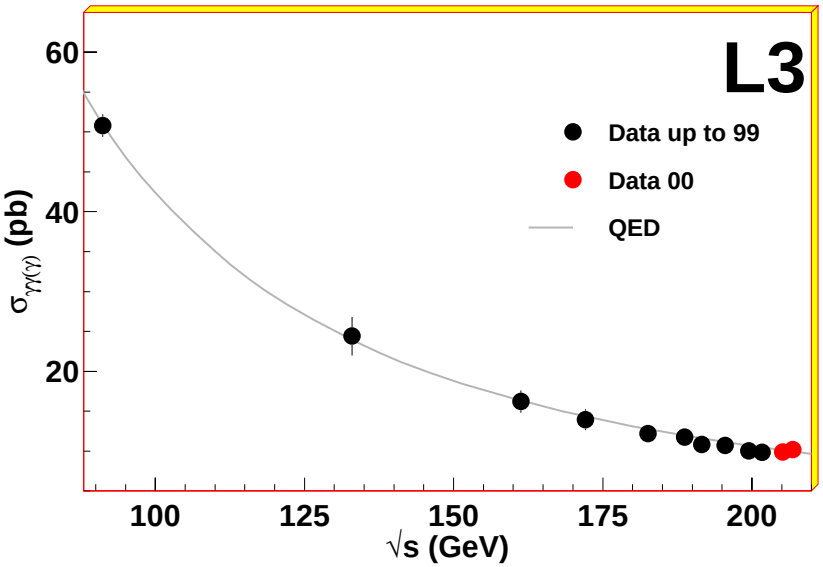


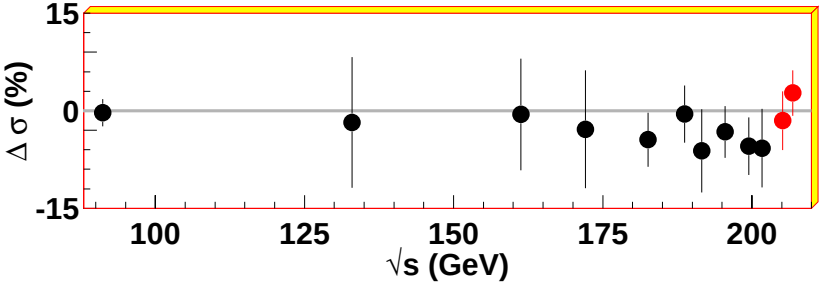
Z-prime boson:



From $f\bar{f}$ measurements and R_b, lower limits (95% CL):

Model	$m_{Z'}$ [GeV]
χ	> 462
ψ	> 275
η	> 330
LR	> 444
SSM	> 1277

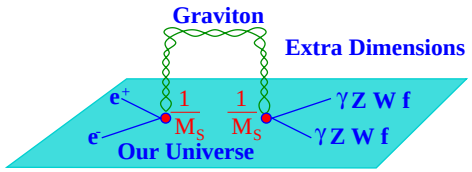




Limits on deviation from QED (95% C.L.):

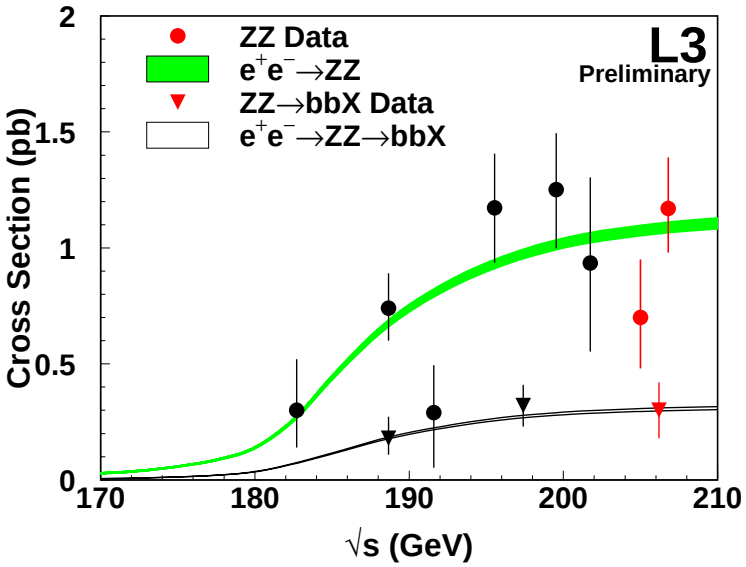
$\Lambda > 1566$ GeV $\quad m_{e^*} > 325$ GeV

Limits on graviton exchange (95% C.L.):

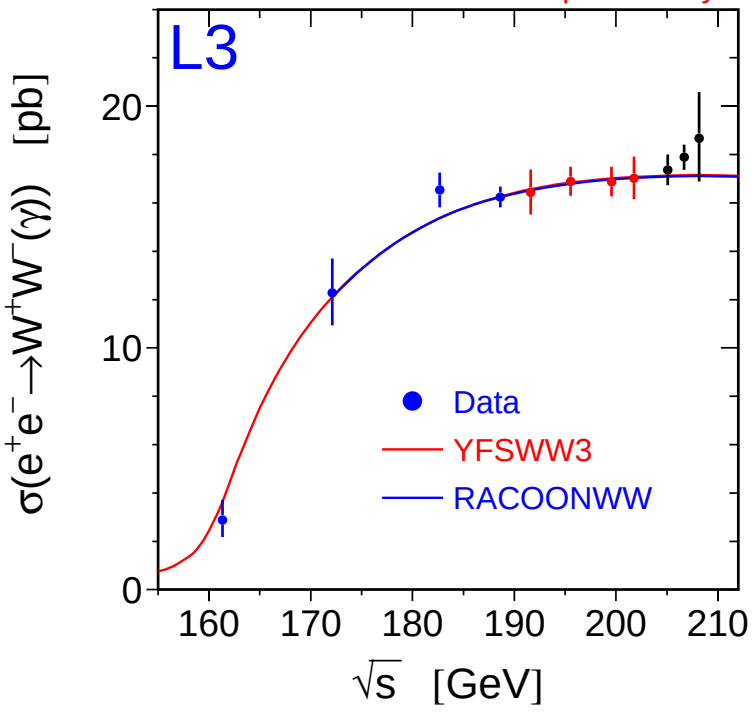


$M_S(\lambda = +1) > 0.84$ Te

$M_S(\lambda = -1) > 0.99$ Te

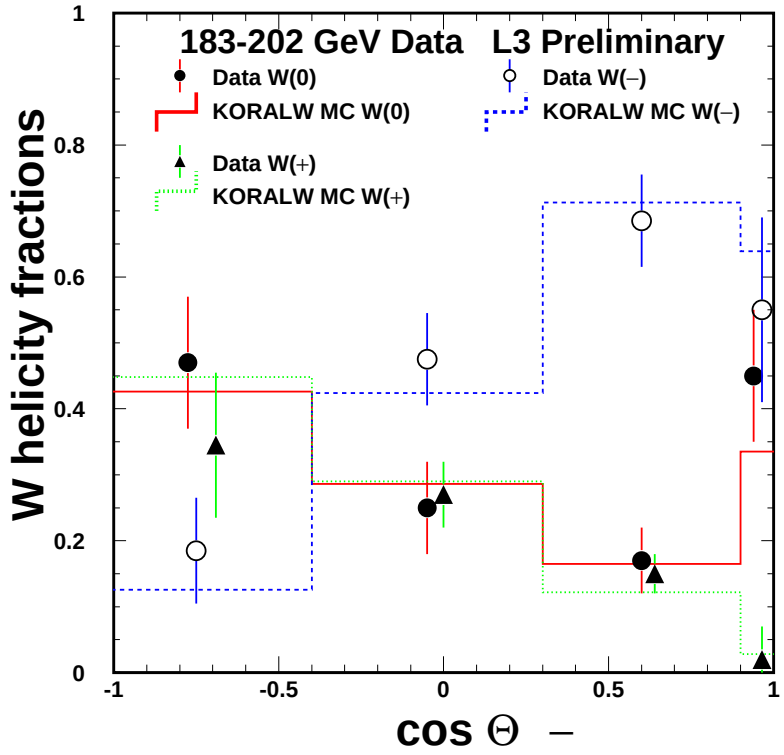


√s ≥ 192 GeV: preliminary

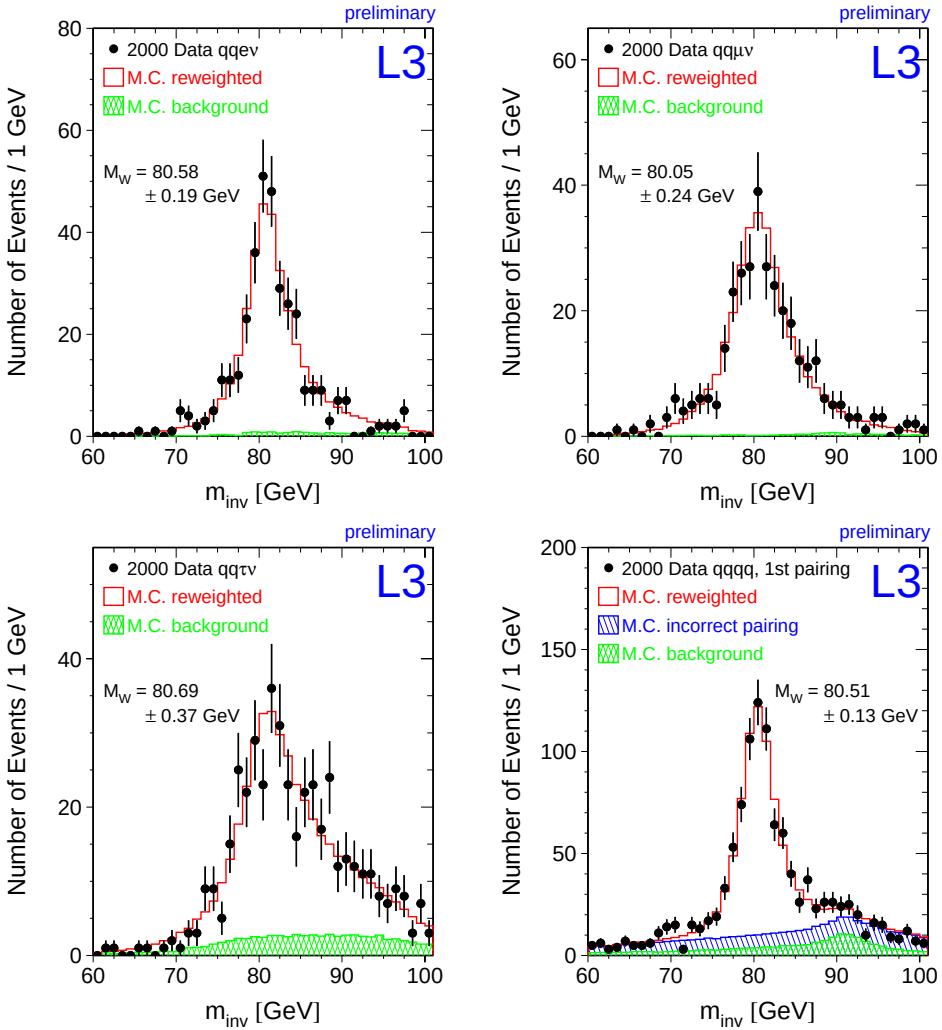


Contributions of W helicity states:

	183-202 GeV		204-209 GeV	
Helicity	L3 [%]	SM [%]	L3 [%]	SM [%]
0	25.9 ± 3.5	24.8	21.6 ± 5.3	22.0
-1	56.2 ± 4.5	57.6	64.7 ± 6.6	62.3
$+1$	17.9 ± 2.3	17.6	13.7 ± 3.4	15.7



W Mass

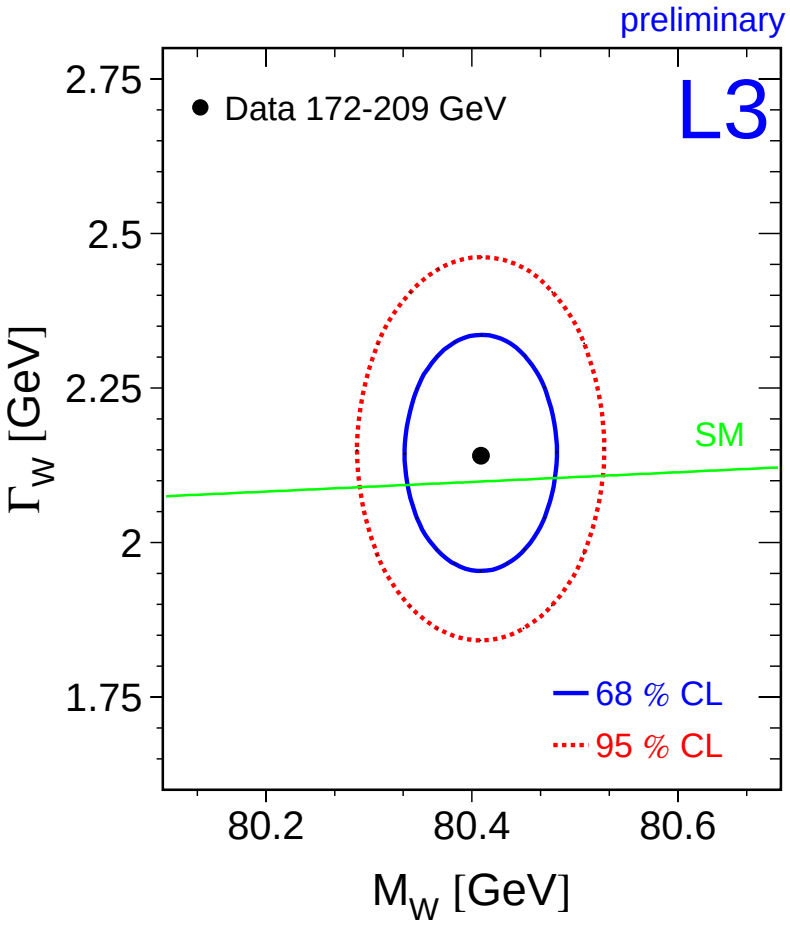


172 GeV - 209 GeV data:

hadronic	$80.478 \pm 0.063 \pm 0.069$ GeV
semileptonic	$80.314 \pm 0.074 \pm 0.045$ GeV
Δ	$0.163 \pm 0.097 \pm 0.046$ GeV

All data combined: $80.398 \pm 0.048 \pm 0.050$ GeV

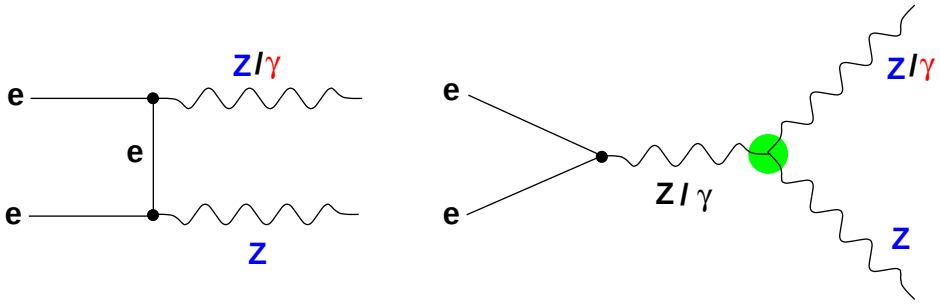
W width



172 GeV - 209 GeV data:

$\Gamma_W = 2.24 \pm 0.11 \pm 0.15$ GeV

Anomalous ZZ and Zγ couplings



Anomalous ZZZ, ZZγ and ZγZ, Zγγ couplings:

CP − violating : $f_4^V \; h_{1,2}^V$

CP − conserving : $f_5^V \; h_{3,4}^V$

V = γ/Z
all values 0 in SM

From event rates & distributions in $e^+e^- \to ZZ$:
1-parameter limits at 95% C.L. (183-209 GeV):

$-0.45 < f_4^\gamma < 0.43$ $\quad -0.76 < f_4^Z < 0.72$

$-0.91 < f_5^\gamma < 0.98$ $\quad -1.41 < f_5^Z < 1.75$

From event rates & γ spectrum in $e^+e^- \to q\bar{q}\gamma$:
1-parameter limits at 95% C.L. (183-202 GeV):

$-0.16 < h_1^\gamma < 0.05$ $\quad -0.16 < h_1^Z < 0.07$

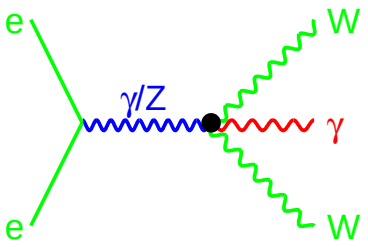
$-0.04 < h_2^\gamma < 0.09$ $\quad -0.05 < h_2^Z < 0.10$

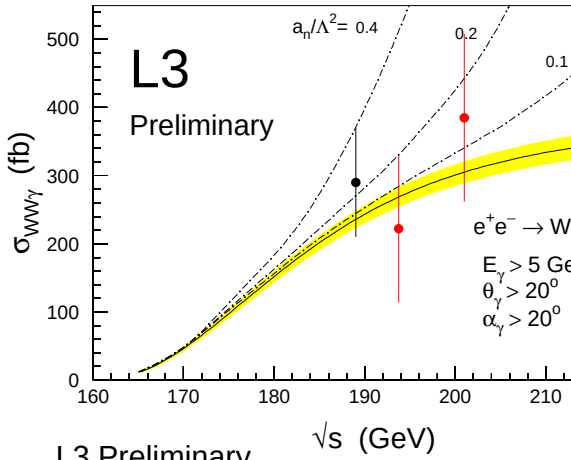
$-0.12 < h_3^\gamma < 0.00$ $\quad -0.19 < h_3^Z < 0.13$

$-0.00 < h_4^\gamma < 0.08$ $\quad -0.07 < h_4^Z < 0.12$

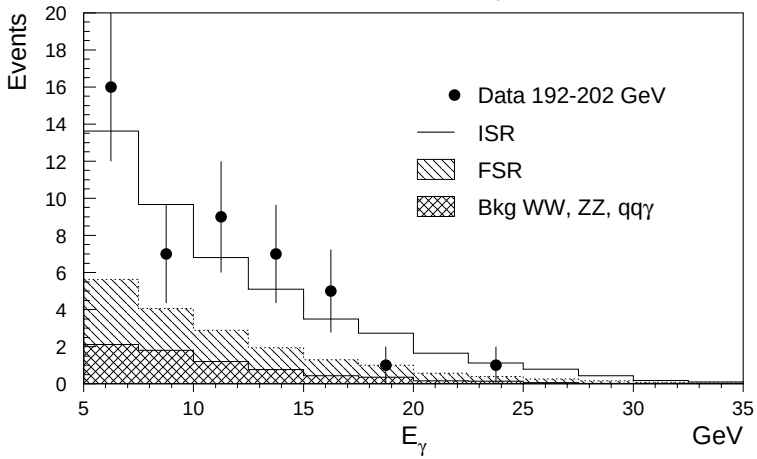
Anomalous quartic couplings: $W^+W^-\gamma$

Anomalous couplings: a_0, a_c CP-conserving, a_n CP-vio





L3 Preliminary

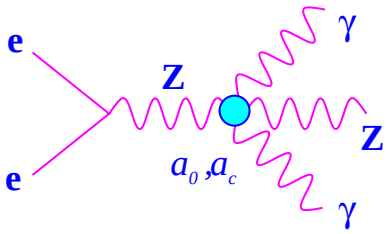


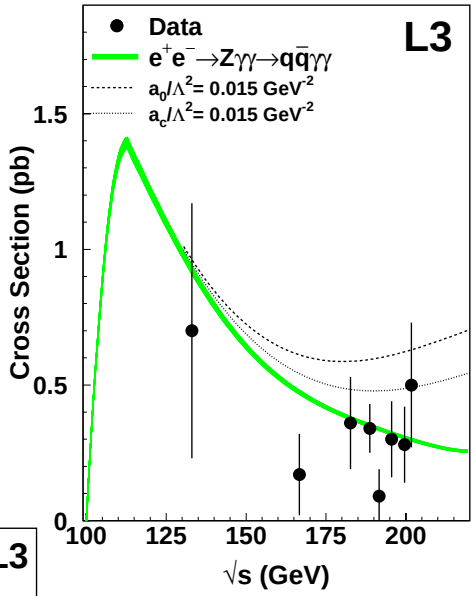
1-parameter 95% C.L. limits at 200 GeV [1/ GeV^2]

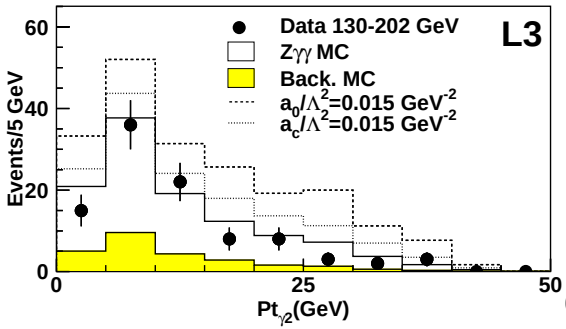
$-0.310 < a_n/\Lambda^2 < 0.290$

$-0.035 < a_0/\Lambda^2 < 0.036$

$-0.068 < a_c/\Lambda^2 < 0.096$





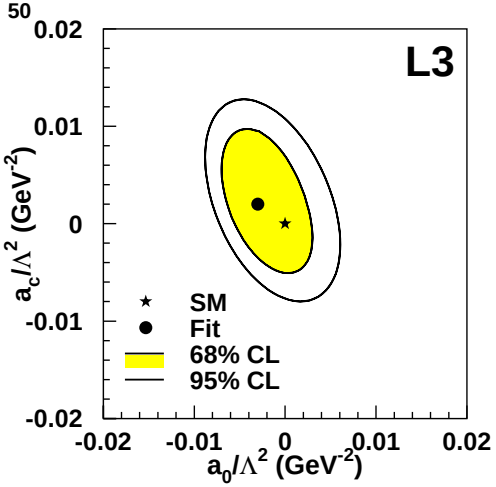


No evidence for anomalous QGC

1-parameter limits (95%CL) [1/ GeV^2]:

$-0.008 < a_0/\Lambda^2 < 0.005$

$-0.007 < a_c/\Lambda^2 < 0.011$



Basic assumptions for MSSM searches:

- R-parity conservation → pair production of Sparticles
- Lightest SParticle (LSP) is $\tilde{\chi}_1^0$, → stable, invisible

Event characteristics:

sleptons: $e^+e^- \to \tilde{\ell}\tilde{\ell} \to \ell\ell\tilde{\chi}_1^0\tilde{\chi}_1^0$ $\not{E}$ and: 2 le

charginos: $e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^- \to W^*W^*\tilde{\chi}_1^0\tilde{\chi}_1^0$

$\not{E}$ and: 4 jets or 2 jets, 1 lepton or 2 le

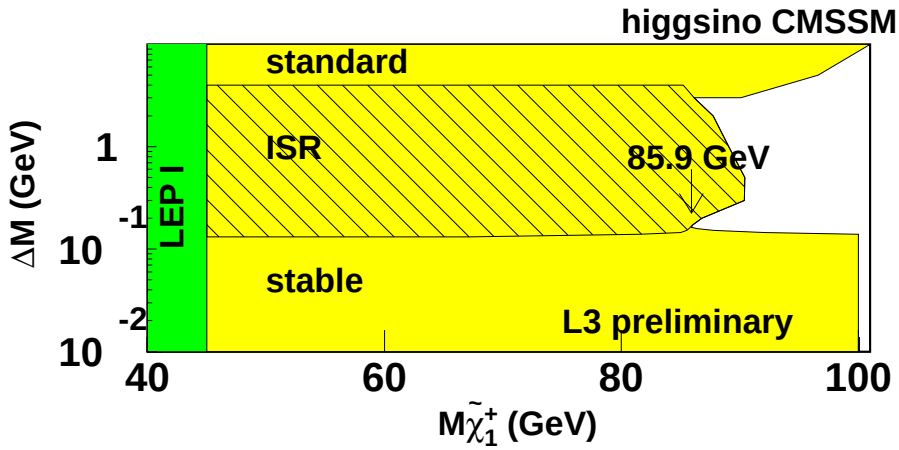
neutralinos: $e^+e^- \to \tilde{\chi}_2^0\tilde{\chi}_1^0$ $\not{E}$ and: 2 jets or 2 le

Analyses depend on $\Delta M = (M_{Sparticle} - MLSP)$

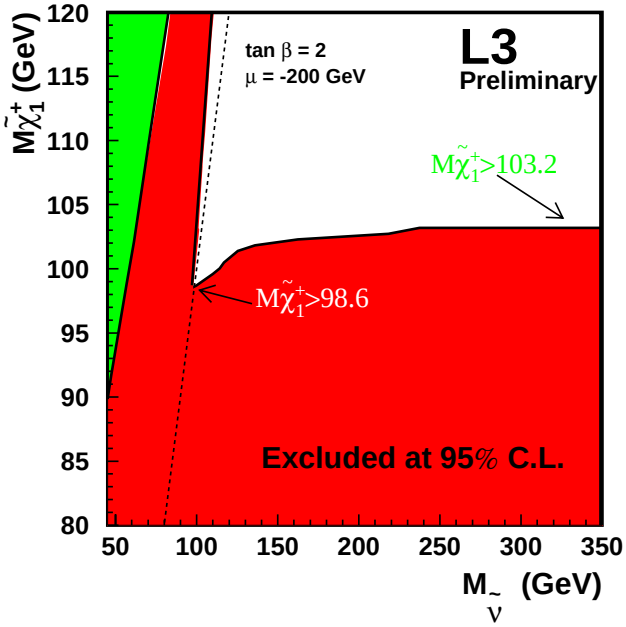
	Low ΔM		Medium ΔM		High ΔM		.OR.	
N	data	exp	data	exp	data	exp	data	ex
$\tilde{e}$	21	24.8	8	10.7	15	19.4	38	4
$\tilde{\mu}$	39	31.0	16	14.2	26	30.2	73	6
$\tilde{\tau}$	172	160	52	53.4	38	26.5	198	18
$\tilde{\chi}_1^\pm$	55	47.0	33	36.7	24	26.1	112	11
$\tilde{\chi}_2^0$	15	17.7	4	5.7	5	2.9	24	2

No signal seen in year 2000 data

Higgsino like: Mass limit independant of ΔM



Mass exclusion from $\tilde{\chi}_1^\pm$ and slepton searches

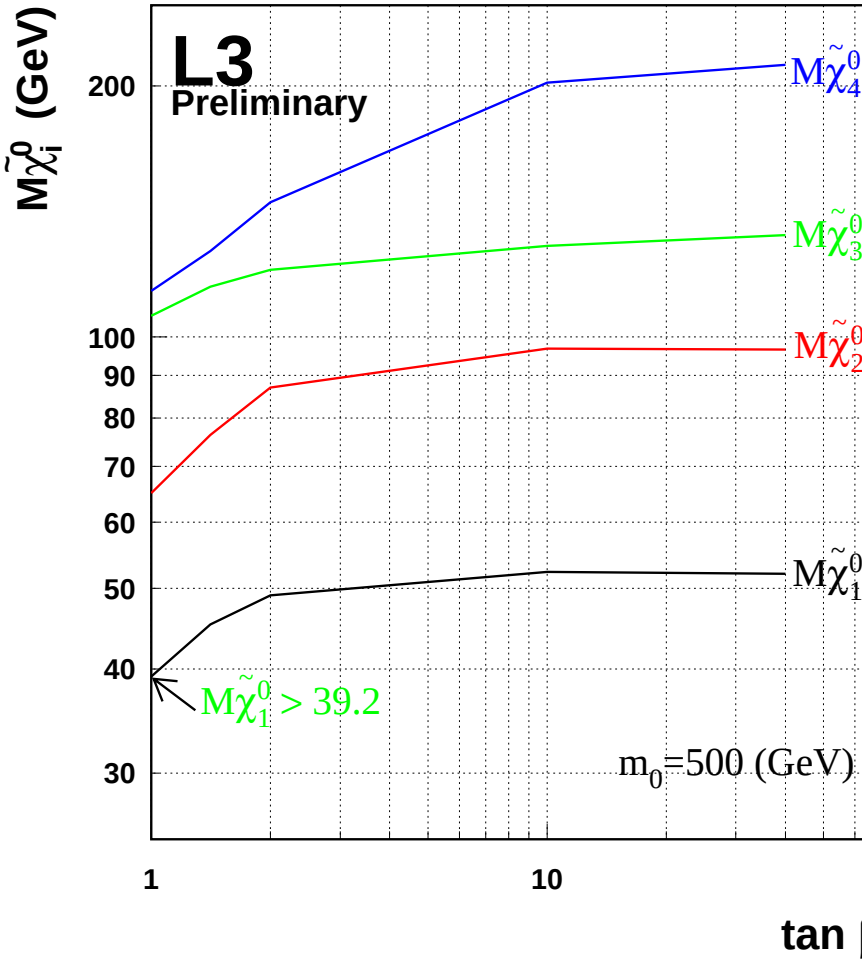


For large $M_{\tilde{\nu}}$:

$M_{\tilde{\chi}_1^\pm} > 103.2$ GeV

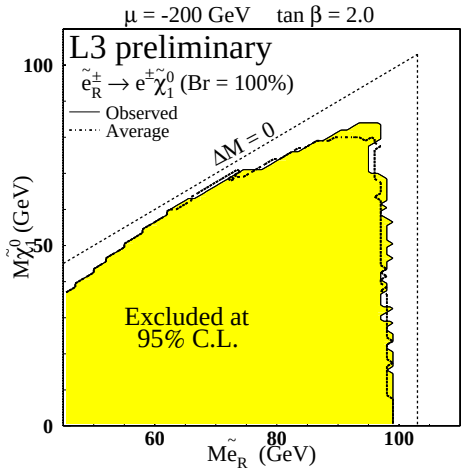
Mass exclusion in the CMSSM, based on results from:

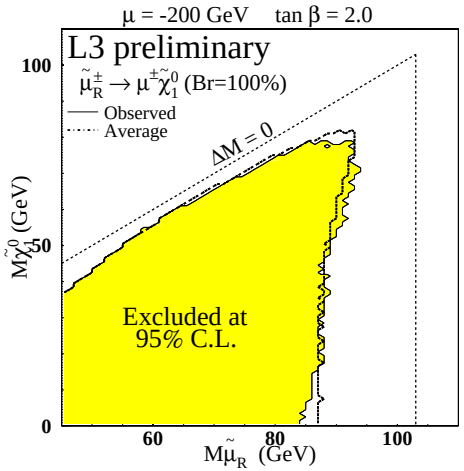
- neutralino search
- chargino search

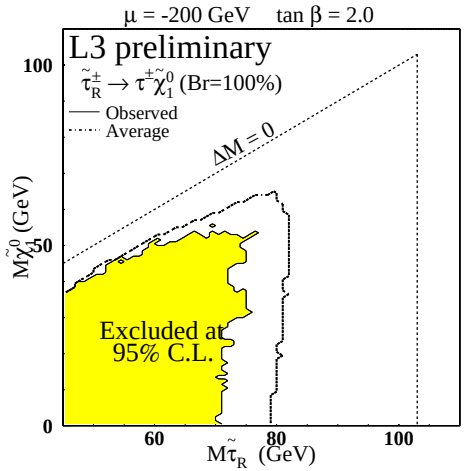


$M_{\tilde{\chi}_1^0} > 39.2$ GeV

For μ=-200 GeV, $\tan\beta$=2, $\Delta M > 10$ GeV







$M_{\tilde{e}_R} > 97$ GeV

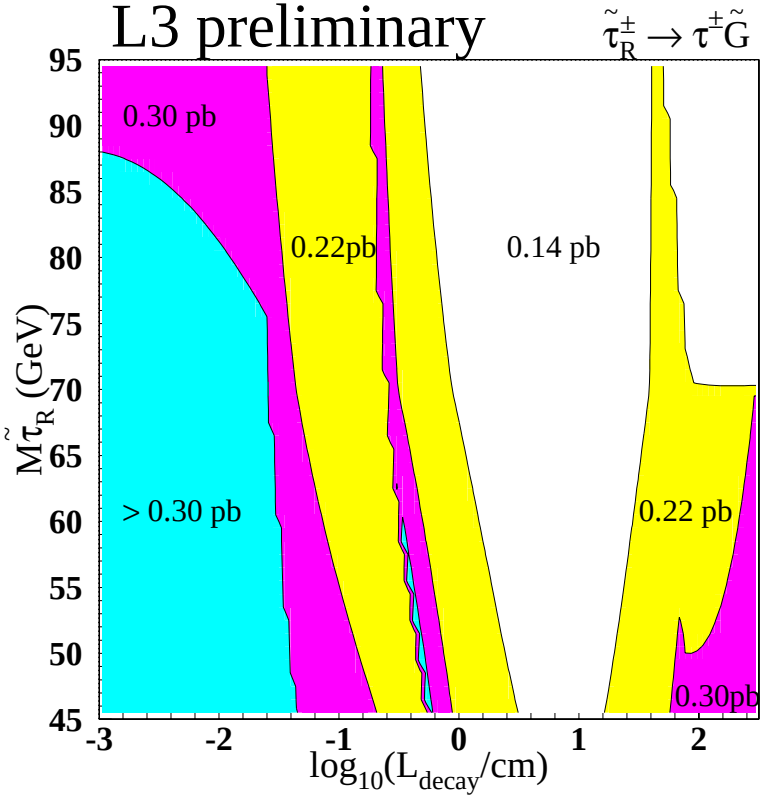
$M_{\tilde{\mu}_R} > 85$ GeV

$M_{\tilde{\tau}_R} > 71$ GeV

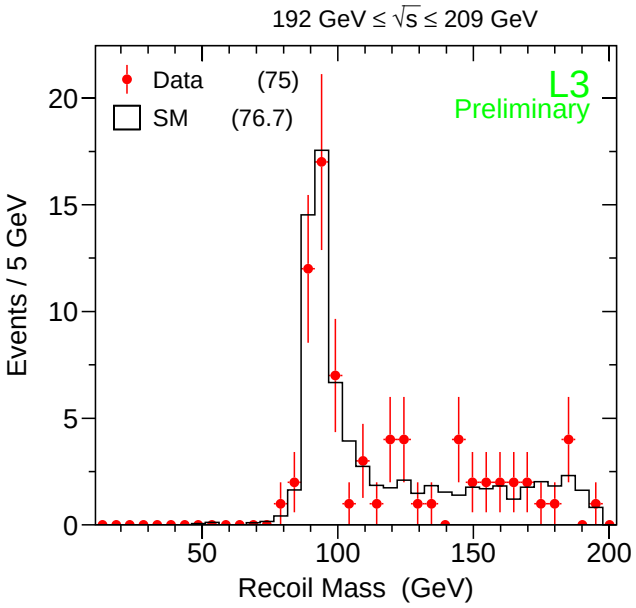
Reaction: $e^+e^- \to \tilde{\tau}\tilde{\tau} \to \tilde{G}\tilde{G}\tau\tau$

Selection depending on decay length L

L	< 1 mm		> 1 mm		> 5 cm		> 50 cm	
	$\not{E}$		DCA $\neq 0$		kink		"stable"	
200 GeV	data	exp	data	exp	data	exp	data	ex
$\tilde{\tau} \to \tilde{G}\tau$	35	39.7	11	16.7	1	0.7	6	5.6

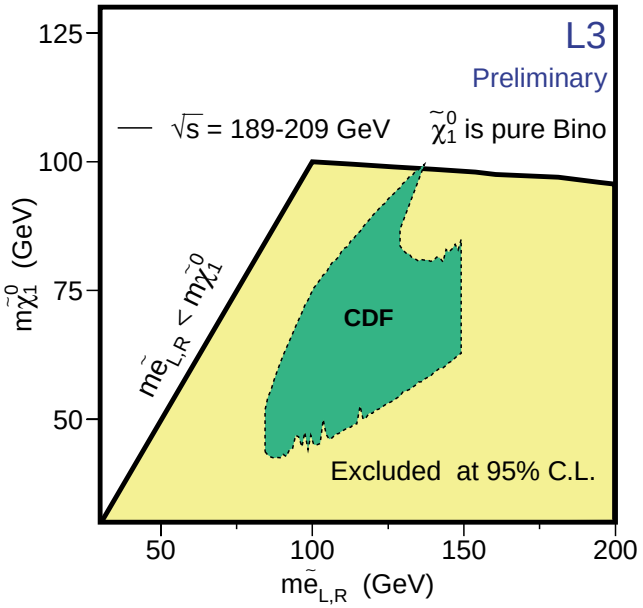


Susy: Acoplanar photons



SM:
$e^+e^- \rightarrow \nu\bar{\nu}\gamma\gamma$

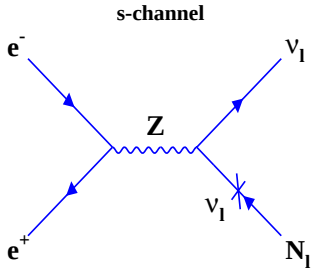
Susy:
$e^+e^- \rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^0$
$\rightarrow \tilde{G}\tilde{G}\gamma\gamma$

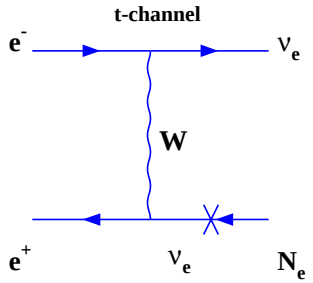


CDF $ee\gamma\gamma$ event
Gravitino LSP
interpretation:
ruled out

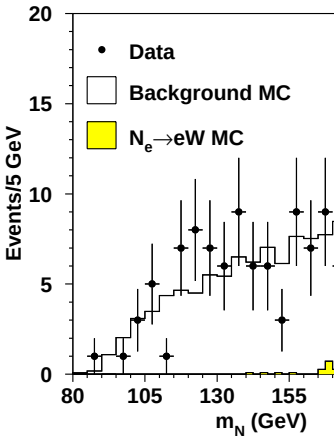
Exotica: Isosinglet heavy neutrinos

Single production: $e^+e^- \rightarrow \nu_e N_e$
Through mixing with isodoublet neutrino

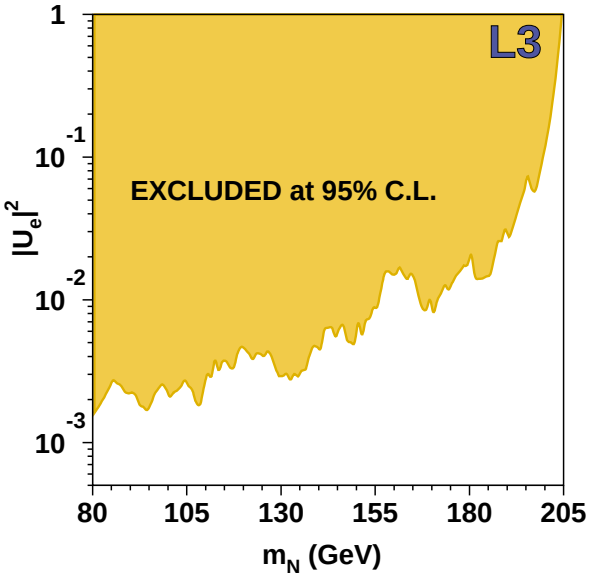




Decay: $N_e \rightarrow eW \rightarrow eqq'$



Limit on mixing amplitude:



Mass limits in GeV at 95% C.L.:
close to the kinematic limit

Neutral: $e^+e^- \rightarrow L^0\bar{L}^0$

Decay	Model	Dirac	Majorana
	Sequential	101.3	89.5
$L^0 \rightarrow eW$	Vector	102.6	—
	Mirror	100.8	89.5
	Sequential	101.5	90.7
$L^0 \rightarrow \mu W$	Vector	102.7	—
	Mirror	101.0	90.7
	Sequential	90.3	80.5
$L^0 \rightarrow \tau W$	Vector	99.3	—
	Mirror	90.3	80.5

Charged: $e^+e^- \rightarrow L^+L^-$

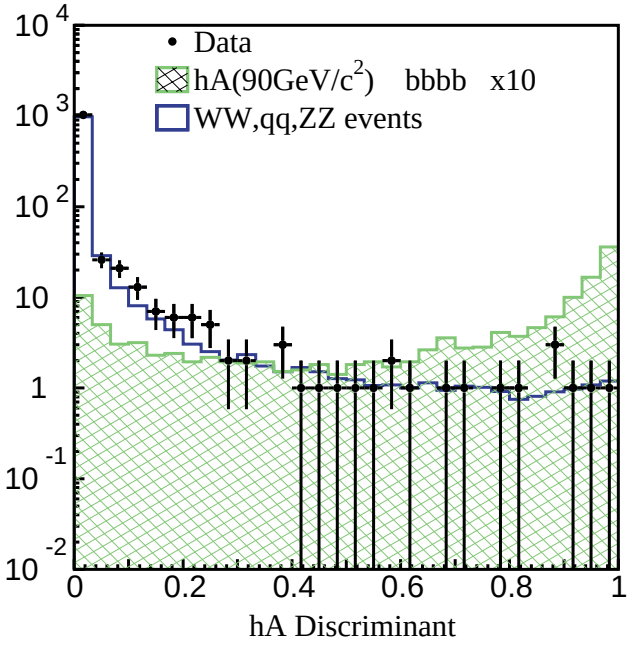
Decay	Model	Limit
	Sequential	100.8
$L^\pm \rightarrow \nu W$	Vector	101.2
	Mirror	100.5

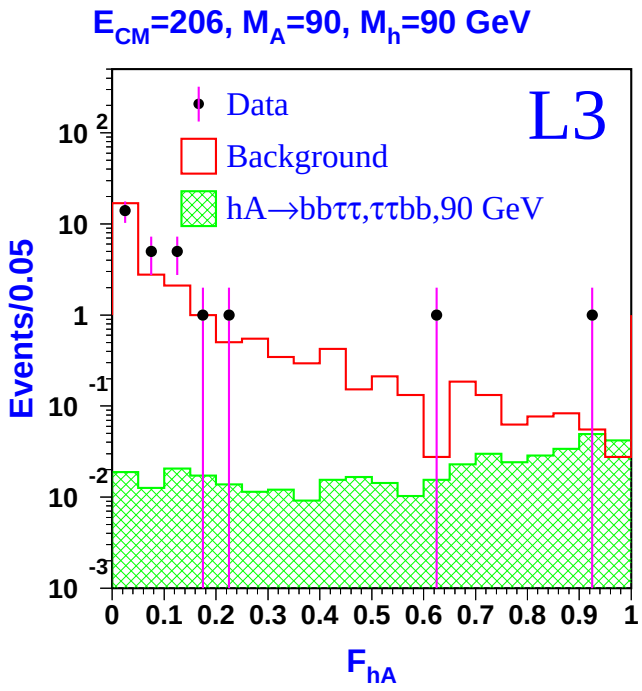
Analysis ongoing

No new results released

Production: $e^+e^- \rightarrow hZ,\ hA$

Decay: $h, A \rightarrow b\bar{b}$(dominant),$\tau^+\tau^-$

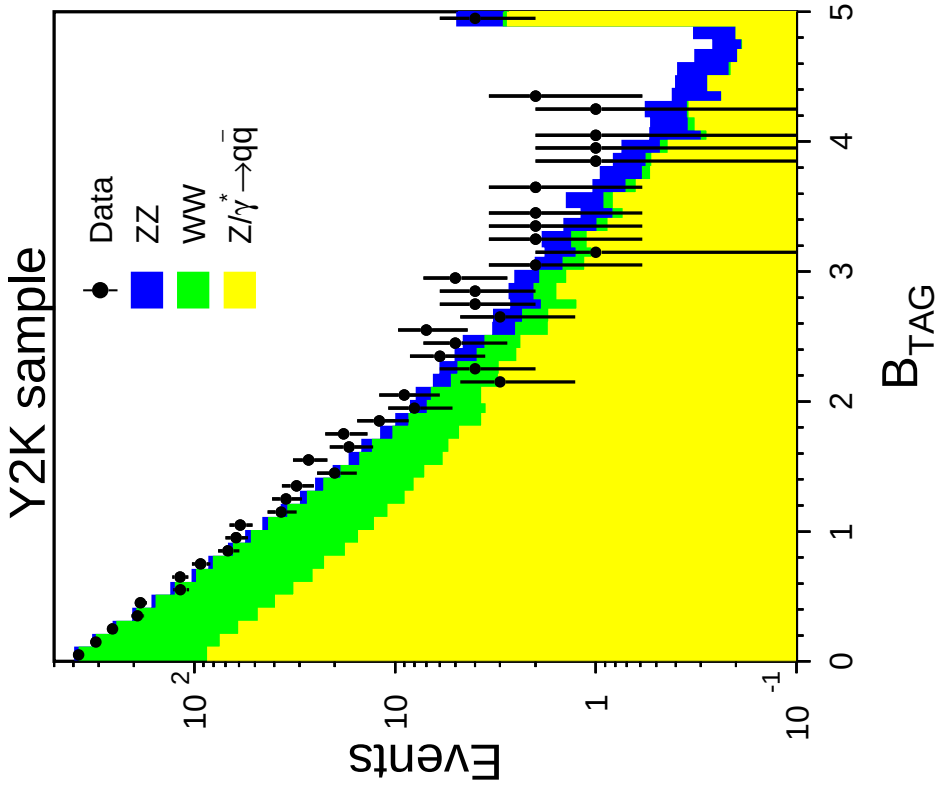


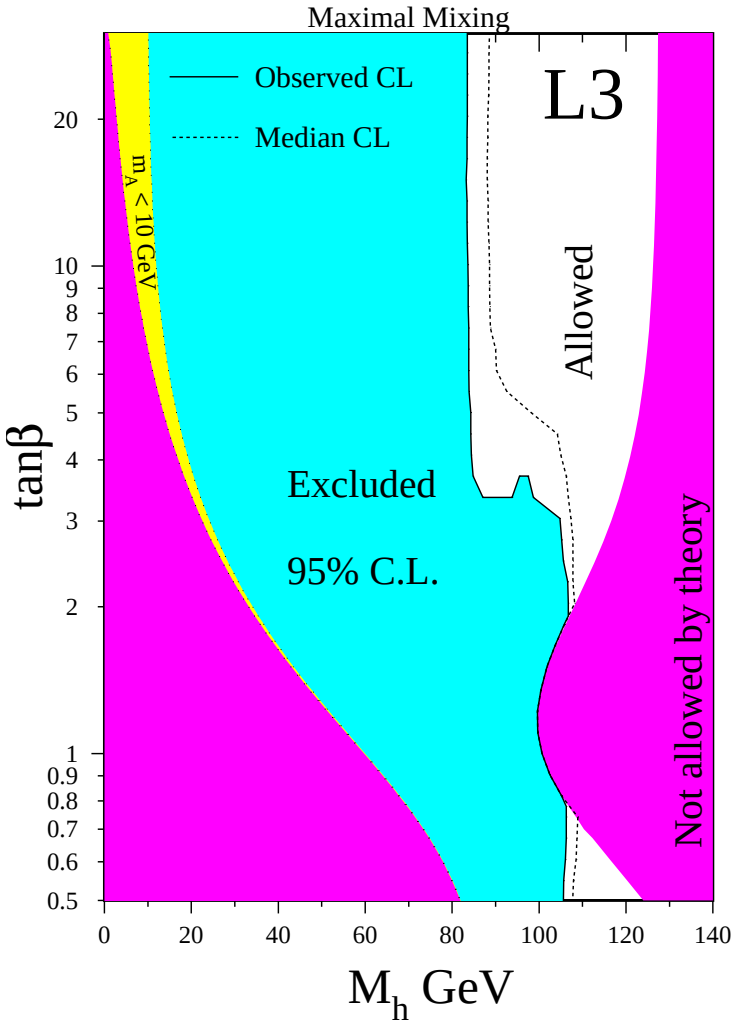


Standard Model Higgs

Improvements since Physics Letters B495 (2000) 18:

- Reconstruction with final calibrations
- Monte-Carlo including detector efficiencies





Exclusions at 95% C.L.:

$M_h > 83.7$ GeV (88.1 GeV expected)

$M_A > 83.9$ GeV (88.3 GeV expected)

$0.77 < \tan\beta < 1.9$ excluded

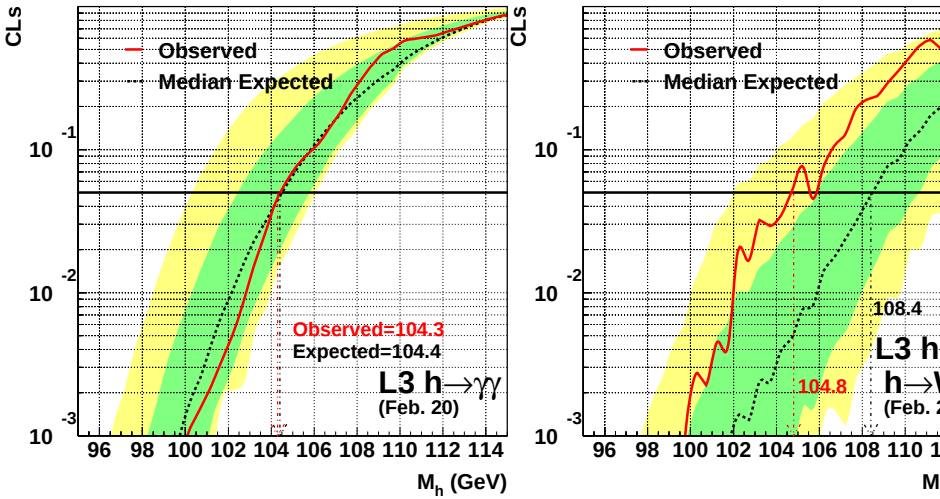
Production: $e^+e^- \to Zh$

$h \to \gamma\gamma$, $Z \to$

qq		$\nu\nu$		e^+e^-		$\mu^+\mu^-$		$\tau^+\tau^-$	
data	exp	data	exp	data	exp	data	exp	data	e
56	65.8	4	5.9	2	4.2	2	3.5	2	2

$h \to WW^* \to$

	$qqqq$		$qql\nu$	
$Z \to$	data	exp	data	exp
qq	81	70.9	43	36.5
$\nu\nu$	10	5.4	10	5.7

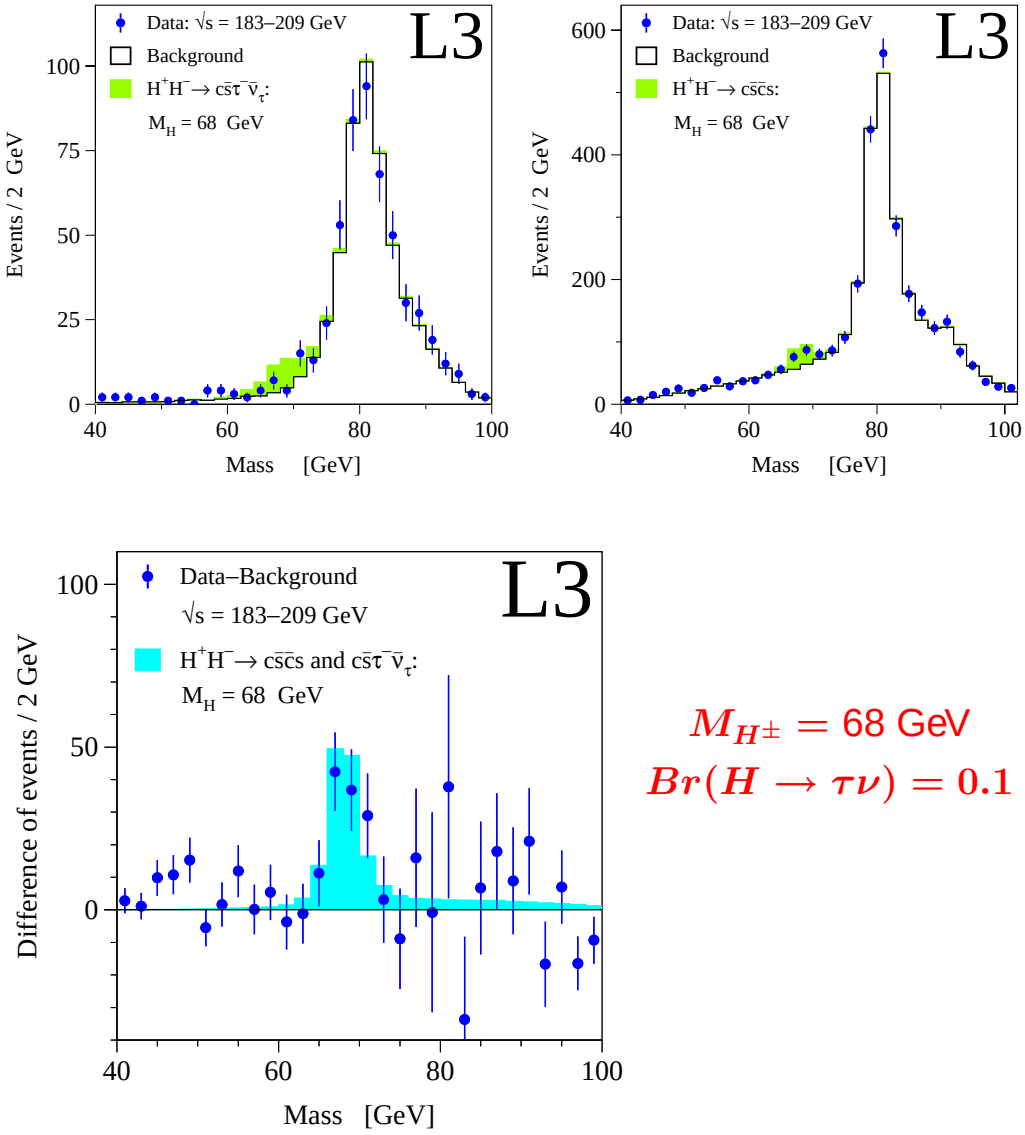


No evidence for fermiophobic Higgs

$M_h > 104.8$ GeV (at 95% C.L.)

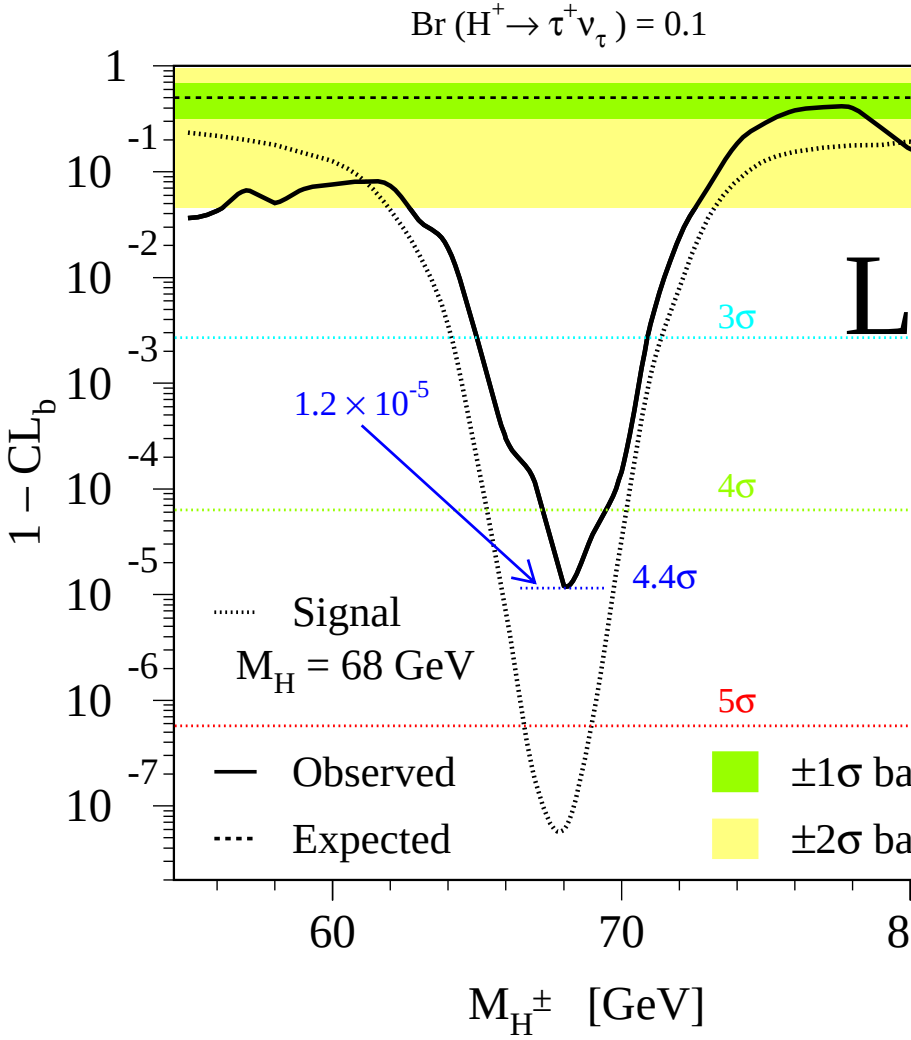
Production: $e^+e^- \rightarrow H^+H^-$ Decay: $H^\pm \rightarrow cs, \tau\nu$

All three decay channels studied. No anti-b-tag applied.



$M_{H^\pm} = 68$ GeV

$Br(H \rightarrow \tau\nu) = 0.1$



Increased from 2.7σ measured with data up to 202 G

- Successful running for 12 years!
- A very exciting last year
- Thanks to the CERN accelerator divisions and technical staff
- L3 is relying on ongoing support from CERN to continue and finish the analyses