L3 Results up to 208 GeV

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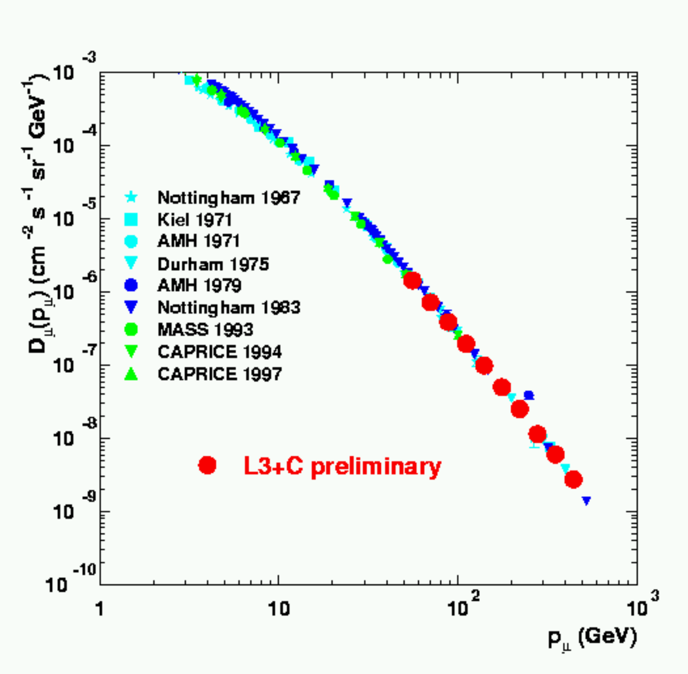
Université de Genève

On behalf of the L3 Collaboration

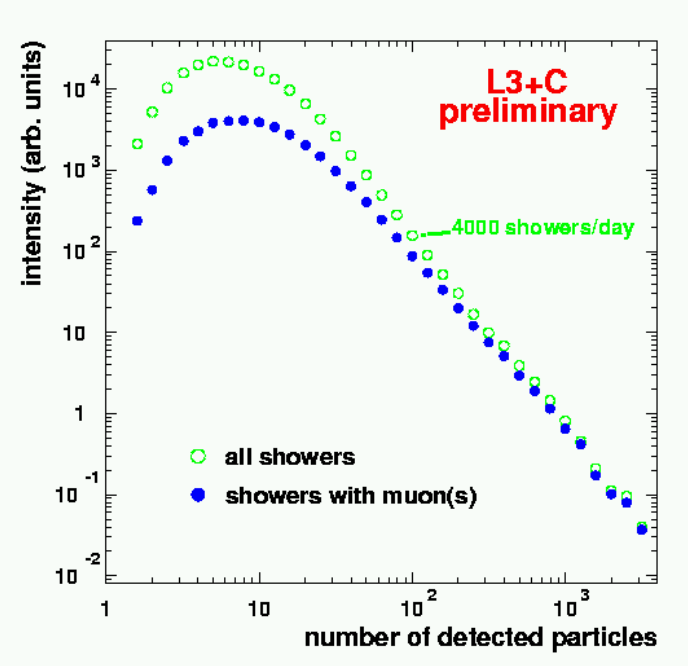
October 10th, 2000

Most of the results are preliminary.

In parallel with the main physics stream.



Differential momentum spectrum for vertical muons

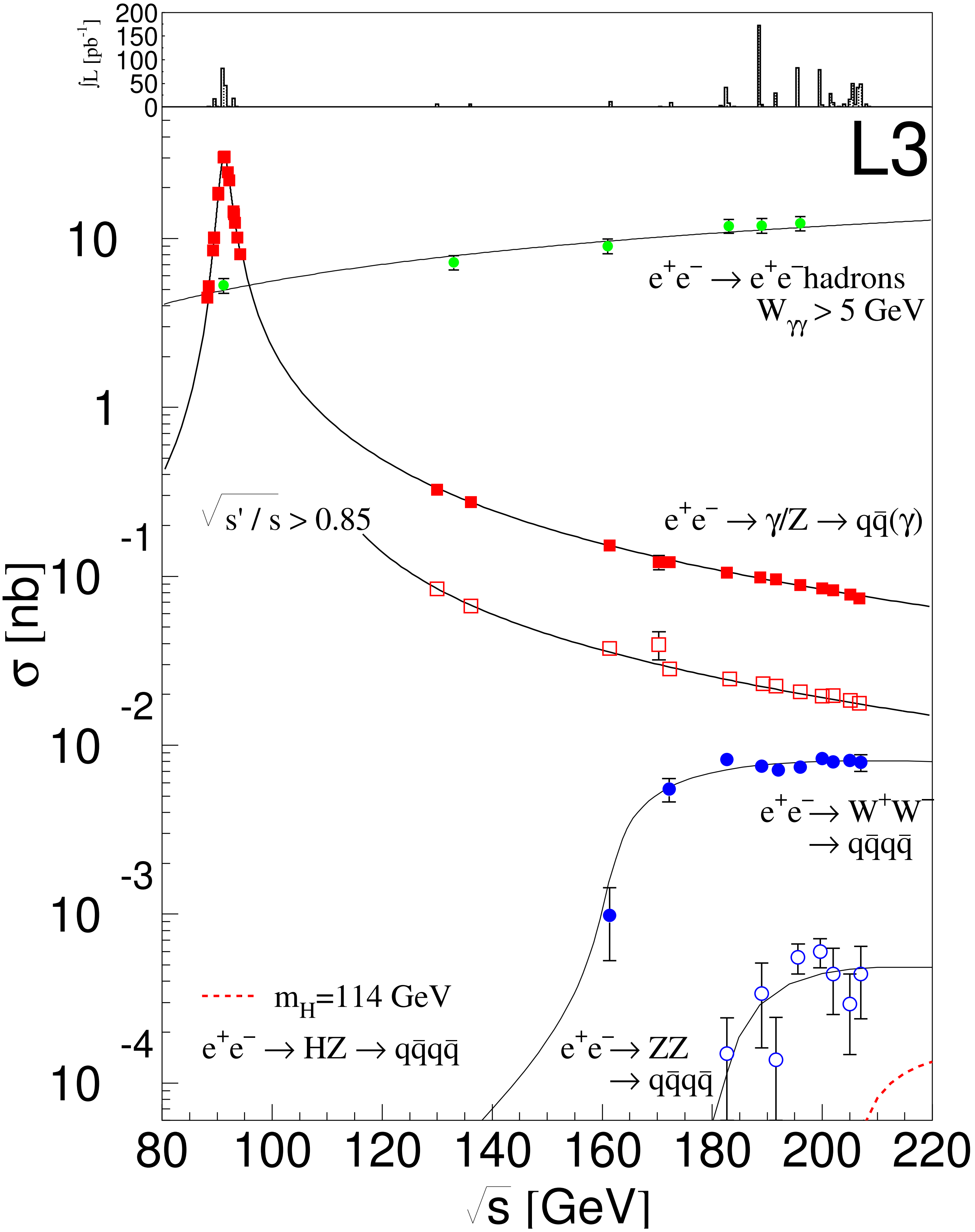


Coincidence with shower array

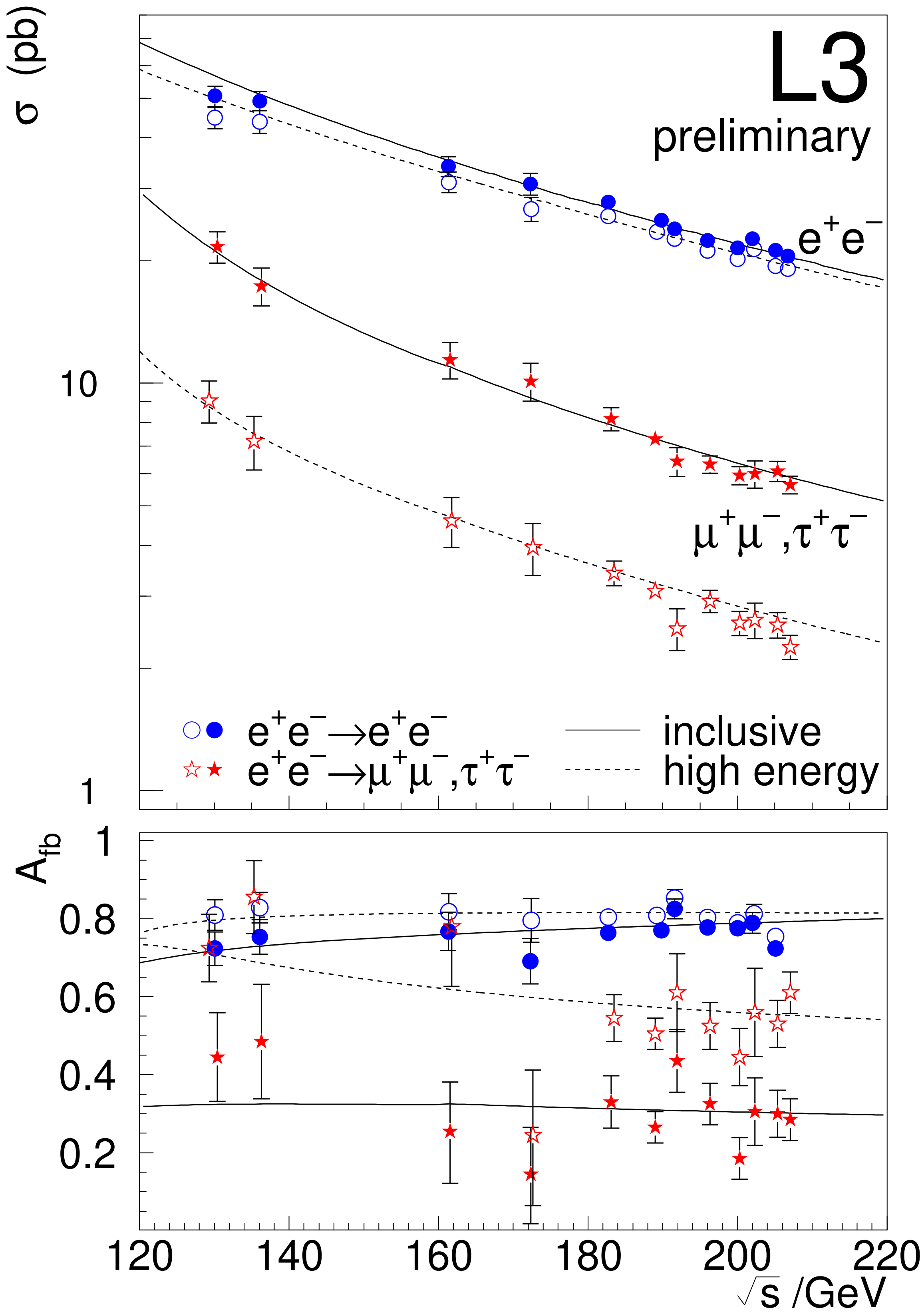
Final result: 10^{10} events, 20 GeV $\leq p_\mu \leq 2$ TeV,
$<$1% stat and 2.5% syst errors.

Accurate measurements necessary for atmospheric ν.

12 years of data taking

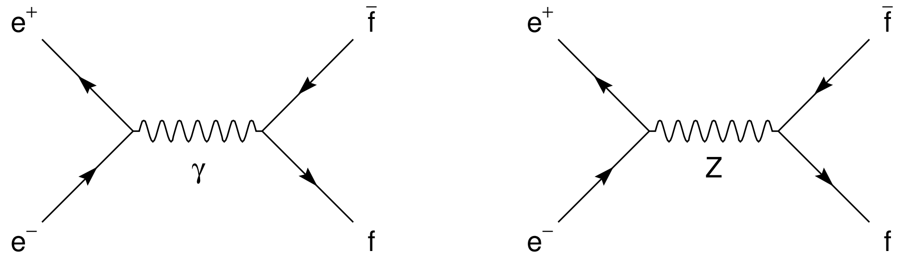


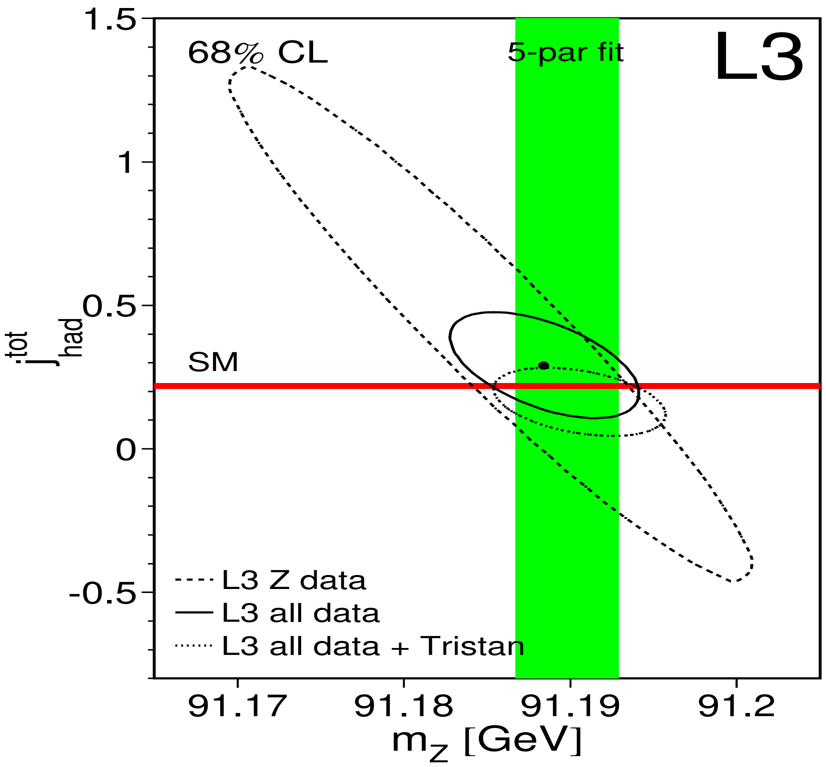
Fermion Pair Production - Leptons



Model-independent Z-mass

Hadronic γ—Z interference term j_{had}^{tot}

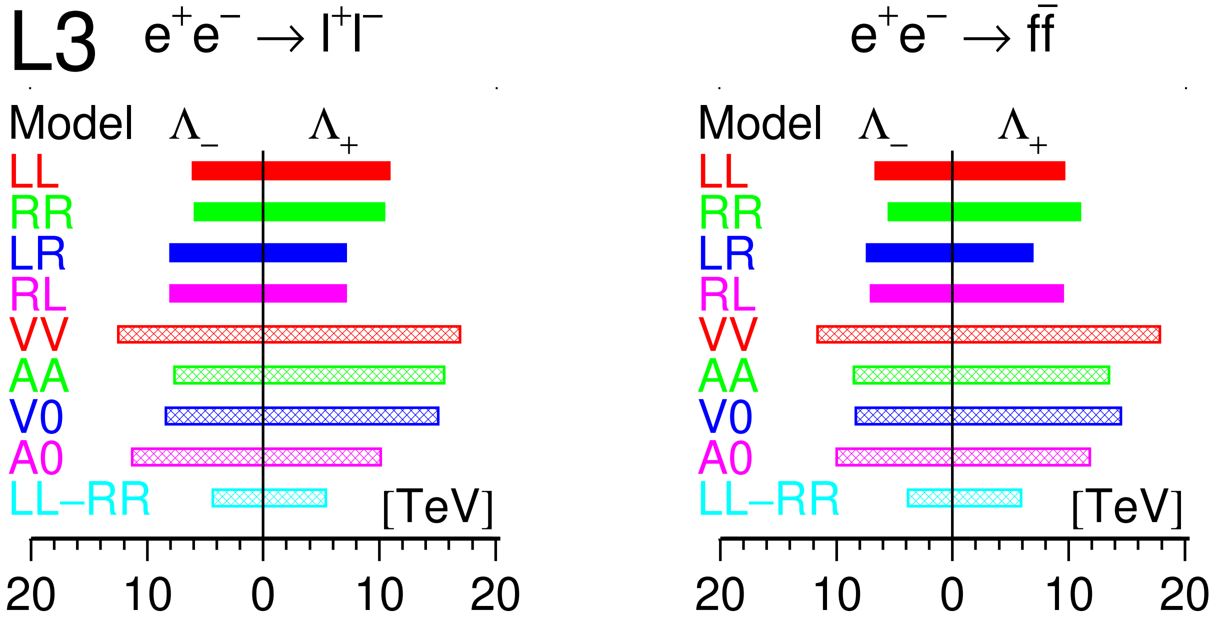


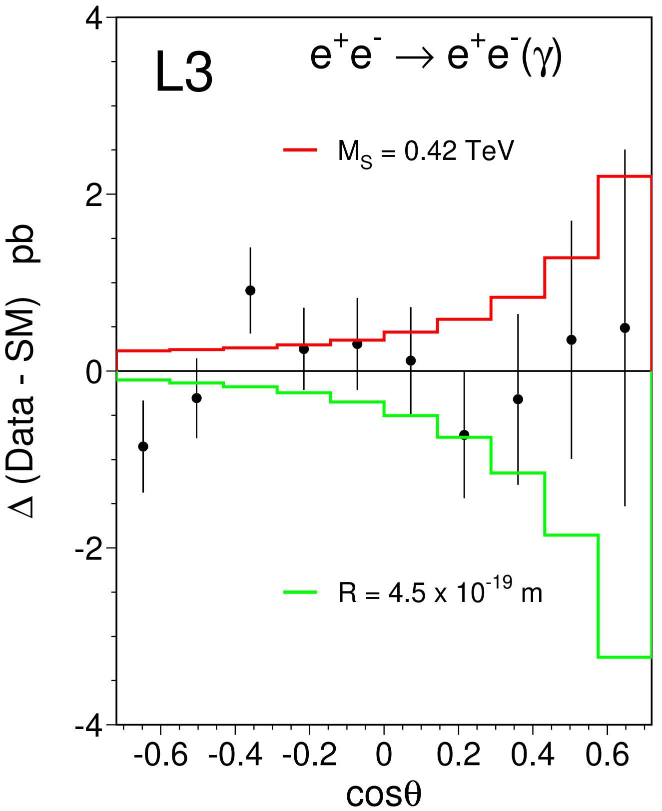


Data	j_{had}^{tot}	M_Z [MeV]
Z pole	0.44 ± 0.59	91185.2 ± 10.3
$\sqrt{s} \rightarrow 208$ GeV	0.29 ± 0.12	91188.4 ± 3.7
Standard Analysis	0.22 fixed	91189.5 ± 3.1

Contact interactions:

$$\mathcal{L} = \frac{1}{1+\delta_{ef}} \sum_{i,j=\mathrm{L,R}} \eta_{ij} \frac{g^2}{\Lambda_{ij}^2} (\bar{e}_i \gamma^\mu e_i)(\bar{f}_j \gamma_\mu f_j)$$

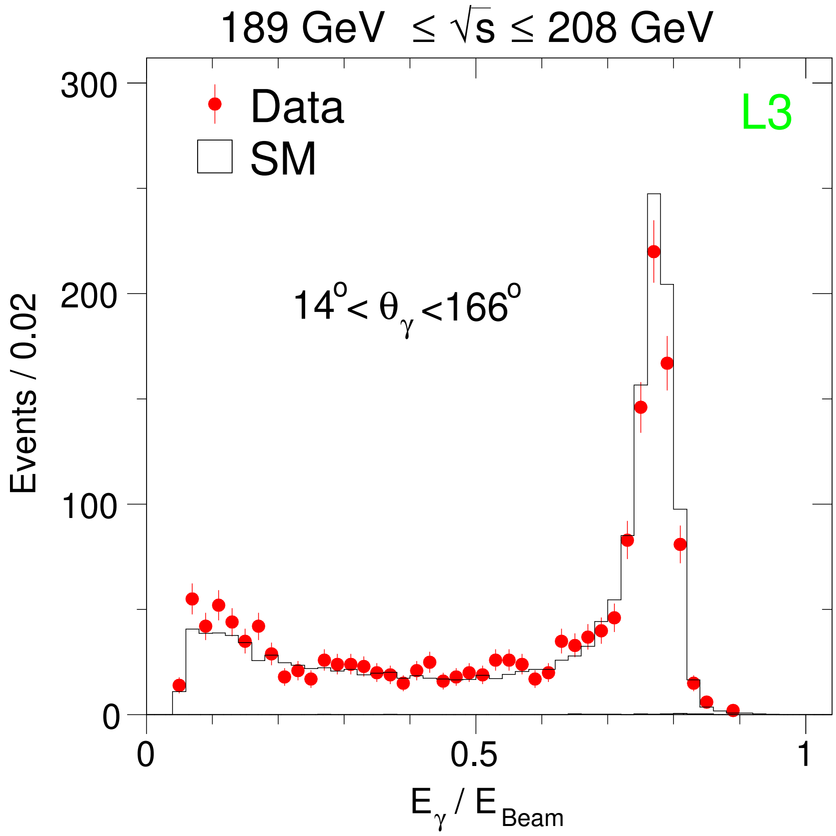


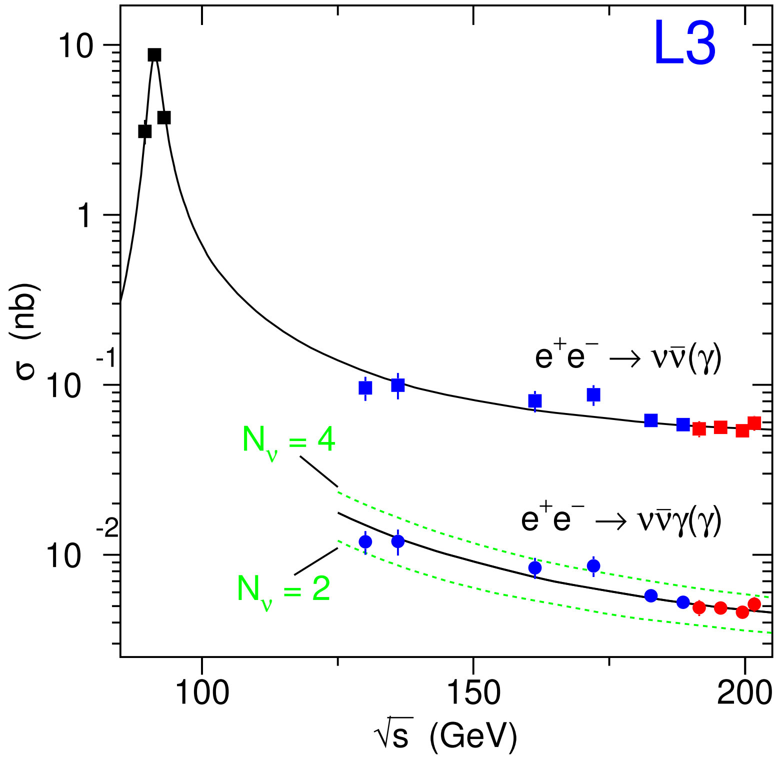


String theory
of Quantum Gravity
$M_S > 0.49$TeV

Fermion radii:
$< 2 \times 10^{-19}\ m \quad (e^+e^- \longrightarrow l^+l^-)$
$< 3 \times 10^{-19}\ m \quad (e^+e^- \longrightarrow q\bar{q})$

$e^+e^- \to \nu\bar{\nu}\gamma$





From single photon:

N_ν = 2.86 ± 0.13 (LEP 2)

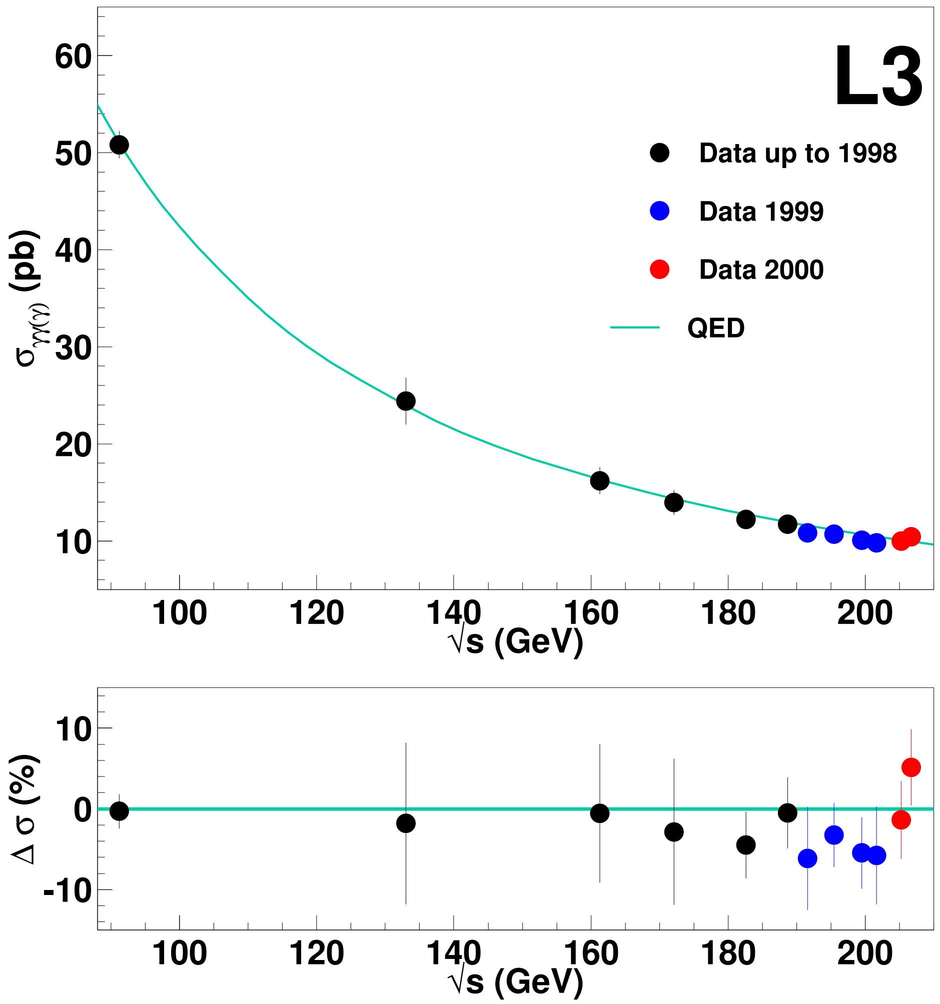
N_ν = 2.98 ± 0.10 (LEP 1)

From Z width:

N_ν = 2.978 ± 0.014

Search for $e^+e^- \to \tilde{G}\tilde{\chi}_1^0 \to \tilde{G}\tilde{G}\gamma$ No signal observed

$e^+e^- \to \gamma\gamma(\gamma)$ and QED Tests



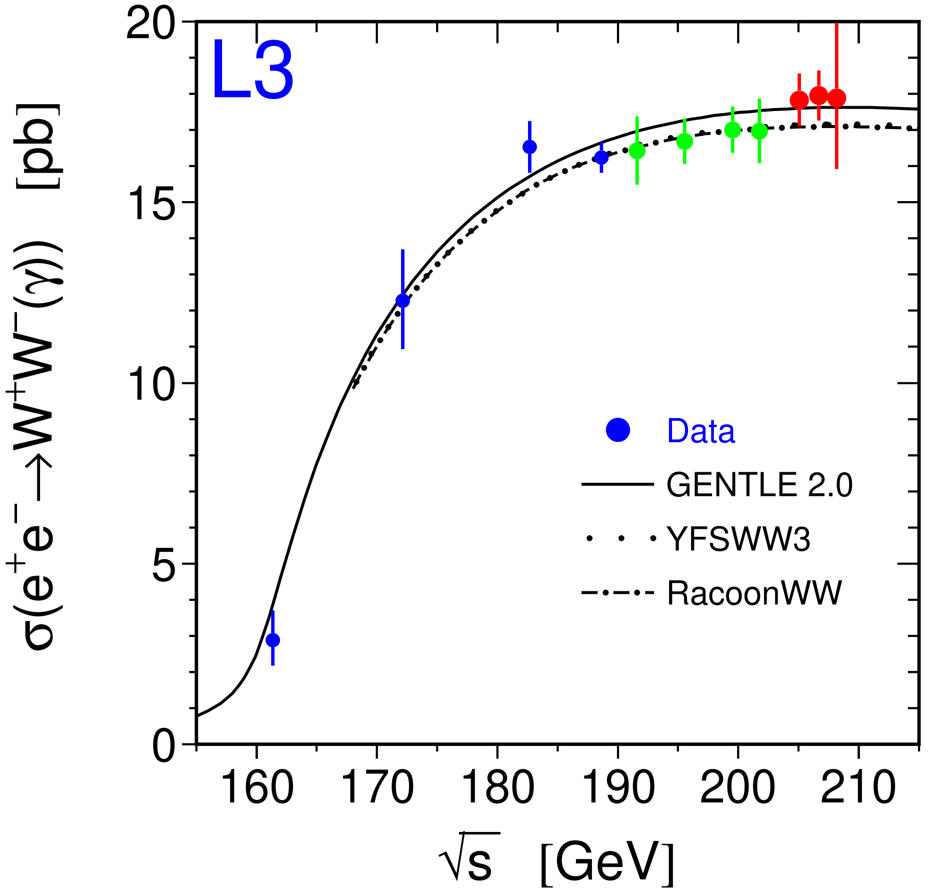
Limits on deviation from QED :

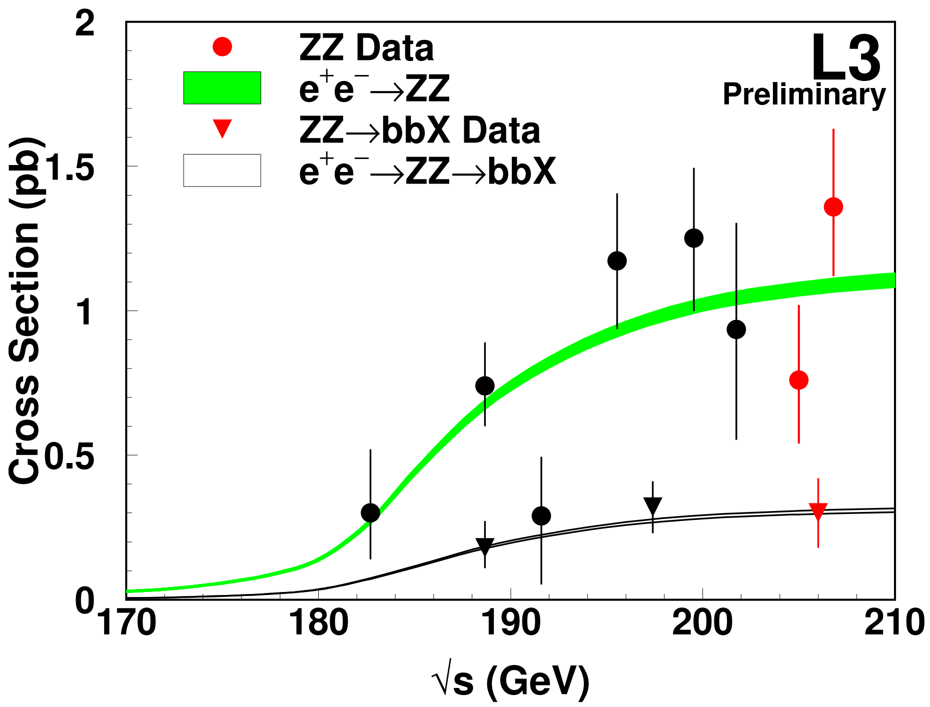
$\Lambda > 1536$ GeV $\quad m_{e^*} > 319$ GeV

Limits on graviton exchange:

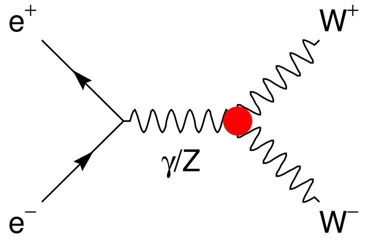
$M_S(\lambda = +1) > 0.84$ TeV

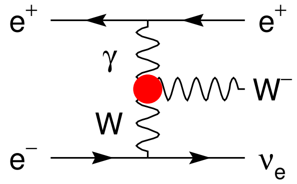
$M_S(\lambda = -1) > 0.95$ TeV

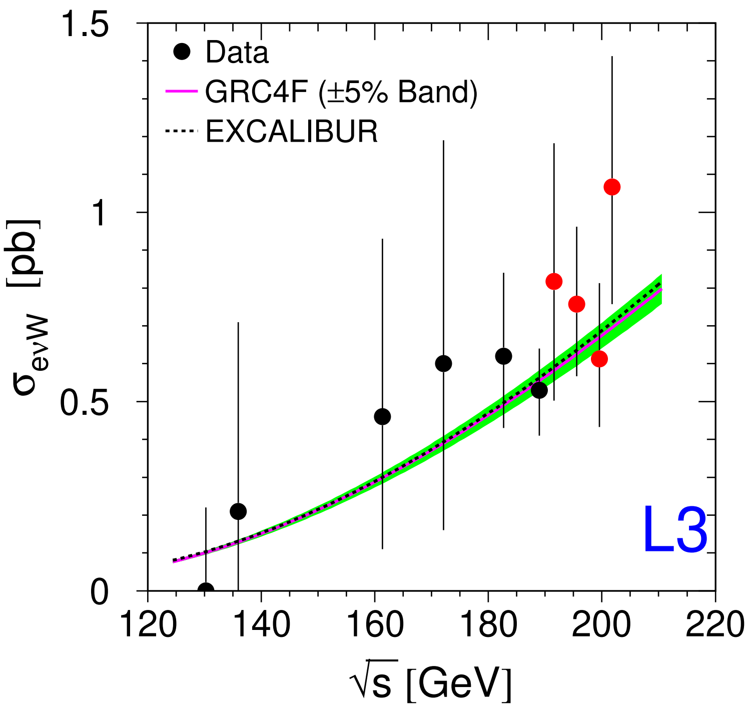

L3
Data
GENTLE 2.0
YFSWW3
RacoonWW
σ(e+e−→W+W−(γ)) [pb]
√s [GeV]
0
5
10
15
20
160
170
180
190
200
210


ZZ Data
e+e−→ZZ
ZZ→bbX Data
e+e−→ZZ→bbX
L3
Preliminary
Cross Section (pb)
√s (GeV)
0
0.5
1
1.5
2
170
180
190
200
210

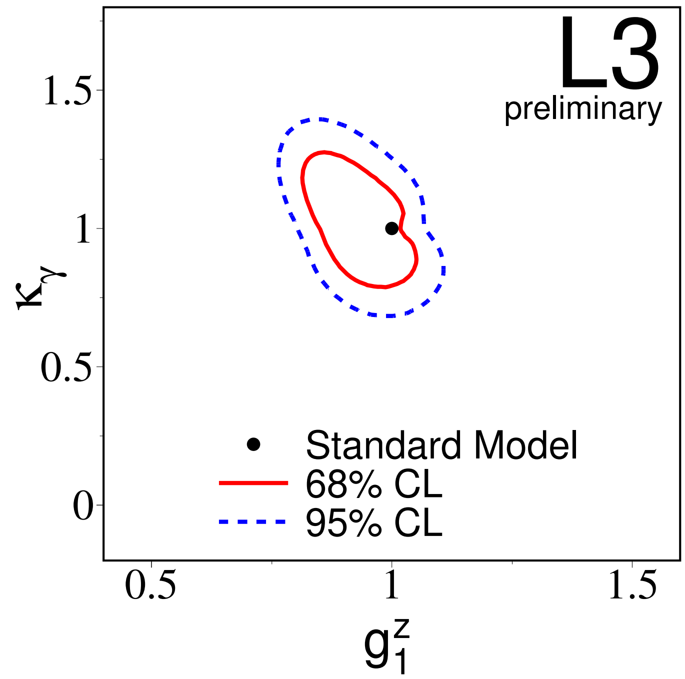
W Gauge Couplings







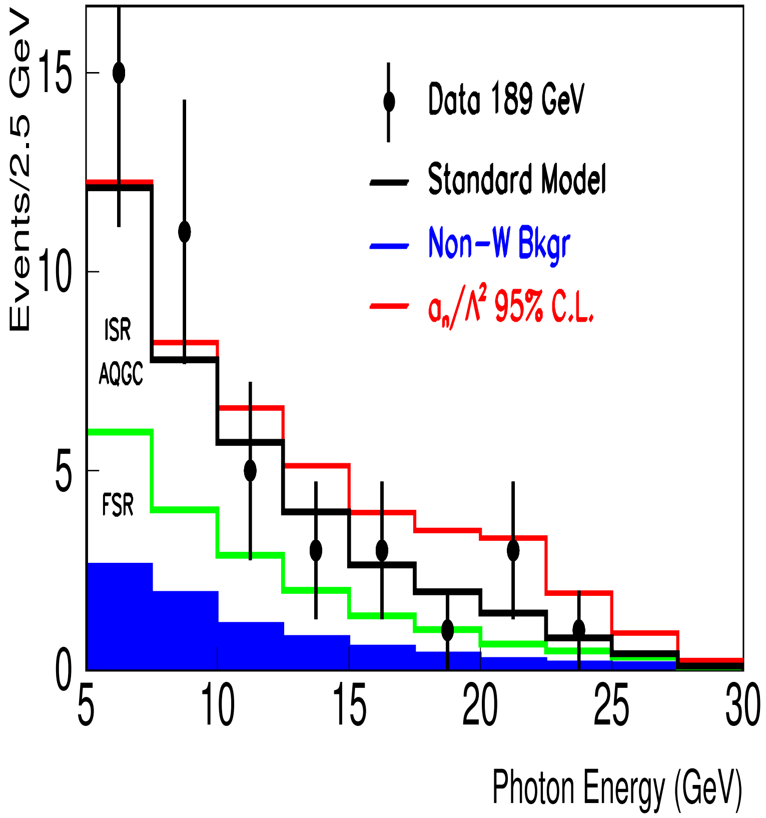
Single W:
130 - 202 GeV



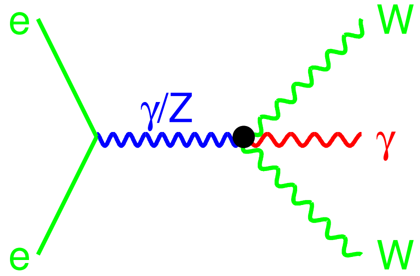
1-parameter fit:

$$g_1^Z = +0.93 \pm 0.06$$
$$\kappa_\gamma = +0.96 \pm 0.12$$
$$\lambda_\gamma = -0.08 \pm 0.06$$

Anomalous Quartic Gauge Couplings

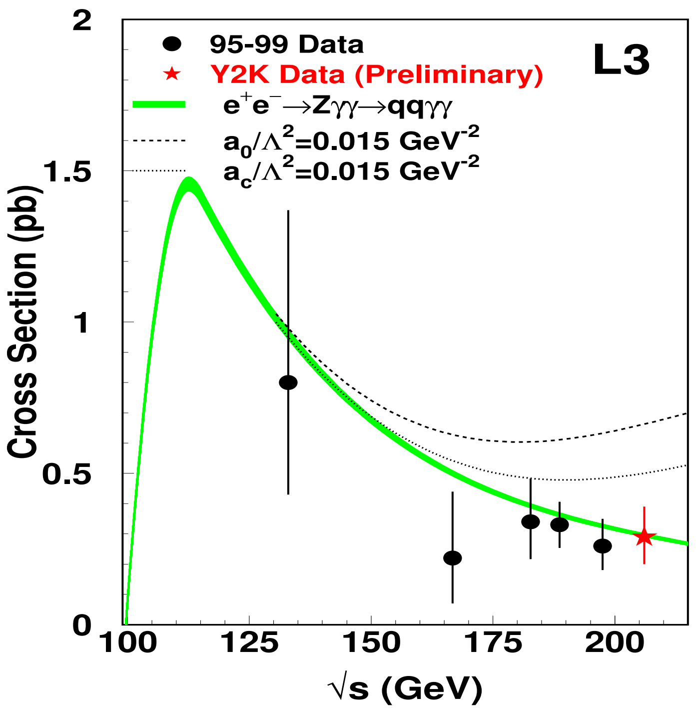


$e^+e^- \rightarrow W^+W^-\gamma$

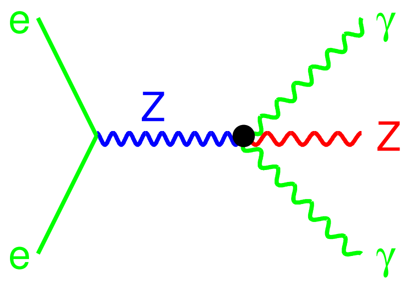


CP-violating [1/GeV^2]:

$-0.41 < a_n/\Lambda^2 < 0.37$



$e^+e^- \rightarrow Z\gamma\gamma$

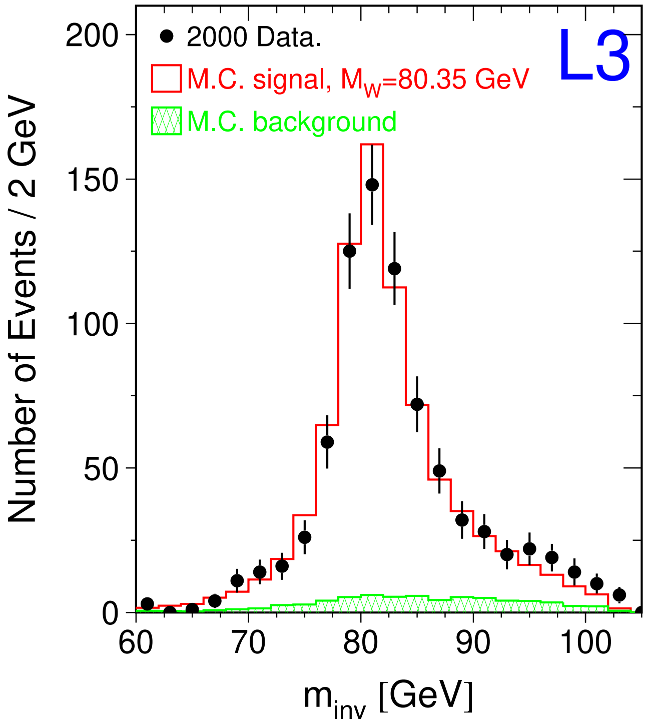


CP-conserving [1/GeV^2]:

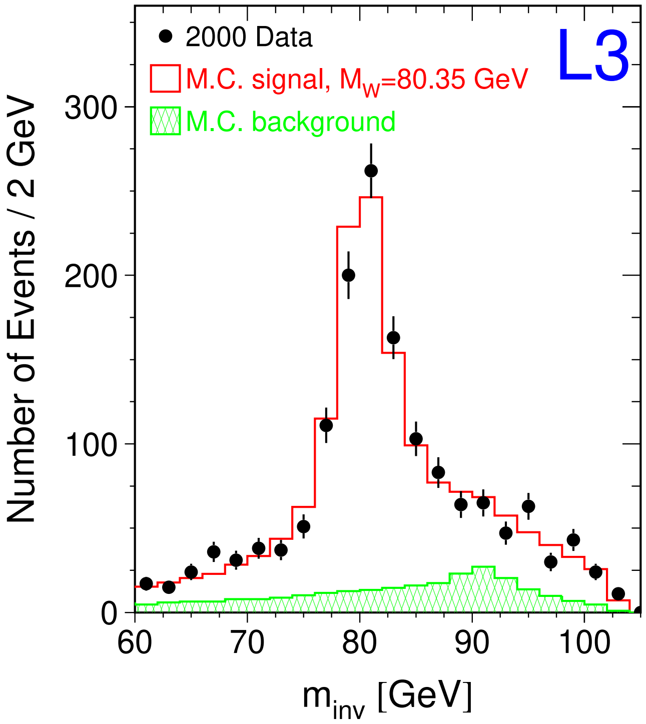
$-0.008 < a_0/\Lambda^2 < 0.005$

$-0.006 < a_c/\Lambda^2 < 0.012$

WW $\longrightarrow q\bar{q}\ell\nu$



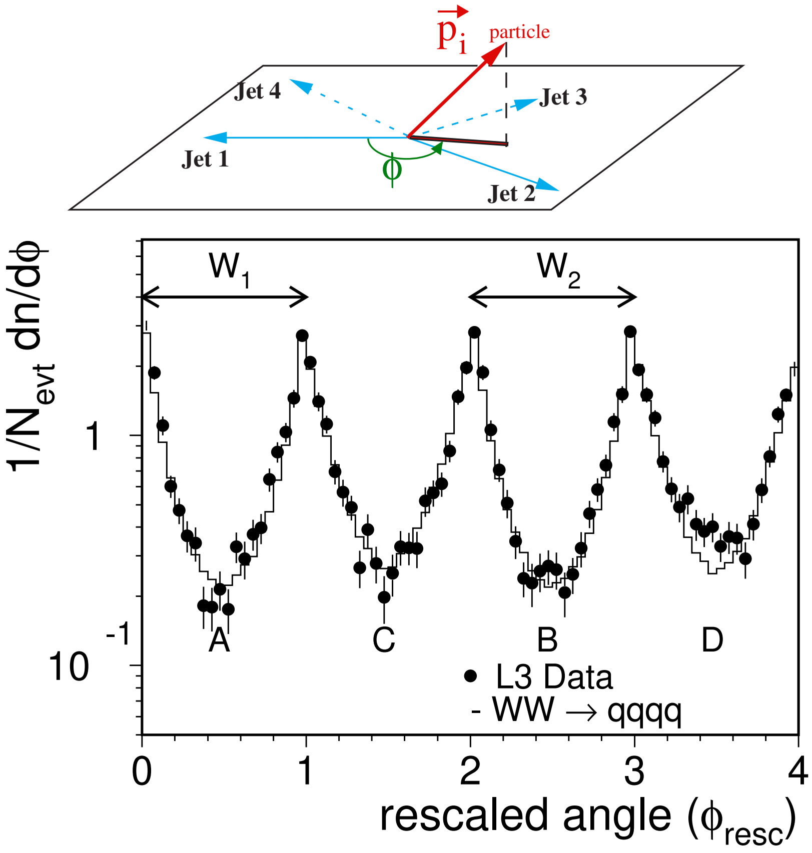
WW $\longrightarrow q\bar{q}q\bar{q}$

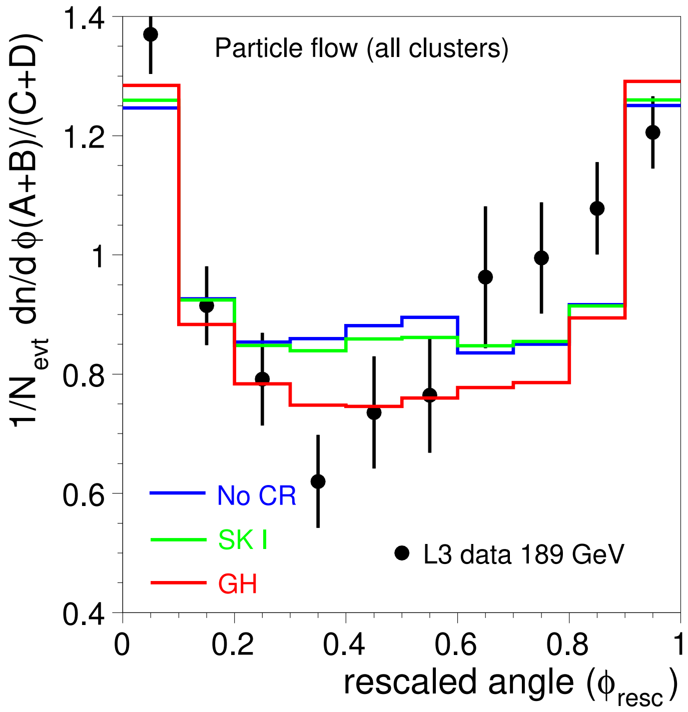


172 GeV – 202 GeV data:

$q\bar{q}q\bar{q}$	$80.46 \pm 0.08 \pm 0.07$ GeV
$q\bar{q}\ell\nu$	$80.27 \pm 0.09 \pm 0.05$ GeV
Mass difference	$0.19 \pm 0.12 \pm 0.05$ GeV
	calculated without FSI systematics
All combined	$80.375 \pm 0.058 \pm 0.051$ GeV

Colour Reconnection

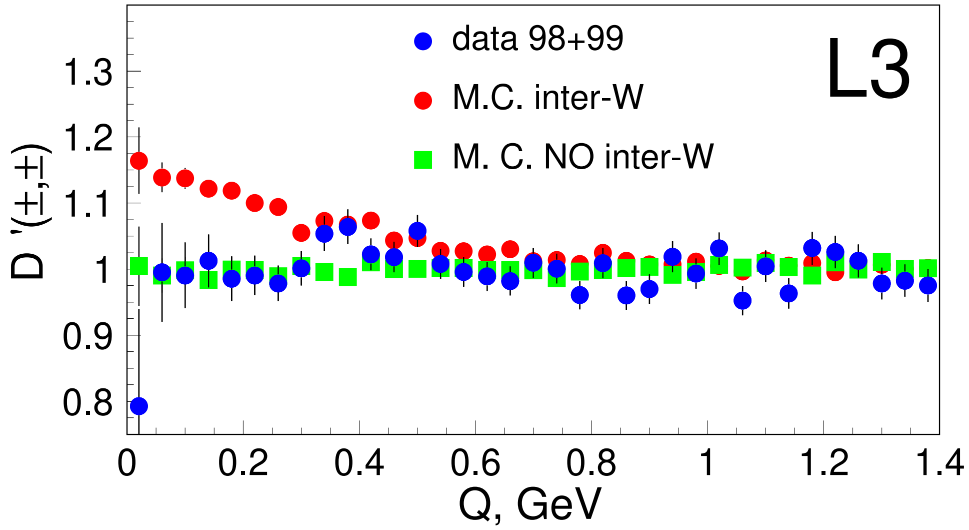




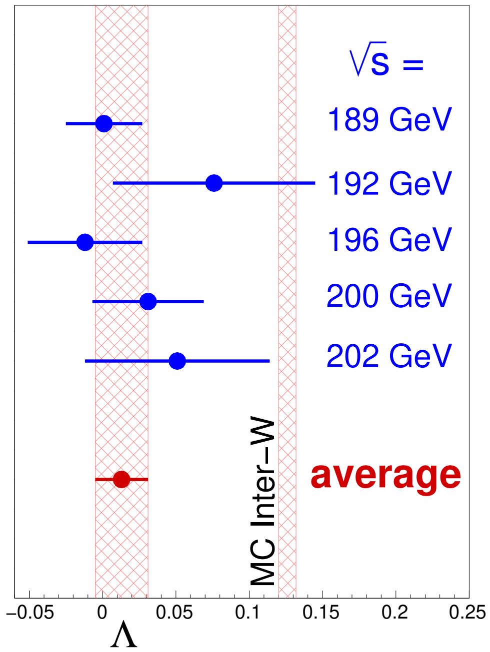
Models with ∼40 % reconnection probability are favoured.

Cross talk in $W^+W^- \rightarrow q\bar{q}q\bar{q}$?

Distribution of identical pions close in phase space:



Q = 4-momentum difference of identical pions.

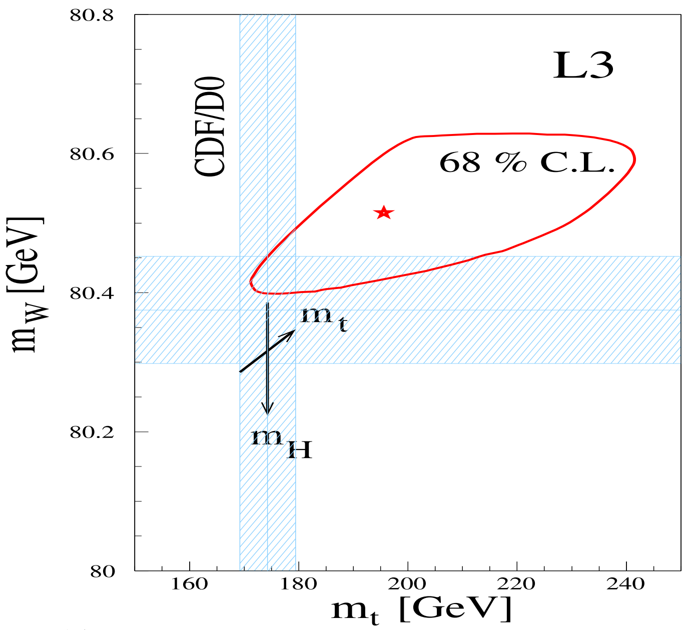


$$D'(Q) =$$
$$(1 + \epsilon Q)\left(1 + \Lambda \exp(-k^2 Q^2)\right)$$

$$\Lambda = 0.013 \pm 0.023$$

$$\Delta M_W \leq 20 \text{ MeV}$$

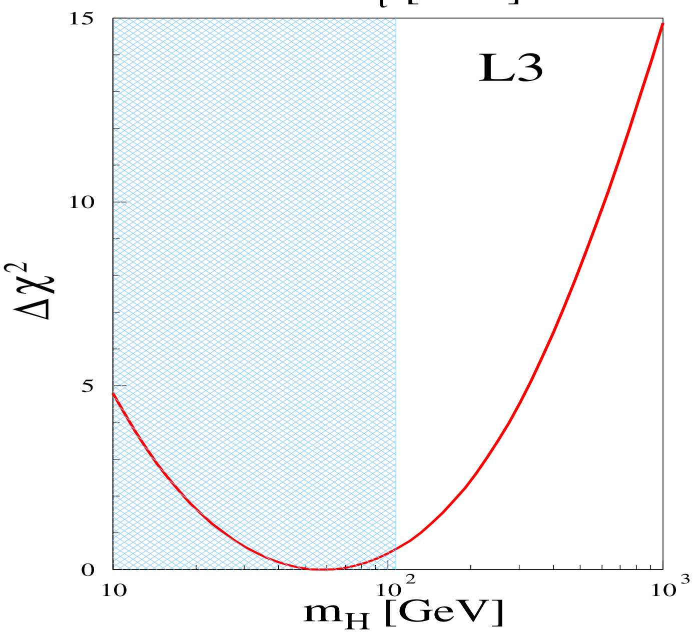
Fit of the Standard Model to all L3 electro-weak data:



$$M_W = 80.52 \pm 0.08 \text{ GeV}$$

$$M_{top} = 195^{+31}_{-17} \text{ GeV}$$

within 1σ of measured values



$$M_H = 58^{+73}_{-33} \text{ GeV}$$

Higgs must be around the corner !

or "New Physics" !

SM Higgs: HZ $\longrightarrow b\bar{b}f\bar{f}$

Discriminant variable combining:

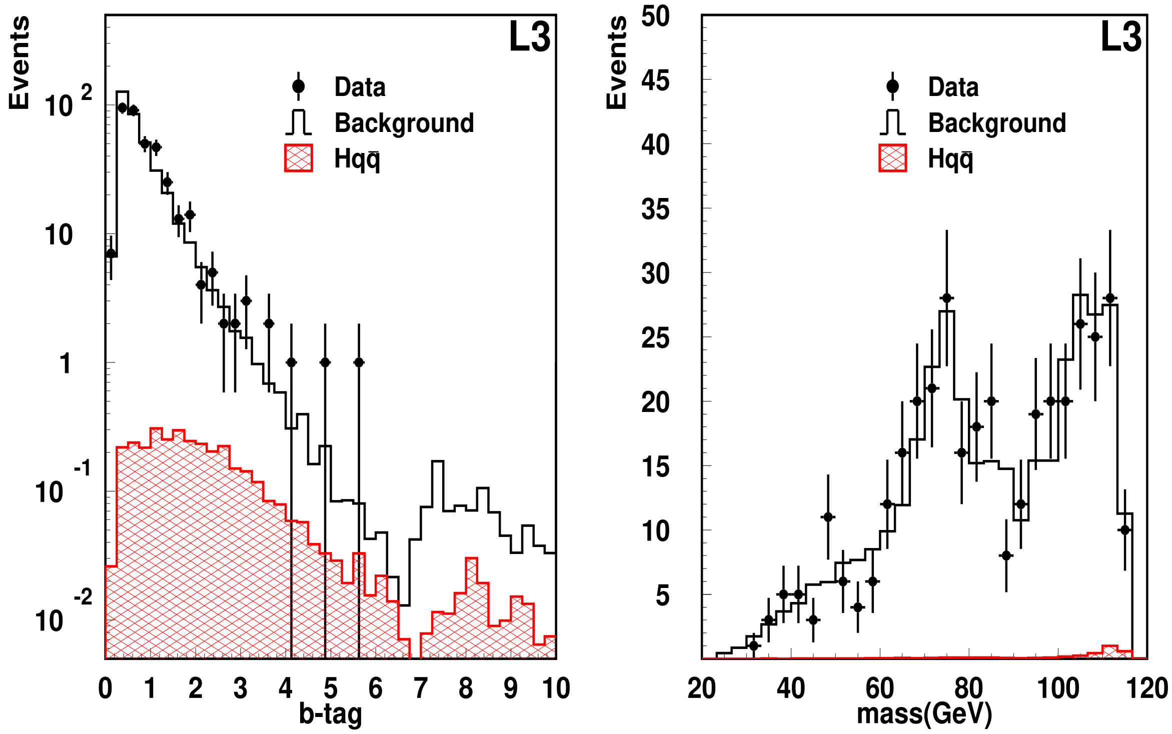
b-tag, neural network, recoil mass to Z.

Total luminosity 170.3 pb^{-1}

82.9 pb^{-1} for $\sqrt{s} \leq 206.5$ GeV

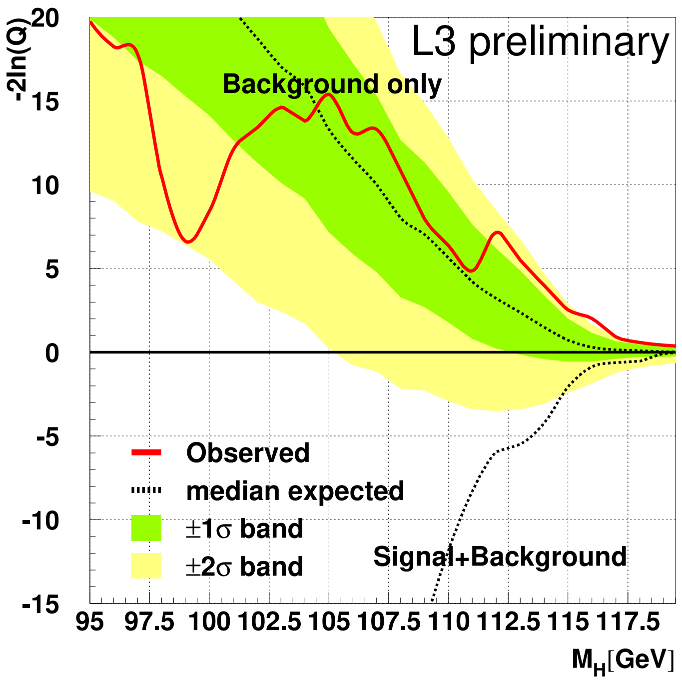
87.4 pb^{-1} for $\sqrt{s} > 206.5$ GeV

For qqqq selection:

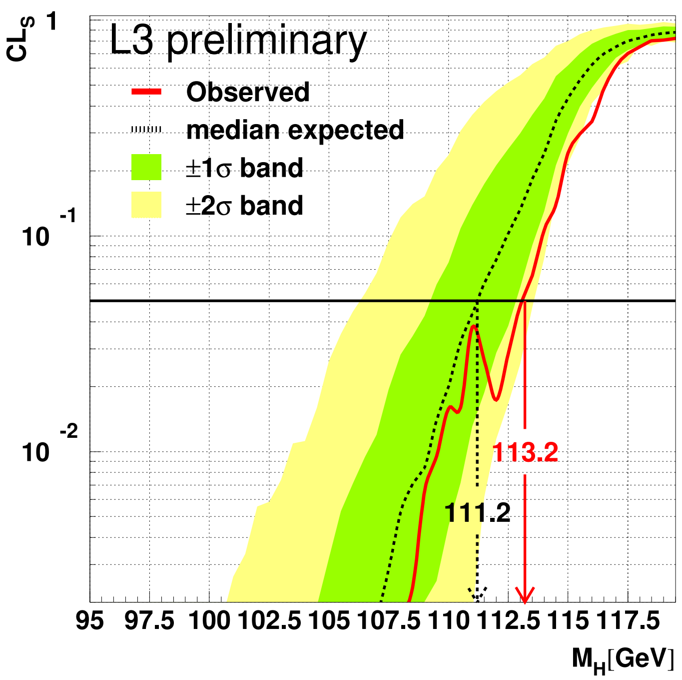


Final Discriminant

Combining qqqq, qq$\nu\nu$ and all qqll channels



$$Q = \frac{L(s+b)}{L(b)}$$



$M_H > 113.2$ GeV
at 95 % CL

expected limit : 111.2 GeV

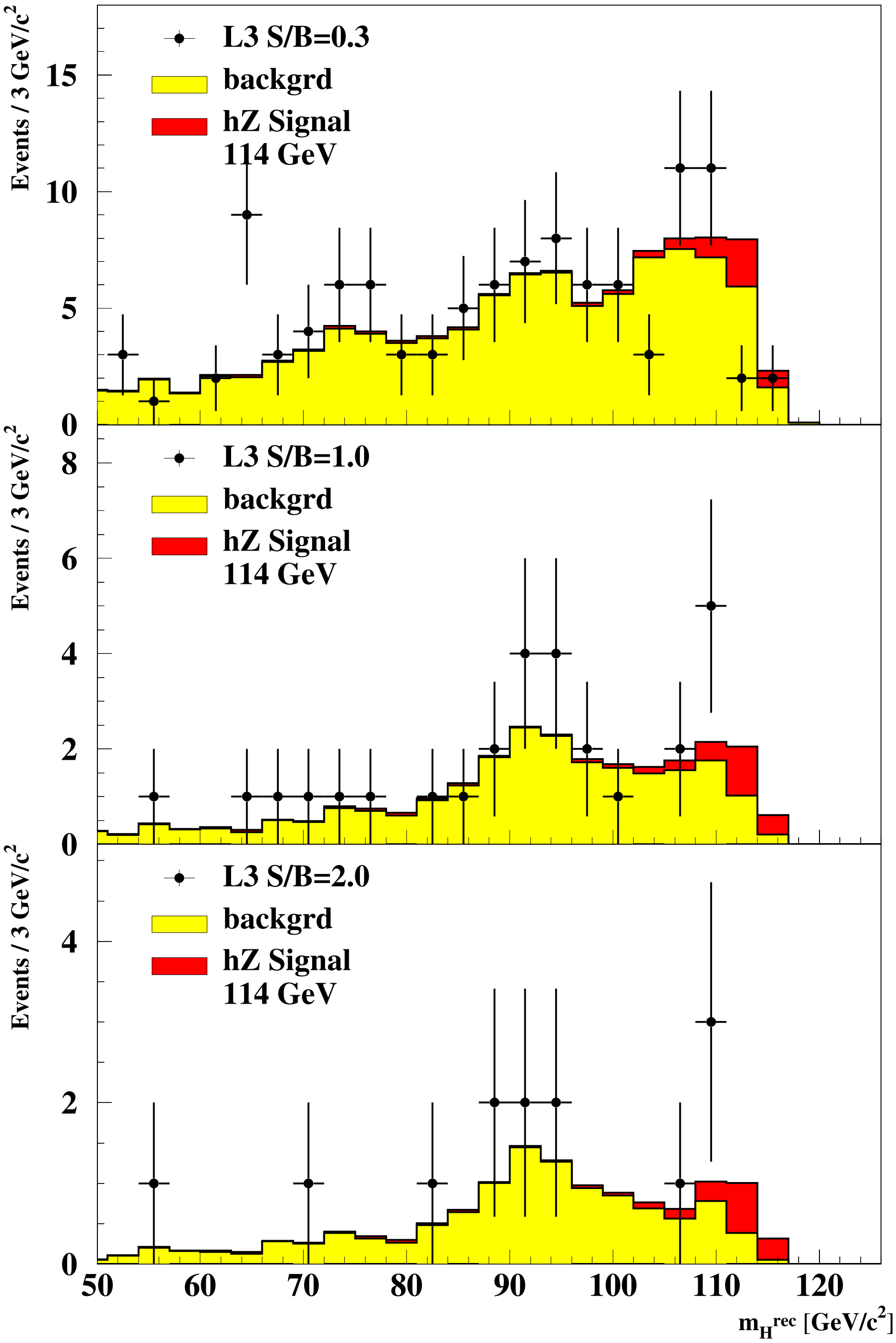
SM Higgs: HZ $\rightarrow b\bar{b}f\bar{f}$

Combining qqqq, qq$\nu\nu$ and all qqll channels

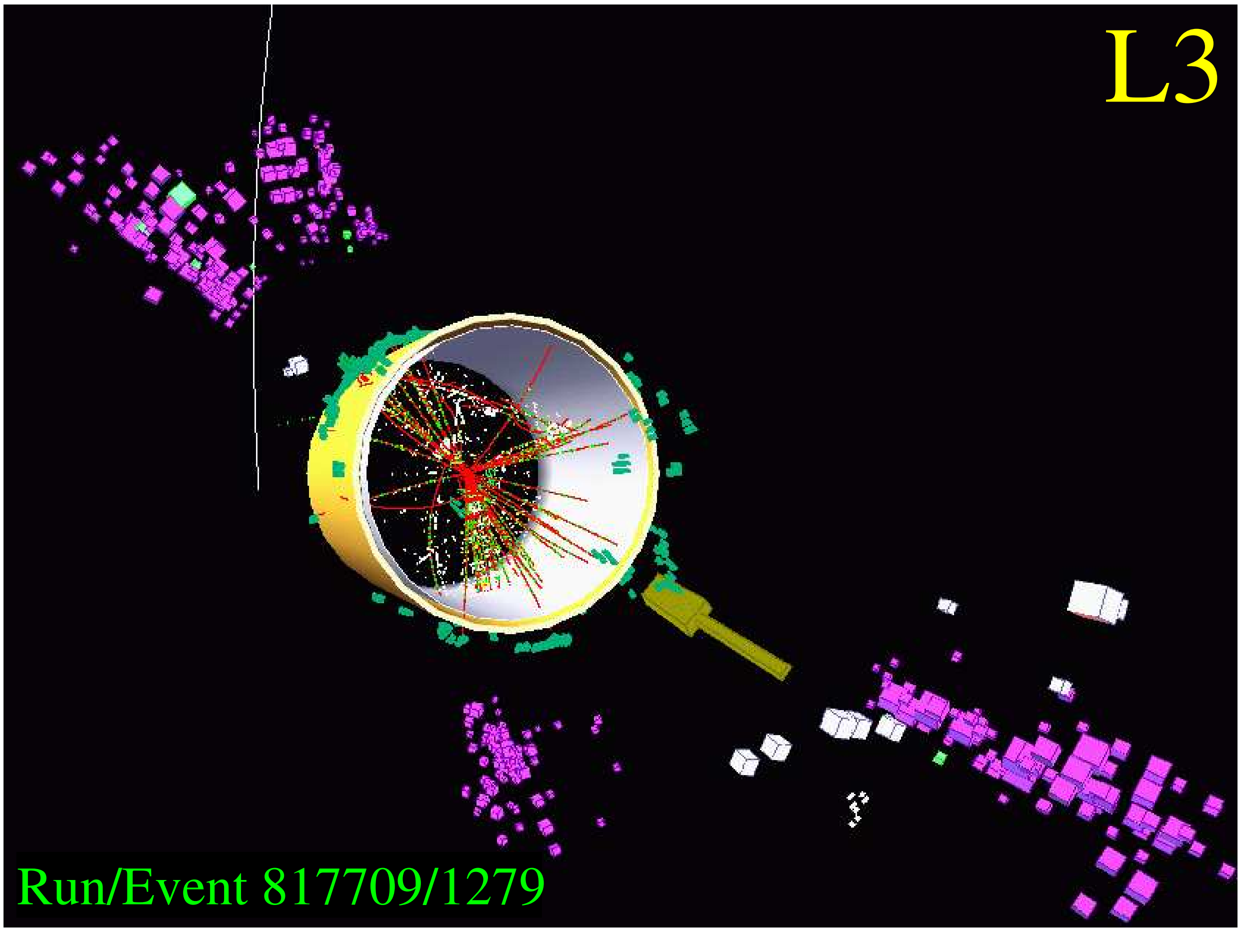
Use mass-independent cuts

S/B defined for recoil mass$>$ 109 GeV

L3 preliminary ($\sqrt{s}$ = 200-209 GeV)



An event bbqq

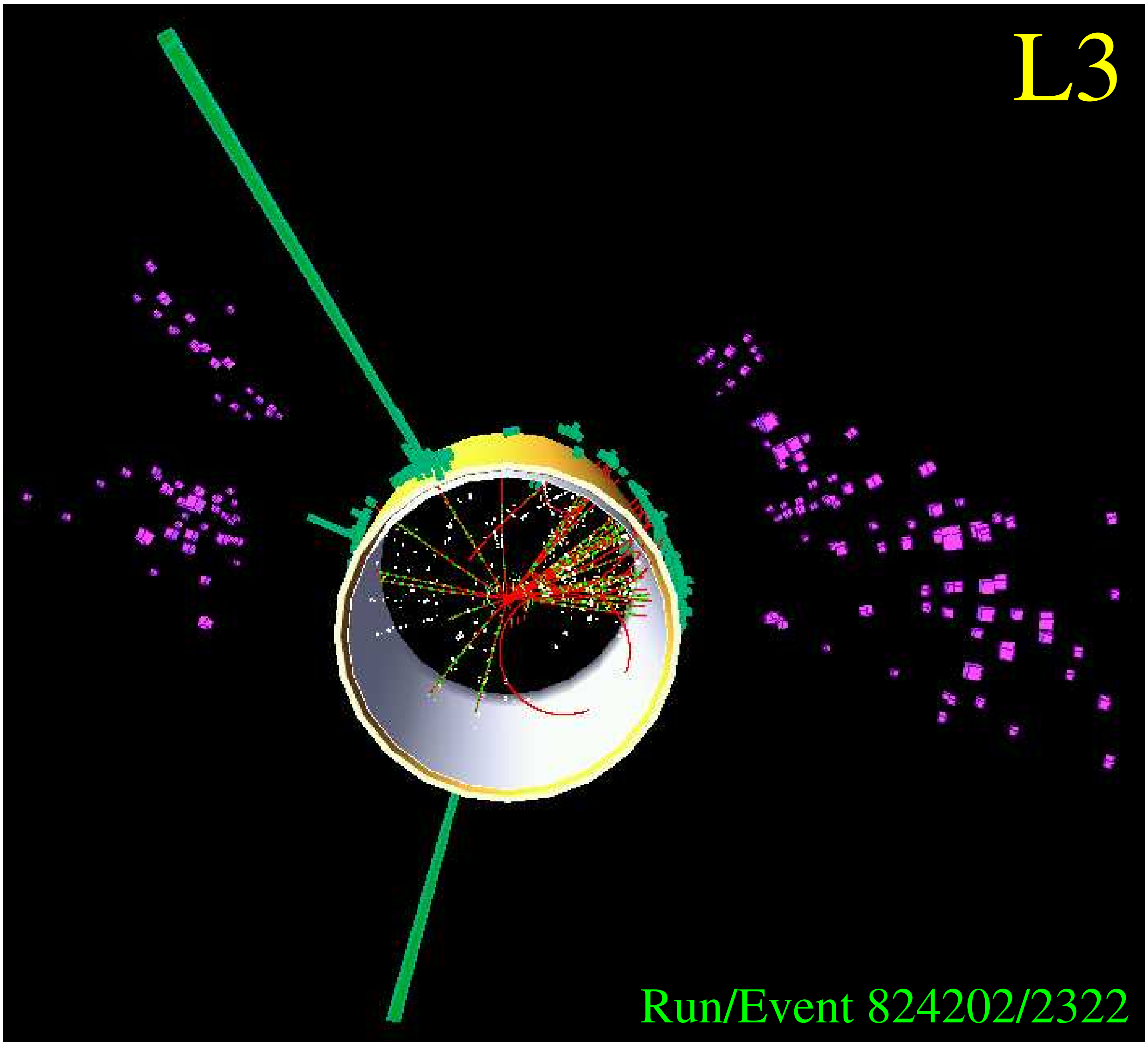


$\sqrt{s} = 206.7$ GeV, S/B =2 , btag = 3.2

5-C fit $e^+e^- \rightarrow HZ$: $M_H = 109.9$ GeV

5-C fit with equal masses : 89.3 GeV

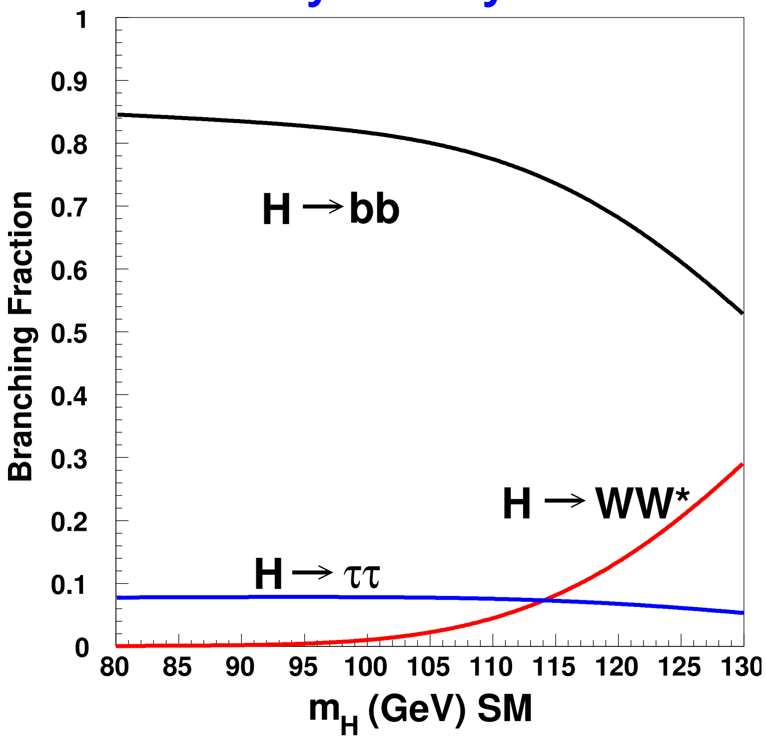
An event bbe^+e^-



$\sqrt{s} = 205.4$ GeV, S/B =2

5-C fit $e^+e^- \rightarrow HZ$: $M_H = 105.5$ GeV
4-C fit: $M_H = 108.0$ GeV

Preliminary analysis looking for the channels:

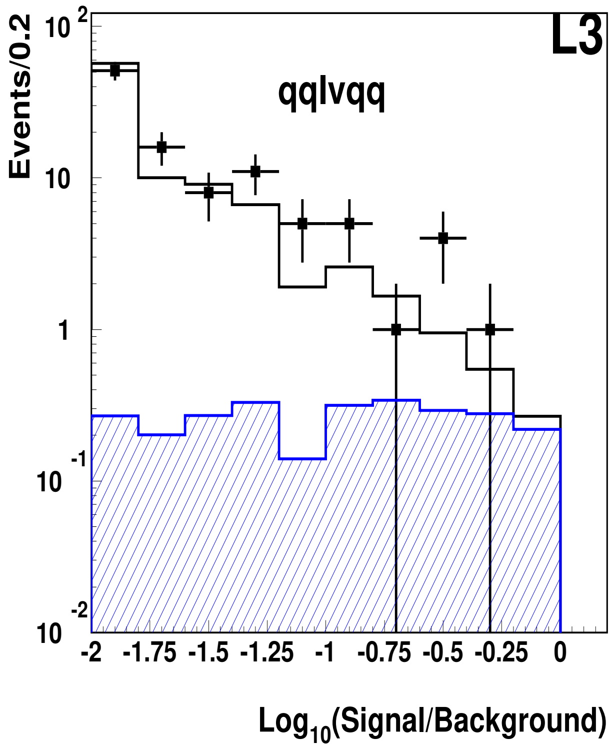


qqqqqq

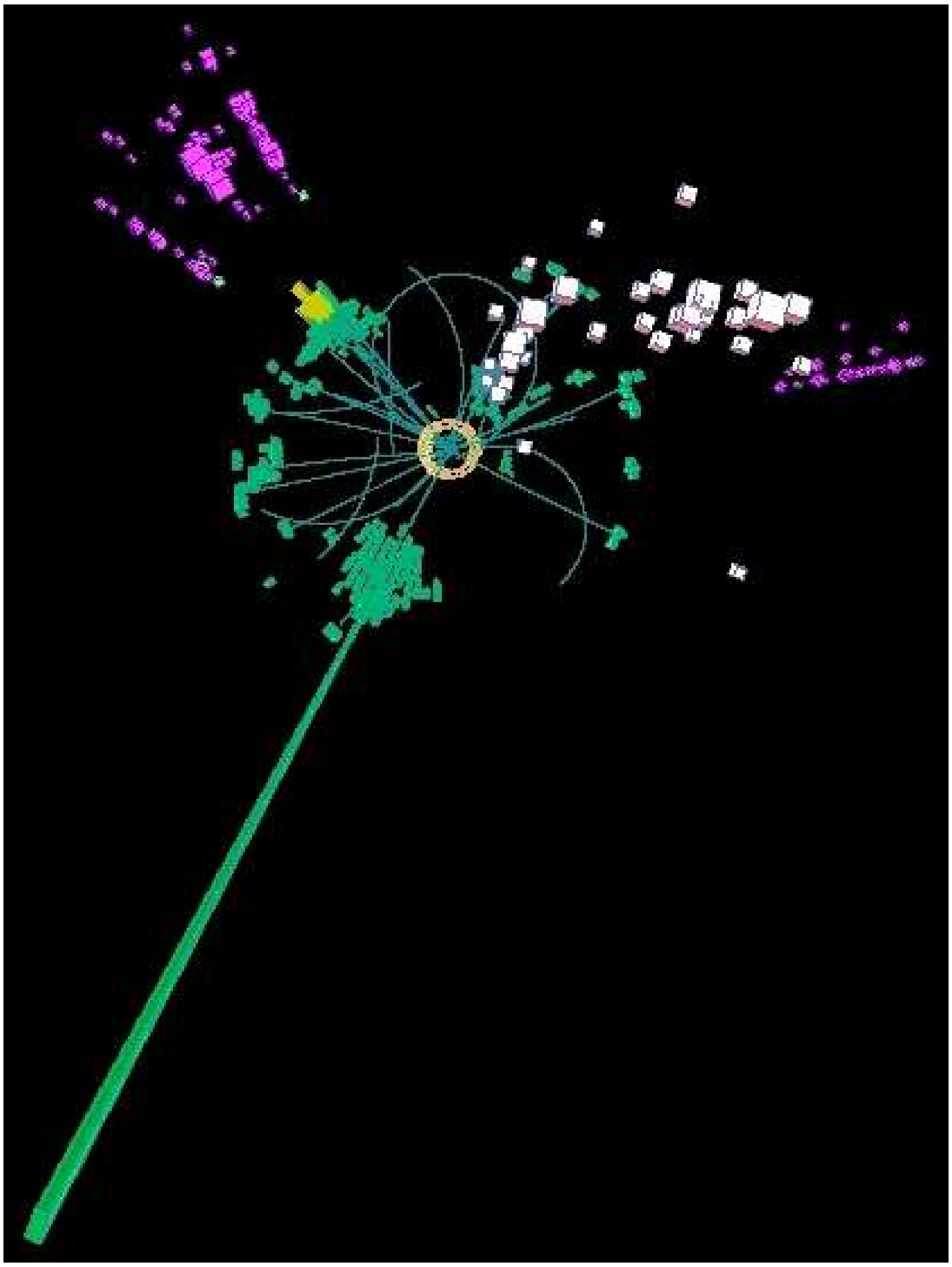
qqlνqq

qqqq$\nu\nu$

qql$\nu\nu\nu$



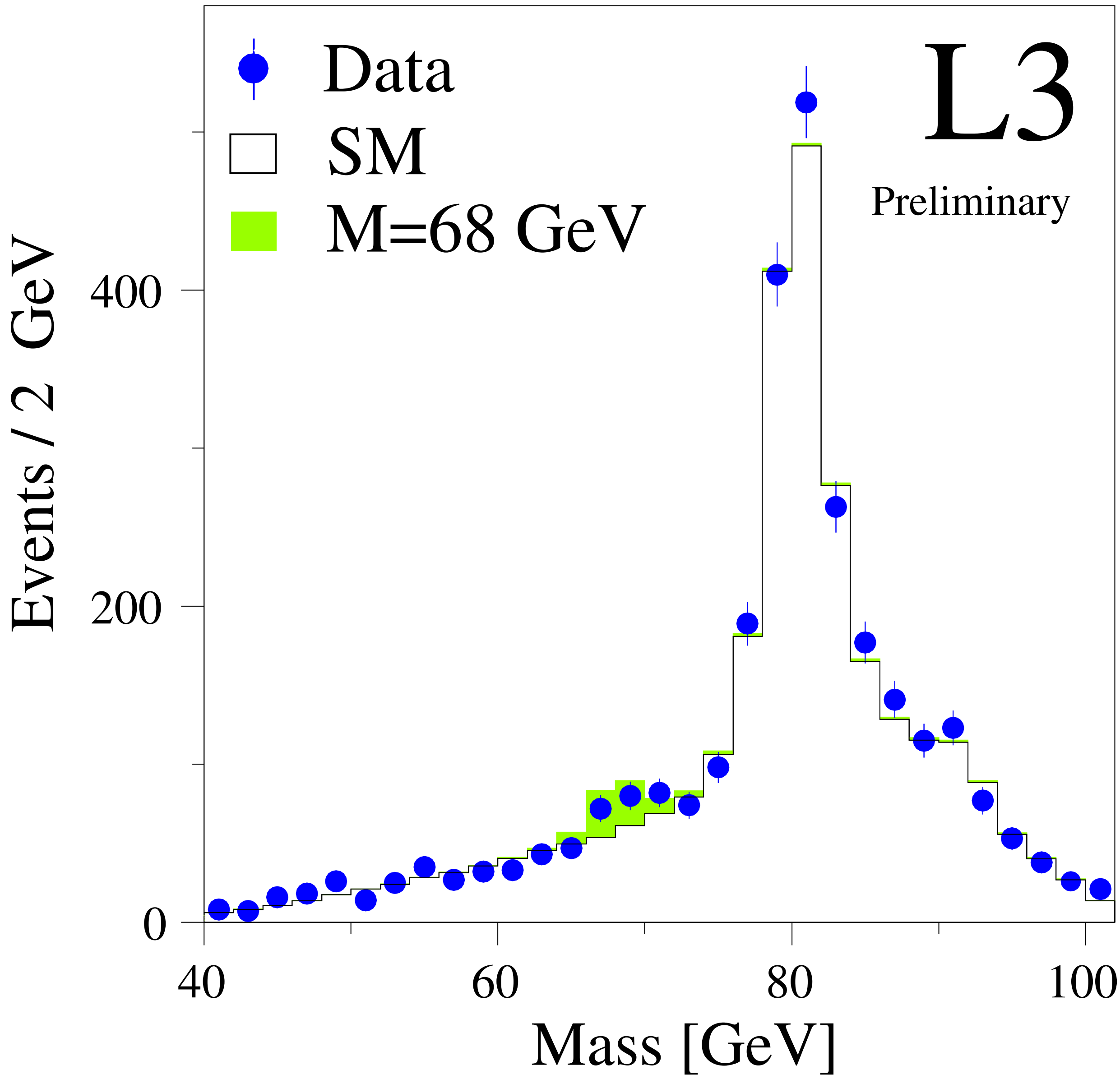
An event qqeνqq, candidate WW*Z



Run 868610, Event 378, $\sqrt{s} = 206.8$ GeV

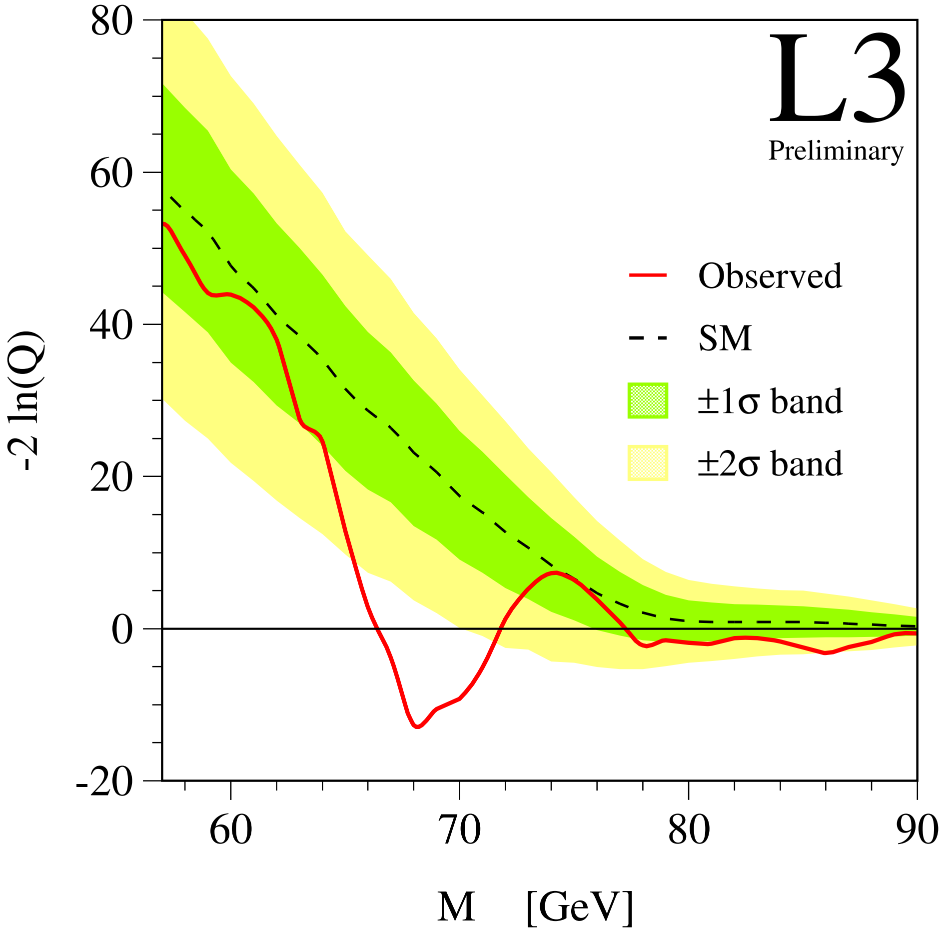
$\sqrt{s} = 183 - 209$ GeV

Require genuine $e^+e^- \to qqqq$ events :
reduce QCD (qqgg) and W-pair background
5-C fit with equal mass (M) constraint



Excess of events at $\simeq 68$ GeV.
Expectation calculated for the reaction $e^+e^- \rightarrow H^+H^-$ with the HZHA Monte Carlo.

$$\sqrt{s} = 183 - 209 \text{ GeV}$$



The effect
(2.7σ above background in 183-202 GeV)
increases to $3.6\,\sigma$

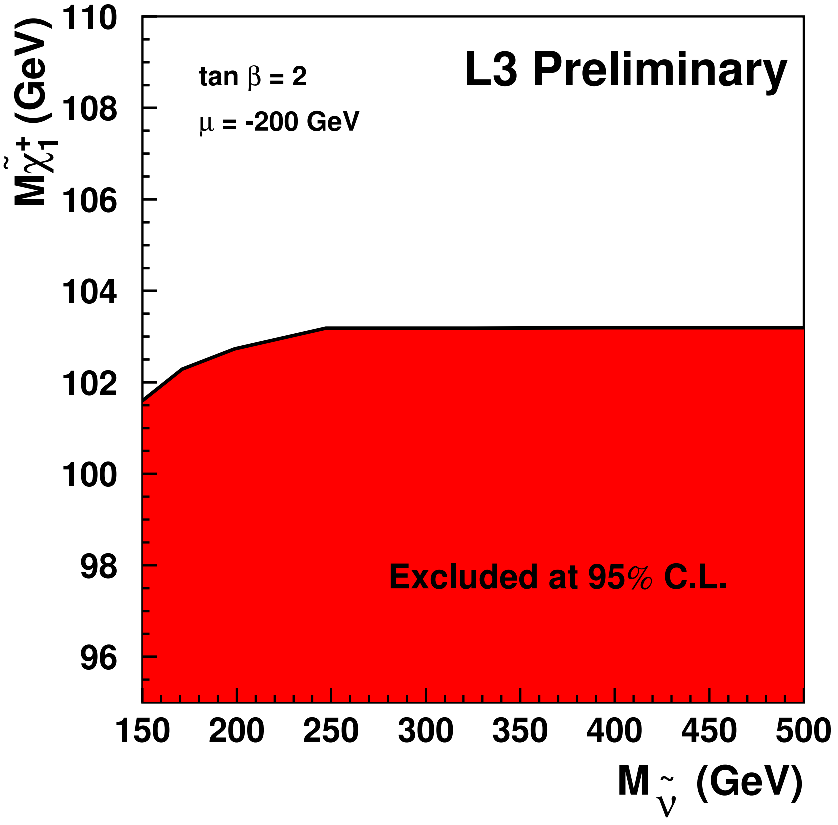
Chargino Searches $e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^-$

$$\Delta M = M_{\tilde{\chi}_1^\pm} - M_{\tilde{\chi}_1^0} > 3 \text{ GeV}$$

Topologies: $l^+l^- + \not{E}$, $ljj + \not{E}$, $jjjj + \not{E}$

ΔM (GeV)	3–10		20–40		> 50		.OR.	
$\sqrt{s}$ (GeV)	data	exp	data	exp	data	exp	data	exp
208	0	1.6	2	1.2	0	0.9	2	3.7
205-208	40	35.8	26	27.8	17	19.9	83	83.6

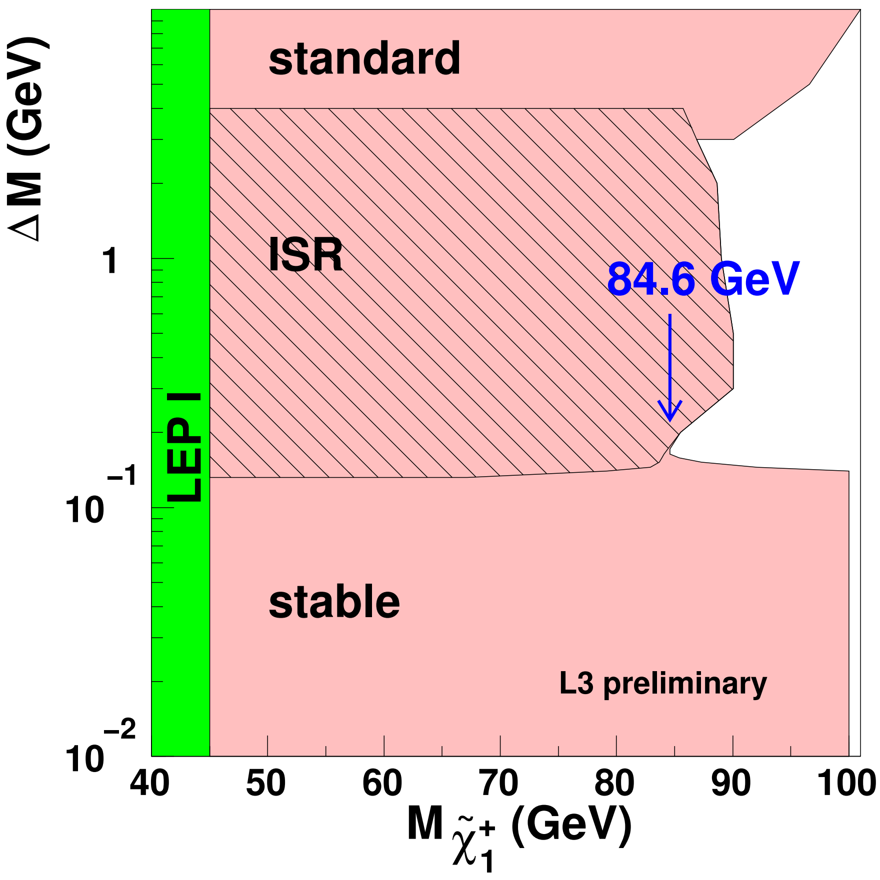
Gaugino like and $M_{\tilde{\nu}} > 300$ GeV :
Kinematic Limit reached



$\Delta M < 3$ GeV
Tag chargino decays with ISR photons

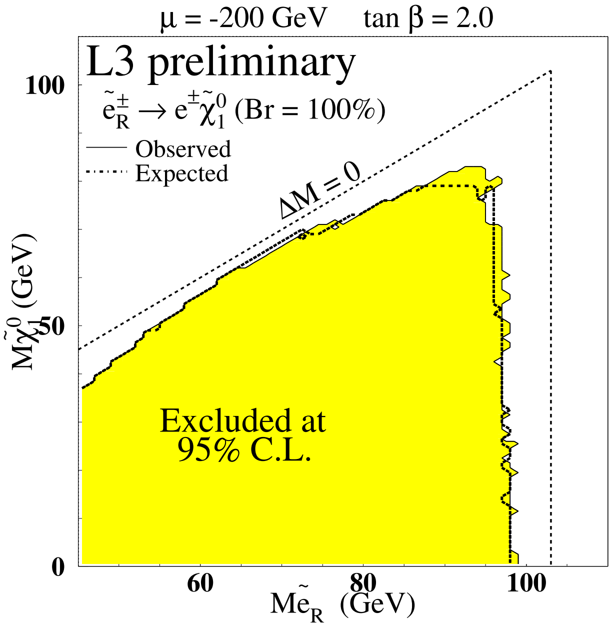
ΔM $\sqrt{s}$ (GeV)	$\sim$ 3 GeV data	 exp	$\sim$ 1 GeV data	 exp	$\sim$ 0.3 GeV data	 exp	.OR. data	 exp
205-208	6	5.6	2	2.0	3	1.2	8	6.8

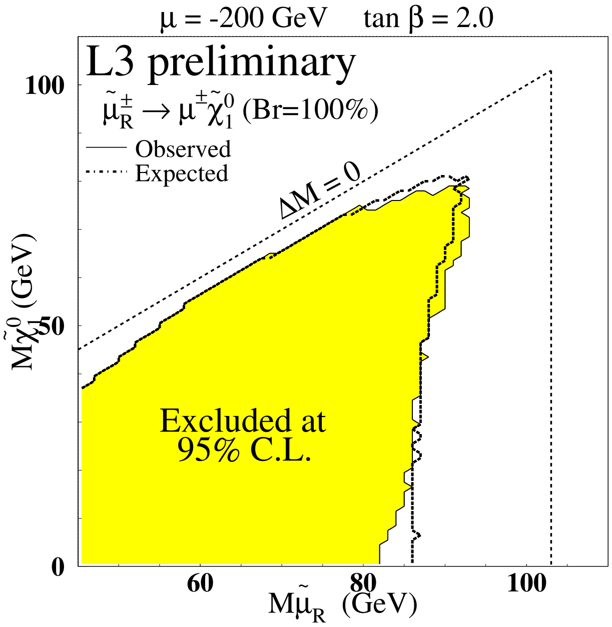
Higgsino Like (CMSSM): Mass limit independant of ΔM

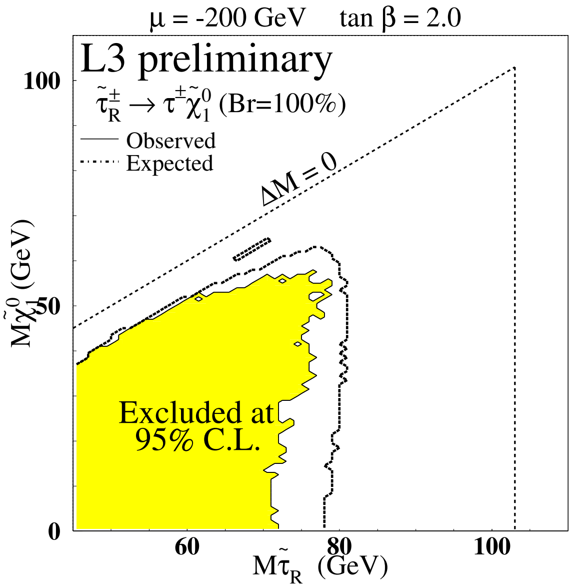


Scalar Leptons $e^+e^- \rightarrow \tilde{\ell}^+\tilde{\ell}^-$

For μ=-200 GeV, $\tan\beta$=2, $M_{\tilde{\chi}_1^0}$>15 GeV, ΔM >10 GeV







$M_{\tilde{e}_R}$ >95 GeV

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

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

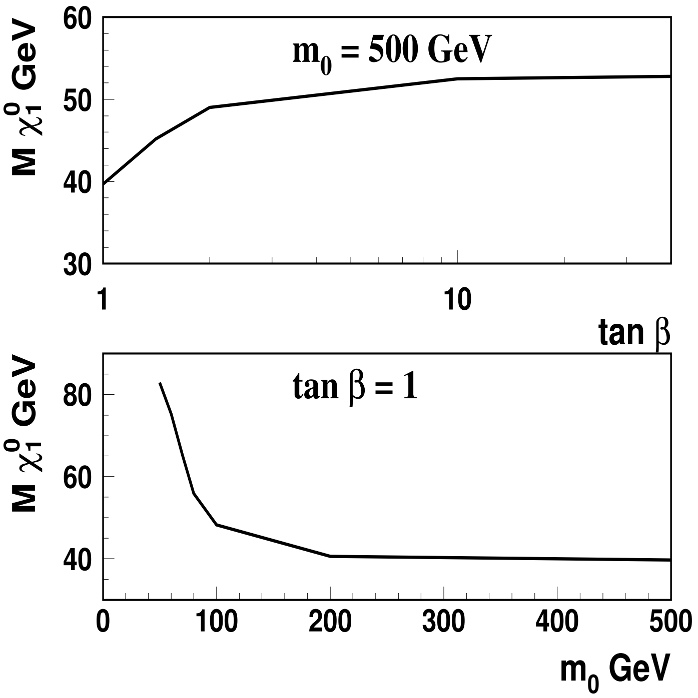
Indirect limits from slepton, chargino, neutralino:

$M_{\tilde{\chi}_1^0}$ > 39.4 GeV

Search for $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}^0_{J=1,4}$ and $\tilde{\ell}$

$\tilde{\chi}_1^0$ is no more stable $\longrightarrow$ final states with:
many leptons (λ), many jets (λ'') or both (λ').

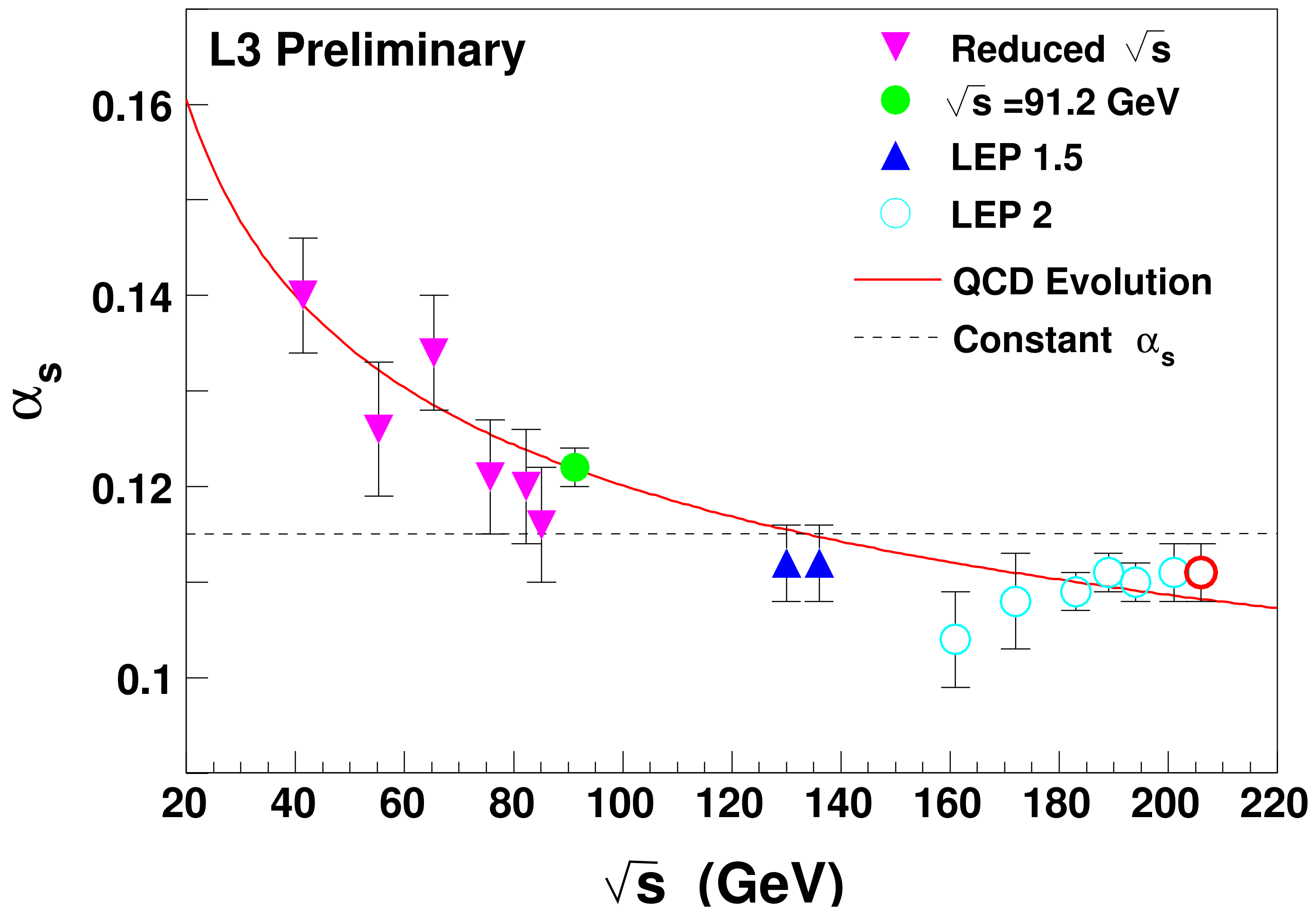
Including 2000 data: (λ'' only)



Limits on $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_1^0$ similar to the one obtained assuming R–Parity conservation

Running α_S from 4 event shape variables.

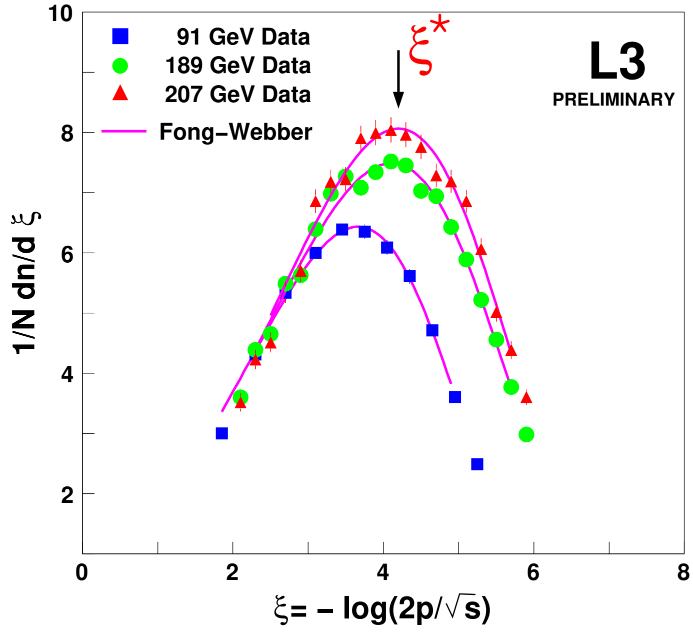
QCD fits to $\mathcal{O}(\alpha_S^2)$ with resummed LO and NLO terms.

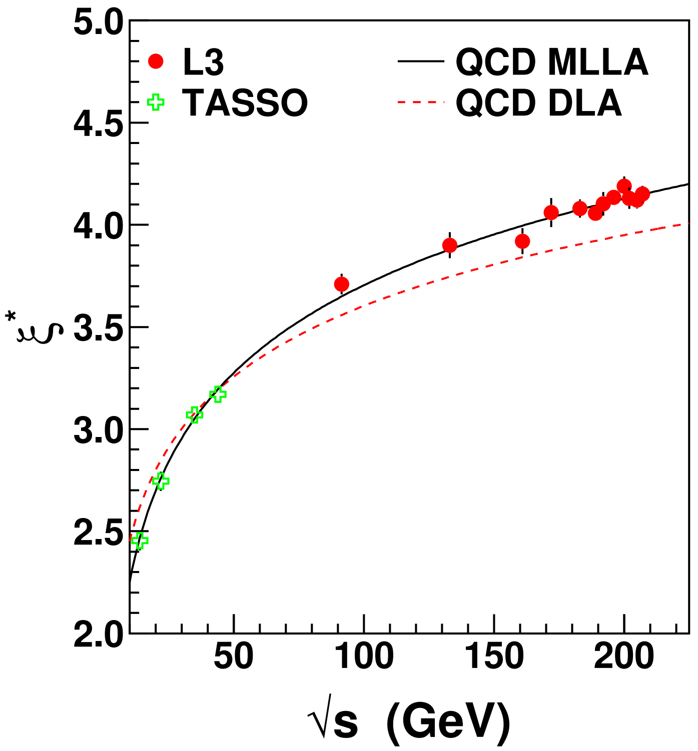


$$\alpha_S(M_Z) = 0.1218 \pm 0.0012(\mathrm{exp}) \pm 0.0061(\mathrm{th})$$

Number of active flavours: $5.0 \pm 1.3(\mathrm{exp}) \pm 2.0(\mathrm{th})$

QCD - Inclusive Charged Particle



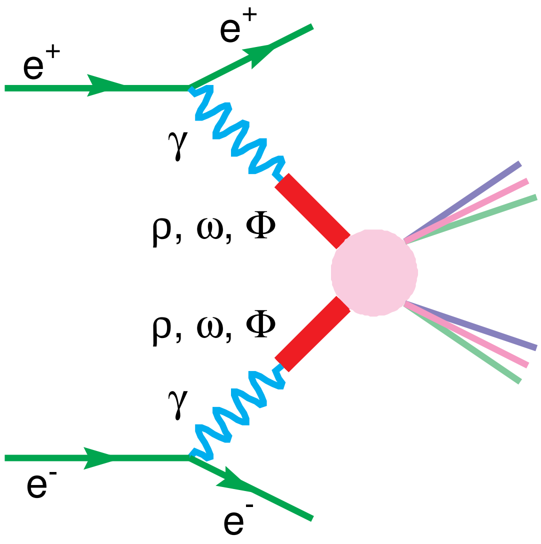


DLA : $\chi^2 = 57$ for 16 points

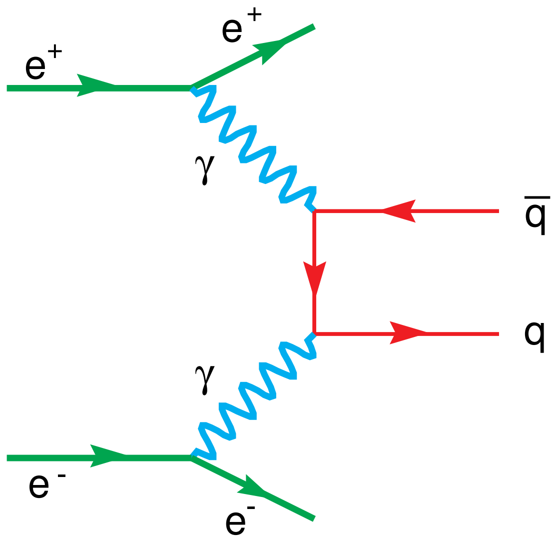
MLLA : $\chi^2 = 16$ for 16 points

Evidence of gluon coherence

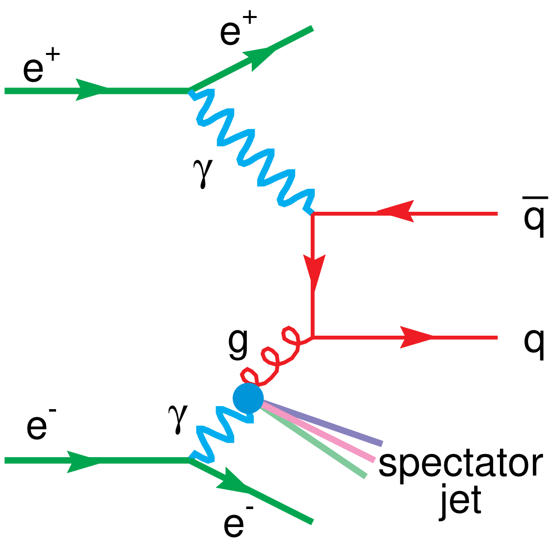
Two-Photon Physics



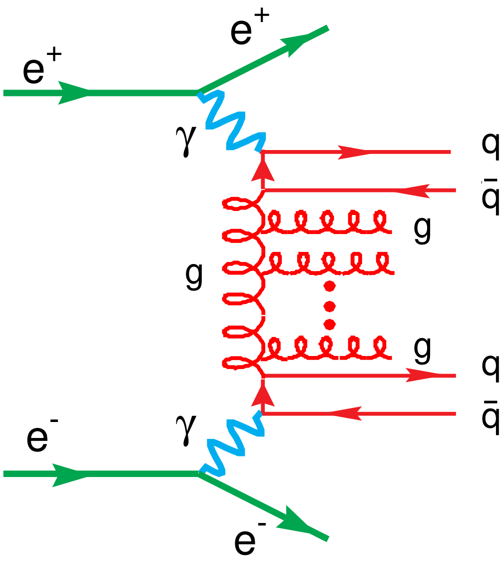
VDM



Direct



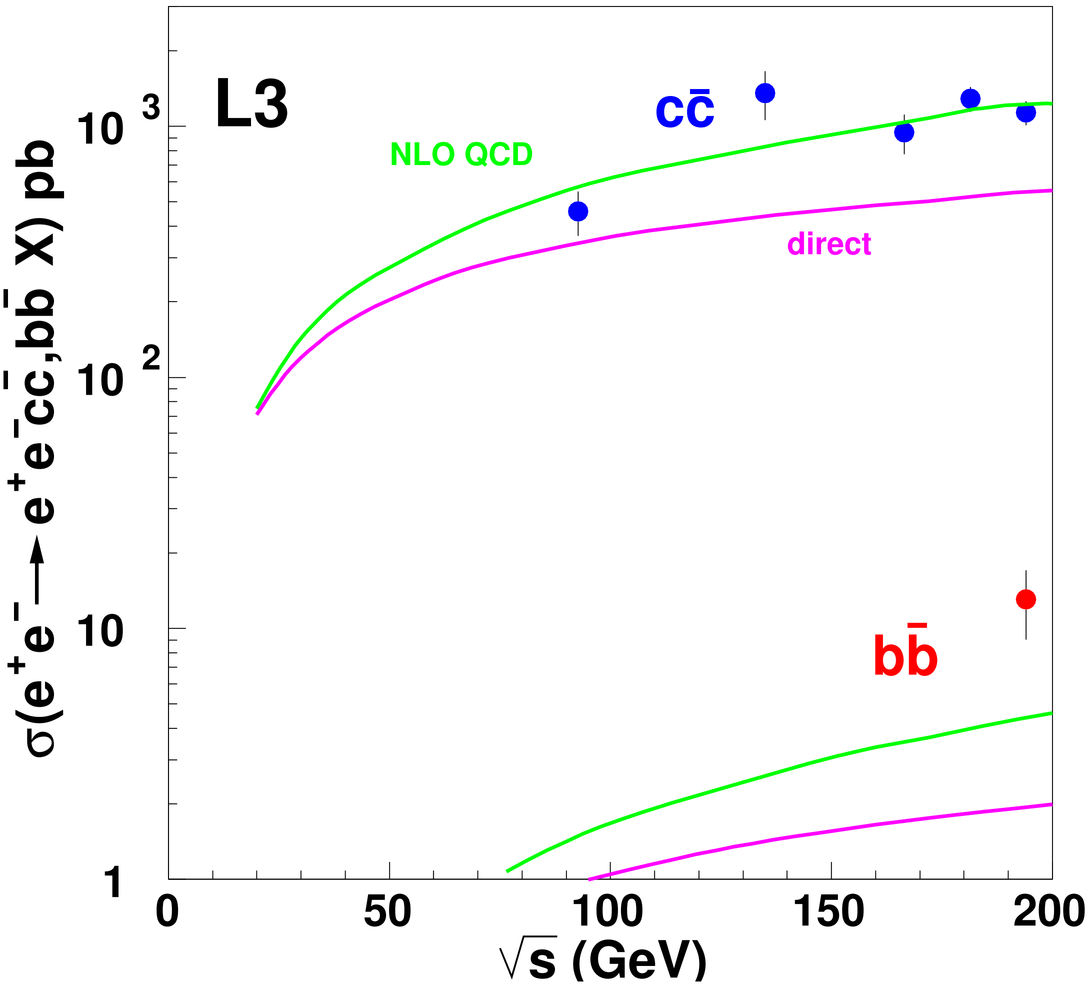
Single Resolved



BFKL

$$e^+e^- \to e^+e^- c\bar{c},\, b\bar{b}\, \mathrm{X}$$

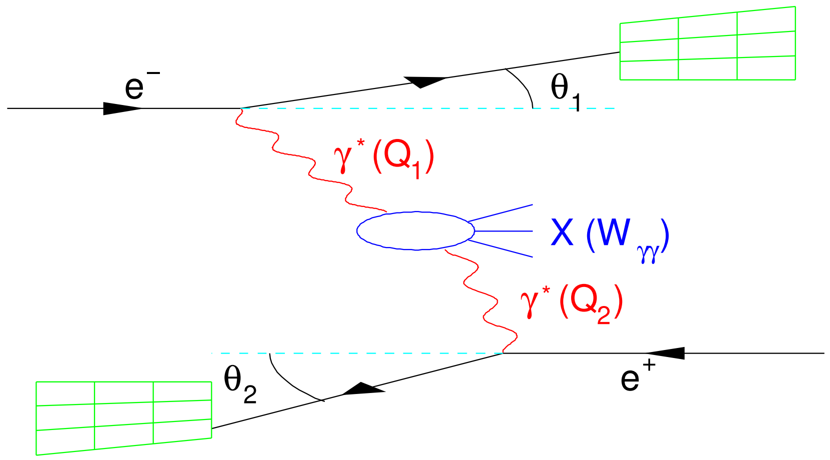
NLO QCD: $\gamma\gamma \to q\bar{q}$ (direct)
$g\gamma \to q\bar{q}$ (single resolved)



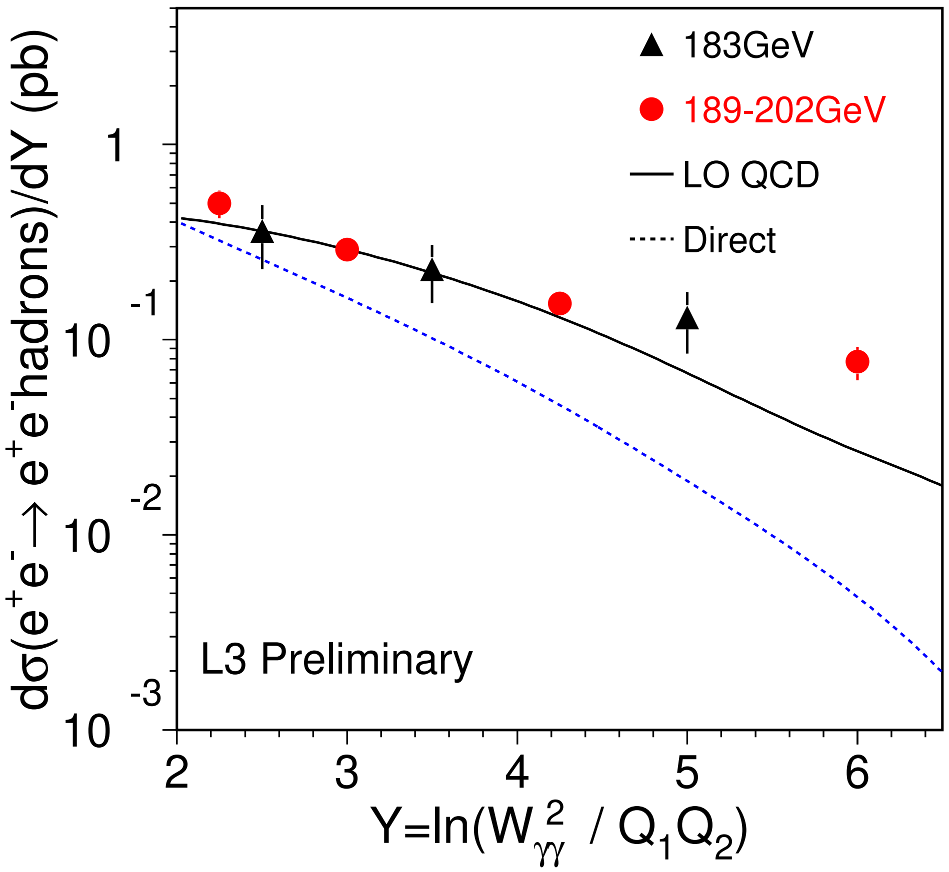
$$\sigma(\mathrm{e^+e^-} \to \mathrm{e^+e^-b\bar{b}X}) = 14 \pm 3 \text{ pb}$$

(Expected 4.6 pb)

Two-Photon: double-tag

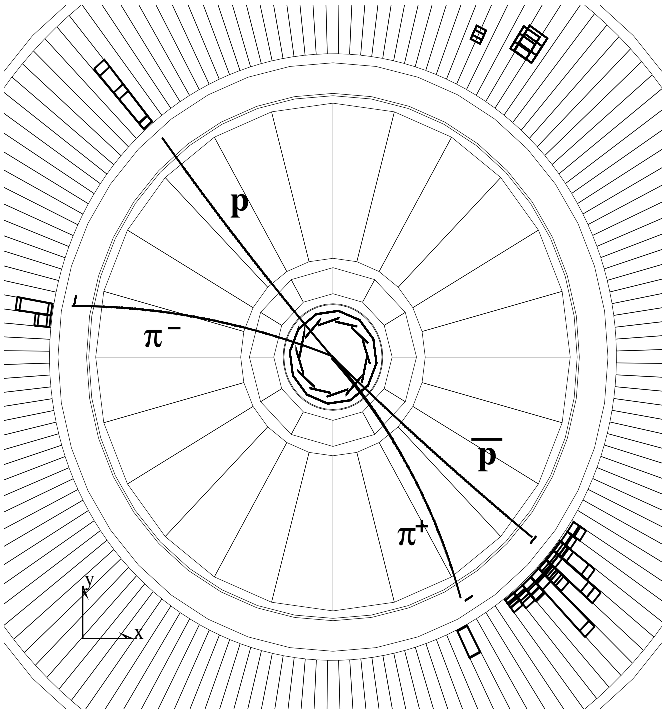


$< Q_1^2 >=< Q_2^2 >= 15 \mathrm{GeV}^2$

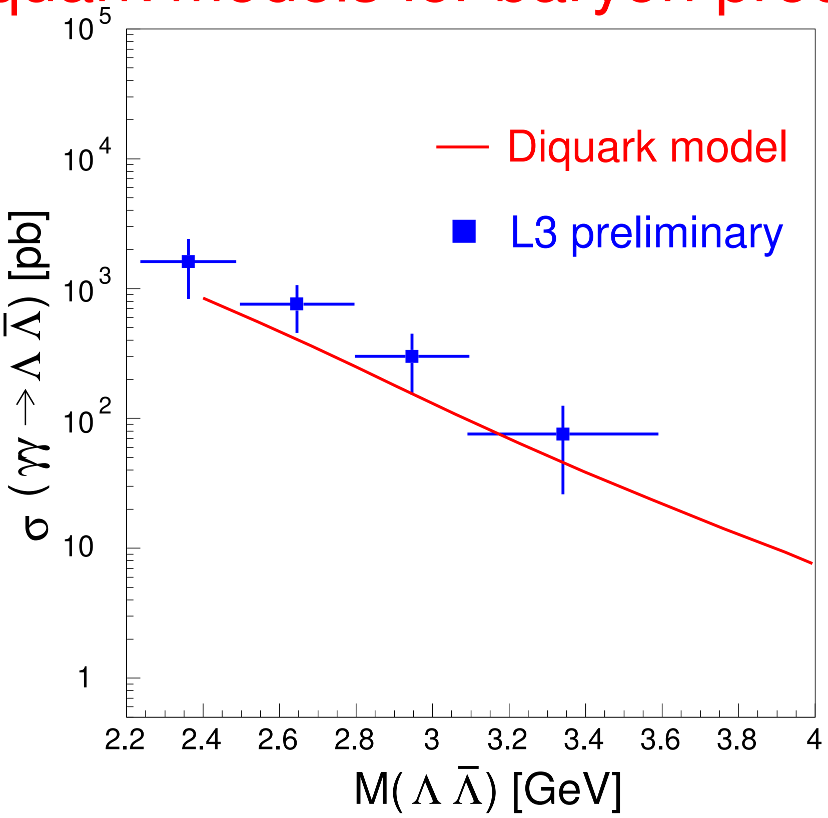


Test of BFKL models

$\gamma\gamma \rightarrow \Lambda\bar{\Lambda}$



Test of diquark models for baryon production.



Grand final

The Standard Model is a wonderful construction...

The San Petronio church in Bologna

... let's complete it!

Long life to LHC and to Linear Colliders