Year 2000 update for L3

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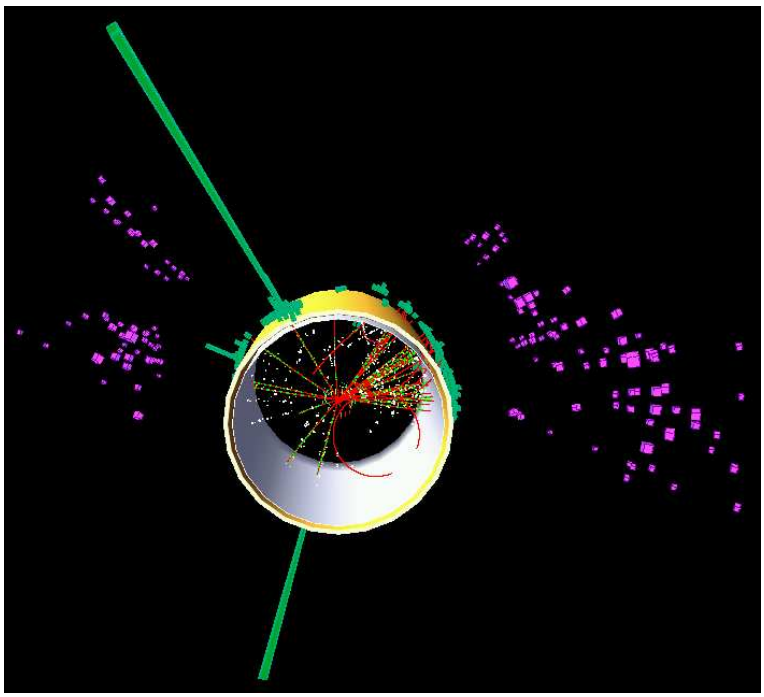


XXXth International Conference on High Energy Phyiscs

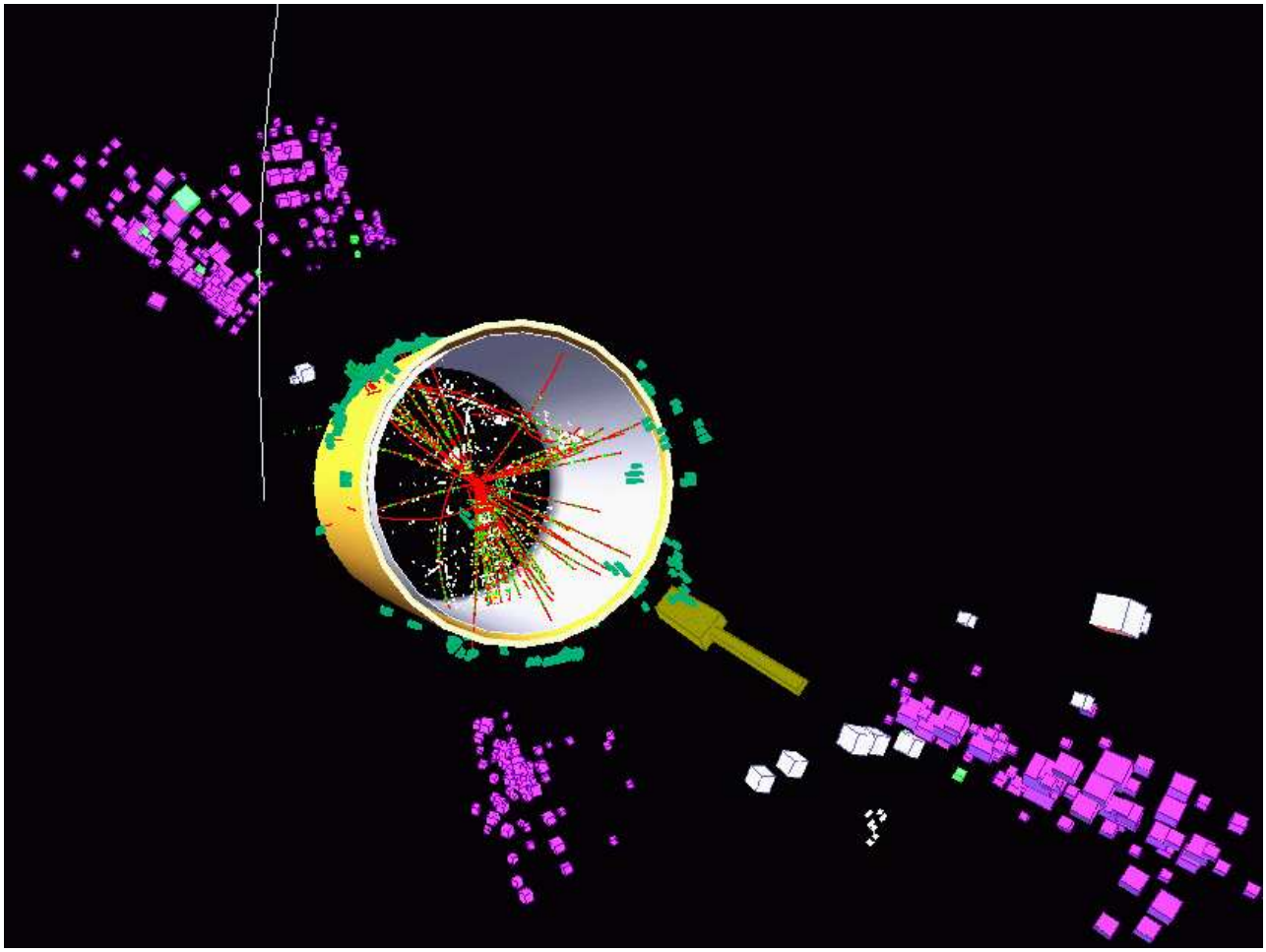
27 July - 2 August, Osaka,Japan.

PRELIMINARY results on 2000 data by L3 experiment on:

- $\sqrt{s}$ up to 205.5 GeV data, $\int \mathcal{L}\,dt \approx 62 pb^{-1}$
- $\sqrt{s}$ up to 207.5 GeV data, $\int \mathcal{L}\,dt \approx 32 pb^{-1}$
- $\sqrt{s} \geq$ 207.5 GeV data, $\int \mathcal{L}\,dt \approx 1.8 pb^{-1}$

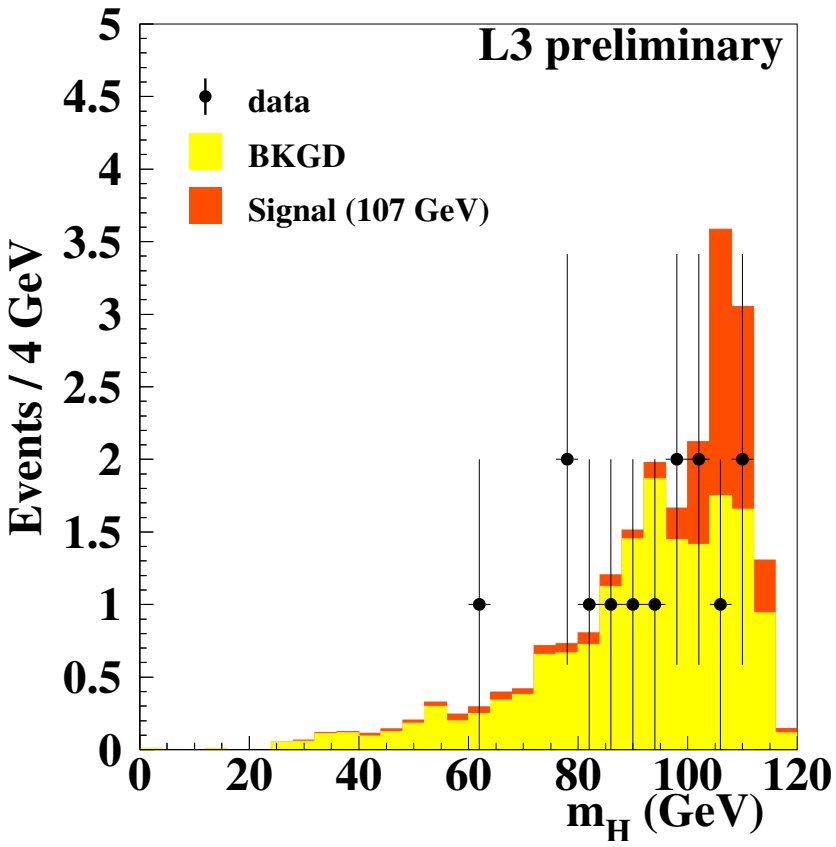
- **Search for Higgs bosons.**
  - Standard Model Higgs
  - MSSM Higgs
  - Charged Higgs
  - Invisible Higgs,fermiophobic Higgs
- **Search for SUSY particles.**
  - Scalar Leptons,Charginos and Neutralinos
  - Scalar Top and Scalar Bottom Quarks
  - Single and Multi-Photons events with missing energy
- **Search for exotica and new physics.**
  - Heavy Neutral and Charged Leptons
  - Excited Leptons

$HZ \rightarrow qqqq$ candidate ($\sqrt{s} = 206.6$ GeV)



$m_H = 109.9$ GeV, event b tag $= 2.6$

Combined mass plot of this year data after cut on b tag



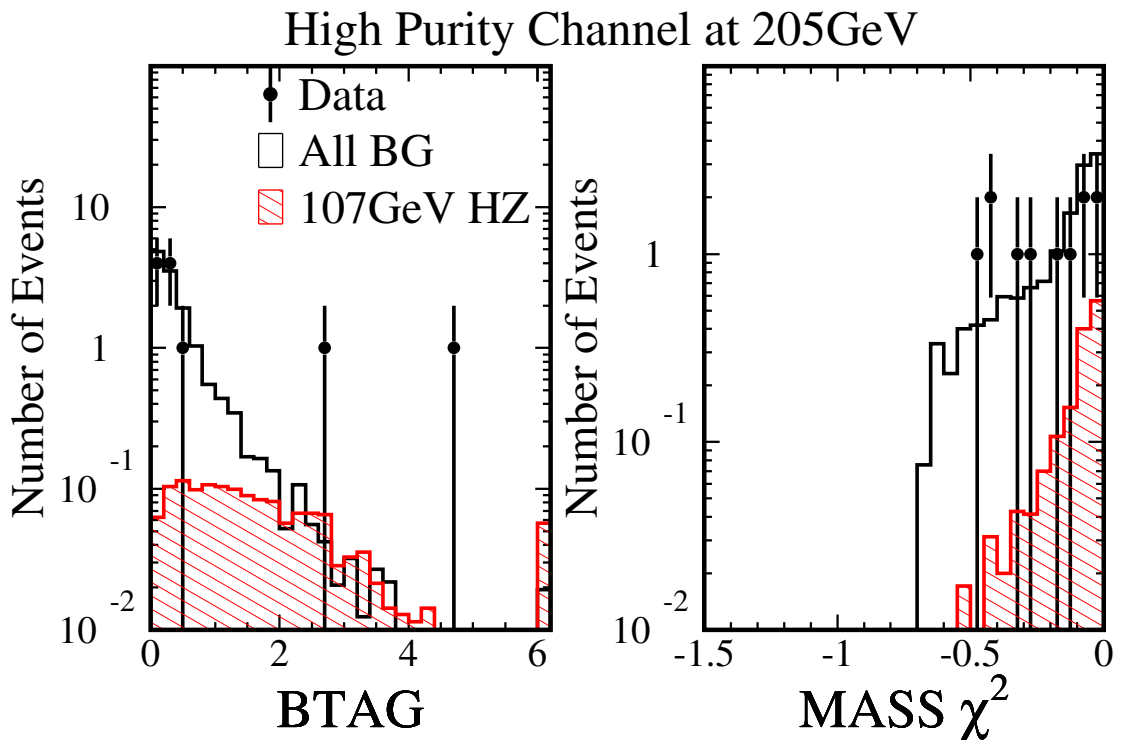
reconstructed Higgs mass

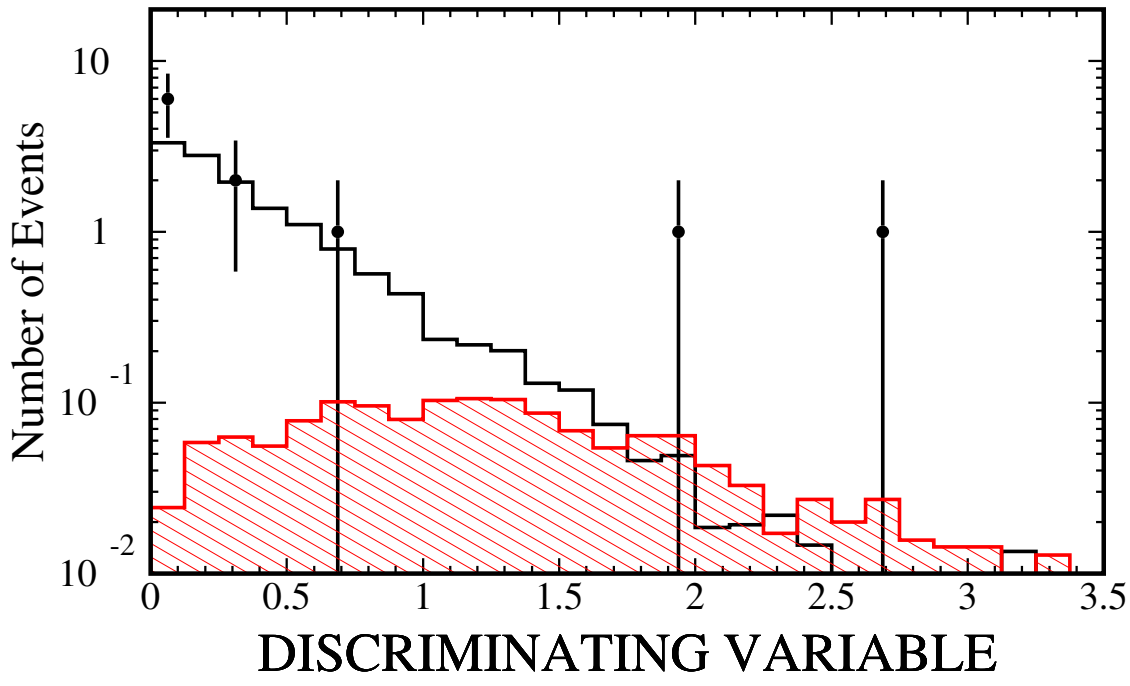
observed / expected events

Channel	Data	BG	Signal 107 GeV	$m_H \geq 100$ GeV Data	BG	Signal 107 GeV
qqqq	9	9.9	2.8	4	2.9	2.0
qq$\nu\nu$	5	4.6	2.0	1	2.8	1.9
qq$\ell\ell$	0	1.5	0.5	0	0.2	0.4
Sum	14	16.0	5.3	5	5.9	4.3

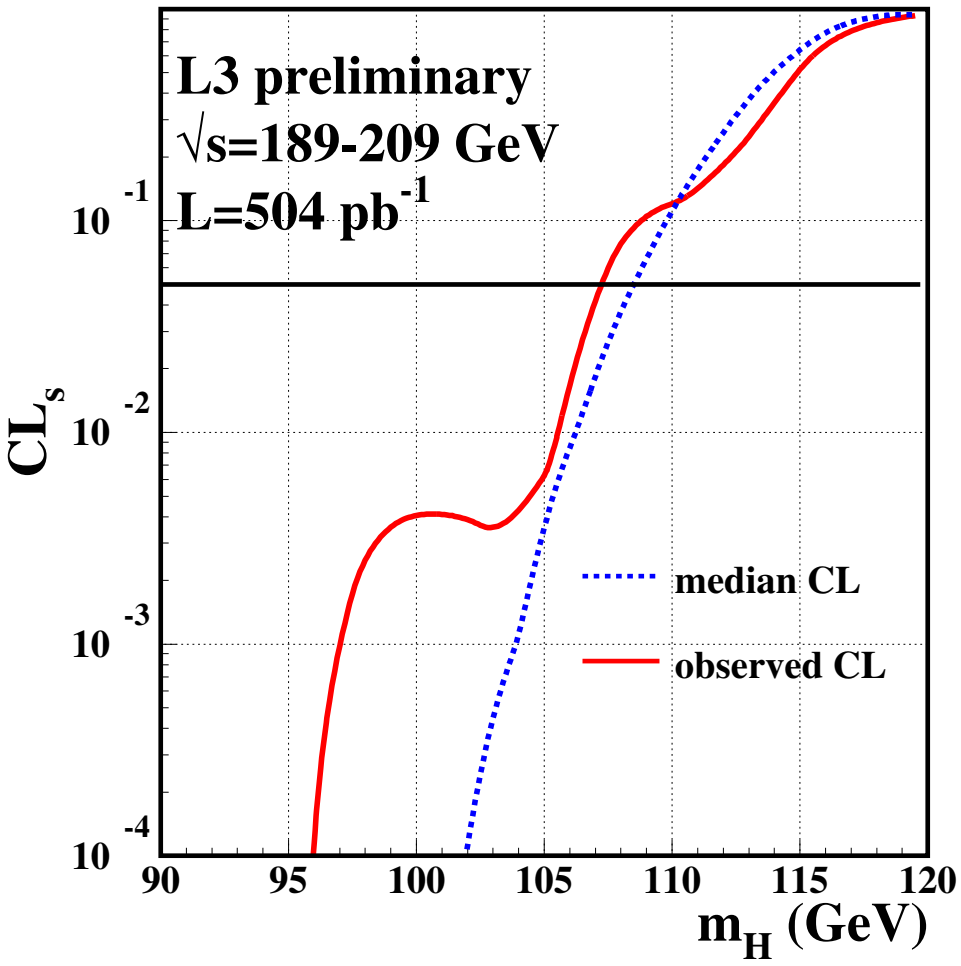
Four jet channel HZ → qqqq

Mass, b tag and discriminating variable distribution





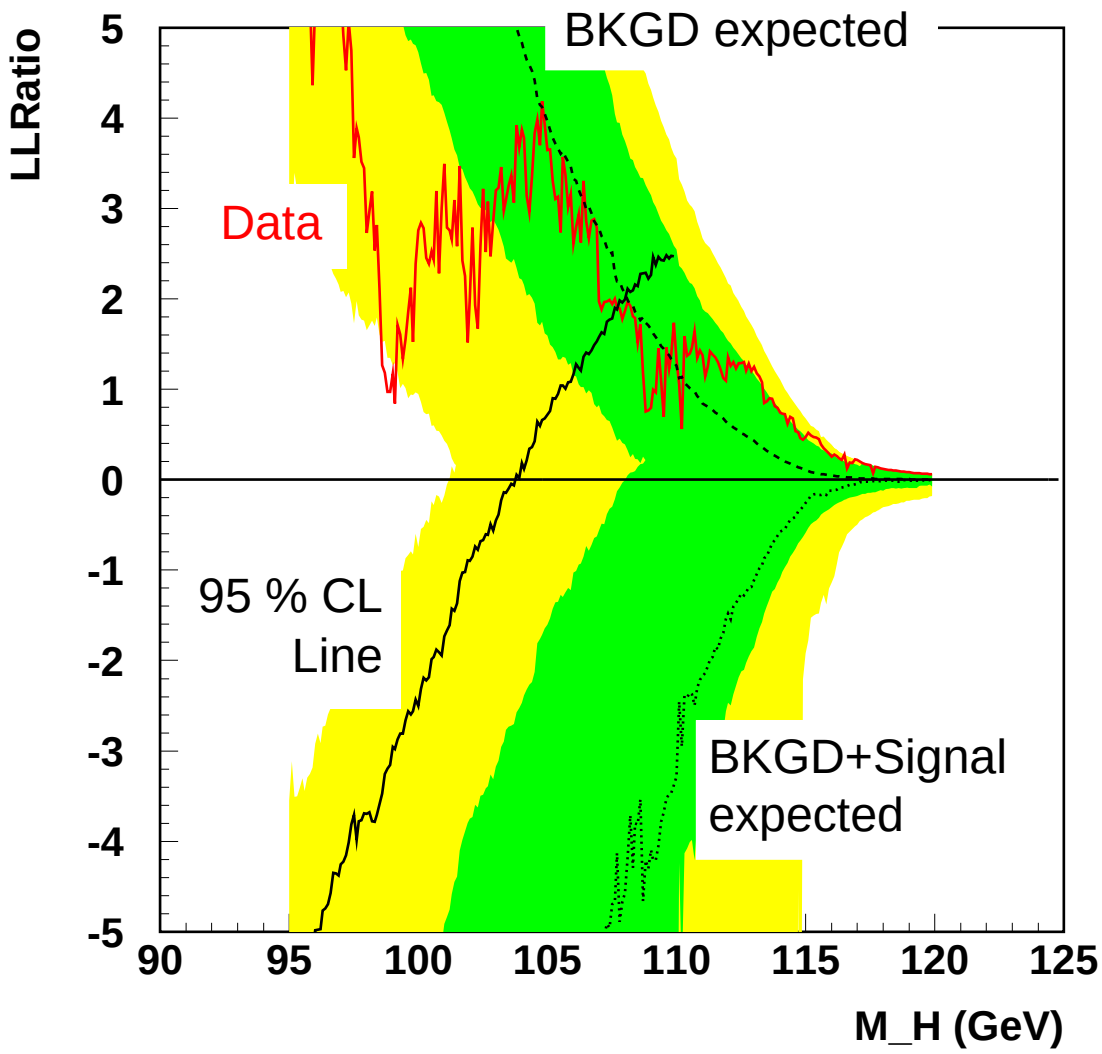
No signal observed
→ limits set at 95% CL



Observed: $m_H > 107.6$ GeV

median expected: $m_H > 108.5$ GeV

Log Likelihood Ratio $\log \frac{\mathcal{L}(x|bkgd)}{\mathcal{L}(x|sig+bkgd)}$

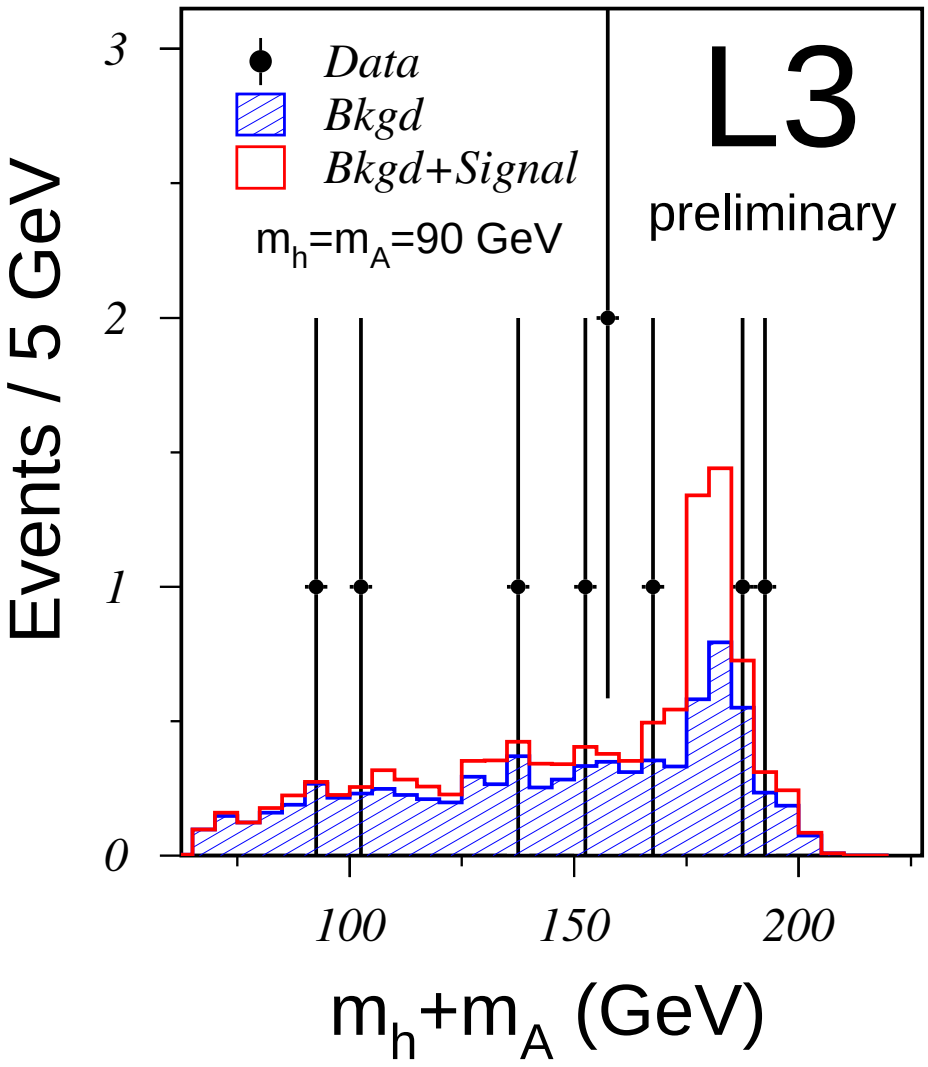


No clear evidence for a signal
→ mass limits at 95% CL

Observed: $m_h > 107.7$ GeV

Median Expected : $m_h > 108.0$ GeV

Four jet channel hA → bbbb



			$m_h + m_A \geq 160$ GeV		
Data	BG	Signal 90 GeV	Data	BG	Signal 90 GeV
9	7.9	2.9	3	3.5	2.1

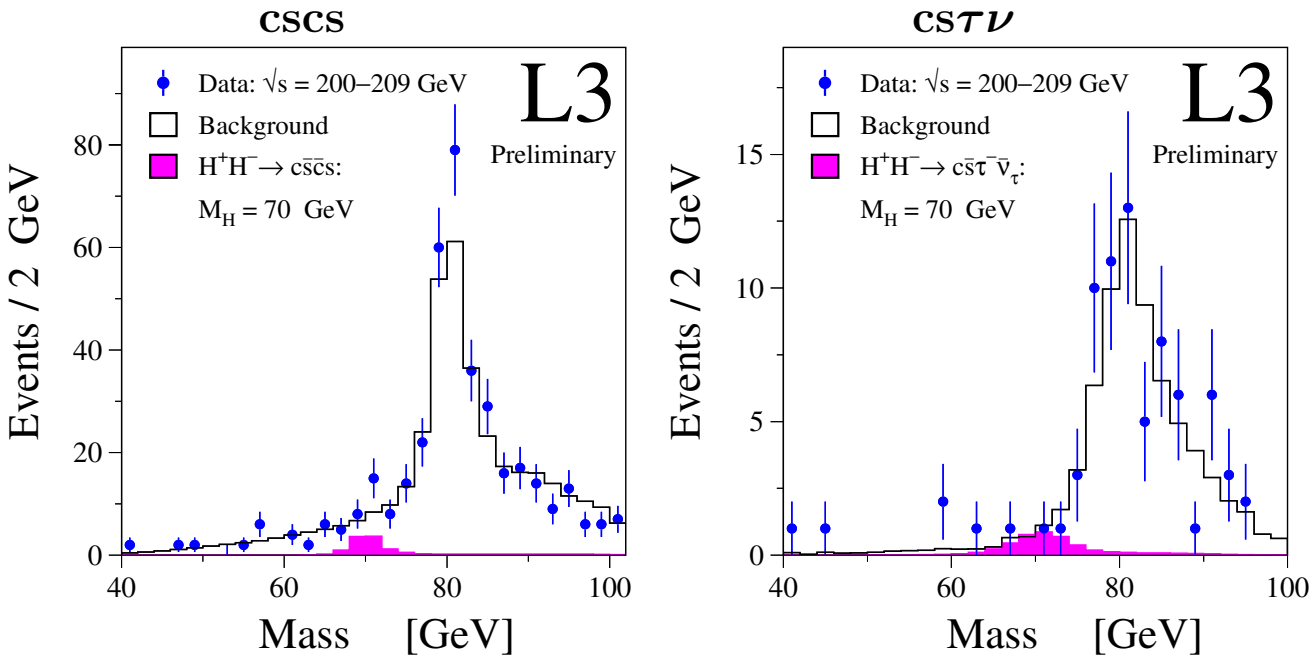
MSSM high tan β limit:

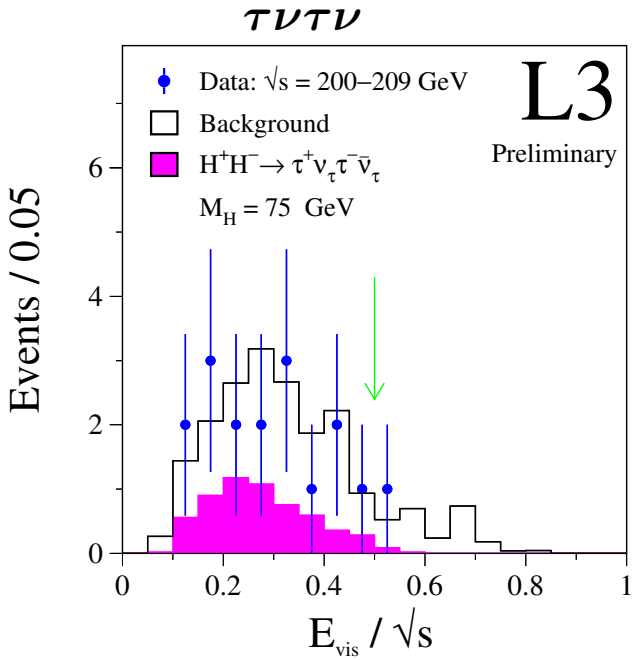
$m_h > 87$ GeV (expected 87 GeV)

$m_A > 87$ GeV (expected 87 GeV)

Searches for Charged Higgs Bosons $H^{\pm} \rightarrow cs, \tau\nu$

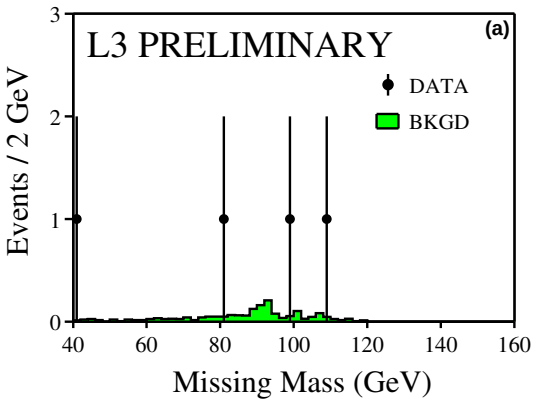
Higgs candidate masses (this year data, $\int \mathcal{L}dt \approx 92.1\text{pb}^{-1}$)



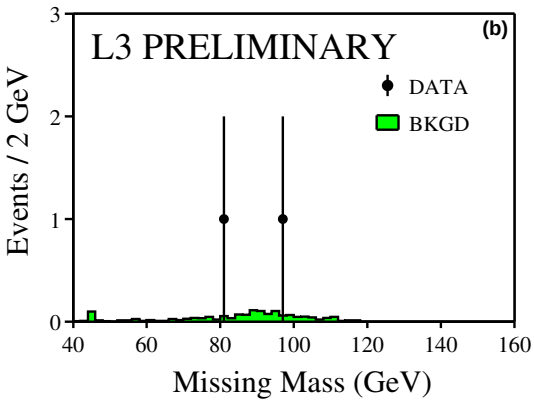


$HZ \rightarrow (\text{invis})Z$: Invisible mass

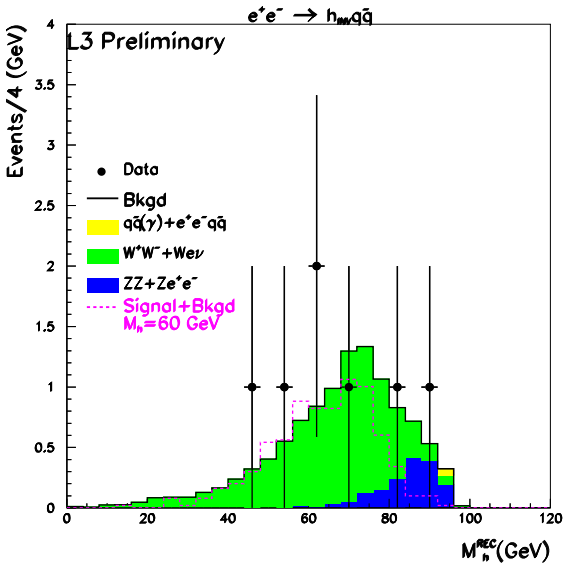
ee(invis)



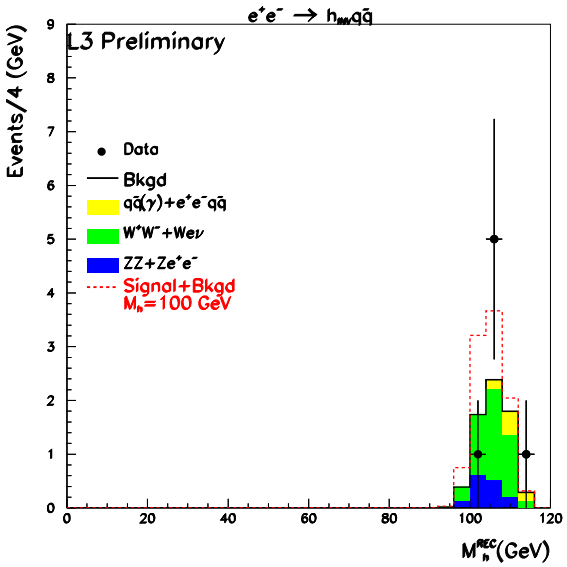
$\mu\mu$(invis)



qq(invis) light

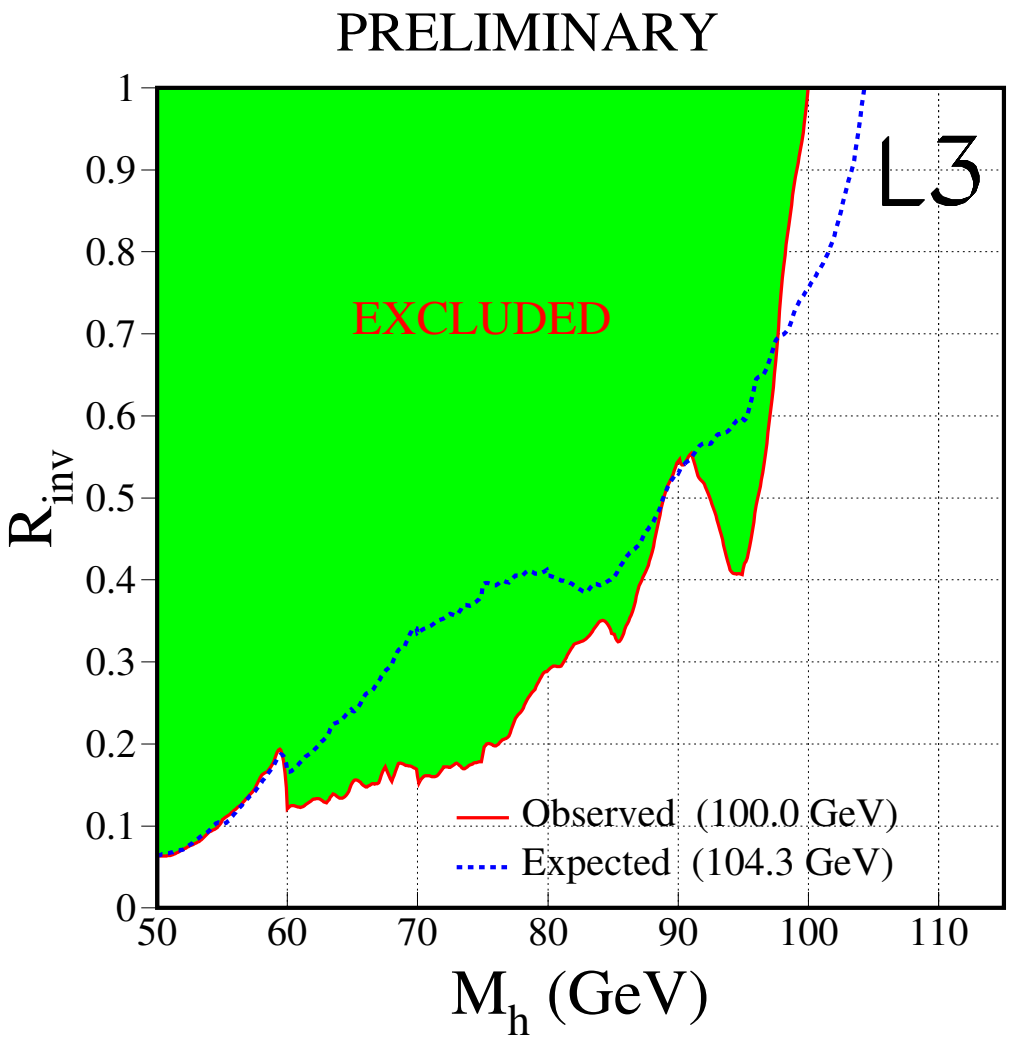


qq(invis) heavy



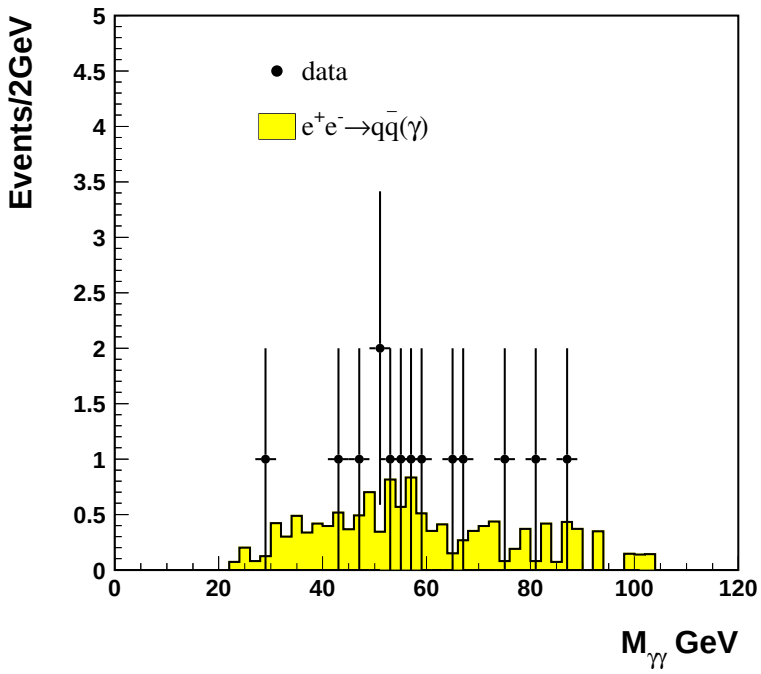
sum of all channels: Data: 20 BG: 20.9

Invisible Higgs excluded regions in the plane M_H vs. BR($H \rightarrow$ invisible)

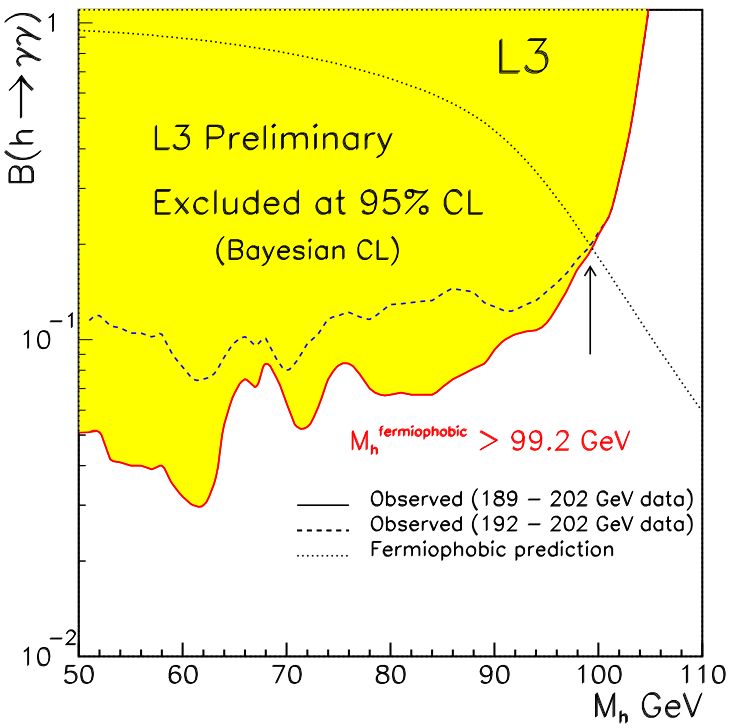


Fermiophobic Higgs scenario

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



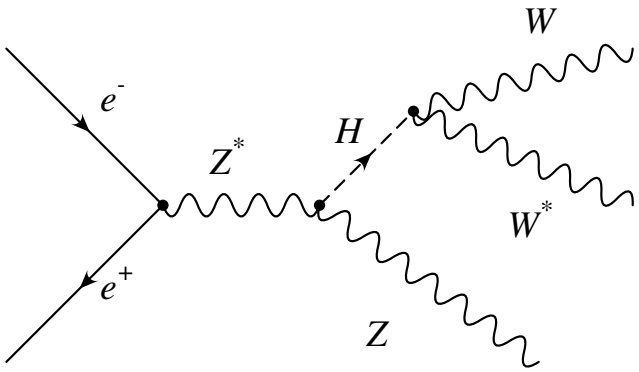
$H \rightarrow \gamma\gamma$: Invariant mass of photons (1999 data)



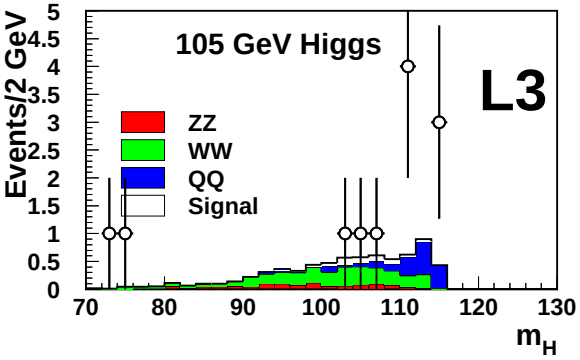
Excluded regions in the Plane m_H / BR($H \rightarrow \gamma\gamma$)

New Analysis: H → WW*

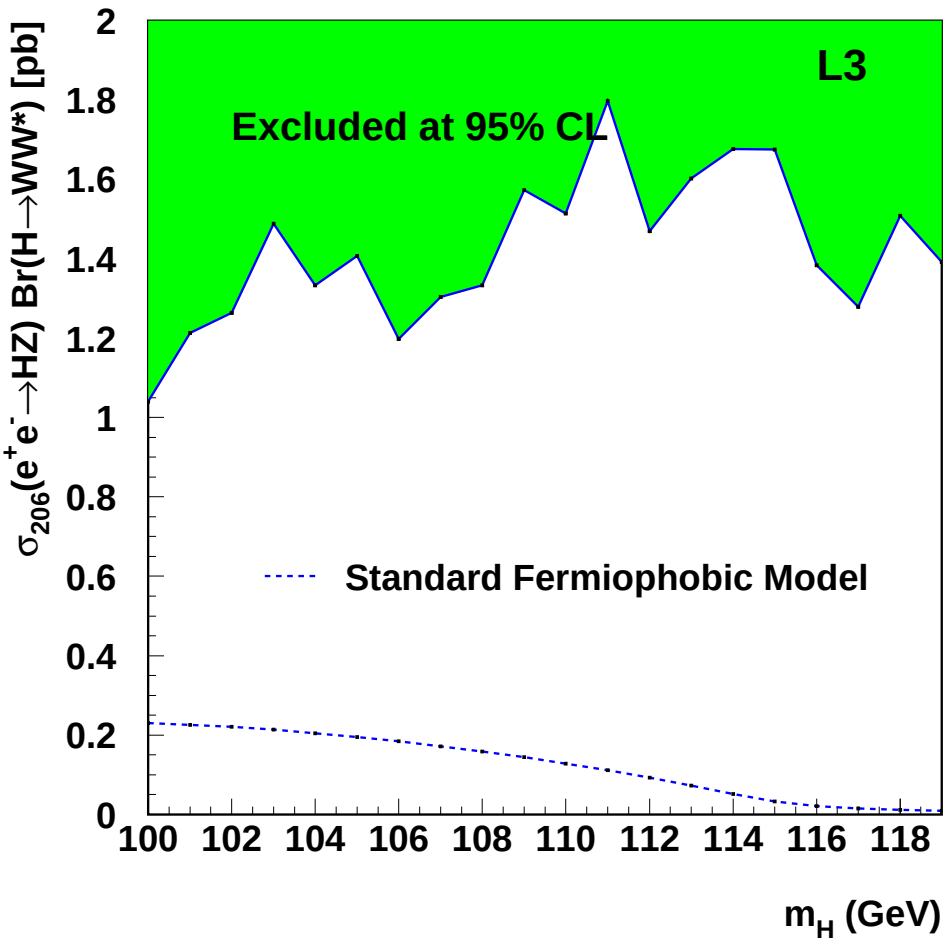
Production mechanism



reconstructed mass



Limits on Cross section × Br(H→ WW*)



• At $\sqrt{s} > 202$ GeV searches in the following channels are performed:

- $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_1^0$
- $\tilde{e}, \tilde{\mu}, \tilde{\tau}, \tilde{t}, \tilde{b}$
- γ+missing energy, $\gamma\gamma$+missing energy:

•Basic assumptions:
R-parity conservation: pair production of S-particles

and Lightest S-particle (LSP) $\tilde{\chi}_1^0$ stable and invisible

- Sleptons: $e^+e^- \rightarrow \tilde{\ell}\tilde{\ell} \rightarrow \ell\ell\tilde{\chi}_1^0\tilde{\chi}_1^0$
  2 leptons, E_{miss}
- Squarks: $e^+e^- \rightarrow \tilde{q}\tilde{q} \rightarrow q\bar{q}\tilde{\chi}_1^0\tilde{\chi}_1^0$
  2 jets, E_{miss}
- Charginos: $e^+e^- \rightarrow \tilde{\chi}_1^+\tilde{\chi}_1^- \rightarrow W^*W^*\tilde{\chi}_1^0\tilde{\chi}_1^0$
  E_{miss} and :4 jets, or 2 jets and 1 lepton,or 2 leptons

$$\Delta M = (M_{Sparticle} - M_{LSP})$$

Most important parameter for all analyses

- 30 selections for Charginos, Neutralinos, Sleptons

Neutralinos

$\sqrt{s} = 202 - 208$ GeV, $\int \mathcal{L}\, dt = 56.7 \text{pb}^{-1}$

$\sqrt{s} > 205.5$ GeV, $\int \mathcal{L}\, dt = 14.0 \text{pb}^{-1}$ (high energy sample)

	Low ΔM		Medium ΔM		High ΔM		.OR.	
	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}
$\tilde{\chi}_2^0$	11	13.3	1	3.5	0	1.2	12	17.4
$\tilde{\chi}_2^0$	4	3.3	0	0.9	0	0.3	4	4.3

$N^{\text{Exp}}_{\tilde{\chi}_2^0} \sim 28$ $N^{\text{Exp}}_{\tilde{\chi}_2^0} \sim 7$

Charginos

$\sqrt{s} = 202 - 208$ GeV, $\int \mathcal{L}\, dt = 84.3 \text{pb}^{-1}$

$\sqrt{s} > 205.5$ GeV, $\int \mathcal{L}\, dt = 28.0 \text{pb}^{-1}$ (high energy sample)

	Low ΔM		Medium ΔM		High ΔM		.OR.	
	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}
$\tilde{\chi}_1^\pm$	20	16.7	17	10.5	9	13.8	44	37.4
$\tilde{\chi}_1^\pm$	7	5.4	3	3.4	3	4.6	13	12.4

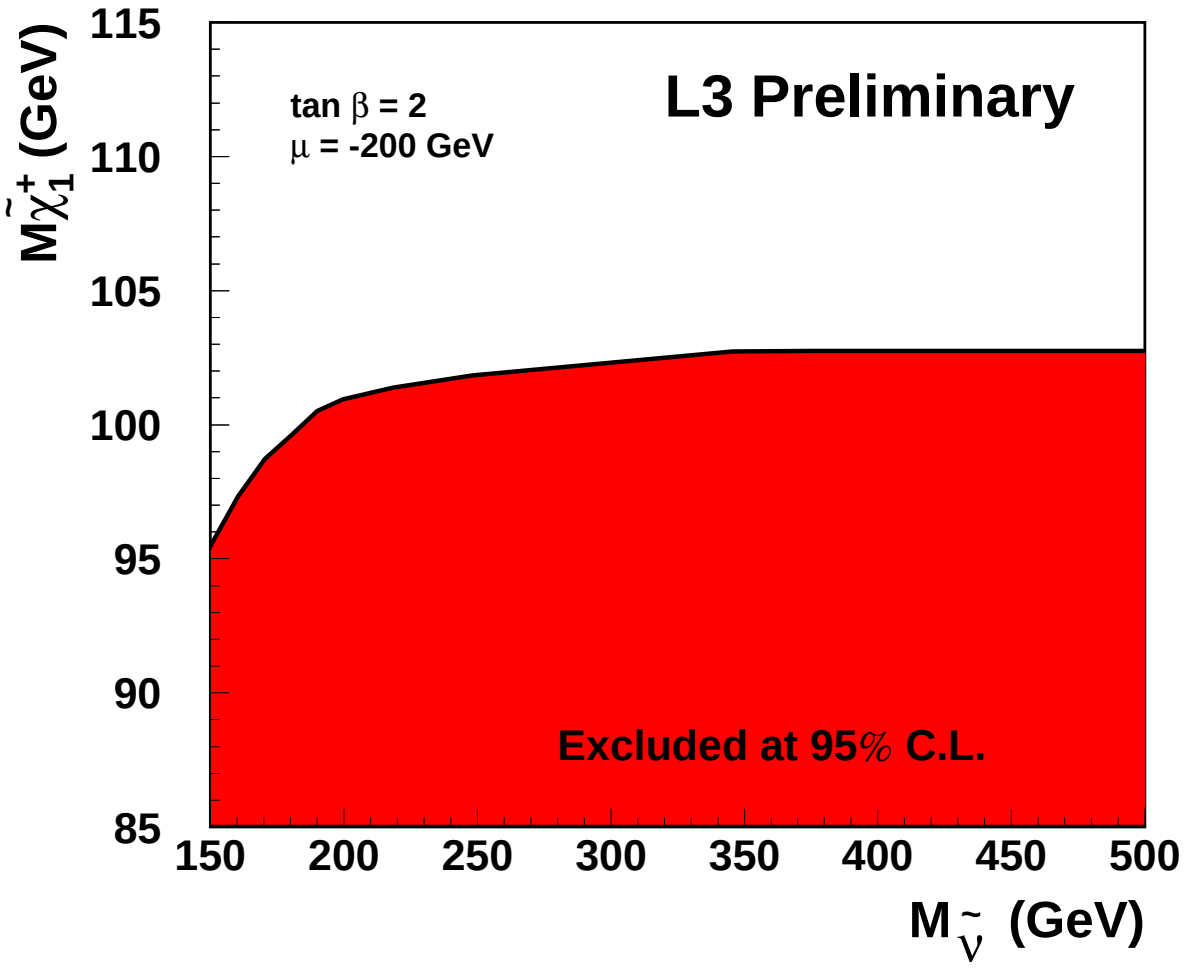
$N^{\text{Exp}}_{\tilde{\chi}_1^\pm} \sim 42$ $N^{\text{Exp}}_{\tilde{\chi}_1^\pm} \sim 14$

No excess respect to SM predictions

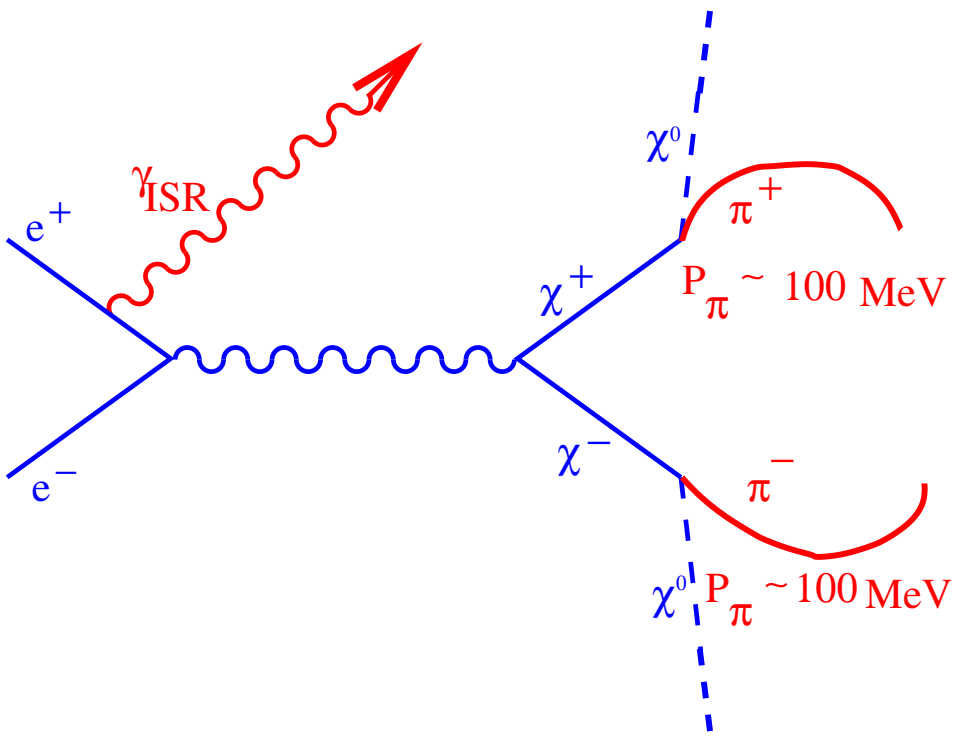
- Enough $\int \mathcal{L}\, dt$ for $\tilde{\chi}_1^\pm$ exclusions

- $M_{\tilde{\chi}_1^\pm} > 102.7$ GeV
  for large s-neutrino masses

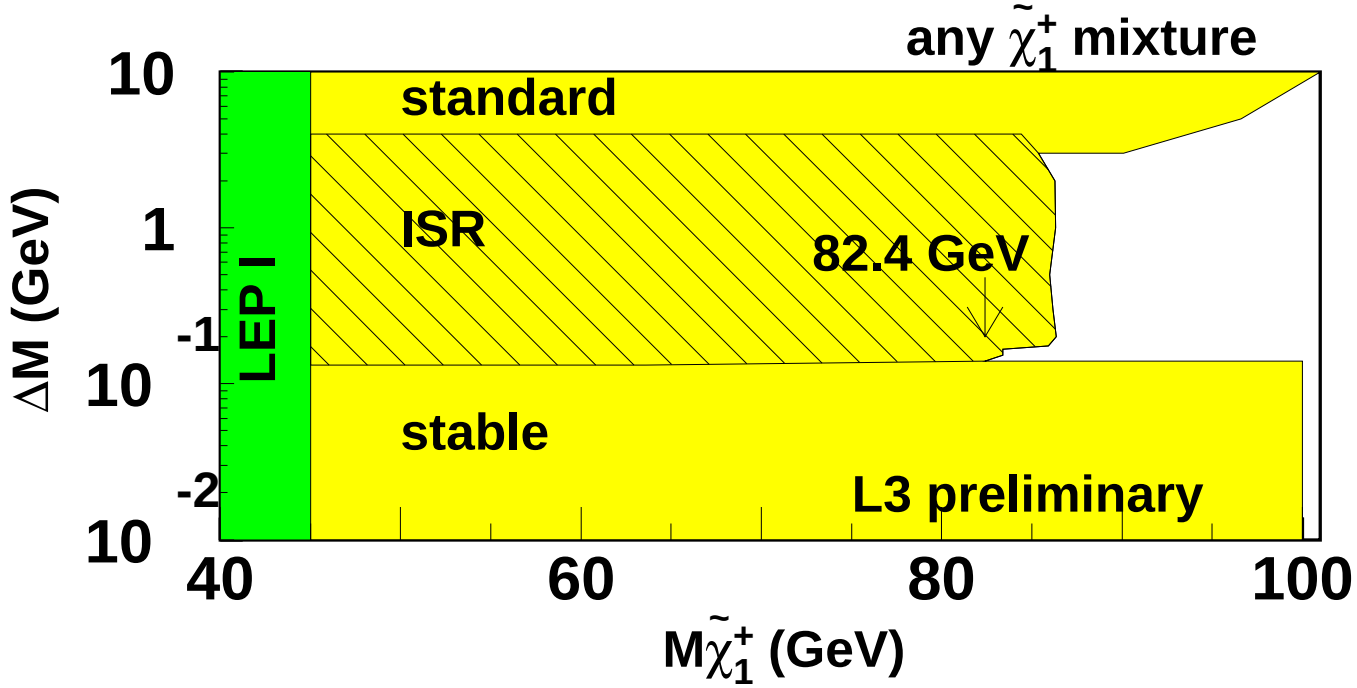
- Very small s-neutrino masses are indirectly excluded by s-lepton exclusions (in particular s-electrons)



- Setting model independent chargino mass limits is now possible by combining: standard missing energy search with ISR analysis and highly ionising track analysis.
- New results from ISR analysis. Assuming no signal in 1998–1999 past years data used as precise background prediction.



selection	low ΔM $\Delta M \sim$ 3GeV	very low ΔM $\Delta M \sim$ 1GeV	ultra low ΔM $\Delta M \sim$ 300MeV	OR
1998 (176 pb)	6	1	1	8
1999 (232 pb)	8	4	2	9
2000 (76.5 pb)	3	1	3	5
98-99 scaled	2.6 ± 0.7	0.9 ± 0.4	0.6 ± 0.3	3.2 ± 0.8

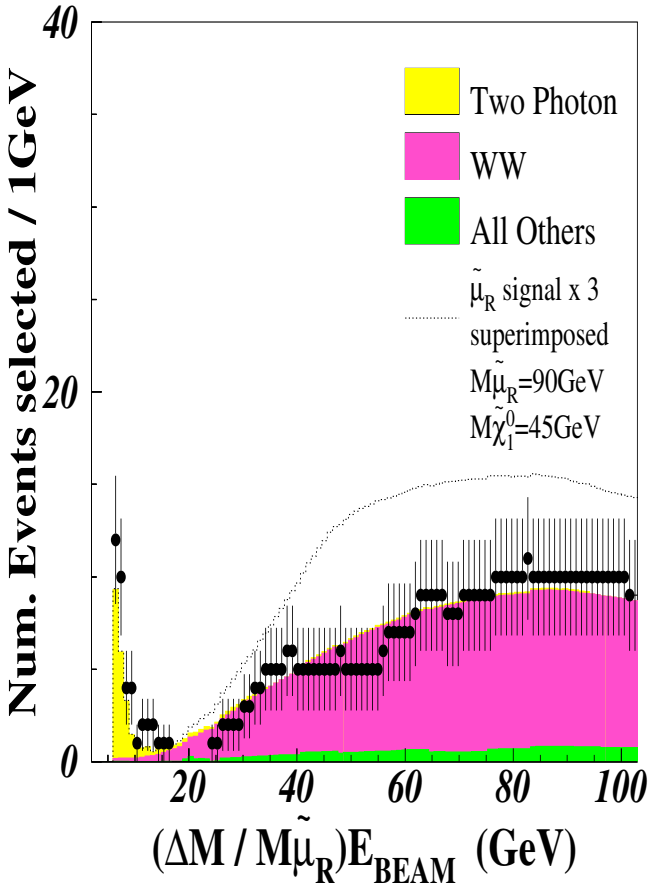


$\sqrt{s} \approx 205$ GeV, $\int \mathcal{L}\, dt = 84.6 pb^{-1}$

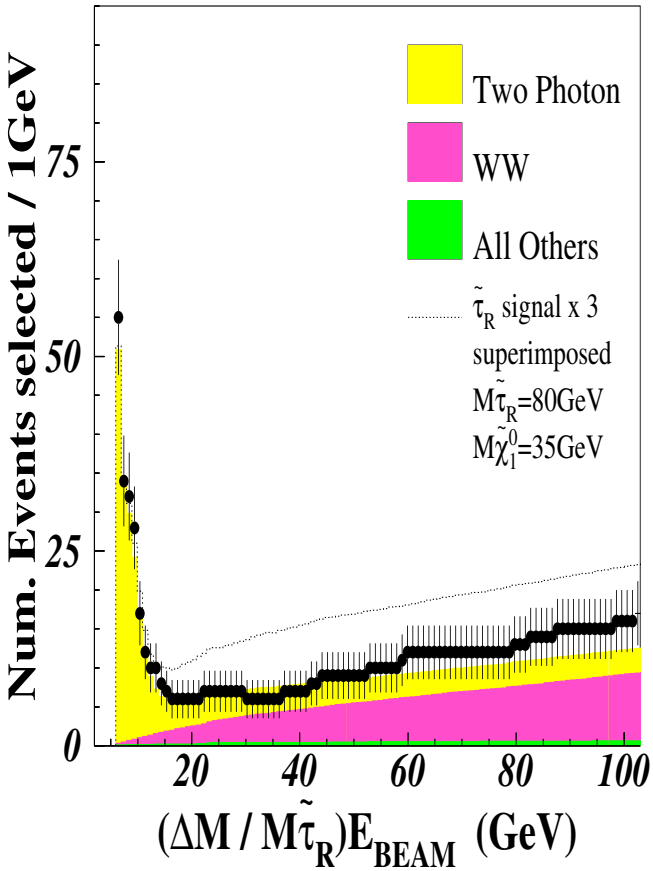
	Low ΔM		Medium ΔM		High ΔM		.OR.	
	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}
$\tilde{e}$	9	9.9	0	4.3	5	9.2	14	20.4
$\tilde{\mu}$	17	13.6	6	5.4	14	12.8	33	27.5
$\tilde{\tau}$	76	66.4	21	21.6	17	12.5	89	76.6

$N^{exp}_{\tilde{e},\tilde{\mu},\tilde{\tau}} \sim 4 - 10$

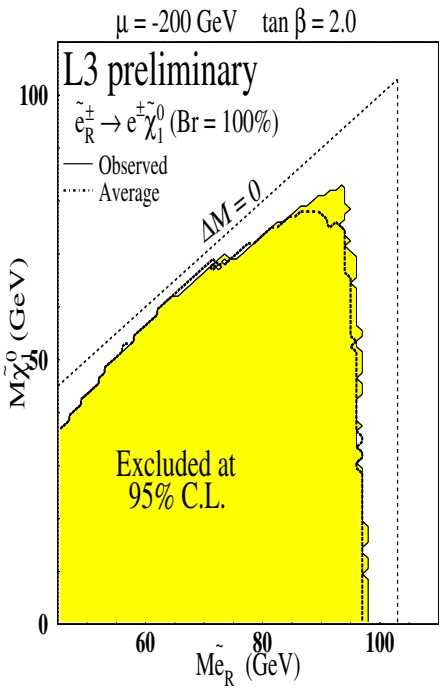
smuons

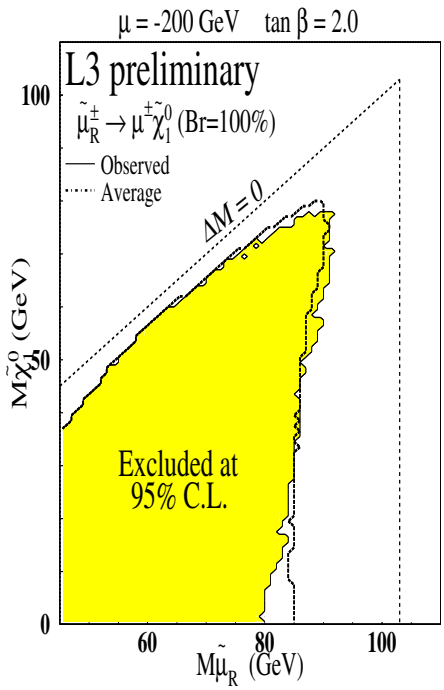


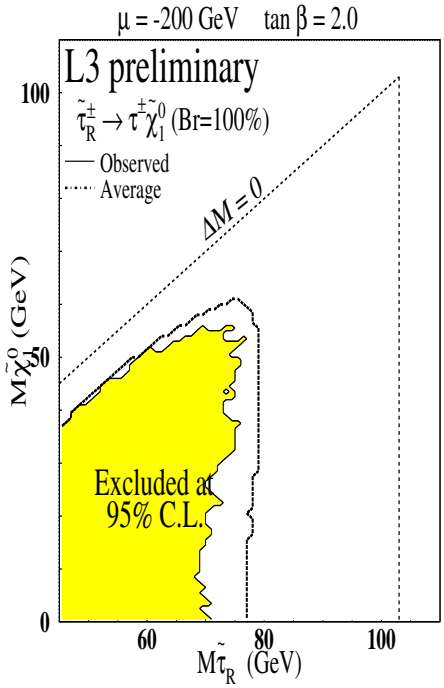
staus



- **New s-lepton mass limits including all data from 189 to 208 GeV**







At $\sqrt{s} \sim 205\text{GeV}$ $\int \mathcal{L}\, dt = 49.3\text{pb}^{-1}$

- **Scalar top**

  $e^+e^- \to \tilde{t}_1\bar{\tilde{t}}_1 \to c\tilde{\chi}_1^0\ \bar{c}\tilde{\chi}_1^0 \implies 2\text{jets} + E_{\text{miss}}$

  $e^+e^- \to \tilde{t}_1\bar{\tilde{t}}_1 \to b\ell^+\tilde{\nu}\ \bar{b}\ell^-\tilde{\nu} \implies 2\text{b-jets} + 2\ell + E_{\text{miss}}$

- **Scalar bottom**

  $e^+e^- \to \tilde{b}_1\bar{\tilde{b}}_1 \to b\tilde{\chi}_1^0\ \bar{b}\tilde{\chi}_1^0 \implies 2\text{b-jets} + E_{\text{miss}}$

Channel	Vlow ΔM		Low ΔM		Medium ΔM		High ΔM		OR	
	Data	N_{MC}	Data	N_{MC}	Data	N_{MC}	Data	N_{MC}	Data	N_{MC}
$\tilde{t}_1 \to c\tilde{\chi}_1^0$	21	14.2	0	2.12	3	2.00	4	3.03	28	21.1
$\tilde{t}_1 \to b\ell\tilde{\nu}$	10	8.11	5	2.52	1	0.20	-	-	16	10.60
$\tilde{t}_1 \to b\tau\tilde{\nu}$	4	4.98	2	4.08	1	0.91	-	-	7	9.39
$\tilde{b}_1 \to b\tilde{\chi}_1^0$	13	9.93	1	1.138	0	0.34	0	0.33	14	11.74

No significant excess with respect to SM

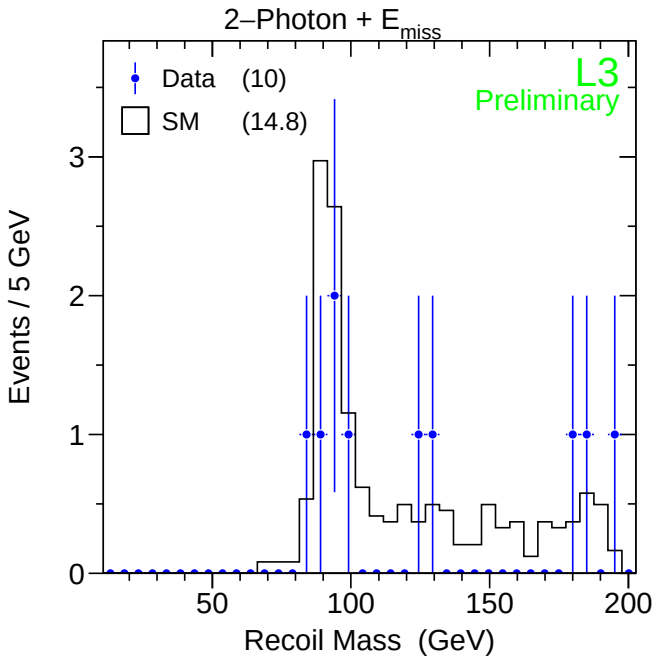
$\gamma(\gamma)$ + missing energy

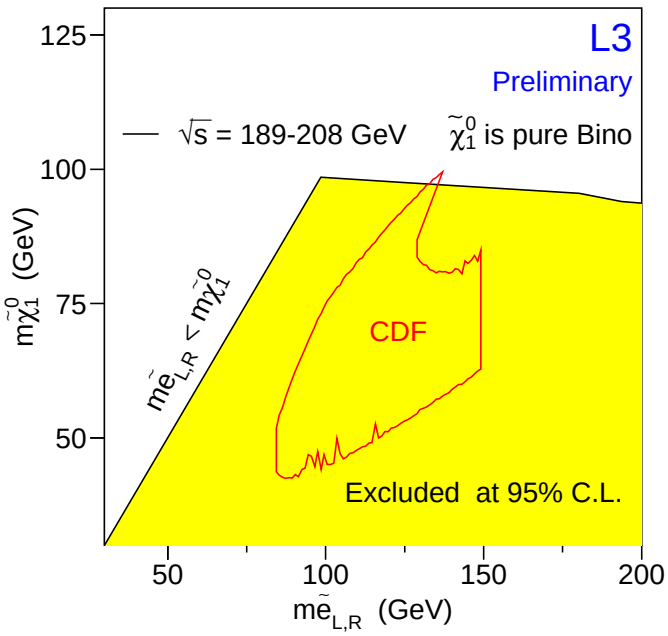
Standard Model Process $e^+e^- \to \nu\bar{\nu}\gamma(\gamma)$

In the GMSB scenario, with $\tilde{G}$ LSP, the possible decay channels are :

- $e^+e^- \to \tilde{\chi}_1^0\tilde{G} \to \tilde{G}\tilde{G}\gamma$
- $e^+e^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 \to \tilde{G}\tilde{G}\gamma\gamma$

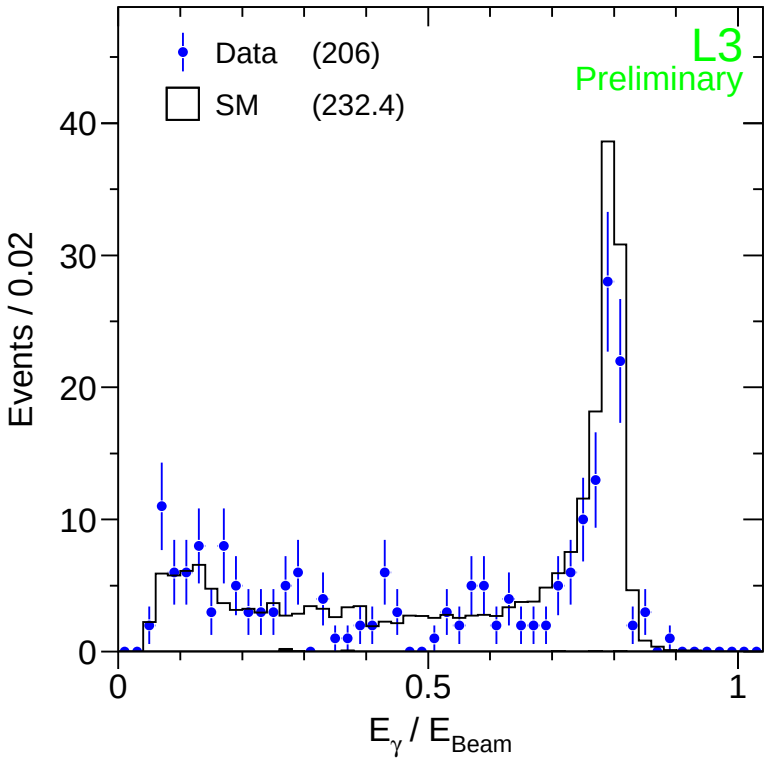
$\sqrt{s} > 202$ GeV $(\theta \geq 14\,\mathrm{deg})$





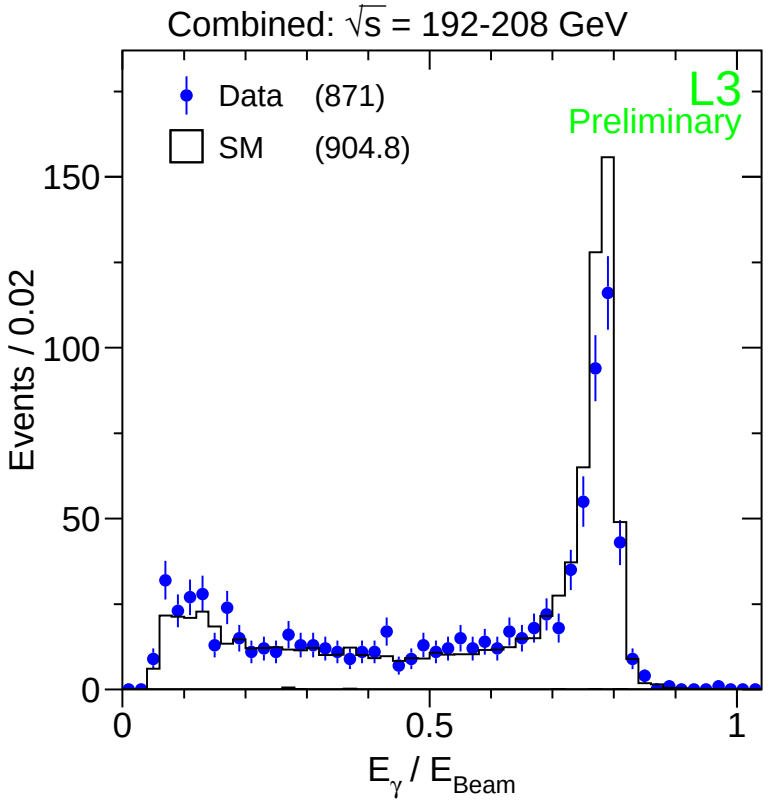
Rule out SUSY interpretation of CDF ee$\gamma\gamma$ event

$\sqrt{s} = 202 - 208$ GeV, $\int \mathcal{L}\, dt = 90.7 \mathrm{pb}^{-1}$

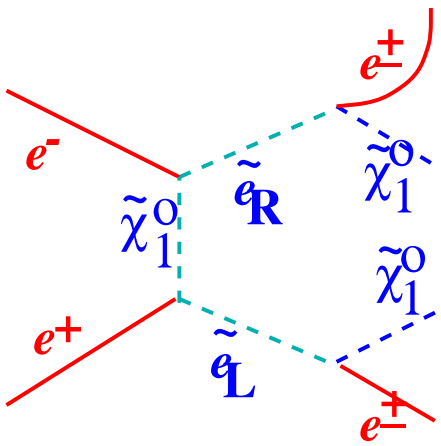


This year's data confirm continue to show a slight disagreement in the shape of the differential cross section.

$\sqrt{s} = 192 - 208$ GeV, $\int \mathcal{L}\, dt = 323 \mathrm{pb}^{-1}$



$$\tilde{e}_R\tilde{e}_L \rightarrow (e)e\tilde{\chi}_1^0\tilde{\chi}_1^0$$



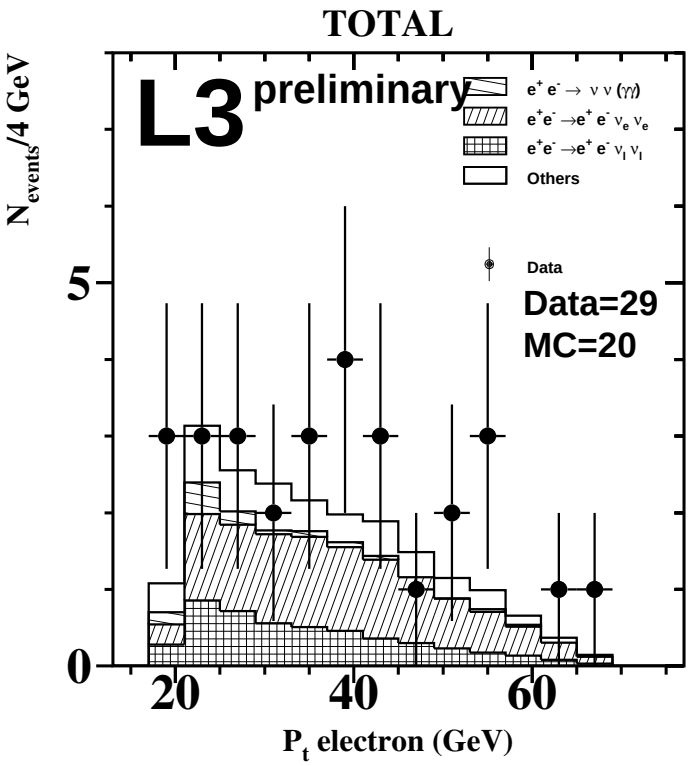
$0\ \text{GeV} \leq M_{\tilde{e}_R} - M_{\tilde{\chi}_1^0} \leq 3\ \text{GeV}$
$M_{\tilde{e}_R} + M_{\tilde{e}_L} \leq \sqrt{s} \simeq 200\ \text{GeV}$

RESULTS at $\sqrt{s} = 192$ to 209 GeV

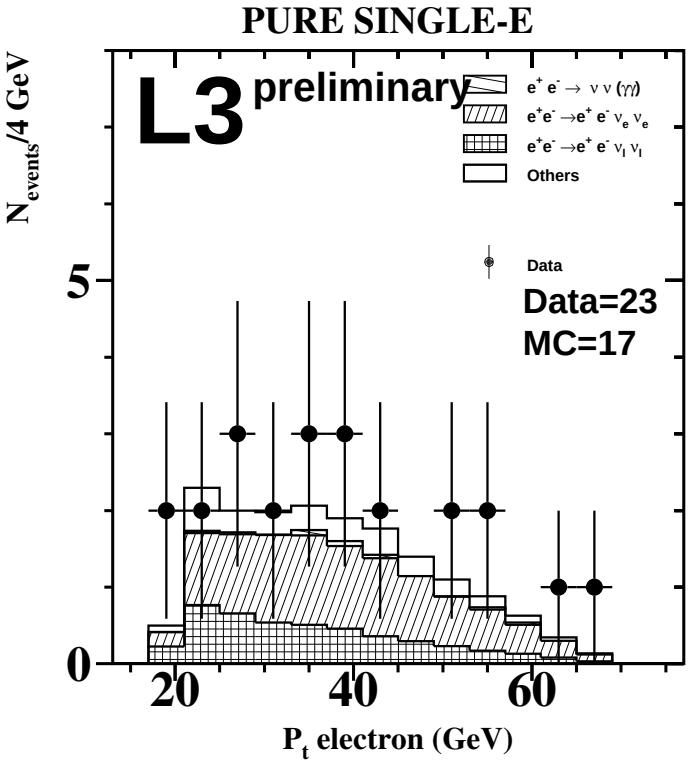
$\sqrt{s}$	Hard + soft		Single-electron		Total	
	N_{Data}	N_{Expec}	N_{Data}	N_{Expec}	N_{Data}	N_{Expec}
192 GeV	1	0.4	2	1.8	3	2.2
196 GeV	1	1.0	7	6.0	8	7.0
200 GeV	1	0.9	9	6.4	10	7.3
202 GeV	3	0.6	5	2.8	8	3.4
205-209 GeV	1	0.9	8	7.0	9	7.9
All $\sqrt{s}$	7	3.8	31	24.0	38	27.8

4 experiments combined : N_{data} =132,N_{MC} = 134

DISTRIBUTIONS at $\sqrt{s} = 192$-202 GeV



P_t of the
most energetic electron
1 electron + eventual
soft system



P_t of the electron
single-electron sub-sample

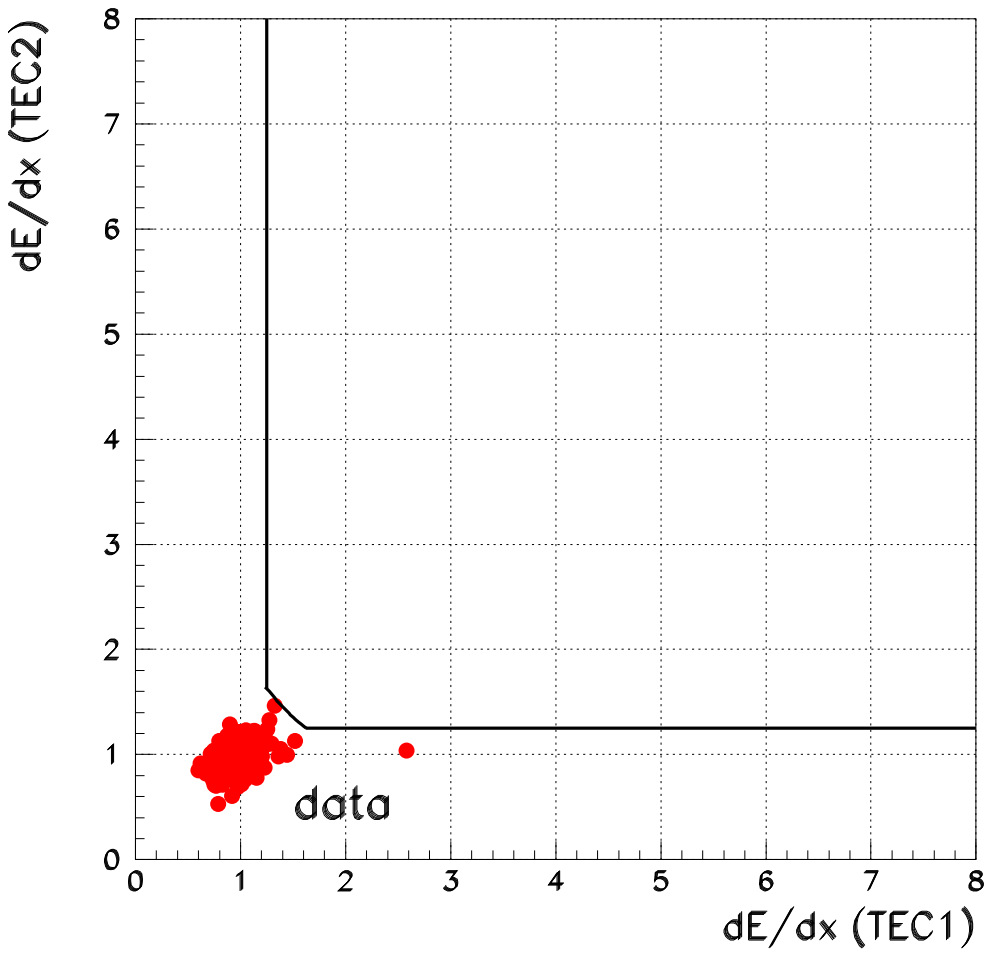
Search for new Unstable Neutral Heavy Leptons. $\mathcal{L} = 96$ pb^{-1}

Channel	Data	Background
$e^+e^- \rightarrow L^0L^0 \rightarrow eWeW$	2	2.1
$e^+e^- \rightarrow L^0L^0 \rightarrow \mu W \mu W$	1	0.6
$e^+e^- \rightarrow L^0L^0 \rightarrow \tau W \tau W$	20	26.5

No signal - good agreement between the number of candidates and expected background

Search for Stable Charged Heavy Leptons

103.4 GeV and above, L=23pb-1



Two highly ionising tracks are searched for

No signal $\Longrightarrow$ $Mass > 102.4$ GeV

Search for Pair Production of Excited Leptons. $\mathcal{L} = 90$ pb^{-1}

Signal	Data	Bkg	Signal	Data	Bkg
$e^*e^* \to ee\gamma\gamma$	0	0.3	$\nu_e^*\nu_e^* \to eeWW$	0	0.1
$\mu^*\mu^* \to \mu\mu\gamma\gamma$	0	0.2	$\nu_\mu^*\nu_\mu^* \to \mu\mu WW$	0	0.3
$\tau^*\tau^* \to \tau\tau\gamma\gamma$	0	0.1	$\nu_\tau^*\nu_\tau^* \to \tau\tau WW$	1311	1255
$\ell^*\ell^* \to \nu\nu WW$	1311	1255	$\nu^*\nu^* \to \nu\nu\gamma\gamma$	1	0.7
$e^*e^* \to e\gamma\nu W$	3	2.6	$\nu_e^*\nu_e^* \to \nu\gamma eW$		
$\mu^*\mu^* \to \mu\gamma\nu W$	1	1.3	$\nu_\mu^*\nu_\mu^* \to \nu\gamma\mu W$	2	2.3
$\tau^*\tau^* \to \tau\gamma\nu W$	15	13	$\nu_\tau^*\nu_\tau^* \to \nu\gamma\tau W$		

No signal $\Longrightarrow$ Mass limits are set

Excited Lepton Coupling	95% CL Mass Limit (GeV)		
	$f = f'$	$f = -f'$	Coup. Indep.
e^*	102.5	95.9	95.7
μ^*	102.5	95.9	95.9
τ^*	102.4	95.9	94.9
ν_e^*	101.5	102.1	101.3
ν_μ^*	101.8	102.1	101.3
ν_τ^*	93.5	101.9	92.7

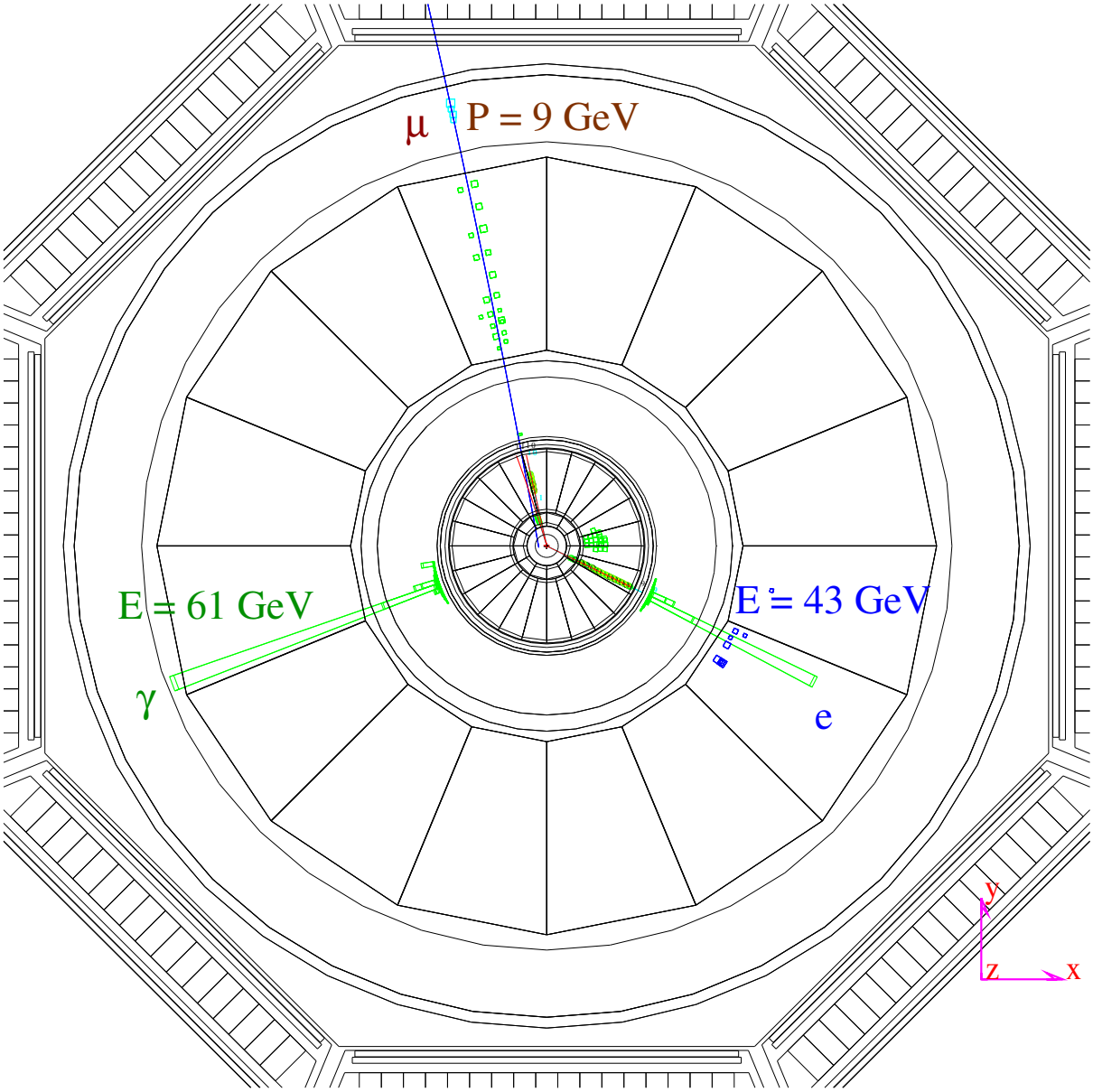
From single production searches, limits are derived on the coupling constant $|f|/\Lambda$

Excited Electrons Candidate

Candidate to e*e* production at $\sqrt{s} = 204$GeV

m(e , γ) = 95 GeV m_recoil(e ,γ) = 90 GeV

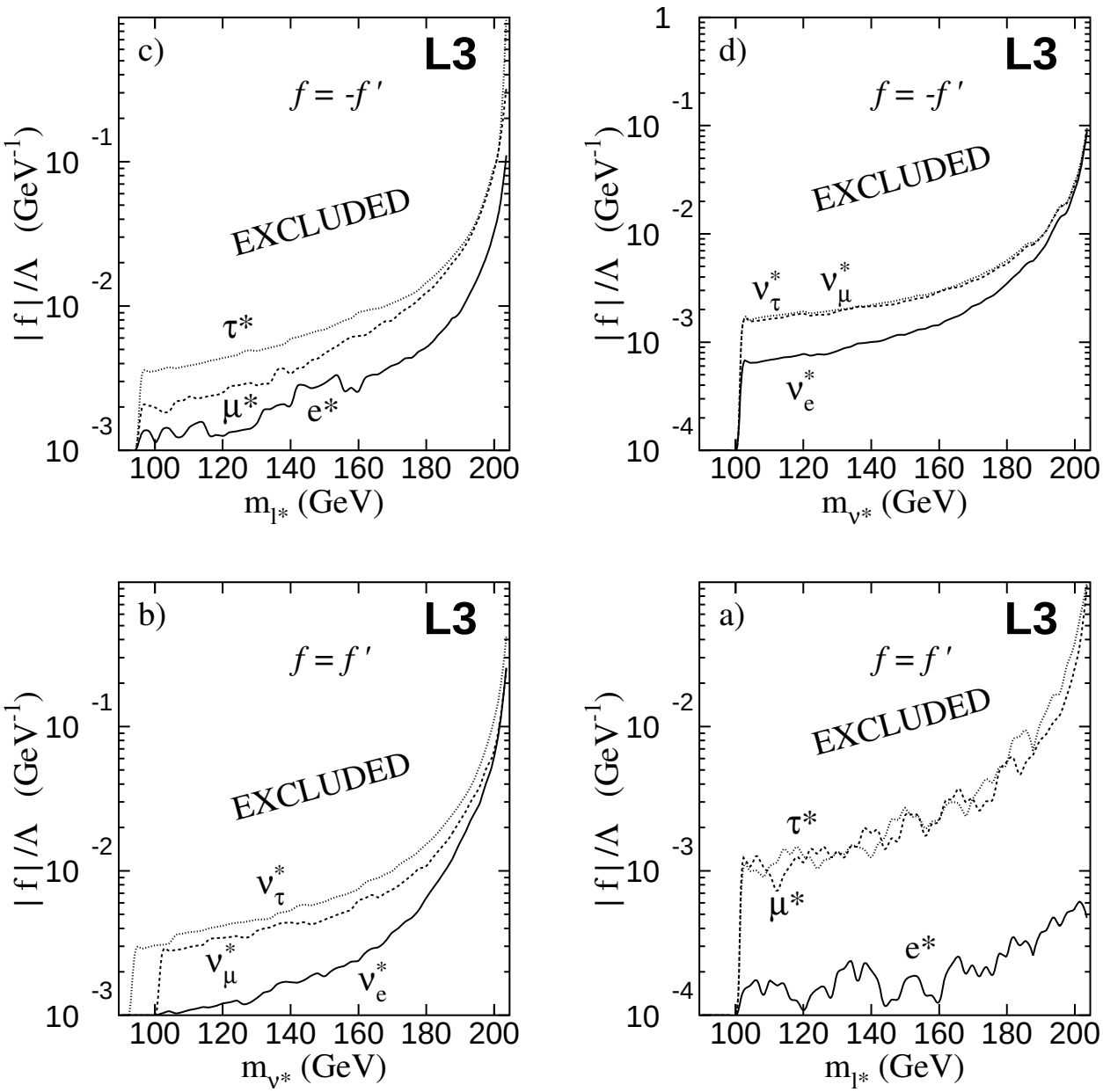
Run # **812802** **Event #** **630** Total Energy : 121.44 GeV



Transverse Imbalance :	.2681		**Longitudinal Imbalance :**	.0098	
Thrust :	.8491	**Major :**	.4177	**Minor :**	.1099
Event DAQ Time :	*420 52213*				

$e^+ e^- \longrightarrow e^* e^* \longrightarrow e\,\gamma\,\nu\,W \longrightarrow e\,\gamma\,\nu\,\mu\,\nu$

Excited leptons coupling constants



Conclusions

Preliminary results on 2000 data by L3 experiment has been presented based on data at $\sqrt{s}$= 202-208 GeV, with $\int \mathcal{L}\, dt \approx =$ 90pb^{-1} .

- Standard Model Higgs:

  $m_H > 107$GeV at 95% C.L

- SUSY
- $M_{\tilde{\chi}_1 \pm} > 102.7$ GeV (for large s-neutrino masses.)
- No significant excess to S.M. predictions for Scalar Leptons in Standard SUSY Scalar Top and Bottom Quarks
- Search for exotica and new physics.
- No sign of existence of Heavy Neutral and Stable Charged Leptons.

  $m_L^{\pm} > 102.4$ GeV at 95% C.L
- No sign of existence of Excited Leptons

  mass $\ell^* \geq 100\ GeV$ at 95% C.L

Any sign of new physics in 2000 L3 Data?

NOT YET

Need more Luminosity at highest possible energy