Sign of new physics in 1999 L3 Data?

Simonetta Gentile
L3 collaboration
CERN, Università "La Sapienza"(Roma)

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Outline

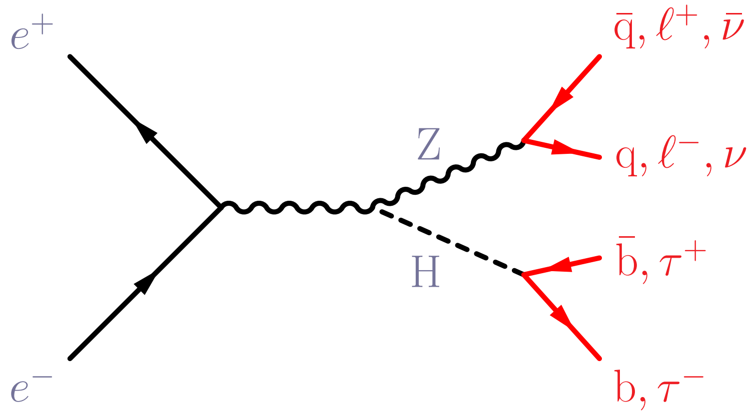
Preliminary results on 1999 data
by L3 experiment on:

- $\sqrt{s}$=192 GeV data, $\int\mathcal{L}$=28 pb^{-1}

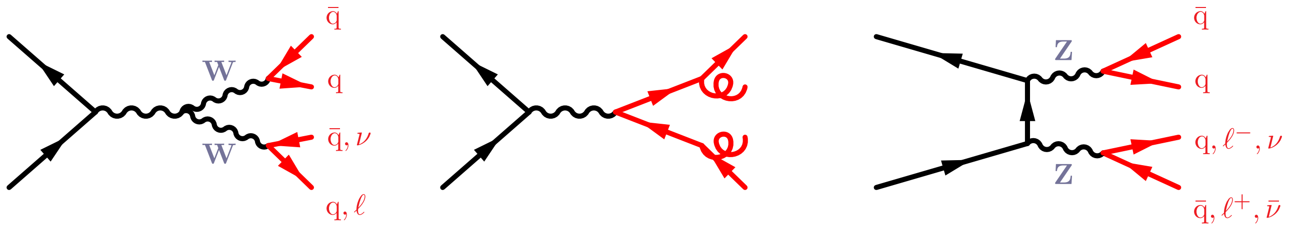
- $\sqrt{s}$=196 GeV data, $\int\mathcal{L}$=35 pb^{-1}

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

Signal



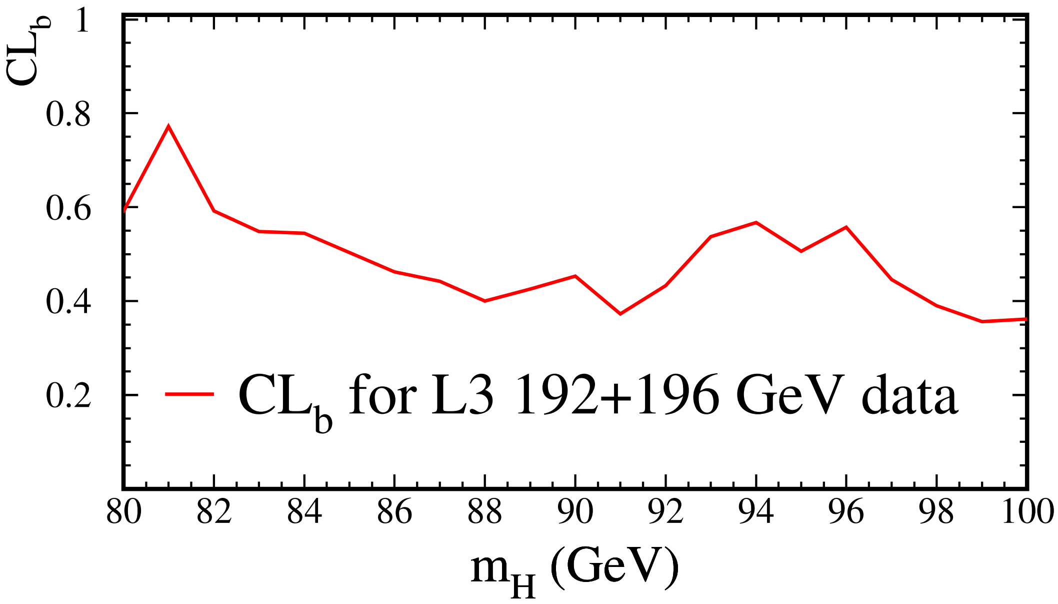
Background



- **Analyses Performed for**
  - $HZ \rightarrow b\bar{b}q\bar{q}$
  - $HZ \rightarrow b\bar{b}\nu\bar{\nu}$
  - $HZ \rightarrow b\bar{b}\ell^+\ell^-$ $(\ell = e, \mu)$
- **Data collected: 27.4 pb^{-1} at** $\sqrt{s} = 192$ GeV **and 27.9 pb^{-1} at** $\sqrt{s} = 196$ GeV**. Combined** $192 + 196$ **results presented.**

Standard Model Higgs

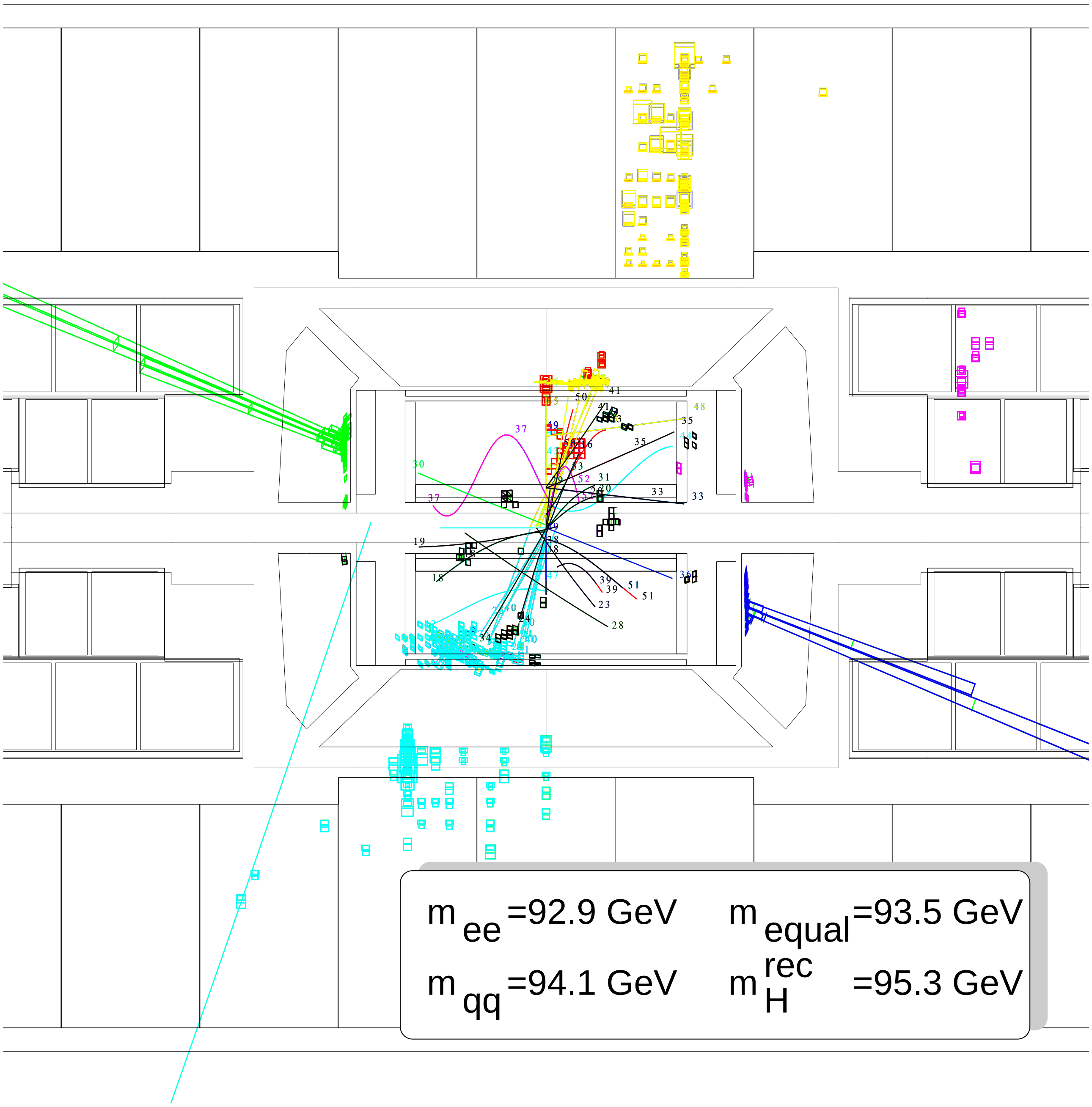
Selection		Mass hypothesis $m_H = 85$ GeV			$m_H = 90$ GeV			$m_H = 95$ GeV		
H	Z	SIG	BG	DATA	SIG	BG	DATA	SIG	BG	DATA
$b\bar{b}$	$q\bar{q}$	7.3	37.3	40	5.7	28.5	32	3.8	22.8	24
$b\bar{b}$	$\nu\bar{\nu}$	2.9	6.7	8	2.3	5.7	7	1.4	4.6	4
$b\bar{b}$	e^+e^-	0.5	0.9	0	0.4	1.4	0	0.3	1.0	2
$b\bar{b}$	$\mu^+\mu^-$	0.4	0.6	0	0.3	0.7	2	0.2	0.5	1



- Calculate CL_b, CL from final variable spectra
- $CL_b \sim 50\%$ indicates consistency of observed data with BG MC expectations.
- No large values of $CL_b \Rightarrow$ no clear excess anywhere

At $\sqrt{s} = 192$ GeV Candidate $HZ \rightarrow b\bar{b}e^+e^-$

Run # 745710 Event # 1437

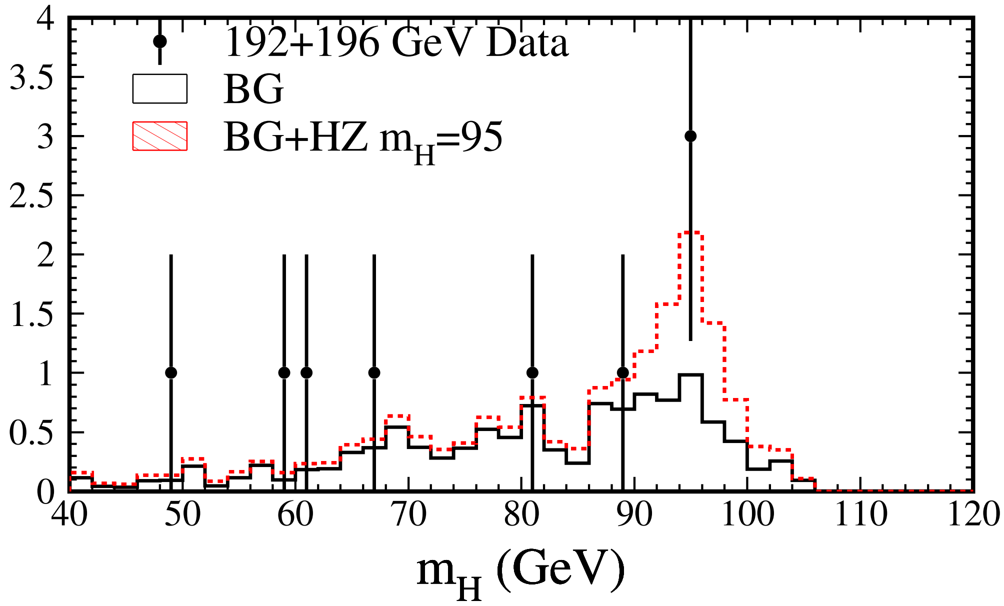


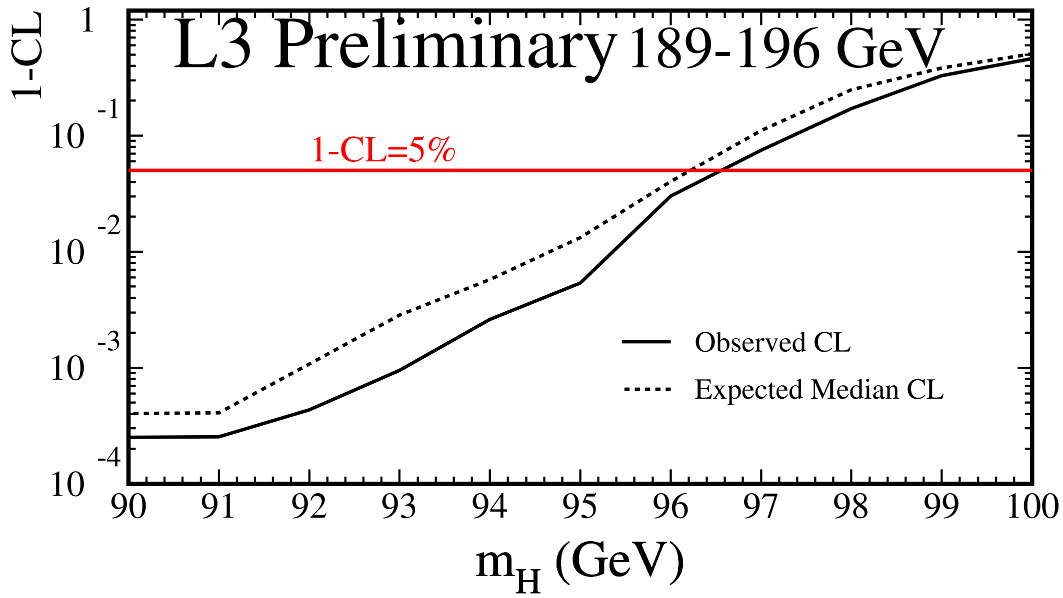
m_{ee} =92.9 GeV m_{equal} =93.5 GeV

m_{qq} =94.1 GeV m_H^{rec} =95.3 GeV

Standard Model Higgs (con't)

At $\sqrt{s} = 192 - 196$ GeV No evidence of signal





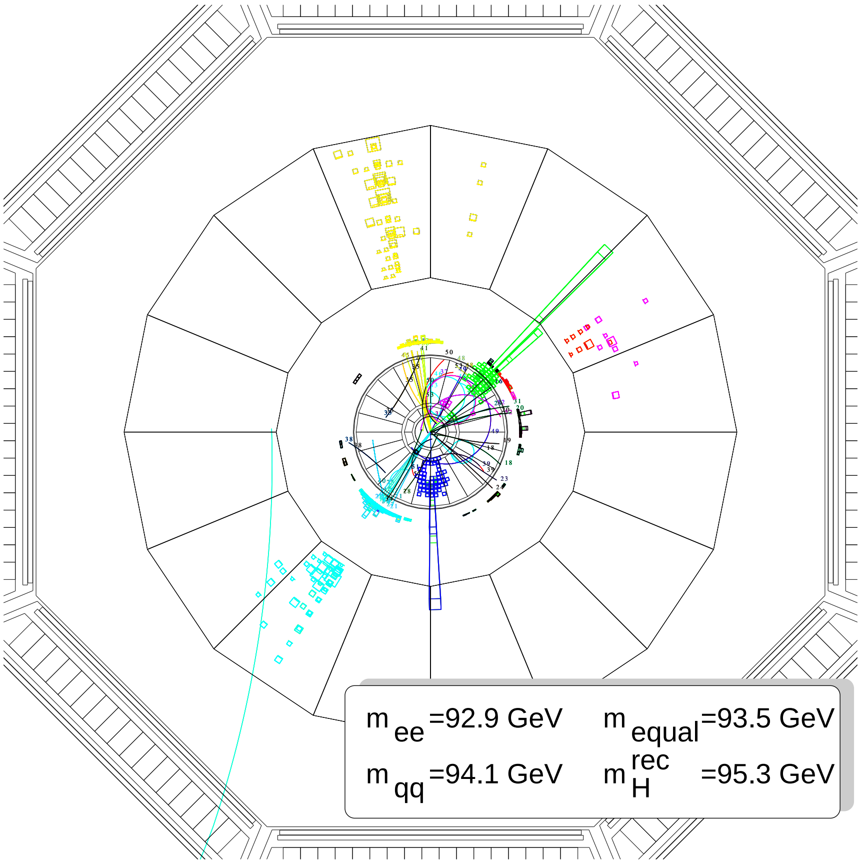
$m_H > 96$ GeVat 95 % C.L.

Standard Model Higgs (con't)

$\sqrt{s}$ 192 GeV Candidate

$$HZ \longrightarrow b\bar{b}e^{+}e^{-}:$$

Run # 745710 Event # 1437



if $m_{ee} = M_Z \Longrightarrow$ M(Jet-Jet)=$m_H^{rec} = 95.3$GeV

At $\sqrt{s} = 192, 196\ GeV$ the search has been performed to following channels :

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

Updated limits of $\tilde{\chi}_1^{\pm}$ ($|\mu| \gg M_2$) and $\tilde{\chi}_1^0$ ($m_0 \geq 500\ GeV$).

NOT enough luminosity to improve 189 GeV limits for $\tilde{e}, \tilde{\mu}, \tilde{\tau}, \tilde{t}, \tilde{b}$ and $\tilde{e}, \tilde{\mu}, \tilde{\tau}$ in GMSB

- $\tilde{\chi}_1^{\pm}$ M $>$ 67.7 GeV$\Longrightarrow$ indep.MSSM par.
- $\tilde{\chi}_1^0$ M $>$ 32.5 GeV$\Longrightarrow$ indep.MSSM par.
- $\tilde{e}$ M $>$ 85.5 GeV,$\Delta M > 10$ GeV
- $\tilde{\mu}$ M $>$ 78 GeV,$\Delta M > 15$ GeV
- $\tilde{\tau}$ M $>$ 65 GeV,$\Delta M > 15$ GeV
- $\tilde{t}$ M $>$ 87 GeV,$\Delta M > 15$ GeV
- $\tilde{b}$ M $>$ 84 GeV,$\Delta M > 15$ GeV

Standard Susy Searches

$\sqrt{s} = 192\ GeV,\ \mathcal{L} = 27.9\ pb^{-1}$

30 selections for Charginos, Neutralinos, Sleptons

	Low ΔM		Medium ΔM		High ΔM		.OR.	
	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}
$\tilde{e}$	0	1.0	1	0.8	2	2.0	3	3.7
$\tilde{\mu}^0$	0	1.8	1	0.2	2	1.4	2	3.3
$\tilde{\tau}^0$	1	0.4	3	1.3	5	1.9	6	2.5
$\tilde{\chi}_1^{\pm}$	8	10.6	3	1.7	12	12.2	21	23.5
$\tilde{\chi}_2^0$	6	6.2	2	1.2	1	0.4	9	7.6
Combined	10	15.3	7	4.0	18	16.0	29	32.8

$$N_{\tilde{\chi}_1^{\pm},\tilde{\chi}_2^0} \sim 14$$

$$N_{\tilde{e},\tilde{\mu},\tilde{\tau}} \sim 1.4$$

No signal seen

Standard Susy Searches

$\sqrt{s} = 196\ GeV,\ \mathcal{L} = 34.9\ pb^{-1}$

30 selections for Charginos, Neutralinos, Sleptons

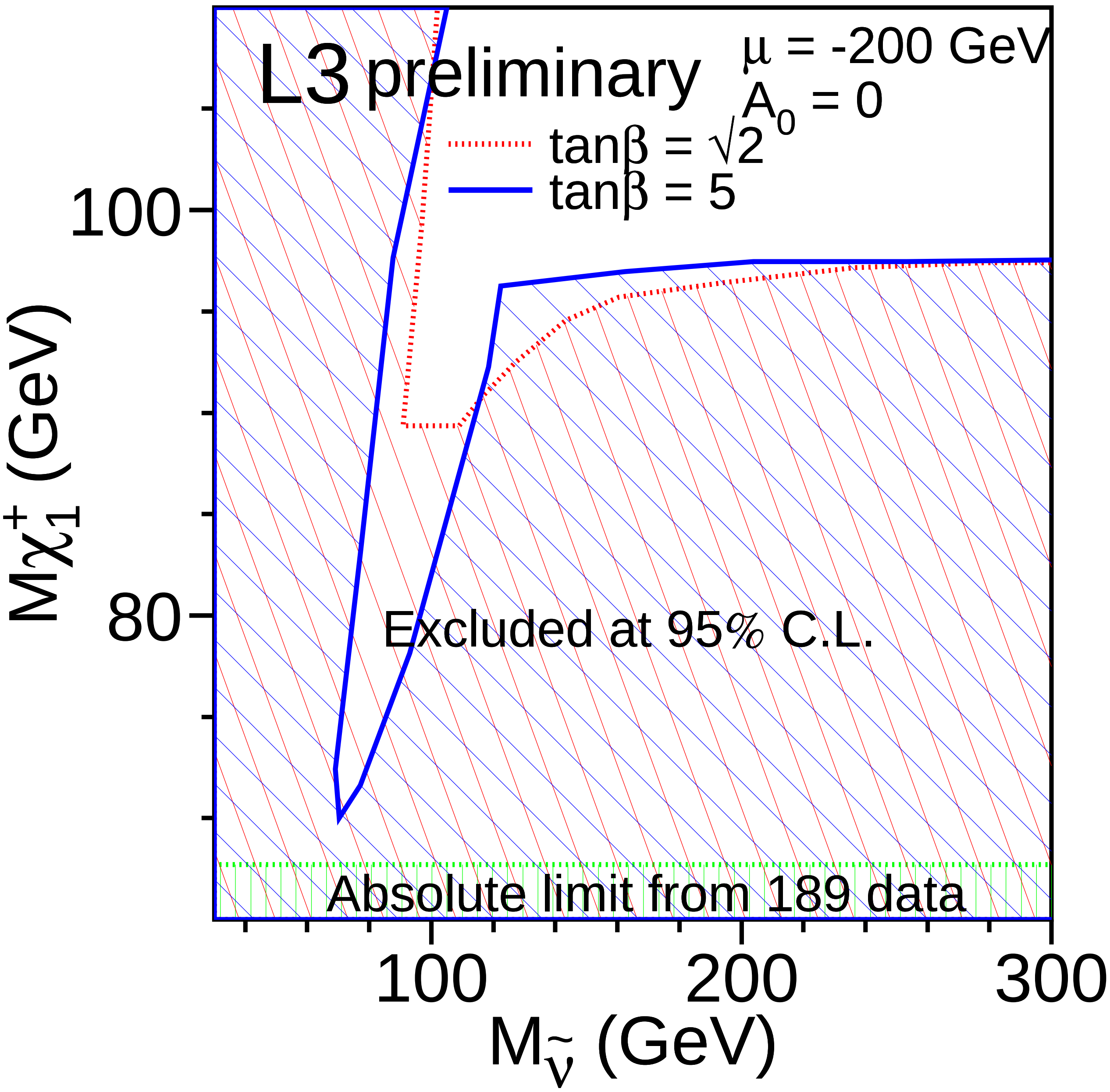
	Low ΔM		Medium ΔM		High ΔM		.OR.	
	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}
$\tilde{e}$	2	1.0	2	0.8	4	2.2	8	4.0
$\tilde{\mu}^0$	0	2.0	0	0.2	0	1.6	0	3.7
$\tilde{\tau}^0$	2	0.5	3	1.5	4	2.1	6	2.7
$\tilde{\chi}_1^\pm$	11	11.7	3	1.9	13	13.4	24	25.9
$\tilde{\chi}_2^0$	9	6.9	0	1.4	1	0.4	10	8.4
Combined	19	16.9	4	4.4	20	17.6	38	36.2

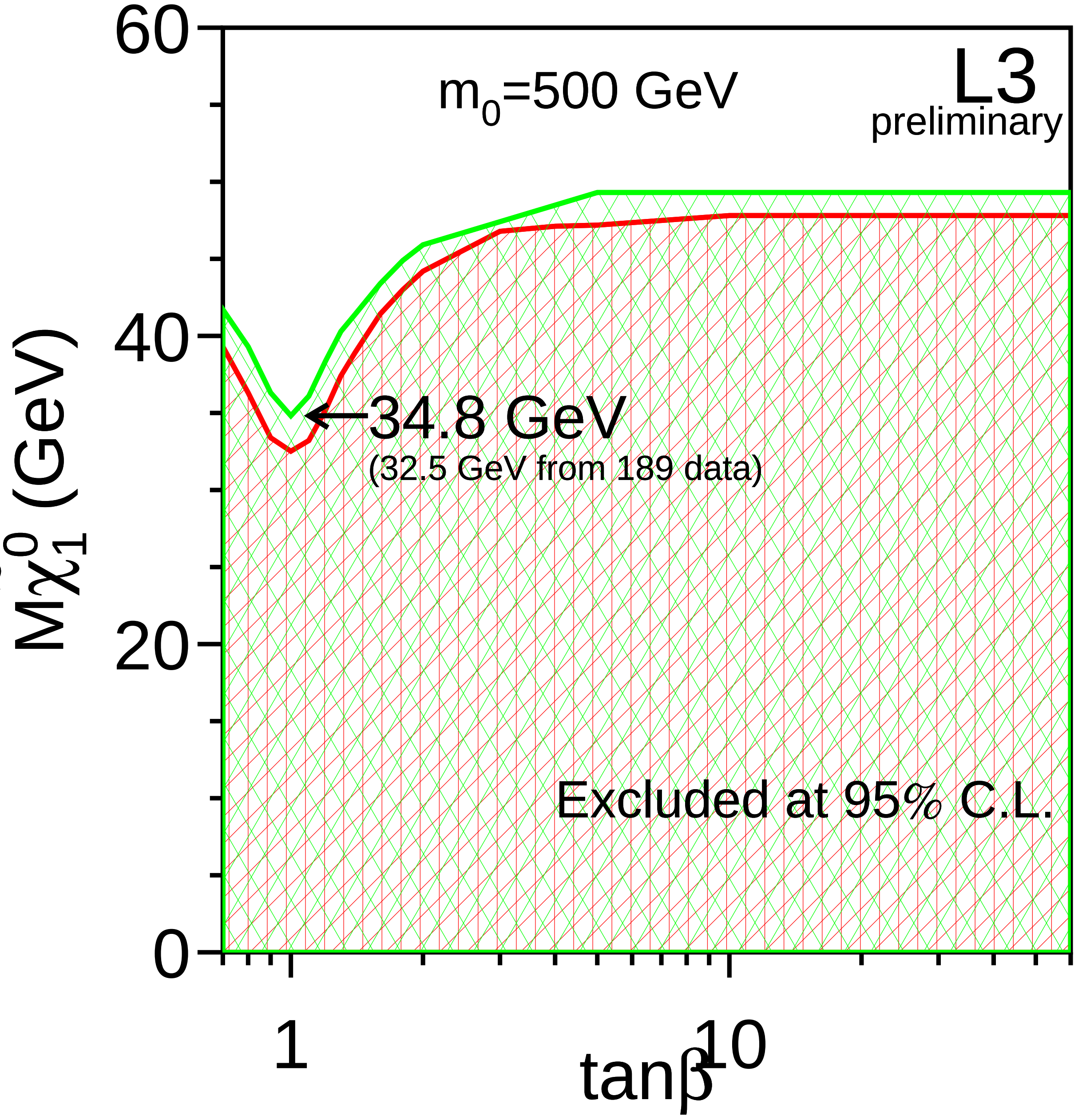
$$N_{\tilde{\chi}_1^\pm,\tilde{\chi}_1^0} \sim 15\ N_{\tilde{e},\tilde{\mu},\tilde{\tau}} \sim 1.5$$

No excess to S.M. predictions

- Enough $\mathcal{L}$ for $\tilde{\chi}_1^\pm, \tilde{\chi}_1^0$ exclusions
- $M_{\tilde{\chi}_1^\pm} > 97.7$ GeV (For most MSSM param.)
- for $m_0 = 500$ $M_{\tilde{\chi}_1^0} > 34.8$ GeV

Standard Susy Search(con't)





60
40
20
0
m0=500 GeV
L3
preliminary
←34.8 GeV
(32.5 GeV from 189 data)
Excluded at 95% C.L.
Mχ10 (GeV)
1
10
tanβ

GMSB Searches

$\sqrt{s} = 192\ GeV$,$\mathcal{L}$ =27.9 pb^{-1}

Sleptons search in
Gauge Mediated SUSY Breaking Model

- Usually the mass $\tilde{\ell}_R$ is lower than $\tilde{\ell}_L$
- Scalar lepton $e^+e^- \rightarrow \tilde{\ell}_{\mathrm{R}}\tilde{\ell}_{\mathrm{R}} \rightarrow \ell^-\tilde{\chi}^0_1\ \ell^+\tilde{\chi}^0_1 \rightarrow \ell^-\tilde{\mathrm{G}}\gamma\ell^+\tilde{\mathrm{G}}\gamma \implies 2\mathrm{leptons} + 2\gamma + \mathrm{E_{miss}}$
- With respect to Standard SUSY $\tilde{\chi}^0_1$ now is unstable. Final state is with 2 photons

	Low ΔM		Medium ΔM		High ΔM	
	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}
$\tilde{\mathrm{e}}^{\pm}_R$	0	0.05	0	0.99	1	0.19
$\tilde{\mu}^{\pm}_R$	1	0.5	0	0.4	0	0.47
$\tilde{\tau}^{\pm}_R$	1	0.14	0	0.97	0	0.37

No excess to S.M. predictions

Assuming $M_{\tilde{\ell}} = 90$ GeV

$$N^{exp}_{\tilde{\mathrm{e}}_R,\tilde{\mu}_R,\tilde{\tau}_R} \sim 0.4$$

Not enough Luminosity to set limits with these data

GMSB Searches

$\sqrt{s} = 196\ GeV\ , \mathcal{L} = 27.9\ pb^{-1}$

Sleptons search in Gauge Mediated SUSY Breaking Model

	Low ΔM		Medium ΔM		High ΔM	
	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}
$\tilde{e}^{\pm}_R$	0	0.05	0	0.43	1	0.49
$\tilde{\mu}^{\pm}_R$	0	1.01	0	0.80	0	0.39
$\tilde{\tau}^{\pm}_R$	0	0.30	0	0.97	0	0.78

No signal seen

Assuming $M_{\tilde{\ell}} = 90$ GeV

$$N^{exp}_{\tilde{e}_R, \tilde{\mu}_R, \tilde{\tau}_R} \sim 0.6$$

Not enough Luminosity to set limits with these data

At $\sqrt{s} = 189\ GeV$ High ΔM, mass limits :

$\tilde{e}^{\pm}_R \geq 87.5$ GeV, $\tilde{\mu}^{\pm}_R \geq 84.9$, $\tilde{\tau}^{\pm}_R \geq 83.4$

Squarks

At $\sqrt{s}$=192, 196 GeV $\mathcal{L}$=27.4, 28.0 pb^{-1}

- **Scalar top**

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

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

- **Scalar bottom**

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

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}
$\tilde{t}_1 \to c\tilde{\chi}^0_1$	4	5.4	1	1.2	3	1.3	5	2.2	13	9.9
$\tilde{t}_1 \to b\ell\tilde{\nu}$	3	2.6	1	0.70	0	0.17	-	-	4	3.4
$\tilde{t}_1 \to b\tau\tilde{\nu}$	5	3.8	1	2.6	1	0.47	-	-	7	6.5
$\tilde{b}_1 \to b\tilde{\chi}^0_1$	2	3.8	0	0.14	0	0.21	0	0.15	2	4.1

$N^{exp}_{Bkg} = 18.3$ $N_{Data} = 23$ **No excess to S.M.**

Assuming $M_{\tilde{t}}, M_{\tilde{b}} = 90$ GeV

$$N^{exp}_{\tilde{t}} = 4.9\ \sigma^{max}\ ,\ = 2.4\ \sigma^{min}$$

$$N^{exp}_{\tilde{b}} = 3.1\ \sigma^{max}\ ,\ = 0.60\ \sigma^{min}$$

Single and Multiphoton events

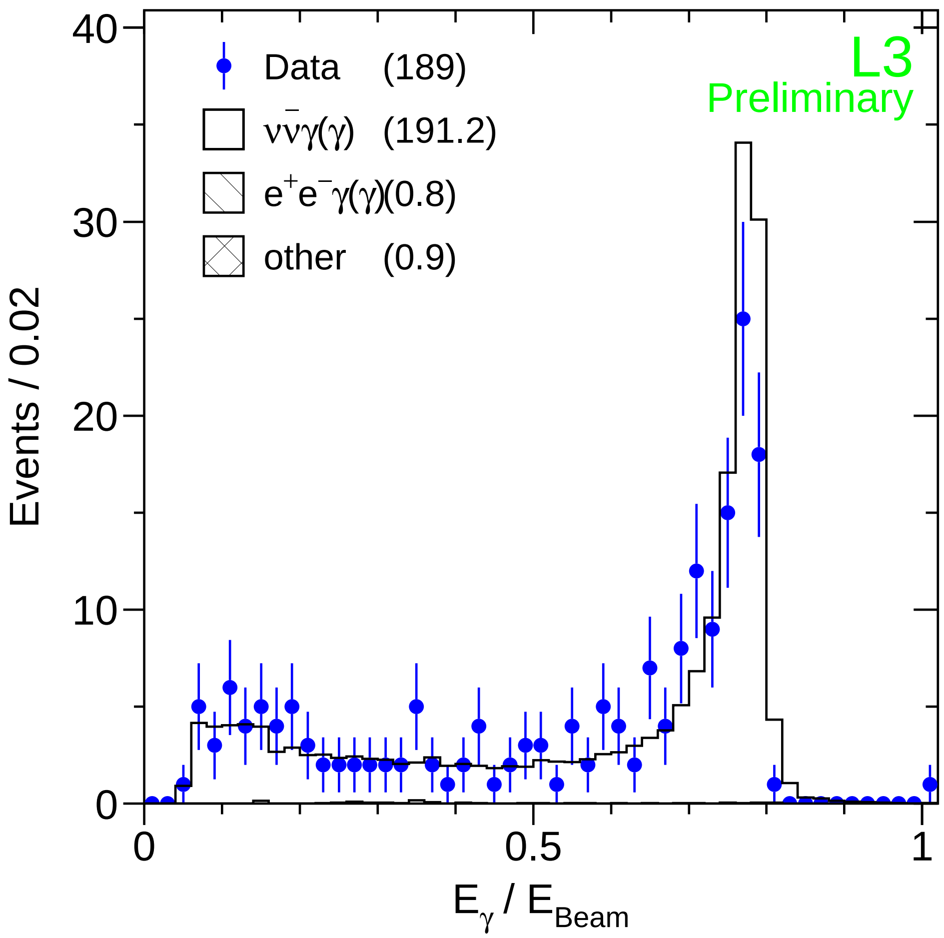
γ + missing energy

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

In GMSB scenario, with $\tilde{G}$ LSP, the decays channels possibles:

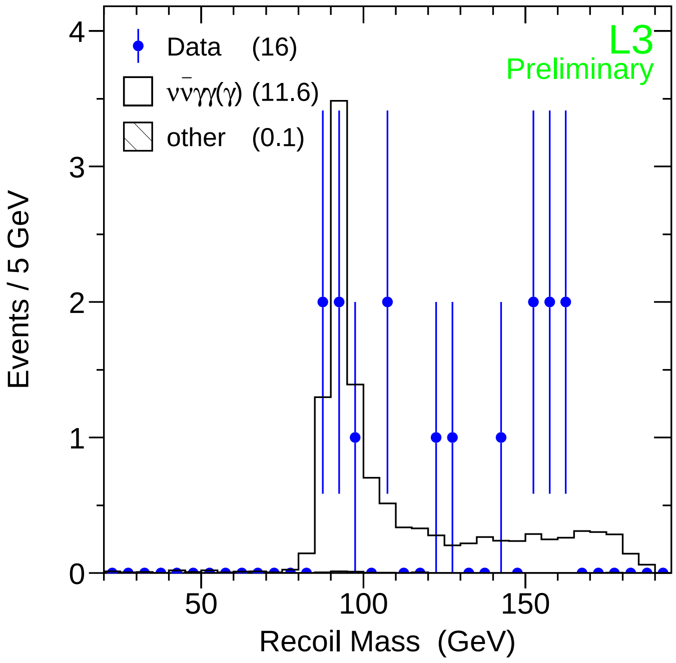
- $e^+e^- \rightarrow \tilde{\chi}_1^0\tilde{G} \rightarrow \tilde{G}\tilde{G}\gamma$
- $e^+e^- \rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^0 \rightarrow \tilde{G}\tilde{G}\gamma\gamma$

$\sqrt{s} = 192\ ,196\ GeV\ ,\mathcal{L} = 27.9 + 34.9\ pb^{-1}$ $(\theta \geq 14\,\mathrm{deg})$

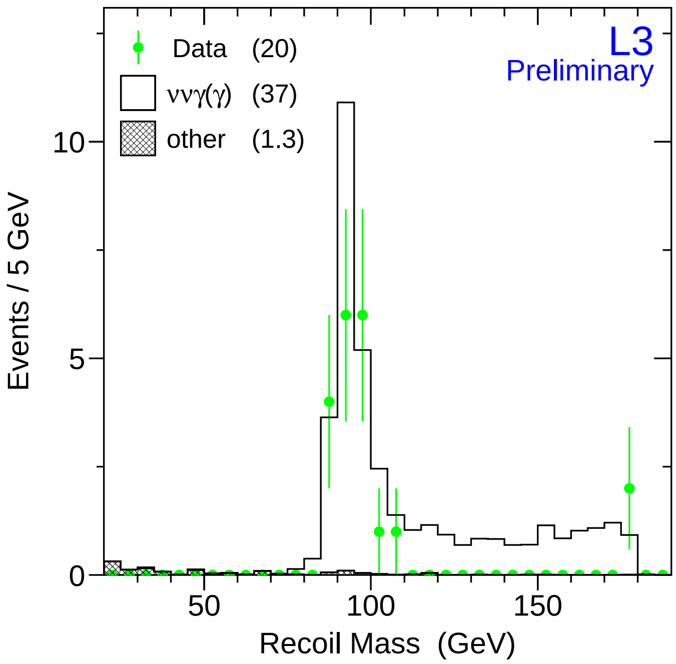


$\gamma\ \gamma$ + missing energy

$\sqrt{s} =\ 192, 196\ GeV, \mathcal{L} = 27.9 + 34.9\ pb^{-1}$



$\sqrt{s} =\ 189\ GeV, \mathcal{L} = 176\ pb^{-1}$



Unstable Neutral Heavy Leptons

At $\sqrt{s}$ 192, 196 GeV

Integrated Luminosity $\approx$ 52 pb^{-1}

Unstable Neutral Heavy Lepton

Number of candidates and expected background:

Channel	Data	Background
$L^0 \longrightarrow e^{\pm}W^{\mp}$	2	1.6
$L^0 \longrightarrow \mu^{\pm}W^{\mp}$	0	0.4
$L^0 \longrightarrow \tau^{\pm}W^{\mp}$	7	7.4

Good agreement between the number of candidates and expected background

Stable Charged Heavy Lepton

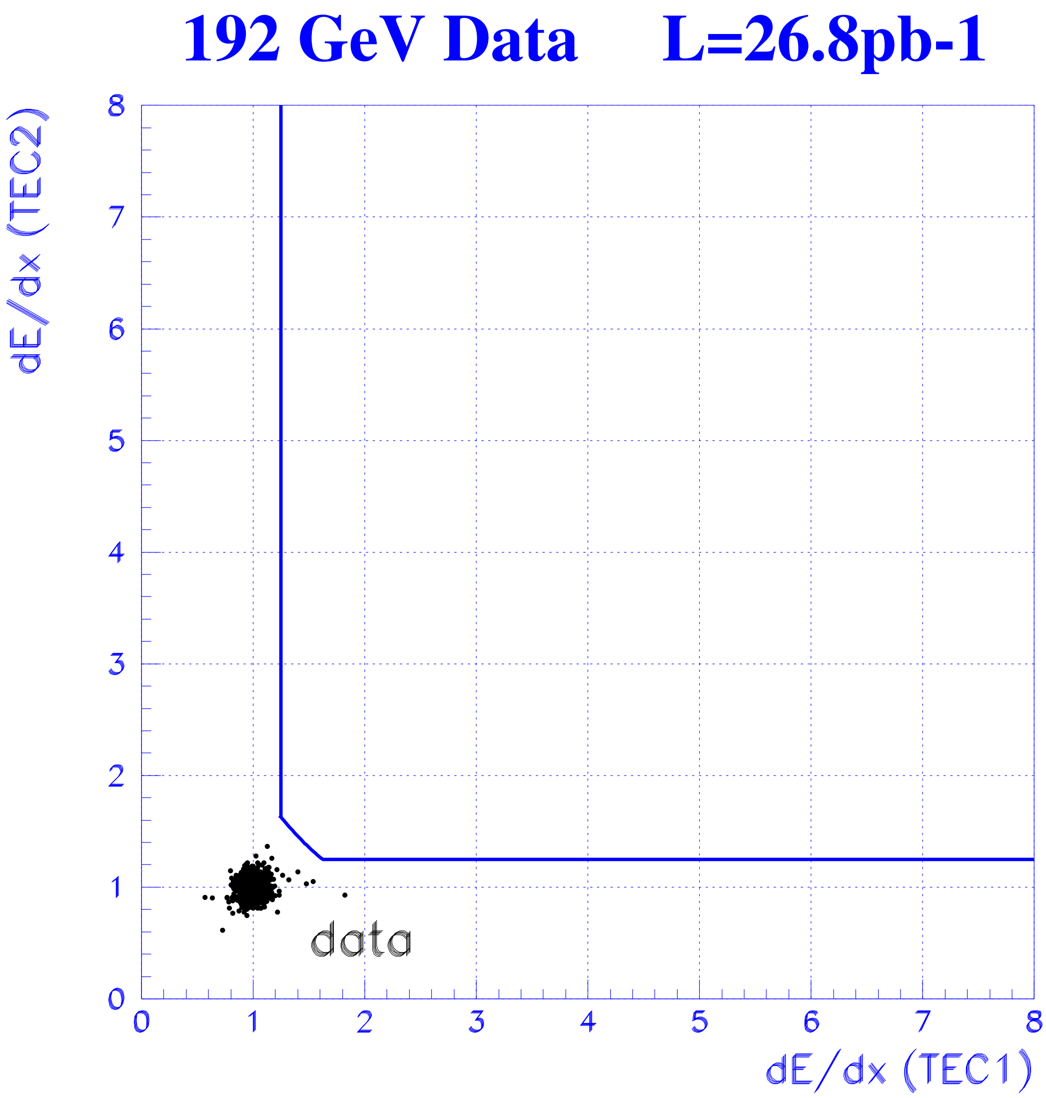
Search strategy:

- **Pair production of new stable charged heavy leptons would appear as two back to back charged tracks in the detector.**
- **If $m_{L\pm}$ close to $E_{beam} \Longrightarrow$ small kinetic energy $\Longrightarrow$ L$\pm$ tracks with large dE/dx**
- **dE/dx information from tracking chamber is used to search for stable charged heavy lepton**

Selection:

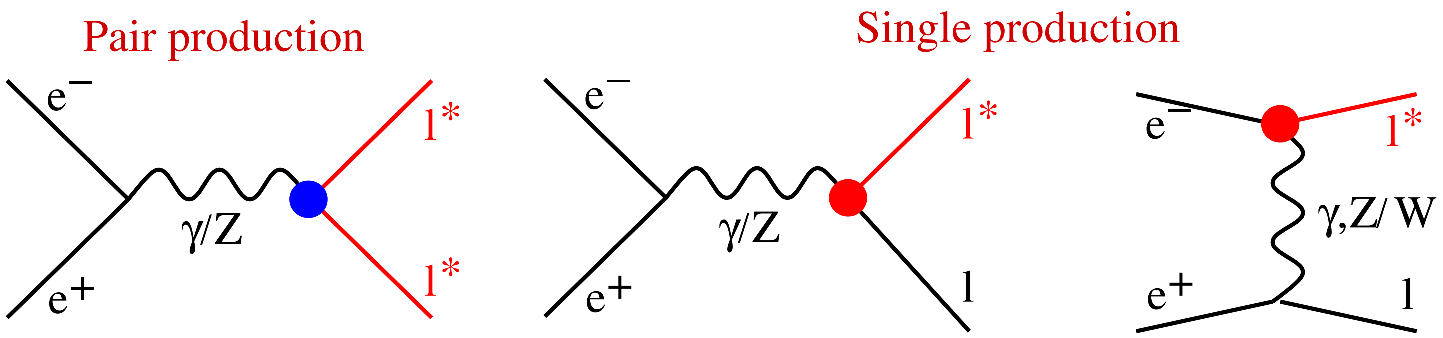
- **High momentum collinear tracks well measured in the detector**
- **The normalised track ionisation energy loss for both tracks $dE/dx_{1,2} > 1.25$ and $dE/dx_1 \times dE/dx_2 > 2$**

Stable Charged Heavy Lepton

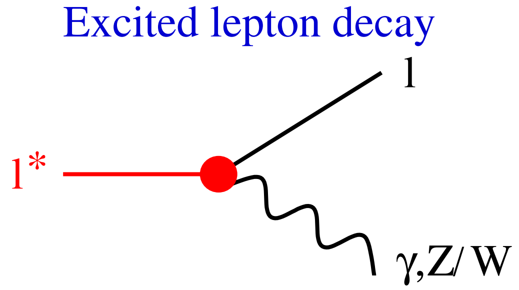


$$m_L \geq 94.8 \text{ GeV}$$

Excited Leptons



They would decay almost immediately into a standard lepton and a gauge boson



At $\sqrt{s} = 192, 196$ GeV these processes have been searched for:

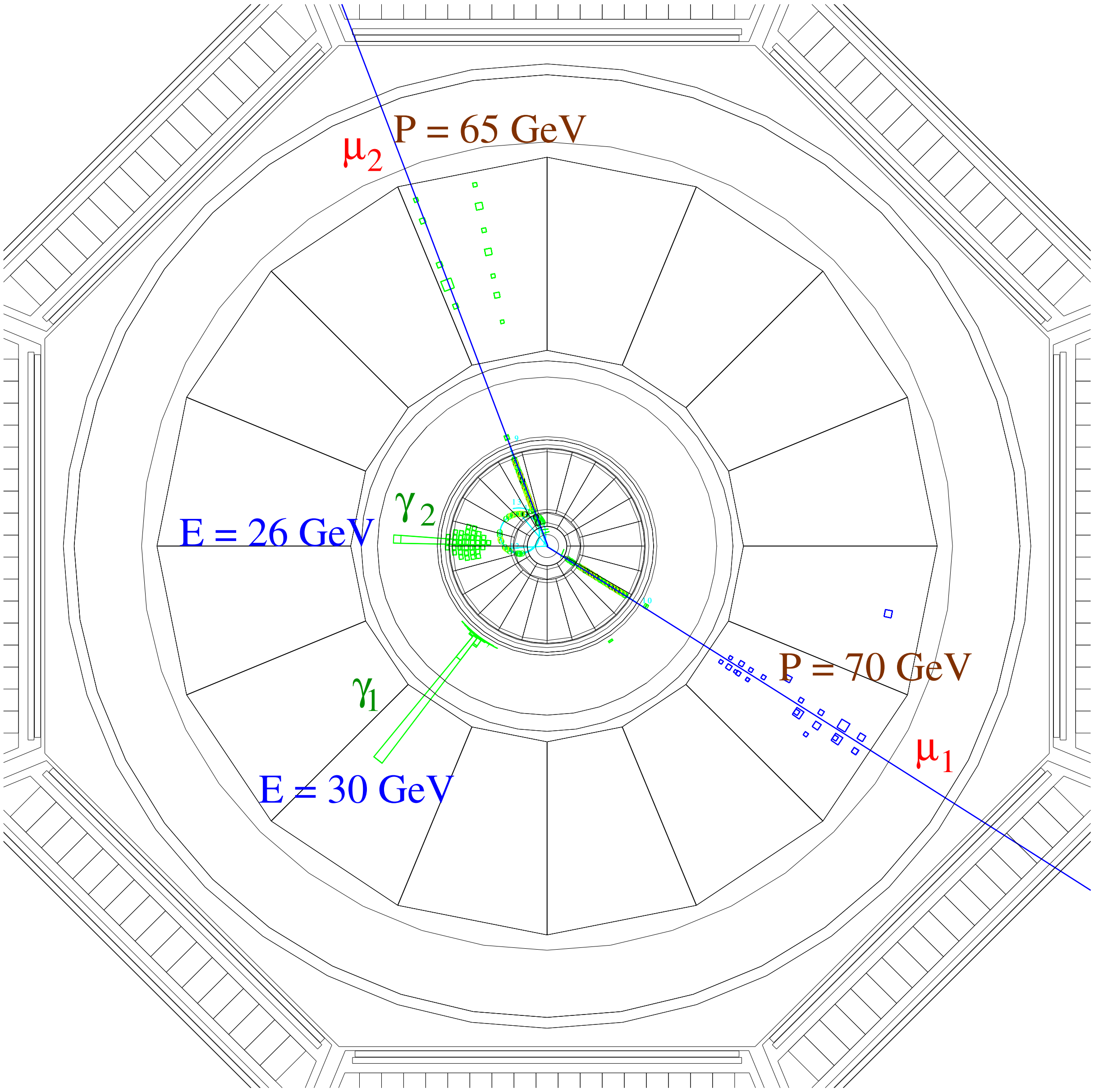
- **Radiative Decays**
  - Pair Production
    - $e^+e^- \longrightarrow \ell^*\ell^* \longrightarrow \ell\gamma\ell\gamma$
    - $e^+e^- \longrightarrow \nu^*\nu^* \longrightarrow \nu\gamma\nu\gamma$
  - Single Production
    - $e^+e^- \longrightarrow \ell\ell^* \longrightarrow \ell\ell\gamma$
    - $e^+e^- \longrightarrow \nu\nu^* \longrightarrow \nu\nu\gamma$
- **Weak Decays**
  - Pair Production
    - $e^+e^- \longrightarrow \ell^*\ell^* \longrightarrow \nu W \nu W$
    - $e^+e^- \longrightarrow \nu^*\nu^* \longrightarrow \ell W \ell W$
  - Single Production
    - $e^+e^- \longrightarrow \ell\ell^* \longrightarrow \ell\nu W$
    - $e^+e^- \longrightarrow \nu\nu^* \longrightarrow \nu\ell W$

Excited Leptons

At $\sqrt{s} = 196$ GeV candidate $e^+e^- \to \mu^*\mu^* \to \mu\gamma\mu\gamma$:

$m(\mu_1, \gamma_2) = 84$ GeV $\qquad$ $m(\mu_2, \gamma_1) = 77$ GeV

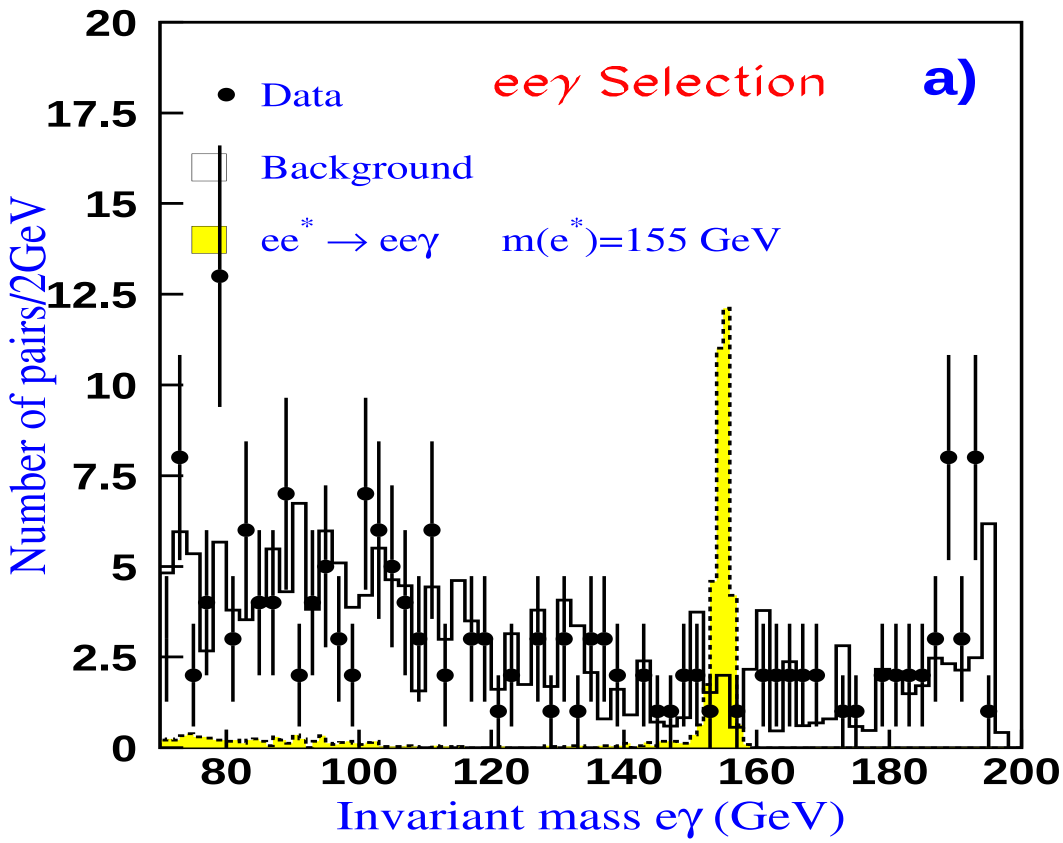
Run # **747001** **Event #** **26** Total Energy : 192.38 GeV

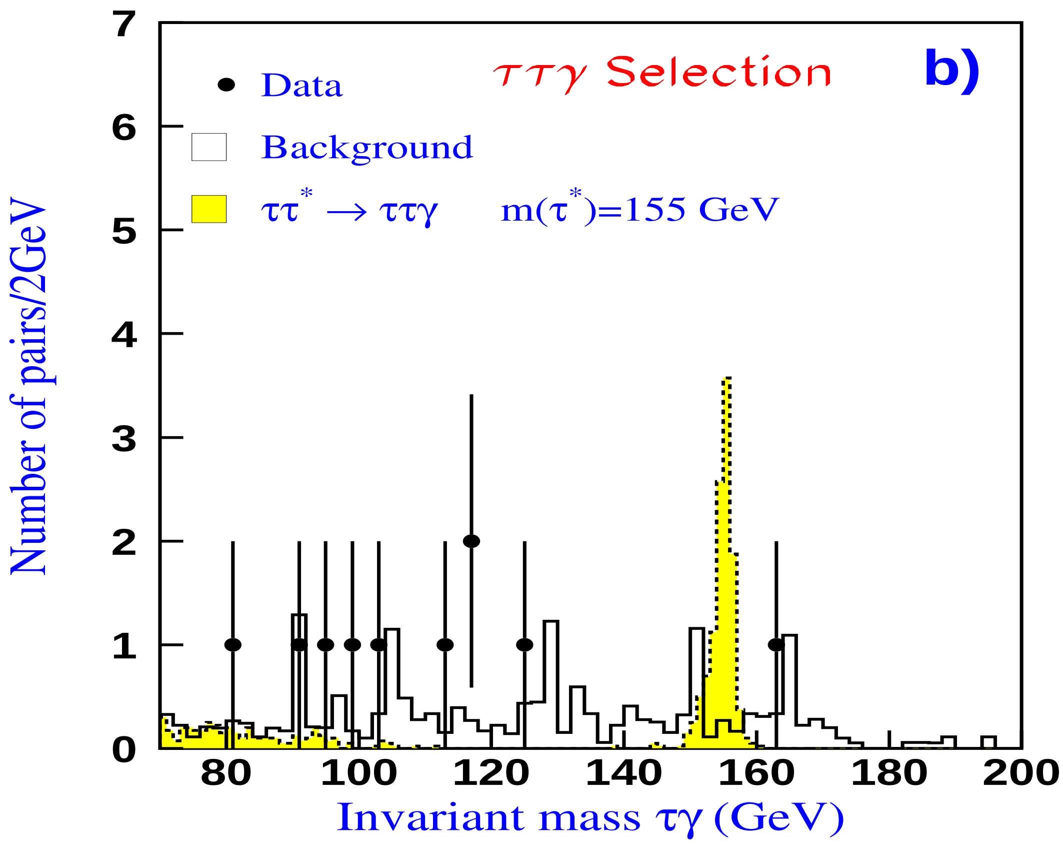


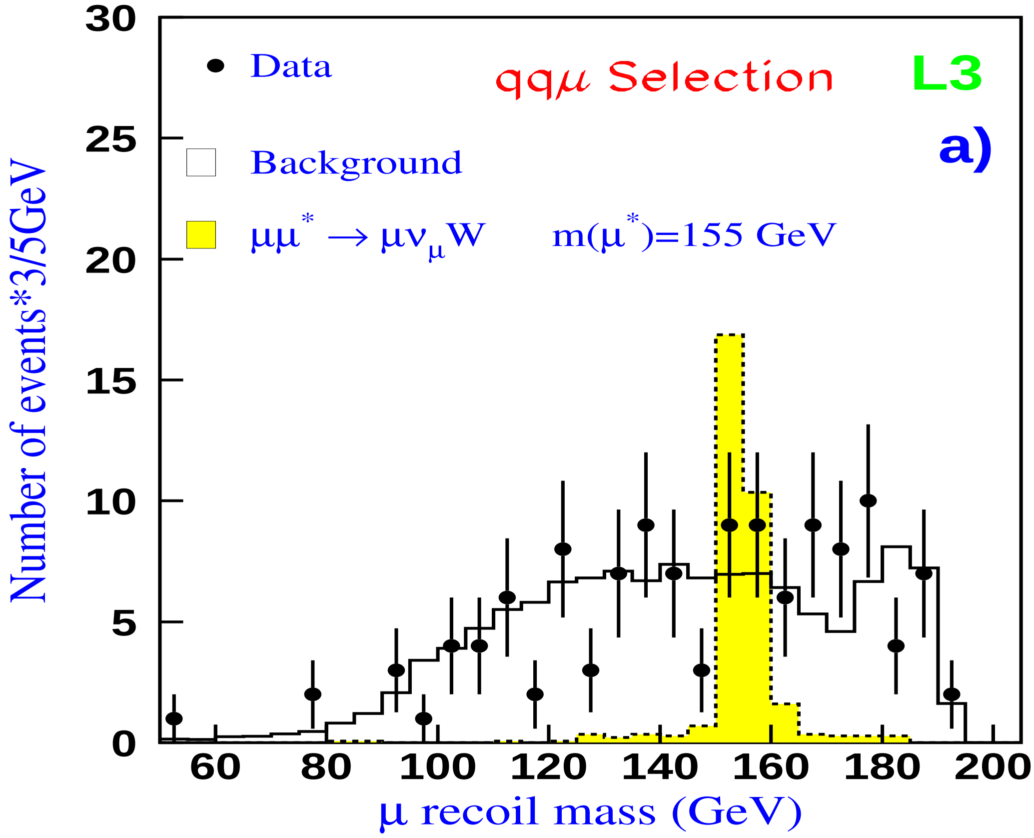
Transverse Imbalance :	.0230	**Longitudinal Imbalance :**	-.0080

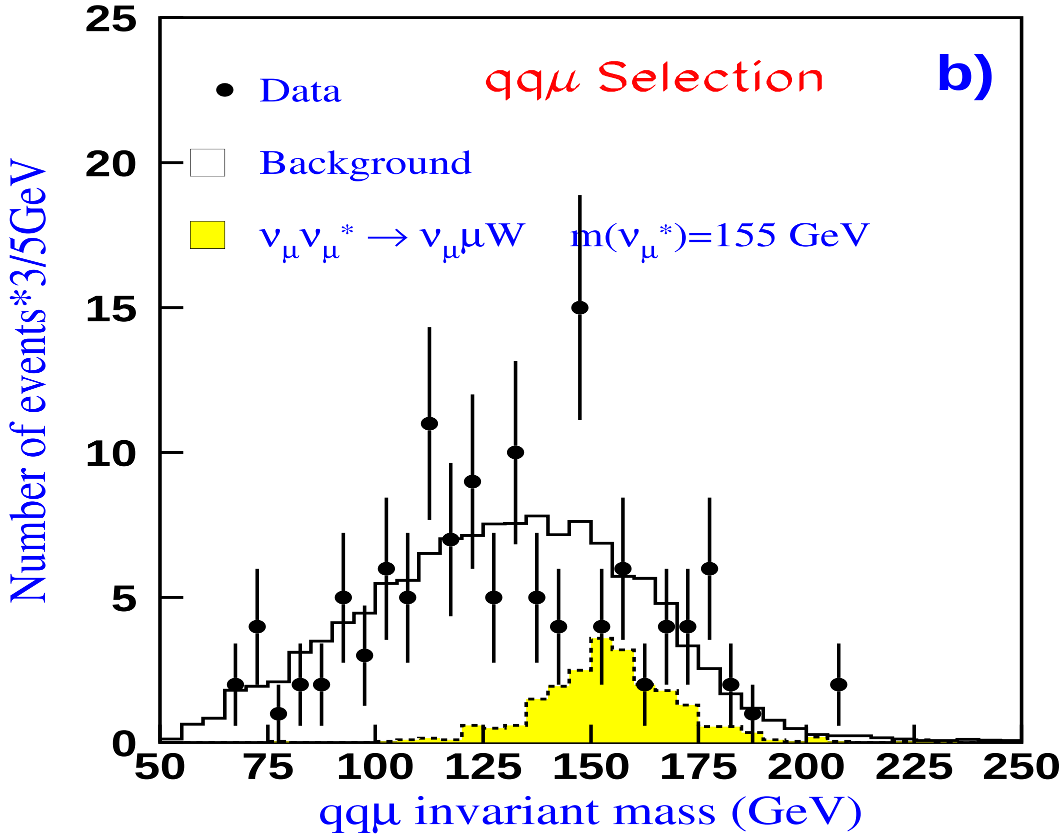
Thrust :	.8027	**Major :**	.4595	**Minor :**	.1925
Event DAQ Time :	*990610 182400*				

Excited Leptons






Number of events*3/5GeV
Data
qqμ Selection
L3
a)
Background
μμ* → μν_μW   m(μ*)=155 GeV
μ recoil mass (GeV)
0 5 10 15 20 25 30
60 80 100 120 140 160 180 200


Number of events*3/5GeV
Data
qqμ Selection
b)
Background
ν_μν_μ* → ν_μμW   m(ν_μ*)=155 GeV
qqμ invariant mass (GeV)
0 5 10 15 20 25
50 75 100 125 150 175 200 225 250

Results at $\sqrt{s} = 192$ and 196 GeV $\mathcal{L} = 55\ \mathrm{pb}^{-1}$

	Radiative Decays			Weak Decays		
Signal	Data	Bkg	Eff	Data	Bkg	Eff
e^*e^*	0	0.18	49%	831	873	67%
$\mu^*\mu^*$	1	0.12	46%			
$\tau^*\tau^*$	0	0.06	40%			
$\nu^*_\tau\nu^*_\tau$	0	0.49	44%			71%
$\nu^*_e\nu^*_e$				0	0.45	19%
$\nu^*_\mu\nu^*_\mu$				0	0.14	21%
e^*e	169	171	63%	196	191	24%
$\mu^*\mu$	21	18	61%	147	148	49%
$\tau^*\tau$	6	14	43%	283	287	44%
$\nu^*_e\nu_e$	68	63	66%	196	191	47%
$\nu^*_\mu\nu_\mu$				147	148	51%
$\nu^*_\tau\nu_\tau$				283	287	41%

Mass Limits from $\sqrt{s} = 189$, 192 and 196 GeV

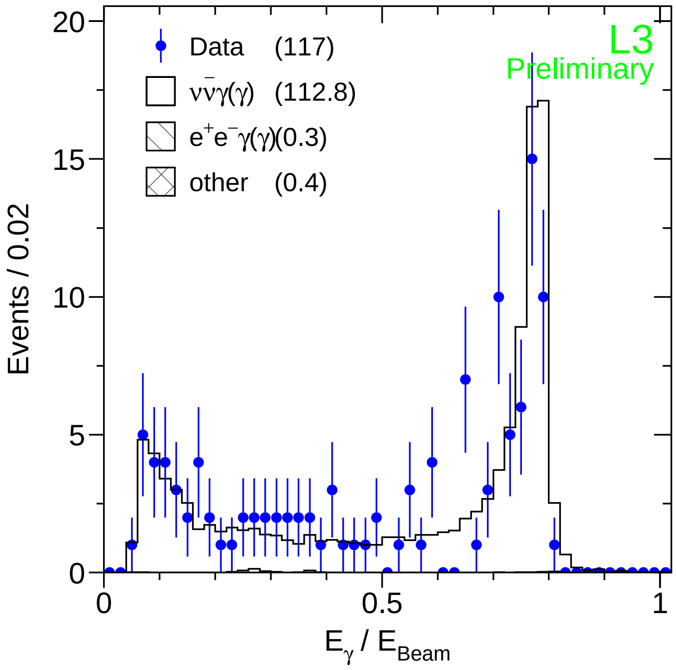
Excited Lepton	95% CL Mass Limit (GeV)	
	$f = f'$	$f = -f'$
e^*	97.0 (96.9)	93.8 (92.5)
μ^*	96.2 (96.8)	93.8 (92.5)
τ^*	96.7 (96.7)	93.8 (92.5)
ν^*_e	95.3 (94.9)	96.1 (95.7)
ν^*_μ	95.4 (95.3)	96.1 (95.7)
ν^*_τ	93.0 (90.7)	96.0 (95.7)

Single and Multiphoton events

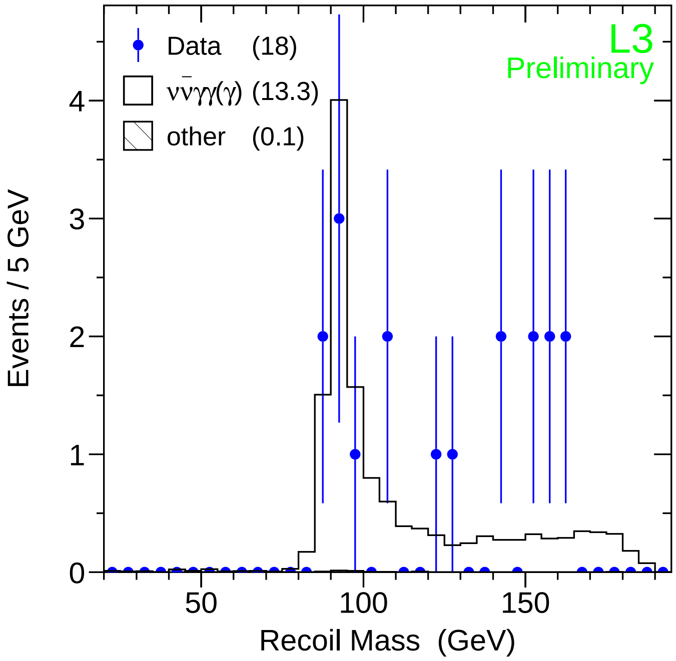
γ + missing energy

$\sqrt{s} = 192, 196\ GeV, \mathcal{L} = 27.9 + 43.4\ pb^{-1}$,

- Monday 13th July



$\gamma\ \gamma$ + missing energy



Conclusions

Preliminary results on 1999 data by L3 experiment has been presented based on data at $\sqrt{s}$=192 GeV,=196 GeVwith $\int \mathcal{L}$=28 pb^{-1} and 35 pb^{-1} .

- **Standard Model Higgs:**

  $m_H > 96$ GeV **at 95% C.L**

  $m_H > 95.3$ GeV **at 95% C.L. $\sqrt{s}$=189 GeV**

- **SUSY**
- $M_{\tilde{\chi}_1{}^{\pm}} > 97.7$ **GeV** (for most MSSM param.)
- **for m_0 =500 $M_{\tilde{\chi}_1^0} > 34.8$ GeV**
- **No significant excess to S.M. predictions for Scalar Leptons in Standard SUSY and GSMB models, Scalar Top and Bottom Quarks**
- **No significant excess to S.M. predictions for gravitino from Single and Multi-Photons events with missing energy**

Conclusions

- **Search for exotica and new physics.**
- **No sign of existence of Heavy Neutral and Stable Charged Leptons.**

  $m_L^{\pm} > 94.8\ GeV$ **at 95% C.L**

  $m_L^{\pm} > 93.5\ GeV$ **at 95% C.L.** $\sqrt{s}$**=189 GeV**
- **No sign of existence of Excited Leptons**

  mass $\ell^* \geq 93\ GeV$ **at 95% C.L**

Any sign of new physics in 1999 L3 Data?

NOT YET

Need more Energy and Luminosity