L3 Report to LEPC

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Outline:

- Status of detector and calibration
- Shutdown activities
- Results from 1997 run
  - Fermion pair production
  - Boson pair production
  - Search for new particles
- Conclusions

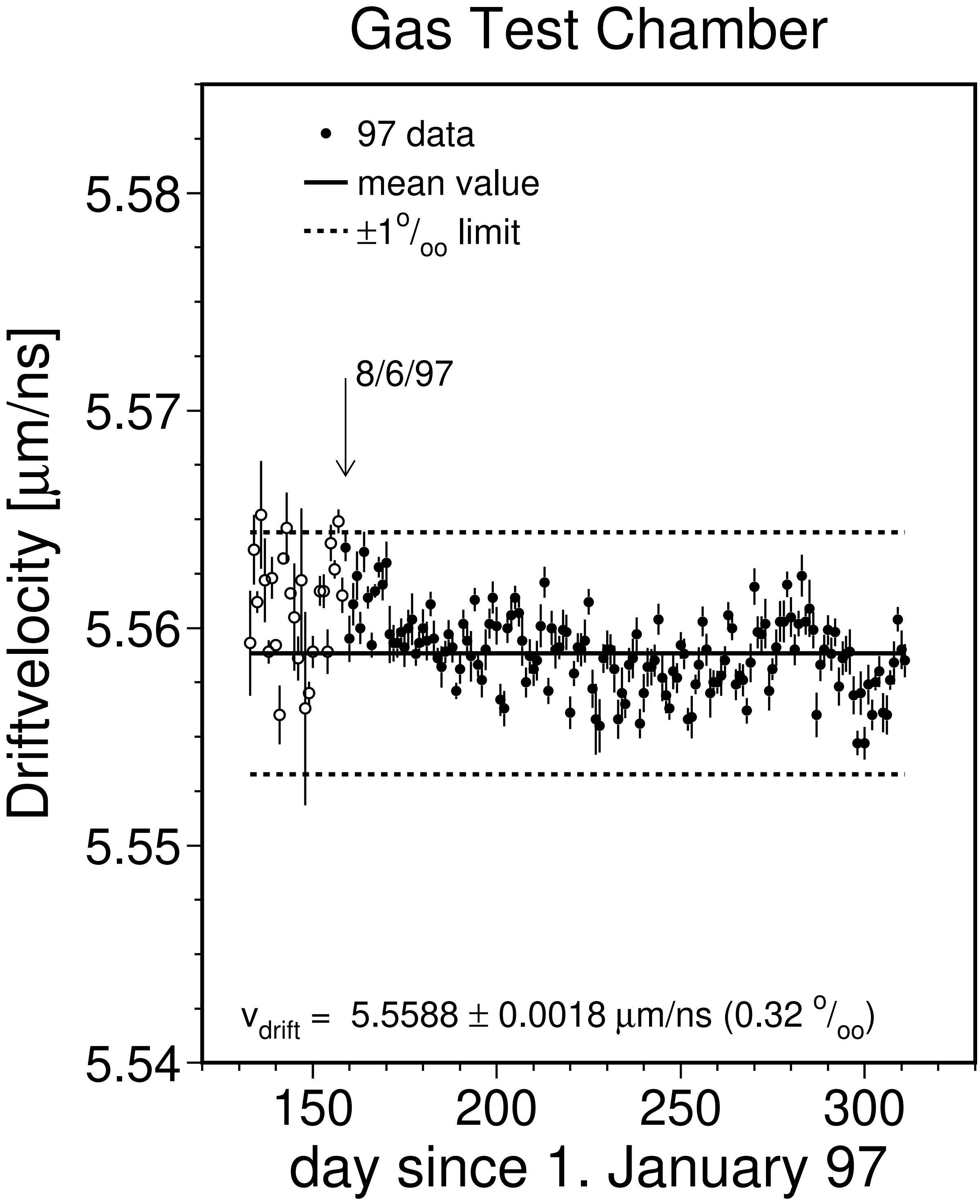
All Results Preliminary

L3 in 1997

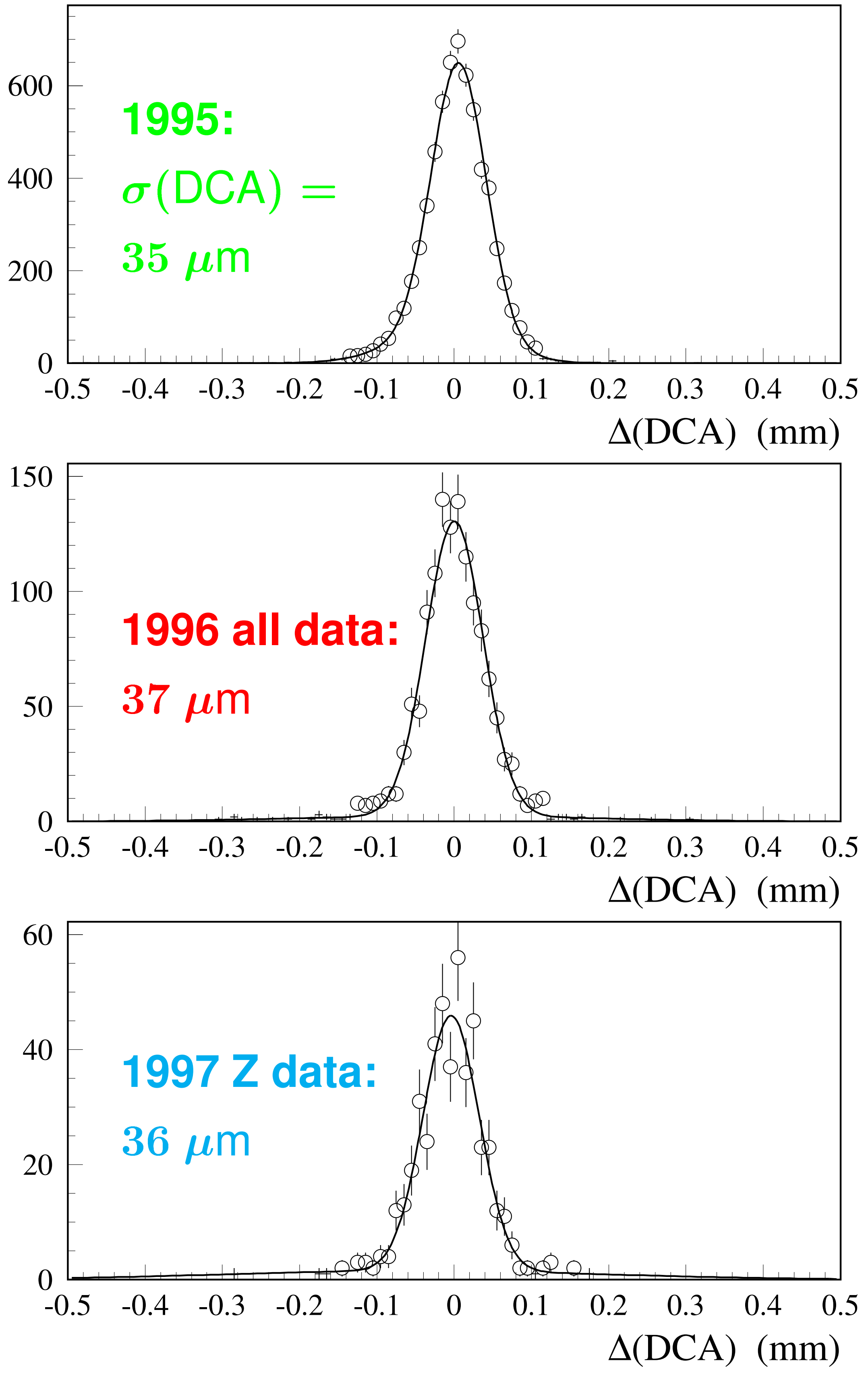
- **Collected Luminosities:**
  - $2.5\ \mathrm{pb}^{-1}$ **at 91 GeV**
  - $7.0\ \mathrm{pb}^{-1}$ **at 132 and 136 GeV**
  - $55.5\ \mathrm{pb}^{-1}$ **at 181 to 184 GeV**
  - **Data taking efficiency 89%**
  - **Most results from** $52\ \mathrm{pb}^{-1}$ **at** $\simeq$ **183 GeV**
- **Largest luminosity ever delivered to L3 in a single year**
- **Congratulations to the LEP crew for excellent performance**

- **All detector subsystems functional, except:**
- **Short in one of the coils of forward toroid**
  - **degradation of muon momentum resolution in** $20^\circ < \theta < 35^\circ$
  - **degradation of background rejection power in that region**
- **Calorimeter resolutions excellent**
- **Expected central tracker resolutions reached after Z calibration run**

Central Tracker Stability



DCA Resolution

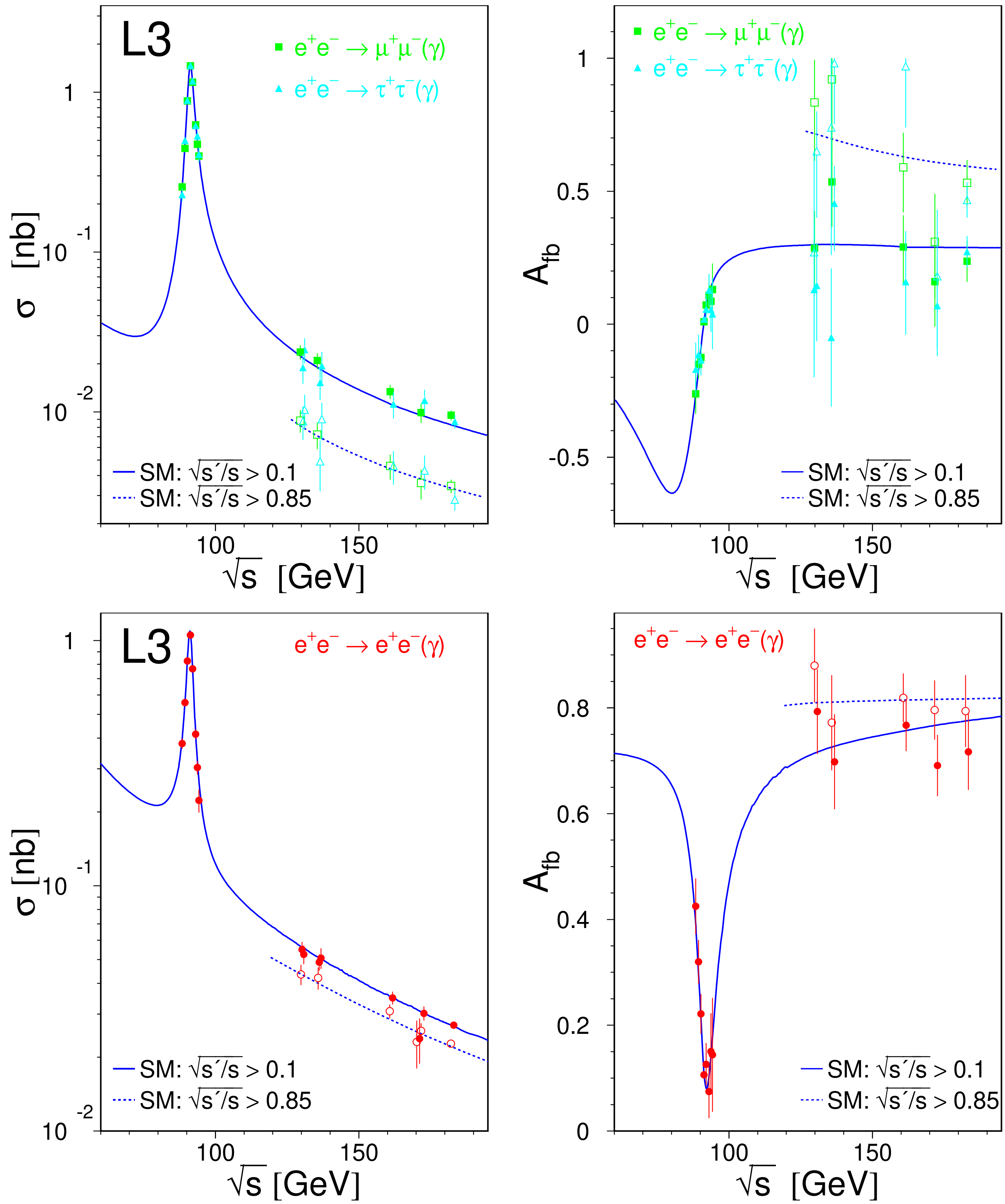


10 pb^{-1}

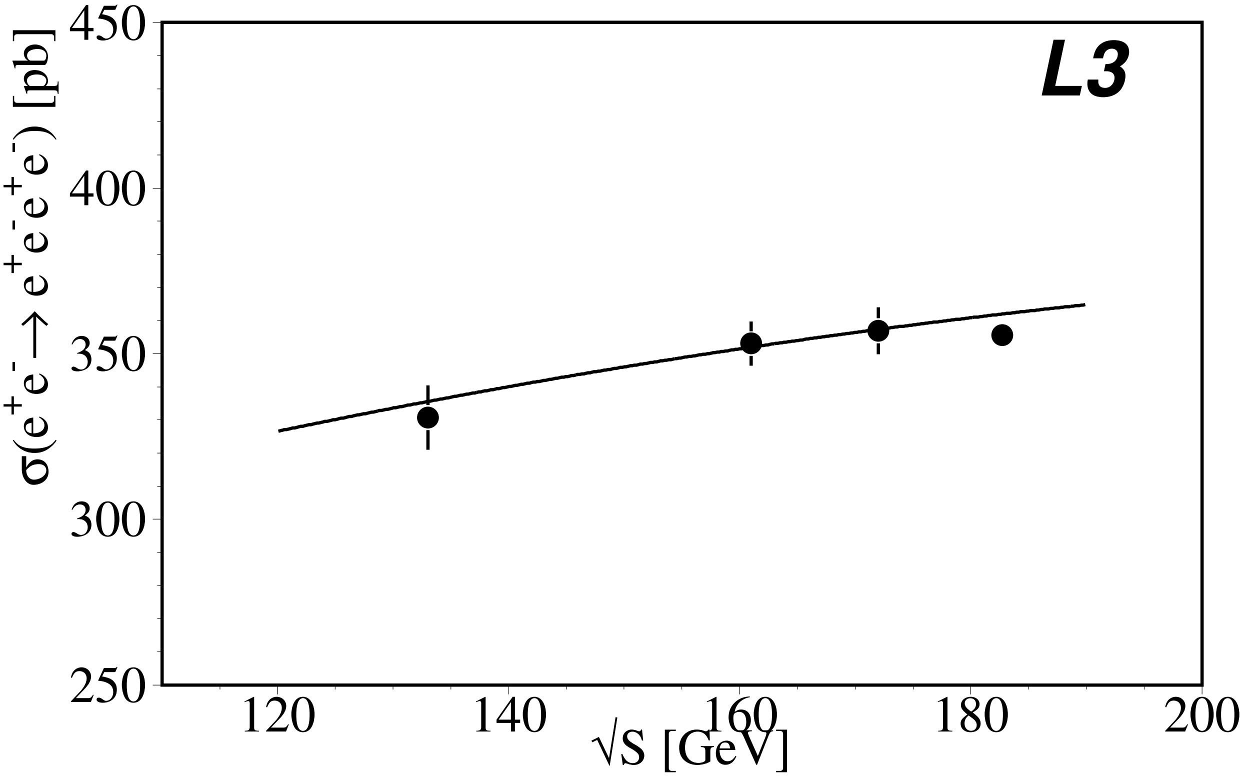
2.5 pb^{-1}

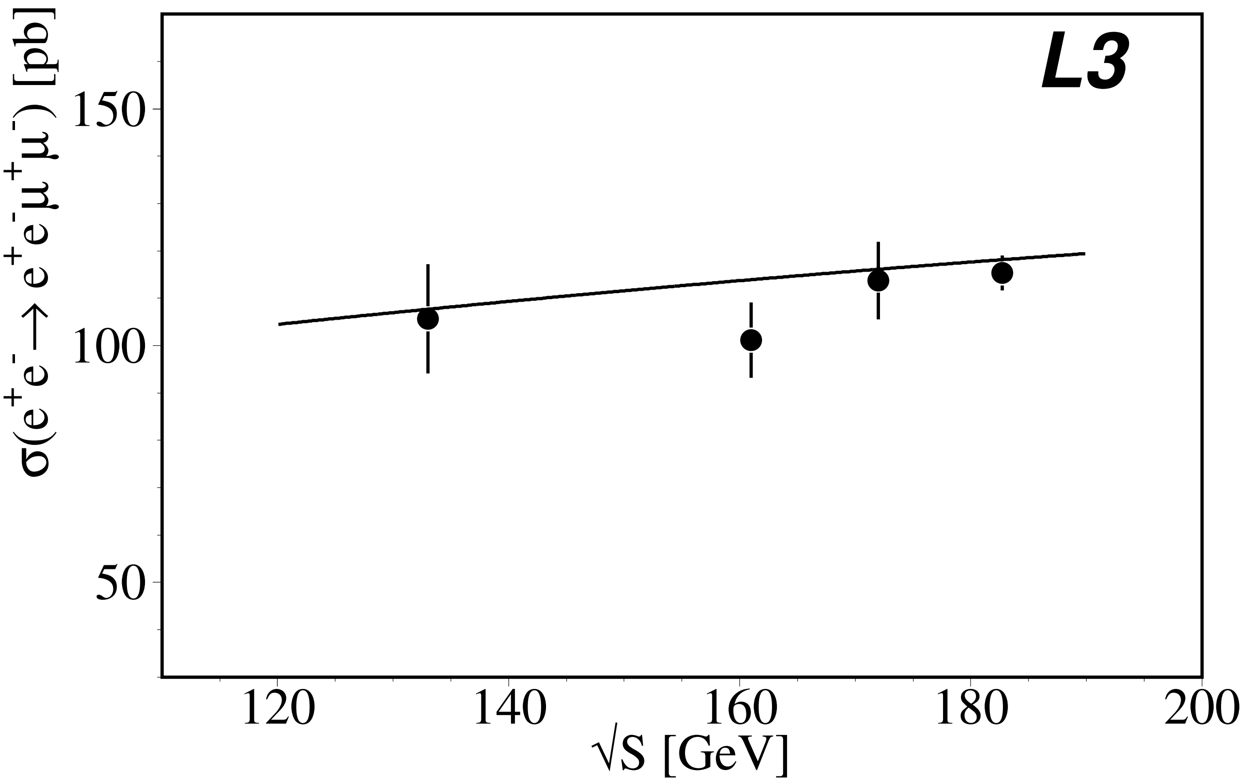
2.5 pb^{-1}

Lepton Pair Production at LEP 200

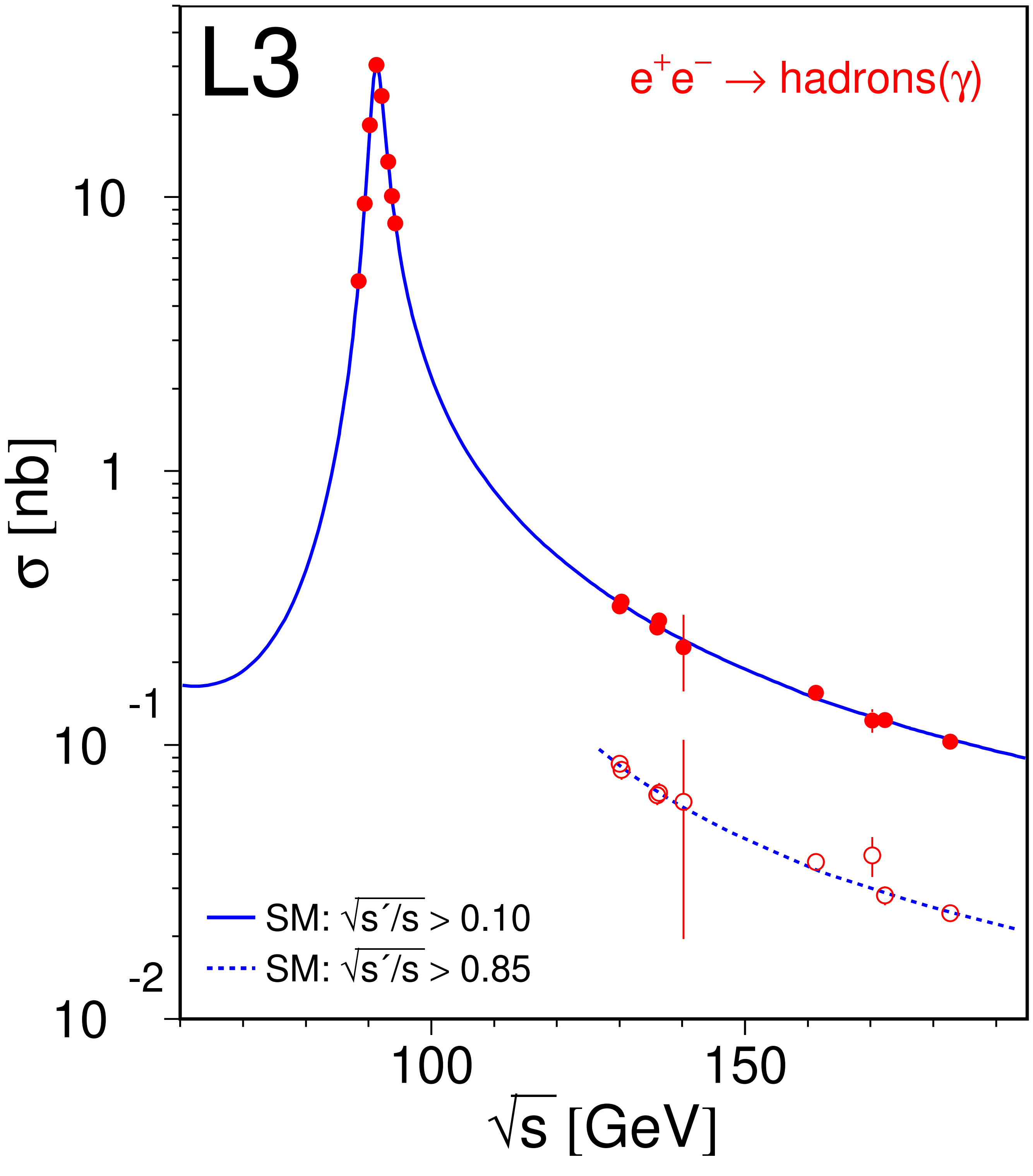


Lepton Pairs from Two-Photon Collisions

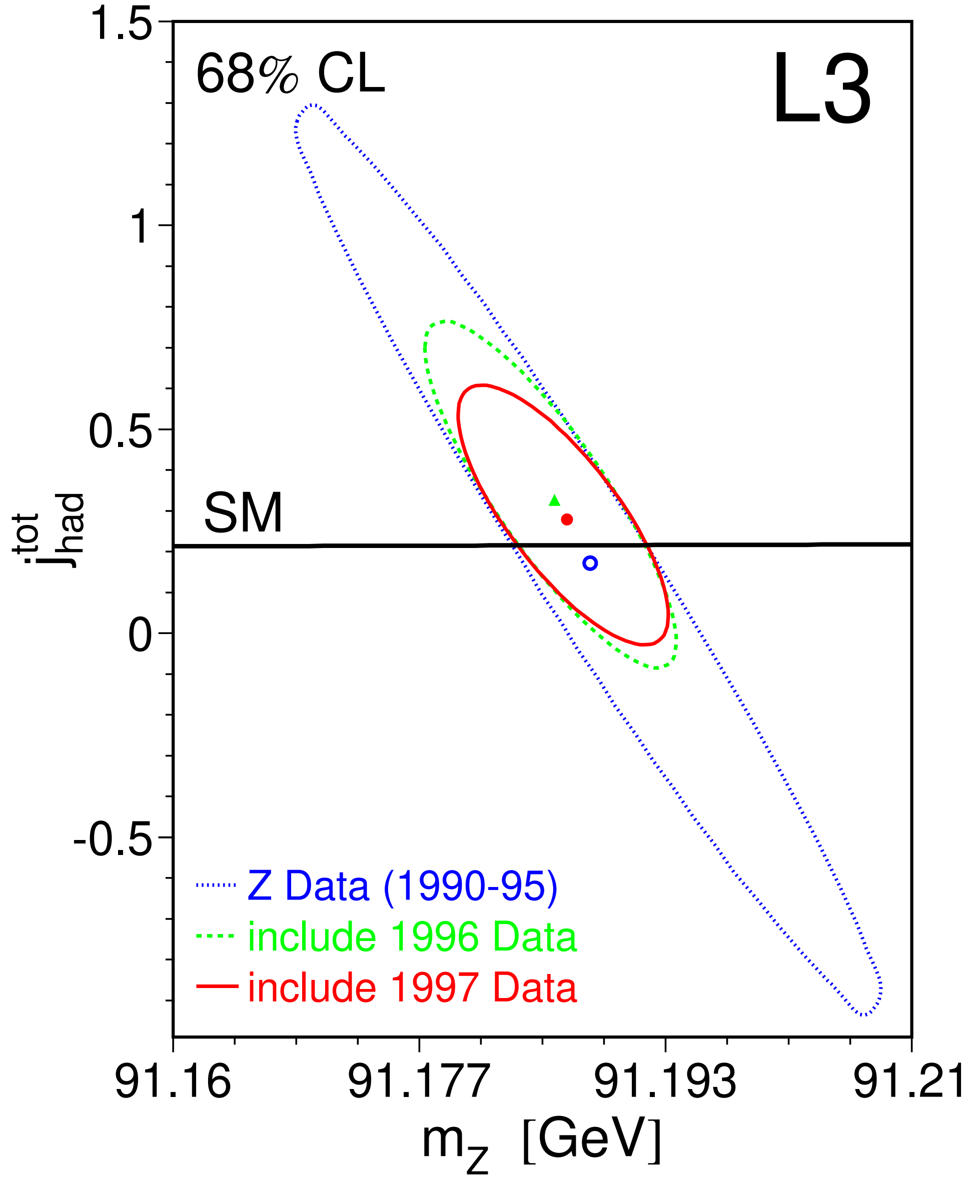




Hadronic Cross Sections at LEP 200

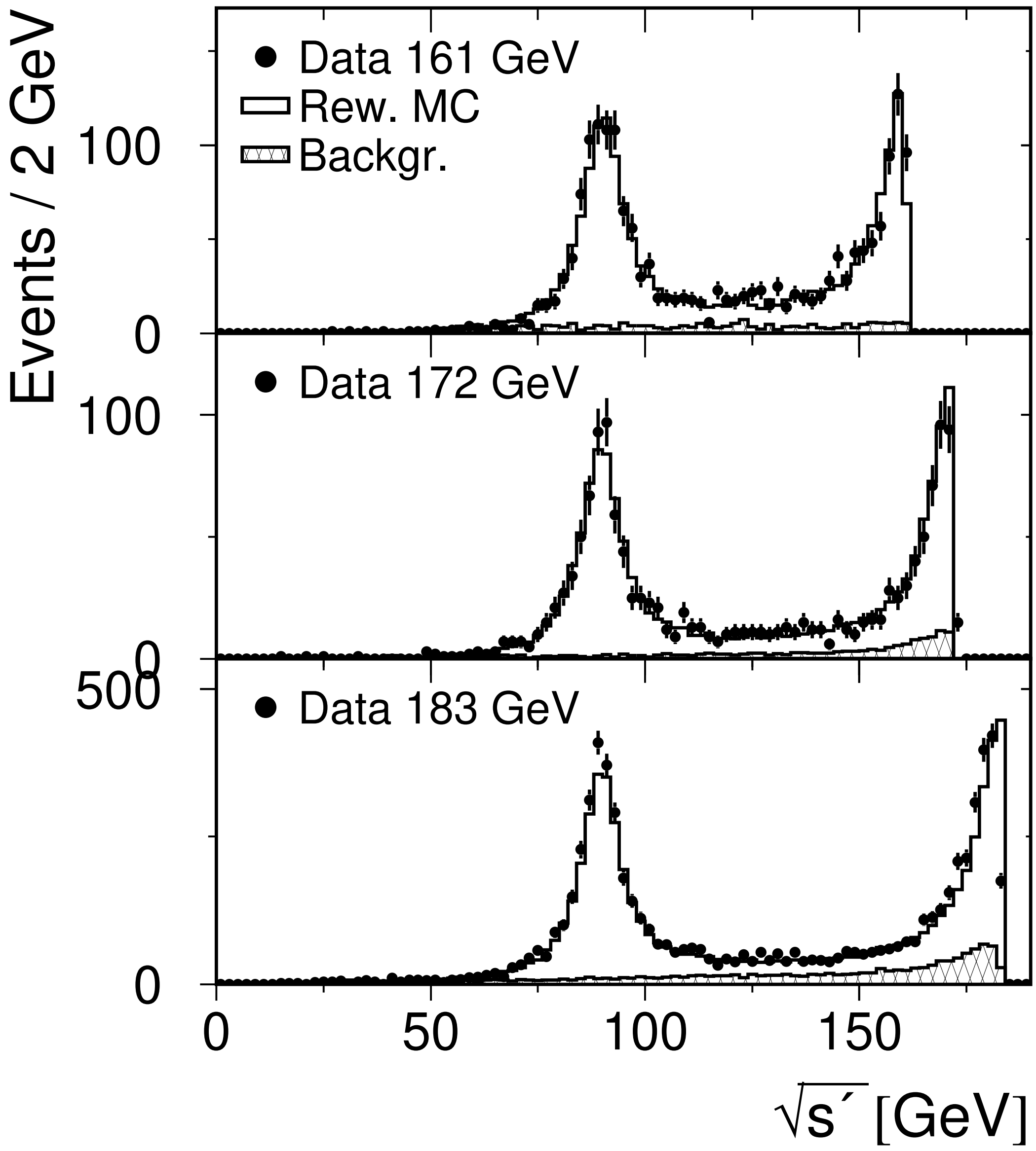


Hadronic Interference Term



Data	j_{had}^{tot}	M_Z
LEP 1	0.18 ± 0.73	$91154. \pm 13.$
LEP 1 + LEP 2	0.29 ± 0.21	$91152. \pm 4.7$
SM:	**0.21**	

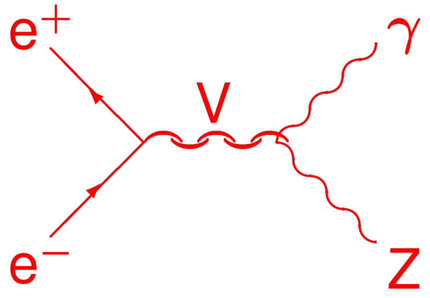
Z Mass from Radiative Returns



$M_Z = 91.040 \pm 0.105$**(stat) GeV**

- **Method analogous to W mass measurement**
- **Excellent cross check on systematics**

Anomalous $Z\gamma$ Couplings



$ie\Gamma^{\alpha\beta\mu}_{Z\gamma V}$

- **8 anomalous couplings** h_i^V
- **Deviations suppressed by** $(p_Z/E_Z)^n$
- **Better limits at LEP 200 than at LEP 1**

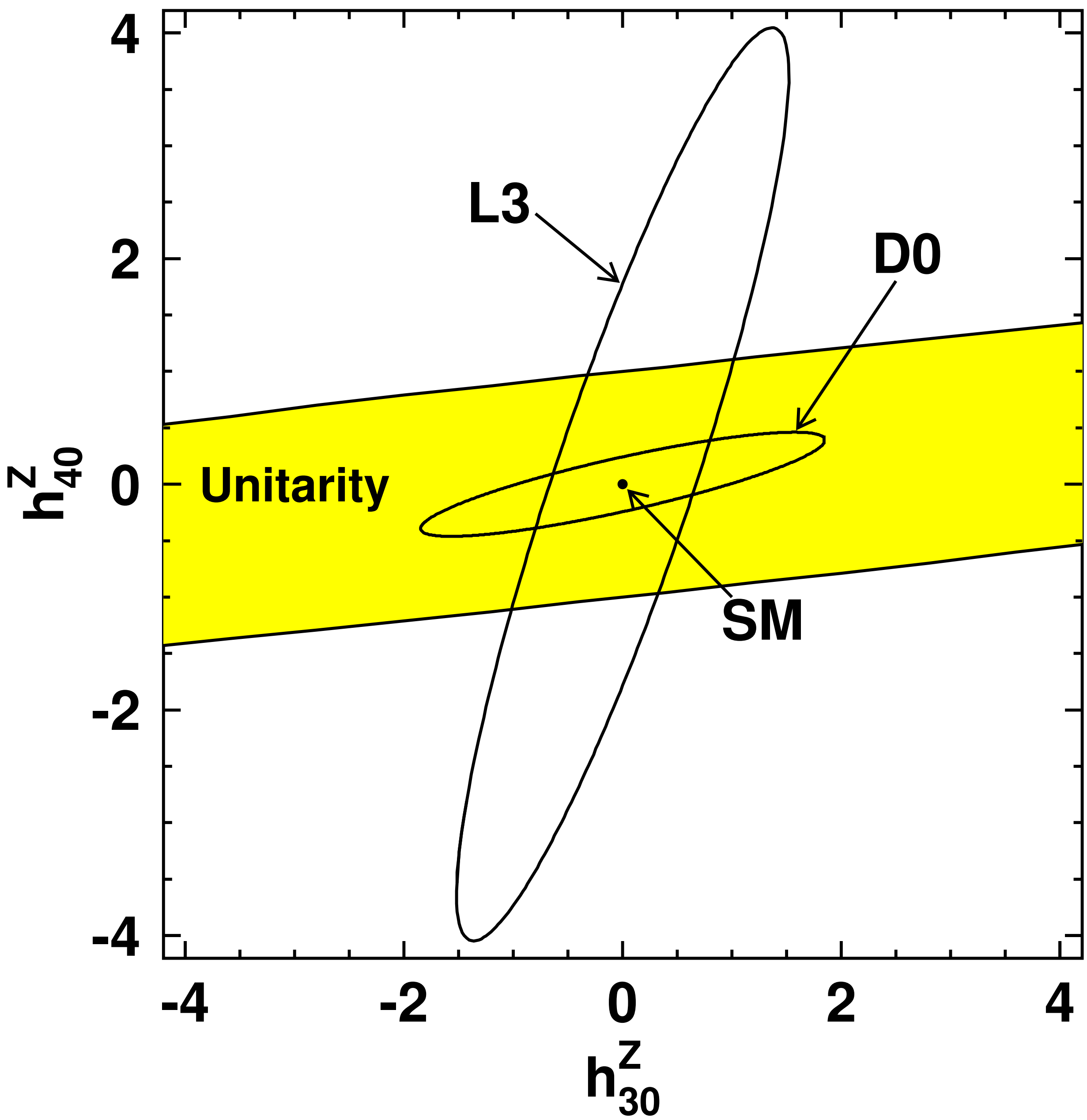
Cross section for $e^+e^- \to Z\gamma \to q\bar{q}\gamma$**:**

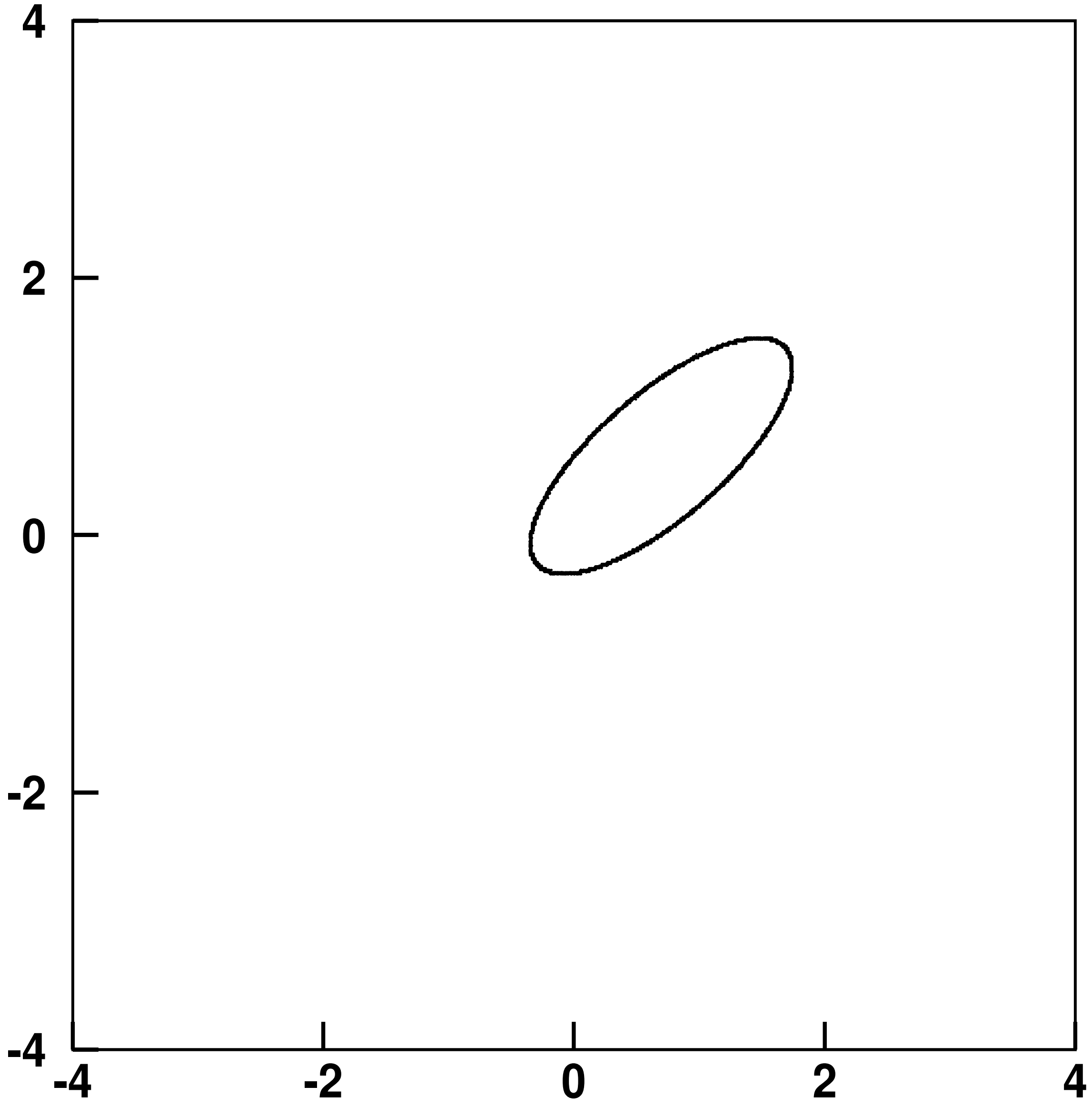
$\sqrt{s}$(GeV)	Sel. Events	σ_{gen} (pb)	σ (pb)
161	119	54	57 ± 5
172	72	45	39 ± 4
183	407	39	40 ± 2

Cross section for $e^+e^- \to Z\gamma \to \nu\bar{\nu}\gamma$**:**

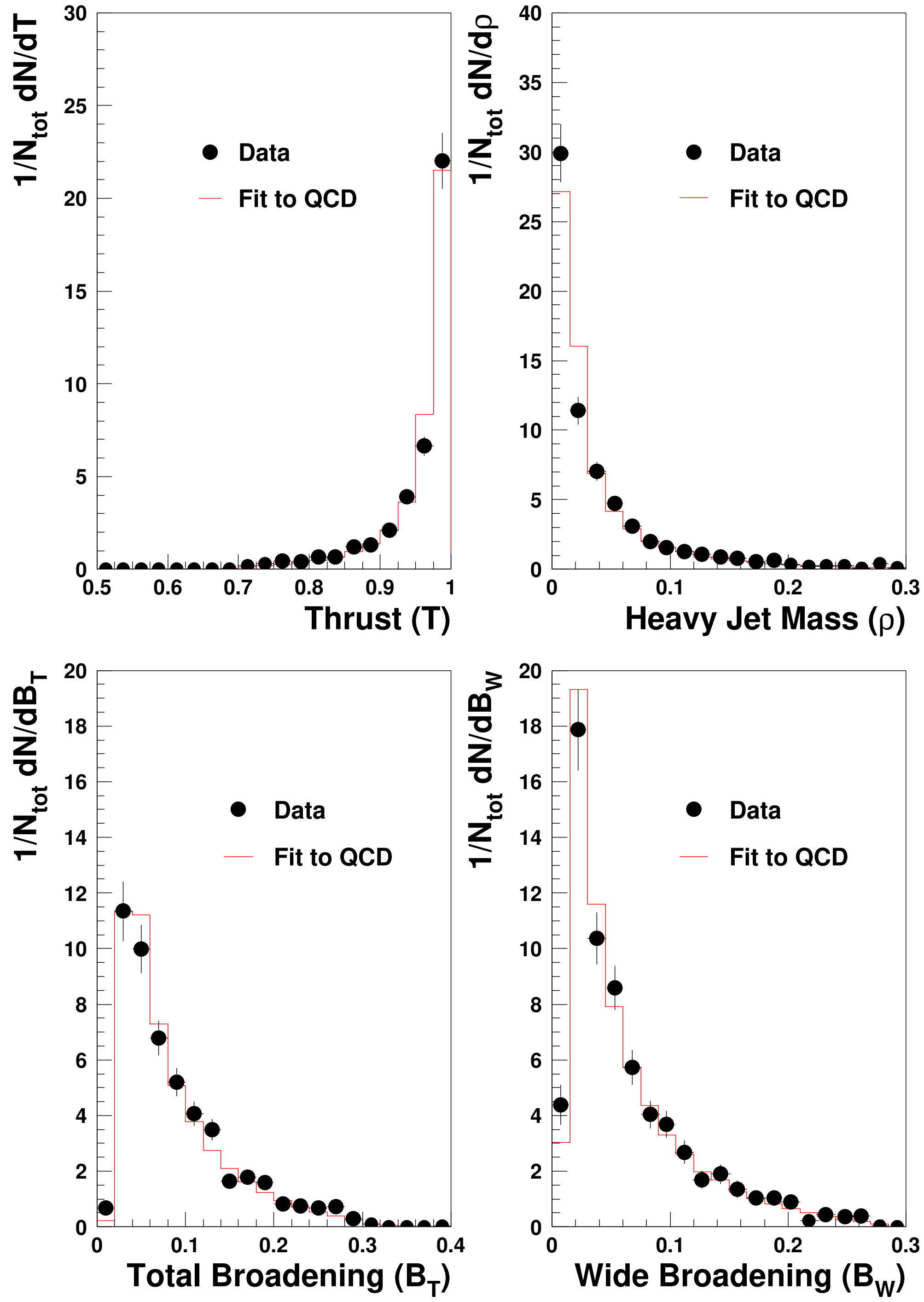
$\sqrt{s}$(GeV)	Sel. Events	σ_{gen} (pb)	σ (pb)
161	29	72	88 ± 18
172	22	67	82 ± 20
183	94	60	65 ± 7

Limits on Anomalous Zγ Couplings




4
2
0
-2
-4
-4
-2
0
2
4

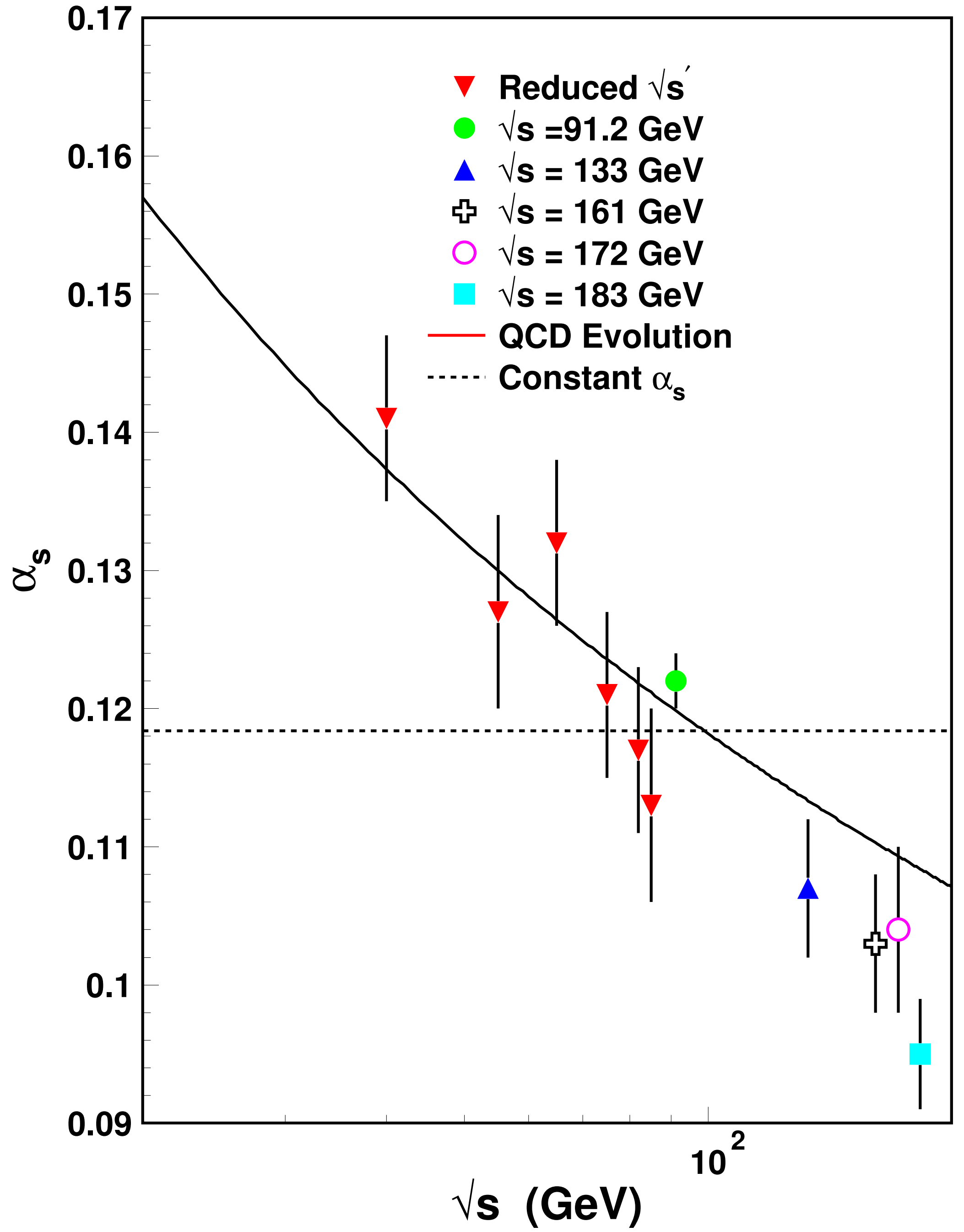
Event Shape Variables at 183 GeV



$$\alpha_s(183\ \textbf{GeV}) = 0.095 \pm 0.005 \pm 0.005$$

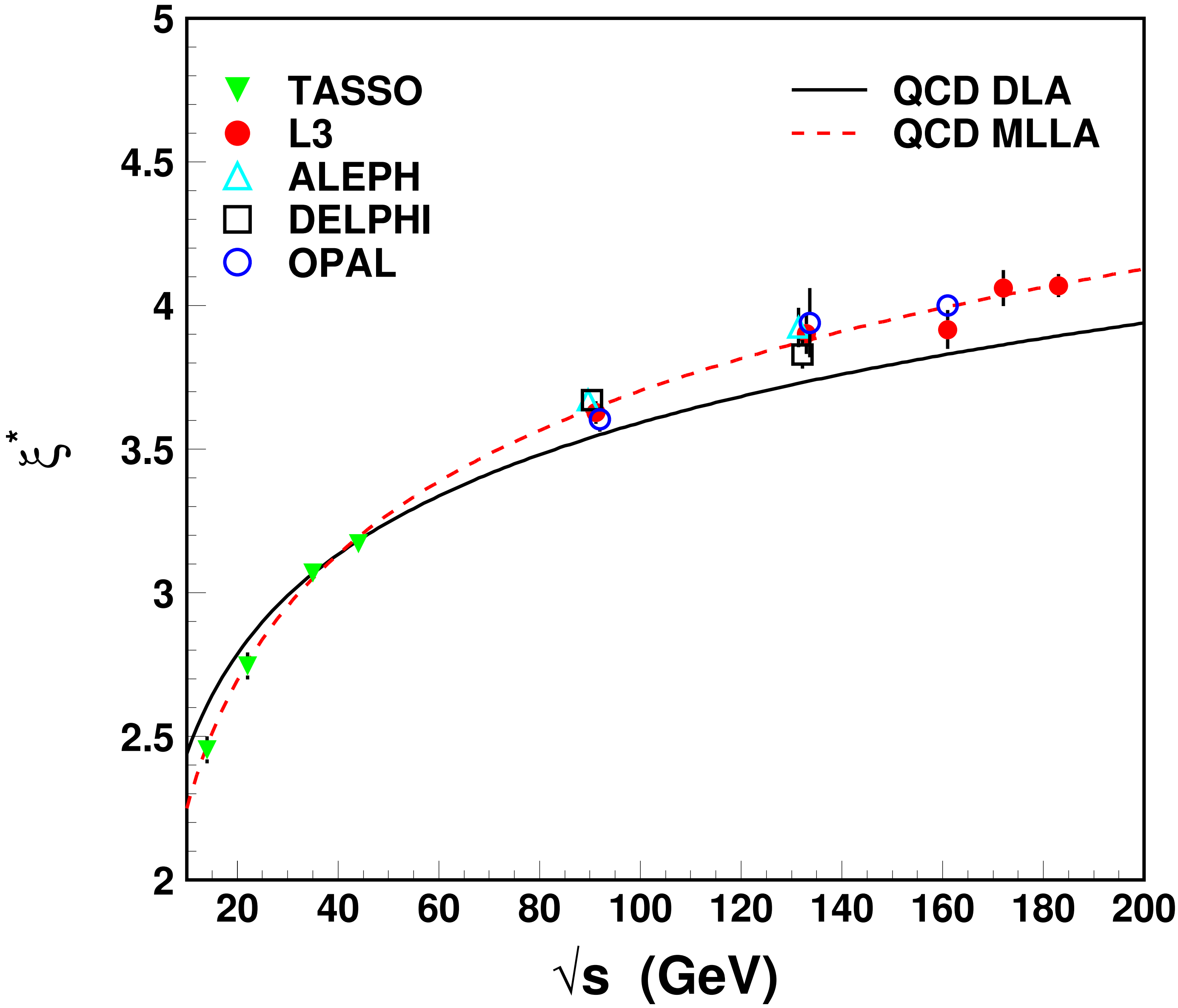
Strong Coupling Constant

L3 Preliminary **Experimental errors only**



Note: $\alpha_s(m_\tau) = 0.36 \pm 0.06$

Charged Particle Spectra



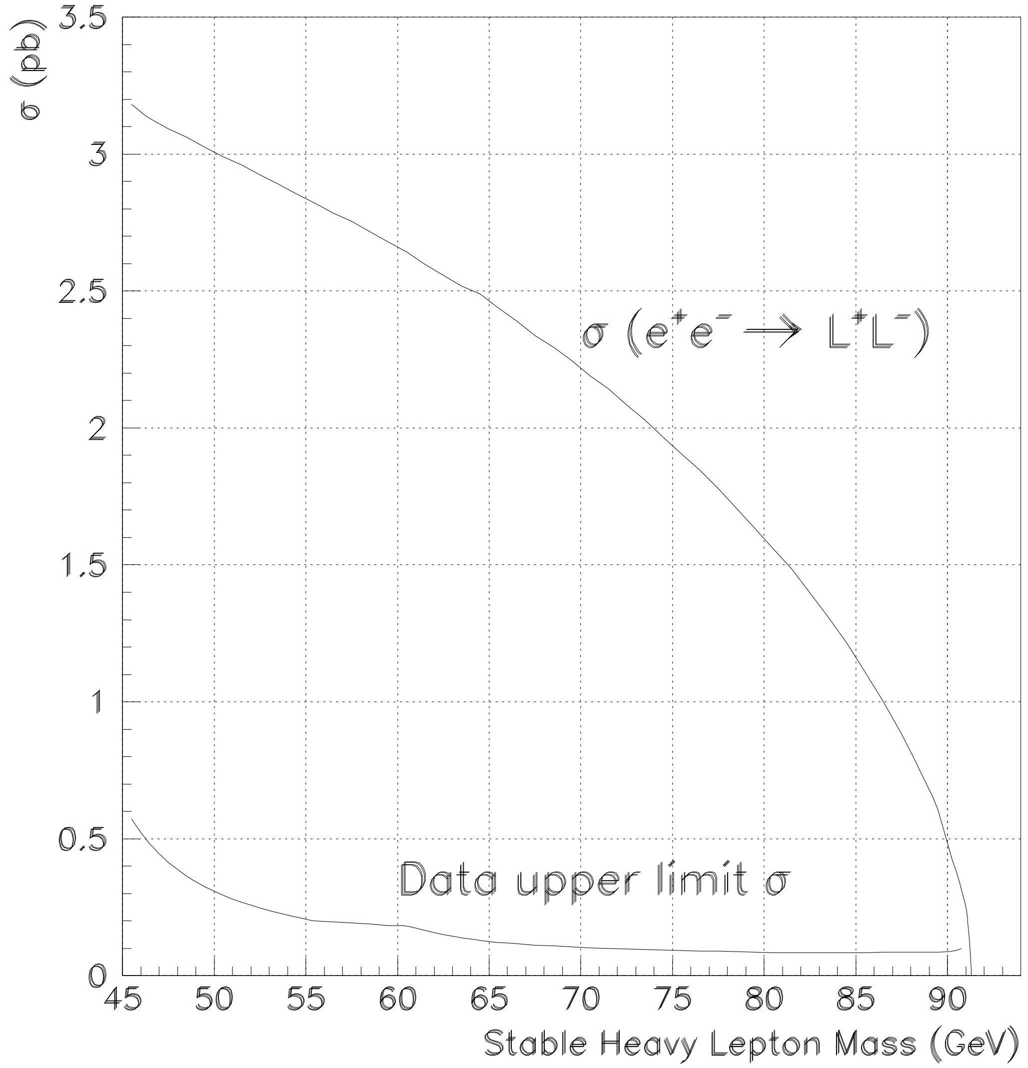
Peak position of the spectrum in $\xi = \log 1/x$:

$$\xi^*(183\ \textbf{GeV}) = 4.07 \pm 0.03 \pm 0.03$$

Charged and Neutral Heavy Leptons

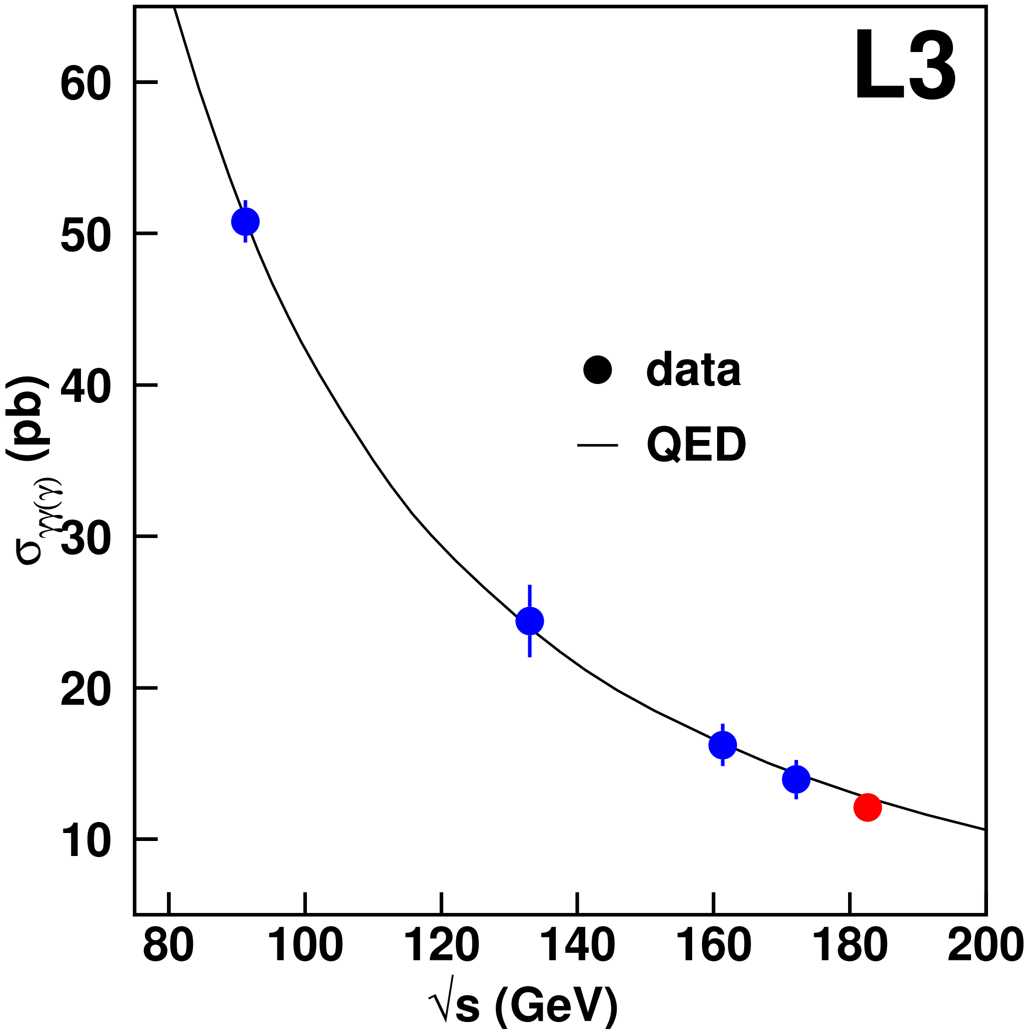
Channel	Data Events	Exp. Backg.	95% CL Mass Limit [GeV] Dirac	Majorana
$L^0 \to eW$	0	0.9	86	77.5
$L^0 \to \mu W$	0	0.8	85	76.5
$L^0 \to \tau W$	4	5.1	75	62

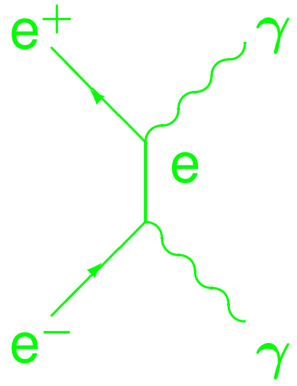
Ecm = 183GeV



From absence of highly ionising pairs

Boson Pair Production: $e^+e^- \to \gamma\gamma$

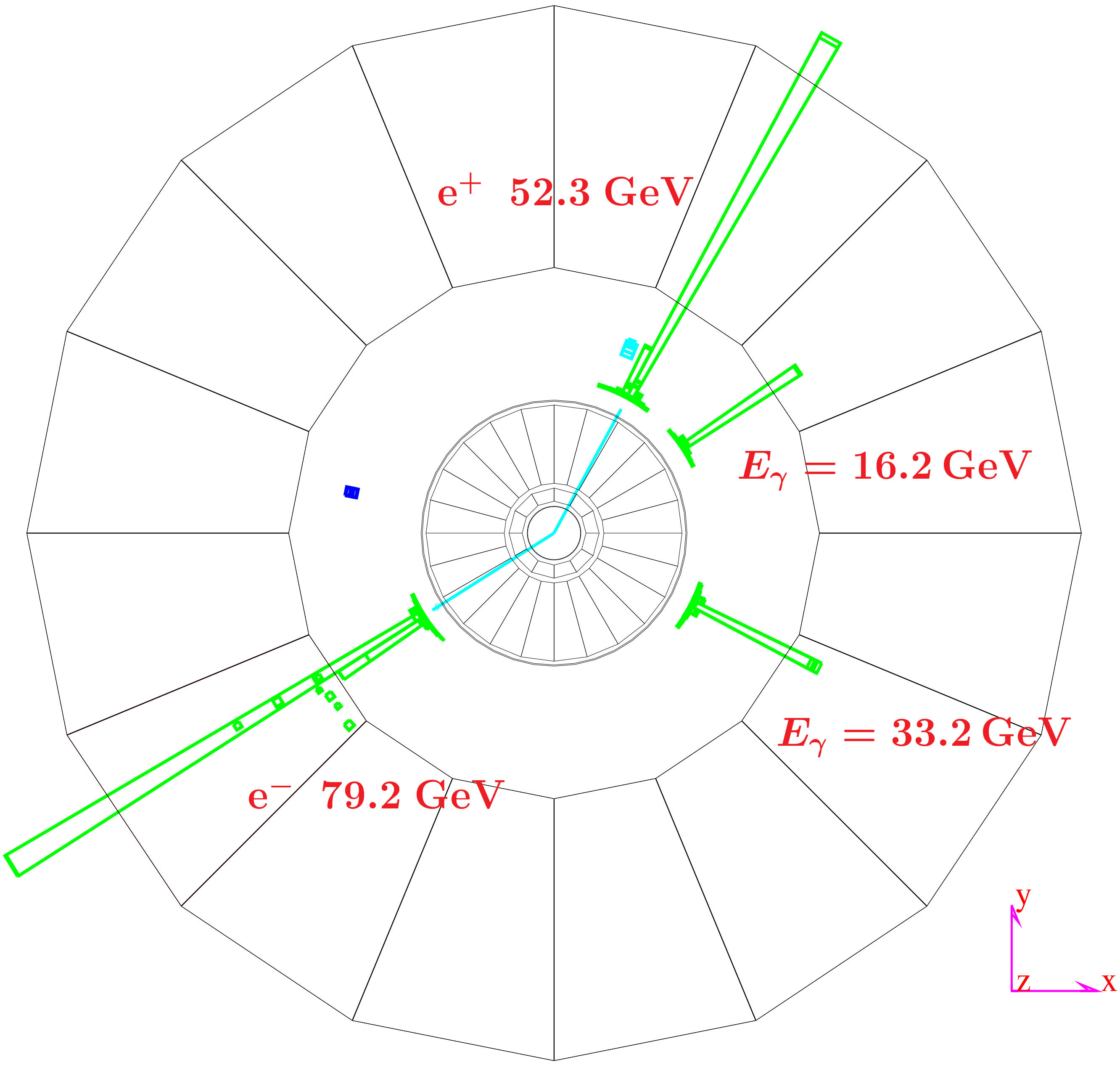




Formfactor:	**Contact:**	**Excited e:**
$\Lambda_- > 242$GeV	$\Lambda > 1085$GeV	$m_{e^*} > 242$GeV (L+R)
$\Lambda_+ > 267$GeV	$\Lambda' > 612$GeV	$m_{e^*} > 177$GeV (L/R)

Direct Search for Excited Leptons

Run # 686708 Event # 4923 Total Energy : 190.75 GeV

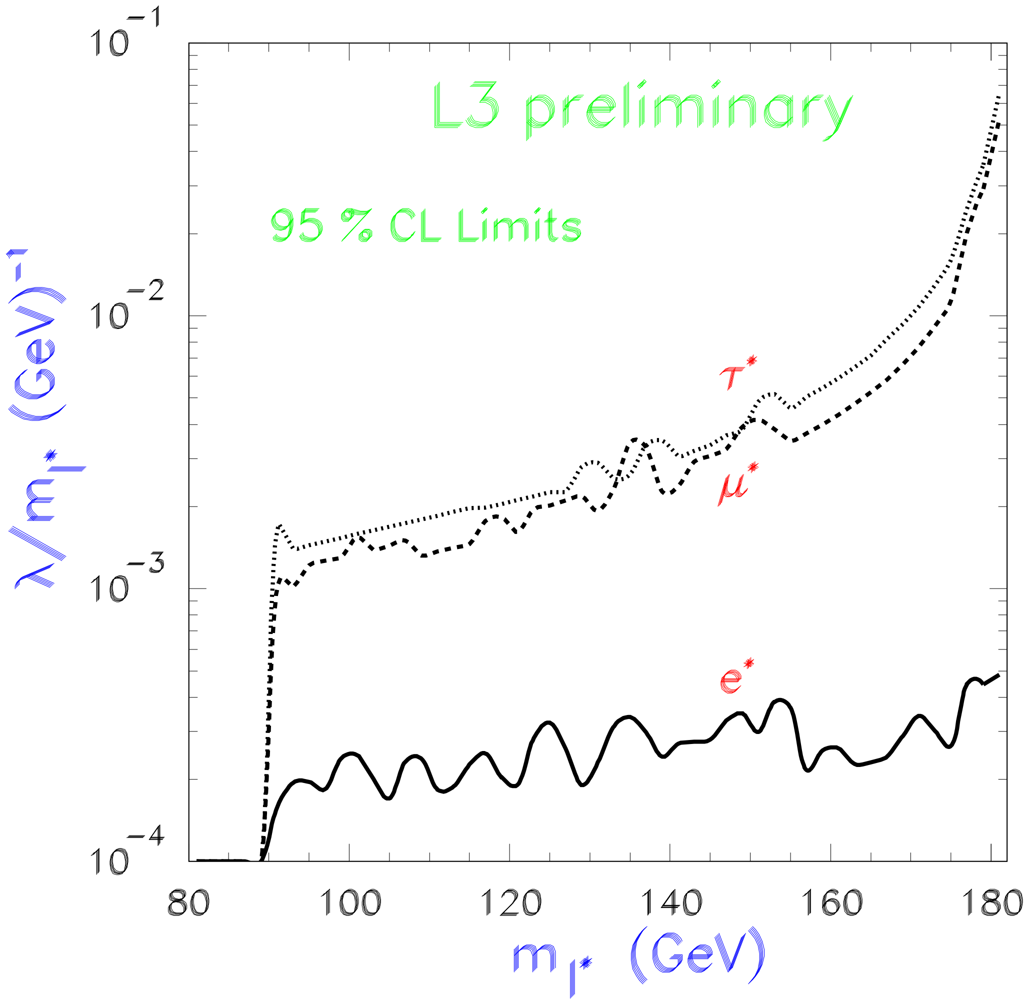


Direct Search for Excited Leptons

Pair Production:

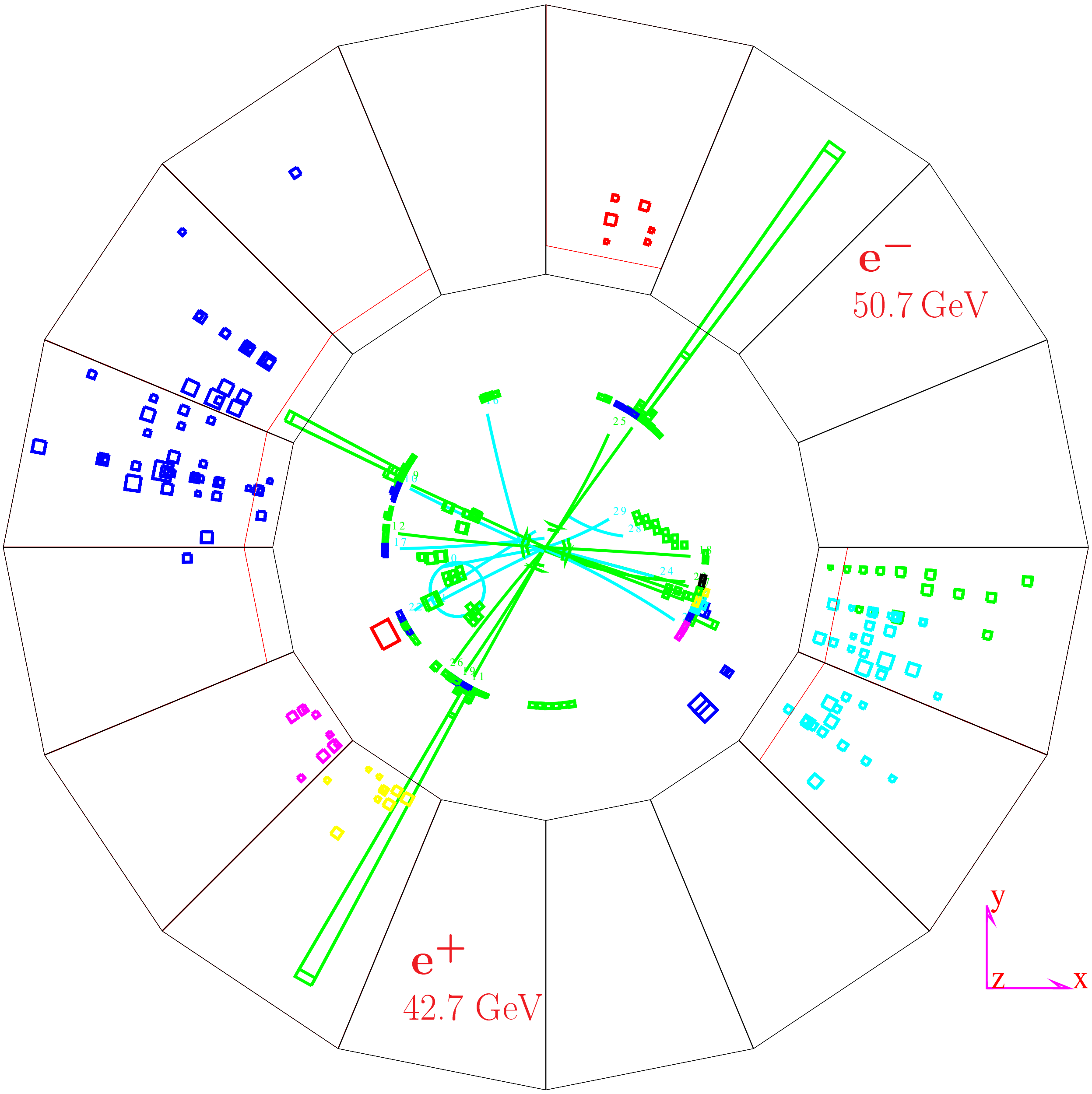
$$m_{e^*} > 91.0 \text{ GeV}$$
$$m_{\mu^*} > 91.1 \text{ GeV}$$
$$m_{\tau^*} > 91.0 \text{ GeV}$$

Single Production:



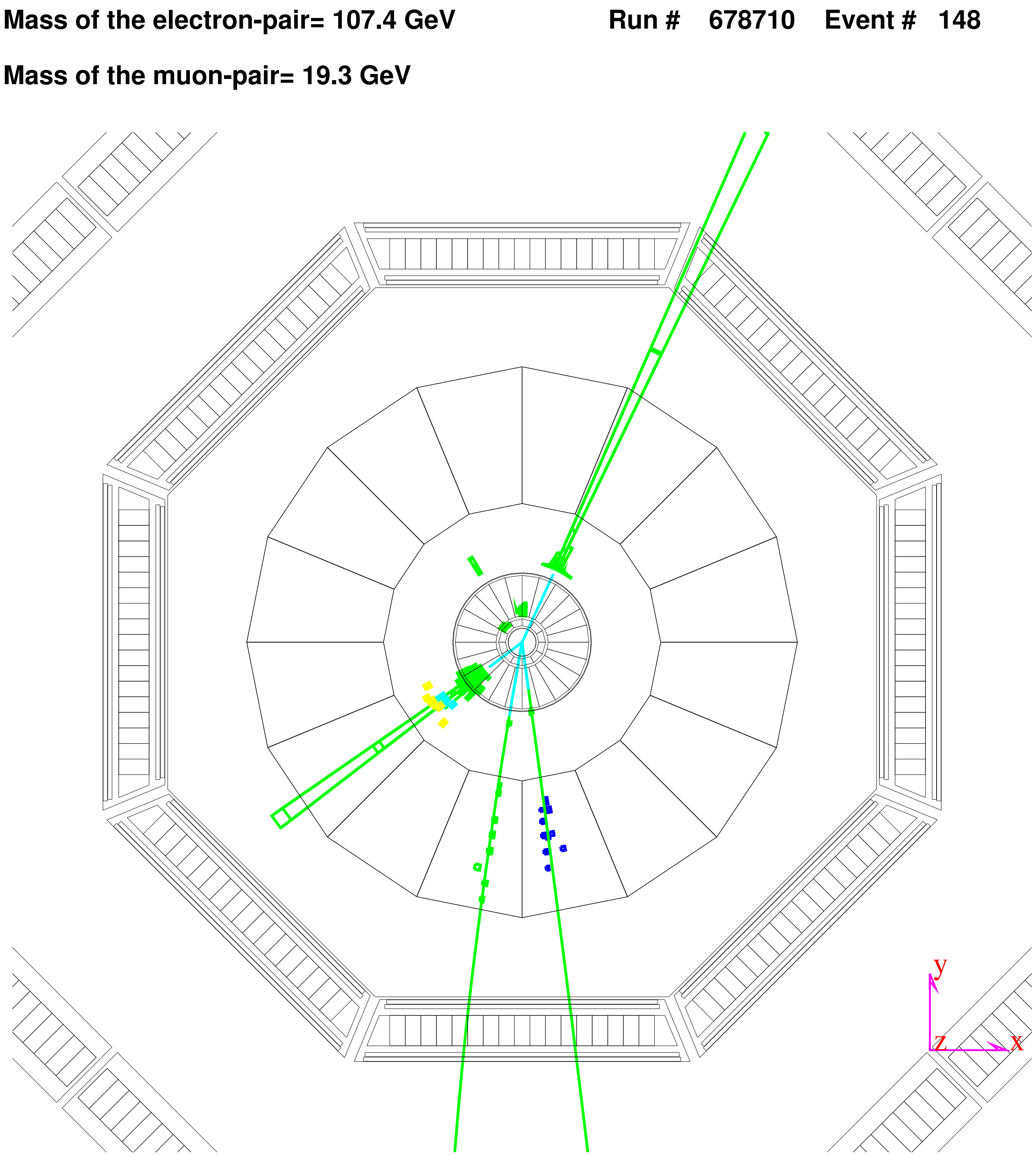
Boson Pair Production: $e^+e^- \to ZZ$

Run # 688905 Event # 1652 Total Energy : 180.75 GeV



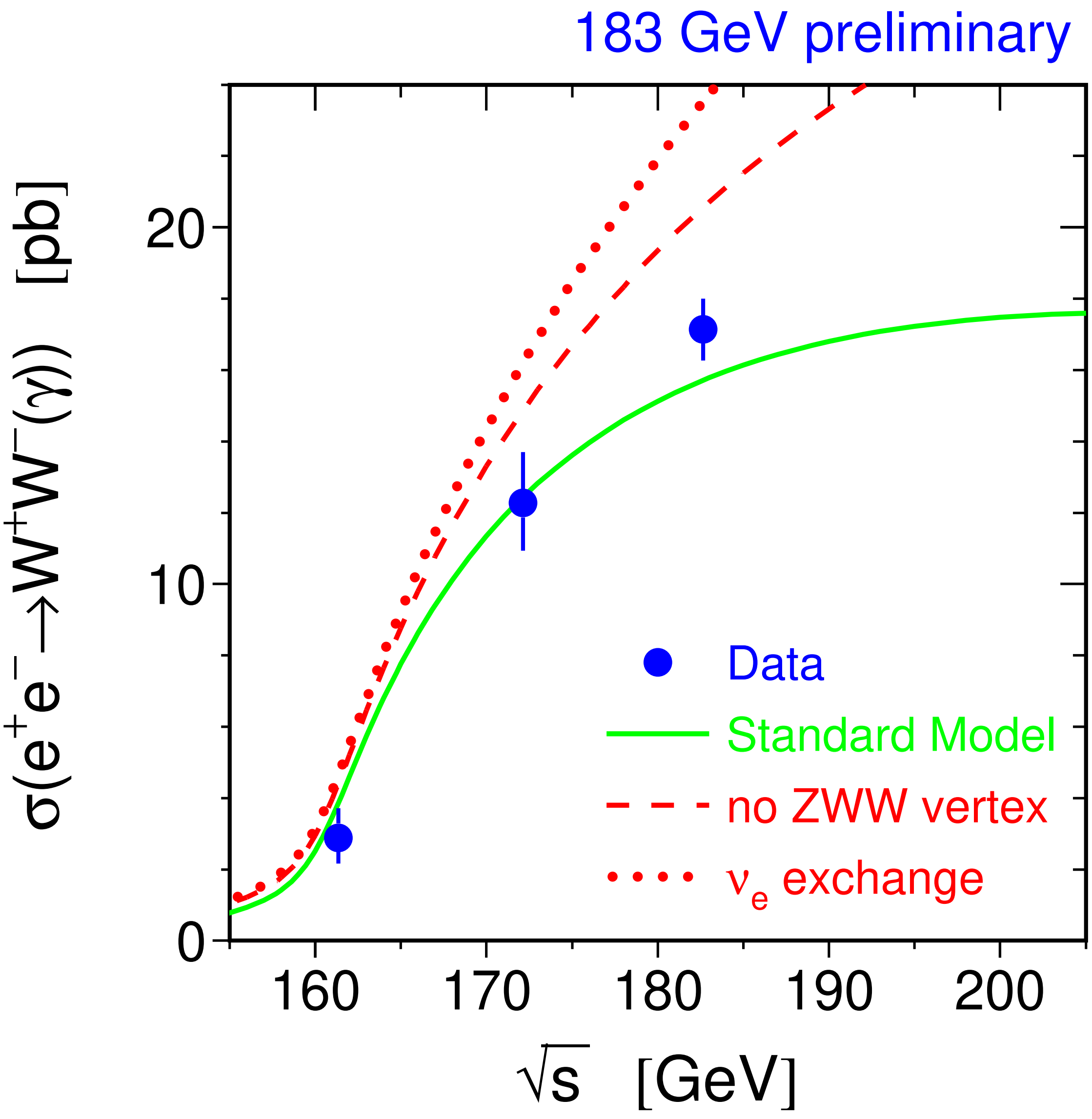
$$m_{ee} = 92.8\ \mathrm{GeV} \qquad m_{jj} = 88.8\ \mathrm{GeV}$$

Neutral Current Four Fermion Production



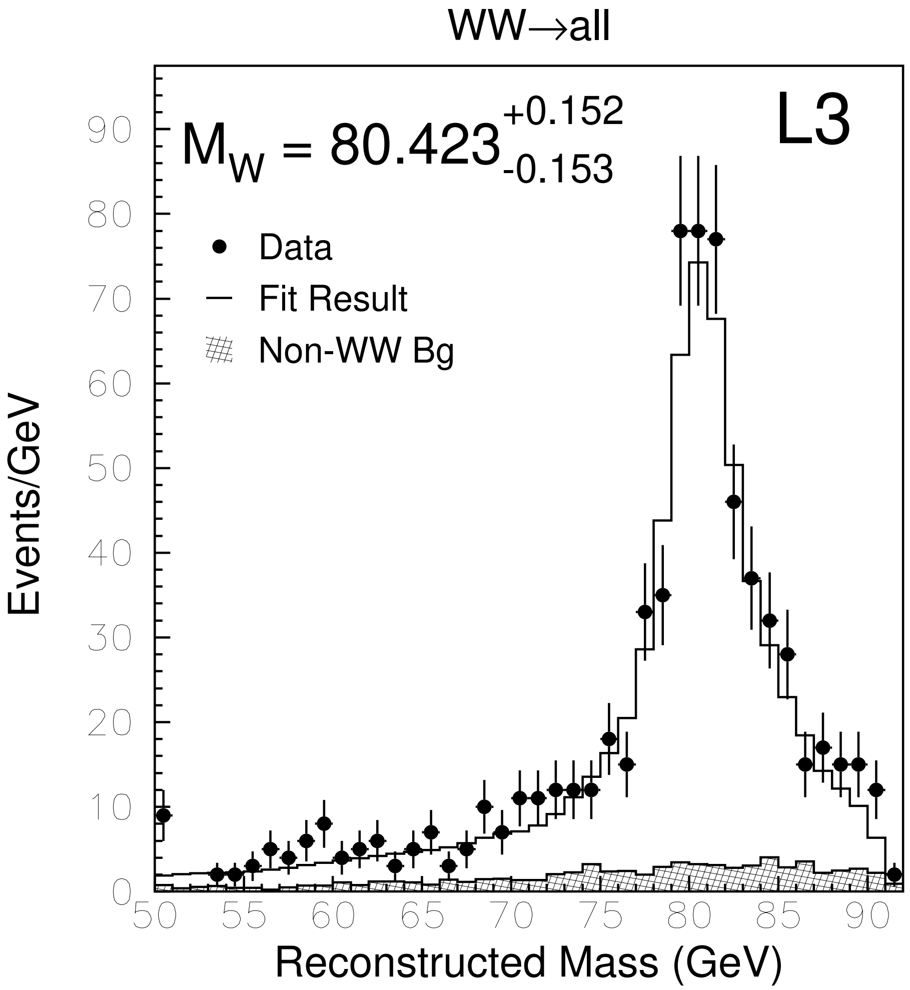
Channel	Obs. Ev.	Exp. Ev.	σ [pb]	σ_{SM} [pb]
$l^+l^-q\bar{q}$	13	10.9	2.1 ± 0.8	1.75
$l^+l^-l'^+l'^-$	11	8.1	1.5 ± 0.7	0.98

Boson Pair Production: $e^+e^- \to W^+W^-$



Channel	**Events**	σ **[pb]**	σ_{SM} **[pb]**
$q\bar{q}q\bar{q}$	**450**	8.35 ± 0.47	7.16
$l\nu q\bar{q}$	**277**	2.36 ± 0.15	2.29
$l\nu l\nu$	**49**	1.65 ± 0.25	1.66

W Mass from Direct Reconstruction



Direct reconstruction 172 + 183 GeV assuming 100 MeV syst., 100 MeV LEP error at 183 GeV:

$m_W = 80.59 \pm 0.20 \pm 0.14$ GeV **($q\bar{q}q\bar{q}$)**

$m_W = 80.35 \pm 0.23 \pm 0.09$ GeV **($q\bar{q}l\nu$)**

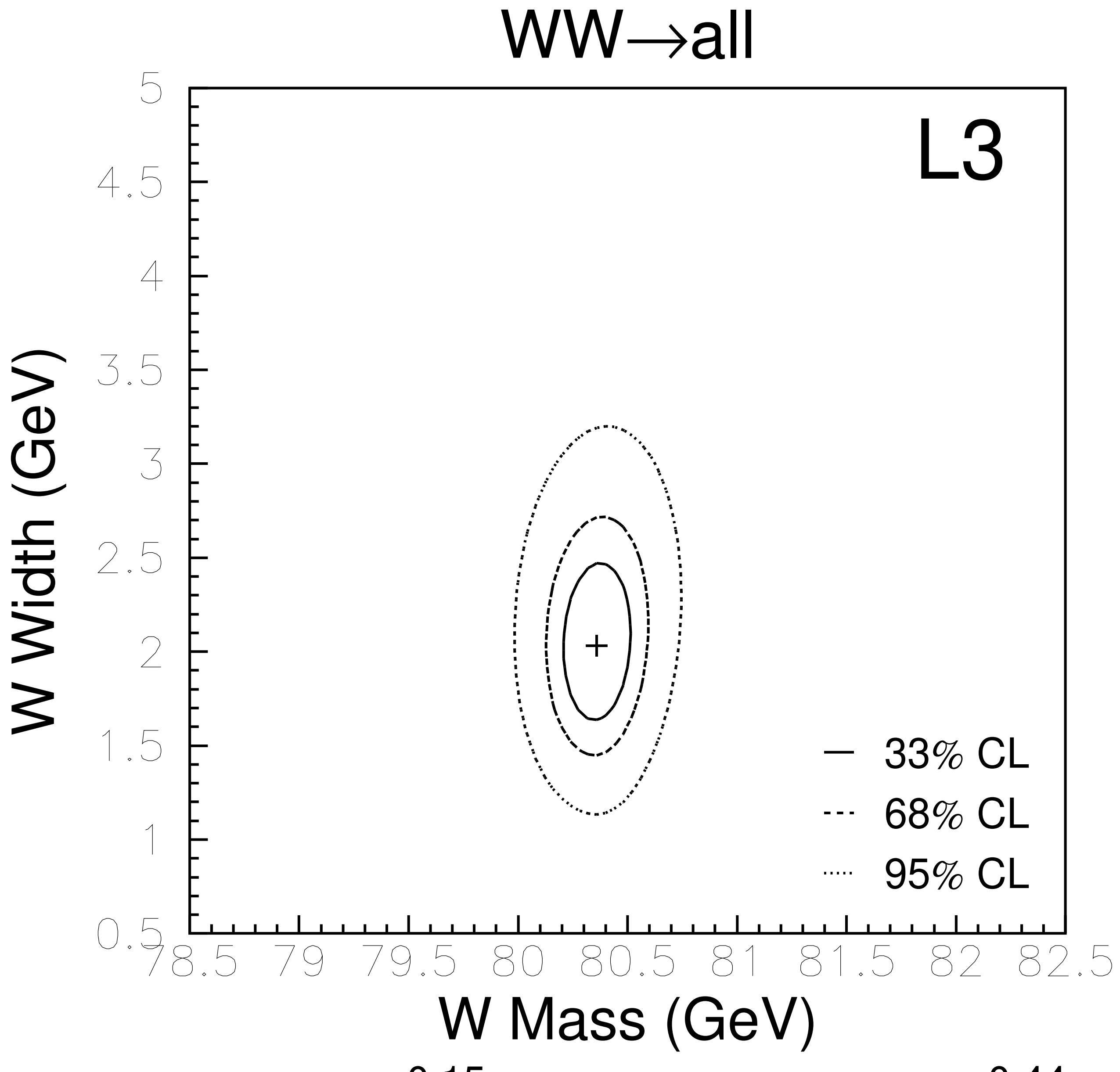
Together with 161 GeV cross-section:

$m_W = 80.53 \pm 0.18$ (exp + LEP) GeV **(all data)**

Systematic errors under study

W Width

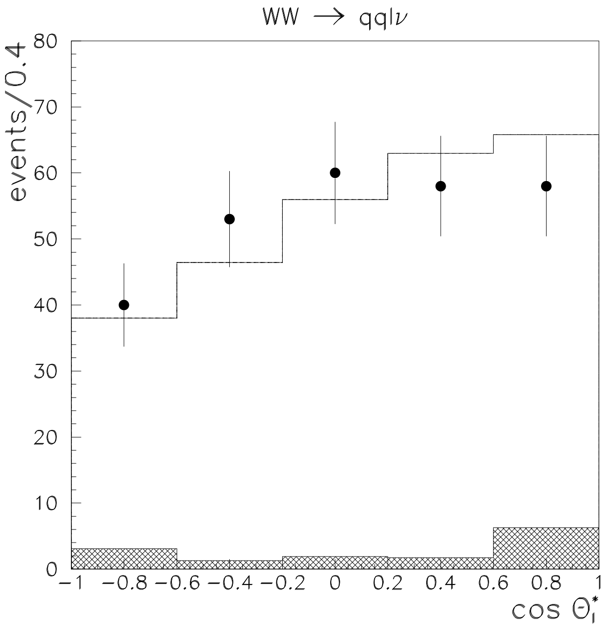
183 GeV

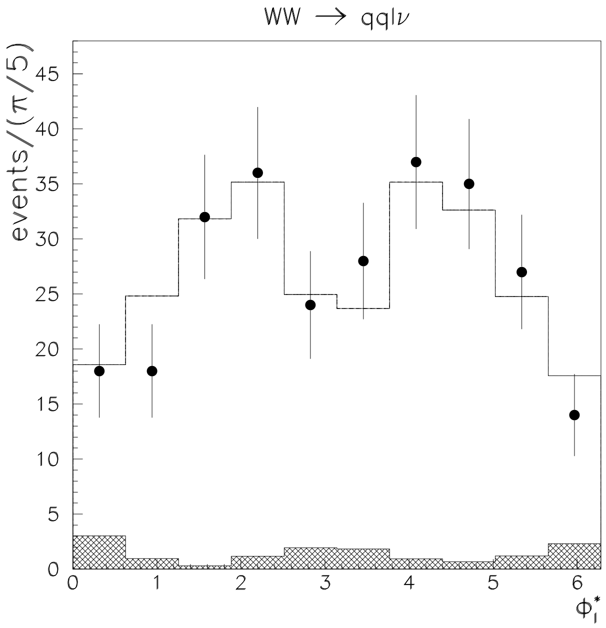


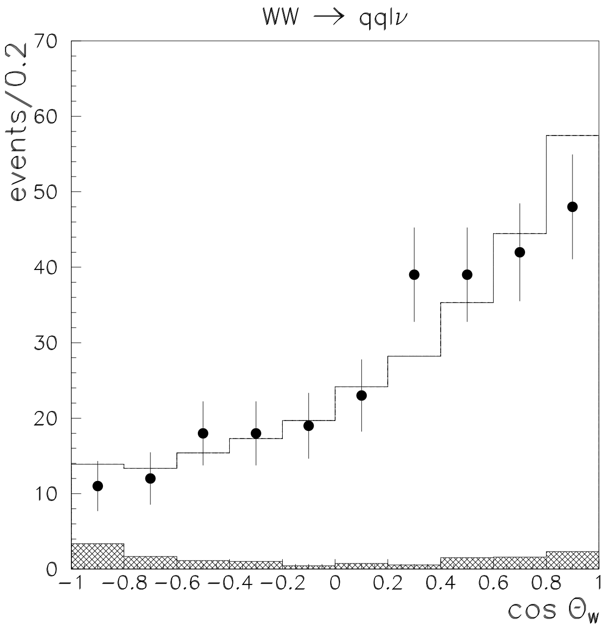
$M_W = 80.36^{+0.15}_{-0.15}$ $\Gamma_W = 2.03^{+0.44}_{-0.40}$

Systematic error under study

W Production and Decay Angles 183 GeV







ZWW coupling:

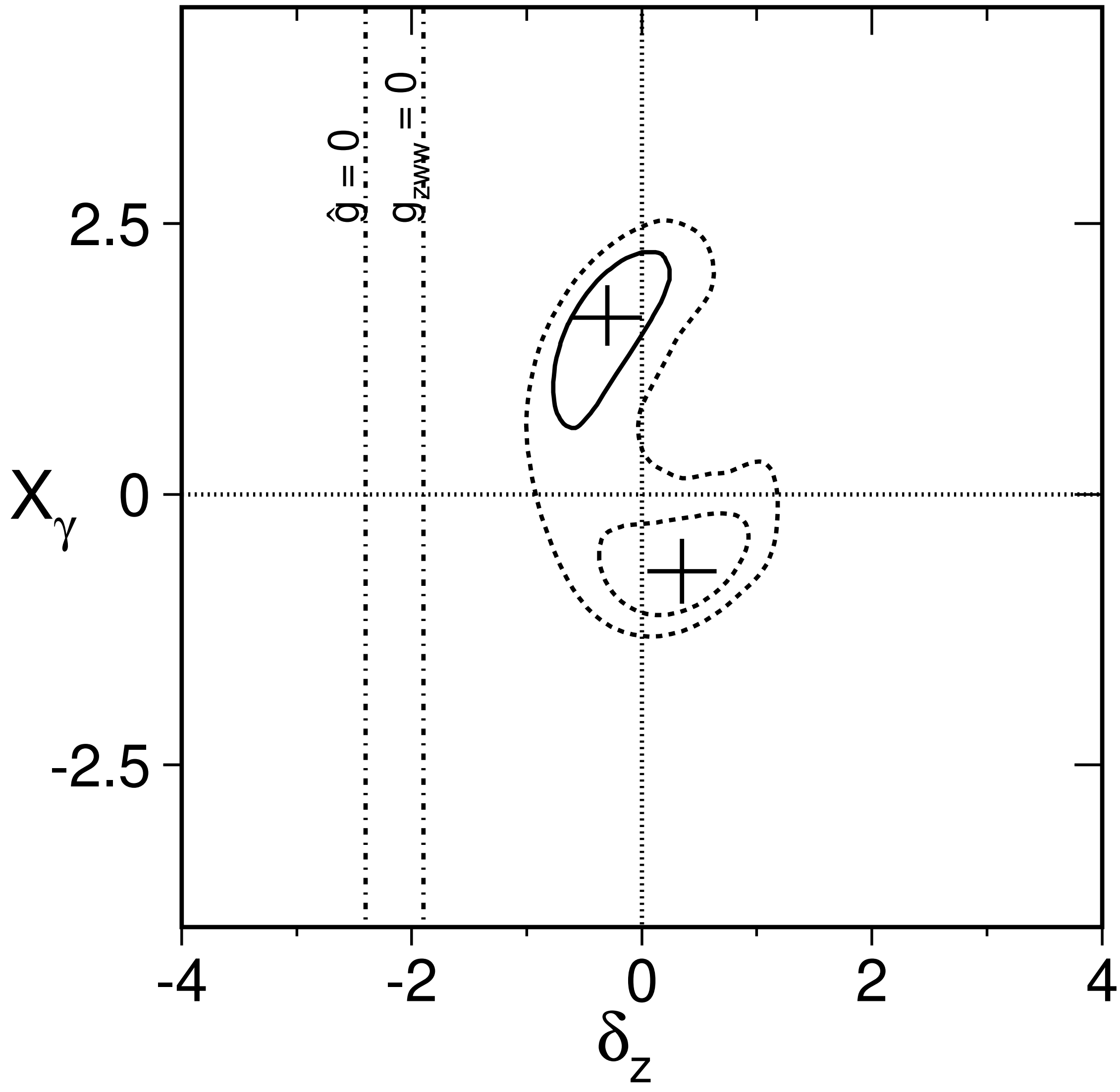
$$\delta_Z \equiv g_{ZWW} - \cot\theta_W$$
$$= -0.37^{+0.32}_{-0.25}$$
$$\in [-0.57, 0.08]$$

Coefficients of "unsuppressed operators":

	max L(-0.5)	∫L = 68%
$\alpha_{W\phi}$ =	$-0.12^{+0.11}_{-0.10}$	$\in[-0.21, 0.02]$
α_W =	$-0.18^{+0.23}_{-0.16}$	$\in[-0.29, 0.19]$
$\alpha_{B\phi}$ =	$-0.50^{+0.30}_{-0.25}$	$\in[-0.66, 1.20]$

W Weak Charge and Magnetic Moment

161, 172 and 183 GeV **L3 Preliminary**



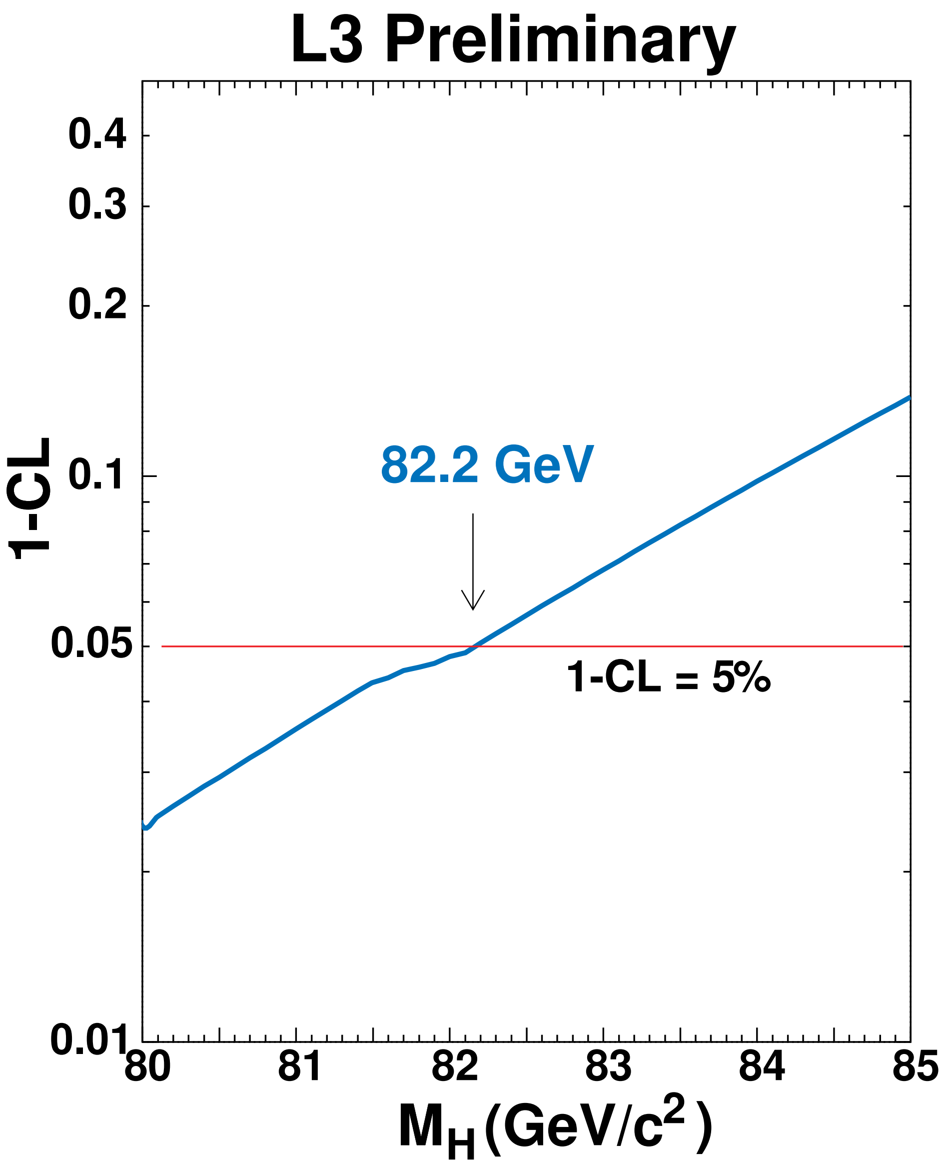
Existence of ZWW vertex established, independent of W magnetic moment

Double minimum due to high qqqq **cross section**

Limit on Standard Model Higgs

Intermediate result from 36 pb^{-1}:

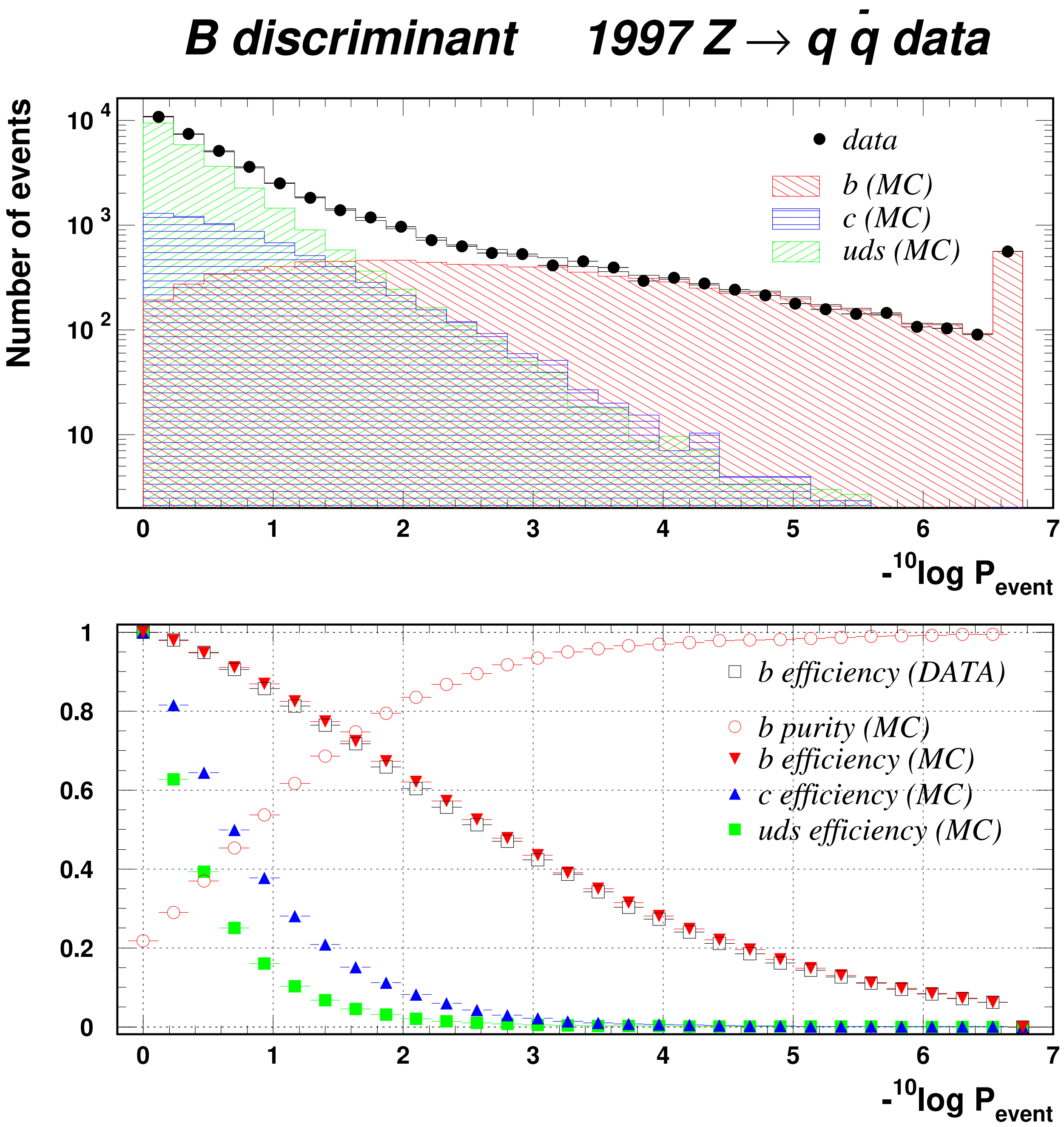
(Data collected untill 29.09.97)



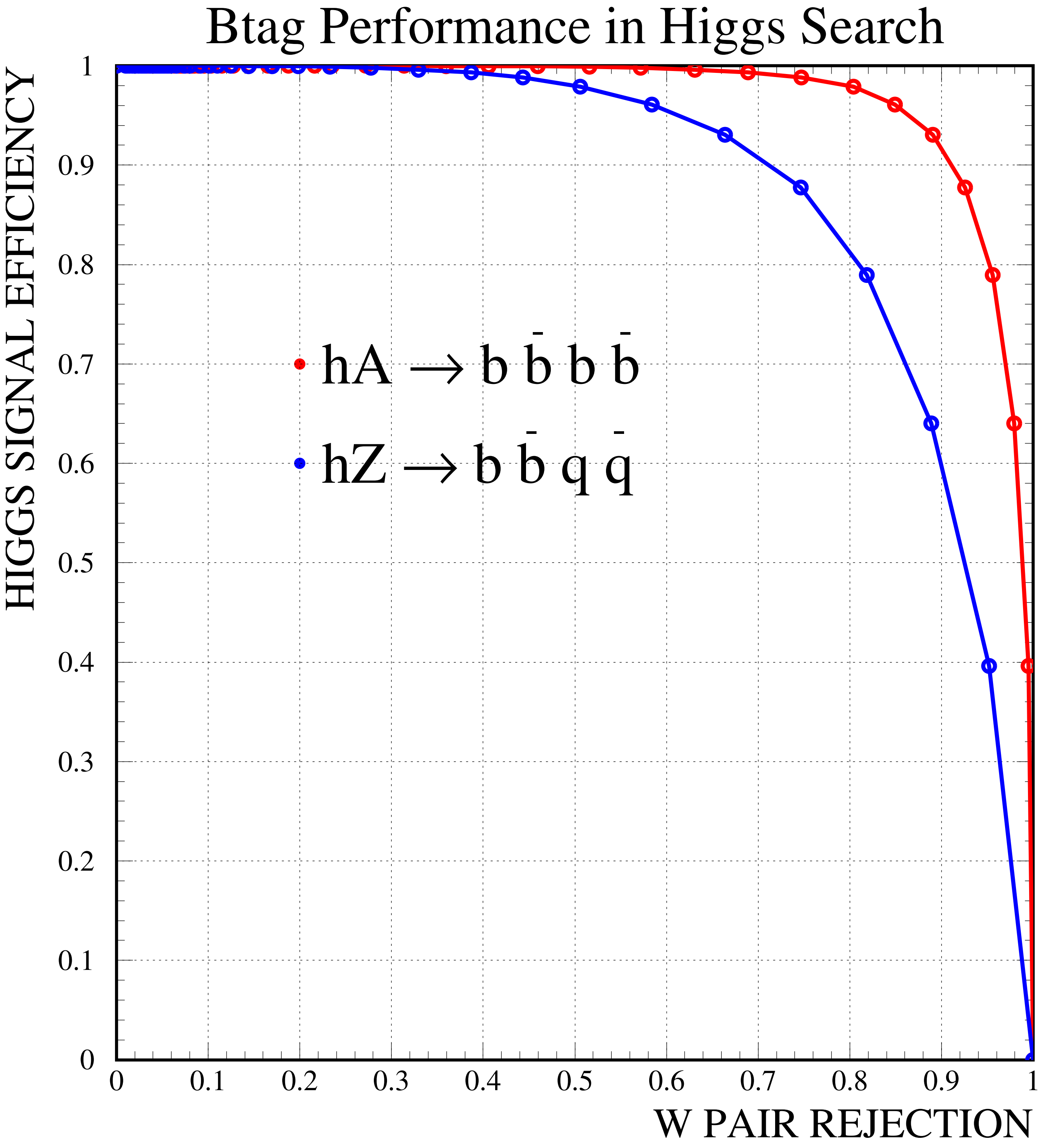
$$M_H > 82.2 \mathrm{GeV\ at\ } 95\% \mathrm{\ CL}$$

B-tag Progress

Since then: 3-D b-tag progress



Increased Sensitivity at 183 GeV

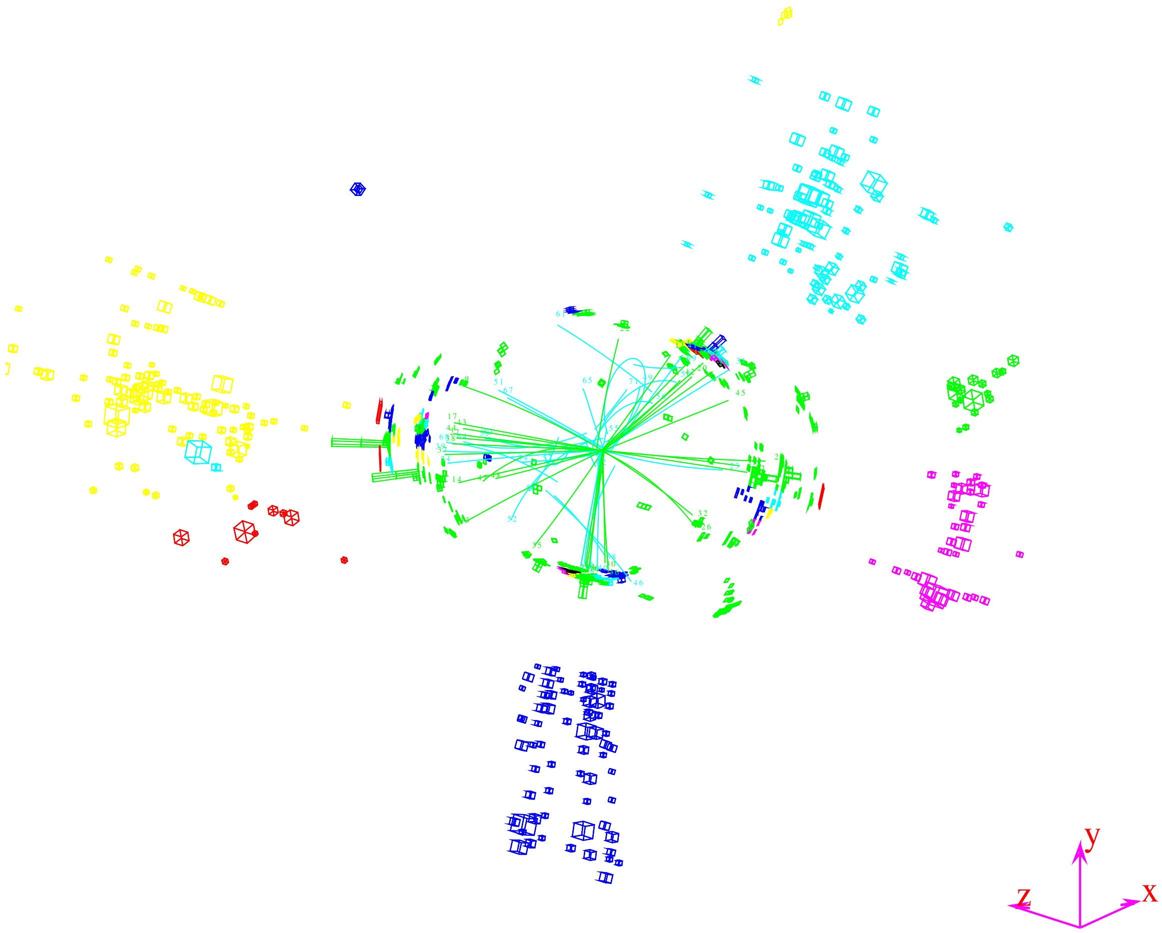


Higgs Candidate Example

$M_Z^{rec} = 93.2\,\mathbf{GeV}$ $M_H^{rec} = 78.2\,\mathbf{GeV}$

$B_{tag} = 3.3$

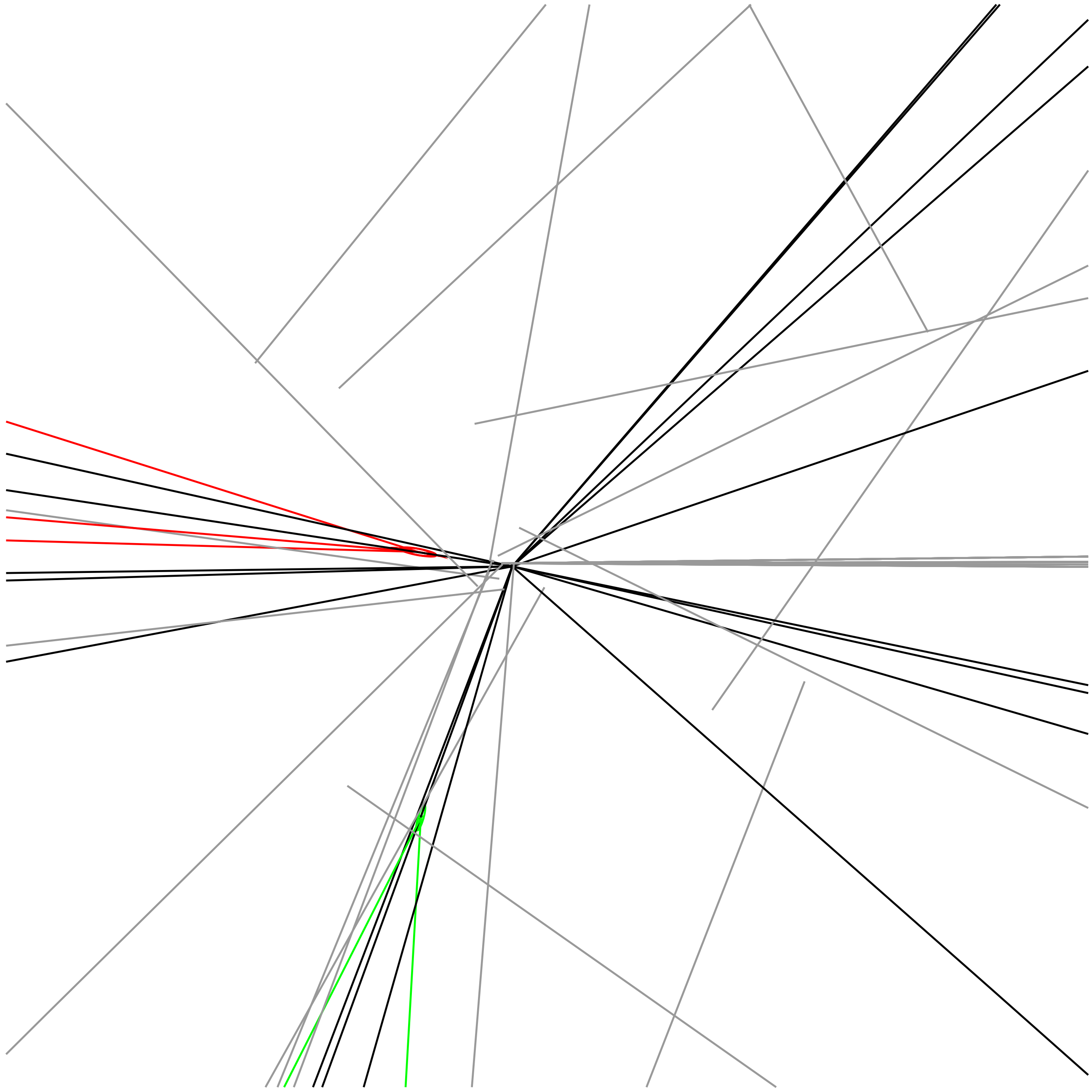
Run # **685703** **Event #** **3598** Total Energy : 196.25 GeV



Candidates under study, no new limits

Higgs Candidate Example

Run# 685703 Event# 3598



Vertex at 1.5 mm

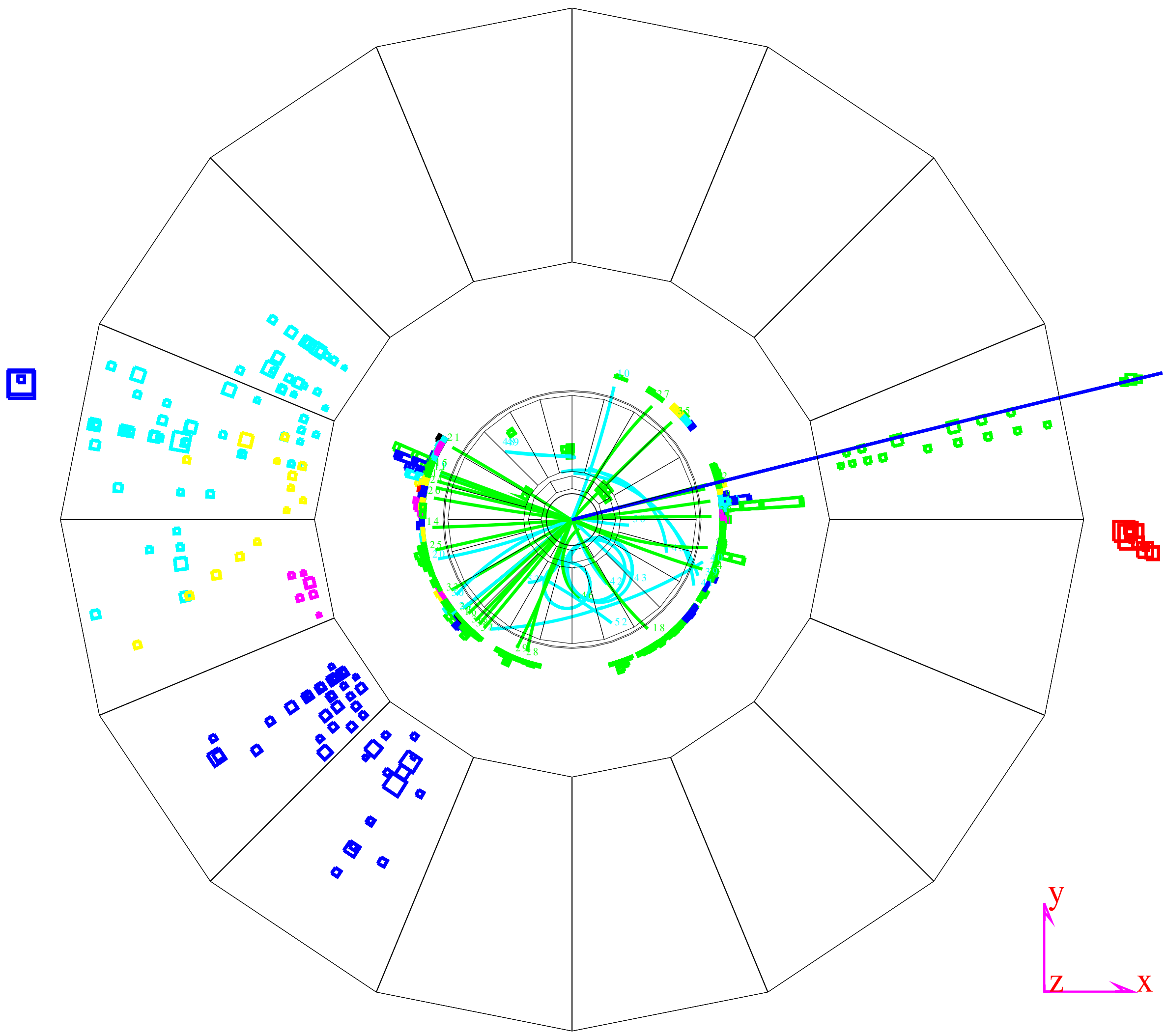
Vertex at 4.1 mm

SUSY Higgs Candidate Example

Di-jet masses:

50.38 GeV	84.01 GeV	36.80 GeV
44.29 GeV	64.15 GeV	142.72 GeV

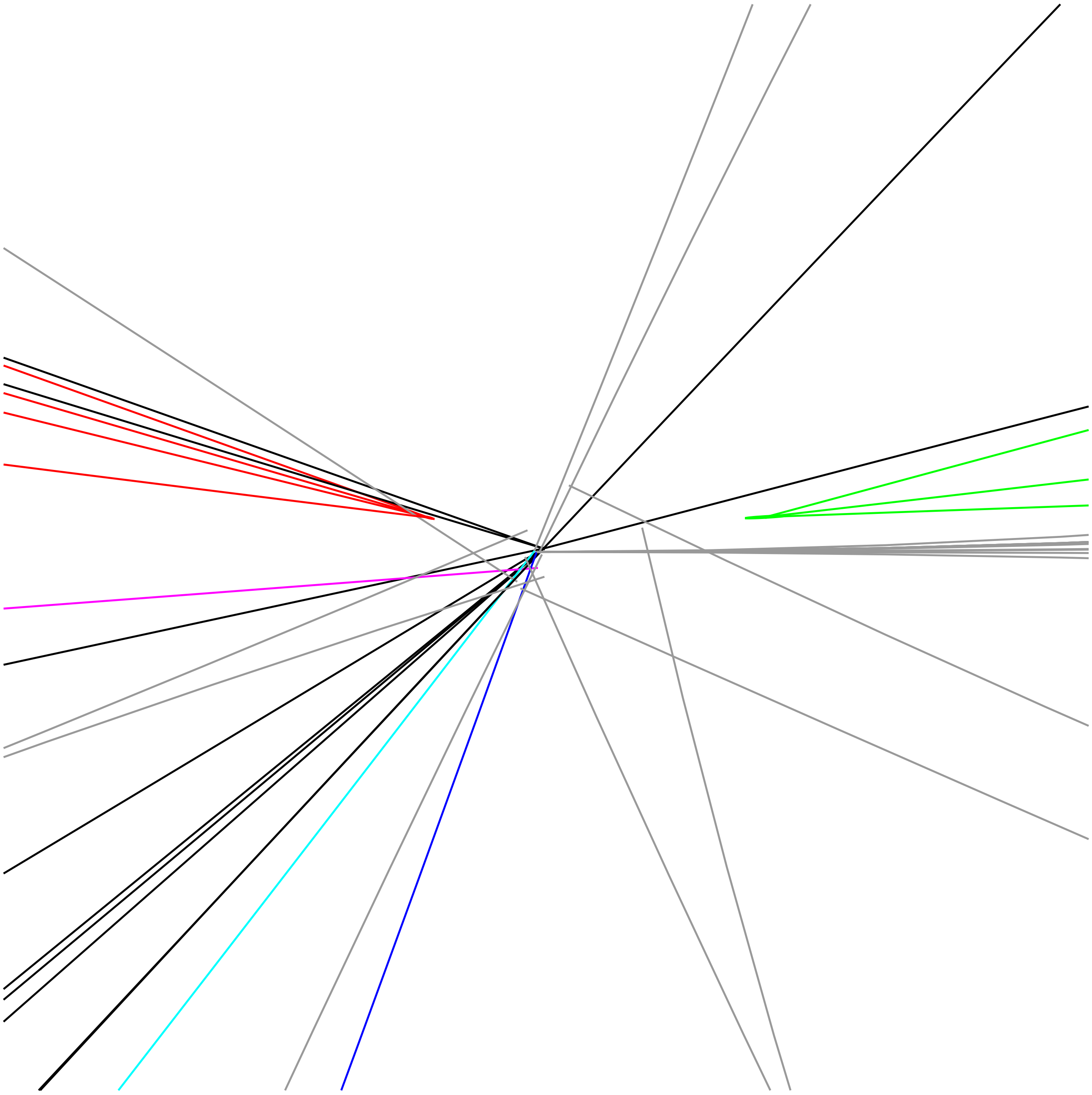
Run # **678511** **Event #** **4665** Total Energy : 118.31 GeV



Candidates under study, no new limits

SUSY Higgs Candidate Example

Run# 678511 Event# 4665



Vertex at 6.5 mm

Vertex at 12.3 mm, μ

Supersymmetric Particles

Exclusive searches for $\tilde{\chi}^{\pm}$, $\tilde{\chi}^{0}$, $\tilde{\mathrm{l}}$, $\tilde{\mathrm{t}}$

Inclusive search for 11 topologies in three different ΔM ranges:

- **Two acoplanar e, μ or τ**
- **Hadrons with an isolated e, μ or τ**
- **Purely hadronic final state with high multiplicity**
- **Monojet or two acoplanar jets**
- **Single photons or acoplanar photon pairs**

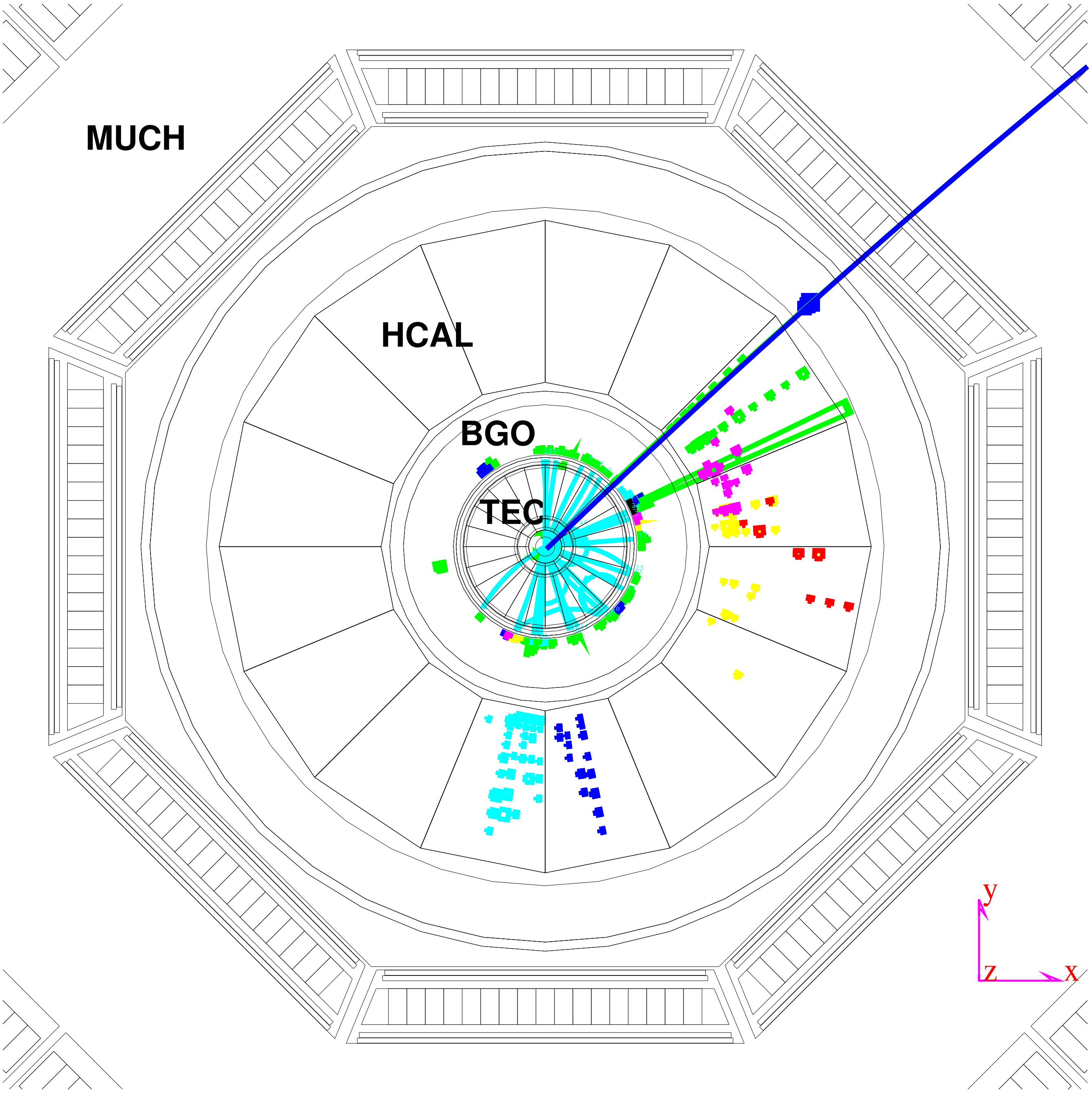
All with missing energy, momentum, mass etc.

L3 Preliminary

	Inclusive Search		Exclusive Search	
Class	Data Events	Exp. Backg.	Data Events	Exp. Backg.
$\tilde{\chi}^{\pm}, \tilde{\chi}^{0}$	21	39±13	8	11.3
$\tilde{\mathrm{e}}$	4	6.9	4	6.9
$\tilde{\mu}$	5	6.1	5	6.1
$\tilde{\tau}$	9	9.7	9	9.7
$\tilde{\mathrm{t}}$	4	16±7	1	3.35
all	35	56±15		

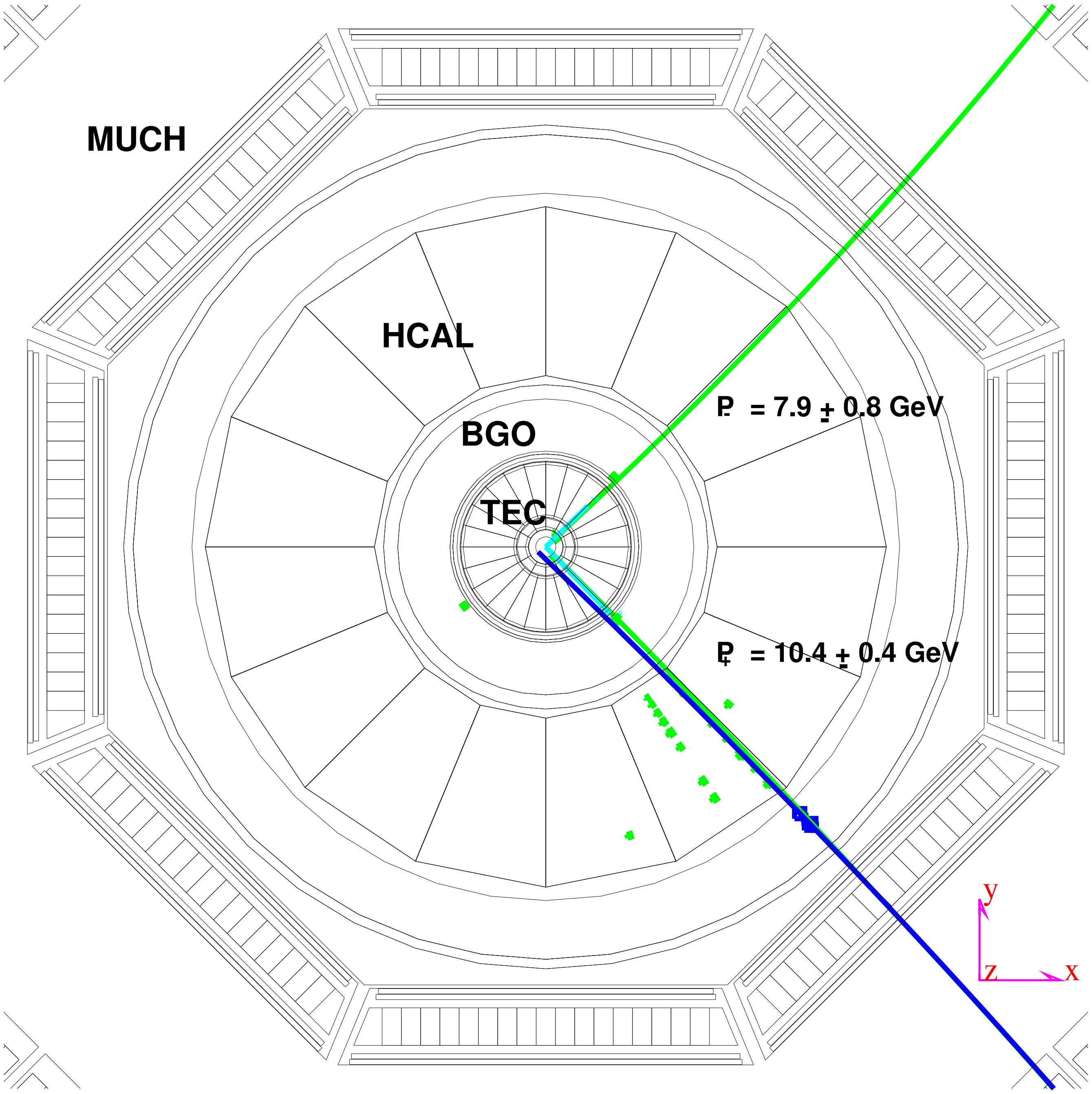
Chargino Candidate

Run #   679704   Event #   818

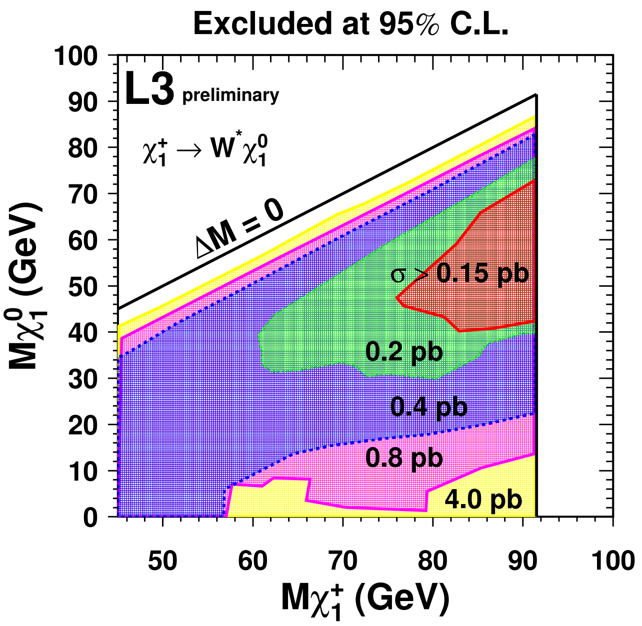


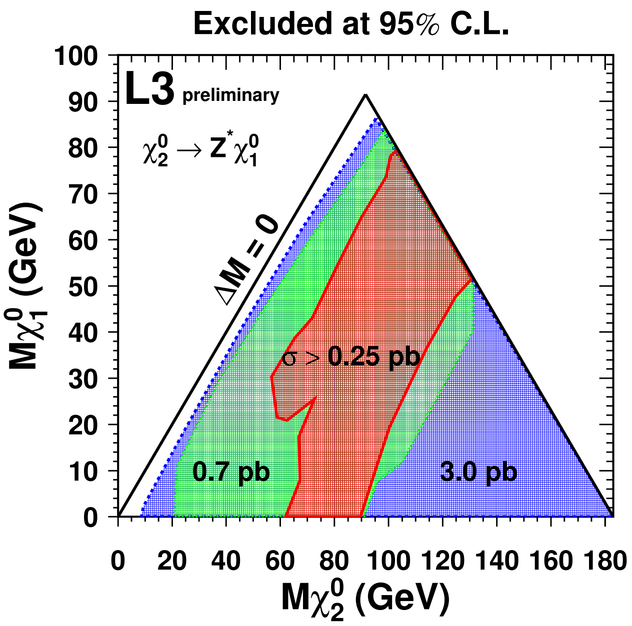
Smuon Candidate

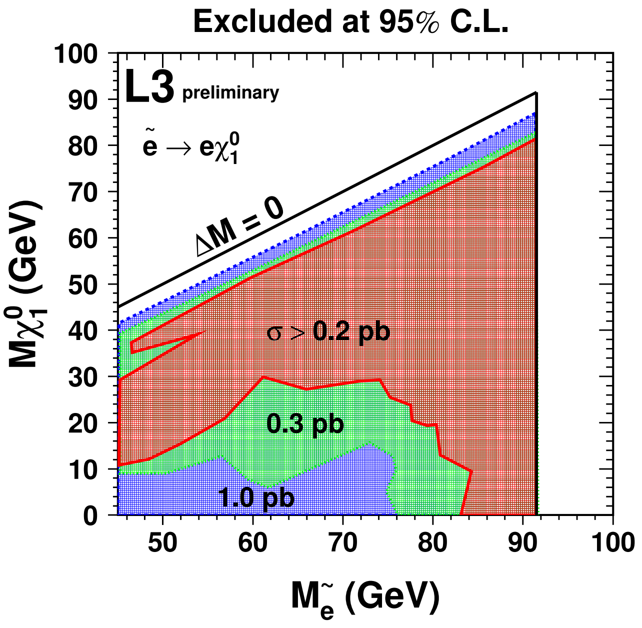
Run # 676811 Event # 4701

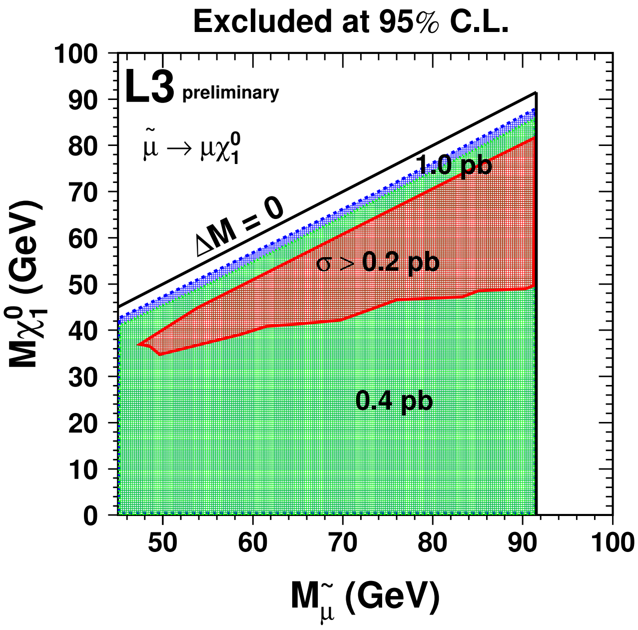


Cross Section Limits

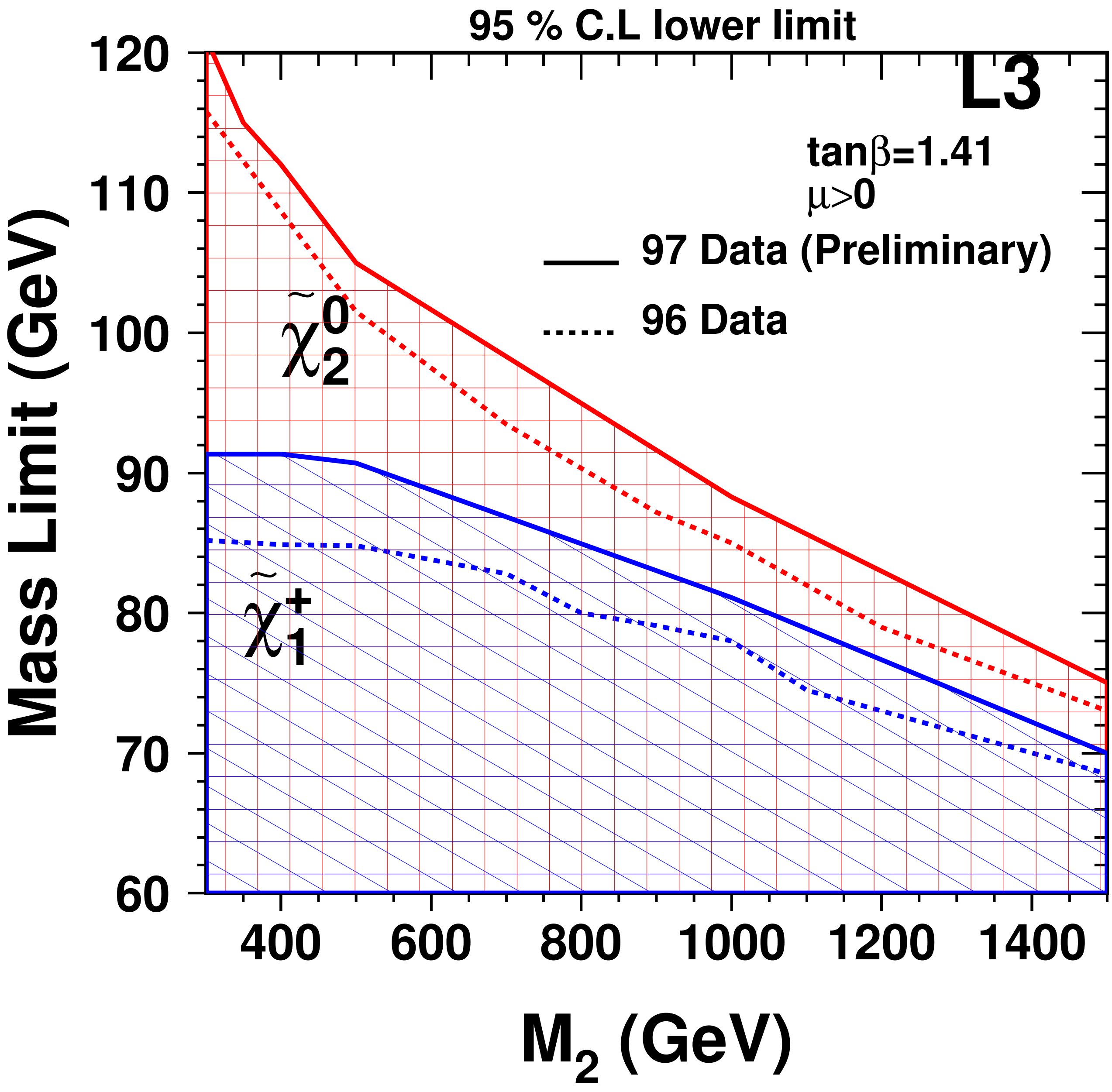






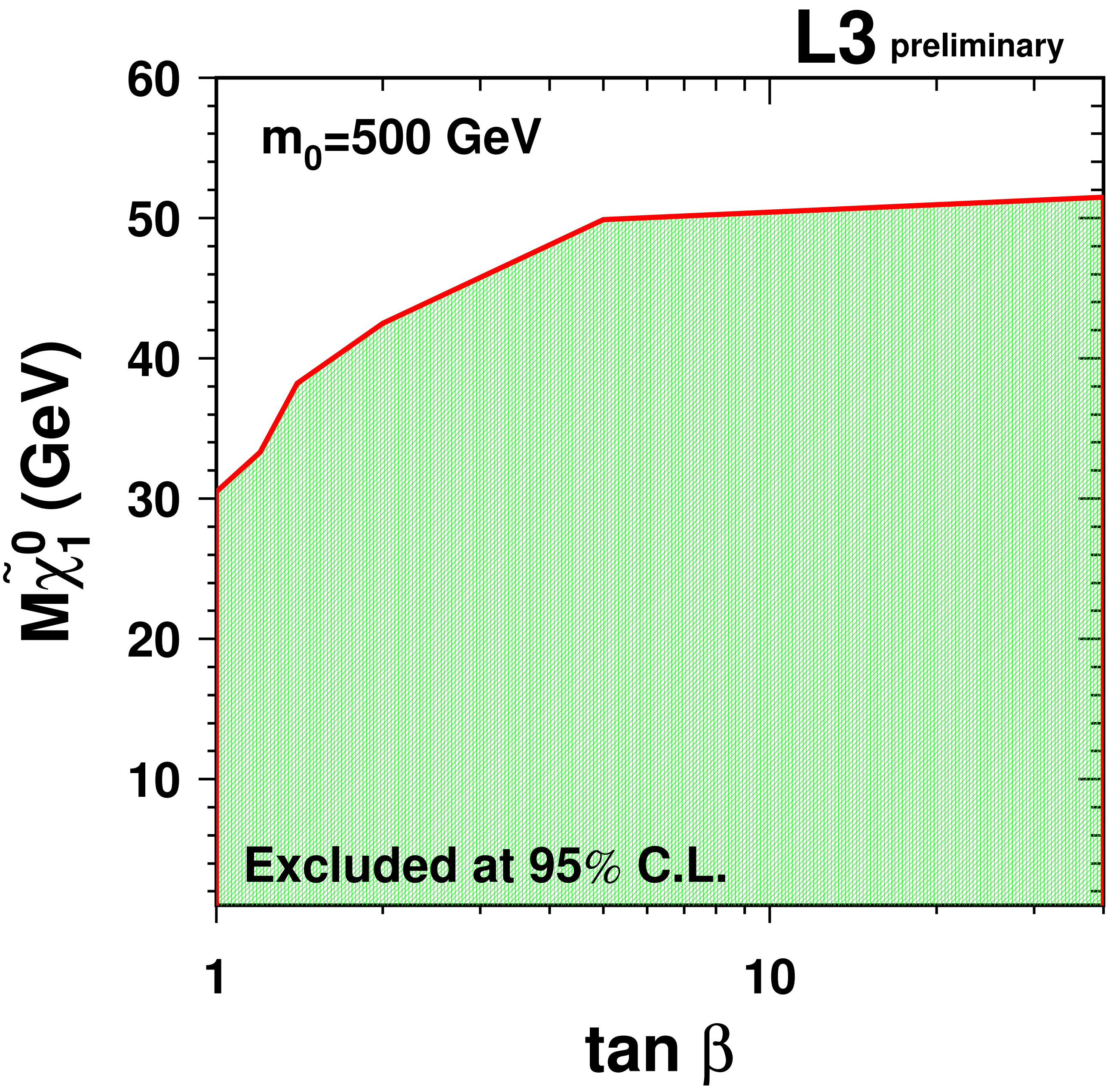


Chargino/Neutralino Limits in MSSM



$\Delta M(\tilde{\chi}^+) \simeq 15$ $\Delta M(\tilde{\chi}^+) \simeq 5$ $\Delta M(\tilde{\chi}^+) \simeq 3$ GeV

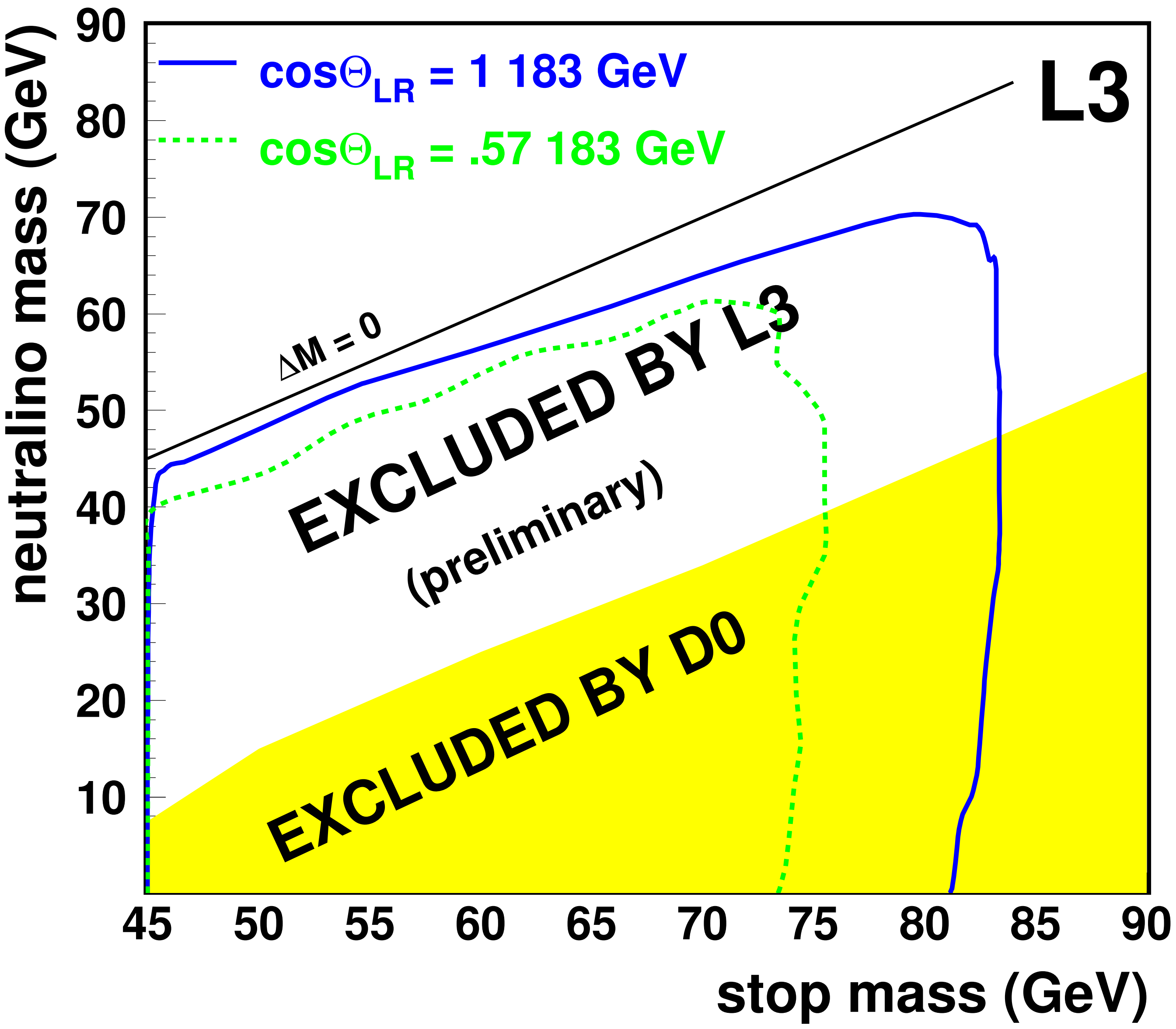
Neutralino Limits in MSSM



New limit for large m_0

Stop Limits in MSSM

From exclusive search:

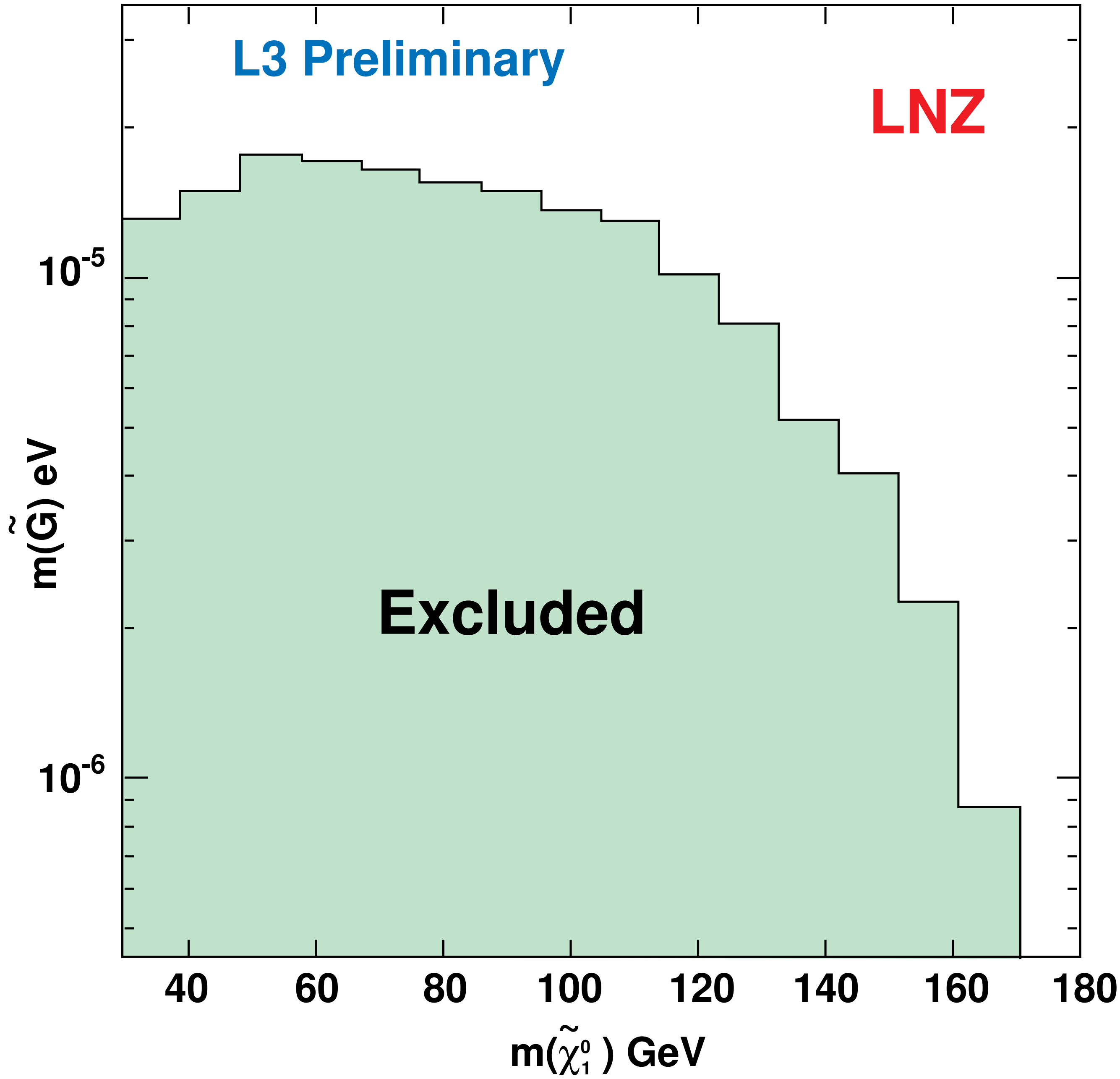


Radiative Neutralino Decays

Channel	Data Events	Exp. Backgr.
Single Photon	164	169.7
Acopl. Photon Pairs	11	11.5

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

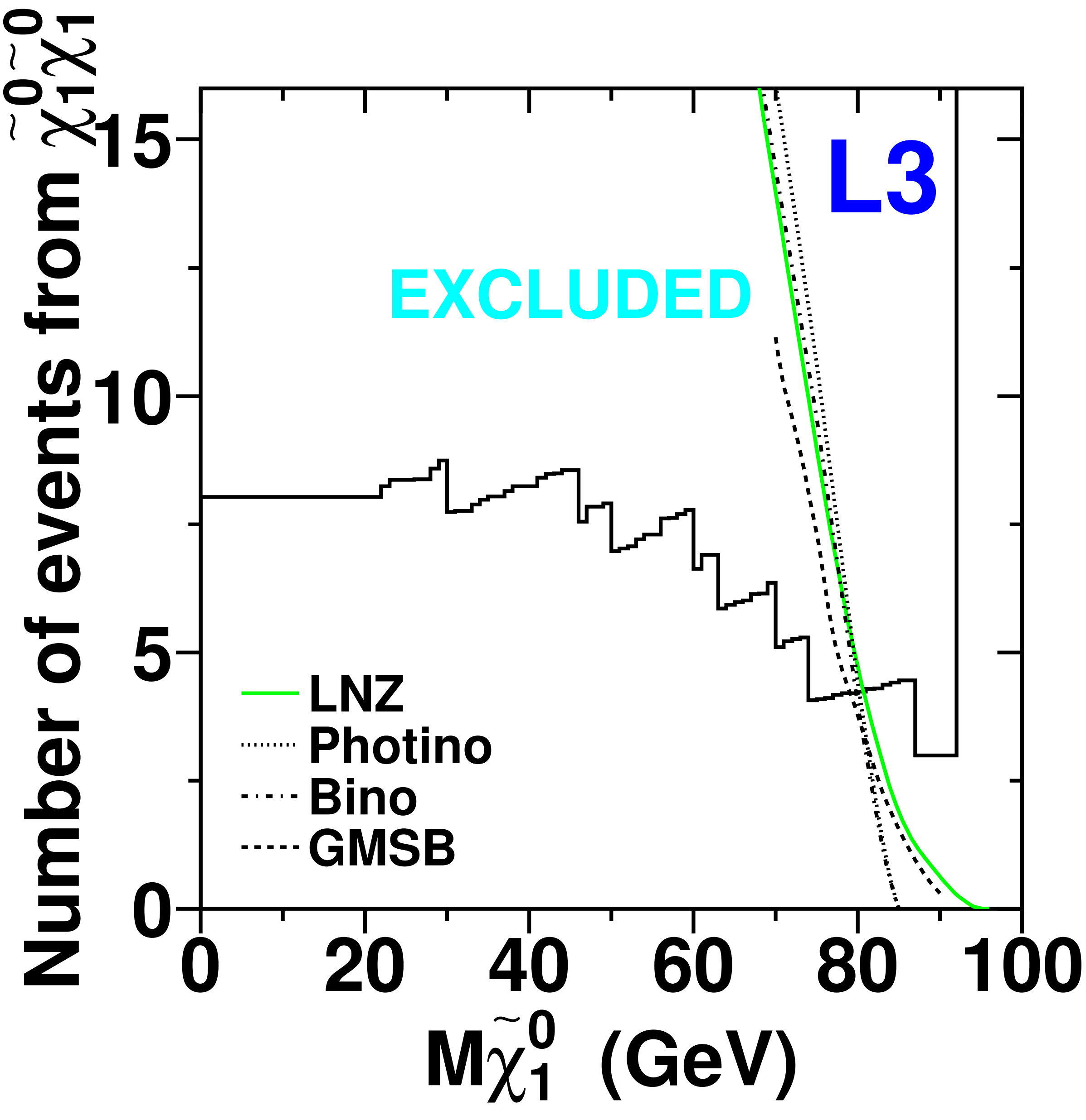
Preliminary



Radiative Neutralino Decays

Acoplanar Photon Pairs

$\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0\gamma$ or $\tilde{\chi}_1^0 \rightarrow \tilde{G}\gamma$ **Preliminary**



Conclusions

- **Cross sections and asymmetries for fermion pair production in agreement with SM expectation**
- **Limits on non-standard contributions**
- **QCD evolution of α_s steep**

- **776 WW events observed above 180 GeV**
- **W mass** $m_{\mathrm{W}} = 80.53 \pm 0.18$ (exp + LEP) GeV
- **Couplings better determined**

- **First candidates for ZZ production observed**
- **SM Higgs and other Higgses under study**
- **Improved limits on SUSY**

- **No major shutdown activities, except maintenance and toroid repair**
- **Eagerly awaiting higher energies and luminosities**
- **Actively preparing to run in 2000**