Results from L3 at LEP2

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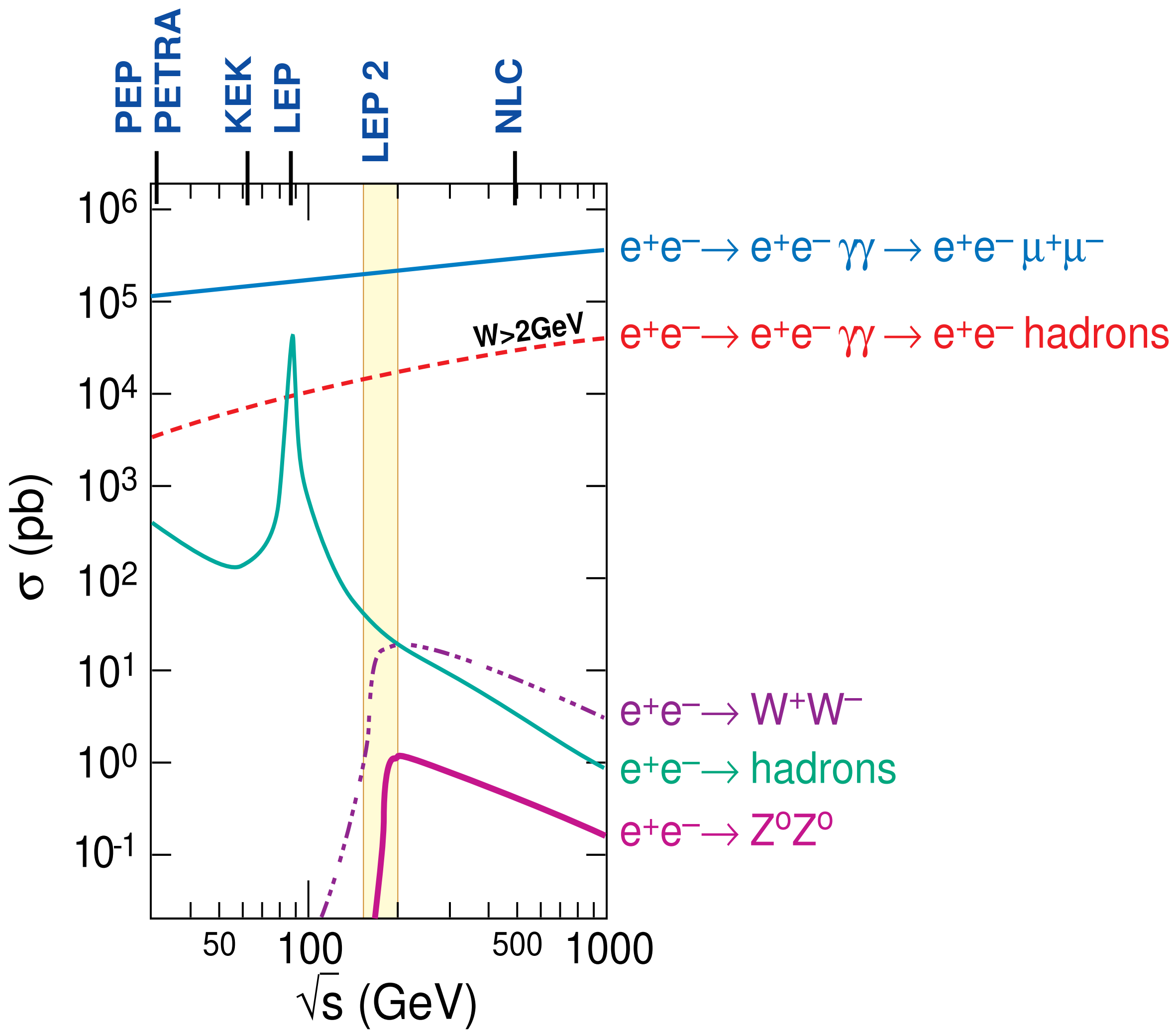
Outline

1. Introduction
2. Fermion pair production
3. Boson pair production
4. New particle searches
5. $\gamma\gamma$ physics
6. Conclusions

Most Physics Results are Preliminary

Cross Sections vs c.m. Energy



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At LEP2:

- **Cross the threshold for W^+W^- and $Z^0\bar{Z}^0$ production**
- **$\gamma\gamma$ interactions will dominate event rate**

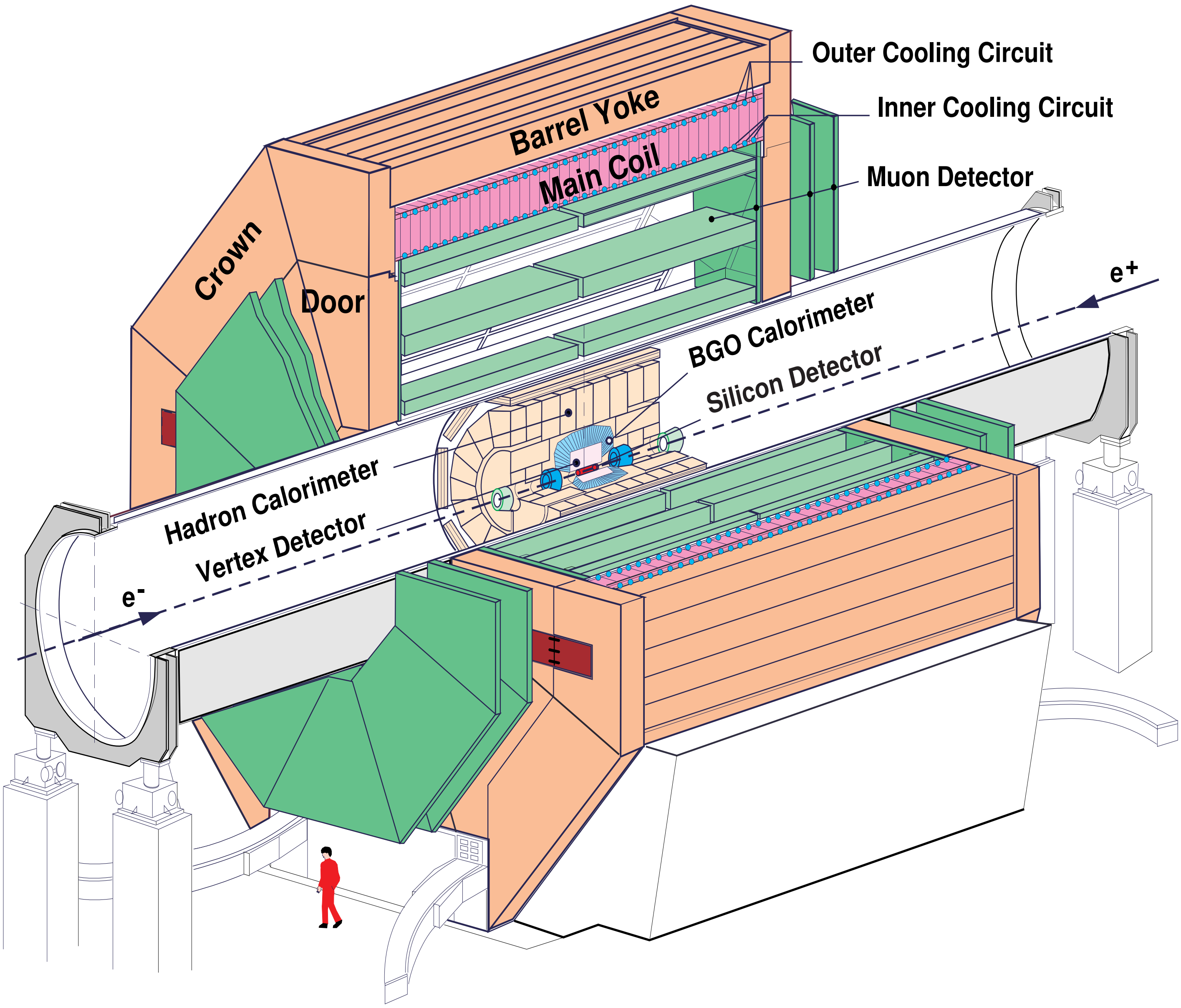
LEP2 Running

Luminosities Collected by L3

130-136 GeV	5 pb^{-1} **in 1995 and 7**pb^{-1} **in 1997**
161 GeV	11 pb^{-1} **in 1996**
172 GeV	10 pb^{-1} **in 1996**
183 GeV	56 pb^{-1} **in 1997**

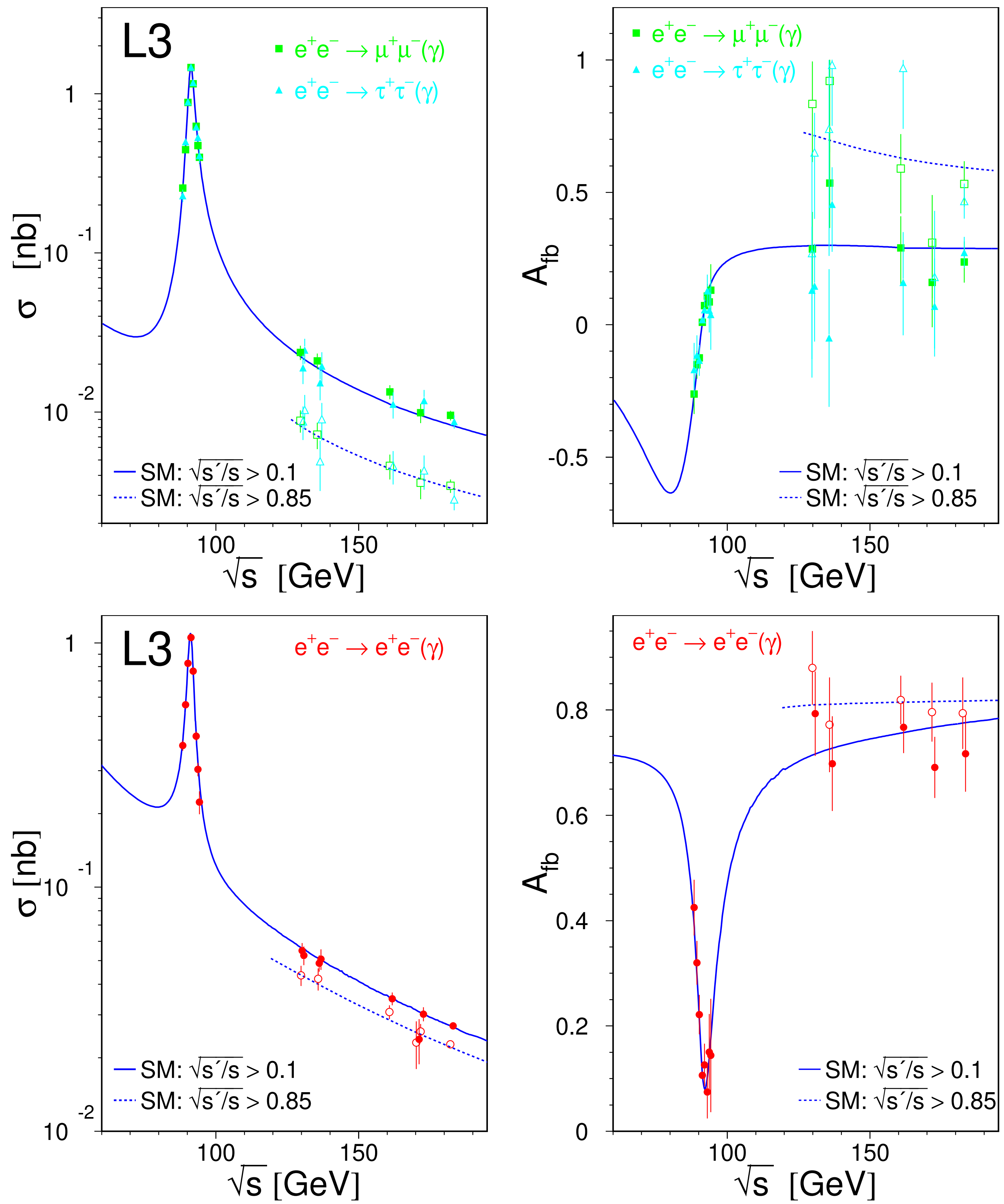
- **The 1997 luminosity was the largest delivered by LEP in a single year**
- **L3 data taking efficiency for 1997 was 89%**

The L3 Detector

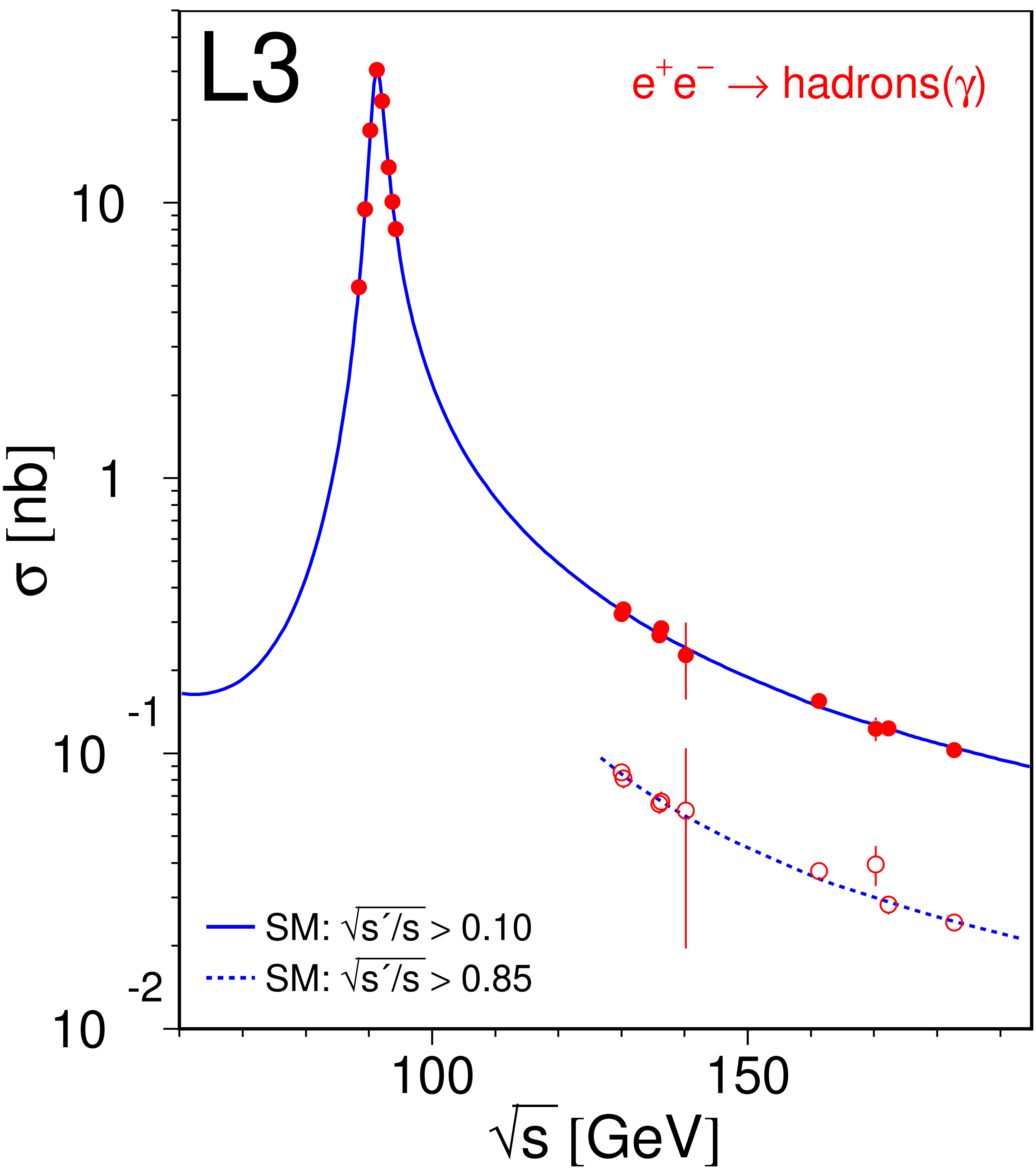


Excellent resolution for e, μ, γ measurements

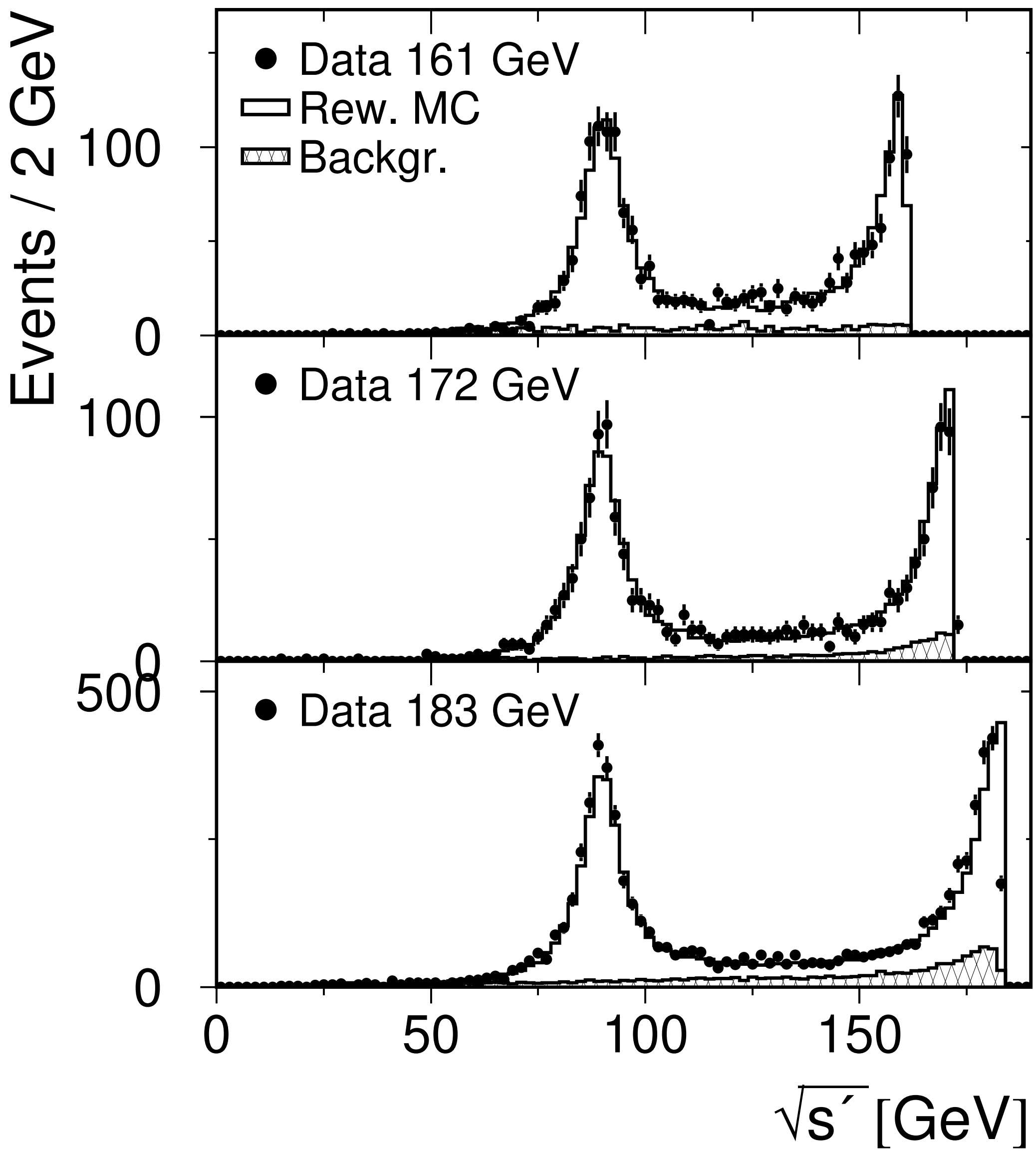
Lepton Pair Production at LEP 200



Hadronic Cross Sections at LEP 200



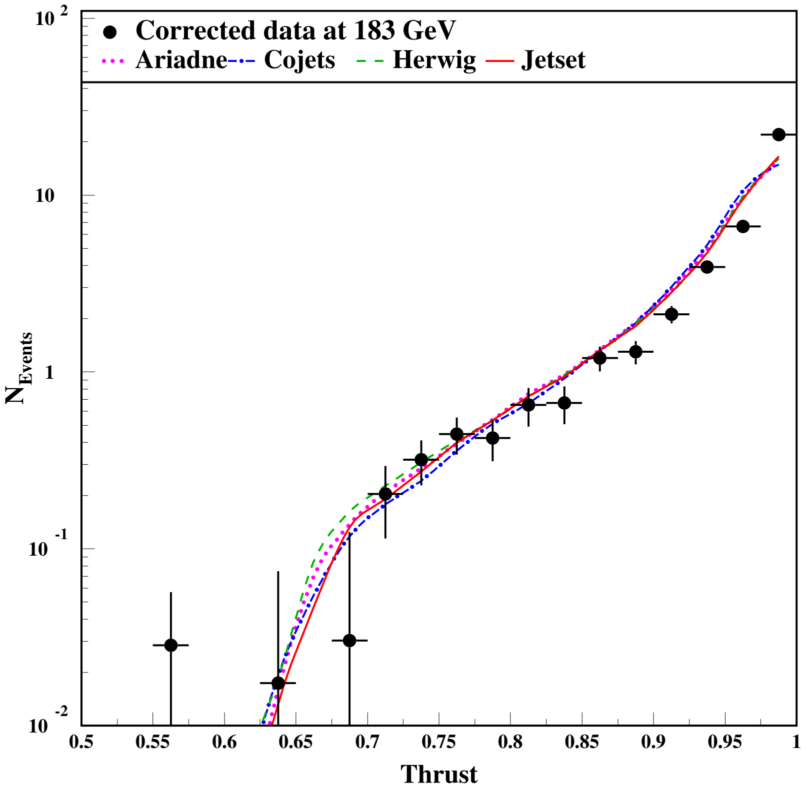
Z Mass from Radiative Returns

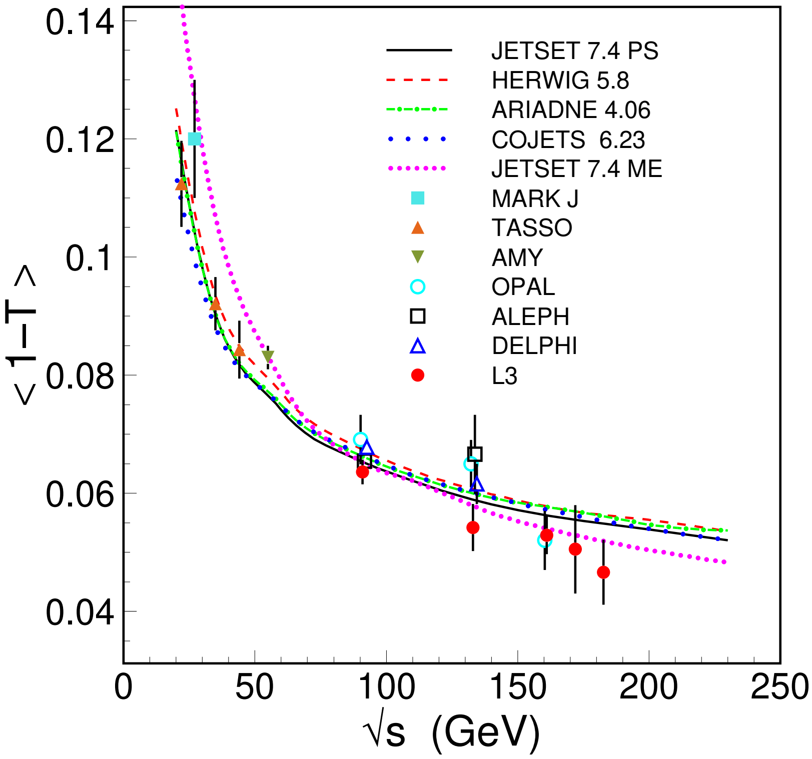


$M_Z = 91.040 \pm 0.105$**(stat) GeV**

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

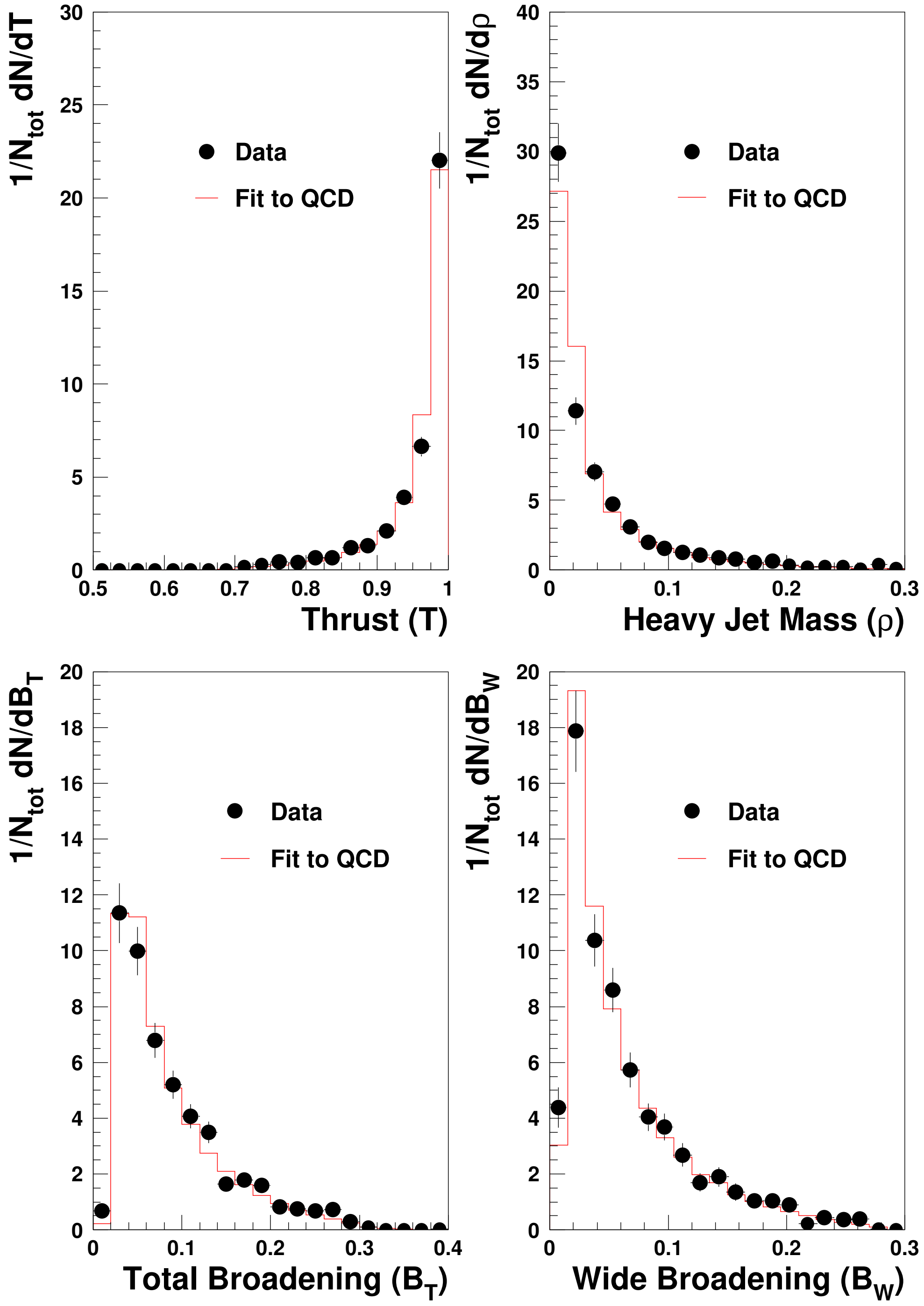
Properties of Hadronic Events





Event shape indicates low α_s

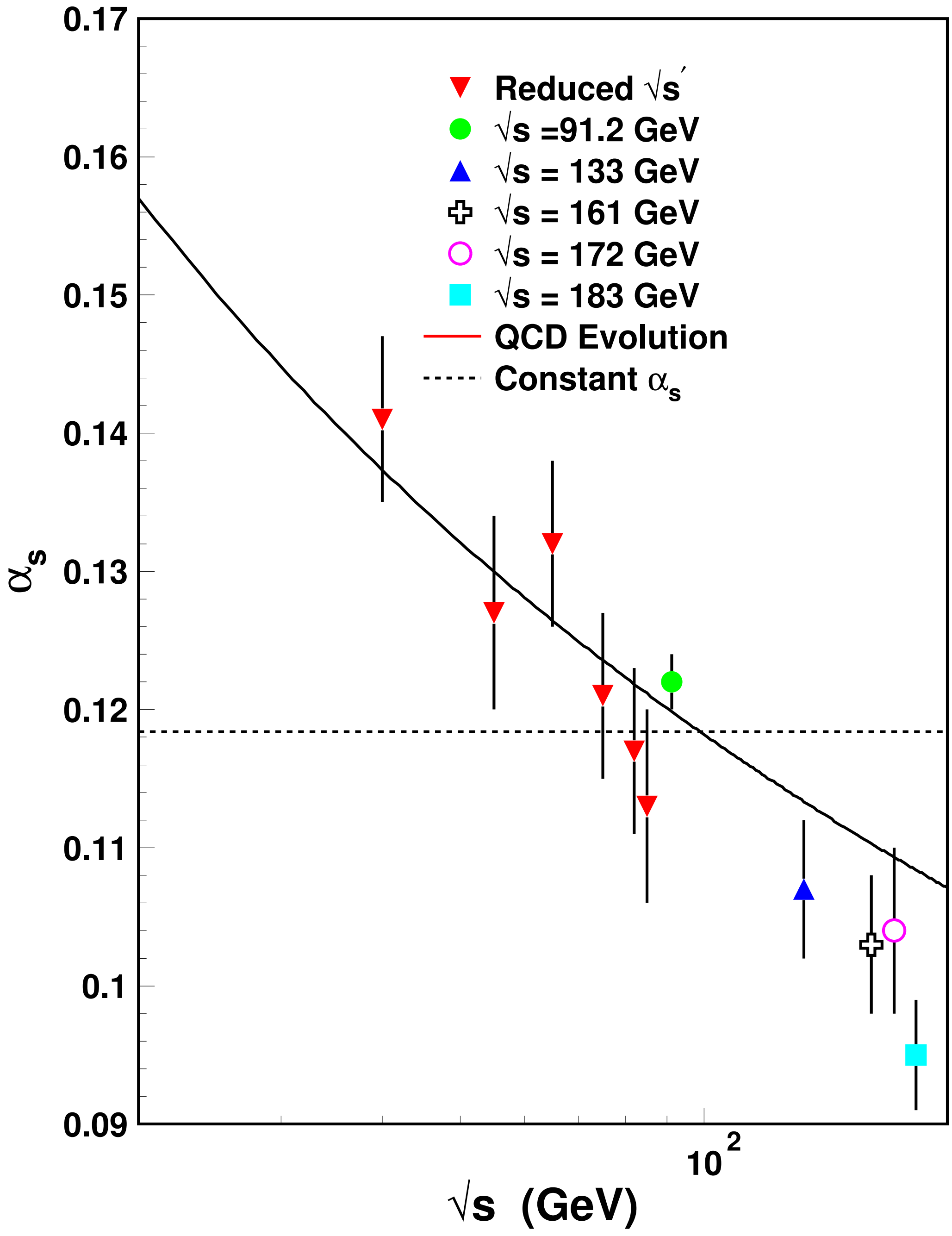
Event Shape Variables at 183 GeV



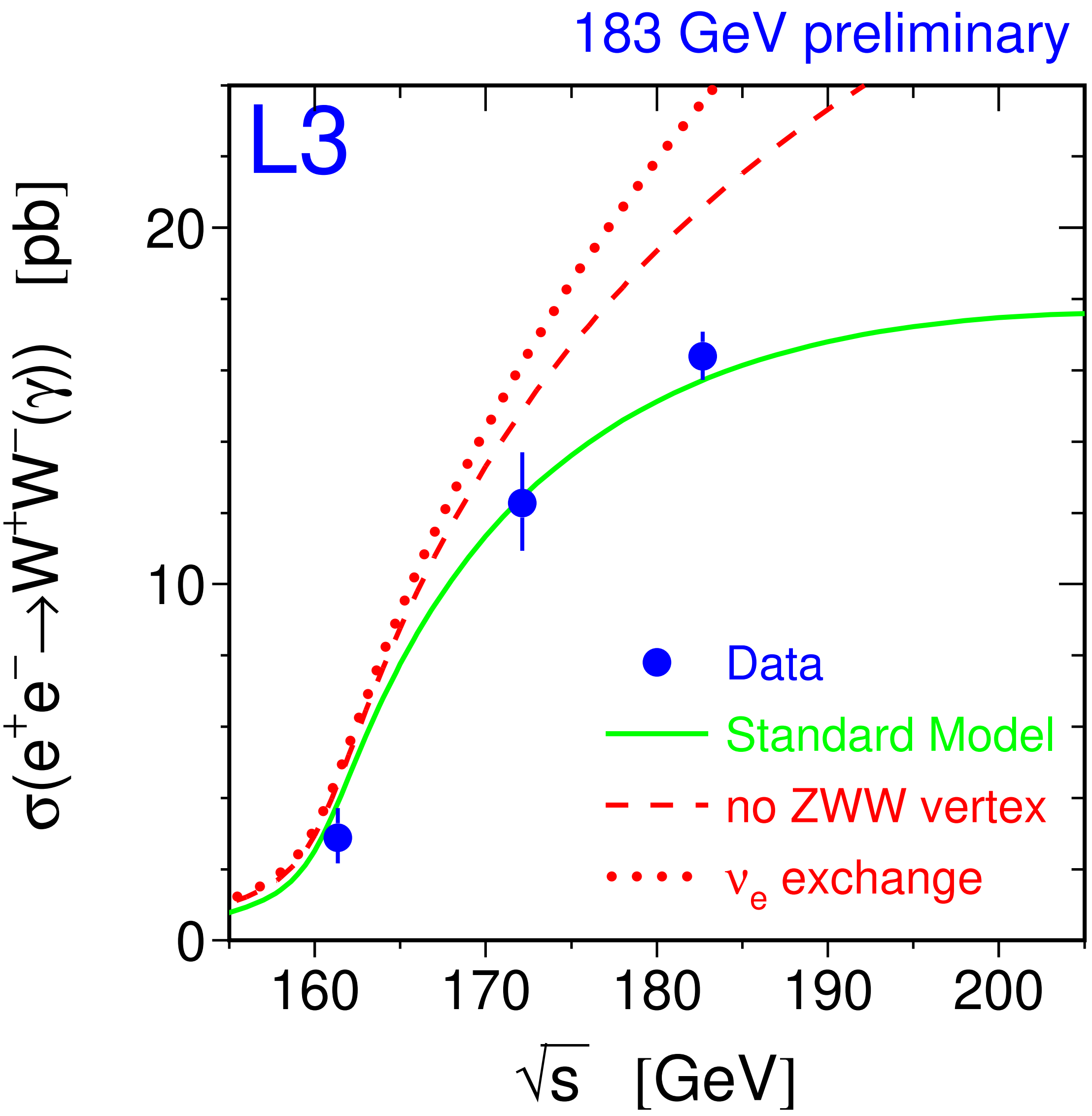
$$\alpha_s(183\ \textbf{GeV}) = 0.095 \pm 0.005 \pm 0.005$$

Strong Coupling Constant

L3 Preliminary **Experimental errors only**

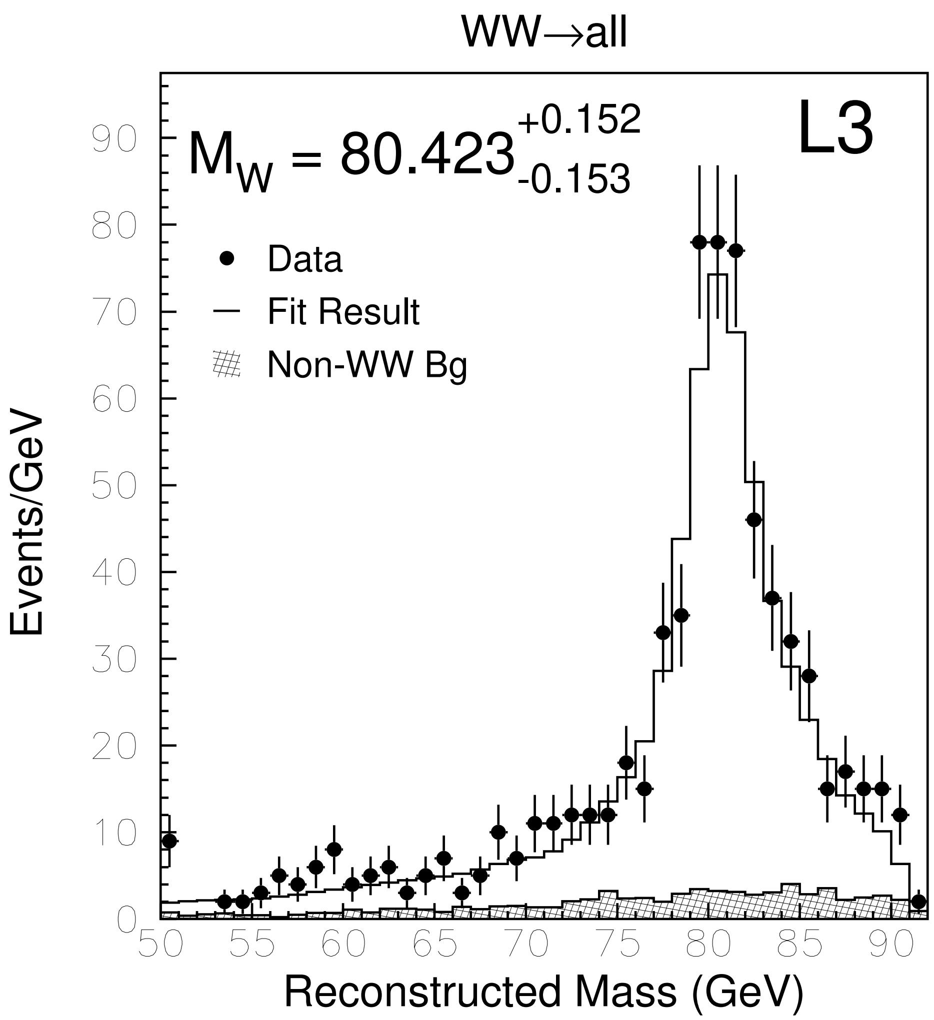


Boson Pair Production: $e^+e^- \to W^+W^-$



Channel	Events	σ [pb]	σ_{SM} [pb]
$q\bar{q}q\bar{q}$	493	8.16 ± 0.46	7.17
$l\nu q\bar{q}$	290	2.21 ± 0.14	2.29
$l\nu l\nu$	54	1.56 ± 0.25	1.67

W Mass from Direct Reconstruction



Direct reconstruction, assuming 100 MeV syst.error, 100 MeV LEP error:

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

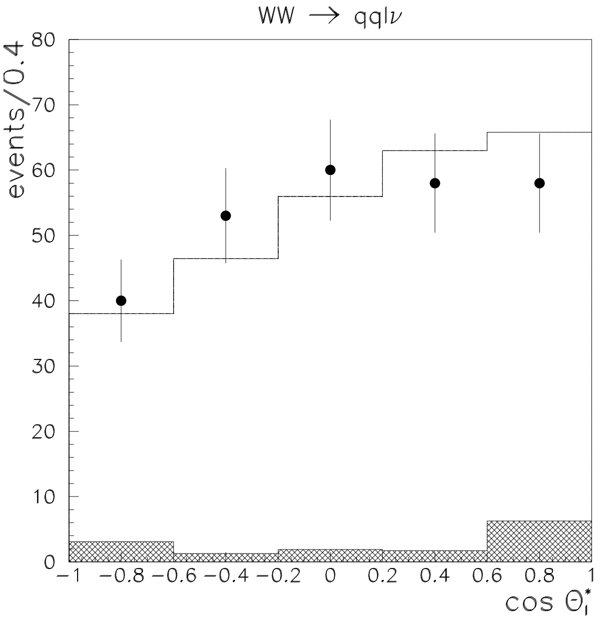
$m_W = 80.35 \pm 0.23 \pm 0.09$ GeV $\qquad (q\bar{q}l\nu)$

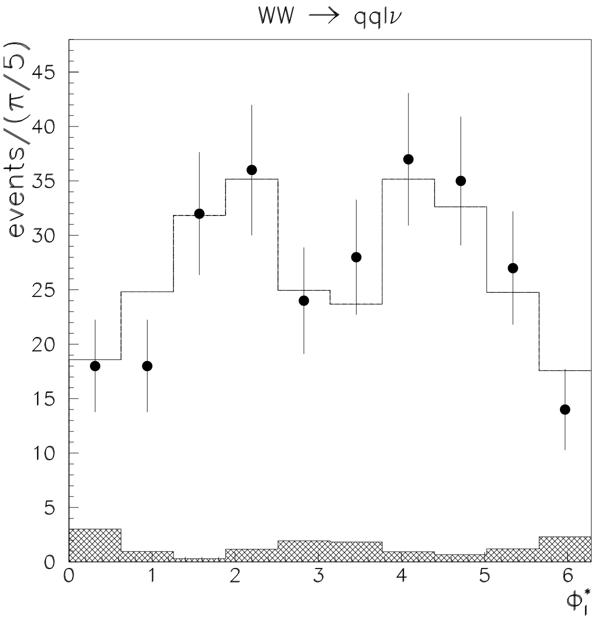
All together with 161 GeV cross-section:

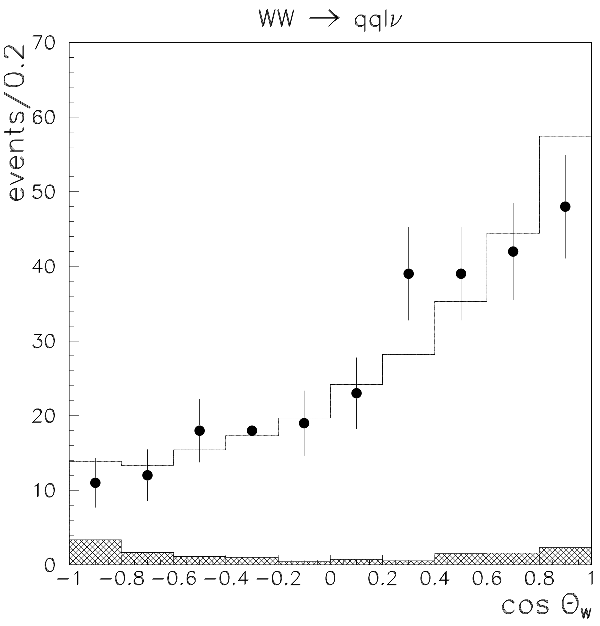
$m_W = 80.53 \pm 0.18$ (exp + LEP) GeV $\qquad$ **(all data)**

Systematic errors under study

W Production and Decay Angles







ZWW coupling:

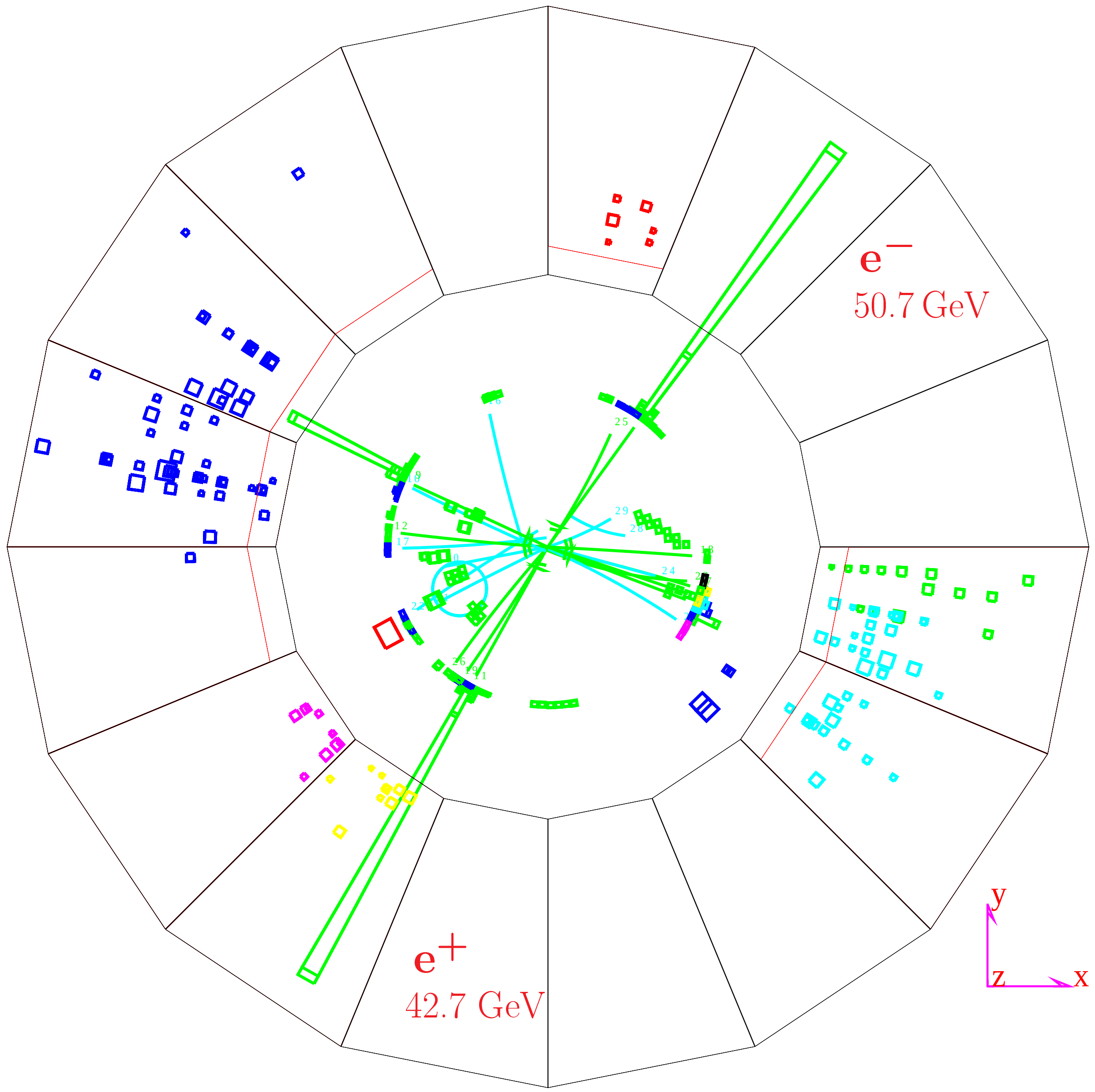
$$\begin{aligned}\delta_Z &\equiv g_{ZWW} - \cot\theta_{\mathrm{W}} \\ &= -0.37^{+0.32}_{-0.25} \\ &\in [-0.57, 0.08]\end{aligned}$$

Coefficients of "unsuppressed operators":

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

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

Run # 688905 Event # 1652 Total Energy : 180.75 GeV

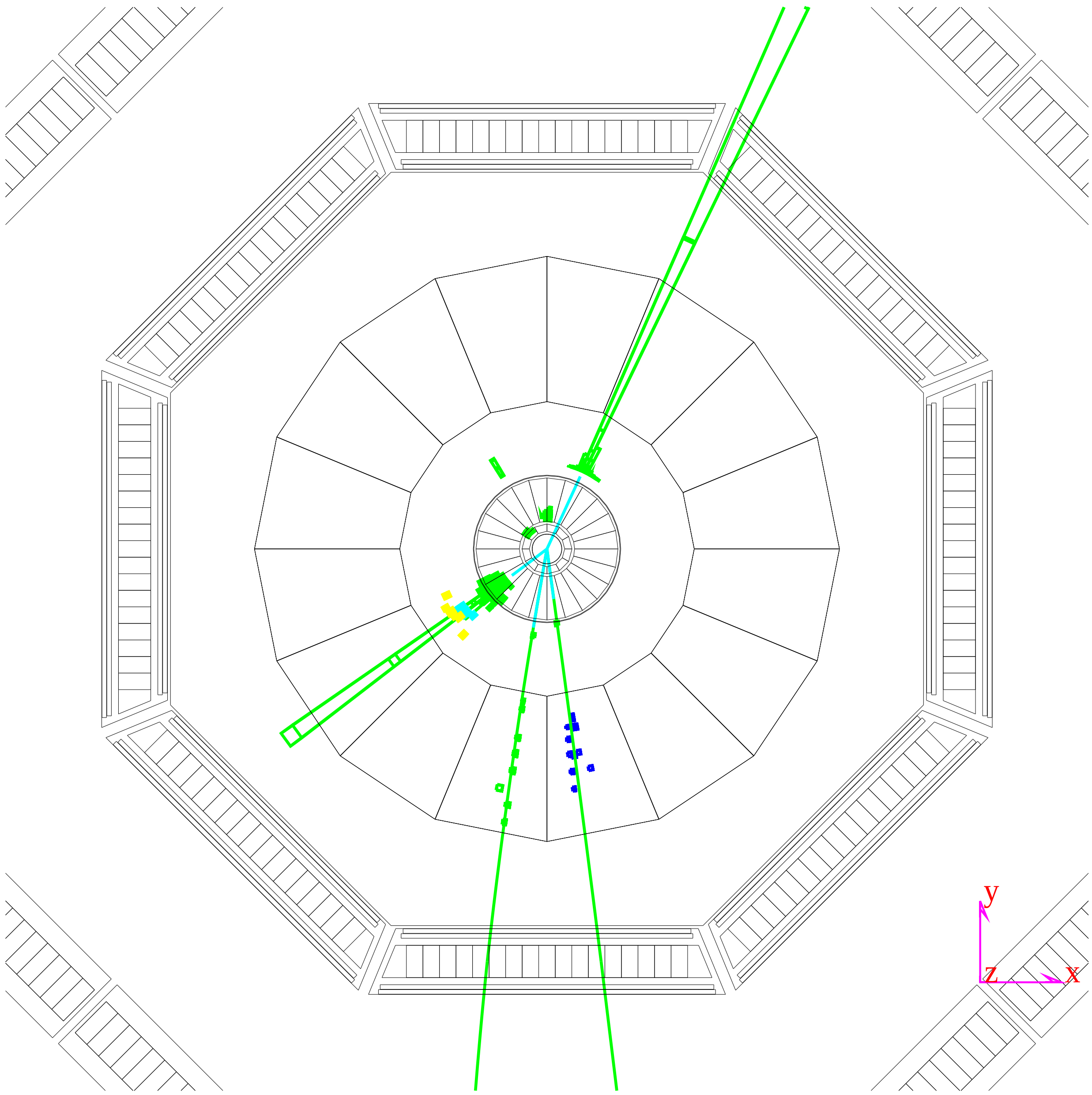


$m_{ee} = 92.8$ GeV $m_{jj} = 88.8$ GeV

Neutral Current Four Fermion Production

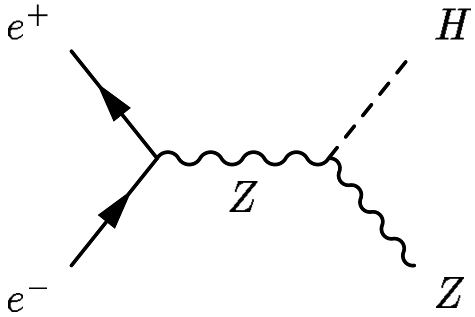
Mass of the electron-pair= 107.4 GeV   Run # 678710   Event # 148

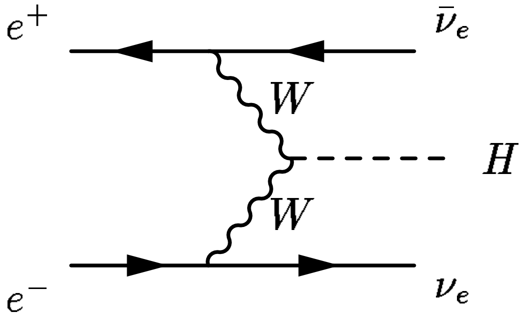
Mass of the muon-pair= 19.3 GeV

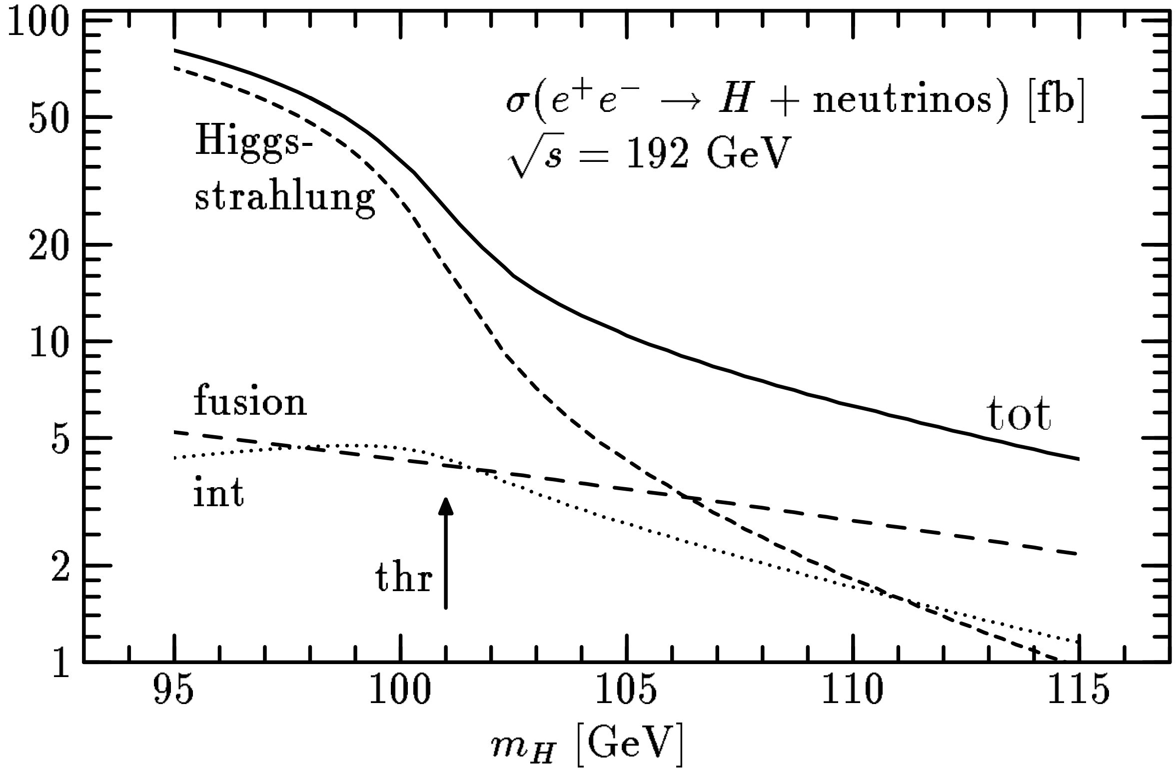


Channel	Obs. Ev.	Exp. Ev.	σ [pb^{-1}]	σ_{SM} [pb^{-1}]
$l^+l^-q\bar{q}$	13	10.9	2.1 ± 0.8	1.75
$l^+l^-l'^+l'^-$	11	8.1	1.5 ± 0.7	0.98

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



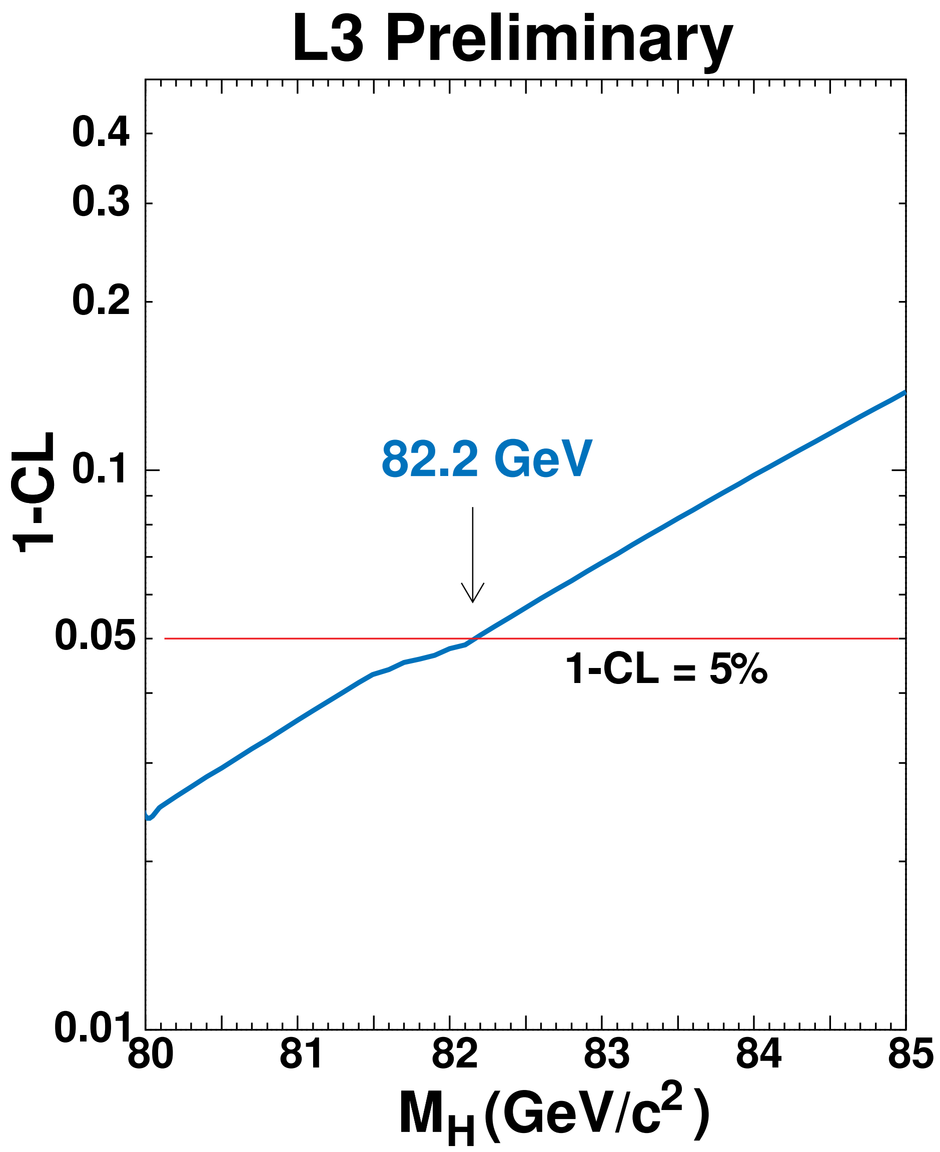




Limit on Standard Model Higgs

Intermediate result from 36 pb^{-1}:

(Data collected untill 29.09.97)



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

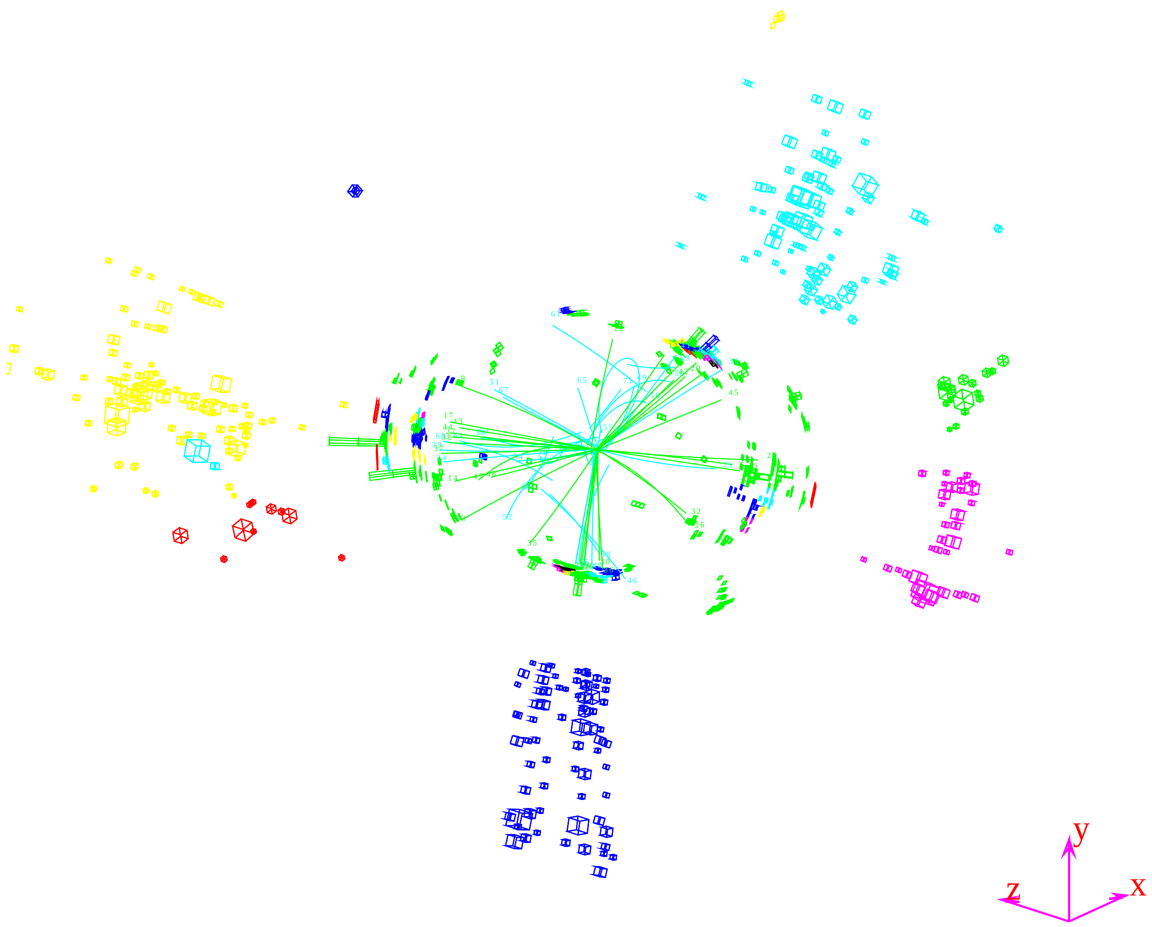
Higgs Candidate Example

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

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

$B_{tag} = 3.3$

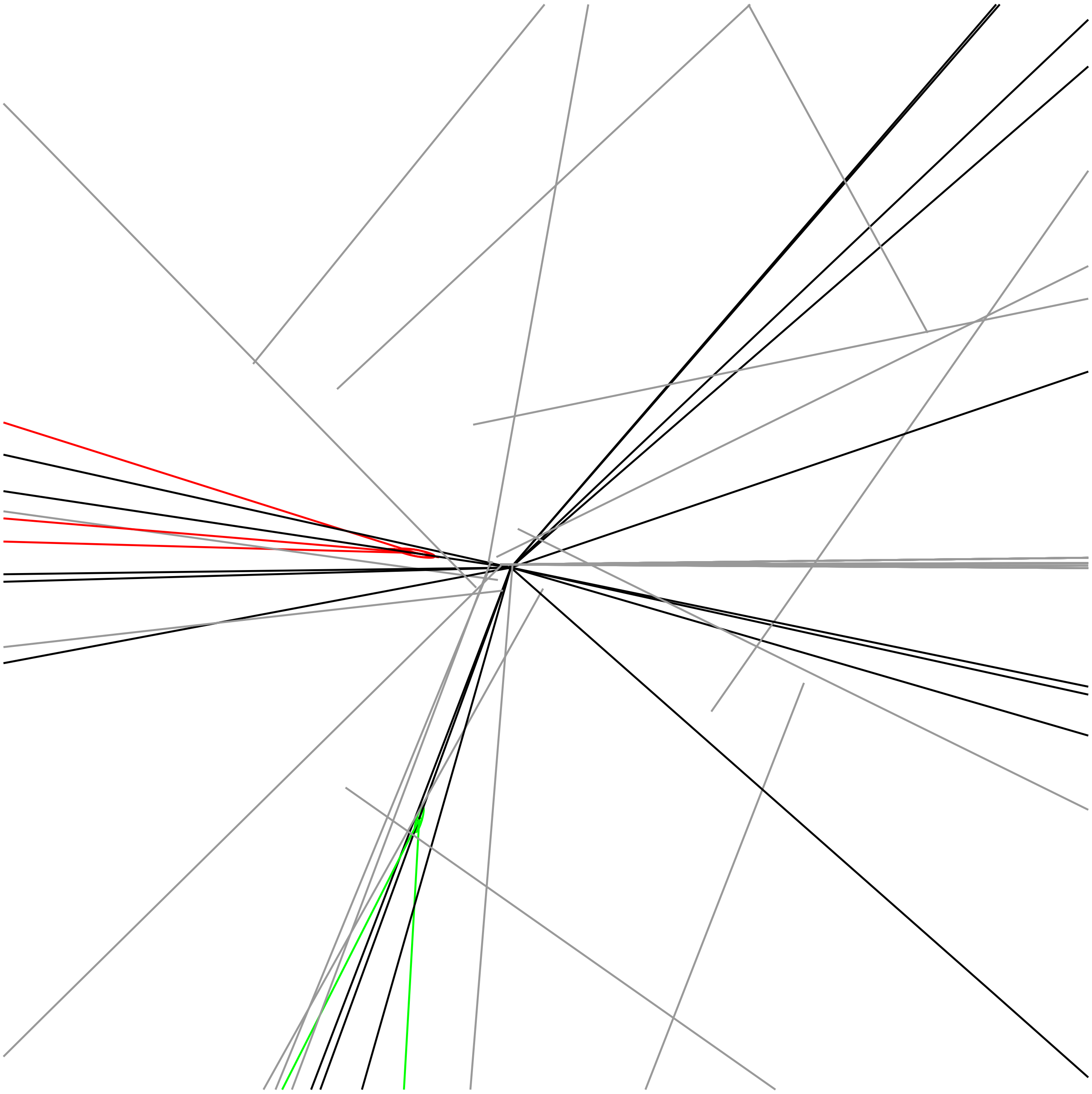
Run # 685703 Event # 3598 Total Energy : 196.25 GeV



Candidates under study, no new limits

Higgs Candidate Example

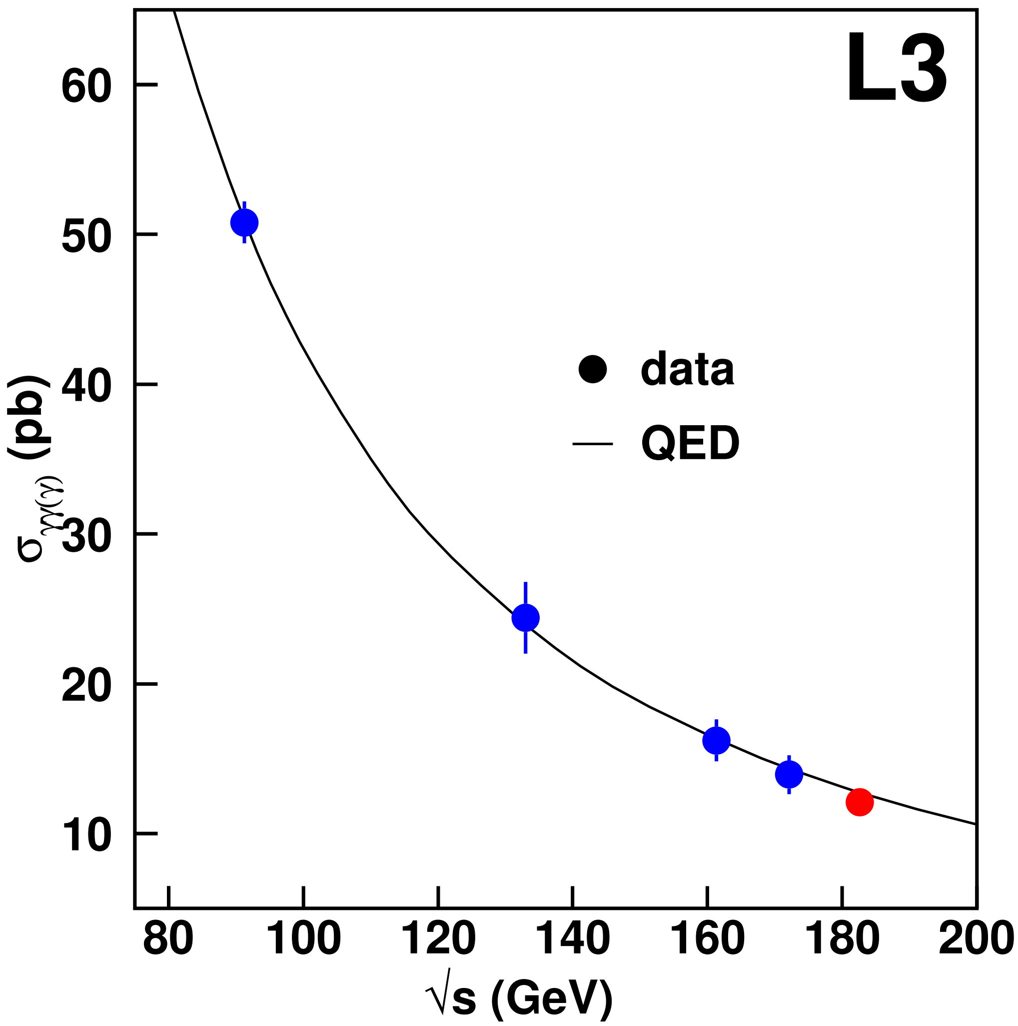
Run# 685703 Event# 3598

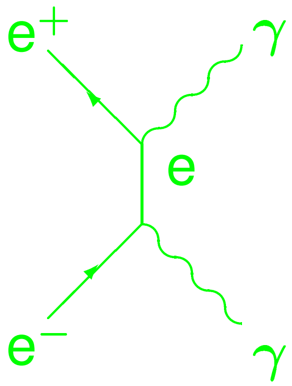


Vertex at 1.5 mm

Vertex at 4.1 mm

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

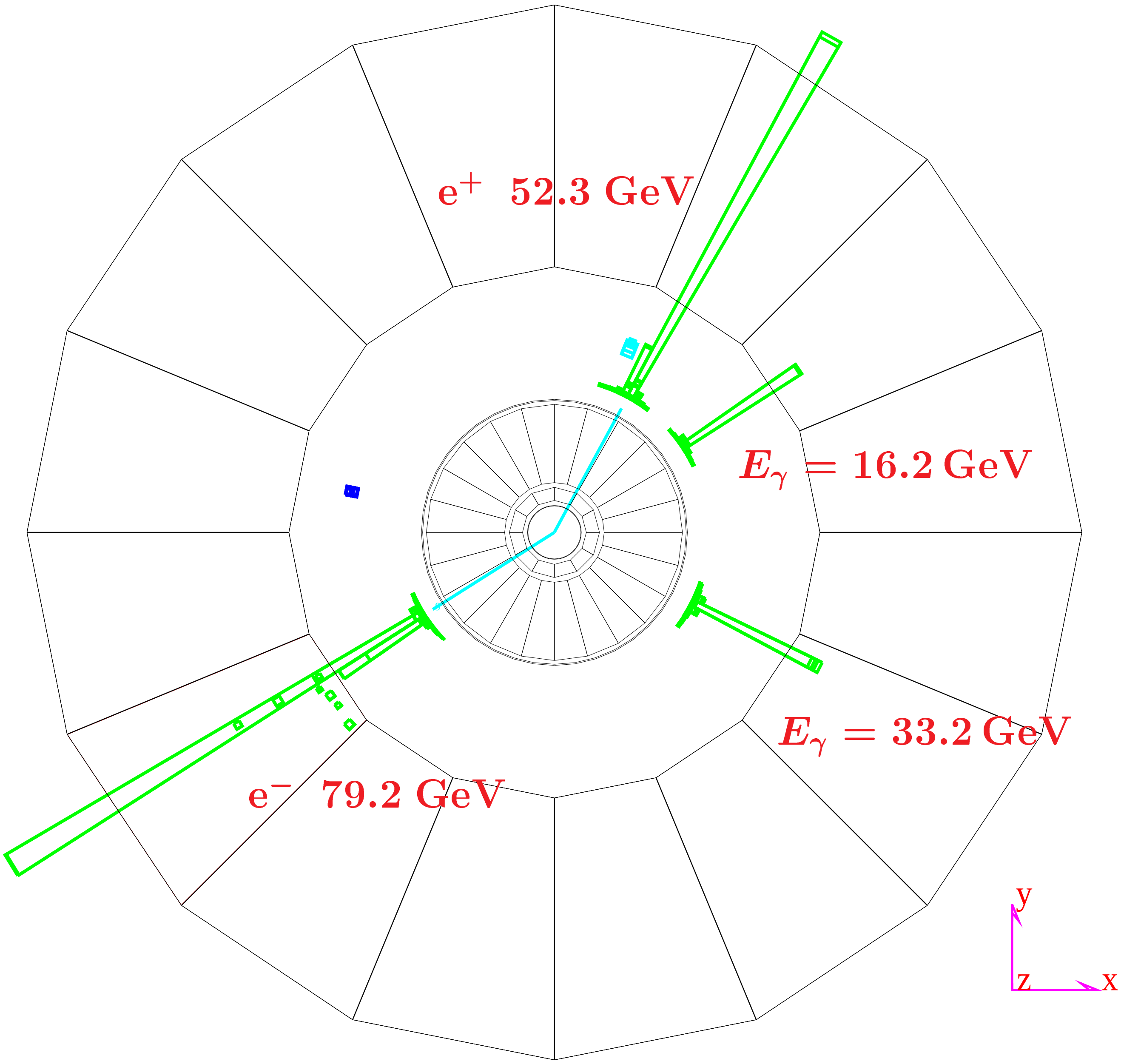




Formfactor:	Contact:	Excited e:
$\Lambda_- > 242$GeV	$\Lambda > 1085$GeV	$m_{e^*} > 242$GeV (L+R)
$\Lambda_+ > 267$GeV	$\Lambda' > 612$GeV	$m_{e^*} > 177$GeV (L/R)

Direct Search for Excited Leptons

Run # **686708** **Event #** **4923** Total Energy : 190.75 GeV



Direct Search for Excited Leptons

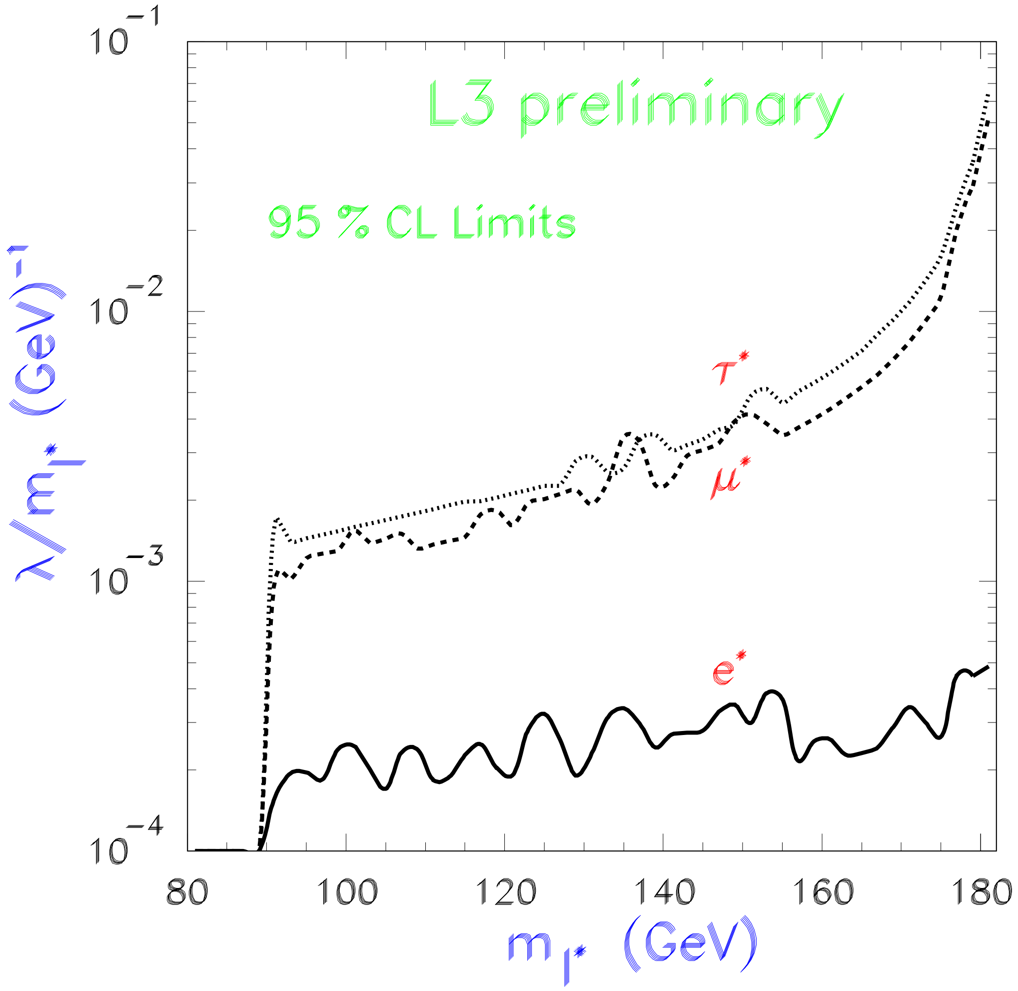
Pair Production:

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

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

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

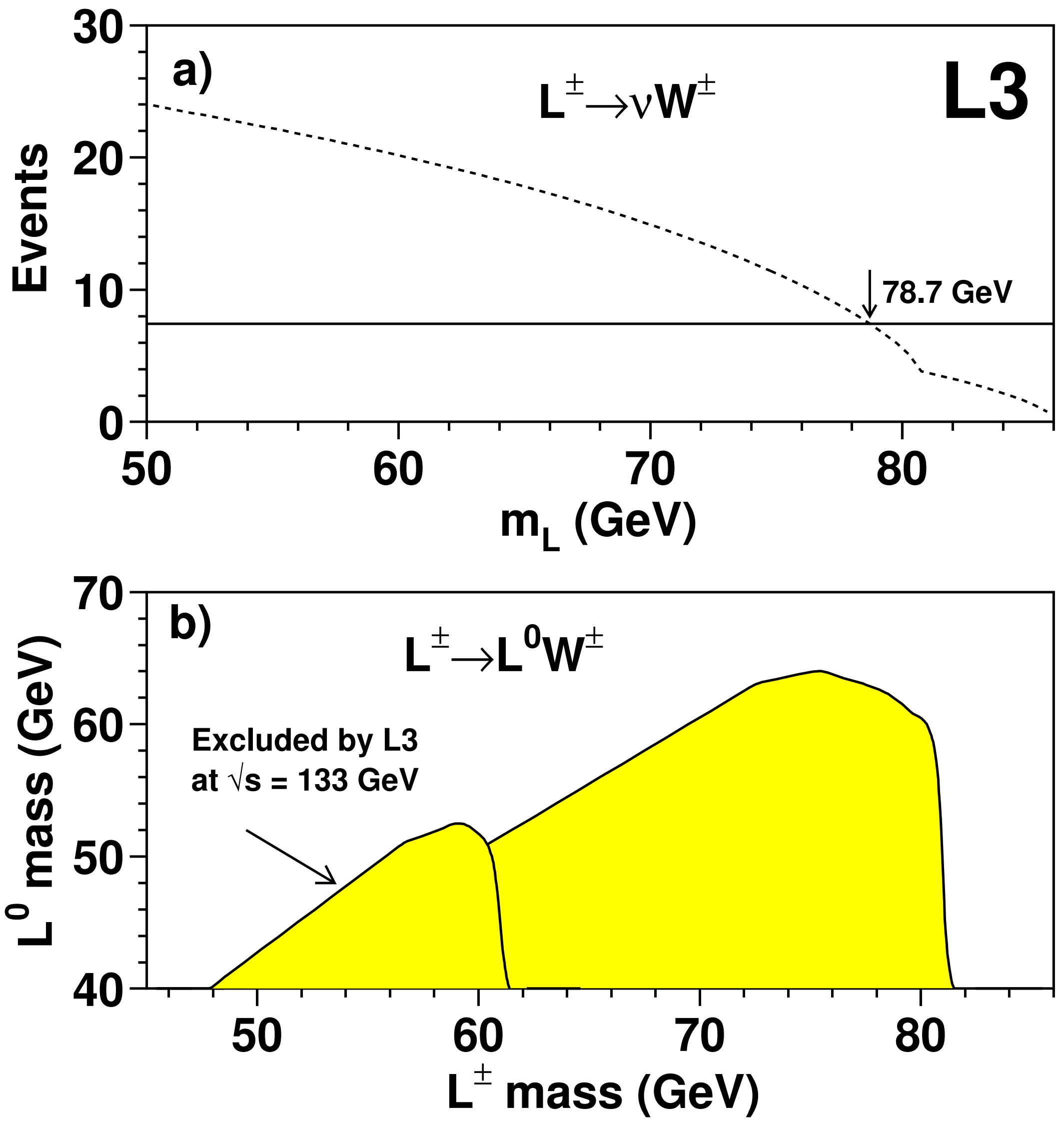
Single Production:



Charged and Neutral Heavy Leptons

Unstable Charged Heavy Leptons:

- $\mathrm{L}^{\pm} \rightarrow \nu_{\ell}\mathrm{W}^{\pm}$ **via mixing**
- $\mathrm{L}^{\pm} \rightarrow \mathrm{L}^{0}\mathrm{W}^{\pm}$ L^{0} **stable**

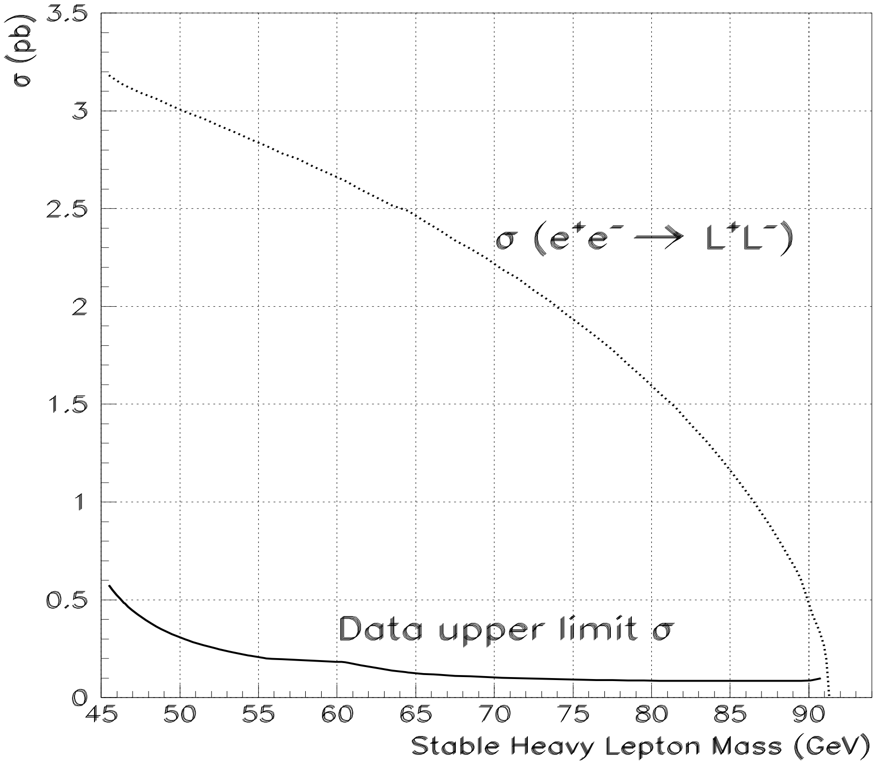


Charged and Neutral Heavy Leptons

Stable Charge Heavy Lepton: $\mathrm{M_{L^0} > M_{L^\pm}}$

Signature – two collinear, highly ionizing tracks

Ecm = 183GeV



Unstable Neutral Heavy Leptons: $\mathrm{L^0 \rightarrow \ell^\pm W^\mp}$.

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

L3 Preliminary

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**

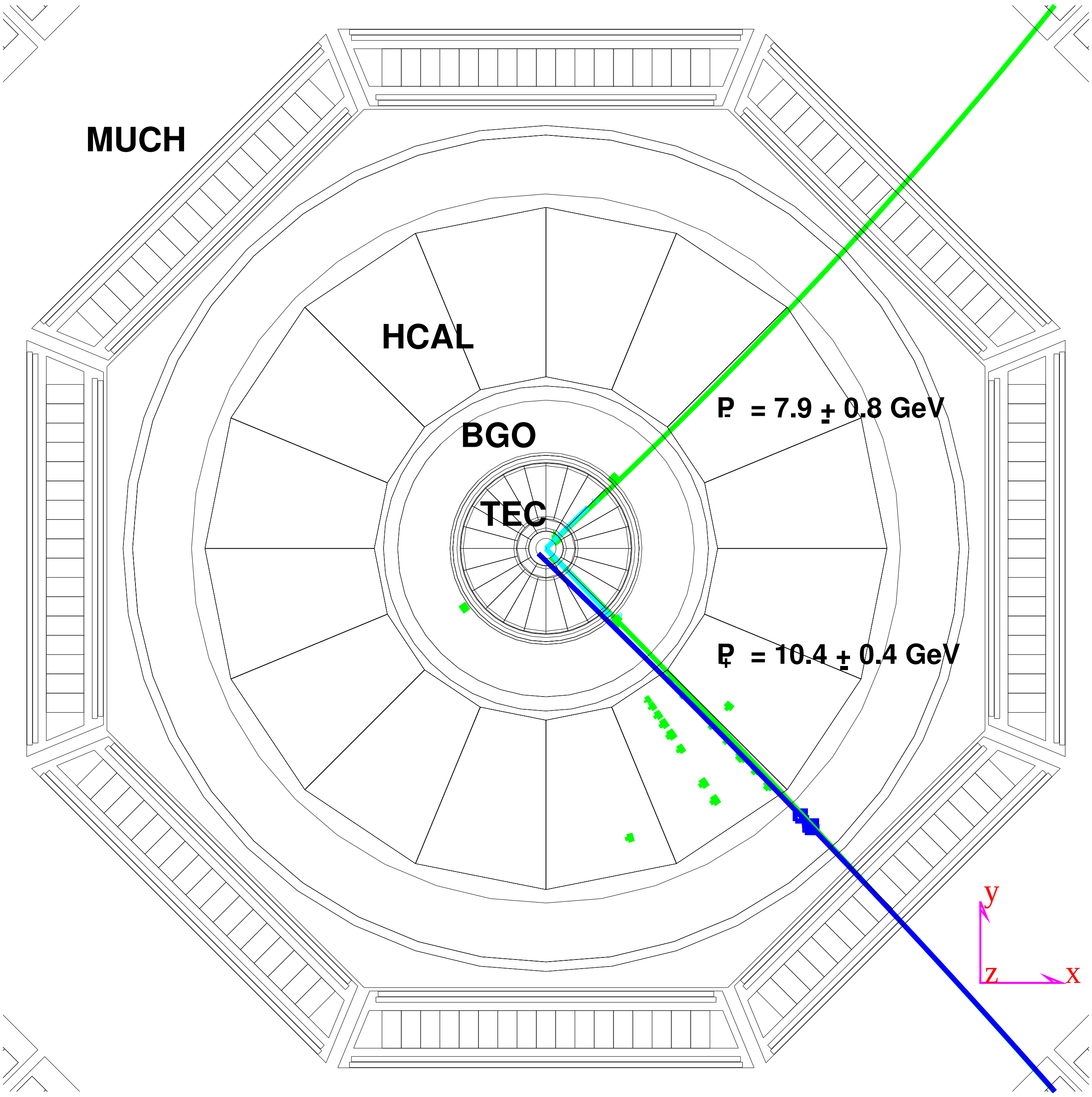
All with missing energy, momentum, mass etc.

L3 Preliminary

	Inclusive Search		Exclusive Search	
Class	Data Events	Exp. Backg.	Data Events	Exp. Backg.
$\tilde{\chi}^{\pm}, \tilde{\chi}^{0}$	21	39$\pm$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$\pm$7	1	3.35
all	35	56$\pm$15		

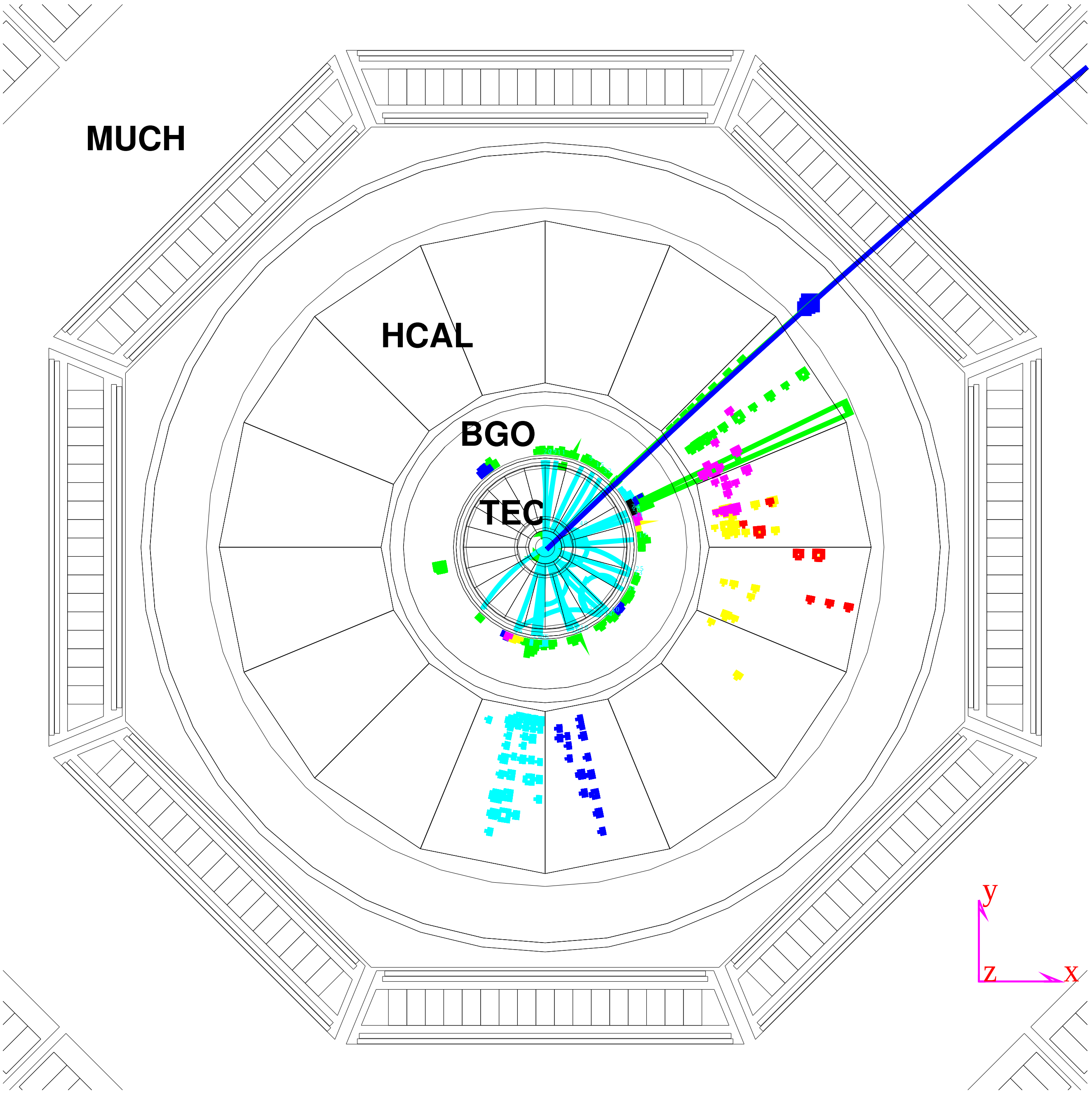
Smuon Candidate

Run # 676811 Event # 4701

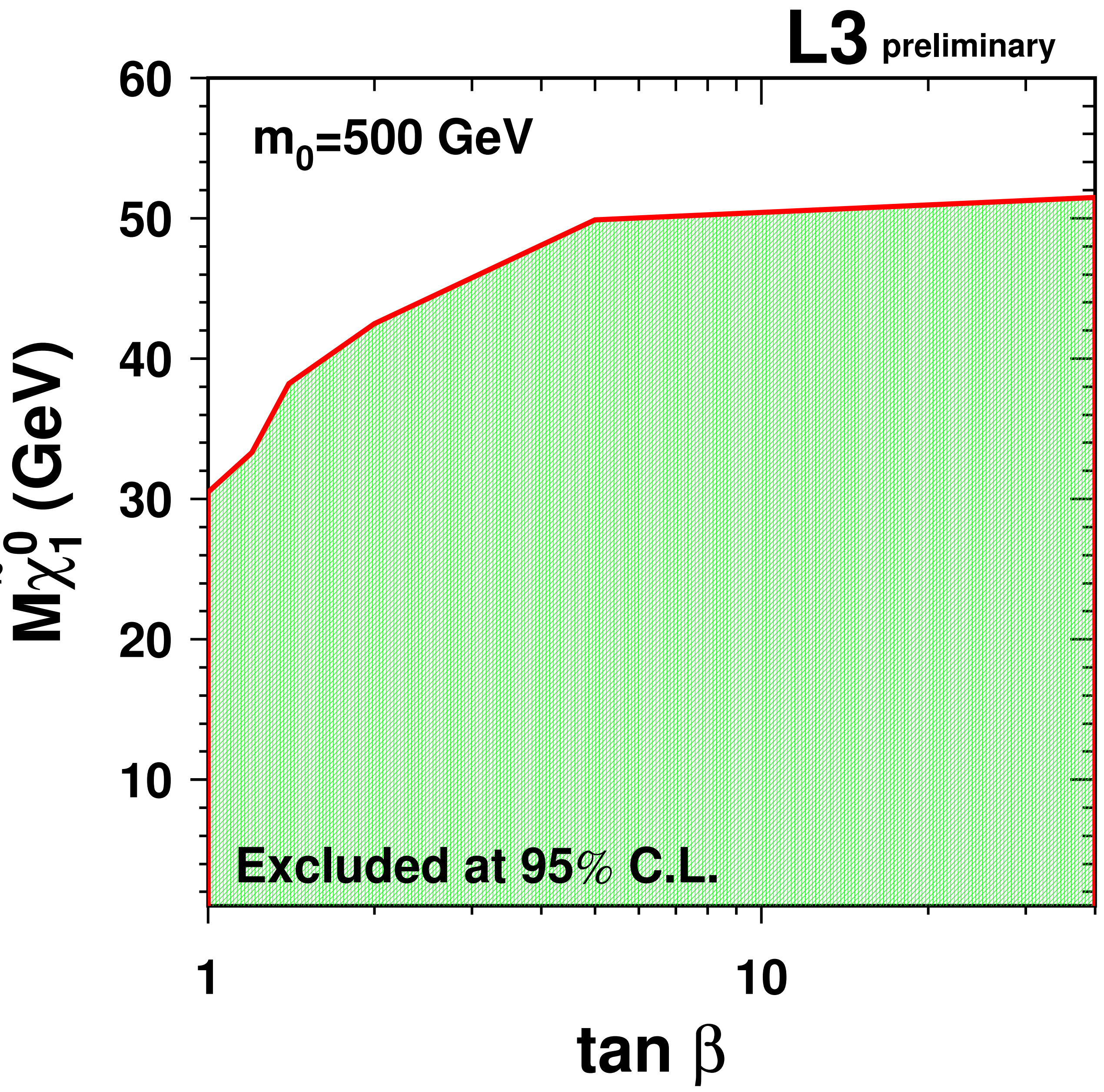


Chargino Candidate

Run # 679704 Event # 818



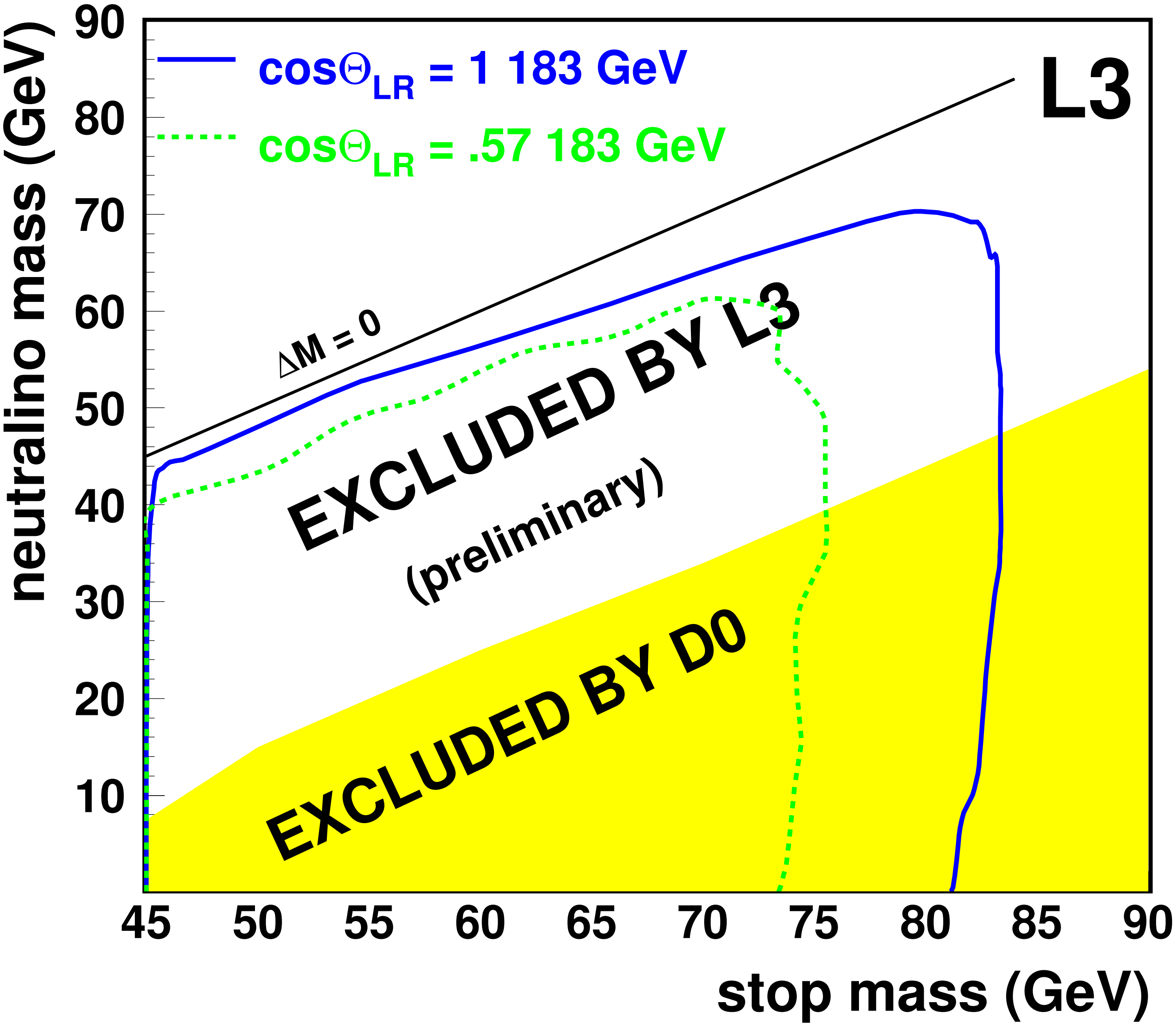
Neutralino Limits in MSSM



New limit for large m_0

Stop Limits in MSSM

From exclusive search:

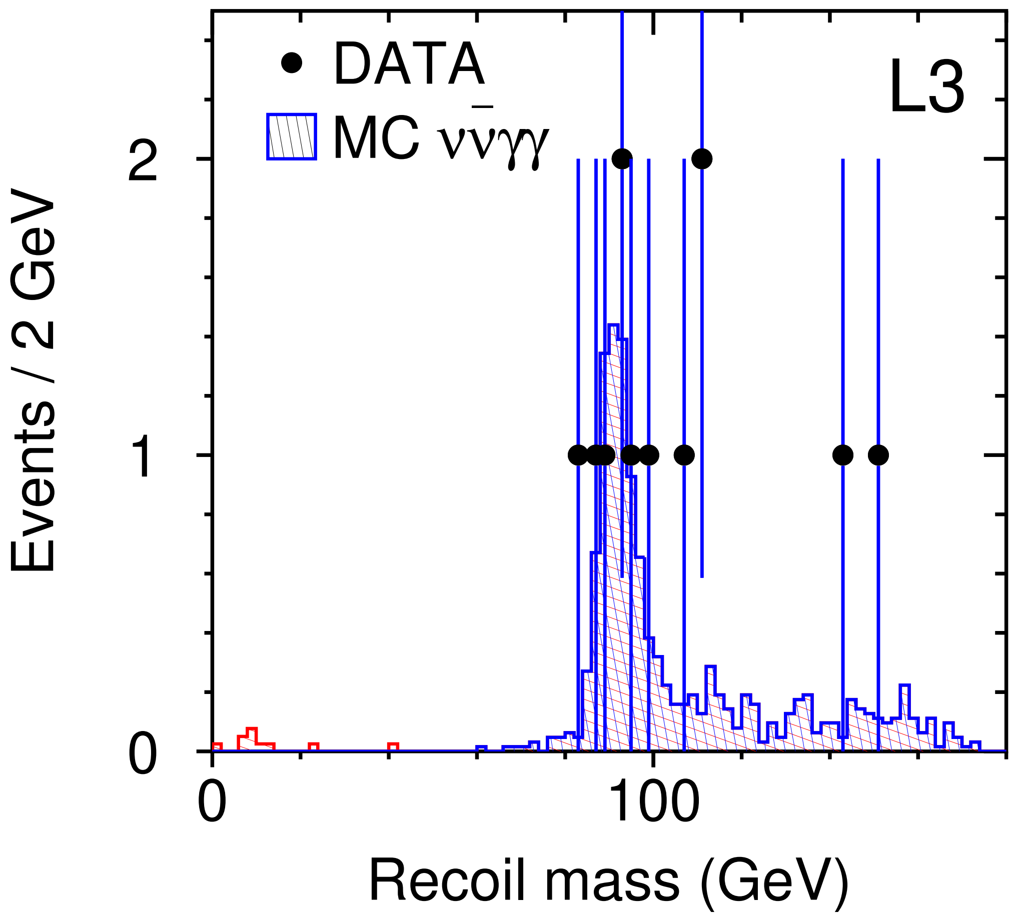


Radiative Neutralino Decays

Channel	Data Events	Exp. Backgr.
Acopl. Photon Pairs	12	12.3

$\tilde{\chi}_2^0 \to \tilde{\chi}_1^0\gamma$ or $\tilde{\chi}_1^0 \to \tilde{G}\gamma$

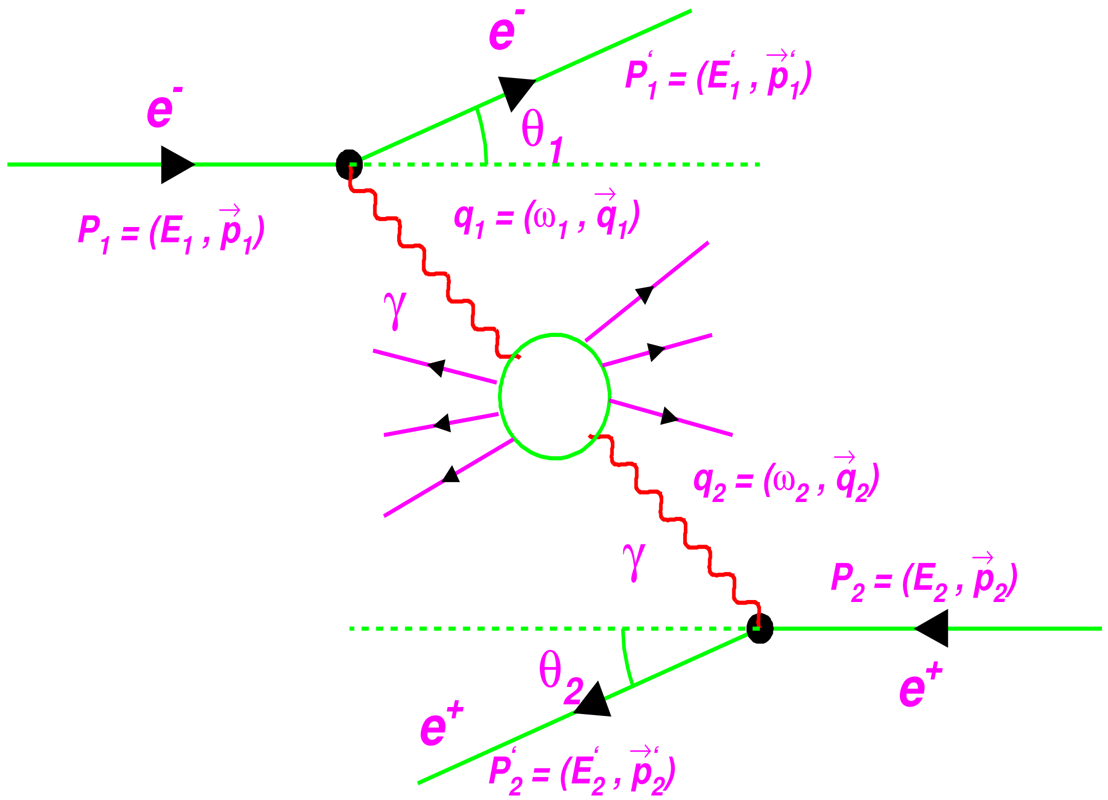
183 GeV Preliminary



$M_{\tilde{\chi}_1^0} >$ 80 **GeV at 95% CL**

$\gamma\gamma$ Physics

$$\gamma\gamma \rightarrow \mathrm{X}$$

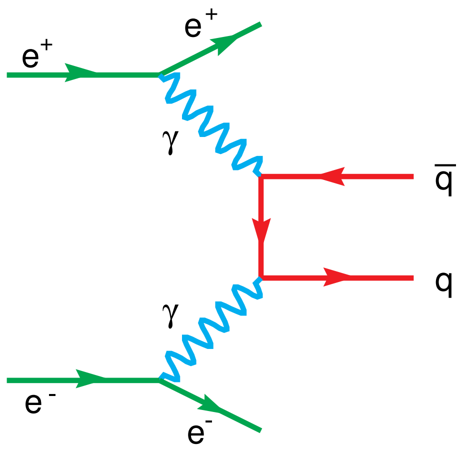


- **Resonance Production**
- **Lepton-pair production**
- **Inclusive hadron production**
- **Exclusive hadron production**

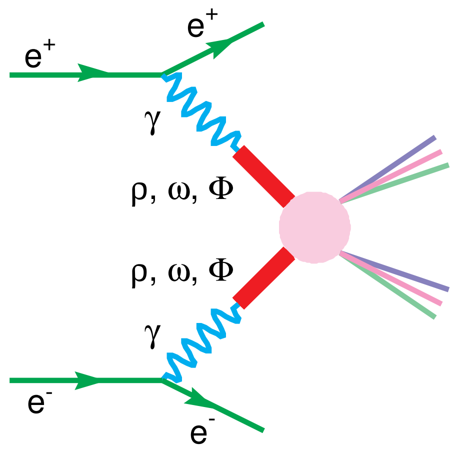
Outstanding Opportunities at LEP2

$\gamma\gamma$ Physics - Hadron production

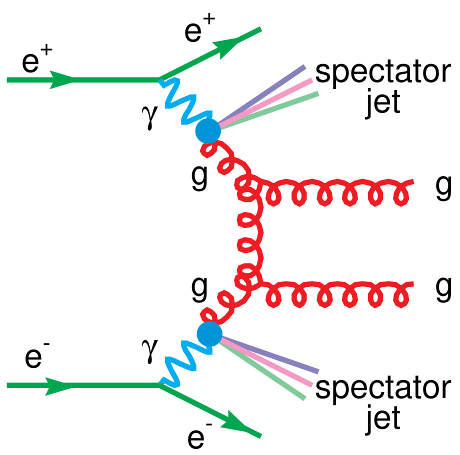
$$ee \to ee\gamma\gamma \to eeqq$$



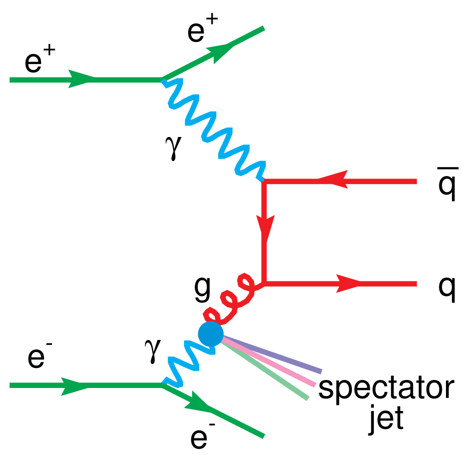
Direct



VDM

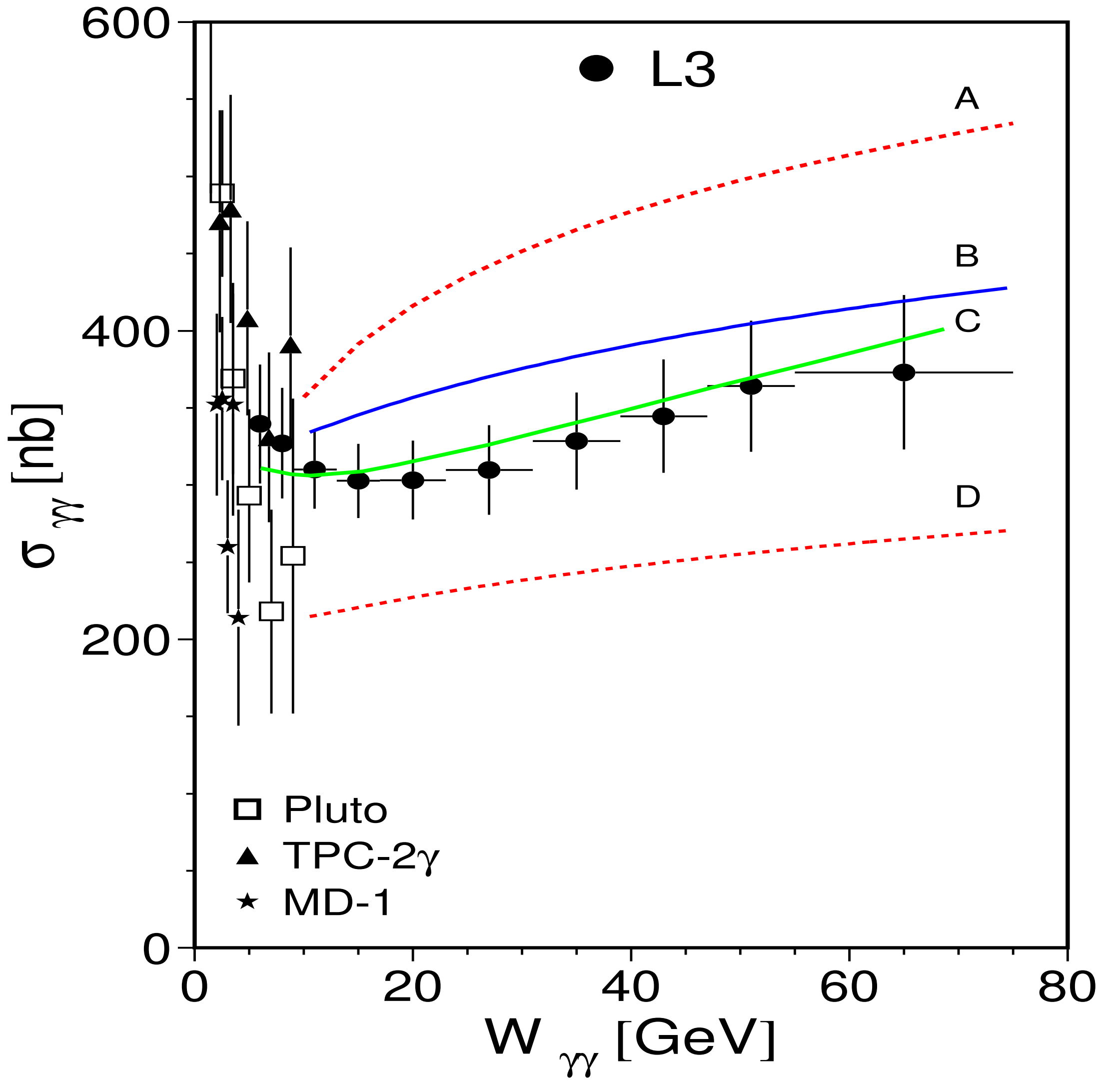


Double Resolved



Single Resolved

Total Cross Section $\sigma(\gamma\gamma \to \text{hadrons})$



A,B,D – G.A. Schuler and T. Sjöstrand
C – R. Engel and J. Ranft

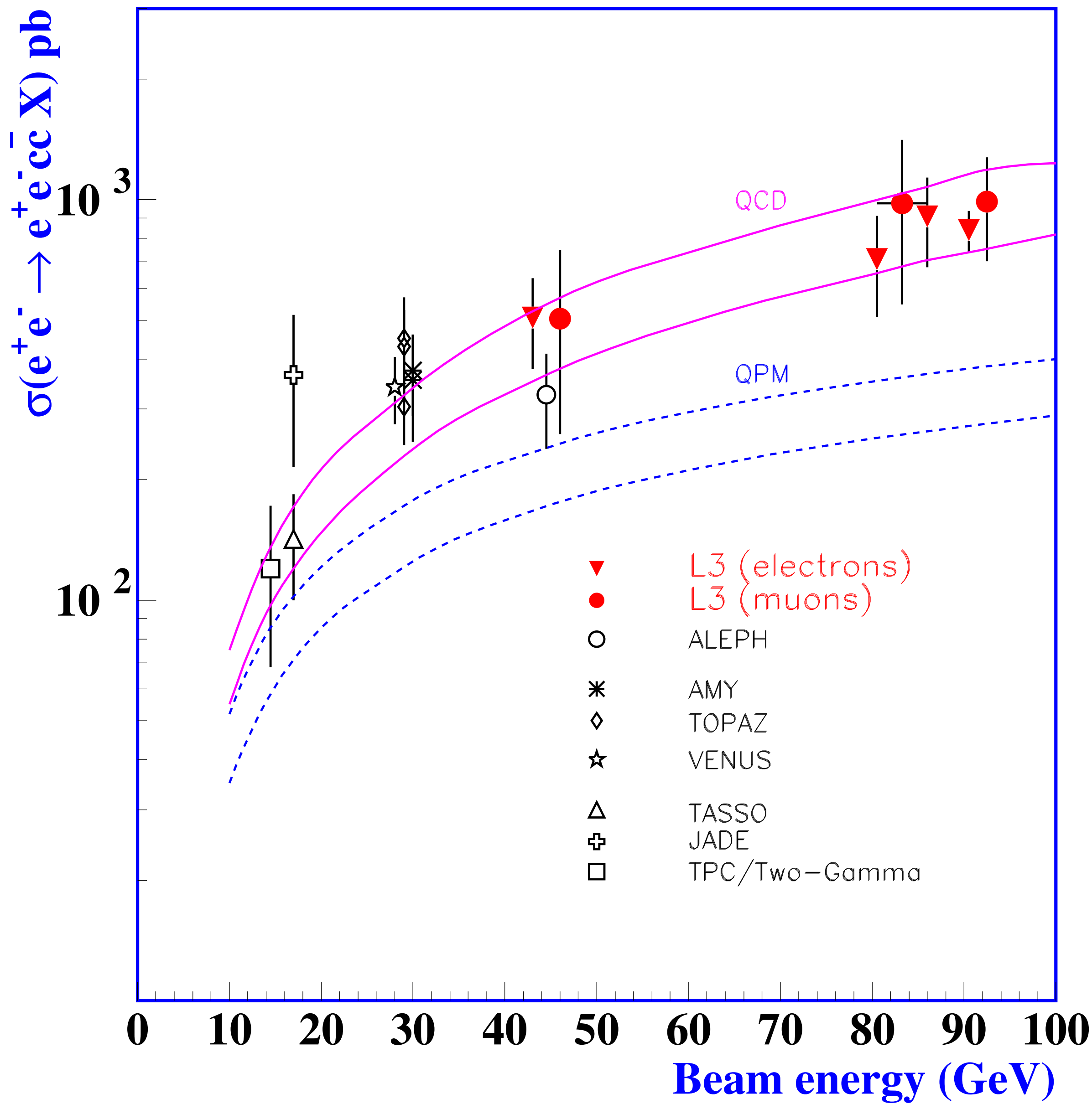
Fits to:

$$\sigma_{\gamma\gamma} = A\, s^{-.0790} + B\, s^{-0.4678}$$

$$A = 173 \pm 7\, nb \quad B = 519 \pm 125\, nb \quad \chi^2/d.o.f. = 3/8.$$

Charm production in $\gamma\gamma$ collisions

L3 Preliminary



Summary/Outlook

- Cross sections and asymmetries for $\mathrm{e^+e^-} \to \mathrm{f\bar{f}}$ are in agreement with Standard Model predictions;
  α_s steep

- W mass accuracy better than 200 MeV;
  TGC better determined

- Lots of candidates for new particles, but no excesses yet

- New $\gamma\gamma$ physics measurements. Extra reach at LEP2

LEP has been great!

Looking forward to more luminosity and higher energy.