



DPF'04, UC Riverside, August 26-31
Marat Gataullin (Caltech)
on behalf of the L3 (LEP) Collaborations

- **Neutrino Production at LEP**
- **Searches for New Physics**
- ✓ **Various SUSY Scenarios**
Phys. Lett. B587 16 (2004)
- ✓ **Extra Dimensions**
Phys. Lett. B597 145 (2004)
- ✓ **Anomalous Gauge Couplings**
Phys. Lett. B586 151 (2004); Phys. Lett. B597 119 (2004)

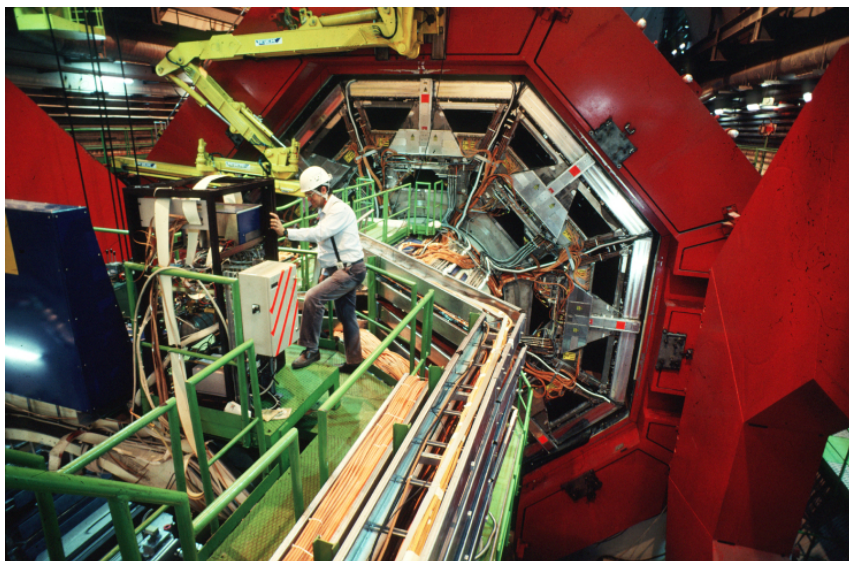
LEP 2: 650 pb⁻¹/experiment at $\sqrt{s} = 189 - 208$ GeV
All limits are at the 95% confidence level



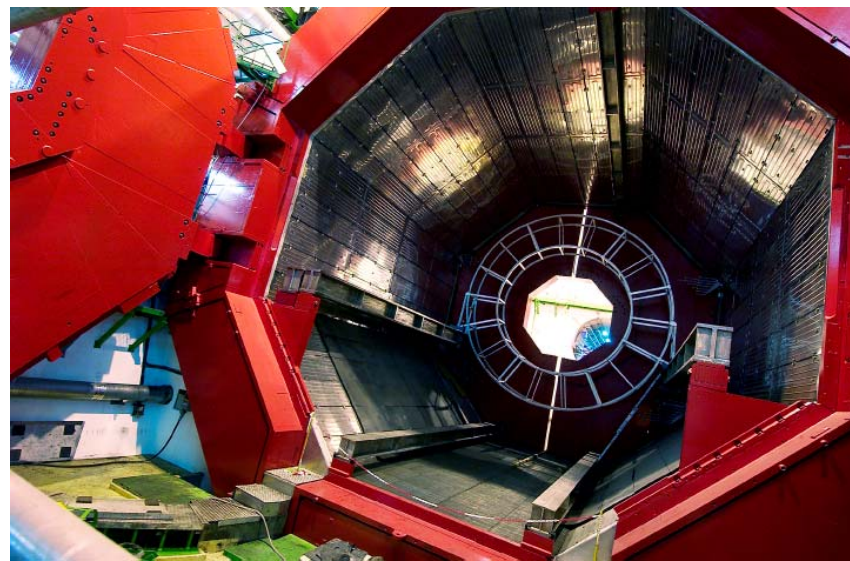
Status of L3/LEP



1989-2000



2001



2001-2004 Published 58 papers (17 in the past 12 months)

Still an active experiment: 30 full/part time physicists

Focus on the final publications and LEP-wide combinations

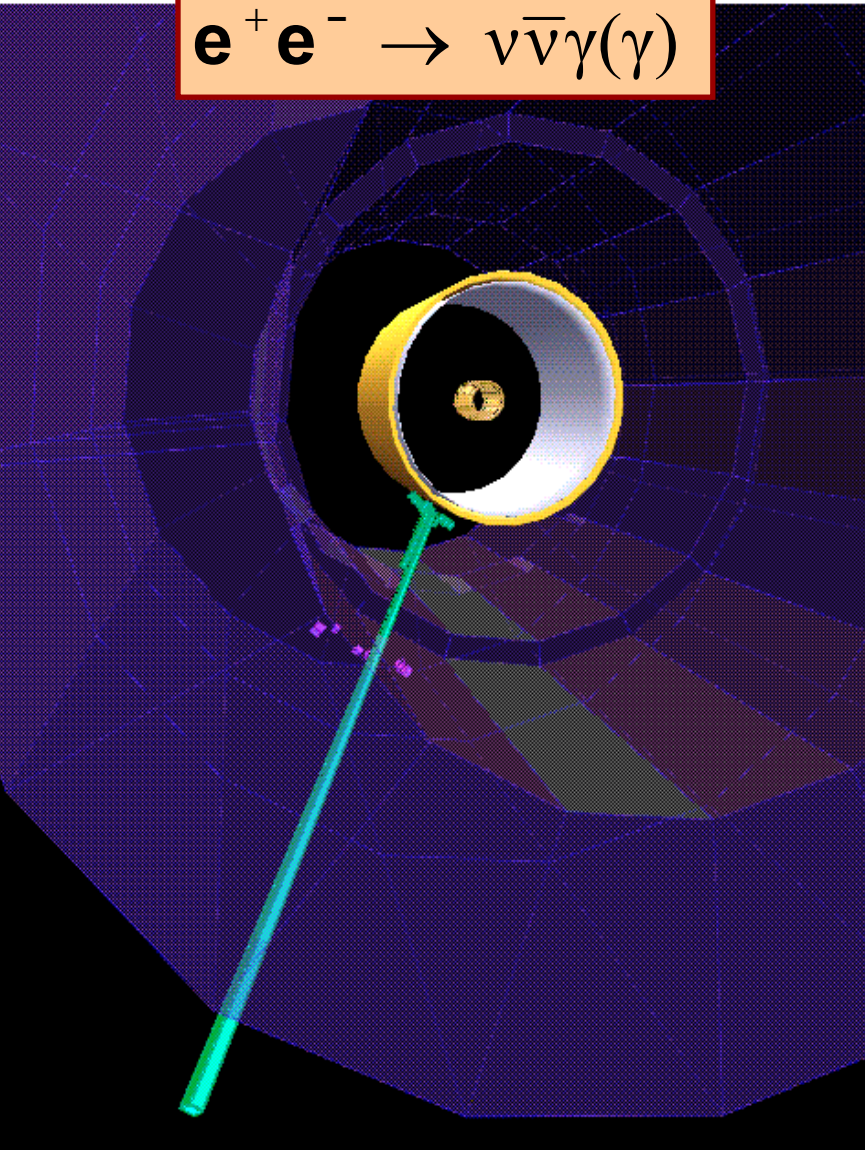
Some of these results are still Preliminary !



Selection of Single & Multi-Photons



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



❑ L3 BGO calorimeter was the best electromagnetic calorimeter at LEP
RFQ calibration provided $\sigma(E)/E=1\%$

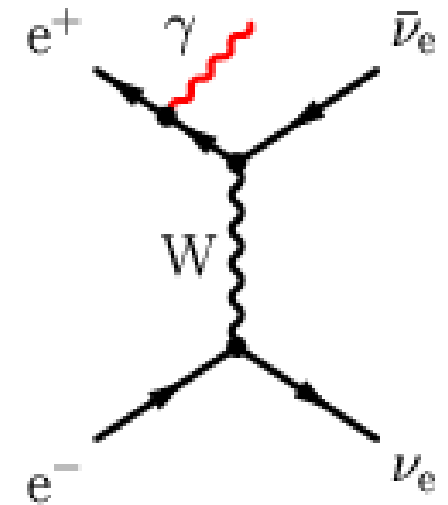
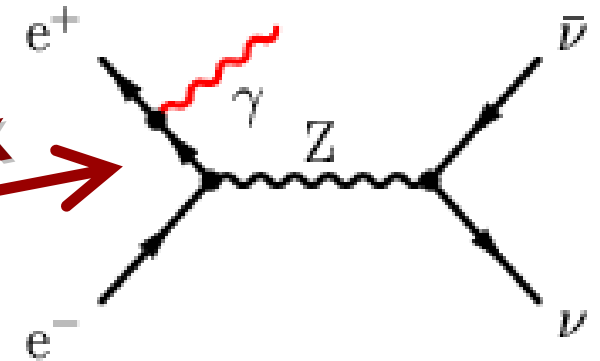
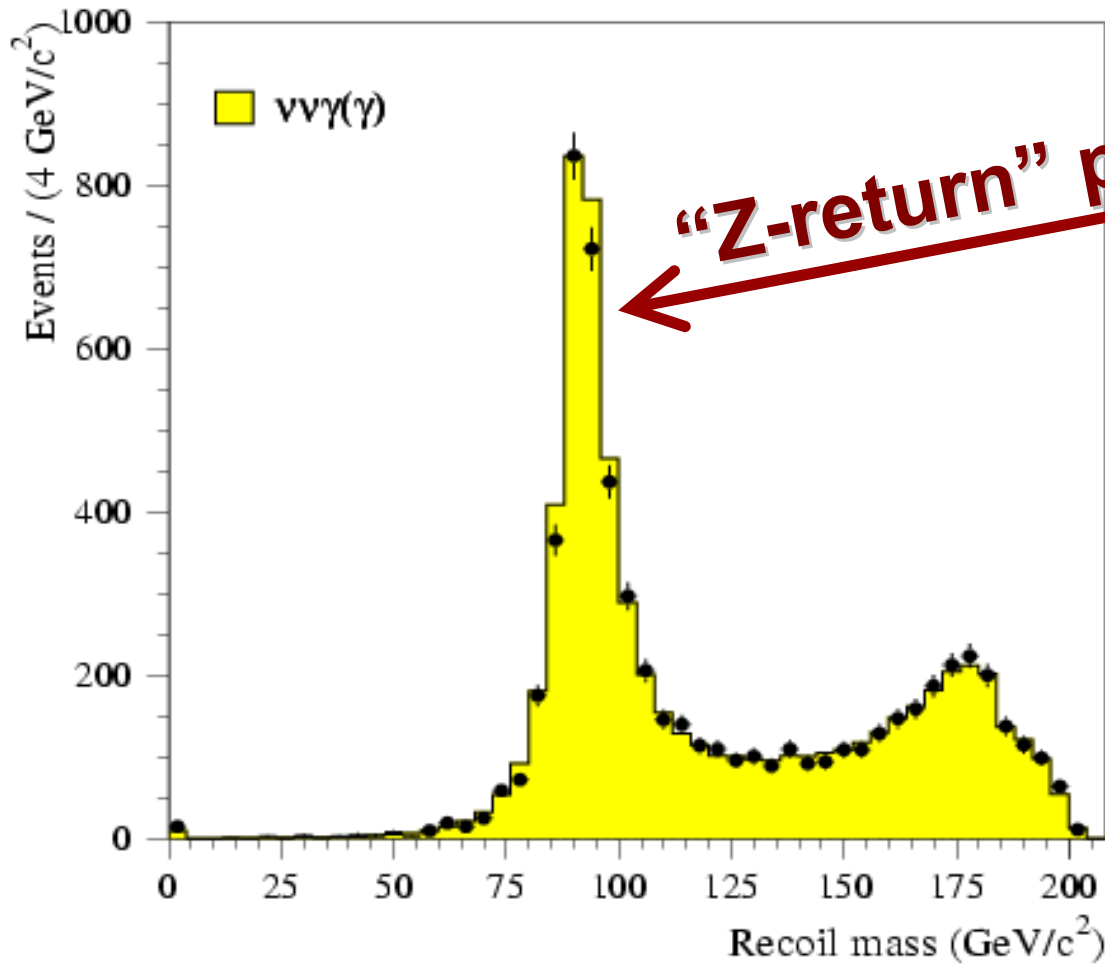
❑ Selection

$P_T > 0.04 \cdot E_{\text{BEAM}}$ and $\theta > 14$ degrees
efficiency $\sim 70-80\%$ purity $\sim 99\%$

❑ Significant amount of work required to reduce the theoretical error to 1%
KK MC and NUNUGPV independent MC programs are in good agreement
KK MC released in 09/2002 (thanks!)

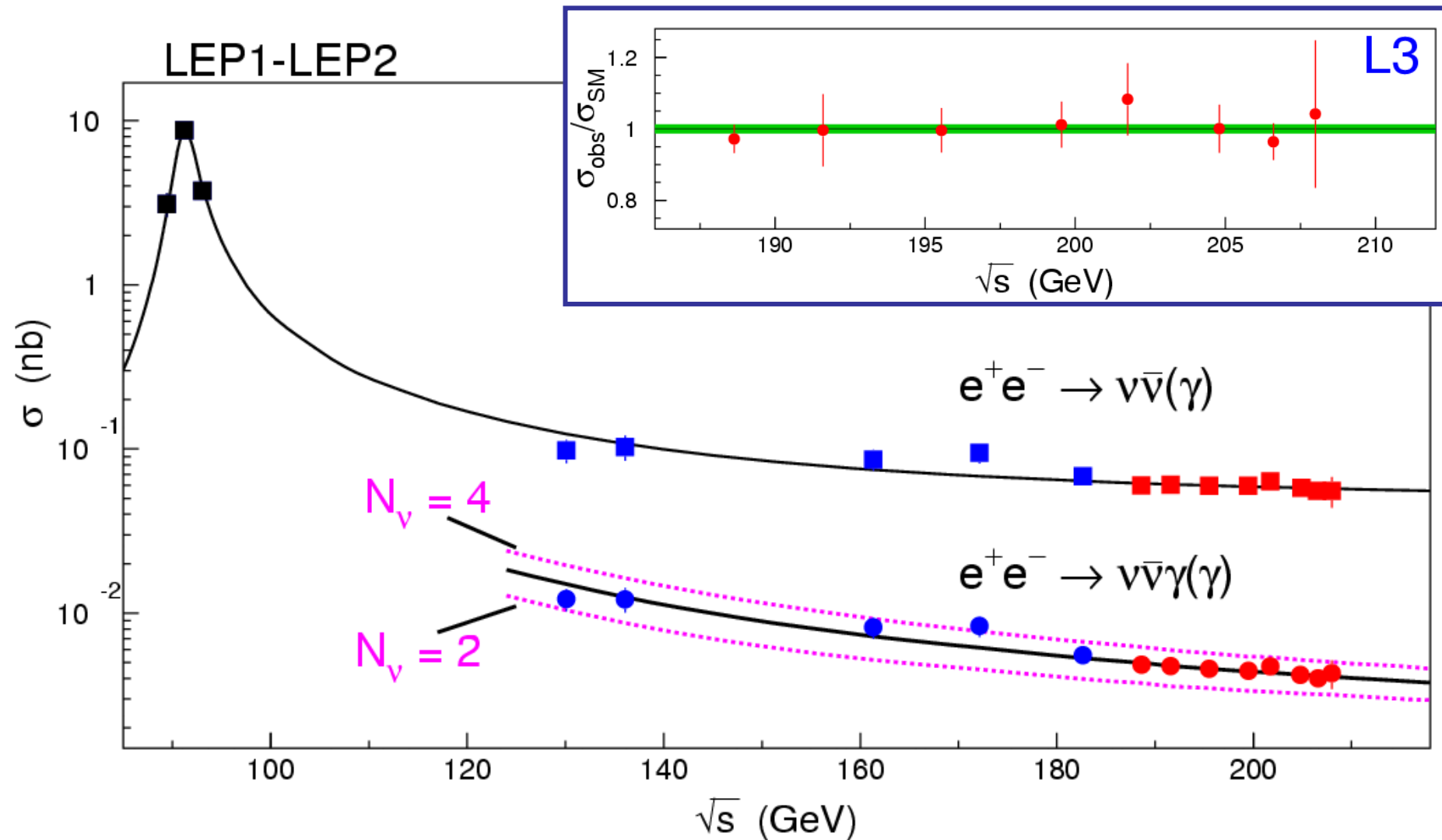
- ❑ Tests detector hermeticity
- ❑ Main selection challenges:
 - Trigger efficiency
 - Photon conversion
 - Cosmic rejection
 - Dead channels

$130 \leq \sqrt{s} \leq 208$ GeV
ALEPH DELPHI L3 OPAL

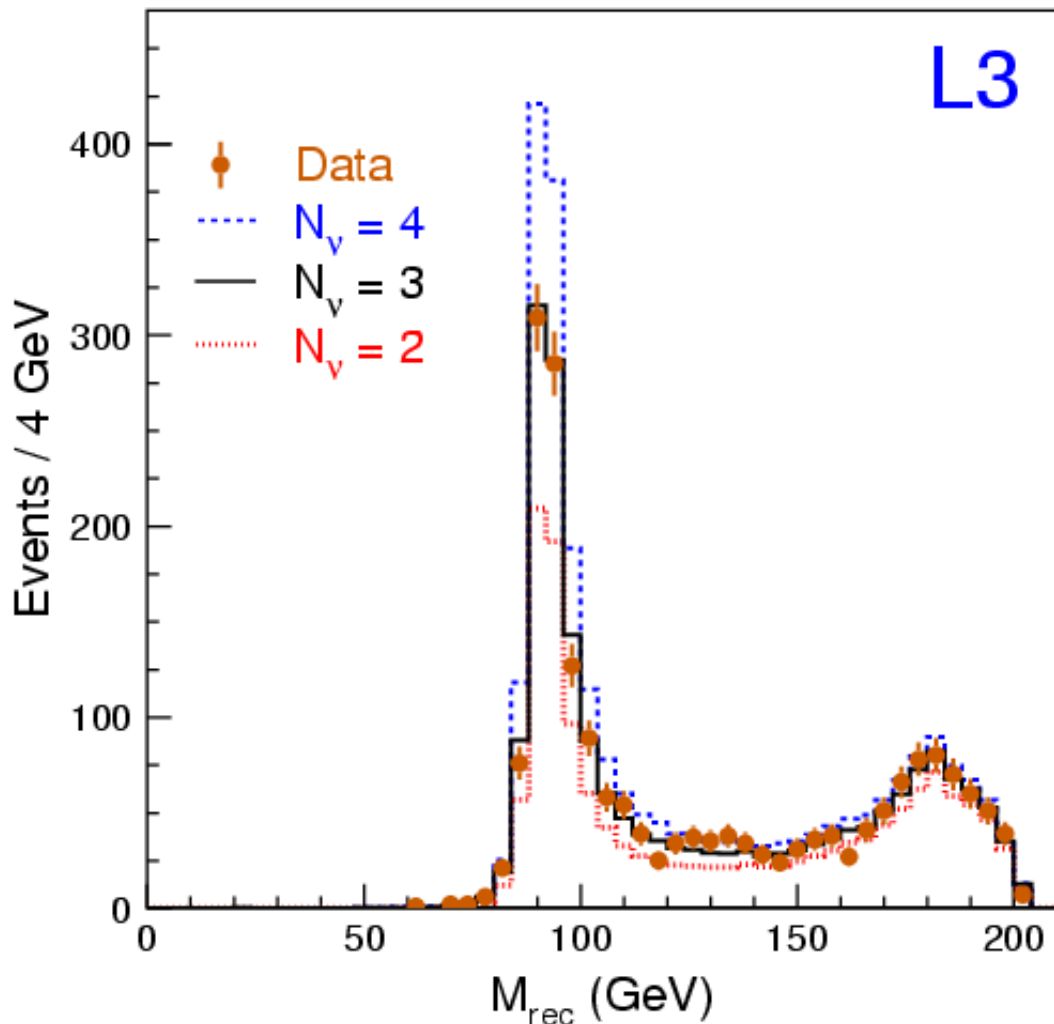


□ Total rates in good agreement with SM for all experiments

$\sigma(e^+e^- \rightarrow \nu\bar{\nu})$ measured by extrapolating the radiative cross section



$\sqrt{s} = 189-208 \text{ GeV}$



Total cross section & spectrum shape depend on the number of light neutrino families

Good agreement with the SM expectation of three neutrino families

$$\text{L3: } N_\nu = 2.98 \pm 0.06$$

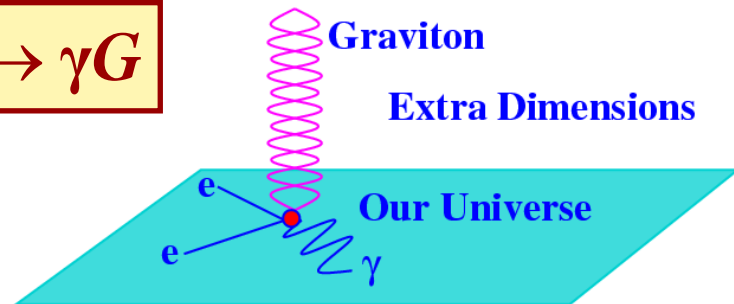
Compared to world average (PDG'04)

$$N_\nu = 3.00 \pm 0.08$$

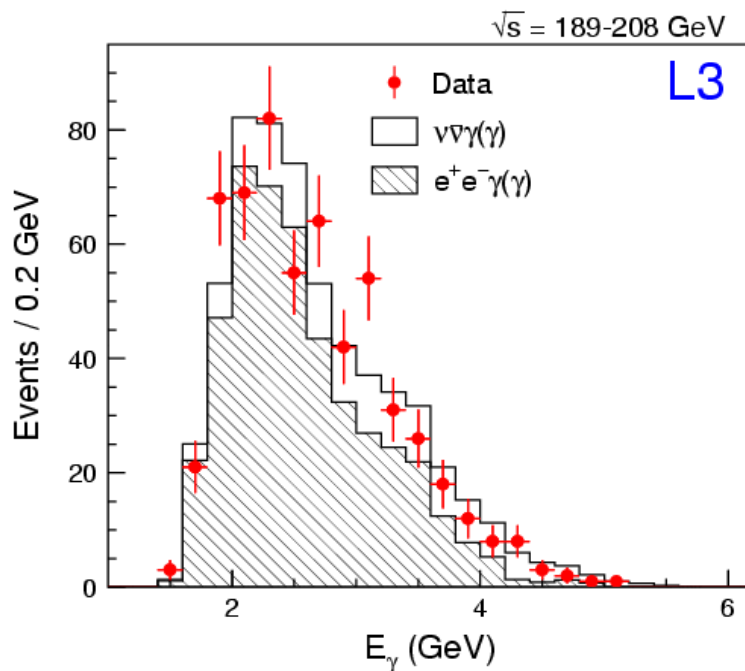
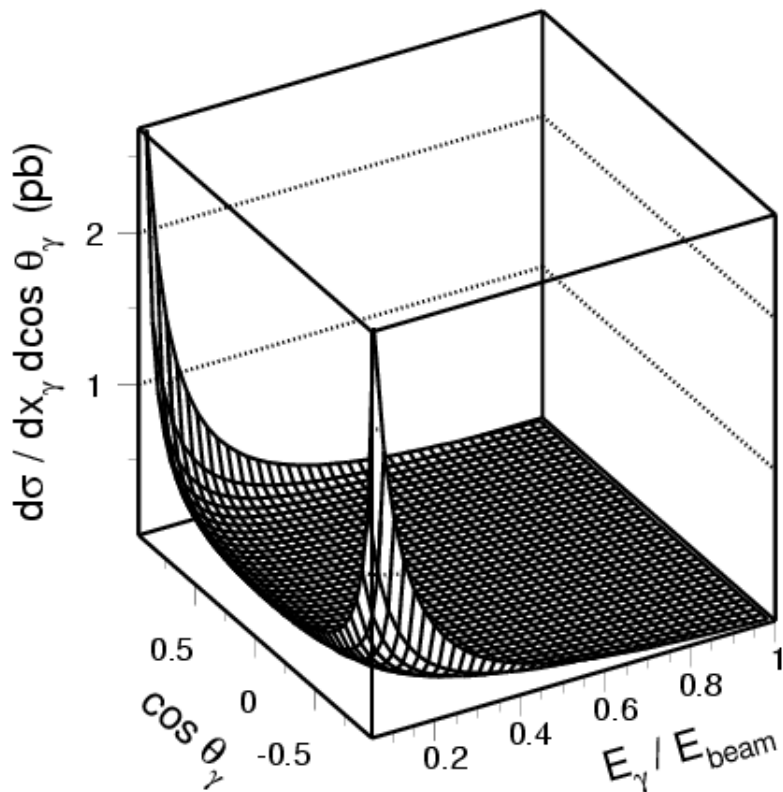
Extra Dimensions with Single Photons

- ◆ Gravity propagates in **extra dimensions** but the **SM particles live on a 3D wall**
- ◆ Explains the weakness of the gravity force in our world and solves the hierarchy problem

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



Cross section peaks at low P_T
To improve sensitivity standard selection extended (L3 only)



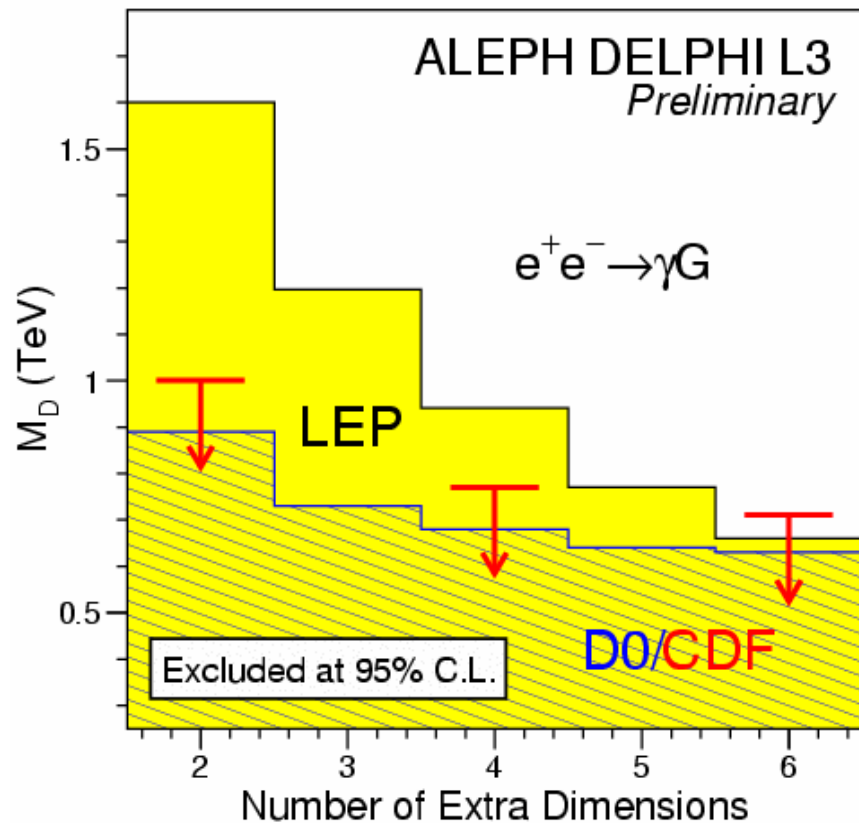
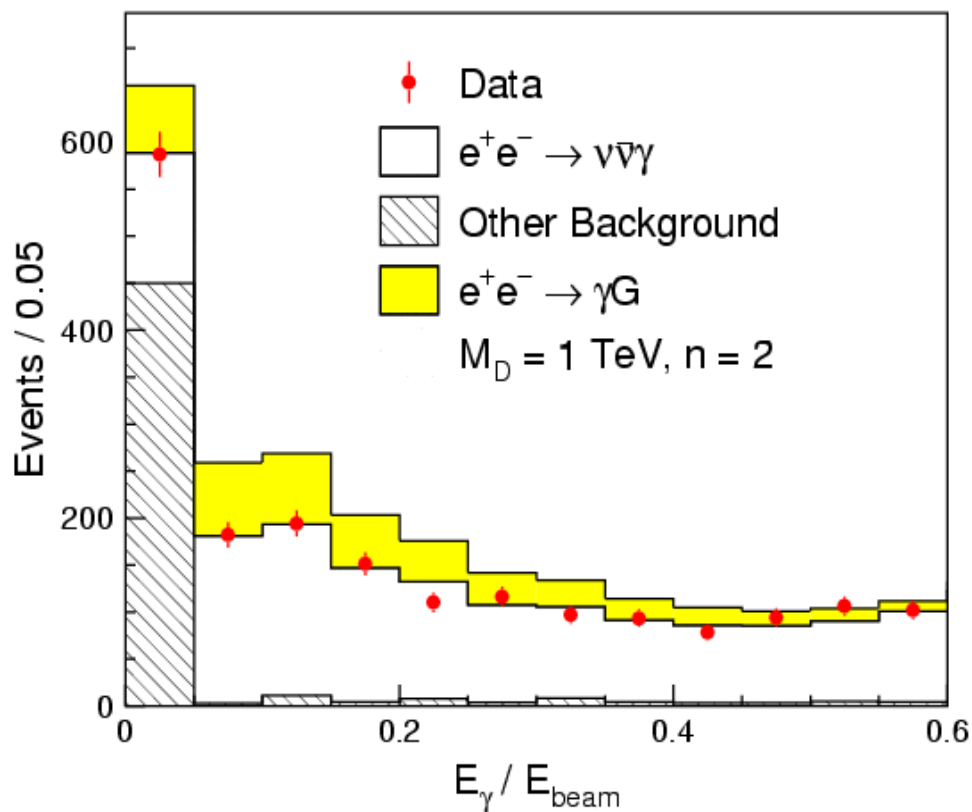


Searches for Extra Dimensions



LEP-combined (ADL) limits on the new gravity scale (07/04)

L3 DELPHI Preliminary

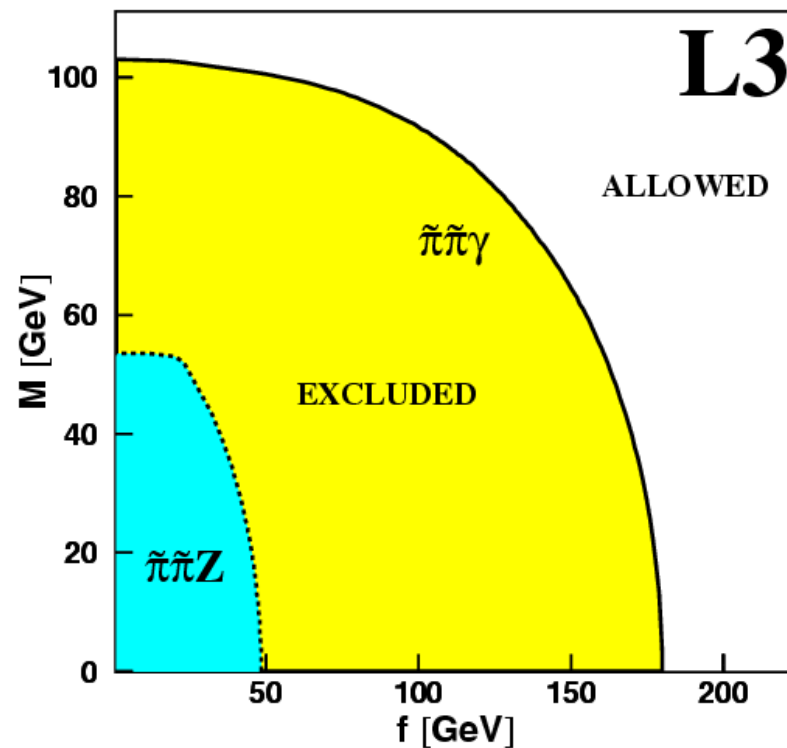
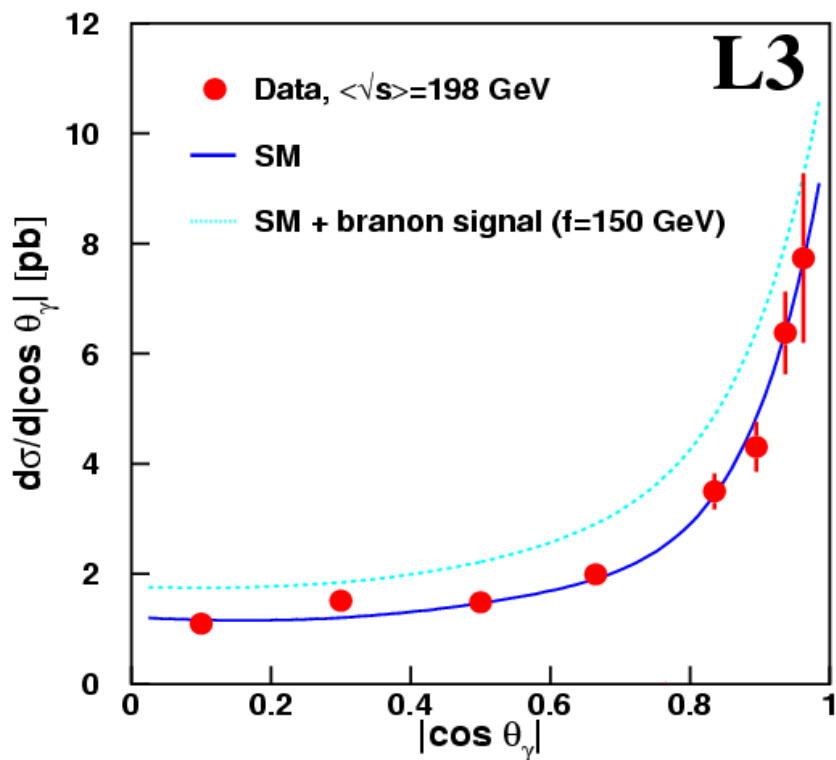




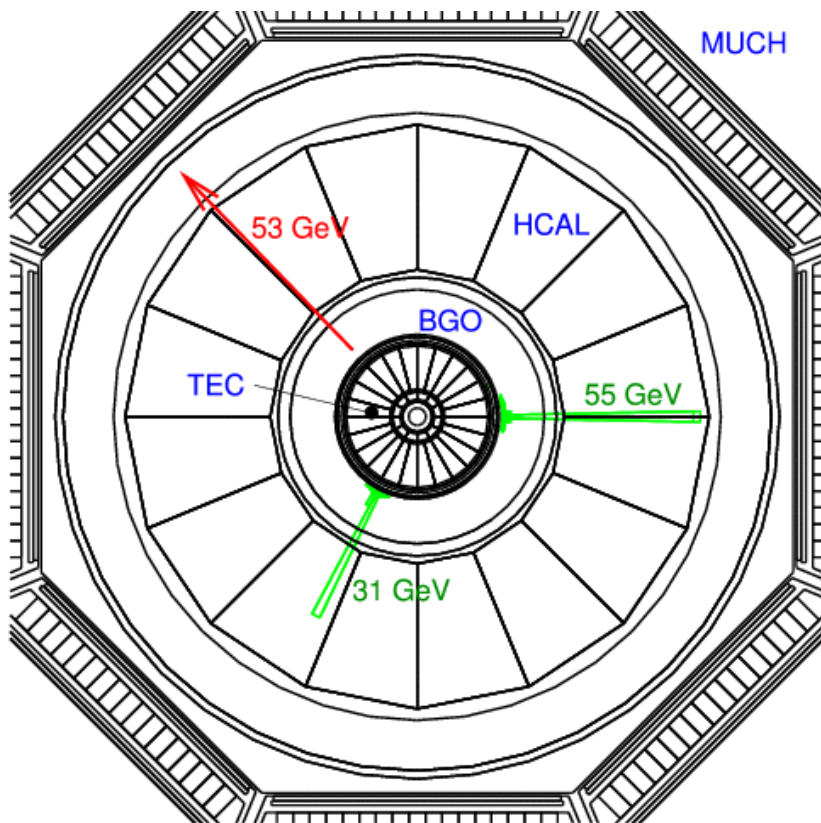
Searches for Extra Dimensions



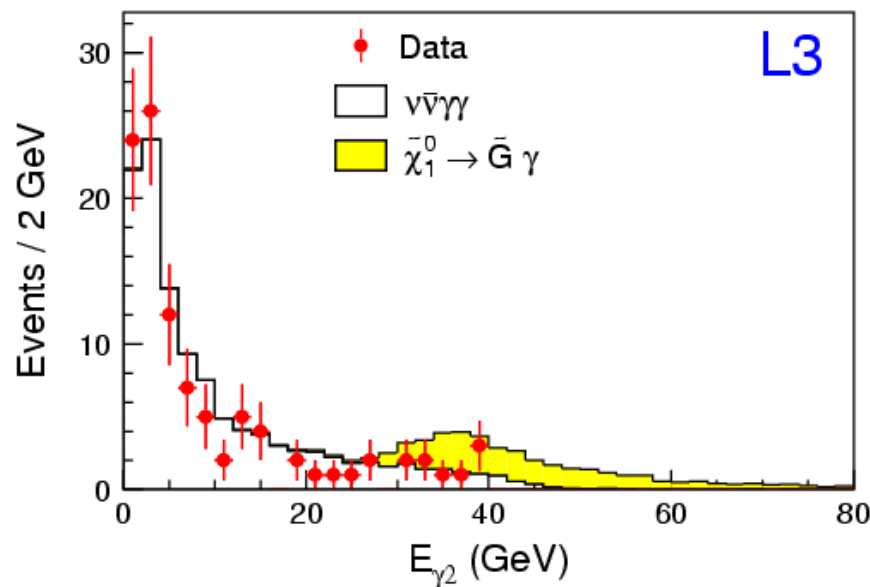
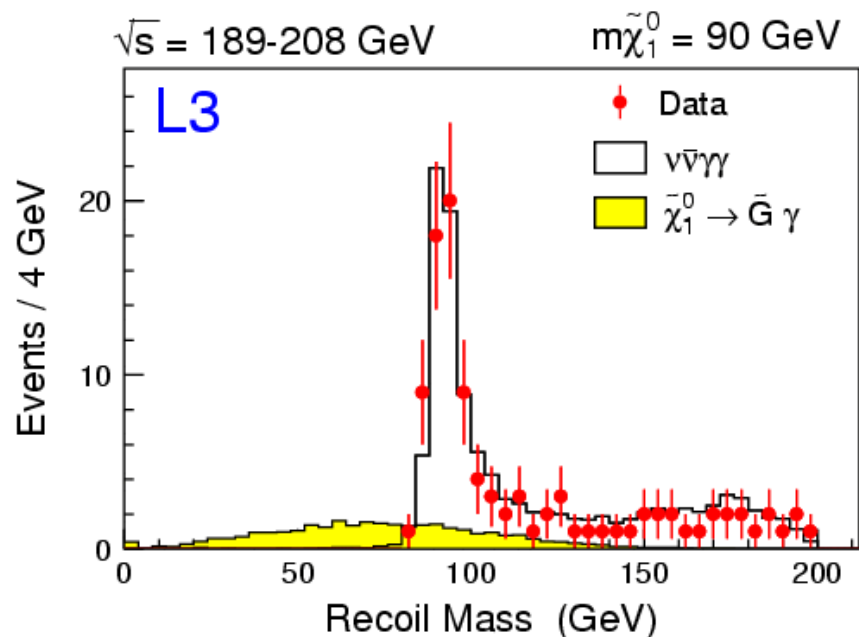
- ❑ **Complementary search (L3)**
 - Brane excitations can lead to production of branons**
- ❑ **Parameters: Branon Mass and tension f**
- ❑ **Condition: f should be much less than M_D**
- ❑ **Same search method as for the ADD scenario**



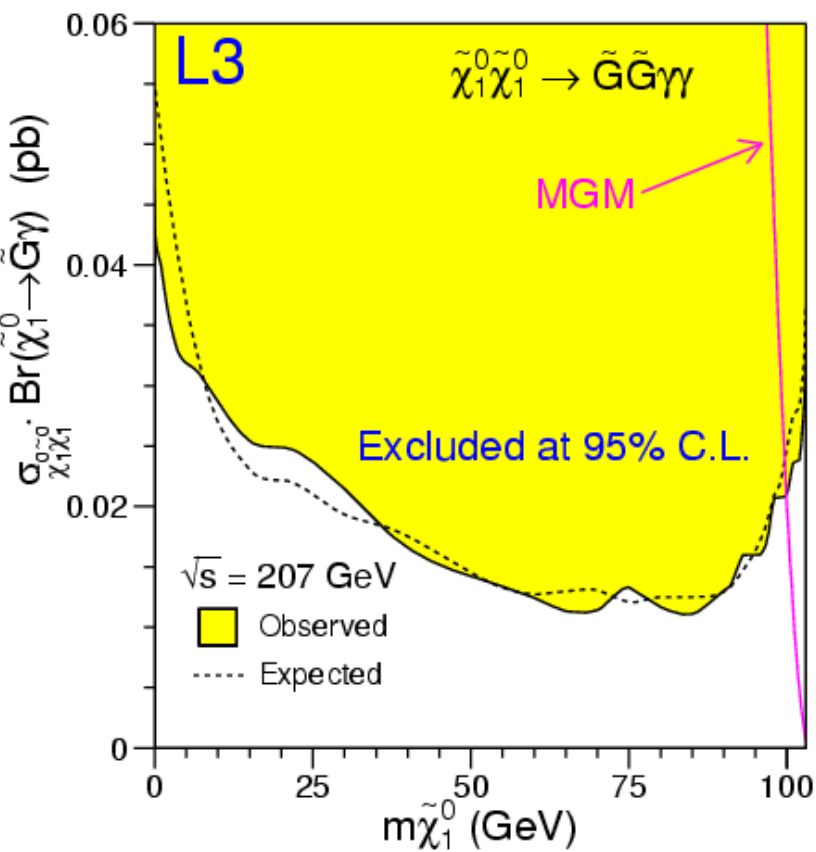
$$e^+ e^- \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0 \rightarrow \gamma \gamma \tilde{G} \tilde{G}$$



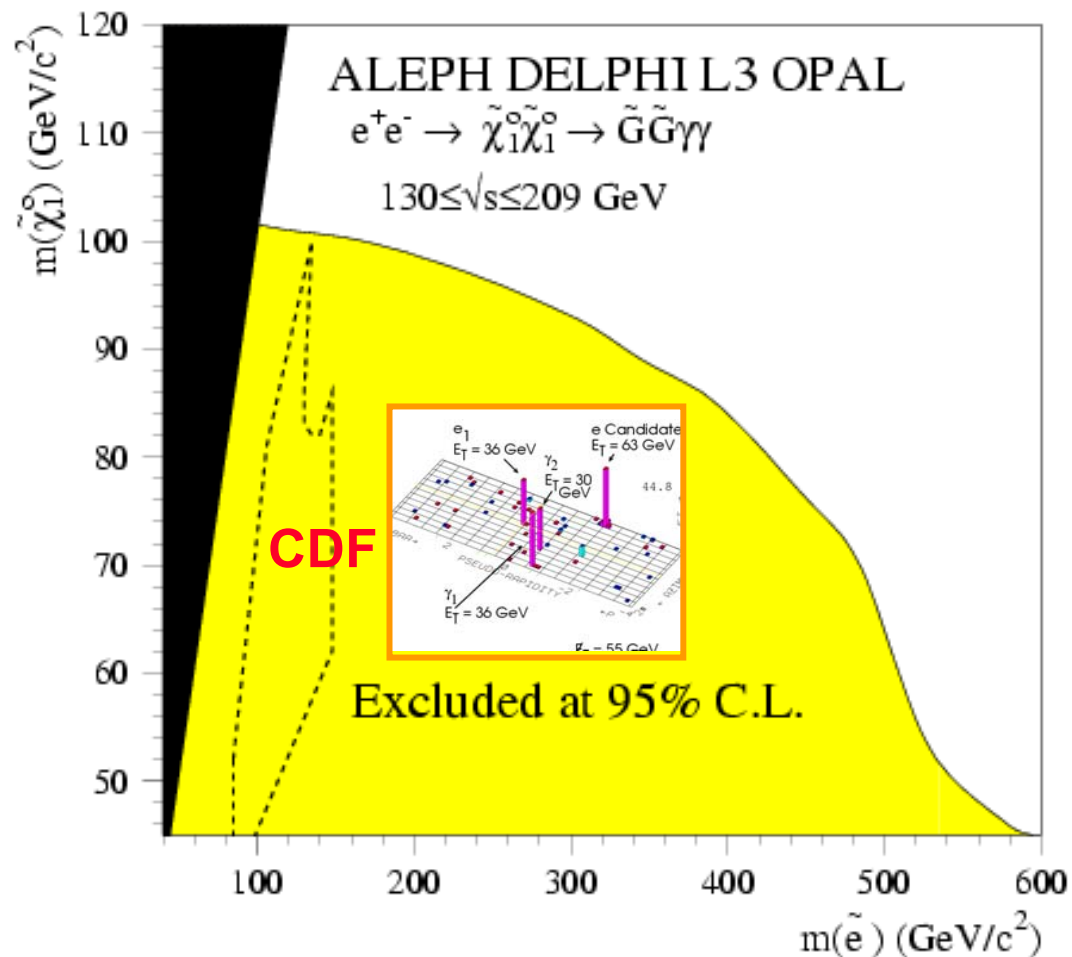
Signal is easy to separate
Efficiency ~ 60-70%



Cross Section Limit



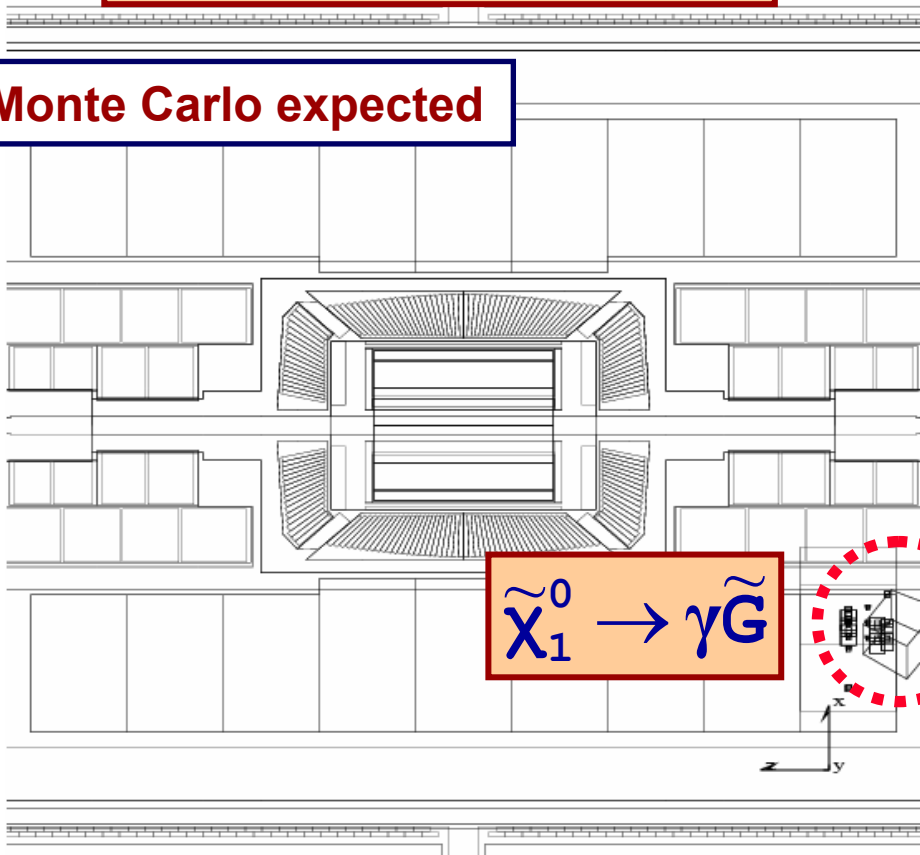
GMSB Interpretation



In GMSB SUSY neutralino decay length can be **macroscopic**
 Experimental signature: photon in HCAL (!) or BGO (non-pointing)

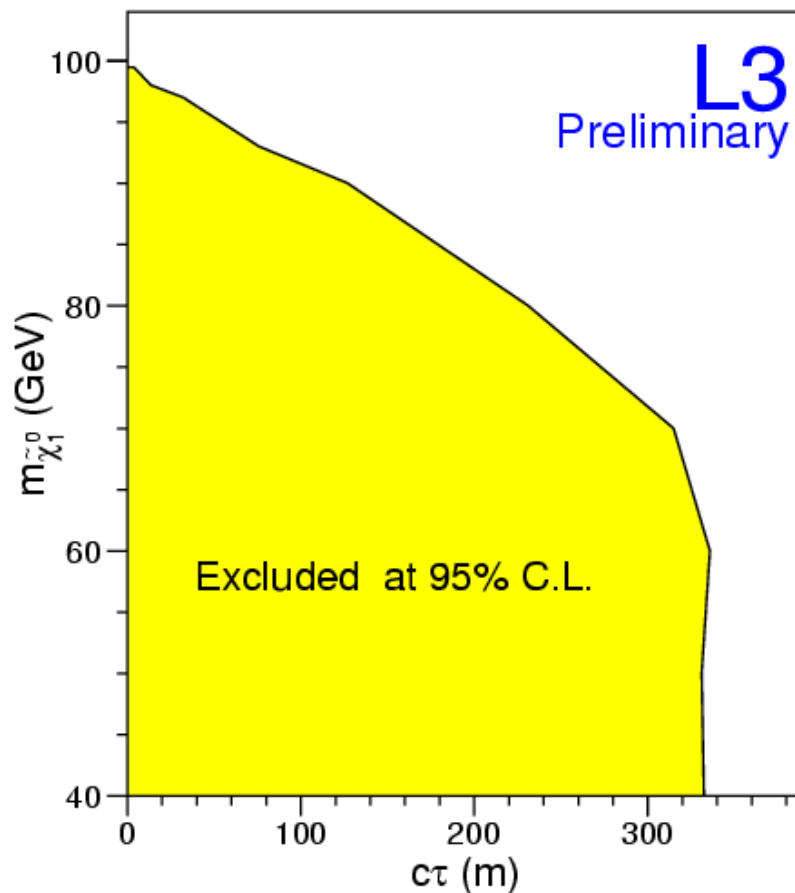
$$e^+ e^- \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0 \rightarrow \gamma \gamma \tilde{G} \tilde{G}$$

Monte Carlo expected



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

No signal observed





Search for Superlight Gravitinos

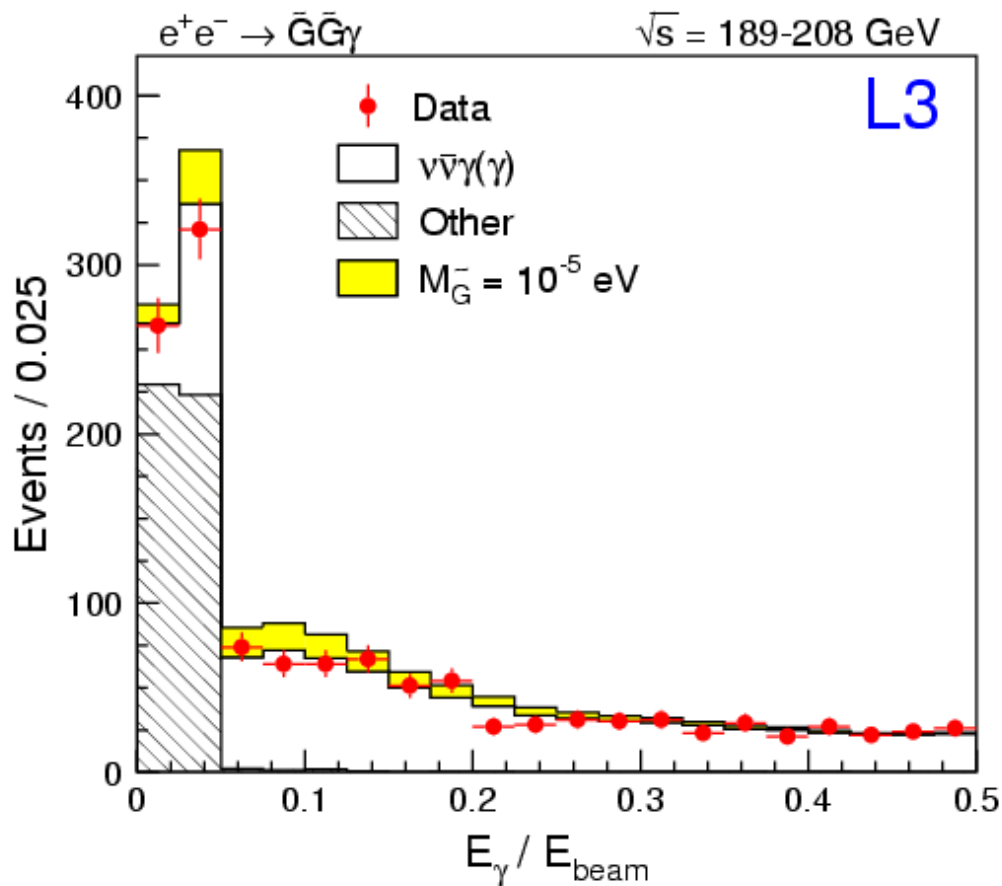


$$e^+ e^- \rightarrow \gamma \tilde{G} \tilde{G}$$

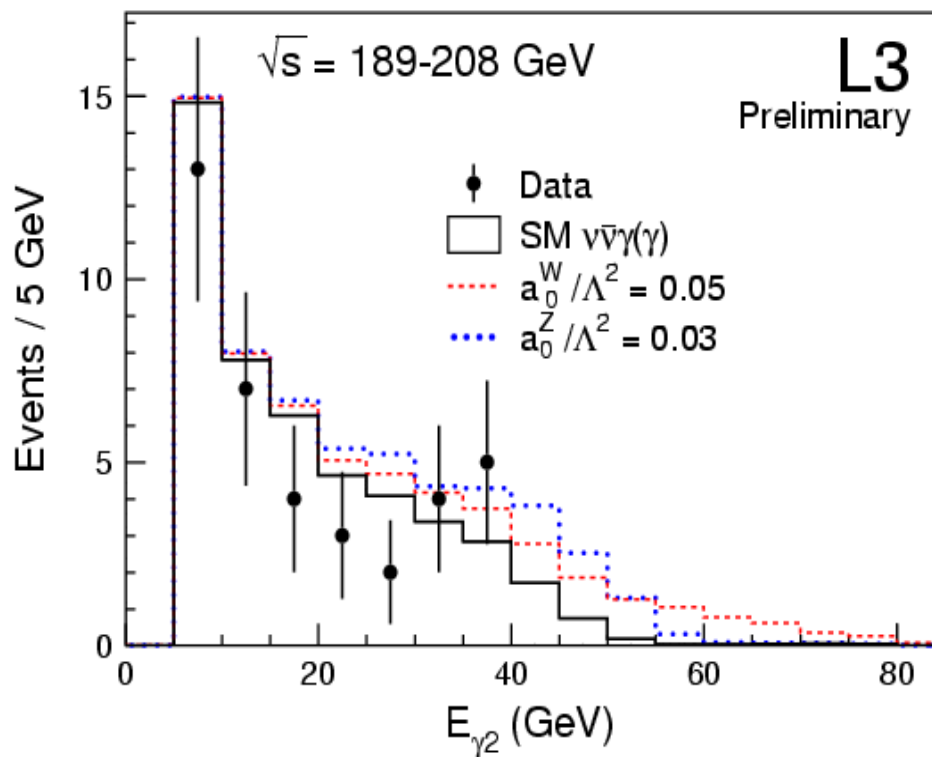
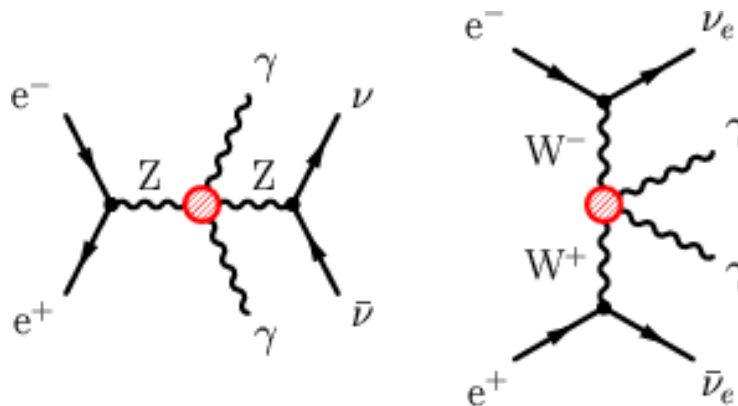
- ◆ Gravitino is light and all other SUSY particles are too heavy to be observed at LEP
- ◆ Pair production of gravitinos with a photon (ISR) leads to a single photon signature
- ◆ Search strategy similar to to extra dim. and production cross section is $\sim 1/M_{Gr}^4$

L3+DELPHI preliminary limit on the SUSY breaking scale

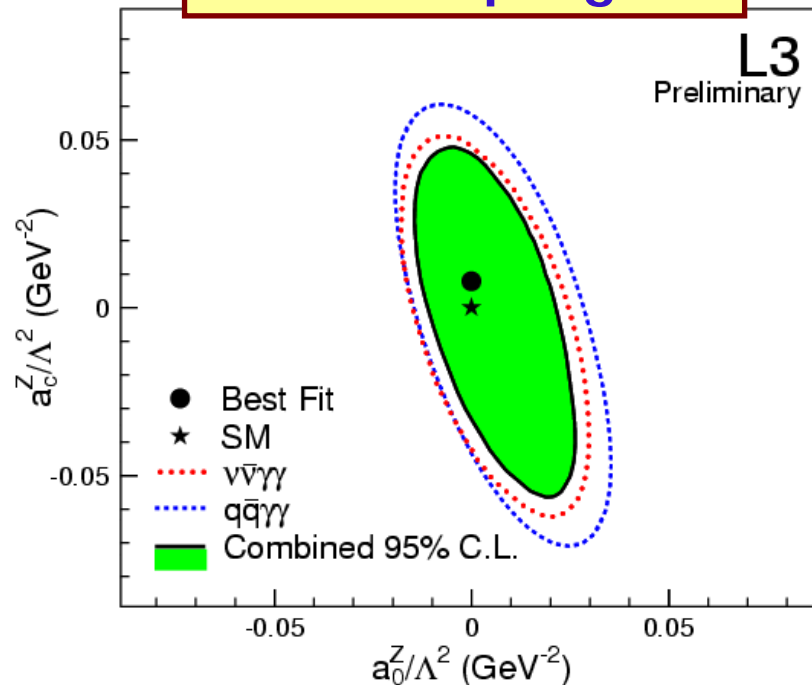
$$\sqrt{F} > 240 \text{ GeV}$$



- Anomalous quartic gauge interactions indicate New Physics
- Acoplanar photons provide unique sensitivity to both $WWgg$ and $ZZgg$
- A likelihood fit to the photon energy spectrum is performed and gives



Improved limits on the couplings





Summary



- ❖ **Deviations from the Standard Model are searched for in a wide range of new physics scenarios (only a brief review is given in this talk)**
- ❖ **New Physics effects are not found in differential and total cross sections nor in model dependent searches**
- ❖ **Thanks to H. Newman, S. Mele, S. Ask, W. Adam and to authors of the KK MC and NUNUGPV programs**
- ❖ **Final LEP combination and papers will be ready very soon**
Additional information can be found at

<http://l3.web.cern.ch/l3/>

<http://lepsusy.web.cern.ch/lepsusy/>

<http://lepexotica.web.cern.ch/LEPEXOTICA/>