(LEP, TEVATRON, HERA)

(BABAR, BELLE, CLEO, E821)

(DAMA)

(NUTEV, DONUT, SK, K2K)

Introduction: searches at LEP

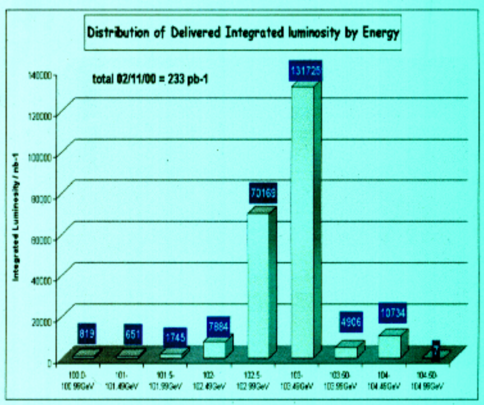
INDIRECT SEARCHES

		Bck at LEP2 (200 pb^{-1})	Sig. sens. ($1\sigma, \varepsilon \sim 50\%$)
	Constraints from SM measurement ($\sigma(ff\gamma)$, $\sigma(WW)$, $\sigma(\gamma\gamma)$,...)	$\sim 10^3$ ev	~300 fb
	Z', Contact interactions,...		
	Topological searches Anomalous (3-VB or 4-VB) couplings		
	New fermion families		
	Extra dimensions	$\sim 10^2$ ev	~100 fb
Mass peaks	Technicolor		
Mass peaks	Excited leptons		
Mass peaks	FCNC and single Top Leptoquarks		
More constrained models	RpV SUSY	$\sim 10^1$ ev	~30 fb
More constrained models	GMSB SUSY Constrained MSSM MSSM Higgs SM Higgs		
		$\sim 10^0$ ev	~10 fb

DIRECT SEARCHES

Most searches updated with year 2000 data:

- ☞ $202 < \sqrt{s} < 209$ GeV
- ☞ $\int \mathcal{L} \sim 220$ pb^{-1}



"Exotic" final states investigated at LEP2

(Excluding the Higgs sector)

	Contact Int.	Z'	Extra-dim.	GMSB SUSY	Mass. sgoldstino	Spont. RpV SUSY	RpV SUSY	Technicolor	Excited fermions	Anom. coupl.	New fermions	FCNC	LeptoQuarks
single-γ	X	X	X	X		X		X	X	X			
Non-pointing single-γ				X									
$\gamma\gamma E_{miss}$				X					X	X			
$\gamma\gamma(\gamma)$	X		X		X				X	X			
$ll(\gamma)$	X	X	X				X	X	X				
$jj(\gamma)$, $gg\gamma$	X	X	X		X			X		X			
$\tau\tau E_{miss}$				X		X							
$jjl\ E_{miss}$									X		X		X
jjjj, bjjj, bbjj							X	X				X	
$bjl\ E_{miss}$							X					X	X
$jj\ E_{miss}$													X
$ll\ E_{miss}$				X					X				
jjll													X
$WW(\gamma)$, ZZ, $Z\gamma$			X					X		X			
$Z\ E_{miss}$			X										
multi-l, multi-j							X						
$ll\gamma\gamma\ E_{miss}$				X					X		X		
multi-l E_{miss}				X									
"kinked" tracks				X							X		
heavy stable ptcs				X							X		

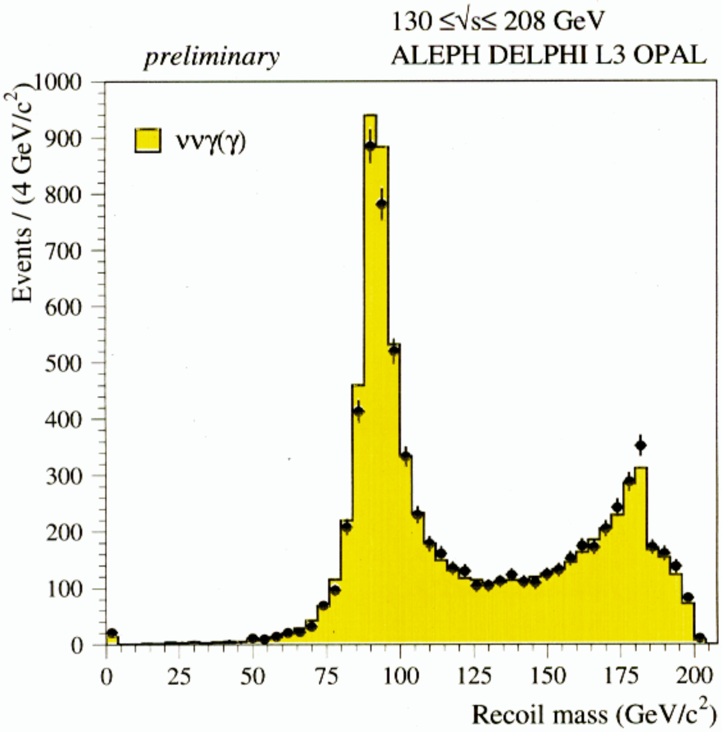
Single-photon final state

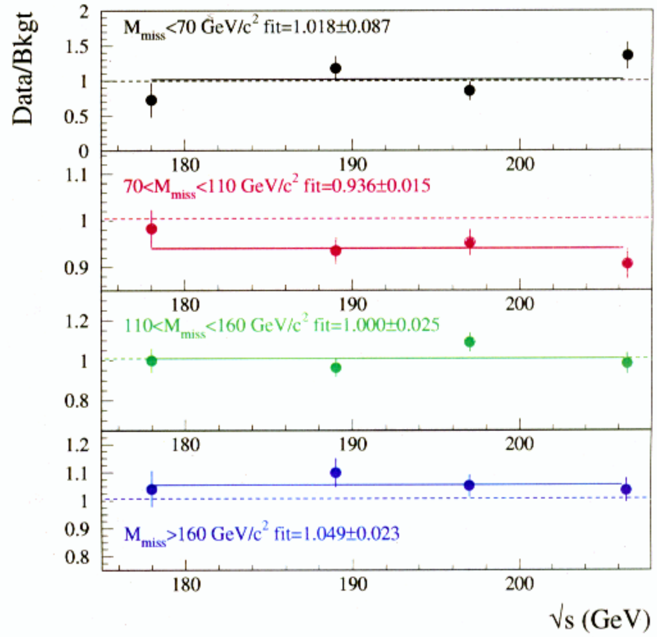
- Main SM source is $e^+e^- \to \nu\bar{\nu}\gamma$
- Special case of $e^+e^- \to ff(\gamma)$ SM process:
  - not coupled to the s-channel γ
  - sensitive to new neutral stable particles (X) produced via $e^+e^- \to X\gamma$ or $e^+e^- \to XX\gamma$ (Majorons, heavy ν, Gravitons (G), Gravitinos ($\tilde{G}$),Neutralinos,...)
- Deviations expected in the single-photon spectrum. For example:
  - $\frac{d^2\sigma(e^+e^- \to \gamma\tilde{G}\tilde{G})}{dx_\gamma d\cos\theta_\gamma} \sim \frac{s^3}{m^4_{\tilde{G}} x_\gamma \sin^2\theta_\gamma}$ when the other SUSY particles are heavy
  - $\frac{d^2\sigma(e^+e^- \to \gamma G)}{dx_\gamma d\cos\theta_\gamma} \sim \frac{s^{\delta/2}}{m^{\delta+2}_{G} x_\gamma \sin^2\theta_\gamma}$ with δ extra-dimensions
- both predict an excess of low-energy photons (at low polar angle)

$$\Downarrow$$

But this is what we do see in LEP data!

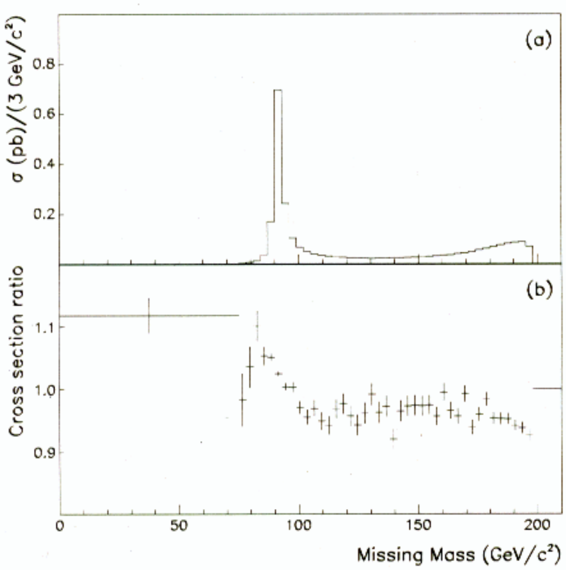
Single-photon final state



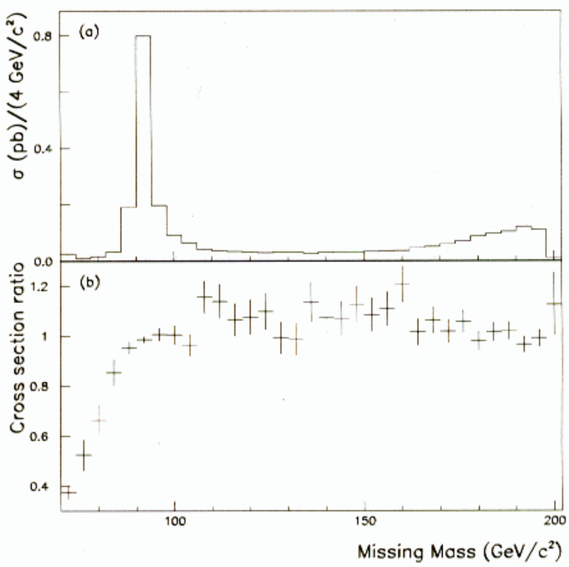


- Do we believe MC? (Koralz mostly used)
- NUNUGPV and Koralz do not agree, KK in the middle between the two

Koralz / NUNUGPV



NUNUGPV / KK

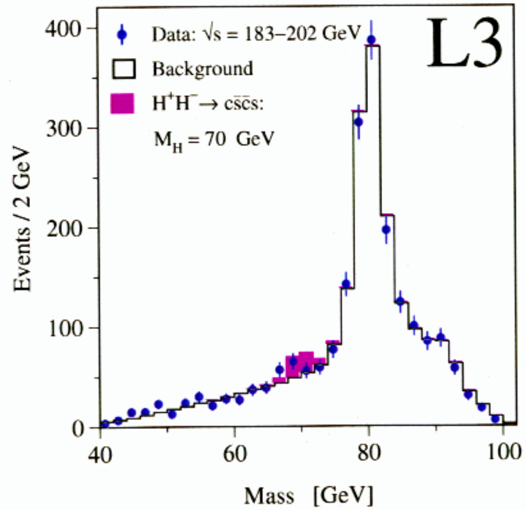


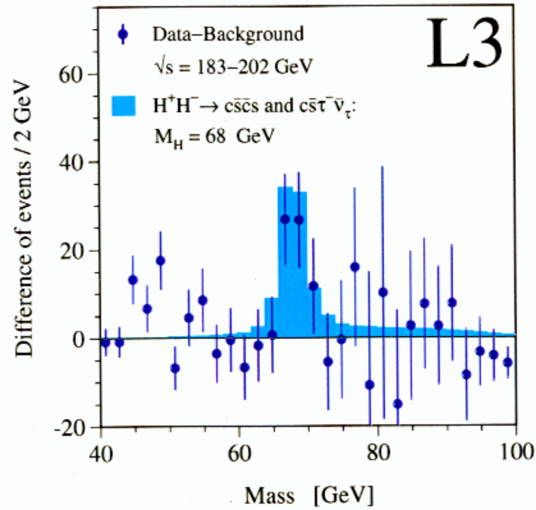
(Courtesy of G.Taylor (ALEPH))

Four-jet final states

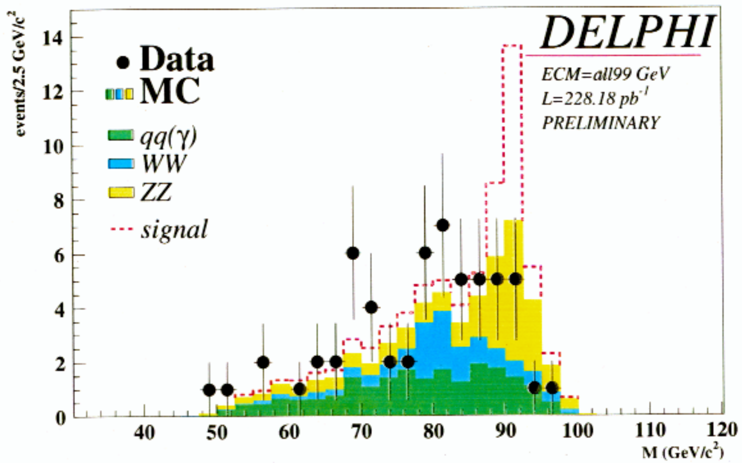
- Leading channel for Higgs search and W physics
- Jet-pairing can be a delicate issue
- Anomalies observed in the (recent) past:

Excess (2.7σ) at 68 GeV seen in L3 1999 $H^{\pm}$ analysis:





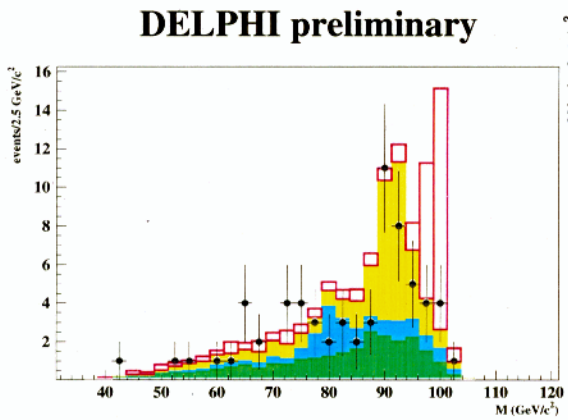
DELPHI technicolor search at Osaka (1999 data):

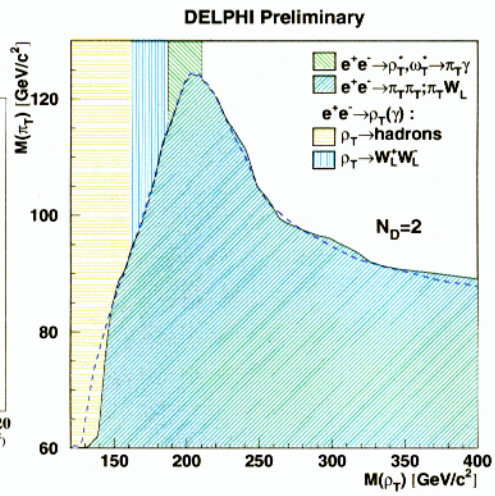


Four-jet final states (cont)

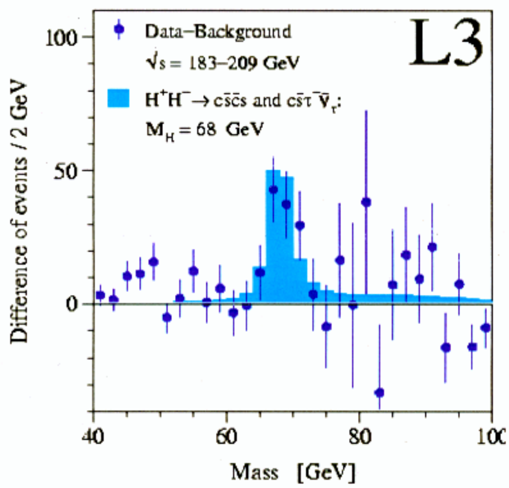
☞ Updates with year-2000 data:

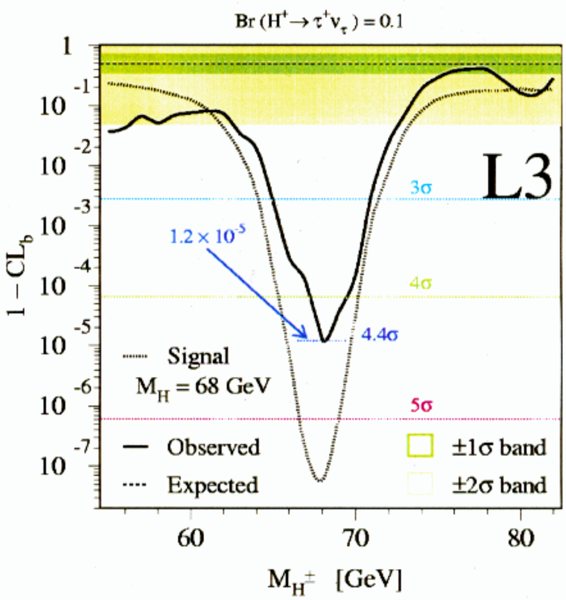
– DELPHI: good agreement with SM





– L3: anomaly confirmed and strengthened (now at 4.4σ)

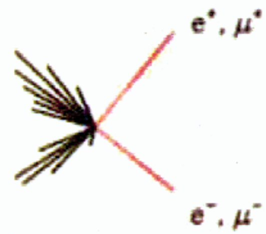
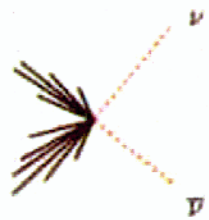
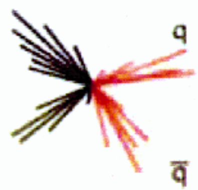
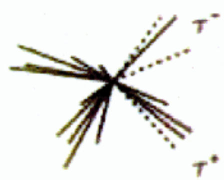




– ALEPH: slight deficit (for $m_{H\pm} \sim$65-70 GeV)

– OPAL: good agreement with SM

STANDARD MODEL HIGGS

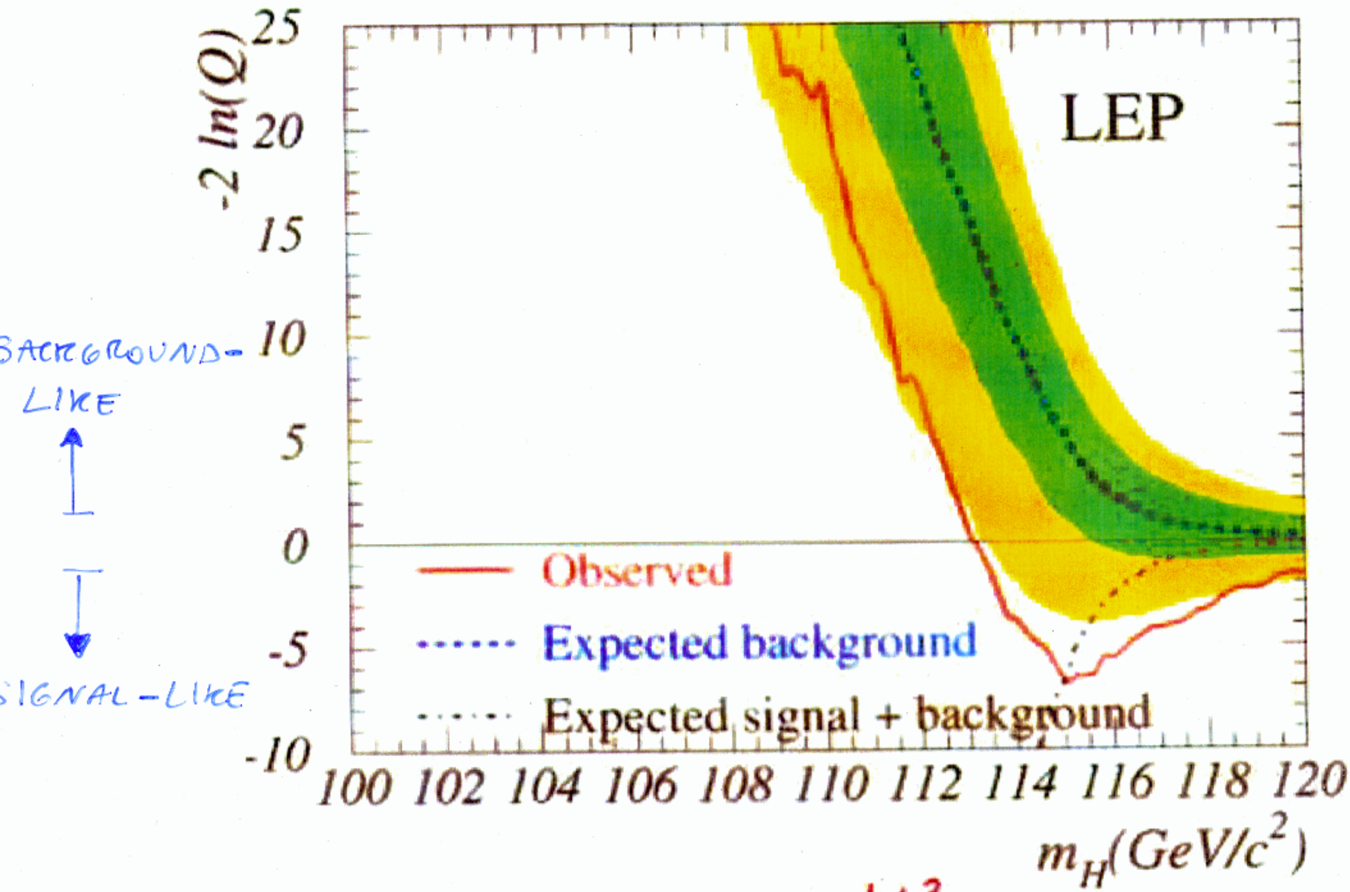
Channel	BR	Signature	
Leptonic channel $he^+e^-, h\mu^+\mu^-$	6.7 %		Two opp. charged $(e^+e^-, \mu^+\mu^-)$ isolated leptons $m_{\ell\ell} \sim m_Z$
Missing energy channel $h\nu\bar{\nu}$	20.0%		Large missing energy Acoplanar jets $\not{m} \sim m_Z$ b-tagging
Four-jet channel $hZ \rightarrow b\bar{b}q\bar{q}, b\bar{b}b\bar{b}$	52.5 %		Well isolated jets m_H, m_Z constraints b-tagging
$h\tau^+\tau^-, \tau^+\tau^- Z$	8.7%		'minijets': 1,3 tracks $m_{jets} \sim m_\tau$ Missing momentum

Likelihood ratio

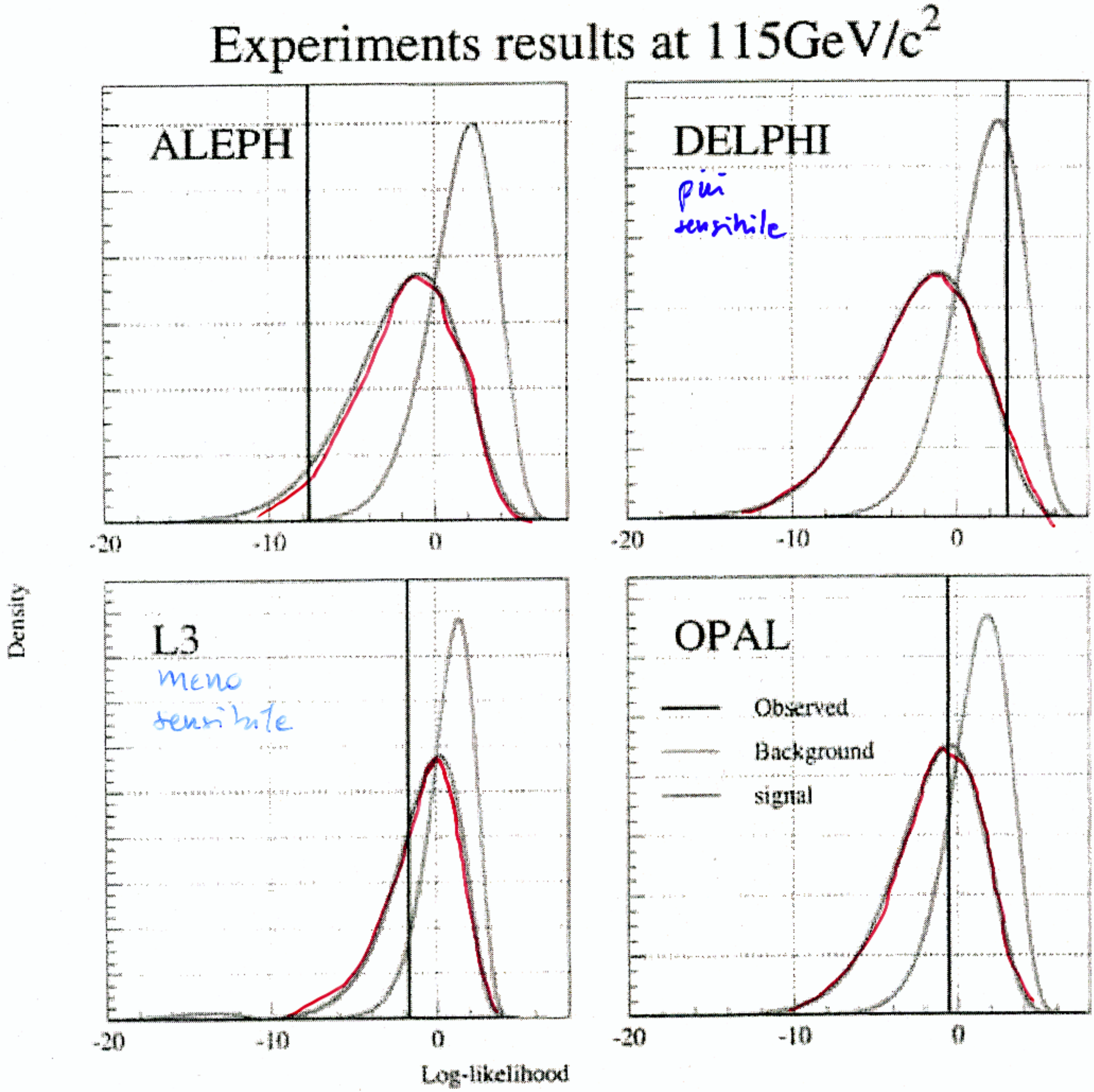
$$Q = \frac{P(n_{obs}; s + b) \times (S(\vec{x}_i) + B(\vec{x}_i))}{P(n_{obs}; b) \times B(\vec{x}_i)}$$

$$-2 \ln Q = 2 s_{tot} - 2 \sum_{i=1}^{n_{obs}} \ln\left(1 + \frac{S(\vec{x}_i)}{B(\vec{x}_i)}\right)$$

to combine different experiments/topologies/$\sqrt{s}$
simply add up respective $-2 \ln Q$ contributions:

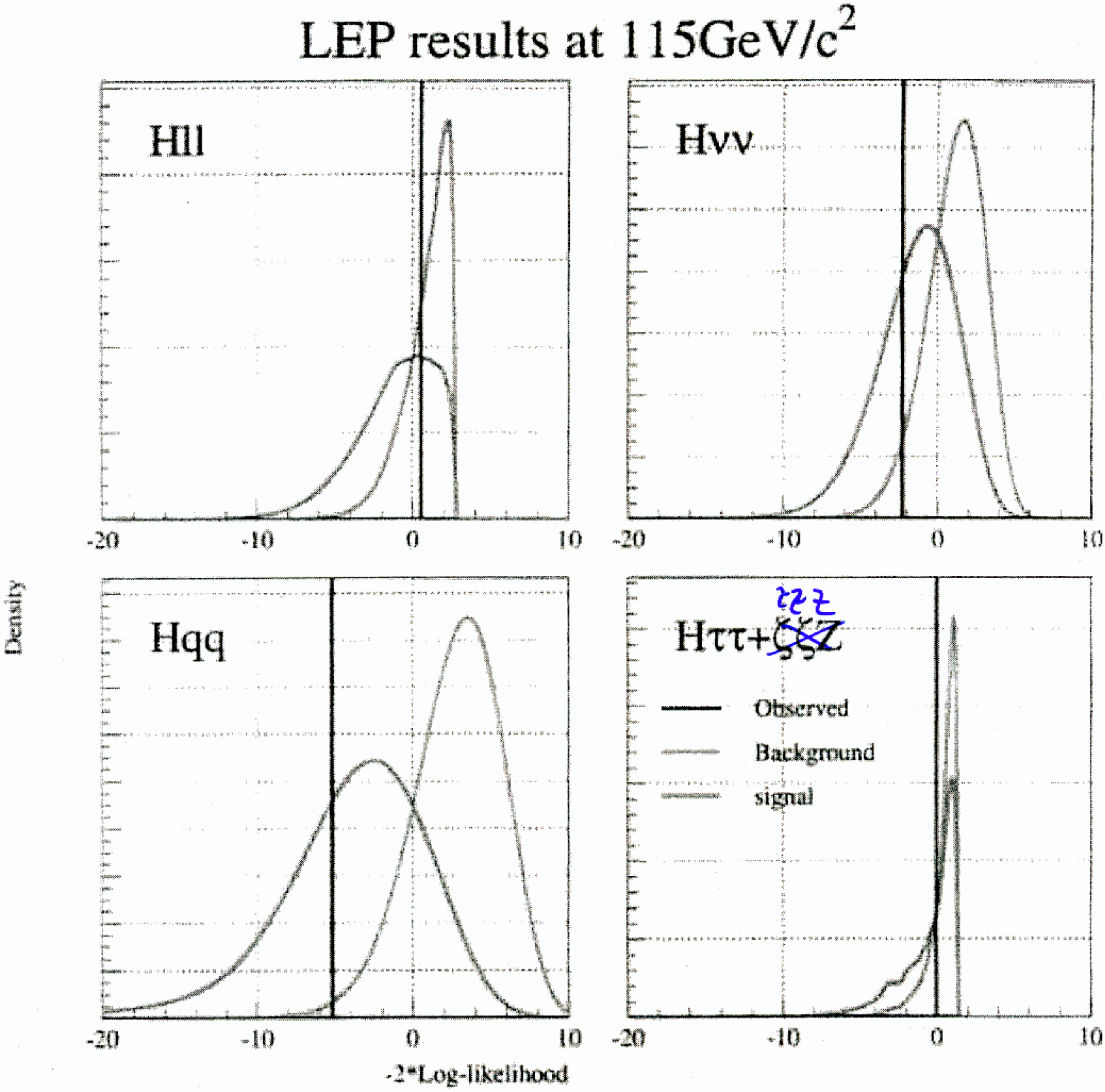


-2lnQ for b and s+b



➽ > 1 experiment signal-like

-2lnQ for b and s+b



➽ > 1 channel signal-like

Global fit with all the data

Include also the direct measurement of m_{top} and M_W

$$\mathrm{Log}(M_H) = 1.99 \pm 0.21$$

$$M_H = 98^{+58}_{-38}\ \mathrm{GeV}$$

$$m_{top} = 175.7 \pm 4.4\ \mathrm{GeV}$$

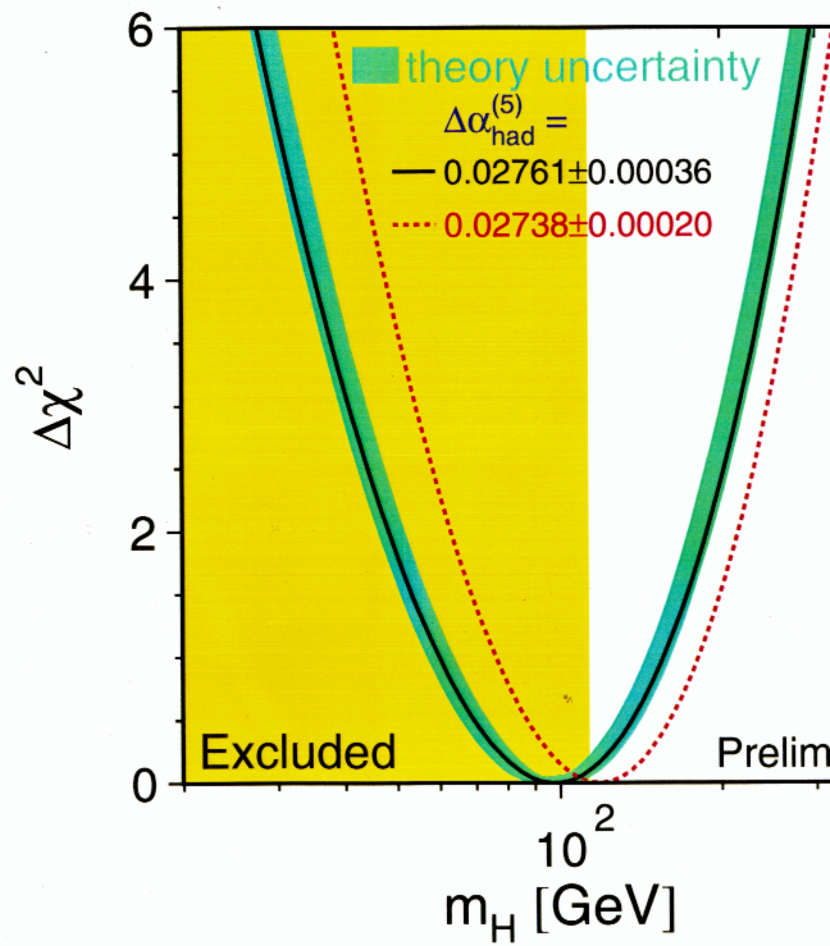
$$M_W = 80.393 \pm 0.019\ \mathrm{GeV}$$

$\Rightarrow M_H < 212$ GeV (95% C.L.)

$\chi^2 = 25/15$ - probability is only 4%!

new value of $\Delta\alpha^5_{had}$ shifts M_H by $+35$GeV

The error on $\mathrm{Log}(M_H)$ arising from $\Delta\alpha^5_{had}$ is reduced from 0.2 to 0.1 $\Rightarrow$ it is no longer the dominant error



Use ZFITTER and TOPAZ0 for the fit

The road ahead...

Significance at m_h=115 GeV

	Nov 3rd, 2000 combination		publication
ALEPH	3.4σ	$\rightarrow$	3.2σ
DELPHI	-1.0σ	$\rightarrow$	-1.0σ
L3	1.7σ	$\rightarrow$	?
OPAL	1.3σ	$\rightarrow$	1.3σ
	2.9σ		

=> some unknown systematics should be added!

L3 will be releasing their results in time for the combined LEP Higgs results to be prepared for the Summer conferences

CONCLUSIONI (PERSONALI)

SULL' HIGGS A 115 GeV

- Se l'Higgs esiste è vicino ai 115 GeV!
  (fit elettrodebole SM, constraints di SUSY)

- Se l'Higgs è vicino ai 115 GeV allora LEP lo ha trovato!
  (LEP ha visto ESATTAMENTE ciò che avrebbe potuto e dovuto vedere)

- LEP è stato chiuso prima che le sue potenzialità fossero sfruttate pienamente
  (altrimenti non saremmo qui a discuterne)

- L'Higgs a 115 GeV verrà sicuramente SCOPERTO o ESCLUSO dal Tevatron
  (la sensibilità di un esperimento cresce con la conoscenza del segnale)

100 pb

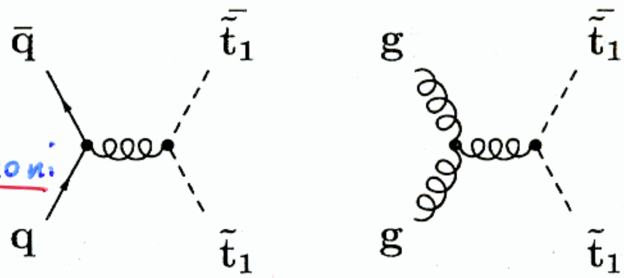
MSSM Stop Search

– Introduction –

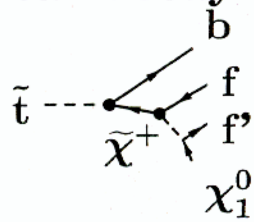
- **Each SM Quark q is predicted to have two scalar SUSY-Partners $\tilde{q}_R$,$\tilde{q}_L$**
  - **mixing with off-diagonal terms prop. to m_q**
  - **mass eigenstates $\tilde{q}_1$, $\tilde{q}_2$**
  - **due to large top quark mass $\tilde{t}_1$ can be very light**

$\rightarrow$ **look for $\tilde{t}_1\tilde{t}_1$ at the Tevatron:**

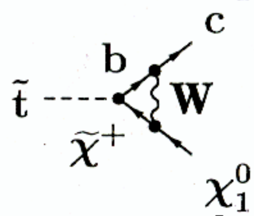
Sensibilità > LEP per particelle soggette alle interazioni forti!



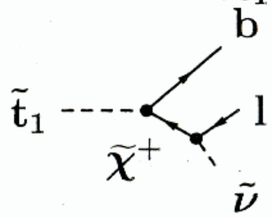
- **In the mass region of interest, $\tilde{t}_1$ can decay to:**



- $b\tilde{\chi}^+$ **(dominant if $m_{\tilde{t}}$ large enough)**



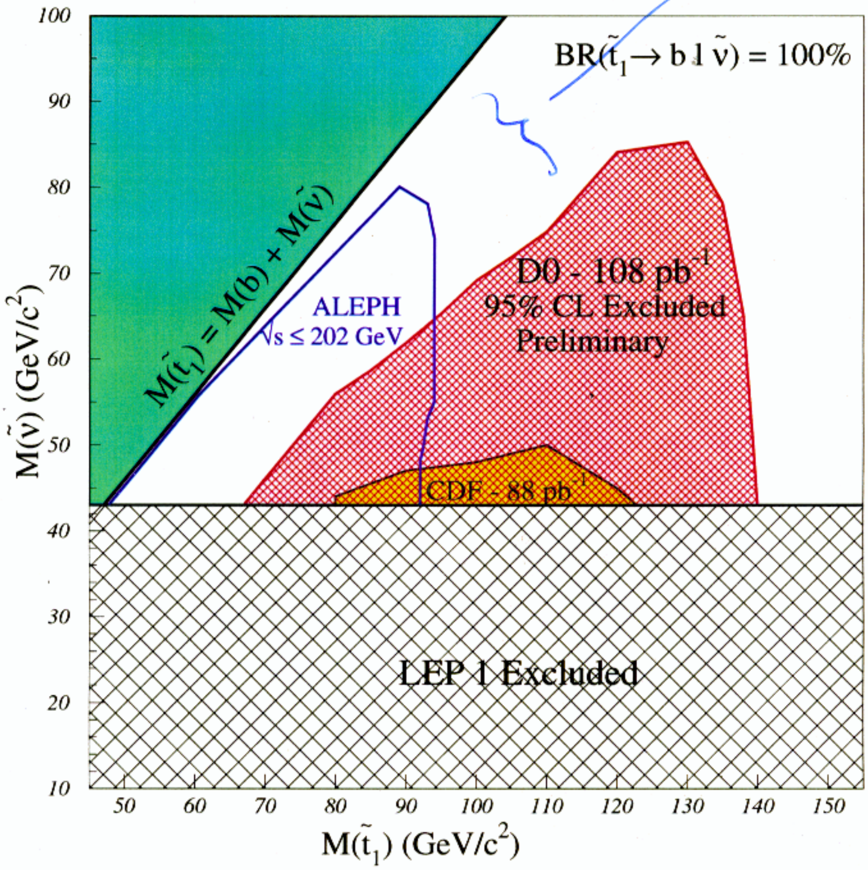
- $bff'\tilde{\chi}_1^0$ **(suppressed)**
- $c\tilde{\chi}_1^0$ **(suppressed)**
- $bl\tilde{\nu}$ **(dominant for light $\tilde{\nu}$)**



MSSM Stop Search

– Results –

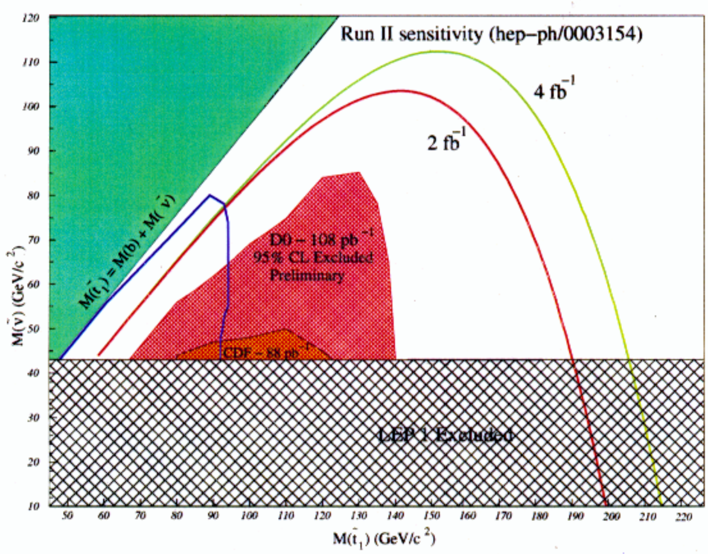
$m(\tilde{t}) - m(\tilde{\nu})$ piccolo
$\Rightarrow$ piccolo p_T^{lept}, p_T^{miss}



Tevatron Run II:

$\sqrt{s} = 2$ TeV, much higher luminosity

Expected Sensitivity estimated in MC studies



Sleuth = SEGUGIO

– Final States –

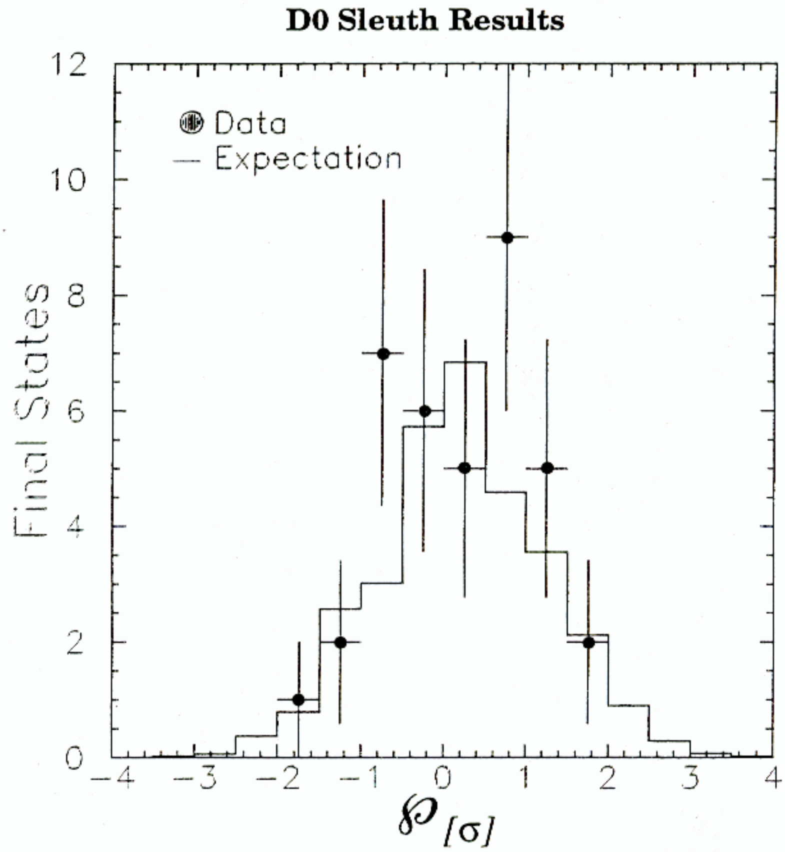
- **32 final states have been considered in D0 data:**
  - $e\mu X$
  - W + jets, e $\not{E}_t$ + jets
  - Z + jets, ee + jets, $\mu\mu$ + jets
  - $l/\gamma\ l/\gamma\ l/\gamma$ **X**
  - $W\gamma$
  - **dijets**
- **Standard ID criteria for** $e, \gamma, \mu, \not{E}_t, j$ **as defined and studied in previous analyses.**
- **Vector Bosons are reconstructed from leptons and** $\not{E}_t$**.**

CAVEAT: QUANDO SI CERCA AL BUIO LA SENSIBILITÀ È BASSA!

Sleuth

– Results –

Analysis has been run for all final states.



Taking into account the number of final states considered, the probability for getting a results "less interesting" is 11%.

⇒ NESSUNA DEVIAZIONE DAL MODELLO STANDARD

Multijet-$\not\!\!E_T$ Results
Visible Background Boxes
CDF Data (84 pb^{-1})

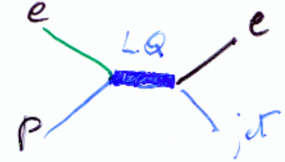
Bin	Description	EWK	QCD	All	Data
1	$\not\!\!E_T \geq 70, H_T \geq 150, N^{iso}_{track} > 0$	14	6.3	20±5	10
2	$\not\!\!E_T \geq 70, H_T < 150, N^{iso}_{track} = 0$	2.3	6.3	8.6±4.5	12
3	$35 < \not\!\!E_T < 70, H_T > 150, N^{iso}_{track} = 0$	1.95	135	137±28	134
4	$\not\!\!E_T > 70, H_T < 150, N^{iso}_{track} > 0$	1.73	-	1.73±0.3	2
5	$35 < \not\!\!E_T < 70, H_T > 150, N^{iso}_{track} > 0$	14	9.4	23.4±6	24
6	$35 < \not\!\!E_T < 70, H_T < 150, N^{iso}_{track} = 0$	5	413	418±69	410
7	$35 < \not\!\!E_T < 70, H_T < 150, N^{iso}_{track} > 0$	3.3	28	31±10	35
8	$\not\!\!E_T \geq 70, H_T \geq 150, N^{iso}_{track} = 0$	35	41	76±13	???
9	$35 < \not\!\!E_T < 70, H_T < 150$	8.2	441	449±72	445

Photon-Lepton Results
CDF Data (86 pb^{-1})

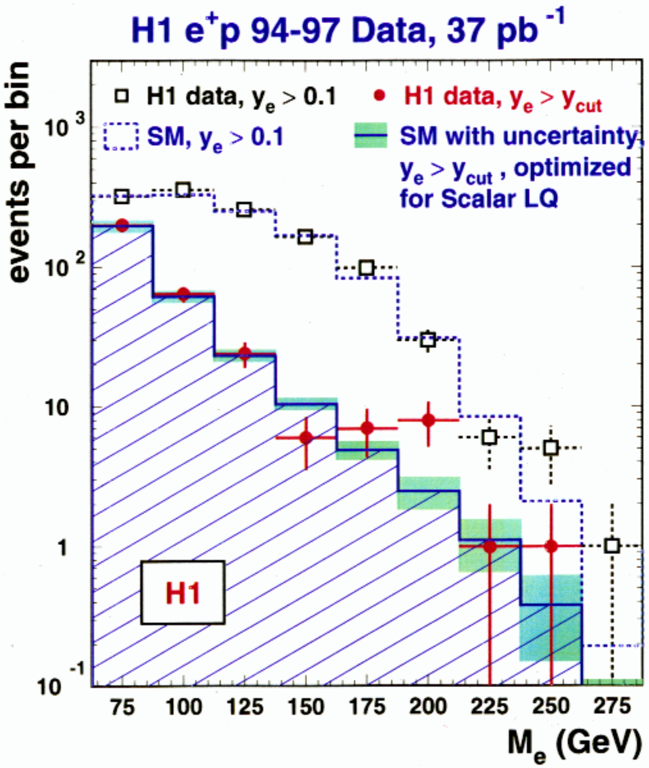
Category	μ_{SM}	N_0	$P(N \geq N_0 \mid \mu_{SM})$ %
All $\ell\gamma X$	—	77	—
Z-like $e\gamma$	—	17	—
Two-Body $\ell\gamma X$	24.9 $\pm$2.4	33	9.3
Multi-Body $\ell\gamma X$	20.2 $\pm$1.7	27	10.0
Multi-Body $\ell\ell\gamma X$	5.8 $\pm$0.6	5	68.0
Multi-Body $\ell\gamma\gamma X$	0.02 $\pm$ 0.02	1	1.5
Multi-Body $\ell\gamma \not{E}_T X$	7.6 $\pm$0.7	16	0.7

- $e\gamma \not{E}_T X$ 5 (3.4 ± 0.3)
- $\mu\gamma \not{E}_T X$ 11 (4.2 ± 0.5)

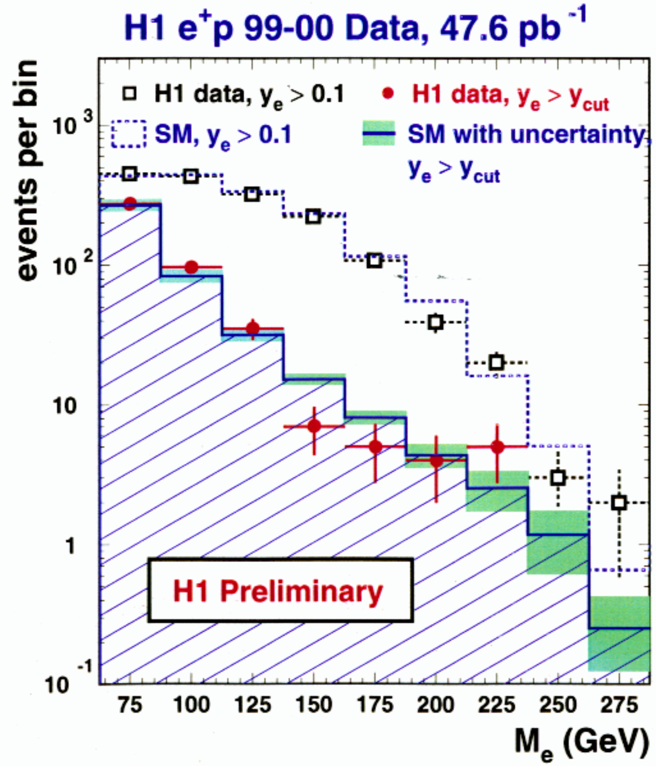
HERA



Resonance Search: old and new data



$\Rightarrow$



EUS: $x > 0.55$ ($M > 220$ GeV) and $y > 0.25$

events		0 events
.9 expected from SM	$\Rightarrow$	1.6 expected from SM
48 pb^{-1} 94-97)		(39 pb^{-1} 99-00 April)

xcess in old data not confirmed by new data of both experiments

The "Mystery" of H1's Isolated Leptons

observed an excess of high p_t isolated lepton events with large
ssing transverse momentum $\not{p}_t$ (H1 Coll. Eur.Phys.J. C5(1998) 575)

in selection cuts:

10 GeV, ≥ 1 track

12 GeV, $5^\circ < \Theta_\ell < 145^\circ$

> 12 GeV, $D_{\text{jet}} > 1$

- Main background:
  - W production
  - misidentified $\gamma\gamma \rightarrow \mu\mu$

H1 preliminary 994-2000 e^+p (82 pb^{-1})	Electrons Obs./expected (W)	Muons Obs./expected (W)
$p_t^X > 25$ GeV	$3/1.05 \pm 0.27$ (0.83)	$6/1.21 \pm 0.32$ (1.01)
$p_t^X > 40$ GeV	$2/0.33 \pm 0.10$ (0.31)	$4/0.46 \pm 0.13$ (0.43)

p_t^X = hadronic (jet) transverse momentum

cess found in both 94-97 e^+p data and 99-00 (Osaka) e^+p data

Comparison H1 - ZEUS of Isolated Leptons Events

er applying further cuts (ZEUS) to suppress non-W SM processes:

ZEUS preliminary 94-2000 e p (130 pb^{-1})	Electrons Obs./expected (W)	Muons Obs./expected (W)
$p_t^X > 25$ GeV	$1/1.14 \pm 0.06$ (1.10)	$1/1.2 \pm 0.16$ (0. 5)
$p_t^X > 40$ GeV	$0/0.46 \pm 0.03$ (0.46)	$0/0.50 \pm 0.08$ (0.41)

analysis (status Osaka):

H1 preliminary 94-2000 e^+p (82 pb^{-1})	Electrons Obs./expected (W)	Muons Obs./expected (W)
$p_t^X > 25$ GeV	$3/1.05 \pm 0.27$ (0.83)	$6/1.21 \pm 0.32$ (1.01)
$p_t^X > 40$ GeV	$2/0.33 \pm 0.10$ (0.31)	$4/0.46 \pm 0.13$ (0.43)

ackground consistent but with increasing integrated luminosity observed

vent yields were becoming more and more inconsistent in the last years

CP Violation in B decay

Belle	$\sin 2\phi_1 = 0.58^{+0.32}_{-0.34}(stat.)^{+0.09}_{-0.10}(syst)$
BaBar	$\sin 2\phi_1 = 0.34 \pm 0.20(stat.) \pm 0.05(syst)$
CDF	$\sin 2\phi_1 = 0.79^{+.41}_{-.44}$
World Average	$\sin 2\phi_1 = 0.48 \pm 0.16$

It is my view that CP violation is established

$\mathcal{B}(b \to s\gamma)$ and γ energy spectrum (I)

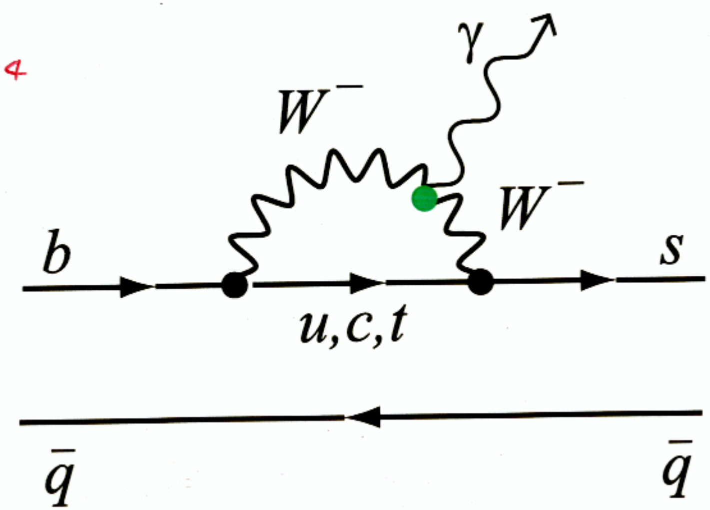
NEW

CLEO: $(2.85 \pm 0.35 \pm 0.22) \times 10^{-4}$

BELLE: $(3.37 \pm 0.53 \pm 0.42 \pm 0.50) \times 10^{-4}$

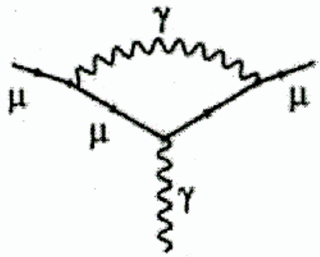
ALEPH: $(3.11 \pm 0.80 \pm 0.72) \times 10^{-4}$

AVERAGE: $(2.96 \pm 0.35) \times 10^{-4}$ ⇩

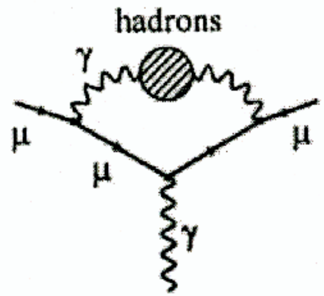


- Pure electroweak penguin ($\to V_{ts}^* V_{tb}$)
- Sensitive to new physics
- SM prediction : $\mathcal{B}(b \to s\gamma) = (3.28 \pm 0.33) \times 10^{-4}$ ⇧ ⇒ IMPLICAZIONI IN SUSY: $\mu > 0$ (higgs mixing parameter)
- Photon energy in range $2.0 < E_\gamma < 2.7\text{GeV}$
- γ spectrum $\to$ helps extracting V_{ub} and V_{cb}
- Probes HQET parameters $\bar{\Lambda}$ and λ_1 via moments

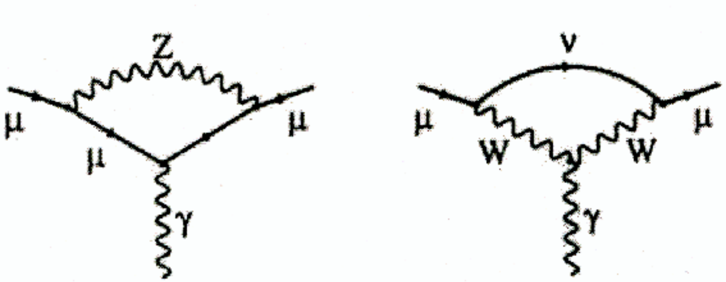
SOURCES OF THE MUON MAGNETIC ANOMALY



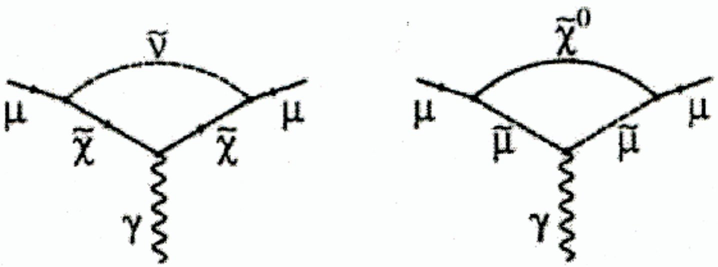
$$\Delta a_\mu(\mathrm{QED}) = \frac{\alpha}{2\pi} \simeq 10^{-3}$$



$$\Delta a_\mu(\mathrm{had}) \simeq 7 \cdot 10^{-8}$$



$$\Delta a_\mu(\mathrm{EW}) \simeq 1.5 \cdot 10^{-9}$$



$$\Delta a_\mu(\mathrm{SUSY}) \simeq \left(\frac{100\,\mathrm{GeV}}{M_{\mathrm{SUSY}}}\right)^2 \tan\beta \cdot \Delta a_\mu(\mathrm{EW}$$

BNL E821 accuracy (planned): $\Delta a_\mu^{\mathrm{exp}} \simeq 0.4 \cdot 10^{-9}$

E821 EXPERIMENT

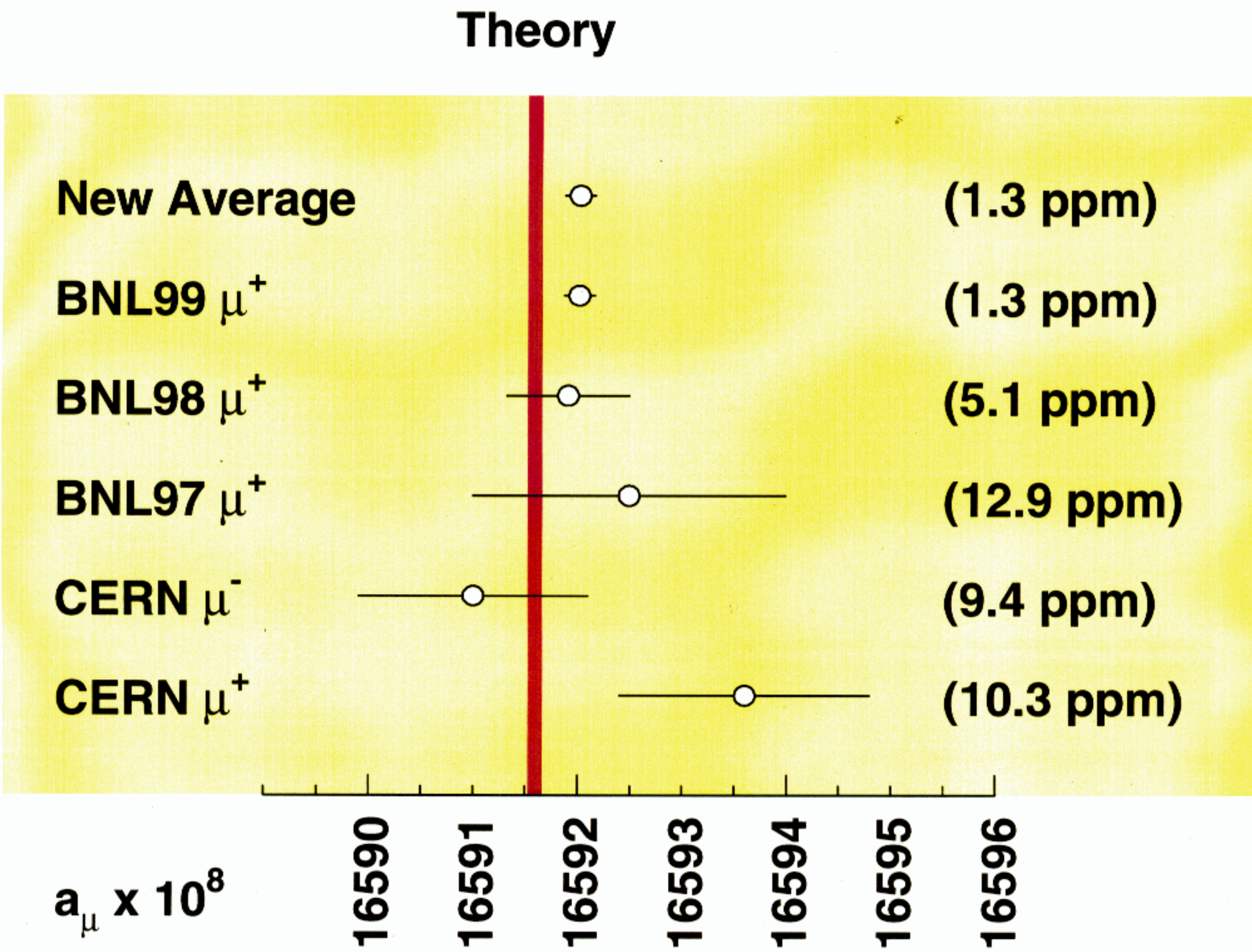
Measuring $(g-2)_\mu$ with a precision of 1.3 ppm

by

Gerco Onderwater

- Theoretical Foundation;
- Experimental Method;
- Result;
- Conclusion.

Boston, BNL, BINP, Cornell, Fairfield, Heidelberg, Illinois, KEK, Minnesota, Tokyo, Yale



$$a_\mu^{theory} = 116\,591\,596(67)\times10^{-11} \quad (0.57 \text{ ppm})^\dagger$$
$$a_\mu^{expt} = 116\,592\,03(15)\times10^{-10} \quad (1.3 \text{ ppm})^\ddagger$$

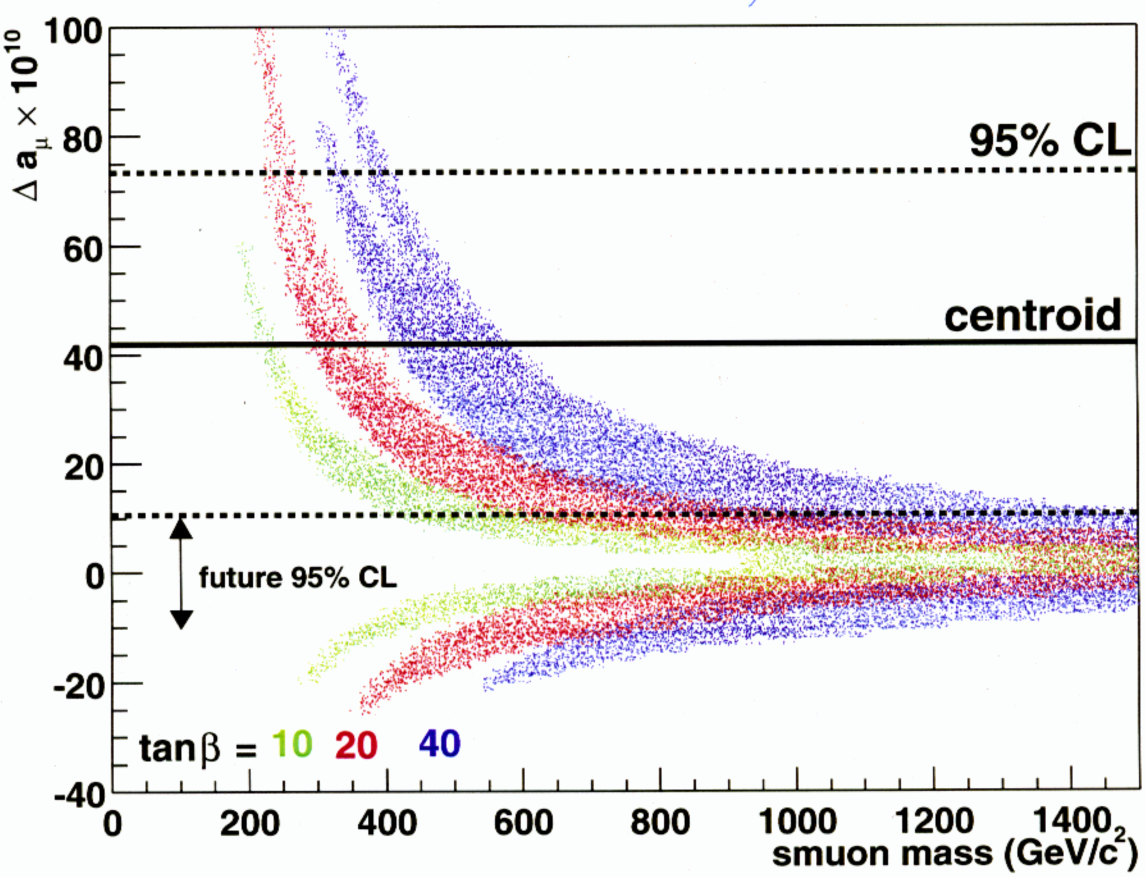
$$a_\mu^{expt} - a_\mu^{theory} = 42(16)\times10^{-10}$$

† A. Czarnecki and W.J. Marciano, hep-ph/9810512; Santander 1998, Tau'98, 245-252

‡ Combining all measured values from CERN and BNL

What if $\Delta a_\mu = a^{SUSY}$?

$\mu > 0$ favorito!



At 95% CL, the left-handed scalar muon mass must by smaller than 600, 900 and 1500 GeV/c^2 for $\tan\beta$ 10, 20 and 40, respectively.

Data from T. Goto, Y. Okada and Y. Shimizu, hep-ph/9908499 for minimal supergravity.

This is speculative, because $\Delta a_\mu = \sum a^{NewPhysics}$.

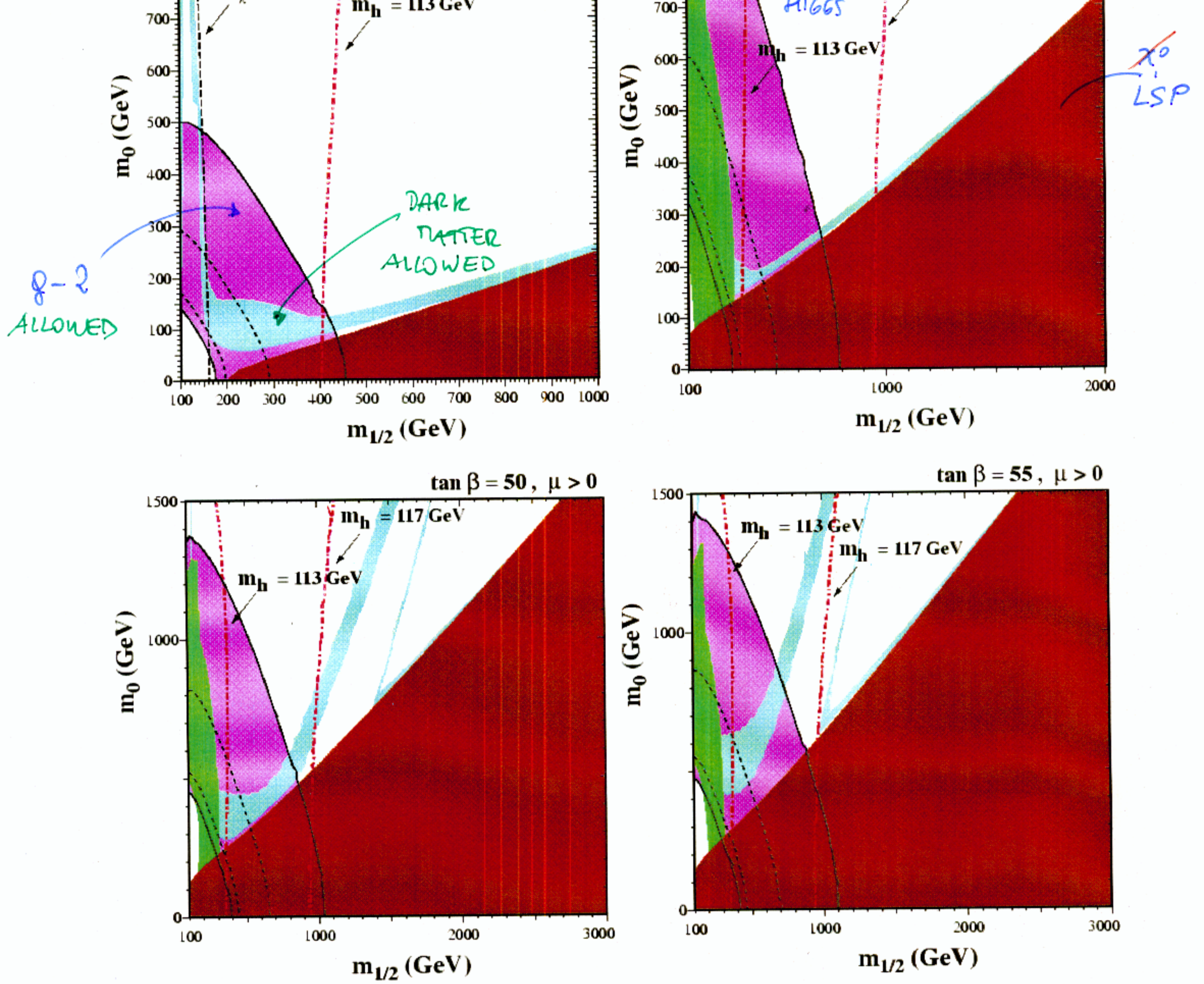


Figure 1: *The* $(m_{1/2}, m_0)$ *planes for* $\mu > 0$ *and* $\tan\beta =$ *(a) 10, (b) 30, (c) 50 and (d) 55, found assuming* $A_0 = 0, m_t = 175$ *GeV and* $m_b(m_b)^{\overline{MS}}_{SM} = 4.25$ *GeV. The near-vertical (red) dot-dashed lines are the contours* $m_h = 113, 117$ *GeV, and the near-vertical (black) dashed line in panel (a) is the contour* $m_{\chi^\pm} = 104$ *GeV. The medium (dark green) shaded regions are excluded by* $b \to s\gamma$*. The light (turquoise) shaded areas are the cosmologically preferred regions with* $0.1 \leq \Omega_\chi h^2 \leq 0.3$*. In the dark (brick red) shaded regions, the LSP is the charged* $\tilde{\tau}_1$*, so this region is excluded. The regions allowed by the E821 measurement of* a_μ *at the 2-*σ *level are shaded (pink) and bounded by solid black lines, with dashed lines indicating the 1-*σ *ranges.*

⇒ GOOD NEWS FOR LHC

Results from DAMA experiment

DAMA coll.
Roma2, Roma, IHEP/Beijing

see also DAMA site on: www.lngs.infn.it

P. Belli
INFN - Roma2

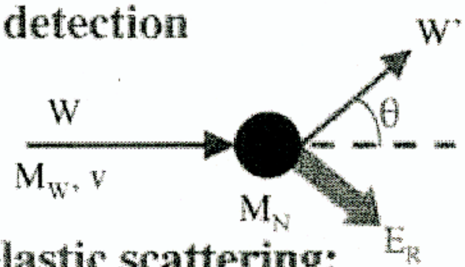
XXXVI Rencontres de Moriond
March 2001

WIMP direct detection

- WIMPs: relic Cold Dark Matter particles from primordial Universe
- in thermal equilibrium in the early stage of the Universe
- non relativistic at the decoupling time
- $<\sigma_{ann} v> \sim (10^{-26}/\Omega_W h^2)\ cm^3 s^{-1}$ $\sigma_{ordinary\ matter} \sim \sigma_{weak}$
- expected flux: $\sim 10^7\ (1GeV/m_W)\ cm^{-2}\ s^{-1}$ $(0.2<\rho_{halo}<0.7\ GeVcm^{-3})$
- form a dissipationless (or quasi-) gas trapped in the gravitational field of Galaxy (velocity $\sim 10^{-3}$ c)

A candidate must be neutral, stable (or τ~age of Universe) and massive

- **Direct detection**



by inelastic scattering:

^{127}I (Eijiri et al.), ^{129}Xe (DAMA/LXe); good signature but very large exposure are necessary and very low counting rates.

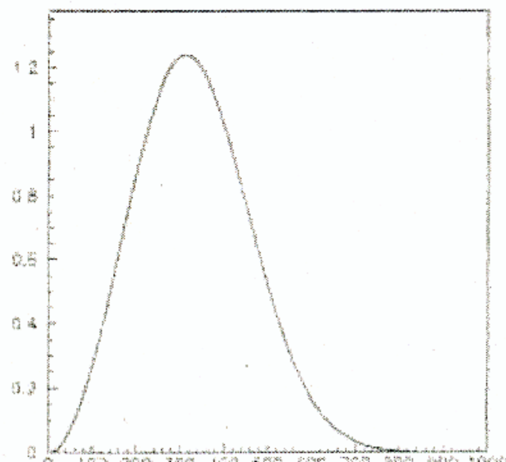
^{127}I: NP B35 (1994) 400
^{129}Xe: PLB 387 (1996) 222
New Jou. of Phys. 2(2000)15.1

by elastic scattering:

$$\frac{dR}{dE_R} = N_T \frac{\rho_W}{M_W} \int_{v_{min}}^{v_{max}} v \cdot f(v \mid v_{\oplus}) \frac{\sigma_{point-like}}{E_{R\max}} F^2(E_R) dv$$

$$v_{min} = \sqrt{\frac{M_N \cdot E_R}{2 \cdot m_{red}^2}} \qquad E_{R\max} = \frac{2 \cdot m_{red}^2 \cdot v^2}{M_N}$$

$v_{\oplus}$ = Earth velocity in the galactic frame



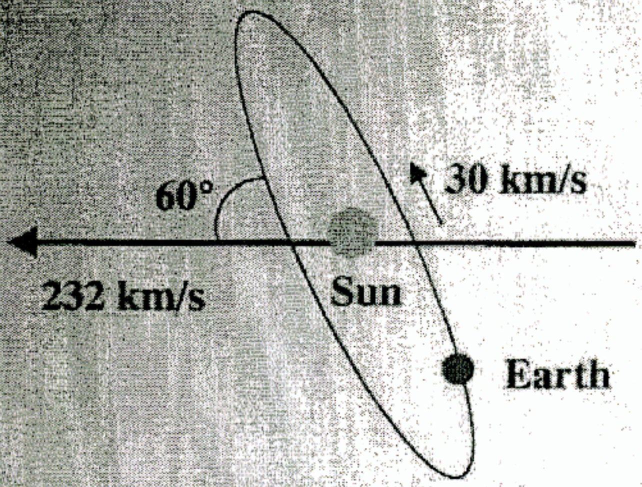
Measured quantity : E_R in the keV region (quasi-exponential behaviour)

...ing for a distinctive ...gnature for WIMPs?

- **Annual modulation of the rate**

  The only feasible one

- Drukier, Freese, Spergel PRD86
- Freese et al. PRD88



- $v = 232$ km/s (Sun velocity in the halo)
- $v_{orb} = 30$ km/s (Earth velocity around the Sun)
- $\gamma = \pi/3$
- $\omega = 2\pi/T$ $\quad T = 1$ year
- $t_0 = 2^{nd}$ June (when $v_{\oplus}$ is maximum)

$$v_{\oplus}(t) = v + v_{orb}\cos\gamma\cos[\omega(t-t_0)]$$

$$S_k[\eta(t)] = \int_{\Delta E_k} \frac{dR}{dE_R} dE_R \cong S_{0,k} + S_{m,k}\cos[\omega(t-t_0)]$$

→ expected rate in given energy bin change because the yearly motion of the Earth around the Sun moving in the Galaxy

- **Annual modulation is a distinct signature**

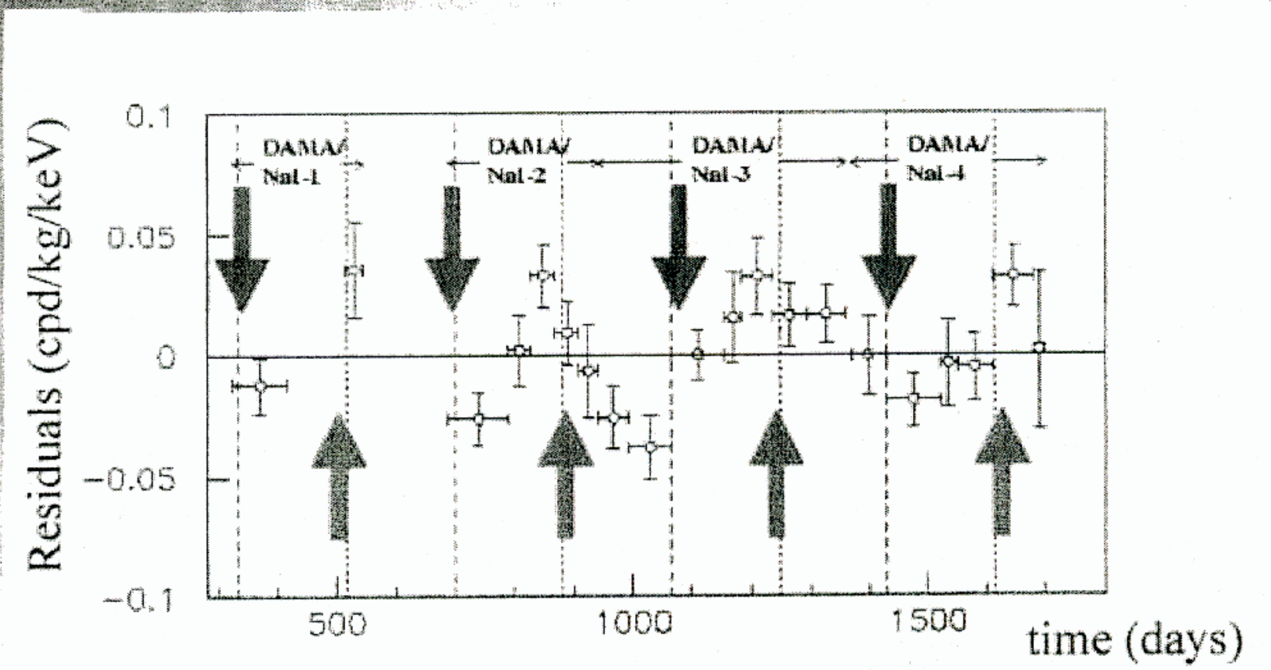
1) Modulated rate according cosine
2) In a definite low energy range
3) With a proper period (1 year)
4) With proper phase (about 2 June)
5) For single hit in a multi-detector set-up
6) With modulated amplitude in the region of maximal sensitivity < 7%

To mimic this signature, the spurious effects and side reactions must satisfy

model independent result

2-6 keV residuals of the rate vs time

- 4 annual cycles
- 57986 kg day



$A \cos[\omega(t-t_0)]$

χ^2_0 (A=0)/dof = 48/20 (P = 4 x 10^{-4})

1) t_0 = 152.5 days (fixed)
A=(0.022±0.005) cpd/kg/keV
T=2π/ω=(1.00± 0.01) years
χ^2 / dof = 23/18

2) T = 1 years (fixed)
A = (0.023 ± 0.005) cpd/kg/keV
t_0 = (144 ± 13) days
χ^2 / dof = 23/18

Global analysis in the given scenario

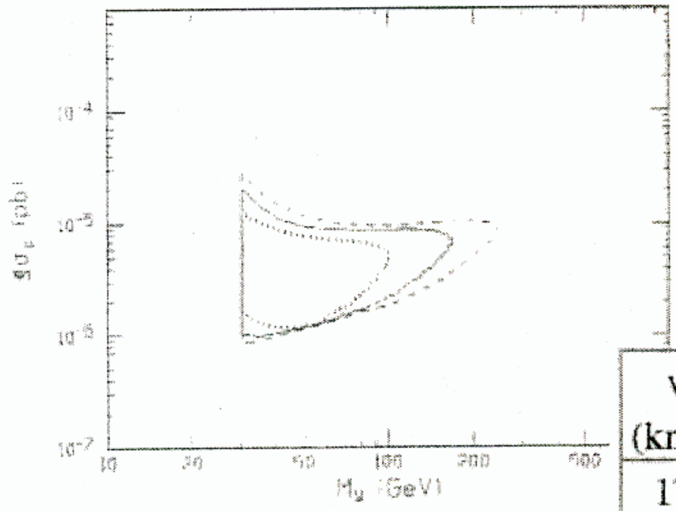
- **SI coupling**
- **DAMA/NaI-0 to 4**
- **Accounting for v_0 uncertainties**

- $v_0 = 220$ km/s (dotted)
- $v_0 = (220 \pm 50)$ km/s (90% C.L.) (solid)
  $v_{esc} = (550 \pm 100)$km/s (90% C.L.) ←negligible effect

$30 \text{ GeV} \leq M_W \leq 105 \text{ GeV}$ (1σ C.L.)

- including possible Dark halo rotation (dashed)

$30 \text{ GeV} \leq M_W \leq 132 \text{ GeV}$ (1σ C.L.)



~ 4σ C.L.

v_0 (km/s)	M_W (GeV)	$\xi\sigma_p$(pb)
170	72^{+18}_{-15}	$(5.7 \pm 1.1)10^{-6}$
220	43^{+12}_{-9}	$(5.4 \pm 1.0)10^{-6}$
270	32^{+8}_{-7}	$(5.7^{+1.2}_{-1.1})10^{-6}$

In progress: investigation of the effect of halo models, WIMP velocity distributions, uncertainties associated to all experimental and theoretical parameters.

SEGNALE COMPATIBILE NON SOLO CON SUSY MA ANCHE CON
IL LEP-HIGGS A 115 GeV !!

DFTT 51/2000

Implications of a possible 115 GeV supersymmetric Higgs boson on detection and cosmological abundance of relic neutralinos

A. Bottino, N. Fornengo and S. Scopel *
Dipartimento di Fisica Teorica, Università di Torino
and INFN, Sez. di Torino, Via P. Giuria 1, I–10125 Torino, Italy

Abstract

We show that a supersymmetric neutral Higgs boson with a mass of about 115 GeV and with the other prerequisites required by the LEP Higgs events would be compatible with the detection of relic neutralinos in current set–ups for WIMP direct search. Thus this putative Higgs would fit remarkably well in an interpretation in terms of relic neutralinos of the annual–modulation effect recently measured in a WIMP direct experiment. We also show that the cosmological abundance of the relevant neutralinos reaches values of cosmological interest.

DAMA →

Recent Results from the *NuTeV Experiment* at Fermilab

Michael Shaevitz
Fermilab and Columbia University
for the NuTeV Collaboration

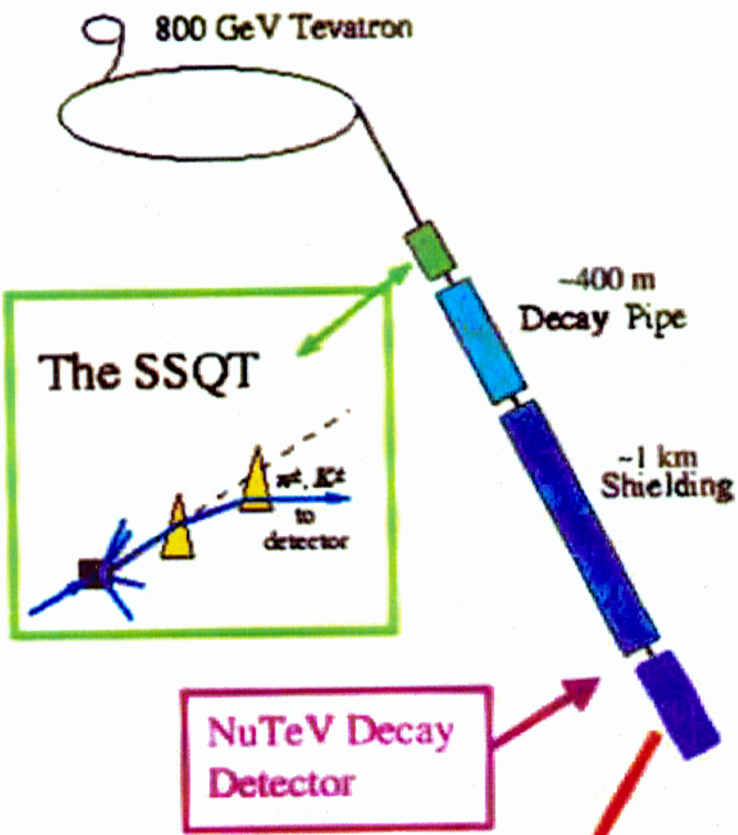
- Introduction to the NuTeV experiment
- Short update on $\sin^2\theta_W$ measurement
- Inverse muon decay xsec measurement and lepton number violation search
- Search for Long-lived Neutral Particles in the NuTeV "Decay Channel Detector"

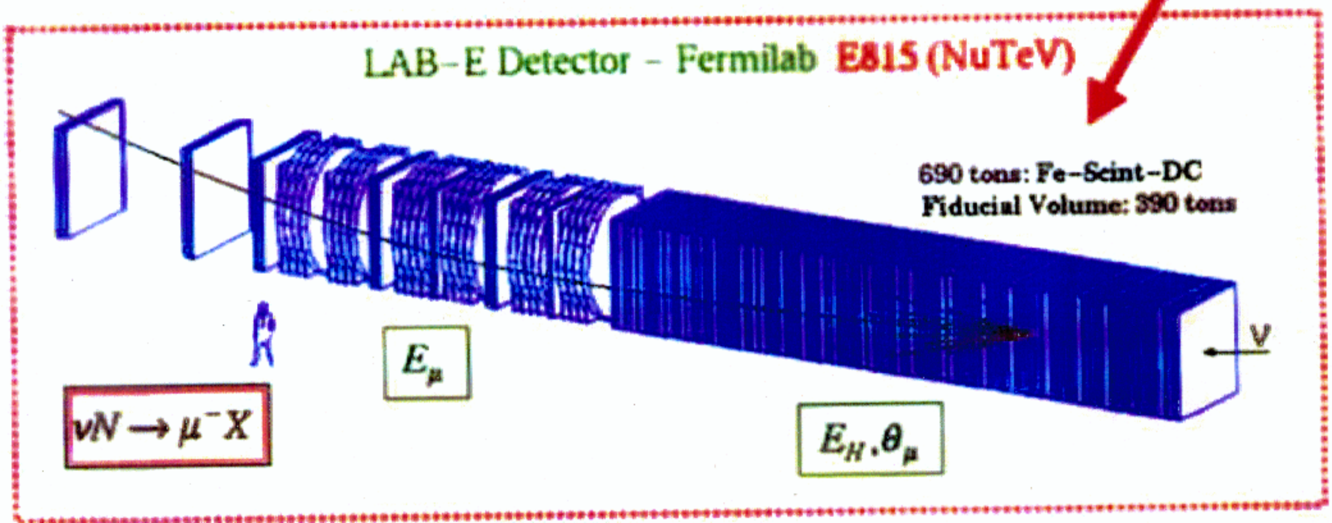
⇒ "NuTeV Anomaly"

NuTeV Neutrino Experiment

- Tevatron 800 GeV primary proton → π and K meson (Sign-selected Quad Triplet *SSQT* beam) → ν_μ and $\bar{\nu}_\mu$

- 1996-97 Data Run
- ~4.5 million ν and $\bar{\nu}$ interactions (6:1 ratio)



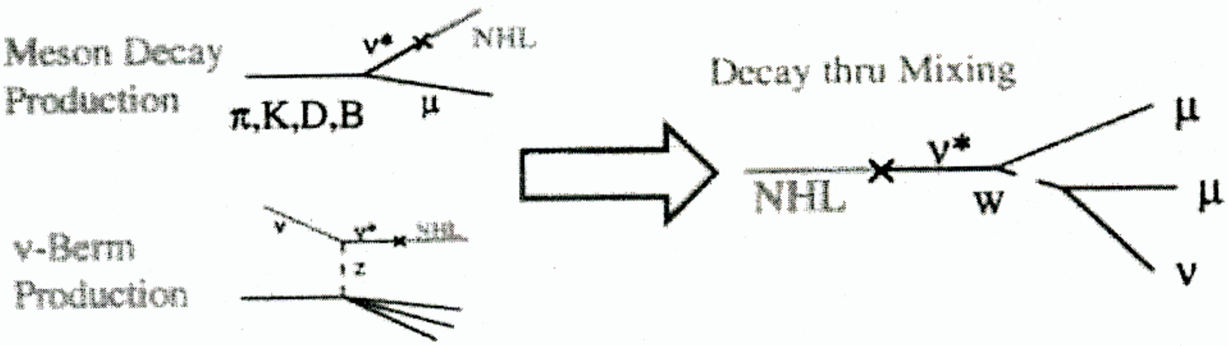


NuTeV Decay Detector Search for N^0's

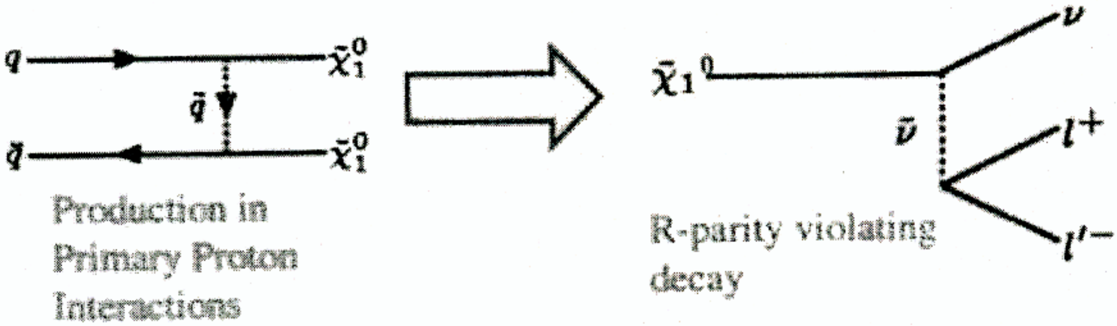
Search for few-GeV, long-lived neutral particles (N^0's) that decay into two charged tracks ($\mu\mu\nu$, $\mu e\nu$, $\mu\pi$)

Examples:

- Neutral Heavy Leptons (NHLs)
  - Isosinglet ("sterile") heavy neutrinos that are produced and decay through mixing with ordinary neutrinos



- Neutralinos
  - Long-lived neutralinos which decay through R-parity violation ($\gamma c\tau \sim 500$ - 5000m)



CONCLUSIONI

- LEP HA SCOPERTO L'HIGGS
- DAMA HA SCOPERTO IL NEUTRALINO
- B-FACTORIES HANNO SCOPERTO $C\!\!\!/P$ NEI B's
- DONUT HA SCOPERTO CHE $\nu_\tau \xrightarrow{CC} \tau$
- SK HA SCOPERTO CHE $\nu_\mu \longrightarrow \nu_\tau$
- $(g-2)$ E $(b \to s\gamma)$ DEVIANO DAL MS
- OGNI ESPERIMENTO (QUASI) HA LA SUA ANOMALIA:
  - SINGLE-γ (LEP)
  - $H^\pm$ (L3)
  - $\mu\gamma E\!\!\!/_T X$ (CDF)
  - Lept. Isol. (H1)
  - $N^0 \to \mu\mu X$ (NuTeV)

CHE COSA SI PUÒ CHIEDERE DI PIÙ ?

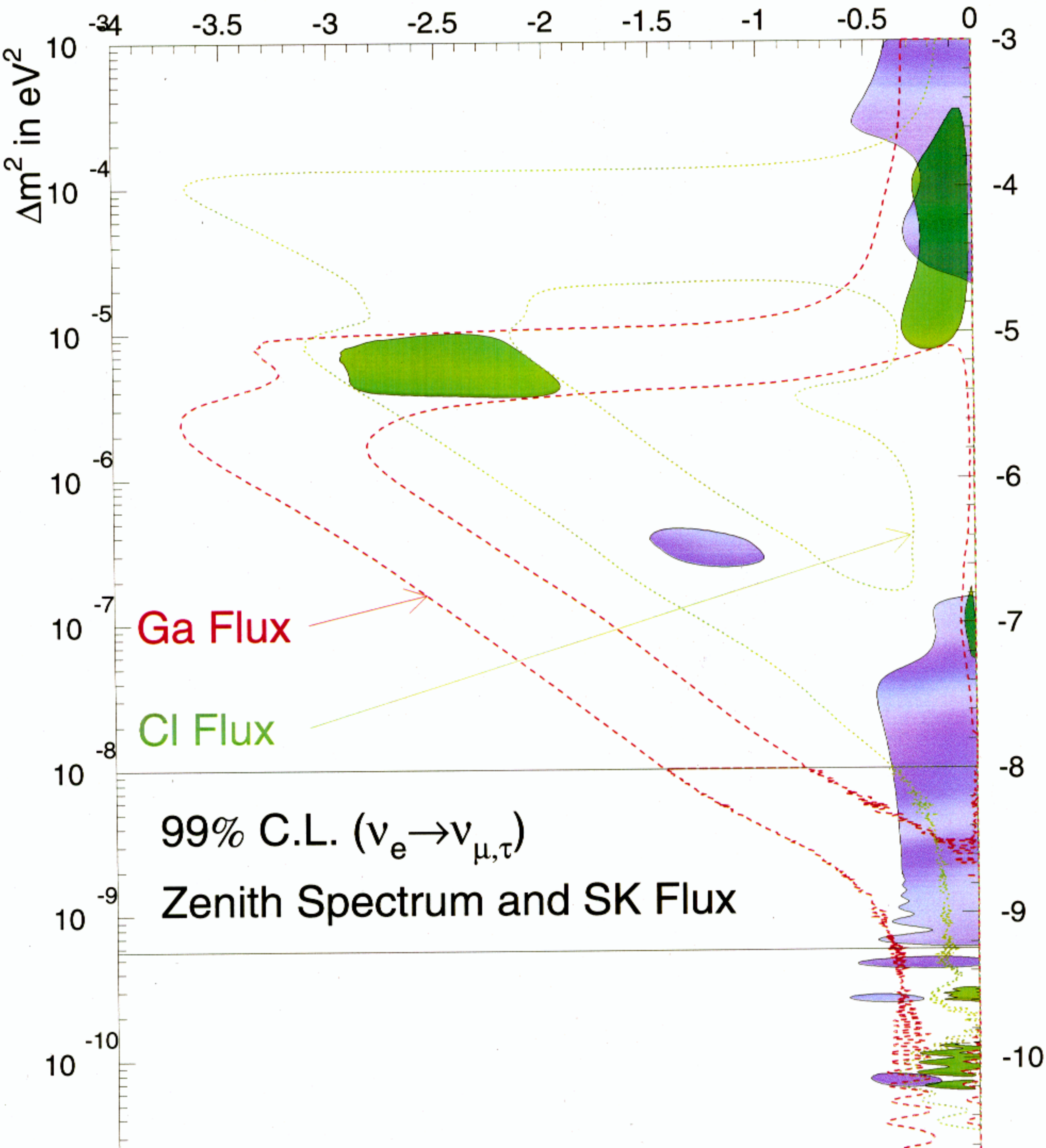
SK SOLAR ν

Summary

- No "smoking gun" for oscillation
- SMA mostly disfavoured at about 95% C.L.
- Homestake, SK conflict for sterile neutrinos at 95% C.L. $\Longrightarrow$ sterile neutrinos disfavored at 95% C.L.
- SK spectrum+flux alone define an enlarged 'LMA' and 'LOW' extending down to the vacuum region

NESSUN UPDATE SIGNIFICATIVO ASPETTATO PER I PROSSIMI 10 ANNI !

Allowed Regions



Oscillation Signatures

- No spectral distortion

  affects SMA
  affects vacuum oscillation

- No core-enhancement

  affects SMA

- No day-night effect

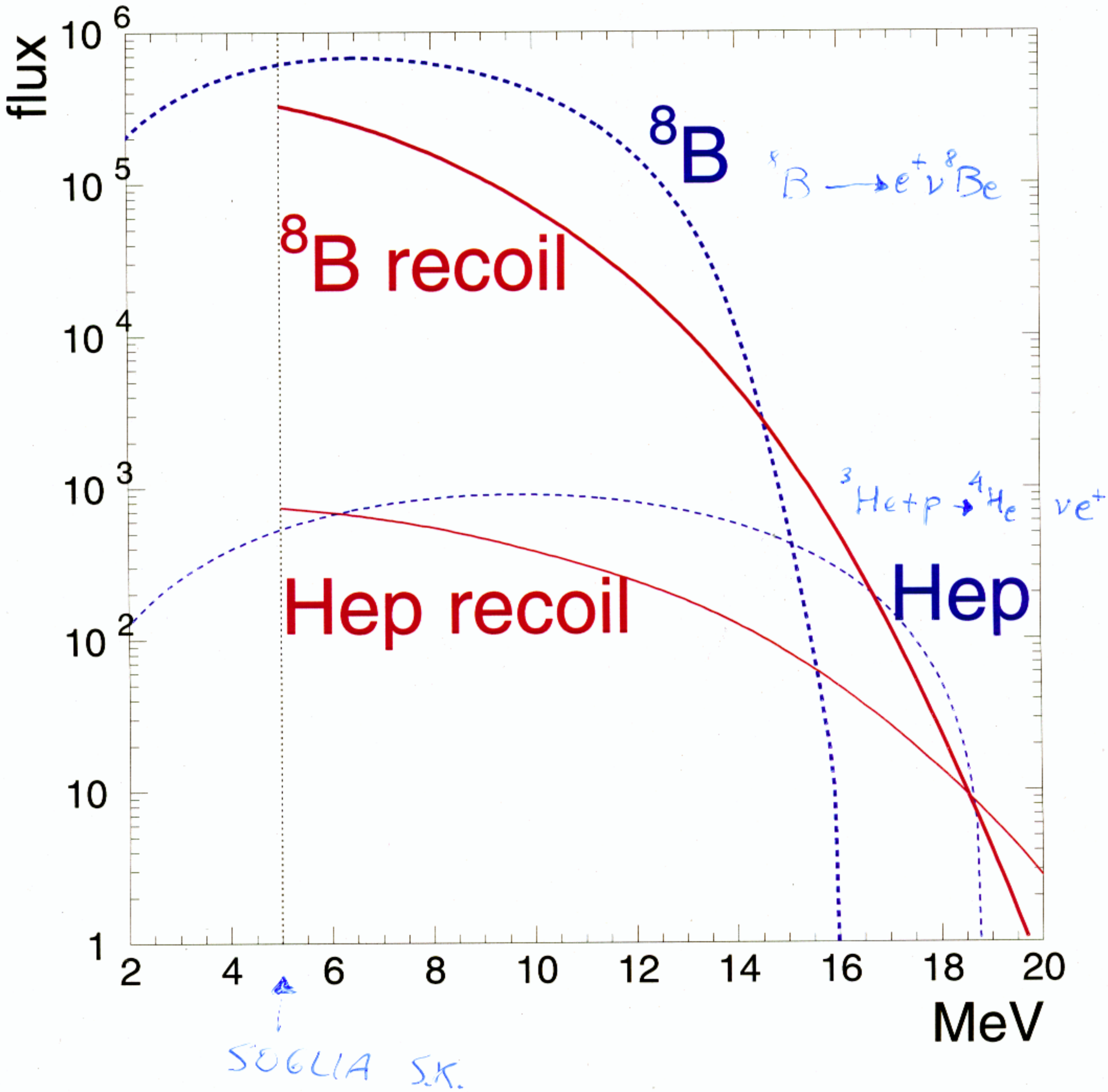
  affects LMA

- No additional seasonal variation

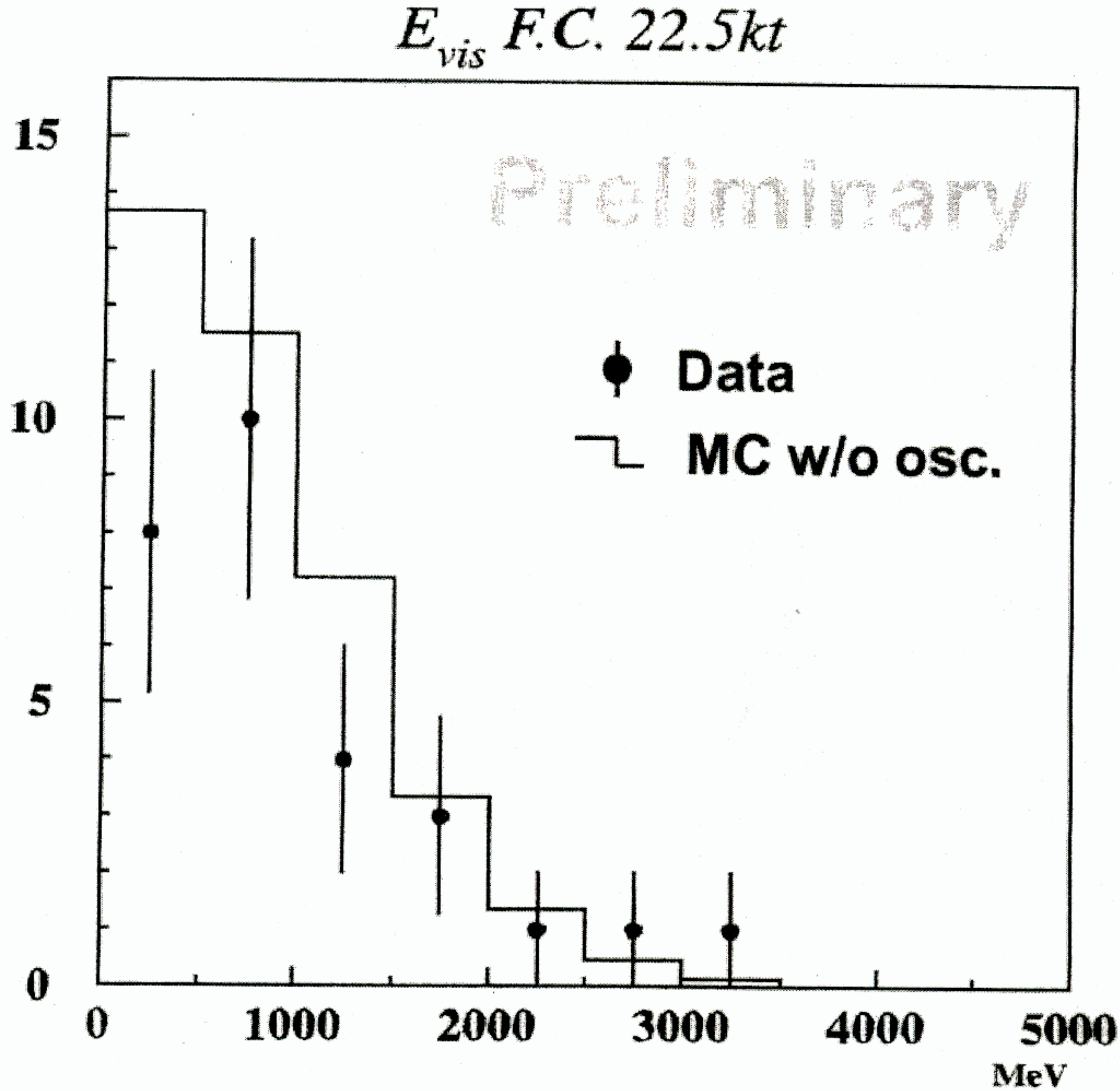
  affects vacuum oscillation

- Reduced Flux (45%)

Solar ν Spectrum



Visible Energy



need to estimate syst. err. in MC expect.

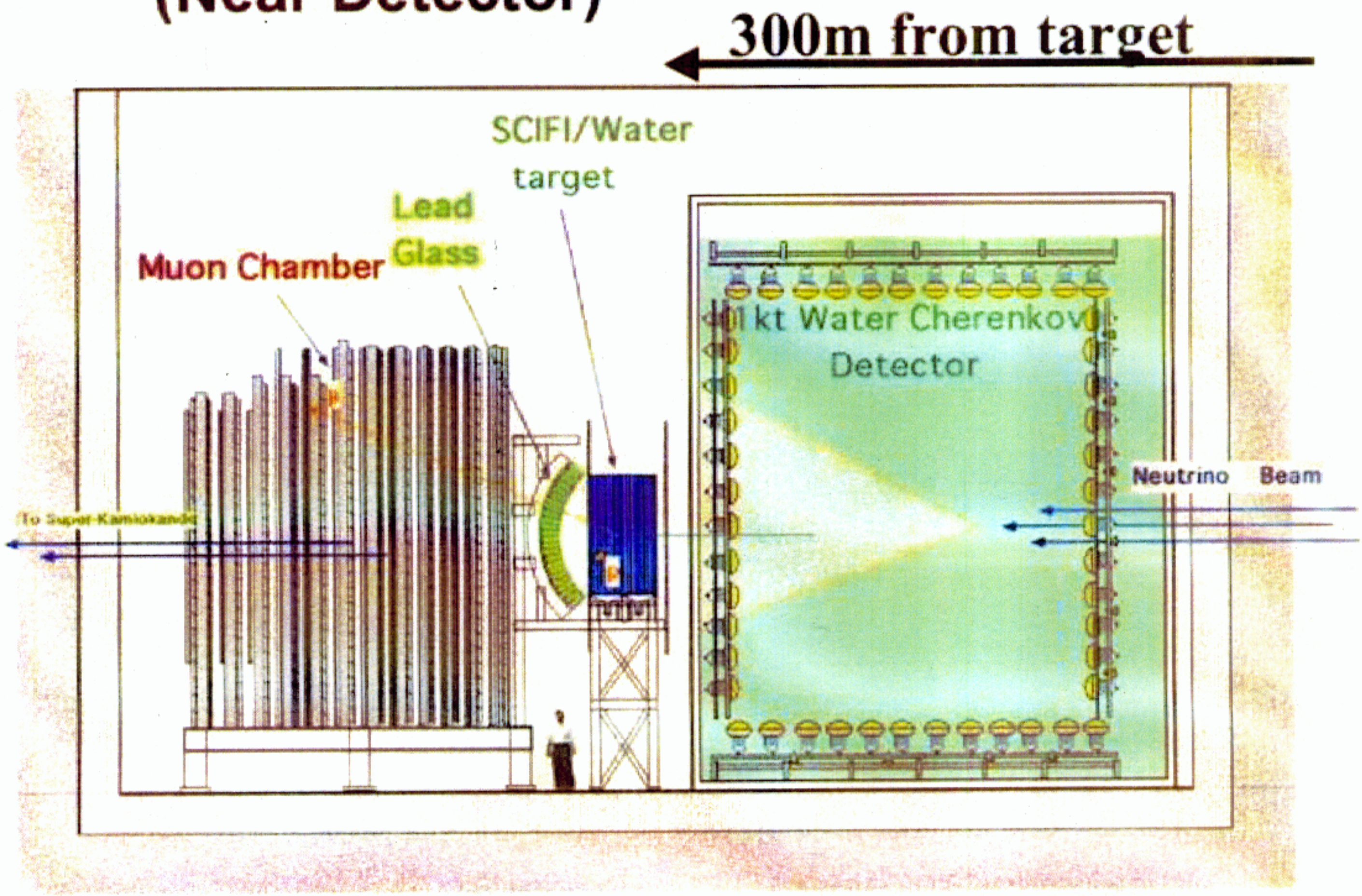
of observed and expected events @ SK

	Obs.	No Ocsi.
FC 22.5kt	28	$37.8^{+3.5}_{-3.8}$
1-ring	15	22.7 ± 3.2
μ-like	14	20.8 ± 3.2
e-like	1	1.9 ± 0.4
multi ring	13	15.1 ± 2.5

CONSISTENTE CON I PARAMETRI DEGLI

Front Neutrino Detector(FD)

(Near Detector)



Purpose

1. Measure ν_μ flux, spectrum, profile
2. Study ν_μ interactions at 1GeV region
3. Measure ν_e contamination

- ➢1kt water Cherenkov detector
- ➢Scintillation Fiber Tracker(SCIFI): SF sheets+water
- ➢Electromagnetic calorimeter : lead glass
- ➢Muon range detector (MRD) : drift tubes+iron plates

Expected # of SK events from 1kt measurement

CLOSE DETECTOR

$$N_{SK}^{\exp} = \frac{N_{kt}^{\text{obs}}}{\varepsilon_{kt}} \cdot R \cdot \varepsilon_{SK}$$

$$R = \frac{M_{SK}}{M_{kt}} \cdot \frac{\int \Phi_{SK}(E_\nu) \cdot \sigma_{\text{H}_2\text{O}}(E_\nu) dE}{\int \Phi_{kt}(E_\nu) \cdot \sigma_{\text{H}_2\text{O}}(E_\nu) dE}$$

N_{kt}^{obs} : observed events in 1kt

ε_{kt} : detection eff. of 1kt

ε_{SK} : detection eff. of SK

M_{SK}/M_{kt} : fiducial mass ratio

$$N_{SK}^{\exp} = 37.8 \pm 0.2(\text{stat.})\ {}^{+3.5}_{-3.8}(\text{syst.})$$

c.f.: $N_{SK}^{\exp} = 41.0^{+6.0}_{-6.6}$ from MRD events

: $N_{SK}^{\exp} = 37.2^{+4.6}_{-5.0}$ from SCIFI events

Agree with each other

Summary

79kt year of SK atmospheric neutrino data

- 2-flavor oscillation analysis $\nu_\mu - \nu_\tau$

$\sin^2 2\theta > 0.88,\ 1.6\times10^{-3} < \Delta m^2 < 4\times10^{-3}\ \mathrm{eV}^2$ (at 90% C.L.)

- $\nu_\mu - \nu_\tau$ vs $\nu_\mu - \nu_s$

Pure $\nu_\mu \rightarrow \nu_s$ is disfavored at 99% C.L.

Phys.Rev.Lett.85(2000)3999

- Search fot C.C. ν_τ

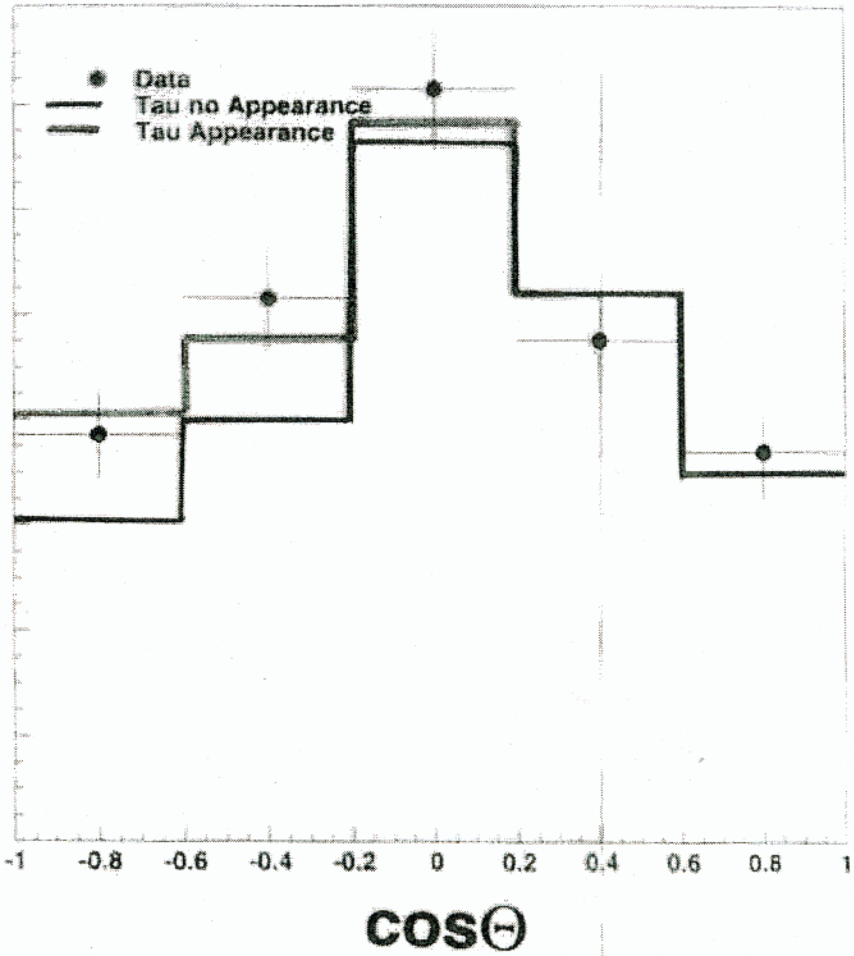
Consistent with ν_τ appearance

⇒ Bad news for CERN-GS long baseline?

- Pattern di oscillazione non ancora provato (dati compatibili anche con ν-decay)

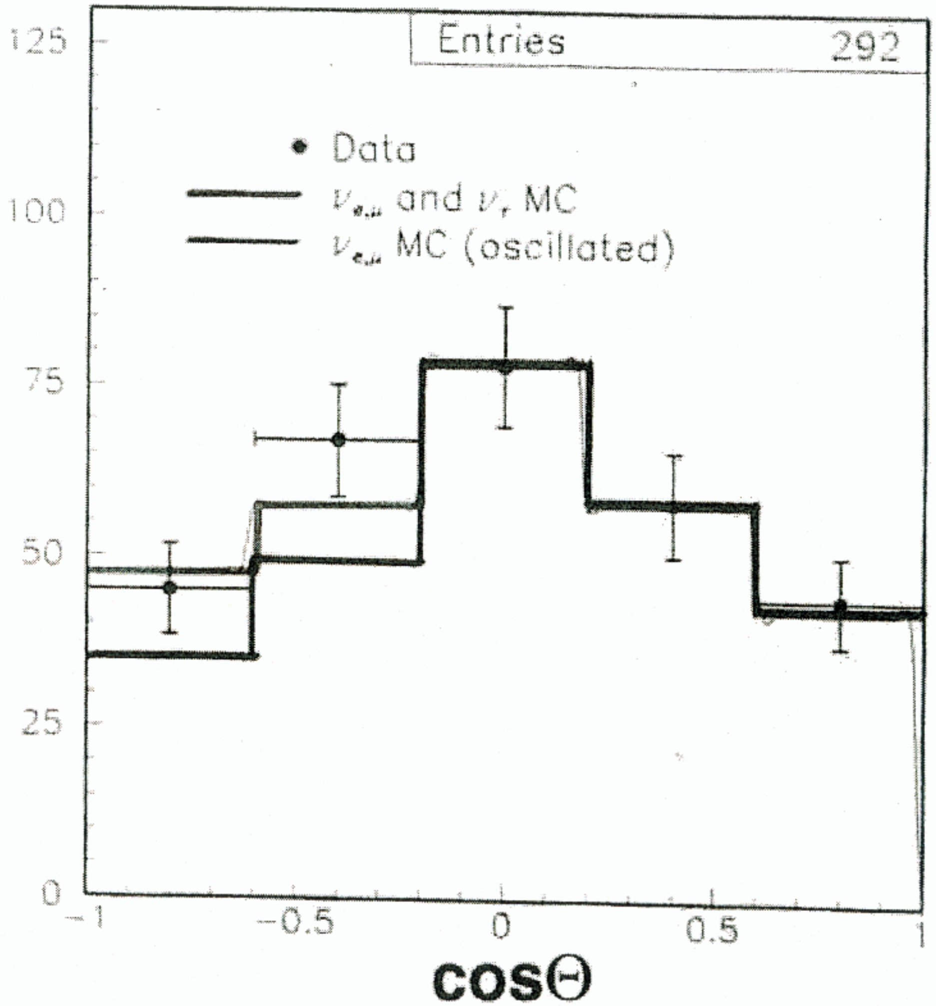
enith angle distribution

Analysis(2)



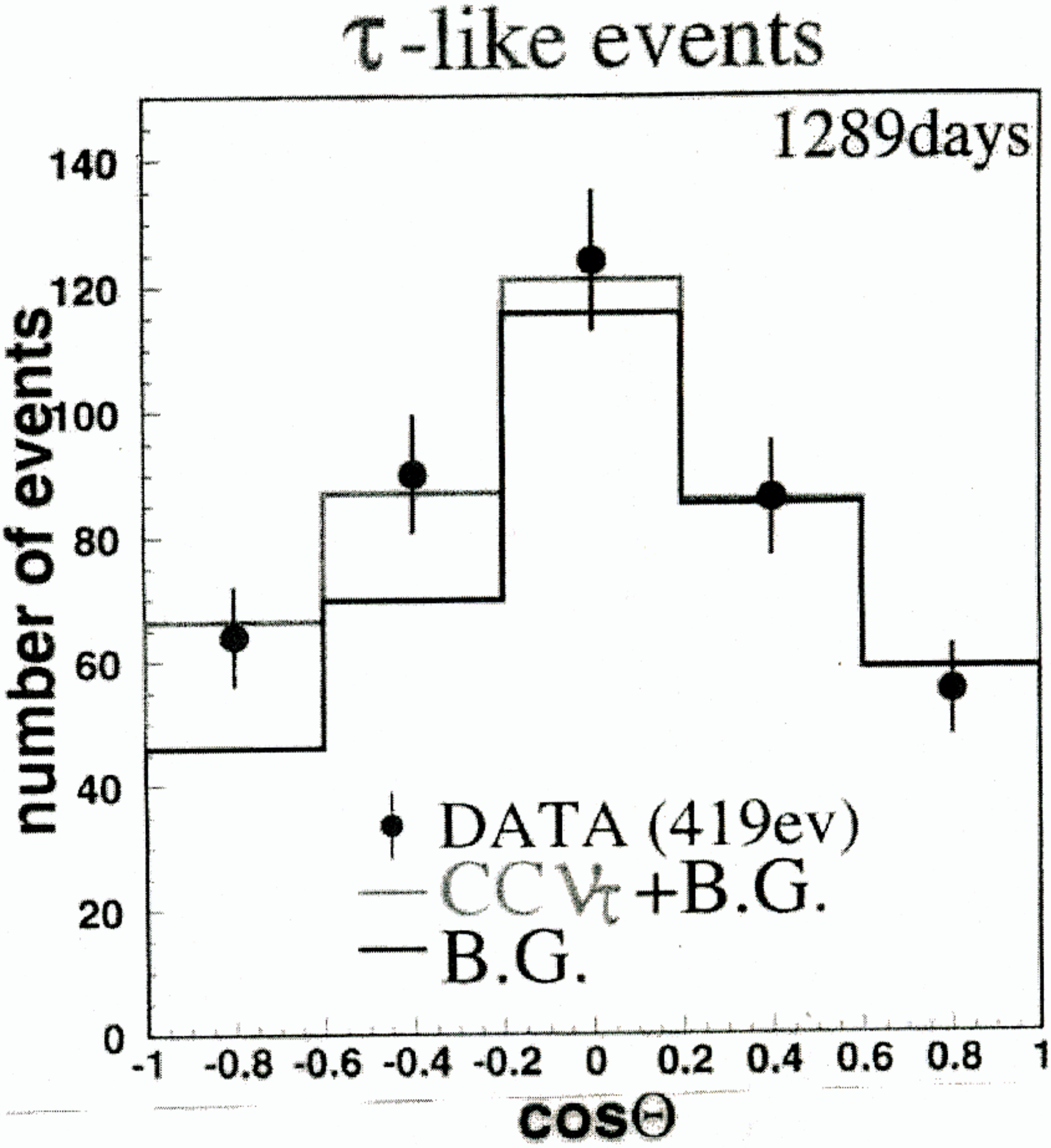
$N^{\tau obs.} = 44 \pm 20$

Analysis(3)



$N^{\tau obs.} = 25.5 \pm^{14}_{13}$

Zenith angle distribution



MC is normarized to minimize χ^2 ;

$$\chi^2 \equiv \sum_{\cos\theta_i}^{5\mathrm{bin}} \left\{ \frac{N_i^{DATA} - (\alpha N_i^{\tau MC} + \beta N_i^{B.G.\,MC})}{\sigma_i} \right\}^2$$

α, β : free

$\rightarrow N^{\tau obs.} \equiv \alpha N^{\tau MC}$

Search for CC ν_τ

Assumption

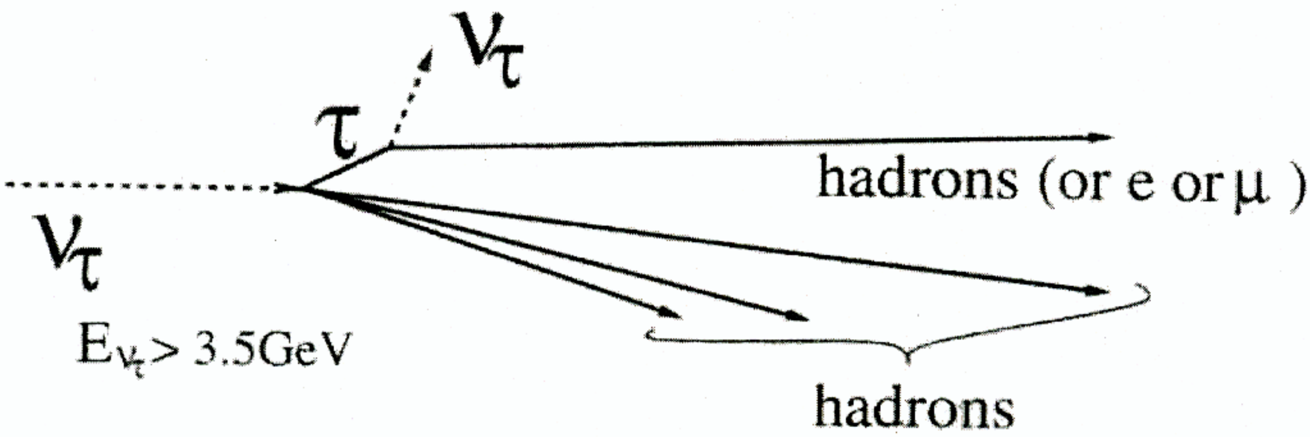
$\nu_\mu \rightarrow \nu_\tau$ oscillation

at $\Delta m^2 = 3 \times 10^{-3} eV^2$, $\sin^2 2\theta = 1$

~20 events/year

S/N ~ 0.7%

CC ν_τ CCν_e ,CCν_μ ,NC



Many hadrons are produced!

Three different analyses to enrich CCν_τ

1)likelihood method using Evis,# of decay-e,rings etc

2)neural network method

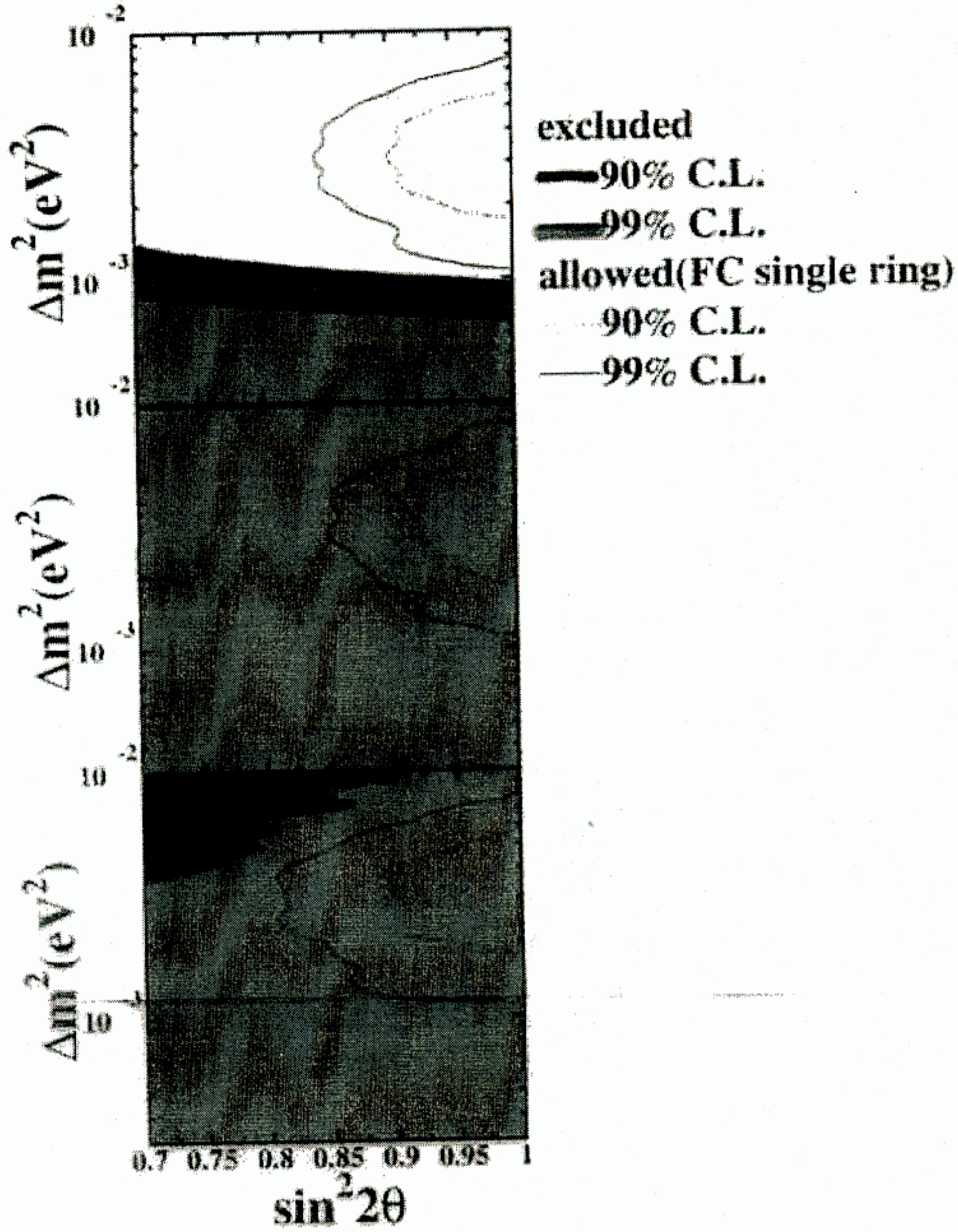
3)likelihood method using energy flow and event shape such as sphericity

Excluded region by combined analysis

$\nu_\mu \rightarrow \nu_\tau$

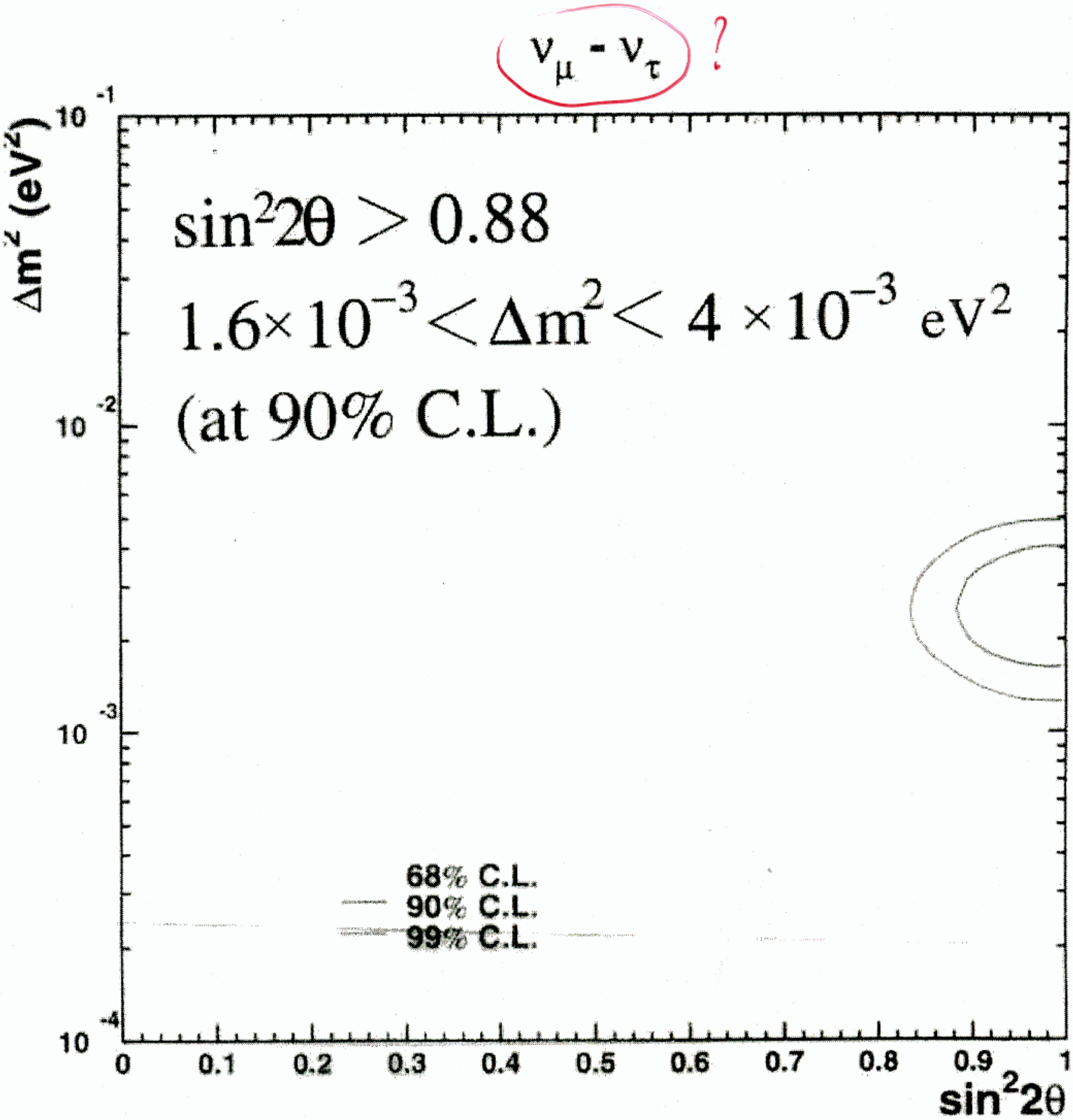
$\nu_\mu \rightarrow \nu_s$ ($\Delta m^2 > 0$)

$\nu_\mu \rightarrow \nu_s$ ($\Delta m^2 < 0$)



$\Longrightarrow$ pure $\nu_\mu \rightarrow \nu_s$ is disfavored at 99% C.L.

Allowed region (FC+PC+upmu)

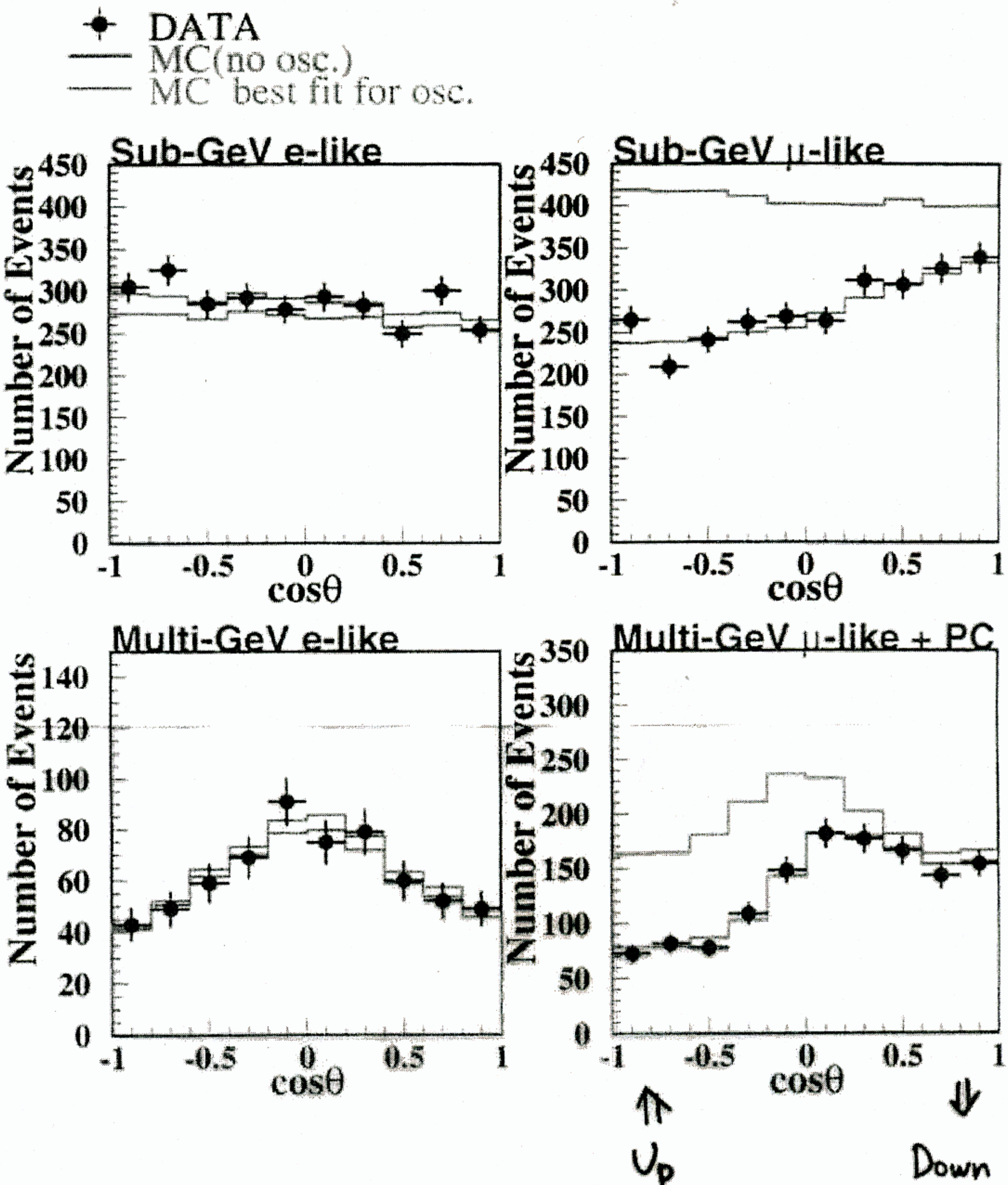


Best fit $\chi^2_{min} = 142.1/152$ d.o.f

$(\sin^2 2\theta, \Delta m^2) = (1.00, 2.5\times10^{-3}\,eV^2)$

No oscillation

Zenith angle distributions FC,PC



Event summary (79kton year)

Contained events (1289days)

sub-GeV Evis<1.33GeV Pe>100MeV/c,Pμ>200MeV/c

		DATA	MC	
single ring	e-like	2864	2668	ν_eC.C. 87%
	μ-like	2788	4073	ν_μC.C. 95%
multi-ring		2159	2585	

$$\frac{(\mu/e)_{DATA}}{(\mu/e)_{MC}} = 0.638\,^{+0.017}_{-0.017} \pm 0.050$$

multi-GeV Evis>1.33GeV(FC)+PC → μ-like

		DATA	MC	
single ring	e-like	626	613	ν_eC.C. 84%
	μ-like	558+754	838+1065	ν_μC.C. 98%
multi-ring		1318	1648	

$$\frac{(\mu/e)_{DATA}}{(\mu/e)_{MC}} = 0.675\,^{+0.034}_{-0.032} \pm 0.080$$

Up-μ events

through (1268days) 1416

stop (1247days) 345

March,2001

Super-Kamiokande atmospheric neutrino

@ Moriond EW 2001

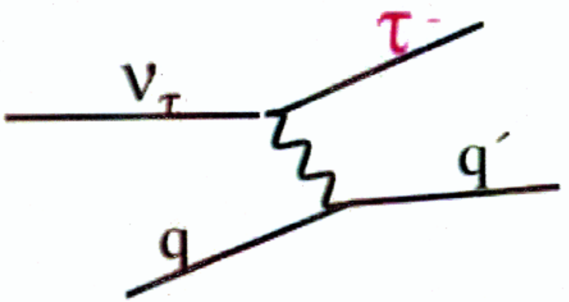
T.Toshito (ICRR)

for the Super-Kamiokande collaboration

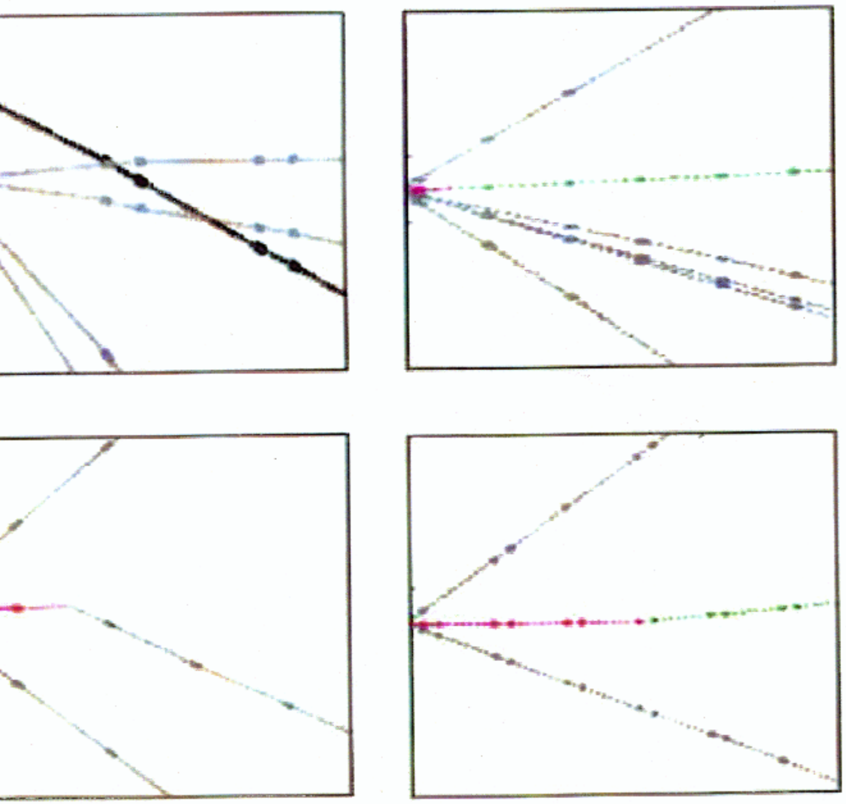
recent results of

- $\nu_\mu - \nu_\tau$ 2 flavor oscillation analysis
- $\nu_\mu - \nu_\tau$ vs $\nu_\mu - \nu_s$
- A search for CC ν_τ events

Observation of ν_τ CC interactions



$$\tau \longrightarrow \nu_\tau + \nu_e + e$$
$$\longrightarrow \nu_\tau + \nu_\mu + \mu$$
$$\longrightarrow \nu_\tau + \geq 0 h^0 + h$$



E872 has analyzed 203 neutrino interactions recorded in nuclear emulsion targets.

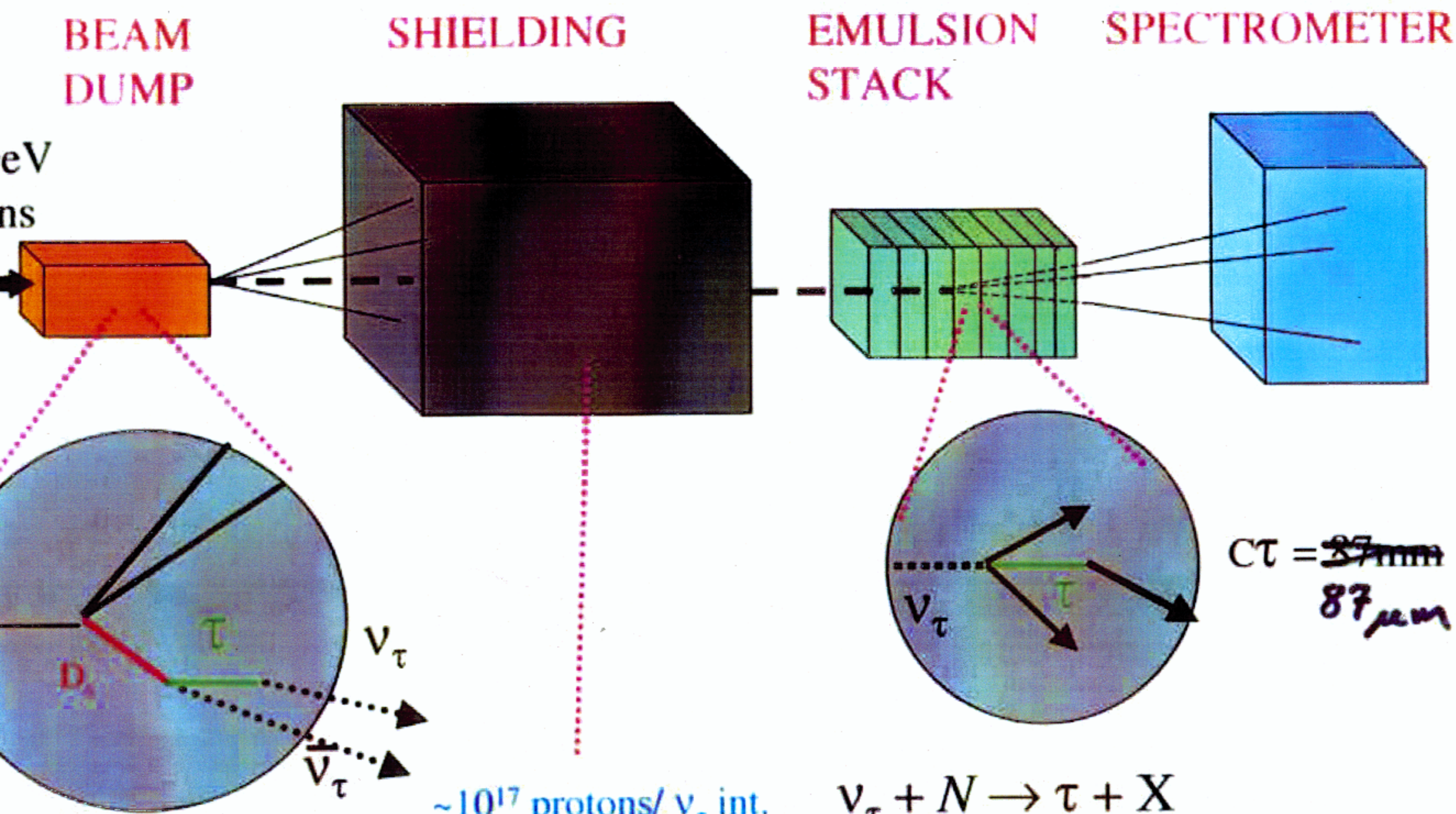
Four events are due to ν_τ interactions.

The expected background is .3 events.

The probability that all 4 events are from background sources is $< 4 \times 10^{-4}$

DONUT:

Production and detection of ν_τ



$c\tau$ = ~~37mm~~ 87 μm

~10^{17} protons/ ν_τ int.

μ flux:

~10^7 @ 35cm

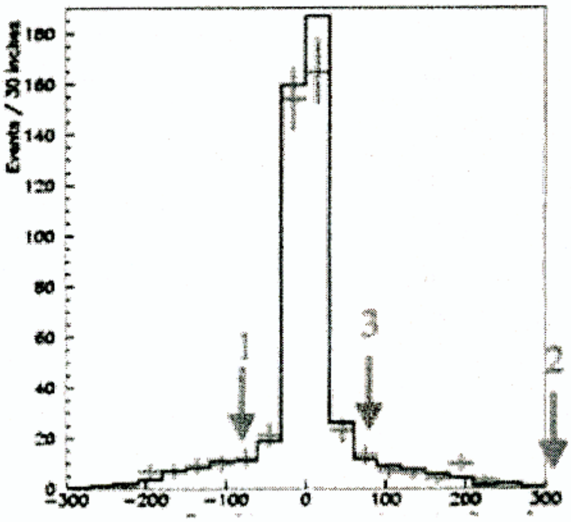
~10^{12} @ 2m

$\nu_\tau + N \rightarrow \tau + X$

$\tau \rightarrow \nu_\tau + 1$ charge

Event Characteristics

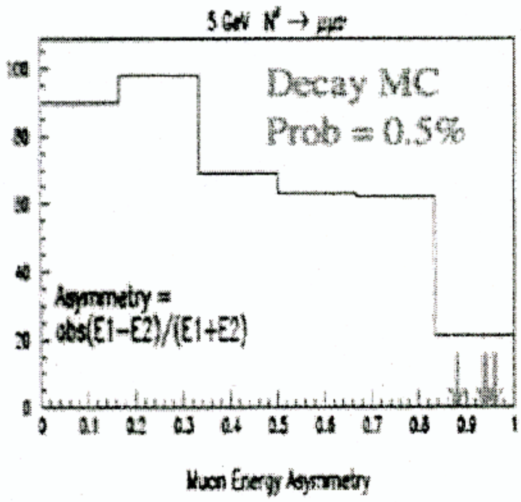
- Events distributed in z away from massive chambers
  ⇒ Looks like a decay not an interaction

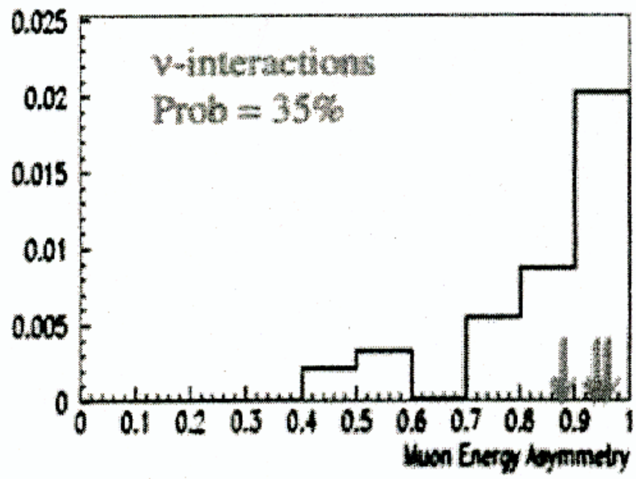


Distance to Closest Chamber

Histogram and data points from multi-track sample

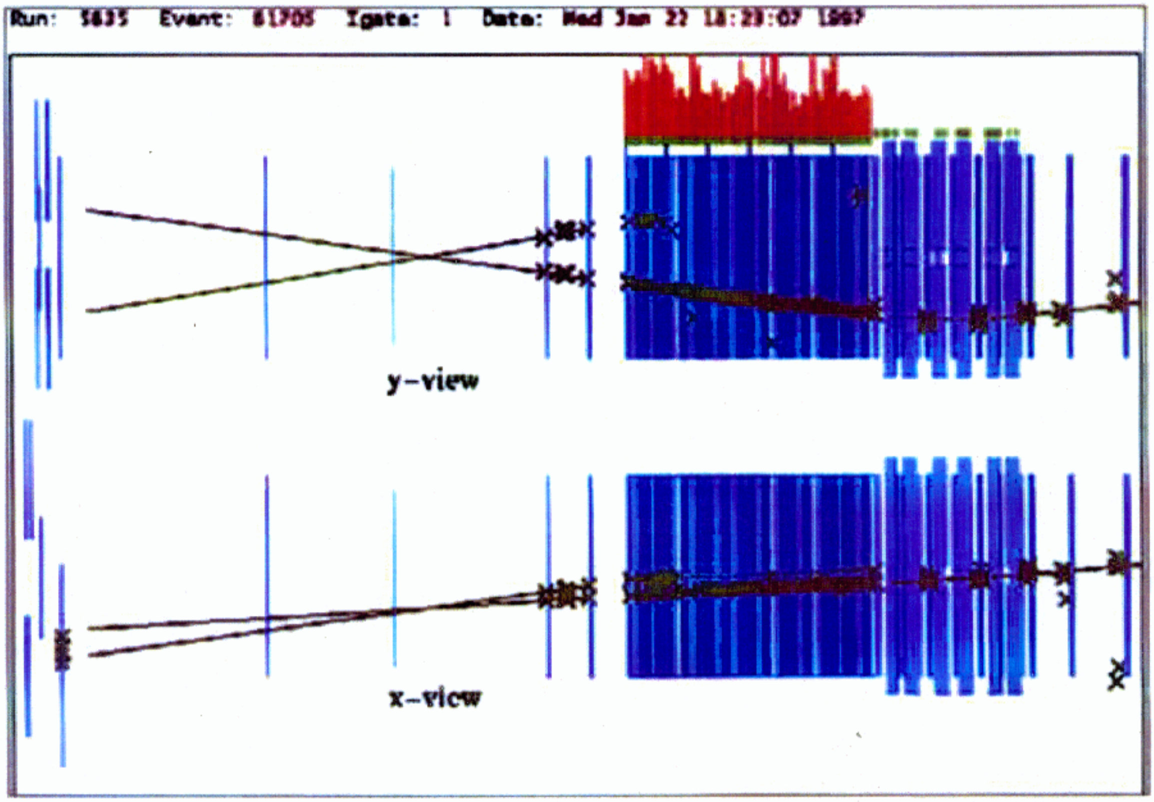
- Two muons in each event are highly asymmetric
  ⇒ Looks like a ν interaction not a decay





CHORUS + NOMAD non hanno la sensibilità per un

Event 1



- Transverse Mass : 5.1 GeV
- Track Info :
  - Track 1 : 78 GeV μ^+
  - Track 2 : 2.6 GeV μ
- Vertex Info :
  - Distance to Chamber: 77 $\pm$ 10 in.
  - χ^2/d.o.f : 6.3/9 (Prob = 62 %)
- Oddities:
  - Energy asymmetry

Results

- ***Events with <u>vertex in He</u> region***
  - *Three μ μ events seen*
  - *No μ π or μ e events seen.*

Event Type	Data Events	Backgnd (Prelim.)
μ μ	3	0.040 ± 0.009
μ e	0	0.14 ± 0.02
μ π	0	0.13 ± 0.02

Prob(≥ 3 μμ events) = 1.2×10^{-5}

Prob(All modes with ≥ 3 events) = 4.1×10^{-3}

- ***Events with vertex in <u>chamber region</u> (±6 in of cham.) All other cuts applied***
  - Don't see any μμ events (Fid. mass ×20 He)

Type	Observed	MC
μμ	0	0.2
μe	1	0.9
μπ	2	1.5