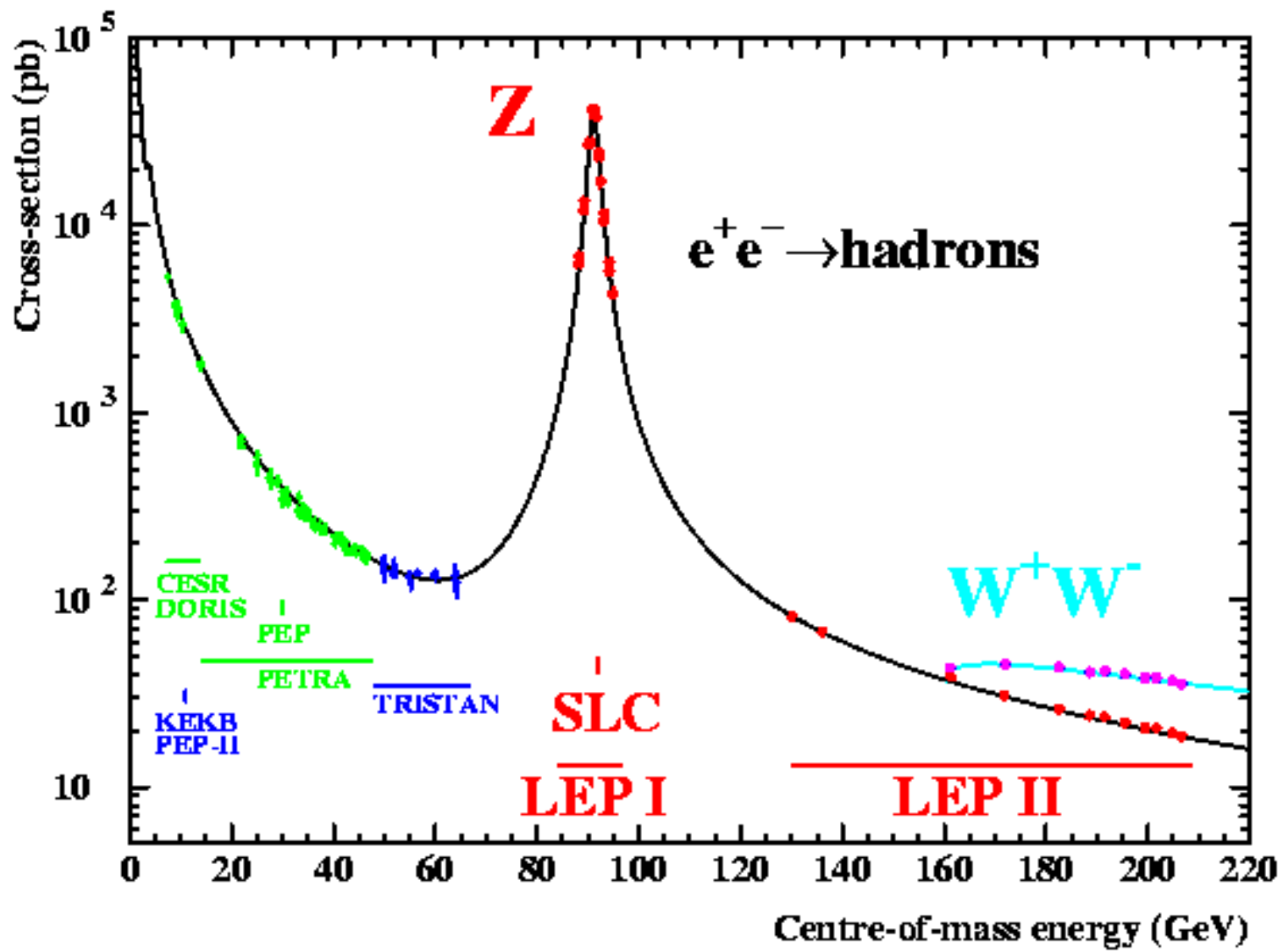
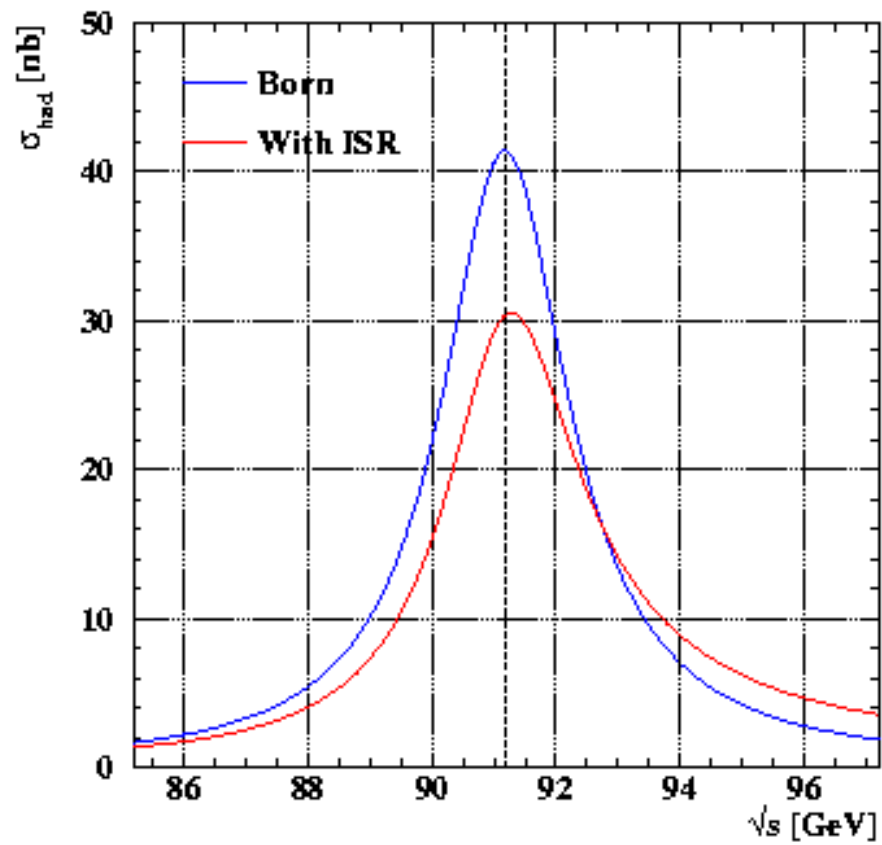
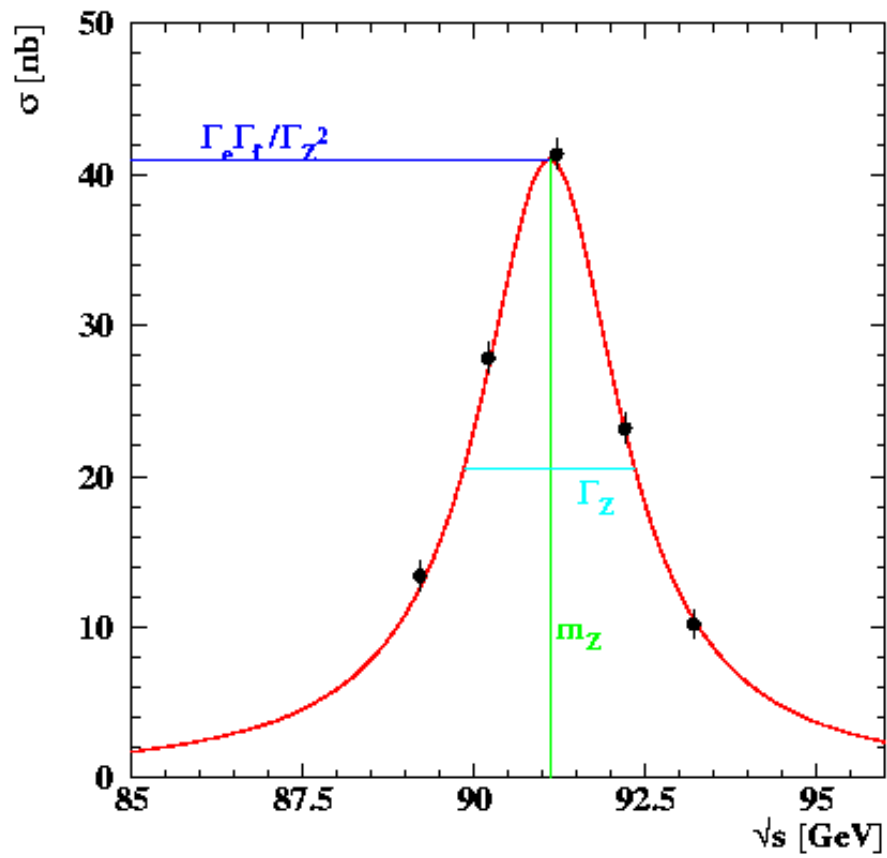
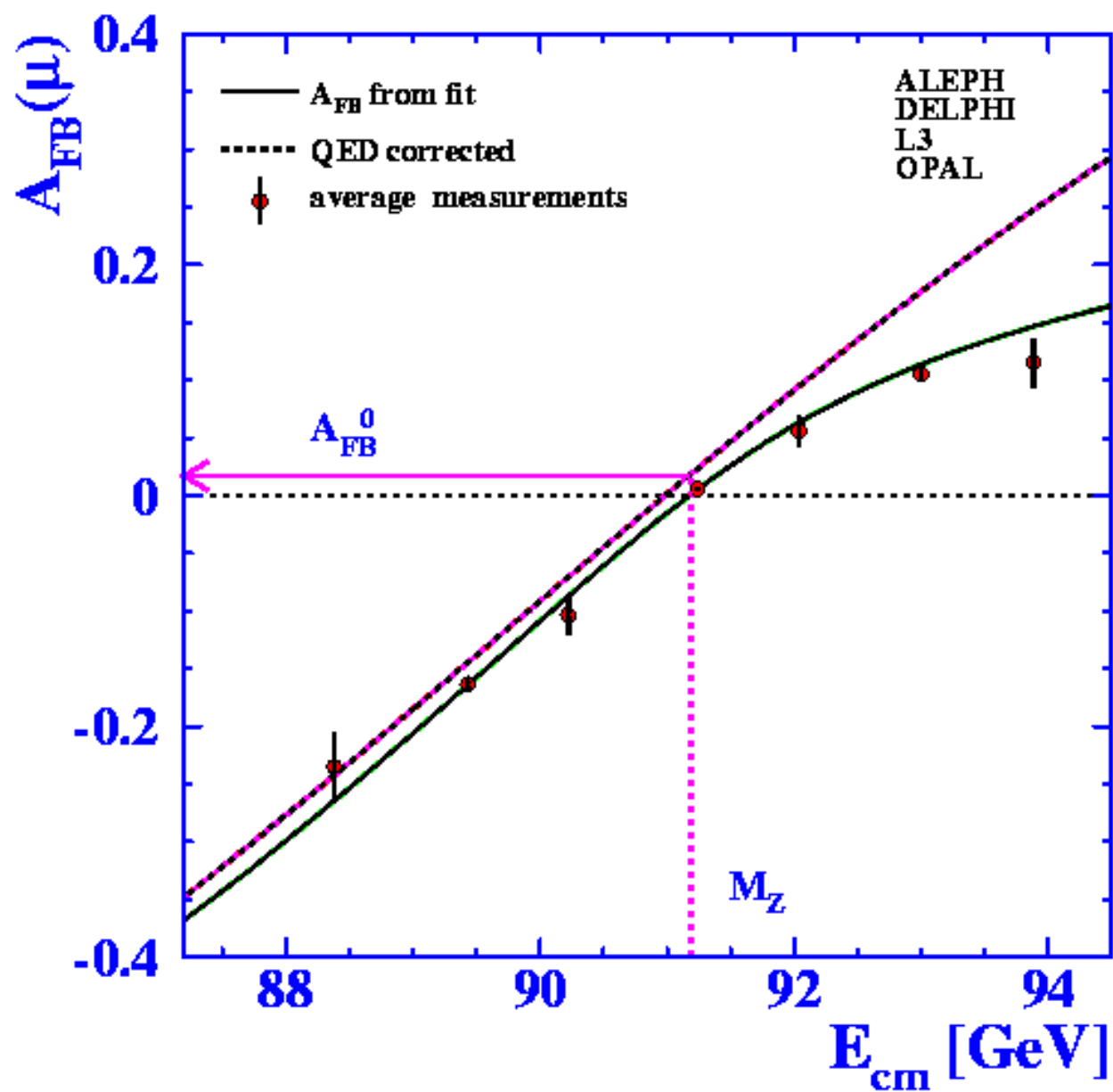
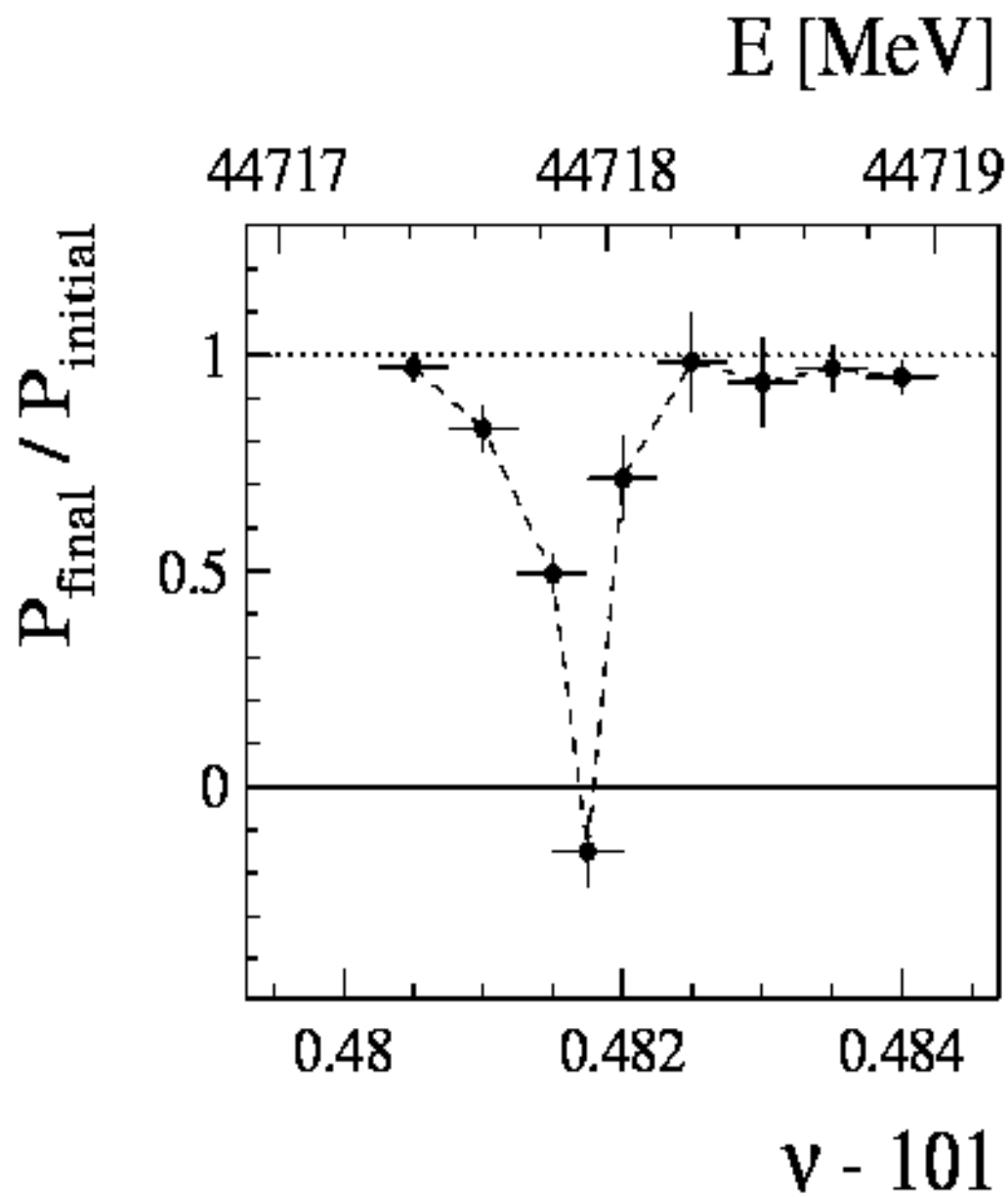


DELPHI







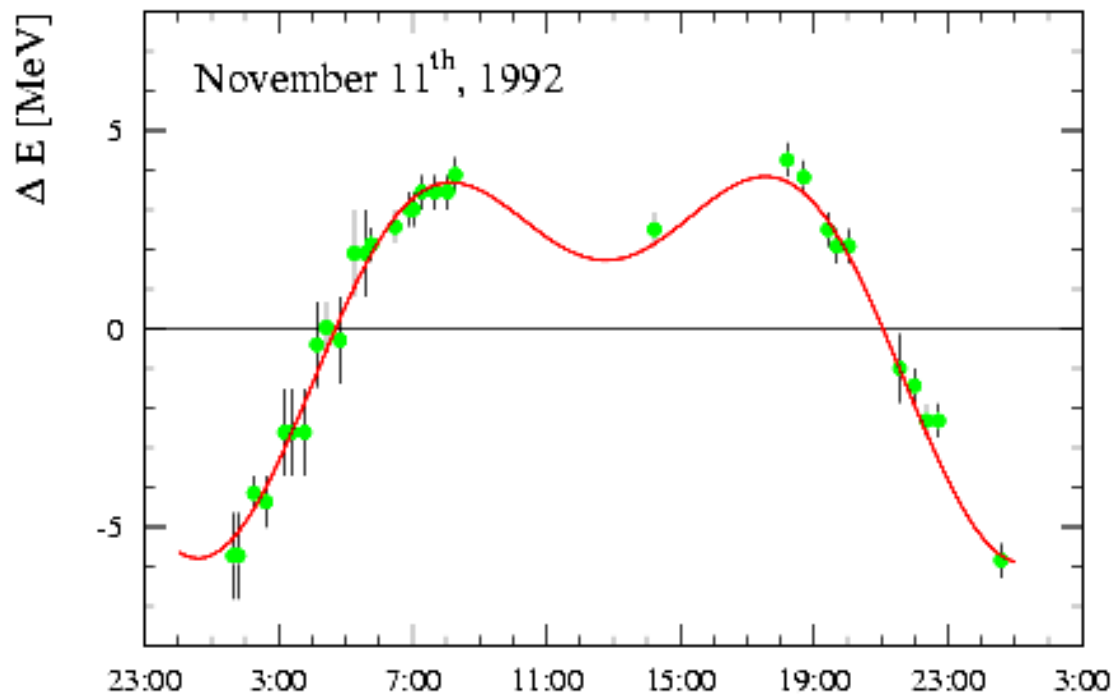


L'energia di LEP: l'effetto della luna

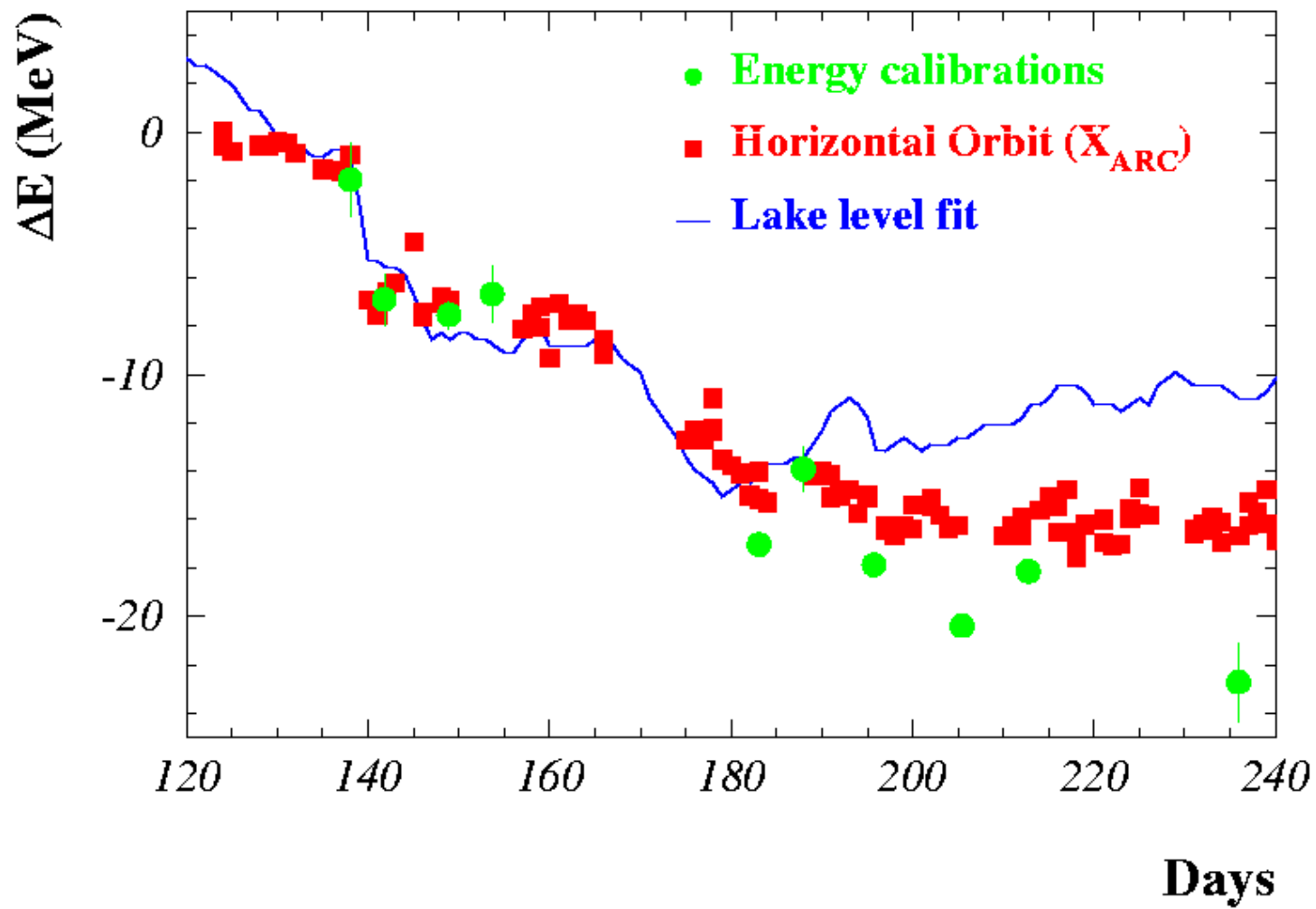
Le maree della luna muovono la superficie della terra di ~ 25 cm nella zona di Ginevra (i.e. un cambio locale del raggio terrestre di $4 \cdot 10^{-8}$).

\Rightarrow l'orbita di LEP viene cambiata di meno di 1 millimetro.

Ma LEP lo sente !!!!! Circa 10 MeV di variazione, ma ben capiti!



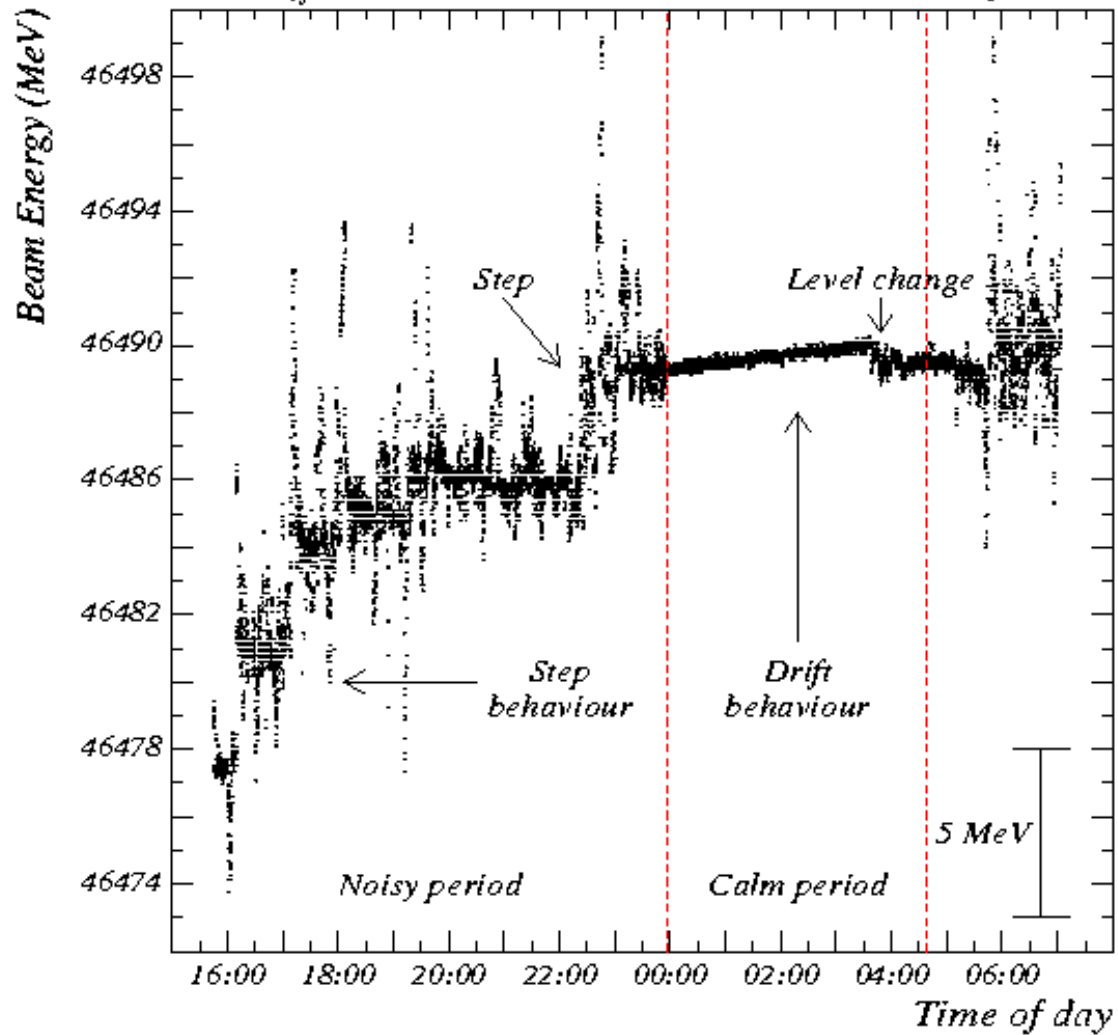
Effetti simili si hanno a causa del livello dell'acqua del lago di Ginevra



Behaviour of LEP NMR

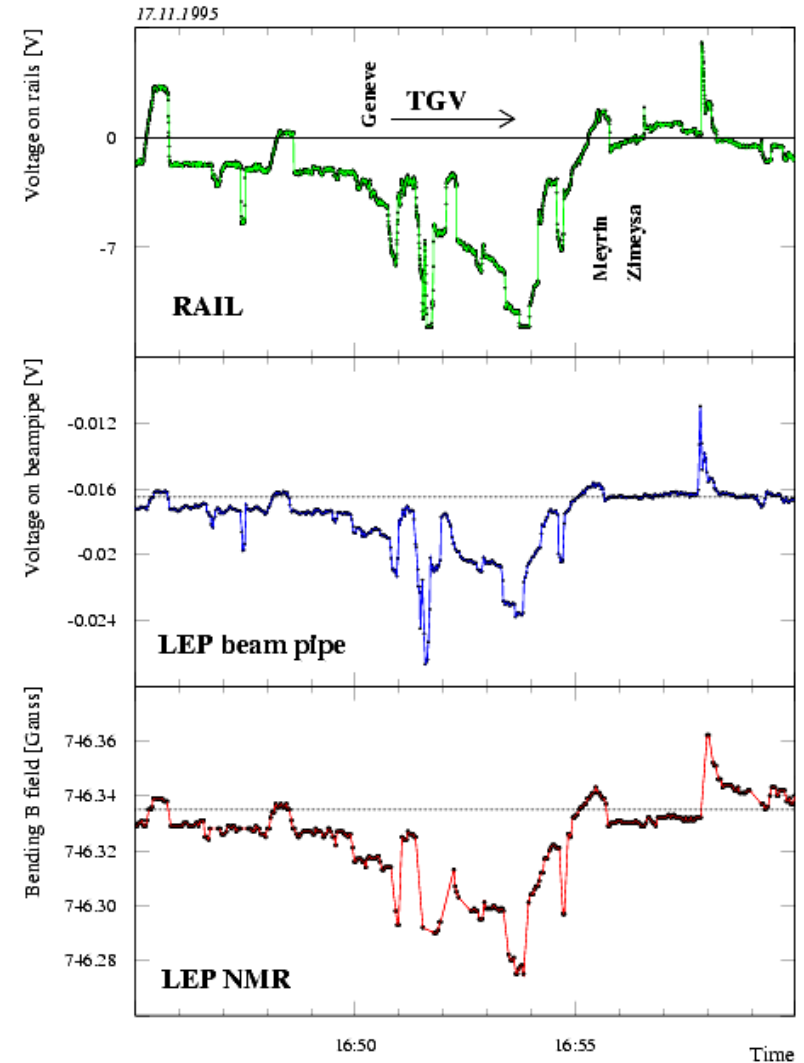
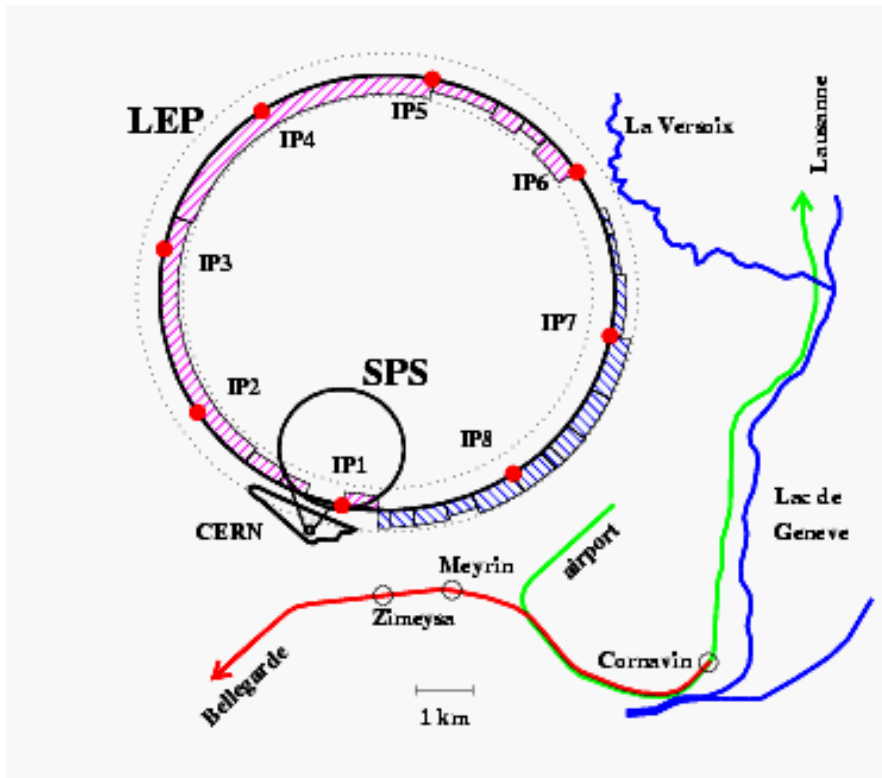
16.08.1995, fill 2899

LEP Polarization Team

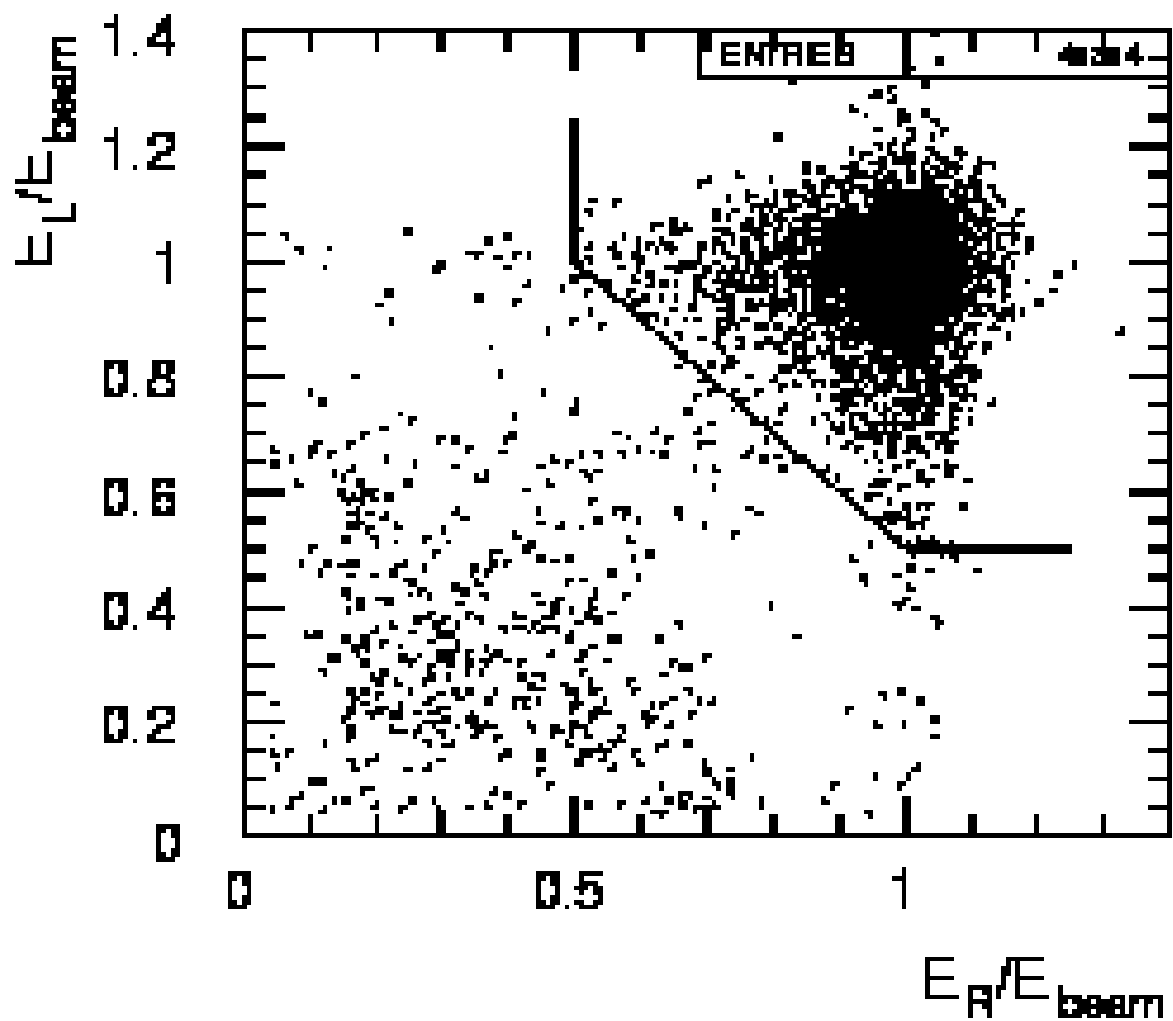


L'energia di LEP: l'effetto del TGV

Correnti vagabonde causano un drift nel campo dei dipoli durante un fill di ~ 10 MeV



OPAL

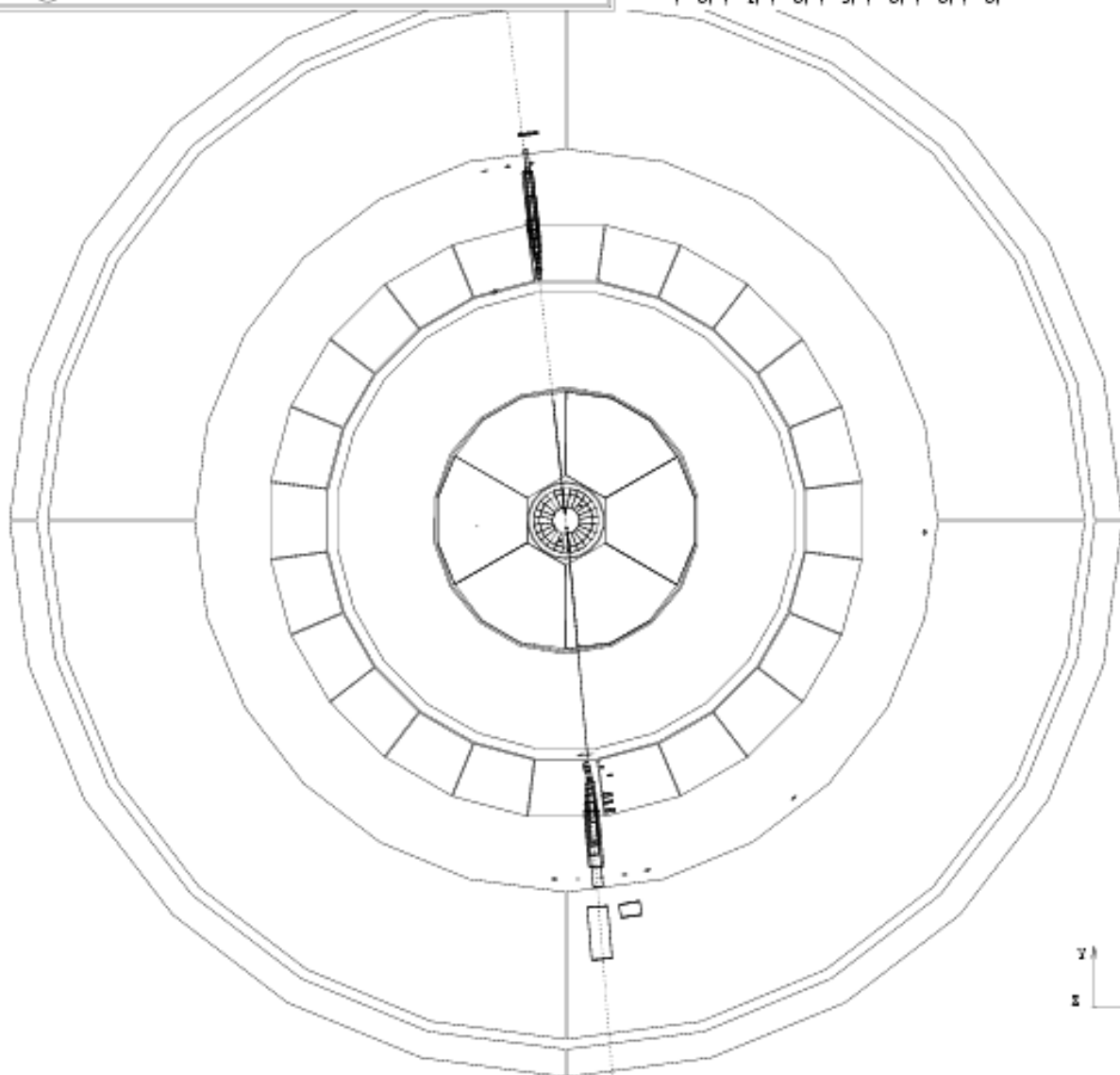


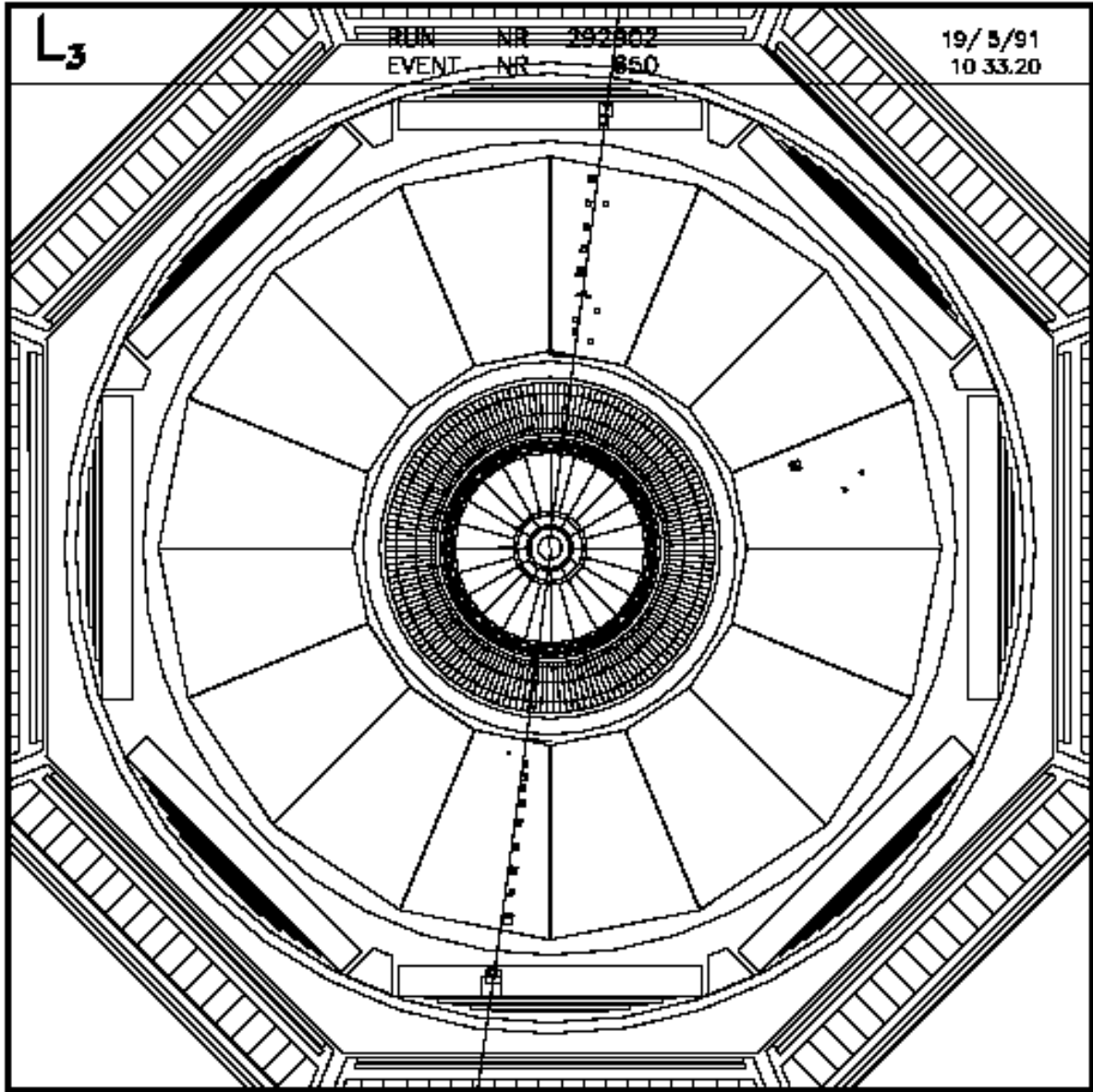


DELPHI Interactive Analysis

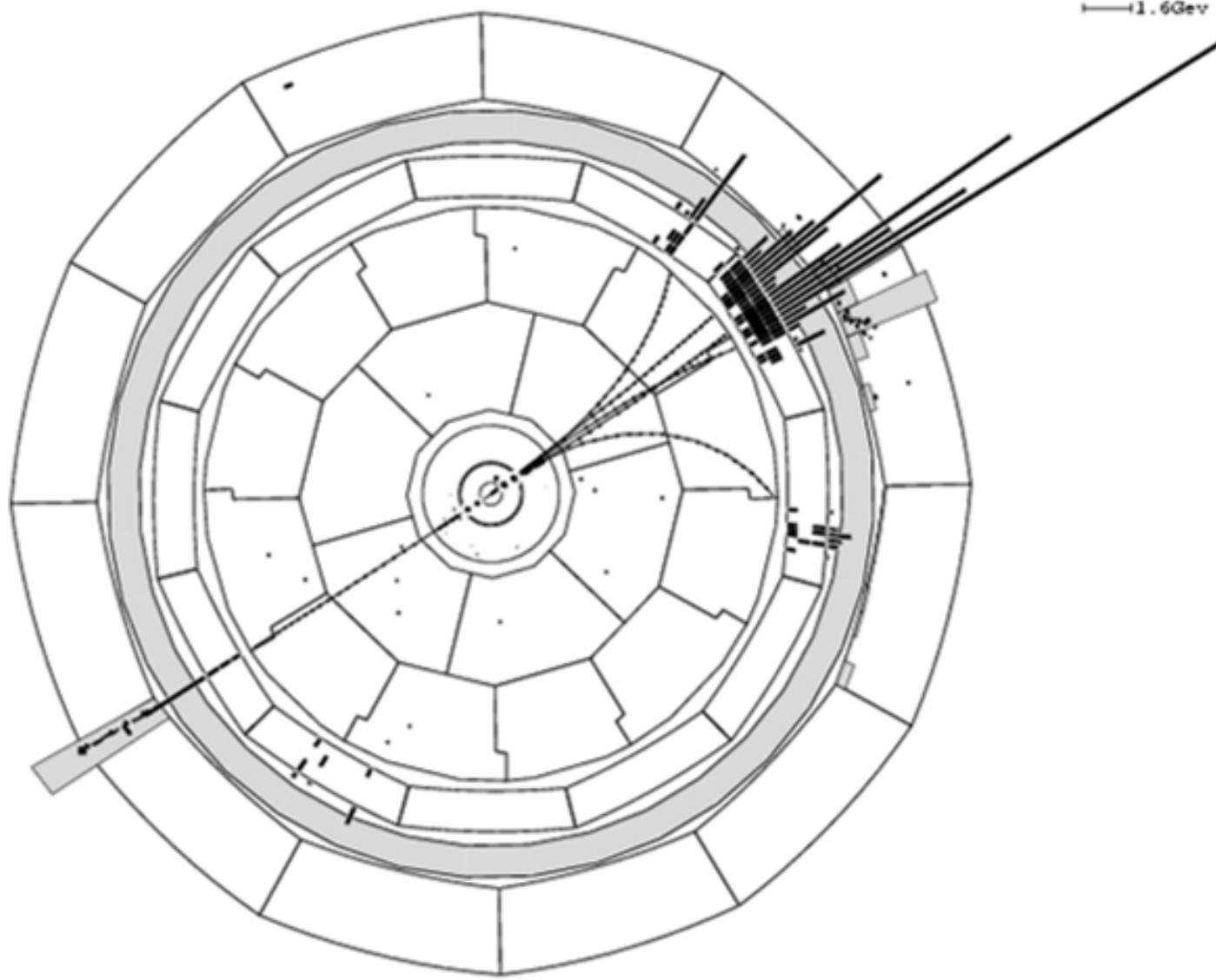
Beam: 45.6 GeV Run: 26154 DAS : 25-Aug-1991
Proc: 1-Oct-1991 Evt: 2958 21:46:38
Scan: 4-Dec-1992

	V0	V6	V5	V4	V7	V8	V9
Act	1	35	0	2	0	0	0
	37	35	0	4	0	0	0
Deact	0	0	0	0	0	0	0
	0	1	0	3	0	0	0

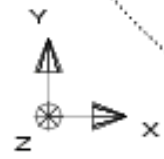
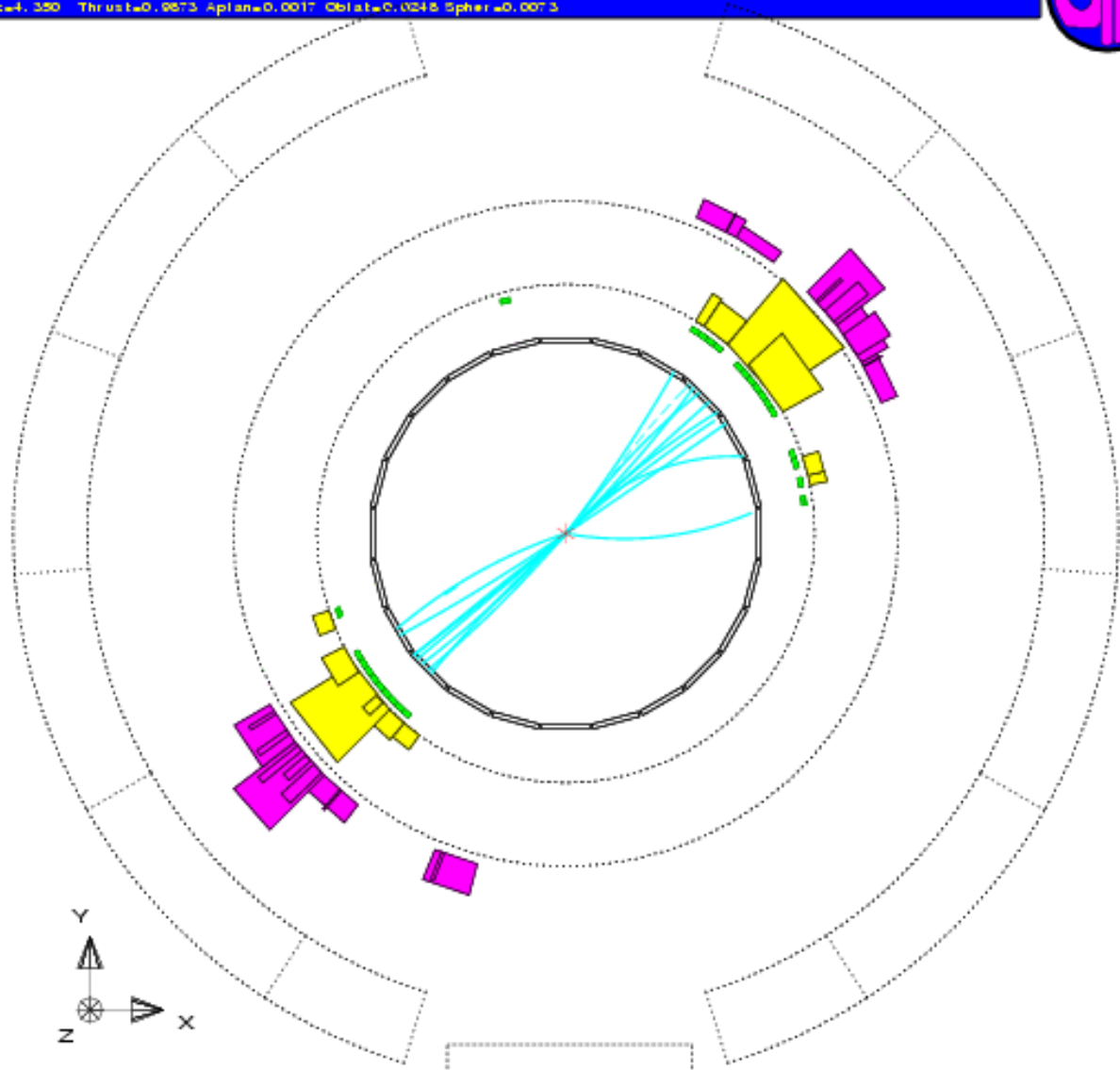




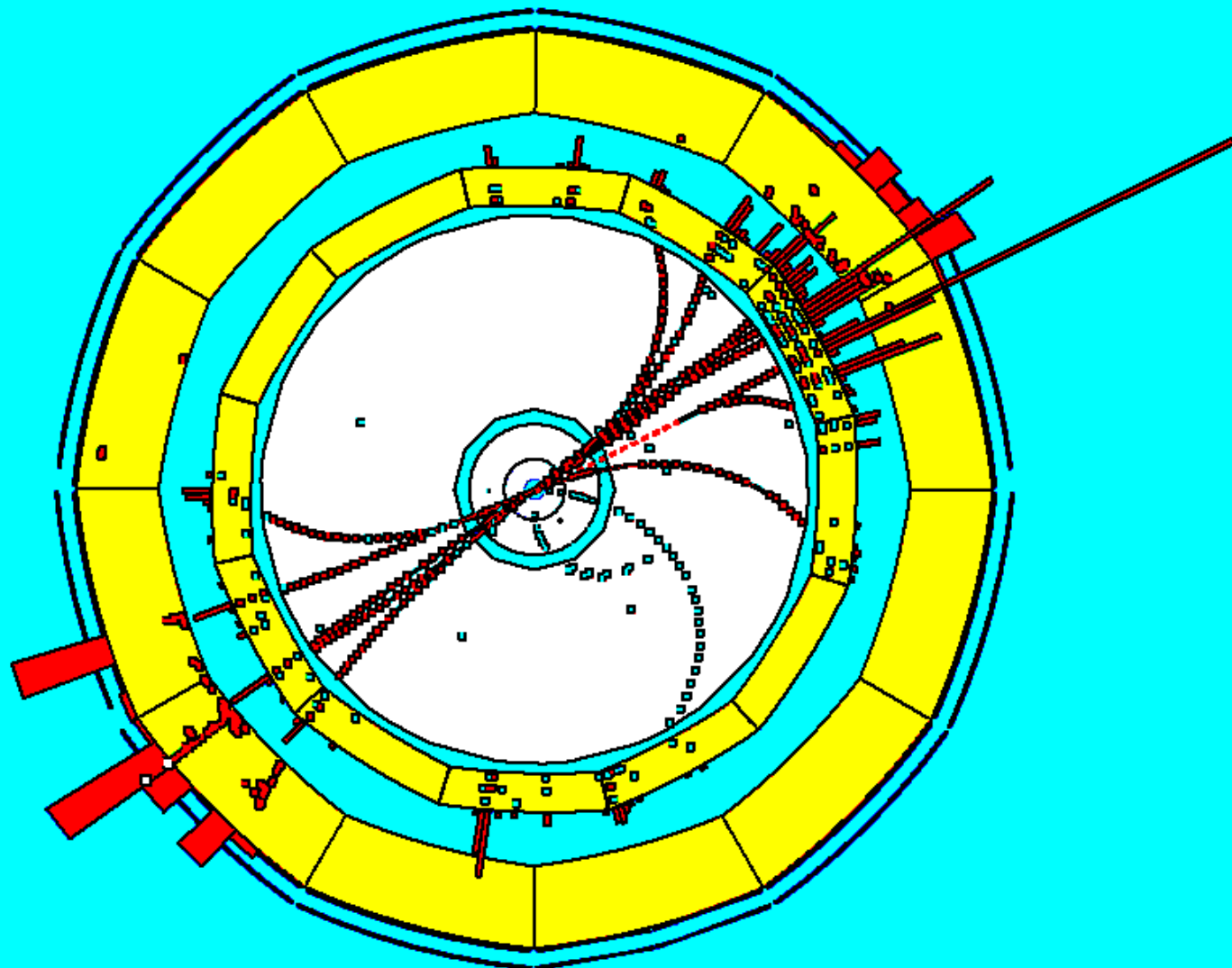
— 1.40Gev BC
— 1.6Gev HC

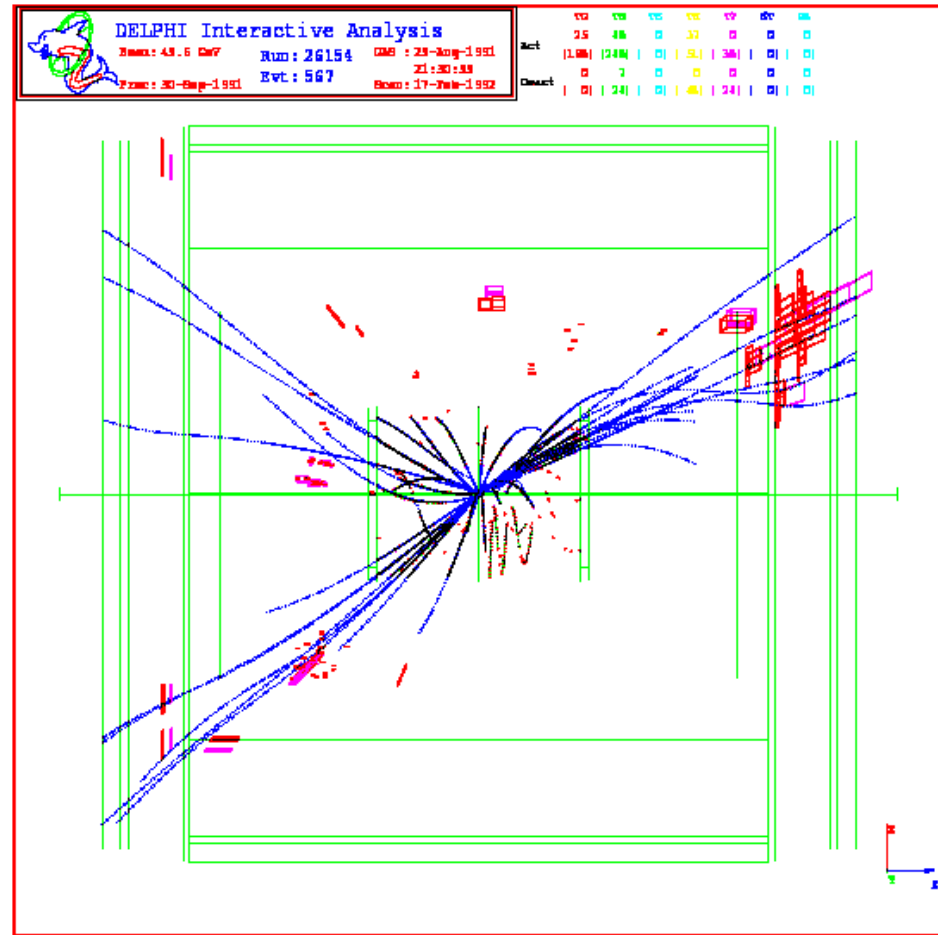
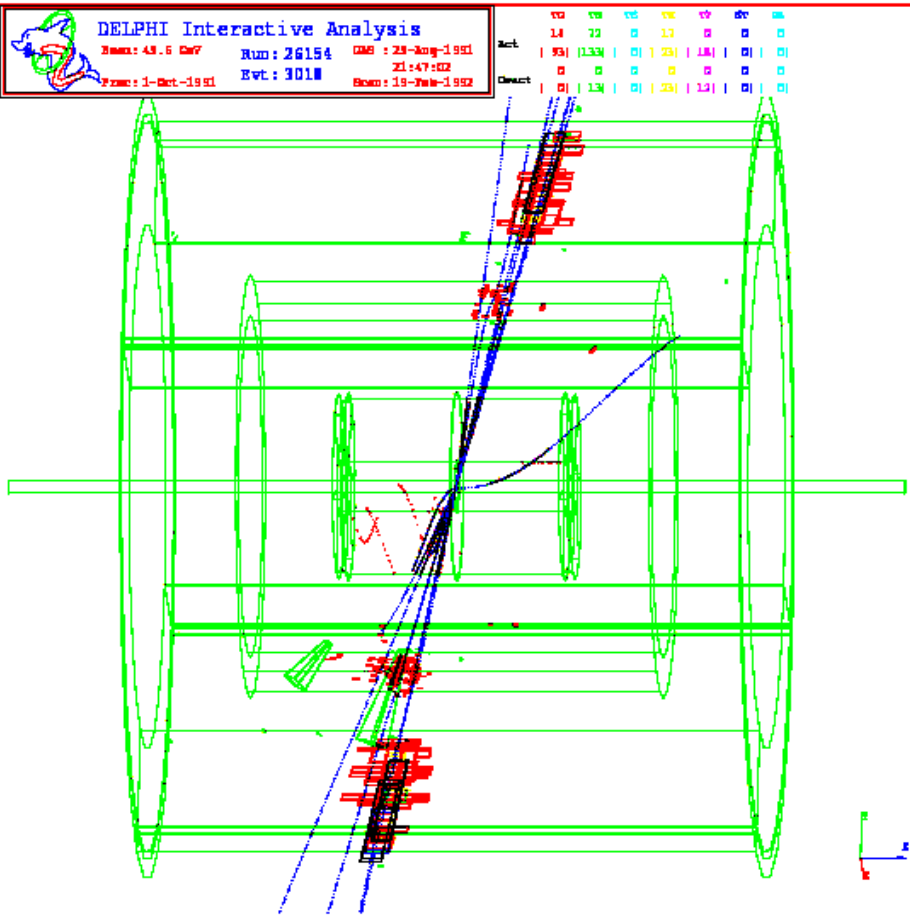


Run: event 4093: 1000 Date: 930527 Time: 20716 Ckx(H= 39 Surp= 73.3) Ecal(H= 25 SurE= 32.6) Hcal(H=22 SurE= 22.6)
 Ebeam: 45.656 Evis: 99.9 Emiss: -8.6 Vtx: (-0.07, 0.00, -0.50) Muon(H= 0) Sec Vtx(H= 3) Pdet(H= 0 SurE= 0.0)
 Ecal: 350 Thrust=0.9573 Aplan=0.0017 Oblat=0.0248 Spher=0.0073

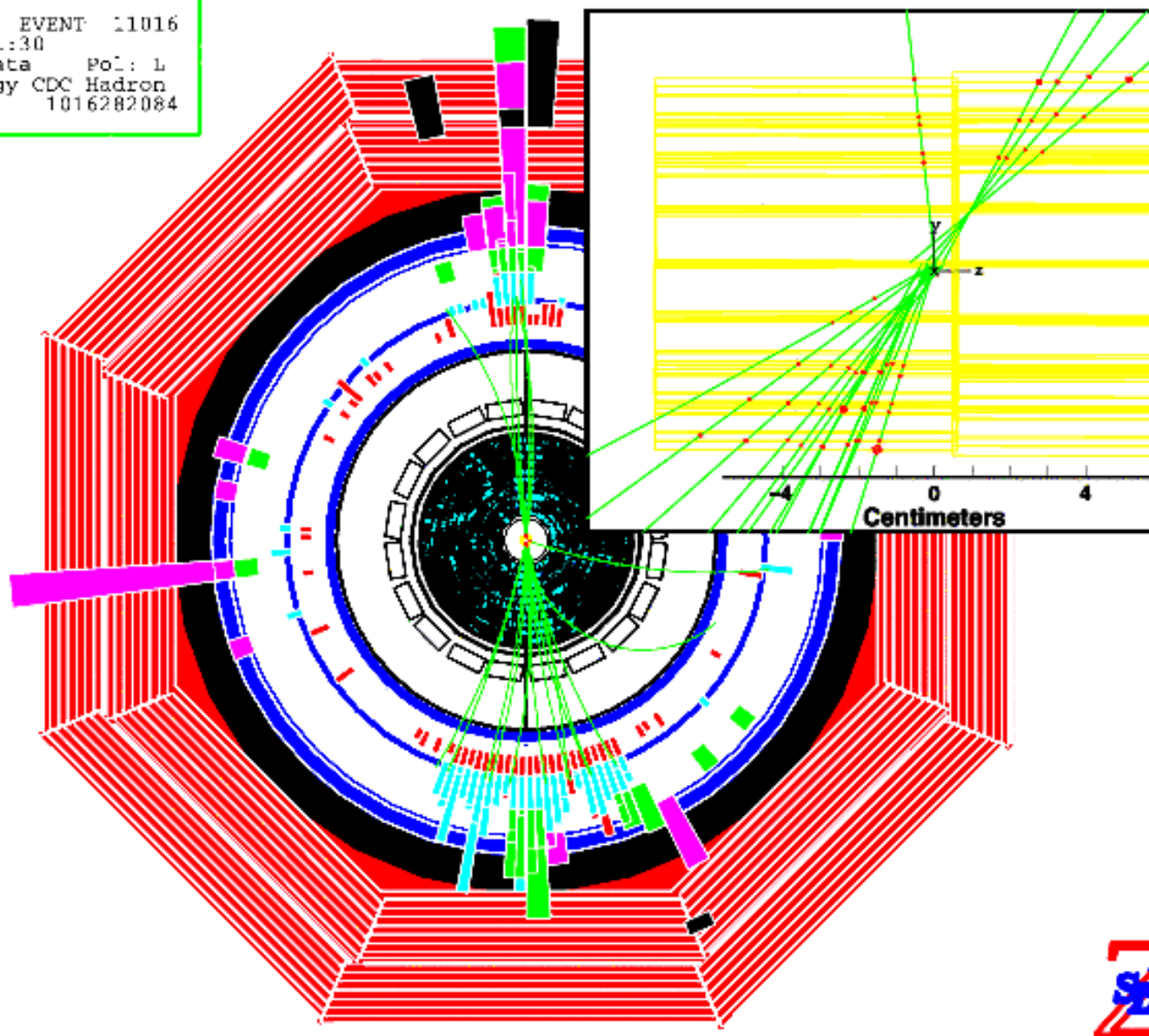


Centre of screen is (0.0000, 0.0000, 0.0000)



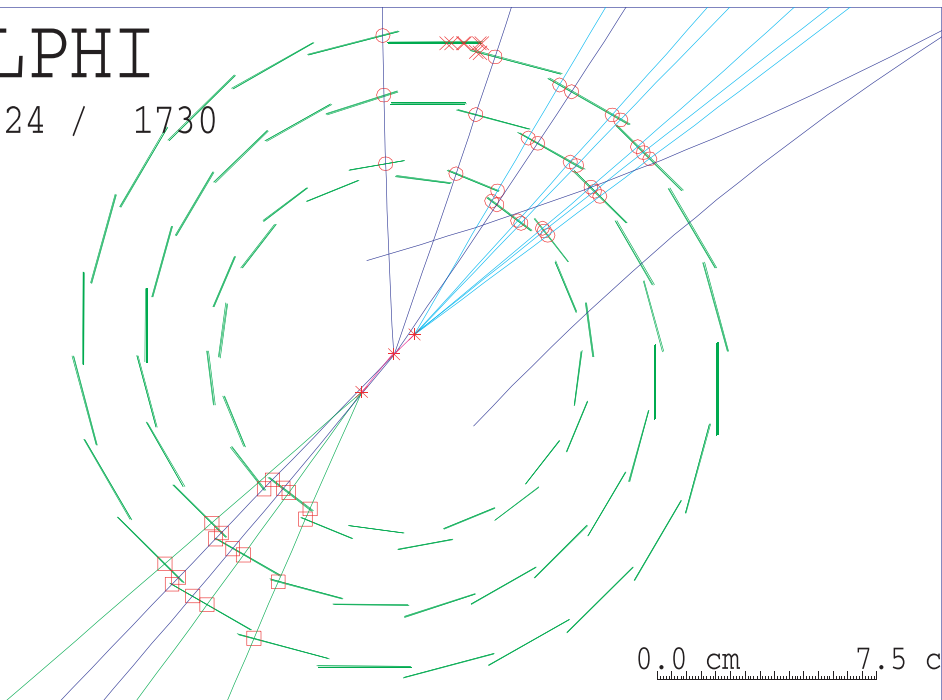


42725, EVENT 11016
R-1998 01:30
s: Run Data PoL: L
er: Energy CDC Hadron
Crossing 1016282084



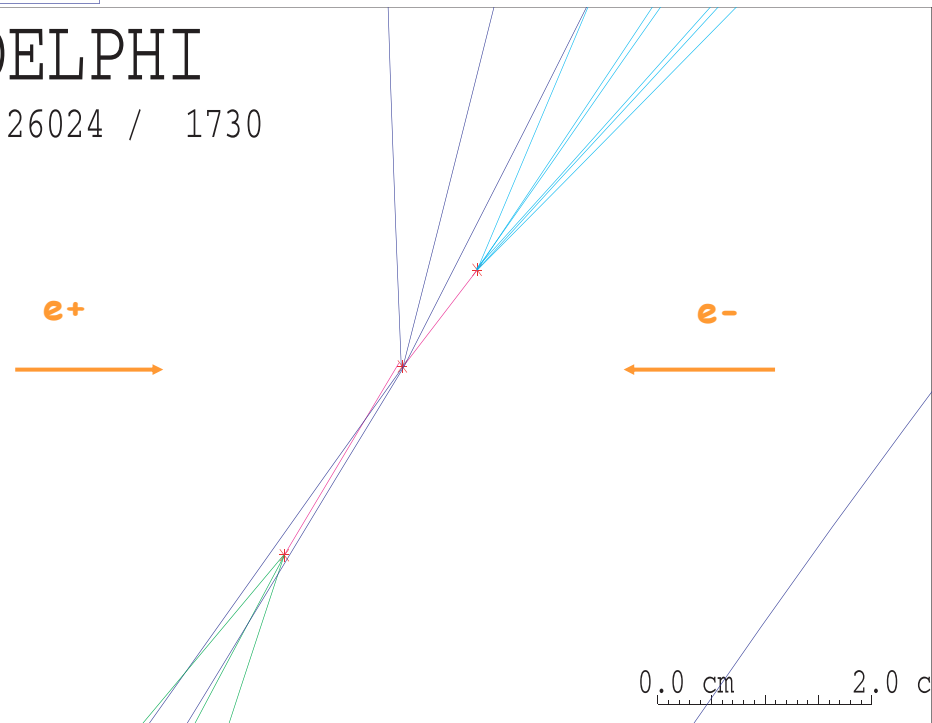
DELPHI

26024 / 1730

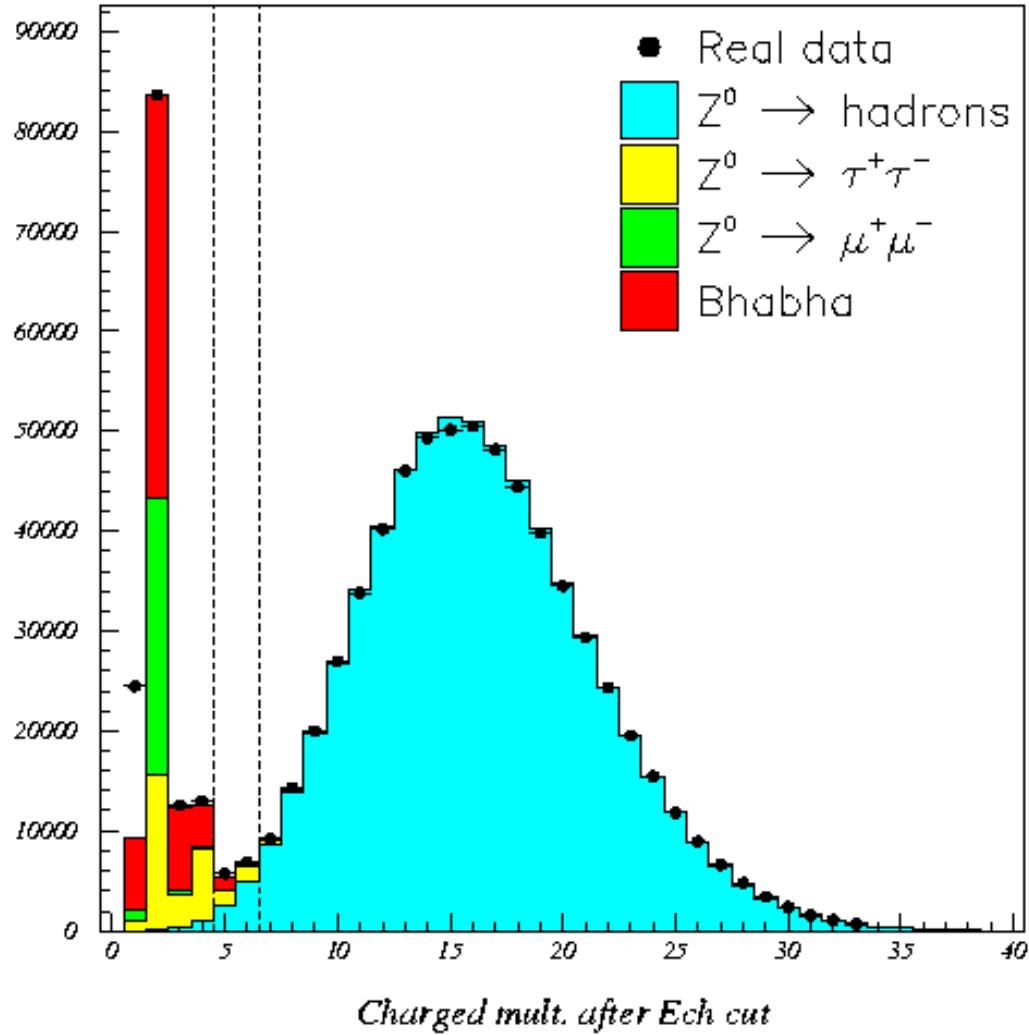


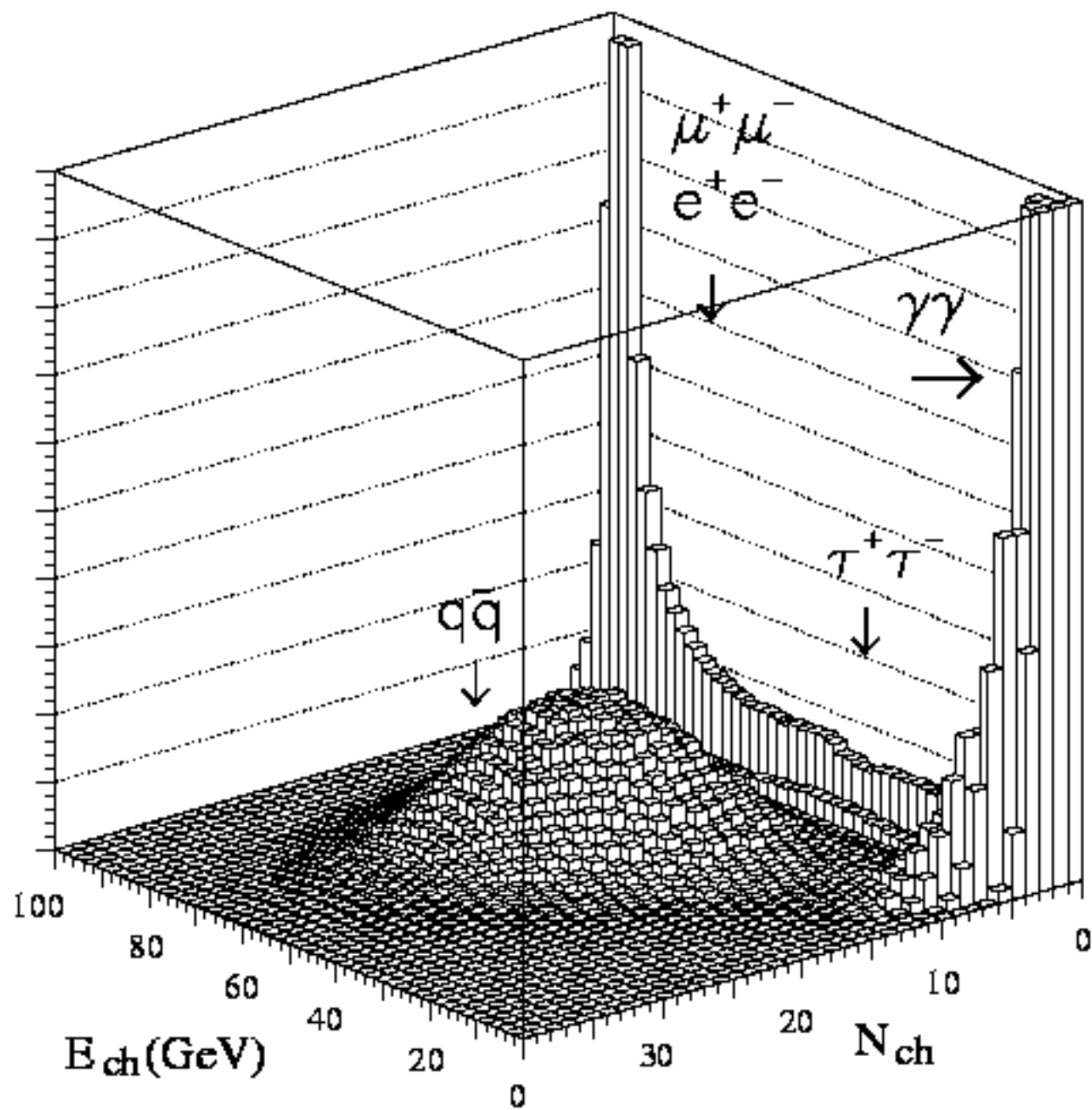
DELPHI

26024 / 1730



DELPHI





Il run di LEP e SLD

LEP-1

Luminosità

polarizzazione

year	centre-of-mass energy range [GeV]	integrated luminosity [pb^{-1}]
1989	88.2 – 94.2	1.7
1990	88.2 – 94.2	8.6
1991	88.5 – 93.7	18.9
1992	91.3	28.6
1993	89.4, 91.2, 93.0	40.0
1994	91.2	64.5
1995	89.4, 91.3, 93.0	39.8

7 milioni di eventi!

SLD

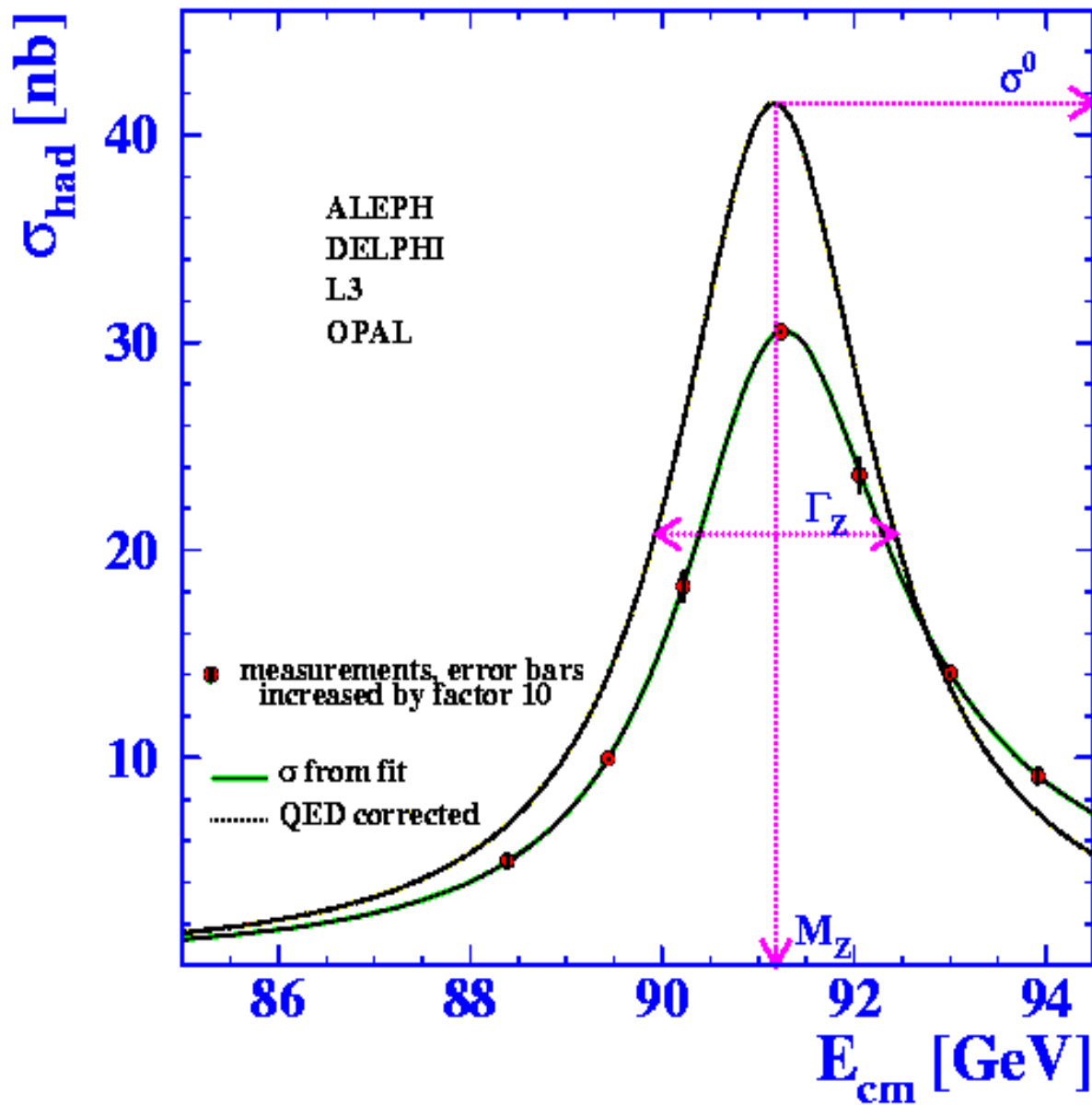
Year	$\langle P_e \rangle$	Int Lum
1992	0.244	0.2
1993	0.630	1.2
1994/5	0.7723	2.2
1996	0.7616	1.3
1997/8	0.7292	8.0

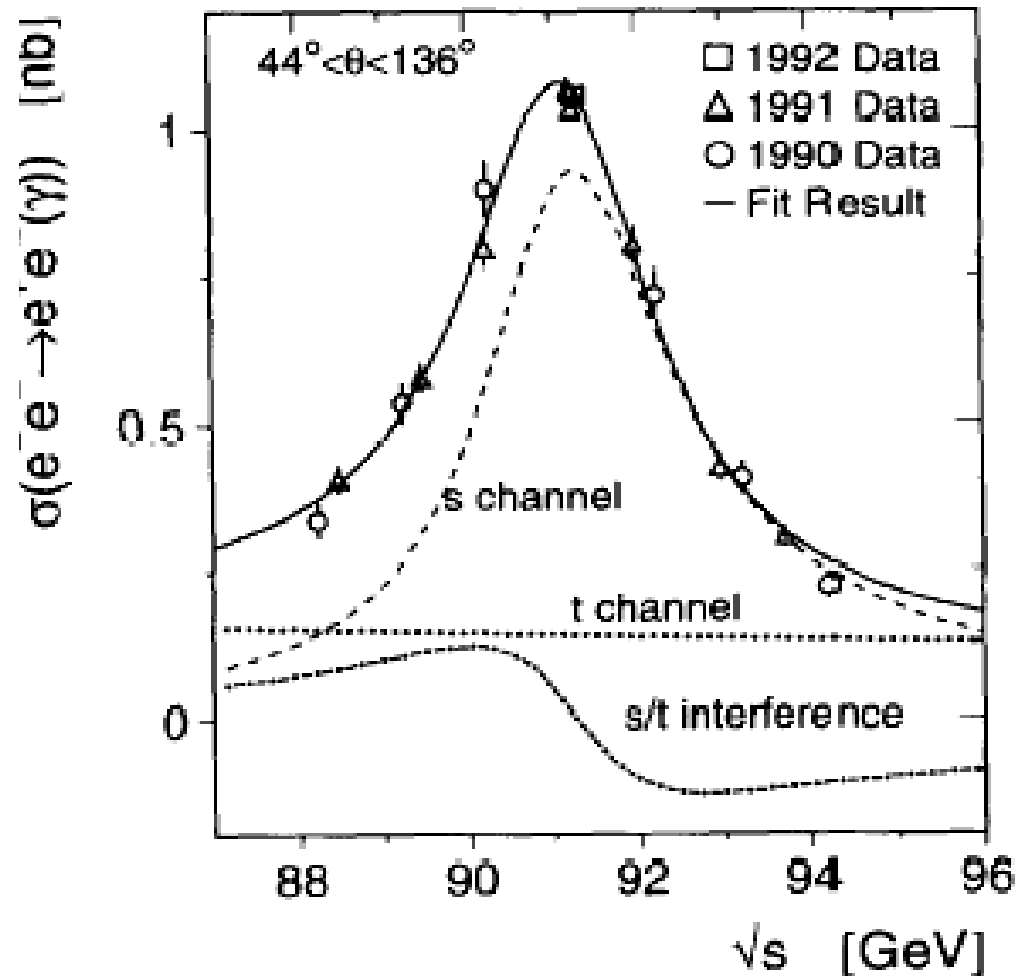
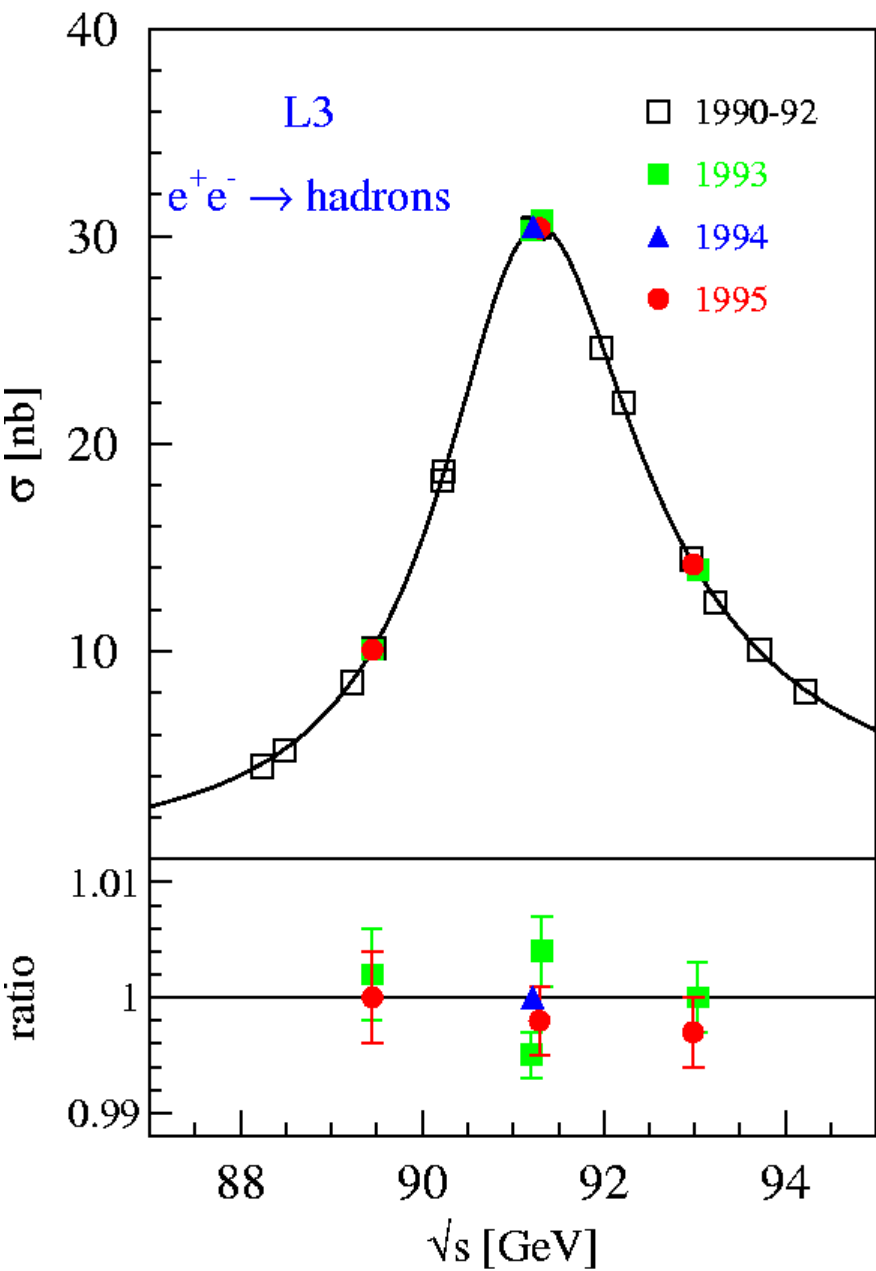
540 k eventi

LEP1 + LEP2

$E_{\text{cm}}(\text{GeV})$	1989-1995	1995		1996		1997	1998	1999			2000	
$E_{\text{cm}}(\text{GeV})$	91	130	136	161	172	183	189	192	196	200	202	204-209
Lum(pb^{-1}) per exp.	175	2.5	2.5	11	11	55	160	30	80	80	40	220

Lum(LEP2) > 2 fb^{-1}





Combinazione dei risultati

Ogni misura dei 4+1 esperimenti viene combinata con le altre:
combinazione di molti valori ognuno con errore che ha varie sorgenti:
statistico sistematico teorico
di cui alcune componenti sono correlate tra le varie misure e/o
tra i vari esperimenti.

Ex: -energia di LEP correlata tra misure ed esperimenti
-sottrazione del canale t nello stato finale e+e-
-input usati da altri esperimenti o di altre misure

r_i^m = misura i

x^m = valore aspettato

$$\chi^2 = \sum_{ij} (r_i^m - x^m) C_{ij}^{-1} (r_j^n - x^n)$$

C_{ij} matrice di covarianza = C_{ij} stat + $\sum_k \sigma_i^k \sigma_j^k$ + correlazione tra misure

Z⁰

$$m_Z = 91.1875 \pm 0.0021 \text{ GeV}$$

Accuratezza di $2 \cdot 10^{-5}$
per una delle costanti fondamentali !

1989: $m_Z = 91.12 \pm 0.16 \text{ GeV}$

$$\Gamma_Z = 2.4952 \pm 0.0023 \text{ GeV}$$

$$\sigma_0^{\text{had}} = 41.540 \pm 0.037 \text{ nb}$$

$$R_e = 20.804 \pm 0.050$$

$$R_\mu = 20.785 \pm 0.033$$

$$R_\tau = 20.764 \pm 0.045$$

Da cui le quantita' derivate: Γ_{had} , Γ_e , Γ_μ , Γ_τ , Γ_l , Γ_{inv}

Le asimmetrie Forward-Backward

$$A_{FB} = N_F - N_B / N_F + N_B$$

Misura della carica e dell'angolo

$$\partial\sigma / \partial\cos\theta \propto (3/8 (1+\cos^2\theta) + A_{FB} \cos\theta)$$

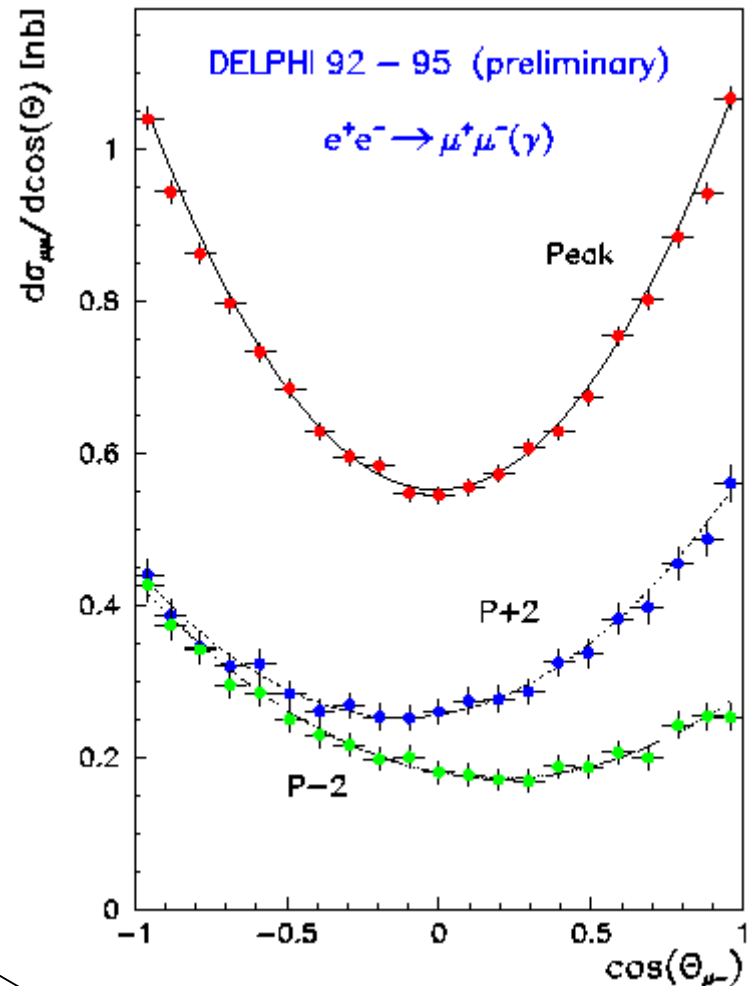
Solo scambio di Z:

$$A^{0,f}_{FB} = 3/4 \mathcal{A}_e \mathcal{A}_f$$

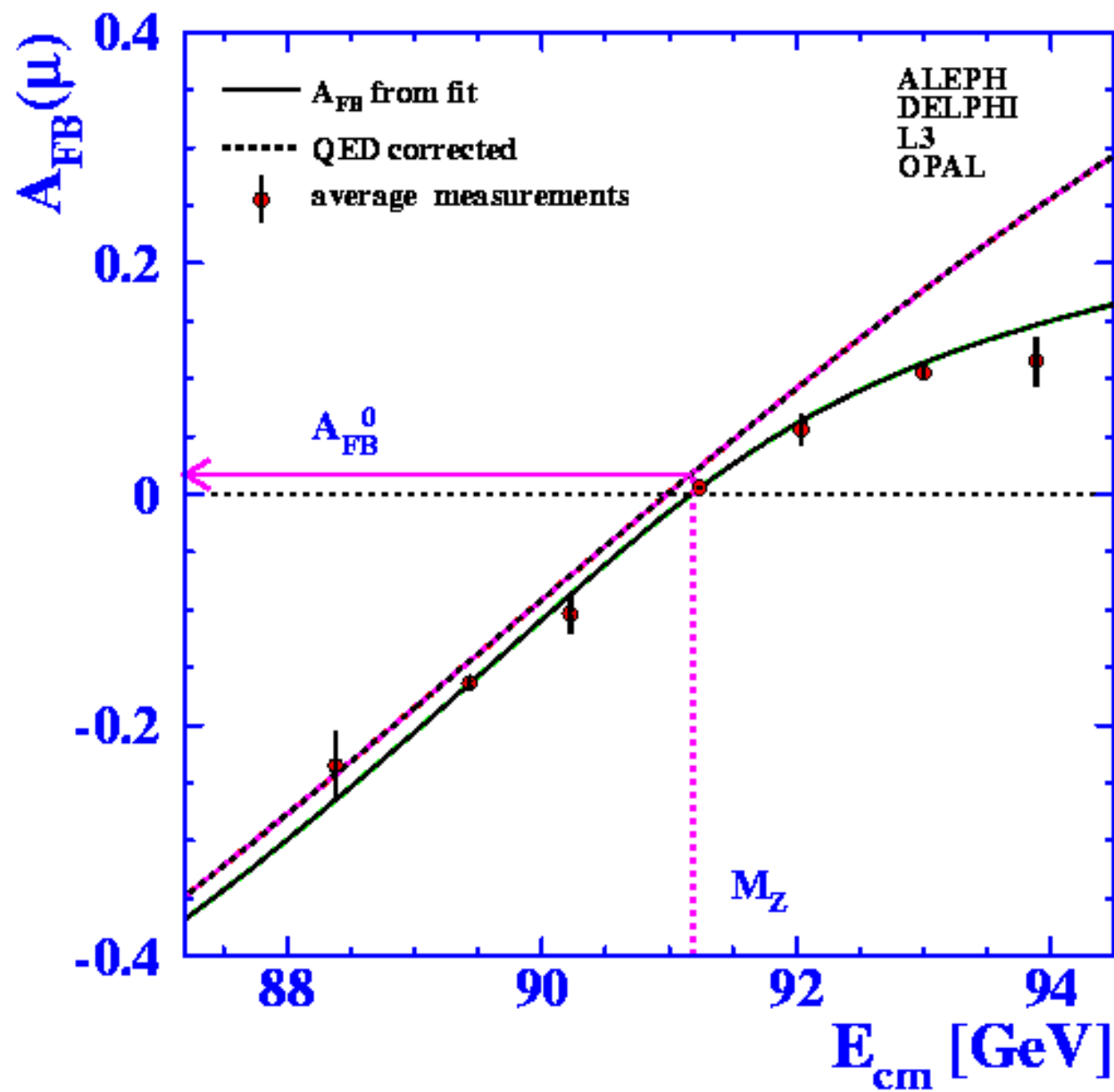
$$\mathcal{A}_f = 2 g_{Vf} / g_{Af} / (1 + g_{Vf}^2 / g_{Af}^2)$$

$$g_{Vf} / g_{Af} = 1 - 4|Q_f| \sin^2\theta_{eff}^f$$

Forte dipendenza dall'energia
a causa della interferenza γ -Z.



A_{FB} al picco = $1 - 4 \cdot 1 \cdot 0.23 \sim 0$,
Pari alle correzioni di QED



L'universalita' leptonica

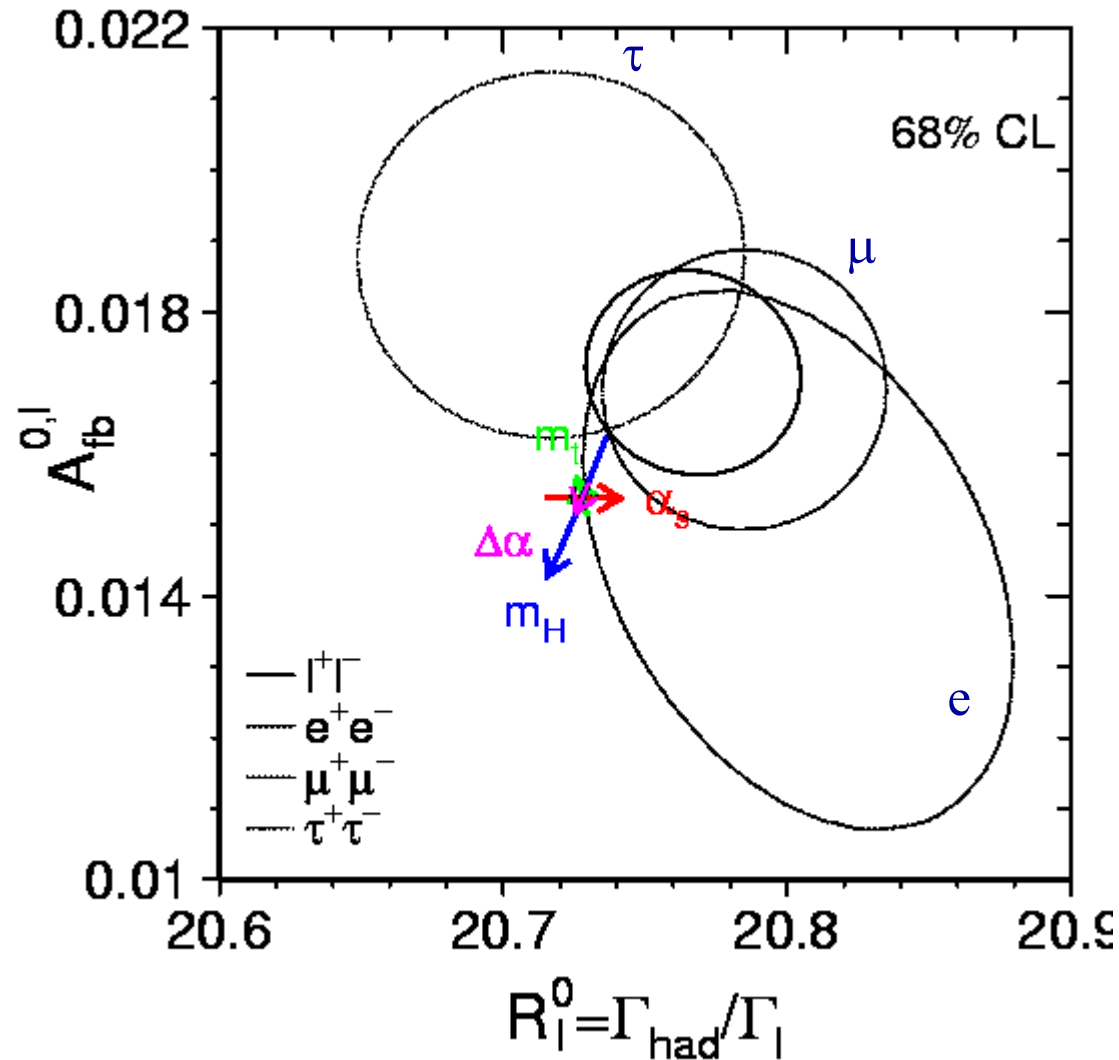
La misura delle larghezze
e delle asimmetrie
per i 3 leptoni
e assumendo
l'universalita' leptonica

Il SM con:

$$m(\text{top}) = 174.3 \pm 5.1 \text{ GeV}$$

$$m(\text{H}) = 300^{+700}_{-200} \text{ GeV}$$

$$\alpha_s(m_Z) = 0.119 \pm 0.002$$



Il numero dei neutrini

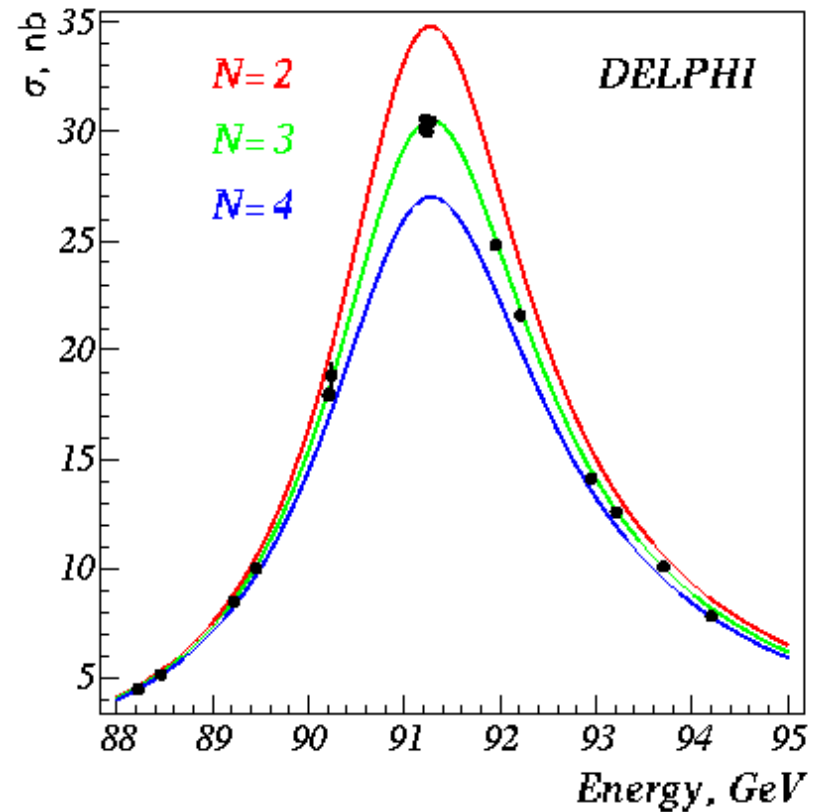
Dalla misura di

$$R_{inv} = \Gamma_{inv}/\Gamma_{ll} = (\Gamma_Z - \Gamma_{had} - 3\Gamma_{ll})/\Gamma_{ee}$$

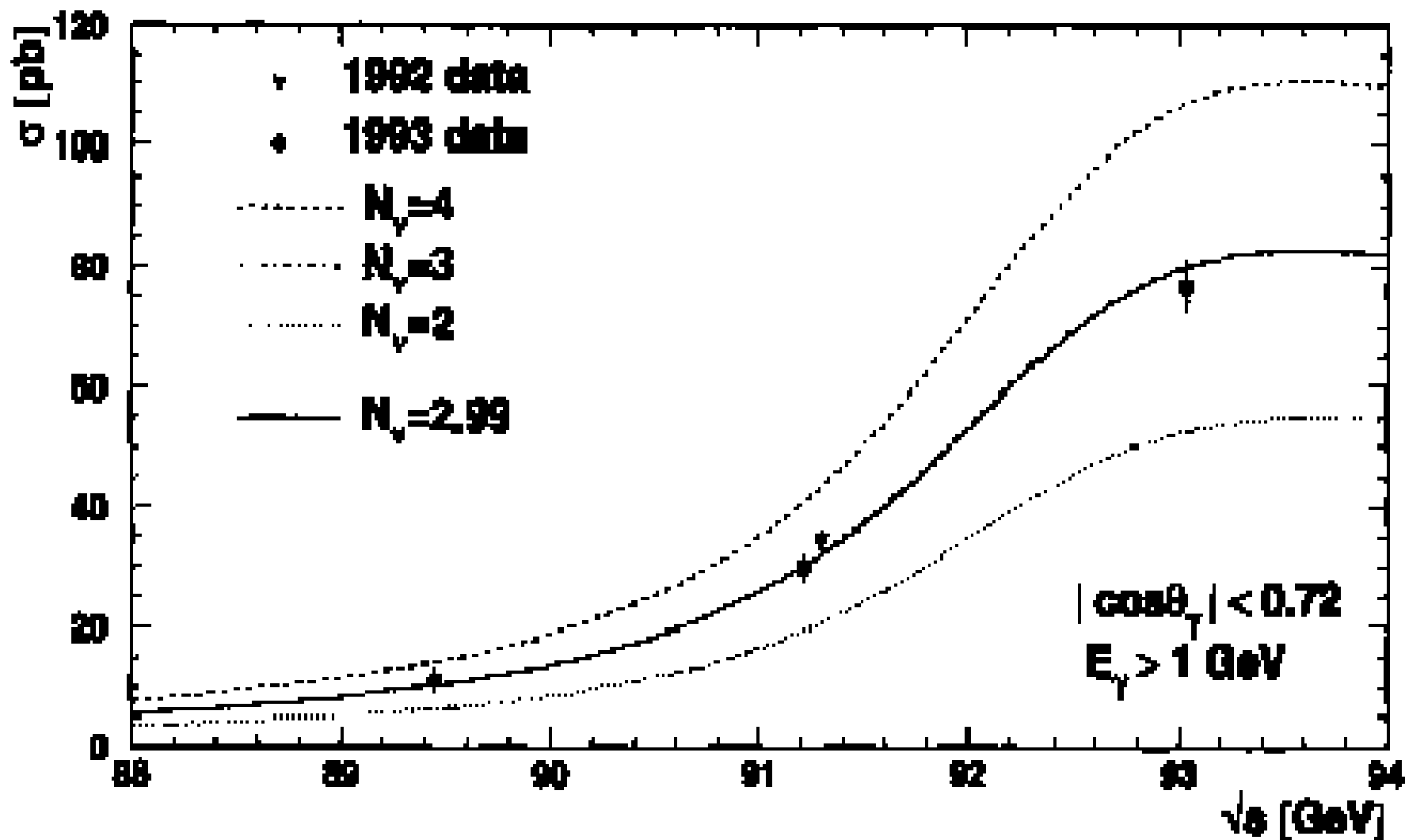
$$R_{inv} = N(\nu) * [\Gamma_{\nu\nu}/\Gamma_{ll}]_{SM}$$

$$N(\nu) = 2.9841 \pm 0.0083$$

2σ sotto 3



1989: $N(\nu) = 3.0 \pm 0.9$



ALR

$$A_{LR} = \sigma_{LR} / \sigma_{TOT} = \mathcal{A}e = 2 g_{Ae} g_{Ve} / (g_{Ae}^2 + g_{Ve}^2)$$

$$A_{LR} = (N_L - N_R) / (N_L + N_R) \cdot 1 / \langle \mathcal{P}_e \rangle$$

Tutti i decadimenti della Z possono essere usati (a parte ee)
→ piccolo errore statistico

Basta semplicemente contare:
accettanze e efficienze sono identiche per L e R
→ piccolo errore sistematico

Problemi:

I fasci devo essere altamente polarizzati

Bisogna misurare la polarizzazione

$$A_{LR} = 0.15138 \pm 0.00216 \quad , \quad \mathcal{A}l = 0.1513 \pm 0.0021$$

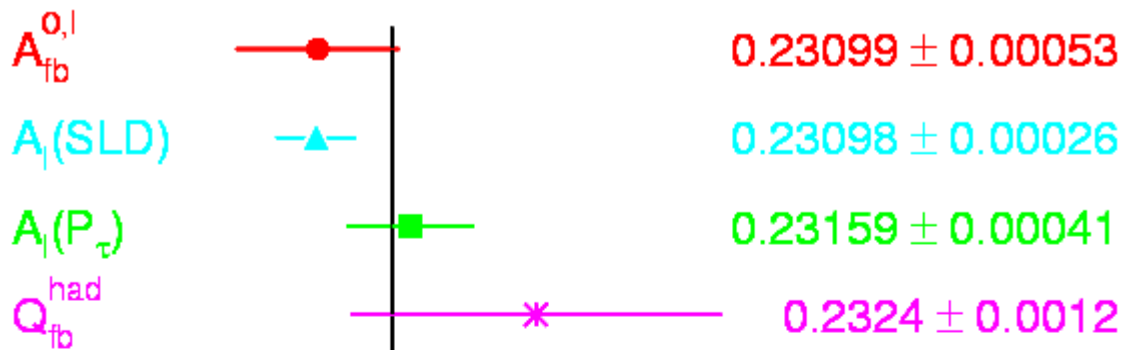
La misura piu' precisa al polo della Z.

Errore statistico doppio del sistematico.

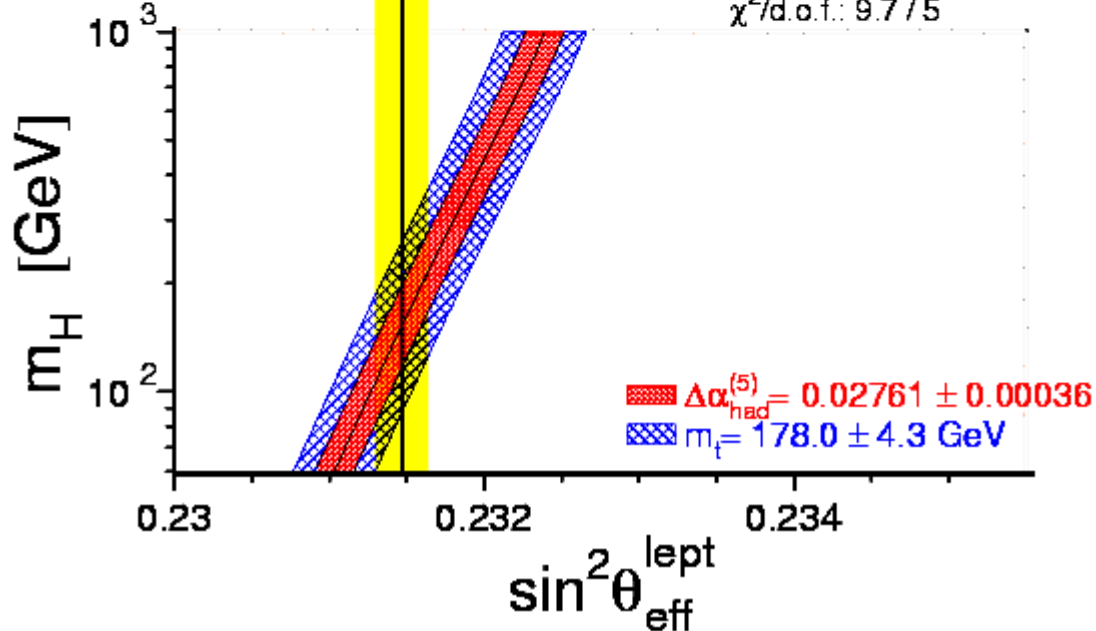
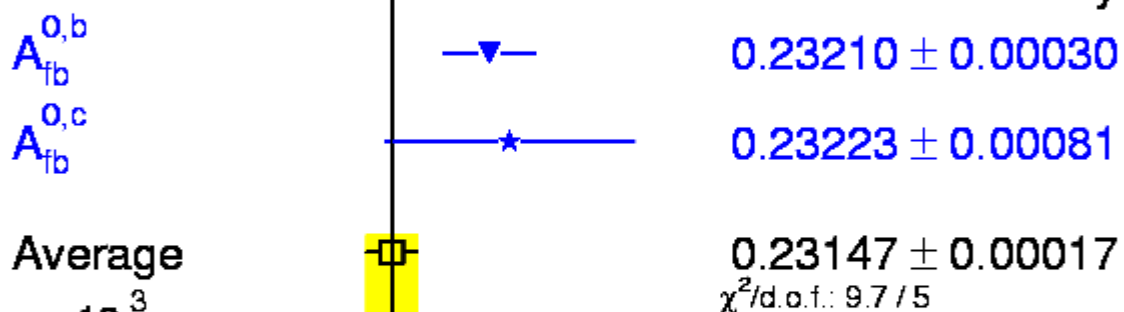
~assenza di errore teorico

La misura piu' sensibile a $\sin^2\theta$

Final



Preliminary



L'accoppiamento della Z ai leptoni

Da LEP:

$$A_{FB} = 3/4 A_e A_f$$

Larghezze Leptoniche $\propto g^2_{vf} + g^2_{Af}$

τ polarizzazione A_τ

Da SLD:

ALR

A_e, A_μ, A_τ

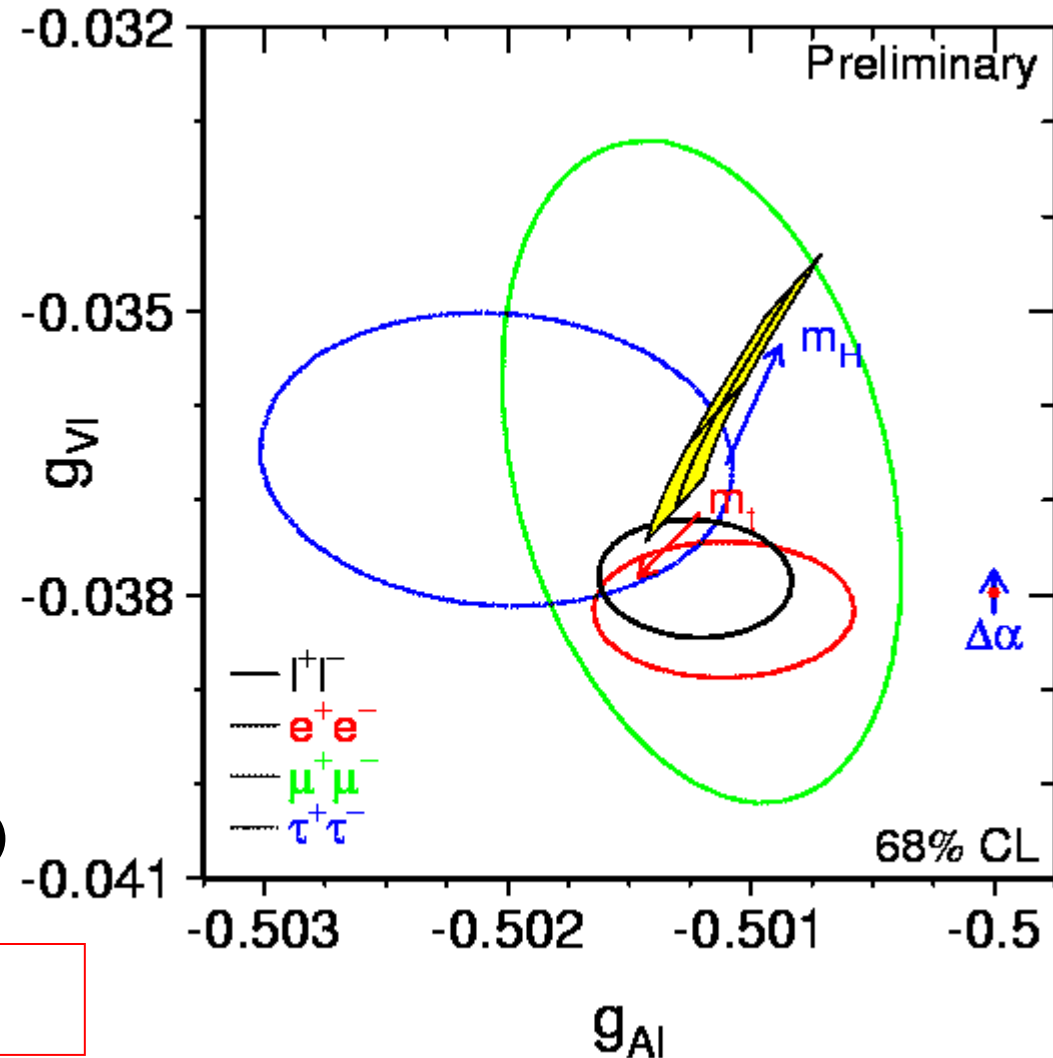
$$A_f \propto g_{vf}/g_{Af}$$

$$g_v = \sqrt{\rho} (I_3 - 2 Q \sin^2 \theta_W)$$

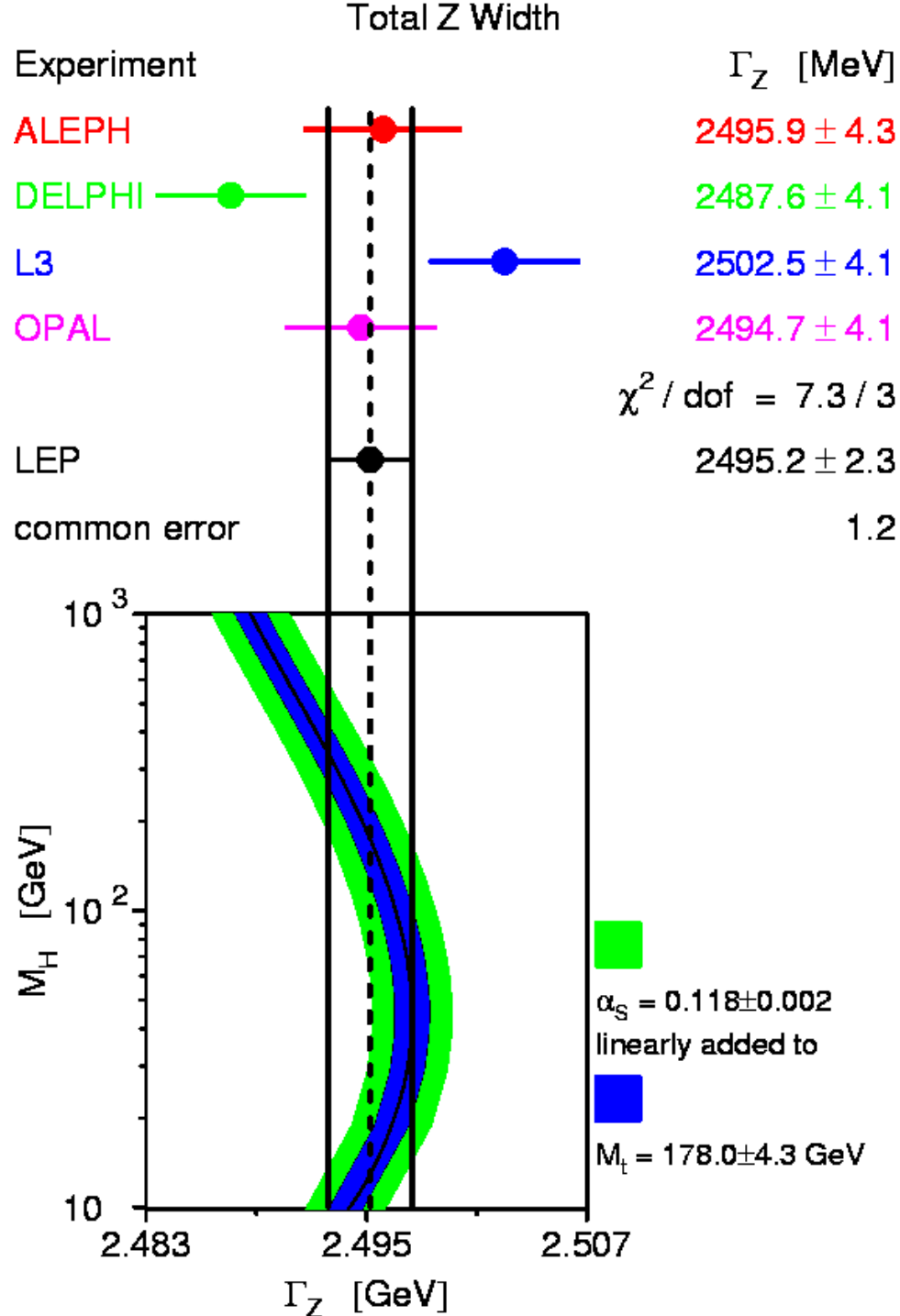
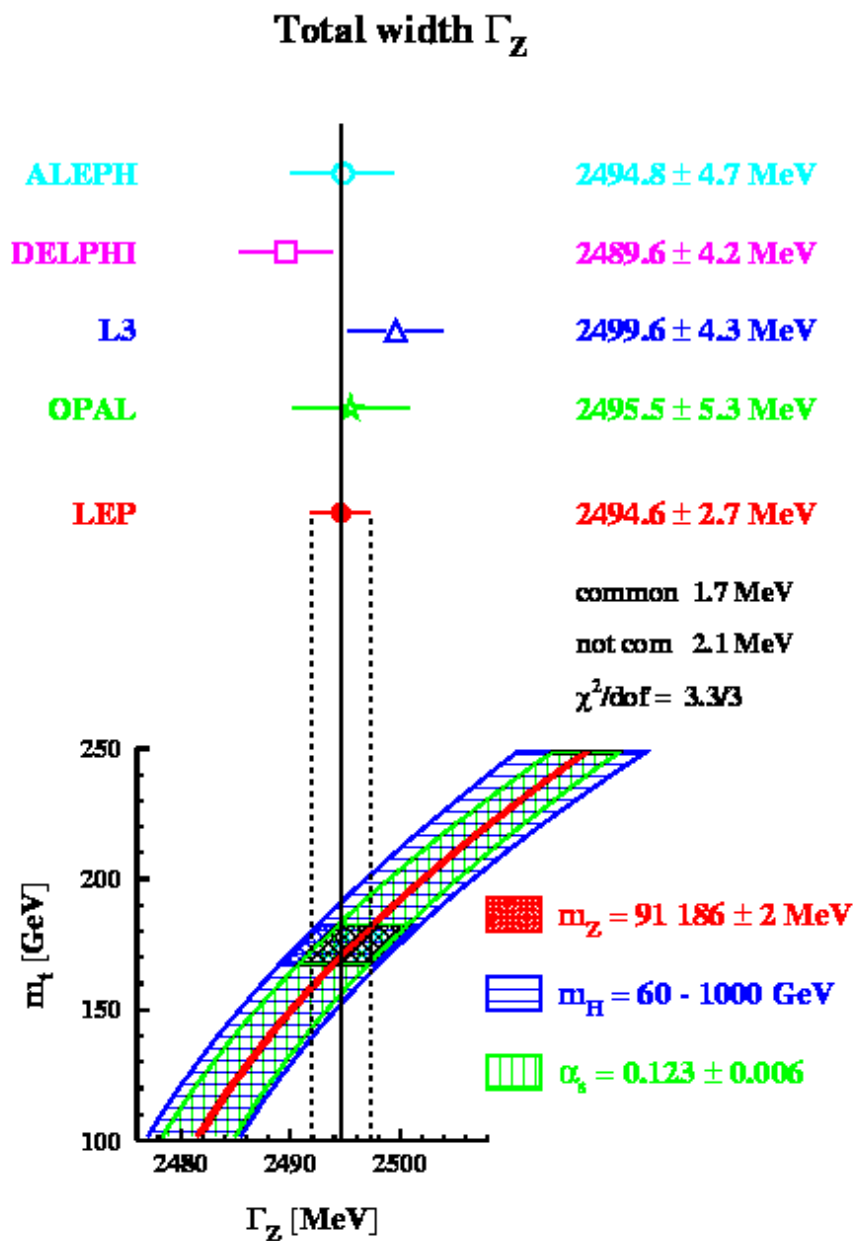
$$g_A = \sqrt{\rho} I_3$$

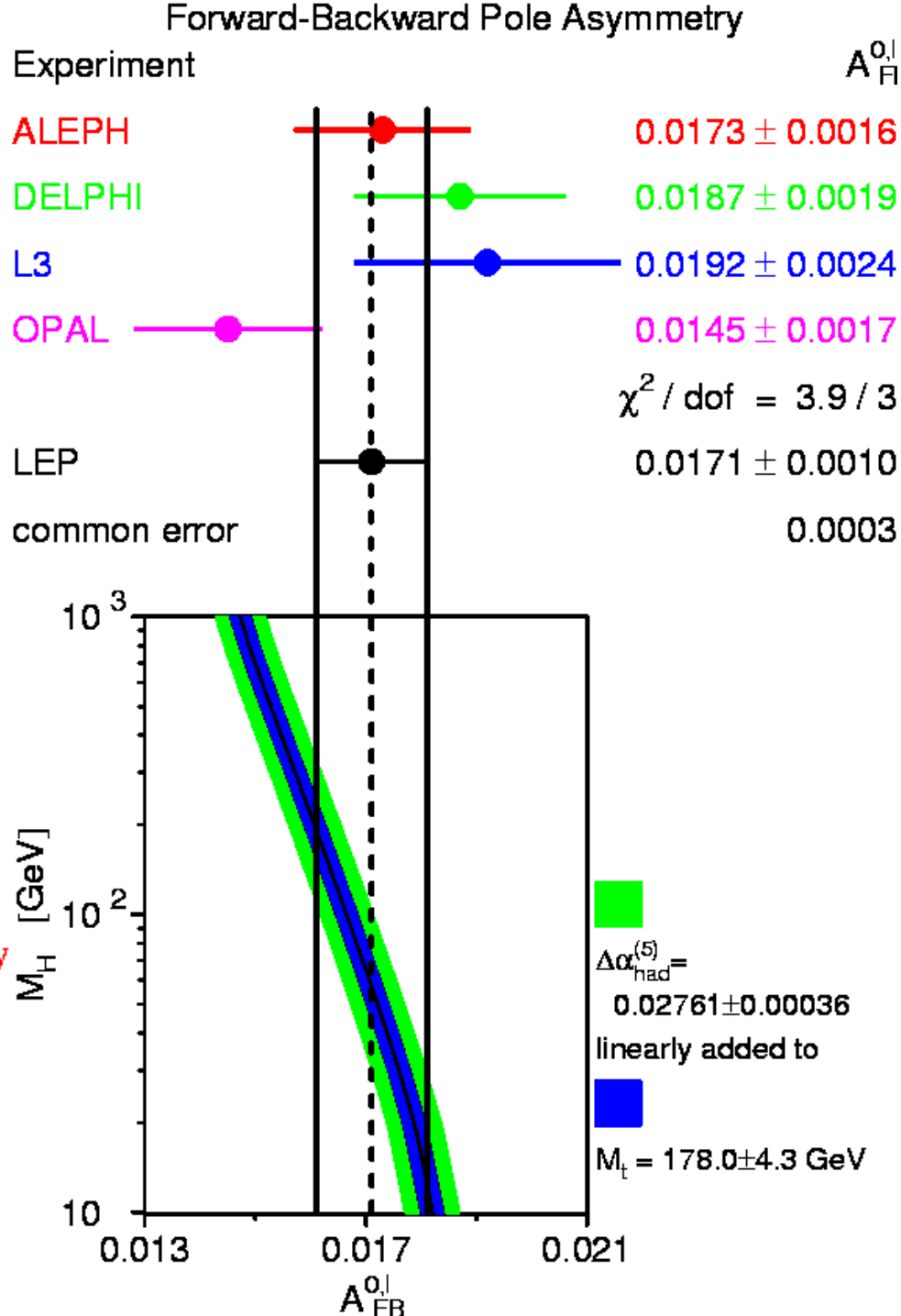
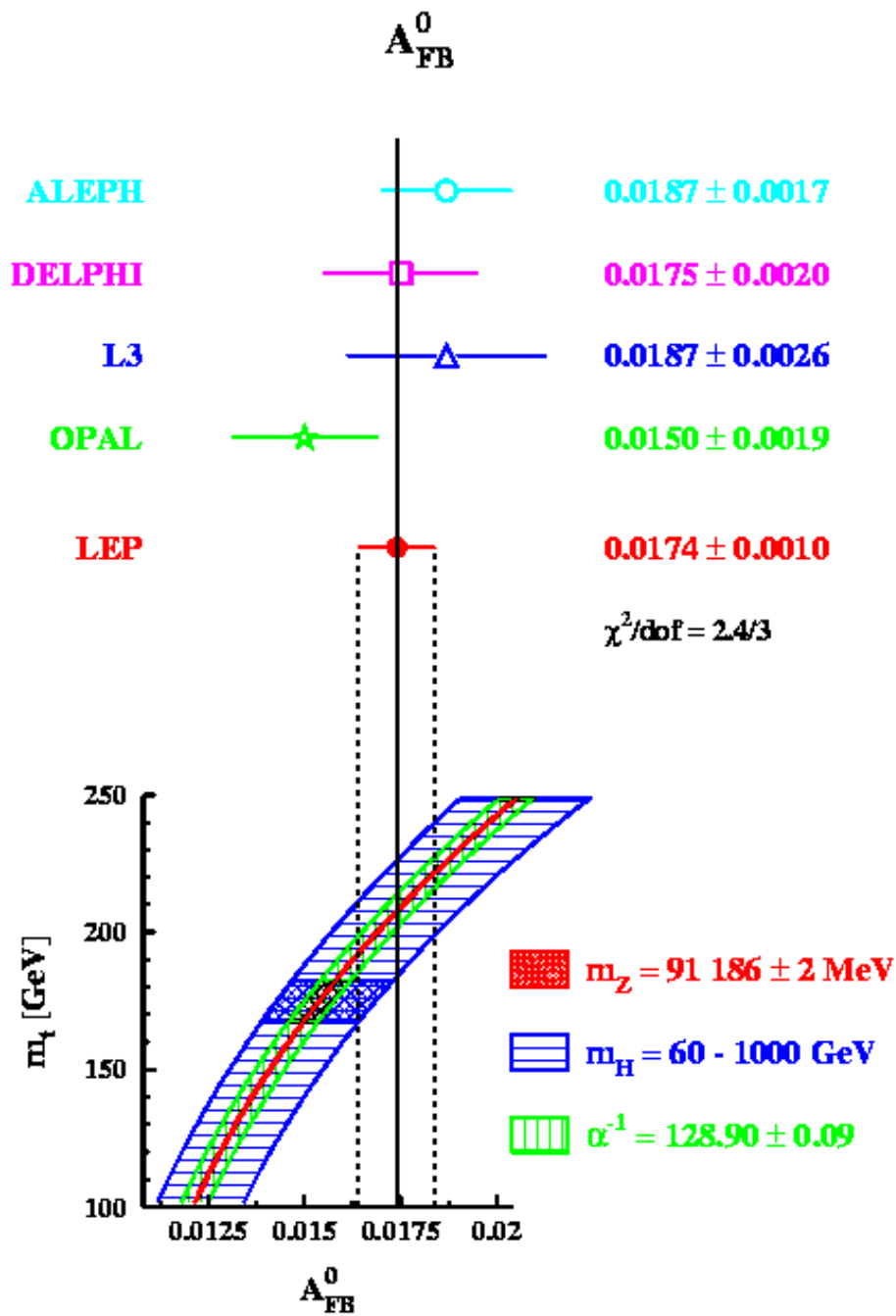
$$\rho = 1 + \Delta\rho, \quad \Delta\rho = f(m_t^2, \ln M_H)$$

$$\Rightarrow \bar{\rho}^{\text{lept}} = 1.0050 \pm 0.0010$$



5σ sopra il valore di “tree-level” $\rho = 1$, il che prova che effettivamente a LEP+SLD si “vedono” le correzioni radiative ElettroDeboli in accordo con SM



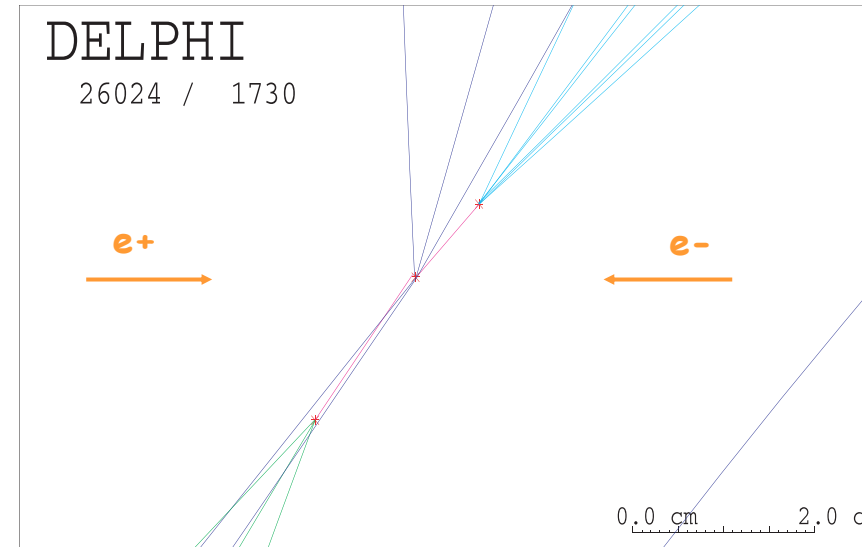
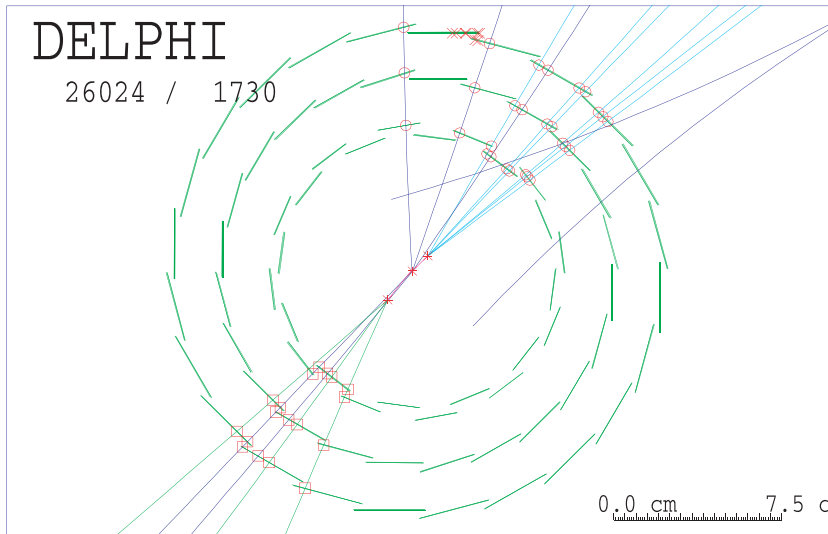


L'identificazione dei quark b

Massa b quark $m(b) \approx 4.5 \text{ GeV}/c^2$
Vita-media b quark $\tau(b) = 1.564 \pm 0.014 \text{ ps}$

Gli adroni B prodotti a LEP volano per pochi millimetri e il loro prodotto di decadimento ha grande p_T e grande parametro di impatto rispetto agli adroni con quark leggeri

$ee \rightarrow Z \rightarrow bb$



Beam spot size $\approx 120 \times 10 \mu\text{m}$

Resolutions on:

Primary vertex $\approx 20 \times 10 \mu\text{m}$

Impact Par $\approx 22 \mu\text{m}$ in $R\phi$

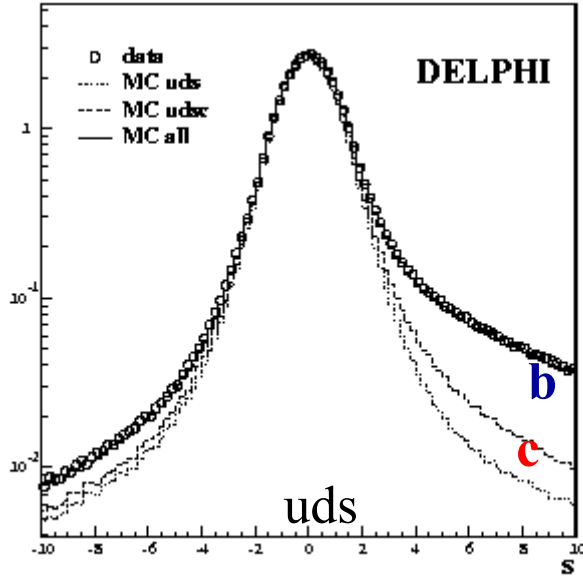
$\approx 35 \mu\text{m}$ in z

	ALEPH	DELPHI	L3	OPAL	SLD
Num. of layers	2	3	2	2	3
Radius of layers (cm)	6.5/11.3	6.3/9/11	6.2/7.7	6.1/7.5	2.9-4.1
$R\phi$ imp. par. res. (μm)	25*	20	30	16	13
z imp. par. res. (μm)		30	100	35	24
Primary Vertex res. $x \times y \times z$ (μm)	58×10 $\times 60$	22×10 $\times 22$	77×10 $\times 100$	80×12 $\times 85$	6.4×6.4 $\times 15$

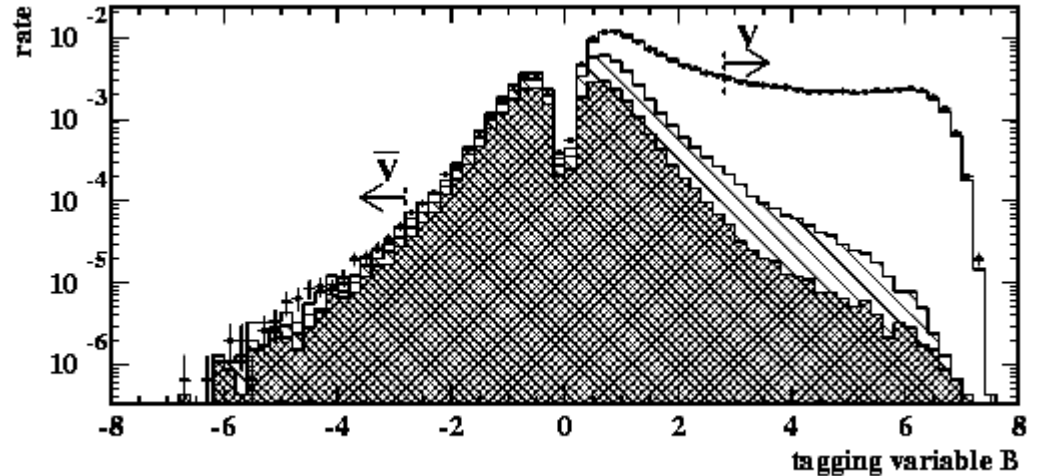
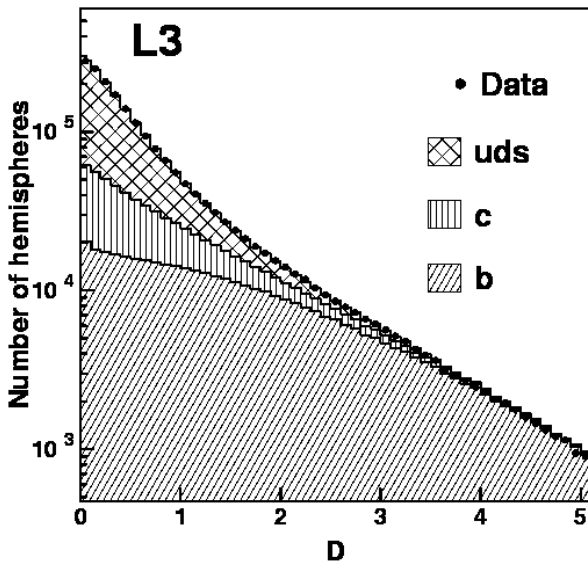
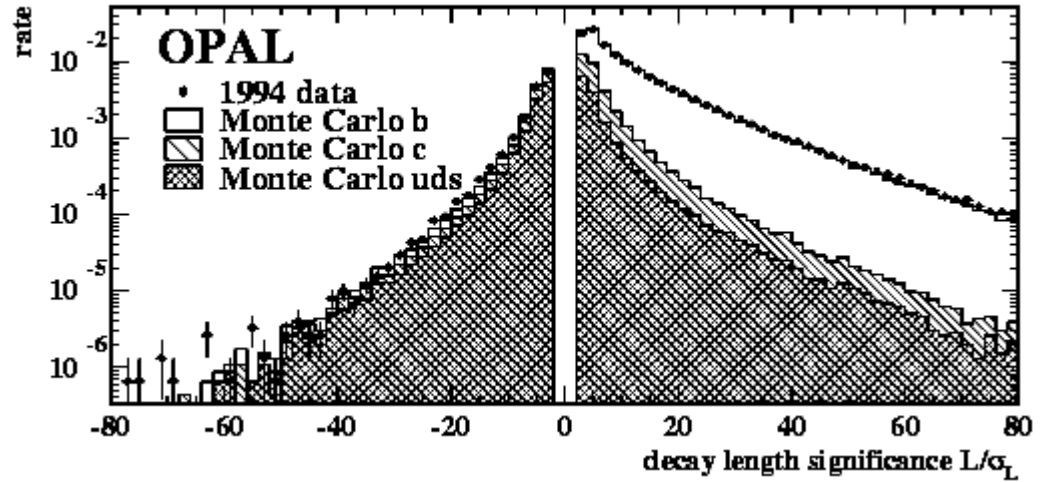
LEP
beamspot
150x10 μm

SLD
beamspot
5x5 μm

Il parametro d'impatto e i vertici secondari



Ip/σ



Il tag con i leptoni

Uno dei primi usati...

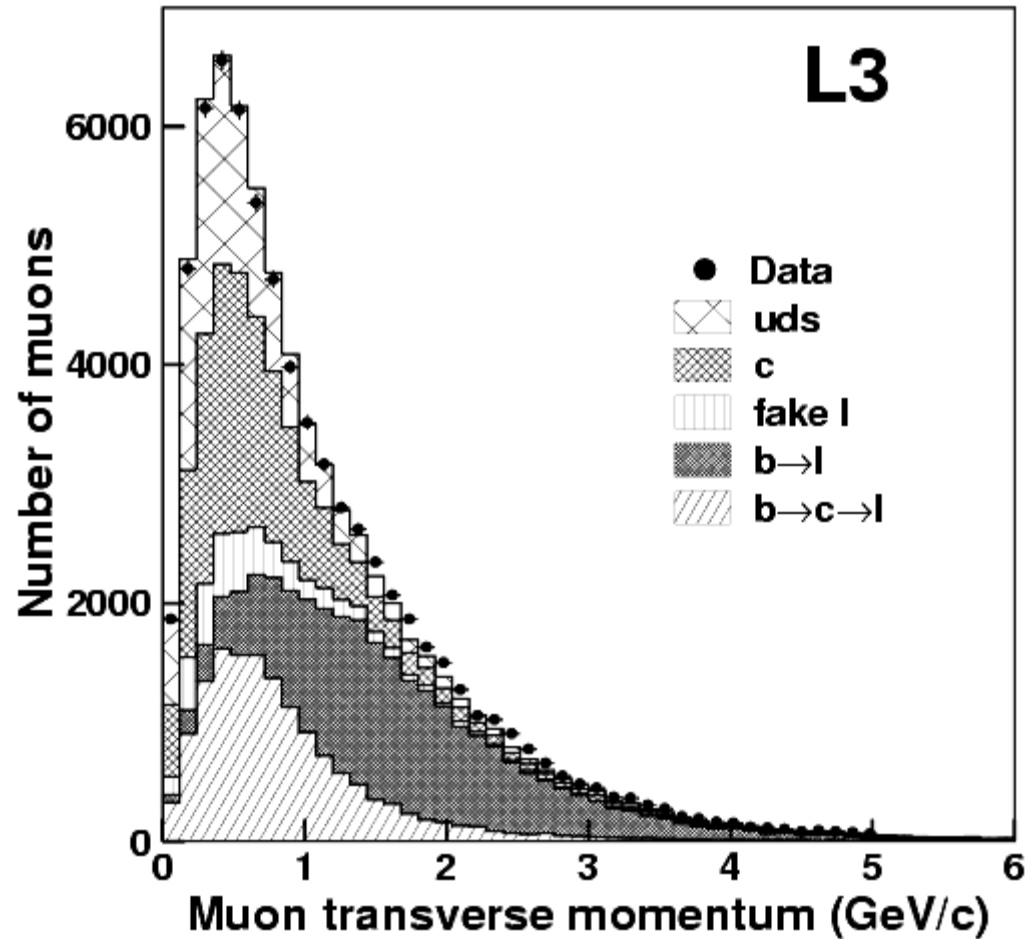
c e b decadono semileptonicamente
con $BR = 2 \times 10\%$

c e b hanno una frammentazione
dura \rightarrow leptoni hanno grande p

c e b hanno grande massa \rightarrow
leptoni hanno grande p_T

$b \rightarrow l$: alta purezza con semplice p_T cut

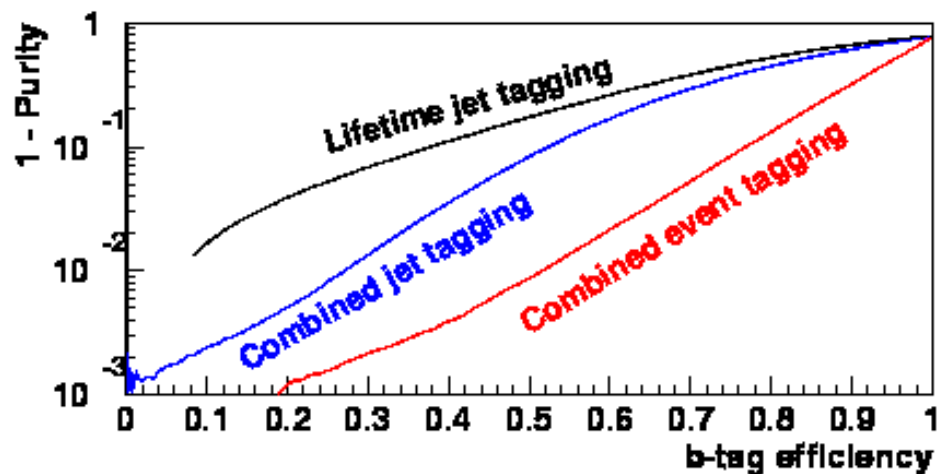
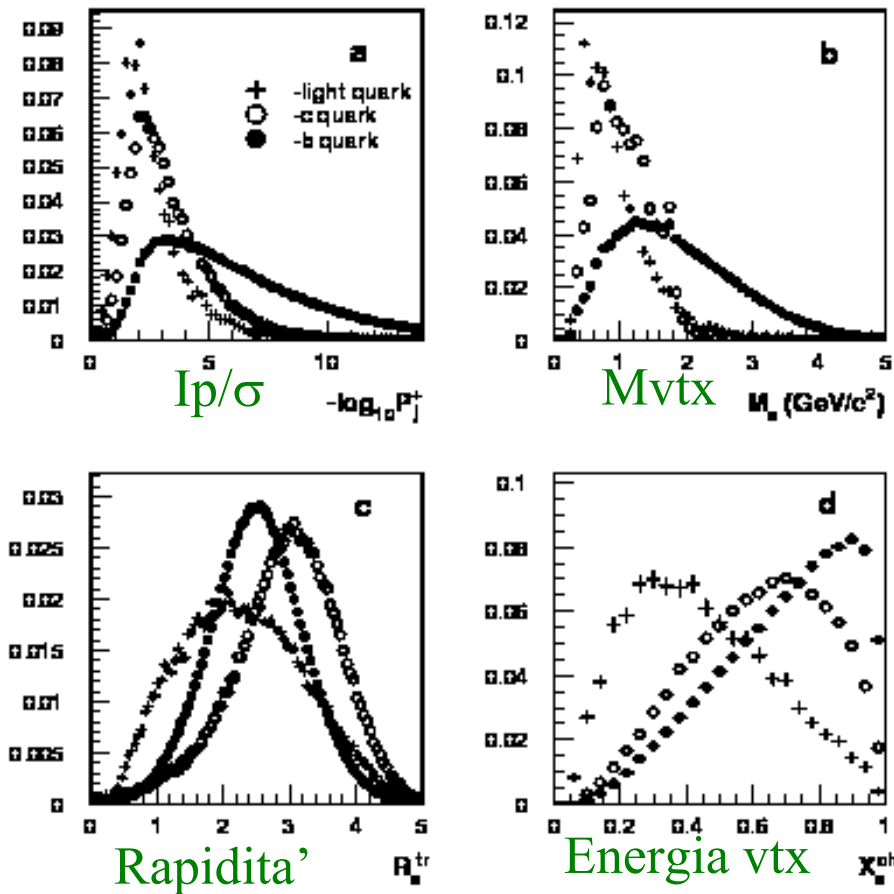
$c \rightarrow l$: difficile da separare da $b \rightarrow c \rightarrow l$
e da adroni leggeri.



Metodi combinati

I metodi piu' potenti combinano varie variabili via tecniche di likelihood o reti neurali

DELPHI



DELPHI raggiunge per jet-tag

Pur=98.6% a Eff=30%

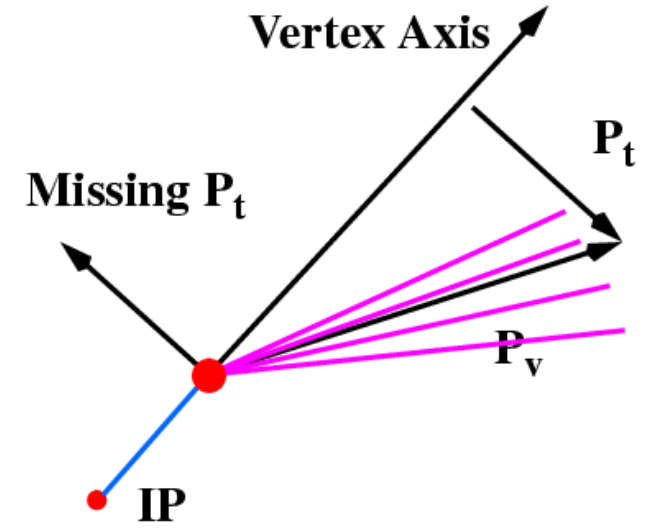
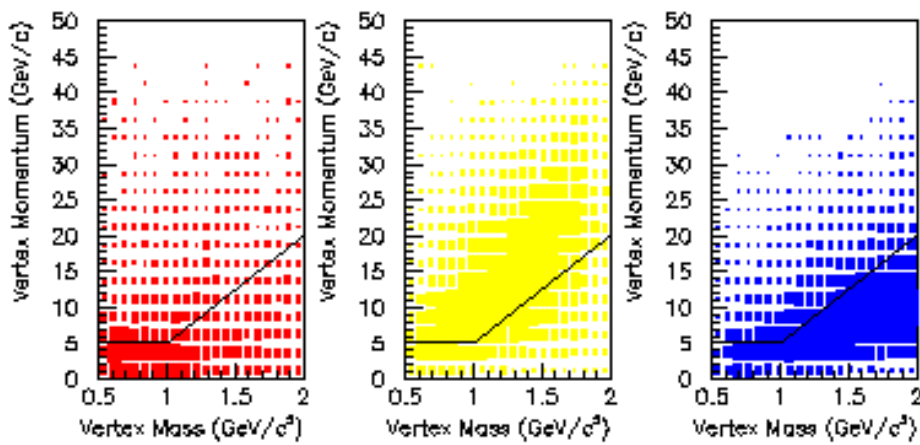
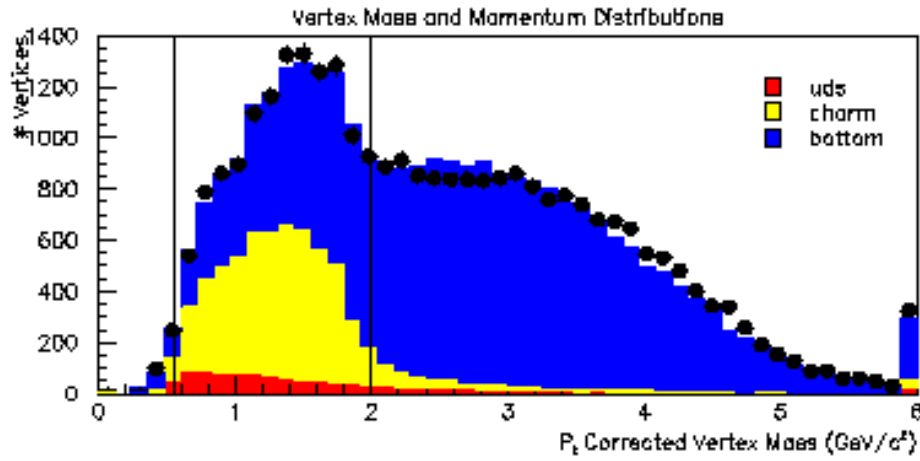
Per evento:

Pur=90% a Eff=80%

+ miss $p_T(vtx)$ neutri, + p_T leptoni

Il tag a SLD

Il tag in assoluto piu' performante !
sia per i quark b sia per i quark c



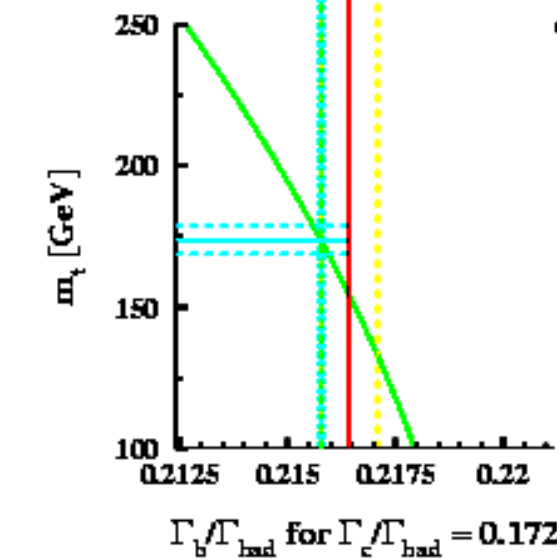
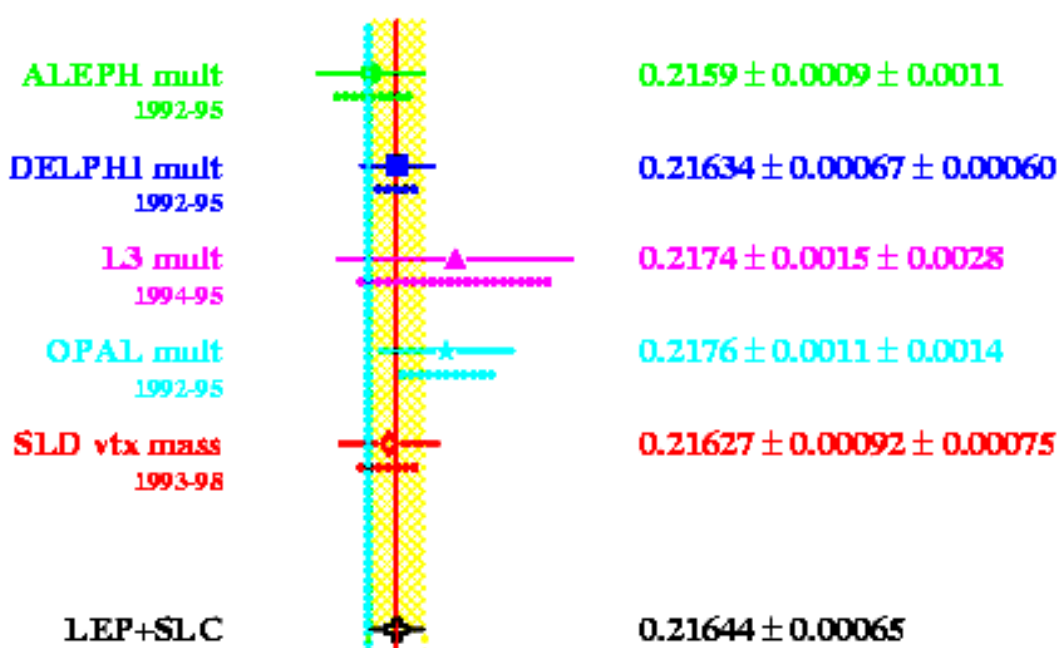
Ricostruzione del
vertice secondario:

- massa del vtx
- correzione per miss pT dei neutrini

Jet-b-tag :
Pur=98.3% Eff=61.8%

Jet-c-tag:
Pur= 52% Eff=17.6%

$$\Gamma_b/\Gamma_{\text{had}}$$



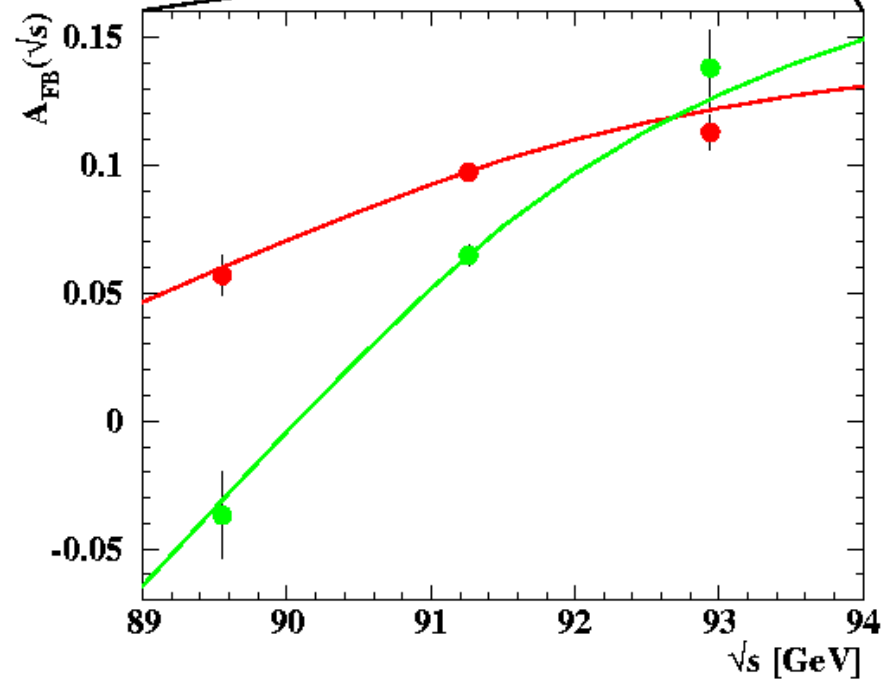
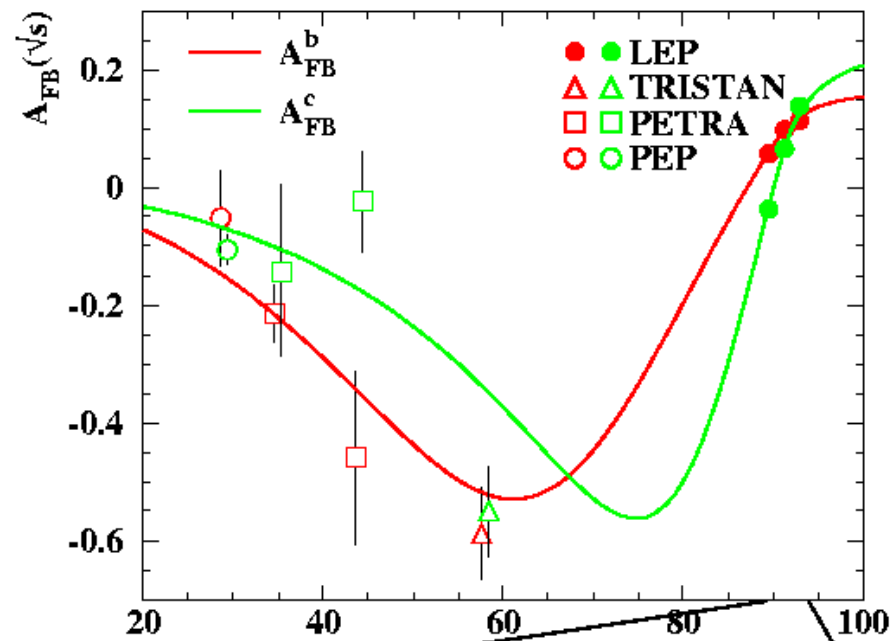
Incertezze su Rb

	ALEPH	DELPHI	L3	OPAL	SLD
Num. of layers	2	3	2	2	3
Radius of layers (cm)	6.5/11.3	6.3/9/11	6.2/7.7	6.1/7.5	2.9-4.1
$R\phi$ imp. par. res. (μm)	25*	20	30	16	13
z imp. par. res. (μm)		30	100	35	24
Primary Vertex res. $x \times y \times z$ (μm)	58×10 $\times 60$	22×10 $\times 22$	77×10 $\times 100$	80×12 $\times 85$	6.4×6.4 $\times 15$

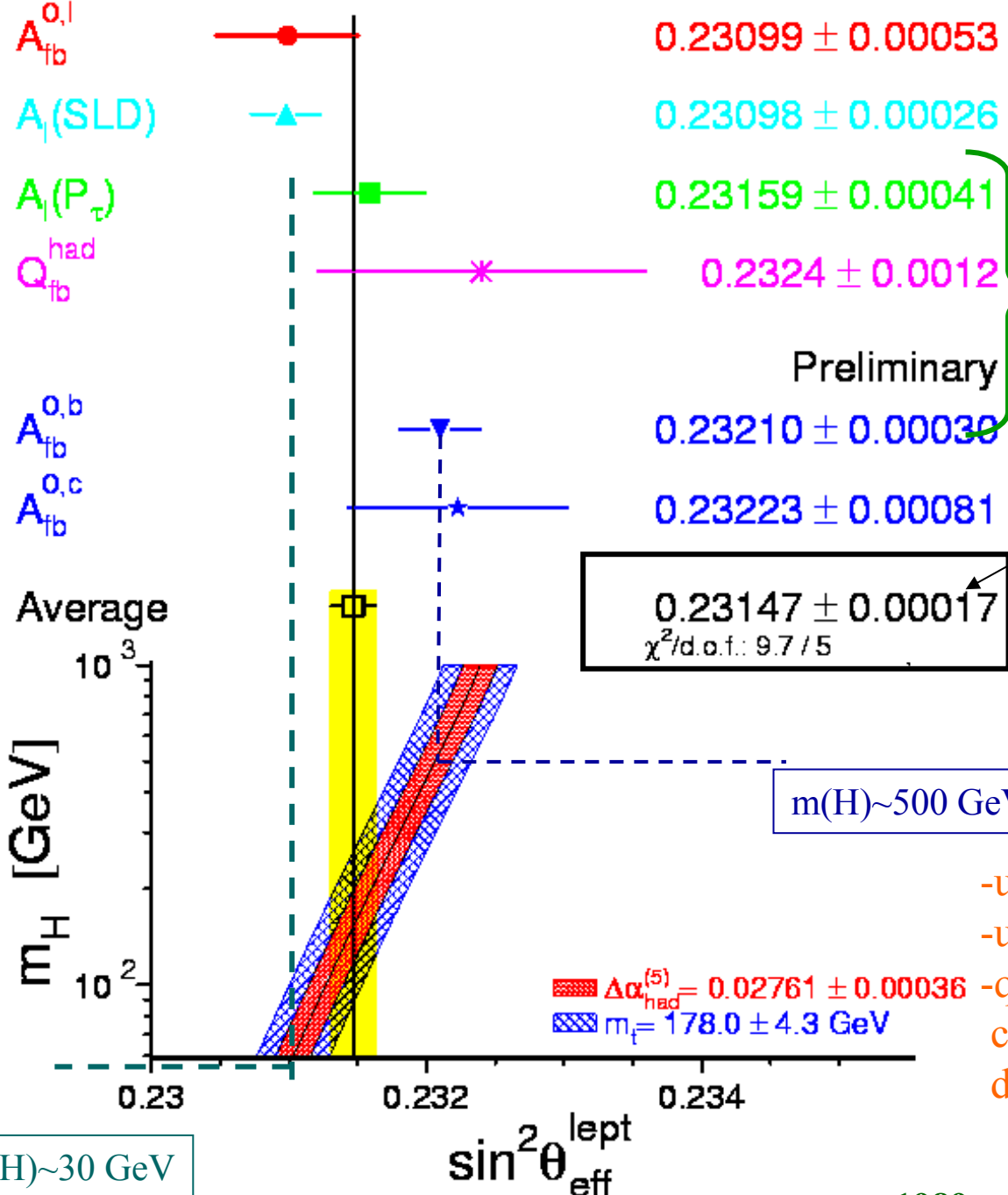
LEP
beamspot
150x10 μm

SLD
beamspot
5x5 μm

Experiment	ALEPH	DELPHI	L3	OPAL	SLD
b -tag method	multivar.	multivar.	impact+ ℓ	vtx-NN+ ℓ	vtx-mass NN
b -tag efficiency	19.6%	29.5%	23.7%	20.9%	61.8%
b -tag purity	98.5%	98.5%	84.0%	97.9%	98.3%
$\delta R_b \times 10^{-5}$					
statistics	87	67	150	112	94
$\epsilon_c, \epsilon_{uds}$ physics	39	25	218	74	44
Hemisphere correlation	36	28	116	71	23
$g \rightarrow b\bar{b}$	38	27	11	25	22
$g \rightarrow c\bar{c}$	22	8	13	17	18
Detector effects	46	13	43	25	42
Event selection	7	9		33	70
Internal (MC stat. etc.)	47	33	81	59	14
$\delta R_c \pm 0.005$	10	12	108	35	17



$\sin^2\theta_{\text{eff}}$



2.9 σ discrepanza

dominata dall'incertezza su α_{em}

Prob = 7%

Solo il valor medio di $\sin^2\theta_{\text{eff}}$ e' consistente con $m(H) \sim 100 \text{ GeV}$

$m(H) \sim 500 \text{ GeV}$

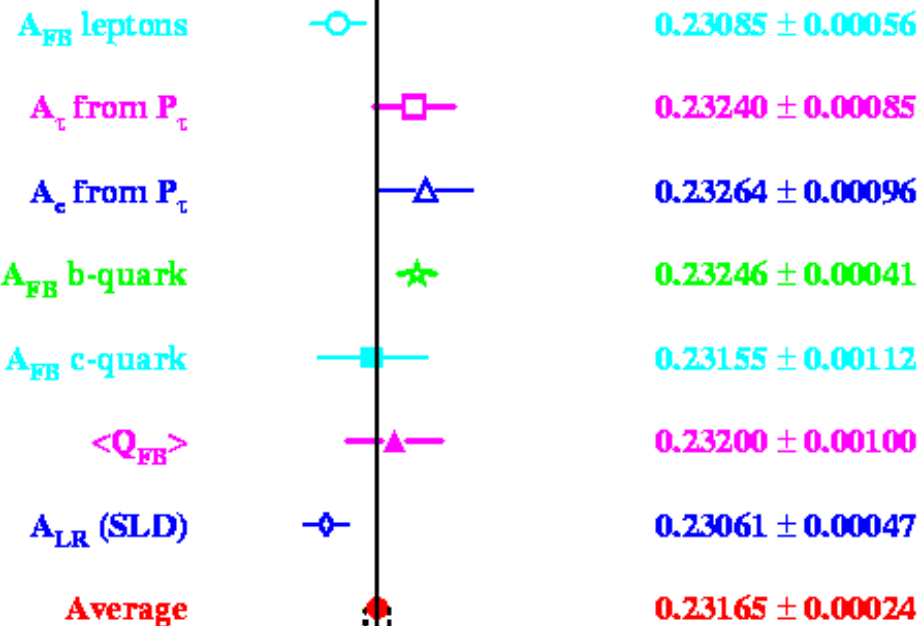
$m(H) \sim 30 \text{ GeV}$

- una fluttuazione statistica
- un problema sistematico
- qualcosa di "nuovo" che si manifesta in una differenza tra quark e leptoni?

1989: $\sin^2\theta_{\text{eff}} = 0.227 \pm 0.006$

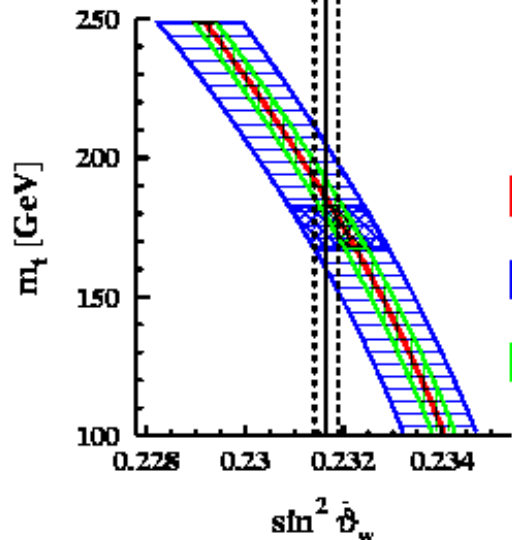
1996

$\sin^2 \bar{\theta}_w$



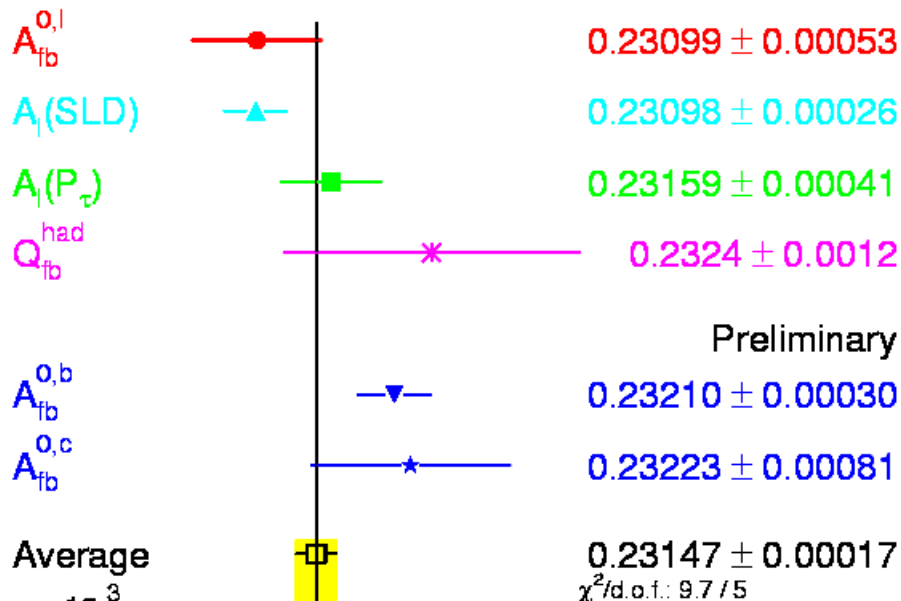
$\chi^2/\text{dof} = 12.8/6$

- $m_Z = 91\,186 \pm 2 \text{ MeV}$
- $m_H = 60 - 1000 \text{ GeV}$
- $\alpha^{-1} = 128.90 \pm 0.09$

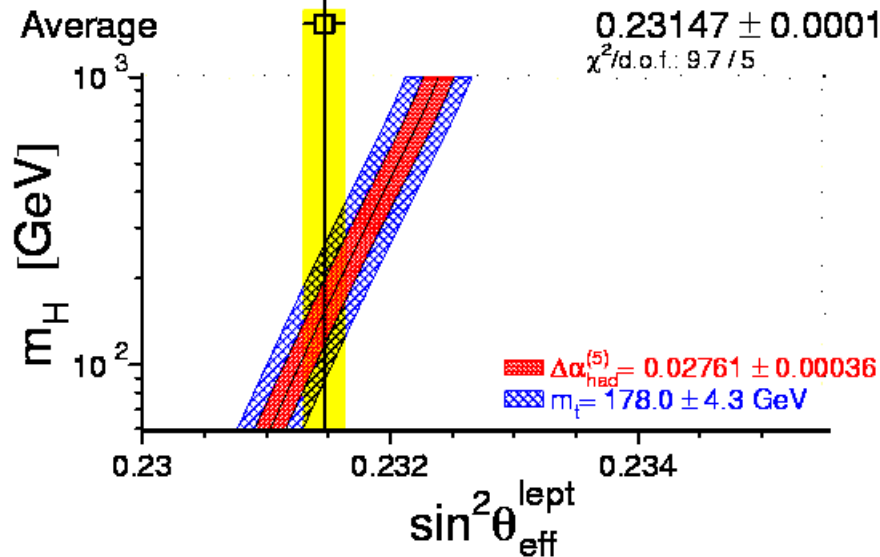


2004

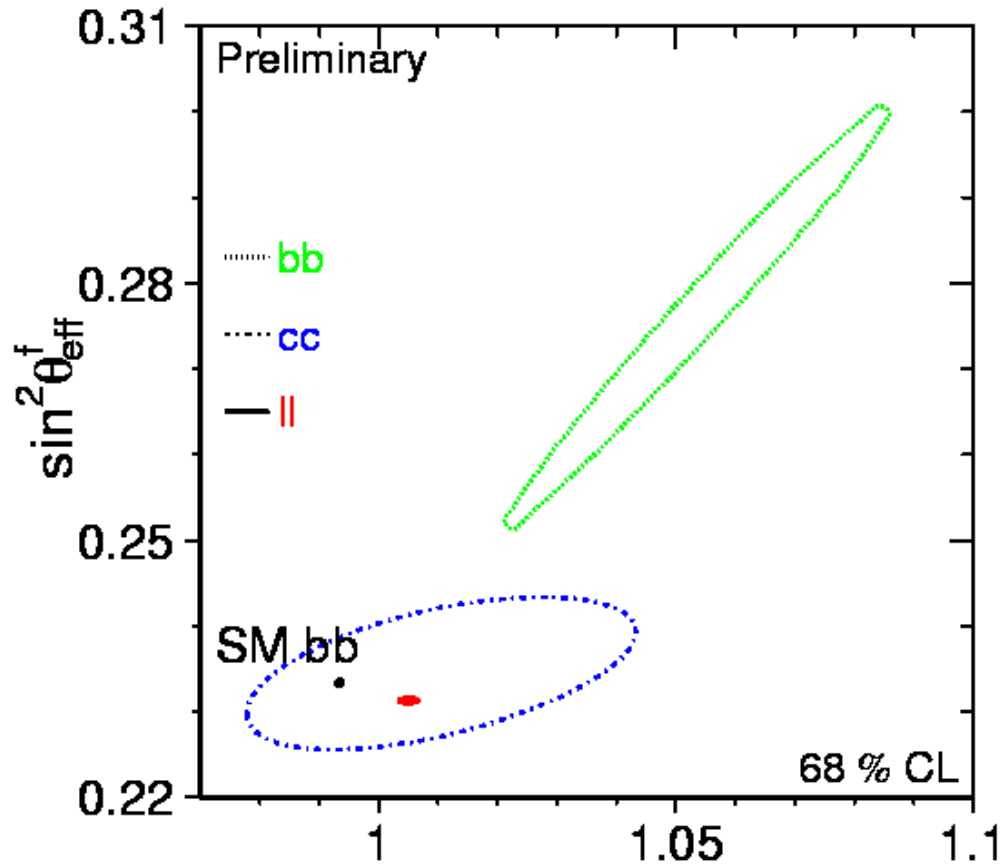
Final



Preliminary



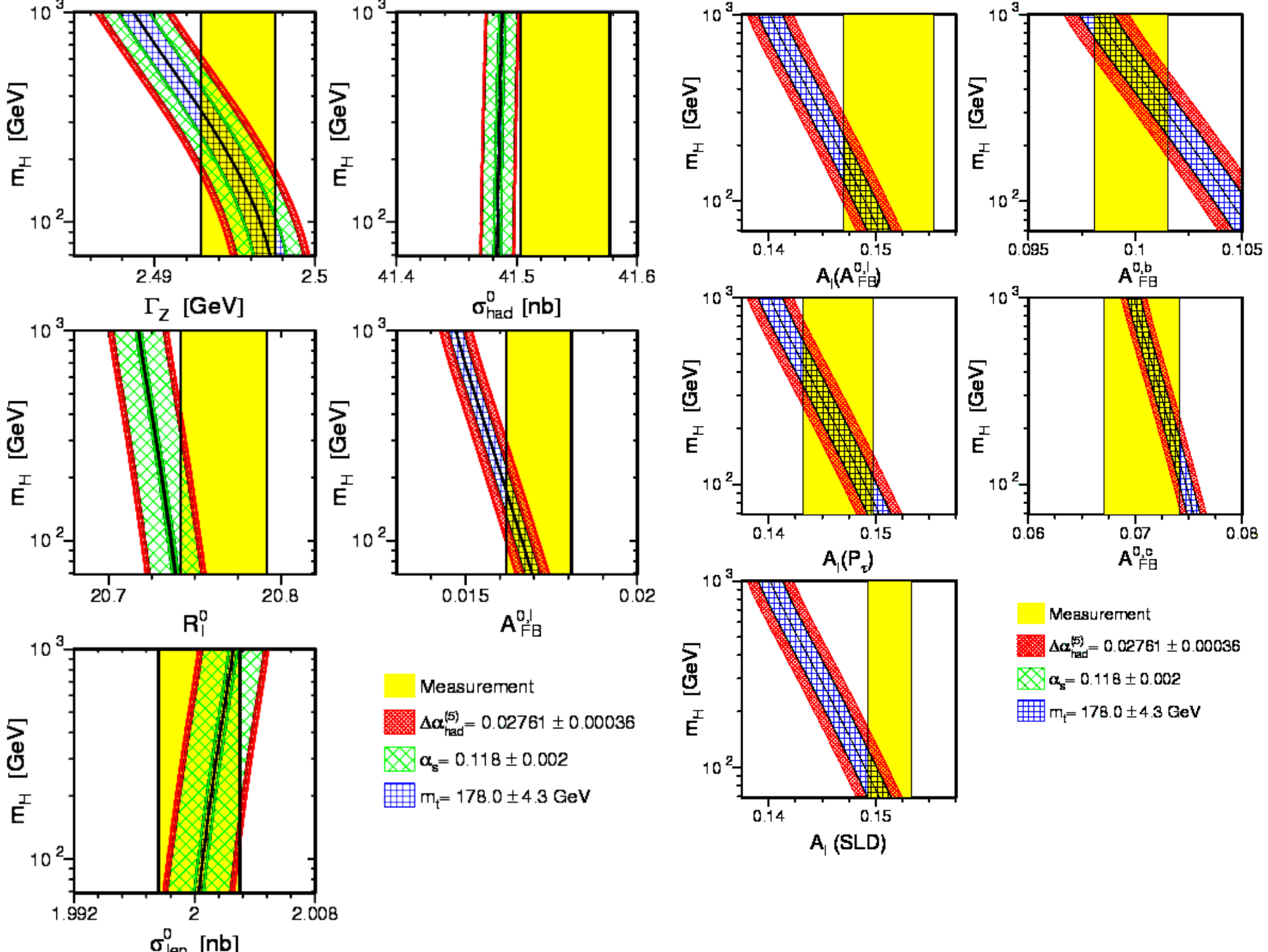
$\bar{\rho}_b$

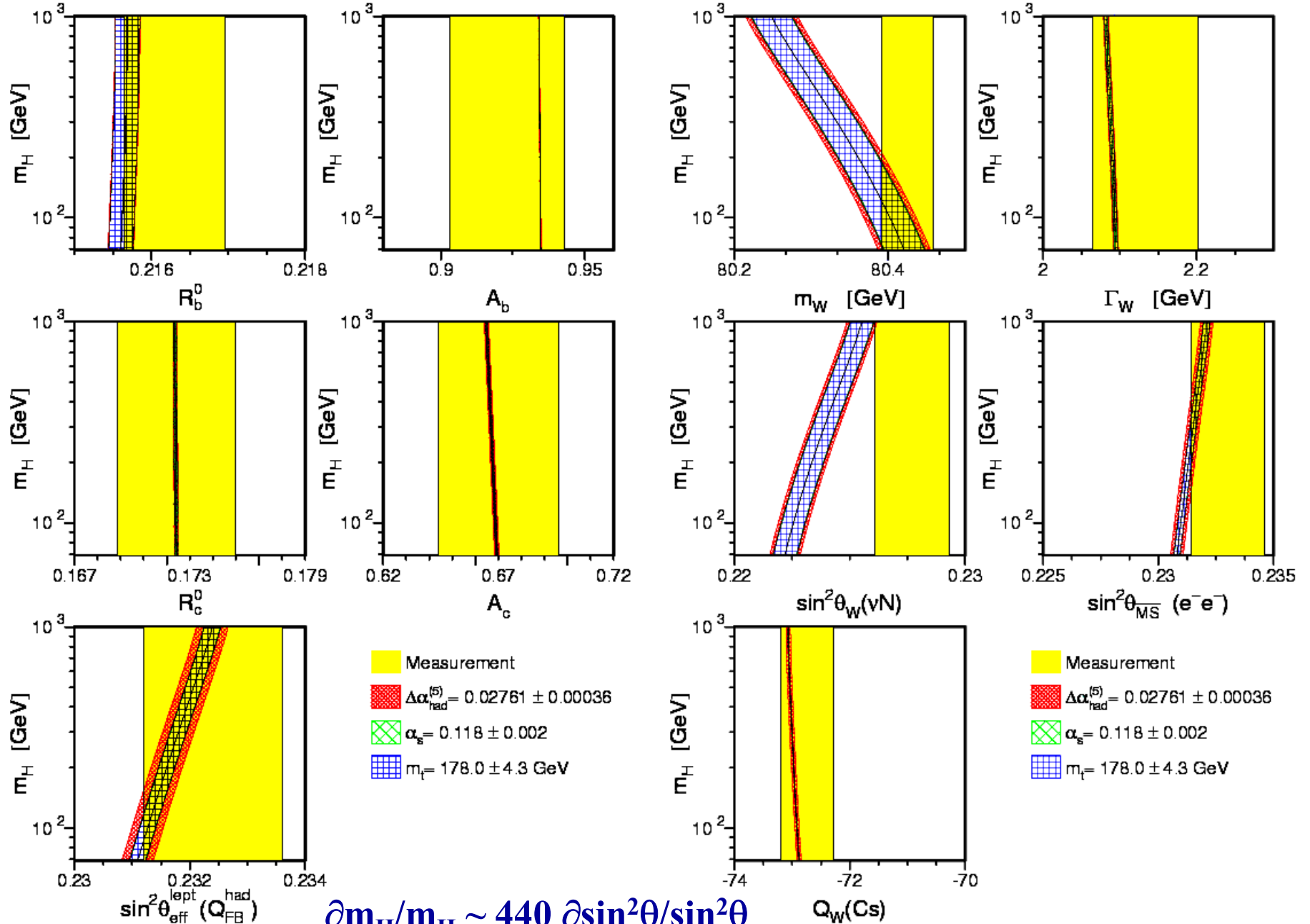


$$\Rightarrow \bar{\rho}_b = 1.064 \pm 0.021$$

$$\Rightarrow \bar{\rho}^{\text{lept}} = 1.0050 \pm 0.0010$$

3 sigma dal SM, ma
20 volte meno preciso di ρ^{lept}

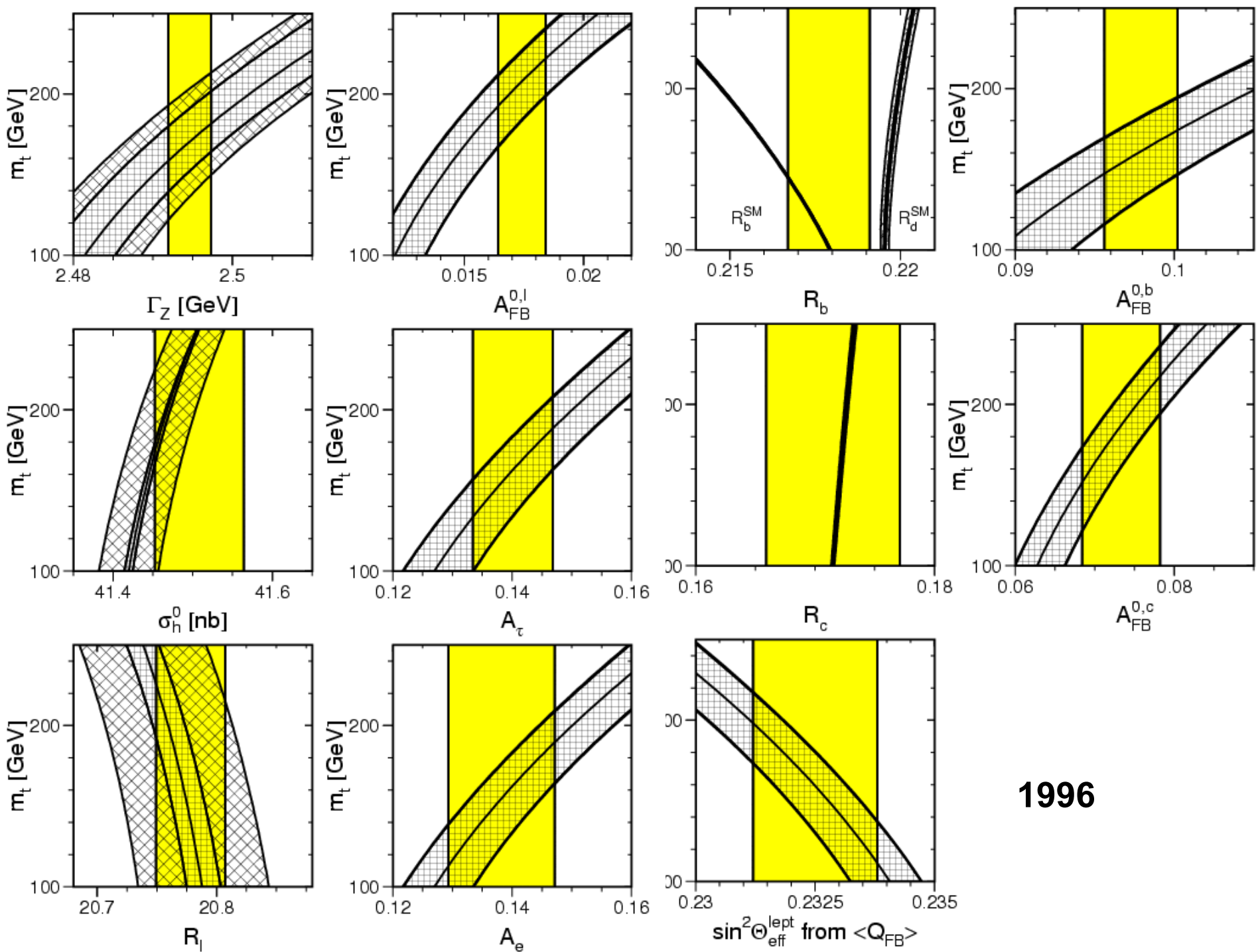




$$\partial m_H / m_H \sim 440 \partial \sin^2\theta / \sin^2\theta$$

$$\partial m_H / m_H \sim 1300 \partial M_W / M_W$$

3 volte piu' sensibile!



1996