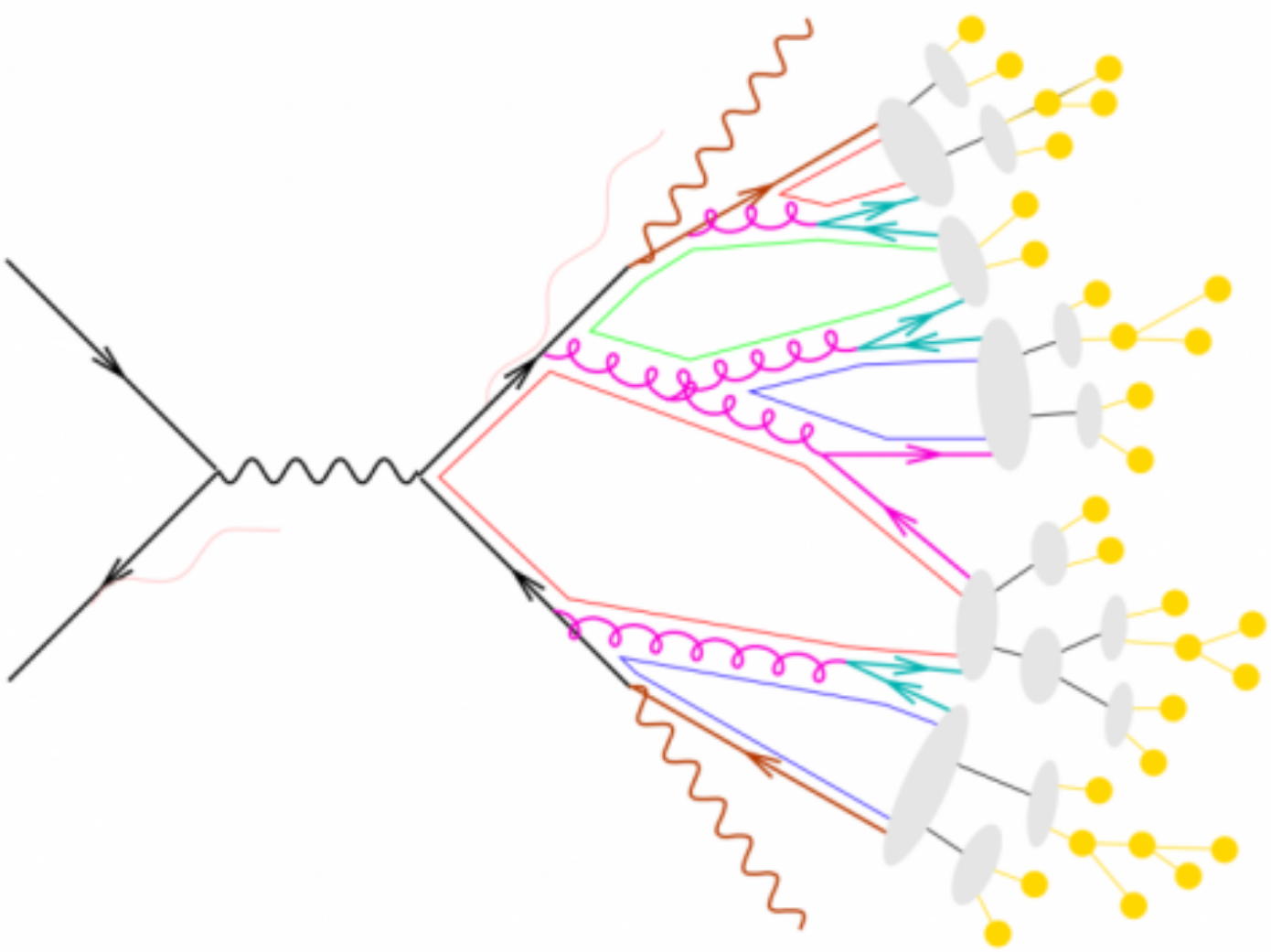
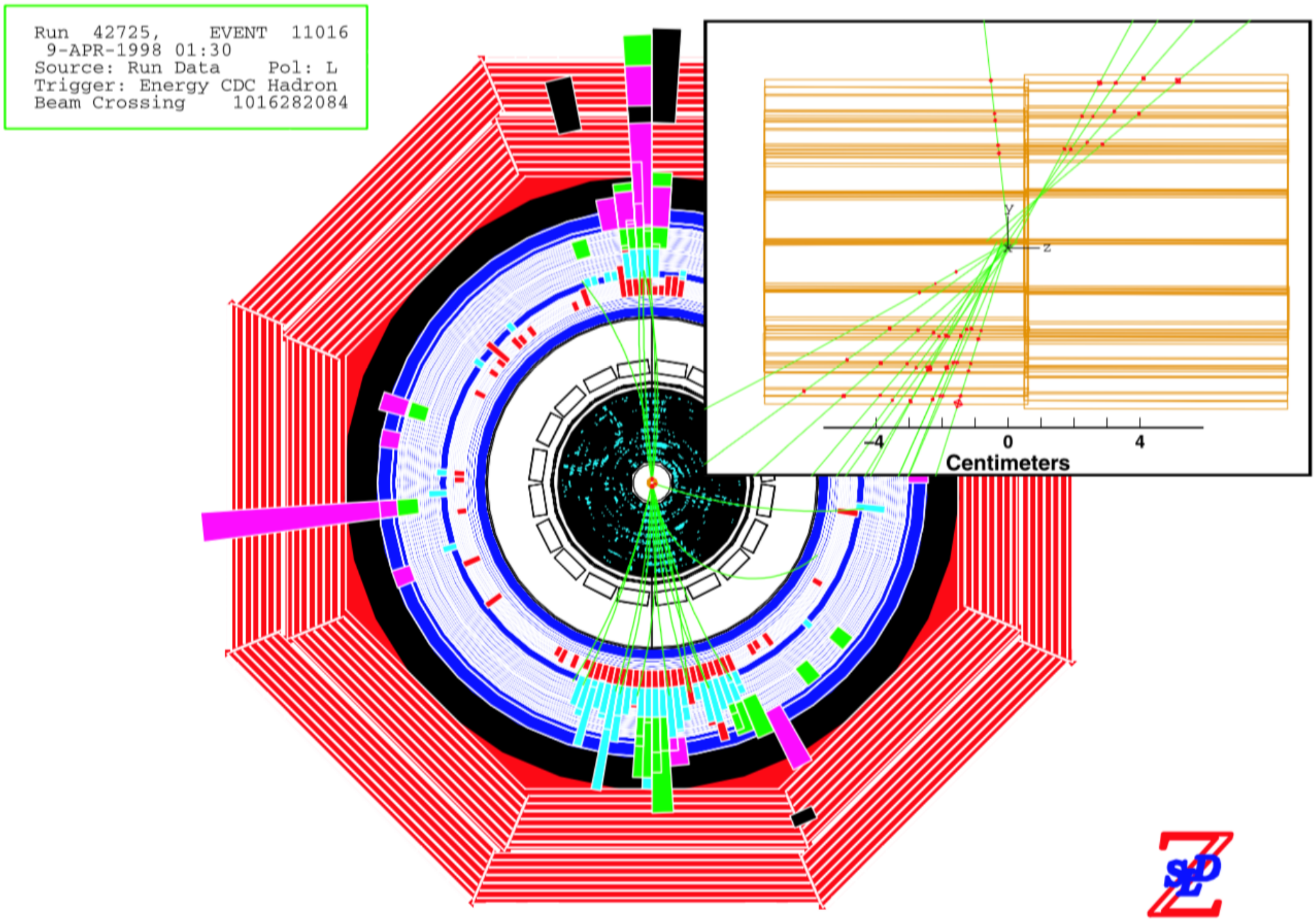
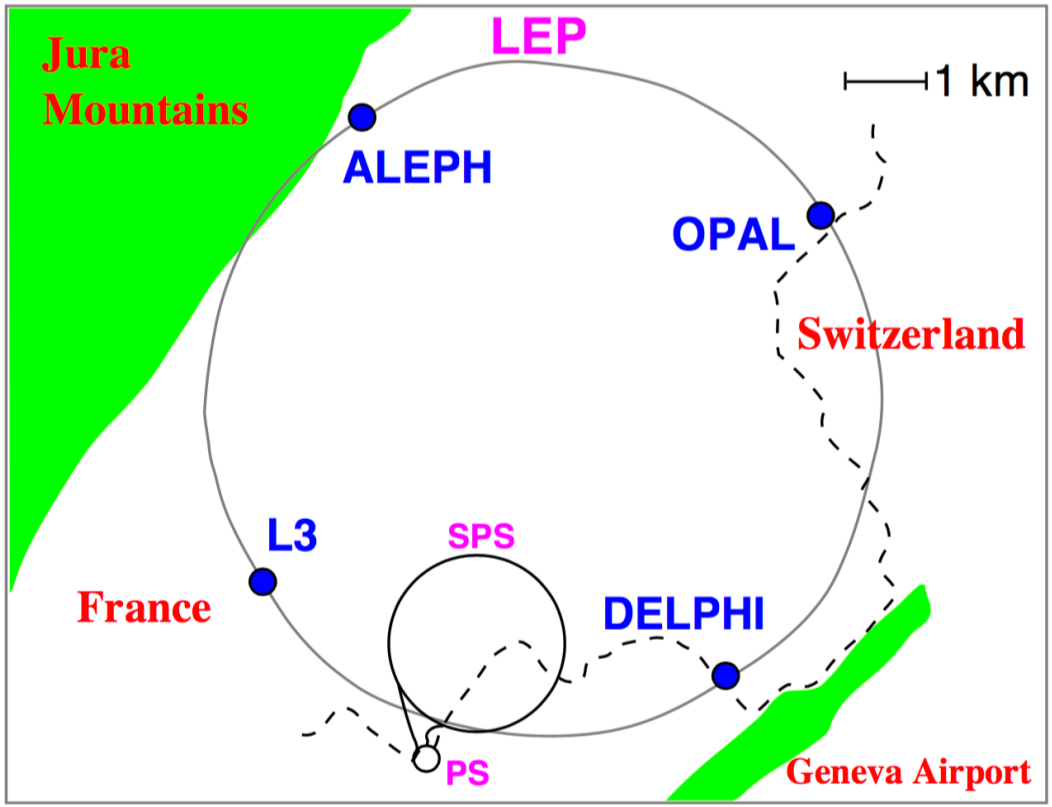


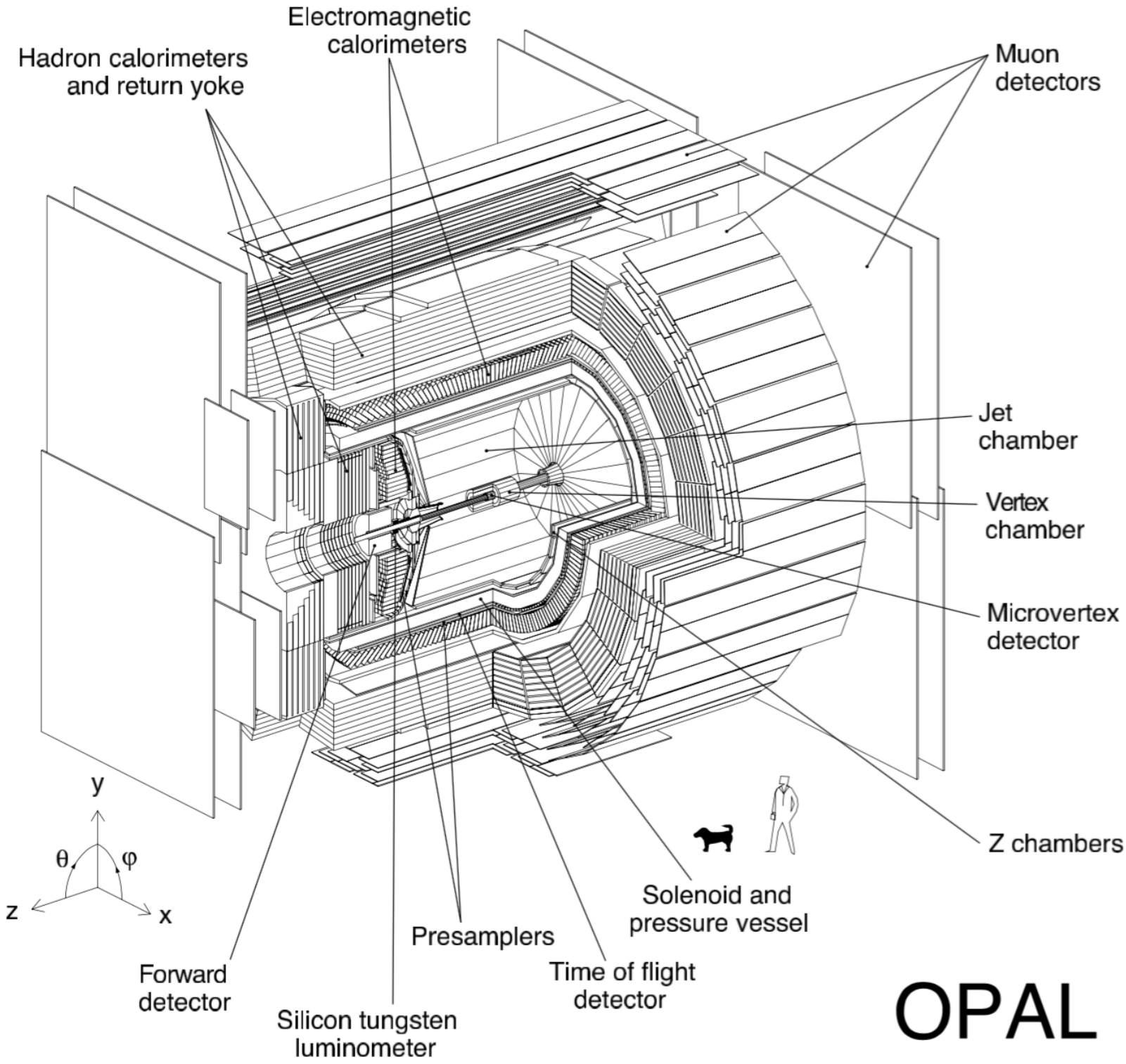

Run 42725, EVENT 11016
9-APR-1998 01:30
Source: Run Data Pol: L
Trigger: Energy CDC Hadron
Beam Crossing 1016282084
Y
Z
-4
0
4
Centimeters
SLD



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

Number of Events										
	$Z \to q\bar{q}$					$Z \to \ell^+\ell^-$				
Year	A	D	L	O	LEP	A	D	L	O	LEP
1990/91	433	357	416	454	1660	53	36	39	58	186
1992	633	697	678	733	2741	77	70	59	88	294
1993	630	682	646	649	2607	78	75	64	79	296
1994	1640	1310	1359	1601	5910	202	137	127	191	657
1995	735	659	526	659	2579	90	66	54	81	291
Total	4071	3705	3625	4096	15497	500	384	343	497	1724

Table 1.2: The $q\bar{q}$ and $\ell^+\ell^-$ event statistics, in units of 10^3, used for Z analyses by the experiments ALEPH (A), DELPHI (D), L3 (L) and OPAL (O).


Hadron calorimeters
and return yoke
Electromagnetic
calorimeters
Muon
detectors
Jet
chamber
Vertex
chamber
Microvertex
detector
Z chambers
Solenoid and
pressure vessel
Presamplers
Time of flight
detector
Forward
detector
Silicon tungsten
luminometer
y
θ
φ
z
x
OPAL

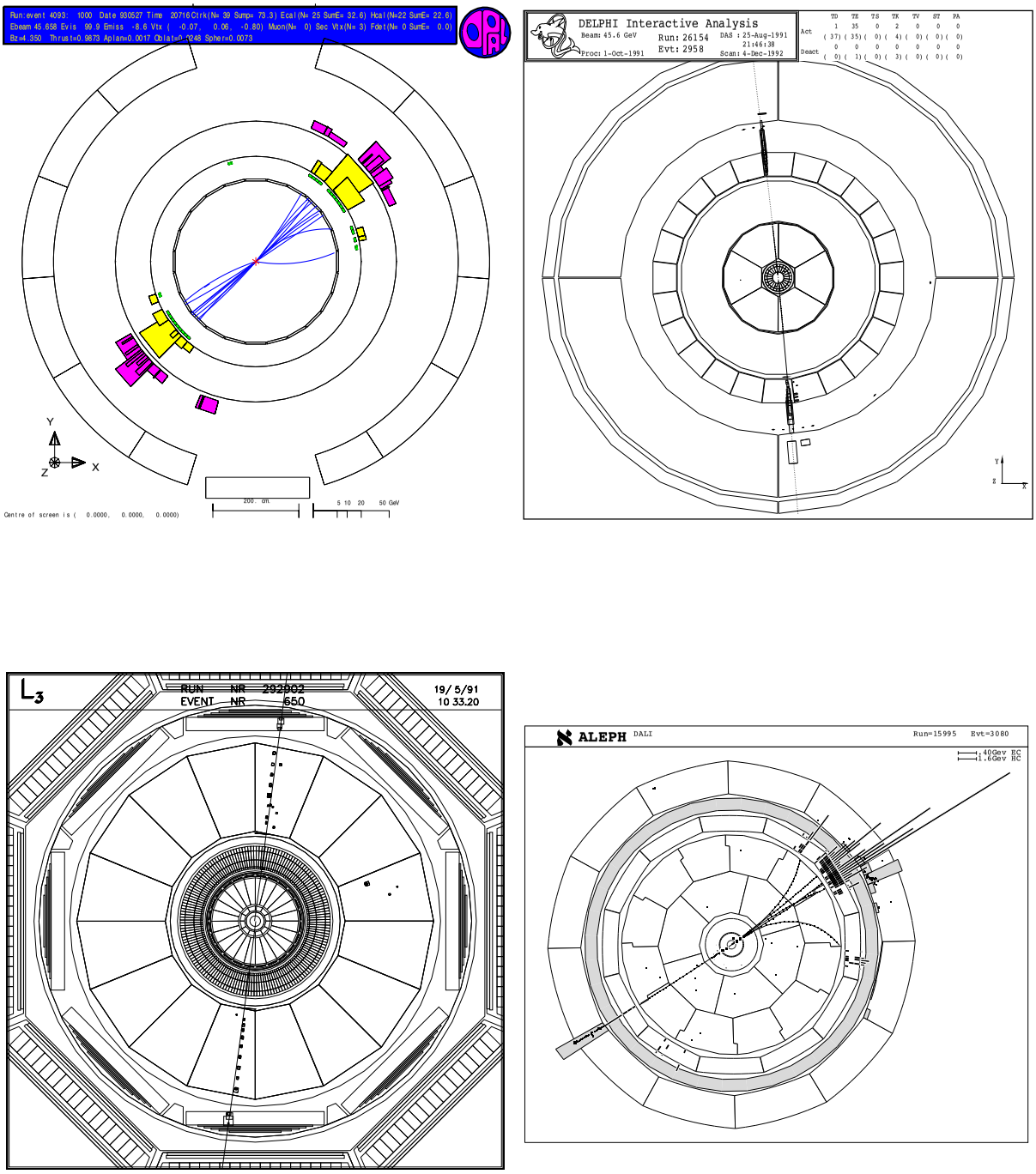
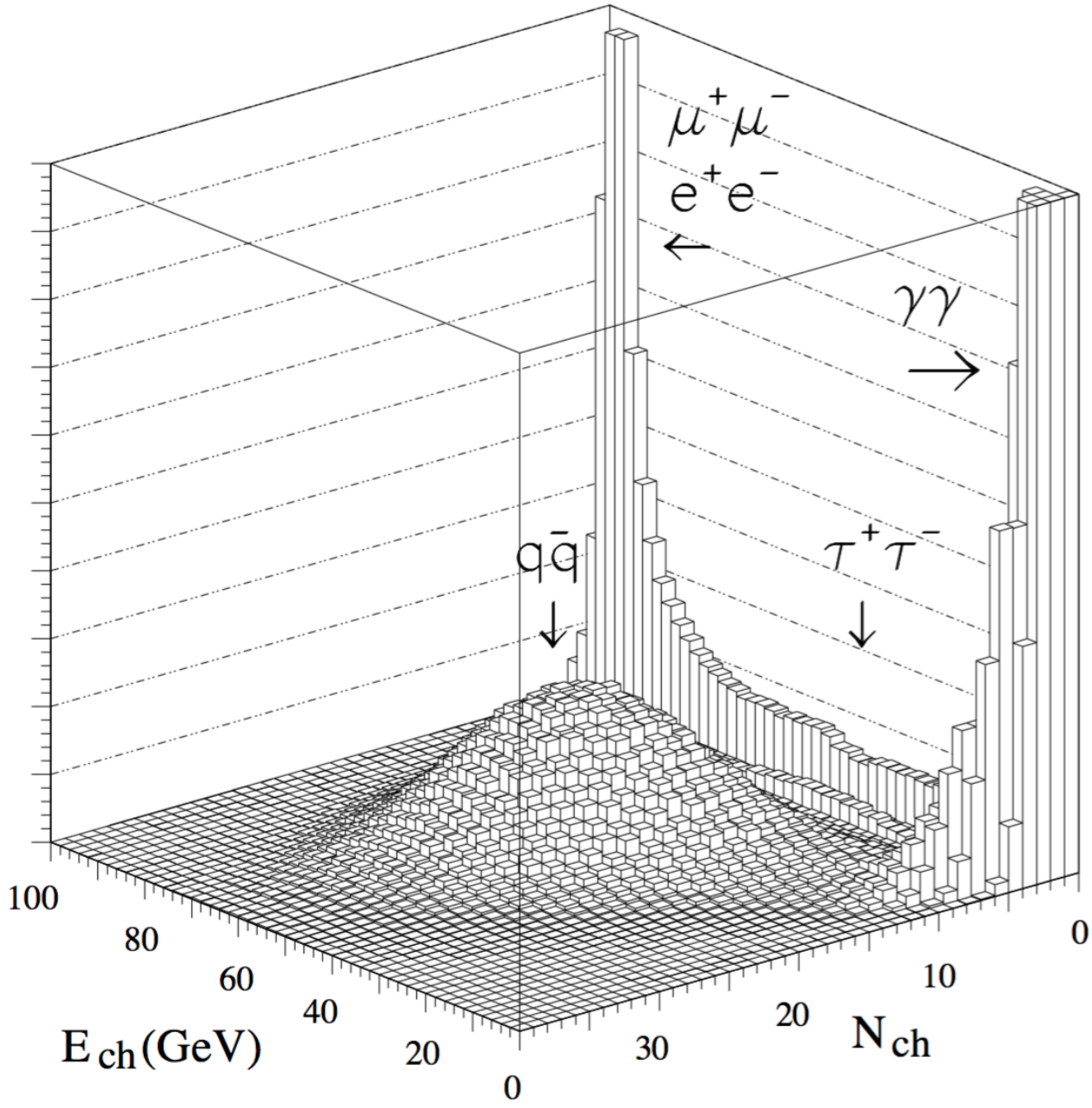


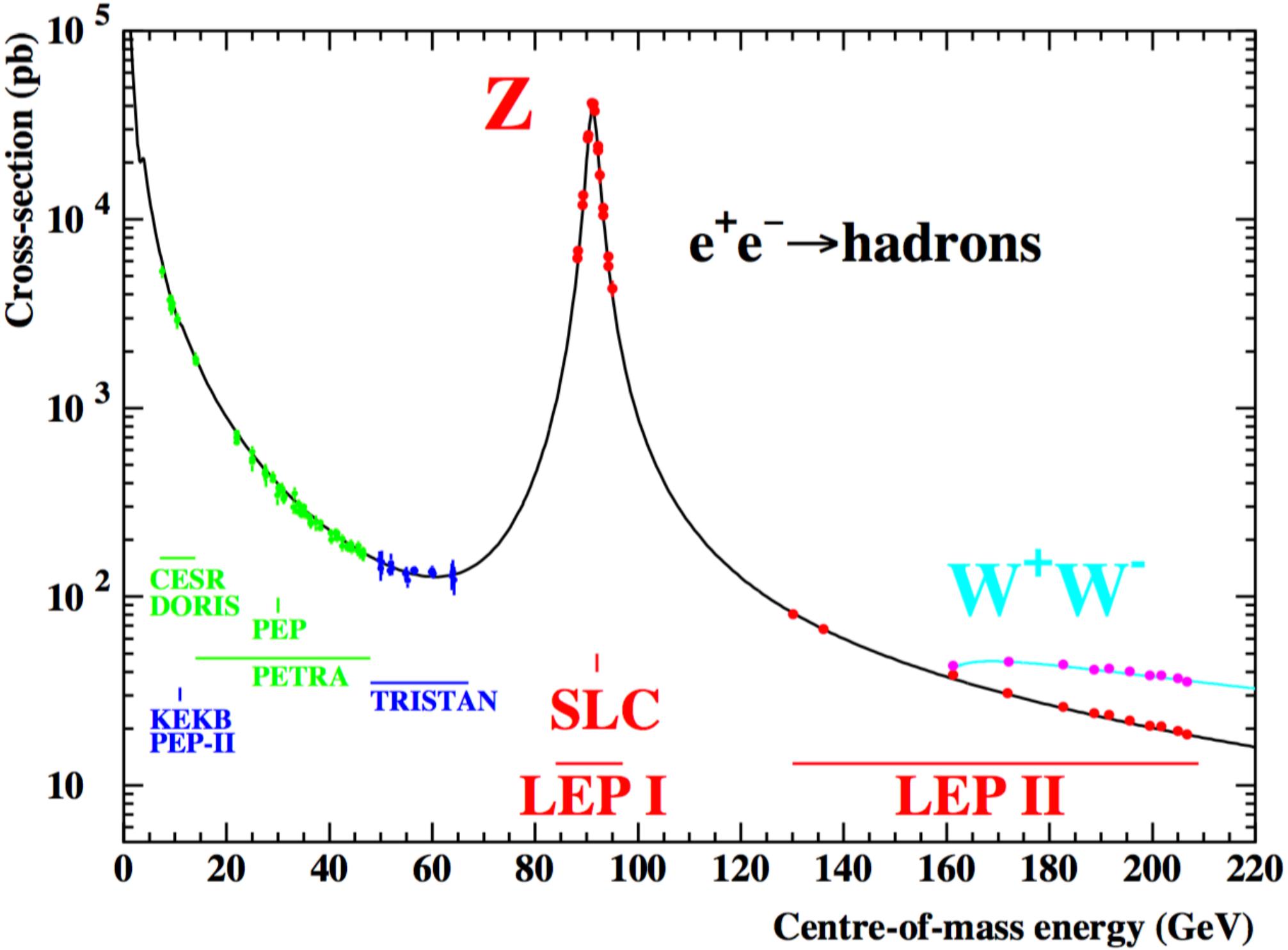
Figure 1.7: Pictures of $q\overline{q}$, e^+e^-, $\mu^+\mu^-$ and $\tau^+\tau^-$ final states, visualised with the event displays of the OPAL, DELPHI, L3 and ALEPH collaborations, respectively. In all views, the electron-positron beam axis is perpendicular to the plane of the page. The stability of the electron and the long lifetime of the muon allow these fundamental Z decays to be directly observed, while the low-multiplicity products of τ decays are confined to well-isolated cones. Hadronic Z decays result in higher-multiplicity jets of particles produced in the QCD cascades initiated by the initial $q\overline{q}$ pair.

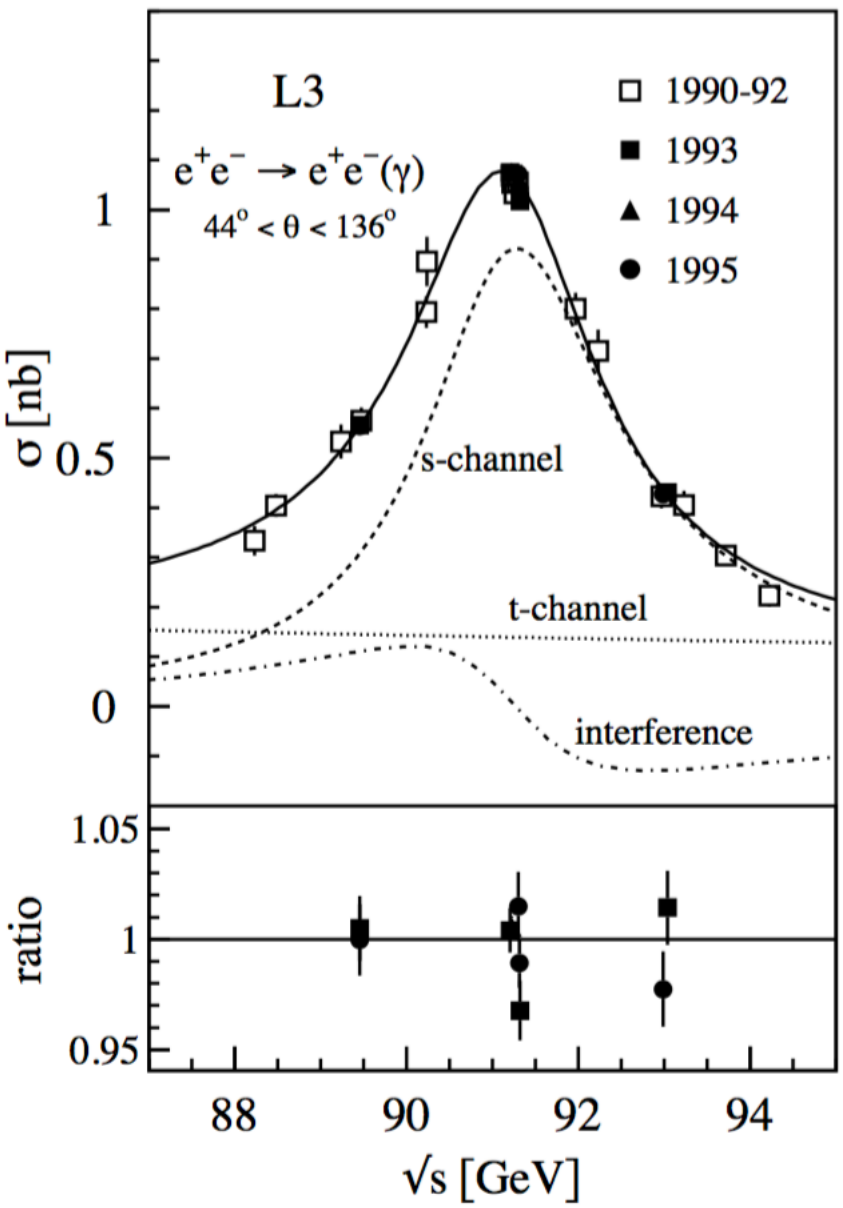

ALEPH
$\mu^+\mu^-$
e^+e^-
$\gamma\gamma$
$q\bar{q}$
$\tau^+\tau^-$
100
80
60
40
20
0
E_{ch}(GeV)
0
10
20
30
N_{ch}

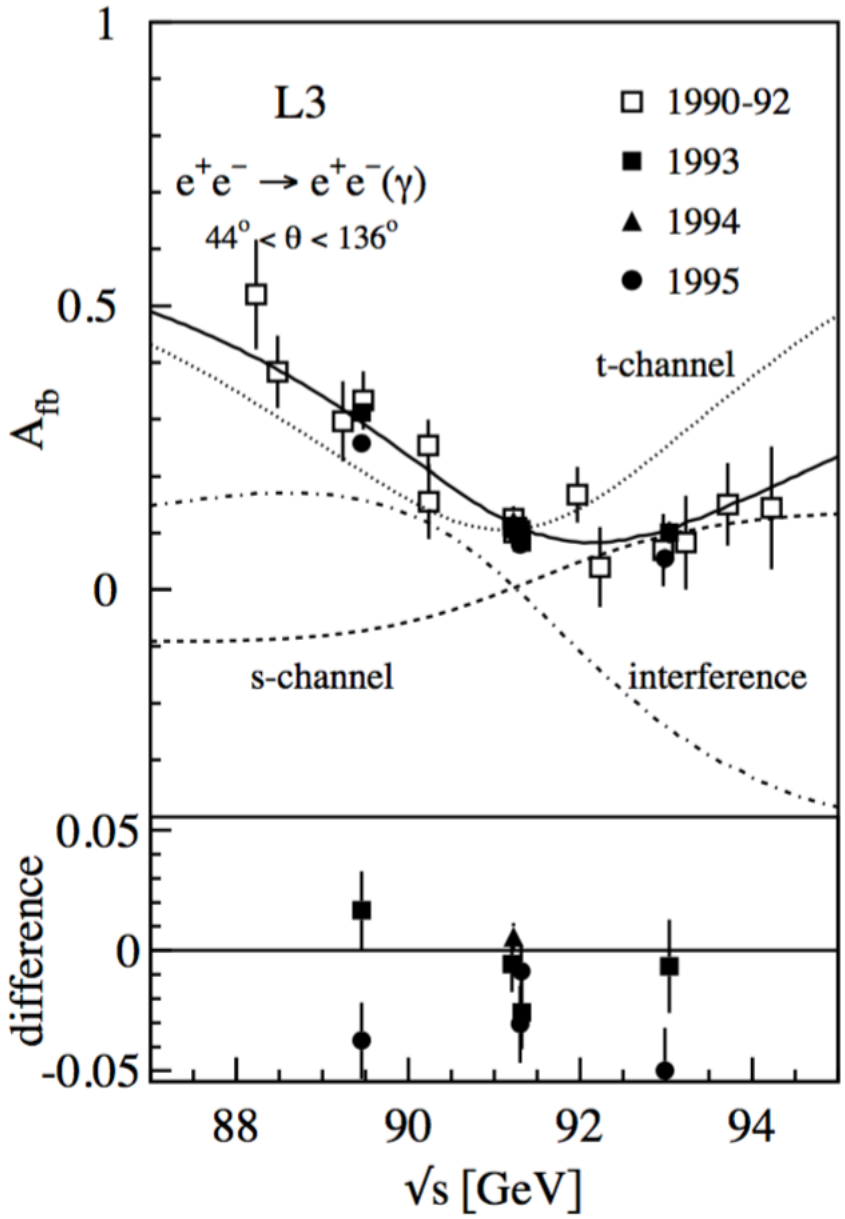
	ALEPH	DELPHI	L3	OPAL
$q\bar{q}$ final state				
acceptance	$s'/s > 0.01$	$s'/s > 0.01$	$s'/s > 0.01$	$s'/s > 0.01$
efficiency [%]	99.1	94.8	99.3	99.5
background [%]	0.7	0.5	0.3	0.3
e^+e^- final state				
acceptance	$-0.9 < \cos\theta < 0.7$ $s' > 4m_\tau^2$	$\lvert\cos\theta\rvert < 0.72$ $\eta < 10°$	$\lvert\cos\theta\rvert < 0.72$ $\eta < 25°$	$\lvert\cos\theta\rvert < 0.7$ $\eta < 10°$
efficiency [%]	97.4	97.0	98.0	99.0
background [%]	1.0	1.1	1.1	0.3
$\mu^+\mu^-$ final state				
acceptance	$\lvert\cos\theta\rvert < 0.9$ $s' > 4m_\tau^2$	$\lvert\cos\theta\rvert < 0.94$ $\eta < 20°$	$\lvert\cos\theta\rvert < 0.8$ $\eta < 90°$	$\lvert\cos\theta\rvert < 0.95$ $m_{f\bar{f}}^2/s > 0.01$
efficiency [%]	98.2	95.0	92.8	97.9
background [%]	0.2	1.2	1.5	1.0
$\tau^+\tau^-$ final state				
acceptance	$\lvert\cos\theta\rvert < 0.9$ $s' > 4m_\tau^2$	$0.035 < \lvert\cos\theta\rvert < 0.94$ $s' > 4m_\tau^2$	$\lvert\cos\theta\rvert < 0.92$ $\eta < 10°$	$\lvert\cos\theta\rvert < 0.9$ $m_{f\bar{f}}^2/s > 0.01$
efficiency [%]	92.1	72.0	70.9	86.2
background [%]	1.7	3.1	2.3	2.7

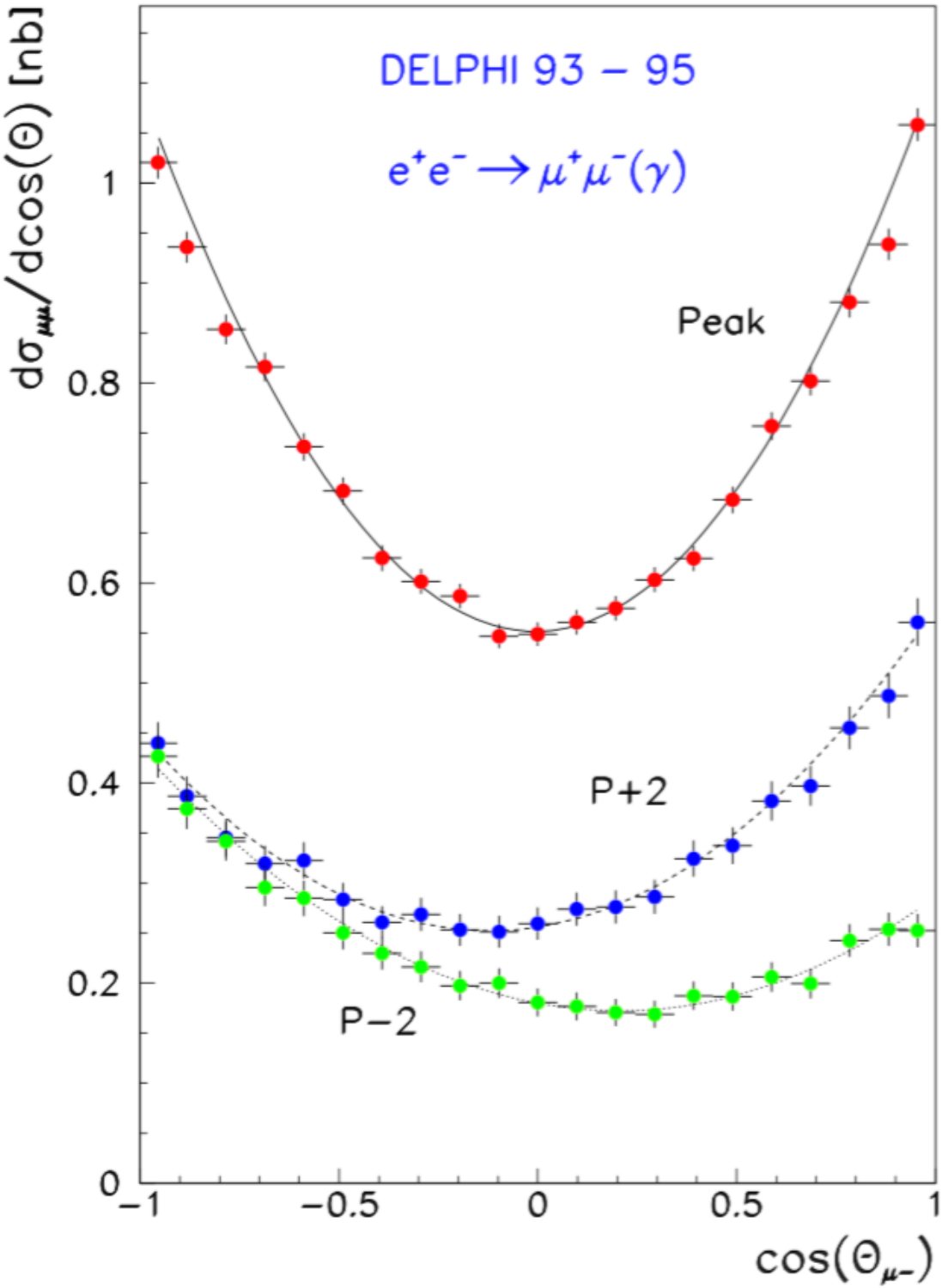
Table 2.1: Ideal acceptances, selection efficiencies* and background contribution at the peak of the resonance (1994 data).

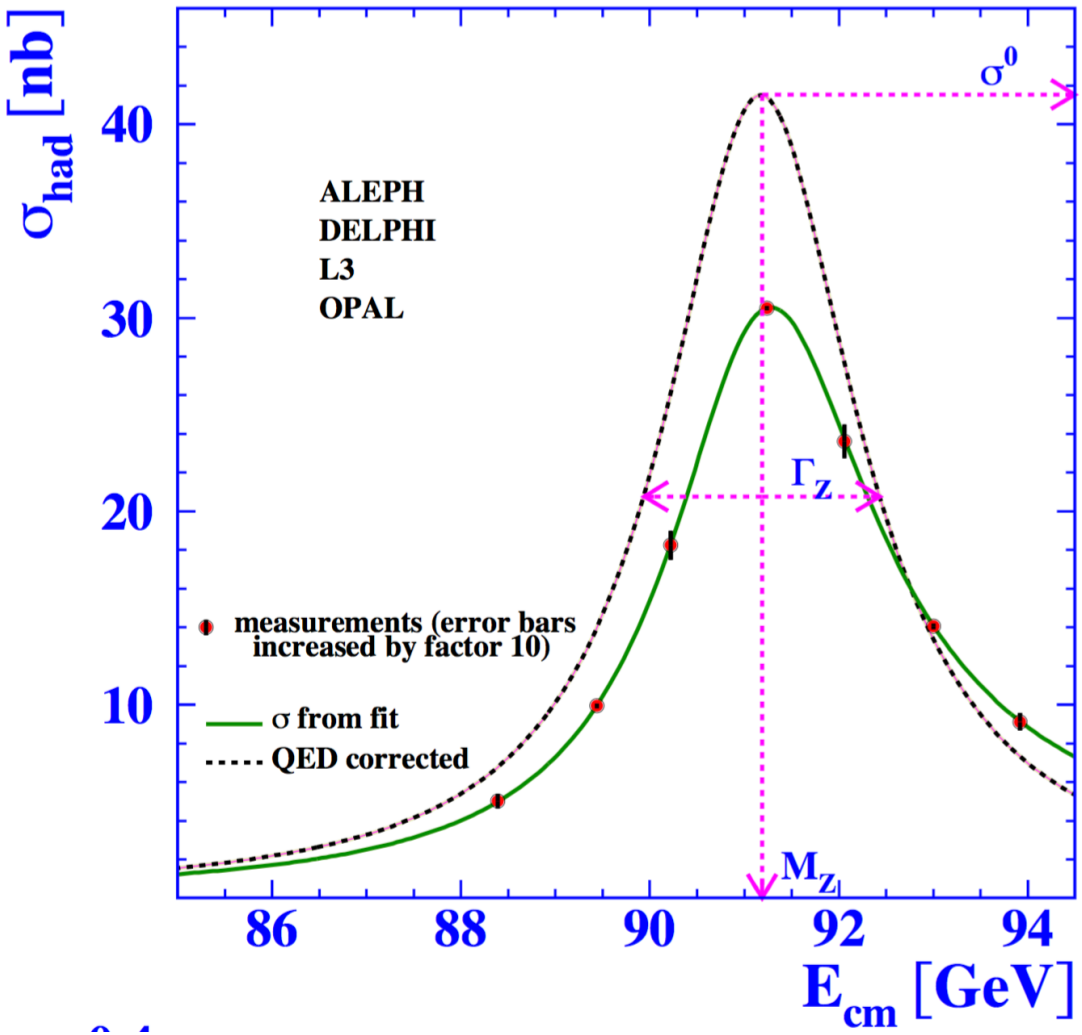
*The lepton selection efficiencies given by the experiments were in some cases quoted with respect to full acceptance in $\cos\theta$; for the purpose of comparison, they were corrected to the fiducial cuts in $\cos\theta$ actually used in the analyses, assuming a shape of the differential cross-section according to $(1 + \cos^2\theta)$.

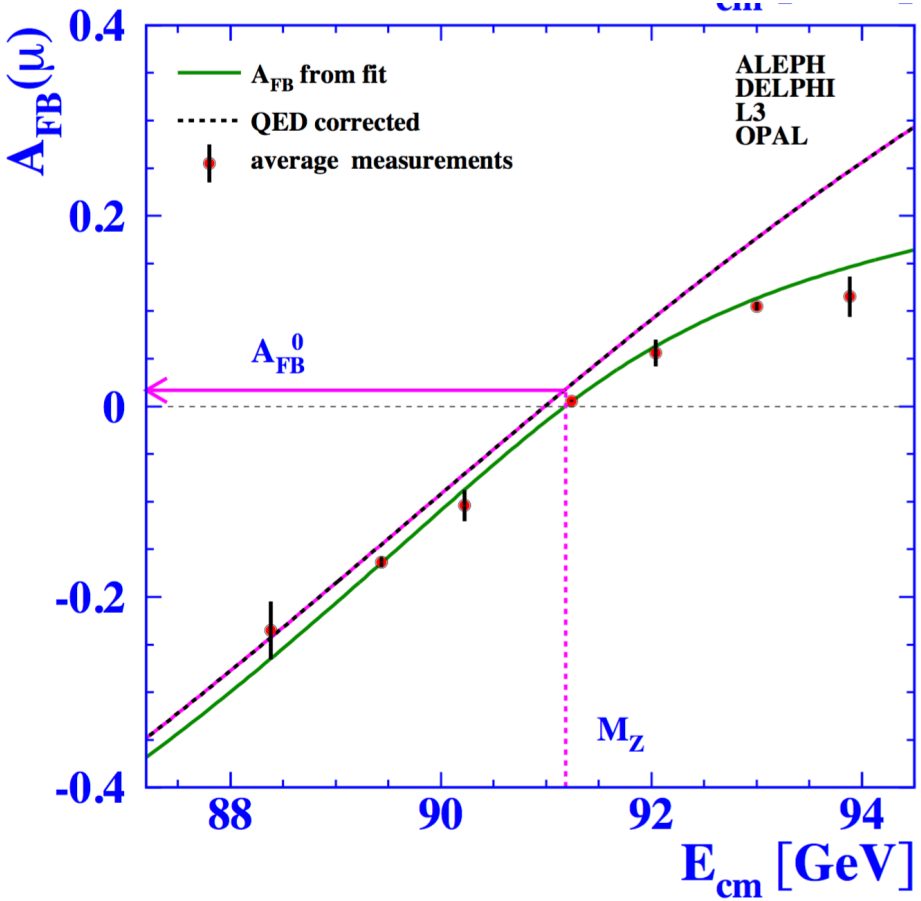

Cross-section (pb)
10 5
10 4
10 3
10 2
10
Z
e+e−→hadrons
W+W-
CESR
DORIS
PEP
PETRA
TRISTAN
KEKB
PEP-II
SLC
LEP I
LEP II
0
20
40
60
80
100
120
140
160
180
200
220
Centre-of-mass energy (GeV)


L3
$e^+e^- \to e^+e^-(\gamma)$
$44^\circ < \theta < 136^\circ$
1990-92
1993
1994
1995
s-channel
t-channel
interference
σ [nb]
ratio
$\sqrt{s}$ [GeV]


L3
$e^+e^- \to e^+e^-(\gamma)$
$44^\circ < \theta < 136^\circ$
1990-92
1993
1994
1995
t-channel
s-channel
interference
A_{fb}
difference
$\sqrt{s}$ [GeV]

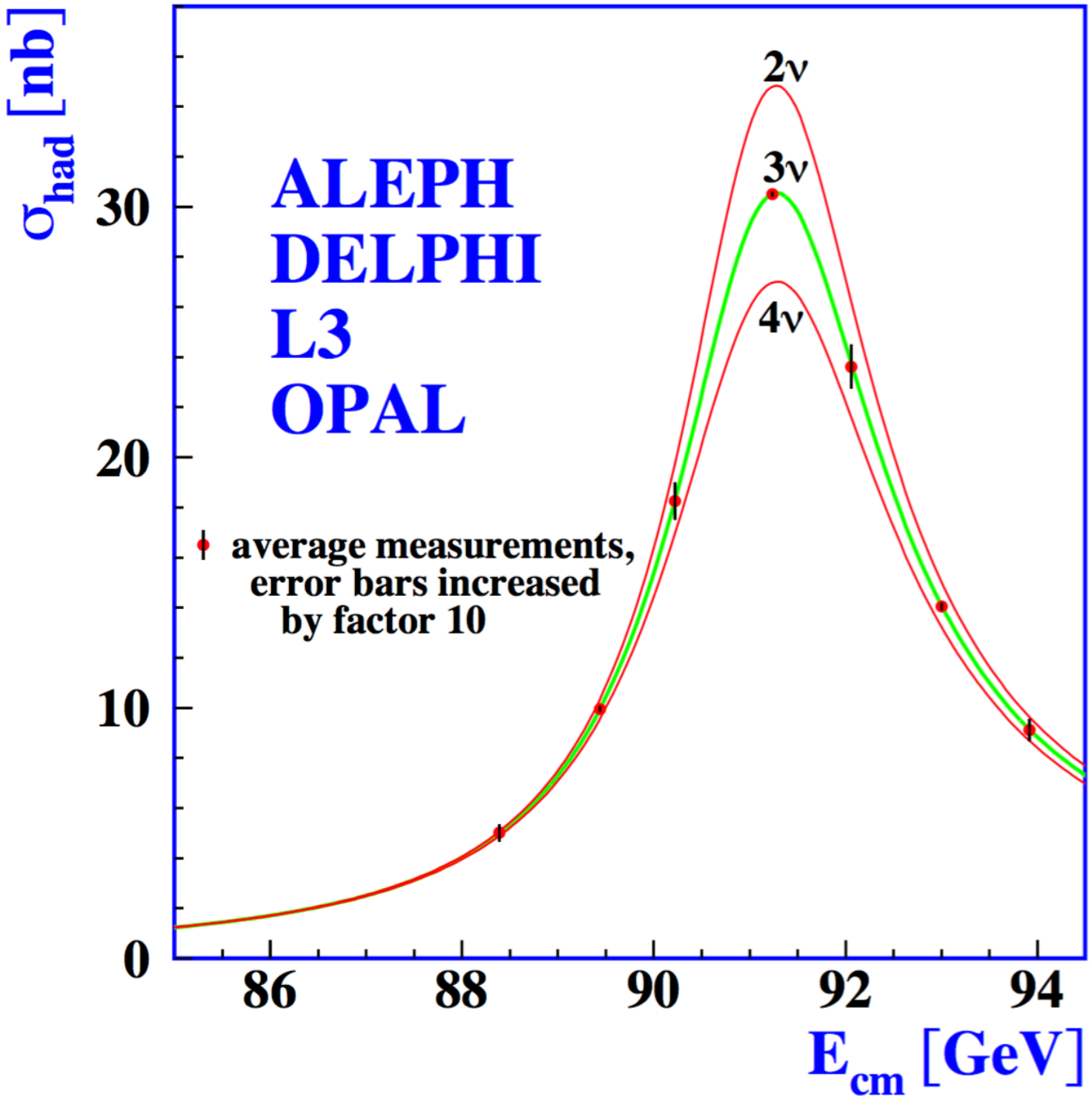

DELPHI 93 – 95
$e^+e^- \to \mu^+\mu^-(\gamma)$
Peak
P+2
P−2
$d\sigma_{\mu\mu}/d\cos(\Theta)$ [nb]
$\cos(\Theta_{\mu^-})$
0
0.2
0.4
0.6
0.8
1
−1
−0.5
0
0.5
1

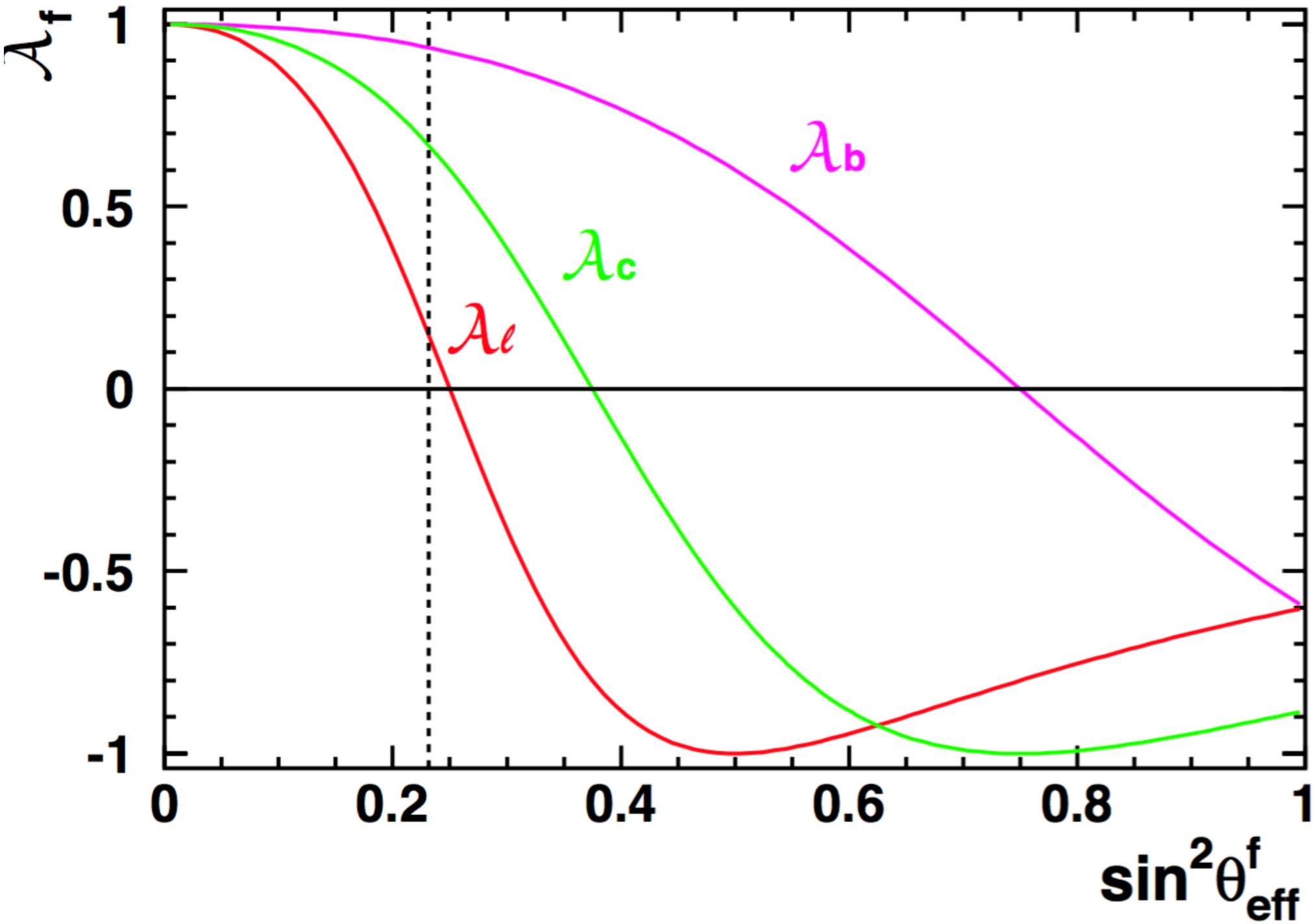

σ_{had} [nb]
40
30
20
10
ALEPH
DELPHI
L3
OPAL
σ^0
Γ_Z
M_Z
measurements (error bars increased by factor 10)
σ from fit
QED corrected
86
88
90
92
94
E_{cm} [GeV]


$A_{FB}(\mu)$
0.4
0.2
0
-0.2
-0.4
A_{FB} from fit
QED corrected
average measurements
ALEPH
DELPHI
L3
OPAL
A_{FB}^0
M_Z
88
90
92
94
E_{cm} [GeV]

Without lepton universality		Correlations								
$\chi^2/\mathrm{dof} = 32.6/27$		m_Z	Γ_Z	σ^0_had	R^0_e	R^0_μ	R^0_τ	$A^{0,\mathrm{e}}_\mathrm{FB}$	$A^{0,\mu}_\mathrm{FB}$	$A^{0,\tau}_\mathrm{FB}$
m_Z [GeV]	91.1876± 0.0021	1.000								
Γ_Z [GeV]	2.4952 ± 0.0023	−0.024	1.000							
σ^0_had [nb]	41.541 ± 0.037	−0.044	−0.297	1.000						
R^0_e	20.804 ± 0.050	0.078	−0.011	0.105	1.000					
R^0_μ	20.785 ± 0.033	0.000	0.008	0.131	0.069	1.000				
R^0_τ	20.764 ± 0.045	0.002	0.006	0.092	0.046	0.069	1.000			
$A^{0,\mathrm{e}}_\mathrm{FB}$	0.0145 ± 0.0025	−0.014	0.007	0.001	−0.371	0.001	0.003	1.000		
$A^{0,\mu}_\mathrm{FB}$	0.0169 ± 0.0013	0.046	0.002	0.003	0.020	0.012	0.001	−0.024	1.000	
$A^{0,\tau}_\mathrm{FB}$	0.0188 ± 0.0017	0.035	0.001	0.002	0.013	−0.003	0.009	−0.020	0.046	1.000

With lepton universality		Correlations				
$\chi^2/\mathrm{dof} = 36.5/31$		m_Z	Γ_Z	σ^0_had	R^0_ℓ	$A^{0,\ell}_\mathrm{FB}$
m_Z [GeV]	91.1875± 0.0021	1.000				
Γ_Z [GeV]	2.4952 ± 0.0023	−0.023	1.000			
σ^0_had [nb]	41.540 ± 0.037	−0.045	−0.297	1.000		
R^0_ℓ	20.767 ± 0.025	0.033	0.004	0.183	1.000	
$A^{0,\ell}_\mathrm{FB}$	0.0171 ± 0.0010	0.055	0.003	0.006	−0.056	1.000


σ_{had} [nb]
30
20
10
0
86
88
90
92
94
E_{cm} [GeV]
ALEPH
DELPHI
L3
OPAL
average measurements,
error bars increased
by factor 10
2ν
3ν
4ν


$\mathcal{A}_f$
1
0.5
0
-0.5
-1
0
0.2
0.4
0.6
0.8
1
$\mathcal{A}_b$
$\mathcal{A}_c$
$\mathcal{A}_\ell$
$\sin^2\theta^f_{eff}$