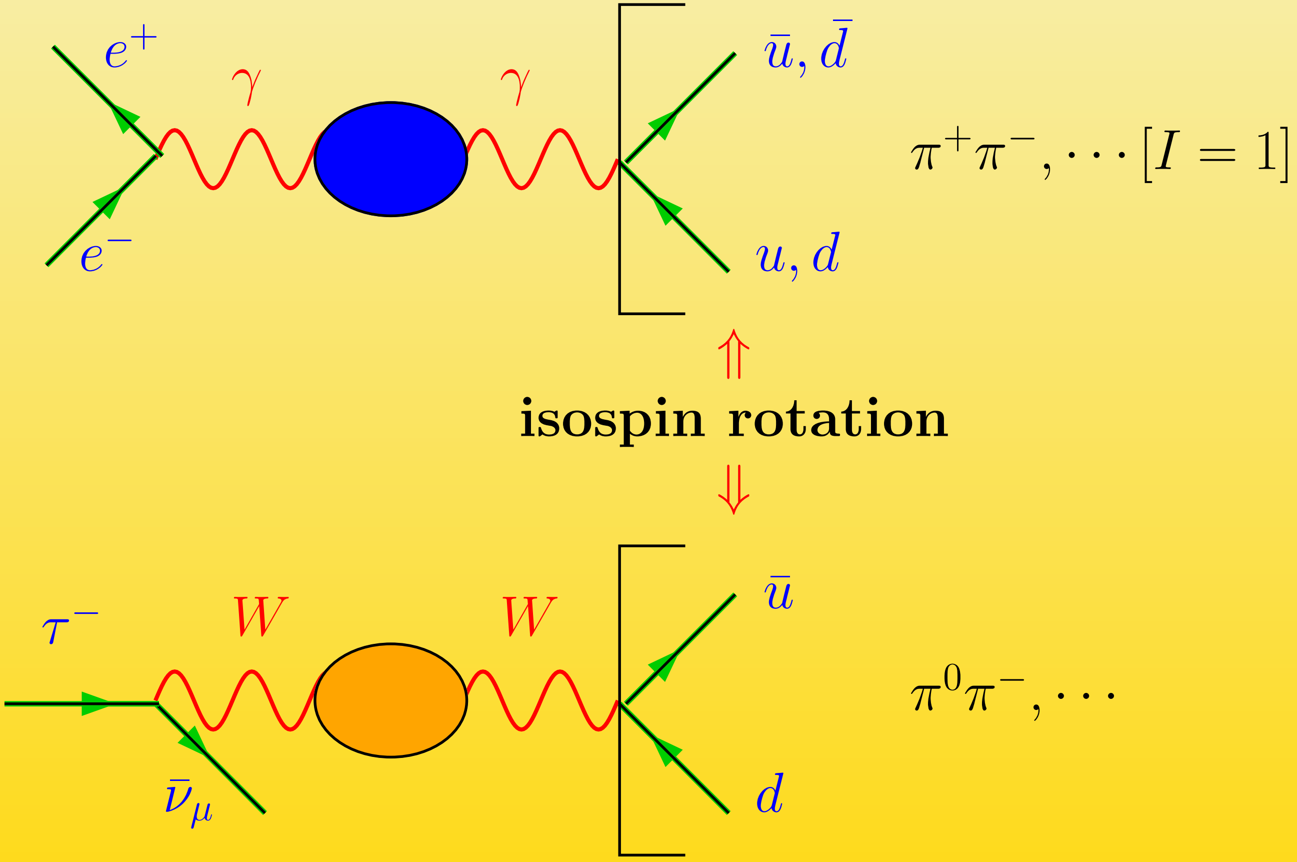
④ Other Applications and Problems, future prospects, the role of DAFNE-2

1. The τ vs. e^+e^- problem
2. Recent BaBar ISR $\pi^+\pi^-$–spectrum and its impact for $g-2$
3. New Physics constraints from $g-2$ and elsewhere
4. Future prospects in VP physics
5. The role DAFNE-2 would play

1. The τ vs. e^+e^- problem

① **Additional data: τ–data $+$ CVC**



ALEPH–Coll., (OPAL, CLEO), Alemany, Davier, Höcker 1996,
Belle–Coll. Fujikawa, Hayashii, Eidelman 2008

$$\tau^- \to X^- \nu_\tau \quad \leftrightarrow \quad e^+ e \to X^0$$

where X^- and X^0 are hadronic states related by isospin rotation. The e^+e^- cross–section is then given by

$$\sigma^{I=1}_{e^+e^- \to X^0} = \frac{4\pi\alpha^2}{s} v_{1,X^-} \quad , \quad \sqrt{s} \leq M_\tau$$

in terms of the τ spectral function v_1.

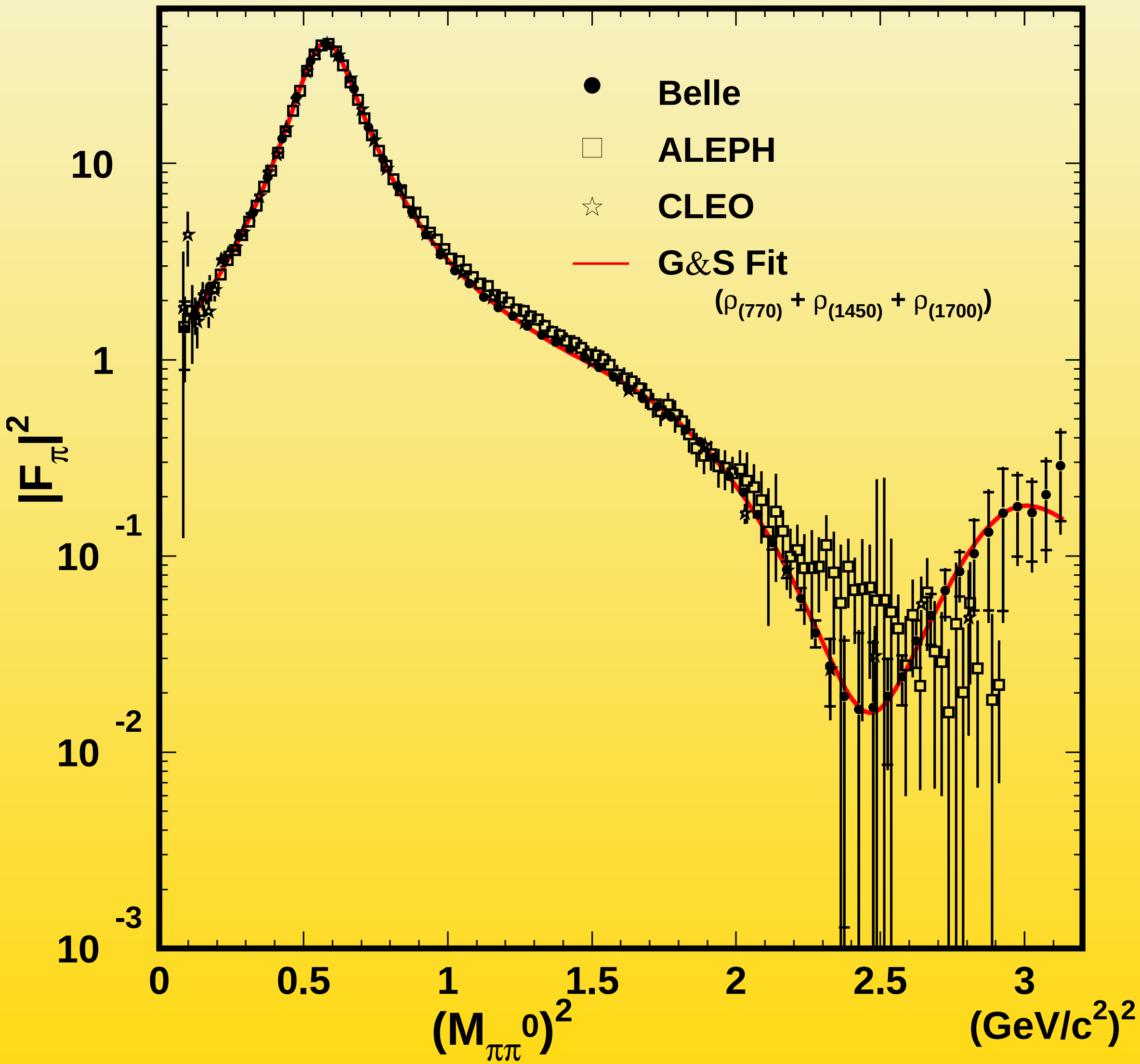
- mainly improves the knowledge of the $\pi^+\pi^-$ channel (ρ–resonance contribution)
- which is dominating in $a_\mu^{\rm had}$ (72%)

$$I = 1 \sim 75\% \,;\; I = 0 \sim 25\%$$

τ–data cannot replace e^+e^-–data

$$\begin{array}{llccc} \delta a_\mu & : & 15.6 \times 10^{-10} & \to & 10.2 \times 10^{-10} & \\ \delta\Delta\alpha & : & 0.00067 & \to & 0.00065 & (ADH1997) \end{array}$$

Most recent measurement from Belle (2008):



e^+e^-–data*= data corrected for isospin violations:

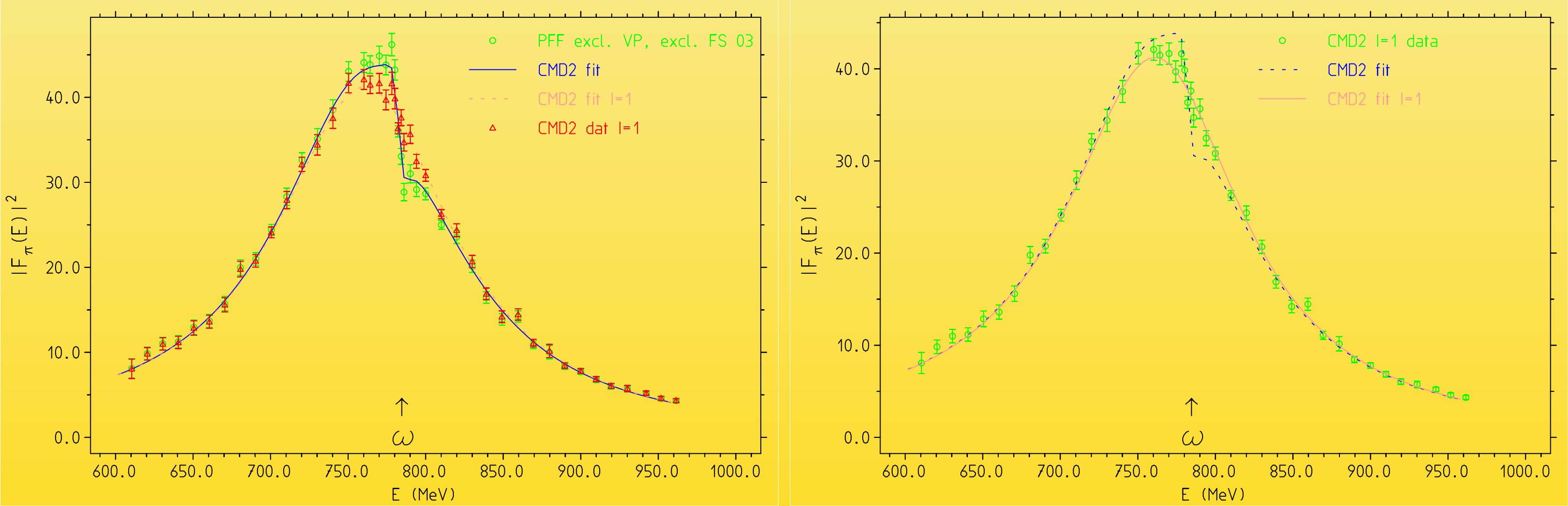
In e^+e^- (neutral channel) $\rho-\omega$ mixing due isospin violation be quark mass difference

$$m_u \neq m_u \;\Rightarrow$$

I=0 component; to be subtracted for comparison with τ data

$$|F(s)|^2 = (|F(s)|^2\text{–data}) \,/\, \left|\left(1+\frac{\epsilon s}{(s_\omega - s)}\right)\right|^2 \quad \text{with } s_\omega = (M_\omega - \tfrac{i}{2}\Gamma_\omega)^2$$

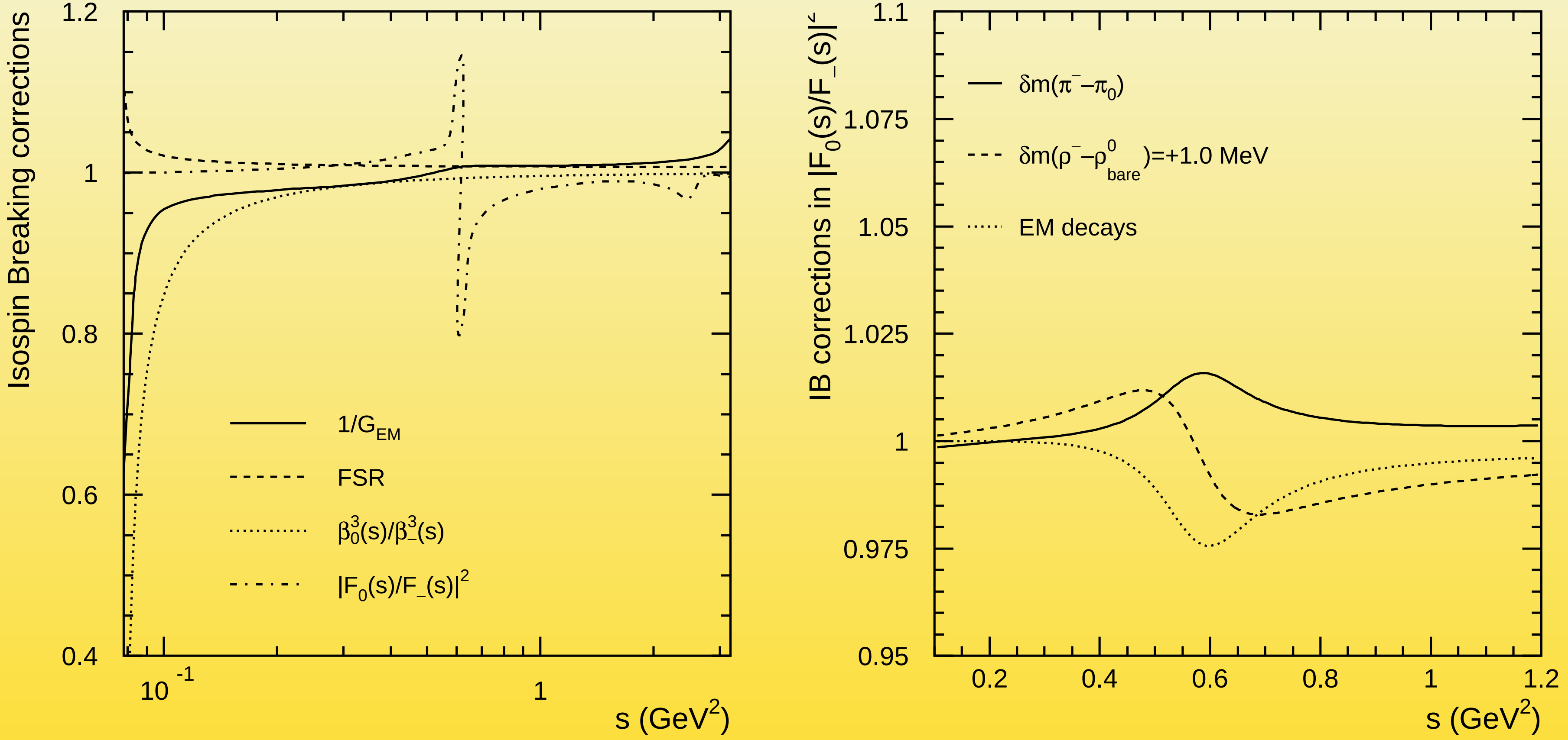
ϵ determined by fit to the data: $\epsilon = 0.00172$



CMD-2 data for $|F_\pi|^2$ in $\rho-\omega$ region together with Gounaris-Sakurai fit. Left before subtraction right after subtraction of the ω.

I=0 component to be added to τ data for calculating $a_\mu^{\rm had}$!

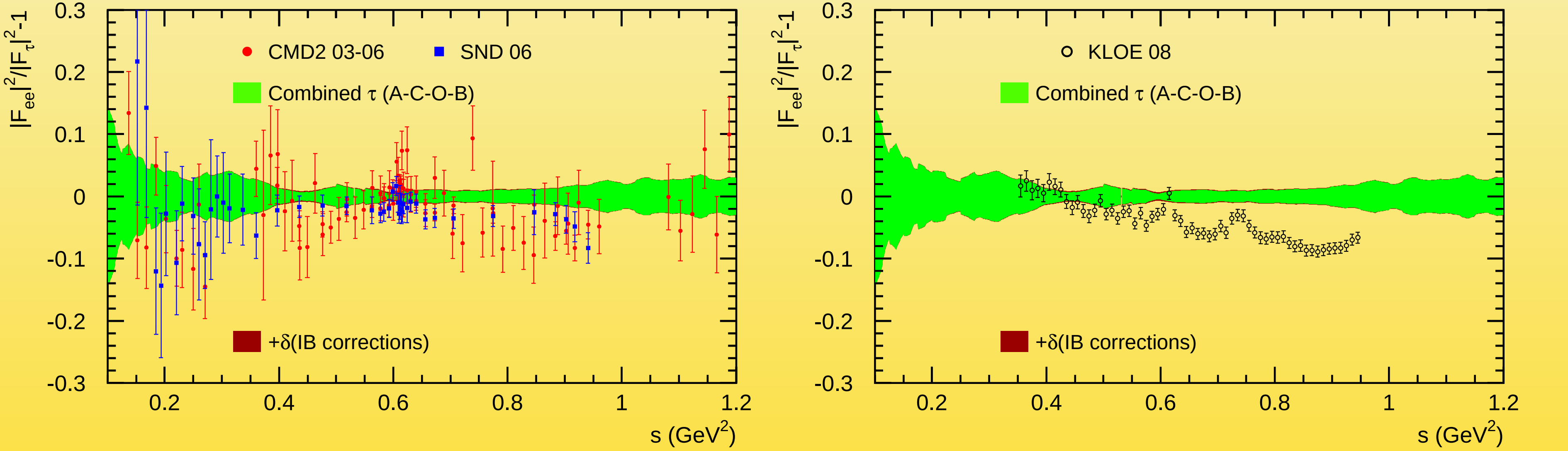
Other isospin-breaking corrections (Cirigliano et al. 2002, López Castro el al. 2007)



Left: Isospin-breaking corrections $G_{\rm EM}$, FSR, $\beta_0^3(s)/\beta_-^3(s)$ and $|F_0(s)/F_-(s)|^2$.

Right: Isospin-breaking corrections in $I=1$ part of ratio $|F_0(s)/F_-(s)|^2$: π mass splitting $\delta m_\pi = m_{\pi^\pm} - m_{\pi^0}$, ρ mass splitting $\delta m_\rho = m_{\rho^\pm} - m_{\rho^0_{\rm bare}}$, and ρ width splitting $\delta\Gamma_\rho$.

New isospin corrections applied shift in mass and width [as advocated by S. Ghozzi and FJ in 2003!!!] plus changes [López Castro, Toledo Sánchez et al 2007] below the ρ which Davier et al say are not understood! The discrepancy now substantially reduced but with the KLOE data persists.



e^+e^- vs τ spectral functions: $|F_{ee}|^2/|F_\tau|^2-1$ as a function of s. Isospin-breaking (IB) corrections are applied to τ data with its uncertainties included in the error band.

CVC prediction of

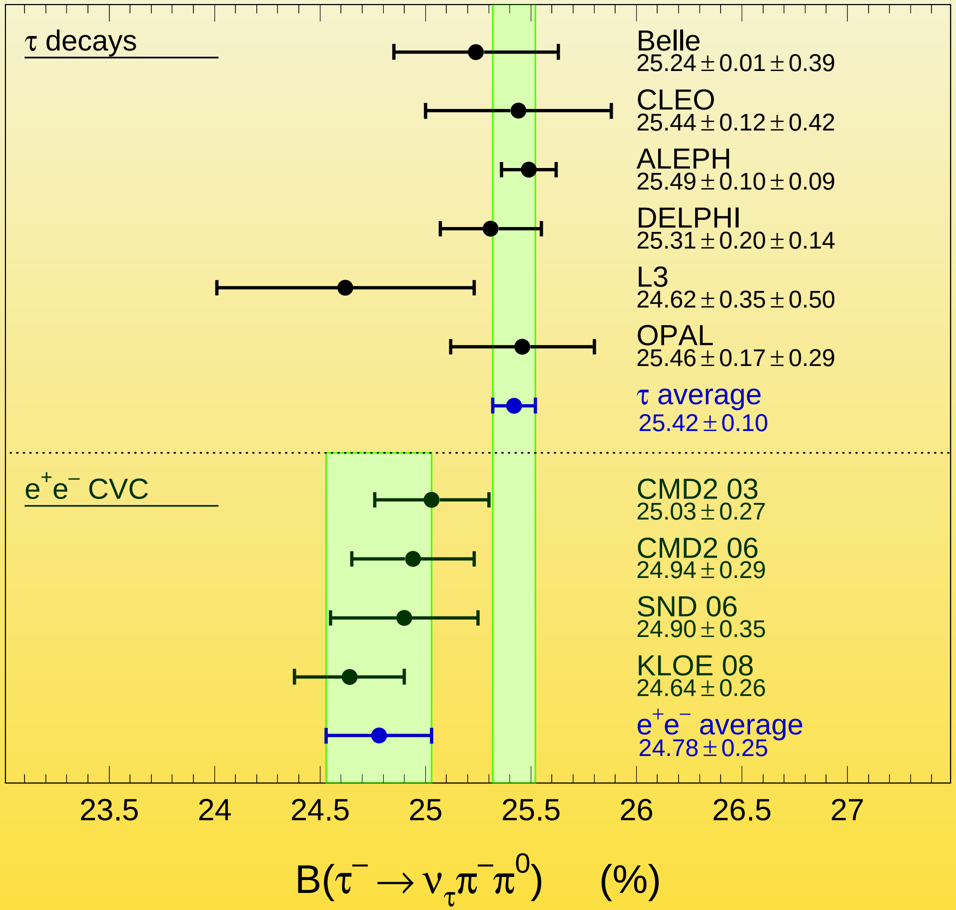
$$\mathcal{B}_{\pi\pi^0}$$

normalization of

BELLE, CLEO and OPAL

not fixed

by the experiment itself

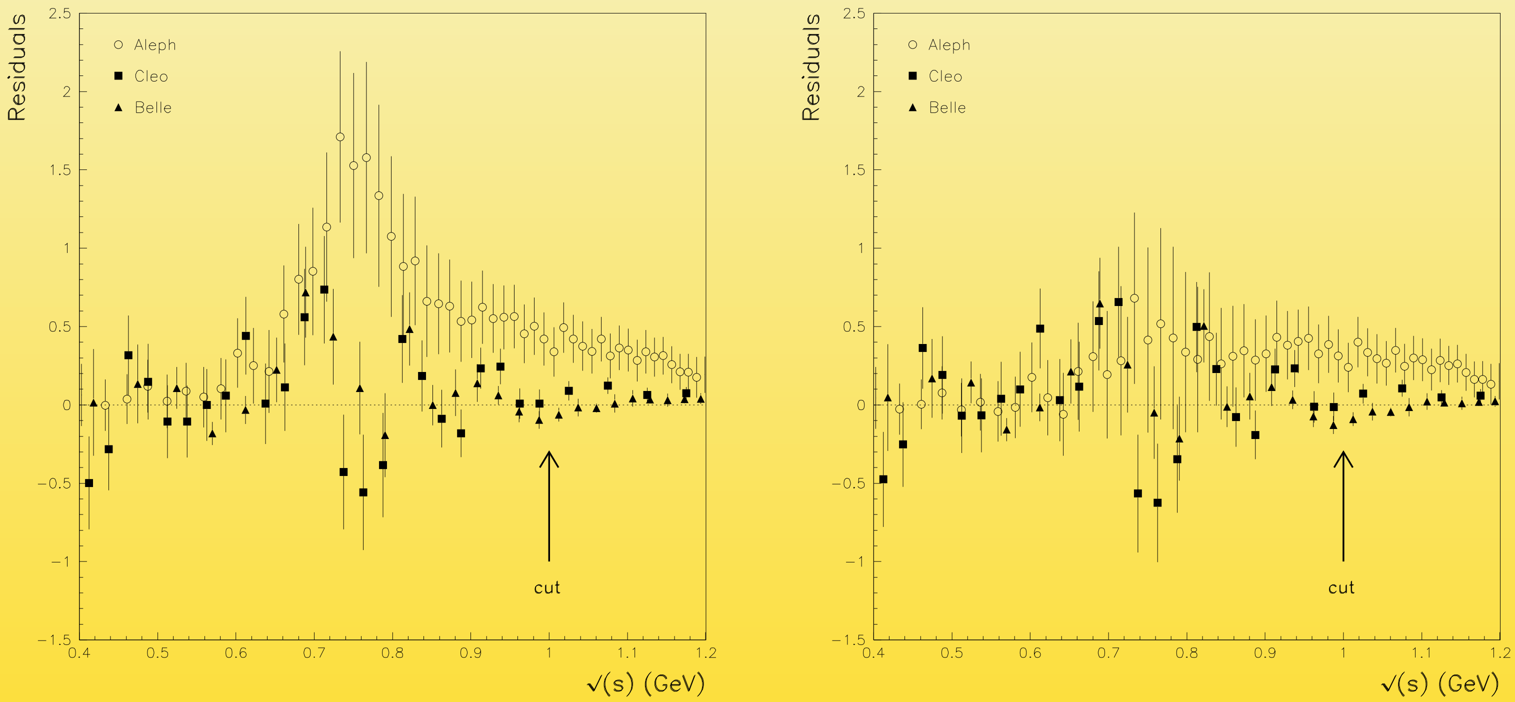


The measured branching fractions for $\tau^- \to \pi^-\pi^0\nu_\tau$ compared to the predictions from the $e^+e^- \to \pi^+\pi^-$ spectral functions (after isospin-breaking corrections). (Named e^+e^- results for $0.63 - 0.958$GeV). The long and short vertical error bands correspond to the τ and e^+e^- averages of 25.42 ± 0.10 and 24.76 ± 0.25, respectively.

Note -2% in Belle τ data means $25.42 \to 24.91$ in agreement with e^+e^- $[|F_\tau(0)|^2 = 1.02 \to |F_\tau(0)|^2 = 1]$

Physics of vacuum polarization ...

❏ hadronic final state photon radiation not under quantitative control, in τ–decay enhanced short distance sensitivity (UV-log modeled by quark parton model, rest by sQED)



τ data vs. residual distribution in the fit of τ data: Left: BELLE+CLEO, Right: ALEPH+BELLE+CLEO (from Benayoun et al 09))

BELLE: best fit of $|F_\tau(s)|^2$ yields $F_\tau(0) = 1.02 \pm \pm 0.01 \pm 0.04 \Rightarrow$ this violates em current conservation. Benayoun et al. 2009 suggest that normalization may be wrong $\longrightarrow$ shift down data by 2%; actually with global shift by -4.5 % perfect agreement with Novosibirsk e^+e^- data (as a distribution). Is the main problem that ALEPH lies very high ???

τ vs. e^+e^- problem:

- Unknown isospin violations in parameters: $m_{\rho^+} - m_{\rho^0}, m_{\rho'^+} - m_{\rho'^0}, m_{\rho''^+} - m_{\rho''^0}$
- Needed what is measured in e^+e^-: $|A_{I=1}(s) + A_{I=0}(s)|^2 < |A_{I=1}(s)|^2 + |A_{I=0}(s)|^2$;
  τ evaluations based on $|A^{\tau}_{I=1}(s)|^2 + |A^{e^+e^-}_{I=0}(s)|^2$ which may overestimate the effects;
  separation of $|A^{e^+e^-}_{I=0}(s)|^2$ using Gounaris-Sakurai fit of the $\rho - \omega$ [$\varepsilon_{\rho\omega} = (2.02 \pm 0.1) \times 10^{-3}$];

HLS model calculation of Benayoun et al. suggests large diminution by interference.

Look at $\delta_m = (m_{\rho^+} - m_{\rho^0})/\bar{m}_\rho$ etc.

δ	ρ	ρ'	ρ''
m	0.2%	7.4 %	[0.0] %
Γ	2.9%	4.8 %	[0.0] %
γ	$-$	45.3 %	65.7 %
ϕ_γ	$-$	21.5 %	[0.0] %

Cottingham formula calculating $m^2_{\pi^-} - m^2_{\pi^0}$ very successfully suggests

$$\Delta m^2_\rho = \Delta m^2_\pi \Rightarrow m_{\rho^+} - m_{\rho^0} \simeq 0.88 \text{ MeV} \sim 1 \text{ MeV}$$

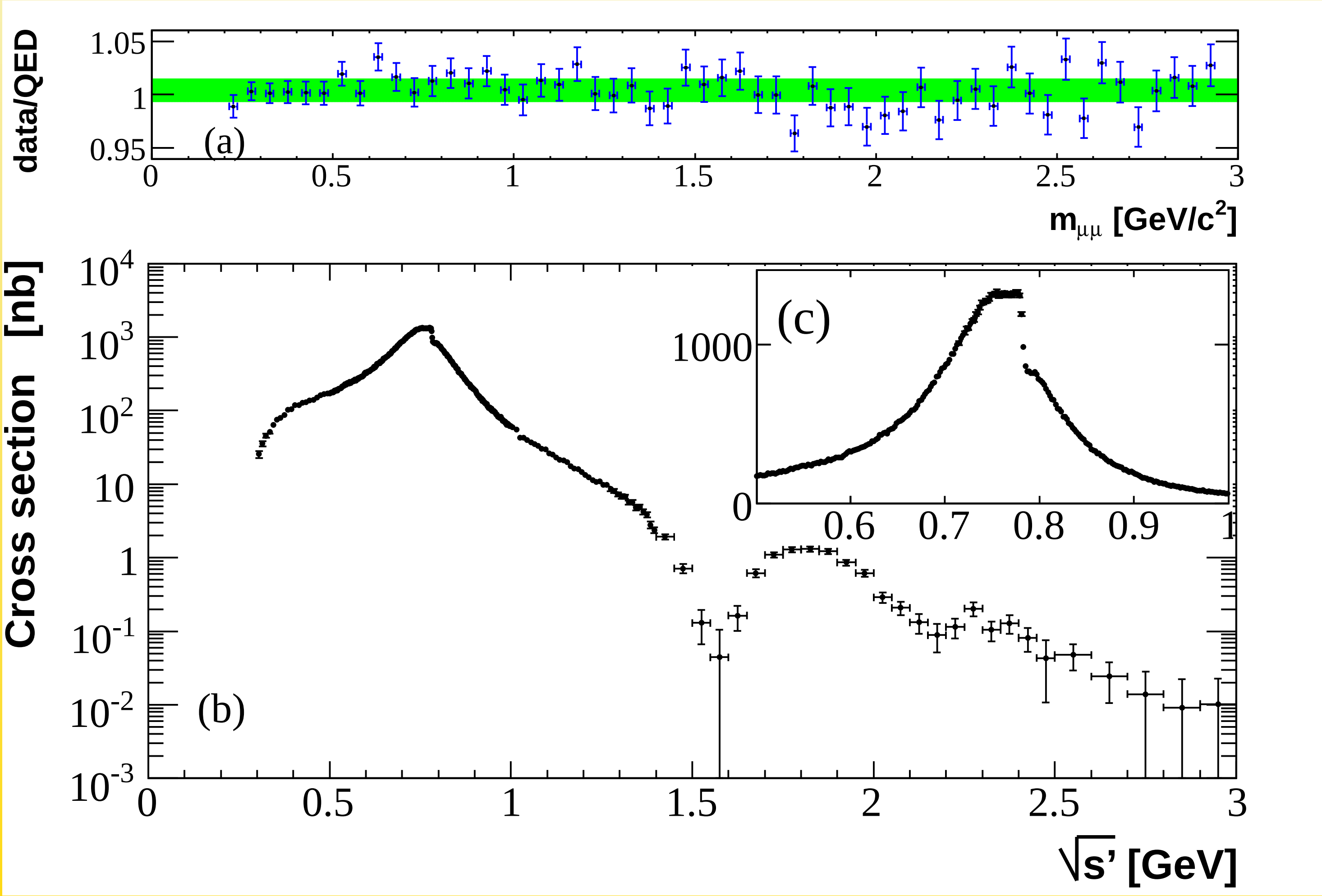
Also: $\Gamma_{\rho^0} = \left(\frac{m_{\rho^0}}{m_{\rho^-}}\right)^3 \left(\frac{\beta^0}{\beta^-}\right)^3 \Gamma_{\rho^-} + \Delta\Gamma_{\rm em} \Rightarrow \Gamma_{\rho^-} - \Gamma_{\rho^0} \simeq 2.1 \pm 0.5$ MeV

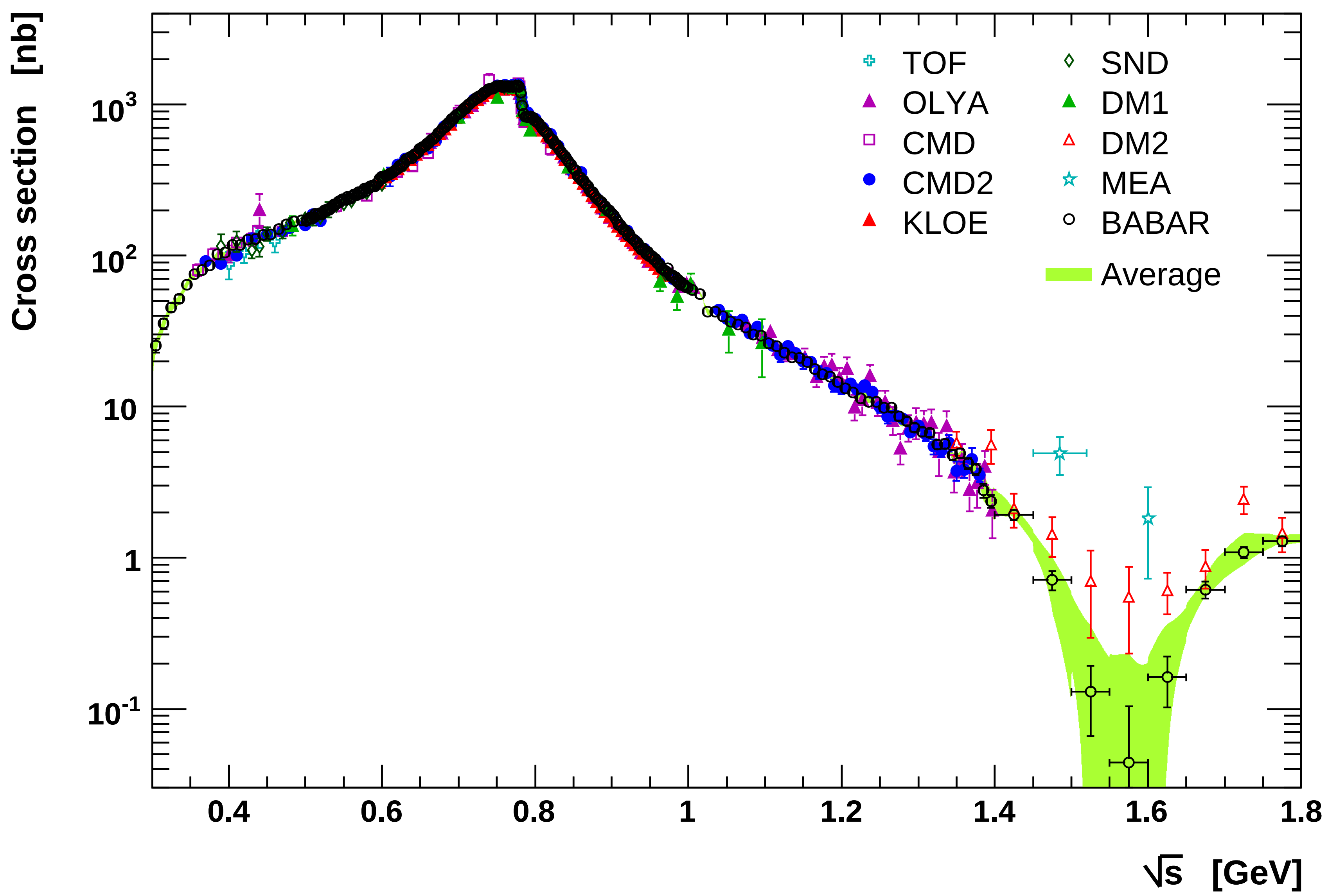
	τ	e^+e^-	combined
m_{ρ^0}	-	773.3 $\pm$ 0.6	772.7 $\pm$ 0.5
Γ_{ρ^0}	-	145.2 $\pm$ 1.3	146.4 $\pm$ 0.9
m_{ρ^-}	775.0 $\pm$ 0.6	-	775.3 $\pm$ 0.6
Γ_{ρ^-}	149.5 $\pm$ 1.1	-	149.5 $\pm$ 0.8
$\alpha_{\rho\omega}$	-	$(2.02 \pm 0.10)\ 10^{-3}$	$(1.98 \pm 0.10)\ 10^{-3}$
β	0.195 $\pm$ 0.028	0.123 $\pm$ 0.011	0.172 $\pm$ 0.006
ϕ_β	173.0 $\pm$ 7.0	139.4 $\pm$ 6.5	178.2 $\pm$ 4.5
$m_{\rho'}$	1440 $\pm$ 34	1337 $\pm$ 35	1415 $\pm$ 15
$\Gamma_{\rho'}$	597 $\pm$ 102	569 $\pm$ 81	528 $\pm$ 42
γ	0.095 $\pm$ 0.029	0.048 $\pm$ 0.008	0.072 $\pm$ 0.006
ϕ_γ	0.	0.	0.
$m_{\rho''}$	1713	1713 $\pm$ 15	1741 $\pm$ 20
$\Gamma_{\rho''}$	235	235	235

$|F_\pi(s)|^2$ Gounaris-Sakurai fit for τ and e^+e^- data (ALEPH and CLEO) separately, then combined. Mass and width values are in MeV, phase ϕ_β in degrees.

2. Recent BaBar ISR $\pi^+\pi^-$–spectrum and its impact for $g-2$

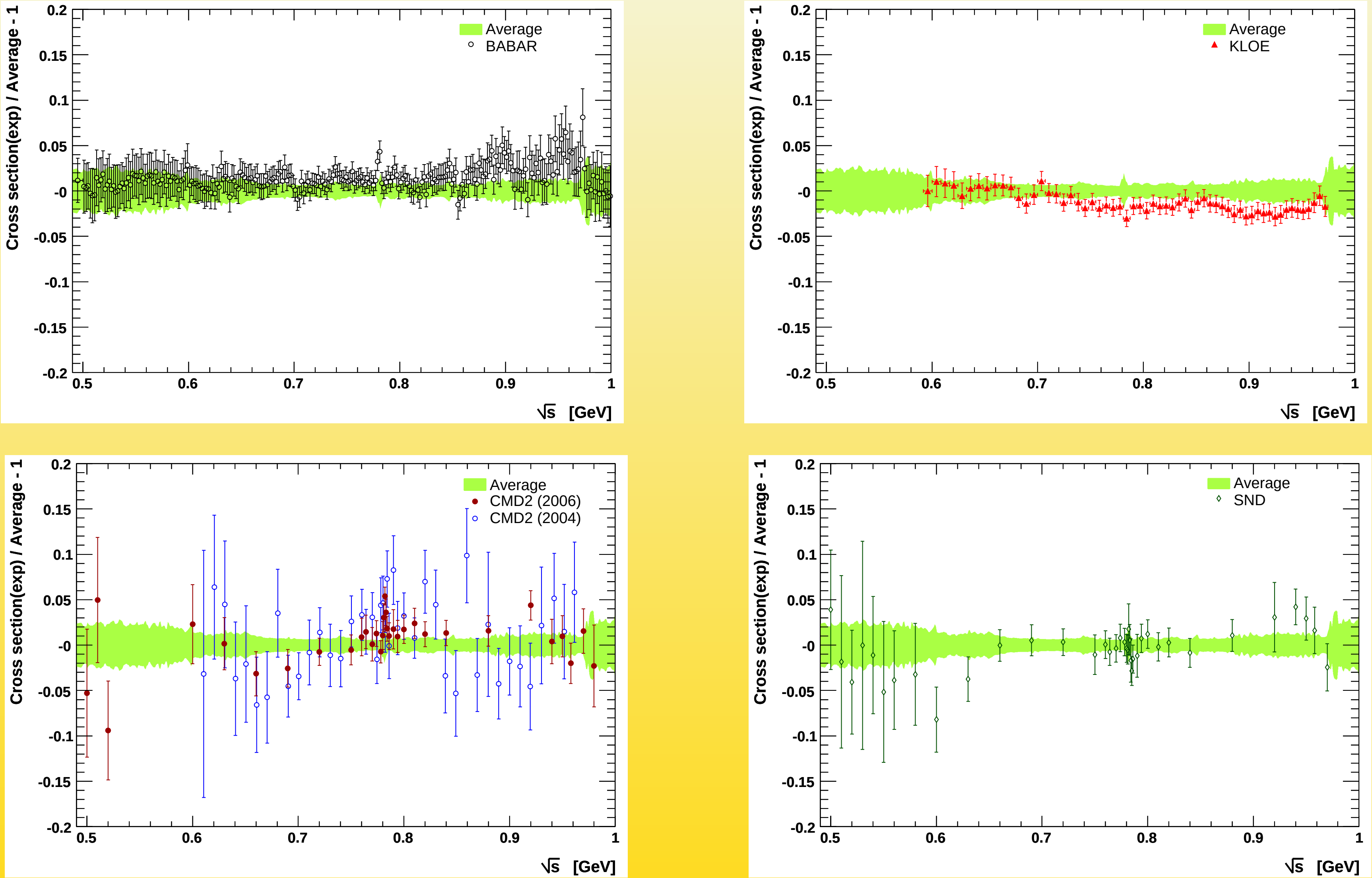
BaBar: New: final $e^+e^- \to \pi\pi\gamma$ data Aug 2009 $\pi\pi$-spectrum from one experiment in large energy range!



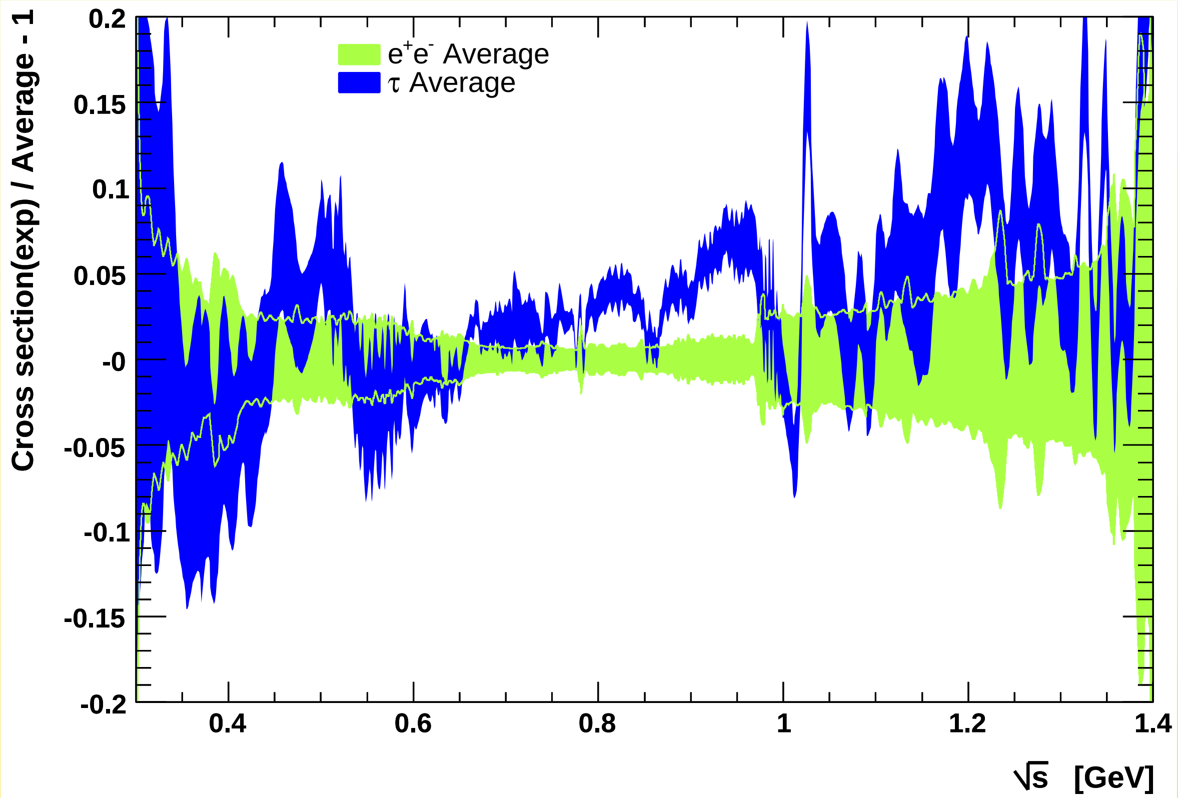


Compilation of $\pi\pi$–data including new BaBar data from radiative return measurement at the $\Upsilon(4S)$ resonance (Davier et al 2009).

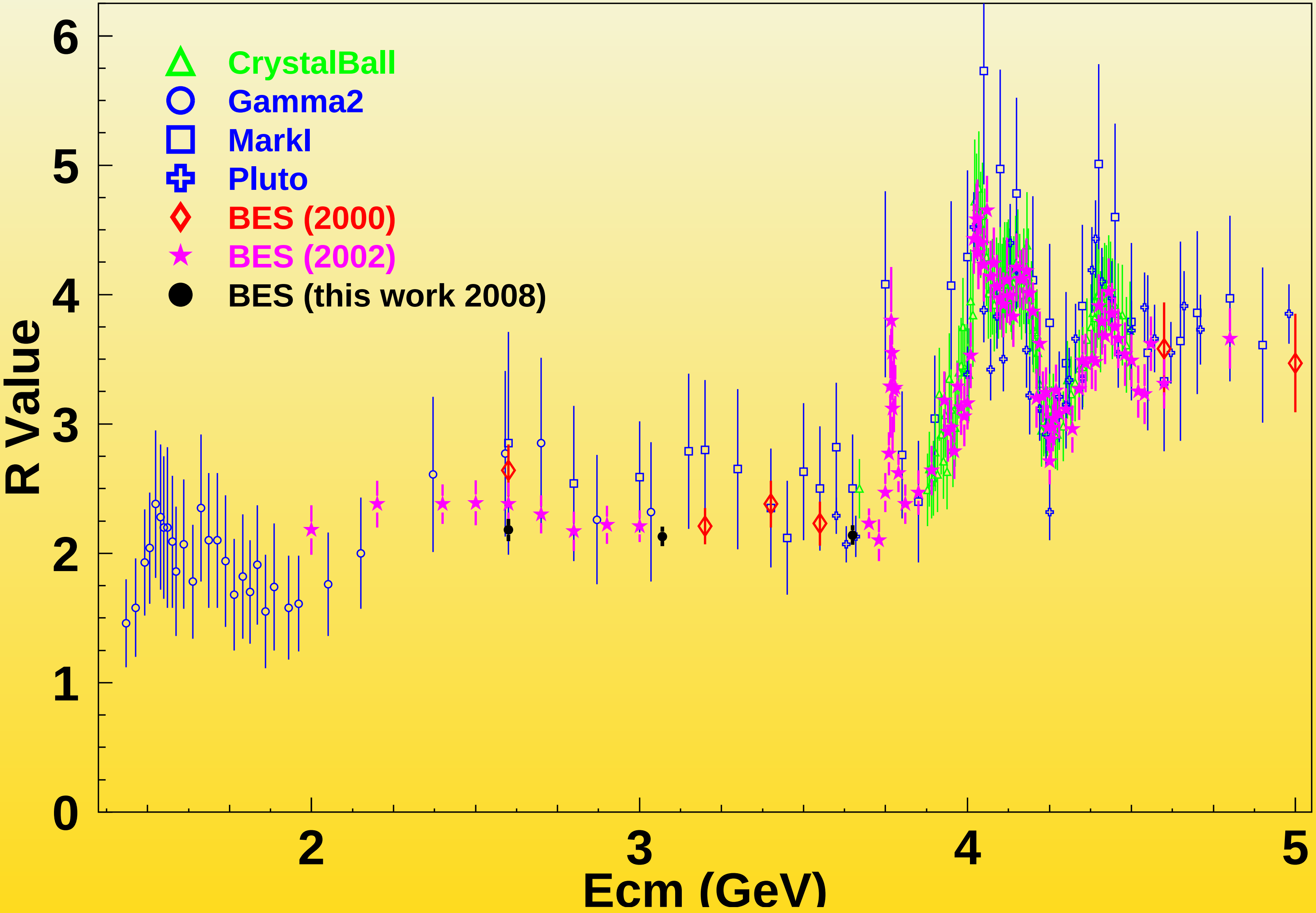
Physics of vacuum polarization ...



Relative cross section comparison between individual experiments Shown are BABAR (top left), KLOE (top right), CMD2 (bottom left) and SND (bottom right).



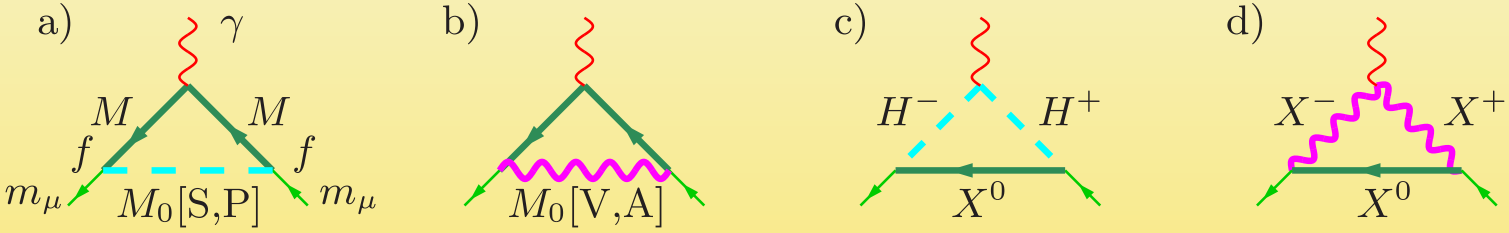
Relative comparison between the combined τ (dark shaded) and e^+e^- spectral functions (light shaded), normalized to the e^+e^- result.



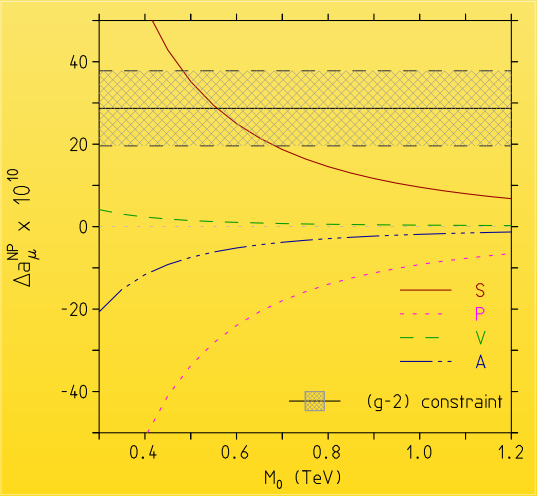
New R values at 2.6,3.07 and 3.65 GeV form BESII at 3.5% !

3. New Physics constraints from $g-2$ and elsewhere

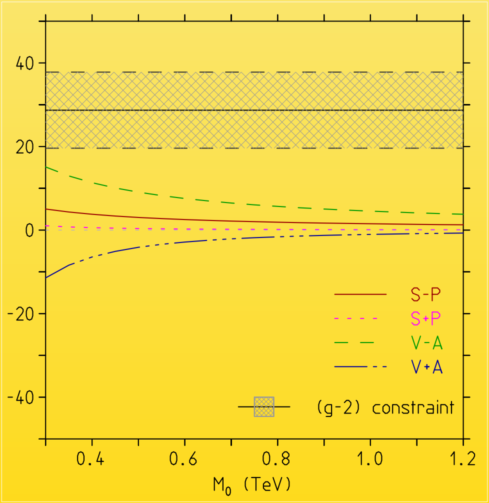
New physics contributions: (examples)



Possible New Physics contributions: neutral boson exchange: a) scalar or pseudoscalar and c) vector or axialvector, flavor changing or not, new charged bosons: b) scalars or pseudoscalars, d) vector or axialvector



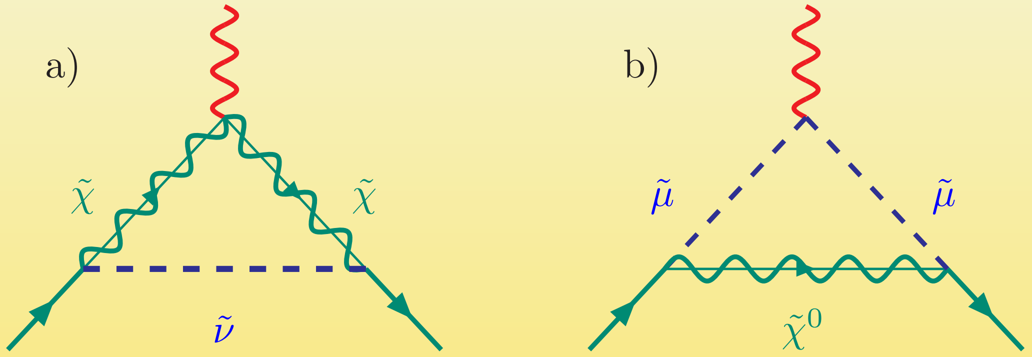
(c) Case: $m_\mu = M \ll M_0$



(d) Case: $m_\mu \ll M_0 = M$

Object	mass bound			comment
Heavy neutrino	$m^M_{\nu'}$	$>$	39 GeV	Majorana-ν $[\nu \equiv \bar{\nu}]$
Heavy neutrino	$m^D_{\nu'}$	$>$	45 GeV	Dirac-ν $[\nu \neq \bar{\nu}]$
Heavy lepton	m_L	$>$	100 GeV	
4th family quark b'	$m_{b'}$	$>$	199 GeV	$p\bar{p}$ NC decays
W'_{SM}	$M_{W'}$	$>$	800 GeV	SM couplings
W_R	M_{W_R}	$>$	715 GeV	right–handed weak current
Z'_{SM}	$M_{Z'}$	$>$	825 GeV	SM couplings
Z_{LR} $(g_R = g_L)$	$M_{Z_{LR}}$	$>$	630 GeV	of $G_{LR} = SU(2)_R \otimes SU(2)_L \otimes U(1)$
Z_χ $(g_\chi = e/\cos\Theta_W)$	M_{Z_χ}	$>$	595 GeV	of $SO(10) \to SU(5) \otimes U(1)_\chi$
Z_ψ $(g_\psi = e/\cos\Theta_W)$	M_{Z_ψ}	$>$	590 GeV	of $E_6 \to SO(10) \otimes U(1)_\psi$
Z_η $(g_\eta = e/\cos\Theta_W)$	M_{Z_η}	$>$	620 GeV	of $E_6 \to G_{LR} \otimes U(1)_\eta$
H Higgs	m_H	$>$	114.4 GeV	SM
$h^0 \equiv H^0_1$ Higgs	$m_{H^0_1}$	$>$	89.8 GeV	SUSY $(m_{H^0_1} < m_{H^0_2})$
A^0 pseudoscalar Higgs	m_A	$>$	90.4 GeV	THDM, MSSM
$H^\pm$ charged Higgs	$m_{H^\pm}$	$>$	79.3 GeV	THDM, MSSM

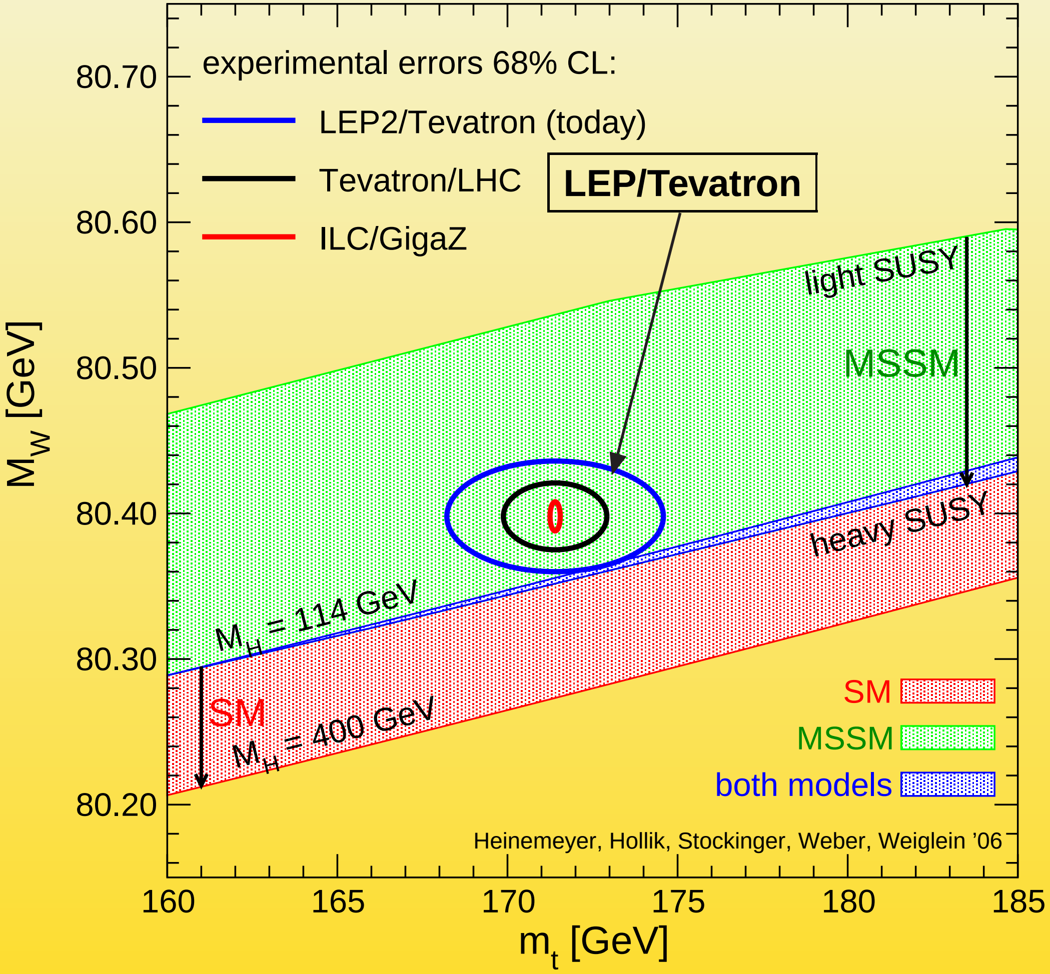
Most promissing New Physics scenario: SUSY



Leading SUSY contributions to $g-2$ in supersymmetric extension of the SM.

- $\tilde{m}$ lightest SUSY particle; SUSY requires two Higgs doublets
- $\tan\beta = \frac{v_1}{v_2}, v_i =< H_i > \quad ; \quad i=1,2$
- $$a_\mu^{\rm SUSY} \simeq \frac{{\rm sign}(\mu M_2)\,\alpha(M_Z)}{8\pi\sin^2\Theta_W}\;\frac{(5+\tan^2\Theta_W)}{6}\;\frac{m_\mu^2}{M_{\rm SUSY}^2}\,\tan\beta\left(1-\frac{4\alpha}{\pi}\ln\frac{M_{\rm SUSY}}{m_\mu}\right)$$

  with $M_{\rm SUSY}$ a typical SUSY loop mass and the sign is determined by the Higgsino mass term μ, RG improved.
- $\tan\beta \sim m_t/m_b \sim 40 \quad [4-40]$



a function of m_t in comparison with the present experimental results for M_W and m_t and the prospective accuracies (using the current central values) at the Tevatron/LHC and at the ILC. Courtesy of S. Heinemeyer et al.

There are a lot of “SUSY’s”

- General MSSM has $>$ 100 free parameters
  - Advantage: we do not know them, frankly speaking
  - Disadvantage: Not predictive, but experiments can “restrict” parts of the multidimensional parameter space
  - No way “Ruling out SUSY”
- CMSSM – “constrained” and, related but even more constrained MSUGRA, and others
  - These models assume many degeneracies of masses and couplings in order to restrict the number of parameters
  - Typically, $m_o, m_{1/2}, \mathrm{sign}(\mu), \tan\beta, A$ (or even more)
- Then there is R–parity – is sparticle number conserved (dark matter candidate?)
- Many ways to describe EW symmetry breaking

Role for LHC searches:

3 σ deviation in muon g-2 (if real) requires $\mathrm{sign}(\mu)$ and $\tan\beta$ preferable large

Note:

- $\mathrm{sign}(\mu)$ **cannot be obtained from LHC (hadron collider)**
- $\tan\beta$ **can't be pinned down by LHC (hadron collider)**

so muon g-2 important hint for constraining SUSY parameter space (is SUSY)

More scenarios:

- **two Higgs doublet models (see Krawzcyk) field**

  $\tan\beta$ **enhanced contributions:**

$$a_\mu^{(2)\;\mathrm{2HDM}}(h) \simeq \frac{\sqrt{2}G_\mu m_\mu^2}{4\pi^2}\,\tan^2\beta\,\frac{m_\mu^2}{m_h^2}\,\left(\ln\frac{m_h^2}{m_\mu^2}-\frac{7}{6}\right) > 0\;,$$

$$a_\mu^{(2)\;\mathrm{2HDM}}(A) \simeq \frac{\sqrt{2}G_\mu m_\mu^2}{4\pi^2}\,\tan^2\beta\,\frac{m_\mu^2}{m_A^2}\,\left(-\ln\frac{m_A^2}{m_\mu^2}+\frac{11}{6}\right) < 0\;.$$

Potentally large 2–loop contributions: Barr-Zee type diagrams:

$a_\mu^{\mathrm{bos,2L}}(\mathrm{MSSM}-\mathrm{SM}) < 3\cdot 10^{-11}$**, parameter range** $m_A \gtrsim 50$ **GeV,** $\tan\beta \lesssim 50$**.**

- **sequential fermions (4th family?)**

  Present bounds $m_L > 100$ GeV heavy lepton, $m_{b'} \gtrsim 200$ GeV heavy quark. Note $a_\mu(\tau) \simeq 42 \cdot 10^{-11}$ only!

- **Grand Unified Theories: Z', W', leptoquarks etc**

  Present bounds $M_{Z',W'} > 600 - 800$ GeV depending on the GUT scenario.

  Essentially rescaling weak contribution with $(M_W/M_{W'_{\mathrm{SM}}})^2 \sim 0.01$, i.e., 1% of $19.5 \cdot 10^{-10}$ only, too small to be of relevance.

- **extra dimensions, graviton excitations etc**

  Integrating out the extra coordinates under the hypothesis of factorization one obtains $\overline{M}_{Pl} = M_{Pl}/\sqrt{8\pi} = (\sqrt{8\pi\, G_N})^{-1} = 2.4 \cdot 10^{18}$ GeV (G_N Newton's gravitational constant) from the relation

$$\overline{M}^2_{\mathrm{Pl}} = \overline{M}_D^{2+\Delta}\, V_\Delta = \overline{M}_D^{2+\Delta}\, (2\pi\, R)^\Delta = M_D^{2+\Delta}\, R^\Delta \quad .$$

  Phenomenology: $1/R$ is about ~ 300 GeV or larger, contributions to $g-2$ small, model dependent, towers of Kaluza-Klein excitations:

Barbieri, Hall and Nomura

$$\Delta a_\mu^{(2)\,\mathrm{KK}} = -\frac{g^2}{192}\,\frac{11-18s^2}{12c^2}\,(m_\mu\, R)^2$$

numerically, for $1/R = 370 \pm 70$ **GeV**, it is given by

$$\Delta a_\mu^{(2)\,\mathrm{KK}} \;=\; -0.07^{+0.04}_{-0.02}\cdot a_\mu^{(2)\,\mathrm{EW}} = -(13.6^{+7.1}_{-4.0})\cdot 10^{-11}$$

Appelquist, Chang and Dobrescu model (universal extra dimension),

$$\Delta a_\mu^{(2)\,\mathrm{KK}} = -0.276\cdot a_\mu^{(2)\,\mathrm{EW}} = -53.7[-24.8]\cdot 10^{-11} \;\; .$$

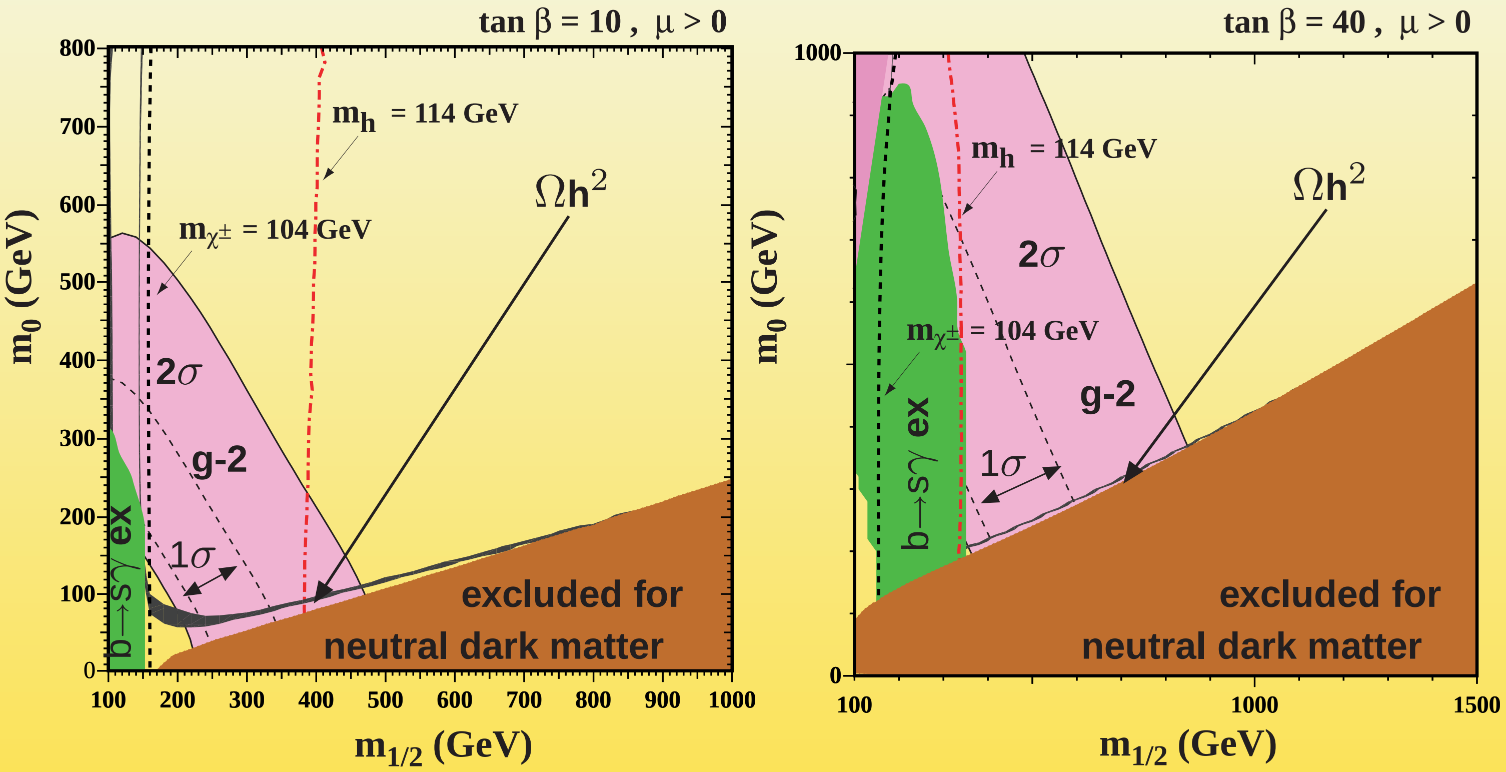
which again for any sensible value of R yields a result well inside the uncertainties of the SM prediction.

- Little Higgs Models of EW symmetry breaking

  Contributions at most $a_\mu^{\mathrm{LH}} \sim 10 \times 10^{-11}$.

  Littlest Higgs model with T-parity

$$a_\mu^{\mathrm{LHT}} < 12 \times 10^{-11} \;\; .$$



The $(m_0, m_{1/2})$ plane for $\mu > 0$ for (a) $\tan\beta = 10$ and (b) $\tan\beta = 40$ in the constrained MSSM (mSUGRA) scenario. The allowed region by the cosmological neutral dark matter constraint is shown by the black parabolic shaped region. The disallowed region where $m_{\tilde{\tau}_1} < m_\chi$ has dark shading. The regions excluded by $b \to s\gamma$ have medium shading (left). The $g_\mu - 2$ favored region at the 2 σ [$(287 \pm 182) \cdot 10^{-11}$] (between dashed lines the 1 σ [$(287 \pm 91) \cdot 10^{-11}$] band) level has medium shading. The LEP constraint on $m_{\chi^\pm} = 104$ GeV and $m_h = 114$ GeV are shown as near vertical lines. Plot courtesy of K. Olive

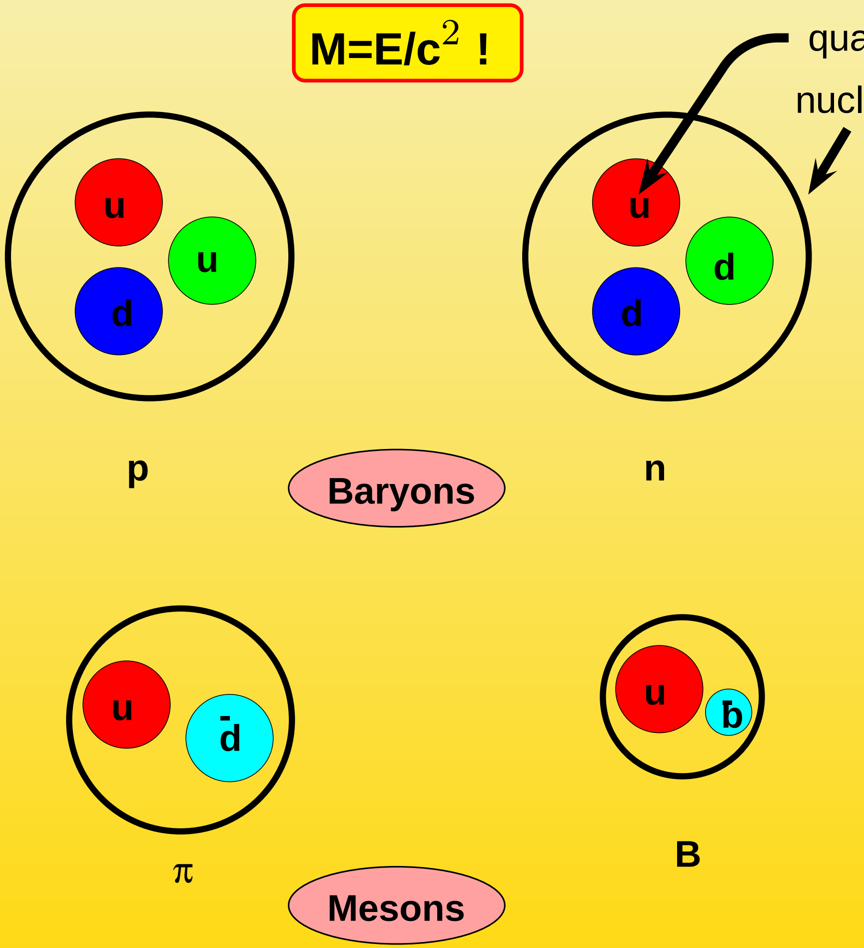
Comment on the Dark Matter problem

QCD strong interaction which hamper our ability to systematically improve the precision of theoretical predictions, is a really revolutionary theory, a priory non-perturbative: fields are not the interpolating fields of physical states.

Light hadronic matter: 90% binding energy $M = E/c^2$ Baryonic matter in the universe almost 100% pure binding energy, completely non-perturbative phenomenon.

Hadrons are made of Quarks and Gluons

QUARKS are permanently confined in HADRONS



M=E/c^2 !

quarks: light $\lesssim$ 10 MeV

nucleon: heavy $\sim$ 1 GeV

Hadrons are elementary composite systems [Wigner state]

Higgs mechanism usually said to be responsible for all masses. Not true in hadronic sector, mass of universe would essentially not change if we would be in the symmetric phase, with all primary fermions close to massless (Nambu was the first to notice that!)

Dark matter problem: why do we suppose that some elementary particle like neutralino should be responsible for it? I think dark matter could also be just condensed energy.

4. Future prospects in VP physics

- Recent and future high precision experiments on $a_\mu = (g-2)/2$ (BNL/KEK project may gain factor 10?) and $\sin^2\Theta_{\rm eff}$, etc. (LEP/SLD⟶TESLA/ILC) imposed and further impose a lot of pressure to theory and experiment to improve, in particular, in reducing the hadronic uncertainties which mainly are due to the experimental errors of $R(s)^{\rm exp}_{\rm had}$.
- In electroweak precision physics at non-zero energies (note $E \sim m_\mu$ in $(g-2)_\mu$) there is now way around determining $\alpha_{\rm eff}(E)$ via precision measurements of $\sigma_{\rm hadronic}$ or lattice QCD simulations via Adler function approach (which is a very difficult long term project).
- Needs for linear collider (like ILC): requires $\sigma_{\rm had}$ at 1% level up to the $\Upsilon \Rightarrow \delta\alpha(M_Z)/\alpha(M_Z) \sim 5\times 10^{-5}$. New cross section measurements at VEPP-2000, DAFNE-II, radiative return measurements at DAFFNE-I, BABAR and Belle, and at CLEOc and BESS-III are able to reduce the hadronic uncertainties to ???? for a_μ and to ???? for $\alpha(M_Z)$. Together with improved measurements of the top mass m_t from LHC, at present this would allow to get much better Higgs boson mass limits but

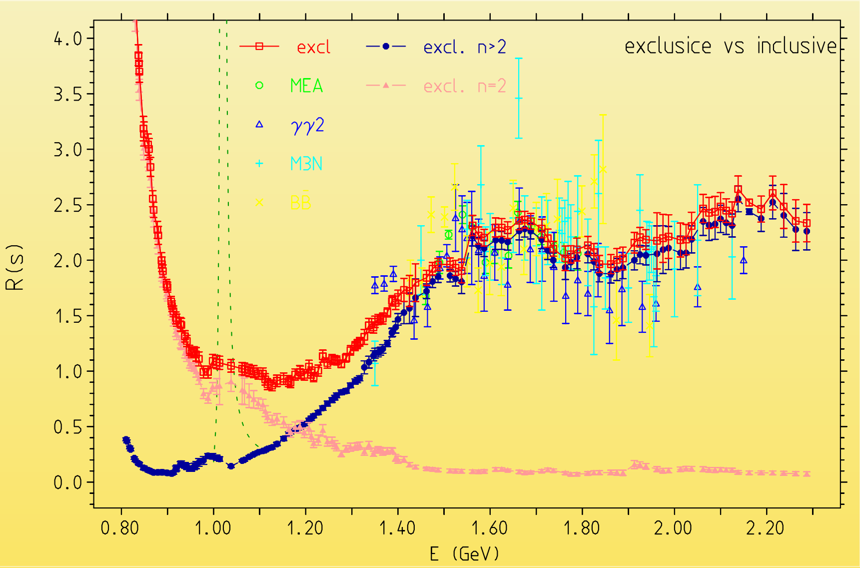
much more than that.

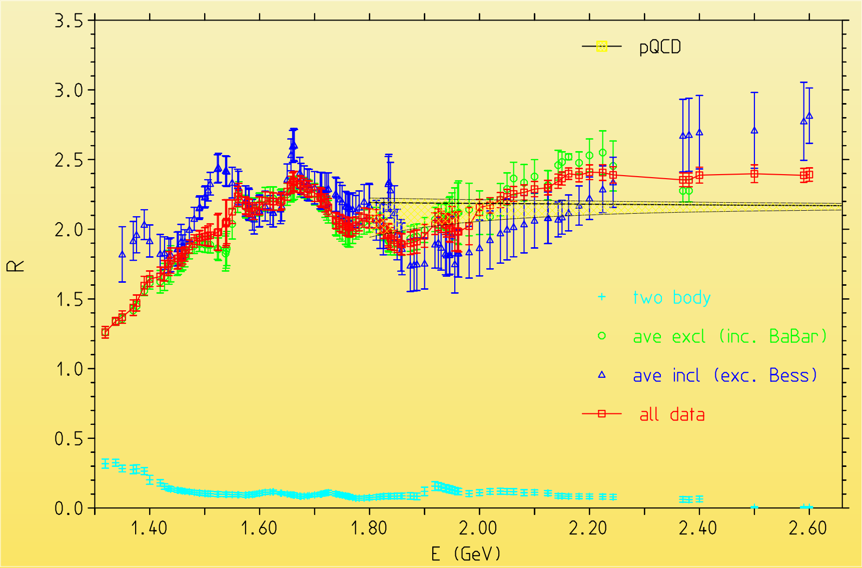
- Future precision physics requires dedicated effort on $\sigma_{\rm had}$ experimentally as well as theoretically (radiative corrections, final state radiation from hadrons etc.)
- Improving hadronic cross section measurements must be seen as a global effort in particular in the context of ILC project, which primarily makes sense as a high precision physics project. The $\sigma_{\rm hadronic}$ efforts have to be pushed at any machine able to perform such a measurement up tp 10 GeV! One has to see this activity as an integral part of the international linear collider (ILC) project and to ask for support by the international community. However, a more $\alpha_{\rm eff}$ will be needed at many other places: $\alpha_{\rm eff}(m_p)$, Bhabha,...
- Projects VEPP-2000 and DAFNE–II can play a major role in this respect. What is required is a scan measurement with a good energy calibration (preferable using resonance depolarization). In radiative return at higher energies and multiplicities one has to precisely reconstruct the invariant mass event by event which I think is a difficulty. Dedicated Monte Carlo simulations has to be done to study what precision in which scenario can be achieved.
- Don’t believe people claiming very small errors and that everything has been solved

already or that some other lab is already doing the same; in high precision physics any experiment becomes a real challenge and I think at least two experiments should be performed for cross check.

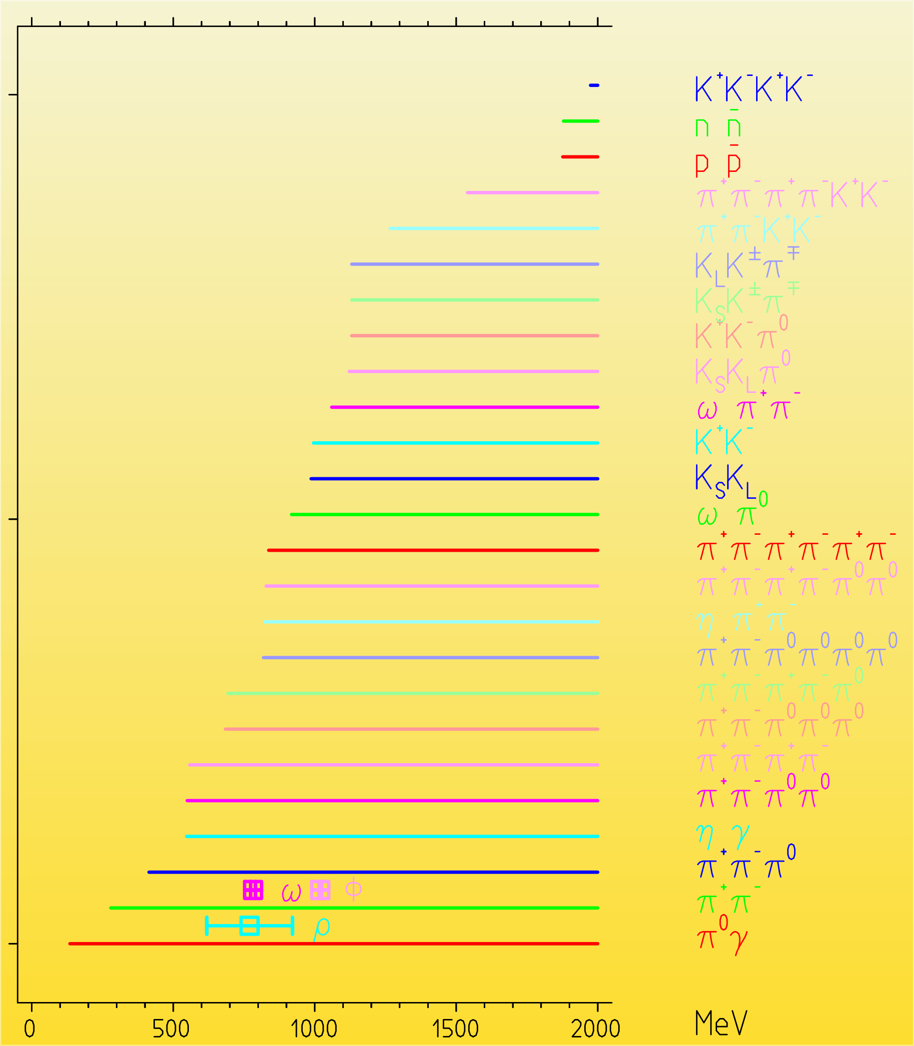
- Note complementary approach important: direct $R(s)$ integration vs. Adler $D(Q^2)$; in particular for the latter as well as for $(g-2)_\mu$ projects like DAFNE–II are a real need!

5. The role of DAFNE-2 would play





Physics of vacuum polarization ...



Thresholds for exclusive multi particle channels below 2 GeV

Future: ILC requirement: improve by factor 10 in accuracy

- **direct integration of data: 58% from data 42% p-QCD**

  $\Delta\alpha^{(5)\,\mathrm{data}}_{\mathrm{had}} \times 10^4 = 162.72 \pm 4.13$ **(2.5%)**

  1% overall accuracy ± 1.63

  1% accuracy for each region (divided up as in table)

  added in quadrature: ± 0.85

  Data: [4.13] vs. [0.85] ⇒ improvement factor 4.8

  $\Delta\alpha^{(5)\,\mathrm{pQCD}}_{\mathrm{had}} \times 10^4 = 115.57 \pm 0.12$ **(0.1%)**

  Theory: no improvement needed !

- **integration via Adler function: 26% from data 74% p-QCD**

  $\Delta\alpha^{(5)\,\mathrm{data}}_{\mathrm{had}} \times 10^4 = 073.61 \pm 1.68$ **(2.3%)**

  1% overall accuracy ± 0.74

  1% accuracy for each region (divided up as in table)

  added in quadrature: ± 0.41

  Data: [2.25] vs. [0.46] ⇒ improvement factor 4.9 (Adler vs Adler)

  [4.13] vs. [0.46] ⇒ improvement factor 9.0 (Standard vs Adler)

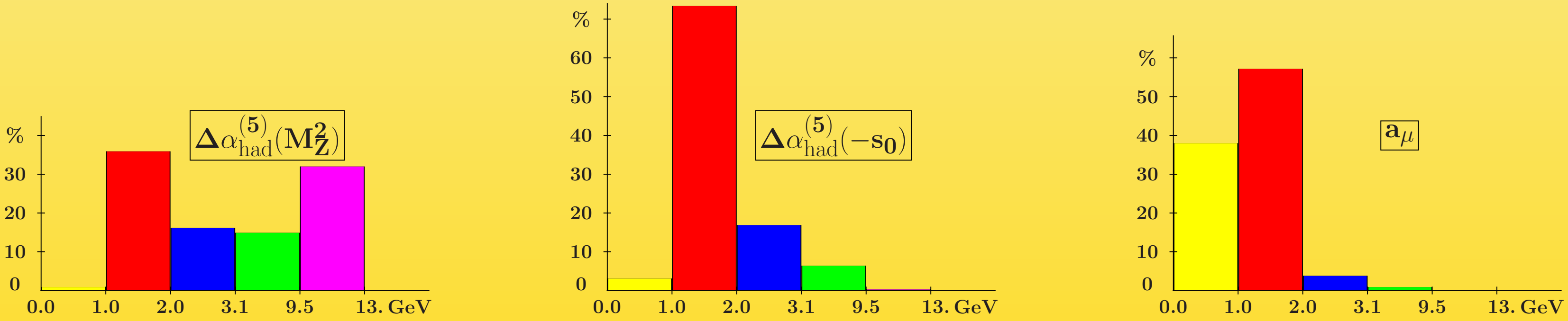
  $\Delta\alpha^{(5)\,\mathrm{pQCD}}_{\mathrm{had}} \times 10^4 = 204.68 \pm 1.49$

Theory: (QCD parameters) has to improve by factor 10 ! $\longrightarrow \pm 0.20$

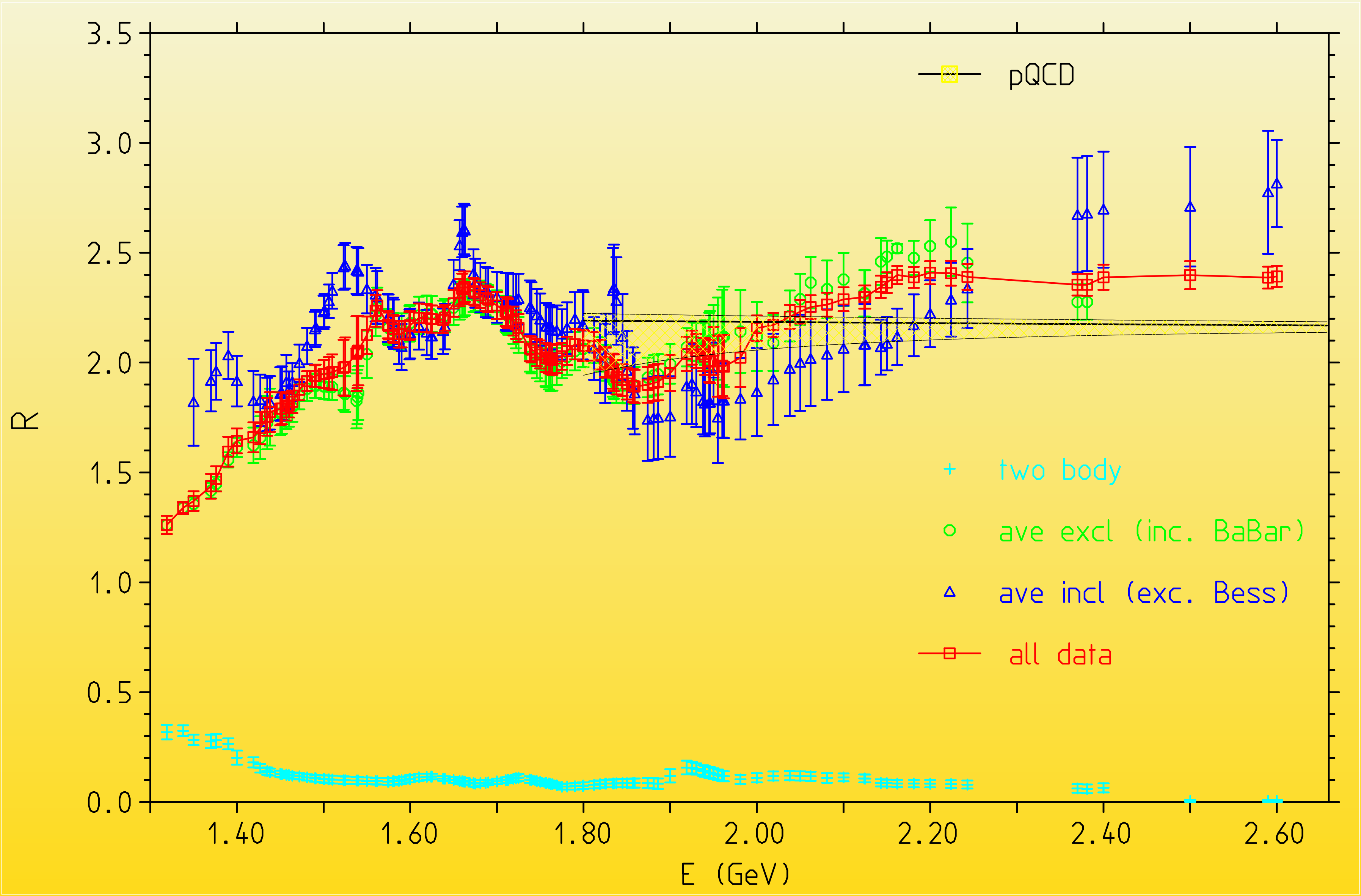
Requirement may be realistic:

- **pin down experimental errors to 1% level in all non-perturbative regions up to 10 GeV**
- **switch to Adler function method**
- **improve on QCD parameters, mainly on m_c and m_b**

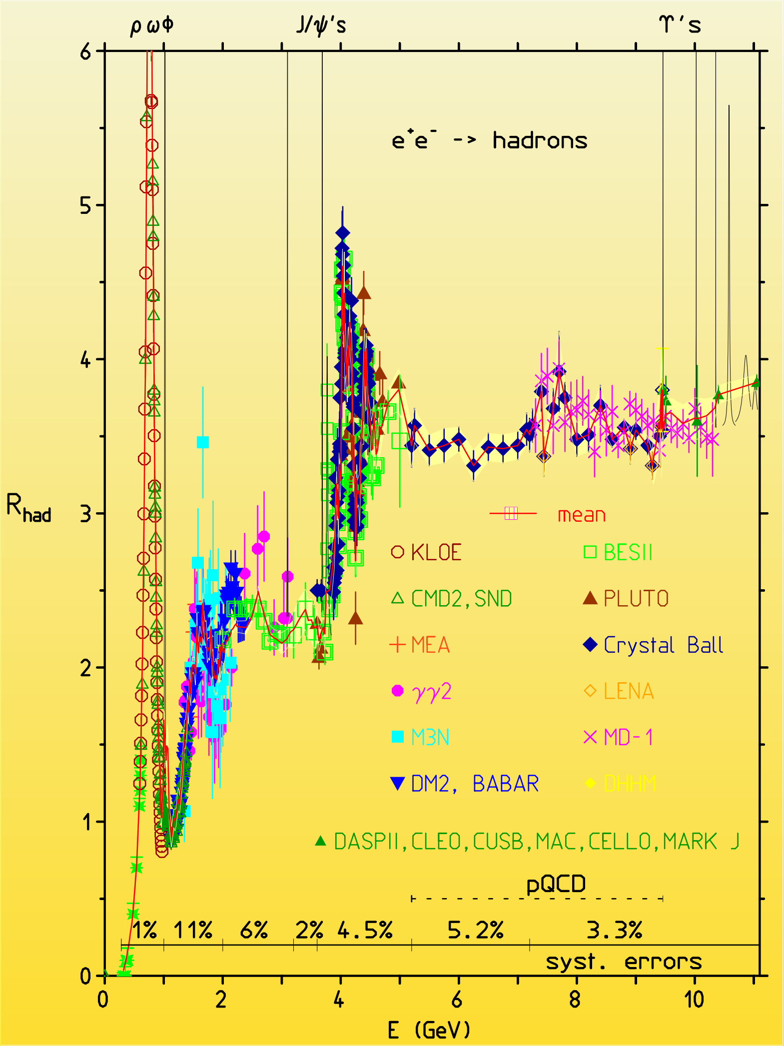
DAFNE-2 in conjunction with Adler function approach



Unique chance for DAFNE-2 to improve precision of $\alpha_{\rm eff}(E)$ substantially! In conjunction with improvement of QCD parameters (lattice QCD!). Mandatory for ILC project, but in many other places e.g. $g-2$ of the muon.


3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
R
1.40
1.60
1.80
2.00
2.20
2.40
2.60
E (GeV)
pQCD
two body
ave excl (inc. BaBar)
ave incl (exc. Bess)
all data

Physics of vacuum polarization ...



Compilation of a fairly complete collection of $e^+e^- \rightarrow \mathrm{hadrons}$ data in comparison with up-to-date pQCD predictions for $R(s)$. Only statistical errors of data points are shown. The uncertainty band of the theory is due to the uncertainties in QCD parameters (mainly α_s).

DAFNE-2 challenge

- rich and challenging physics program ahead
- key issues: $R(s)$ measurements inclusive vs exclusive
- two photon physics: urgently need more data to constrain $\pi^0 \to \gamma\gamma$ form-factor (present status BaBar vs CLOE/CELLO confusing)
- urgently need to investigate hadronic Final State Radiation mechanism
- one big advantage: $e^+e^- \to$ hadrons clean environment clear answers
- big chance to contribute substantially to precision physics: improving α_{eff}**!** If not a factor 5 a factor 2 is big progress already now! Example Higgs bound from $\sin^2\theta_{\mathrm{eff}}$ already now a big step forward! Allows to get more out from LEP data a posteriori!

Take the Chance, Do it!

Thank you for your Attention

Great Thanks for the kind invitation

Arrivederci, see you soon again!