Report on Flavianet Activities

UNIVERSITÄT BERN

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- Outline

What is Flavianet ?

Activities: New Physics searches

Activities: Predicting hadronic parameters

Conclusion

What is FlaviA net ?

A. European Research and Training Network

Marie Curie RTN within the FP6

Duration: 4 years (2006-2010)

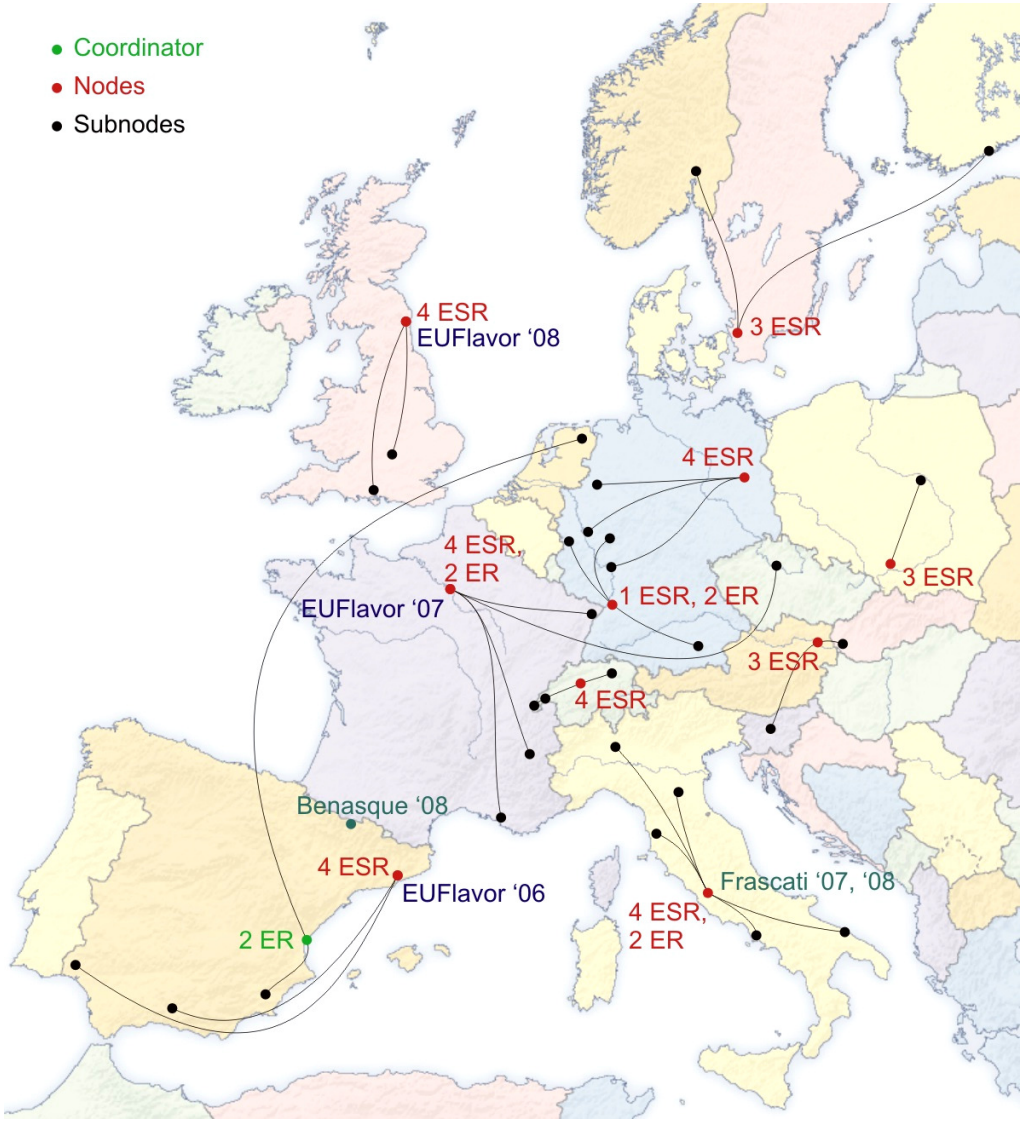
Over 45 institutes,
with ~ 215 particle physicists.

(http://ific.uv.es/flavianet/)

Predecessors:

1990's: EuroDaphne I & II
2000's: Euridice.

A. European Research and Training Network



Focus on *training !*

Research positions (total years):

- Early stage (ESR) : 34 years.
- Experienced (ER) : 8 years.

Network activities:

- Meetings,
- Schools,
- Inter-node visits,…

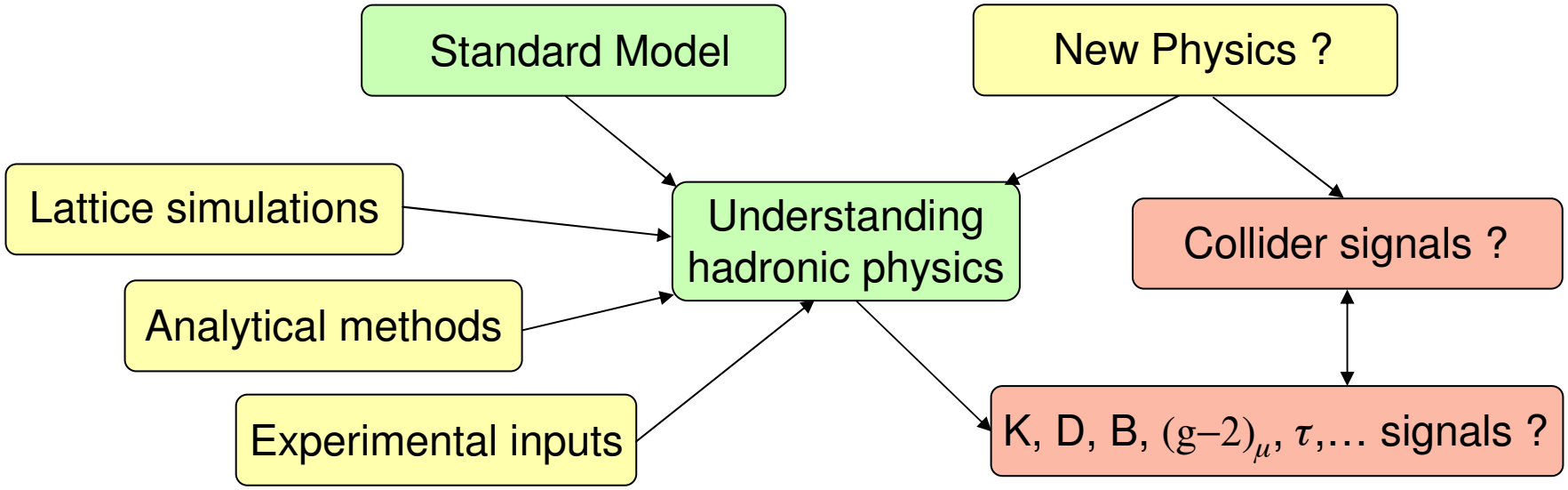
Outreach activities,…

B. Scientific Objectives

Entering the high-precision era of flavour physics through the alliance of lattice simulations, effective theories, and experiment.

Historically, related to the experimental program of Frascati, i.e. physics at the 1 GeV scale (see DaΦne Physics Handbook).

Extended to the broad issue/puzzle of *flavor physics in the SM and beyond*. This requires again an excellent control over the *hadronic physics*.



B. Scientific Objectives

Phenomenological approach, with both theoretical and experimental groups.

Organized in six working groups, based on *individual expertises*:

WG1 : Kaon physics (KTeV, *KLOE*, *NA48* / *NA62*, J-PARC, Project X?)

WG2 : Beauty physics (*Belle*, *BaBar*, Fermilab / *LHCb*, superB?)

WG3 : Tau, Charm and Quarkonia (Cleo, *Belle*, *BaBar*, Fermilab / *LHCb*, BES)

WG4 : Analytic approach to Non-Perturbative QCD, e.g. effective theories

WG5 : Lattice Methods

WG6 : Radiative Return and Monte Carlo tools

Working groups ↔ *scientific goals* ⇒ drives network collaborations and unity:

		K	B	τ,c	Eff. th.	Lattice	M.C.
SM strong sector	Meson-meson interactions	•			•		
	Strong chiral LEC's	•			•	•	
	m_q and α_S	•	•	•		•	
	Spectroscopy		•	•	•	•	•
	Light-cone distribution amplitudes		•		•	•	
	Vacuum polarization and (g-2)$_\mu$			•	•		•
SM electroweak sector	V_{us} from K and τ	•		•		•	•
	Weak chiral LEC's	•		•	•	•	
	Kaon matrix elements	•			•	•	
	D & B non-leptonic decays		•	•	•		•
	D & B semi-leptonic form-factors		•	•	•	•	•
	Monte Carlo generators	•	•	•			•
	Global assessment of CKM	•	•	•			
Physics beyond the SM	Rare K and B decays	•	•		•	•	
	b → s transitions		•		•	•	•
	τ and charm			•	•	•	•
	Supersymmetric GUT's		•			•	
	Alternatives to SUSY	•	•		•	•	
	Global CKM fits for New Physics	•	•	•			

C. Activities

Over 300 papers between Sept. 2006 and Sept. 2007, and probably as much since then.

The following review is neither complete in the activities, nor in the references!!!

Rather: some selected activities related to

- *New Physics searches,*

- *Predicting hadronic parameters : K, B,* α_S , $(g-2)_\mu$.

Essentially taken out from the Sept. 2007 report sent back to Brussels.

(available for download at the flavianet webpage http://ific.uv.es/flavianet/)

New Physics searches

A. The New Physics flavor puzzle

- Most New Physics (NP) models have either *new flavored particles*, or *new flavor-breaking interactions* between quarks and leptons.

  → *New contributions to FCNC's*!

- At the same time, there is *no signal of NP in low-energy experiments.*

  → Experiments ~ SM predictions

  → $\begin{cases} b \to s: \\ |V_{tb}^* V_{ts}| \sim \lambda^2 \end{cases}$ $\begin{cases} b \to d: \\ |V_{tb}^* V_{td}| \sim \lambda^3 \end{cases}$ $\boxed{\begin{cases} s \to d: \\ |V_{ts}^* V_{td}| \sim \lambda^5 \end{cases}}$

  Most constraining!

- New Physics cannot be *both light and generic*:

$$\mathcal{L}_{eff} = \frac{c_{bs}}{\Lambda^2}(\bar{b}\Gamma s)(\bar{\nu}\Gamma\nu) + \frac{c_{bd}}{\Lambda^2}(\bar{b}\Gamma d)(\bar{\nu}\Gamma\nu) + \boxed{\frac{c_{sd}}{\Lambda^2}(\bar{s}\Gamma d)(\bar{\nu}\Gamma\nu)} + \ldots$$

$c_{sd} \approx 1, \quad \Lambda \gtrsim 75\,\mathrm{TeV}$: NP very massive, beyond the reach of LHC,

$\Lambda \approx 1\,\mathrm{TeV}, \quad c_{sd} \lesssim V_{ts}^* V_{td}$: NP flavor structures highly non-generic.

FLAVOUR COUPLINGS

(→ decreasing SM contribution →)

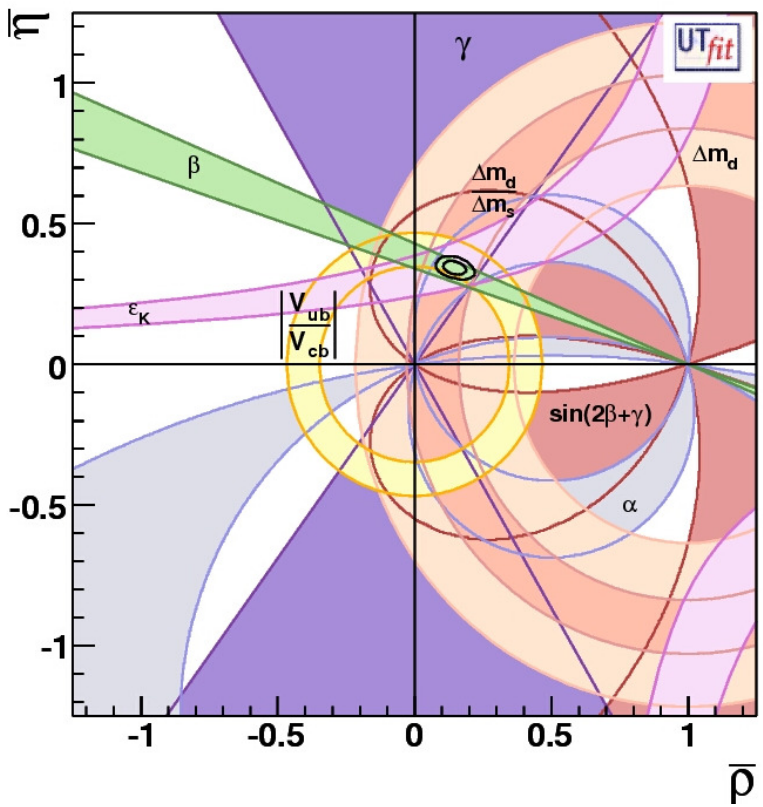
ELECTROWEAK STRUCTURE
(← decreasing SM contribution ←)

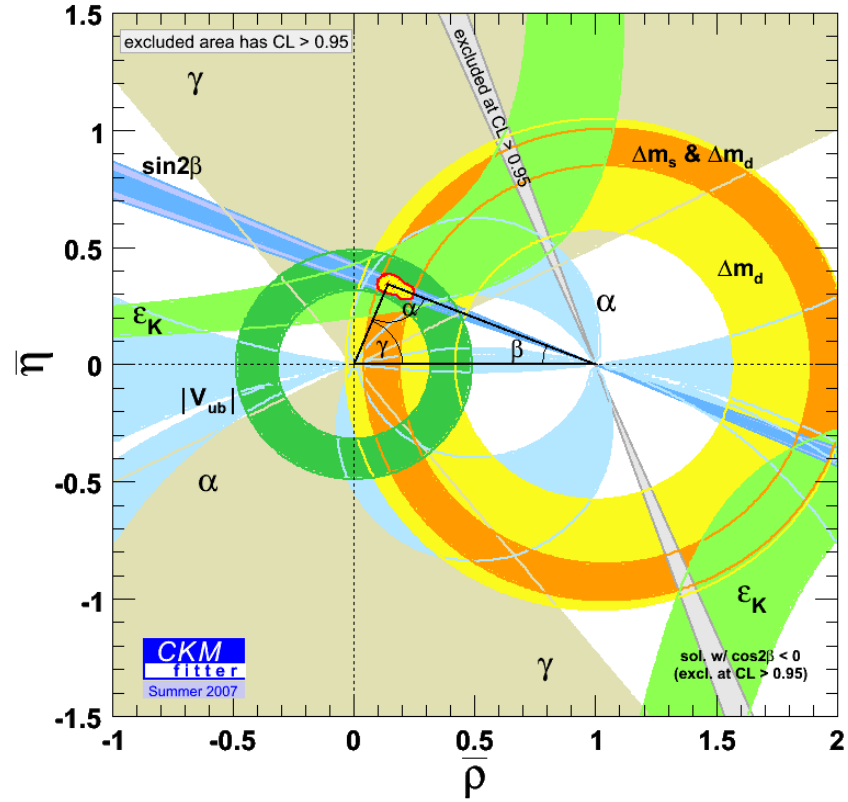
FCNC	$b \to s\ (\sim \lambda^2)$	$b \to d\ (\sim \lambda^3)$	$s \to d\ (\sim \lambda^5)$
$\Delta F = 2$	ΔM_{Bs} $A_{CP}(B_s \to \psi\phi)$	ΔM_{Bs} $A_{CP}(B_d \to \psi K)$	$\Delta M_K, \varepsilon_K$
$\Delta F = 1$ 4-quark	$B_d \to \phi K,\ \pi K, \ldots$	$B_d \to \pi\pi,\ \rho\pi, \ldots$	$\varepsilon'/\varepsilon,\ K \to \pi\pi\pi, \ldots$
gluon penguin	$B_d \to X_s\gamma,$ $B_d \to \phi K,\ \pi K, \ldots$	$B_d \to X_d\gamma,\ \pi\pi, \ldots$	$\varepsilon'/\varepsilon,$ $K_L \to \pi^0\ell^+\ell^-, \ldots$
γ penguin	$B_d \to X_s\gamma,\ X_s\ell^+\ell^-,$ $B_d \to \phi K,\ \pi K, \ldots$	$B_d \to X_d\ell^+\ell^-,$ $B_d \to X_d\gamma,\ \pi\pi, \ldots$	$\varepsilon'/\varepsilon,$ $K_L \to \pi^0\ell^+\ell^-, \ldots$
Z^0 penguin	$B_d \to X_s\ell^+\ell^-,$ $B_s \to \mu^+\mu^-,$ $B_d \to \phi K,\ \pi K, \ldots$	$B_d \to X_d\ell^+\ell^-,$ $B_d \to \mu^+\mu^-,$ $B_d \to \pi\pi, \ldots$	$\varepsilon'/\varepsilon,$ $K \to \pi\nu\bar{\nu}, \ldots$ $K_L \to \pi^0\ell^+\ell^-, \mu^+\mu^-$
H^0 penguin	$B_s \to \mu^+\mu^-$	$B_d \to \mu^+\mu^-$	$K_L \to \pi^0\ell^+\ell^-,$ $K_L \to \mu^+\mu^-$

Gino Isidori's table of FCNC observables

B. Global CKM fits and constraints on New Physics

Flavianet members contribute to CKMfitter and UTfit analyses:





Bayesian vs. frequentist? *Charles,Hocker,Lacker,Le Diberder,T'Jampens '06*

Hint of a large new physics phase in b → s transitions? *Bona et al. '08*

C. Bottom-up approach to the New Physics flavor puzzle

Minimal Flavor Violation: New Physics scale as in the SM.

$$\mathcal{L}_{eff} = \frac{c_{qq'}}{\Lambda^2}(\bar{q}\Gamma q')(\bar{\nu}\Gamma \nu) + \ldots \quad \text{with} \quad c_{qq'} \sim \left|V_{tq}^* V_{tq'}\right| \quad \Rightarrow \Lambda \leq 1\ \text{TeV}$$

"Constrained" MFV: No new phase, no new operator.

"Symmetric" MFV: Only the Yukawas can break the $SU(3)^5$ flavor-symmetry.

- MSSM at large $\tan\beta \equiv v_u / v_d$ — *Freitas,Gasser,Haisch '07*; *Isidori,Mescia,Paradisi,Temes '07*
- MSSM: UT fit in the B sector — *Altmannshofer,Buras,Guadagnoli '07*; *Altmannshofer,Buras,Guadagnoli,Wick '07*
- MSSM: running MFV — *Paradisi,Ratz,Schieren,Simonetto '07*
- MFV as an alternative to R-parity — *Nikolidakis,CS '07*
- Extra quarks: connection with LHC — *Grossman,Nir,Thaler,Volansky,Zupan '07*
- Generic: constraints from $Z \to b\bar{b}$,... — *Haisch,Weiler '07*
- Lepton sector & leptogenesis — *Cirigliano,De Simone,Isidori,Masina,Riotto '07*

....

D. Top-down approach to the New Physics flavor puzzle

Specific New Physics models: identifying interesting scenarios, and studying their impact on flavor physics, including their correlation with LHC observables.

Supersymmetry:
- Generic MSSM
- with MFV
- with large $\tan\beta$
- with RPV

(see e.g. Refs. on the previous slide)

Supersymmetric *GUT scenarios*

Dorsner,Fileviez Perez,Rodrigo '06

Cuichini,Masiero,Paradisi,Silvestrini,Vempati,Vives '07

Albrecht,Altmannshofer,Buras,Guadagnoli,Straub '07
Altmannshofer,Guadagnoli,Raby,Straub '08

Alternatives:
- *Little Higgs* — *Blanke,Buras,Recksiegel,Tarantino,Uhlig '07*; *Blanke,Buras,Recksiegel,Tarantino '08*
- *Higgsless* — *Bernard,Oertel,Passemar,Stern '07*; *Barbieri,Isidori,Rychkov,Trincherini '08*
- *Extra-dimensions* — *Davidson,Isidori,Uhlig '07, Haisch,Weiler '07*; *Colangelo,De Fazio,Ferrandes,Pham '06*
- *Unparticles* — *Zwicky '07, Freitas,Wyler '07*

....

Predicting hadronic parameters

A. Kaon physics and the QCD non-perturbative regime

Goal: V_{us} / Probe QCD at low-energy / Signal of New Physics
Tools: ChPT, OPE,… & Lattice
Data: KLOE, KTeV, NA48, and prepare for NA62, J-PARC, Project X ?

- $K \to \pi\nu\bar{\nu}$ for their NP sensitivity, but also: identify new opportunities!!!
  - *Other rare K decays* $K_L \to \pi^0 \ell^+ \ell^-$
  - *Leptonic and semi-leptonic* decays for V_{us} & universality,…
  - *Radiative* decays $K \to \pi\gamma\gamma$, $K \to \gamma^*\gamma^*$ for ΔM_K, $K_L \to \mu^+\mu^-$,…
  - *Forbidden* decays like $K \to (\pi)e\mu$ for LFV.

$\to$ See talk by E. Passemar

- *Chiral Perturbation Theory*:
  - *SU(2)-SU(3) at* p^6 — *Haefeli,Ivanov,Schmid,Ecker '07, Gasser,Haefeli,Ivanov,Schmid '07*
  - *Large* N_C — *Rosell,Sanz-Cillero,Pich '07, Portoles,Rosell,Ruiz-Femenia '07*
    Masjuan,Peris '07, Kampf,Novotny,Trnka '06
  - $\eta \to 3\pi$ — *Bijnens,Ghorbani '07*
  - $\gamma\gamma \to \pi\pi$ — *Gasser,Ivanov,Sainio '06, Oller,Roca,Schat '07,Pennington '07*

- *Lattice simulations*: Many activities! See report at http://ific.uv.es/flavianet/ .

B. Beauty physics

Goal: Unitary triangle & signals of New Physics

Tools: QCDf, SCET, HQET,… & Lattice

Data: BaBar, Belle, Cleo, Fermilab, and prepare for LHCb, superB ?

Semi-leptonic B decays (V_{ub}, V_{cb}, charged Higgs): *Albertus et al. '06, Ball '06, '07 De Fazio,Feldmann,Hurth '07 Flynn, Nieves '07, Nierste,Trine,Westhoff '08 Kamenik,Mescia '08, Duplancic et al. '08*

$b \to s\gamma$ and other rare B decays *Misiak et al. '06, Misiak,Steinhauser '06 Asatrian,Ewerth,Gabrielyan,Greub '06 Colangelo,De Fazio,Ferrandes,Pham '06*

$\Delta M_{d,s}$ *Lenz,Nierste '06, Becirevic,Fajfer,Kamenic '06, Ball '07 Grozin et al. '07, Della Morte et al. '07 Mannel,Pecjak,Pivovarov '07*

Hadronic decays *Descotes-Genon '07, Ciuchini,Pierini,Silvestrini '07 Zupan '07, Cavoto,Fleischer,Trabelsi,Zupan '07, Botella,Nebot '07 Baek,London,Matias,Virto '06, Descotes-Genon,Matias,Virto '07 Beneke,Rohre,Yang '06, Beneke,Jager '06 Fleischer,Recksiegel,Schwab '07*

SuperB physics case *Bona et al. '07, Browder,Gershon,Pirjol,Soni,Zupan '08*

C. The strong coupling constant

Goal: To improve the extraction of the least precisely known SM coupling
Tools: τ decays, quarkonia (NRQCD),…
Data: BES, Cleo, Belle, BaBar,…

Extraction of $\alpha_S(\mu)$ and value at M_Z:

- Υ(1S) decays : $\alpha_S(M_Z) = 0.119^{+0.006}_{-0.005}$ *Brambilla,Garcia i Tirmo, Soto,Vairo '07*

- $\sigma(e^+e^- \to hadrons)$: $\alpha_S(M_Z) = 0.119^{+0.009}_{-0.011}$ *Kuhn,Steinhauser,Teubner '07*
  $E < 10GeV$

- τ decays : $\alpha_S(M_Z) = 0.1180^{+0.0008}_{-0.0008}$ *Beneke,Jamin '08*

Running of $\alpha_S(M_Z)$ up to the GUT scale *Harlander,Jones,Kant,Mihaila,Steinhauser '06*
Harlander,Mihaila,Piclum,Steinhauser '07
Harlander,Mihaila,Steinhauser '07

Value of the *charm mass*: $m_c(m_c) = 1.286(13)\,GeV$ *Kuhn,Steinhauser,Sturm '07*

D. The muon anomalous moment

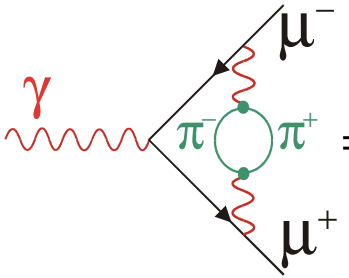
Goal: To precisely estimate the hadronic contributions to $(g-2)_\mu$, $\alpha_{em}(M_Z)$

Tools: ChPT, τ decays, Monte-Carlo,…

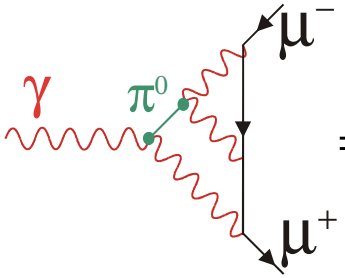
Data: KLOE, BaBar, Belle, Novosibirsk,…

Current: $a_\mu^{exp} - a_\mu^{th} = (28 \pm 9) \cdot 10^{-10} \ (\sim 3\sigma)$ *Hertzog,Miller,de Rafael,Roberts '07*

Hadronic contributions:



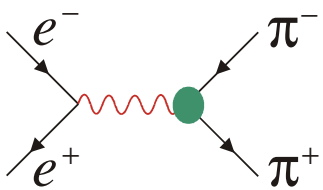
$= (692 \pm 6) \cdot 10^{-10}$

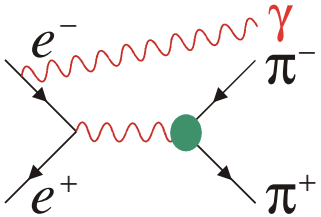


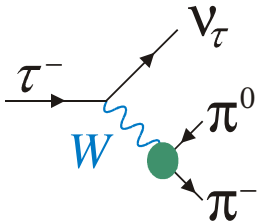
$= (11 \pm 4) \cdot 10^{-10}$

Bijnens,Prades '07

Vacuum polarization from energy scans, radiative return, or τ decays:







Radiative corrections: Phokhara, Tauola, Photos

Was '06, Rodrigo '07,Czyz,Grzelinska '07

Conclusion

Euroflavour 08

Annual meeting
& Mid-term Review
of FlaviA net network

September 22 - 26, 2008
Durham