How to bring the error of the VP contributions down and how the WG could contribute in this important task?

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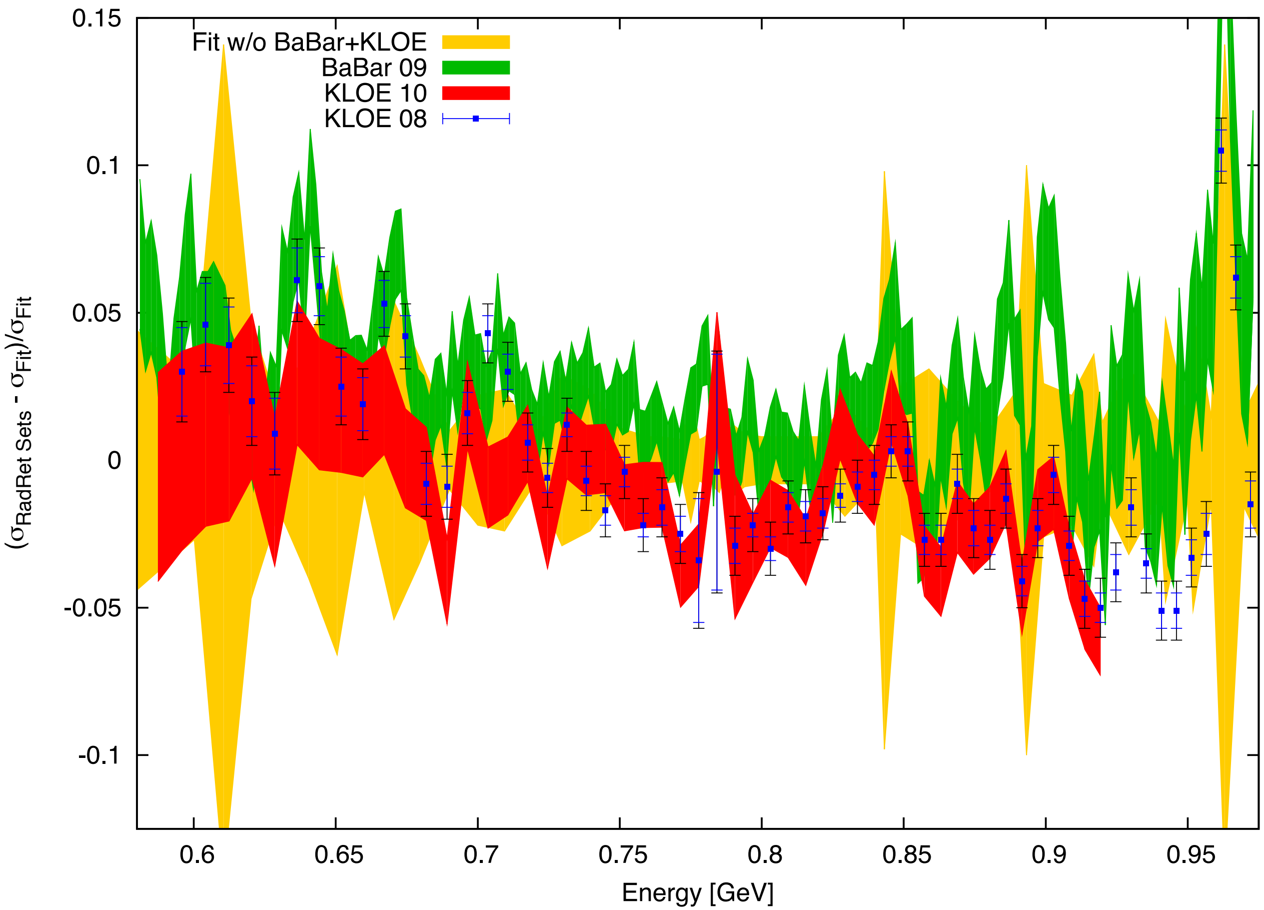
LIVERPOOL THEORETICAL PHYSICS

- The BIG differences in the ππ channel; HLMNT vs Benayoun et al
- Ways to solve the `BaBar puzzle'
- Other important contrib. Subleading channels. Inclusive analyses?
- Radiative corrections
- Less is more
- The role of our WG. Annotated database. Funding. Discussion

Data combination in the $\pi^+\pi^-$ channel

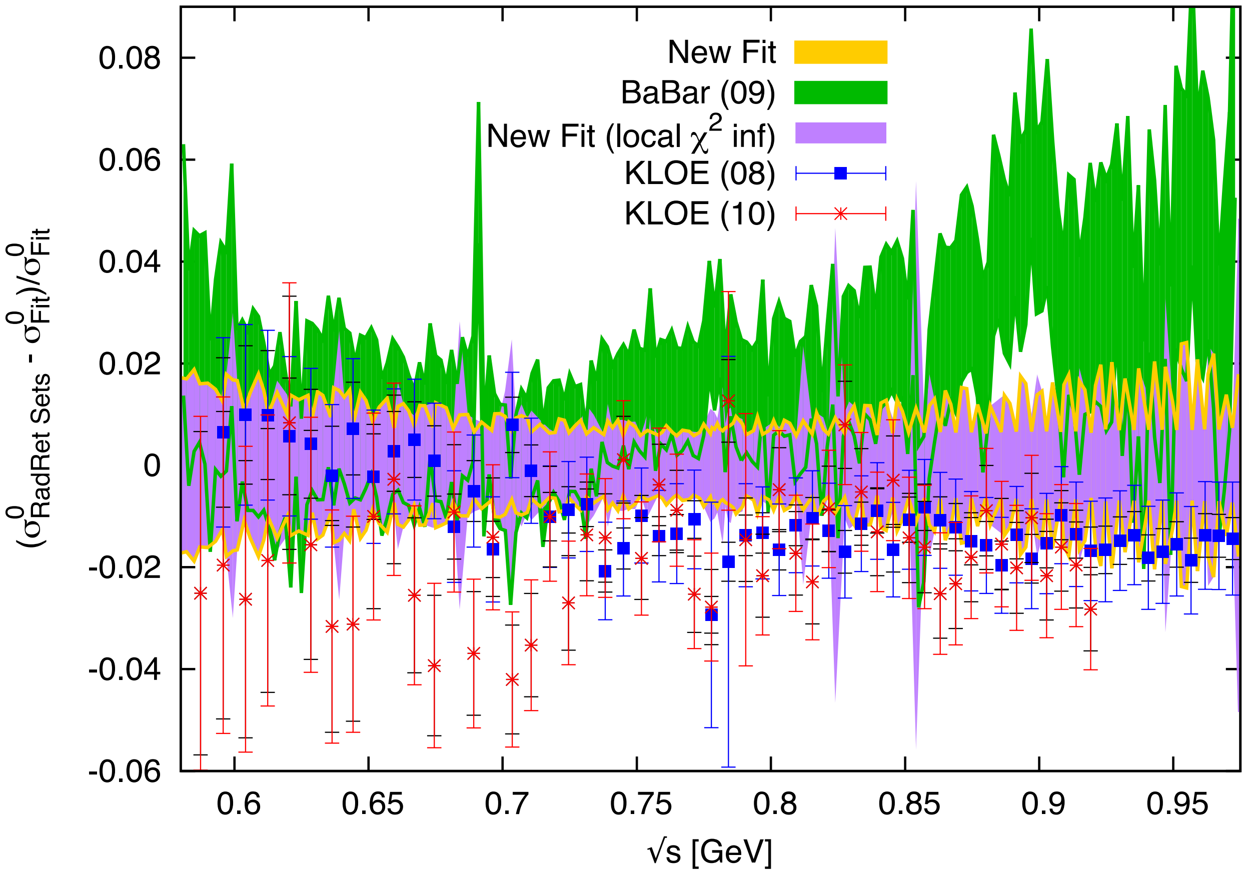
Radiative Return data compared to 2π fit w/out them



New KLOE12 data will add to this tension

Data combination in the $\pi^+\pi^-$ channel

Radiative Return data in the combined fit of HLMNT 11



2π fit: overall $\chi^2_{min}/\text{dof} \sim 1.5$

Note: $a_\mu^{\pi\pi,\ \text{w/out Rad Ret}} = 498.7 \pm 3.3$ BUT $a_\mu^{\pi\pi,\ \text{with Rad Ret}} = 504.2 \pm 3.0$

➔ i.e. a shift of +5.5

Data comb. in the $\pi^+\pi^-$ channel: Benayoun et al

HVP Results with scan & τ data

- (Updated) Central value shifted by ≈ 3 10^{-10}

Channel	Solution B	Direct Estimate
$\pi^+\pi^-$	495.40 ± 1.92	498.53 ± 3.73 (497.72 ± 2.12)
$\pi^0 \gamma$	4.61 ± 0.04	3.35 ± 0.11
$\eta \gamma$	0.64 ± 0.01	0.48 ± 0.01
$\eta' \gamma$	0.01 ± 0.00	---
$\pi^+ \pi^- \pi^0$	41.16 ± 0.59	43.24 ± 1.47
$K_L K_S$	11.90 ± 0.08	12.31 ± 0.33
K^+K^-	17.59 ± 0.21	17.88 ± 0.54
Total up to 1.05 GeV	571.30 ± 2.02	575.79 ± 4.06

Diff=3.1 units

Data comb. in the $\pi^+\pi^-$ channel: Benayoun et al

↓ another shift by -4.3

Channel	NSK +KLOE 10&12 + τ (ABC < 1 GeV)	scan only(NSK) + τ (ABC < 1GeV)	Direct Estimate
$\pi^+\pi^-$	491.12 ± 1.35	495.40 ± 1.92	498.53 ± 3.73 (497.72 ± 2.12)
$\pi^0\,\gamma$	4.63 ± 0.04	4.61 ± 0.04	3.35 ± 0.11
$\eta\,\gamma$	0.64 ± 0.01	0.64 ± 0.01	0.48 ± 0.01
$\eta'\,\gamma$	0.003 ± 0.000	0.003 ± 0.000	---
$\pi^+\,\pi^-\,\pi^0$	40.78 ± 0.64	41.16 ± 0.59	43.24 ± 1.47
$K_L\,K_S$	11.94 ± 0.08	11.90 ± 0.08	12.31 ± 0.33
K^+K^-	17.48 ± 0.21	17.59 ± 0.21	17.88 ± 0.54
Total up to 1.05 GeV	566.58 ± 1.50	571.30 ± 2.02	575.79 ± 4.06

Data combination in the $\pi^+\pi^-$ channel

- Benayoun et al: -3.1 from HLS-based fit, -4.3 from KLOE10+12
- HLMNT: +5.5 from KLOE and BaBar (compared to scan only)

- So the extreme difference ($\sim 13\times10^{-10}$) comes mostly from the data input, i.e. if BaBar's 2π is used or not.
  (If used: error relatively poor and inflated in addition.)

- How to solve this puzzle?

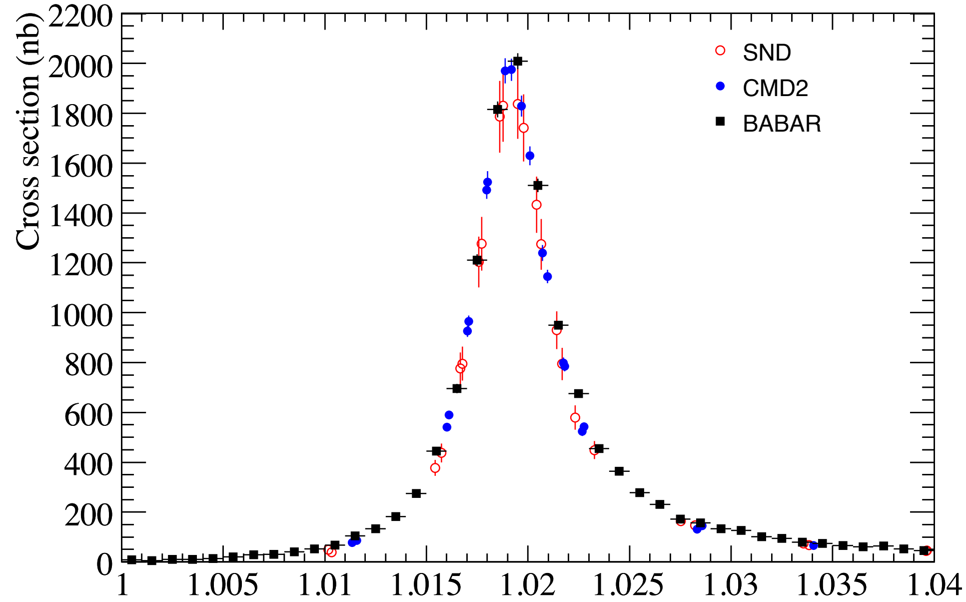
- Future SND, CMD-3, BELLE and BESIII 2π data may dilute the strong significance of BaBar.
  Would be better to find out why the diffferent data sets are not consistent. If this can be achieved the 2π channel would be great!

  ➔ possible task for our WG: MC checks, comparison of analyses

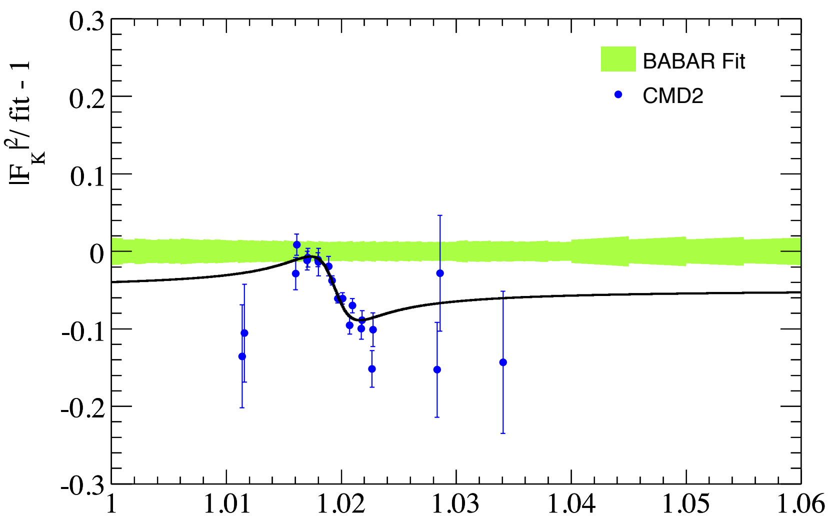
σ_{had}: some recent new data: $K^+K^-(\gamma)$ from BaBar

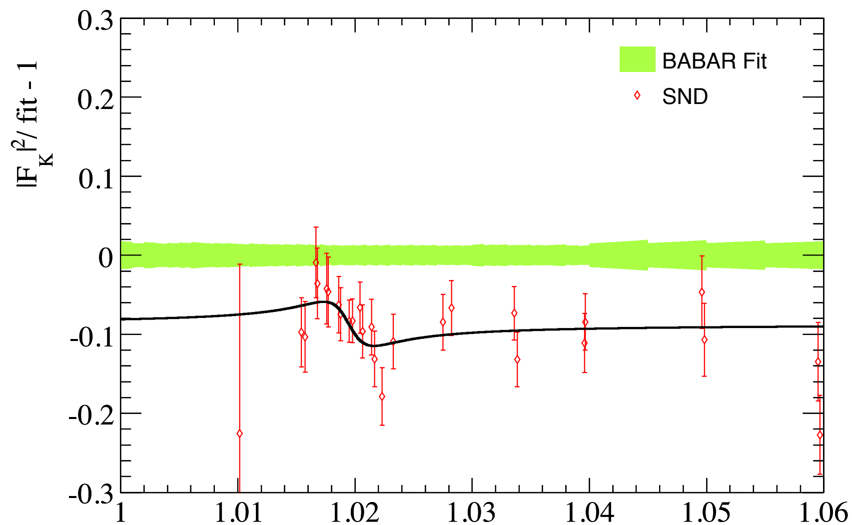
arXiv:1306.3600, see talk by E. Solodov

- $a_\mu = 22.94 \pm 0.18 \pm 0.22$ up to 1.8 GeV
  vs. $21.63 \pm 0.27 \pm 0.68$ for combined previous data
- significant shift up! Why?
- may need to take into account mass shift for best combination



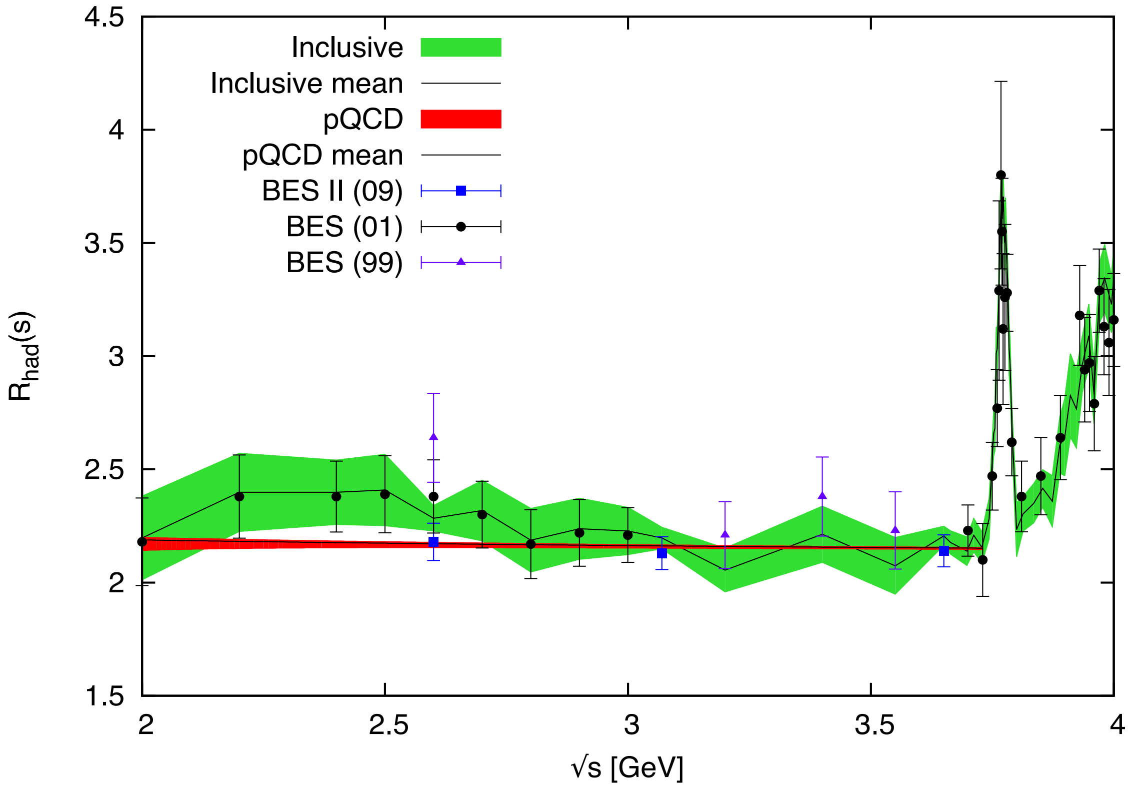
- Comp. plots BaBar vs Novosibirsk:





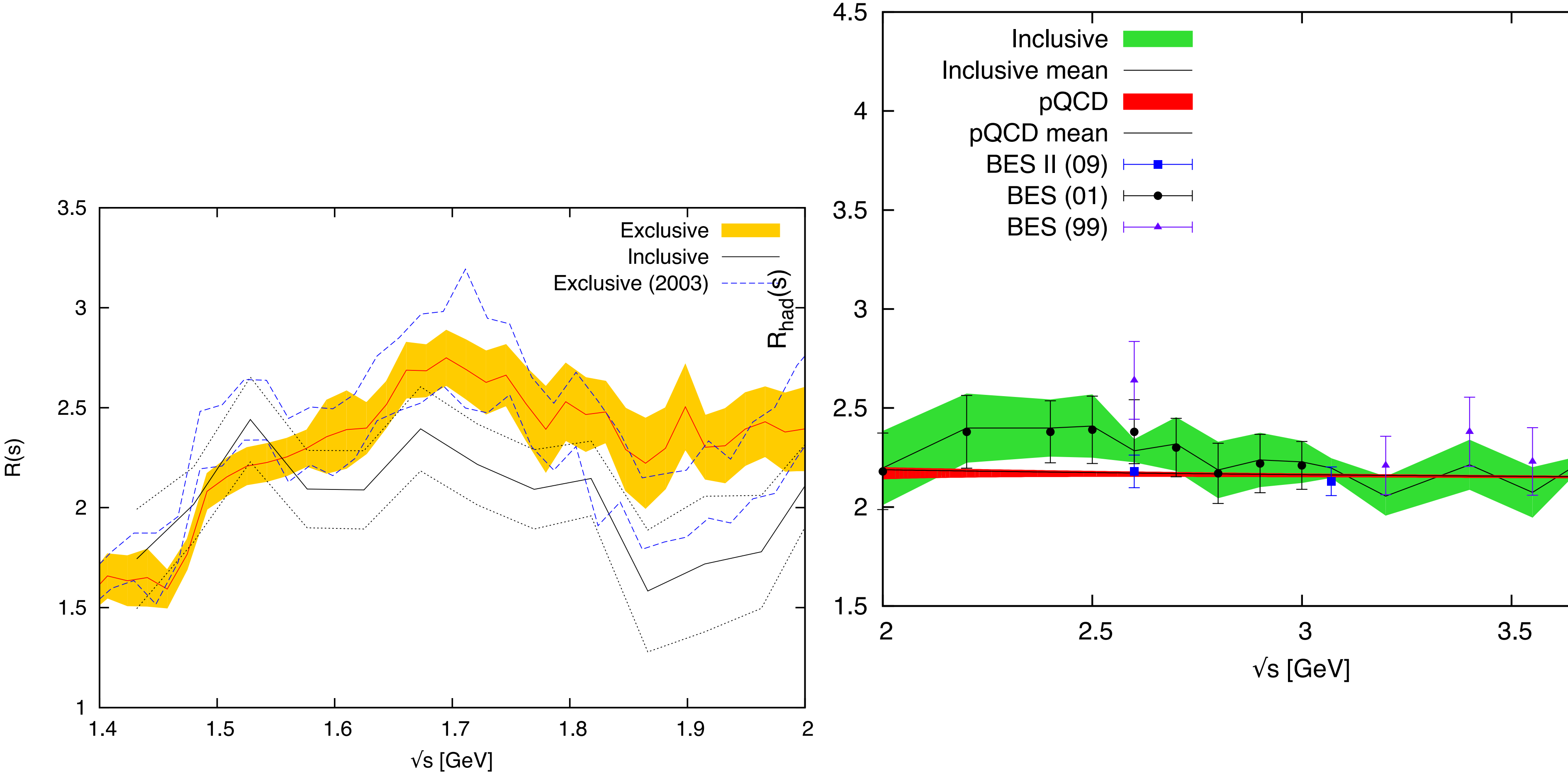
New data from BESIII eagerly awaited... 2011 status:

Perturbative QCD vs. inclusive data above 2 GeV (below the charm threshold)



- Latest BES data (blue markers) in perfect agreement with perturbative QCD; data slightly higher than pQCD for $\sqrt{s} > 2.6$ GeV
- HLMNT use pQCD for $2.6 < \sqrt{s} < 3.7$ GeV and with (larger) BES errors
  - would have small shift downwards ($\sim \mathbf{-1.4 \cdot 10^{-10}}$ for a_μ) if used from 2 GeV
  - Davier et al. use pQCD from 1.8 GeV

Inclusive vs. sum of exclusive, match to incl/pQCD



➔ small step at transiition from sum of exclusive to incl. (or pQCD), similar accuracy

Future incremental improvements with new data

Importance of various 'channels' [Numbers from HLMNT, 'local error infl.', $\cdot 10^{-10}$]

- Errors contributions to a_μ from leading and subleading channels (ordered) up to 2 GeV

Purely from data:

channel	error
$\pi^+\pi^-$	3.09
$\pi^+\pi^-\pi^0\pi^0$	1.26
3π	0.99
$2\pi^+2\pi^-$	0.47
K^+K^-	0.46
$2\pi^+2\pi^-2\pi^0$	0.24
$K_S^0K_L^0$	0.16

'Higher multiplicity' region from 1.4 to 2 GeV with use of isospin relations for some channels: [Use of old inclusive data disfavoured.]

Channel	contr. $\pm$ error
$K\bar{K}2\pi$	3.31 ± 0.58
$\pi^+\pi^-4\pi^0$	0.28 ± 0.28
$\eta\pi^+\pi^-$	0.98 ± 0.24
$K\bar{K}\pi$	2.77 ± 0.15
$2\pi^+2\pi^-\pi^0$	1.20 ± 0.10

- 'Inclusive' region from 2 to ~ 11 GeV: $\mathbf{41.19 \pm 0.82}$

  Can be 'squeezed' by using pQCD (done by DHMZ from 1.8 GeV);

  region from 2 to 2.6 GeV: $\mathbf{15.69 \pm 0.63} \ \rightarrow\ \mathbf{14.49 \pm 0.13}$, only small changes for higher energies.

Future incremental improvements with new data

- Many subleading channels also important (see tables):
  3π, $4\pi(2n)$, $KK\pi\pi$
- Sometimes asked which analyses would have most impact…
- Sadly there seems to be very limited manpower (another argument for trying to get funding), so should we try to guide what should be done with highest priority?

- Problem with region below 2 GeV:
  - (too?) many channels contribute
  - iso-spin relations not reliable for high precision

→ what are the prospects for new inclusive analyses?
Showstoppers?

Radiative corrections

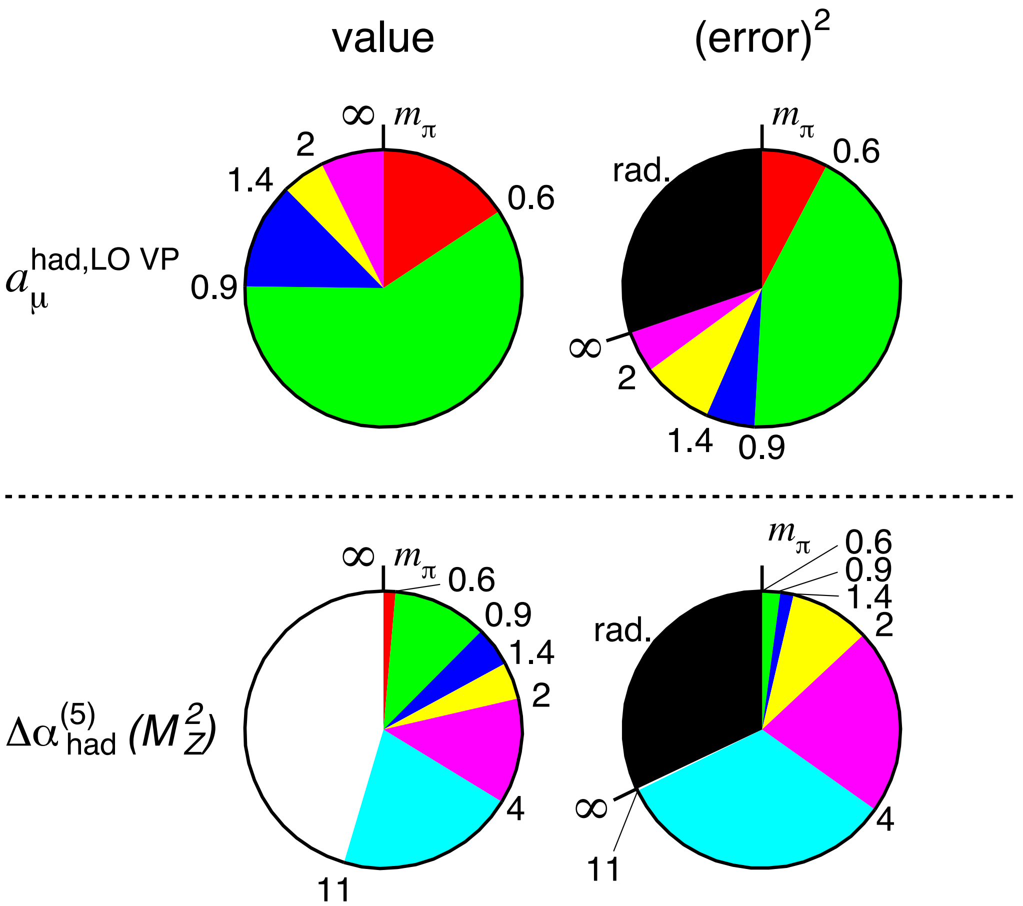
The black pieces are from

$\delta a_\mu^{\text{had, RadCor VP+FSR}} = 2 \times 10^{-10}$

the addional Radiative Correction error assigned due to uncertainties in the correct treatment of VP and FSR corrections

- VP: mostly relevant for older sets so will improve with time
- FSR: most probably too conservative in HLMNT (work has started for KK, collaboration of Exp and Th important)
- re-visit set by set, data-base?!

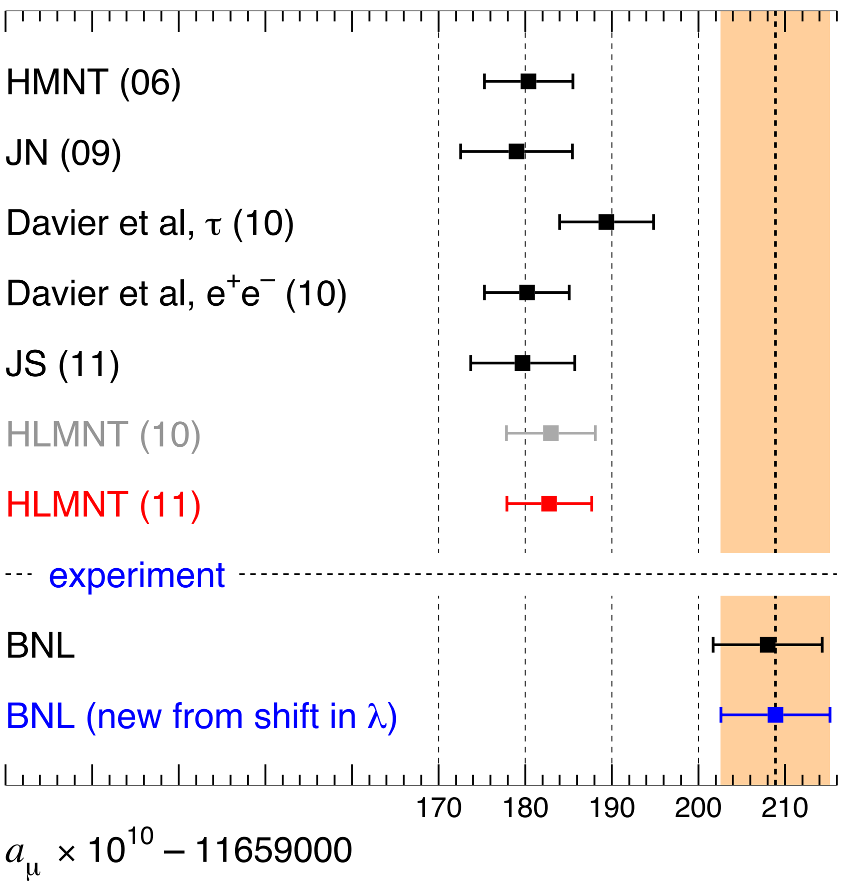
Pie diagrams from HLMNT 11:



Outlook/Discussion (more Qs than As)

- Can we get the required ~ or > factor 2 in HVP improvement?
  I believe we can, but the path may be thorny…
- Is there a way to agreement on the treatment/use of τ data?
- WG in the position to make a real impact, e.g.
  - help to settle the new 2π puzzle
  - build data-base for hadronic cross sections, with additional information w.r.t. Rad. Corrs., possible correlations, warnings, \`superseeds…' and similar
- Case for dropping old/unreliable sets (\`Less is more'):
  - can we make recommendations (based on hidden information and experience) w.r.t. to usability?
- All to go into database, which may be sited (technically) at IPPP Durham (connection to PDG)
- Dare to say: All this could be a major part of a new 2nd WGreport
- and certainly a strong point to be included in funding application.

Recent `history' plot. g-2 HVP numbers



$a_\mu^{HVP,\,LO}$ (10^{-10}):

- Fair agreement between different e^+e^- analyses, including recent updates:

HLMNT (11): 694.9 ± 3.7 (exp) ± 2.1 (rad)
Jegerlehner (11): 691.0 ± 4.7
Davier et al (11): 692.3 ± 4.2

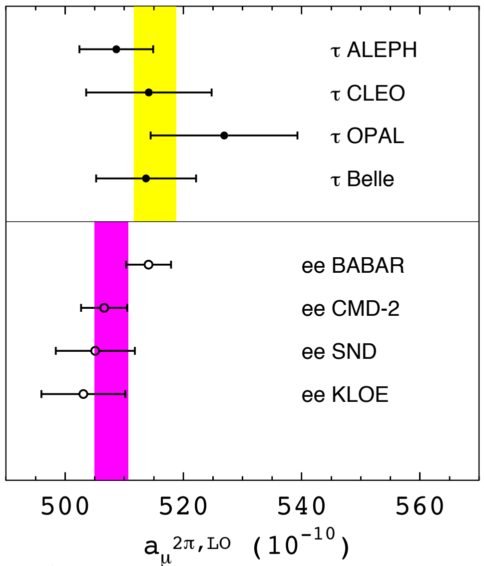
- The `extremes' (both with τ data):

Davier et al (11): 701.5 ± 4.7
Benayoun et al (12): 681.2 ± 4.5

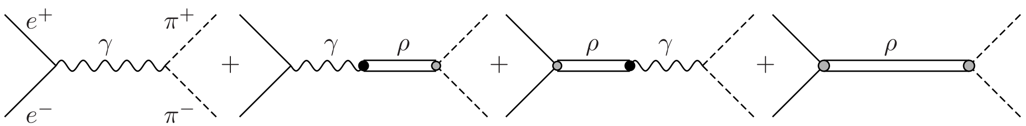
- New data available now will not shift the mean value strongly, but incrementally improve determination of a_μ^{HVP}

Another `puzzle': Use of tau spectral function data?

- Use CVC (iso-spin symmetry) to connect $\tau^- \to \pi^0\pi^-\nu_\tau$ spectral functions to $e^+e^- \to \omega, \rho \to \pi^+\pi^-$ but have to apply iso-spin corrections
- Early calculations by Alemany, Davier, Hoecker: use of τ data complementing e^+e^- data originally resulted in an improvement w.r.t. use of e^+e^- data alone; discrepancy smaller with tau data; later increased tension between e^+e^- and τ
- Recent compilation by Davier et al in BaBar's PRD86,032013:



- Jegerlehner+Szafron: crucial role of γ-ρ mixing:



- They found discrepancy gone but τ data improved e^+e^- analysis only marginally, however BaBar $\pi^+\pi^-$ data not used
- Analyses by Benayoun et al: combined fit of e^+e^- and τ based on Hidden Local Symmetry (HLS) (see talk by M Benayoun): no big tension betw. e^+e^- and τ but for BaBar e^+e^-, increased $\Delta a_{\mu:}$ of ~ 4.5σ
- Davier+Malaescu refute criticism, claim fair agreement betw. BaBar and their τ comp.
- HLMNT: stick to e^+e^- (do not use τ data). With e^+e^- (incl. BaBar) discrepancy of 3-3.5σ