Updates from the 8th Plenary Workshop of the Muon $g-2$ Theory Initiative (Orsay 2025)

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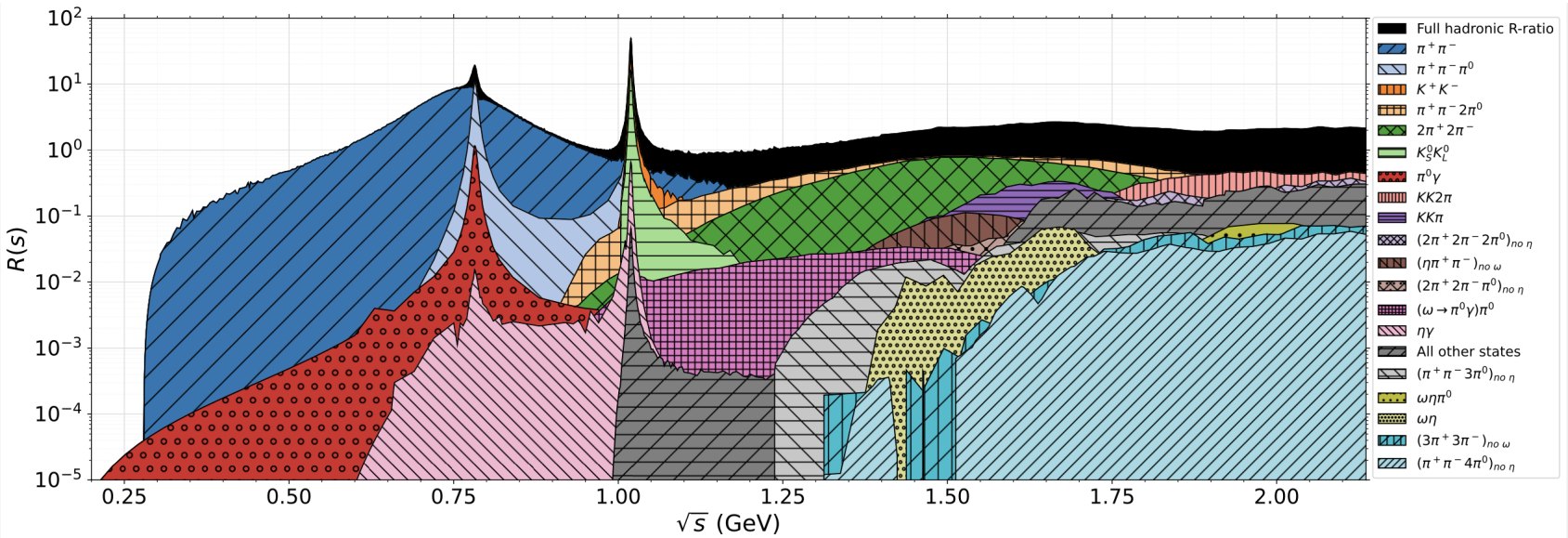
LEVERHULME TRUST



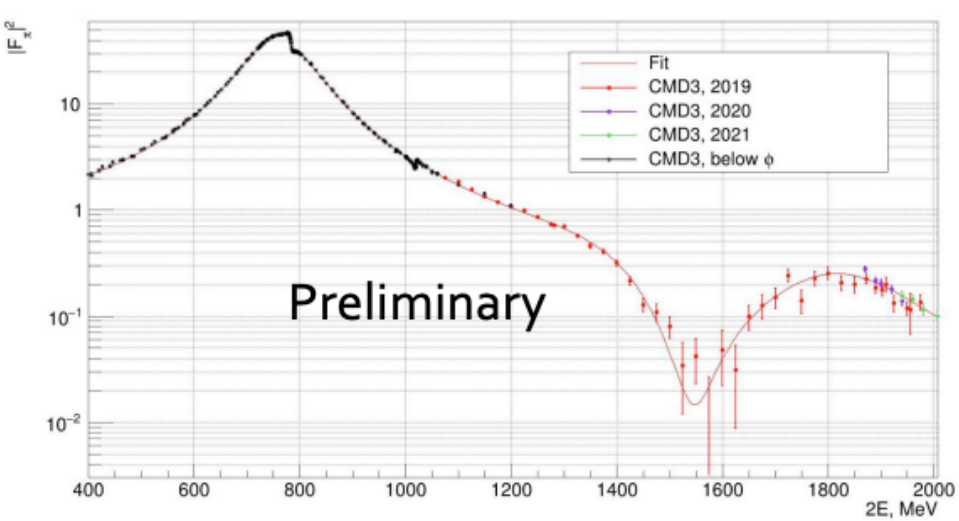
Disclaimer

- This presentation focuses on what I prioritised, presuming it to be interesting to the group (and had my own detailed notes on).
- Covered in detail:
  - Updated experimental measurements and collaboration plans.
  - Dispersive $g-2$ updates.
- Covered in less detail:
  - Developments concerning τ data.
  - Lattice HVP.
  - HLbL – lattice and dispersive.

Apologies!

CMD-3

- Presently no $\pi^+\pi^-$ updates. Working on > 1 GeV at 0.8% $\rightarrow$ 7%.
- No complete CMD-2/3 difference explanation.
- At > 1 fb^{-1}, plan more scans below 1 GeV (down to ~ 0.4 GeV).
- Planned upgrade to measure $\sigma[\pi^+\pi^-]$ to FNAL precision.



E. Solodov - 8th Plenary Workshop of the Muon $g-2$ TI

BESIII

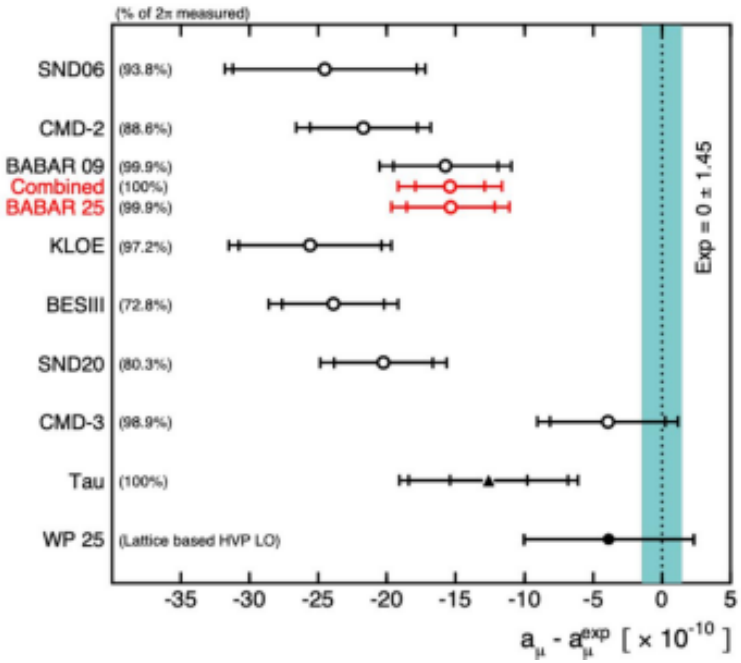
- ISR study for 0.3 $\rightarrow$ 1 GeV $\pi^+\pi^-$.
- Expected 0.5% precision.
- Blinded analysis on $\psi(3770)$ and $D_s\overline{D}_s^*$ datasets.
- Also measuring $R < 2$ GeV and on charm.

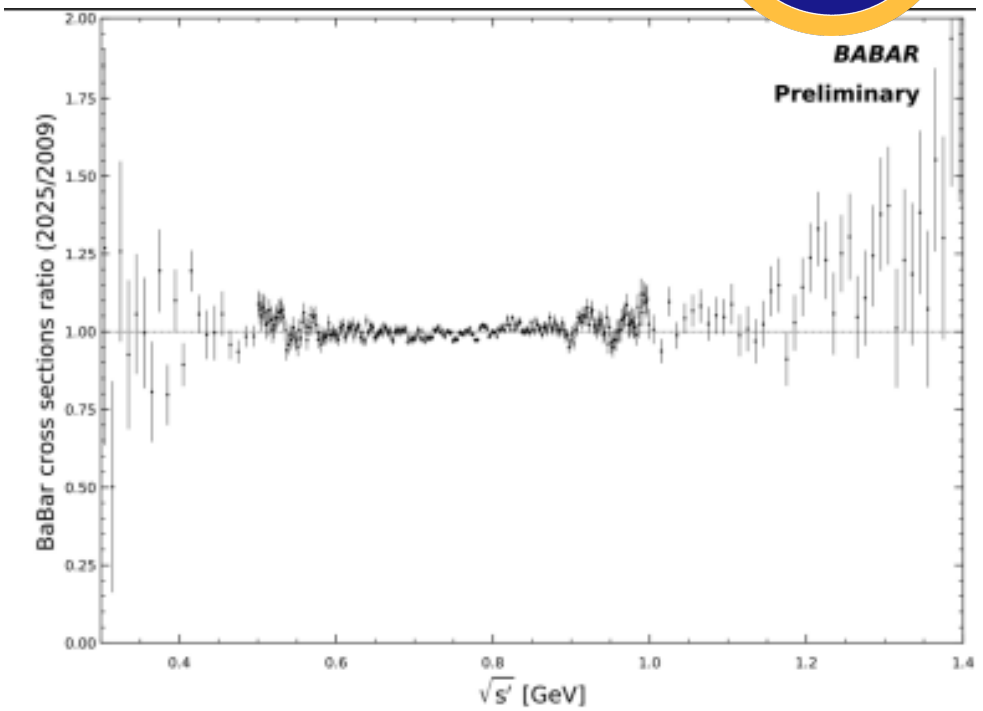
Belle II

- Targeting 0.5% $\pi^+\pi^-$ on 427 fb^{-1}.
- Successfully sanity checked (reasonable data-MC agreement on subsample).
- Potentially within 2 years?

BaBar

- Used full 460 fb^{-1} dataset.
- Entirely new method – angular fit on $\cos\theta^*$; angle between π^- and ISR γ. Looser track cut.
- Used PHOKHARA rather than AfkQED.
- Blinded analysis.
- Phenomenal agreement with BaBar09. Average in preparation.





Energy range [GeV]	2025 ($a_\mu^{\pi\pi} \pm \text{stat} \pm \text{syst}$ [10^{-10}])	2009 ($a_\mu^{\pi\pi} \pm \text{stat} \pm \text{syst}$ [10^{-10}])
Below 0.5	$58.0 \pm 5.5 \pm 1.7$	$57.6 \pm 0.6 \pm 0.6$
0.5 – 1.4	$456.2 \pm 2.2 \pm 1.7$	$455.6 \pm 2.1 \pm 2.6$

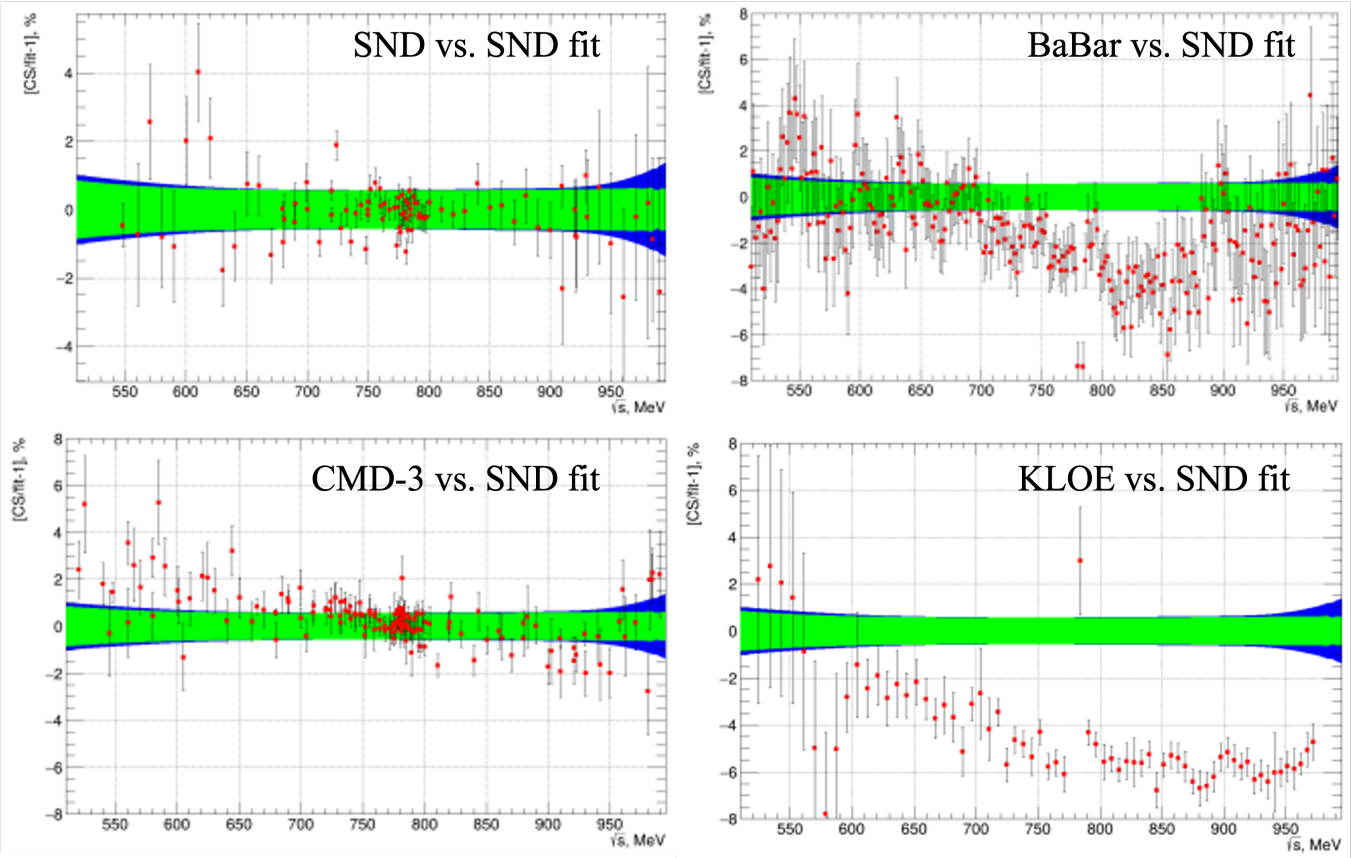
Energy range [GeV]	2025–2009 average (preliminary) $a_\mu^{\pi\pi}$ [10^{-10}]
Below 0.5	58.2 ± 0.8
0.5 – 1.4	455.9 ± 2.1
Below 1.4	514.1 ± 2.5
Below 1.8 (1.4 – 1.8 from 2009)	514.4 ± 2.5

A. Pinto - 8th Plenary Workshop of the Muon $g-2$ TI

SND

- Unknown $2 \to 3\%$ effect in SND20 dataset $\implies$ superseded.
- New (blinded?) dataset at $\sim 0.7\%$ precision.

- **Higher** than SND20.
- Comparable to CMD-3 ($\sim 0.5\sigma$).
- Consistently above BaBar on ρ-peak ($\sim 2\sigma$).



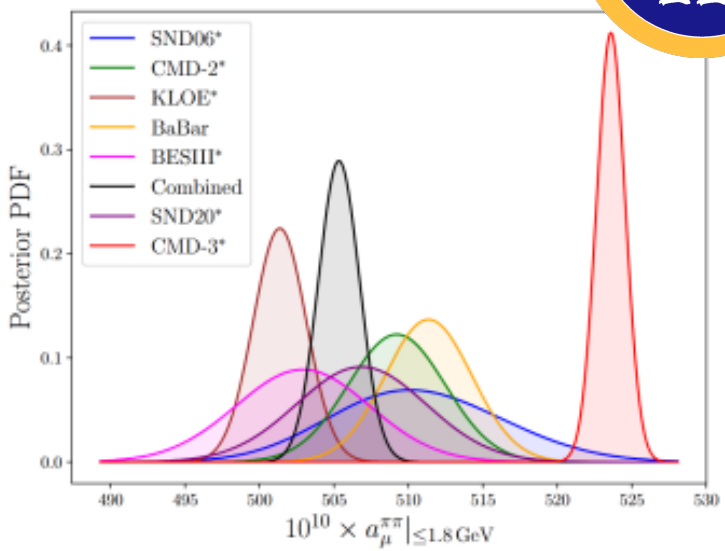
CHKLS Recent Work

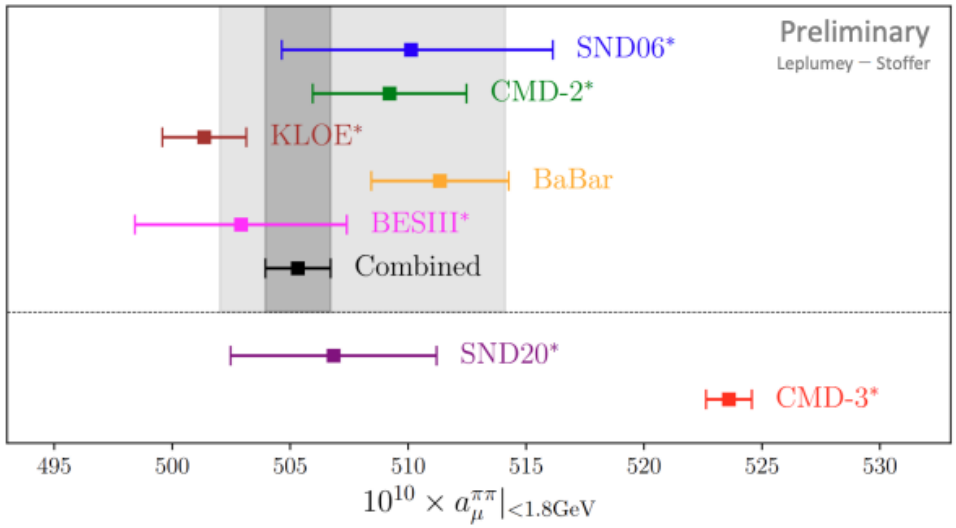
$$F_\pi^V(s) = \underbrace{\Omega_1^1(s)}_{\text{2 param.s}} \times \underbrace{G_{\omega(\phi)}(s)}_{\text{3(6) param.s}} \times G_{\text{in}}(s)$$

- Improved inelastic function:

$$G_{\text{in}}(z) = \frac{1}{\phi(z)} \frac{P_N(z)}{\prod_j (z - z_j)(z - z_j^*)}$$

  for OF $\phi(s)$, polynomial P_N and poles s_j.
- Bayesian parameter interference for improved fitting.
- **Exacerbated** CMD-3 tension.
- Strong correlation of lattice windows $\implies$ further issues with hybrid.
- Discussion of 'most conservative' use of systematics in CHKLS framework.

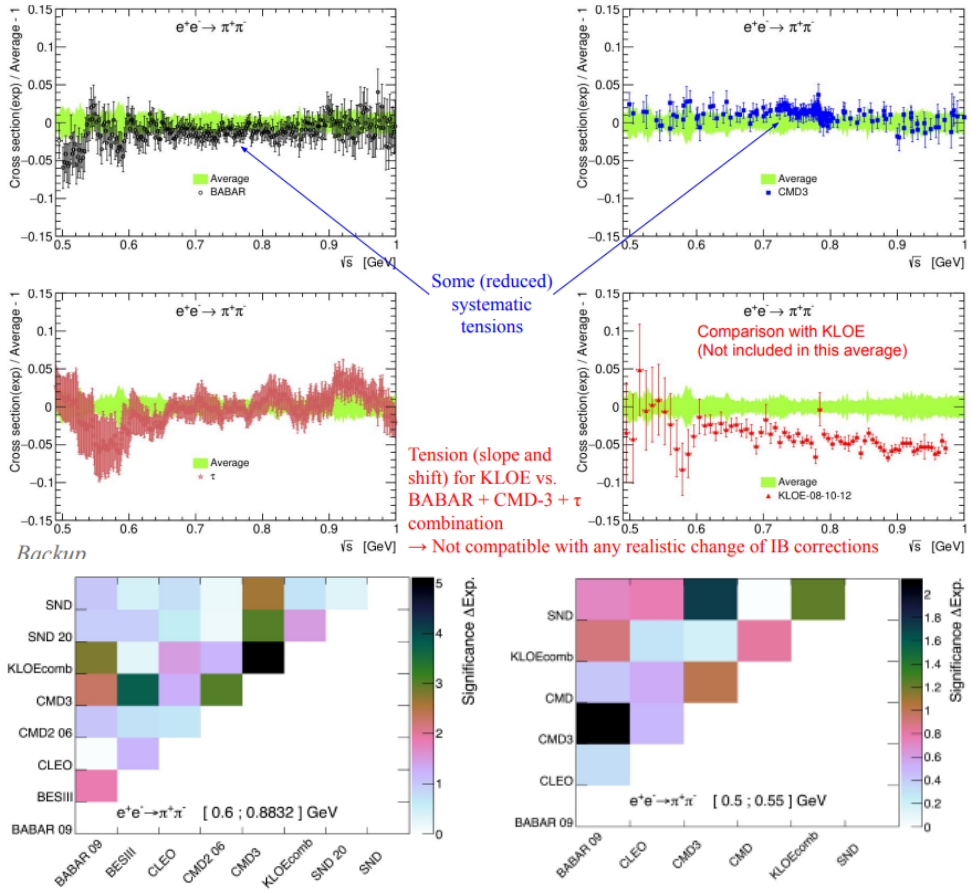




T. Leplumey - 8th Plenary Workshop of the Muon $g-2$ TI

DHMZ Recent Work

- Significant effort to better understand tensions.
- Data from τ, BaBar and CMD-3:
  - Had proposed combinations based on these data.
  - Prior to interference concern, agreement was quite good...
- **Volodymyr Biloshystkyi et al.:**
  - Work on HVPγ (FSR) dispersive-lattice comparisons.
  - Found considerable interference terms for 'dispersive diagram interpretation' - necessary for comparisons.
  - **Significant** implications for τ IBCs.
- Local tensions assessment:
  - Measurements exhibit different levels of tension in different regions.
  - Most significant tensions are on and above ρ peak.
  - Datasets are compatible at low energies.



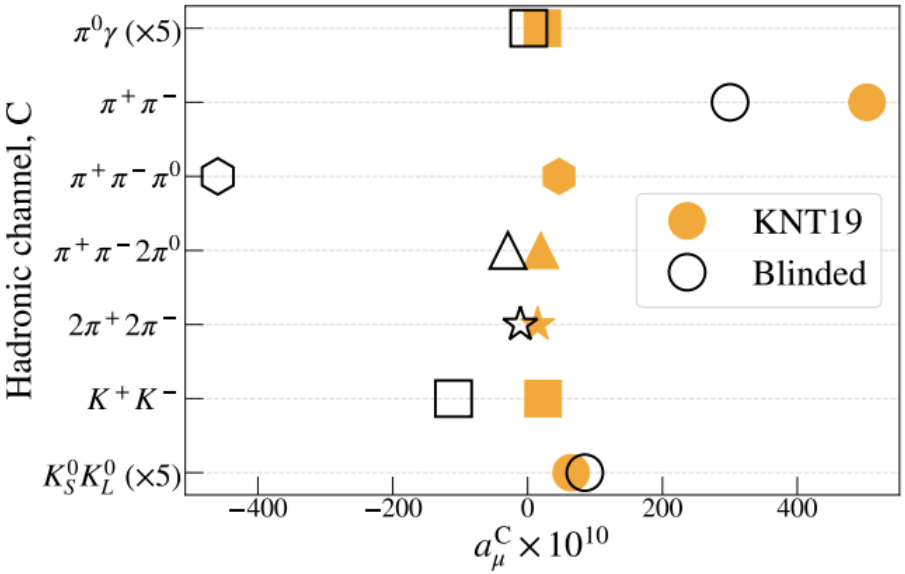
B. Malaescu - 8th Plenary Workshop of the Muon $g-2$ TI

KNTW Recent Work

Blinded New Analysis

- KNTW-DHMZ difference $\Longrightarrow$ analysis choices influence central value.
- Current tensions $\Longrightarrow$ need to be certain making best analysis choices.
- KNTW new analysis: mitigate/quantify any biases from analysis choices.
- Certainty of optimal choices: blind with

$$a_\mu^{\text{blind}}[i] = \frac{1}{4\pi^3}\int_{s_{th}}^{\infty} ds\left\{\sigma_i^0(s)K_\mu(s)\,B_i(s)\right\}$$



"Re-Baselining"

- (*Minor*) KNT19 corrections.
- 'Completions' of KNT19 analysis.
- KNT19 method systematics estimated.

FSR Studies

- Revisited $K\bar{K}$ - confident in KNT19 conclusions for scan experiments.
- Looking at 3π with input of MH.
- New inclusive channel FSR – $\sim 20\%$ reduction in error on $\Delta\alpha^{(5)}_{\text{had.}}$.
- Moving onto 2π soon...

Correlation Study

- Highly relevant analysis choice – use of systematic correlations.
- Study to quantify additional systematic $\Longrightarrow$ small effect.
- Favouring KLOE vs BaBar in 2020 combination down to BaBar statistics.

Lattice QCD/Hadronic Light by Light/Other

Lattice QCD

- Groups looking in more detail at isospin-breaking and long-distance contributions.
- Typically aiming for $\sim 0.5\%$ precision.
- Cross checks at different scales/in different schemes.
- Hybrids:
  - BMW/DMZ going ahead with hybrid - very low energy dispersive data used to supplement lattice long distance.
  - Hybrid ultimately seems likely to optimise precision at next WP.
  - However, tensions still need to be tamed.
- Also looking at R-ratio, NLO.

Hadronic Light by Light

- Good agreement between dispersive and lattice HLbL.
- Lattice systematically higher, potentially due to tensor and excited states.
  - These tensor parts still need to be calculated dispersively; methods suffer from ambiguities or missing processes.
  - Lattice focusing on a sign discrepancy of $\pi^0 \to \gamma\gamma$ disconnected, working on other small improvements.
- Aiming for more detailed lattice/dispersive comparisons.

Other

- Improved pQCD below charm: duality violations $\implies$ better agreement with low $\sqrt{s}$ data.
- BESIII individually discrepant but not overly influential in combination.

Theory Initiative Next Steps

- Focus groups/task forces being set up.
  - Thorough cross examination of new major cross section measurements (c.f. CMD-3 $\pi^+\pi^-$).
  - Use of systematic uncertainties/correlations.
  - Tau isospin breaking corrections.
  - Work with RadioMonteCarLow2.
  - Improved dispersive/lattice HLbL combination.
- Conflict resolution procedures brought in - Steering Committee will resolve conflicts if all else fails.
- Open letter to support JPARC $g-2$ (& reinforce WP25 conclusions about next steps).