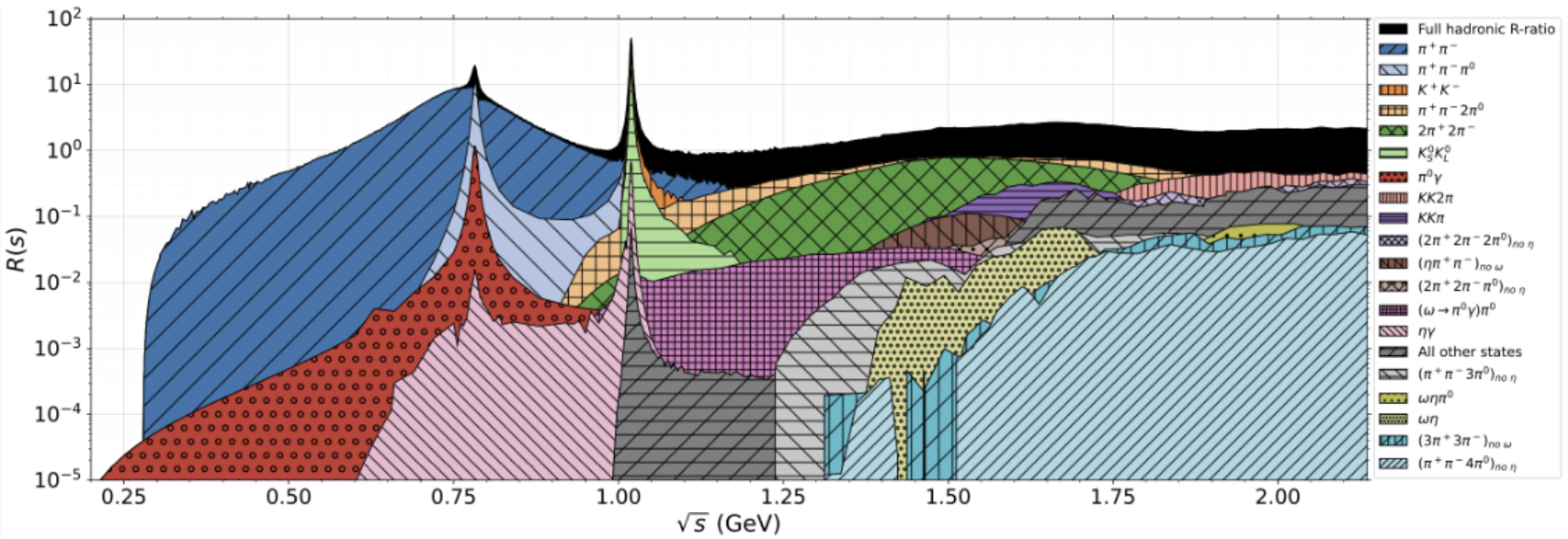
Flash Talk - Updates to the KNTW Combination

Aidan Wright

Science and Technology Facilities Council

LIVERPOOL THEORETICAL PHYSICS

LEVERHULME TRUST



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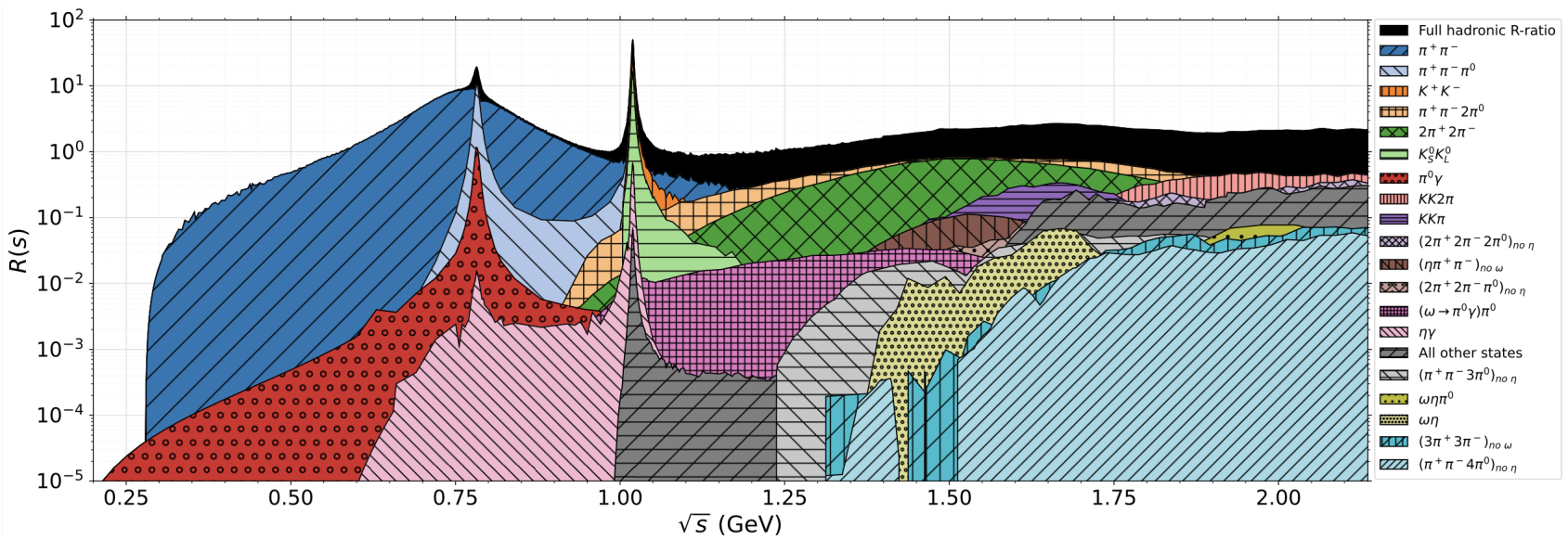
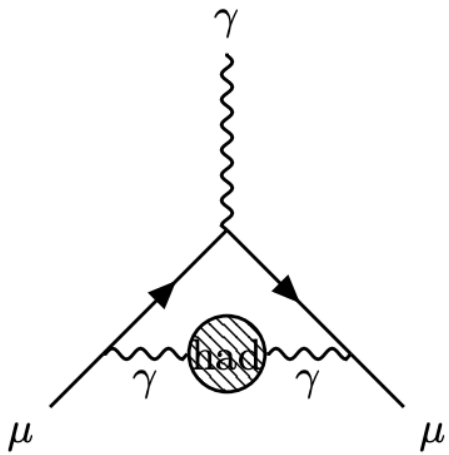
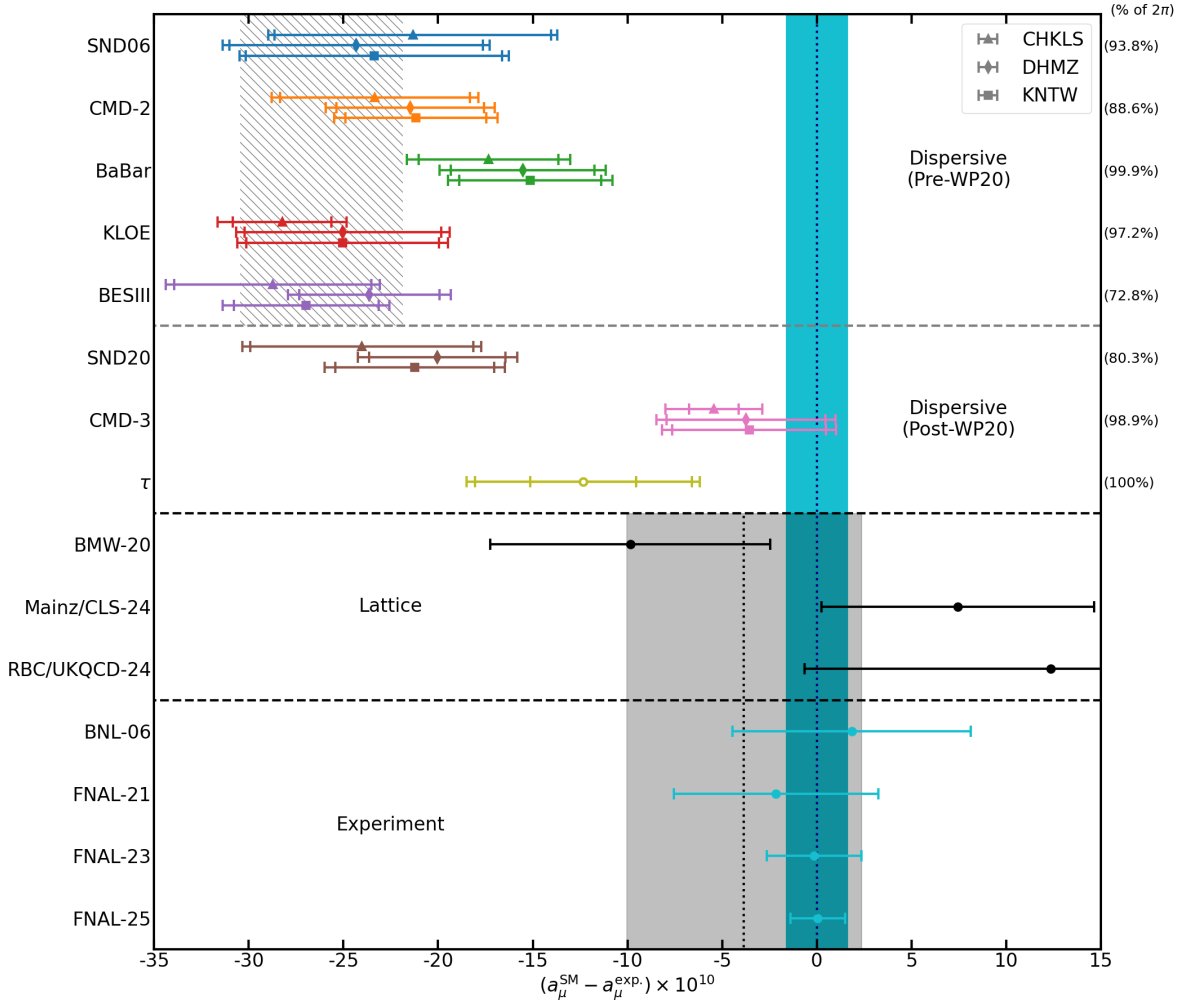


The Muon Anomalous Magnetic Moment



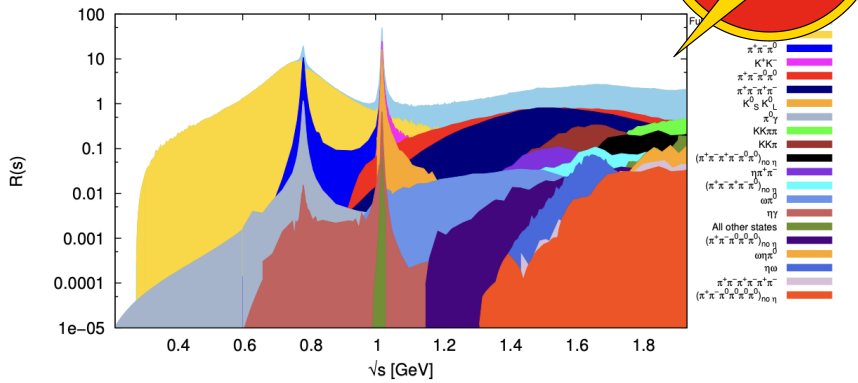
- Dispersive approach to a_μ^{HVP} - input experimental cross sections to dispersion integral.
- Significant unexplained tensions exist.
- Thorough new analysis $\Longrightarrow$ value that reflects full dispersive picture...

$$a_\mu^{\text{HVP}} = \frac{1}{4\pi^3}\int_{s_{th}}^{\infty} ds\left\{\sigma^0(s)K_\mu(s)\right\}$$

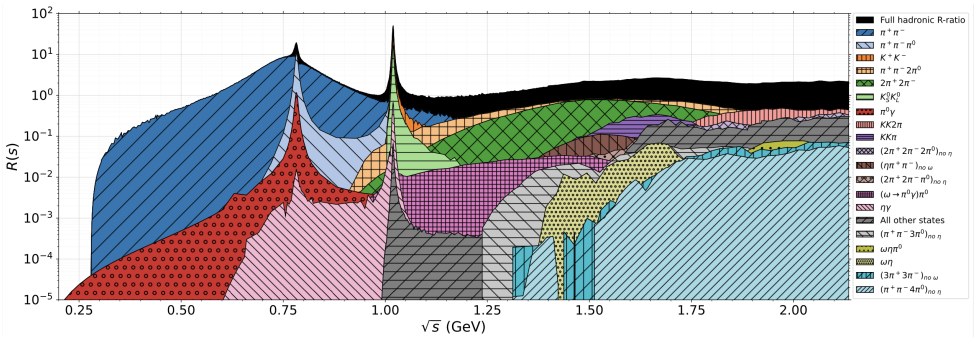


KNTW (and Code Rewrite) [10/23 - 11/24]

- Three dispersive HVP analysis groups:
  - **CHKLS** - Dispersive (model indep.) fits in $2, 3\pi, 2K$ + radiative.
  - **DHMZ** - All channels combinations; central values from spline averaging using local correlations.
  - **KNTW** - ...
- KNTW - maximally data driven, minimal modelling:
  - All non-defective data used.
  - Radiative corrections from robust routines + FsQED.
  - Clustering - dynamic data-driven combination.
  - Fitting - incorporate **full** correlation information whilst avoiding bias.
  - Integration for $a_{\mu,e,\tau}^{\text{HVP, LO+NLO}}$, $\Delta\alpha_{\text{had.}}^{(5)}(M_Z^2)$, VP routine, etc.
- This talk/my PhD: updates and improvements...



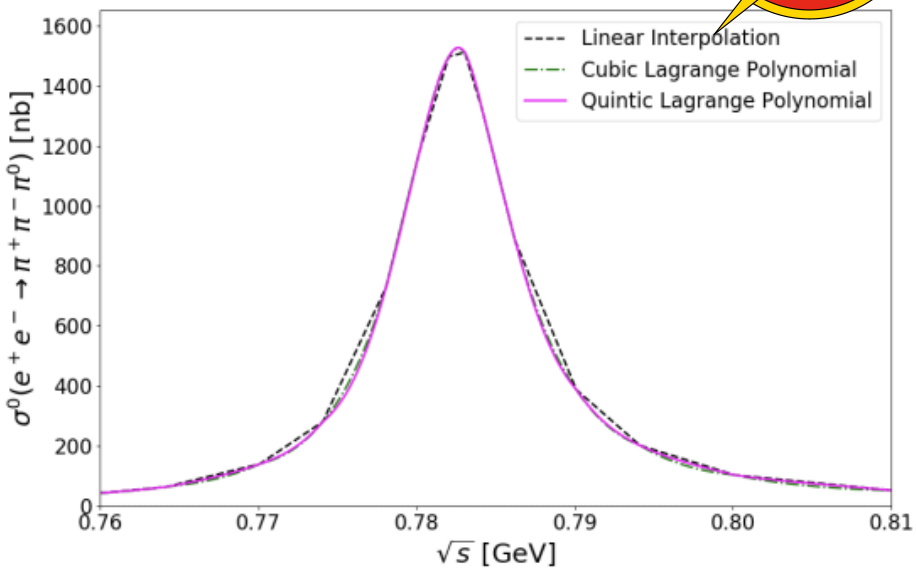
- Code rewrite `FORTRAN` $\rightarrow$ `Python`.
- 'Database' `.txts` $\rightarrow$ `SQLite`.
- Very minor bug fixes.
- Code still runs < 1 minute.



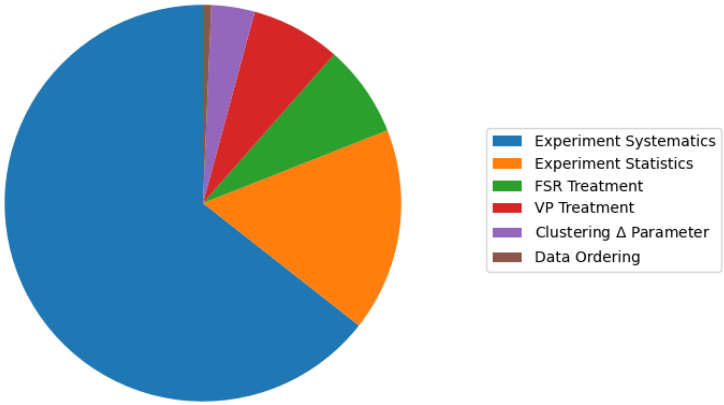
KNTW Re-Baselining [07/24 - 05/25]

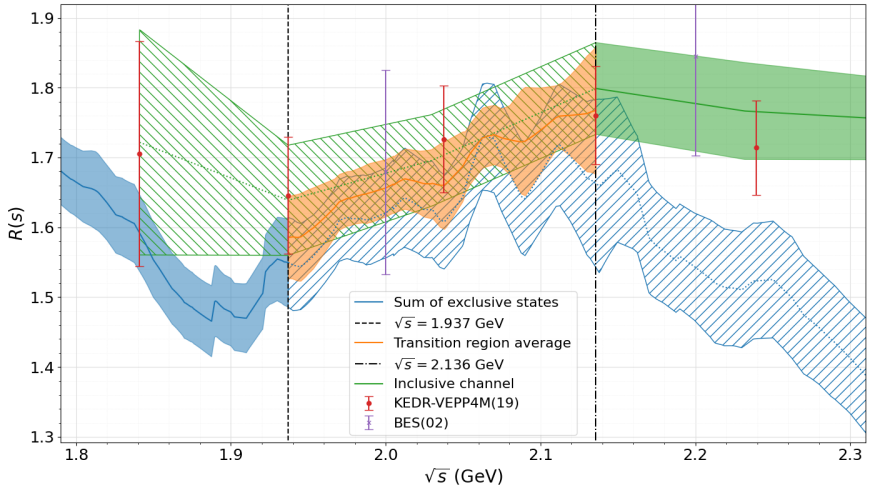
"Re-Baselining"

- (*Minor*) Corrections of KNT19 analysis:
  - Checks of database against literature.
  - More detailed systematic covariance matrix construction.
- Completions of KNT19 analysis features:
  - Lagrange polynomial interpolation of all resonances.
  - Exclusive/inclusive transition region.
- Estimates of KNT19 method systematics:
  - Two unfixed aspects of procedure.
  - Systematics would be $\sim 4.3\%$ of KNT19 squared error budget.



Breakdown of the re-baselined KNTW squared error





Correlations Study [01/25 - 04/25]

- KNTW/DHMZ $\iff$ different correlation handling?
- Assess 'uncertainties on uncertainties' with decorrelation procedure for **systematic**s:

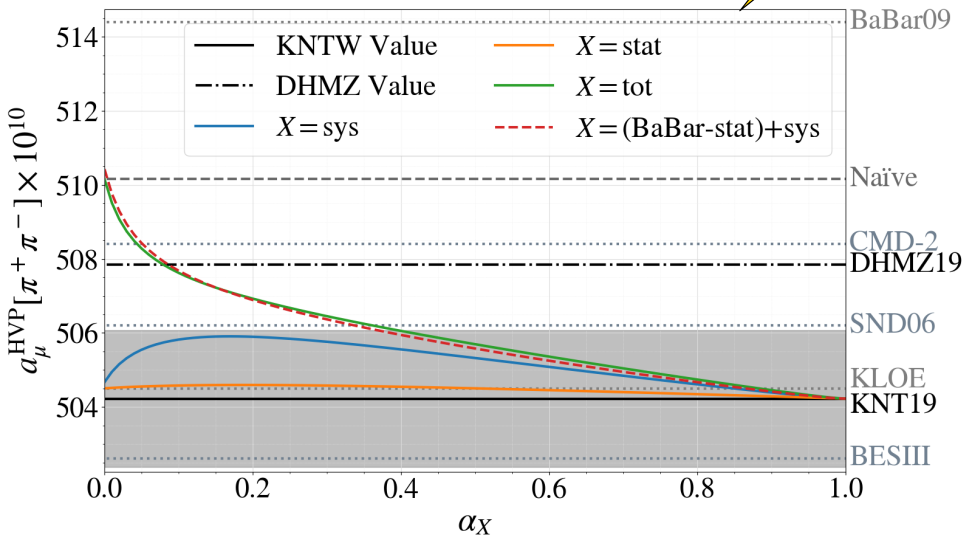
$$\tilde{C}_{ij} = \alpha\, C_{ij} + (1-\alpha)\,\mathrm{diag}\Big[C_{ij}\Big].$$

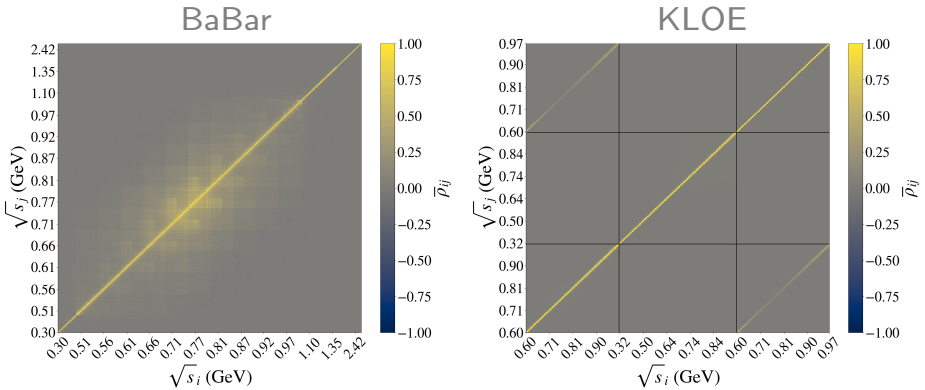
- Blue line - does not replicate DHMZ etc.
- Use to estimate systematic uncertainty:

$$d^{\rho}\, a_{\mu}^{\pi^+\pi^-} = \pm 1.68 << d^{\mathrm{KLOE/BaBar}}\, a_{\mu}^{\pi^+\pi^-};$$

extension to all channels $= \pm 1.95$.

- Implication (green line) - need to vary stat. and syst. or 'KLOE favoured'.
- Difference driven by BaBar statistics - fits naturally favour low precise KLOE.
- More advanced decorr.s possible but this provides an $\sim$upper bound uncertainty.





arXiv2509.XXXXX potentially...

New KNTW Analysis [06/25 - now]

- Avoid biases during new analysis using blinding kernel:

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

$$B_i(s) = \pm b_i(s + s_{0,i})^{c_i}$$

  for each channel i. Generated by seeds held by Mark Lancaster.

- New analysis features:
  1. Improved FSR correction routines:
     - a) $\pi^+\pi^-$
     - b) ✓ $K^+K^-, K_S^0K_L^0$ ✓
     - c) • $\pi^+\pi^-\pi^0$ •
     - d) ✓ Inclusive channel ✓
  2. VP routine - narrow resonance handling, •uncertainty estimates•.
  3. New combination procedure trials.
  4. Inclusion of new datasets.
  5. Channel correlations(?); other minor considerations.

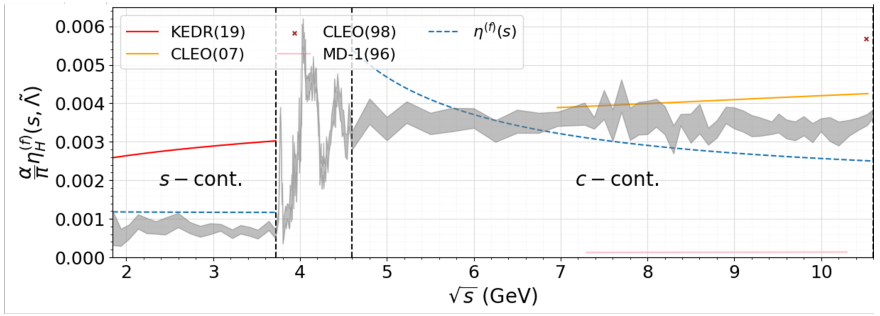
$\Longrightarrow$ KNTW27?

New analysis so far...

- Revisited $K\bar{K}$ - confident in KNT19 conclusions for scan experiments.
- Inclusive channel (grey band):
  - Improve 1% syst. with $q\bar{q}$ treatment.

$$R_{(\gamma)} = \left(1 + \frac{\alpha}{\pi}\sum_{\text{q=uds(c)}} Q_q^2\eta^{(f)}(s, m_q^2)\right) R$$

  - Datasets often FSR inclusive, hard correction needed for four datasets.
  - Estimated 20% drop in $\Delta\alpha_{\text{had.}}^{(5)}(M_Z^2)$ uncertainty!



- Looking at 3π FSR w/ MH - ongoing...