KNTW Re-Analysis of the HVP Contributions to Muon $g-2$

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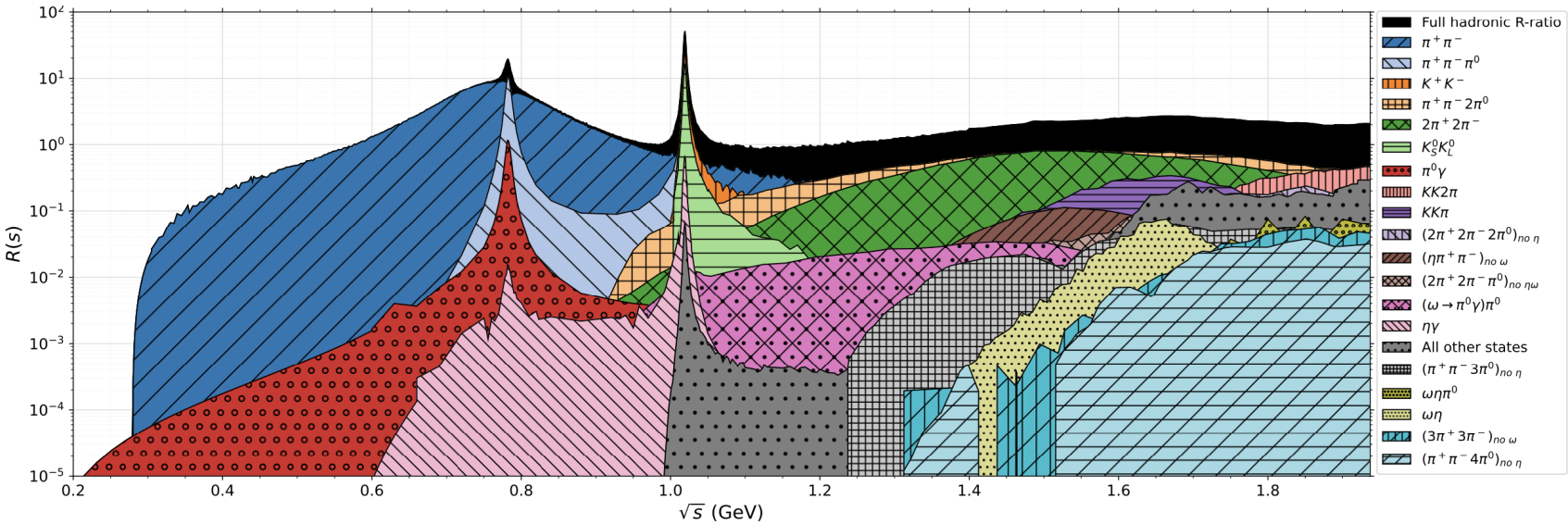
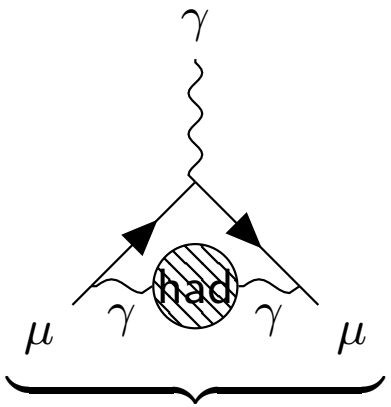


HVP For $g-2$

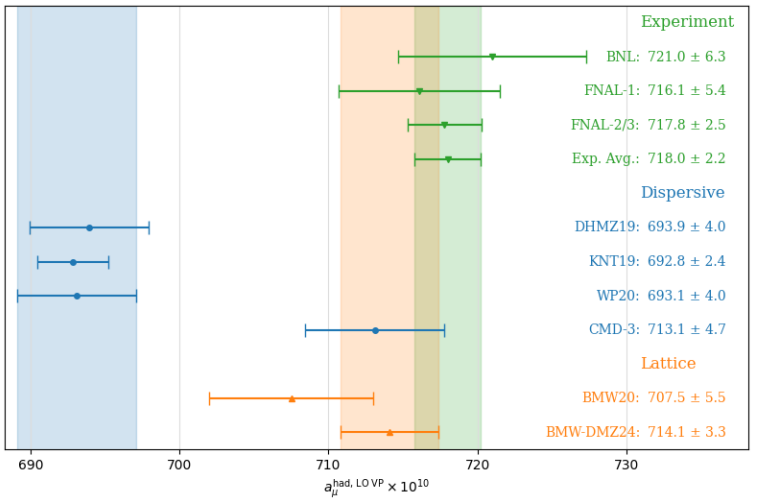
- The anomalous magnetic moment of the muon is half of the deviation from the Dirac case $g = 2$.
- Divided by type of loop - *Hadronic Vacuum Polarisation* contributions require special methods to calculate.
- Two choices of method:
  - Dispersive: Relate the vacuum polarisation tensor in the derived expression for a_μ to experimental cross sections.
  - Lattice QCD: Perform QCD calculations on discretised grid to allow for use of perturbation theory.
- Theory methods in tension with one another; dispersive in tension with experiment.

This talk: the KNTW dispersive approach.

$$a_\mu \supset a_\mu^{\text{HVP, LO}} =$$

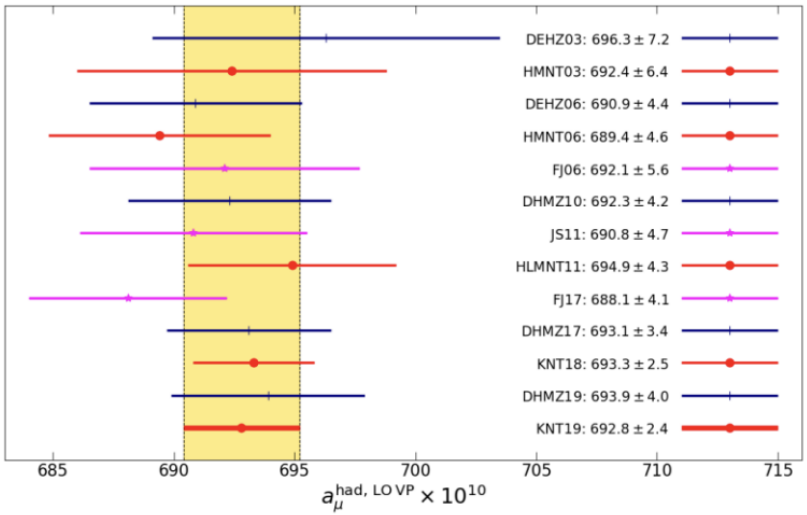


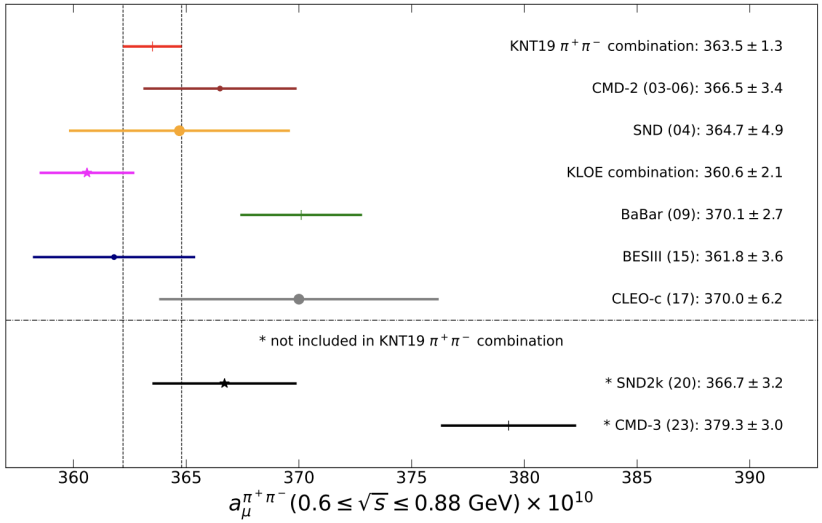
$$684.5(4.0)\times 10^{-10}$$



The Dispersive Approach

- Cross sections from $e^+e^- \to$ hadrons data can be radiatively corrected, combined channel by channel and then numerically integrated.
- Originally the only available method - results stable for ~ 20 years.
- Result from CMD-3 $\pi^+\pi^-$ measurement in significant tension with preceding results...

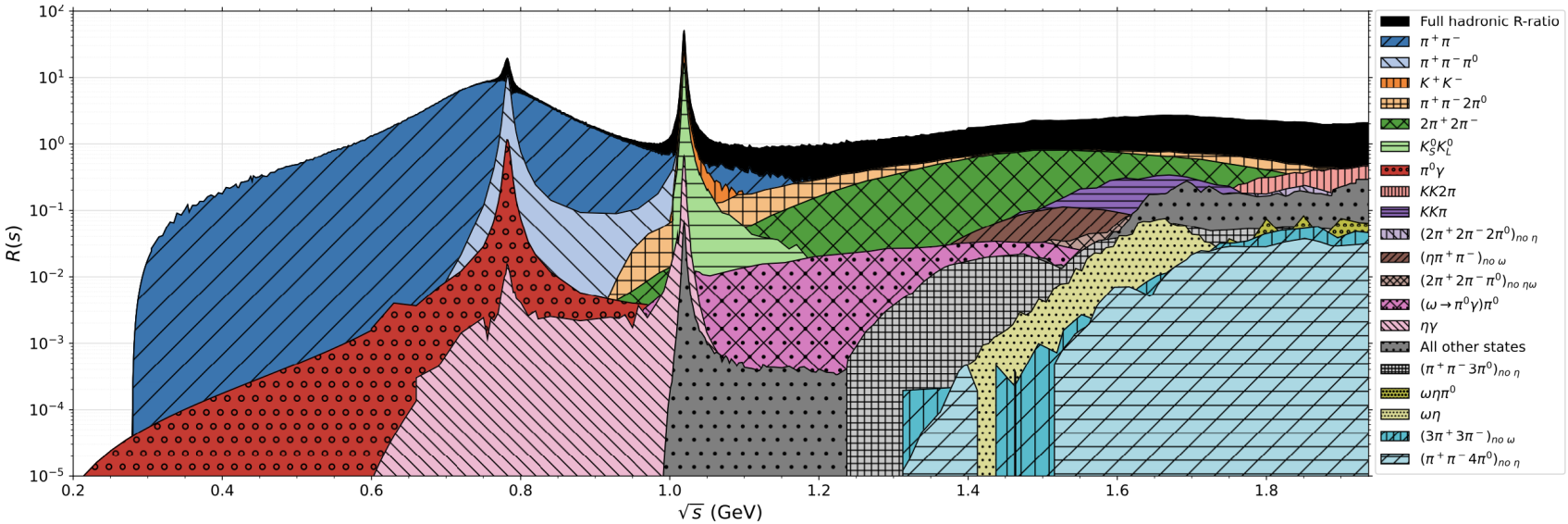




- Now we face an unclear, difficult three way tension: dispersive-dispersive, dispersive-lattice and dispersive-experimental.

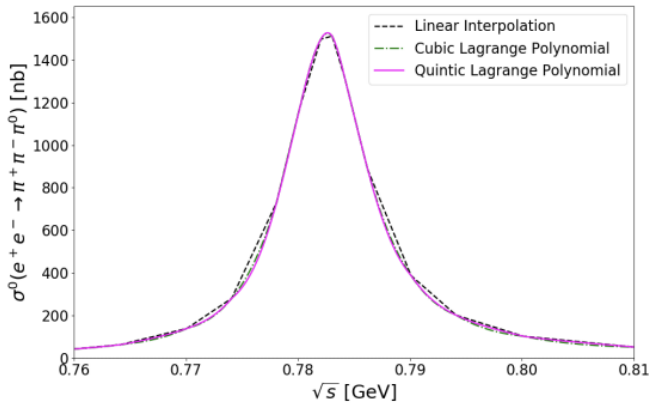
Overall aim: a new KNTW analysis, taking thorough account of all possible sources of uncertainty, producing a dispersive a_μ^{HVP} value to be confident of.

- The 2019 KNT analysis ran in a ~ 20 year-old FORTRAN code accessing experimental data stored in text files.
- My task: (1) update this into a modern Python code accessing a database; (2) check the data stored against ~ 200 papers.
  1. All relevant functionality of the FORTRAN converted into or accessible from the FORTRAN.
  2. All papers checked, all (minor) differences recorded.
- Status: able to replicate the KNT19 analysis...



Analysis Improvements

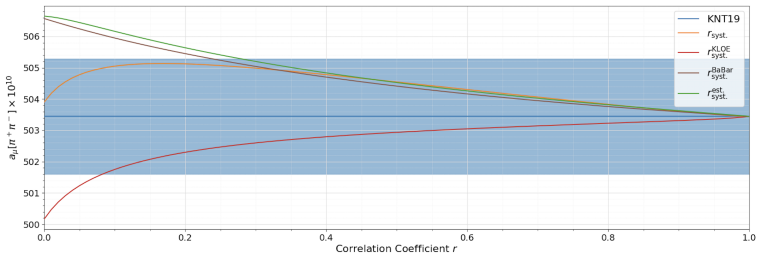
1 Lagrange Interpolation



2 Additional Systematics

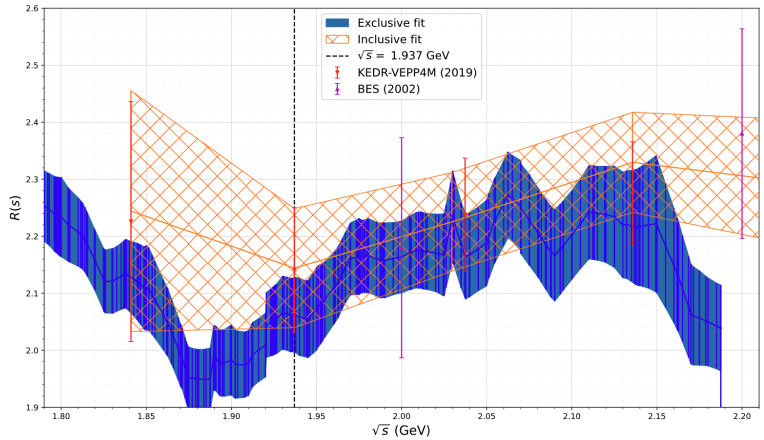
- KNTW clustering procedure has a limited number of unfixed parameters.
- Variation $\Longrightarrow$ systematic uncertainty.

3 Correlation Strength Effects



All of this + more + new data!

4 Exclusive-Inclusive Transition



5 Channel Correlations

- Data from the same experiment is typically correlated across channels.
- Estimate $\Longrightarrow$ systematic uncertainty.
- Can be accounted for better in a potential future "global fit".

6 Spline Interpolation

- KNT19 used a clustering procedure within channels.
- Can potentially be replaced by an average of dataset splines.

Blinding

- Ahead of introducing new data or making significant analysis changes, need to make sure we are not biased.
- Tense situation $\implies$ we need to objectively determine the best methods.
- Therefore blind integrals and plots with a kernel

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

where $a_i, b_i, c_i, s_{0,i}$ and the channel number i are random numbers from externally held seeds.

Summary:

- The dispersive method is a way to calculate a_μ^{HVP} which presents interesting difficulties, technically and w.r.t. the current physics landscape.
- My work so far has primarily consisted of converting to Python and cross-checking the KNT19 $g-2$ analysis code and input data.
- The full KNTW re-analysis with new data will include thorough considerations of potential sources of error and investigation of the optimal methods so as to produce the best possible prediction.