COMBINATION OF 2π AND 4π SPECTRA FROM TAU DECAYS AND APPLICATION TO MUON g-2

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ABSTRACT : Due to the lack of agreement between different e^+e^- data sets for the $\pi^+\pi^-$ channel, evaluating the HVP contribution to $(g-2)_\mu$ from τ-data input was again considered as an alternative. In this work, we discuss the HVP contribution from a new combination of the 2π-channel from ALEPH, OPAL, and Belle τ-data, without applying isospin breaking corrections. We also present a combination of ALEPH and OPAL τ-data for the 4π-channel, comparing the result with KNT19 e^+e^- data using exact isospin symmetry.

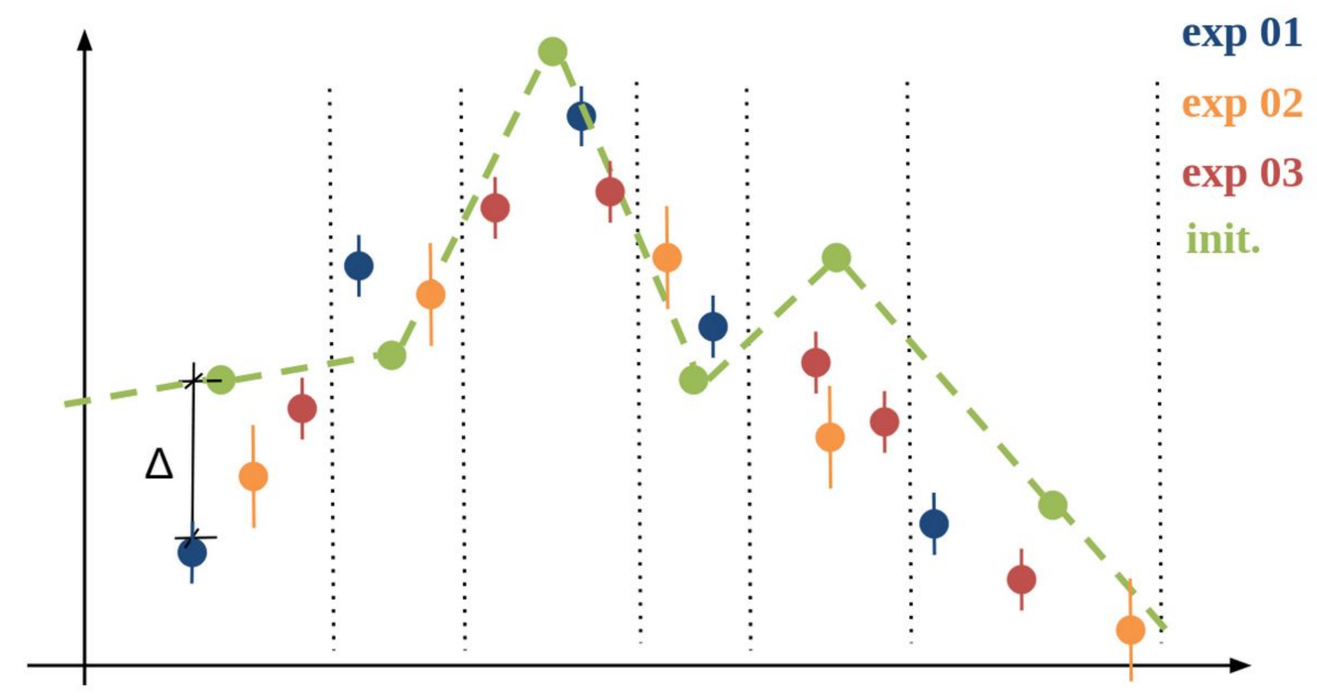
COMBINATION ALGORITHM

Boito, Eiben, Golterman, Maltman, Mansur, and Peris, **2502.08147**

Channel-by-channel combination adapted from the *KNT Algorithm.*

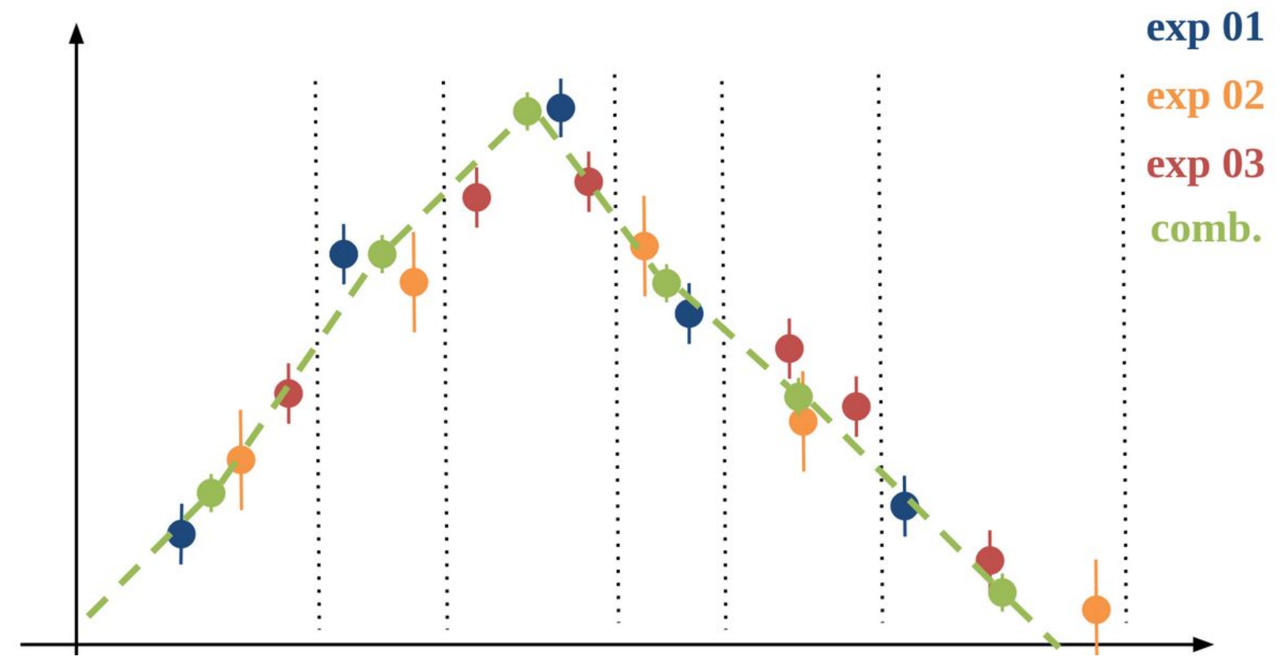
[Keshavarzi, Nomura, Teubner, '18] [Bruno & Sommer, '23]

1. Division of the spectrum into Clusters.



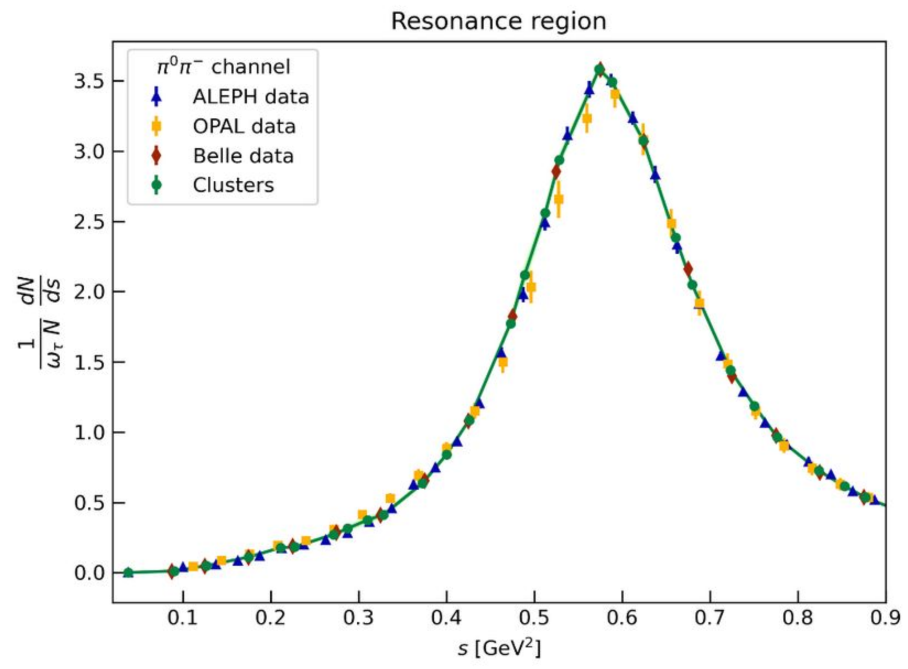
Minimization using a generalized Q^2 function, and standard error propagation.

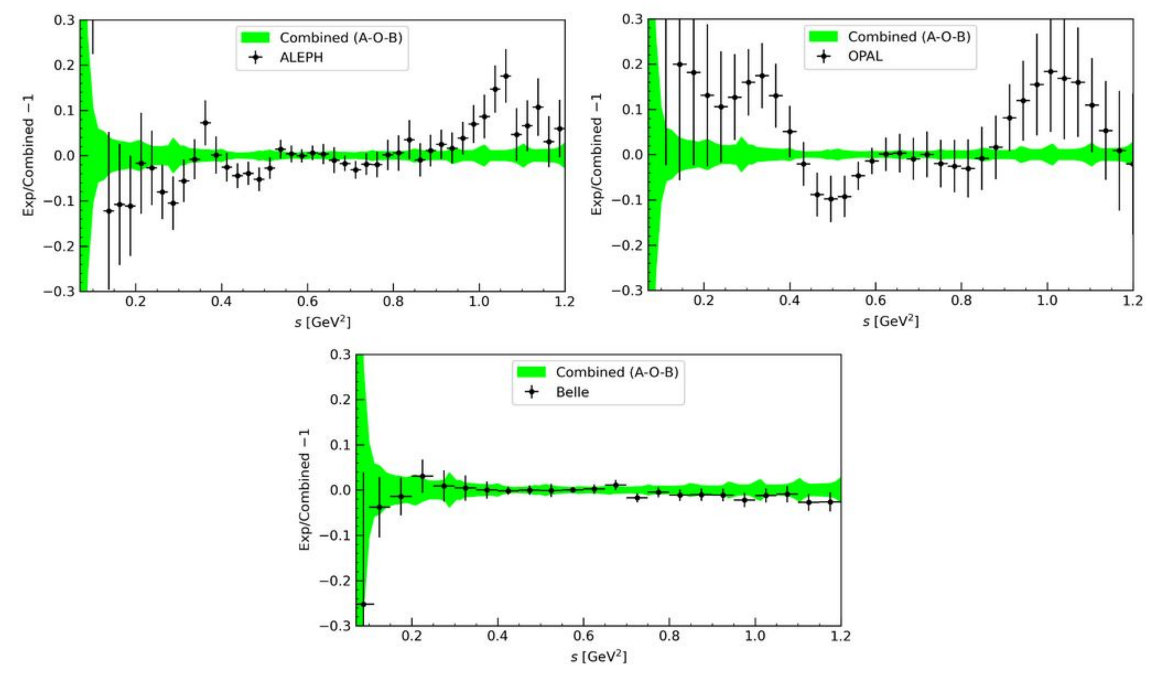
$$Q^2(\rho) = \sum_{i=1}^{N}\sum_{j=1}^{N}(d_i - R(s_i,\rho))W_{ij}(d_j - R(s_j,\rho))$$



COMBINATION OF EXCLUSIVE SPECTRA

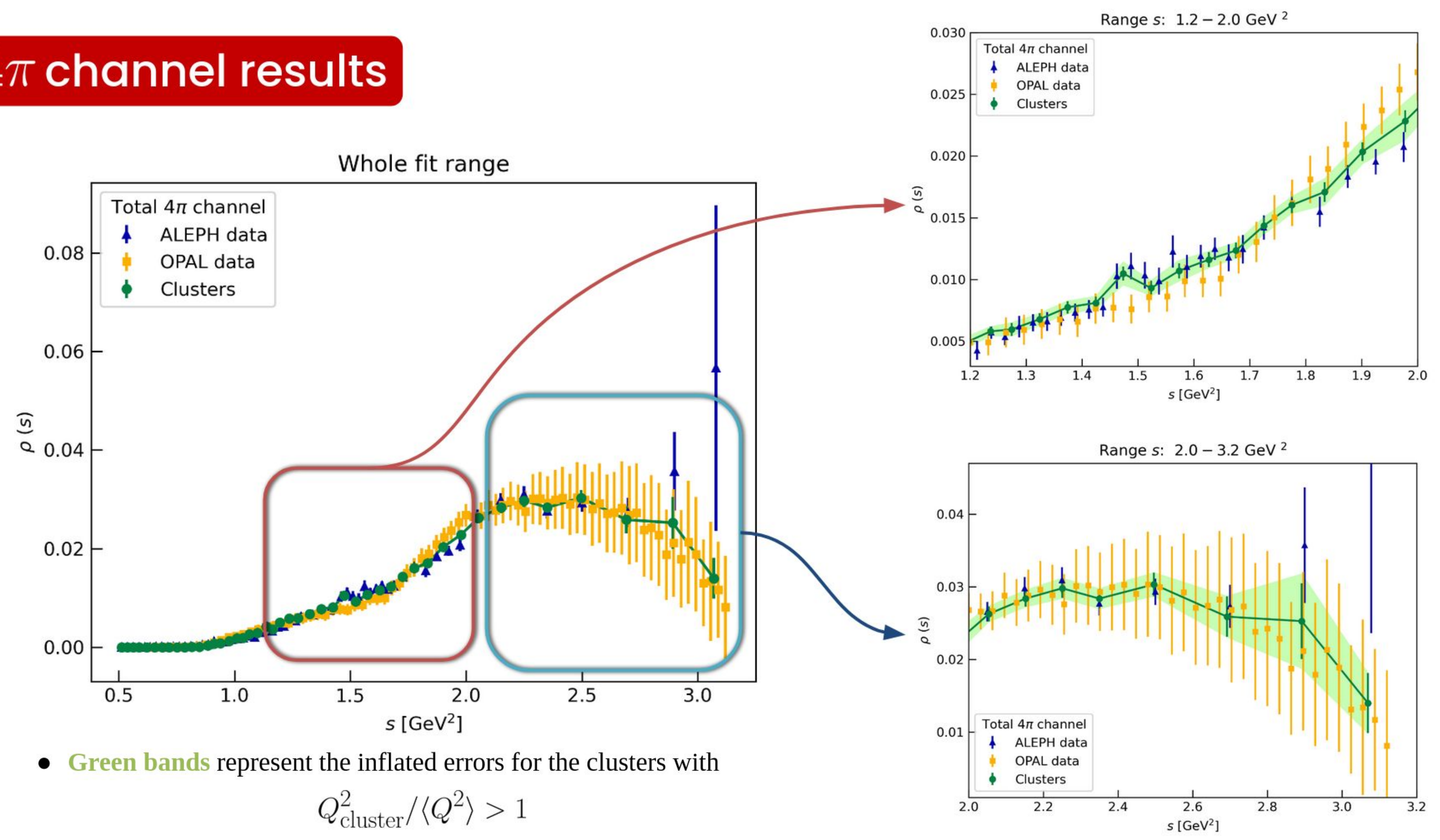
2π channel results



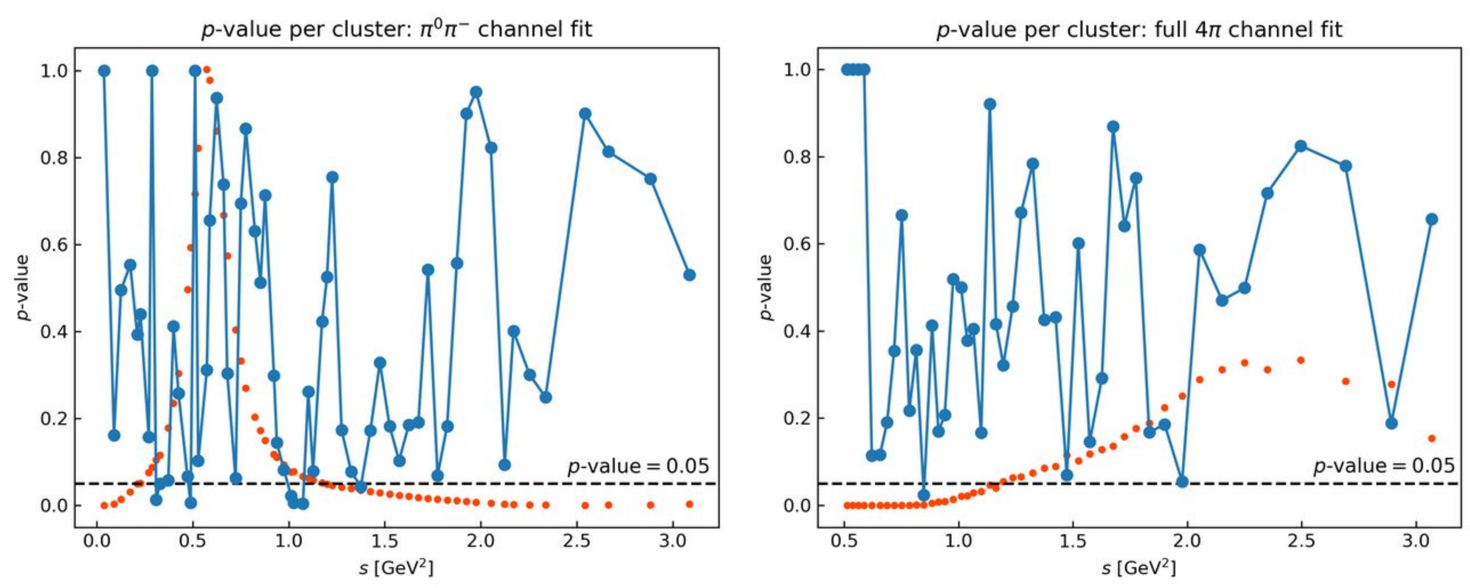


- For this particular channel, we combined the unit-normalized spectral function from ALEPH, OPAL, and Belle experiments (**CLEO not included in our main results** due to a lack of systematic uncertainties bin-by-bin).

4π channel results



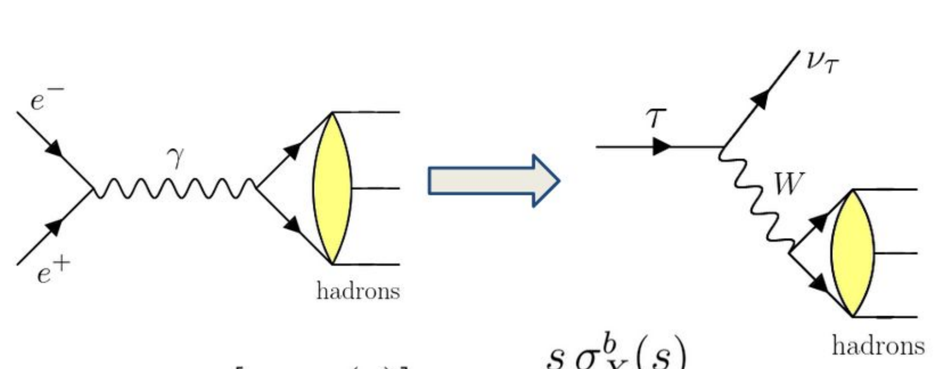
- **Green bands** represent the inflated errors for the clusters with $Q^2_{\rm cluster}/\langle Q^2\rangle > 1$



- *Goodness-of-fit* computed using a Monte Carlo method for general Q^2-function minimizations. [Bruno & Sommer, '23]
- Adaptation of algorithm in the 4π channel to deal with strong correlation in OPAL data, and avoid *d'Agostini bias* in multiplication by global factors. [Ball et al. (NNPDF), '10]

HVP CONTRIBUTION IN THE 2π - CHANNEL

From the ***Conserved Vector Current*** (**CVC**) relation, we can associate the hadronic weak charged current and the isovector component of EM current by a factor



$$[\rho_{ud;V}(s)]_{X^-} = \frac{s\,\sigma^b_X(s)}{8\pi^3\alpha^2_{EM}}$$

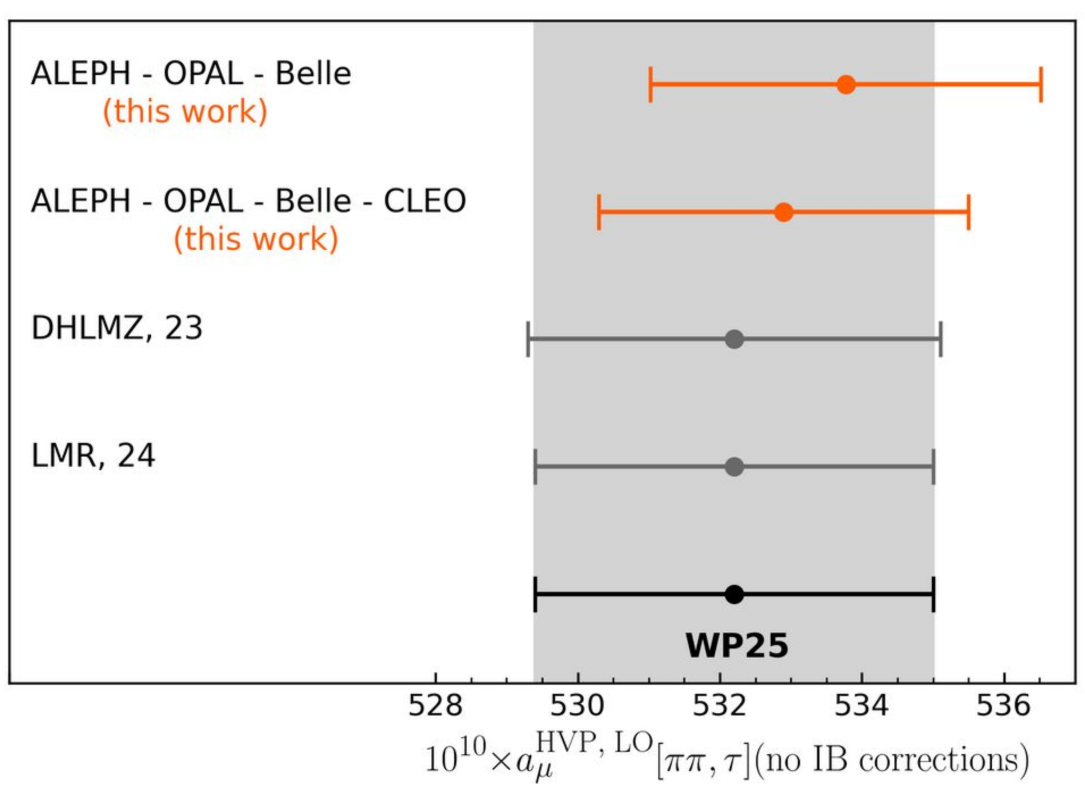
without IB corrections => $S_{\rm EW} = 1.0,\ R_{\rm IB} = 0$

From our definition of spectral function

$$\rho_{\pi^\pm\pi^0}(s) = \frac{m_\tau^2}{12\pi^2 B_e|V_{ud}|^2 w_T^{av}(s;m_\tau^2)}\frac{B_{\pi^\pm\pi^0}}{N}\frac{dN(s)}{ds}$$

we arrive at

$$a_\mu^{\rm HVP,\,LO}[\pi\pi,\tau] = 2\alpha^2\int_{4m^2_{\pi^\pm}}^{m_\tau^2}\frac{K(s)}{s}\left[\rho_{\pi^\pm\pi^0}(s)\right]$$



Using CVC, **without IB corrections** included, we find the results (considering only experimental uncertainties)

ALEPH (A), OPAL (O), Belle (B), and CLEO (C)

$$a_\mu^{\rm HVP,\,LO}[\pi\pi,\tau](\text{A-O-B}) = 533.8(2.8)\times10^{-10}$$

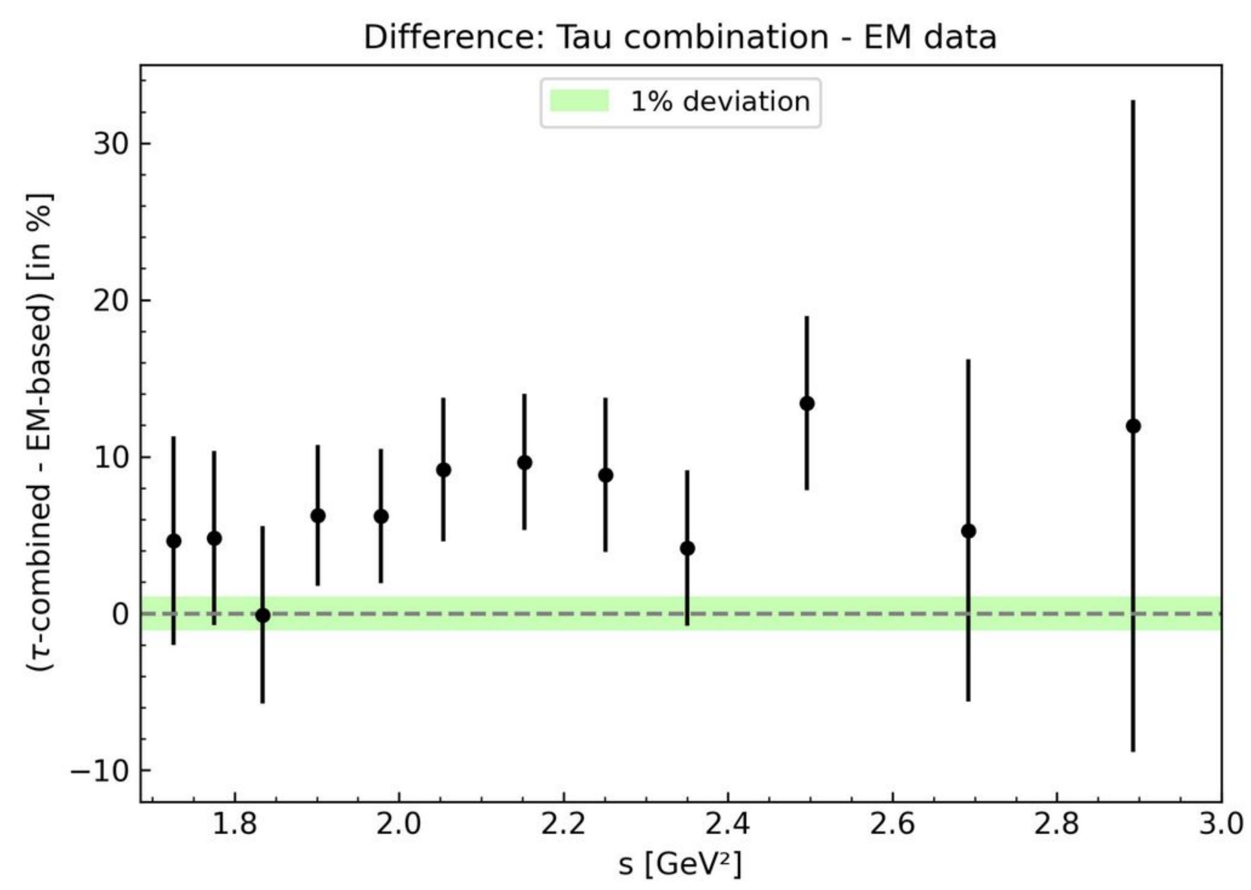
$$a_\mu^{\rm HVP,\,LO}[\pi\pi,\tau](\text{A-O-B-C}) = 532.9(2.6)\times10^{-10}$$

The reference value from the WP25 [Aliberti, et al., '25]

$$a_\mu^{\rm HVP,\,LO}[\pi\pi,\tau](\text{WP25}) = 532.2(2.8)\times10^{-10}$$

4π - CHANNEL: COMBINED vs. EM-BASED DATA

From the ***Pais Relations***, we can obtain a EM-based spectral function using the data from KNT19 [Keshavarzi, Nomura, Teubner. 18'].



- The difference observed between EM-based data and the combined 4π-channel from tau is **above the expected ~1% IB deviation** for these channels.
- The discrepancy appears to be **mostly** coming from the $2\pi^-\pi^+\pi^0$ **channel** ("easier" τ-decay mode).
- **New experimental inputs** for the $2\pi^-\pi^+\pi^0$ and $\pi^-3\pi^0$ can play an important role in the understanding of the above discrepancies.