NPR of Improved Staggered Bilinears

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Motivation

- Precise matching factors needed in ongoing computation of B_K using staggered fermions. Currently the leading source of uncertainty (4.4%).
- Precision value of Z_m for light quark masses (RI/SMOM scheme).
- Detailed comparison to one-loop PT; study of systematic effects.

Outline

- General improved staggered bilinears.
  Compare to one-loop PT (RI/MOM).
  - HYP
  - Asqtad
- RI/SMOM - Preliminary results.

Brief Reminder

- Taste degrees of freedom. $\mathcal{O}_{S\otimes F} \sim \bar{q}(S \otimes F)q$

- Local operators spread over a hypercube.

Details

- Coarse and fine ($a \sim .12, .09$ fm) MILC lattices [asqtad]. 3 sea masses.
- HYP and asqtad valence.
- RI/MOM renormalisation conditions.

Bilinears – Comparison to PT

- We compare ratios of Z-factors with the same spin but different tastes. To one loop:

$$\frac{Z_{S\otimes F}(\mu, a)}{Z_{S\otimes 1}(\mu, a)} = 1 + \frac{\alpha_s(1/a)}{4\pi}\left[C^{\text{lat}}_{S\otimes F} - C^{\text{lat}}_{S\otimes 1}\right]$$

- Ratios depend on $\alpha_s(1/a)$. This persists to all orders in PT.

Bilinears – Comparison to PT

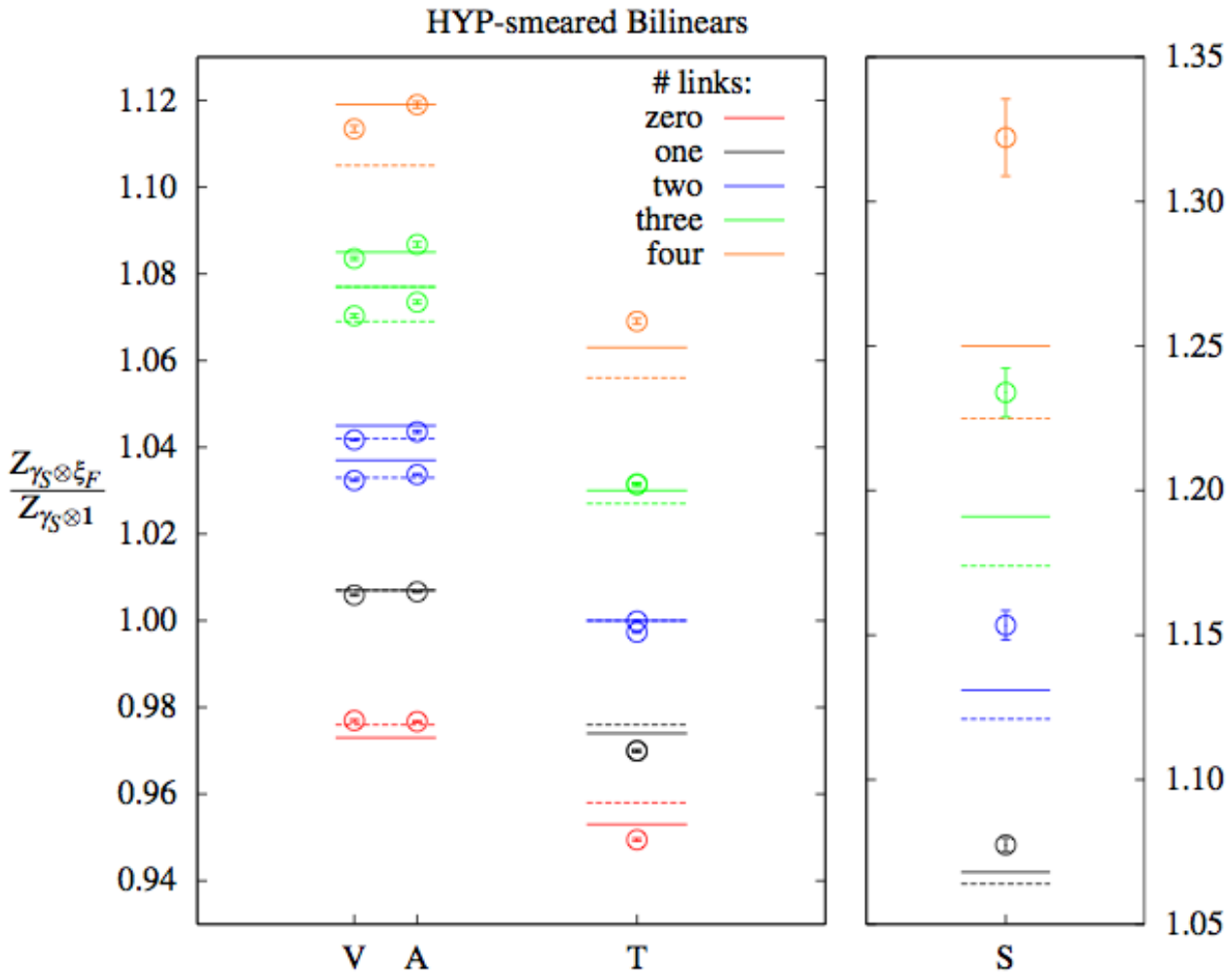
- Ratios are predicted by PT to be constants depending on the lattice spacing, but not the renormalisation scale μ.

- Studying the renormalisation scale dependence provides a fully non-perturbative check of the degree to which the "window condition" is satisfied.

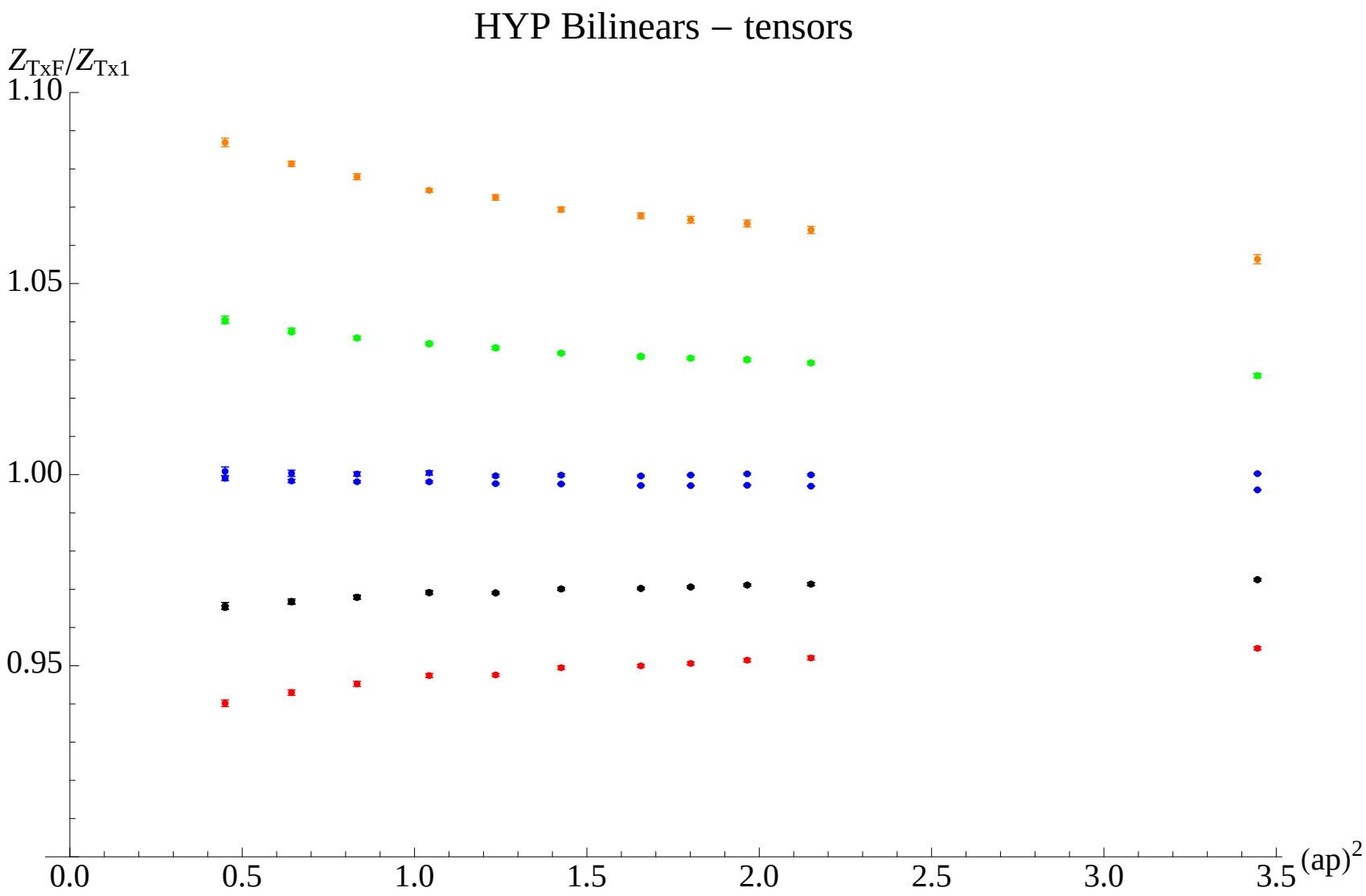
$$\Lambda_{\mathrm{QCD}} \ll \mu \ll (1/a)$$

HYP Bilinears

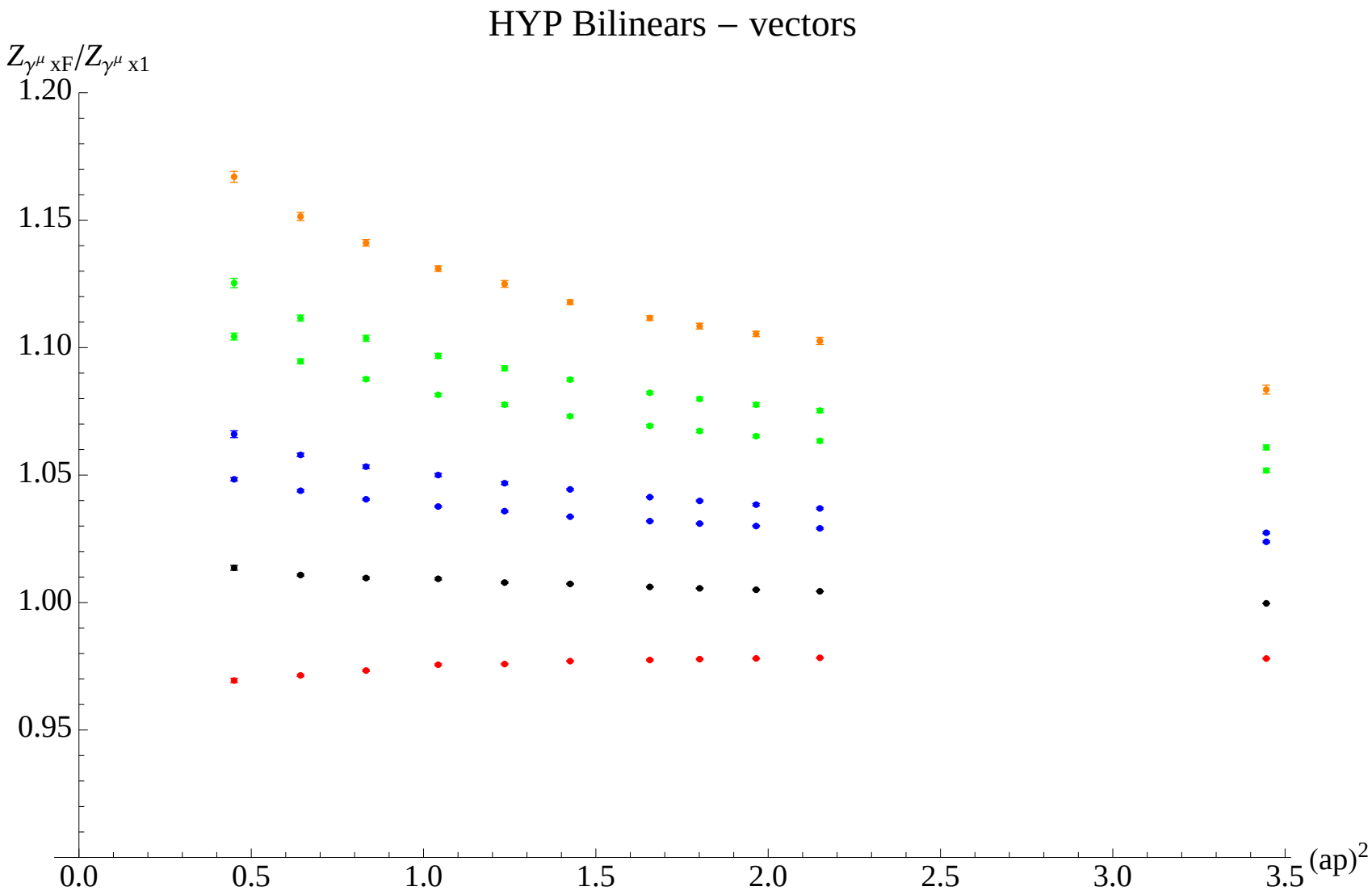
HYP Bilinears – Comparison to PT



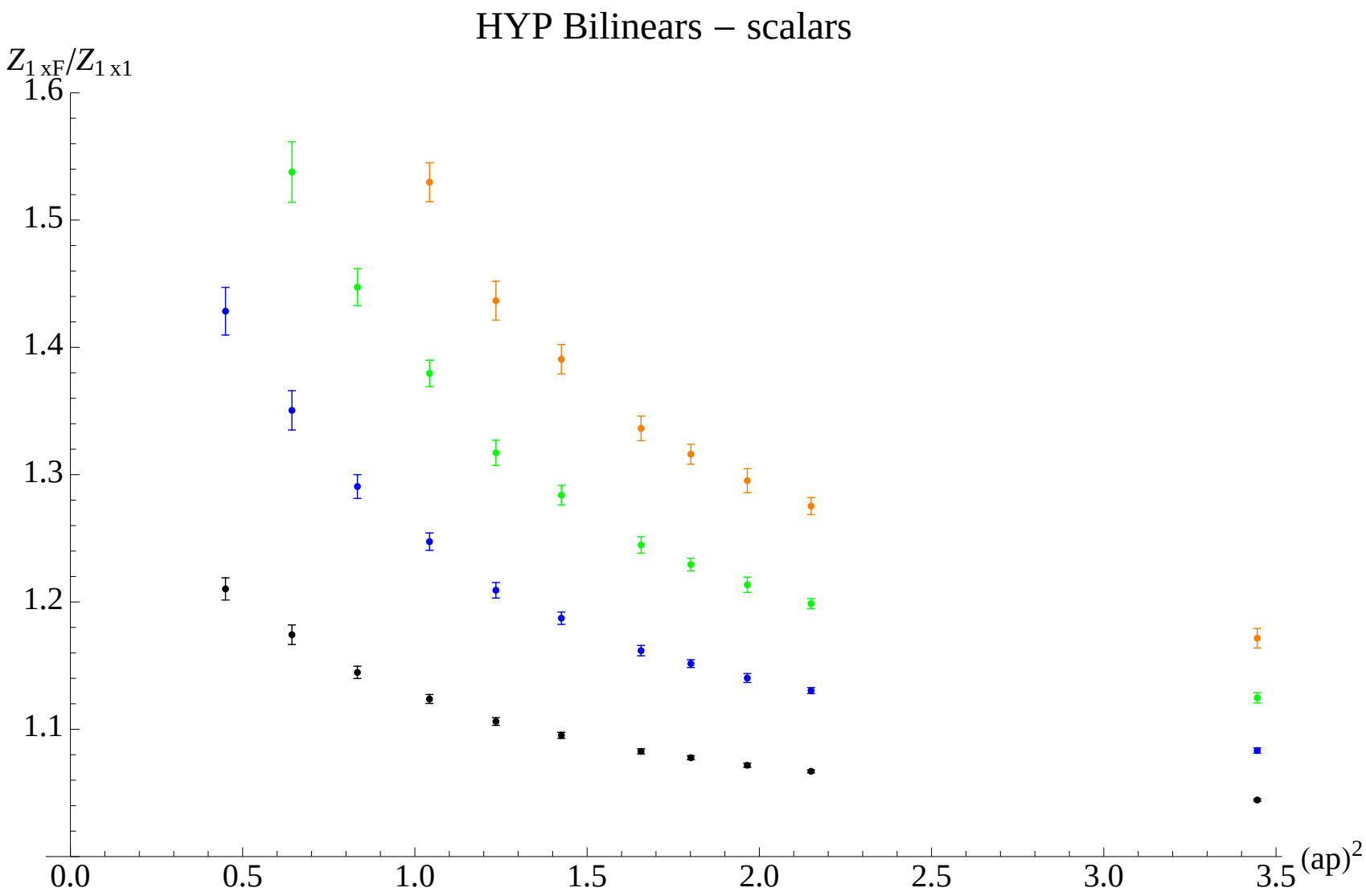
HYP Bilinears – Comparison to PT



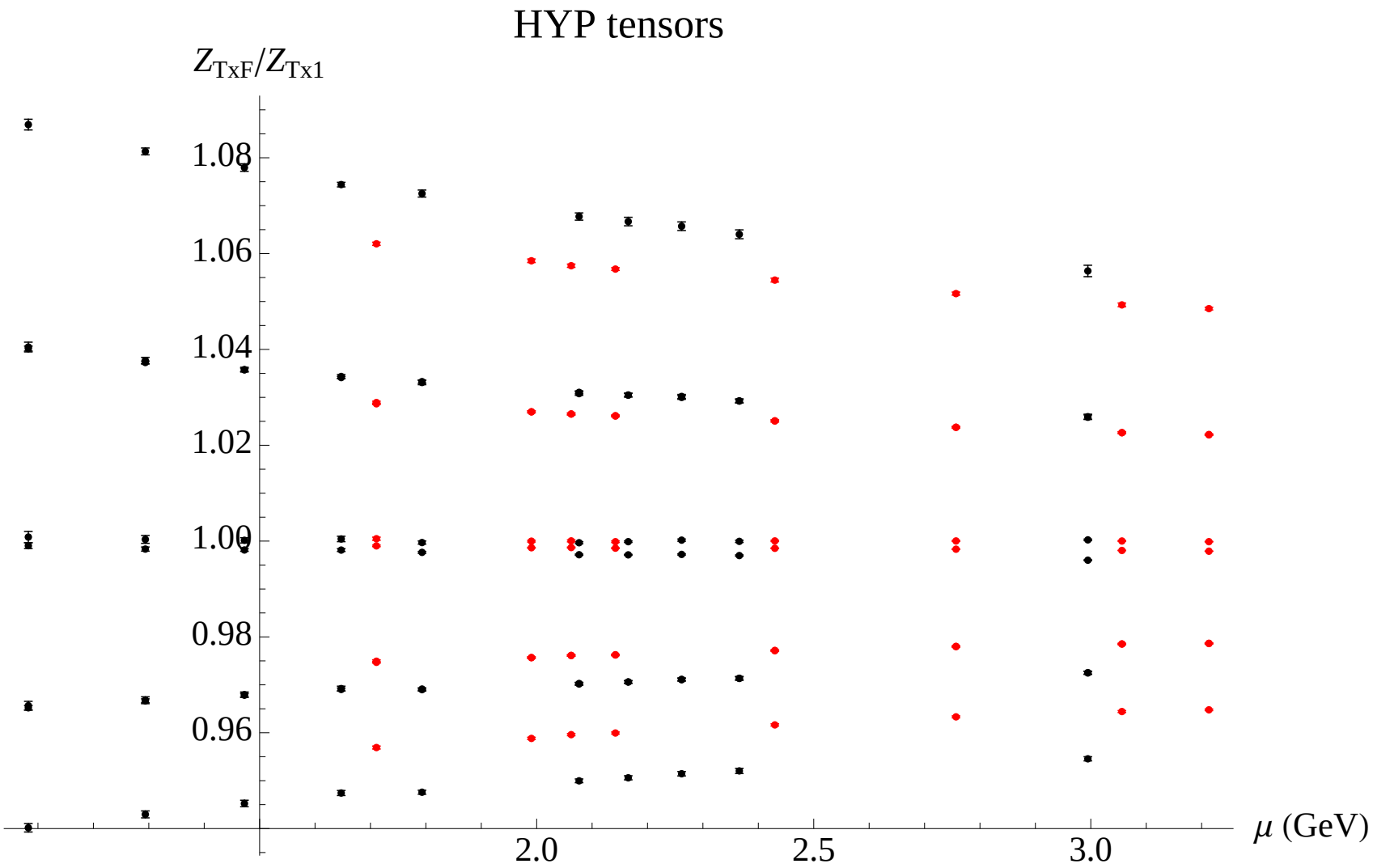
HYP Bilinears – Comparison to PT



HYP Bilinears – Comparison to PT



HYP Bilinears – Comparison to PT



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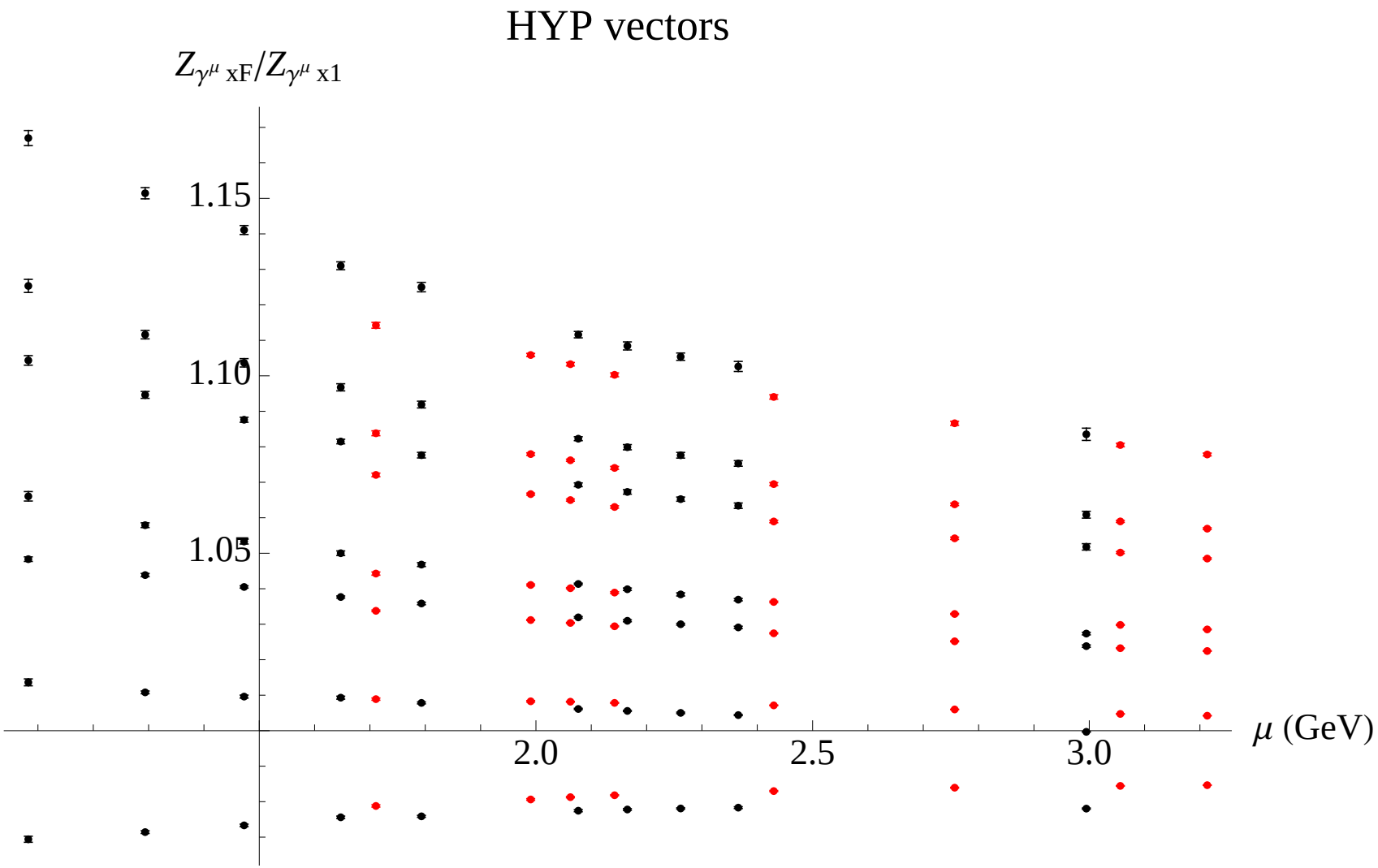

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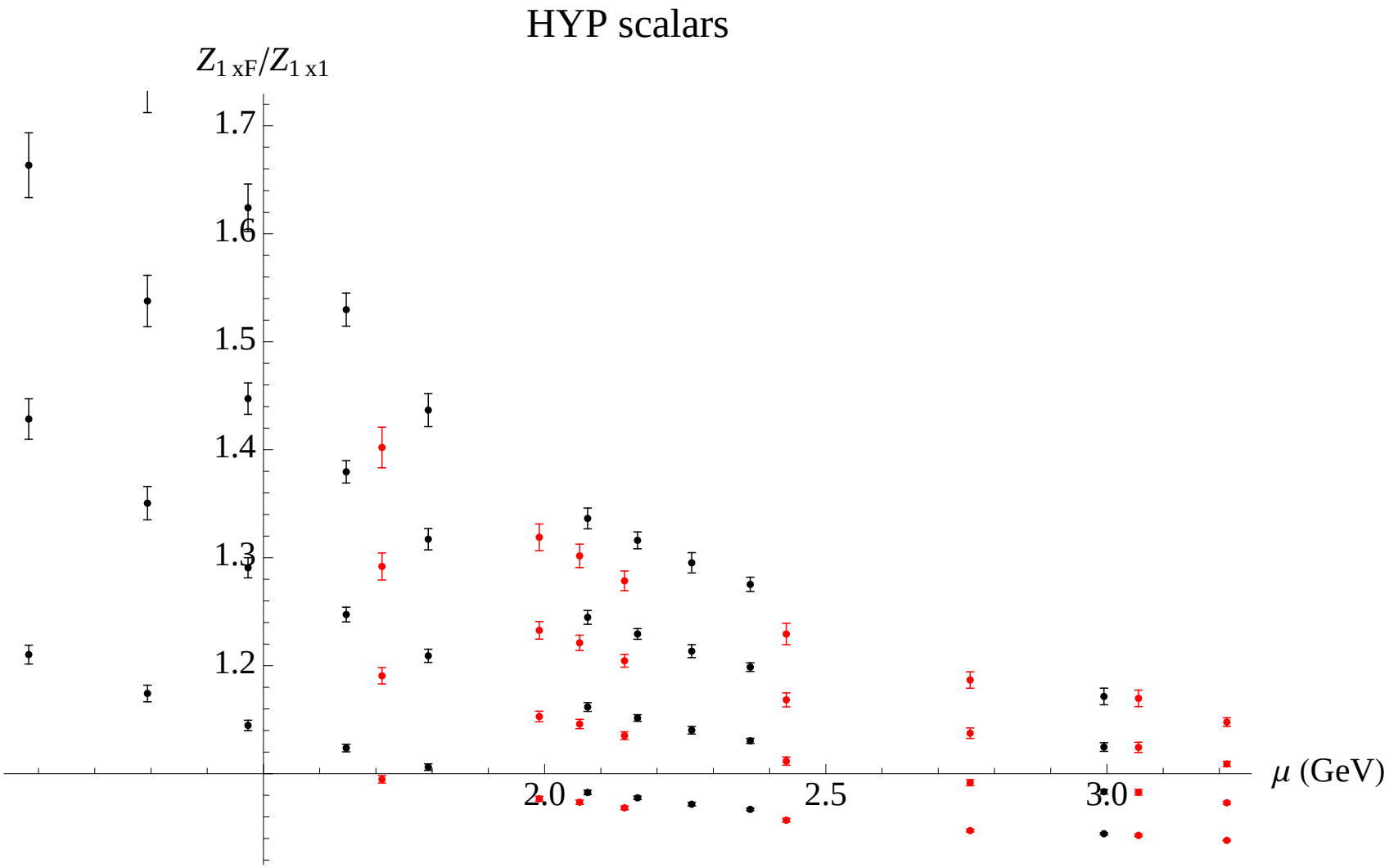
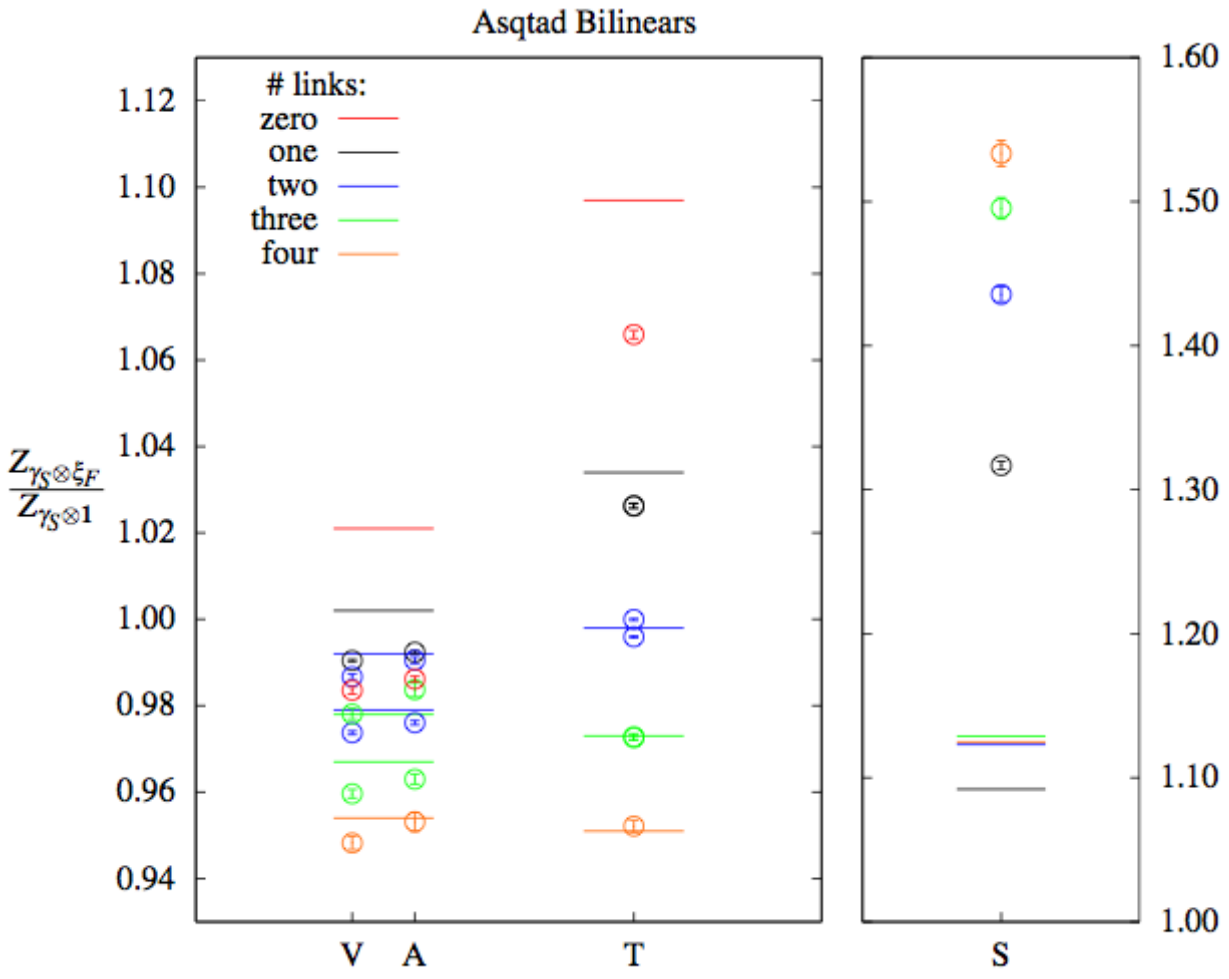
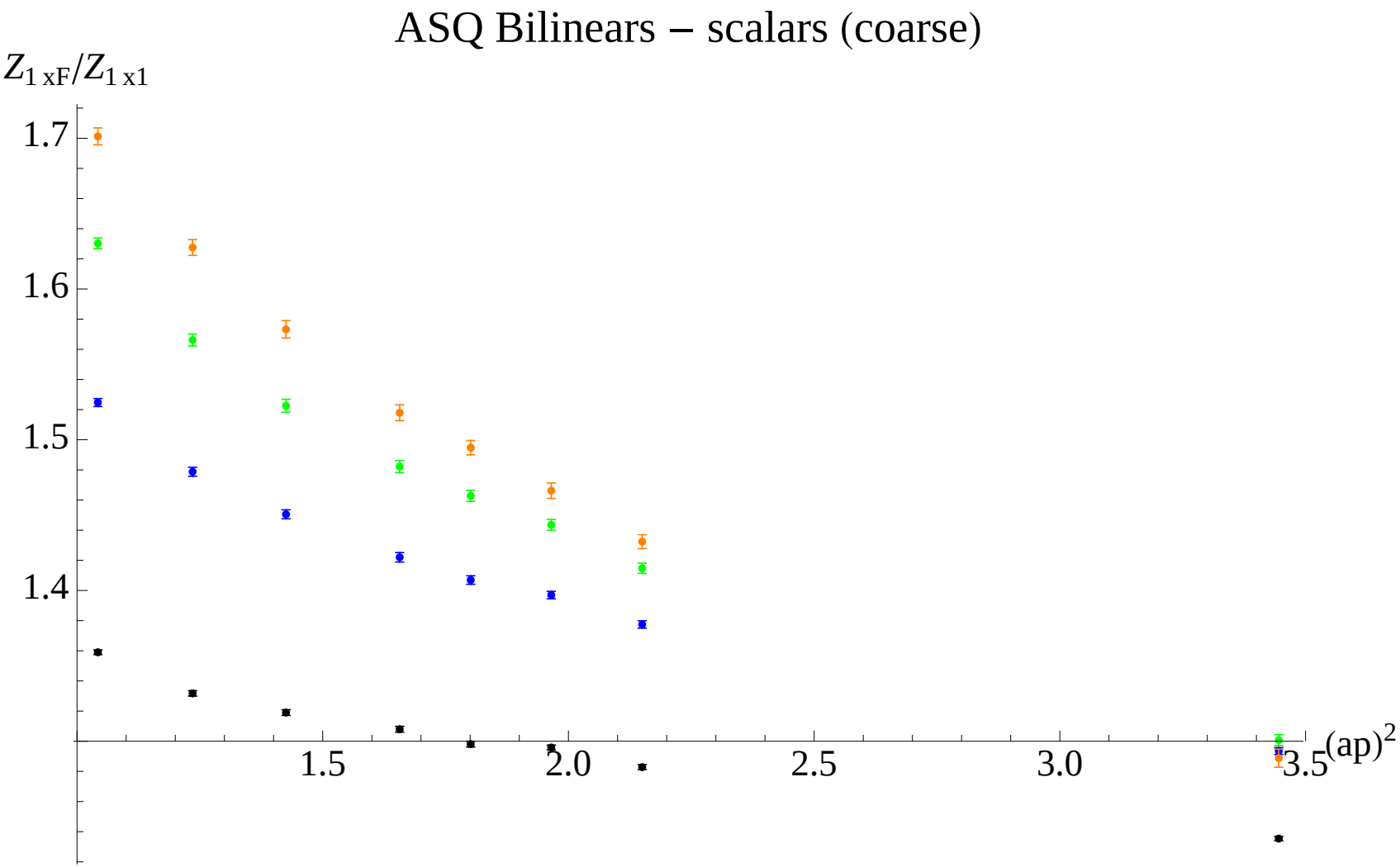


Asqtad Bilinears

Asqtad Bilinears – Comparison to PT



Asqtad Bilinears – Comparison to PT



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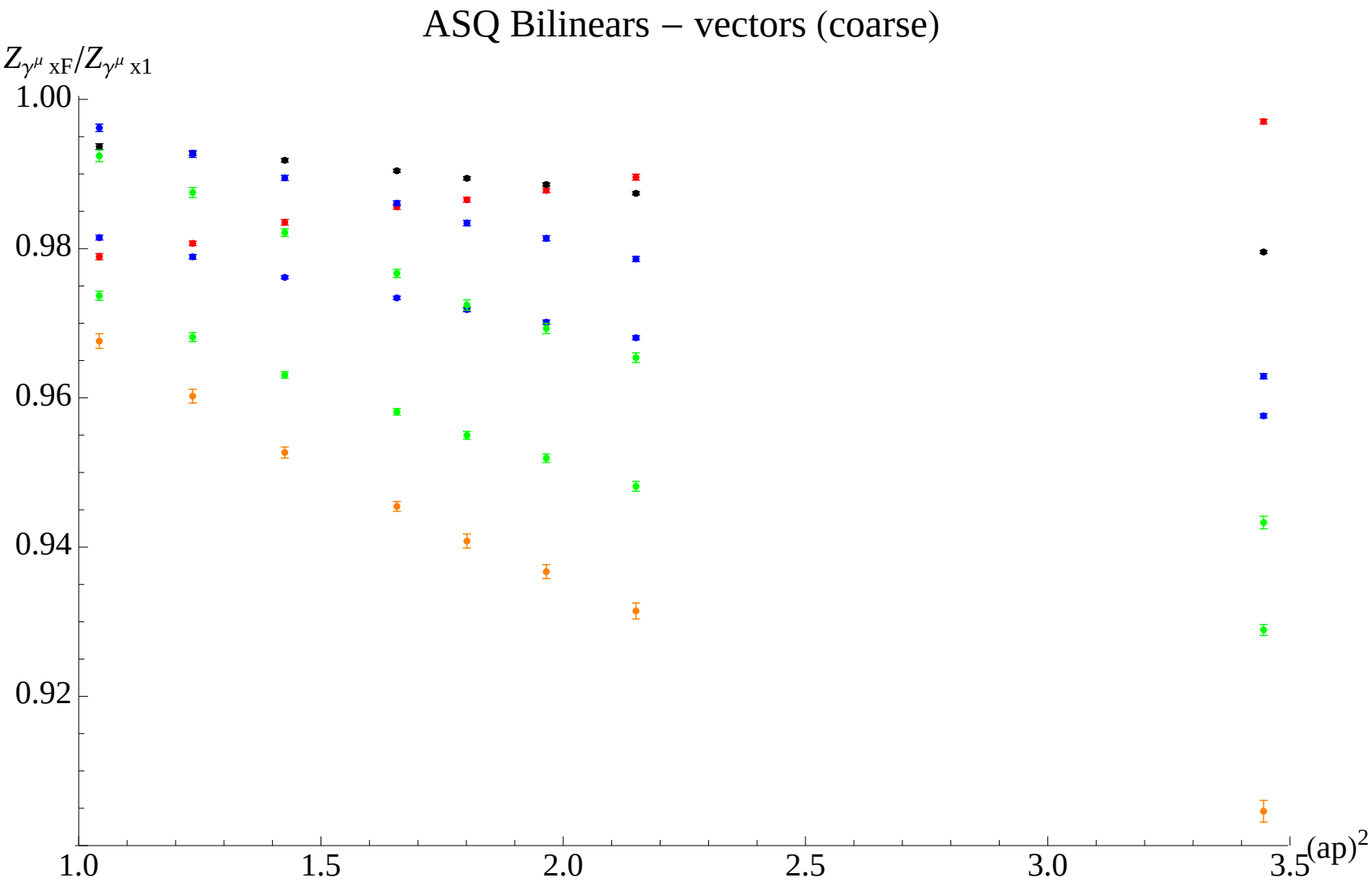

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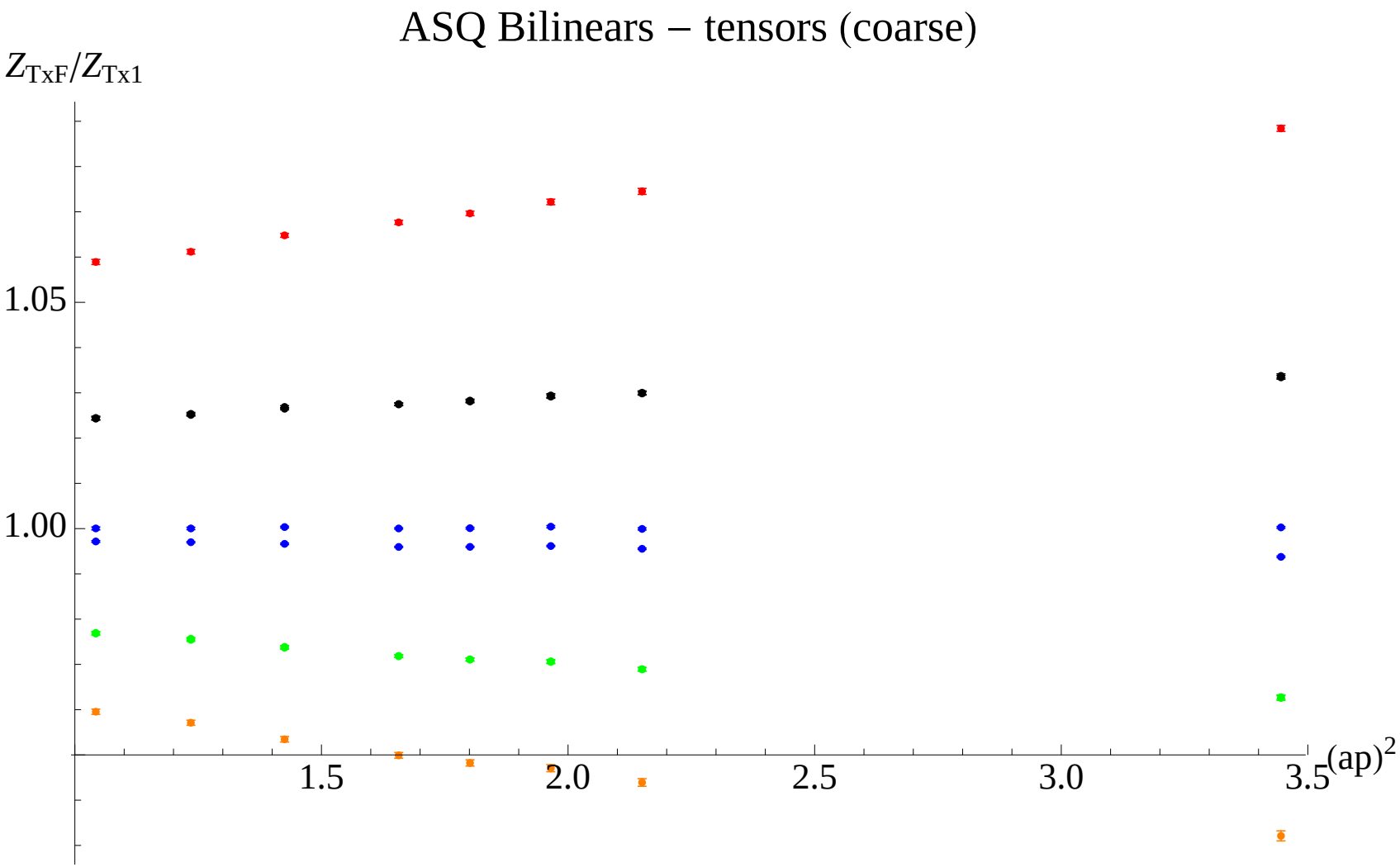
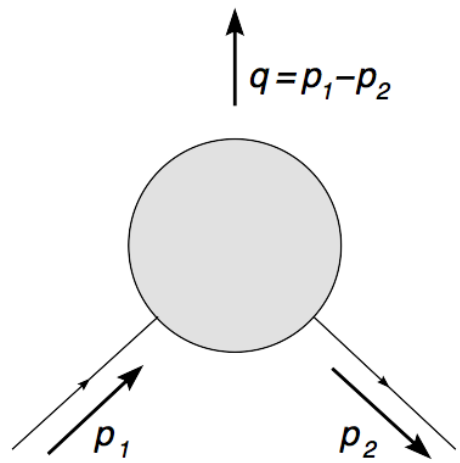


RI/SMOM scheme

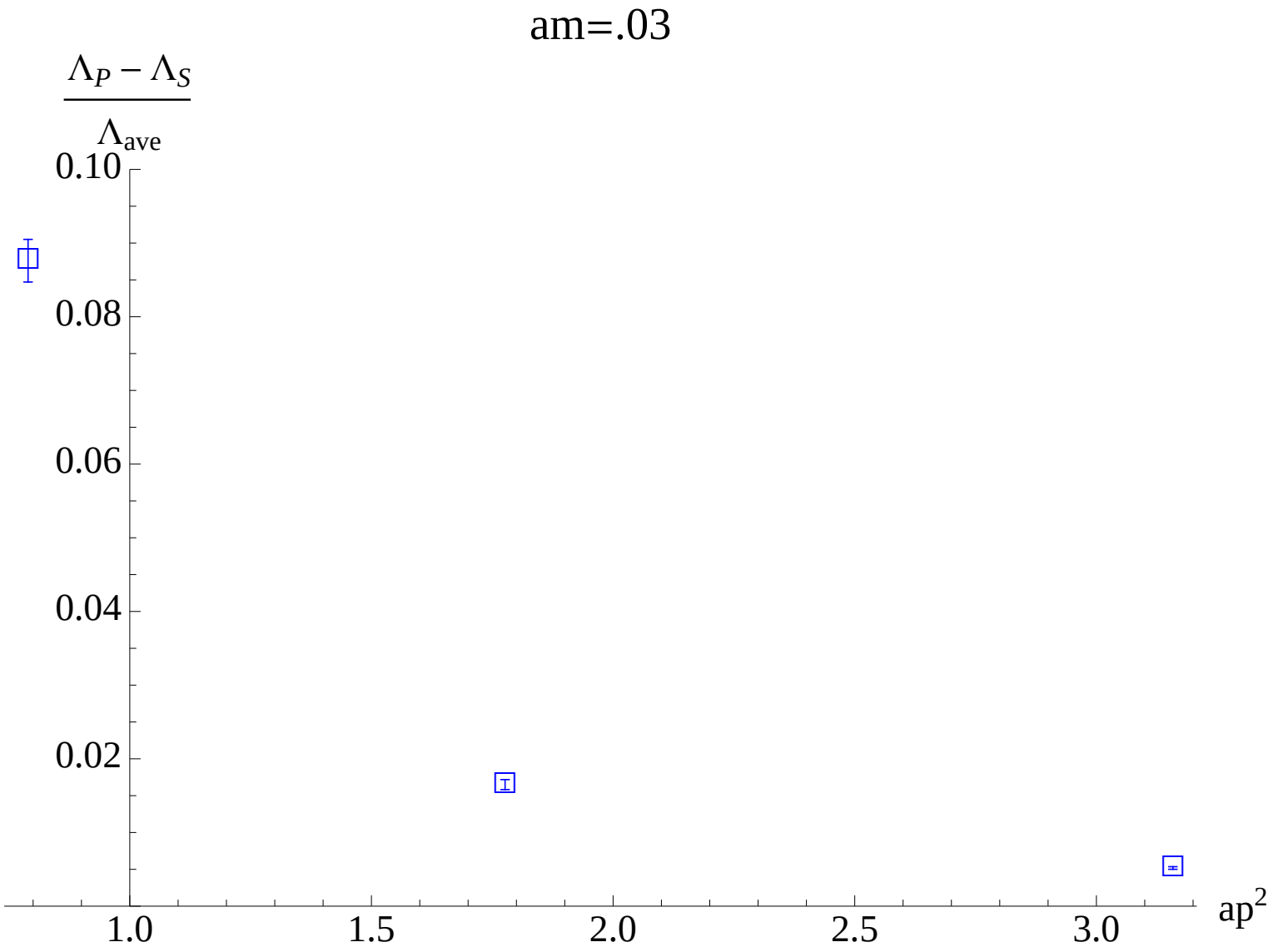
RI/SMOM scheme

- Momentum flow suppresses infrared effects.
  $p_1^2 = p_2^2 = (p_1 - p_2)^2$

- $p_1 \sim (x, x, 0, 0)$,
  $p_2 \sim (0, x, x, 0)$ for
  $x = 2, 3, 4$



RI/SMOM - Preliminary



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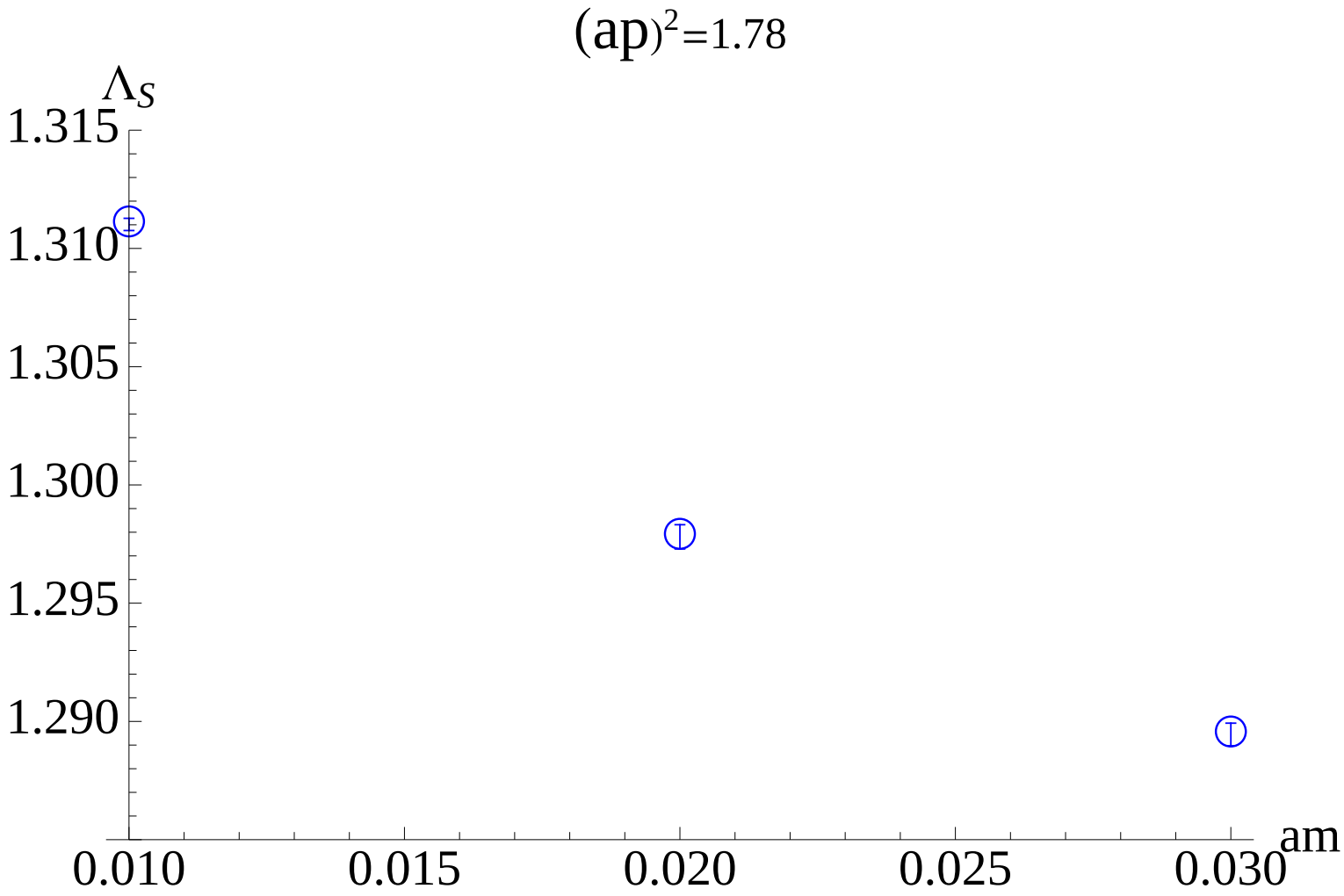

Summary

- Carried out detailed studies of one-loop PT vs NPR for improved staggered fermions.
  - Important for precision determination of B_K with staggered fermions.
  - Study systematic effects when using NPR method.
- Implemented RI/SMOM scheme for staggered fermions.
  - Suppresses infrared effects, opening up the NPR window.
  - Useful for Z_m, and presumably B_K in the future.