Systematic errors in extracting nucleon properties from lattice QCD

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CLS based

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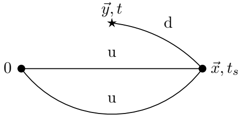
contents:

overview:

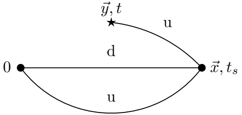
- $N_f = 2$, $O(a)$-improved Wilson fermions
- deflation accelerated DD-HMC algorithm
- lattice sizes: $(64x32^3, 96x48^3)$
- $\beta = 5.3 (a = 0.07 fm)$ (see talk of Hartmut Wittig)
- measurement code for mesons and baryons is based on deflation acceleration and Schwarz preconditioner
- nucleon interpolating field: $J_\gamma = \epsilon^{abc}(u^a C\gamma_5 d^b)u^c_\gamma$
- jacobi-smearing: $N = (150, 175), \kappa = 0.2$, HYP-smeared links

extended source method:

$$\Sigma_d(\vec{y},0;t_s,\vec{p}`) = \sum_{\vec{x}} e^{i\vec{x}\vec{p}`} \otimes$$



$$\Sigma_u(\vec{y},0;t_s,\vec{p}`) = \sum_{\vec{x}} e^{i\vec{x}\vec{p}`} \otimes$$



implemented three-point function:

$$C_3(\vec{q},t,t_s) = \sum_{\vec{y}} Tr\left[\Gamma^P\left(\Sigma_u(0,\vec{y}) \pm \Sigma_d(0,\vec{y})\right) O(y) S(y,0)\right] e^{i\vec{q}\vec{y}}$$

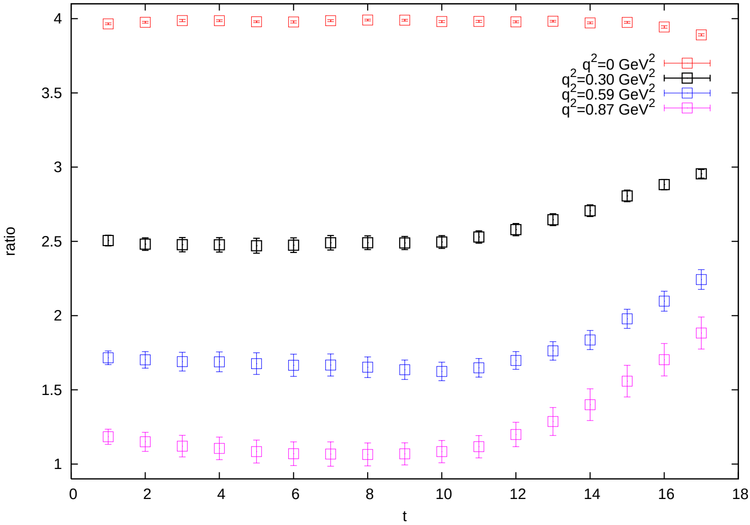
polarisation matrix: $\Gamma^P = \frac{1}{2}(1+\gamma_0), \frac{1}{2}(1+\gamma_0)\frac{1}{2}(1-i\gamma_3\gamma_5)$

local currents: $O = \bar{\Psi}\gamma_\mu\Psi,\ \bar{\Psi}\gamma_5\gamma_\mu\Psi$

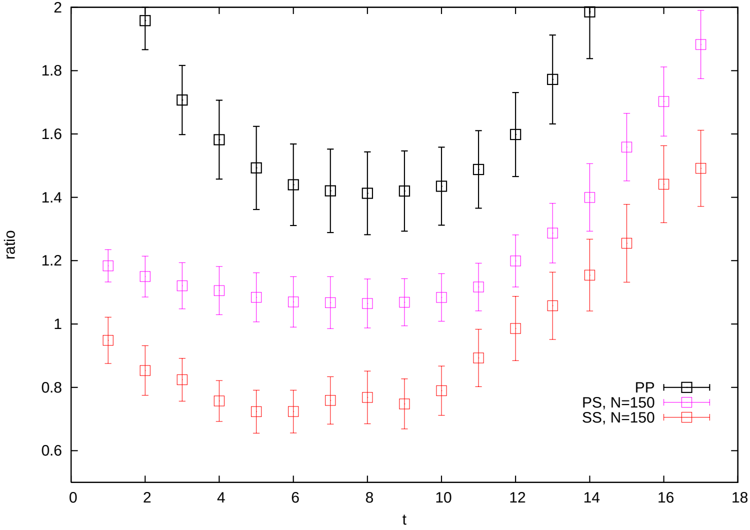
ratio to extract the plateau:

$$R(\vec{q},t,t_s) = \frac{C_3(\vec{q},t,t_s)}{C_2(\vec{0},t_s)}\sqrt{\frac{C_2(\vec{q},t_s-t)C_2(\vec{0},t)C_2(\vec{0},t_s)}{C_2(\vec{0},t_s-t)C_2(\vec{q},t)C_2(\vec{q},t_s)}}$$

connected isoscalar V_0 for different momenta and $t_s = 18$
lattice data: $64x32^3$, $m_\pi = 550 MeV$, smeared-local-operator

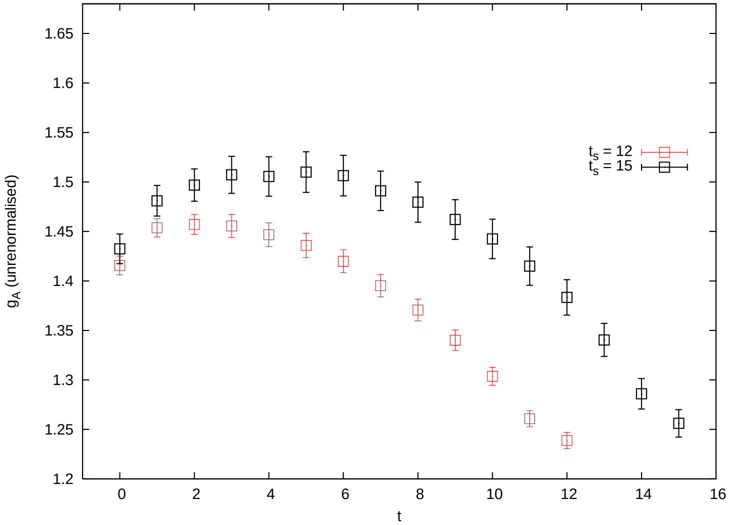


connected isoscalar V^0 for $Q^2 = 0.87 GeV^2$, $t_s = 18$
different source/sink combinations

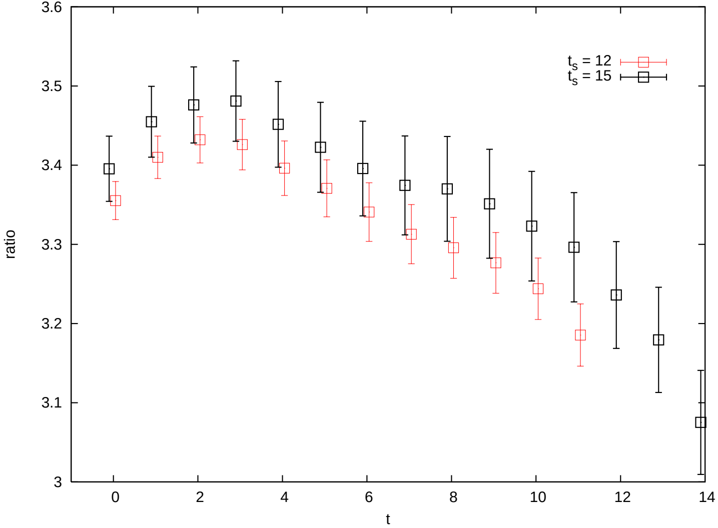


unrenormalised isovector axial charge g_A

lattice data: $64x32^3$, $m_\pi = 550 MeV$, smeared-local-operator



isovector magnetic formfactor for $Q^2 = 0.30 GeV^2$
lattice data: $64x32^3$, $m_\pi = 590 MeV$, smeared-local-operator



the summation method:*

- standard plateau-method:

$$R(\vec{q}, t, t_s) = R_G + \mathcal{O}\left(e^{-\Delta t}\right) + \mathcal{O}\left(e^{-\Delta'(t_s - t)}\right)$$

- sum the ratio int t up to t_s
- after some calculation one gets:

$$\sum_{t=0}^{t_s} R(\vec{q}, t, t_s) = R_G \cdot t_s + c(\Delta, \Delta') + \mathcal{O}\left(e^{-\Delta t_s}\right) + \mathcal{O}\left(e^{-\Delta' t_s}\right)$$

- linear behavior in t_s
- higher state corrections are much smaller for the summation method than for the standard method

how to extract R_G:

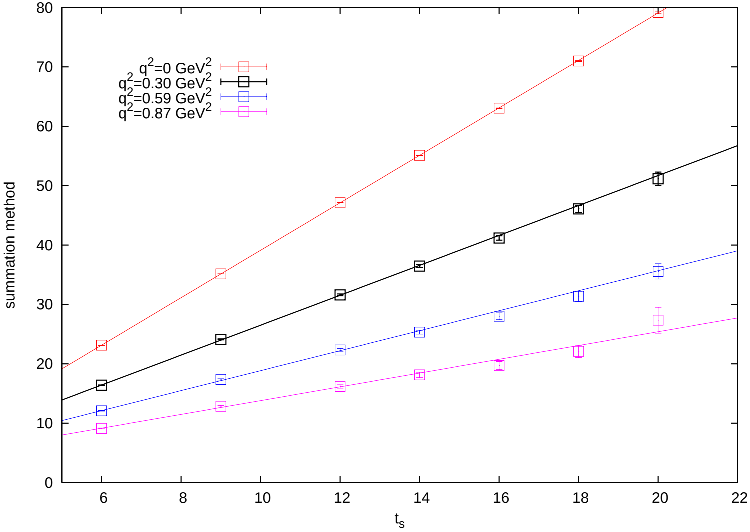
- do inversions for several t_s
- fit a straight line and extract the slope

*(see e.g.: Liu et al., 2009 and earlier papers)

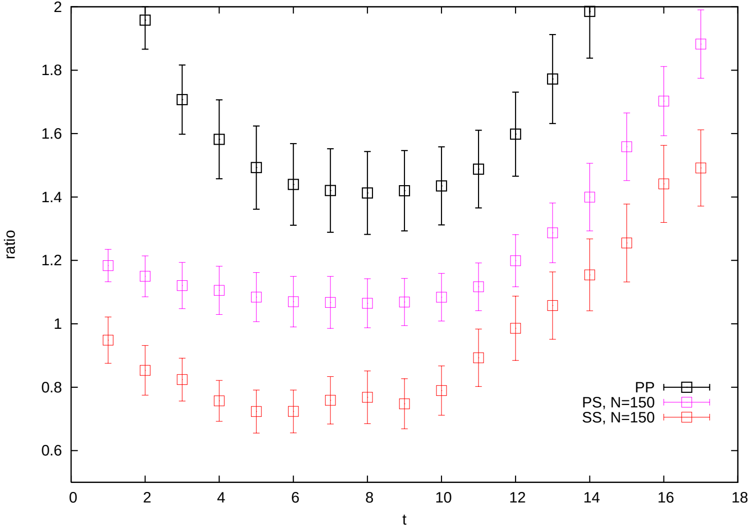
summation method at work:

connected isoscalar V_0 for different momenta

lattice data: $64x32^3, m_\pi = 550 MeV$, smeared-local-operator



connected isoscalar V^0 for $Q^2 = 0.87 GeV^2$, $t_s = 18$
different source/sink combinations



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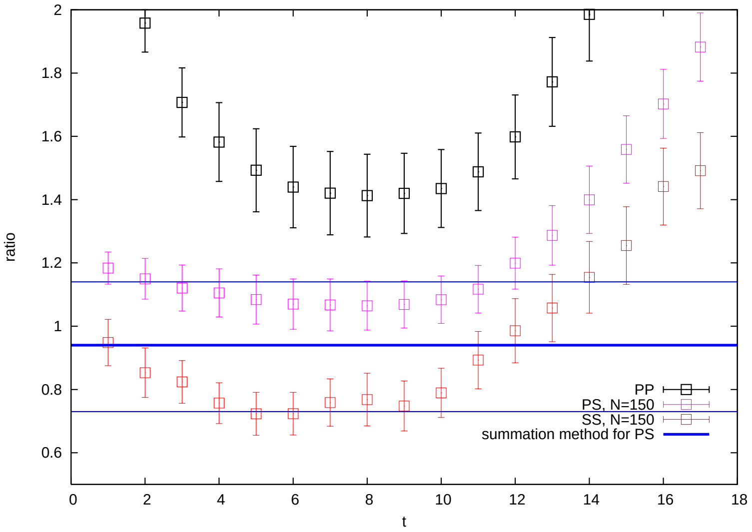

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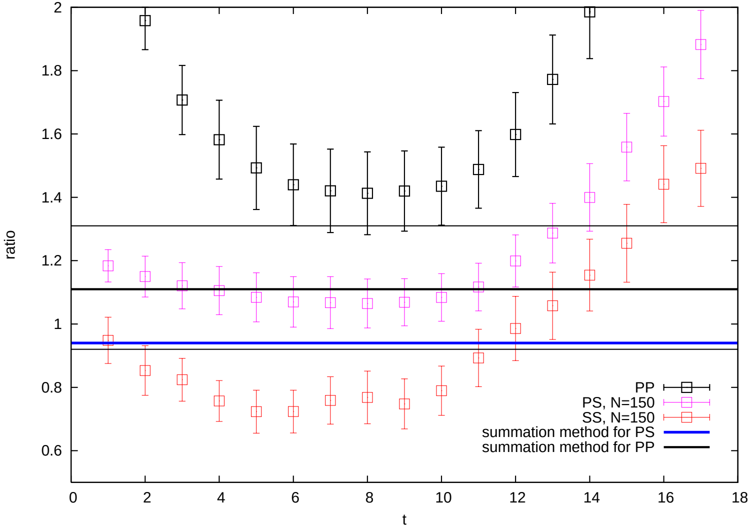

unrenormalised isovector axial charge g_A
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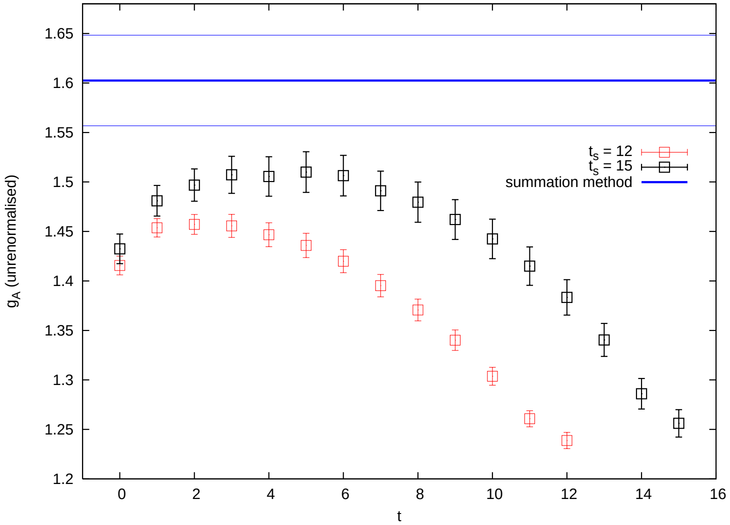

isovector magnetic formfactor for $Q^2 = 0.30 GeV^2$

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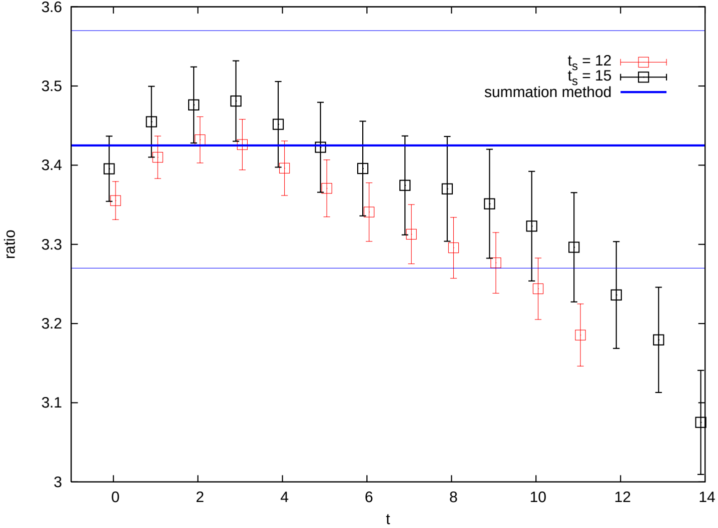
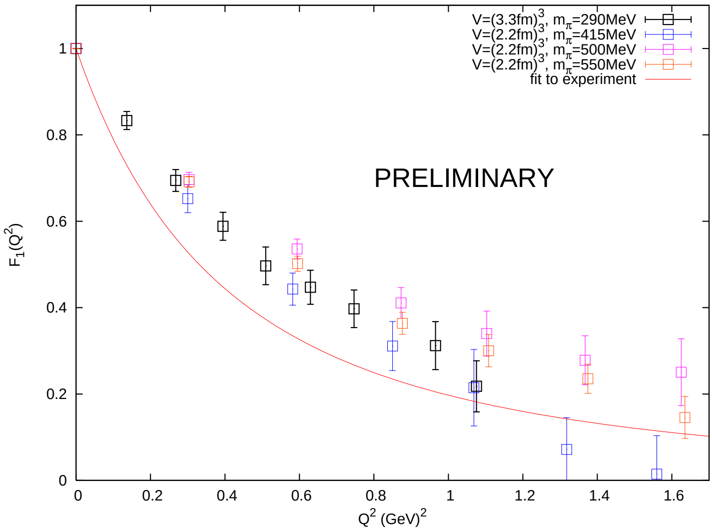
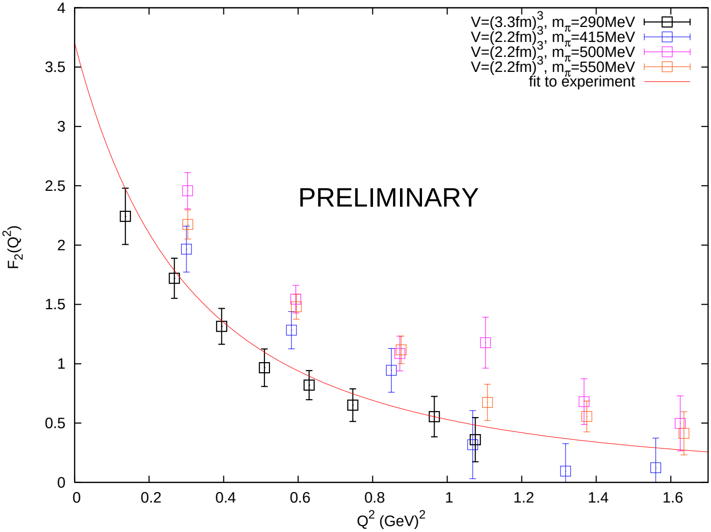


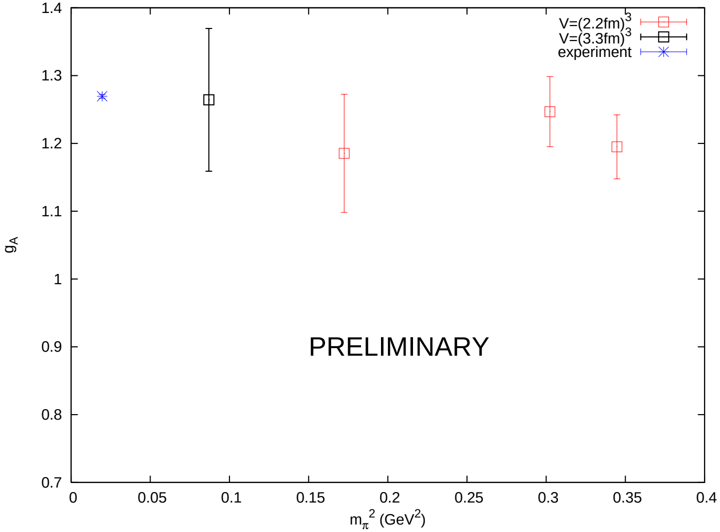
Dirac-Formfactor F1:



Pauli-Formfactor F2:



renormalised axial charge g_A:



conclusions and outlook:

- control of excited states is crucial
- smearing appears to be not enough
- the summation method is promising
- price to pay:
  - more inversions are needed
  - the statistical error grows
- optimise and tune the summation method
- analysis of the axial formfactors: $G_A(Q^2)$, $G_P(Q^2)$
- measurements on lattices with $\beta = 5.2, 5.5$
- continuum-extrapolation

Thank you!