Status in computation of the Form Factors and GPD correlators at ß=3.9 with 4 projectors

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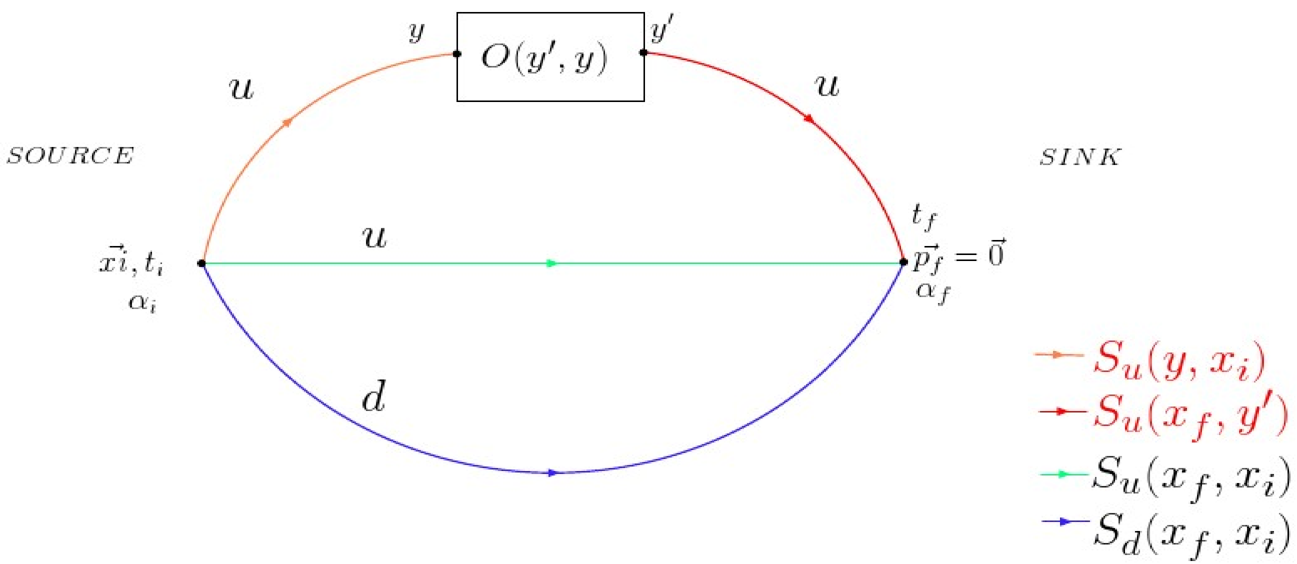
ETMC Meeting in Autrans

- Form Factors and Generalized Parton Distribution functions give access to the hadronic tensor of the nucleon, picture of its structure

- On the lattice: computing operators between nucleon states

$$\langle P_{\alpha_f}(t_f, \vec{p_f} = \vec{0}) O(y', y) P_{\alpha_i}(x_i) \rangle = \prod_{spin,color} S_{u1}(x_f, y') O(y', y) S_{u1}(y, x_i) S_d(x_f, x_i) S_{u2}(x_f, x_i)$$

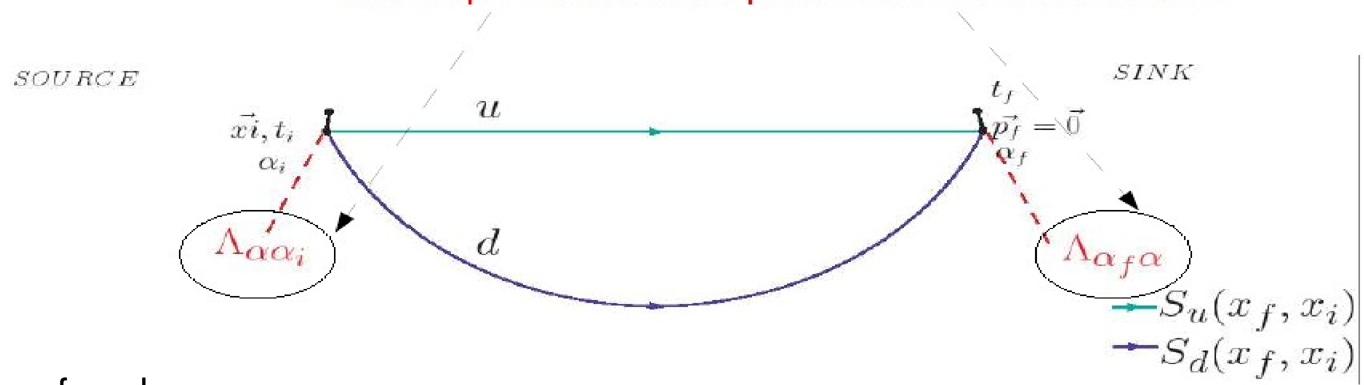


General form of the operator for form factors and GPDs:

$$\mathcal{O}^{\{\mu_1 \ldots \mu_n\}}_{[\gamma_5]} = \overline{q}(0) \gamma^{\{\mu_1} [\gamma_5] i \overleftrightarrow{D}^{\mu_2} \cdots i \overleftrightarrow{D}^{\mu_n\}} q(0)$$

One source for each :

- t_f
- $\vec{p_f}$
- $\alpha_i \ , \ \alpha_f$ → Trace with projecteur on parity (and/or) spin at the spin indices of the proton field in the source term



At zero momentum transfered:

$$\frac{Tr(\Lambda_{\alpha_i\alpha_f} < P_{\alpha_f}(\vec{p}_f = \vec{0}, T_{sink}) | O^{\mu\nu}(\vec{q}, t) | P_{\alpha_i}(x_i)) >}{Tr(\Lambda_0 < P | \bar{P} >)} \longrightarrow \alpha \quad \text{physical value}$$

In practice

→ Computation of generalised propagators where the time of sink (=12), the momentum at the sink and the projector on the nucleon spin indices are fixed

→ APE Smearing and Gaussian Smearing at the source and the sink

→ To avoid disconnected part only isovector current operator computed

→ Twist-1 and twist-2 operators implemented

Study of projectors :

- One projector for non-spin flip operator and spin flip operators : $\frac{1}{4}(1+\gamma_0)\ (1-i\gamma_5\sum_k \gamma_k)$
  - Noise for both type of operators

- One projector for non-spin flip operator : $\frac{1}{2}(1+\gamma_0)$

  one for spin flip operators : $\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\sum_k \gamma_k)$

- One projector for non-spin flip operator: $\frac{1}{2}(1+\gamma_0)$

  3 for spin flip operators, one for each component of the observable

$$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_3)$$
$$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_2)$$
$$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_1)$$

  - Give the smallest errors when each component is summed independantly

    But 4 inversions are needed

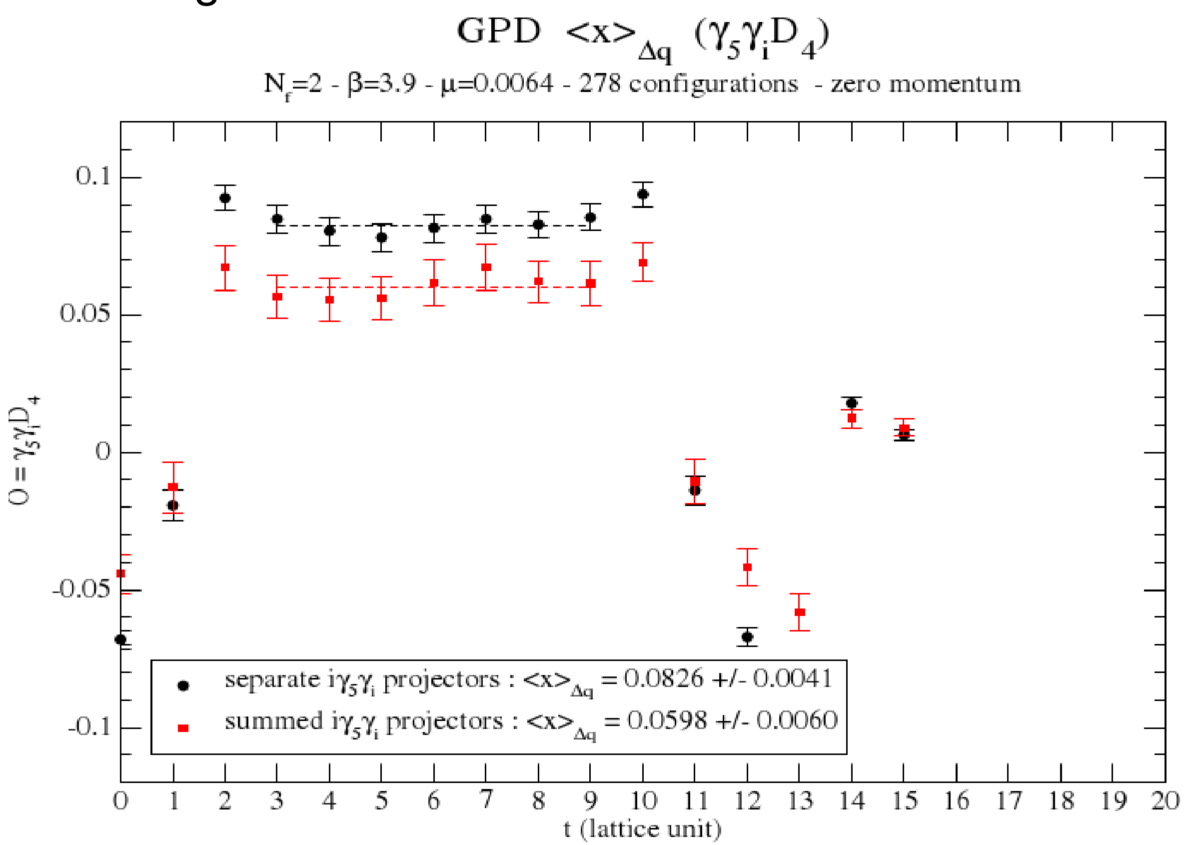
Example for gA:

signal

$$Tr(\tfrac{1}{4}(1+\gamma_0)\ i\gamma_5(\gamma_1+\gamma_2+\gamma_3)P\ (g_A\gamma_5\gamma_3)\ \bar{P})$$

noise

Study at μ=0.0064 with 277 configurations :



→ For fixed number of configurations, improvement of the errors by 1.5 – 2 with 2 more inversions

Number of 3 points correlators with momentum at ß=3.9,L= 24,T=48 for 4 projectors :

	$\mu = 0.01$	$\mu = 0.0085$	$\mu = 0.0064$	$\mu = 0.004$
Statistic	470	0->372	556	953

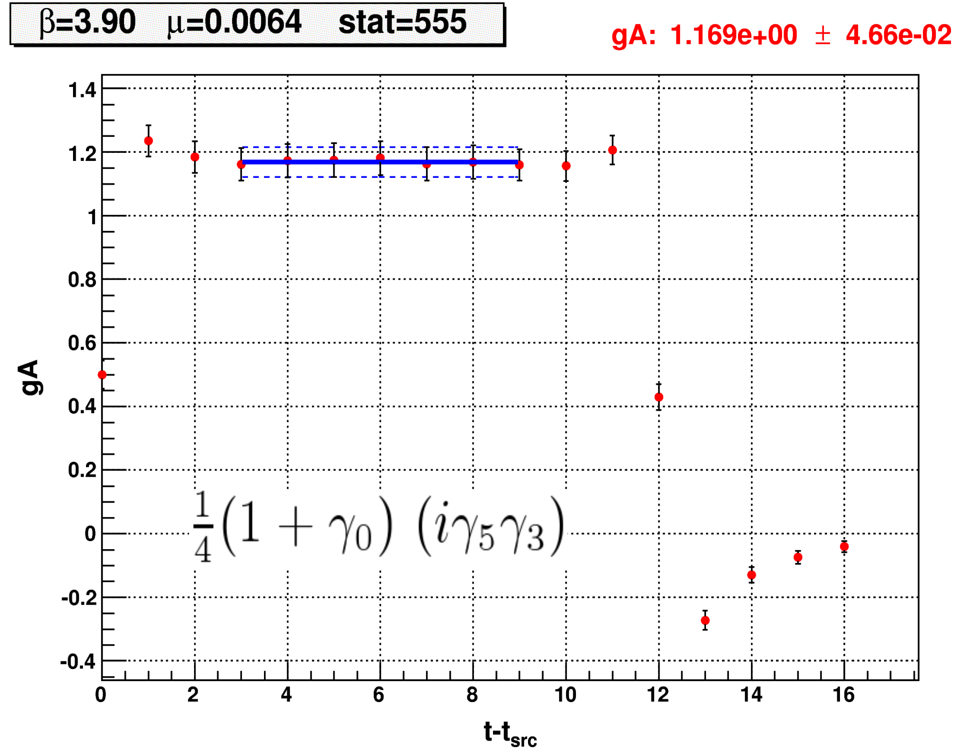
gA:

$$O_{\mu 5} = \gamma_\mu \gamma_5 G_A$$ Z_A=0.76

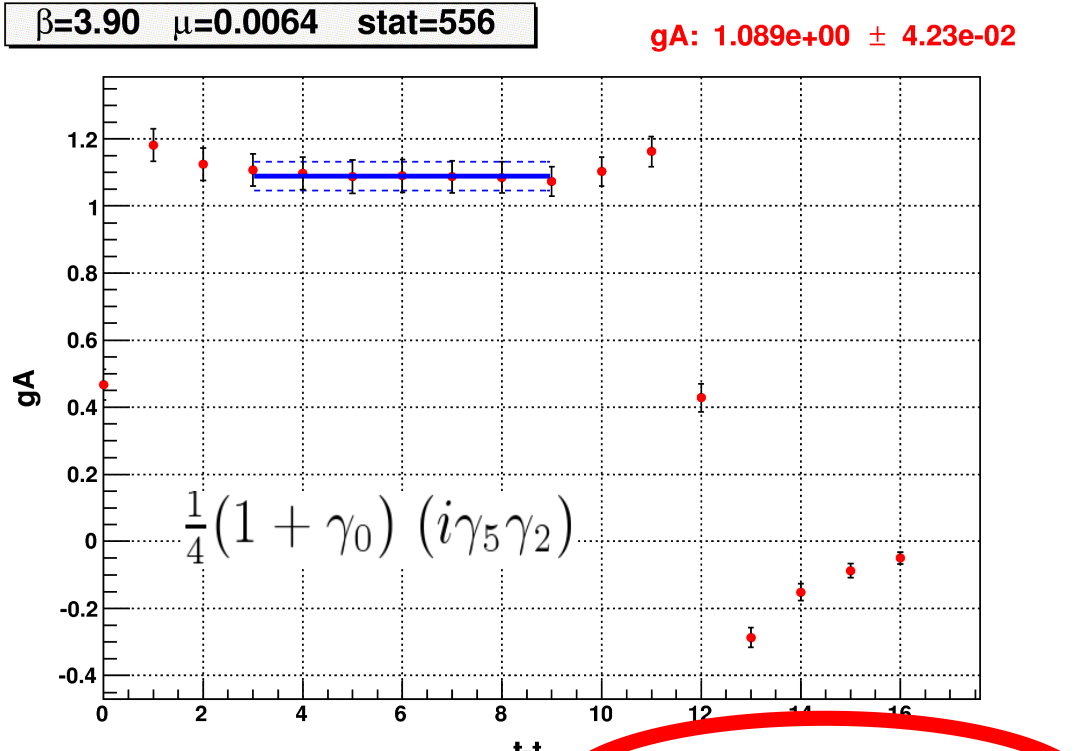
g_A	$\frac{(1+\gamma_0)}{2}(i\gamma_5\gamma_3)$	$\frac{(1+\gamma_0)}{2}(i\gamma_5\gamma_2)$	$\frac{(1+\gamma_0)}{2}(i\gamma_5\gamma_1)$	sum of three
$\mu = 0.01$	1.136 ± 0.03	1.199 ± 0.029	1.159 ± 0.028	1.164 ± 0.019
$\mu = 0.0064$	1.169 ± 0.046	1.089 ± 0.042	1.149 ± 0.043	1.135 ± 0.028
$\mu = 0.004$			1.119 ± 0.023	

Experimental value: 1.27

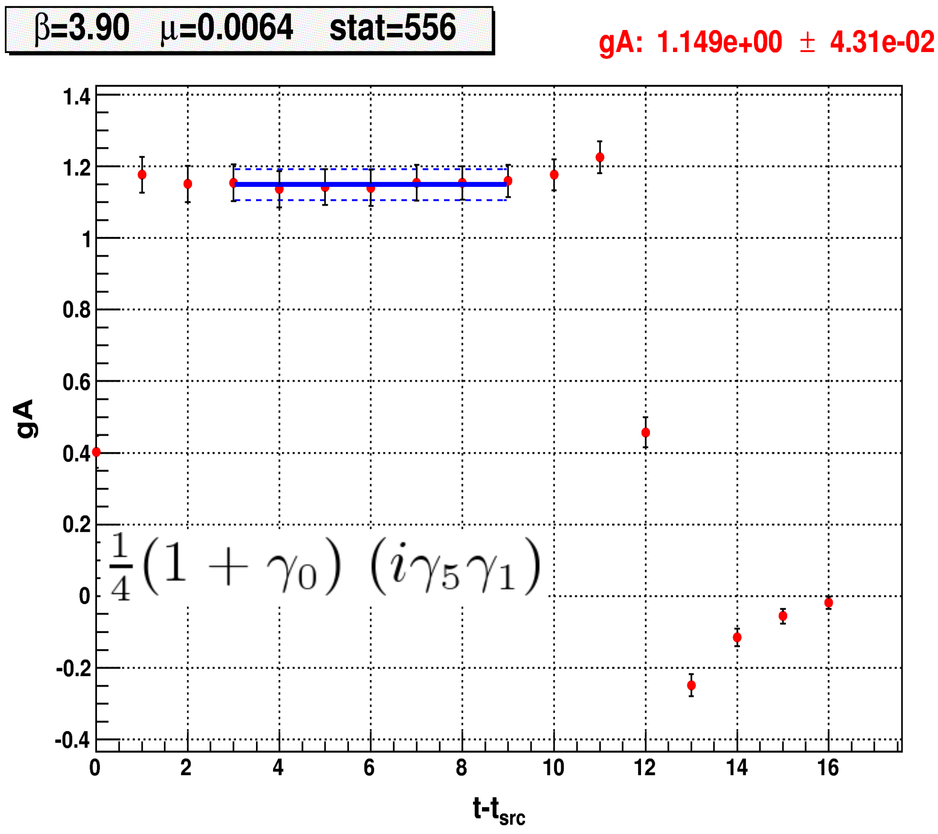
On 705 configurations



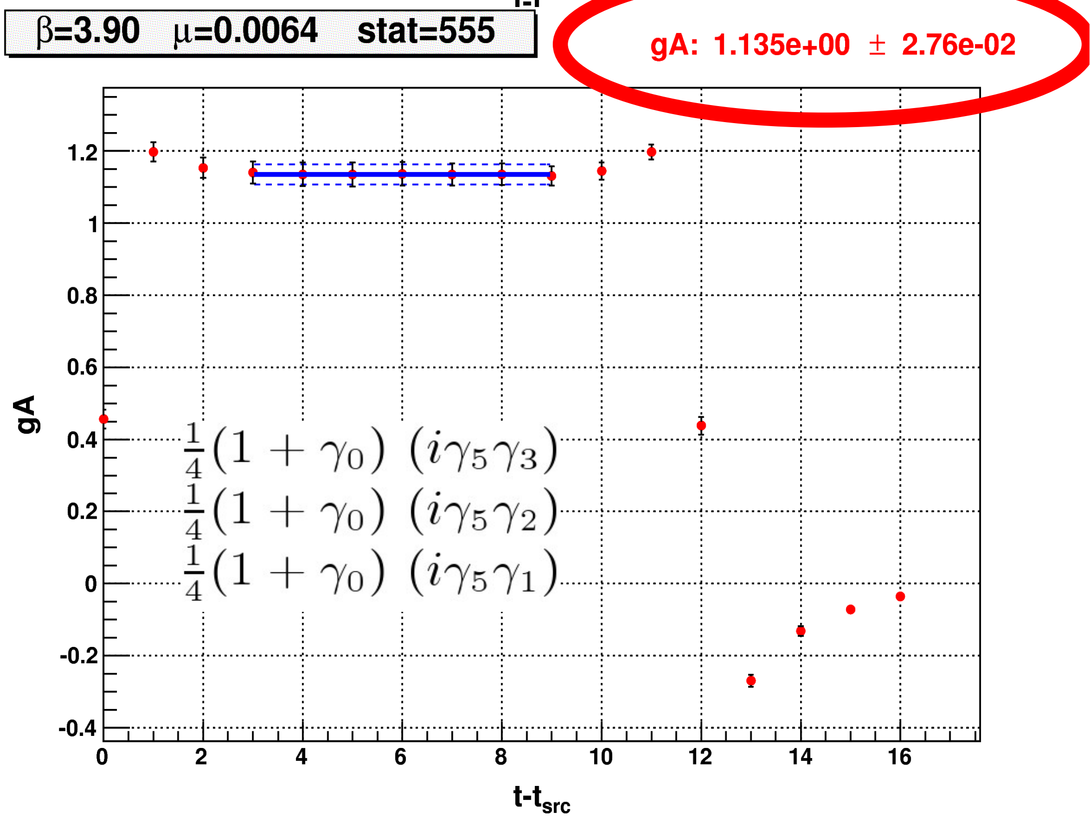
β=3.90 μ=0.0064 stat=555
gA: 1.169e+00 ± 4.66e-02
gA
t-t_src
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_3)$



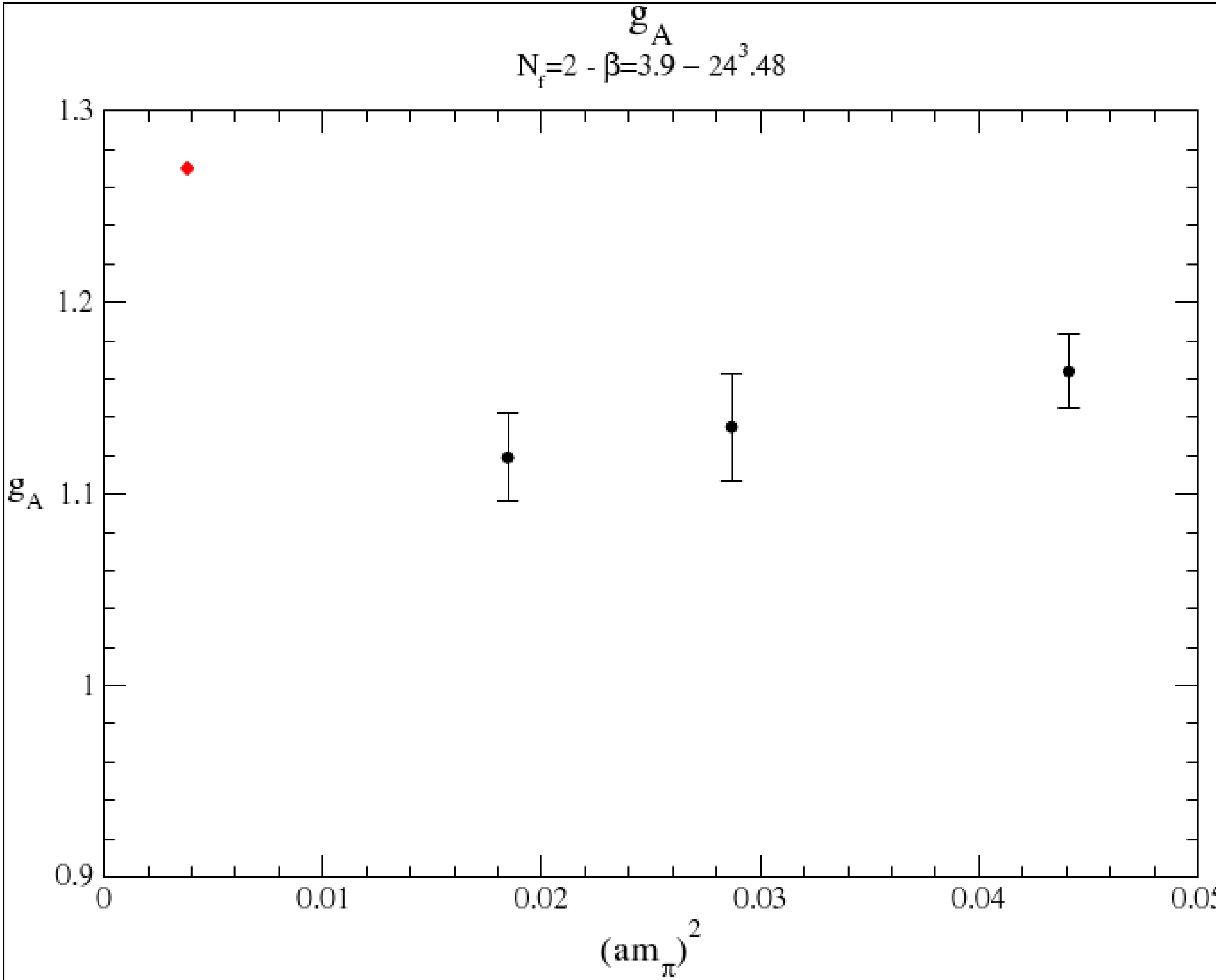
β=3.90 μ=0.0064 stat=556
gA: 1.089e+00 ± 4.23e-02
gA
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_2)$



β=3.90 μ=0.0064 stat=556
gA: 1.149e+00 ± 4.31e-02
gA
t-t_src
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_1)$



β=3.90 μ=0.0064 stat=555
gA: 1.135e+00 ± 2.76e-02
gA
t-t_src
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_3)$
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_2)$
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_1)$



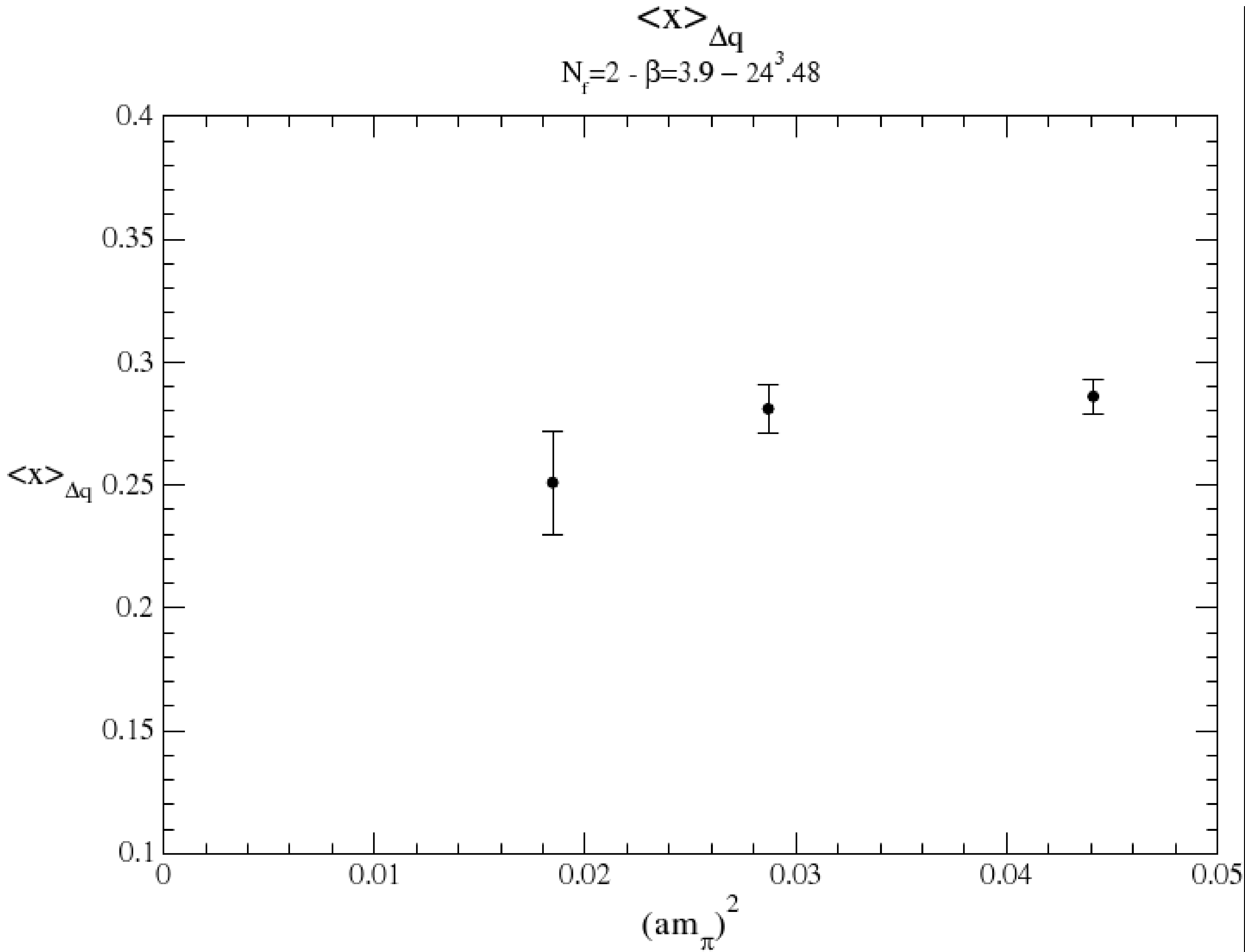
g_A
N_f=2 - β=3.9 – 24^3.48
g_A
1.3
1.2
1.1
1
0.9
0
0.01
0.02
0.03
0.04
0.05
$(am_\pi)^2$

$< x >_{\Delta_q}$

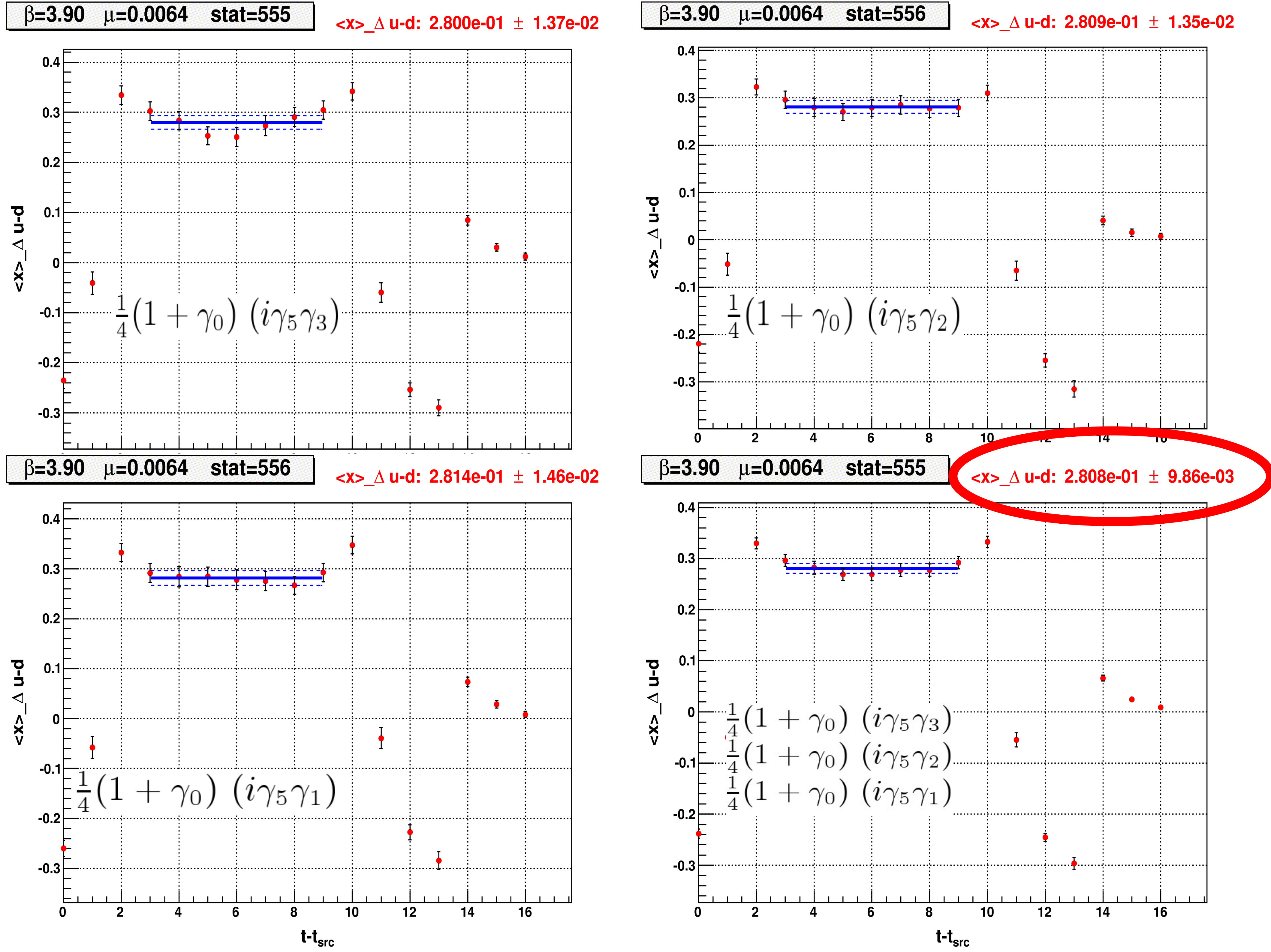
Operator : $\frac{1}{3}\gamma_5(\gamma_{\{1}\overleftrightarrow{D}_{0\}} + \gamma_{\{2}\overleftrightarrow{D}_{0\}} + \gamma_{\{3}\overleftrightarrow{D}_{0\}})$

$< x >_{\Delta_q}$	$\frac{(1+\gamma_0)}{2}(i\gamma_5\gamma_3)$	$\frac{(1+\gamma_0)}{2}(i\gamma_5\gamma_2)$	$\frac{(1+\gamma_0)}{2}(i\gamma_5\gamma_1)$	sum of three
$\mu = 0.01$	0.284 ± 0.010	0.287 ± 0.009	0.285 ± 0.009	0.286 ± 0.007
$\mu = 0.0064$	0.280 ± 0.014	0.281 ± 0.015	0.280 ± 0.014	0.281 ± 0.010
$\mu = 0.004$			0.251 ± 0.021	

On 705 configurations



<x>Δq
N_f=2 - β=3.9 – 24^3.48
0.4
0.35
0.3
0.25
0.2
0.15
0.1
<x>Δq
0
0.01
0.02
0.03
0.04
0.05
(am_π)^2

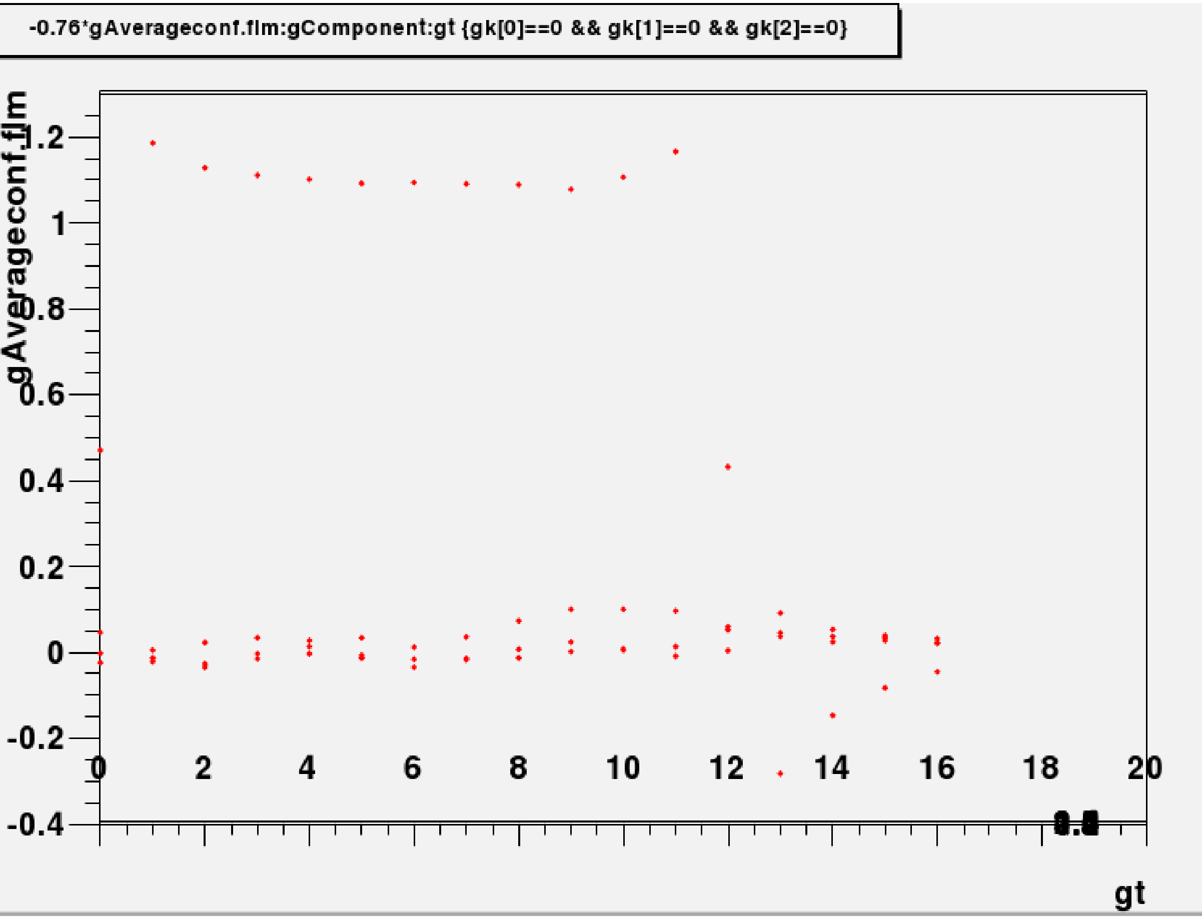


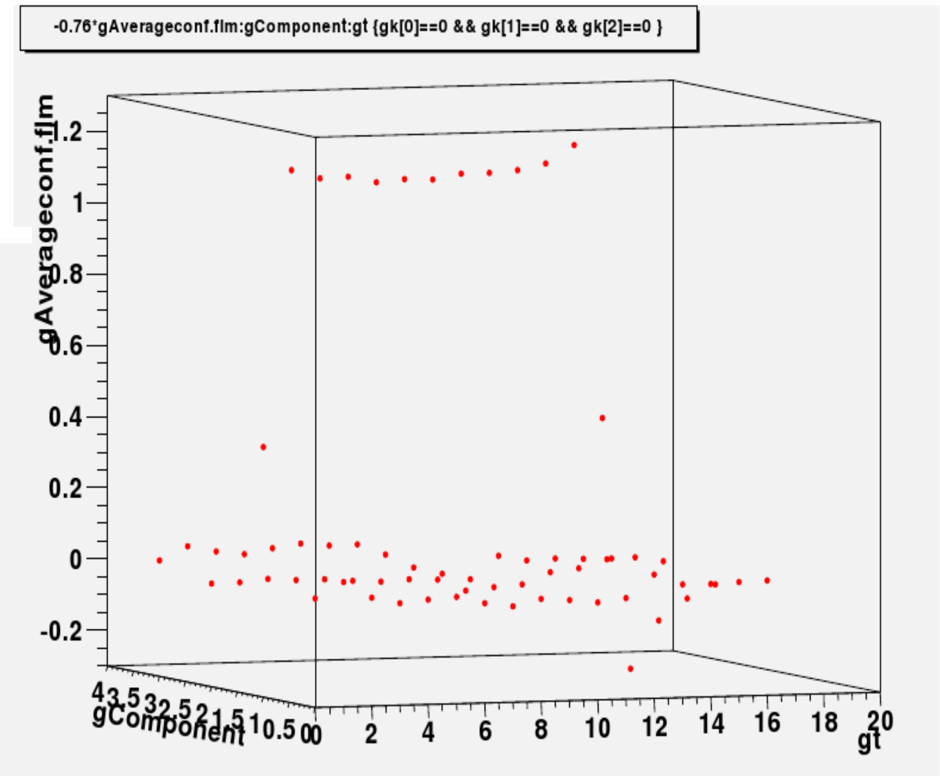
β=3.90 μ=0.0064 stat=555
<x>_Δ u-d: 2.800e-01 ± 1.37e-02
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_3)$
β=3.90 μ=0.0064 stat=556
<x>_Δ u-d: 2.809e-01 ± 1.35e-02
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_2)$
β=3.90 μ=0.0064 stat=556
<x>_Δ u-d: 2.814e-01 ± 1.46e-02
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_1)$
β=3.90 μ=0.0064 stat=555
<x>_Δ u-d: 2.808e-01 ± 9.86e-03
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_3)$
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_2)$
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_1)$
<x>_Δ u-d
t-t_src

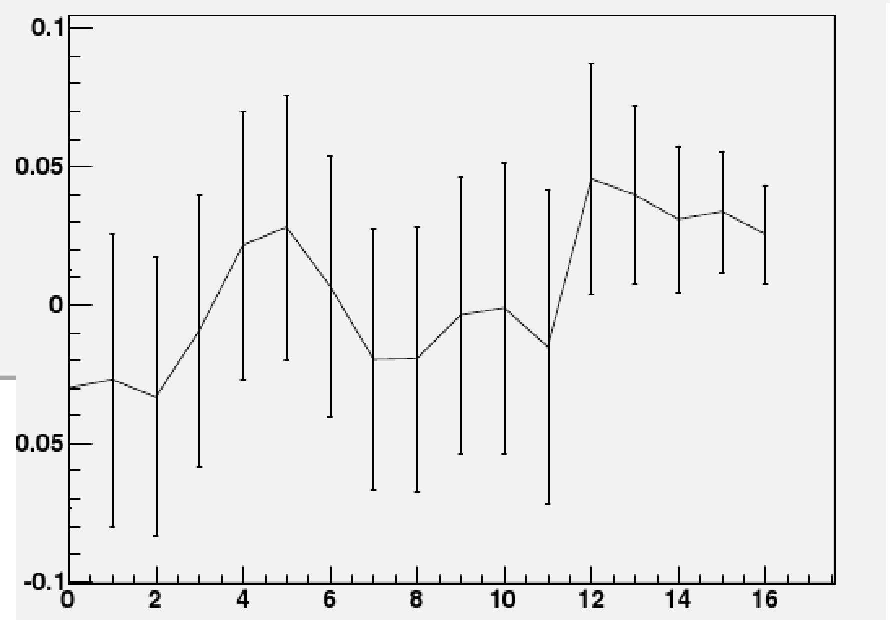
Come back on the « discrepancy between projectors »

Projector : $\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_3)$

$$O_{\mu 5} = \gamma_\mu \gamma_5 G_A$$



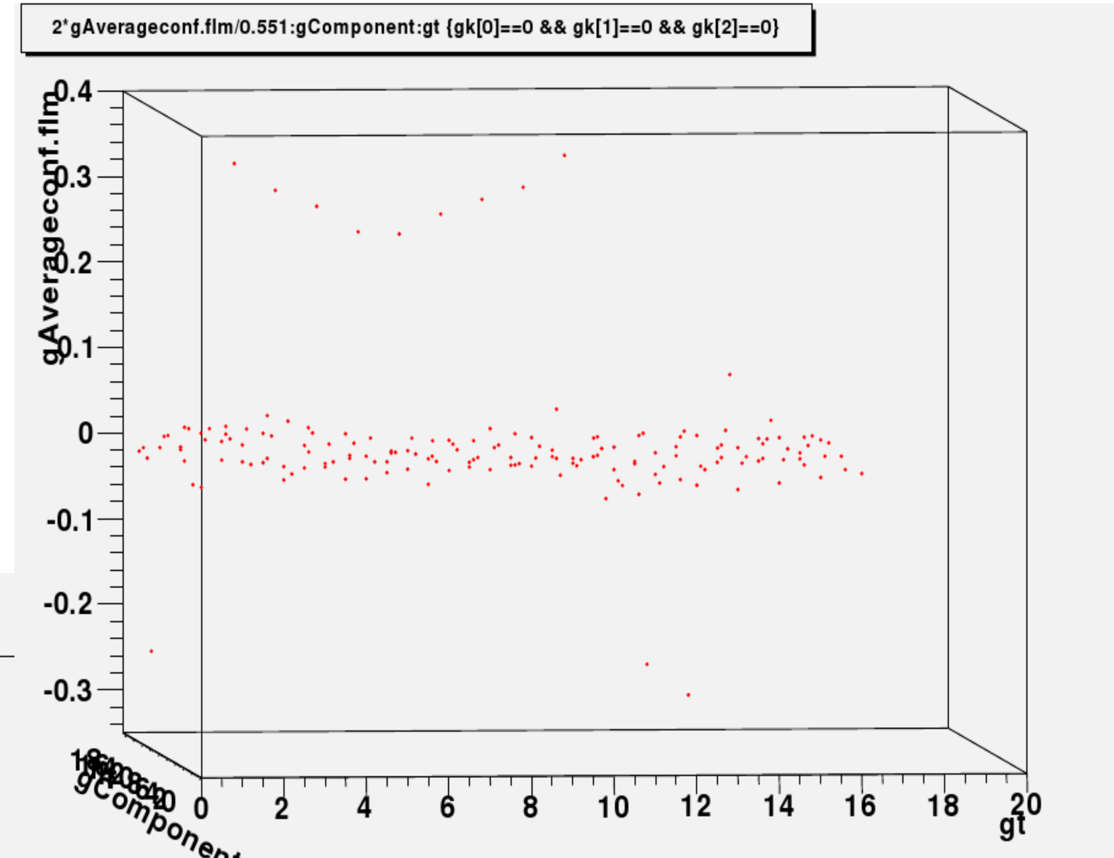


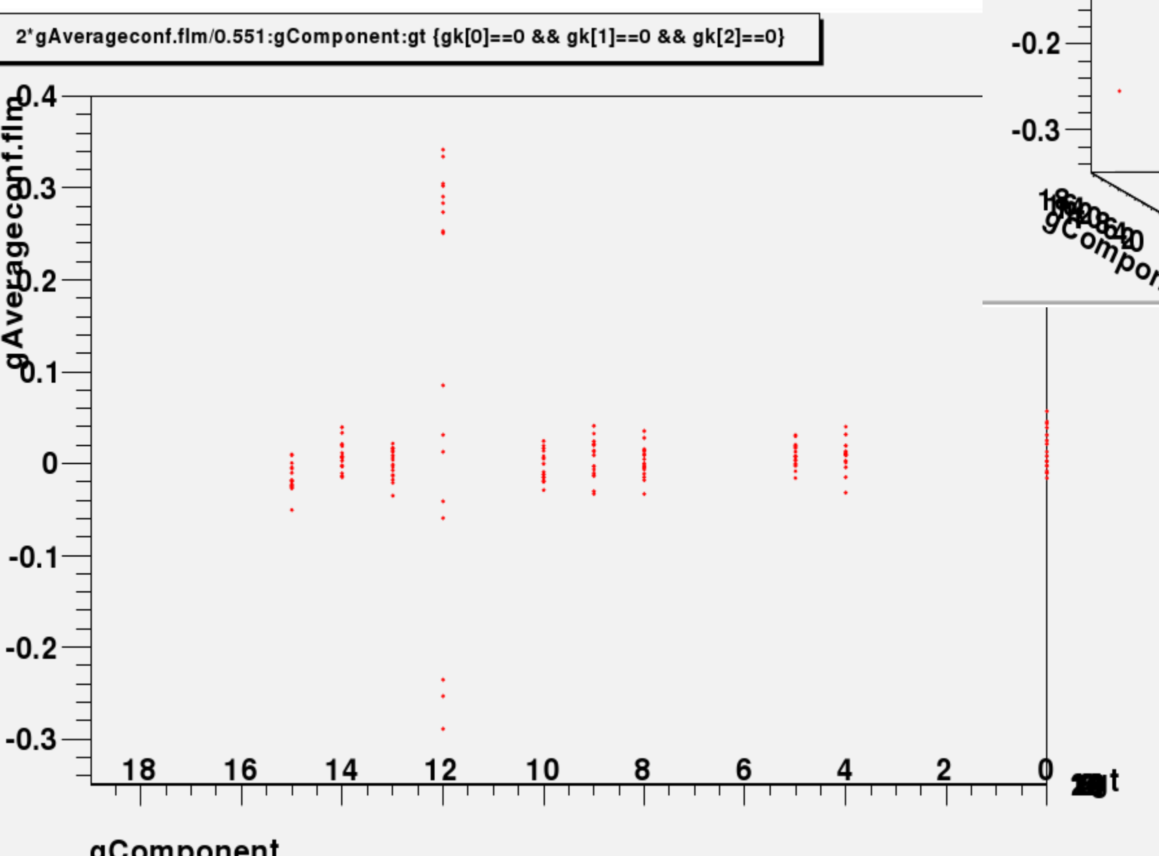


Come back on the « discrepancy » between projectors

Projector $: \frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_3)$

Operator $\gamma_5(\gamma_{\{\mu}\overleftrightarrow{D}_{\nu\}})$





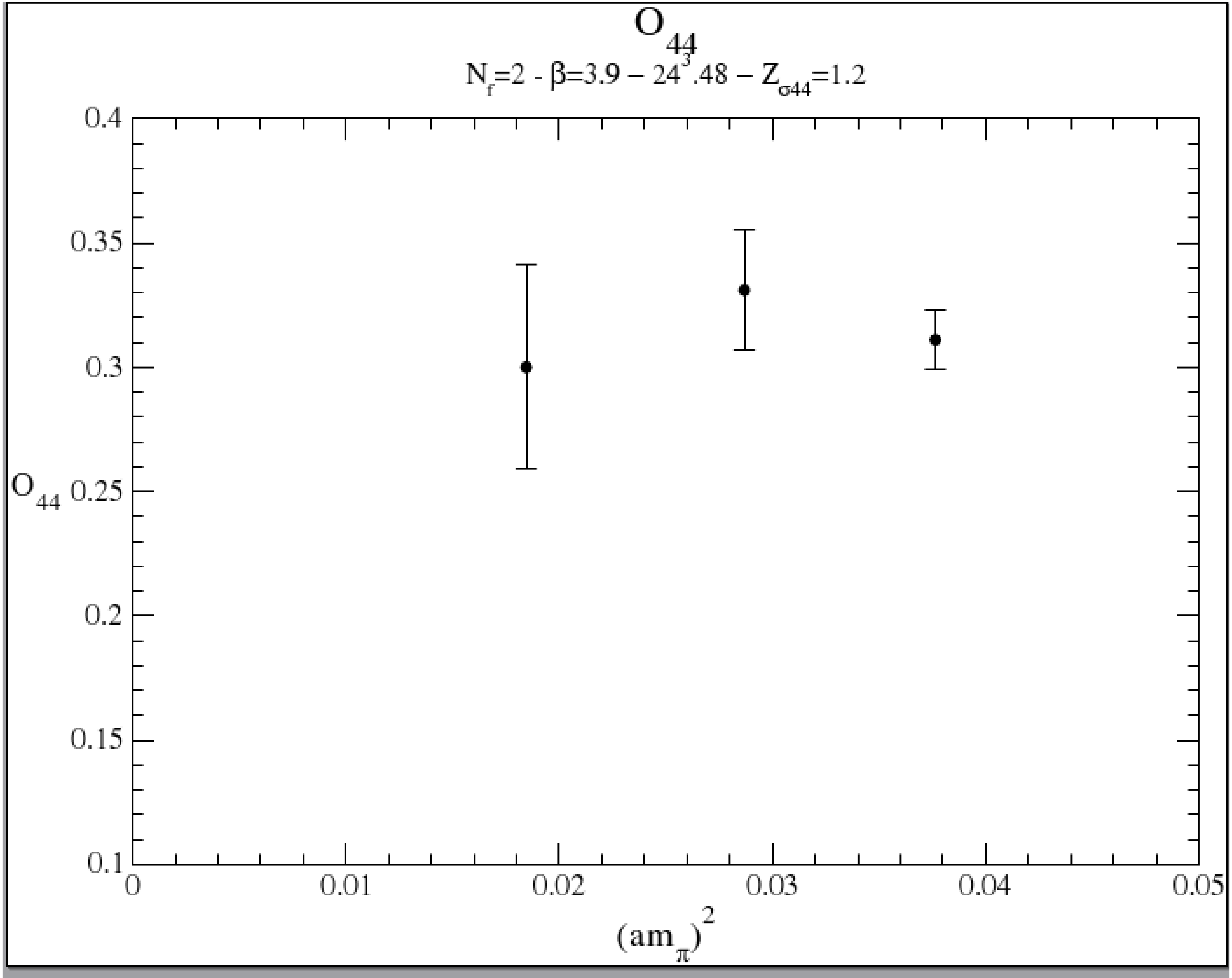
$< x >_q$

Operator : $\gamma_0 \overleftrightarrow{D}_0 - \frac{1}{3}(\gamma_1 \overleftrightarrow{D}_1 + \gamma_2 \overleftrightarrow{D}_2 + \gamma_3 \overleftrightarrow{D}_3)$

Z_{44} = 1.2, computed by Zhaofeng and Vincent Morenas

Results from Tomasz :

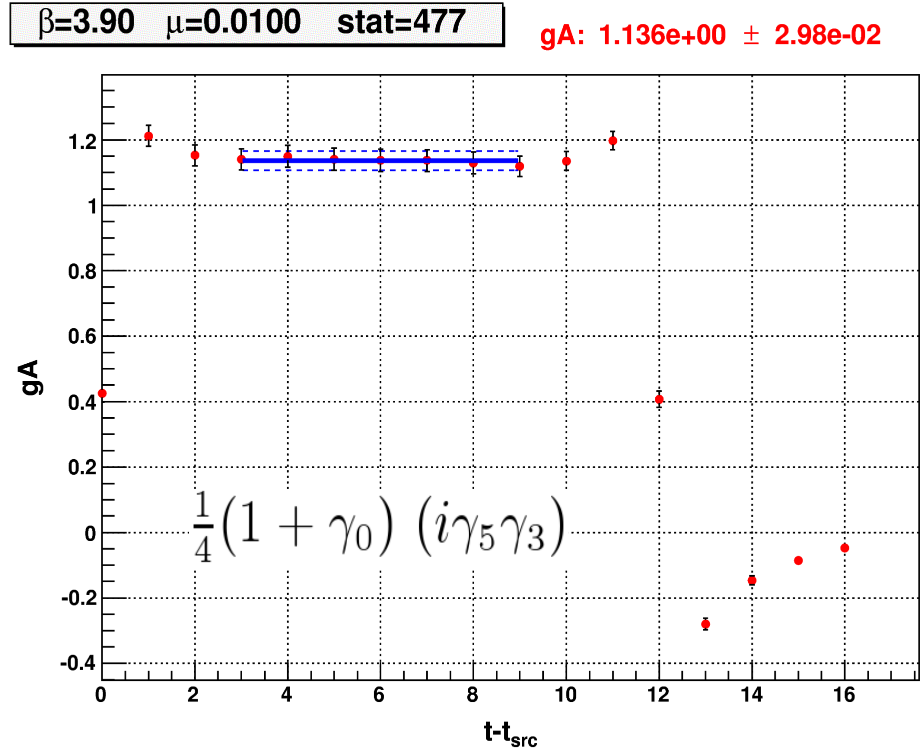
	Stat	$Z_{44}{}^{*}O_{44}$
$\mu = 0.0085$	480	0.311(12)
$\mu = 0.0064$	180	0.331(24)
$\mu = 0.004$	180	0.300(41)

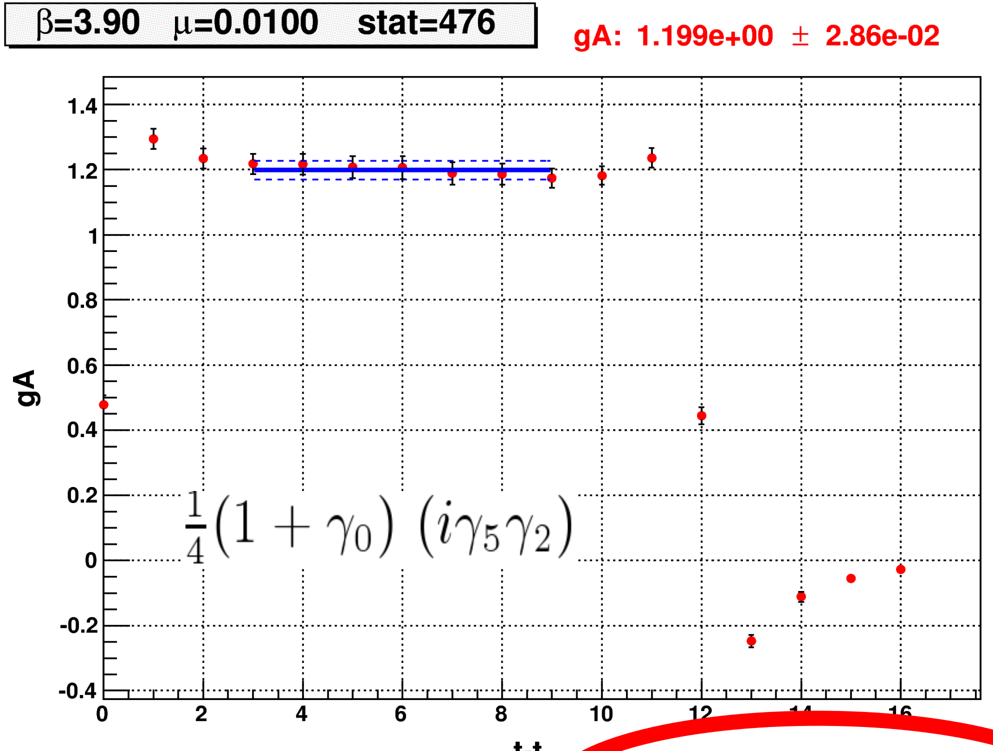


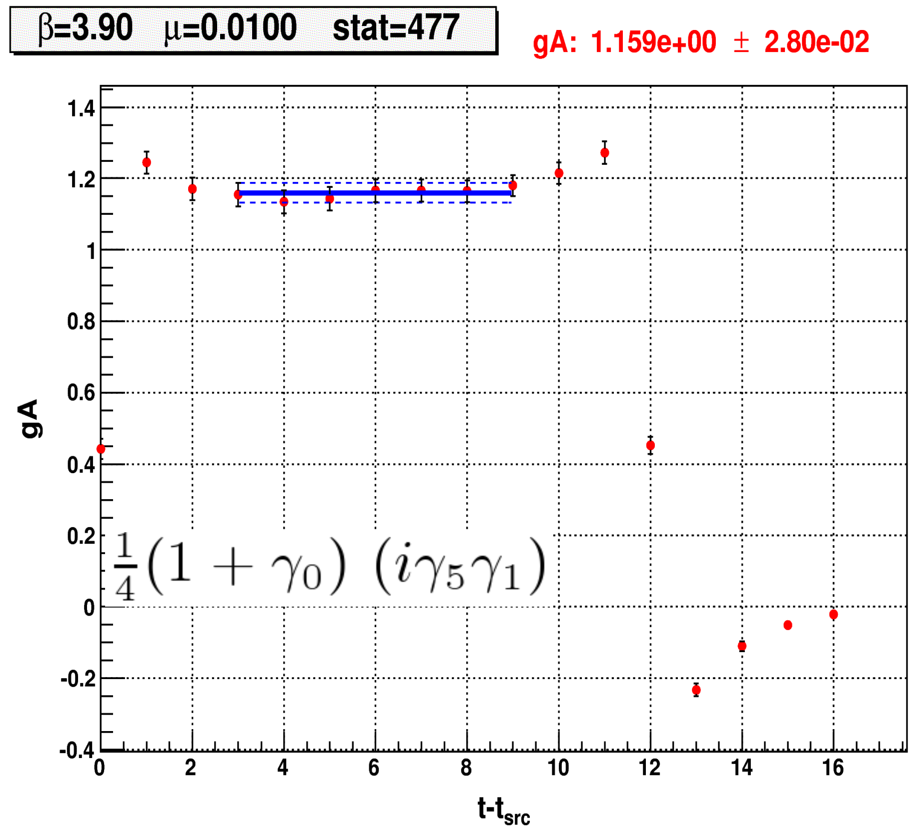
O_{44}
$N_f=2$ - $\beta=3.9$ – $24^3.48$ – $Z_{\sigma 44}=1.2$
O_{44}
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
0.01
0.02
0.03
0.04
0.05
$(am_\pi)^2$

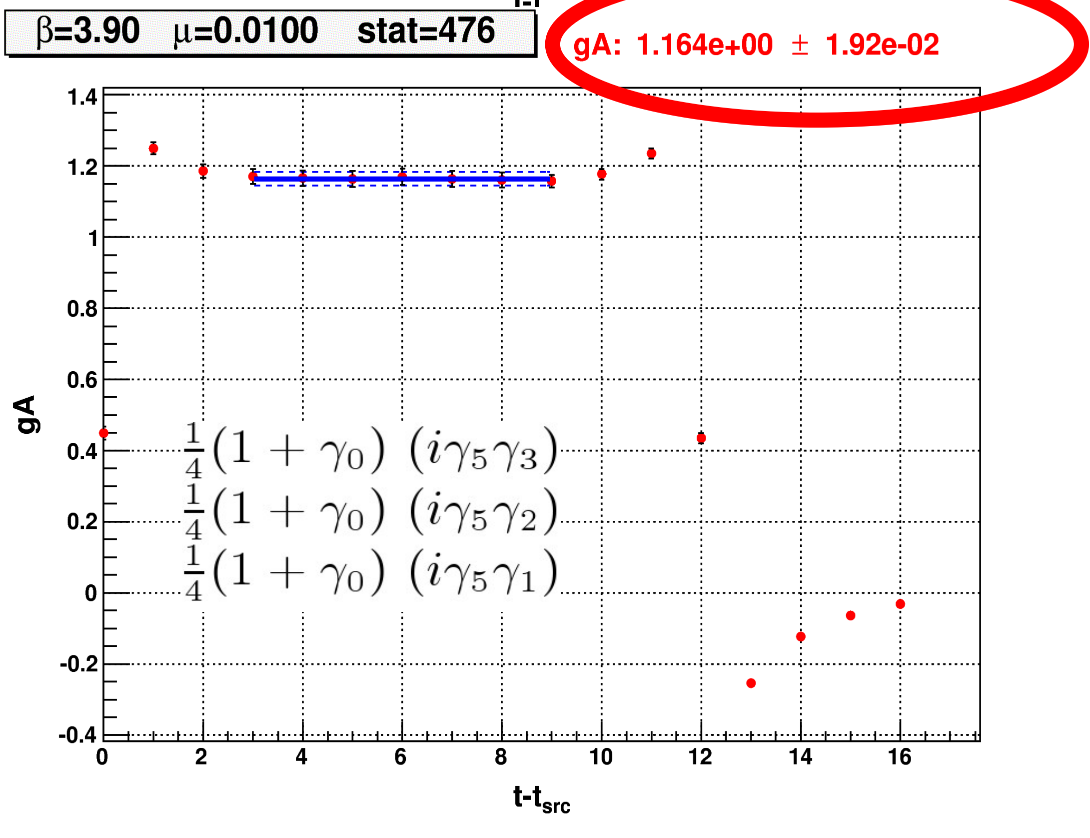
Perspectives

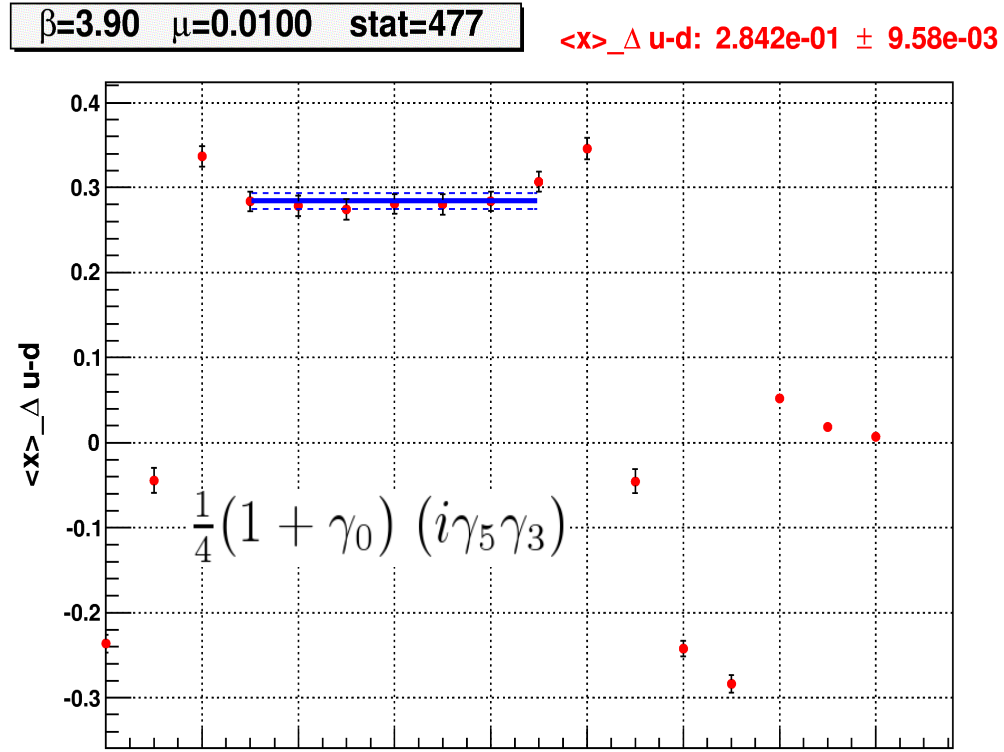
- Analysis of the full statistic with momentum
- Fat link to improve the operator
- Disconnected diagrams with stochastic propagators
- Flavour operator $\bar{u}Od$, $\bar{d}Ou$
- Need to renormalise the operator

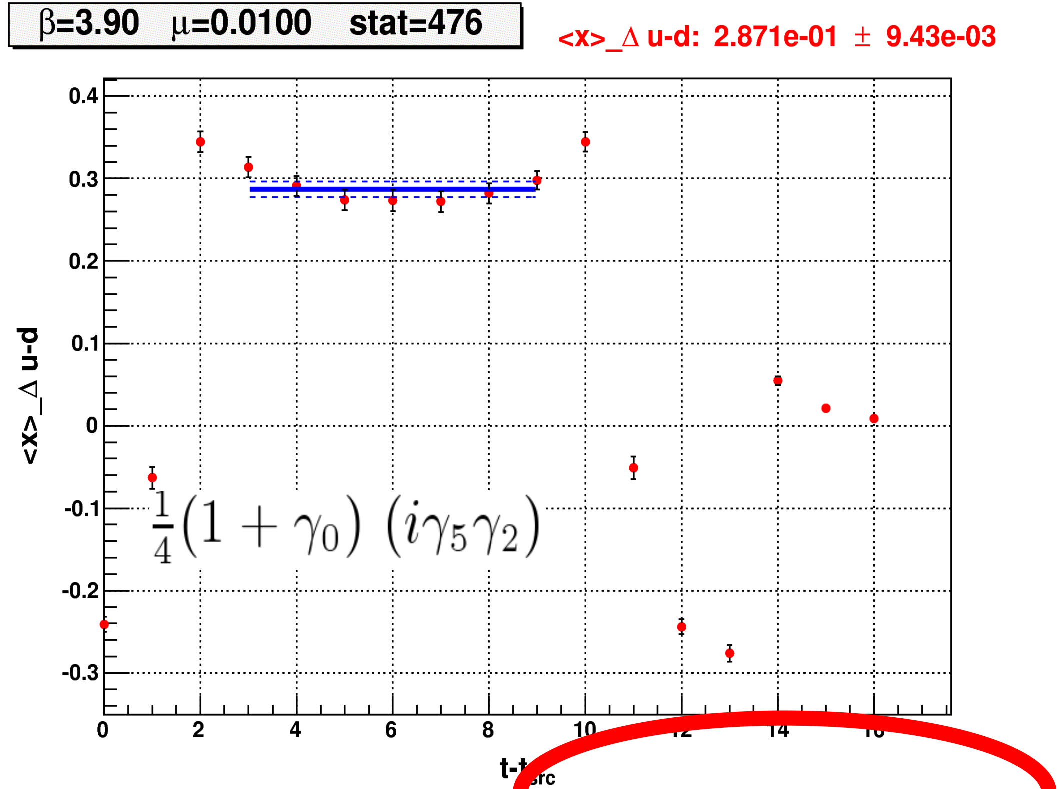

β=3.90 μ=0.0100 stat=477
gA: 1.136e+00 ± 2.98e-02
gA
t-t_src
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_3)$

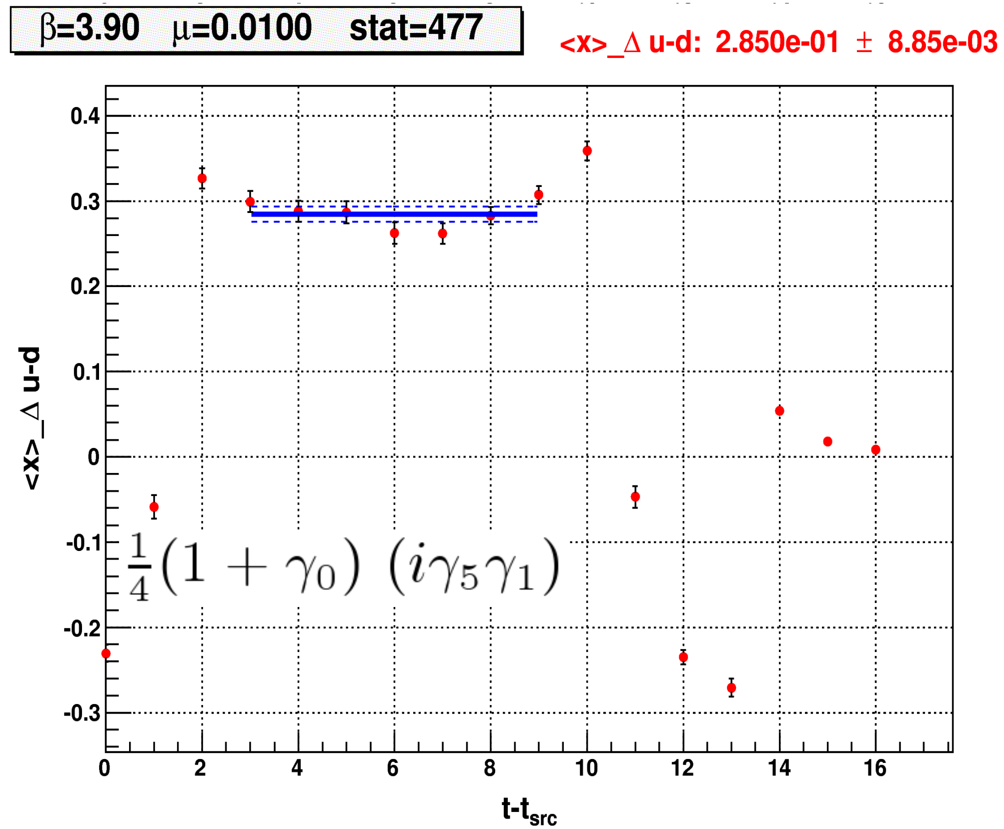

β=3.90 μ=0.0100 stat=476
gA: 1.199e+00 ± 2.86e-02
gA
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_2)$


β=3.90 μ=0.0100 stat=477
gA: 1.159e+00 ± 2.80e-02
gA
t-t_src
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_1)$


β=3.90 μ=0.0100 stat=476
gA: 1.164e+00 ± 1.92e-02
gA
t-t_src
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_3)$
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_2)$
$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_1)$







$$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_3)$$
$$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_2)$$
$$\frac{1}{4}(1+\gamma_0)\ (i\gamma_5\gamma_1)$$