# Discussion on quasi-PDFS

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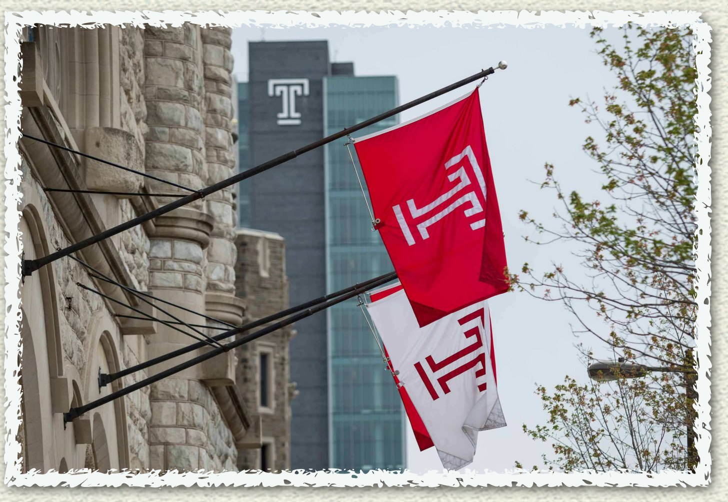


INT workshop on Probing
Nucleons and Nuclei in High Energy Collisions
October 16, 2018

# Crucial aspects of calculation

1. Are there better alternatives for the Fourier transform to the x-space?

# Alternative Fourier

**Standard Fourier (SF):**

$$\tilde{q}(x) = 2P_3 \int_{-z_{\max}}^{z_{\max}} \frac{dz}{4\pi} e^{ixzP_3} h(z)$$

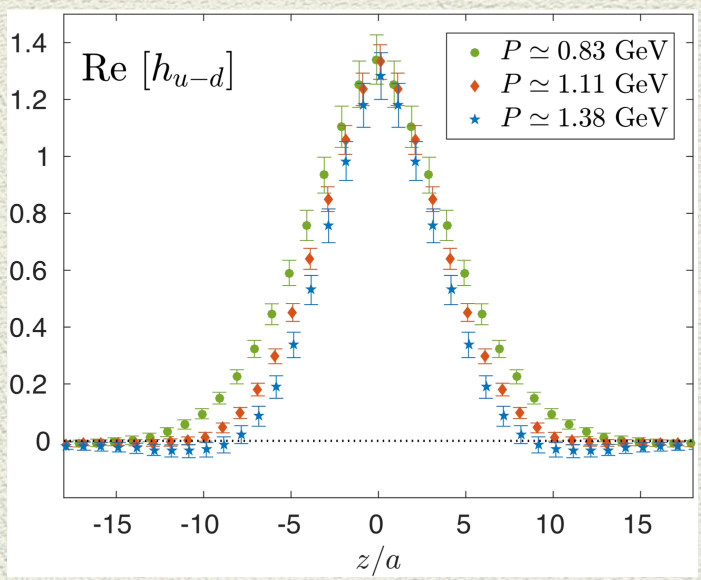
**can be written using integration by parts (DF):**

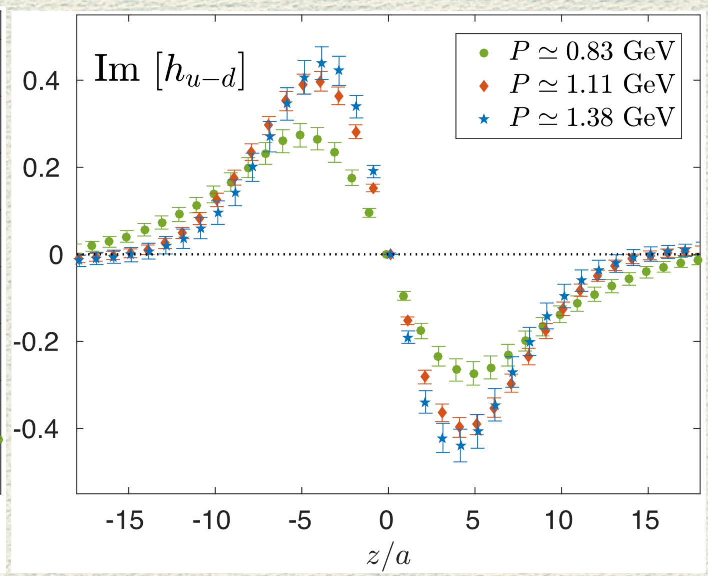
$$\tilde{q}(x) = h(z) \frac{e^{ixzP_3}}{2\pi i x} \Big|_{-z_{\max}}^{z_{\max}} - \int_{-z_{\max}}^{z_{\max}} \frac{dz}{2\pi} \frac{e^{ixzP_3}}{ix} h'(z)$$

[H.W. Lin et al., arXiv:1708.05301]

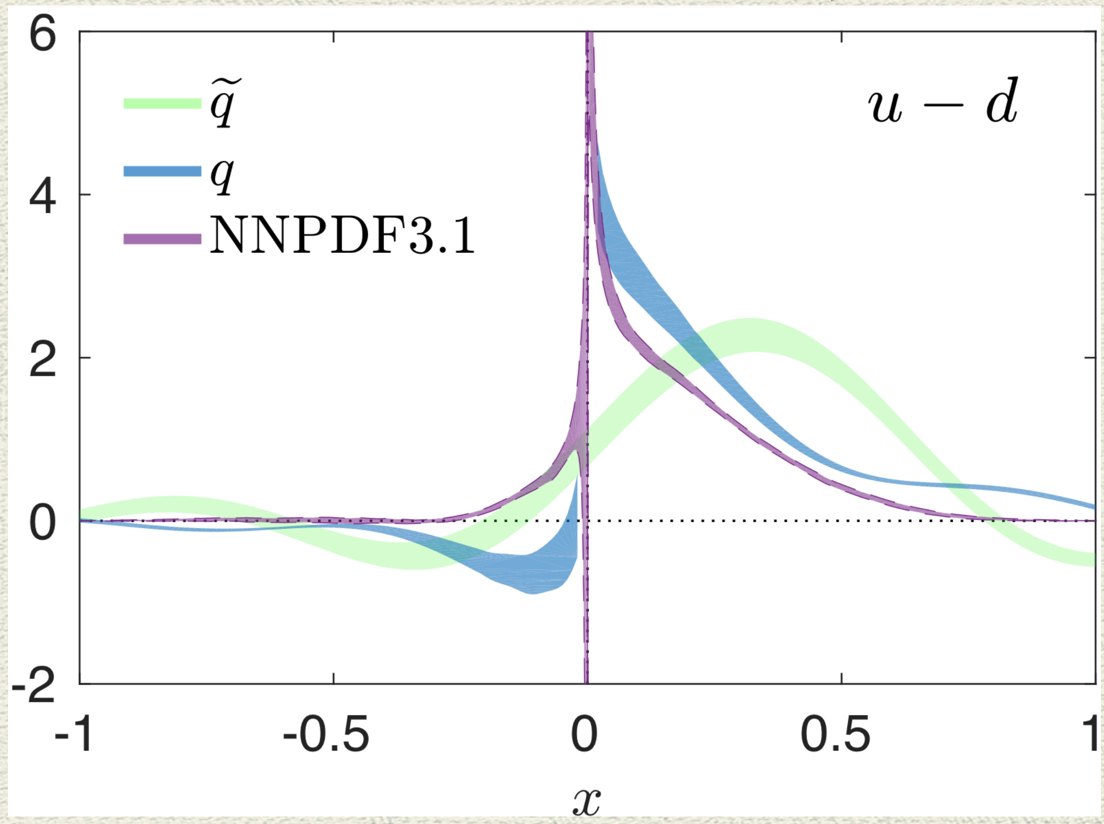
- Surface term ignored, but contribution non-negligible if matrix elements have not decayed to zero at some $z_{max}$
- The 1/x in the surface term may lead to uncontrolled effect for small values of x

# Alternative Fourier

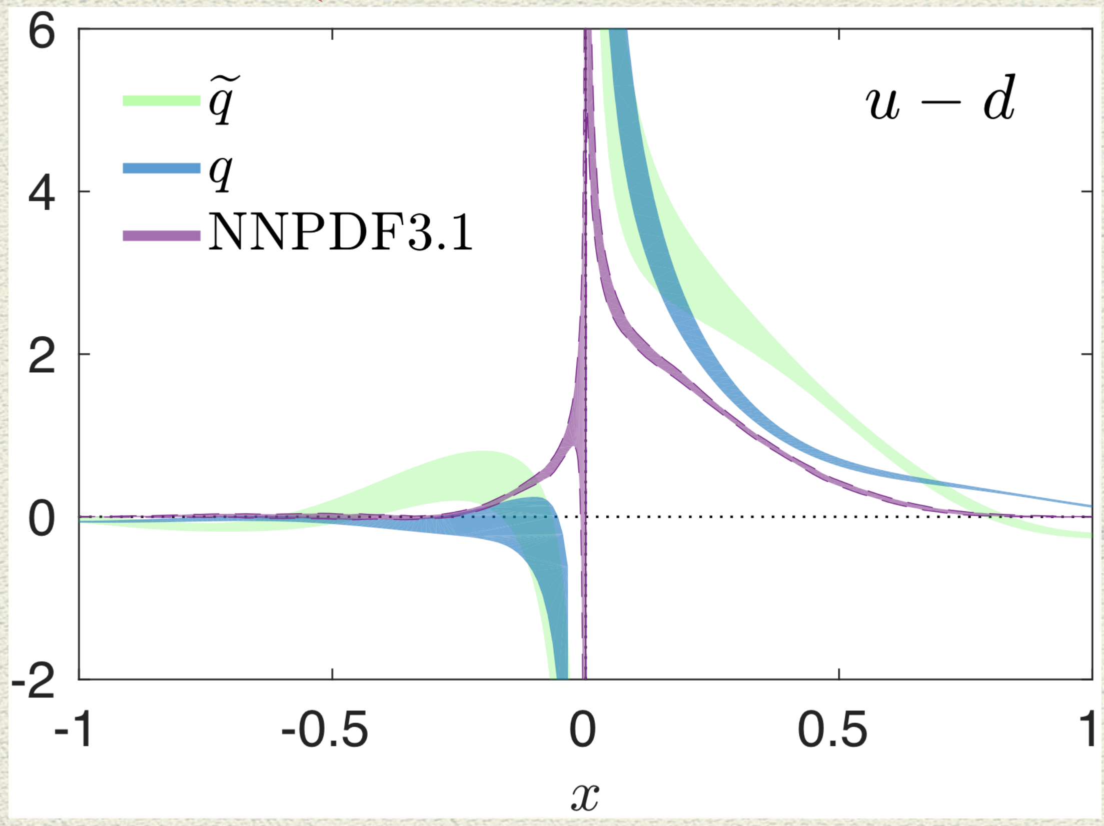



**Standard FT**




**Derivative FT**



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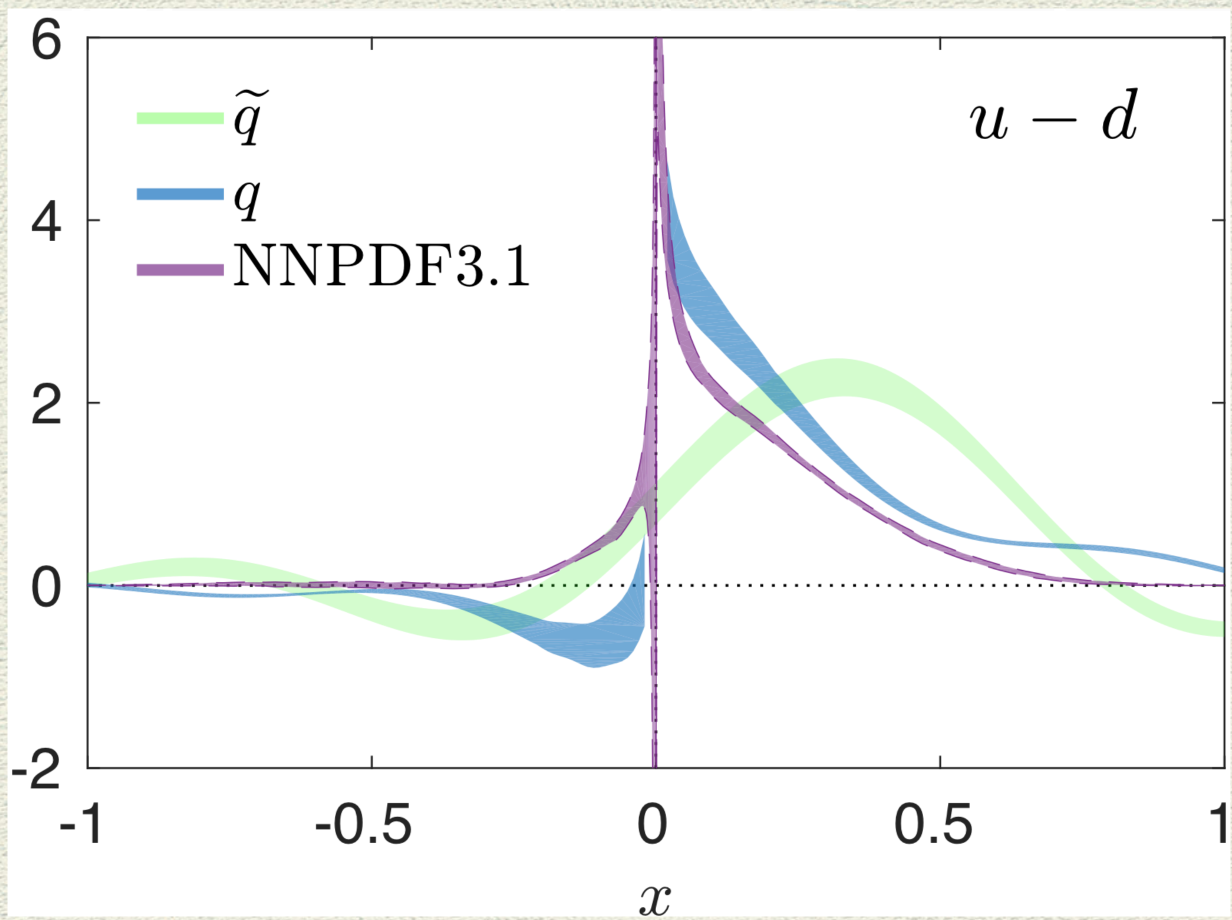


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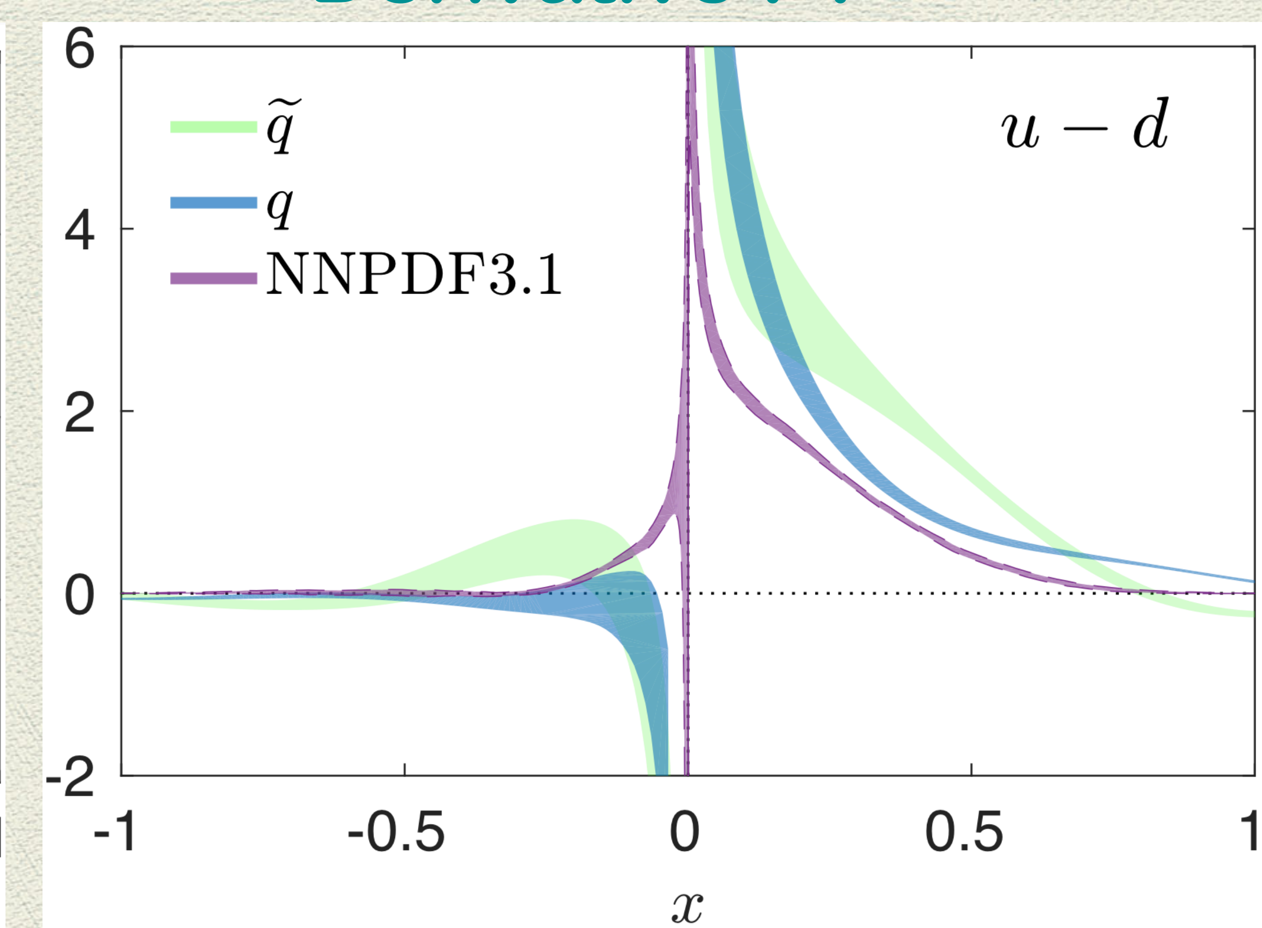


- Truncation at zmax (SF) vs neglecting surface term (DF) (latter non-negligible numerically)
- Oscillations reduced for DF, but small-x not well-behaved
- SF, DF different systematics, but DF may have enhanced cut-off effects

# Crucial aspects of calculation

2. How do we control contamination from excited states effects when the nucleon is boosted with high momentum?

# Parameters of ETMC calculation

[C. Alexandrou et al., (PRL), arXiv:1803.02685], [C. Alexandrou et al., arXiv:1807.00232]

## * Nucleon momentum & statistics:

| $P=\frac{6\pi}{L}$ (0.83 GeV) | | | $P=\frac{8\pi}{L}$ (1.11 GeV) | | | $P=\frac{10\pi}{L}$ (1.38 GeV) | | |
|---|---|---|---|---|---|---|---|---|
| Ins. | $N_{\rm conf}$ | $N_{\rm meas}$ | Ins. | $N_{\rm conf}$ | $N_{\rm meas}$ | Ins. | $N_{\rm conf}$ | $N_{\rm meas}$ |
| $\gamma_3$ | 100 | 9600 | $\gamma_3$ | 425 | 38250 | $\gamma_3$ | 811 | 72990 |
| $\gamma_0$ | 50 | 4800 | $\gamma_0$ | 425 | 38250 | $\gamma_0$ | 811 | 72990 |
| $\gamma_5\gamma_3$ | 65 | 6240 | $\gamma_5\gamma_3$ | 425 | 38250 | $\gamma_5\gamma_3$ | 811 | 72990 |

## * Excited states investigation:

$$T_{\rm sink}=8a, 9a, 10a, 12a \quad (T_{\rm sink}=0.75, 0.84, 0.094, 1.13\text{fm})$$

# Challenges of calculation

Noise-to-signal ratio increases with:

- Hadron momentum boost
- Simulations at the physical point
- Source-sink separation

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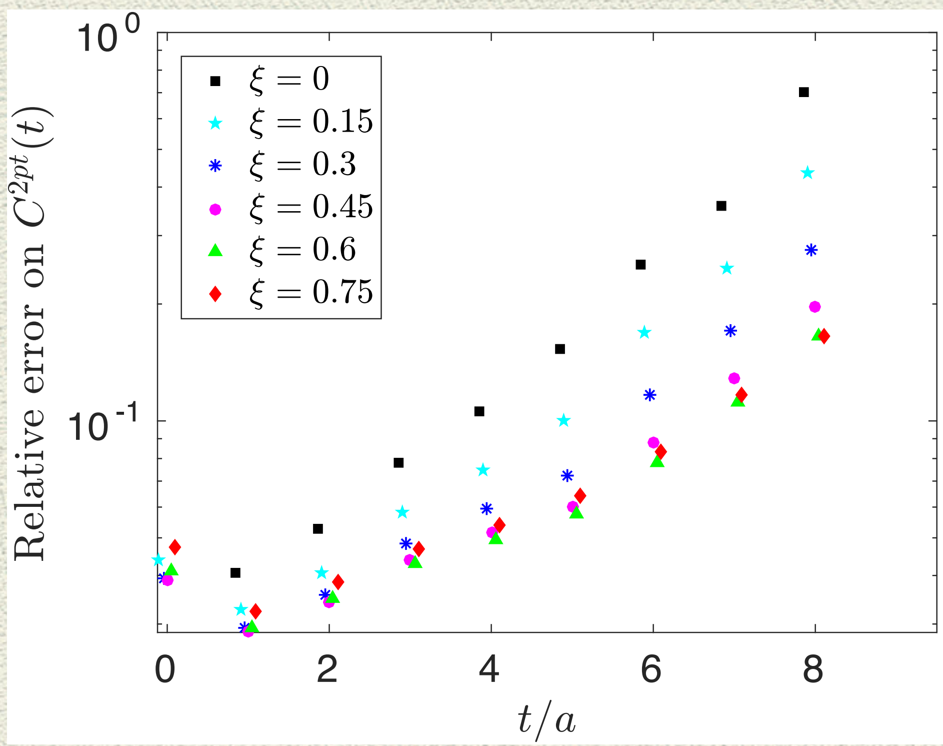
**Momentum smearing**
[G. Bali et al., PRD93, 094515 (2016)]

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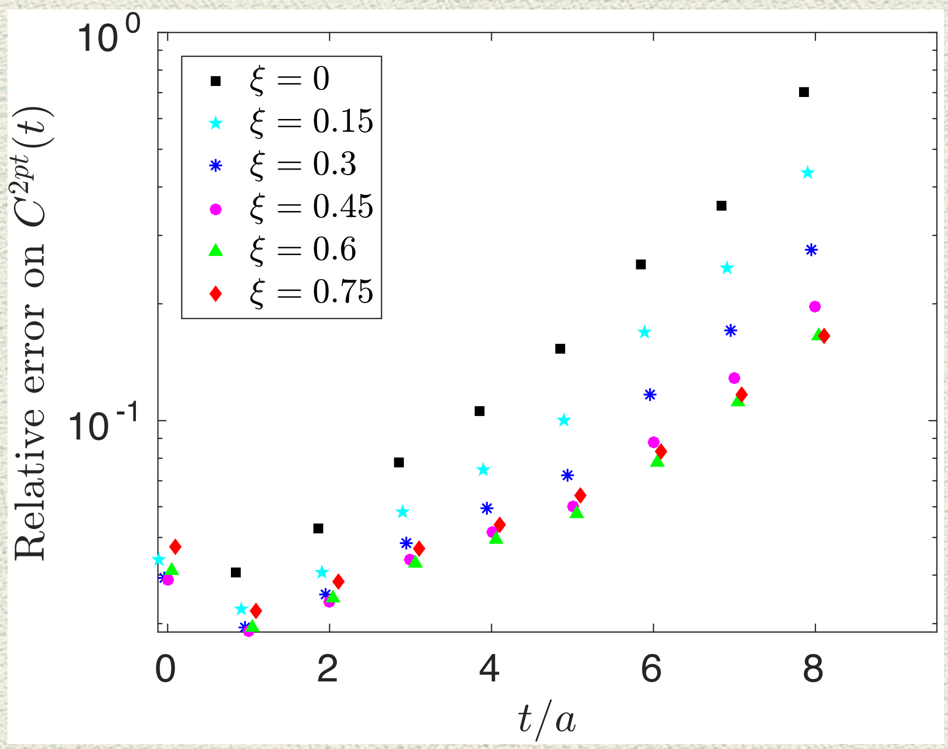
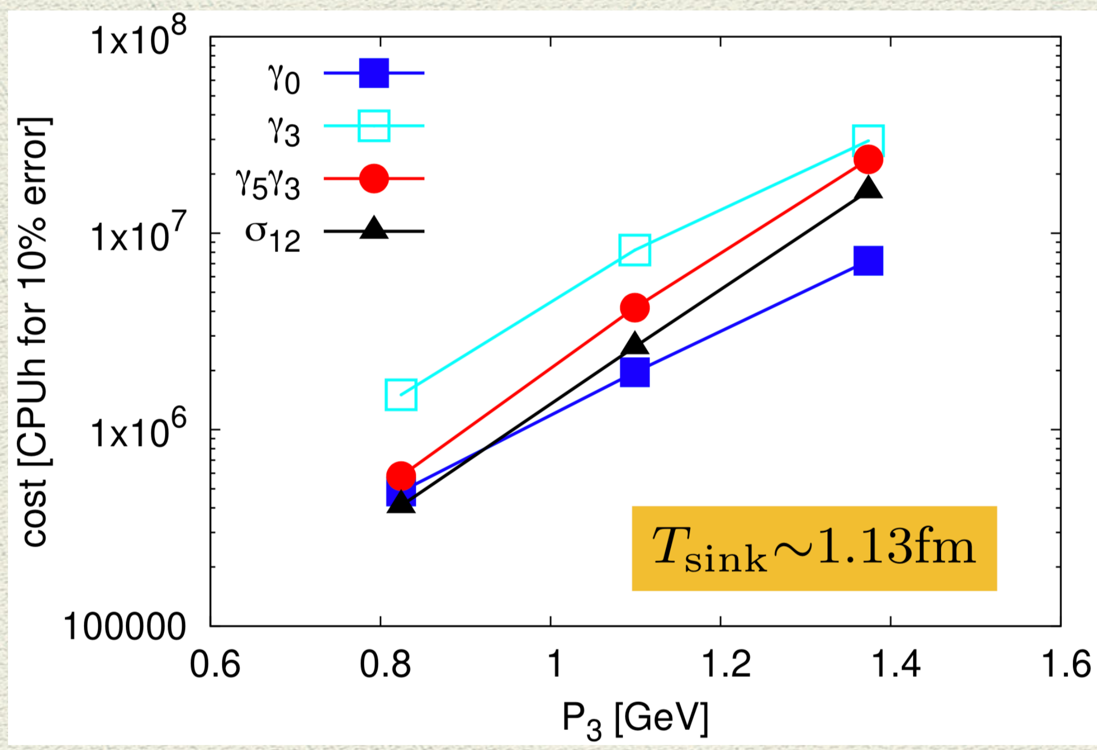
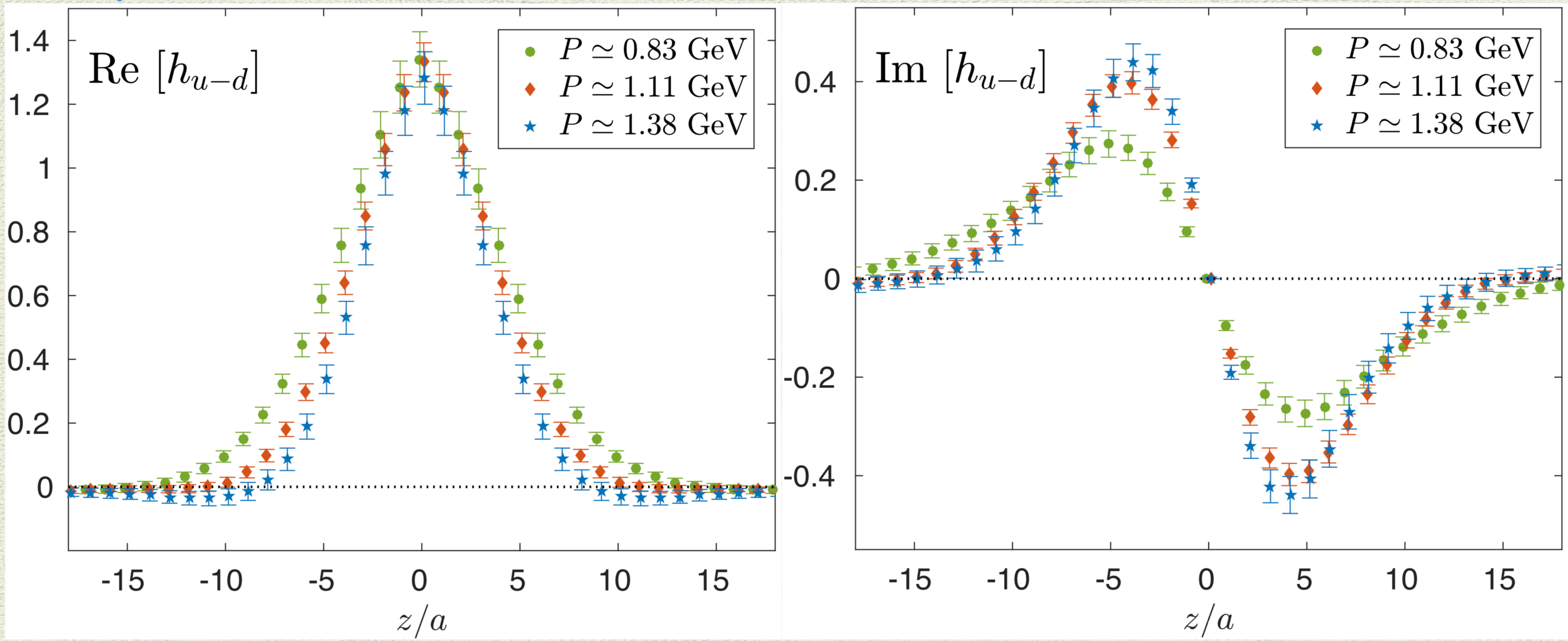



- Momentum smearing helps reach higher momenta
- But limitations in max momentum due to comput. cost

# Bare matrix elements

## Unpolarized:




- Similar general features for polarized and transversity
- Highest priority: deliver reliable results

# Excited states contamination

**Analyses techniques:**

- Single-state fit, Two-state fit, Summation method

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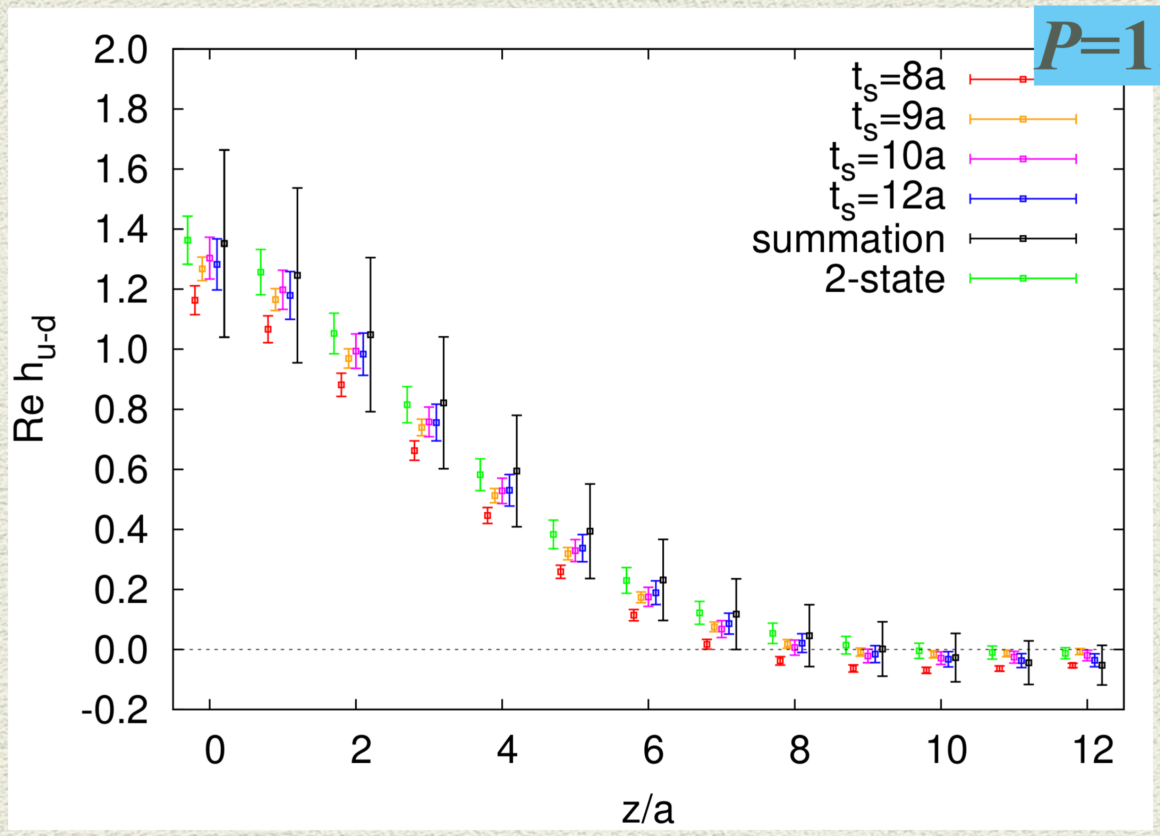
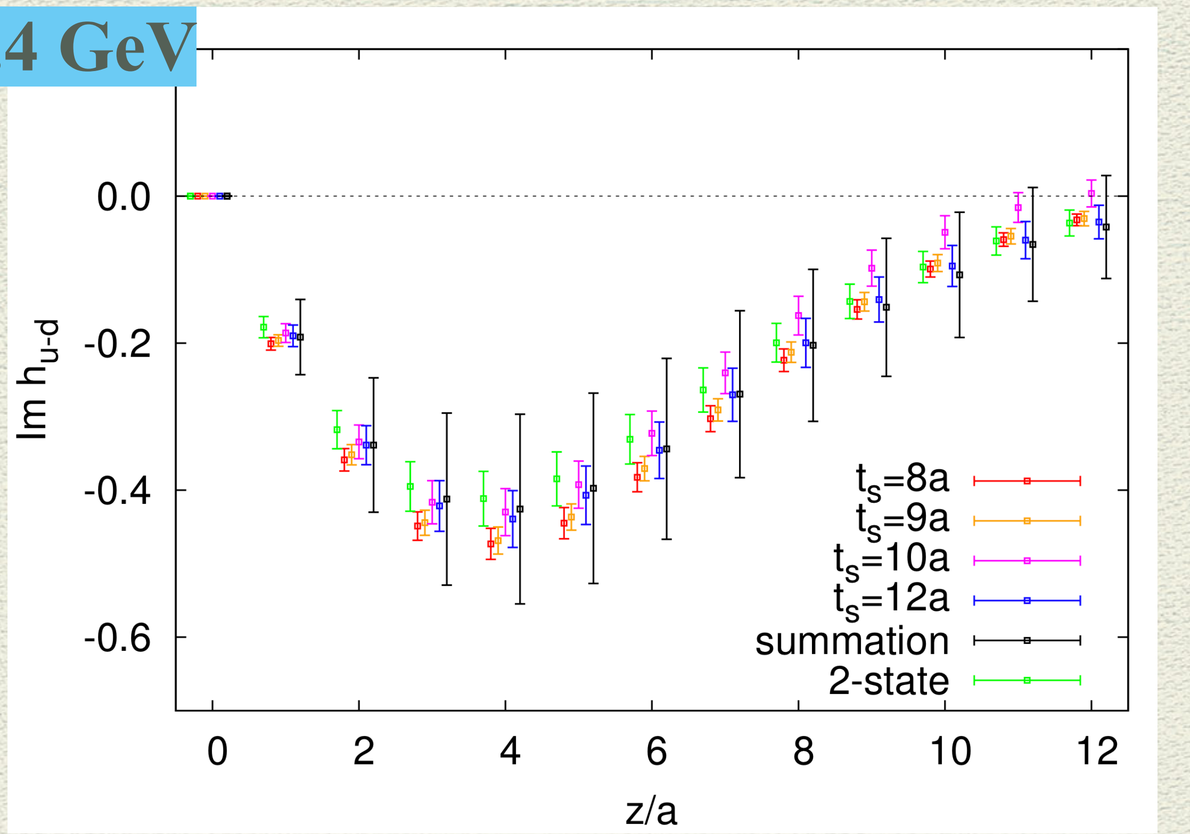
**P=1.4 GeV**



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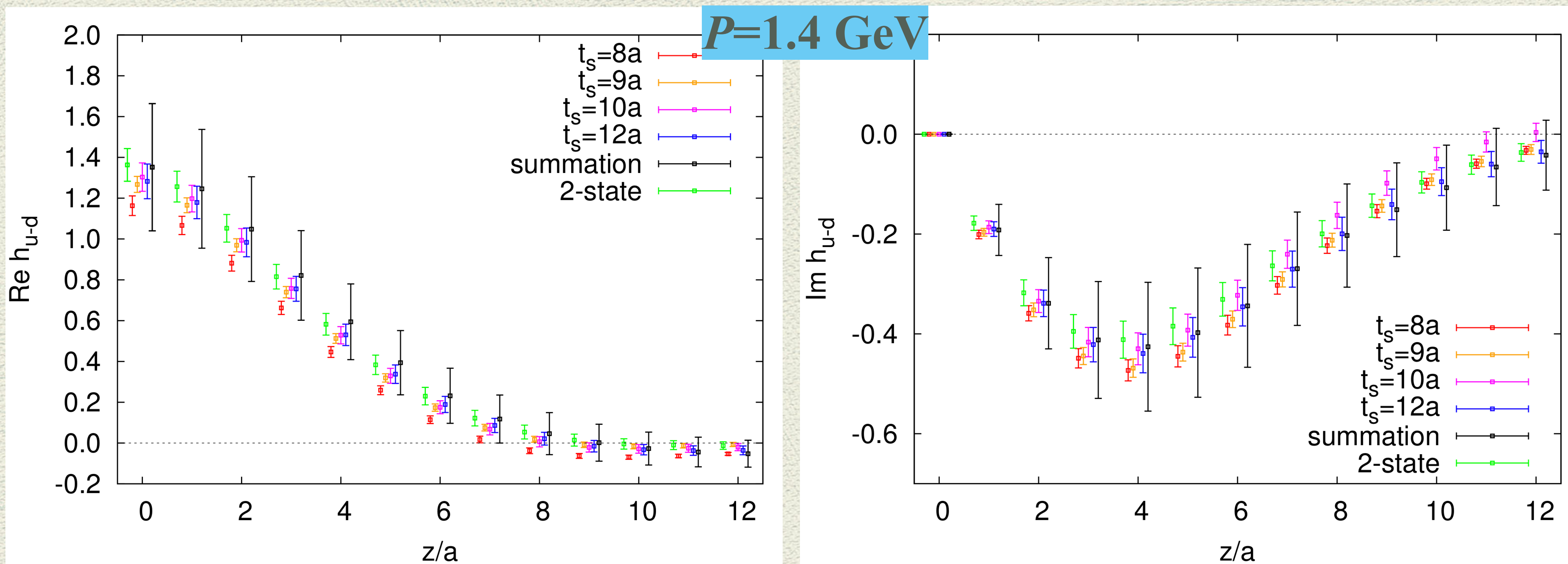


## Conclusions:

- Tsink=8a heavily contaminated by excited states
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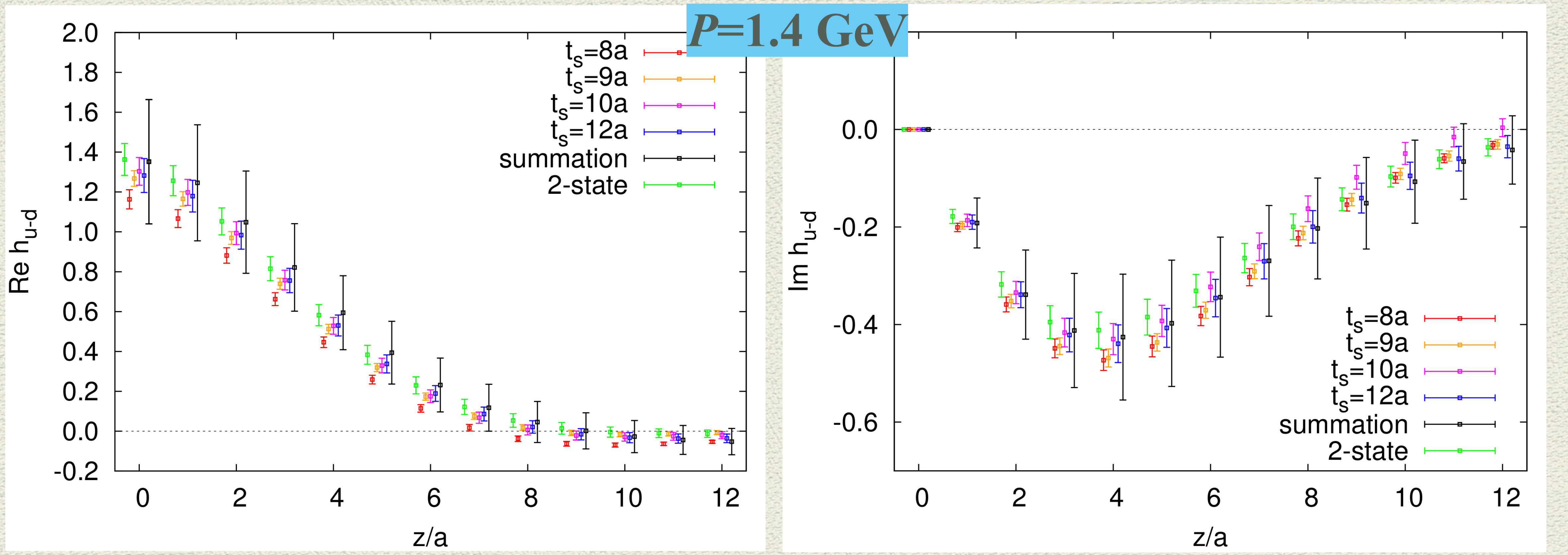
- Single-state fit, Two-state fit, Summation method




## Conclusions:

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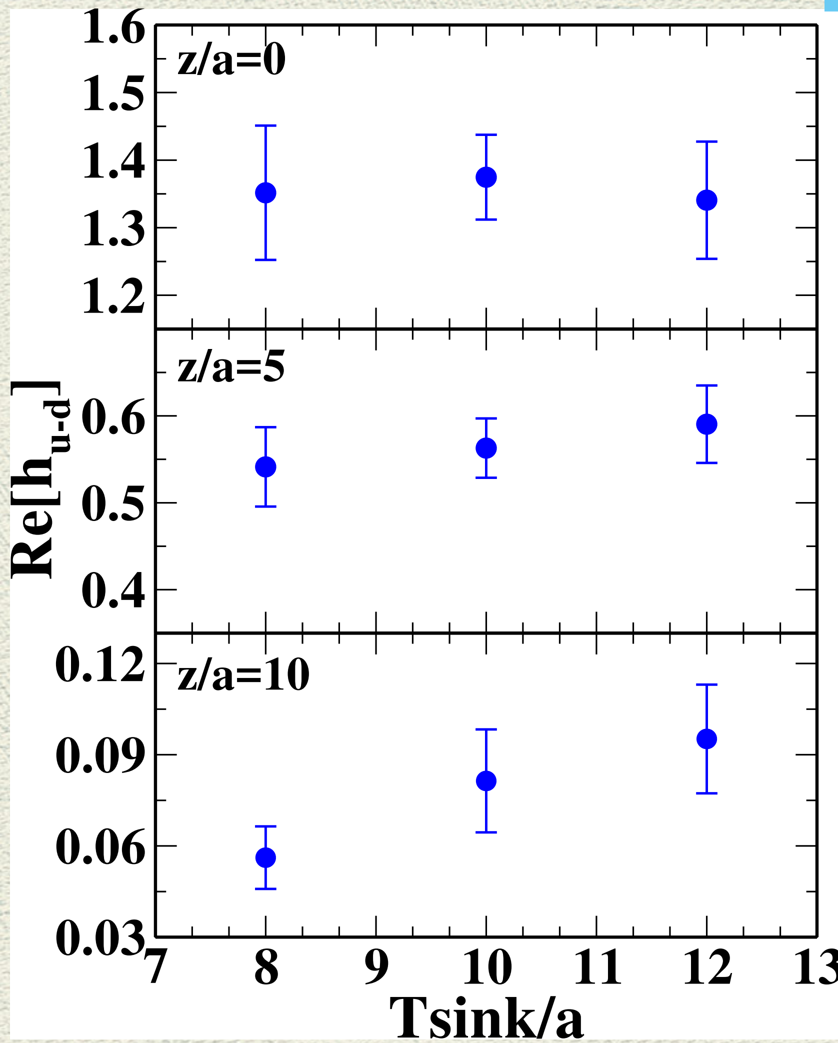
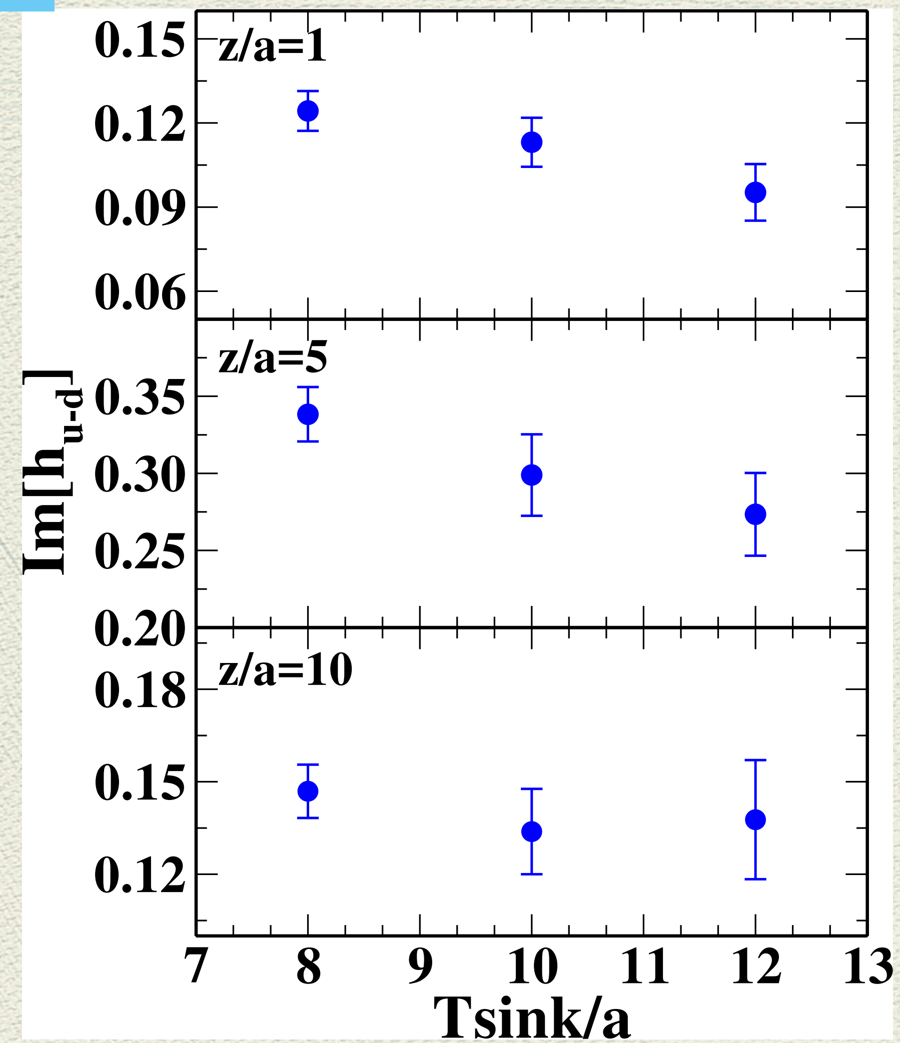
  ! Crucial to have same error for reliable 2-state fit
  ! Excited states worsen as momentum $P$ increases
  ! For momenta in this work, Tsink=1fm is safe

# Excited states contamination

*P*=0.83 GeV




- Non-predictible behavior (depends in $z$ value)
- Real and imaginary part affected differently

## Conclusions:

- Excited states uncontrolled for Tsink <1fm
- Multi-sink analysis demands same accuracy for all data