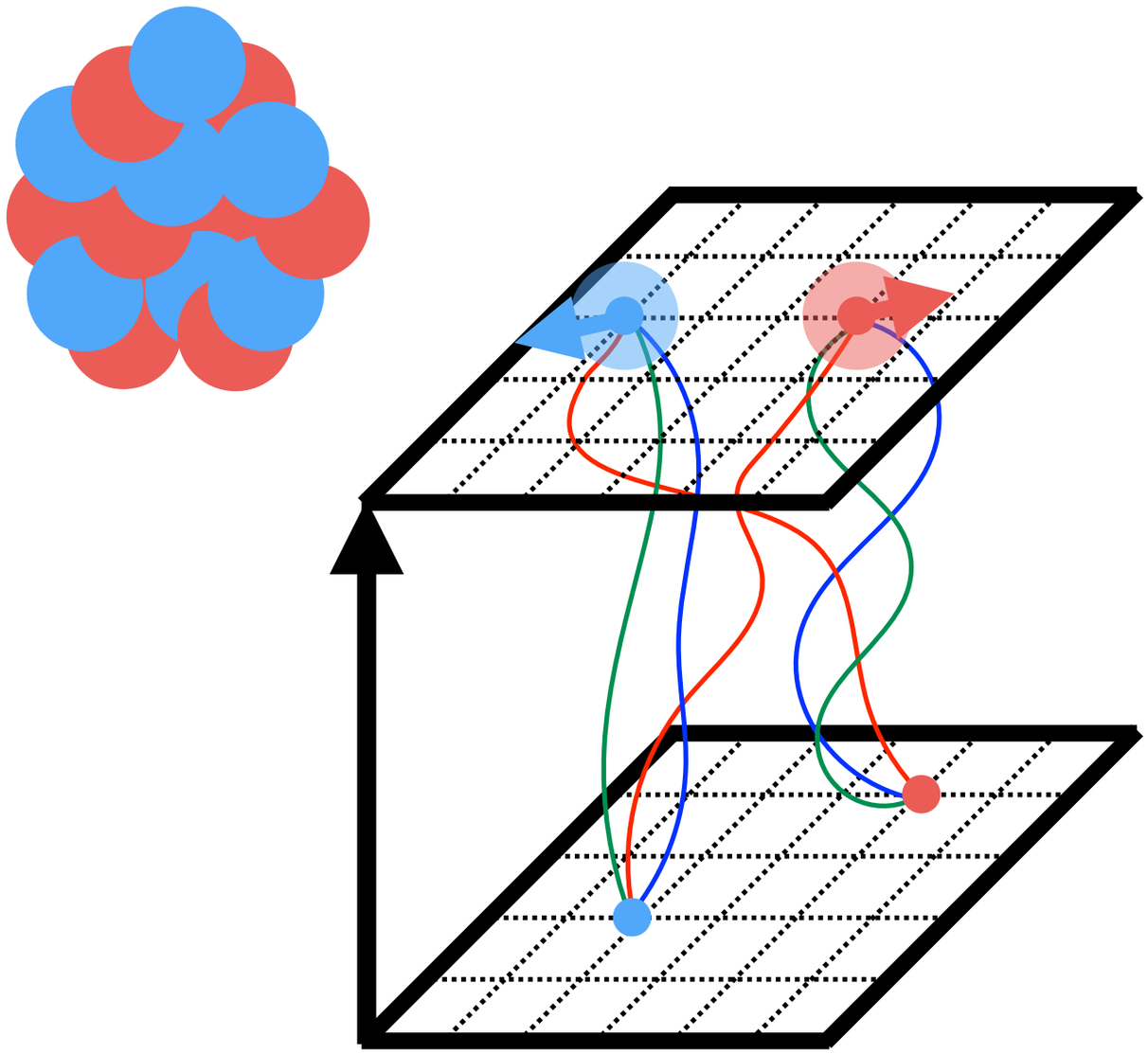
Calm Multi-baryon Operators



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Forschungszentrum Jülich

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LATTICE 2017
Grenada, Spain

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LLNL		Pavlos Vranas
NERSC		Thorsten Kurth
UNC		Amy Nicholson
nVidia		Kate Clark

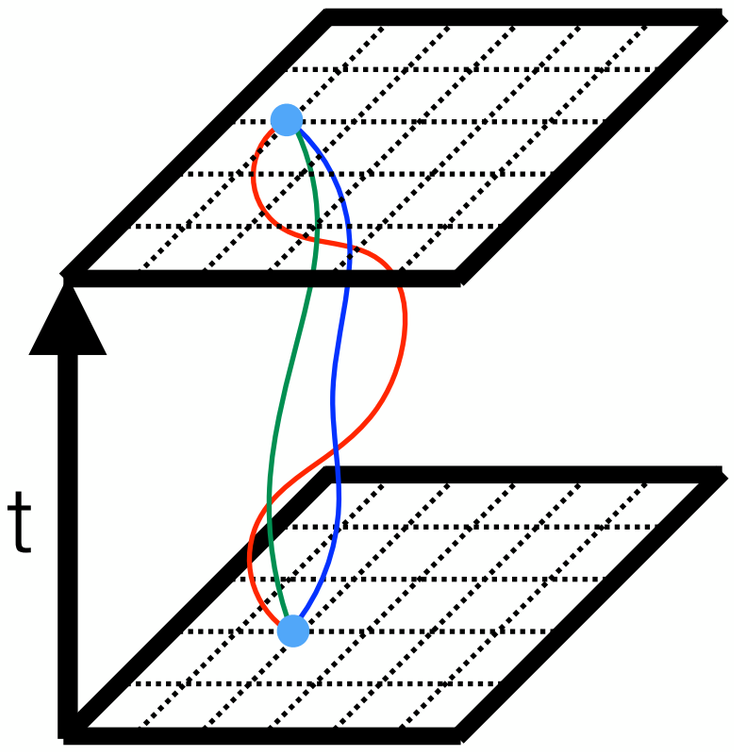
In preparation

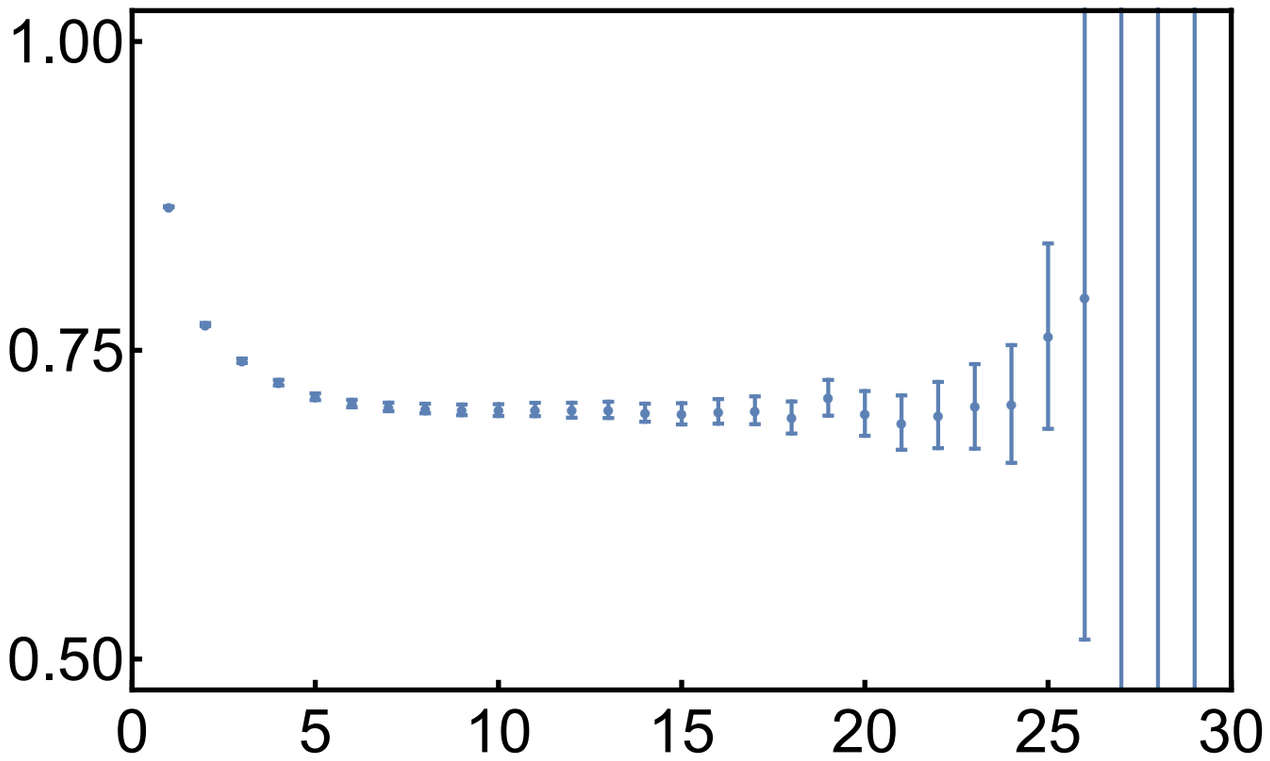
Correlation Functions and Effective Masses

$$C(t) = \left\langle \mathcal{O}(t)\mathcal{O}^\dagger(0) \right\rangle = \frac{1}{\mathcal{Z}} \int \mathcal{D}\psi \, \mathcal{D}\bar{\psi} \, \mathcal{D}U \, \mathcal{O}(t)\mathcal{O}^\dagger(0) e^{-S[\bar{\psi},\psi,U]}$$

$$= \sum_k \left\langle \Omega \mid \mathcal{O} \mid k \right\rangle \left\langle k \mid \mathcal{O}^\dagger \mid \Omega \right\rangle e^{-E_k t}$$

Effective mass $E_0 = \lim_{t\to\infty} -\partial_t \log C(t)$





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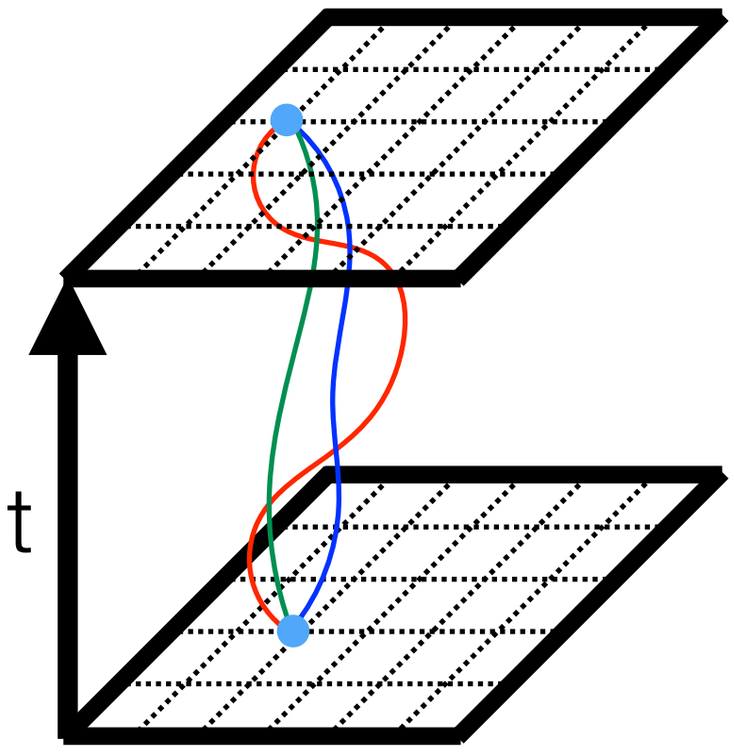

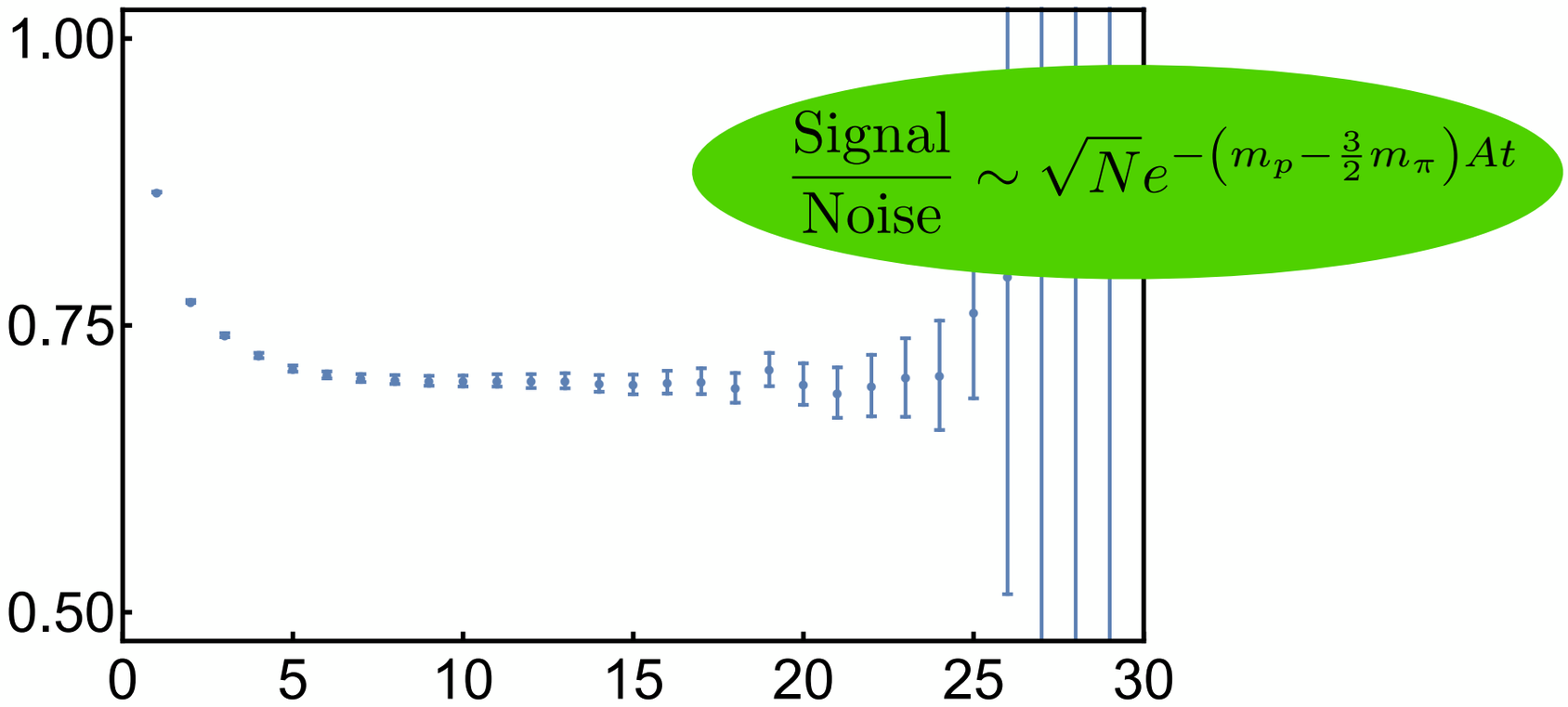

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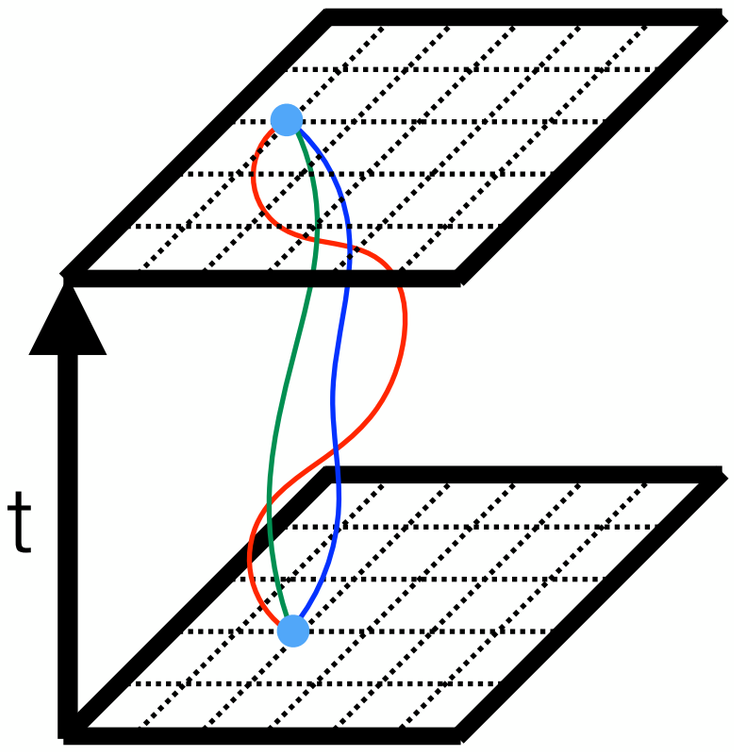

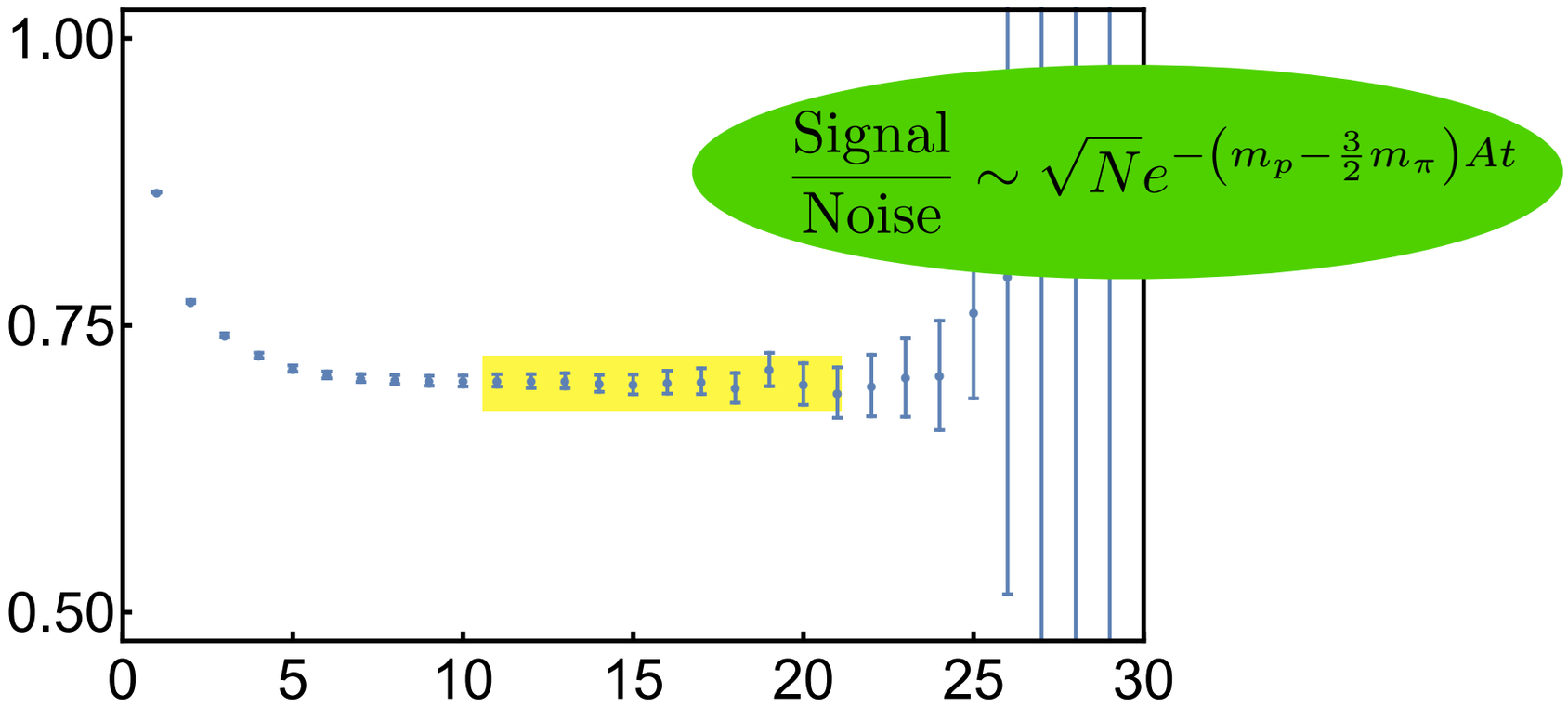

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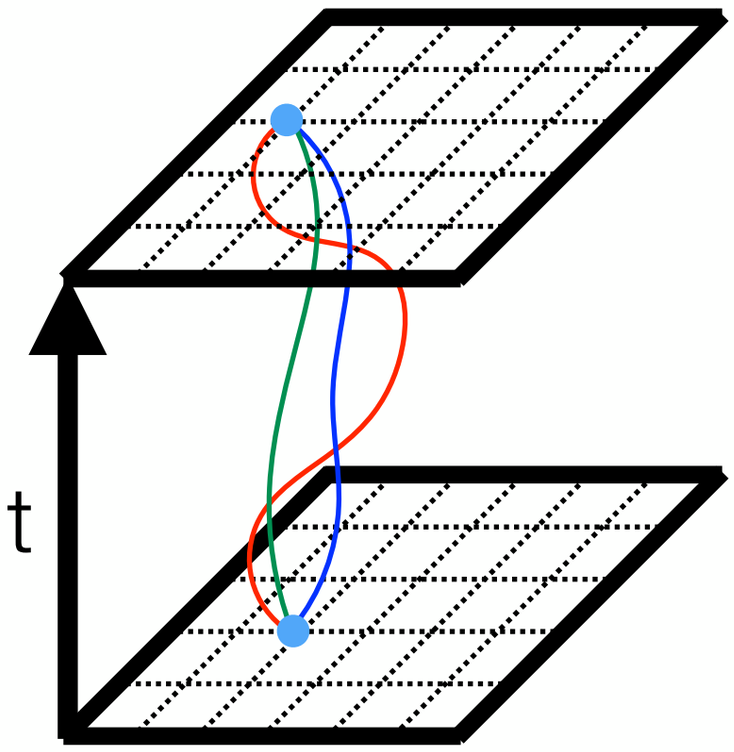
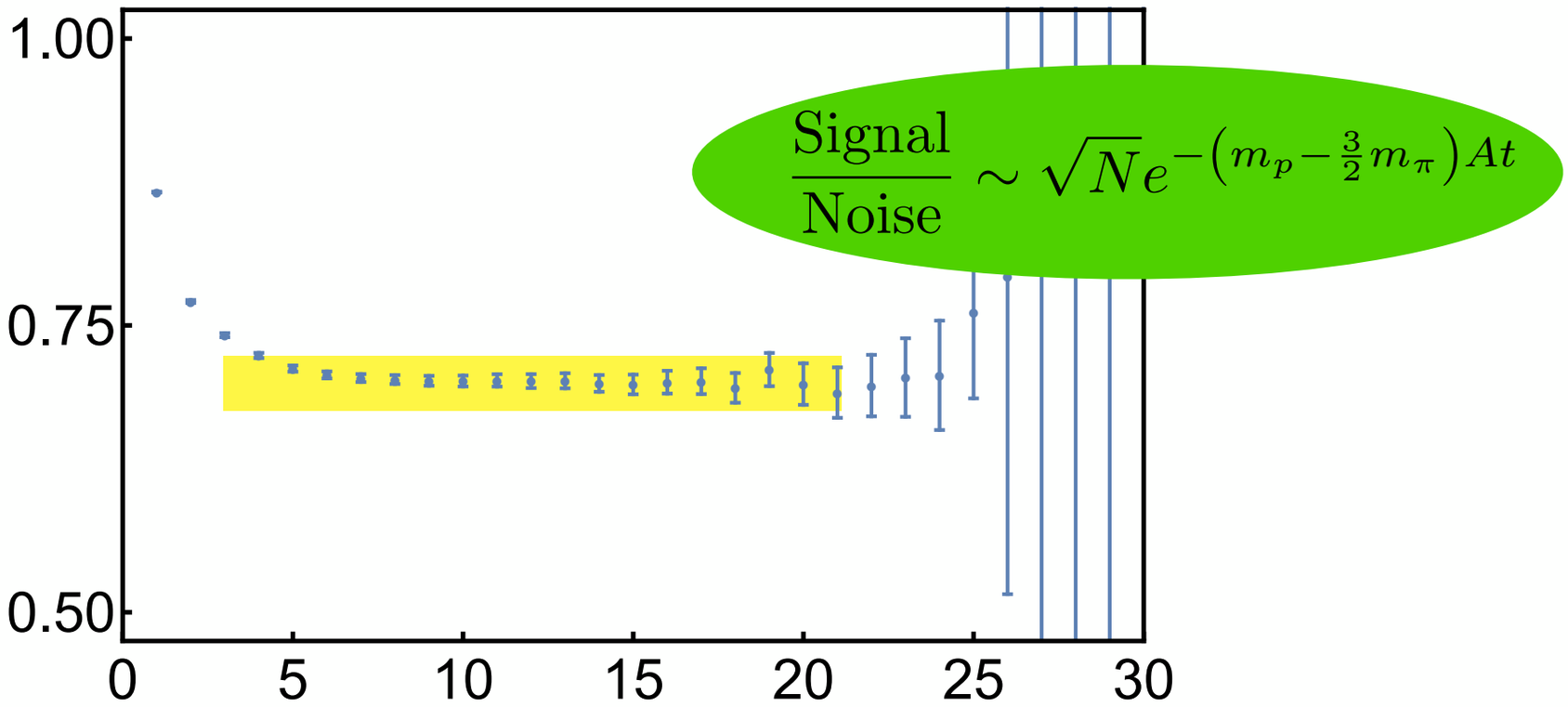
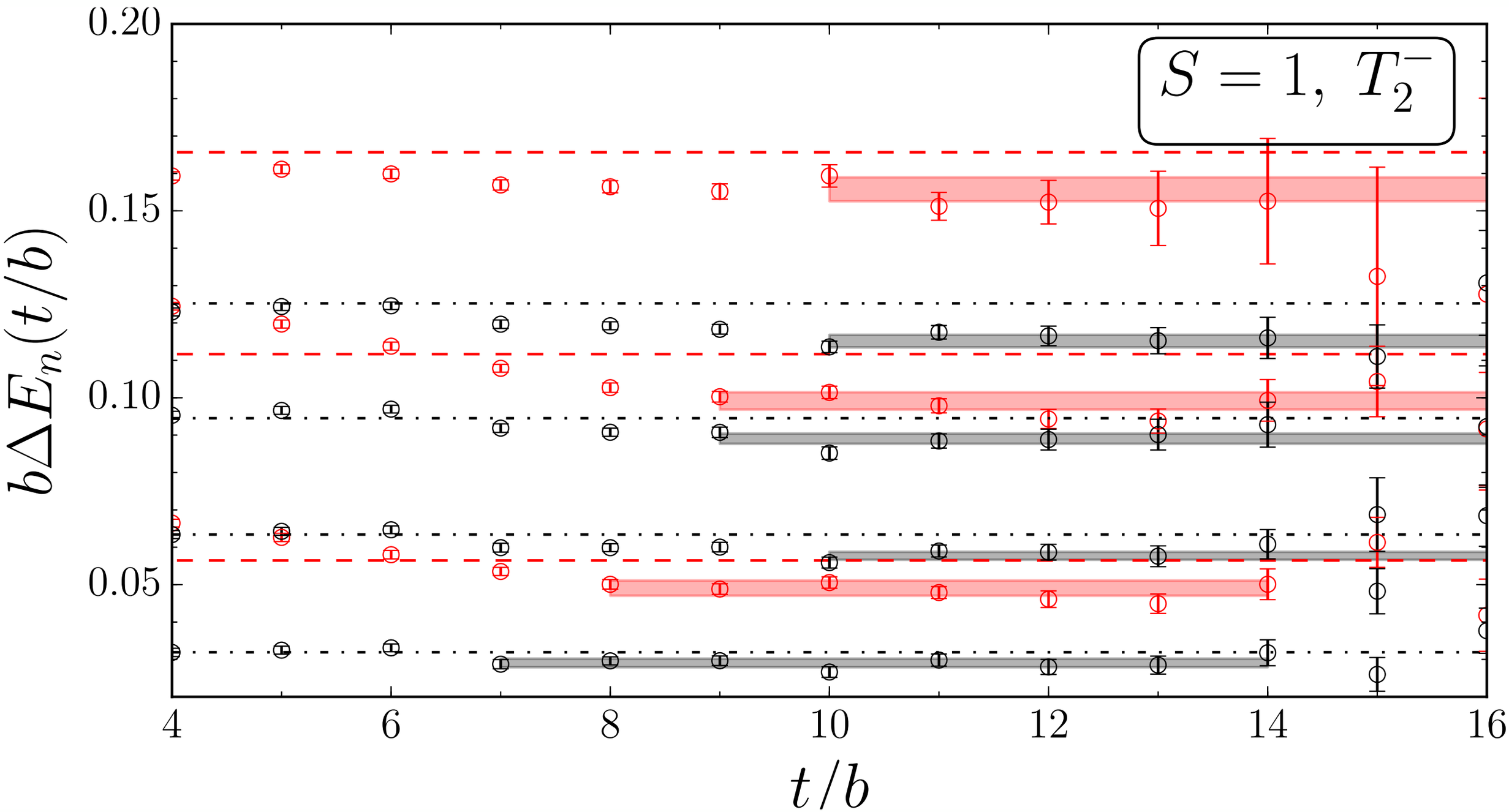




Fitting the Ratio

CalLat 1508.00886 Phys.Lett. B765 (2017) 285-292

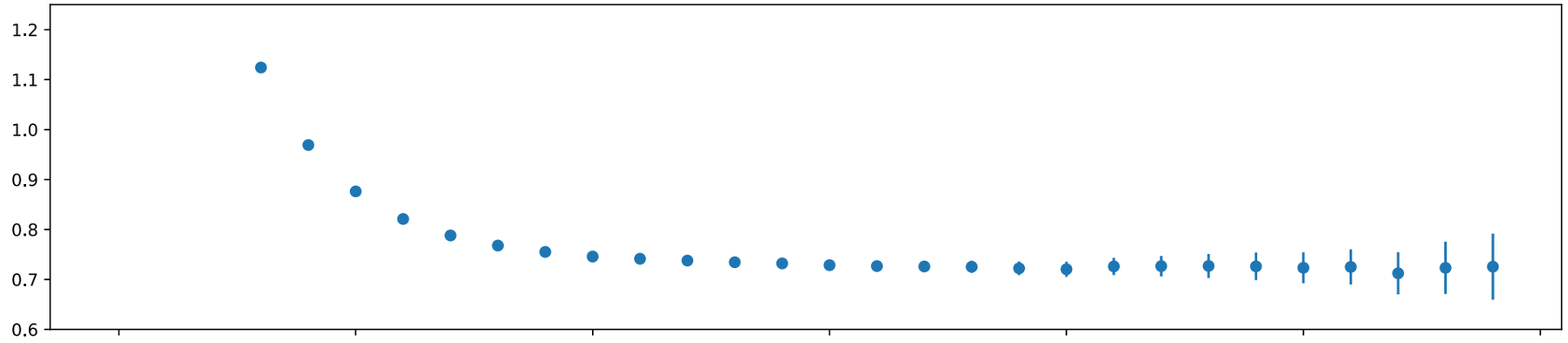
$$E_{\text{interaction}} = \lim_{t\to\infty} \frac{C_{NN}(t)}{C_N(t)^2}$$



Individual correlators

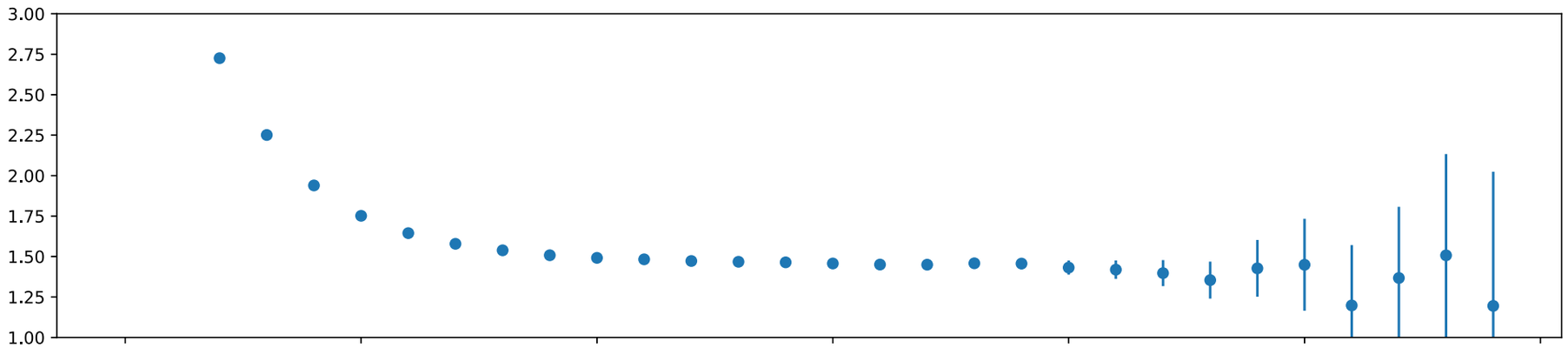
mπ~700 MeV
gauss source

N

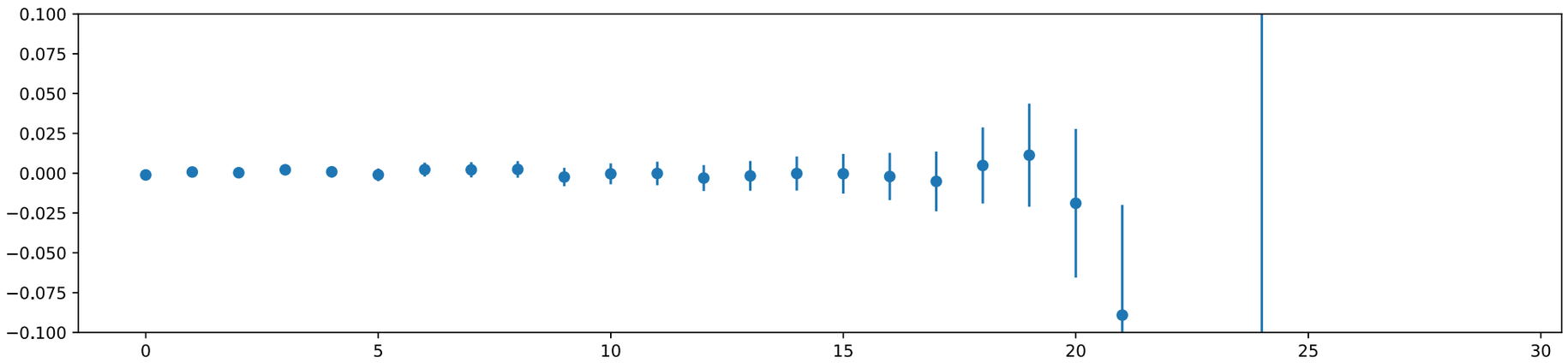


point sink

NN



ratio



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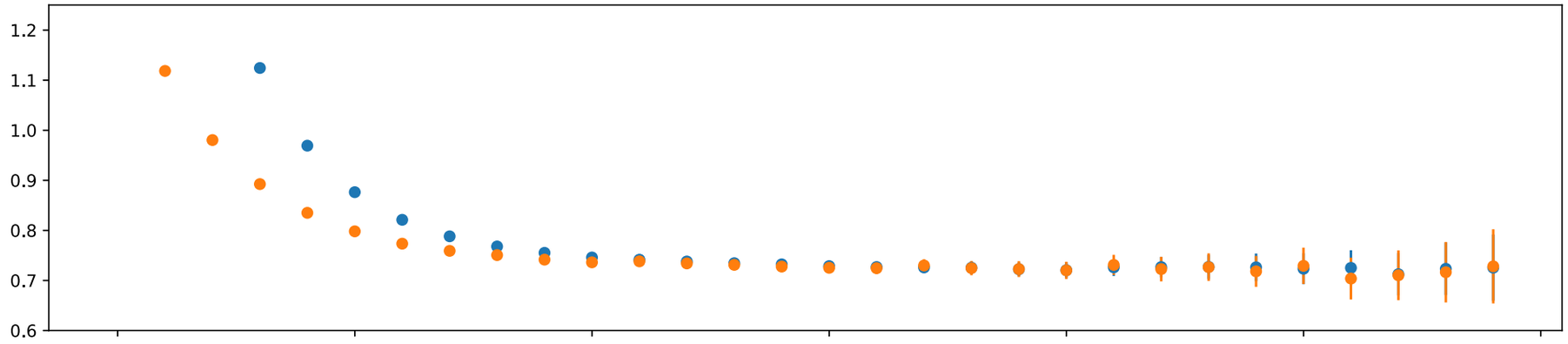

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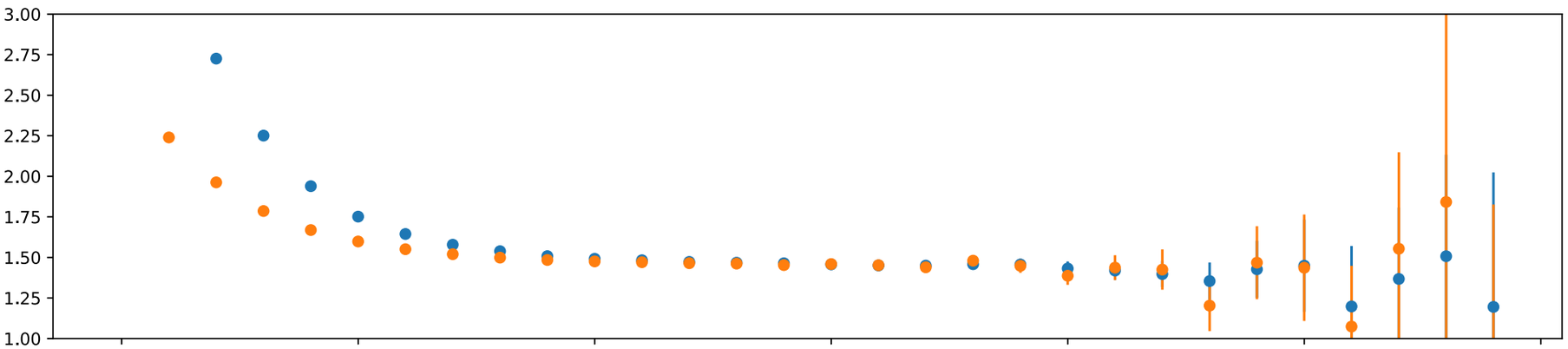
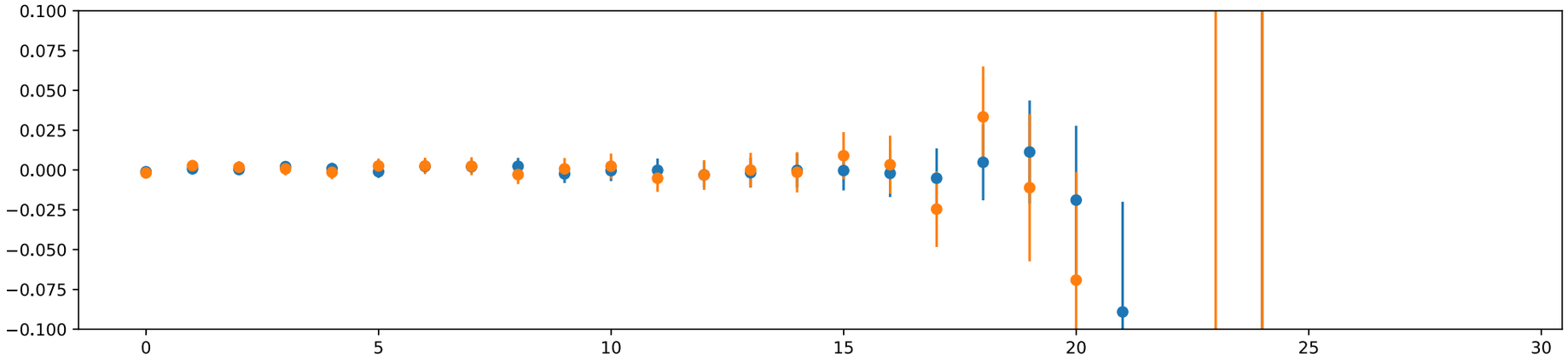


ratio



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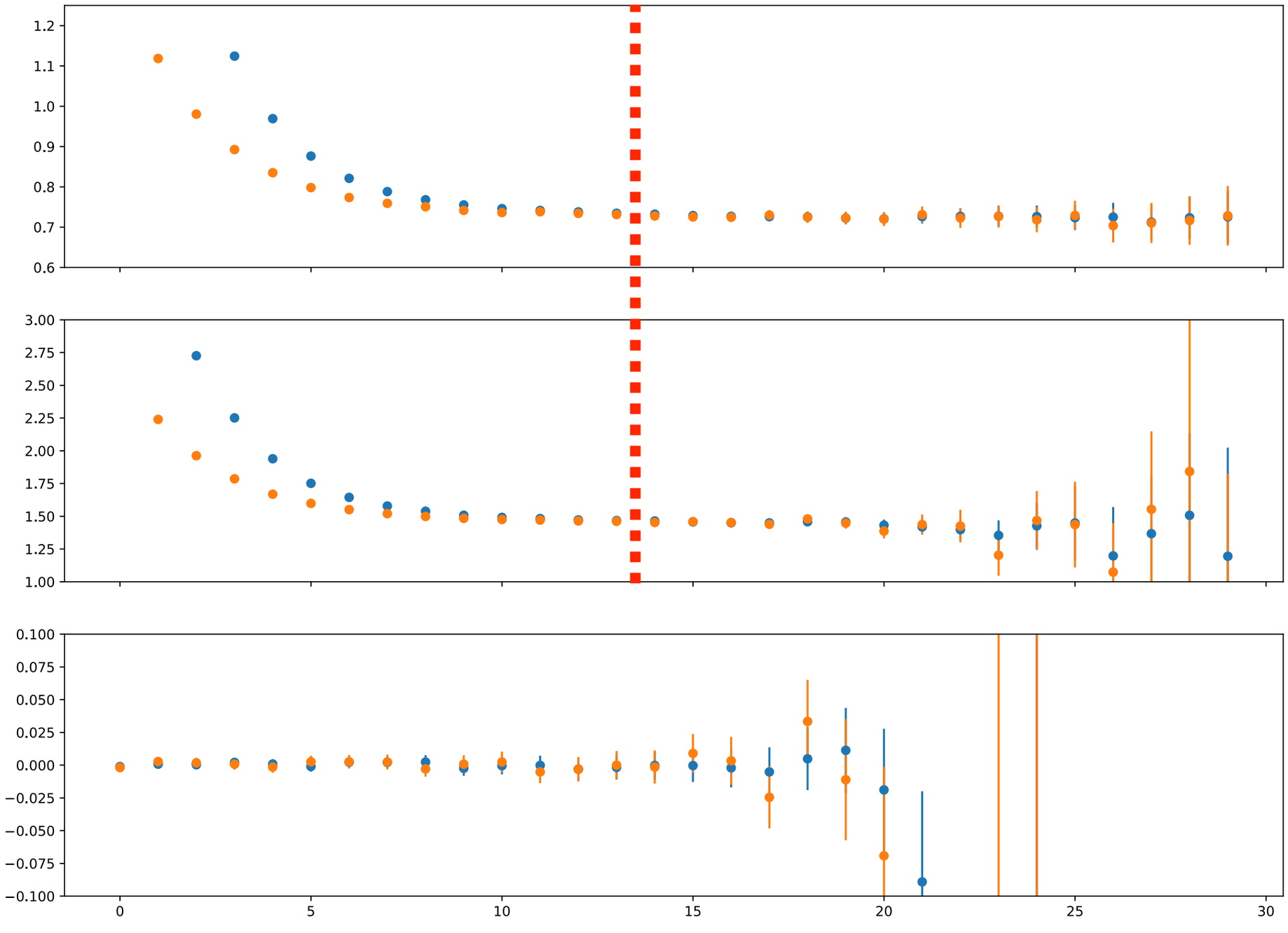

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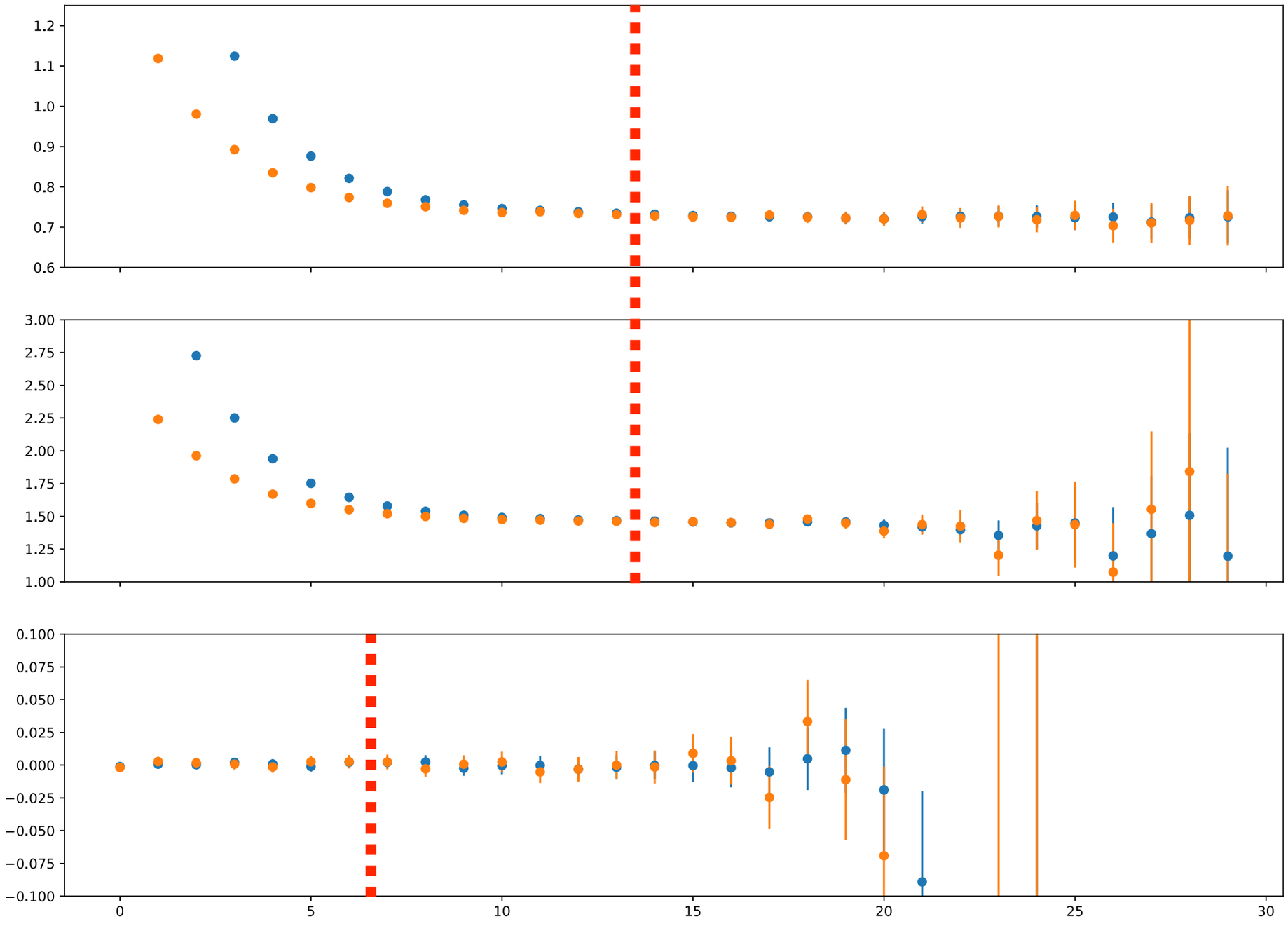

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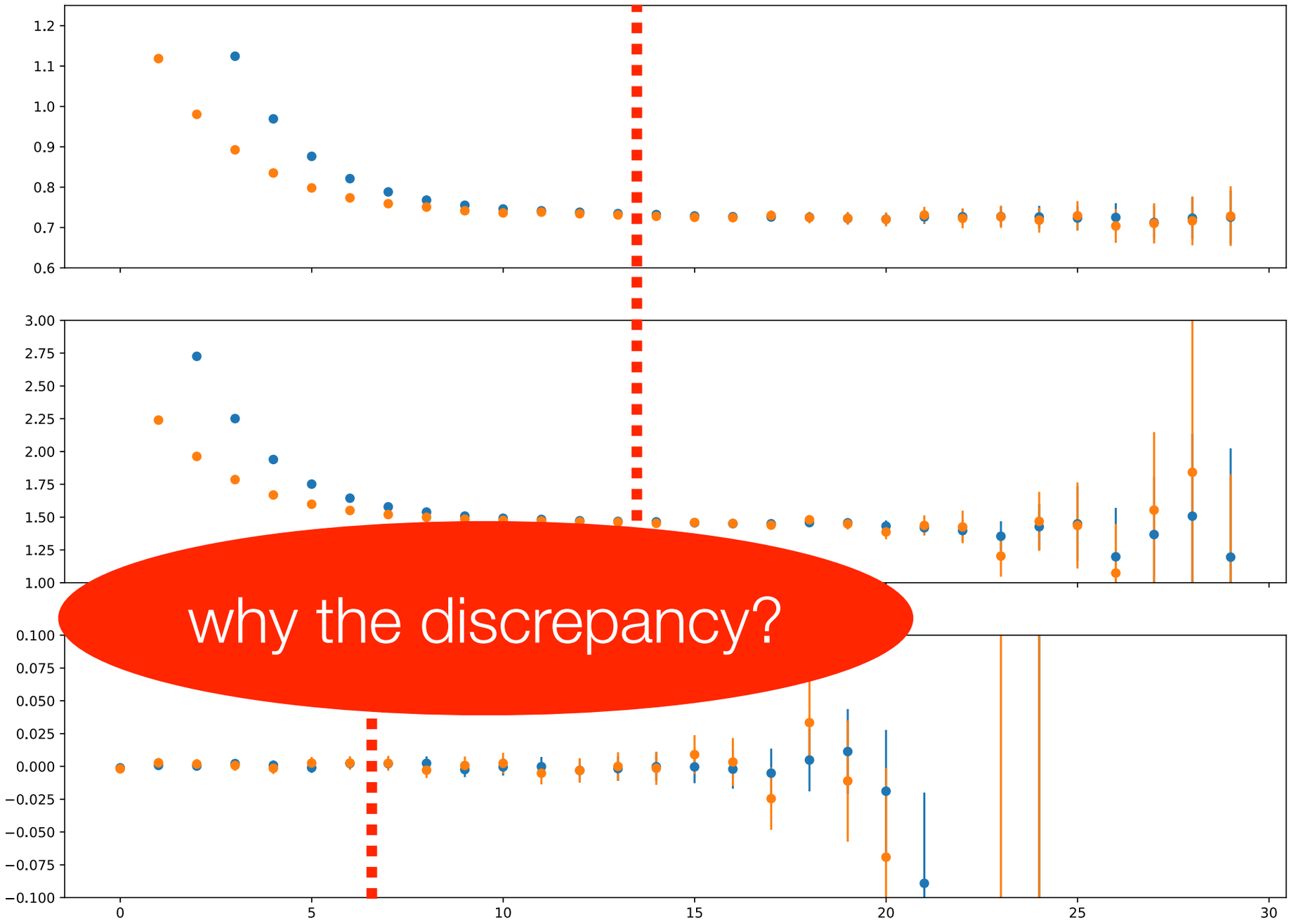

point sink
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why the discrepancy?

Suspicious coincidence

- Ratio does better than is really justified
- Ratio plateau starts way earlier than N or NN plateaus
- Matrix Prony on multiple NN signals doesn't help much

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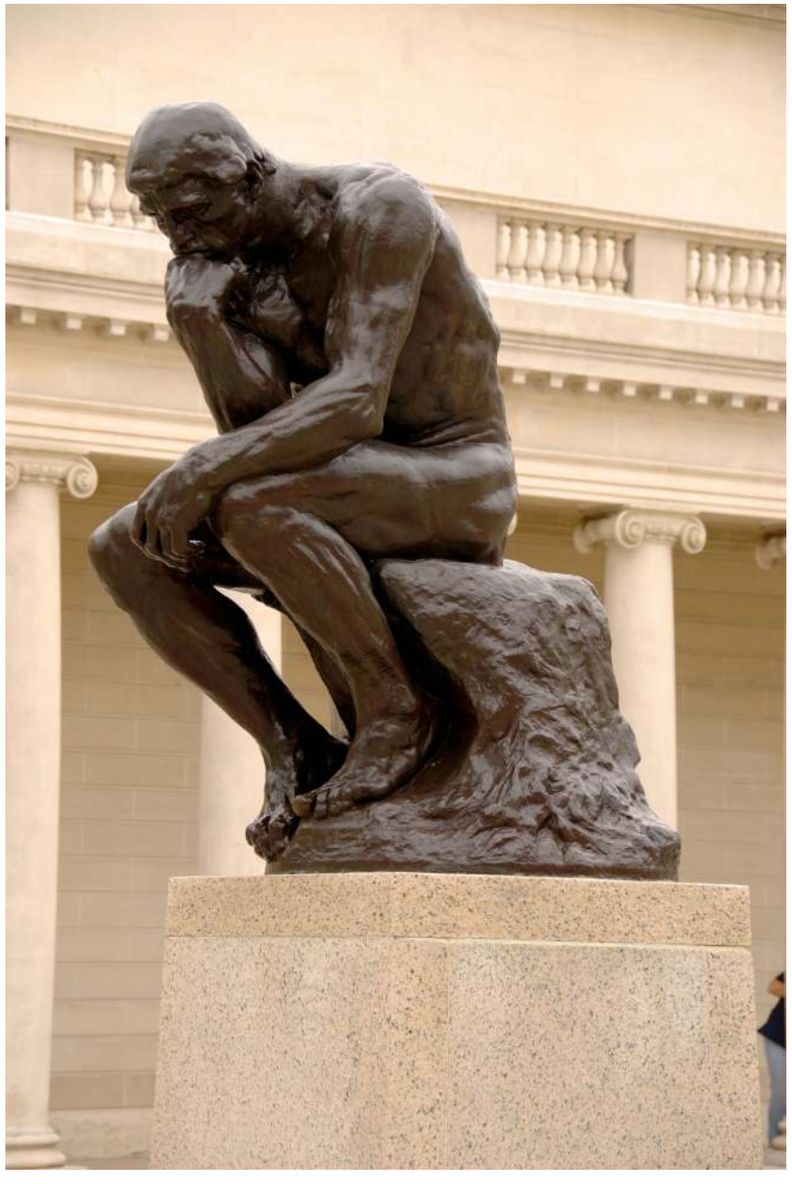
NN excited states are mostly single-nucleon excitations?

Single-Nucleon Improvement

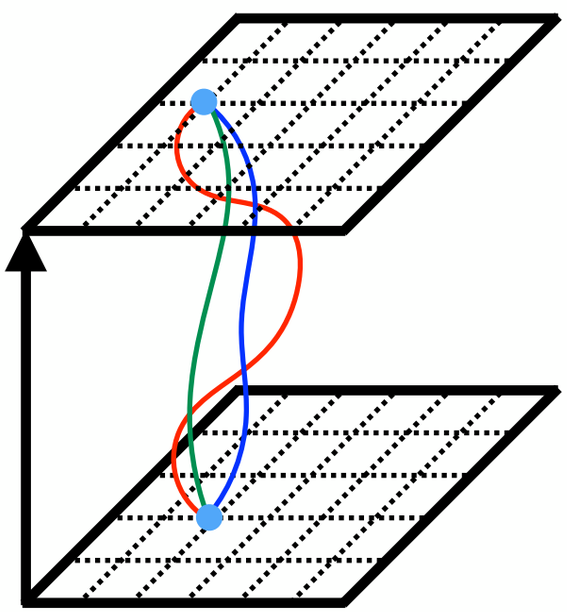


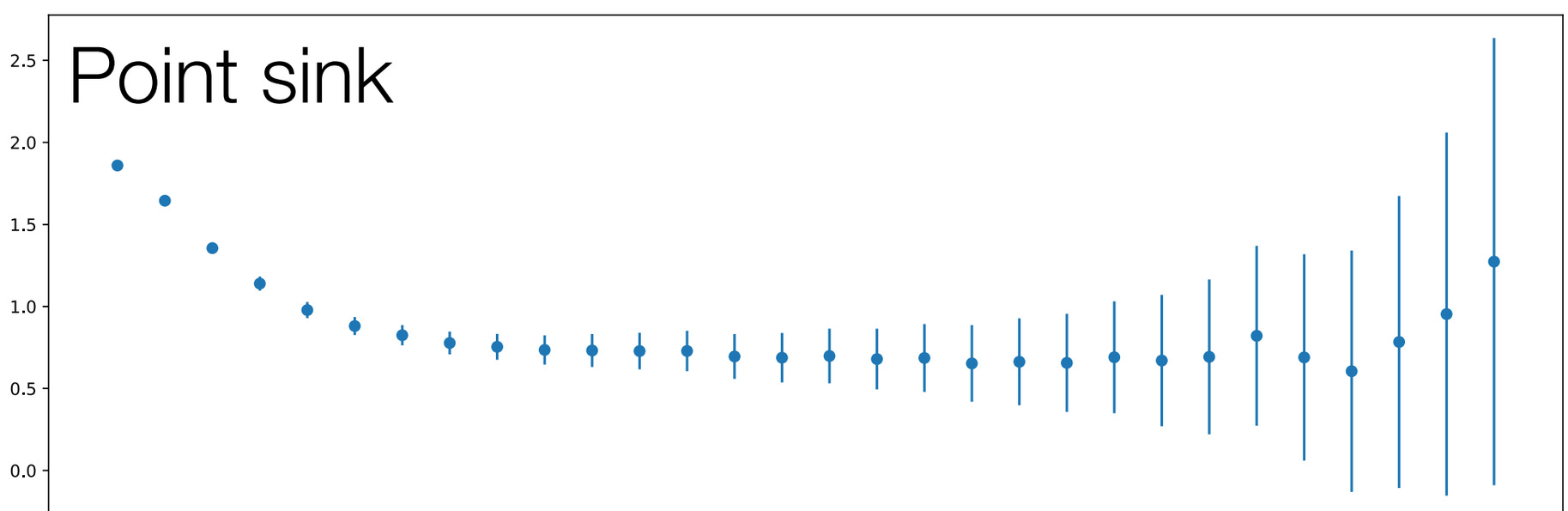
Generally Applicable

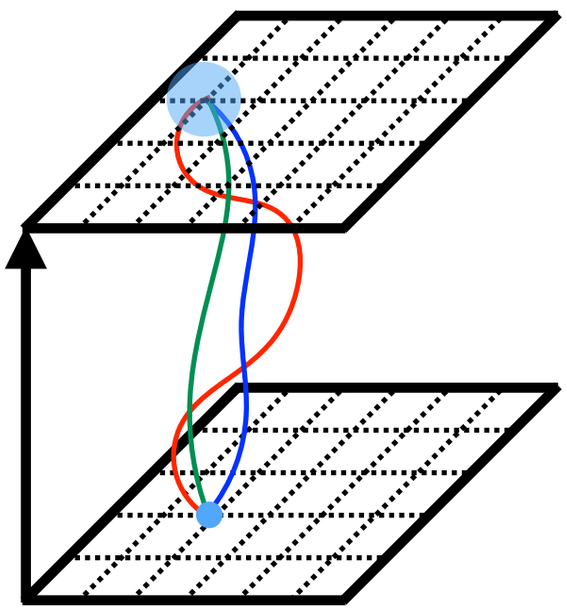
Improved Systematics

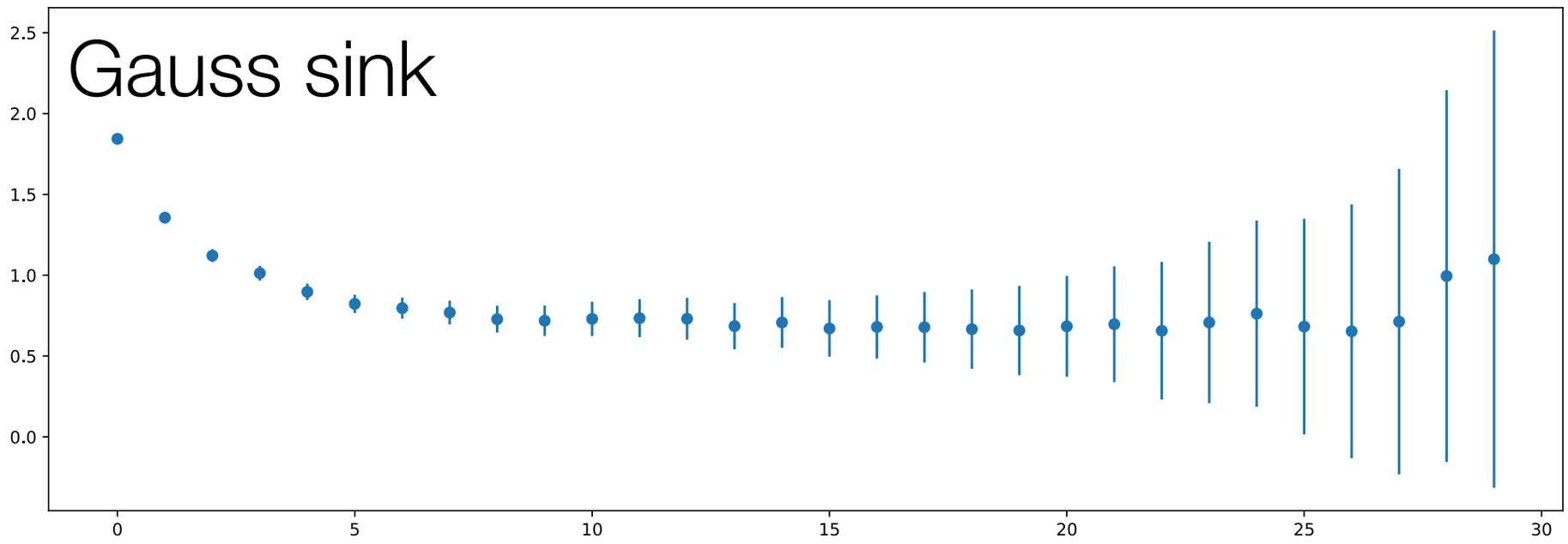
Computationally Affordable

Single Nucleon Operator









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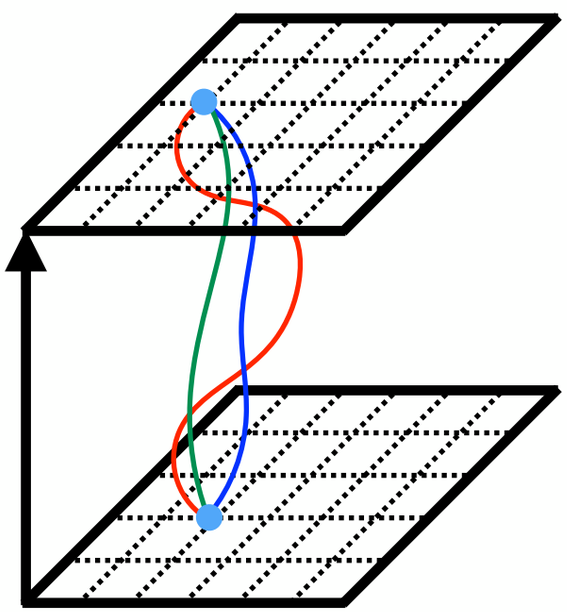
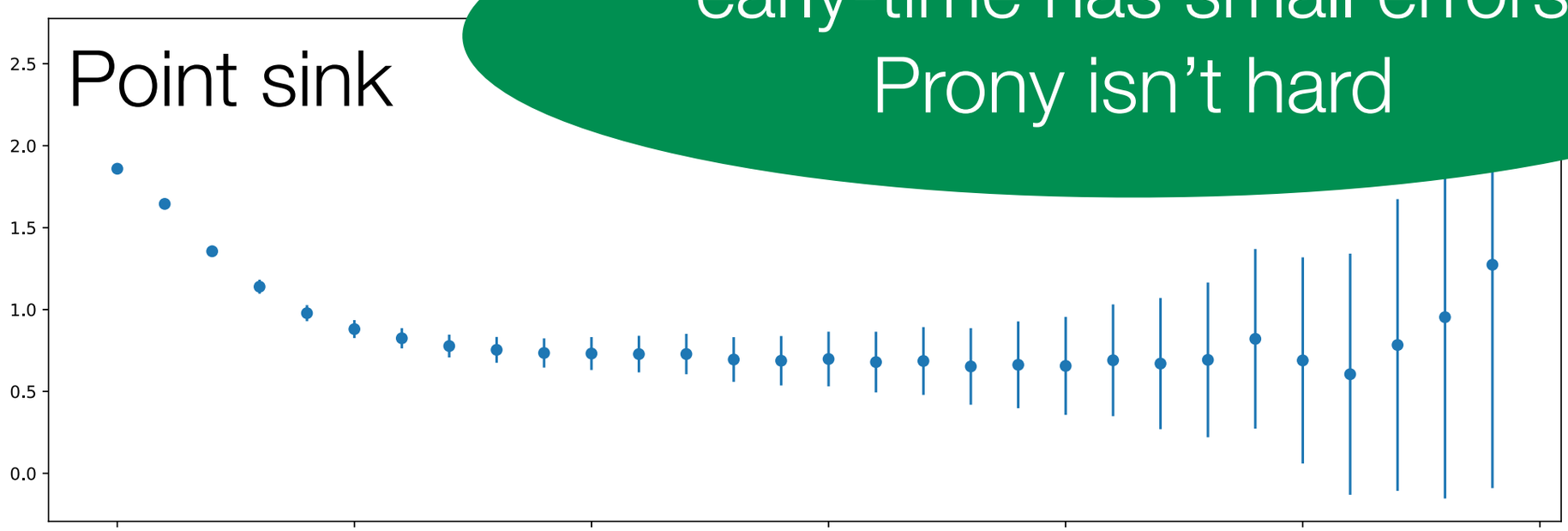
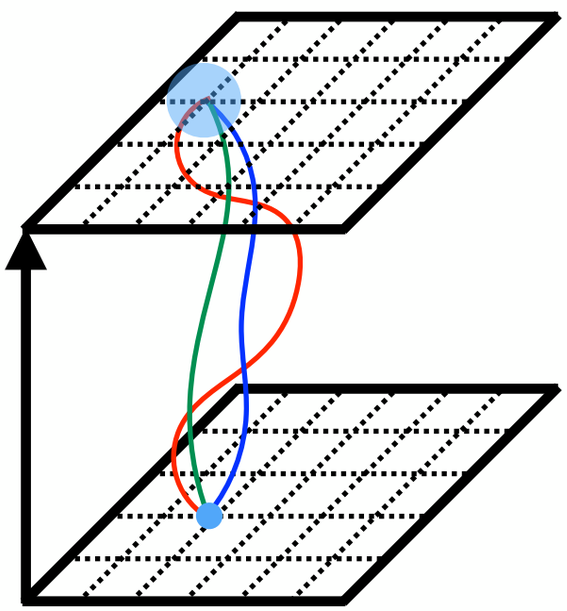
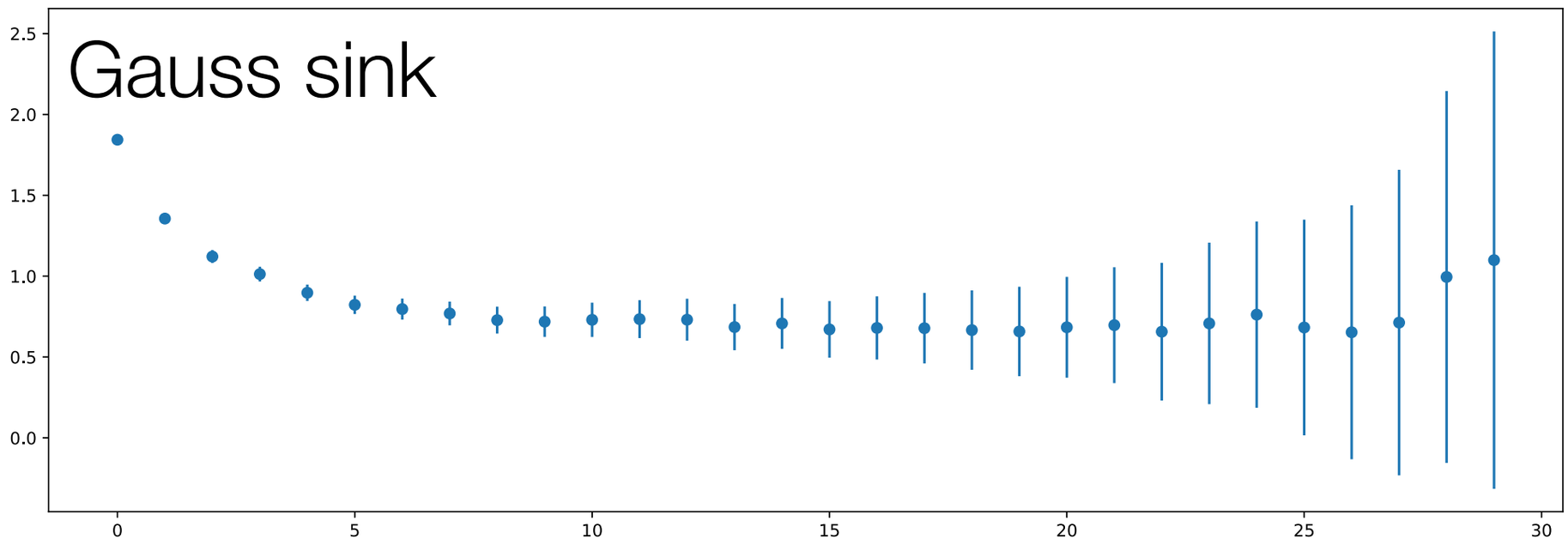




early-time has small errors
Prony isn't hard





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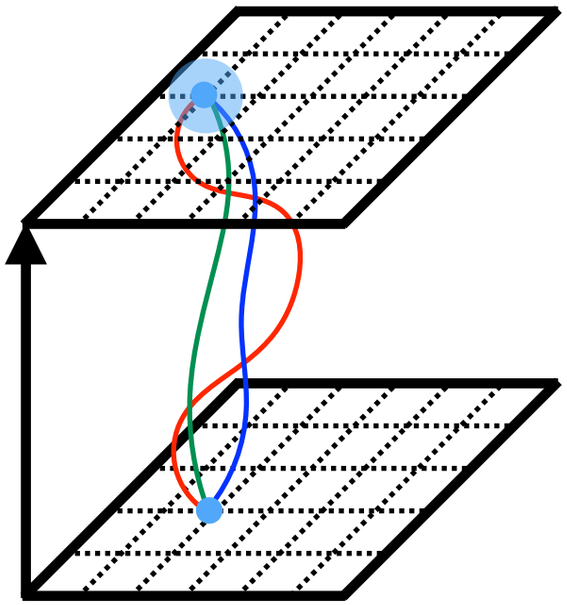

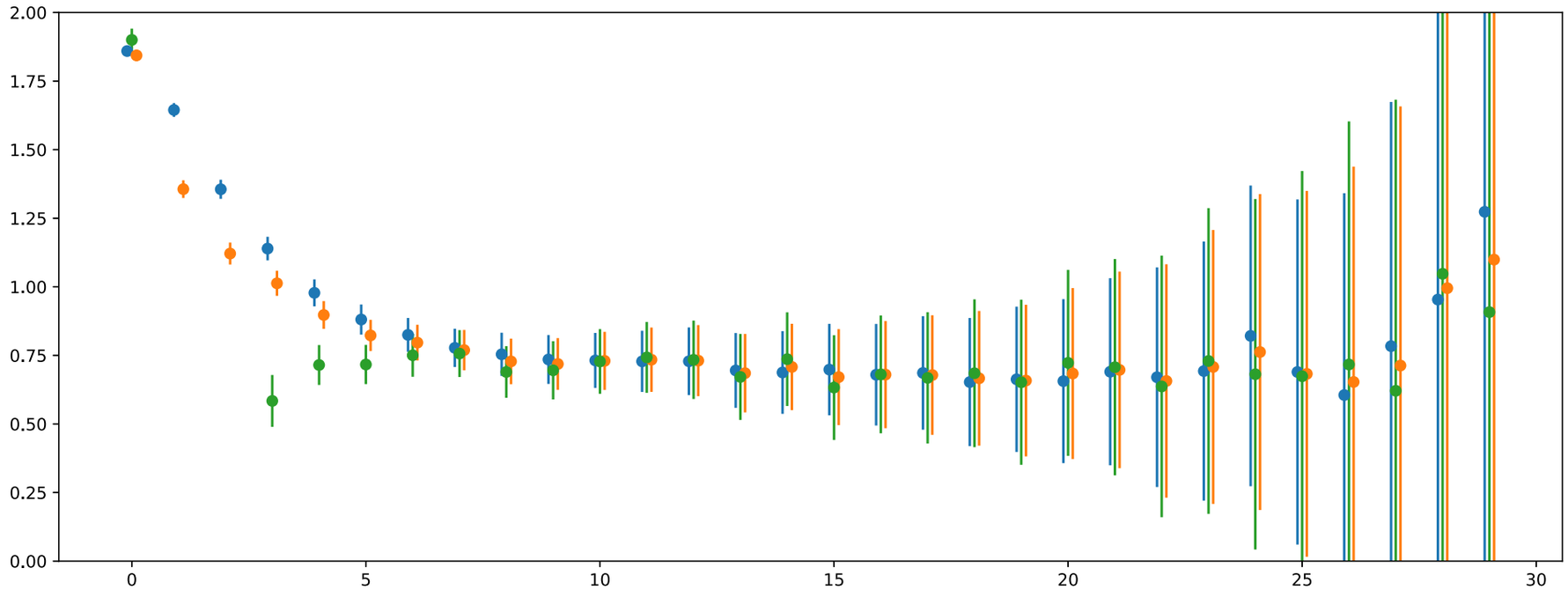

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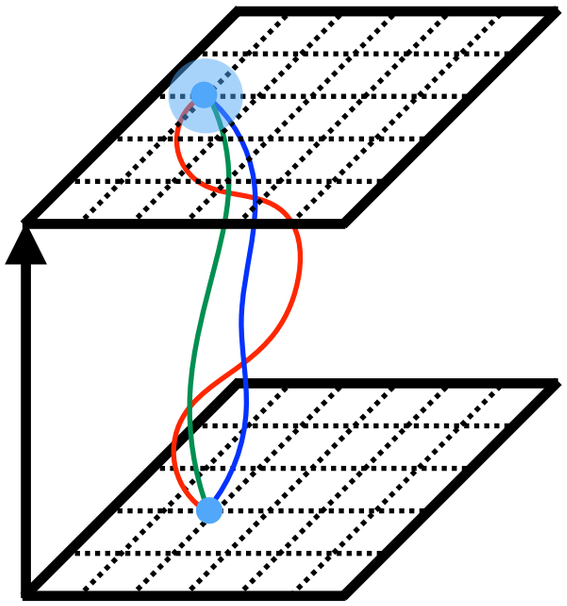
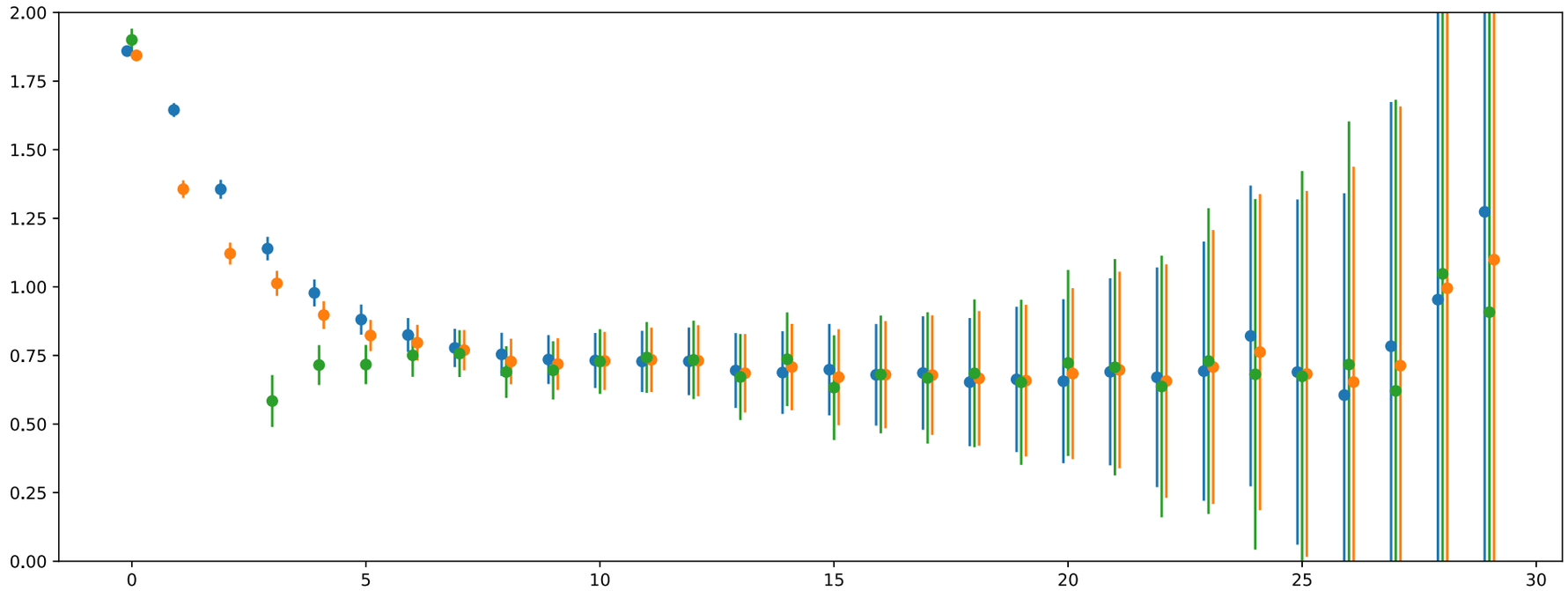
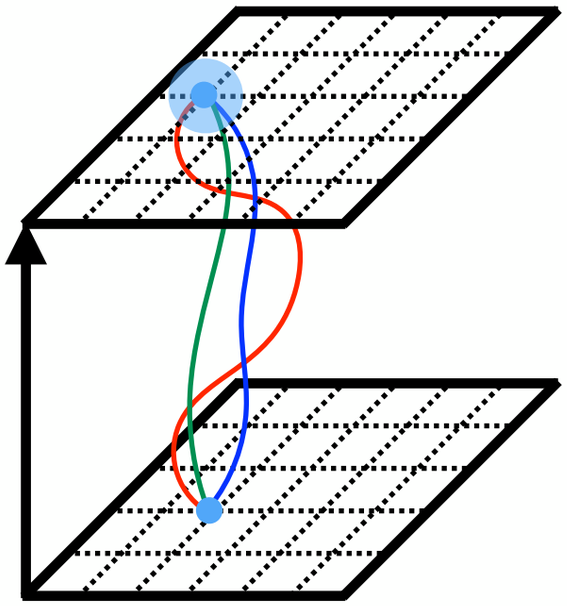


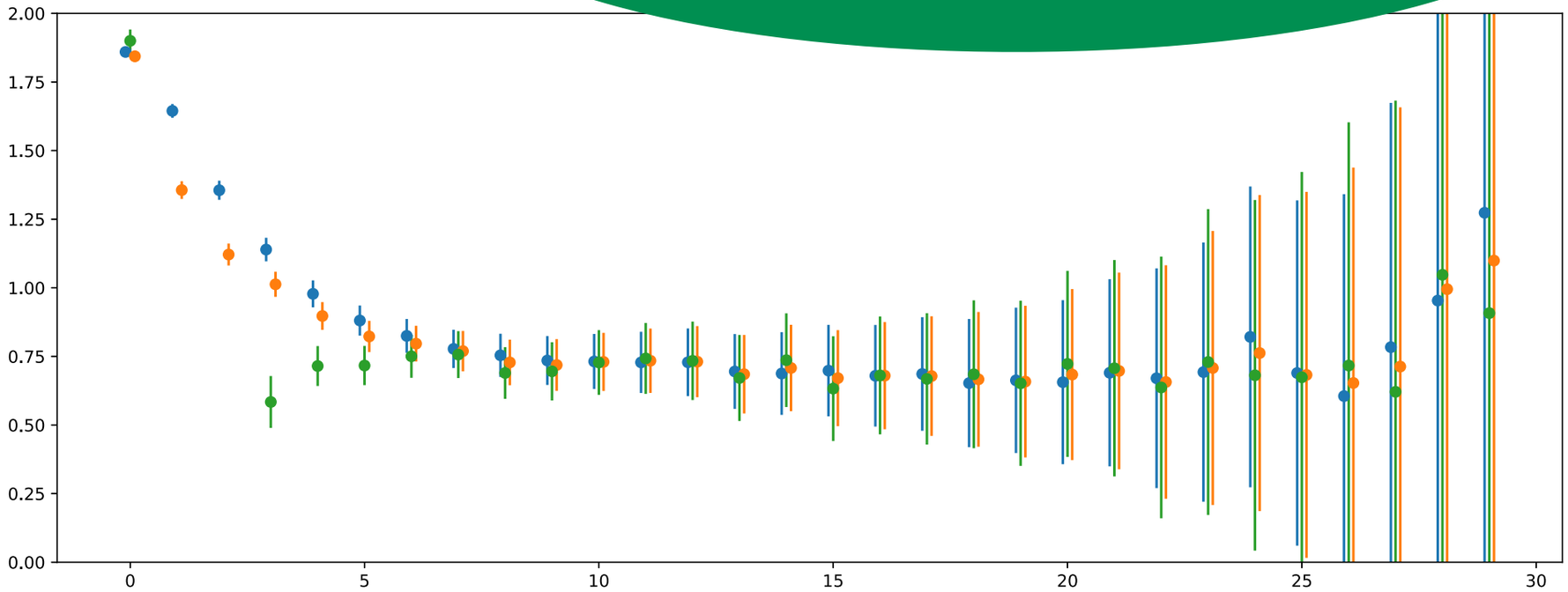


- Determining linear combination doesn’t require large statistics
- No additional inversions.
- One (or more) smearing + single-nucleon contraction

Single Nucleon Operator

LC lengthens N plateau from t~10 to t~5





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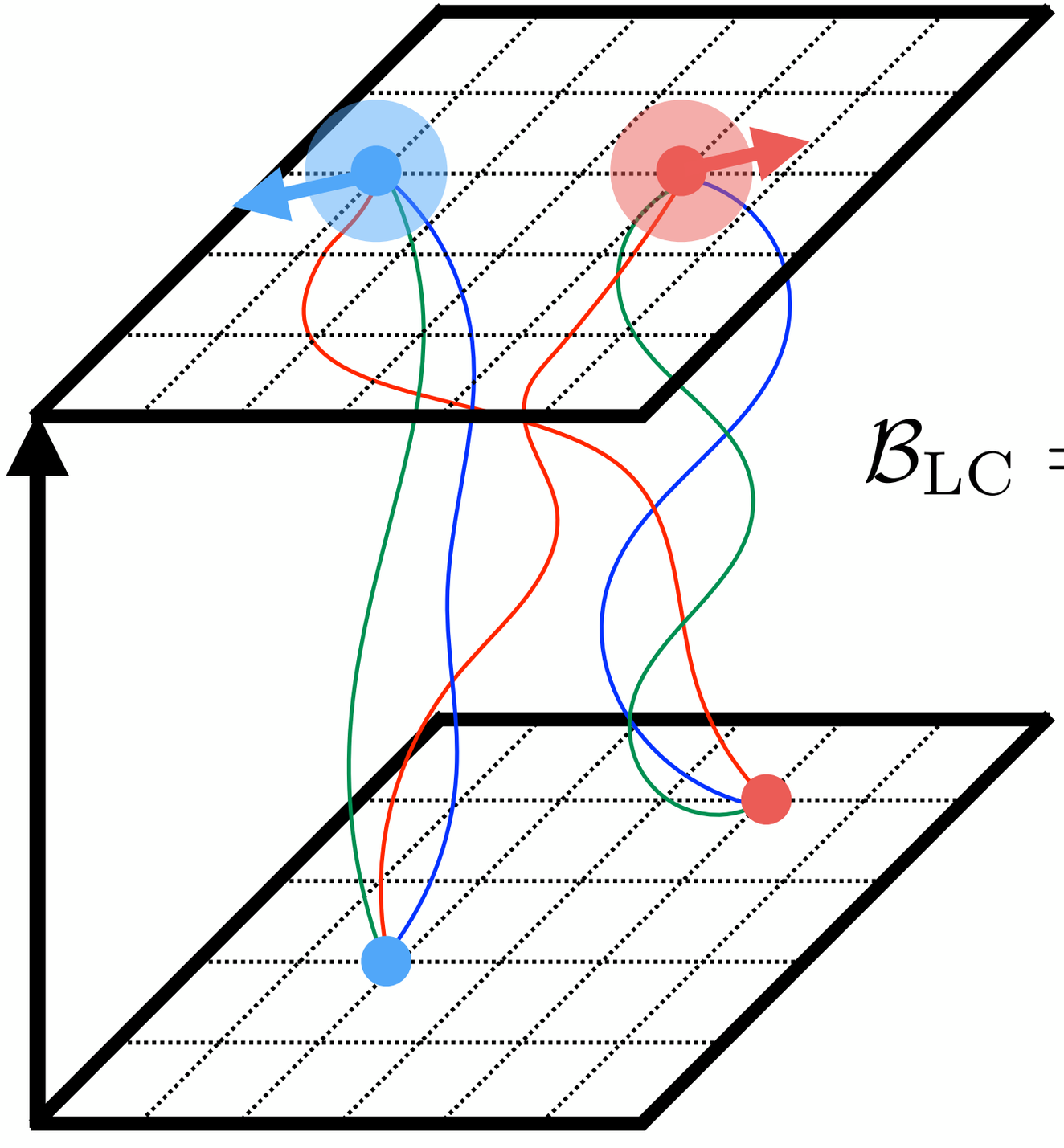
Easy to Incorporate into Baryon Blocks

Doi & Endres 1205.0585, Detmold & Orginos 1207.1452



multiple calls to baryon block construction routine

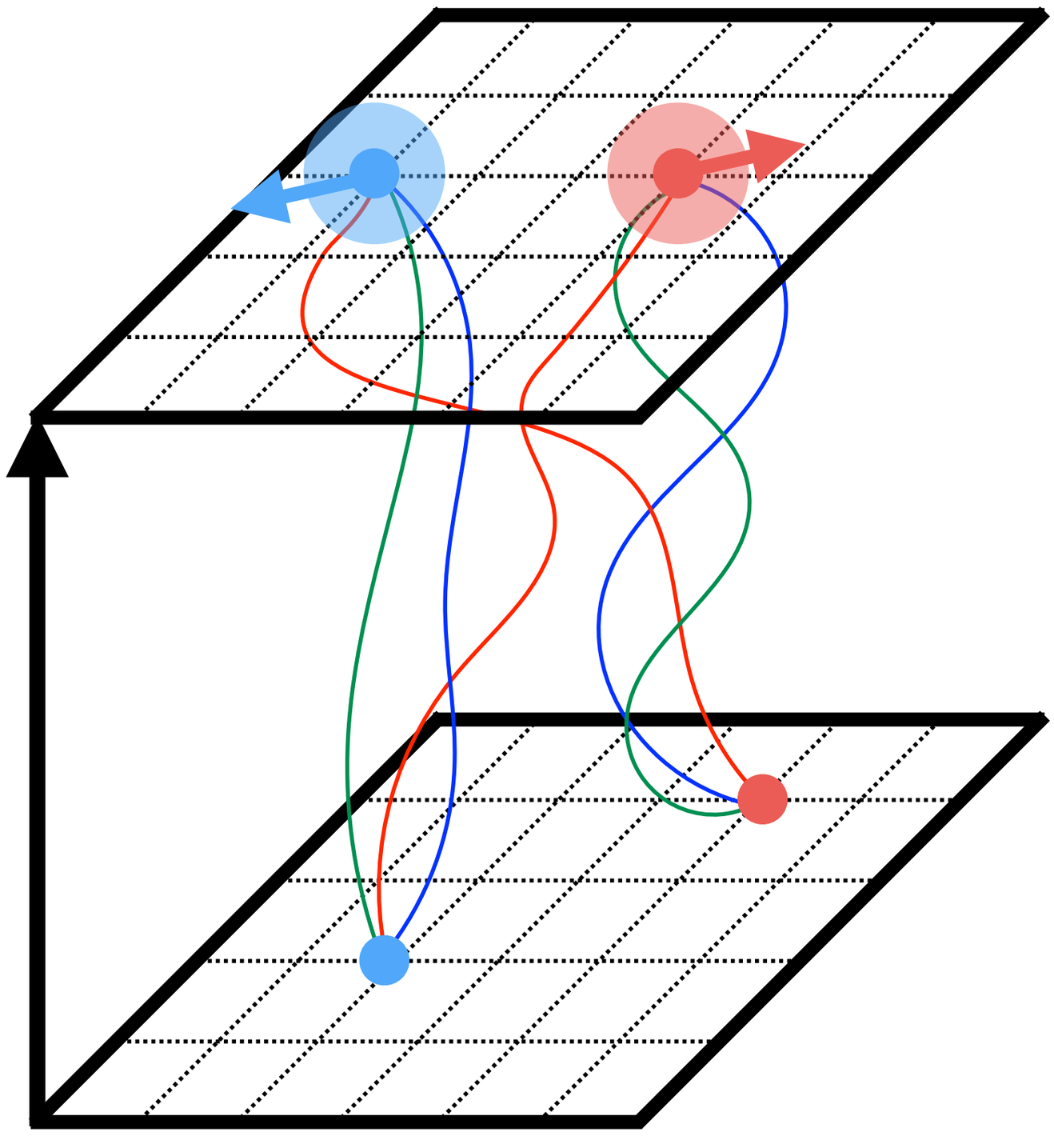
$$\mathcal{B}_{\mathrm{LC}} = \sum_j c_j \mathcal{B}(\mathrm{smearing}_j(S))$$

can be other baryon operators, too
e.g. HadSpec quark-displaced ops

same calls to tensor contraction routine

$$C_{\mathrm{LC}} = C(\mathcal{B}_{LC})$$

Source Improvement?



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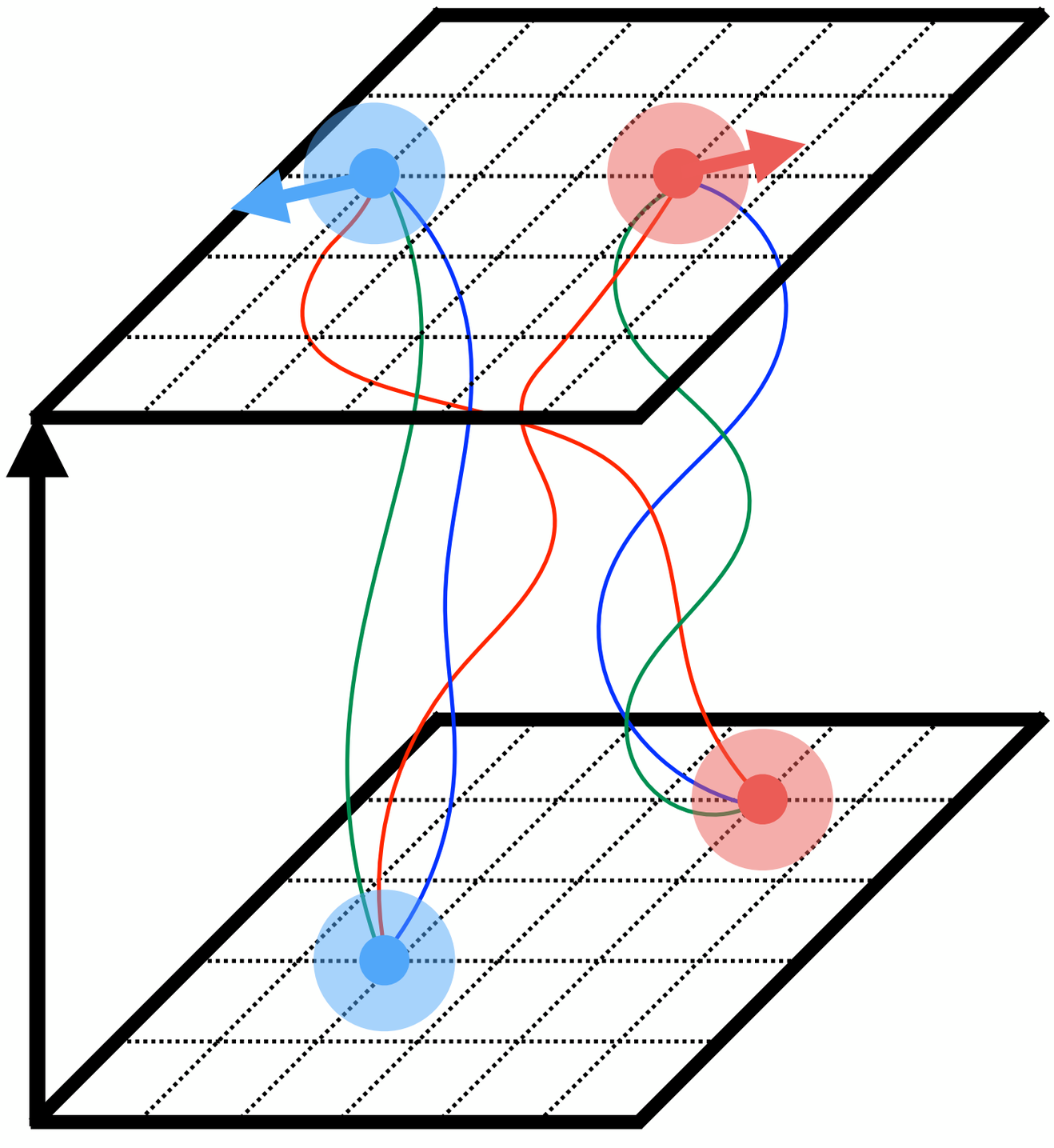

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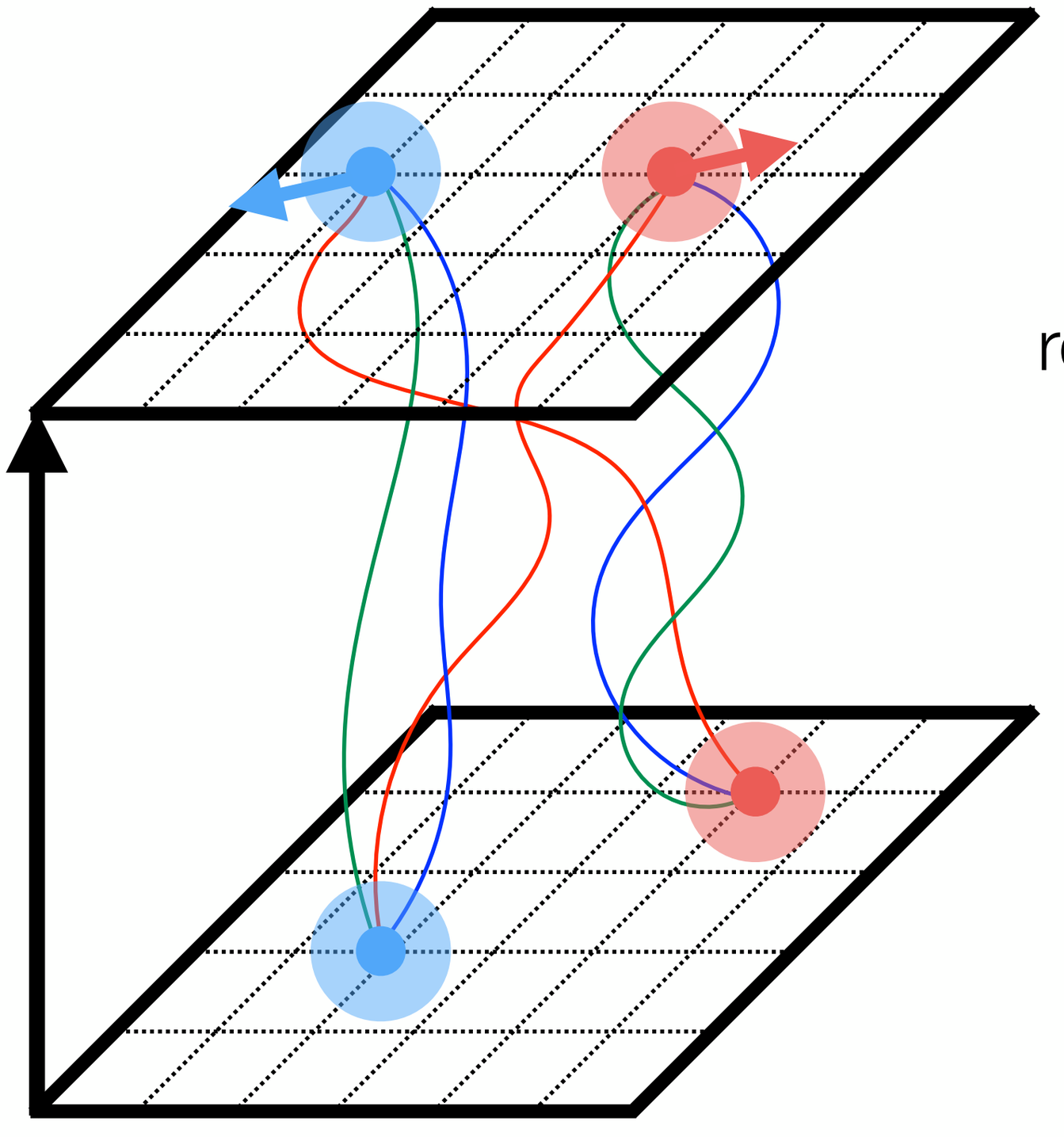
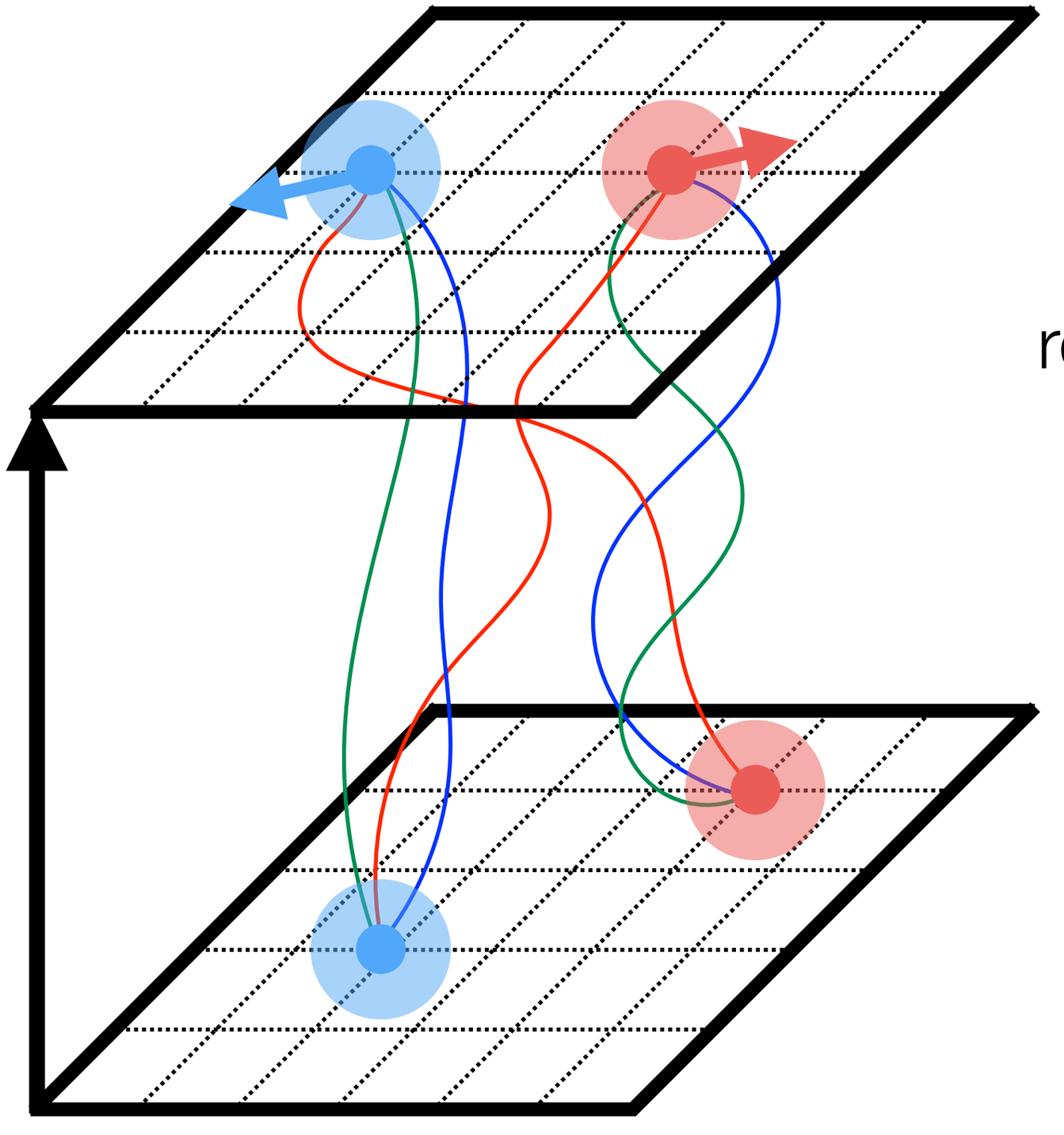


Tuning the ‘whole proton’ requires additional inversions

Source Improvement?



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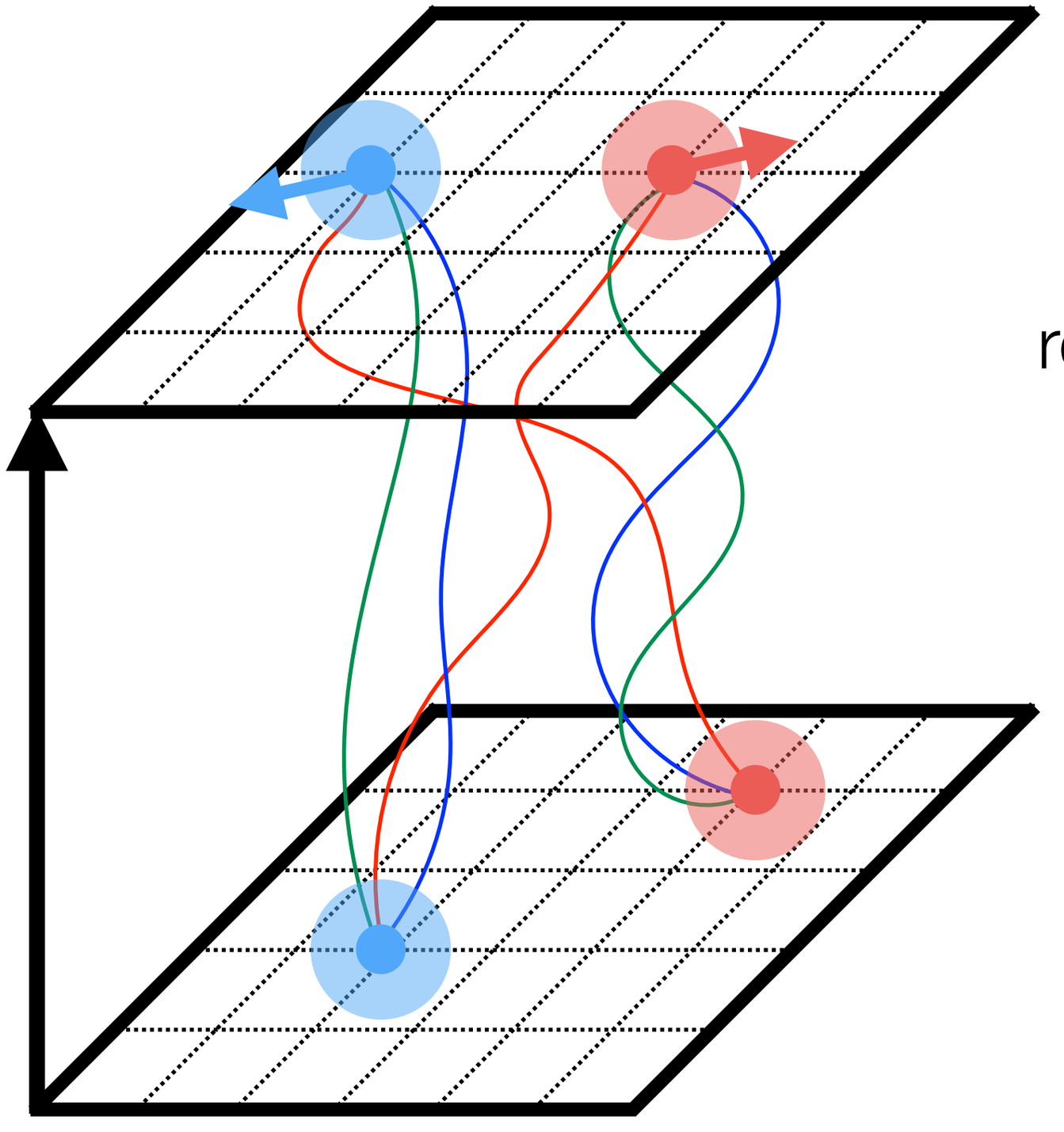
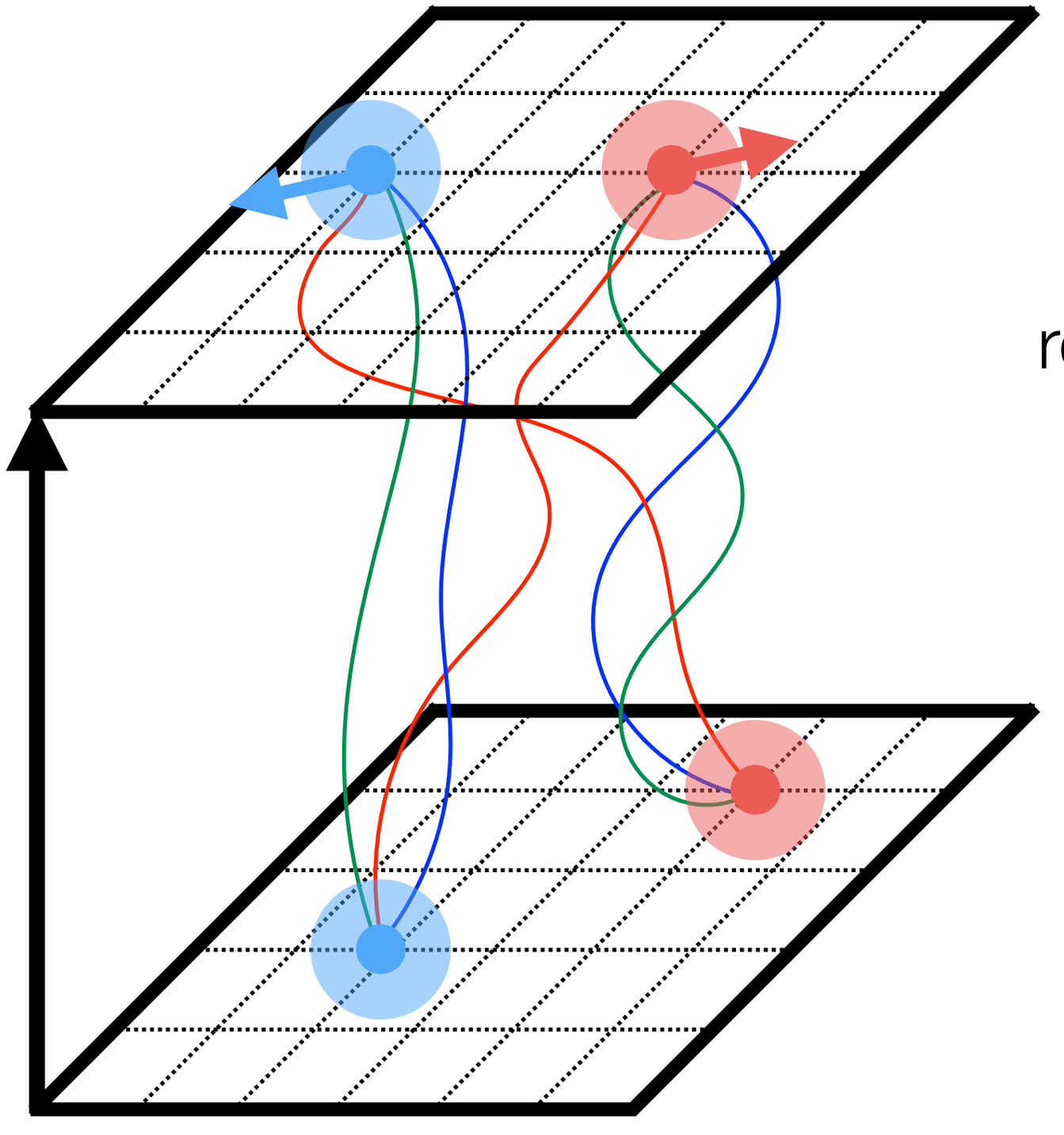


Tuning the ‘whole proton’ requires additional inversions

Adjusting quark sources is feasible but nonlinear

Source Improvement?



Tuning the ‘whole proton’ requires additional inversions

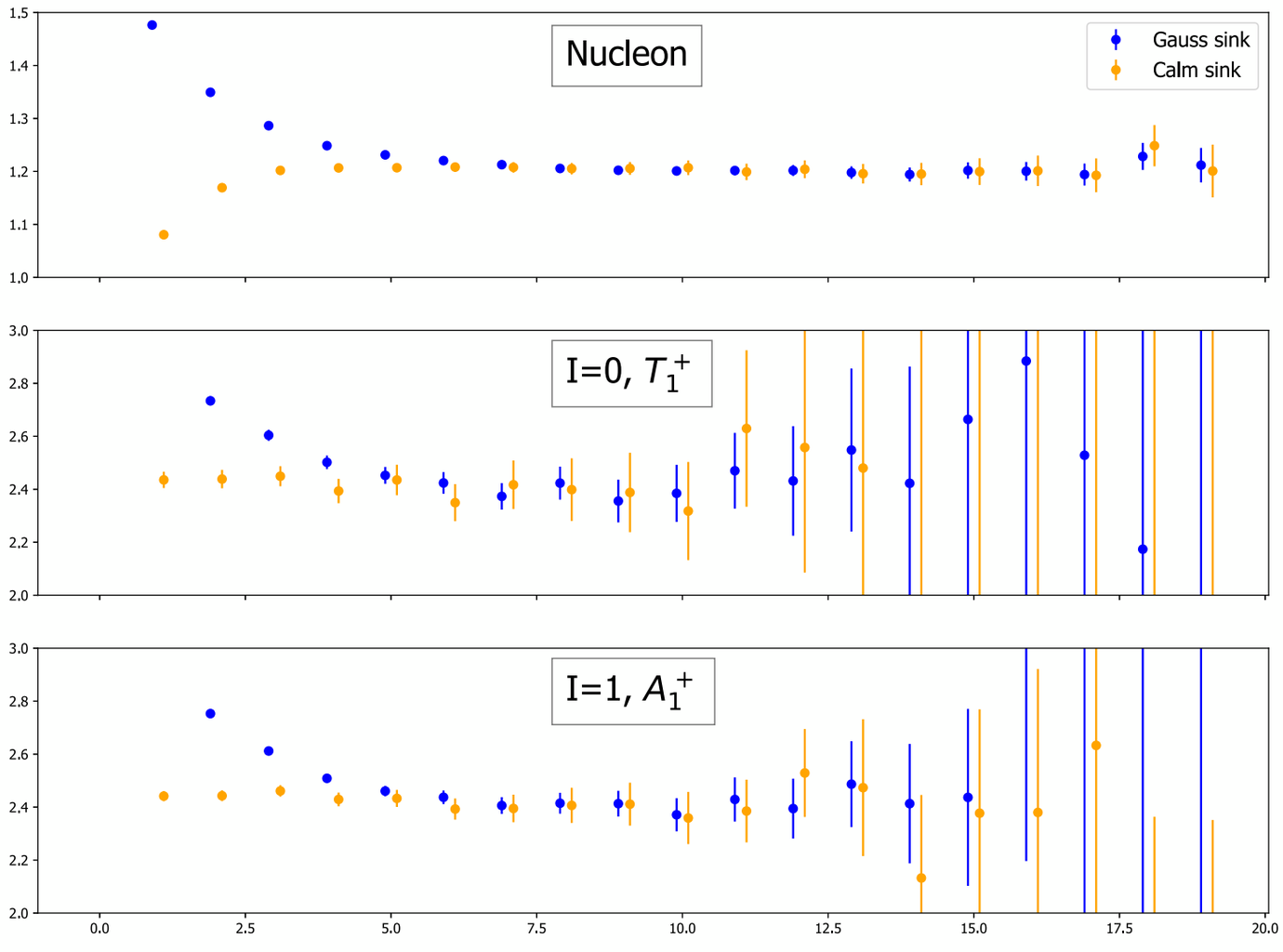
Adjusting quark sources is feasible but nonlinear

so far, unneeded

Defenestrated multi-nucleon Operators?

In preparation

- Easy to code
- Easy to tune
- Marginal additional cost (no extra inversions)
- Works even better on spatially displaced NN sources
  1508.00886
- Don’t fight the noise
  But you still could!
  eg. Wagman & Savage 1704.07356
- Substantially longer plateaus for not much more work.



Defenestrated multi-nucleon Operators?

In preparation

- Ex-post-facto justification for fitting ratio?
- Plateau crisis? NN Prony or excited-state analysis should settle the issue
- Important single-N inelastic excited states in NN signal
- Not baryon (or QCD) specific, quite generally applicable
  1706.06494 / C. Körber 22 June 16:20
- Can be used in matrix element calculations etc.