# THE ROLE OF BOUNDARY CONDITIONS IN QUANTUM COMPUTATIONS OF SCATTERING OBSERVABLES

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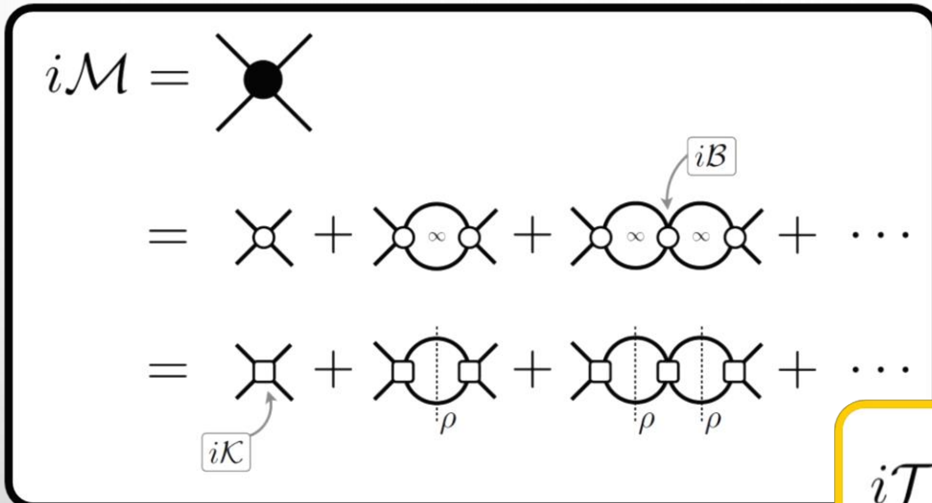
arXiv:2007.01155 [hep-lat]

# MOTIVATION

- RECENTLY PROPOSED THAT REAL TIME CALCULATIONS MAY BE POSSIBLE THROUGH:
  - IMPROVED MONTE CARLO SAMPLING [Alexandru et al. (2016)]
  - QUANTUM COMPUTATIONS [USQCD (2019)]
- IN PRINCIPLE, COULD GIVE ACCESS TO SCATTERING OBSERVABLES FOR HIGH ENERGIES
- VOLUME TRUNCATION LEADS TO NO ASYMPTOTIC STATES
- 2 DIFFERENT POSSIBILITIES TO RESOLVE THIS:
  - LÜSCHER'S SCATTERING FORMALISM
  - DIRECTLY EXTRACT OBSERVABLES FROM $\infty$-VOL. LIMIT

# OBESERVABLES CONSIDERED

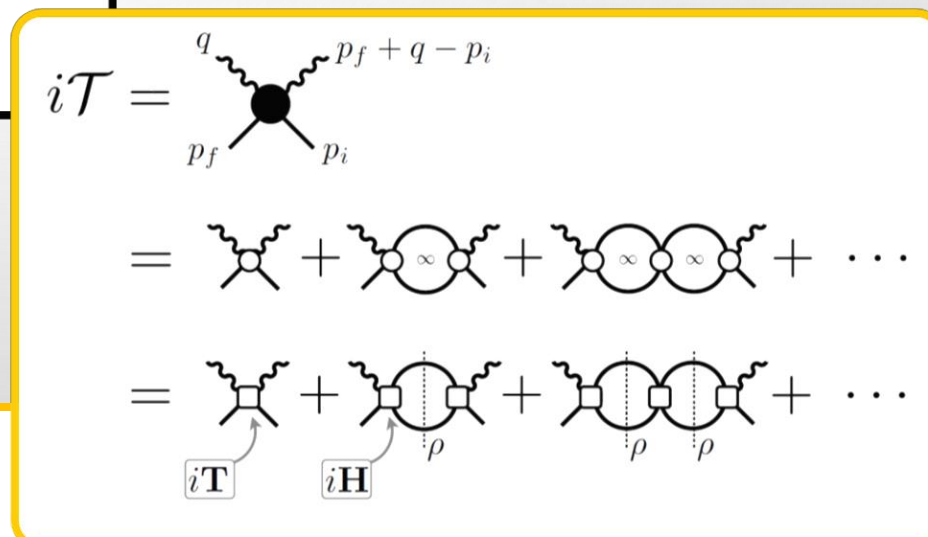
## $2 \rightarrow 2$ HADRONIC AMPLITUDES




- IN 1+1D
- WITHOUT COUPLED CHANNELS

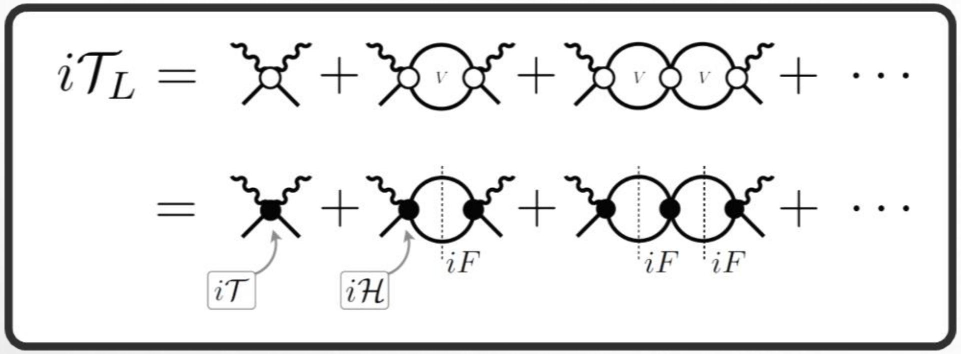
FOCUSING ON THIS

$$\mathcal{T} \equiv i \int d^2x e^{i\omega t - i\boldsymbol{q}\cdot\boldsymbol{x}} \times \langle \boldsymbol{p}_f | T\{\mathcal{J}(x)\mathcal{J}'(0)\} |\boldsymbol{p}_i\rangle_c$$




$1+\mathcal{J} \rightarrow 1+\mathcal{J}$ COMPTON-LIKE AMPLITUDES

# FINITE-VOLUME FORMALISM




Christ et al. (2015)

Briceño, Davoudi, Hansen, Schindler, Baroni (2020)

$$\mathcal{T}_L = \mathcal{T} - \mathcal{H}\frac{1}{F^{-1} + \mathcal{M}}\mathcal{H}'$$

$$F(E^*, \boldsymbol{P}, L) = \frac{1}{2}\left[\frac{1}{L}\sum_n - \int \frac{dk}{2\pi}\right]\frac{1}{2\omega_k}\,\frac{1}{(P-k)^2 - m^2 + i\epsilon}$$

GIVES A METHOD TO EXTRACT $\mathcal{T}$ FROM FINITE-VOLUME INFROMATION

# AN UNEXPECTED APPLICATION

USE $\mathcal{T}_L$ TO PREDICT VOLUME EFFECTS IN MINKOWSKI OBSERVABLES

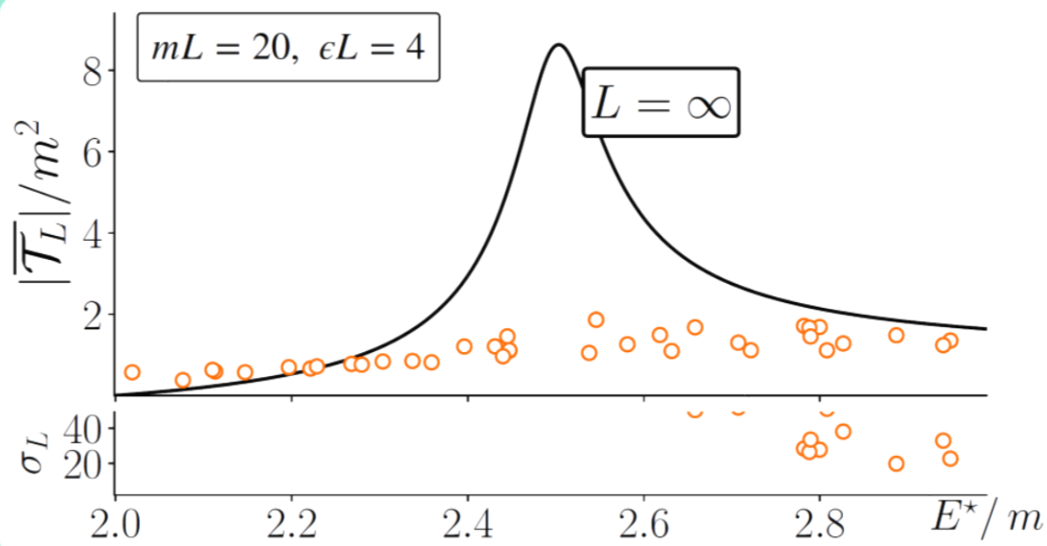
IDENTIFY VALUES OF $\epsilon$ AND $L$ THAT GIVE AN ESTIMATE OF THE LIMIT

$$\lim_{\epsilon \to 0} \lim_{L \to \infty} \mathcal{T}_L(p_f, q, p_i) = \mathcal{T}(E^\star, Q^2, Q_{if}^2)$$

$$E \to E + i\epsilon$$

NON-PERTURBATIVE, MODEL INDEPENDENT APPROACH!

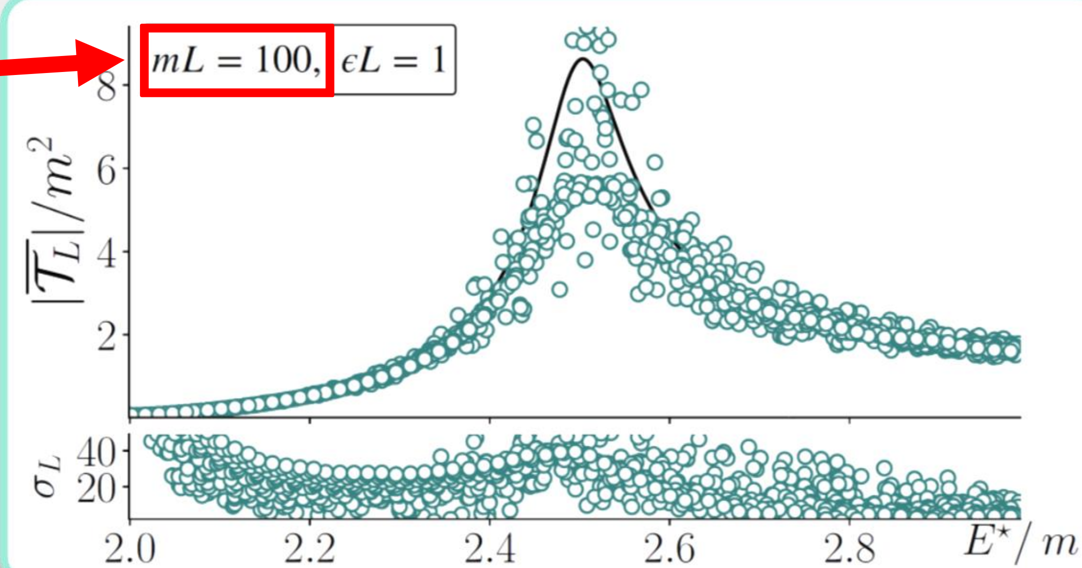
# NUMERICAL RESULTS




$$\mathcal{T}_L = \mathcal{T} - \mathcal{H}\frac{1}{F^{-1} + \mathcal{M}}\mathcal{H}'$$

$\sigma_L$ = % DIFFERENCE

OUCH!

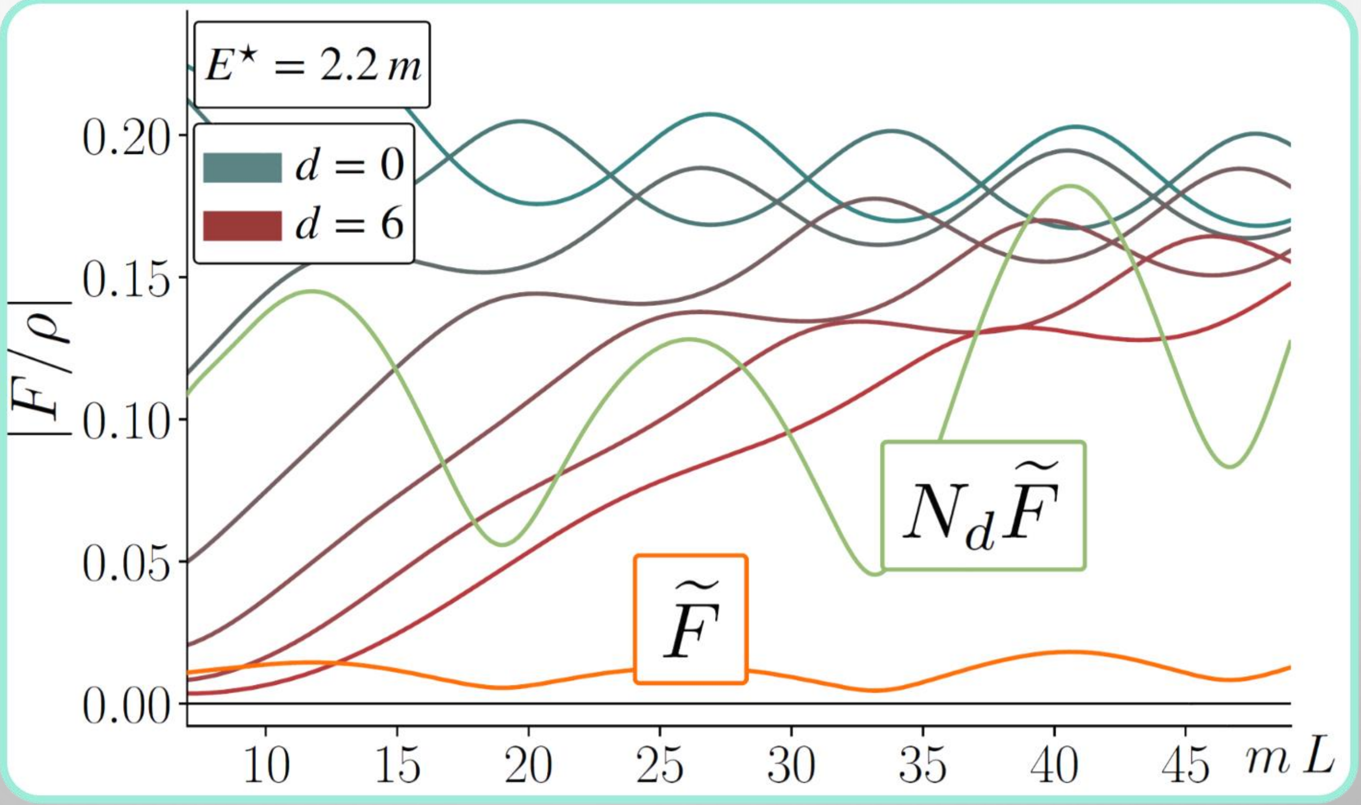



ENHANCED VOLUME EFFECTS $\Longrightarrow$ $F$ IS TOO LARGE

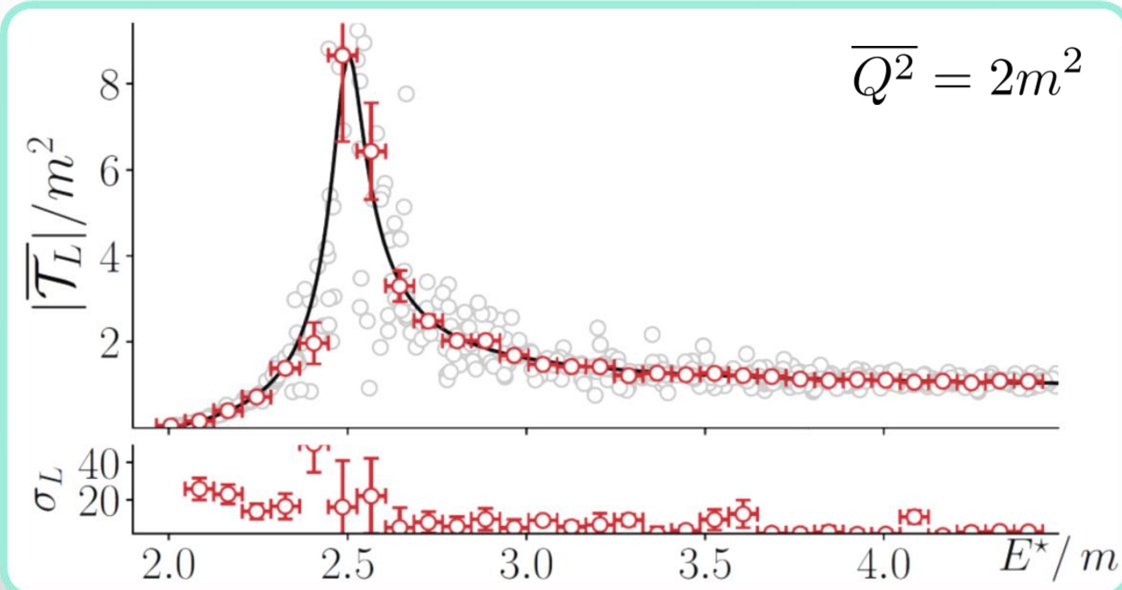
# FINITE-VOLUME DISTORTIONS

$$F(E^*, \boldsymbol{P}, L) = \frac{1}{2}\left[\frac{1}{L}\sum_n - \int \frac{dk}{2\pi}\right]\frac{1}{2\omega_k}\frac{1}{(P-k)^2 - m^2 + i\epsilon}$$

$$\boldsymbol{P} = \frac{2\pi d}{L}$$

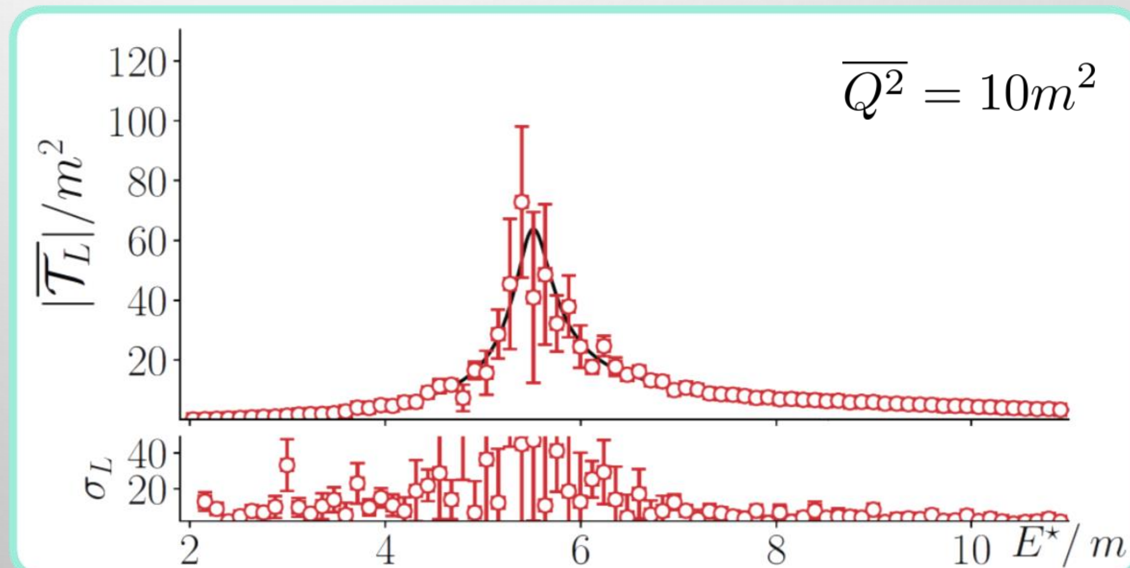


# AVERAGING TECHNIQUE




VARYING $\boldsymbol{P}$ CHANGES $\mathcal{T}_L$ BUT NOT $\mathcal{T}$

AVERAGED OVER $mL = 20, 25, 30$




BINNED OVER REDUNDANT KINEMATICS

# SUMMARY

- WE HAVE EXPLORED THE POSSIBILITY OF EXTRACTING SCATTERING AMPLITUDES FROM FINITE-VOLUME MINKOSWSKI CORRELATION FUNCTIONS

- FOCUS: COMPTON-LIKE AMPLITUDES

- NAÏVE ANALYSIS SHOW THAT ONE NEEDS VOLUMES OF $mL \approx \mathcal{O}(100)$ TO RECOVER INFINITE VOLUME AMPLITUDE

- BINNING: VOLUMES OF $mL \approx 20 - 30$ ALLOW TO RECOVER AMPLITUDE