NSTAR 2026

SCATTERING AND FEMTOSCOPIC CORRELATION FUNCTIONS OF THE $\Sigma_c\pi$ SYSTEMS

Based on: Physics Letters B 878, 140529 (2026), arXiv:2603.02979

and ongoing work

Mikel Fernández Barbat (IFIC, CSIC-UV)

In collaboration with Juan Nieves and Laura Tolos

GENERALITAT VALENCIANA

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MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

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CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

VNIVERSITAT DE VALÈNCIA

IFIC INSTITUT DE FÍSICA CORPUSCULAR

EXCELENCIA SEVERO OCHOA

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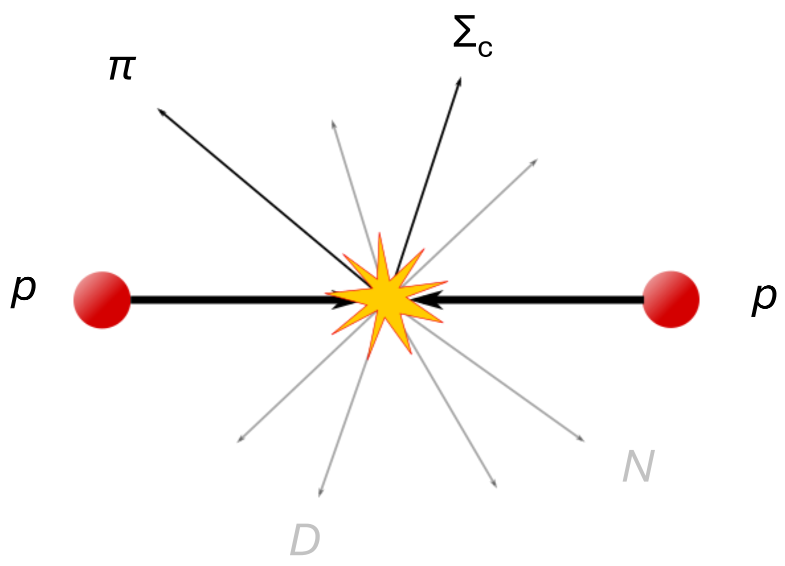

L. Fabbietti et al., Ann. Rev. Nucl. Part. Sci. 71, 377 (2021)

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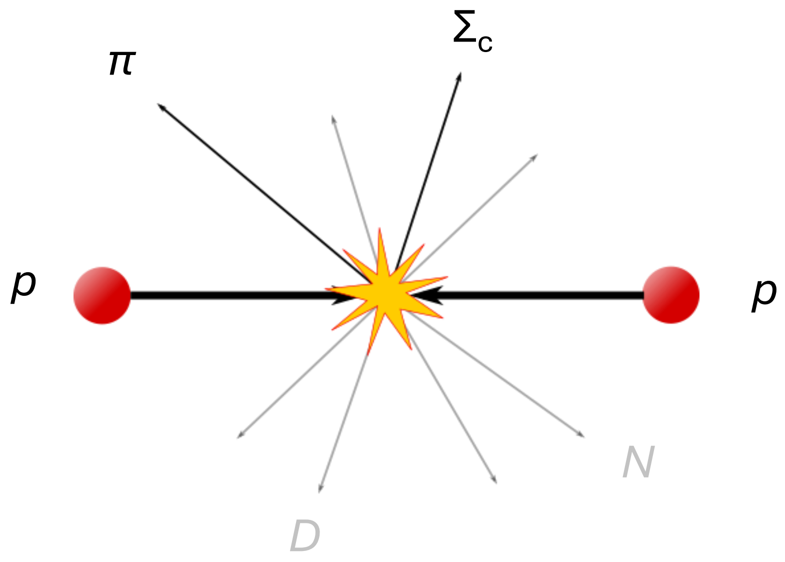

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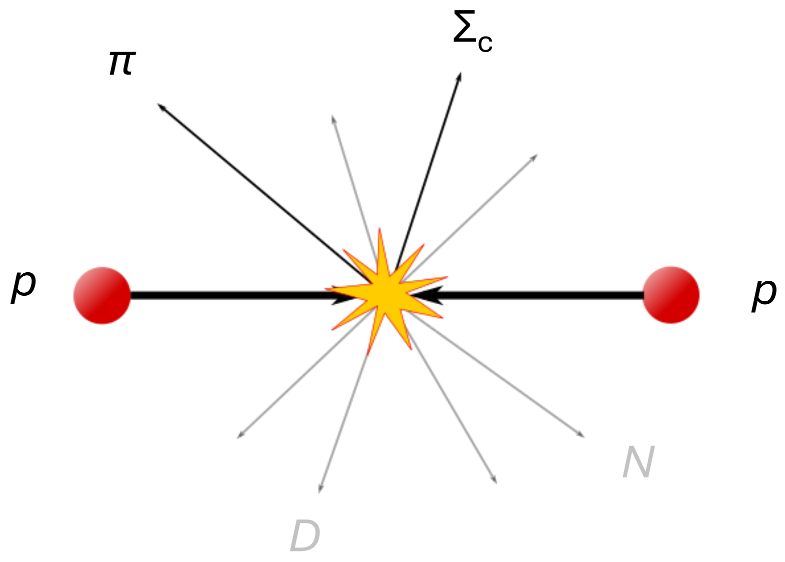

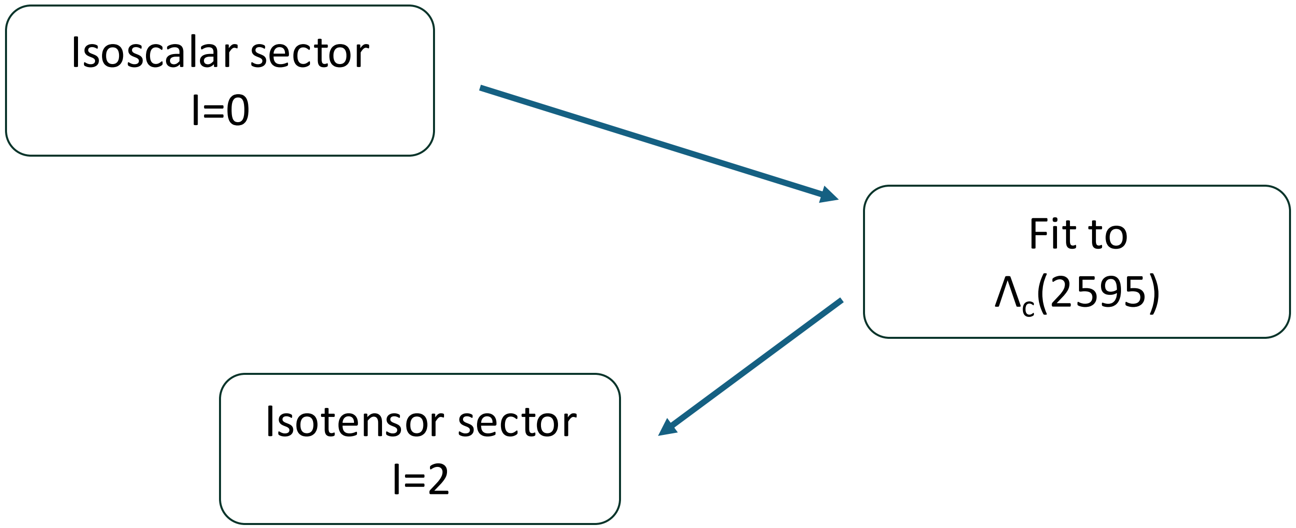

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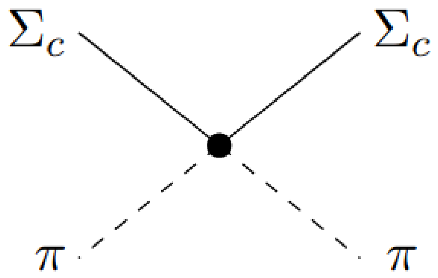
TWO MODELS OF THE STRONG INTERACTION

SU(4) - WT

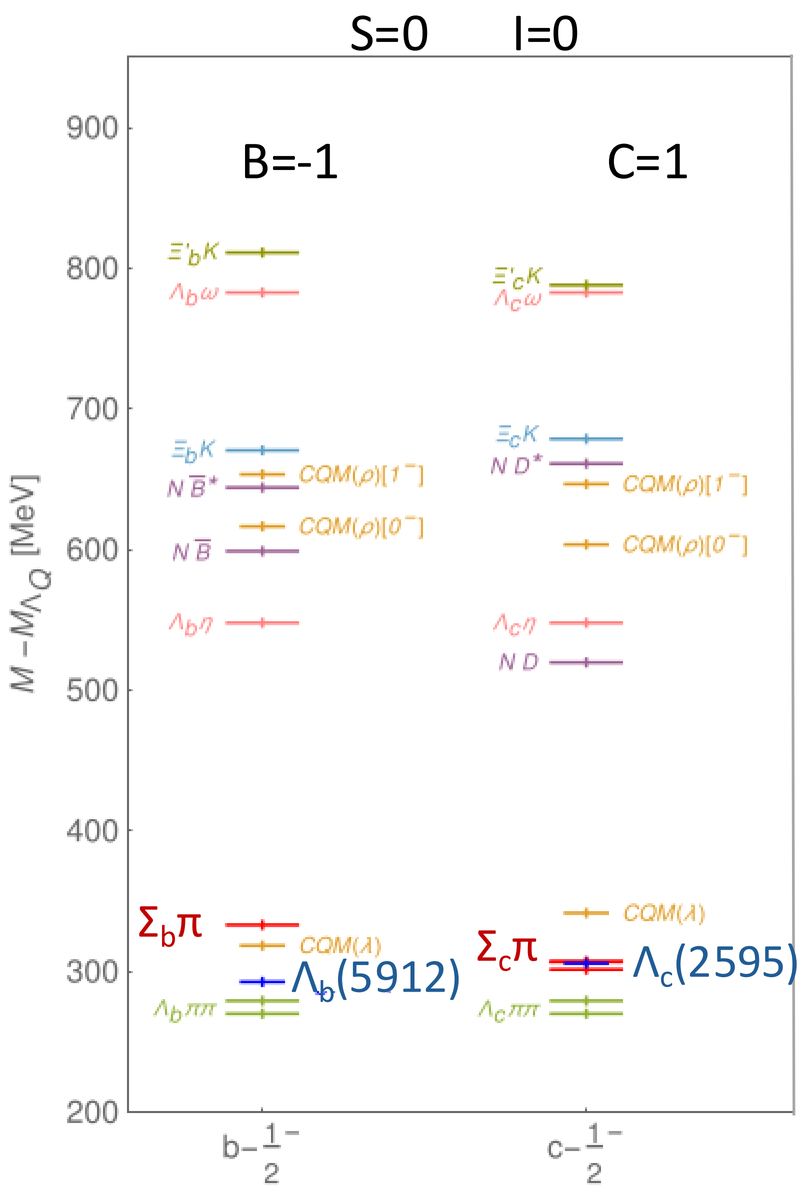
- Interaction between pseudo-scalar mesons and ground-state ½ baryons through a **Weinberg-Tomozawa** (WT) interaction



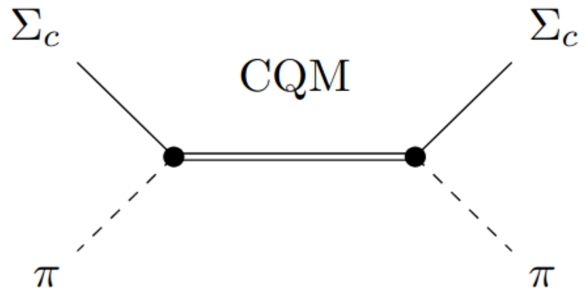
- **Coupled-channel** dynamics in the I=0 sector
- **Sharp-cutoff** regularization fitted to $\Lambda_c(2595)$

J. Hofmann and M. F. M. Lutz, Nucl. Phys. A763, 90 (2005)
M. F. Barbat et al., Phys. Rev. D 113, 056025 (2026)

CQM EXCHANGE MOTIVATION



- The $\Lambda_c(2595)$ lies close to a constituent quark model (CQM) state and to the $\Sigma_c\pi$ threshold



$$V_{ex}(s) = 2\mathring{M}_{CQM} \frac{\boxed{d_c^2}}{s - (\mathring{M}_{\rm CQM})^2},$$

T. Yoshida et al., Phys. Rev. D 92, 114029 (2015)

J. Nieves et al., Progress in Particle and Nuclear Physics 137, 104118 (2024)

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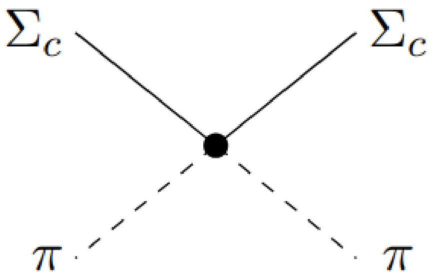

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WT & CQM

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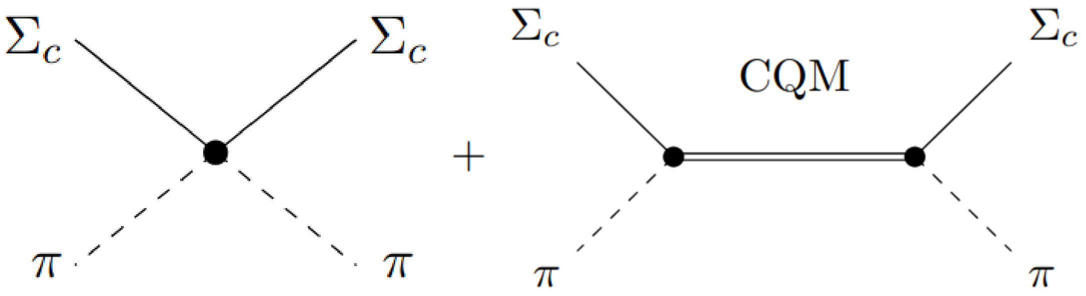

- **Subtraction** of the finite part, divergent contribution regularized with a cutoff
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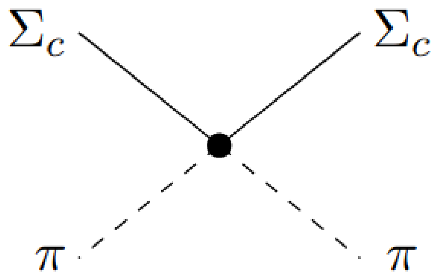

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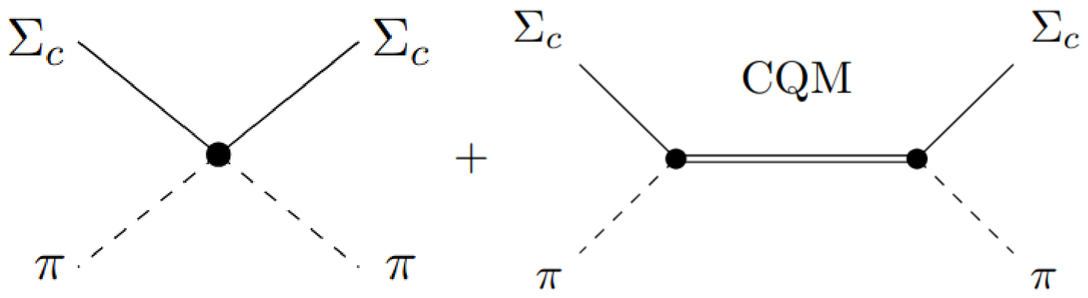

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J. Nieves et al., Progress in Particle and Nuclear Physics 137, 104118 (2024)

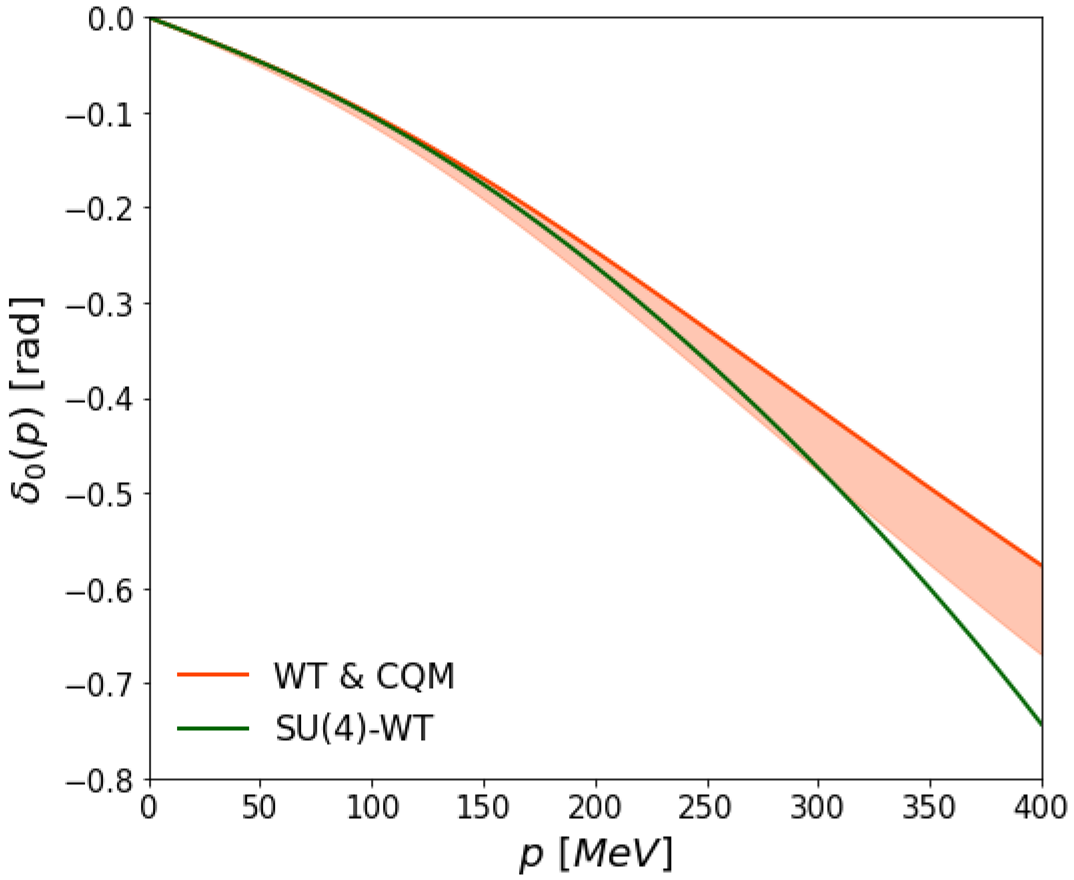
Key point for the I=2 calculation

No CQM-state exchange is possible in I=2 → Models differ in the renormalization scheme

DIFFERENT RENORMALIZATION: DIFFERENT SCATTERING OBSERVABLES

M. F. Barbat et al., PLB 878, 140529 (2026)

Strong



Agreement at low p, visible model dependence above ~ 200 MeV.

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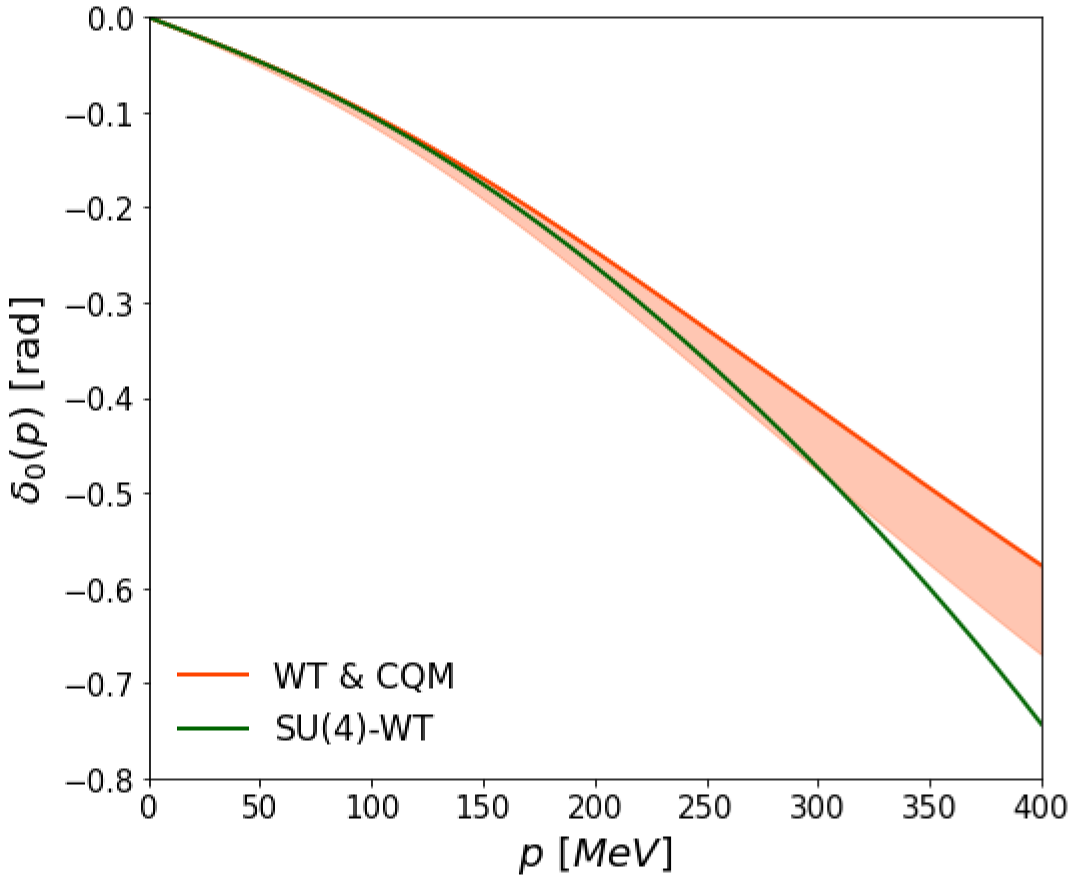

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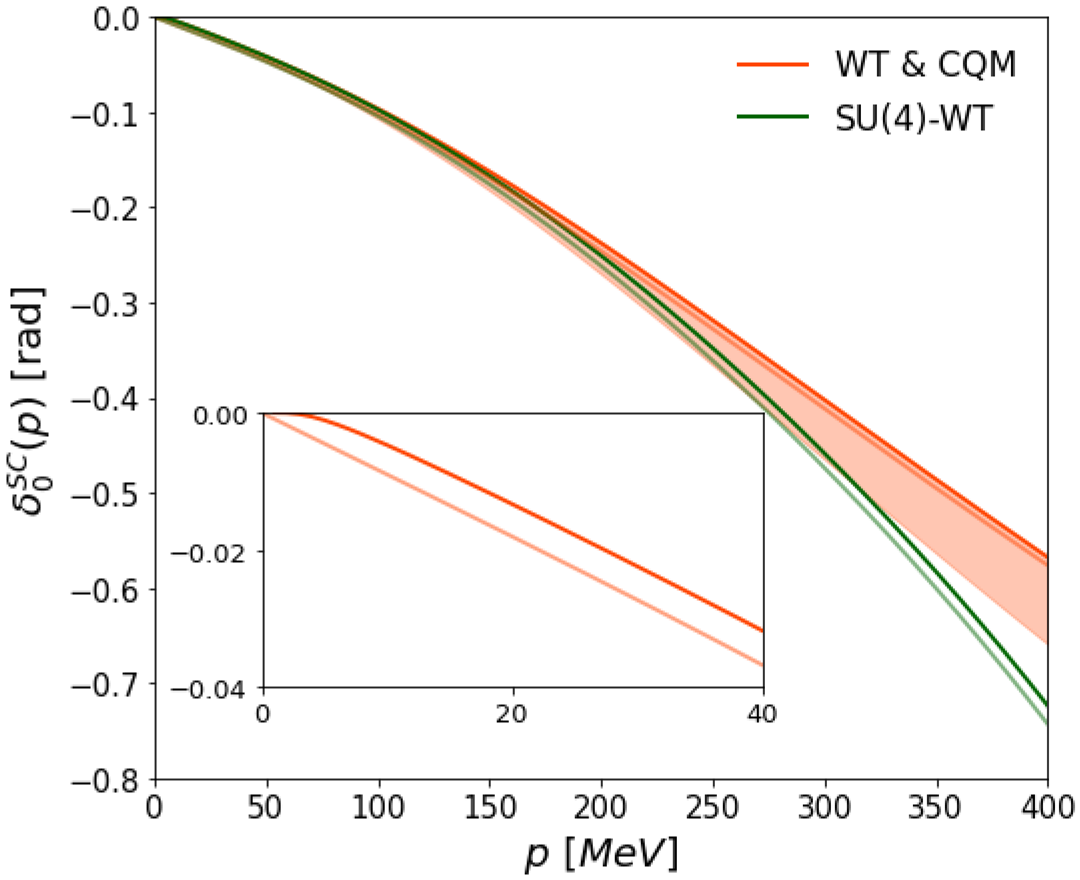
Strong & Coulomb



The repulsive Coulomb interaction slightly weakens the strong interaction at short distances

FROM SCATTERING AMPLITUDE TO THE CORRELATION FUNCTION

Strong interaction

$\downarrow$

$\boxed{\text{Wave function}}$

$$\boxed{|\psi(\boldsymbol{r}, \boldsymbol{p})|^2}$$

FROM SCATTERING AMPLITUDE TO THE CORRELATION FUNCTION

Strong interaction

$\downarrow$

Wave function

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Correlation function

$$\boxed{C(p)} = \int d^3r \; S(\boldsymbol{r}) \boxed{|\psi(\boldsymbol{r}, \boldsymbol{p})|^2}$$

S. E. Koonin, Phys. Lett. B 70, 43 (1977)
S. Pratt et al., Phys. Rev. C 42, 2646 (1990)

FROM SCATTERING AMPLITUDE TO THE CORRELATION FUNCTION

Strong interaction

↓

Wave function

↓ ← Source function

Correlation function

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For a spherical Gaussian source,

$$S(r) = (4\pi R^2)^{-3/2} \, \exp\left(-\frac{r^2}{4R^2}\right)$$

We take R = 1 fm as the reference source size

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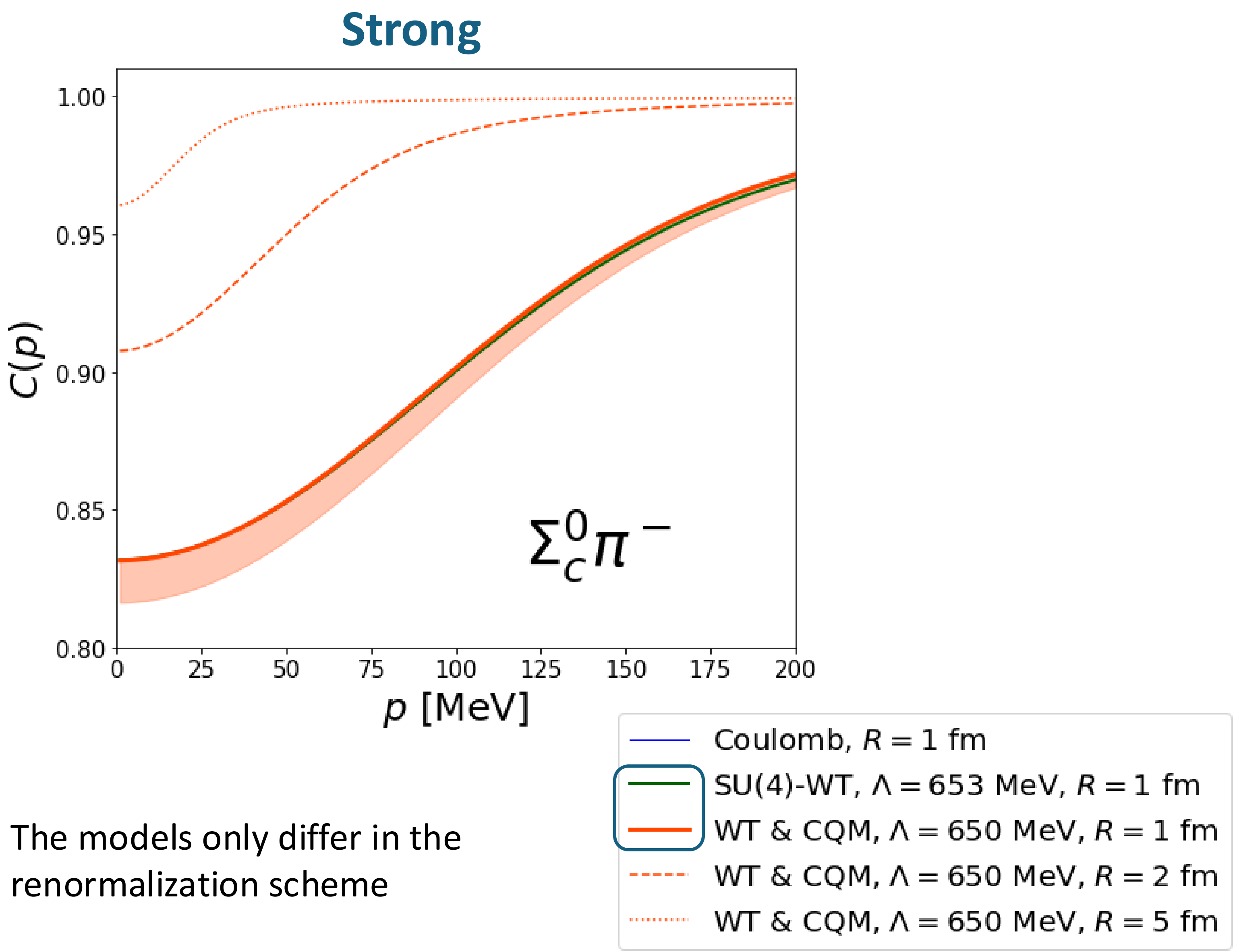
Does the model dependence seen in δ_0(p) remains visible in C(p)?

$\Sigma_c\pi$: STRONG INTERACTION ONLY

M. F. Barbat et al., PLB 878, 140529 (2026)



The models only differ in the renormalization scheme

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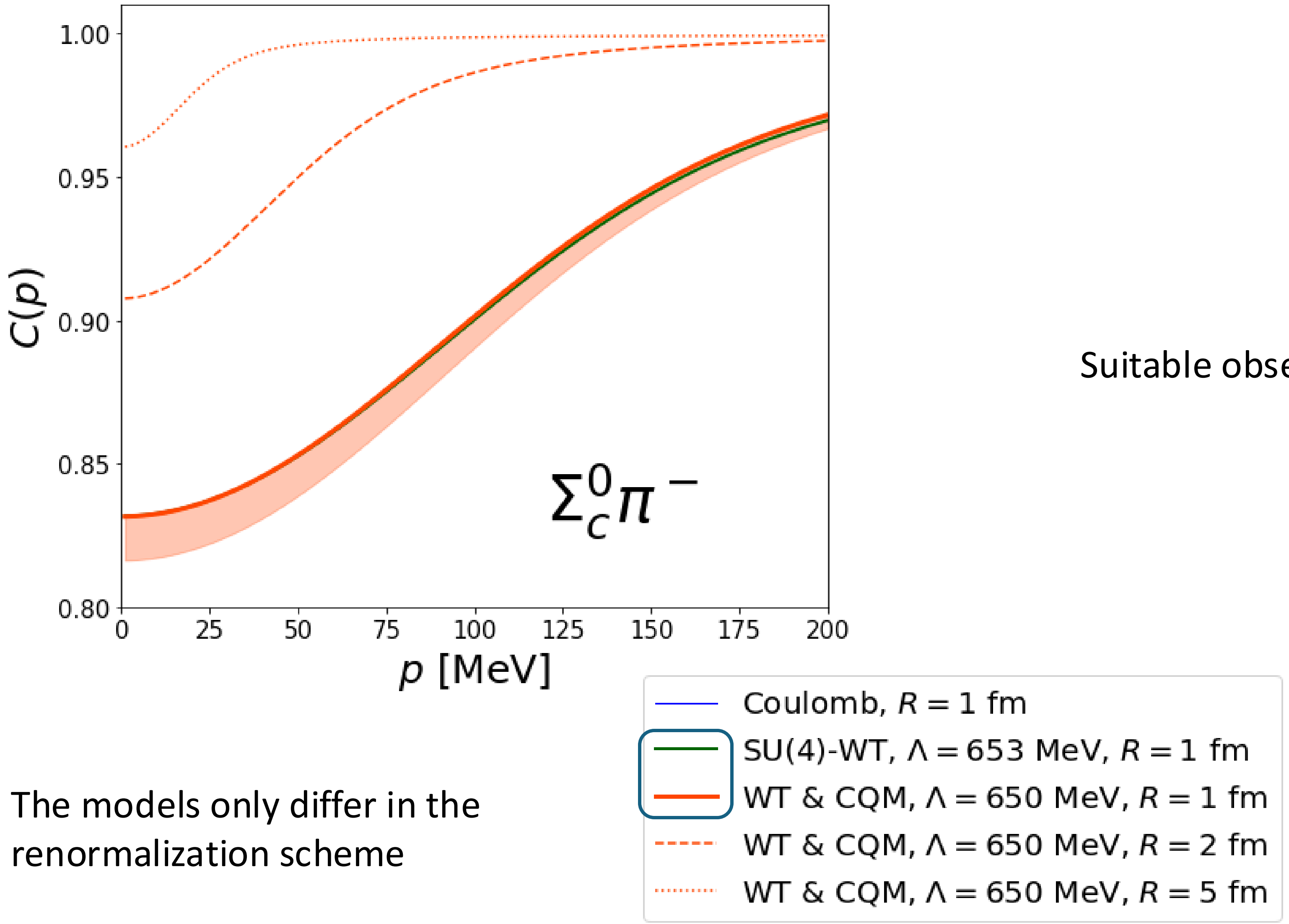

Repulsion

C(p) < 1

No Coulomb interaction

Suitable observable to constrain the strong dynamics of the I=2 sector

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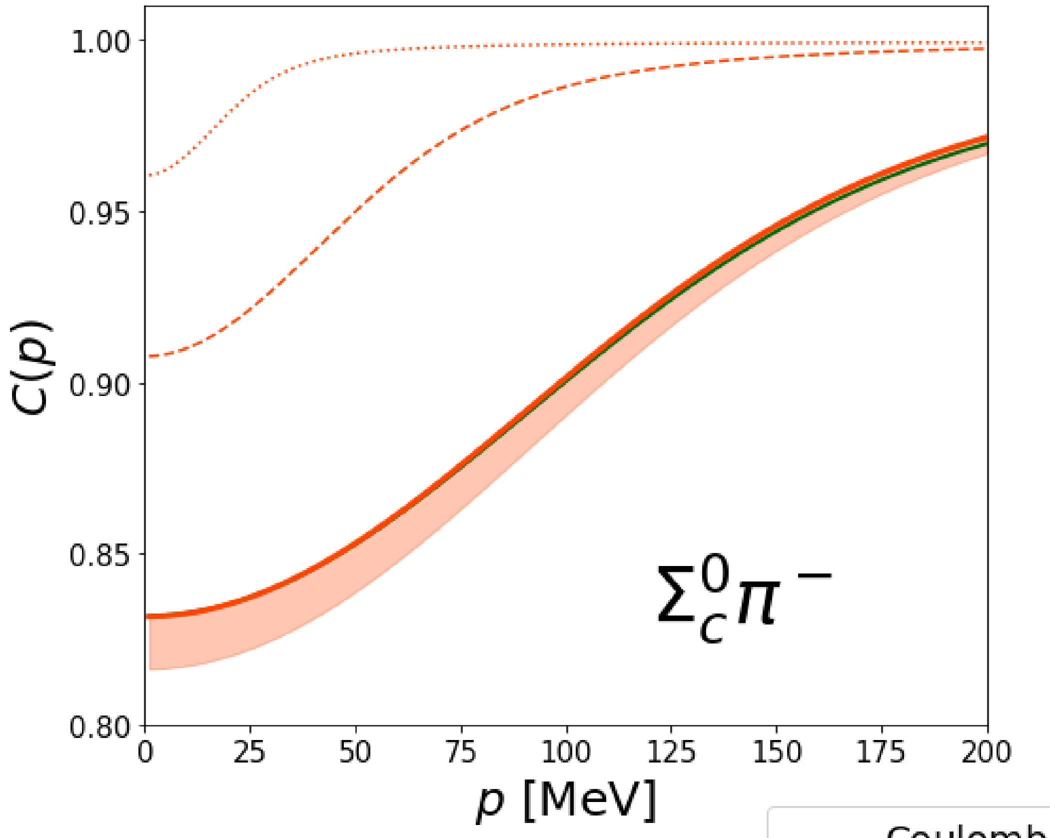

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Source size

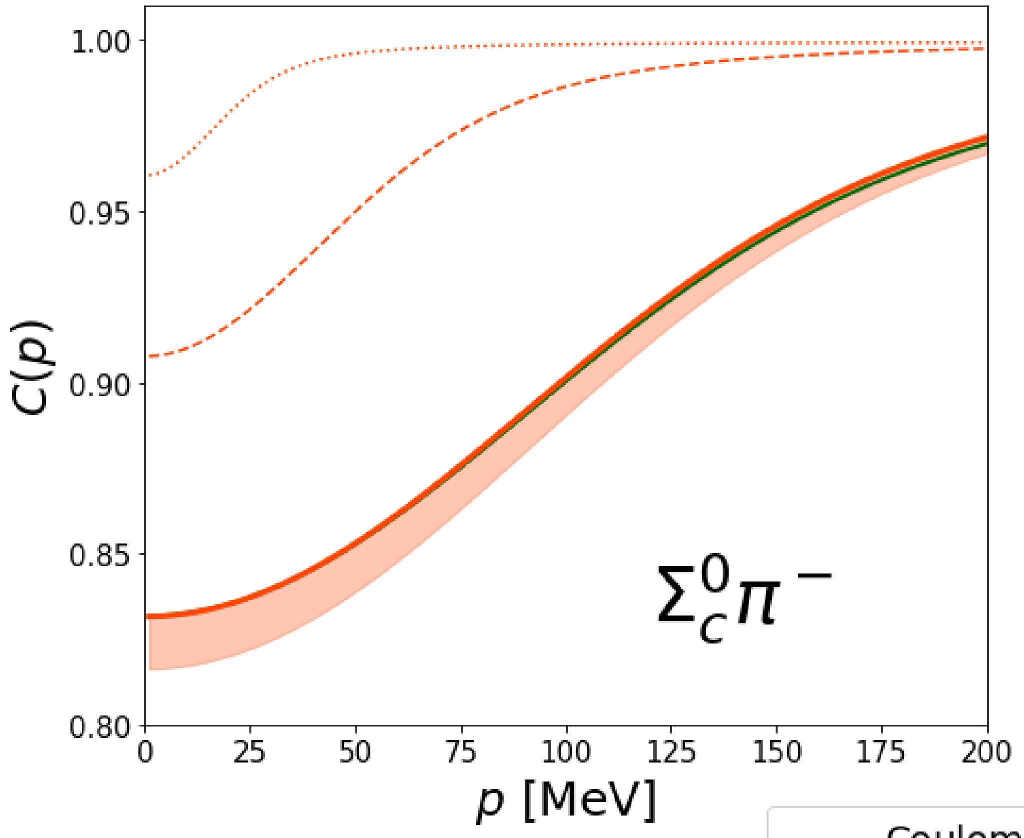
larger R ⟶ sensitivity decreases

The models only differ in the renormalization scheme

BUT WHAT HAPPENS ONCE COULOMB IS INCLUDED?

M. F. Barbat et al., PLB 878, 140529 (2026)

Strong



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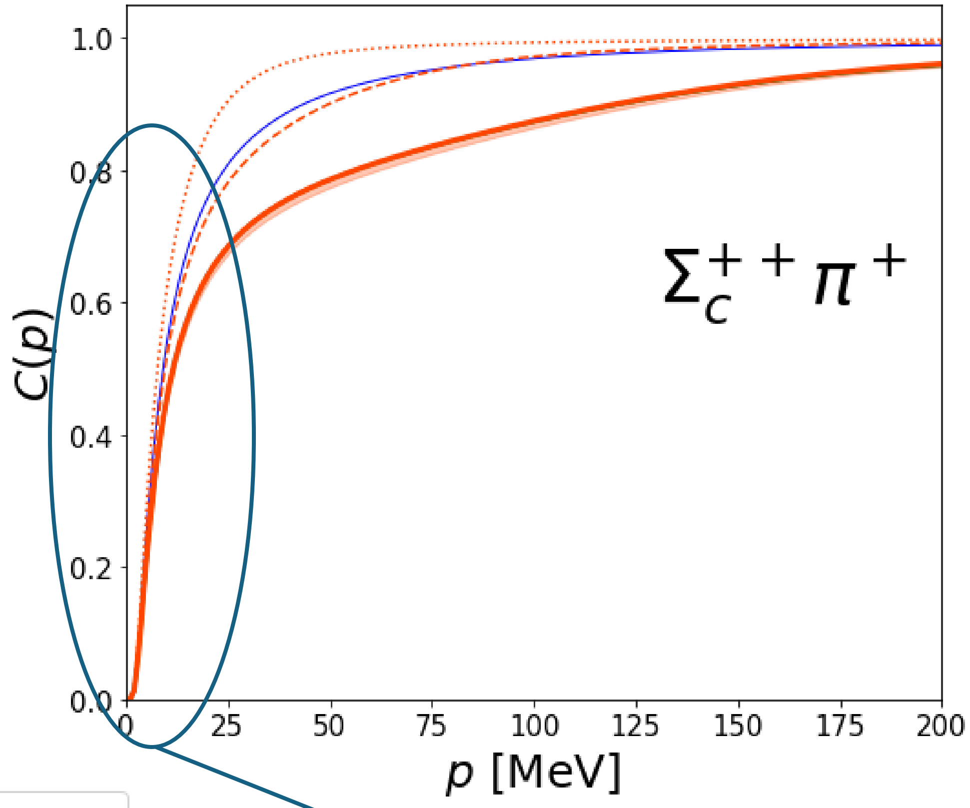

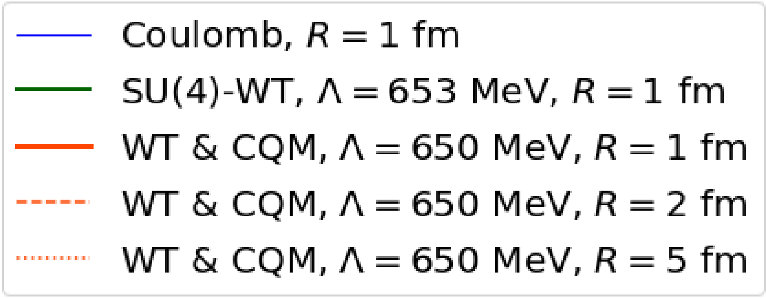

The models only differ in the renormalization scheme

Difficult to distinguish between models (Coulomb interaction dominates)

HEAVY-FLAVOUR SYMMETRY: FROM $\Sigma_c\pi$ TO $\Sigma_b\pi$

J.-X. Lu et al., Phys. Rev. D 92, 014036 (2015)
M. F. Barbat et al., PLB 878, 140529 (2026)

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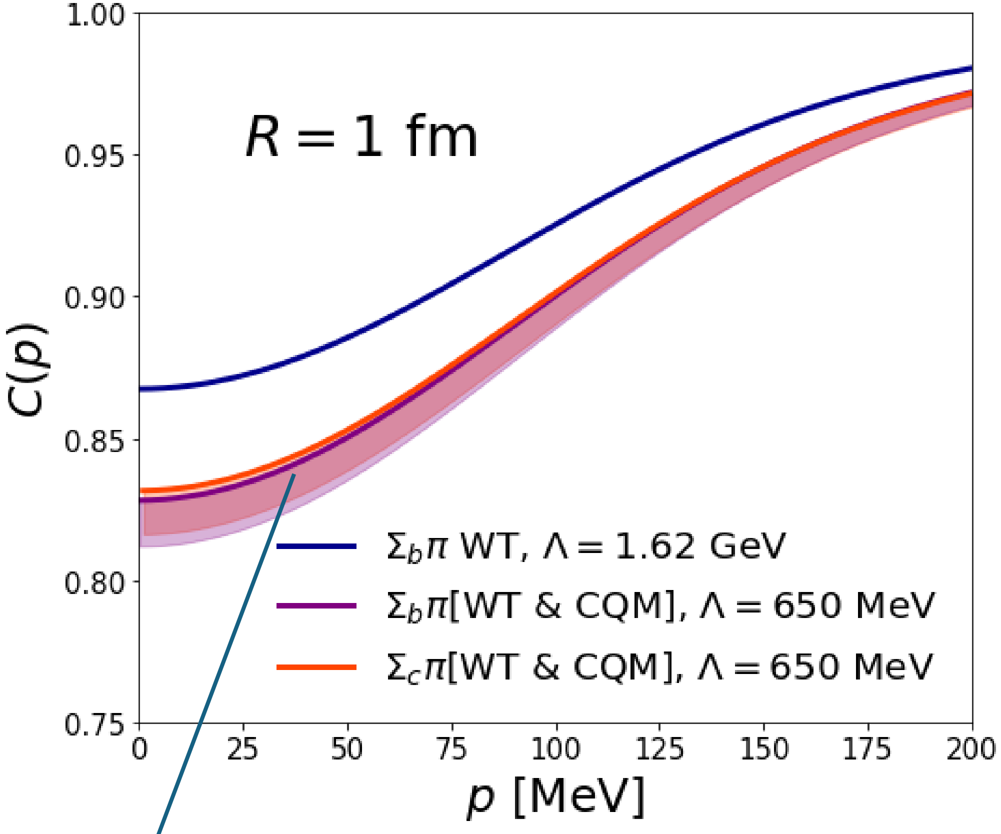

Similar to the charm sector, as expected from heavy-quark flavour symmetry (HQFS)

Differences between models (different cutoff values)

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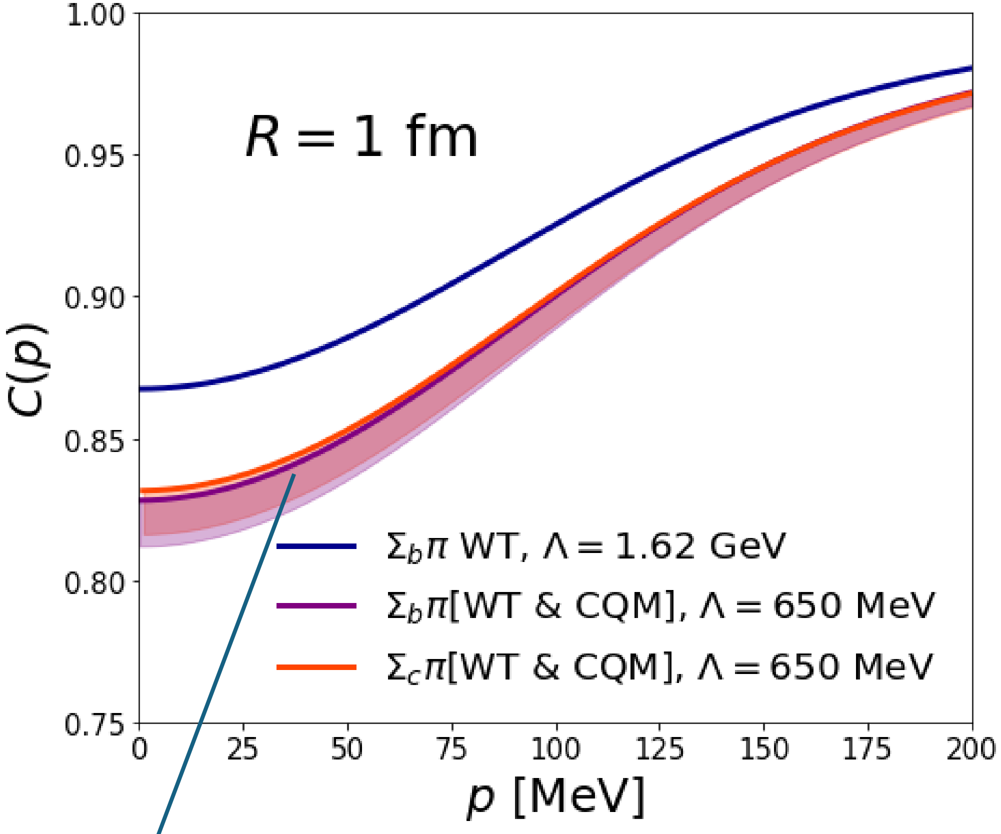

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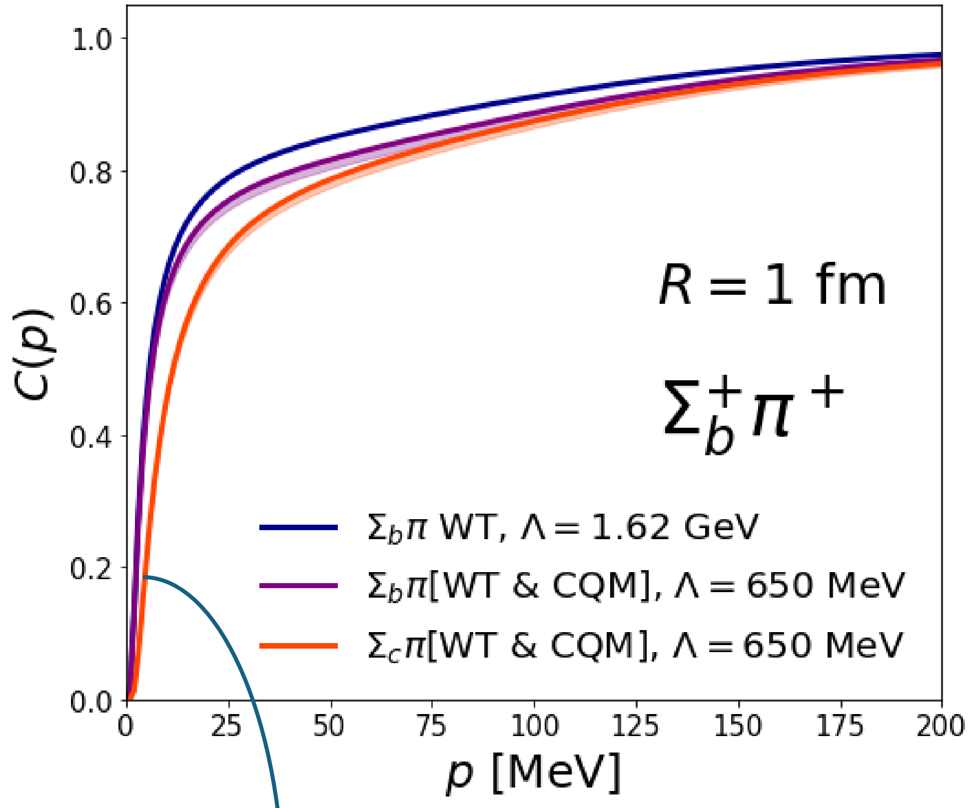

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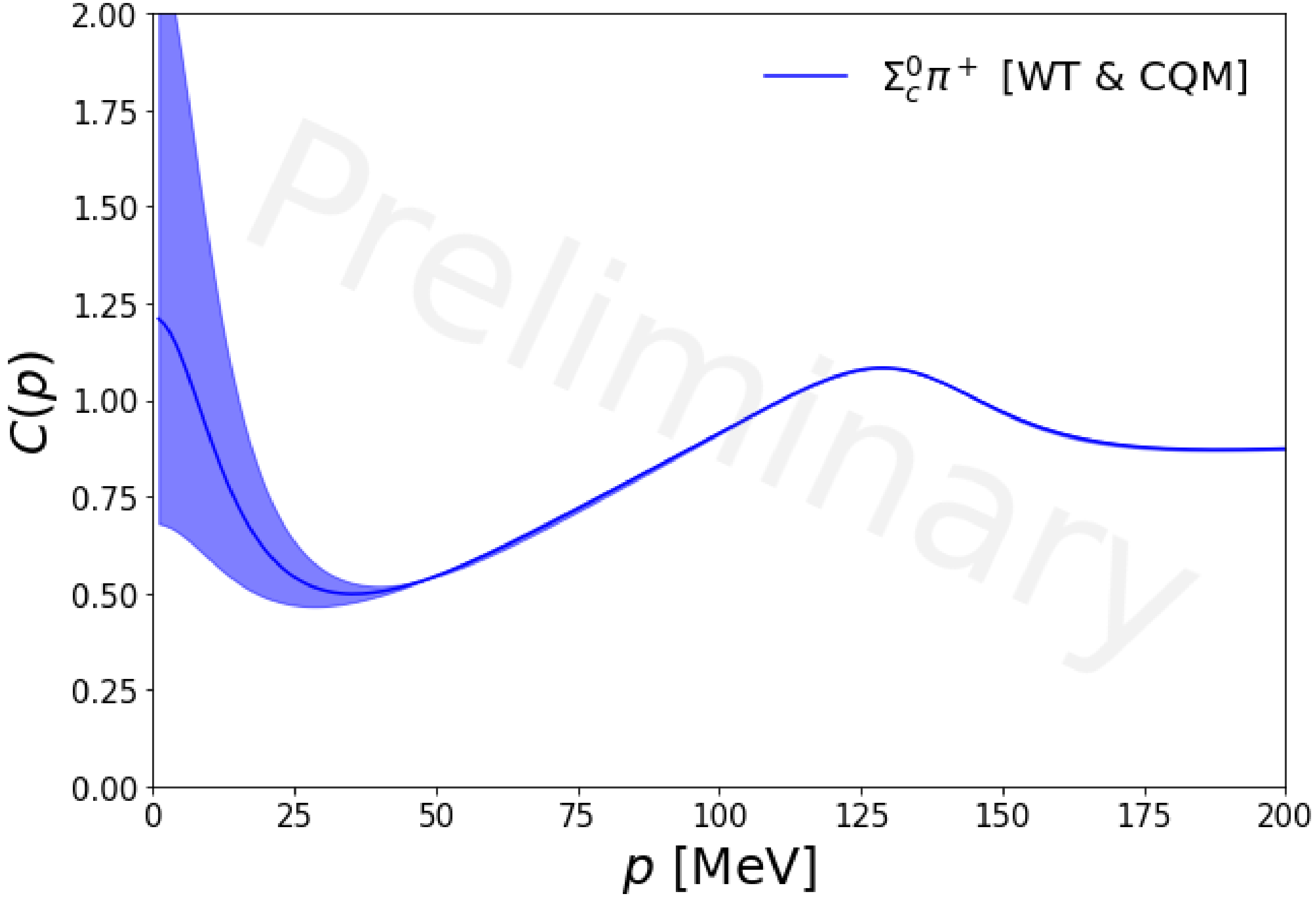
Differences between models (different cutoff values)

Less repulsive correlation function compared with the charm sector

OUTLOOK: PRELIMINARY RESULTS IN THE I=0 SECTOR



- Coupled-channel dynamics and a near-threshold resonance

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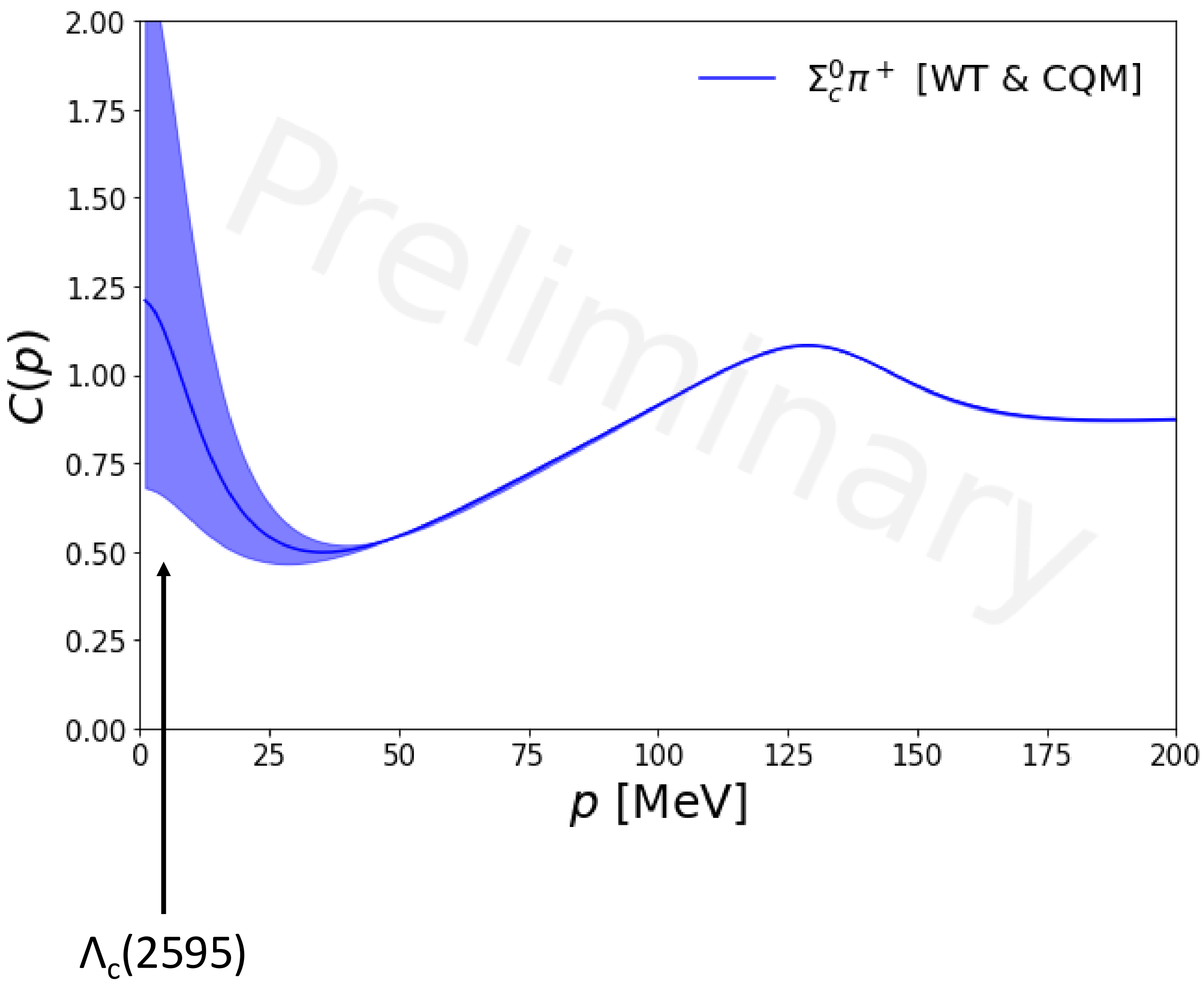

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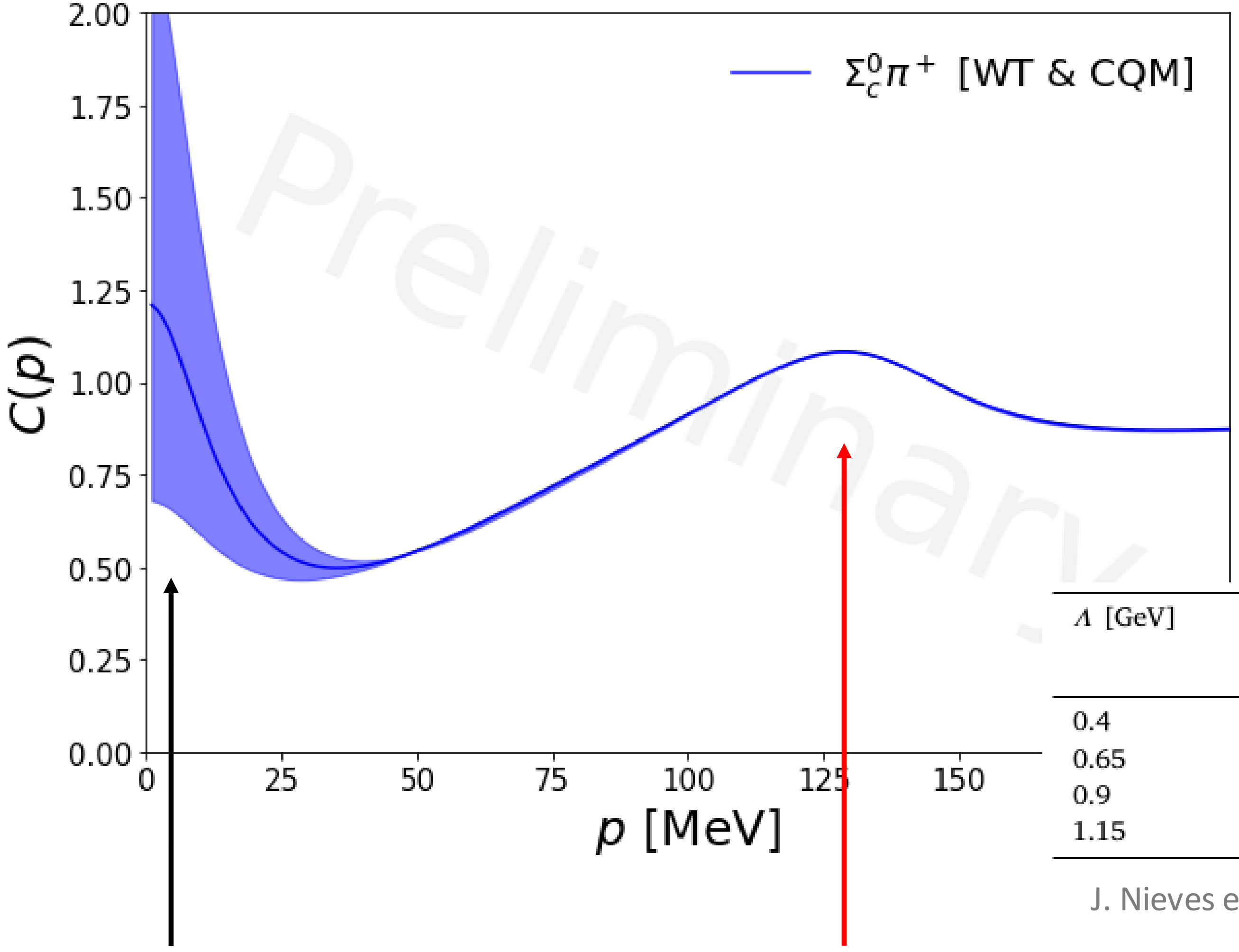

$\Lambda_c(2595)$

$\Lambda_c(2765)$?

- Coupled-channel dynamics and a near-threshold resonance
- A near-threshold bound state associated with the $\Lambda_c(2595)$ leaves a clear signal in the CF
- Evidence of a second pole

Λ [GeV]	$\lvert d_Q \rvert$	$\Sigma_c\pi$ [$J^P = 1/2^-$]			
		M [MeV]	Γ [MeV]	$\lvert g_{\Sigma_c\pi} \rvert$	$\phi_{\Sigma_c\pi}$
0.4	1.79 ± 0.11	2714 ± 6	85.7 ± 0.6	1.60 ± 0.02	-0.92 ± 0.01
0.65	1.06 ± 0.06	2674 ± 4	45.2 ± 1.1	1.33 ± 0.01	-0.75 ± 0.01
0.9	0.75 ± 0.04	2655 ± 2	20.5 ± 0.9	0.98 ± 0.02	-0.61 ± 0.01
1.15	0.55 ± 0.04	2643 ± 2	8.3 ± 0.8	0.67 ± 0.03	-0.49 ± 0.01

J. Nieves et al., Progress in Particle and Nuclear Physics 137, 104118 (2024)

CONCLUSIONS...

- The isotensor $\Sigma_c\pi$ interaction is **weakly repulsive** and **non-resonant**, in agreement with the correlation function
- The correlation function at low momenta is **not sensitive** to the strong-interaction model when Coulomb is included, while some discriminating power remains at intermediate momenta.
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… AND OUTLOOK

- We are now working on the isoscalar I=0 sector

Thank you for your attention!
Any question?

BACKUP: COULOMB IMPLEMENTATION

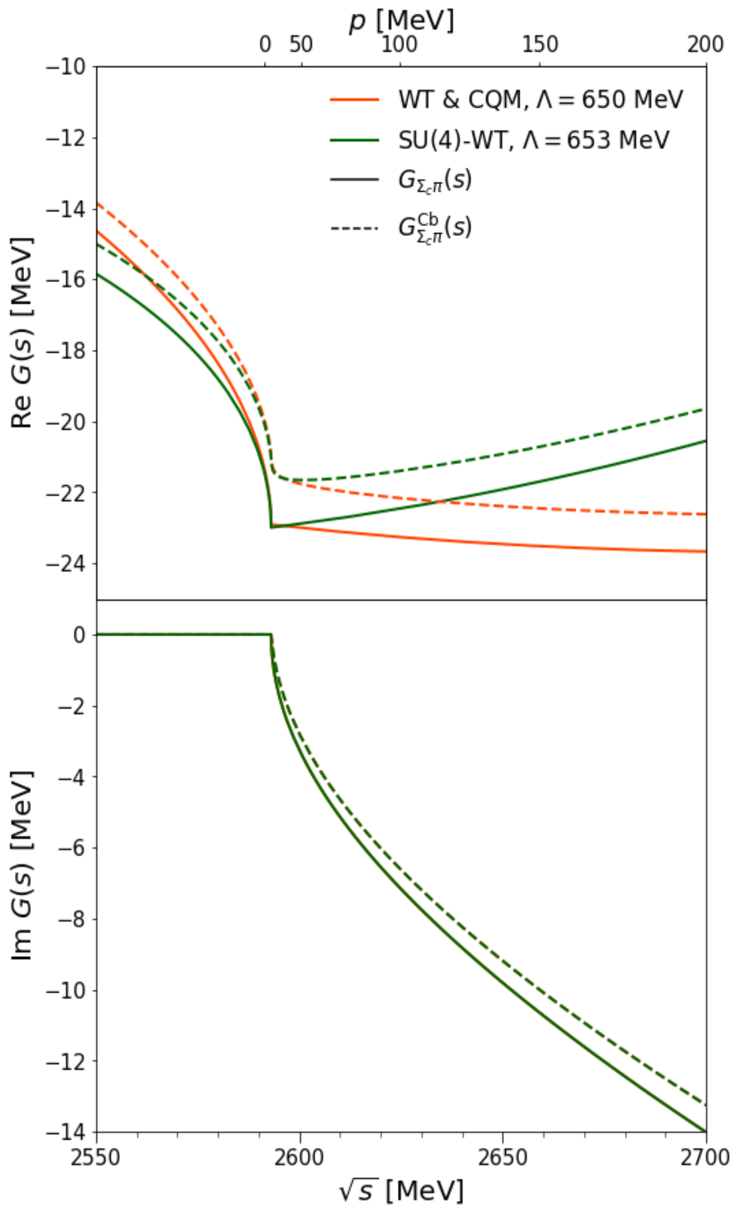
- Coulomb-dressed loop function

$$G^{\rm Cb}_{\Sigma_c\pi}(s) = \int \frac{d^3q}{(2\pi)^3}\frac{E(q)+\omega(q)}{2E(q)\omega(q)}\frac{2M_{\Sigma_c}|\psi(\vec{q},\vec{0}\,)|^2}{s-(E(q)+\omega(q))^2+i\varepsilon}$$

$$C_\eta^2 = \frac{2\pi\eta_p}{e^{2\pi\eta_p}-1}, \quad \eta_p = \alpha e_{\rm eff}\frac{\sqrt{\mu^2+p^2}}{p}, \quad e^{2i\sigma_0} = \frac{\Gamma(1+i\eta_p)}{\Gamma(1-i\eta_p)}$$

$$|\psi(\vec{q},\vec{0}\,)|^2 = \frac{2\pi\eta_q}{e^{2\pi\eta_q}-1}$$

$$\boxed{T_{SC}(s) = \frac{C_\eta^2\; e^{2i\sigma_0}}{V^{-1}(s) - G^{\rm Cb}_{\Sigma_c\pi}(s)}}$$



M. Albaladejo et al., PTEP 2025, 09 (2025)

BACKUP: LOW-ENERGY PARAMETERS

Model	Λ[MeV]	$a_0^{(SC)}$	$r_0^{(SC)}$ (fit)	$r_0^{(SC)}$ (der)
WT	400	0.194	7.77	7.86
WT+Coul.	400	0.198	7.96	8.03
WT	650	0.177	7.71	7.80
WT+Coul.	650	0.181	7.91	7.97
SU(4)	653	0.177	8.26	8.34
SU(4)+Coul.	653	0.181	8.42	8.49

Coulomb produces only a small increase in the scattering length/effective range for the weak, non-resonant I = 2 interaction