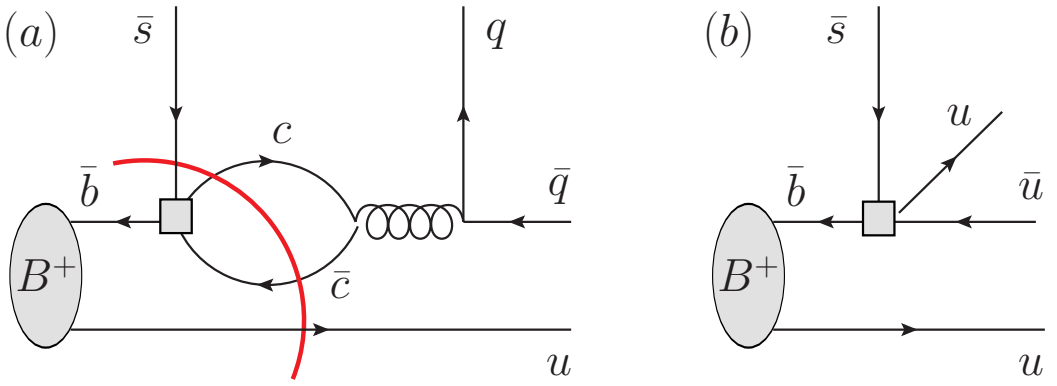
TOWARDS AN UNDERSTANDING OF THE ROLE OF CHARM LOOPS IN $B \to$ LIGHT HADRONS

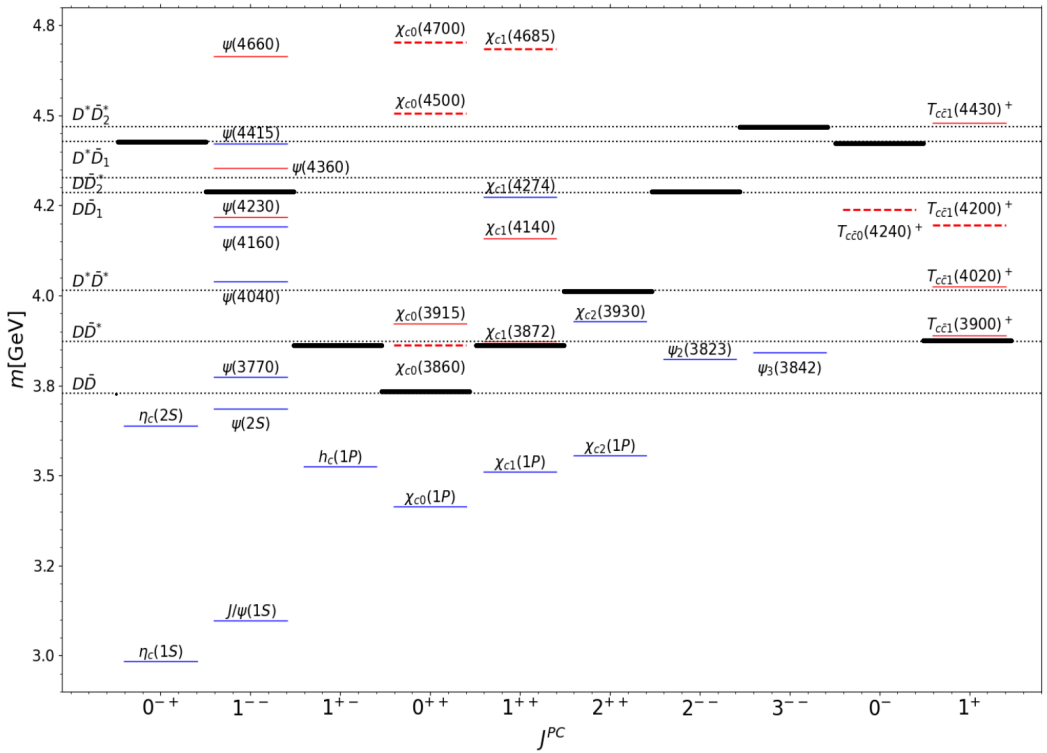
October 21, 2025 | Christoph Hanhart | IKP/IAS Forschungszentrum Jülich

color meets flavor

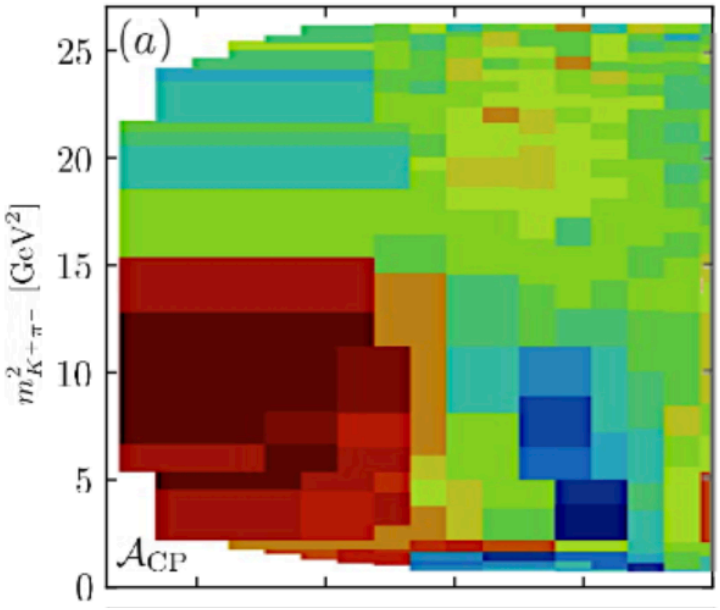
JÜLICH Forschungszentrum

When Color meets Flavor





CP Asymmetry from
$B^\pm \to K^\pm\pi^+\pi^-$



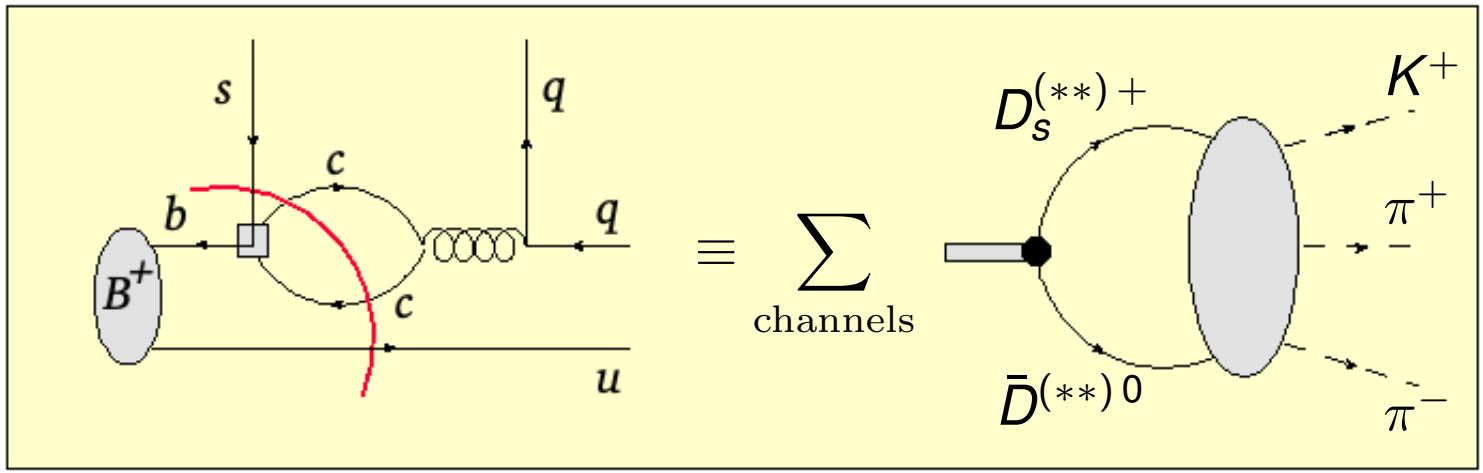
Clearly shows
light resonances!
Role of charmonium
like states?

From our recent study for $B^{\pm} \to K^{\pm}\pi^{+}\pi^{-}$...

We found that CP conserving imaginary parts from $\bar{c}c$ loops are needed

Currently included as imaginary, partial wave dependent numbers

We want to make contact to what is known from hadron phenomenology

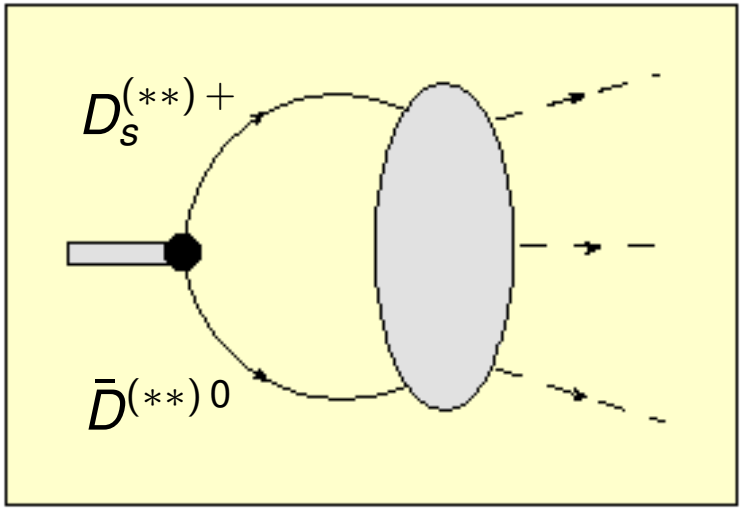


- Can we control the $m_{\pi\pi}$ dependence?
- Is the exclusive evaluation manageable/controllable?
- What is the role of quarkonium-like states?

Candidate channels

We focus on channels with Br $\gtrsim$ 1%:

(1)	$\bar{D}^0 D_s^+$	(0.9 ± 0.6) %
(2)	$\bar{D}^{*0} D_s^+$	(0.7 ± 0.1) %
(3)	$\bar{D}^0 D_s^{*+}$	(0.8 ± 0.2) %
(4)	$\bar{D}^{0*} D_s^{*+}$	(1.7 ± 0.2) %
(5)	$\bar{D}^{*0} D_{s1}(2460)^+$	(1.2 ± 0.3) %
(6)	$\bar{D}^{**0} D_s^{(*)+}$	(3.7 ± 1.2) %



where $\bar{D}^{**0}$ sub-sums $D_1(2420)$, $D_2(2460)^*$, $D_1(2430)$

To be compared to $\mathrm{Br}[B^\pm \to K^\pm \pi^+ \pi^-] = (5.1 \pm 0.3) \times 10^{-5}$

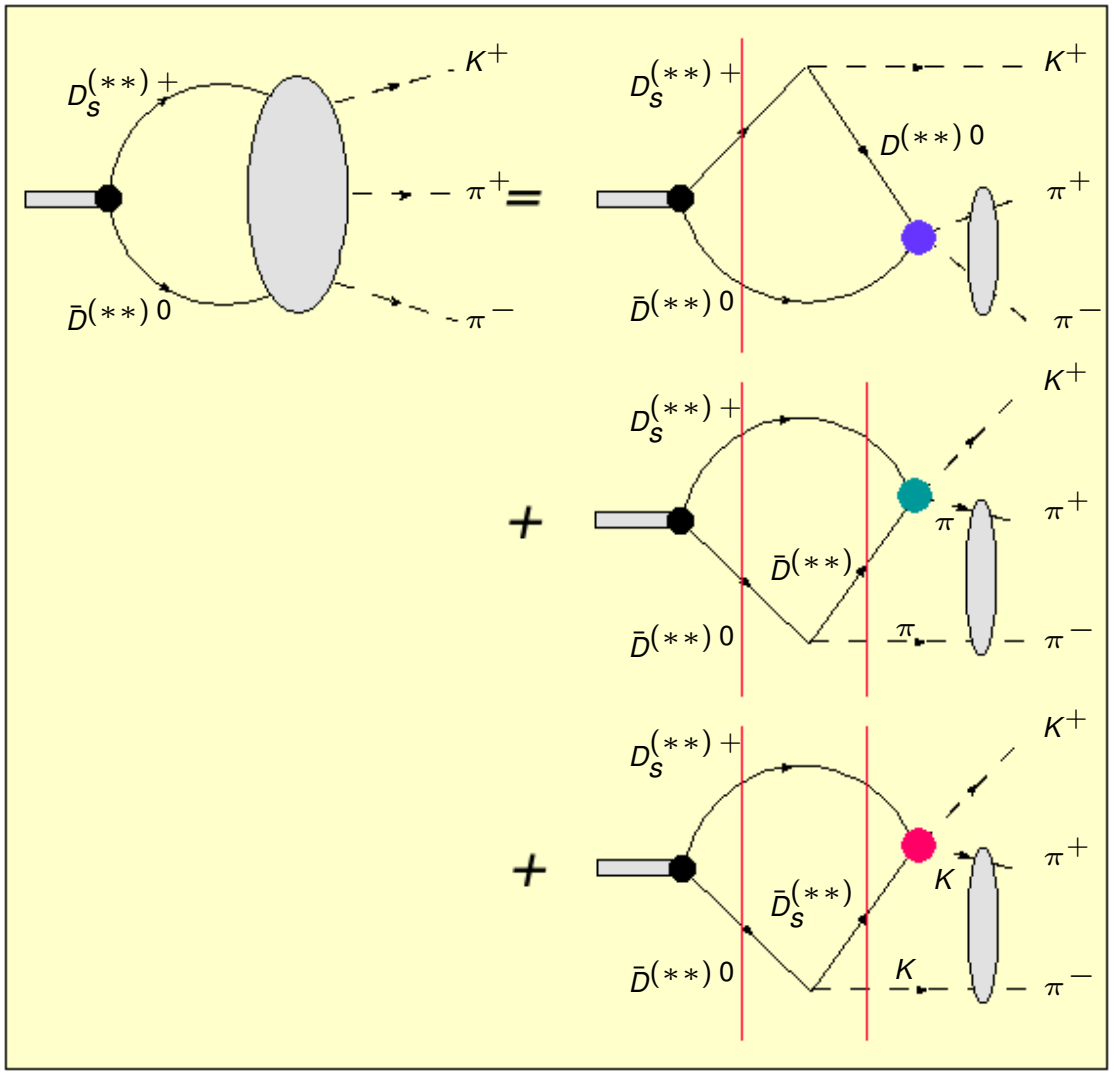
- Two-body intermediate states give constant imaginary part!
- Can couplings can be constrained using heavy quark spin symmetry?
- Is there residual $m_{\pi\pi}$ dependence from $\bar{D}^0 D_s^+ \to K^+ \pi^+ \pi^-$?

... possibly enhanced by QCD exotics?

T. Mannel, K. Olschewsky and K. K. Vos, JHEP06(2020)073

An even closer look

We still restrict ourselves to $m_{\pi\pi} < 1$ GeV and omit 3-body rescatterings



second cut not operative

$\Longrightarrow$ contribution provides

constant Im-part

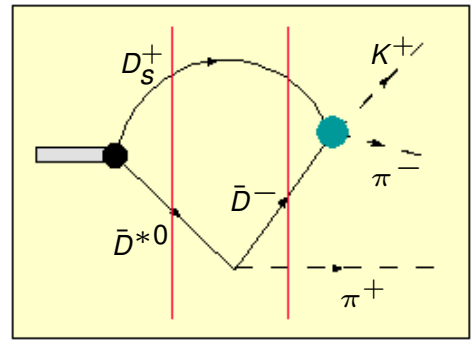
Both cuts operative

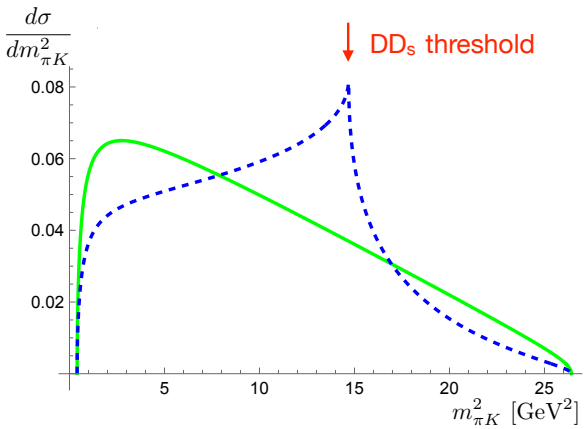
$\Longrightarrow$ additional $m_{\pi\pi}$ or $m_{\pi K}$

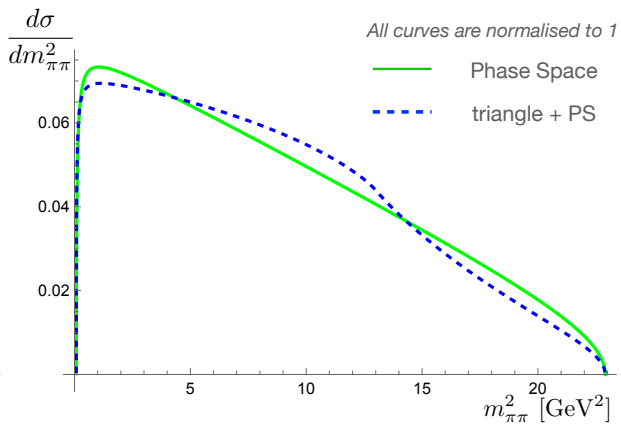
dependence possible

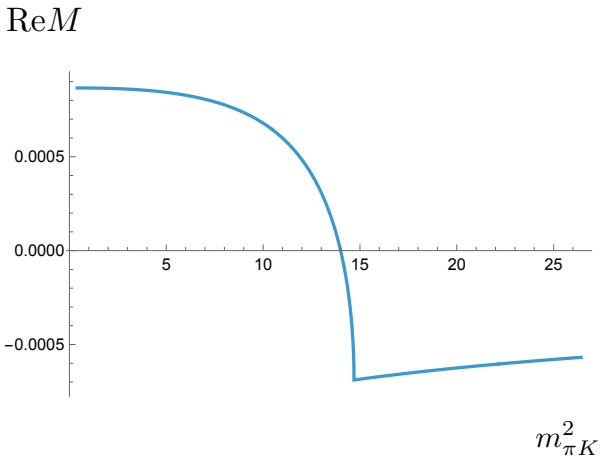
Role of Exotics?

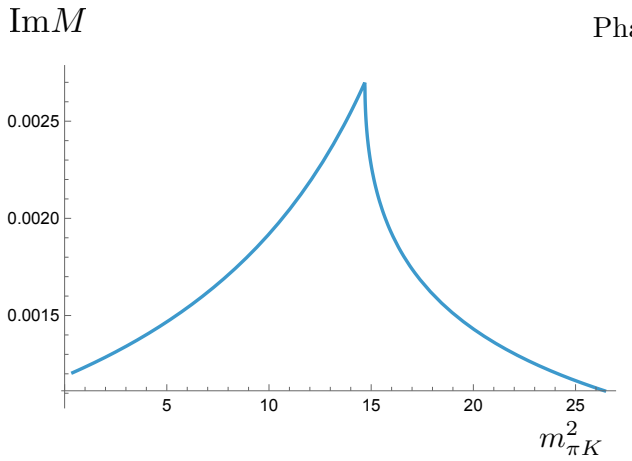
Structure from triangles

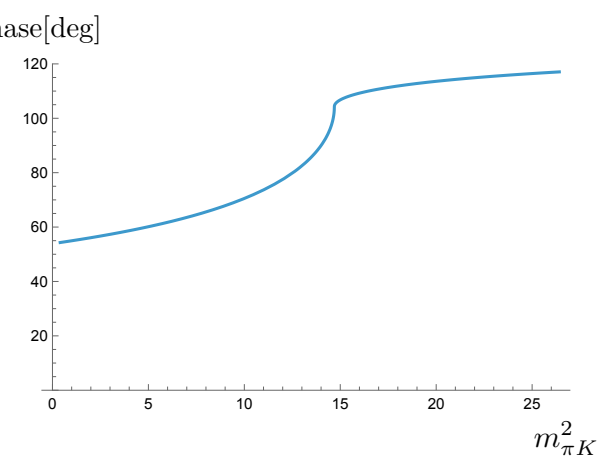








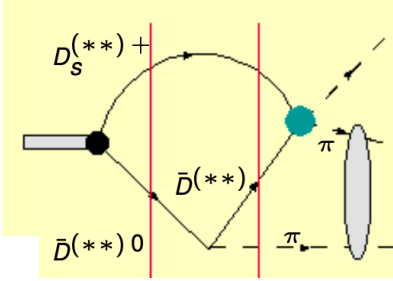




Figs. courtesy of V. Baru

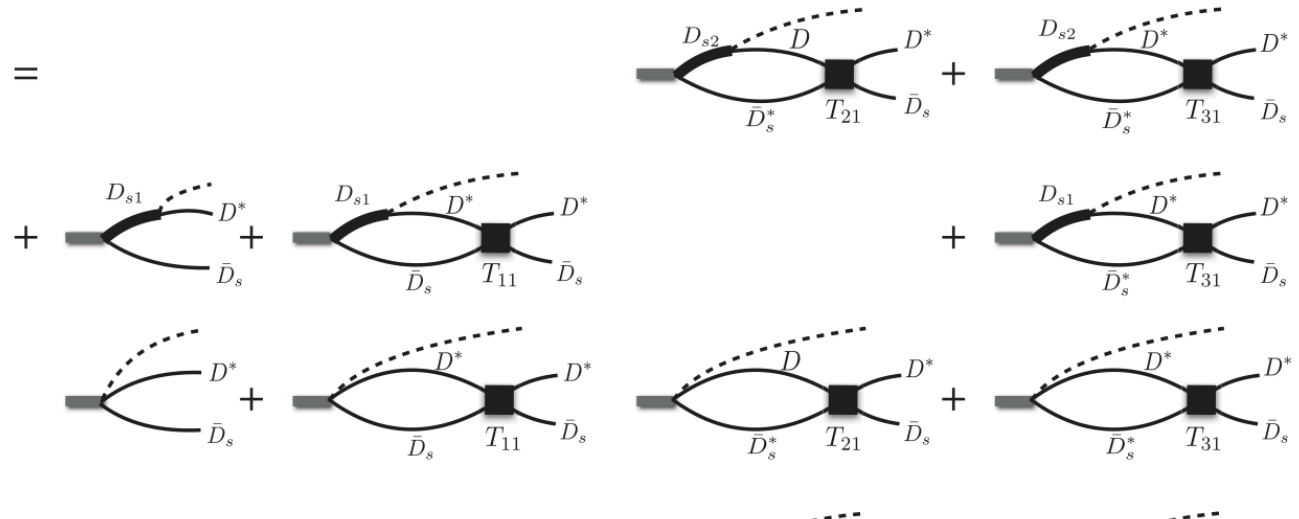
- Non-vanishing phase at $m^2_{\pi K} = 0$—Im-part fixed by couplings!
- Non-trivial phase motion in $m^2_{\pi K}$ even without exotic state
- No significant modification in $m^2_{\pi\pi} \Longrightarrow$ const. Im-part from $\bar{c}c$

Example: $e^+e^- \to K(D\bar{D}_s^*/D^*\bar{D}_s)$



Baru et al., PRD105 (2022)034014

$M_{Y\to KD^*\bar{D}_s} =$



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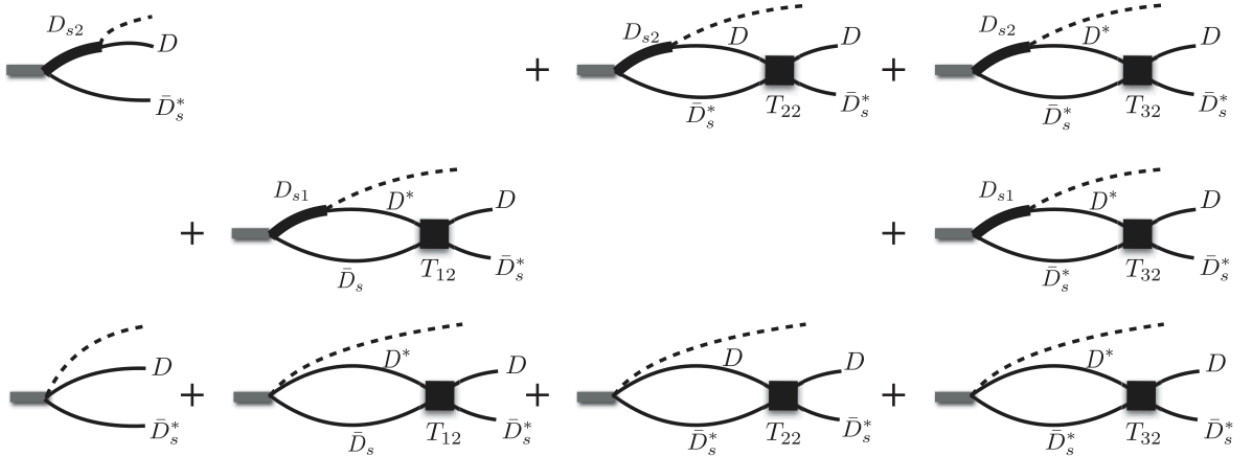
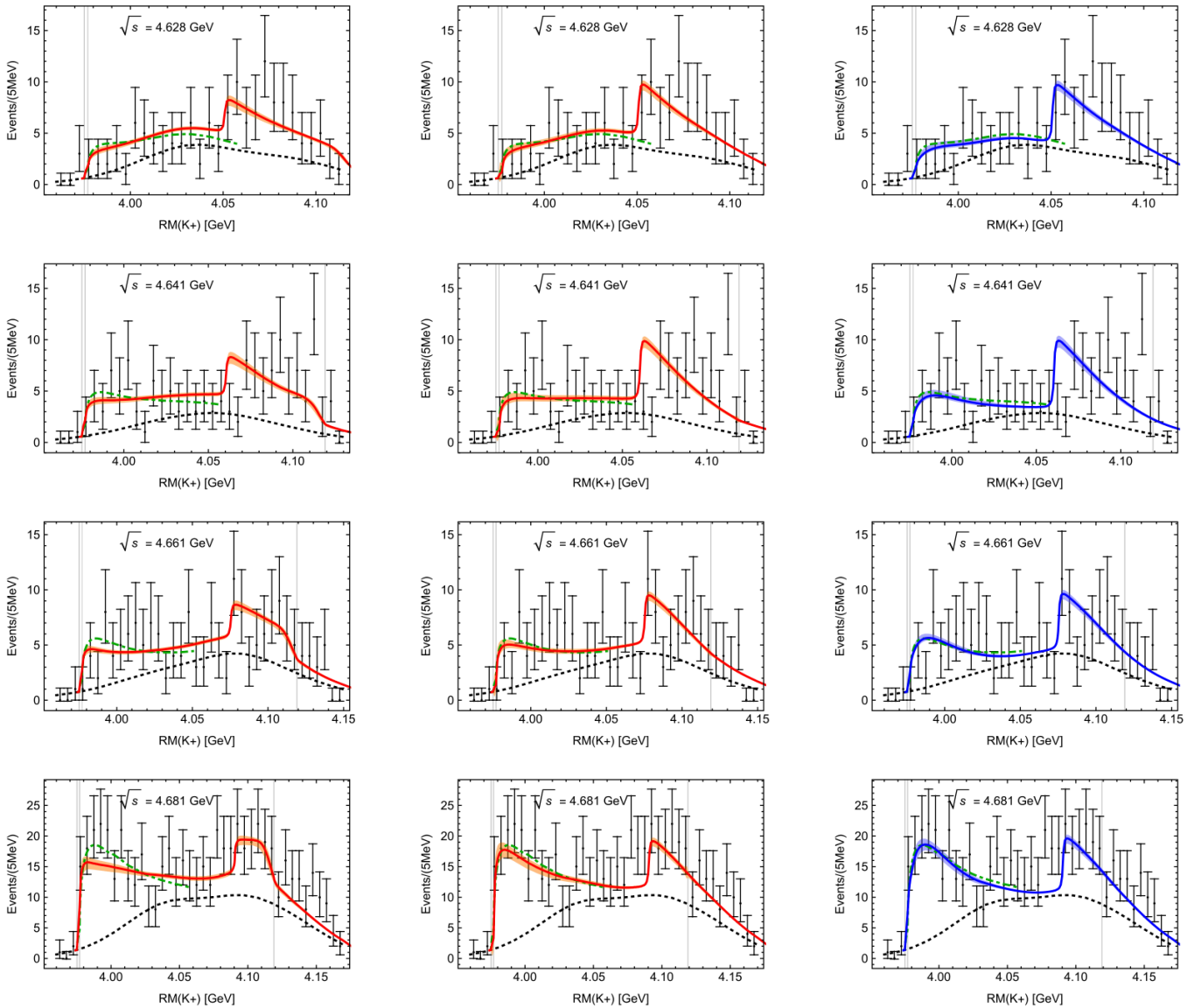


$\Longrightarrow$ The T-matrix features Z_{cs} resonances

Results: $Z_{cs}(3982)$

Baru et al., PRD105 (2022)034014



Three different fits (columns) for 4 energies (lines) with different physics

Lineshapes through interplay of

- tree-level diagrams,
- triangles
- poles

Conclusion/Perspectives

What we need to make further progress are data for, e.g.,

$$\boxed{B \to \pi D_s^{(*)} \bar{D}^{(*)} / K D^{(*)} \bar{D}^{(*)} \text{ Dalitz plots}} \Longrightarrow \text{BelleII, LHCb?}$$

They would allow us to better pin down the charmed contribution to

$$B^{\pm} \to h_1^{\pm} h_2^{+} h_2^{-} \text{ and teach us about exotic mesons}$$

Thus, *B*-decays to light and charmed mesons are rich of physics:

- *CP*-violation within the Standard Model (and beyond?)
- Inclusive vs. exclusive calculations
- Three-body interactions
- Resonance physics (including exotics)

.... since color-meets-flavor